Gruppo 1 Padova

Stato Esperimenti, Anagrafica e Preventivi

CdS

7/7/2020

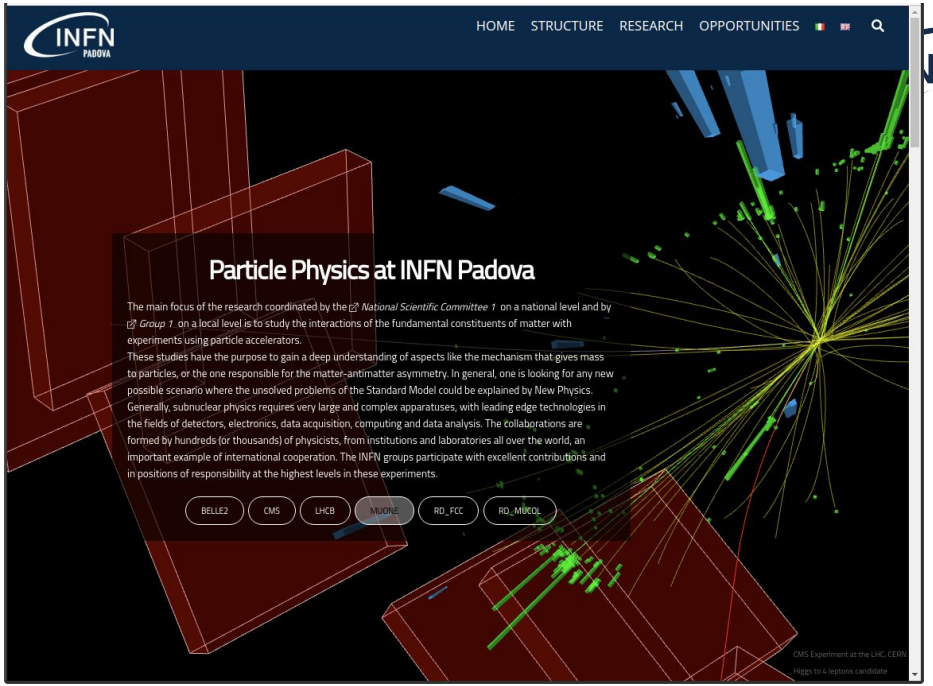
Stefano Lacaprara

INFN Padova

Slides by Roberto S., Roberto R., Gabriele, Enrico, Donatella, Patrizia, Mauro

Outline

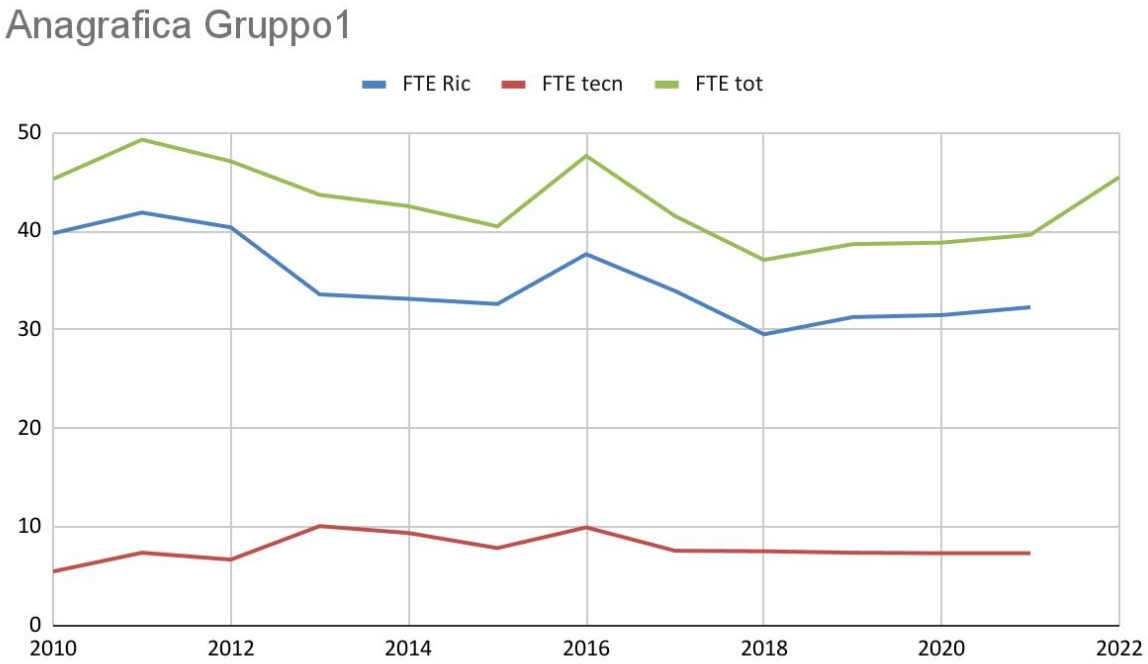
- General Summary
- Belle II
- CMS / Fase2_CMS
- LHCb
- MuonE
- MuColl
- FCC
- LUXE



Nuova [pagina divulgativa di Gr1]:
(con animazione! H->Z(->ee)Z(->$\mu\mu$))
Pietro Grutta, Sabine Hemmer, Alessandra Casotto

Disclaimer: alcune delle slide le ho avute “just in time”, letteralmente.
L’anagrafica potrebbe essere soggetta a piccole variazioni

Anagrafica Gruppo1 ultimi 10 anni



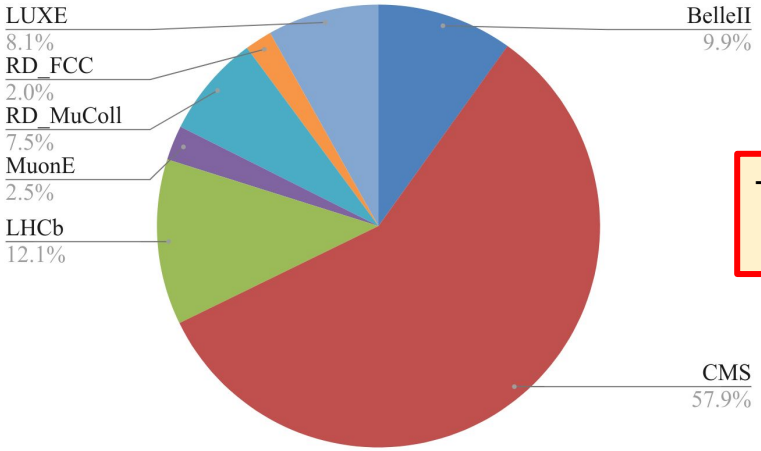
FTE preliminari!!!

Difficile fare il conto delle persone perche' DB conta anche 0% (eg Jennifer or Intense)

FTE e persone per sigla

Da aggiornare

	Belle II		CMS		FASE2_CMS		LHCb		MuonE		RD_MuColl		RD_FCC_DTz		LUXE#	
	FTE	Px	FTE	Px	FTE	Px	FTE	Px	FTE	Px	FTE	Px	FTE	Px	FTE	Px
2021	5.15	11	19.55	24	9.3	22	4.8	10	3.25	9	3.95	15	0.3	2		
2022	4.5	9	FTE: 26.3		Px: 37		5.5	9	1.15	5	3.4	15	0.9	6	3.7	7
Δ	-0.65	-2	-2.5		-		+0.7	-1	-2.15*	-4	-0.5	0	+0.6	+4	+3.7	+7



*AdR+PhD ended

#Signal not approved (yet) PhD+AdR from 2021

Totale:	**Ricercatori+Tecnologi:**	**45.2 FTE**
	2020	**45.5 FTE**

NB anagrafiche da confermare

Belle II

RL: R.Stroili

Belle2 status

pubblicazioni di Fisica:

1) Search for an Invisibly Decaying Z′ Boson at Belle II in $e^+e^- \to \mu^+\mu^-(e^\pm\mu^\mp)$ Plus Missing Energy Final States.

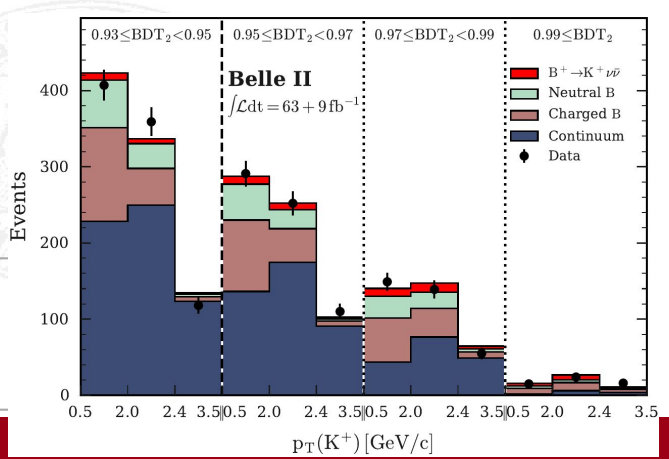
PRL 124, 141801 (2020)

2) Search for Axion-Like Particles Produced in e^+e^- Collisions at Belle II.

PRL 125, 161806 (2020)

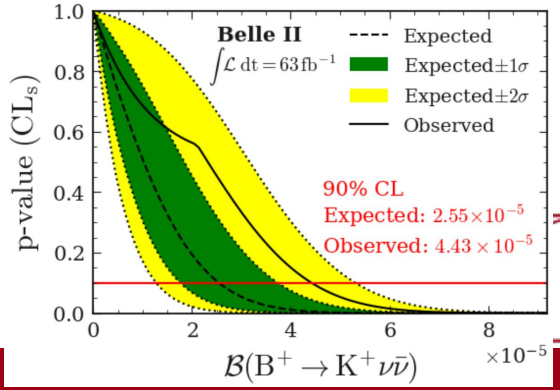
3) Search for $B^+ \to K^+ \nu\nu$ decays with an inclusive tagging method at the Belle II experiment.

- submitted to PRL



- $B^+ \to K^+ \nu\nu$
- nuovo approccio "*inclusivo*" per cercare le transizioni rare:
  - $b \to s \nu\nu$;
- rispetto alle vecchie analisi di Belle e BaBar, non viene ricostruito l'altro candidato B nell'evento, ma si procede con un'analisi multivariate di molte variabili in grado di separare il segnale dai fondi;
- l'analisi è validata su un campione di $B \to J/\psi\, K^+$, rimuovendo i muoni dal decadimento della J/ψ per simulare i neutrini;
- limiti comparabili con quelli delle analisi tagged su statistica 5-10 volte superiore.

$$\mu - \mu_{SM} = 3.6 \pm 3.6$$



conference papers

~10 fb^{-1}

- Charmless B decay reconstruction, arXiv:2005.13559 [hep-ex];
- Measurement of the branching fraction B(anti-$B^0 \to D^{*+} l^- \nu_l$), arXiv:2004.09066 [hep-ex];
- Measurement of the B^0 lifetime using fully reconstructed hadronic decays, arXiv:2005.07507 [hep-ex];

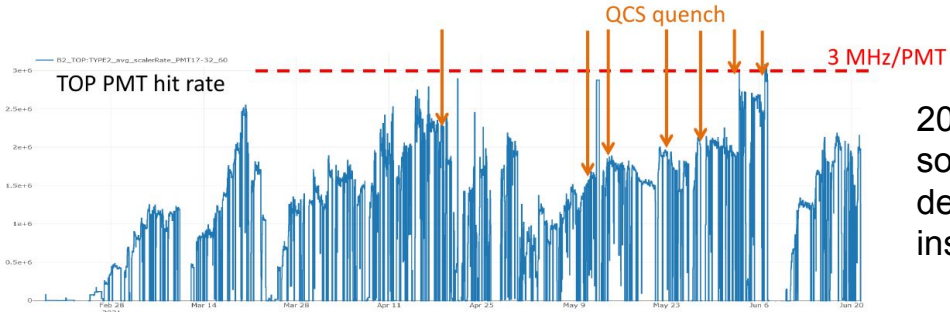
~35 fb^{-1}

- Measurement of the branching ratios of $B^0 \to D^{(*)-} l^+ \nu$ (untagged analysis), arXiv:2008.07198 [hep-ex];
- Calibration of the Belle II hadronic Full Event Interpretation (FEI), arXiv:2008.06096 [hep-ex];
- Measurement of the hadronic mass moments of $B \to X_c l^+ \nu$ decays, arXiv:2009.04493 [hep-ex];
- Measurement of the branching ratios of $B^0 \to D^{*-} l^+ \nu$ (using the hadronic FEI), arXiv:2008.10299 [hep-ex];
- Rediscovery of $B^0 \to \pi^- l^+ \nu$ (using the hadronic FEI), arXiv:2008.08819 [hep-ex];
- Calibration of the Belle II B FlavorTagger, arXiv:2008.02707 [hep-ex];
- Rediscovery of $B \to \varphi K^{(*)}$ decays, and measurement of the longitudinal polarization fraction of $B \to \varphi K^*$, arXiv:2008.03873 [hep-ex];
- Branching ratios and direct CP asymmetries of B → Charmless decays, arXiv:2009.09452 [hep-ex];
- Measurement of the τ lepton mass, arXiv:2008.04665 [hep-ex];

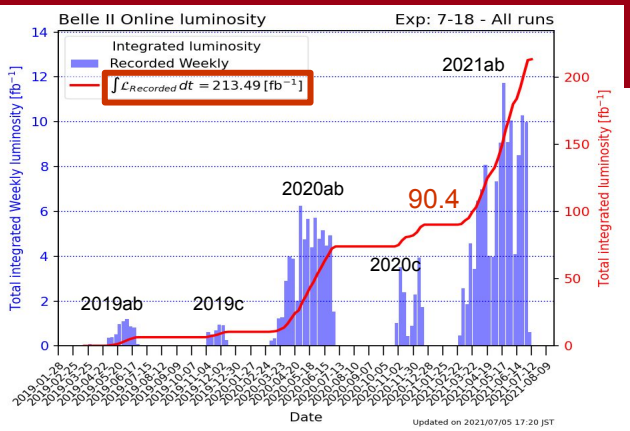
~70 fb^{-1}

- First determination of direct CP-violating asymmetry in $B^0 \to K^0\pi^0$ decays, arXiv:2104.14871 [hep-ex];
- Measurement of the time-integrated mixing probability χ_d with a semileptonic double-tagging strategy, arXiv:2106.00482 [hep-ex];
- Rediscovery of $B \to \eta' K$ decays, arXiv:2104.06224 [hep-ex];
- Measurements of branching fractions and direct CP-violating asymmetries in $B^+ \to K^+\pi^0$ and $\pi^+\pi^0$ decays, arXiv:2105.04111 [hep-ex];
- Measurements of branching ratios and direct CP asymmetries in $B^0 \to K^+\pi^-$, $B^+ \to K_S\pi^+$, $B^0 \to \pi^+\pi^-$, arXiv:2106.03766 [hep-ex];
- $B \to D^{(*)} h$ decays, arXiv:2104.03628 [hep-ex].

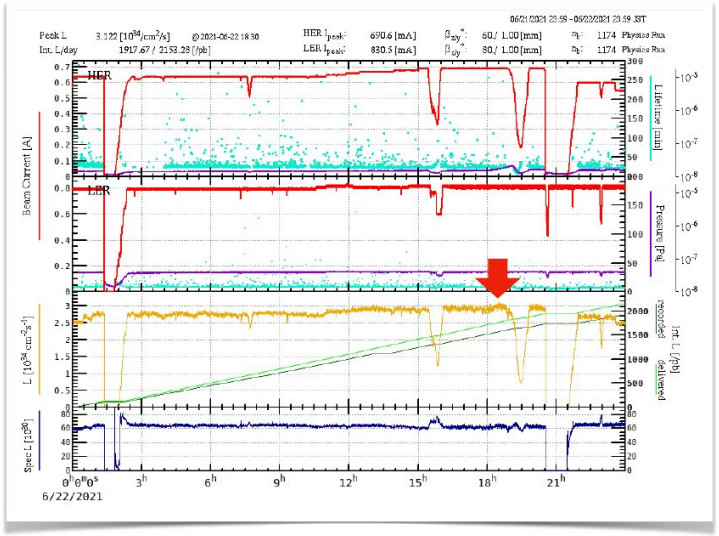
Belle2 status



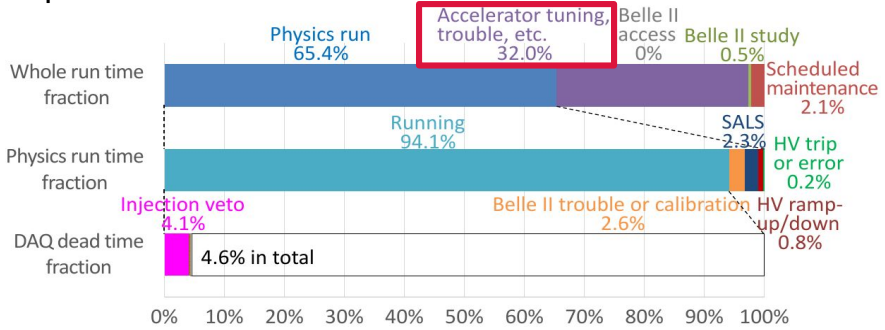
2022: LS1 per sostituzione parte dei PMT TOP e installazione PXD



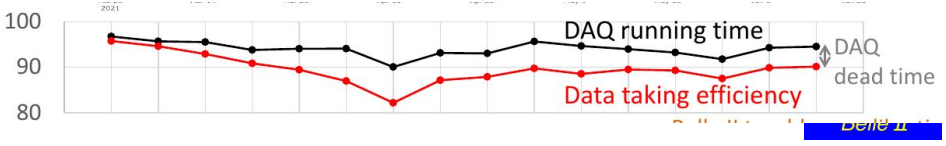
nuovo record di luminosità: $3.12 \cdot 10^{34}$ cm^{-2}s^{-1}



ancora problemi con la macchina



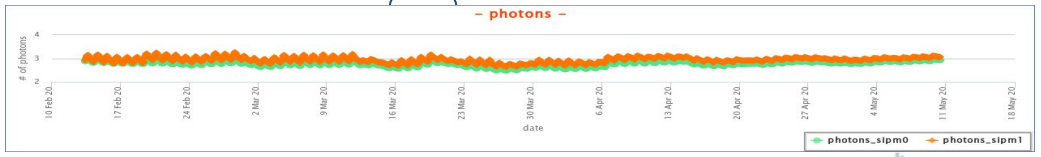
efficienza acquisizione buona



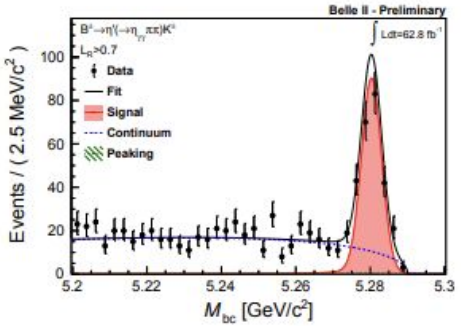
attività a Padova

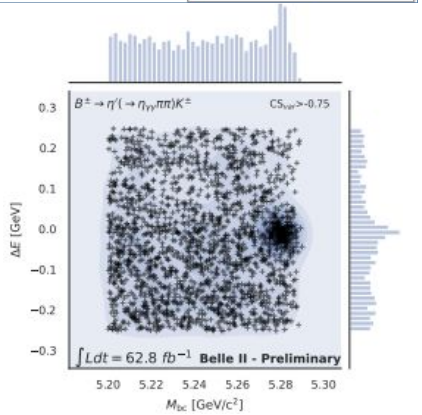
- sistema di monitor del laser di calibrazione:
  - spedito durante il lockdown
  - installato a Marzo 2021
    - in funzione

1 week



- analisi: Misura BR B→η'K
  - $B(B^0 \rightarrow \eta' K^0_S)=(59.9\pm5.8\pm3)\times10^{-6}$
  - $B(B^+ \rightarrow \eta' K^+)=(63.4\pm3.4\pm3.2)\times10^{-6}$
  - analysis based on 62.8 /fb (2019+20)
    - Still stat limited, update is planned





- studio sulla sostituzione dei fotomoltiplicatori in LS2 (2026):
  - definito il sistema di controllo e raffreddamento dei SiPM
  - in fase di assemblaggio
- Data processing per collaborazione

talks a conferenze

- "SIF 2020" Valeria Fioroni "Study of charmless decay B→η′KS at Belle II"
- "La Thuile 2021" Ezio Torassa "Recent Results from Belle II"

responsabilità

	2021	2022
Alessandro Gaz	Physics Coordinator Responsabile allineamento della calibrazione del TOP TOP liason tracking	Responsabile allineamento della calibrazione del TOP TOP liason tracking
Stefano Lacaprara	Contact person Fisica PD Data Processing Manager Convener Physics Group TDCPV	Contact person Fisica PD Production Manager Convener Physics Group TDCPV
Mario Posocco	Membro commissione pari opportunità	Membro commissione pari opportunità
Roberto Stroili	PI Contact person computing PD	PI Contact person computing PD
Ezio Torassa	Membro Executive Board TOP liaison upgrade Deputy coordinator TOP photomultipliers	Membro Executive Board TOP liaison upgrade Deputy coordinator TOP photomultipliers

anagrafica

2021		2022	
Alessandro Gaz	100 %	Alessandro Gaz	100 %
Stefano Lacaprara	100 %	Stefano Lacaprara	100 %
Mario Posocco	0 %		
Paolo Sartori	0 %	Paolo Sartori	0 %
Franco Simonetto	10 %	Franco Simonetto	10 %
Roberto Stroili	80 %	Roberto Stroili	100 %
Ezio Torassa	85 %	Ezio Torassa	90 %
Agnese Giaz	100 %		
totale ricercatori (FTE)	**4.75**		**4.00**
Massimo Benettoni	0 %	Massimo Benettoni	10 %
Flavio Dal Corso	20 %	Flavio Dal Corso	20 %
Fabio Montecassiano	20 %	Fabio Montecassiano	20 %
totale (FTE)	**5.15**		**4.50**

richieste 2021

richieste alla sezione

Servizio progettazione ed officina Elettronica	2+2 m. u.
Servizio officina Meccanica	1 m. u.
Servizio progettazione Meccanica (simulazione termica TOP)	3 m. u.
Servizio calcolo	0 m. u.

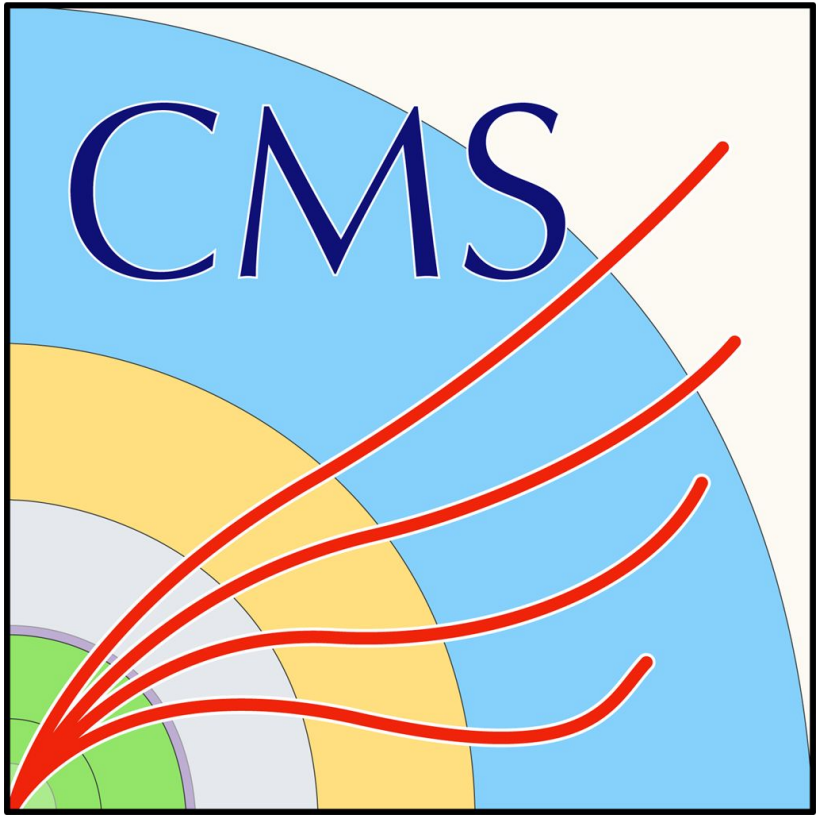
richieste all'INFN

sede	capitolo	descrizione	richiesta (k€)	S. J. (k€)
PD	consumo	Metabolismo (1.5 k€ * FTE)	7.0	0
PD	missioni	Metabolismo [(6.0 k€ + 1.0 k€) * FTE]	31.5	0
PD	missioni	Membro Excutive Board	5.0	0
PD	missioni	Data Processing Manager	0.0	0
PD	missioni	sostituzione PMT TOP	6.0	0
PD	missioni	Coordinatore gruppo TDCPV	5.0	0
PD	inventariabile	stage motorizzato xy	6.0	0

- Missioni per turni centrali fase 3: fondi presso sede del coordinatore nazionale Belle II
- Missioni per turni di componente: fondi presso sede del responsabile nazionale TOP (To)

CMS

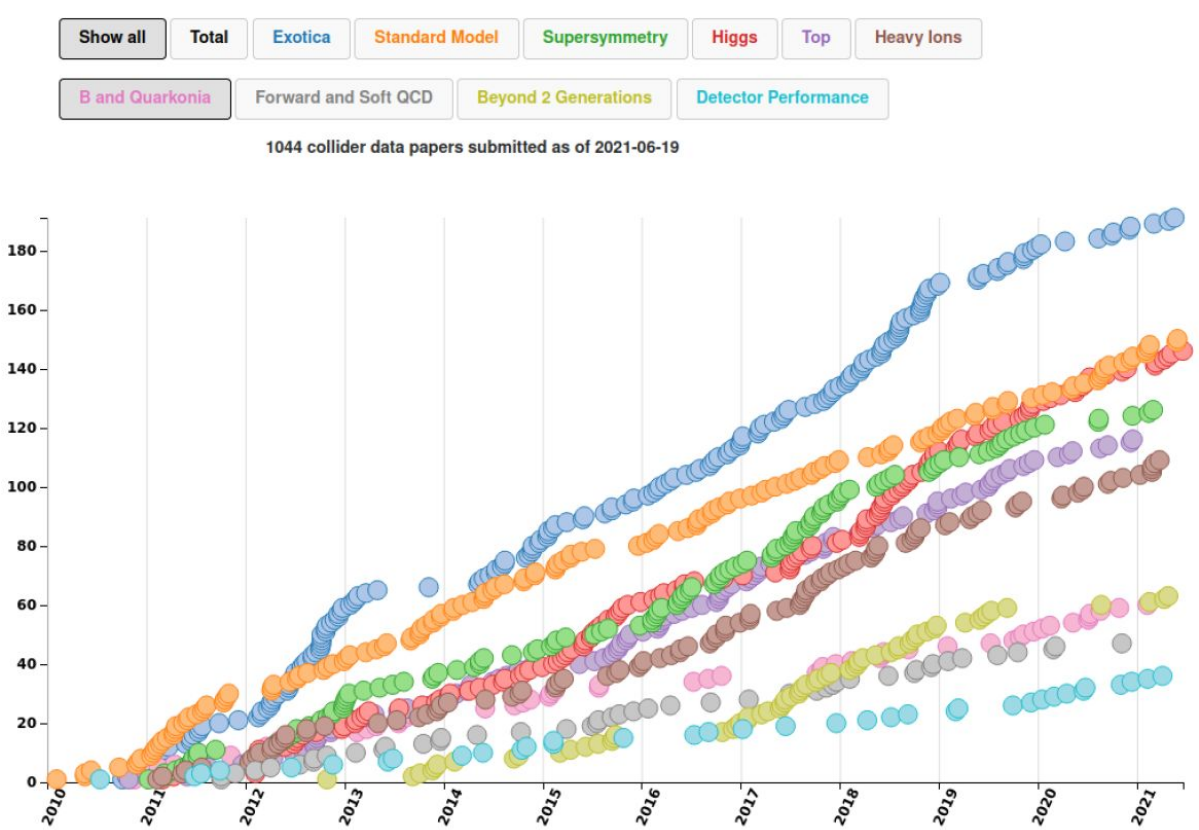
RL: R.Rossin



Sommario

- Highlights da CMS
- Fisica padovana in CMS
  - analisi
  - detector
- Anagrafica 2021 → 2022
- Responsabilita’
- Richieste 2022

CMS supera le 1000 pubblicazioni con dati LHC .



- more than 1000 papers on collision data submitted

CMS highlights

- First Evidence for $H \rightarrow \mu\mu$
- Inclusive and differential cross section measurements of tZq
- Differential $H \rightarrow \tau\tau$ production cross sections
- First observation of the B_c^+ meson in $PbPb$ collisions
- Measurements of production cross sections of the Higgs boson in the four-lepton final state in proton-proton collisions at $\sqrt{s} = 13$ TeV
- Observation of a new excited beautiful strange baryon.
  - (vedi slides)
- Measurement of the CP-violating phase ϕ_s in the $B_S \rightarrow J/\psi\phi(1020) \rightarrow \mu^+\mu^-K^+K^-$ channel in proton-proton collisions at $\sqrt{s} = 13$ TeV
  - (vedi slides)

Fisica padovana in CMS: Analisi

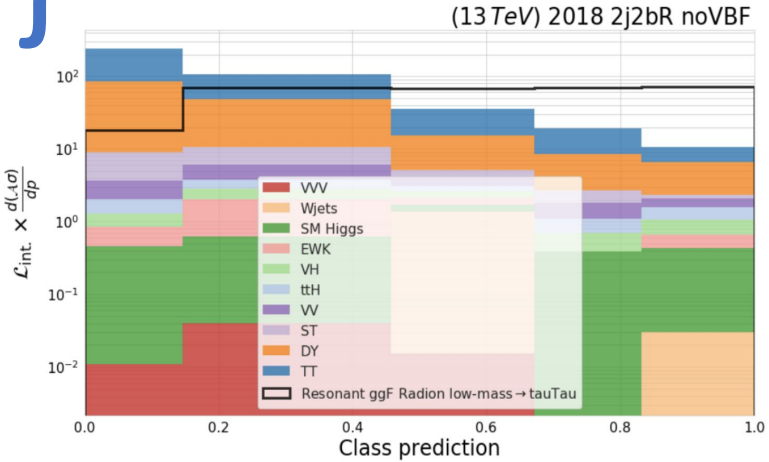
Summary Analisi

- Ricerca di Heavy Composite Neutrino
  - Ricerche per neutrini di Majorana in modelli compositi nella segnatura con due leptoni e due quark. L'analisi e' stato al cuore della tesi di dottorato di Matteo Presilla ora assegnista a Perugia (P. Azzi, M. Presilla)
- Vector Boson Scattering nello stato finale ZVjj semi-leptonico
  - Punta alla prima osservazione di un processo VBS semileptonico ad LHC. Anche questa analisi e' stata parte della tesi di dottorato di Matteo Presilla (P. Azzi, M. Presilla).
- Misura del decadimento $H \rightarrow WW$ in eventi con H prodotto in associazione con un bosone vettore (ZH,WH) in stati finali a piu' leptoni. In particolare $WH \rightarrow same - sign\ leptons + jets$ (S.Y. Hoh, U. Gasparini, M. Zanetti, A. Zucchetta). Tesi di dottorato di S.Y. Hoh. Discussione tesi a meta' Luglio.
- Sviluppo di DNN per le analisi $hh \rightarrow bb\tau\tau$ sia risonante che non risonante (G. Strong, T. Dorigo)

$hh \rightarrow bb\tau\tau$ analyses

- Run-II search for non-resonant $hh \rightarrow bb\tau\tau$ (ggF+VBF)
  - Unblinding in progress. Based on expected limit: Most sensitive channel to non-res di-Higgs @ CMS Run-II (4.55xSM c.f. $bb\gamma\gamma$ 5.2xSM) (HIG-20-010, AN-2018/121)
  - DNN for final summary stat in all inference categories
  - bb and $\tau\tau$ mass-cut optimization
  - Documented in AN-2019/188
- Run-II search for resonant $hh \rightarrow bb\tau\tau$
  - Two DNN approaches for signal classification – parameterised DNN & mass-decorrelated DNN
  - Coding of "learning to pivot" in PyTorch for third
  - possible approach

G. Strong contributions

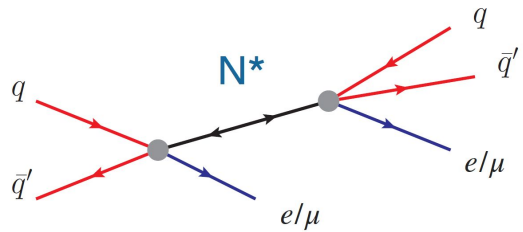


(c) $\tau_h \tau_h b b$ channel

Parameterised DNN

Ricerca di Heavy Composite Neutrino

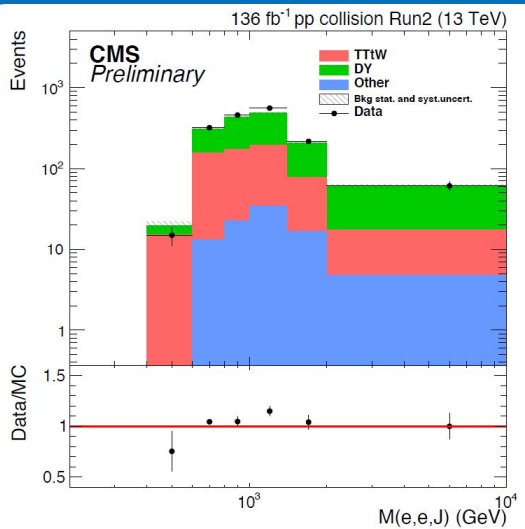
- Heavy Composite Neutrino
  - Ricerche per neutrini di Majorana in modelli compositi nella segnatura con due leptoni e due quark.

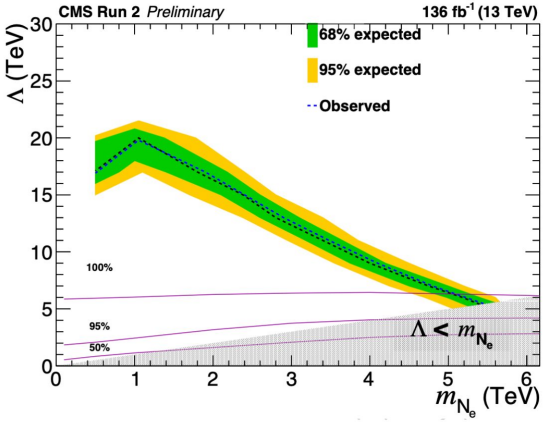


  - Estensione a tutto il data set del Run 2 (136 fb^{-1}) e ottimizzazione dell'analisi guidata dai bound di unitarietà delle interazioni effettive.
  - Nessuna osservazione di deviazioni rispetto al SM. Ottenuti imiti al 95% CL. che escludono la produzione di un HCMN con una massa di 5.10(5.70) TeV e scala fino a Λ = 20 TeV a basse masse.

- **Analisi pre-approvata, pubblicazione in PLB (2021)**

M. Presilla (ora PG), P. Azzi





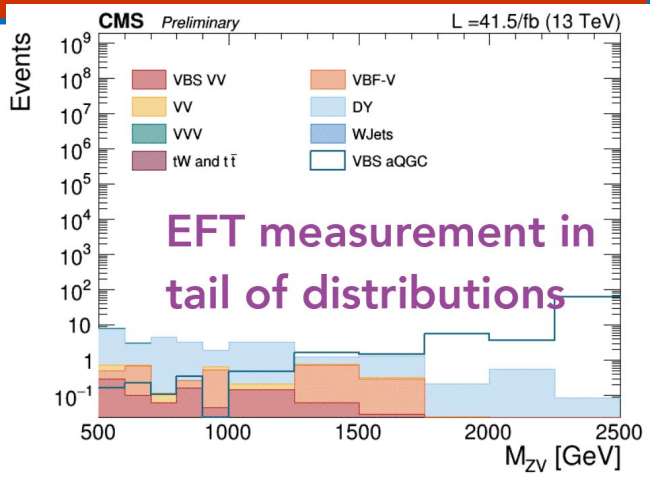
100%, 95%, 50% degli eventi MC che soddisfano l'unitarietà

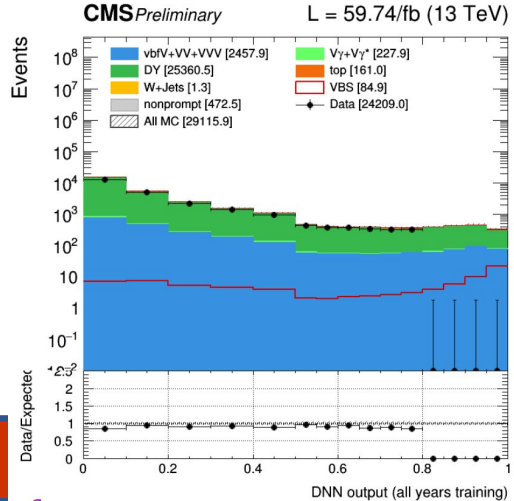
VBS in ZVJJ Semileptonico

- Studio del processo di Vector Boson Scattering, fondamentale per lo studio dell'interazione EW, nel canale $ZVjj$ semi-leptonico con i dati del Run 2 in CMS
- Evento molto raro ad LHC, pochissimi eventi di segnale, fondo dominante da Z+jets
  - Applicazione di metodi DNN/BDT per sopprimere il fondo
- Collaborazione con gruppo VBS italiano (MiBi, canale WVjj in fase di approvazione), Parigi e FNAL.

Target: misura del processo VBS EW e deviazioni EFT in termini di operatori a dimensione 6 e 8 (2022)

M. Presilla (ora PG), P. Azzi

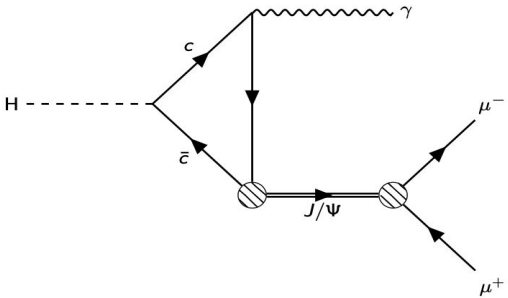


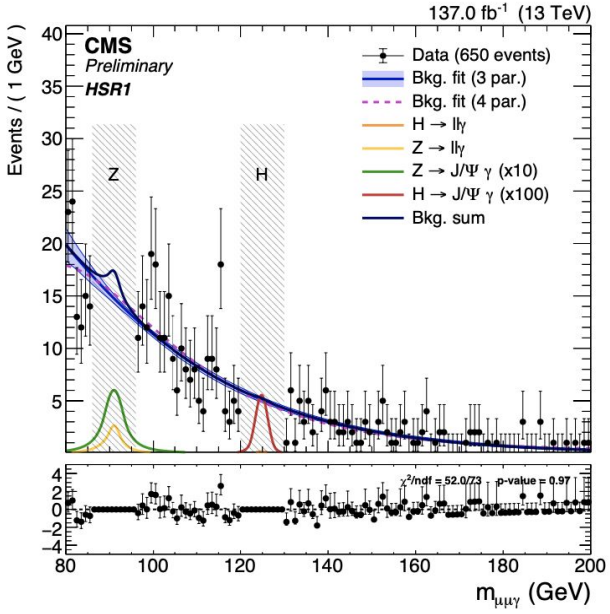


Rare SM Higgs and Z decays

- The Higgs and Z bosons are expected to decay to a J/Psi meson and a photon
- Never observed before due to small branching ratios:
  - $B(Z \to J/\Psi\ \gamma) = 9 \times 10^{-8}$
  - $B(H \to J/\Psi\ \gamma) = 3 \times 10^{-6}$
- The observation would allow a measurement of the Higgs coupling to the c quark
- With the J/Ψ decaying to $\mu\mu$, the final state is clean and the bkg very limited
- For the first time, and thanks to the collaboration with pheno expert in our department (Ramona Groeber), we have an accurate MC simulation that properly accounts for the spin correlations, which can be used for discrimination
- The strategy is to model the QCD (dominant) background with analytic functions
- Minor resonant backgrounds controlled in a dedicated control region
- Analysis is under scrutiny of the CMS Collaboration

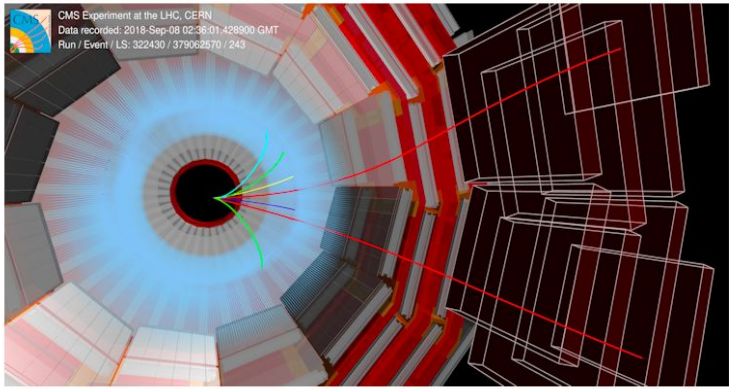
R. Ardino, G. Grosso, M. Migliorini, J. Pazzini, M. Zanetti, A. Zucchetta



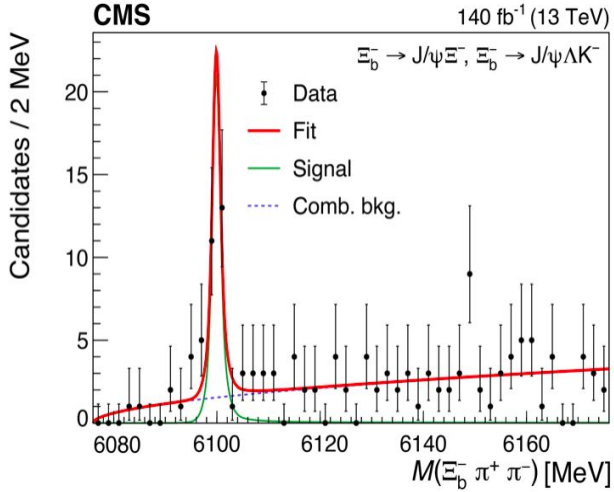


Observation of a new excited beautiful strange baryon

- $\Xi_b^{-**} \to \Xi_b^- \pi^+ \pi^- (\Xi_b^- \to J/\Psi\, \Xi^-, J/\Psi\, \Lambda K^-)$ observed with significance > 6 sigma
  - CMS Physics briefing (17/2/2021)
  - Padova involvement: ARC chair (M. Margoni)
- $M_{\Xi_b^{-**}} = 6100.3 \pm 0.2 \pm 0.1 \pm 0.6\, MeV$, $\Gamma_{\Xi_b^{-**}} < 1.9\, MeV$ (95% CL)
- New baryon consistent with lightest orbitally excited Ξ_b state with $J^P = 3/2^-$
- Natural width surprisingly narrow will help in probing different spectroscopic models



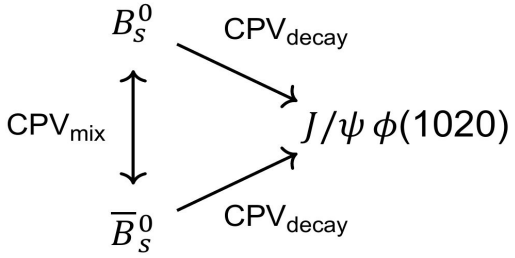
PRL, 126, 252003



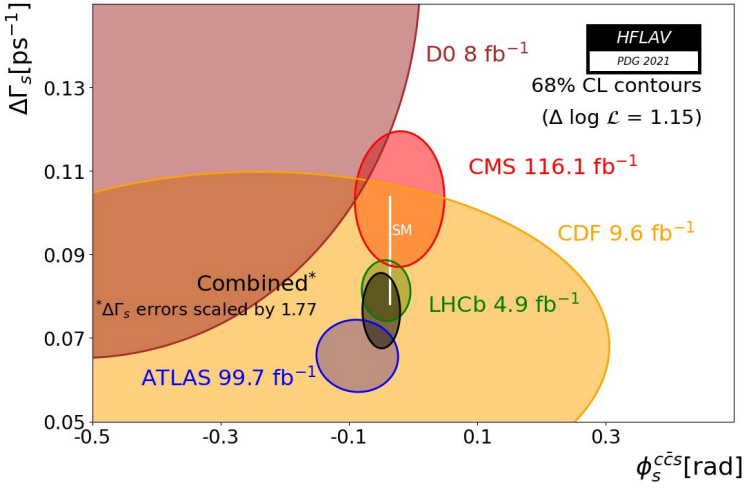
Precision measurement of CP-violation in $B_s \to J/\Psi\,\phi$

- Precise characterization of the $B_s^0 - B_s^0$ system
  - Highly complex time- and flavour-dependent angular analysis
  - Several physics parameters measured with a single analysis
    - ϕ_s: CP violating phase
    - $|\lambda|$: amount of CPV in decay
    - Γ_s: average decay width
    - $\Delta\Gamma_s$: decay width difference between eigenstates
    - Δm_s: mass difference between eigenstates
- Comprehensive test of the physics of CPV and flavour mixing, with room for New Physics
- High-priority measurement for both the experimental and theoretical community
- Heavily statistically limited
  - Long-term commitment (Run-3, HL-LHC)
  - Plenty of room for innovations (DNNs, exotic triggers, …)

A. Bragagnolo, E. Lusiani, M. Margoni, P. Ronchese, F. Simonetto



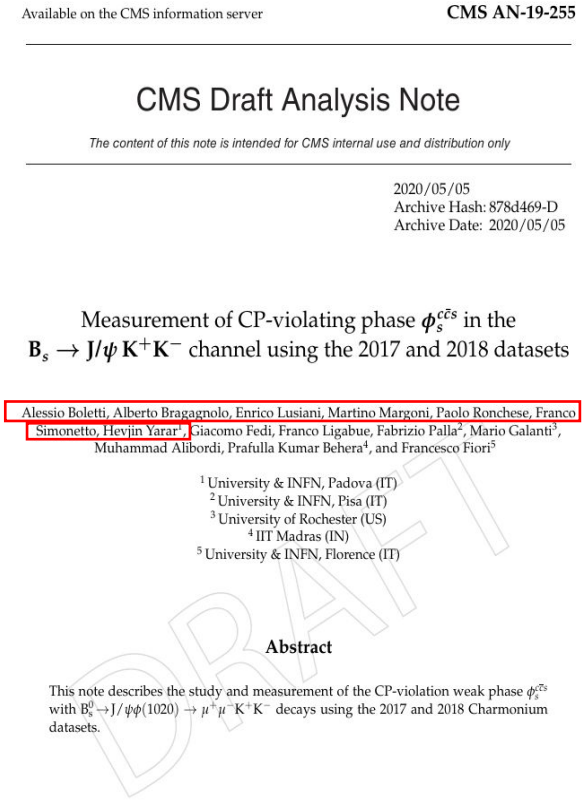
$$\Gamma\left(B_{s\,(\rightsquigarrow \overline{B}_s^0)}^0 \to f\right)(t) \overset{?}{\neq} \Gamma\left(\overline{B}_{s\,(\rightsquigarrow B_s^0)}^0 \to f\right)(t)$$



CPV in $B_s \to J/\Psi\,\phi$. Padova involvement and outlook

- The CMS Padova group has a long standing experience and commitment in high-profile B-Physics results
  - Extended expertise in final-state reconstruction, angular analysis and flavour tagging
  - Involvement in world-averages computation (HFLAV 2021)
- Leading role in past and recent CMS results [PLB816(2021)136188, PLB757(2016)97]
  - Two PhD thesis [A. Bragagnolo (2021), J. Pazzini (2015)]
  - plus one in the making [E. Lusiani (~2022)]

- Goal: complete analysis overhaul with state-of-the-art Deep Learning techniques
  - Aiming to one of the most competitive precise single measurement of ϕs
  - Developing original and innovative ideas that could lead to a paradigm shift for flavour-dependent analyses at hadron colliders



Available on the CMS information server **CMS AN-19-255**

CMS Draft Analysis Note

The content of this note is intended for CMS internal use and distribution only

2020/05/05
Archive Hash: 878d469-D
Archive Date: 2020/05/05

Measurement of CP-violating phase $\phi_s^{c\bar{c}s}$ in the $B_s \to J/\psi\,K^+K^-$ channel using the 2017 and 2018 datasets

Alessio Boletti, Alberto Bragagnolo, Enrico Lusiani, Martino Margoni, Paolo Ronchese, Franco Simonetto, Hevjin Yarar[1], Giacomo Fedi, Franco Ligabue, Fabrizio Palla[2], Mario Galanti[3], Muhammad Alibordi, Prafulla Kumar Behera[4], and Francesco Fiori[5]

[1] University & INFN, Padova (IT)
[2] University & INFN, Pisa (IT)
[3] University of Rochester (US)
[4] IIT Madras (IN)
[5] University & INFN, Florence (IT)

DRAFT

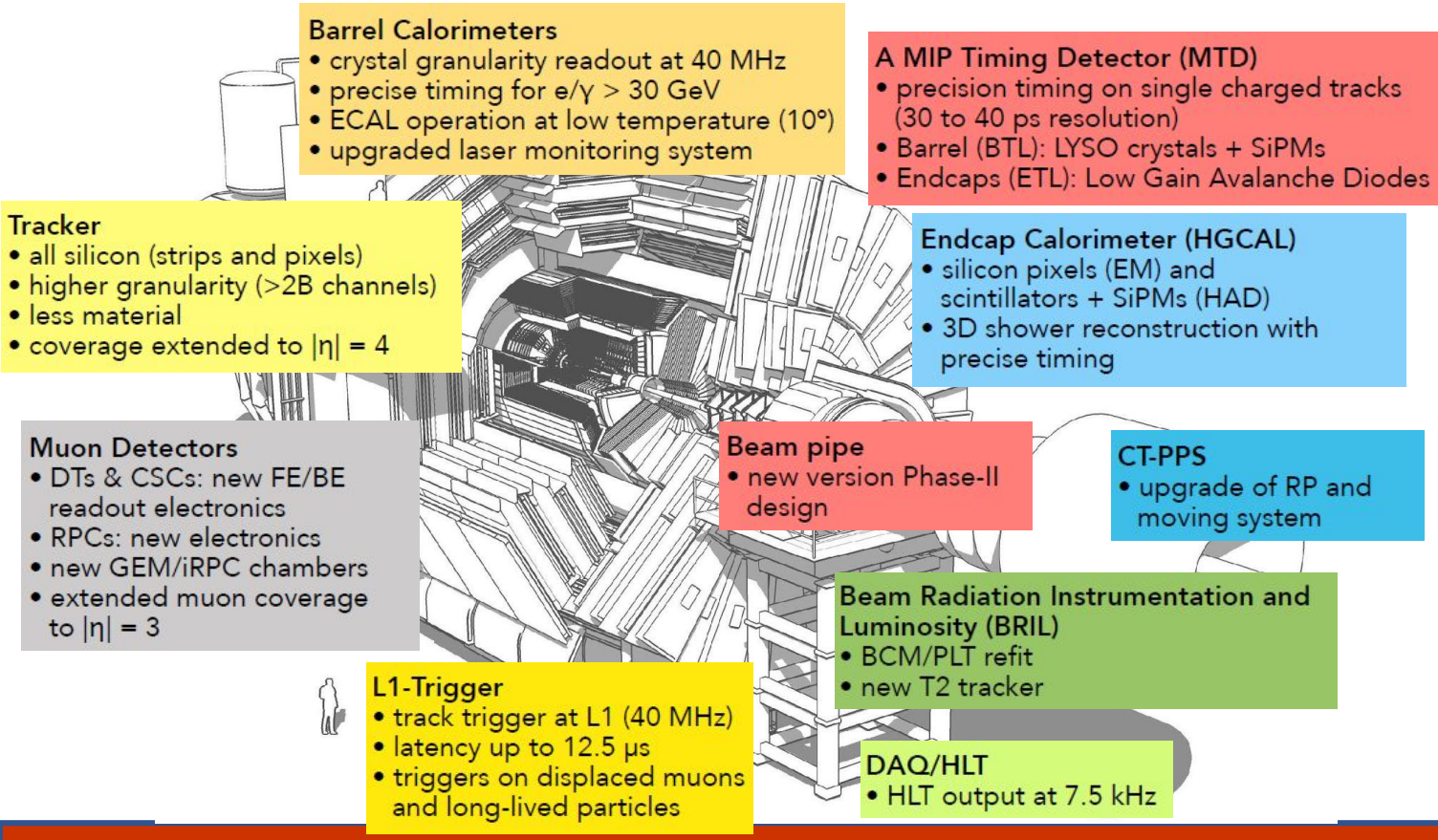
Abstract

This note describes the study and measurement of the CP-violation weak phase $\phi_s^{c\bar{c}s}$ with $B_s^0 \to J/\psi\phi(1020) \to \mu^+\mu^-K^+K^-$ decays using the 2017 and 2018 Charmonium datasets.

A. Bragagnolo, E. Lusiani, M. Margoni, P. Ronchese, F. Simonetto

Fisica padovana in CMS: Rivelatore

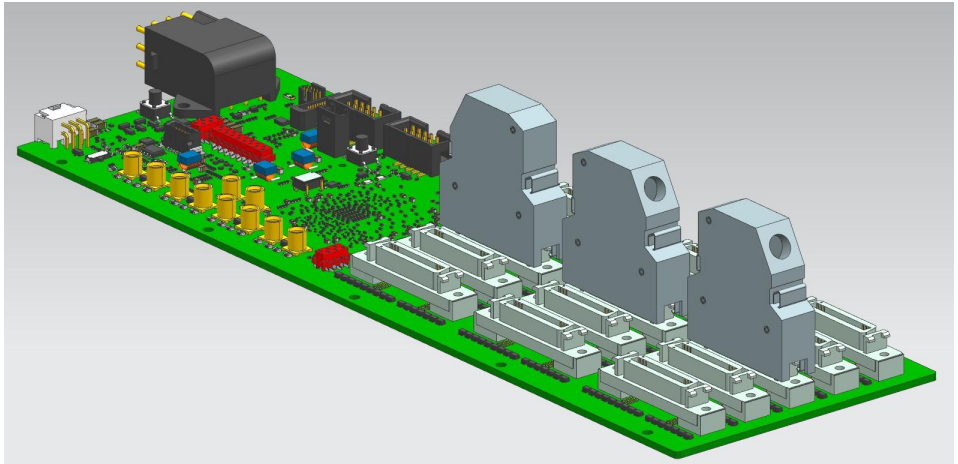
Preparazione al Run 3 e HL-LHC



- CMS sta chiudendo on schedule un lungo shutdown
- Molti lavori di manutenzione e improvements, con contributo padovano nei DT e nei Pixels
- Seconda meta' 2022 inizio di Run 3 di (3-4 anni) con un raddoppio di luminosità, e a energia maggiore.

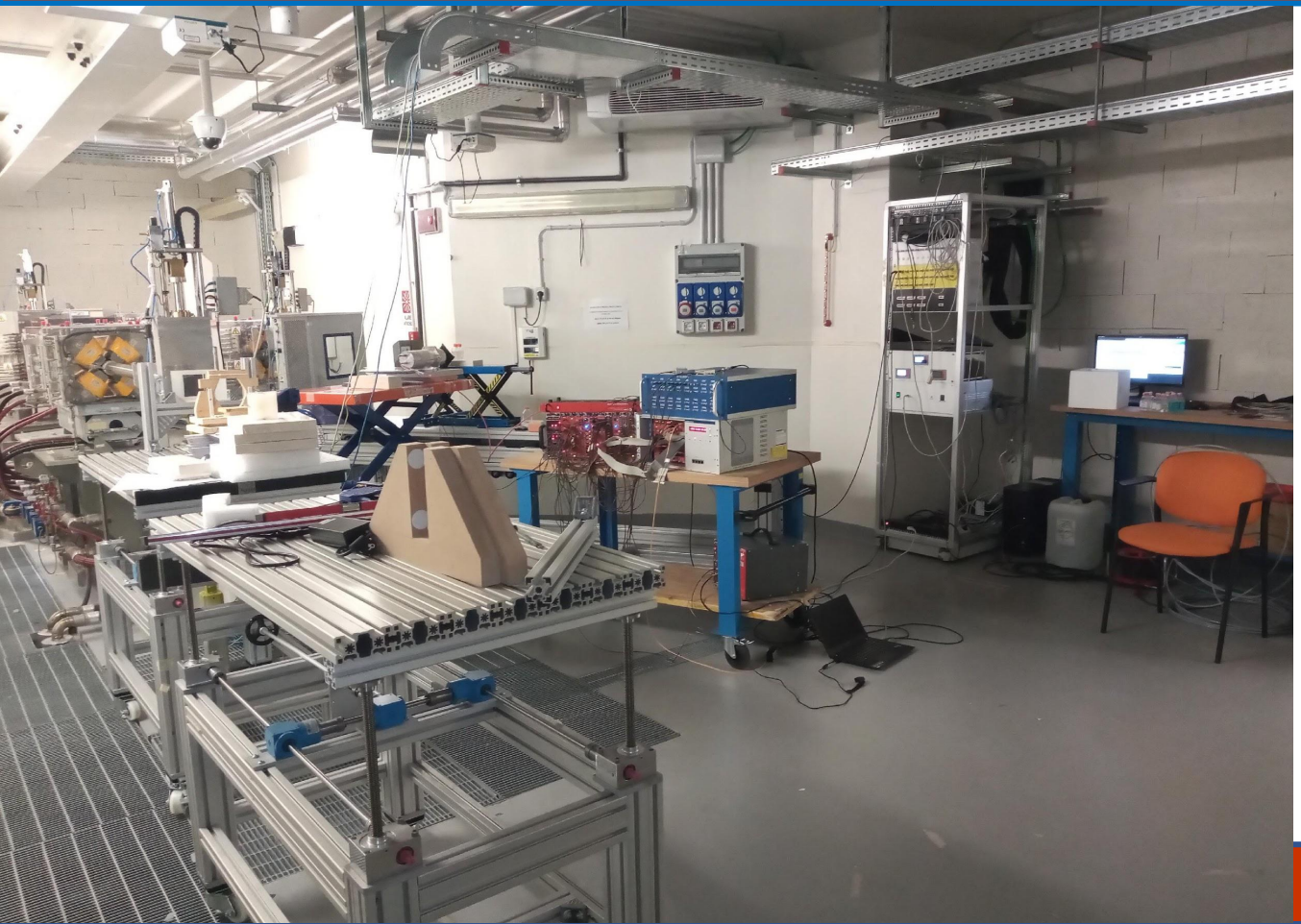
Phase II front-end electronics developments: OBDT

- The On-Board electronics for Drift Tubes is a board based on a FPGA (PolarFire) that implements TDC functionalities
- The OBDT has also control capabilities:
  - FE access, monitoring, test pulse, RPC connection
- It is radiation tolerant (up to 20 krad)
- OBDTv2 currently in assembly stage
  - 240 TDCs with 800ps resolution
  - Radiation tolerant FPGA based
  - 80 Gb/s data throughput on fibers



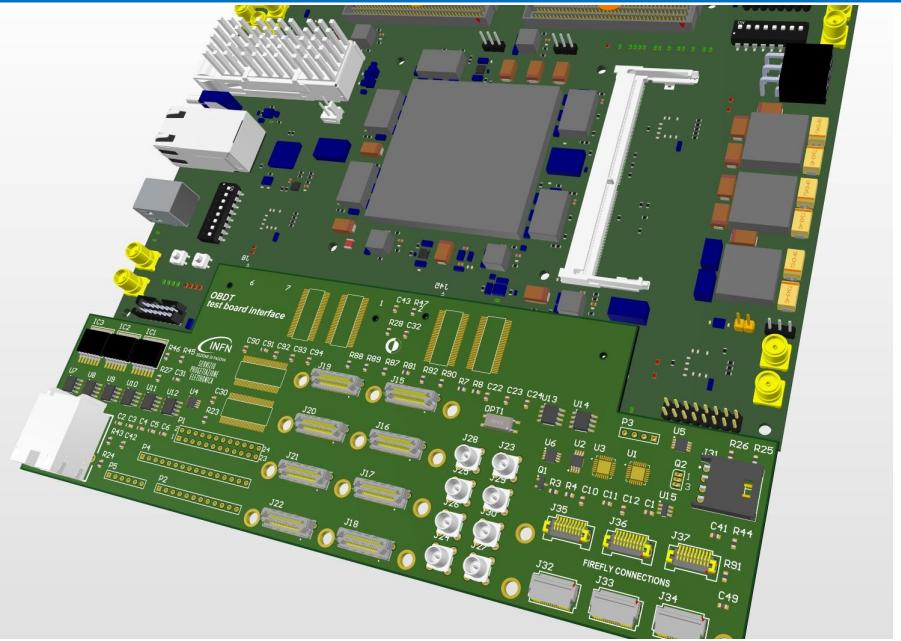
M. Bellato, S. Ventura,
F. Gonella, SPE, Officina meccanica.

OBDT: qualification for radiation tolerance

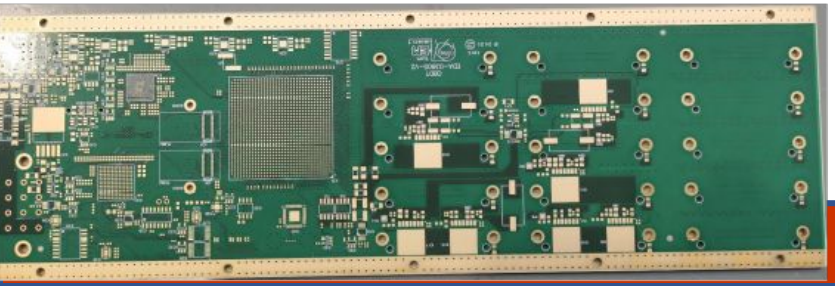


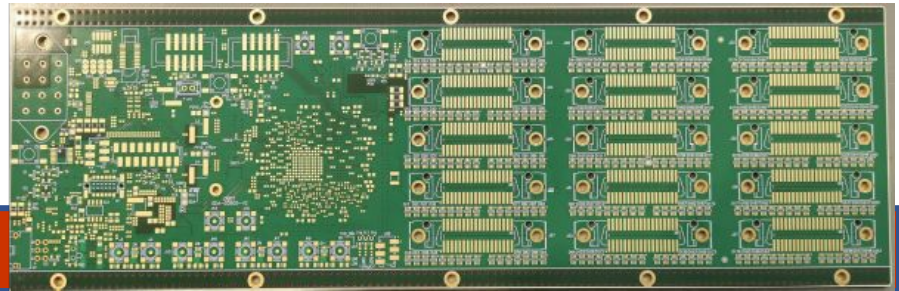
- Test beam at Trento Protontherapy Centre
  - In october 2021
  - 10 years HL-LHC equivalent dose delivered in 5 half-days of irradiation

Frontend Test & Qualification system



- Custom + commercial electronics for full qualification of 1 OBDT
  - standalone
  - in the minicrate
  - in the chamber
  - at the production site
- PCB in production now





Site preparation @ LNL

- Preparing working area @ LNL

DT chambers: Longevity studies

- Irradiation at GIF++:
  - MB1 all layer (2015).; MB2 (2 layers ,2017-2018 and 2018-2019); MB2(8 New wires 2018-2019, one layer). Test Beam Oct 2017; oct 2018. -> Public Results CMSPublic/DTLongevitynewHGCal , CMS DP -2019/018
  - 2021: Displacement of chamber, electronics and DAQ in new position (Gonella, Corti, Griggio). Chamber performances verified with cosmics. Ready for Test Beam (July).
  - 2022: Irradiation in the new position in GIF++ Area w/ 3000 fb^{-1} equivalent integrated dose.
- At LNL: realization of specific detectors for monitor at GIF and for easy investigation of material; tests on aged and not aged wires; inspection (material deposit) with EDS
- At DFA: aged and not aged wires inspection SIMS and FTR (material deposit)
- At Chemistry Department, Unipd (material deposit) investigation

A. Meneguzzo, F. Gasparini, F. Gonella

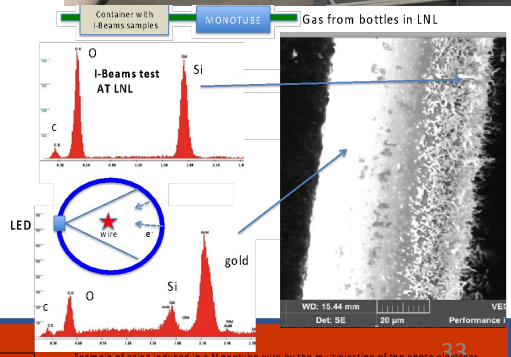
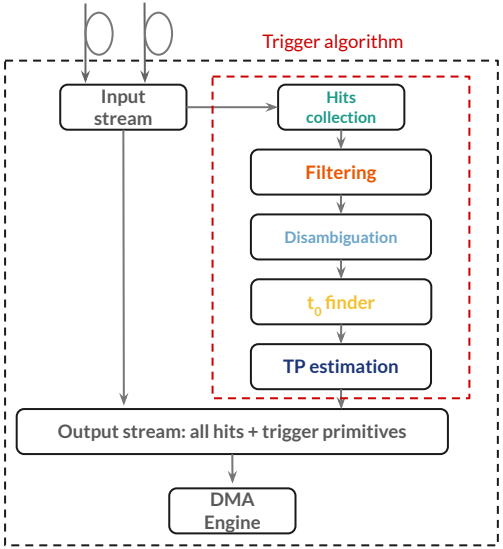


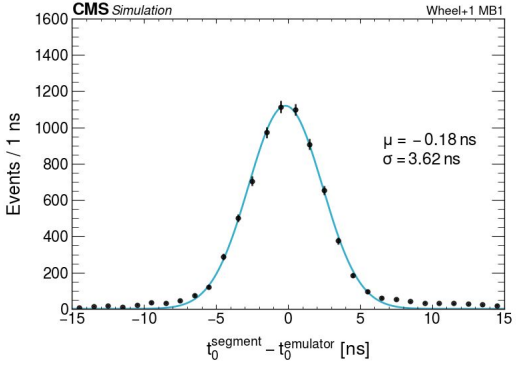
Fig 9

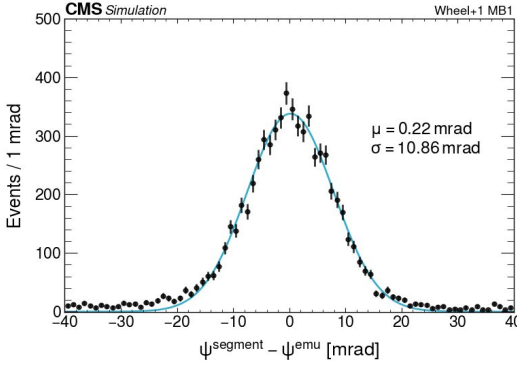
Example of aging induced in a Monotube wire by the multiplication of the photo electrons Extrcted by a LED ligth. Note the different depth of the coating on the two faces of the wire, indicated by the arrows.In the worst case the coating is thick enough to mask the gold plating.

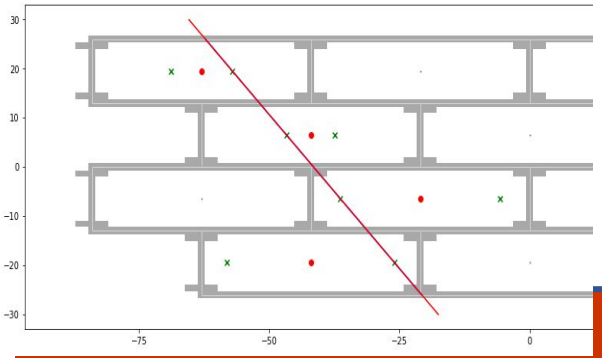
Sviluppo di algoritmi di trigger locale basati su reti neurali

- Definizione delle primitive di trigger per Drift Tube detectors (basati su DT di CMS).
- Attività iniziata in sinergia con gli sviluppi di sistemi di acquisizione veloce di dati per camere a muoni (mini-DT, già costruite e in uso per test-beam collaborazione LEMMA).
- Logica di trigger ibrida basata sulla combinazione di:
  - Reti neurali per riduzione del rumore e pattern recognition
  - Approcci analitici alla stima dei parametri di traccia
- Logica testata con successo in SW sia su simulazioni private, che in simulazioni ufficiali di CMS in condizioni HL-LHC.









F. Gonella, M. Migliorini, J. Pazzini, A. Triossi (Strasburgo), M. Zanetti, A. Zucchetta

Sviluppo di algoritmi di trigger locale basati su reti neurali

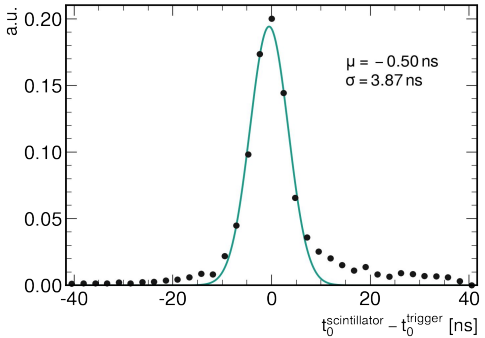
Un dimostratore completamente funzionate della logica di trigger è stato implementato su FPGA (Eval. board Xilinx KCU1500) e testato con acquisizione di muoni da raggi cosmici.

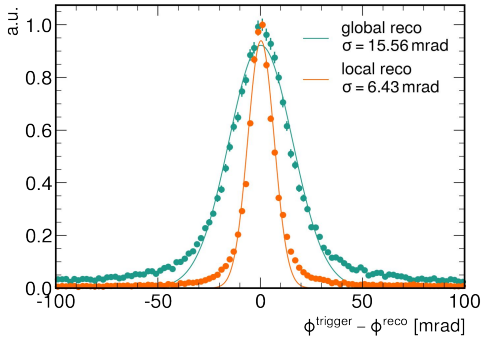
- Utilizzo esiguo di risorse su FPGA (solo LUT, no DSP)
- Bassa latenza (~12 clock cycles @ 40 MHz) per l'intera logica di trigger (fino alla produzione di primitive)
- Performance in linea con le attese da simulazioni SW

Forti sinergie di questa attività con altre in corso a CMS e Gr1:

1. Definizione, implementazione e testing di algoritmi di trigger basati su ML per le condizioni di presa dati previste per HL-LHC
2. Integrazione nel testbed delle camere mini-DT + acquisizione trigger-less (correntemente installato al LAE di LNL)
3. Sistema di testbed indipendente per sviluppi di elettronica, inclusa la validazione e il commissioning delle nuove schede di readout (OBDT) per l'upgrade di Fase 2 di CMS

COSMIC RAYS DATA TAKING

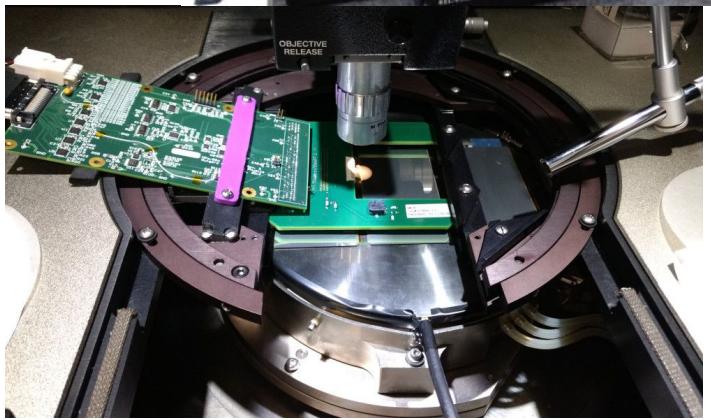




Phase II Tracker Upgrade: MaPSA testing in Padova

- PS modules are a sandwich of Strips/Pixel sensors separated by 1.6, 2.6 or 4.0 mm.
  - A total of 5592 PS modules needs to be built
- MaPSA is the sensor (Pixel)/ Readout-chip (MPA) assembly (flip-chip bump bonded).
- Second round of prototypes has been completed successfully. About to order 40 more parts to two vendors with the latest MPA2 chip and available for testing in Q1-2022
- Target production testing rate is 60 MaPSA per week:
  - Could be done at FNAL by purchasing a second probe station and securing a total of about 6-8 FTE
  - Could be split between FNAL (40/week) and DESY+Padova (20/week)
- We need to prepare ourselves to be able to test MaPSA on a sample basis taking advantage of the last order.
- Need to transfer the FNAL acquired experience and testing parts during Q4-2021 and work on the setup in Padova in Q1-2022.

Alessi REL-6100, 8" chuck (Padova)



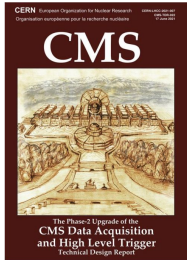
Testing of MaPSA at FNAL with a probe-card

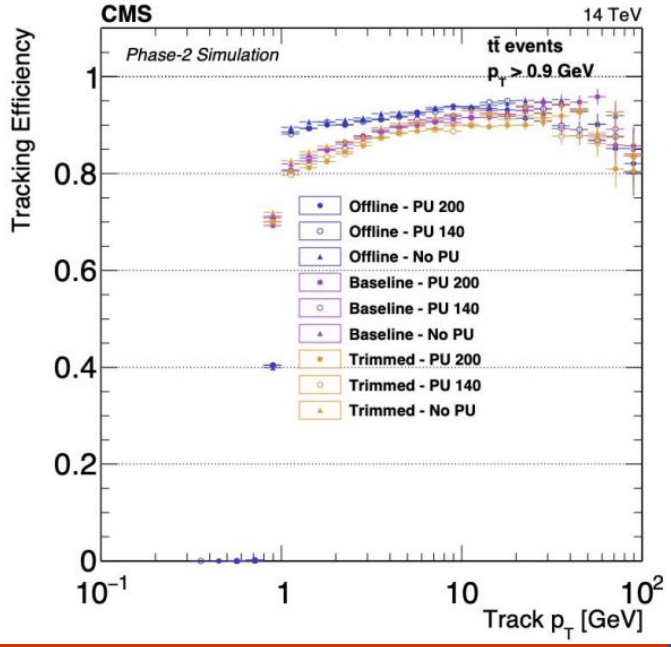
N. Bacchetta, P. Bortignon (CA), R. Carlin, D. Pantano +
1 AdR gia' finanziato per il 2022

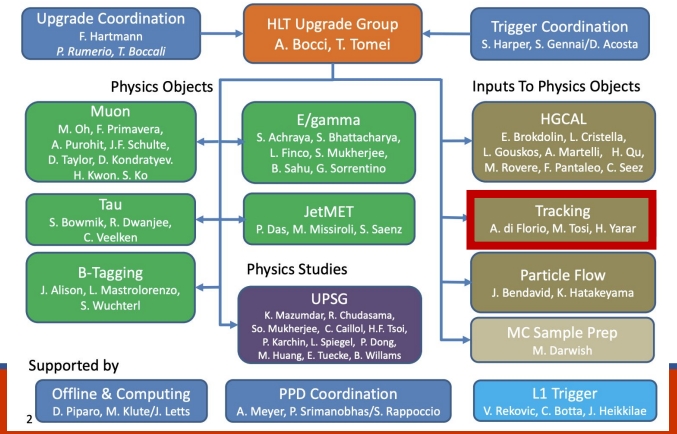
HLT Upgrade TDR

- convincing case that CMS will to be able accurately reconstruct and efficiently select objects at the HL-LHC
- developed tracking baseline, which is used by all other physics objects
  - good physics performance, very similar to offline
  - x6 faster than offline reconstruction !
  - can be easily ported to GPU

→ timing (MTD) information still not exploited







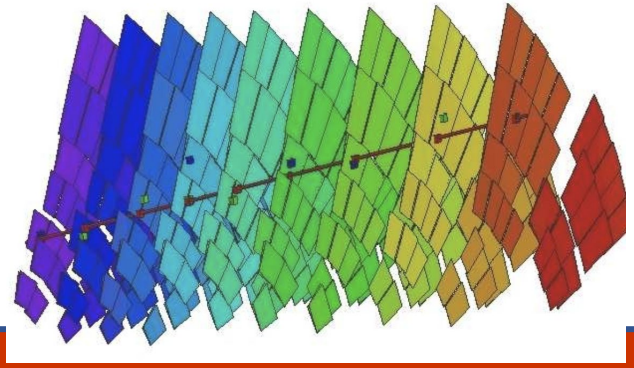
M. Tosi

Outreach

- Organized the CMS Virtual Visit (in w/ other Italian institutes) for the Night of researchers 2020

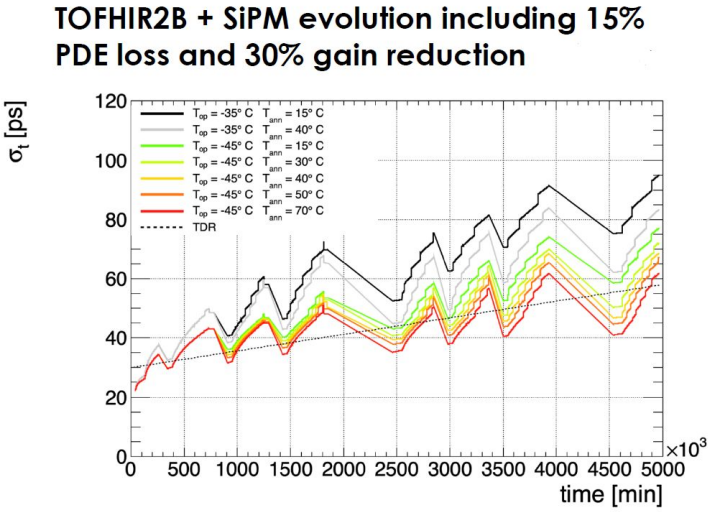
M. Tosi

- Museo della Storia della Fisica: CMS TEC petal



Barrel Timing Layer

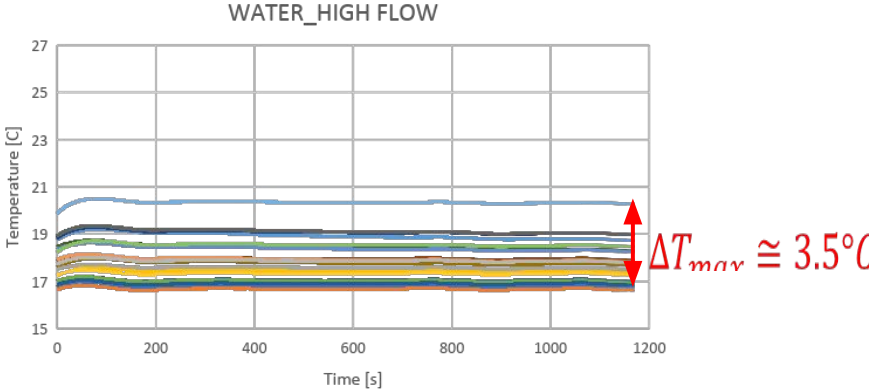
- Il timing detector di CMS fornira' informazione temporale sul passaggio di particelle cariche con una risoluzione temporale di 30-40 ps. L'elettronica di lettura dovra' restare a basse temperature (approx. -40 °C).
- Padova responsabile del disegno e la produzione dei cold plates per il raffreddamento dei moduli del BTL.
- <u>News</u>: La temperatura minima raggiungibile con raffreddamento con CO_2 evaporativa ($T_{op} = -35\ ^oC$) mostra una $\bar{\sigma}_t > 60\ ps$ (target) verso EOL. Proposto l'utilizzo di TEC (Thermo Electric Cooling) per arrivare a $T_{op} = -45\ ^oC$ e $T_{ann} = 70\ ^oC$
- Padova responsabile dei test dei TECs
  - Possibile coinvolgimento anche nel test degli alimentatori dei TECs.

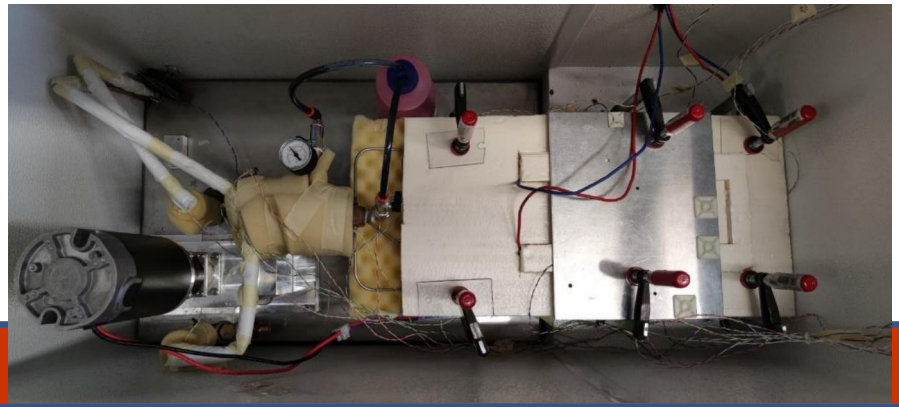


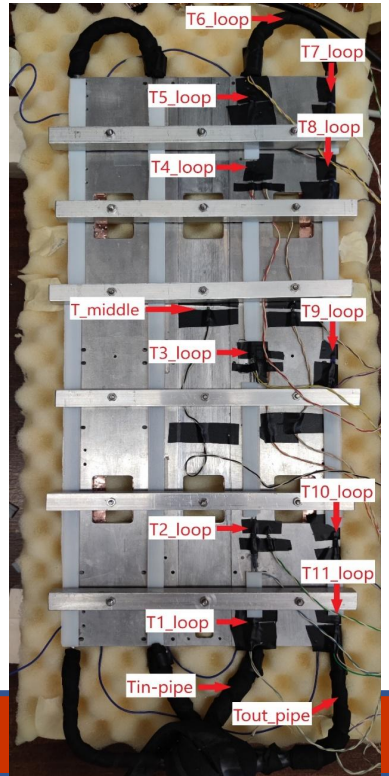
M. Benettoni, E. Borsato, R. Carlin, P. Checchia, R. Isocrate, M. Tosi, D. Rigoni, R. Rossin, L. Silvestrin, S. Ventura, S. Mancin (DTG)

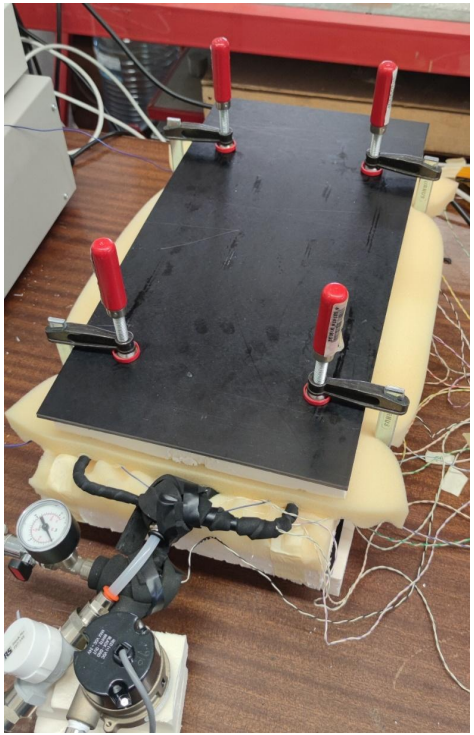
Barrel Timing Layer – Cold plates

- Primi prototipi di cold plates prodotti e testati
- Test eseguiti sia a -35 °C che a temperatura ambiente nel lab Gr1.



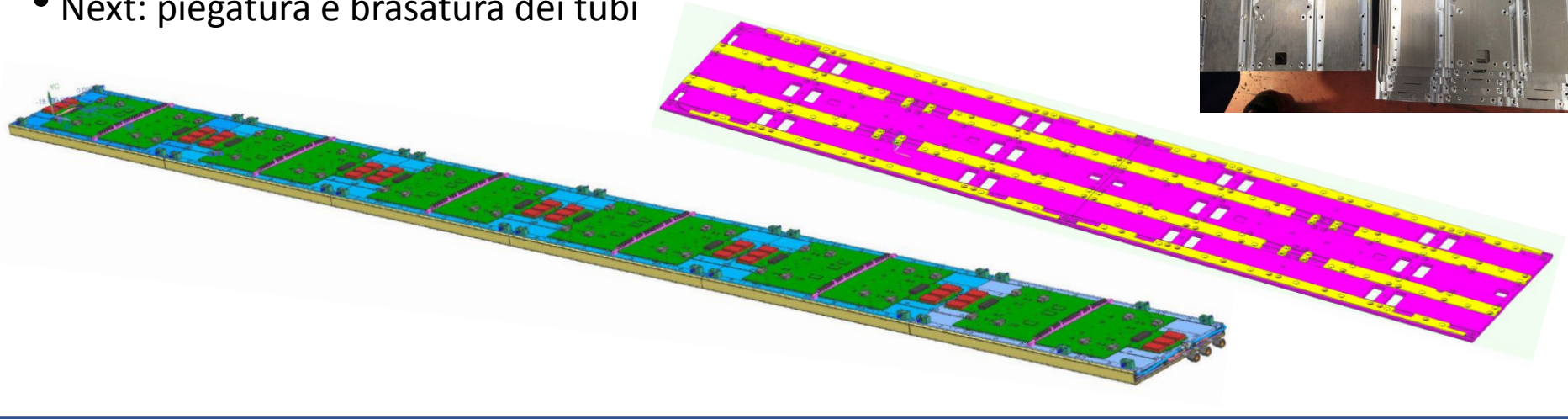






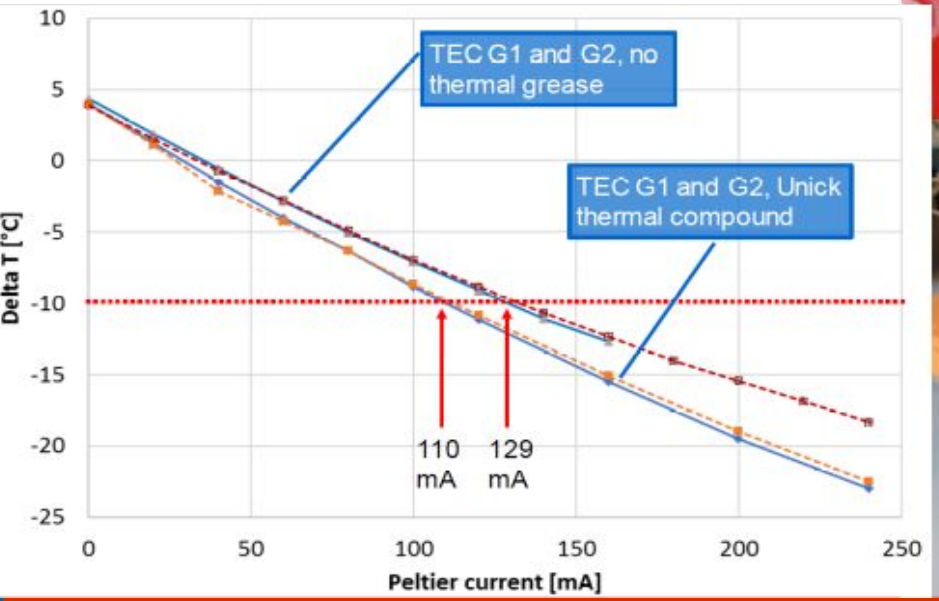
Barrel Timing Layer – Cold Plates

- Nuovo disegno dei cold plates (con lamine di ritenzione per migliorare l'accoppiamento termico tubi-piastre) finalizzato.
  - Prototipi delle CP completato.
  - Lamine in produzione
  - Next: piegatura e brasatura dei tubi



Barrel Timing Layer – TEC tests

- Primi test delle performance dei TEC



Responsabilita' 2022

		Ruolo	Livello	Mesi uomo
Marco Bellato	MU-DT	Electronics coordinator	2	3
Nicola Bacchetta	TRK	TRK Technical coordinator	2	3
Roberto Rossin	MU-DT	DT-DPG deputy coordinator	2	3
Sandro Ventura	Muon	Muon Electronics Coordination Office Representative	2	3
Sandro Ventura	MU-DT	DT Upgrade Coordinator	2	3
Pierluigi Bortignon	MUO	Muon selection convener	3	-
Martino Margoni	BPH	Conference Contact	3	-
Martino Margoni	BPH	Hepdata Coordinator	3	-

Anagrafica 2021

- Out:
  - Hussein
  - Presilla
- In:
  - Rigoni (Ass Tecn)
    - (+2 PhD ma da 2022)

- Strutturati :
  - Gonella : 70% → 50%
  - Montecassiano : 30% → 10%
  - Fanzago: 70% → 50%

Ruolo	Persone	FTE
Ricercatori e studenti	20	19.0
Tecnologi	12	7.0

Richieste CSN1

- **Missioni**
  - Metabolismo+shifts/services: 223 keu
  - Responsabilita': 80 keu
  - Lavori in Long Shutdown 2 e preparazione Fase 2: 65 keu
- **Consumi**:
  - Metabolismo: 43 keu
- **Preprototipi**
  - BTL: acquisto TEC: 6keu
- **CORE**
  - DT: pre-production Back-end electronics: 50k
  - BLT: Meccanica per produzione tray: 174 keu
  - Tracker: Nessuna nuova richiesta (ci sono 11.8 Keuro ma sono già stati approvati per il 2021 e sono da spostare al 2022)

Richieste in Sezione

Officina elettronica		Mesi uomo
Tracker	Setup test in camera pulita	1
TOTALE		1

Ufficio tecnico		Mesi uomo
BTL	Progettazione trays	6
	Benettoni	3
TOTALE		9

Officina meccanica		Mesi uomo
BTL	Supporto test cold plates	6
TOTALE		6

Calcolo		Mesi uomo
	Supporto cluster locale, cloud	3
	Supporto produzione locale dati	3
	Connessione, operazione, mantenimento TIER2 PD-LNL	18
TOTALE		24

SPE		Mesi uomo
DT	Supporto attivita' minicrates	2
	Studio ageing a LNL	2
	Manutenzione sistema test DT LNL	1
	Riparazione e test schede CMS	1
	Manutenzione camere al CERN	3
	Sector test fase 2	3
	Studio ageing a Gif++	2
	Progettazione e realizzazione sistema di qualifica	15
	Qualifica e test OBDT	6
BTL	Setup readout cold box	1
TOTALE		36

Stato di LHCb

Presentazione per preventivi INFN Sezione di Padova

07/7/2021

G. Simi per il Gruppo LHCb di Padova

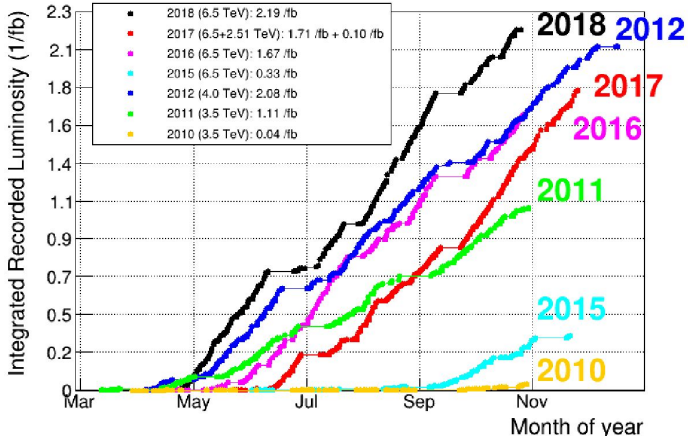
Outline

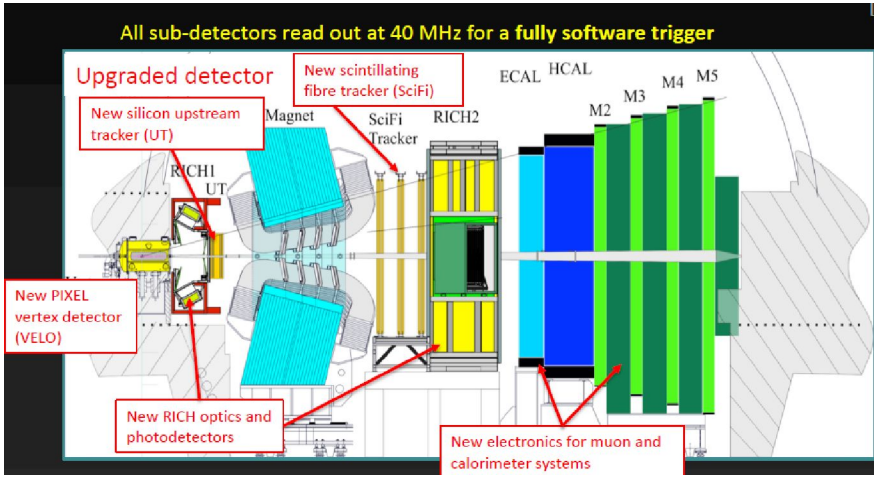
- Stato LHCb Upgrade & Highlights di fisica
- Analisi @ Padova
  - Jets
  - Quantum Algorithms
  - CP Violation
  - Lepton Universality
- RICH & Upgrade I
- Upgrade II R&D
  - RICH
  - ECAL
  - VELO

Stato di LHCb

Stato dell'Upgrade di LHCb

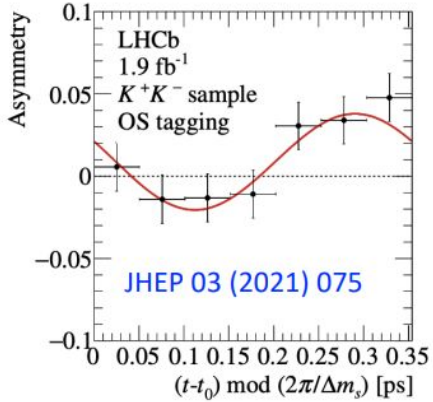
- Run1 1fb^{-1}@7TeV
- Run1 2fb^{-1}@8TeV
- Run2 6fb-1@13TeV
- **Major Upgrade** del rivelatore durante il Long Shutdown II
  - **Trigger a 40MHz, Real Time Reconstruction**
  - **Aumento Granularità nei tracciatori e nel PID**
  - **Resistenza alla radiazione**
- L'installazione procede a passo spedito
  - RICH, Muon detector, Calorimetro sono in fase di commissioning
  - VELO, Upstream Tracker, Sci Fi in fase di assemblaggio
- Padova coinvolta nell'upgrade del RICH1&2 [Simi, Benettoni]

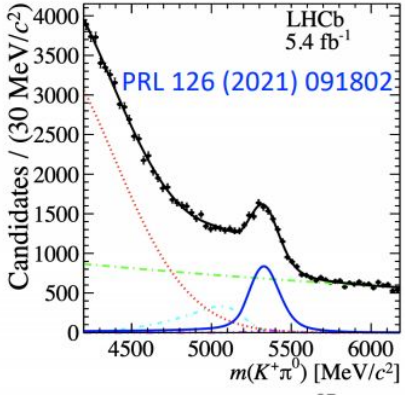


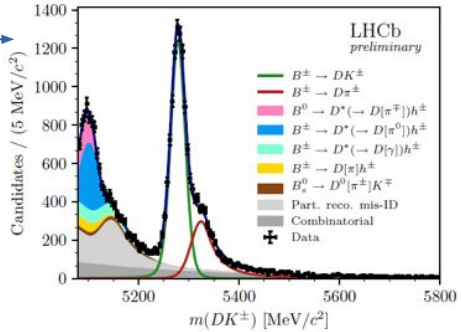


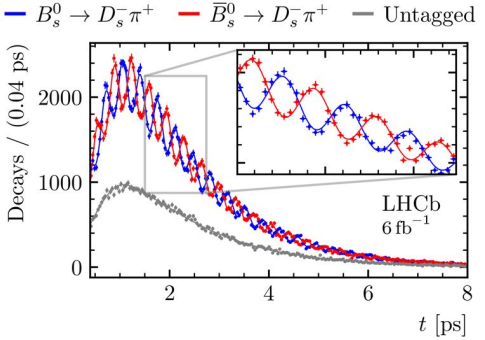
Highlights di fisica di LHCb

- CKM Physics
  - World's first measurement of time-dependent CP violation in Bs mesons[JHEP 03 (2021) 075]
  - World's best measurement of CP violation in $B^+ \to K^+\pi^0$ [Phys. Rev. Lett. 126 (2021) 091802]
  - Angle γ from $B^\pm \to DK^\pm$ with $D \to K_S h^+ h^-$ decays and twobody D decays
  - Precise determination of the B_s^0–B_s^0 oscillation frequency. [Padova analysis]





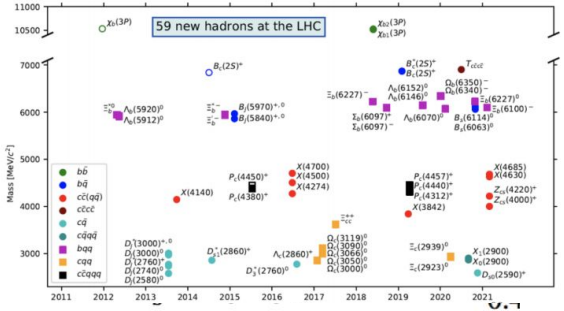




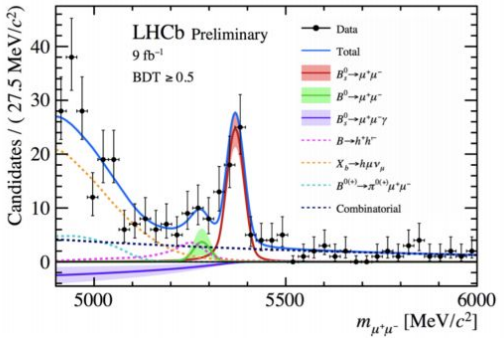
Highlights di fisica

- New Physics Searches
  - Observation of two ccus tetraquarks and two ccss tetraquarks
    - Zcs(4000)+, Zcs(4220)+, X(4630), X(4685)
  - Best measurement from single experiment $B^0 \to \mu\mu$ and $B_s \to \mu\mu$
  - LFU with $B^+ \to K^+\mu^+\mu^-$ and $B^+ \to K^+e^+e^-$

52 of these dscovered by LHCb



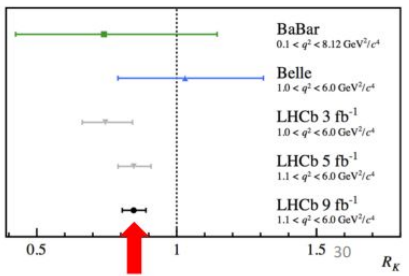
LHCb-PAPER-2020-044

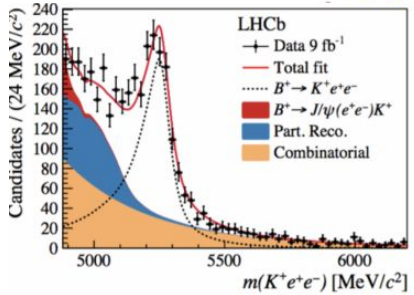


LHCb-PAPER-2021-007

$$R_H \equiv \frac{\int_{q^2_{\min}}^{q^2_{\max}} \frac{\mathrm{d}\mathcal{B}(B \to H\mu^+\mu^-)}{\mathrm{d}q^2}\mathrm{d}q^2}{\int_{q^2_{\min}}^{q^2_{\max}} \frac{\mathrm{d}\mathcal{B}(B \to He^+e^-)}{\mathrm{d}q^2}\mathrm{d}q^2}$$

$$R_K(1.1 < q^2 < 6.0\,\mathrm{GeV}^2/c^4) = 0.846\,^{+0.042}_{-0.039}\,^{+0.013}_{-0.012}$$ 3.1σ from SM

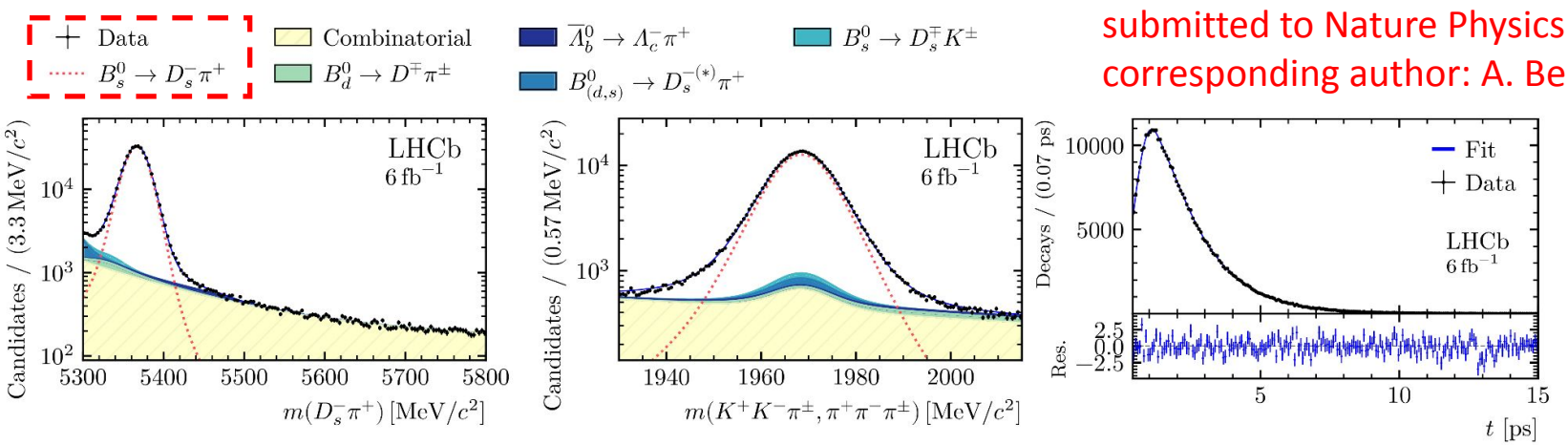


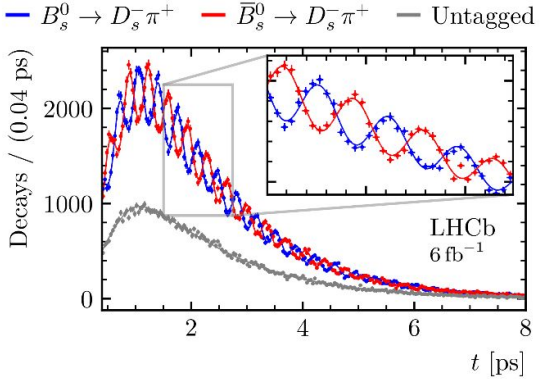


Analisi @ Padova

- LHCb Δm_s mass difference update

arXiv:2104.04421
LHCb-PAPER-2021-005
submitted to Nature Physics
corresponding author: A. Bertolin





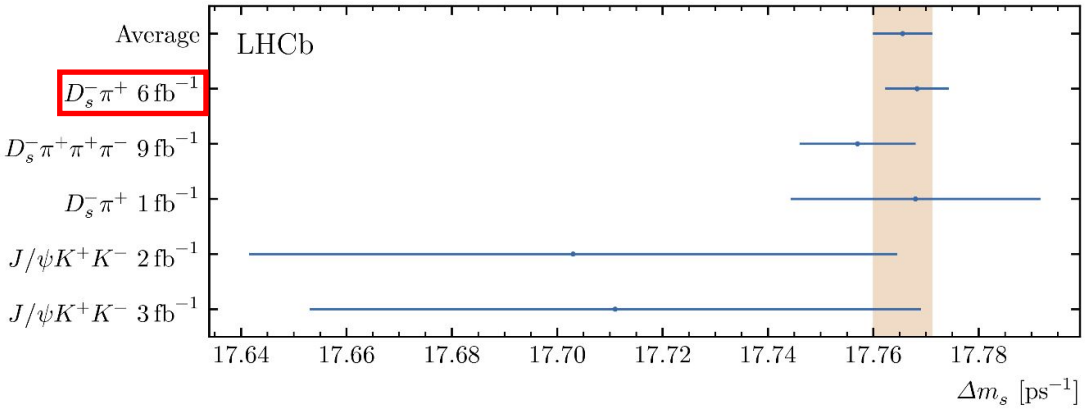
$$A(t) = \frac{N(B_s^0 \to D_s^- \pi^+, t) - N(\overline{B}_s^0 \to D_s^- \pi^+, t)}{N(B_s^0 \to D_s^- \pi^+, t) + N(\overline{B}_s^0 \to D_s^- \pi^+, t)}$$

- exploit the flavor specific nature of this decay i.e. just oscillations
- full Run 2 statistic (6 /fb), partial Run 1 (1 /fb) result already published
- signal yield for a simultaneous fit to the beauty and charm mass distributions: **378.7 k events**
- Δm_s from a fit to the background subtracted decay time distribution

$$\Delta m_s = 17.7683 \pm 0.0051\,(\text{stat}) \pm 0.0032\,(\text{syst})\ \text{ps}^{-1}$$

- spectacular decay time asymmetry distribution

- LHCb Δm_s mass difference update (cont.)



arXiv:2104.04421
LHCb-PAPER-2021-005
submitted to Nature Physics
corresponding author: A. Bertolin

LHCb average: 17.7656 ± 0.0057 ps^{-1}

lattice QCD + sum rule: $18.4^{+0.7}_{-1.2}$ ps^{-1}

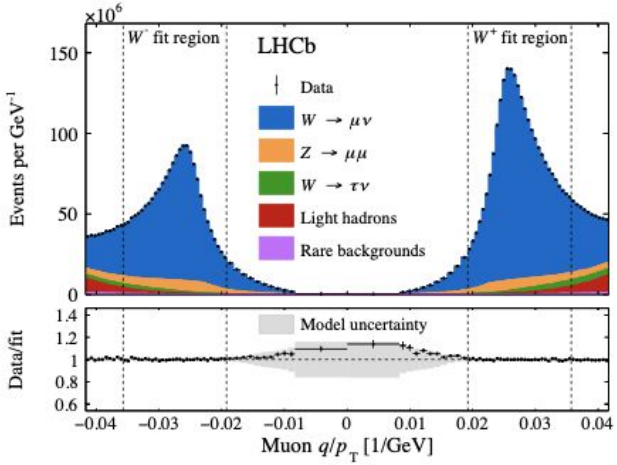
JHEP 12 (2019) 009

- interesting measurement on its own !
- given the large theoretical uncertainties have to fix Δm_s from this dedicated measurement, value obtained will be used as input in many LHCb analyses, like the CKM γ analyses in primis

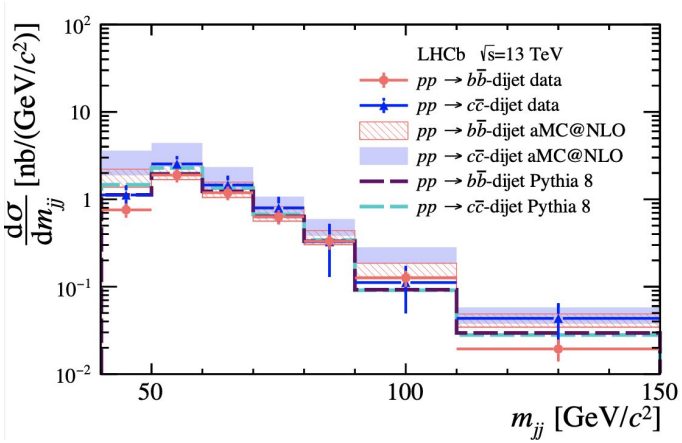
- next step: CKM γ measurement for a TD analysis (decay time distribution) of the decay Bs $\rightarrow$ Ds K
analysis coordinator: A. Bertolin (pool of 3 staff and 4 PhD/post-doc)

Highlights from the QCD, Electroweak and Exotica group at LHCb

Service tasks @LHCb-Padova
Convener: Lorenzo Sestini
Statistics liaison: Davide Zuliani
Run 3 task force: Lorenzo Sestini, Davide Zuliani



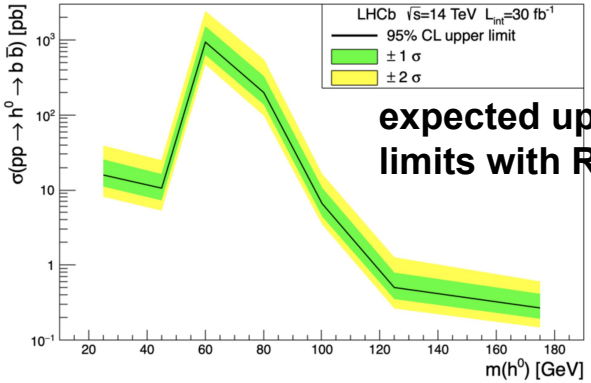
Measurement of the W boson mass at LHCb:
- presented at CERN Seminar on 29/06/2021
- total uncertainty 34 MeV, but proof of principle with just 2016 data
- **incredible achievement for an experiment initially designed for b-hadron physics!**



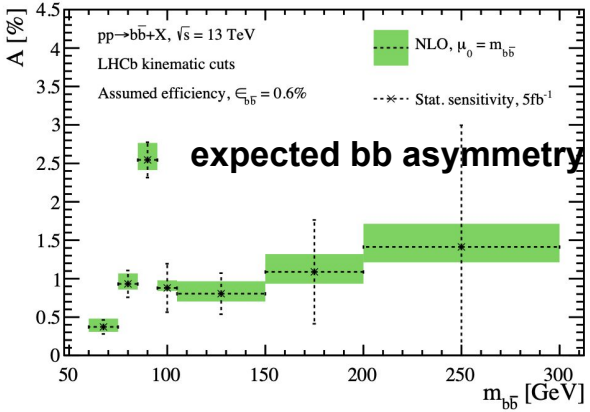
Measurement of differential bb- and cc-dijet cross section:
- Measurement **leaded by LHCb-Padova**
- **Published in JHEP this year**.
- important measurement for testing pQCD predictions in the forward region of pp collisions.

On-going measurements with b- and c-jets

INFN-Padova people involved
Laura Buonincontri, Luca Giambastiani, Davide Nicotra, Donatella Lucchesi, Lorenzo Sestini, Davide Zuliani



expected upper limits with Run 3-4



expected bb asymmetry with Run 2

Search for $b\bar{b}$ and $c\bar{c}$ resonances

- Search for new resonances that decay in two b- or c-quarks with Run 2 dataset (+trigger studies for Run 3-4)
- motivated by Dark Matter/SUSY models
- **Low masses can be tested (down to 10-20 GeV)**, thanks to the low p_T threshold trigger and boosted jet techniques

$b\bar{b}$ and $c\bar{c}$ forward-central charge asymmetry

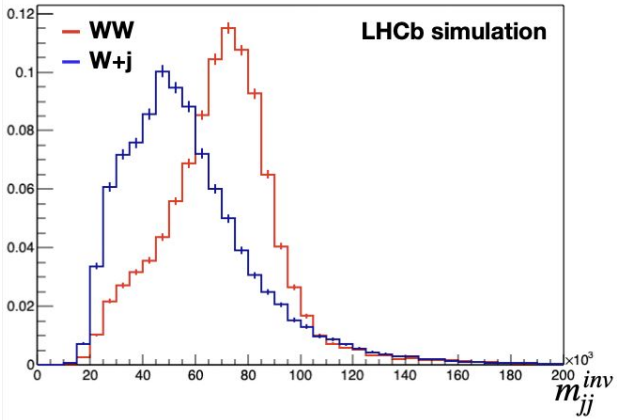
$$A_{FC}^{b\bar{b}} = \frac{N(\Delta y > 0) - N(\Delta y < 0)}{N(\Delta y > 0) + N(\Delta y < 0)} \qquad \Delta y = |y_b| - |y_{\bar{b}}|$$

- Crucial test of the Standard Model
- **Asymmetries are enhanced in the forward region of pp collisions**

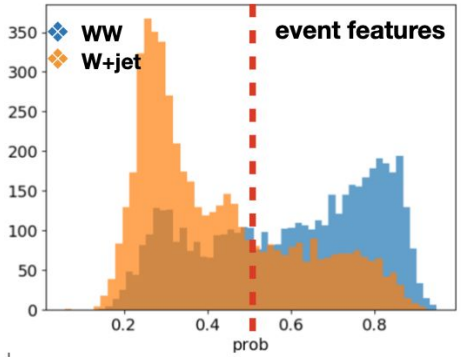
WW with W hadronic decay @ LHCb

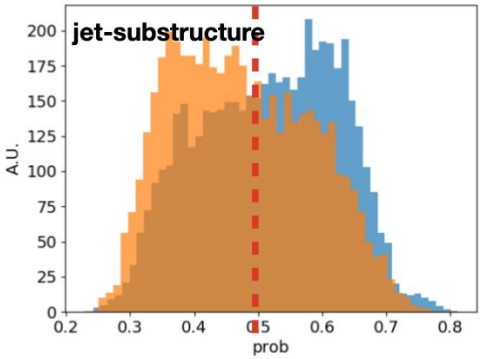
INFN-Padova people involved
Alessio Gianelle, Donatella Lucchesi,
Lorenzo Sestini, Davide Zuliani

- Important measurement to test Standard Model and perturbative QCD @ TeV scale
  - Background for New Physics processes
  - Main background for H → WW
- Measurement of W polarization in WW events
- First study of W hadronic decay @ LHCb



- Run 2 data (2016-2018) will be analyzed
- Main signature: $\mu^{\pm}$ + 2 jets
- Main background: W/Z + jets
- So far feasibility studies have been done
- Main analysis idea: use ML tools considering both event features and jet-substructure, in order to separate signal from background





- First tests of sig vs. bckg already show good results
- Optimization of ML tools is on going

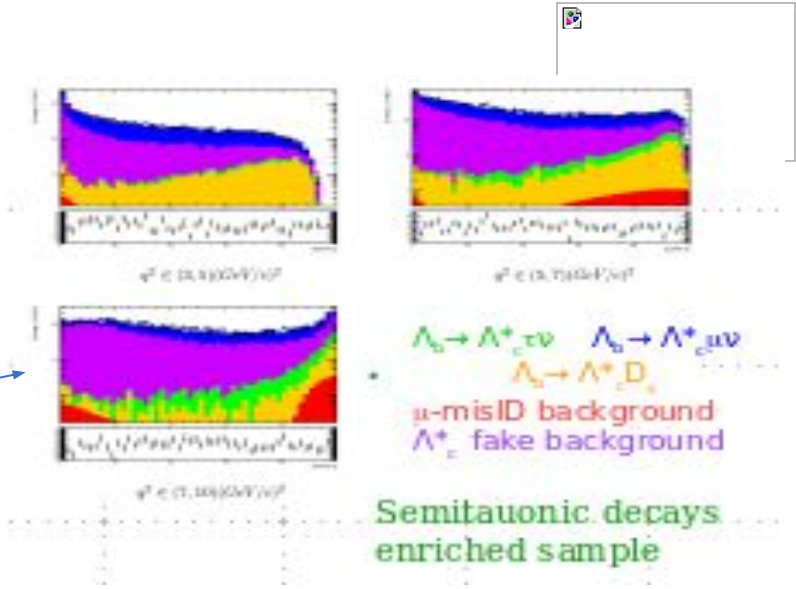
Universalita' leptonica: $R(\Lambda_c^*)$

$R(\Lambda_c^*)$

Prima misura di universalita' leptonica nei barioni

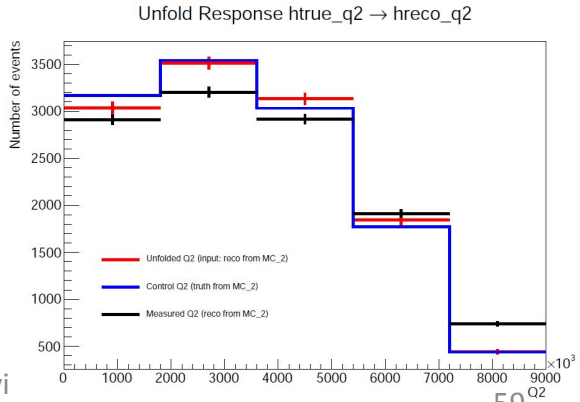
Analisi preliminare con dati run1 **LHCb-ANA-2018-026,** nuova analisi con dati run2 in preparazione Persone coinvolte: **G.Simi**

$$= \frac{\mathcal{B}(\Lambda_b^0 \to \Lambda_c^* \tau^- \bar{\nu}_\tau)}{\mathcal{B}(\Lambda_b^0 \to \Lambda_c^* \mu^- \bar{\nu}_\mu)} = \frac{N(\Lambda_b^0 \to \Lambda_c^* \tau^- \bar{\nu}_\tau)}{N(\Lambda_b^0 \to \Lambda_c^* \mu^- \bar{\nu}_\mu)} \frac{\epsilon_\mu}{\epsilon_\tau} \frac{1}{\mathcal{B}(\tau^- \to \mu^- \bar{\nu}_\mu \nu_\tau)}$$



Misura preliminare: fattori di forma

- Prima misura dei parametri di questo decadimento
- Necessaria per ridurre la sistematica in $R(\Lambda_c^*)$
- Timescale: risultato preliminare pronto, nota pronta, calcolo errori sistematici e unfolding in corso
- Persone coinvolte: **G.Simi**



Universalita' leptonica: $R(\Lambda_c^*)$

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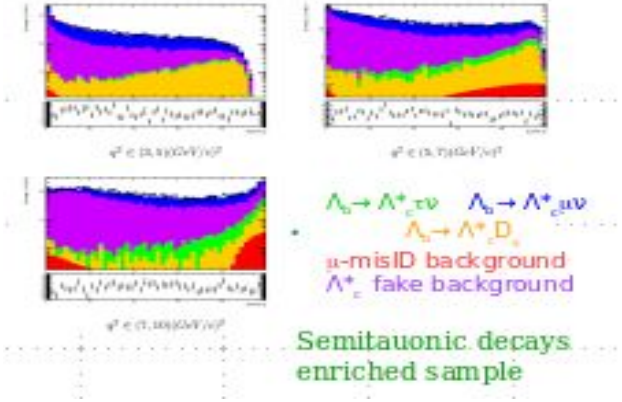
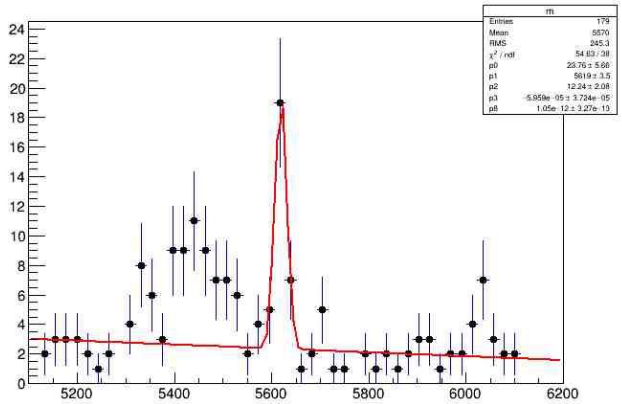


Misura preliminare: BF(B->Λ_c^* D_s)

Misura Necessaria per ridurre la sistematica in $R(\Lambda_c^*)$

Inoltre possibile prima osservazione del decadimento

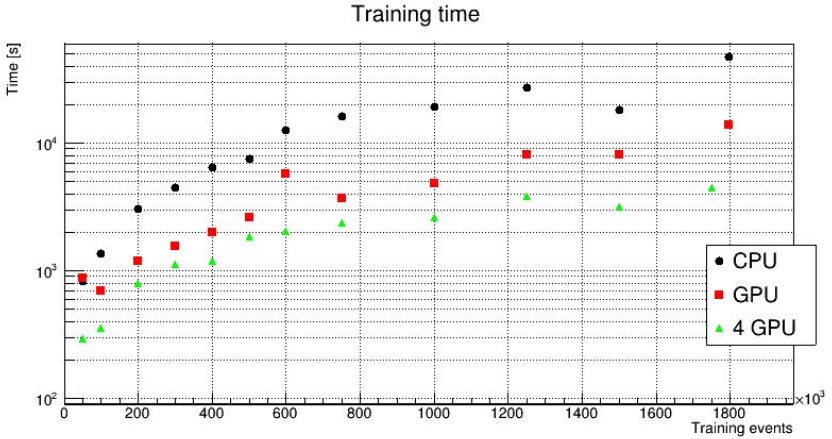
Persone coinvolte: G.Simi, **L. Giambastiani**

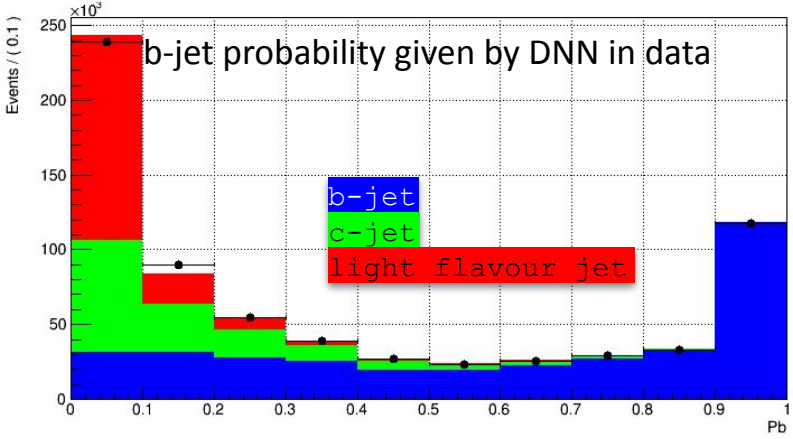


Analysis Tools & Computing

Jet flavour tagging with DNN

- **3-way classification** of hadronic jets according to their flavour (**b vs c vs light flavour jets**) with a **Deep Neural Network (DNN)**
- The goal is to improve the jet identification performance at LHCb
- **Comparison between CPU** (x86-64) and Nvidia **GPU** (Cineca Marconi 100) when used for training the DNN
- **With GPUs we obtained a significant speed-up** with similar tagging performance
- Implementation in the Run 3 trigger under study

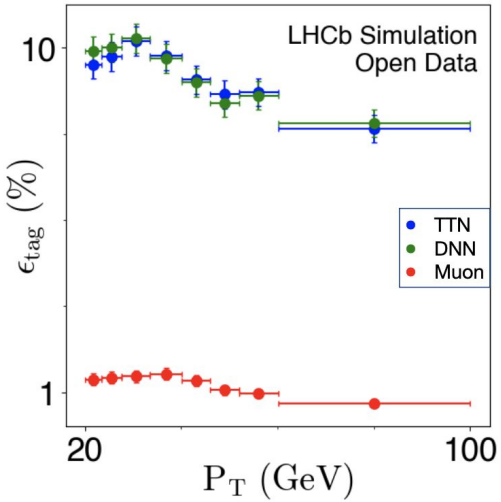




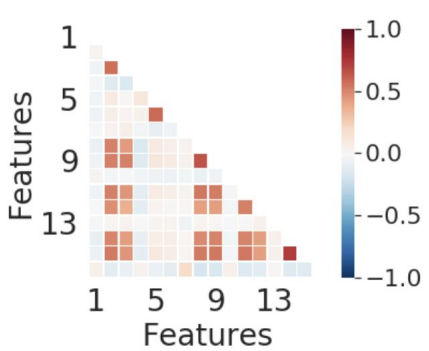
INFN-Padova people involved
Alessio Gianelle, **Luca Giambastiani**, Donatella Lucchesi, Lorenzo Sestini, Davide Zuliani

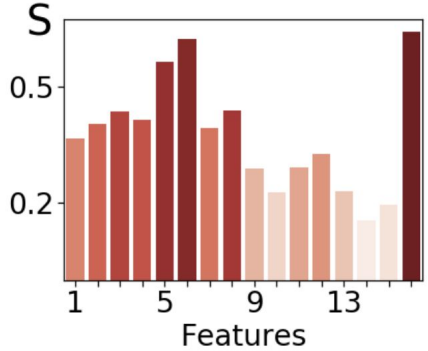
Quantum-inspired ML with Tensor Networks for jet tagging

- Tensor Networks are a mathematical tool to investigate quantum many-body systems on classical computers
- Recently they have been used as classifiers for **supervised ML** problems
- Tagging of b vs bbar jets using **official LHCb simulation**, **tagging power** ε_{tag} is the figure of merit
- Performance is compared between classical DNN, quantum-inspired Tree TN and actual LHCb tagging method



- **TTN performs as good as DNN**
- TTN allows to measure **correlations** and and **entanglement** within the classifier





INFN-Padova people involved

Alessio Gianelle, Donatella Lucchesi, Lorenzo Sestini, Davide Zuliani

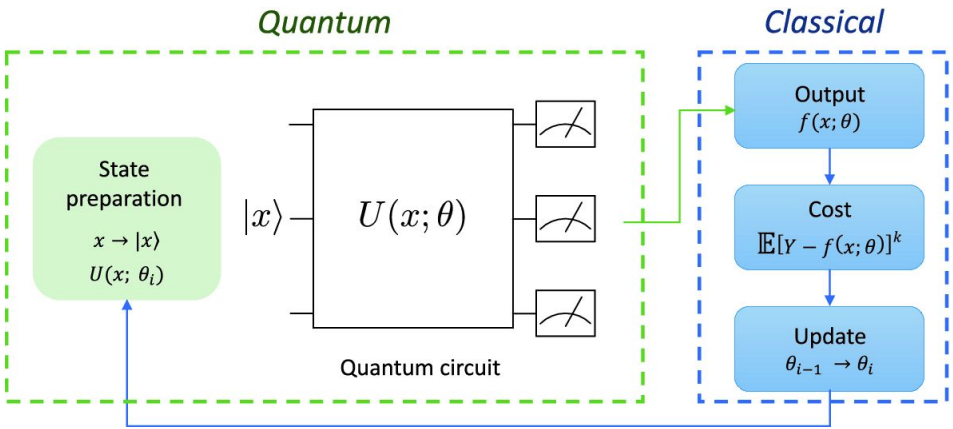
- Work done in collaboration with **Padua Quantum Technologies Research Center** (Prof. Simone Montangero, Timo Felser and Marco Trenti)
- **Soon to be published in Nature Quantum Information**

Jet Tagging with Quantum Machine Learning @ LHCb

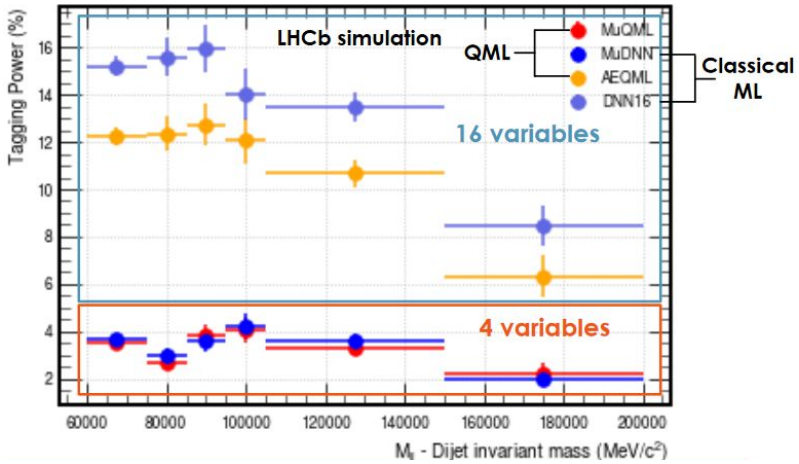
Davide Nicotra Laurea thesis

Quantum Machine Learning model for b vs $\bar{b}$ tagging of b-jets:

- Quantum Circuit with parameterized gates as ML model
  a. Variables from jet particles are encoded in a **quantum state**
  b. The state is processed by **trainable quantum gates**
  c. **Measurements** on the final state are mapped to labels (b or $\bar{b}$)
- Parameters are optimized via a **Gradient Descent** minimization of a cost function (training)



Results



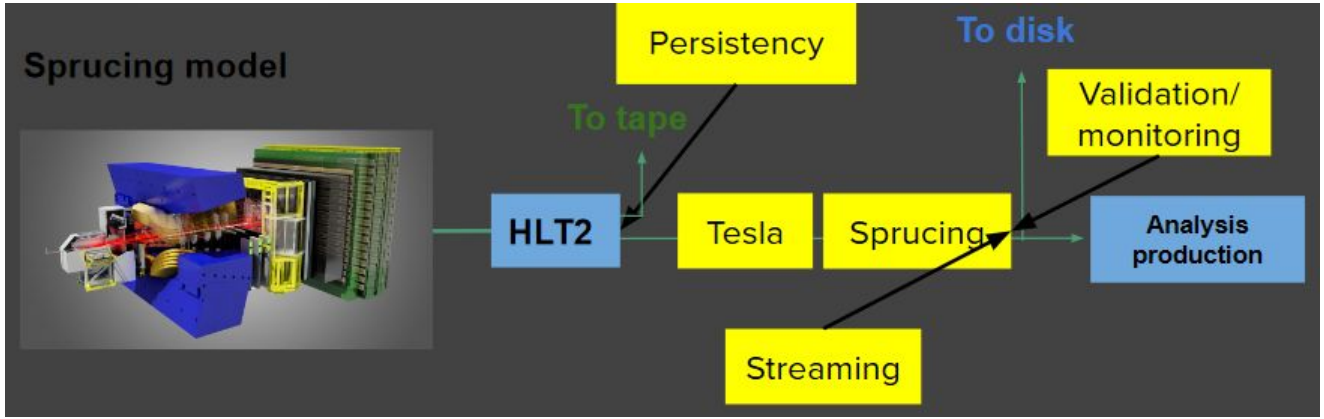
QML vs Classical ML: comparable performances

Quantum models can allow the study of correlations between particles inside the jet

INFN-Padova people involved

Alessio Gianelle, Donatella Lucchesi, Davide Nicotra, Lorenzo Sestini, Davide Zuliani

- LHCb Real Time Analysis project



two data reduction stages:
- HLT2, basically in real time
- Sprucing, offline but concurrent with the data taking
HLT2 and Sprucing are sharing the same software framework (Moore)

Sprucing has at present 3 people: A. Bertolin, a post-doc and a PhD
these 3 people are also often contributing to the HLT2 selection code

Data Processing & Analysis (DPA) Project: WP4-Innovative Analysis Techniques

LHCb coordinator: Donatella Lucchesi

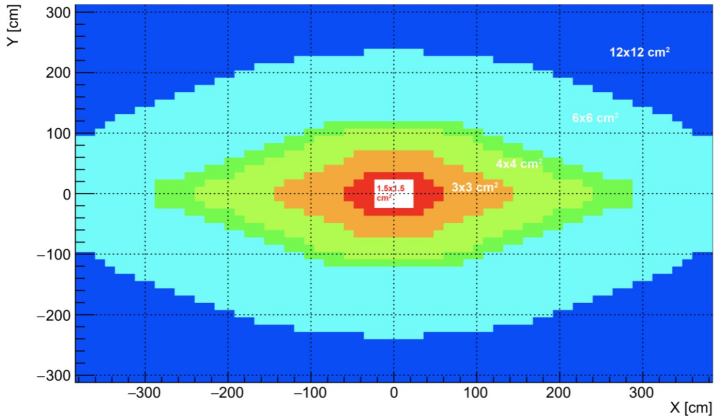
- Coordination of quantum algorithms development for LHCb application in collaboration with CERN Technology Initiative:
  - b-jet tagging (Padova)
  - tracking (Maastricht, Liverpool)
- Coordination of opportunistic usage of GPU clusters:
  - Several LHCb institutes have access to GPU farms, INFN has an agreement with CINECA, often underused;
  - Collect and harmonize the available applications:
    - ZFit (University of Zurich)
    - GPU in Ultra-Fast Simulation (University and INFN Florence)
    - GPUs for b-tagging with ML @CINECA (University and INFN Padova)
    - Machine learning and GPU usage in amplitude analyses (CNRS/IN2P3, CPPM, Marseille)
  - Coordinate development of new application to easier the exploitation of the resources

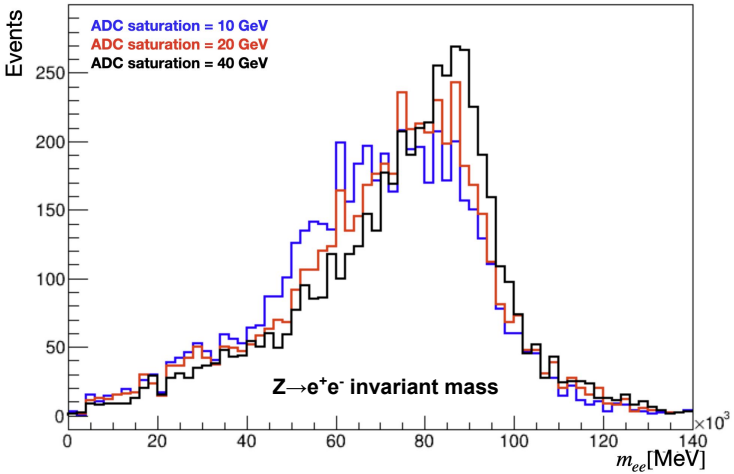
Upgrade II R&D

Upgrade-2 ECAL: studies for $Z \rightarrow e^+e^-$

INFN-Padova people involved
Alessio Gianelle, Donatella Lucchesi,
Lorenzo Sestini, Davide Zuliani

- ECAL will go through some changes in preparation of Run 4+
  - New ECAL region definition
  - New materials (SPACAL & Shashlik)
  - Possibly implementing time information
- From our point of view it is important to study high p_T objects
  - Study ADC range
  - Understand impact of ADC saturation





- Simulation studies for $Z \rightarrow e^+e^-$ are on-going
- Indeed higher values for ADC saturation will allow to get better invariant mass resolution
- Results need to be checked with low energy processes
- Further studies will include:
  - New reconstruction algorithms (ML based possibly…)
  - Different physics processes (H→bb,H→cc, top decays, …)

R&D for Upgrade-2 ECAL

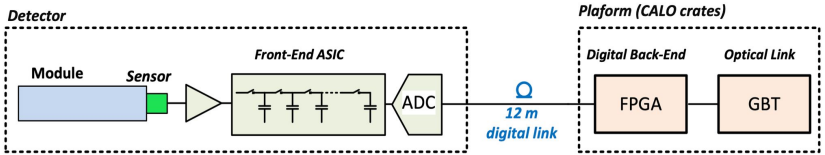
- **Interest from LHCb-Bologna and LHCb-Padova in the realization of a time layer for ECAL Upgrade 2 (Run5+):**
  - time measurement of calorimeter clusters is crucial to reconstruct events in the HL-LHC high pile-up environment
  - baseline technology: LAPPD (Large Area Picosecond Photodetector)

- **LHCb-Padova is interested in the development of the time-layer read-out**:
  - high granularity means a huge number of signals
  - baseline solution is ADC+FPGA
  - **we request 8k euros to buy a basic FPGA, in order to start developing the system**
  - FPGA programming in Padova, integration with sensors and electronics in Bologna, testbeams on calorimeter cell prototypes at CERN/DESY/PSI

INFN-Padova people involved

Laura Buonincontri, Luca Giambastiani, Alessio Gianelle, Donatella Lucchesi, Lorenzo Sestini, Davide Zuliani

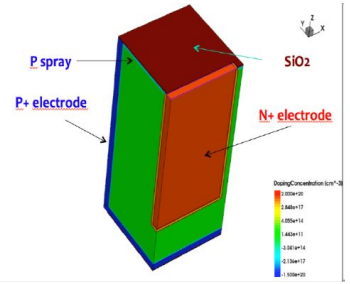
Tentative front-end architecture

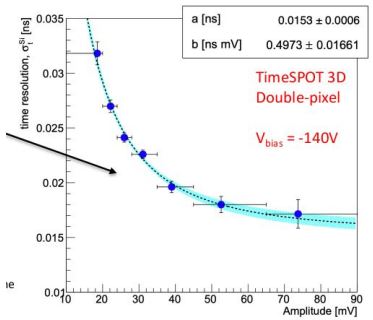


R&D For VELO Upgrade

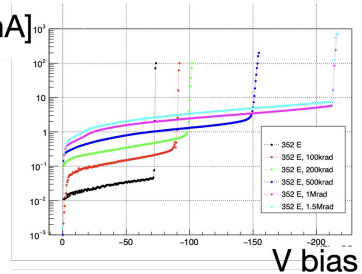
Involvement: G. Simi + Ph.D student

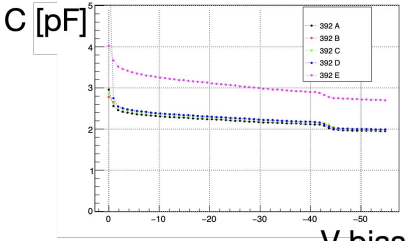
- 4-years INFN-funded gr5 project **TIMESPOT**
  - Development of radiation 3D hard fast
  - pixel sensors for tracking in high luminosity LHC
    - Space resolution 10um
    - Time resolution 20ps
    - Radiation Hardness >10^{16} 1MeV neq/cm^2
  - Sensor developed at FBK showed resolution with pion test beam at PSI better than **20ps**
  - Padova: Sensor static characterization
  - Padova: Sensor efficiency and time resolution tested at Legnaro with innovative technique at microbeam
  - **Next year** continue the work bring to conclusion the project
    - **Full demonstrator** construction and beam test
    - Static and dynamic characterization of **sensor after irradiation**
    - **Readout electronics** development and radiation hardness
  - **Perspective**: official involvement of Italian groups in the VELO discussion has started

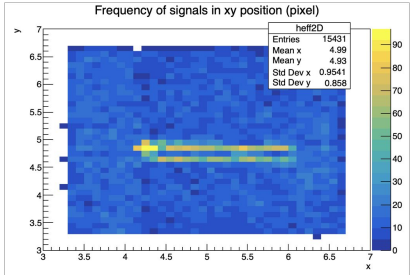




Test-beam at Legnaro

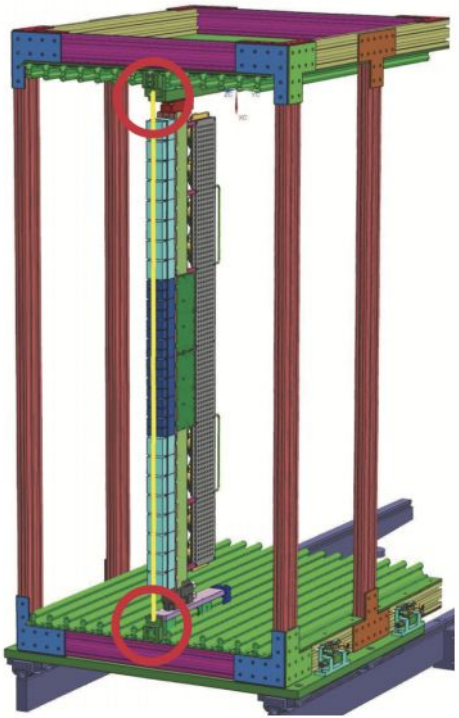






R&D For RICH Upgrade II

- Motivation: Increase granularity for Cerenkov ring reconstruction in high luminosity LHC runs
  - Upgrade: optics, photosensors, time-resolved readout electronics, time calibration system, mechanics
  - Photosensors choices: MaPMT, SiPM at cryo temperatures, MCP
    - **Padova: R&D on critical item rad hardness of SiPM at cryo temp [G. Simi]**
    - **Padova: Mechanical design and cooling system responsibility [M. Benettoni]**
  - Framework TDR in progress
  - Financial requests definition in progress



Anagrafica e Richieste

Anagrafica e Richieste

- **Percentuali (4.9FTE)**
  - A. Bertolin 70%
  - D.Lucchesi 70% (TBC)
  - L. Sestini 70%
  - G.Simi 70%
  - D. Zuliani 70%
  - L. Giambastiani 70%
  - L. Buonincontri 70%
- **Percentuali tecnologi (0.6FTE)**
  - Benettoni 20%
  - Gianelle 40%
- Richieste **finanziarie**
  - Missioni, consumo secondo le formule standard
  - **8kE** per scheda FPGA CAEN
- **Servizi**:
  - Progettazione meccanica **2 m.u**. RICH Upgrade
  - Progettazione elettronica **2 m.u.** VELO Upgrade

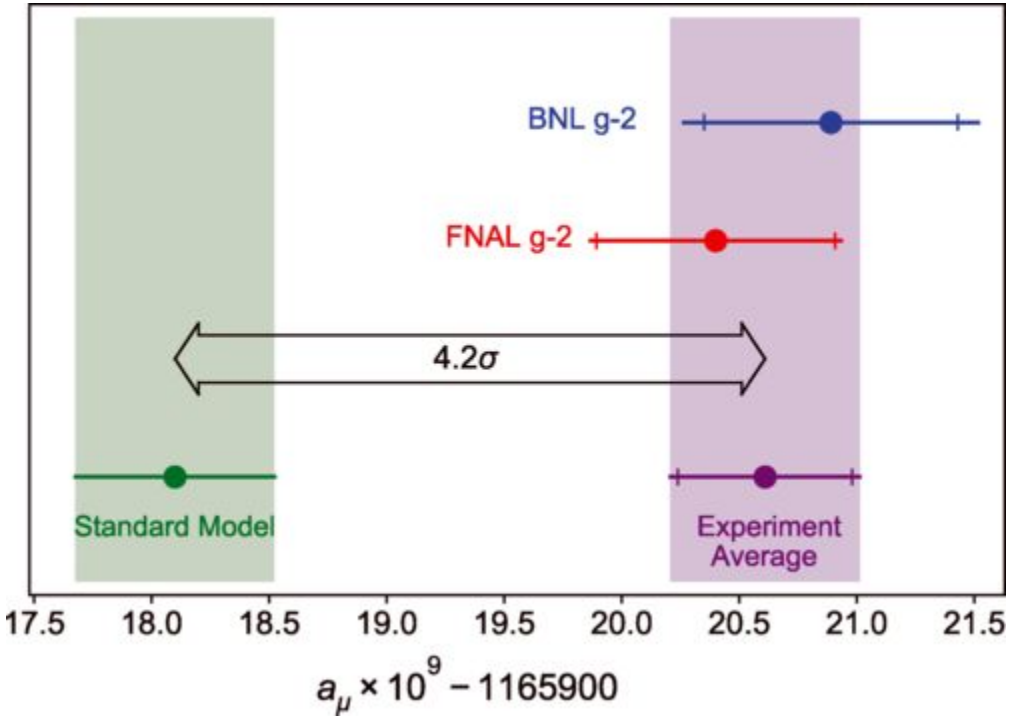
- Richieste di **Spazi**
  - **Stanza piccola nel laboratorio gr1** al primo piano
    - per test PMT eventualmente sostituiti da Hamamatsu
    - Test sensori TIMESPOT per VELO
- Service tasks e responsabilita`
  - Convener del QEE Analysis Working Group (L. Sestini).
  - Convener di Higgs Exotic Decays Group al CERN (L. Sestini).
  - Convenor of the innovative analysis techniques package in the Data Analysis Project (D.Lucchesi)
  - Responsible for Rich threshold calibration (G. Simi)
  - Responsibility for RICH2 mechanics and cooling (M. Benettoni)
  - Responsibility for PMT characterization (G. Simi)

MUONE

Resp. Naz. Umberto Marconi (BO)

Resp. Loc. E. Conti

g-2 recent result



- Il recente risultato sperimentale della collaborazione *g-2* conferma il problema del momento magnetico anomalo del muone.
  MUonE, tramite lo scattering elastico μ-e, misura il running di $\alpha_s(t)$ e tramite esso, il contributo Hadronic Vacuum Polarization ad α_μ

- Per dettagli vedi M.Passera a CSN1 del 18/5
  - https://agenda.infn.it/event/26382/

Attività 2021

- **MUonE** si propone di validare il metodo di misura del running adronico mediante la rivelazione dello scattering elastico utilizzando un rivelatore costituito da 3 stazioni di tracking indipendenti + calorimetro elettromagnetico, con fascio di muoni da 150-160 GeV a CERN-SPS:
  - Rivelare eventi elastici con tracciatori a strip di silicio: moduli 2S di CMS (upgrade)
  - Determinare con precisione l'energia del fascio mediante l'inversione della cinematica dello scattering.
  - ECAL serve per controllare la selezione elastica basata sulle osservabili angolari ottenibili con il tracking
  - Importante definire le prestazioni di ECAL nella selezione degli eventi elastici
- La produzione dei moduli 2S e' in ritardo: **il test beam è posticipato al 2022**
- Stiamo preparando test della FEE e DAQ con moduli disponibili nel 2021+ECAL con **fascio di μ a SPS in parasitic mode**

Attività 2022

- Test beam con 3 stazioni di tracking (target + tracker) + ECAL.
- Portare a termine il TDR per ECAL per proposizione alle agenzie per finanziamento

Attività Padova 2021

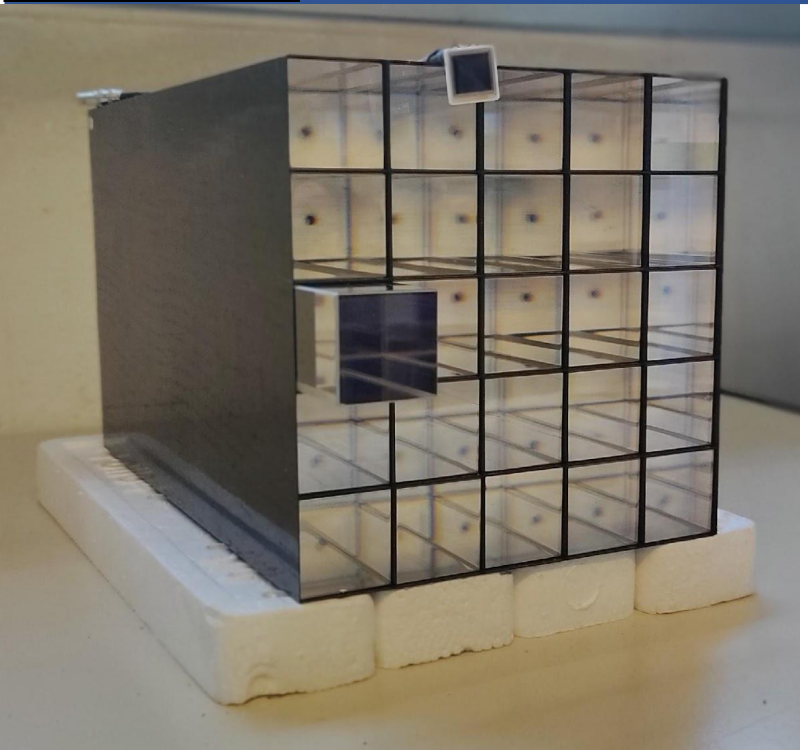
- Da febbr. 2021, MUonE Padova ha assegno di ricerca tecnologico annuale (fondi INFN): Chiara Bonini
- Attività:
  - progettazione e sviluppo del modulo 5x5 cristalli $PbWO_4$ per il Test Beam
  - misure con i cristalli PWO di CMS (in prestito da CMS forward-ECAL, $3x3cm^2$, 21cm length)
  - misure dei nuovi cristalli PWO ($2x2\ cm^2$, 22cm length) prodotti dalla Crytur
  - Simulazioni MonteCarlo

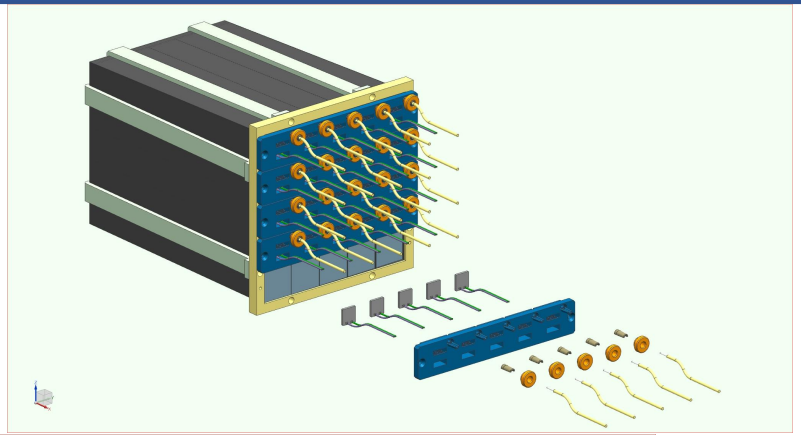
$PbWO_4$ e' nota come "Stolzite" da J.A.Stolz (1803-1896)

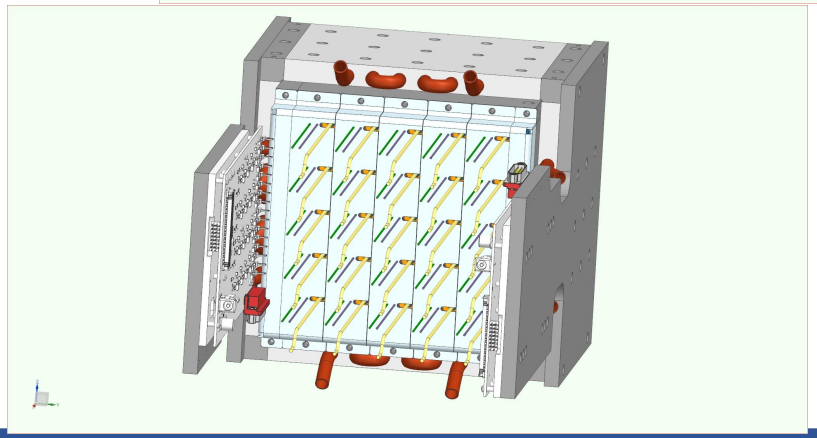
Progetto e sviluppo del modulo ECAL per Test Beam

- Padova
  - progettazione e realizzazione meccanica
  - termoregolazione
  - test dei cristalli PWO
  - coordinamento
- Univ. of Virginia
  - APD: fornitura, test e caratterizzazione, sistema di montaggio
- Imperial College
  - Front End electronics, DAQ boards

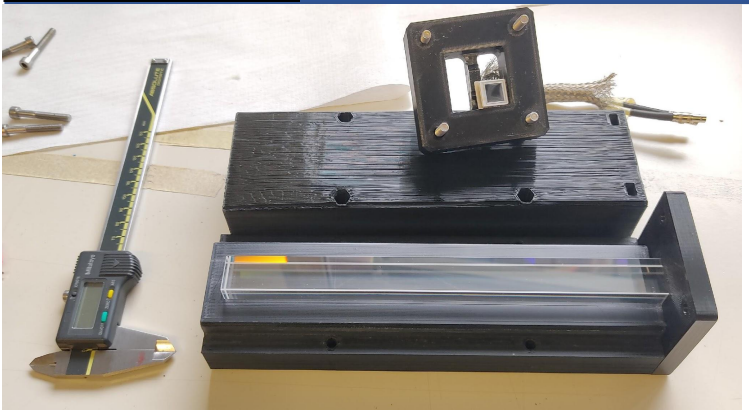
Sviluppo modulo ECAL



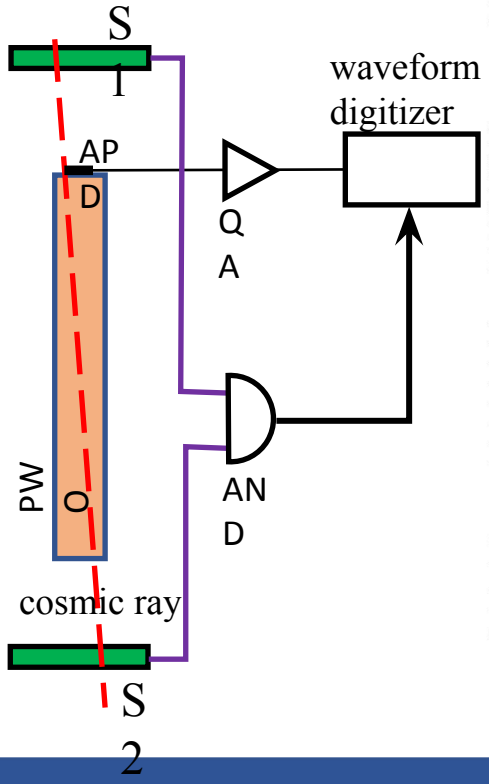


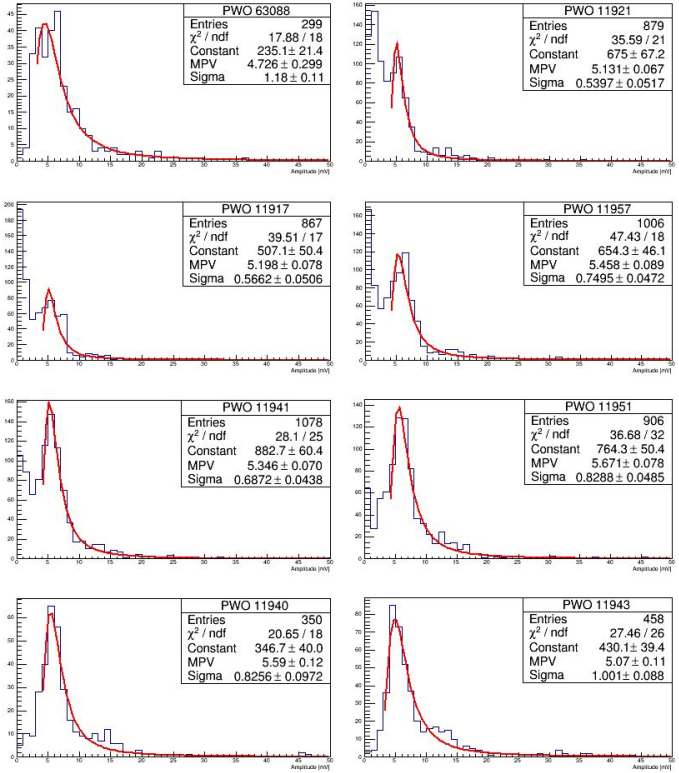


Misure con PbWO4 e APD



Luce di scintillazione del PWO, rivelata da Si APD 10x10mm2, prodotta dal passaggio di un raggio cosmico per tutta la lunghezza del cristallo (22cm, ~ 350 MeV rilasciati).
Segnale vicino al rumore elettronico ma comunque rilevabile.
8 cristalli analizzati, risposta identica entro gli errori





Presentazioni - talk

- C. Bonini: “The electromagnetic calorimeter for the MUonE experiment: PbWO4 crystals characterization”
- A. Ghosh: “Performance study of the MUonE calorimeter from GEANT4 Monte Carlo simulation”

presentazioni a *SIF2021*

Anagrafica

Nome		% FTE 2021	% FTE 2022
M. Benettoni		10	10
C. Bonini	assegnista, scade 31 genn 2022		
E. Conti		65	55
A. Ghosh	assegnista	70	0
Whali Hussain	dottorando	100	0
P. Mastrolia		10	
M. Passera		10	10
P. Ronchese		20	20
F. Simonetto		20	20
R. Stroili		20	0
TOT		3.25 FTE	1.15 FTE

provvisorio

Richieste 2022

- Trasferte: to be defined
- Consumo: tbd
- Inventariabile: tbd

- Richieste servizi di sezione:
  - Uff. tecnico: 3 mu
  - Off. meccanica: 3 mu
  - Off. Elettronica: 1 mu

provvisorio

RD MuColl

D. Lucchesi

Status of International Collaboration

Web site

Two community meetings have been organized:

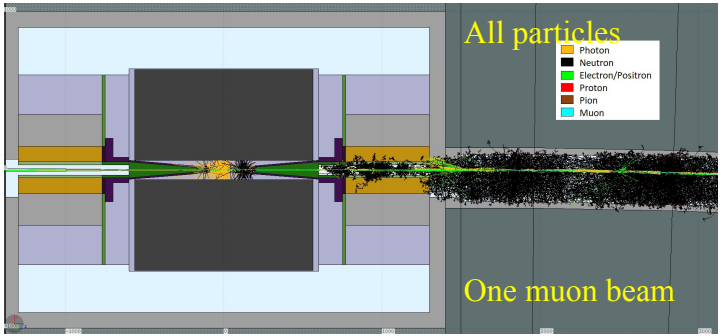
May 20-21 1st Community Meeting

July 12-14 2nd Community Meeting

- CERN Council has charged the Laboratory Directors Group (LDG) to develop the Accelerator R&D Roadmap for the next decade.
- Roadmap is expected to be voted by CERN council at the end of 2021 and will define the R&D for the next decade.
- A Muon Beam Panel (D. Schulte, chair) has been created by the LDG to prepare the Roadmap.
- The panel has created 11 working groups: Radio-Frequency, Magnets, High-Energy Complex, Muon Production and Cooling, Proton Complex, Beam Dynamics, Radiation Protection, Parameters, Power and Cost, Machine Detector Interface (D. Lucchesi), Synergy, Test facility

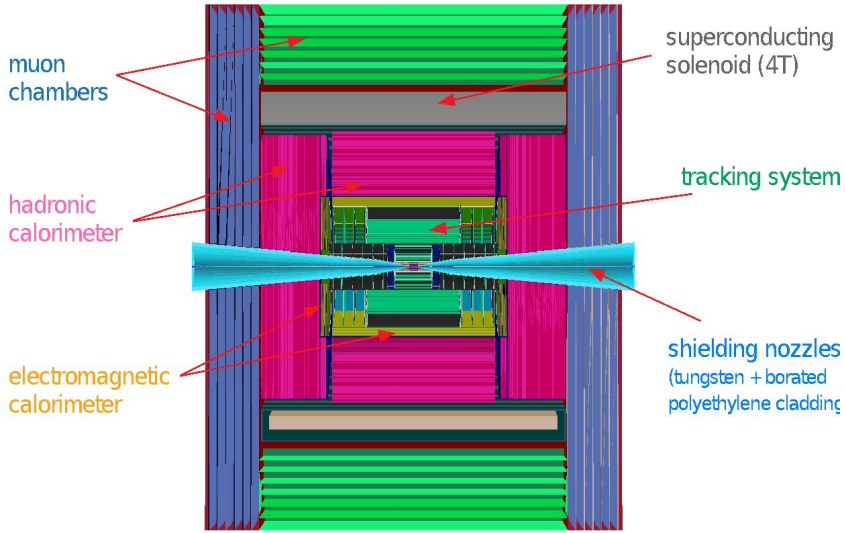
RD_Mucoll - Padova

Machine Detector Interface optimization for beam-induced background mitigation



Paper submitted to JINST, C. Curatolo (corresponding author)
Advanced assessment of Beam Induced Background at a Muon Collider

Detector optimization and Physics Performance studies



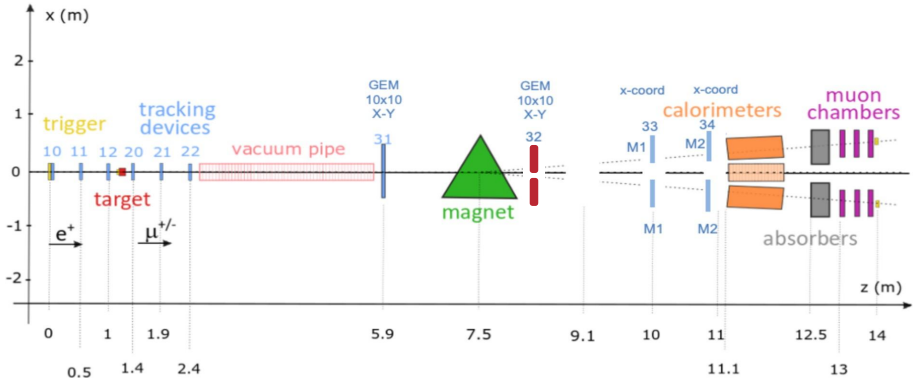
D. Lucchesi P&D coordinator
L. Sestini calorimeter & jets reconstruction coordinator
A. Gianelle and P. Andreeetto International Collaboration code and framework development and maintenance coordinators

Physics and Detector Activities @PD

- Tracks reconstruction: hits clustering algorithm development and test P. Andreetto
- Front-End and DAQ studies D. Lucchesi, L. Sestini, L. Giambastiani, G. Collazuol
- Jets reconstruction algorithm optimization L. Sestini, A. Gianelle, D. Zuliani
  - $H \to WW, W \to \ell\nu\, W \to hadrons$ L. Castelli (Laurea Thesis) D. Zuliani, L. Sestini, D. Lucchesi
- b- and c-jets identification:
  - DNN application for $H \to b\bar{b}, H \to c\bar{c}$ coupling error evaluation G. Dalmolin (Laurea Thesis) L. Sestini, L. Giambastiani, D. Lucchesi, L. Buonincontri, A. Gianelle
  - HH and trilinear coupling error evaluation L. Buonincontri L. Sestini, L. Giambastiani, D. Lucchesi, G. Dalmolin, A. Gianelle
- Study of methods to measure the luminosity at muon collider C. Giraldin (Master Thesis) L. Buonincontri, U. Dosselli, D. Lucchesi, L. Sestini

Test Beam Activities @PD

Measurement of $e^+e^- \rightarrow \mu^+\mu^-$ cross section at the threshold
Study of beam emittance, preparatory to muon collider facility design



Simulation: A. Bertolin

- Silicon tracker, pixel telescope:
  - experience on daq of similar setup (CHROMIE)
  - Possible modifications for Triggerless readout

  M. Zanetti, J. Pazzini, A. Zucchetta
- Trigger & DAQ

  M. Zanetti, J. Pazzini, A. Zucchetta

Both activities on holding due to pandemic

Anagrafica e Richieste

Bertolin Alessandro	30
Buonincontri Laura	30
Collazuol Gianmaria	5
Dosselli Umberto	20
Giambastiani Luca	30
Lucchesi Donatella	30
Mattep Migliorini	20
Pazzini Jacopo	15
Sestini Lorenzo	20
Zanetti Marco	15
Zucchetta Alberto	20
Zuliani Davide	30
	2.65
Andreetto Paolo	25
Gianelle Alessio	40
Gonella Franco	10
	0.75

Test Beam:

Item	Assegnato	Disponibile
Sistema Avanzato DAQ 40MHz	20kEUR	20kEUR

Si chiede per il 2022

Richieste in sezione

Calcolo E Reti	1
Elettronica	4
Officina Meccanica	3
Progettazione Elettronica	12
Progettazione Meccanica	4

L. Sestini (funded) e D. Lucchesi (unfunded) collaborano a AIDAInnova

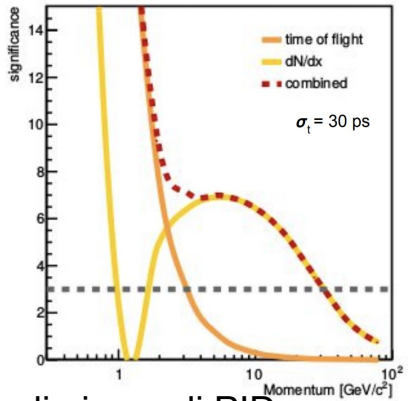
RD FCC

P.Azzi

SIGLA RD-FCC

- Principali attività già in corso:
  - **Coordinazione del lavoro di Simulazione e di Fisica per il gruppo RD-FCC INFN** (P. Azzi(PD)+P. Azzurri(PI))
    - P. Azzi anche convener del “Physics Performance WP” del “FCC Physics Experiment and Detector” Project
  - **Design della regione di interazione per FCC-ee** (N. Bacchetta, convener RD-FCC WP2)
- Per il 2022 focus sullo studio per l’**utilizzo di un timing layer (tipo MTD) all’interno del rivelatore IDEA:** studi di simulazione del rivelatore e di performance di fisica (per PID in eventi di fisica del B o strange tagging, e per fisica BSM)
  - **Attività sinergica con AIDAInnova** per “Sviluppo di Particle Flow in DR calorimeter” (Task 12.5.2)
  - **Attività sinergica con la nuova sigla Gr5 MODE** per “Design di rivelatori per BSM a FCC-ee”
- Fondi esterni:
  - Due PRIN sottomessi: RAZOR (Misura di coupling con heavy flavour) e uno sul TIC (WP5: timing per FCC)
  - La MSCA “Spiral” verrà sottomessa di nuovo entro Nov 2022.

Anagrafica	%
Azzi Patrizia	10% RD-FCC+ 10% AIDA +10% MODE sinergici
Bacchetta Nicola	10
Roberto Carlin	10
Serena Mattiazzo	10
Roberto Rossin	20
Mia Tosi	10
Totale	90



Risultato preliminare di PID con fast simulation di IDEA

AIDAInnova

Resp. Naz. Nadia Pastrone (TO)

Resp. Loc. E. Torassa

TASK 8.4.1
INFN Coord.
Ezio Torassa
(INFN-PD)

Innovative solid-state light sensors
- Systematic study of neutron irradiated SiPMs at different temperatures
- Development of SiPMs with improved radiation resistance

EU proposal: JSI, **INFN-PD**, INFN-TO, CERN, FBK, UiB. FZU

TASK 8.3.1
INFN Coord.
Mattew Moulson
(INFN-LNF)

Innovative calorimeters with optical readout
- Optimization of crystal materials and processes for fast timing applications in radiation environments
- Industrialization of the production process of fast and radiation-hard crystals

EU proposal: CERN, FZU, VU, INFN-PG, INFN-LNF, INFN-TO
new institutes: INFN-NA, INFN-FE, **INFN-PD**

TASK 12.2.1
Coord. Italia
Manuel Rolo
(INFN-TO)

Turnkey software
- Integrated software stack be used for studies of proposed future detectors at new HEP accelerators

EU proposal: DESY, CERN, INFN-PI, **INFN-PD**, INFN-BA, INFN-BO

TASK 12.5.2
Coord. Italia
Biagio di Micco
(INFN-RM3)

Particle Flow Reconstruction
- PFA algorithm with particle ID for dual-readout calorimeters

EU proposal: UWAR, CERN, INFN-RM3, CNRS-LLR, CNRS-IP2I, UOS
new institutes: **INFN-PD**, INFN-PV, INFN-RM1

TASK	Sigla sinergica	FTE 2021		FTE 2022	
8.4.1	Belle II	Ezio Torassa	0.1	Ezio Torassa	0.1
		Flavio Dal Corso	0.1	Flavio Dal Corso	0.1
		Massimo Benettoni	0.1		
		TOT 2021	0.3	TOT 2022	0.2
8.3.1	RD_MUCOL	Lorenzo Sestini	0.1	Lorenzo Sestini	0.1
		TOT 2021	0.1	TOT 2022	0.1
12.5.2	RD_FCC	Patrizia Azzi	0.1	Patrizia Azzi	0.1
		TOT 2021	0.1	TOT 2022	0.1

LUXE

M.Morandin

Note: discussa a CdS 29 Giugno, solo richieste e anagrafica

Presentazione M.Morandin

Anagrafica LUXE

Personale a tempo indet. (tot.: 1.6 FTE)

- U. Dosselli - 0.8 FTE
- M. Morandin - 0.5 FTE
- G. Simi - 0.15 FTE
- M. Benettoni - 0.1 FTE
- D. Pantano

Personale a tempo det. (tot. 2.1 FTE) (acquisito su fondi residui da progetti europei)

- S. Mattiazzo - 0.15 FTE
- Dottorando (da 9/21, borsa a tema su LUXE) - 1 FTE
- Post-doc (da fine 2021 / inizio 2022) - 1 FTE

Altri collaboratori

- Alessandro Marchioro

Richieste in sezione

Servizi in sezione

- **Servizio Progettazione Meccanica** (*) (tecn. + disegn.): 1 + 1 m.u. nella II metà del 2021, 1 + 3 m.u. nel 2022
- **Officina meccanica** (*) (2022)
  - realizzazione struttura meccanica: 4 m.u.

Richieste alla Sezione

- **Supporto fornito da tecnici DipFA** (oltre al personale già indicato in precedenza)
  - 1 m.u. nella II metà del 2021
  - 2-3 m.u. nel 2022
- Eventuale **supporto del servizio Elettronica** per bonding prototipi
  - max 2 settimane nel 2021

Conclusioni

- **Belle II**
  - in piena attivita': fisica sta crescendo, per 2022 lavoro per upgrade MCP-PMT
  - Prospettive per futuri upgrade
- **CMS:** Attivita' Padova continua, sia analisi che fase2:
  - Impegno su molti fronti su analisi, grande impatto in B-physics
  - Impegno per DT, Pixel, e BTL
- **LHCb** grande impegno in analisi e anche upgrade II
  - Highlight per $B_s^0-B_s^0$-Δm_s
  - Sinergia con Quantum ML
- **MUonE**:
  - Attivita' per ECAL, testbeam rimandato 2022, personpower issue
- **MuColl**: PD ben rappresentata e attiva
  - Sinergia con upgrade II LHCb e CMS
- **FCC**
  - Gruppo sta crescendo
- **LUXE**
  - Notevole interesse in sezione

Backup

Responsabilita' 2021

		Ruolo	Livello	Mesi uomo
Marina Passaseo	MU-DT	TSG FOG coordinator	2	3
Mia Tosi	FIS	TRK POG coordinator	2	3
Marco Bellato	MU-DT	Electronics coordinator	2	3
Nicola Bacchetta	TRK	TRK Technical coordinator	2	3
Roberto Rossin	MU-DT	DT-DPG deputy coordinator	2	3
Sandro Ventura	Muon	Muon Electronics Coordination Office Representative	2	3
Sandro Ventura	MU-DT	DT Upgrade Coordinator	2	3
Paolo Ronchese	FIS	BPH-PAG software coordinator	3	-
Martino Margoni	FIS	BPH-PAG conference contact+HEPDATA coordinator	3	-
Sandro Ventura	MU-DT	Online software coordinator	3	-

Conferenze 2019

Speaker	Conferenza	Titolo		Localita'	Proceedings
		CMS			
Bragagnolo Alberto	*Alps 2019. Alpine LHC Physics Summit*	*Flavour anomaly updates from ATLAS and CMS*	ple	Obergurgl	**Y**
Ronchese Paolo	*FPCP 2019: Conference on Flavor Phy...*	*Production rates and branching fractions of heavy hadrons & quarkonia at LH...*	ple	Victoria	**Y**
Pozzobon Nicola	*21st International Workshop on Radi...*	*The CMS Muon System: performance during the LHC Run-2*	ple	Kolymbari	**Y**
Tosi Mia	*8th International Conference on New...*	*Highlights from CMS*	ple	Kolymbari	**Y**
Dorigo Tommaso	*8th International Conference on New...*	*From SU(3) to 3 Families of Quarks*	inv	Kolymbari	**N**
Alessio Boletti	*Moriond/EW2019: 54th Rencontres de ...*	B-physics results in CMS in Run2	ple	La Thuile	**Y**
Alessio Boletti	*Beauty2019*	Angular Analysis of B-> K(*) μμ Decays at CMS	ple	Lubiana	**Y**
Matteo Presilla	LakeLouise2019: Lake Louise Winter Institute 2019	Beyond-Standard-Model Physics at the High-Luminosity LHC with the CMS detector	ple	Lake Louise (Alberta, Canada)	**N**
		CMS FASE 2			
Pozzobon Nicola	*TWEPP 2019 Topical Workshop on Elec...*	*FPGA implementation of a histogram-based parent bunch-crossing identificati...*	par	Santiago de Compostela	**Y**
Zanetti Marco	*24th International Conference on C...*	*Big Data solutions for the online processing of trigger-less detectors data...*	par	Adelaide	**N**
Conveners/session chairs/org committee					
Martino Margoni	*LHCP 2020*				
Sandro Ventura	*ACES 2020*				
Mia Tosi	*ICHEP 2020*				
P. Azzi, M. Presilla	*COMPOSE-IT*				

Anagrafica 2020

Out:
- Boletti
- Pozzobon

In:
- Dosselli
- Pazzini (RTDb)
- Bortignon (RTDb Cagliari)
- Lukas (PhD EU-Insights - UniNa)
- Strong (Postdoc EU-Insights)

Strutturati :
- Lacaprara : 10% → 0%
- Montecassiano : 60% → 30%
- Torassa : 10% → 0%

Ruolo	Persone	FTE
Ricercatori e studenti	26	22.65
Tecnologi	11	6.15

Missioni
- Metabolismo+shifts/services: 254 keu
- Responsabilita': 80 keu
- Lavori in Long Shutdown 2 e preparazione Fase 2: 79 keu
- BTL Test Beam: 4 keu

Consumi:
- Metabolismo: 48 keu

Preprototipi
- BLT: Meccanica per intero tray: 22.5 keu
- DT: preproduzione splitter boards (PCB + componenti): 15keu
- DT: preprod testboards FMC x QC setups ((PCB + componenti)): 12keu
- Tracker: Nessuna nuova richiesta (ci sono 11.8 Keuro di CORE ma sono già stati approvati per il 2020 e sono solo spostati al 2021)

Richieste in Sezione

SPE		Mesi Uomo
DT	Supporto attivita' Mini Crates	2
	Studio ageing a LNL	2
	Manutenzione sistema test DT LNL	1
	Riparazione e test schede CMS	1
	Manutenzione camere al CERN	3
	Sector Test Fase 2	3
	Studio aging G++	2
	Sviluppo OBDT	15
Tracker	-	0
BTL	Setup readout cold box	1
TOTALE		**30**

Officina Meccanica		Mesi Uomo
BTL	Cold plate	3
TOTALE		**3**

Officina Elettronica		Mesi Uomo
BTL	Setup readout cold box	1
TOTALE		**1**

Ufficio tecnico		Mesi Uomo
BTL	Cold plate	3
TOTALE		**3**

Calcolo		Mesi Uomo
	Supporto cluster locale, cloud, CMS center	3
	Supporto produzione locale dati	3
	Connessione, operazione, mantenimento TIER2 PD-LNL	18
TOTALE		**24**

Richieste & Percentuali

- **Percentuali (4.0+0.3FTE)**
  - A. Bertolin 70%
  - G. Collazuol 0% (+10% TIMESPOT)
  - D.Lucchesi 70%
  - M. Morandin 70%
  - L. Sestini 70%
  - G.Simi 50%(+20% TIMESPOT)
  - D. Zuliani 70%
- Richieste **finanziarie**
  - Missioni, consumo secondo le formule standard
- **Tecnologi (0.6FTE)**
  - Benettoni 20%
  - Gianelle 40%

- Richieste di **Spazi**
  - **Stanza piccola nel laboratorio gr1** al primo piano per test PMT eventualmente sostituiti da Hamamatsu
- **Service tasks e responsabilita`**
  - Convener di Higgs & Exotica Working sub-Group (L. Sestini).
  - Convener di Exotic Higgs Decays Group al CERN (L. Sestini).
  - Convener del jet reconstruction sub-group di
  - QEE (L. Sestini).
  - Convenor of the innovative analysis techniques package in the Data Analysis Project (D.Lucchesi)
  - Convener sub-group B2OpenCharm Time Dependent (A. Bertolin)
  - Responsible for Rich threshold calibration (G. Simi)
  - Responsibility for RICH2 mechanics and cooling (M. Benettoni)
  - Responsability for PMT characterization (G. Simi)

responsabilità

	2020	2021
Stefano Lacaprara	Contact person Fisica PD Data Processing Manager Convener Physics Group TDCP	Contact person Fisica PD Production Manager Convener Physics Group TDCPV
Mario Posocco	Membro commissione pari opportunità	Membro commissione pari opportunità
Roberto Stroili	PI Contact person computing PD	PI Contact person computing PD
Ezio Torassa	Membro Executive Board	Membro Executive Board
Alessandro Gaz		Physics Coordinator

anagrafica

2020		2021	
Stefano Lacaprara	90 %	Stefano Lacaprara	100 %
Mario Posocco	0 %	Mario Posocco	0 %
Paolo Sartori	0 %	Paolo Sartori	0 %
Franco Simonetto	30 %	Franco Simonetto	10 %
Roberto Stroili	100 %	Roberto Stroili	80 %
Ezio Torassa	85 %	Ezio Torassa	95 %
Agnese Giaz	100 %	Agnese Giaz	100 %
		Alessandro Gaz	100 %
totale ricercatori (FTE)	**4.05**		**4.85**
Flavio Dal Corso	20 %	Flavio Dal Corso	20 %
Fabio Montecassiano	20 %	Fabio Montecassiano	20 %
		Massimo Benettoni	10%
totale (FTE)	**4.45**		**5.35**

richieste 2020

richieste alla sezione	
Servizio progettazione ed officina Elettronica	2+1 m. u.
Servizio officina Meccanica	1 m. u.
Servizio progettazione Meccanica (simulazione termica TOP)	3 m. u.
Servizio calcolo	0 m. u.

richieste all'INFN

sede	capitolo	descrizione	richiesta (k€)	S. J. (k€)
PD	consumo	Metabolismo (1.5 k€ * FTE)	8.0	0
PD	missioni	Metabolismo [(6.0 k€ + 1.0 k€) * FTE]	38.0	0
PD	missioni	Membro Excutive Board	5.0	0
PD	missioni	Data Processing Manager	0.0	0
PD	missioni	Physics Coordinator	5.0	0
PD	missioni	Test PMT in campo magnetico	5.0	0
PD	missioni	Coordinatore gruppo TDCPV	5.0	0
PD	inventariabile	Digitizer spare per KEK	6.0	0

- Missioni per turni centrali fase 3: fondi presso sede del coordinatore nazionale Belle II
- Missioni per turni di componente: fondi presso sede del responsabile nazionale TOP

Anagrafica Padova

	% FTE	
M. Benettoni	10	
E. Conti	70	
Anusree Ghosh	70	assegnista
Whali Hussain	100	dottorando
P. Mastrolia	10	
M. Passera	10	
P. Ronchese	20	
F. Simonetto	20	
R. Stroili	20	
TOT	**3.3 FTE**	

Richieste finanziarie e servizi sezione

- Consumo: 15kEu (?)
  - per meccanica modulo calorimetro e controllo temperatura
- Missioni: da definire
  -
- Richieste servizi di sezione:
  - Uff. tecnico: 2 mu
  - Off. meccanica: 3 mu
  - Off. elettronica: 1 mu

Attività e richieste a Padova

1) Sviluppo e mantenimento del codice per MDI, simulazione del rivelatore e ricostruzione degli eventi (Gianelle e Andreetto)

2) Contributo per le machine e disco a VenetoCloud: 5k€

3) R&D rivelatori: 10 k€

4) Test beam per LEMMA $e^+e^- \rightarrow \mu^+\mu^-$:
   - Sviluppo readout delle camere:
     - 10k€ e supporto officina elettronica (Bellato)
   - Sviluppo DAQ camera:
     - 10k€ e supporto di S. Ventura
   - Sviluppo dei supporti meccanici camere, officina meccanica

5) Missioni da calcolare a tabella

Nome Cogome	**Percentuale**
Paolo Andreetto	25
Alessandro Bertolin	30
Camilla Curatolo	100
Giamnaria Collazuol	10
Tommaso Dorigo	20
Umberto Dosselli	20
Franco Gonella	10
Alessio Gianelle	40
Donatella Lucchesi	25
Mauro Morandin	tbd
Jacopo Pazzini	25
Lorenzo Sestini	30
Marco Zanetti	tdb
Alberto Zucchetta	30
Davide Zuliani	30
Totale	**395**

International MUON Collider Collaboration

BACKUP

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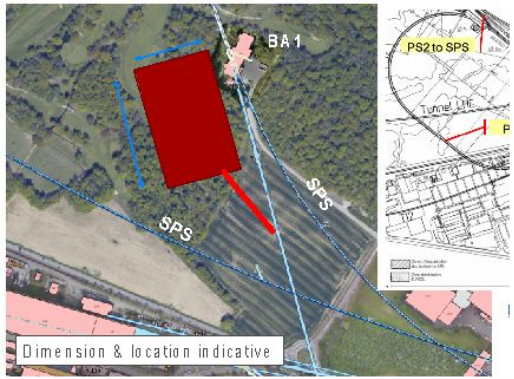

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Technically Limited Long-Term Timeline