Attività LHCb - 2015

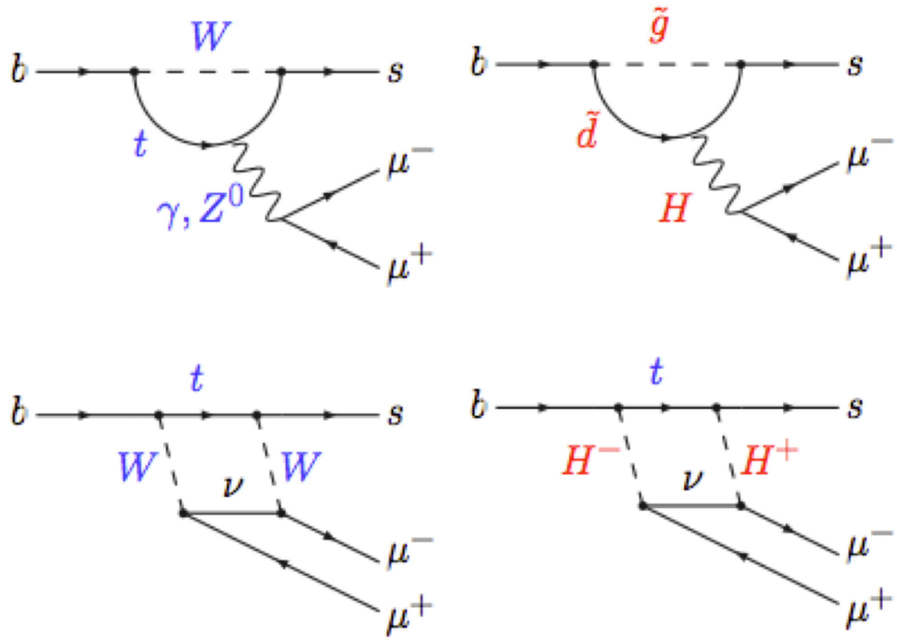
Nicola Neri
INFN - Sezione di Milano

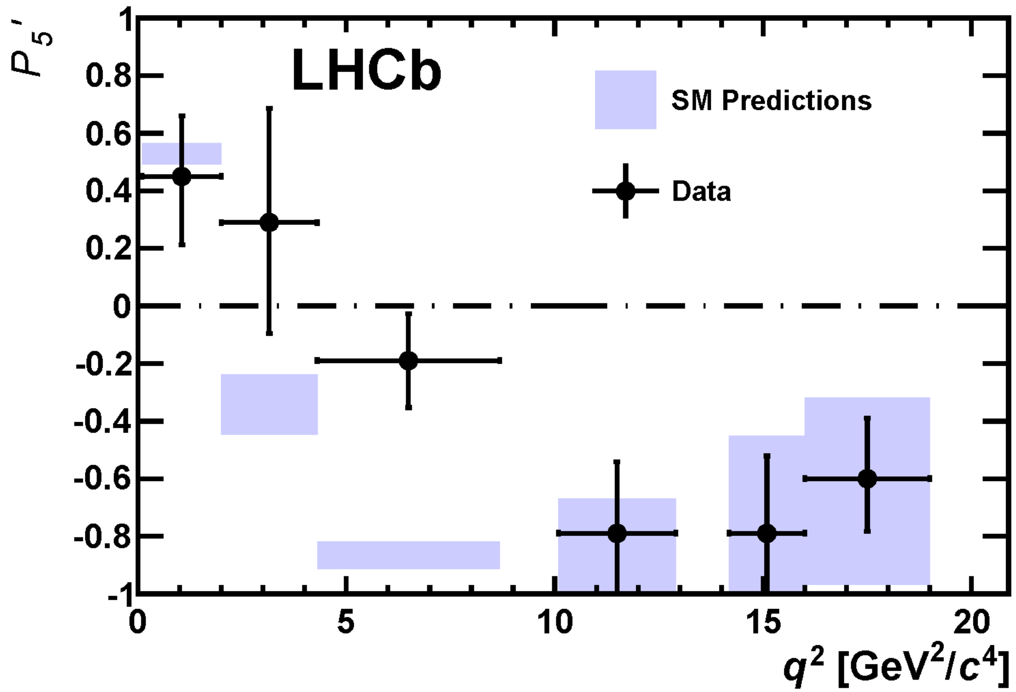
9 Luglio 2014

Physics highlights

Tension with SM in $B^0 \to K^{*0}\mu^+\mu^-$

- FCNC transition. New physics effects can modify the angular distribution of the decay products.



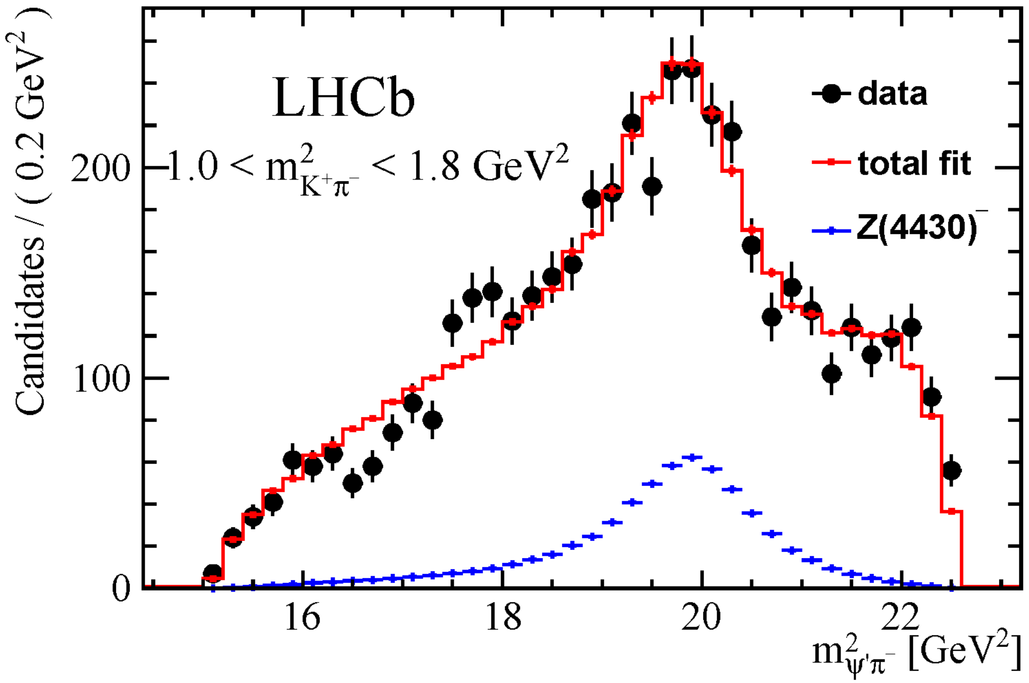


- Tension with SM at 3.7σ level in the region 4.3<q^2<8.68 GeV^2

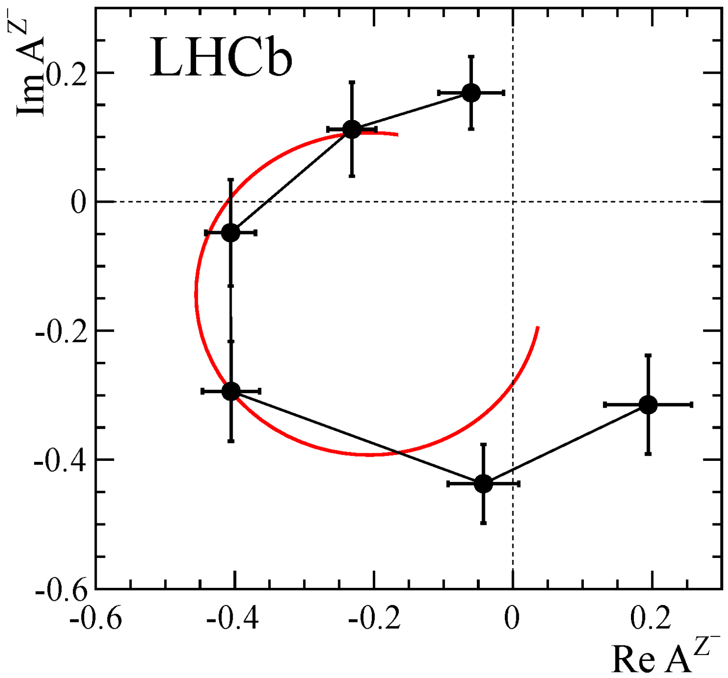
The Z(4430)$^-$ is a tetraquark state

- The resonant character of the Z(4430)$^-$ has been established for the first time
- The minimal quark content of the state is $c\bar{c}\bar{u}d$

$B^0 \to \psi' \pi^- K^+$

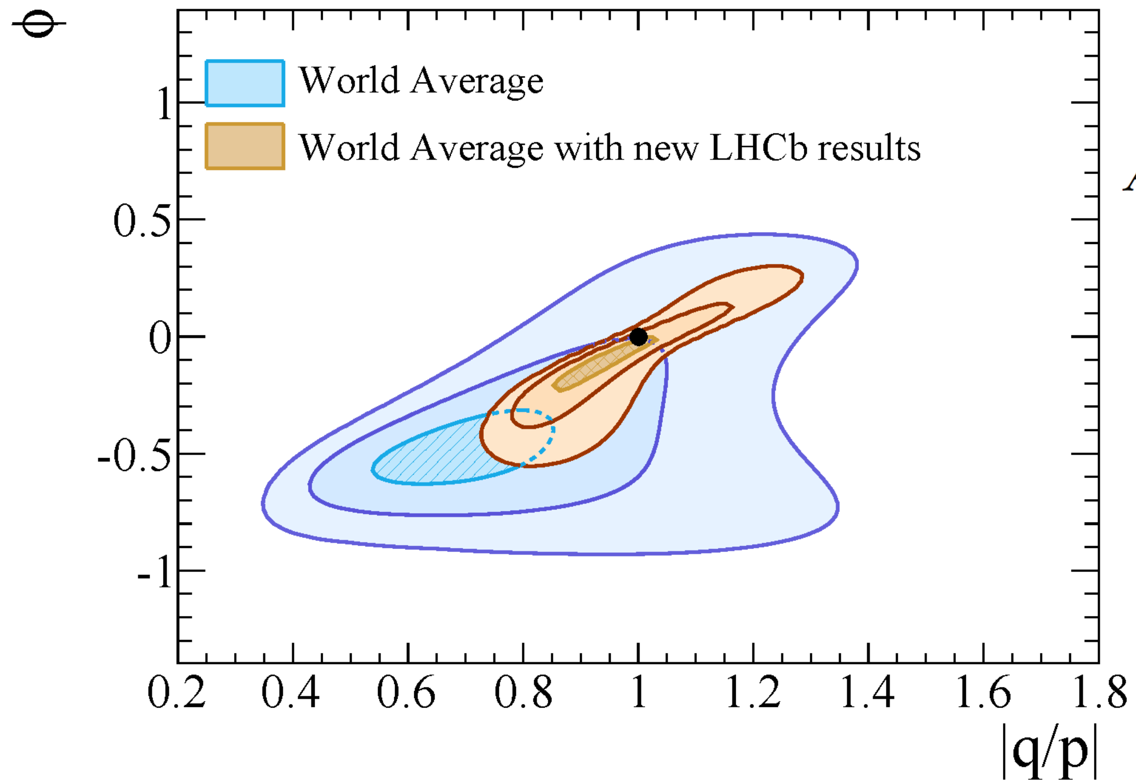


Argand diagram



CP violation in charm

- CP violation in charm is expected to be very small in the SM. Null test, sensitive to new physics effects.



Lifetime difference between D^0 and $\bar{D}^0$ events

$$A_\Gamma \equiv \frac{\hat{\Gamma} - \hat{\bar{\Gamma}}}{\hat{\Gamma} + \hat{\bar{\Gamma}}} \approx \eta_{CP} \left(\frac{A_m + A_d}{2} y \cos\phi - x \sin\phi \right)$$

$A_\Gamma(KK) = (-0.35 \pm 0.62 \pm 0.12) \times 10^{-3}$

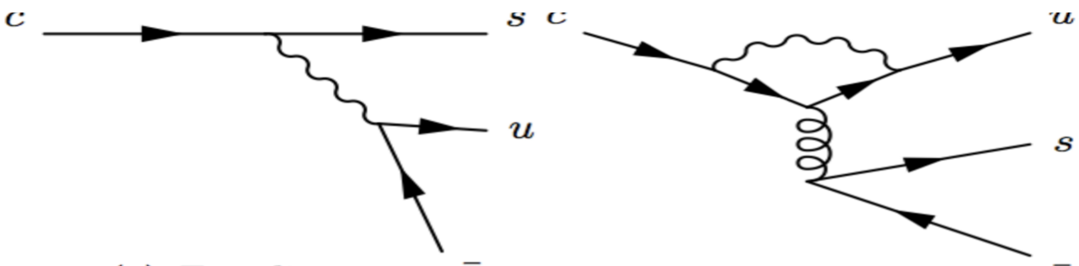
$A_\Gamma(\pi\pi) = (0.33 \pm 1.06 \pm 0.14) \times 10^{-3}$

Phys. Rev. Lett. 112, 041801 (2014)

CP violation in $D^0 \to K^+K^-\pi^+\pi^-$

J. Fu, N. Neri

The study of *CPV* in SCS charm decays: uniquely sensitive to NP, in paticular to new contribution to $\Delta C = 1$ *QCD* penguin and chromomagnetic dipole operators.



(a) *Tree diagram.* (b) *Penguin diagram.*

- Search for CPV using T-odd correlations:
  - Phase space integrated measurement
  - Measurements in different regions of the phase space
  - Measurements vs D^0 proper time

- *Analysis approved by LHCb Collaboration on July 2nd.*
- *Paper draft in circulation*
- *To be submitted to JHEP*

Interesting features of this technique

- T-odd triple products can be constructed in the $D^0(\bar{D}^0)$ rest frame:
  $C_T \equiv \vec{p}_{K^+} \cdot (\vec{p}_{\pi^+} \times \vec{p}_{\pi^-}),$
  $\bar{C}_T \equiv \vec{p}_{K^-} \cdot (\vec{p}_{\pi^-} \times \vec{p}_{\pi^+})$
- T-odd observable:
  $A_T \equiv \frac{\Gamma(C_T>0)-\Gamma(C_T<0)}{\Gamma(C_T>0)+\Gamma(C_T<0)}$, measured using D^0 *decays*;
  $\bar{A}_T \equiv \frac{\Gamma(-\bar{C}_T>0)-\Gamma(-\bar{C}_T<0)}{\Gamma(-\bar{C}_T>0)+\Gamma(-\bar{C}_T<0)}$, measured using $\bar{D}^0$ decays
- True *CP*-violating observable cancel FSI effects:
  $\mathcal{A}_T = \frac{1}{2}(A_T - \bar{A}_T)$

- Alternative approach for CP violation searches. Very low systematic errors
  - not sensitive to particle/antiparticle production asymmetries
  - not sensitive to charged particle reconstruction asymmetries
- Recently started a new analysis on $\Lambda_b \to p h^+ h^- h^-$ where h=Kaon, pion

J. Fu, A. Merli (laureando), N. Neri

LHCb upgrade

Future plans

2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020 2021 2022 2023 2024 2025 2026

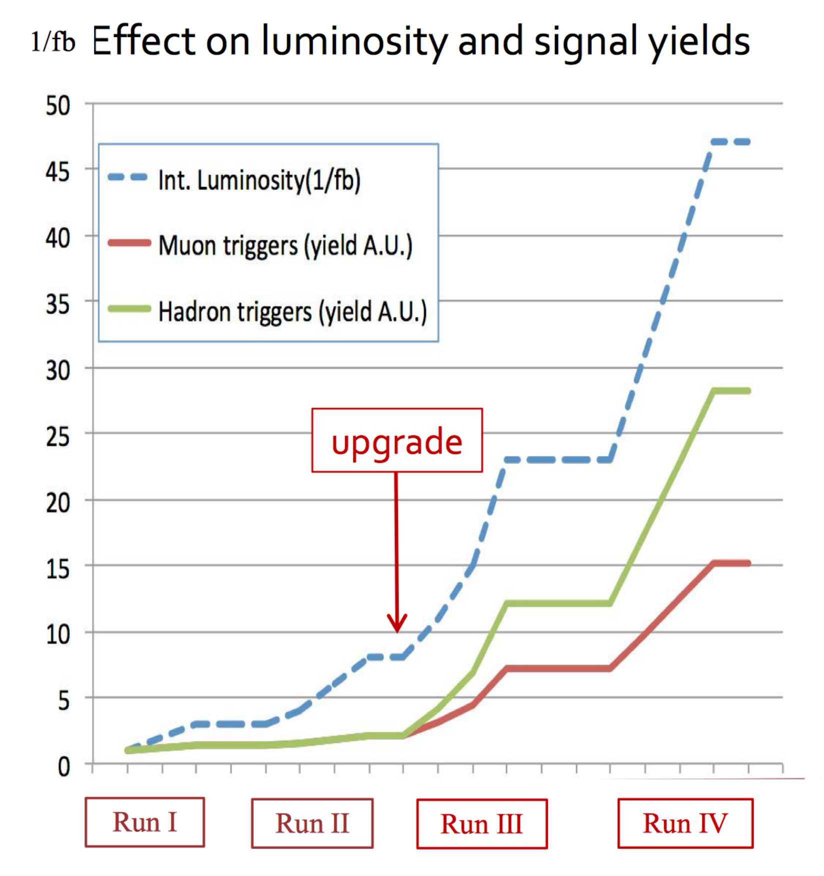
LHC Run I	LS1	LHC Run II	LS 2	LHC Run III	LS3	LHC Run IV
pp runs with - 50ns bunch spacing - E_{CM} 7TeV and 8 TeV LHCb $\mathcal{L}$~4x10³²/cm²/s LHCb $\int\mathcal{L}$ ~3/fb	LHC splice consoli-dation	pp runs with - 25ns bunch spacing, - E_{CM} 13 TeV LHCb $\mathcal{L}$>4x10³²/cm²/s LHCb $\int\mathcal{L}$ >5/fb	LIU prep. LHCb upgrade	pp runs with - 25ns b.spacing - E_{CM} 14 TeV $\mathcal{L}$ > 1x10³³/cm²/s LHCb $\int\mathcal{L}$ > 15/fb	HL-LHC prep GPD phase 2 upgrades	$\mathcal{L}$=2x10³³/cm²/s $\int\mathcal{L}$ > 23/fb

LHCb up to 2018 → ~ 8 fb⁻¹:

- find or rule-out large sources of flavour symmetry breaking at the TeV scale

LHCb upgrade → ≥ 50 fb⁻¹:

- increase precision on quark flavour physics observables
- aim at experimental sensitivities comparable to theoretical uncertainties



Sensitivities to key observables

Table 16: Statistical sensitivities of the LHCb upgrade to key observables. For each observable the current sensitivity is compared to that which will be achieved by LHCb before the upgrade, and that which will be achieved with 50 fb^{-1} by the upgraded experiment. Systematic uncertainties are expected to be non-negligible for the most precisely measured quantities. Note that the current sensitivities do not include new results presented at ICHEP 2012 or CKM2012.

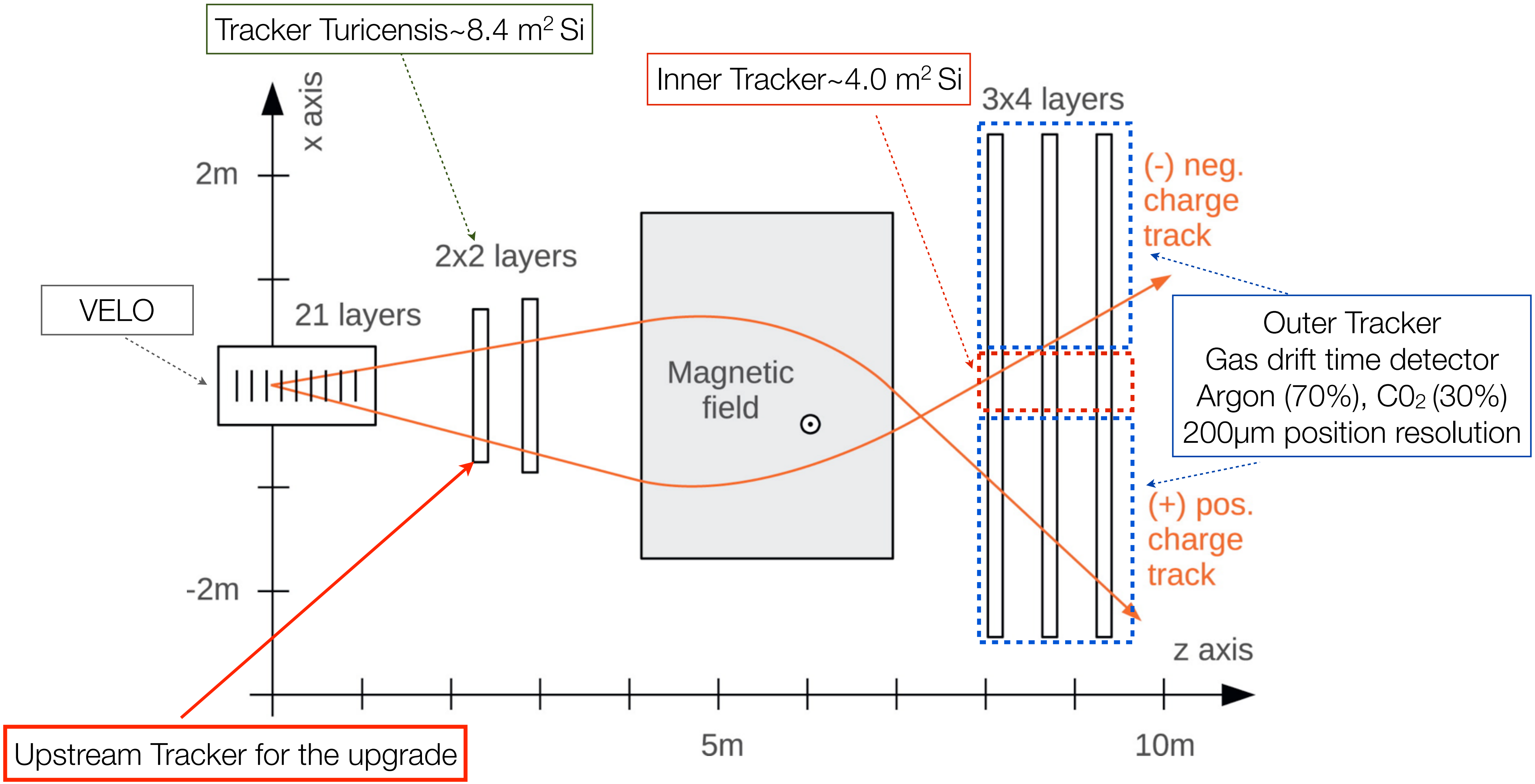
Type	Observable	Current precision	LHCb 2018	**Upgrade** (50 fb^{-1})	Theory uncertainty
B_s^0 mixing	$2\beta_s$ ($B_s^0 \to J/\psi\ \phi$)	0.10 [138]	0.025	0.008	~ 0.003
	$2\beta_s$ ($B_s^0 \to J/\psi\ f_0(980)$)	0.17 [214]	0.045	0.014	~ 0.01
	$a_{\rm sl}^s$	6.4×10^{-3} [43]	0.6×10^{-3}	0.2×10^{-3}	0.03×10^{-3}
Gluonic penguins	$2\beta_s^{\rm eff}(B_s^0 \to \phi\phi)$	–	0.17	0.03	0.02
	$2\beta_s^{\rm eff}(B_s^0 \to K^{*0}\bar{K}^{*0})$	–	0.13	0.02	< 0.02
	$2\beta^{\rm eff}(B^0 \to \phi K_S^0)$	0.17 [43]	0.30	0.05	0.02
Right-handed currents	$2\beta_s^{\rm eff}(B_s^0 \to \phi\gamma)$	–	0.09	0.02	< 0.01
	$\tau^{\rm eff}(B_s^0 \to \phi\gamma)/\tau_{B_s^0}$	–	5 %	1 %	0.2 %
Electroweak penguins	$S_3(B^0 \to K^{*0}\mu^+\mu^-; 1 < q^2 < 6\,{\rm GeV}^2/c^4)$	0.08 [67]	0.025	0.008	0.02
	$s_0\ A_{\rm FB}(B^0 \to K^{*0}\mu^+\mu^-)$	25 % [67]	6 %	2 %	7 %
	$A_{\rm I}(K\mu^+\mu^-; 1 < q^2 < 6\,{\rm GeV}^2/c^4)$	0.25 [76]	0.08	0.025	~ 0.02
	$\mathcal{B}(B^+ \to \pi^+\mu^+\mu^-)/\mathcal{B}(B^+ \to K^+\mu^+\mu^-)$	25 % [85]	8 %	2.5 %	$\sim 10\,\%$
Higgs penguins	$\mathcal{B}(B_s^0 \to \mu^+\mu^-)$	1.5×10^{-9} [13]	0.5×10^{-9}	0.15×10^{-9}	0.3×10^{-9}
	$\mathcal{B}(B^0 \to \mu^+\mu^-)/\mathcal{B}(B_s^0 \to \mu^+\mu^-)$	–	$\sim 100\,\%$	$\sim 35\,\%$	$\sim 5\,\%$
Unitarity triangle angles	γ ($B \to D^{(*)}K^{(*)}$)	~ 10–12° [244, 258]	4°	0.9°	negligible
	γ ($B_s^0 \to D_s K$)	–	11°	2.0°	negligible
	β ($B^0 \to J/\psi\ K_S^0$)	0.8° [43]	0.6°	0.2°	negligible
Charm CP violation	A_Γ	2.3×10^{-3} [43]	0.40×10^{-3}	0.07×10^{-3}	–
	$\Delta\mathcal{A}_{CP}$	2.1×10^{-3} [18]	0.65×10^{-3}	0.12×10^{-3}	–

INFN Milano activities

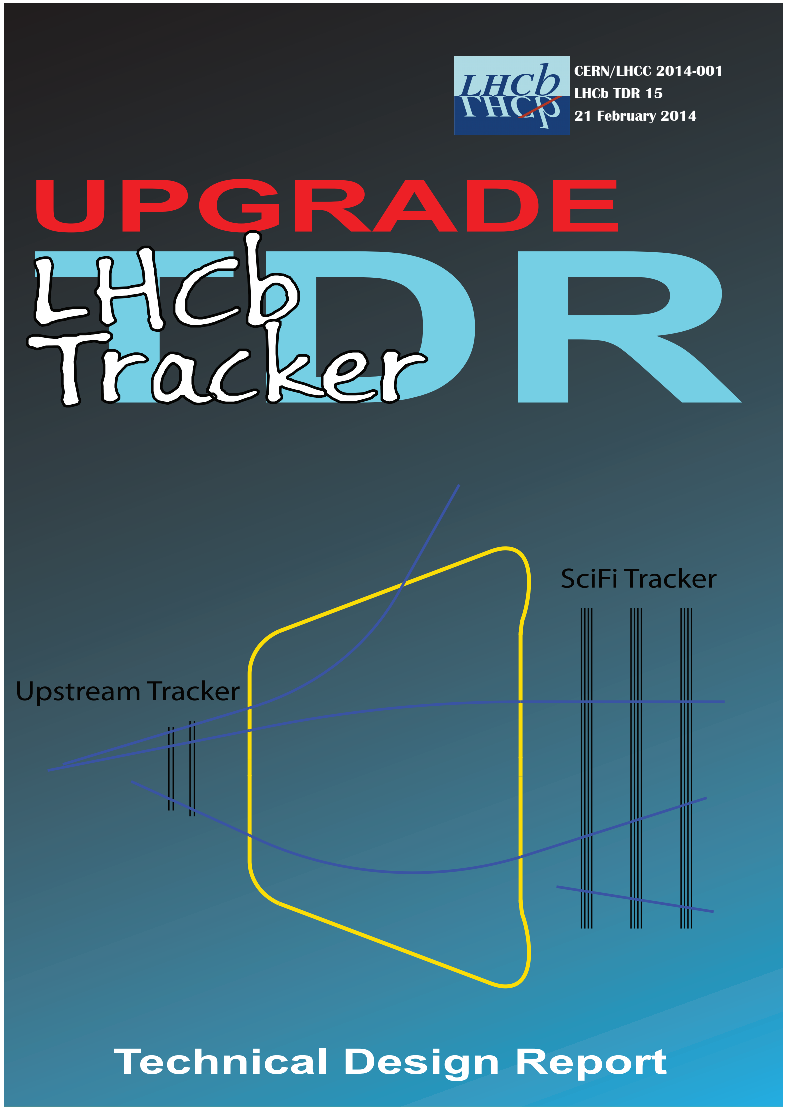
- Activities for Upstream Tracker upgrade
  - Design and construction of flex cables and hybrid circuits for front-end electronics
  - Design and prototyping of the CO_2 cooling system
  - Thermal and mechanical simulations of the UT stave
  - Test and characterisation of prototype silicon strip sensors
  - Test beam: developed software for reconstruction and analysis of the data.

LHCb spectrometer

Silicon Tracker: 500μm thick, single sided Si strip detector, pitch~200μm, vertical and stereo angle strips arrangement (x-u-v-x)=(0°,-5°,+5°,0°)



LHCb Tracker TDR



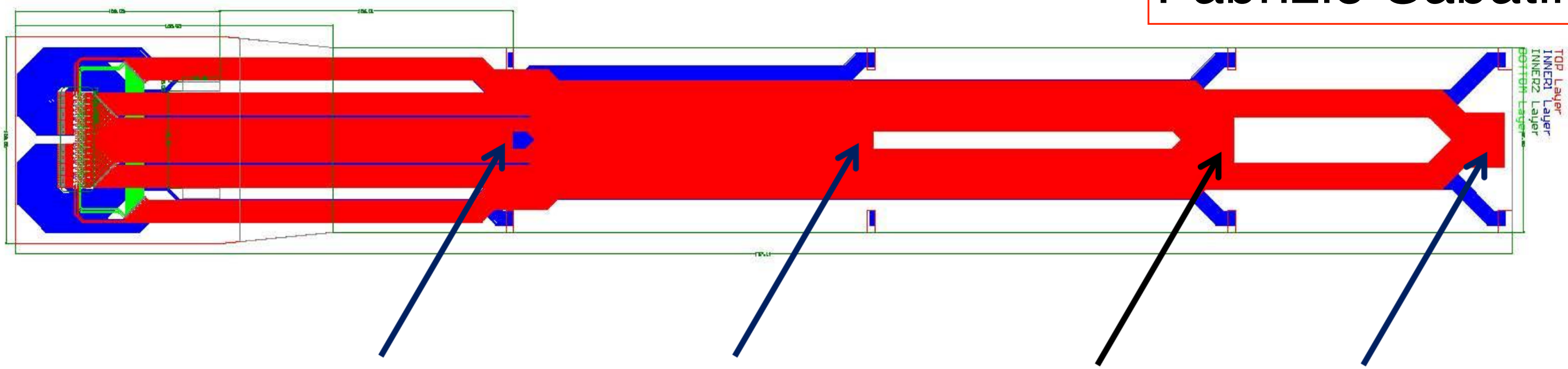
- Authors of Tracker TDR

A. Abba[u], F. Caponio[u], M. Citterio, S. Coelli, A. Cusimano[u], J. Fu, A. Geraci[u], M. Lazzaroni[t], M. Monti, N. Neri, F. Palombo[t]
[25] *Sezione INFN di Milano, Milano, Italy*

- Responsibilities for UT upgrade
  - Sensor and Hybrids WG (M. Citterio co-convener)
  - Mechanics and Cooling WG (N. Neri —> S. Coelli co-convener)
  - Editor of Tracking TDR (N. Neri "Mechanics and cooling" chapter)

Design of the flex cables

Mauro Citterio
Fabrizio Sabatini

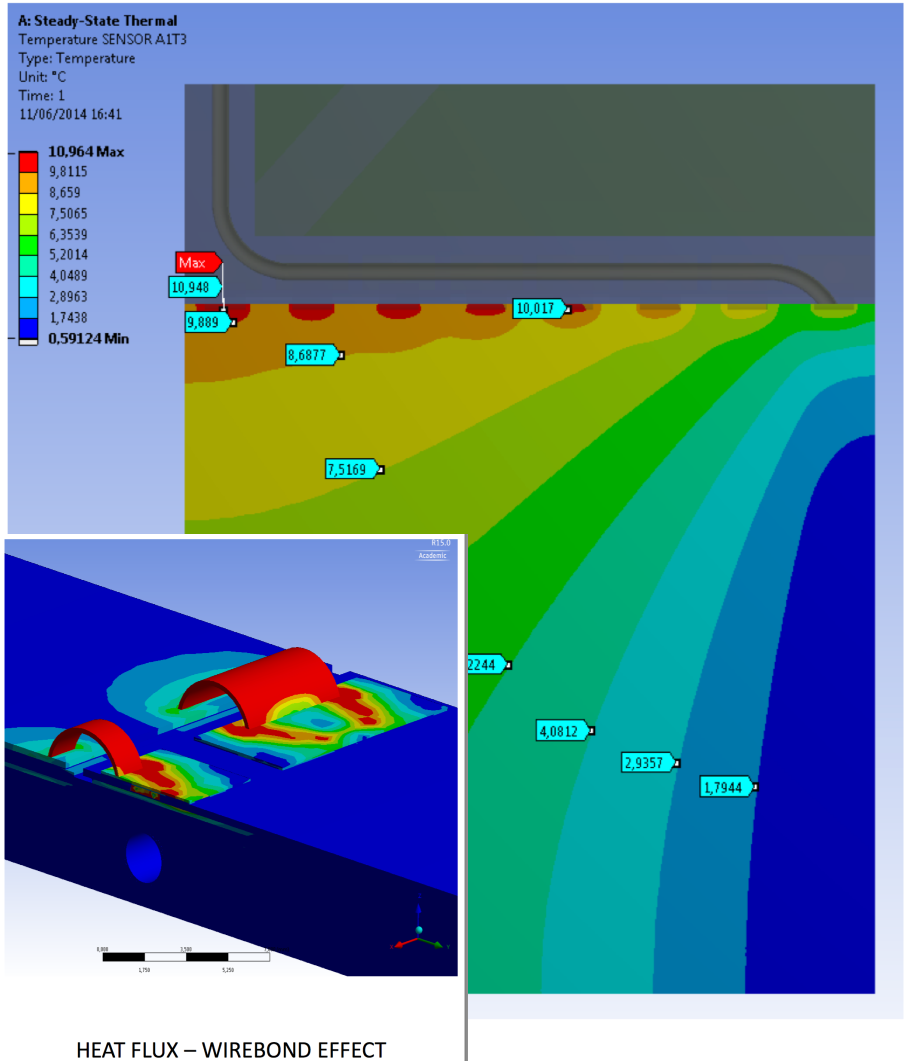


Traces are terminated with bonding pads (96+80+32+32), where hybrids will be mounted

- Cable for data and power lines, 80 cm long: Kapton + Cu (Al) traces.
- Low impedance, long traces, signal integrity: technological challenge
- First prototypes in the fall, ready for testing

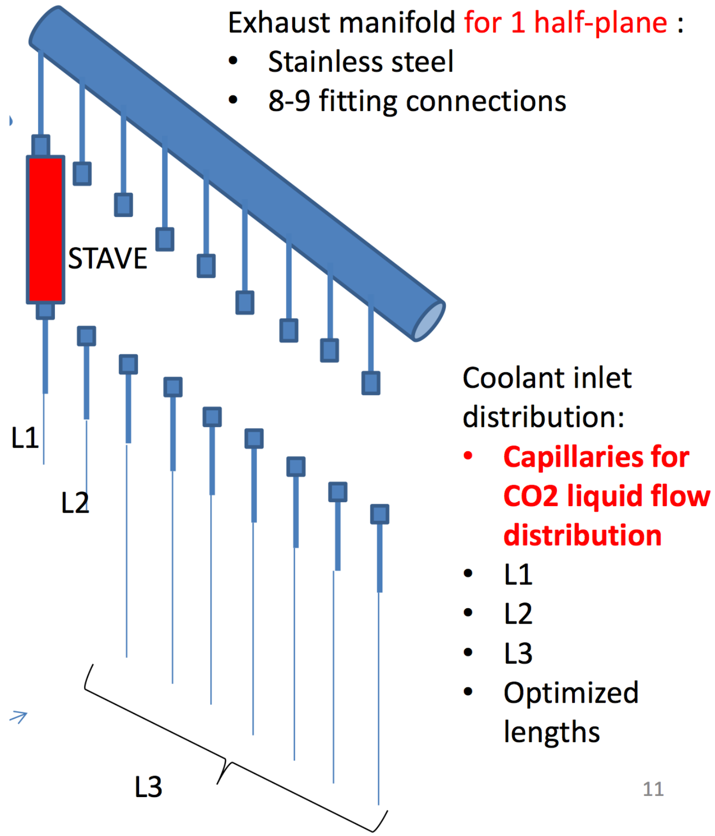
Design of the CO_2 cooling system

Simone Coelli
Mauro Monti



HEAT FLUX – WIREBOND EFFECT

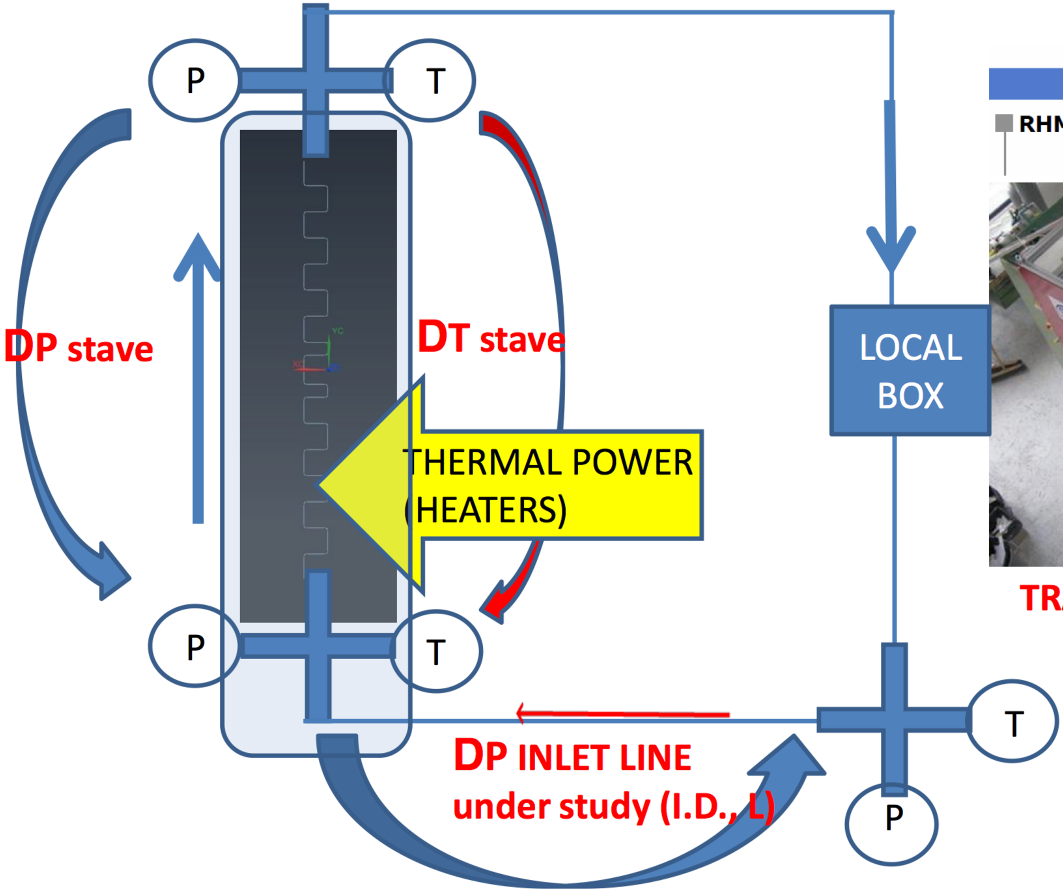
- Thermal and mechanical simulations of the CO_2 cooling system and the stave
- Crucial contribution for the design and the optimisation of the entire system



$C0_2$ cooling system prototype

- Test setup in Milano based on Traci system (September/October).
- Request for room/laboratory for Traci

Simone Coelli
Carlo Gesmundo, Mauro Monti



MASS FLOWMETER

TRACI COOLING SYSTEM

⇒ Measurements with capillary:
⇒ from 0 to L max

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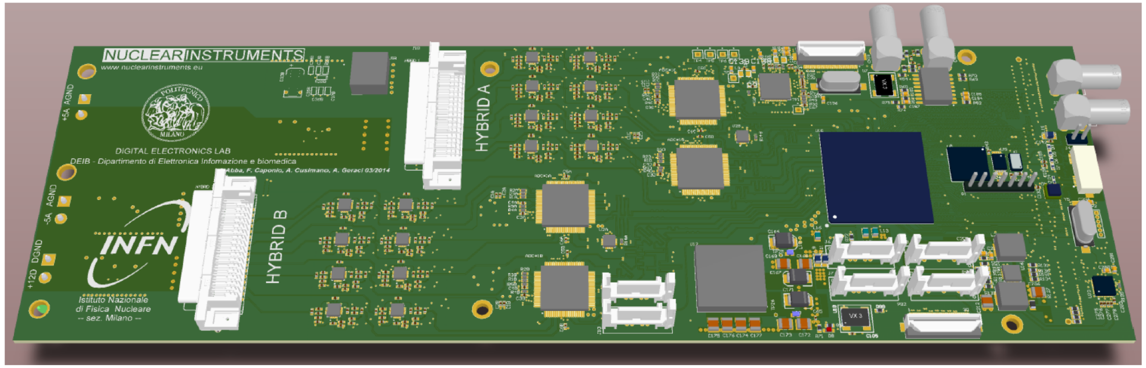
Prototype sensor testing

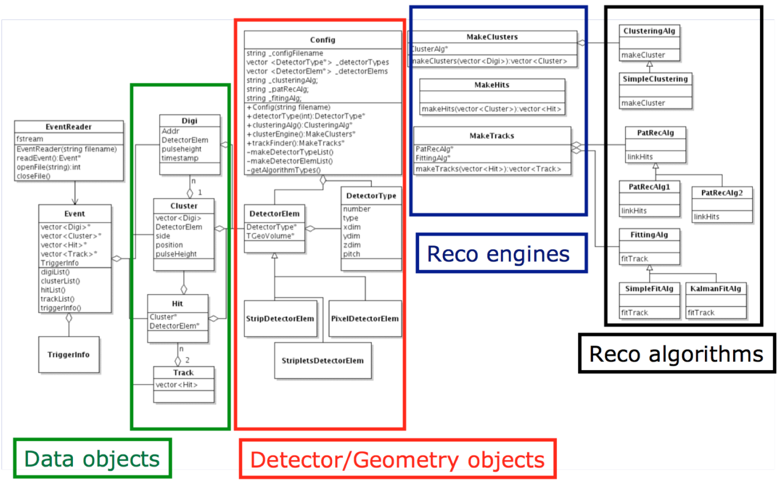
- Designed a DAQ board for detector under test. Signal digitalisation and zero suppression (Beetle chip Asic)

Angelo Geraci
Andrea Abba, Francesco Caponio

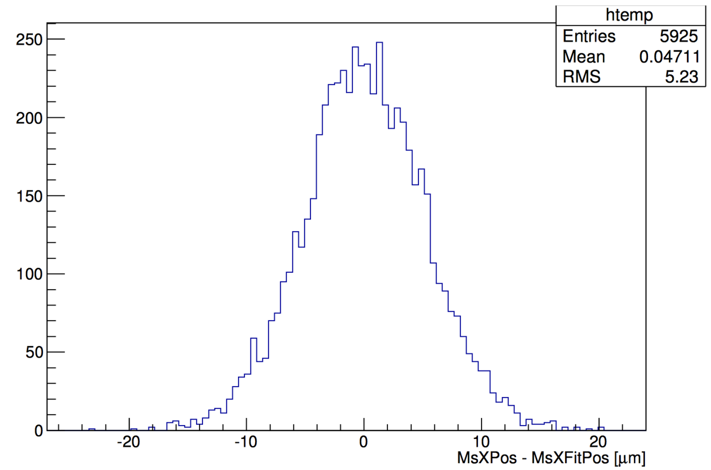


- Developed a software package (Sbt) for track reconstruction and data analysis of testbeam data

Nicola Neri
Marco Petruzzo (laureando)



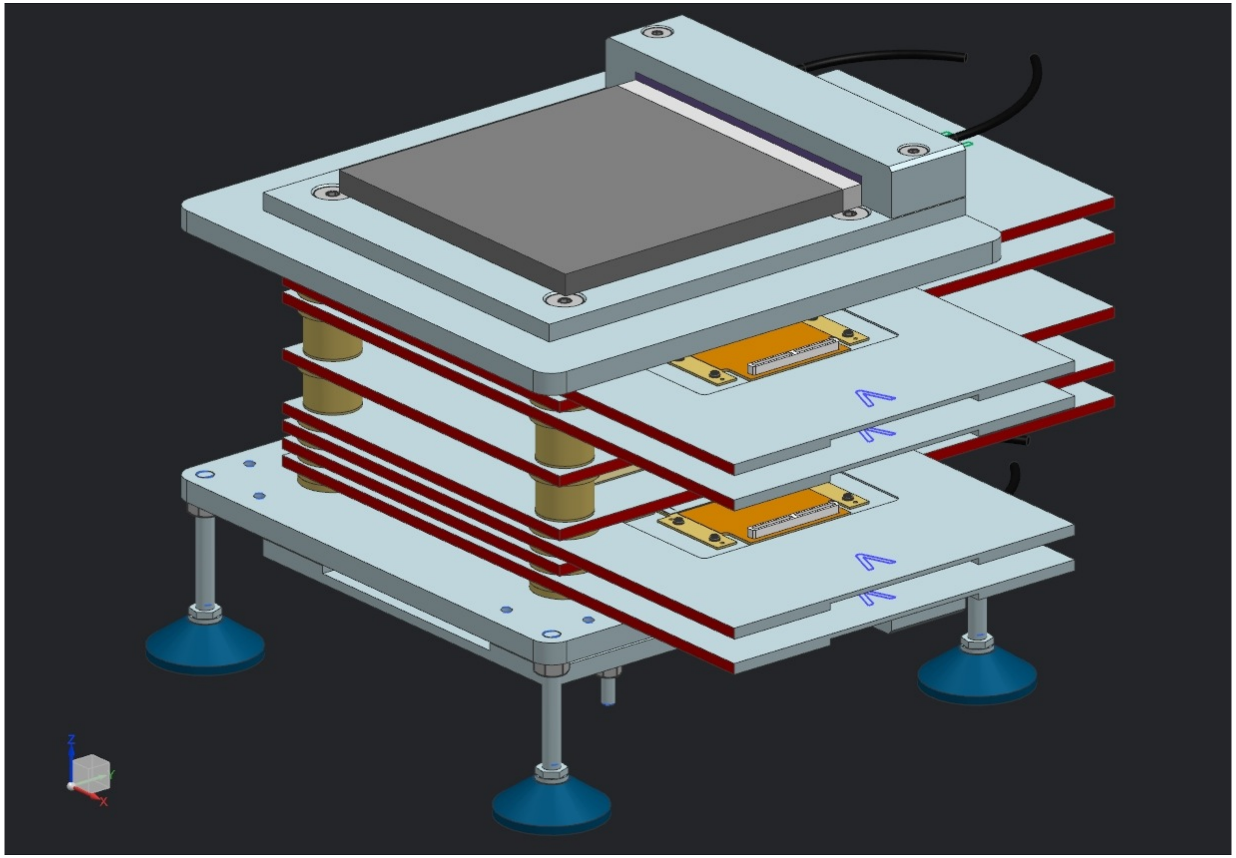
Residual on DUT



Telescope for sensor testing

Simone Coelli (Mechanics)
Mauro Monti

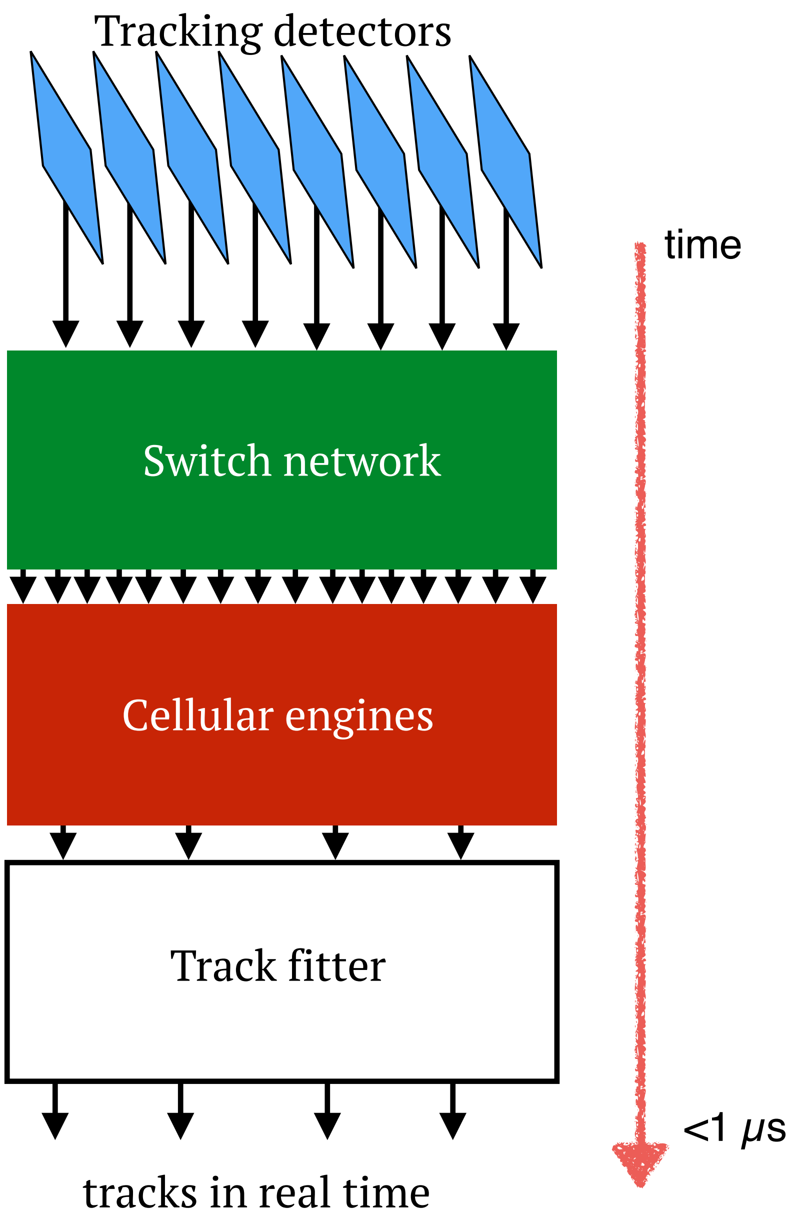
Nicola Neri (System design, simulations)
Marco Petruzzo (laureando)



- Telescope for cosmic rays based on single-sided silicon strip detectors
- 100 cm^2 active area
- Expected rate from muons ~1 Hz
- Test prototype sensors in Milano, e.g. efficiency, hit resolution, S/N.
- Prototype for "artificial retina" for fast track finding. New activity in CSN5

Angelo Geraci (DAQ)
Andrea Abba, Francesco Caponio

Artificial retina for fast track finding



- The *"artificial retina"* algorithm for fast track finding was originally proposed by *Luciano Ristori* in *NIM A 453 (2000) 425-429.* It takes inspiration from neurobiology and applies to positions sensitive detectors (*e.g.* pixel, strip detectors).
- The algorithm allows massive parallelisation of the calculations for pattern recognition and track parameter determination
- The tracking performance are comparable with offline results with a latency of the response < 1μs.
- Capable to operate 40 MHz, LHC bunch crossing rate, and take L0 trigger decisions
- R&D for LHCb upgrade. Now proposed R&D experiment in CSN5

Contributions at conferences

- N. Neri, “The silicon upstream tracker for the LHCb upgrade”, Vertex 2013, Berg, Germany (September 2013)
- A. Abba, “The Readout Architecture for the Retina-Based Cosmic Ray Telescope”, RT2014, Nara, Japan (May 2014)
- F. Caponio, “A Retina-Based Cosmic Ray Telescope”, RT2014, Nara, Japan (May 2014)
- N. Neri, “First prototype of a tracking system with artificial retina”, TIPP2014, Amsterdam, The Netherlands (June 2014)
- J. Fu, “Search for CP and T violation in multibody D decays”, Beauty, Edinburgh, UK (July 2014)
- N. Neri, “First Prototype of a Tracking System with Artificial Retina for Fast Track Finding”, IEEE Nuclear Science Symposium, Seattle, USA (November 2014) (accepted contribution)

Group composition

- The research group is composed of individuals affiliated to INFN - Sezione di Milano, Università di Milano and Politecnico di Milano.

  - participation in LHCb in 2014: 10 people - 7.4 FTE + 2 master students

  - participation in LHCb in 2015: 10 people - 6.45 FTE

People	Position	LHCb 2014	LHCb 2015	CSN5 2015	BaBar 2015
B. Dey	INFN PostDoc	0	0,75	0,0	
J. Fu	INFN PostDoc	1	0,8	0,2	
N. Neri	PhD Staff	0,9	0,7	0,2	0,1
F. Palombo	Faculty	0,9	0,9	0	0,1
A. Abba	Engineer PostDoc	1	0,7	0,3	
F. Caponio	Engineer PhD student	1	0,7	0,3	
M. Citterio	Applied Physicist Staff	0,3	0,4	0	
S. Coelli	Mechanical Engineer Staff	0,3	0,4	0	
A. Cusimano	Engineer Post Doc	1	0	0	
A. Geraci	Electronic Engineer Staff	0,7	0,8	0,2	
M. Lazzaroni	Electronic Engineer Staff	0,3	0,3	0	
FTE		7,4	6,45	1,2	0,2

Richieste per servizi in Sezione

- Servizio officina meccanica e progettazione: 30 mesi uomo
- Servizio elettronica: 30 mesi uomo
- Stanza pulita per test sensori
- Laboratorio per sistema Traci (CO_2 cooling) da individuare. Setup del sistema a Settembre/Ottobre

Backup

Richieste 2015 - Milano

Anagrafica

People	Position	LHCb 2014	LHCb 2015
B. Dey	INFN PostDoc	0	0,75
J. Fu	INFN PostDoc	1	0,8
N. Neri	PhD Staff	0,9	0,7
F. Palombo	Faculty	0,9	0,9
A. Abba	Engineer PostDoc	1	0,7
F. Caponio	Engineer PhD student	1	0,7
M. Citterio	Applied Physicist Staff	0,3	0,4
S. Coelli	Mechanical Engineer Staff	0,3	0,4
A. Cusimano	Engineer Post Doc	1	0
A. Geraci	Electronic Engineer Staff	0,7	0,8
M. Lazzaroni	Electronic Engineer Staff	0,3	0,3
FTE		7,4	6,45

- Missioni:
  - MI: 6.5 kEuro
  - ME: 102.0 kEuro (m.u.: serv. 10, resp. 6.0, met. 10, testbeam 1.5)
- Consumo:
  - Metabolismo 10 kEuro
- Upgrade UT:
  - prototipi ibridi FEE 30 kEuro
  - prototipi $C0_2$ cooling 30 kEuro
- MOF Silicon Tracker
  - 5 kEuro

Sito preventivi 2015

MISSIONI	1. Interne (6.45 FTE)	6.50	
	2. Estere - servizi (10 m.u.)	37.00	
	3. Estere - metabolismo (10 m.u.)	37.00	
	4. Estere - Resposabilita': S. Coelli (UT mechanical & cooling WG co- convener), M. Citterio (UT sensor and hybrid WG co-convener), B. Dey (Silicon Tracker run coordinator): 6 m.u.	22.00	
	5. Estere - testbeam (1.5 m.u.)	6.00	108.50
CONSUMO	1. Metabolismo (6.45 FTE)	10.00	
	2. Prototipi circuiti ibridi per elettronica di front-end per upgrade UT	30.00	40.00
APPARATI	1. Prototipo di sistema di cooling a CO_2 per UT upgrade	30.00	30.00
SPSERVIZI	1. MOF Silicon Tracker	5.00	5.00

Collected data sample 2011-2012

- Integrated luminosity ~3.2 fb^{-1}
- Number of events within detector acceptance
  - $c\bar{c}$ 59×10^{11}
  - $b\bar{b}$ 26×10^{10}