Consultivi scientifici attività di gruppo 1

Sezione di Pavia: 2015-2016

Andrea.Negri@unipv.it

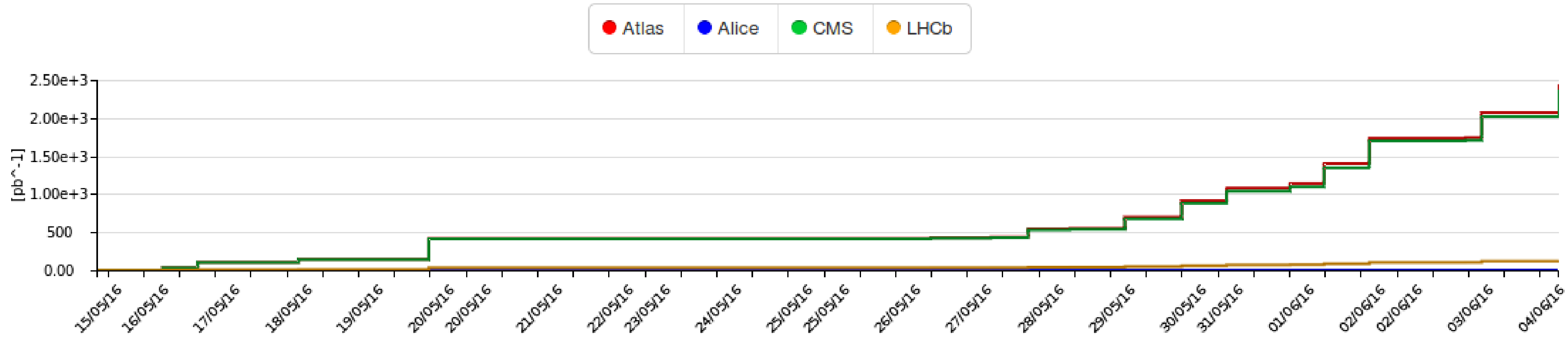
Attività pavesi

- Frontiera dell'energia
  - **ATLAS** [Responsabile Locale: G. Gaudio]
  - **CMS** [Responsabile Locale: P. Salvini]
  - **Fase 2** [Responsabile Locale: C. Riccardi]
- Frontiera della precisione:
  - **MEG** [Responsabile Locale: P. Cattaneo]

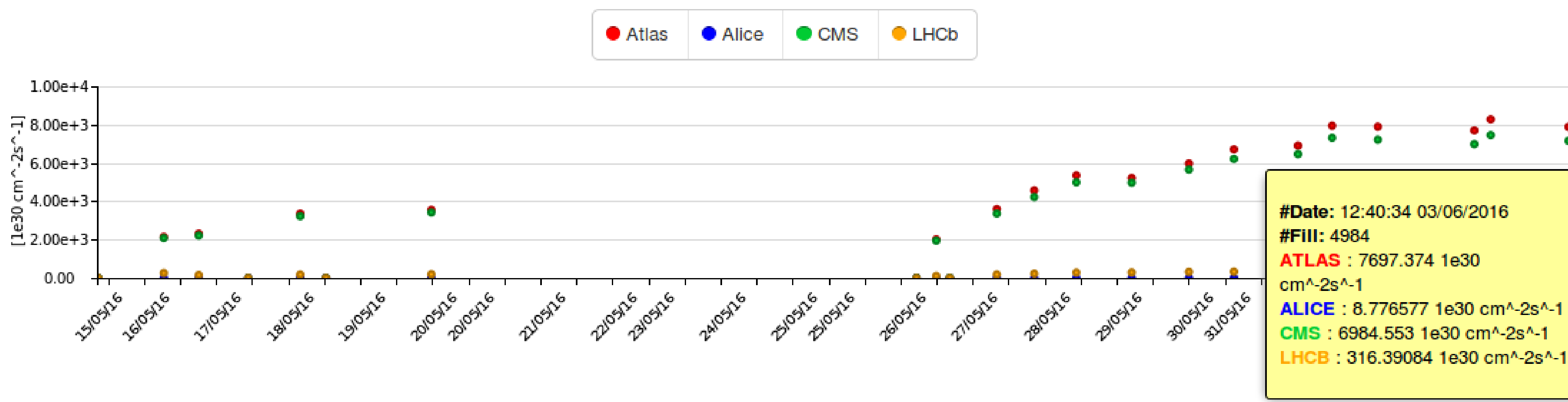
LHC a pieno regime

ATLAS: 2.45 fb^{-1} **ALICE**: 1.53 pb^{-1} **CMS**: 2.37 fb^{-1} **LHCb**: 137.98 pb^{-1}

Integrated Luminosity Evolution Export to CSV Download Undo Zoom Hide

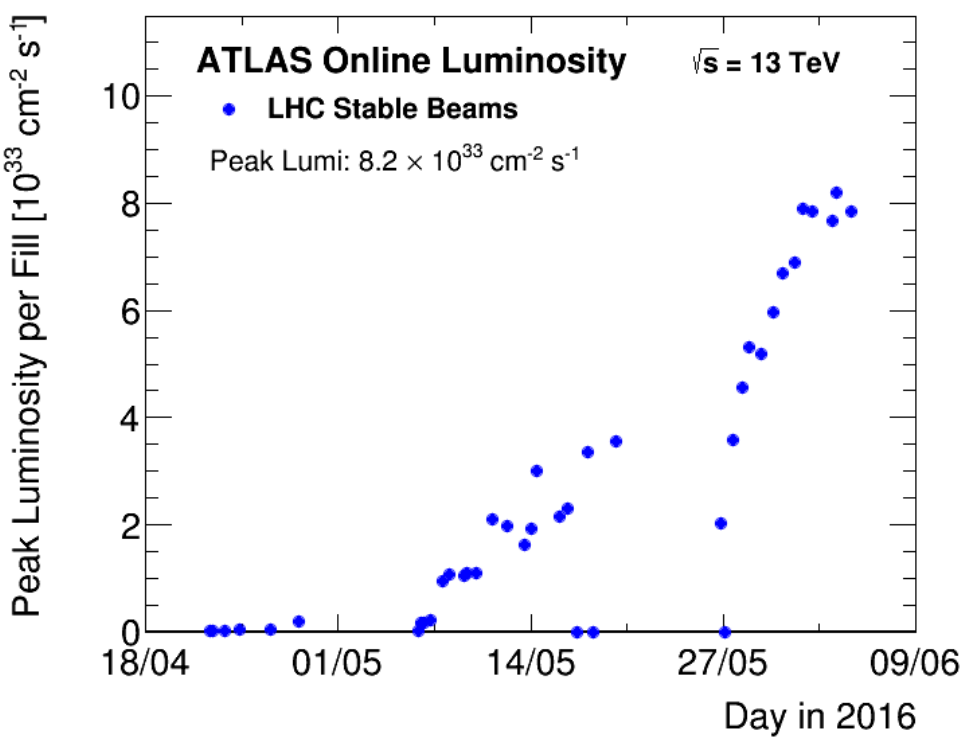


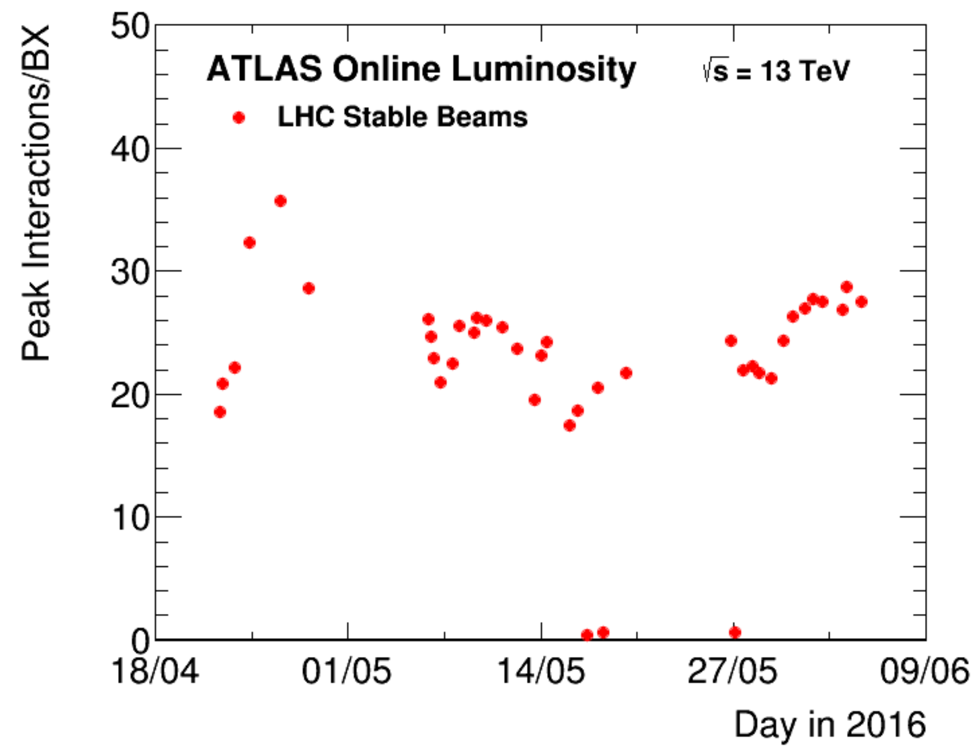
Performance Evolution (Peak Luminosity) Export to CSV Download Undo Zoom Hide



Stato LHC

- Alcuni ritardi iniziali, ora a pieno regime
  - Luminosità record: $8.2 \cdot 10^{33}\ cm^{-2}s^{-1}$
  - Pacchetti 2028, $1.1 \cdot 10^{11}$ p per bunch, <μ>~25
  - TS/MD ridotto per massimizzare fb^{-1} per ICHEP



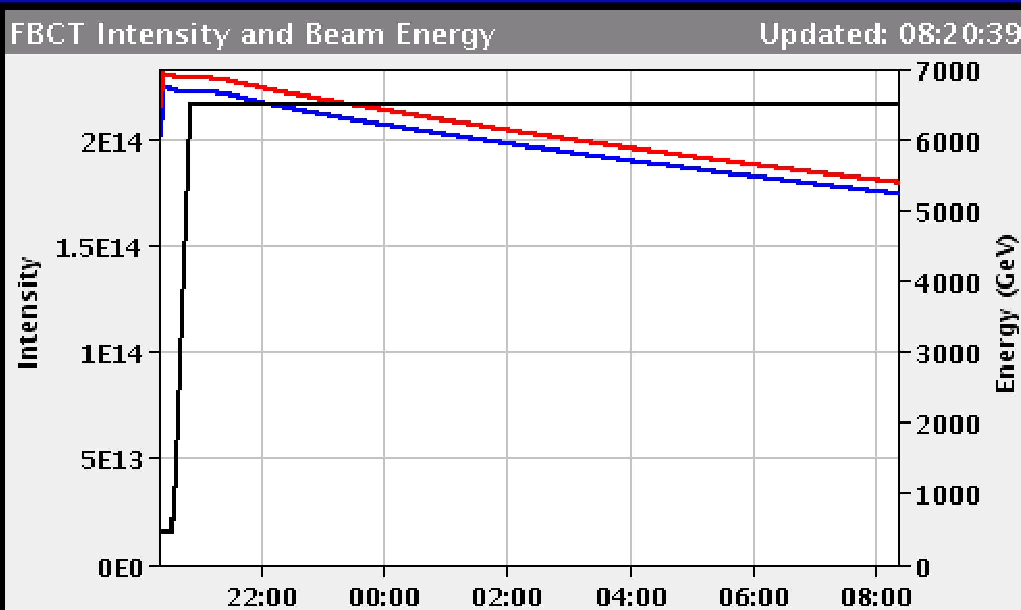


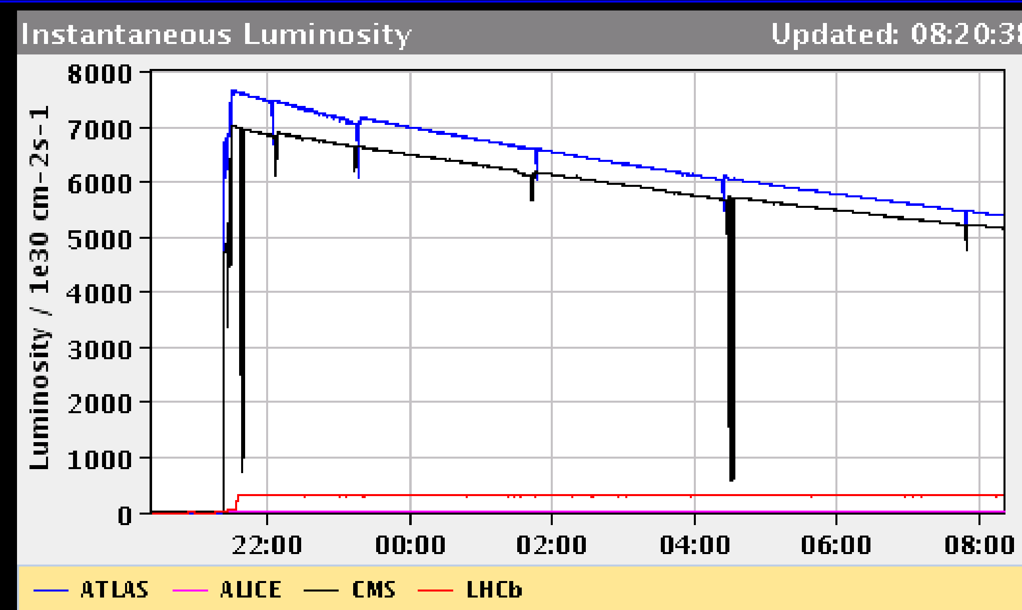
LHC Page1 Fill: 4990 E: 6500 GeV t(SB): 10:48:58 06-06-16 08:20:38

PROTON PHYSICS: STABLE BEAMS

Energy:	6500 GeV	I(B1):	1.74e+14	I(B2):	1.77e+14

Inst. Lumi [(ub.s)^-1]	IP1: 5390.54	IP2: 3.07	IP5: 5155.47	IP8: 304.95





Comments (06-Jun-2016 04:36:29)

TOTEM XRP in
Physics, 2040 bunches/beam

BIS status and SMP flags	B1	B2
Link Status of Beam Permits	true	true
Global Beam Permit	true	true
Setup Beam	false	false
Beam Presence	true	true
Moveable Devices Allowed In	true	true
Stable Beams	true	true

AFS: 25ns_2040b_2028_1697_1712_72bpi_30inj PM Status B1 ENABLED PM Status B2 ENABLED

Consuntivi 2015
ATLAS

ATLAS Pavia 2015: people

	Qualifica	ATLAS	Call GRV	Tot
Carrà Sonia	Borsista	1		1
Ferrari Roberto	DR	0,6	0,2	0,8
Fraternali Marco	PA	1		1
Gaudio Gabriella	Ric	1		1
Introzzi Gianluca	RU	1		1
Livan Michele	PO	1		1
Negri Andrea	PA	1		1
Polesello Giacomo	PR	1		1
Rebuzzi Daniela	PA	1		1
Rimoldi Adele	PA	0,7	0,1	0,8
Vercesi Valerio	DR	0,8		0,8
De Vecchi Carlo	Tecnologo	0,6		0,6
Lanza Agostino	DT	0,8		0,8
Totale:		11,5	0,3	11,8

Laureati magistrali:

Sonia Carrà (Apr. 2015) - Edoardo Farina (Set. 2015)

Laureandi magistrali:

Matteo Facchini, Riccardo Poggi, Simone Sottocornola

ATLAS Pavia 2015: responsibilities

Responsibilities in ATLAS experiment:

- Lanza:
  - Responsabile servizi MDT
  - Responsabile servizi NSW
  - Responsabile integrazione HW FTK
- Negri:
  - Responsabile dataflow ATLAS
  - Responsabile integrazione DAQ FTK
- Polesello: Deputy Chair ATLAS Publication Committee (Mar 2015)
- Rebuzzi: Monte Carlo Manager for the Higgs group (Ott 2013)

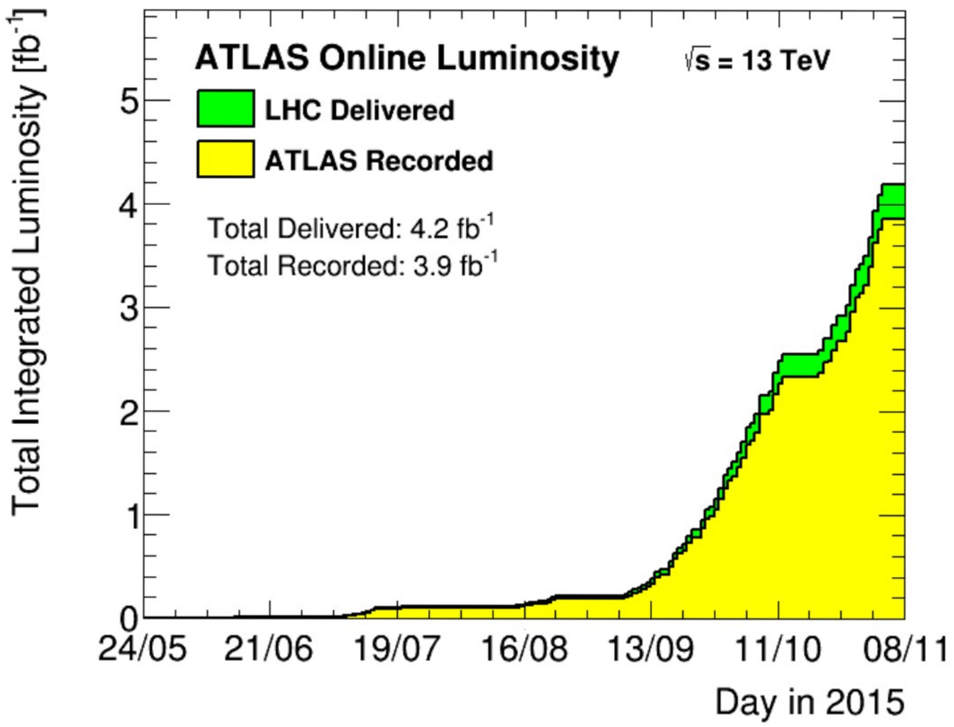
Responsabilities in ATLAS-Italia:

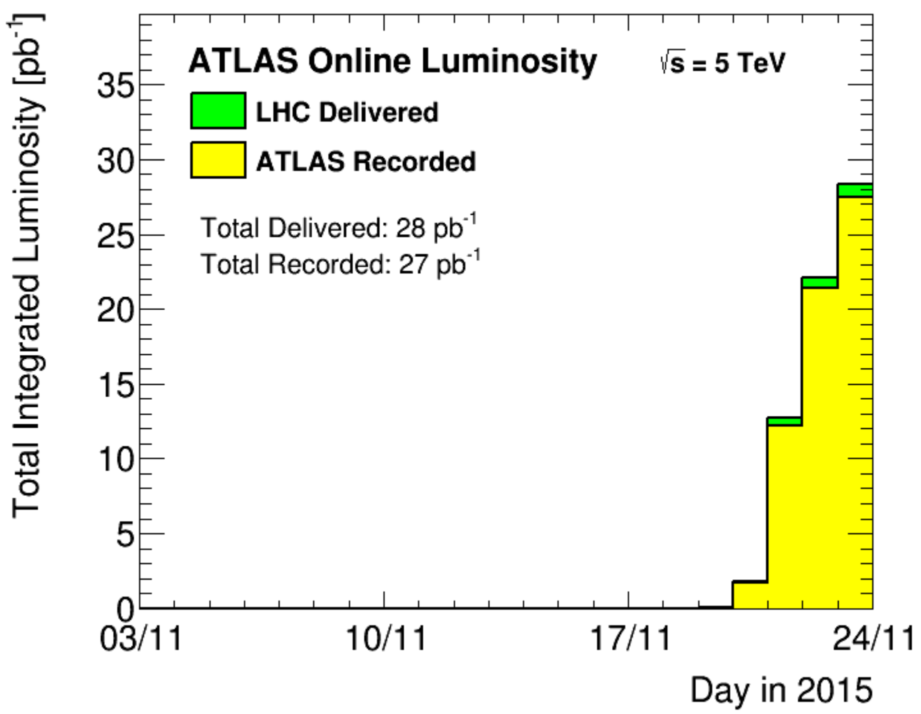
- Ferrari: Responsabile nazionale Upgrade

ATLAS data taking in 2015

- April 5th 2015 the first beams circulated in the LHC and beam splash events were seen
- May 5th first collisions at injection energy
- May 19th first collisions at 13 TeV
- June 3th stable beam
- In the coming months: started with 50ns bunch spacing (as in Run-1) and later 25ns, from few tens of colliding bunches at the beginning of June up to instantaneous luminosities of $5 \times 10^{33} cm^{-2} s^{-1}$
- Nov 3rd end of proton-proton run and Pb-ions collision program start

Physics results:
https://indico.cern.ch/event/442432/

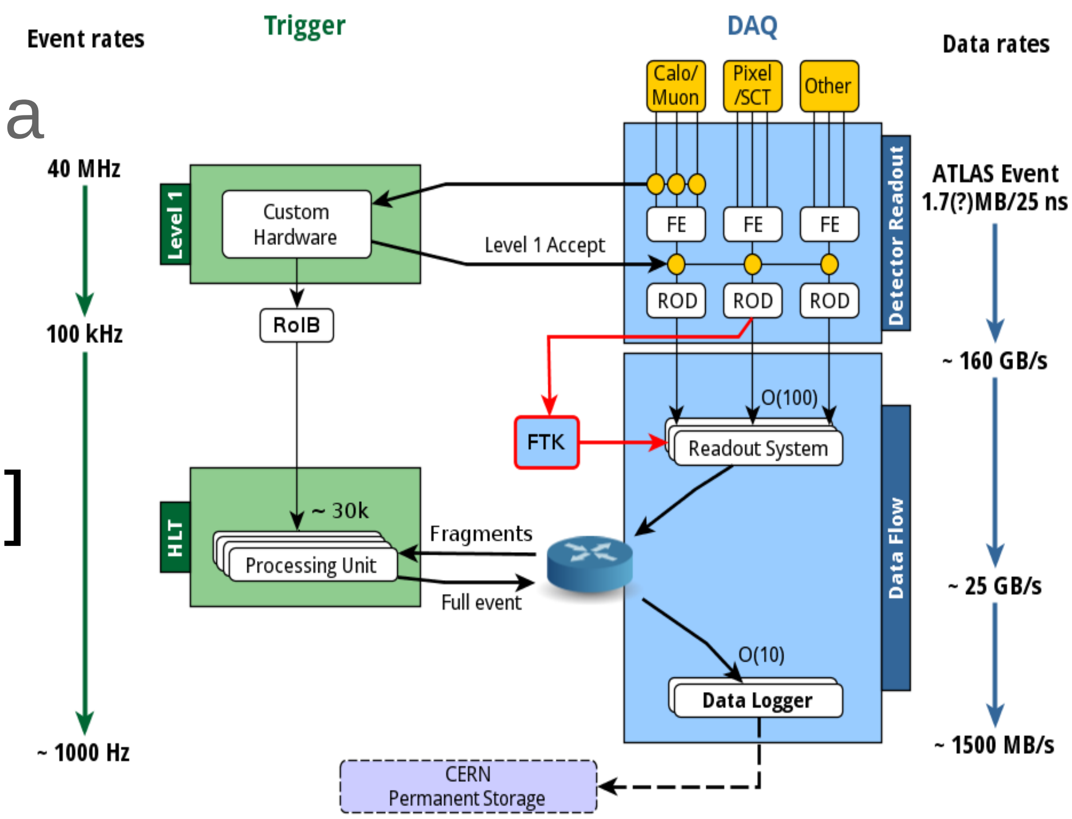




T/DAQ

A.Negri, R.Poggi

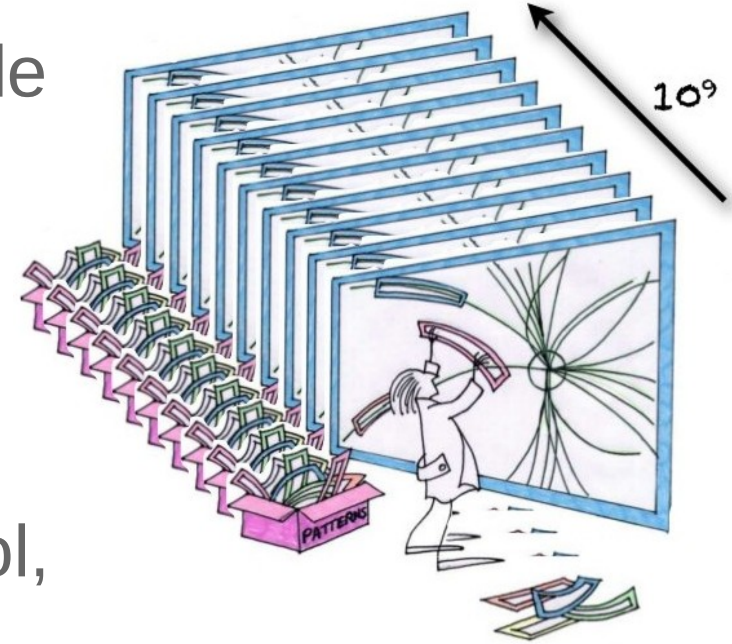
- DataFlow: responsabilità pavese da sempre
  - Completamente ridisegnato durante il LS1
  - 2015: campagna di review di ogni componente, e implementazione di nuove funzionalità emerse dalle esigenze di operation
  - 2016: nessun problema emerso al momento
  - Fase I/II: R&D in corso
- Run Control [R. Poggi]
  - esplorazione di nuove tecnologie per la gestione dei processi



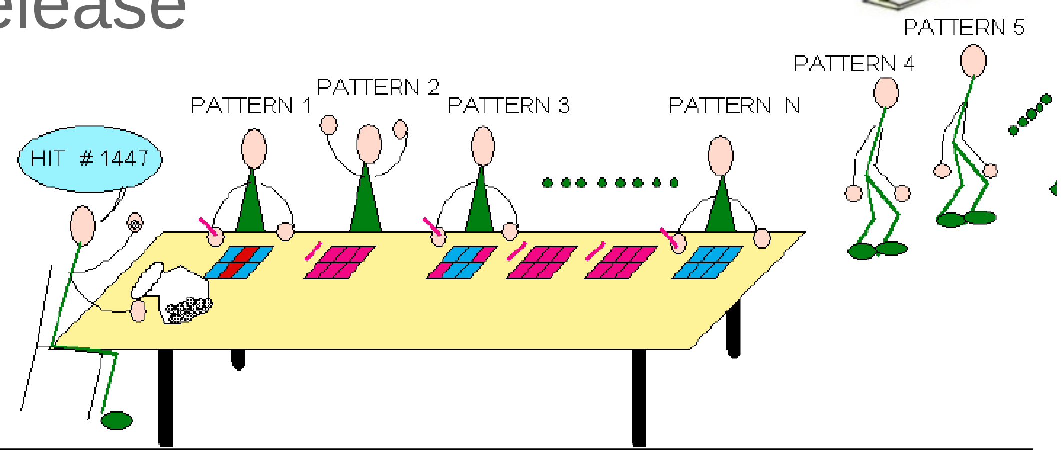
FTK

M.Facchini, A.Lanza, A.Negri

- Tracciatore HW basato su memorie associative e successivo fit con FPGA delle road identificate
  - Tracce con risoluzione comparabile con l'offline, disponibili all'inizio degli algoritmi di HLT (pochi µs)

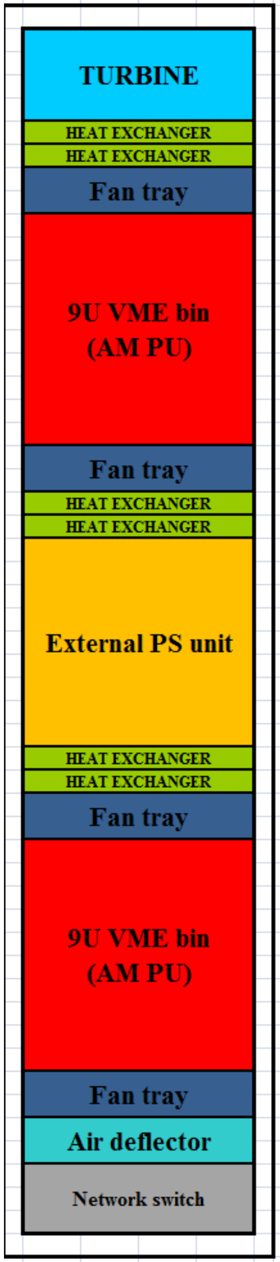


- Contributo pavese
  - Integrazione del sistema nell' infrastruttura sw DAQ: Run Control, Monitoring, gestione release
  - Integrazione nell'infrastruttura HW
  - Integrazione nell'infrastruttura DCS



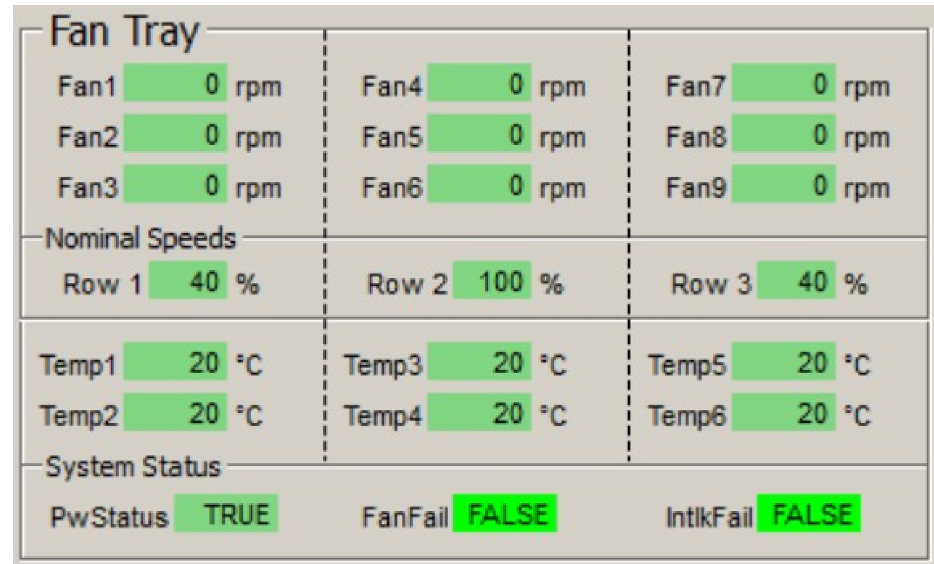
FTK infrastructure

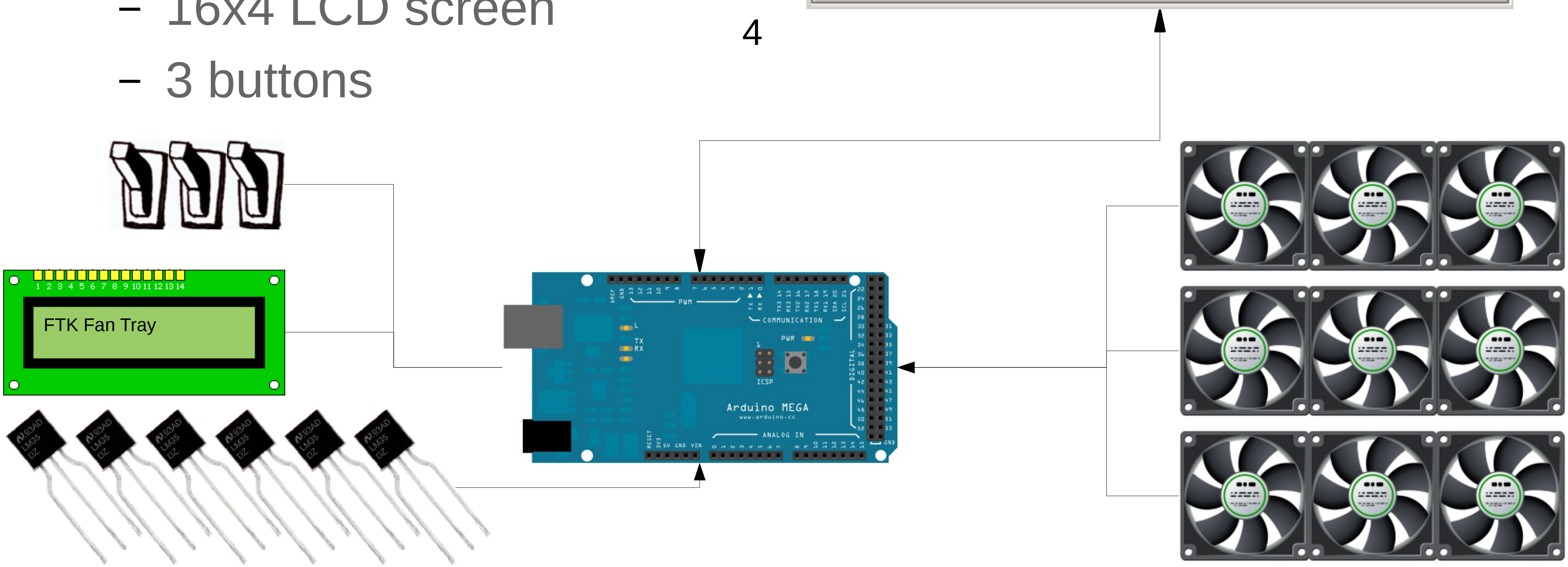
- In 2015 FTK moved to the 6 racks assigned in USA15
- Installed optical fibers routed inside the two ATCA racks
  - prepared for hosting three hundred of them each rack
- Chosen PS for VME 9U crates (4 racks): a CAEN custom unit, which prototype was used for many cooling tests
  - This PS has two channels able to supply up to 8kW each;
- CAEN PS implies the use of a custom fan tray. INFN Pavia is in charge to design and procure the necessary fan trays (16) and the relative DCS sw:
  - 2 fan tray prototypes built by Pavia workshop & electronics service and installed in a crate, one on bottom and one on top
  - Several cooling tests done to check performance of the fan trays
  - Chosen fan type: Sanyo Denki able to work at 10k rpm. The current consumption of this fan is very high, 12.6 A for one fan tray, but the air pressure ensure a very good cooling of the electronics.
  - DCS integration →



Fan Tray monitor and control

- For each fan tray
  - 1 Arduino Mega 2560
  - 1 Ethernet Shield
  - 6 temperature sensors
  - 9 fans
  - 16x4 LCD screen
  - 3 buttons

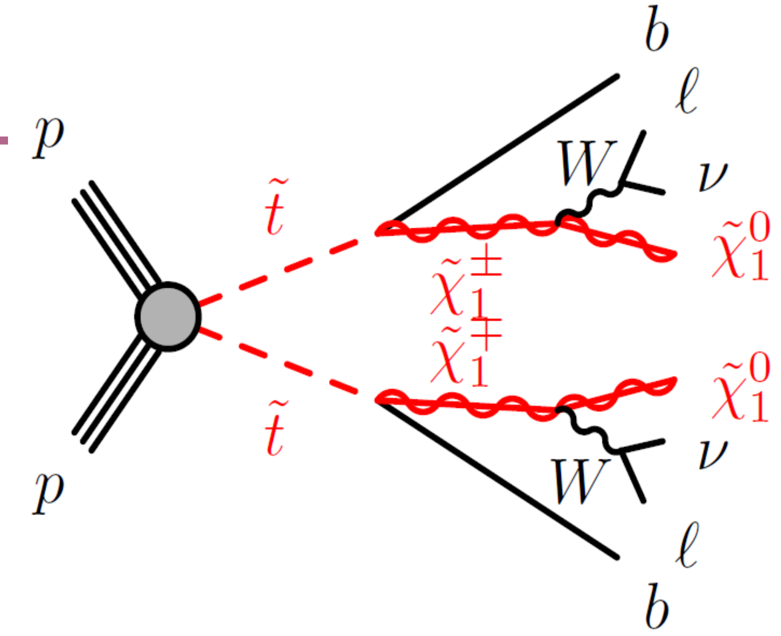




ATLAS – Muon Services

- Under the responsibility of INFN Pavia, in 2015 services of Muon Barrel expanded to connect the new MDT-RPC chambers BME and BOE;
- The cables of other 12 new MDT chambers, BMG (2017 winter shutdown), were also procured and laid out, ready for the connections;
- Project to equip every single Muon rack in cavern (103 in total) with a hardware interlock to prevent electrical blackouts causing damage to power supplies, which started in 2014, was realized up to installation of 9 prototype interlock boxes.
  - Test carried out by turning off power: the circuits proven to work fine. Next step: construction of ~100 boxes and their installation in racks
- Failure rate of the CAEN PS was quite low, for many types under 1%.
  - The only critical module is MDT HV, which is still around some percent. The maintenance costs were significantly lower than expected at the time the CERN contract was signed (2009);
- Campaign to increase spare modules continued.
  - Two HV modules used by the TGC and two DCS modules used by the RPC were purchased at the end of the year.

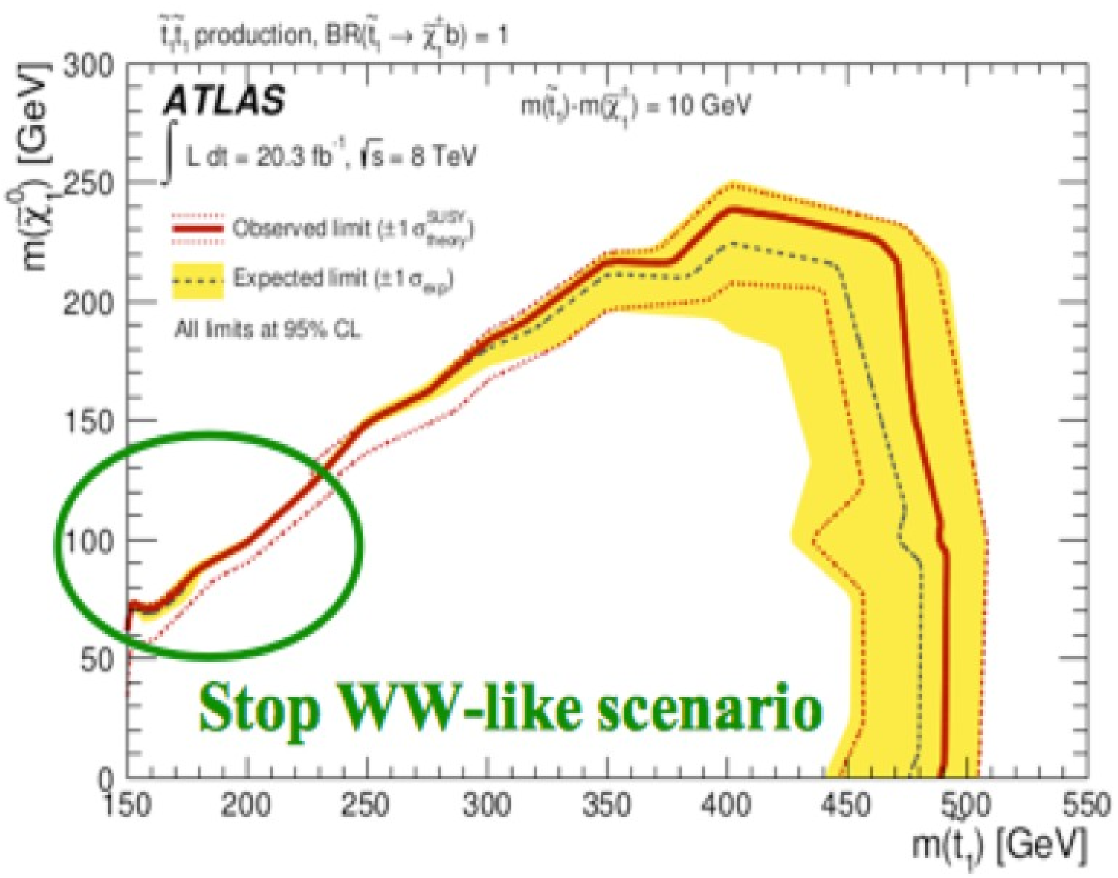
Susy Analysis 2015



Decadimento dello stop in un canale a due leptoni, 2 b-quark ed E_t^{miss}

Regione non ancora coperta da altre analisi con:

1) m_{stop}-m_{ch}< 30 GeV
2) m_{ch}-m_{neu}< 100 GeV
3) m_{stop} < 200 GeV

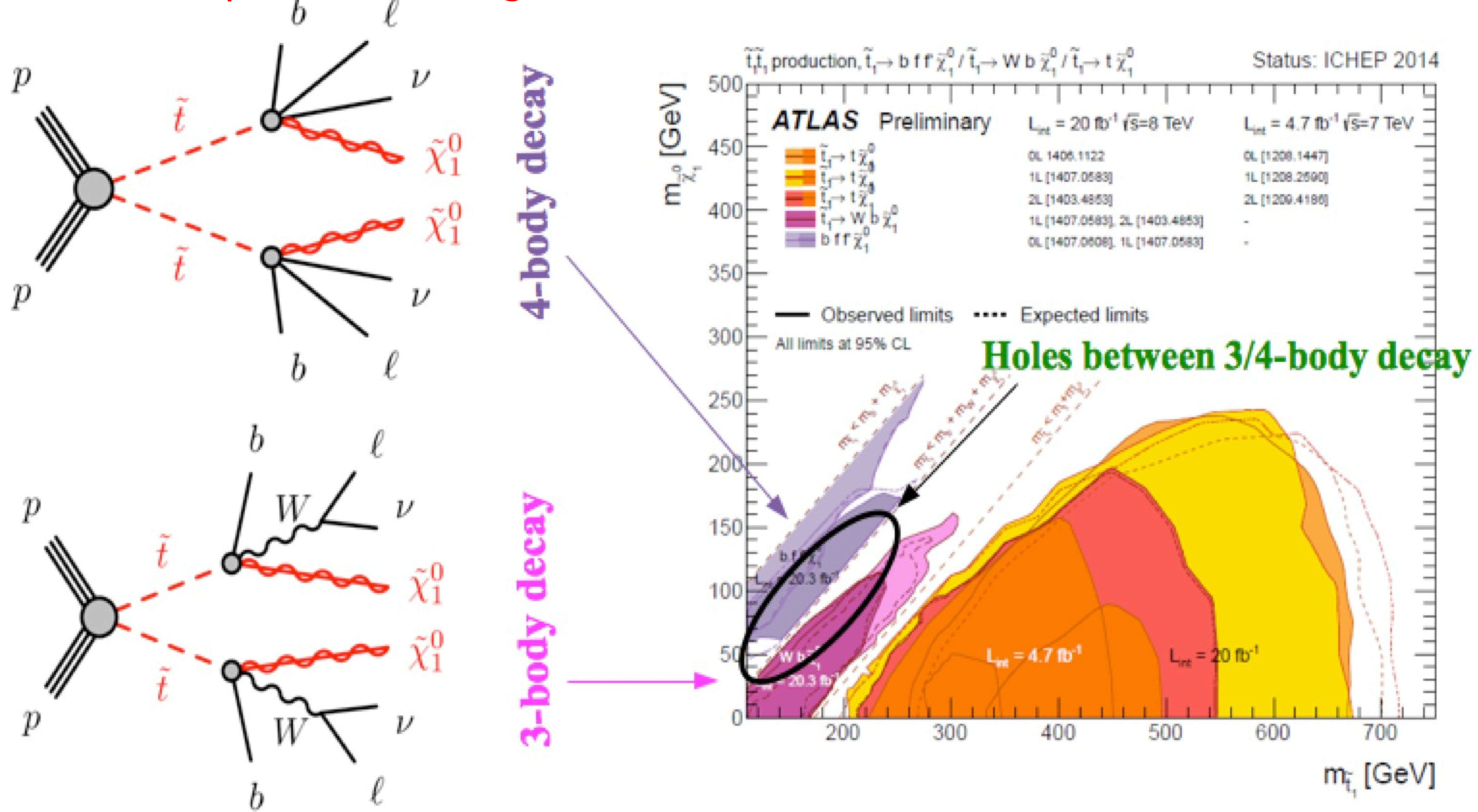


In questa regione il decadimento dello stop è simile alla produzione di WW, che avrebbe potuto spiegare il piccolo eccesso nella sezione d'urto misurata.

L'analisi, iniziata nel 2014, era in stato avanzato (luglio 2015) quando è stata proposta una reinterpretazione al decadimento dello stop a 3 e 4 corpi

WW-like Susy Analysis 2015

L'analisi si è mostrata sensibile alla regione di interfaccia tra il decadimento dello stop a 3 e 4 corpi. Questa reinterpretazione è diventata parte integrante dell'analisi, coprendo una regione molto critica.



INFN Istituto Nazionale di Fisica Nucleare

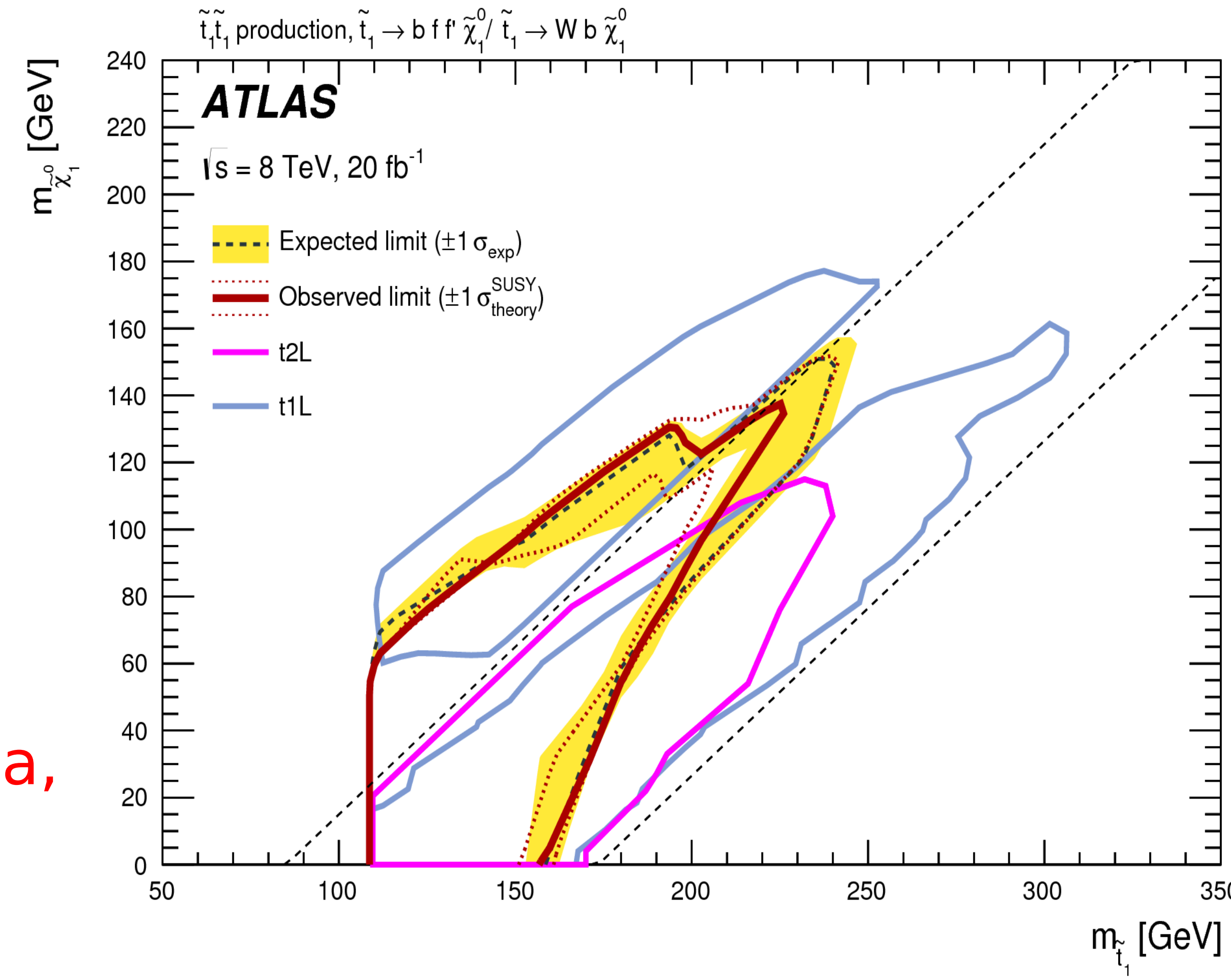
WW-like Susy Analysis 2015

Analisi confluita nella tesi di P.Dondero (Gennaio 2016)

Pubblicata nel 3rd generation summary paper di ATLAS
http://link.springer.com/article/10.1140/epjc/s10052-015-3726-9
di cui costituisce la parte più innovativa

Coperta una zona su cui attenzione
Fenomenologica si era concentrata

http://arxiv.org/abs/arXiv:1510.07688
http://arxiv.org/abs/arXiv:1506.00604



Analisi completamente eseguita a Pavia,
Sulla base degli strumenti comuni di
SUSY-Italia

Carrà, Dondero, Gaudio, Polesello

WW-like Susy Analysis 2015

Nel corso del 2015, oltre a seguire la pubblicazione del paper, si ci è dedicati alla preparazione dell'analisi per il RUN II.

- Continuare a dedicarsi al canale stop in due leptoni con un team di analisi composto da diversi gruppi (Pavia, Milano, Lecce, Berna...)
- Contributo alla definizione iniziale delle selezioni nella seconda parte del 2015
- Per il momento (da Marzo) attività seguita senza contributi effettivi per mancanza di manodopera, si pensa di riprendere in autunno
- In parallelo studi fenomenologici sul canale DM+ttbar e monojet+Etmiss, come risultato del workshop di Les Houches 2015 (GP)

Higgs Activity

Since October 2013, D. Rebuzzi appointed as ATLAS Higgs MonteCarlo manager, together with E. Feng (CERN)

- Gather the requests from all Higgs subgroups and prepare priority lists
- Prepare Higgs MonteCarlo requests (jobOptions, input files, etc.) and submit them to the Physics Coordinator for approval
- Coordinate the MC validation efforts
- Inform the Higgs group about latest developments in MC and their tunings
- Member of the Higgs Coordination board - weekly reports at the Higgs coordination meetings, monthly reports at the Higgs plenary

This task is considered **part of the Higgs management**, with OTP credits rewarding it

- Nominal duration: 2 years - now DR is at her second mandate

Since March 2010, D. Rebuzzi is member of the LHC Higgs Cross Sections WG

- Work for the combination of the ATLAS and CMS results together with the theory predictions
- ATLAS contact for the Higgs vector-boson fusion production process (until 2014) and for the Higgs BR predictions for the Higgs vector-boson fusion production process (until 2014) and for the Higgs BR predictions

ATLAS Muon Upgrade: MicroMegas Module 0 and 0.5 for the New Small Wheels

MicroMegas Pavia Group

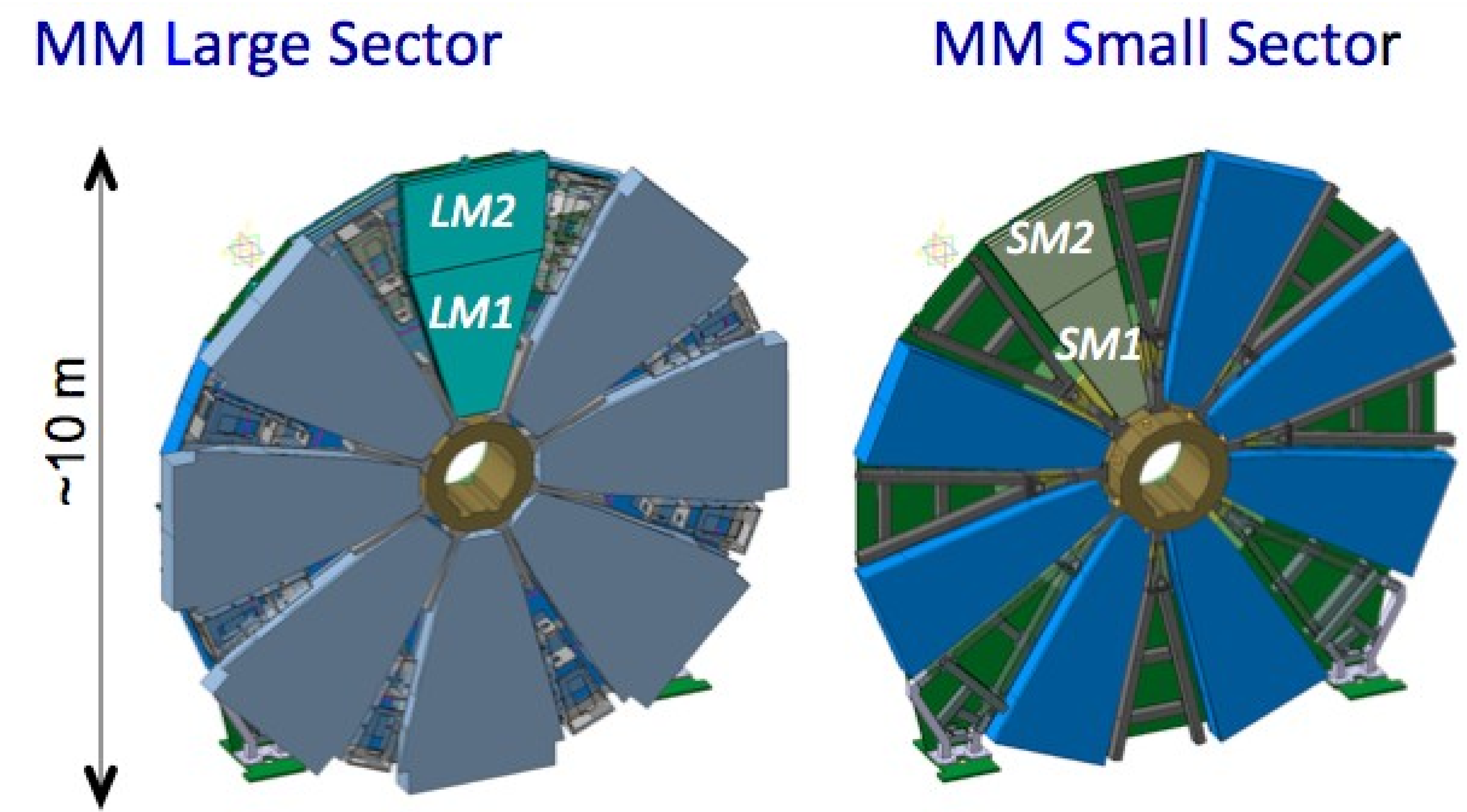
Pavia MM Group (2015/16)

Sonia Carrà – Athina Kourkoumeli-Charalampidi (from 2016) - Edoardo Farina – Marco Fraternali – Gabriella Gaudio – Gianluca Introzzi – Agostino Lanza – Roberto Ferrari – Simone Sottocornola

With an outstanding support from

Domenico Calabrò – Alessandro Caserio - Angelo Freddi – Samuel Guelfo Gigli - Claudio Scagliotti – Filippo Vercellati

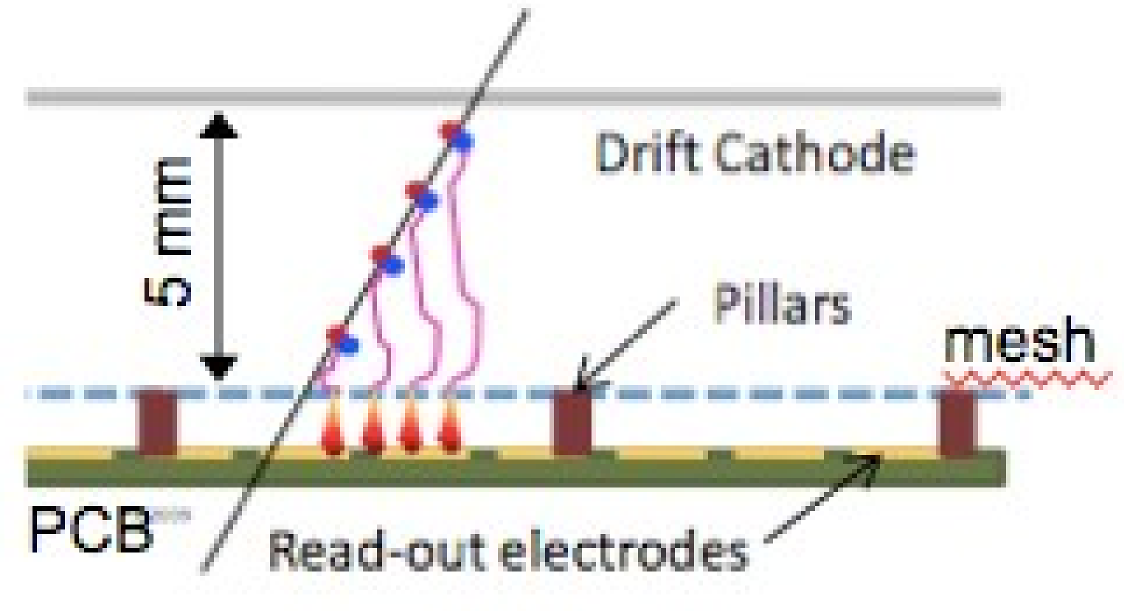
Layout of a New Small Wheel

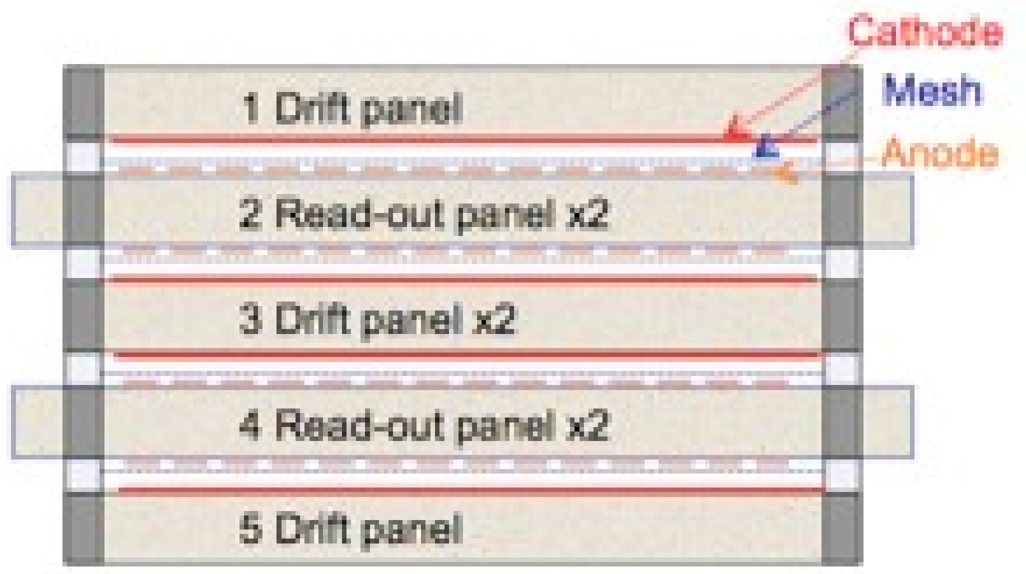


Pavia commitment to MicroMegas

A MM chamber is composed by 5 panels: 3 Drift (DR) interleaved by 2 ReadOut (RO), for a total of 4 active areas in each detector (Quadruplet).

Pavia is in charge of the construction and test of the RO panels for the SM1 type of MM modules. It's a total of 66 (64 + 2 spare) RO panels, to equip 32 Quadruplets located in 4 octants (2 NSW) with 8 (16) quadruplets each.





Pavia Measuring System

Measuring System reliability

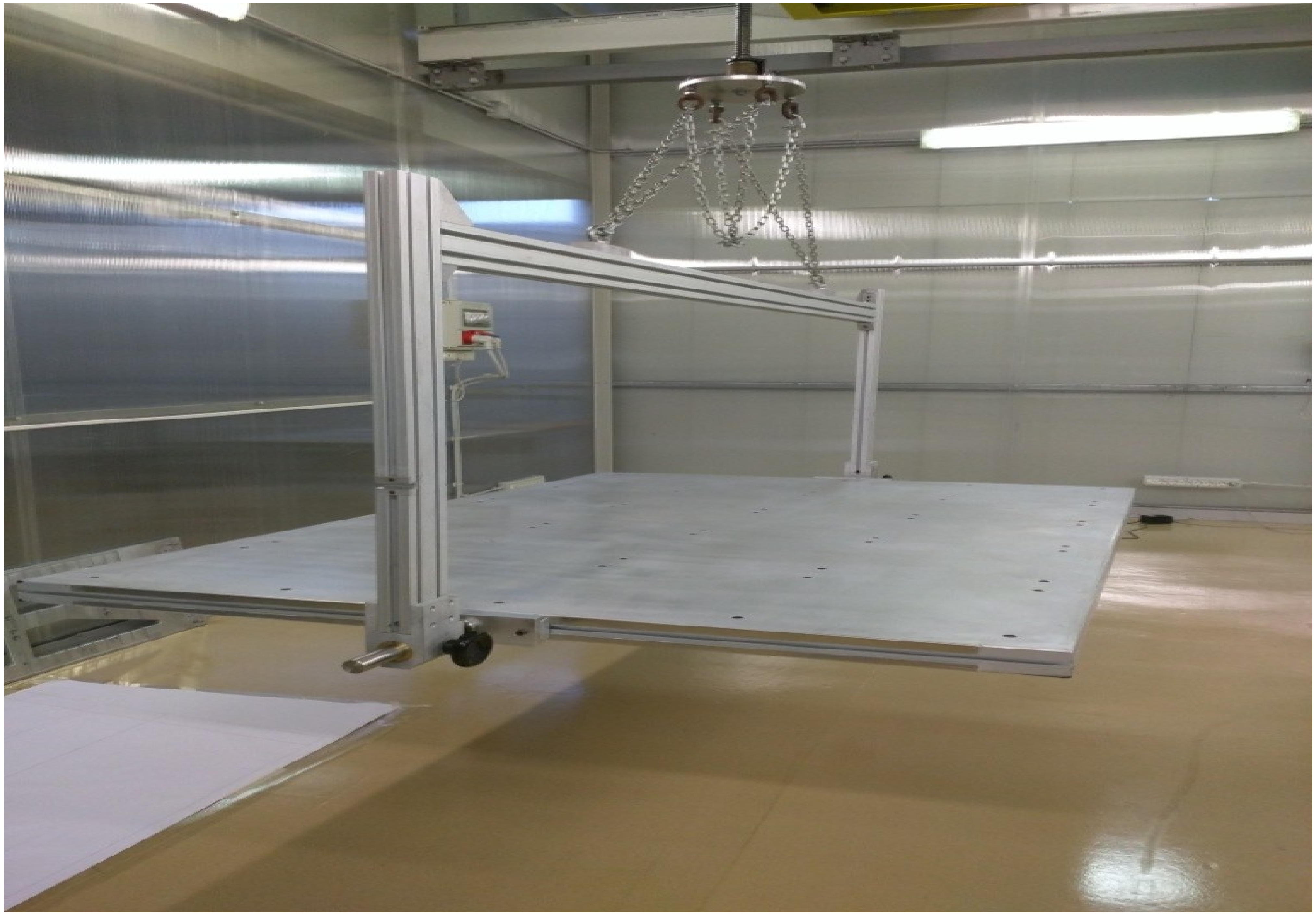
The Pavia mechanical shop has realized a highly sophisticated Coordinate Measuring Machine (CMM) of industrial level, at the bare cost of the component materials (rails, engines, Al profiles).

The measuring system (granite table + moving bridge) planarity and data repeatability has been tested at the end of May 2015 using a Brown & Sharpe Type 60 indicator.

The measuring system planarity RMS is 8 micron.

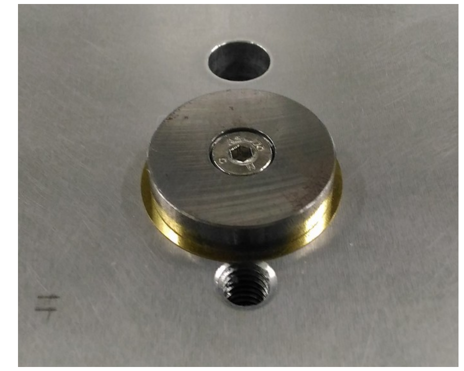
The data repeatability (same position measured 3 times in the same conditions) is 3 micron.

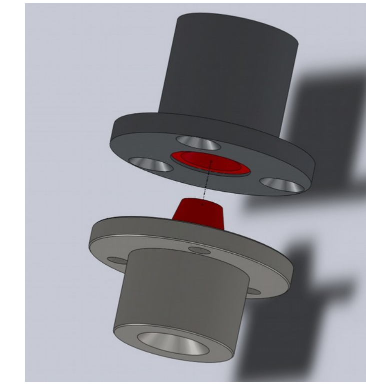
Stiff-Back moving table



Stiffback supports

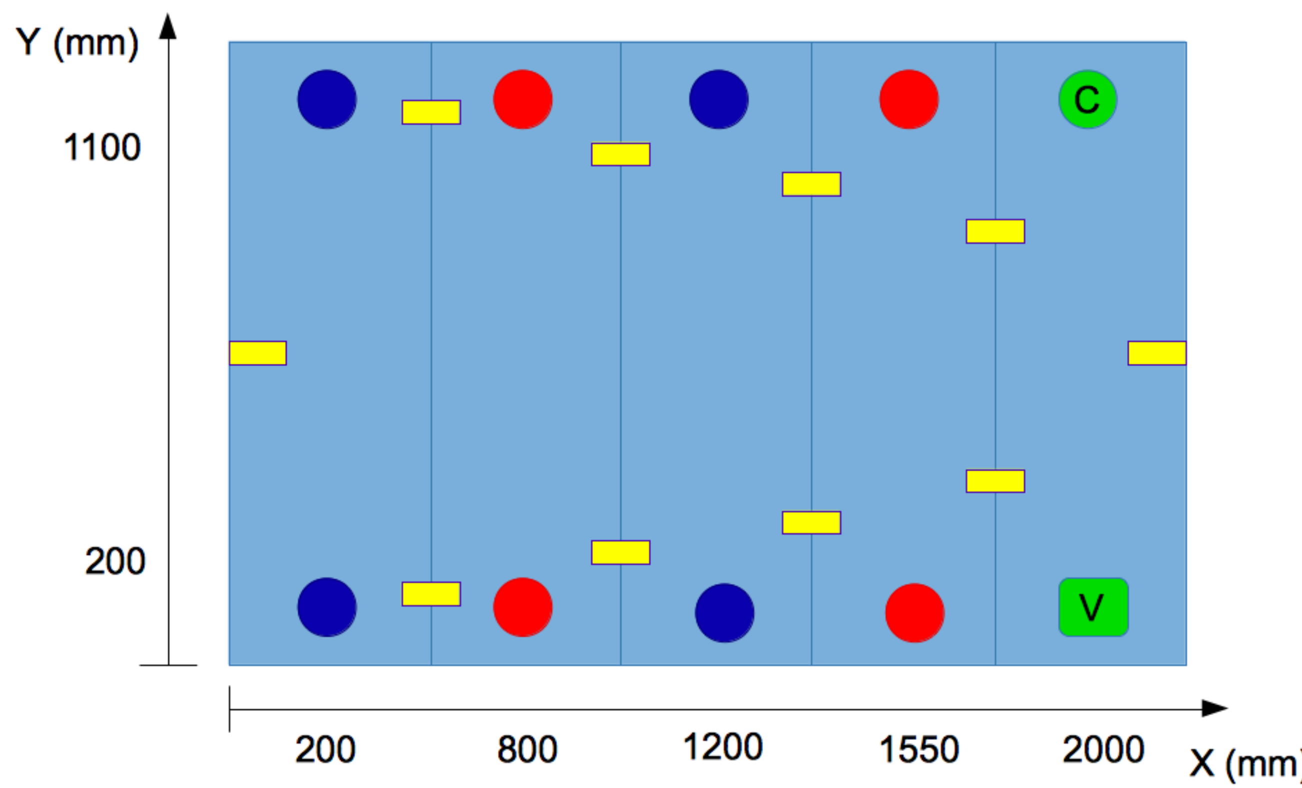
The number of supports has increased through the “learning period” (dummy panels construction) to correct for not sufficient stiffness of the stiffback



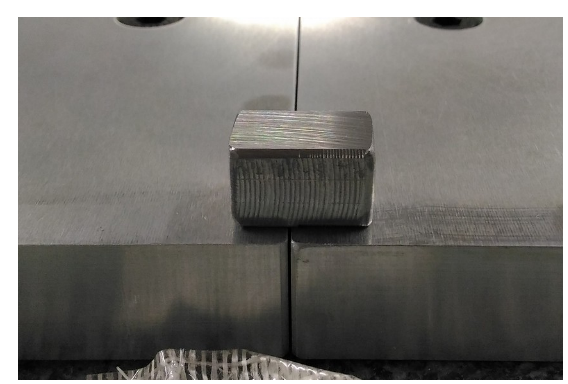


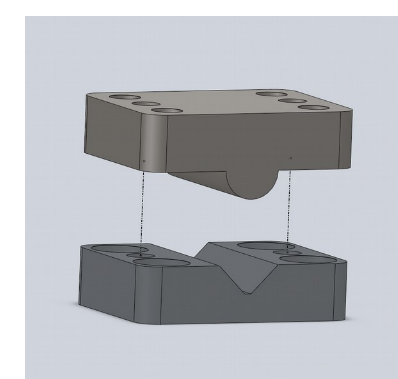
Final configuration as shown:

- Tapered interlock and v-shaped interlock fix the x-y position
- Blue and red supports define panel height (11.770 mm)
- Yellow supports limit the stiffback bending



Need to redo all the supports with stainless steel and fix them to the table and stiff-back plates before starting the production





PV experience with RO panels

5 dummy RO panels glued to understand the system

M0 RO panels: Eta & Stereo with final PCBs

Better and better results on the RMS (limit 37 micron)

		UP v. OFF	DW v. ON	DW v. OFF	comment
Dummy1					No correctly glued – Wrong stiffback support height
Dummy2	63	65	-	62	6 supports only
Dummy3	32	35	-	36	10 supports
Dummy4	26	29	27	22	Additional supports
Dummy5	20	23	21	21	Only HC core
stereo	23	30	-	-	
eta	24	21	-	-	

02.07.2015

27.07.2015

26.08.2015

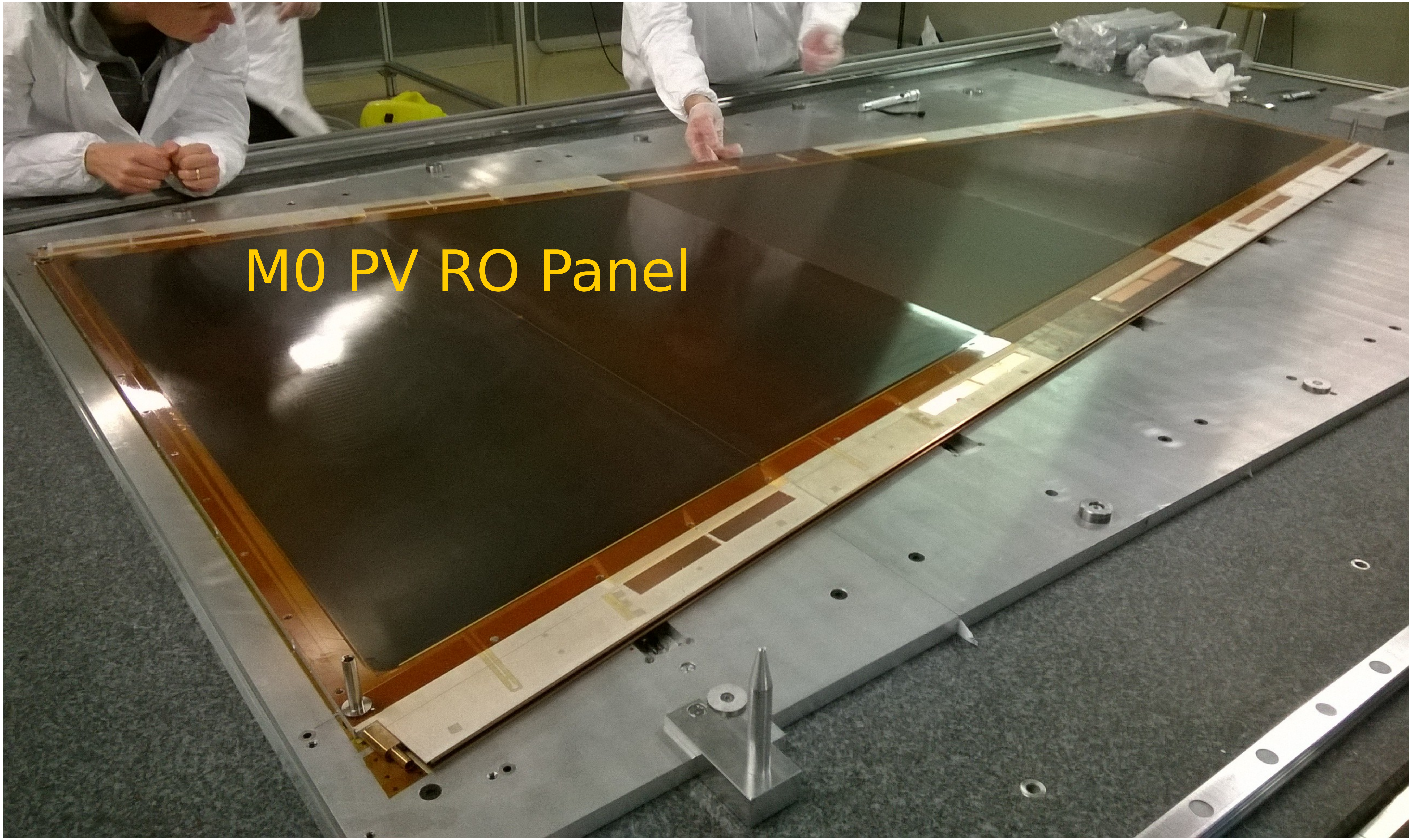
21.10.2015

18.11.2015

08.03.2016

31.03.2016

M0 PV RO Panels (March 2016)



CMM Scan on Panel Surface (pillar region)

Results on M0 PV RO **Stereo Panel**

The Max RMS should be 37 um, corresponding to a Tolerance Range of ± 110 um from the expected thickness (11.770 mm)

Average thickeness: 11.770 mm
Tolerance Range   :   0.110 mm
min (11.660 mm) < (11.770 mm) < (11.880 mm) MAX

	Average (mm)	RMS (um)	Min (mm)	Max (mm)	Max-min (um)
Vacuum on	11.760	23	11.694 (- 66 um)	11.807 (+ 47 um)	113
Vacuum off	11.810	30	11,736 (- 74 um)	11,868 (+ 58 um)	132

Results on M0 PV RO **Eta Panel**

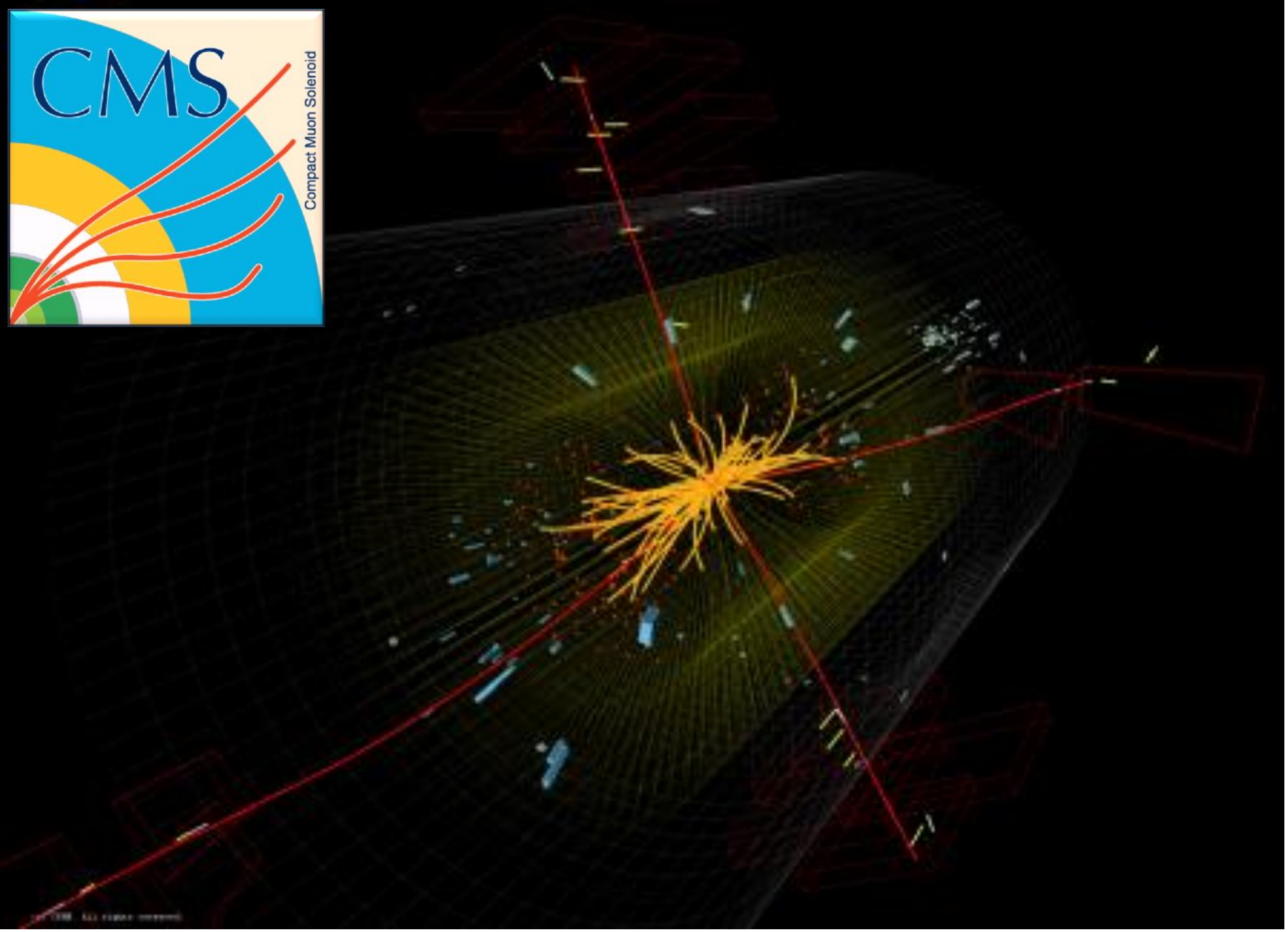
The Max RMS should be 37 um, corresponding to a Tolerance Range of ± 110 um from the expected thickness (11.770 mm)

Average thickeness: 11.770 mm
Tolerance Range : 0.110 mm
min (11.660 mm) < (11.770 mm) < (11.880 mm) MAX

	Average (mm)	RMS (um)	Min (mm)	Max (mm)	Max-min (um)
Vacuum on	11.770	24	11.677 (- 93 um)	11.819 (+ 49 um)	142
Vacuum off	11.770	21	11,705 (- 65 um)	11,818 (+ 48 um)	113

ATLAS – NSW Services

- INFN Pavia is responsible for the off-chamber services of the NSW upgrade project for both detectors MM and sTGC
- Major issues covered:
  - Routing of pipes for gas and cooling systems from gas racks and cooling station up to the detector wedges, including placement of on/off valves, flow restrictors, flow monitors within the assigned envelope;
  - Routing of cables for the HV, LV, DCS and alignment systems, and routing of fibers for the read-out systems;
  - Placement of passive and active electronics boxes on the rim of the wheels (trigger electronics, LV power systems, DCS converters, HV splitters, LV distributors, fiber splitters, alignment electronics, …);
  - Procurement (tenders) of the HV and LV systems.
- In 2015 there were many studies and attempts finalized to include in the ATLAS model (Catia) all pipes, cables, fibers, boxes and their mechanical supports, with non-italian personnel working at CERN. This activity will continue in 2016 with the market surveys and tender assignments for the HV and LV systems, with the goal of almost concluding all studies of the project by the end of the year



CMS Pavia

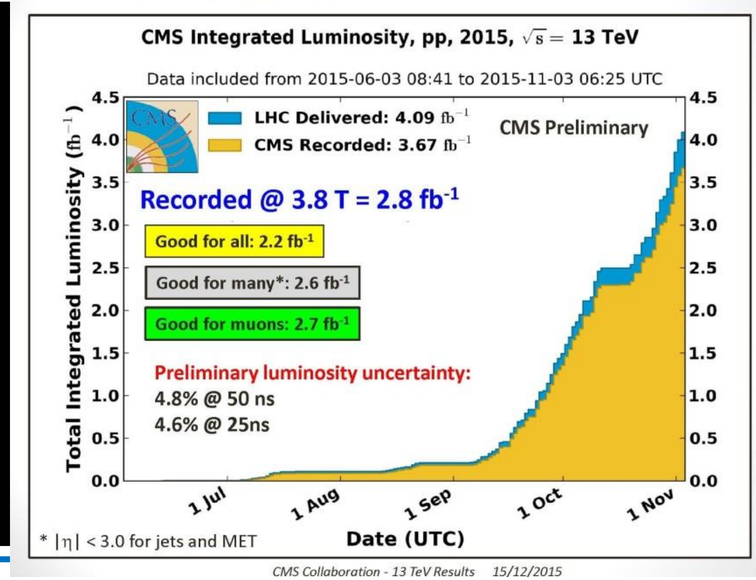
CMS PAVIA

		CMS	FaseII	CHIPIX	
Alessandro Braghieri	Ric. INFN	0.4	0.1		MUON
Daniele Comotti	Dottorando	0.3			TRACKER
Francesco De Canio	Assegnista	0.8		0.2	TRACKER
Lorenzo Fabris	Dottorando	0.4		0.2	TRACKER
Alice Magnani	Dottoranda	1.			MUON
Massimo Manghisoni	RU	0.5		0.2	TRACKER
Paolo Montagna	RU	0.6	0.1		MUON
Benedetta Nodari	Dottorando	0.8		0.2	TRACKER
Lodovico Ratti	RU	0.2			TRACKER
Valerio Re	PO	0.7		0.2	TRACKER
Cristina Riccardi	PA	0.6	0.1		MUON
Paola Salvini	Ric. INFN	0.7	0.1		MUON
Aurora Tamborini	Assegnista	0.5			MUON
Gianluca Traversi	RU	0.6		0.2	TRACKER
Carla Vacchi	RU	0.4		0.2	TRACKER
Ilaria Vai	Dottoranda	1.			MUON
Paolo Vitulo	PA	0.3	0.4		MUON

totale FTE = 9.9(cms)+0.8(faseII) +1.4(chipix)

CMS RUN 2

Data collected from March to November 2015

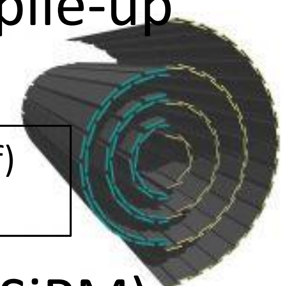


After YETS : CMS magnet is 100% back !!!!

In 2015 : about ¾ of data taking with magnet on (2.8 fb^{-1}@3.8T)

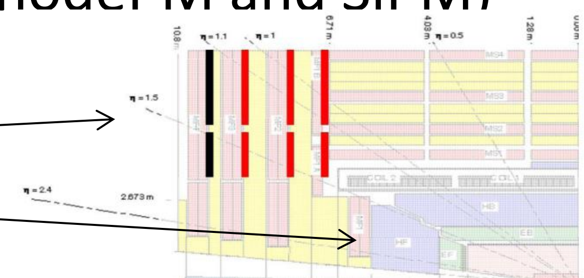
- ✓ Tracker improve track separation and operation in severe pile-up conditions (4° layer and cooling system)

pixel barrel layers before (left half) and upgraded version (right)

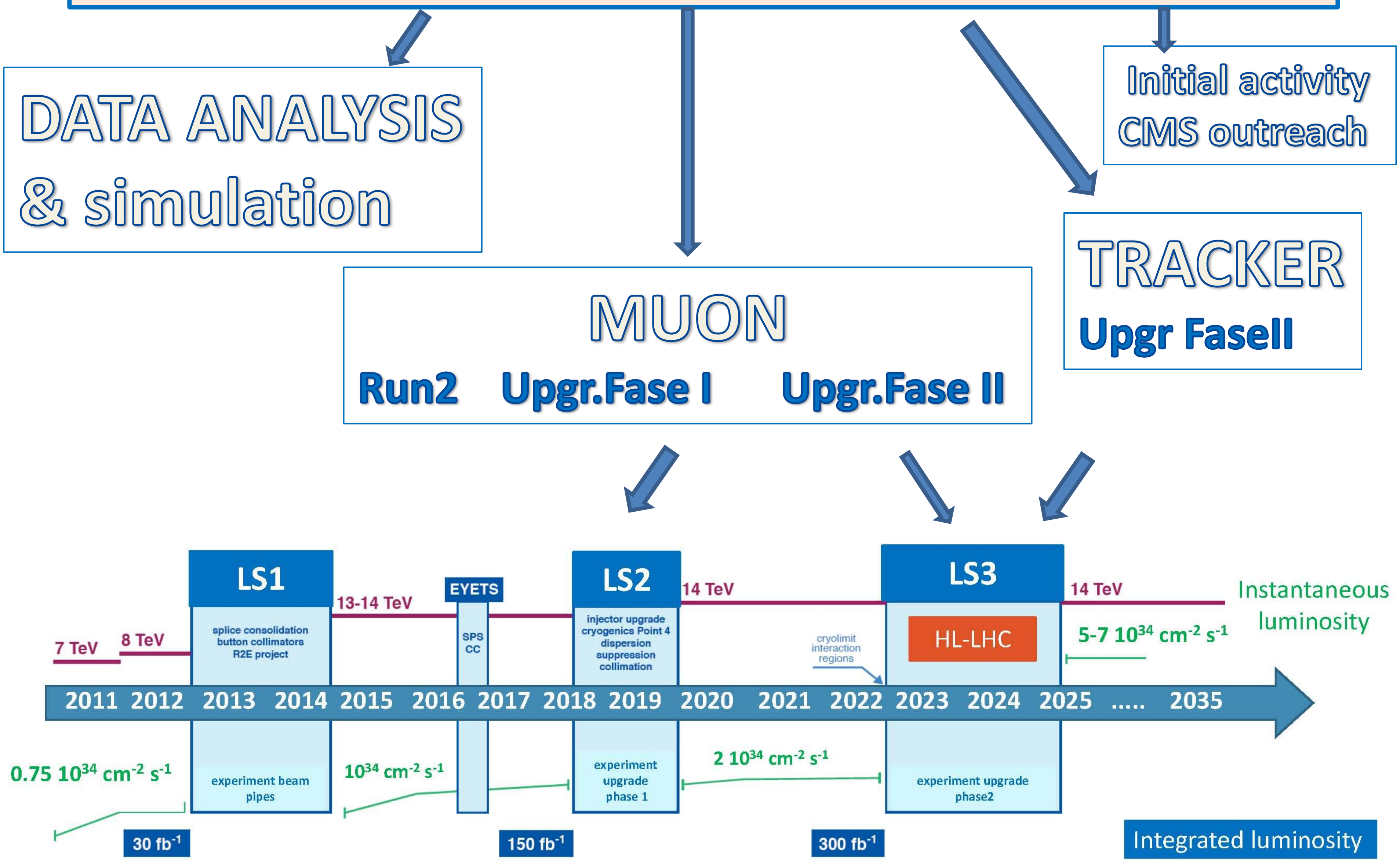


- ✓ Hadronic calorimeter (replacement of photodetectors with MultiAnodePM and SiPM)
- ✓ Muon :

Improved endcap coverage (4° layerRPC and CSC ME1/1 station)=> Muon trigger efficiency in L-1 and HL trigger



CMS Pavia


DATA ANALYSIS
& simulation
MUON
Run2
Upgr.Fase I
Upgr.Fase II
Initial activity
CMS outreach
TRACKER
Upgr FaseII
LS1
LS2
LS3
EYETS
7 TeV
8 TeV
13-14 TeV
14 TeV
14 TeV
splice consolidation
button collimators
R2E project
SPS
CC
injector upgrade
cryogenics Point 4
dispersion
suppression
collimation
cryolimit
interaction
regions
HL-LHC
5-7 10^{34} cm^{-2} s^{-1}
Instantaneous luminosity
2011 2012 2013 2014 2015 2016 2017 2018 2019 2020 2021 2022 2023 2024 2025 2035
0.75 10^{34} cm^{-2} s^{-1}
experiment beam pipes
10^{34} cm^{-2} s^{-1}
experiment upgrade phase 1
2 10^{34} cm^{-2} s^{-1}
experiment upgrade phase2
30 fb^{-1}
150 fb^{-1}
300 fb^{-1}
Integrated luminosity

Search for light charged Higgs H^+->cb

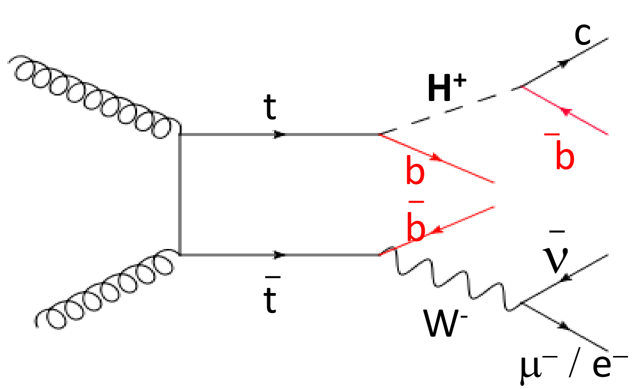
C. Riccardi and A. Magnani (similfellow 2015/16)

The final state into cb is sensitive to low tanβ region in the MSSM , and it can be dominant in some 2HDM scenarios arXiv:1304.1787v2, 2013 , arXiv:1002.4916v2 2010

Similar searches have been performed by CMS & ATLAS in the H+->cs final state (Eur. Phys. J. C (2013) 73:2465, CMS-PAS-HIG-13-035) The third b jet allows a better rejection of the tt background.

We are finalizing the analysis @ 8 TeV targeting ICHEP

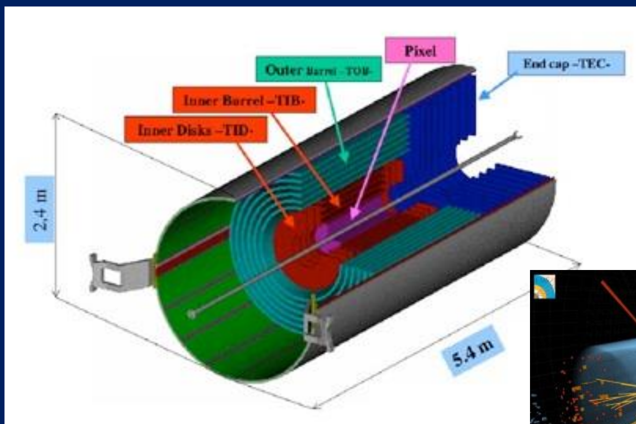
Analysis Note in preparation !

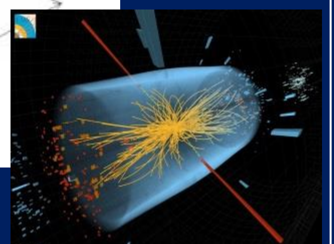


The H+ can be looked for reconstructing the M_{JetJet} from the W decay with a kinematic fit technique and looking for a secondary peak , which should appear if the H+ signal is present, in addition to the peak due to the main background source (t-tbar)
A model independent search can be carried out assuming BR(H^+→cb) = 1 an upper limit can be set on BR(t→H^+b)

TRACKER FASE II main activities in 2015

D.Comotti, F.De Canio, L.Fabris, L.Gaioni, M.Manghisoni, B.Nodari, L.Ratti, V.Re, E.Riceputi, G.Traversi C.Vacchi





Inner Tracker :

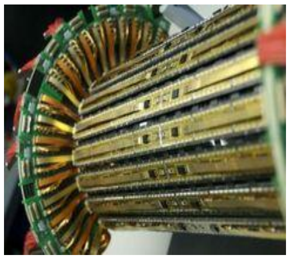
- **Front-end for the RD53A chip**
  - Characterization of a continuous-time analog channel **(INFN-PV design)**
  - Design of a front-end analog **channel together with the FNAL Microelectronics group**
- **IP Blocks for the RD53A chip**
  - Characterization (test bench and X-rays irradiation) of bandgap voltage reference circuits
  - Design of a high speed (≈1.2Gbps) driver and receiver
- **Study of the radiation hardness of the 65nm TSMC CMOS Technology**
  - Characterization of MOSFETs transistors up to 1Grad

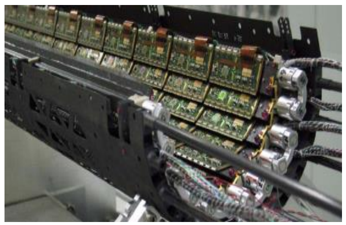
Outer Tracker

- **Development of the Marco Pixel ASIC (MPA) Chip for the Pixel-Strip (PS) Module in collaboration with the Micro Electronics group of CERN**
- Characterization of a SLVS link at 640Mbps
- Integration of the SLVS link with ESD protections in a new layout

CMS Activities of the Pavia "Tracker" Group

Inner tracker: Front-end readout chip for hybrid pixels and IP blocks (RD53)





Phase 2 Pixel Challenges

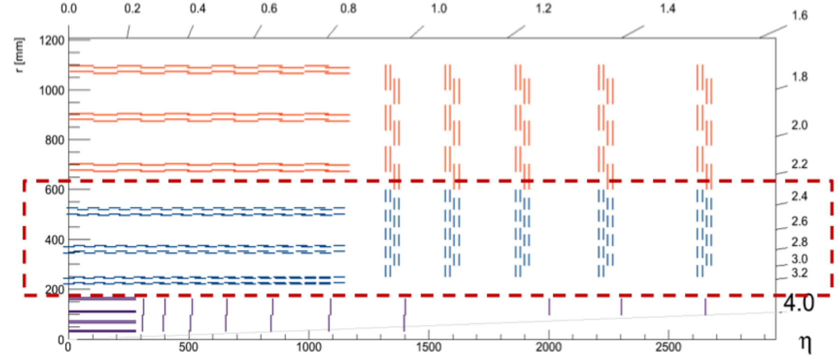
ATLAS and CMS phase 2 pixel upgrades very challenging
- Very high particle rates: 500MHz/cm^2
  - Hit rates: 1-2 GHz/cm^2 (factor 16 higher than current pixel detectors)
- Smaller pixels: $\frac{1}{4}$ - $\frac{1}{2}$ (25 – 50 um x 100um)
  - Increased resolution
  - Improved two track separation (jets)
- Participation in first/second level trigger ?
  A. 40MHz extracted clusters (outer layers) ?
  B. Region of interest readout for second level trigger ?
- Increased readout rates: 100kHz -> 1MHz
- Low mass -> Low power

Unprecedented hostile radiation: 1Grad, 10^{16} Neu/cm^2
- Hybrid pixel detector with separate readout chip and sensor.
- Phase2 pixel will get in 1 year what we now get in 10 years

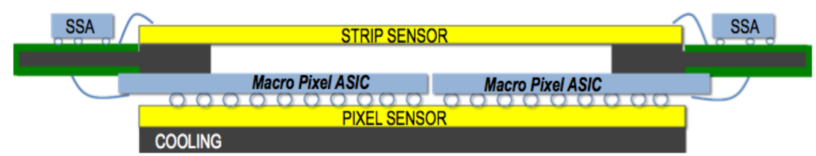
Pixel sensor(s) not yet determined
- Planar, 3D, Diamond, HV CMOS, , ,
- Possibility of using different sensors in different layers
- Final sensor decision may come relatively late.

Very complex, high rate and radiation hard pixel readout chips required

Outer tracker: MPA chip for the PS module



- Provides high pT information to the Level-1 Trigger
- Stores Events for the L1 latency duration and provides it when requested.
- Provides accurate Z information



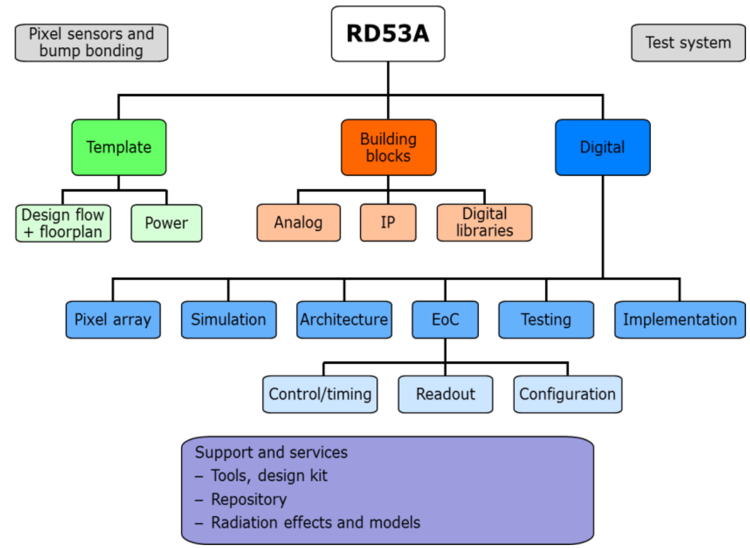
- Strips are readout from 16 Short Strip ASICs, while Pixels are readout from 16 Macro Pixel ASICs
- The SSA processes the sensor signals, and immediately sends strip data to the corresponding MPA chip, at BX frequency.
- The MPA processes signals from each pixel. It correlates the bottom sensor hits with the data received from the SSA strips and builds stubs. A stub is a particle with a momentum > 2 GeV/c which crosses the two sensor layers.
- The MPA sends out stubs at each BX (25 ns) while it stores the full event for the duration of L1 Latency.

RD53: an ATLAS-CMS-LCD collaboration

- Focussed R&D program to develop pixel chips for ATLAS/CMS phase 2 upgrades and LCD vertex
- Extremely challenging requirements for HL-LHC:
  - Small pixels: $50 \times 50 \mathrm{um}^2$ ($25 \times 100 \mathrm{um}^2$) and larger pixels
  - Large chips: ~2cm x 2cm (~1 billion transistors)
  - Hit rates: 3 GHz/cm^2
  - Radiation: 1Grad, 2 10^{16} neu/cm^2 over 10 years (unprecedented)
  - Trigger: 1MHz, 10us (~100x buffering and readout)
  - Low power - Low mass systems
- Baseline technology: 65nm CMOS
- Full scale demonstrator pixel chip in 2016 (RD53A)
- 19 collaborating institutes and many Guests

RD53A Chip

- Demonstrator chip:
  - Full size chip (~2cm x 2(1)cm), small pixels ($50x50um^2$), Large pixels, Very high hit and trigger rates, Radiation and SEU tolerance, Effective in-time threshold: 1000e, Low power, Serial powering, Functional in test beams, etc.
  - Specification document agreed with CMS and ATLAS phase 2 pixel communities.
  - Engineering run ~1M$ (we better get this right !)
    - Shared run with other project(s) (CMS MPA)
    - Demonstrator will be ~1/2 size, but designed as being full size
    - Starting to collect required funds (500k$)



- Converge all activities in RD53 and WGs on this vital goal/milestone
- Schedule:
  - Up-scaling small demonstrator: Now
  - First version of near final chip: Q3 2016
  - Final version: Q4 2016
  - (plus some months for extensive verifications)
- **Core design team and responsibilities**
  - **Valerio Re (INFN-PV): Analog Working Group**
  - **Luigi Gaioni (INFN-PV): Analog Matrix and Analog EOC**
  - **Francesco De Canio (INFN-PV): Analog EOC**

GeneralFloorPlaning_new	Floorplaning, power and bias distribution, templates, Macro-blocks	Responsible/Coordinator
IoPowerBlock	I/O pads, ESD, Shunt LDO, SLVS, Clock&Data recovery, Ser/Des	Hans Kruger
AnalogMatrix	This the analog pixel region (all front-end variants + column bias)	Luigi Gaioni ...
DigitalMatrix	This the digital pixel region (main pixel array)	Tomasz Hempereck-Roberto Beccherle..
AnalogEOC	All analog building blocks: bias DACs, Calibration, PLL, monitoring IPs	Luigi Gaioni, Francesco De Canio, Moshine Menouni
DigitalEOC	EOC logic, Readout, Chip configuration, Config. memory	Tomasz Hempereck-Roberto Beccherle..

Pavia nel Tracker di Fase II

- Impegno su due fronti (Inner e Outer Tracker)
- Workshop INFN CMS Tracker per HL-LHC, 8-9 Giugno a Perugia per avviare una discussione su impegni finanziari e di man power all'interno dell' INFN
- https://indico.cern.ch/event/525779/overview

Conference Presentations and Papers (TRACKER)

Conferences

1.V. Re: “Analog circuit design in 65 nm CMOS for the readout of silicon pixel detectors”, presented at the **10th Trento Workshop on Advanced Silicon Radiation Detectors**, Feb. 17 – 19, 2015, Trento (Italy).

2.V. Re: “The RD53 effort towards the development of a 65 nm CMOS pixel readout chip for extreme data rates and radiation levels”, presented at the **Frontier Detectors for Frontier Physics - 13th Pisa Meeting on Advanced Detectors**, May 24 – 30, 2015, La Biodola, Isola d’Elba (Italy).

3.L. Gaioni et al.: “Design and test of clock distribution circuits for the Macro Pixel ASIC”, presented at the **Frontier Detectors for Frontier Physics - 13th Pisa Meeting on Advanced Detectors**, May 24 – 30, 2015, La Biodola, Isola d’Elba (Italy).

Papers

1.G. Traversi et al., " Transmission Lines Implementation on HDI Flex Circuits for the CMS Tracker Upgrade", **JOURNAL OF INSTRUMENTATION**, 11, 1-10. doi:10.1088/1748-0221/11/01/C01081

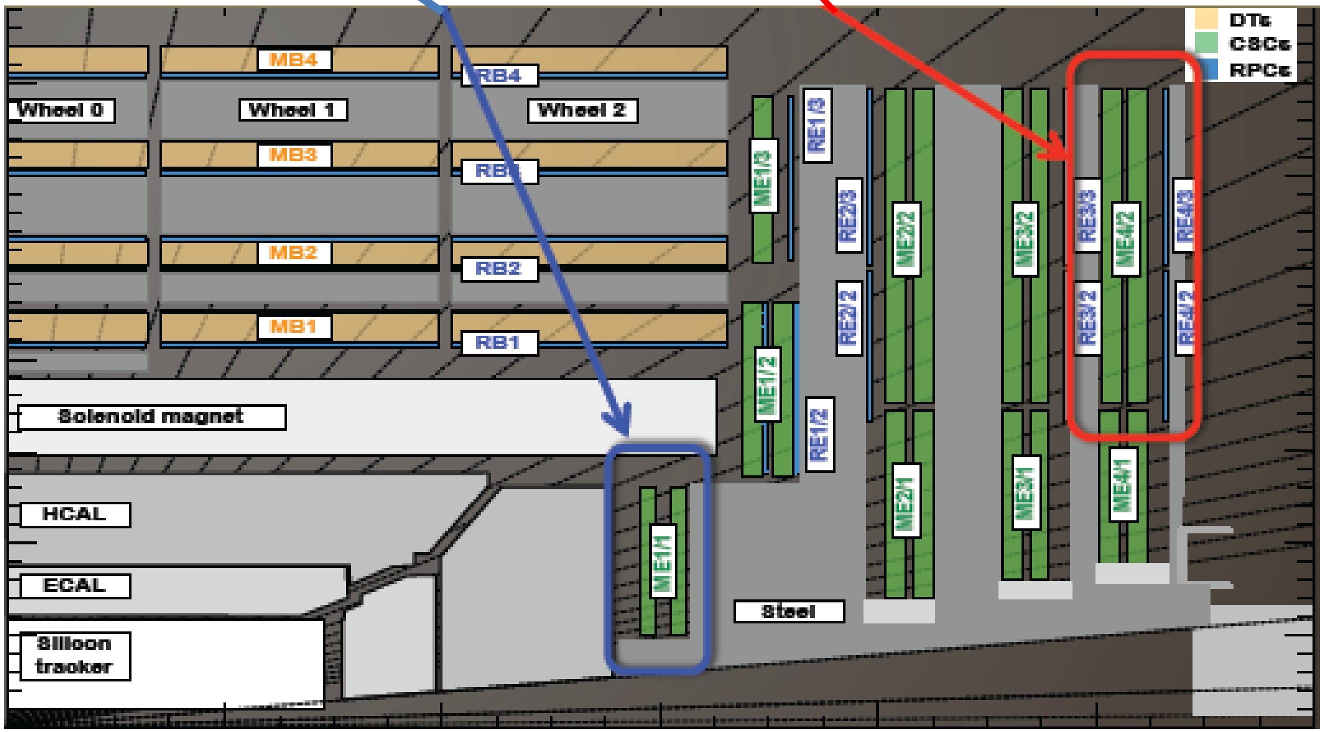
2.G. Traversi et al., "Design of low-power, low-voltage, differential I/O links for High Energy Physics applications", **JOURNAL OF INSTRUMENTATION**, 10, 1-10. doi:10.1088/1748-0221/10/01/C01055

3.L. Gaioni et al., "Low-power clock distribution circuits for the Macro Pixel ASIC", **JOURNAL OF INSTRUMENTATION**, 10, 1-10. doi:10.1088/1748-0221/10/01/C01051

Muon Detector (DT+ RPC+ CSC) – situazione attuale -

- Muoni : completata stazione 4 (144 RPC + ME4-2) (L-1 trigger and muon reconstruction efficiency)
- Revisione di ME1/1 (CSC) **(improved triggering and read-out $2.1 < |\eta| < 2.4$)**
- Elettronica DT

- **L1 upgrades**: nuove camere + maggiore granularità CSC in endcap
- **HLT updates**: algoritmi L3



Attività pavese sul rivelatore RPC

- **Lavori di manutenzione:** controlli su bakelite, riparazioni e controlli sistema gas (barrel gaps - LS1), controllo performance del rivelatore.

  Importante contributo di **Filippo Vercellati, Samuel Gigli**

- **Misure di ageing** su gap RPC del Barrel e EndCap di CMS a P5. Studiata la curva caratteristica I-V con Ar per valutare la resistività degli elettrodi e confrontarla con misure di anni precedenti. **C.Riccardi,P.Vitulo**

- **RPC current monitor** **P.Montagna, P.Salvini**

RPC current monitor

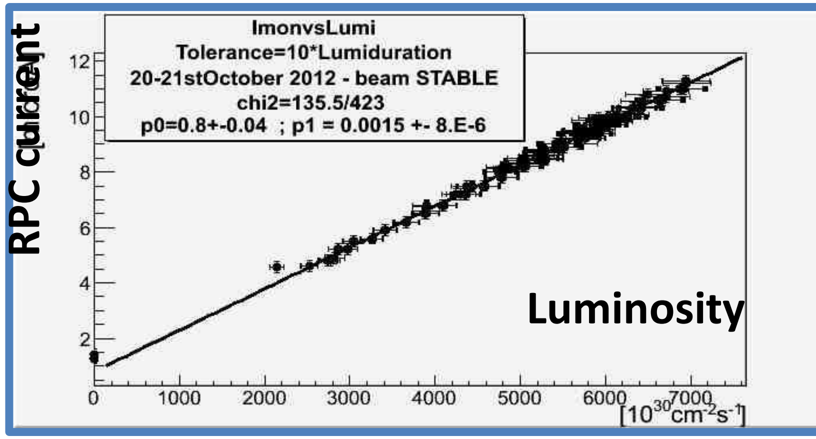
P.Montagna,P.Salvini

- currents linearly depend on the luminosity (confirmed by background simulation studies) =>use this dependence to **<u>monitor online the currents with boundary values depending on the luminosity within WBM (Web Based Monitoring)</u>**

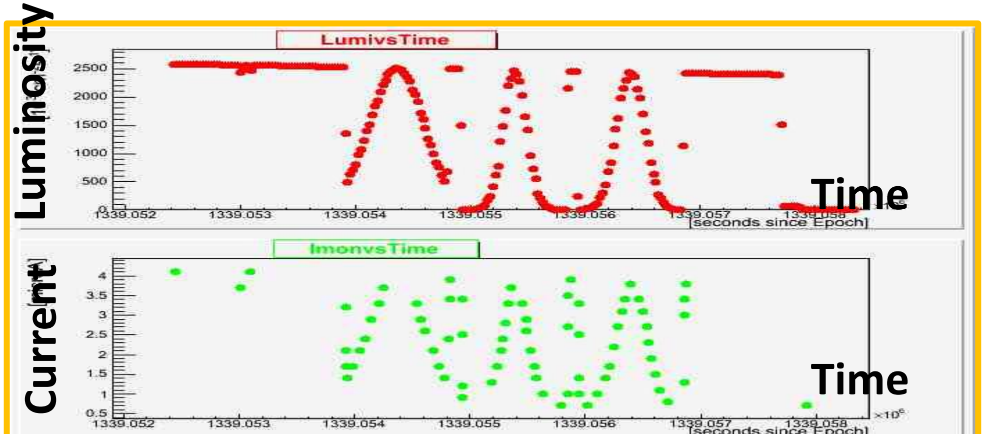
Data from Run1 – Stable beam

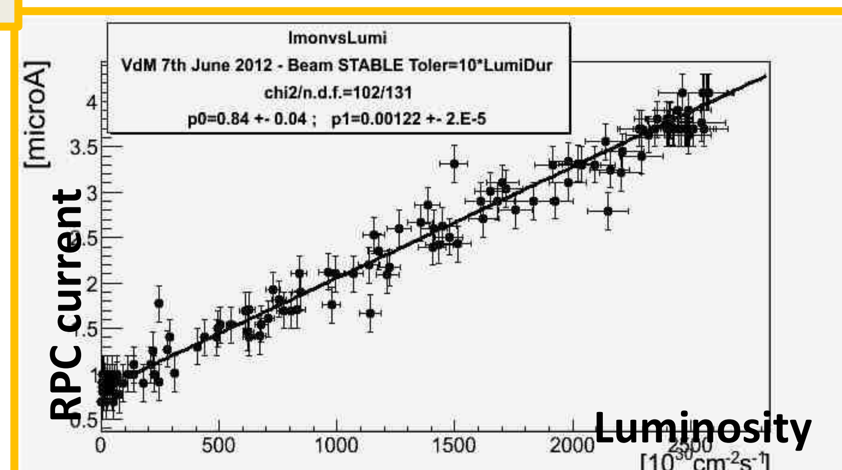
One luminosity value each ≈23s

Analysis still going on Run2 data



Van Der Meer Scan : possible to determine absolute luminosity $\mathcal{L}(\delta x, \delta y) = \frac{N_1 N_2 f N_b}{A_{eff}} F(\delta x, \delta y)$



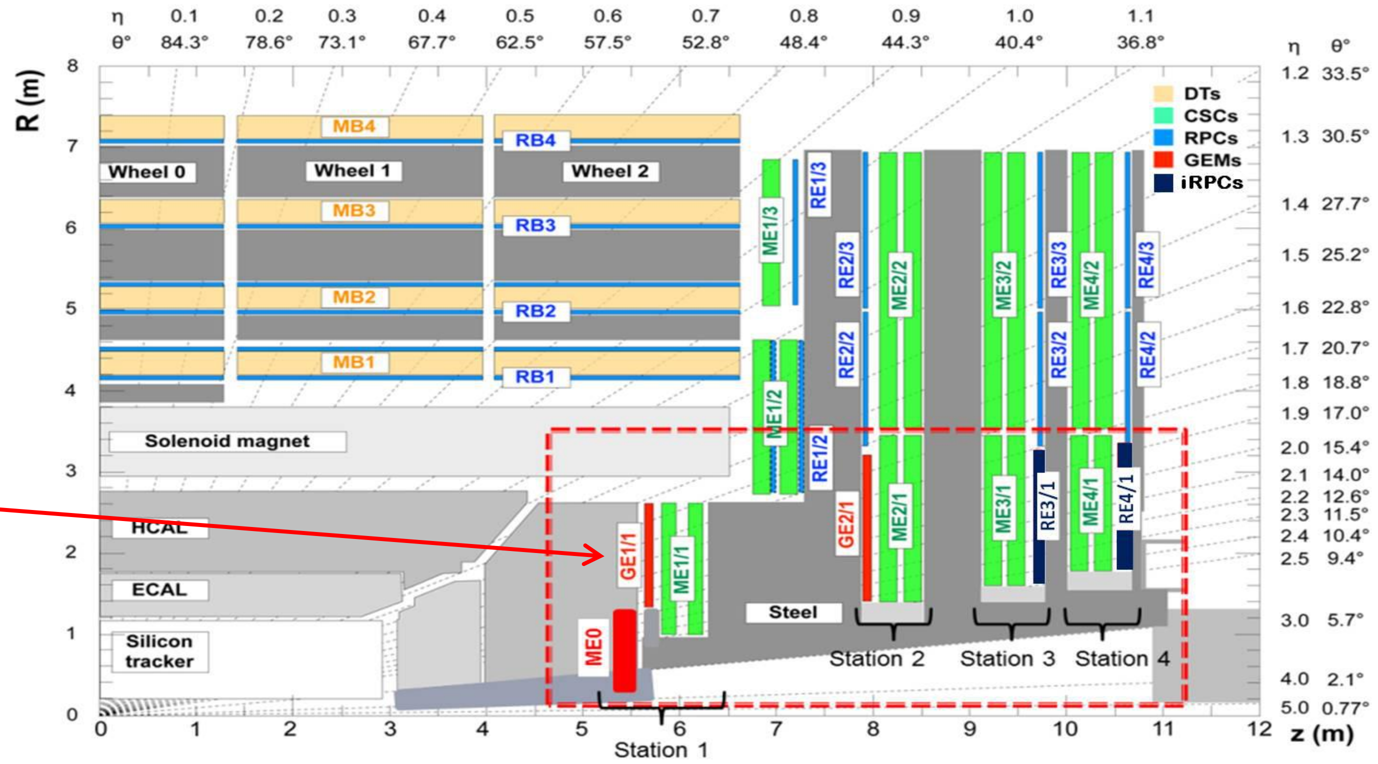


FASE 1 : GE1/1 project

Full installation in LS2 (2019-2020)

- **Improvement of the L1 and HLT muon momentum resolution, to reduce or maintain global muon trigger rate**
- **redundancy restored**

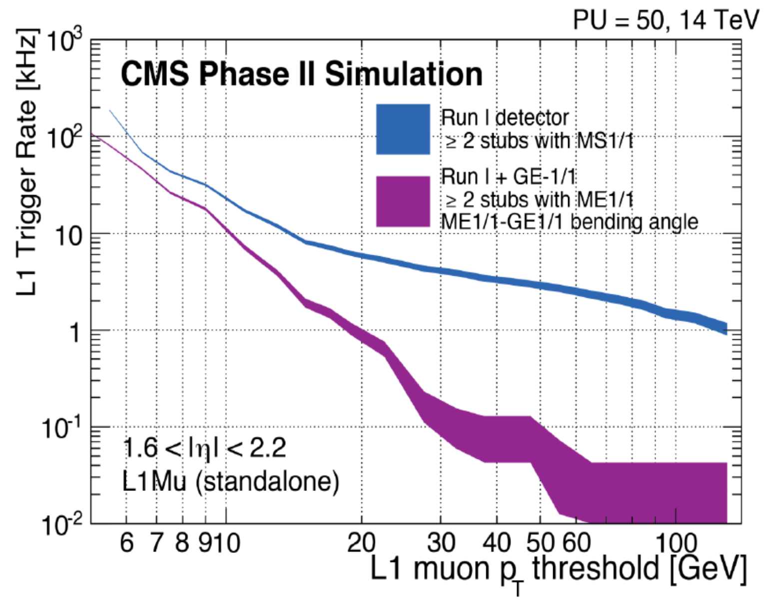
GE1/1 - Fase I
TDR approvato (10/2015)
Triple GEM

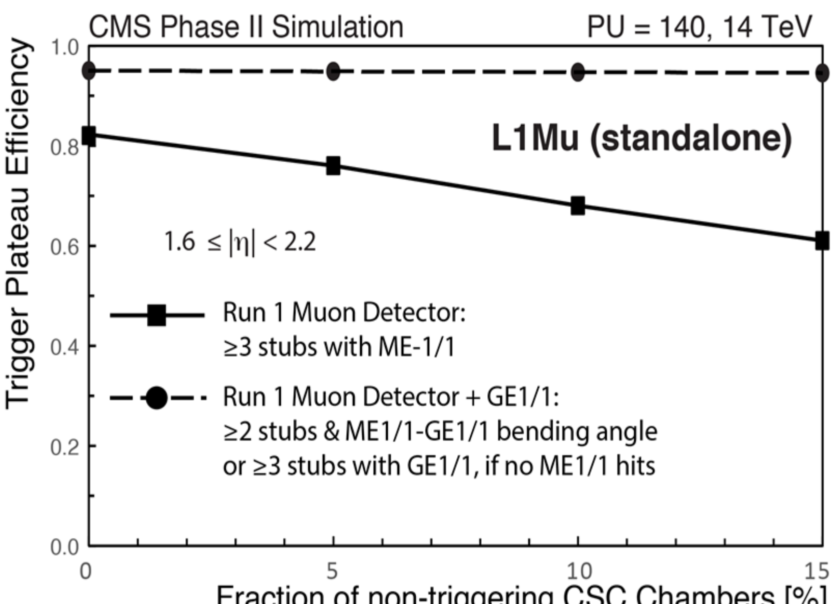


GE1/1 project

- **Improvement of L1 trigger rate as as function of p_T muon with GE1/1**

- **redundancy restored**



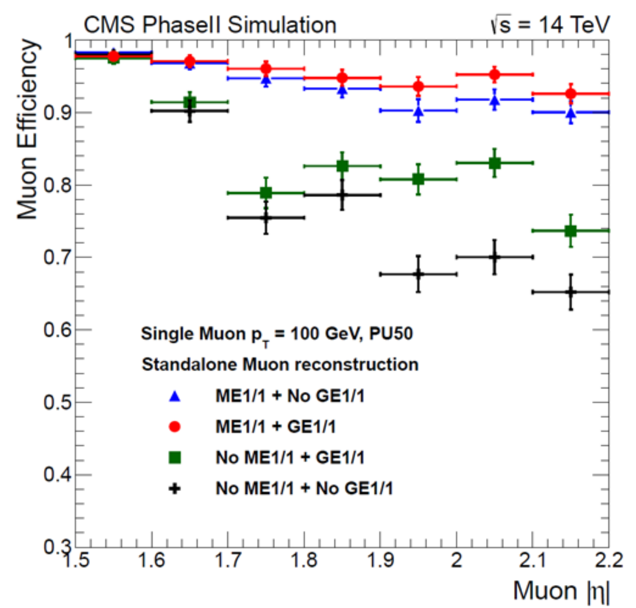


Only CSCs

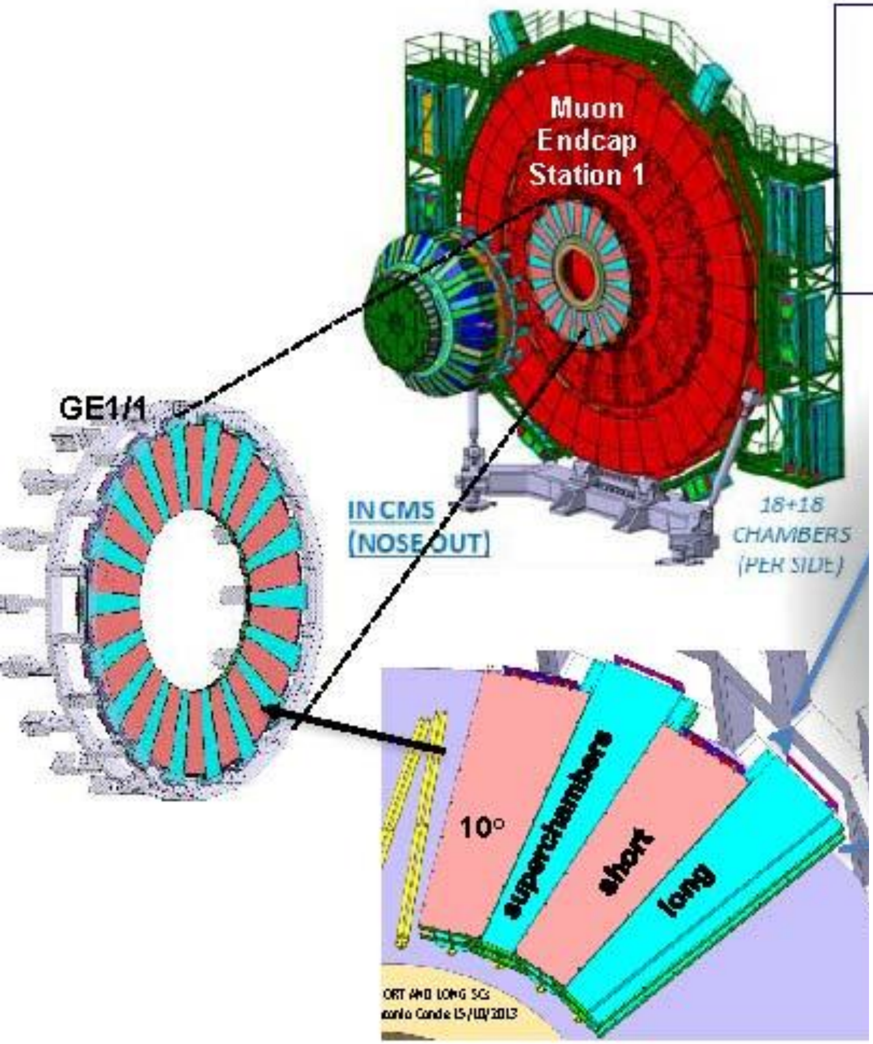
GEMs + CSCs

damaged CSCs

GEMs + damaged CSCs



THE GE1/1 DESIGN



Installation in LS2

GE1/1 in high-η region 1.5<|η|<2.2

10^0 trapezioidal triple-GEM Superchambers

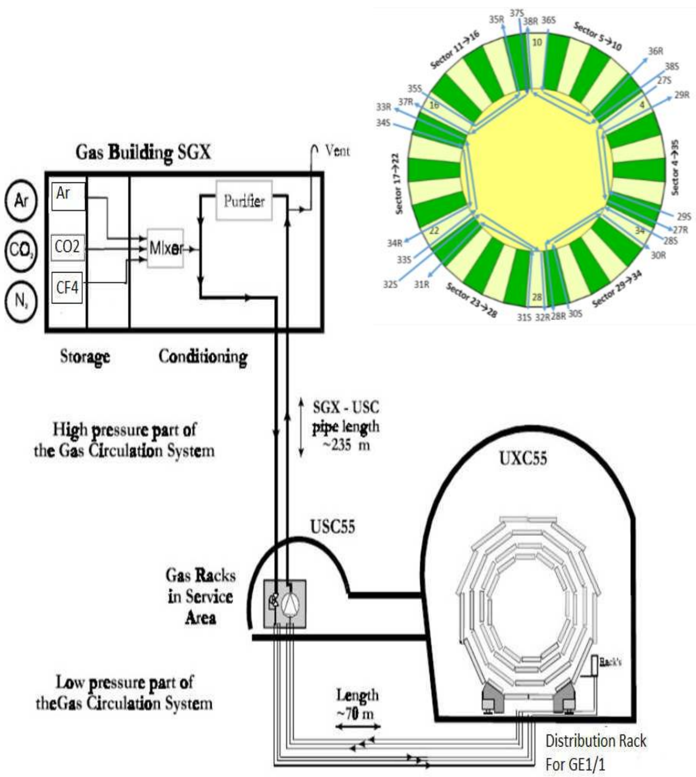
Long (1.5<|η|<2.2) and short (1.6<|η|<2.2) version

36 superchambers in each endcap

- Construction at CERN begun end of 2015 , now completed 4 SuperCh for «slice test»
- Services per integration are getting ready (see next slide) for the «slice test» (with four superchambers) to be installed during YETS 2016

GE11 Detector Control System (DCS) – Gas Panel

Ilaria Vai (similfellow 2016)

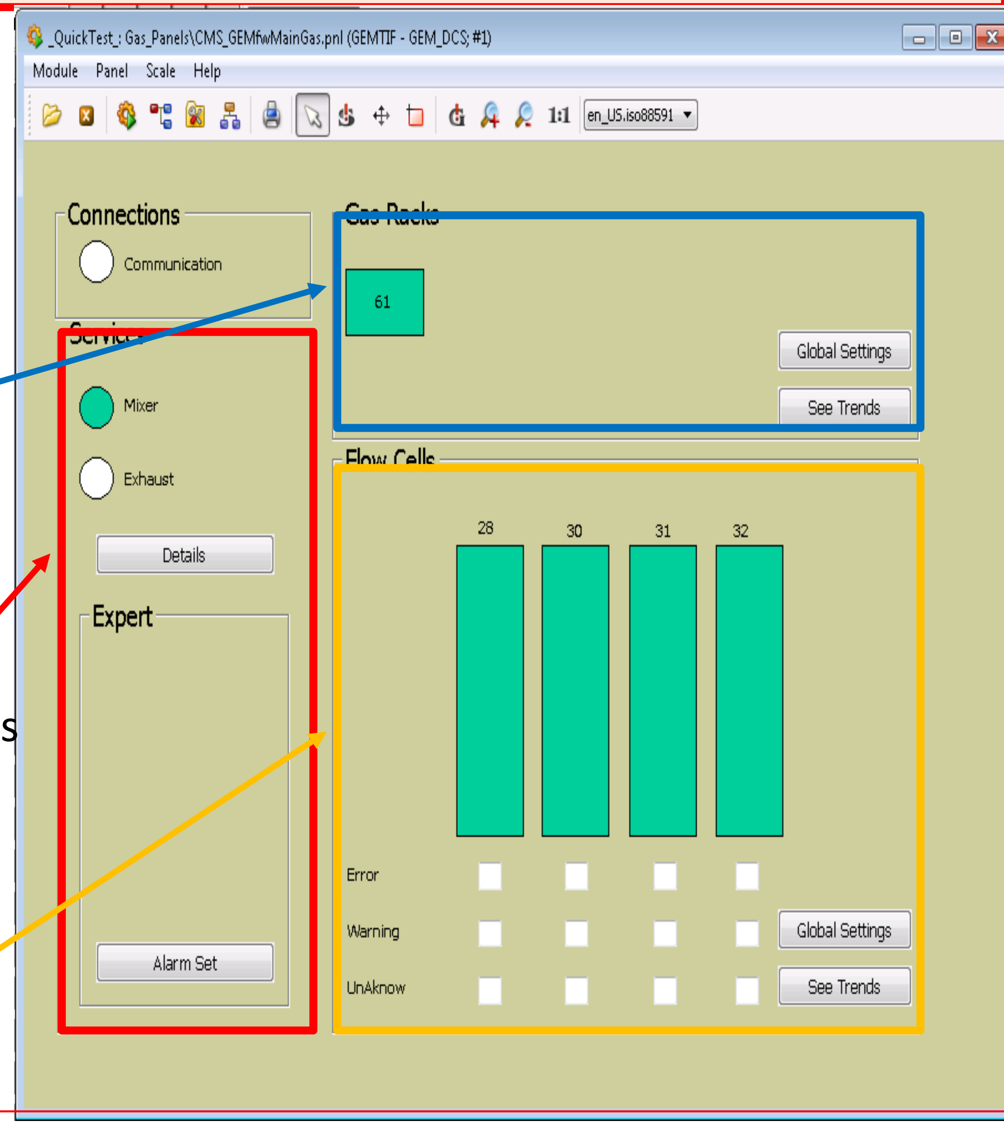


GE11 Gas System overview

Gas Racks

Services

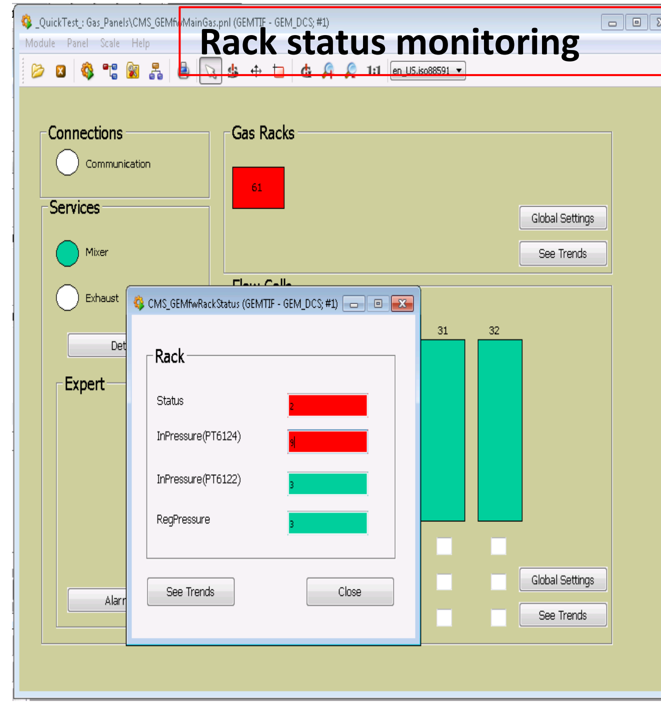
Flow Cells

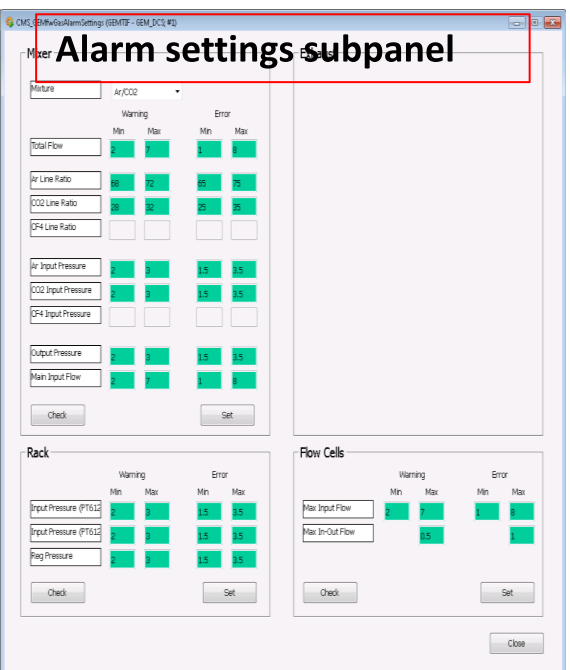


The main panel of the DCS Gas System includes three areas: the services, including the mixer, the exhaust and the alarm settings, the gas racks and the flow cells. The DCS, for the gas system, can onky be used to monitor parameters, not to set them, through DIP server.

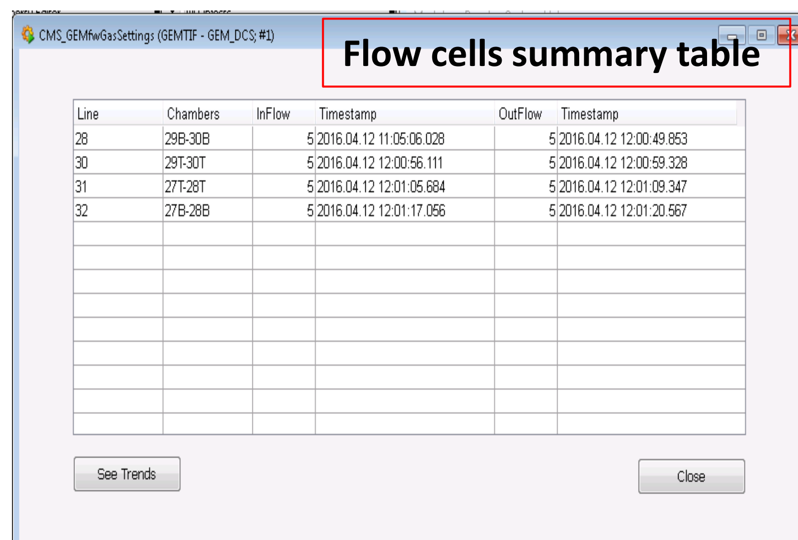
GE11 Detector Control System (DCS) – Gas Panel I.Vai

- The main structure of the gas panel for the DCS is completed and is implemented in the GEM FSM.
- Still some work is going on, in order to check and complete the error/warning implementation.
- Information on the relevant parameters for the Exhaust are needed in order to complete the services panel.

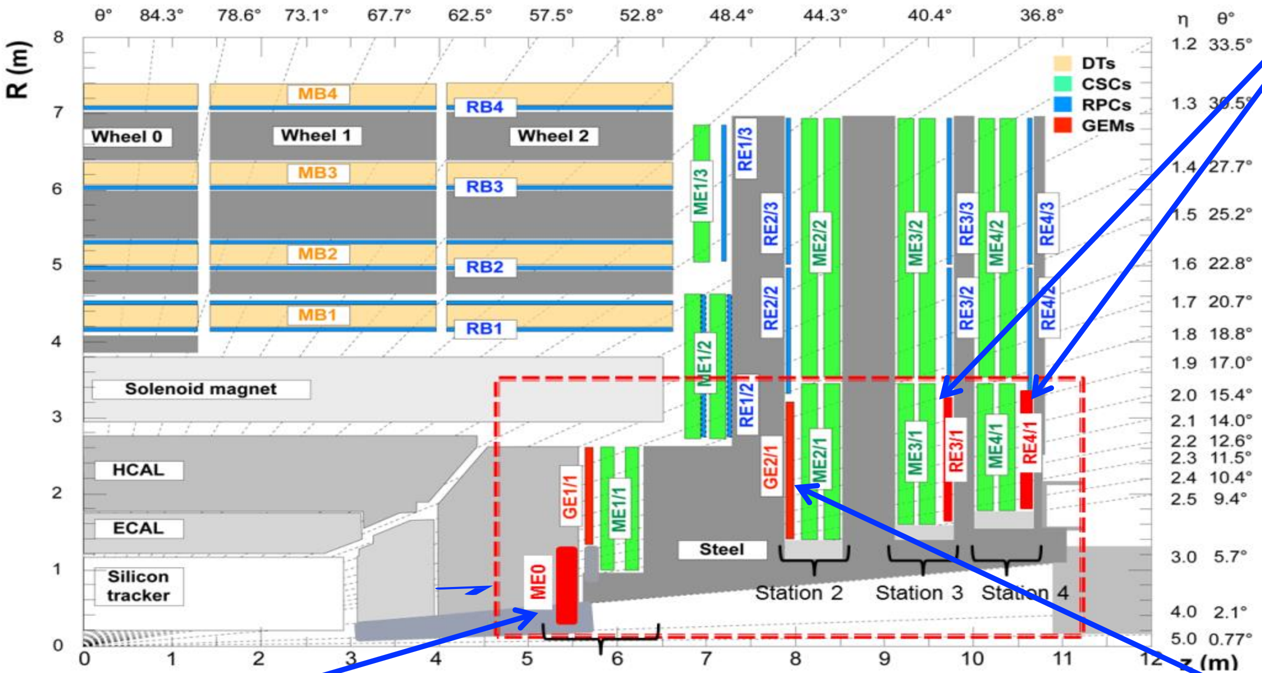




Similar work started on cooling panel.



Fase2 Forward muon system



RPCs:

NEW STATIONS RE3/1 and RE4/1
(1.6< |η| <2.4)
- 144 chambers (about 1.5-2.0 m^2 area) for the inner (ring n.1) region of disks 3 and 4

GEM Phase 2 : Trigger and reconstruction

ME0:

- **Muon tagger** at highest η (η <2.8)

1. *GEM*: GE1/1-like station, with more layers to reject background (6 layers)
2. *New improved MPGD detectors* for high time resolution

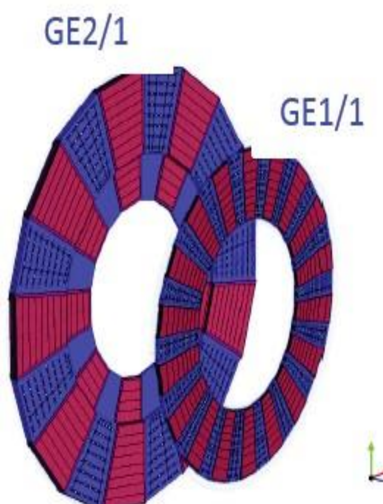
- Installation: LS3 (2022-24)

GE2/1:

- 1.6 < |η| < 2.5
- 18 staggered SC per endcap, each chamber covers 20°

1. *GEM*: GE1/1-like station
2. *New improved MPGD detector*
   μRWELL

- Installation: LS3 (2022-24)



CMS Pavia phase 2 R&D

Responsabilities :

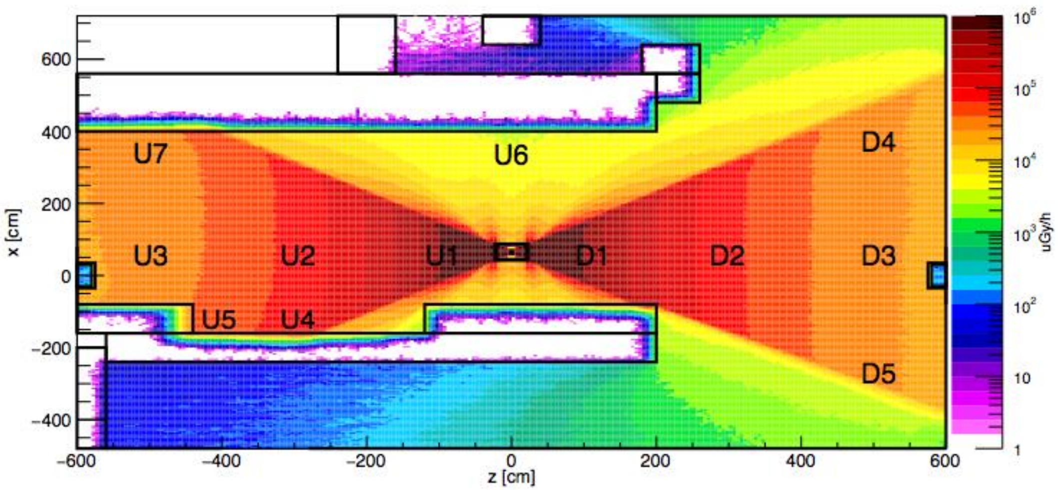
- P.Vitulo → coordinator R&D Phase II Upgrade Office
- I.Vai → Co-convener of the FTM detector R&D working group; responsible for CMS GEM DCS Gas Panel
- C.Riccardi → Responsabile Nazionale del progetto GEM di CMS
  → Deputy Chair del Muon Institutional Board di CMS

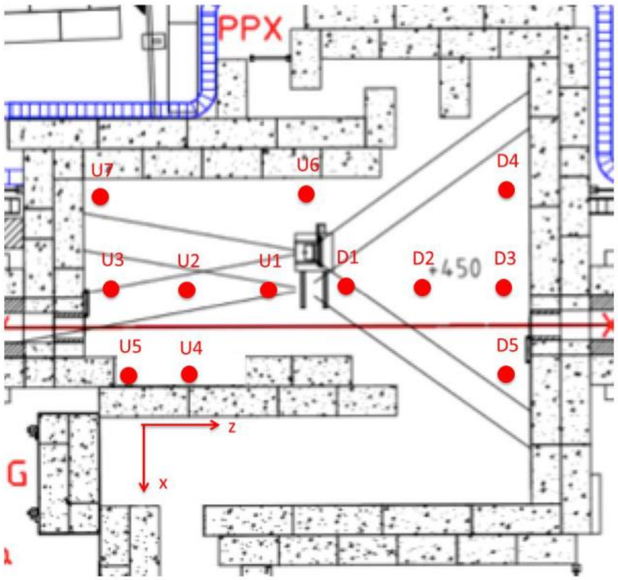
Activities:

- Very forward Muon system
  - Tests on FTM prototype for ME0 detector (F.Fallavollita,A.Magnani, M.Ressegotti, C.Riccardi, I.Vai,P.Vitulo)
- RPC Irradiation tests
  - Aging test on detectors and materials at GIF++ (A. Braghieri)
  - Resistivity measurements: C.Riccardi, P.Vitulo

Gamma Irradiation Facili

1. **16 TBq radioactive ^{137}Cs source (30 times more intense** than the old GIF (566 GBq)) - **Gamma rays 662 keV**
2. γ irradiation in the two directions **(upstream and downstream).** Adjustable intensity by moving filters.
3. **SPS secondary muon beam line in 2015.**





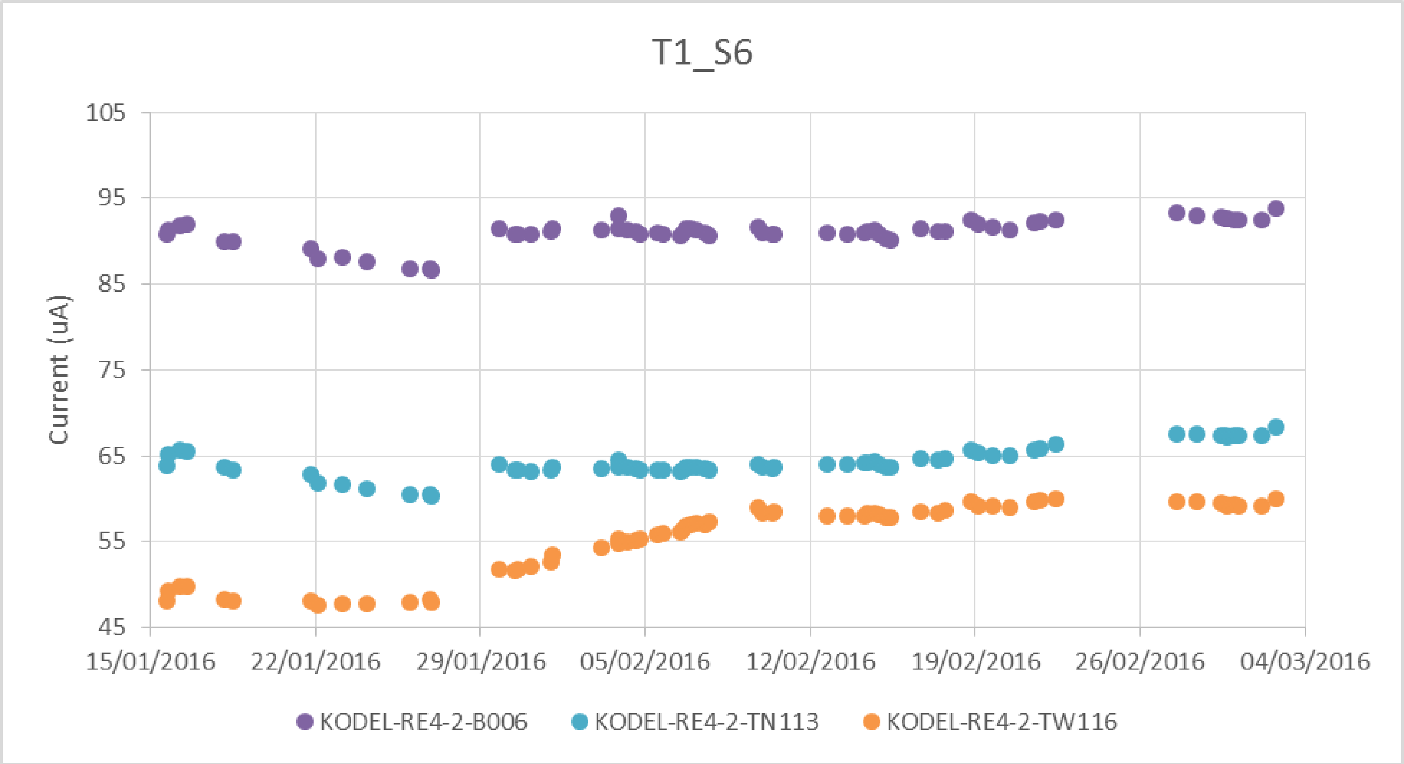
At the location of RPCs, we expect:

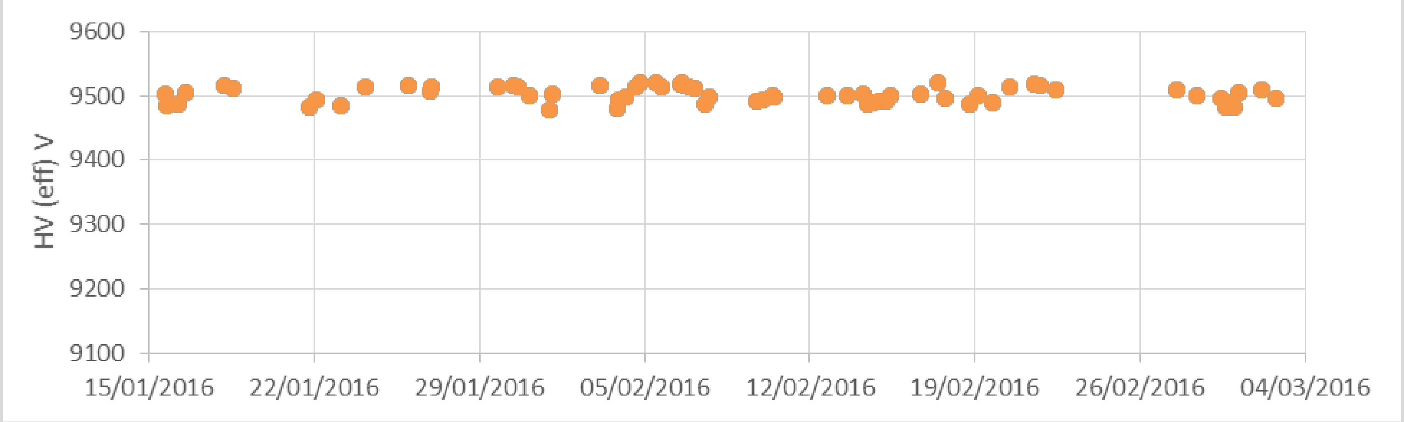
	U3-U7	U5	Note
Flux rate (g/s cm^2)	3.6 10^6	5.4 10^6	simulation presented on 25 April
Hit rate rate (kHz /cm^2)	8.6	13	Sensitivity ≈ 2.4 10^{-3}

Current Analysis for the RPC at GIF++
(A. Braghieri)

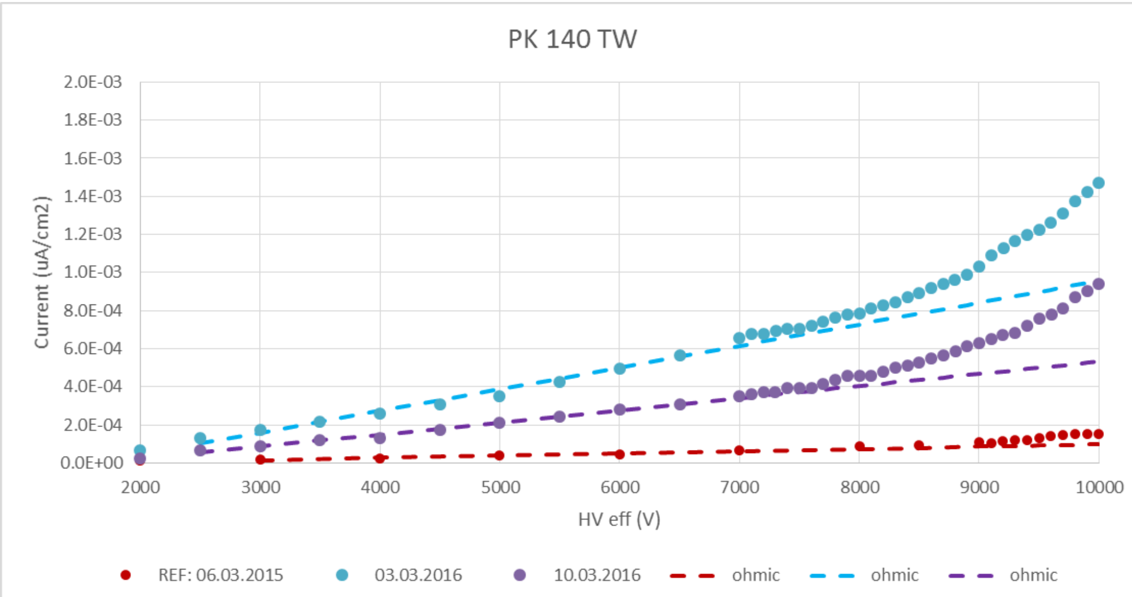
- The commissioning of the GIF++ facility started in February 2015 and user operations begun in March.
- After the set-up of the detectors and electronics, some test measurements were realized during the Summer, but the first systematic studies were not scheduled to start until October 2015.
- Several different measurements have been performed: current and HV monitoring focused on the «aging» measuments.
- Two chambers have been setup for that. The chamber:
- **PK140** (a CMS_RE2-2 type chamber)
- And a chamber assembled with 3 spare gaps, namely:
- **KODEL-RE4-2 B006, KODEL-RE4-2 TN113, KODEL-RE4-2 TW116**
- The currents of the gaps were monitored during several irradiation cycles. Each cycle was normally 8 days long. The gaps were kept at the operative voltage, about 9.8 kV for the PK140 gaps and about 9.5 kV for the others.
- The source intensity was at the maximum value (no attenuators).
- The gap PK140 Top Wide was switched on only in a few cycles, while the others were constantly operative. Therefore, this gap provides a reference for unirradiated case

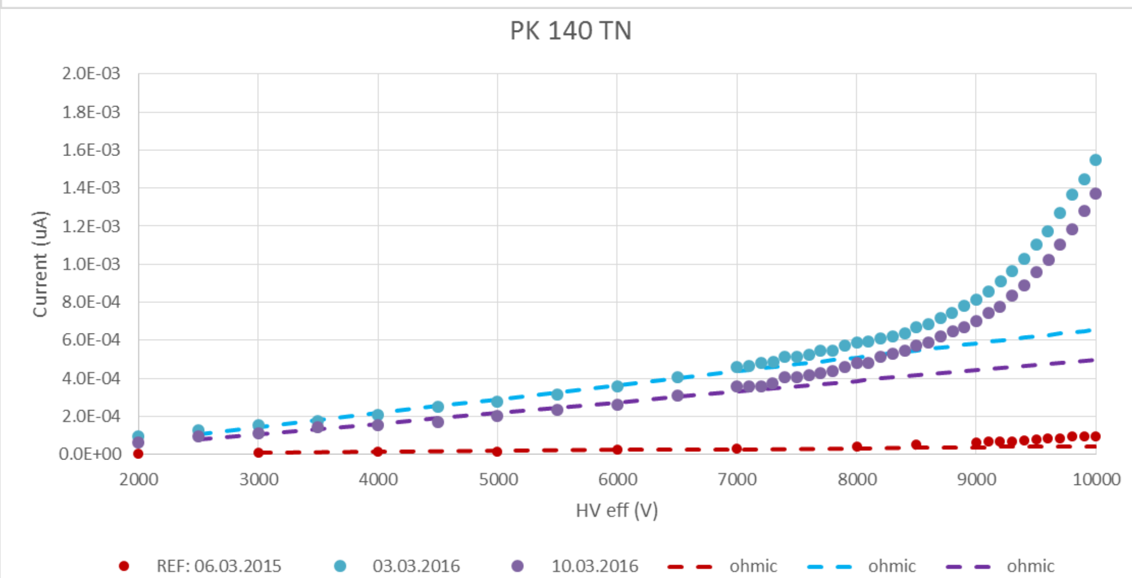
Current and HV monitor





HV scans (source OFF)

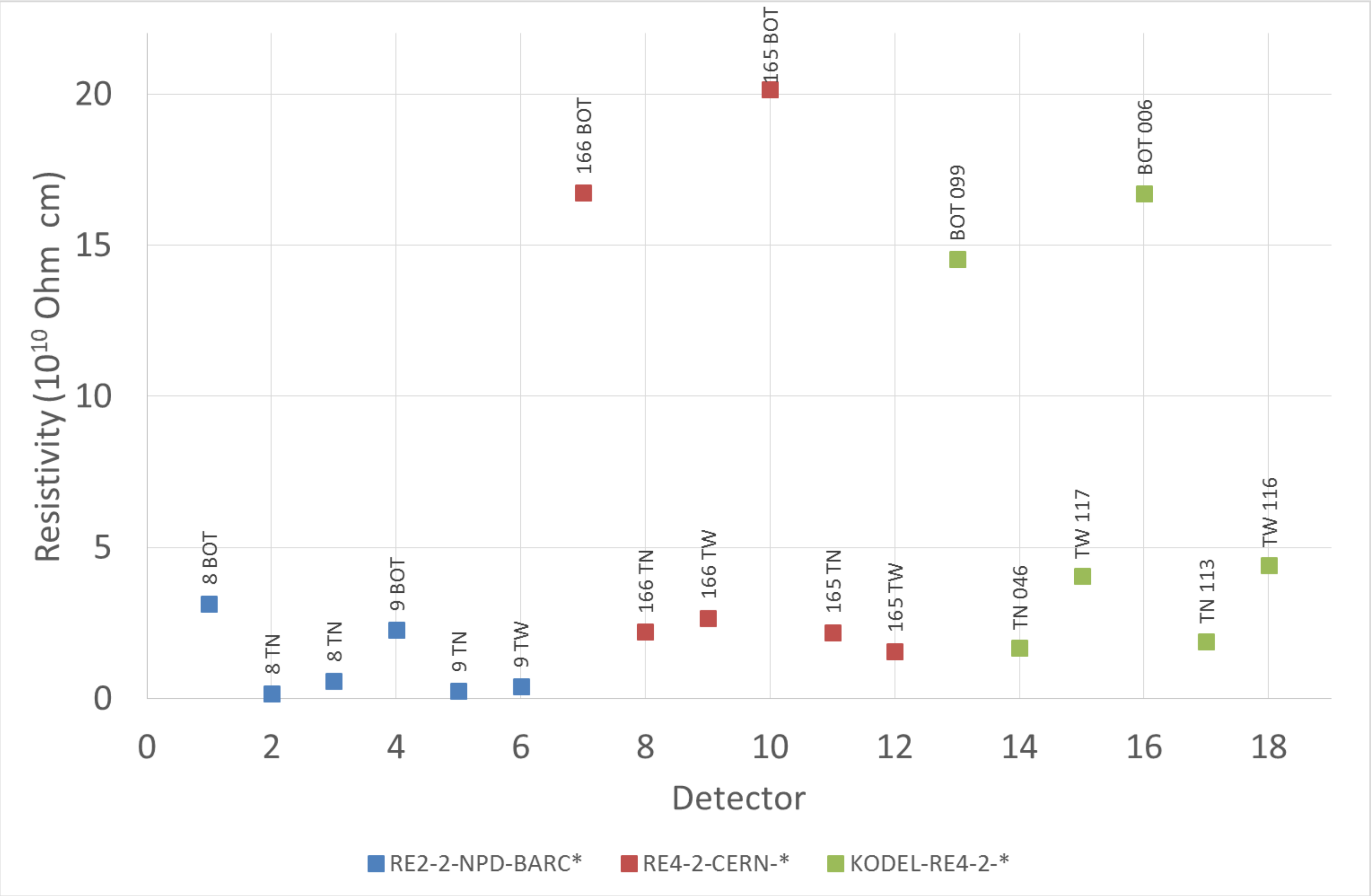




- The gaps current has been measured at different voltages, ranging from zero to the operative voltage in steps of few tens of Volts.
- This procedure allows to study the ohmic and the multiplicative components of the gap.
- A similar measurement was obtained in March 2015, before moving the gaps to the GIF++. Therefore, the comparison between this and the following measurements is important to study the performance of the gaps having received some radiation dose.

RPC Resistivity Measurements at GIF++ (A.Braghieri, C.Riccardi,P.Vitulo)

- Oct9-10 2015 : Pure Argon



Very forward extension: ME0

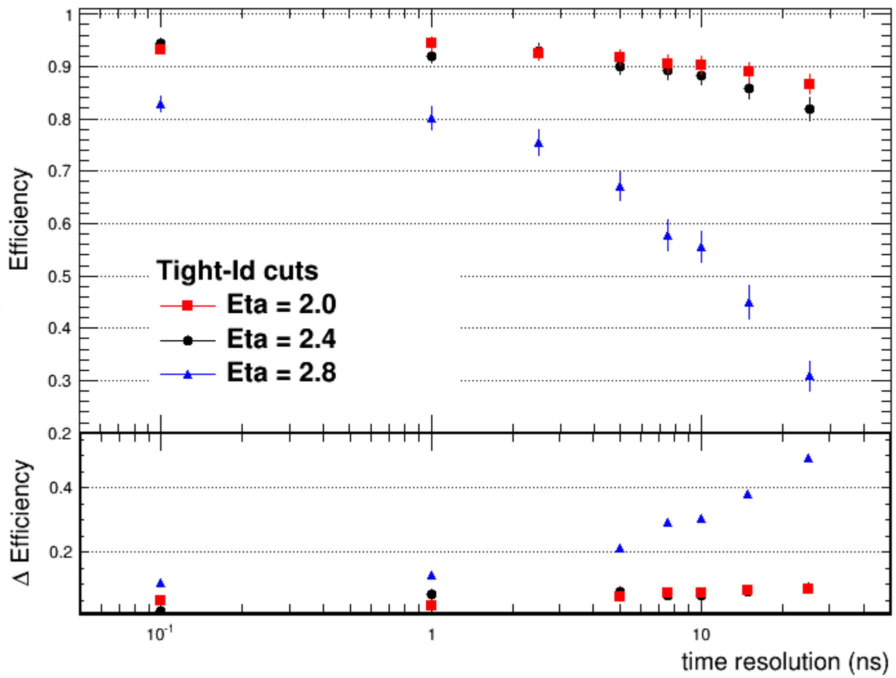
ME0 extends muon coverage behind the new endcap calorimeter to take advantage of the pixel tracking coverage extension for efficient muon ID with low background.

Detector requirement:

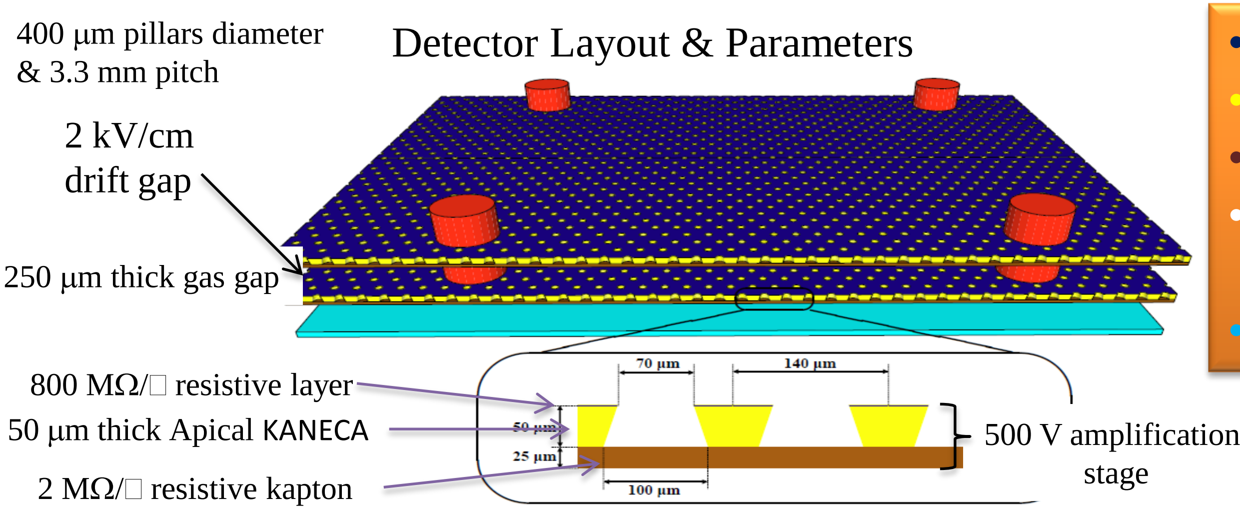
- Multilayer structures
- High rate capability O(MHz/cm^2)
- Good time resolution for triggering and PU mitigation
- Good spatial resolution O(100 μm) for tracking

- Tracking & triggering with p_t measurement
- Low sensitivity to neutrons
- Improvement muon-ID from HGC and tracker

In presence of neutron background, we see unaffected Tight ME0 MuonID efficiency plateau for high time resolution detectors (100 ps – 1 ns).



MEO: Fast Timing Micropattern detector



- **DLC coating on the top**
- **Perforated foils**
- **Antistatic polymide foils**
- Two layers separated by **Pillars**
- **Pick-up electrode**

arXiv:1503.05330v1

Maggi, De Oliveira, Sharma

- **two independent drift-amplification stages**
- **resistive layers**
  - which solve problem of **sparks** between anode and cathode
  - The overall structure is **transparent** to the signal which can be extracted in every amplification stage
  - allow the construction of **consecutive drift-amplification stages**

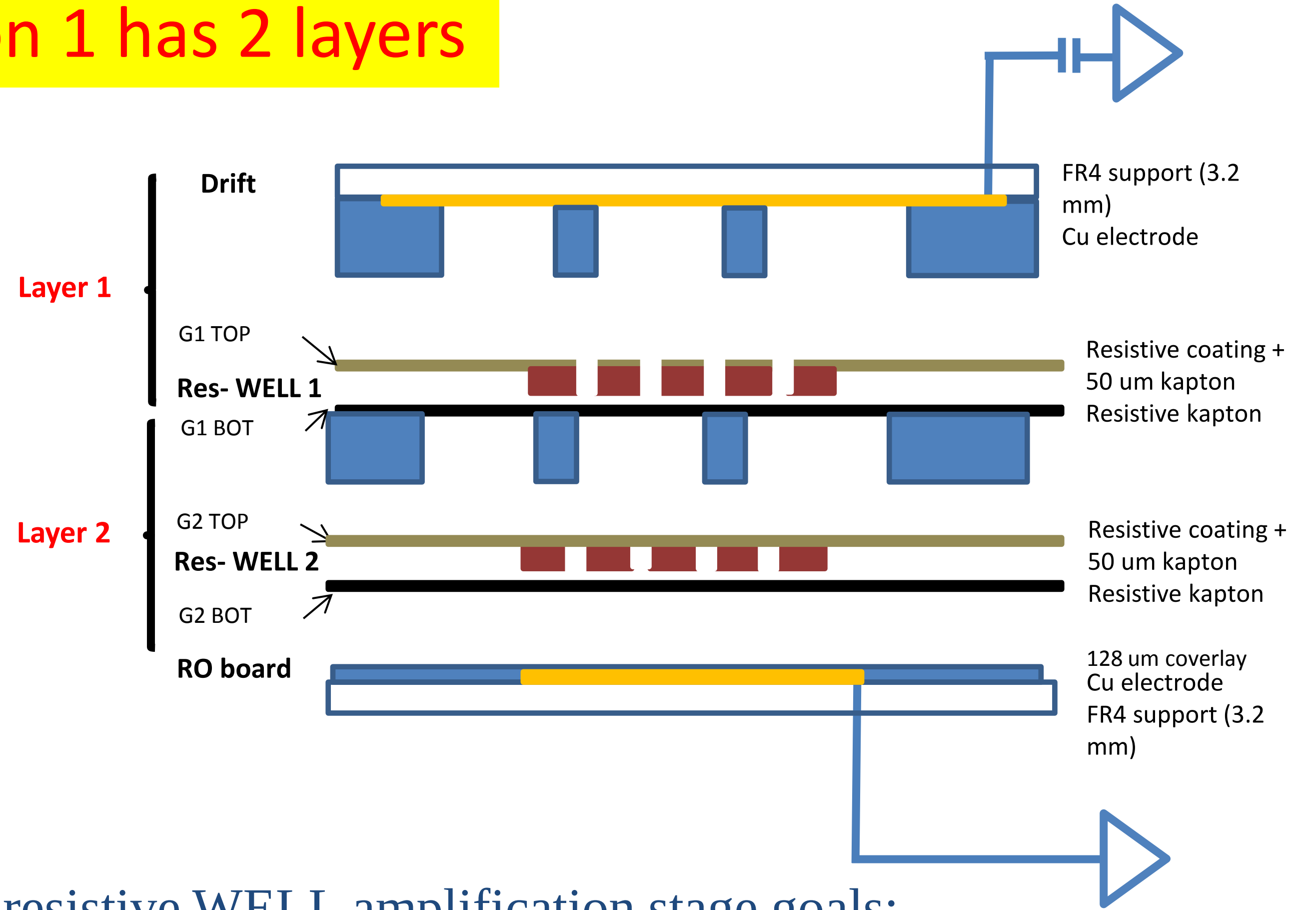
- **Improvement in time resolution** :

  - Decrease of the arrival time of the nearest ionization to any multiplication volume → Decrease in the fluctuations

Test on FTM detector

(F.Fallavollita, M.Ressegotti, I.Vai, P.Vitulo)

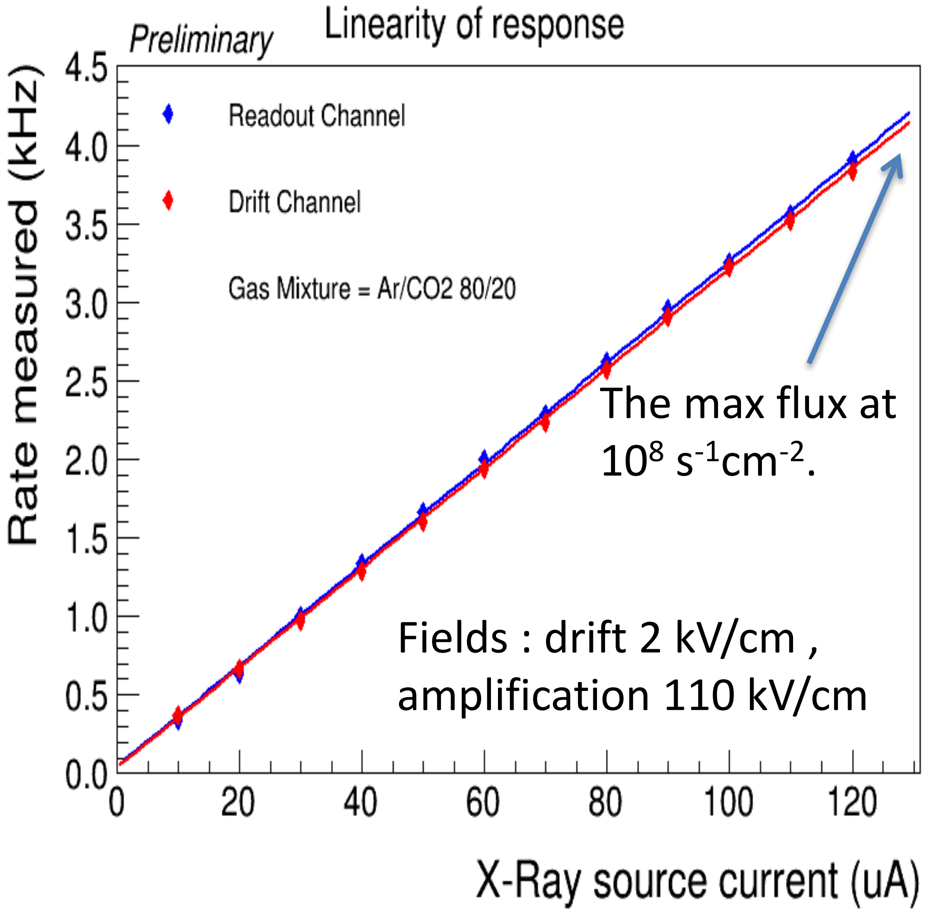
Version 1 has 2 layers



Full resistive WELL amplification stage goals:

- Signals picked up by the external electrodes;
- High rate capability;
- Sub ns time resolution with more gaps in cascade;

Linearity and transparency

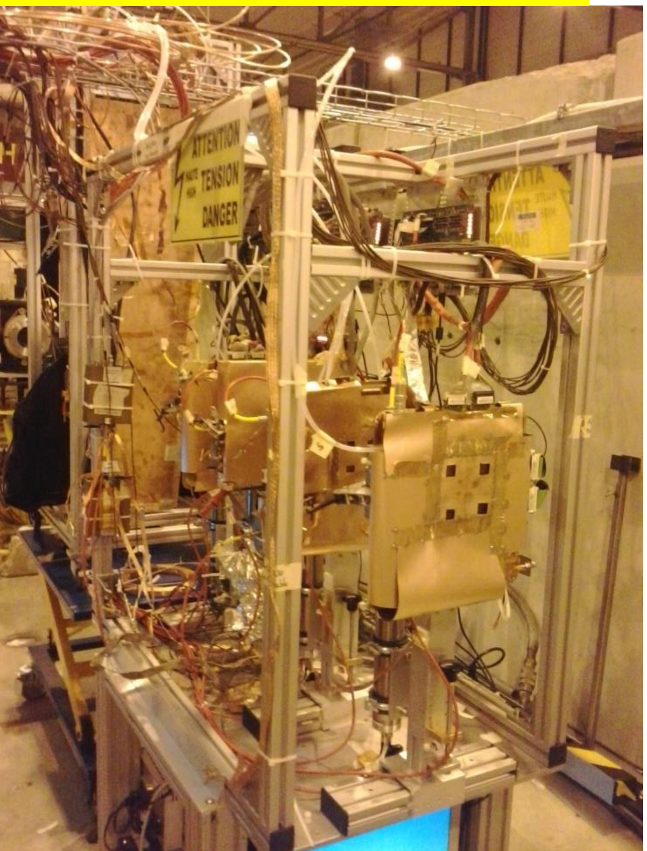


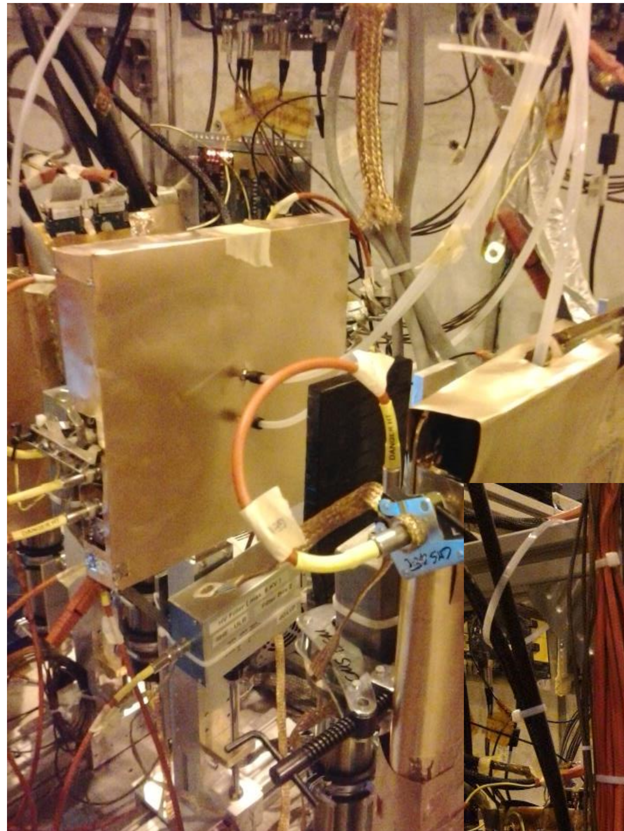
Ag - MiniX Amptek:
10^6 s^{-1} mm^{-2} on the axis
at 30 cm (50 keV/1 μA)

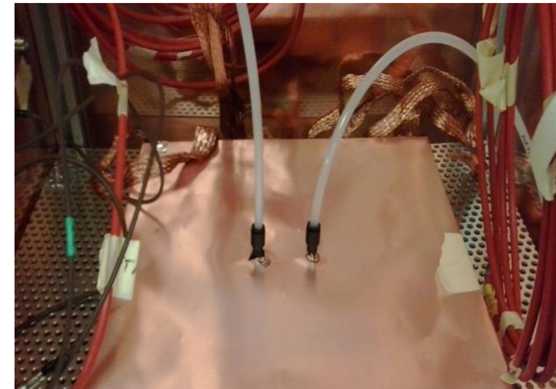
preamplifier ORTEC 142PC
amplifier ORTEC 474.

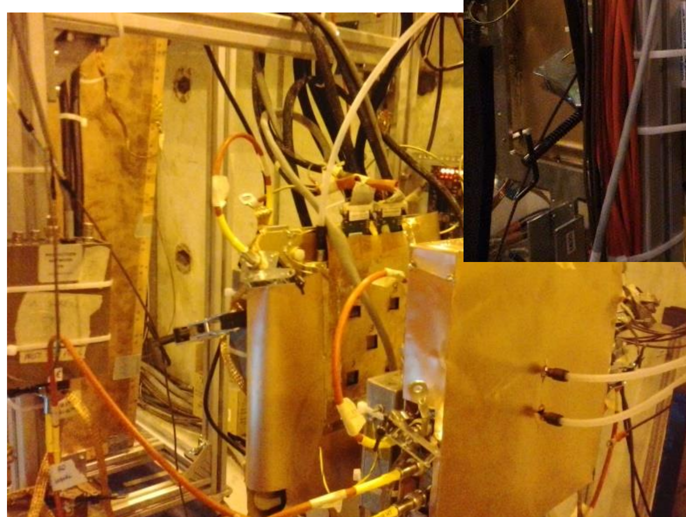
- **Linearity of response** with the incident flux for both data sets, i.e.: signals collected from readout board and drift cathode.
- **Electrical transparency** of the layers → Rates obtained with signals from readout board and drift cathode are comparable

Installation in H4



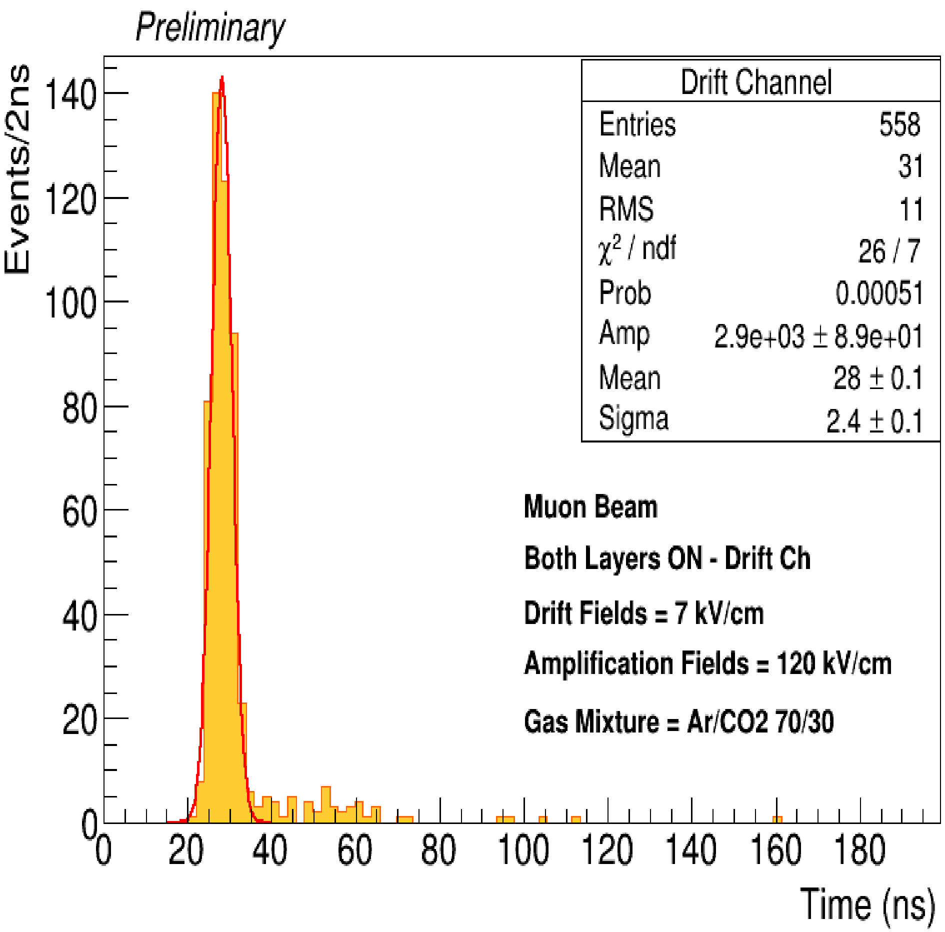




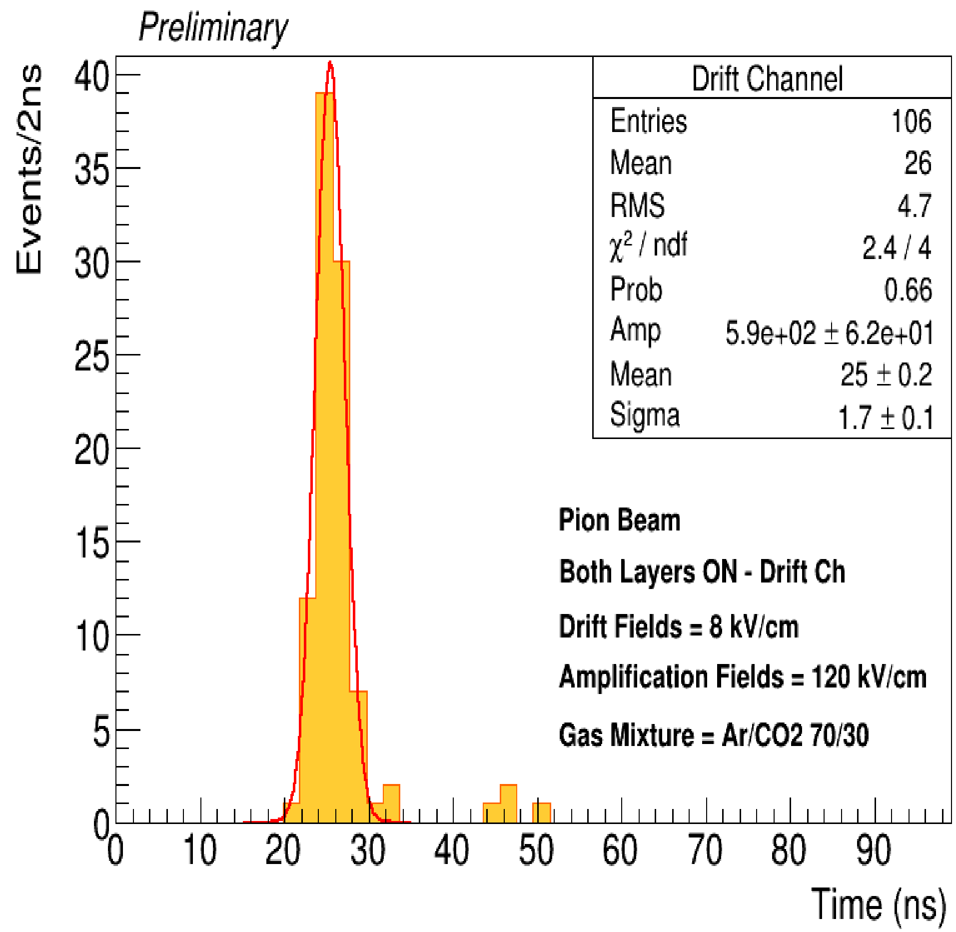


TDC output : signal from drift channel

Muon beam



Pion beam



Readout chain: Cividec broadband diamond amplifier and Lecroy linear amplifier.

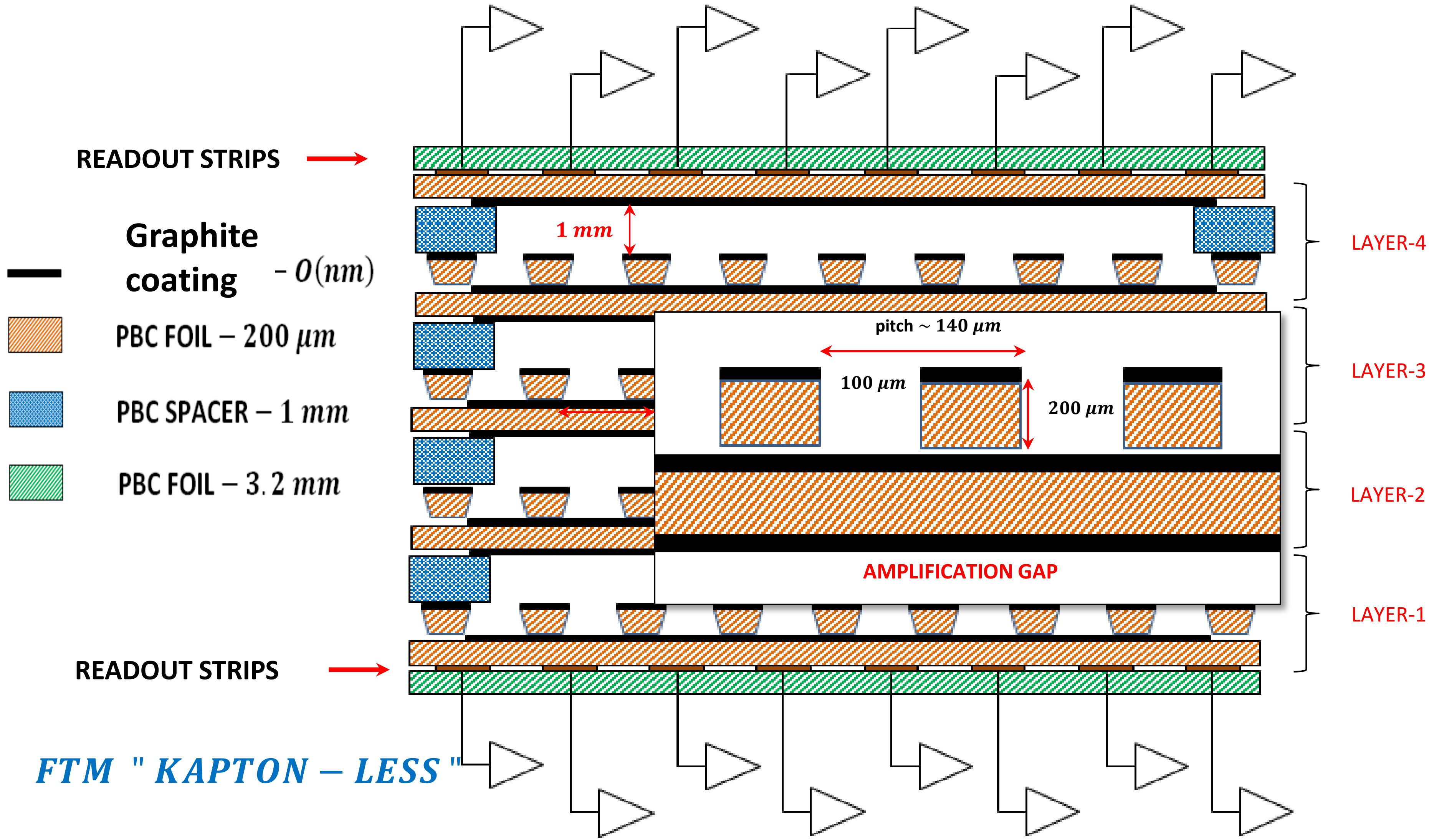
Typical energy 150 GeV with an intensity of 10^4 part/spill

Results presented in a parallel talk at VCI2016, proceedings NIMA_PROCEEDINGS-D-16-00179 in publication

FTM: Design of the new Prototype under test in 2016 :

- 4 drift gaps and 4 amplification regions

F.Fallavollita,



FTM " KAPTON – LESS "

MONSTER & CO

***Mon**itoraggio di **St**ruttura **E**dili mediante **R**aggi **Co**smici*

L'esperienza del gruppo pavese sulla rivelazione dei muoni è proposta in ambito edilizio

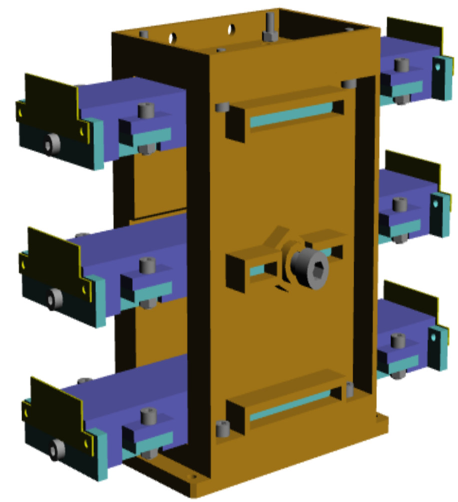
Francesco Fallavollita, Paolo Vitulo

(in collaborazione con il Dipartimento di Ingegneria Meccanica e Industriale - Università di Brescia [Zenoni et al.])

SISTEMA DI MISURA PER IL MONITORAGGIO DI STABILITÀ DI GRANDI COSTRUZIONI CIVILI TRAMITE L'USO DI RAGGI COSMICI

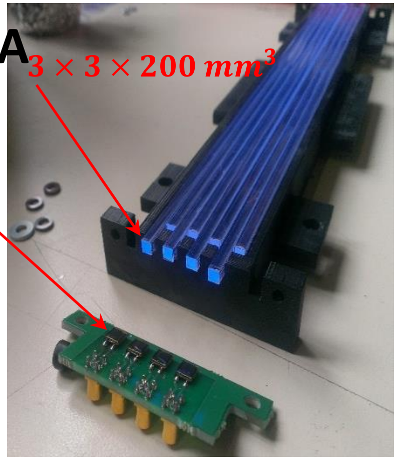
(in collaborazione con il Dipartimento di Ingegneria Meccanica e Industriale - Università di Brescia [Zenoni et al.])

PROTOTIPO DI RIVELATORE SU SCALA RIDOTTA



- due telescopi muonici costituiti da tre sottomoduli
- tutti i supporti meccanici realizzati in ABS mediante stampa 3D
- ogni sottomodulo costituito da 8 fibre scintillanti
  (BCF-10 della Saint-Gobain)
- ogni fibra otticamente accoppiata ad un SiPM
  (SiPM3S-P della AdvanSiD)

CONTROLLO DEL SISTEMA CON NUOVA ELETTRONICA



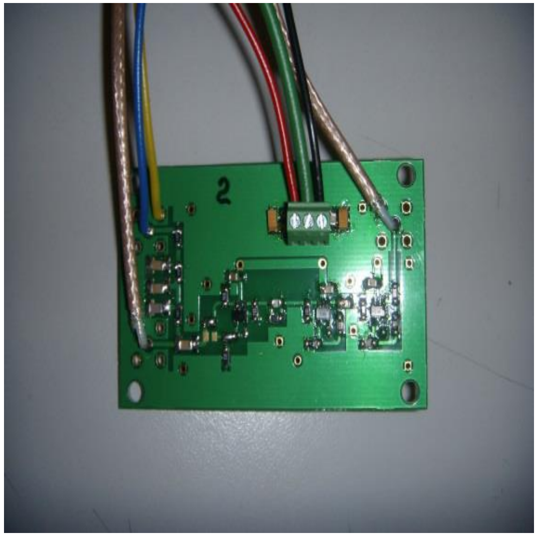
- CARATTERIZZAZIONE DEI SiPM
  (misure di corrente di buio e tensione di breakdown)
- CARATTERIZZAZIONE DEL SISTEMA FIBRE SCINTILLANTI ACCOPPIATE AI SiPM
  (misure di lunghezza di attenuazione, risoluzione temporale e cross-talk tra fibre)

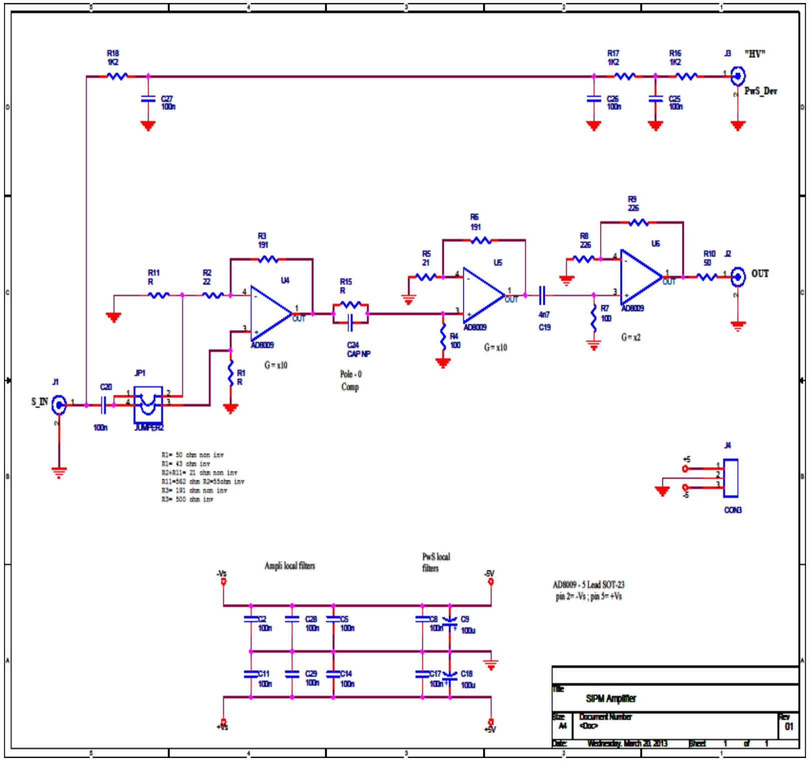
SISTEMA DI MISURA PER IL MONITORAGGIO DI STABILITÀ DI GRANDI COSTRUZIONI CIVILI TRAMITE L'USO DI RAGGI COSMICI

(in collaborazione con il Dipartimento di Ingegneria Meccanica e Industriale - Università di Brescia [Zenoni et al.])

REALIZZAZIONE FINALE E CARATTERIZZAZIONE DEGLI STADI DI AMPLIFICAZIONE

- misure di guadagno e linearità
- misura della banda passante
- risposta al doppio impulso





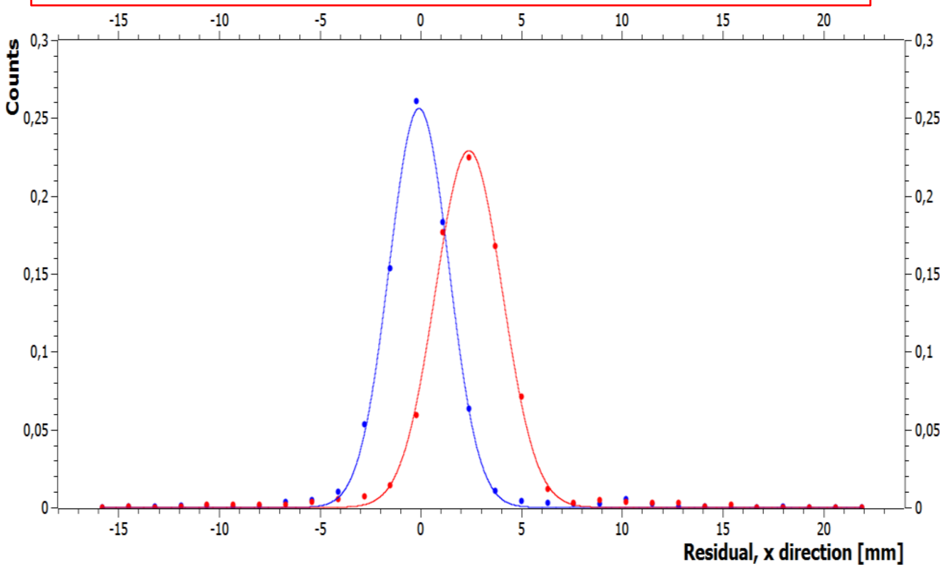
STADIO DI AMPLIFICAZIONE (ELETTRONICA SMD - *SURFACE MOUNT DEVICE*)

I segnali dai SiPM amplificati con un modulo di amplificazione a tre stadi (3 amplificatori AD8009 - 10 dB di guadagno)

SISTEMA DI MISURA PER IL MONITORAGGIO DI STABILITÀ DI GRANDI COSTRUZIONI CIVILI TRAMITE L'USO DI RAGGI COSMICI

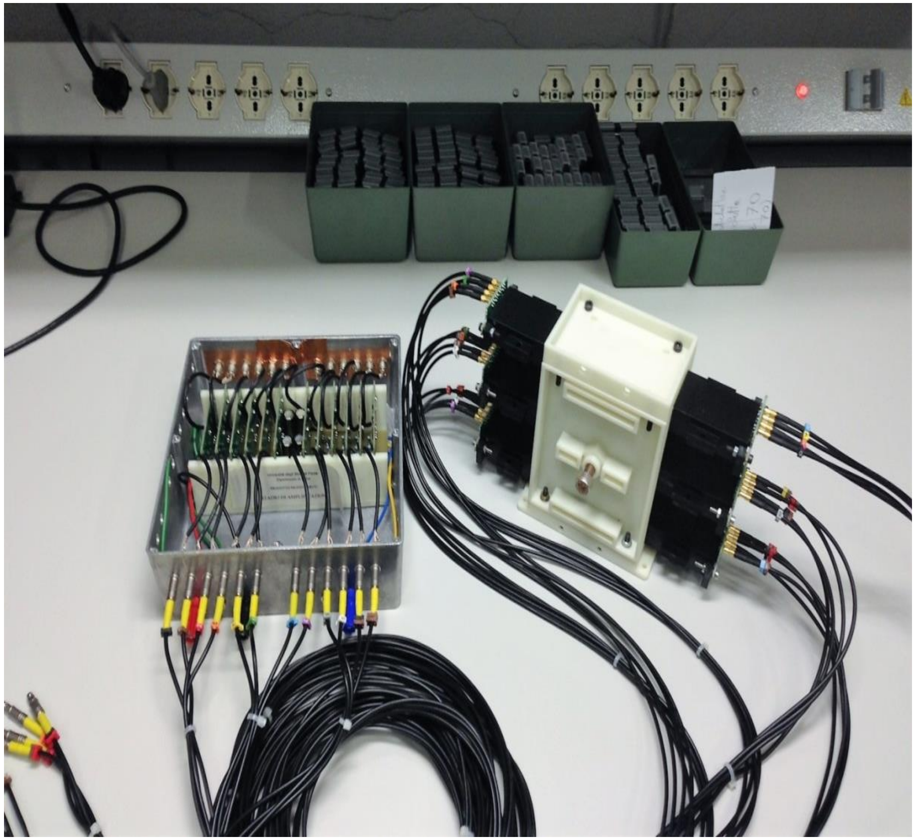
(in collaborazione con il Dipartimento di Ingegneria Meccanica e Industriale - Università di Brescia [Zenoni et al.])

ESEMPIO DI DISALLINEAMENTO DEL PIANO CENTRALE DI $3mm$ RISPETTO AI DUE RIVELATORI DI TRIGGER



- realizzazione dell'*hardware* e del *software* di acquisizione dati
  (DAQ realizzato mediante LabVIEW)

- misura dell'efficienza del rivelatore
- realizzazione di un algoritmo per la ricostruzione delle tracce e misura del disallineamento dei rivelatori sul piano orizzontale



TELESCOPIO MUONICO ULTIMATO E CABLATO CON RELATIVA ELETTRONICA DI AMPLIFICAZIONE

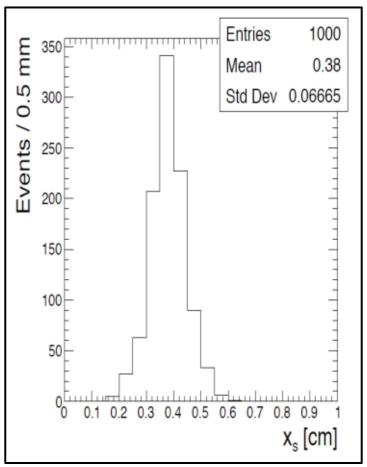
SISTEMA DI MISURA PER IL MONITORAGGIO DI STABILITÀ DI GRANDI COSTRUZIONI CIVILI TRAMITE L'USO DI RAGGI COSMICI

(in collaborazione con il Dipartimento di Ingegneria Meccanica e Industriale - Università di Brescia [Zenoni et al.])

Studio degli effetti di scattering multiplo dovuto al materiale (Al) interposto tra il target e il telescopio muonico

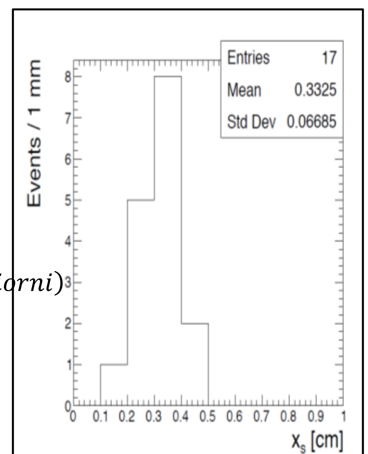
ESEMPIO DI DISALLINEAMENTO DEL TARGET MUONICO DI $3{,}7 mm$ RISPETTO AL TELESCOPIO MUONICO

SIMULAZIONI MONTE CARLO



CAMPIONI DA 100 EVENTI CIASCUNO ($\sim 2\ giorni$)

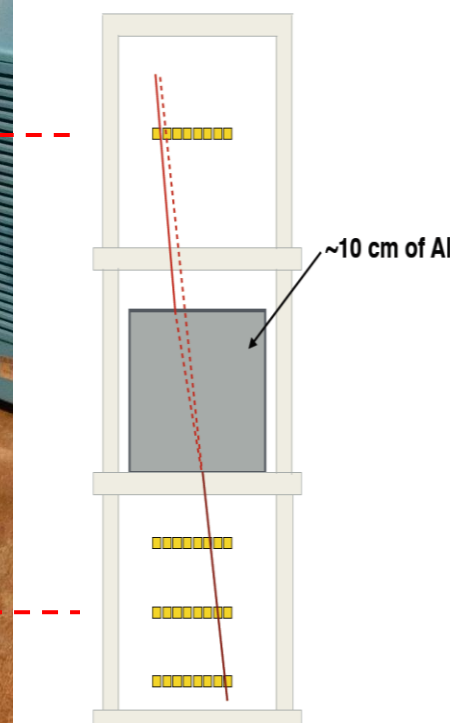
DATI SPERIMENTALI



17 CAMPIONI DA 100 EVENTI CIASCUNO ($\sim 2\ giorni$)

ASSEMBLAGGIO DEL TARGET MUONICO

RIVELATORE BERSAGLIO



TRACCIATORE DI MUONI

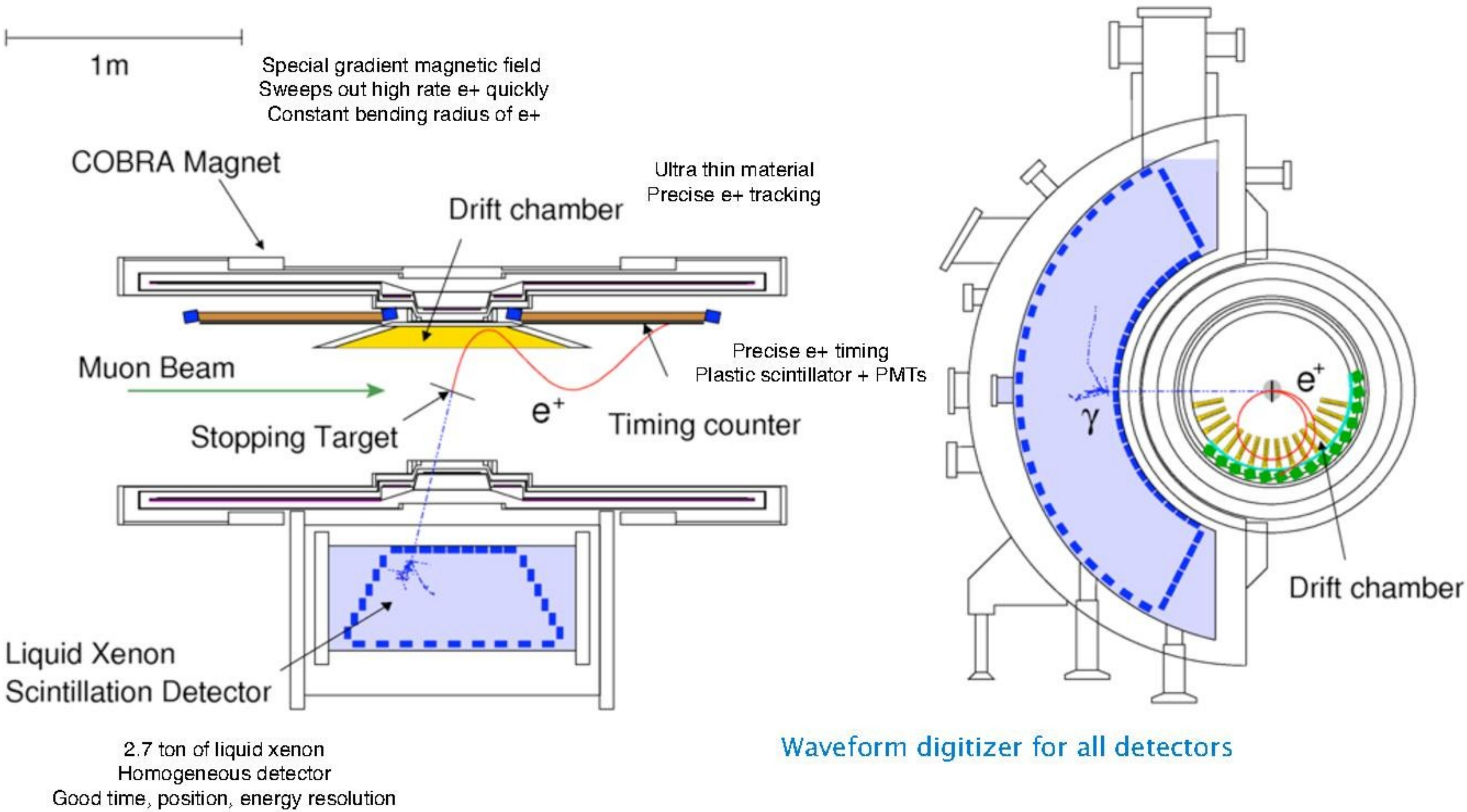
Report on MEG experiment

Search for Lepton Flavor Violation in $\mu \to e^+\gamma$ decay

Paolo Walter Cattaneo
Consiglio di Sezione
6 Giugno 2016

MEG Experiment

The most intense DC muon beam, 3×10^7 μ/s @ PSI, Switzerland



Waveform digitizer for all detectors

Likelihood Analysis Summary

	Best fit	UL (90% C.L.)	Sensitivity
2009-2011	1.3×10^{-13}	6.1×10^{-13}	8.0×10^{-13}
2012-2013	-5.5×10^{-13}	7.9×10^{-13}	8.2×10^{-13}
2009-2013	-2.2×10^{-12}	4.2×10^{-13}	5.3×10^{-13}

Result submitted for publication: arxiv:1605:05081

Papers in 2015/2016

1) Measurement of the radiative decay of polarized muons in the MEG experiment, EPJC 76(3) (2016) 108.

2) Muon polarization in the MEG experiment: predictions and measurements, EPJC in press (2016).

3) Time resolution of time-of-flight detector based on multiple scintillation counters readout by SiPMs, NIMA 828 (2016) 92

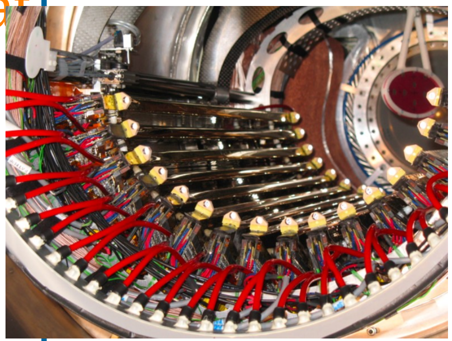
4) Test and characterization of SiPMs for MEGII high resolution timing counter, NIMA 824 (2016) 145

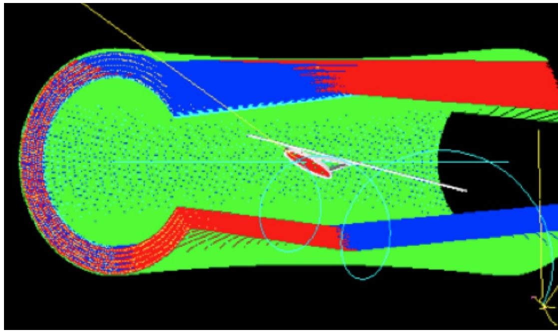
5) A high resolution TC for the MEGII experiment, NIMA 824 (2016) 92

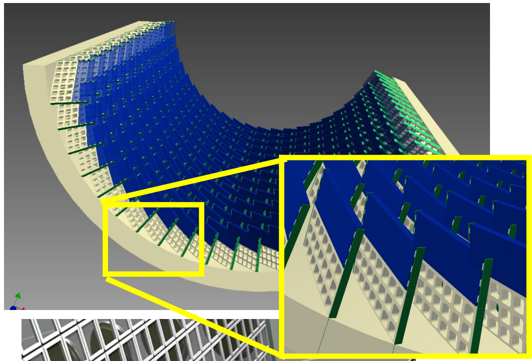
6) A dedicated calibration tool for the MEG and MEGII positron spectromenter, NIMA 824 (2016) 575

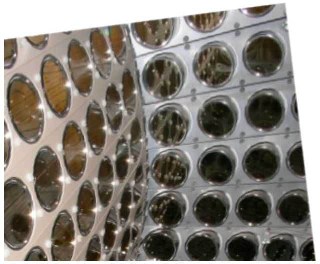
MEG Upgrade

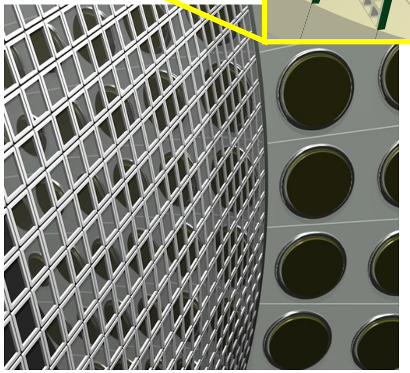
- MEG upgrade approved at PSI in Jan. 2013
- Upgraded items
  - Higher μ intensity
  - Single volume drift chamber with stereo angle configuration
  - Pixelated timing counter with SiPM readout
  - LXe detector with SiPM readout
  - Thinner target









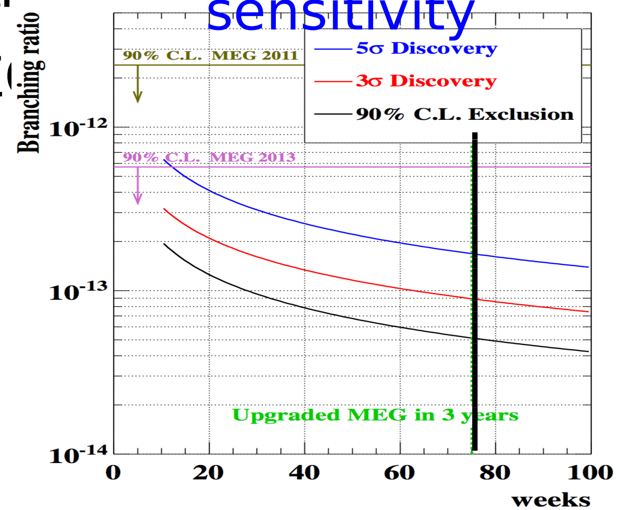


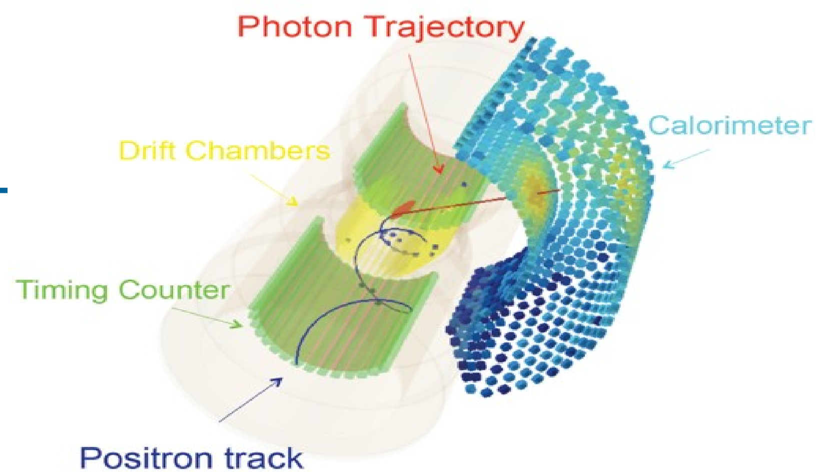
MEG Upgrade

- Upgraded MEG is expected to search for $\mu \to e\gamma$ down to $B \sim 5\times10^{-14}$ in three year
  - ×10 improvement w.r.t. current ME
- More details in arXiv:1301.7225

PDF parameters	Present MEG	Upgrade scenario
e^+ energy (keV)	306 (core)	130
e^+ θ (mrad)	9.4	5.3
e^+ ϕ (mrad)	8.7	3.7
e^+ vertex (mm) Z/Y(core)	2.4 / 1.2	1.6 / 0.7
γ energy (%) (w <2 cm)/(w >2 cm)	2.4 / 1.7	1.1 / 1.0
γ position (mm) $u/v/w$	5 / 5 / 6	2.6 / 2.2 / 5
γ-e^+ timing (ps)	122	84
Efficiency (%)		
trigger	≈ 99	≈ 99
γ	63	69
e^+	40	88

Projected sensitivity





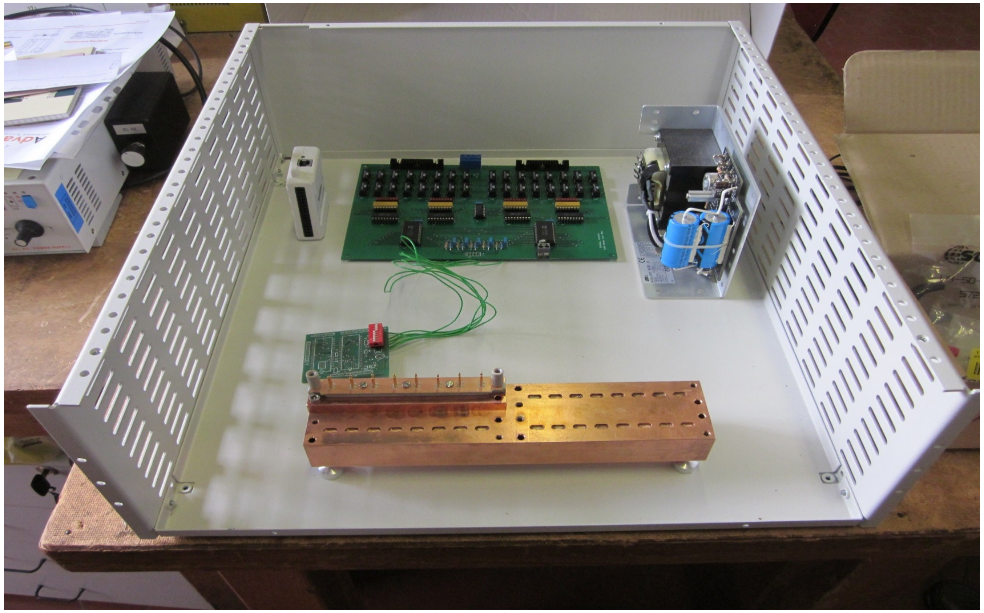
Upgrade Pavia

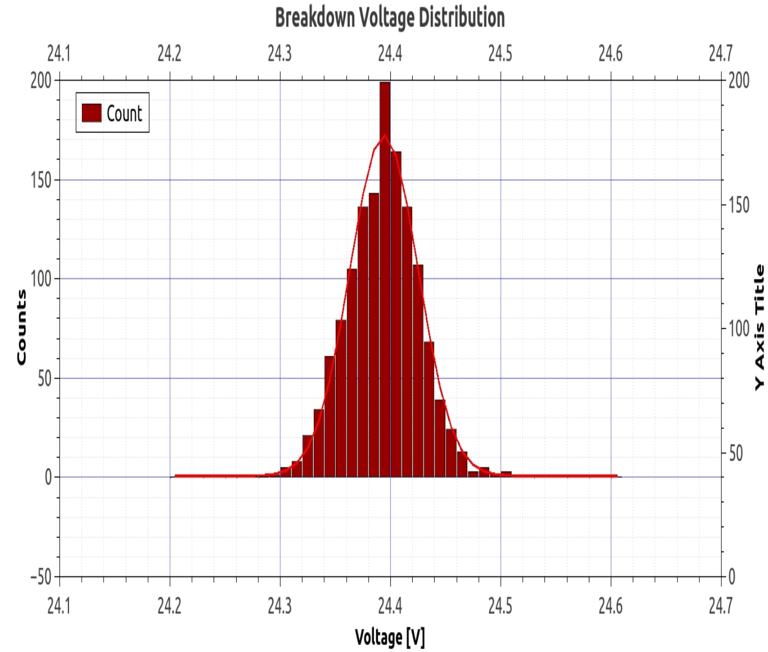
Pavia/Genova/Tokyo has been working on an upgrade of the TC for MEG2 (2017-2019)

Choice of SiPM for reading scintillator pixels, production and systematic test in Pavia and PSI: Single device, 6-in series boards, pixel equipped with SiPM boards.

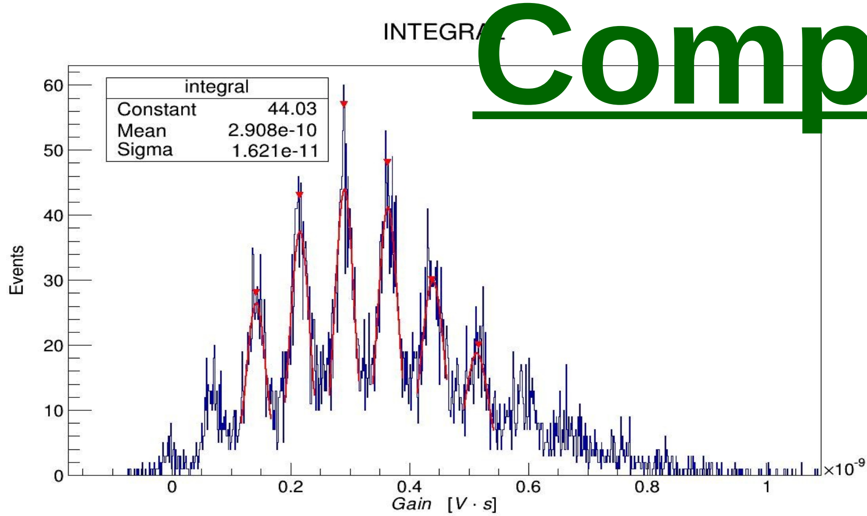
Tests under beam in single particle mode (BTF) and in high rate (PSI) (pre-pre-engineering run).

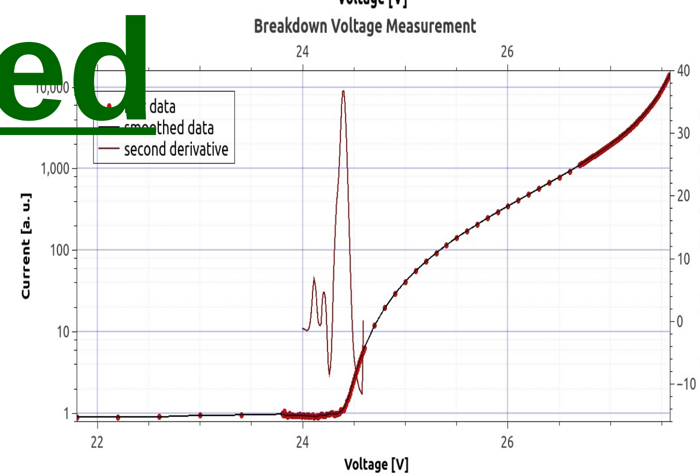
SiPM test in Pavia





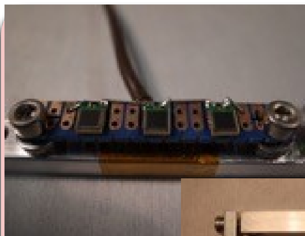
Completed





A 3 years long R&D…

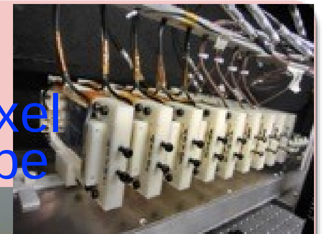
Single pixel R&D



1st pixel prototype

probe single pixel

1st multi-pixel prototype



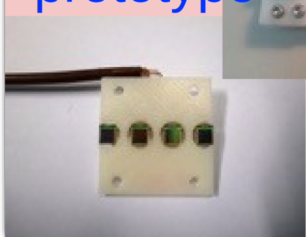
test @BTF, SiPMs choice

Multipixel prototypes solution for final dete

high rate test

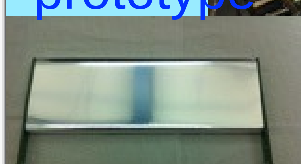
test @PSI

2nd pixel prototype



comparison tests

2nd multi-pixel prototype



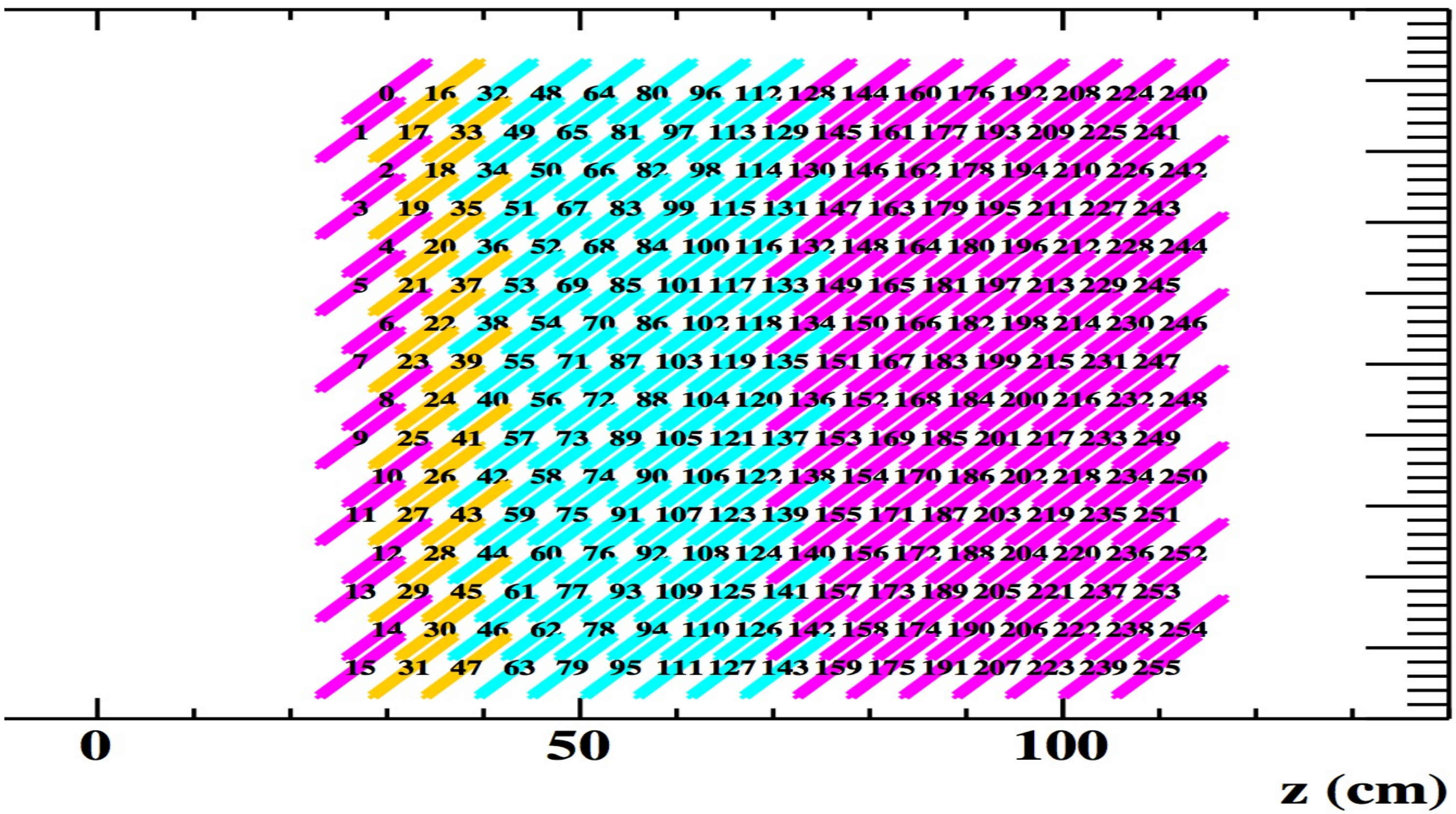
test @BTF backplanes readout

final TC construction

NOW!

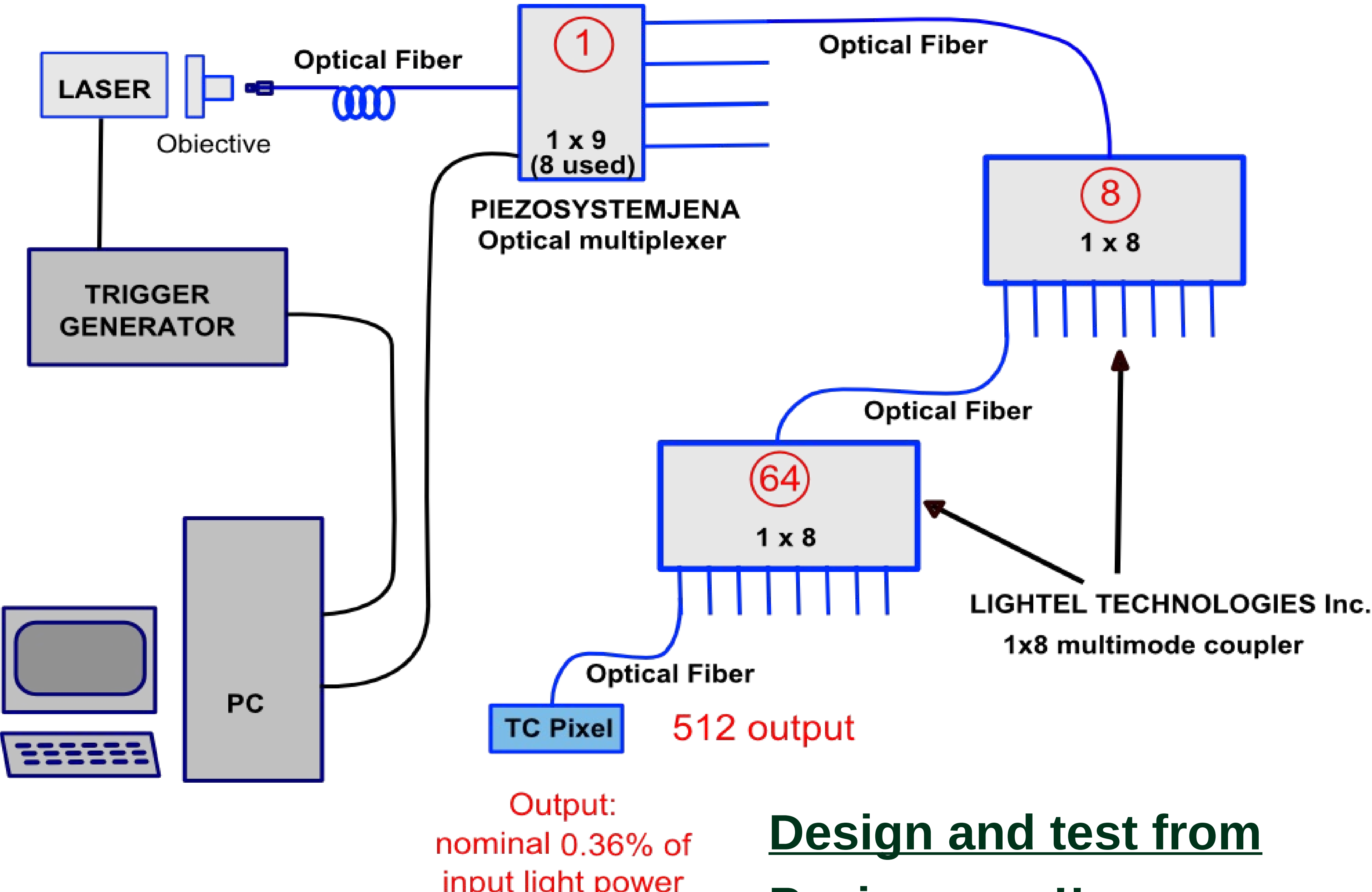
Beam test 2015@PSI: results

We tested 128 (half sector) at end of 2015.
TC behaviour good. Problems with readout electronics.
Run very useful for debugging readout electronics.



New test June 2016.

Design of the calibration system



Design and test from Pavia group!!

Design of the calibration system

Laser event

- Subset of laser system installed in beam area
- Multiplexer followed by two optical splitters in cascade branching into 8 channels