

Consuntivo delle attività di Gruppo I a Pavia nel 2014/2015

Andrea Negri, Giacomo Polesello

Attività a Pavia

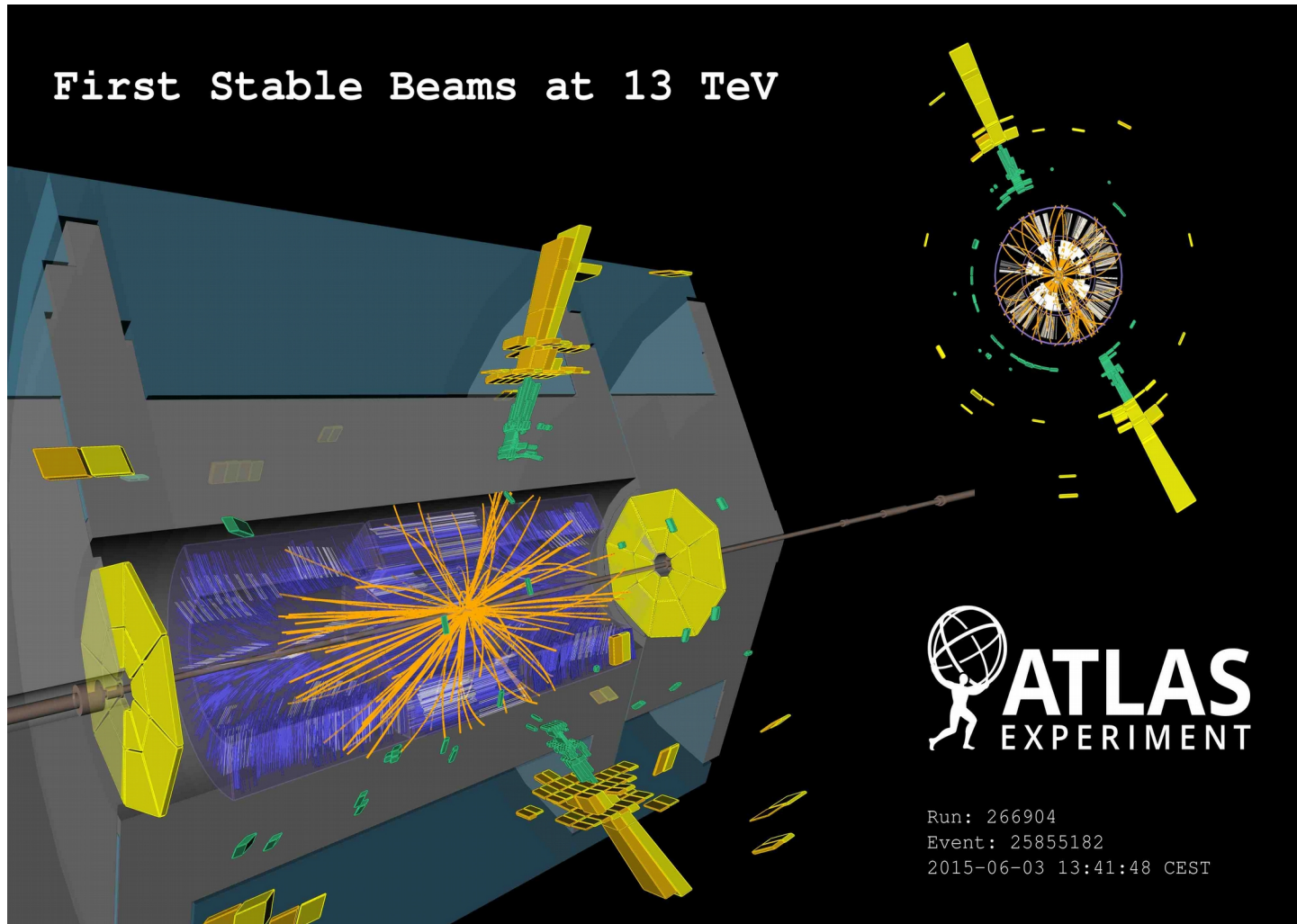
- A Pavia gruppi attivi su entrambe le principali linee di ricerca del gruppo 1
 - Frontiera dell'energia
 - ATLAS
 - CMS
 - Frontiera della precisione
 - MEG

LHC

2014/15 – un altro anno di consolidamento per l'LHC

- Acceleratore spento alla fine del 2012, attività 2014/2015 in tre direzioni
 - Completamento analisi dati
 - Completamento riparazione/miglioramento dei rivelatori durante shutdown
 - Riavviamento dei rivelatori e dell'acquisizione
- I lavori di sviluppo (upgrade) per la fase ad alta (300 fb-1) luminosità, cosiddetta fase 1, sono ormai in fase di prototipi finali
- Si comincia a mettere in piedi la struttura per rendere i rivelatori adatti all'altissima luminosità (3000 fb-1), cosiddetta fase 2

La presa dati a 13 TeV è partita



(plot equivalente di CMS nella parte dedicata)

GRUPPO ATLAS

Anagrafica 2014

	Qualifica	ATLAS	Call GR5	tot
Conta Claudio	PO	1		1
Dondero Paolo	Dottorando	1		1
Ferrari Roberto	DR	0.8	0.2	1
Fraternali Marco	PA	1		1
Gaudio Gabriella	Ric	1		1
Grossi Michele	Borsista	1		1
Introzzi Gianluca	RU	1		1
Livan Michele	PO	1		1
Negri Andrea	RU	1		1
Polesello Giacomo	PR	1		1
Rebuzzi Daniela	RU	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
		13.7	0.3	14

4 laureandi magistrali: S. Carrà, E. Farina, C. Giroletti, R. Poggi

MicroMegas Module 0 for the New Small Wheels (ATLAS Muon Upgrade)

MicroMegas Pavia Group

Pavia - 11 June 2015

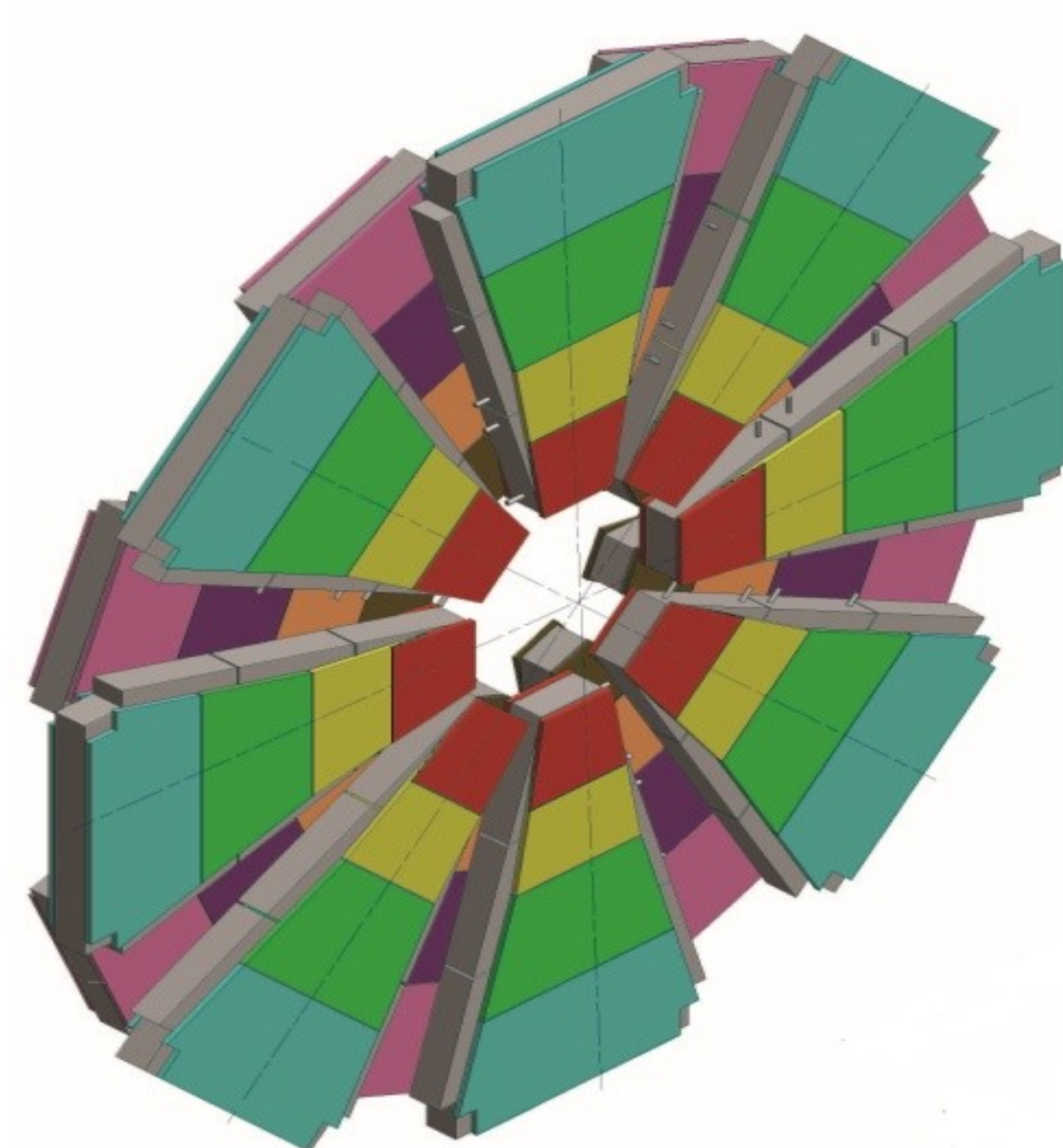
Pavia MM Group (2014/15)

† Edoardo Farina – Marco Fraternali – Gabriella Gaudio – Chiara Giroletti – Michele Grossi – Gianluca Introzzi – Agostino Lanza – Roberto Ferrari

With an outstanding support from

† Domenico Calabrò – Angelo Freddi – Samuel Guelfo Gigli – Claudio Scagliotti – Filippo Vercellati

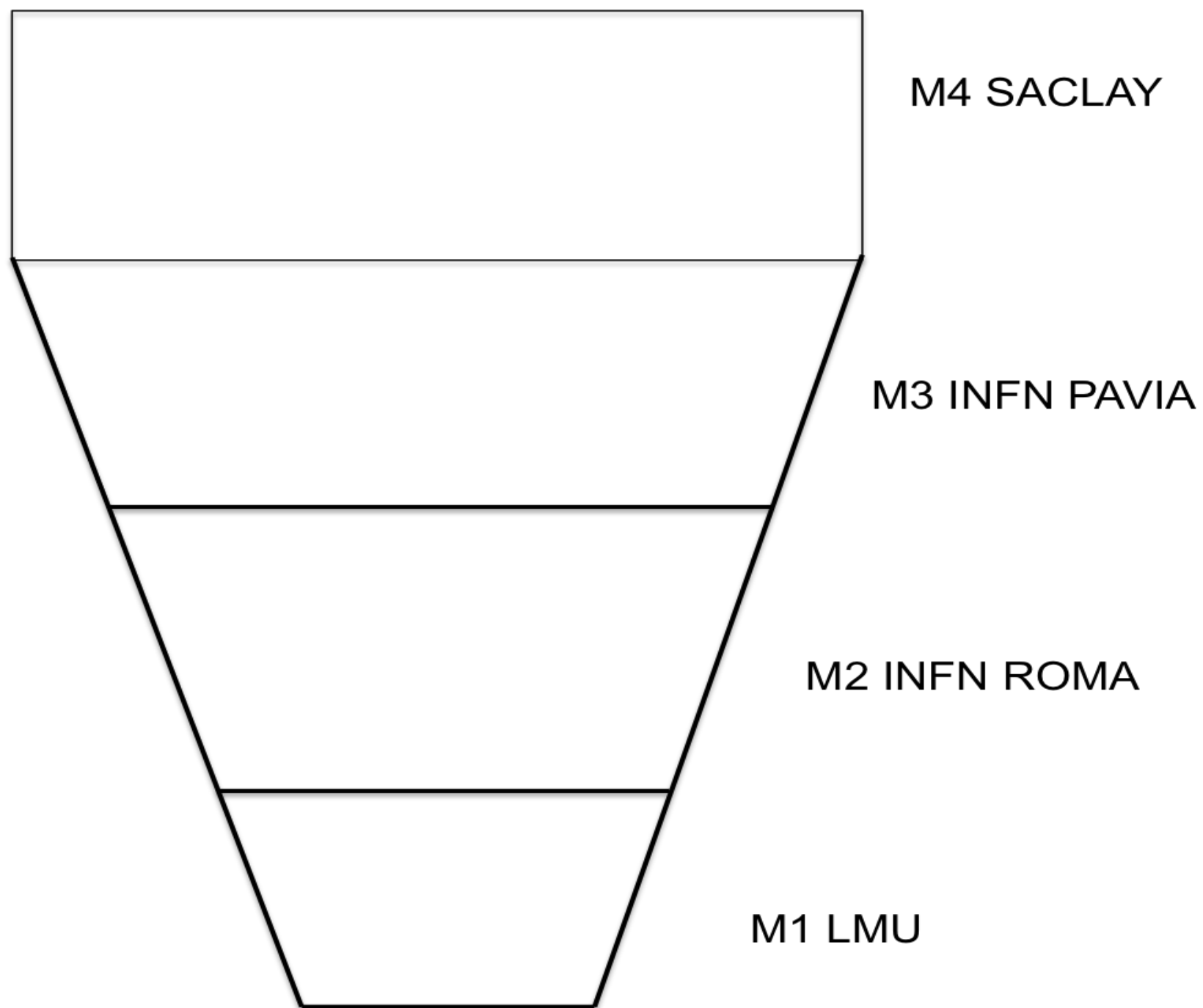
Layout of a New Small Wheel



Pavia's Task & Past Achievements

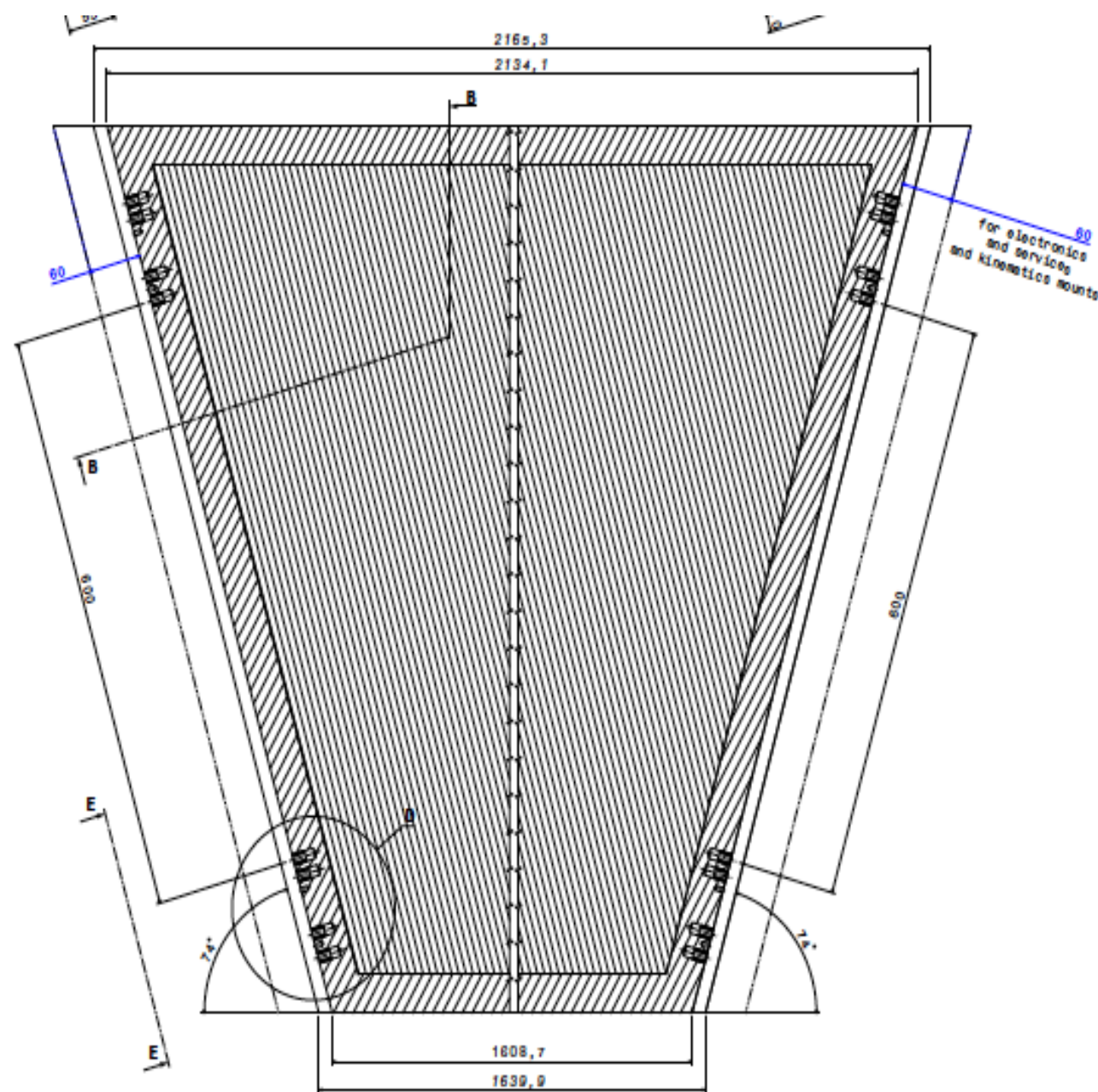
- † The ATLAS MM-Pavia group will construct part ReadOut panels (RO) of the MicroMegs (MM) detectors for the Atlas New Small Wheels (NSW) upgrade of the forward muon system.
- † Since the required accuracy of these detectors is very high (100 micron), each and every construction step has to be controlled and certified.
- † A mechanical prototype of a MM module (M3) was built and tested in Pavia during 2013/14.
- † It was moved to Freiburg University in March 2014 to be integrated with MM modules built at different centers, realizing a NSW sector prototype.

Original layout of a NSW sector



M3 prototype (2013/14)

- † Surface $\sim 1.7 \text{ m}^2$
- † Gas gap volume $\sim 8 \text{ l}$



Clean Room refurbishing

- † After the completion of M3 (Spring 2014), there has been a long shut down of the clean room.
- † All the tools and systems (granite table, moving bridge, DAQ, climatic condition controls) have been dismantled during Summer 2014 to be refurbished.
- † Since the end of 2014, there has been an effort to re-install, put in place and reconnect all the machinery and equipment.
- † The C++ and LabView codes for the DAQ have been rewritten after the end of the hardware upgrade, to have the measuring/construction system newly operational by May 2015.

New Measuring System (2014/15)

- † The system used for M3 construction has been upgraded since Summer 2014 to perform at the level of mechanical precision required for MM.
- † The granite table, in use since 2013, was recertified to 9 micron tolerance in July 2014.
- † The measuring system has been re-done by our mechanical shop during Fall 2014: new high precision ball bearing rails; a new stiff bridge.
- † A Baumer Laser and a B&S indicator are mounted on the moving arm of the table bridge since the end of 2014. The gluing system has been upgraded in March 2015 with a new dispenser.

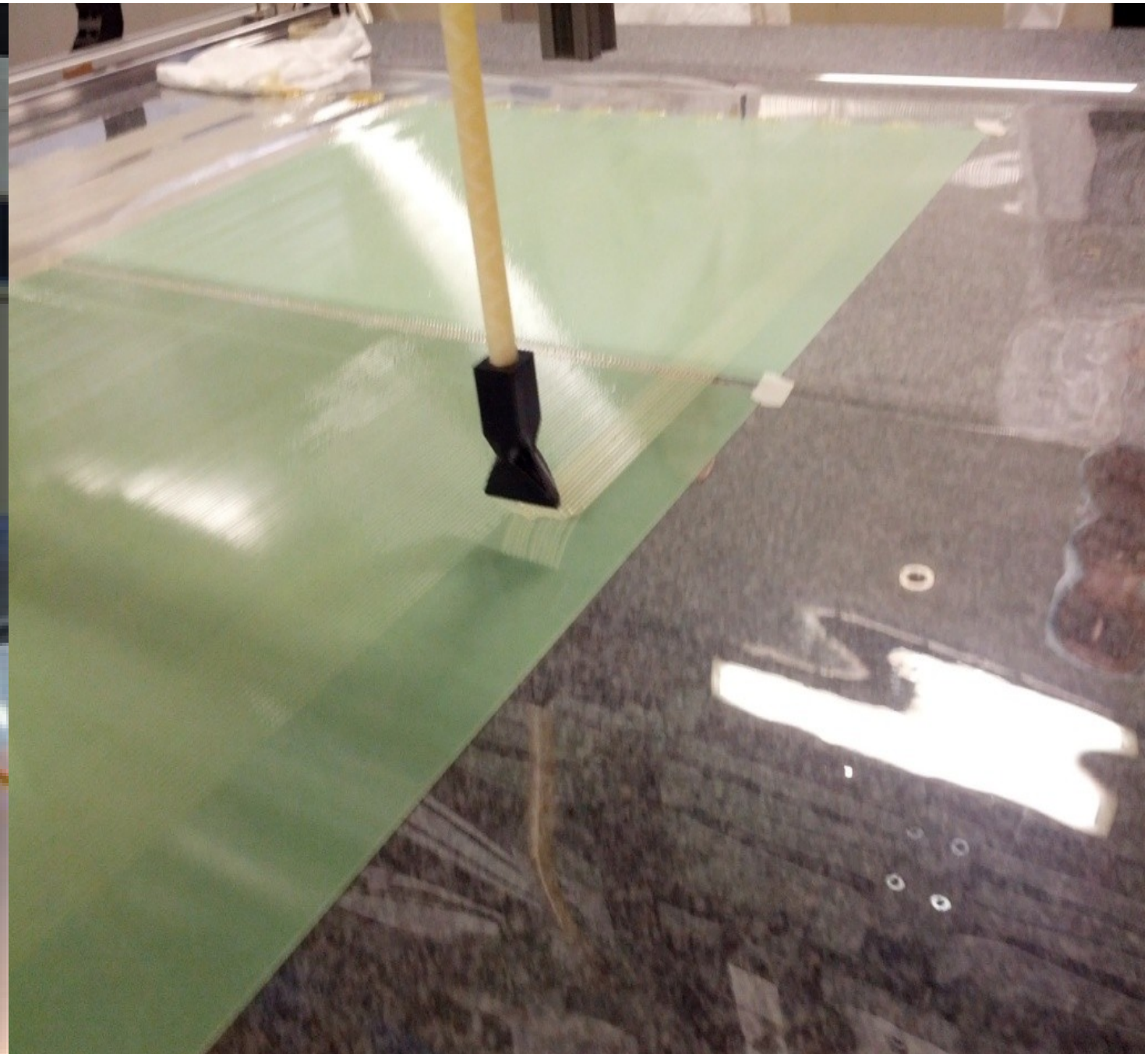
New Measuring System



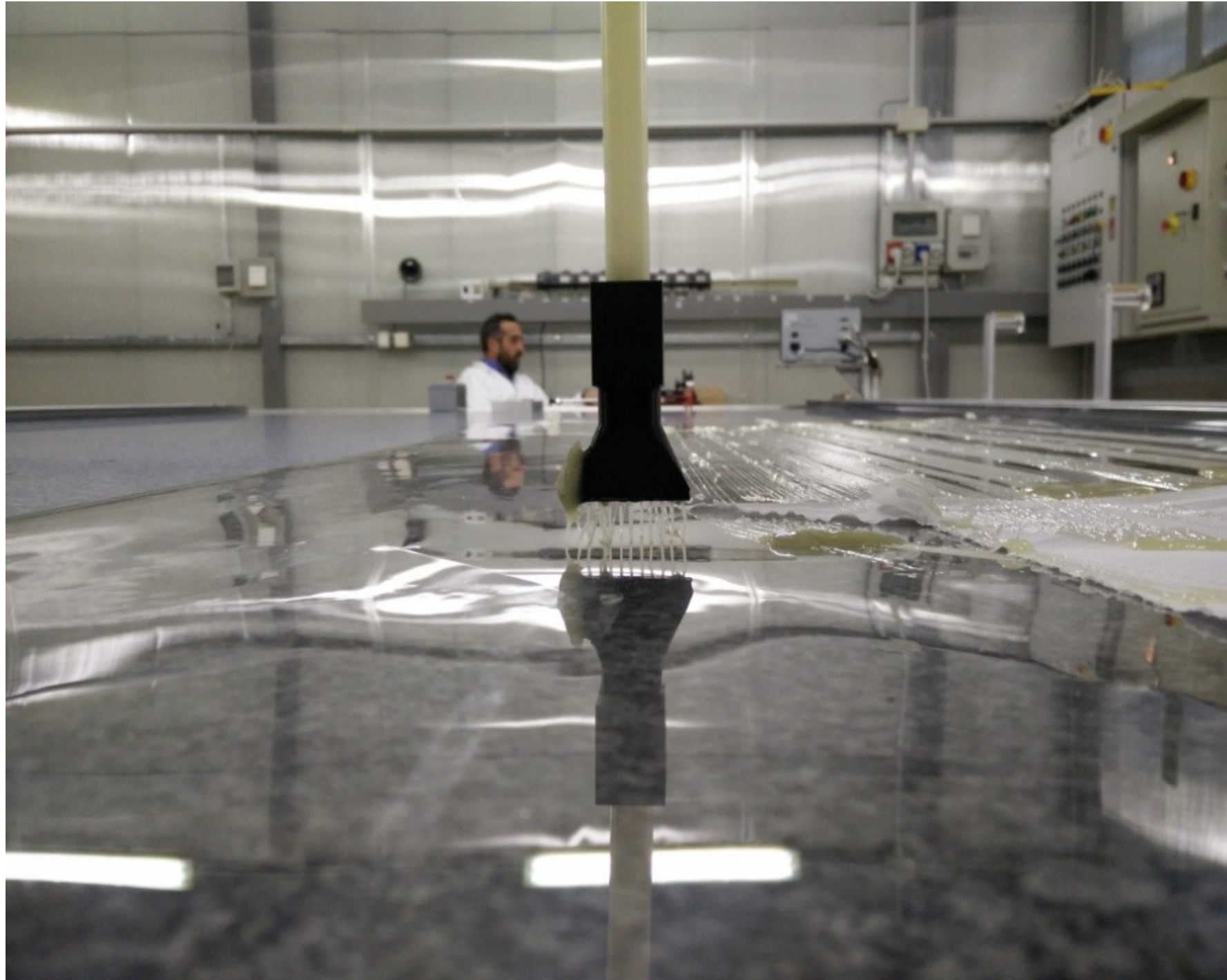
Baumer Laser S35A



Gluing System & New Dispenser



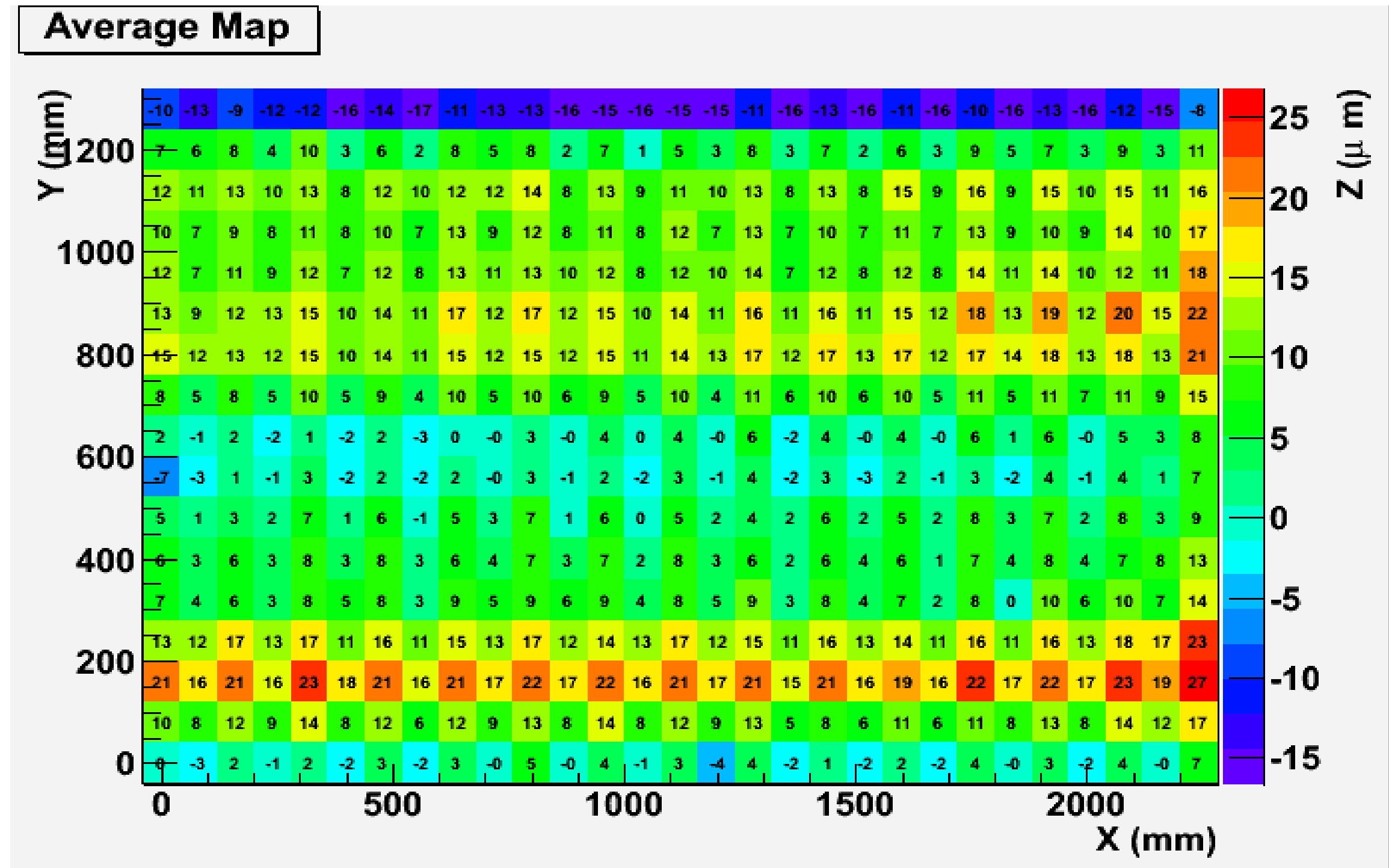
Glue Dispenser remote control



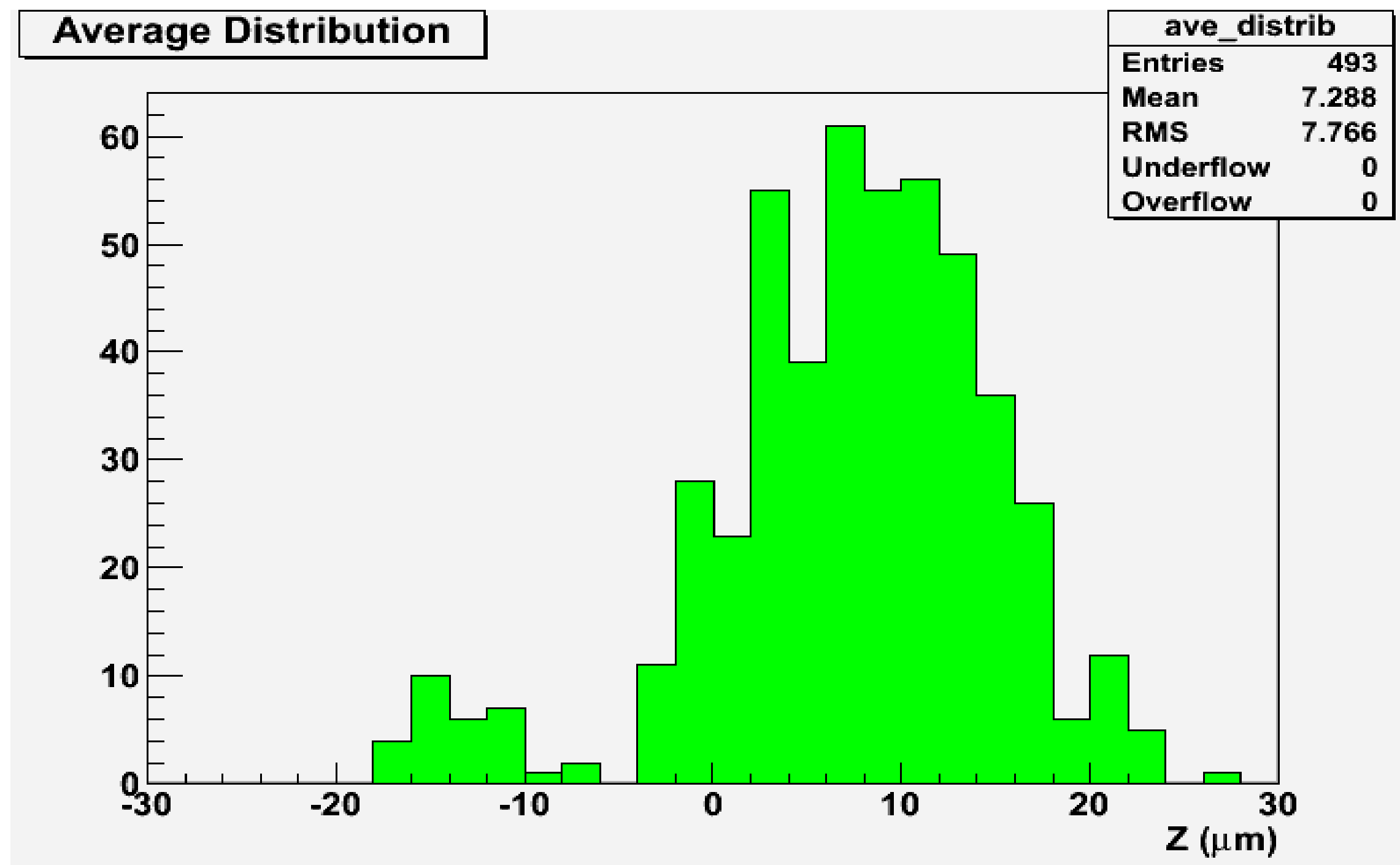
Measuring System reliability

- † The Pavia mechanical shop has realized a highly sophisticated Coordinate Measuring Machine (CMM) of industrial level, at the bare cost of the component materials (engines, rails, Al profiles).
- † The measuring system (granite table + moving bridge) planarity and data repeatability has been tested at the end of May 2015 using the 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.

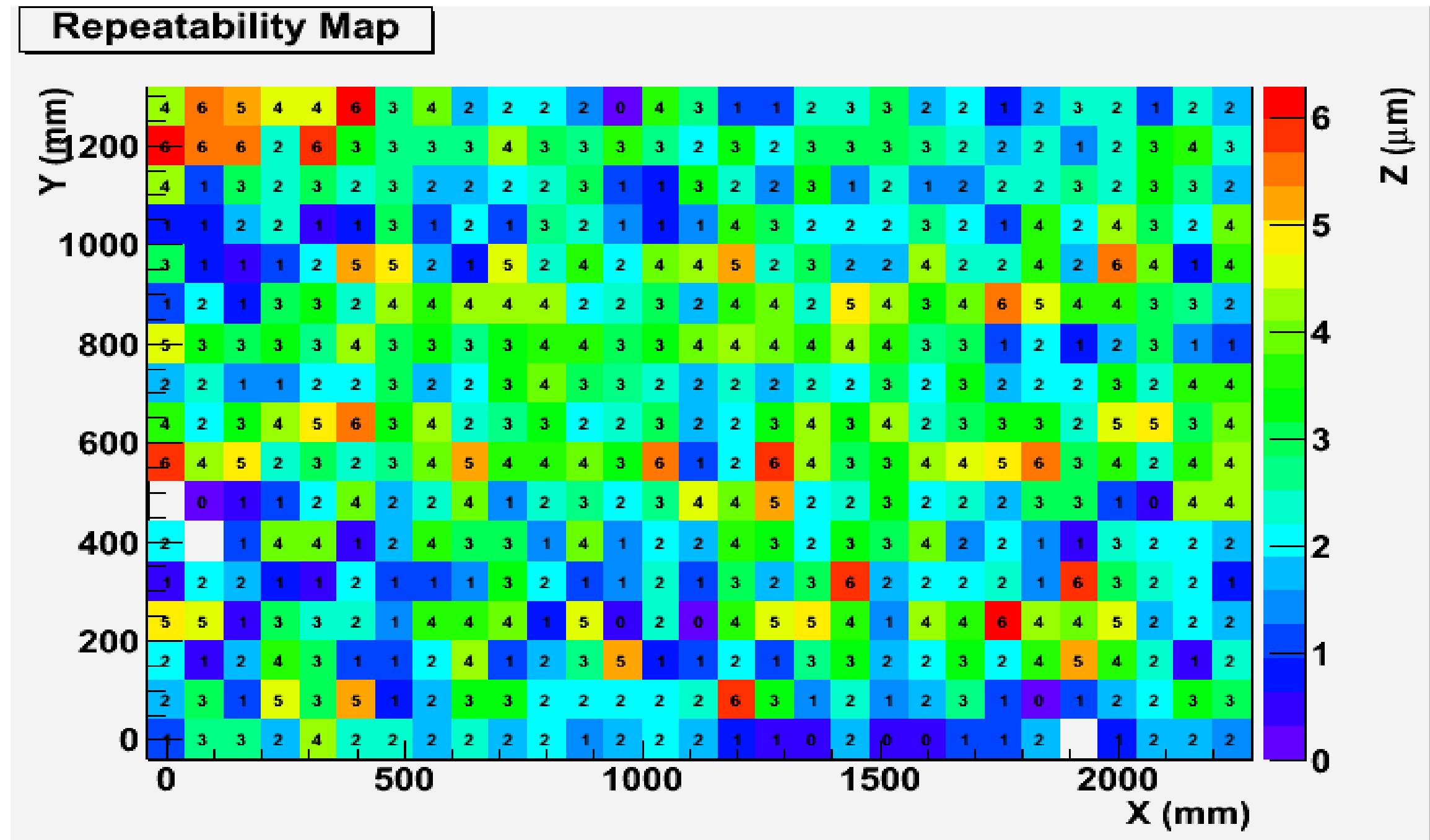
Z average Map



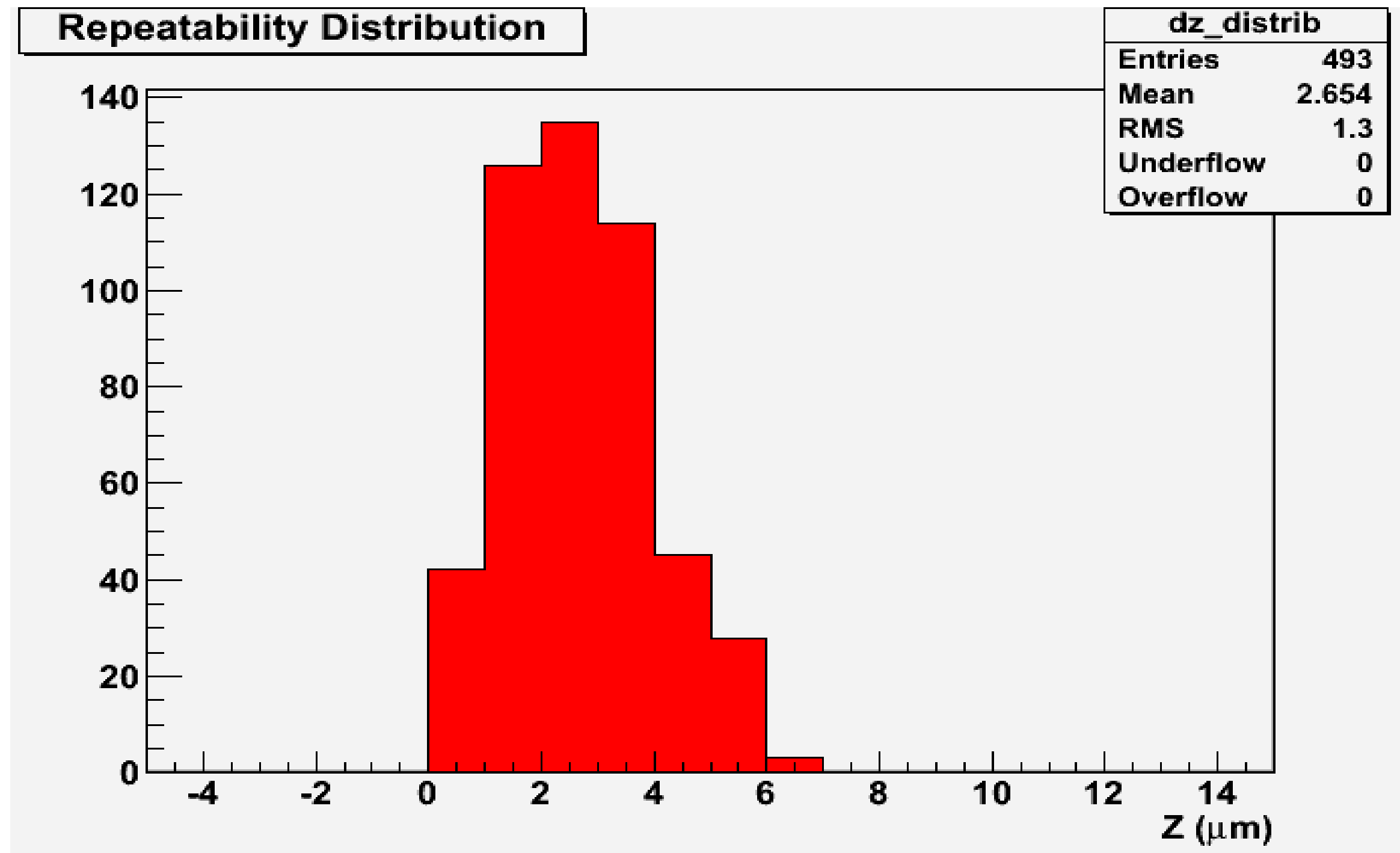
Z average Distribution



$(Z_j \text{ max} - Z_j \text{ min}) \text{ Map}$



$(Z_j \text{ max} - Z_j \text{ min})$ Distribution



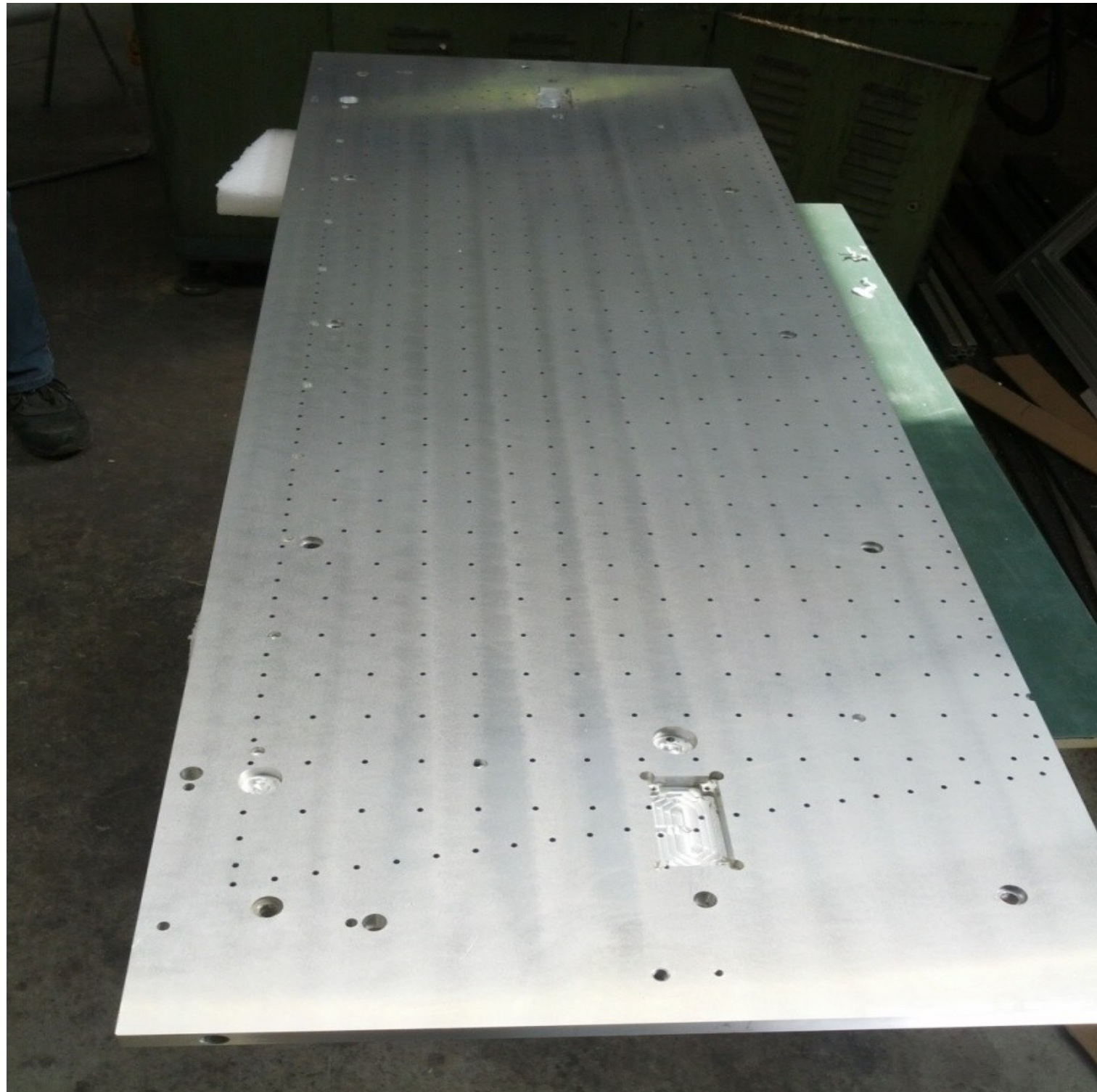
New Tools construction (2014/15)

- † To build a RO Panel for MM, it is necessary to realize a series of high precision tools, which construction is ongoing since the Summer of 2014.
- † A long list of dedicated pieces and parts for M0 also has been machined by the Pavia mechanical shop, along with INFN Frascati and Napoli .
- † Major tools realized in the mechanical shop are:
 - 5 Aluminum (Al) reference plates located on the granite table, and an Al alignment gauge for their relative precise positioning;
 - a stiff-back moving table, also equipped with 5 Al reference plates.

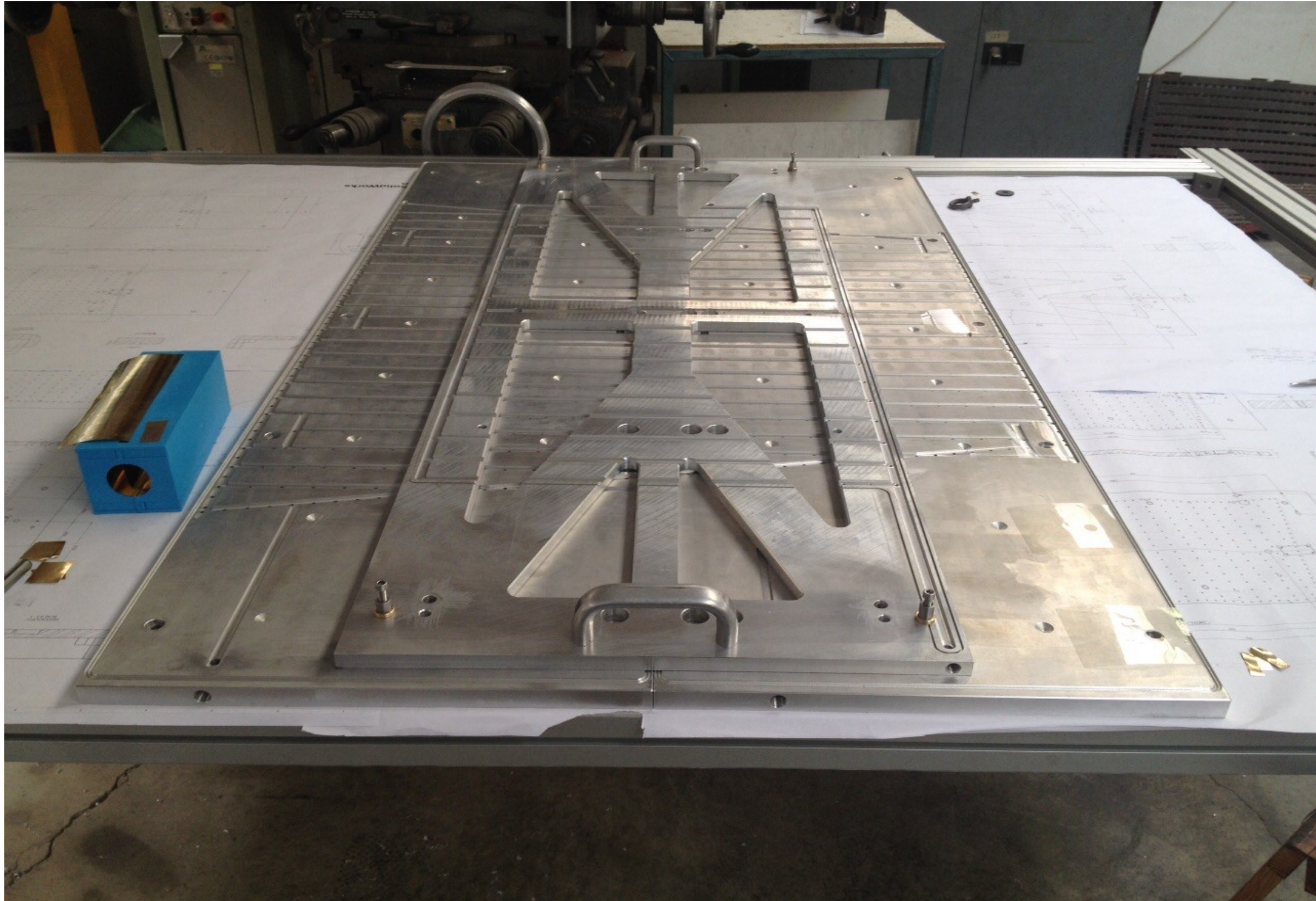
Stiff-Back moving table



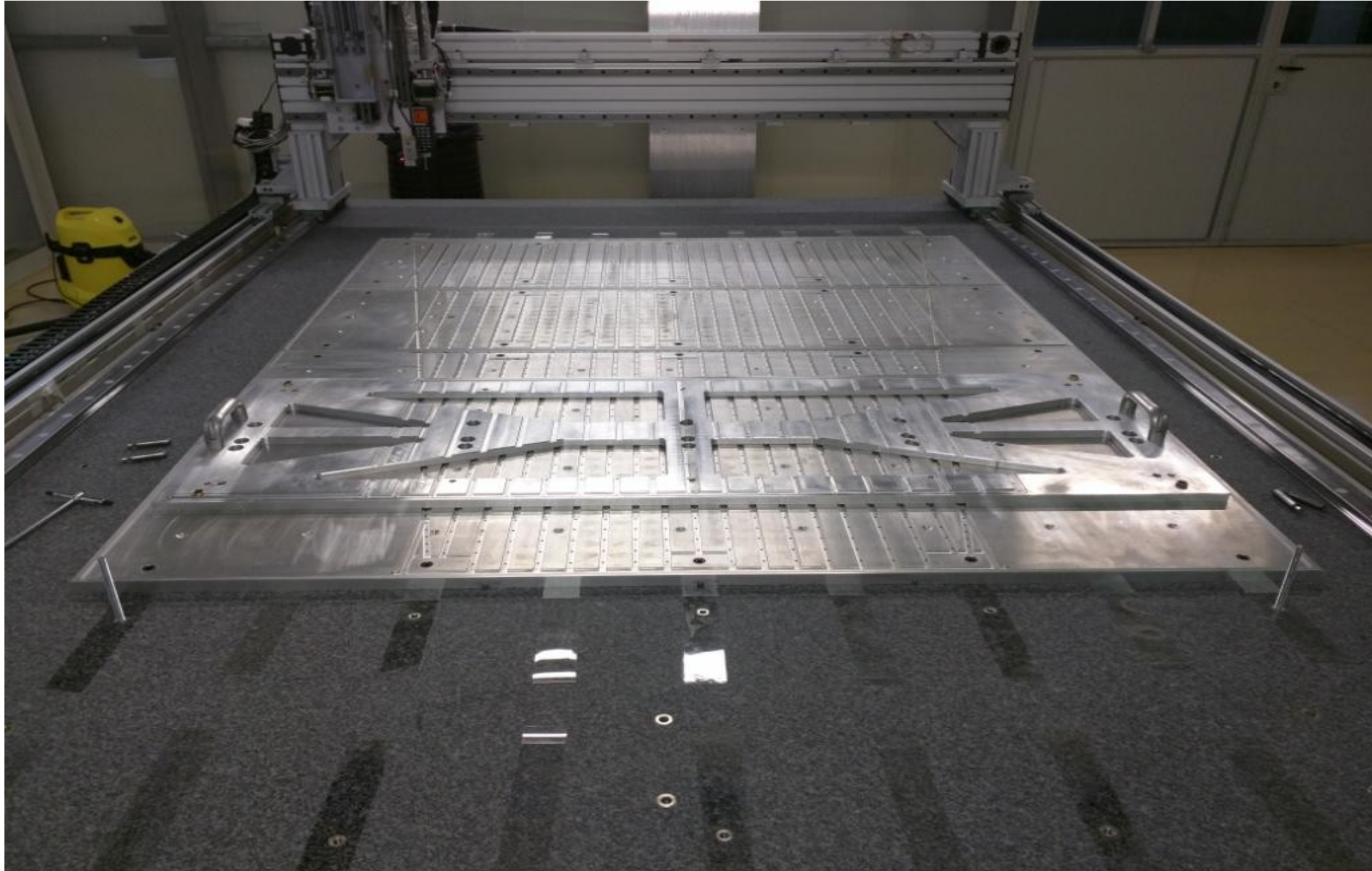
Single Reference Plate



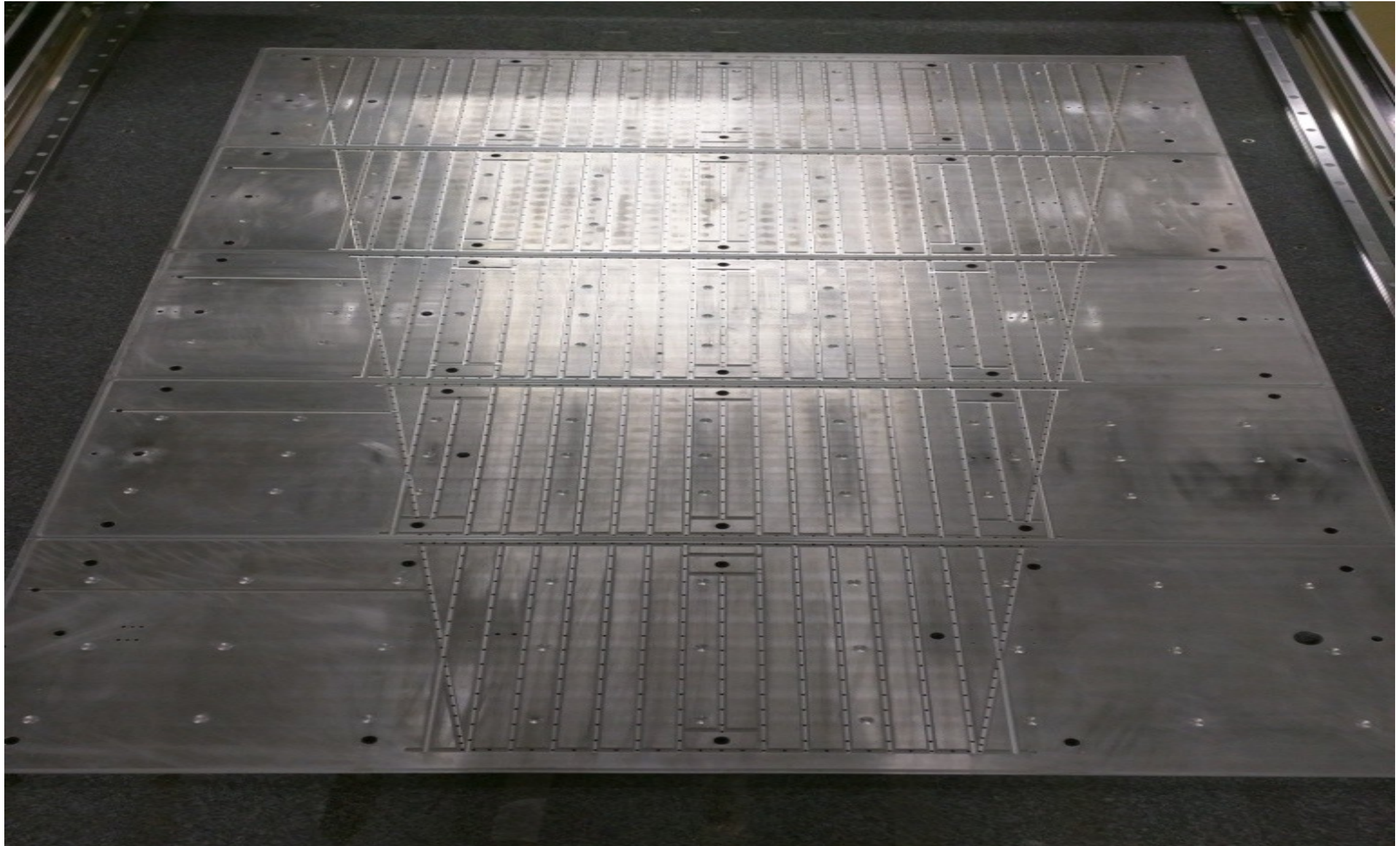
Alignment Gauge for 2 plates



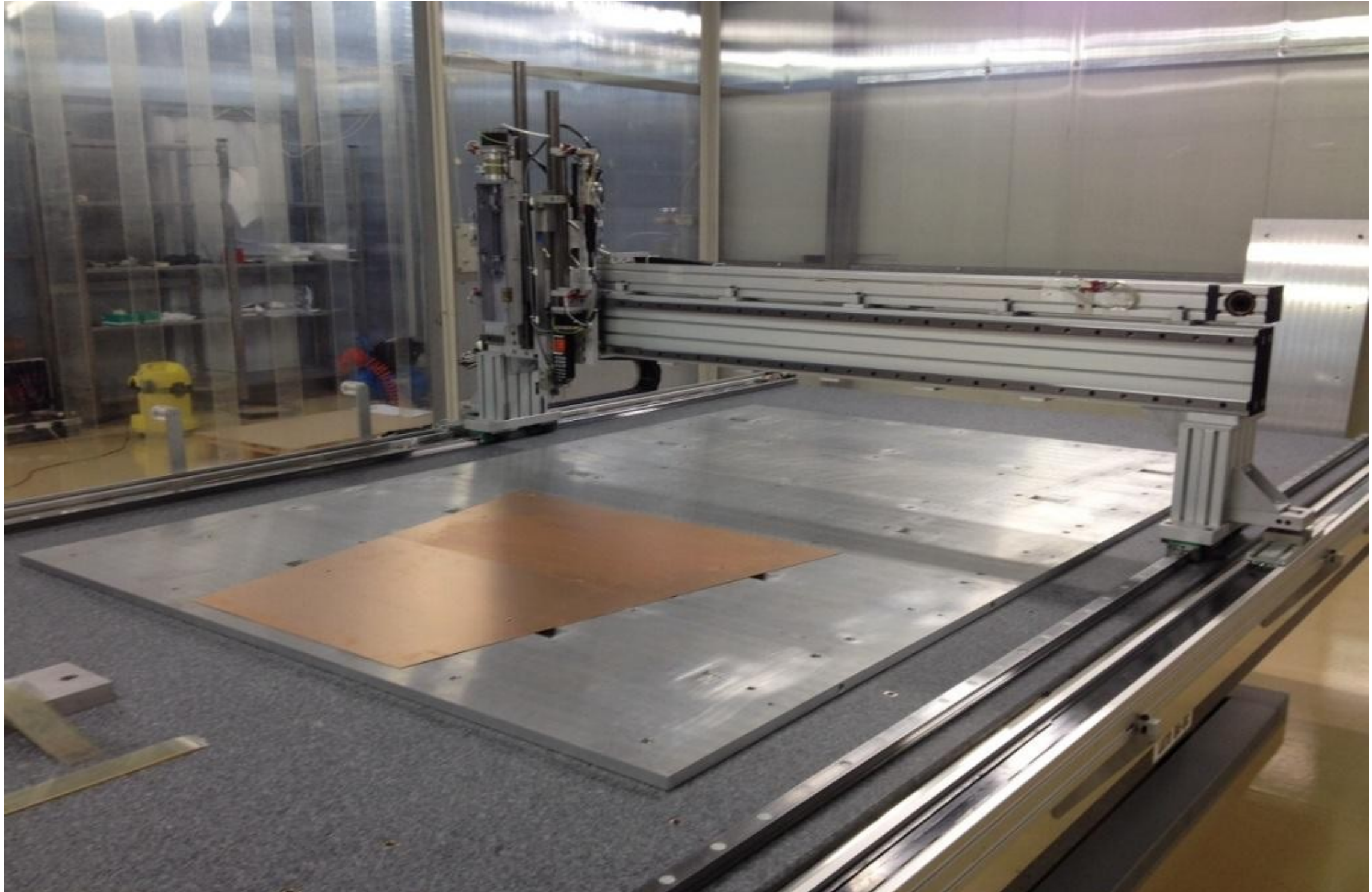
Sequential plate alignment



Final plate configuration



2 RO PCBs on reference plates



Critical issues

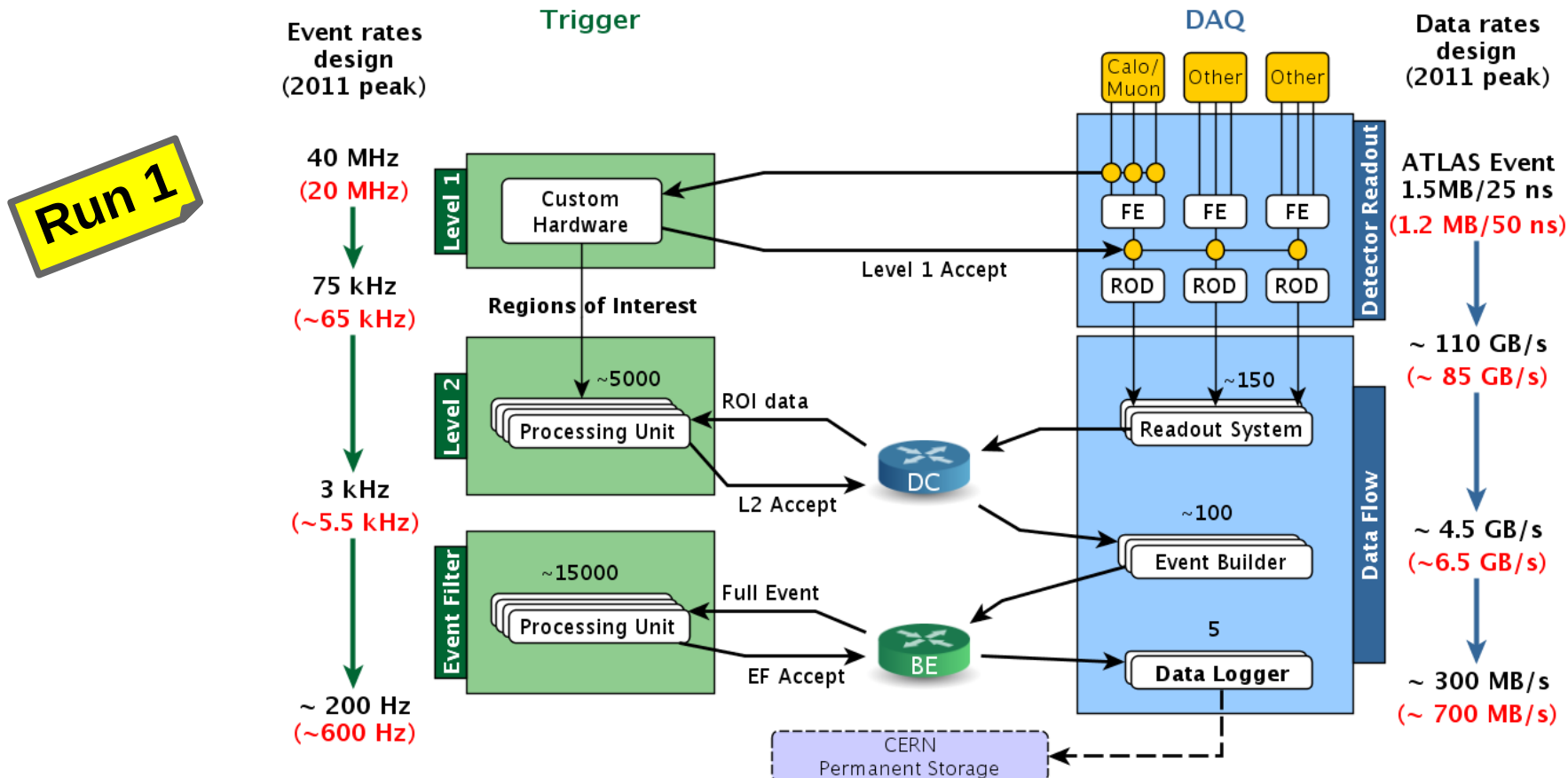
- † The DAQ system (Field Point by National Instruments) is out of date. It will be replaced after M0 completion with Arduino boards (micro controllers taking inputs from a variety of switches or sensors, and able to control devices as lights, motors, and other actuators).
- † The Rockwell cooling/conditioning system - used to keep the clean room at constant temperature and humidity - is obsolete (25 years old ?). A major breakdown could represent a serious operational delay for MM production. The possibility to replace it has been evaluated at the end of 2014, but there was not available budget.

MM Pavia Group Time Schedule

- † A new (pre-production) MM module (M0) will be made and tested in Pavia soon (July/Sept. 2015).
- † The construction of a total of 35 RO panels for MM detectors is foreseen to begin March 2016.
- † A production rate of 2 RO panels/ week seems to be achievable.
- † The effective production rate will indeed be dictated by the availability of RO PCBs; the last 1/2 shipment is foreseen for February 2017.
- † The construction of 35 RO panels should therefore be completed by October 2017.

ATLAS TDAQ: Data Flow

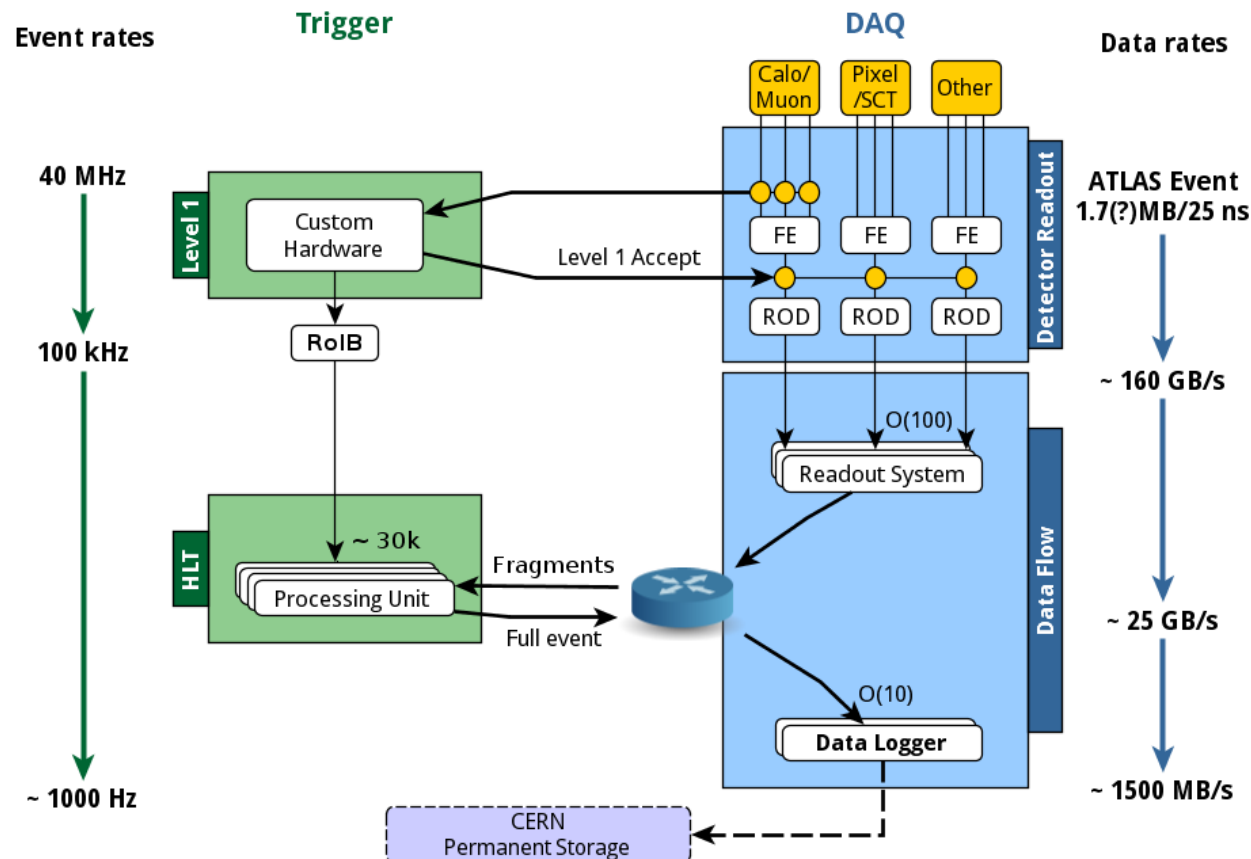
- Data-flow ri-disegnato per run 2 (coordinazione pavese)
 - Unificate le farm di Livello 2, Event Filter e Event Builder
 - Rifatta l'infrastruttura di network
 - Riscrittura completa del sw di dataflow



ATLAS TDAQ: Data Flow

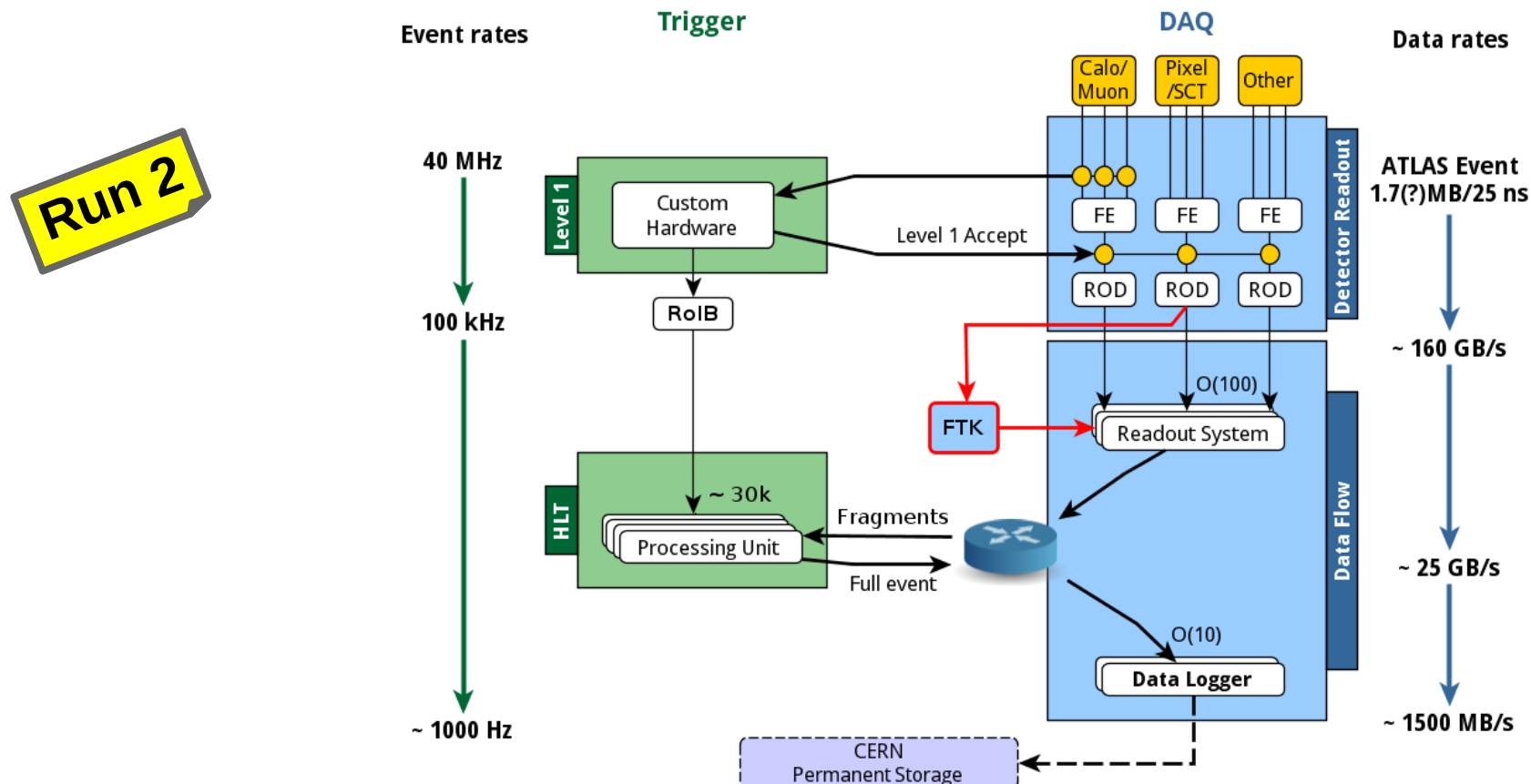
- Significativa semplificazione del sistema e rimozione dei colli di bottiglia sulla scalabilità
 - => Riorganizzazione dell'infrastruttura di selezione eventi
 - In produzione dal 2014, migliorie e ottimizzazioni in corso

Run 2



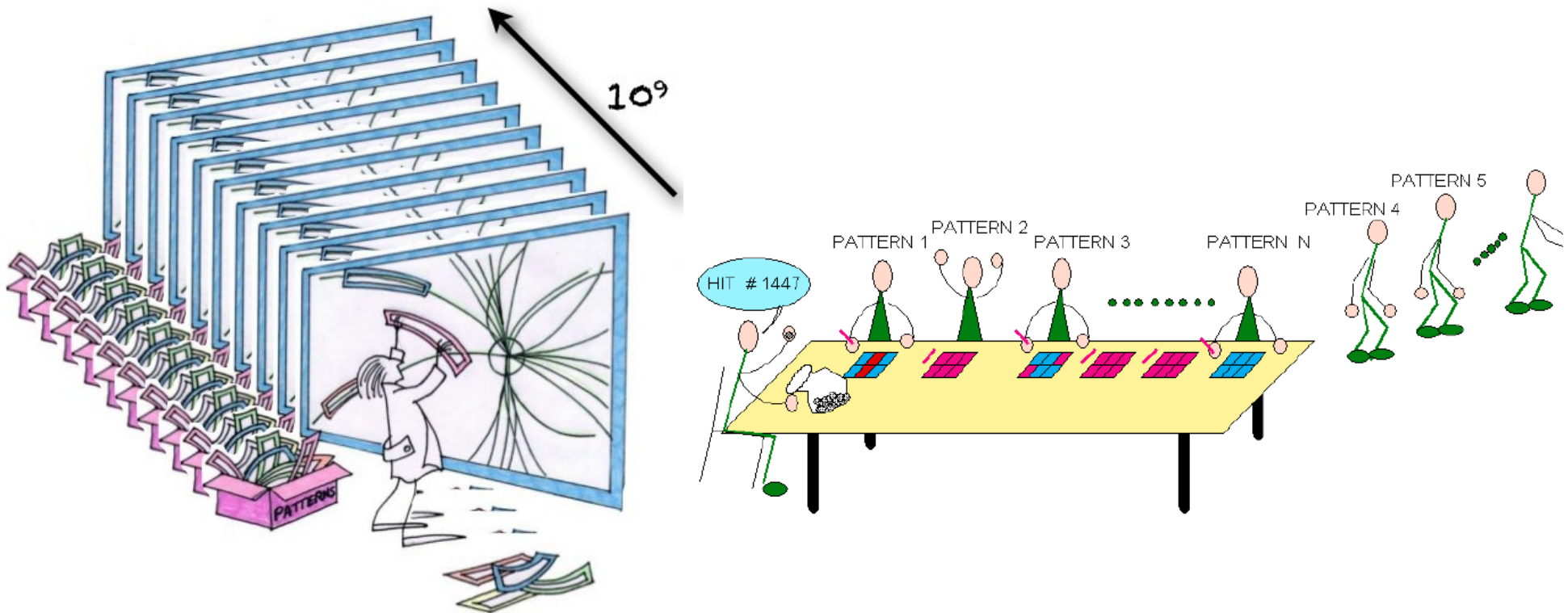
Fast Tracker

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



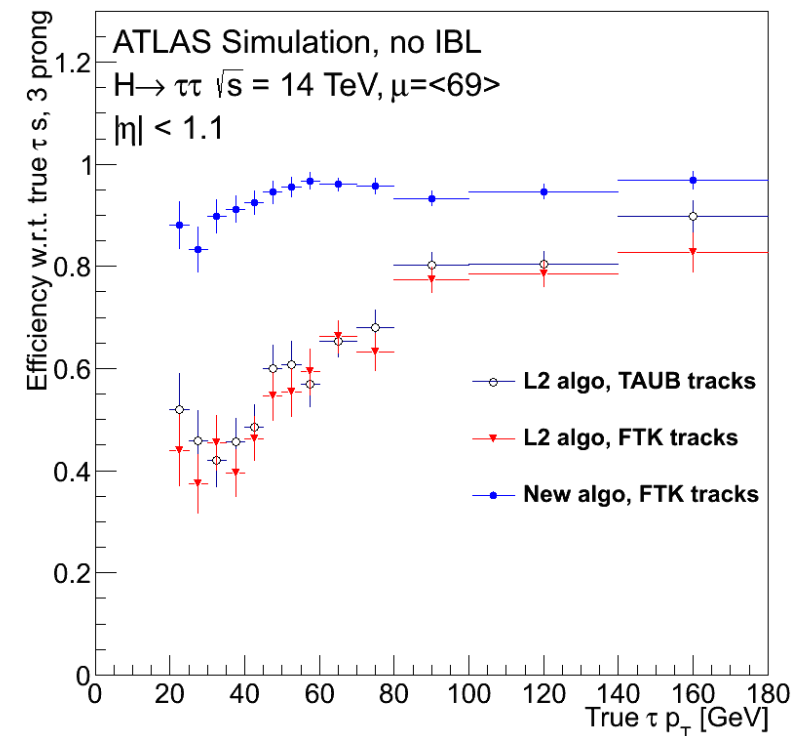
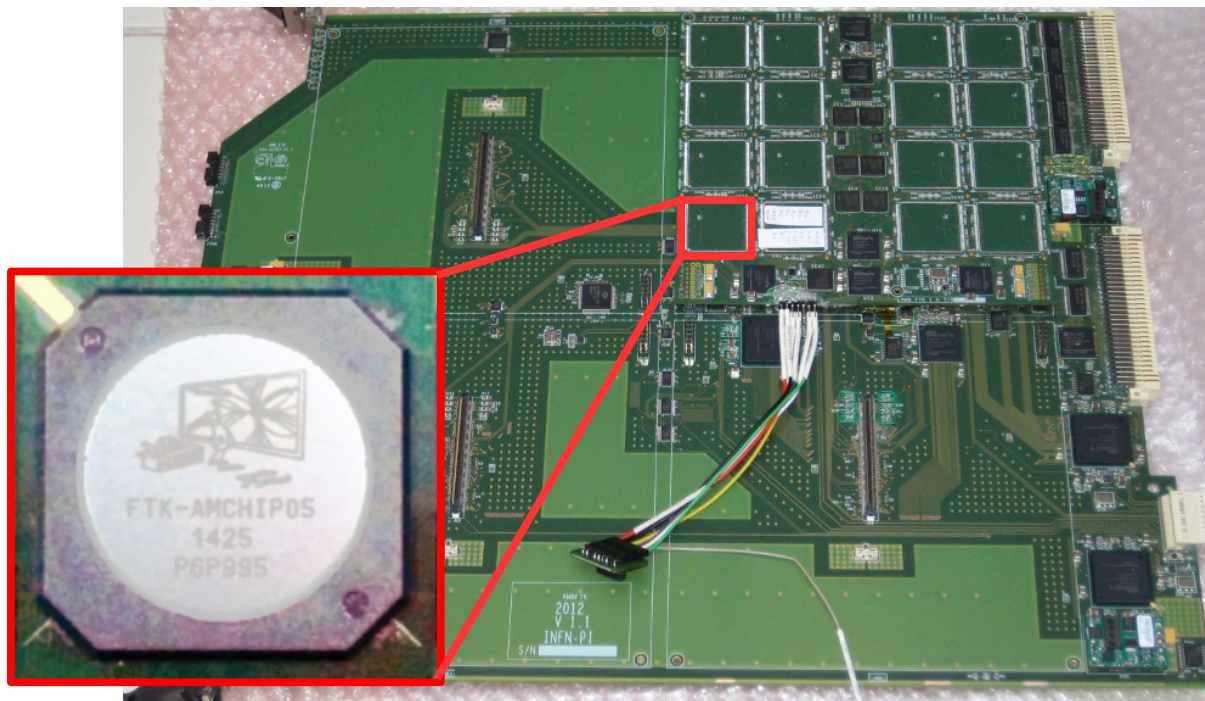
Fast TrackEr

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



FTK

- FTK HW: 4 rack VME e 4 rack ATCA
 - 16000 AM (1Gpattern) in 128 schede VME
 - 512 FPGA su schede VME e ATCA
- Permette utilizzo informazioni di full-tracking all'HLT
 - Aumento efficienza signature tau, b-tagging, missing-ET

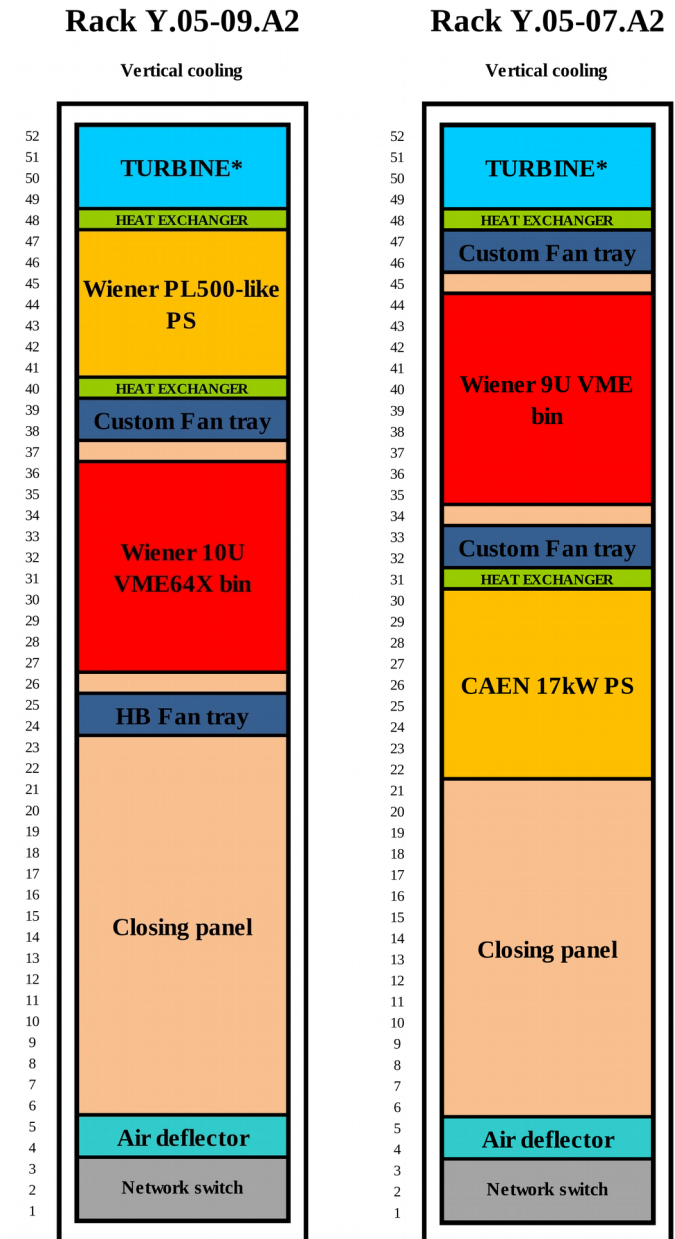


FTK

- Programma di installazione
 - Nov 2015: installazione minimale (1 AM board)
 - Feb 2016: copertura barrel per $\mu < 40$ (16 AM board)
 - Set 2016: copertura totale per $\mu < 40$ (32 AM board)
 - 2018: sistema finale (128 AM board)
- Contributo pavese
 - Simulazione efficienza di traccia
 - Integrazione del sistema nell'infrastruttura sw DAQ
 - Run Control
 - Monitoring
 - Gestione sw release
 - Integrazione del sistema nell'infrastruttura HW
 - Integrazione del sistema nell'infrastruttura DCS

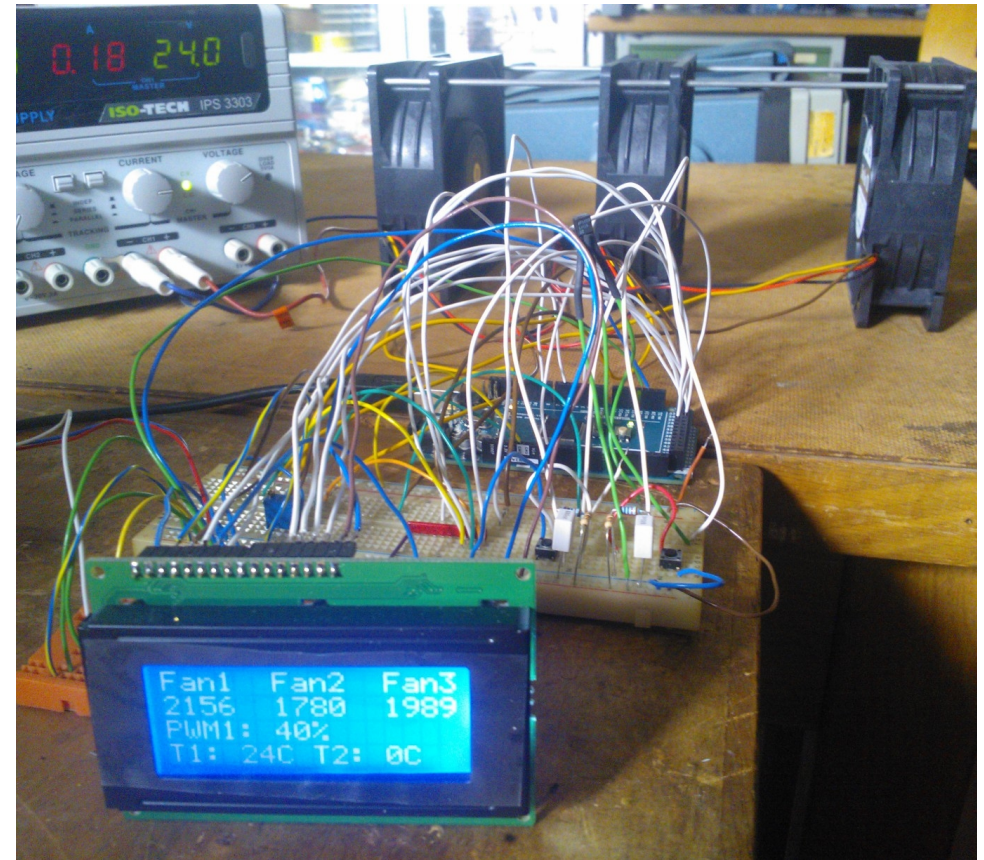
FTK: integrazione HW

- Studio dissipazione di potenza:
 - 4.5 kW / crate; 2 crate per rack
 - Test a PV ed in ATLAS con sonde di temperatura su scheda di carico e su vecchie memorie associative
- Scelta del Power Supply e dei fan tray non ancora presa
 - Wiener PS non ha la potenza necessaria per alimentare 2 crate
 - Custom CAEN PS non ancora pronto
- Nel secondo caso è necessario un Fan Tray custom
- Simulazioni in corso in collaborazione con facoltà di ingegneria di Parma
 - Simulazione delle diverse configurazioni

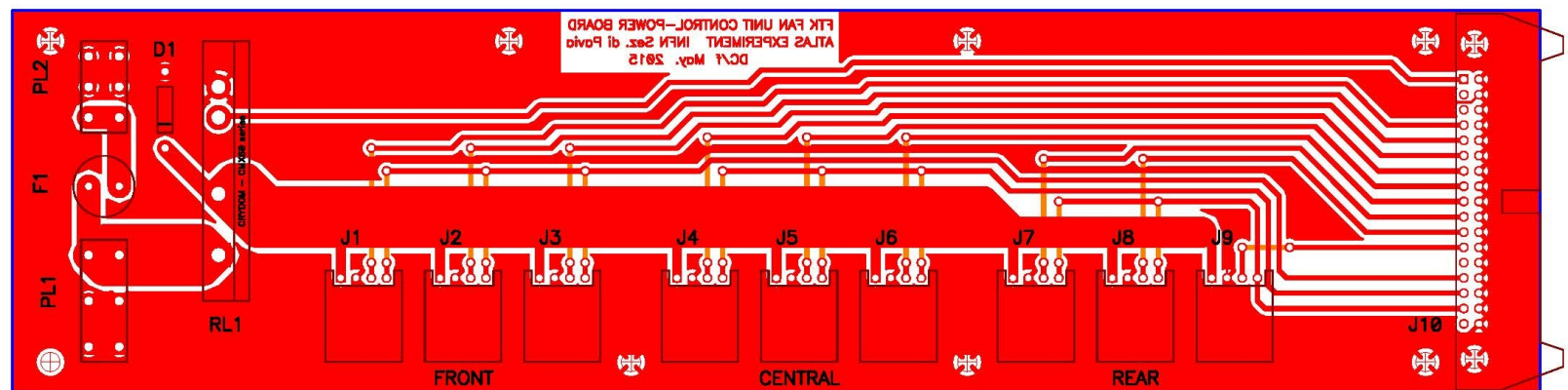


Custom Fan Tray

- Controllo elettronico e monitoraggio via Arduino
 - Con local display
 - O attraverso interfaccia CANBus (DCS)
- Funzionalità
 - Local/remote ON/OFF
 - 4 velocità per ogni gruppo di 3 ventole
 - 6 sensori di temperatura



Power
Distribution
Board



- Since October 2013, D. Rebuzzi has been appointed **ATLAS Higgs MonteCarlo manager**, together with J. Tanaka (Tokyo University)
- The role of the MC contacts is the following:
 - 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 the latest developments in MC and their tunings
 - Update and maintain a Web page giving the relevant information
 - 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
<https://twiki.cern.ch/twiki/bin/viewauth/AtlasProtected/HiggsWorkingGroup>
- Nominal duration of the responsibility: 2 years, with possible extension

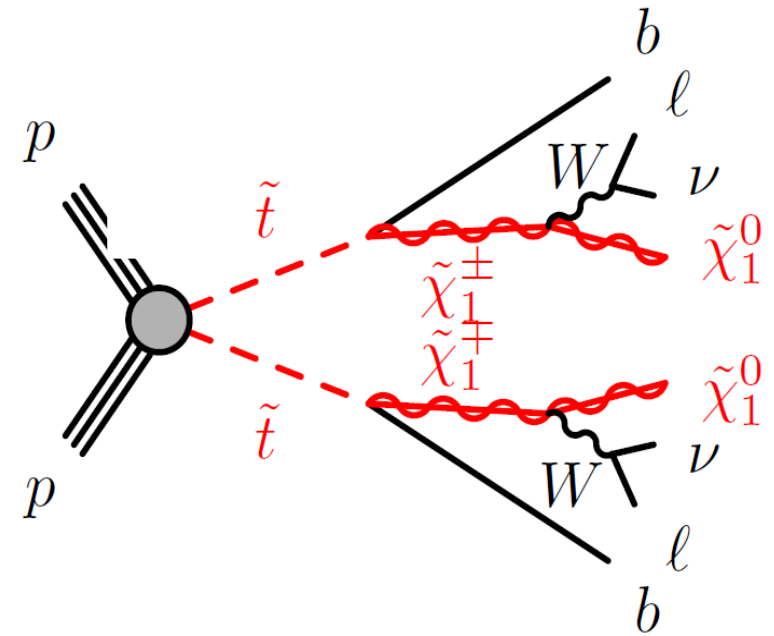
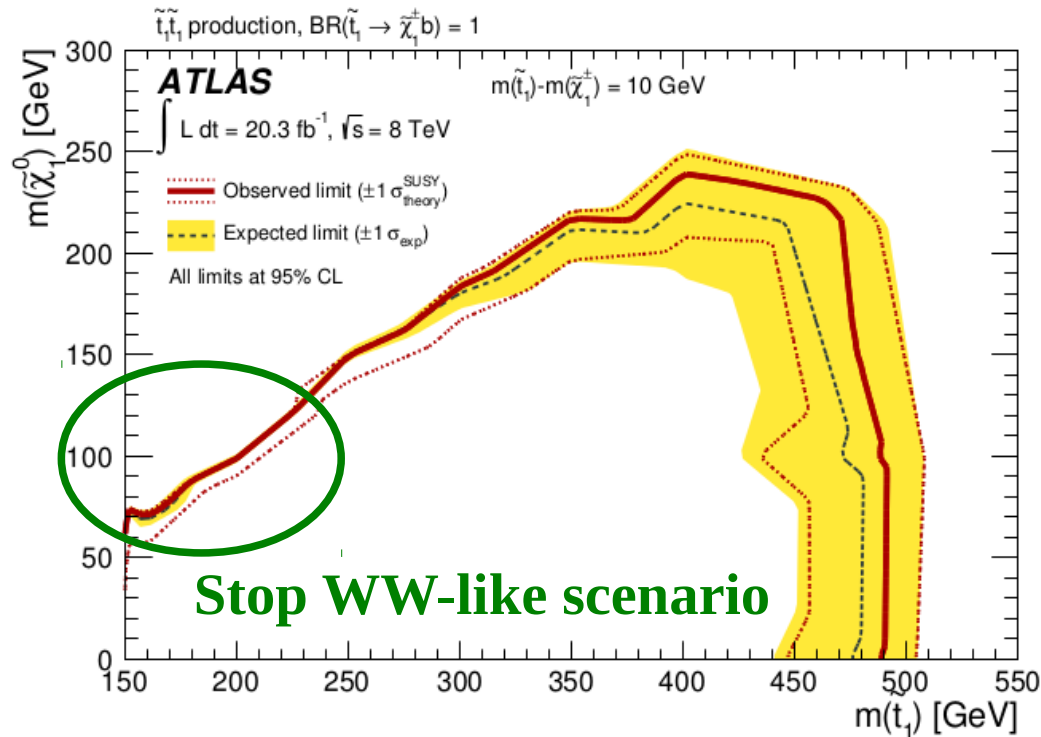
Attività di analisi SUSY

S. Carrà, P. Dondero, G. Gaudio, G. Polesello

Analisi “Stop WW-like”

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) $m_{\text{stop}} - m_{\text{ch}} < 30 \text{ GeV}$
- 2) $m_{\text{ch}} - m_{\text{neu}} < 100 \text{ GeV}$
- 3) $m_{\text{stop}} < 200 \text{ GeV}$

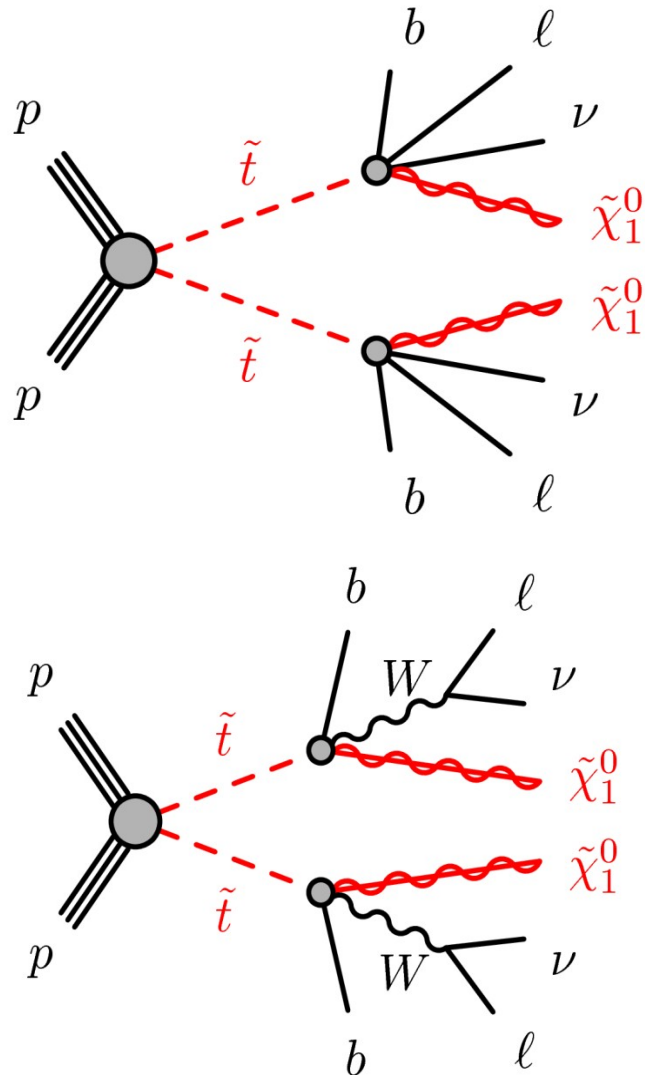


In questa regione il decadimento dello stop è simile alla produzione di WW, che avrebbe potuto spiegare il piccolo eccesso nella sezione d'urto misurata.

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

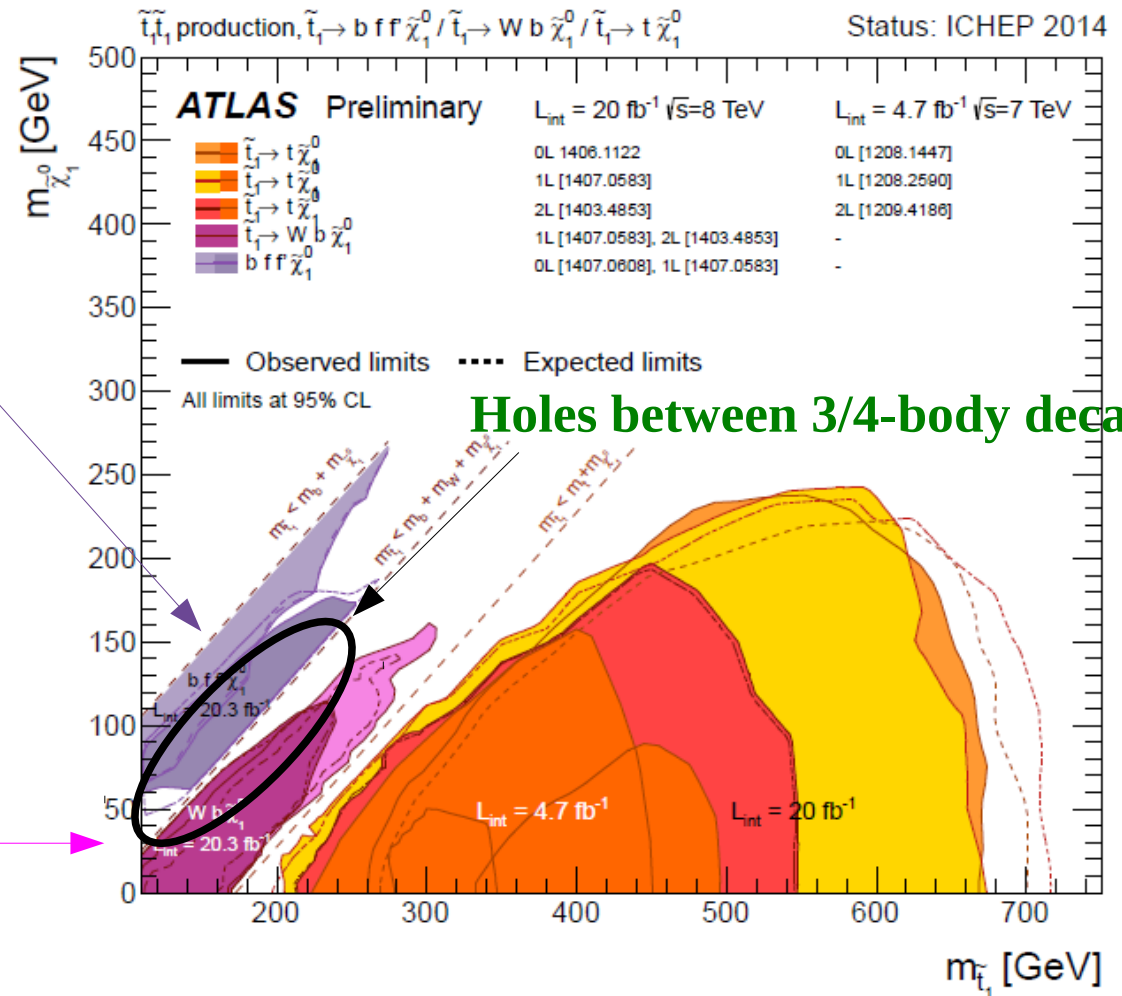
WW-like analysis

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.



4-body decay

3-body decay



WW-like analysis

- Buona copertura delle regioni desiderate (sia WW-like che 3/4-corpi)
- Dopo la reinterpretazione è stata scritta la supporting internal note (approvata internamente dal gruppo susy a dicembre)
- L'analisi farà parte del Third Generation Summary Paper (“ATLAS Run 1 searches for direct pair production of third generation squarks at the Large Hadron Collider”), attualmente in via di pubblicazione.
- Presentazione del lavoro al workshop di ATLAS Italia e poster a IFAC 2015 (P. Dondero).

WW-like analysis

Da dicembre in poi, 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...)
- Sviluppo del codice di analisi all'interno del nuovo software framework di ATLAS
- Primi studi di sensitività a 13 TeV svolti dal gruppo di Pavia, mostrati a maggio in meeting dedicati, tesi di laurea di S. Carrà
- Confronto incrociato dei risultati preliminari con gli altri gruppi (confronto dei “cut-flow”)

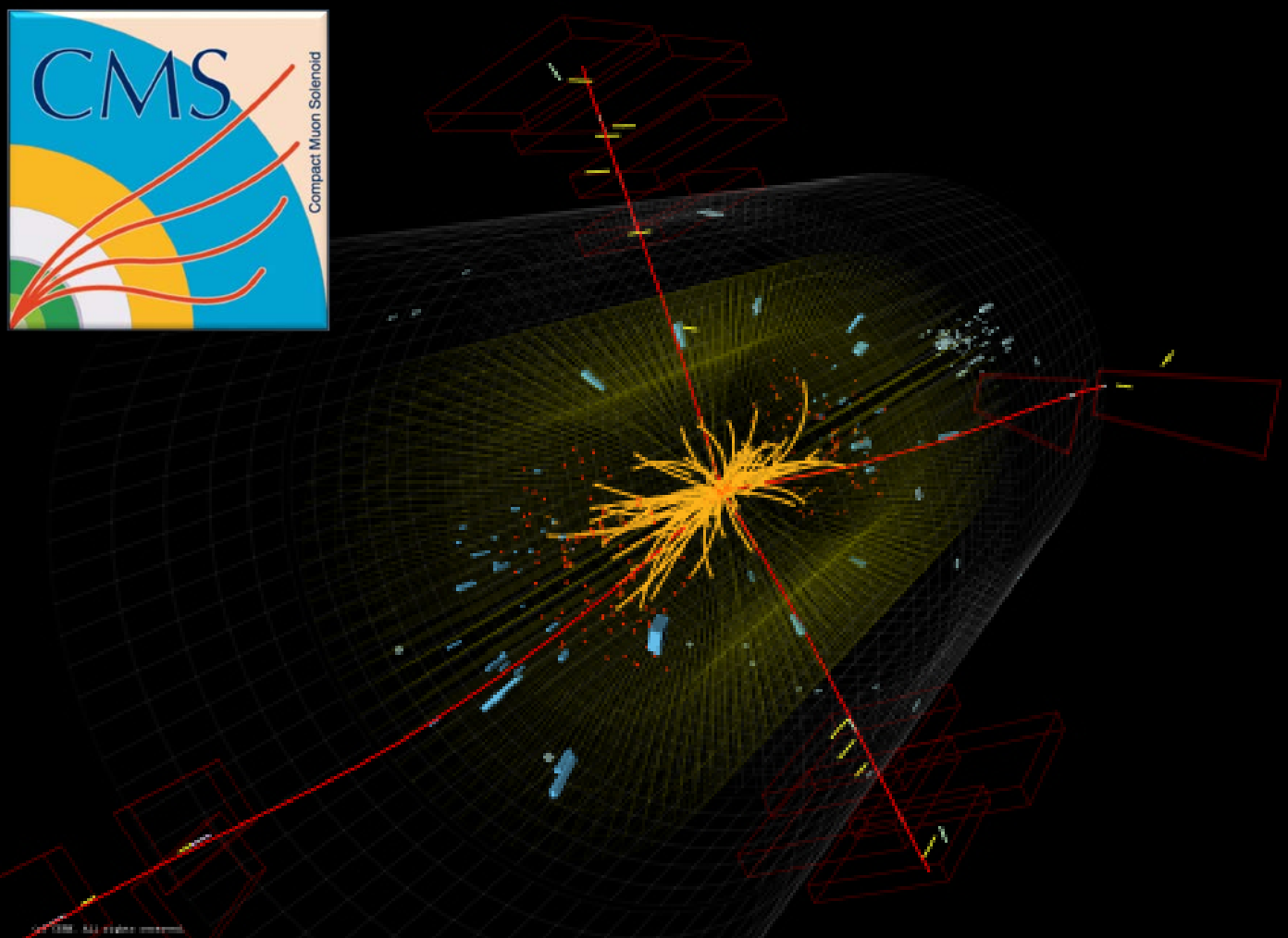
Pavia in ATLAS

Responsabilità gruppo PV in ATLAS:

- **Gaudio**: responsabile monitoring online MDT
- **Lanza**:
 - Responsabile servizi MDT
 - Responsabile servizi NSW
 - Responsabile integrazione HW FTK
- **Negri**:
 - Responsabile dataflow ATLAS
 - Responsabile integrazione DAQ FTK
- **Polesello**: Deputy Chair del Publication Committee di ATLAS (da 03/2015)
- **Rebuzzi**: Monte Carlo Manager for the Higgs group

Responsabilità gruppo PV in ATLAS-Italia:

- **Ferrari**: Responsabile nazionale Upgrade
- **Negri**: Responsabile nazionale TDAQ



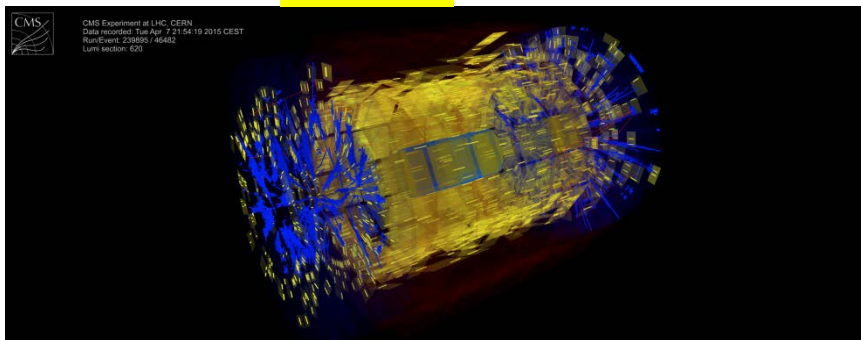
CMS PAVIA

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	1.0			MUON
Massimo Manghisoni	RU	0.5		0.2	TRACKER
Paolo Montagna	RU	0.6	0.1		MUON
Roberto Nardò	Tecnologo	0.4			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	RU	0.8	0.1		MUON
Paola Salvini	Ric. INFN	0.9	0.1		MUON
Gianluca Traversi	RU	0.6		0.2	TRACKER
Carla Vacchi	RU	0.4		0.2	TRACKER
Ilaria Vai	Dottoranda	1.0			MUON
Paolo Vitulo	RU	0.6	0.4		MUON

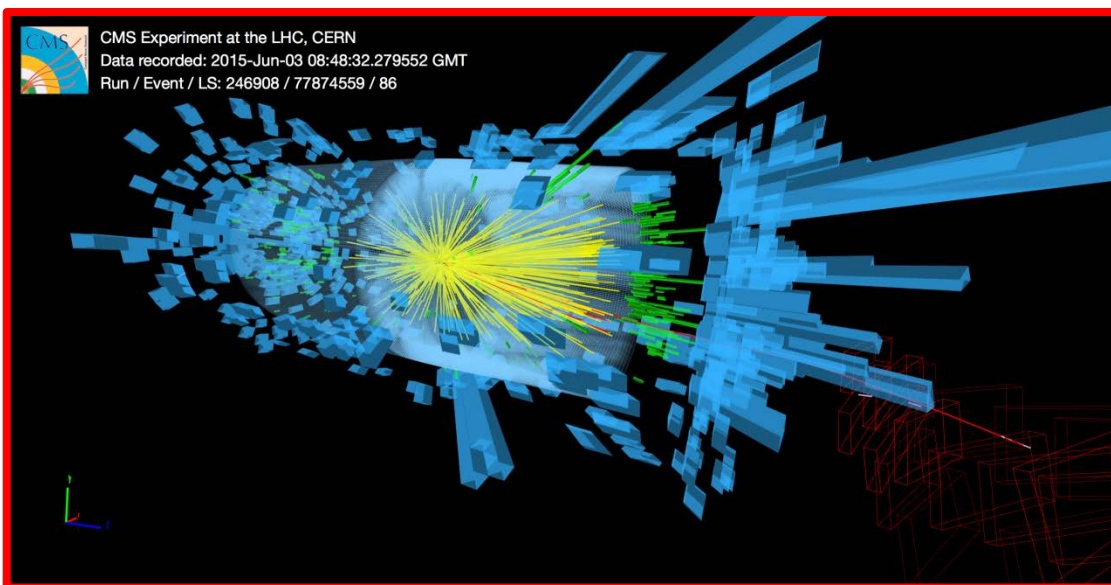
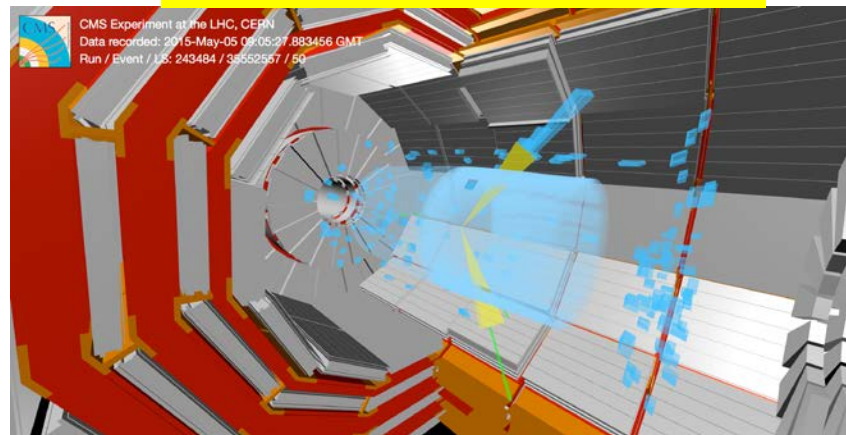
totale FTE = 12.6 + tre laureandi CMS (tesi LM) Francesco Fallavollita, Alberto Imperiale, Martina Ressegotti

Run 2 è partito!

Aprile



Maggio p-p a 900 GeV

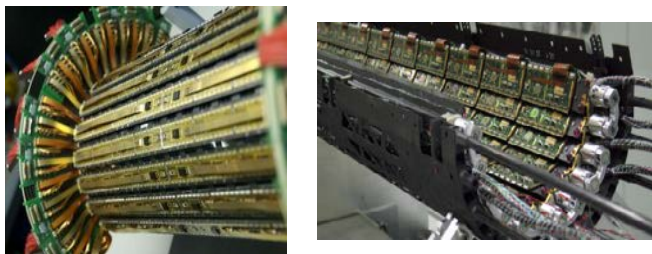


**p-p a 13 TeV Stable Beam.
3 Giugno 2015 08:48**

CMS Tracker Activities of the Pavia Group

D.Comotti, F.DeCanio, L.Fabris, M.Manghisoni, B.Nodari, L.Ratti, V.Re, G.Traversi, C.Vacchi

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/cm²
 - **Hit rates: 1-2 GHz/cm²** (factor 16 higher than current pixel detectors)
- **Smaller pixels:** $\frac{1}{4}$ - $\frac{1}{2}$ (25 - 50 μ m x 100 μ m)
 - 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 $\rightarrow$ 1MHz
- Low mass $\rightarrow$ Low power

Unprecedented hostile radiation: 1Grad, 10¹⁶ Neu/cm²

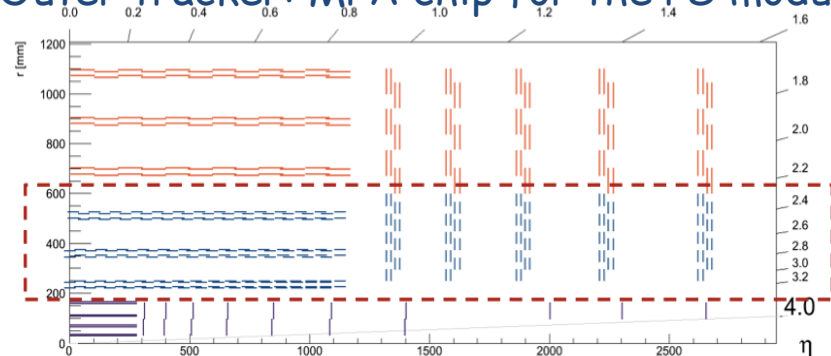
- Hybrid pixel detector with separate readout chip and sensor.
- Phase2 pixel will get in 1 year what we now get in 10 years

Pixel sensor(s) not yet determined

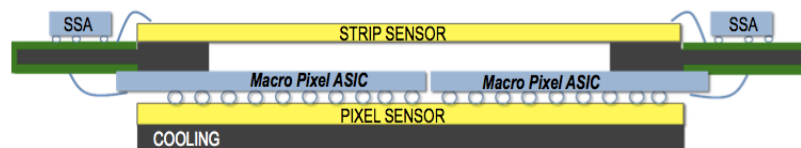
- Planar, 3D, Diamond, HV CMOS, , ,
- Possibility of using different sensors in different layers
- Final sensor decision may come relatively late.

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.

inner tracker: RD53: an ATLAS-CMS-LCD collaboration

➤ Front-end for hybrid pixels

- Design of a front-end analog channel together with the FNAL Microelectronics group
- Characterization of a continuous-time analog channel (PA + discriminator) **submitted for fabrication at the end of 2014**

➤ IP Blocks

- Characterization (test bench and X-rays irradiation) of bandgap voltage reference circuits (**submitted in 2014**)
- Design of a low speed ($\approx 160\text{MHz}$) and high speed ($\approx 1.2\text{GHz}$) driver and receiver (**submitted in May 2015**)

➤ Study of the radiation hardness of the 65nm TSMC CMOS Technology

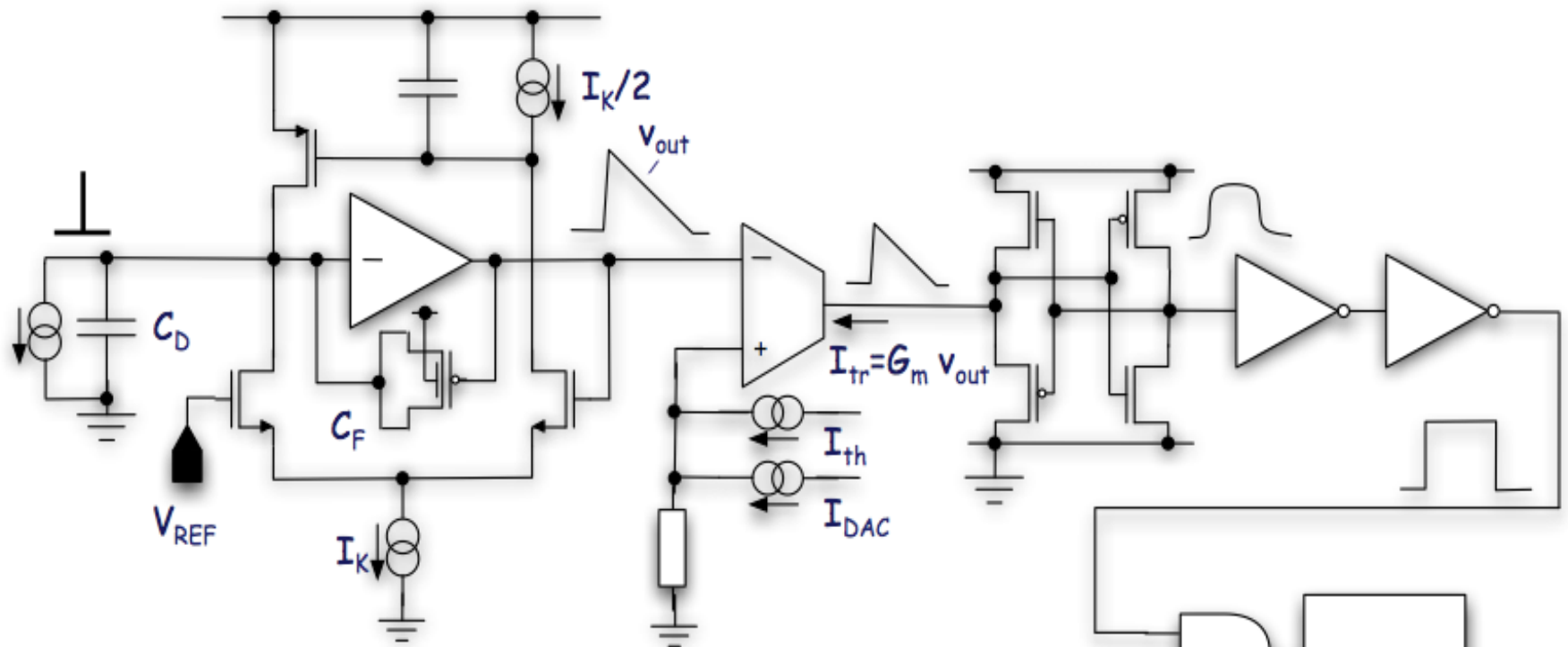
- Characterization of MOSFETs transistors up to 1Grad

outer tracker: PH/ESE-ME group (CERN)

➤ Development of the Macro Pixel ASIC (MPA) Chip for the Pixel-Strip (PS) Module in collaboration with the Micro Electronics group of CERN

- Study of a low-power clock distribution schemes **fabricated at the end of 2014**
- Design of a sLVDS link at 320Mbps

Front-end channel scheme



- Single amplification stage for minimum power dissipation
- Krummenacher feedback to comply with the expected large increase in the detector leakage current
- High speed, low power current comparator
- Relatively slow ToT clock - 80 MHz
- 5 bit counter - 400 ns maximum time over threshold

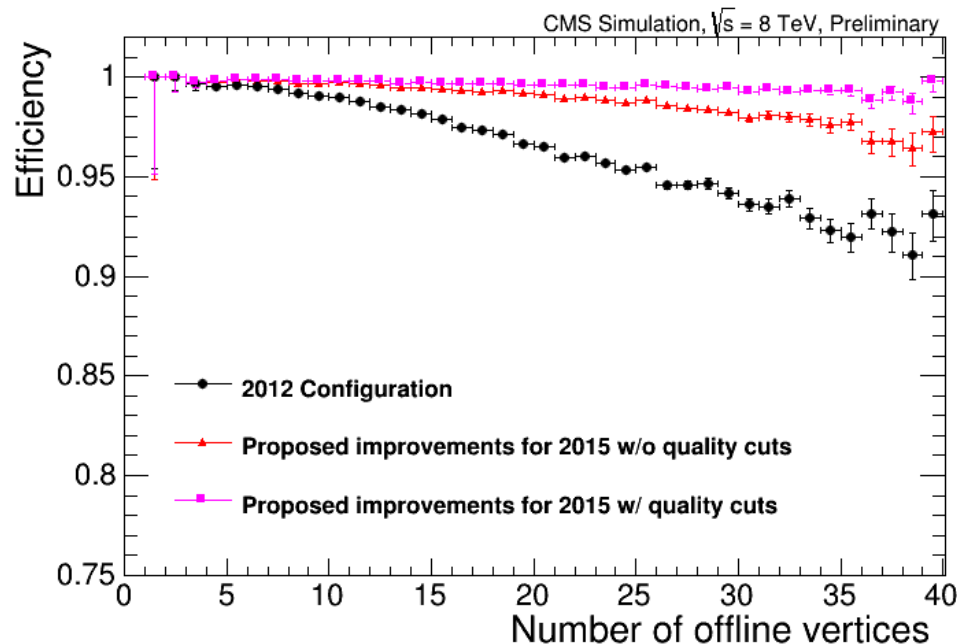
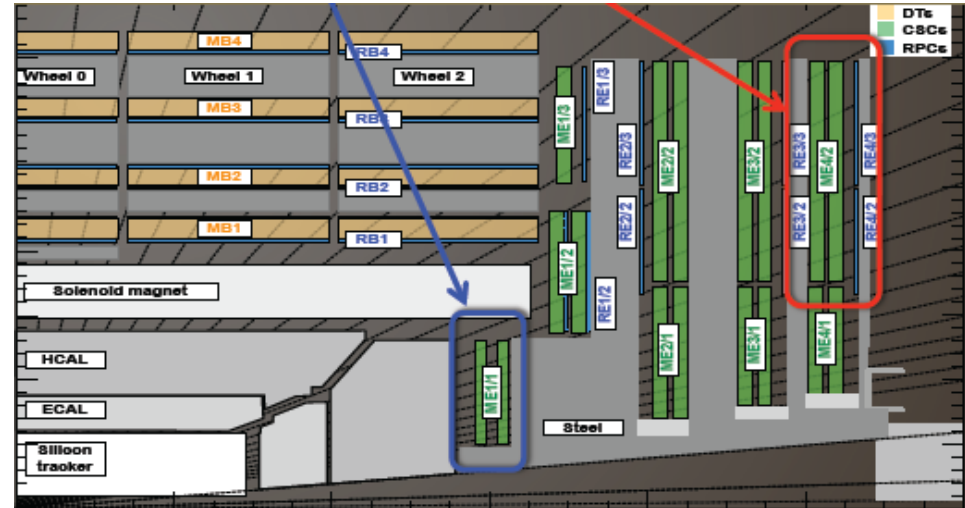
- 30000 electron maximum input charge, ~500 mV preamplifier output dynamic range

Conference and Workshop Presentations

1. 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)
2. F. De Canio et al.: "Characterization of Bandgap Reference Circuits designed for High Energy Physics Applications", 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)
4. L. Gaioni et al., "65 nm CMOS analog front-end for pixel detectors at the HL-LHC", to be presented at the **Topical Workshop on Electronics for Particle Physics, TWEPP 2015**, Sept. 28 - Oct. 2, 2015, Lisbon (Portugal)
5. L. Ratti et al., "An asynchronous front-end channel for pixel detectors at the HL-LHC experiment upgrades", to be presented at the Nuclear Science Symposium and Medical Imaging Conference, NSS 2015, **Topical Workshop on Electronics for Particle Physics, TWEPP 2015**, Oct. 31- Nov. 7, 2015, San Diego (CA), USA
6. G. Traversi et al., "Transmission Lines Implementation on HDI Flex Circuits for the CMS Tracker Upgrade", to be presented at the **Topical Workshop on Electronics for Particle Physics, TWEPP 2015**, Sept. 28 - Oct. 2, 2015, Lisbon (Portugal)
7. 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)

Rivelatore di Muoni (DT+ RPC+ CSC) da Run 1 a Run 2

- Muoni : completata stazione 4 (**144 RPC + ME4-2**)
- Revisione di **ME1/1**
- Elettronica DT



Rate x 4 (at least)

In time pileup from $\langle \text{PU} \rangle \sim 25$ (Run1) up to $\langle \text{PU} \rangle \sim 40$ (Run2)

L1 ~ 100 kHz and HLT output rate ~ 1 kHz

- **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 confrontata con misure di anni precedenti.
C.Riccardi,P.Vitulo
- Offline monitor di rate e correnti durante la presa dati **P. Salvini, P.Montagna**

**Responsabilità L3
per aging RPC:
P.Vitulo**

Monitor di correnti per gli RPC

L'idea è quella di utilizzare la relazione lineare tra luminosità e corrente per realizzare un monitor di corrente e di background nelle diverse parti dell'apparato

con quantità mediate su un run o con granularità temporale maggiore

Condizione necessaria: studio della stabilità temporale del fit corrente vs.luminosità

Realizzazione di un sistema di controllo automatico da implementare durante il run

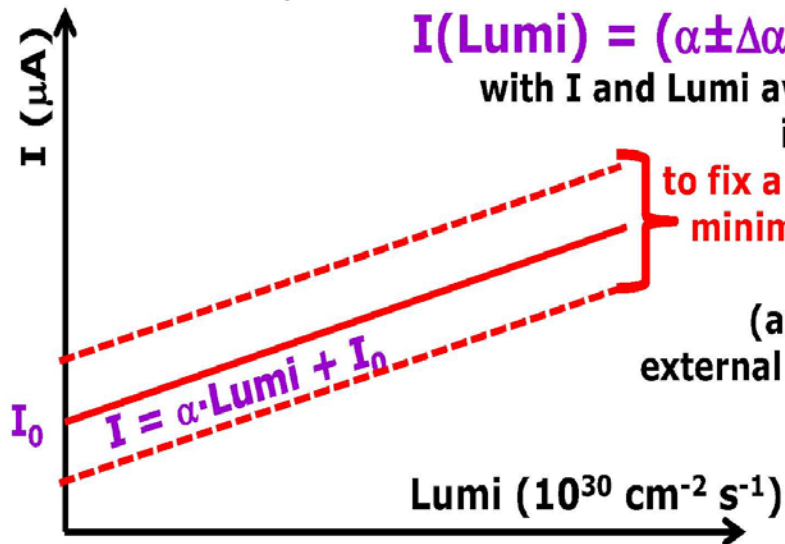
So, on the basis of the current-luminosity relationship

$$I(\text{Lumi}) = (\alpha \pm \Delta\alpha)\text{Lumi} + (I_0 \pm \Delta I_0)$$

with I and Lumi averaged over the runs,
it would seem possible

to fix a well-defined region of
minimum-maximum current
expected values

(and so to flag runs with
external values as "no good"?)



P. Salvini, P.Montagna

E' possibile assegnare a ogni disco dell'endcap (simmetria avanti/indietro) un range di valori di corrente «attesi» sulla base dei parametri del fit (stabili all'interno del %). Verificato sull'ENDCAP

The CMS GEM Upgrade project for the Upgrade

A. Colaleo CMS Referee 29-06-2014

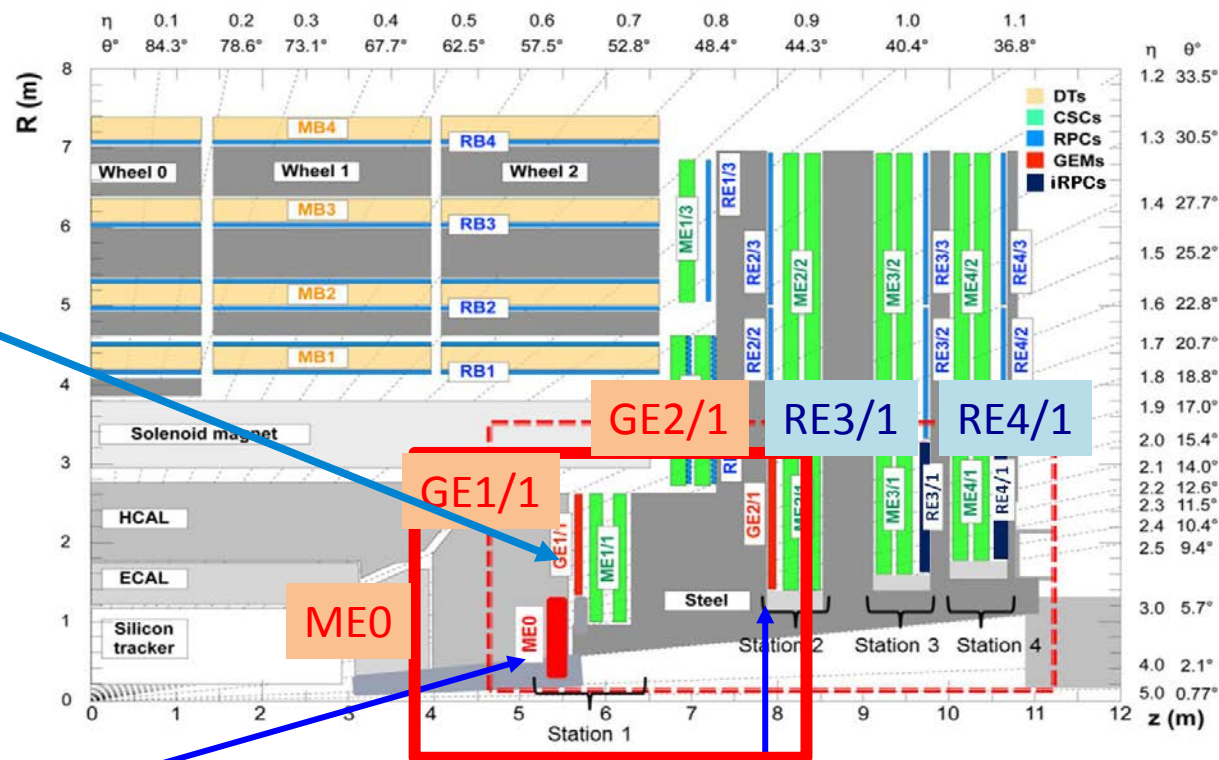
Phase1 LS2

GE1/1: precision chambers to improve trigger momentum selectivity and reconstruction

GE1/1 $\eta=2.1$: 5th generation prototypes, assembly techniques optimized - **144 chambers: 72 two 10° triple-GEM (“superchamber”)**

GE2/1 $\eta=2.4$ very similar to GE1/1 (area 3.5 GE11 chamber) - **72 chambers: 36 two 20° triple-GEM**

ME0 $\eta=4$: same size but more layers (for neutron background rejection): - **216 chambers: 36x6 20° triple-GEM**

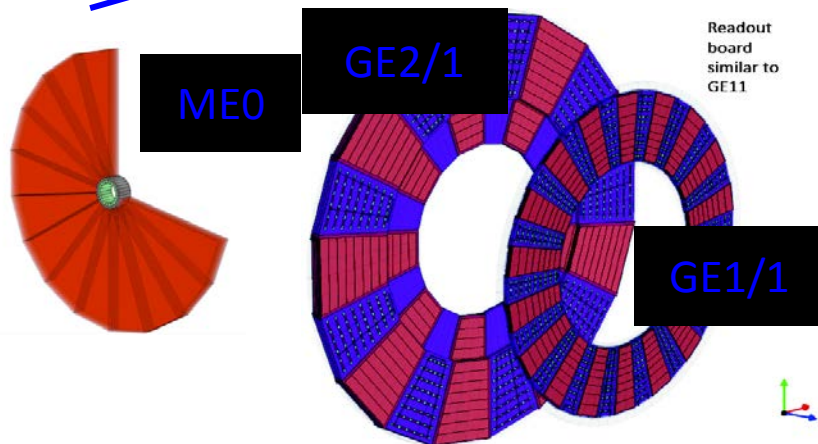


Phase 2 LS3

ME0 module to provide muon tag in highest η region

Several tens of kHz expected
→ GEM or alternative MPGD

R&D for ME0 launched



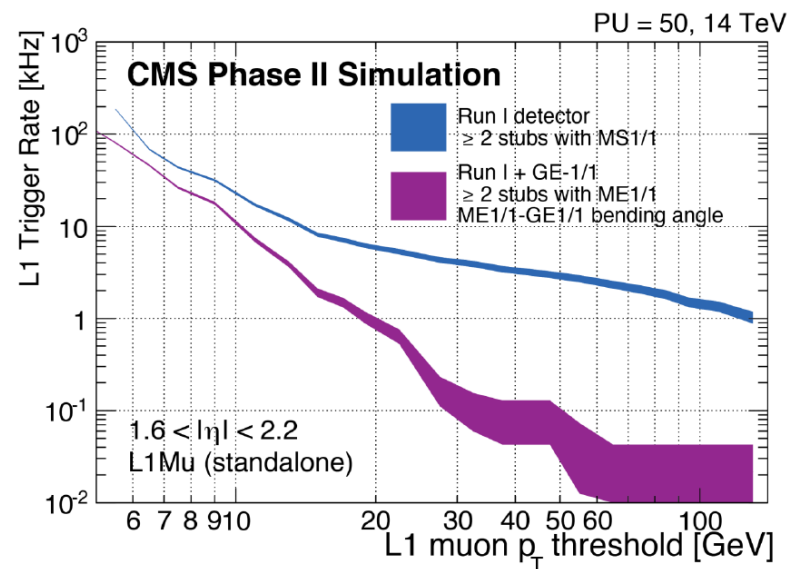
Phase 2 LS3

Station GE2/1: 20 degrees precision chamber up to $\eta=2.45$ to improve trigger momentum selectivity and reconstruction

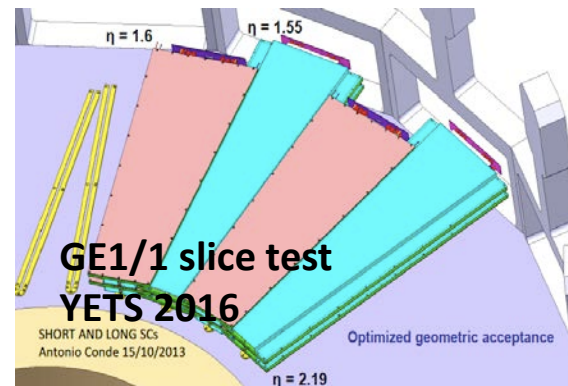
The GE1/1 station

- **CMS Technical Design Report for the muon endcap GEM upgrade pronto per LHCC (CMS-TDR-15-001-001)**

Spatial resolution	$\approx 100 \text{ } \mu\text{m}$
Time resolution	4-5 ns
Efficiency	98%
Rate capability	100 MHz/cm ²

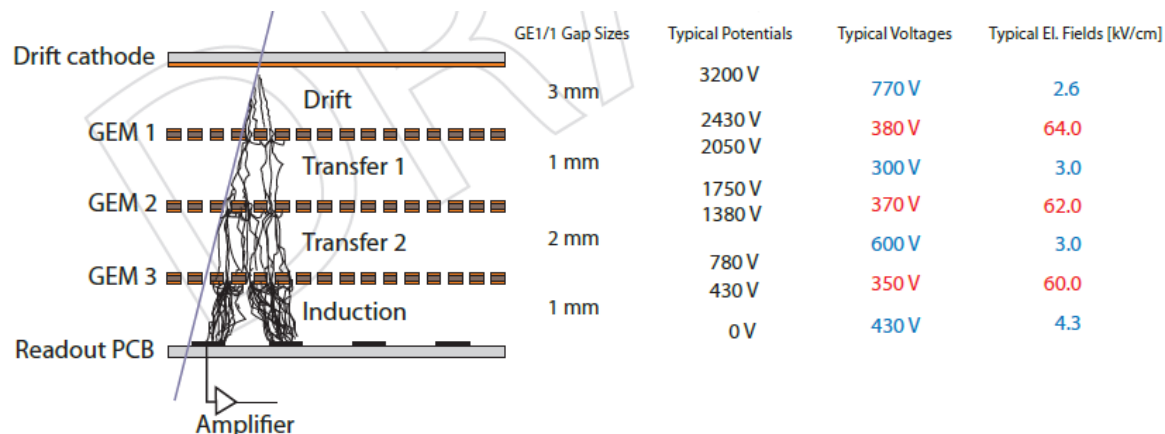


- Slice test programmato per 2016
- Inserimento GE1/1 previsto per 2018

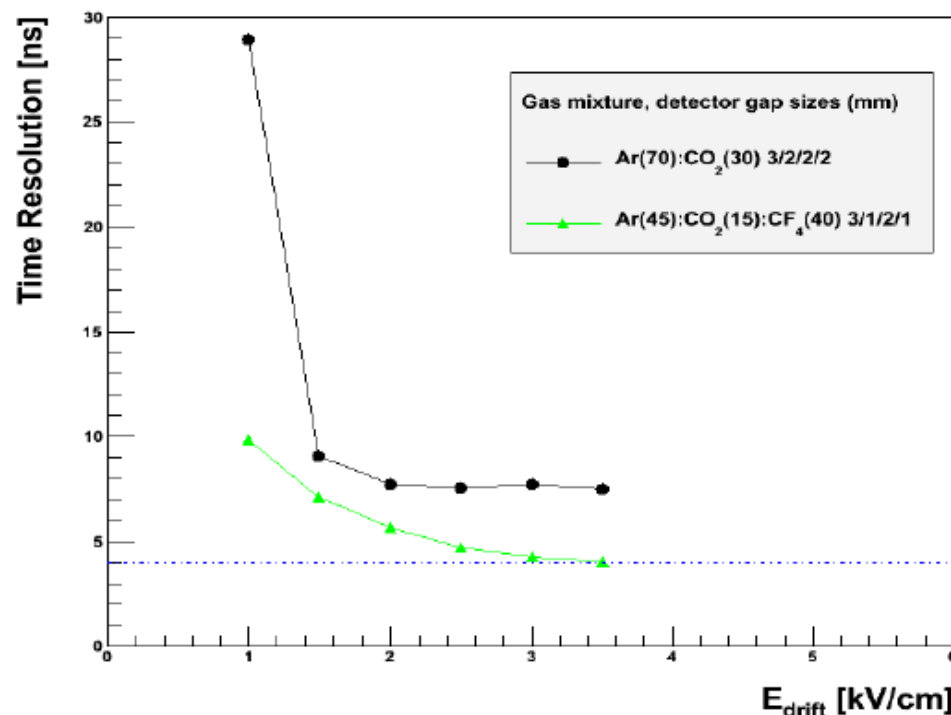


The GE1/1 station

1. **R&D** su metodi di costruzione :
dimensioni 1mx0.4m
2. **Test beam** con muoni e pioni di 150 GeV a SPS linee H2-H4 e Fermilab
3. **Irradiation test at GIF**
Aging tests con sorgente ^{137}Cs source of 566 GBq (Gamma rays 662 keV).
Guadagno stabile fino a 10 mC/cm² (circa 2 anni HL-LHC).



Standard GEM Timing Performance

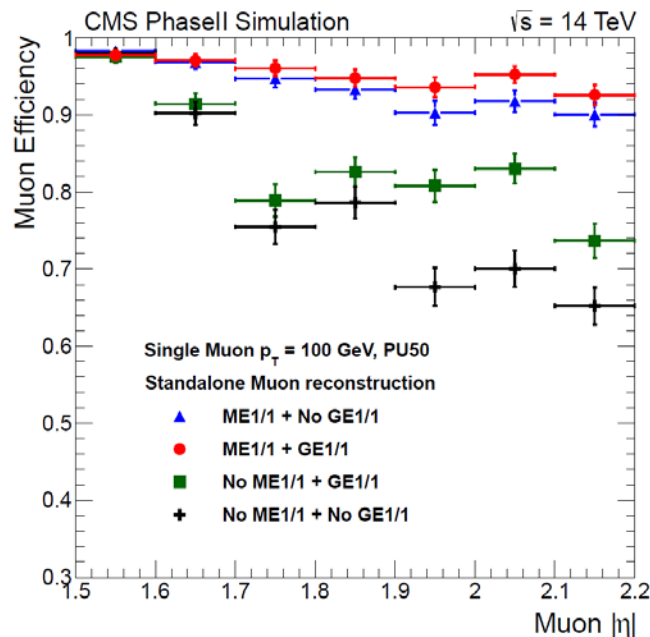
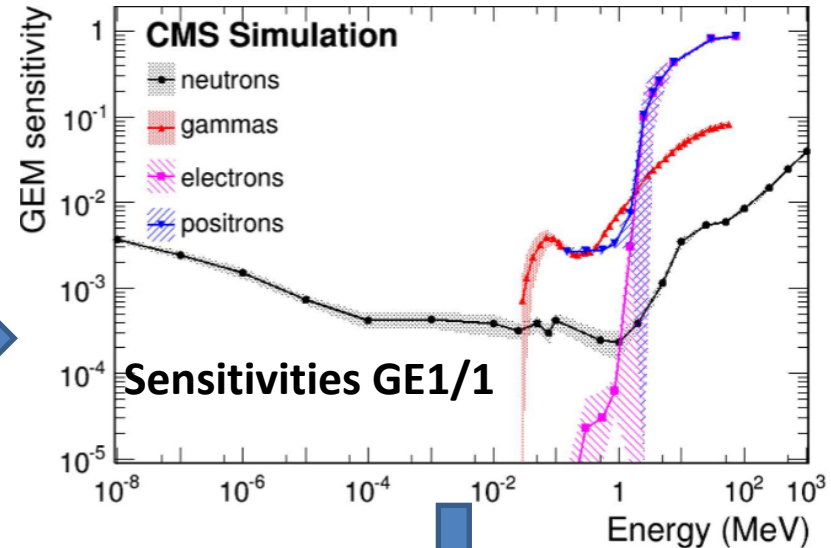
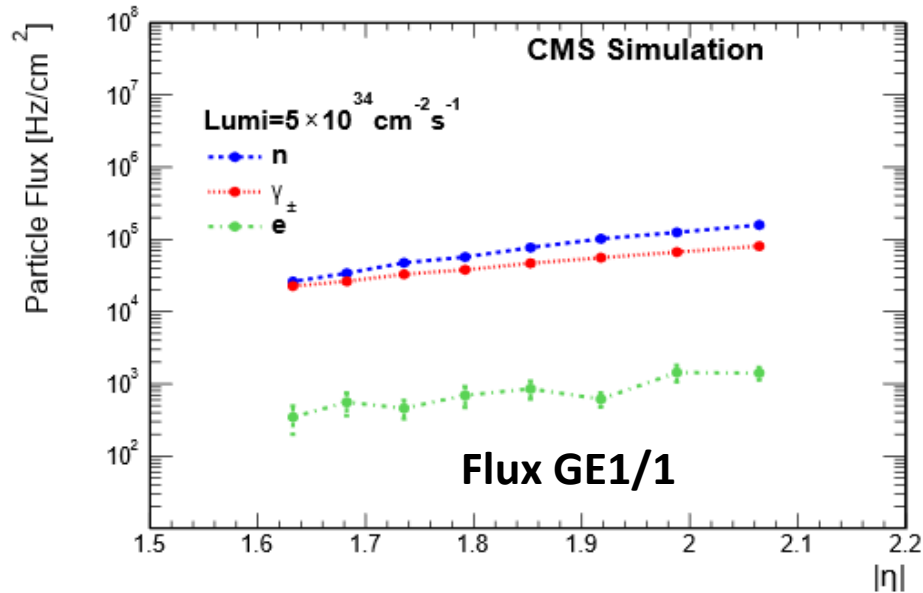


Partecipazione a test beam e alla preparazione per slice test (I.Vai)

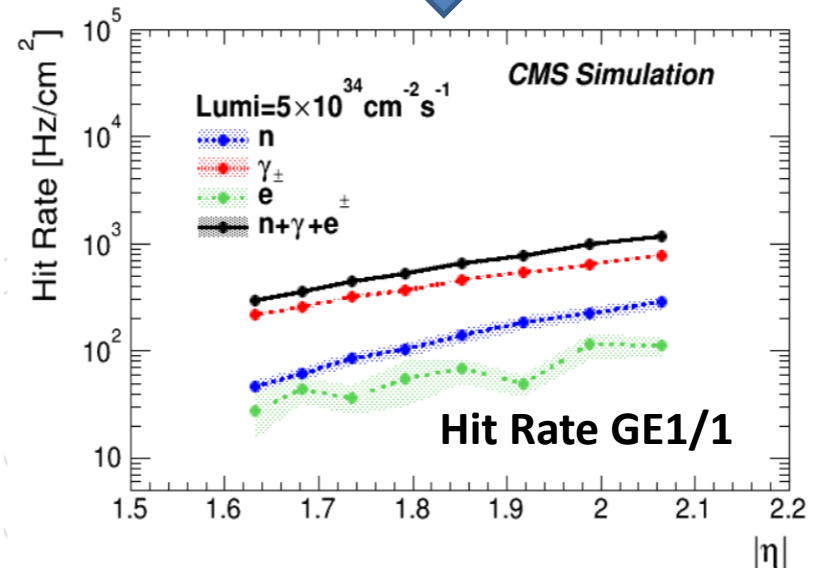
Sensitivity to cavern background evaluated using Geant4

(contributo a CMS GEM Technical Design Report)

A.Magnani, C.Riccardi



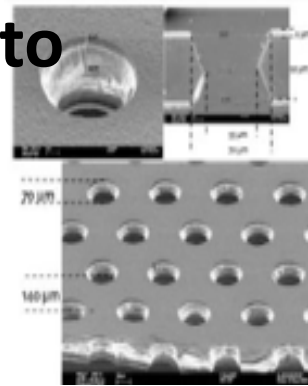
**Muon
Standalone
reconstruction
efficiency**



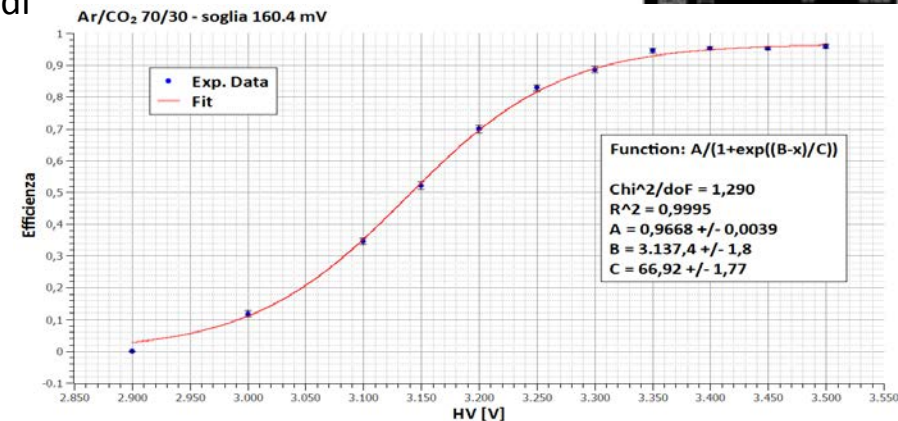
Attività GEM a Pavia e alle facilities di irraggiamento

- **Caratterizzazione di un prototipo Triple-GEM 10 x 10 cm² nel laboratorio CMS a Pavia**

M. Ressegotti, P.Vitulo



- **Misure Effettuate**
- con Ar/CO₂ 80/20
 - Identificazione del picco di Ba-133 tramite misure di attenuazione in alluminio → 30keV
 - Efficienza ai muoni cosmici
- con Ar/CO₂ 70/30
 - Efficienza ai muoni cosmici
 - Efficienza al Ba-133
 - Misure di corrente e guadagno
 - Spettro del Ba-133 al plateau
 - Risoluzione temporale usando raggi cosmici.



HV=3400 V → efficienza (96.7 ± 0.4) %.

- **Misure e simulazioni di sensitività a γ (X-Ray at TIF / Cd source) e n (Louvain)**

X-Ray at TIF

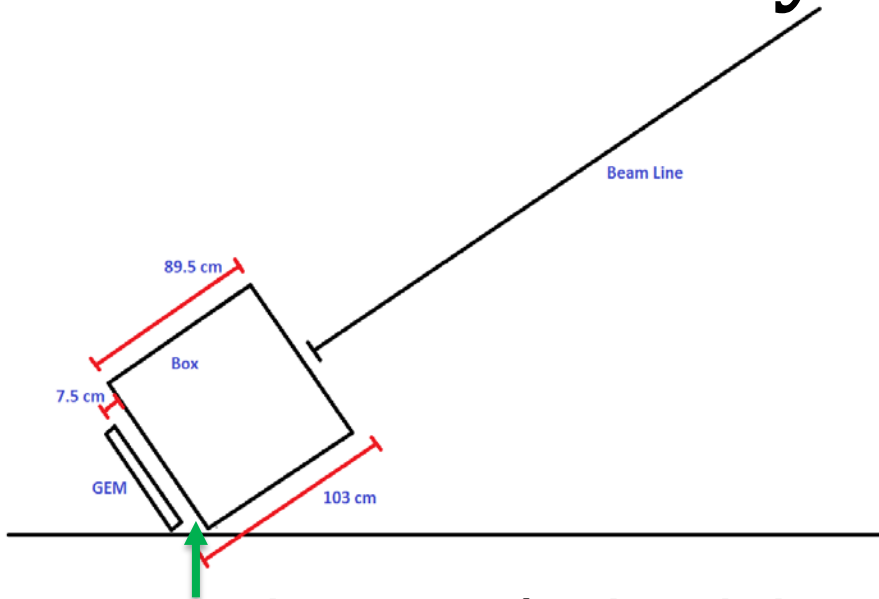
- 5-50keV (peak at 22keV)
- Maximum flux $10^6 \frac{\text{part}}{\text{mm}^2\text{s}}$

I. Vai, A. Braghieri, A. Magnani, C.Riccardi, P.Vitulo

Cadmium¹⁰⁹ source

- Energy 22 keV
- Activity: 4.98 MBq at 07/08/2013, Half life: 461.2 days → $\lambda = 1.74 \times 10^{-8} \text{ s}^{-1}$
- Current activity (after 1 year and a half) = 2.19 MBq → $\Phi = 4.82 \times 10^4 \text{ part/cm}^2\text{s}$

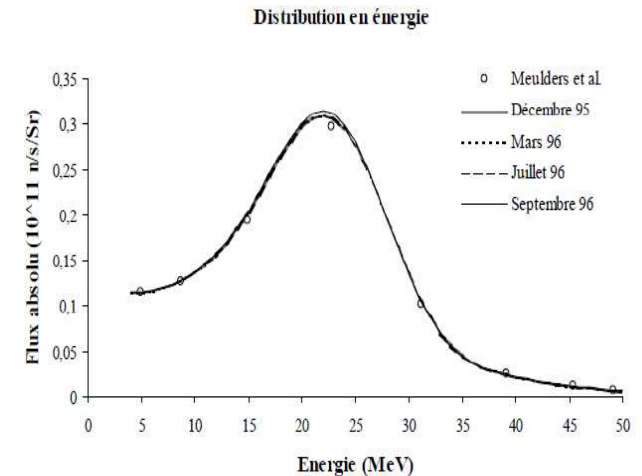
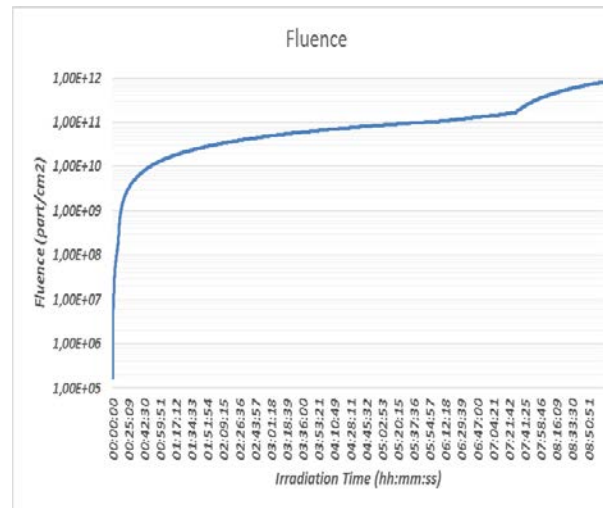
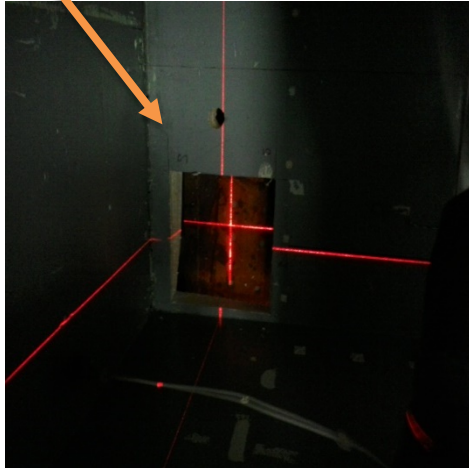
Louvain Facility Characteristics



Characteristics of the beam:

- Energy: 5-50 MeV, peak at ~ 20 MeV
- Flux ($\text{n}/\text{cm}^2\text{s}$):
 - $4,4 \times 10^6$
 - 1×10^7
 - 1×10^8
- Beam spot: $\varnothing 20$ cm $\rightarrow$ centered on sector 5:3 of the chamber

Empty Polistirene Box $\rightarrow$ Hole on the beam axis with size greater than $20 \times 20 \text{ cm}^2$ in order to avoid contamination of the beam



Accumulated Fluence =
 $7.91 \times 10^{11} \text{ part}/\text{cm}^2$

R&D Fase 2

CMS Technical Proposal June 2015
CMS Scope Document RRB October 2015
CMS Technical Design Reports 2016-17

LS2 starting in 2018 (July) 18 months + 3 months BC (Beam Commissioning)
LS3 LHC: starting in 2023 => 30 months + 3 BC
injectors: in 2024 => 13 months + 3 BC



CMS Phase 2 Upgrades

New Tracker

- Radiation tolerant - high granularity - less material
- Tracks in hardware trigger (L1)
- Coverage up to $\eta \sim 4$

Muons

- Replace DT FE electronics
- Complete RPC coverage in forward region (new GEM/RPC technology)
- Investigate Muon-tagging up to $\eta \sim 4$

New Endcap Calorimeters

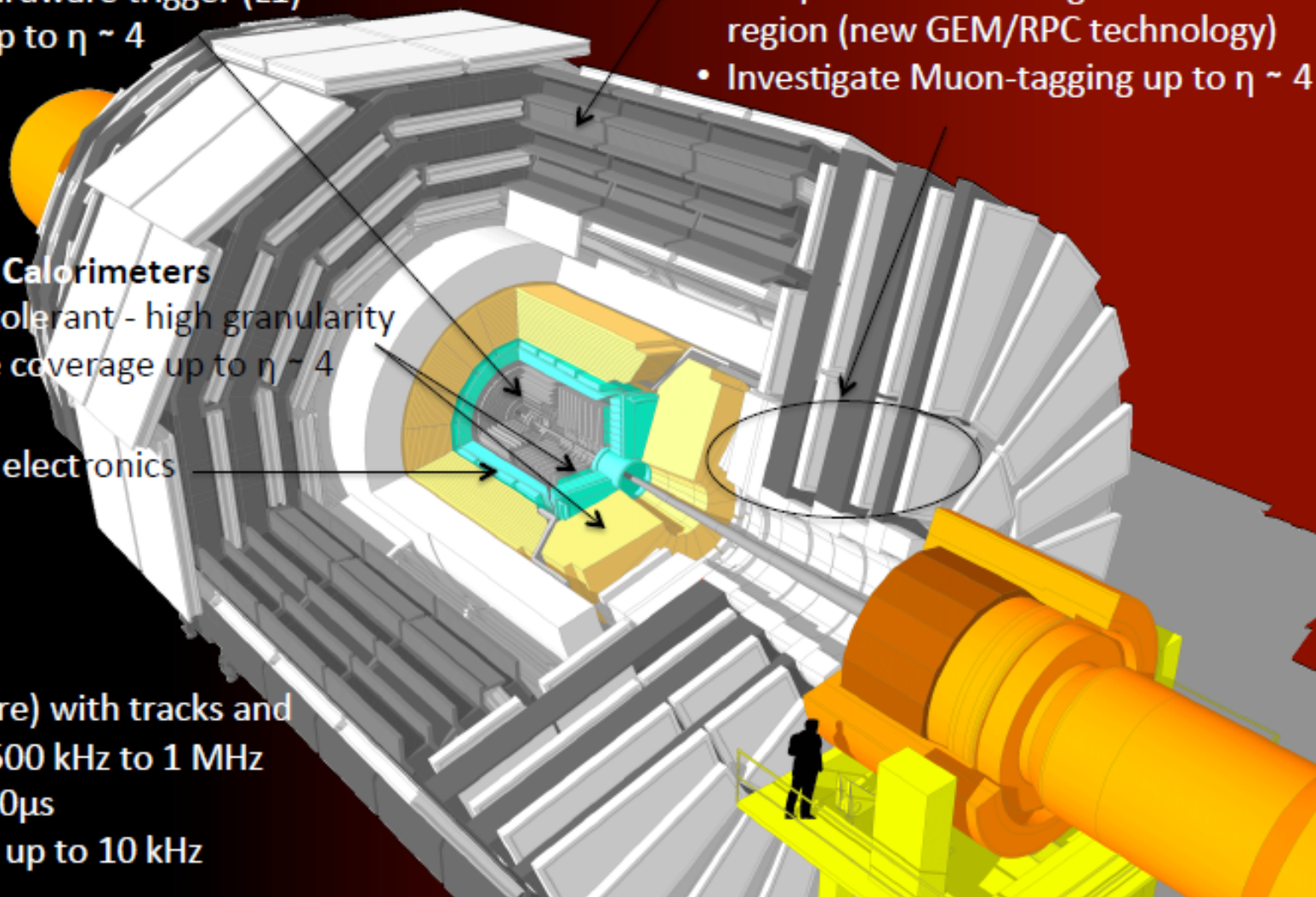
- Radiation tolerant - high granularity
- Investigate coverage up to $\eta \sim 4$

Barrel ECAL

- Replace FE electronics

Trigger/DAQ

- L1 (hardware) with tracks and rate up ~ 500 kHz to 1 MHz
- Latency $\geq 10\mu\text{s}$
- HLT output up to 10 kHz



CMS Fase 2 Muoni

- ▶ **New MPGD detector with high time and spatial resolution (THRAC) to provide muon tag in highest eta region**
- ▶ **PU mitigation with very high time resolution (100 ps) new detector**
- ▶ **Up to 100 kHz hit rate expected: more layers and (for neutron background rejection): multi- μ -well detector**
- **Front-end with tracking/trigger capabilities under design**



Upgrade of high eta region: keep performance of trigger and low ($p_T < 20$ GeV) threshold even at an increased luminosity

- Background rejection and muon reconstruction
- Constant trigger rate with $P_T < 20$ GeV
- **NEW STATIONS RE3/1 and RE4/1** ($1.6 < |\eta| < 2.4$)
 - 144 chambers (about 1.5-2.0 m² area) for the inner (ring n.1) region of disks 3 and 4
 - Rate: 1-2 kHz/cm² → **x5 limit tested for existing RPC chambers**
 - Integrated charge: 1-2 C/cm² @ 3000fb⁻¹

R&D per iRPC

Elettrodi: produzione (Puricelli) 20 lastre bassa resistività , spessore 1.6-1.8-2 mm
→ settembre ([P.Vitulo](#))

Ecogas : preparazione test in collaborazione con Frascati, Bari, Cern, Ghent , Atlas-Tor Vergata (Prevessin -904)

Irradiation test a GIF++ :

upgrade : rate capability, longevity test (settembre ?) - gas mixture (2016)

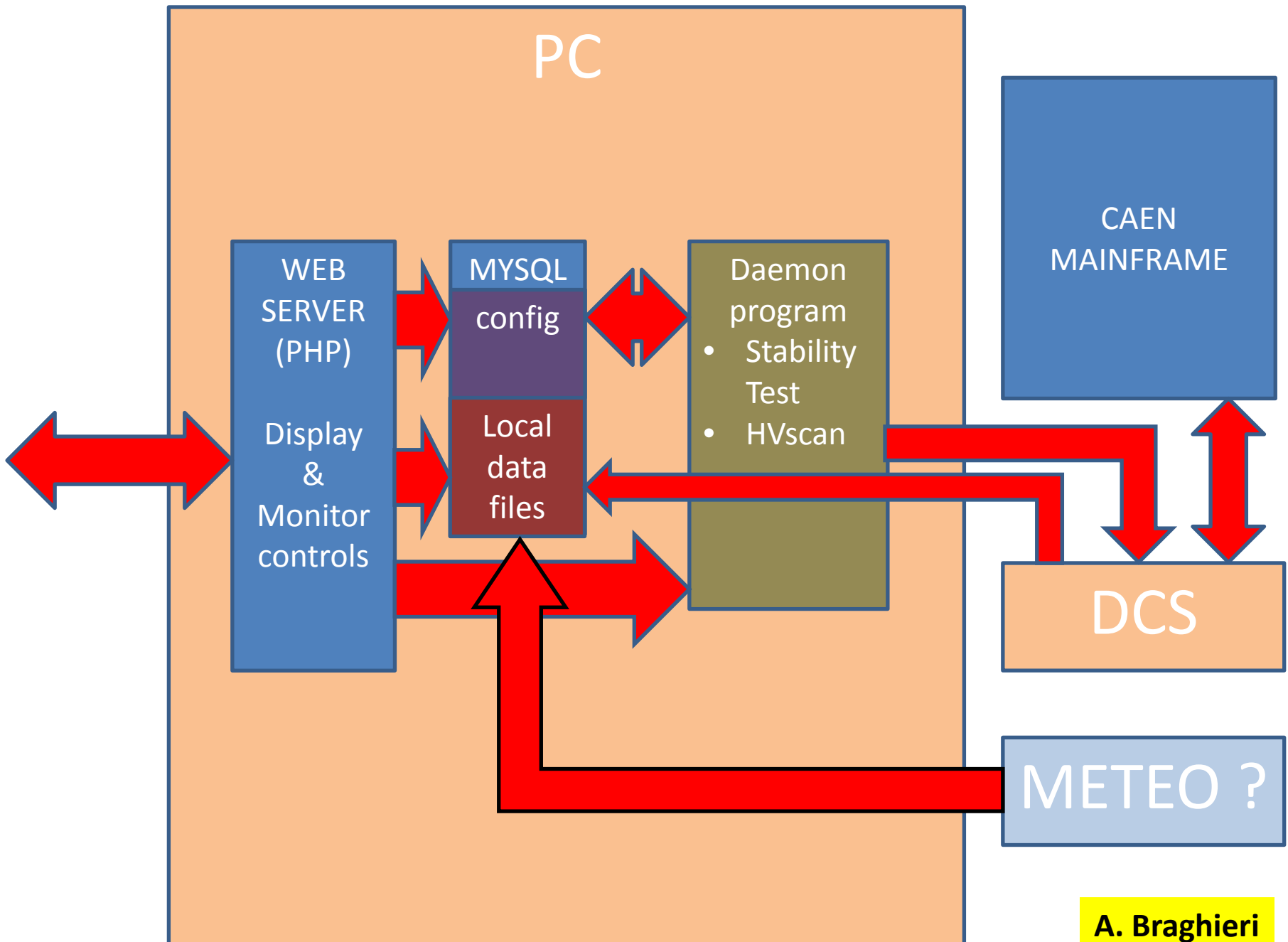
aging per consolidation: camere (2 RE3- 2 RE4) pronte a metà giugno, stesso mixer Atlas-CMS

Sistema di acquisizione e DCS in preparazione



**Messa a punto di un sistema di monitor HV –correnti che verrà
successivamente integrato con PVSS per Test Beam di luglio ([A. Braghieri](#))**

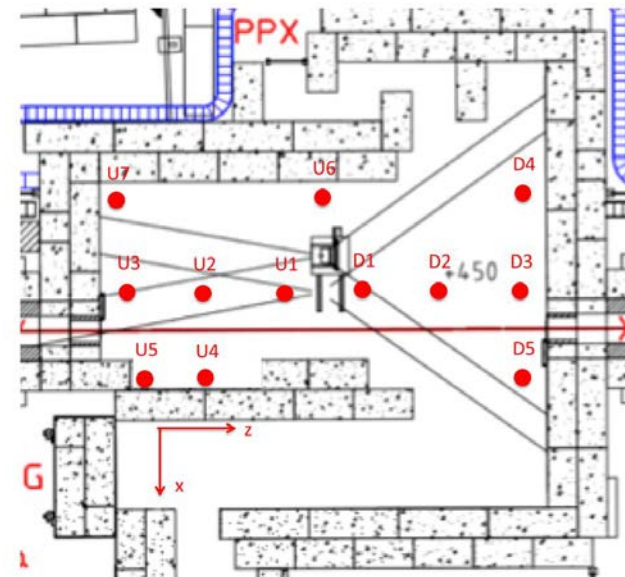
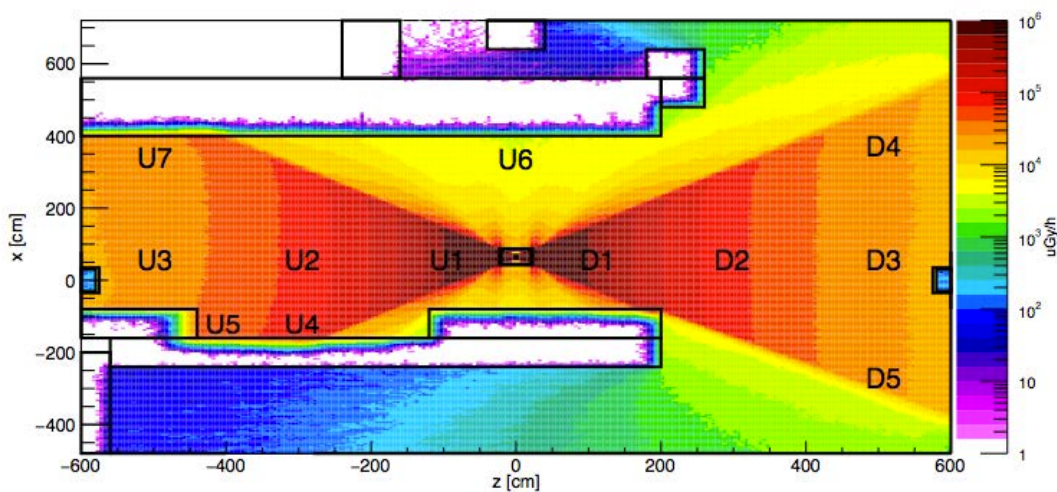
Schema DCS per test beam GIF++



New Gamma Irradiation Facility



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 Sensitivity $\approx 2.4 \cdot 10^{-3}$
Hit rate rate (kHz /cm ²)	8.6	13	

R&D di nuovi rivelatori MPGD per R&D Fase II

- Attività pavese recentemente iniziata su questo item (test con sorgenti [I.Vai](#))
- [F. Fallavolita](#) summer student al Cern quest'estate
- responsabilità di L2 ([P. Vitulo](#) convener dell' office R&D Fase II per GEM project)



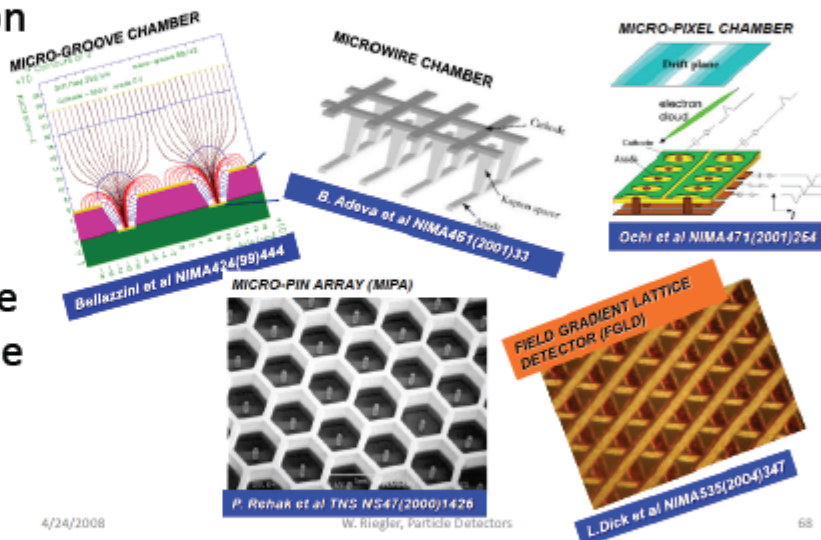
Timing in : Micropattern detectors



Though time resolution of few ns is perfectly adequate in several applications, it would represent a limiting factor in others, where precise timing could be required, for example triggering at high luminosity:

GE0

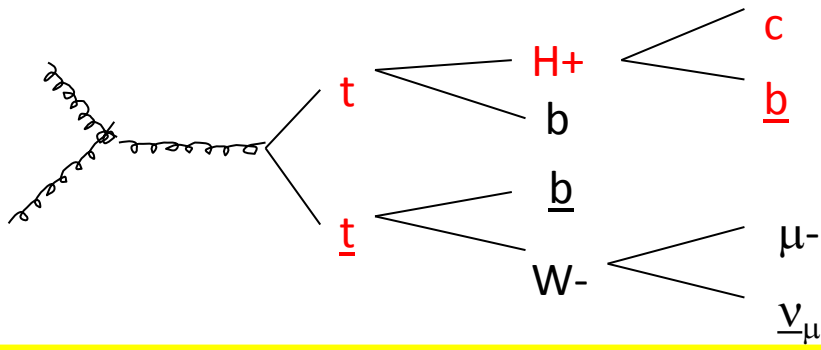
GE2/1



- **Novel MPDG architectures:**
High space, time res. and high rates capability
- **Engineering optimization:**
stability of large detector in over 20 yrs operation

Ricerca di Higgs carico leggero $H^+ \rightarrow cb$

A. Magnani, C. Riccardi



Analisi dati 8 TeV in corso e preparazione per 13 TeV.

A. Magnani simil-fellow Cern da luglio

BR dipendente da modelli e parametri

- Canale rilevante anche in **High-Scale Susy, Split Susy** per $\tan\beta < 3 \rightarrow \text{BR} \sim \%$

*A. Djouadi and J. Quevillon,
arXiv:1304.1787v2, 2013*

- Canale dominante nel flipped 2HDM per $m_{H^+} < 170$ GeV e $\tan\beta > 5 \rightarrow \text{BR} \sim 60\%$

*H. E. Logan and D. MacLennan,
arXiv:1002.4916v2, 2010*

- Canale rilevante in scenari 3 Higgs Doublet 3HDM $\rightarrow \text{BR} \sim 80\%$

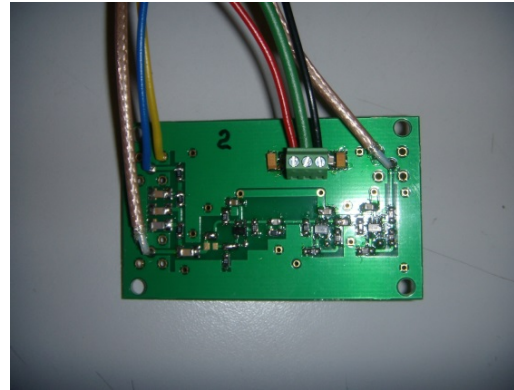
S. Moretti et al., arXiv:1409.7596v1, 2014

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

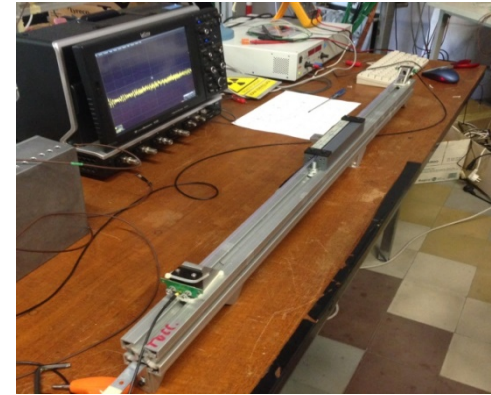
(in collaborazione con il Dipartimento di Ingegneria Meccanica e Industriale - Università di Brescia [Zenoni et al.])

REALIZZAZIONE FINALE E CARATTERIZZAZIONE DEGLI STADI DI AMPLIFICAZIONE

1. Misure di guadagno e linearità;
2. Misura della banda passante;
3. Risposta al doppio impulso.



AMPLIFICATORE (ELETTRONICA SMD - SURFACE MOUNT DEVICE)



CONTROLLO DEL SISTEMA CON NUOVA ELETTRONICA

CARATTERIZZAZIONE DEI SiPM (Silicon PhotoMultiplier - ADVANSID NUV SiPM): misure di corrente di buio e tensione di breakdown

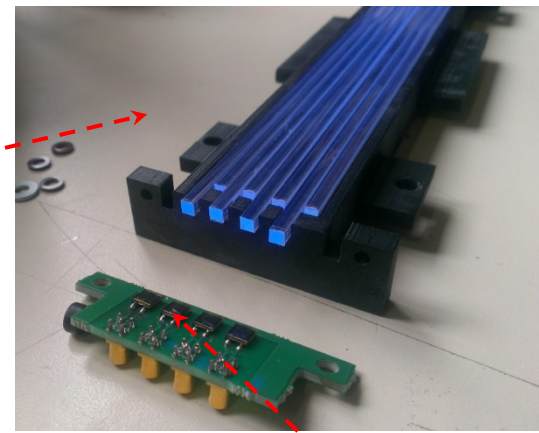
CARATTERIZZAZIONE DEL SISTEMA FIBRE SCINTILLANTI OTTICAMENTE ACCOPPIATE AI SiPM: misure di lunghezza di attenuazione, risoluzione temporale e cross talk fra fibre

Francesco Fallavollita, I. Vai, P. Vitulo, R. Nardò, M. Rossella

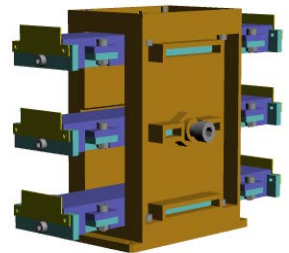
REALIZZAZIONE E CARATTERIZZAZIONE DEL PROTOTIPO IN LABORATORIO:

- 1. Realizzazione dell'*hardware* e del *software* di acquisizione dati (LabVIEW);
- 2. Misura dell'efficienza del rivelatore;
- 3. Realizzazione di un algoritmo per la ricostruzione delle tracce e misura del disallineamento dei rivelatori sul piano orizzontale .

FIBRE SCINTILLANTI
BCF-10

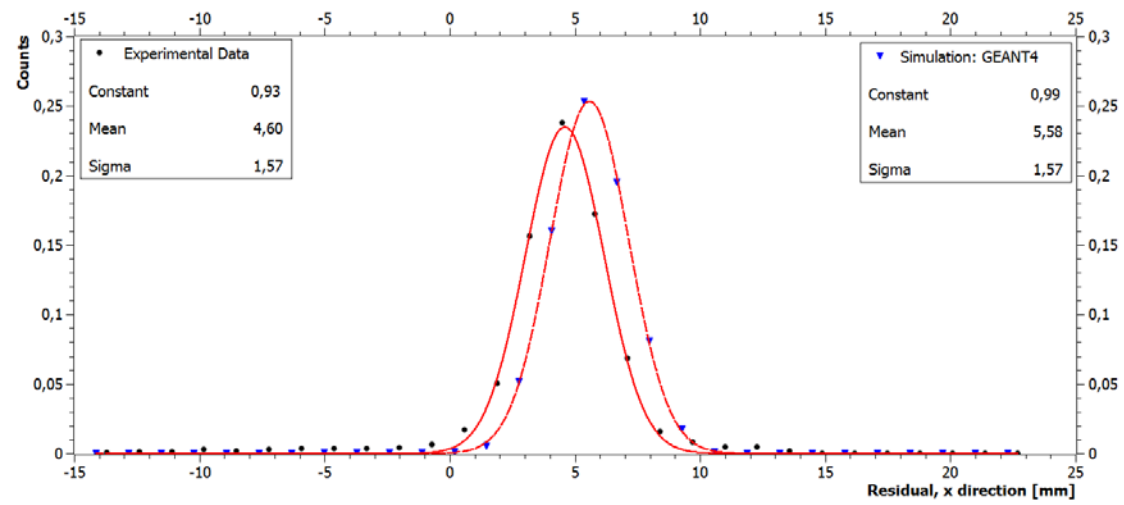


ALLOGGIAMENTO FIBRE

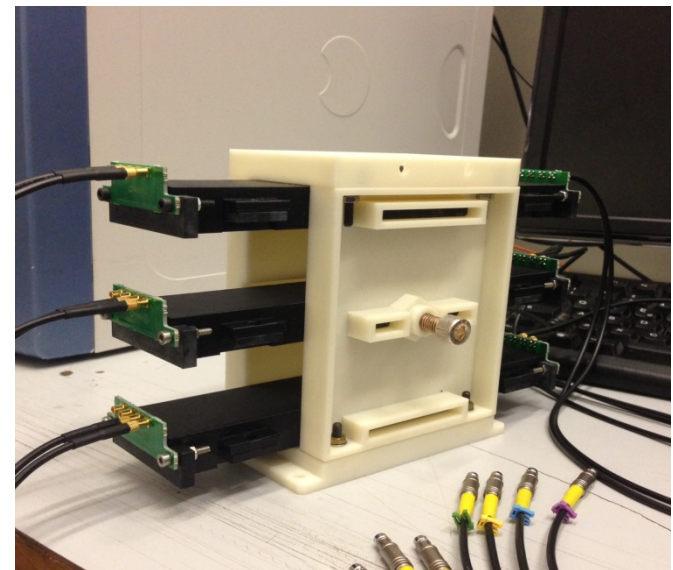


AdvanSiD NUV - SiPM

IL PROTOTIPO È STATO REALIZZATO CON
STAMPANTE 3D IN MATERIALE ABS



ESEMPIO DI DISALLINEAMENTO DEL PIANO CENTRALE RISPETTO
AI DUE RIVELATORI DI TRIGGER E CONFRONTO CON
SIMULAZIONI MONTE CARLO



Talks and posters

SIF2014:

- Francesco Fallavollita: *Caratterizzazione di un rivelatore a fibre scintillanti per il monitoraggio di stabilità di grandi costruzioni civili tramite l'uso dei raggi cosmici.*
- Alice Magnani: *Simulazione della sensitività di Gas Electron Multiplier al background di CMS (Sensitivity of GEM detectors to the cavern background in CMS)*
- Ilaria Vai: *Studi preliminari di longevità di rivelatori Resistive Plate Chambers (RPC) dell'esperimento CMS (Preliminary Longevity and radiation damage studies for CMS RPC)*

IFAE2015:

- Alice Magnani: *Impatto della stazione GE1/1 sulle performance dello spettrometro a muoni di CMS (Impact of the GE1/1 station on the performance of the muon system in CMS)*
- Ilaria Vai: *Sviluppo e performance dei rivelatori Triple-GEM per l'upgrade del Sistema a Muoni dell'esperimento CMS (Development and performance of Triple-GEM detectors for the Upgrade of the Muon System of the CMS experiment)*

XIII Pisa Meeting – Elba2015:

- Alice Magnani: *Impact of the GE1/1 station on the performance of the muon system in CMS*
- Ilaria Vai: *Test beam and irradiation test results of Triple-GEM detector prototypes for the Upgrade of the Muon System of the CMS experiment*

Report on MEG experiment

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

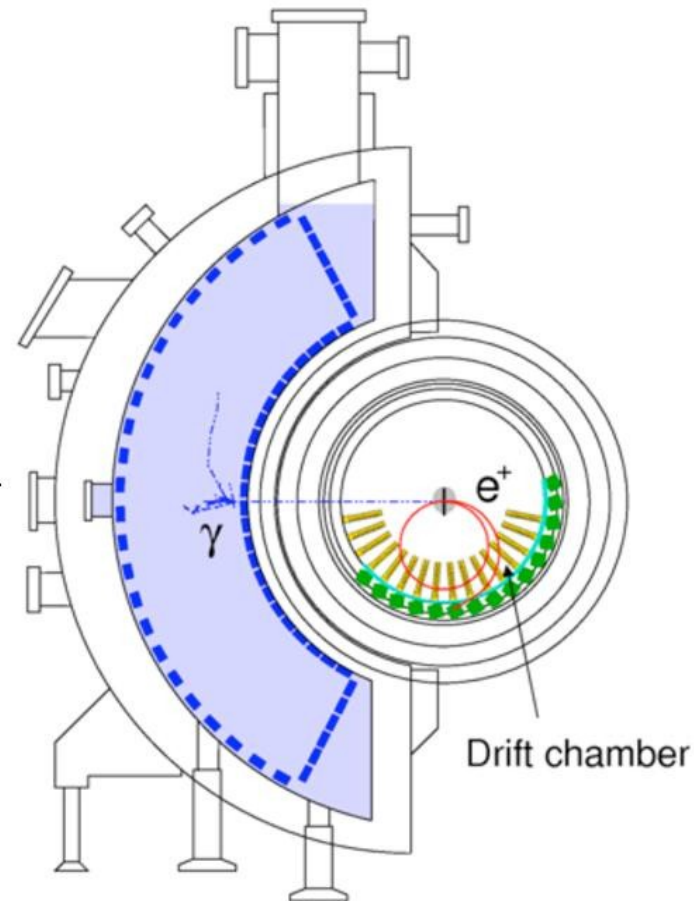
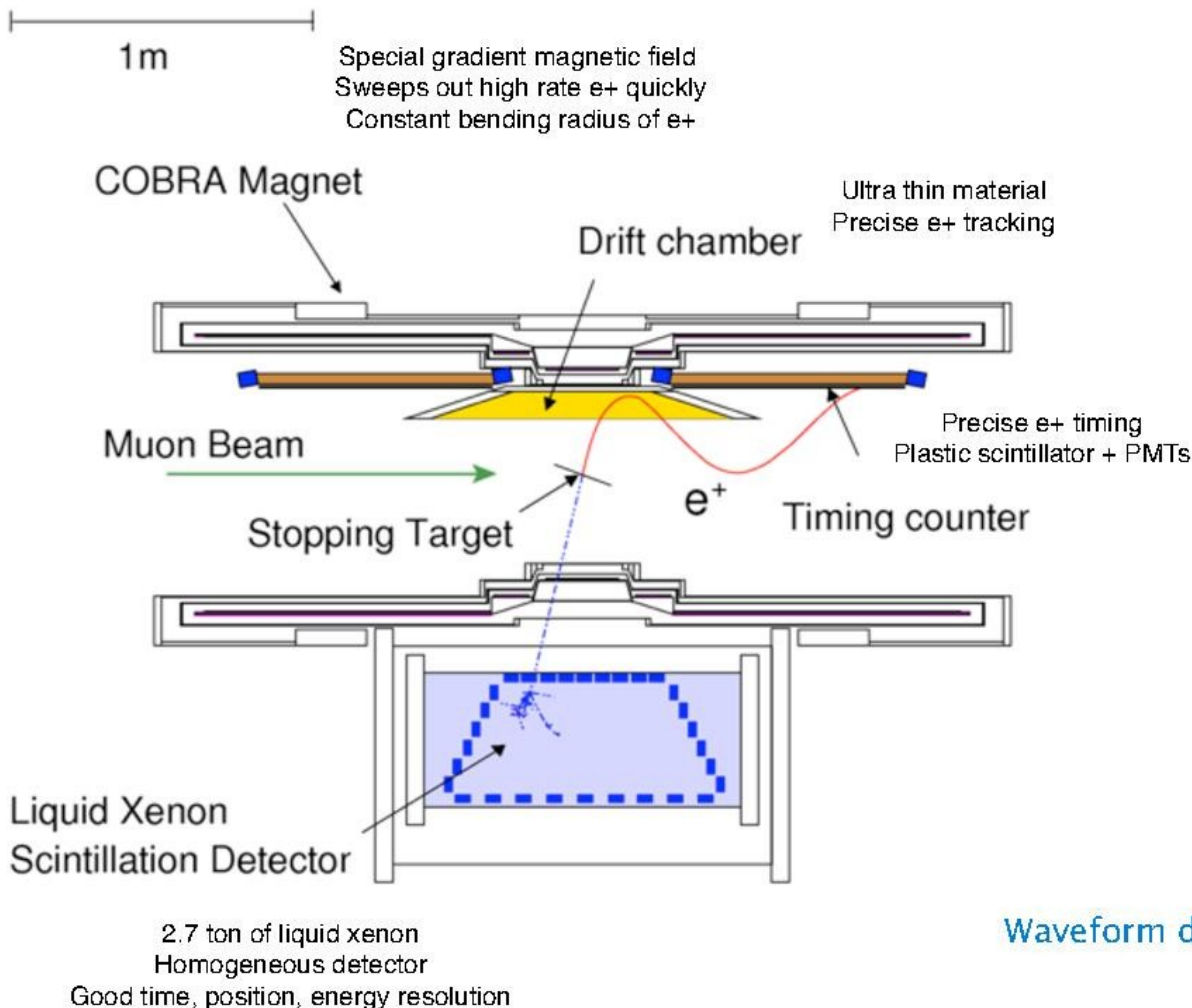


Paolo Walter Cattaneo
Consiglio di Sezione
11 Giugno 2015

MEG Experiment



The most intense DC muon beam, $3 \times 10^7 \mu/s$ @ PSI, Switzerland



Waveform digitizer for all detectors

Likelihood Analysis Summary

	Best fit	UL (90% C.L.)	Sensitivity
2009-2010	0.09×10^{-12}	1.3×10^{-12}	1.3×10^{-12}
2011	-0.35×10^{-12}	6.7×10^{-13}	1.1×10^{-12}
2009-2011	-0.06×10^{-12}	5.7×10^{-13}	7.7×10^{-13}

For the full sample 2009-2013 the sensitivity will be $\sim 4 \times 10^{-13}$ a
Analysis is ongoing: final result published for middle 2015.

Papers in 2014/2015

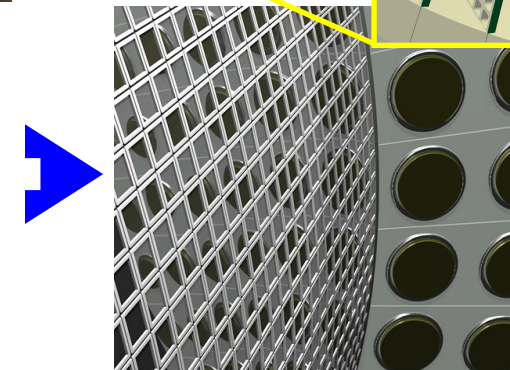
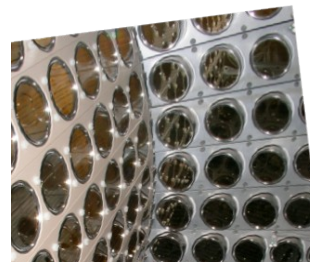
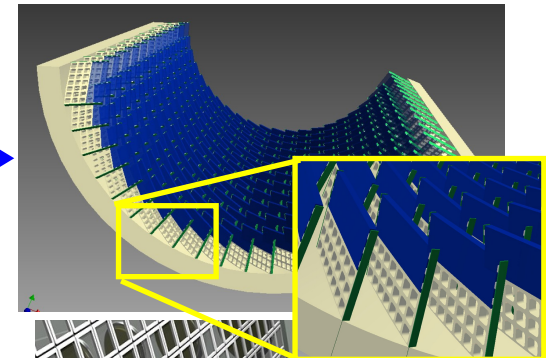
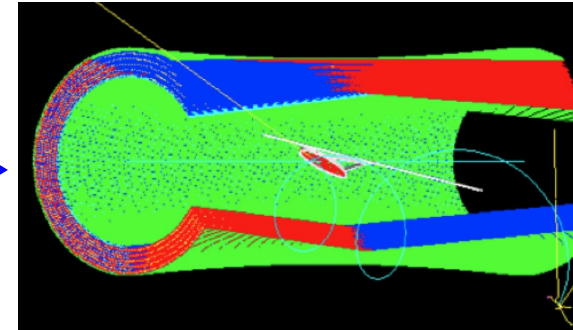
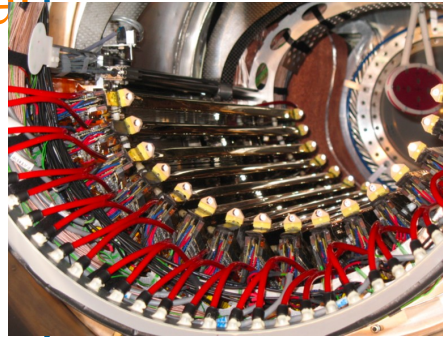
- 1) P.W. Cattaneo et al., Development of SiPM-based plastic scintillator counter for high precision time measurements, IEEE TNS 61 (2014) 5 2657
- 2) Measurement of the radiative decay of polarized muons in the MEG experiment, Submitted to EPJC
- 3) Muon polarization in the MEG experiment: predictions and measurements, Submitted to EPJC

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

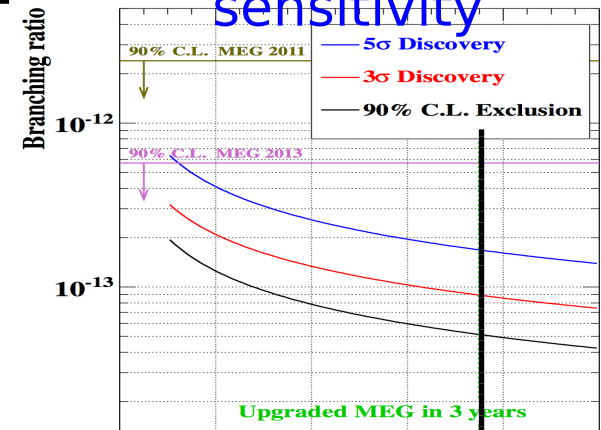
$\mu \rightarrow e\gamma$ down to $B \sim 5 \times 10^{-14}$ in three years!

✓ $\times 10$ improvement w.r.t. current MEG

✓ 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



Photon Trajectory

Drift Chambers

Timing Counter

Calorimeter

Positron track

MEG upgrade
timeline



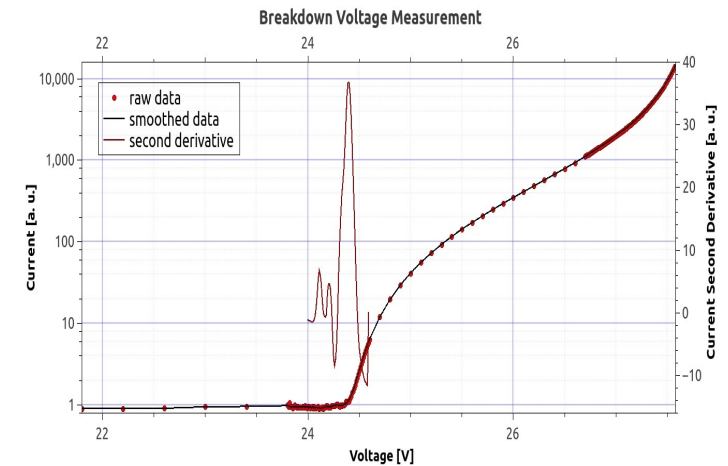
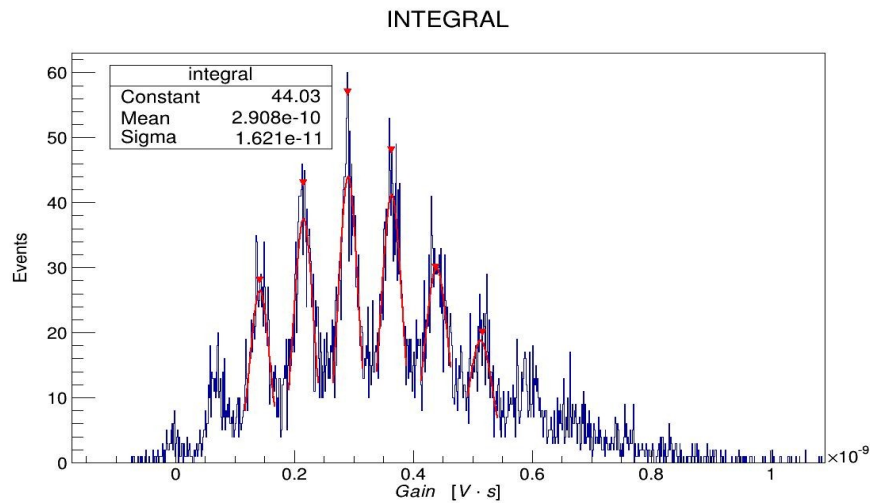
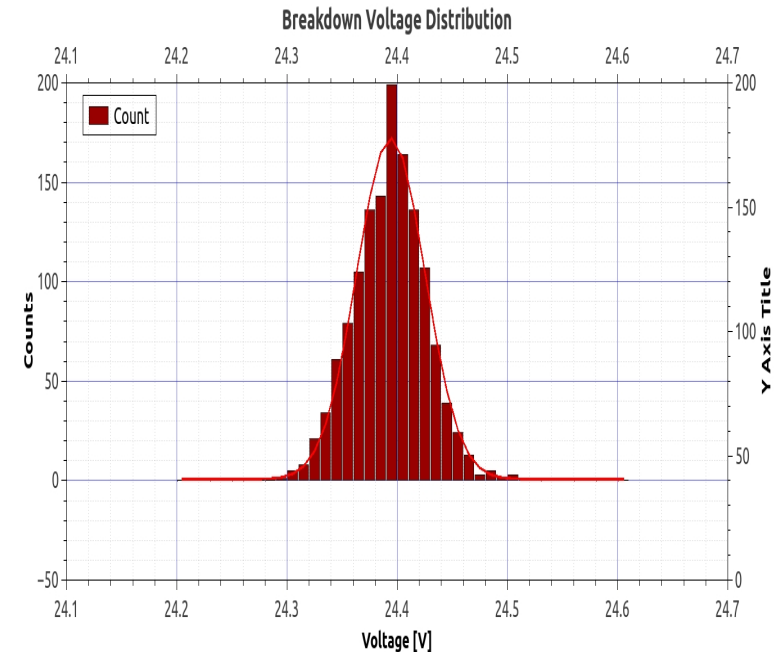
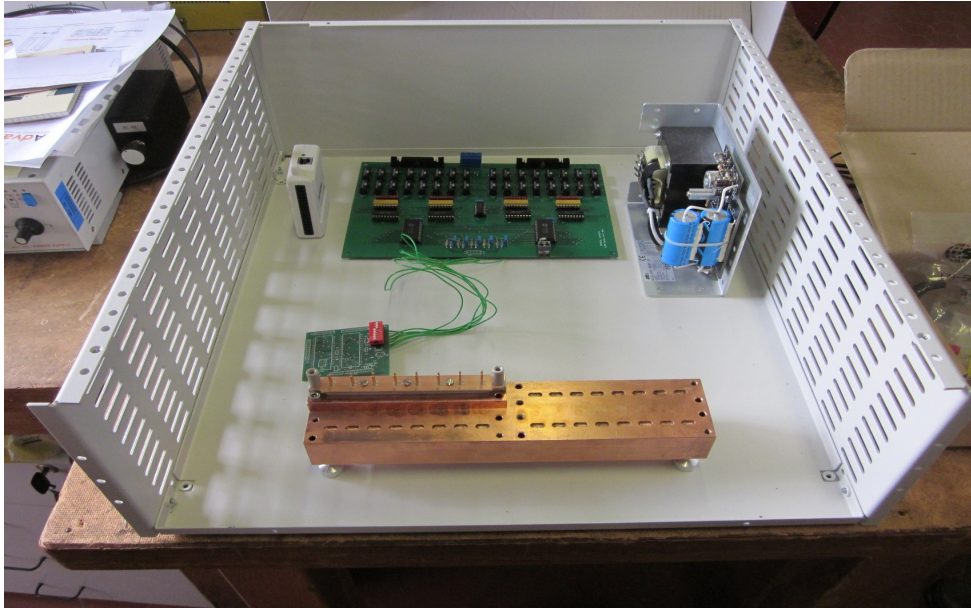
Upgrade Pavia

Pavia/Genova/Tokyo has been working on an upgrade of the TC for MEG2 (2016-2018)

Choice of SiPM for reading scintillator pixels, production and systematic test.

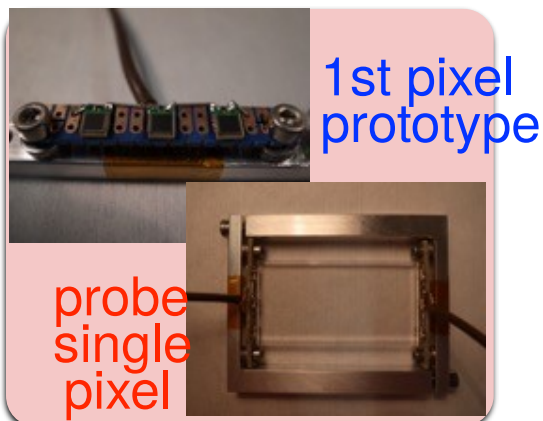
Tests under beam in single particle mode (BTF) and in high rate (PSI)

SiPM test in Pavia

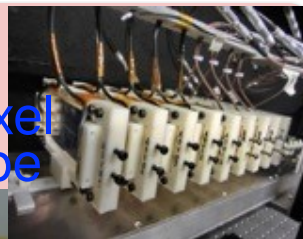


A 3 years long R&D...

Single pixel R&D



1st multi-pixel prototype



test @BTF, SiPMs choice

2012

2013

2014

2015

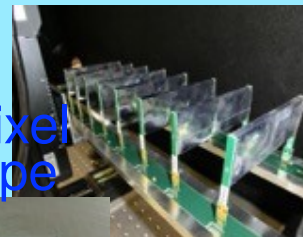
MEG II RUN

2nd pixel prototype



comparison tests

2nd multi-pixel prototype



test @BTF backplanes readout



Multipixel prototypes solution for final detector

high rate test



test @PSI



final TC construction

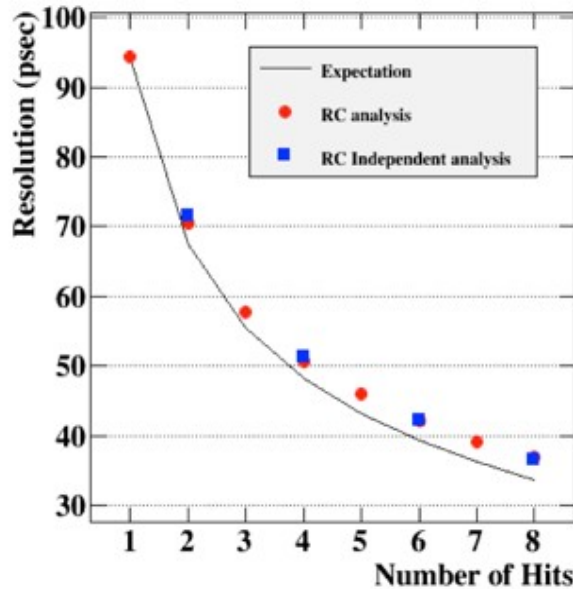
NOW!



Beam test @PSI: results

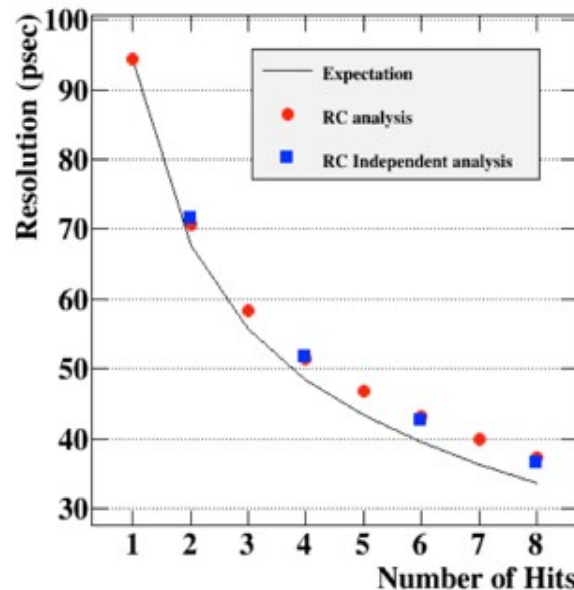
20-60KHz

Resolution vs. Number of Hits (lower rate)



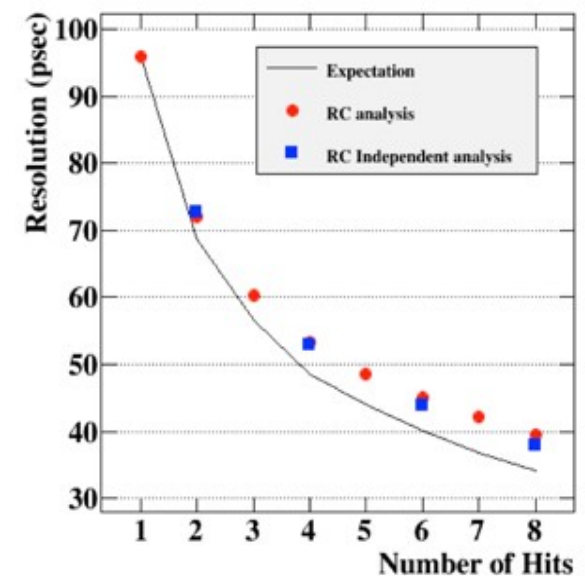
50-150KHz (MEG expected)

Resolution vs. Number of Hits (expected rate)



90-290KHz

Resolution vs. Number of Hits (higher rate)



Resolution does not depend from beam rate in the range ~20-300 kHz.
~35ps resolution was found at the expected MEG II rate (~150 kHz).