SDHCAL STATUS

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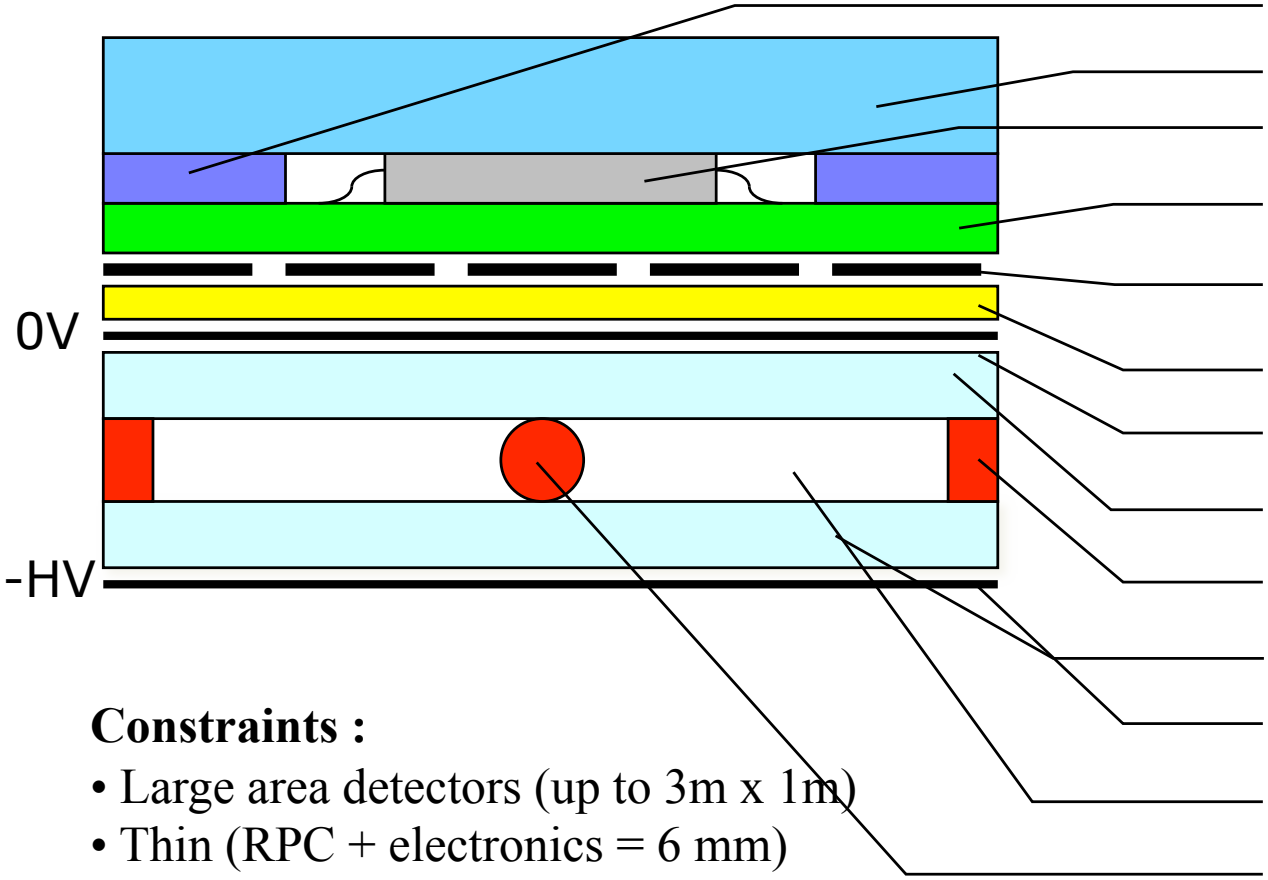
for GRPC-SDHCAL community
(CIEMAT, Ghent, IPNL, LLR, Louvain, Tsinghua, Tunis)

Contents

- Status of 1M^2 GRPC R&D
  - Resistive coating
  - Gas
  - DAQ
  - First Results
- Simulation work
- Conclusion

GRPC and semi-digital calorimeter



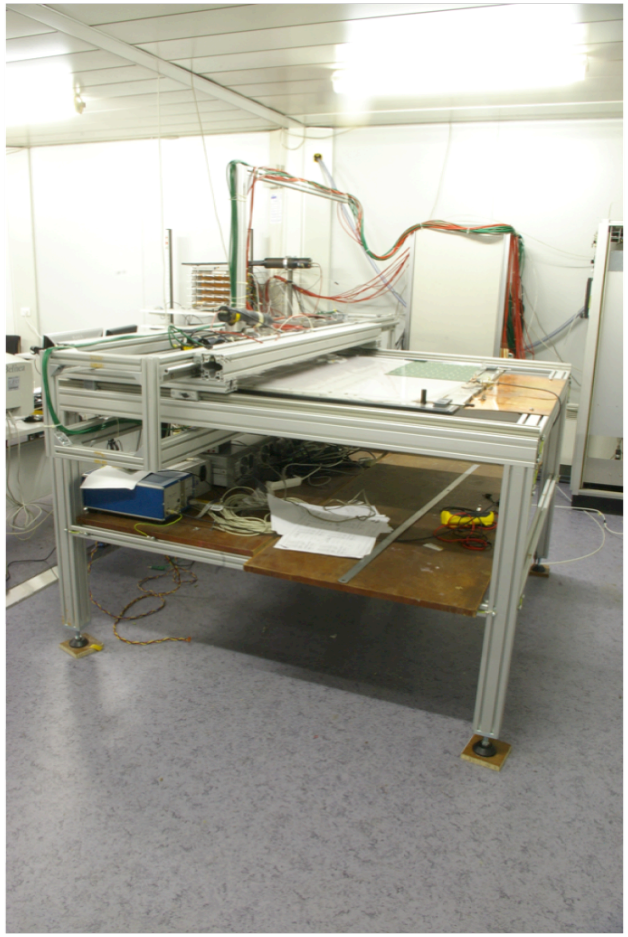
Grid (Steel)
Absorber (2 cm)
ASIC (HARDROC1)
PCB
Pads (copper, 1 cm2)
Insulation (Mylar)
Anode coating(~10 MΩ/□)
Glass plate (0.7mm)
Chamber wall (1.2mm)
Glass plate (1.1mm)
Cathode coating(~10 MΩ/□)
Gas
Spacer (ceramic ball)

Constraints :

- Large area detectors (up to 3m x 1m)
- Thin (RPC + electronics = 6 mm)
- Low cost
- Industrialized easily

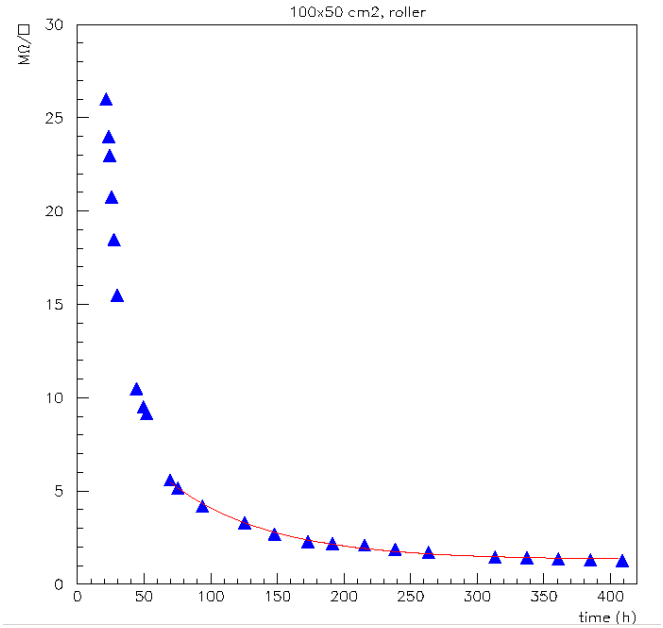
Semi-conductive paint (1)

- Many chambers successfully built using Statguard product
- Applied to large areas using paint brush up to now
- Recently established industrial contacts to investigate option of silk screen printing
- Covered several m^2 using this method → now build chambers



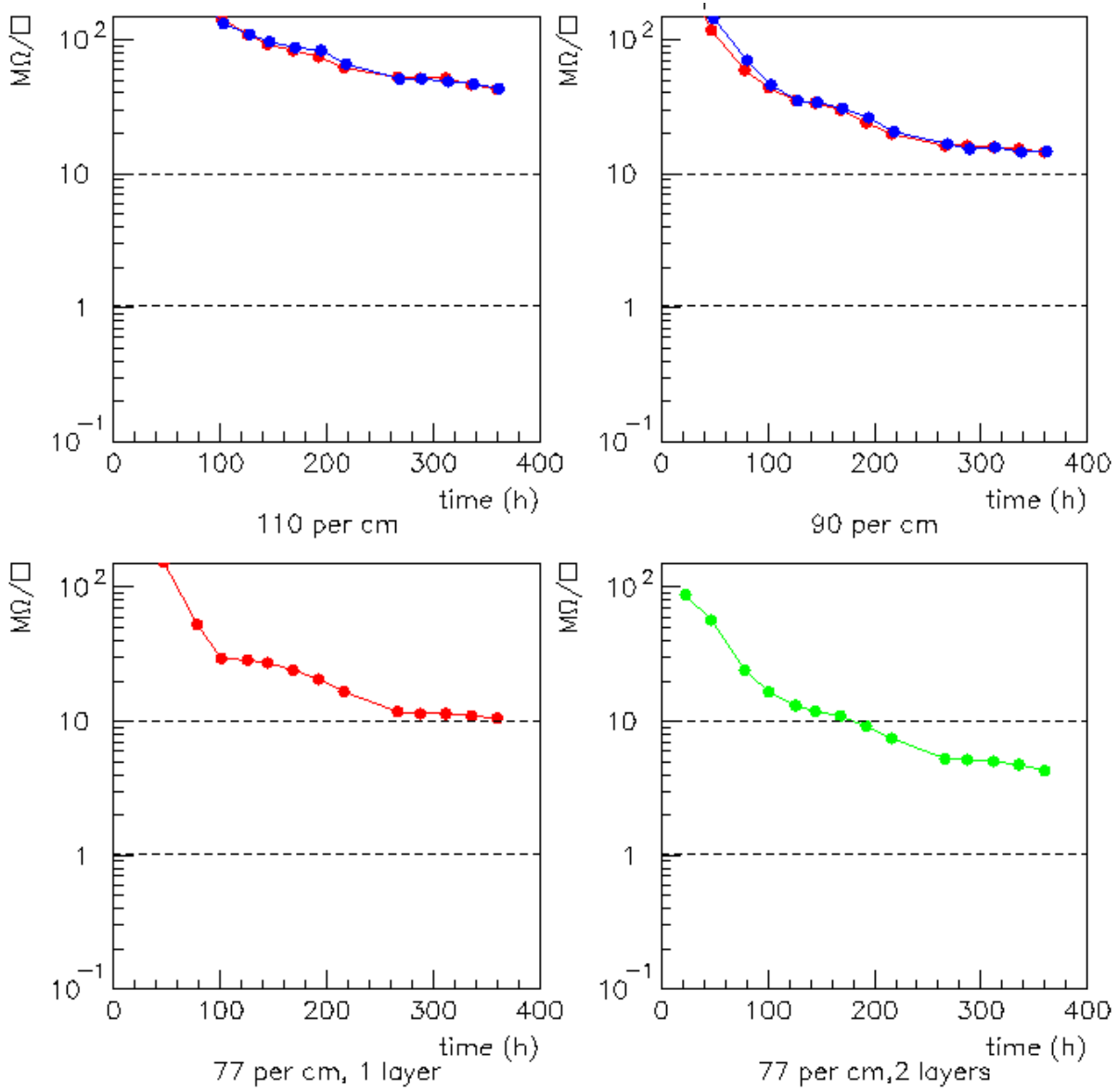
Semi-conductive paint (2)

- Statguard: disadvantages
  - Not produced specifically for silk screen printing
  - Hard to clean silk screens
  - Long time constant for stable resistivity



- Investigating new product: colloidal graphite
  - Very stable resistivity
  - Specifically produced for silk-screen printing
  - BUT needs large oven or UV curing facilities

Statguard time stability - different layer thicknesses

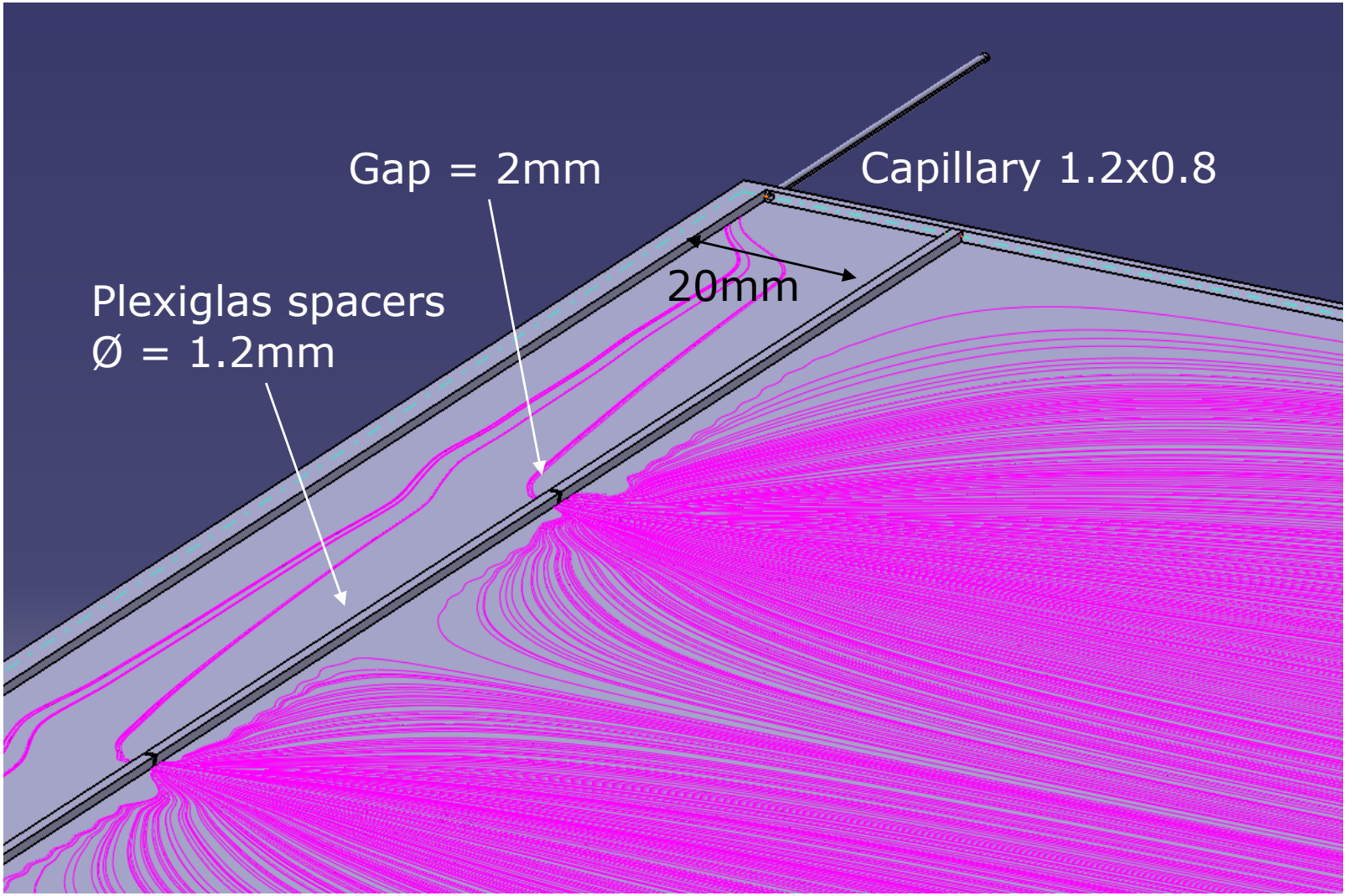


Gas Tightness

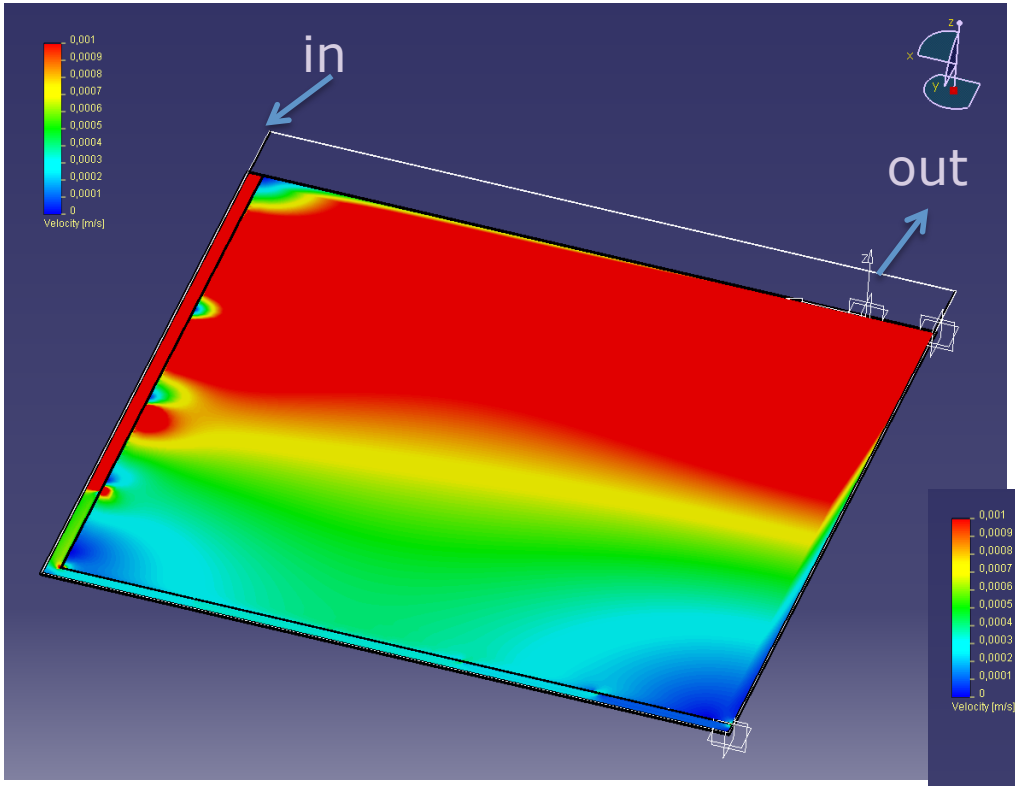
- Closed chamber design makes chambers sensitive to overpressure → leaks
- 1 mbar overpressure ≡ 10 kg/m^2
- Attempted to make chambers more robust by replacing small fraction of ceramic balls with cylindrical spacers (much larger gluing area) → failed
- Now trying to reduce Δp by increasing surface area of outlet capillaries (multiple capillaries)
  - Successful at SPS Testbeam : no leak in vertical position without HV

Gas distribution

May be an issue for large area, very thin chambers



Gas circulation simulations (1)

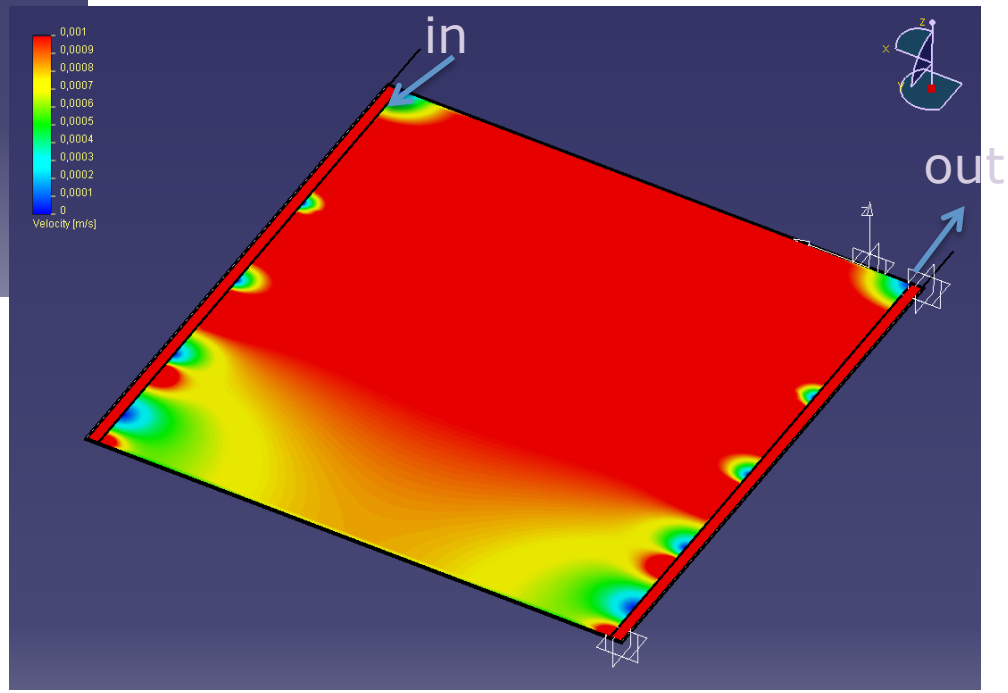


Velocity – old chamber design

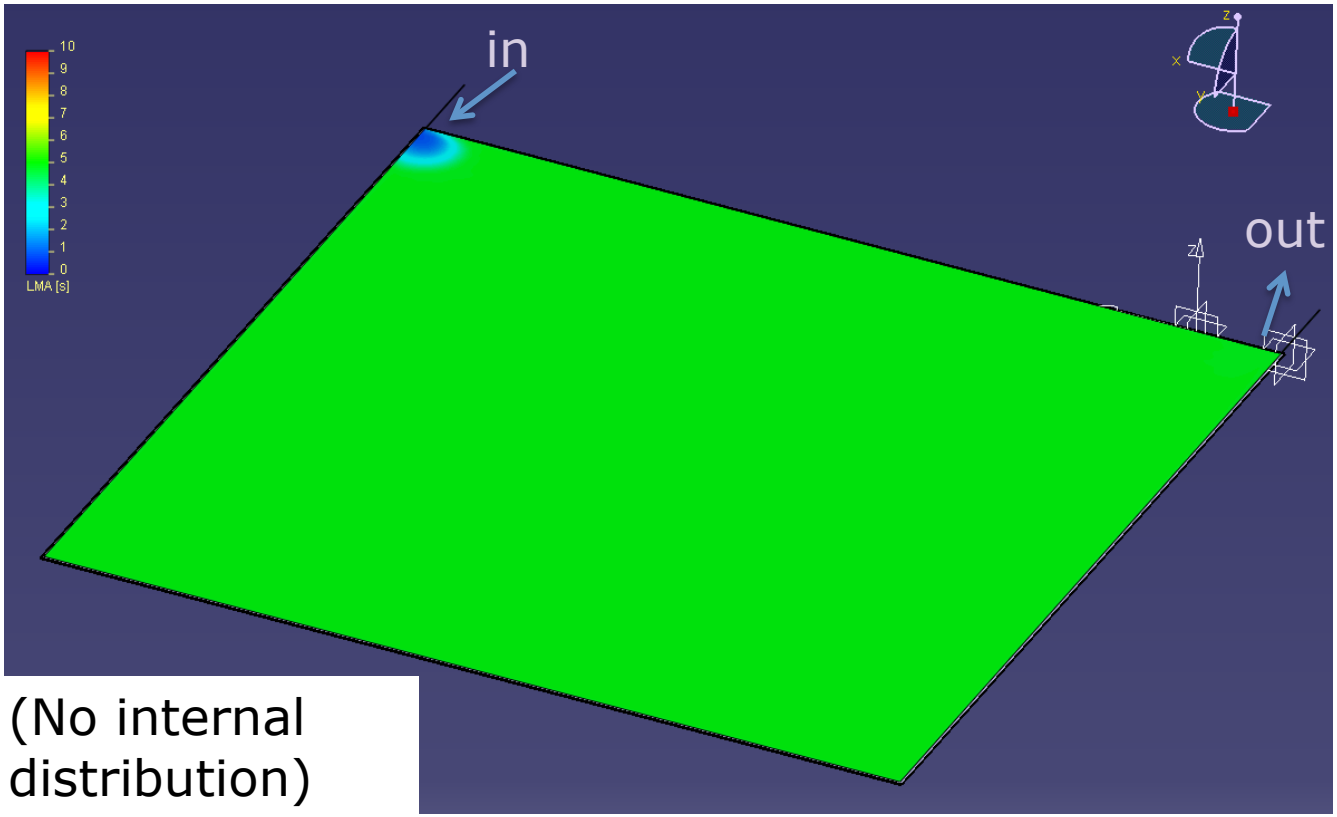
Max. (red) ~1mm/s

Diffusion not included in simulation

Velocity – new chamber design



Gas circulation simulations (2)



(No internal distribution)

Least mean age: time for gas to reach any given point in chamber

- Includes diffusion effects (seems to dominate)

Suggests gas reaches almost all areas of chamber within ~5s

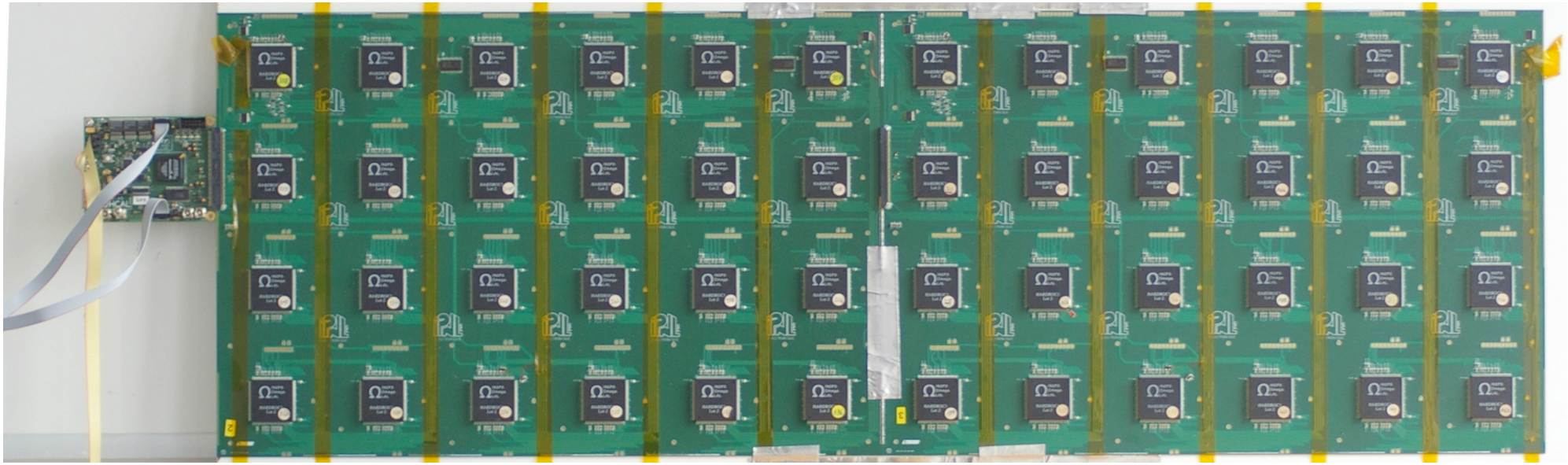
- Is channeling of gas within chamber really necessary?

Gas system

- Unable to use isobutane in latest test beams due to flammable gas safety issues with Lyon gas mixer
- Propose new system which will also serve for $1m^3$ tests
  - 40 channel mixer
  - ATEX certified mass flow meters
  - Fine outlet pressure regulation
- Recent discussion with CERN DT1 gas group which could build the system

Readout electronics status for M^2 detector

- 8 PCB of 50X33.3 cm^2 were conceived and produced
- 8-layer, class 6 (buried vias)
- 6 were equipped with hardroc1 (plastic packaging)→ 144 ASICs
- PCB are connected 2 by 2 using zero resistor

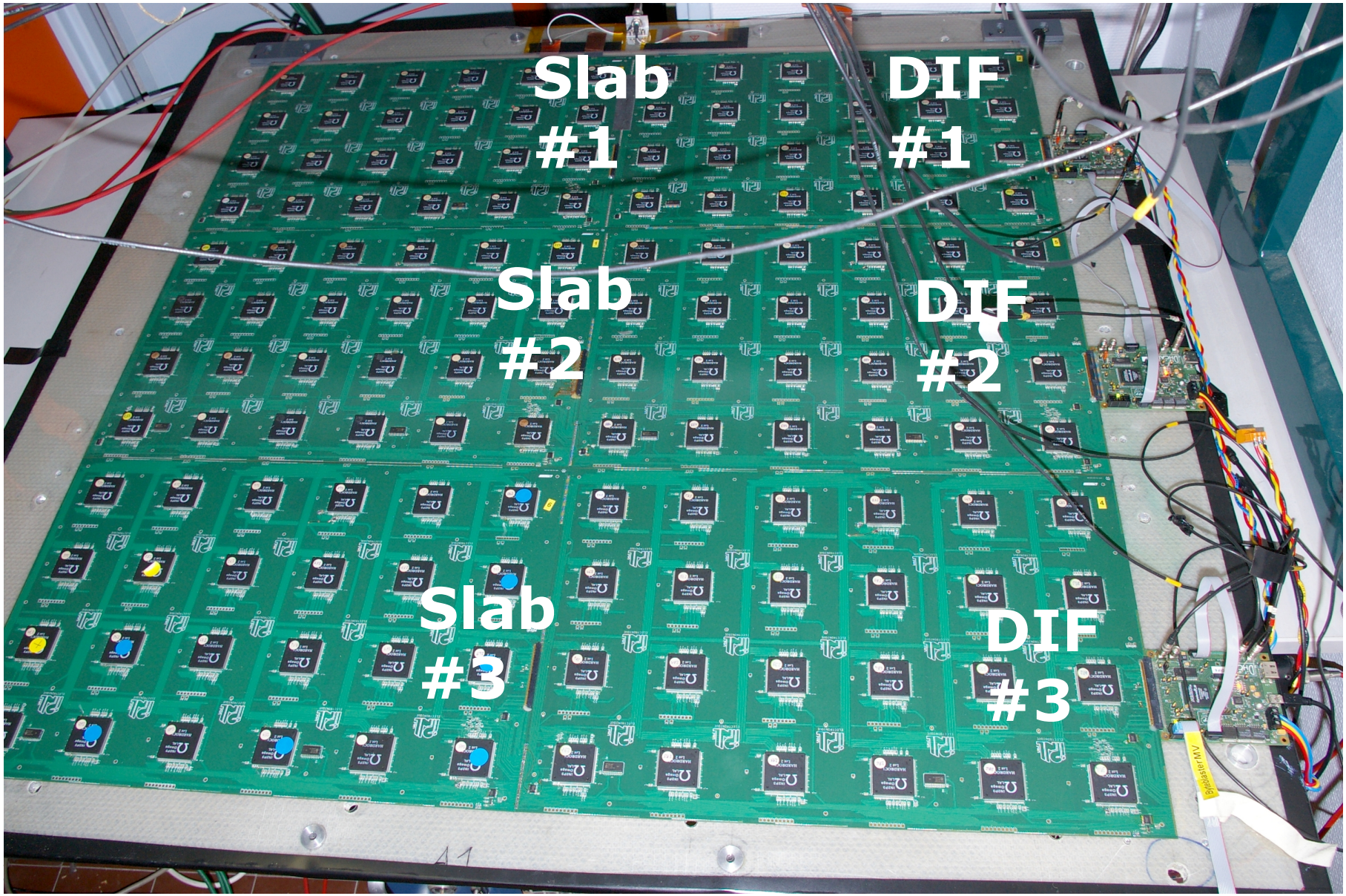


DIF

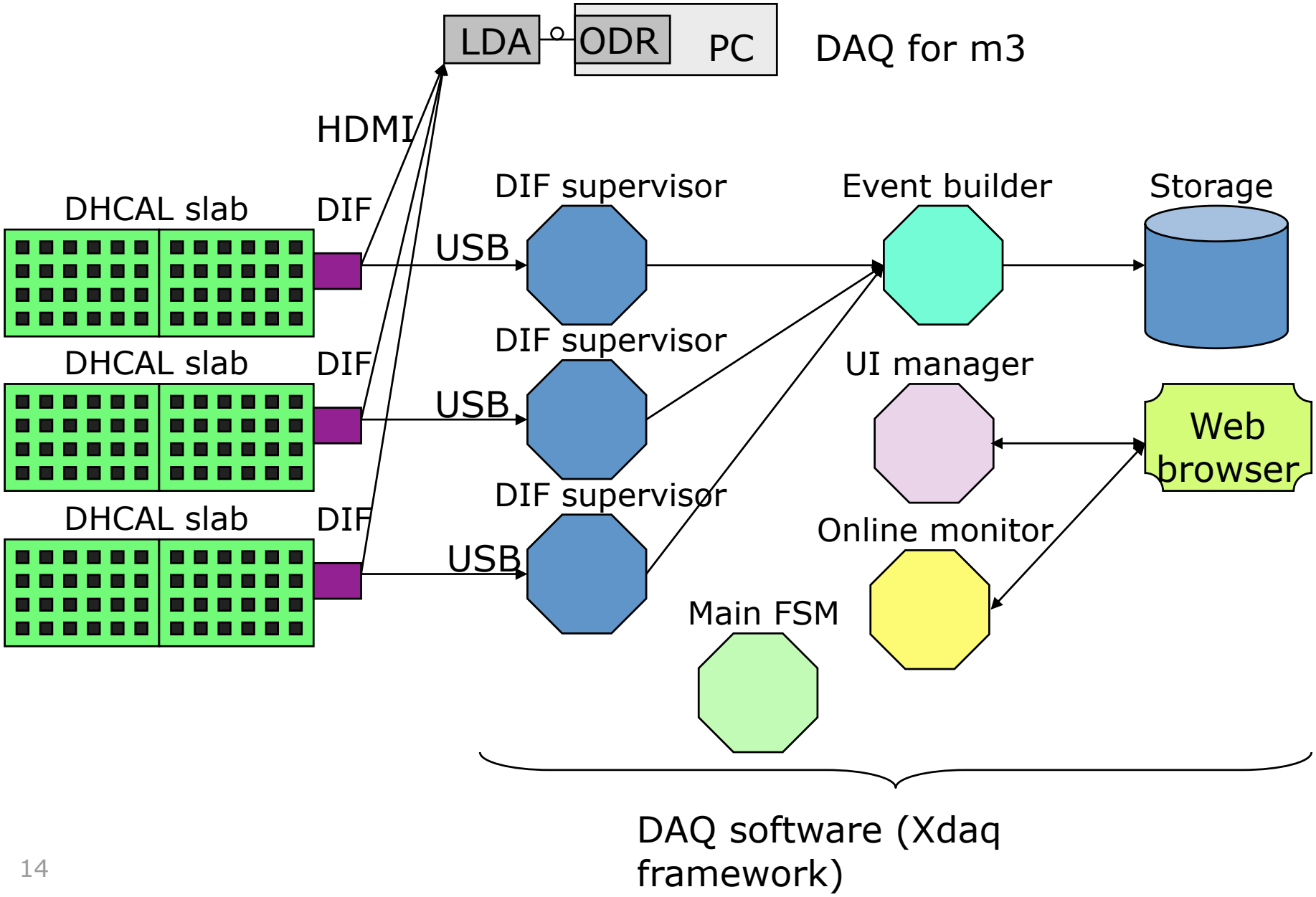
Slab 1

Slab 2

1 m^2 of equipped detector



DAQ Schematic view



DAQ capabilities

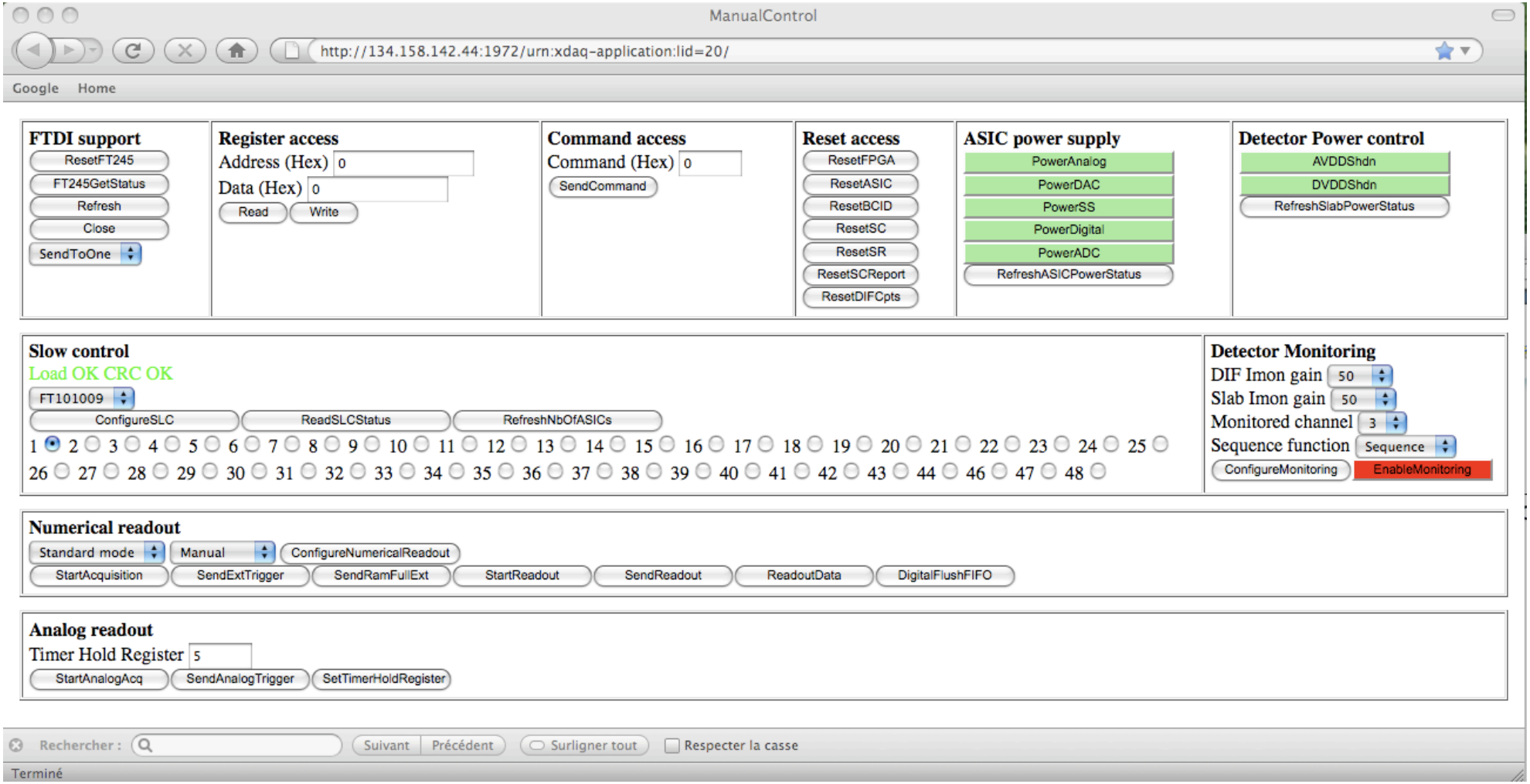
3 modes to operate the DAQ :

- *Manual mode* : all functions, commands and registers of one or several DIF(s) are accessible one by one (mainly used for debug purpose)
- *Semi Automated mode* : More complex functions of one or several DIF(s) can be performed, ie send slow control, start acquisition
- *Automated mode* : All behavior is driven by main finite state machine

2 trigger modes :

- *Standard mode* :
  Hardrocs store data on the external trigger
  Data are sent to the DAQ PCs when RAM is full
- *Beamtest Mode* :
  Hardrocs store all valid data (internally autotrigged)
  Hardrocs stop storing on external trigger (i.e. common stop) and send data to DAQ PCs

Remote DAQ operation



Low voltages also operated via the web interface

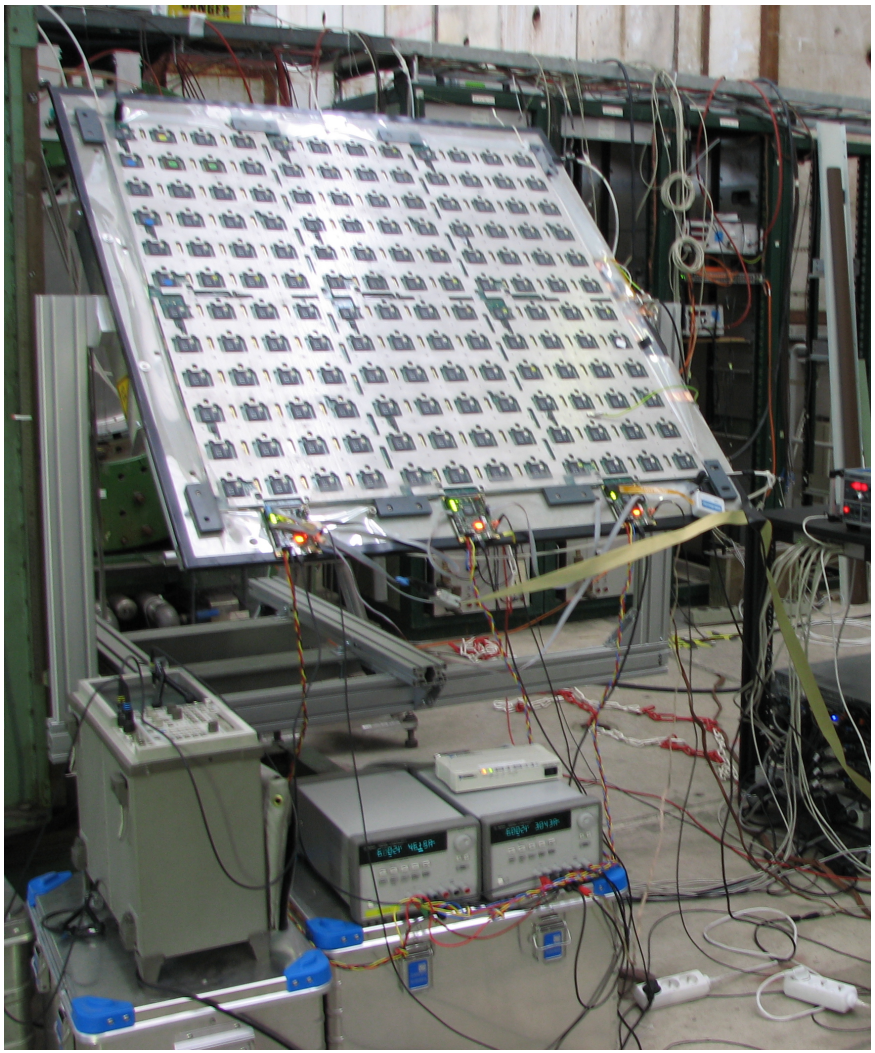
Readout and DAQ in testbeam

Problems found and fixed (thx *G.Vouters*):

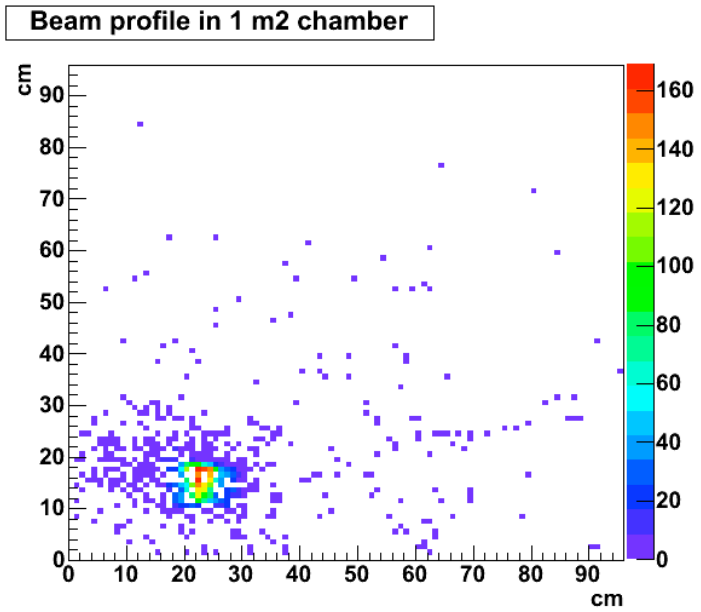
- DIF firmware updates
- XDAQ acquisition
  →3 DIF synchronisation made possible

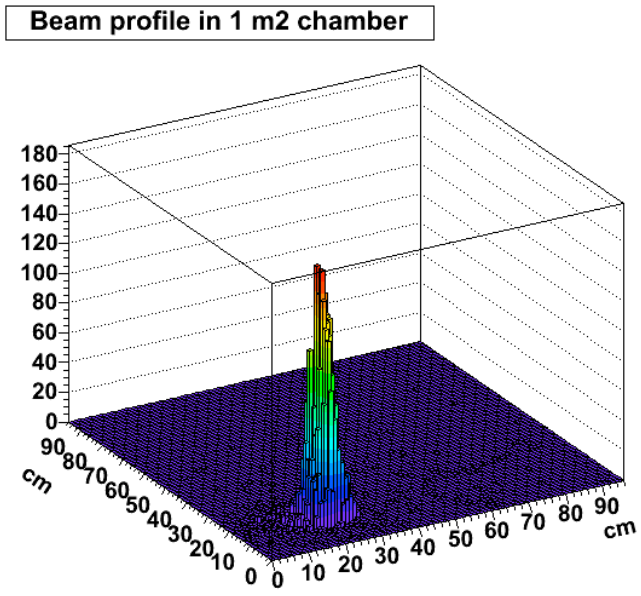
Data taking in 2 test beams:

- debugging at the PS in July with a Licron chamber
- Datataking at the SPS in August with a Statguard chamber.



Success @ SPS test beam

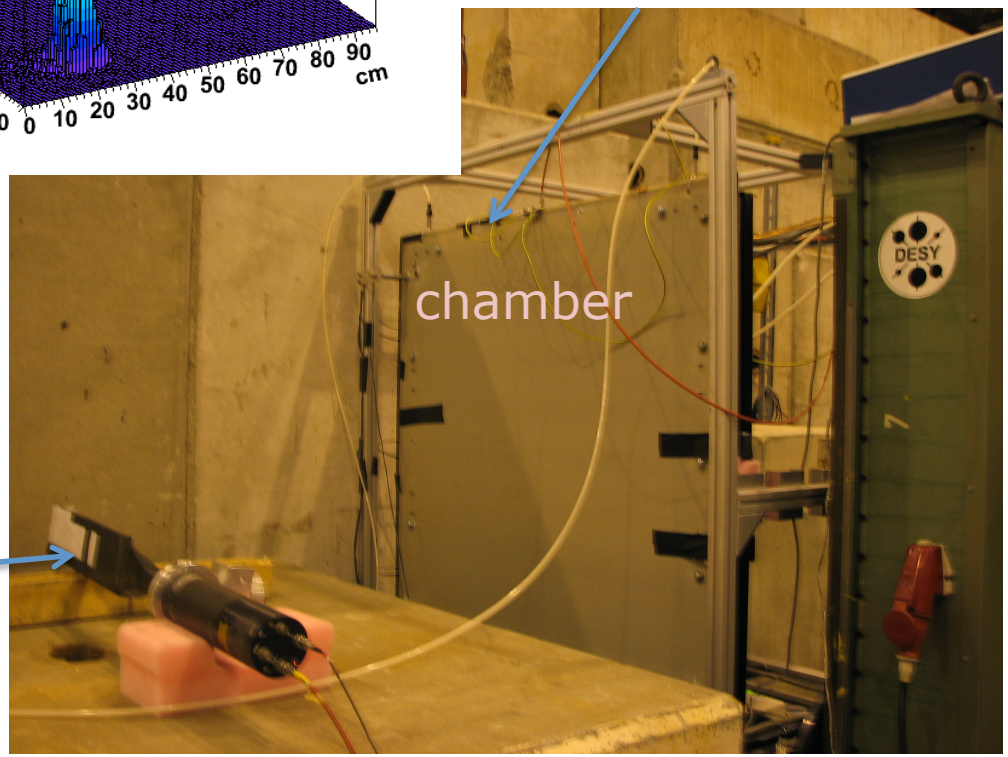




Pads over (low) threshold

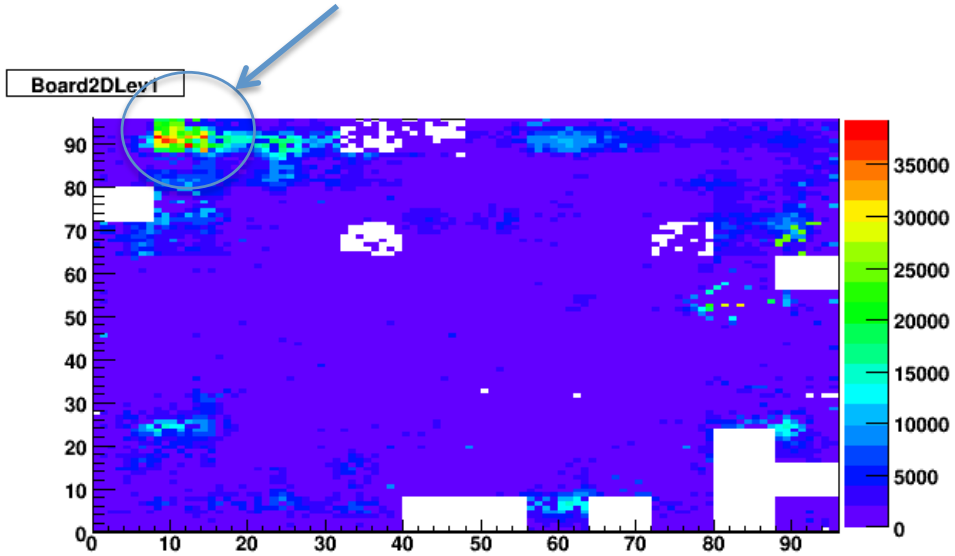
DAQ successful in testbeam mode
With 3 DIFs synchronised
Up to 93% efficiency

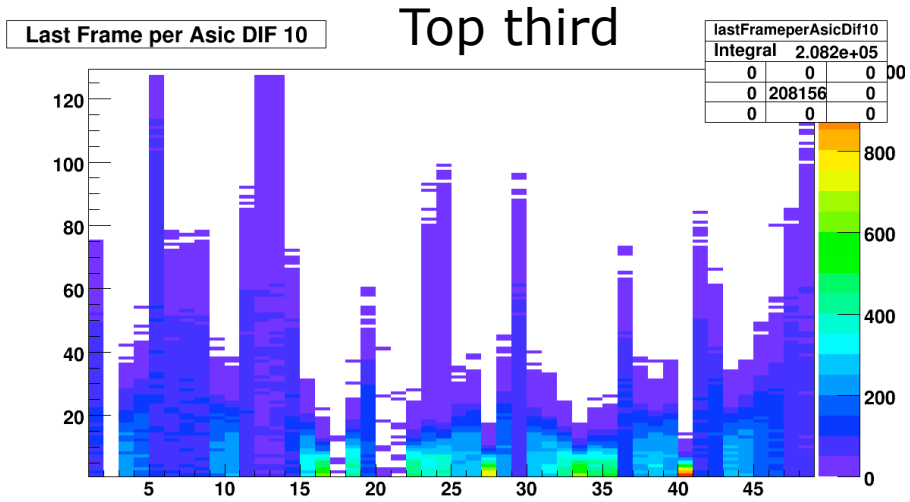
HV connection

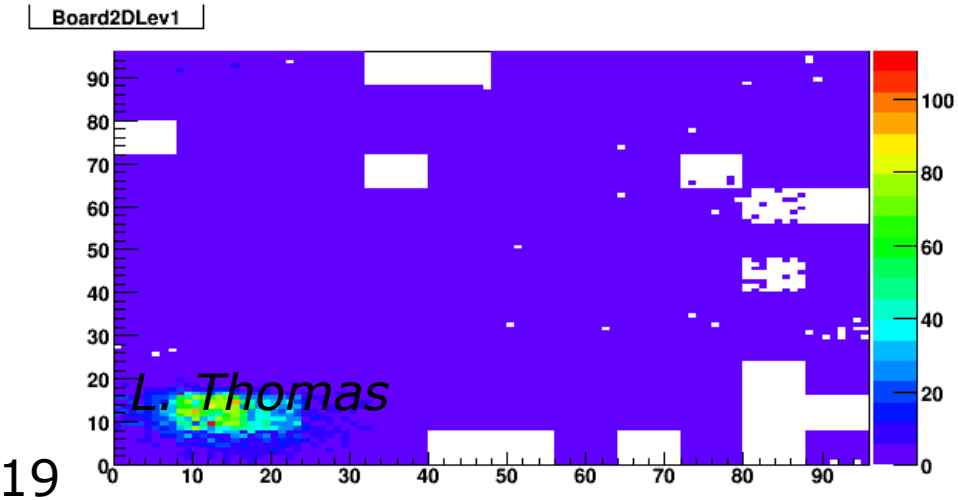


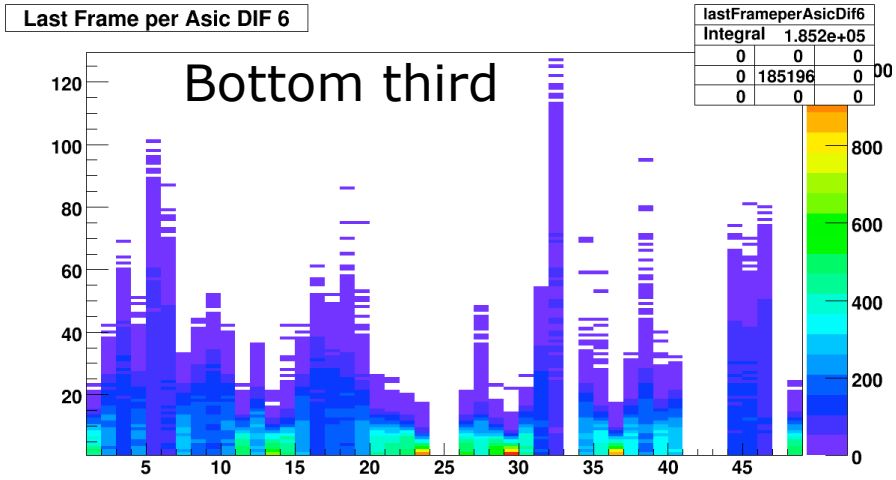
Some issues under investigation

Some noise in the HV connector region



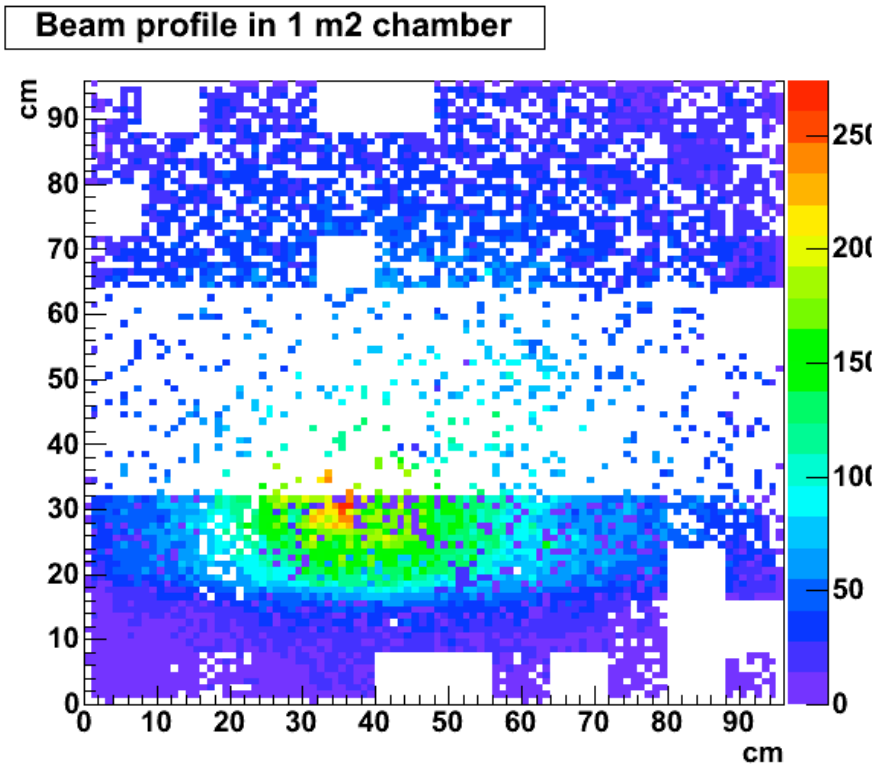


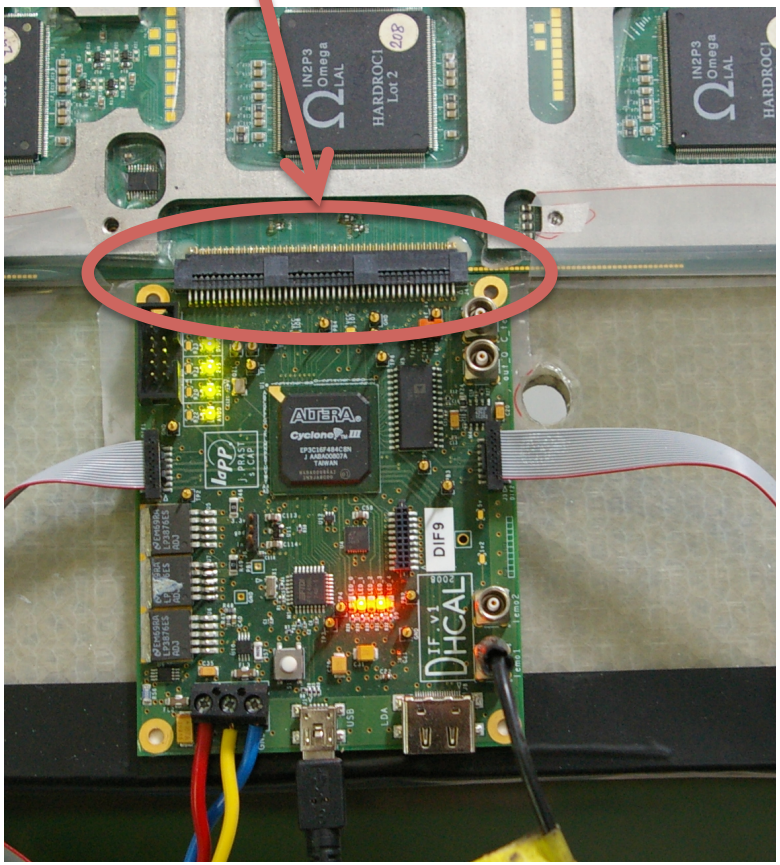




Fragile connections

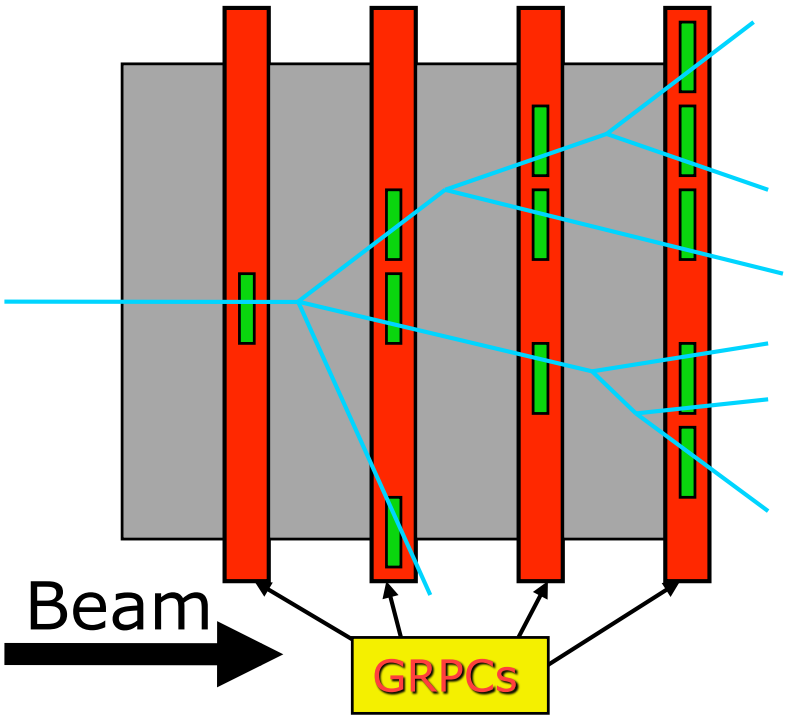
- DIF connector very fragile and do not withstand multiple connections

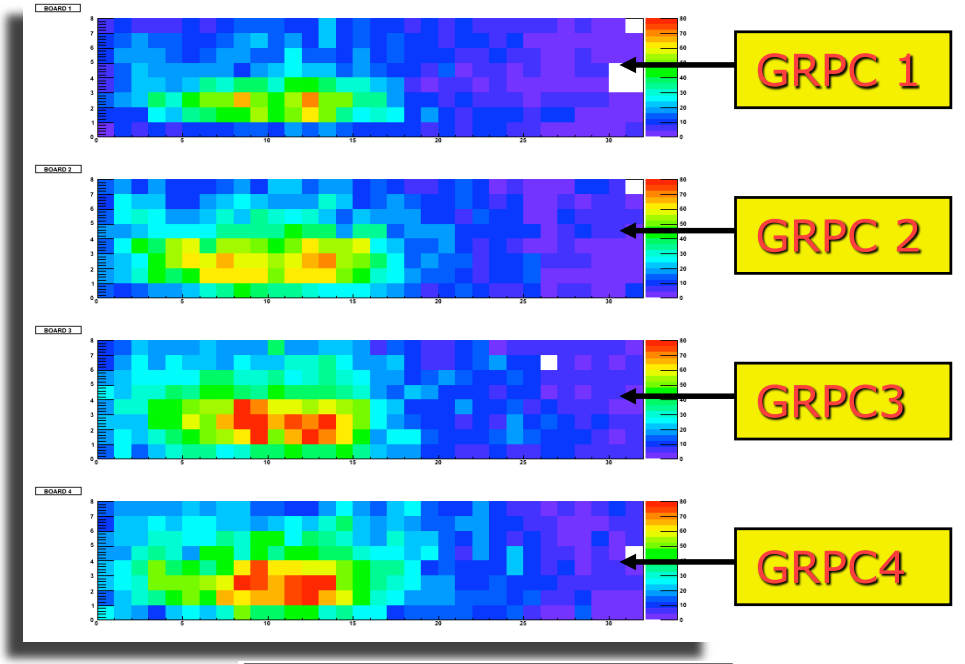


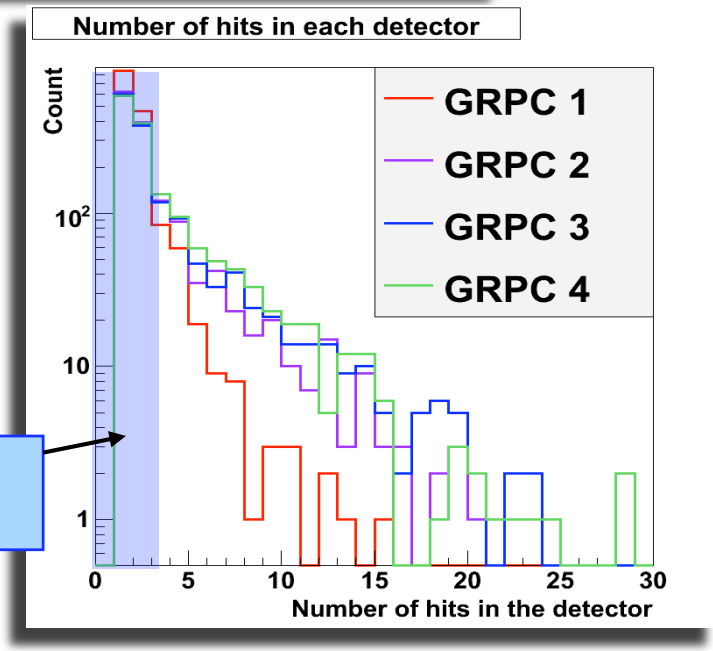


 Flat kapton cable under development for next prototype

Hadronic showers







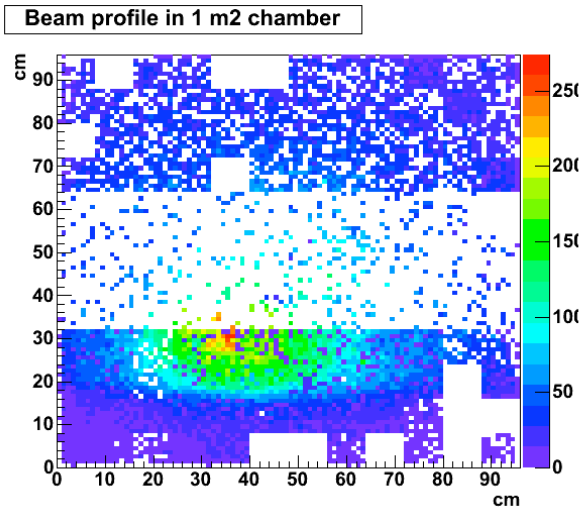
Hadronic showers are **mostly uncontained** in Mini DHCAL but these profiles give a **first idea** of shower development, and energy deposition.

Muon contamination area

kieffer@ipnl.in2p3.fr

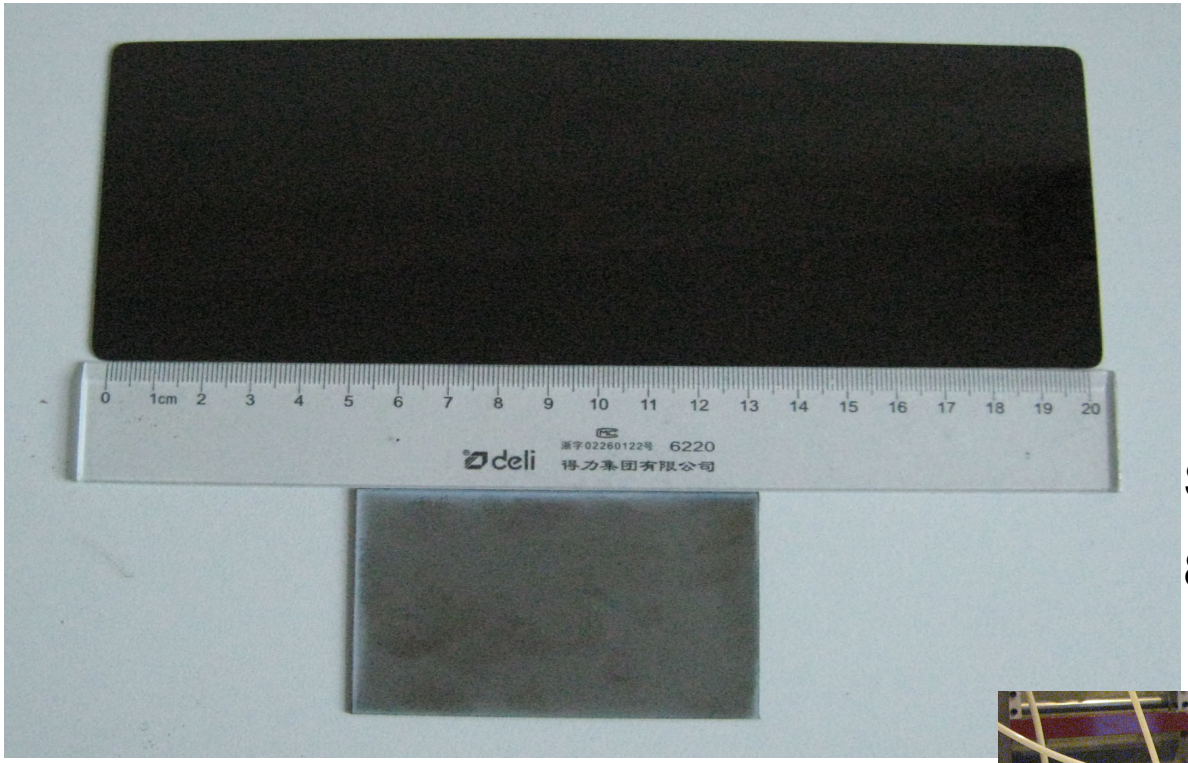
Physics Programme

- 1 to 6 Lead walls
- 30 to 150 GeV pion energies
- Analysis of the data in terms of physics ongoing



GRPC activities

Tsinghua University



Semiconductive glass

210mm*70mm*0.7mm

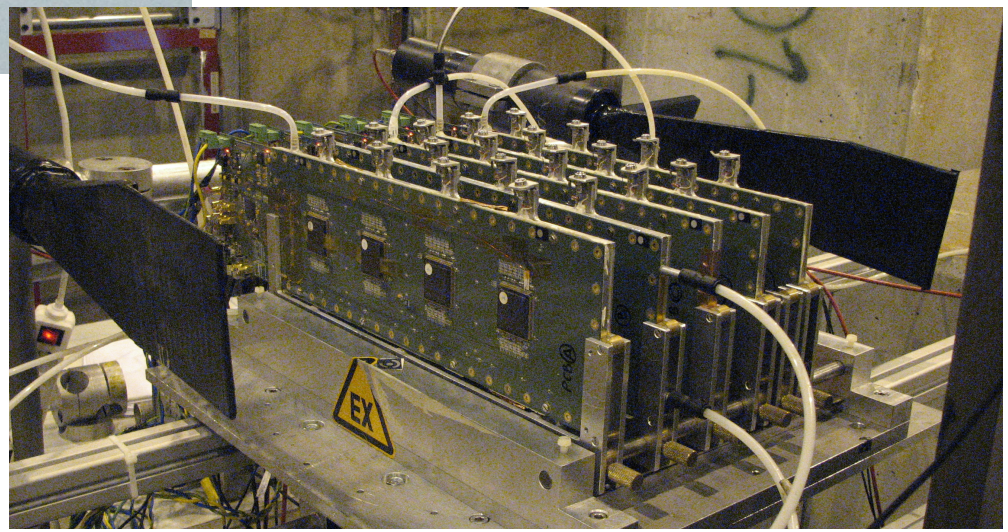
~$10^{10}\Omega$.cm

Rate: >26 kHz/cm^2

Semiconductive ceramics

80mm*50mm*1mm

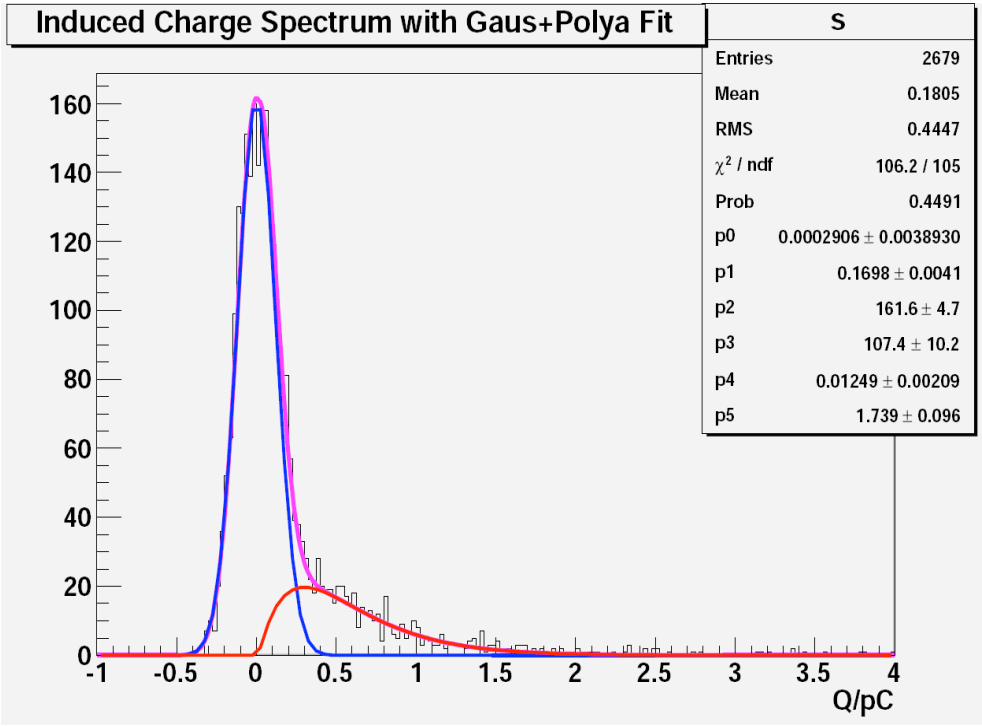
10^6 ~$10^9\Omega$.cm

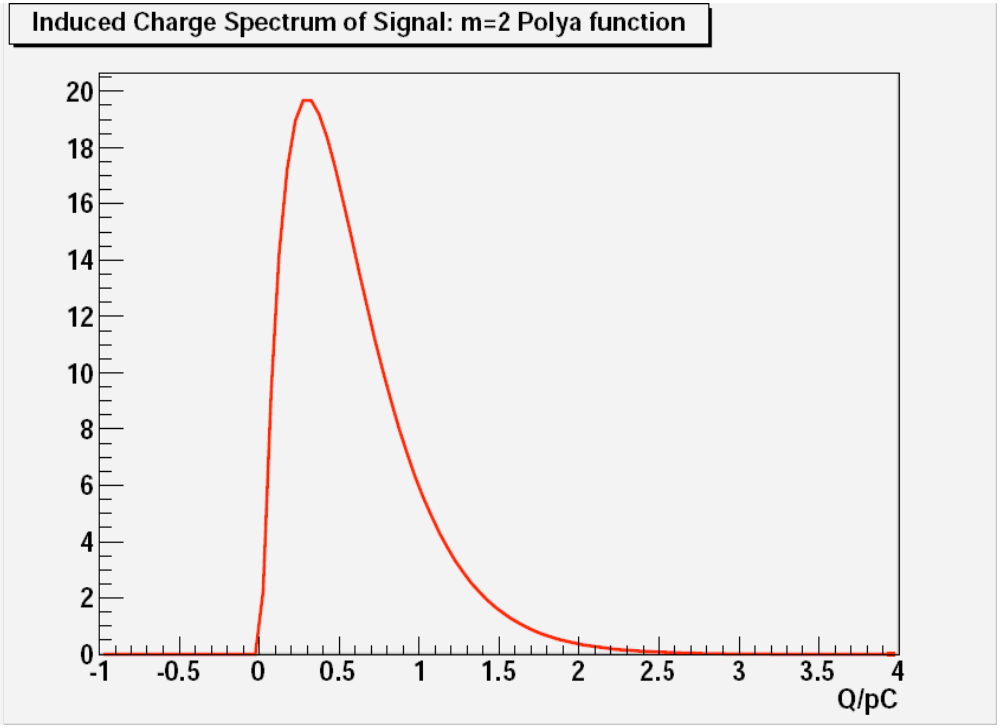


2 licron and 2 statguard 8x32cm^2 chambers built at IPNL with Chinese glass and tested with the SDHCAL electronics in the 2 summer TB at cern (See R.Kieffer's talk)

Simulation Progress

Fix G_0 with Experimental Input: Induced Charge of one Mip





Induced Charge Spectrum of ~2700 cosmic evts;
fit to a Gaussian Noise + m=2 Scaled Polya Signal (av~ 0.6 pC)

1 Mip ~ n Ionization, then G_0 ~ 0.6/n pC. Using a m=2 Scaled Polya function to estimate the Induced charge for each ionization

Estimate average energy needed for each ionization

Table 1

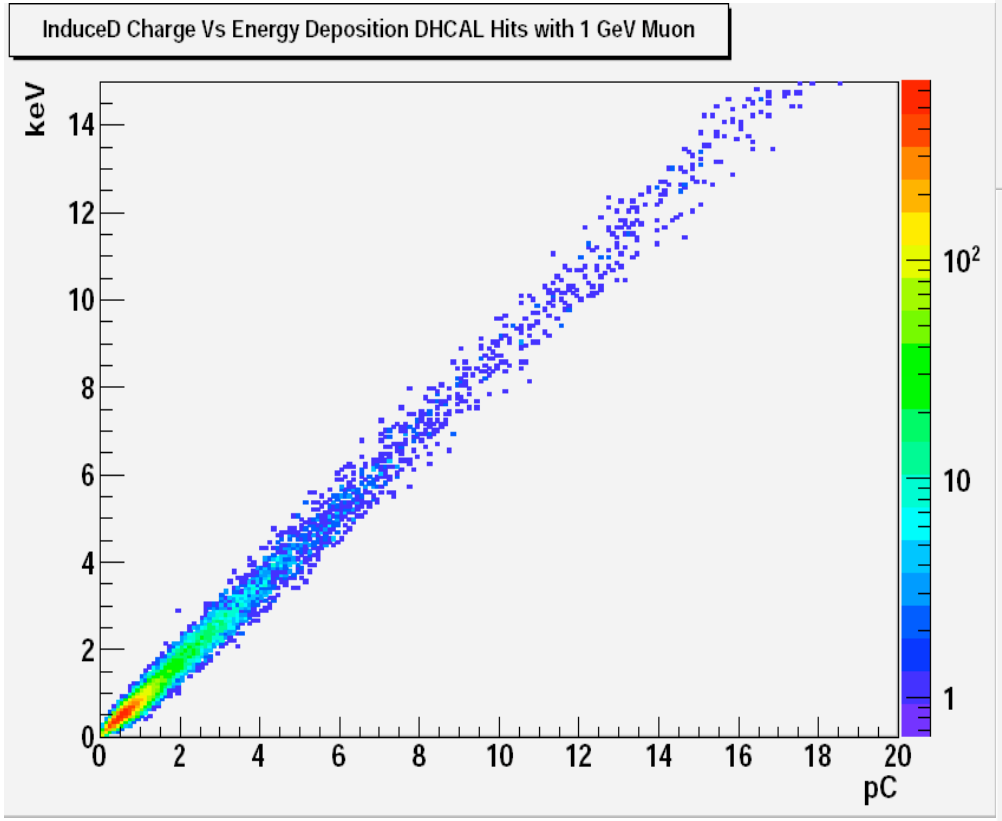
Properties of several gases used in proportional counters (from different sources, see the bibliography for this section). Energy loss and ion pairs per unit length are given at atmospheric pressure for minimum ionizing particles

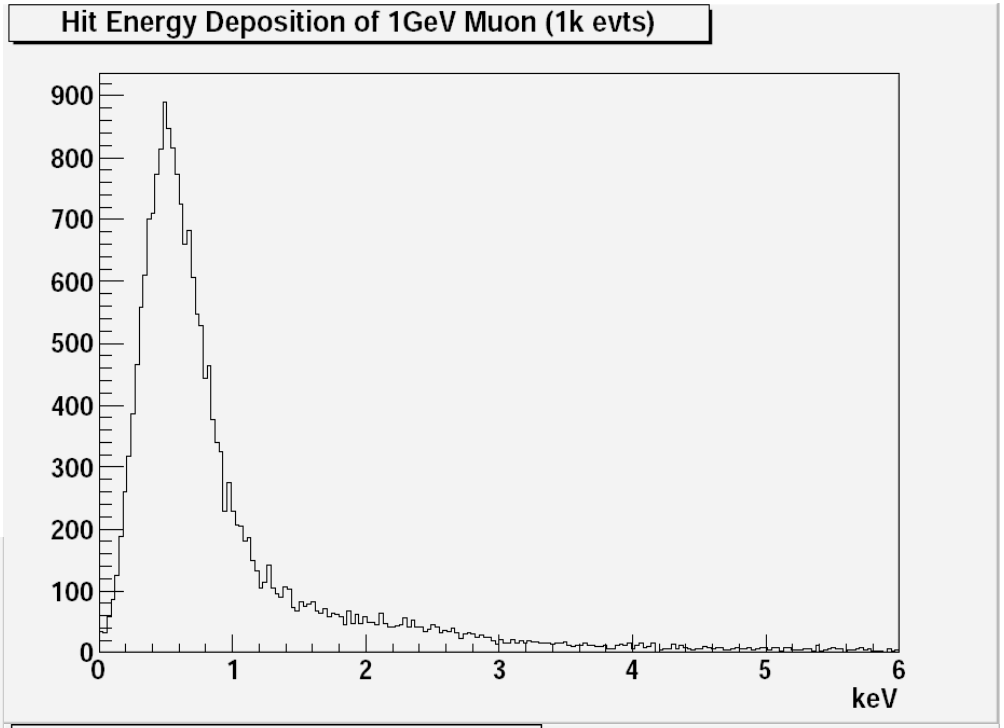
Gas	Z	A	δ (g/cm³)	E_{ex}	E_i (eV)	I_0 (eV)	W_i	dE/dx (MeV/g cm⁻²)	dE/dx (keV/cm)	n_p (i.p./cm) a)	n_T (i.p./cm) a)
H_2	2	2	8.38×10^{-5}	10.8	15.9	15.4	37	4.03	0.34	5.2	9.2
He	2	4	1.66×10^{-4}	19.8	24.5	24.6	41	1.94	0.32	5.9	7.8
N_2	14	28	1.17×10^{-3}	8.1	16.7	15.5	35	1.68	1.96	(10)	56
O_2	16	32	1.33×10^{-3}	7.9	12.8	12.2	31	1.69	2.26	22	73
Ne	10	20.2	8.39×10^{-4}	16.6	21.5	21.6	36	1.68	1.41	12	39
Ar	18	39.9	1.66×10^{-3}	11.6	15.7	15.8	26	1.47	2.44	29.4	94
Kr	36	83.8	3.49×10^{-3}	10.0	13.9	14.0	24	1.32	4.60	(22)	192
Xe	54	131.3	5.49×10^{-3}	8.4	12.1	12.1	22	1.23	6.76	44	307
CO_2	22	44	1.86×10^{-3}	5.2	13.7	13.7	33	1.62	3.01	(34)	91
CH_4	10	16	6.70×10^{-4}		15.2	13.1	28	2.21	1.48	16	53
C_4H_{10}	34	58	2.42×10^{-3}		10.6	10.8	23	1.86	4.50	(46)	195

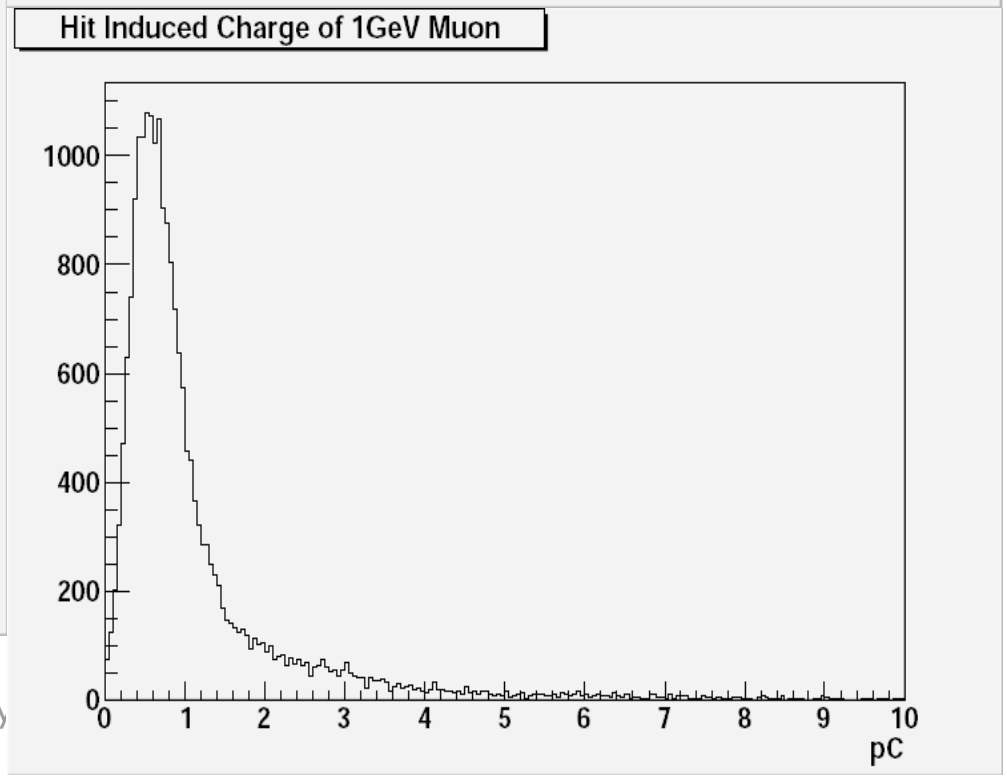
a) i.p. = ion pairs

Take E_{ion} = 35eV

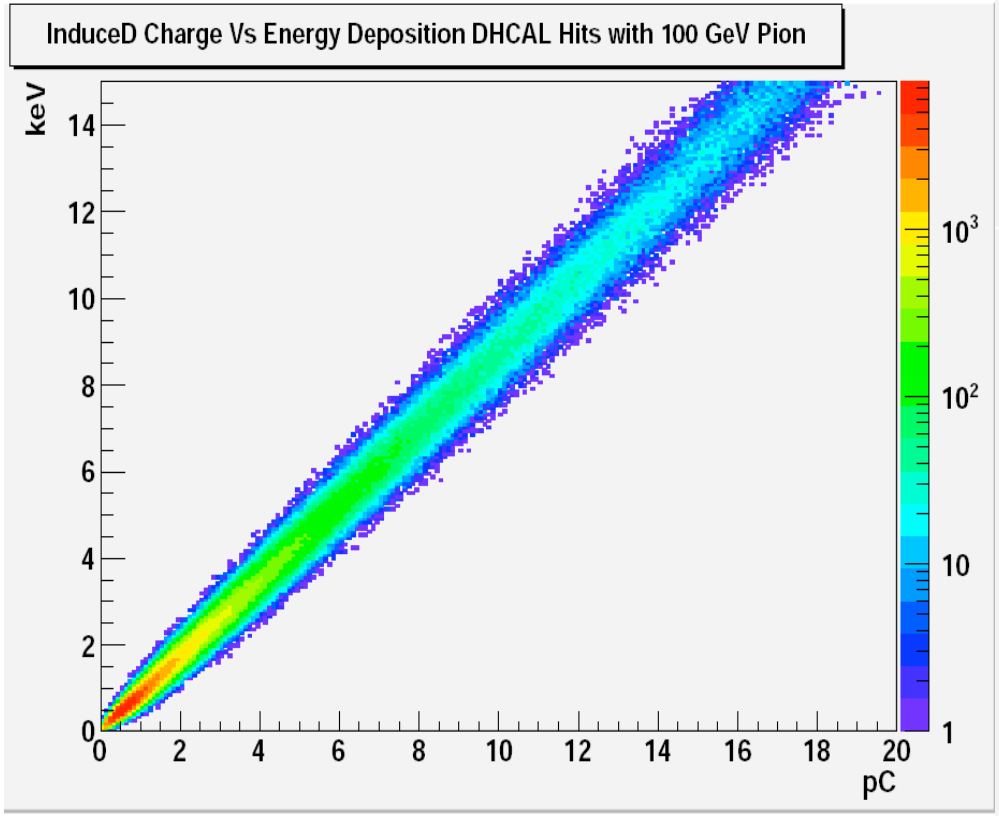
Digitization with 1 GeV Muon

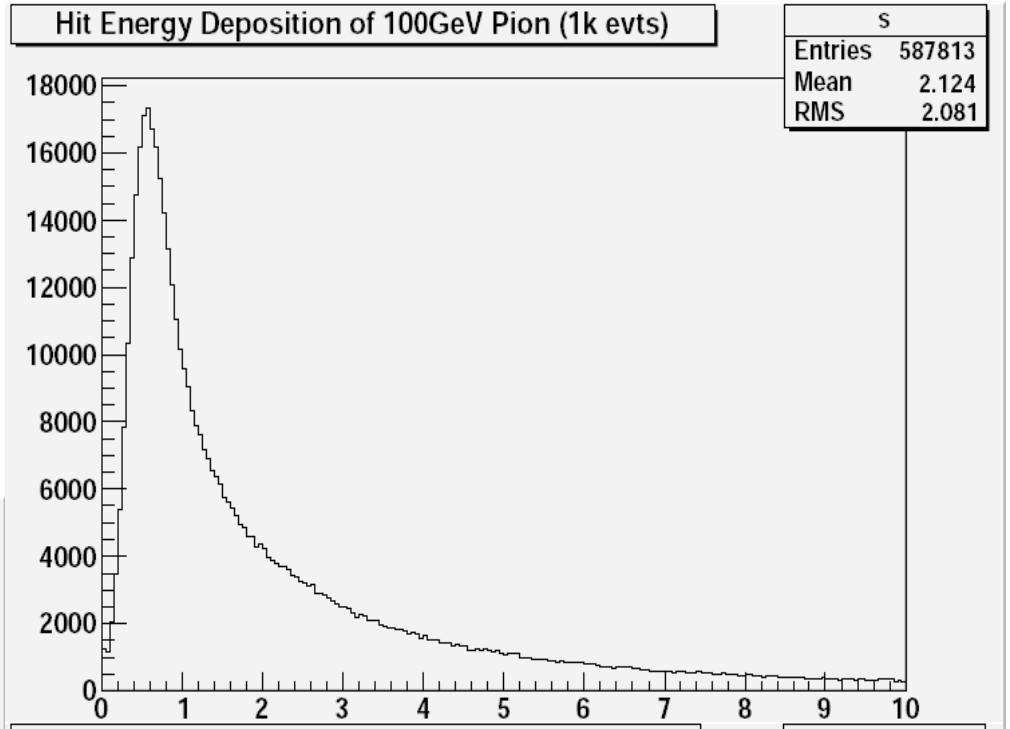


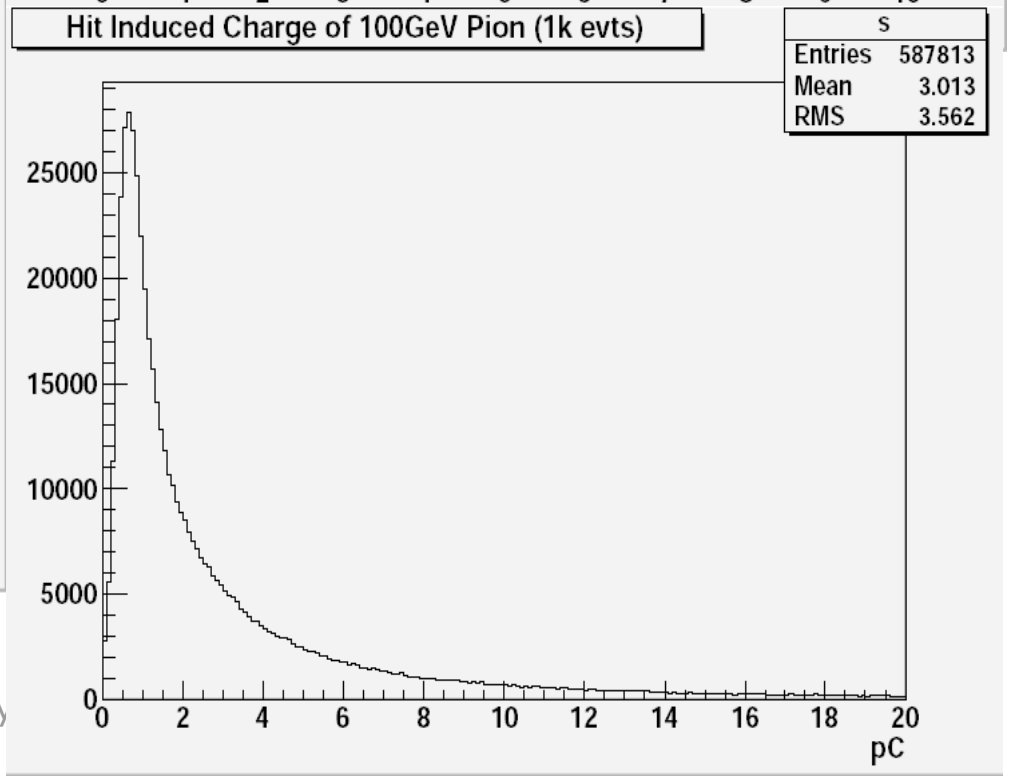




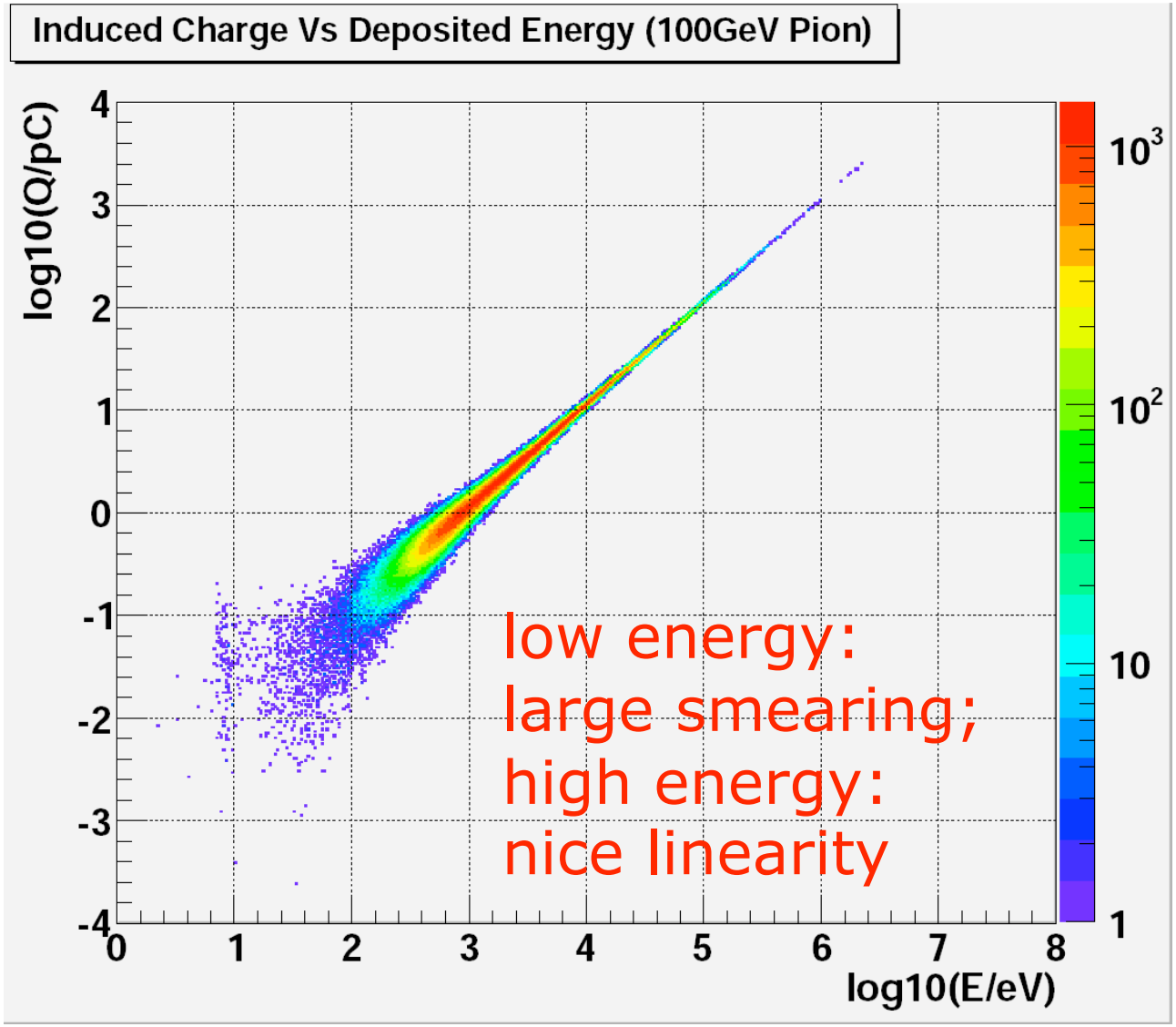
Digitization with 100 GeV Pion







Digitization with 100 GeV Pion:



To do list:

- Taken into account the Saturation effect
- Threshold optimization study (**Important!**)
- Polish the software package & release as a MarlinReco module

Conclusion

- Building ILC-like large GRPCs is now a controlled technique
- Electronics readout for 1m^2 is debugged and works for Hardroc 1 and Hardroc 2
- Simulation and threshold optimization (see S. Mannai's talk) progress in parallel
- Mechanical structure to hold GRPC+ equipped PCB has been successfully used in testbeam.
- Another equipped 1m^2 with HR2 is under preparation
- Many thanks to everyone @ CIEMAT, Ghent, IPNL, LLR, Louvain, Tsinghua, Tunis for the help in preparing this report