Status & plans for semi-digital HCAL

Manqi Ruan

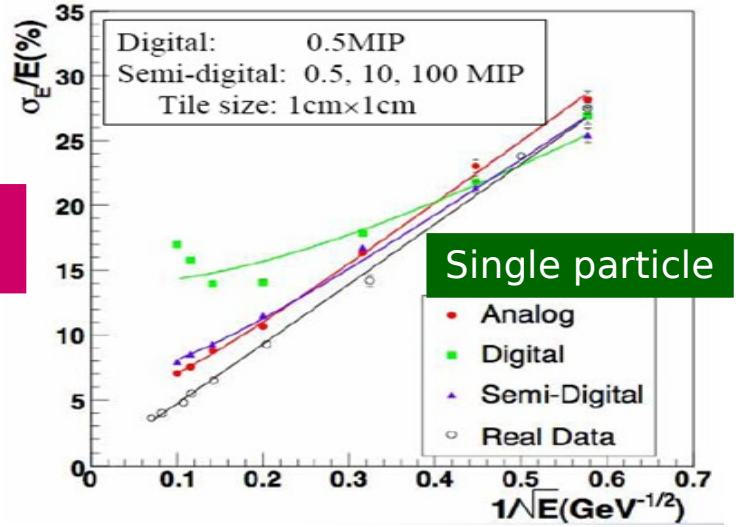
Outline

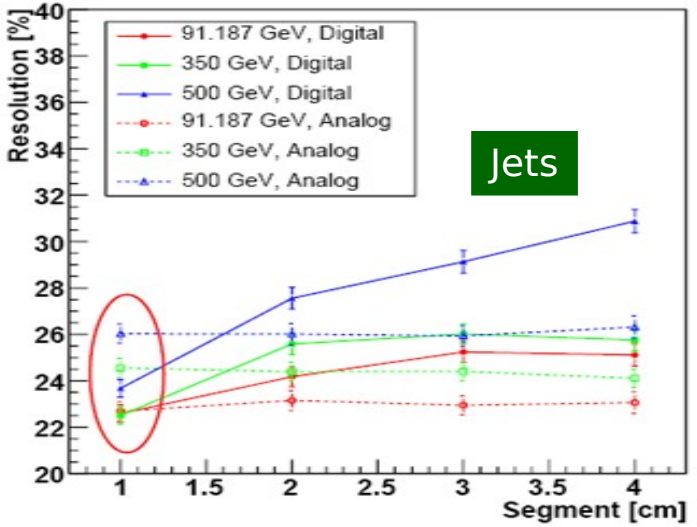
- Introduction:
  - **Motivation**
  - **Semi-digital HCAL collaboration**
- Milestones & Plans
- Current Status:
  - **Hardware & Electronics: new technology adopted**
  - **Analysis & Software developments**
- Conclusion

Motivation

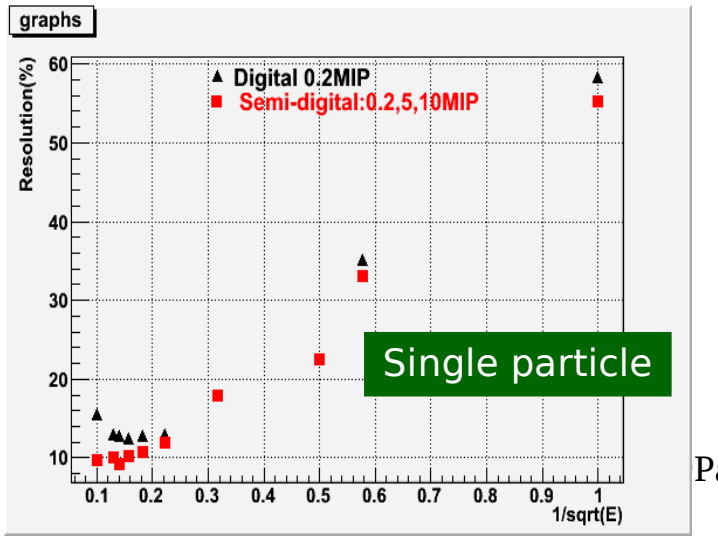
- Semi-digital HCAL: promising technology for the ILD!
  - **High efficiency, homogeneous, low cost and low consumption, Negligible dead zones, robust & Higher Granularity!**

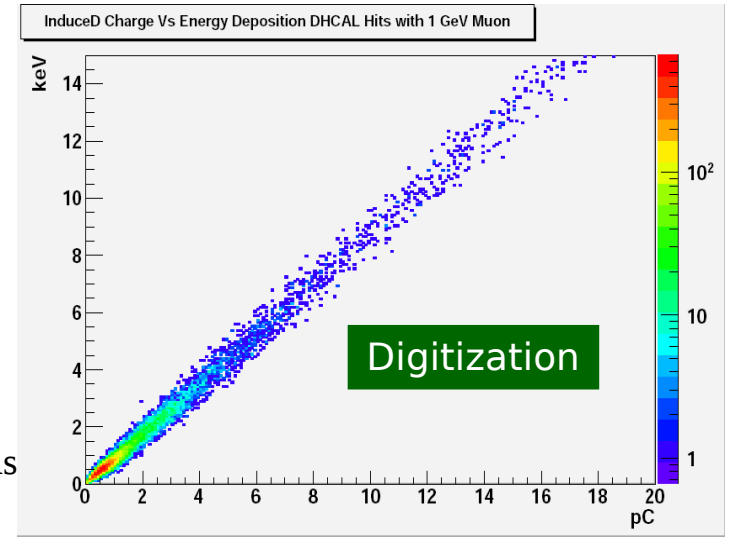
KEK(Matsunaga et al): Scintillator





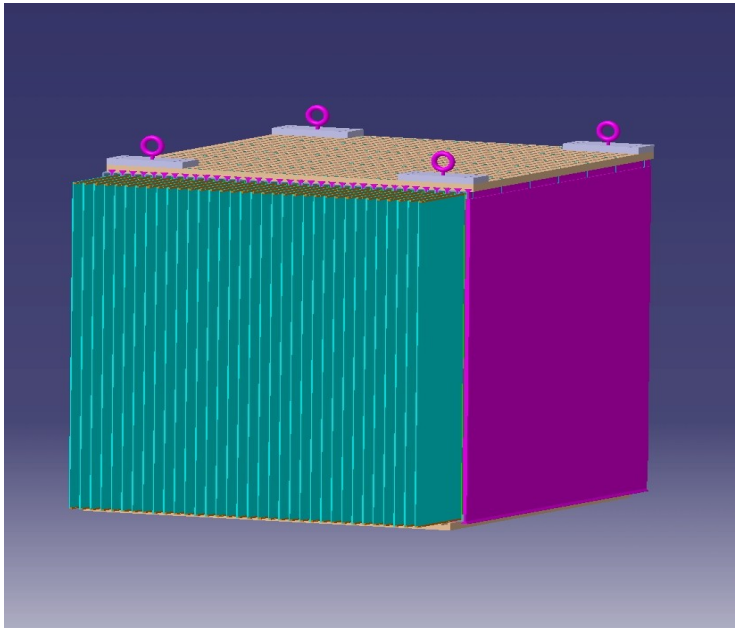
Gas (GRPC)





Semi-DHCAL Collaboration

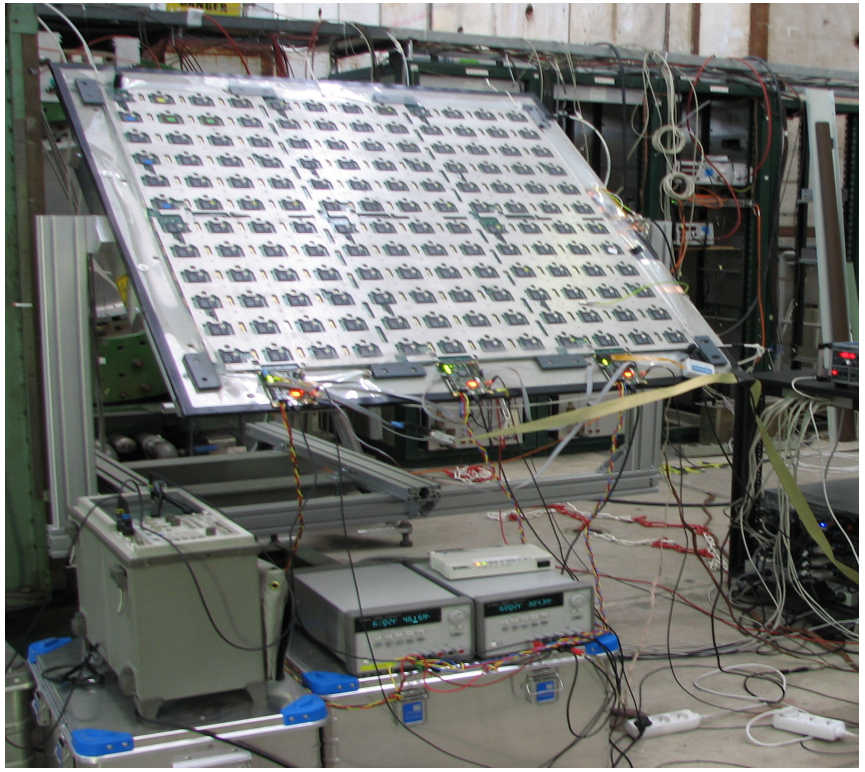
- Build cubic meter SDHCAL prototype as proposed in LoI
  - **Self supporting mechanic structure**
  - **Power pulsed embedded readout electronics**
  - **~400,000 channels (40 layers of 100x100cm²)**
    - **Current Prototype: MiniDHCAL + 1m²**
- International cooperation:
  - **France: IPNL, LAL, LLR, LPC;**
  - **Russia: IHEP-Protvino**
  - **Spain: CIEMAT**
  - **Belgium: Louvain-La-Neuve, Ghent**
  - **China: Tsinghua**
  - **Tunisia: Tunis**
  - **Collaboration with: CERN-Bologna (MCRPC) and LAPP (DIF)**
  - **Communication with US DHCAL group**

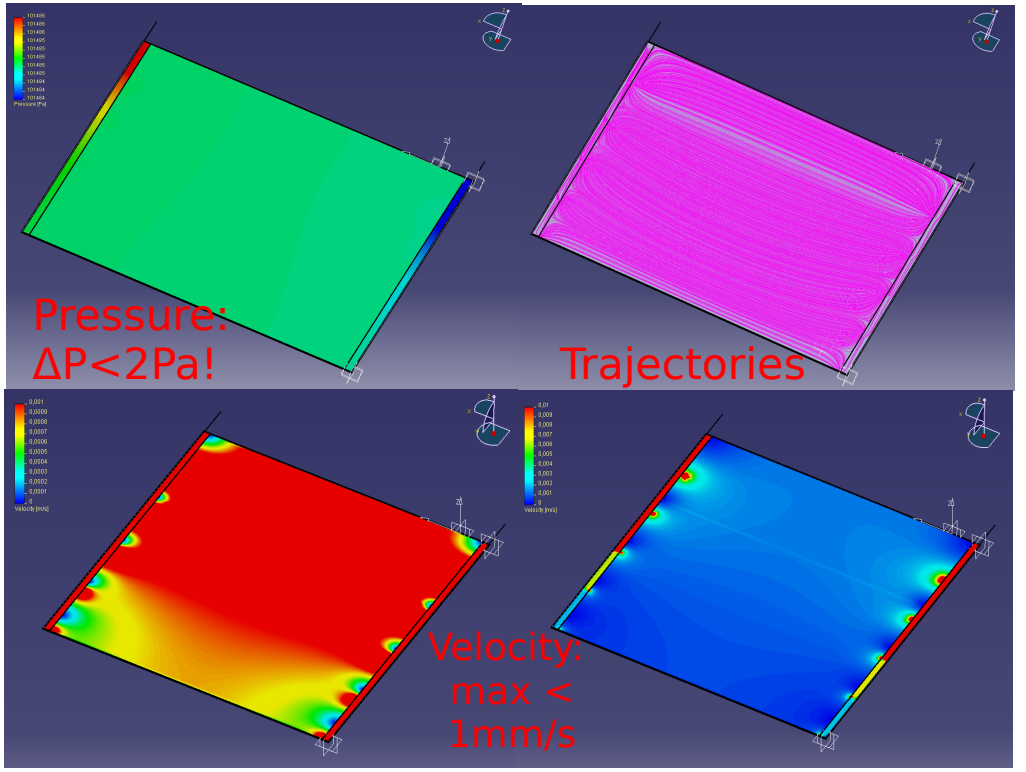


Milestones & plan

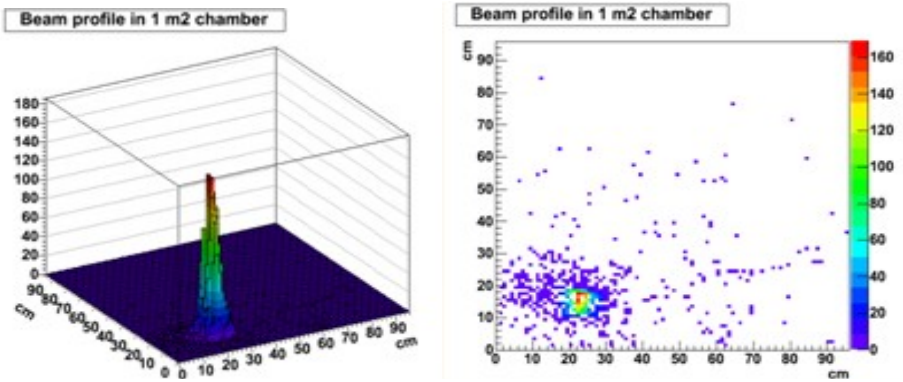
- Milestones:
  - **Project started in 2006**
  - **Construction of mini DHCAL (2008) & square meter (2009)**
- Future plans: toward the proof of principle!
  - **Test of power pulsing on detector in 3T magnet at CERN H2 beam before summer 2010; now being tested in lab.**
  - **Construction of cubic prototype of SDHCAL according to ILD design (electronics, mechanics, DAQ) before end of 2010;**
  - **Calibration at large scale (with charge injection & cosmic rays) in first semester of 2011;**
  - **Data taking, analysis and technology evaluation in 2011 and 2012;**
  - **PFA development using DHCAL in 2010;**
  - **PFA tests with high intensity beam and/or with target in 2011;**

1 m² prototype





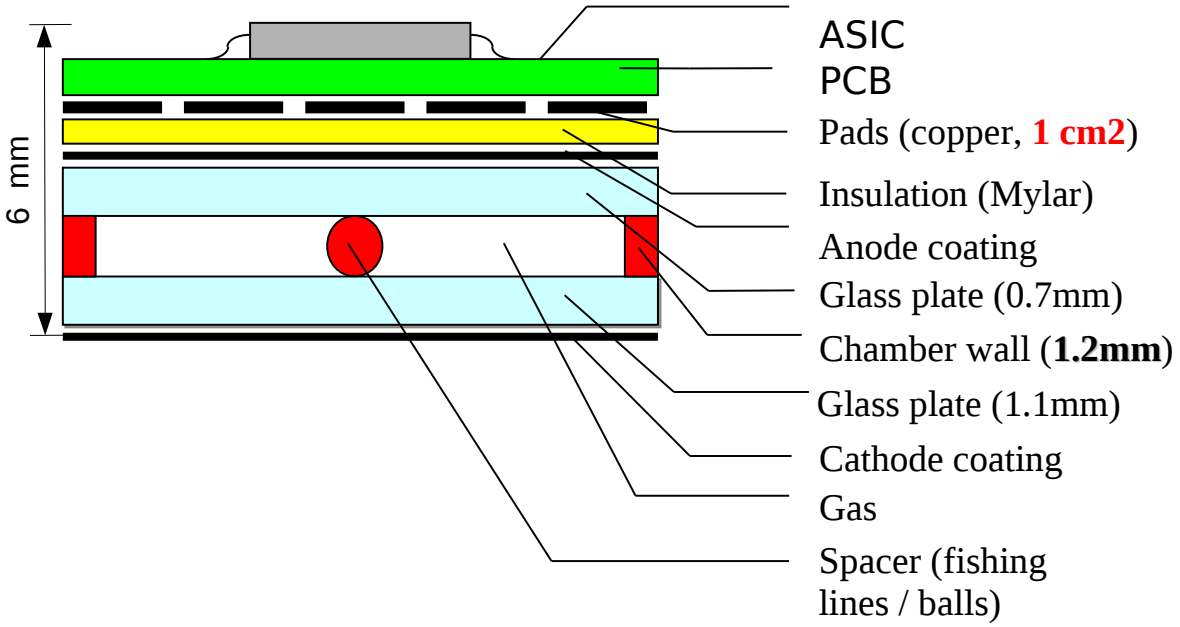
- 144 ASICs, each connected to 8*8 1cm² cells, totally 9216 channels;
- Highly homogenous & low consumption gas system!

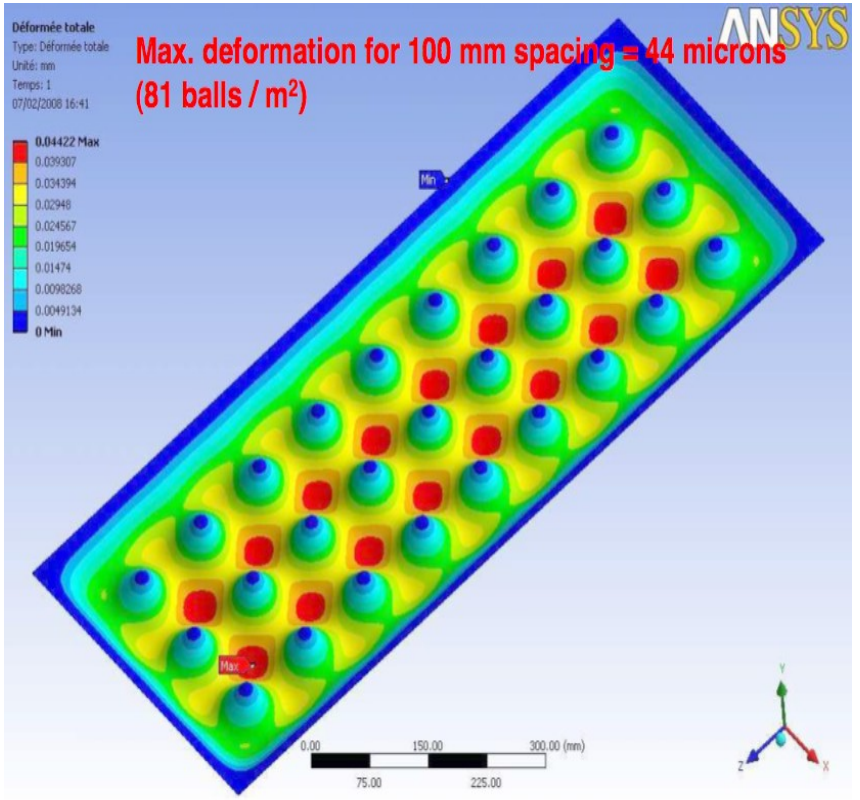


Test beam shower profile reconstruction

GRPC & Spacer

- Thickness of few millimeters→ to reduce the coil cost
- Efficient, Homogenous, cheap and easy to build





To reduce dead zone: Replacing fishing lines with ceramics mini balls

Glass layer under self-weight (~17Pa)+ 8kV electronic field (~140Pa):

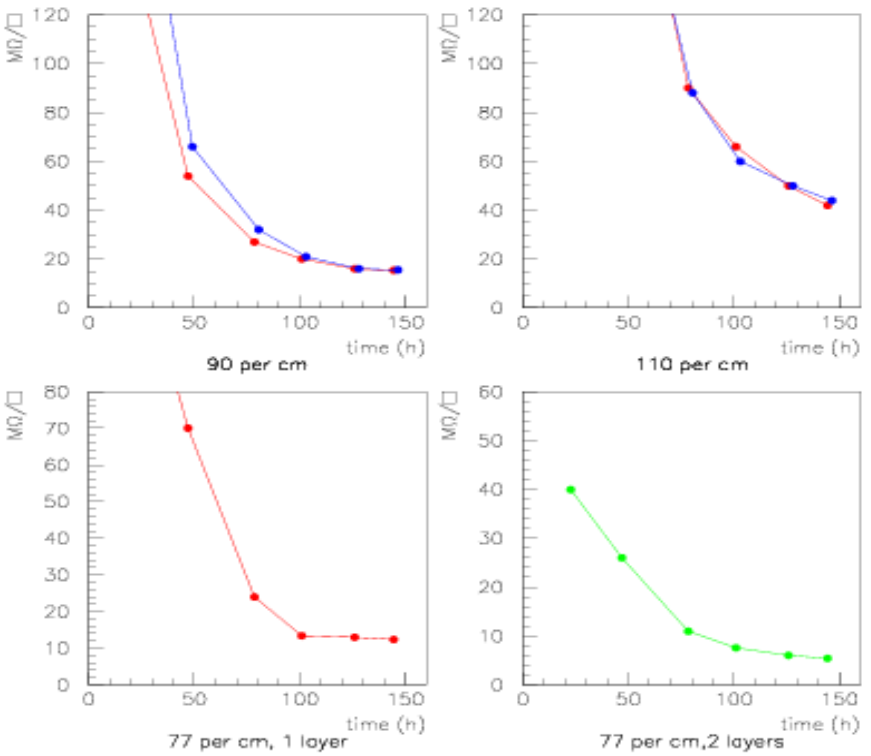
Deformation<40µ

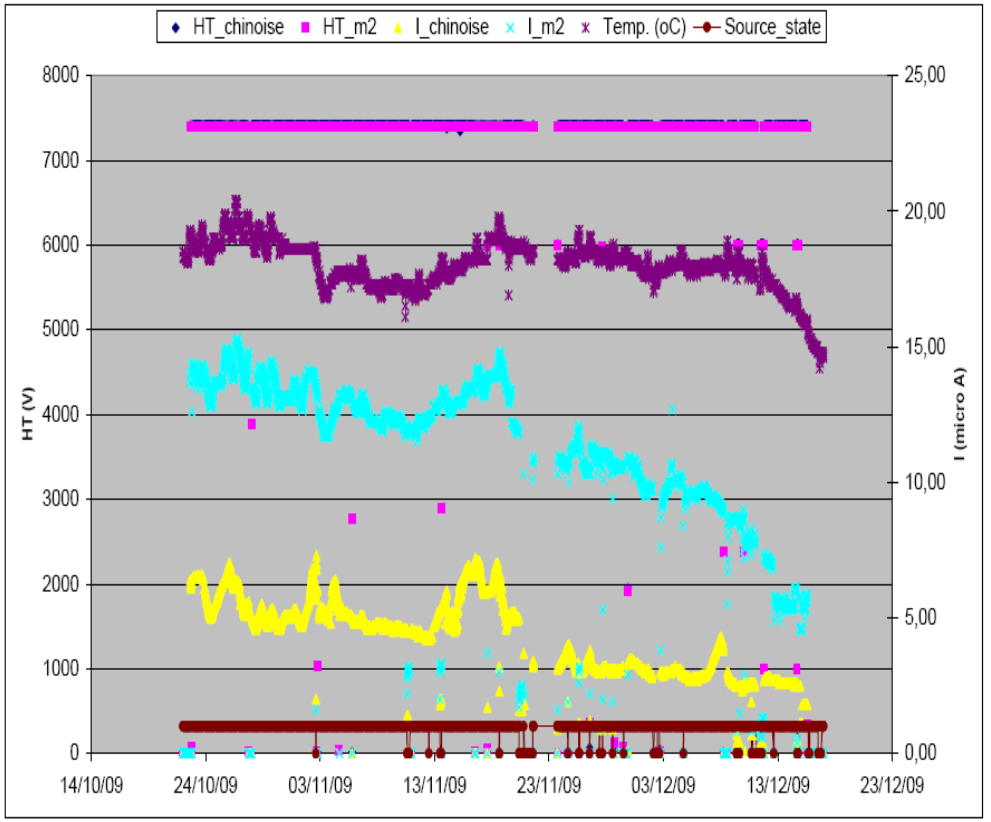
Monitoring of coating resistance stability & aging

Resistive coatings: select the most appropriate painting which provides the lowest pad multiplicity and the highest efficiency

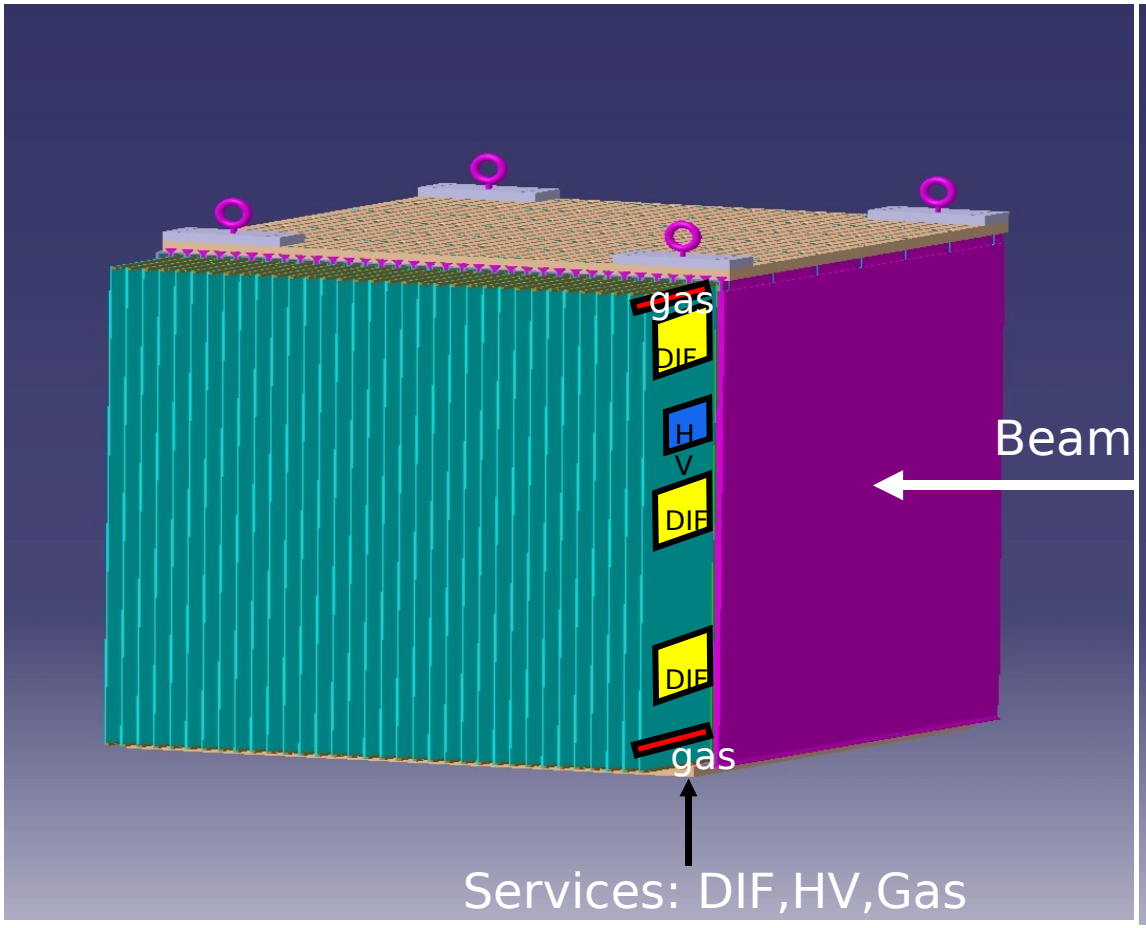
Silk-Screen printing: Provides homogenous and well controlled coating

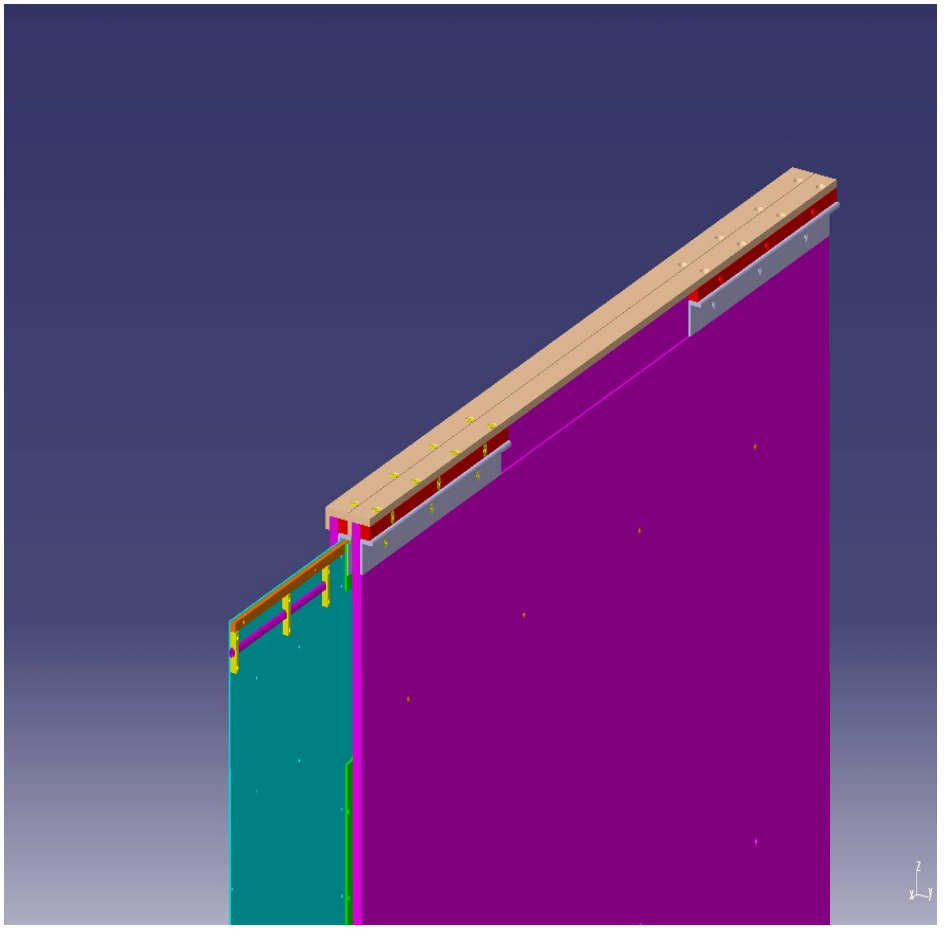
Aging monitoring: Tools available at GIF@CERN





1 m³: Self-supporting Mechanics

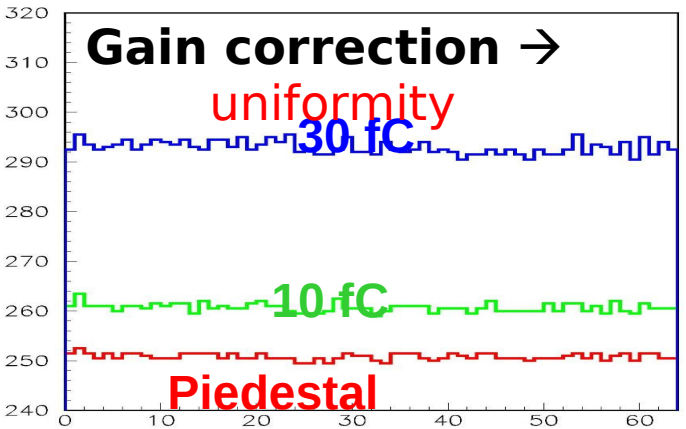


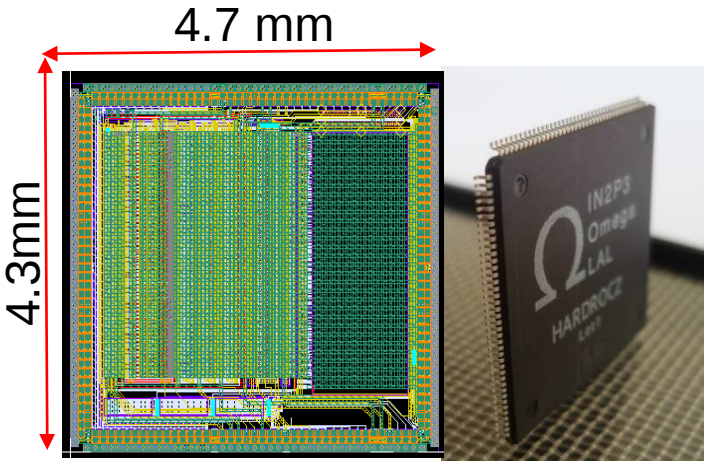


Self-supporting Iron structure: 16mm Iron layer + (6 mm PCB + 4mm Iron layer);

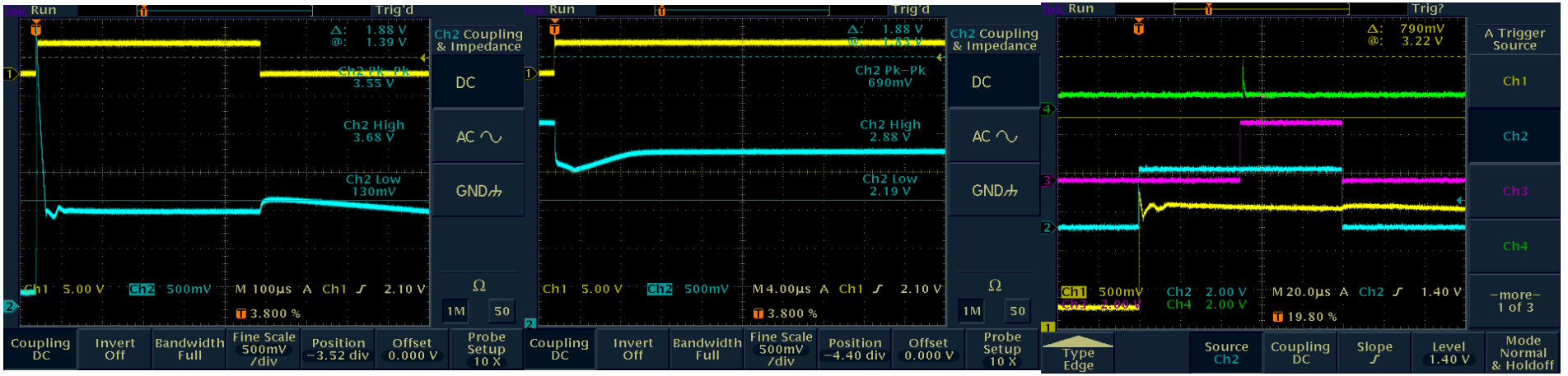
Electronics

The first use of HARDROC1(2): 64 channels with **2(3) thresholds**
Range: 10 fC-10pC





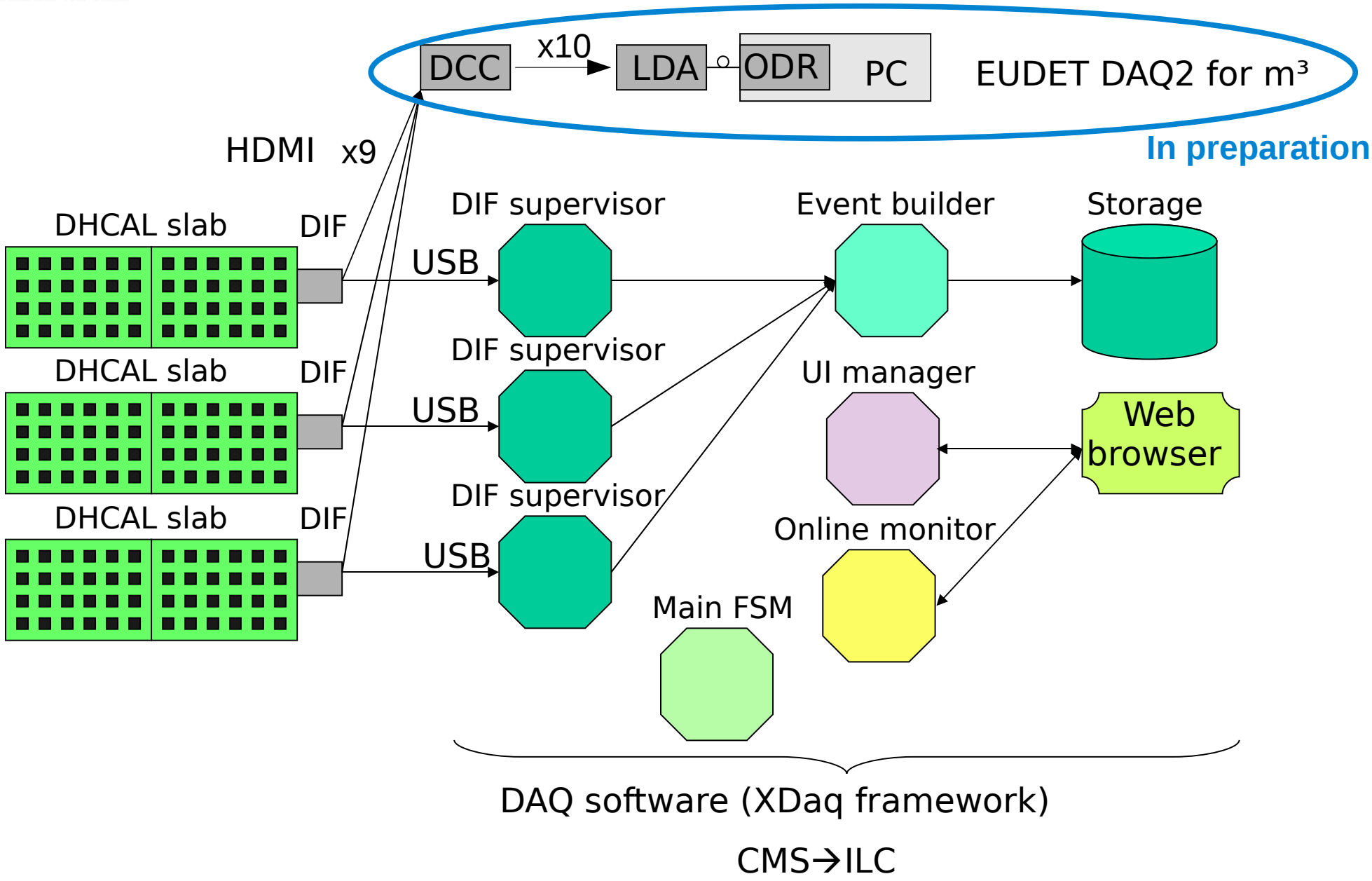
Test of Power-pulsed→ consumption< 10µW/ch (0.5% duty cycle), X-talk < 2%:
Stabilized in ~10 µs! Confirmed by analogue & digital readout



Testing of ASICs

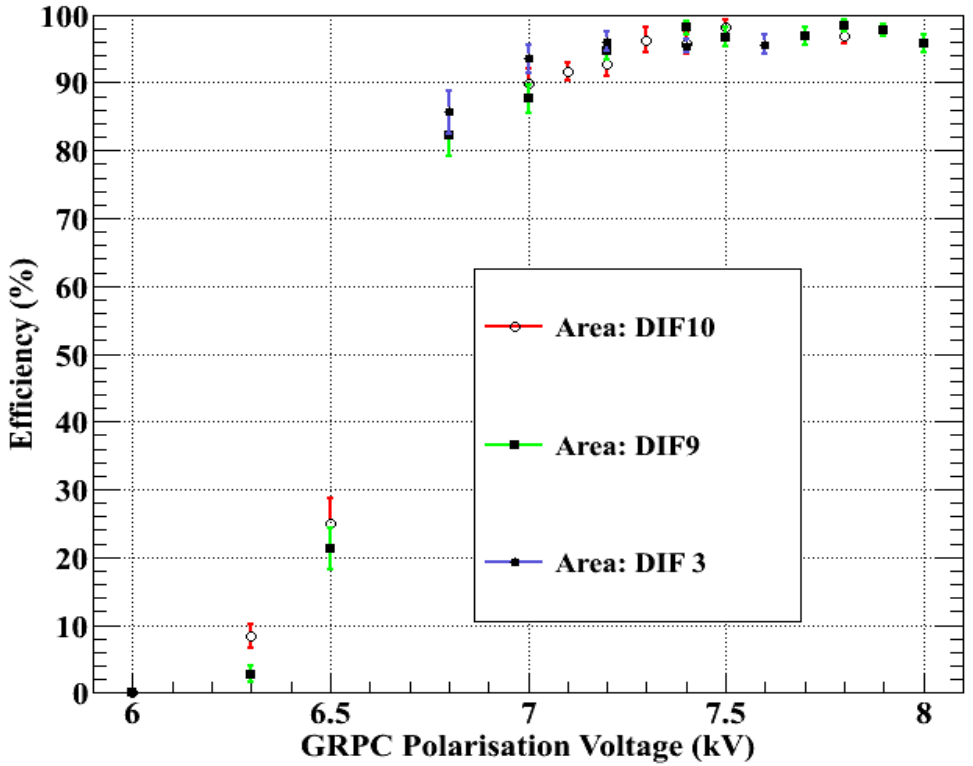
Robot to test the 8000 ASIC's
(CMS→ILC transfer)

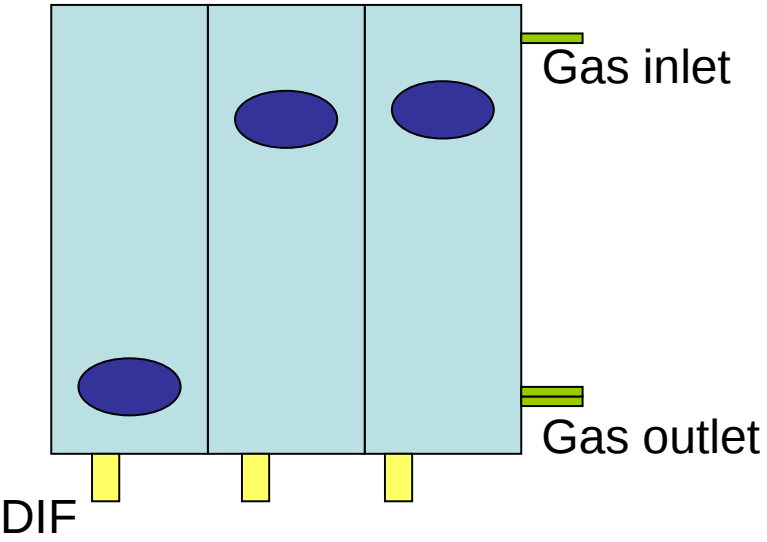
DAQ Schematic View

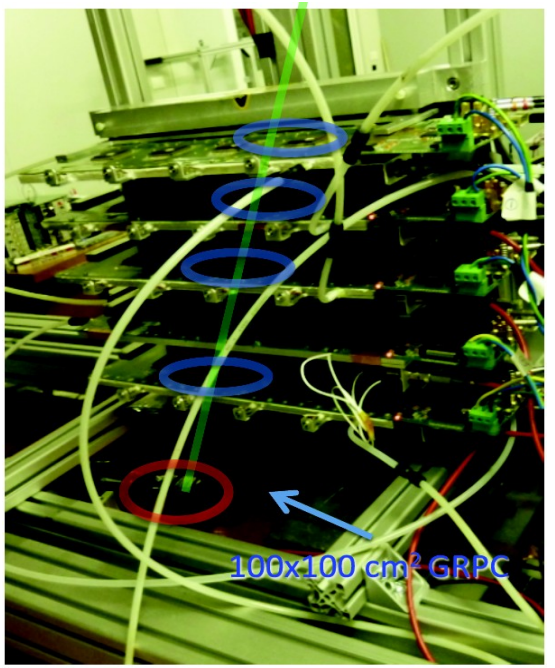


Analysis: efficiency homogeneity

Efficiency in three different zones of the detector

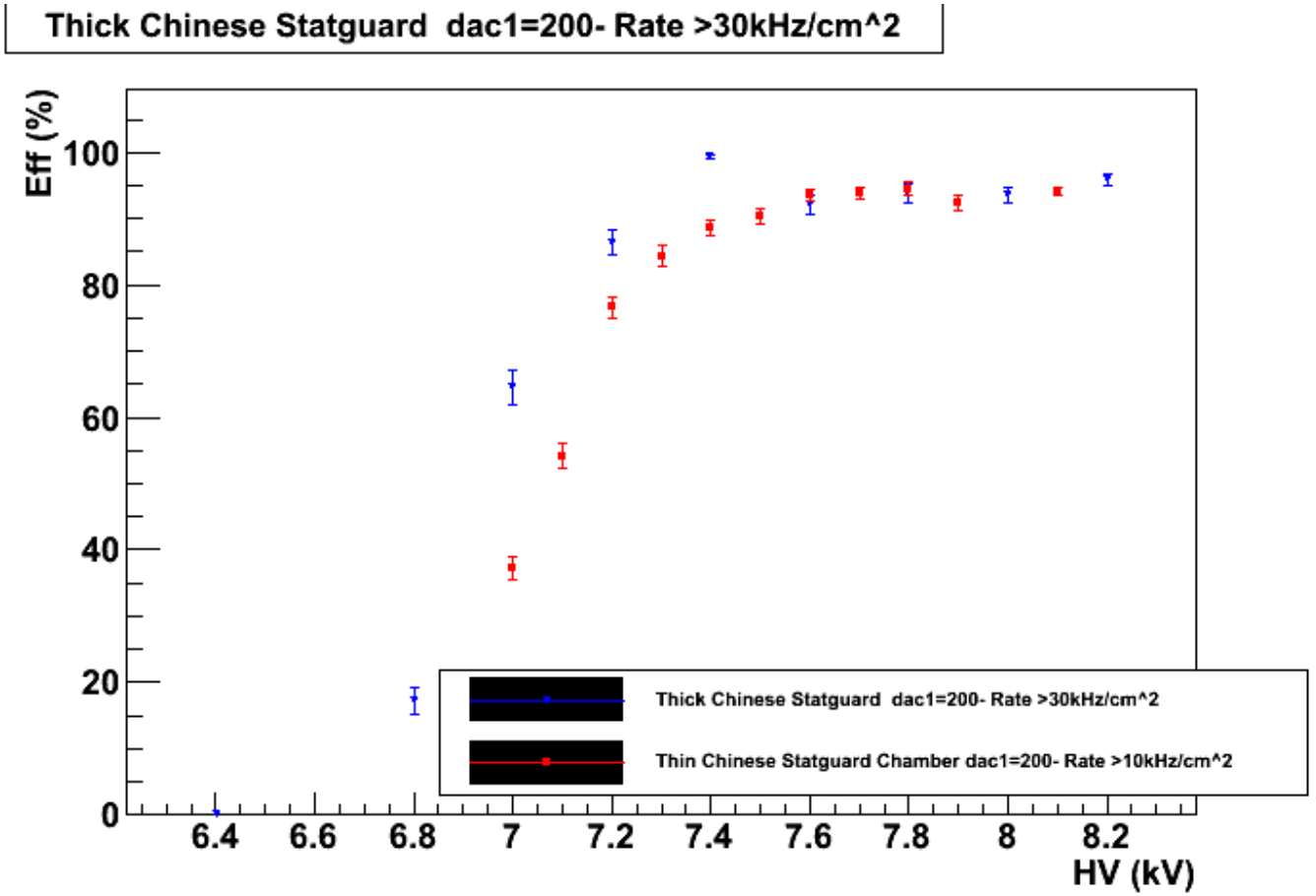






Check the efficiency homogeneity with cosmic ray experiment: MiniDHCAL used as tracking system

Enhance the rate capabilities

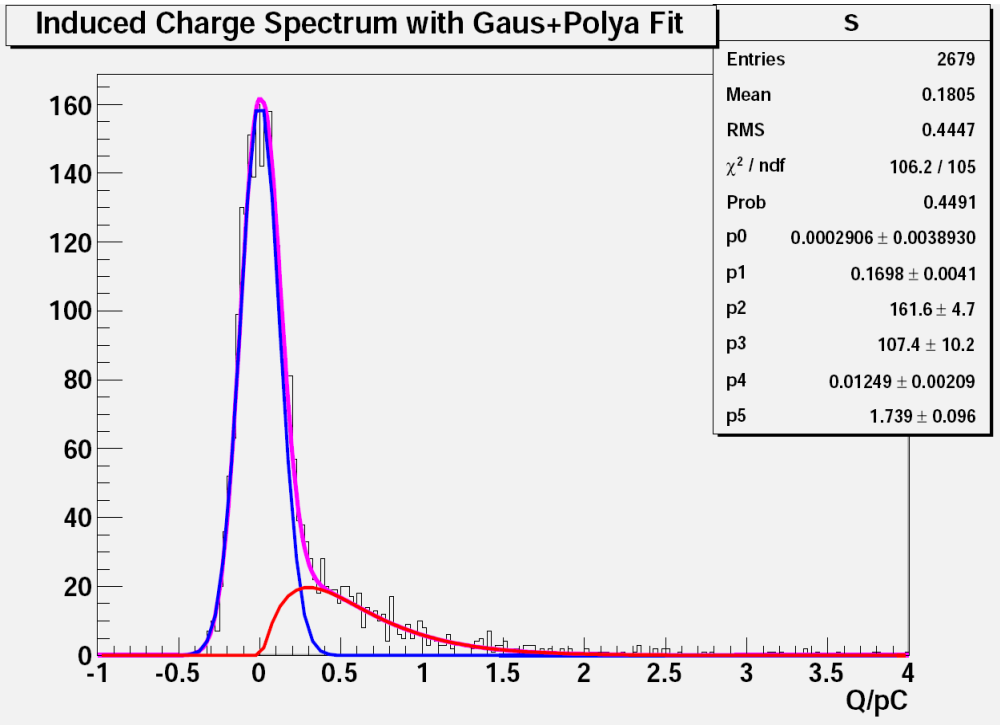


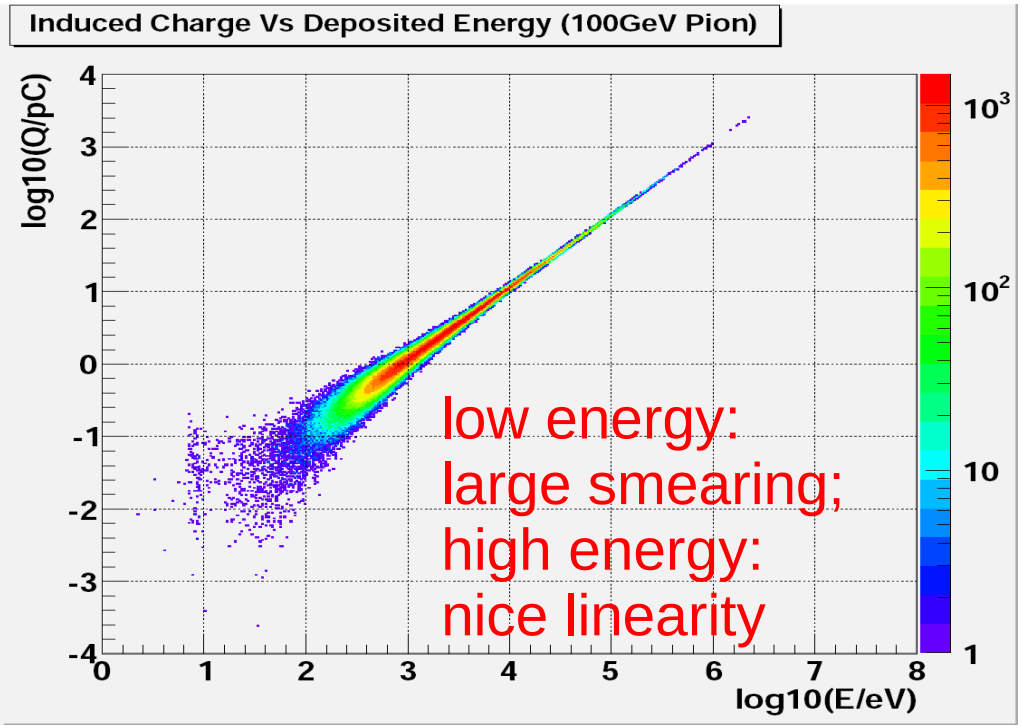
Float glass : 10^{13} Ω.cm → GRPC rate detection < 100 Hz/cm²

Tsinghua University: Semi-conductive glass 10^{10} Ω.cm → GRPC rate detection > 10 KHz/cm2 (high efficiency)

It's possible to record multiple events in test beam, providing real samples with 1*1 cm² granularity for PFA reconstruction

Software: Digitization





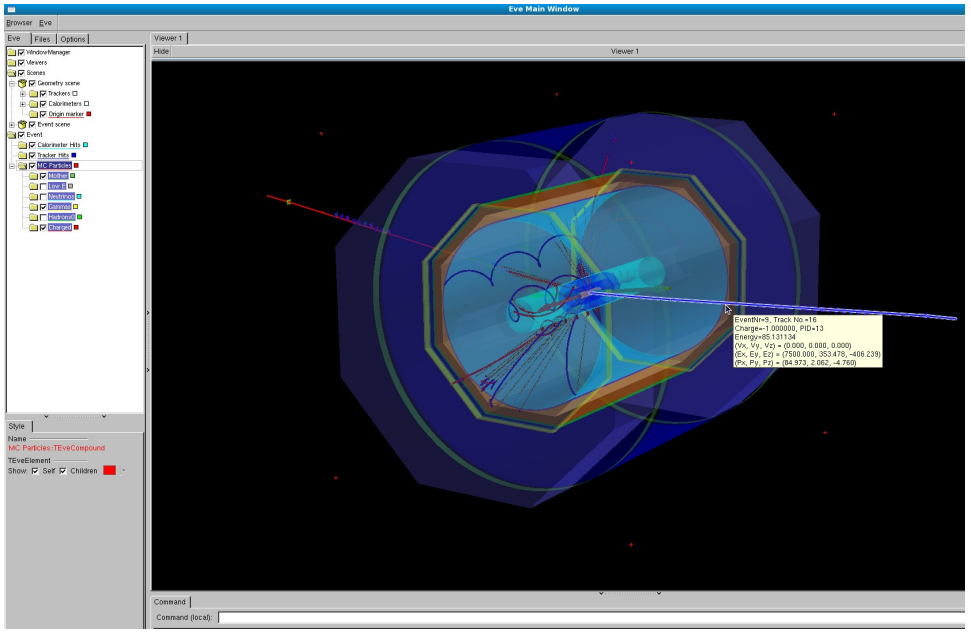
- Study the dependency of energy deposition in each cell and induced charge on each pad with cosmic ray data -> basis for the threshold optimization study
- Marlin digitization module developed, can be used for other type of gaseous detector with experimental input

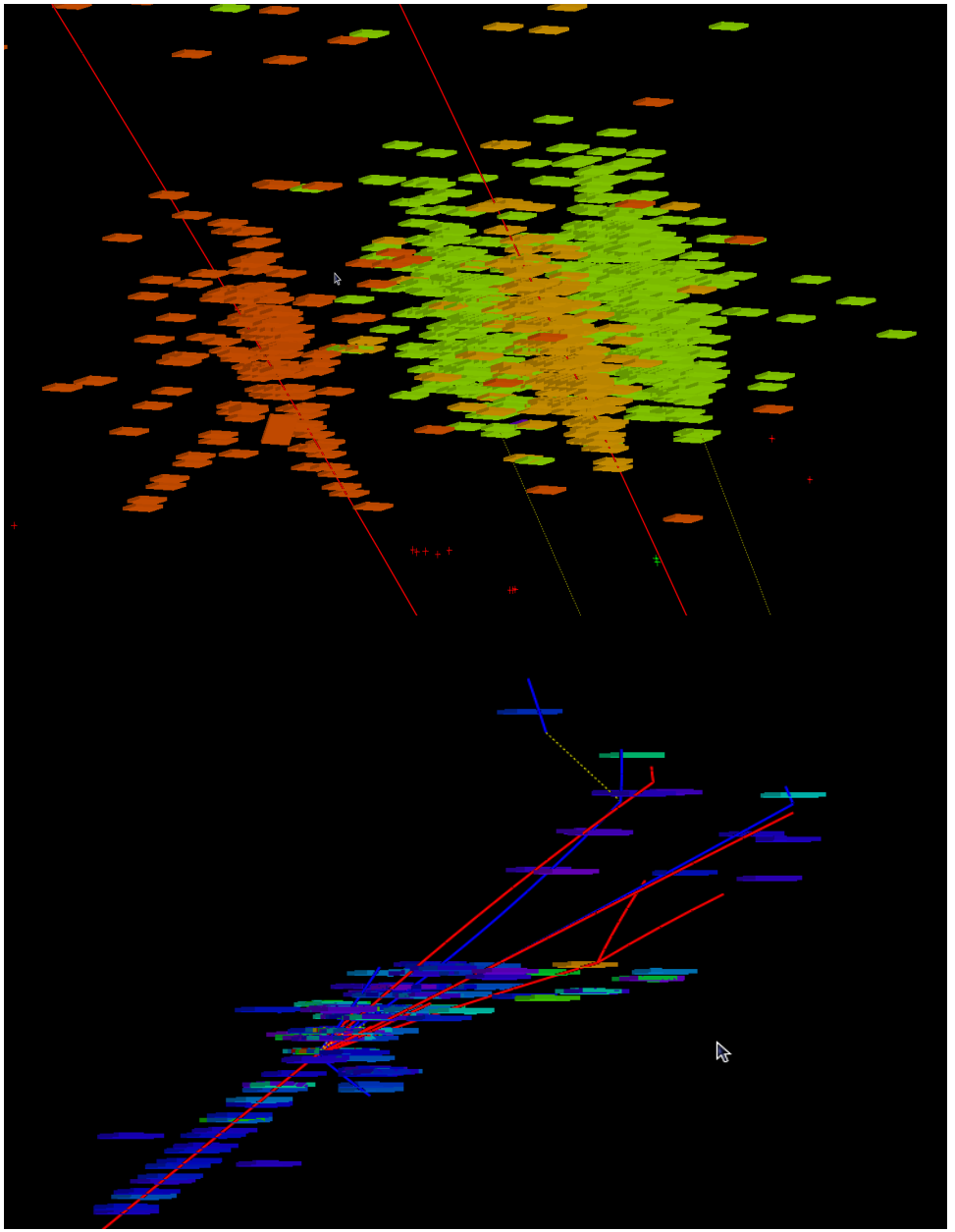
Software: Druid

Druid: to achieve better understanding to ILD events & Shower details;

Simultaneously display reconstructed & MCTruth objects: tools to analysis the performance of reconstruction software;

With Mokka option to keep tracks generated in calorimeter region: tools to develop calorimeter based algorithms;

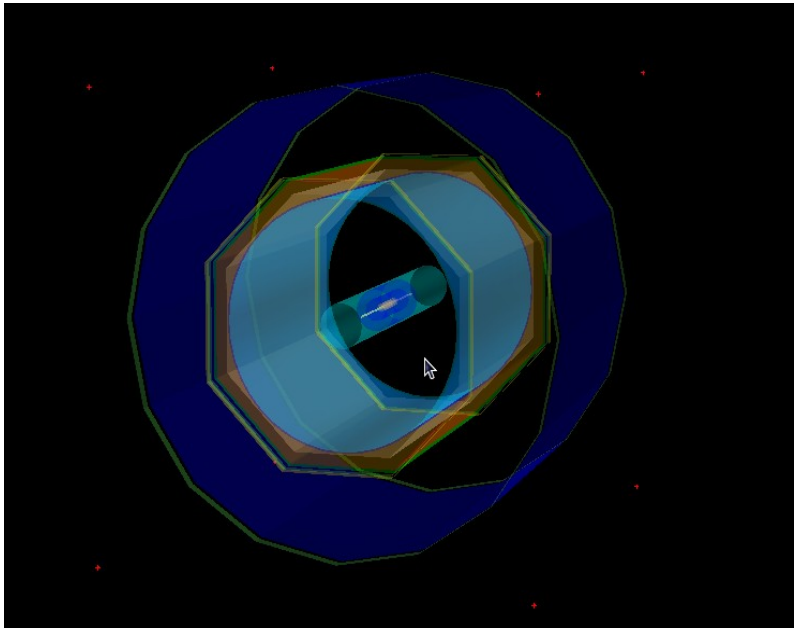


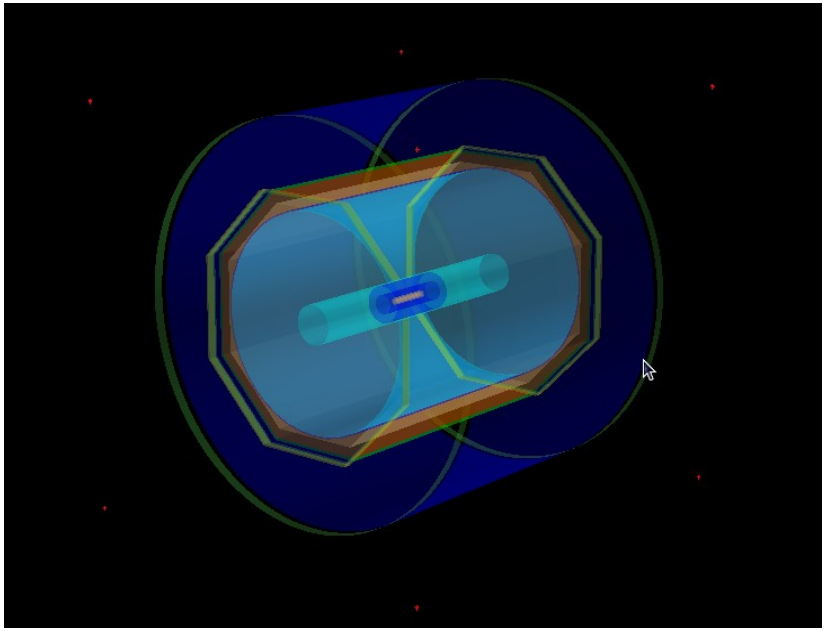


Central MC production

- Data samples with different detector geometries:
  - **Single particle events (partially finished);**
  - **Benchmark ILC events, especially events with double/Multiple jets, largely boosted jets & jets overlay**
- Serve as the base for later analysis
  - **Global detector property analysis: leakage, calibration, hit rate...**
  - **Geometry & detector parameters optimization study: i.e, DHCAL thresholds optimization**
  - **PFA algorithm optimization for DHCAL**
- Will be upgrade with new geometry data base and new type of events

PFA algorithm optimization





- Current Pandora PFA is optimized for Si-W ECAL and Analogy HCAL --> optimization is needed for DHCAL with higher granularity & different geometry (a la Videau)

- Software tools (Digitization, Display, etc.) and samples (Central MC Production) are under preparation

Conclusion

- Semi-digital HCAL is a solid option for future ILD.
- The Semi-digital HCAL collaboration is aiming at producing and testing a cubic meter technological prototype (before 2012) according to the LoI design:
  - **A platform for many new technologies**
    - **Self-supporting Mechanical structure,**
    - **power-pulsed embedded readout**
    - **Semi-digital readout**
  - **Capability to produce & operate, monitoring the cubic meter**
    - **Manufacturing of large sample of large RPCs, test ASICs, coating, etc.**
    - **Tools for monitoring the aging, stability & calibration on a large number of channels.**
  - **Progress are made at steady pace as expected**
- Software developments & central MC production is undergoing:
  - **Aiming at optimize the PandoraPFA with DHCAL geometries & electronic readouts**
  - **Test reconstruction of energy from semi-digital information**
  - **Test DHCAL vs AHCAL options on number of benchmark channels & geometry optimization**