Construction and commissioning of the SDHCAL technological prototype

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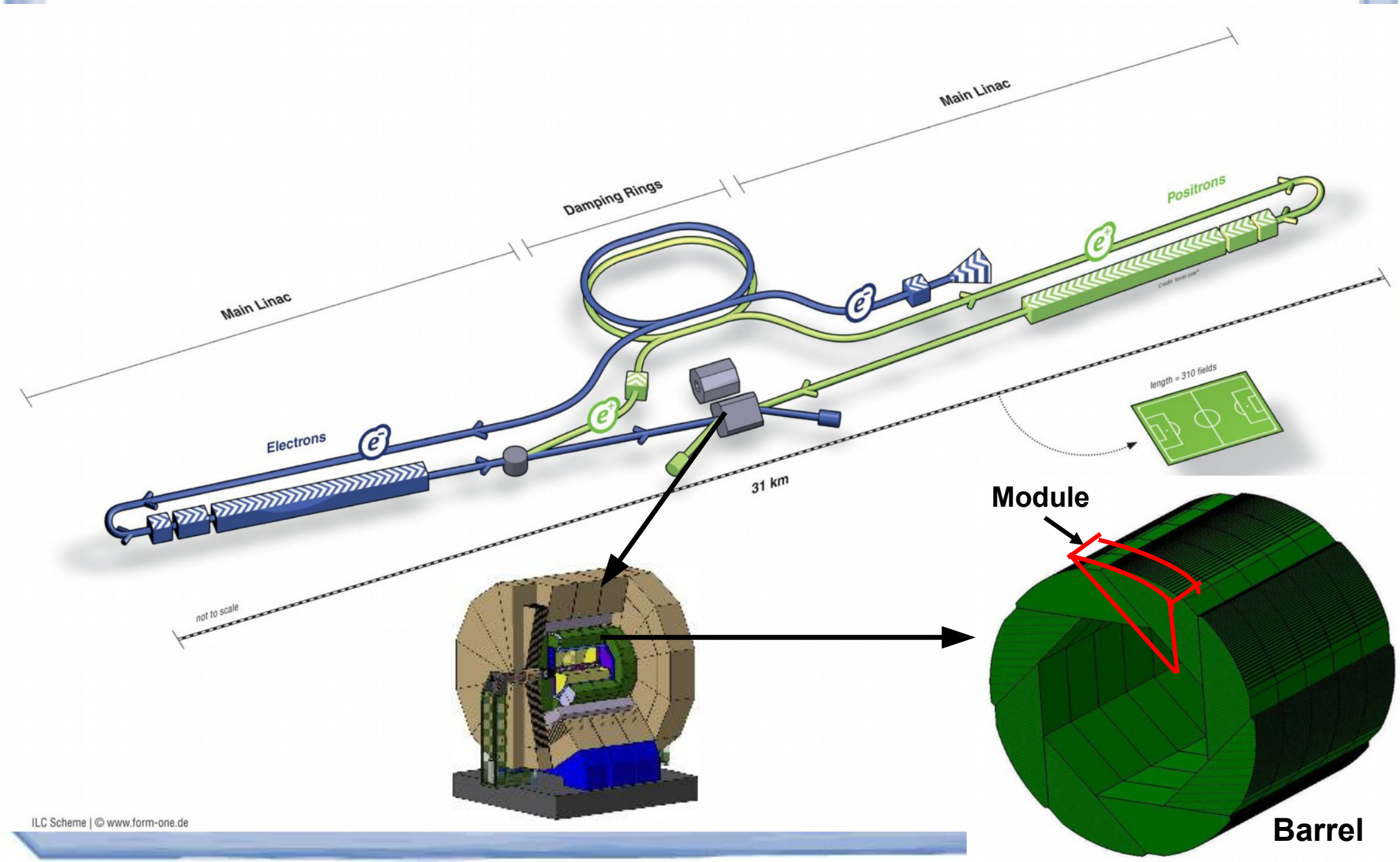
The ILC and ILD projects

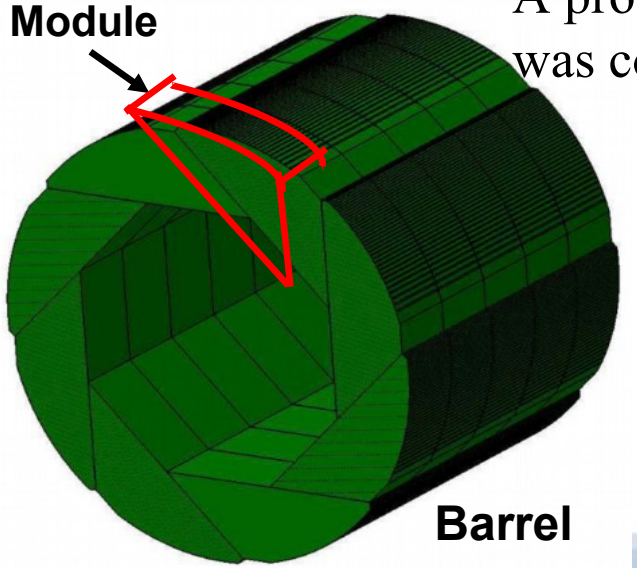


Motivation

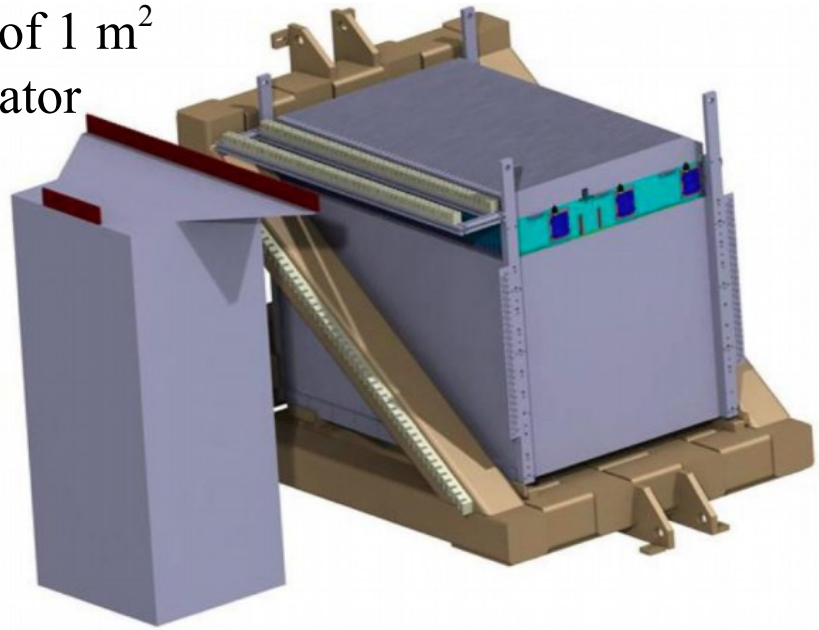
- The Semi-Digital HCAL is one of two options proposed in the ILD LOI. It uses gaseous detectors as sensitive medium with embedded auto-triggering electronics providing $1cm^2$ lateral segmentation.
- Designed for **P**article **F**low **A**lgorithms
- A genuine mechanical structure is proposed for the SDHCAL.

Glass Resistive Plate Chamber was chosen as the baseline :
-Cost-effective
-High efficiency
-Adequate resolution

Challenges
-homogeneity for large surfaces
-Thickness of only few mms
-Services from one side
-Embedded electronics



A prototype with 50 GRPCs of 1 m^2 was conceived as a demonstrator



The m^3 prototype

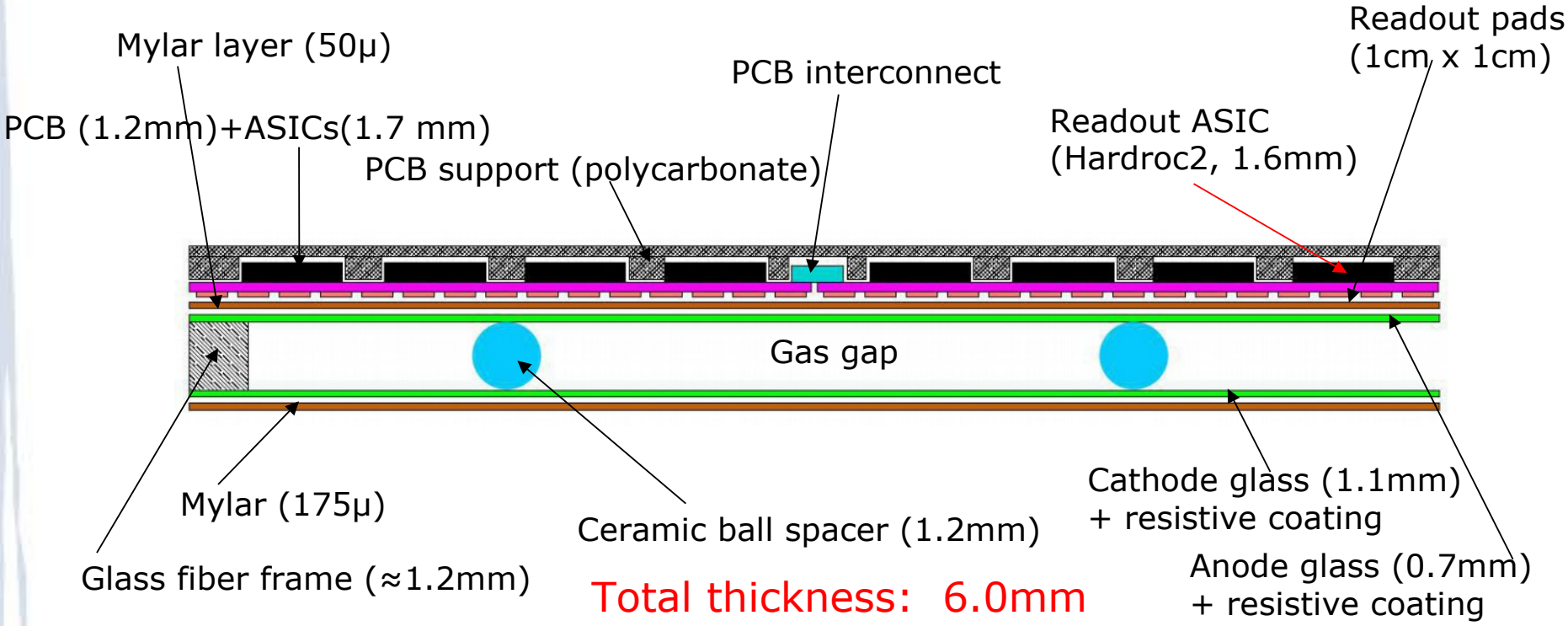
- Self supporting steel (absorber) structure

50 chambers build

6 mm thick GRPC cased in steel : total thickness 11 mm

1 m^2 GRPC cross-section view

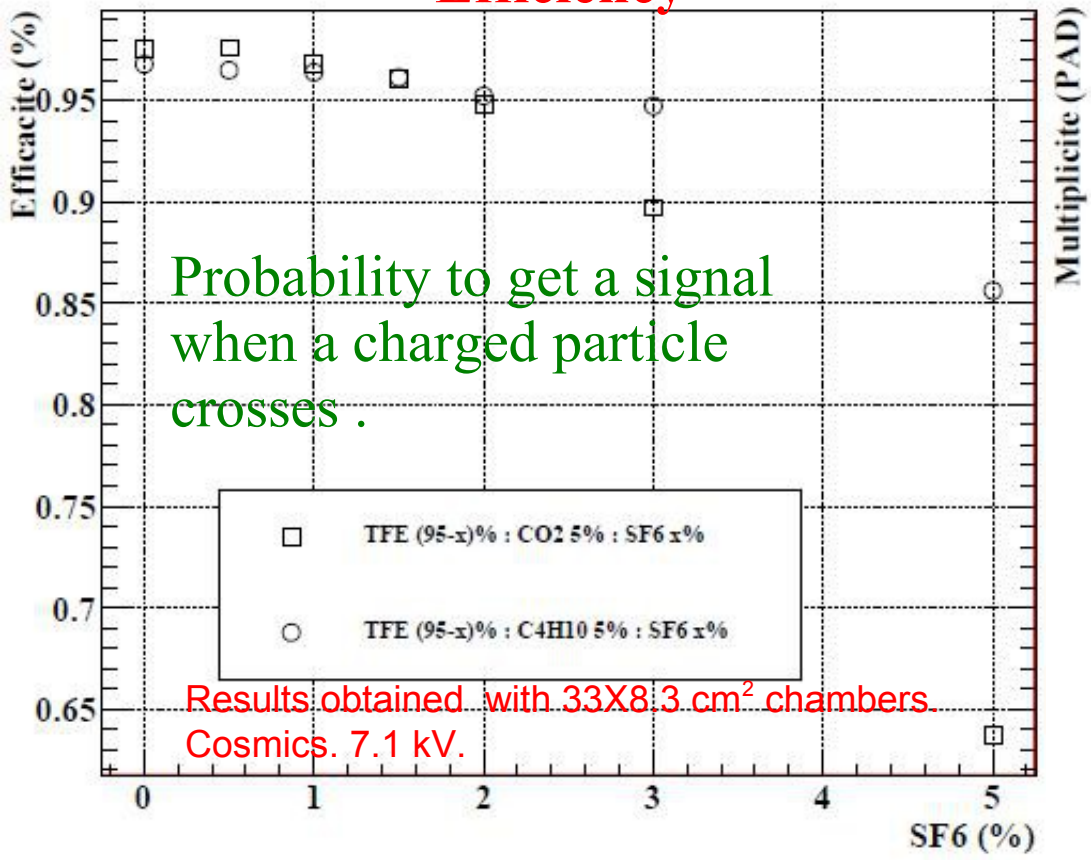
- Saturated avalanche mode: spatial charge distribution on glass anode ~ 1 mm^2
- Read by 1cm^2 copper pads: particle density in shower up to ~100/cm^2: 3 readout thresholds.
- Embedded readout electronics



Gas study

- Low ionisation energy gas (TetraFluoroEthane) for efficient avalanche creation with thermal electron (TFE + SF_6) and photon (CO_2) quenchers
- 93% TFE, 5% CO2, 2% SF6
- Performance parameters

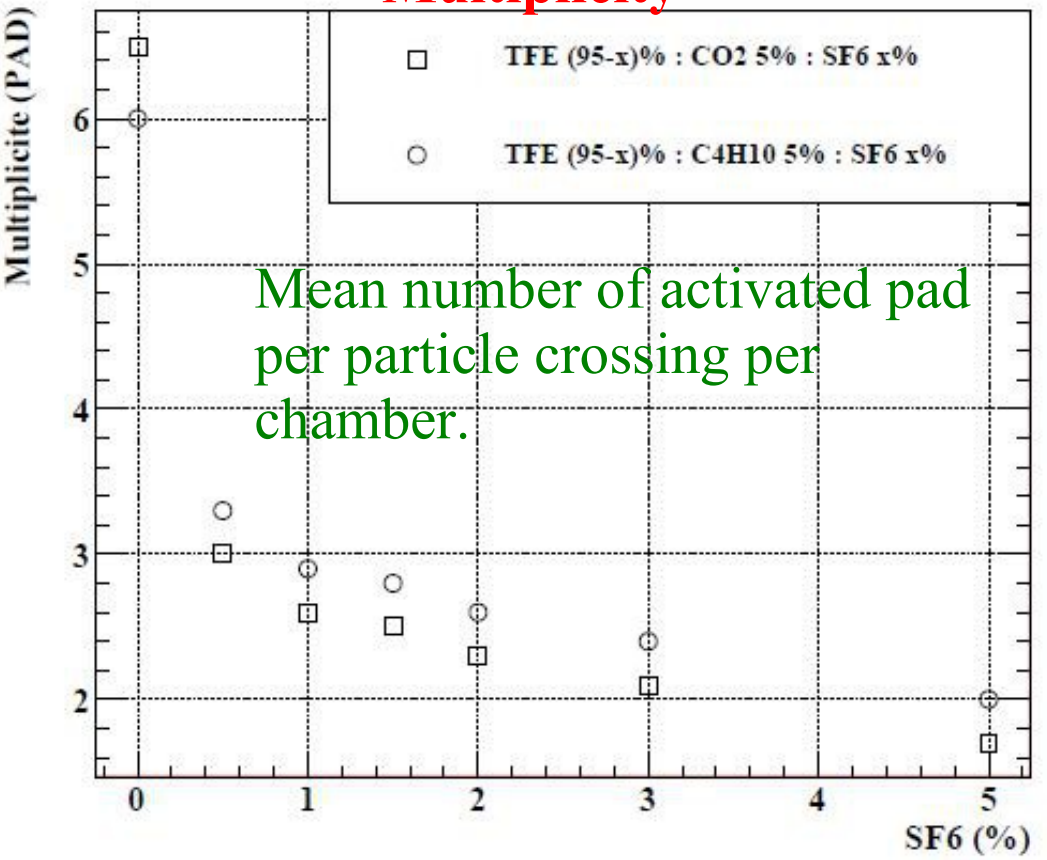
Efficiency



Probability to get a signal when a charged particle crosses .

Results obtained with 33X8.3 cm^2 chambers. Cosmics. 7.1 kV.

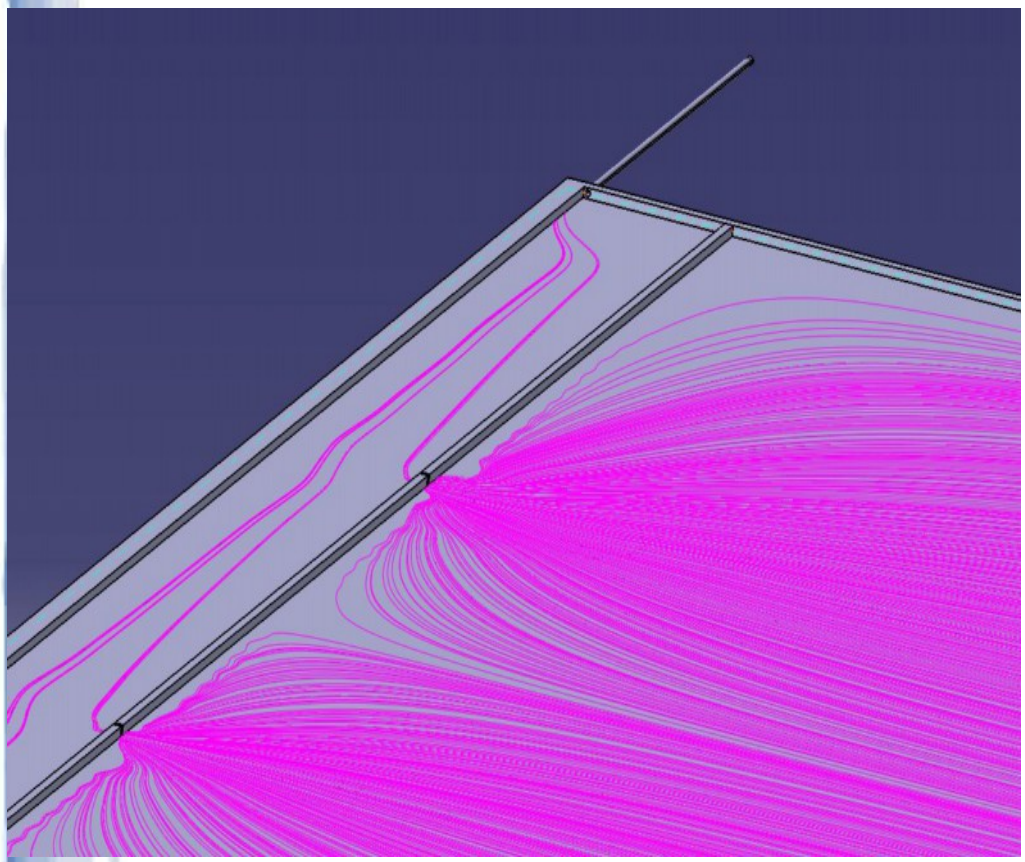
Multiplicity

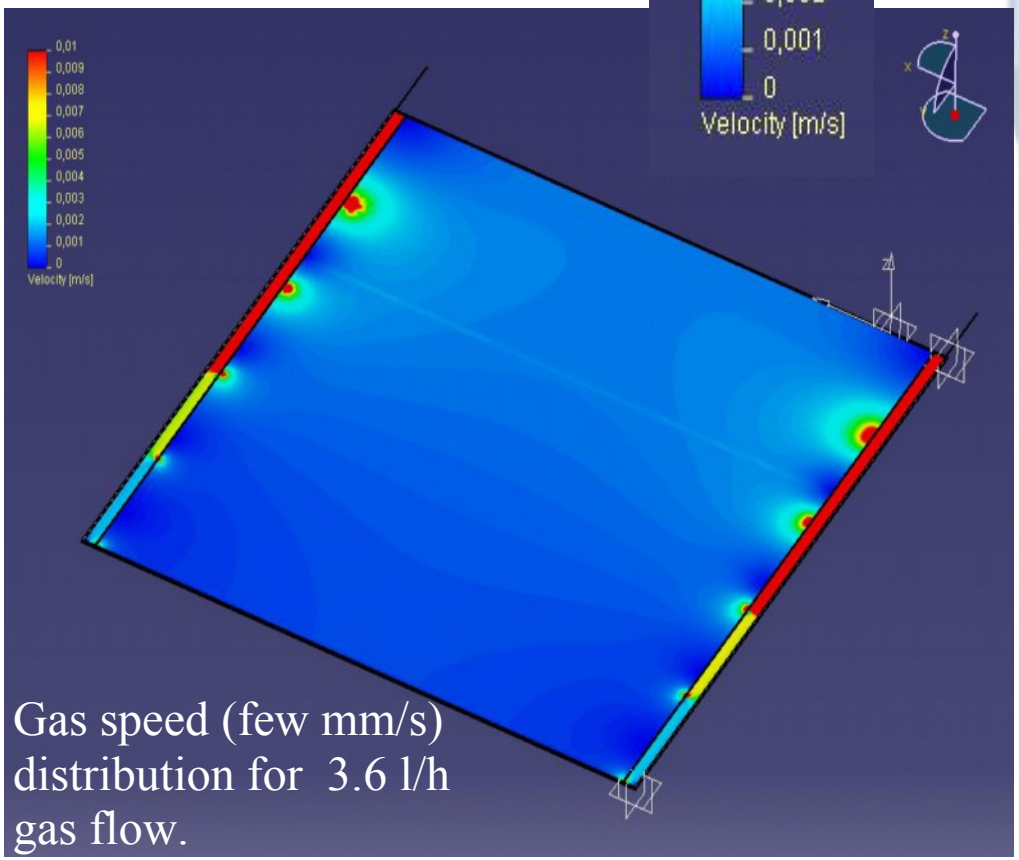


Mean number of activated pad per particle crossing per chamber.

Gas flow design

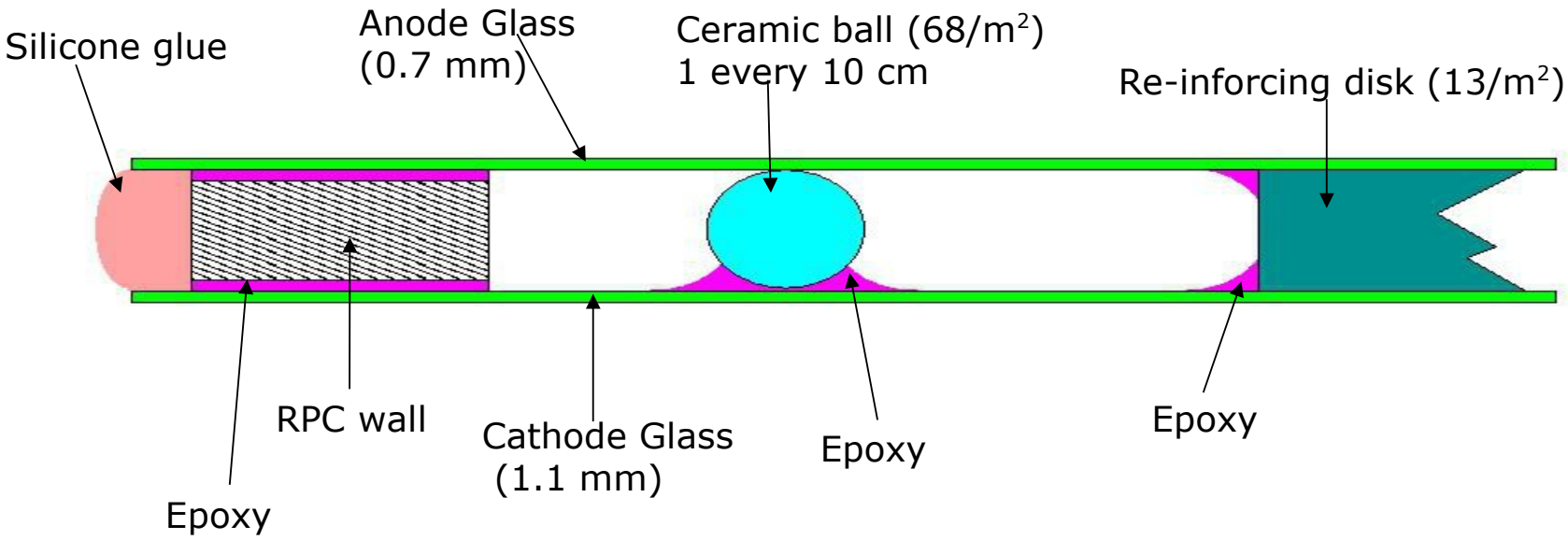
- Gas inlet and outlet on the same side.
- Designed for homogeneous gas distribution.

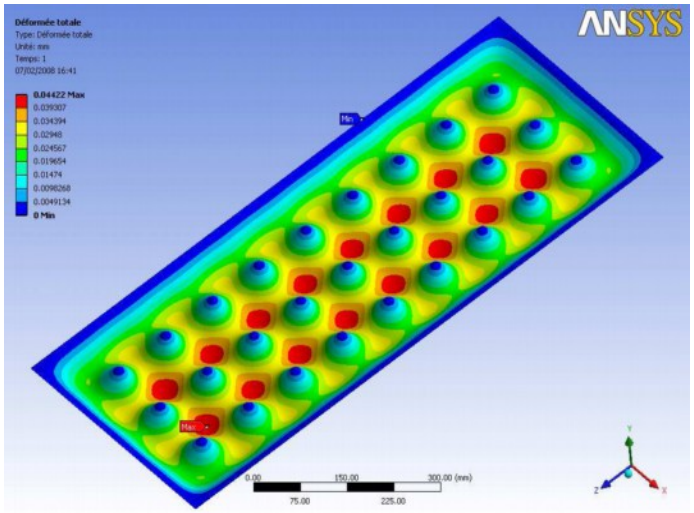




Gas speed (few mm/s) distribution for 3.6 l/h gas flow.

Homogeneous gas thickness





Max deformation 44 µm

includes :

- Glass weight
- Electrostatic force

Ignores :

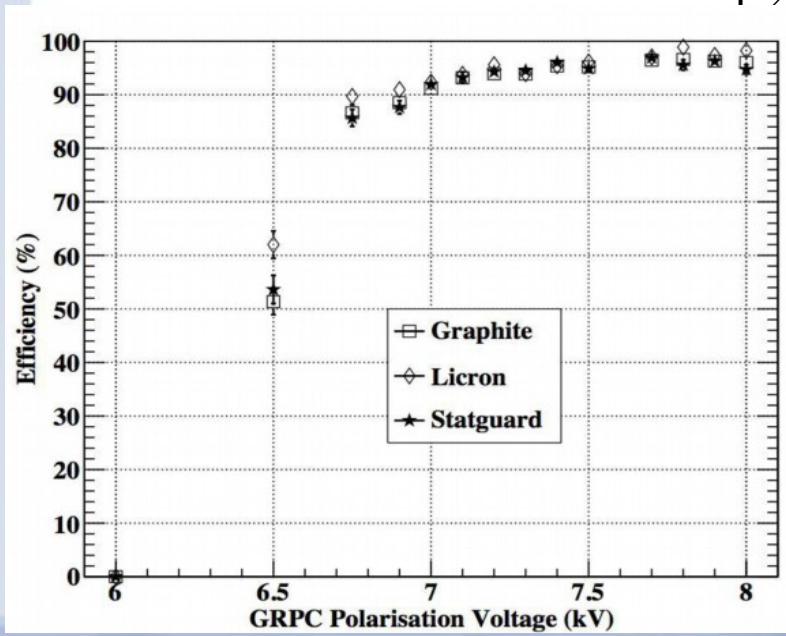
- Gas pressure (1 mbar overpressure)

Resistive coating study

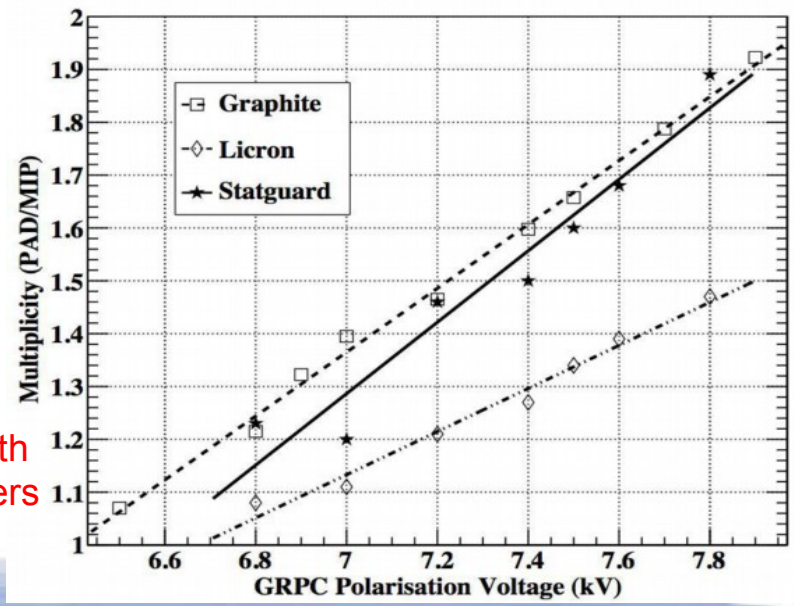
Resistive coating needed to distribute HV on the glass electrode.

- Higher resistivity leads to lower multiplicity.
- 3 coating tested:

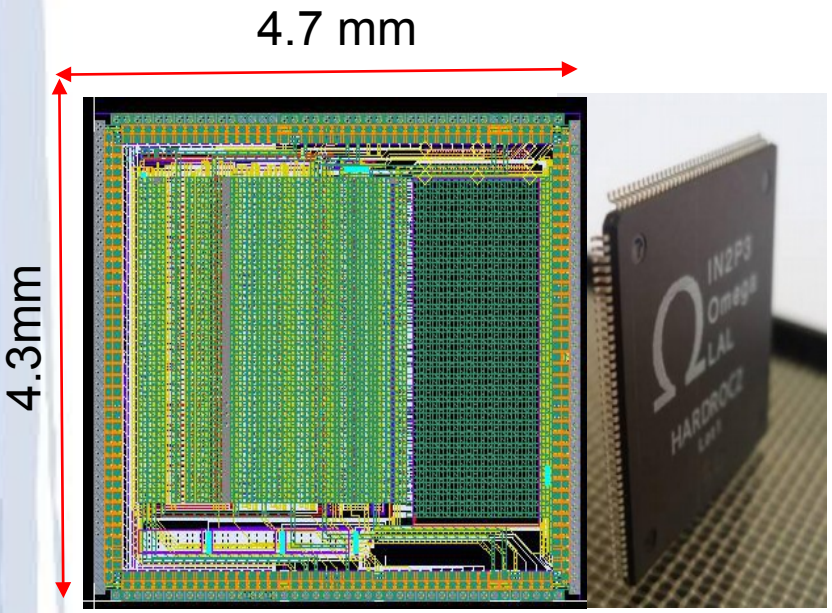
	Licron	**Statguard**	**Colloidal Graphite**
Surface resistivity (MΩ/□)	~20	1-10	Depends on mix ratio; choose ~0.7
Best application method	Spray	Brush	Silk screen printing
Experience	Loss HV connection after 1-2 months	Poor homogeneity	Cheaper, good homogeneity



Results obtained with 33X8.3 cm^2 chambers



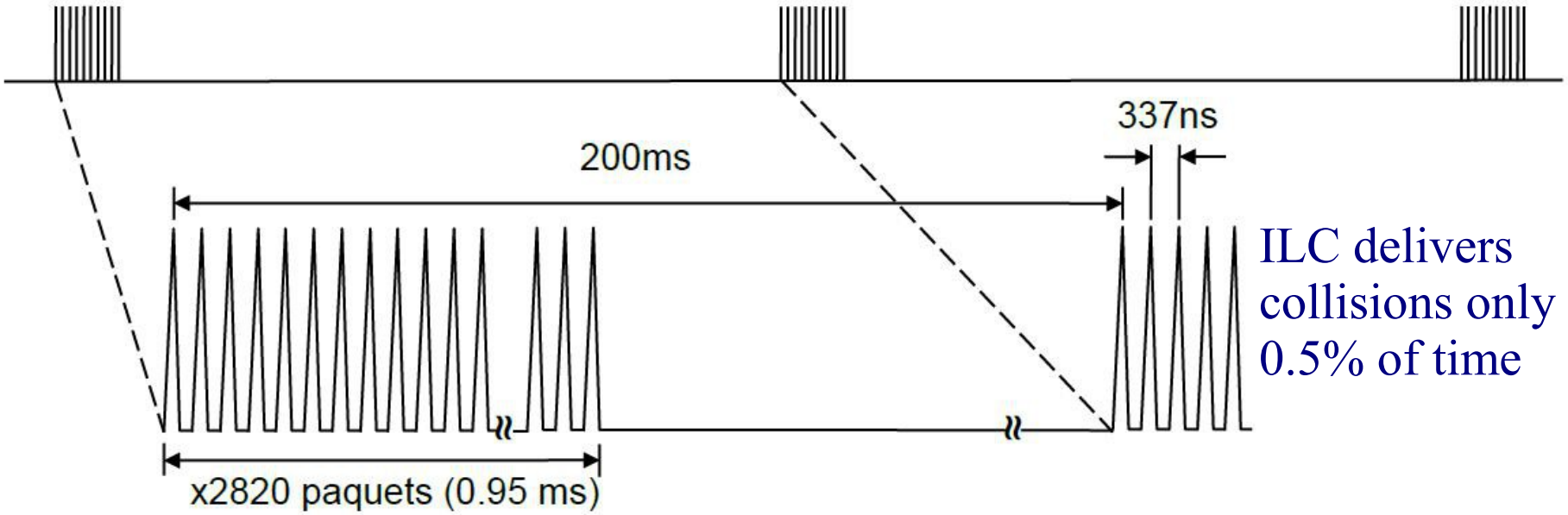
Readout electronic



- ASICs=HARDROC2 (http://omega.in2p3.fr)
- Each ASIC reads 64 copper pads,
  - Adjustable gain, shaping
  - 3-level discriminator (dynamic range 10 fC to 30 pC)
  - Local auto-trigger : store up to 127 first threshold crossing (pad ID and time (200 ns clock))
- ASICs are daisy-chained
  - data readout
  - configuration
    - thresholds values
    - amplification gain per pad (response uniformity)
    - etc ...

Power pulsing

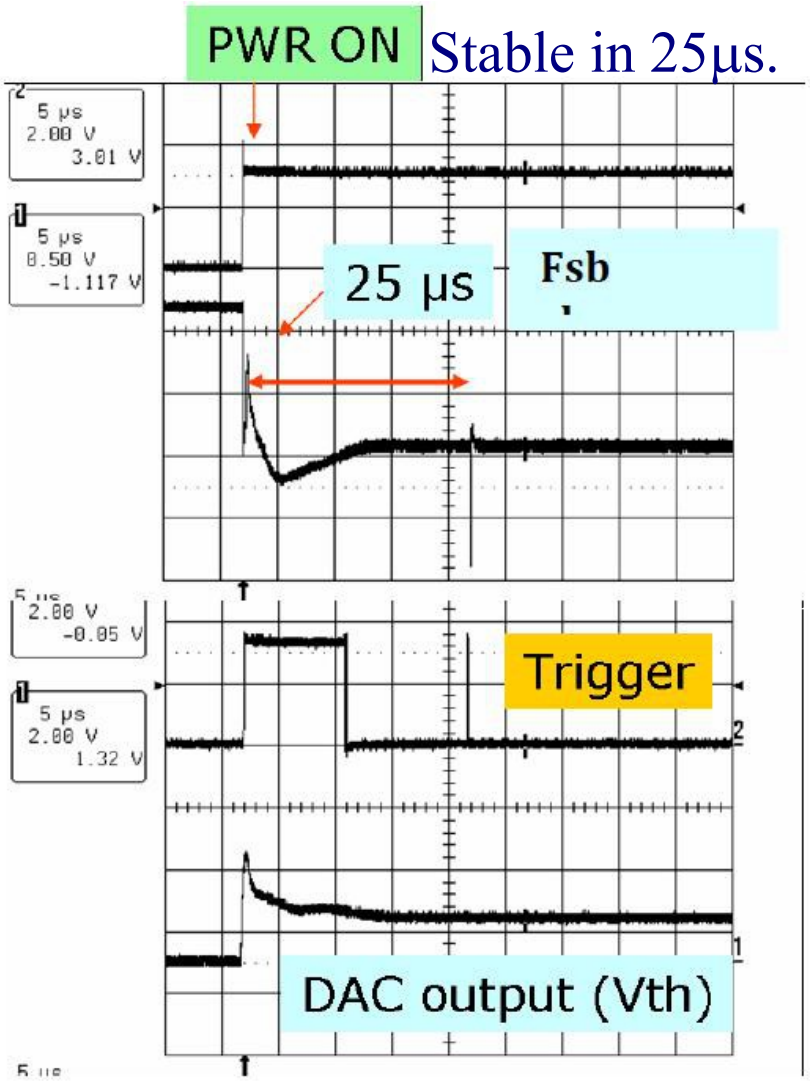
- ILD : stable temperature without cooling inside detector ⇒ < 10 µW/channel



- HARDROC2 use 1.5 mW per pad * 0.5%=7.5µW/channel
  - Controllable ASIC switch off (I<4µA) and on (I~28 mA).

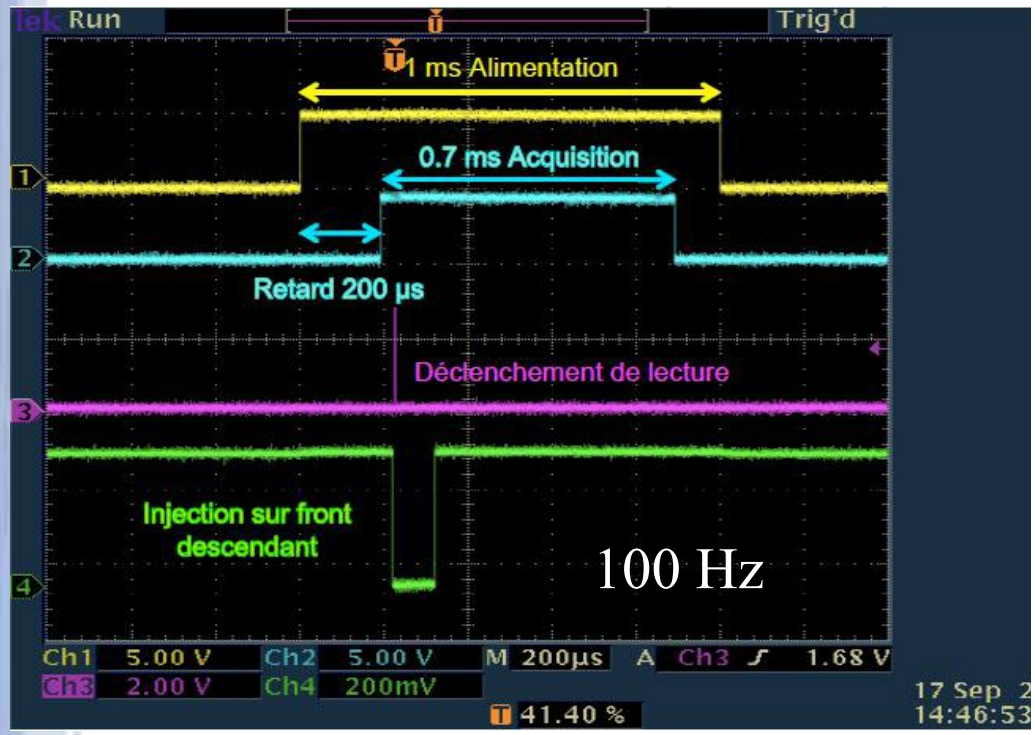
Power pulsing (II)

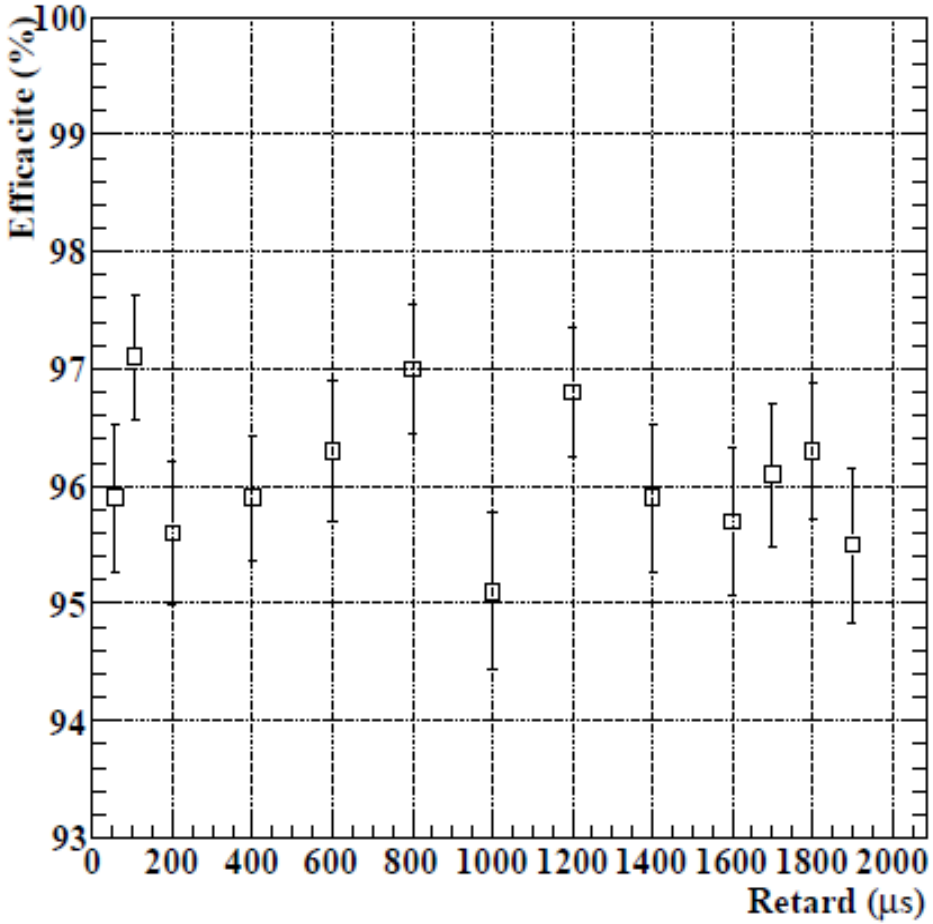
- Test power pulsing in 3T magnetic field



Power pulsing (III)

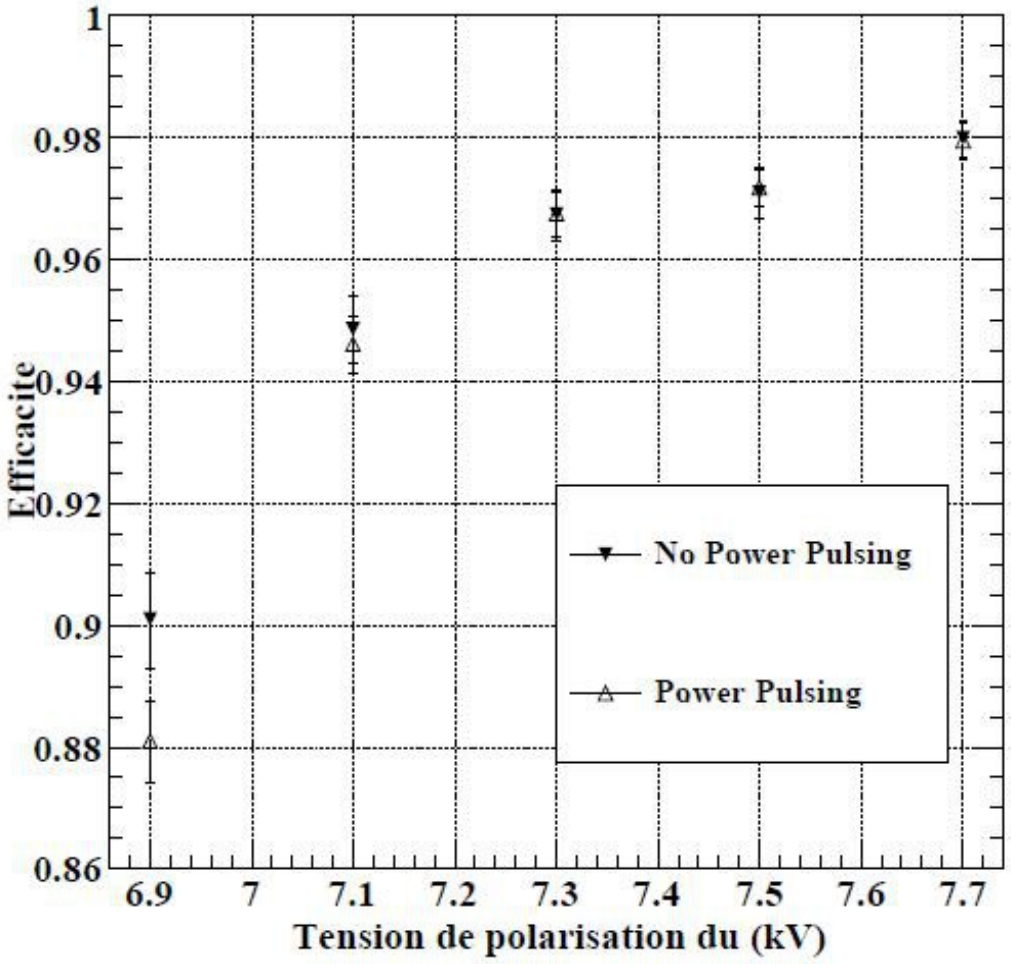
- Test power pulsing in 3T magnetic field





Power pulsing (IV)

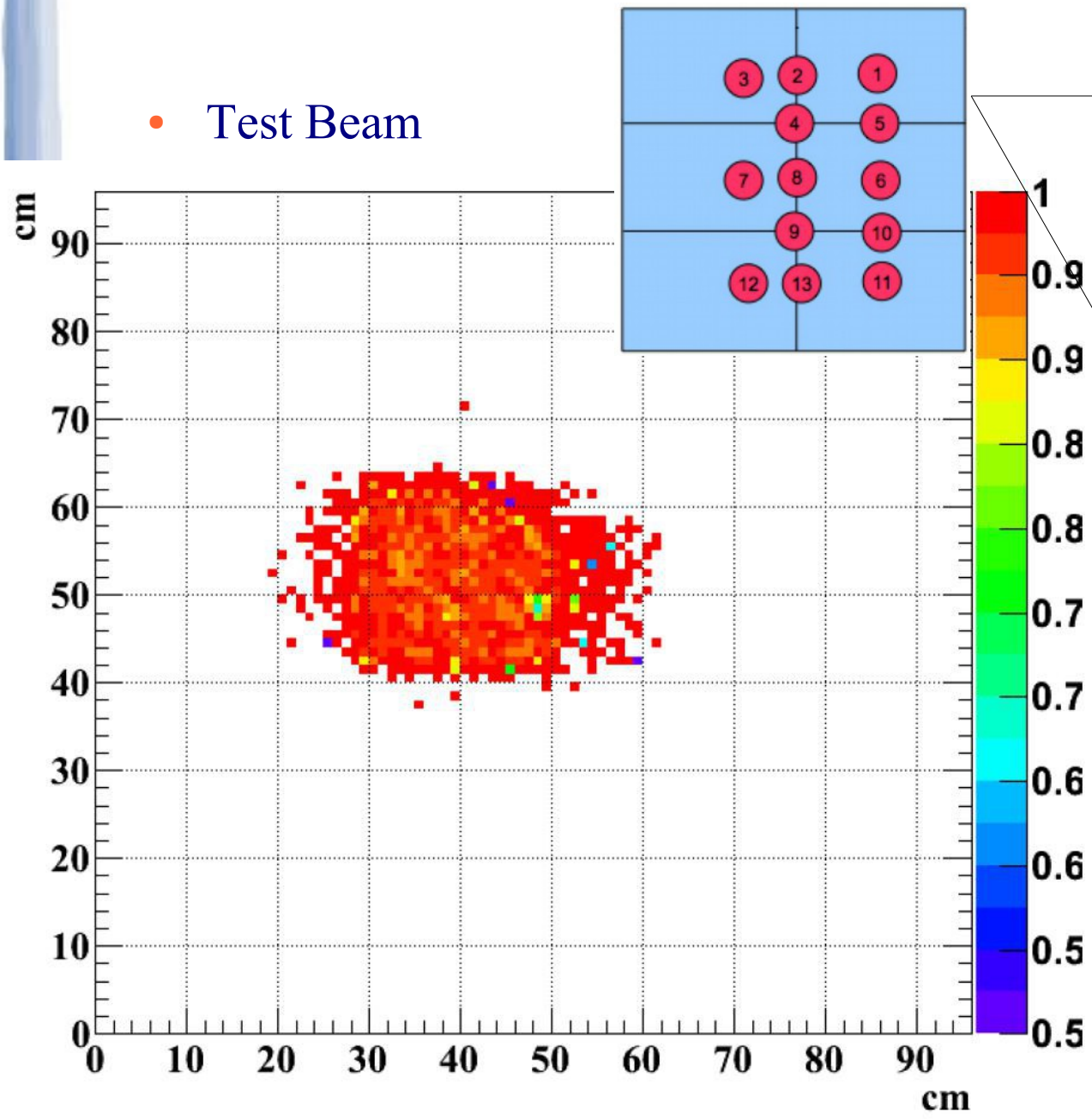
- Test power pulsing in 3T magnetic field

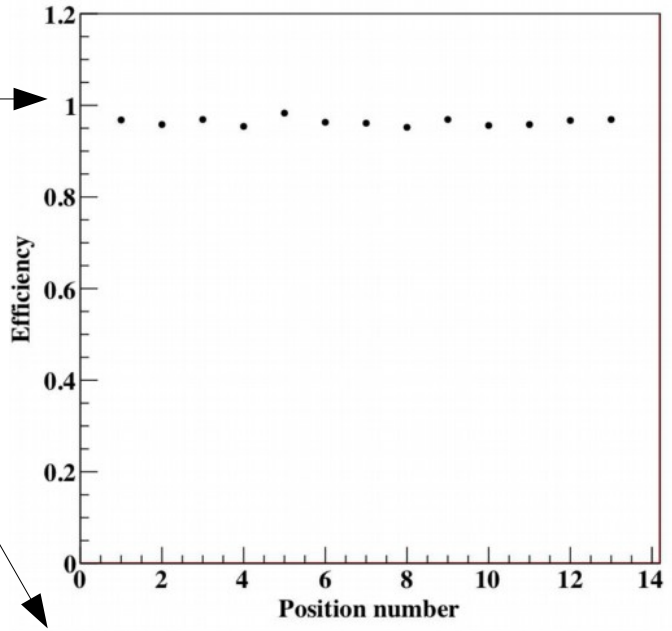


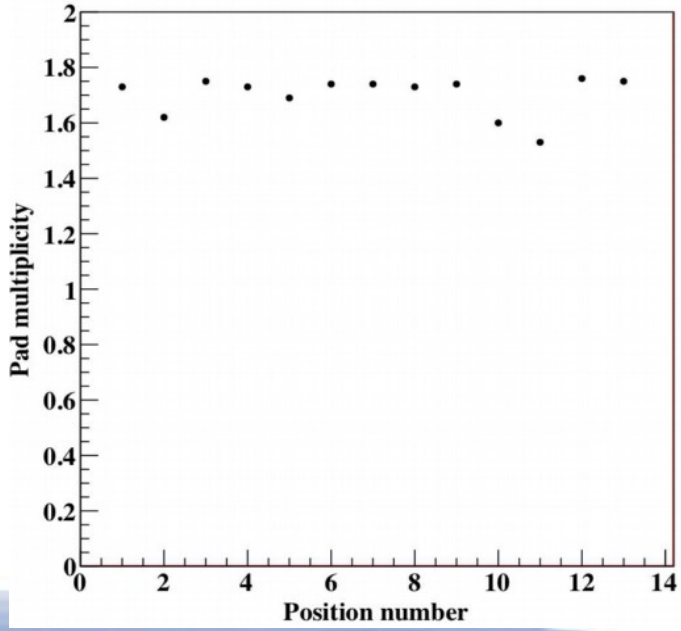
Identical efficiency with/without power pulsing.

Response uniformity

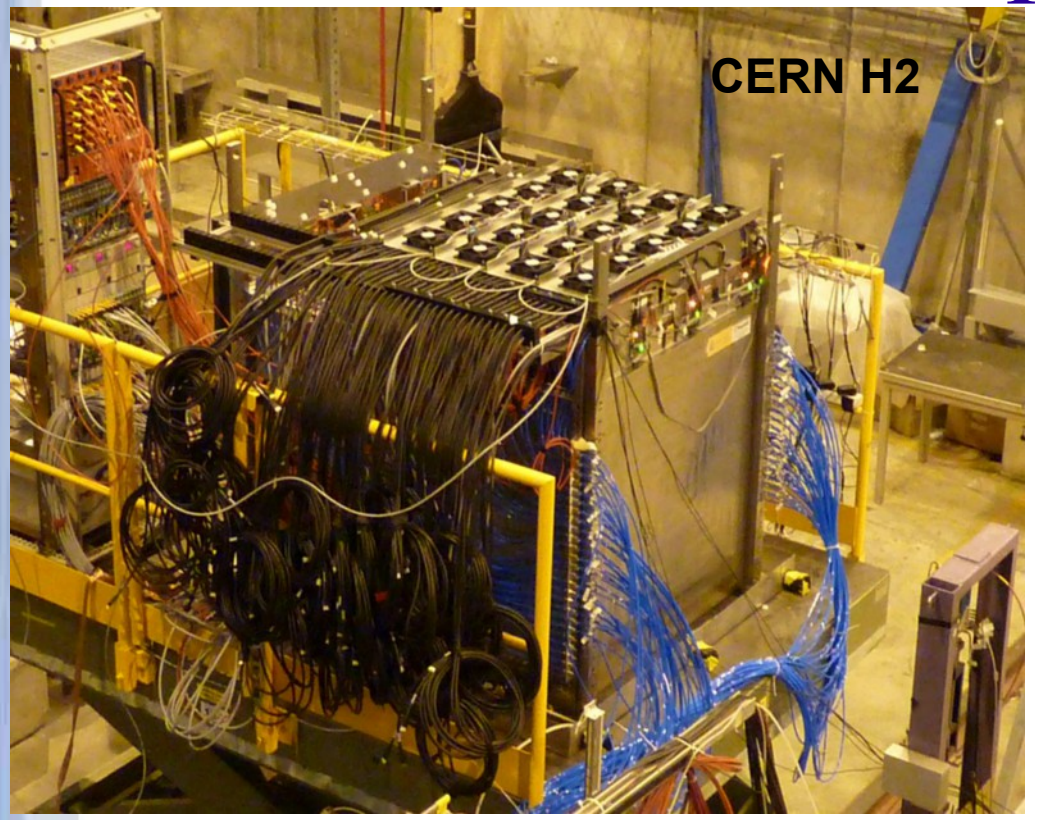
- Test Beam







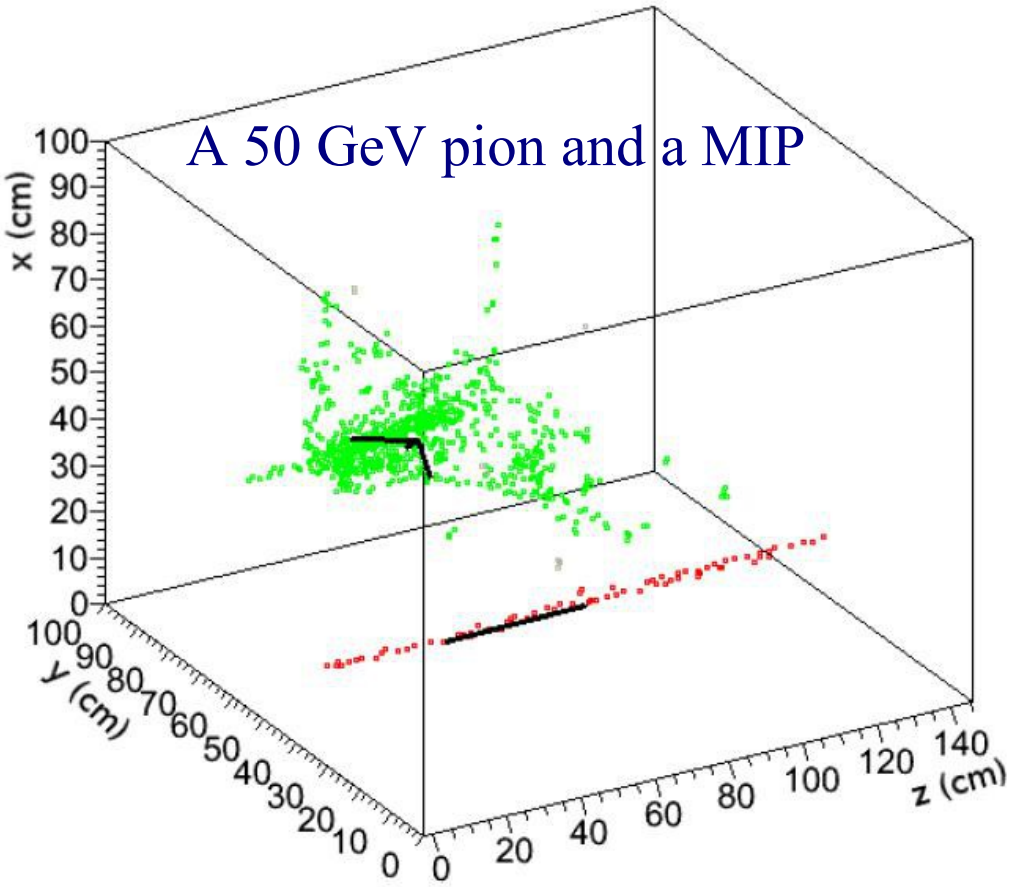
The full prototype

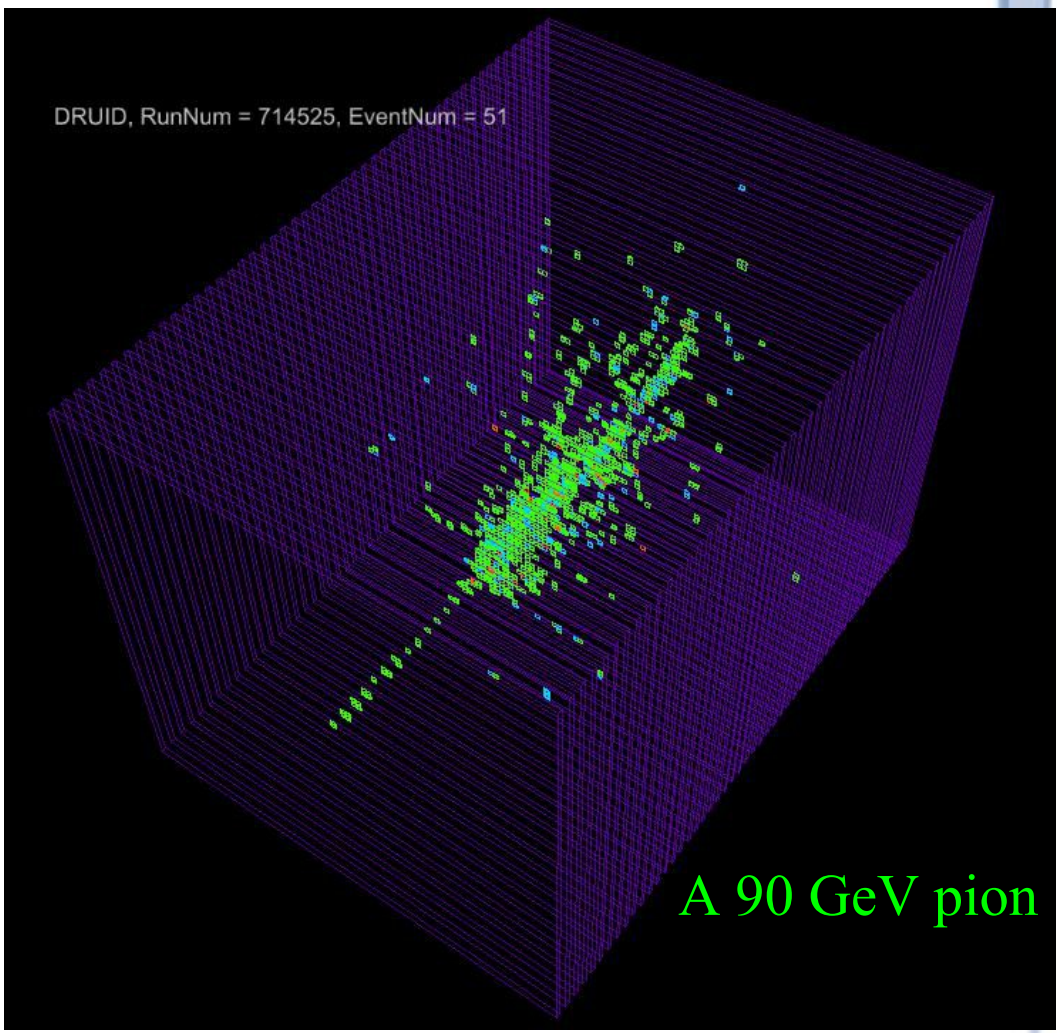


- 50 chambers
  - 50*144 = 7200 ASICs;
  - 50*9216 = 460800 channels
- DAQ:
  - CALICE DAQ2 HW for fast signals
  - USB for readout and configuration
  - XDAQ framework for control and configuration management
- 1‰ dead channels
- Noise rate ≤~1 Hz/cm²

The prototype has been extensively tested at CERN PS and SPS in 2011-12.
See first results details in Y. Haddad's presentation.

These are not simulations





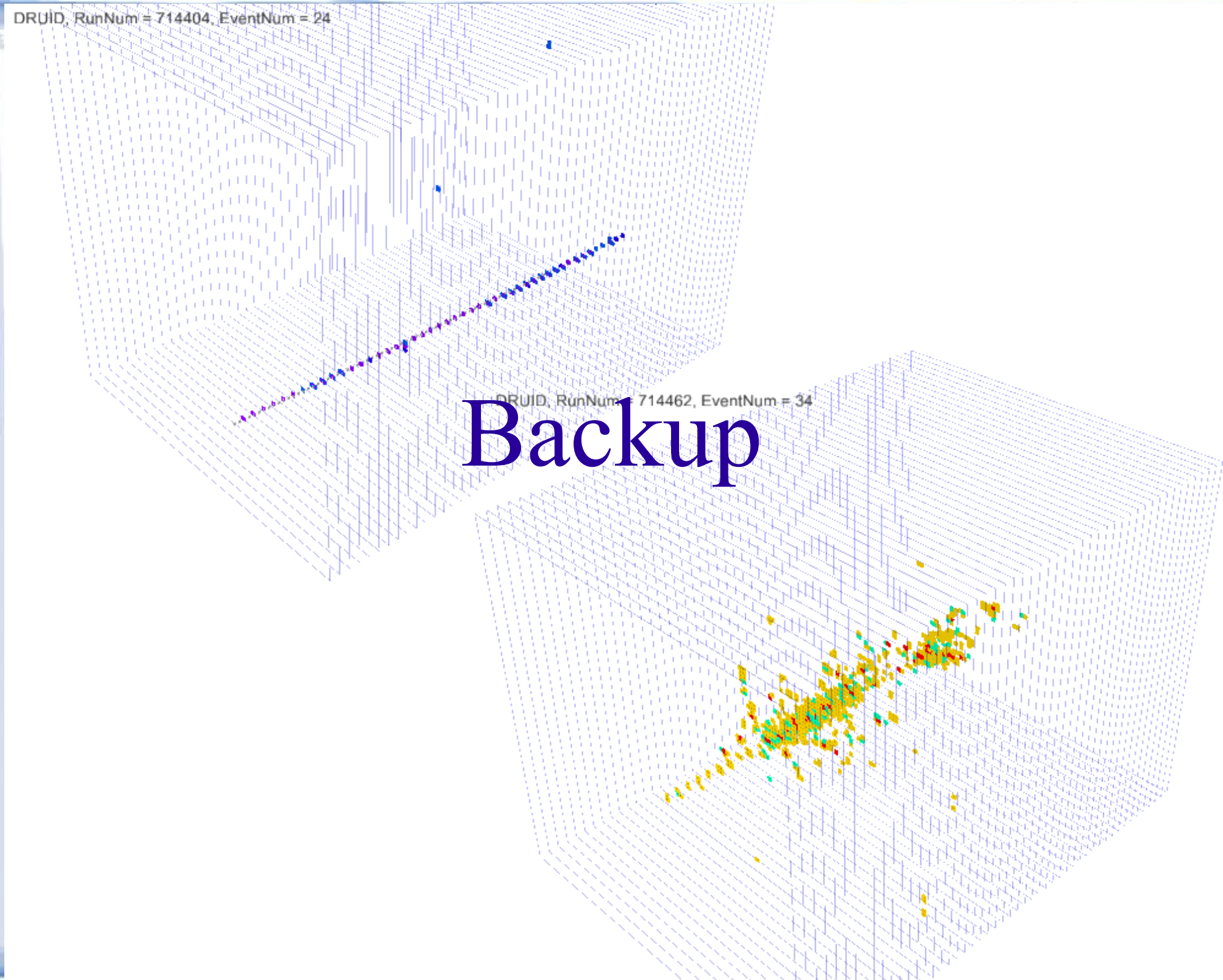
Conclusion

- A large volume 1m³, finely segmented (50 layers, 1×1cm² cells)

hadronic imaging calorimeter

in self-supporting mechanical structure has been build and sucessfully tested in test beam.

- The construction of the prototype has validated:
  - The use of large surface GRPC:
    - low noise, very limited dead regions, cheap, thin.
    - The feasibility of homogeneous large surface GRPC.
  - The feasability of power pulsed auto-triggered embbeded readout electronics.
  - The tackling of large number of readout channels (~0.5M)
  - The semi-digital readout (see next talk).
- Next steps:
  - Build 3 m^2 chambers.
  - Use semi-resistive glass electrode for higher counting rate.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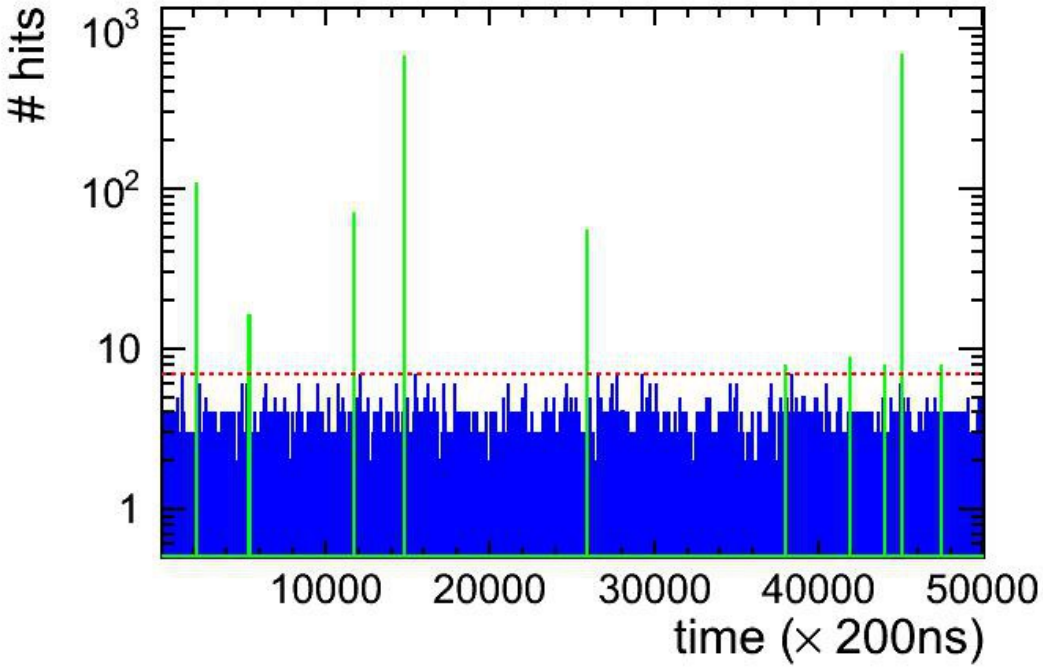
Backup

Noise



- Noise rate : ~1 Hz/cm^2
- 0.35 noise hits/clock tick (200 ns) (48 chambers)