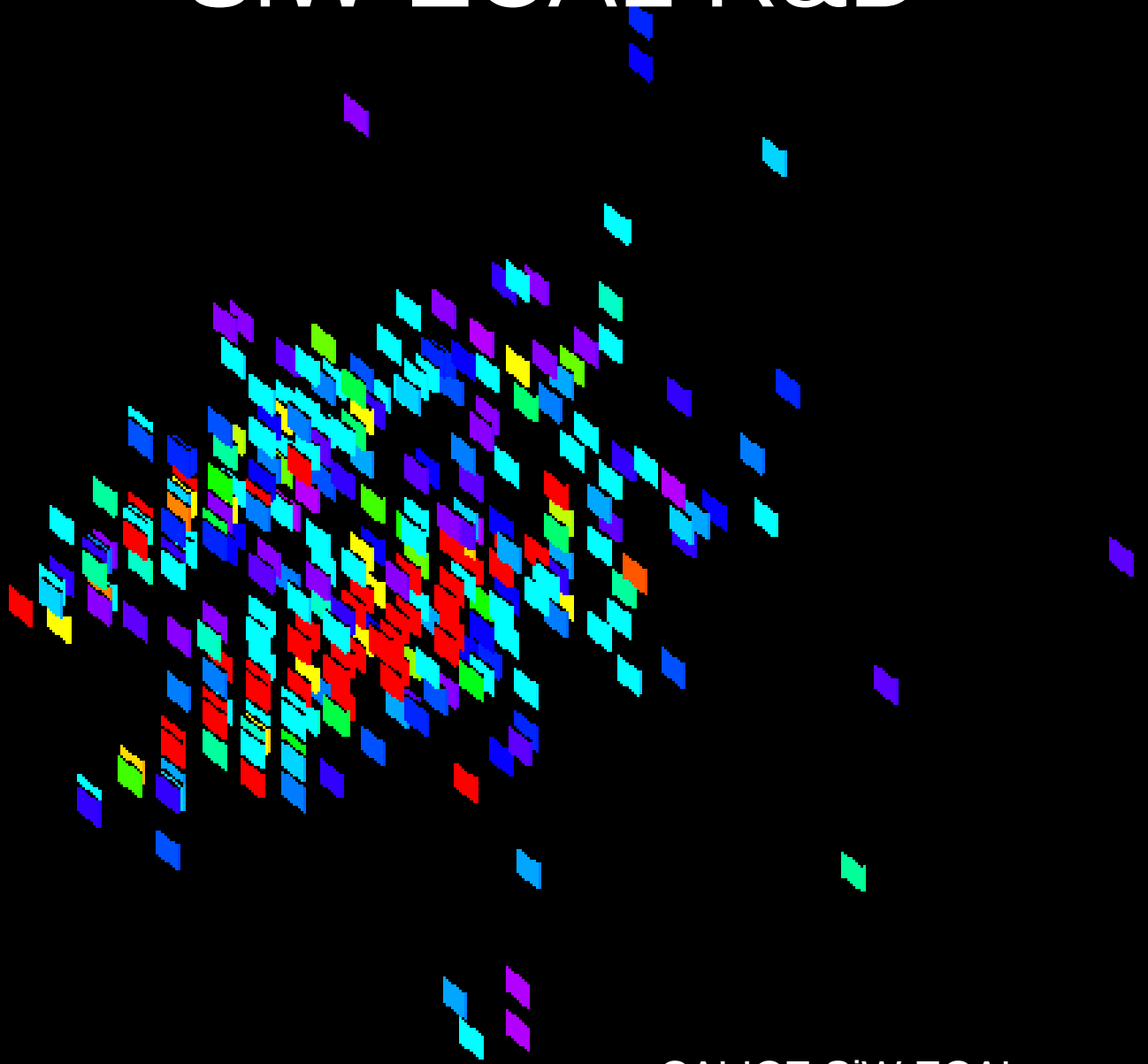
SiW ECAL R&D



Daniel Jeans
LLR École polytechnique
CNRS/IN2P3

CALICE SiW ECAL groups
- Fr: LLR, LAL, Omega, LPSC, LPNHE
- Jp: Shinshu, Kyūshu
- Kr: SKKU

Requirements

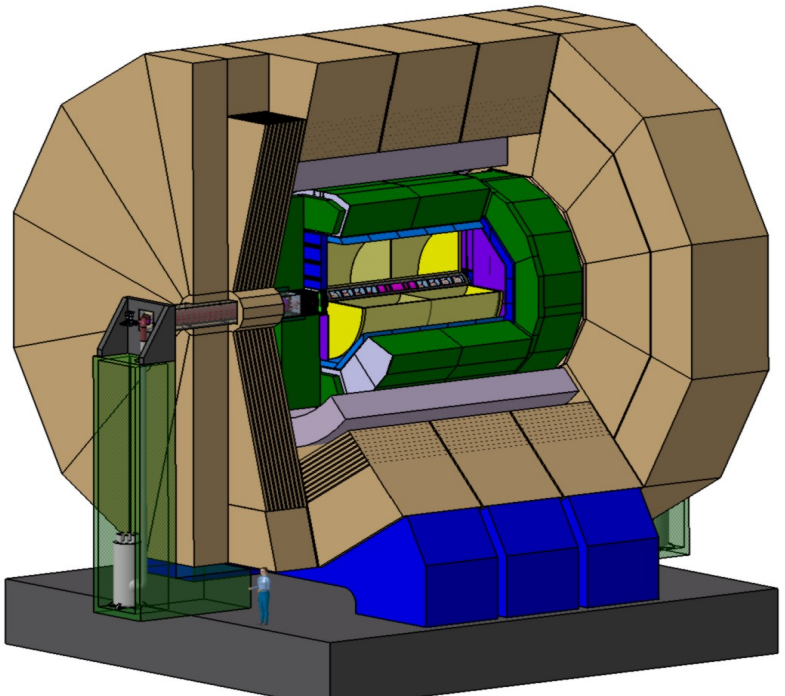
Design driven by Particle Flow and compactness

Particle Flow thrives on excellent two-particle separation
- High granularity
- Compact particle showers (minimise Molière radius for ECAL)

Thin to minimise solenoid radius

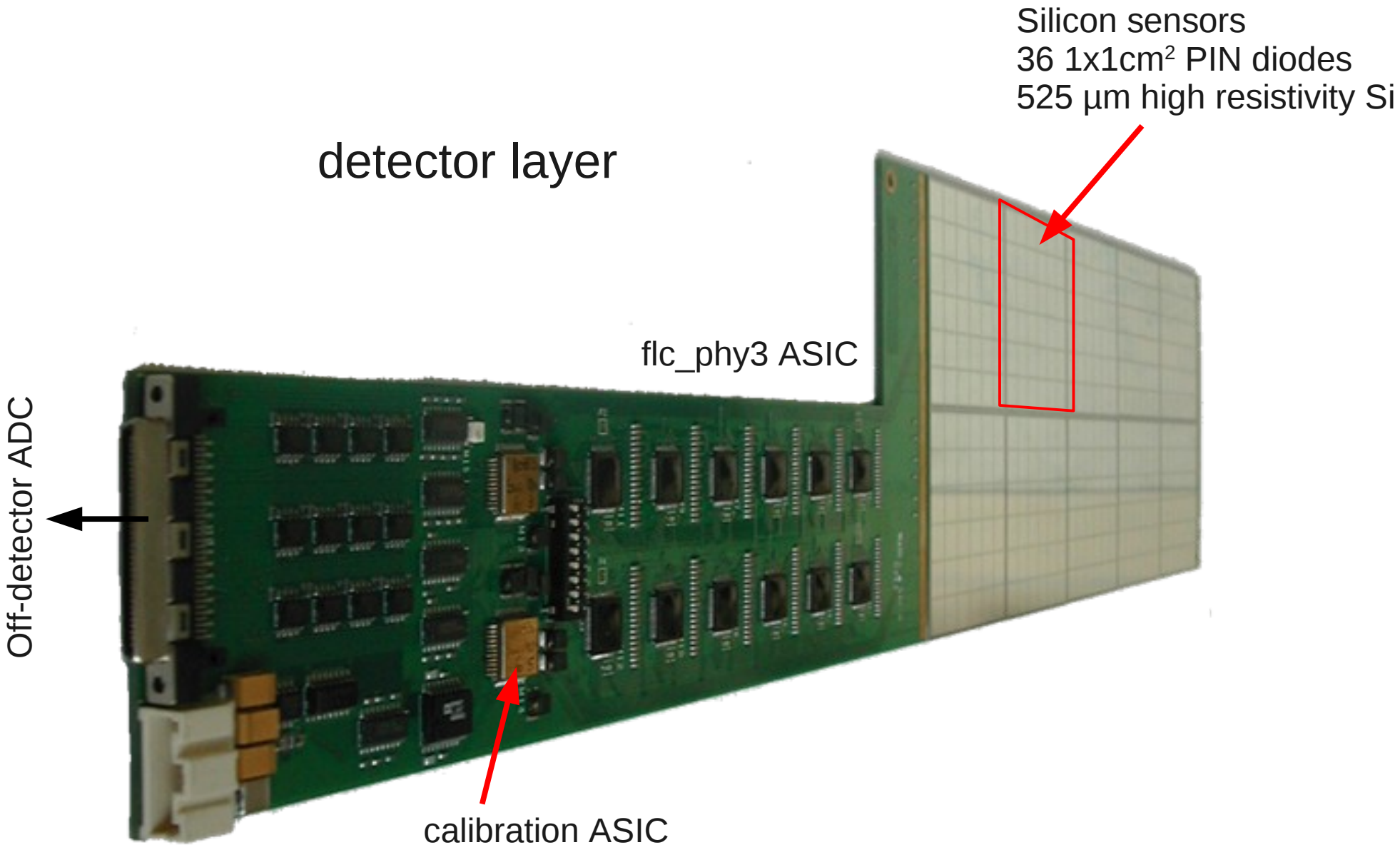
maintenance access will be ~impossible -> robust design, operational stability

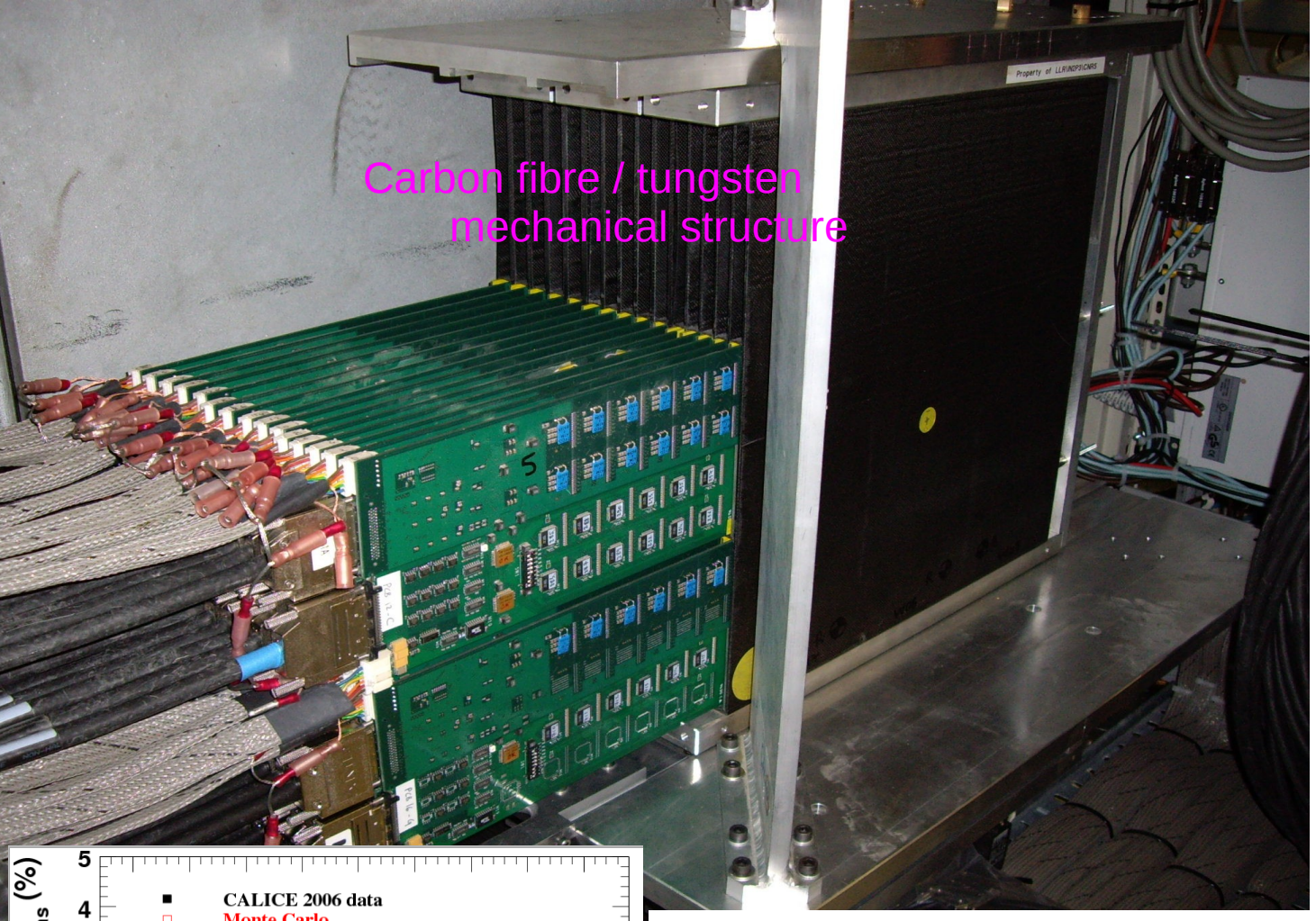
Tungsten radiator: X_0, Molière radius, X_0/λ
Silicon sensors: easily segmented, thin, stable



ILD ECAL (Si option)
- 30 layers
- 20cm / $24X_0$ thick
- effective Molière radius ~19mm
- $5x5mm^2$ granularity
- 2500 m^2 Si sensors
- 100M readout channels

“physics prototype” beam tests 2006-2011

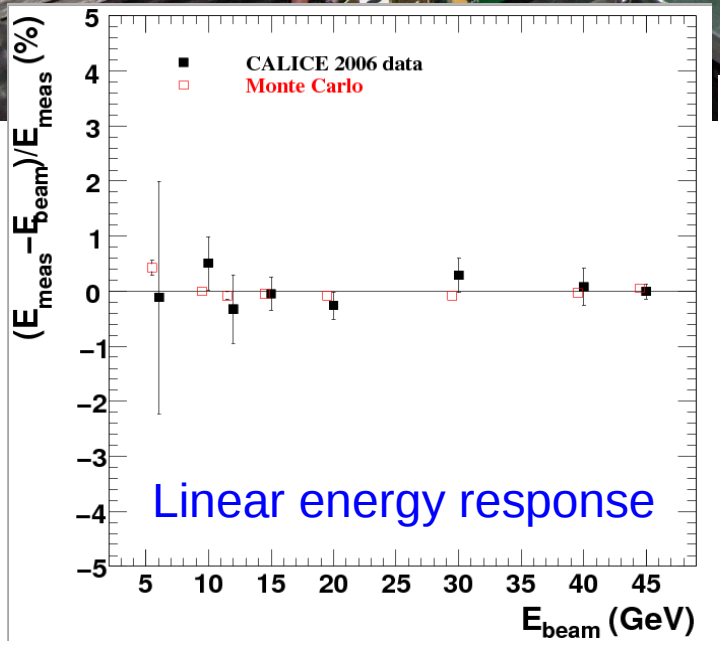


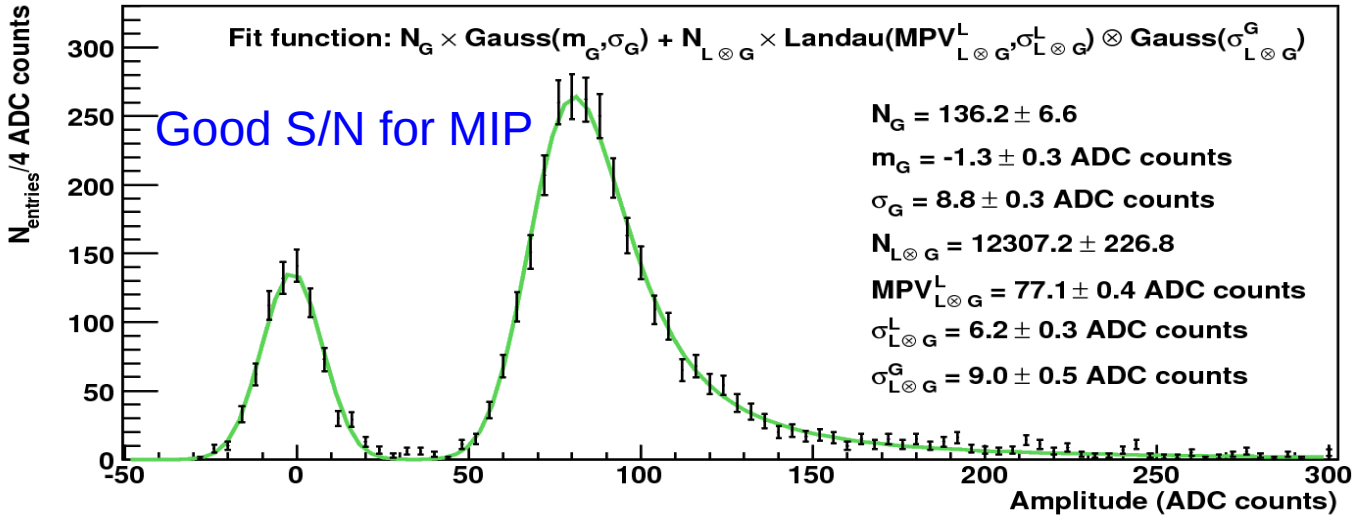


30 layers
18x18 cm^2 active area
~10k readout channels

performance well described by simulation

stable running over 5 years of data taking





Now developing “technological prototype”

Develop and test strategies to integrate ECAL into detector

- silicon sensors (performance, cost)
- FE electronics inside detector volume
- low power consumption -> power pulsing
- realistic mechanical structure
- high volume assembly techniques
- cooling
- compact, scalable DAQ system

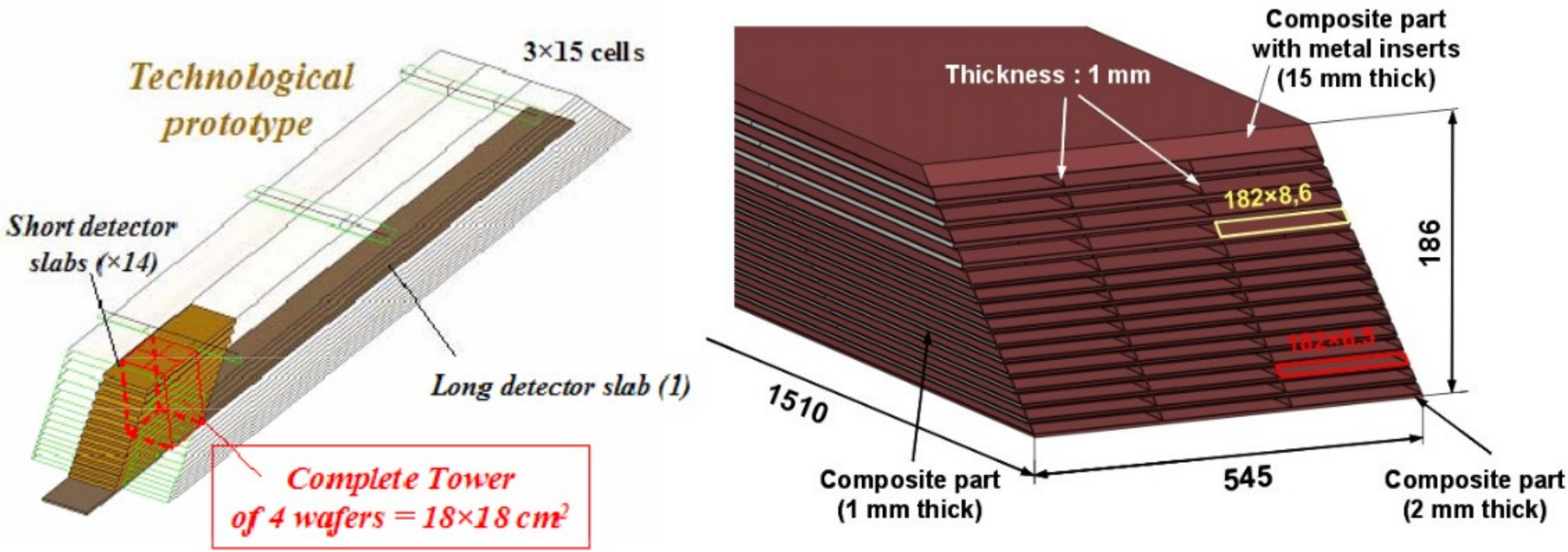
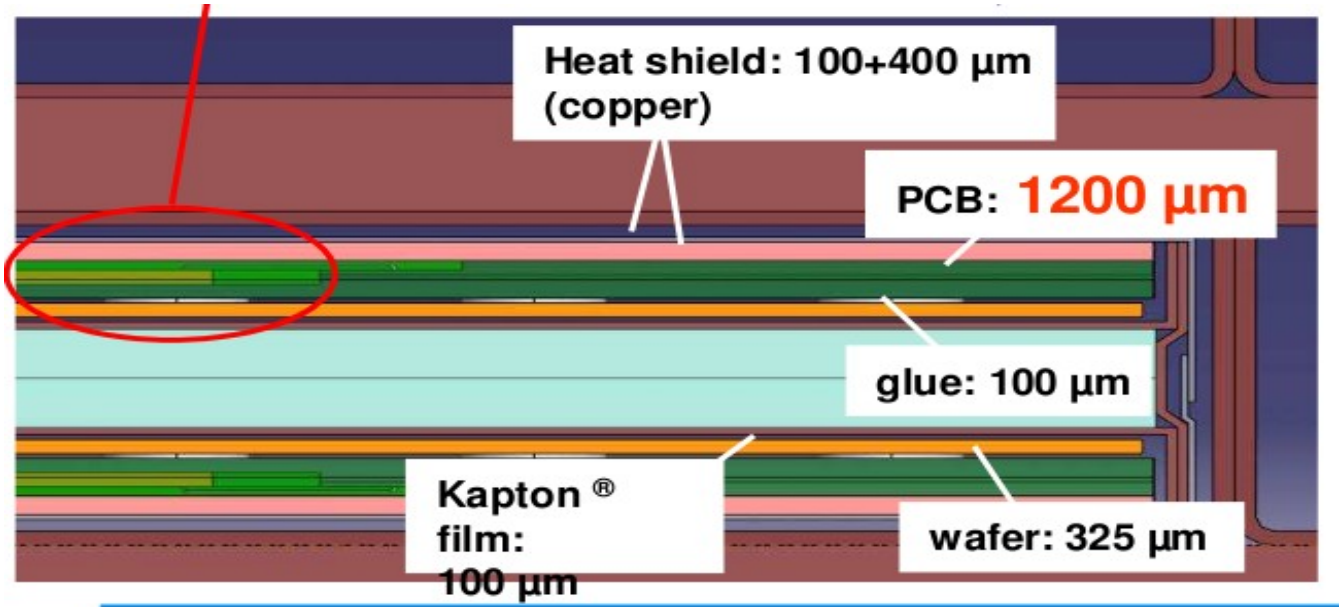
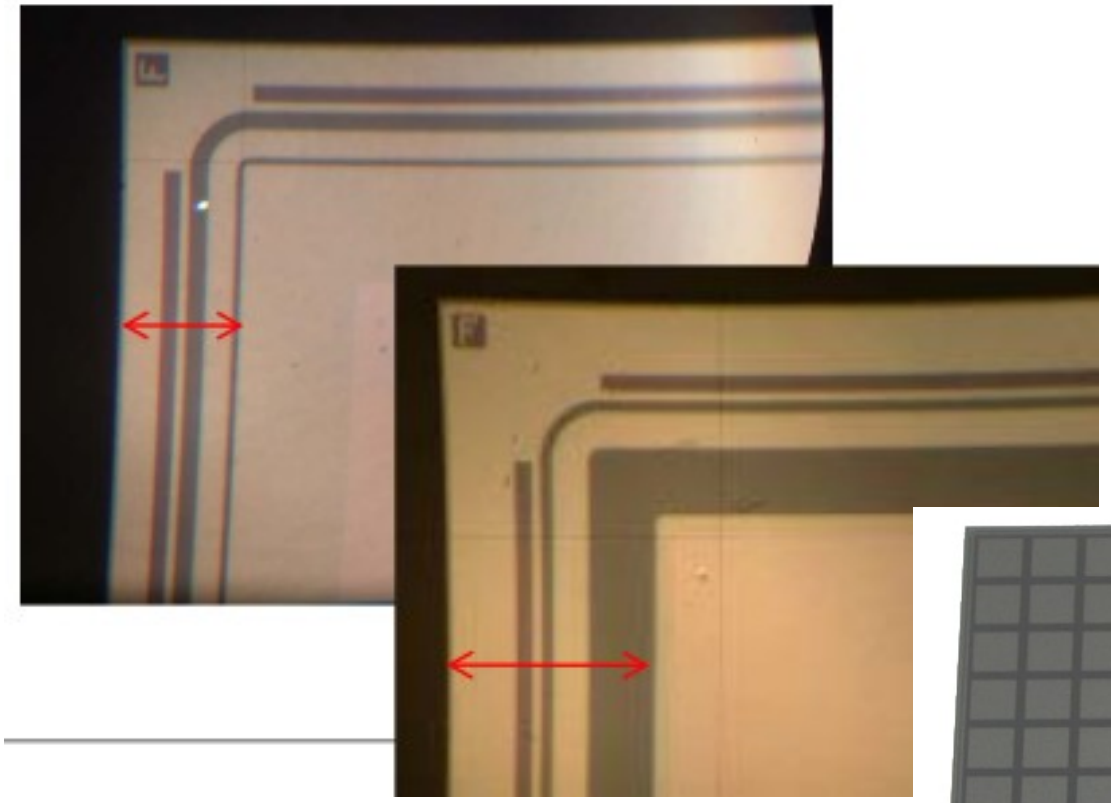


Fig.1 – Schematic 3D view of the prototype and design of the alveolar structure

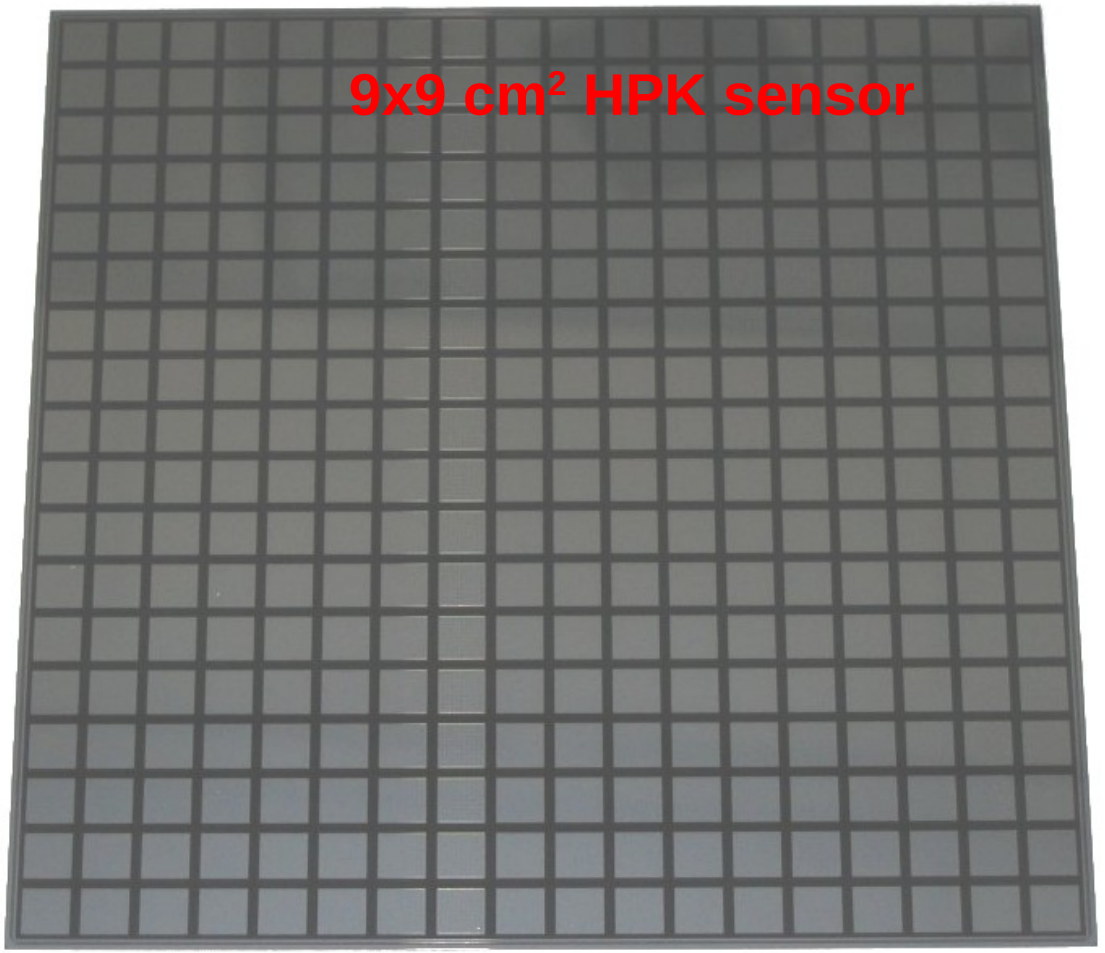
Embedded FE electronics





Silicon sensors

Matrix of PIN diodes
- High resistivity Si
- Pixel size 5x5mm^2
- Thickness 300-500 μm
- ILD ~2500 m^2



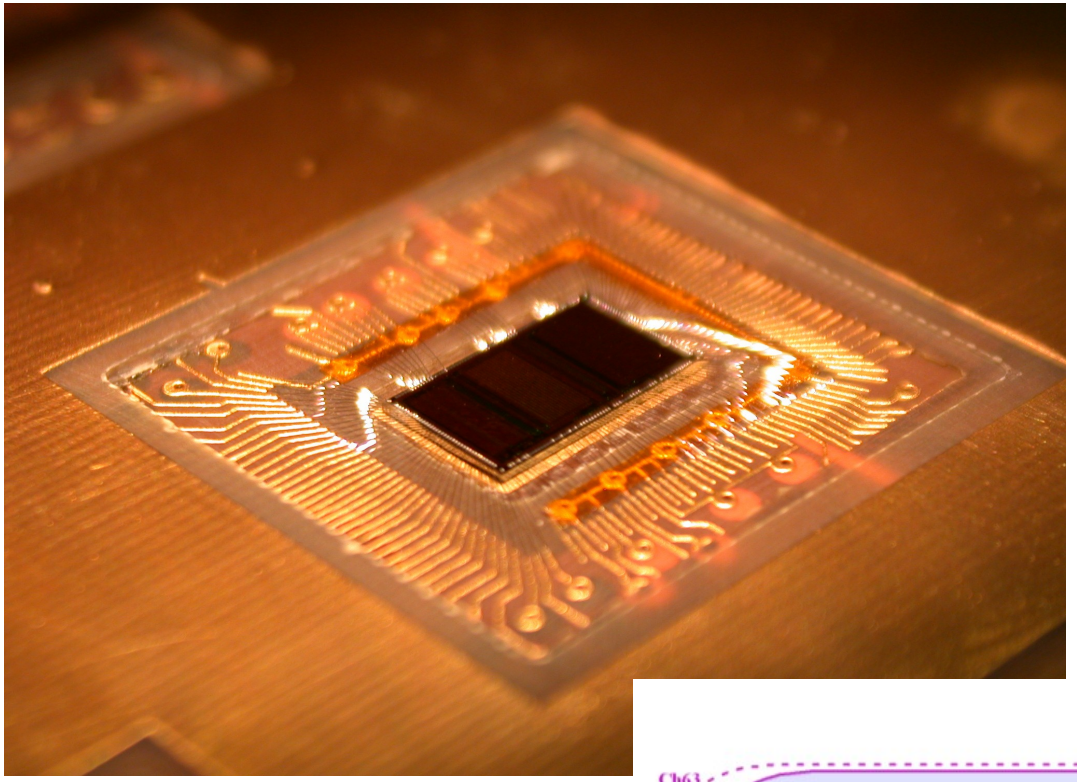
Research topics

Understand / reduce cost

Inter-pixel cross-talk

Dead area at sensor edge

Working with producers
- HPK in particular



SKIROC2 ASIC

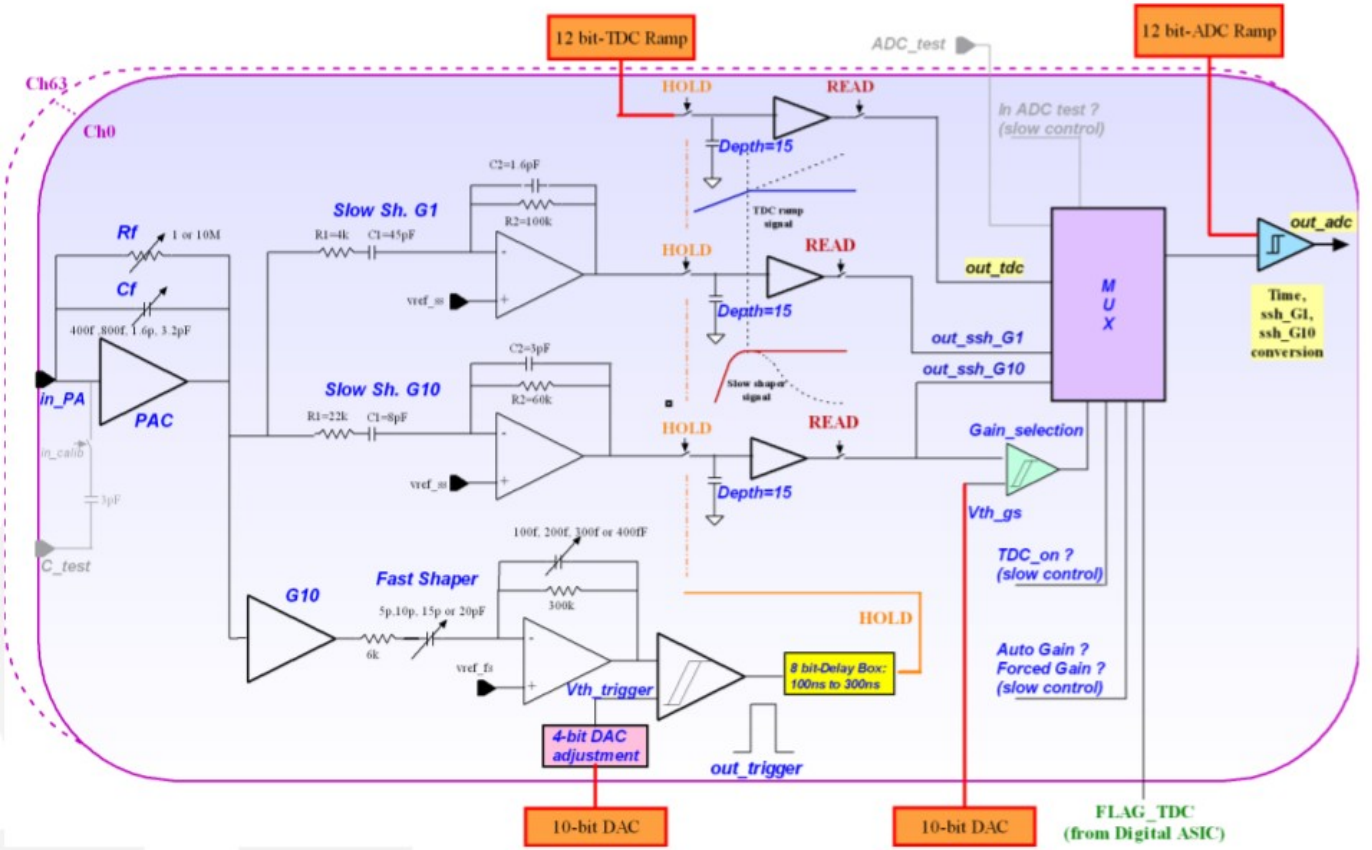
64 channels

Pre-amp, self trigger,
var gain shaper, ADC, TDC

Power-pulsing -> ~25µW/channel

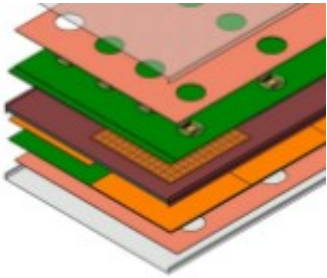
Produced (~1000 pieces)

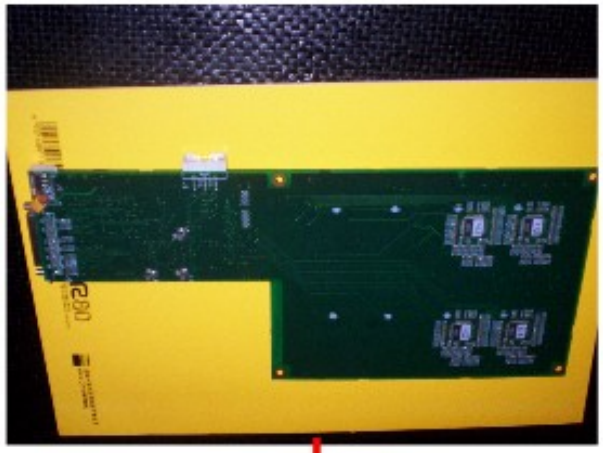
Now being tested in lab



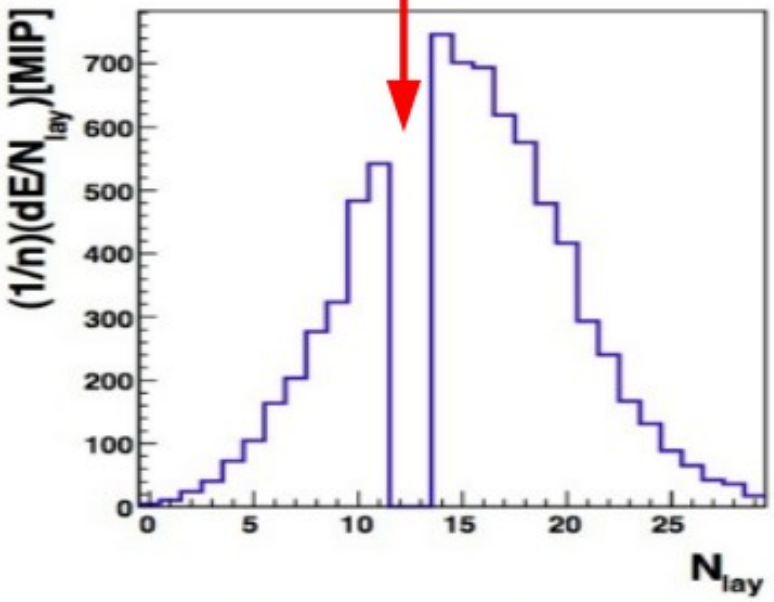
Embedded electronics - Parasitic effects?

Exposure of front end electronics to electromagnetic showers



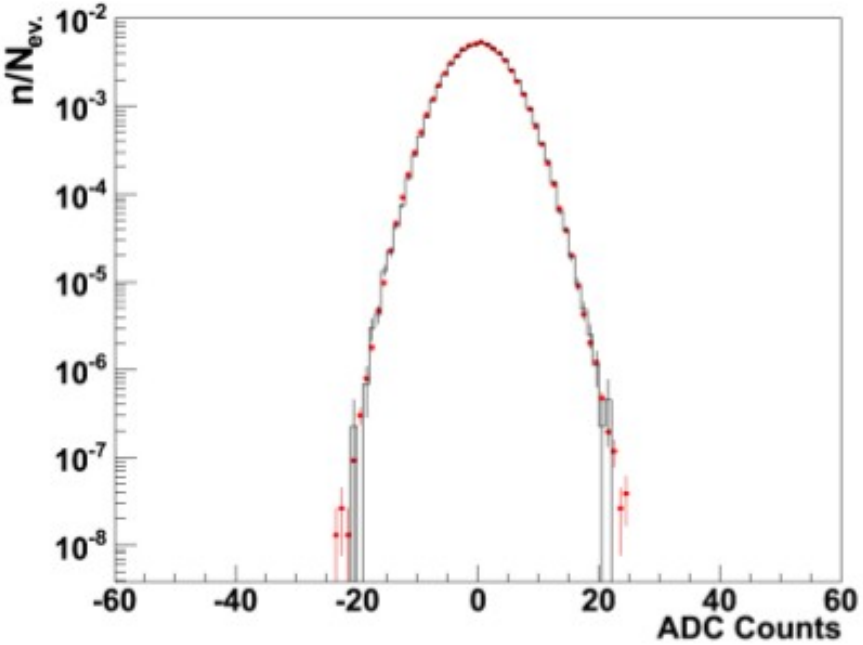


Chips placed in shower maximum
of 70-90 GeV elm. showers



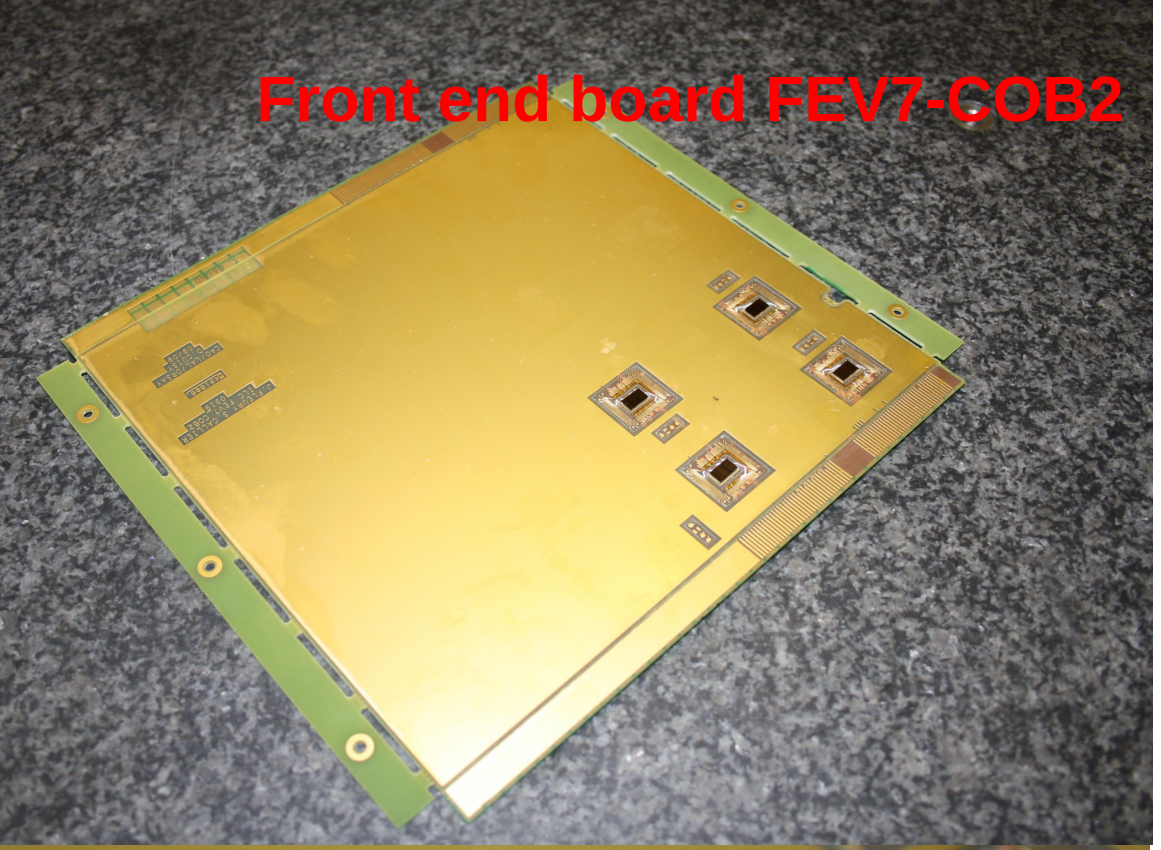
Possible Effects: Transient effects
Single event upsets

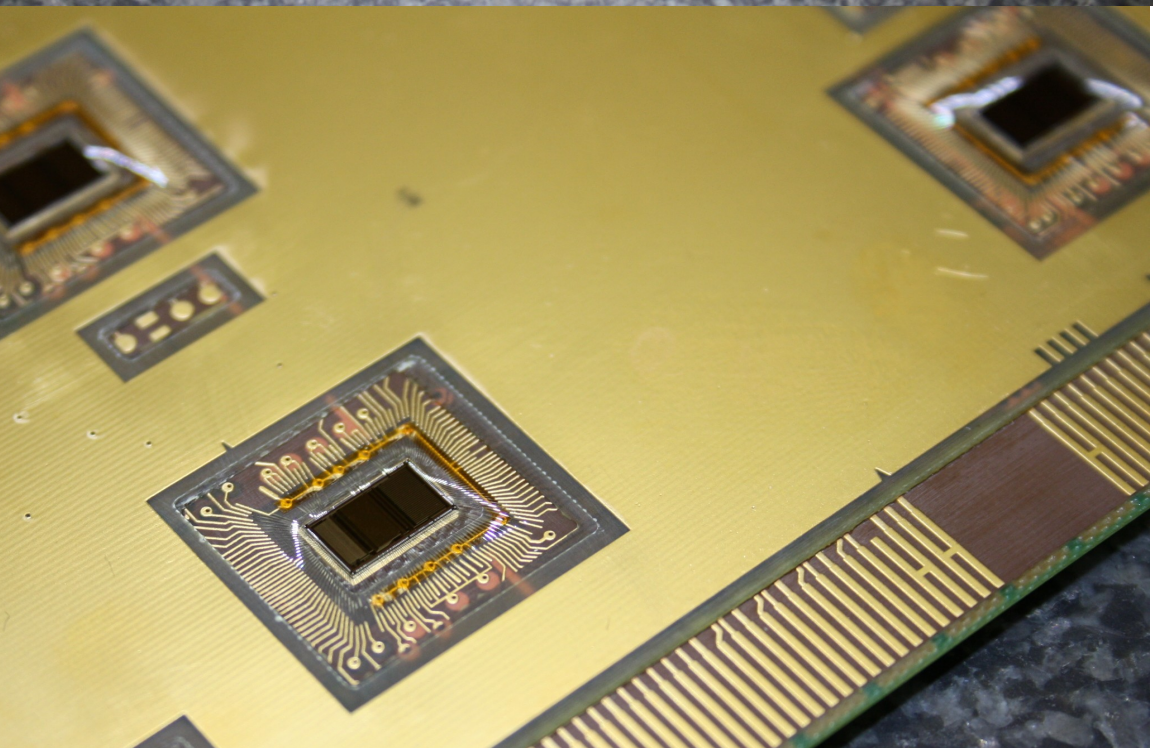
Comparison: Beam events
(Interleaved) Pedestal events



- No sizable influence on noise spectra by beam exposure
  ΔMean < 0.01% of MIP ΔRMS < 0.01% of MIP
- No hit above 1 MIP observed
  => Upper Limit on rate of faked MIPs: ~7×10^{-7}

Front end board FEV7-COB2

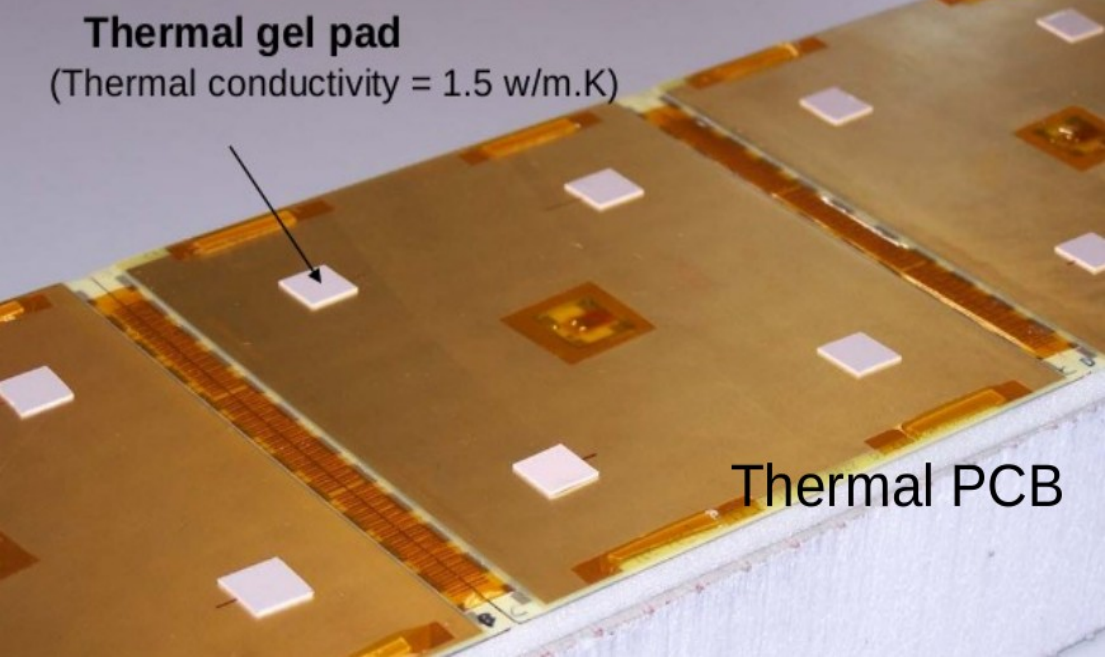




Sensitive layers made up of
string of Active Sensor Units (ASU)

Modular assembly

ASU built around front-end board:
- supports 4 sensors
- incorporates 16 ASICs
- routes slow control, DAQ
- must be thin and flat



Assemble ASUs into detector slab

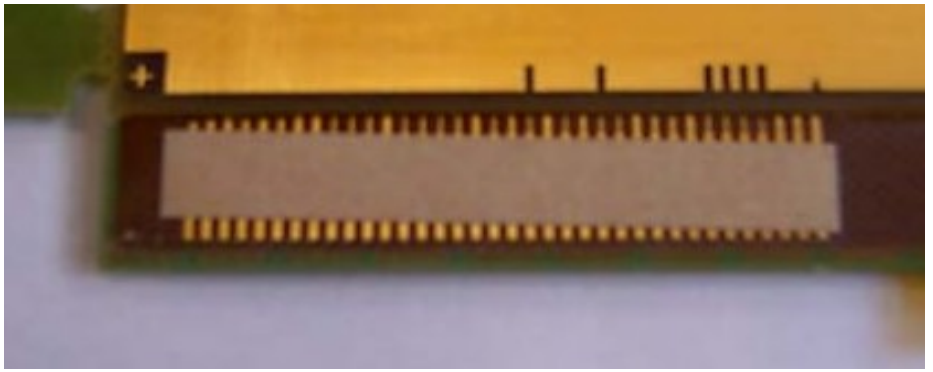
Investigate industrial techniques used in electronics industry

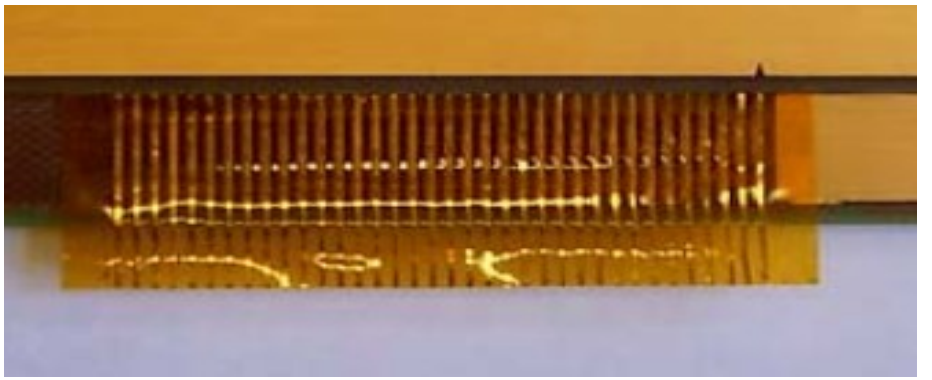
e.g. Anisotropic Conductive Tape

Often require high temperature/pressure

Complications

Individual ASU fragile and expensive
- gentle procedure preferred

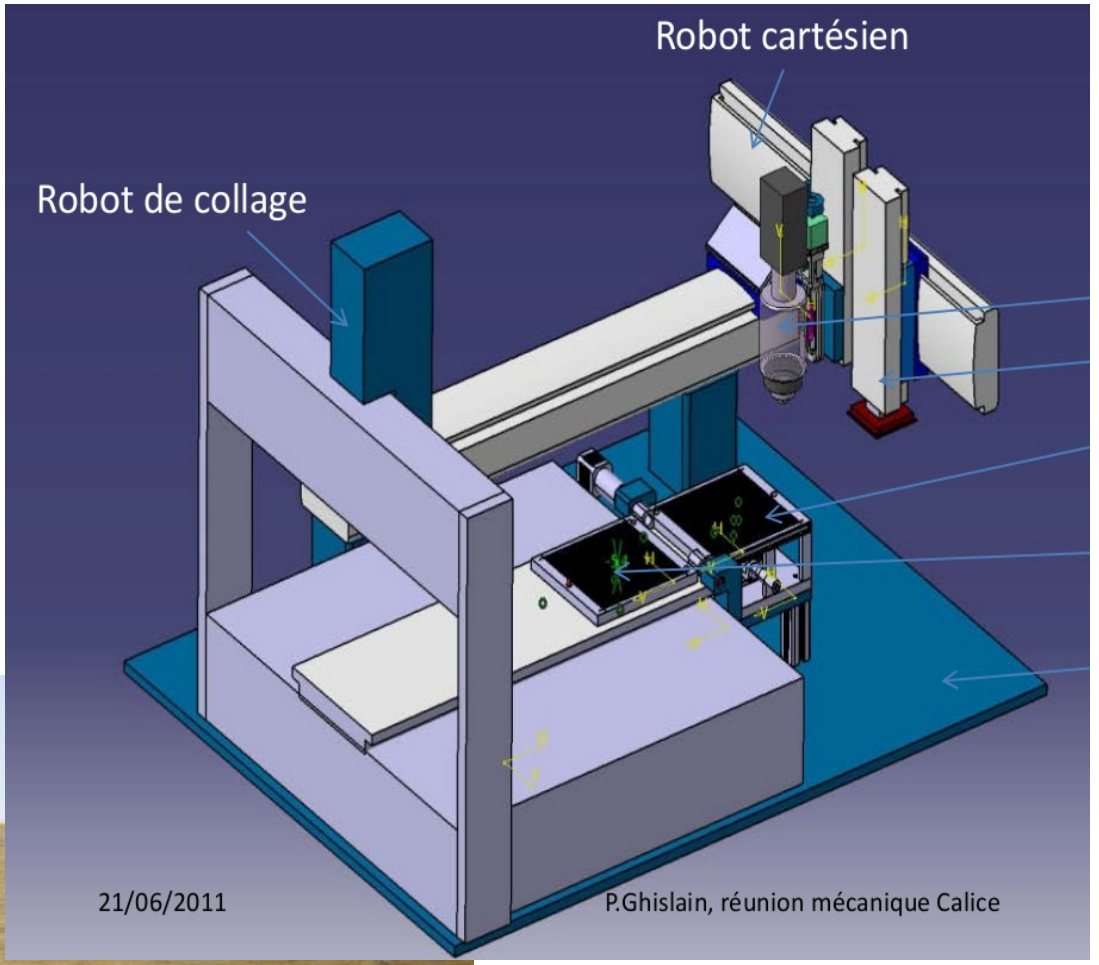




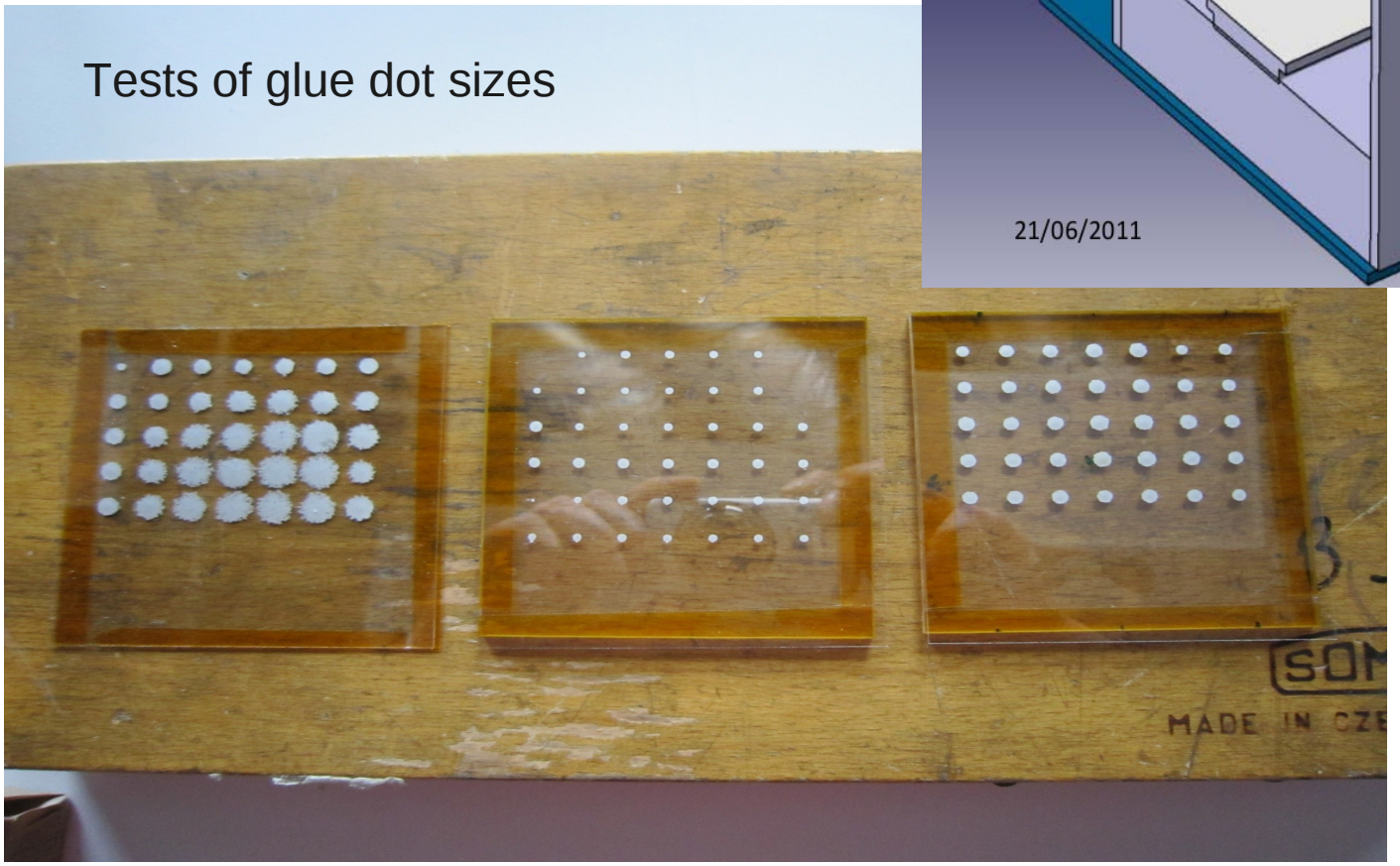
Gluing of sensor to FEV board

EPOTEK conductive glue

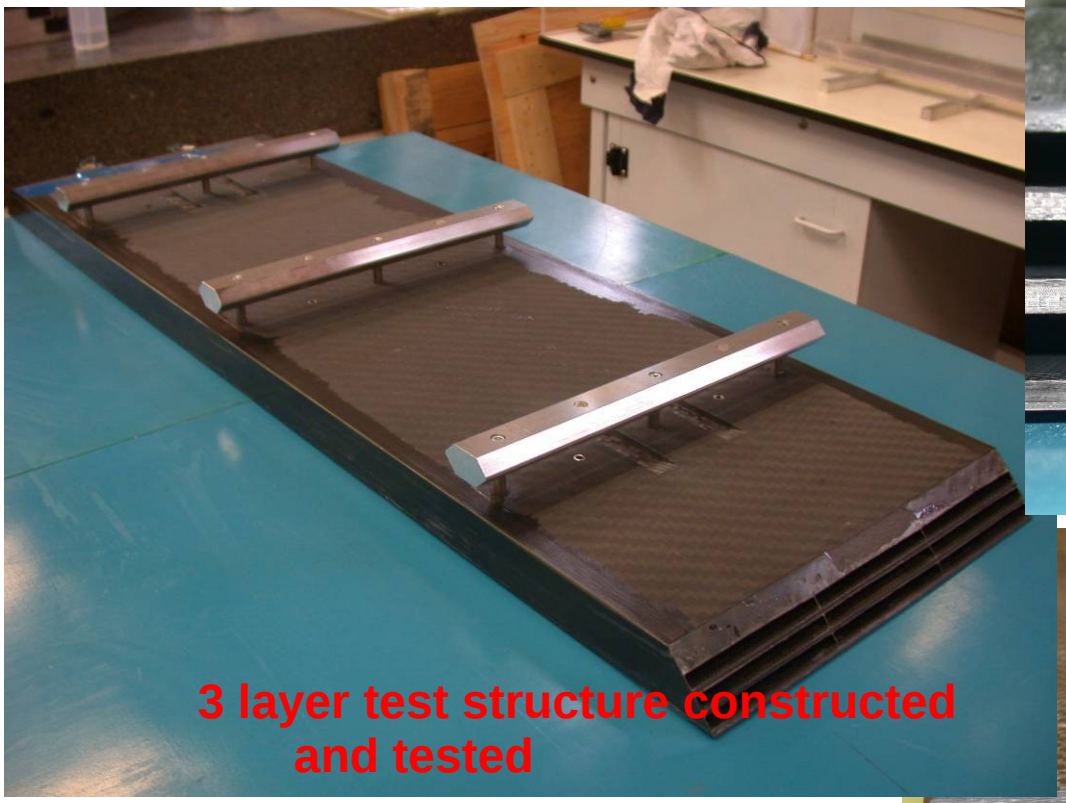
Prepare for gluing of 100M pixels
- automated system essential

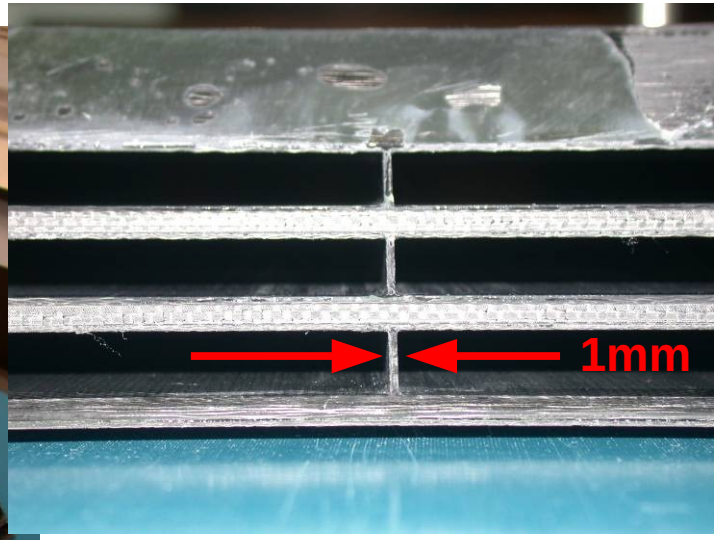


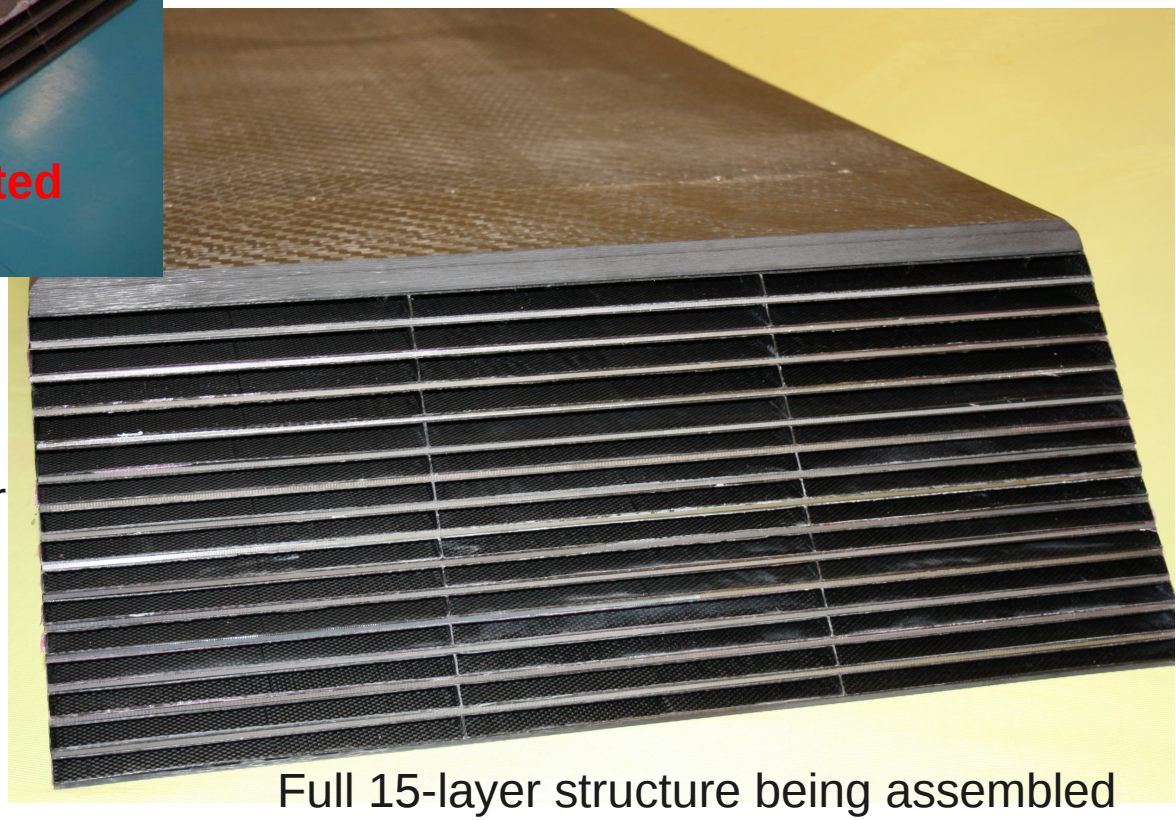
Design of gluing robot



Mechanical structure: approach an ILD barrel module






Full 15-layer structure being assembled

Carbon fibre composite structure
incorporates half of tungsten radiator

Modular construction
-> quality control

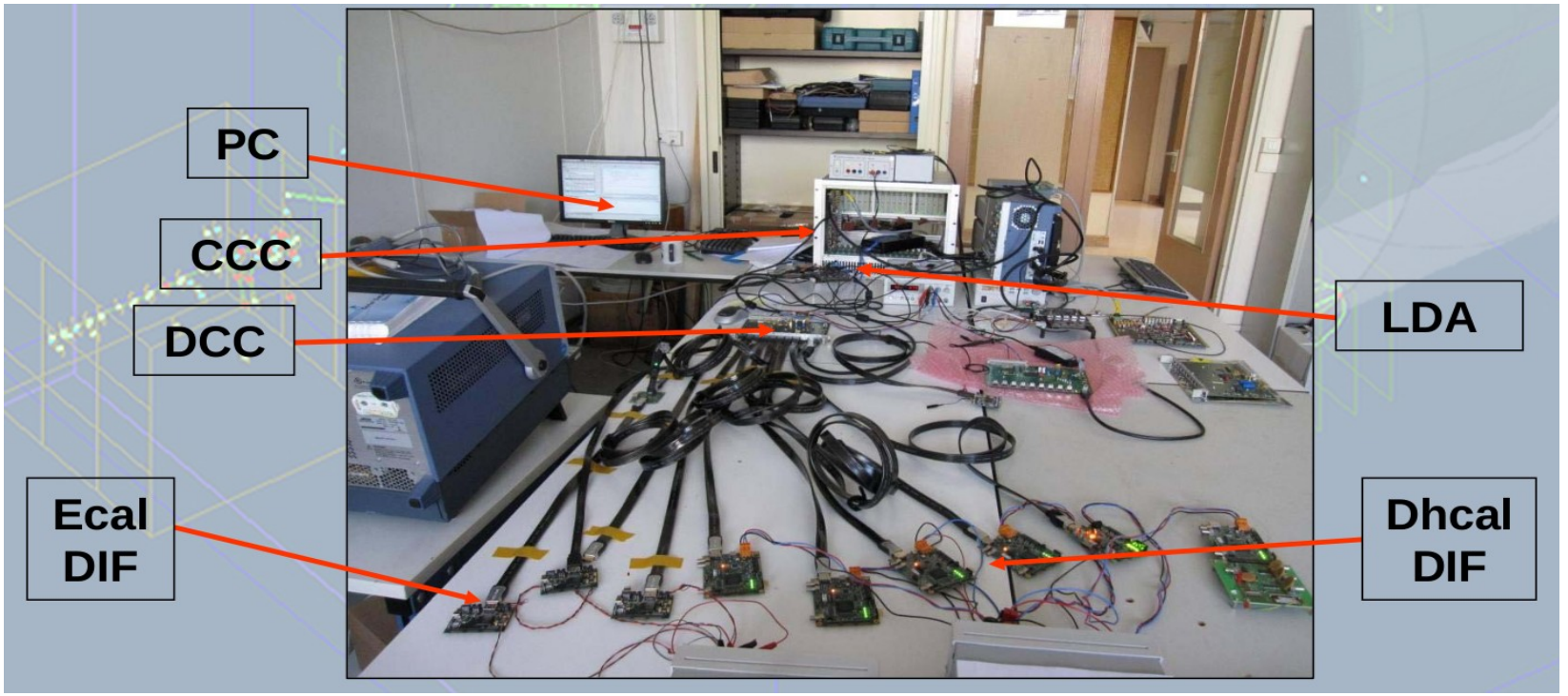
CALICE DAQ system (generic, not ECAL-specific)

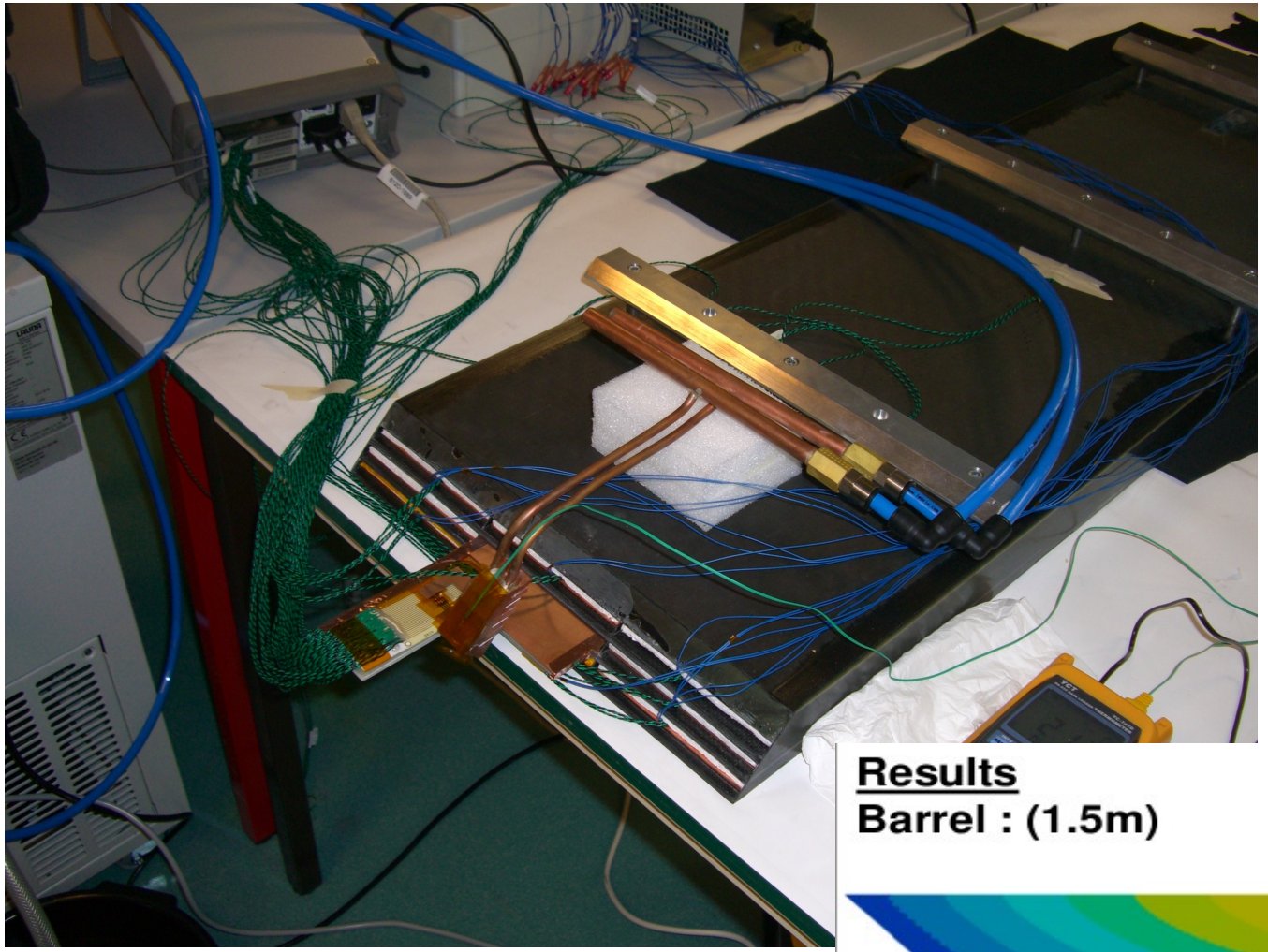
Detector InterFace card (DIF)
at end of each ASU string
up to ~10k channels

Data from ~10 DIFs
concatenated within detector
(LDA, DCC)

One optical link/LDA

Large-scale tests underway





Cooling system

Limit thermal gradients

Extract produced heat
ASICs, DAQ

Water-based system produced, tested

Used to tune thermal simulations of detector module
-> apply to ILD modules

Results
Barrel : (1.5m)

Thermal simulations

ΔT = 2,2℃

End Cap : (2.5m)

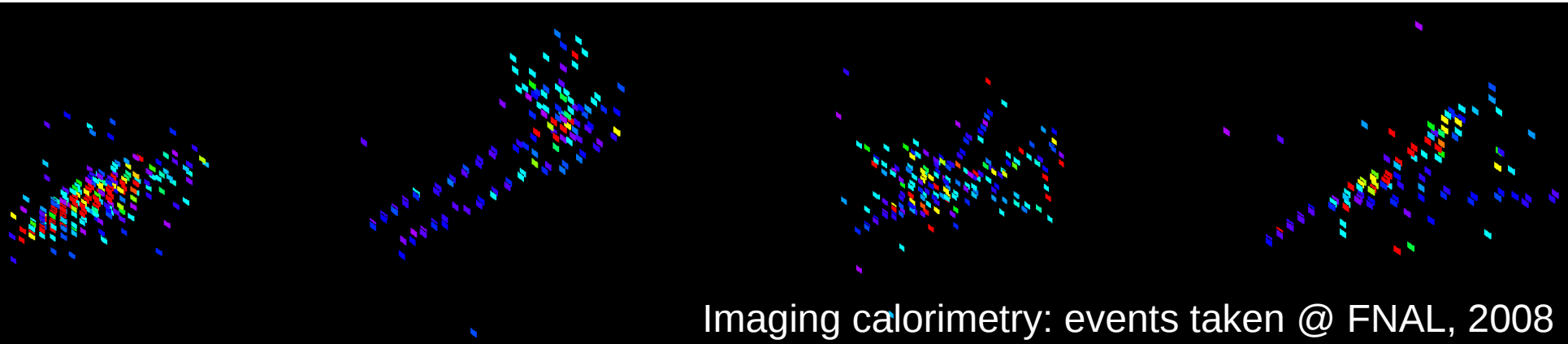
ΔT = 6℃

Summary

Silicon-tungsten technology ideal for an ECAL at ILC

Feasibility of technique demonstrated by first detector prototype

Now addressing “real world” technical aspects
towards an integrate-able sub-detector



Imaging calorimetry: events taken @ FNAL, 2008