Summary on Calorimetry talks

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LCWS07 closing plenary

Contributers(I)

- LCWS: Calorimeter I: RPCs and Muons

- Digital Hadron Calorimeter with RPCs Jose Repond (*ANL*)
- GEM DHCAL Jaehoon Yu (*University of Texas at Arlington*)
- Status of DHCAL R&D in Europe Vladimir Ammosov
- Muon Identification without Iron John Hauptman (*Iowa State*)
- Photosensor Options for Dual-Readout Calorimetry in the 4th-Concept Aldo Penzo (*Trieste*)

- Calorimeter II: Photosensors and Electronics

- First results of SiPM properties study at Rome Ekaterina Kuznetsova (*INFN, Sezione di Roma I*)
- Beam test of small scintillation tiles with SiPM Readout Sandro Calcaterra (*LNF - IFN*)
- MPPC and Scintillator Readout Uriel Nauenberg
- Solid State Photosensors and Scintillator Direct Coupling Measurements Gerald Blazey (*NIU*)
- Study of MPPC Performance for the GLD Calorimeter Readout Satoru Uozumi
- PMT Studies, Couplings, Direct Tile Coupling Mikhail Danilov (*Inst. for Theoret. & Exptl. Phys. (ITEP)*)
- R&D for a 2nd generation AHCAL prototype Mathias Reinecke (*DESY*)
- ASIC Developments Christophe De La Taille (*Institut National de Physique Nucleaire... (IN2P3)*)
- LC Scintillator - based Muon/Tail-catcher R&D Giovanni Pauletta (*Universita degli Studi di Udine*)

Contributers(II)

- LCWS: Calorimeter III: ECAL and FCAL

- ECAL ADC Laurent Royer (*Lab. de Physique Corpusculaire (LPC)*
- Si/W ECal with Integrated Electronics: Progress & Plans Raymond Frey (*University of Oregon*)
- Design of the front-end electronics for FCAL Marek Itzik
- Digitizer and DAQ for FCAL Krzysztof Swientek
- A MAPS-based Readout of an Electromagnetic Calorimeter for the ILC Anne-Marie Magnan (*Imperial College - University of London*)

- LCWS: Calorimeter IV: ECAL and Test Beam Results

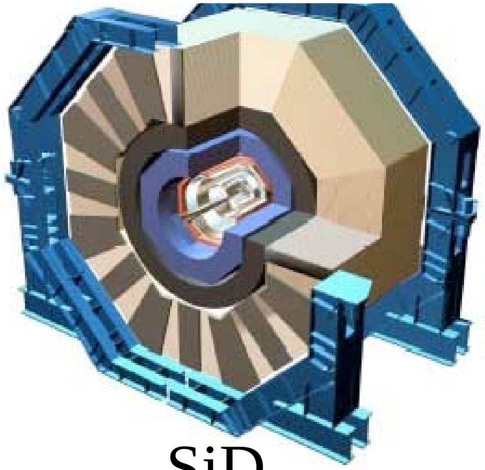
- ECAL barrel & End-cap mechanical R&D Denis Pierre Grondin (*Lab. de Phys. Subatom. et Cosmolog. (LPSC) - Univ.Joseph Fourier*)
- CALICE ECAL Analysis I Anne-Marie Magnan (*Imperial College - University of London*)
- CALICE ECAL Analysis II Cristina Carloganu (*Lab. de Physique Corpusculaire (LPC*)
- CALICE AHCAL Analysis Niels Meyer (*DESY*)
- Tail Catcher and Combined Analysis Dhiman Chakraborty (*Northern Illinois University*)
- Scintillator+ MPPC ECAL testbeam results Daniel Jeans
- DESY Beam Test Results of EM Calorimeter Prototype Donghee Kim (*Kyungpook National University*)

Skeleton of given talks

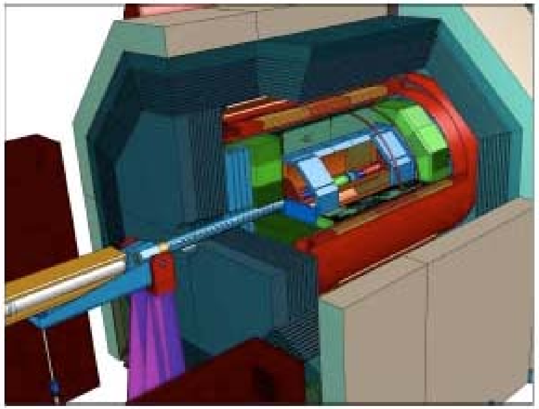
- Total 26 talks
- Talks on sensors, prototype test and beam test results etc..
- Prototypes
  - Silicon/W ECAL,
  - Scint/W ECAL readout w/ MPPC
  - Scint/Fe HCAL readout w/SiPM
  - RPC and GEM : DHCAL
  - ForwardCAL
  - Dual-readout calorimeter :compensation

Detector Concepts

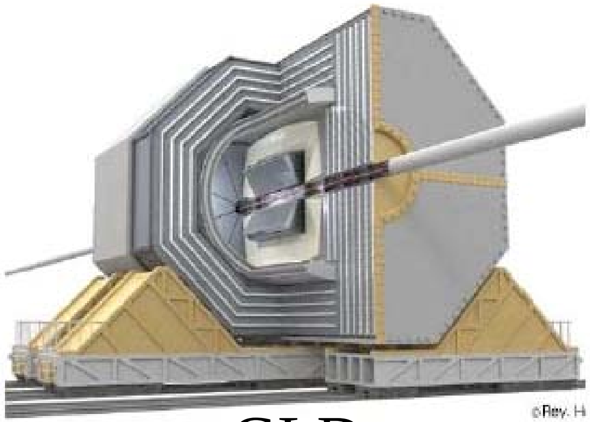
- Particle Flow Algorithm (PFA)



SiD

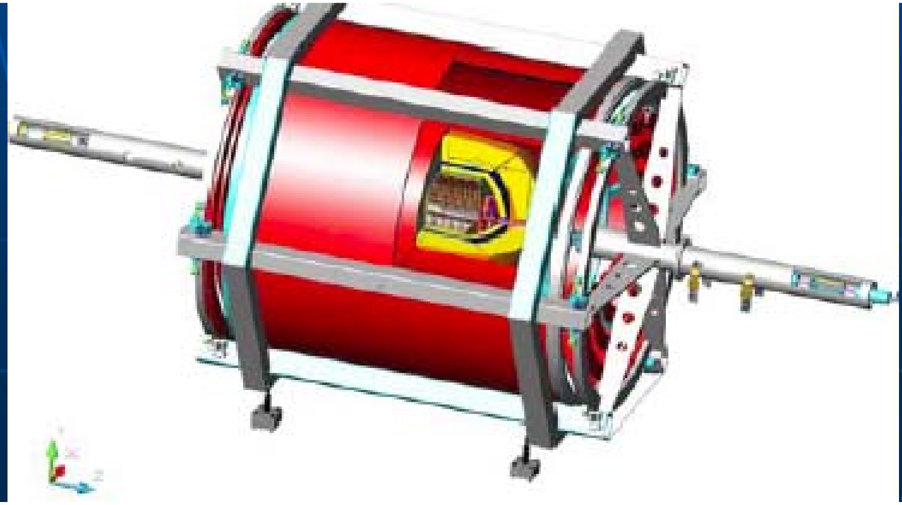


LDC



GLD

- Compensation (Dual-Readout Calorimeter)



Calorimetry and the Concepts

CALORIMETRY	
ECALs	Silicon – Tungsten
	MAPS – Tungsten
	Scintillator – Tungsten
HCALs	Scintillator – Steel
	RPCs – Steel
	GEMs– Steel
	MicroMegas – Steel
TCMT	Scintillator – Steel
Dual-Readout	Scintillator – Steel

Detector Concept	Optimized for PFA	Compensating Calorimetry (hardware)
SiD	Yes	No
LDC	Yes	No
GLD	Yes	Yes
4th	No	Yes

All calorimeters with very fine segmentation of the readout

ECAL

: Si/W & Scint/W

ECAL configuration w/ PFA

ECAL : Sampling calorimeter

Solution 1 :

tungsten (density) – silicon (pixel size ≪ Molière radius)

Pixels size <1cm² and about 20–30 readout layers
(15 to 250 Millions channels)

or silicon (pixel size ~ Mip density in showers)

Pixels size ~ 50x50 μm²
(Tera Pixel Calorimeter)

Solution 2 :

tungsten – MPPC and scintillator strip

Scint. Strip 1x4–5 cm X, Y and about 30 readout layers
(about 10 Millions channels)

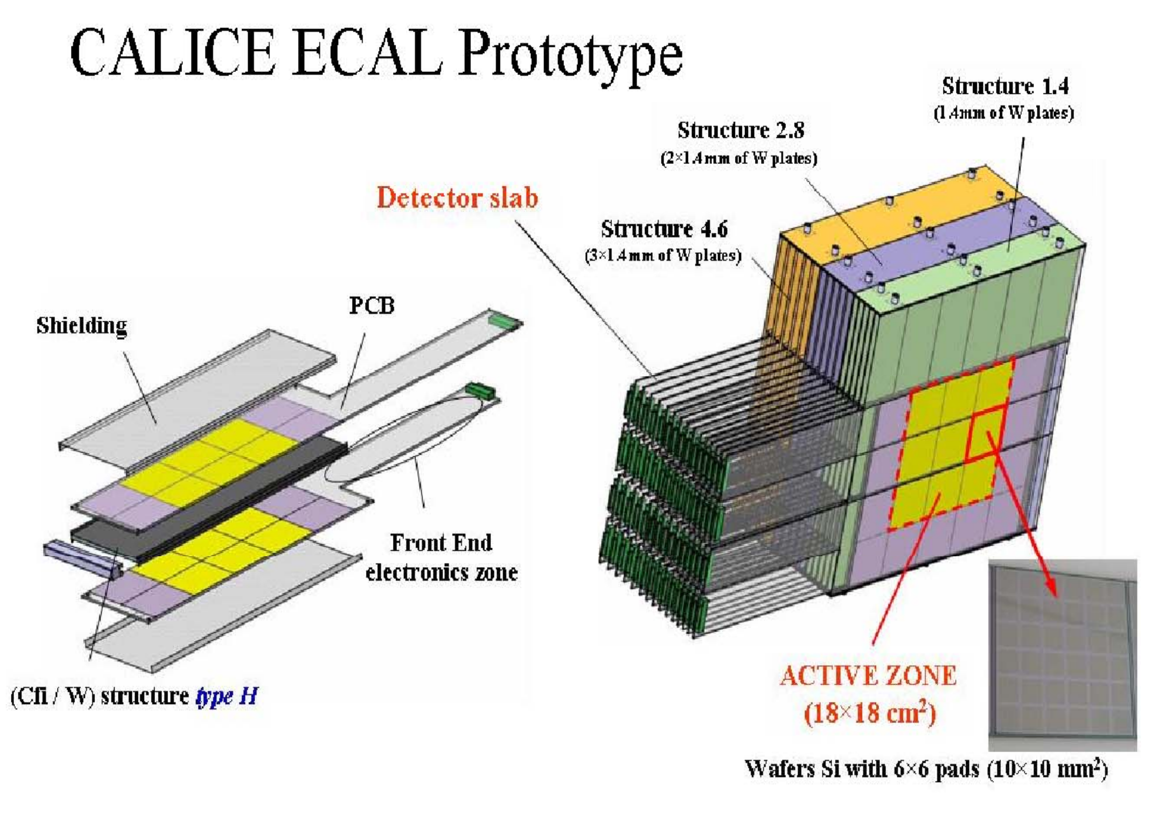
Si-W ECAL prototype

Czech Rep., France, Korea, UK

Design: 30 Si-W layers x 9 wafers x
6x6 1cm x 1cm cells. Three modules, each with different W thicknesses:

- layers 1-10 - 1.4mm
- layers 11-20 - 2.8mm
- layers 21-30 - 4.2mm

Oct/2006 run: all 30 layers are partially
instrumented (6 out of 9 wafers / layer).
Total of 30 x 6 x 36 = 6480 channels.



Detailed view of ECAL PCB

ECAL board

6 active wafers

- 36 silicon PIN diodes each
  $\rightarrow$ 216 channels per board.
- Diode size: $1 \times 1\,\mathrm{cm}^2$.

Calibration chips

- 2 calibration switches chips.
- 6 calibration channels per chip.
- 18 diodes per calibration channel.

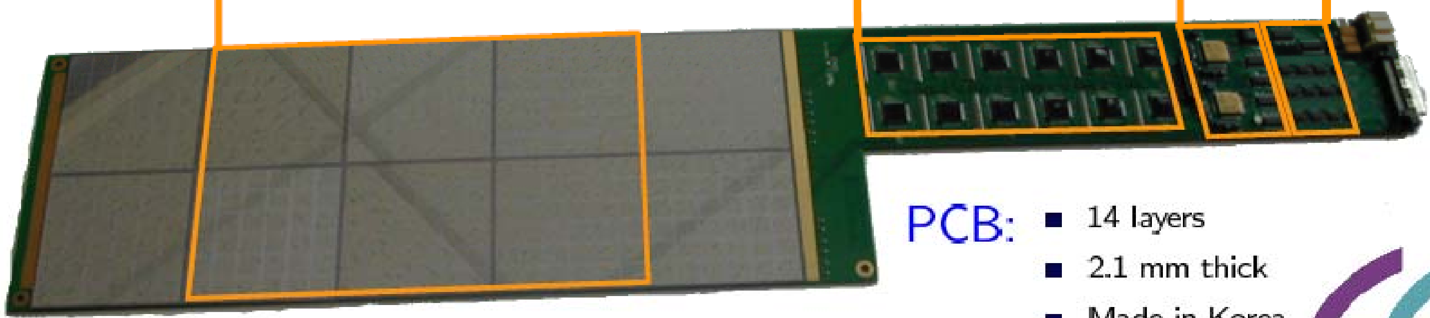
Line buffers

- To DAQ part
- Differential.

Front-End chip

12 FLC_PHY3 front-end chip

- 18 channels / chip
- 13 bit dynamic range



PCB:

- 14 layers
- 2.1 mm thick
- Made in Korea

2006 Test Beam

May

DESY TB area, with only 24 layers . 14 days in total
~8 Million triggers, 7 energies (1-6 GeV), 5 angles, 3 positions

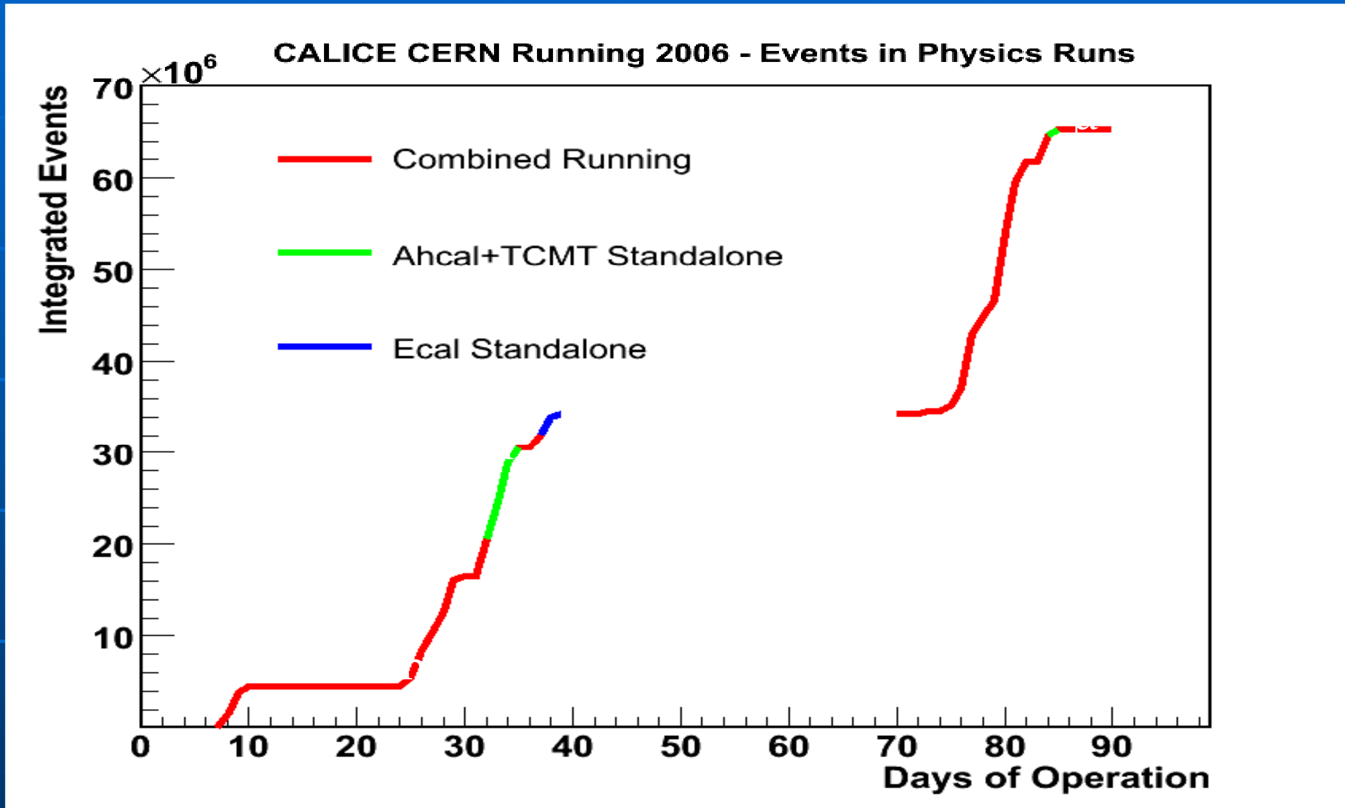
Aug 25th – Sept 6th

CERN TB area, with 30 layers.
ECAL+AHCAL: 1.7 M triggers, pions beam, 5 energies (30-80 GeV), 3 angles,
ECAL alone: 8.6 M triggers, electron beams, 6 energies (10-45 GeV), 4 angles,
+ 30 Million muons for calibration.

Oct 11th – Oct 30th

CERN TB area.
Combined ECAL+AHCAL + TCMT:
e+, e-: 3.8 M triggers, 10 energies (6-45 GeV)
π+,π-: 22 M triggers, 11 energies (6-80 GeV)
+ 40 Million muons for calibration.

Summary of the data taken



Size on disk: ~ 40 kB/evt

➔ 65M events = 2.5 TB for CERN Physics runs

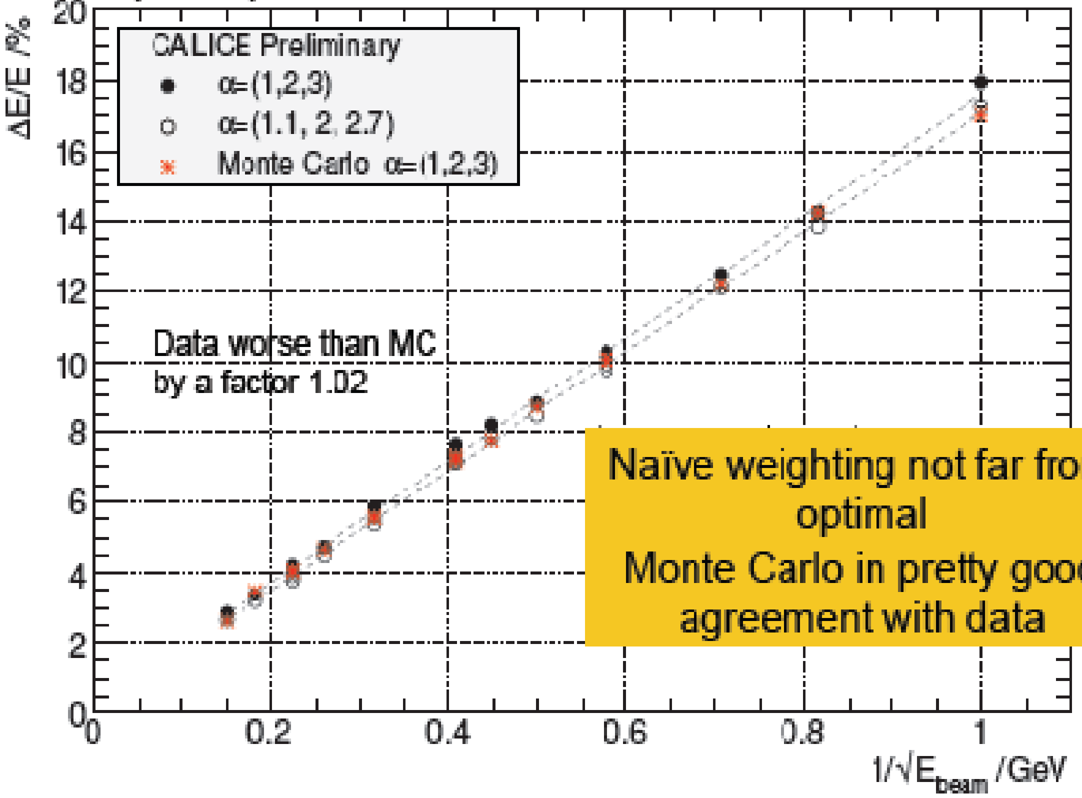
➔ + 70 M = 3 TB for muon calibration runs

All the reconstruction has been done using the GRID !

Energy Resolution

$$\frac{\Delta E}{E}(\%) = \frac{17.7 \pm 0.07}{\sqrt{E\,(GeV)}} \oplus (1.1 \pm 0.08)$$

$(\alpha_1, \alpha_2, \alpha_3) = (1, 2, 3)$



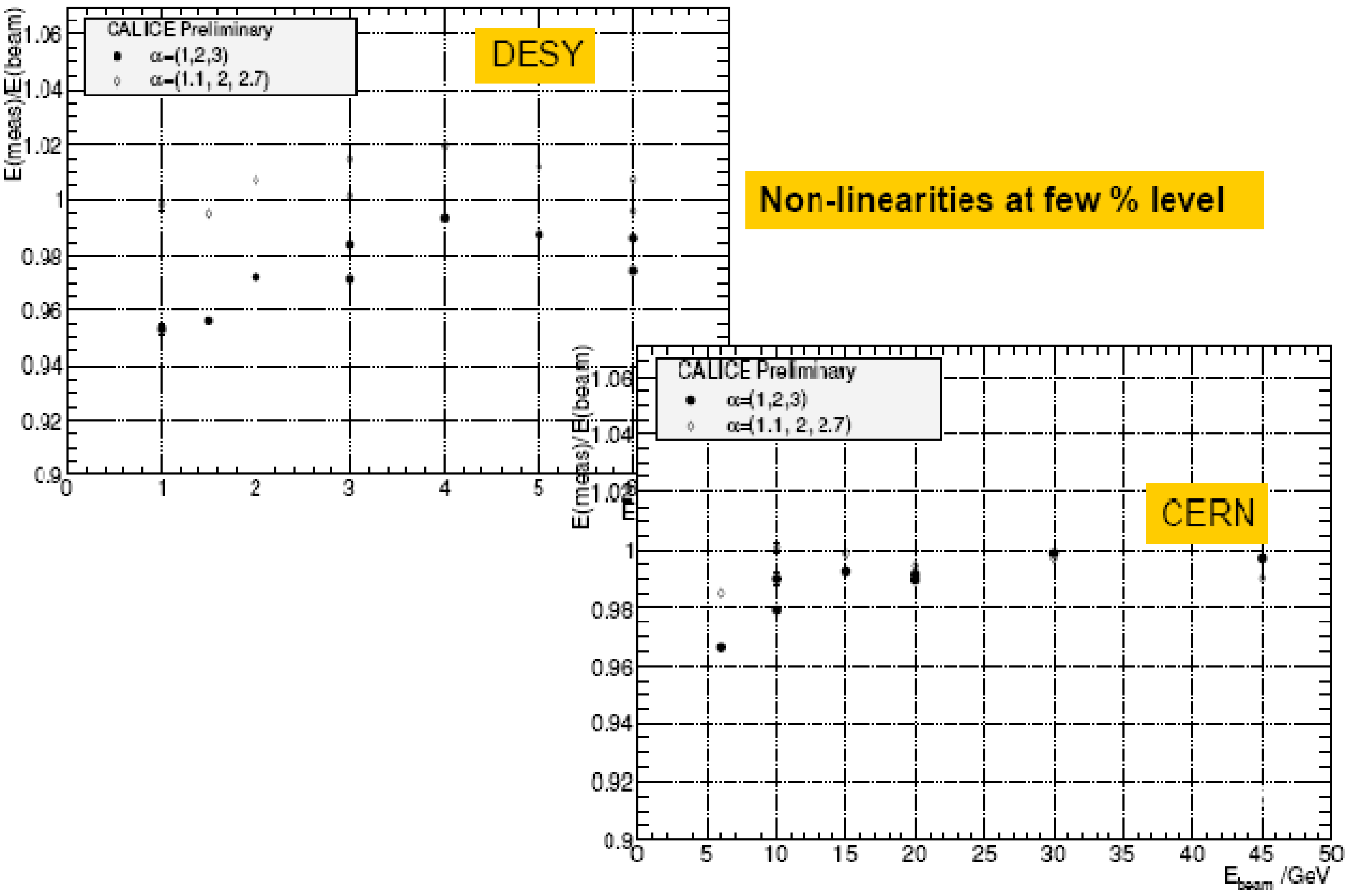
Naïve weighting not far from optimal

Monte Carlo in pretty good agreement with data

$$\frac{\Delta E}{E}(\%) = \frac{17.1 \pm 0.07}{\sqrt{E\,(GeV)}} \oplus (0.5 \pm 0.15)$$

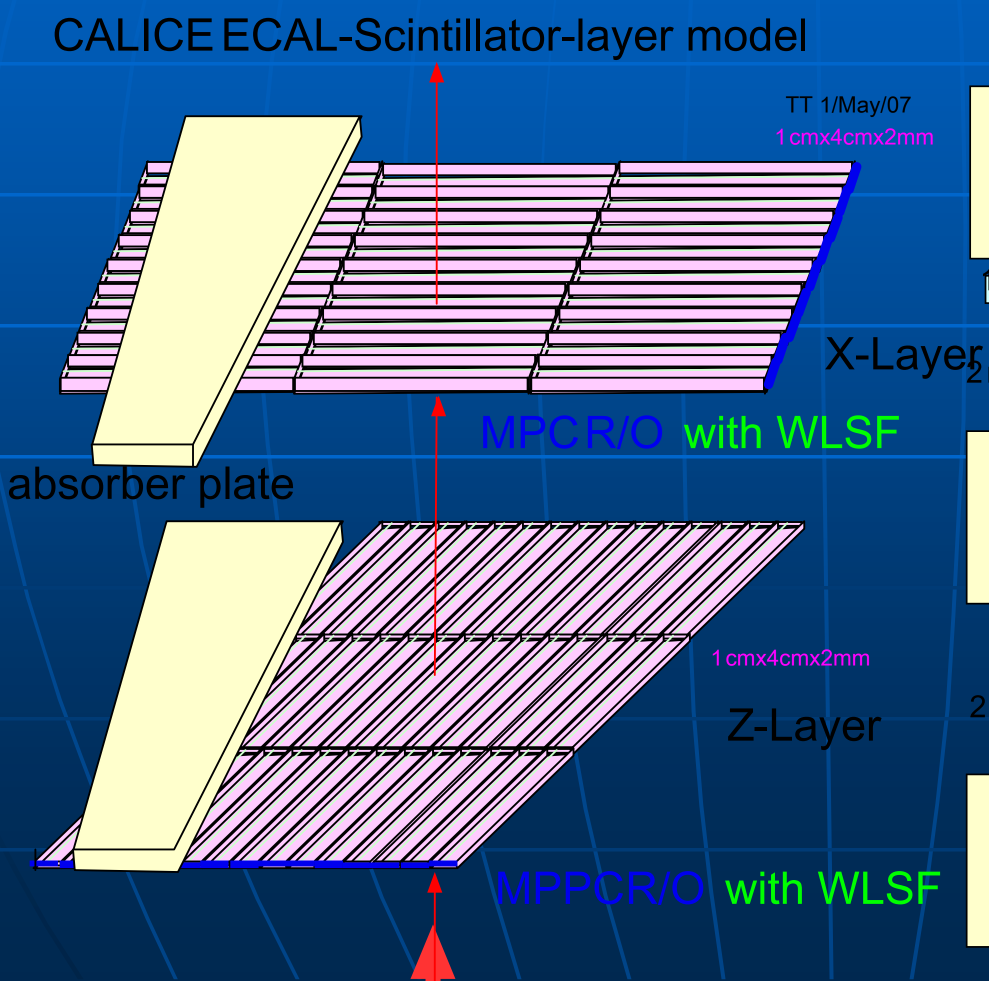
$(\alpha_1, \alpha_2, \alpha_3) = (1.1, 2, 2.7)$

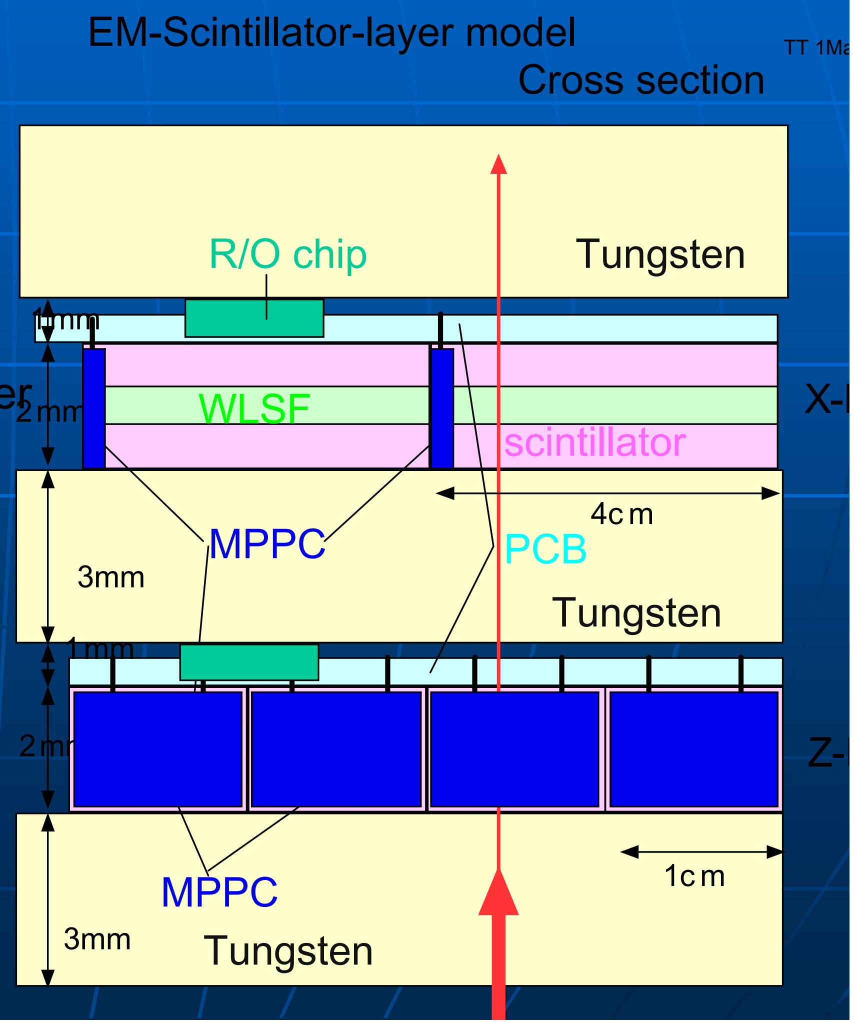
Linearity


CALICE Preliminary
α=(1,2,3)
α=(1.1, 2, 2.7)
DESY
E(meas)/E(beam)
Non-linearities at few % level
CALICE Preliminary
α=(1,2,3)
α=(1.1, 2, 2.7)
CERN
E(meas)/E(beam)
E_{beam} /GeV

Scintillator strip ECAL

- to reduce the number of readout channels
- orthogonal strips
- effective 1cm x 1cm area

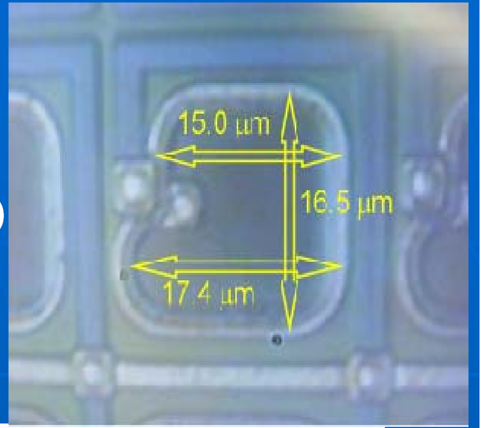


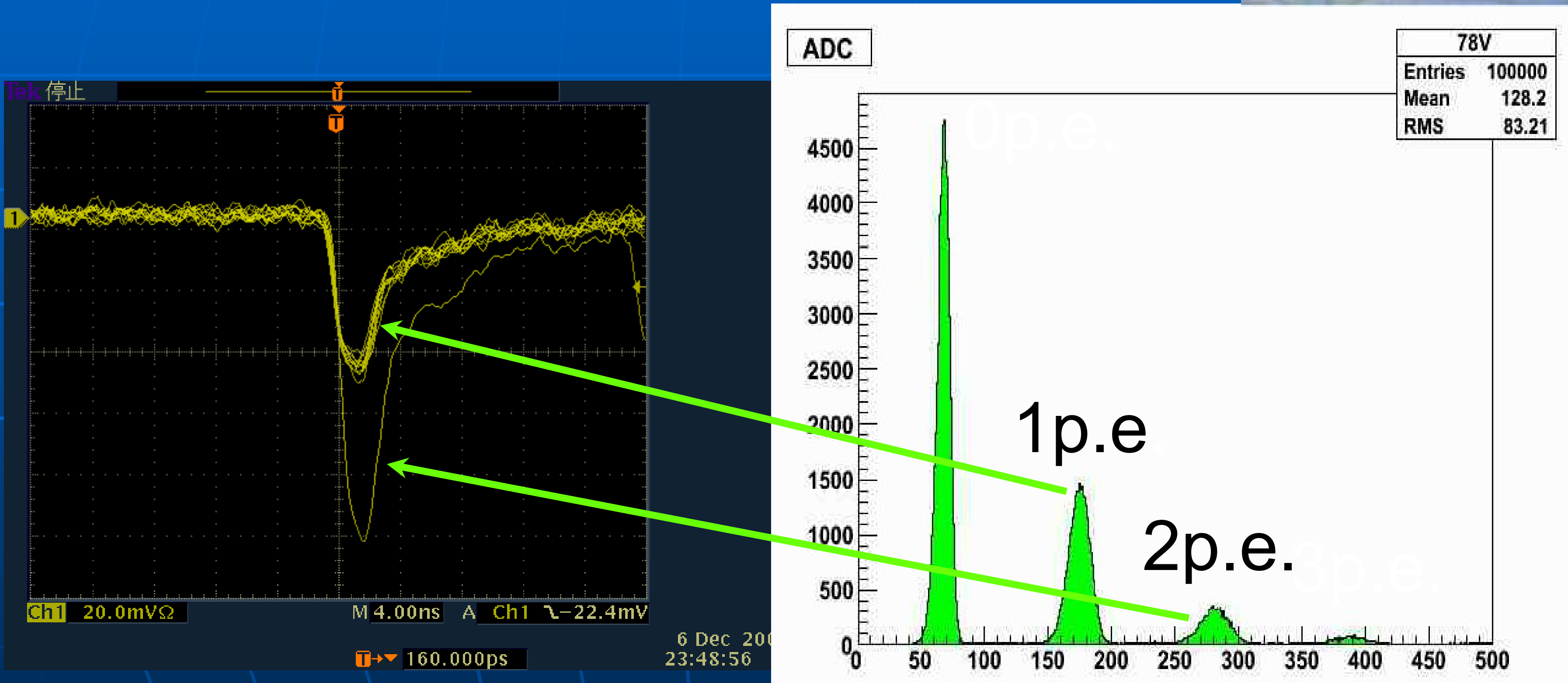


1600pix

MPPC

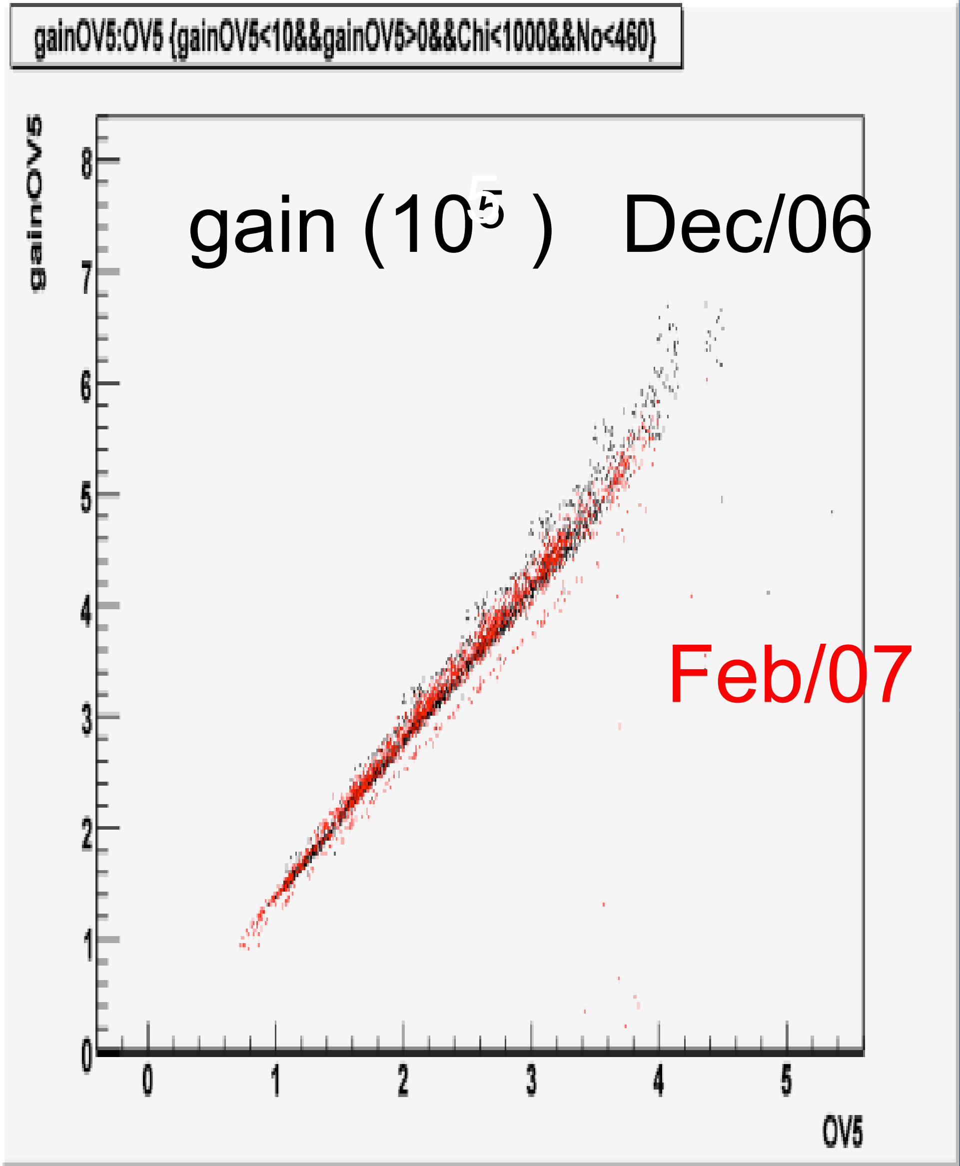
- digital response of each p



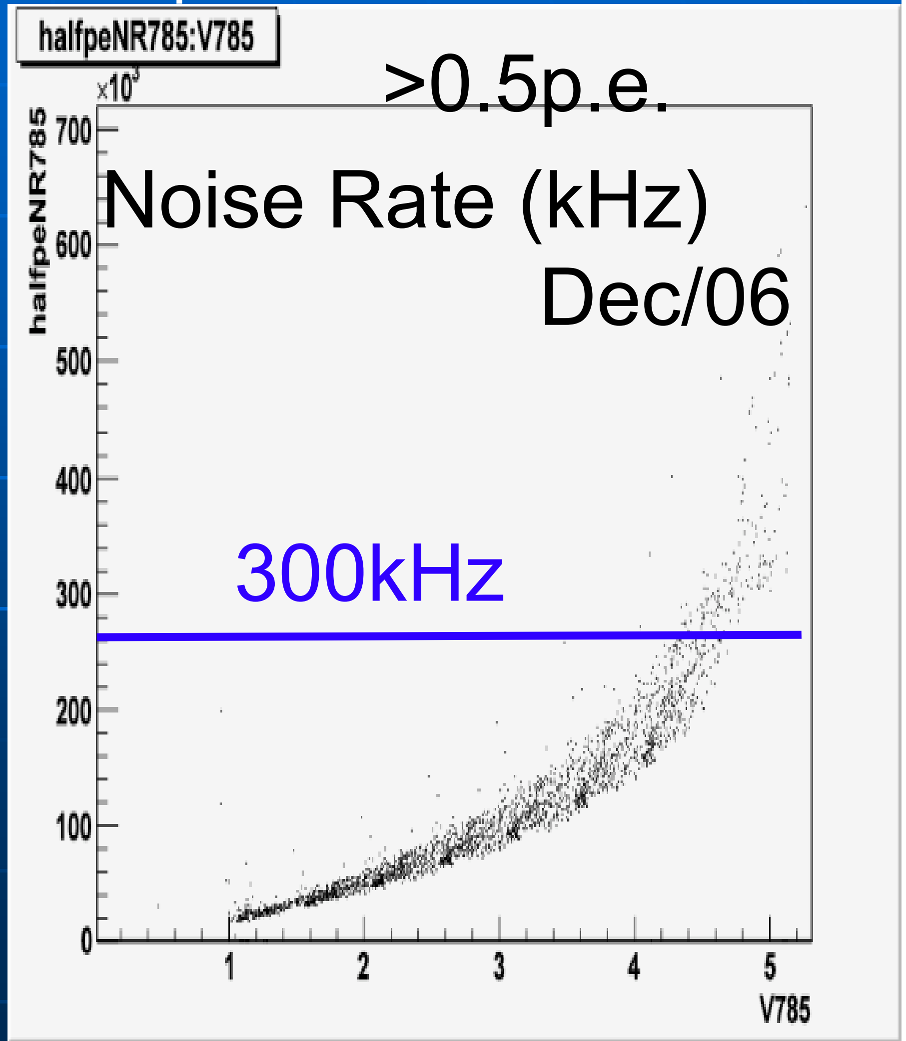


MPPC test 1600pix

800 pieces of MPPC tested



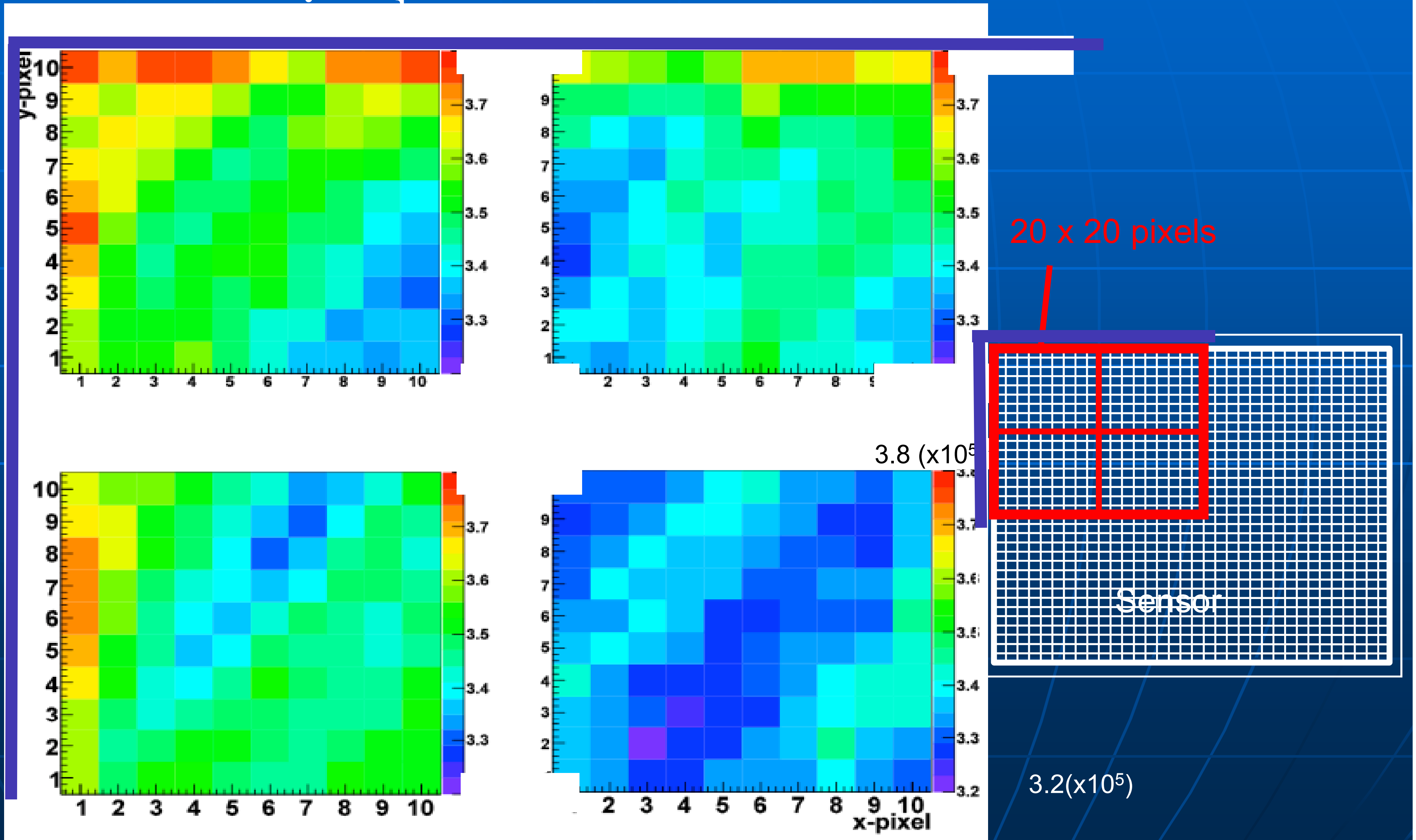
Over voltage (Vbias- V_0)



Vober

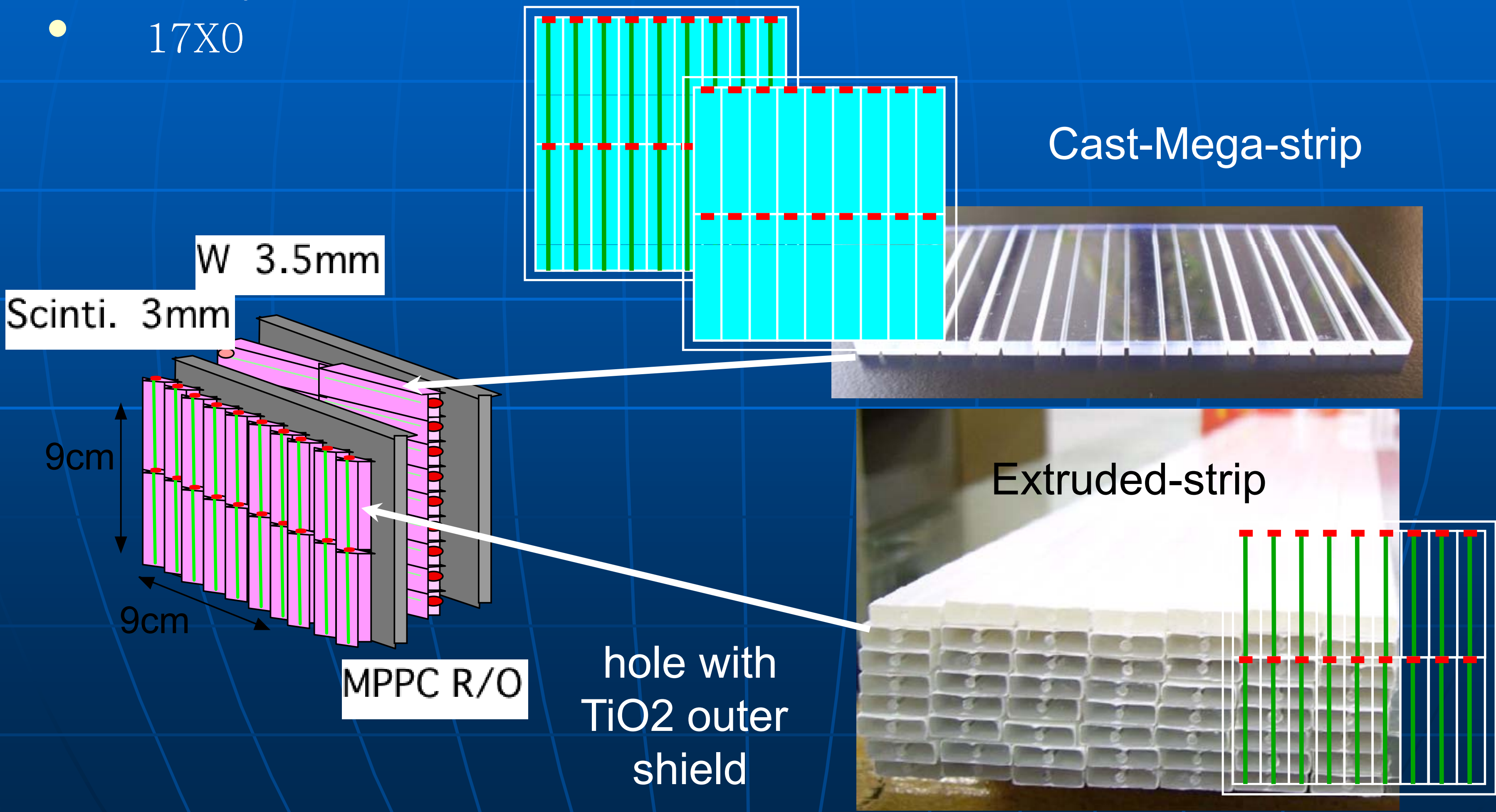
MPPC pixel uniformity

- laser shot at the center of each pixel

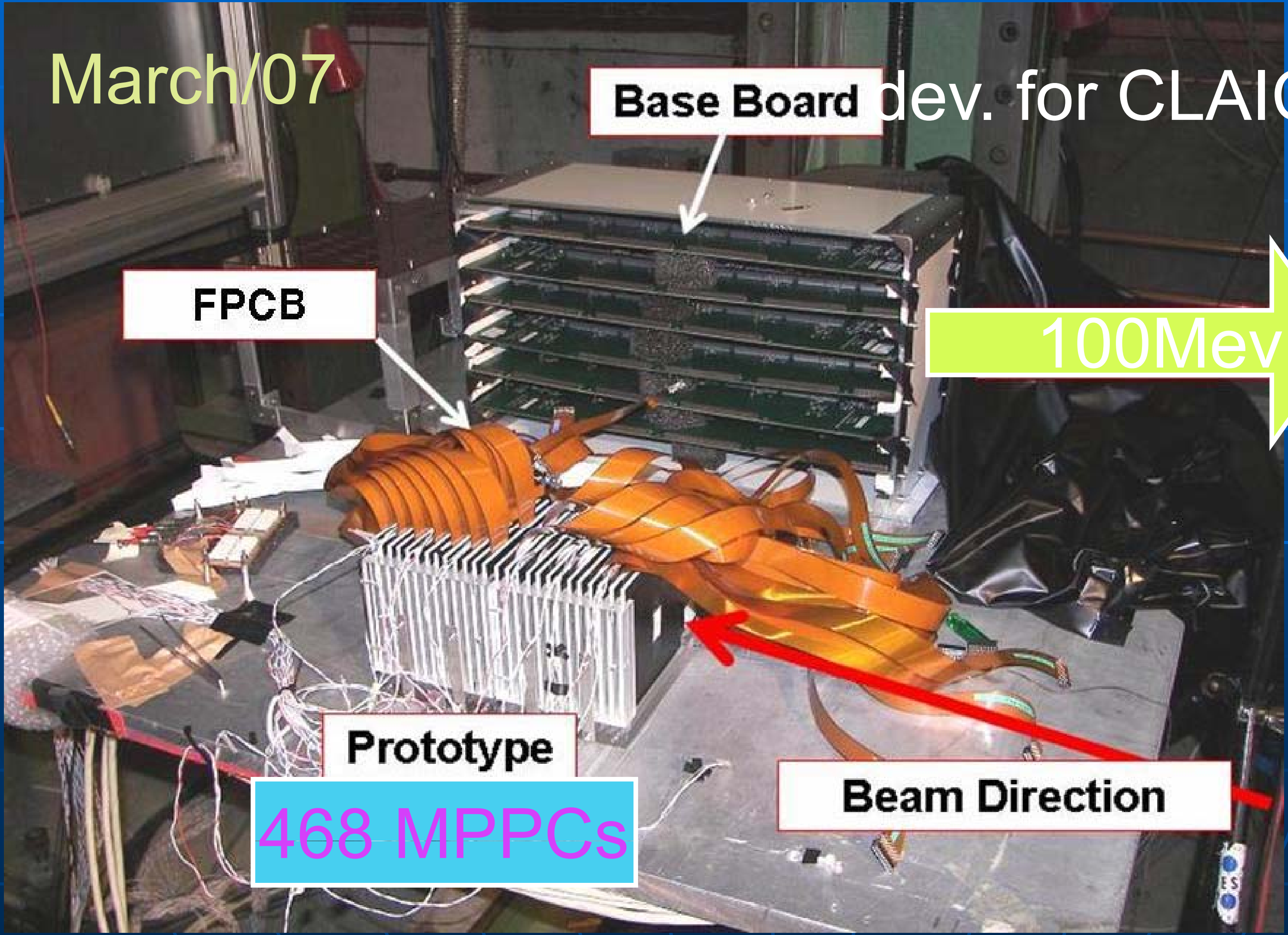


scintillator strip

- two mega-strip and extruded strip
- with and without Wave Length Shifting Fibre
- 26 layers 468ch
- 17X0



prototype ECAL at DESY



dev. for CLAICE AHCAL SiPM

100Mev

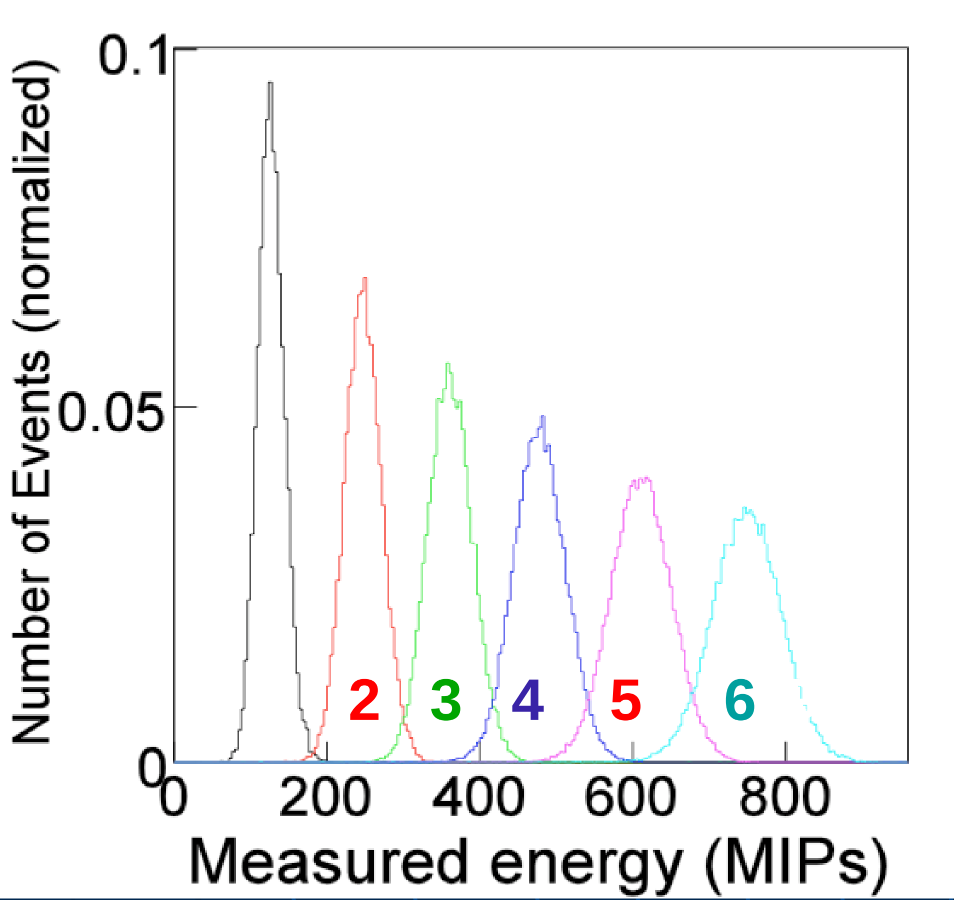
DAQ

GRID VO CALICE

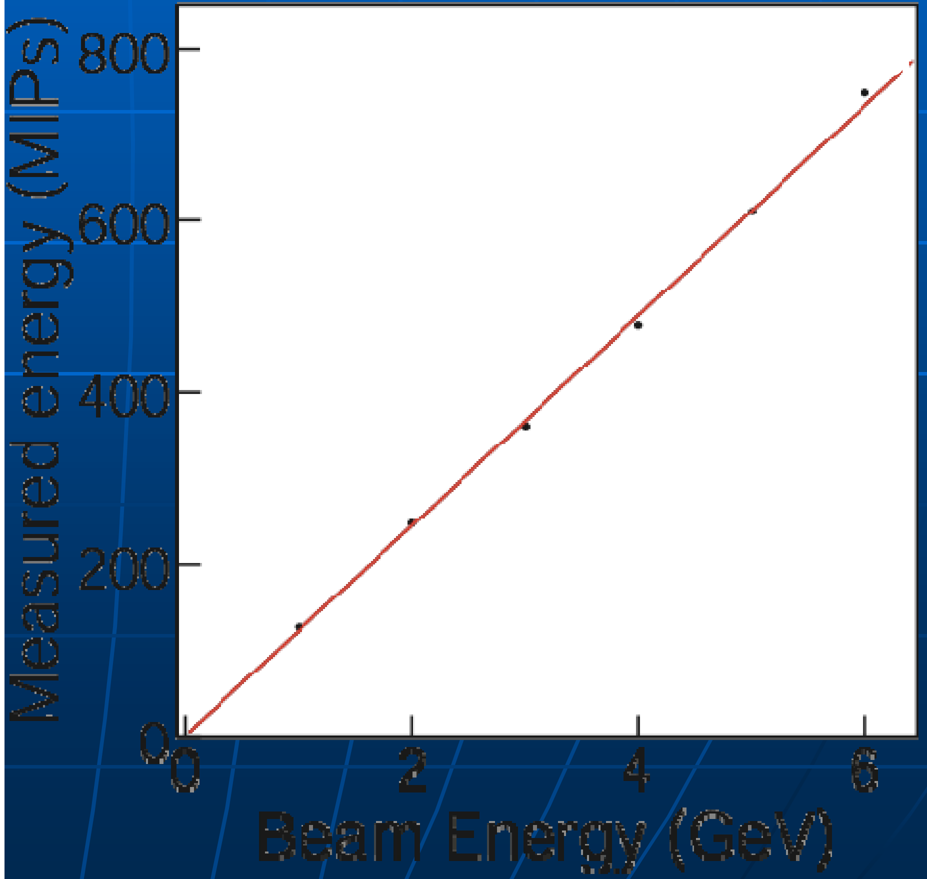
SC-ECAL DESY results (preliminary)

with WLSF

energy measurement



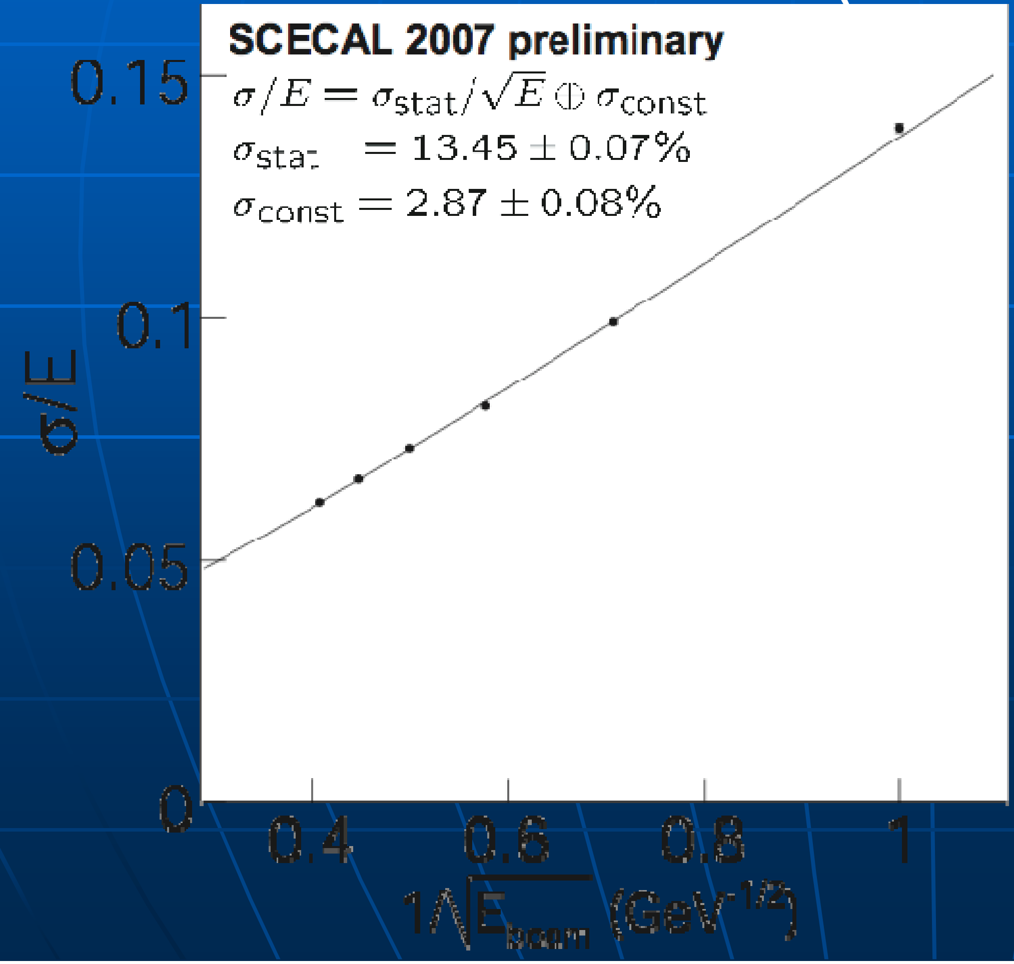
linearity 1-6GeV



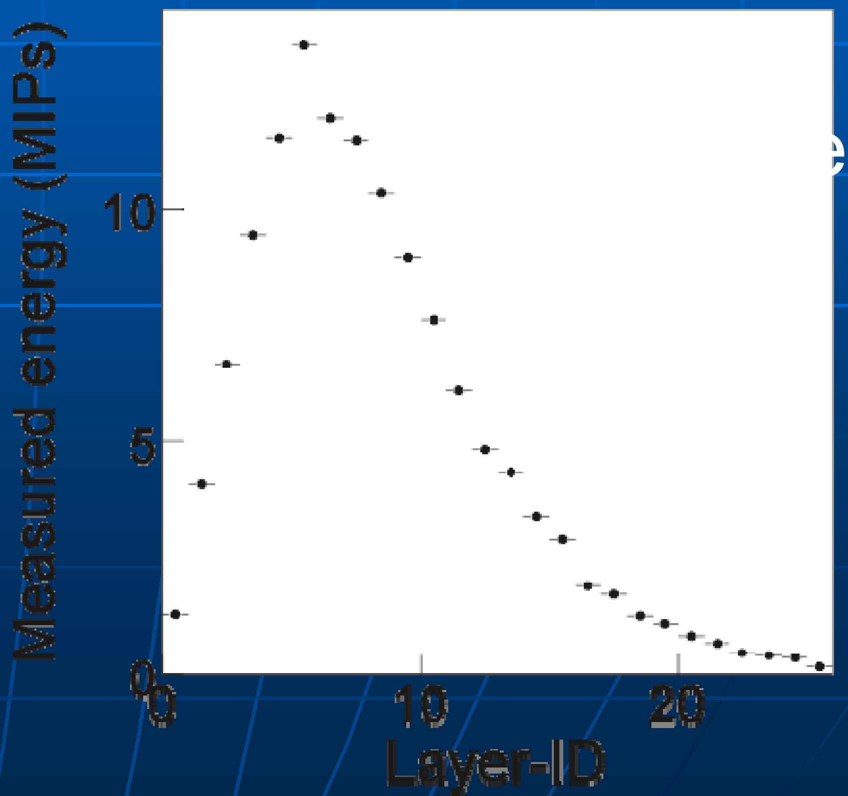
SC-ECAL DESY results (preliminary)

with WLSF

electron resolution (1-6GeV)



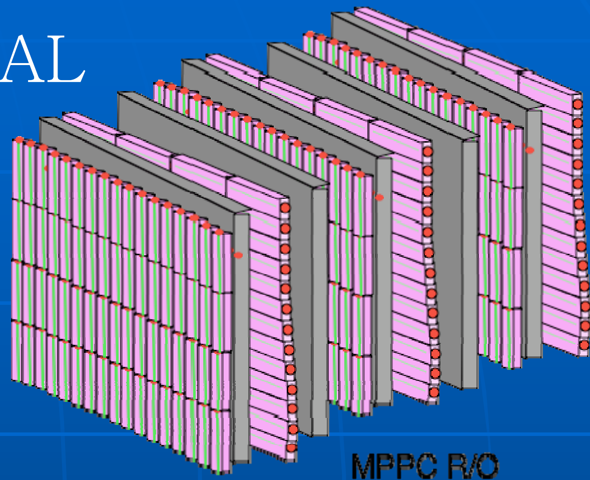
longitudinal shower profile

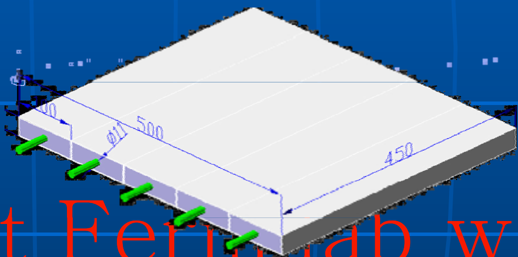


Milestones

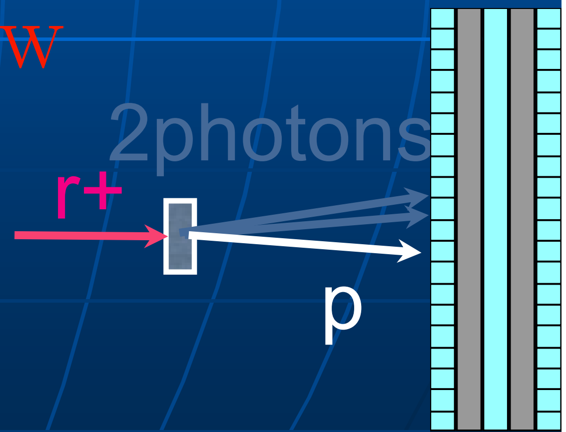
desy data analysis

- const. 4 times bigger Scintillator ECAL
  - MPPC dev. and 2.5k prod.
  - extrusion scintillator prod.
    - embedded WLS fiber to strip
    - Mega-extrusion

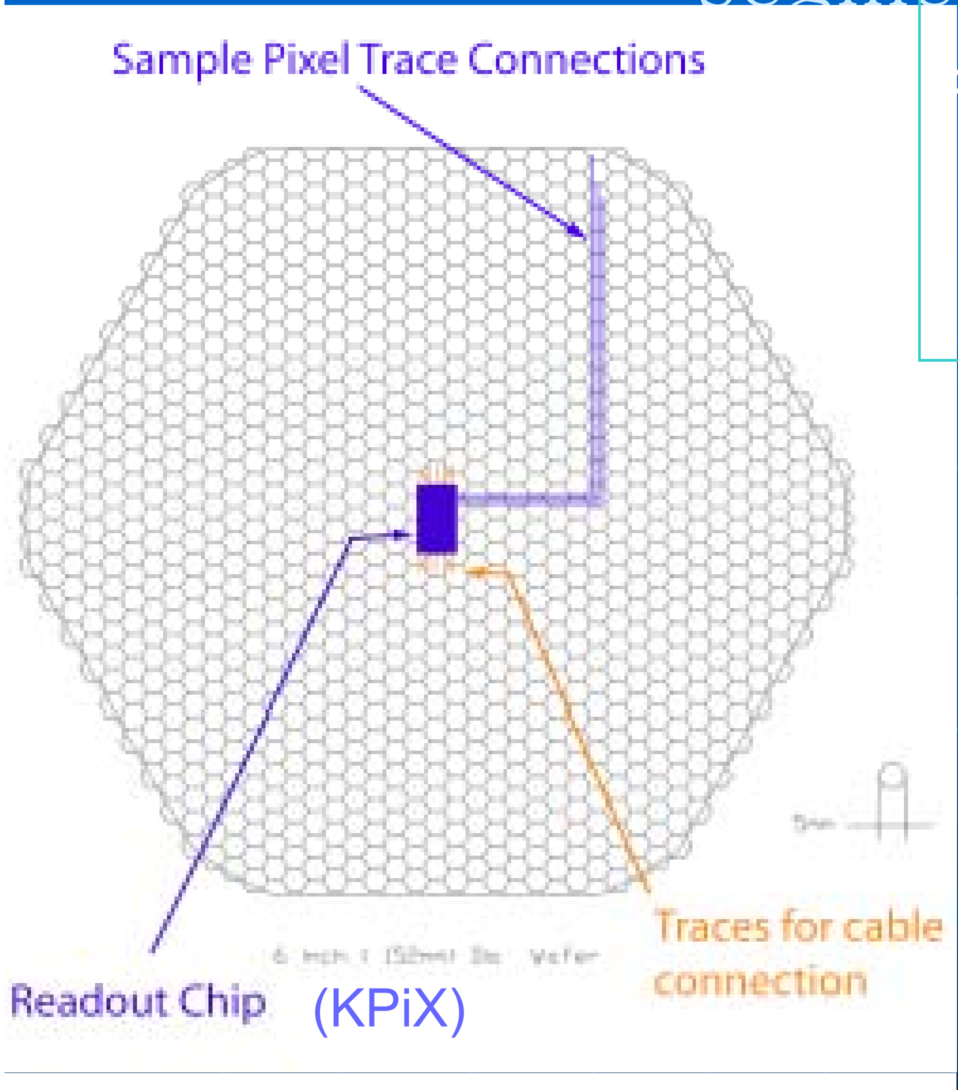




- electronics
- 2008 Beam test at Fermilab w HCAL
  - to test pi0 reconstruction : r+ n>r0+ p



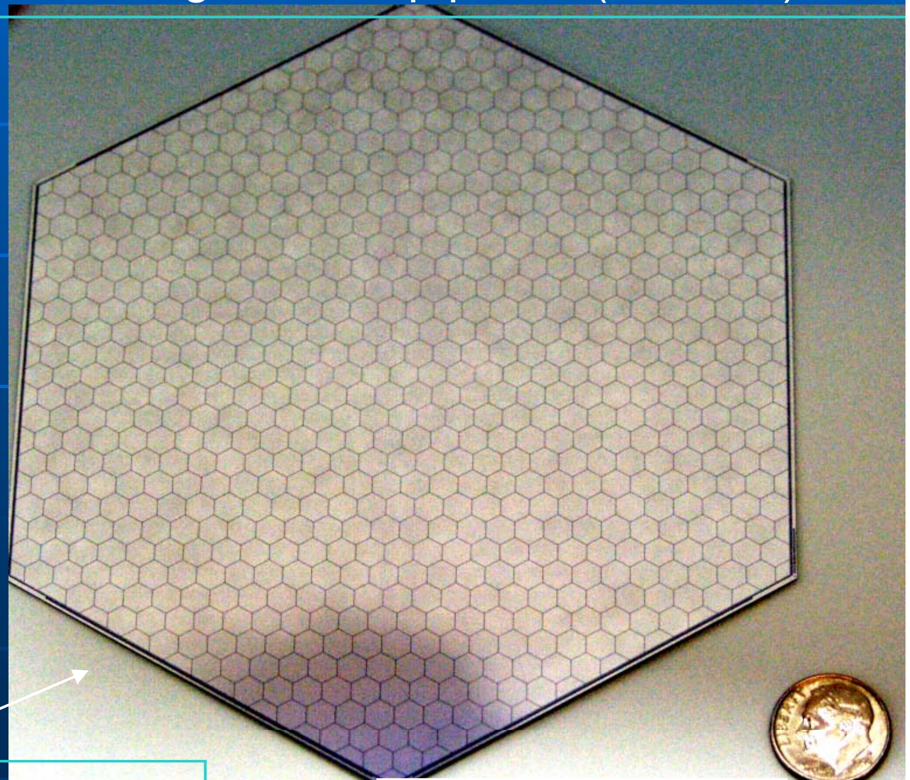
Silicon detector layout and segmentation



One KPiX readout chip for the sensor (1024 pixels, 6 inch wafer)

- KPiX also being considered for Si tracker and DHCal with GEMs

Limit on seg. from chip power (≈2 mm^2)



Fully functional v1 prototype (Hamamatsu)

SiD ECAL group

Status Summary and Plans (near term)

- KPiX readout chip
  - Currently studying v4 prototype (2x32 channels)
  - Submit v5 in next few weeks (4x32 channels)
    - Improved biasing of MOS capacitors; new poser bus for comparators
    - Optimized shaper time constants
  - Perhaps submit 1024-channel KPiX in Fall
- Silicon sensors
  - v2 prototype submitted to industry (40 sensors)
  - Schedule funding limited – hope to acquire sensors Fall-Winter
- Readout flex cable – short version for first module OK
- Bump bonding – first trials (UC Davis) just starting

→ All of the above: a full-depth, single-wafer wide module

→ Test in a beam: (1) electrons; (2) hadrons with HCal

SiD ECAL group

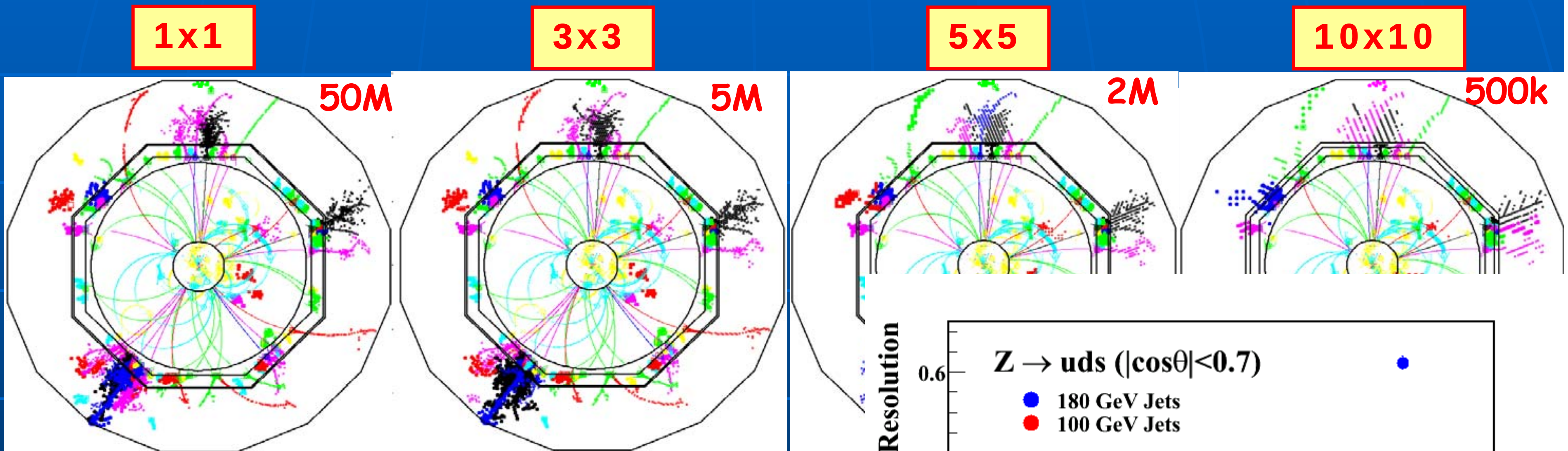
The R&D leading to an "ILC-ready" Si-W ECal technology is progressing well

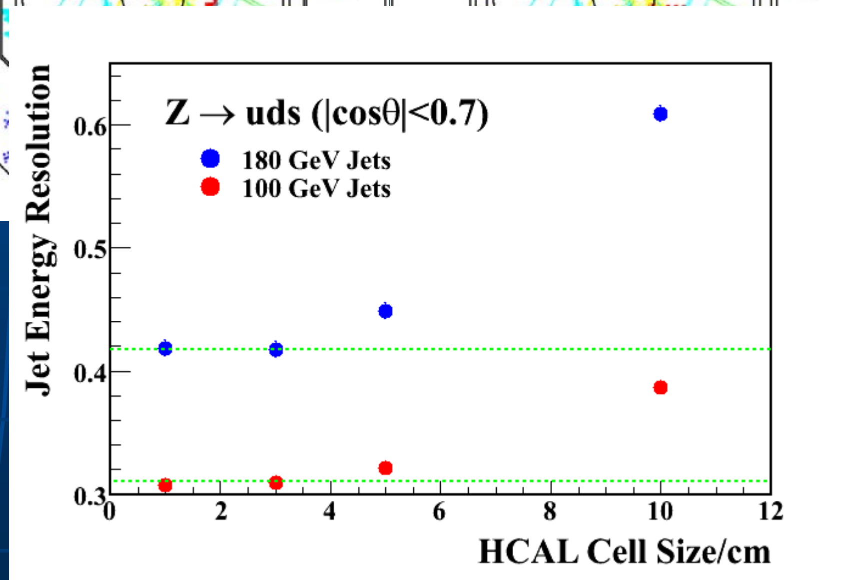
HCAL ：AHCAL with SiPM readout

DHCAL：RPC & GEM

Granularity

- Recent studies with Pandora PFLOW algorithm (M.Thomson)





- Confirms earlier studies for test beam prototype
- 3x3 cm^2 nearly optimal
- Granularity vs depth to be done

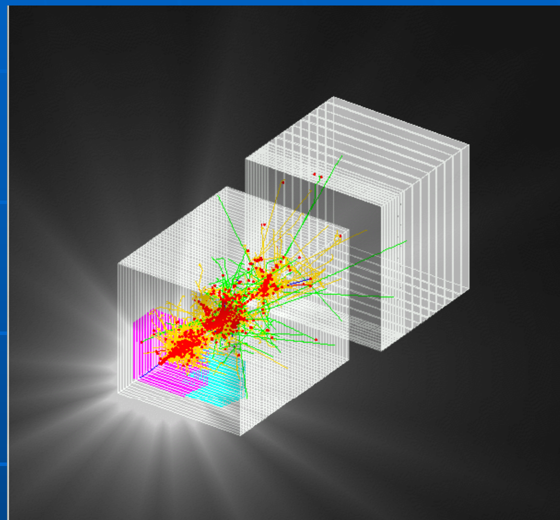
Scintillators

- Originally a baseline/backup solution
- Proven technology
- Robust, high rate capability
- sufficiently rad hard
  - 1 Mrad = 10 kGy or 10^{15} n
- Cheap (not a cost driver)
- Thoroughly optimized
  - Studies at ITEP, DESY, NIU, …

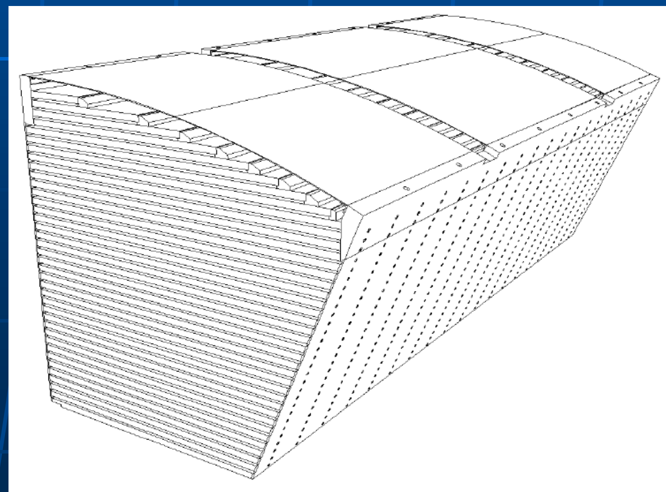
- Trade granularity versus amplitude resolution
- 3 cm size optimized for shower separation
- and semi-digital readout

R&D programme

- Test beam programme
  - Fine structure of hadron showers
  - Validate the simulations
  - Large scale test of novel sensor technology
  - Operational experience for system optimizatio n
    - E.g. calibration and correction strategies

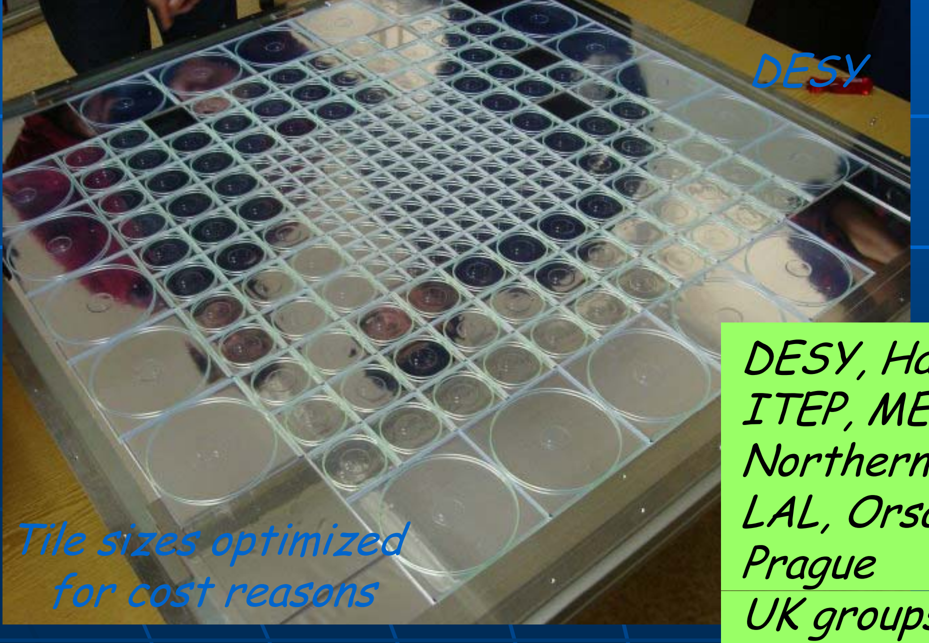


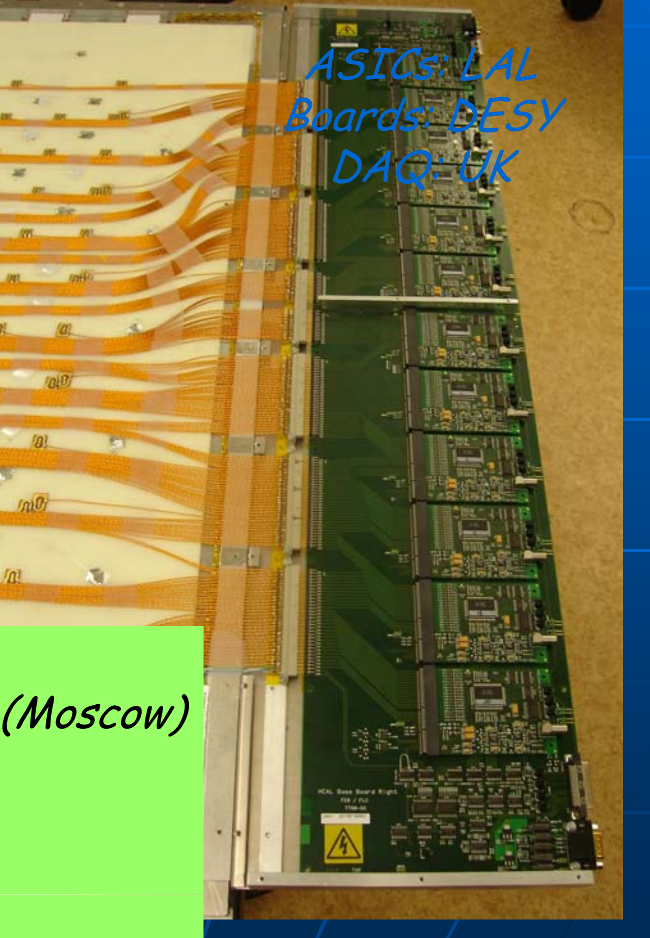
- Technical prototypes
  - Develop solutions for detector integration
    - Embedded electronics
  - Minimize gap width and dead regions
  - Obtain basis for cost estimate



Tile HCAL testbeam prototype

- 1 cubic metre
- 38 layers, 2cm steel plates
- 8000 tiles with SiPMs
- Electronics based on CALICE ECAL design, common back-end and DAQ



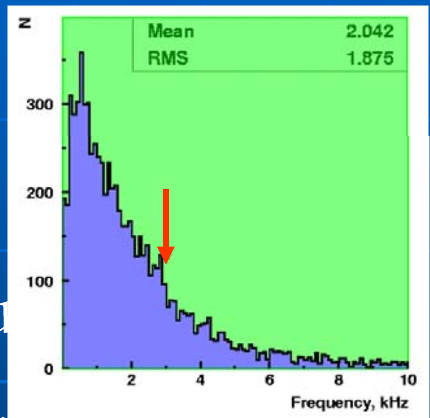


DESY, Hamburg U,
ITEP, MEPHI, LPI (Moscow)
Northern Illinois
LAL, Orsay
Prague
UK groups

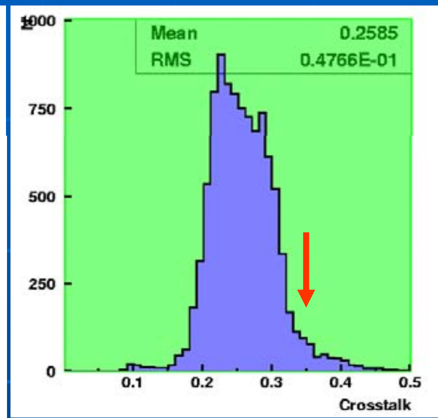
SiPM mass production

~ 10'000 SiPMs

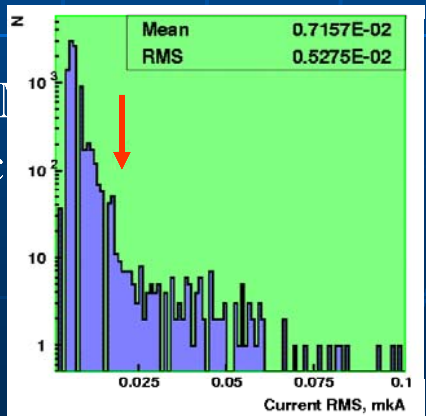
- Production at PULSAR, close collaboration with MEPHI
  - Tests on probe station
- Multi-stage selection procedu ITEP
  - Stability test at elevated ΔV
  - SiPM test bench with calibrated LED
  - Working point adjusted to 15 pixel/
  - Tile WLS SiPM system with Sr sourc
- Results in data base



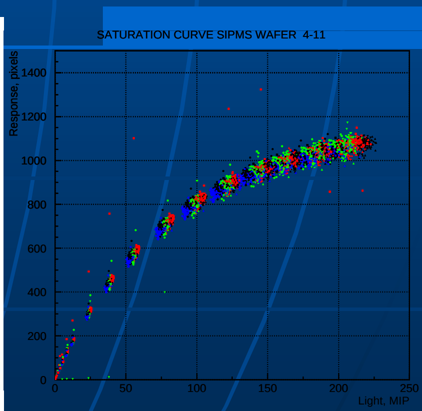
NOISE AT ½ MIP(7.5 pixels)



CROSS TALK



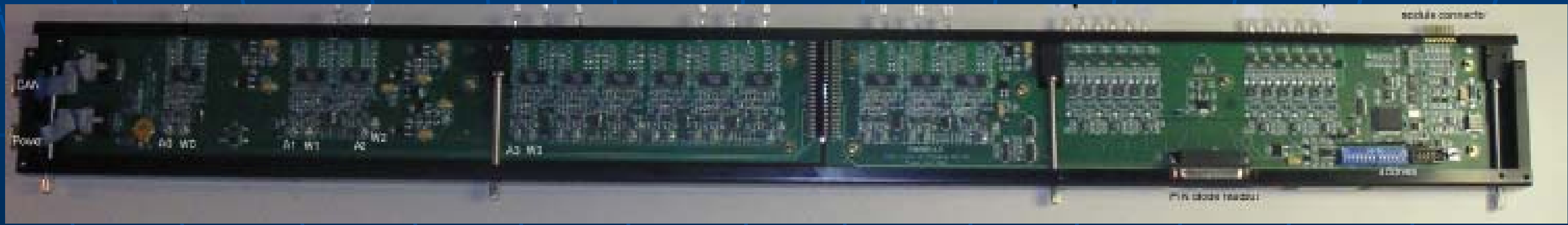
CURRENT STABILITY



SATURATION CURVE

Calibration and monitoring

- SiPM response varies by ~ 5% / K (depending on ΔV)
- The test beam prototype has a highly versatile and redundant LED based monitoring system (electronics: Prague)
  - 1 LED illuminates 18 tiles via fibre bundle
  - PIN-diode controled LED reference signals
  - Low light intensity for gain measurements (single p.e. peaks)
  - Large dynamic range for long-term test of saturation
    - Short pulse length (< 10 ns)
  - Temperature sensors
- Ultimately not needed, goal is here to establish procedures



Mechanics

- Versatile stack
  - Modular structure: absorber plates and cassettes
  - FE boards via connectors; can upgrade
  - Adjustable gap width
  - Exchangeable absorber material
  - Exchangeable active modules
  - Adjustable gap width

DESY

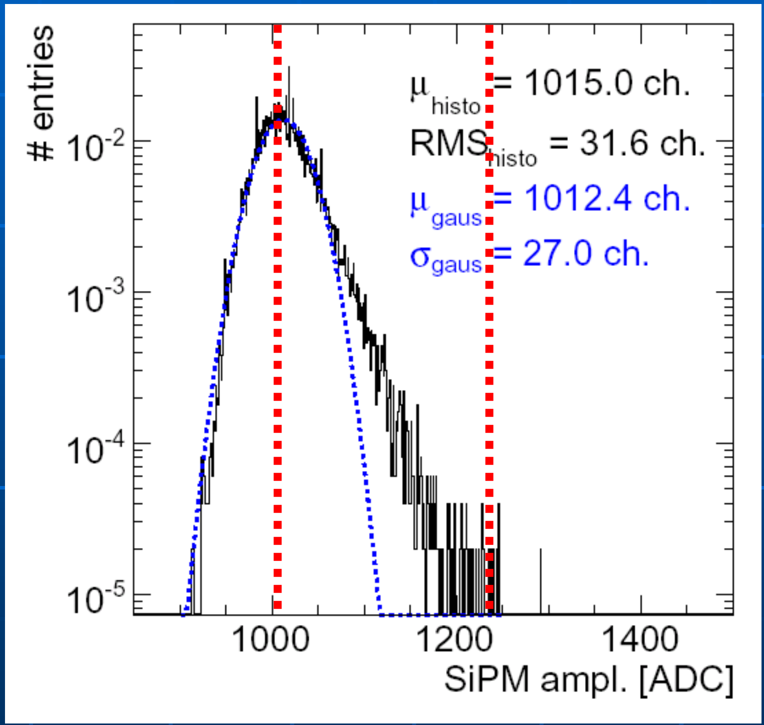
- Movable stage
  - Allow for inclined incidence through high granularity core
  - In situ exchange of active layers possible
  - Provisions for needs of gaseous detectors
  - Integration in CERN and FNAL beams prepared

Noise and dead channels

- Electronics noise (SiPM off): Gaussian, width ~1 p.e
- SiPM dark rate: tail
- Above threshold of ½ MIP:
  - 5 hits in 23 layers
  - Occupancy 10^{-3}
  - 3 MIP, 0.1 GeV equivalent
  - Higher in August data

- Channel statistics
  - 98% good
  - 1% bad soldering
  - 1% SiPM long discharge
    - From early selection, improved

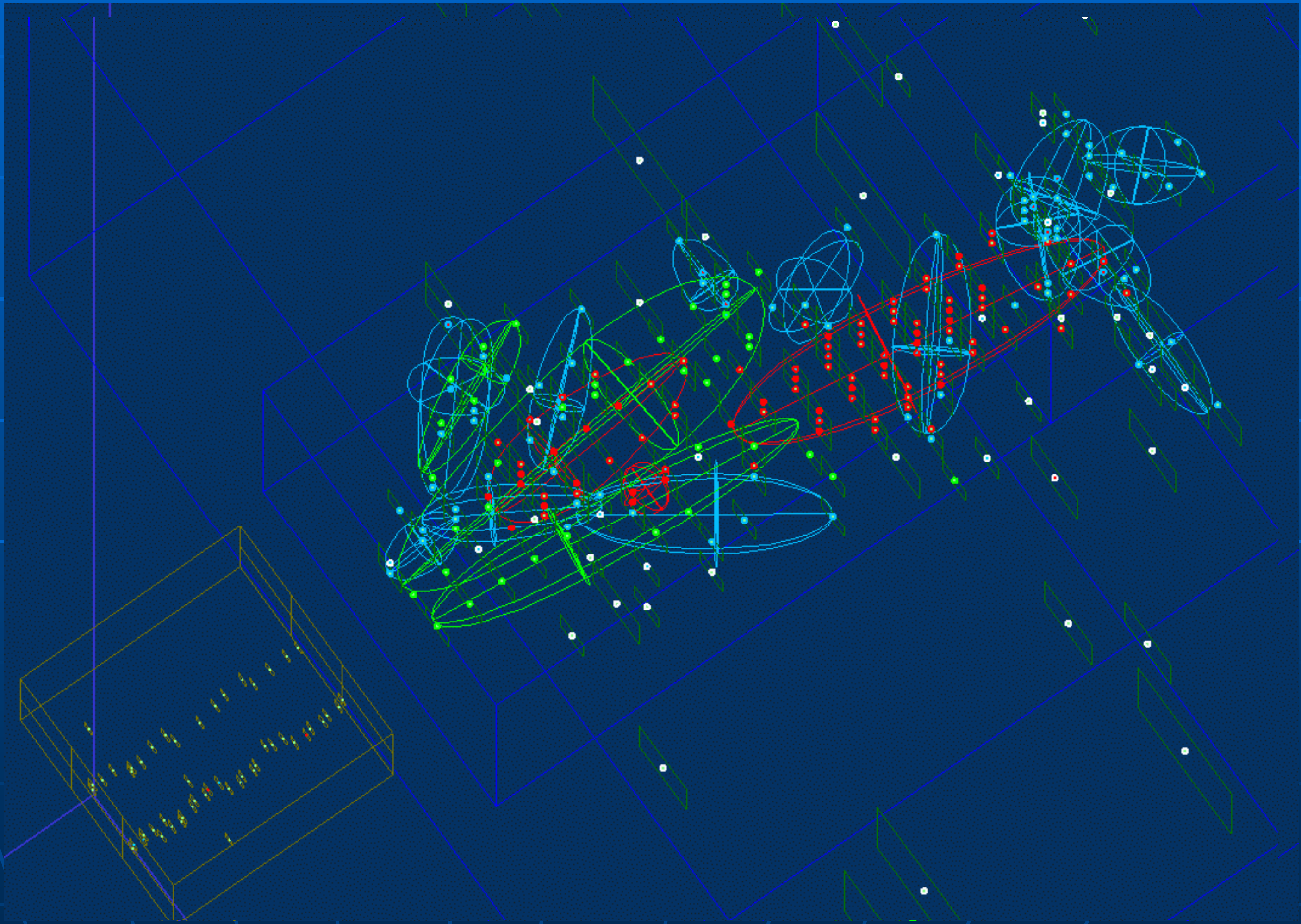
½ MIP



MIP = 450 ch, pixel = 30 ch

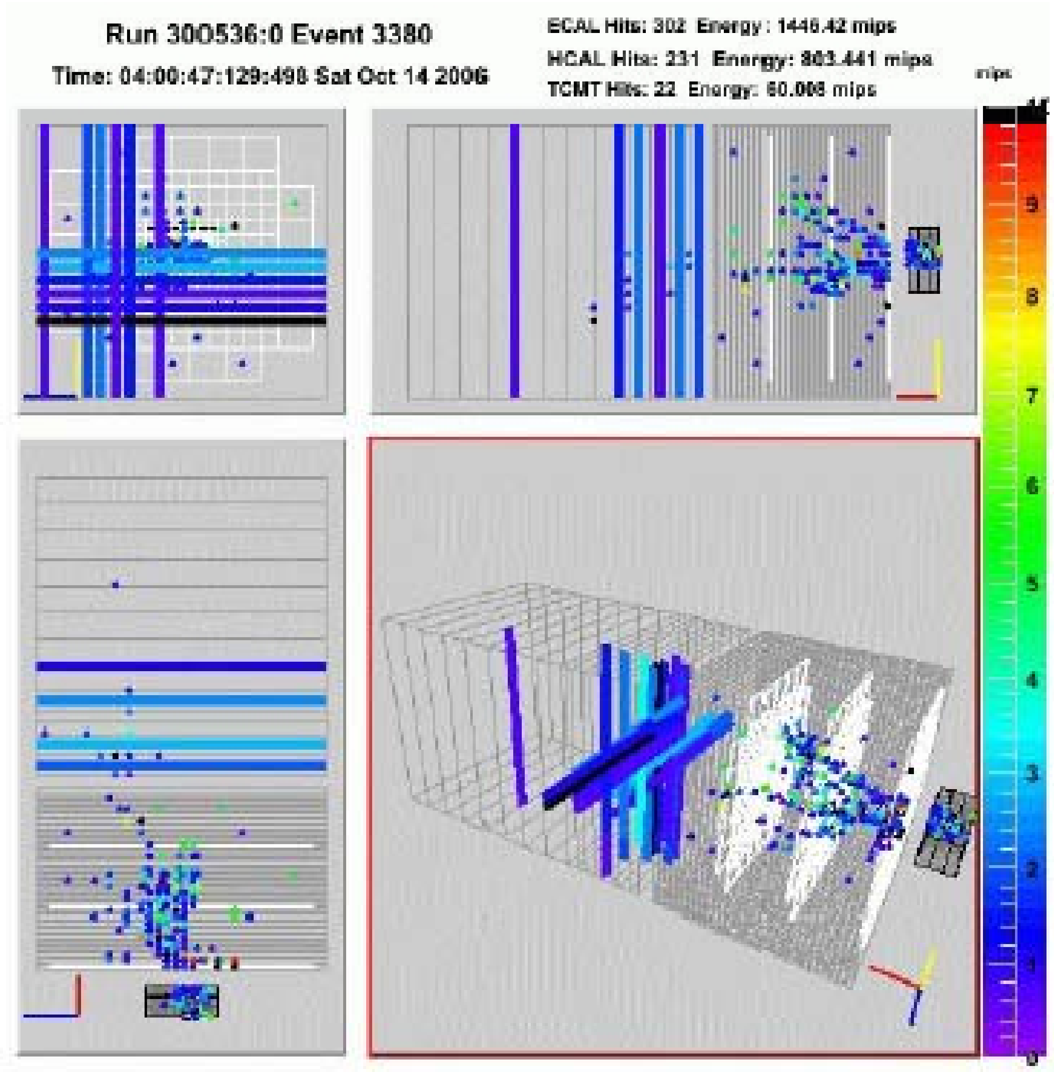
Two hadrons

- Starting point for particle flow studies
  - Event overlays
  - Frag-ments
  - …



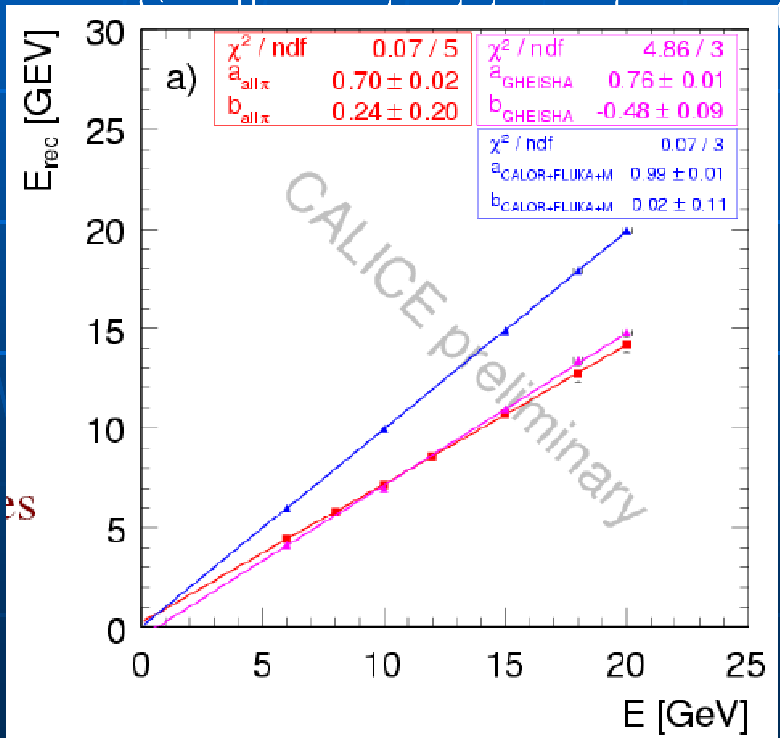
Pion Event display

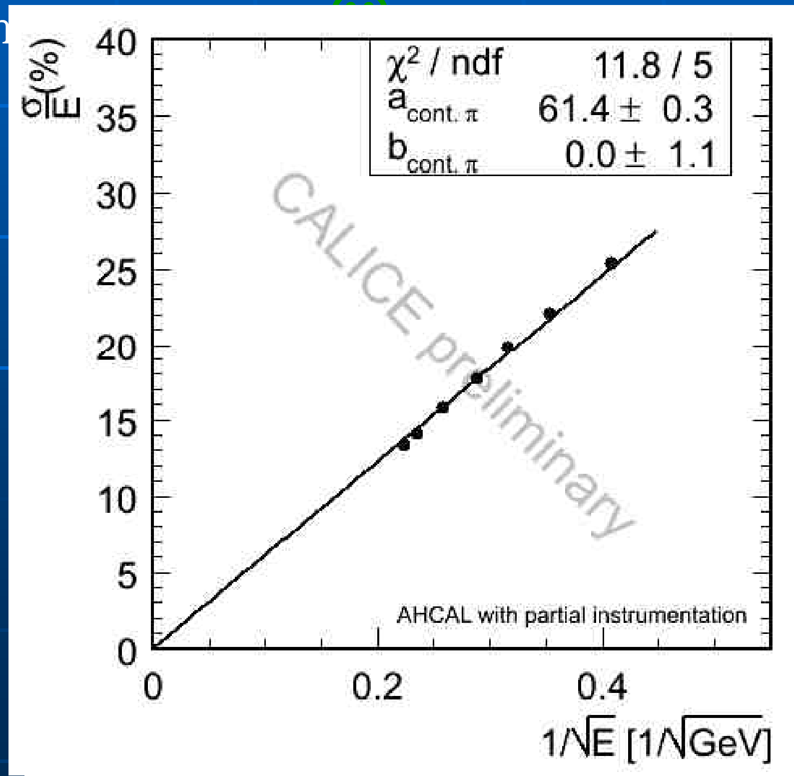
40 GeV π^- shower in the online display



Hadron data

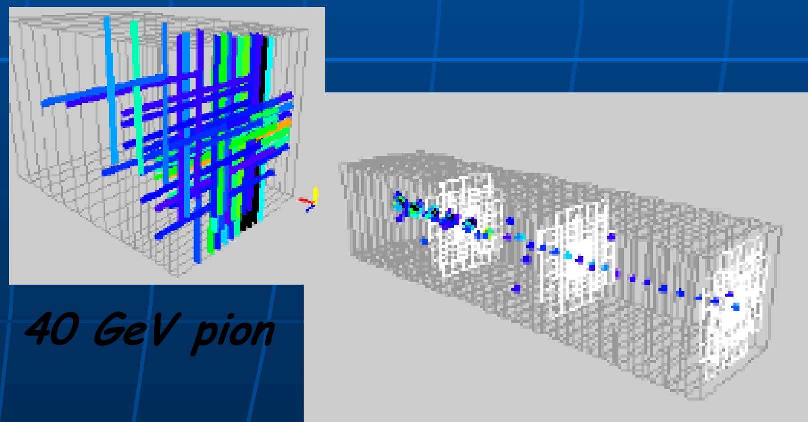
- Hadron data: linearity and resolution "within expectations"
  - Whatever this means: HCAL not complete yet, MC not digitized yet





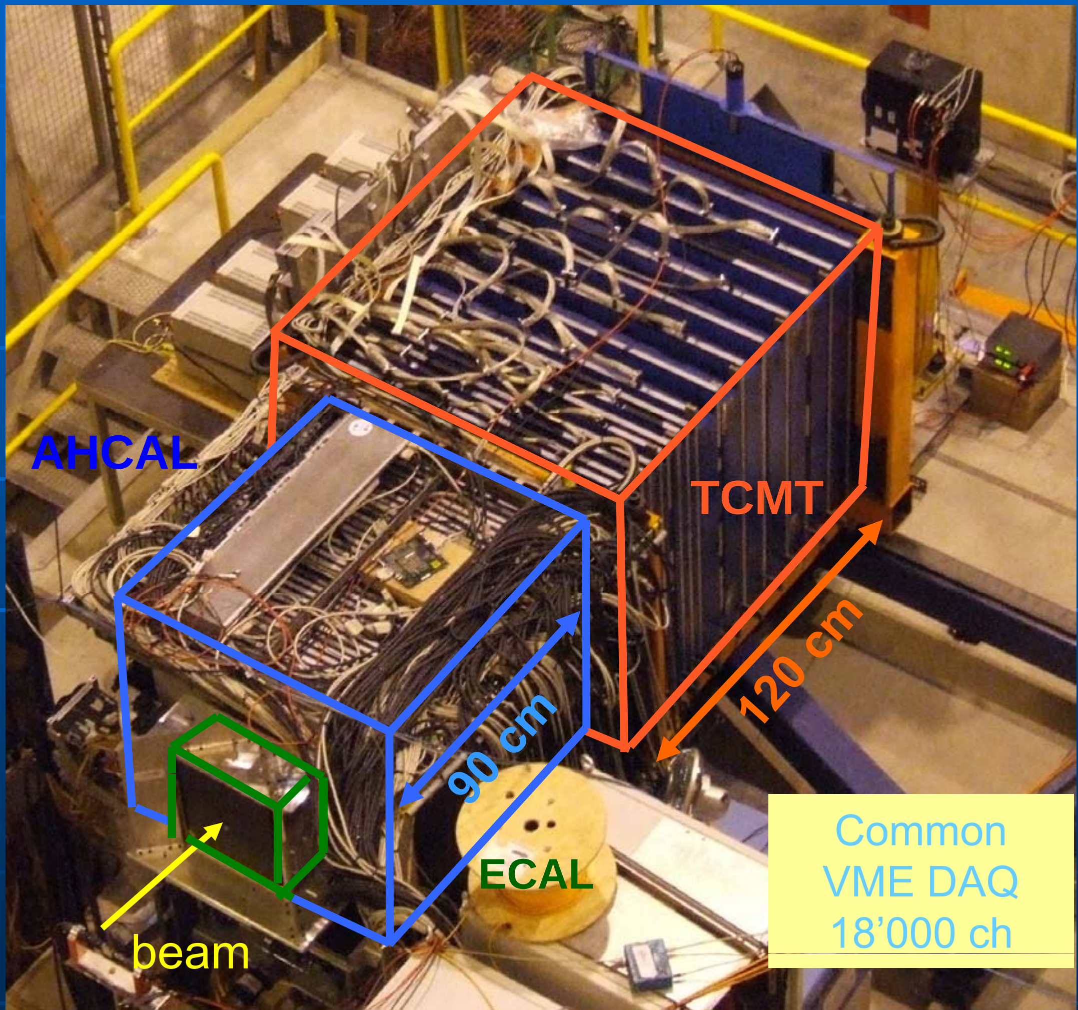
Tail Catcher Muon Tracker

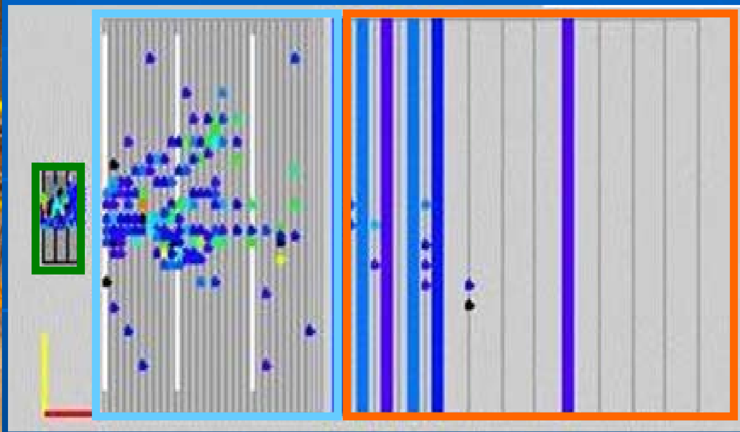
- Scintillator x and y strips ($100 \times 5 \times 0.5 cm^3$) WLS SIPM
- HCAL readout electronics (320 channels)
- NIU with DESY and FNAL



40 GeV pion

CALICE installation at CERN SPS



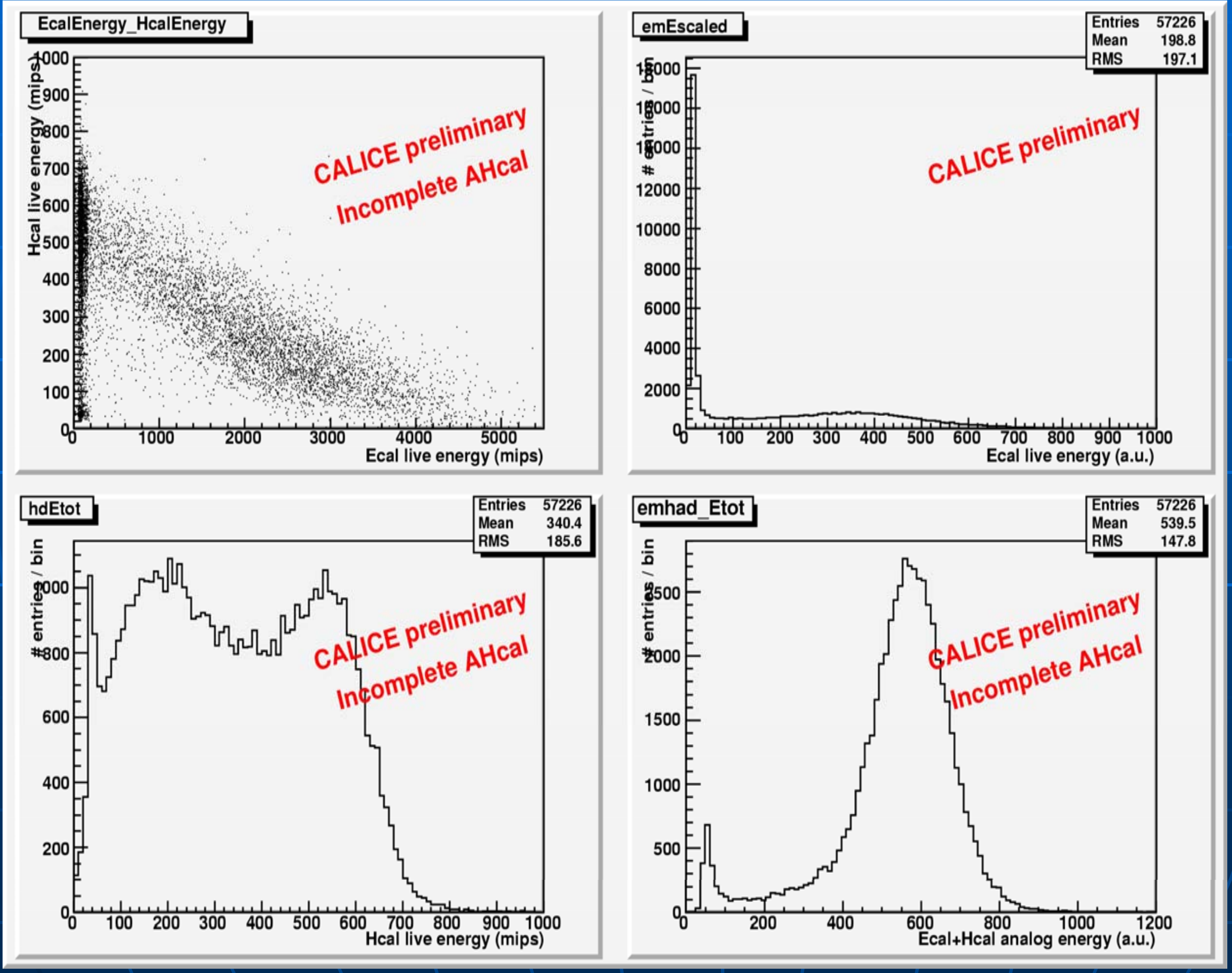


July - Nov. 2006
CALICE detectors installed in the H6b experimental hall at the CERN SPS

successful commissioning

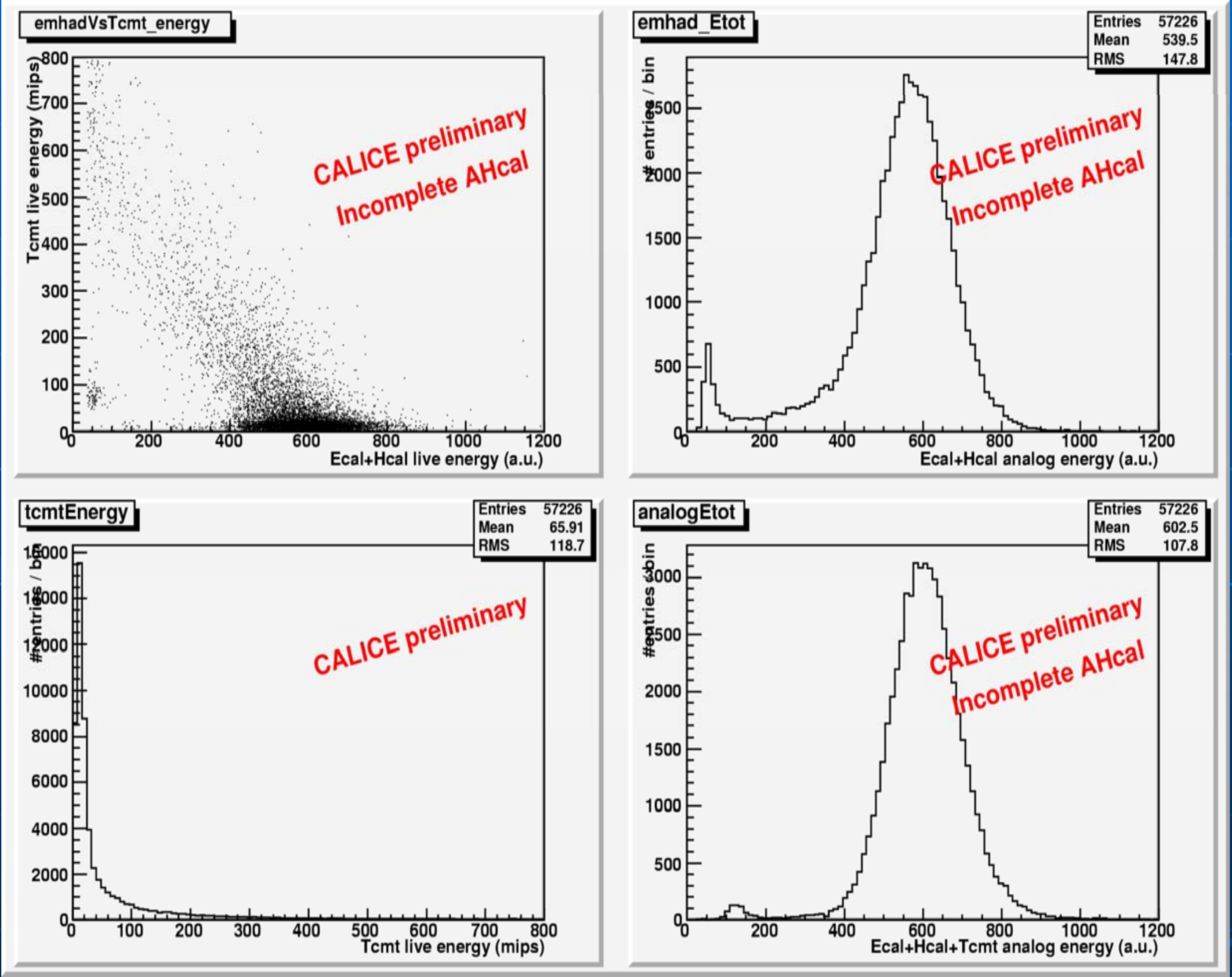
Hadron (electron) beam
6 - 100 (50) GeV

Combining ECAL & HCAL



20 GeV pions

Adding TCMT to ECAL & HCAL

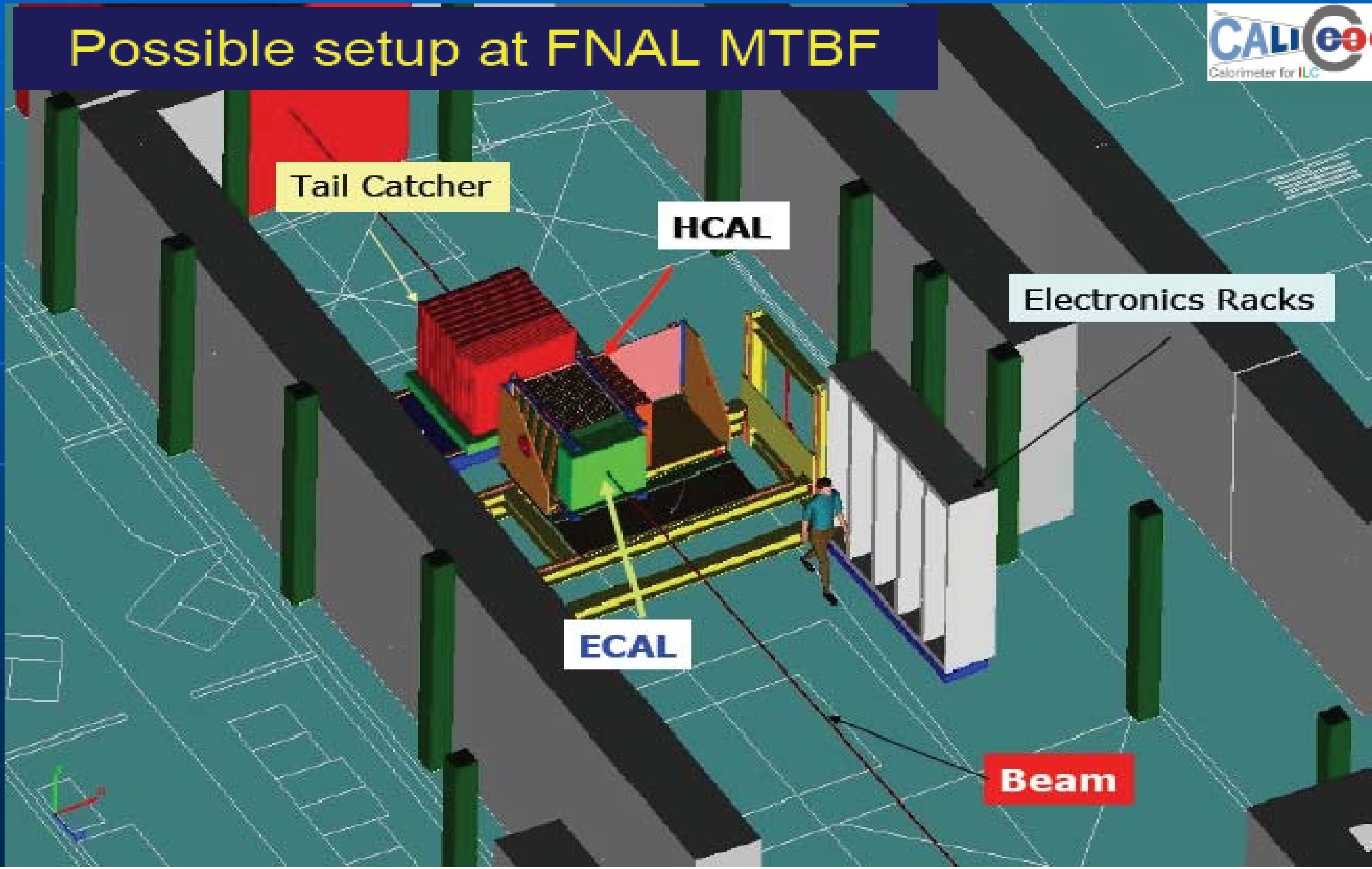


20 GeV pions

HCAL Testbeam Milestone

- CERN 2007: 2 periods of 3 weeks each in July and August
  - Use same beam line (H6) as in 2006
  - Complete detector, angular incidence for HCAL and combined data
- Move to FNAL end of this year
- Goals at FNAL 2008:
  - Low energy hadrons (1 GeV), particle ID
  - CERN FNAL connection of data samples
  - Gas scintillator comparison reference points
  - Common "all scintillator" run with Scint W ECAL (el'x being prepared)
- And beyond:
  - Test neutron hit tagging for PFLOW and Lead as HCAL absorber
  - Time-sensitive (2nd generation) electronics hadronic energy resolution
  - Maybe test strip option, *if* encouraged by simulation and PFLOW reconstruction studies

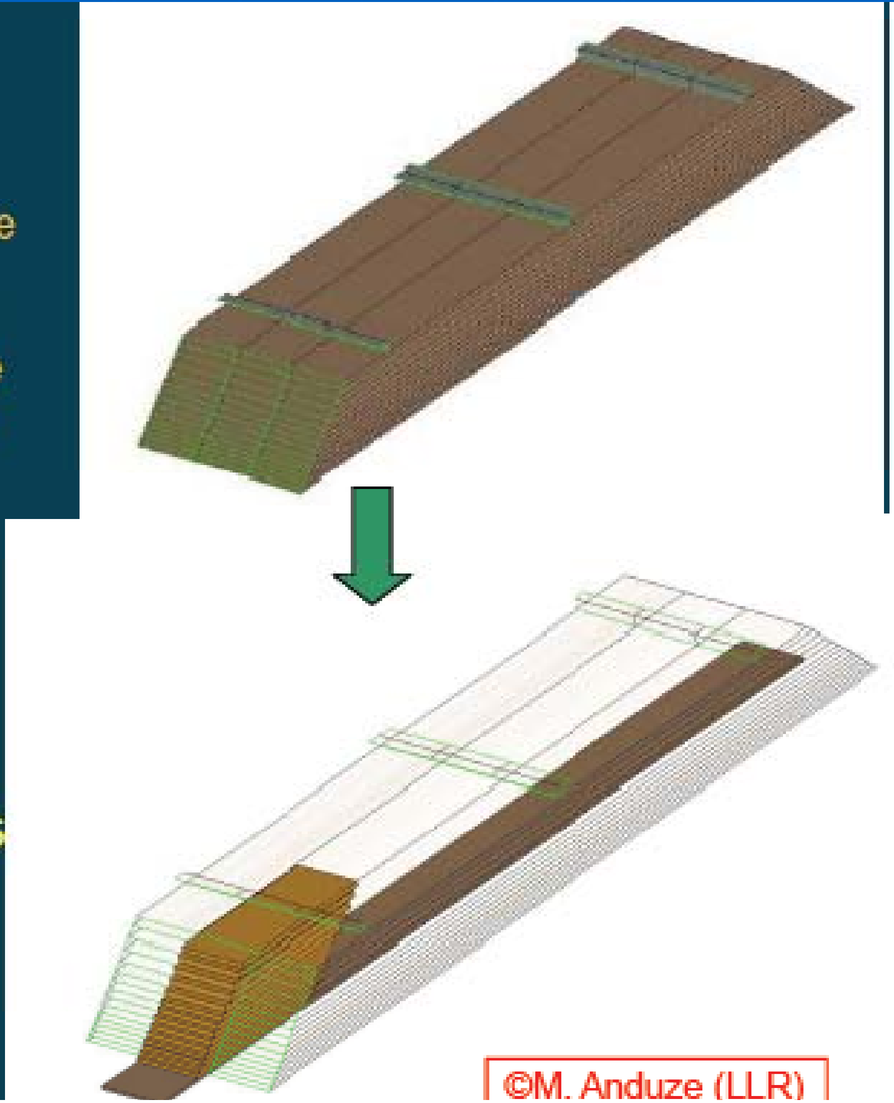
FNAL Test Beam



ECAL Technological Prototype

- Mechanical prototype of a (~ 1/2) module

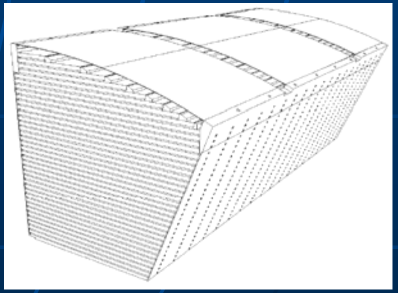
  150 cm long, 3x18 cm wide, 30 layers
  - partially equipped with detector: **one line & one column, 5x5 mm^2 cells**
  - 1800 + 10800 channels
  - Test full scale mechanics + PCB
  - Can go in test beam
  - Test full integration + edge connections
- Similar in channel # to physics prototype



HCAL technological prototype

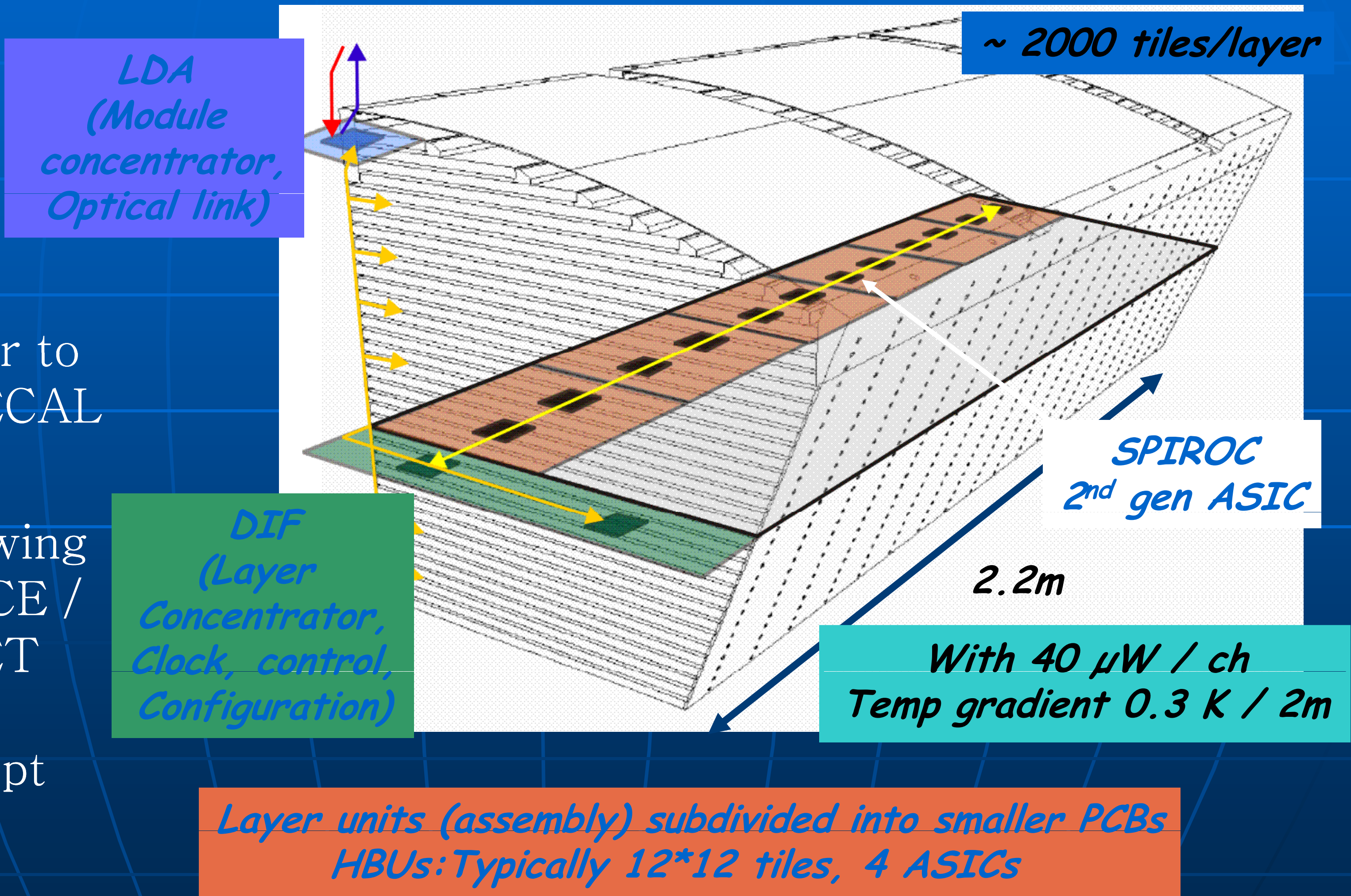
- Limitations of test beam prototype: not scalable
  - Front end electronics components can be integrated
  - Scintillator and active layer thickness can be minimized
  - Electronics can be optimized to SiPM signal
  - Calibration system can be simplified
  - Assembly can be less labour-consuming

- An example for a scintillator calorimeter with integrated photo-sensors does not exist
- Integration issues:
  - Tile SiPM coupling, tile positioning, SiPM connection
  - ASIC integration, power pulsing, power supply, cooling
  - PCB sub-division, interconnections
  - DAQ interface
  - Calibration system



Technical prototype architecture

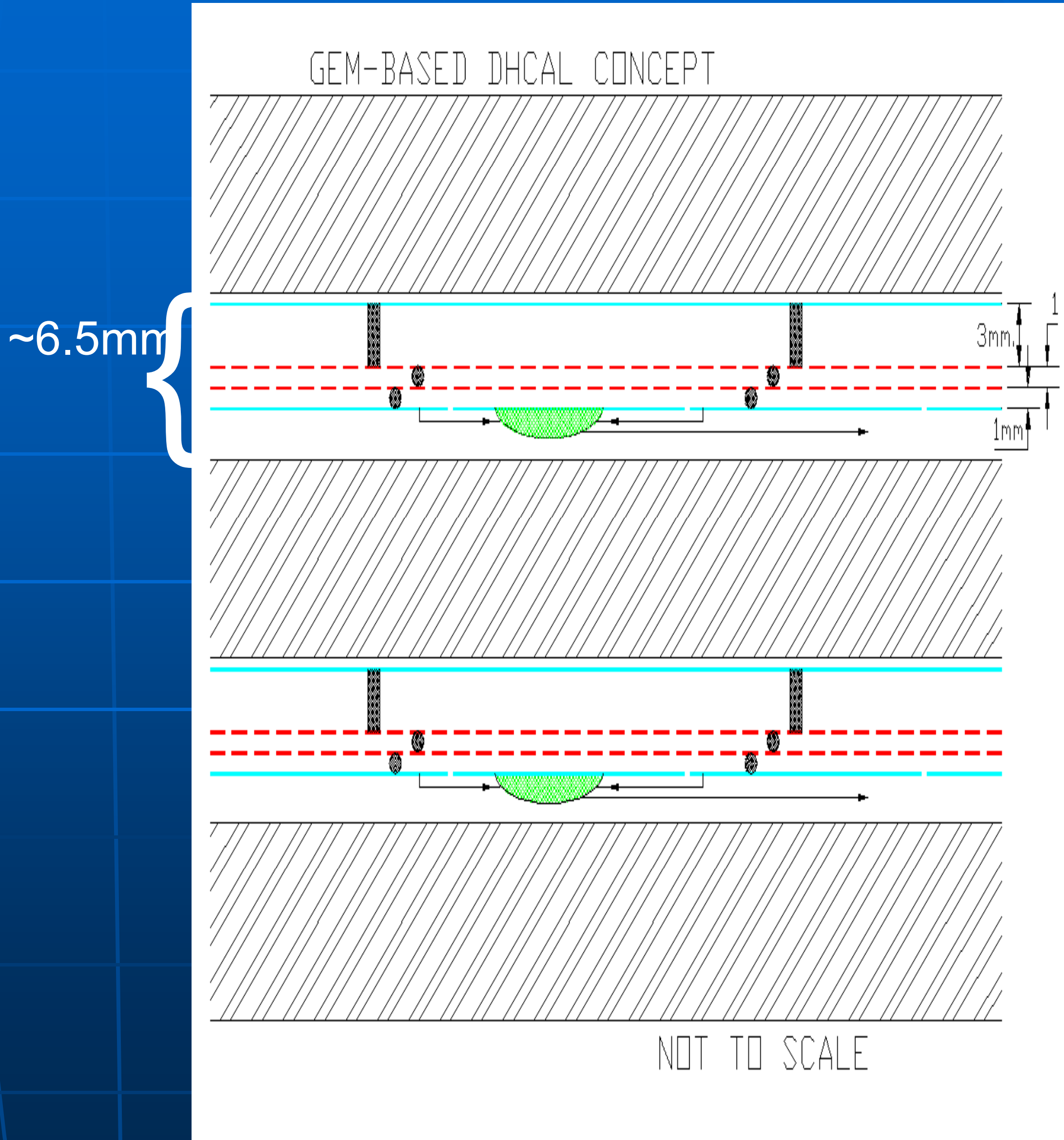
- Very similar to SiW ECAL
- Following CALICE / EUDET DAQ concept



DHCAL : RPC and GEM etc..

Basic Concepts

- Layer of gas detector sandwiched by absorber plates
- Embedded on-board digital electronics for rapid amplification
- Maintain active gap small to prevent excessive lateral shower spread

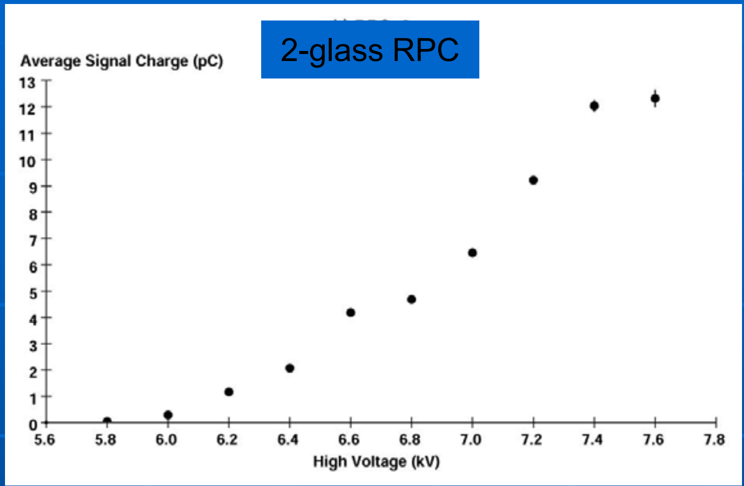


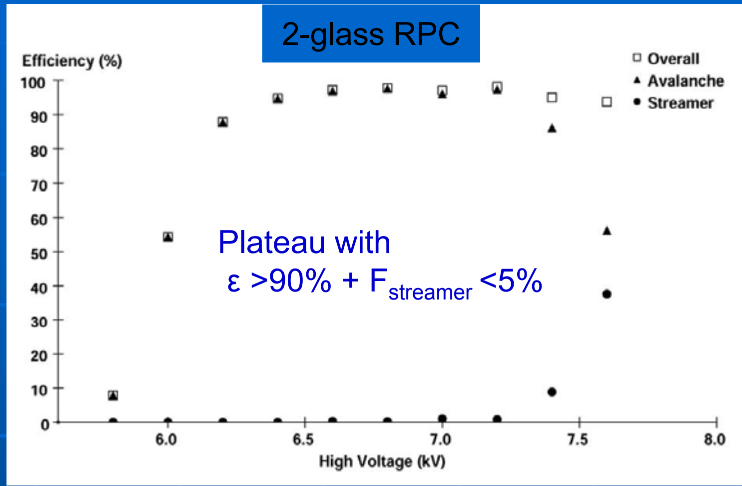
Active Media

- Resistive Plate Chambers (RPC): ANL and Protvino
  - Low cost and simple construction
  - Behaviors well understood
  - Rate limited by the recovery time (a few 100Hz)
- Gas Electron Multiplier (GEM): UTA
  - Low operation HV
  - Relatively new technology and characterization in progress
  - Short recovery time → can handle high rate
  - Large area coverage → GEM foil cost must be reduced
- Micromegas: LAPP, IPNL
  - R&D effort just begun
  - Similar to GEM
  - Cost relatively low

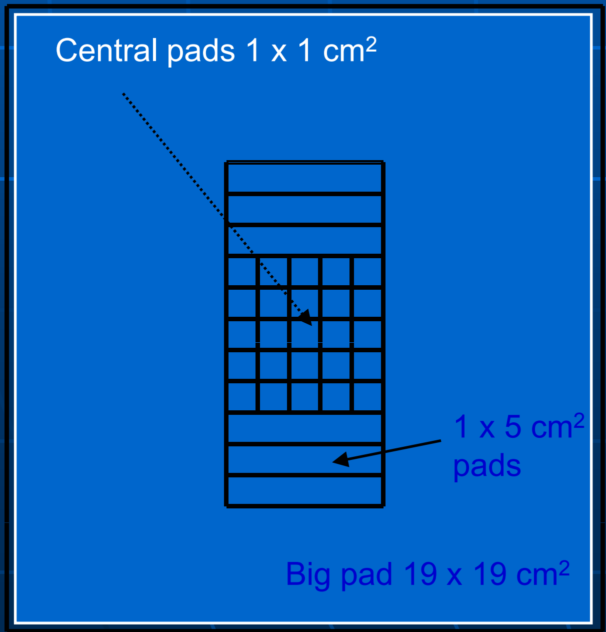
RPC Characterization Study Results

…some results with single readout pad of 16 x 16 cm^2



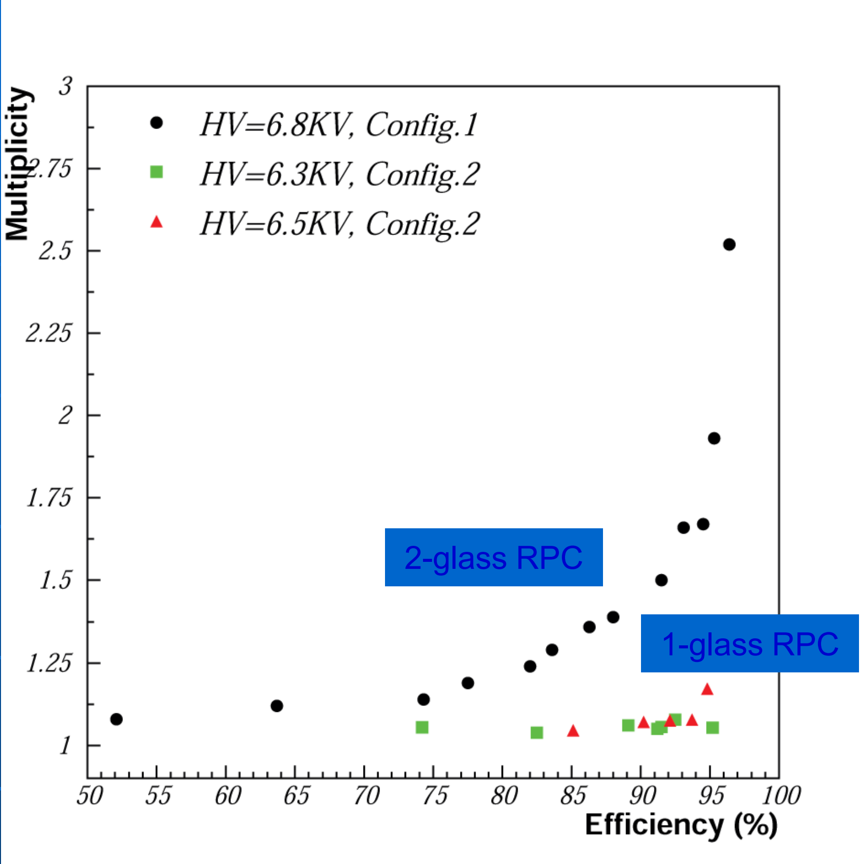


…some results with multiple readout pads of 1 x 1 cm^2



G. Drake *et al.*, NIM A, 2007.04.160

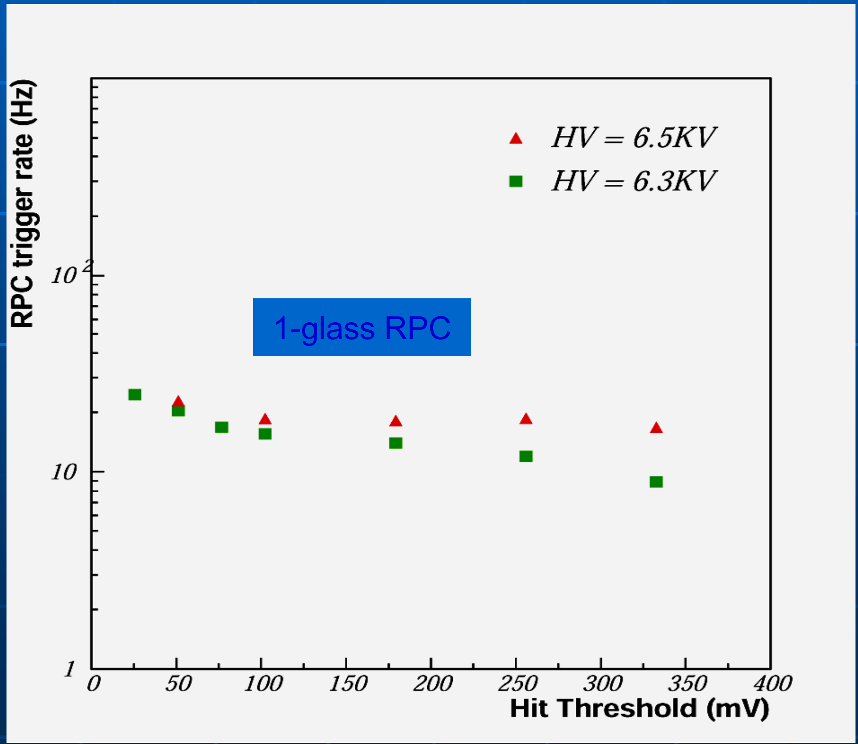
RPC Characterization Study Results, cnt'd



Pad multiplicity much reduced with 1-glass RPC

For ε ~ 70 - 95% → M ~ 1.1

(this result recently confirmed by the Protvino group)



Long-term stability of 1glass RPC to be proven`

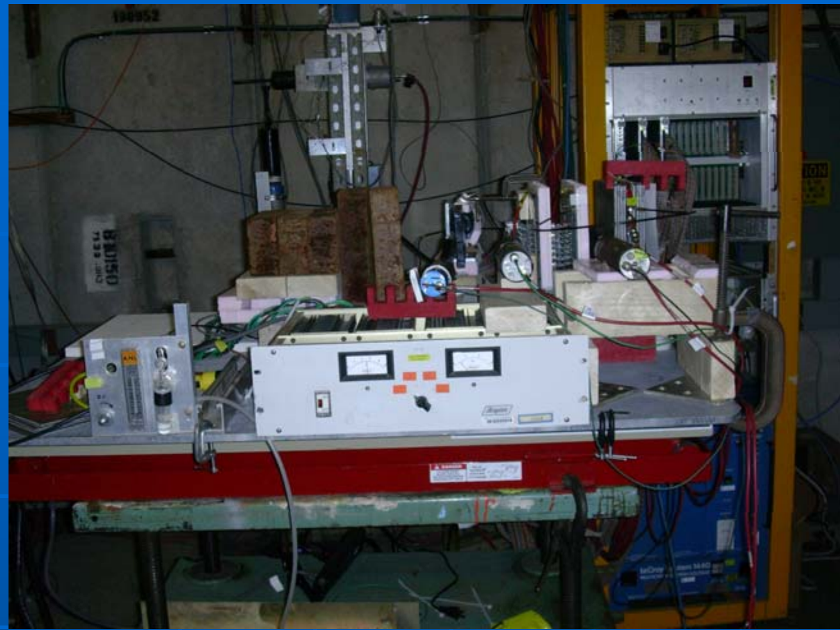
C) RPC Test beam @ FNAL

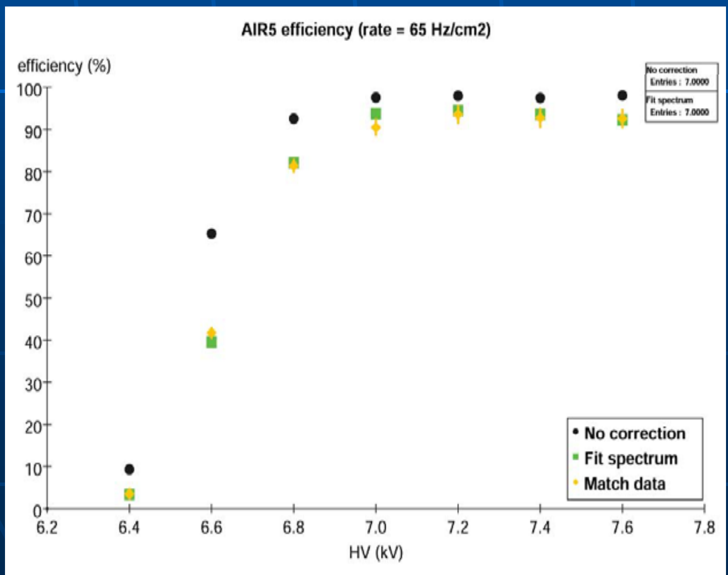
Tests included 3 chambers

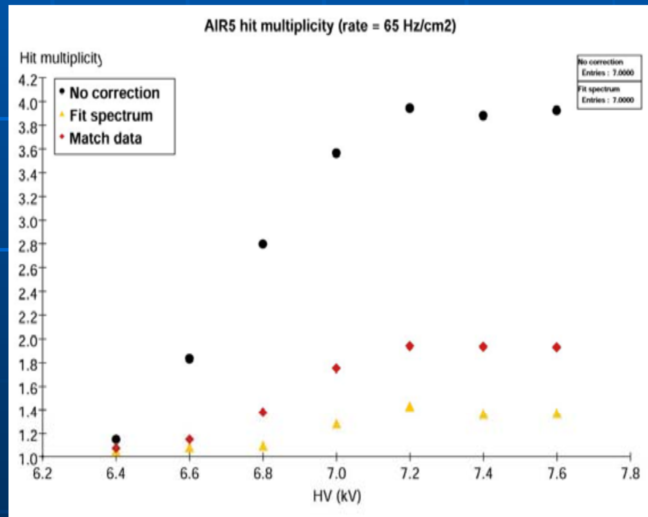
2-glass RPC with digital readout
1-glass RPC with digital readout
(2-glass RPC with independent digital readout)

Tests took place in February 2006

Mostly ran with 120 GeV protons







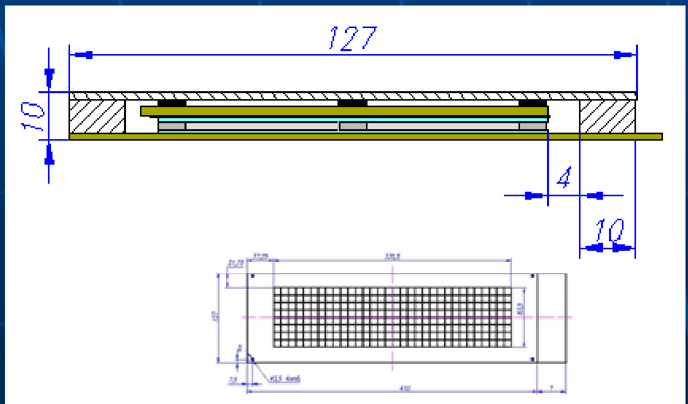
Great learning experience !!!!
Results (after corrections) confirmed previous measurements with cosmic rays

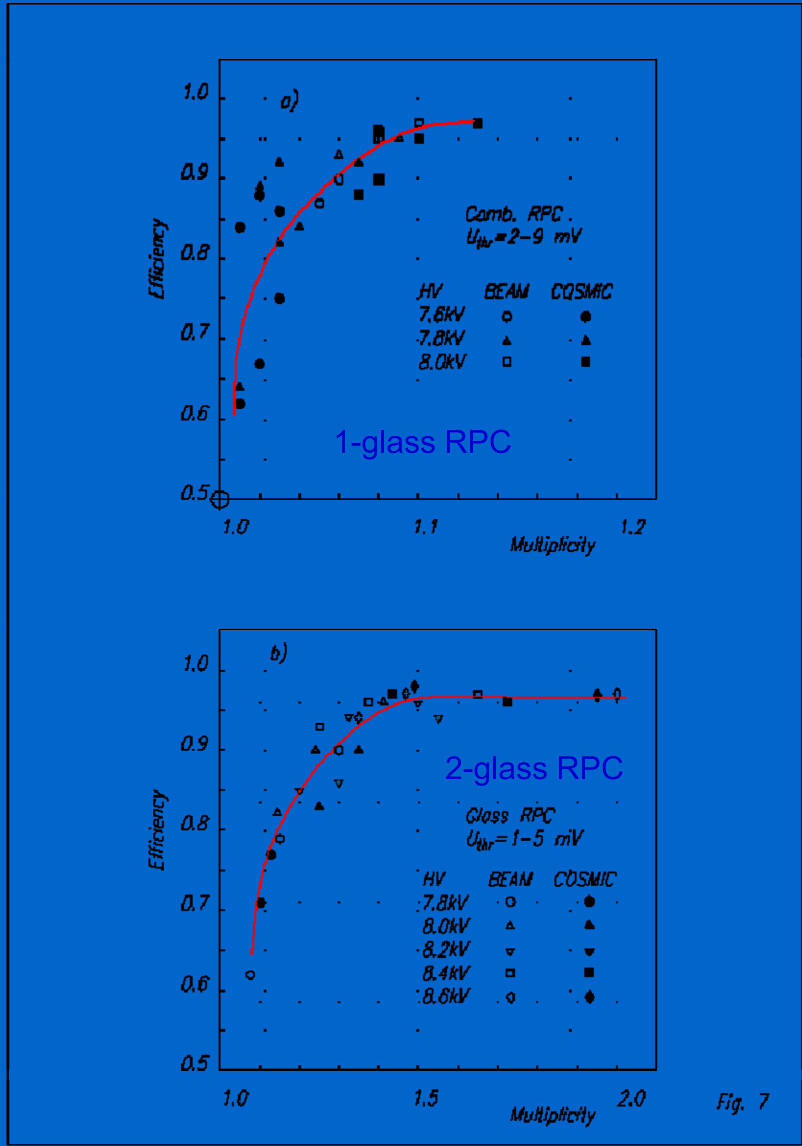
RPC construction and testing (Protvino)

Measurements with 1-glass plate chambers
- Pad multiplicity ~1.1 for an efficiency of 95%
- Confirms results obtained at ANL
- Long term tests ongoing

Constructed 4 chambers with 8x32 pads
- One sent to Lyon for testing
- Others waiting for MAROC chip + FE-board
- Successfully tested with strip readout

Preparation for 1 m^2 chamber construction
- Preparation of facility
- Cosmic ray test stand being assembled
- Design being finalized





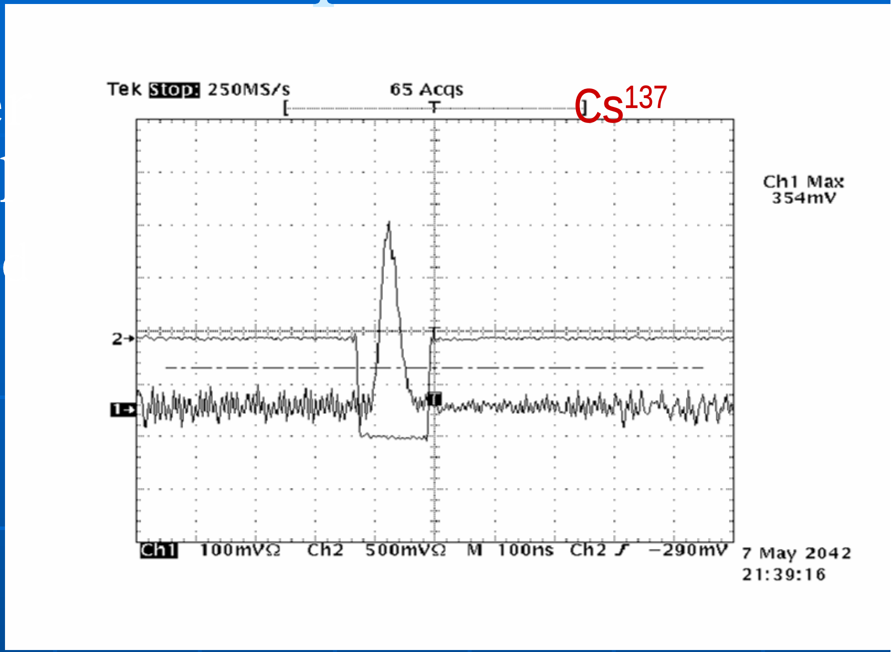
Summary of R&D with RPCs

Measurement	RPC Russia	RPC US
Signal characterization	yes	yes
HV dependence	yes	yes
Single pad efficiencies	yes	yes
Geometrical efficiency	yes	yes
Tests with different gases	yes	yes
Mechanical properties	?	yes
Multi-pad efficiencies	yes	yes
Hit multiplicities	yes	yes
Noise rates	yes	yes
Rate capability	yes	yes
Tests in 5 T field	yes	no
Tests in particle beams	yes	yes
Long term tests	ongoing	ongoing
Design of larger chamber	ongoing	ongoing

Many R&D topics completed

GEM DHCAL Development

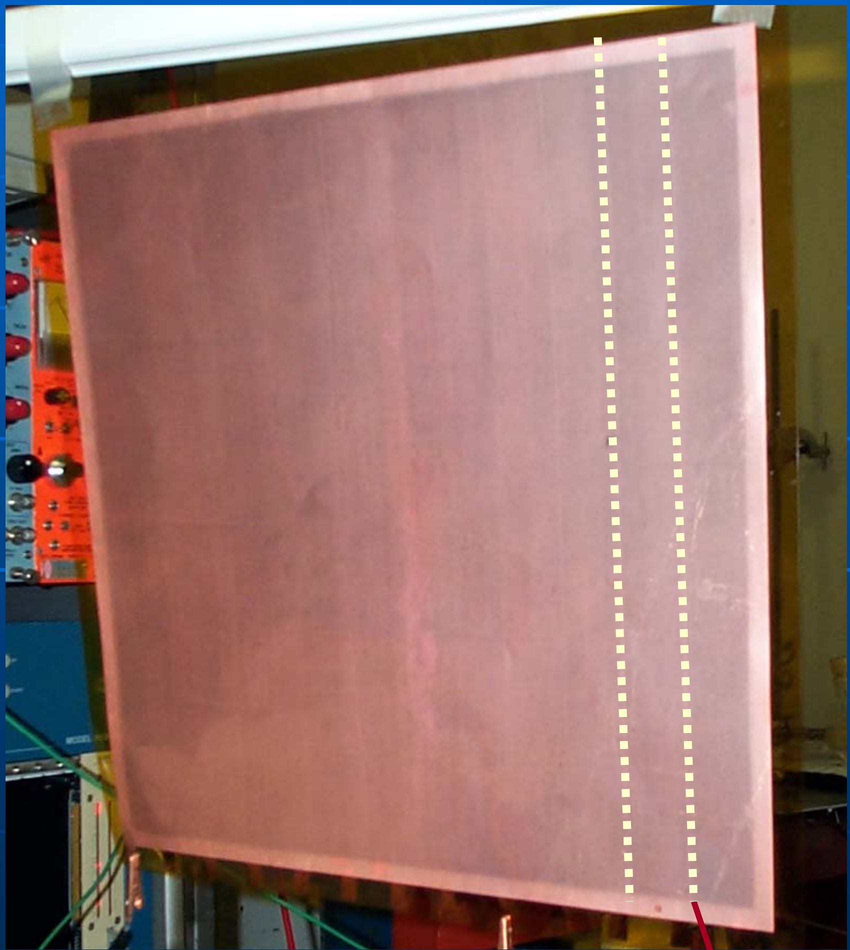
- Constructed prototype chambe
w/ 10cmx10cm CERN GEM foi
  - Understood basic signal shape an
behaviors of GEM foil chambers
  - Understood issues related to
constructing chambers



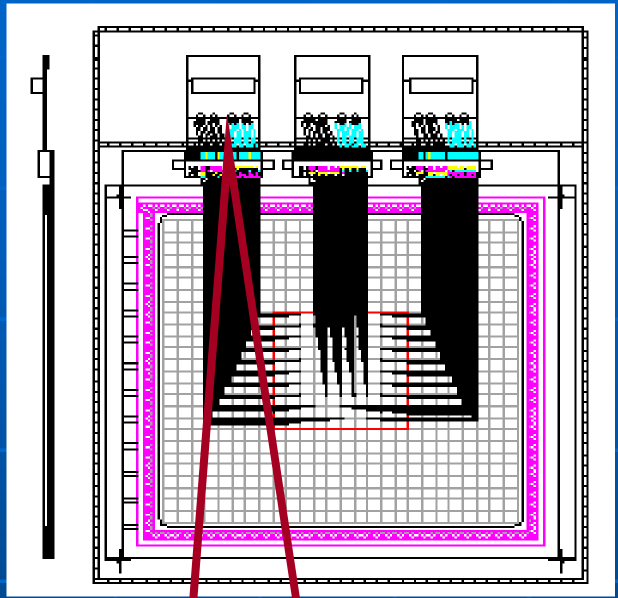
- Developed 30cmx30cm GEM foils with 3M Inc.
  - Foils HV tested and certified
  - Jigs made to mount foils, stack chamber.
  - Multilayer 30cmx30cm anode board made to work w/ Fermilab QPA02-based preamp cards
  - Continually operated, verifying operational stability
- Constructed and beam tested several chambers using these 30cmx30cm foils for beam tests for characterization

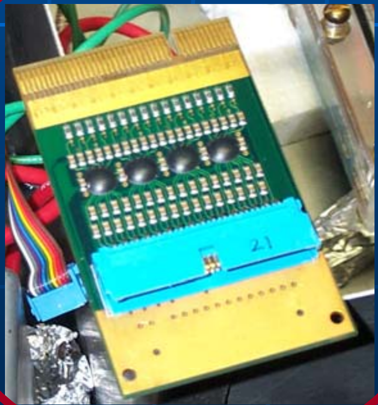
30cm x 30cm 3M GEM foils

12 HV sectors on one side of each foil.



HV Sector Boundary





Preamps configured to read 96 pads in the center

Use 32 channel FNAL preamps

GEM Beam Tests

- KAERI in May 2006
  - Exposed a 30cmx30cm chamber to high flux, low energy electron beams
  - Exposure dosage equivalent to about 10 years of ILC running
  - No issues with the chamber operation found

- FNAL-MTBF in Spring 2007
  - Chamber characterization runs
  - 8 GeV mixed beam and 120 GeV protons
  - Data analysis in progress

Some GEM Results

- At the bench test using Sr90 source
  - W/ 40mV threshold ➔ 95% MiP efficiency observed
    - Consistent with our simulation study
  - Multiplicity: ~ 1.27
- From the beam test, the initial measurement of efficiency on 1cmx1cm pad
  - ~90% on the center 1cmx1cm pad when beam is well constrained on the pad
    - Corrections for multi particle events in the 200ns trigger gate needed
  - Initial measurement of the cross talk rates
    - In the two neighboring pads ➔ <25% but need to clean up results
  - Initial studies on double proton events show about 20% double proton events
  - Initial noise rate measurement : <0.2Hz

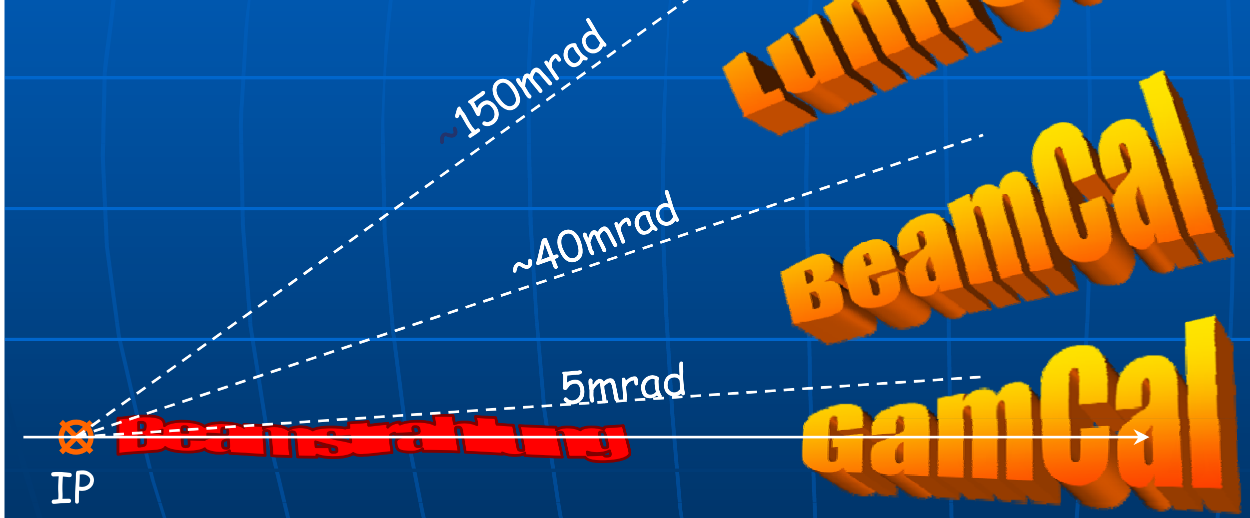
RPC&GEM Schedule and Plans

- Late 2007 – Mid 2008
  - Complete $1m^3$ prototype RPC
  - Construct large scale GEM unit boards (30cmx1m)
  - Start constructing GEM chambers for $1m^3$ prototype if funding allows
  - Test 8X32 fully equipped GRPC/μMEGAS w/ 2^{nd} generation ASICs at DESY
- Mid – late 2008
  - Complete RPC beam exposure for MC validation together with CALICE Si/W and/or Sc/W ECAL
  - Construct a large area ($1m^2$) fully equipped GRPC/μMEGAS w/ 2^{nd} generation ASICs and test at FNAL
  - Start GEM $1m^3$ prototype stack construction
  - Beam test TGEM based prototype as an alternate, cost reducing solution
- Late 2008 – 2009
  - Complete GEM $1m^3$ prototype stack
  - Beam exposure of (hopefully) a full 40 layer stack GEM DHCAL
  - Prototype stack w/ 2^{nd} generation ASICs and mechanics

FCAL

ECal and Very Forward Tracker acceptance region.

Physics at the ILC, e.g.:
10^6 ($e^+e^- \rightarrow W^+W^-$) per year
10^6 ($e^+e^- \rightarrow q^+q^-$) per year
GigaZ: 10^9 events per year



•Precise measurement of the integrated luminosity ($\Delta L/L \sim 10^{-4}$)
•Provide 2-photon veto

•Provide 2-photon veto
•Serve the beamdiagnostics using beamstrahlung pairs

•Serve the beamdiagnostics using beamstrahlung photons

<u>Challenges:</u>

<u>High precision, high occupancy, high radiation dose, fast read-out!</u>

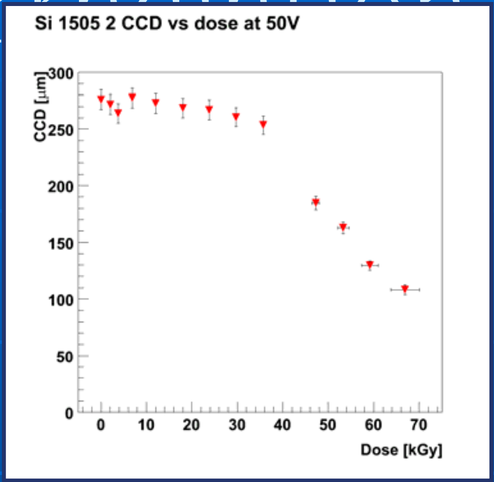
FCAL Status

- The FCAL Collaboration develops the detectors in the very forward re gion of the ILC independent of a detector concept.
- MC simulations allowed to develop a very clear understanding of the p hysics background, beam-beam effects and the requirements on positi oning and precision.
- Precision and position monitoring is essential for the LumiCal. Radiati on hard sensors are of crucial importance for the BeamCal.
- We have an intensive R&D activity on radiation hard sensors. We inve stigate CVD diamond, GaAs, SiC and start to investigate radiation hard Si.

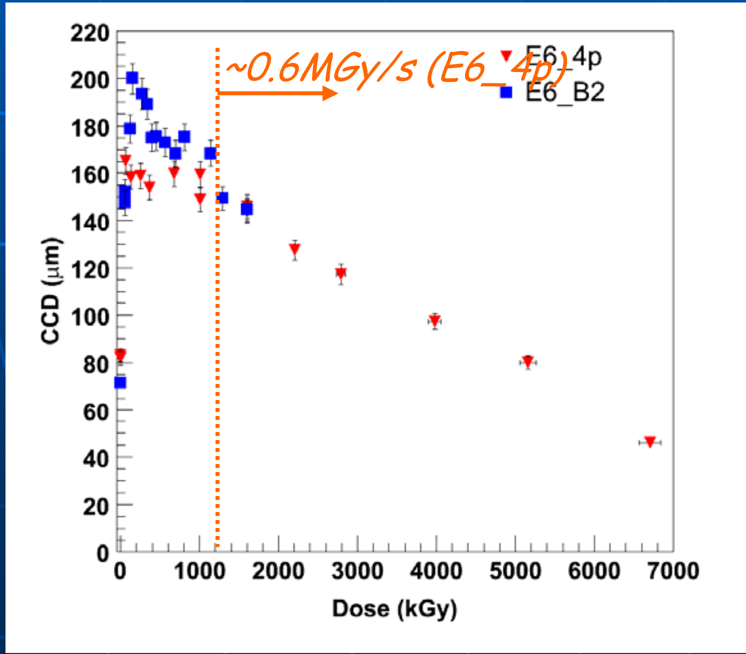
Results for High Dose Irradiation

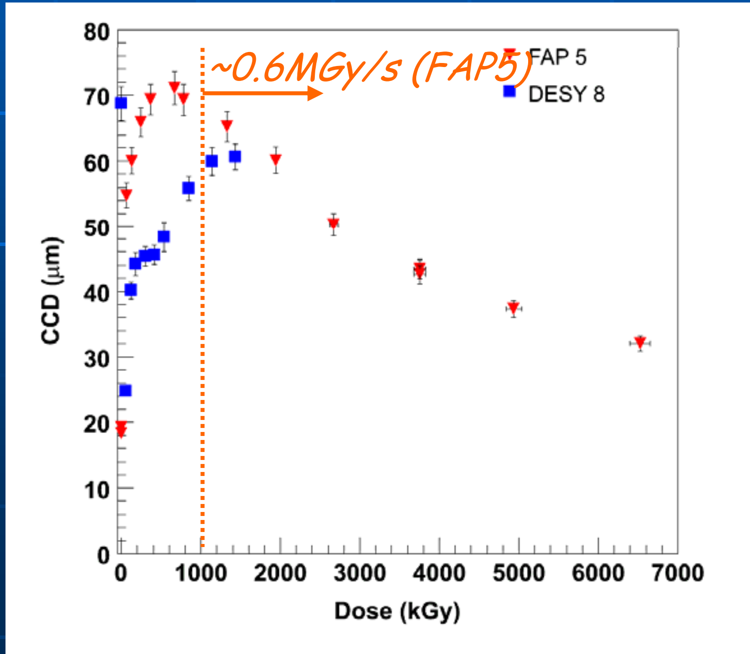
Test beam at the
S-DALINAC
Tech. University of Darmstadt

Silicon starts to degrade at 30 kGy.
High leakage currents.
Not recoverable.



CVD diamonds still operational after absorbing 7MGy.





Summary

- ECAL(Si/W,Sc/W) prototype has been tested with beam and preliminary results out
- HCAL (Sc/Fe, RPC and GEM) Prototype also
- More test beam will happen with more prototype mainly at Fermilab for the next few years
- Efforts have been started for technological prototypes
- Fruitful results expected at the next meeting.