Scintillator HCAL project overview

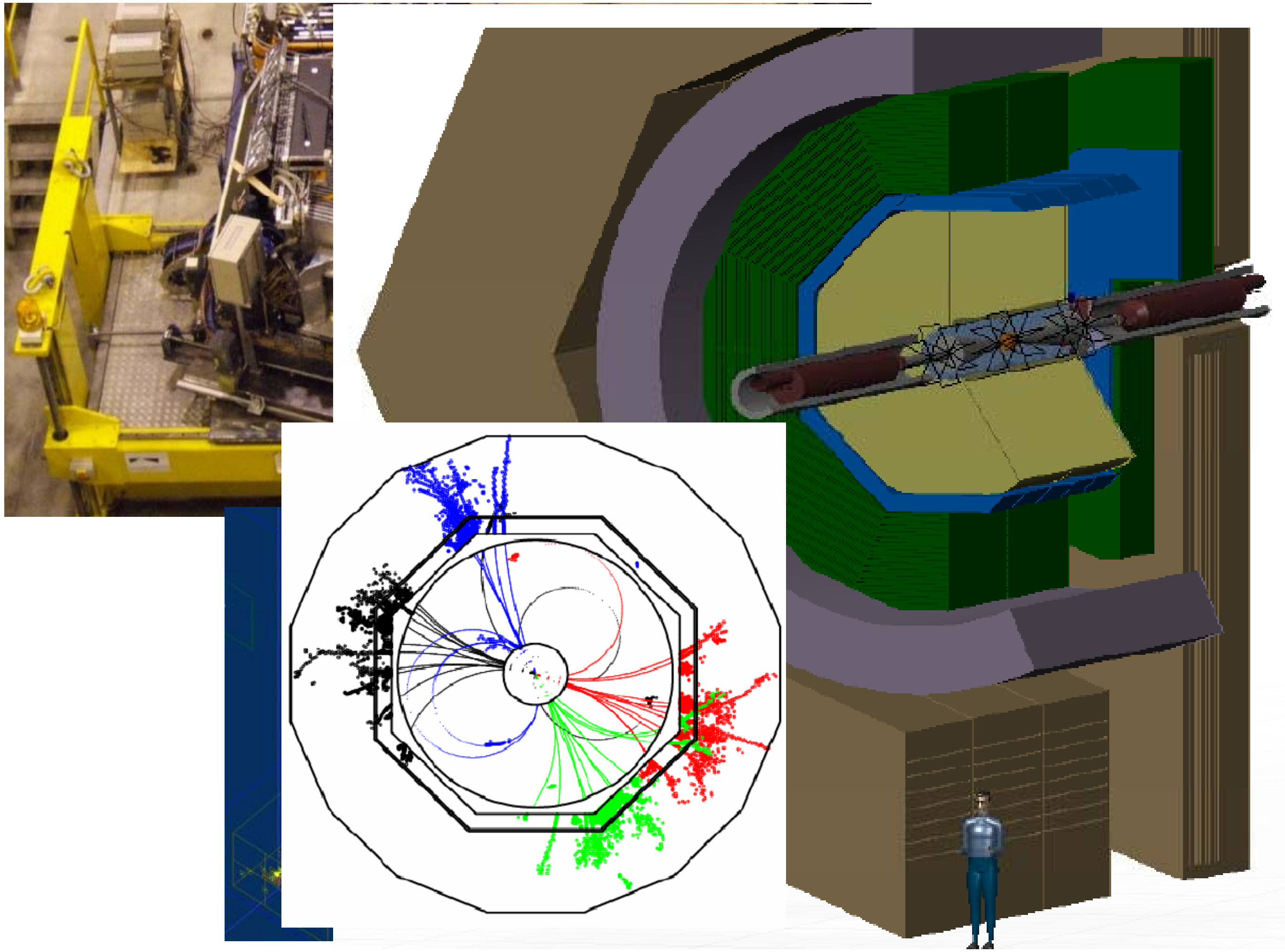
Felix Sefkow

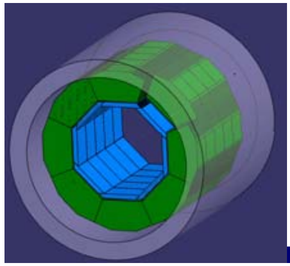
HCAL Main Meeting
June 30, 2008

Where we are, where we go:

- Analysis: status and opportunities
- Test beam at FNAL
- R&D, EUDET and beyond

From proof-of principle to reality





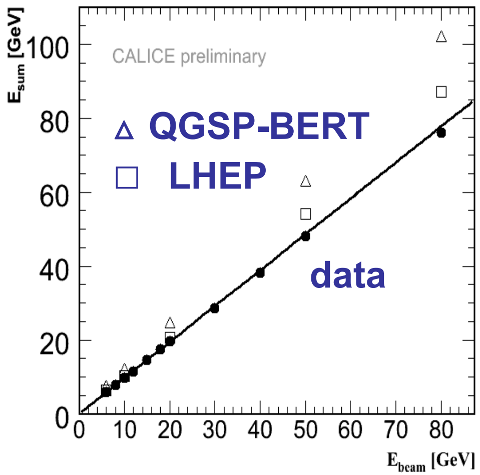
Validate shower models

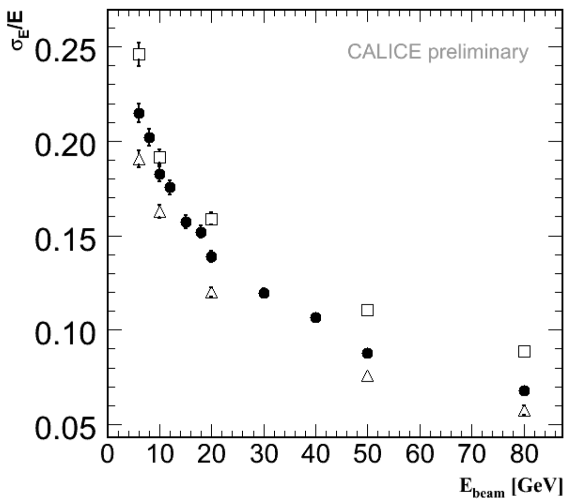
M. Thomson (Cambride)

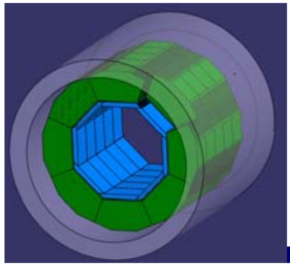
1. Model uncertainties on PFLOW performance

(PandoraPFAv02 +trackCheater)		E_{JET}	$\sigma_E/E = \alpha/\sqrt{E_{jj}}$ $\lvert\cos\theta\rvert<0.7$
LDC00Sc	QGSP_BERT	45 GeV	22.6 %
LDC00Sc	LHEP	45 GeV	23.2 %
LDC00Sc	QGSP_BERT	100 GeV	29.3 %
LDC00Sc	LHEP	100 GeV	30.2 %

2. Confront shower models with test beam data
   - First results on global properties
   - Next: fully exploit granularity for fine structure

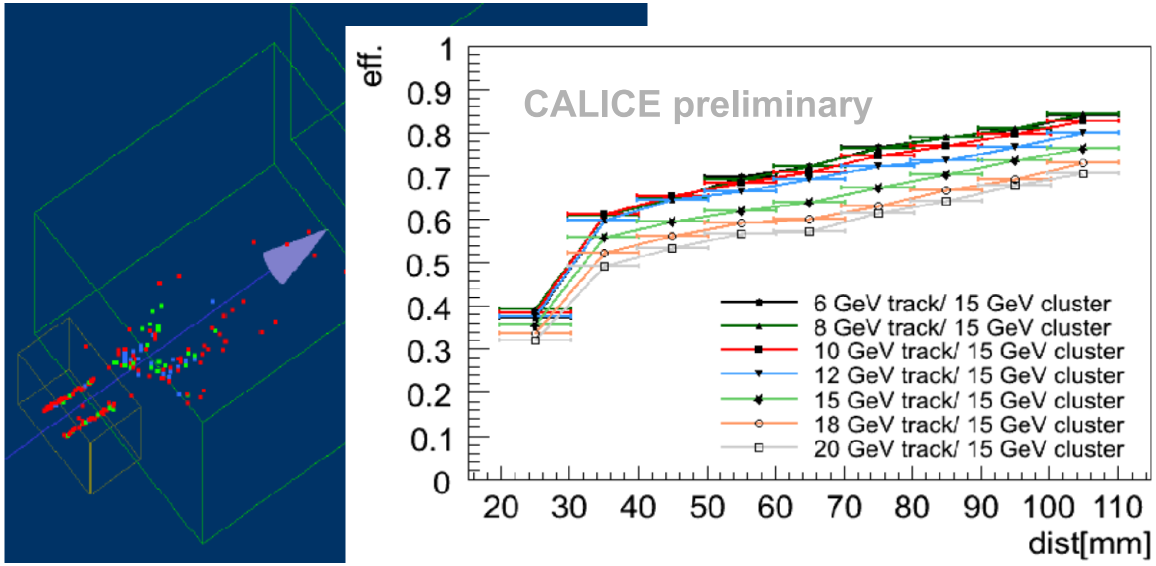


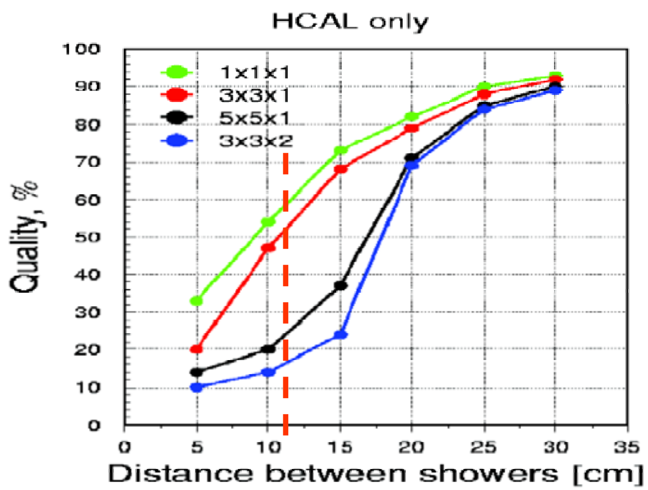




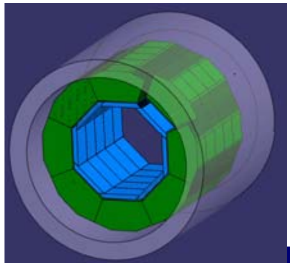
Validate PFLOW performance

- Test beam 'jets' would require magnet and tracker (future)
- Jet energy resolution depends on hadronic energy resolution and confusion
- High granularity, low occupancy: use event overlay techniques
- Two particle separation in test beam data and Monte Carlo:





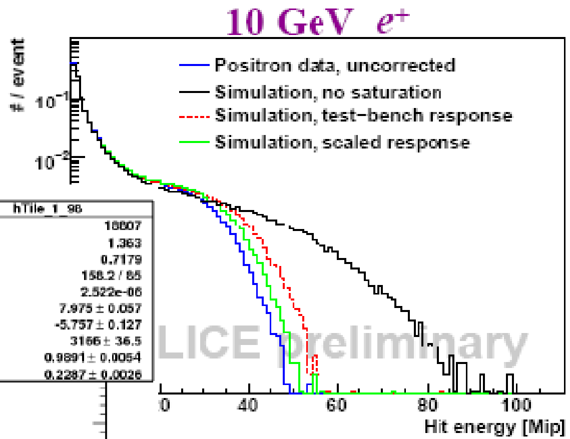
A. Raspereza

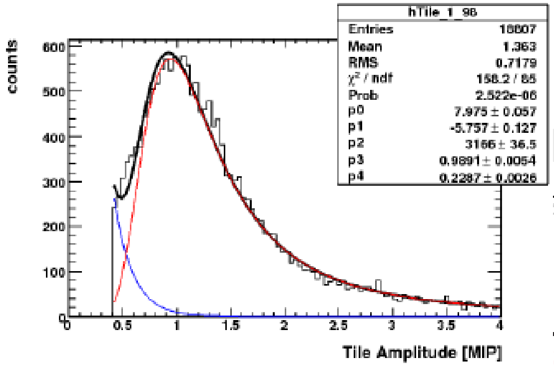


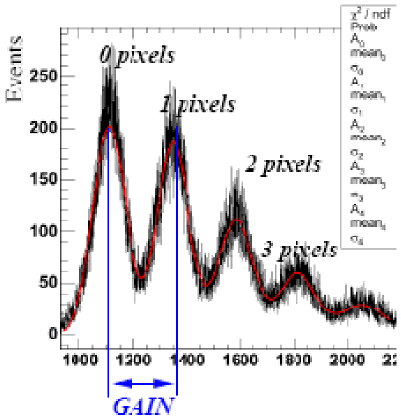
Calibration procedures

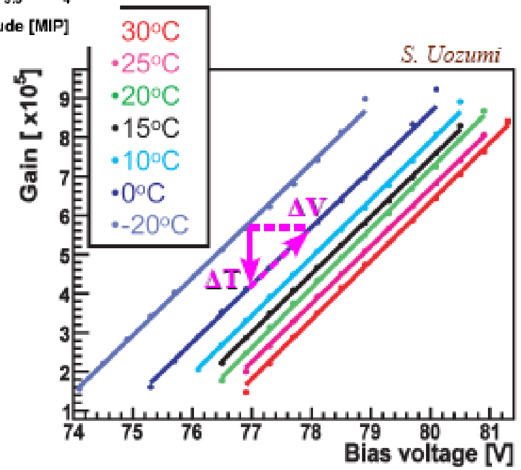
- Non-linearity correction: test with electron data
- MIP calibration: in test beam data, explore use of MIP segments in hadron showers
- Correct for temperature-induced variations
  - Use T-sensors and measured T dependences
- Use gain monitoring, adjust voltage

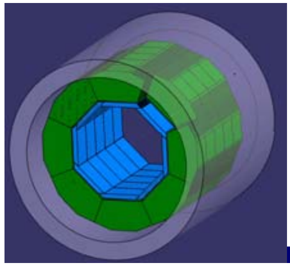
Talks by Sebastian, Shojun, Trygve









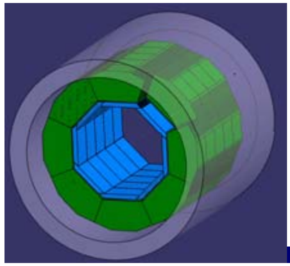


Analysis opportunities

- Wonderful results - and there is so much more to do…

- precision: model uncertainties ~ exp errors
- 3d profiles, correlations, sub-structure
- software compensation (weighting), ultimate resolution
- temperature corrections applied
- PFLOW: 2 part sep: more distances, energies, MC
  - Pandora-Tbeam
- angular incidence, protons, low energies
- ECAL HCAL combined: E res and PFLOW

- new generation of PhD students, more institutes



Collaborating institutes

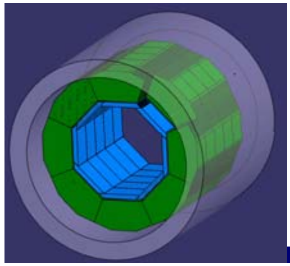
- Czech R.: Prague
- France: LAL Orsay
- Germany: DESY, Hamburg, Heidelberg, MPI Munich, Wuppertal
- Japan: Kobe, Shinshu
- Russia: JINR; ITEP, LPI, MEPHI Moscow
- UK: Cambridge, Imperial C, UCL, ,Manchester, RAL
- US: Northern Illinois

In preparation

- Canada: McGill
- Norway: Bergen

Under discussion:

- Italy: INFN Rome I



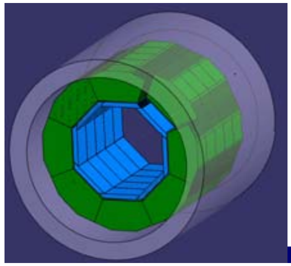
HCAL software

- Reconstruction software and data base continuously improving
  - see talks by Niels and Andrea
- data should be analyzable outside DESY - already now!

- still a lot to do on spatial dimensions
  - tracking, alignment, shower centre, bias corrections,…

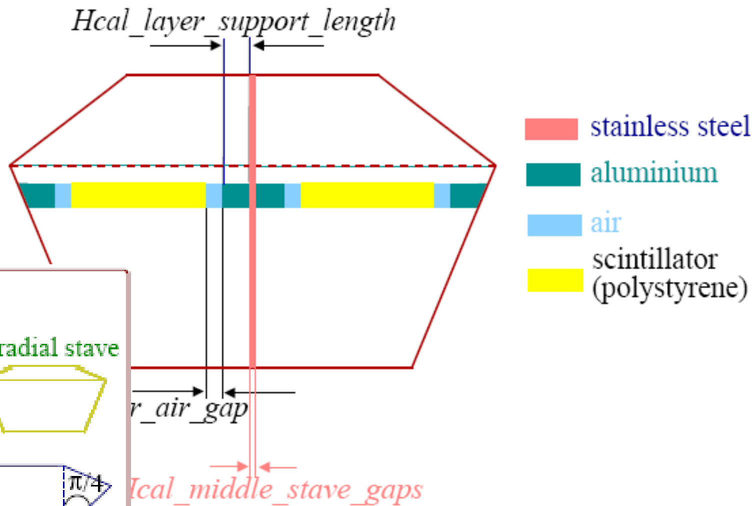
- integrate with sci ECAL: reco, sim, digit
- And later with DHCAL…

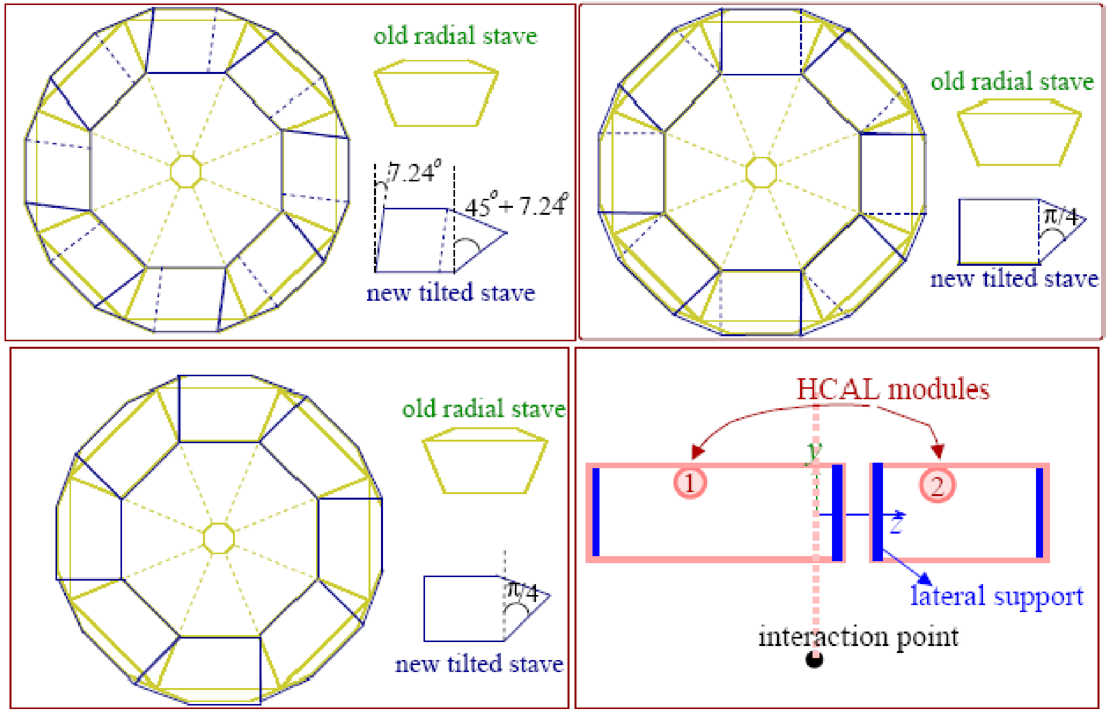
- Maintain link to optimization studies
  - Core software: as much as possible and reasonable



New Mokka model

- Revised, refined, realistic parameterization
- New degrees of freedom



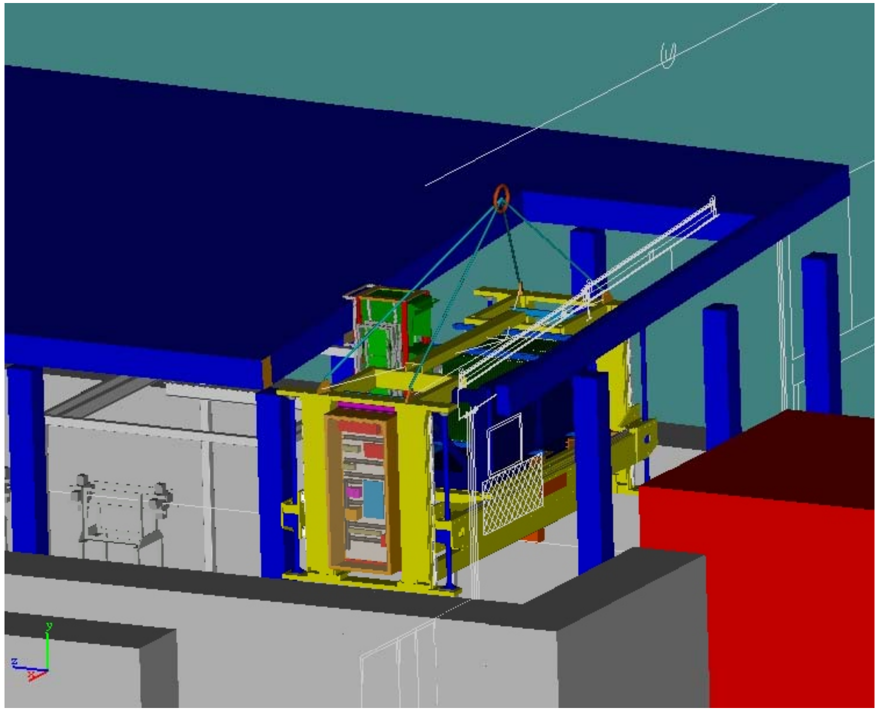


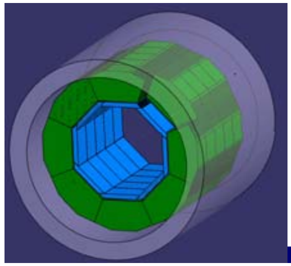
- Detailed modelling of layer edges
- Non-pointing cracks in rφ and z possible
- End caps

A. Lucaci, R. Diener (DESY)

Test beam at Fermilab

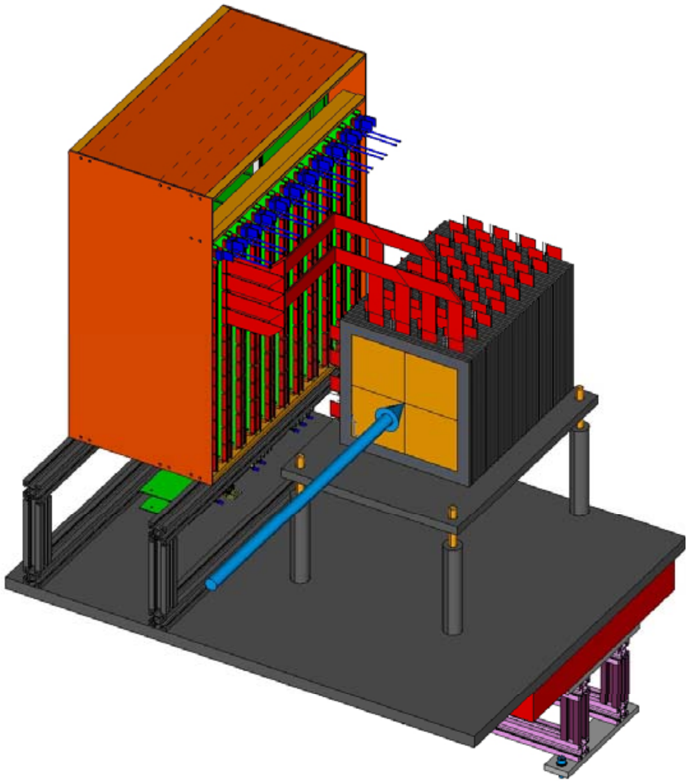
- Preparation is everything!



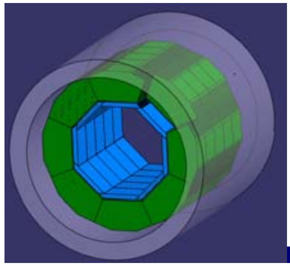


CALICE@FNAL plans

- Experience from May and plans for July
  - Low energies and good statistics for technology comparison
  - See talk by Erika
- September: integration of SciECAL
- Early next year: possibly 2nd all-scintillator run
- Later in 2009: expect first set of DHCAL layers from US



K.Gadow

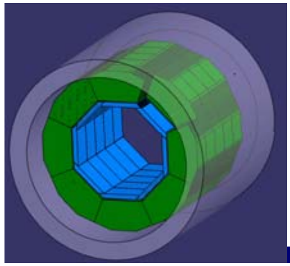


R&D on scintillators and sensors

Progress with photo-sensors: new options (?)

- See talks by Roman, Simon

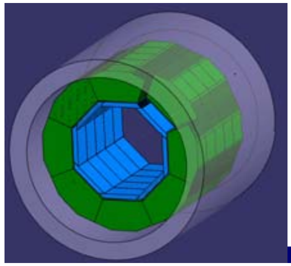
- sensor on tile, with fibre: OK
  - Thinner scintillator possible with MRS-APD or MPPC
- sensor on tile, direct coupling: ?
  - in principle possible with blue-sensitive sensors (MPPC, + ?)
  - Light yield OK for 5mm tiles, but non-uniform
  - 3mm tiles, non-uniformity compensation: needs larger area, new package
  - Strips: works in ECAL, LY and unif. OK but less advantageous for HCAL
- sensor on PCB: studied at NIU, T2K electronics
  - issues: optical stability, integration chain



EUDET prototypes

- The “integration prototype”
  - 2nd generation ASICs
  - electronics integration, c
  - calibration system,
  - compact mechanics

- 2nd generation ASICs:
  - On-chip zero-suppression, digitization and TDC
- SPIROC1: on the test bench since end 07 ➔ see Wei’s talk
  - some bugs (ADC ramp polarity, probe bus) and some mircales on analogue side
  - tests to expand on digital side with new test board
- SPIROC2: submitted in June, expected in October ➔ Ludovic’s talk
  - "1st chip where everything works"
  - hopefully OK for EUDET, but possibly one more version needed
- 3rd generation (beyond EUDET):
  - individual channel trigger handling
  - signal to noise for low gain sensors

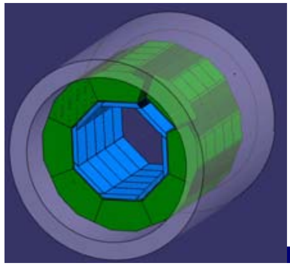


EUDET, cont.

- Calibration system: ➔ talks by Sebastian, Ivo
  - two approaches: electrical and optical distribution
  - both make progress, both have open issues

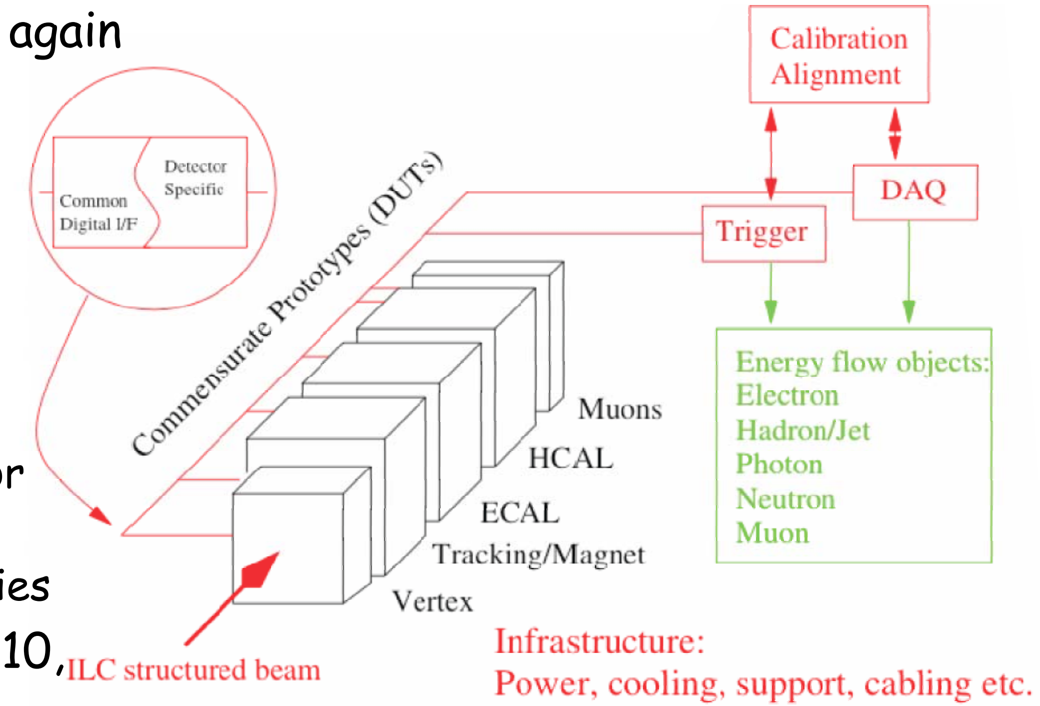
- Electronics integration: ➔ tall by Mathias
  - First layer board (HBU): layout waiting for tile dimensions
  - Work on digital interface started
- Prototyping sequence:
  - first proto: tile integration and readout chain ➔ 2008
  - second proto: "real" readout board for cassette and end board ➔ 2009
- goal: a "demonstrator module" - 2m long, 7mm thin
- possibility: new minical: 12 layers x 12x12 tiles

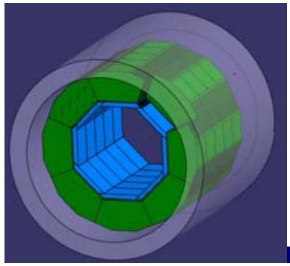
- Absorber mechanics: ➔ talk by Kirsten
  - Detailed FEM calculations confirm design with minimal dead space and no gaps
  - 1st step layer demonstrator, 2nd step 1:1 model



Far future: DevDet

- EU FP7 DevDet proposal submitted in Feb 08
  - evaluated 12.5/15, but approval not very likely
- Even without funding: we know what we want and will apply again
- EUVIF: vertical integration facility
- HCAL project:
  - 2nd generation prototype, compact
  - stainless steel absorber for tests with B>0
  - scalable integration facilities
- Eudet to be extended -> 2010, next FP7 call 2010



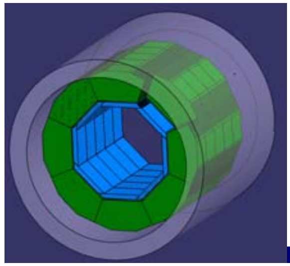


Conclusion

- Test beam data: a treasure
- Ongoing data taking: needs your support
- EUDET and beyond: focussed R&D

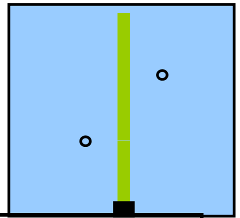
- Enjoy the meeting!

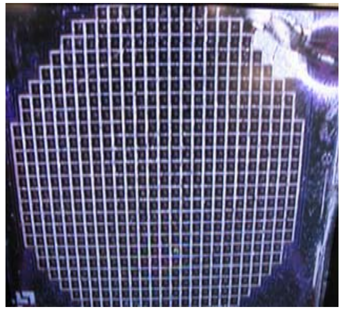
Backup slides



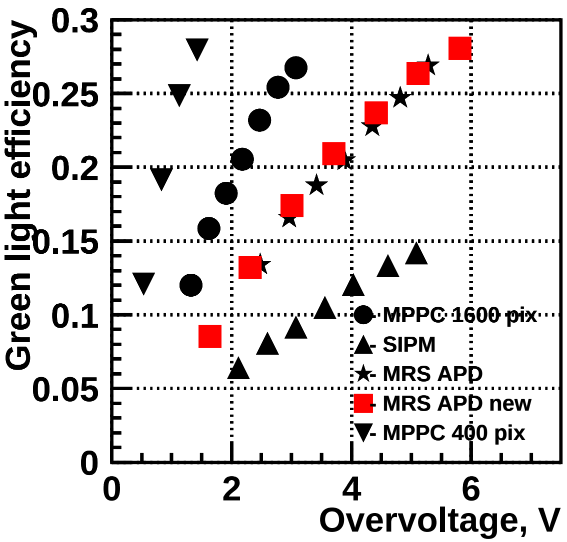
Tile sensor systems with WLS fibre

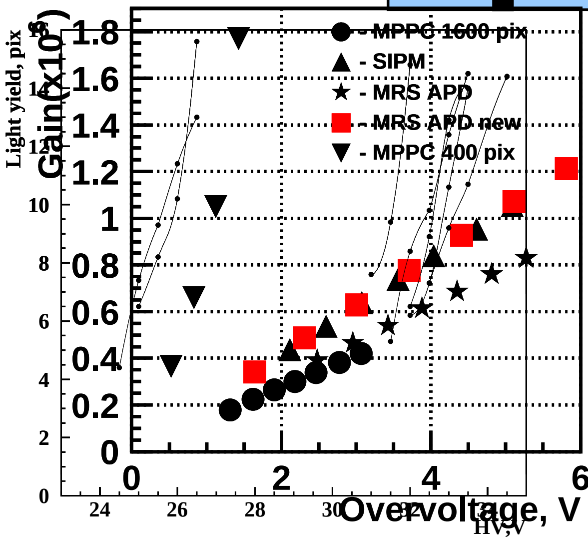
- Present test beam system
  - 5mm thick tile with fibre, MEPHI/ PULSAR SiPM, 15 pixels/MIP
- Several new options: reduce to 3 mm thick tiles
  - Hamamatsu MPPC-1600
  - MRS APDs (CPTA)

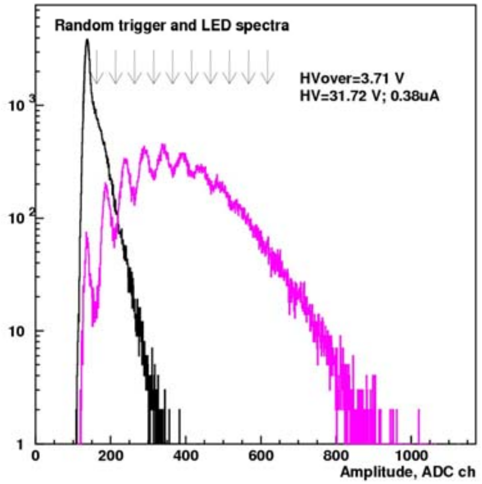


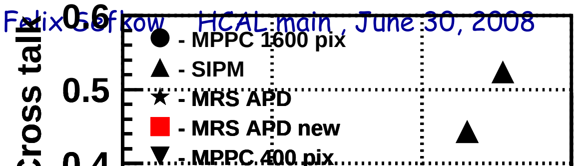


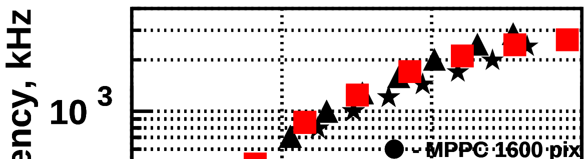
M.Danilov (ITEP)

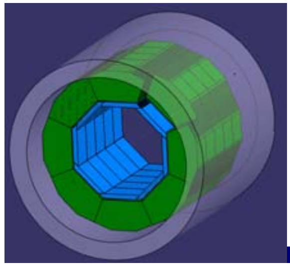








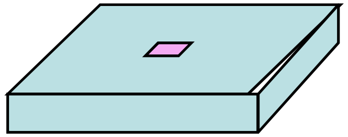


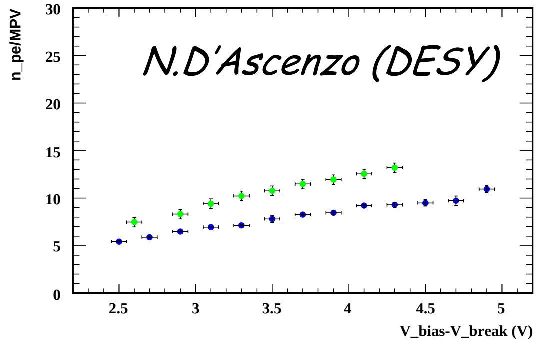


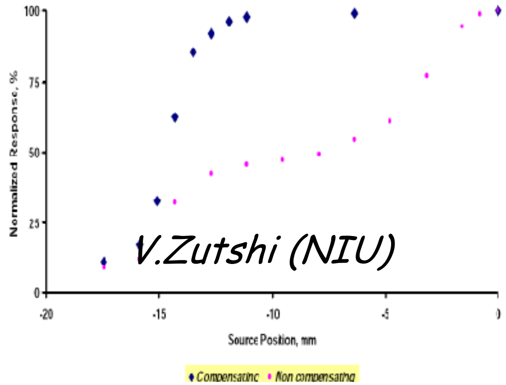
Tile sensor direct coupling

- Possible with blue-sensitive sensors
  - Hamamatsu MPPC 1600 (400)
- Obtain about 7 (11) px/MIP from 5 mm tiles; low noise
  - ➔ increase area
- Need to restore uniformity
  - Some add[al] light cost
- Other proven option: strips
  - CALICE SciW ECAL

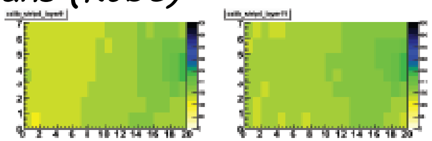
Tile 30x30x5 mm3





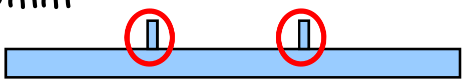


D.Jeans (Kobe)

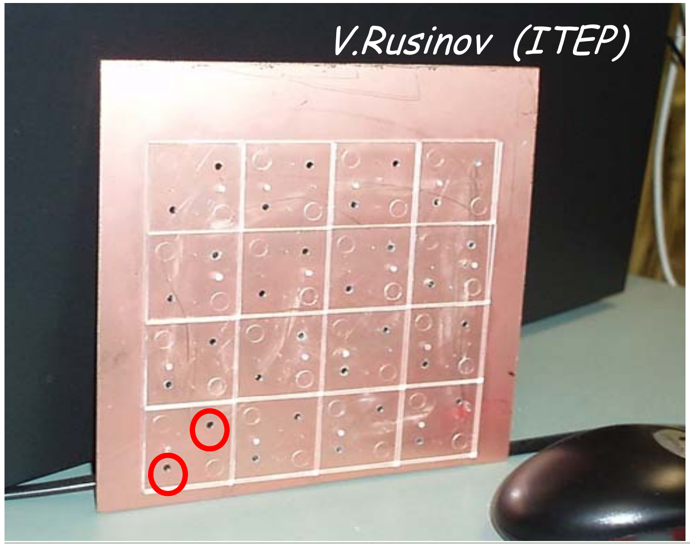


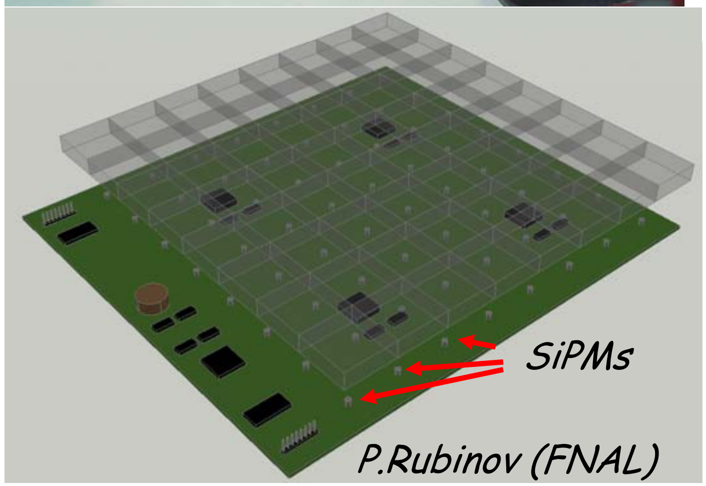
Tile PCB coupling

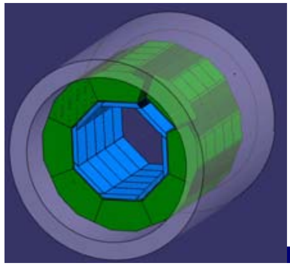
- Scintillator photo-sensor system has to match electronics PCB tolerances
- Several options
  - Mega-tiles (easier assembly, but some optical cross-talk
  - New: idea “lego” tiles with alignment pins
    - 30x30x3mm^3



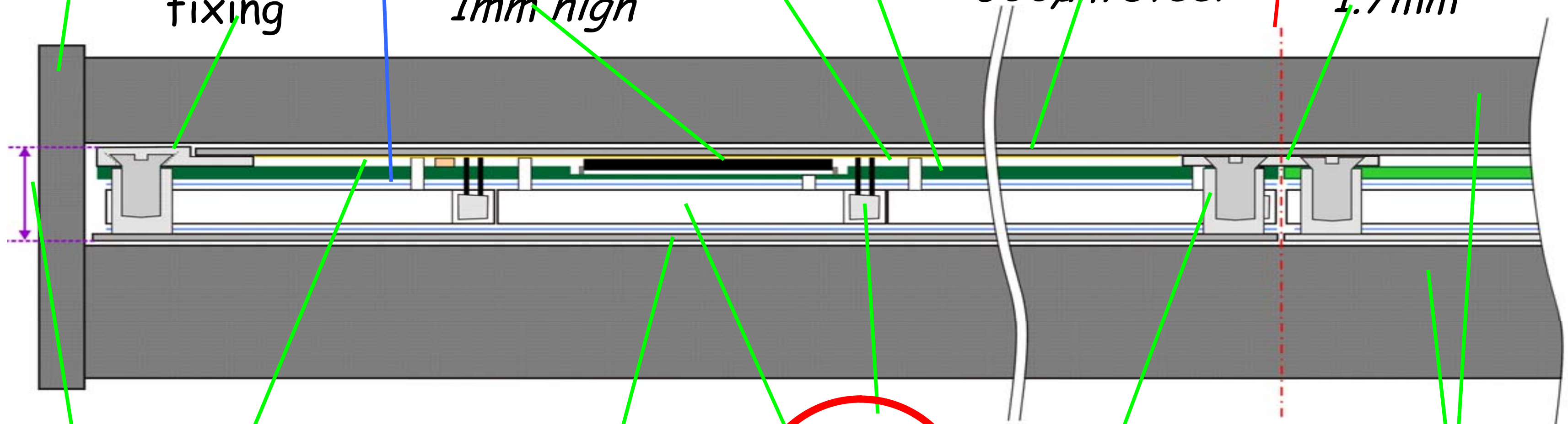
- Other option: surface-mounted sensors on PCB
  - Different integration chain

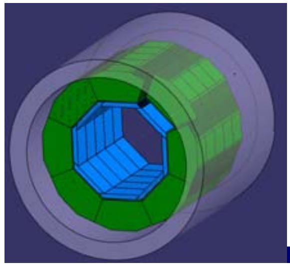






Integrated layer design

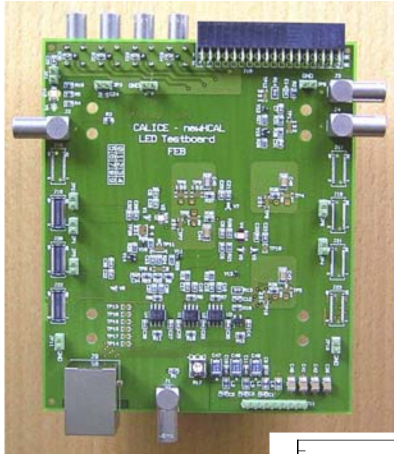


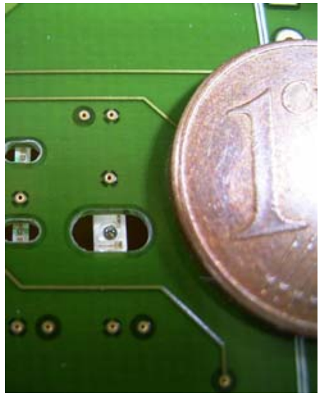


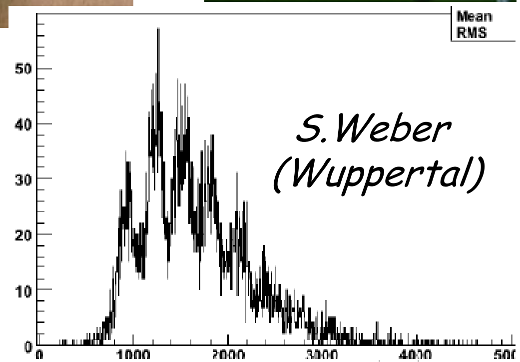
Optical calibration system

- SiPMs, MPPCs are self-calibrating
  - Ph.e. peak distance ~ gain
- Embedded LEDs
  - electronic signal distribution
  - tested, no cross-talk to sensors seen
  - To be optimized: dynamic range, LED uniformity
- Alternative: central driver and optical signal distribution

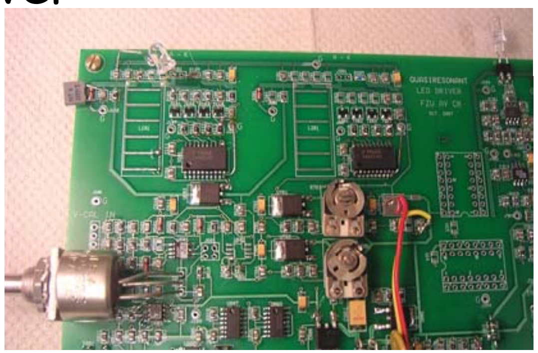
M.Reinecke (DESY)



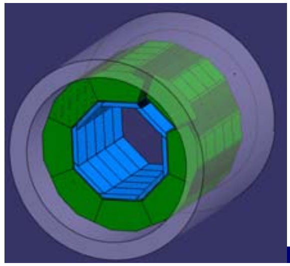




S.Weber (Wuppertal)

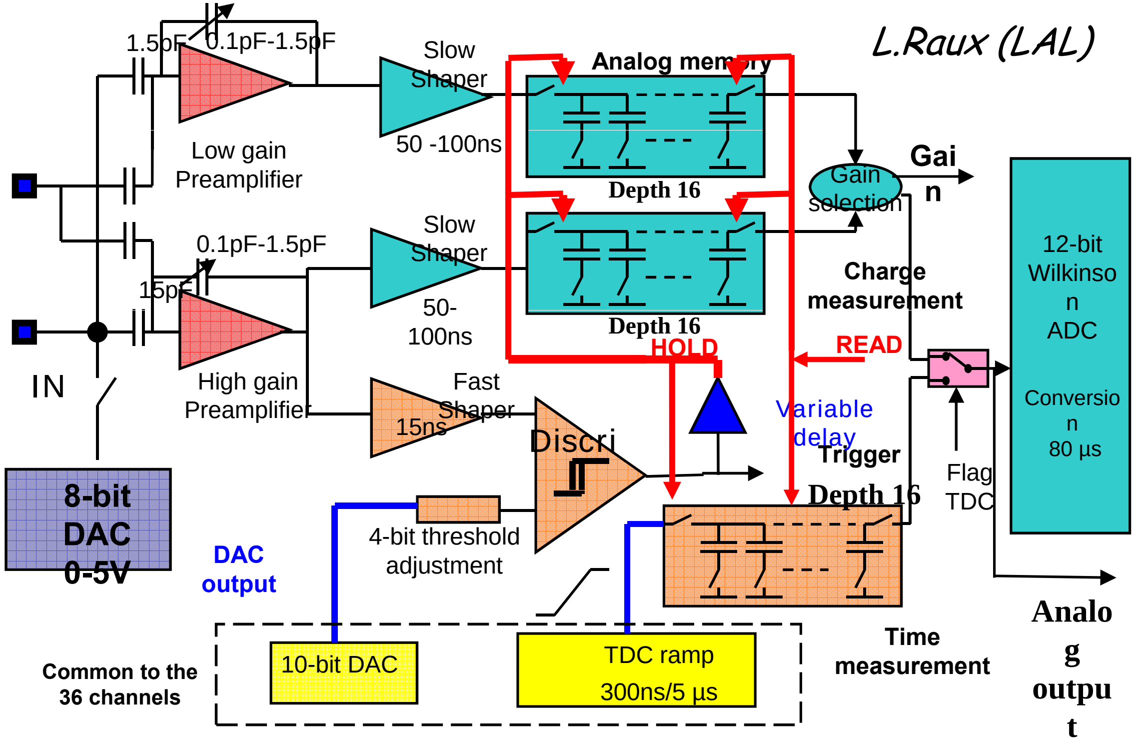


I.Polak (Prague)

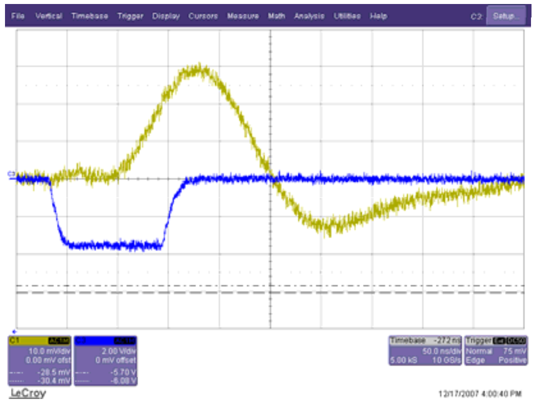


New ASIC on the test benches

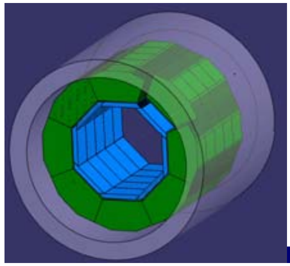
- Auto-triggering and time measurements
- ADC and TDC integrated
- Power pulsing, low (continuous) power DAC



L.Raux (LAL)

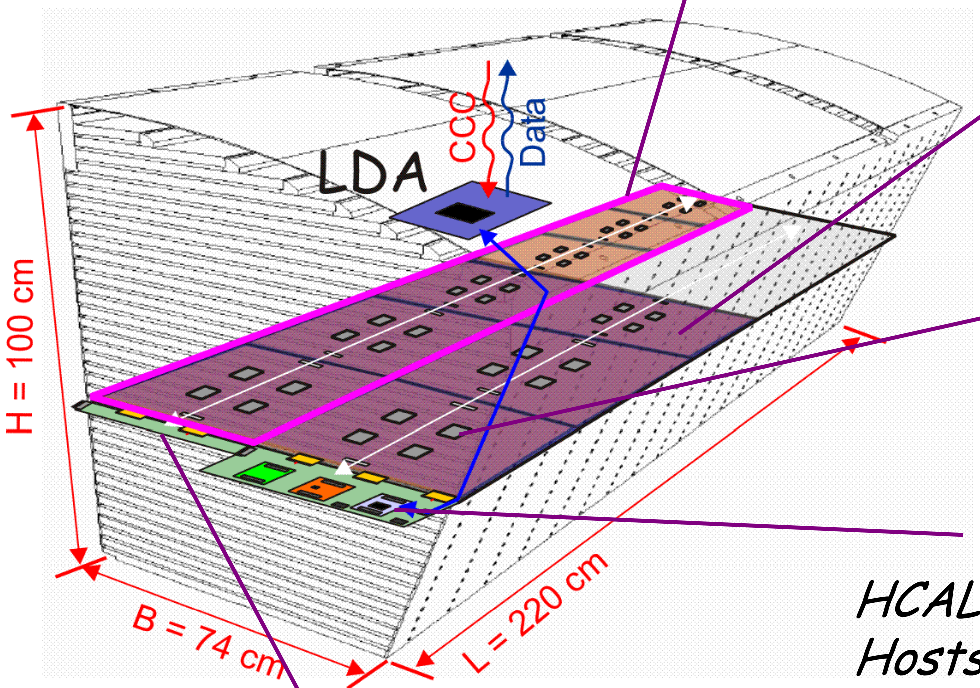


R.Fabbri (DESY)



Barrel HCAL architecture

1/16 of barrel half



AHCAL Slab

6 HBUs in a row

Front end ASICs embedded
Interfaces accessible

HBU

HCAL Base Unit

12 x 12 tiles

SPIROC

4 on a HBU

Power:

40 µW / channel

Heat:

T grad. 0.3K/2m

Time constant: 6 d

HEB

HCAL Endcap Board

Hosts mezzanine modules:

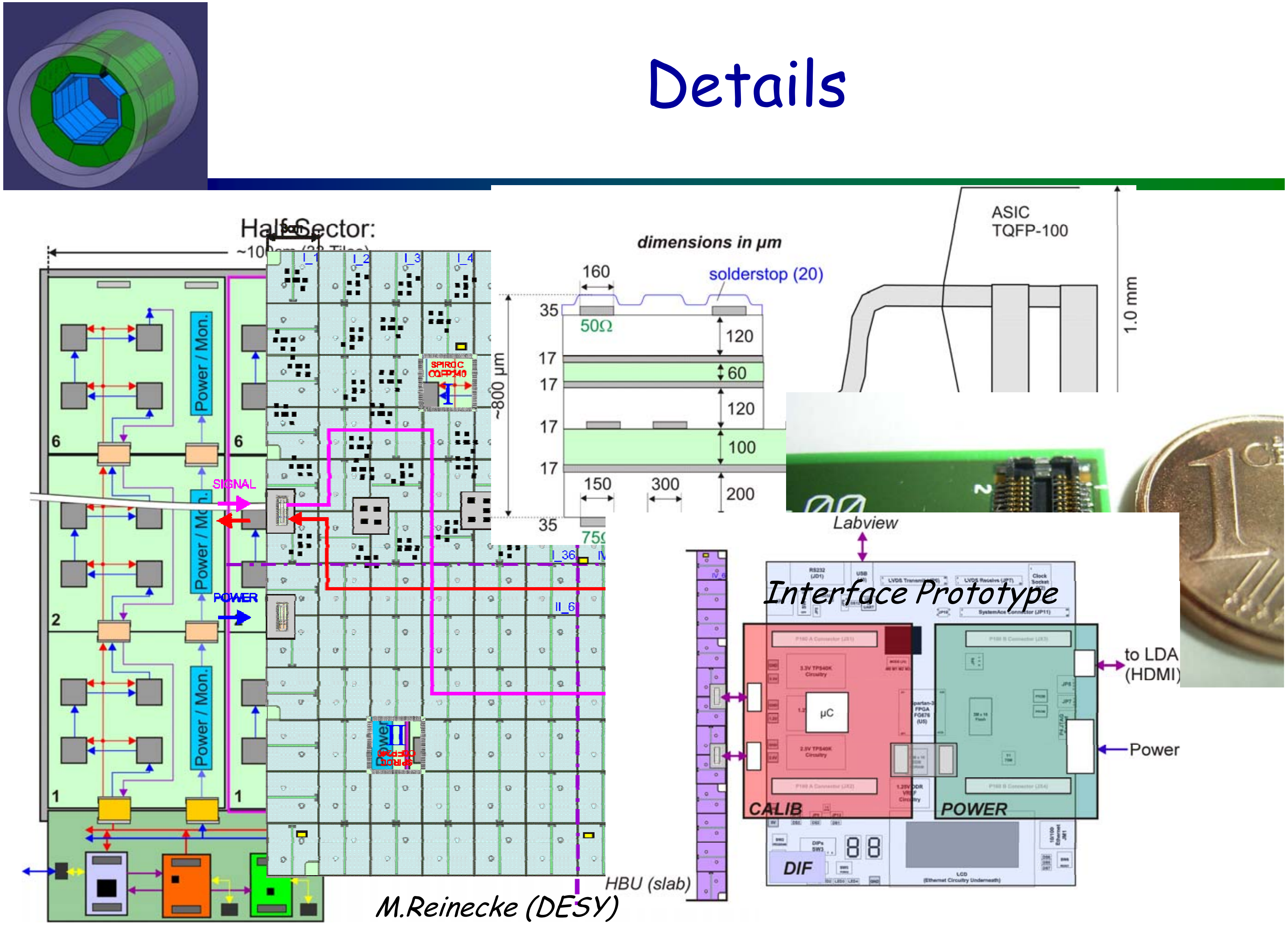
DIF, **CALIB** and **POWER**

P.Goettlicher (DESY)

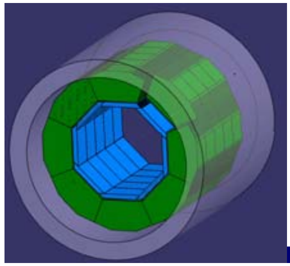
HLD

HCAL Layer Distributor

Details

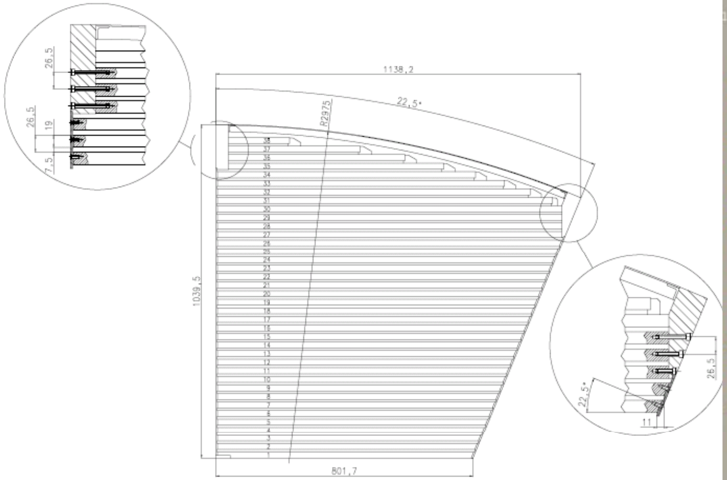


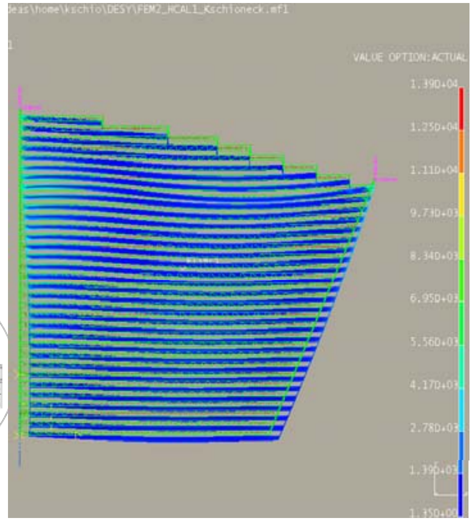
Half Sector:
Power / Mon.
SIGNAL
POWER
SPIROC
dimensions in µm
160
solderstop (20)
50Ω
~800 µm
35
17
120
60
100
150
300
200
ASIC
TQFP-100
1.0 mm
Labview
Interface Prototype
to LDA
(HDMI)
Power
CALIB
POWER
DIF
µC
HBU (slab)
M.Reinecke (DESY)

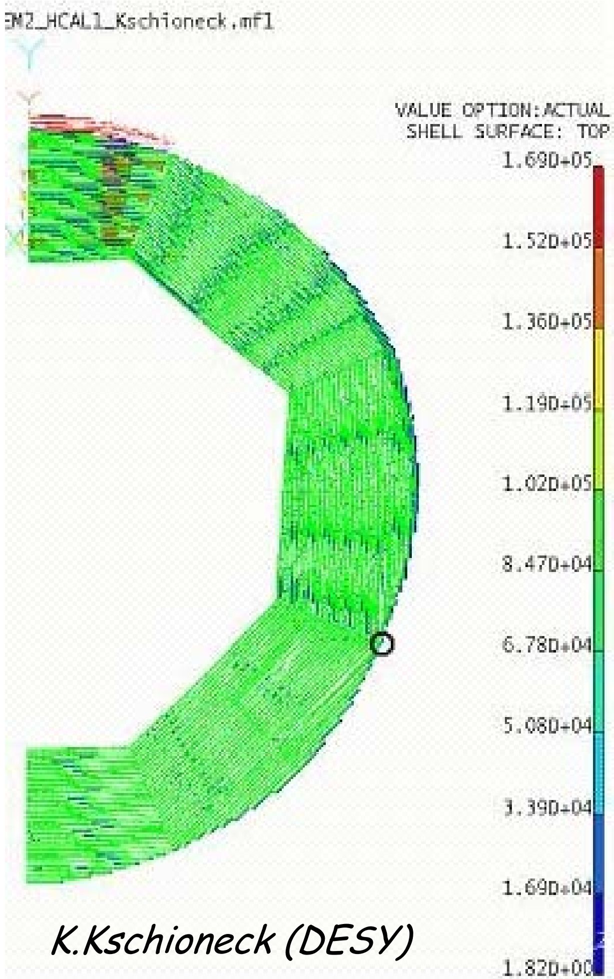


Mechanical structure

- Aggressive design: 3mm walls
- No additional spacers
- FEM calculation with sector details for full barrel
  - Max displacement 2mm, stress ✓
  - Integration with cryostat and ECAL







K.Kschioneck (DESY)