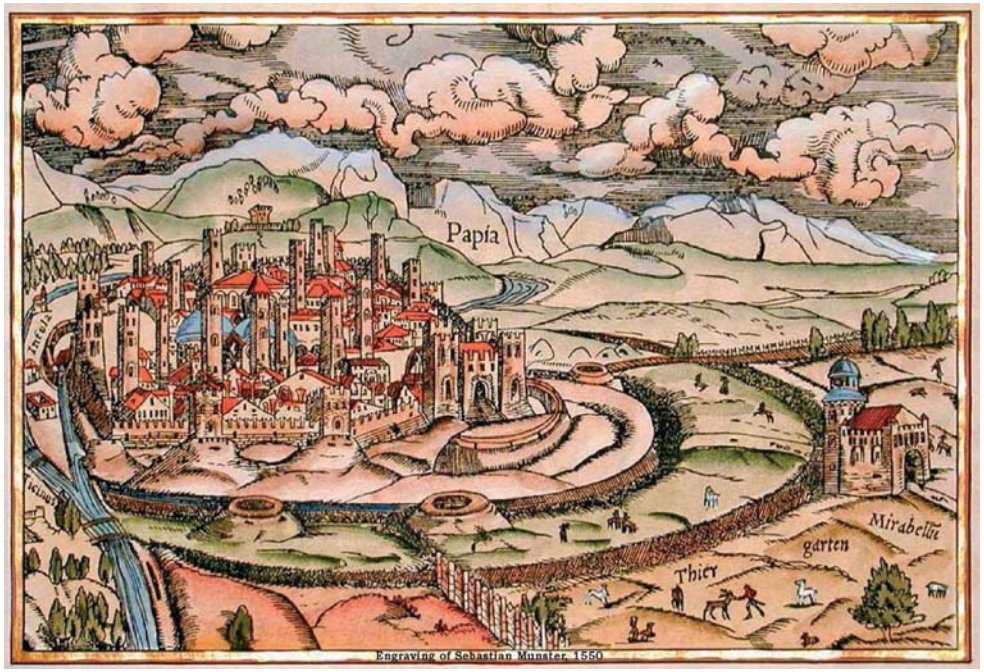
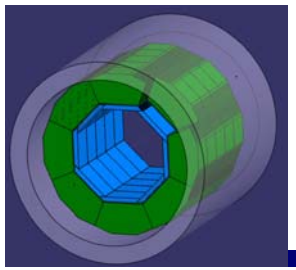


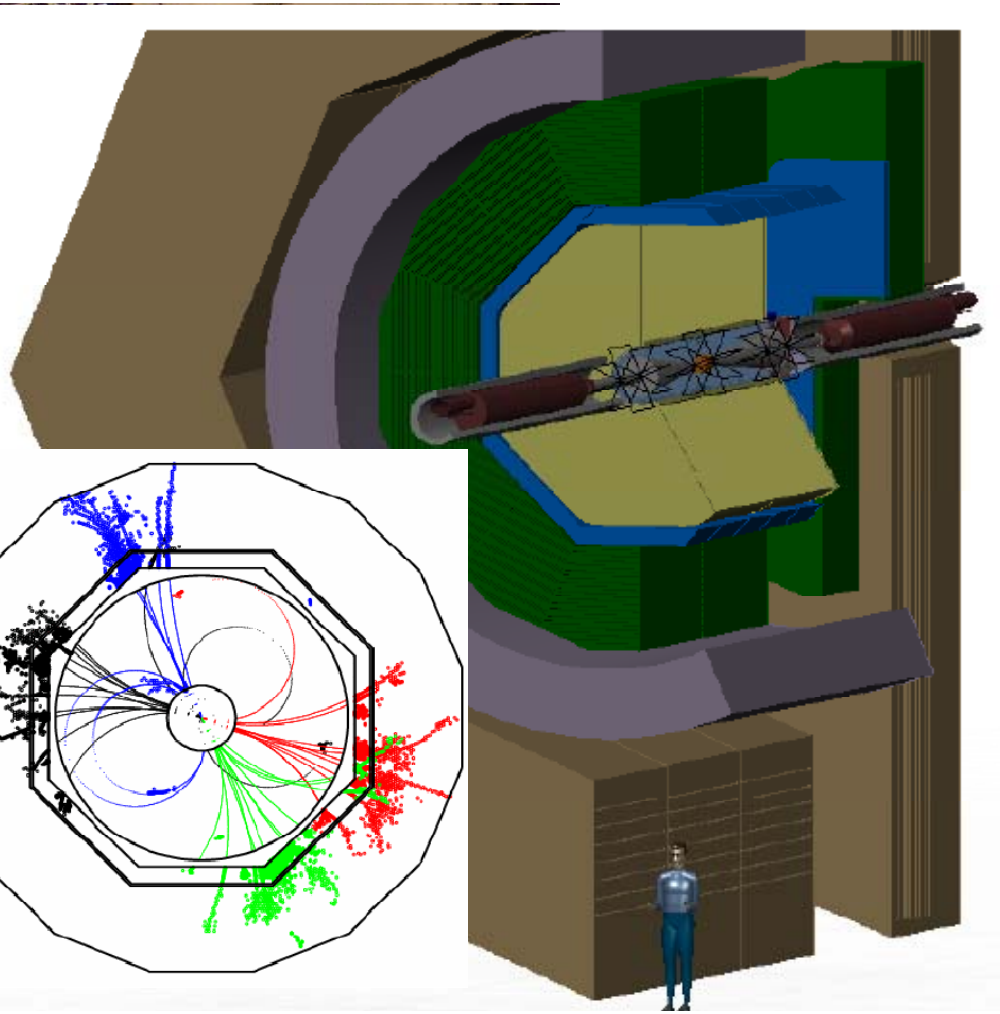
Towards a realistic Scintillator HCAL with SiPM read-out

Felix Sefkow

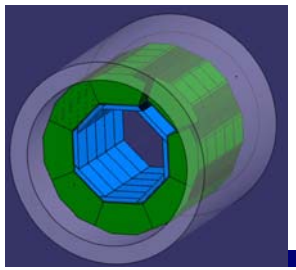
CALOR08, Pavia
May 30, 2008



From proof-of principle to reality

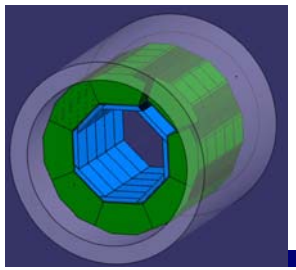


See talks by
Erika Garutti (test beam results)
Angela Lucaci (Calibration)



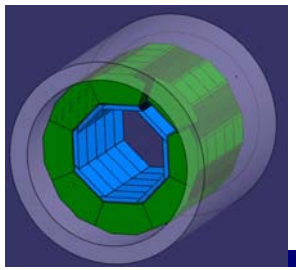
Collaborating institutes

- 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, RAL
- US: Northern Illinois



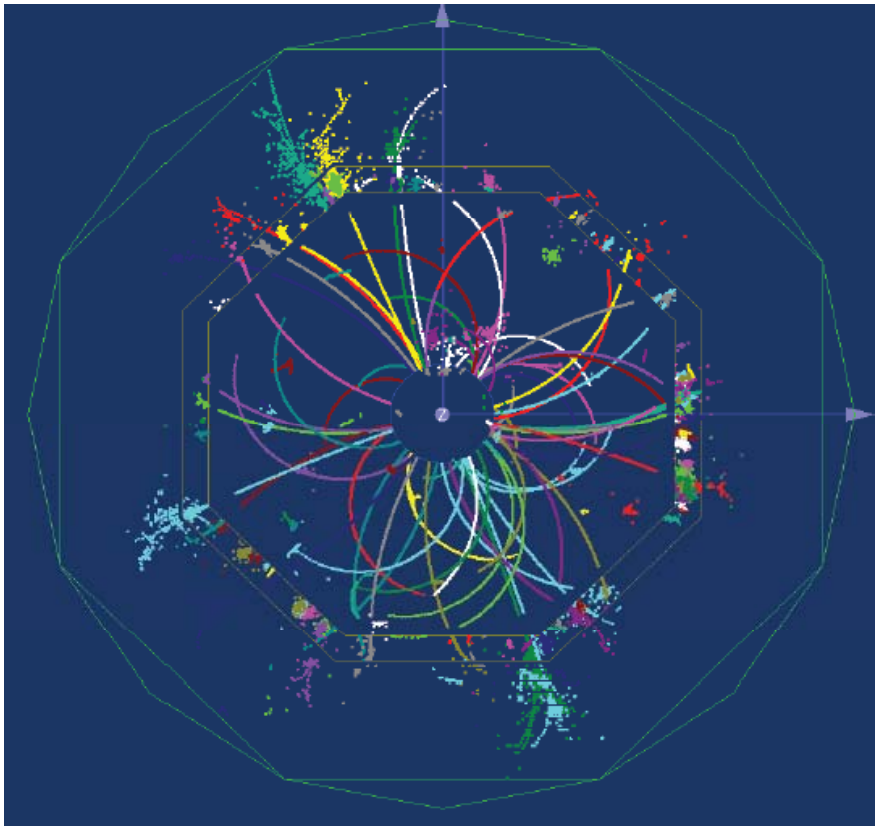
Outline

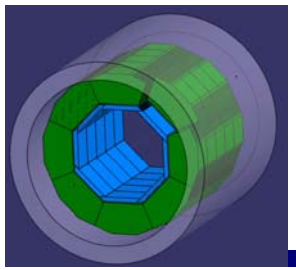
- Physics requirements and design goals
- A compact design with integrated sensors and electronics
- For the electronics itself, see subsequent talks by
  - Christophe De La Taille (front end ASICs)
  - Valeria Bartsch (DAQ)
  - Common design for ECAL, scint and gas HCAL



Calorimetry at the ILC

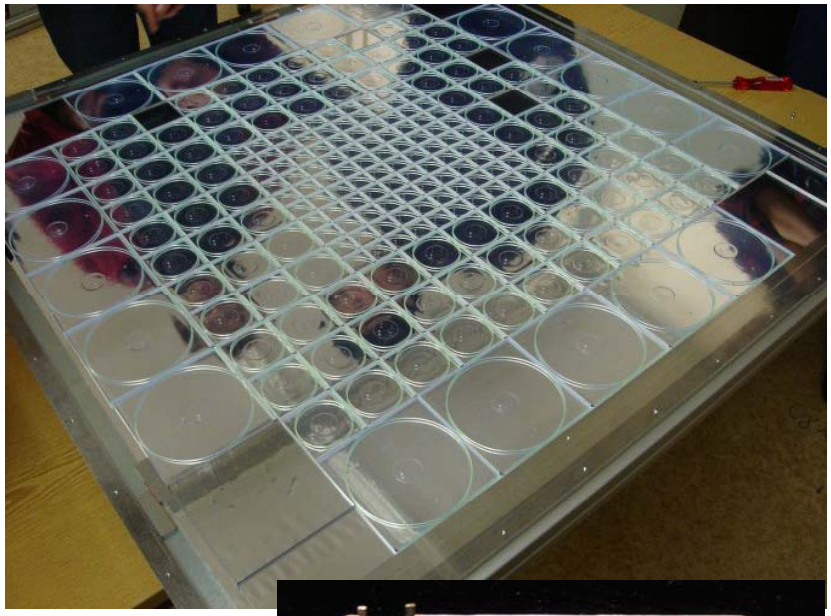
- $\sqrt{s}$ (e^+e^-) =0.5-1 TeV
- Multi-jet events, typically:
  - E_{jet} ~ 50 … 150 GeV
  - E_{hadron} ~ 1 … 100 GeV
- An imaging HCAL for particle flow reconstruction
  - Two-particle separation
  - Hadronic energy resolution
- High longitudinal and transverse granularity
    - Software compensation



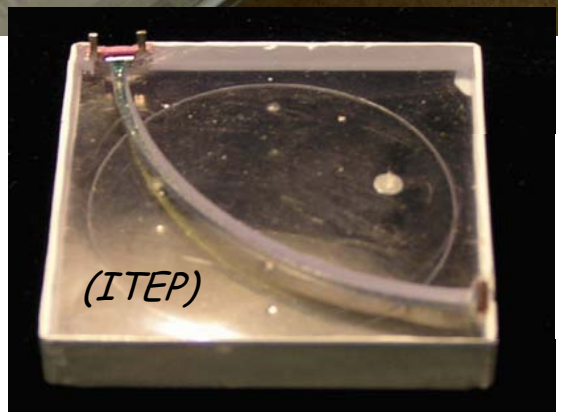


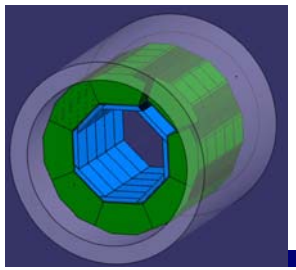
Design goals

- Novel multi-pixel Geiger mode photo-diodes (SiPMs)
  - B-field proof, small, affordable
- High granularity with scintillator at reasonable cost
  - photo-sensors integrated
- Opens revolutionary design options:
  - embedded electronics and calibration system for minimal dead zones
  - thin readout gap
- Granular, compact, hermetic



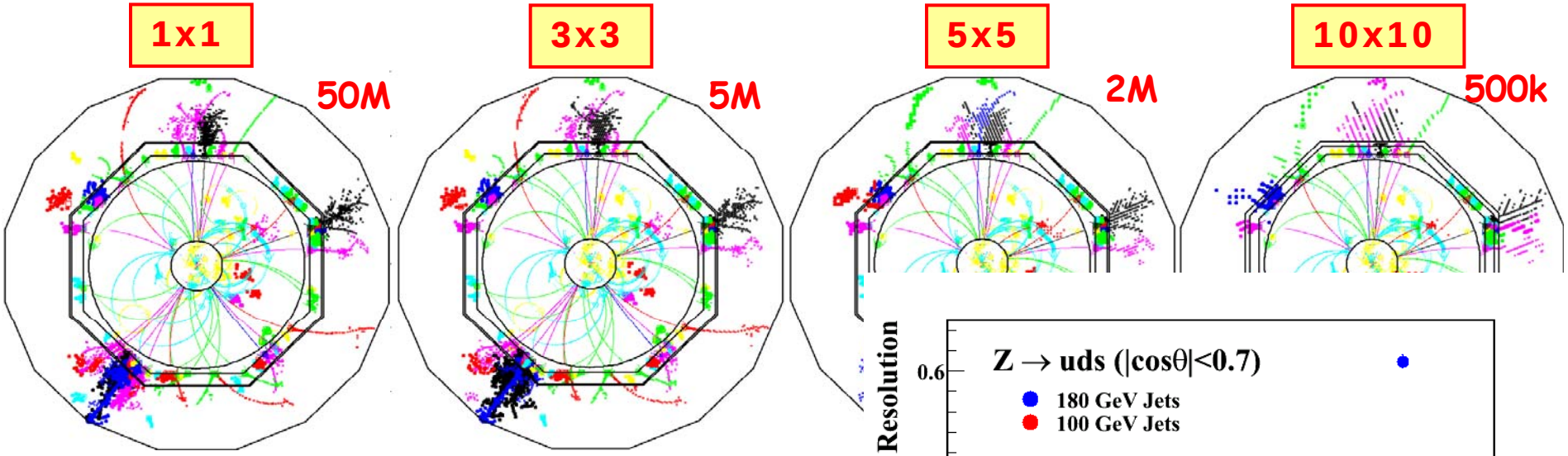
(DESY)



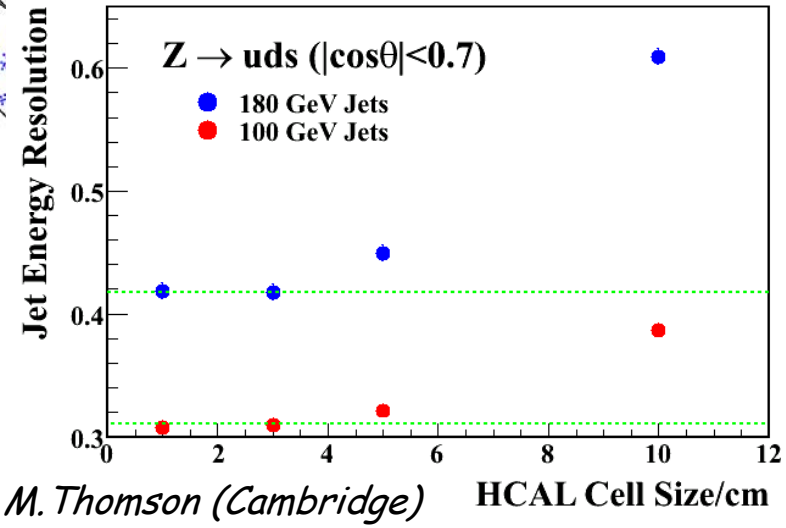


Tile granularity

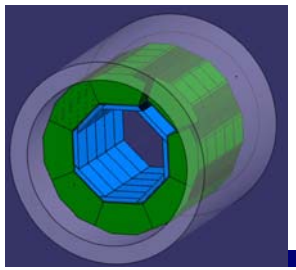
- Recent studies with PFLOW algorithm, full simulation and reco.



- Confirms earlier studies for test beam prototype
- 3x3 cm^2 nearly optimal

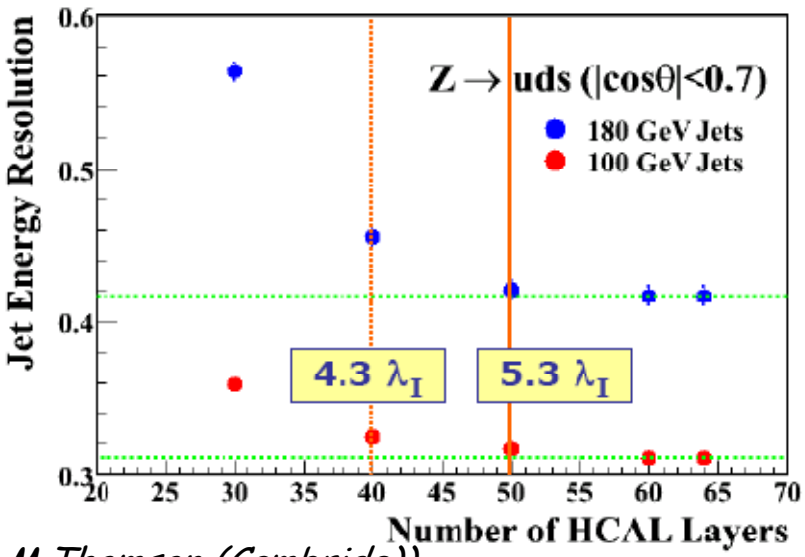


M. Thomson (Cambridge)



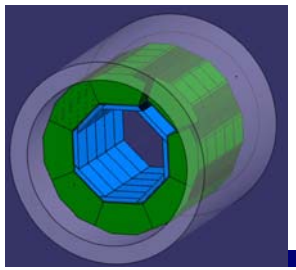
Geometry, optimization, integration

- Presently starting new round of detector optimization, using detailed simulations and state-of-the art reconstruction algorithms
- Baseline: stainless steel, square tiles
  - Also considered: brass or lead
  - Scintillator striplets
- R&D and integration issues are largely independent on details of final geometry
  - Sensors and tiles
  - Ultra-low power electronics, interfaces
  - Mechanical structure



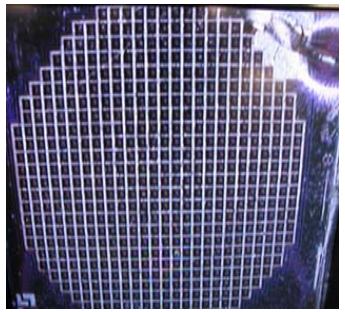
M. Thomson (Cambride))

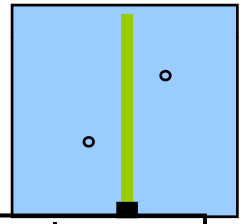
A scintillator based calorimeter with embedded sensors and electronics has not been built before



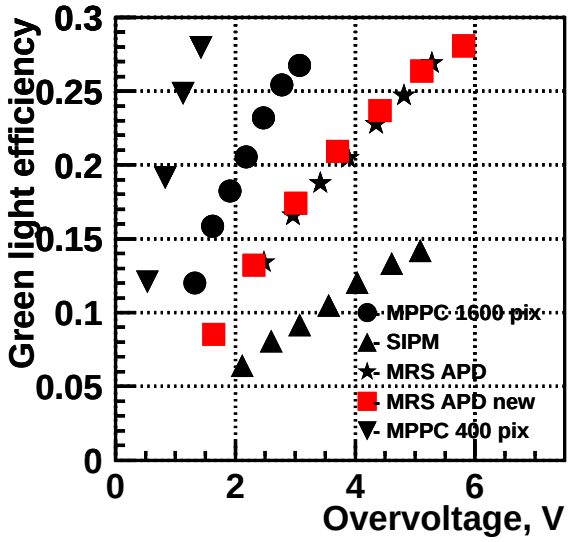
Tile sensor systems with WLS fibre

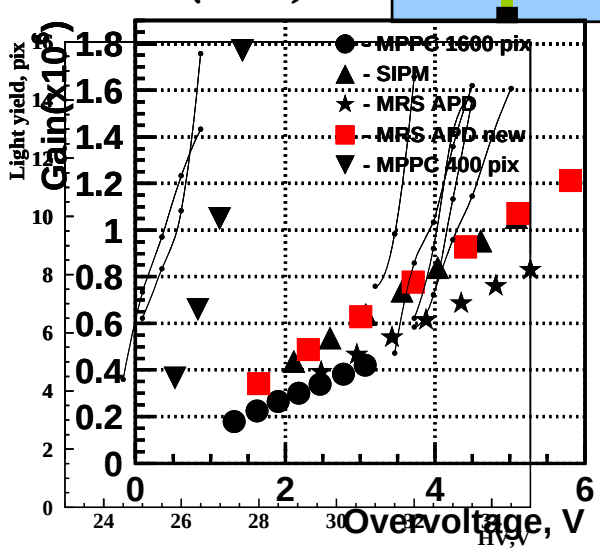
- Present test beam system
  - 5mm thick tile with fibre, MEPHI/ PULSAR SiPM, 15 pixels/MIP
- Several new options: reduce to 3 mm thick tiles
  - Hamamatsu MPPC-1600
  - MRS APDs (CPTA)

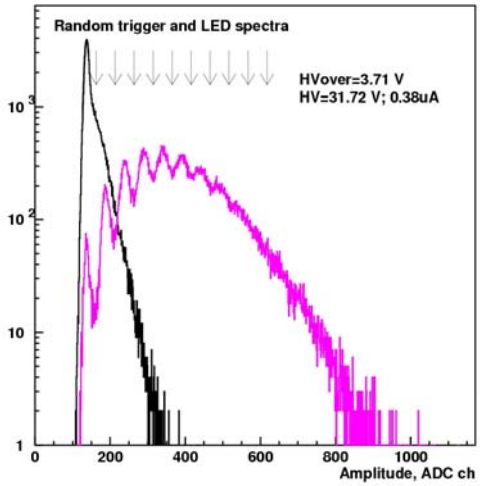


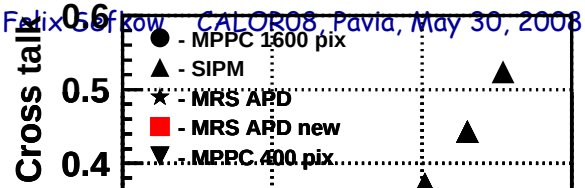


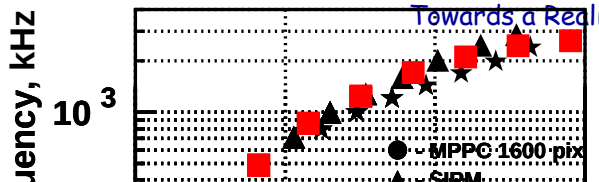
M.Danilov (ITEP)

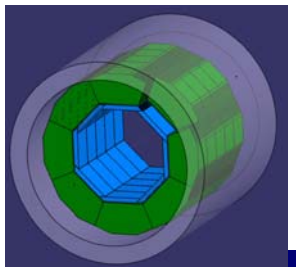








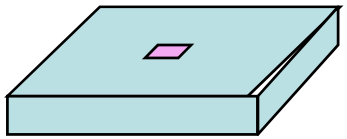


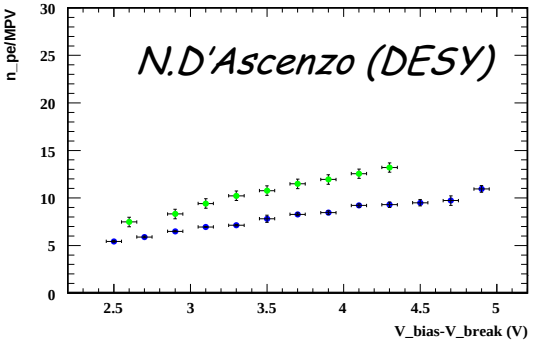


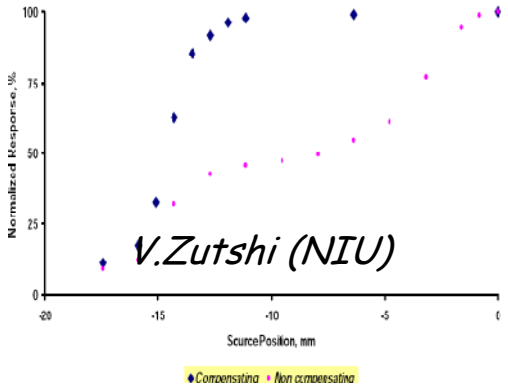
Tile sensor direct coupling

- 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

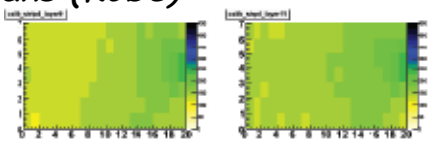
Tile 30x30x5 mm3



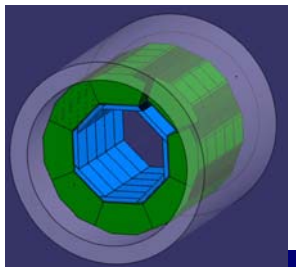




D.Jeans (Kobe)

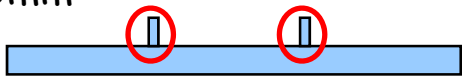


strip MPPC

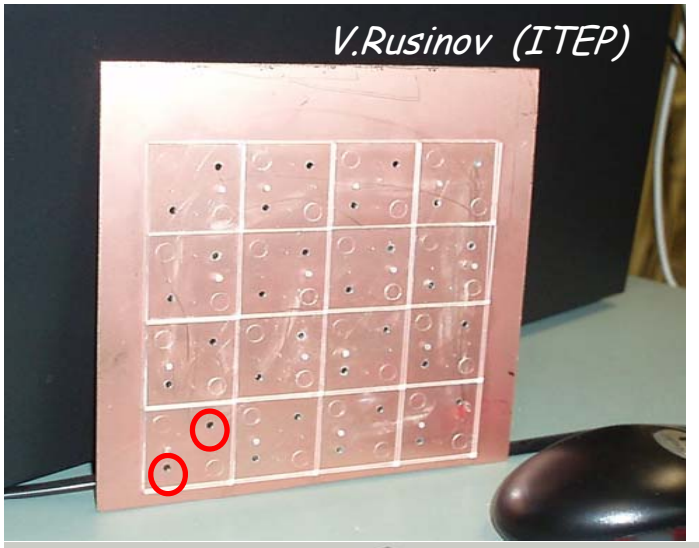


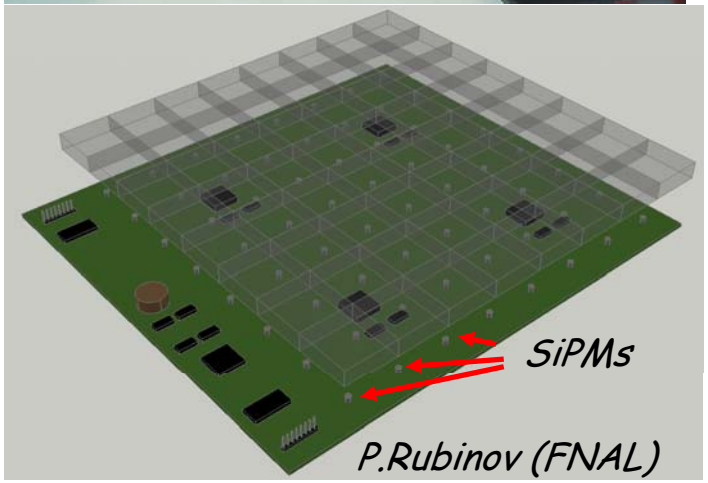
Tile PCB coupling

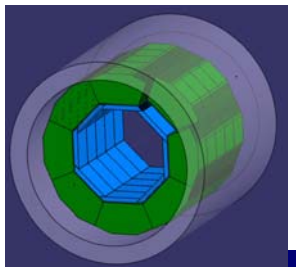
- Scintillator photo-sensor system has to match electronics PCB tolerances
- Several options
  - Mega-tiles (easier assembly, but some optical cross-talk
  - New: idea "lego" tiles with alignment pins
    - 30x30x3mm^3



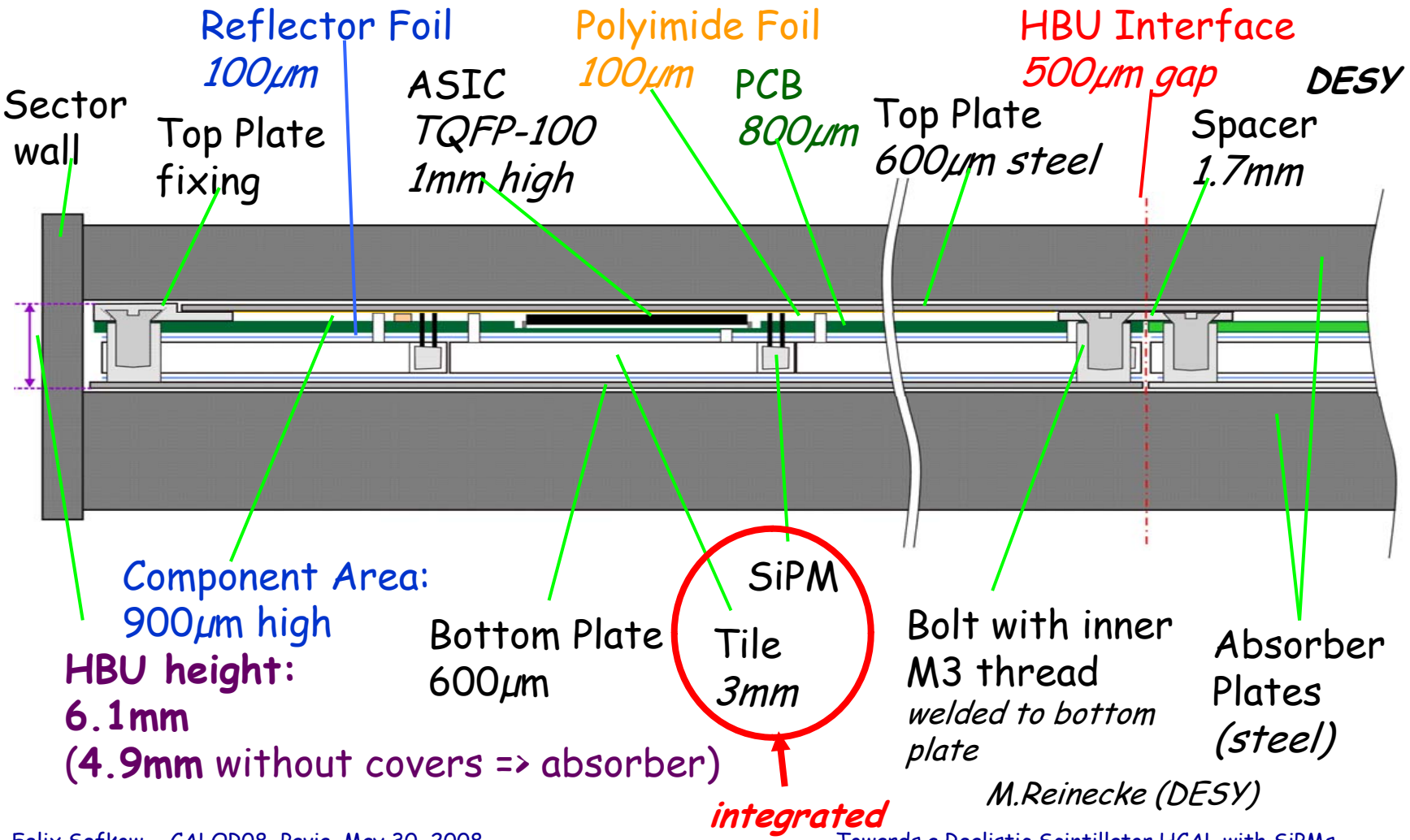
- Other option: surface-mounted sensors on PCB
  - Different integration chain

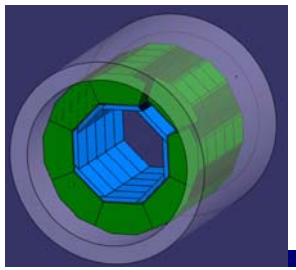






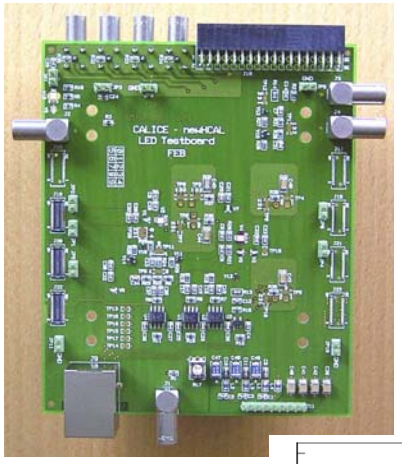
Integrated layer design



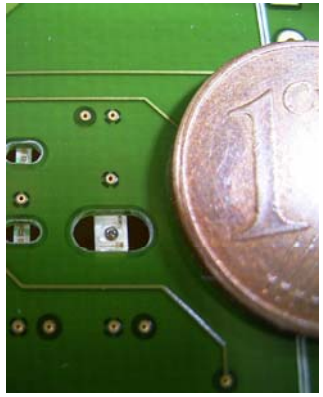


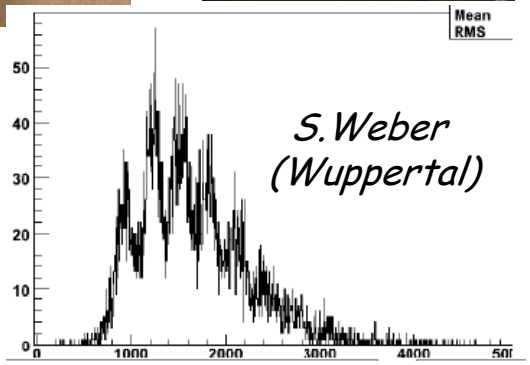
Optical calibration system

- 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

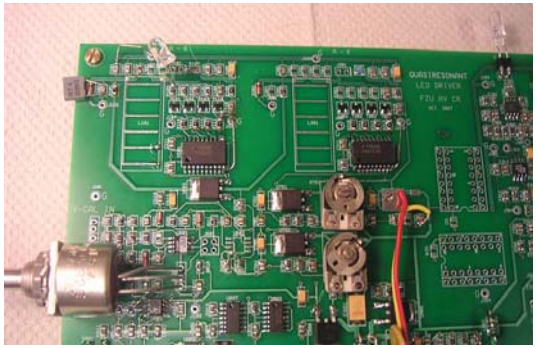


M.Reinecke (DESY)

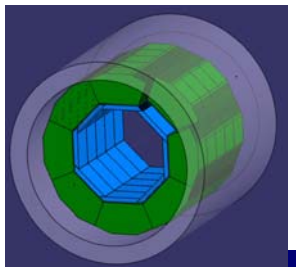




S.Weber (Wuppertal)



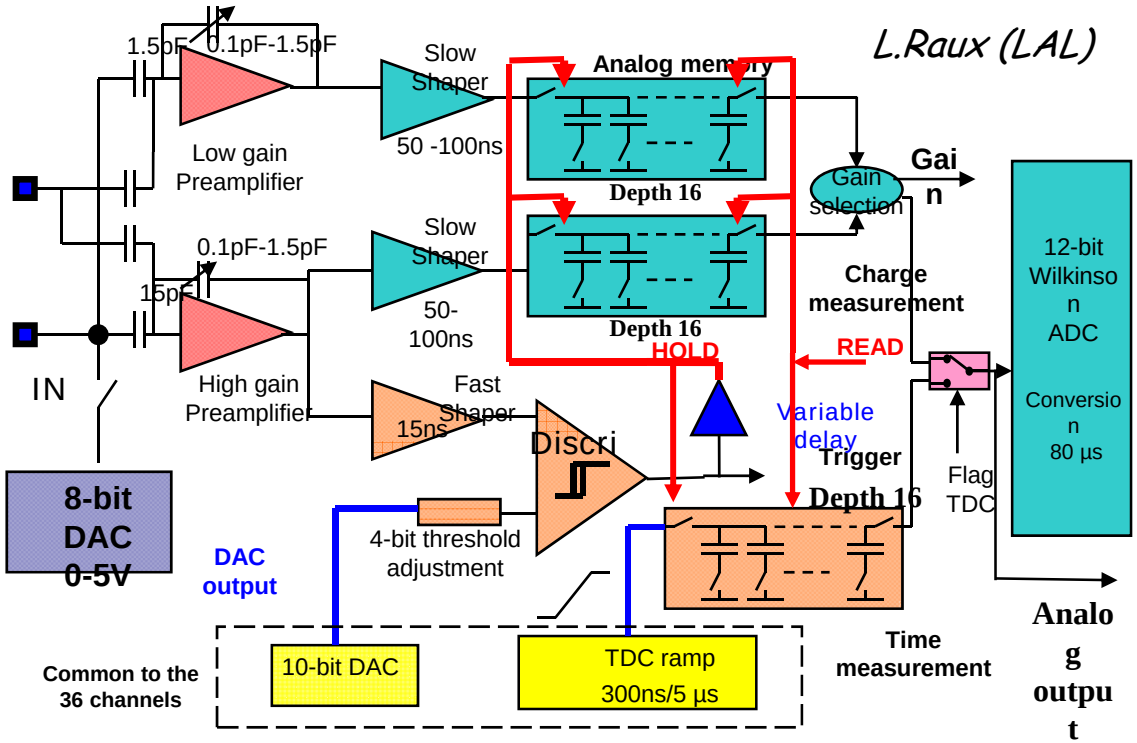
I.Polak (Prague)

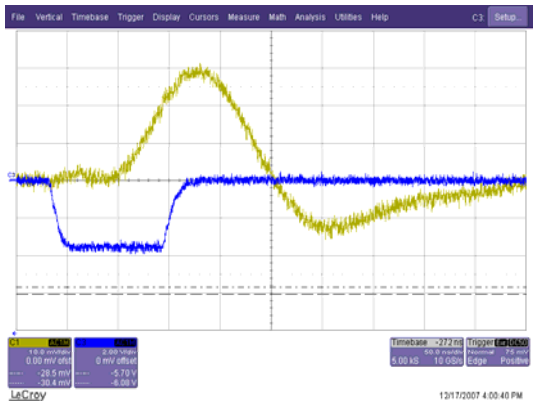


New ASIC on the test benches

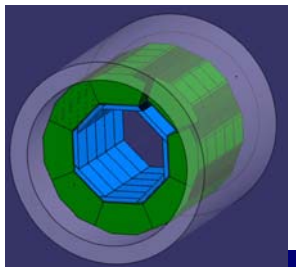
- Auto-triggering and time measurements
- ADC and TDC integrated
- Power pulsing, low (continuous) power DAC

L.Raux (LAL)



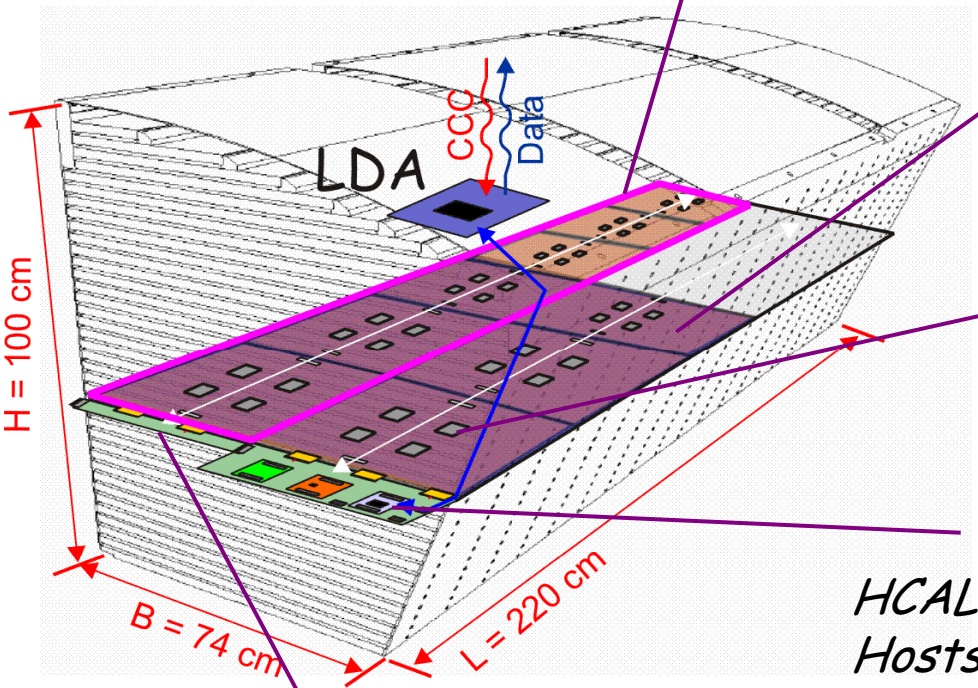


R.Fabbri (DESY)



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

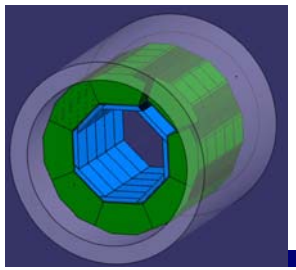
HEB
HCAL Endcap Board
Hosts mezzanine modules:
DIF, **CALIB** and **POWER**

HLD
HCAL Layer Distributor

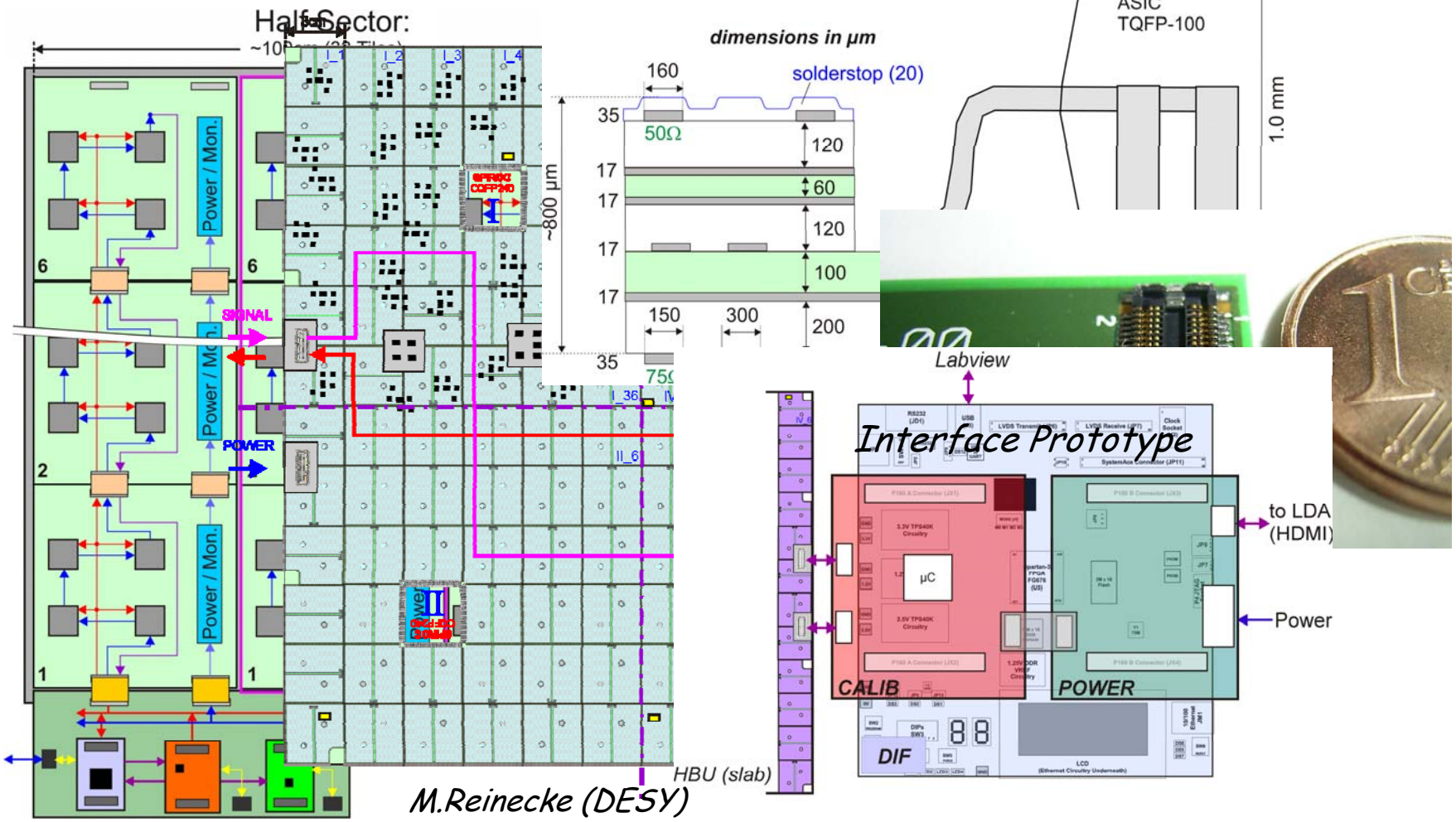
Power:
40 µW / channel

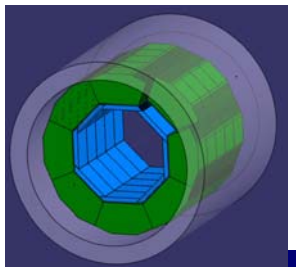
Heat:
T grad. 0.3K/2m
Time constant: 6 d

P.Goettlicher (DESY)



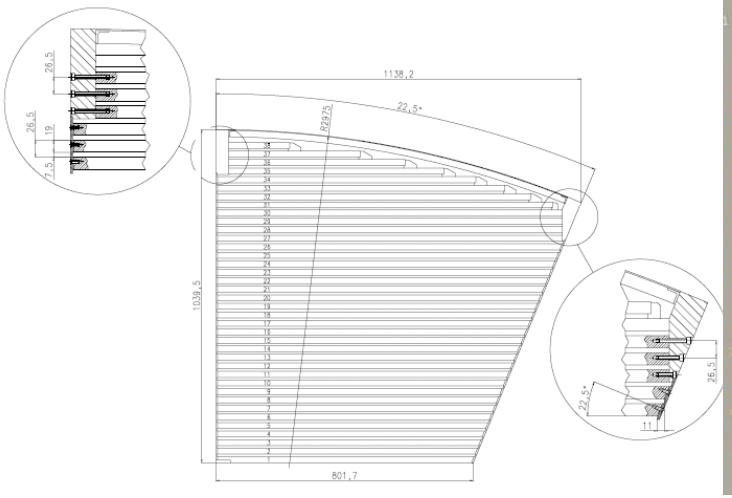
Details

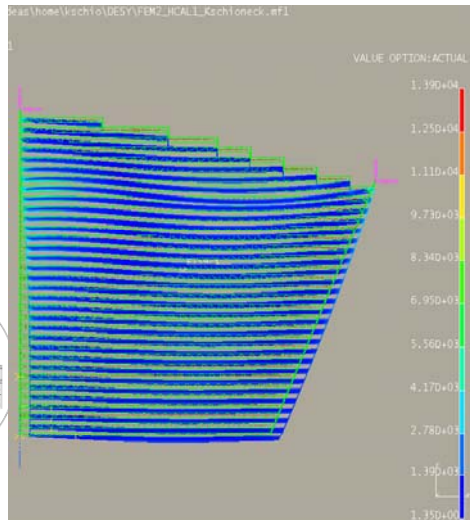

Half Sector:
Power / Mon.
SIGNAL
POWER
M.Reinecke (DESY)
HBU (slab)
dimensions in µm
solderstop (20)
50Ω
~800 µm
ASIC
TQFP-100
1.0 mm
Labview
Interface Prototype
to LDA
(HDMI)
Power
µC
CALIB
POWER
DIF

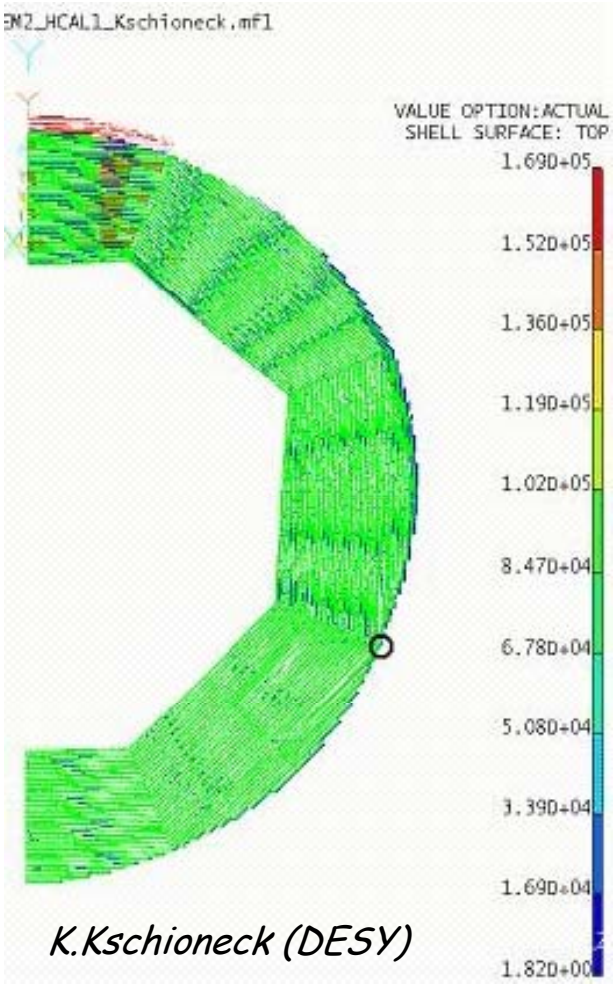


Mechanical structure

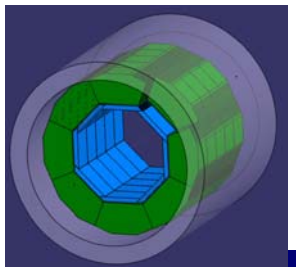
- Aggressive design: 3mm walls
- No additional spacers
- FEM calculation with sector details for full barrel
  - Max displacement 2mm, stress ✓
  - Integration with cryostat and ECAL







K.Kschioneck (DESY)



Conclusion

- A technical design for a highly granular scintillator HCAL
  - Meets particle flow requirements
  - 1000 tiles / m^2, individually read out
  - Latest generation SiPMs, MPPCs
- Embedded photo-sensors, ASICs, calibration system
  - No fibres, no HV lines, no cooling pipes
- Compact mechanical design
  - Thin r/o gap, no cracks, ~99% instrumented
- Build it:
  - Electronics prototype with tiles and r/o chain in 2008
  - Layer demonstrator in 2009