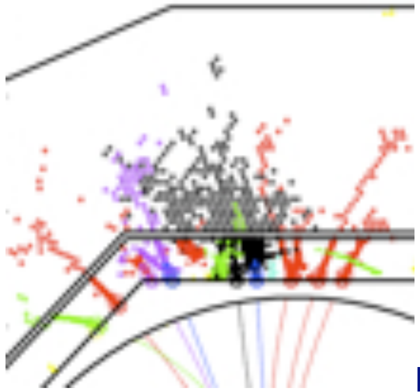
AHCAL optimisation challenges towards a TDR

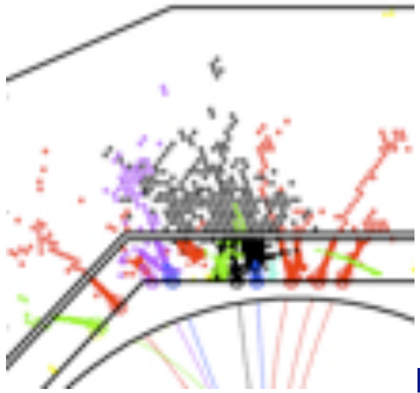
Felix Sefkow

ILD workshop
Cracow, 24.-26. September 2013



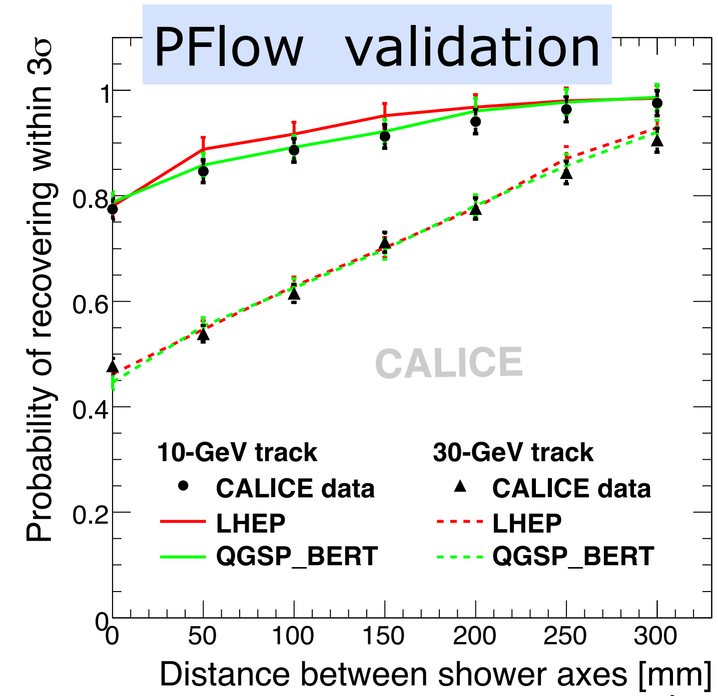
Outline

- Geometry : cost
- Industrialisation : time
- Calibration : precision
- Technology : options

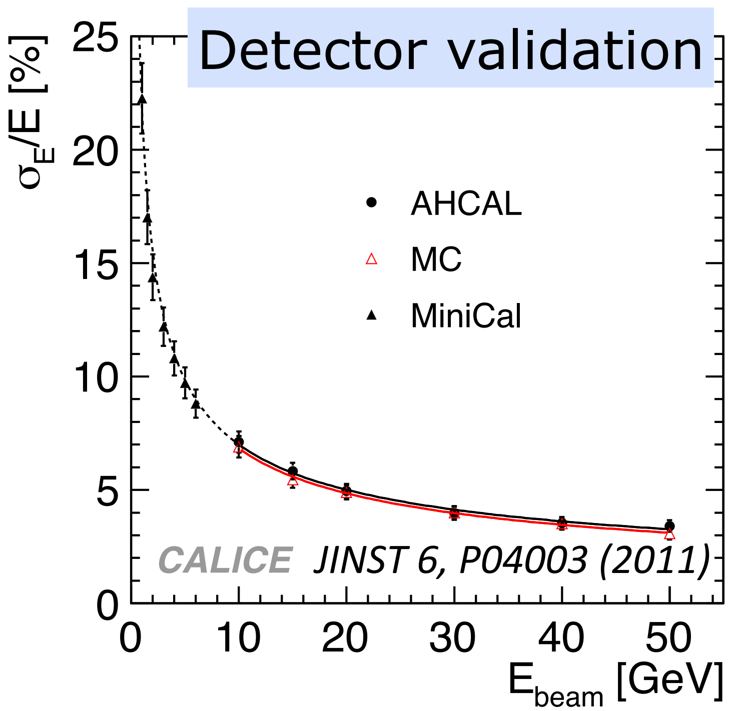


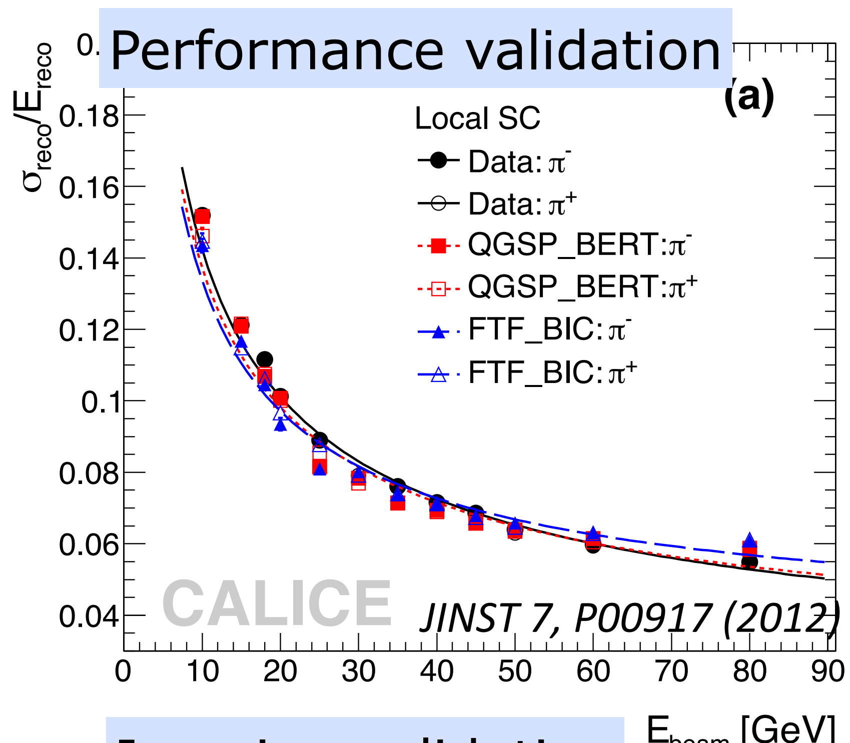
Validation of Simulation

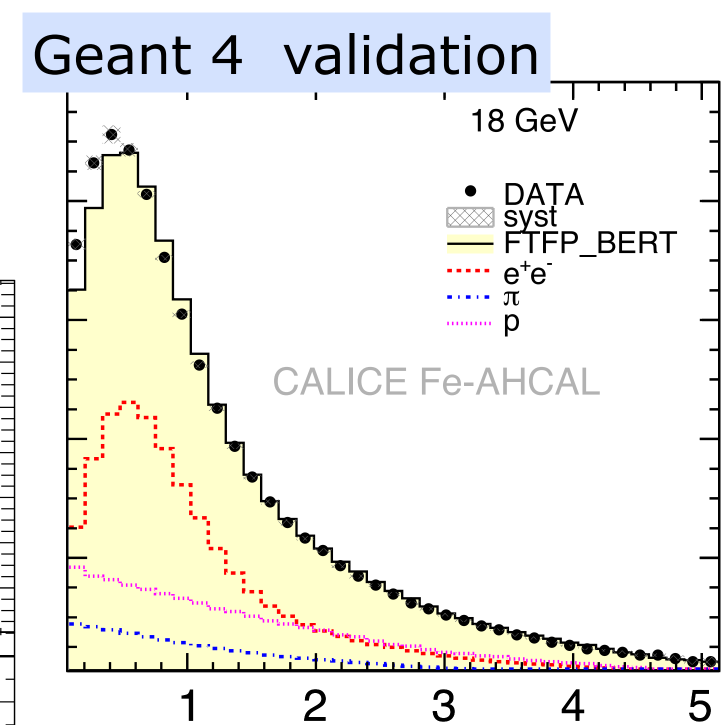
- Optimisation = performance vs. cost
- Validation with first generation prototype

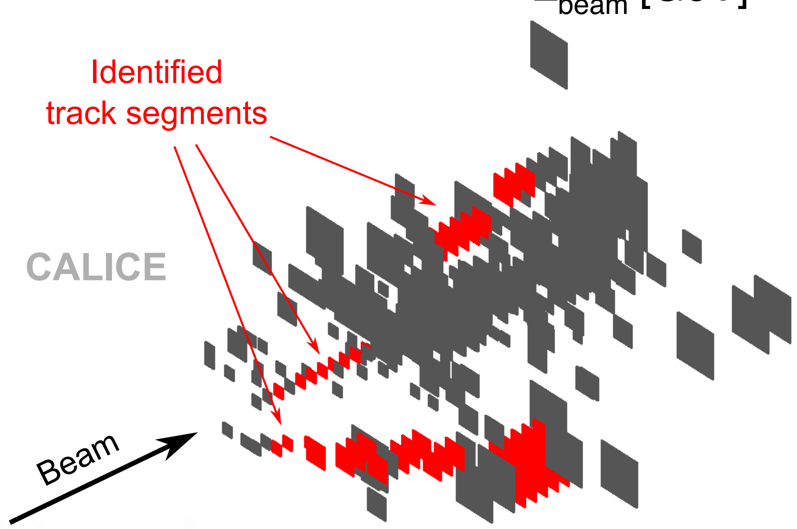


JINST 6, P07005 (2011)

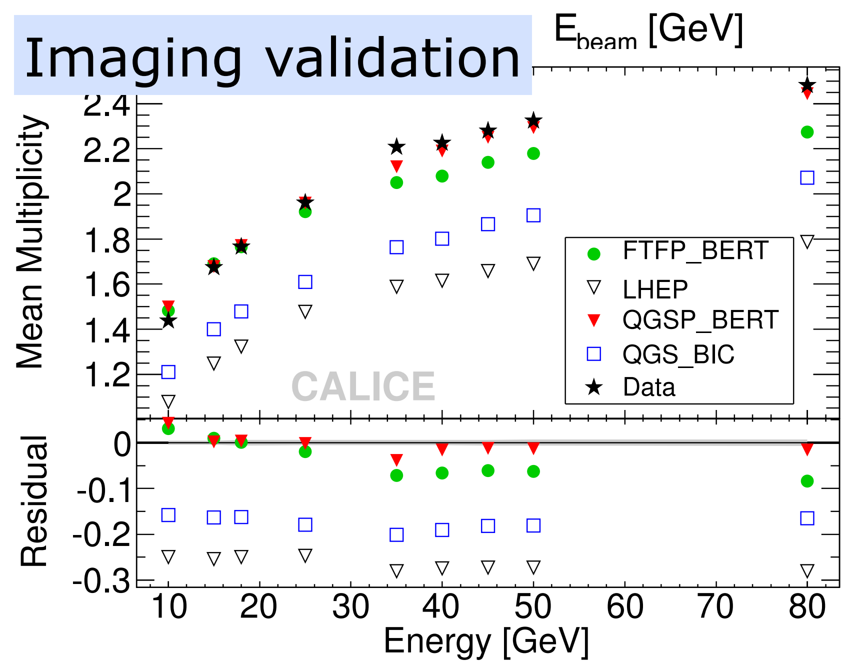




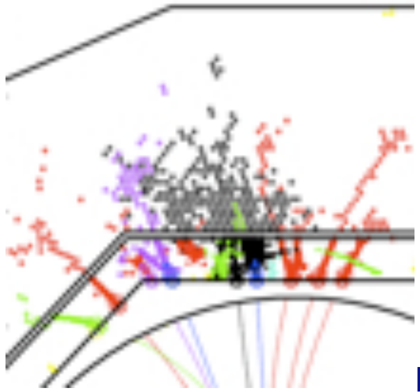




JINST 8, P09001 (2013)

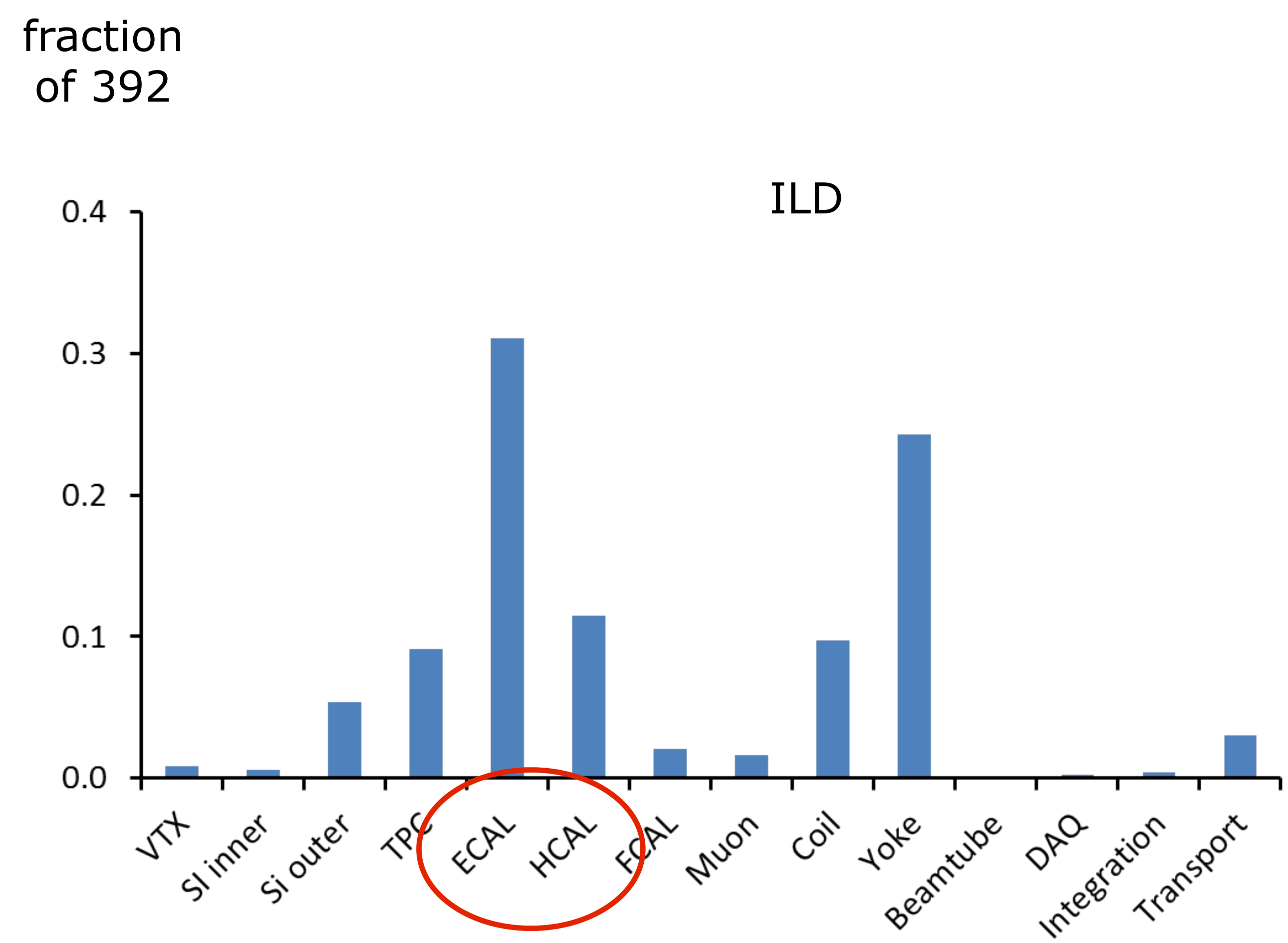


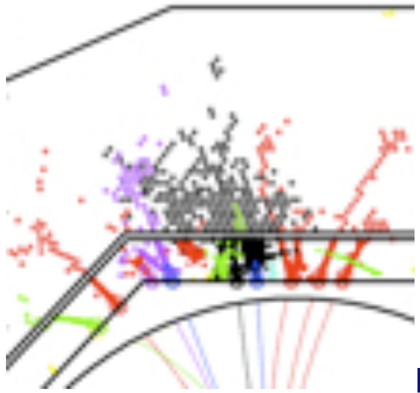
JINST 8, P07005 (2013) $z\ [\lambda_I]$



AHCAL cost

- DBD costing is far from final, but much better than anything we had before, largely based on 2nd gen. prototyping
- Many lessons to be learnt
- What are the real cost drivers at present?
- What are the scaling laws?





AHCAL cost drivers and scaling

- Absorber 10M ~ volume
- SiPM 8M ~ channel
- PCBs 22M ~ area

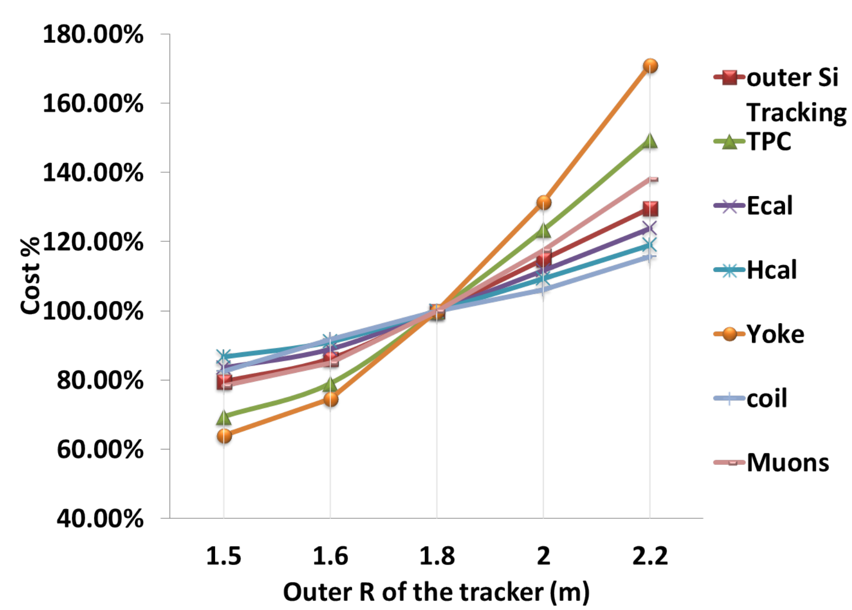
- and not

- Scintillator 1.5M
- ASICs 1.8M
- Interfaces 1.4M
- ...

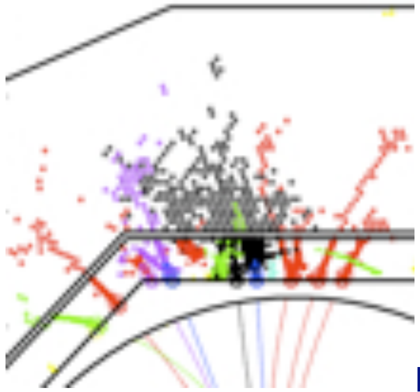
- total 50M

- Parameterize as function of
  - inner radius R_i
  - thickness $T = R_o - R_i$
  - absorber layer thickness d
  - tile size g

- and study performance as a function of cost



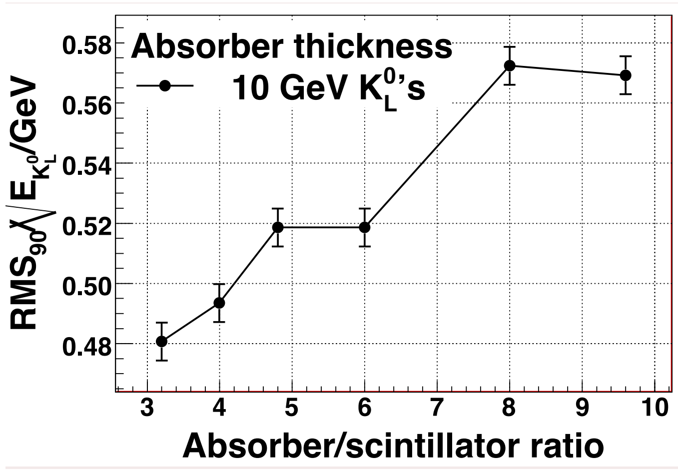
include outer part in derivative

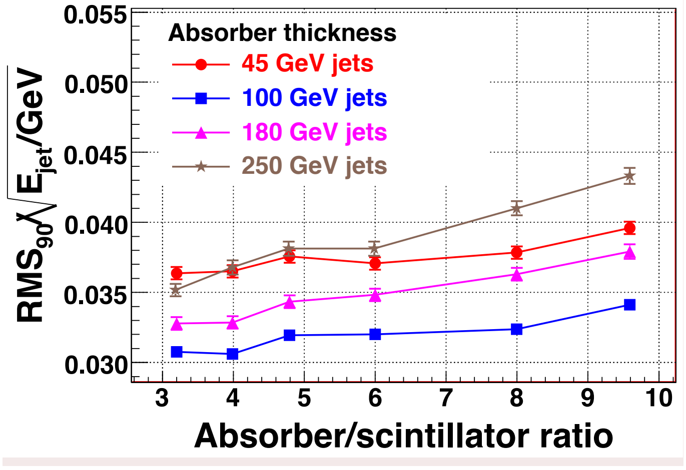


Parameter optimisation

- Was done for the LOI
  - see Angela Lucaci's talk at ILD meeting in Cambridge, 2008
  - tile size
  - tile thickness
  - absorber material
  - absorber plate thickness
  - total thickness
  - dead zones
- Revise main cost drivers with new Pandora
  - absorber plate thickness d
  - tile size g; varying?
  - total thickness T
- Strip option: need SSA

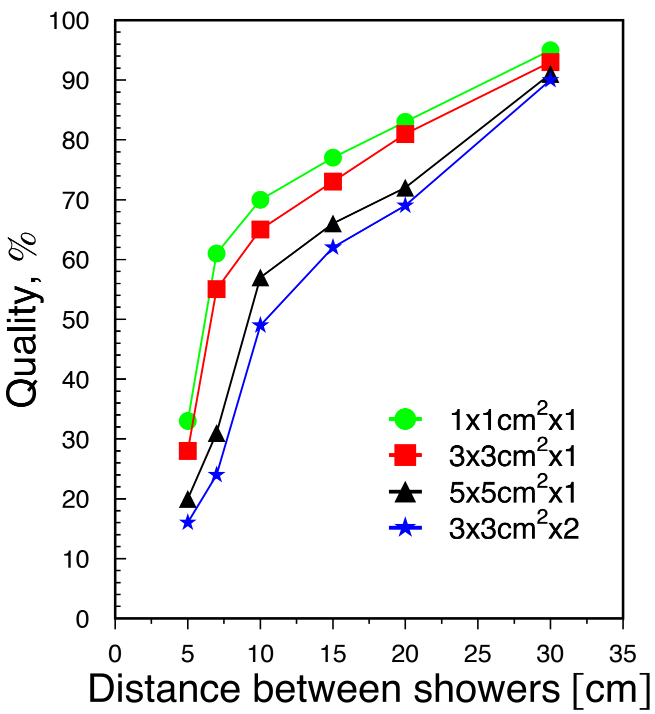
single hadrons and jets:



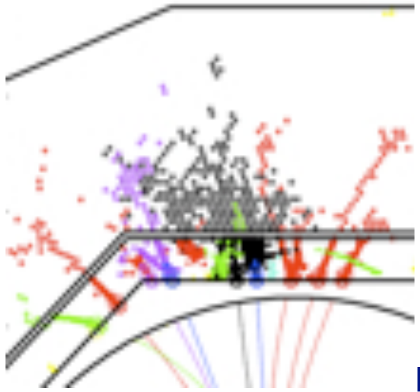


note zero suppression

ECAL+HCAL

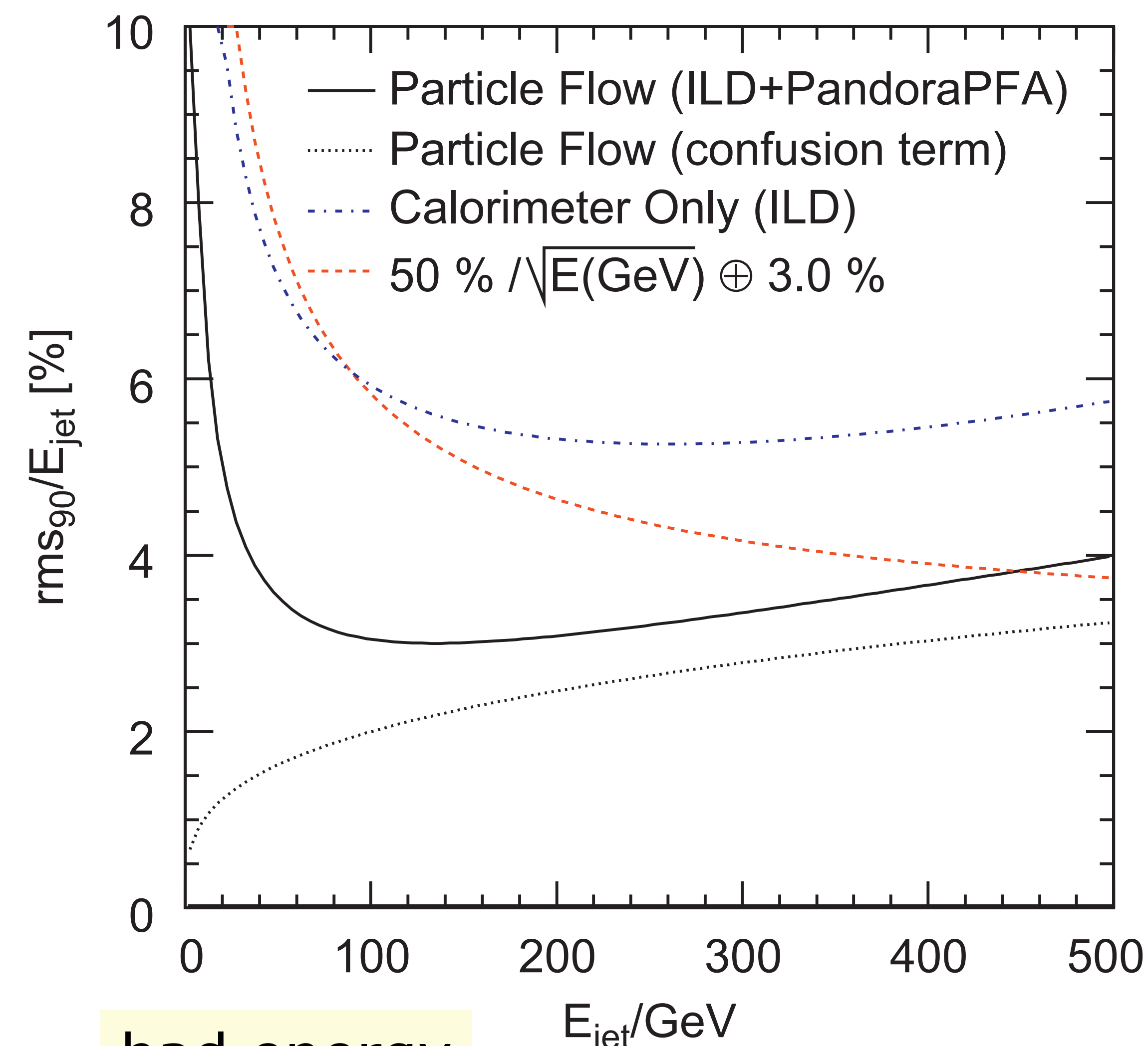


Raspereza 2004: transverse *and* longitudinal sampling important for shower separation



Physics optimisation

  - Impact of detector design on particle flow performance
  - and impact of PFlow performance on physics output
- factorize quite well
- Separate discussions
  - avoid moving target
- However: staging might be an interesting topic
  - physics targets move with energy - and thus time
  - performance drivers change with energy

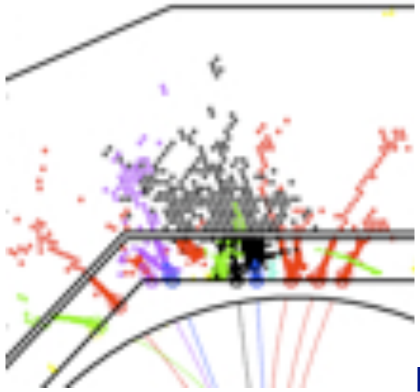


had energy resolution

energy and topology

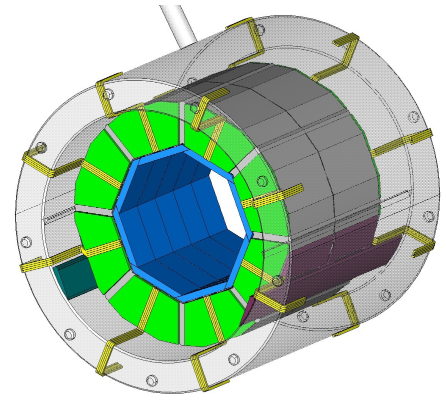
containment, constant term

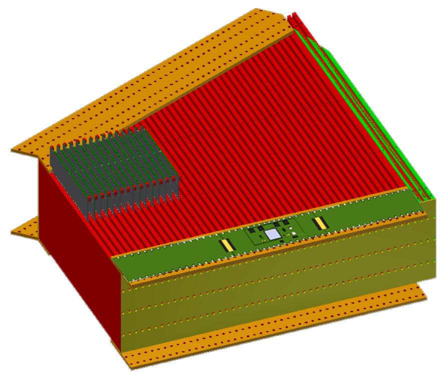
needs sensitive benchmark

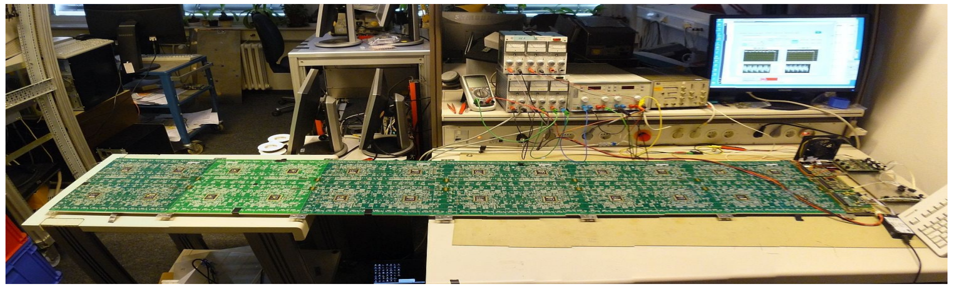


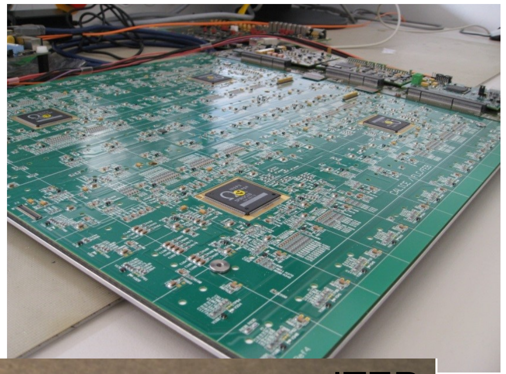
Industrialisation: Numbers!

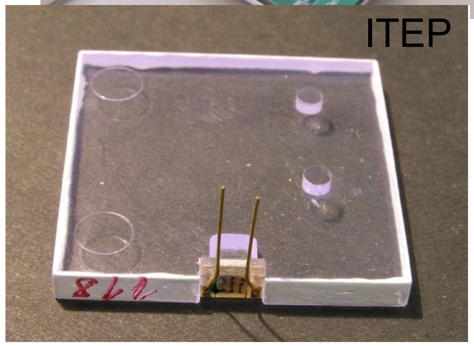
- The AHCAL
- 60 sub-modules
- 3000 layers
- 10,000 slabs
- 60,000 HBUs
- 200’000 ASICs
- 8,000,000 tiles and SiPMs



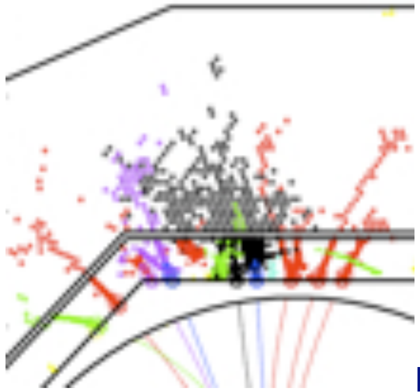






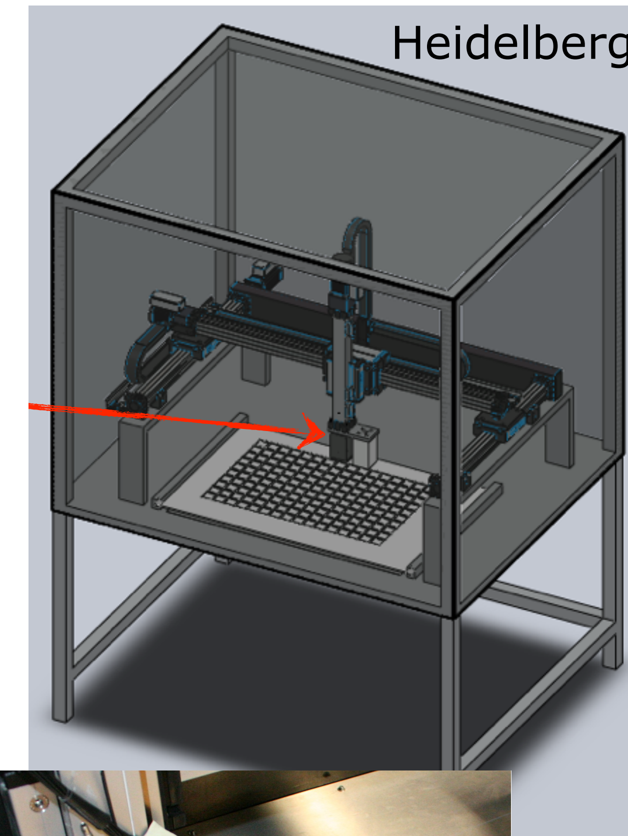


- One year
- 46 weeks
- 230 days
- 2000 hours
- 100,000 minutes
- 7,000,000 seconds

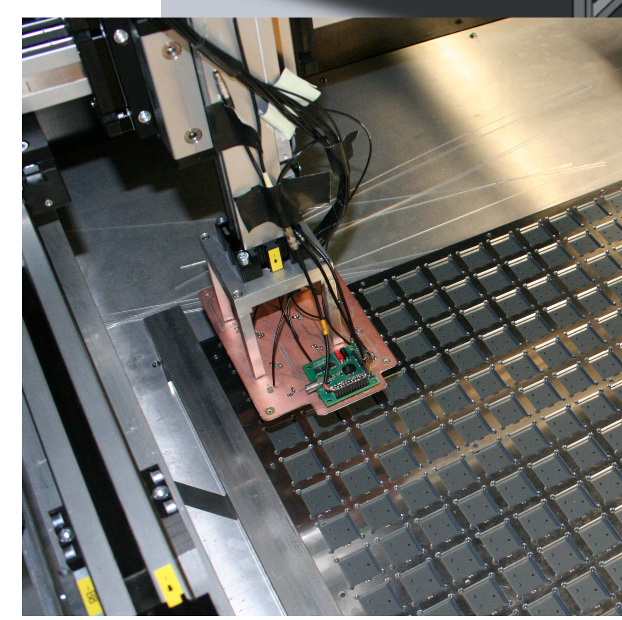


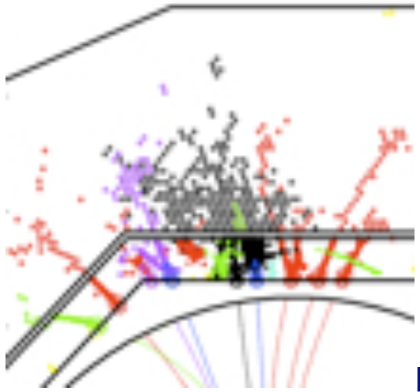
Quality control and production

- Can be done: our engineers are looking forward to it
- There are interesting problems to solve
- Some efforts started:



- SiPM and tile QC and characterisation
  - with UV light and beta source
  - fully automatised, fast parallel readout
- LED ad ASIC tests
- HBU assembly
  - place tiles, solder SiPMs
  - close relation to tile design and SiPM coupling
  - impact on QC chain





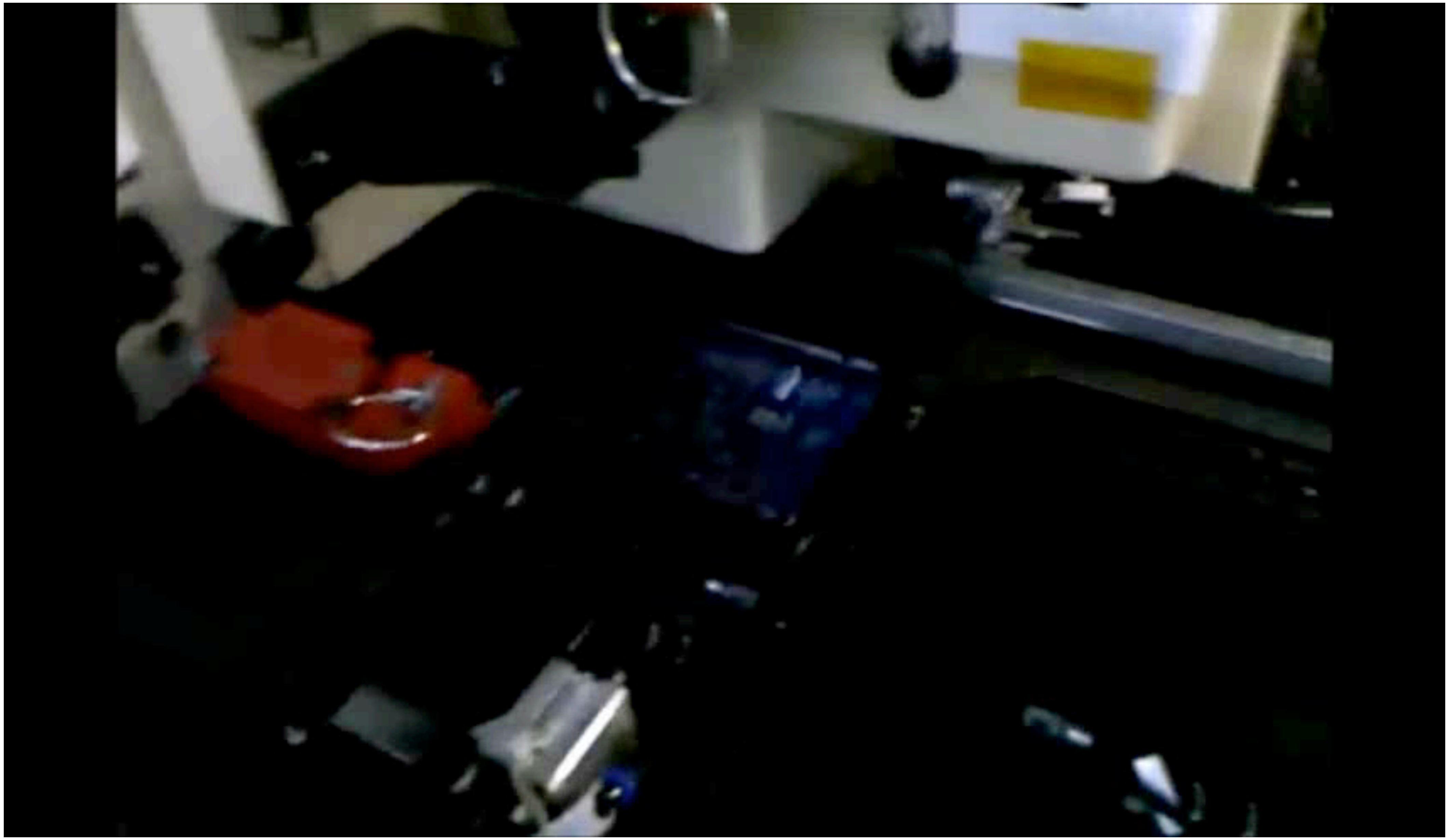
Automatic assembly

- pick and place machine

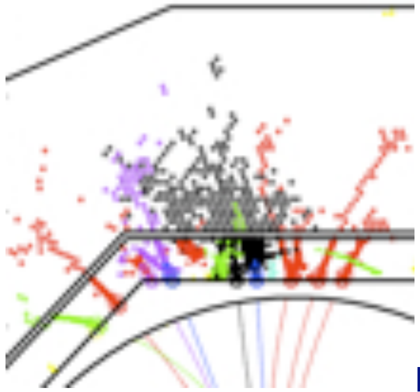
Phi Chau, Mainz

Automatic assembly

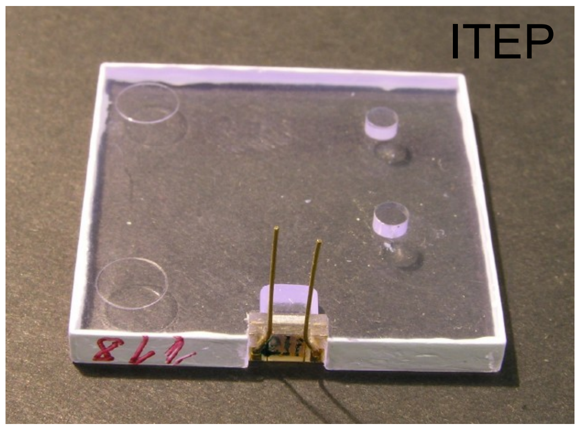
- pick and place machine



Phi Chau, Mainz

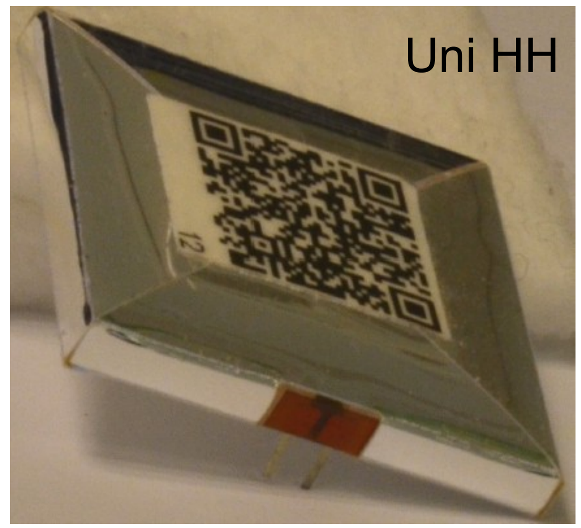


Scintillator tile options

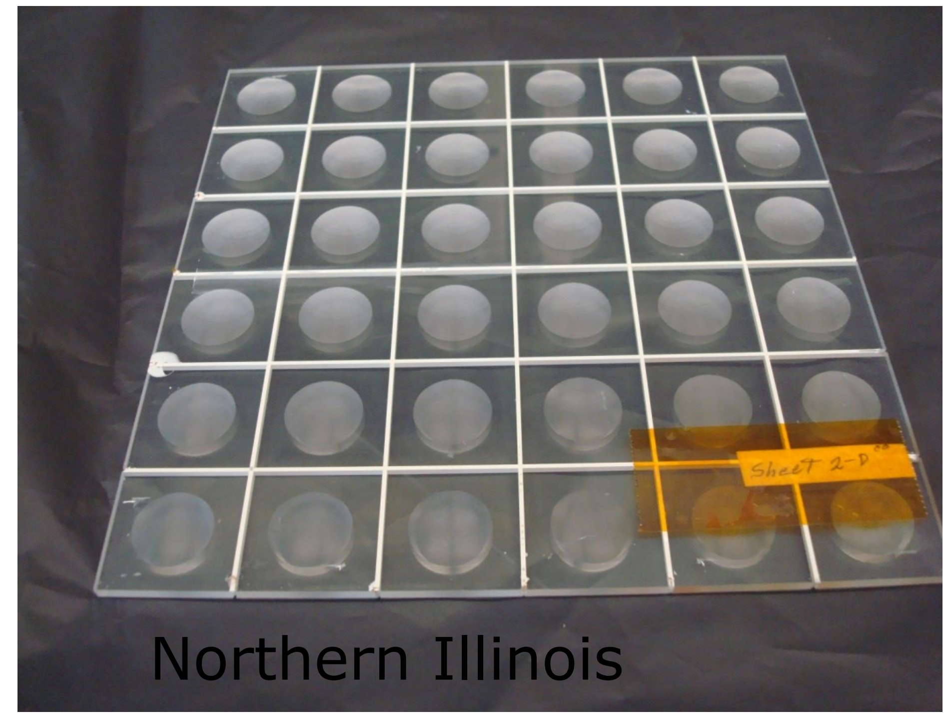


CPTA, KETEK or Hamamatsu sensors

no WLS fibre

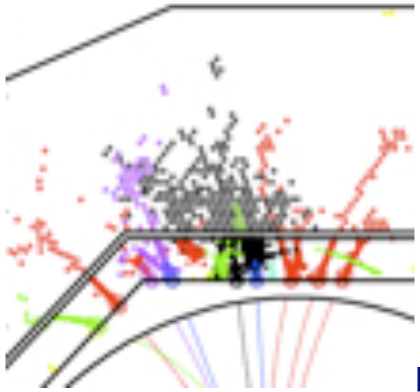


individually wrapped; KETEK sensors



Hamamatsu sensors, on PCB surface

- Megatiles interesting alternative
  - need to understnd limitations and impact of optical cross talk
- need to optimise design and production together
- implication for QC chain: scintillator SiPM system independent of final electronics - or not

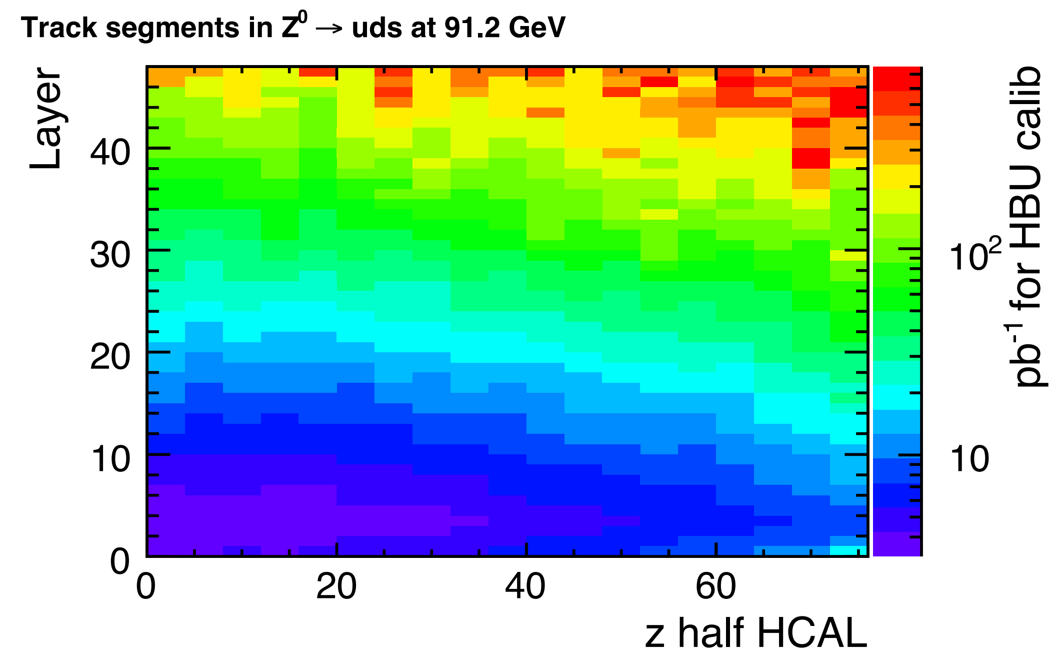


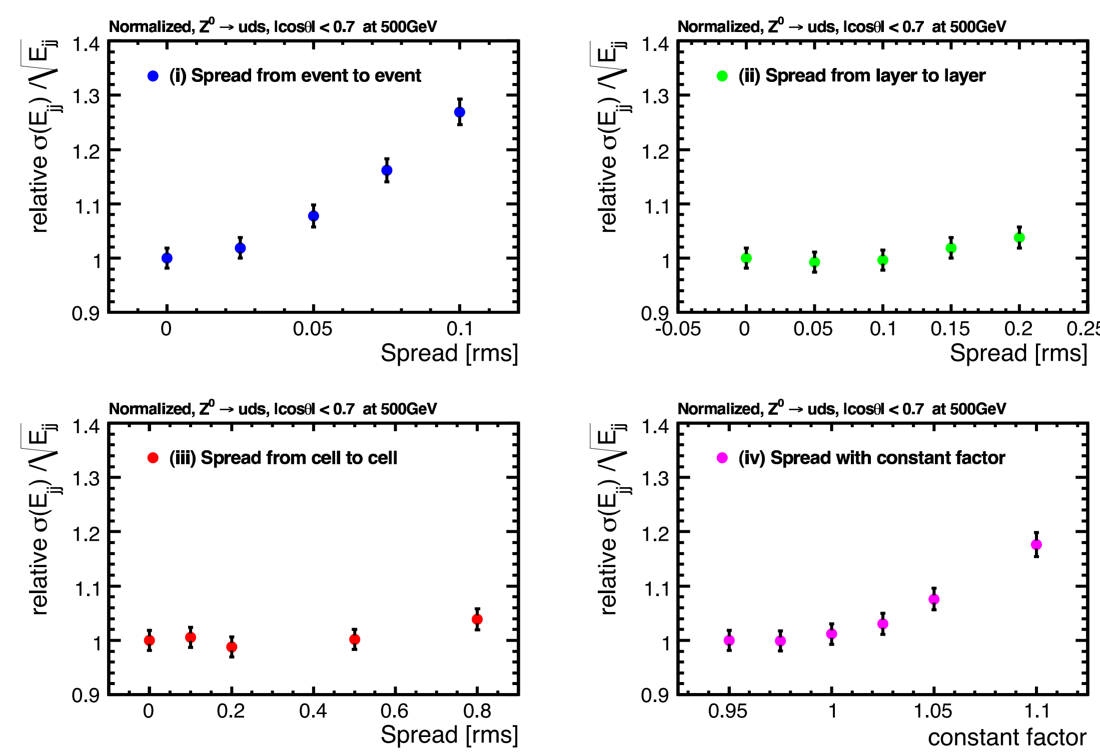
Calibration: look at full chain

- LOI validation: IDAG triggered study of required precision and luminosity for calibration
- MIP (= cell energy) scale well understood

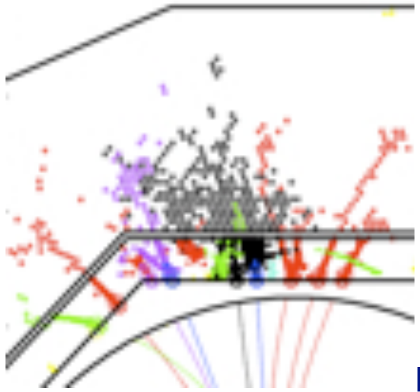
- LEDs for gain monitoring: issue is not cost, but time, and bandwidth
- need to optimize strategy, possible feedback on design and specs

- Test bench is part of calibration - study required precisions vs. time needed for procedures
- "Precision" = measurement accuracy or device-to-device non-uniformity





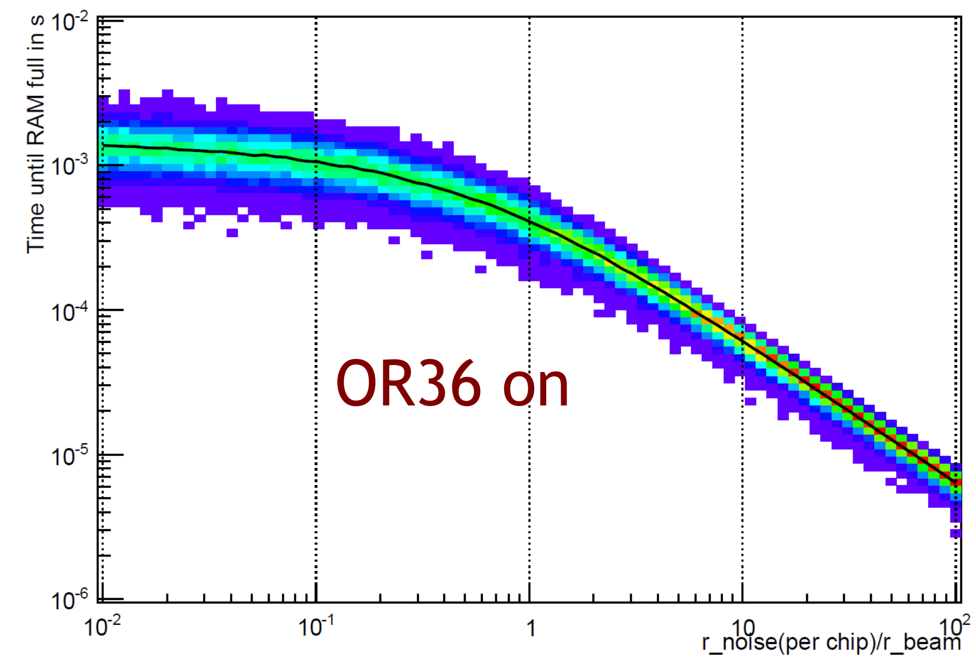
Calice Analysis note 18 and ILD note

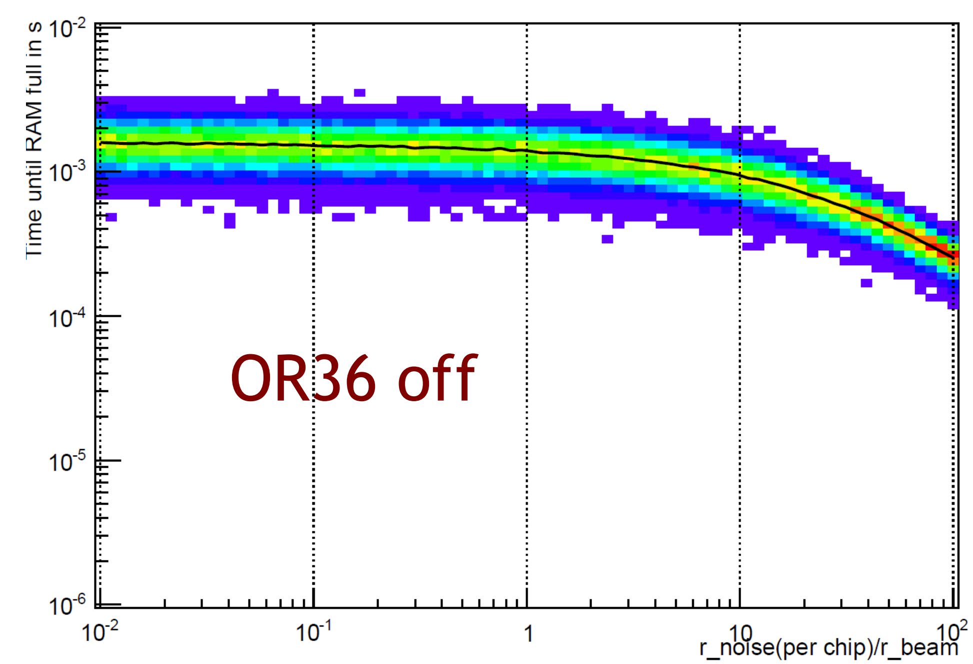


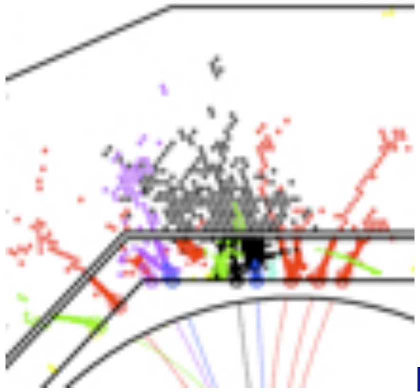
Front end band width

- Bottle neck for ILC calorimeter DAQ is the in the front end
- Auto-trigger, read-out after bunch train
- None of the 8,000,000 buffers must ever over-flow
- Studies for test-beam prototype
- For ILD, need occupancy including gamma gamma background
  - polar angle dependent, including safety margin from machine side
  - by all means exclude back-ground dependent inefficiencies
  - possible impact on electronics design and cost

O.Hartbrich



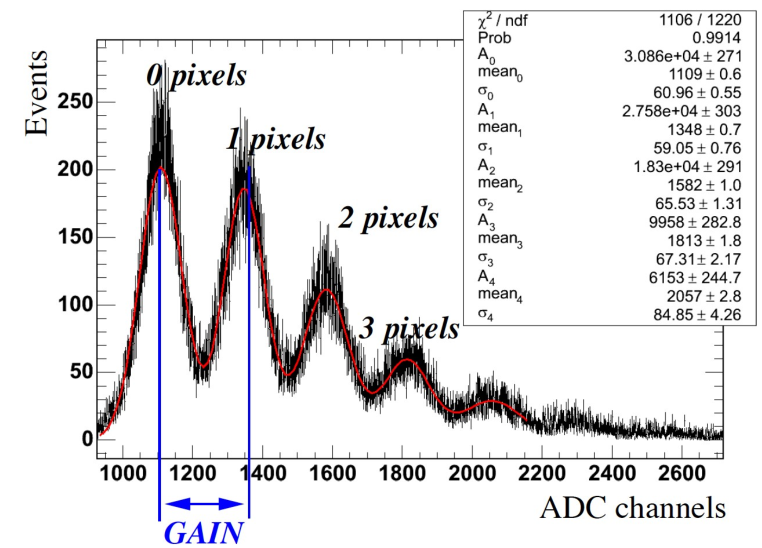




Technologies

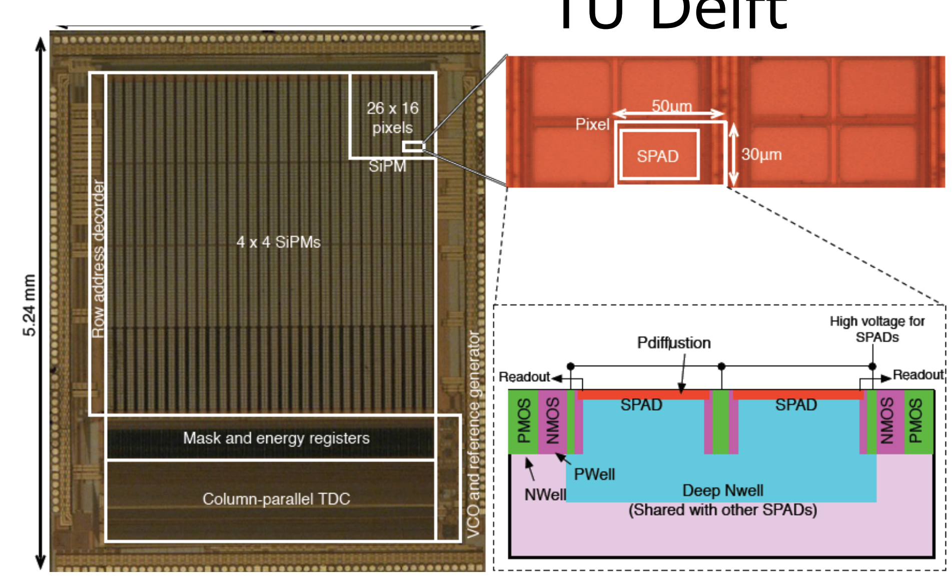
- Some more advanced technical ideas:

- On-detector gain calibration:
  - analyse SiPM spectra and extract gain
  - no raw data read-out for LED events

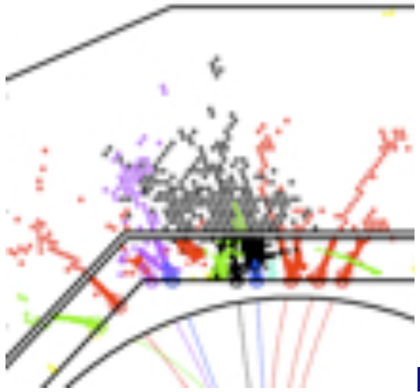


- Digital SiPMs
  - no temp dependence, no analogue electronics
  - digital network much more complex

TU Delft



- should do some conceptual studies
- rather topics for an upgrade

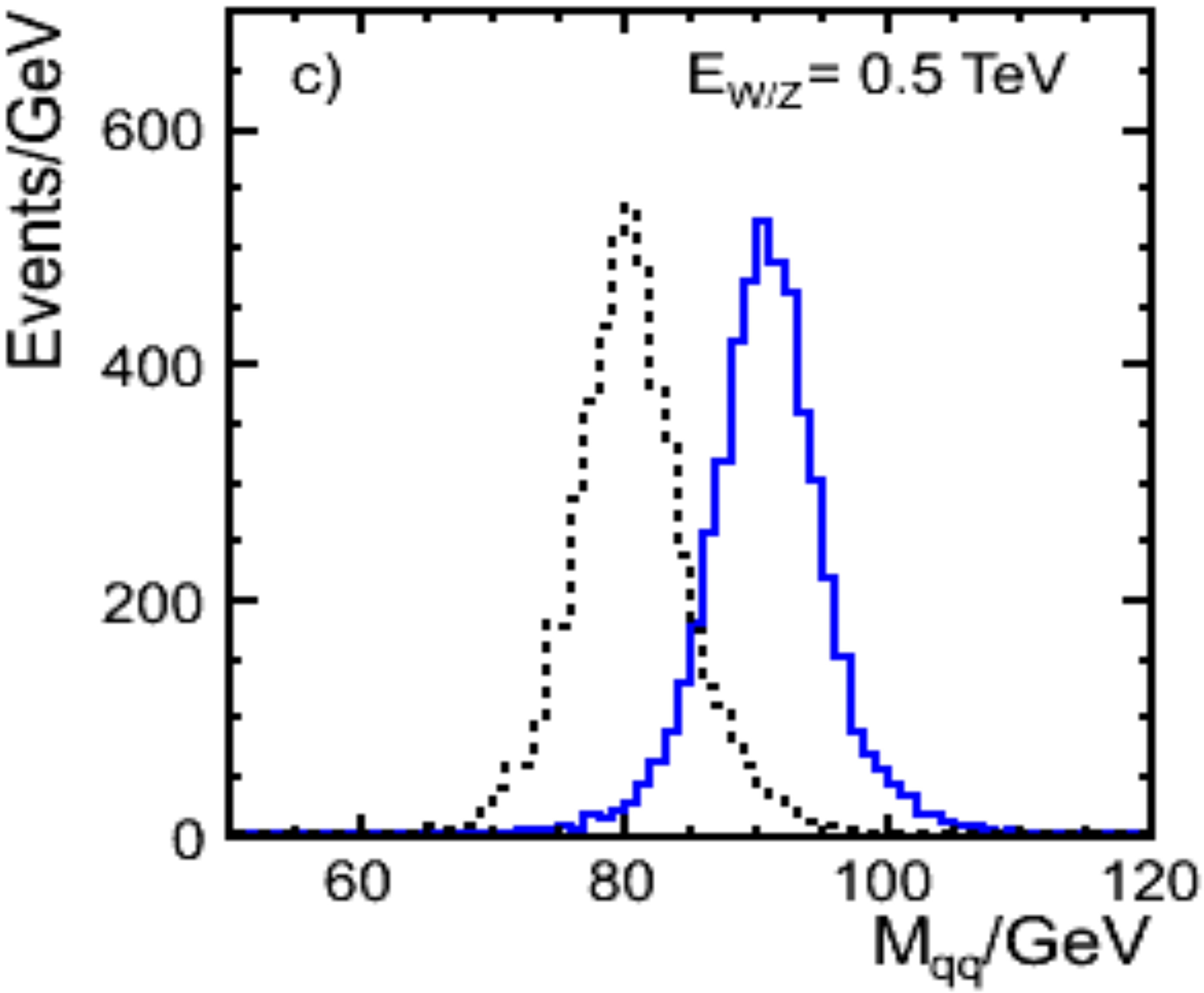


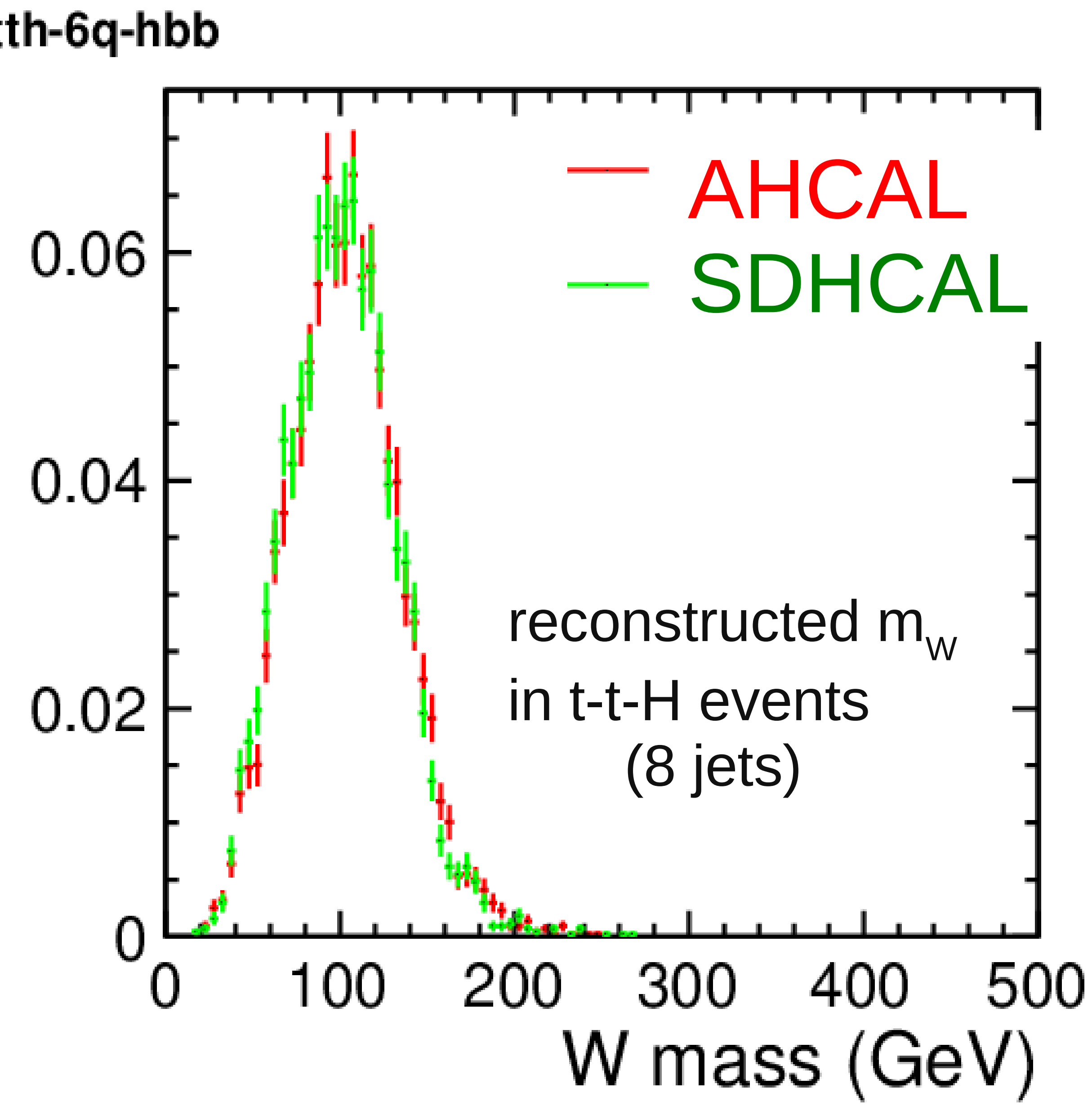
Conclusions

- Cost performance optimisation: can now be done, should now be done
  - instrumented area is the main driver
- Industrialisation: need to make the next step and face the big numbers - the real challenge
  - look at design details and production sequence together
- No real progress without serious prototyping
- Options for technology leaps
- Optimisation does not interfere with R&D plan and prototyping
  - coarser is cheaper and easier, finer is demonstarted by ScECAL

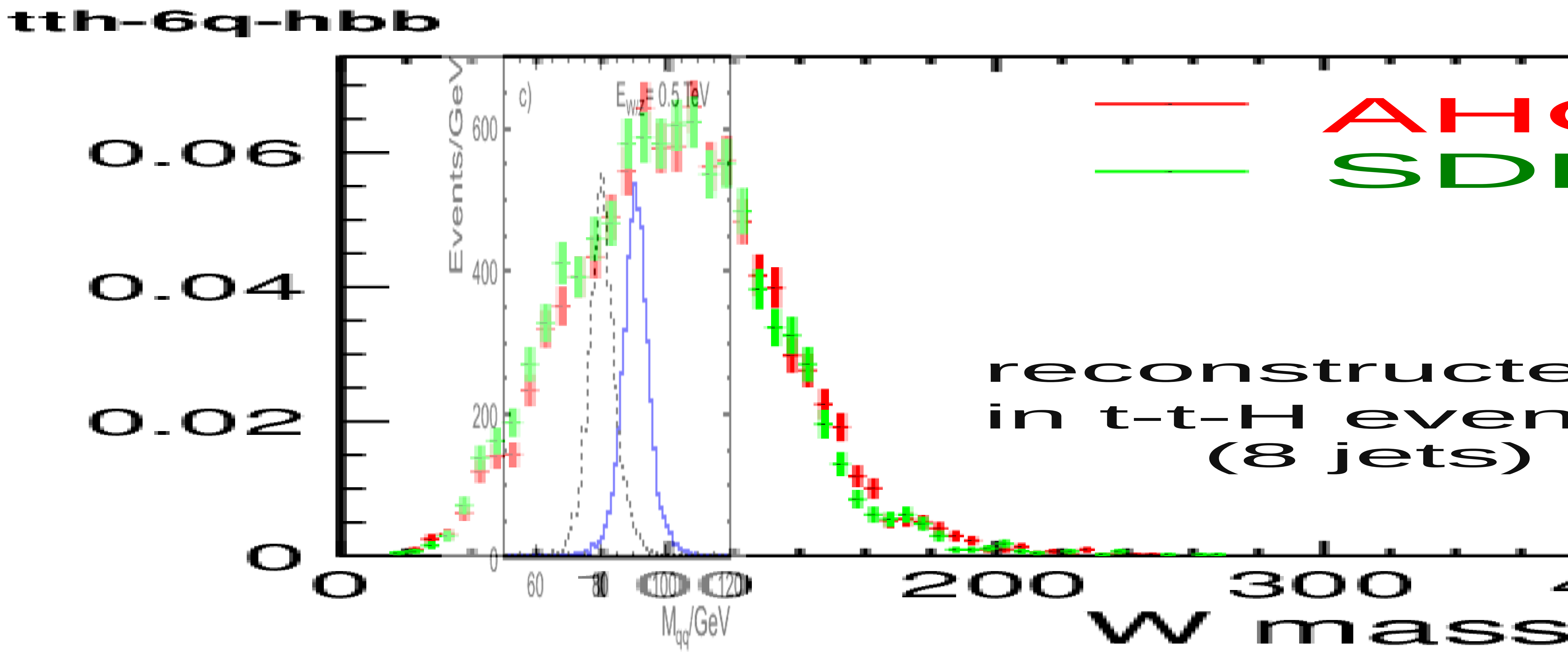
Back-up

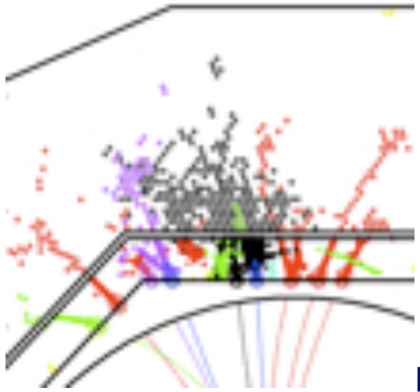
W Z separation





W Z separation





Better choice

- Chargino and neutarlino production
- Decays in WW, ZZ and missing energy
- studied for LOI

models had similar jet energy performance