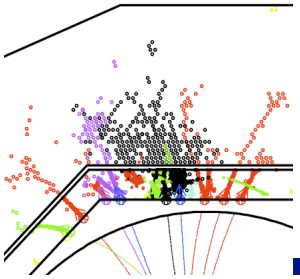
AHCAL project overview

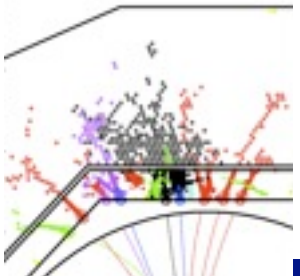
Felix Sefkow

HCAL Main meeting
DESY, December 09, 2013



Outline

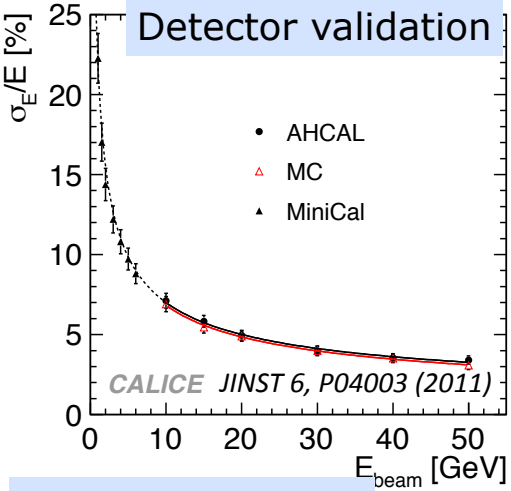
- Analysis
- Next prototype
- Test beams
- Optimisation



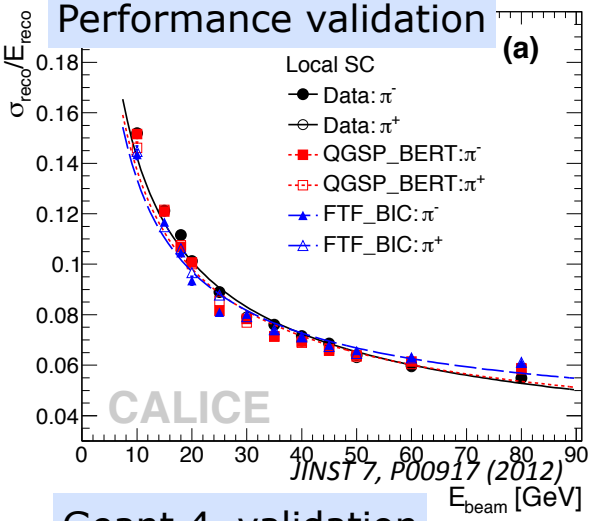
Validation of Simulation

- Validation with first generation prototype
- Published

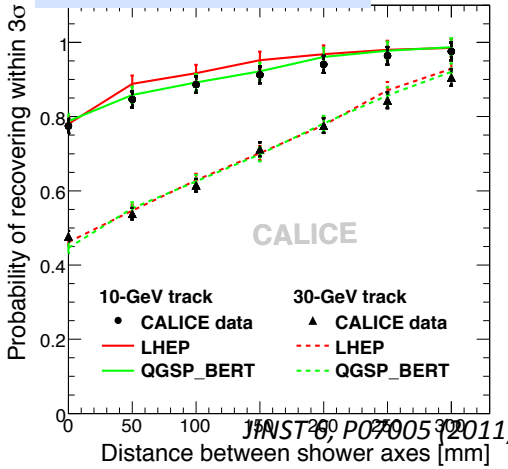
Detector validation



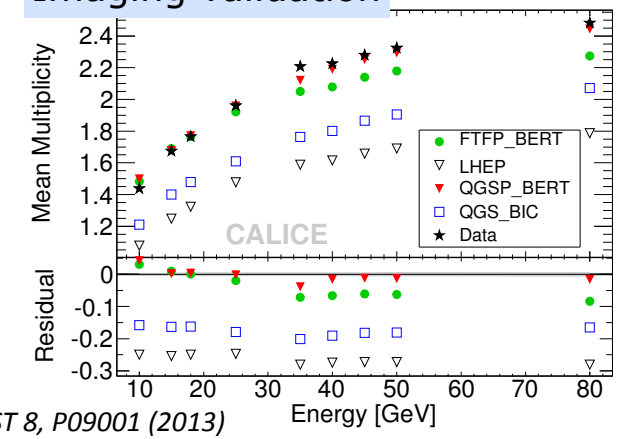
Performance validation



PFlow validation

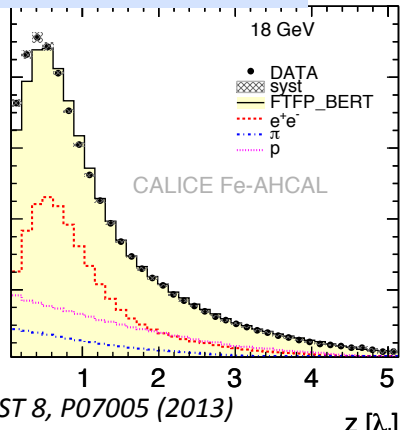


Imaging validation



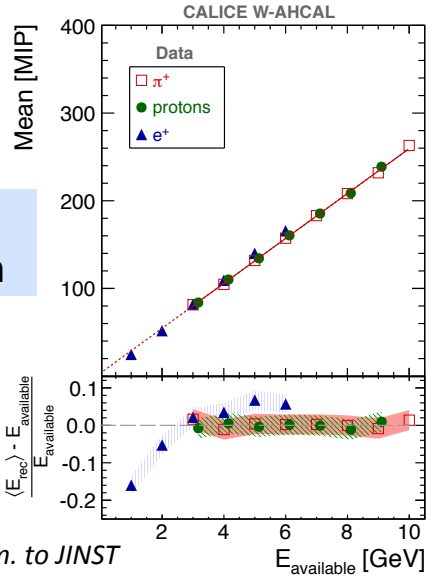
JINST 8, P09001 (2013)

Geant 4 validation

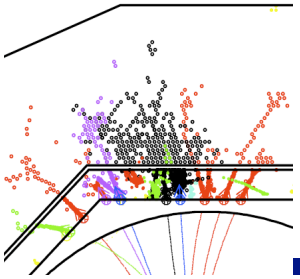


JINST 8, P07005 (2013)

Tungsten validation



subm. to JINST

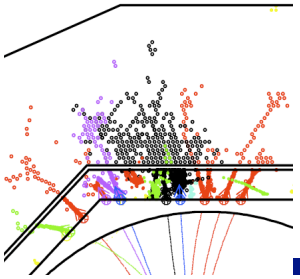


Analysis

- 3 papers in 2013
  - track segments , pions vs Geant 4, tungsten < 10 GeV
- 3 more in the pipeline
  - tungsten 10-100 GeV, tungsten timing, protons

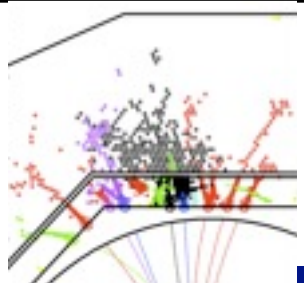
- More: spatial resolution, semi-digital study, W > 100 GeV
- FNAL all scintillator analysis re-started

- Analysis ~~nearing~~ reaching completion
- Time to worry about fresh data…



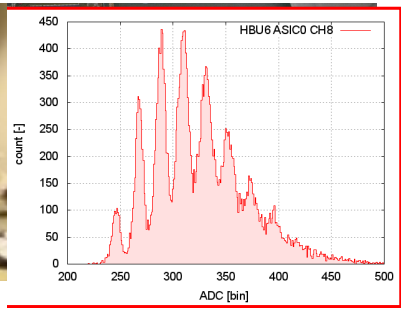
Hardware: Outlook Dec 2012

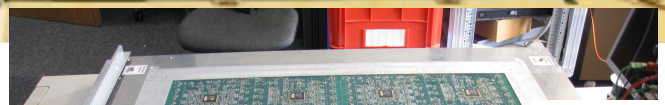
- Proceed at the integration frontier
- while remaining open for different sensor options
- Electronics is versatile
- and ready to make a start



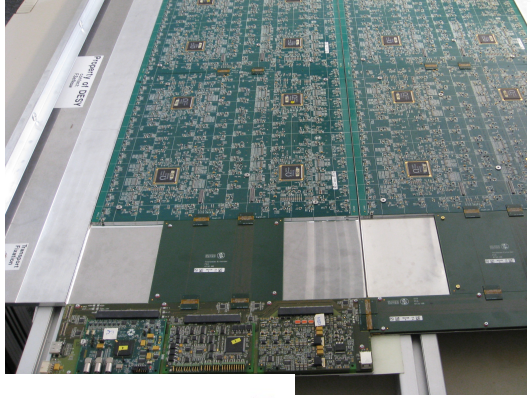
2nd generation prototype

- Full slab: signal integrity

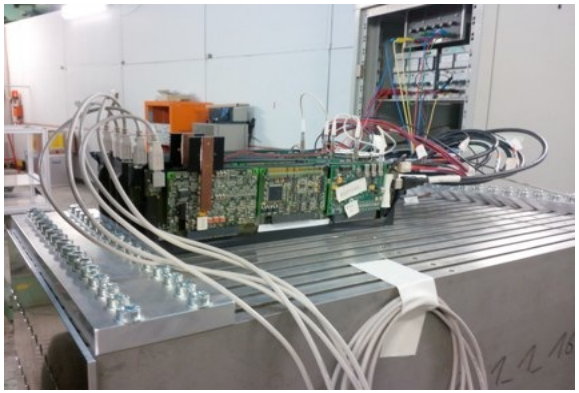


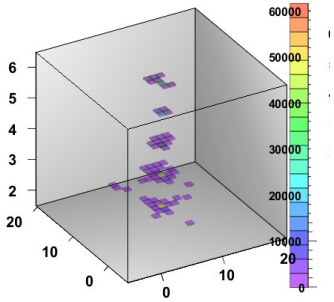


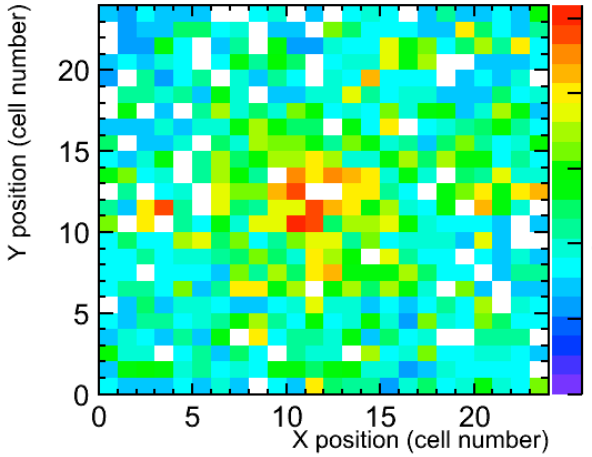
- Full layer: hadrons



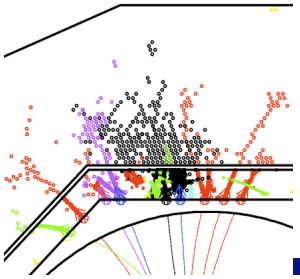
- First stack: electrons





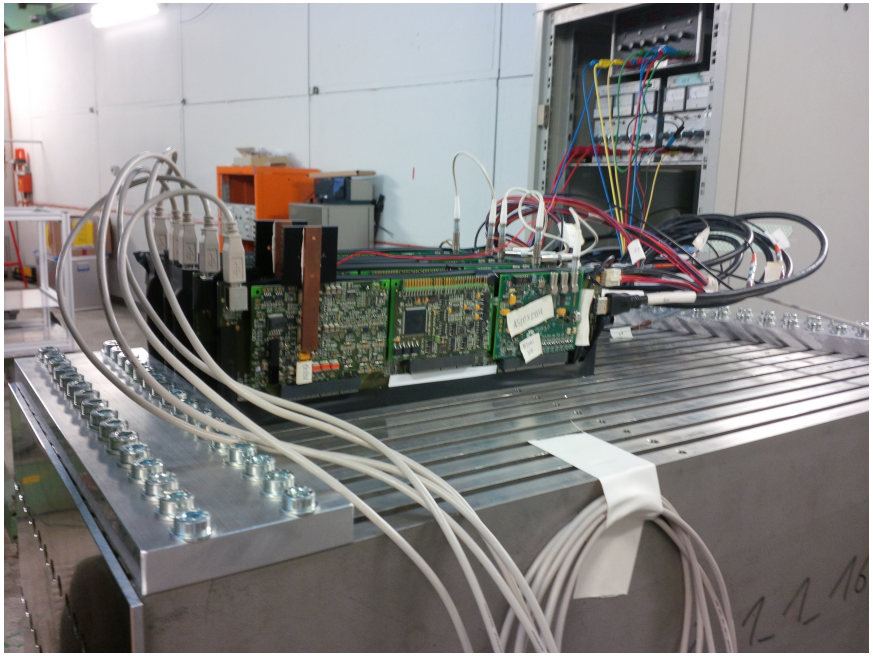


synchronous! ✔

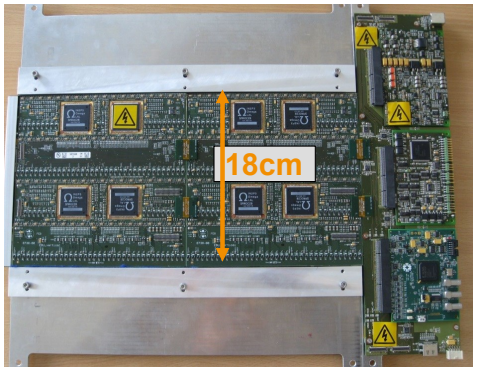


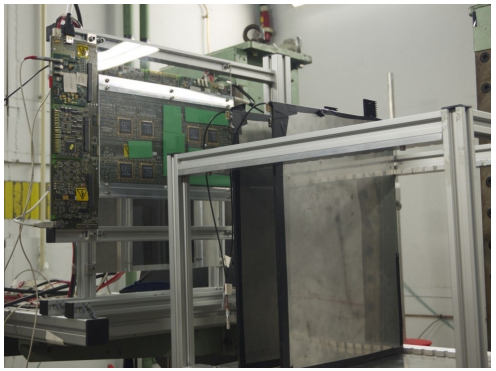
2013: first stack

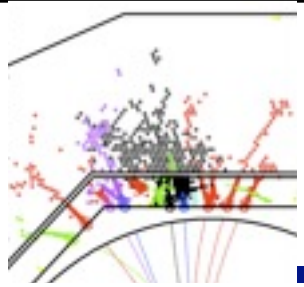
- breakthrough in summer: synchronous 5 layer operation
- intermediate DAQ: USB, HDMI
- using new CCC
  - clock & control card
- Next: integrate LDA and gradually evolve to full HDMI



- also worked with ECAL and HCAL layers together
- ECAL group expressed interest to join next HCAL test beam

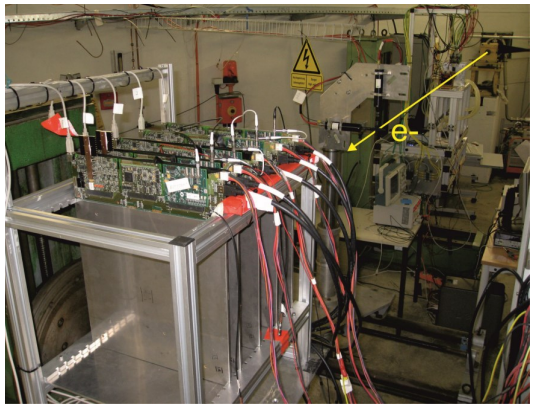




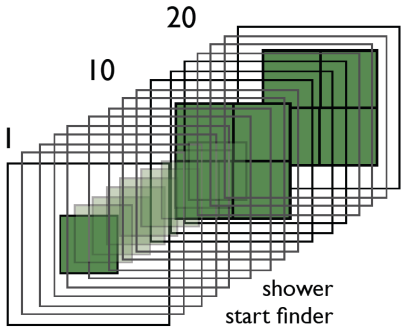


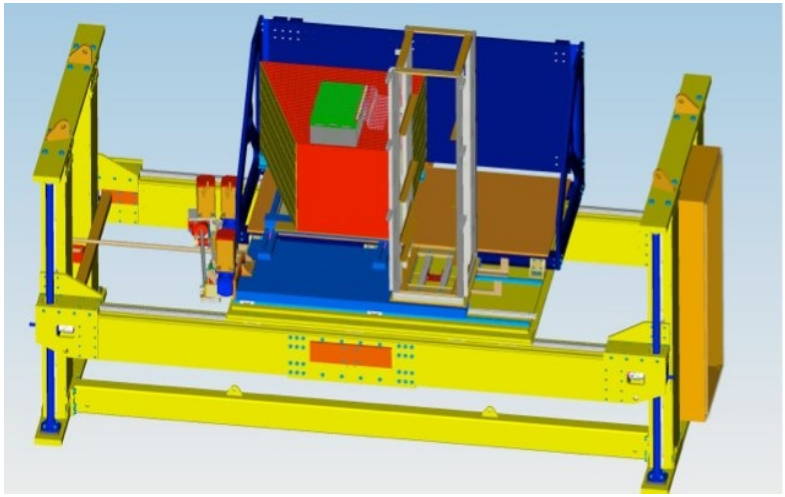
Flexible test beam roadmap

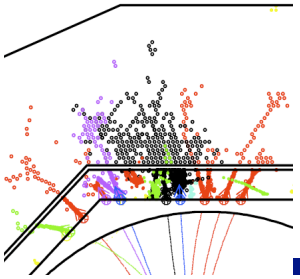
- 2013-14:
  - e.m. stack, 10-15 layers, ~200 ch
- 2015-16:
  - hadron stack with shower start finder, 20-30 HBUs, ~ 4000 ch
- 2017-18:
  - hadron prototype, 20-40 layers, 10-20,000 ch
- Gradual SiPM and tile technology down-select
- Exercise mass production and QC procedures



Fe and W

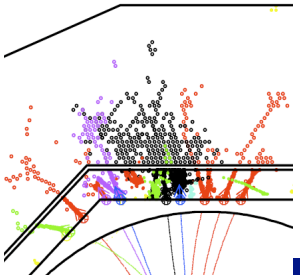






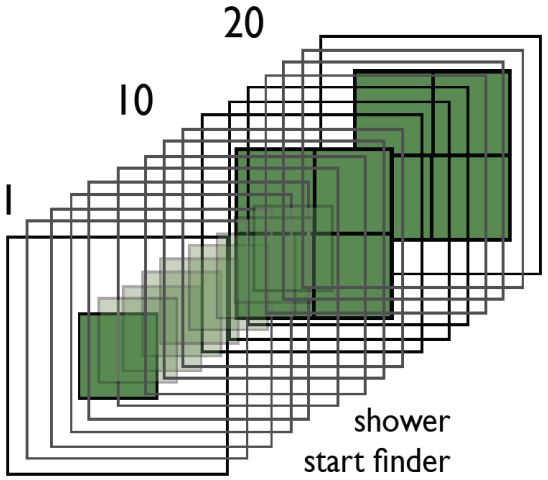
Obstacles

- Bottle-necks in DAQ development
  - both manpower and component delivery - temporary
- Test beam operation: some bad surprises
  - dying ASICs, non-reproducible config - both solved
  - open issues in ASIC and QC
- Delays in SiPM delivery
  - Ketek, Hamamatsu, ITEP
  - different reasons, same consequences:
  - not well prepared test beam modules, or none at all
  - no "standard commissioning procedure" yet
- DESY shutdown in 2014
  - next 3.5 weeks (b/a Xmas) last chance for quite some time
  - further running in 2014 unclear, maybe 2 months
  - difficult to prepare for CERN



Keep the momentum

- 5 HBUs running
- 8 HBUs in production at Hamburg
- Tiles for 2 HBUs left ITEP
- Sensors for 8 more ordered (HH, HD)
- More? To be discussed..
- >2 EBUs



18 HBUs

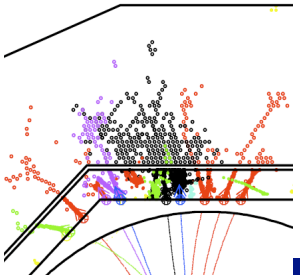
- Test beam at 2014
- CERN re-opens PS in July and SPS in October

ILC Timeline

Proposed by LCC

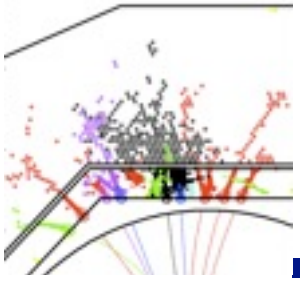
- 2013 - 2016
  - Negotiations among governments
  - Accelerator detailed design, R&Ds for cost-effective production, site study, CFS designs etc.
  - Prepare for the international lab.
- 2016 – 2018
  - 'Green-sign' for the ILC construction to be given (in early 2016)
  - International agreement reached to go ahead with the ILC
  - Formation of the ILC lab.
  - Preparation for biddings etc.
- 2018
  - Construction start (9 yrs)
- 2027
  - Construction (500 GeV) complete, (and commissioning start)

    (250 GeV is slightly shorter)



Mid-term

- Realistically assign an asymmetric error to this time line
  - +3 -0 y
  - TDR 16 - 18, construction start 18-21
- Technology down-select in 2-5 years
- Not imminent, but - with given low level of funding and low rate of progress - not so far, either.
- A window to re-optimise - and justify - cost
  - tackle cost drivers
  - physics justification: HCAL / PFLOW sensitive channels
- and time!
  - AHCAL deals with 1000x larger number of basic units than competitors
- Re-optimise tile design, assembly and QC chain together



Cost optimisation

- Chose a parameterisation basis for cost and performance study
  - **R** inner radius ⟷ confusion
    - ε aspect ratio
    - z barrel length εR
  - **T** total thickness ⟷ leakage
  - **N** number of layers ⟷ resolution
    - g active gap thickness (const)
    - d absorber layer thickness (T-Ng)/(N+1)
  - **s** tile size ⟷ confusion

physics motivated parameters

- Cost = $C_V * V + C_C = 45M$
  - Constant $C_C = 10M$
  - Rest scales with Volume ~ $2R^2T+RT^2$
    - Absorber 10M ~ **V** * d/(d+g)
    - Instrum. Area 16M ~ V/(d+g) = **N** * V/(T-d)
    - Channels 10M ~ V / $\mathbf{s^2}$(d+g)
    - adjusted to DBD numbers after Cracow

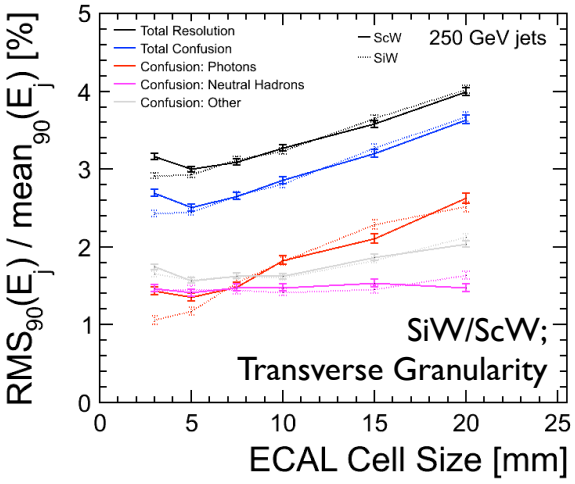
Cost impact factor

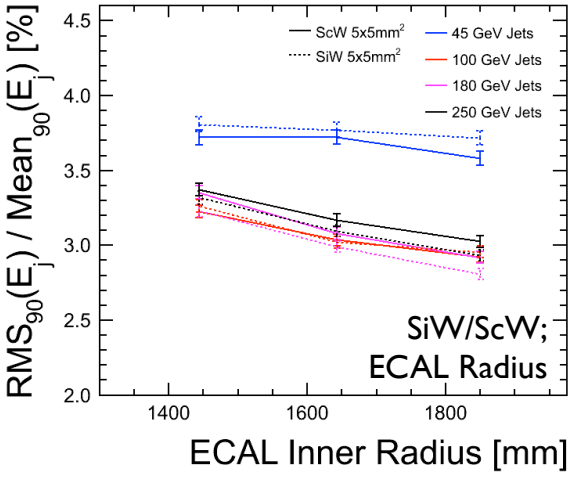
	[% / %]
Radius	1.4
Thickness	0.5
No layers	0.5
Tile size	0.4

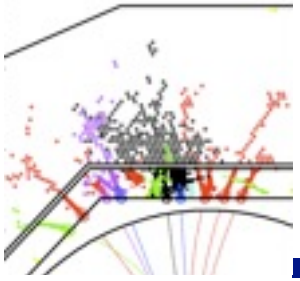
for small variations only!

Current Status

- Have now completed investigation of jet energy resolution as function of ECAL parameters.
- Complete study by providing basic parameterisation of jet energy resolution. Then prepare a publication.
- Break resolution down into component parts (energy resolution, confusion, …) and parameterise separately.
- Aim to keep parameterisation simple; don't try to reproduce fine details, but provides overall "scalings".
- Should describe variation of each jet energy resolution term as a function of following:
  - Energy
  - ECAL Cell Size
  - ECAL Inner Radius
  - ECAL #Layers
  - Cell Thickness (Sc only)
- Won't attempt to describe multiple transverse granularity ECALs unless there is demand to do this.

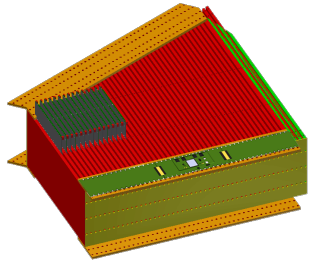


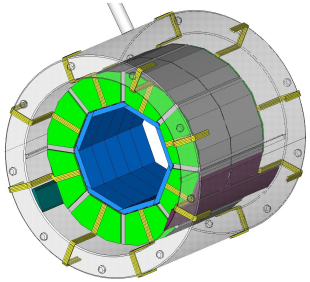


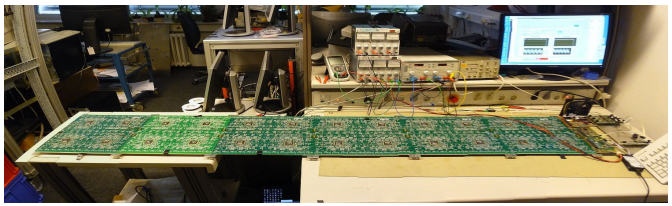


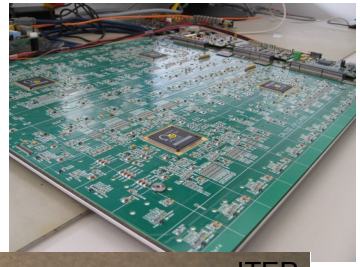
Industrialisation: Numbers!

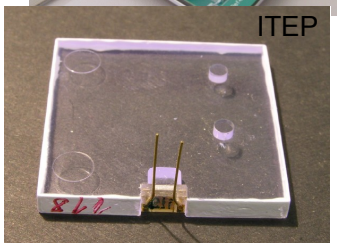
- The AHCAL
- 60 sub-modules
- 3000 layers
- 10,000 slabs
- 60,000 HBUs
- 200’000 ASICs
- 8,000,000 tiles and SiPMs



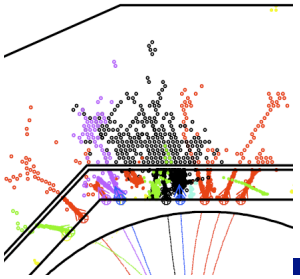








- One year
- 46 weeks
- 230 days
- 2000 hours
- 100,000 minutes
- 7,000,000 seconds



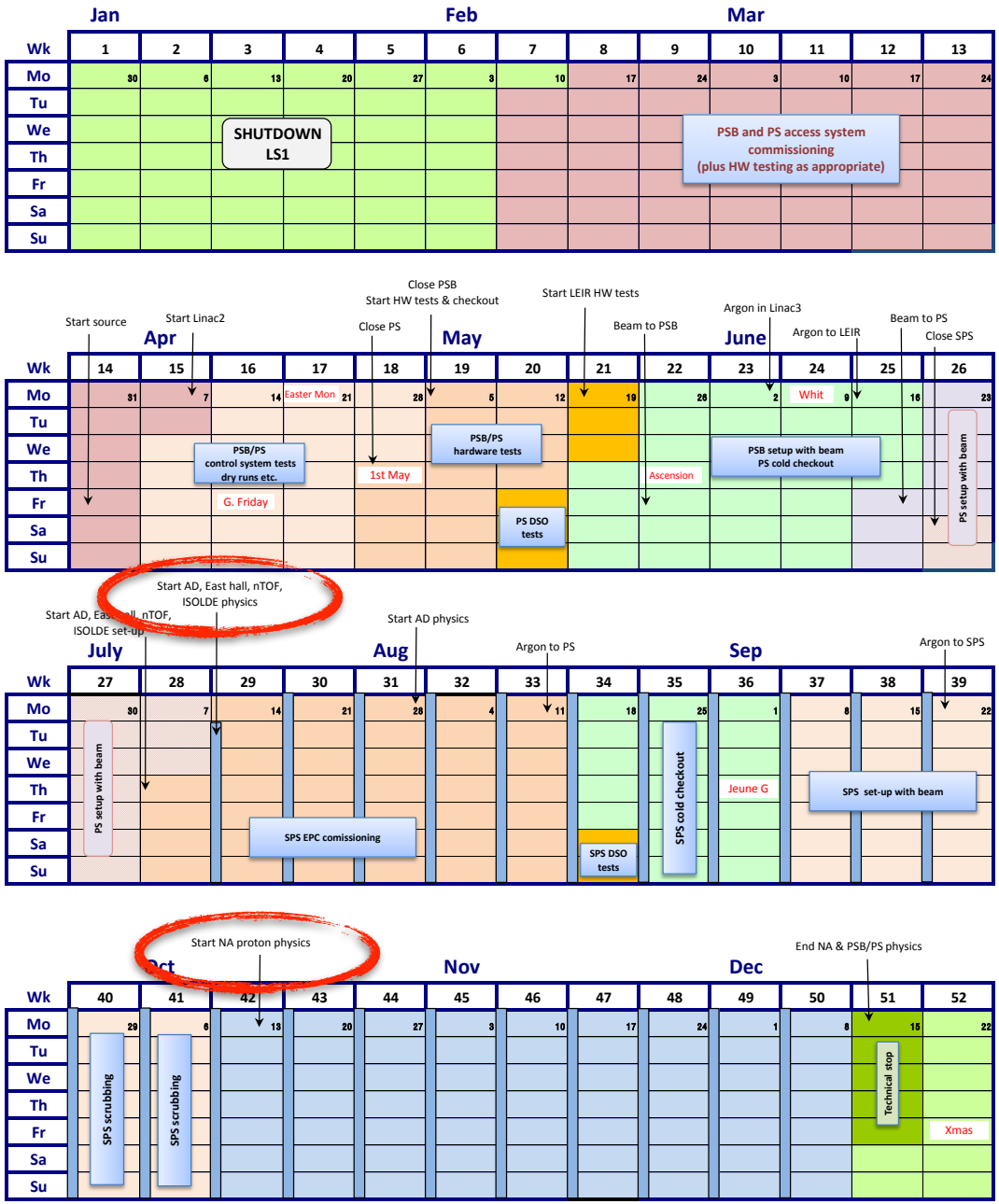
To summarize:

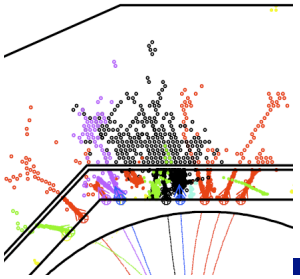
- 2013: first new calorimeter stack since 2006
- Hardware for 2014 CERN test beam comes at hand
  - a lot of work on procedures
- Opened up basic design options - but need to converge in not so far future
- Prepare a strong case

Test beam 2014

2014 Injector Accelerator Schedule

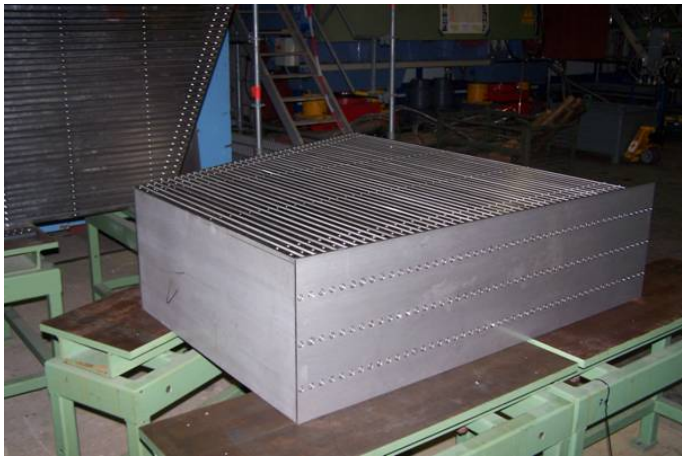
Preliminary

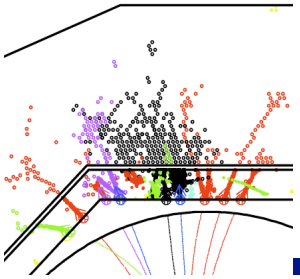




AHCAL test beam

- What?
  - how many and which tile SiPM combinations
- How?
  - to prepare and to qualify
- Where?
  - PS, SPS
- When?
  - and how often
- Which?
  - absorber: both W and Fe available

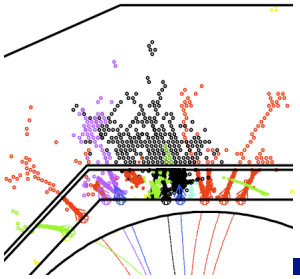




Proposal

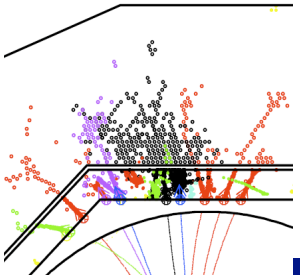
- Go for it!
- 2x 2 weeks, > 4 weeks in-between, late
- 1st: muons and electrons in steel
  - calibration and validation
- 2nd: pions in steel and tungsten
  - physics
- Exercise commissioning of new HBUs in January
  - integrate as they become ready
  - establish procedure and qualification

AIDA’



Some facts

- EUDET 2006 - 2010, calo 2 of 7 M
  - from powerpoint to stack and HBU, SPIROC2
- AIDA 2011-2014, calo 0.8 of 8 M
  - interfaces, TB support for W, temp. stabil., Hardroc3
- AIDA' call 12/2013, proposal 9/2014, **EoI 12/2013**
  - more - or less - LHC participation
  - fewer, larger projects
  - fewer direct partners
  - equal or more trans-national access
- Need to think about projects that serve us all
  - research for the improvement of infrastructure (see EUDET/AIDA)
- Examples:
  - common DAQ: re-focus on ILC detector integration
  - infrastructure to instrument the EUDET stack:
    - ASIC dev and tests, HBU assembly



Next steps

- Today: discuss and collect ideas
- Put together one or two AHCAL EoIs
- Liaise with ECAL, SDHCAL
- Early next year: coordinate at ILC level
- February: proposal preparation meeting at CERN
- March: first draft for AIDA annual meeting in Vienna