SPIDER DECAL

- SPIDER
- Digital calorimetry
- TPAC
  - Deep Pwell
- DECAL
- Future beam tests
- Wishlist

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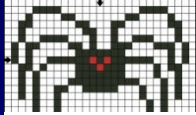
for the
SPIDER collaboration

University of BRISTOL

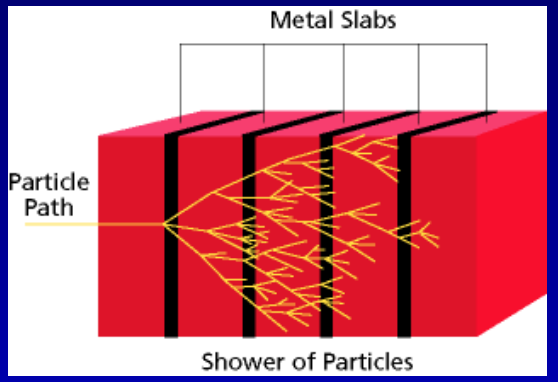


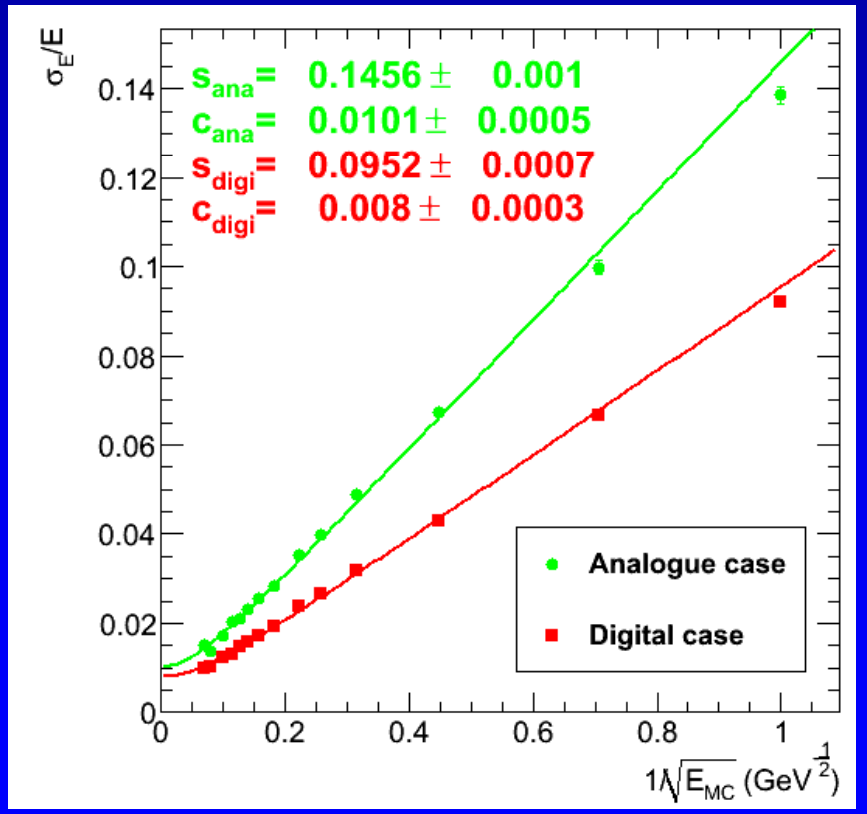
SPIDER

- UK Collaboration working on Silicon Pixel R&D for future colliders.
  - Demonstrate a new improved technique for EM calorimetry
  - Develop a MAPS sensor with in-pixel data processing for tracking applications
- In principle funded until end of 2012

TPAC: Digital Calorimetry

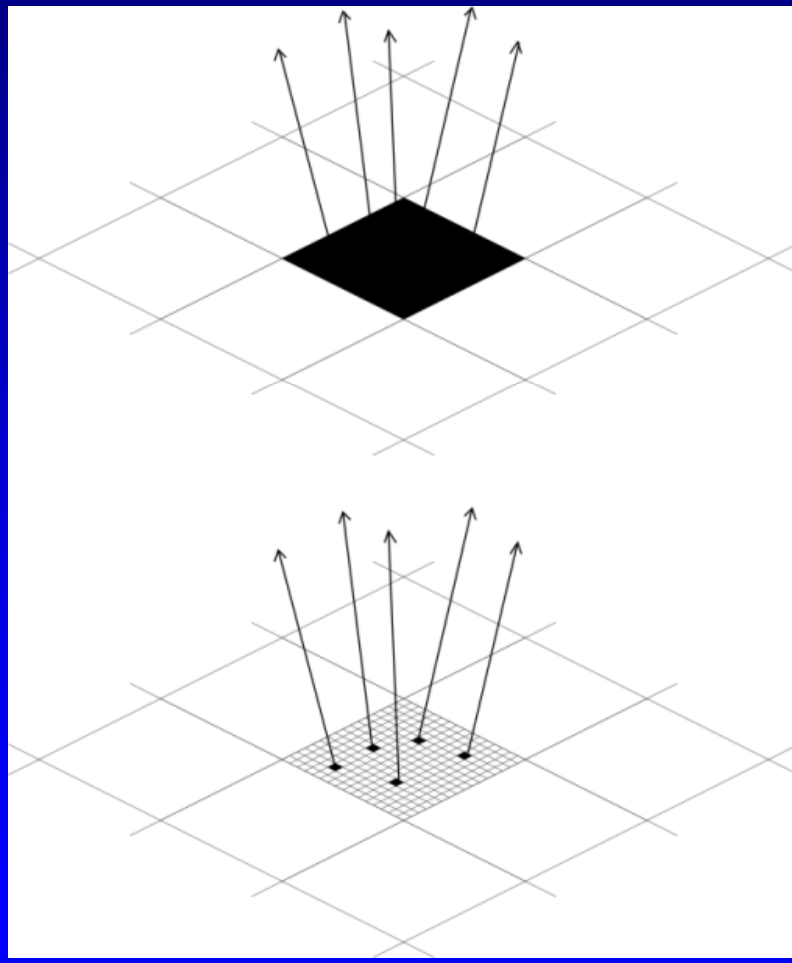
- Average number of charged particles in EM shower ∝ incident energy
  - Fluctuations due to statistical nature of shower
- Average energy in sensitive layers ∝ number of charged particles
  - Fluctuations due to angle of incidence, velocity and Landau spread
- Hence, number of charged particles is an intrinsically better measure than the energy deposited
  - Clearest with ideal calorimeter; no experimental effects
  - Energy deposited ("analogue" ECAL) resolution ~50% worse than number of particles ("digital" ECAL) resolution





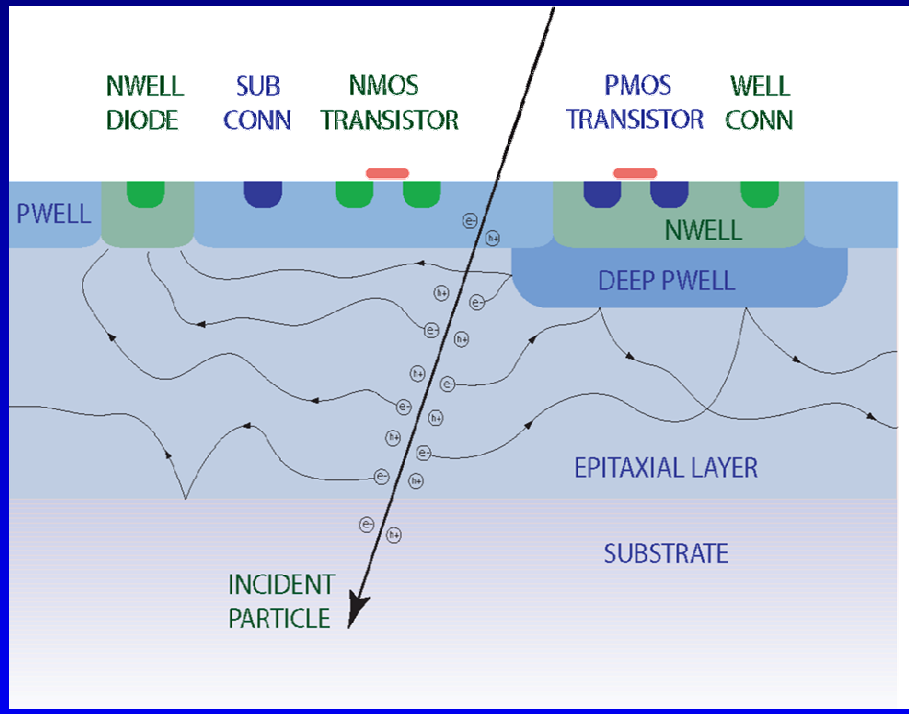
Digital Calorimetry: Concept

- Can we measure the number of charged particles?
  - Possible to get close to the analogue ideal resolution with low noise electronics
- Can we get anywhere near the ideal resolution for the digital case?
  - Make pixellated detector with small pixels
    - Probability of more than one charged particle per pixel can be made small
    - Allows binary readout = hit/no hit
    - Problem: charge sharing
- EM shower density ~100/mm^2 in core
  - Need pixels ~ 50μm
  - Results in huge number of pixels in a real ECAL ~ 10^{12} pixels
  - Need readout integrated into pixel
- Implement as CMOS MAPS sensor



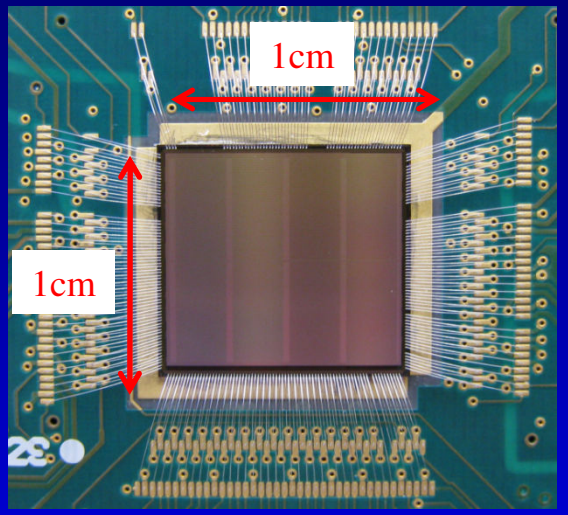
Deep Pwell

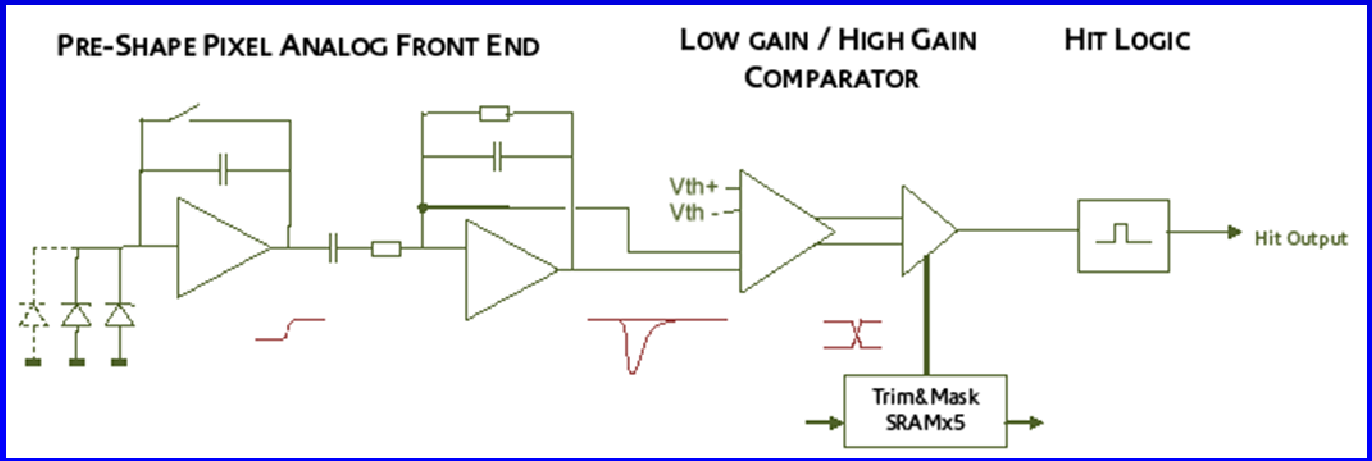
- Problem in MAPS:
  - PMOS electronics need Nwell
  - Nwell acts as charge collection diode
  - So can't make PMOS without losing huge amount of Q
- New development: make deep pwell with Nwell inside → can do CMOS
  - Road to data processing in pixel



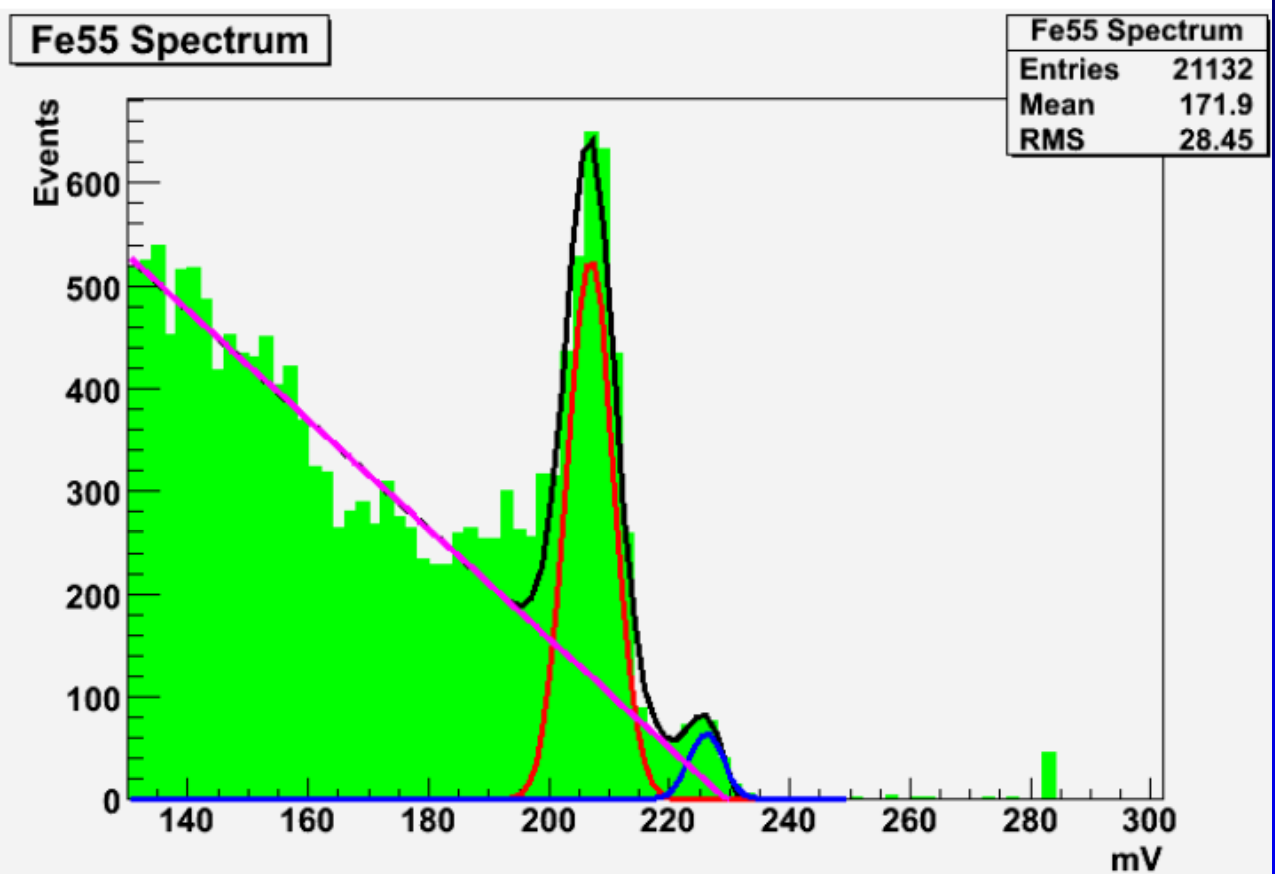
TPAC sensor

- 168x168 pixels=28k, each 50×50μm^2
  - 0.18 μm CMOS
- Every pixel has 4 diodes, Q-preamp, mask and 4-bit pedestal trim, asynchronous comparator and monostable to give hit/no hit response
- Pixel hits stored with 13-bit timestamp on-sensor until end of bunch train
- Memory for data storage inactive; 11% dead area in four columns





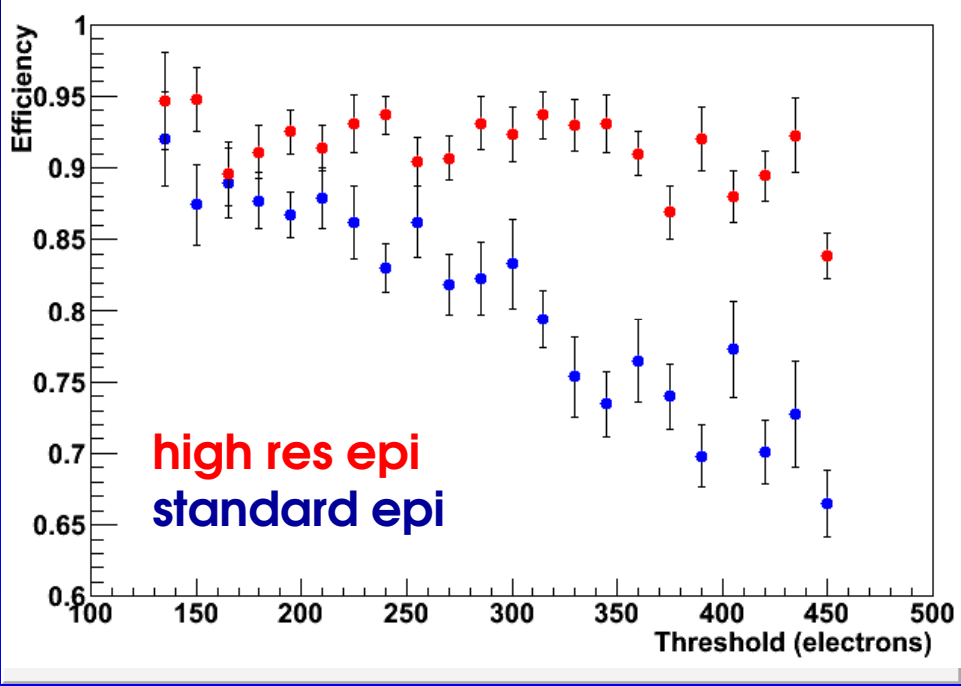
TPAC Fe55



- Primary ^{55}Fe peak gives calibrated gain of 128μV/e-
- Width of ^{55}Fe peak gives noise of 27e-
- See Kα and Kβ clearly separated

TPAC beam test

- TPAC in beam tests
  - 120 GeV π & 20-120 GeV e^-
  - 6 TPAC sensors (layers) in stack
  - 170k pixels in total
  - 1cm x 1cm active area
  - Three scintillators/PMTs installed
    - Used to tag time of particles within bunch trains
- Data seems good
  - Scintillators/PMTs give good time tags for particles
  - Events were seen in all layers (including high resistivity)



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DECAL chip

- TPAC too small for real EM shower containment; make large scale sensor
- SPIDER will develop a new chip for calorimetry: DECAL
  - Chip fabricated in 2011
- Will build proof-of-principle stack from DECAL
  - 6×6 cm2 planes
  - 30 layers
  - 24 X_0 deep
  - Beam test stack in 2012
  - Part of CALICE collaboration
- DECAL tests are addressing an open question: can digital calorimeter yield very good energy resolution?

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Future beam tests

- TPAC: beam test at DESY in Feb 2010
  - Electron scan done at CERN, 20-100 GeV but no tracking
  - Need telescope to reconstruct start of shower
  - DESY 1-6GeV with tracking to locate shower centre
- Testing large DECAL sensor stack in 2012
  - Major sample needed for full proof-of-principle
  - CERN electrons 6-100 GeV ~ 6 weeks
  - DESY electrons 1-6 GeV ~ 3 weeks
  - Also some pion runs for calibration
  - All with tracking telescope

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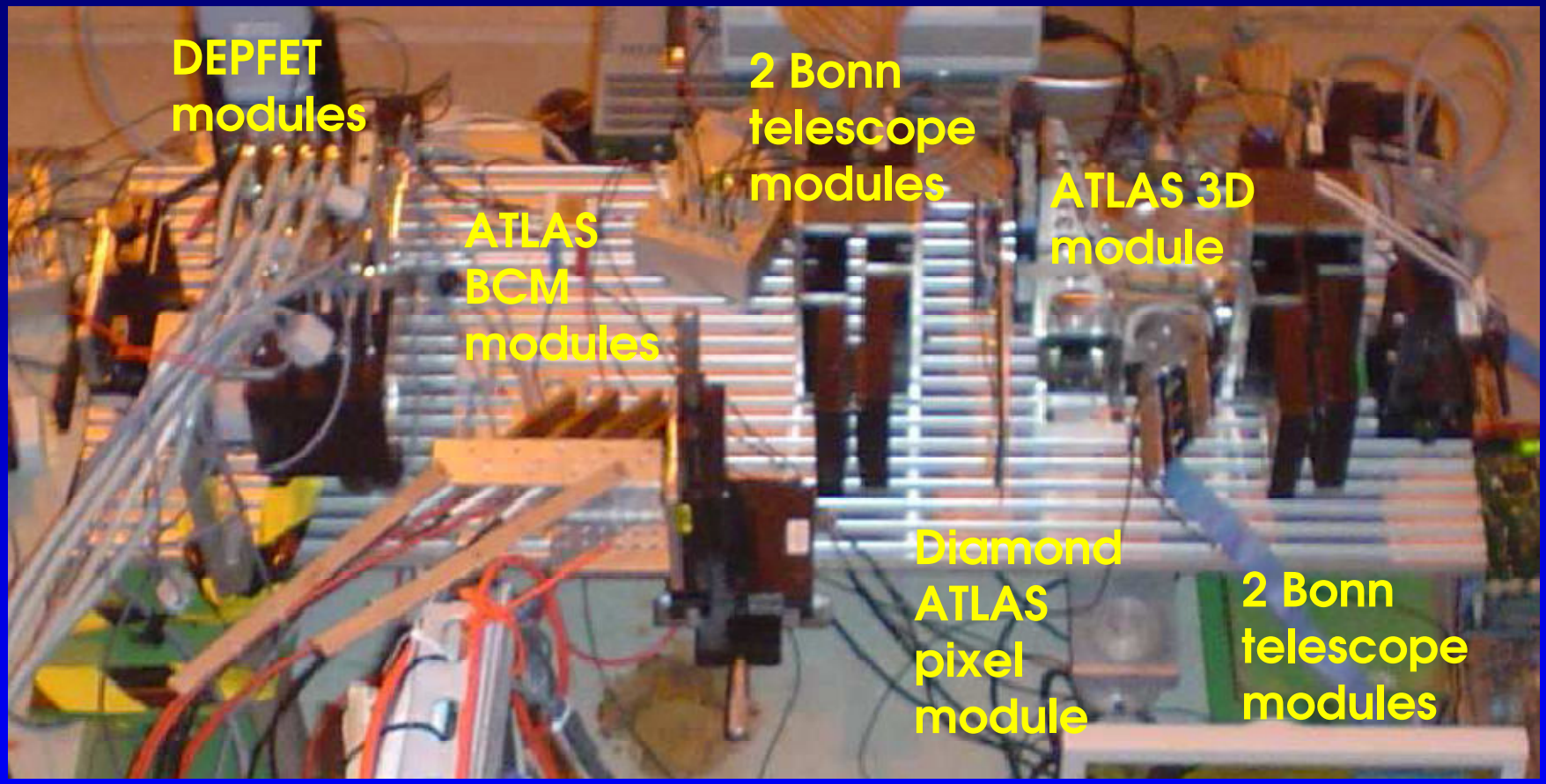
Our needs/wishes

- Beam time!
- Need for telescope
  - Really like EUDET concept:
    - Know the TLU; no big interfacing problems to be solved onsite
    - Tracking and alignment software provided
    - Essentially get the tracks
- Would like patch panels (bnc and fiber optic) between hut and area
  - Cabling is pain
- Would like large XY-stage
- If possible could arrange many user beam tests
  - Remote shifts; saves lots of travel money

Nice example



- Tested 4 different devices at the same time
  - Currently only possible because 1 institute + very friendly colleagues

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Summary

- SPIDER is developing a digital calorimeter proof-of-principle device.
  - New MAPS chip will be developed
  - Stack complete in 2012
- Would be great to have common infrastructure: patch panels, large XY stage & TLU
- Very interested in collaborating with many other users