University of Glasgow

Kenneth Wraight
UK Atlas Pixel group

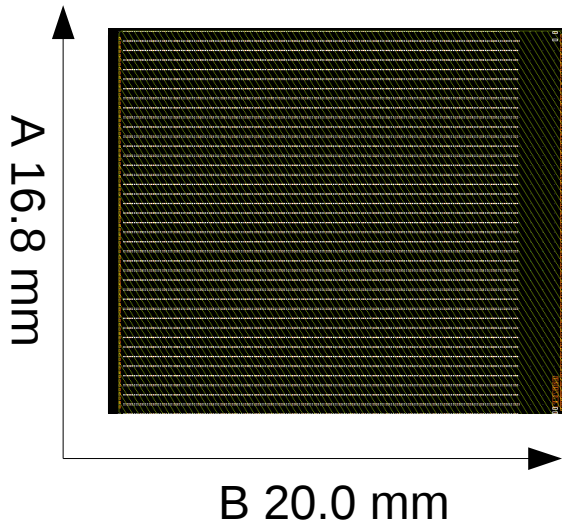
SLAC Testbeam

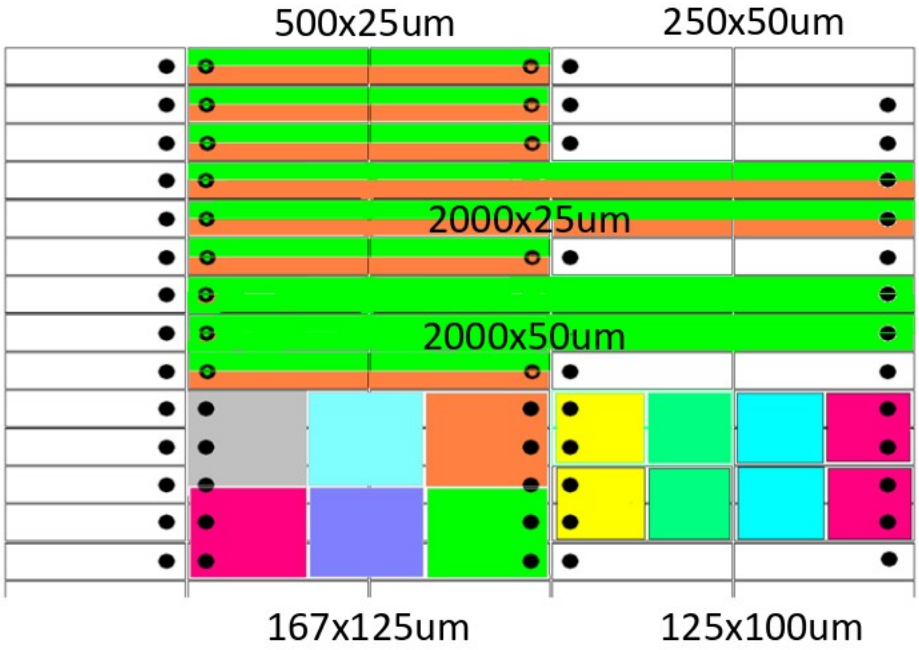
- ITk motivations
- SLAC testbeam
- EUTelescope
- Strip testbeam

University of Glasgow

ITk Upgrade Sensors

- New generation of Si pixel detectors for Atlas upgrade
  - Greater resolution and radiation hardness



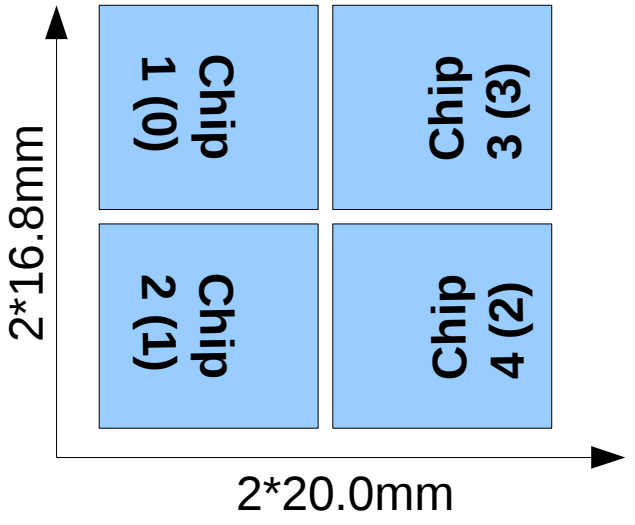


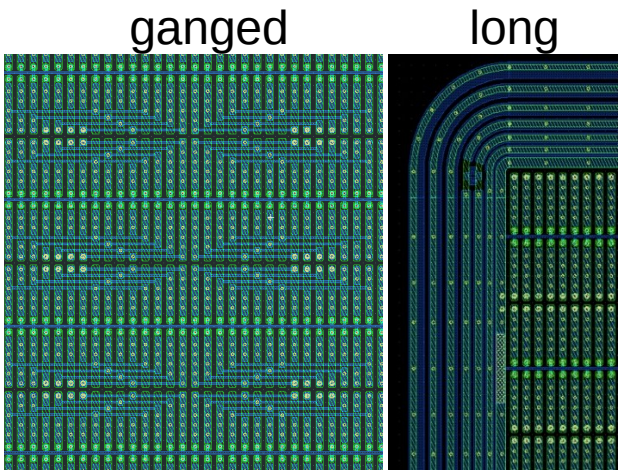
- Current R&D: FE-I4 chips with various pixel geometries
  - 250x50um^2 standard (26880 channels)

University of Glasgow

Quad anatomy

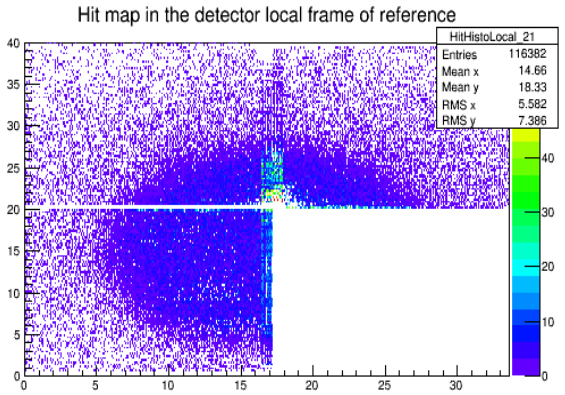
- 4 250x50um^2 FeI4 chips
- Adapted inter-chip regions to keep active area
  - Horizontal: Ganged pixels (multiple pixels per channel)
  - Vertical: Long pixels (250->500µm)
- Consequences for DAQ and analysis

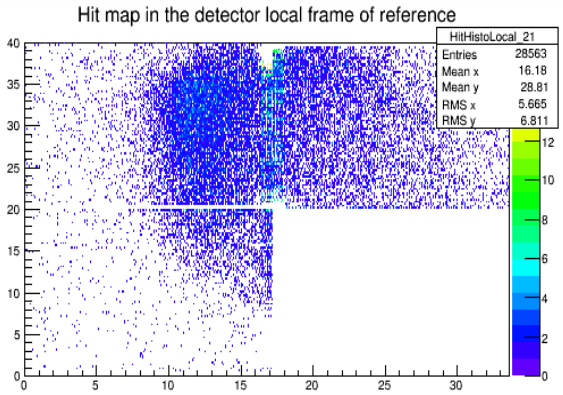


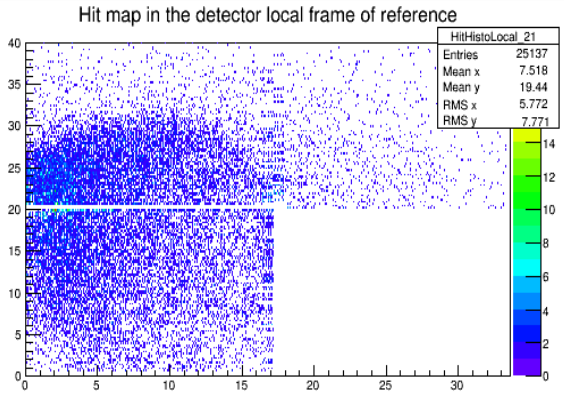


University of Glasgow

Quad DAQ evolution







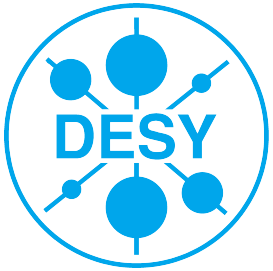
- Initially (preNov `13) regions read out singly
  - Required orientation “by hand”
  - Problems with reconstruction&analysis with same plane DUTs

- EUDaq plugin: Martin Kocian (Nov `13)
  - Data format compatible with EUDAQ: 4 chips --> 1 DUT
  - Edit RCE producer
    - Module3.ModuleType = 4 (1) for quad (single)

University of Glasgow

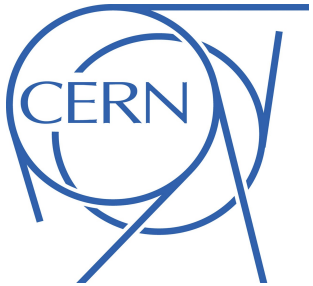
Testbeam Facilities

- DESY (March `13-Feb `14)
  - 4GeV electrons
  - Scintillator trigger (constant beam flux)



- SLAC (April `14)
  - 12.5GeV electrons
  - Trigger from beam: 5 & 10 Hz

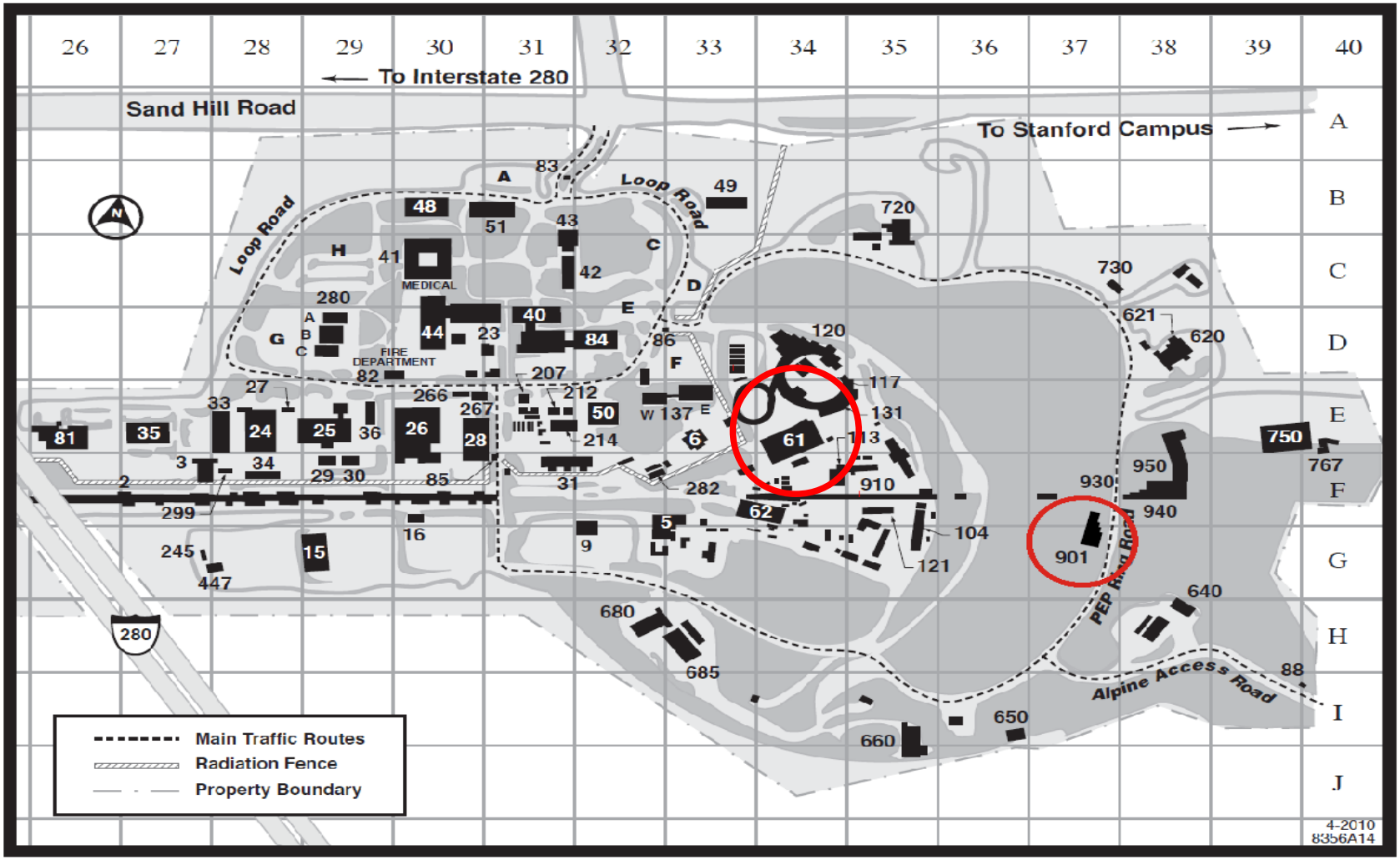
- CERN SPS (October `14)
  - 120GeV pions
  - Scintillator triggering



- All organised by ATLAS PPS group

ACONITE visiting from DESY from Apr-Jul

SLAC 29/04 – 10/05

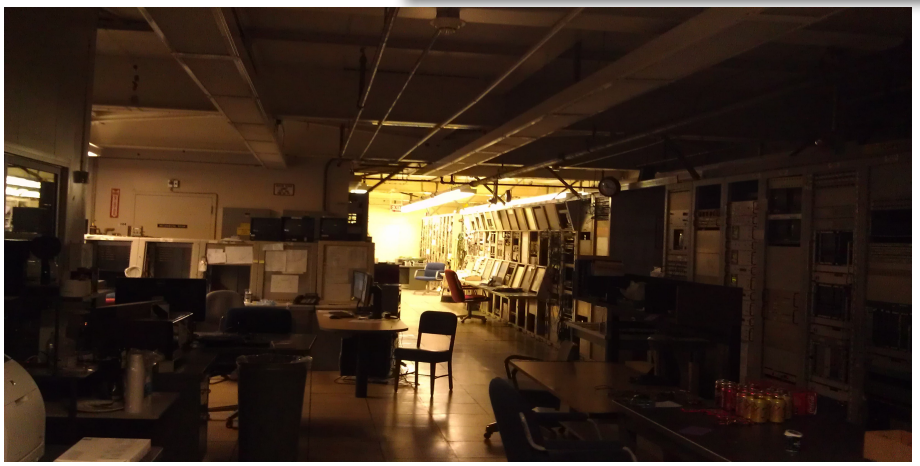


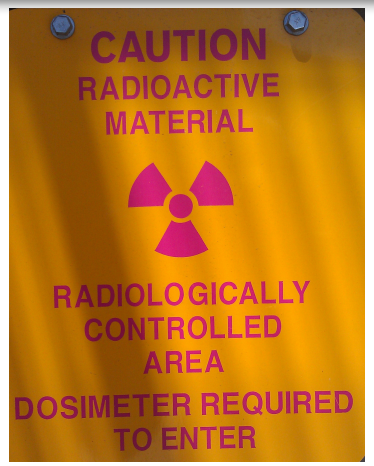
University of Glasgow

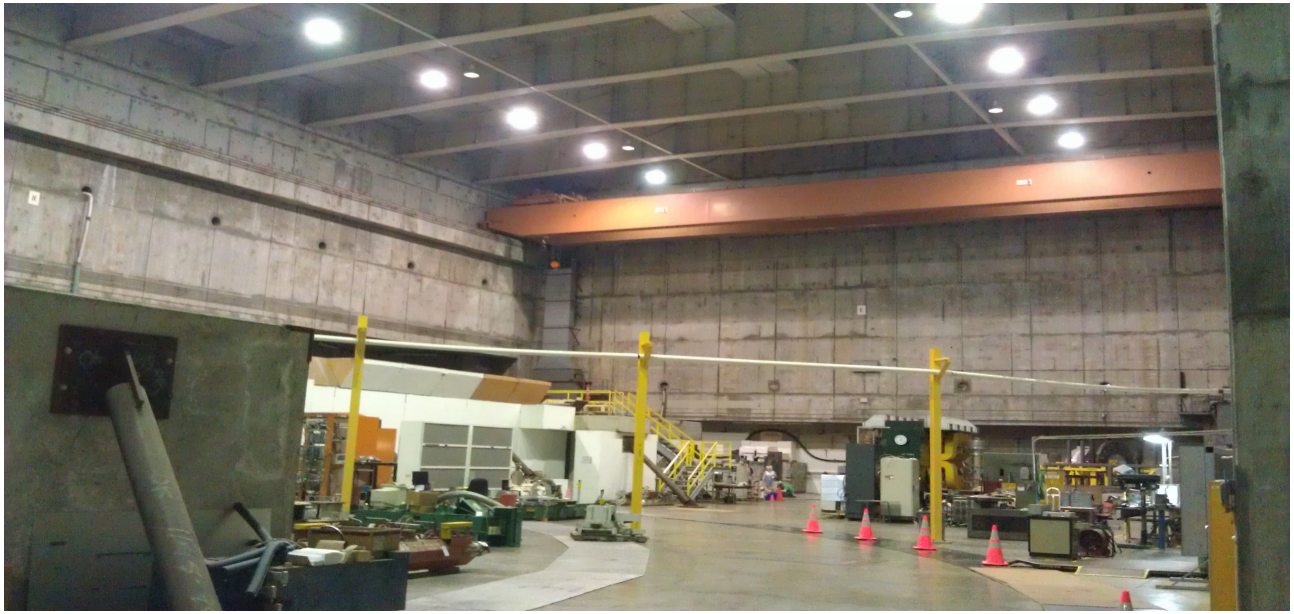
End Station A (a.k.a. ESTB)

University of Glasgow

End Station A (a.k.a. ESTB) ctd.







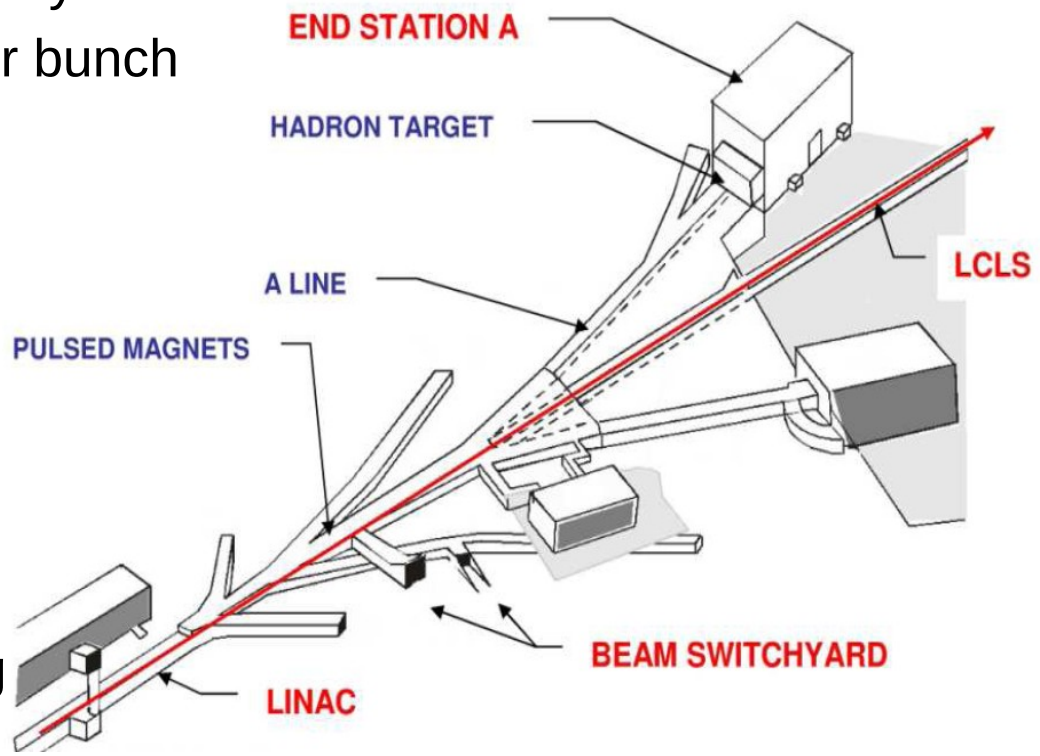
Remote control required!

University of Glasgow

Parasites & Particles

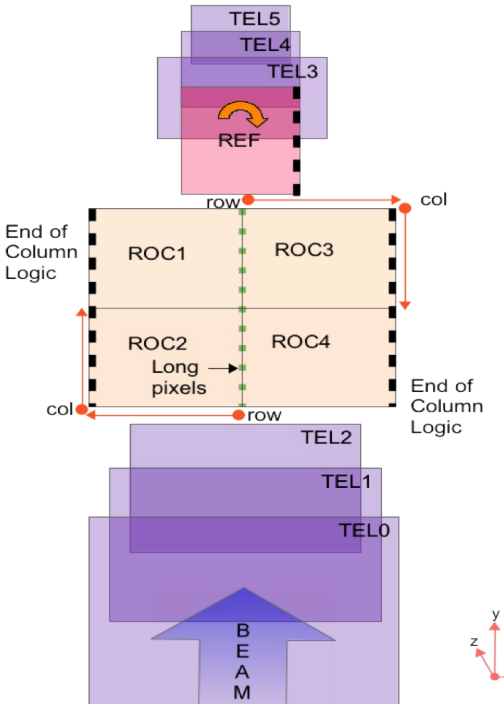
- ESTB is parasitic beam from Linac Coherent Light Source
  - Secondary beam of electrons up to 13.6GeV of LCLS beam
  - 5Hz standard bunch frequency
  - Variable particle number per bunch

- SLAC benefits
  - Triggering available from beam
    - Larger region of interest than previous scintillator limited area
  - Reduced multiple scattering
    - Possible to take data with more devices in beam

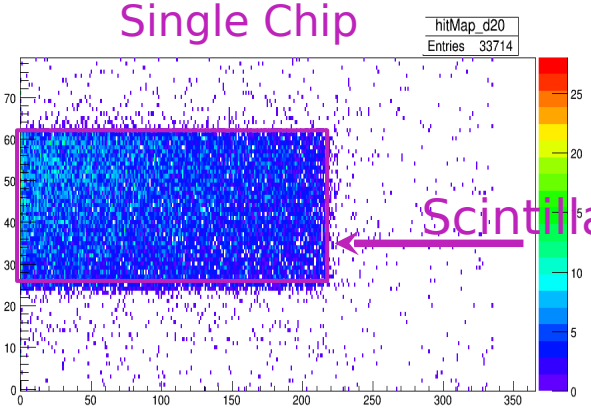


Triggering techniques

- Trigger is from a scintillator attached to 1st telescope plane
  - Only a fraction of coverage of 1 CMOS chip

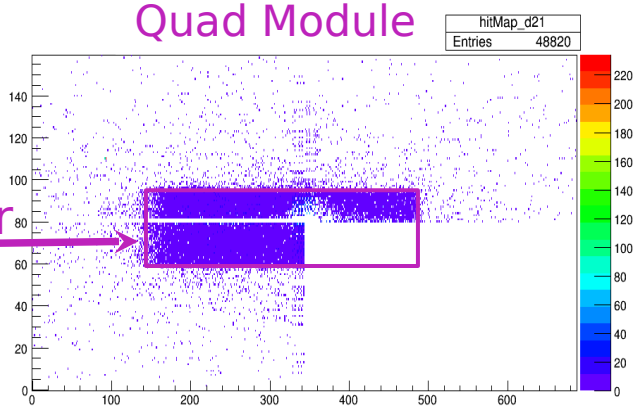


Single Chip

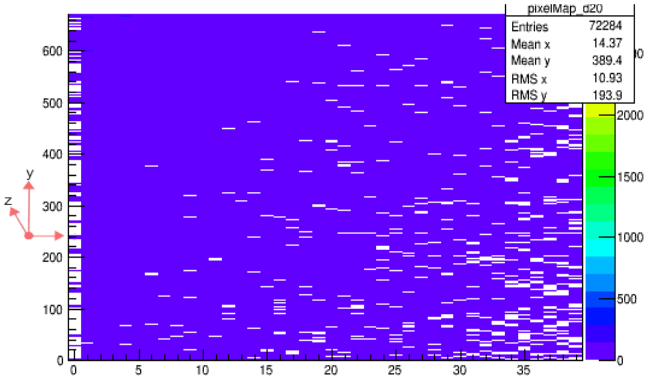


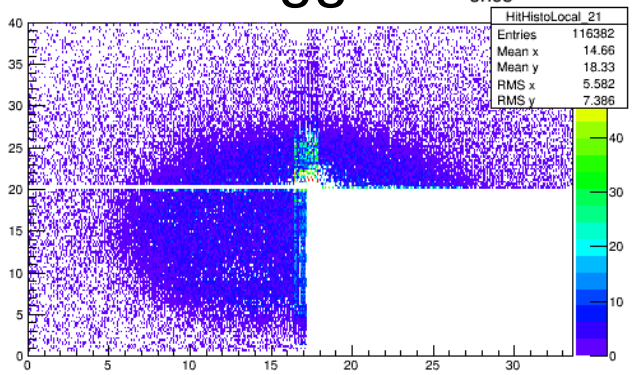
Scintillator

Quad Module



- Full coverage from beam trigger





University of Glasgow

Beam Conditions

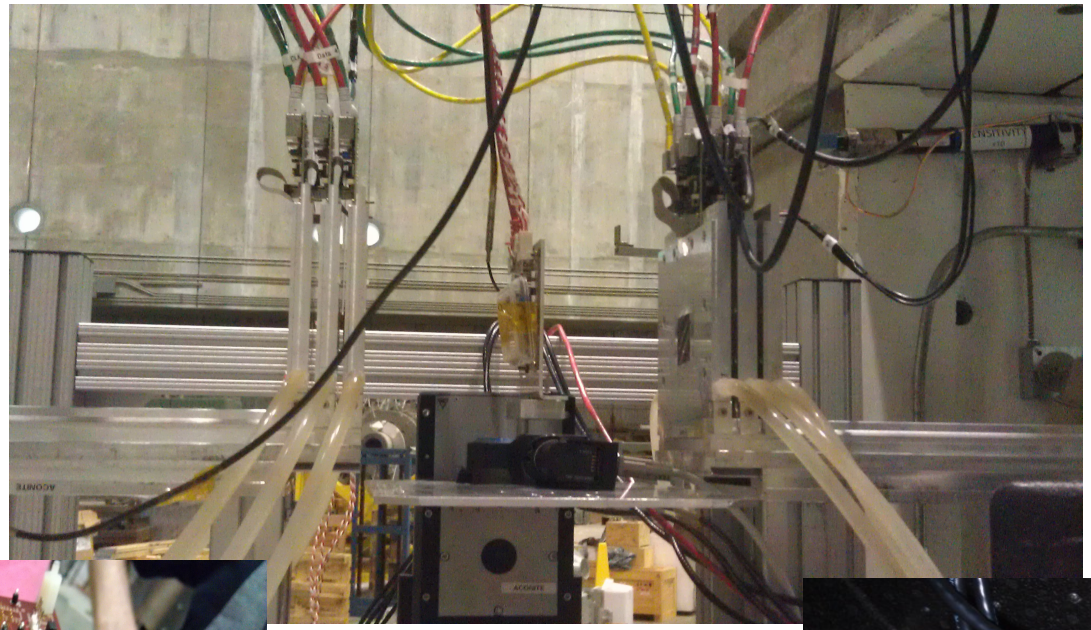
- Data taken with various conditions
  - 5 & 10Hz frequencies --> better statistics
    - dependent on LCLS users
  - Varying charge per bunch
    - Dependent on LCLS users
    - some control with beam slits
  - Consistent beam energy of 12.5GeV

- Used multiple devices in beam
  - 2 – 4 devices used --> 6 – 10 sensor planes
  - Limited by available power, mounts and cooling for devices
    - More made as testbeam developed
  - Constancy of beam energy essential

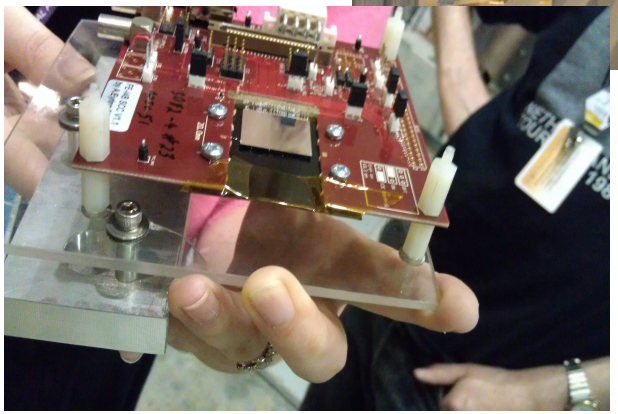
University of Glasgow

Telescope and device set-up

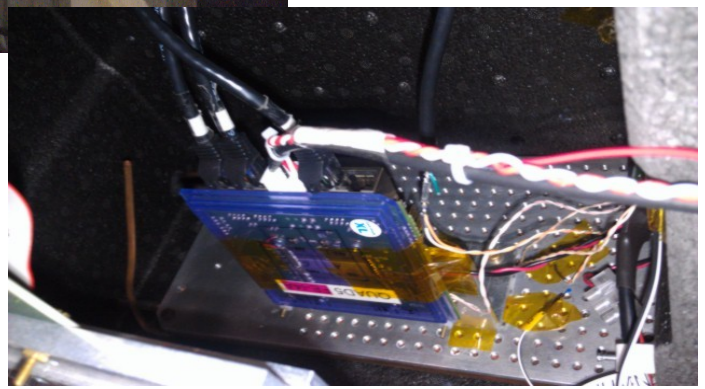
Far side
(Mimosa 5)



Beam side
(Mimosa 0)



Device mounts

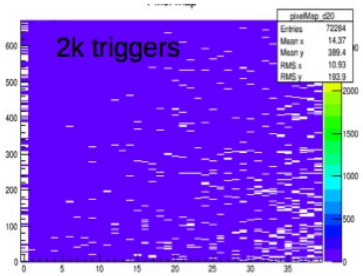


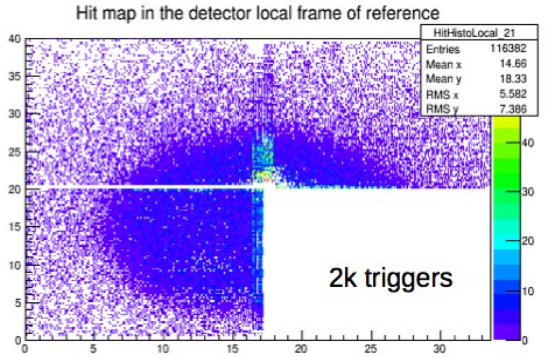
Device cooling

University of Glasgow

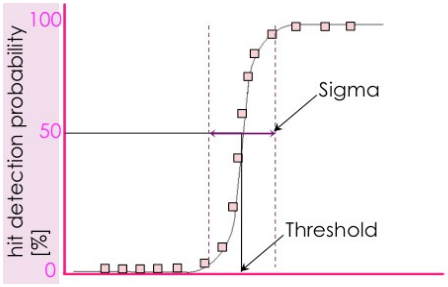
Control of Testbeam

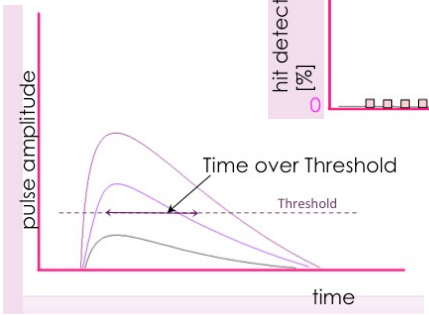
- EUTelescope
  - Config for runs (devices)
  - (semi-)Online monitor
    (full quad monitor with plugin)





- Reconfigurable Cluster Element System
  - Setting DUT configs and thresholds
- Detector Control System
  - Chip low voltage and bias settings





- Anything else (cooling)
  - Peltier control (team view + labview)
  - additional temperature & humidity monitoring

University of Glasgow

Data taken

Unirradiated

- Quad – data taken: 3 regions @ 100V, THL=2500 & 3000e
- 250x50 – data taken: 50 & 100V, THL=2500e
- 500x25 – data taken: 50 & 100V, THL=1.5, 2, 2.5, 3 ke
- 125x167 – data taken: 50 & 100V, THL=2500 & 3000 ke

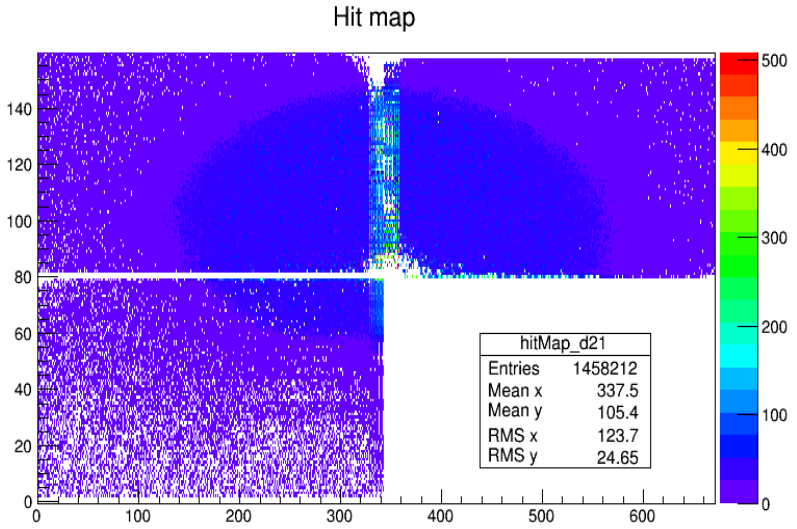
irradiated

- Quad – no data: unable to tune, 8mA @ 15V (no analogue)
- 250x50 – data taken: 0V, THL=1.5, 2, 2.5, 3 ke (broken bonds?)
- 500x25 – data taken: 100V, THL=1.5, 2, 2.5, 3 ke
- 125x167 – data taken: 100V, THL=1.5, 2, 2.5, 3 ke

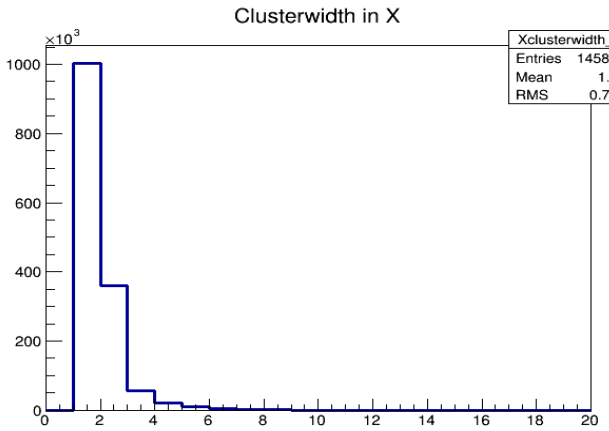
University of Glasgow

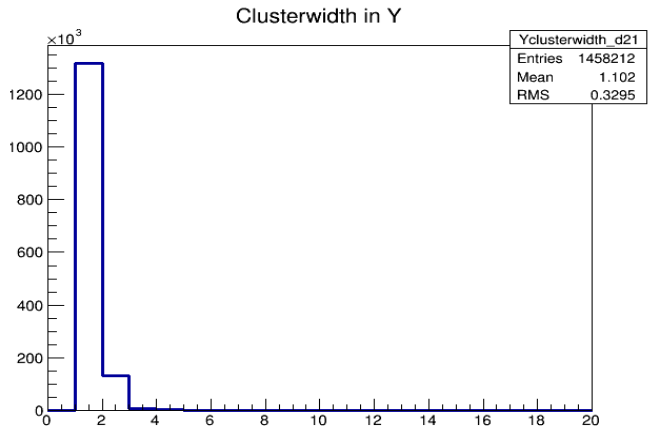
Post-Testbeam: reconstruction & analysis

- Full results delayed due to software changes
  - TBmonII two required for quad set-up
  - EUTelescope overhaul
- Look forward to stable benchmark



SLAC reconstruction has begun (April `14)
THL=3000e
100V





University of Glasgow

Positive Experience

- Facility
  - Very helpful local support from equipment to personnel
    - Personel: Philippe Grenier, Max Swiatlowski, Carsten Hast, Keith Jobe
    - Equipment: mounts, cables, dry ice
  - >21hrs beam/day (2hrs MD); always updated by MCC
  - Presence of primary users important i.e. 5->10Hz (+ beam energy)
- Telescope
  - After ironing out a few bugs, everyone gained experience
    - Important to have experts available: Martin, Igor
  - Bonus of triggering from beam
  - DCS system was simple and easy to use: Voltage, humidity, temp
- Detectors
  - Despite customs trouble, managed good runs
  - Multiple devices tested in beam (e.g. Q+2sc, 4sc)

University of Glasgow

Strips at SLAC

- Strips community are about to use the EUDET telescope for 2 one week long testbeams (Early July)
- ABC next is CMOS readout (made in 130nm process)
  - Goals
    - accurately measure gain of ABC next 130 module
    - Testing the Fast Cluster Finder option on the new ABCn130

The single chip readout board and associated driver board

University of Glasgow

Testbeam preparation

- Berkeley and UCL worked on integrating strips DAQ with the TLU
- Mechanical fixtures have been made to hold the sensors
- Cabling, PC, DAQ systems have been shipped and supplied for the beam
  - Will interface with HSIO and (for FCF work) Vertex 6 FPGA board

- Specialist single chip readout boards and driver boards were deigned and manufactured for testbeam
  - Interested in studying (74.5um pitch) channels with single hits
  - Compare gain measured to internal calibration circuit in chip

University of Glasgow

Recon & Analysis

- Previous work at DESY has shown online monitor (correlation plots) to work with HSIO readout with EUDET
  - Aiding alignment

- Will need help with reconstruction of data after testbeam
  - Pixels to Strips…..
  - Even simple question like “what number of event is good enough for 100 strips?”

University of Glasgow

Conclusions and Next steps

- Positive SLAC experience form PPS (Glasgow)
  - More customers to ESA from strips
- Now have wealth of TB data to analyse (SCs & quads)
  - several environments (DESY, SLAC, tbc CERN)
- Full quad reconstruction and analysis software ready(?)
  - EUTelescope improvements ongoing
    - More tracks reconstructed per spill
    - Adaptable DUT geometries: including quad inter-chip pixels
  - New TBmon version compatible with quad set-up
    - Adaptable DUT geometries
- Cooperate: debugging == development

Back up

University of Glasgow

FCF option in the ABCn130

- Fast Cluster Finder (FCF) block.
  - The outputs of the FCF block, along with an external correlator, allow to find cluster hit coincidences and relate them to track transverse momentum (pT) information of the incident particles.
  - An initial L0 trigger stage could then be implemented on-chip from that information, by rejecting low momentum incident hits.
  - This is the so-called self-seeded trigger concept: in the stave and petal geometry
  - A high speed input clock (FastCLK, running at 640 MHz), synchronized with the regular 40 MHz BCO
  - An external correlator chip that correlates clusters, selects high pT coincidences and sends a trigger decision is required per pair of modules.