The FE-I4 telescope

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and quite a lot of other people
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Motivation

- ATLAS Pixel sensors R&D devices based on FE-I4 readout chip
- Former testbeams using EUDET Telescopes
  - High resolution
  - Lots of experience and great support
  - ...but rather complex system (TLU, separate ROI trigger plane)
  - Shutter based readout (telescope) ↔ trigger based readout (FE-I4)
  - FE-I4 reference plane

...and we wanted our own telescope

- Goal: Build telescope based on FE-I4 planes
  - Fully synchronized with DUT
  - Portable
  - Fast
  - Compatible to EUDET mechanics and EUTelescope

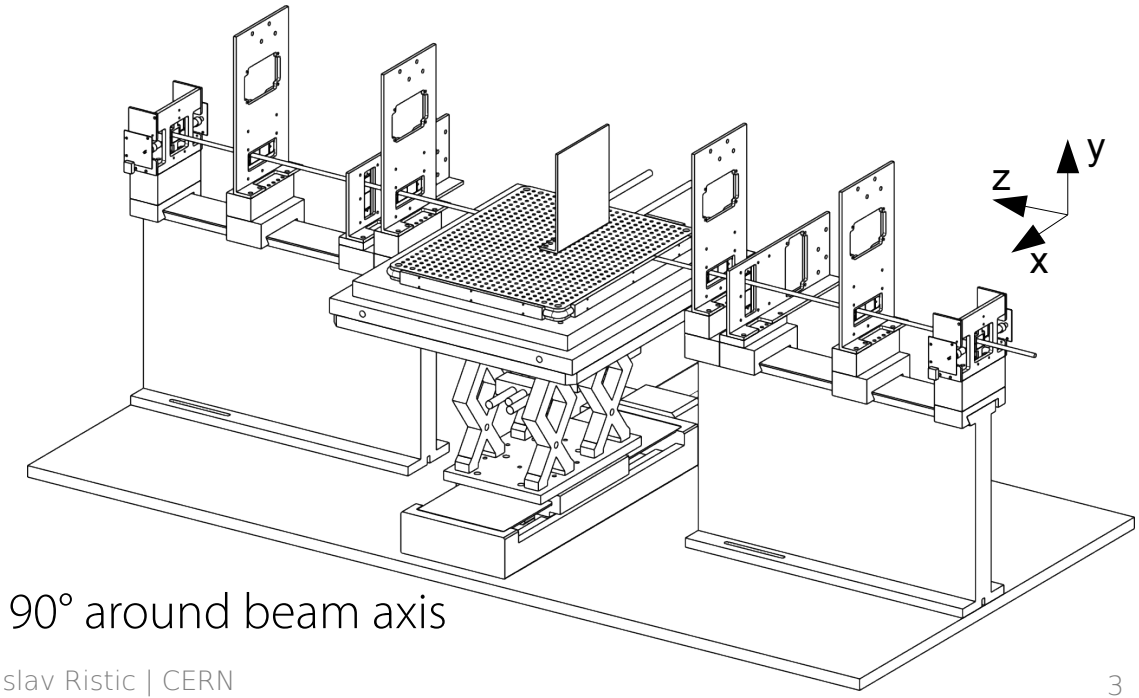
The FE-I4 telescope

The telescope

- 6 pixel sensor planes in two arms
- Sensors: IBL double chip sensors (200um n^+-in-n, 250x50um Pitch)
- Readout: FE-I4 (40MHz sampling, 4 bit charge resolution (ToT), trigger based)
- Trigger: First and last sensor plane, easy generation and application of masks

Mechanics

- Two movable arms hosting 3 planes each
- Planes can be tilted around x and y
- XY stage with DOBOX style DUT box
- Cooling by chiller or dry ice possible



Speciality

- Sensor pixels not square shaped
- Middle planes of telescope arms tilted by 90° around beam axis

The FE-I4 telescope

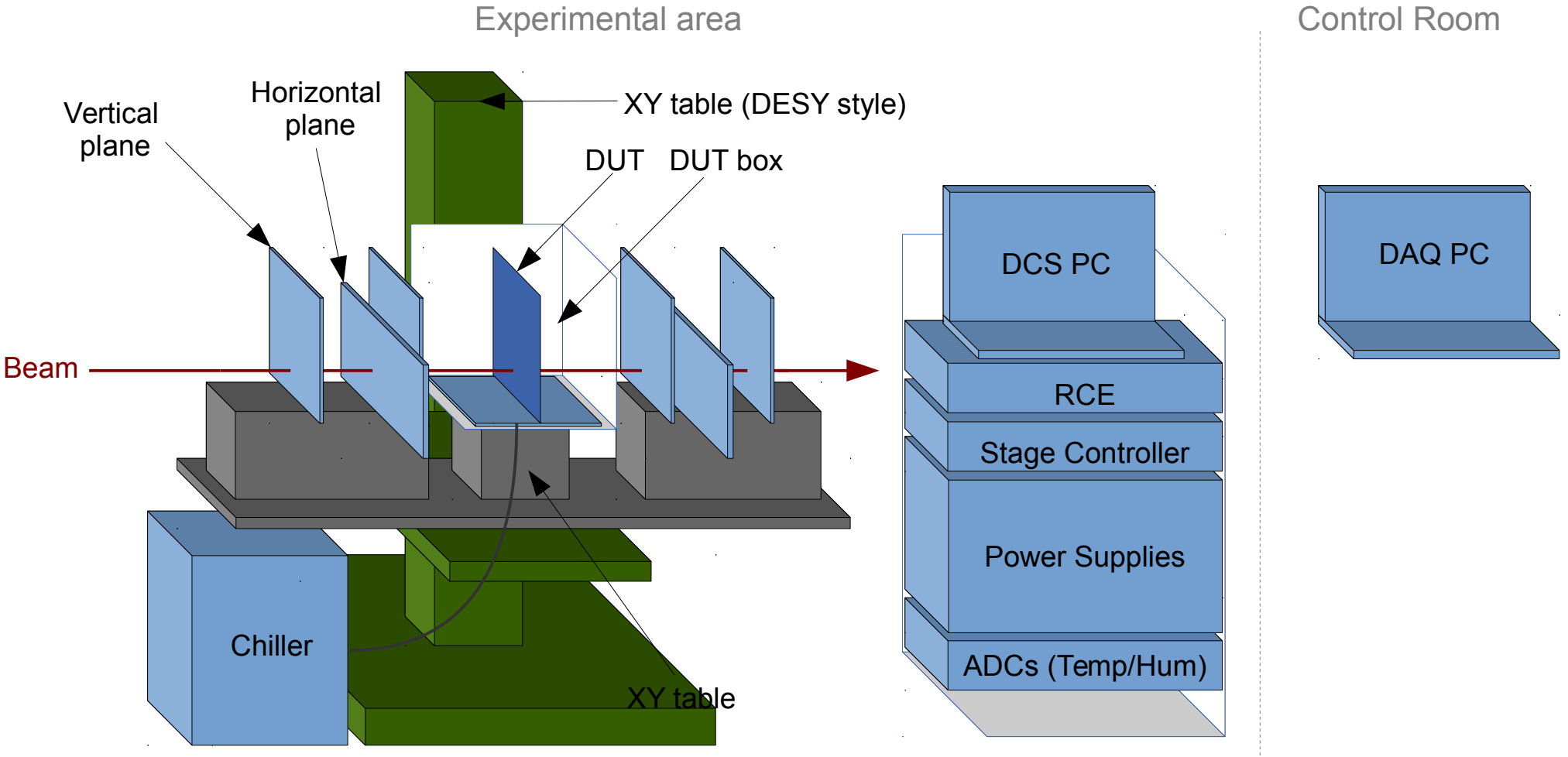
DAQ: HSIO (High Speed IO) / RCE (Reconfigurable Cluster Element) system developed at SLAC

- HSIO: FPGA board interfacing telescope and DUT FEs, trigger handling
- RCE: Power PC based computing units
- DAQ PC: Laptop running SLC 6 and custom C++ based software
- Extensively used for IBL production and commissioning
- Basic functionality already implemented for cosmics telescope at SLAC
- Highly extended for testbeam in terms of performance and stability
- Data output in Judith ROOT format, EUDET raw format and RCE raw format

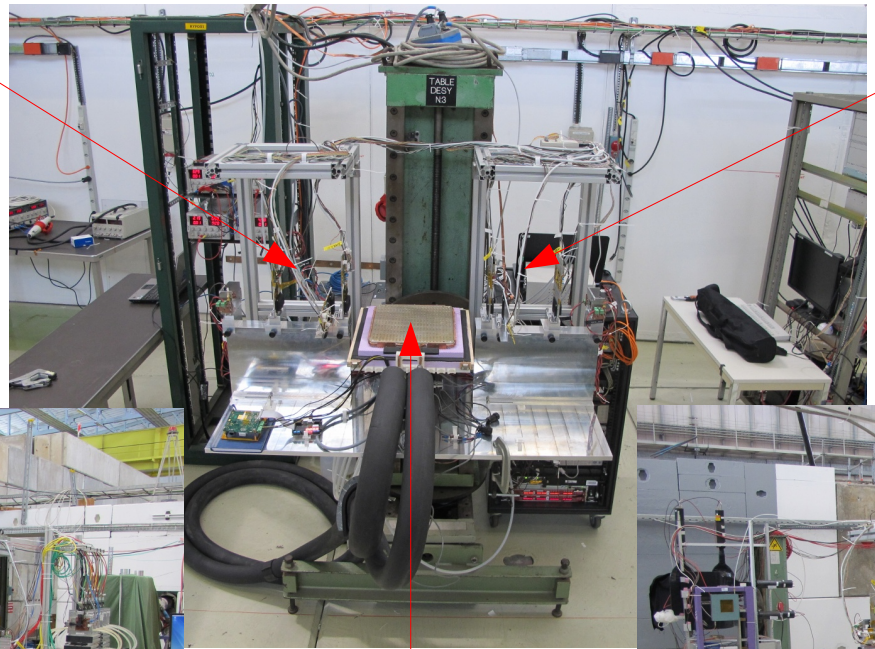
Services/DCS

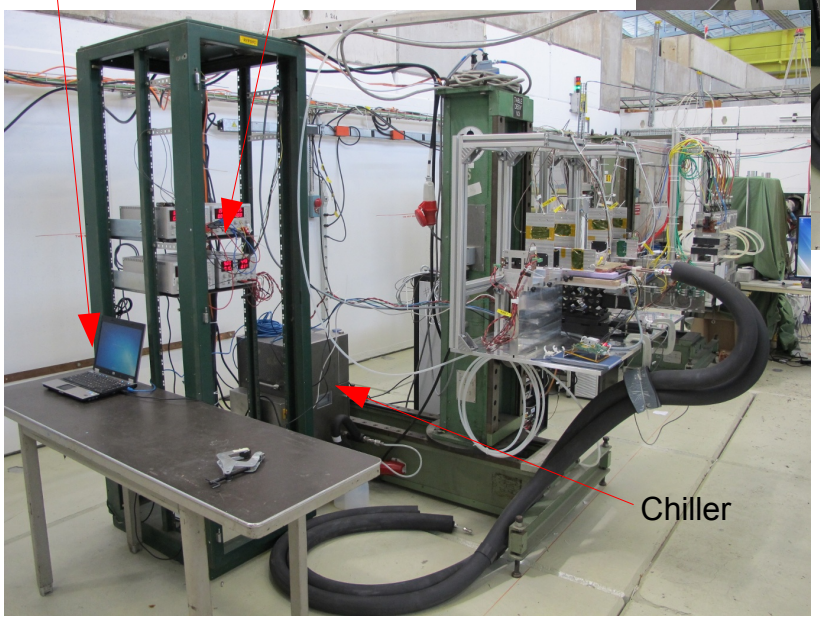
- Small movable rack
- Programmable HAMEG LV and Keithley/Iseg HV power supplies
- NTC and humidity sensors
- All remotely controllable by LabView interface

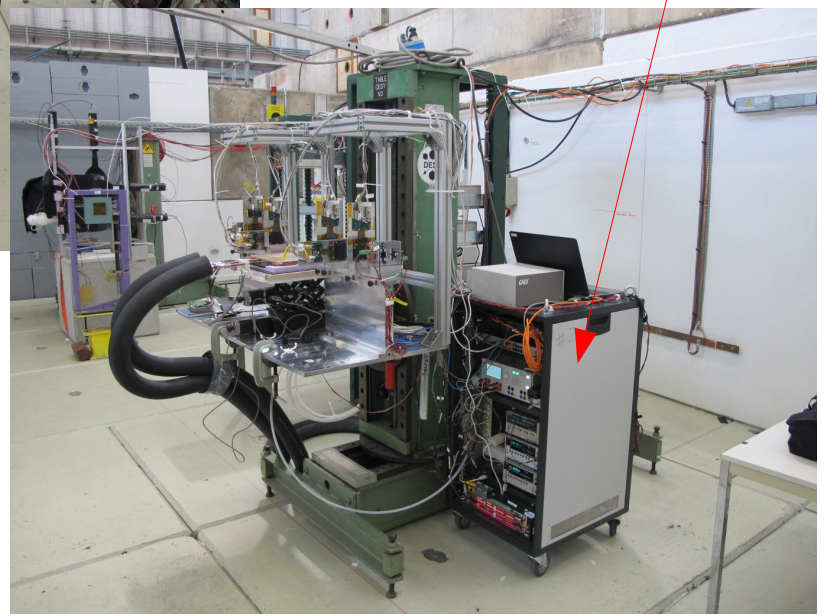
Schematic overview



The real thing







User interface

Hardware

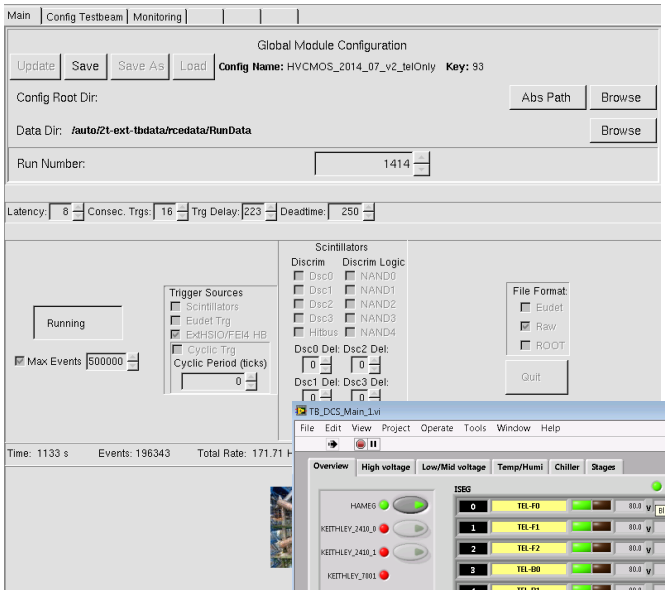
- FE-I4 device: RJ-45
- All other devices: trigger output, busy input line, both LVTTL over LEMO

DAQ

- ROOT/Qt based GUI
  - Planes/DUTs can be added and configured individually
  - Readout windows (Number of Lv1A) and delays can be set seperately for telescope and DUTs
- Plain text configuration files
- Setup via one shell script
- In case of a failing DAQ (very unlikely): Recovery via one shell script

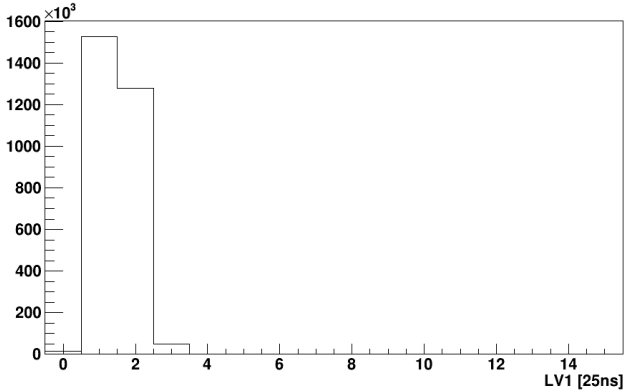
DCS

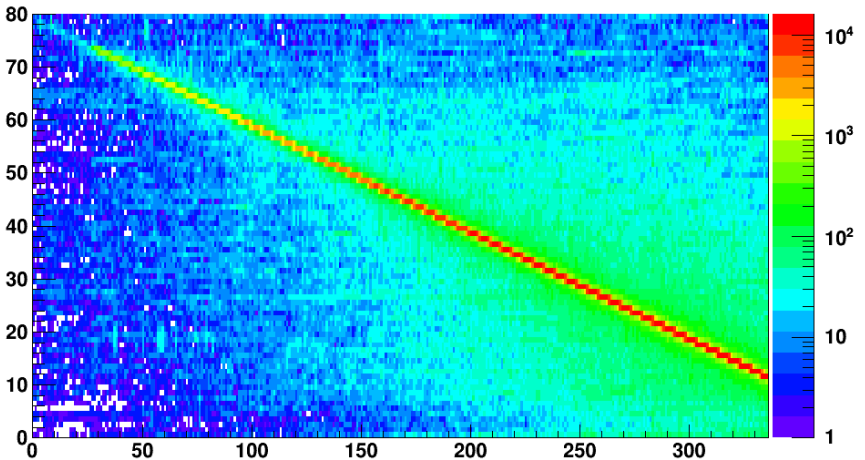
- LabView GUI controlling power supplies, stages and chiller
- All data is logged in plain text files



Telescope features and performance

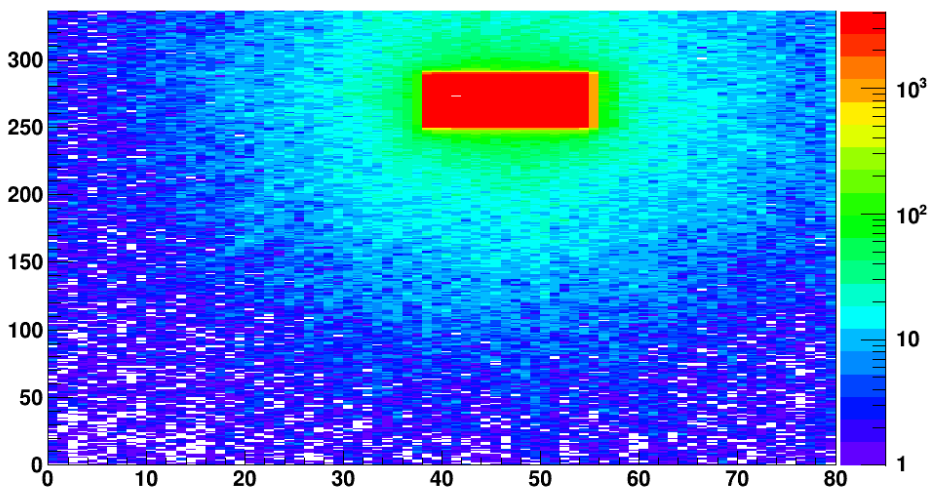
- Built May 2014 and commissioned July 2014 in the PS T9 testbeam
- Currently 2 DUTs supported (will be extended)
- Telescope practically noise free
- Trigger frequency in SPS H8 beam (average during spill)
  - ~17kHz trigger rate with one DUT (upgrade ongoing)
  - ~4kHz triggering on 3% of FE-I4 (720 pixel)
- Resolution at DUT: ~8µm x 10µm
- DCS and DAQ hardened
  - ~1 problem/crash per week
- All remotely controllable
- Plug&Play for FE-I4 devices
  - Not much more difficult for others

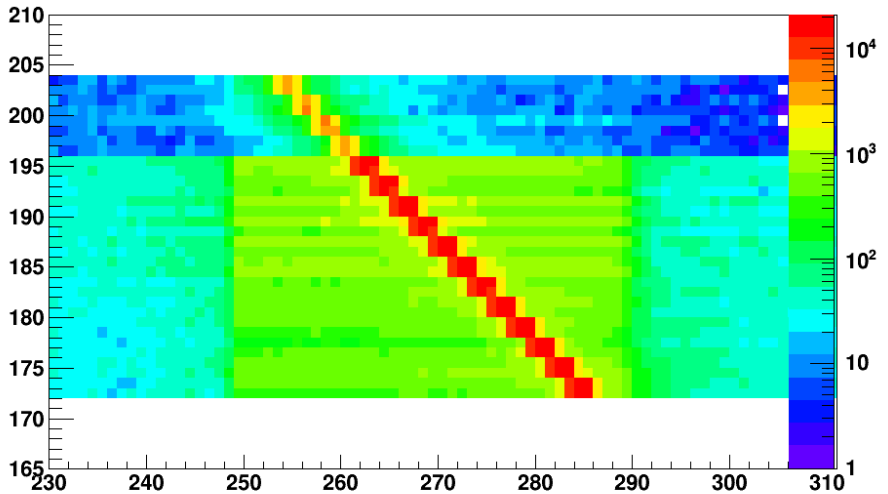




ROI trigger

- ROI defined by plain text mask
- Mask generation by Python/Bash scripts
  - Rectangular mask by x/y range
  - Arbitrary mask from png file
- Used successfully for HVCMOS CCPD (~3x4um^2) devices





The telescope's clients

- Multiple flavors of ATLAS HVCMOS sensors
- IBL like modules (Track separation studies)
- New planar pixel sensors

Non-FE-I4 devices

- Efficiency studies of DAMPE strip detectors
- Commissioning and performance measurements with new strip detector readout from KEK

Additional devices: maybe yours?

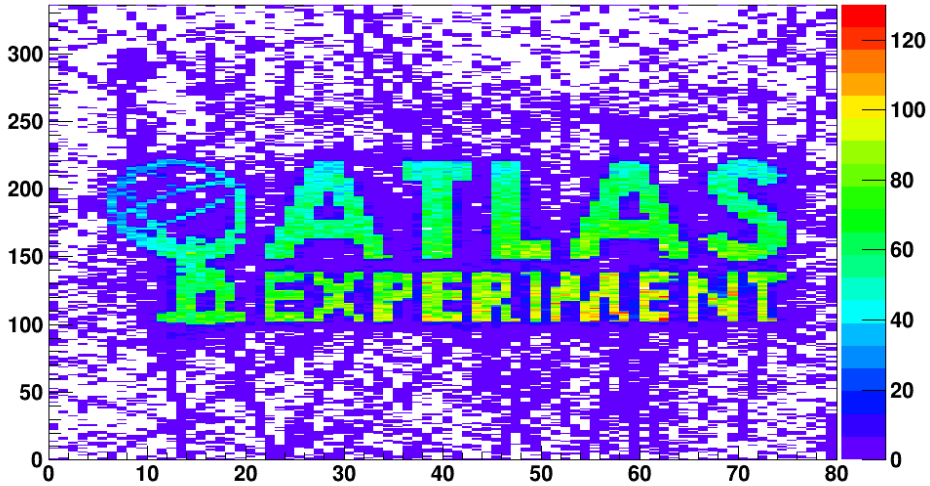
Upgrades

- Resolution: Tilting of planes
  - Already some data taken → Will be analyzed soon
- Speed: HSIO firmware upgrade ongoing
- Functionality: New adapter card interfacing the HSIO to the FEs
  - Up to 32 devices
  - Added CMOS lines (direct configuration of HVCMOS devices) → Has to be implemented in SW
- DCS: Unification of power supplies in Mpod crate
  - 16 0-5V LV channels
  - 8 0-120V LV channels
  - 8 0-2kV HV channels

Summary

A new FE-I4 based telescope has been built and commissioned

- Rather simple system
- Synchronized readout
  (no reference/timing plane needed)
- High trigger rate
- Resolution ~8-10μm
- ROI
- Stable and simple to use DAQ
- Plug&Play (for FE-I4 devices)



- Lots of data has been taken during last year
- Similar telescope built by ATLAS Inner Detector group at CERN

A huge thanks goes to Martin Kocian for his continuous effort on improving the telescope and support for data taking and Garrin McGoldrick et al. for the Judith reconstruction framework