An EUDET / AIDA Pixel Beam Telescope for Detector Development

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on behalf of the AIDA collaboration for the IEEE NSS 2012

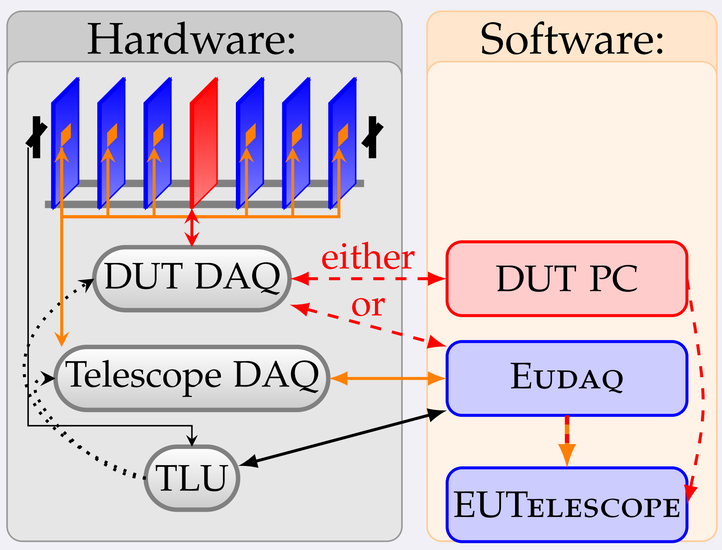
The EUDET Beam Telescope

The motivation for the EUDET high-resolution pixel telescope was to design an easy-to-use system with well-defined interfaces allowing test beam studies on a short time scale.
The telescope performs well at both high and low momentum beams. Currently it is used at the CERN SPS proton/pion beam and at the 1–6 GeV electron test beam at DESY, where the precision is limited by multiple scattering.

From EUDET to AIDA

Within the European AIDA project, one work-package is devoted to the development of a precision pixel detector infrastructure.
Based on the EUDET telescope, a next generation device is under way, which will offer the user the choice between different detector technologies: ATLAS pixel modules based on FE-I4 allowing LHC-speed timing, TIMEPIX sensors for high precision timing and high resolution, and MIMOSA MAPS offering high resolutions at low material budgets.

Telescope Framework



Sensors: Six planes of MIMOSA26 (monolithic active pixels), 576×1152 pixels with 18.4 µm pitch and an active area of $10.6 \times 21.2\,\mathrm{mm}^2$.
Mechanics: A lightweight mechanical frame allows easy transport of the telescope when needed, precise positioning of the sensor planes, and flexibility for the device under test (DUT).
Triggering: A trigger logic unit (TLU) distributes the trigger signal from e.g. scintillators to the telescope and the connected DUTs.
Data Acquisition (DAQ): Formerly, the sensors were read out with a DAQ board, the EUDRBS. For performance and availability reasons, the upgraded telescopes use a National Instruments system based on the PXI express bus instead.
Data Taking & Analysis Software: EUDAQ allows the easy (but optional) integration of the DUT and its DAQ into the telescope data stream and offers online monitoring facilities. The EUTELESCOPE software tools can be used for offline track reconstruction and data analysis.

Acknowledgments

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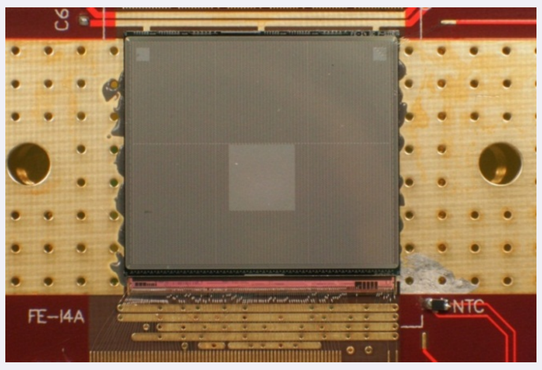
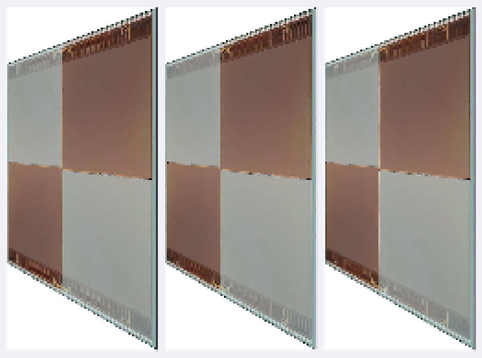
Current and Future Pixel Technologies for AIDA Beam Telescopes

ATLAS FE-I4



- 50 µm × 250 µm pixel size
- array size: 80 col × 336 rows
- total thickness: ∼ 400 µm
- large area: 4 cm²
- max. trigger rate: 200 kHz
- HitOr signal for self-trigger

MIMAIDA

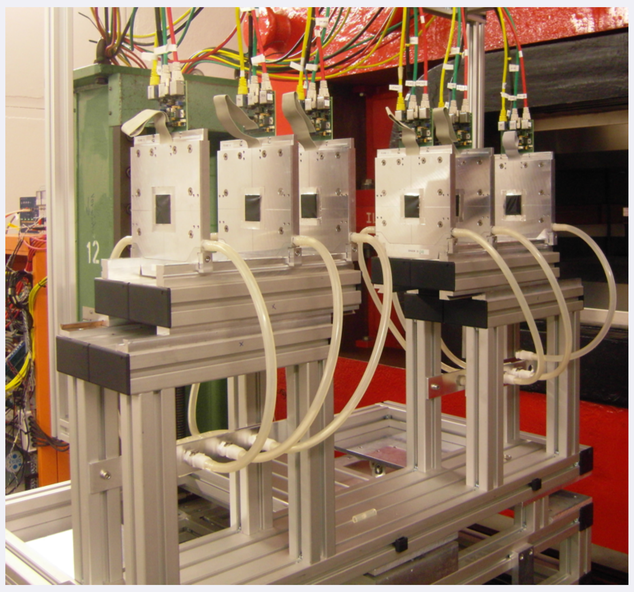


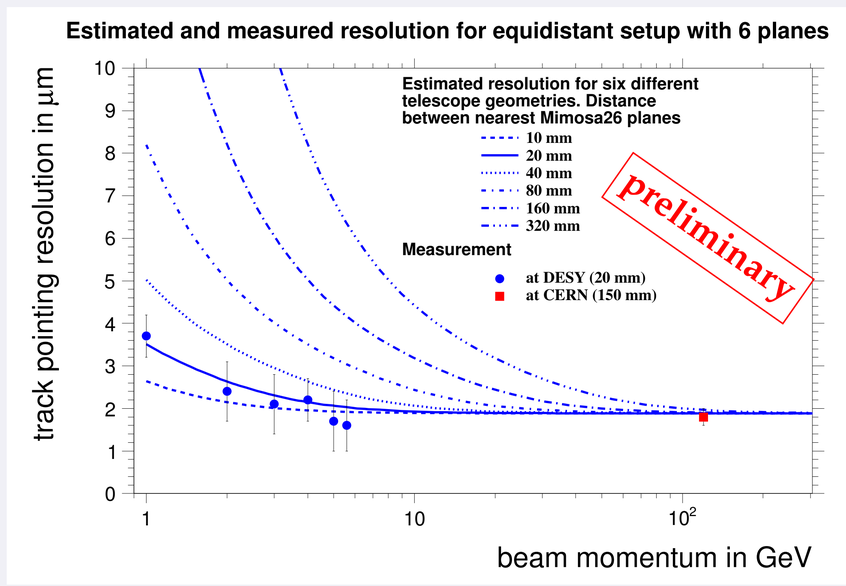
- very little material: 50 µm Si
- high resolution: ∼ 4 µm
- large active area: 4 × 6 cm²
- rolling shutter readout mode
- final sensors available for users by 2015

TIMEPIX

- TIMEPIX readout chip with 300 µm thick Si pixel sensor
- 256 × 256 pixels of (55 µm)²
- op. modes: counting, time of arrival, time over threshold
- global shutter signal controls when pixels are active

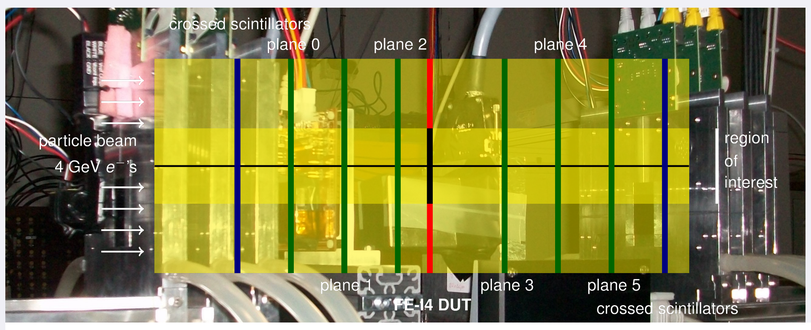
Current Generation of Telescopes and their Performance

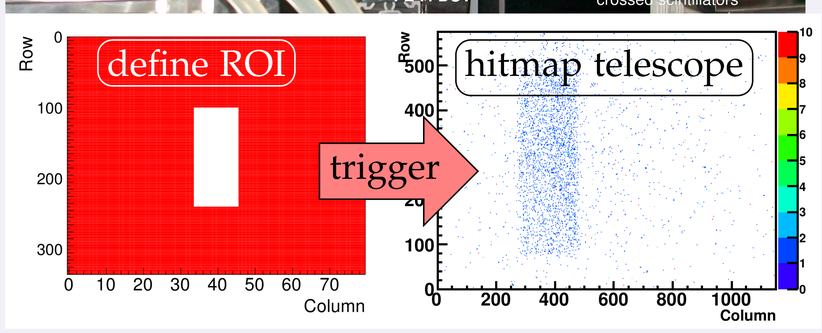




The move to a more easily available NI based DAQ system allows to fulfill the user demand for additional beam telescopes. The DATURA beam telescope at DESY (*left*) is the most recent replica in a series evolved from the original EUDET telescope. Further copies include the ANEMONE (ELSA, Bonn) and ACONITE (SPS, CERN) telescopes. With this EUDET family of telescopes, a track-pointing resolution of < 2 µm at the DUT position with trigger rates up to 4.3 kHz has been measured in the 120 GeV pion beam at CERN. Similar results can be achieved at the 1–6 GeV electron beam lines at DESY with an appropriate geometry to minimize multiple scattering.
The TIMEPIX-based telescope offers a track-pointing resolution of ~ 1.5 µm in high-energy beams at a track rate of $\sim$ 12 kHz with 1 ns track time stamping. Various readout systems have been successfully integrated into the TIMEPIX telescope, including ATLAS FE-I4, silicon strips using e.g. BEETLE chips, and PXI-based MEDIPIX readout systems.

Integrating the FE-I4 into an AIDA Telescope





The ATLAS FE-I4 chip features a fast (20–30 ns) HitOr signal formed from an OR of the discriminator output of all pixels.
Since each pixel's HitOr can be switched on/off individually, a *region of interest* (ROI) can be defined. Using the HitOr as input to the TLU of the telescope, the FE-I4 can provide a very flexible selective trigger for the telescope and DUT readouts.

This setup has been successfully tested:

- with the ANEMONE telescope at DESY,
- using four FE-I4 planes at ELSA (Bonn),
- using four FE-I4 planes at SPS (CERN).

Telescopes are Available to Interested Users!

- EUDET telescope and copies at CERN and DESY, TIMEPIX telescope at CERN
- Open to use for everybody, travel support available through AIDA for EU institutes
- contact: `pixel-telescopes@desy.de`