An EUDET / AIDA Pixel Beam Telescope for Detector Development

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on behalf of the AIDA collaboration

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Workpackage 9.3.1 within European AIDA project aims at building a **versatile beam telescope**:

- able to characterize detector prototypes, satisfying the demanding user requirements in terms of cooling infrastructure, read-out speed and precision
- using state-of-the-art pixel devices:
TimePix, ATLAS FE-I4 and MIMOSA
- capable of LHC-speed response and time-stamping

Outline

① Introduction

Telescope Infrastructure by Example: EUDET

② Technologies

ATLAS FE-I4

MIMOSA

TimePix & TimePix Telescope

③ Summary

The EUDET Beam Telescope Family

- easy-to-use system with well-defined interfaces
- allows test beam studies on a short time scale
- telescope being used by many different groups
- performs well at both high and low momentum beams: **track pointing resolution $\sim 2\mu\text{m}$** at 4.3 kHz trigger rate
- Currently at SPS-H6B, running at DESY during SPS maintenance
- commercial DAQ hardware $\rightarrow$ “easy” copies:
 - ▶ Bonn copy (ANEMONE)
 - ▶ ATLAS copy (ACONITE)
 - ▶ DESY test beam (DATURA)
 - ▶ ...
- Goal: same infrastructure at DESY TB and CERN SPS TB

Components of the EUDET Telescope

Upgrade of the DAQ in 2011

DAQ (15,5 k€) → **Crate + Flex RIO + CPU + RAID (Option)**

Much faster
⇒ ready for the future

EUDET SW
Run ctrl & Monitoring

DAQ development Done & Used in Beam Test

- ▶ Telescope 6 x **Mimosa 26** = 12 links @ 80 MHz = 120 MB/s
- ▶ Telescope 6 x **Ultimate** = 12 links @ 160 MHz = 240 MB/s

System set up by Strasbourg, connection to EUDAQ done by DESY

The Trigger Logic Unit (TLU)

- Gives a simple but flexible interface to trigger/timing signals
- Low cost
- Well documented (→ EUDET-Memo-2009-4)
- Many copies build by Uni Göttingen to fulfill growing demand
- Existing TLU works. Why a new one?
 - ▶ Want to move to **one-trigger-per-particle** (instead of one trigger per telescope frame)
 - ▶ Faster → needed for LHC detectors.
 - ▶ Cheaper to produce TLUs for integration in home labs.
 - ▶ Mini TLU prototype in preparation

EUDAQ (Data Acquisition Software)

- Allows **full integration** of *device under test* (DUT) independent of its technology **including pre-existing DAQ** systems
 - Modular and flexible design
- ⇒ in usage by many groups already!

EUTelescope (Track Reconstruction & Analysis)

- stepwise transition from single pixel array to 3D coordinates of fitted tracks in global frame
- based on Marlin (ILCSoft)

One Technology: ATLAS FE-I4

- FE-I4 properties:
 - ▶ $50\ \mu\text{m} \times 250\ \mu\text{m}$ pixel size
 - ▶ array size: 80 col $\times$ 336 rows
 - ▶ total width: $\sim 400\ \mu\text{m}$
 - ▶ max. trigger rate: 200 kHz
 - ▶ HitOr signal for self-trigger
- FE-I4 module-based reference planes offer...
 - ▶ high rate and high occupancy capability
 - ▶ large area $\sim 4\ \text{cm}^2$
 - ▶ fast self-triggering in defined region of interest
- R/O fully integrated in common infrastructure of the “AIDA telescope” framework:
 - ▶ mechanics: cold operation
 - ▶ DAQ-software based on the EUDAQ package
 - ▶ reacts to TLU signal
 - ▶ can send trigger signal to TLU

ATLAS FE-I4 as Telescope Trigger

- FE-I4 features fast **HitOr**:
a wired OR over all pixels
 - each pixels HitOr can be switched on/off
- ⇒ can define *region of interest*
- successfully tested with **EUDET** telescope at DESY using MIMOSA26 reference planes
 - successfully tested **two** FE-I4 planes at ELSA

trigger mask
 $3 \times 10 \text{ mm}^2$

EUDET hitmap

FE-I4 Hitmap, $10 \times 5 \text{ mm}^2$ window

MIMAIDA Sensors

- Prominent features of MIMAIDA:
 - ▶ very low material budget: $50\ \mu\text{m Si}$
 - ▶ high resolution: $\sim 4\ \mu\text{m}$
 - ▶ large detection area : $4 \times 6\ \text{cm}^2$

- Production of sensors in two steps:
- Start with demonstrator based on MIMOSA-28 sensors
- Replace demonstrator sensors with final sensors;
⇒ available for users by 2015
 - ▶ relies on new $0.18\ \mu\text{m}$ CMOS process, currently investigated (MIMOSA-32), which provides stitching

TimePix Planes

- TimePix readout chip on 300 μm thick Si pixel sensor
- 256×256 pixels of $55 \mu\text{m} \times 55 \mu\text{m}$
- **operating modes: counting, time of arrival, time over threshold**
- global shutter signal controls when pixels are active

TimePix Telescope Features:

- $\sim 12 \text{ kHz}$ track rate
- **Spatial resolution $\sim 1.5 \mu\text{m}$**
- **Time stamping with $\sim 1 \text{ ns}$ precision**
- (disadvantage: material budget degrades resolution for lower energy beams)
- Telescope available to LHCb collab. and in the framework of AIDA WP9.3 to external

TimePix Telescope: Integration with external users

Effort to make external integration as simple as possible:

- DAQ systems run independently, information combined offline
- CO₂ cooling, remote controlled translations and full rotations, large space in z and y directions provided to DUT
- External integration works with 40 MHz style readouts without need for tagging plane.
- Proved with scintillating fibers, FE-I4 with full rotations, strip detectors, etc.
- Excellent quality FE-I4 data:

Summary

- The EUDET-family of telescopes continues to evolve and will be available at DESY and CERN in different stages most of the time
- TimePix telescope is installed at CERN (and is now a part of AIDA)
- AIDA will not provide one telescope with a lot of features but a couple of telescopes with different features!

Telescopes are available to interested users!

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