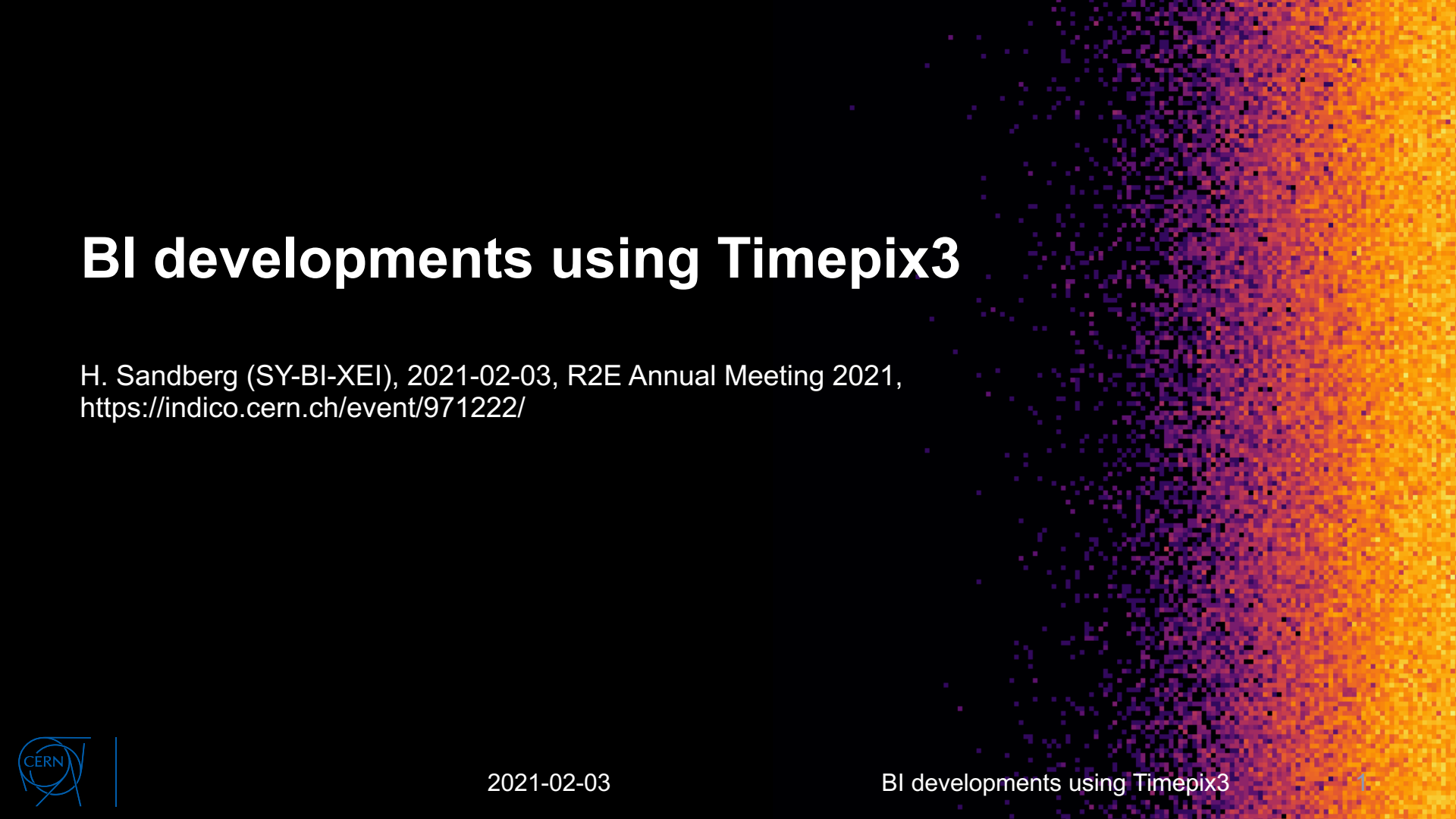
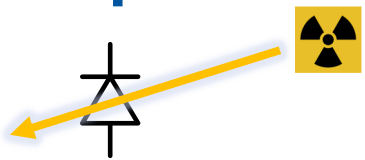
BI developments using Timepix3

H. Sandberg (SY-BI-XEI), 2021-02-03, R2E Annual Meeting 2021,
https://indico.cern.ch/event/971222/

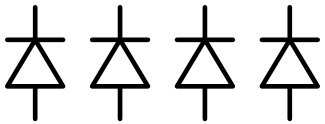


What is Timepix3?

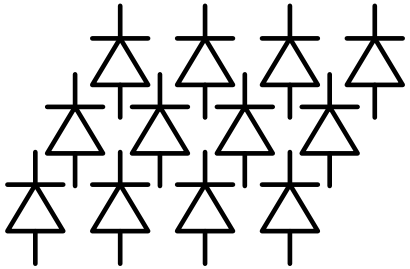
0D: Diode
Qty: 1

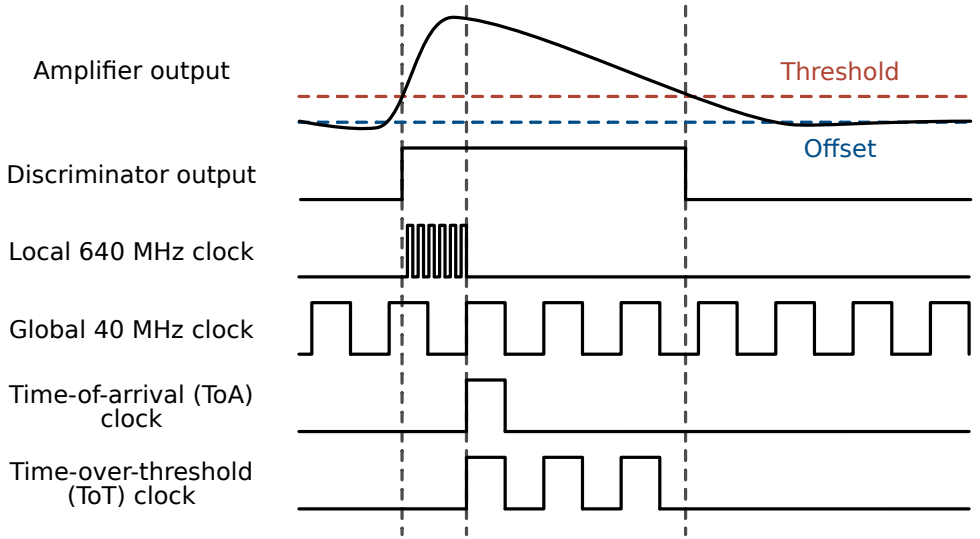


1D: Silicon strip
Qty: ~10-1000



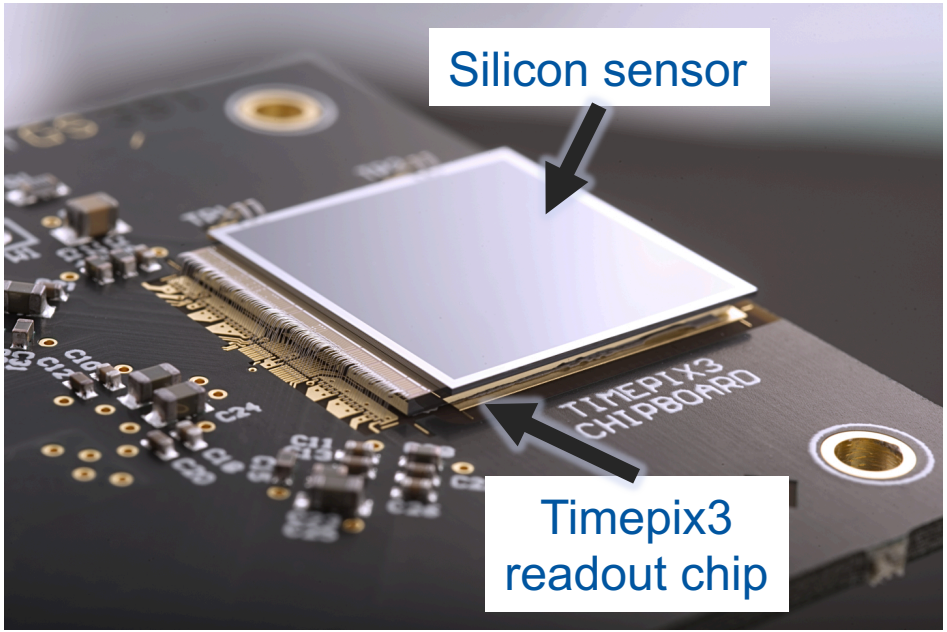
2D: Pixel detector
Qty: >10000





Timepix3 is a hybrid pixel detector from the Medipix collaboration at CERN
Collaboration website: https://medipix.web.cern.ch

Timepix3 hybrid pixel detector



https://cds.cern.ch/record/2253263

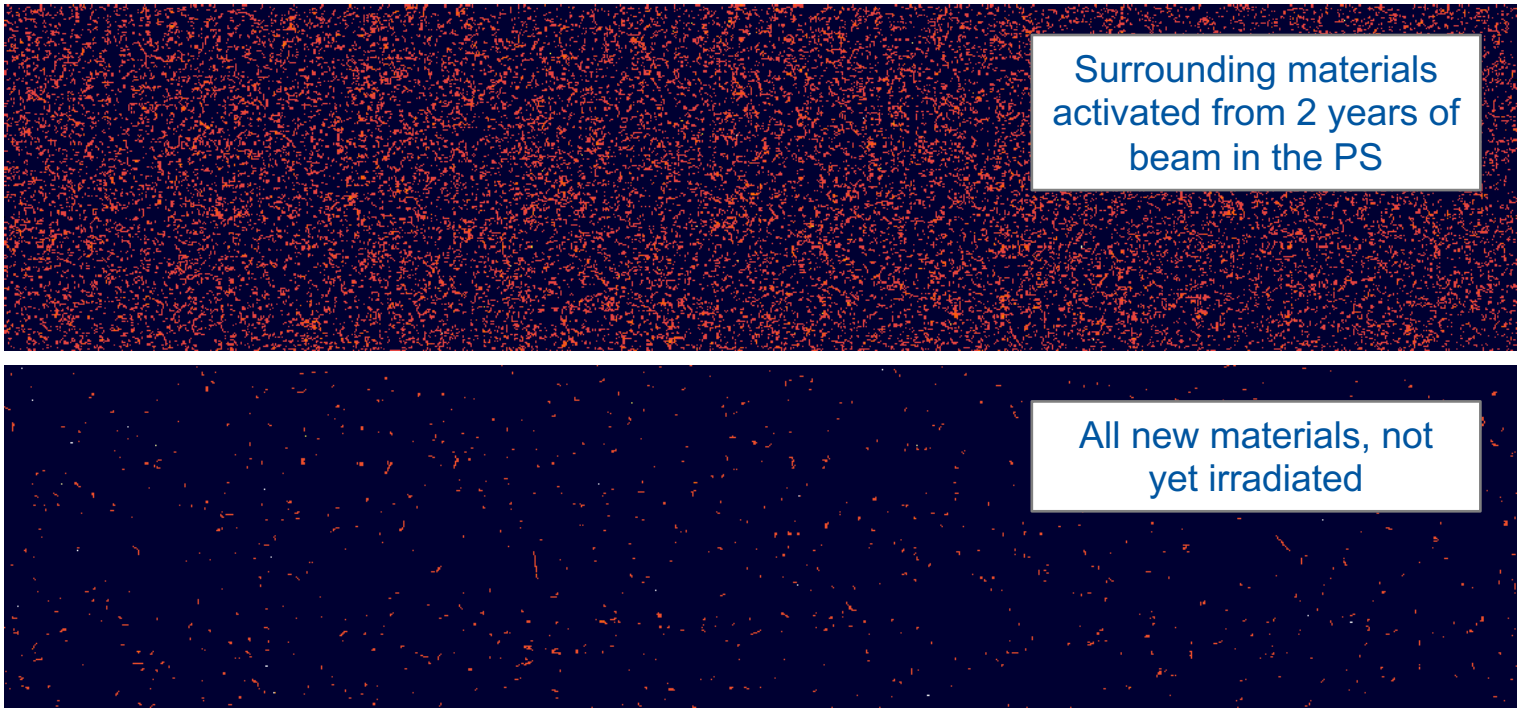
- Hybrid means sensor and readout are separate
- Readout chip is Timepix3, CMOS 130 nm
- Sensor can be made of Si, GaAs, CdTe, etc.

- 256 x 256 pixels (65536 pixels)
- 55 um pitch
- Timestamp resolution of 1.5625 ns
- Time-over-threshold to energy with calibration
- 8x serial links up to 640 Mbit/s = 5.12 Gbit/s

Historical overview of the Medipix and Timepix family: https://doi.org/10.1016/j.nima.2017.07.029

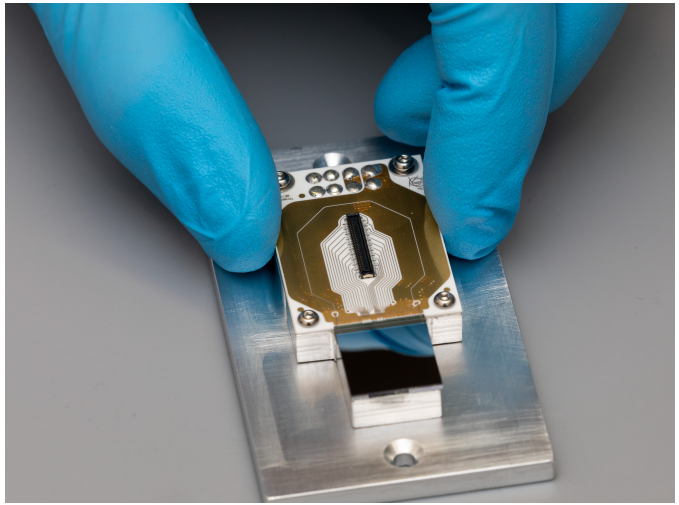
Example of Timepix3 image

20 minute exposures inside the CERN PS vacuum



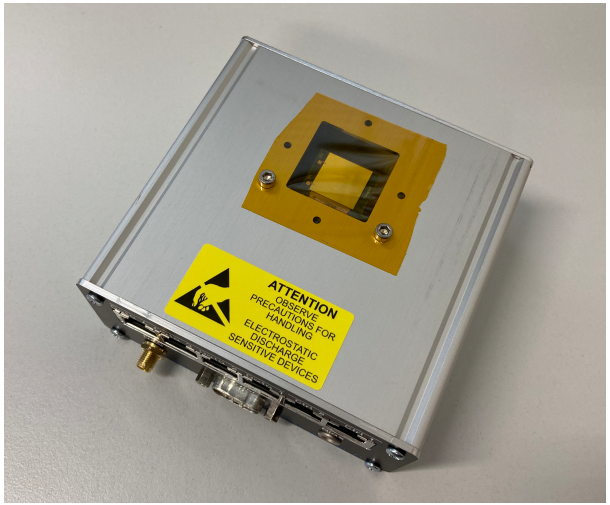
BI Timepix3 (BIPXL) detector development

In-vacuum detector module



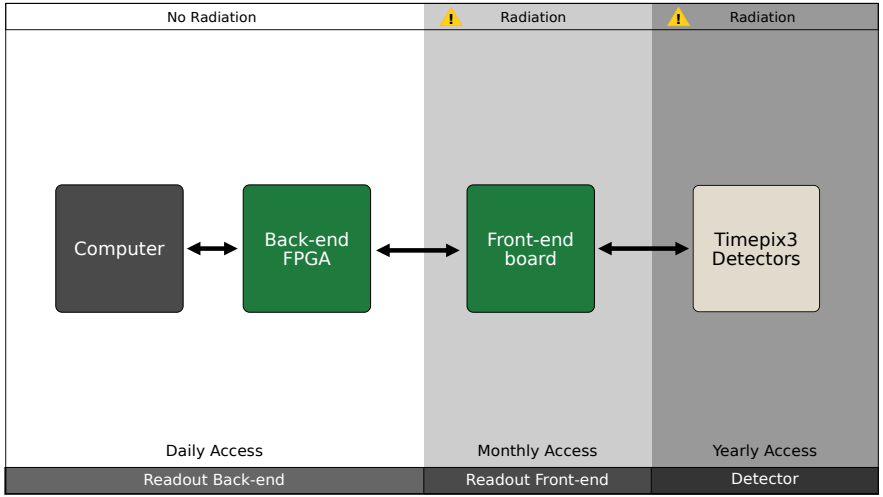
- Material choices driven by vacuum-compatibility
- Mounted on metal base for increased conduction for cooling
- Power provided from outside the vacuum

“In-air” detector module



- Plug-and-play detector box
- FEASTMP rad-hard DC/DC modules inside

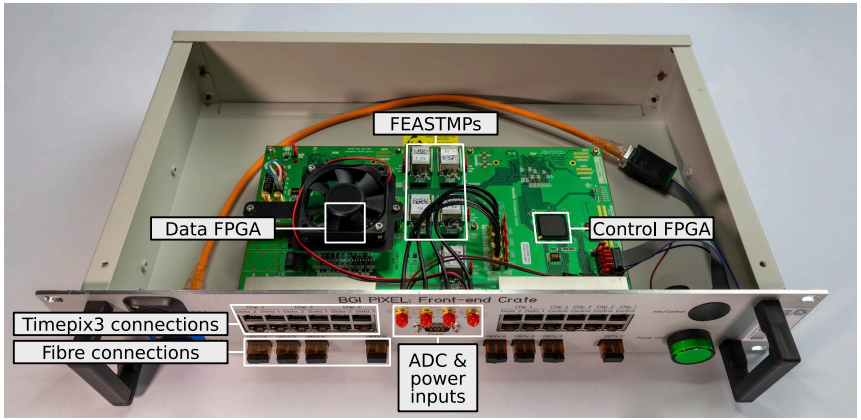
BIPXL readout system overview

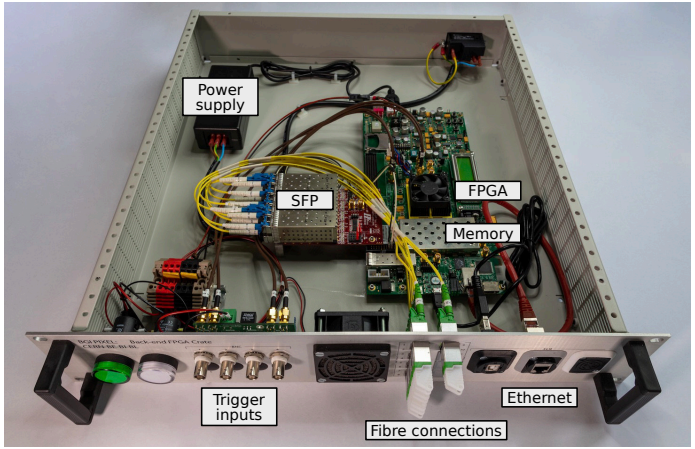


The BIPXL readout system consists of 3 main parts: the **back-end**, the **front-end** and the **detector.**

- The front-end is responsible for interfacing with the Timepix3 detectors (radiation)
- The back-end is responsible for communicating with the front-end over optical links and provides an interface to the computer (no radiation)
- The physical separation between front-end and back-end allows for readout of the Timepix3 detectors in radiation environments

BIPXL readout - current





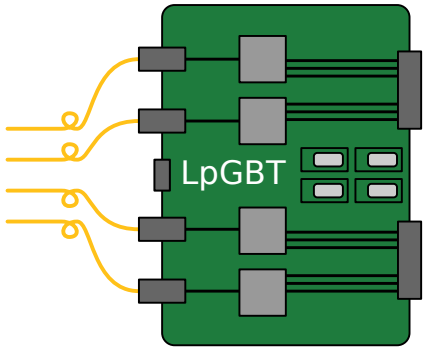
Front-End FPGA

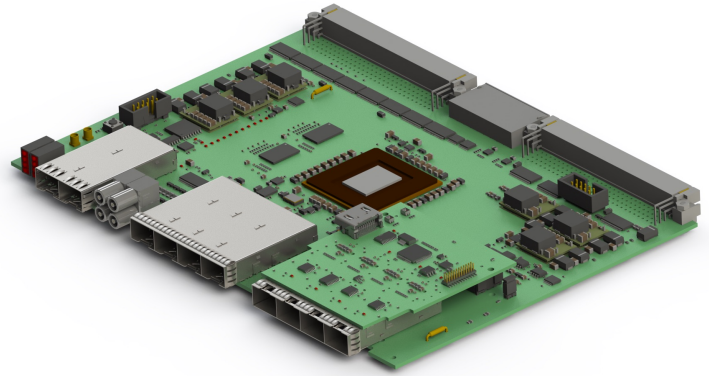
- Versatile processing board (EDA-03830)
  - 5x FEASTMP
  - ProASIC3E (A3PE1500-FG484)
  - Kintex7 (XC7K70T-1FBG676C)
- Quad GBTx board (EDA-03812)
  - GBTx, GBT-SCA and VTRx

Back-End FPGA

- Xilinx VC707 board
- 8x SFP compatible with GBT-link
- External trigger inputs
- 1G Ethernet to computer

BIPXL readout - future





Front-End

- LpGBT directly connected to Timepix3
- FEASTMP
- VTRx+

Increases the radiation tolerance of the front-end

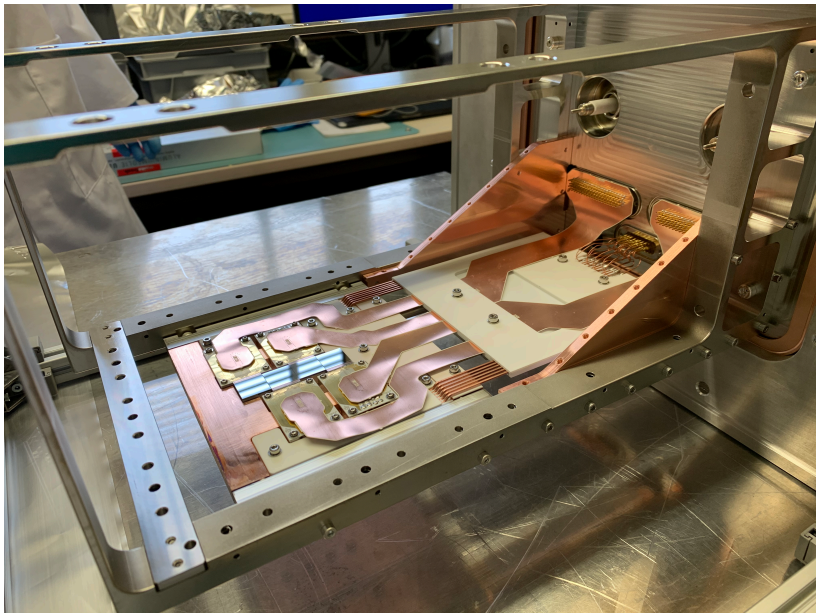
Back-End FPGA

- CERN BI VFC-HD (EDA-03133)
- FMC with 4x SFP, HDMI and memory for storing detector configuration (EDA-04252)
- 8x SFP compatible with GBT-link

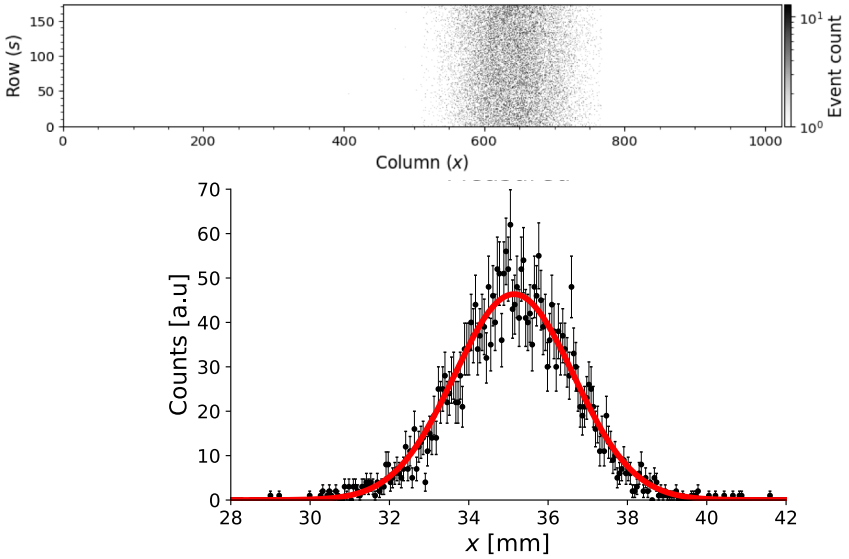
Standardization

BIPXL applications - beam profile monitoring

Beam gas ionization profile monitor (BGI) - measures the transverse beam width in the PS
More info on: https://bgi.web.cern.ch



4x Timepix3 detectors side-by-side

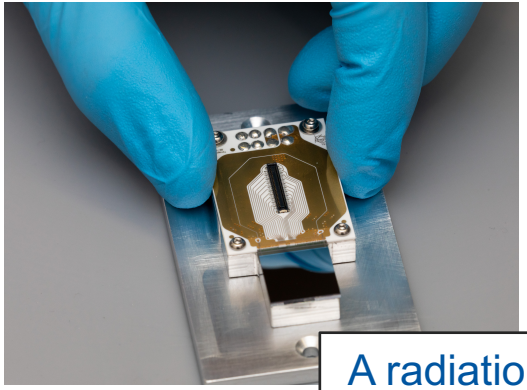


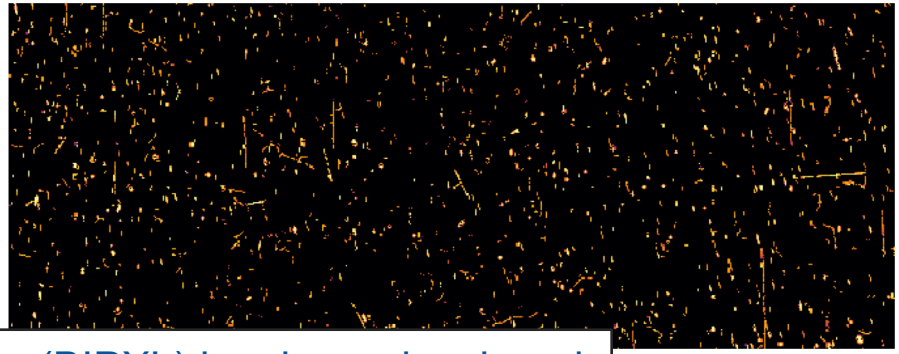
Other BIPXL applications at CERN

- **BGI instruments for SPS and LHC**
- **Rapid deployment Timepix3-BLM**
- **R2E team evaluating the BIPXL system for use during irradiation campaigns**
- **Beam Image Monitor (BIM) for crystal assisted beam manipulation**

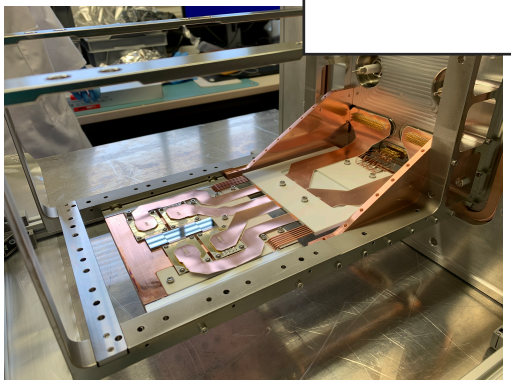
Other applications of Timepix/Medipix

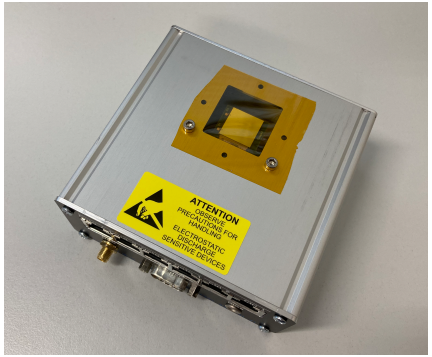
- Radiation monitoring on the International Space Station
  - https://doi.org/10.1016/j.nima.2015.02.016
- 3D color X-ray
  - https://home.cern/news/news/knowledge-sharing/new-3d-colour-x-rays-made-possible-cern-technology
- Radiation imaging
  - https://indico.cern.ch/event/48618/contributions/1163509/
- Luminosity & radiation field characterization at ATLAS
  - https://doi.org/10.1109/TNS.2019.2918365
- More examples on https://medipix.web.cern.ch

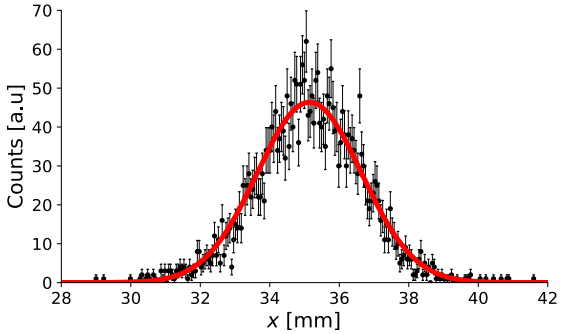




A radiation tolerant system (BIPXL) has been developed for Timepix3 which facilitates new applications of this technology at accelerator facilities







Thank you for your attention!