HEPHY
INSTITUT FÜR HOCHENERGIEPHYSIK

ÖAW

Test-Beam Instrumentation and Results of the RD50-MPW3 HV-CMOS Detector

BTTB11

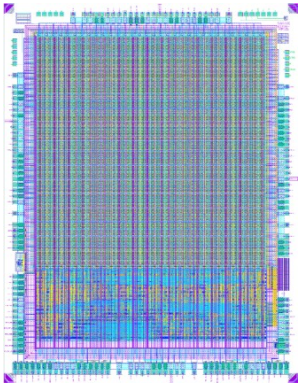
Bernhard Pilsl on behalf of RD50

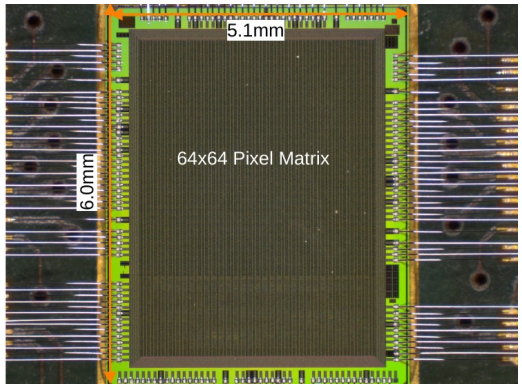
CERN RD50 HV-CMOS

- **17 institutes**
- **Developing radiation hard DMAPS**
  - Large-fill-factor design
  - So far 3 detectors (RD50-MPW1, -MPW2 and -MPW3) developed
- **ASIC design**
- **TCAD studies**
- **DAQ development**
- **Detector Characterization**

RD50-MPW3

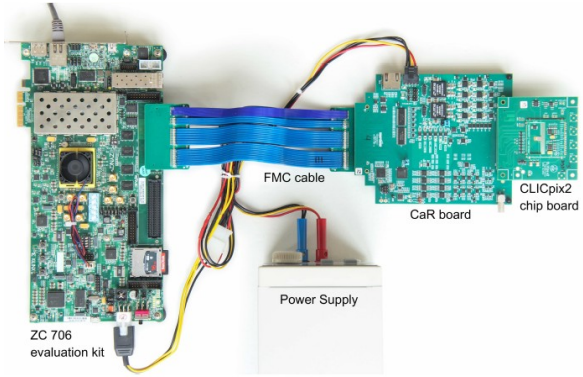
- **64 x 64 Pixel with pitch of 62µm**
  - Arranged in 32 double columns
- **Full analog and digital electronics inside pixel**
- **Fast clock at 320MHz**
- **8 bit timestamps for ToT**
- **Digital periphery**
  - I2C slave for configuration
    - 8 bit per pixel
  - Data FIFO depth of 32 words for each double column

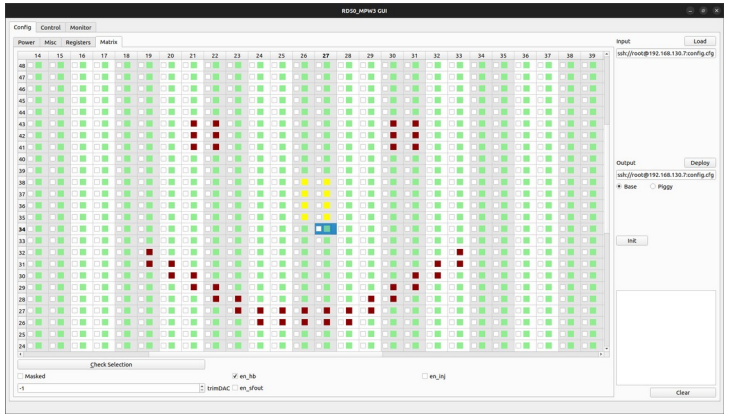




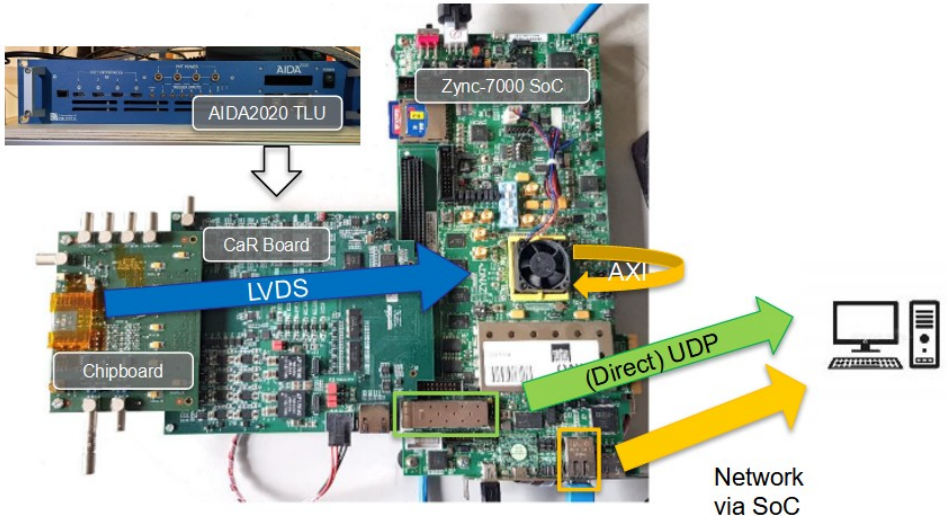
Base DAQ

- **Caribou system**
- **Implemented Peary Device**
  - Custom I2C interface (16 bit addresses)
- **GUI for configuration**
  - Generating Peary config files





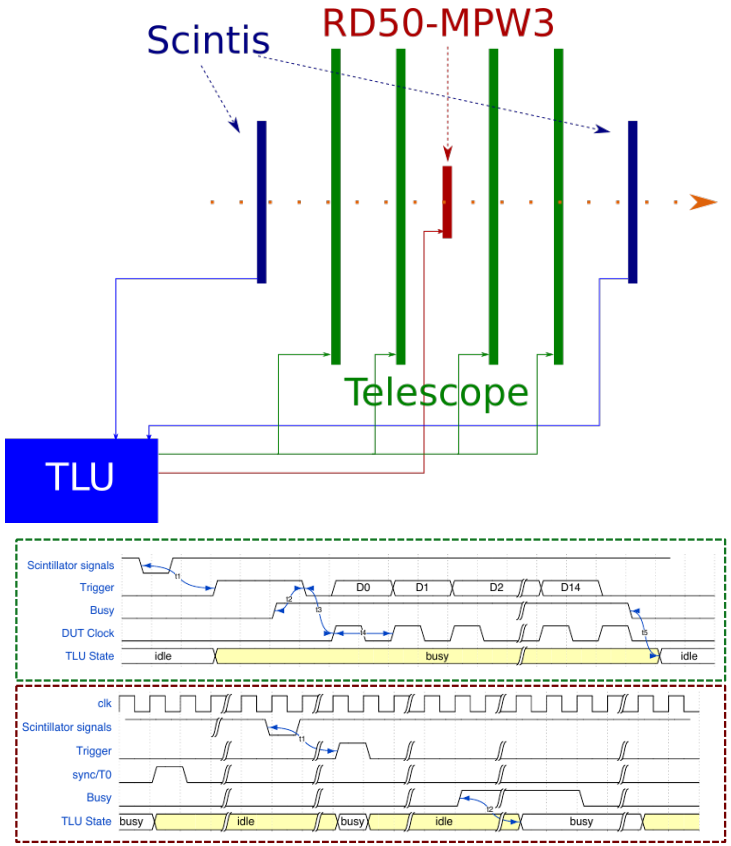
Testbeam DAQ



- **EUDAQ**
- ***CaribouProducer* too slow for full read-out rate**
  - Only used for run-control commands
- **Custom UDP (1 Gbit/s) Data-Collector implemented**
  - Multi–threaded approach
  - More like a EUDAQ-producer, but directly storing to disk
- **EUDAQ-monitor integrated in GUI**
- **EUDAQ-Run-Control for submission of run info to *ELog* server**

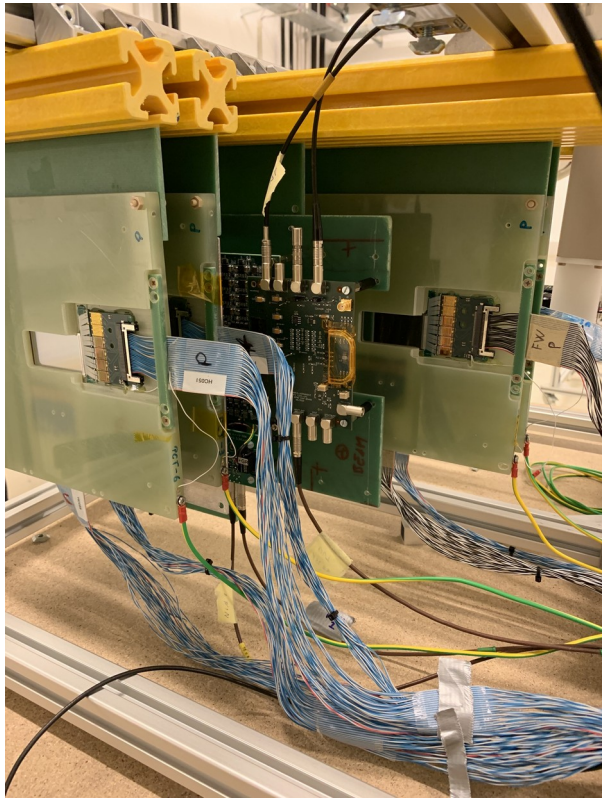
Synchronization

- **MPW3 has a data-driven readout**
  - Syncing via timestamps (TS)
  - Faster than sampling trigger-numbers
- **Telescope triggered by scintillators**
- **AIDA-TLU**
  - EUDET mode for telescope
  - Synchronous AIDA mode for MPW3
- **EUDAQ *AidaTluProducer***
  - Matching trigger-numbers to TS



TB MedAustron

- ***MedAustron* is a medical facility located close to Vienna**
- **800MeV 200kHz proton beam**
  - Gaussian shape of Ø ~ 3mm
- **Telescope consisting of 4 DSSD planes**
  - 512 x 512 “quasi” pixel with pitch of 100µm x 50µm
  - Telescope veto time ~25µs
- **2 scintillators and AIDA-TLU for triggering**

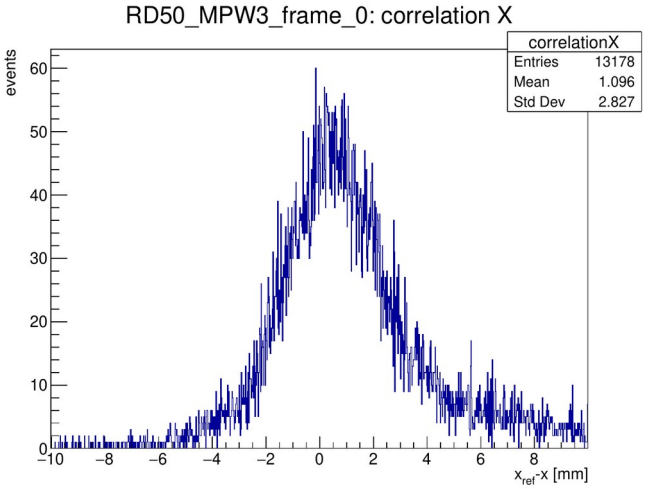


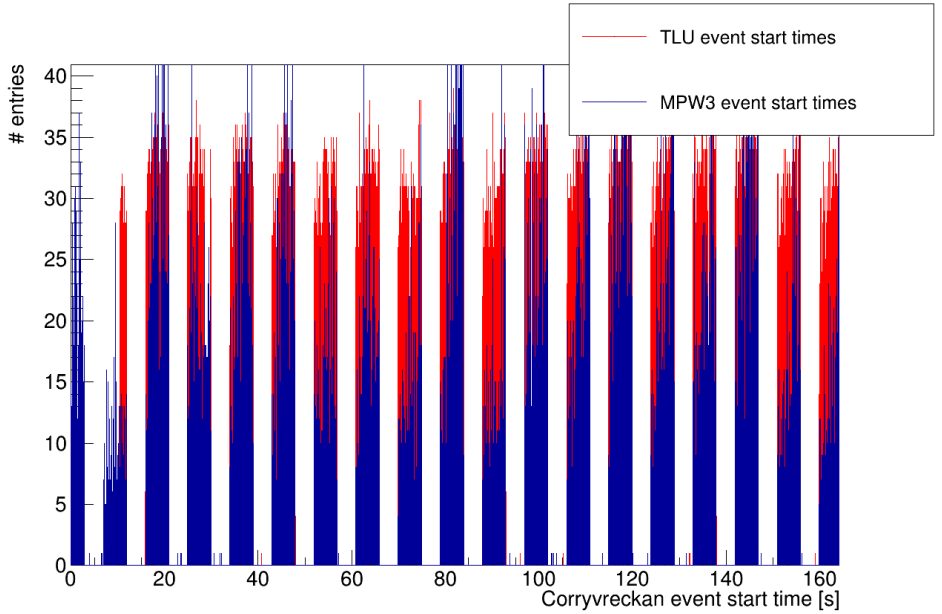
TB Analysis

- ***Corryvreckan*** **used for data analysis**
- **TLU defines events with trigger-number and time window**
  - Initially *[EventLoaderEUDAQ2]* used
- **Telescope hits matched to trigger-number**
  - Custom event loader developed
- **RD50-MPW3 hits matched to TLU time windows**
  - *[EventLoaderEUDAQ2]* used

Event-Building

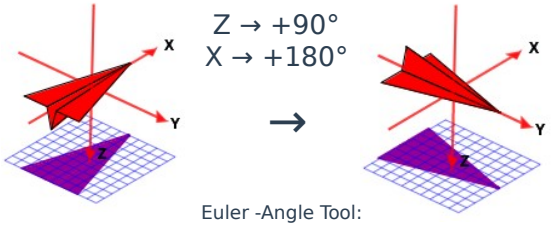
- **Beam structure well represented**
  - 5 sec spill, 5 sec pause, ...
- **TLU and MPW3 events line up fine**
- **Very few hits matched, no correlations**



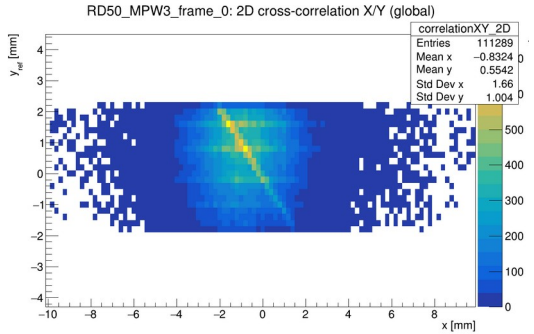


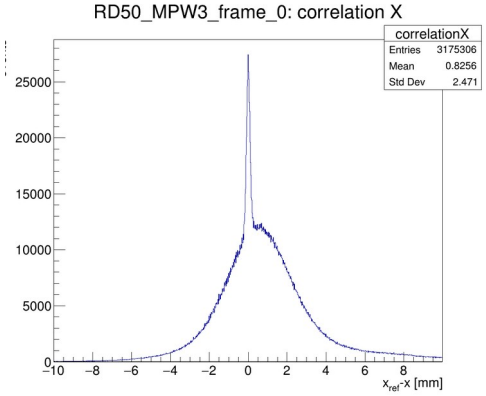
Road to Correlations

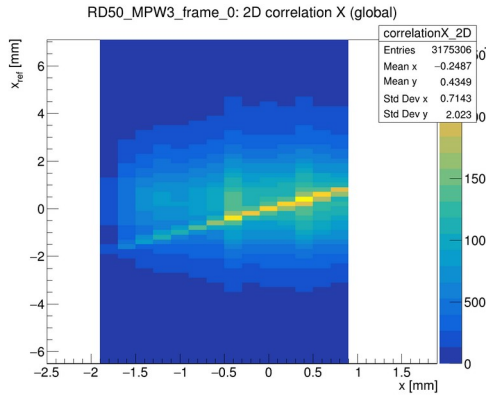
- **TLU time LSB: 25ns**
  - Also “native” length of most events
- **MPW3 time LSB: 50ns**
- **Hits matched only when start times line up perfectly**
- **Enlarged TLU event-window**
- **Anti correlations between X → Y**
  - Wrong initial orientation



Euler -Angle Tool:
https://danceswithcode.net/engineeringnotes/rotations_in_3d/demo3D/rotations_in_3d_tool.html

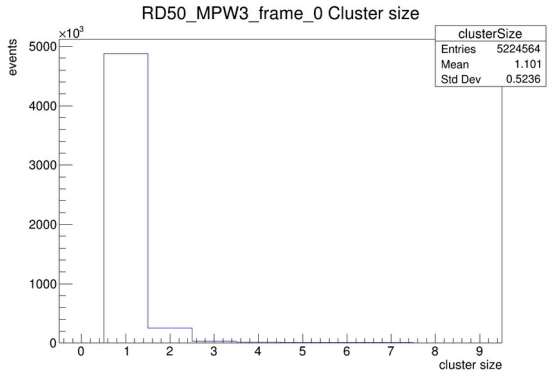


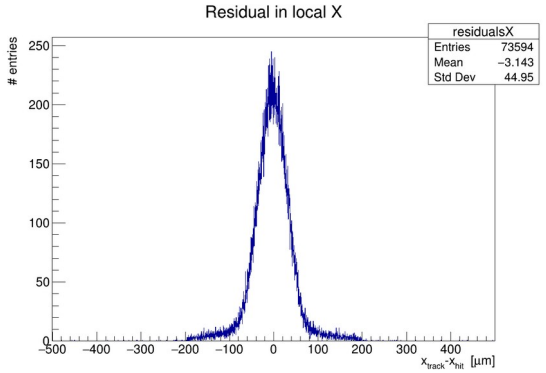




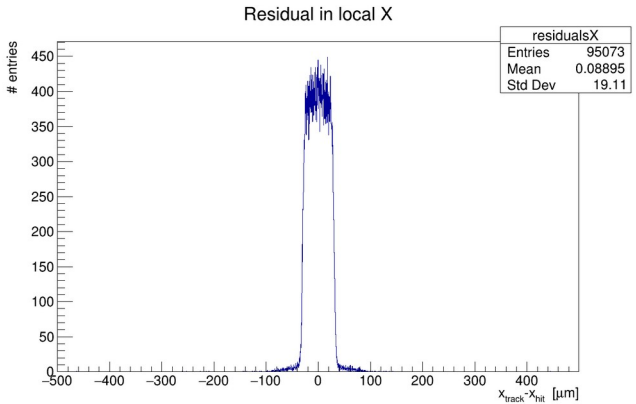
TB Results

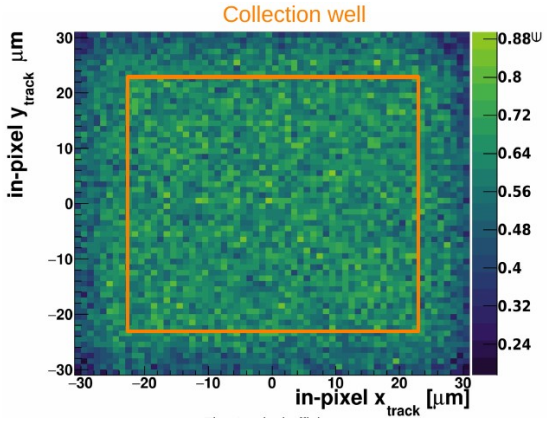
- **Correlations fine, everything fine (right?)**
- **Almost exclusively 1 hit clusters**
  - High bias voltage of ~100V
  - High threshold voltage applied
- **DUT Alignment not working properly**
  - Procedure *[AlignmentDUTResidual]* finishes “too fast”
  - Residuals not well centered at 0
- **Bad efficiency of ~3%**
  - Even with *[DUTAssociation]* cuts of 200µm





CERN SPS Results





- **Earlier TB at CERN SPS in Sep. 2022**
- **EUDET-type telescope with 5 MIMOSA26-planes used**
- **Event building with *[EventDefinitionM26]* module**
- **Total efficiency of ~60% evaluated**
  - Problem most likely due to high threshold voltage
- **Some problems with timestamp assignment to MPW3 hits**
  - DAQ did not provide sufficient range

Possible Problems

- **Telescope operated for the first time in this way**
  - Never used to match to timestamped events before
  - So far (mostly) used stand-alone
  - Possibly trigger-number shift in the data
- **Bug in DAQ system**
  - Timestamping not working properly?
- **Most likely event building procedure not matching MPW3 hits properly**
  - 5M clusters, but only 100k inside an event with a track
  - Time offset in the data?
- **Work in progress**

Outlook

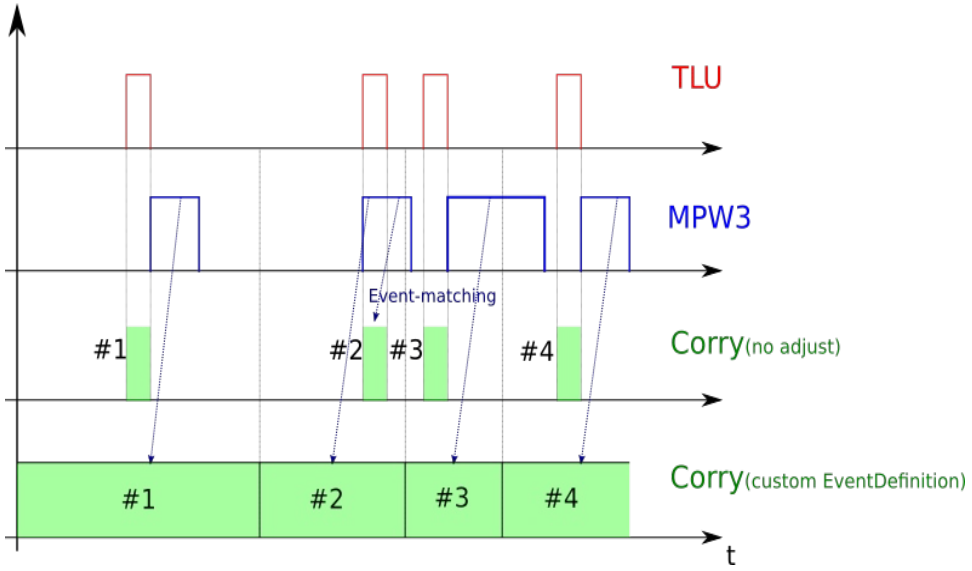
- **Debug event-building**
  - Implement a trigger-number based synchronization
- **File merge-requests**
- **Upcoming testbeams: May at *MedAustron*, July at *DESY***
- **Evaluate irradiated samples**
- **Use multiple MPW3 as “small telescope”**
- **RD50-MPW4 currently in design-phase**
  - Targeted submission in May

- **Thanks for your attention!**
- **Questions?**

Backup

Event definition details

- **Custom event definition module written**
  - Defines Corry event time frames
- **Basically spans whole run-time**
  - Start / end time in middle of two consecutive TLU events
- **Almost all MPW3 hits matched to an event**
  - Most of them to the wrong one(?)



MedAustron tracker

Timing Issues at CERN TB