WP6.3 Valiation and testing of common productions

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Outline

- Recall of milestones and deliverables.
- Set-up:
  - Challenges and solutions.
- Summary of tested DUT at SPS and DESY.
- Next steps

Activity Recall and Related Milestones and Deliverables

Task 6.3. Validation of common 3D and LGAD sensor productions

- Characterisation of the **3D** sensors in terms of **timing, radiation hardness, efficiency and uniformity** via measurements in the laboratory and beam tests

- Characterisation of small pitch **LGAD** and inverse LGAD sensors (iLGADs) from the common production in terms of **timing and efficiency** via measurements in the laboratory and beam tests

- Feedback to the foundries for further process optimisation of 3D and LGAD sensors

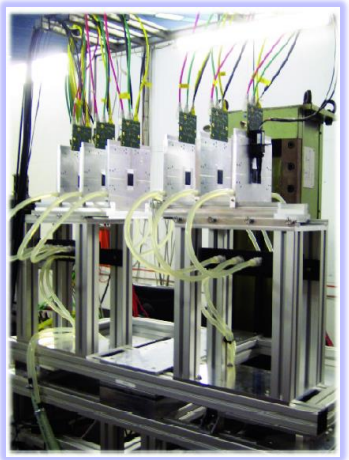
MS & D #	Name	Due date (in months)
M23	Preliminary characterisation of 3D and LGAD prototypes.	23
D6.2	Final validation of timing performance of common productions	46

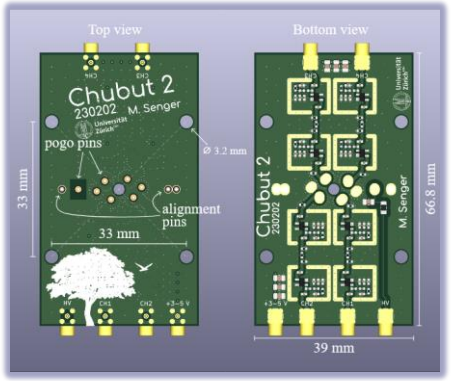
Test beam beam campaign Highlights

- Since the last AIDAInnova anual Meeting:
  - Two test beams at CERN (SPS) in June (two weeks) and September (one week)
  - One test beam at DESY in February (two weeks).
- Large involvement of the WP6 groups:
  - **CNM:** Oscar David Ferrer Naval, Neil Moffat
  - **IFCA:** Ivan Vila Alvarez, Andres Molina Ribagorda, Jordi Duarte Campderros, Efren Navarrete Ramos, Marcos Fernandez Garcia, Ruben Lopez Ruiz
  - **IJS**: Gregor Kramberger, Jernej Debevc
  - **INFN/ University of Torino:** Roberta Arcidiacono, Federico Siviero, Leonardo Lanteri, Luca Menzio, Roberto Mulargia, Valentina Sola, Marco Ferrero
  - **INFN Genova:** Claudia Gemme
  - **UZH:** Anna Macchiolo, Matias Senger, Parisa Rezaei Mainroodi
  - **CERN:** A. Rummler, V. Gkougkousis
- Major milestones:
  - Commission a fully-functional test beam set-up for 4D-tracking DUT characterization.
  - Radiation tolerance study of the AIDAInnova TI-LGAD common production from FBK

Test beam setup and commisioning: Major challenges

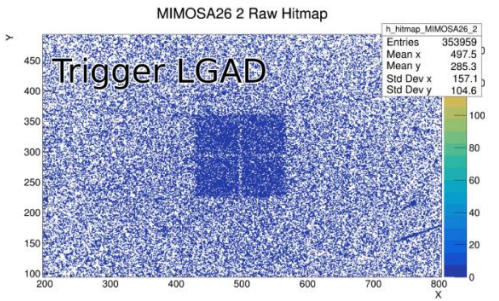
- Characterization of the 4D-tracking DUTs requires:
  - Precision Tracking:
    - AIDA-type telescope (MIMOSA 26 CMOS sensors) for high-resolution track reconstruction.
    - MIMOSA 26 pixels sized 18.4 μm × 18.4 μm, in 1152 columns and 576 rows, covering an active area of 21.2×10.6 mm → binary resolution of 5.3 μm
    - SLOW read out MIMOSA 26 with a rolling-shutter, for correlated double sampling and zero suppression on-chip → integration time equals 115.2 μs, 8680 frames to be read out per second
    - FAST read out using CROC sensors pixel sized 50 μm × 50 μm → Allows for determining the DUT absolute efficiency.
    - Digitizer, CROC producer integrated into EUDAQ2.
  - Precision Timing:
    - No dedicated read out ASIC available.
    - No dedicated time reference device.
    - Discrete front-end electronics (CHUBUT-2) as preamp and shapper.
    - Fast waveform digitizer (DRS4 ASIC):
      - Analog bandwidth 500MHz, 5Gs/s, 16 channels.
  - Trigger logic, rates, latency and dataset sizes:
    - Small area DUTs (pixel size) → small trigger acceptance
    - CAEN digitizer fixed acquisition time window → TLU2 trigger latency too large.
    - Dedicated Lecroy DSO WR8104 for implementing a low latency trigger logic.
  - Mechanics and cooling:
    - Chiller with high power cooling required to achieve -25 C as operating point (at SPS just -12 C)
    - Somewhat cumbersome operation of supporting linear stages.
    - Fine alignment of DUT done with piezo electric stages

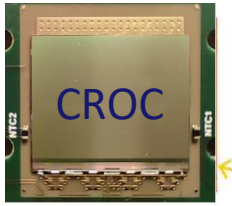




Set-up arrangement

For alignment, each DUT is removed from the CAEN digitizer and connected to the inputs of the oscilloscope. The whole system is then triggered from the DUT and we can observe its shadow in the telescope planes.





Split as close as close as possible to Aux output using regular "T" splitters (avoid Lemo when possible)

Scope settings:
1) Utilities → Utilities setup → Aux Output → Trigger Out → Pulse Duration = 400 ns
2) Timebase → Sampling Mode → Sequence → Number of segments = high (e.g. 999)
3) Trigger → Trigger setup → Holdoff → Time = ~20 ms
4) Check that Aux Output is, before splitting, logic 0 = 0 V and logic 1 = +1 V

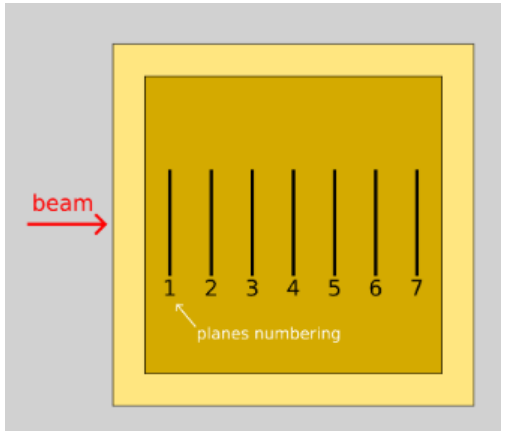
This is the trigger rate of the system

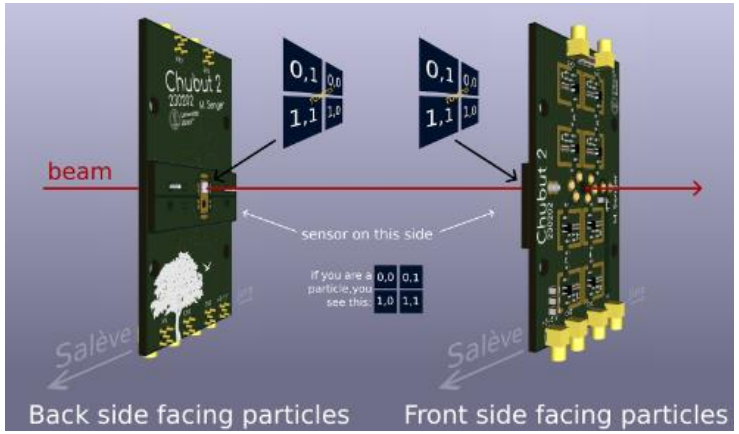
CAEN settings (EUDAQ config):
1) fast_trigger_threshold_ADCu = 30500
2) trigger_polarity = rising
3) post_trigger_size = 0

Adapted from M. Senger

August 2023 TB - batches

batch_number	description
1	First batch, mounted 4 TI-LGADs and 4 FBK RSDs
2	Same devices as batch 1, we only changed TO digitizer by ETH digitizer to see if it can run faster, so we get more data, and also we changed one "Chubut 2" for one RSD that had no signals in batch 1, now it has
3	Irradiated sensors, 4 TI-LGADs and 4 HPK (3 DUTs + 1 time reference)
4	4 BNL AC-LGAD (Matias) + 4 CNM irrad sensors
5	Room T, 3 TI-LGADs with 16ch, and 2 RSDs (FBK) with 4ch

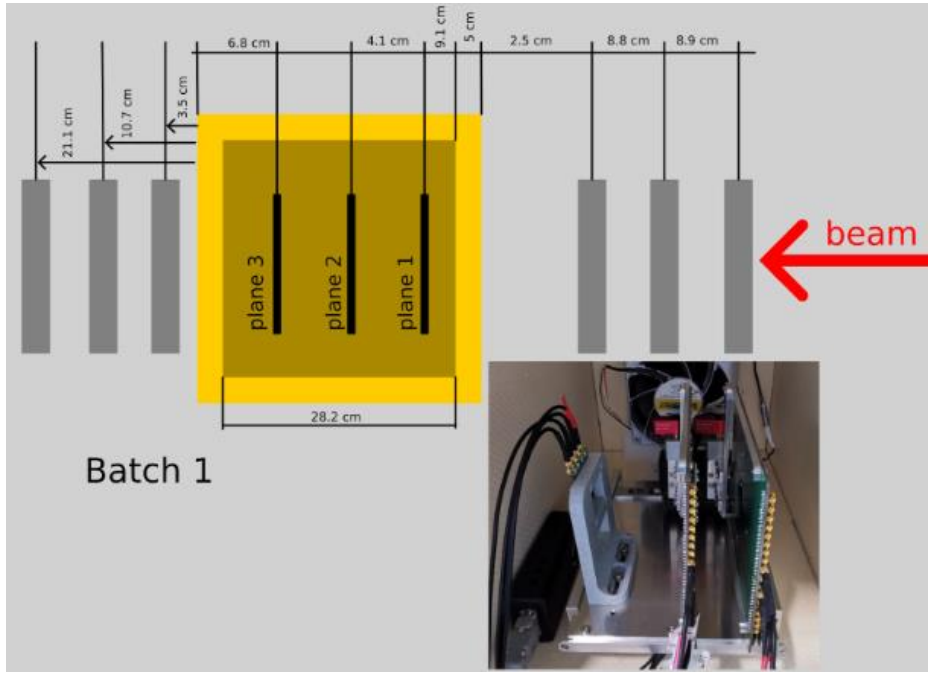




Cold operation for irradiated sensors – we reached -12C.

February 2024 TB - batches

batch_number	description
1	First batch, to debug and check that things work
2	First real data attempt using two AIDAinnova TI-LGADs mounted in Chubut 2 16ch boards. The geometry should be the same as in batch 1.
3	Non irrad **AIDA TI-LGAD Cell C TS1**, time ref and trigger
4	Same as batch 3 but with completely new alignment after we found the problem with the motorized pico stage
5	Irradiated **AIDA TI-LGAD Cell C TS1 8e14**, time ref and trigger
6	Irradiated **AIDA TI-LGAD Cell C TS1 15e14**, time ref and trigger
7	Irradiated **AIDA TI-LGAD Cell C TS1 25e14**, time ref and trigger
8	Non irradiated **AIDA TI-LGAD Cell C TS1**, time ref and trigger (this is the same as batch 4 but now we finally have the CROC working, so we are repeating the data acquisition)
9	An irradiated FBK sensor
10	**CNM RD50 3D timing sensor** JSI7 top position
11	**CNM RD50 3D timing sensor** sensor JSI9 non irradiated
12	**BNL AC17 non irradiated** - square
13	**BNL AC15 non irradiated** - triangular



Cold operation for irradiated sensors – we reached -22C to -25C with two different T sensors used in different positions inside the box. A few (~4) voltage points per batch.

To do next

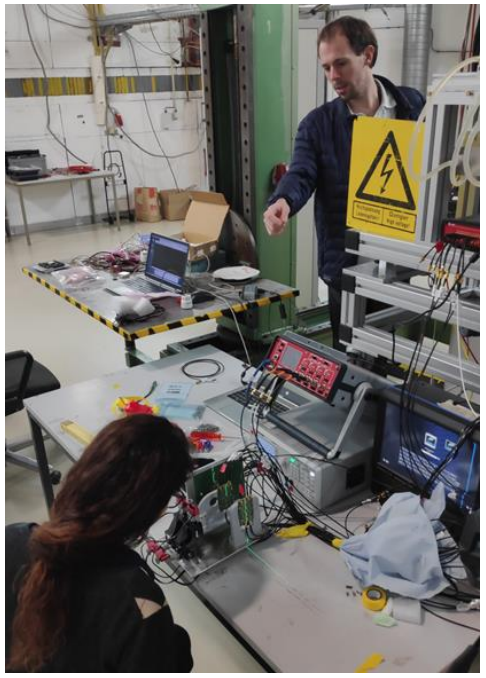
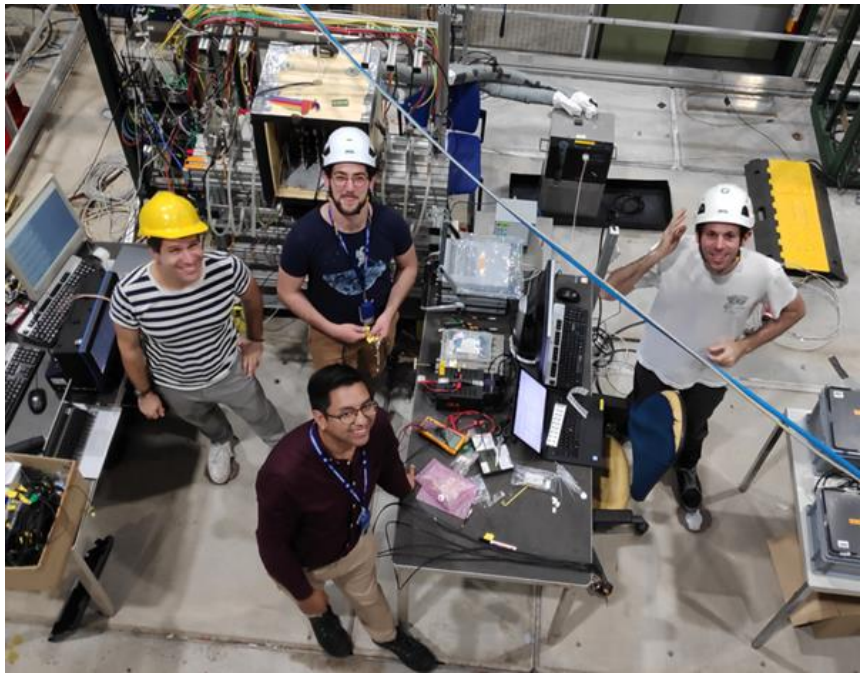
- Analysis – groups should get the data from their samples and proceed quickly – the data should of a good quality. Tools will be provided soon. The data will appear in CERNbox.
- Have a look at the tools provided We have asked to postpone the TB that was supposed to start this week at DESY to later this year or beginning of next year
- We should do for SPS in June (5-12.6.):
  - Increase DAQ rate if possible to 100 Hz
  - Include the new cold box (Vagelis/Aboud/Dominik are working on it)
  - Make sure that software tools are ready for quick analysis
  - **Find replacement for Matias !!**
- Gather the samples from CNM and FBK that are tested before the TB (this time the samples went from FBK – JSI irradiations – Mounting – DESY TB without being looked at beforehand. We can't count on luck.

More information about the Feb. 2024 DESY TB:

https://docs.google.com/document/d/1PaZRG2JTlittsBi-lcAVvut_2GAxnVewadwdJ9exJsY/edit#heading=h.lseuxf2mtipe
https://docs.google.com/spreadsheets/d/1tstzupRahnTA6JT_UTQ68lT75CXcieiVgGFnS1vb-oc/edit#gid=752273753

THANKS !



Special thanks:

- LHCb-Velo group for lending us the equipment.
- Uni-HH group for Chiller and cold finger
- DESY TB coordinators for being super helpful.