ITS3 Sensor Characterisation and Qualification (WP3)
Testbeam @ CERN PS 4 - 18 May 2022

Main Participants:

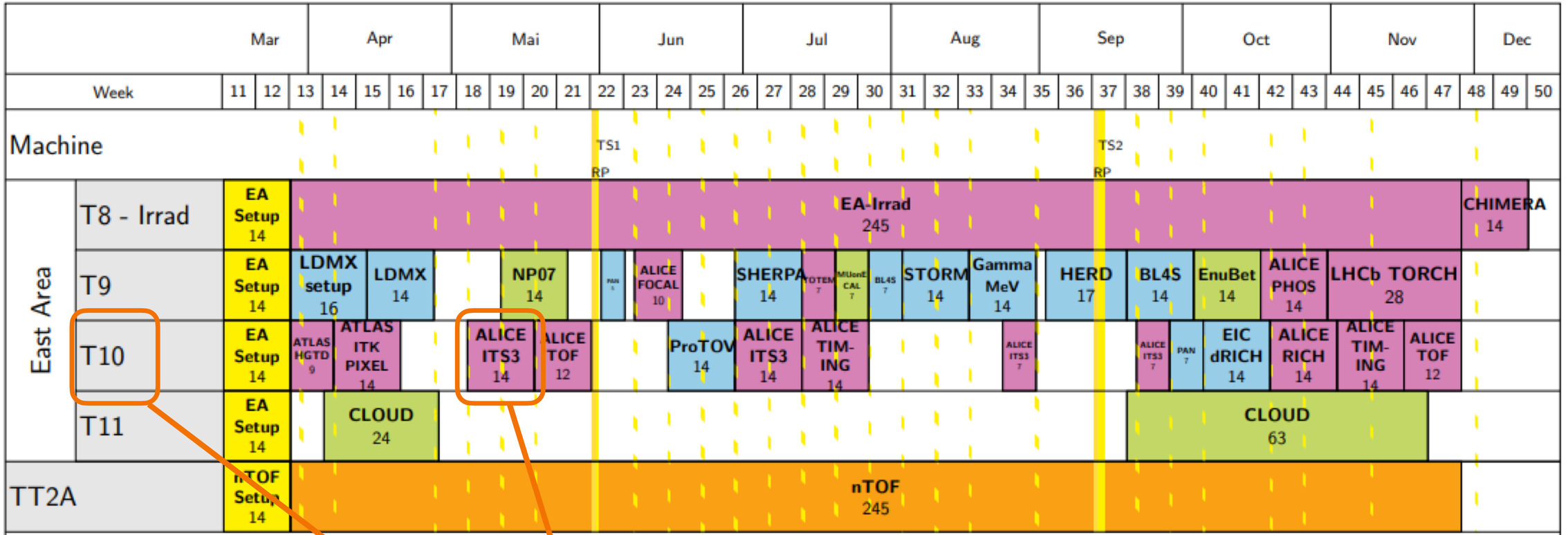
- Paolo Martinengo
- Matthew Daniel Buckland
- Marius Wilm Menzel
- Karoliina Rebane
- Miljenko Suljic
- Serhiy Senyukov

Coordinating the test beam activities.

Experiment area

PS user schedule for 2022

schedule issue date: 18-Mar-2022 Version: 0.4 LHC Exp. PS/SPS Exp. Other Exp. INT Exp.



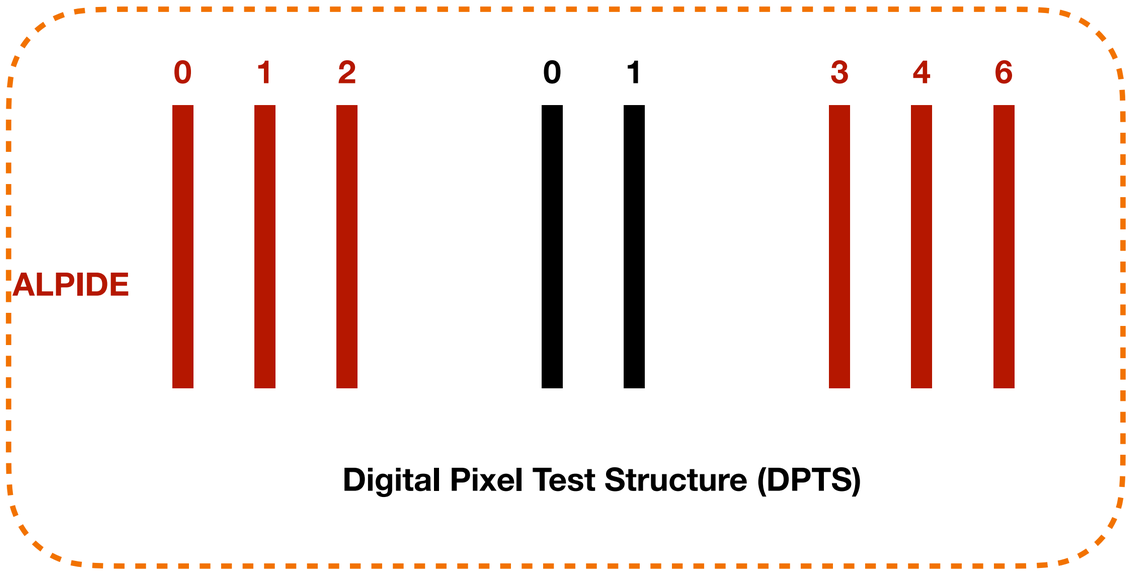
For further information contact the PS/SPS-Coordinator. Email: Sps.Coordinator@cern.ch, Tel: +41 75 411 5275.

The latest version of the schedule are available here: http://cern.ch/ps-sps-coordination
This schedule in synchronized with injector schedule v1.0.
No beam during Technical Stops (TS, full yellow), limited beam availability during Machine Developments (MD, hatched yelow).
For TS a cool down time is needed and will be announced in the days preceding the stop.
Submit your ISIEC at least 2 weeks before your allocated beam time using https://ep-th-safety.web.cern.ch/isiec
Duration of RP cooldowns before Technical Stops will be precisely defined 1 week before the TS.

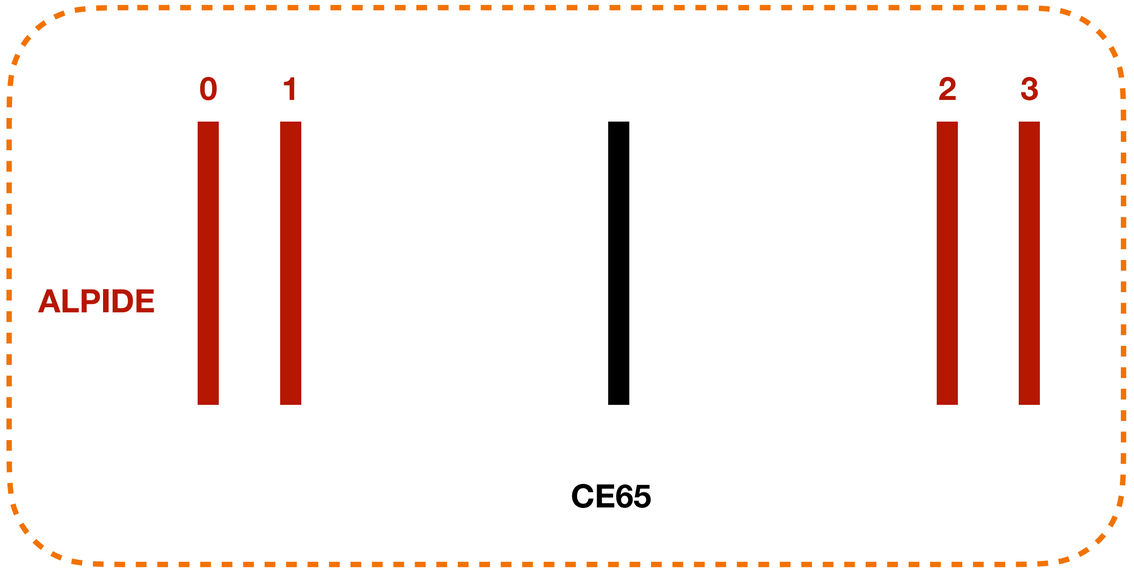
The T10 beam delivers pions particles up to 10 GeV/c

Experiment setup

1



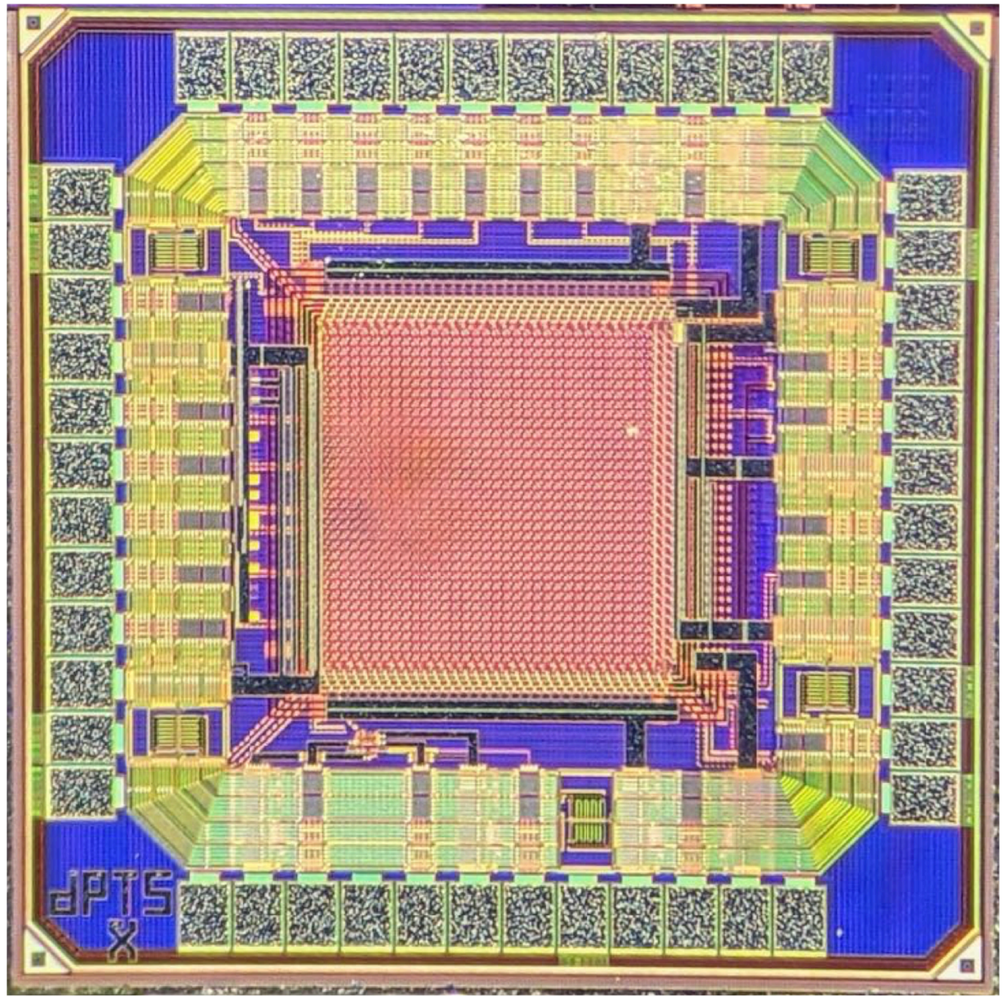
2



Position	Designation	z [mm]	Thickness [µm]	VCLIP	ITHR	VCASN	Threshold
1	ALPIDE_0	111.9	50	60	60	104	10.33 ± 1.85
2	ALPIDE_1	86.9	50	60	60	109	10.22 ± 1.63
3	ALPIDE_2	61.9	50	60	60	108	10.04 ± 1.72
4							
5							
6	ALPIDE_3	-38.1	50	60	60	106	10.74 ± 1.78
7	ALPIDE_4	-63.1	50	60	60	106	10.08 ± 1.38
8	ALPIDE_5	-88.1	50	60	60	109	10.81 ± 1.69

- ALICE PIxel DEtector (ALPIDE) is a $1.5\ \text{cm} \times 3\ \text{cm}$ large Monolithic Active Pixel Sensors (MAPS) with 512×1024 (row×column) $28\ \mu\text{m} \times 28\ \mu\text{m}$ pixels based on 180 nm CMOS technology.
- Used as reference plane for tracking particles.

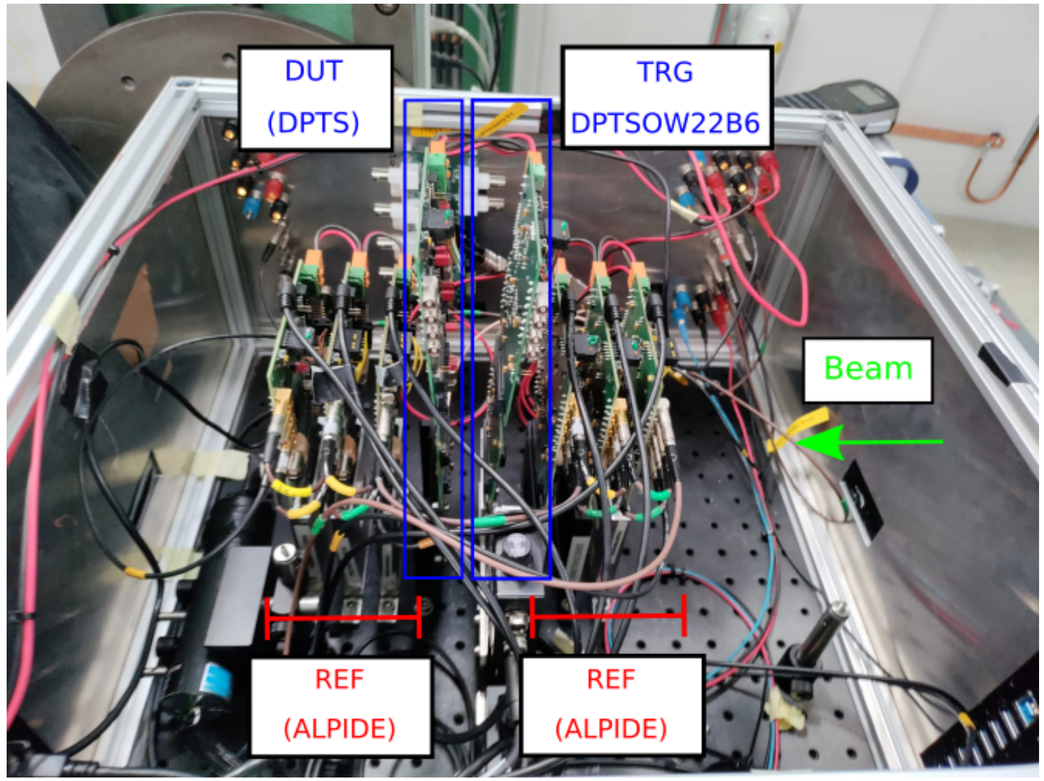
Experiment setup: Digital Pixel Test Structure (DPTS)

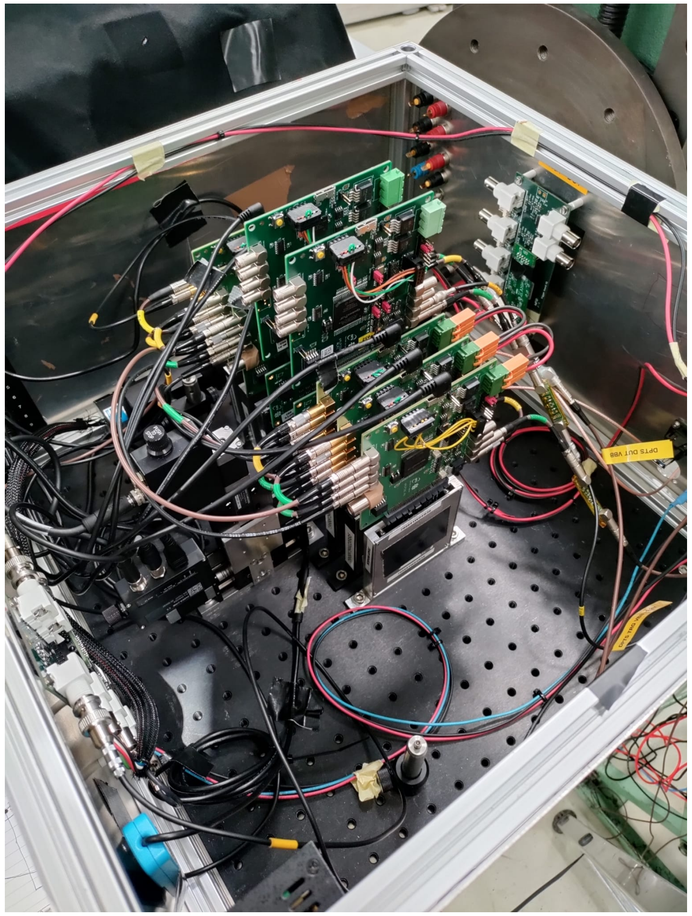


- DPTS is 32 x 32 pixels $15\ \mu\mathrm{m}$ pitch.
  - Size-able prototype, allows for “easy” test beam integration.

- Allows to verify
  - Sensor performance
  - Front end electronics performance
  - Basic digital building block

Experiment setup: DPTS



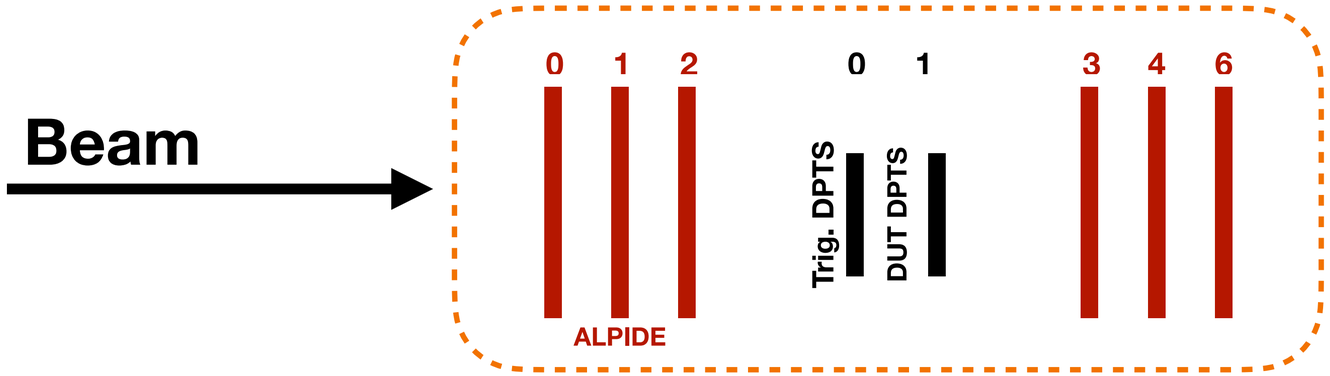


Detector under test (DUT)

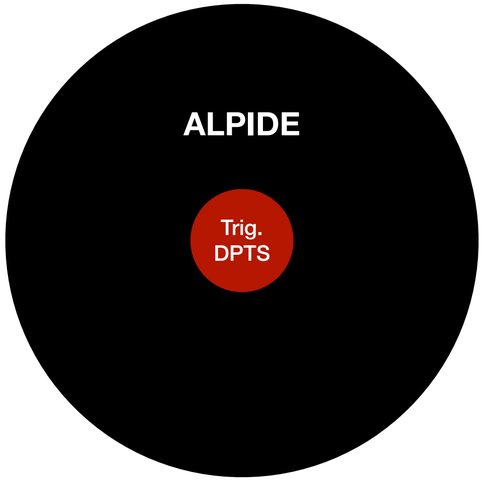
Chip serial	NIEL irradiation level
DPTSOW22B7	non irradiated
DPTSOW22B17	Irradiated NIEL 1E15
DPTSOW22B24	Irradiated NIEL 1E16 , to be tested

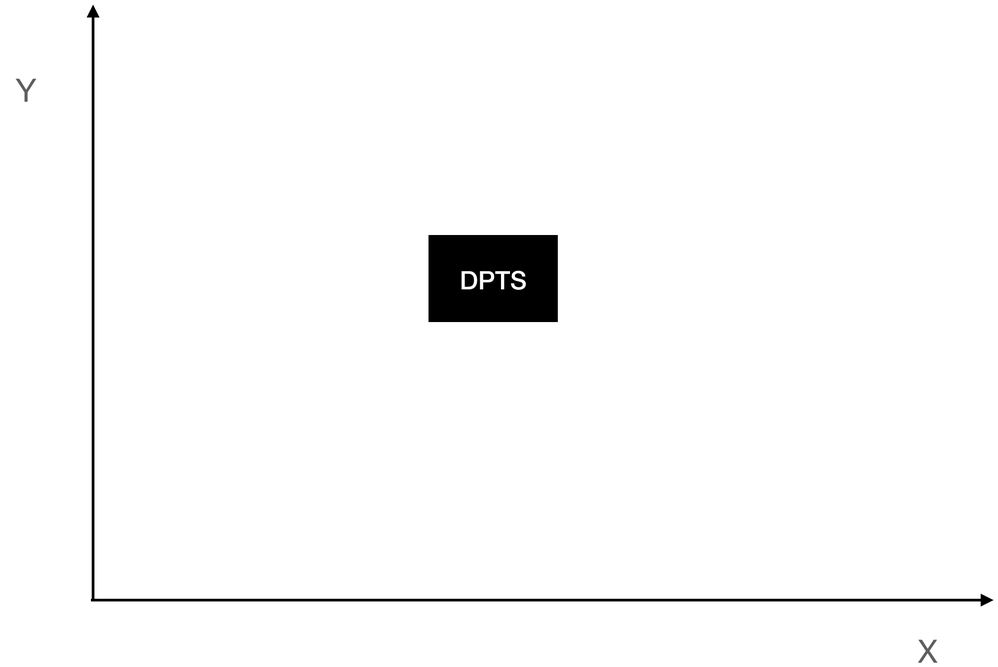
Position	Designation	z [mm]	Picoscope connection	Proximity board	DAQ Board	Serial Number	Chip Serial	ChipID	Thickness [µm]	VCLIP	ITHR	VCASN	Threshold
1	ALPIDE_0	198			daq-fs-86	DAQ-000904250102072C	T705691W04R36	16	50	60	60	105	10.27 ± 1.68
2	ALPIDE_1	175			daq-fs-130	DAQ-000909250959071E	T968879W23BB5	16	50	60	60	109	9,77 ± 1.93
3	ALPIDE_2	150			daq-fs-135	DAQ-000909250959381A	T968879W04R27	16	50	60	60	108	9,73 ± 1.80
4	DPTS TRG	117.5	C	DPTS-004		DAQ-00090101054B130A	DPTSOW22B6						
5	DUT	91	B	DPTS-002	MLR1-003	DAQ-000901010542232A							
6	ALPIDE_3	50.5			daq-fs-85	DAQ-000904250114120A	T705691W04R37	16	50	60	60	108	9,58 ± 1.37
7	ALPIDE_4	26.5			daq-fs-121	DAQ-00090611004E2A11	T700789W10R16	16	50	60	60	107	10.18 ± 1.82
8	ALPIDE_5	0			daq-fs-129	DAQ-000909250959131E	T968879W04R05	16	50	60	60	110	10.24 ± 1.69

Experiment setup



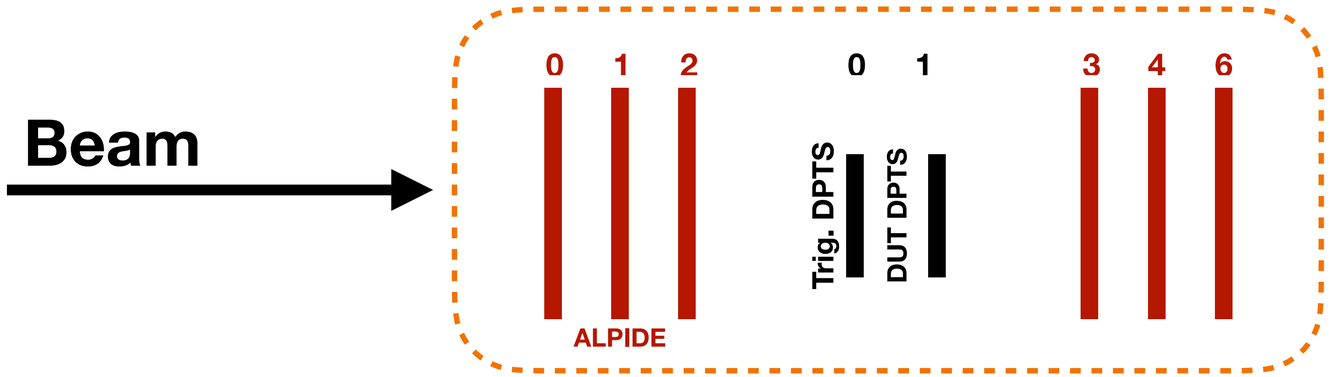
- Size
  ALPIDE -15 mm x 30 mm
  DPTS -1.5 mm x 1.5 mm

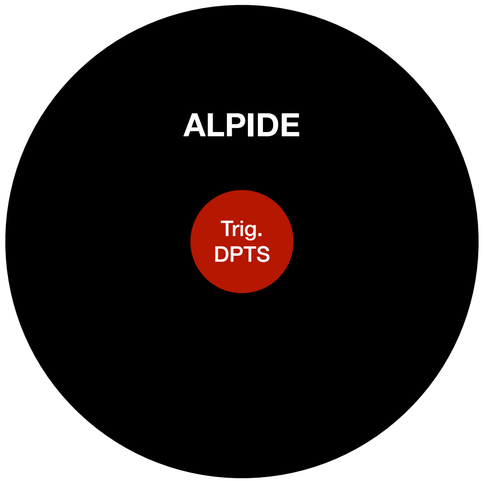




ALPIDE - 2D Hit Map

Experiment setup



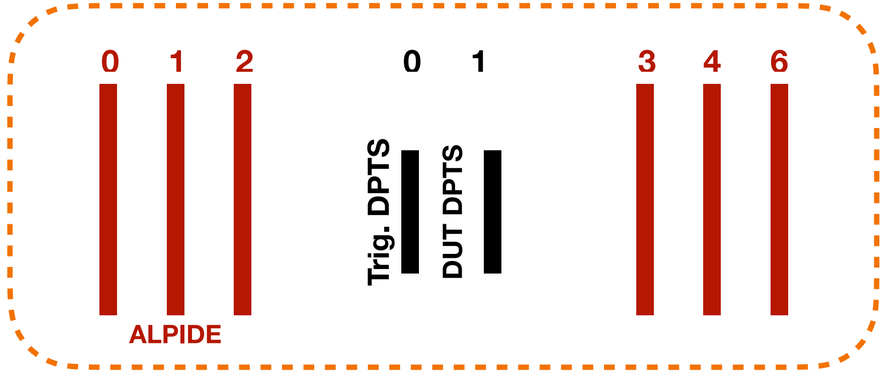


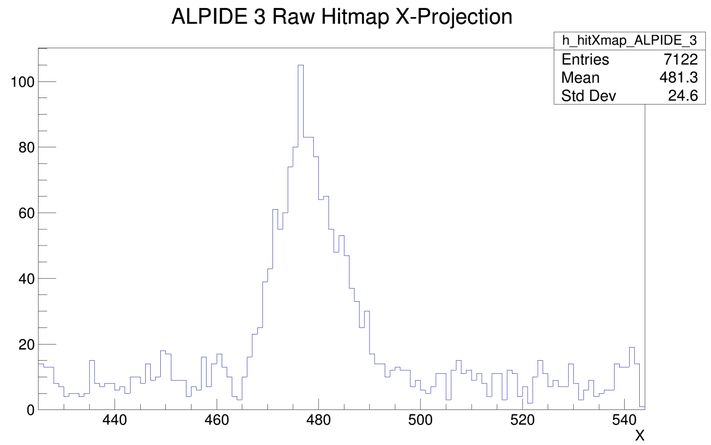
Why DPTS as trigger?
Previous tests showed that the efficiency of DPTS is very good ~100%.

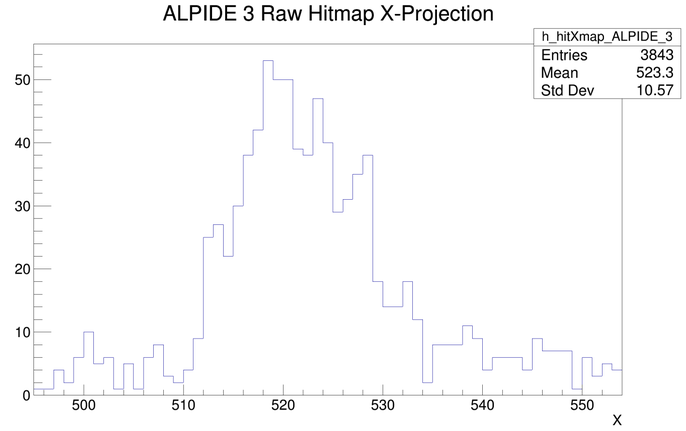
6 ALIPIDE frame as references arms?
Fake hit rate or residual studies.
Need for tracking the particles.

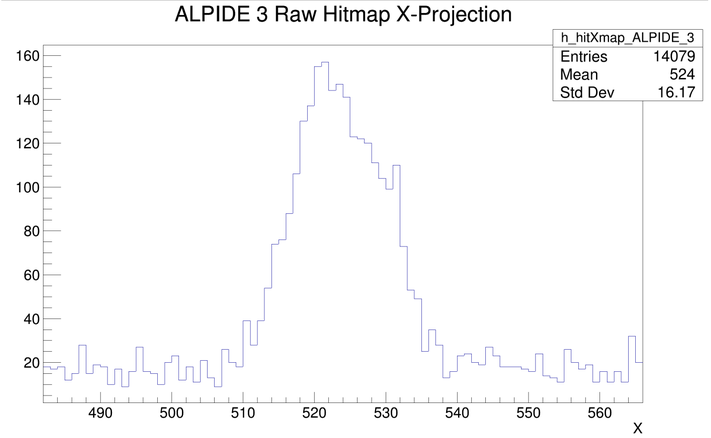
1. Alignment of DPTS

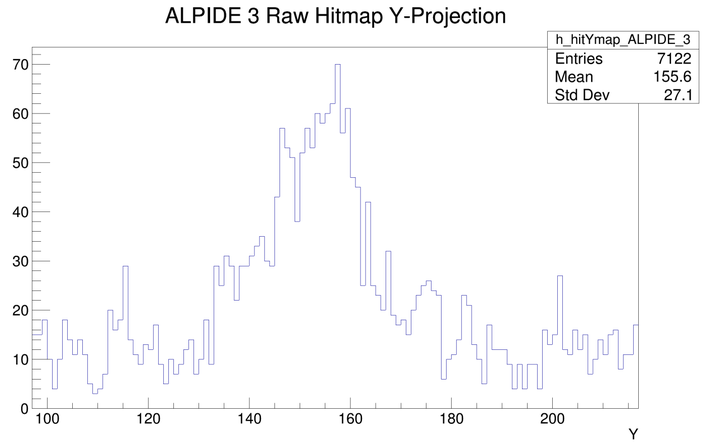
- Gross alignment is done when assembling the telescope.
- Trig. DPTS is moved (using software) along X and Y to align with DUT DPTS.
- ALPIDE are larger in size than DPTS therefore don't need the alignment

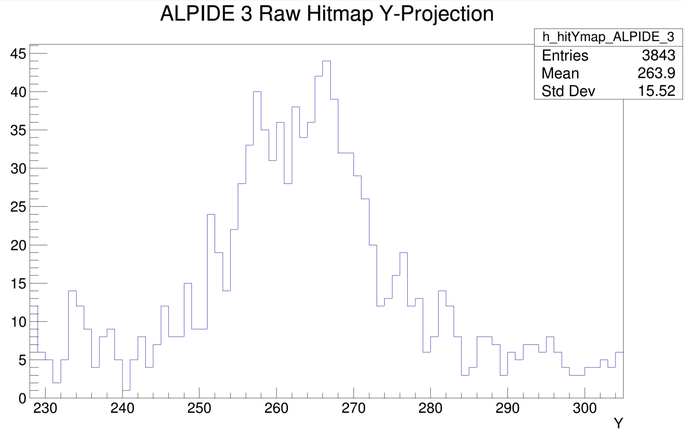


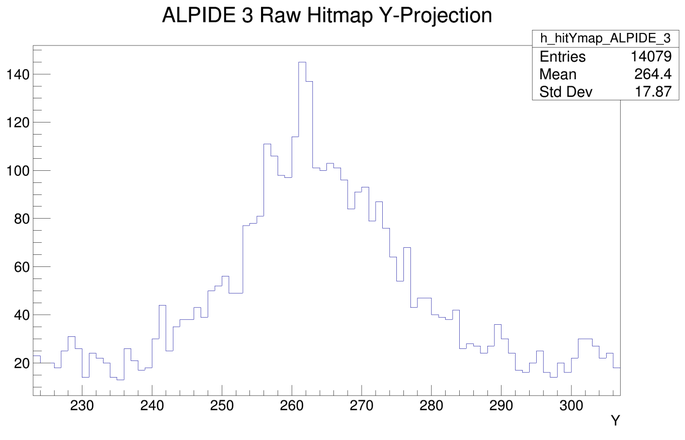










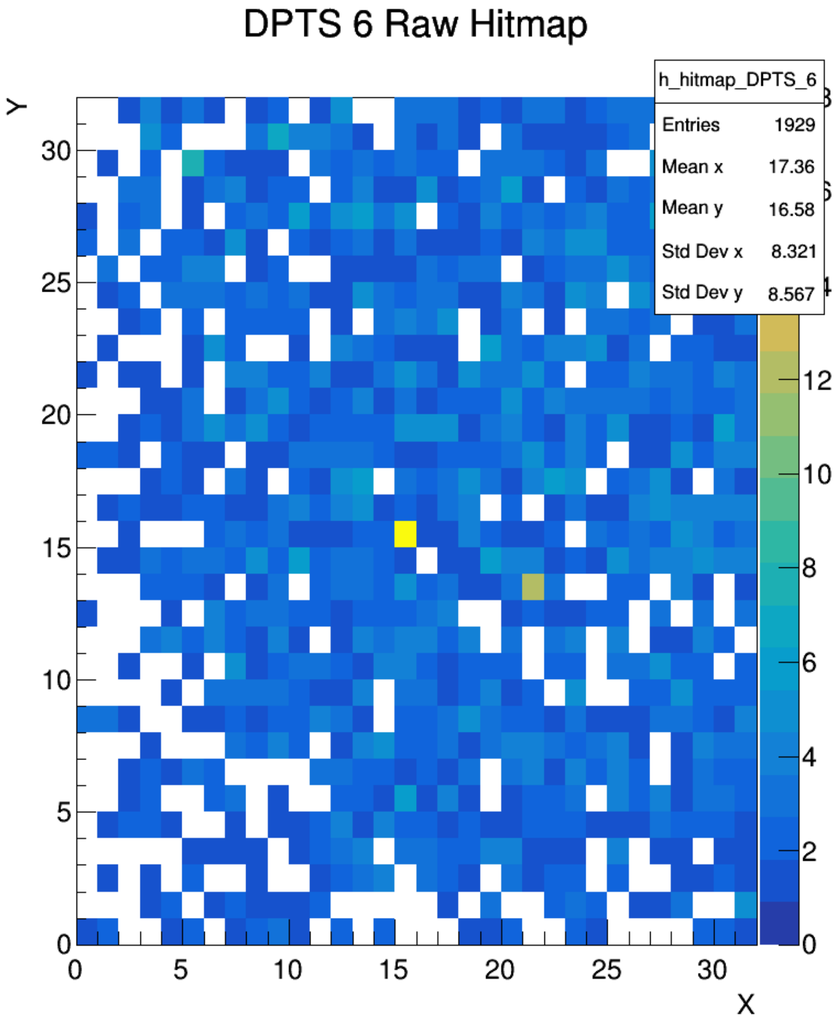


Trig. DPTS initial position

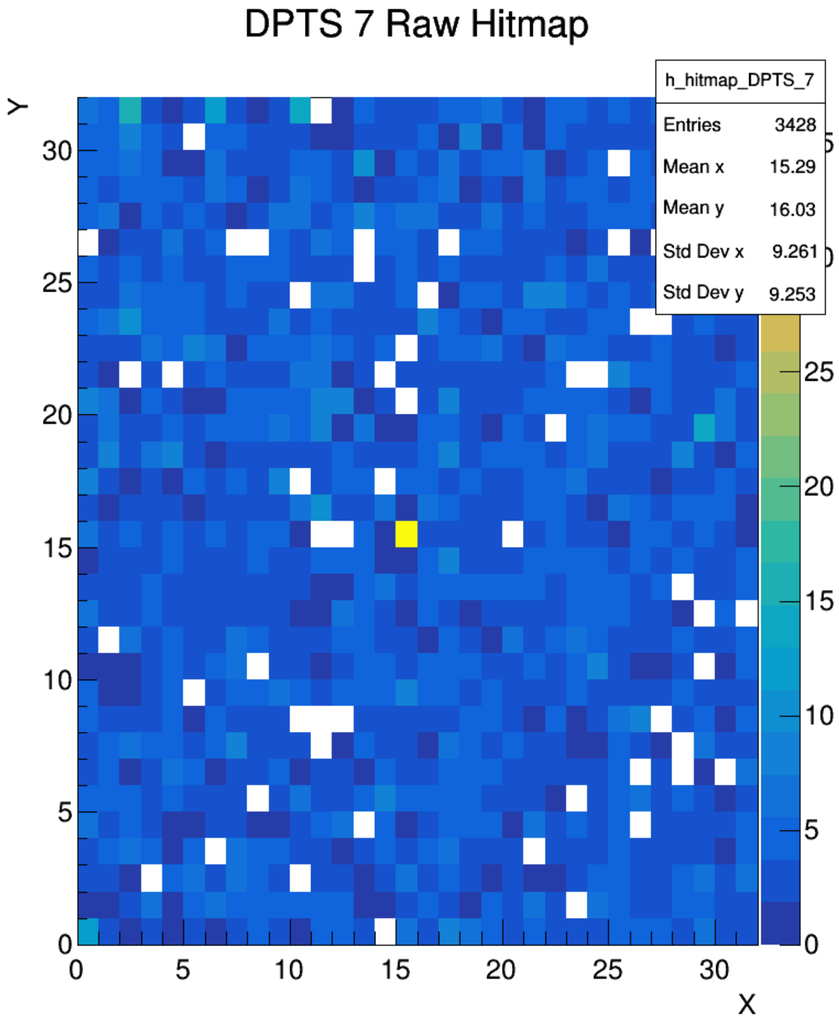
DUT DPTS initial position

Trig. DPTS Final position

2. Preliminary QA check of run



DPTS 6 = Trig. DPTS

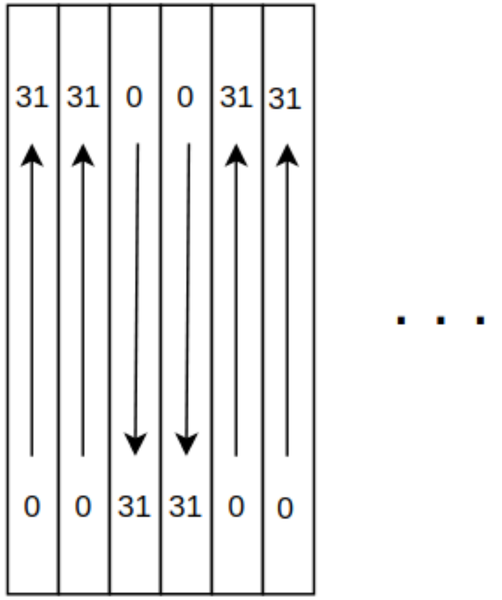


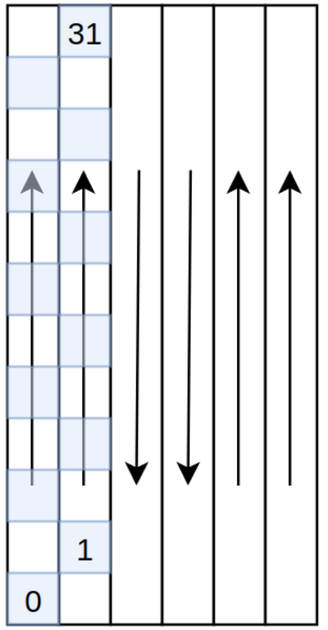
DPTS 7 = DUT DPTS

Digital Pixel Test Structure (DPTS)

DPTS - 32 x 32 pixel matrix

- Each column in the matrix has a group id (GID) ranging from 0 to 31 left to right.
- Each pixel in a single column has a pixel id (PID) ranging from 0 31:
  - every 2 columns the order of PID is inverted (as the column was flipped vertically), starting from bottom left matrix corner as 0.
  - Column flip implemented to avoid readout issue due to charge sharing in the horizontal direction.
  - To minimize charge sharing in the vertical direction, the pixel of each pair of columns are cross-connected to obtain a chequered pattern.(Column cross connect variant DPTS)

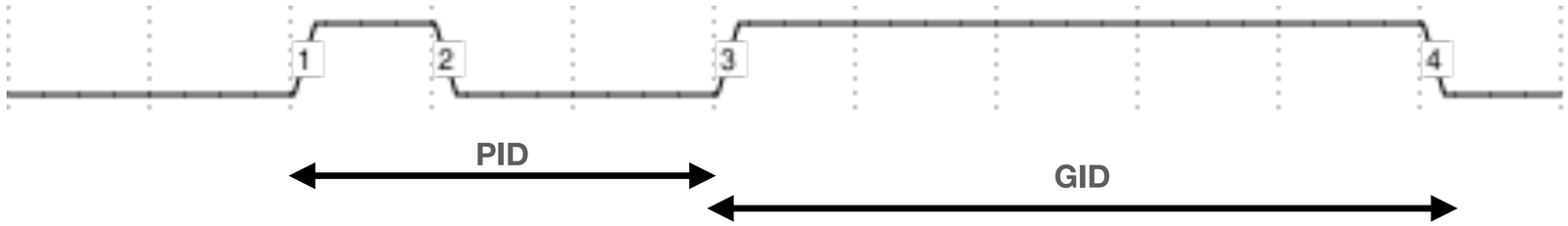




Pixel hit Decoding DPTS:

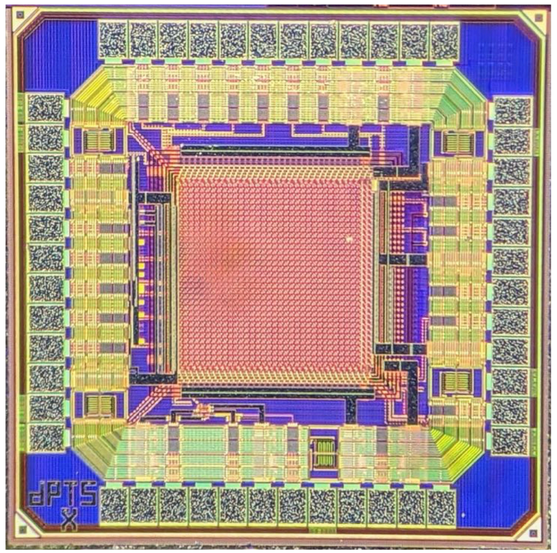
Upon particle hit (or manual pixel pulsing) the digital readout circuitry, to which the pixel belongs to, gets triggered.

After a fixed time offset (that depends on the geometrical position of the hit pixel), the digital output reacts by producing a first set of two pulses.

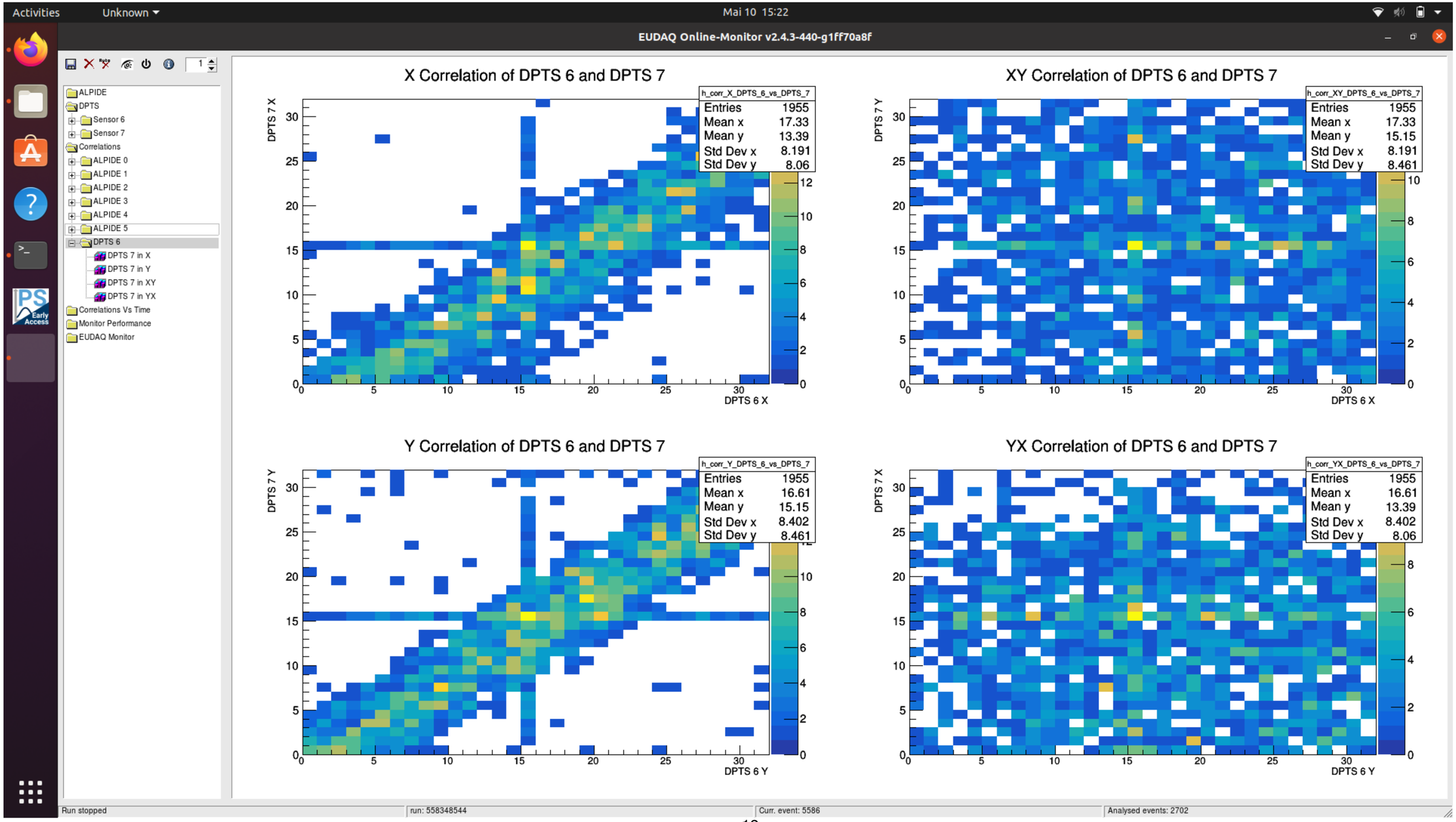


The pixel position is encoded in this pulse pair:

- Pixel position (PID) in the column.
- Position of the column the pixel belongs to (GID) in the matrix



2. Preliminary QA check of run



Digital Pixel Test Structure (DPTS): Parameter scans

Non-irradiated sensor (DPTSOW22B7):

VBB:-1.2V

- IRESET scan (10uA-75uA)
- IBIAS/N scan (1uA-50uA)
- IDB scan (1uA - 80uA)
- VCASN scan (100mV-600mV)

VBB: 0V

- IRESET scan (10uA-75uA)
- IBIAS/N scan (1uA -50uA)
- IDB scan (1uA -50uA)
- VCASN scan (50mV -350mV)

Irradiated sensor 1e15 NIEL (DPTSOW22B17):

- VBB: -**0.6V** @20deg
  - VCASB scan (80mV-360mV)
- VBB: **-1.2V** @20deg
  - VCASB scan (100mV -380mV)
  - IRESET scan (10uA-75uA)
- VBB: **-1.8V** @20deg
  - VCASB scan (120mV - 460mV)
- VBB: **-2.4V** @20deg
  - VCASB scan (140mV-590mV)
- VBB: **-3.0V** @20deg
  - VCASB scan (150mV-700mV)

- VBB: -1.2V @**26deg**
  - VCASB scan (140mV-380mV)
  - IRESET scan (to be measured)
- VBB: -1.2V @**23deg**
  - VCASB scan (140mV-380mV)
  - IRESET scan (10uA-75uA)
- VBB: -1.2V @**17deg**
  - VCASB scan (140mV-380mV)
  - IRESET scan (10uA-75uA)
- VBB: -1.2V @**14deg**
  - VCASB scan (140mV-380mV)
  - IRESET scan (10uA-75uA)

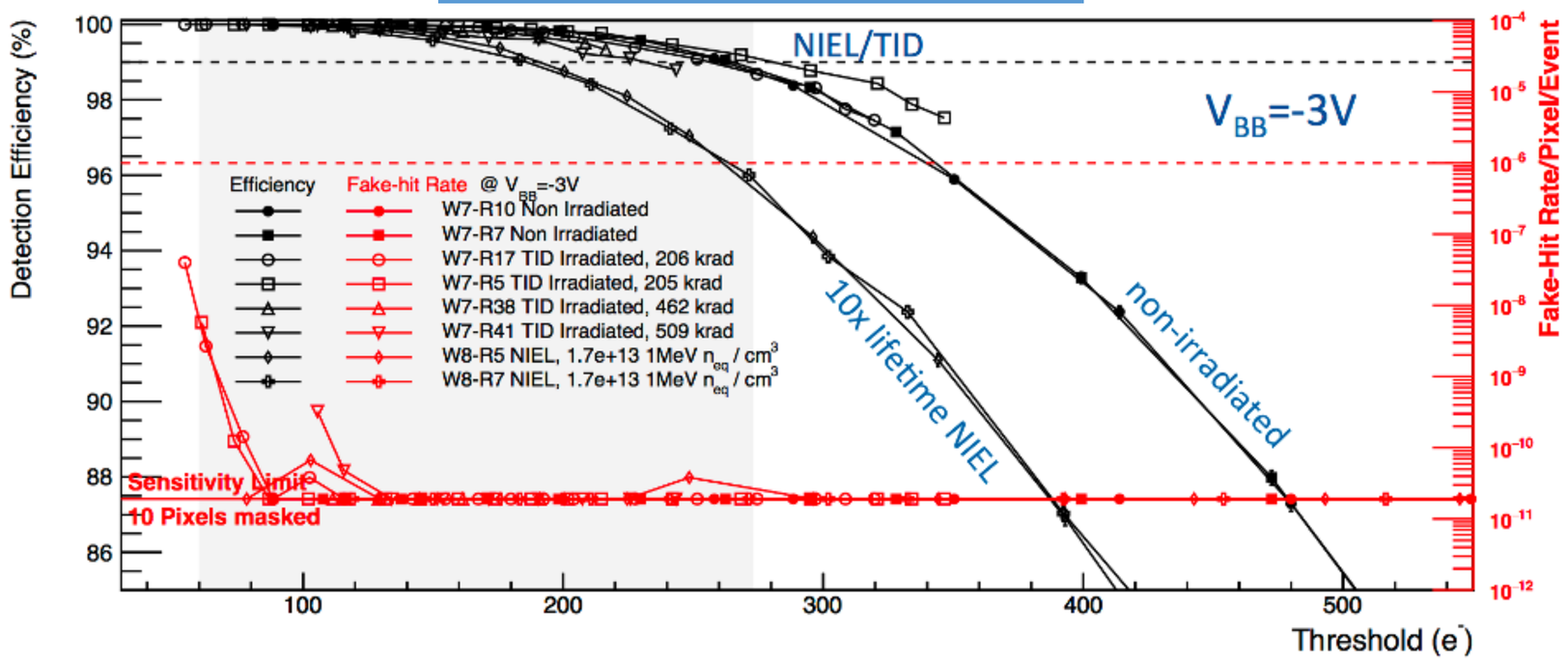
Measurements

- Efficiency vs parameter scan
  e.g Studying hit detection efficiency of detector as a function of threshold

- Higher back bias voltage (V_{bb}),

- Irradiated sensor: 1×10^6 NIEL

Operating threshold ~ 110 e^-



the efficiency drops with an increasing detection threshold

Next steps

- Analysis of the data taken during the test beam

Upcoming test beams

PS July 2022 - 29 June - 13 July 2022 (T10)
PS August 2022 - 24-31 August 2022 (T10)
PS September 2022 - 21-28 September 2022 (T10)

- Try again testing the Irradiated sensor: 1×10^6 NIEL
- Test the new batch of DPTS.