CERN SPS testbeam results with AMS CHESS 1

ATLAS Strip CMOS Regular Meeting, 19.07.2016

Bojan Hiti et al.

Jožef Stefan Institute, Experimental Particle Physics Department (F9)

AMS CHESS 1 Sample

- 350 nm, 20 Ω cm, max. bias voltage 120 V, active pixels

- 3 CHESS 1 chips investigated
  - 1 unirradiated
  - 2 proton irradiated (approx. 5e14 neq cm^{-2})

- Test structure APA08
  - 3 x 3 active pixel array, pixel size 800 x 45 μm
  - read out 2 pixels (2 waveforms), ch. 39,40

CONFIG 8		CONFIG IRRAD	
VPLOAD	2100	VPLOAD	2100
VCASC	2600	VCASC	2600
VNSF	750	VNSF	570
VN	1000	VN	1000
VBIAS	150	VBIAS	300
VPFB	2700	VPFB	2500

- Testbeam at CERN SPS (150 GeV pions)
  - Kartel beam telescope (Ljubljana) – 6 mimosa planes 18 x 18 μm pixel size
  - DUT readout with a DRS oscilloscope
  - Additional FEI4 module for selective triggering, used to narrow down region of interest (ROI)
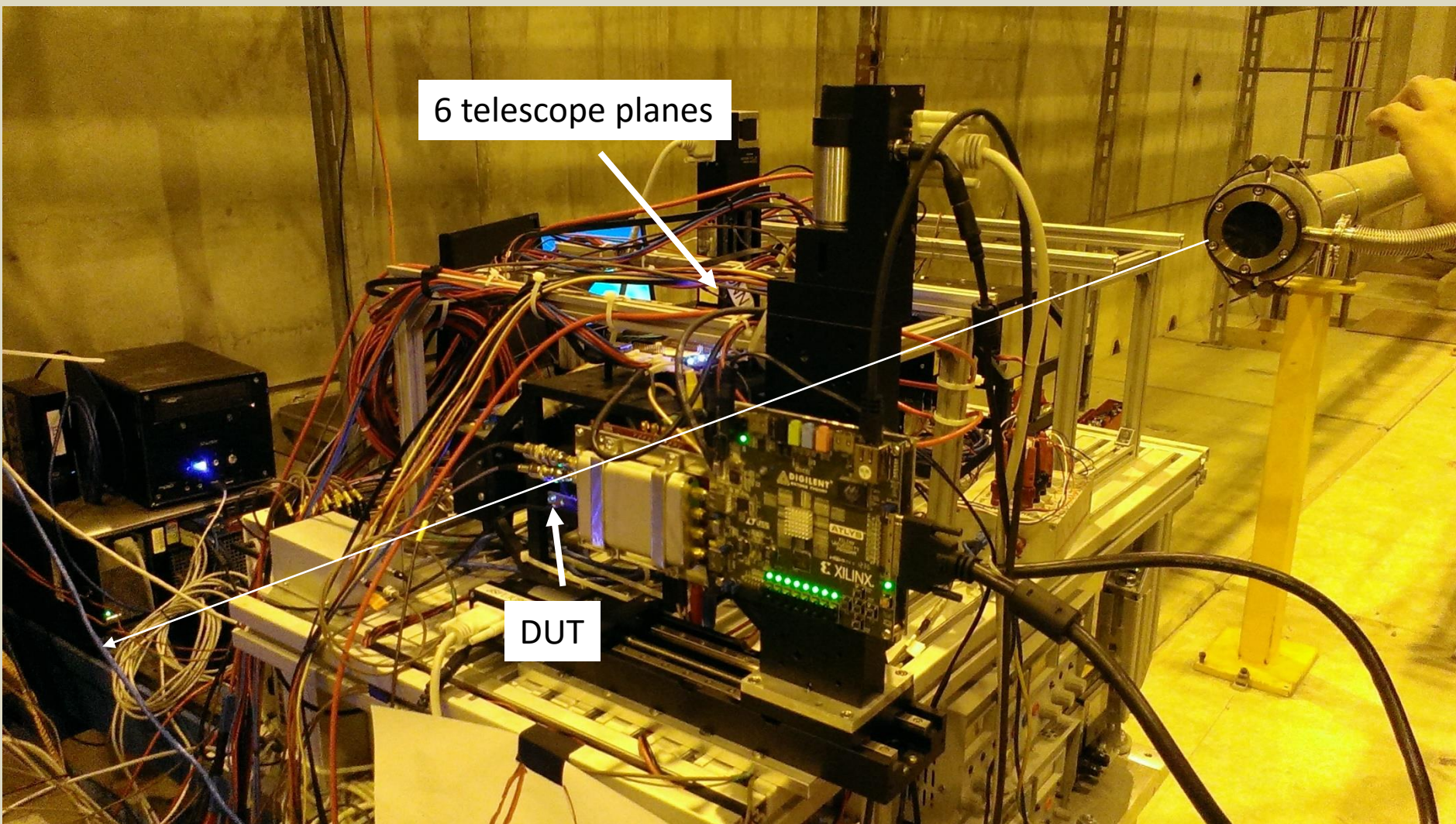
CERN SPS testbeam


6 telescope planes

DUT

Testbeam data

- 2 telescope triggering modes
  - external trigger by 2 scintillators + ROI
  - self trigger on one of the readout channels (trigger is biased)

- Number of events:
  - unirrad.   250k + 4.2k self trigger   80 V bias
  - irrad. 1   410k + 700 self trigger   40 V bias
  - irrad. 2   390k   30 V bias

- Sensor biasing over a HV filter with 4 kΩ series resistance
  - irradiated samples: if $V_{bias} > 40$ V no signals observed
  - does HV influence the VDD level ?

# Induced signals

channel 1
channel 2

DRS artifacts
(mentioned later)
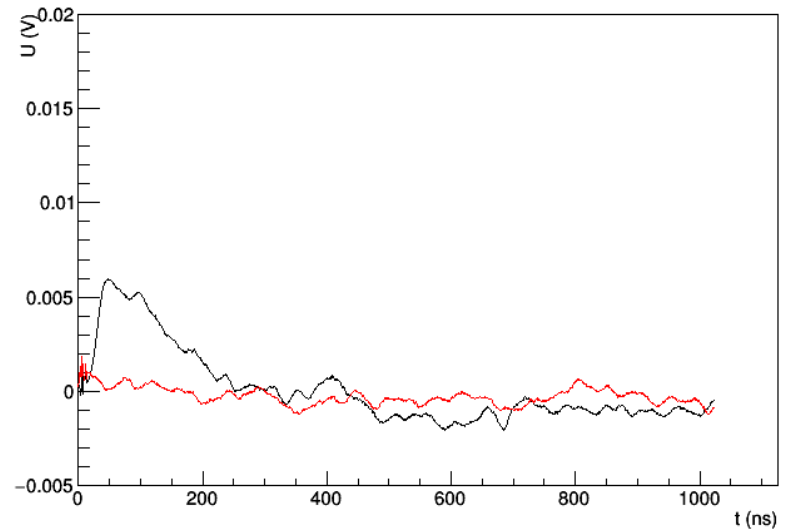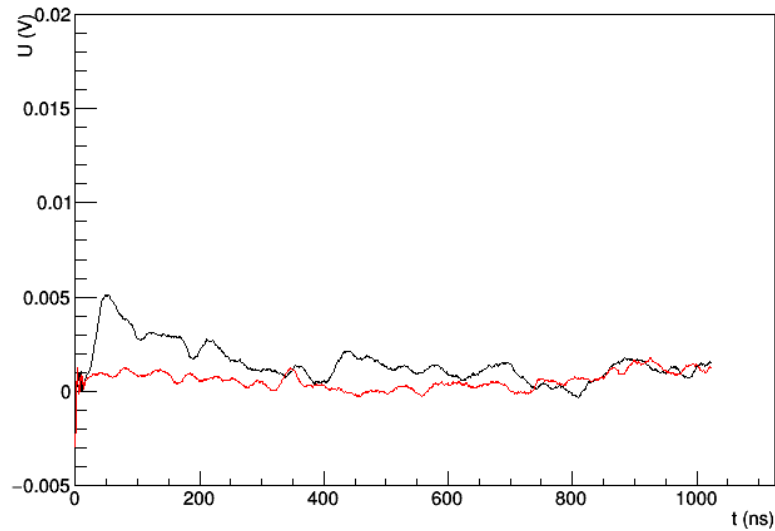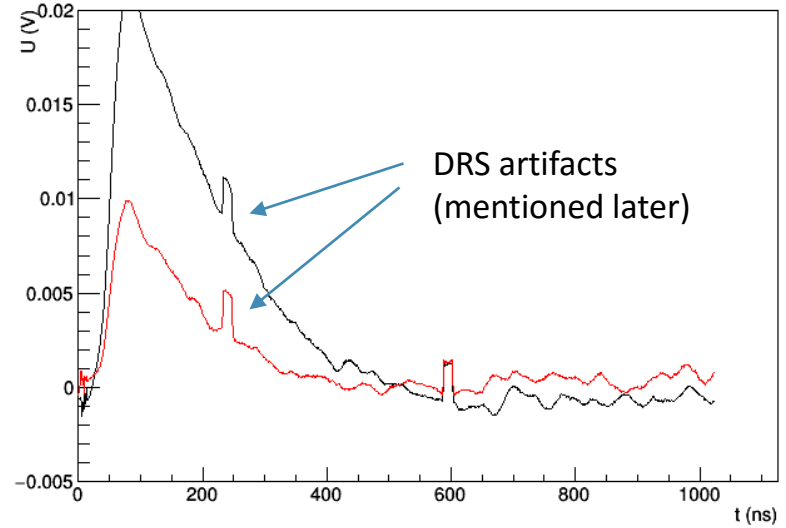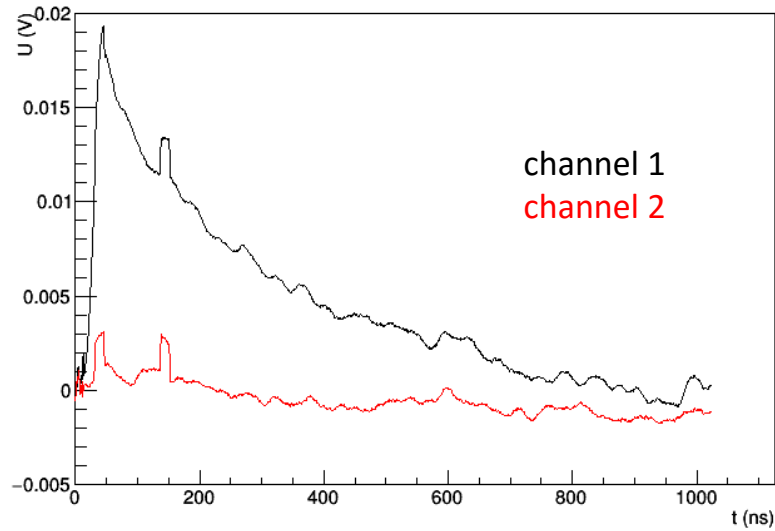
Results irrad. 1 (self trigger)

- self trigger mode
  - recorded 800 events in 3 hours – rate quite low
  - independent FEI4 module recorded approx. 10k events in the same area → DUT efficiency approx. 10 %
  - average track multiplicity in telescope 13 (on average 13 tracks per frame, most not passing through the test structure)
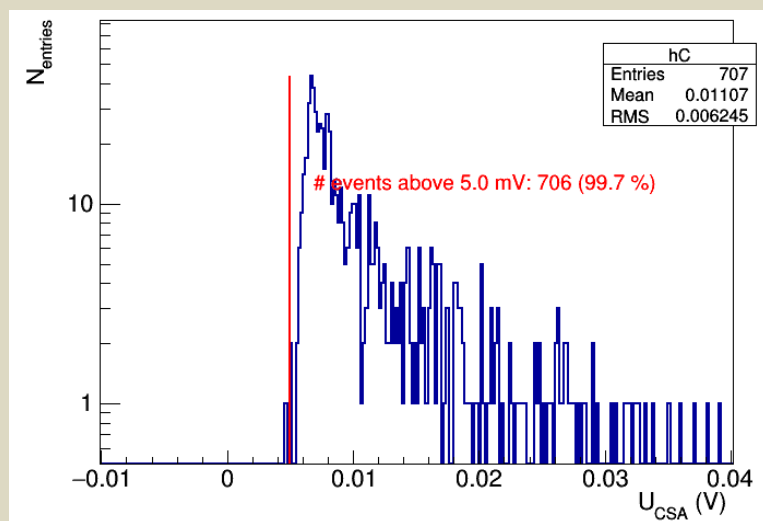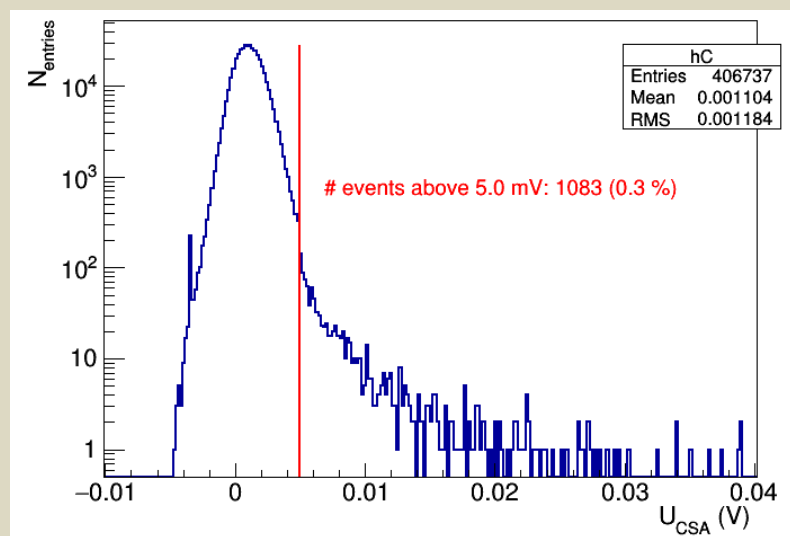

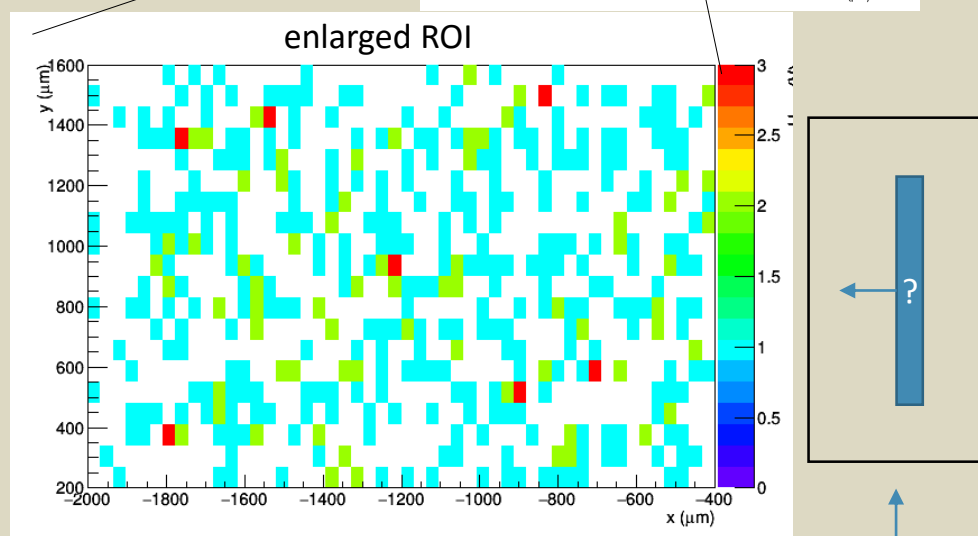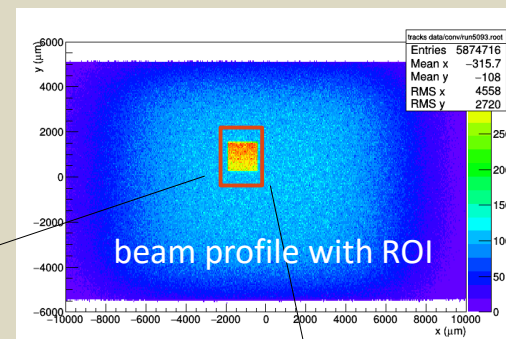- CSA charge spectrum (pulse heights)
- most pulses lower than 10 mV
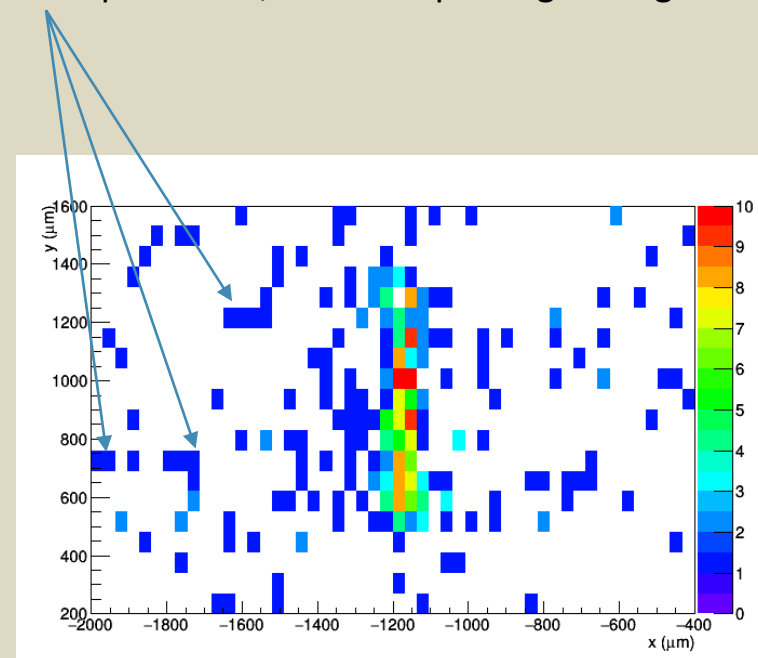
- reconstructed track origins
- outline shape compatible with pixel size
- relative efficiency uniform

Results irrad. 1 (external trigger)

- trigger on 2 scintillators + ROI
  - recorded 410k events in 3 hours
    - ROI area on which is triggered 60x larger than a single pixel
    - therefore expect about 7k tracks passing through the device
  - average track multiplicity in telescope 13


beam profile with ROI

enlarged ROI

- CSA charge spectrum (one pixel)
- 1100 (0.3 %) pulses higher than 5 mV
 (expect 7000 signals from passing particles)

- track origins (only for DUT pulse above 5 mV)
- no visible outline of the pixel – why ?
  - due to low efficiency ?
  - can it be an event synchronization issue?
    (telescope + DRS)

Results unirradiated (self trigger)

- self trigger mode
  - recorded 4200 events in 10 hours – rate quite low
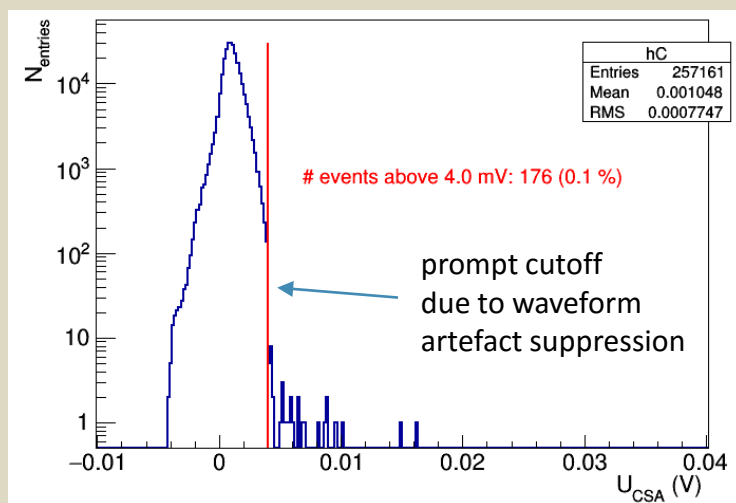 - average track multiplicity in telescope 13
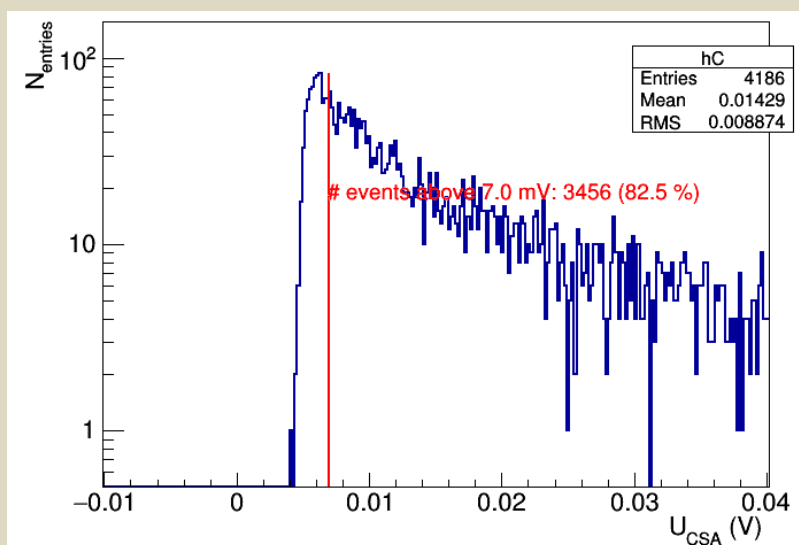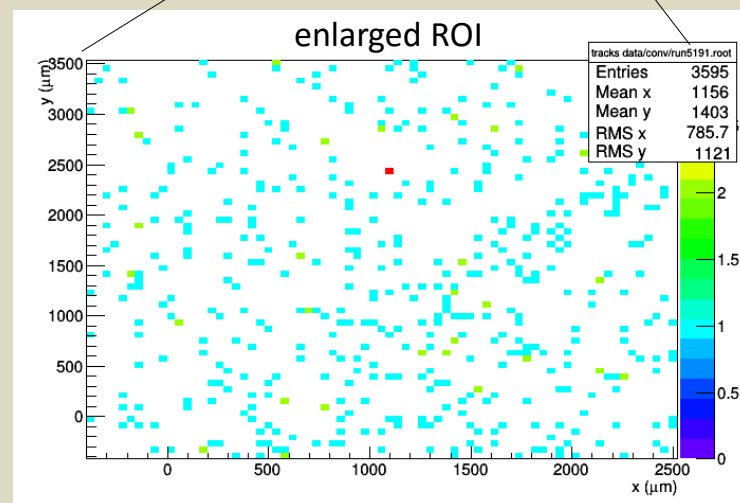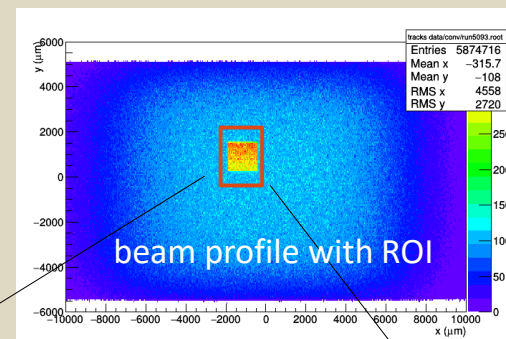

- CSA charge spectrum (pulse heights)
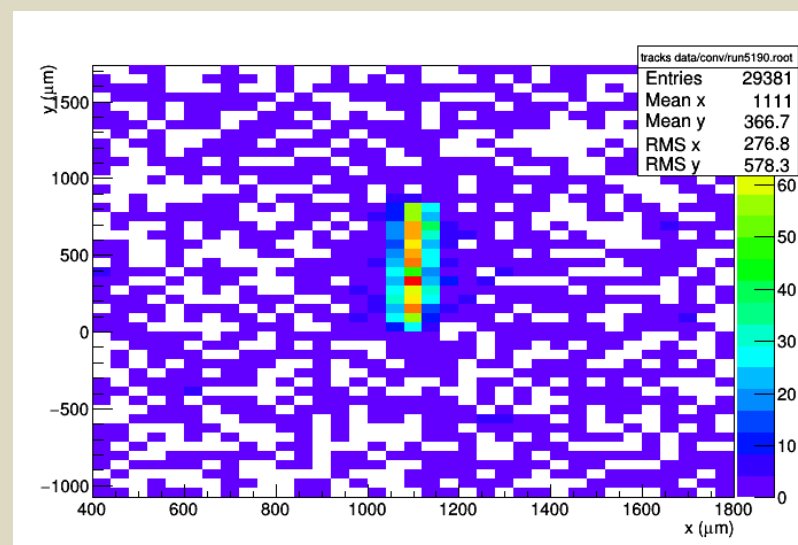
- reconstructed track origins
- outline shape OK
- relative efficiency uniform

Results unirradiated (external trigger)

- trigger on 2 scintillators only
  - no ROI enabled (by mistake)
  - recorded 250k events in 2 hours
    - area on which is triggered MUCH larger than a single pixel
    - expect very low number of tracks through device
  - average track multiplicity in telescope 13

beam profile with ROI

prompt cutoff
due to waveform
artefact suppression

events above 4.0 mV: 176 (0.1 %)
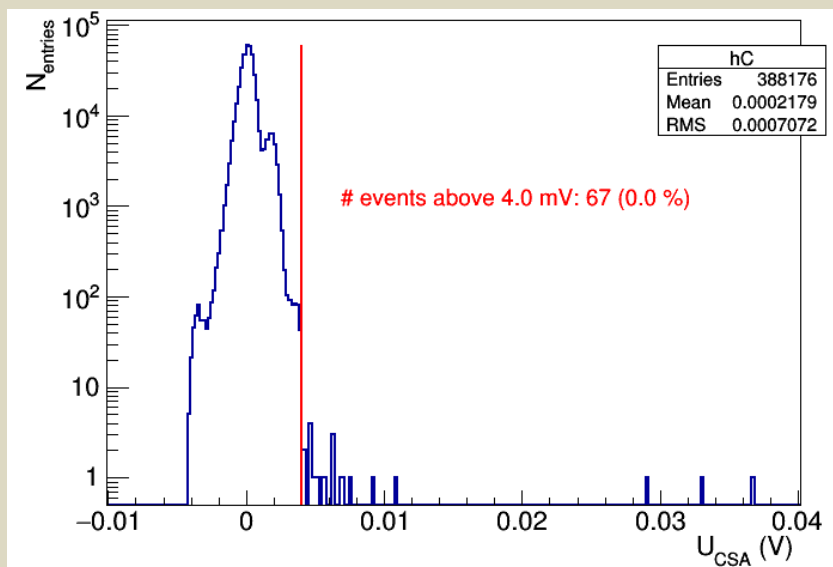
enlarged ROI

- CSA charge spectrum (one pixel)
- 176 (0.1 %) pulses higher than 4 mV
 (expect few high signals)

- track origins (only for DUT pulse above 4 mV)
- no visible outline of the pixel

Results irrad. 2 (external trigger)

- trigger on 2 scintillators + ROI
  - recorded 390k events in 3 hours
    - area on which is triggered 60x larger than a single pixel
    - expect approx. 6500 tracks through device
  - average track multiplicity in telescope 13

beam profile with ROI

enlarged ROI

events above 4.0 mV: 67 (0.0 %)

- CSA charge spectrum (one pixel)
- 67 pulses higher than 4 mV
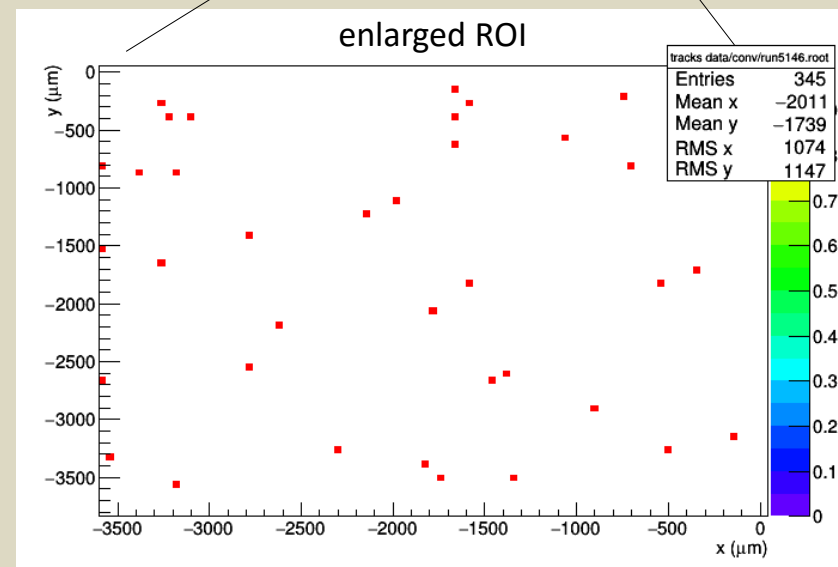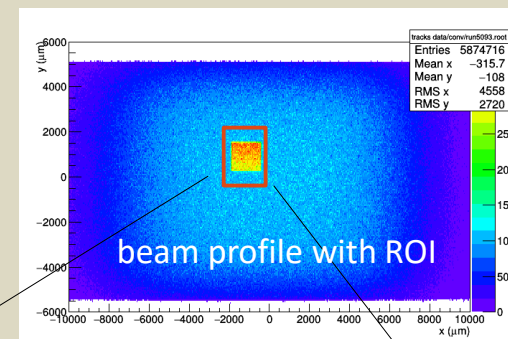
- track origins (only for DUT pulse above 4 mV)
- no visible outline of the pixel

Summary

- Beam test with 3 CHESS 1 samples
  - Active pixel array, DRS readout

- Observed signals generated by the beam
- Pulse heights low (< 10 mV), comparable to noise level
- Observed pixel efficiency only about 10 % relative to a reference FEI4 module
- Pixel outline cannot be distinguished when using external triggering
- On irradiated samples bias voltage above 40 V causes the signals to disappear completely (could be caused by DAC voltage shift ?)