KarTel
Ljubljana telescope based on M26 sensors
(E-TCT with high energy hadron beam)

Andrej Gorišek
J. Stefan Institute, Ljubljana

KarTel

- Reference telescope developed in Ljubljana
- Sensors organized in 2 cages each holding:
  - 3 M26 sensors in individual aluminum frames with alignment pins

  - Trigger scintillator detector of size 2cm x 1cm
  - 1x FEI4 Si module for region of interest (ROI) selection and time anchoring
- Two cages are mounted on base plate with gap in between holding XY remotely controlled stage for DUT placement
- Permanent installation in H6A on retractable table to move it out of acceptance

KarTel
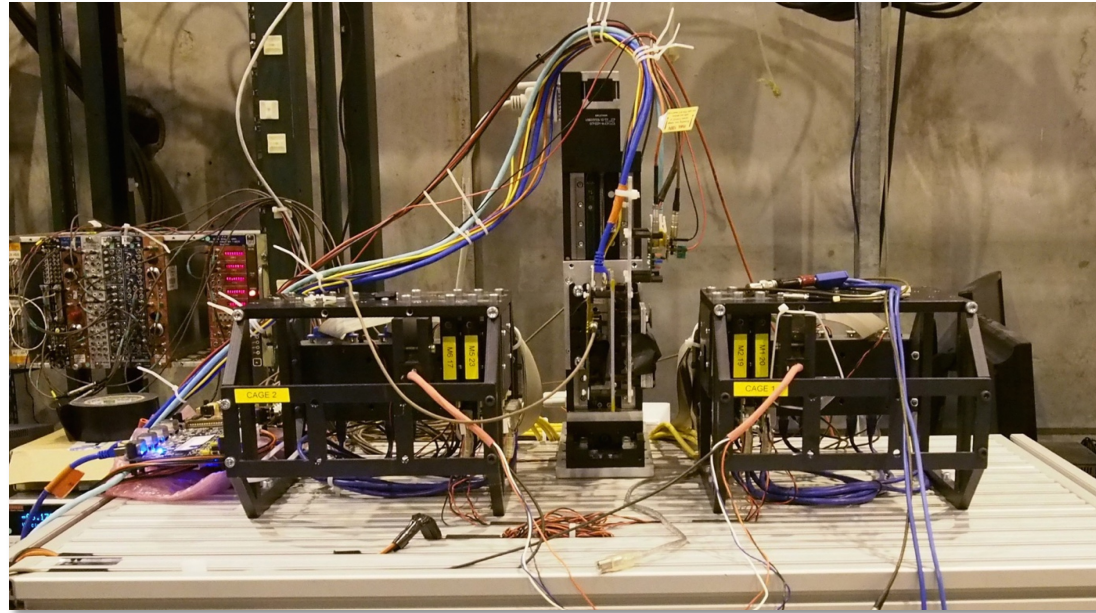
- Mimosa 26 (MAPS) based
  beam telescope (similar to EUDET)
  - 18.4um x 18.4um pixels
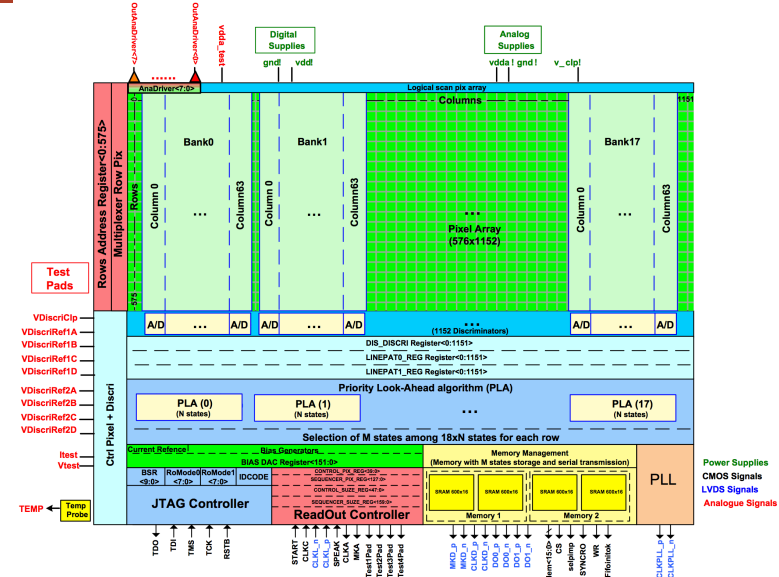 - 1152 x 576 pixels
  - ~2cm x ~1cm active area
  - Red-out window 115.2us
- M26 = M22 (MAPS) with fast
  binary readout + SUZE01 – integrated
  zero suppression
- It is read out pixel columns in parallel,
  row by row.
- The chip readout time is 115.2 μs

- RD42/ATLAS BCM/DBM are the standard users of KarTel

Trigger and ROI selection

- 2 scintillator detectors are used to trigger the telescope/ DUT readout
  - 2cm x 1cm scintillators
  - H5783 Hamamatsu PMTs
  - Telescope outputs a trigger signal only when capable to take the event
- We use a ATLAS DBM type Si module for triggering only events with track inside a chosen region of interest ROI (based on FEI4 readout chip)
  - Used in ATLAS IBL (Pixel upgrade) and Diamond Beam Monitor (DBM)
  - 336x80 channels of 250um x 50um
  - 25 ns
  - TOT readout
  - Hitbus output (OR of all pixels in settable mask)

E-TCTwB

- H6A beam line of SPS North Hall
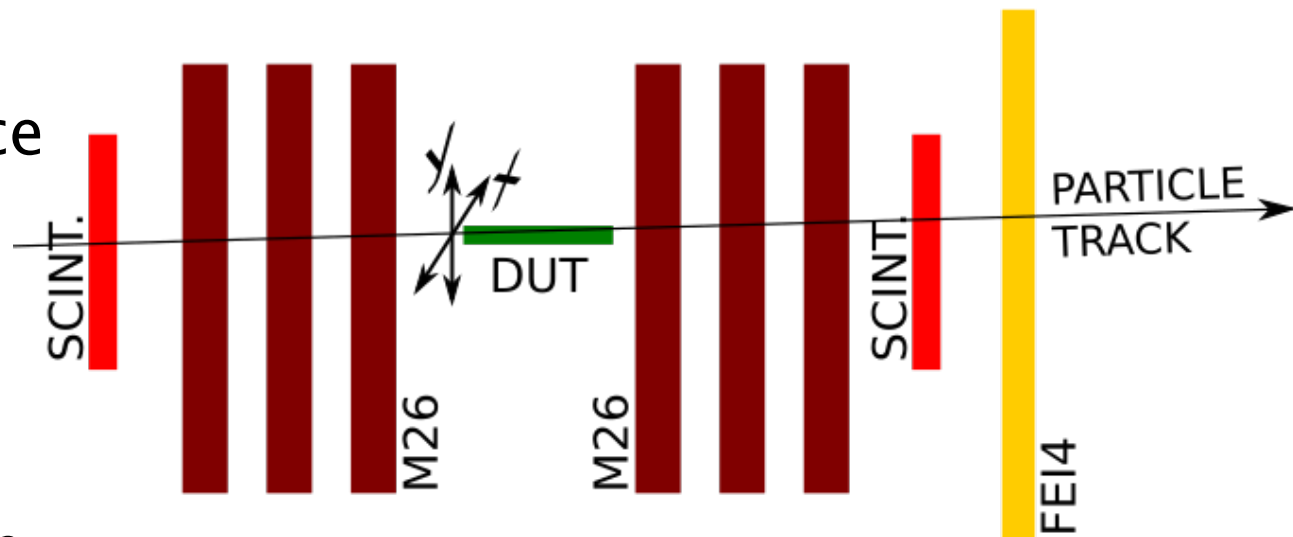- 120 GeV/c hadrons
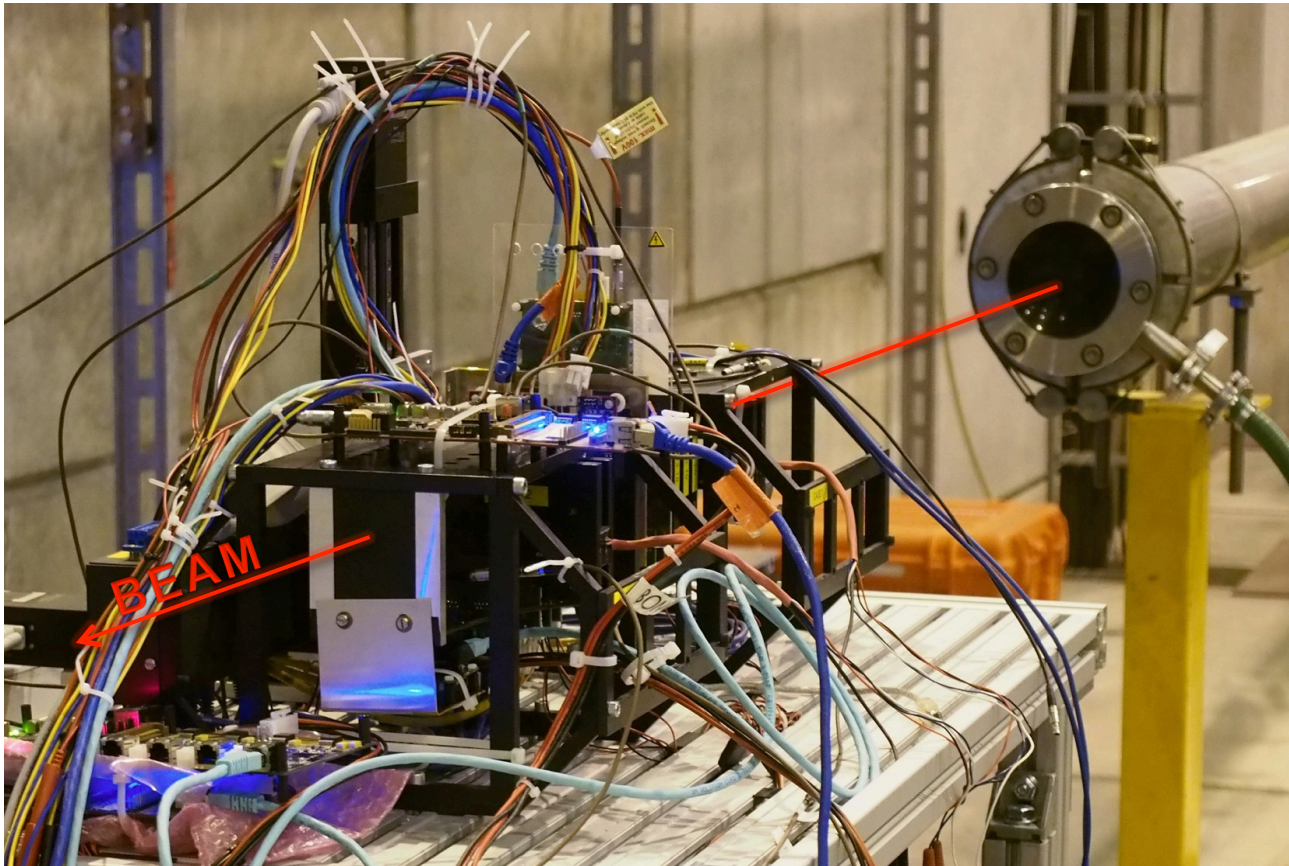
CERN SPS Test Beam Setup

- Mimosa 26
  6 layer reference
  telescope

- DUT on xy
 remotely
  controlled stage

- 2 scintillator detectors for trigger

- FEI4 Si module – ROI selection

Software – Judith

- Judith – a new versatile software package for synchronized analysis of data
  - Built-in KarTel reconstruction
- Software suited to take data from heterogeneous detectors without a need for sophisticated trigger handshake
  - Software package capable of finding missed events in either data-stream – thus synchronizing the data
- Included:
  - Clustering
  - Alignment
  - Simple tracking
- Very efficient and low on CPU consumption

Nucl.Instrum.Meth. A765 (2014) 140-145

Kartel tracking performance

- Track resolution at DUT of about 3um (alignment and final analysis under way)
- Comparable or better than laser focus size in current setups
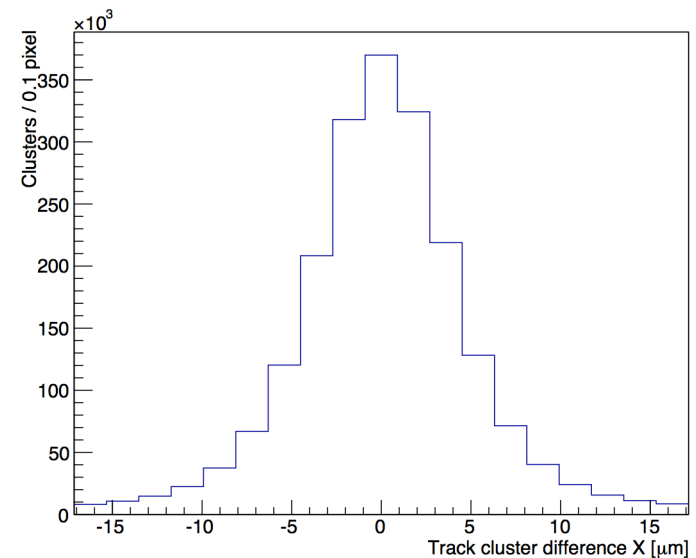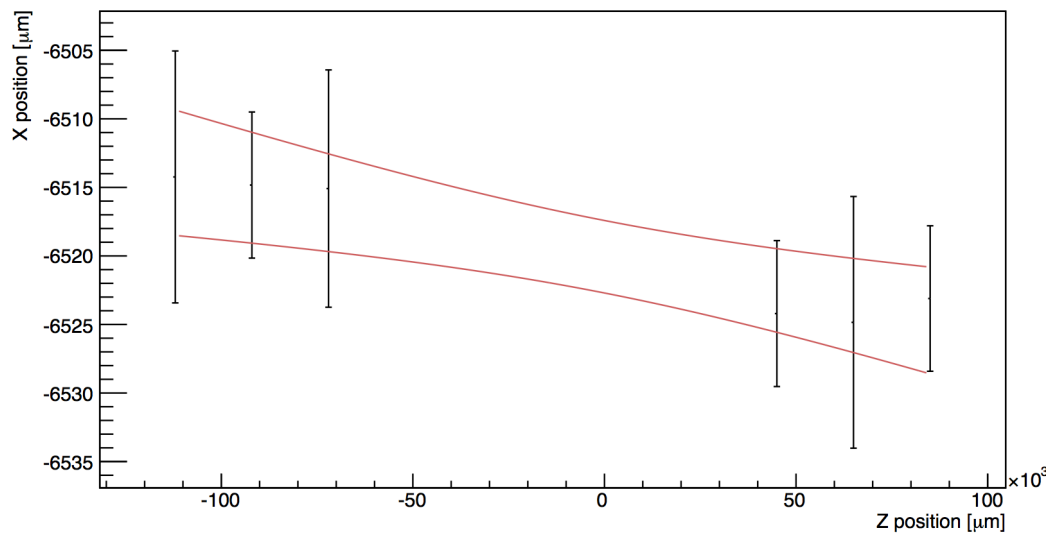
- Conventional Transient Current Technique (TCT) method utilizes short laser pulses to inject free carriers just under the contacts of a Si detector

- Somewhat more recent Edge-TCT (or E-TCT) still uses short pulses of very narrow (well focused) laser beam incident to the edge of Si detector to generate free carriers. With a right setup the size of the laser at focus can get below 10um.

- We propose a complementary method – to use very well collimated beam of charged hadrons in conjunction with a reference beam telescope to scan the volume of the detector under test (DUT)

- Complementary method for Si detectors and probably the only feasible method for diamond detectors due to larger band gap
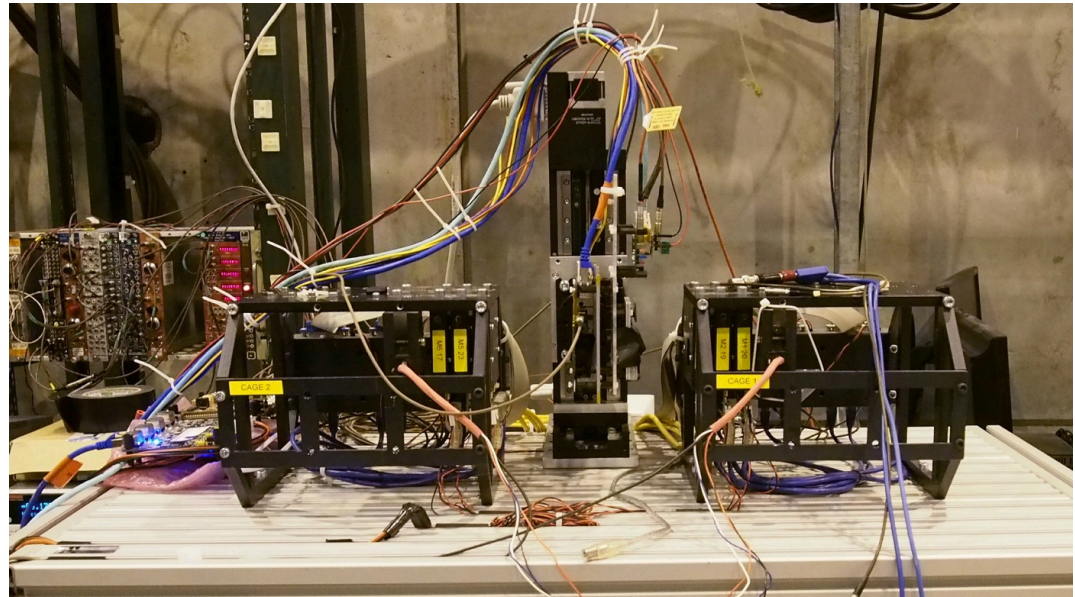
E-TCT with Beam
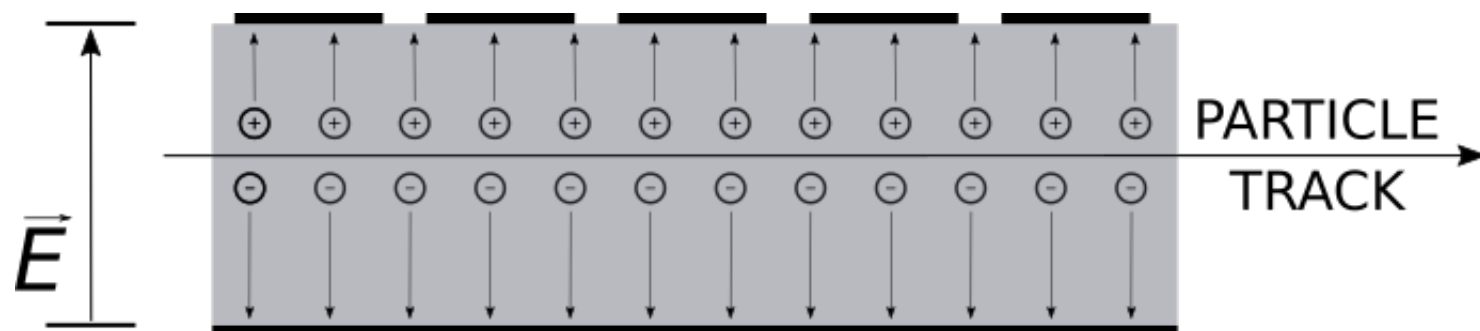
🔲 Incidence points of tracks can be binned in desired manner, waveforms of events with tracks inside one bin can be averaged

■ **For the proof-of-principle we used a standard Si diode**
- ■ STM microelectronics Catania, W339
- ■ n-type, 15kOhm cm, V_{fd}=18V,
- ■ 5mm x 5mm
- ■ 300um thick
- ■ At 80V (fully depleted)

■ **Mounted on USB XY stage**
- ■ For positioning

DUT Readout

W339 diode

Particulars© bias-T
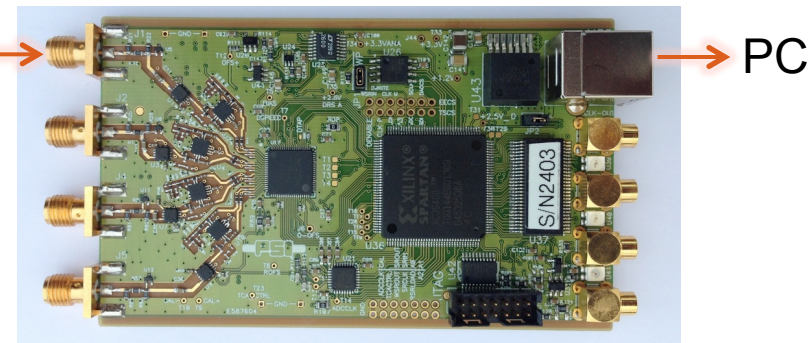
- for decoupling signal from bias voltage

HV

Particulars© wide band current amplifier

- large band-width (up to 2GHz)


www.particulars.si

Pulses readout with PSI DRS4© evaluation board

- ~11.5 bit sampling ADC
- 0.7 GSPS to 5 GSPS with 1024 sampling points

PC

Very collimated beam
- RMS of divergence in X and Y direction below 0.1mrad

On average 10 tracks per event
- DRS readout triggered by scintillators (i.e. the first track in MI26 frame)
- Low efficiency for trigger

Obvious improvement – need to trigger DRS with FEI4 hitbus pulse

Scintillator trig. Track in ROI of FEI4

Results
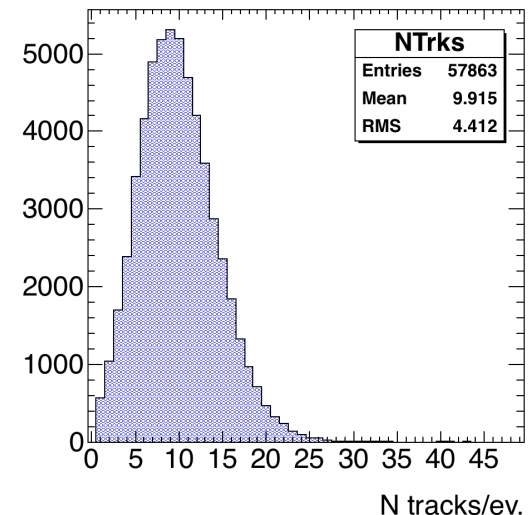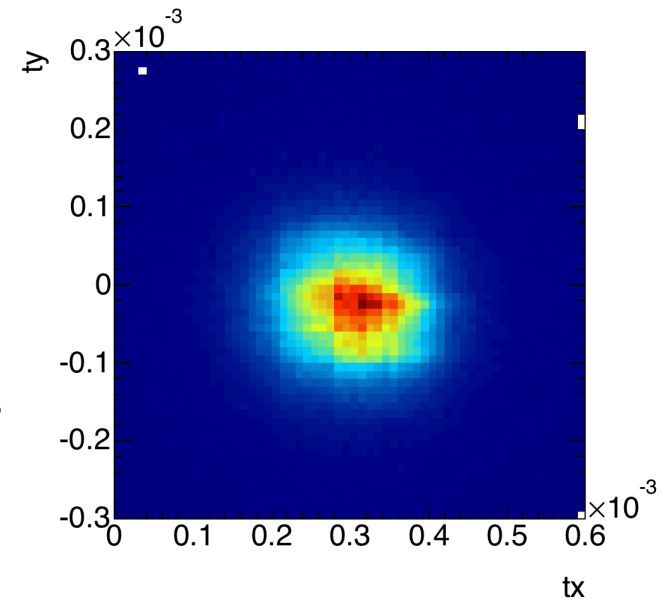
- **Waveforms of single MIPs going trough Si diode were recorded**
- **Signals were triggered by scintillator trigger**
- **Average signal displayed for events with tracks inside the region of the Si diode**
- **Average signals of events without a track inside the region of the Si diode**
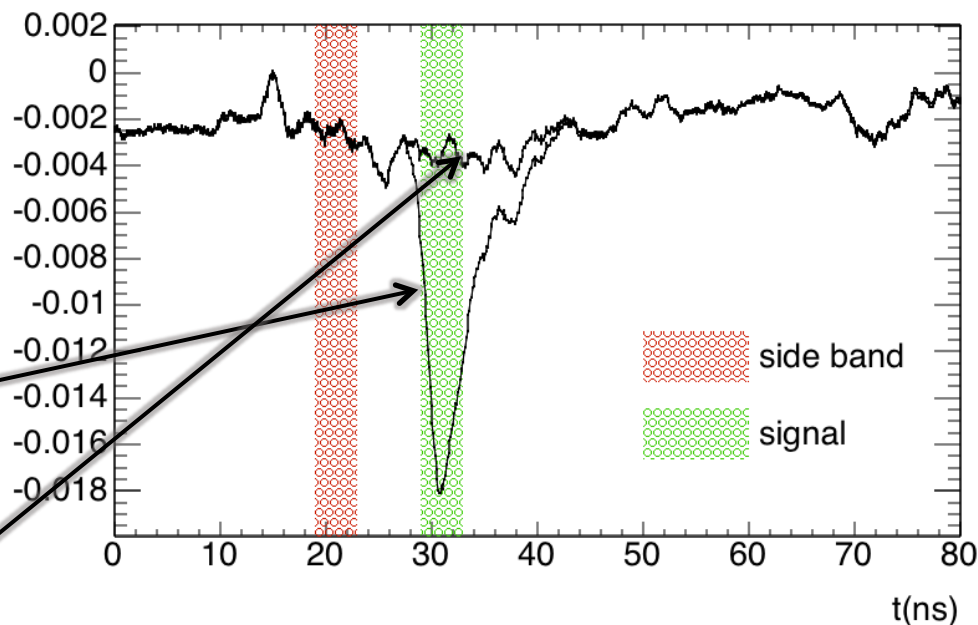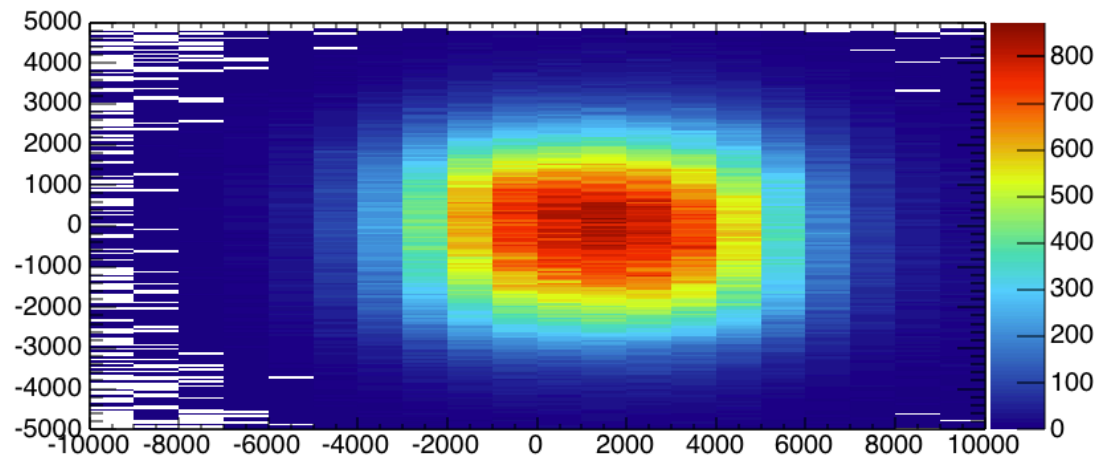
Results

- **Amplitude distribution for:**
  - Inside the peak region (green)
  - In the sideband
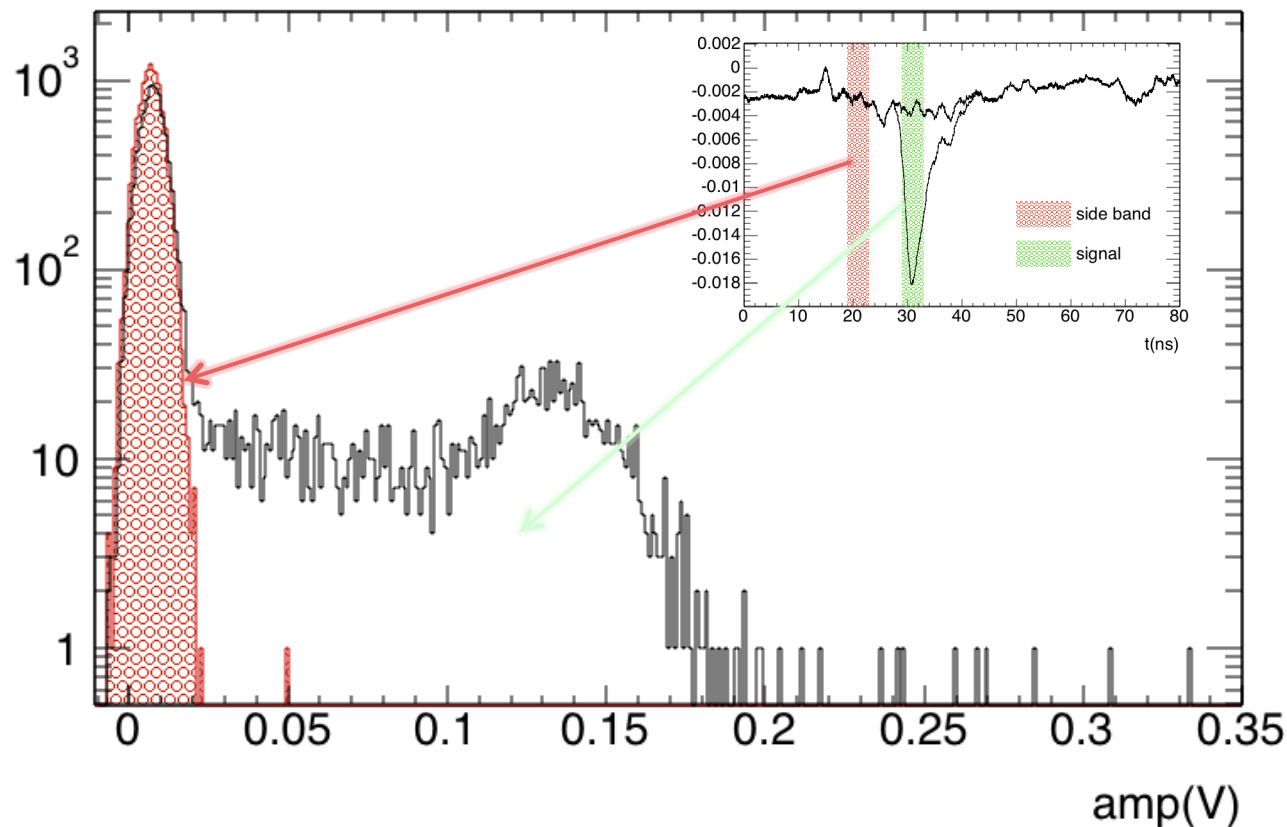
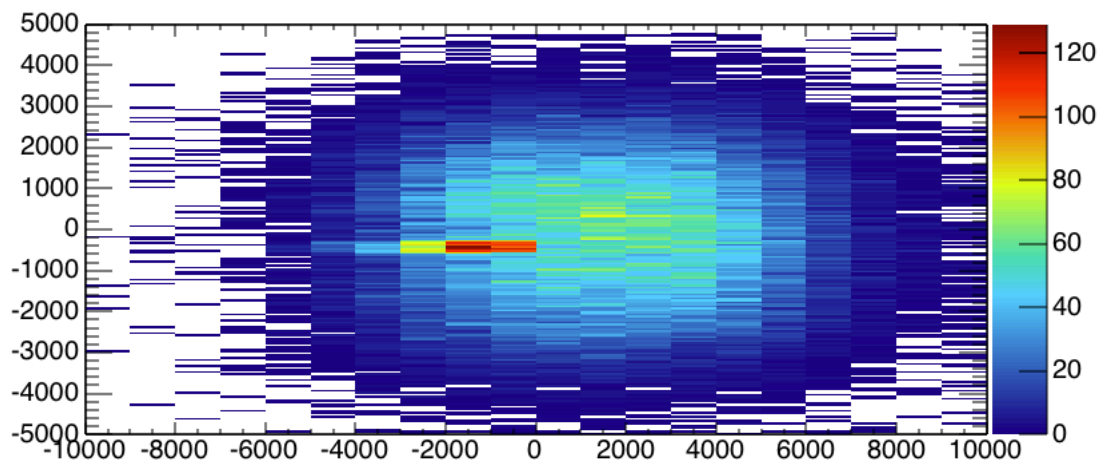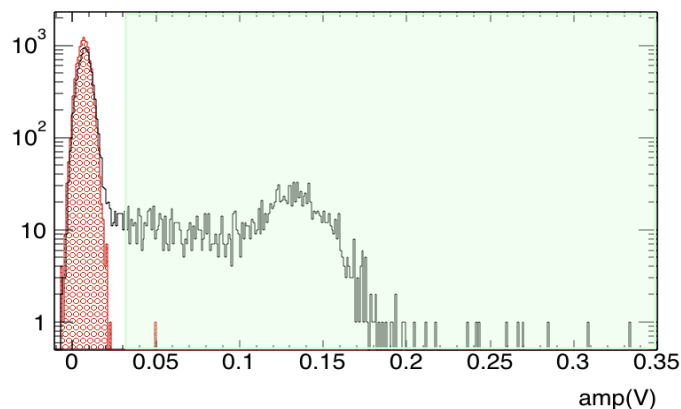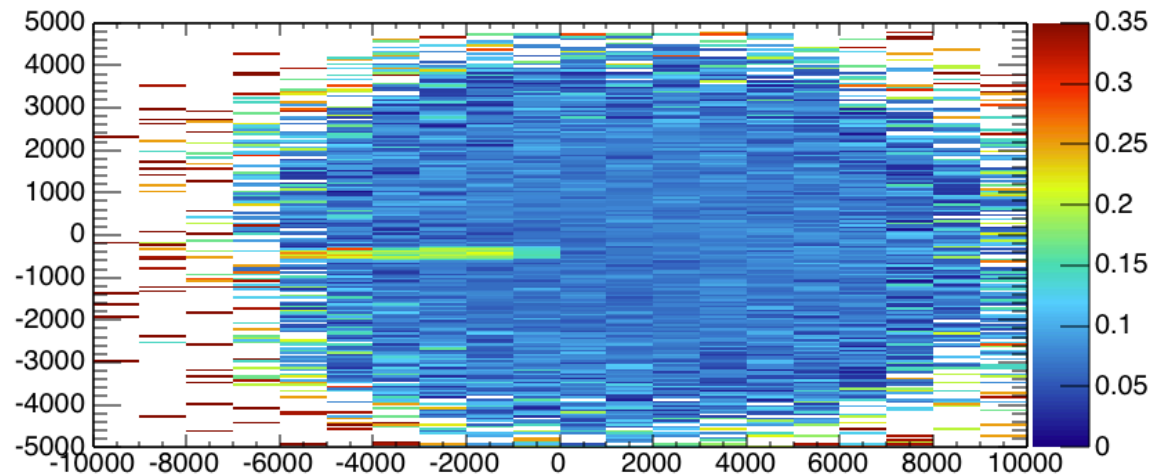# Results

■ Distribution of all incidence points of tracks

■ Requiring there is a waveform with amplitude > 0.3mV in Si diode

Results

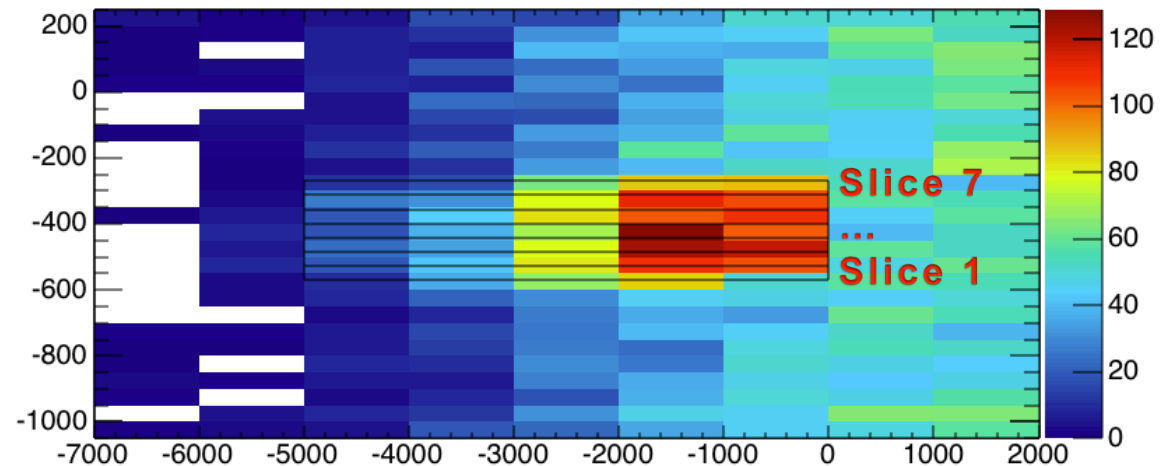⌗ Ratio
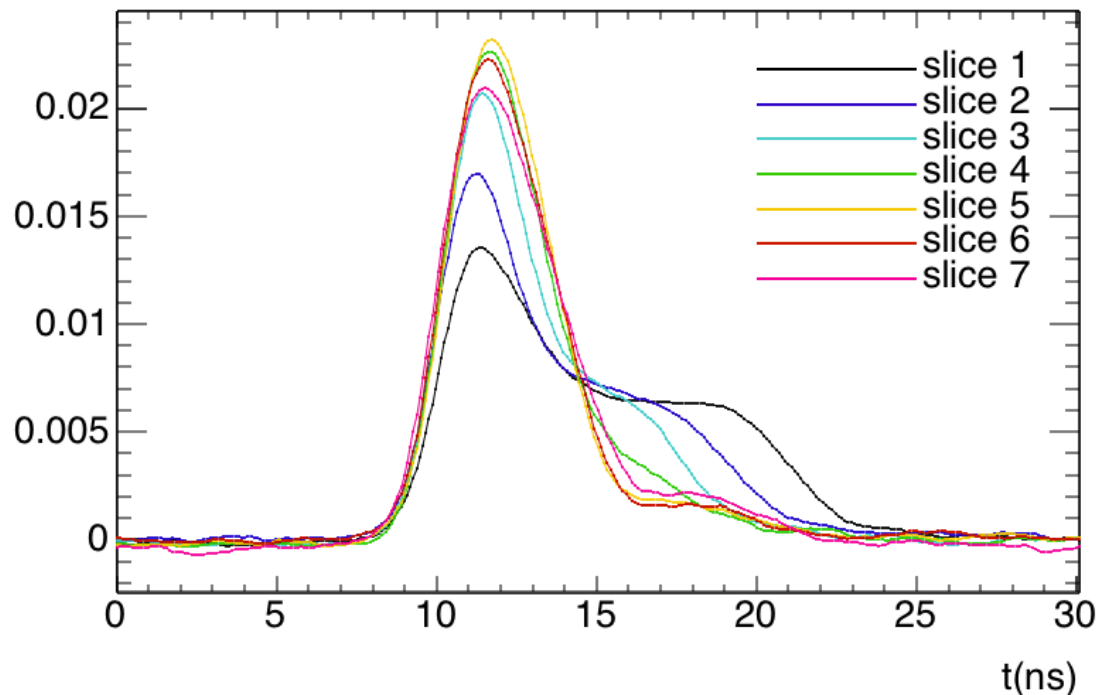

⌗ Zoom into Si diode region

⌗ Divided into 7 slices
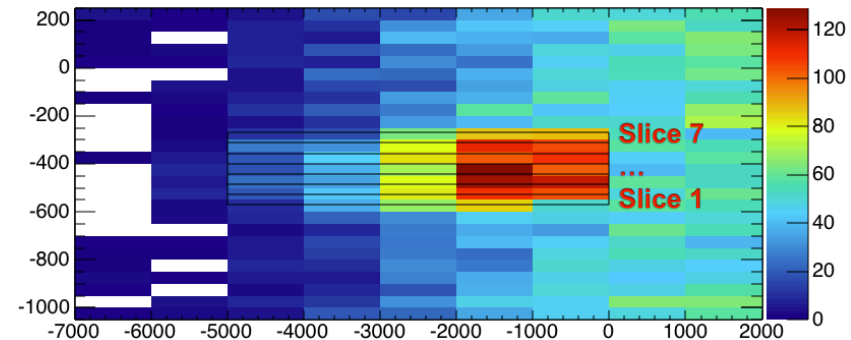

Slice 7

...

Slice 1

Results

- **Slices**
  - **Slice 1 (just under +contact) mostly signal from drift of the holes**
  - **...**
  - **Slice 7 (just under –contact) mostly signal from electron drift**
  - **In all the time e– signal is super-imposed on h+ signal**

- Use KarTel + Judith in CERN test-beams
  - RD42, ATLAS BCM/DBM,…
- Currently implemented DUTs (readout)
  - FEI4, DRS, LeCroy oscilloscope
- Planed additions?
  - Alibava, VA
- Possible measurements
  - pCVD diamond diode with DRS4
    need better – more precise timestamping
  - pCVD diamond strip detector with Alibava (or VA readout)

Conohusions

- We have shown that it is possible to execute a E-TCT measurement in hadron beam with a high precision beam telescope

- Complementary method to laser based E-TCT for Si detectors

- Promising for measuring diamond detectors which are not accessible with low cost laser diodes due to larger band-gap