IDEATE LIA

French-Ukrainian WORKSHOP

Instrumentation developments for high energy physics

November 6-8, 2017 LAL - Orsay, France

TIMEPIX detector tests within Λ_c^+ experiment

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LPC

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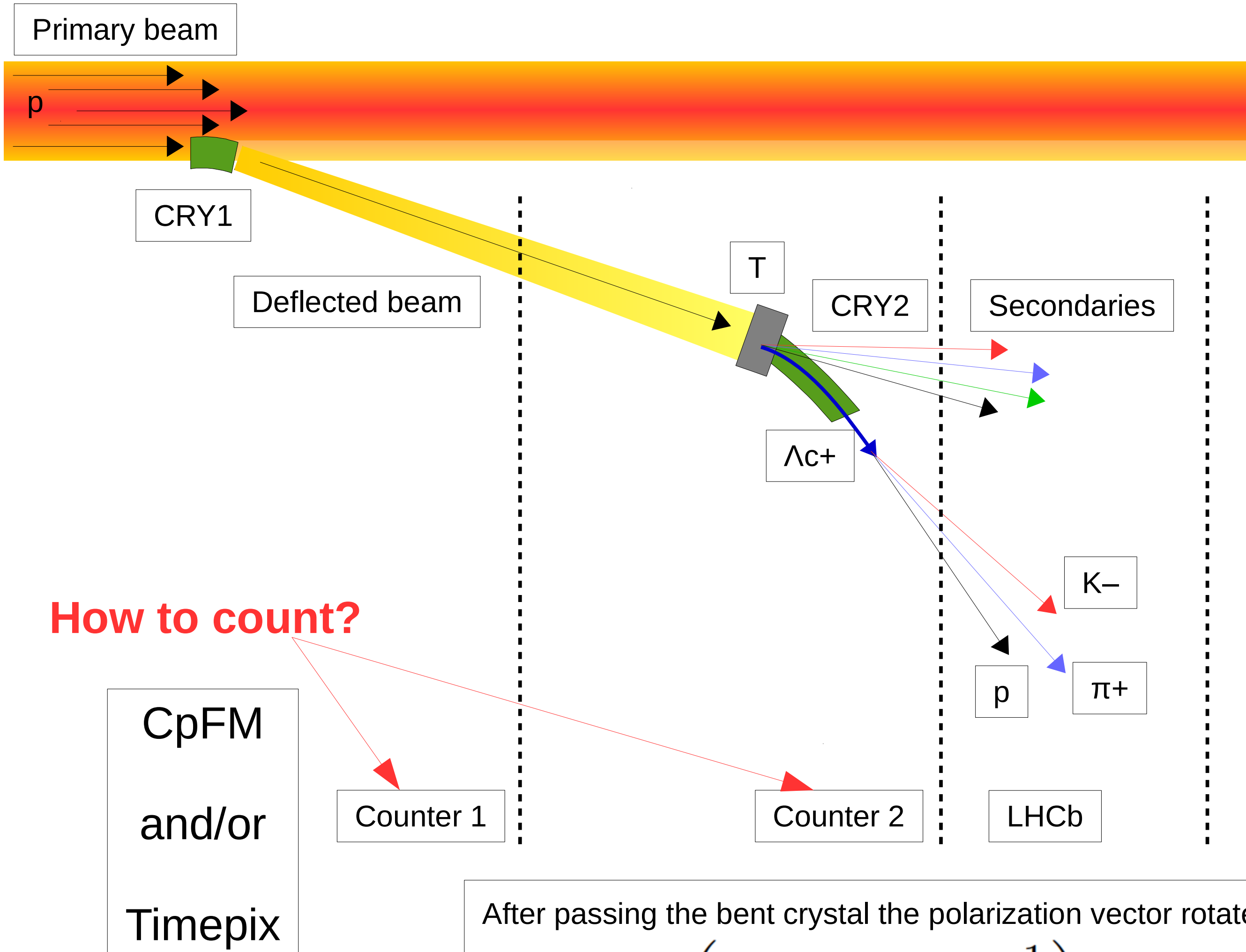
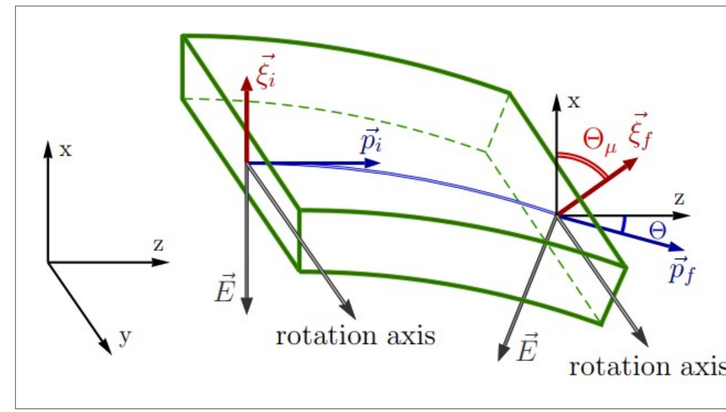
cea

IPN ORSAY

The main idea and goal of the experiment

The proposal is to use the bended crystals for measuring the magnetic moment of the charmed charged hadrons starting from Λ_c^+ ($c\tau(\Lambda_c^+)$ ~ 60 um).





Schematic layout of experiment. Effective electric field **E** is orthogonal to the momentum **p**. The figure shows the case g > 2.

After passing the bent crystal the polarization vector rotates by the angle:

$$\Theta_\mu = \gamma\left(\frac{g}{2} - 1 - \frac{g}{2\gamma^2} + \frac{1}{\gamma}\right)\Theta \approx \gamma\left(\frac{g}{2} - 1\right)\Theta$$

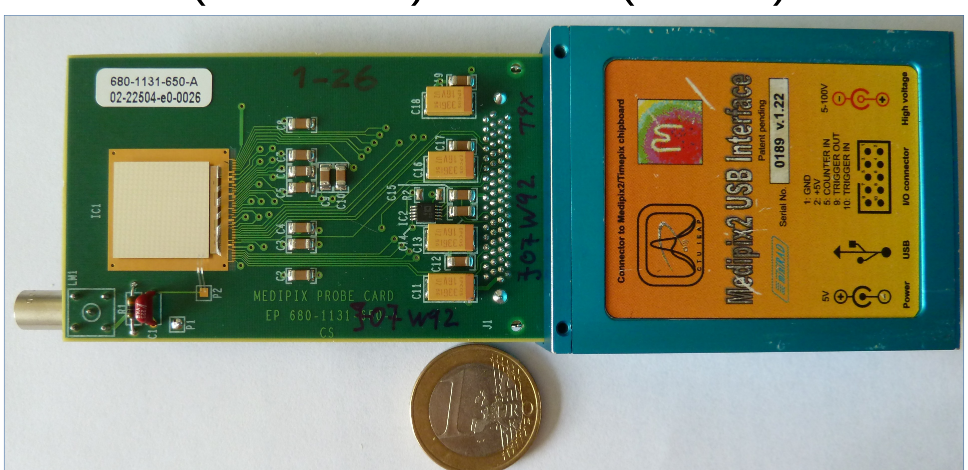
with respect to the direction of the initial polarization vector.

Detection Hardware

Timepix:

Chip: 256x256 pixels
Pixel: 55x55 um
1-96 MHz Clock *(1-0.0104 us)*
<u>Frame mode:</u>
Medipix → count the number of hits in the pixel *(11810 max. counts)*
ToA → count the number of clocks after signal arrived *(11810 max. counts)*
ToT → count the number of signal duration clocks *(11810 max. counts)*

Maximum time acq. window: 11.810 ms
20 Hz data taking (windows soft)
50 Hz (Linux soft) USB2.0 (limited)



<u>Readout:</u> USB2.0 via Fitpix

Timepix3:

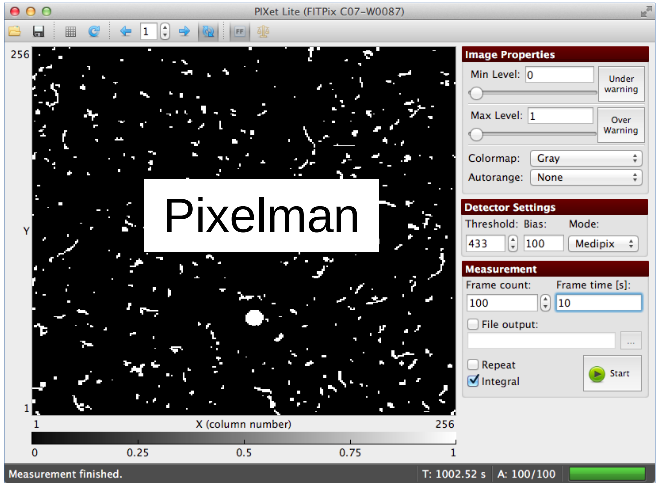
Chip: 180x180 pixels
Pixel: 55x55 um
40 MHz Clock *(0.025 us)*
+
640 MHz for Fast ToA *(0.0015625 us)*
<u>Frame or Pixels mode:</u>
ToA+ToT → count the number of clocks after signal arrived and its duration
(ToA 16384 max. count & ToT 1024 max. count)
ToA → count the number of clocks after signal arrived *(16384 max. count)*
Event count & Integral ToT → count the integrated number of all signals duration and number of hits
(iToT 16384 max. count & eCount 1024 max. count)

Maximum time acq. window: 0.409 ms
20 Hz data taking (windows soft)
50 Hz (Linux soft) USB2.0 (limited)

DAQ Software

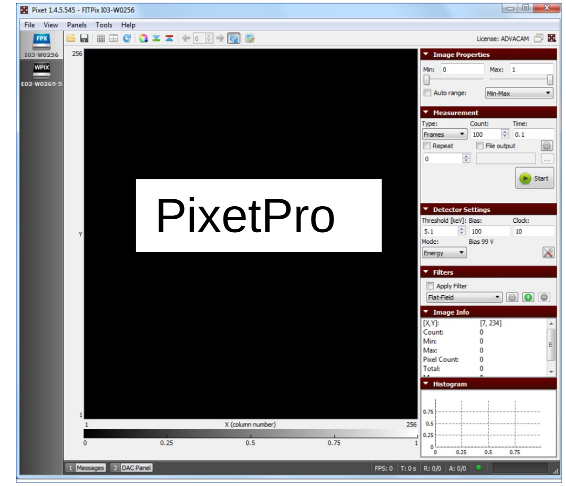
GUI

Timepix



→ Frame acquisition
→ Cluster analysis
→ DAQ rate: up to 20 Hz

Timepix3



→ Frame acquisition
→ Pixels acquisition
→ Cluster analysis
→ DAQ rate: up to 20 Hz

Python scripting

Timepix

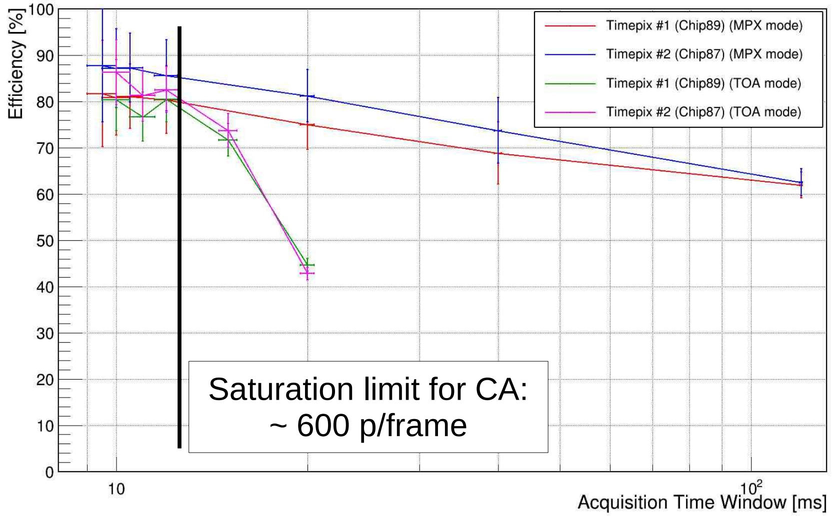
→ Frame acquisition
→ Cluster analysis
→ UA9 publisher
→ DAQ rate: up to 4 Hz

Timepix3

→ Frame acquisition
→ Pixels acquisition *(not implemented)*
→ Cluster analysis *(not implemented)*
→ DAQ rate: up to 20 Hz

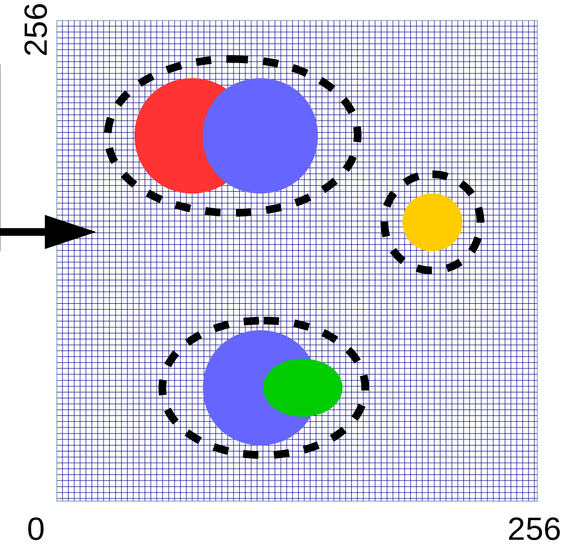
H8 run. Pion beam. May 2017 (TIMEPIX)

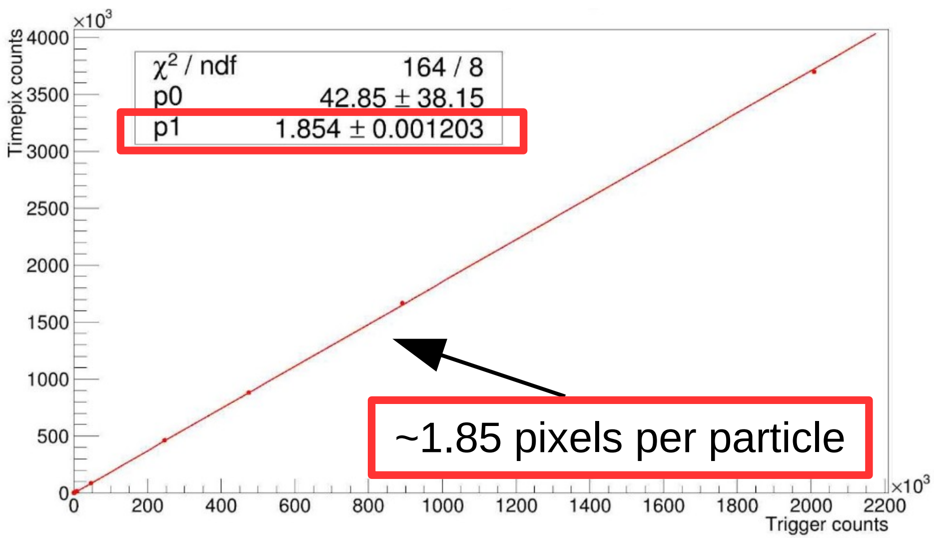
Particle beam flux: 5.3e5 – 7.0e5 per 5.0 sec → ~ 1.1e5 – 1.4e5 p/sec



*Timepix particle counting efficiency vs acquisition time window. With Cluster Analysis (**CA**).*

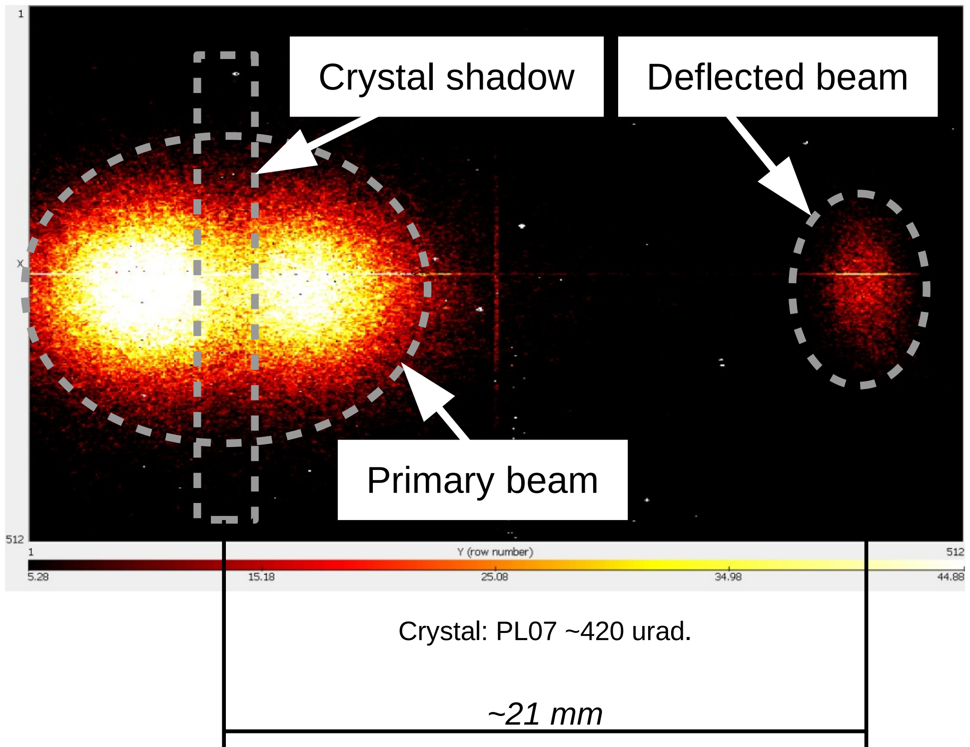
→ In ToA mode we take only first hit of the pixel
→ Overlapping of the clusters





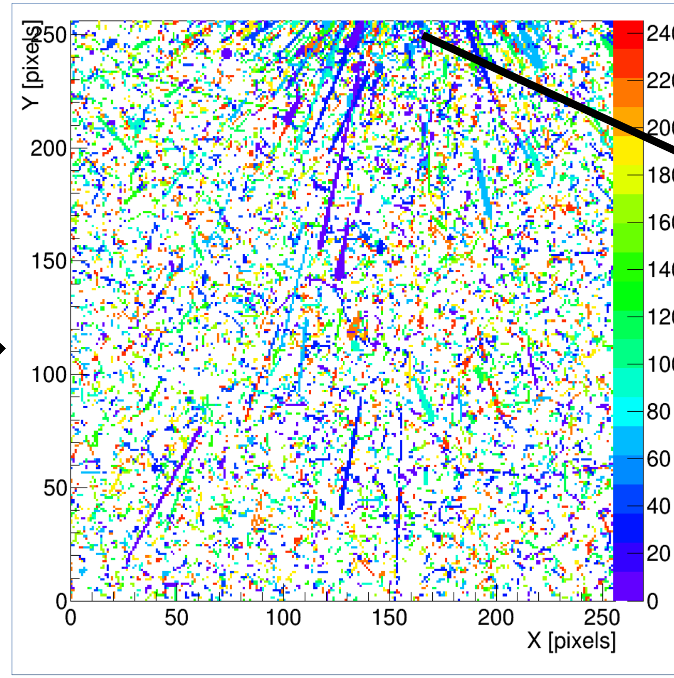
*Timepix integrated counts in the pixels (**Medipix mode**) vs trigger counts. Without CA.*

Quadpix (4 Timepix chips)



Improvement of the Cluster Analysis

SPS (2017-may)

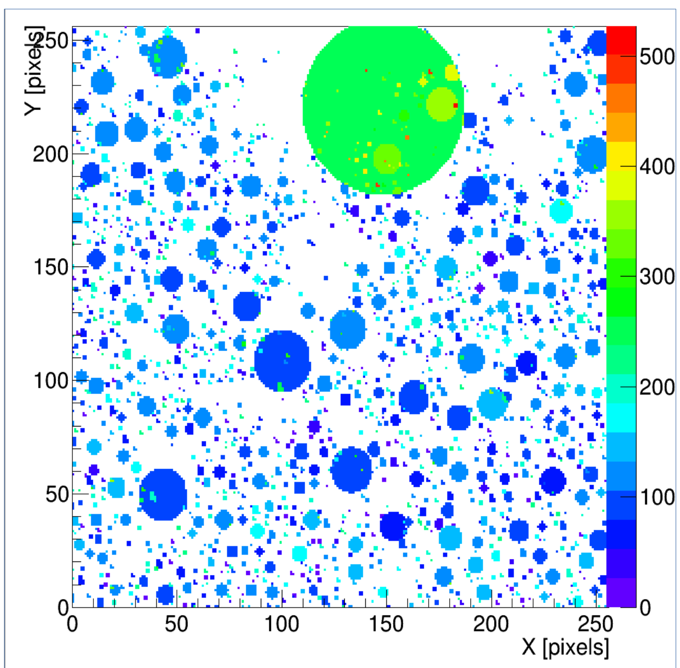


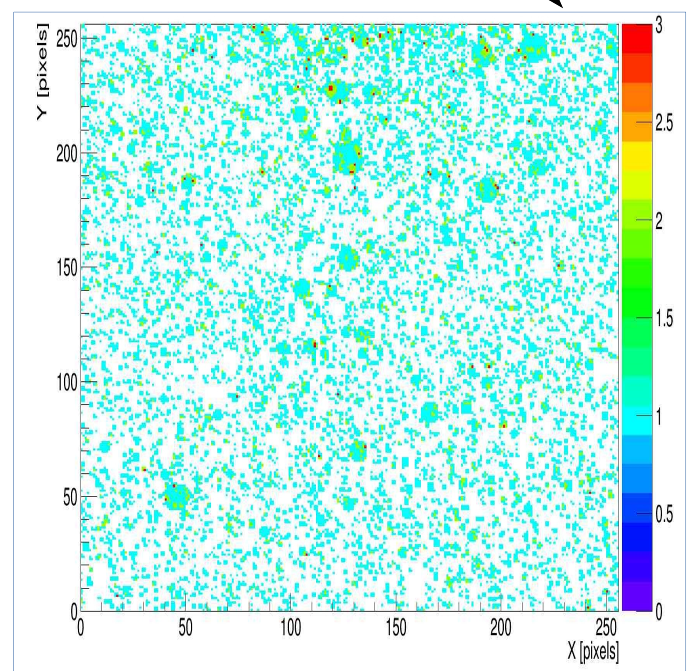
Real Frame

Roma-pot wall
(300 um x 30 mm)

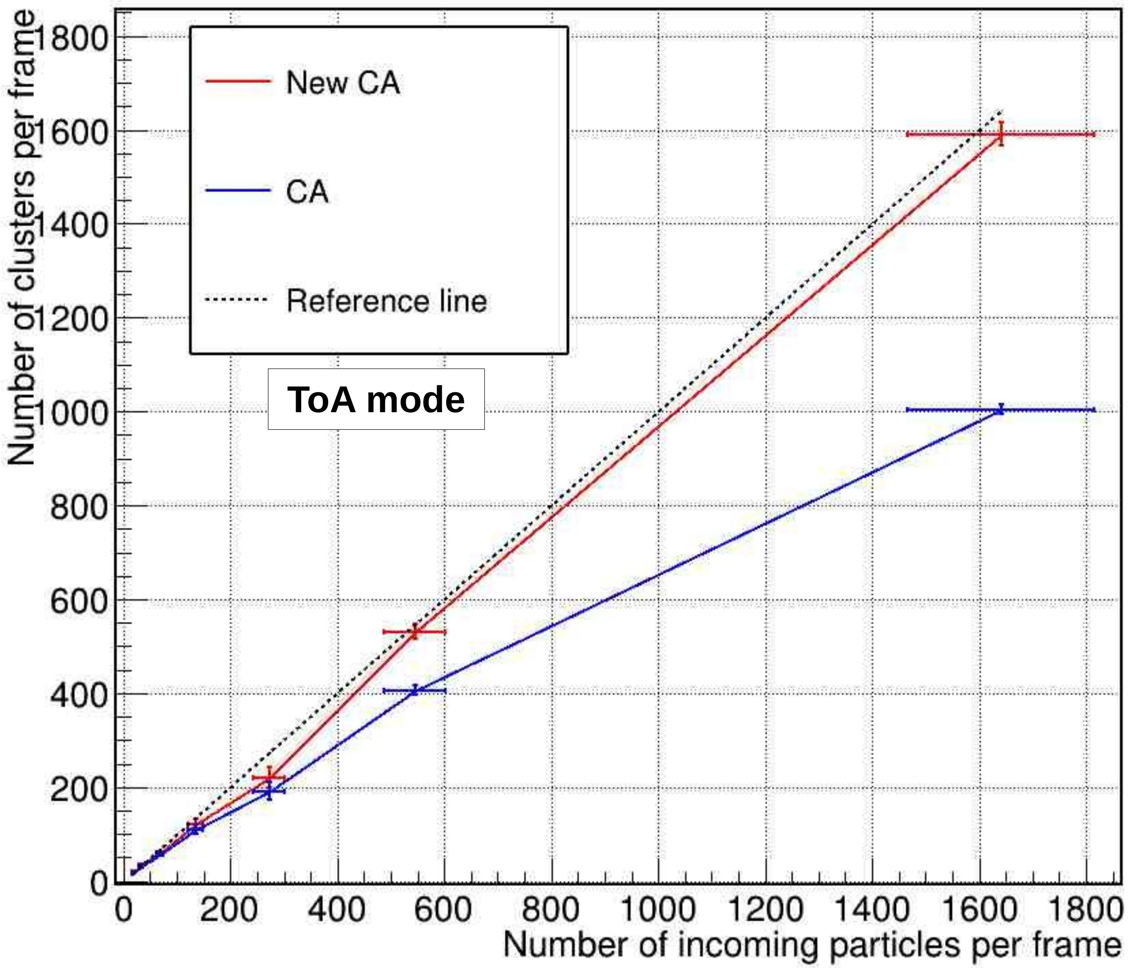
Cluster Analysis (CA)

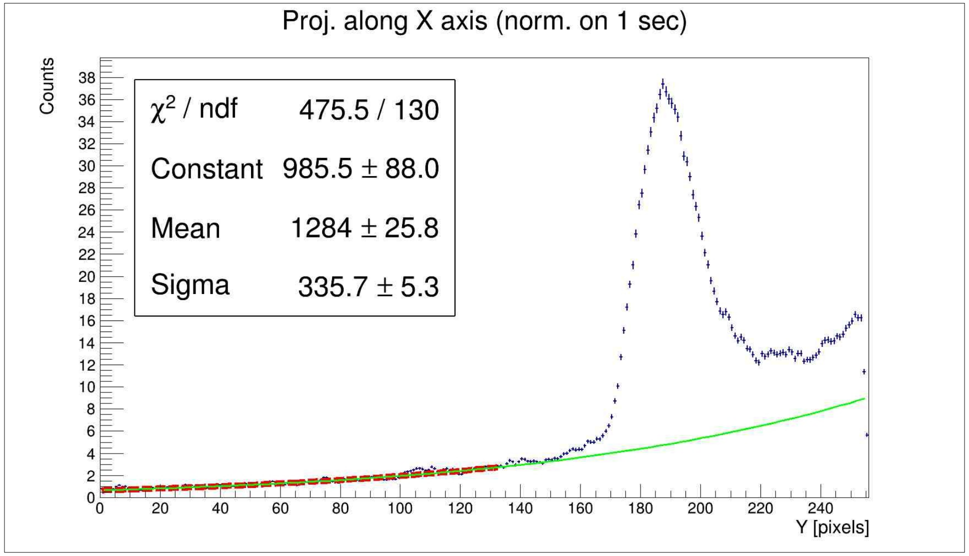
Developed using time info.
New Cluster Analysis (nCA)

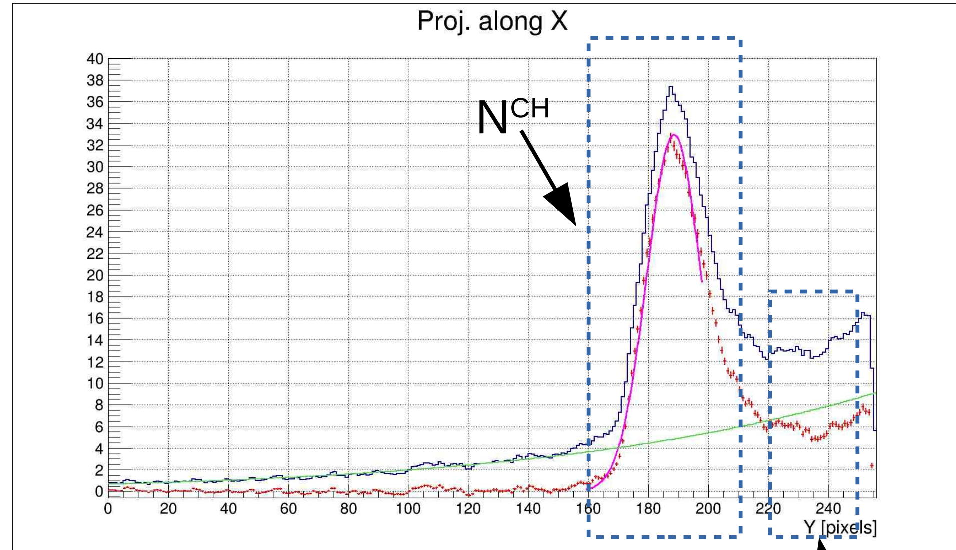




Timepix linearity in ToA mode with new Cluster Analysis

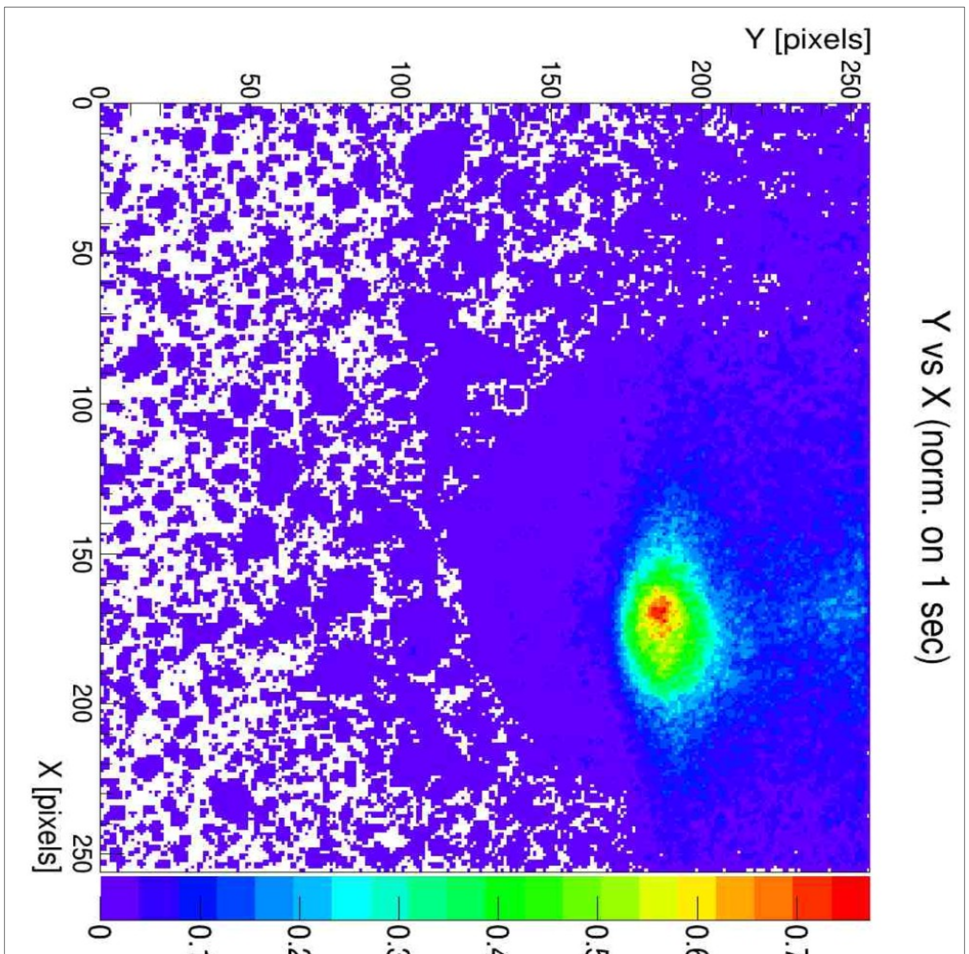






Mean +/- 2*Sigma

30 pixels = 1.65 mm

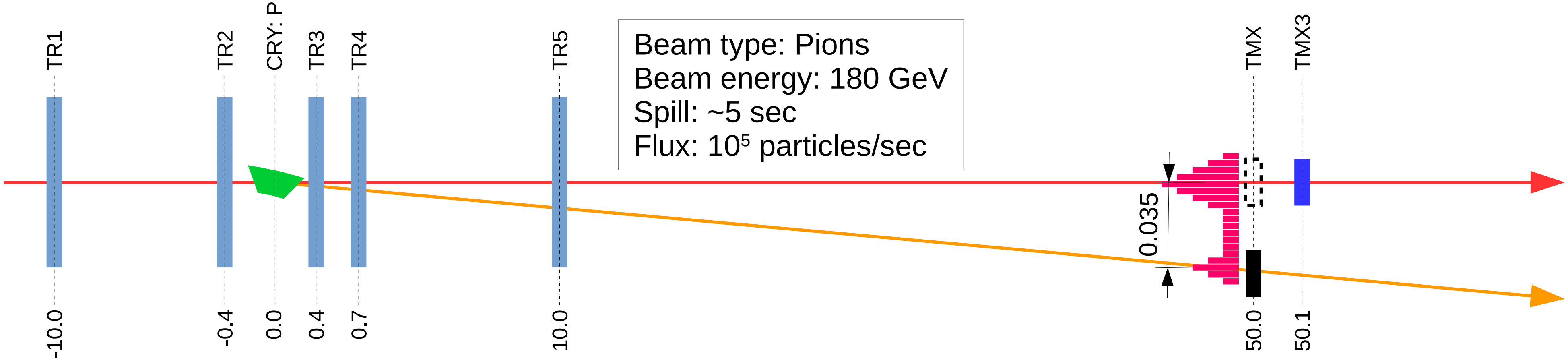


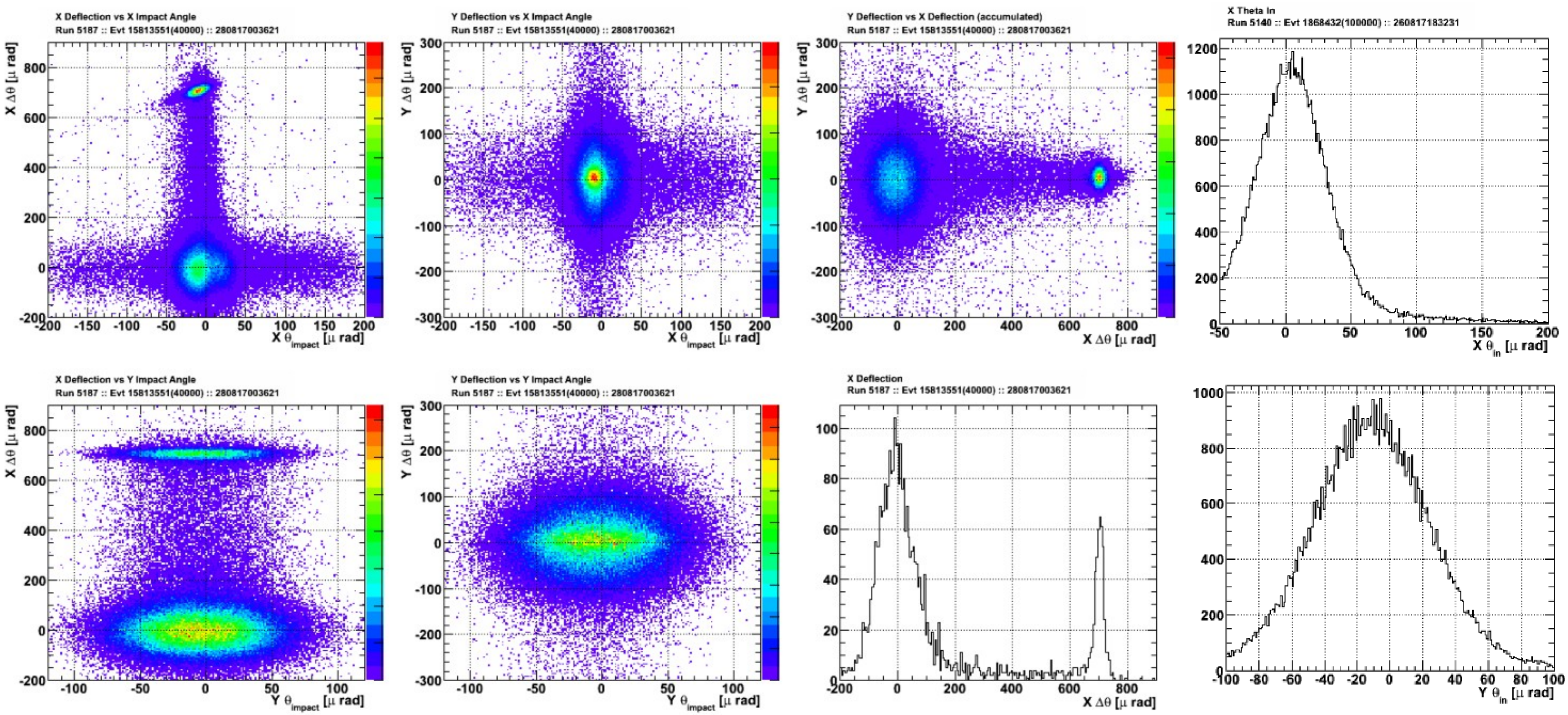
Constant	3.29487e+01	+/-	1.34131e-01
Mean	1.88471e+02	+/-	5.57166e-02
Sigma	9.04205e+00	+/-	4.61026e-02

SPS Protons

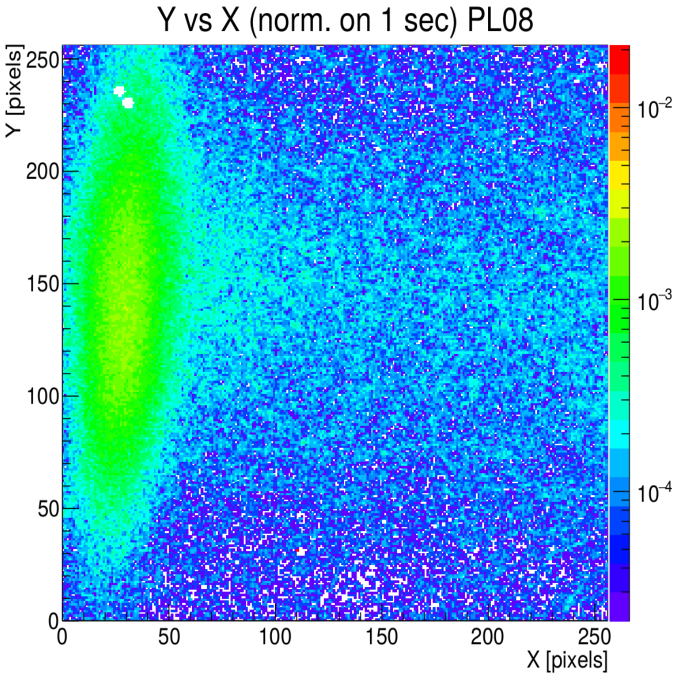
N^{CH}	= 757.989147	+/-	2.349392
N^{DCH}	= 110.782107	+/-	0.948719 (mm^{-1})
N^{CH}/N^{DCH}	= 6.842162	+/-	0.062315
$\delta(N^{CH}/N^{DCH})$	= 0.910748 %		

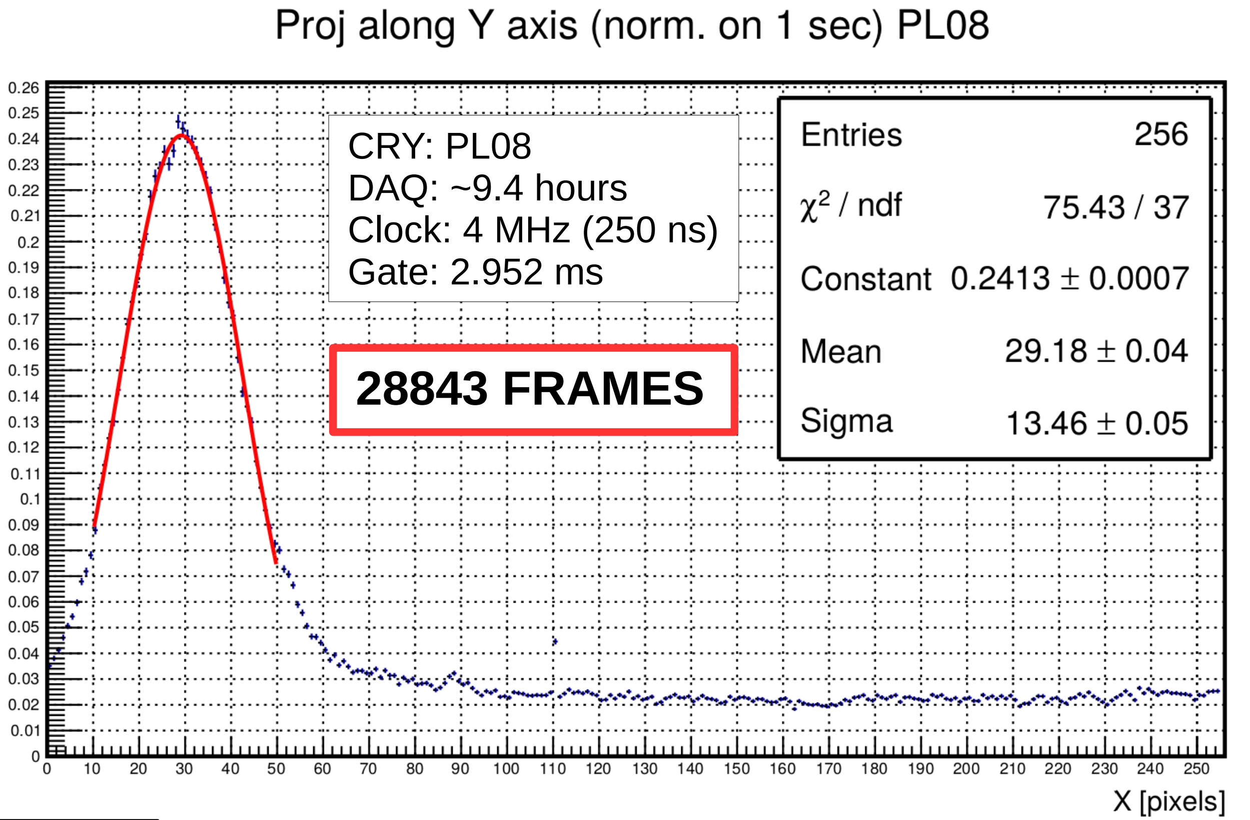
H8 run. Pion beam. August 2017 setup description :





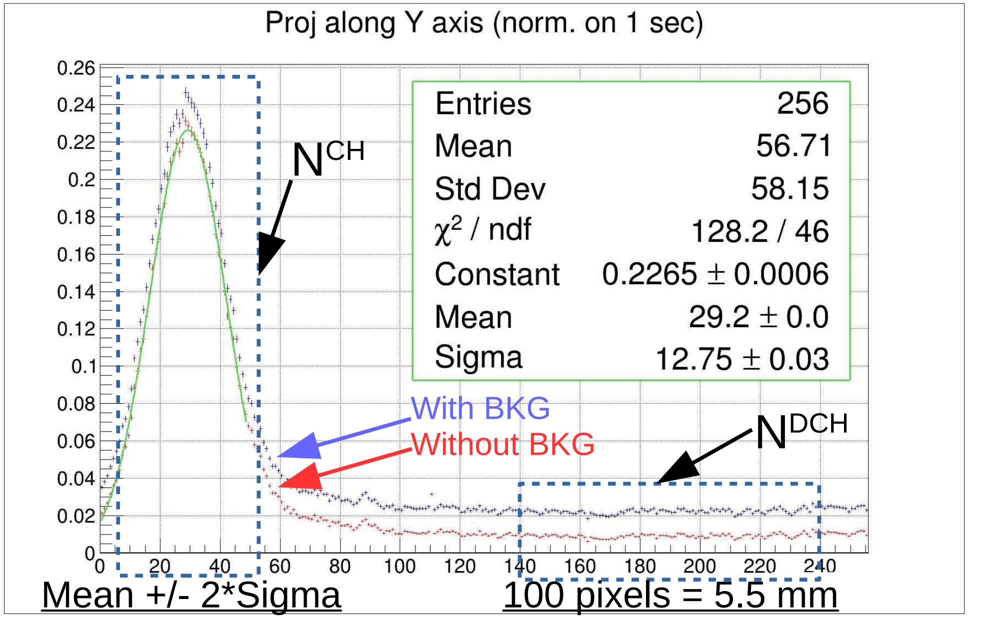
Timepix. Deflected beam image





N^{CH}	= 6.981502	+/- 0.014395
N^{DCH}	= 0.166811	+/- 0.000949 (mm^{-1})
N^{CH}/N^{DCH}	= 41.852768	+/- 0.253259
$\delta(N^{CH}/N^{DCH})$	= 0.605119 %	

H8 Pions



Improvement of the Readout electronics for Timepix3

Katherine: Ethernet Embedded Readout Interface for Timepix3

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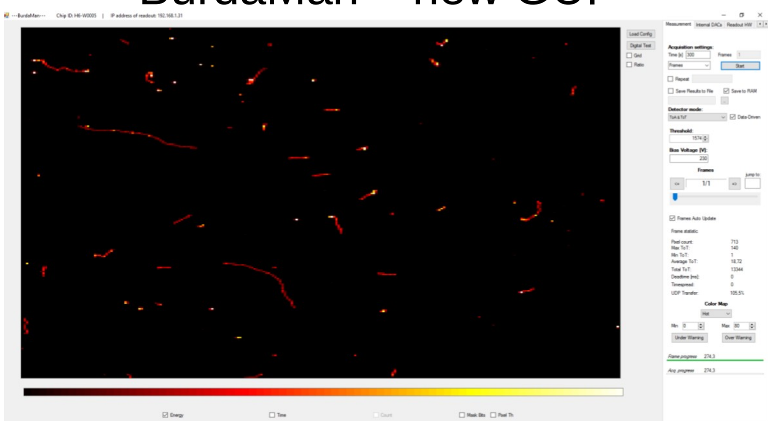
Features:

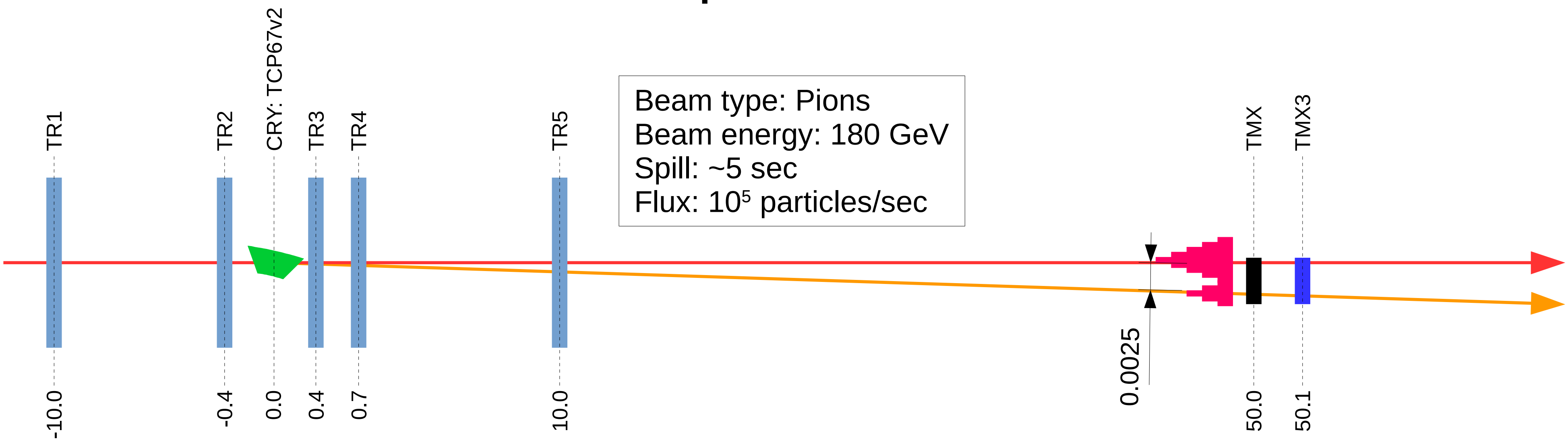
→ Embedded computer + interface for one Timepix3 (CERN chipboard)
→ Optimized for long distance between sensor and readout
→ Source of high voltage for bias – both polarities (±300V)
→ Gigabit Ethernet Interface => max. 15Mhits/s
→ Long-distance access (up to 100m)
→ Dimension: roughly 100x80x28
→ Power supply DC 5V
→ ToA overflow in data-driven mode:
  >> Coarse ToA counter overflow period = 409.6μs
  >> The device adds 32 extra bits for time-stamping
  >> Overall 50-bit (32 extra, 14 ToA, 4 fToa) time-stamping => overflow period is ~20 days
→ Enough computing power for user purpose:
  >> Approximately 8000 ALMs in FPGA free to use
  >> Dual-core ARM Cortex-A9 processor
  >> 1GB DDR3 RAM

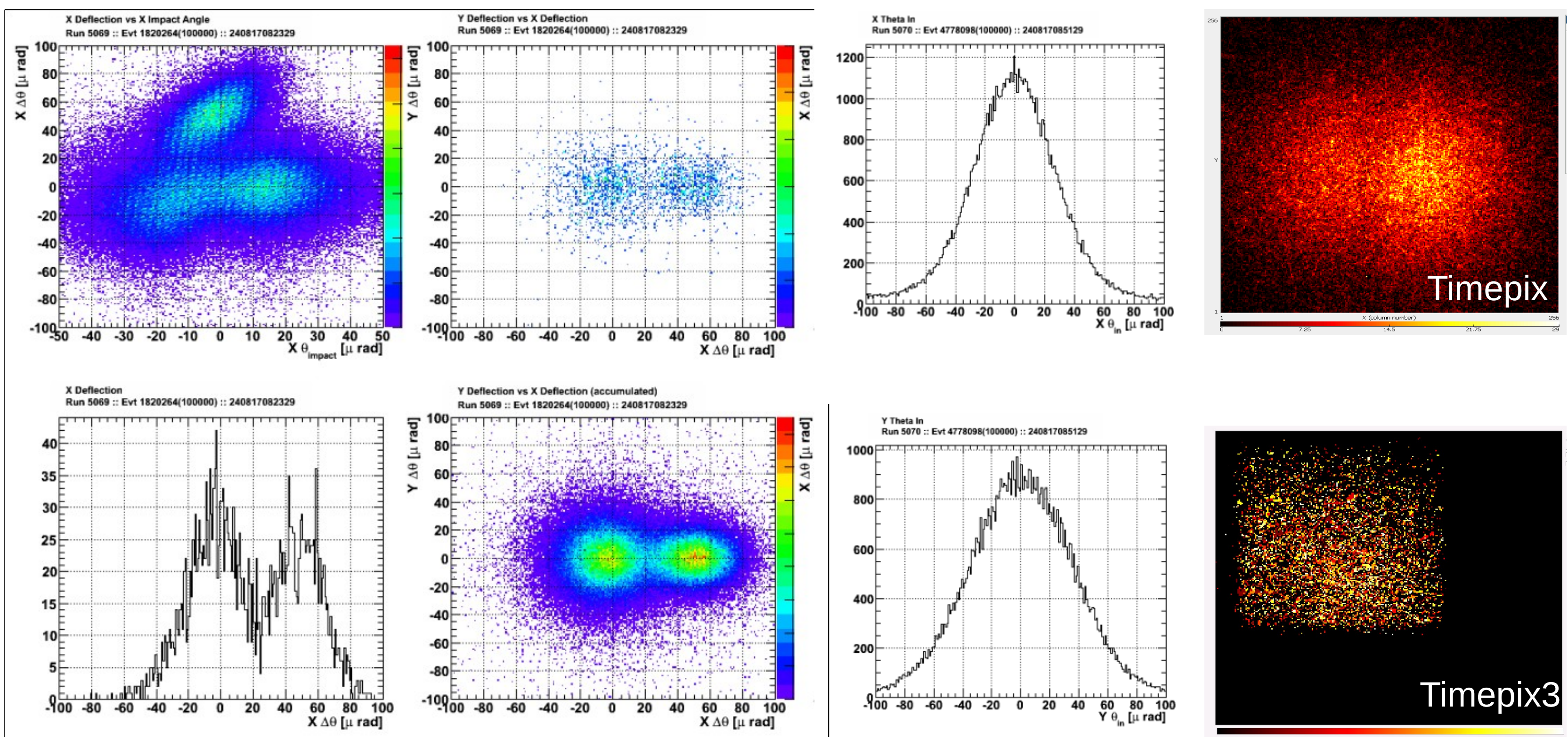
BurdaMan – new GUI



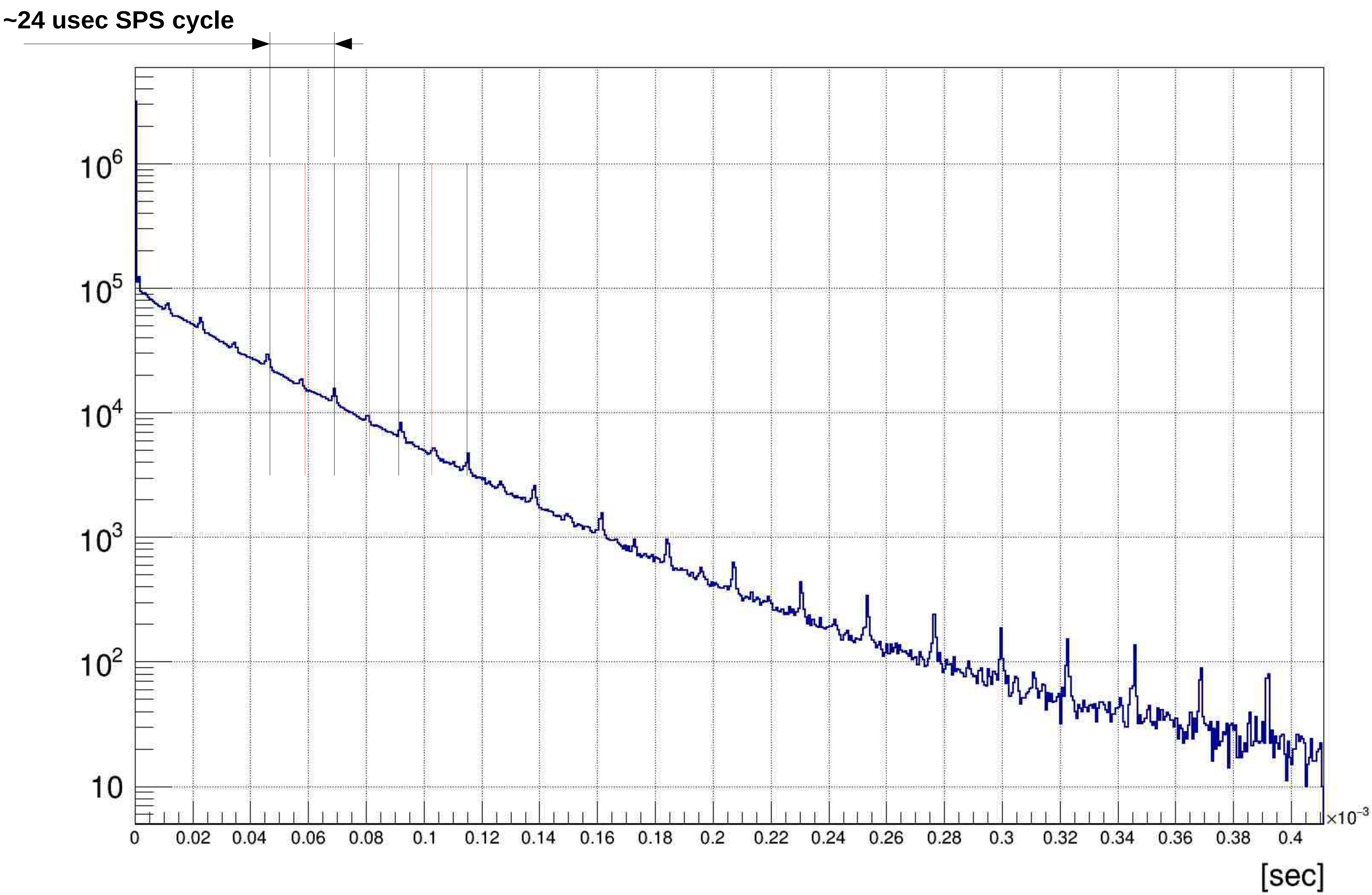
Timepix3 Test at H8

Beam type: Pions
Beam energy: 180 GeV
Spill: ~5 sec
Flux: 10^5 particles/sec

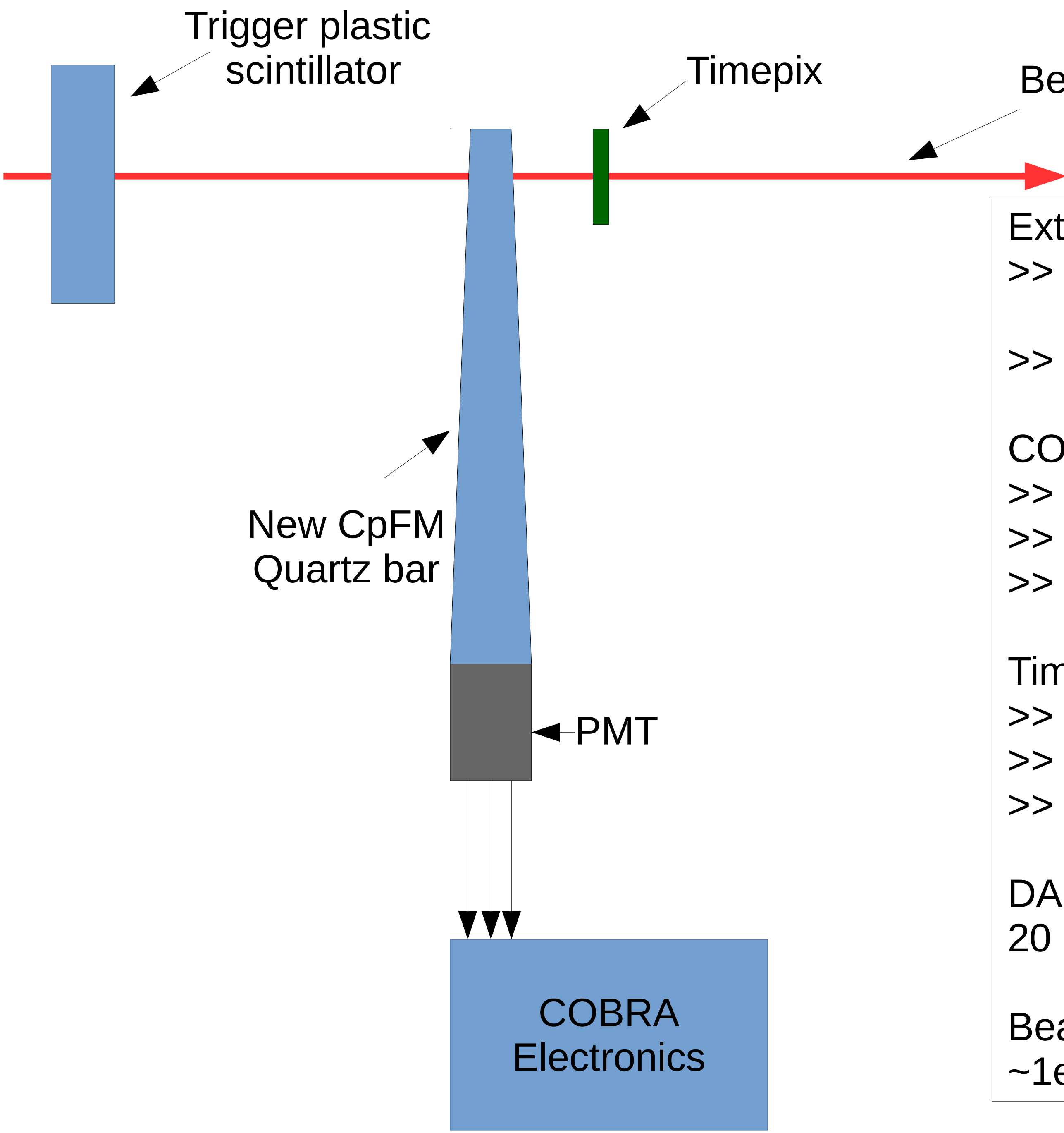




Timepix3 & Katherine. Time distribution of the particles at H8



Timepix & CpFM (COBRA electronics). August 2017



External trigger:
>> Signal from trg. plast. scintillator
&
>> Signal from Spill

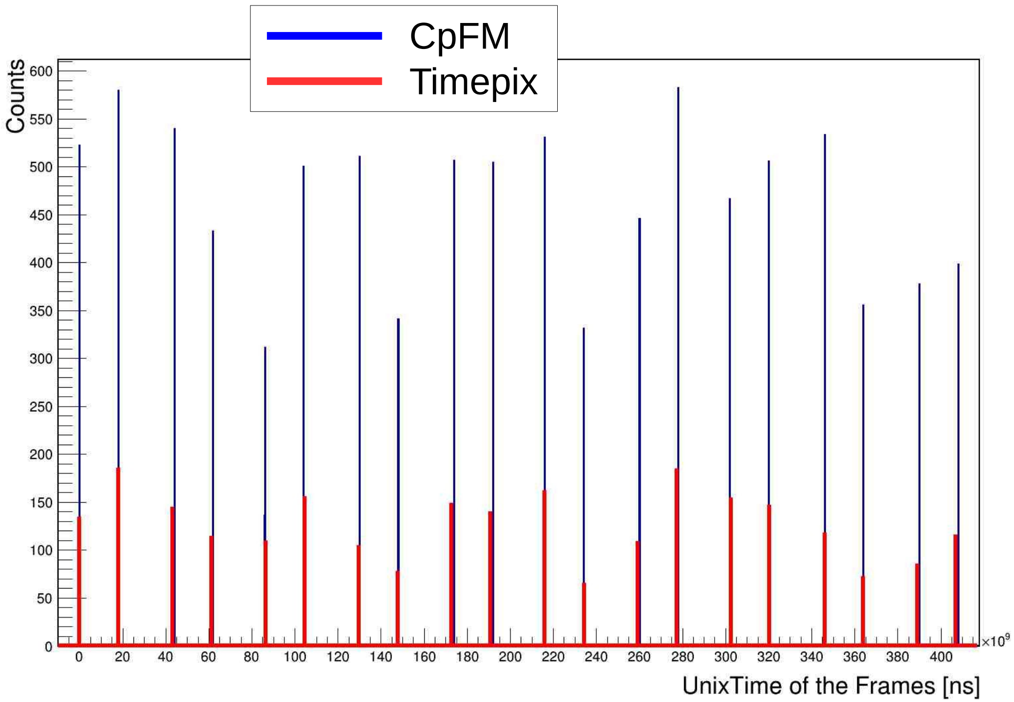
COBRA electr.:
>> 1 GS/s
>> 4 ms DAQ
>> external trig.

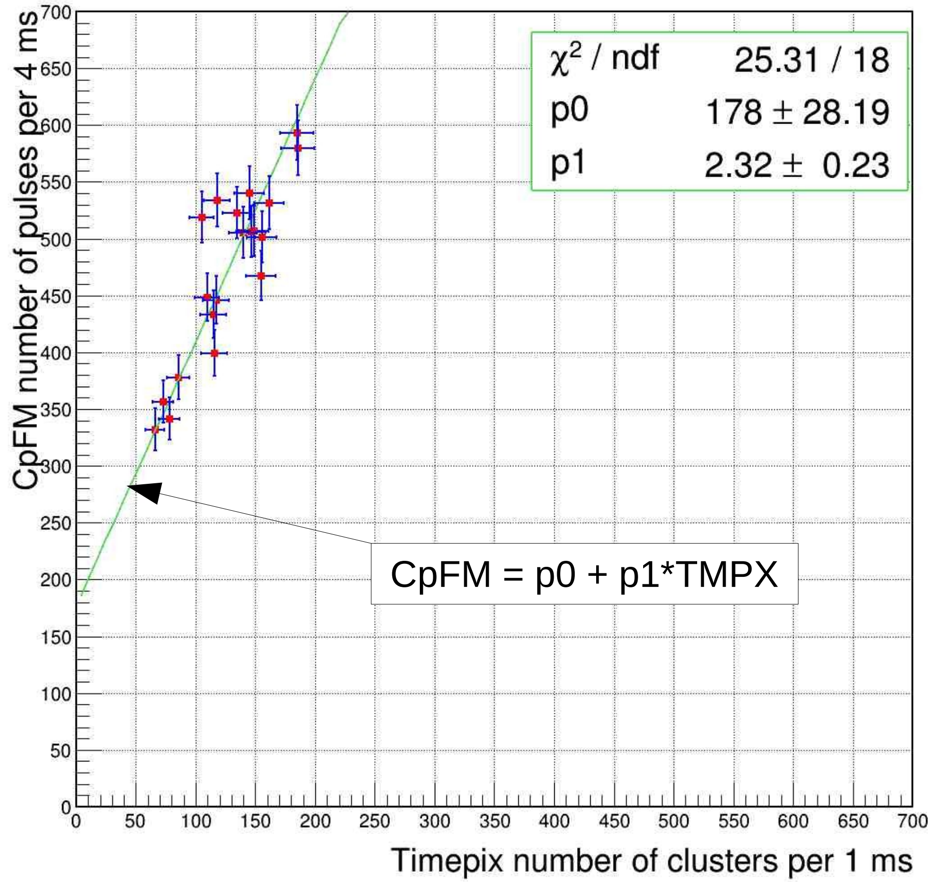
Timepix:
>> 12 MHz (83 ns)
>> 1 ms DAQ
>> external trig.

DAQ:
20 Frames

Beam:
~1e5 p/s

Timepix & CpFM. Synchronization and linearity





Conclutions

→ Timepix detectors which were already tested at SPS energies and fluxes showed very good results.

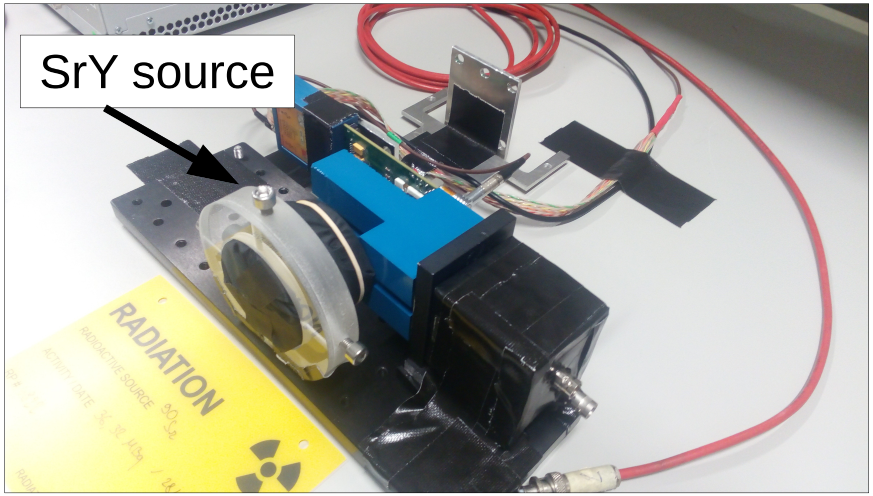
→ Due to DeadTime of Timepix + Fitpix we lose 88-99% of useful data.

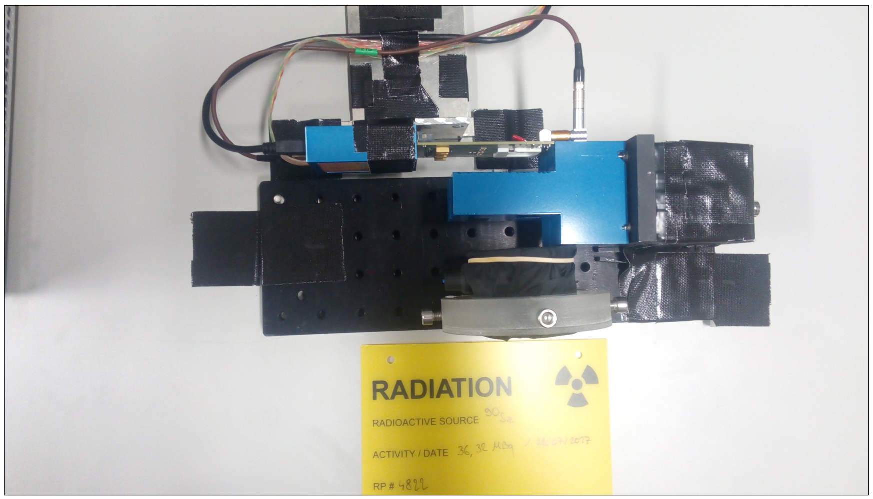
→ The possible solution is to use Timepix3 with Katherine electronics with which we lose <1% of data and are able to follow beam evolution in time with 1.56 ns resolution.

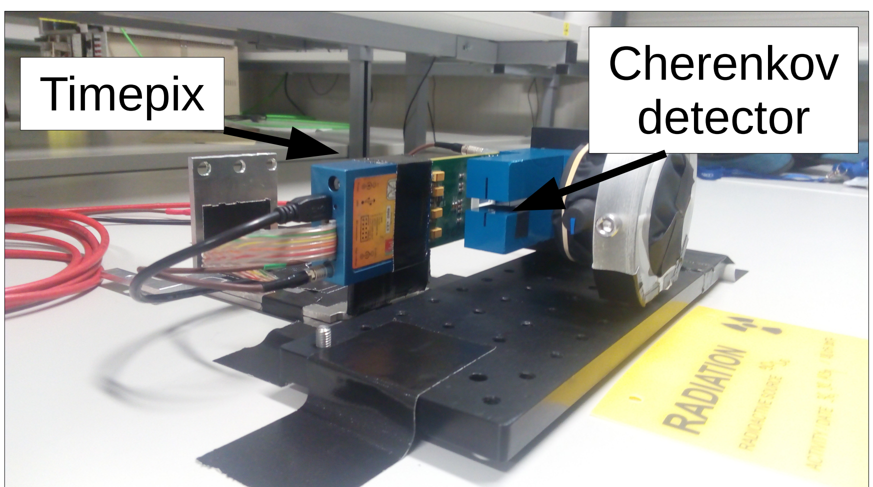
→ Due to the fact that Timepix (Timepix3) is (will be) inside RomanPot (RP) it produces secondaries from interactions with primary beam halo.

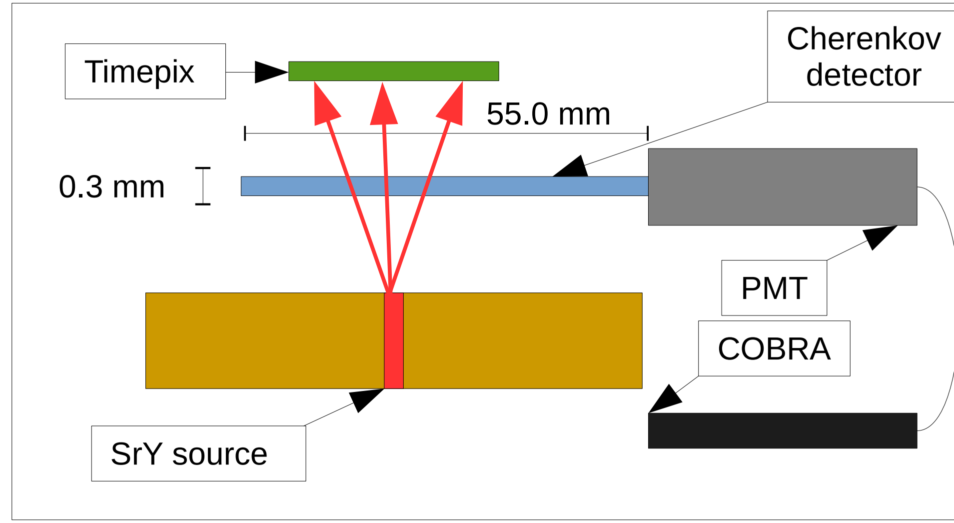
Additional slides

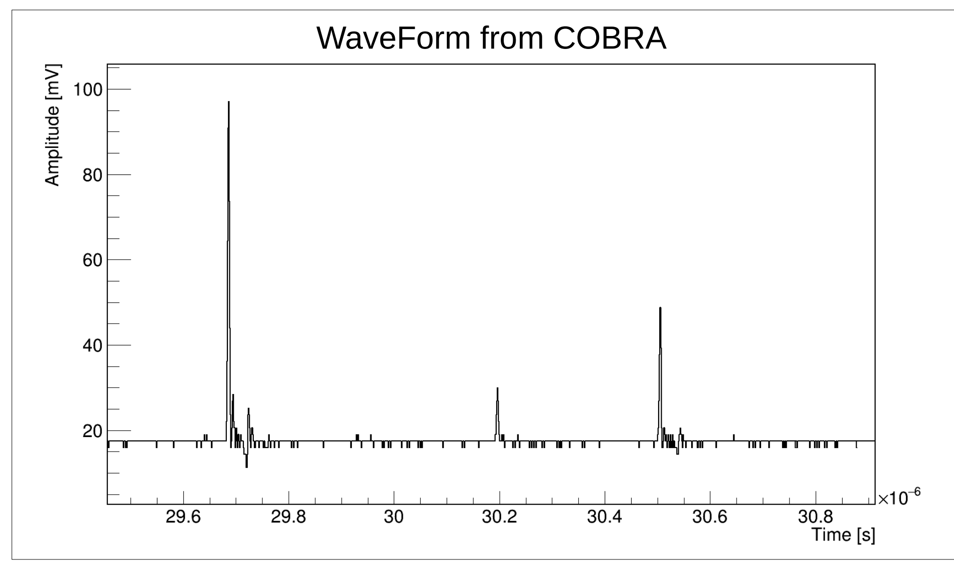
Test with beta-source.
Investigation/Studying of the COBRA electronics
August 2017



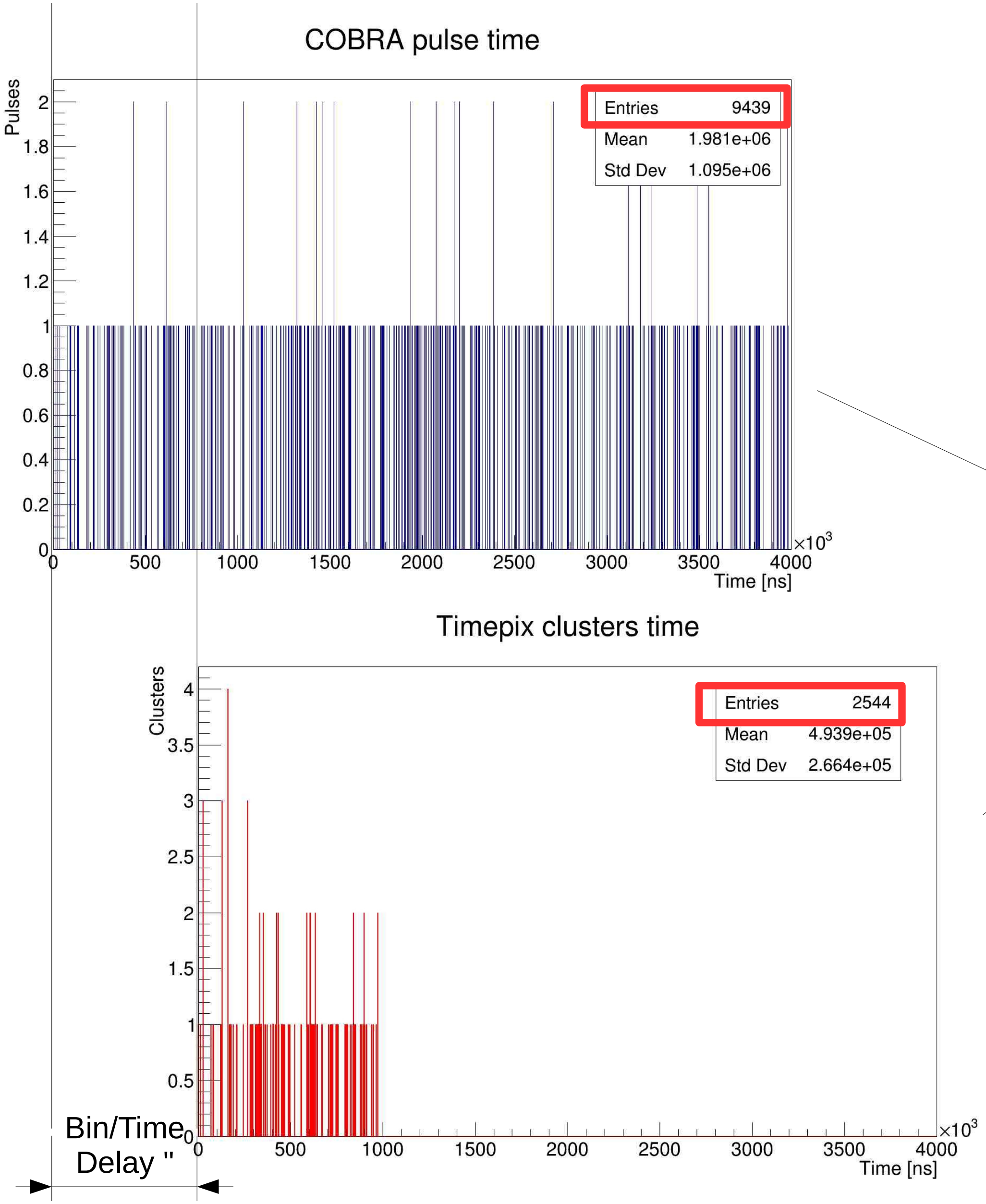


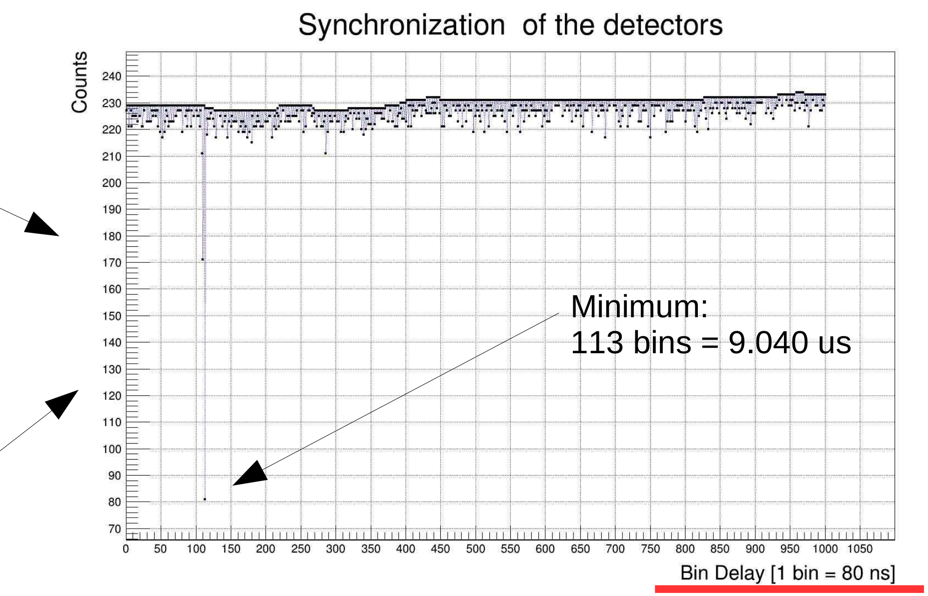






Synchronization method





Difference between histograms