Status on Z resolution of the Asian module with 2016 data

2nd LCTPC Topical Analysis Meeting :
z resolution and evt time

- Rough view for Z resolutions using 2016 beam data
- Simulation on behavior of the Z resolution (with very personal opinion)

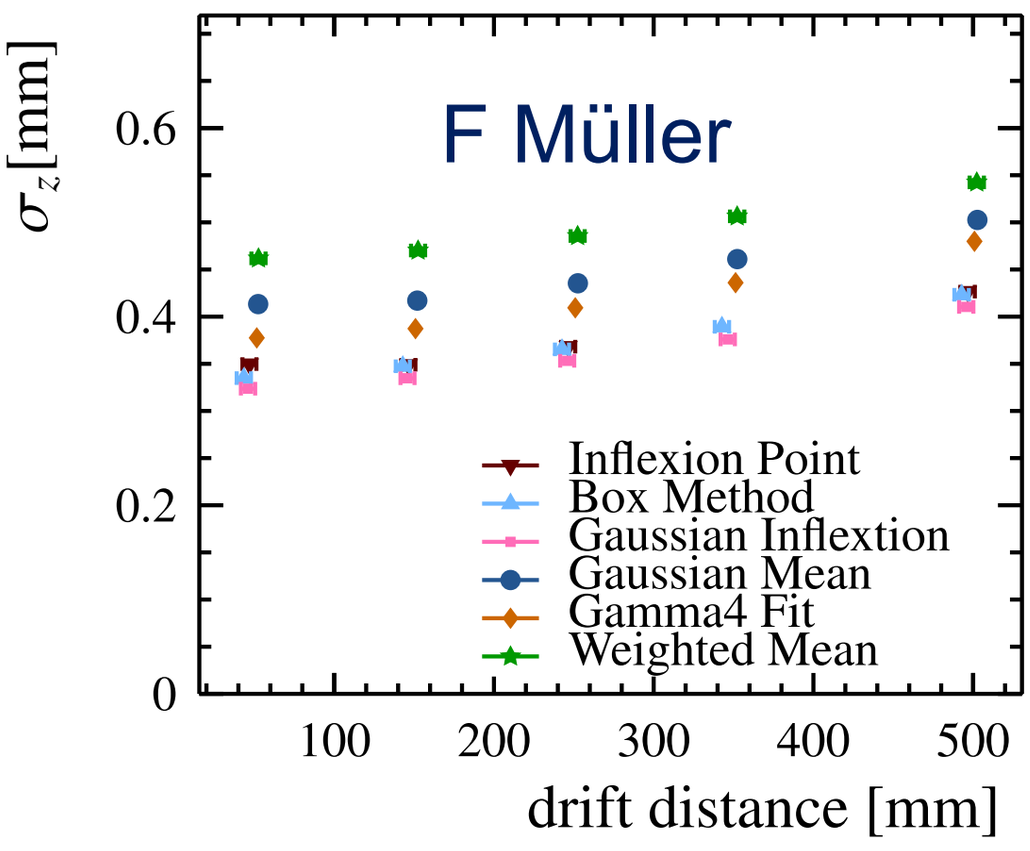
Time Estimators

A first important choice is a time estimator

It was well studied for GEM and Micromegas modules

DESY GEM

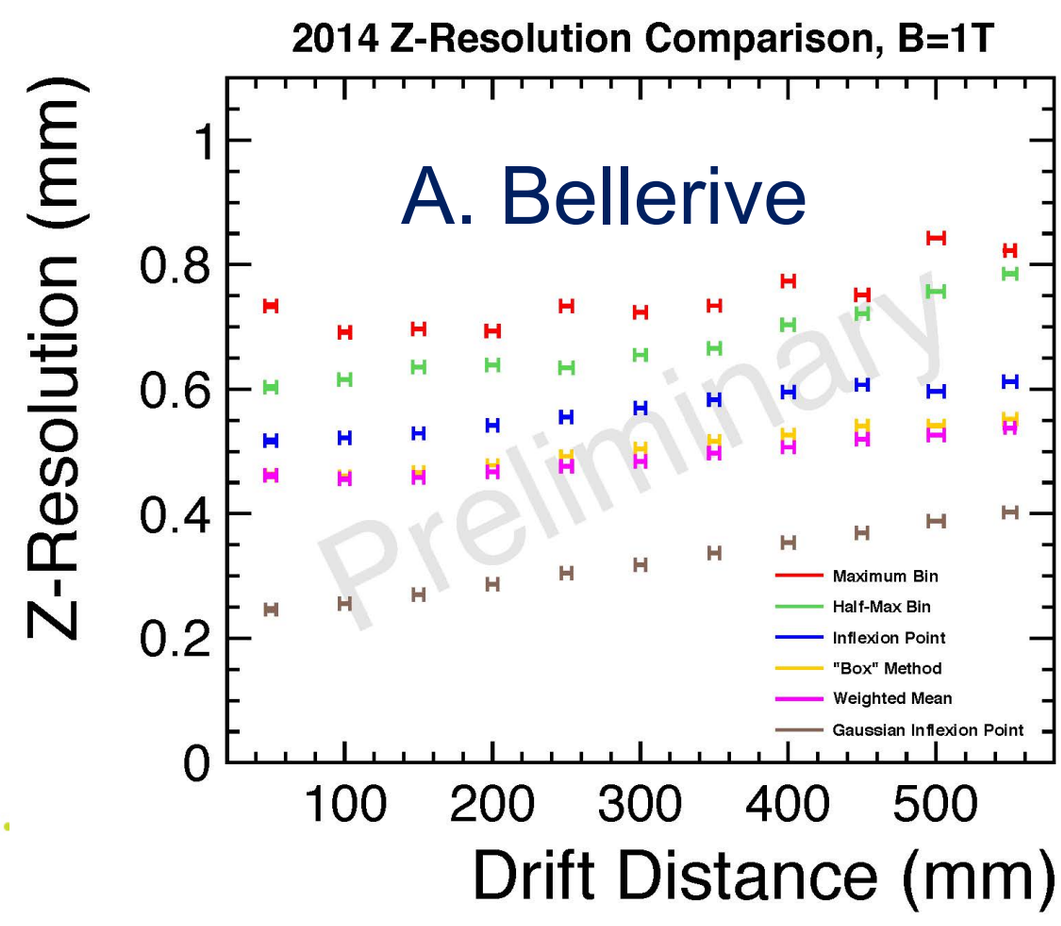
http://bib-pubdb1.desy.de/search?cc=Publication+Database&of=hd&p=reportnumber:DESY-THESIS-2016-018



(b) $B = 1$ T

Micromegas

https://agenda.linearcollider.org/event/6712/contributions/32958/



Time Estimators

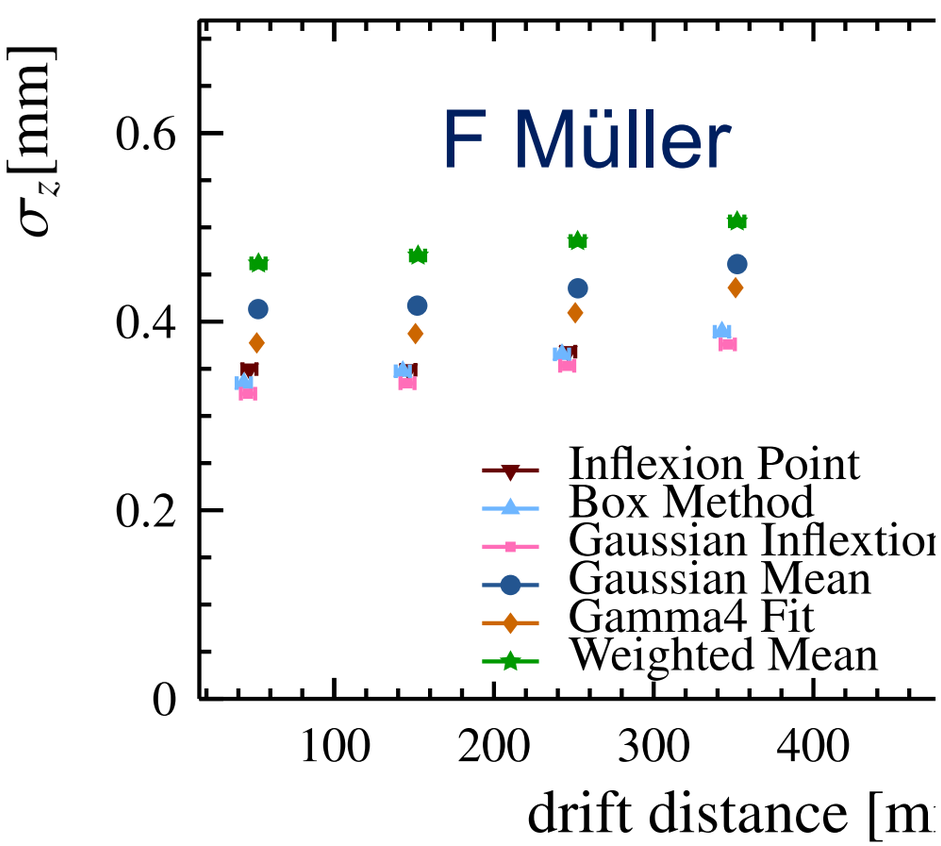
A first important choice is a time estimator
It was well studied for GEM and Micromegas modules

Hit time is { maximum pulse time or
charge weighted mean

Cluster time is given
as a inflection point.
(Marlin default)

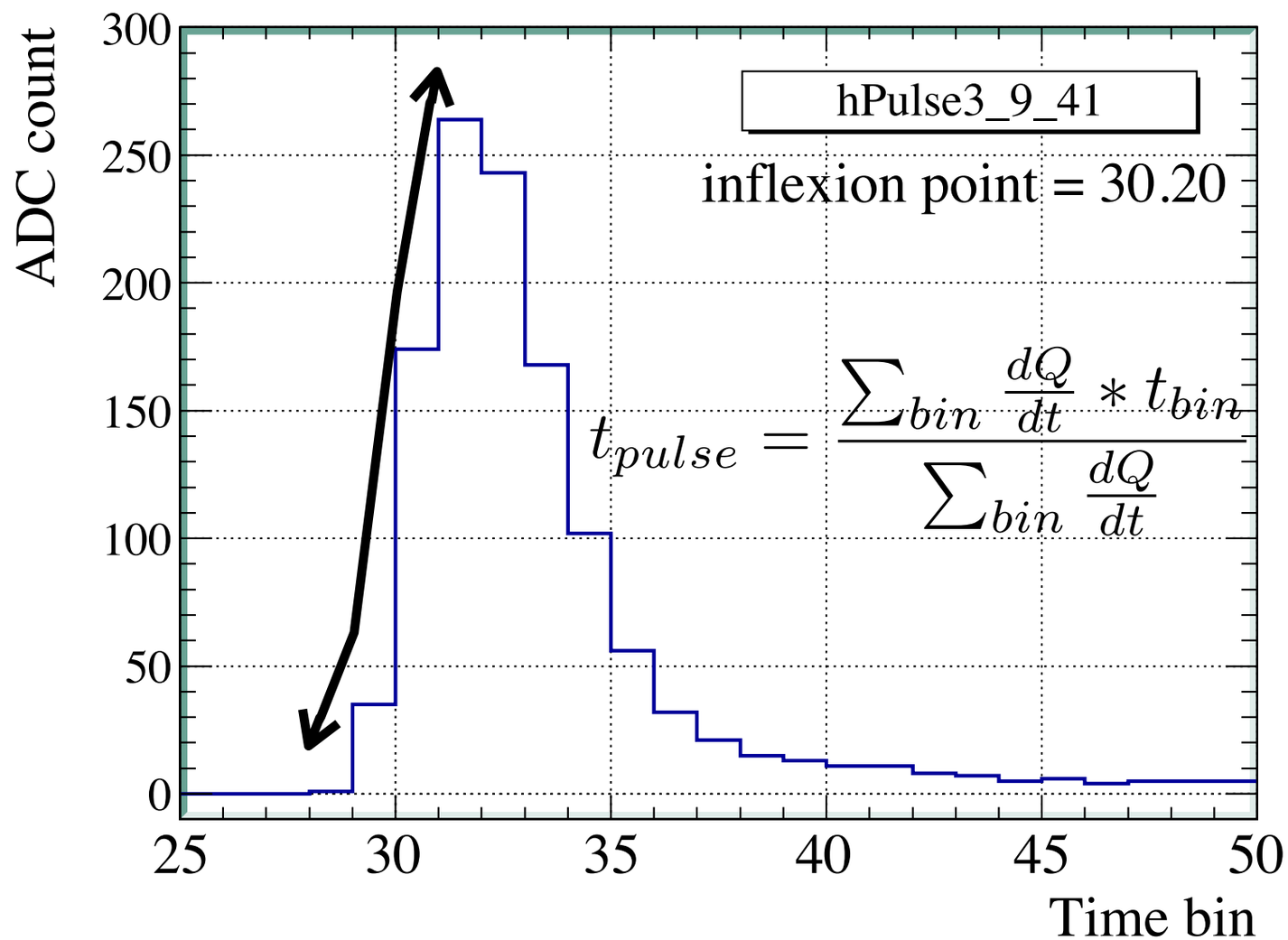
DESY GEM

http://bib-pubdb1.desy.de/search?cc=Publicatior
+Database&of=hd&p=reportnumber:DESY-THESIS-201



(b) B = 1 T

Row pulse distribution in certain pad



Z resolutions

Track quality cut:

full data : 20.0 k events

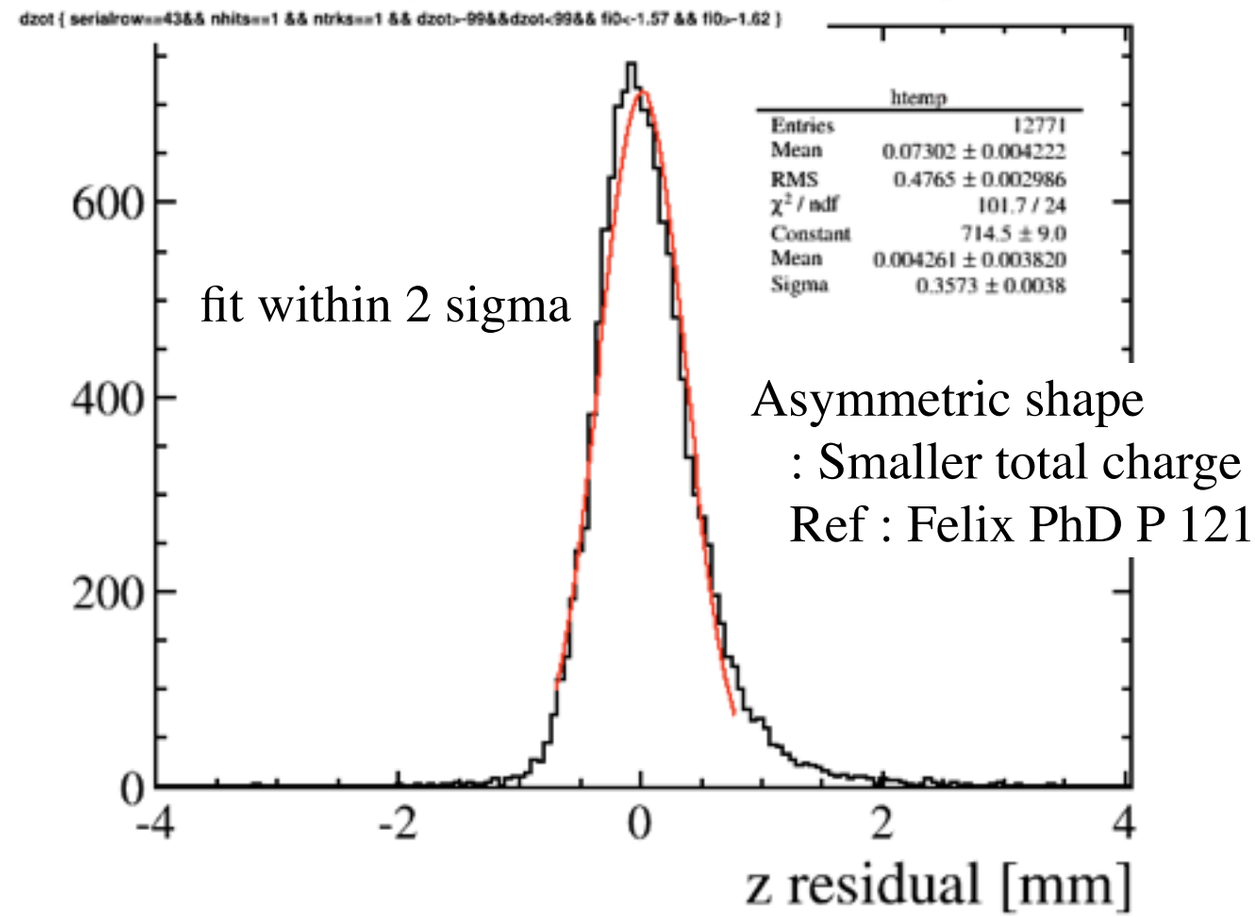
1 track in 1 event : ~16.5 k events

ϕ angle is 0 : 12~13 k events

(a peak is at ϕ~3°)

→ 80% usage of 1 track events.
(no optimize)

Exclude myself from the track fitting



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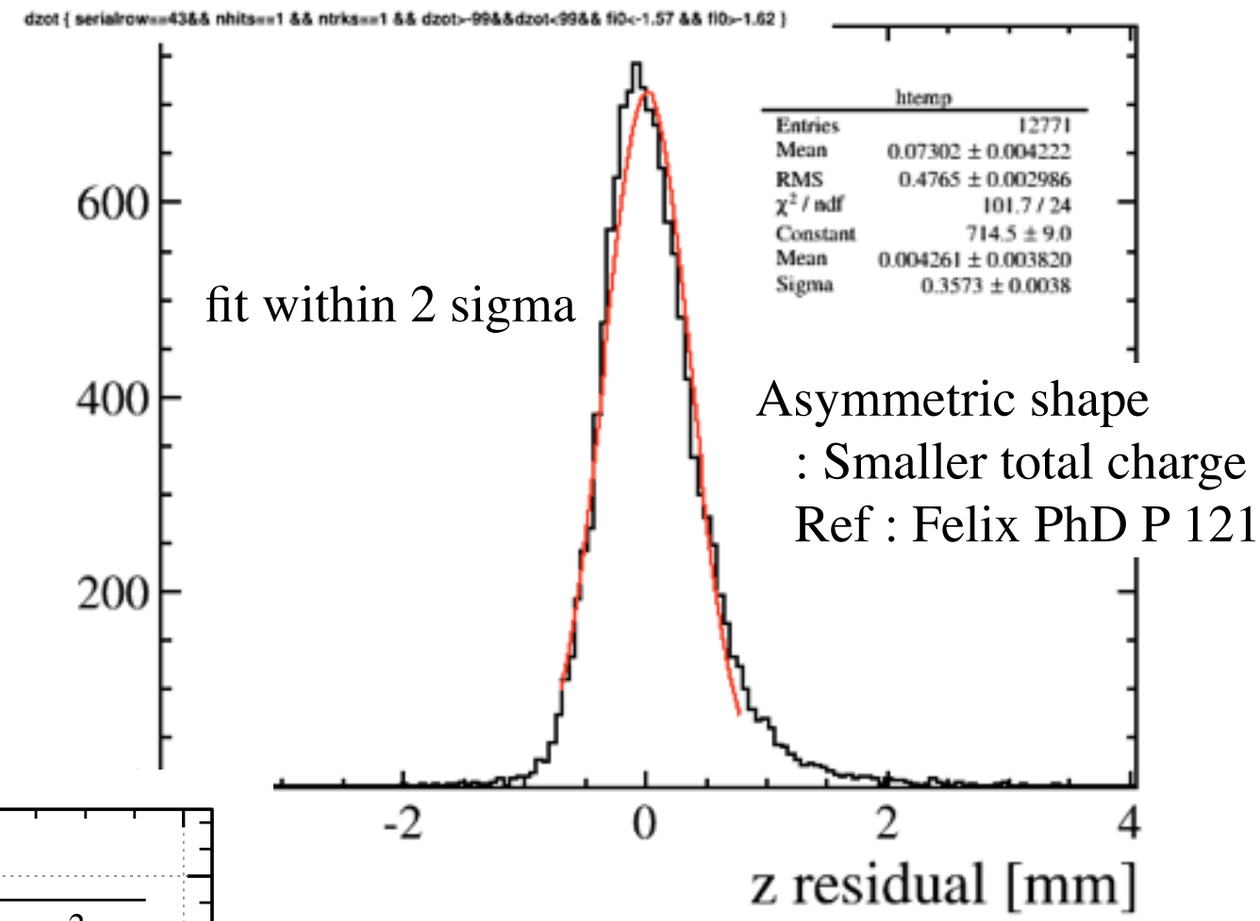
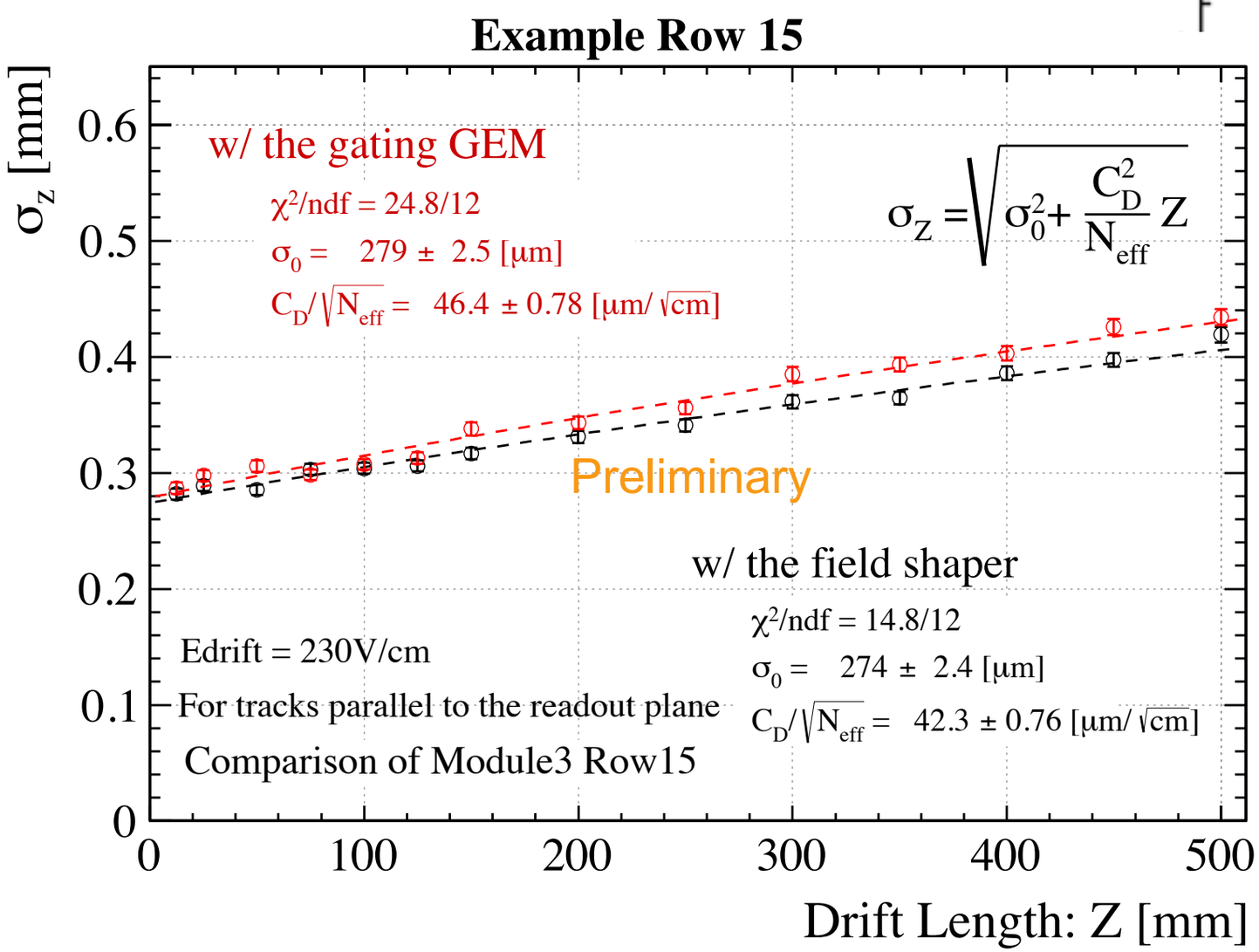




○ Evaluated **Neff** for 2 modules.

Ave. of the central (picked up) 20 rows.

the ion filter : Neff = 22.3 ± 0.7

the field shaper: Neff = 27.0 ± 0.9

(Fix longitudinal Cd=220 μm/√cm)

Ratio of the **Ave. Neff** ~ 82.7 ± 3.8 %

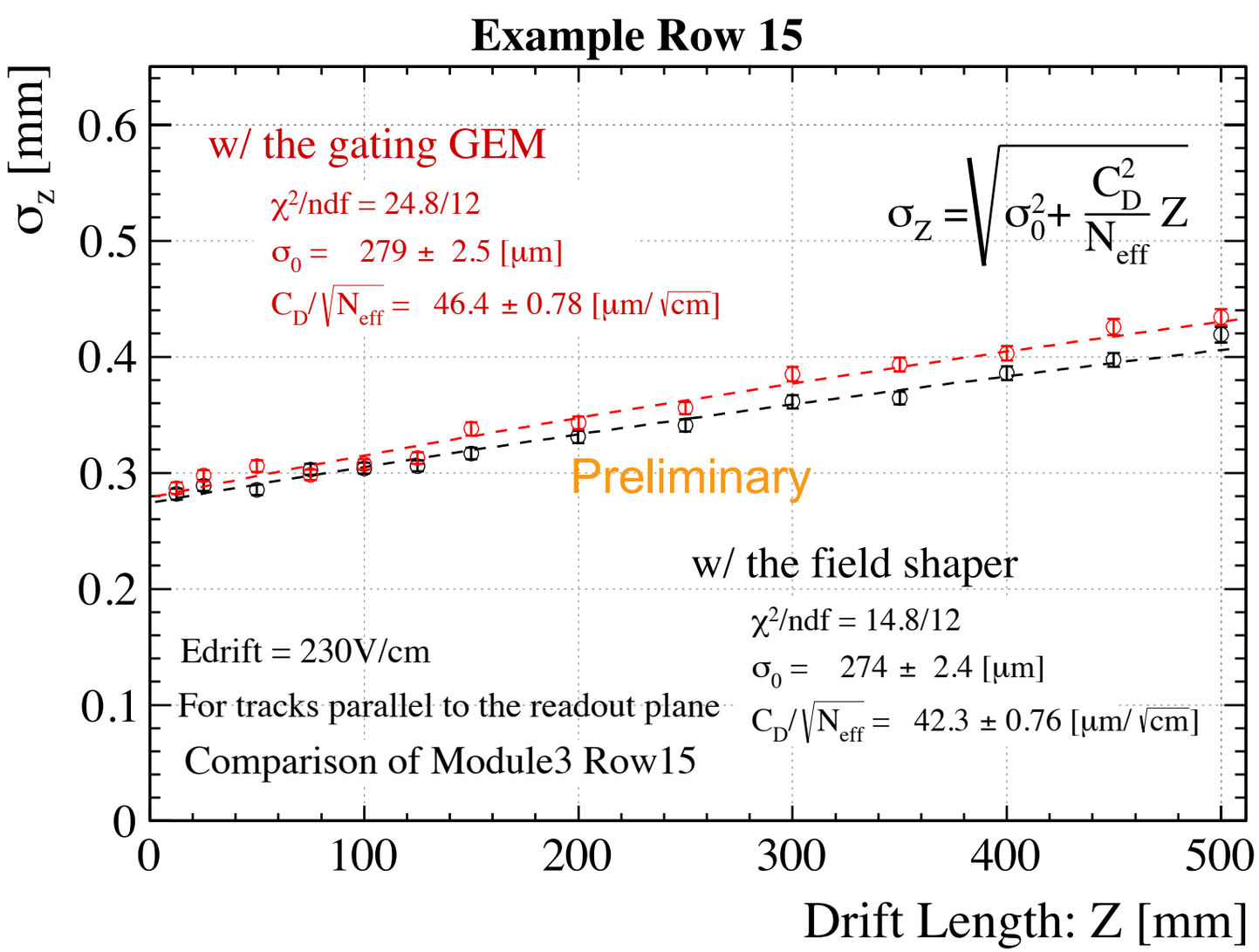
Z resolutions

○ **MIP scale** → Energy loss factor : **1/1.4** (HEED simulation)

○ **Resolution σ_Z ~ 865 [μm]** with the full drift length of 2.2 m

Ave. σ0 (w/ the gatingGEM) = 269.7

Up to here, already results were shown in IEEE17, so, may be no interest….



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Simulation on Z resolution

Detailed Simulation of Large Prototype TPC
Testbeam Data

Astrid Münnich
DESY, Hamburg

September 29, 2014

https://agenda.linearcollider.org/event/6783/

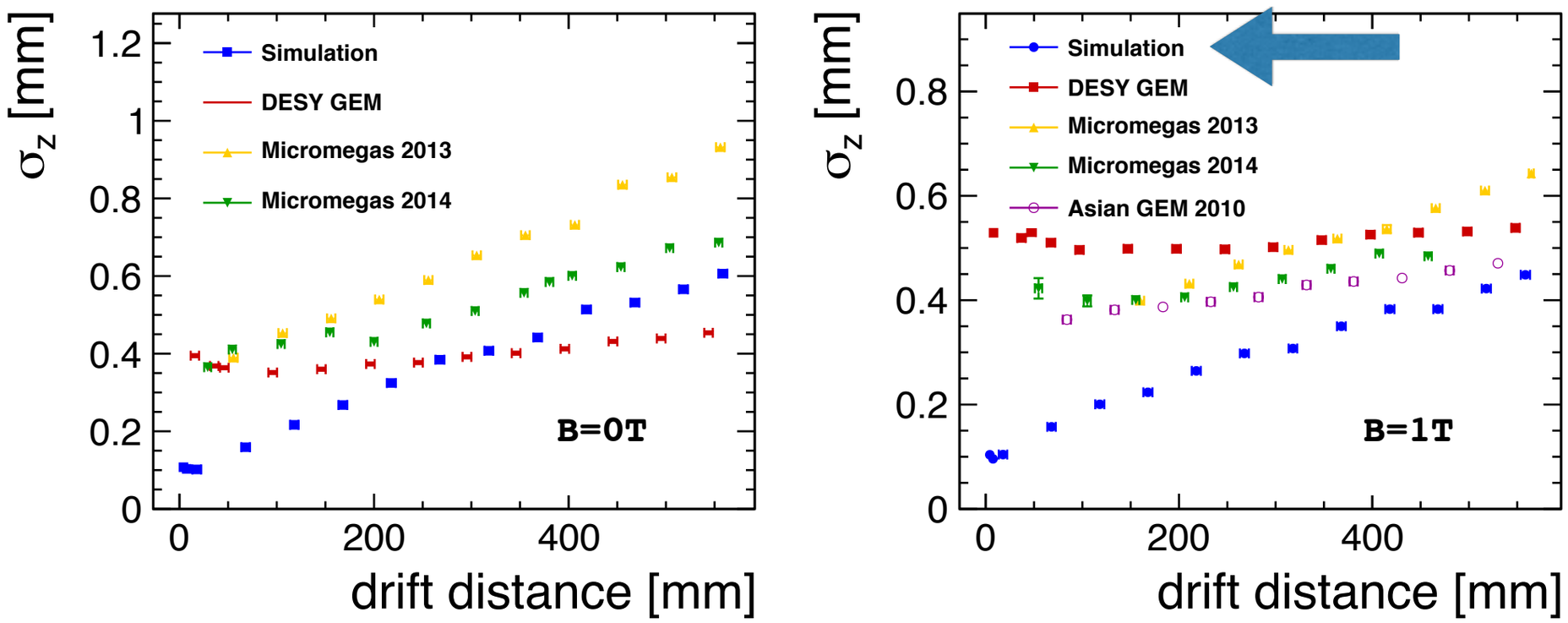


Figure 11: Single point resolution in the z direction for simulation and different data sets without magnetic field (left) and for 1 T (right).

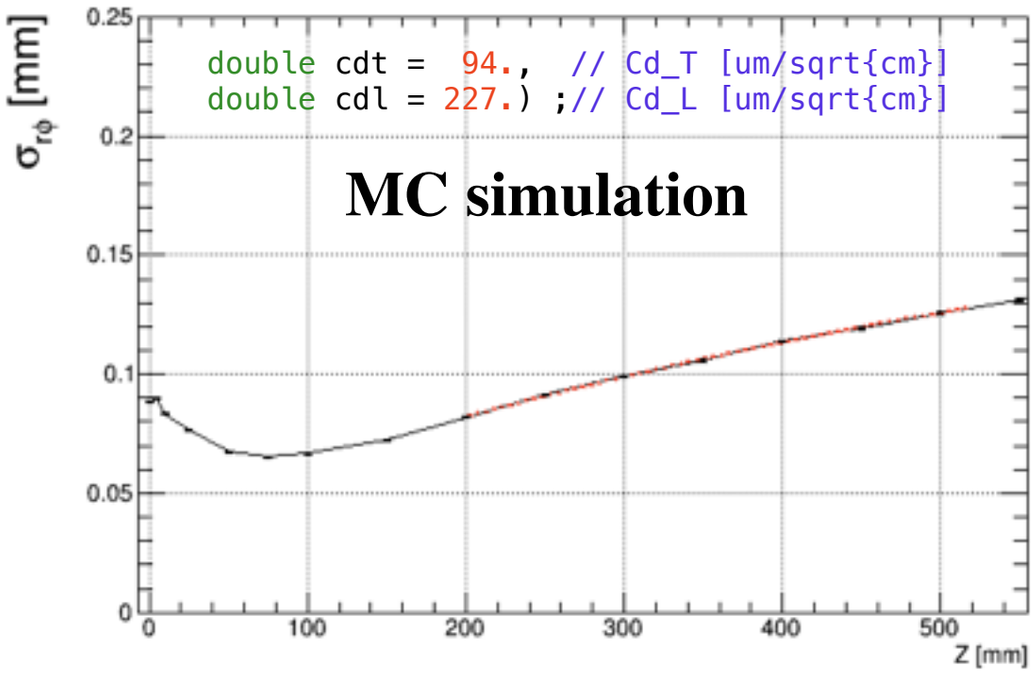
The large difference, She implies in her report,

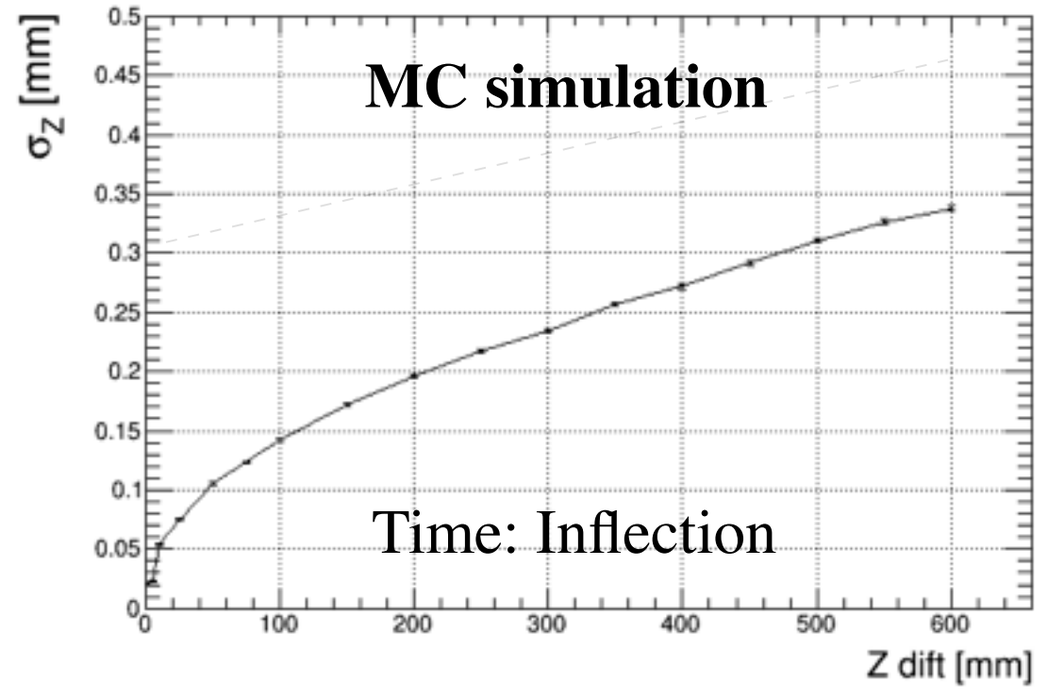
> We suspect that there is some part in the electronics that dominates over the fact that the charge is spread out in time,

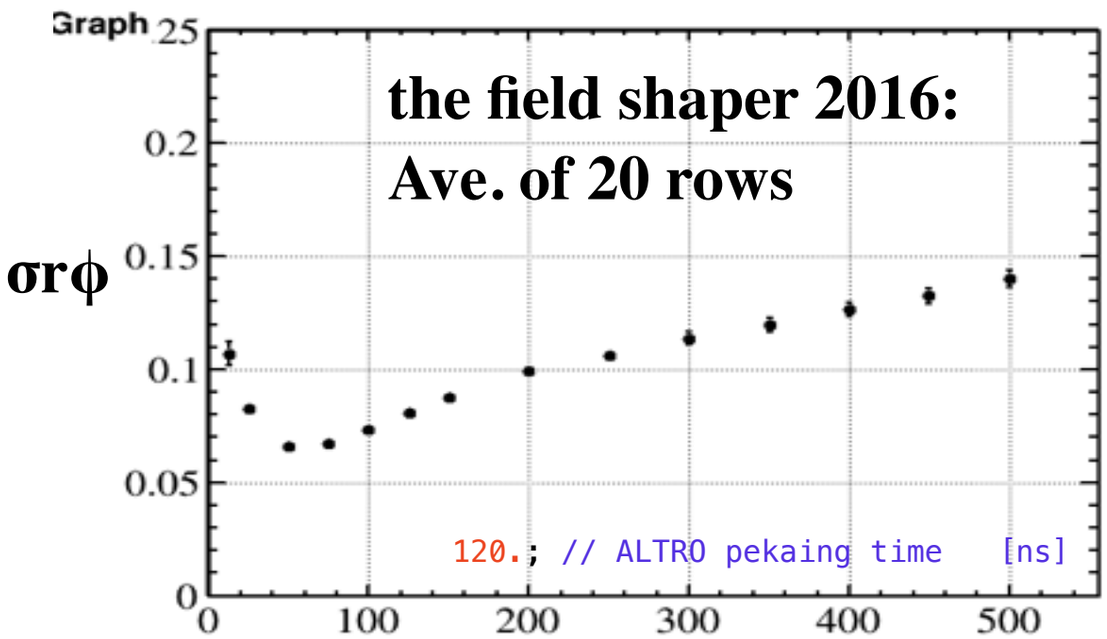
Simulation on Z resolution

Fujii-san has a private simulator for MPGD based TPC

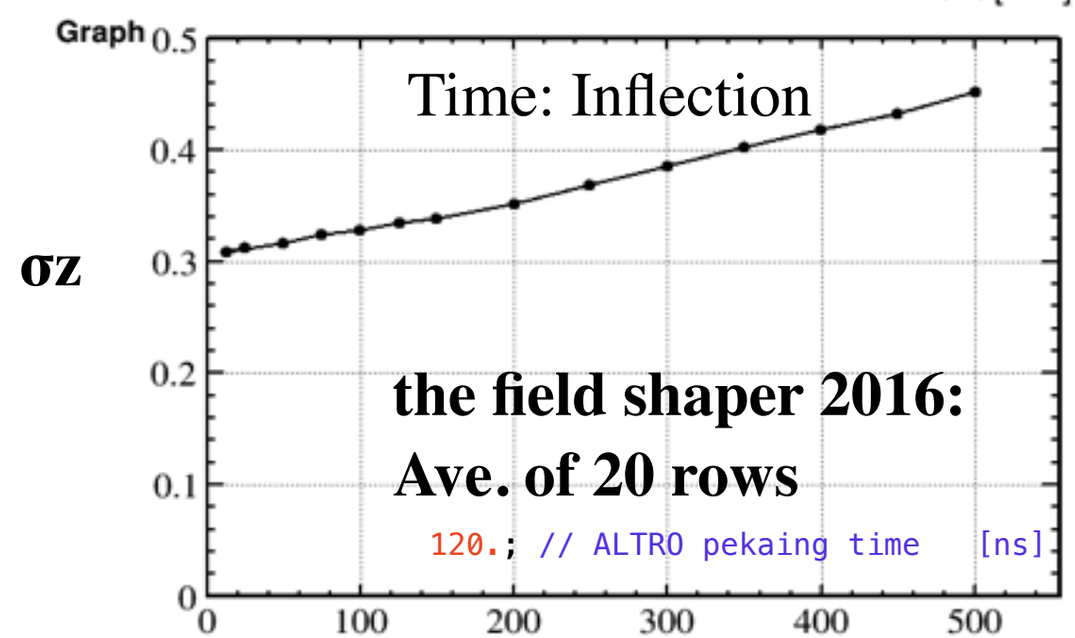
```
// ----- PASA
const double tpk0  = 120.; // pekaing time   [ns]
const int    n0    = 4;    // shaper order
const double w0    = 50.;  // time bin width [ns]
const double noise = 5.;   // noise count
// ----- GEM
double sgprf = 0.27; // sigma_PRF  [mm]
double wpad  = 1.25; // pad pitch  [mm]
double lpad  = 5.20; // pad length [mm]
double len   = 10.;  // seg length [mm]
double nav   = 30.;  // <#primary ionizations>
       nav  *= 1.4;  // 5 GeV electron > MIP
double vd    = 77.;  // drift velocity [um/ns]
```







Good agreement



Bad agreement, what is it?

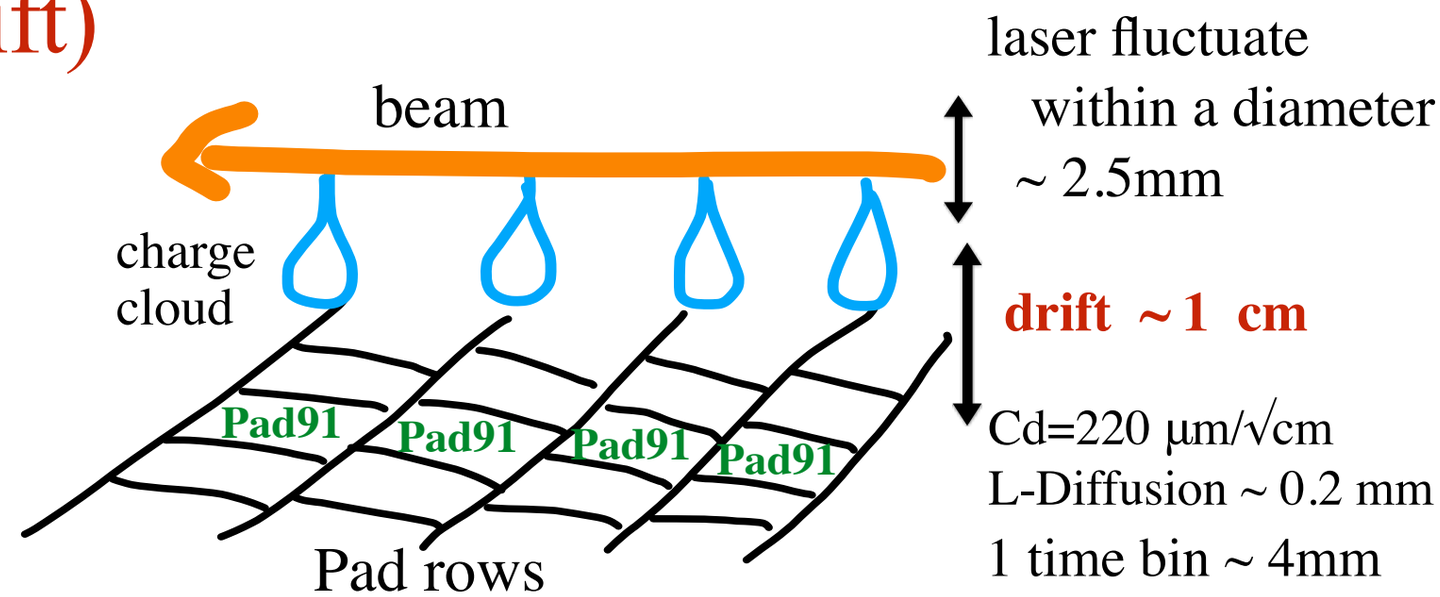
Cluster time (very short drift)

Our Lab. has ALTRO and Laser system

If every channels synchronously
start sampling, pulse time should be same

especially for very short drift data
and pads located in same pads.

Z of laser shot is same position
drift is extremely small ~ 1 cm



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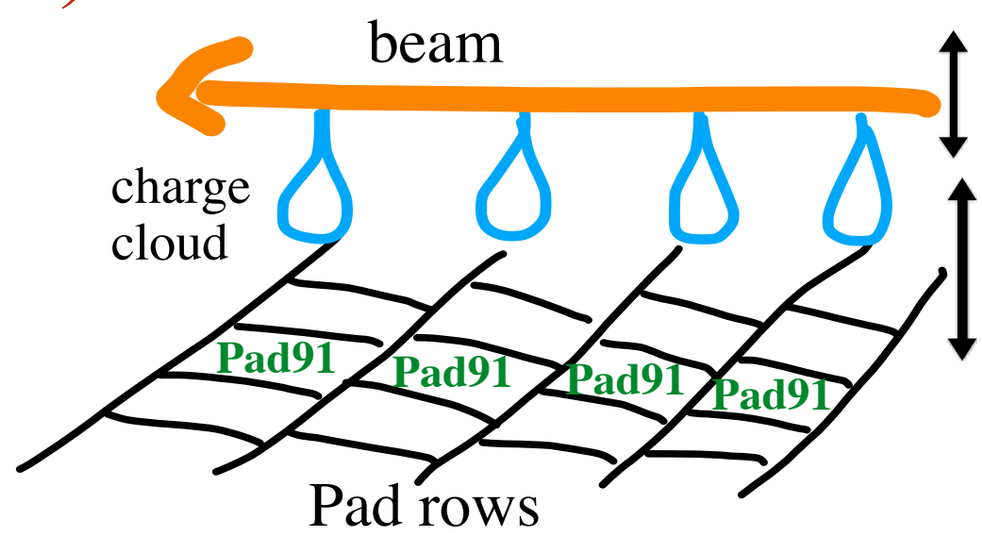
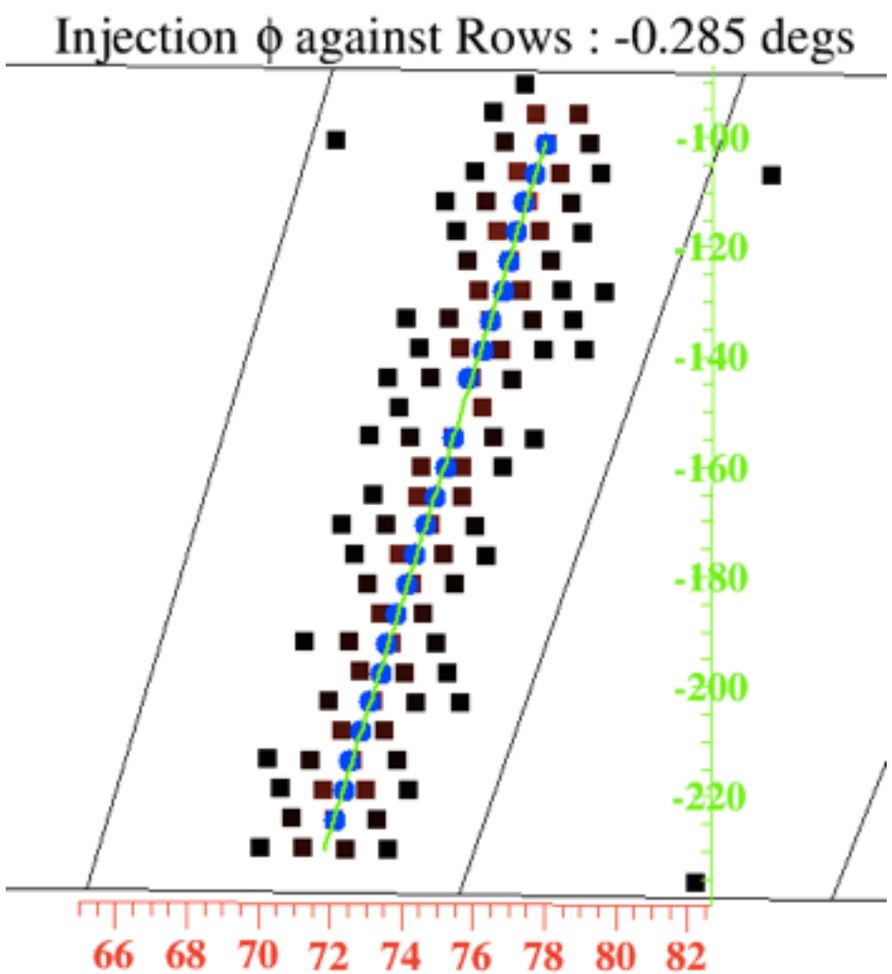
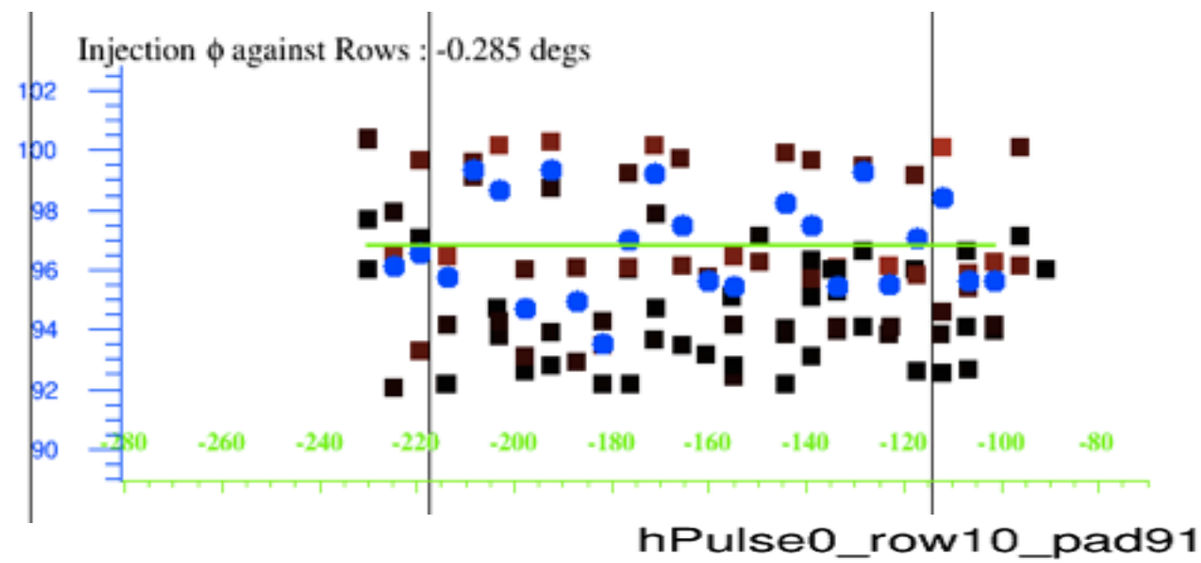


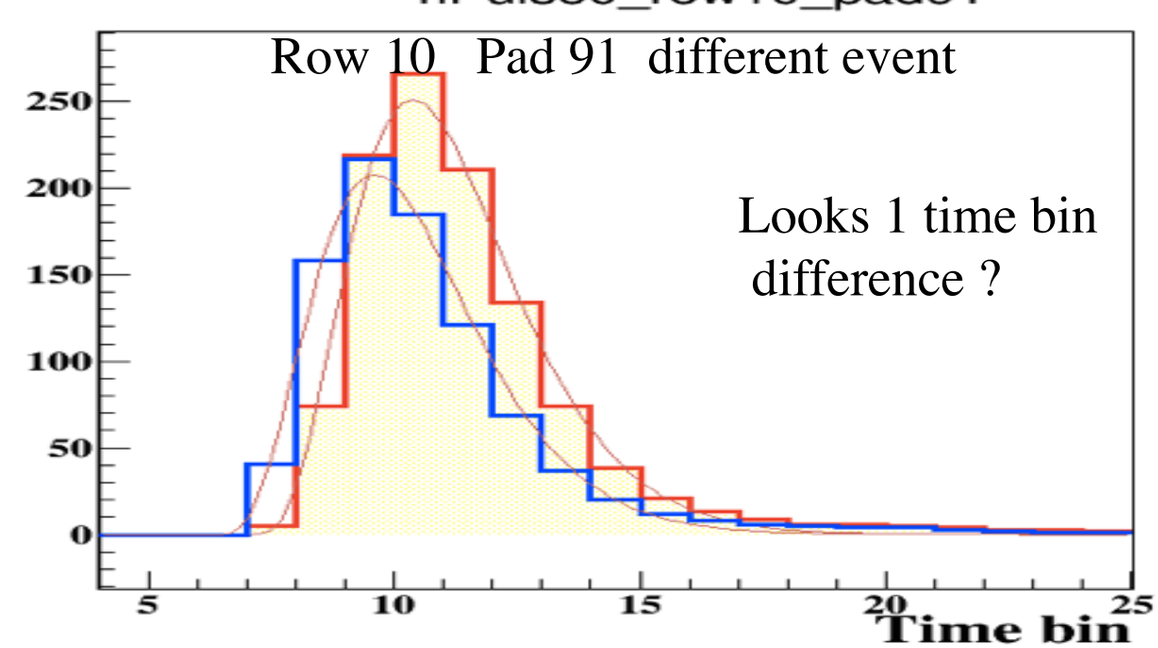
laser fluctuate
within a diameter
~ 2.5mm

drift ~1 cm

Cd=220 μm/√cm
L-Diffusion ~ 0.2 mm
1 time bin ~ 4mm



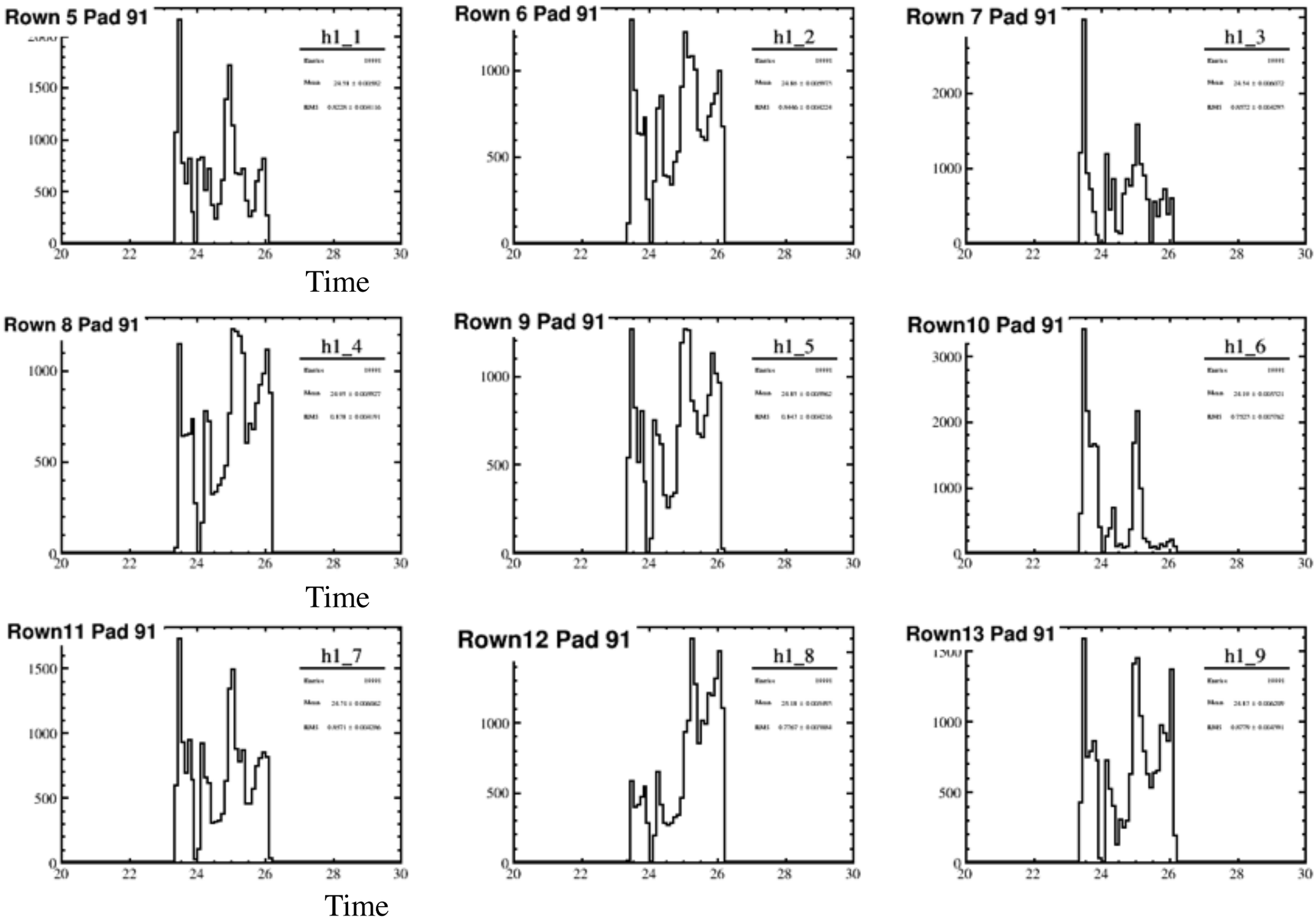




Cluster time (very short drift)

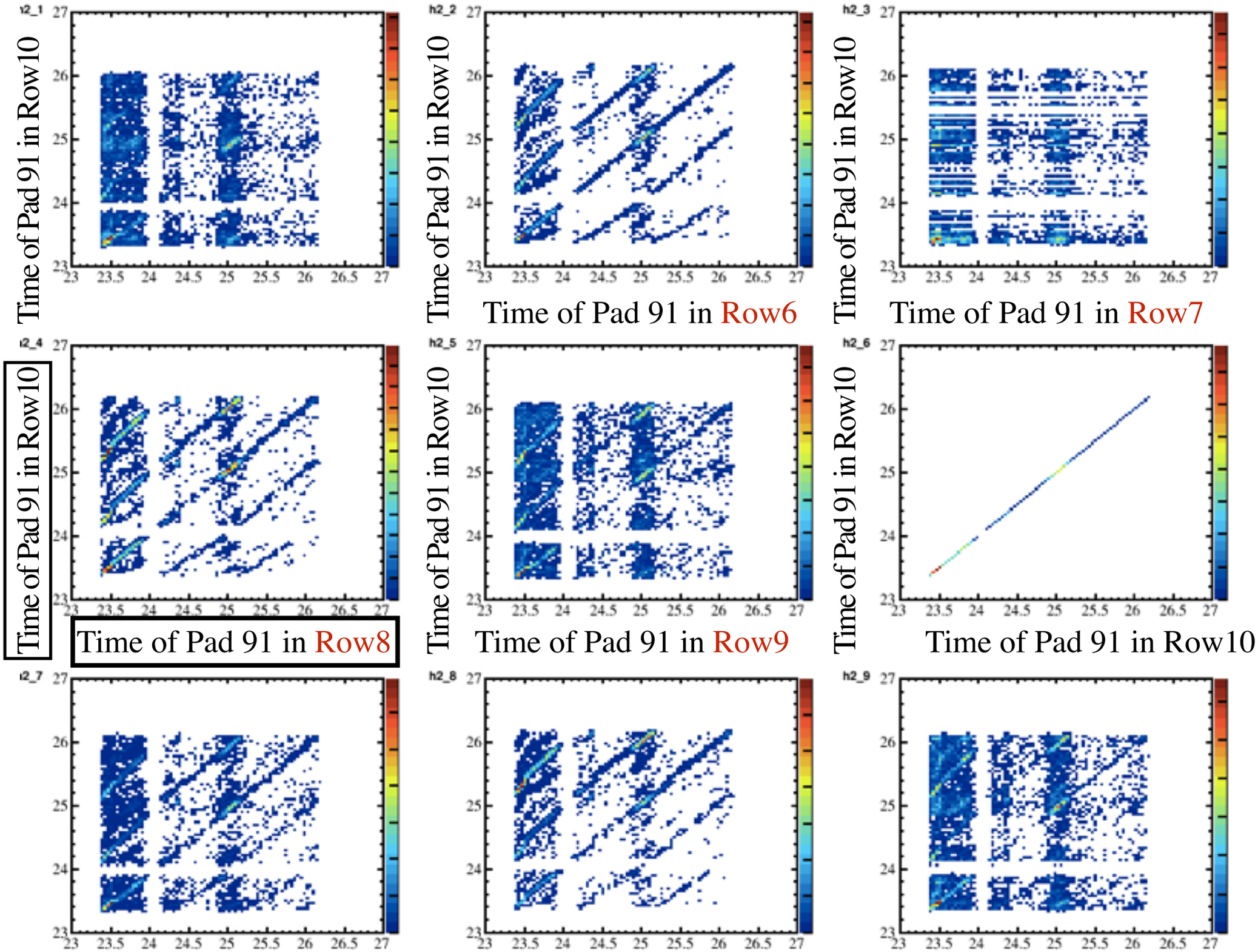
24 * 50 ns * 77 mm/ns
92.4 mm
unit is 10 times difference ?

Cluster Time distribution of Pad 91 in each row
Time Estimator : Inflection Point



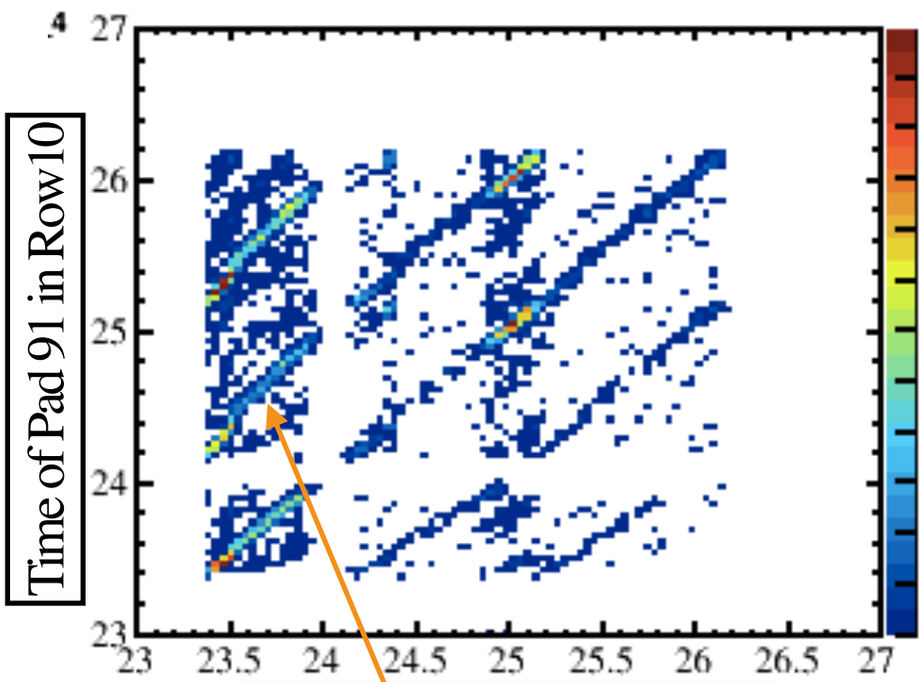
Cluster time (very short drift)

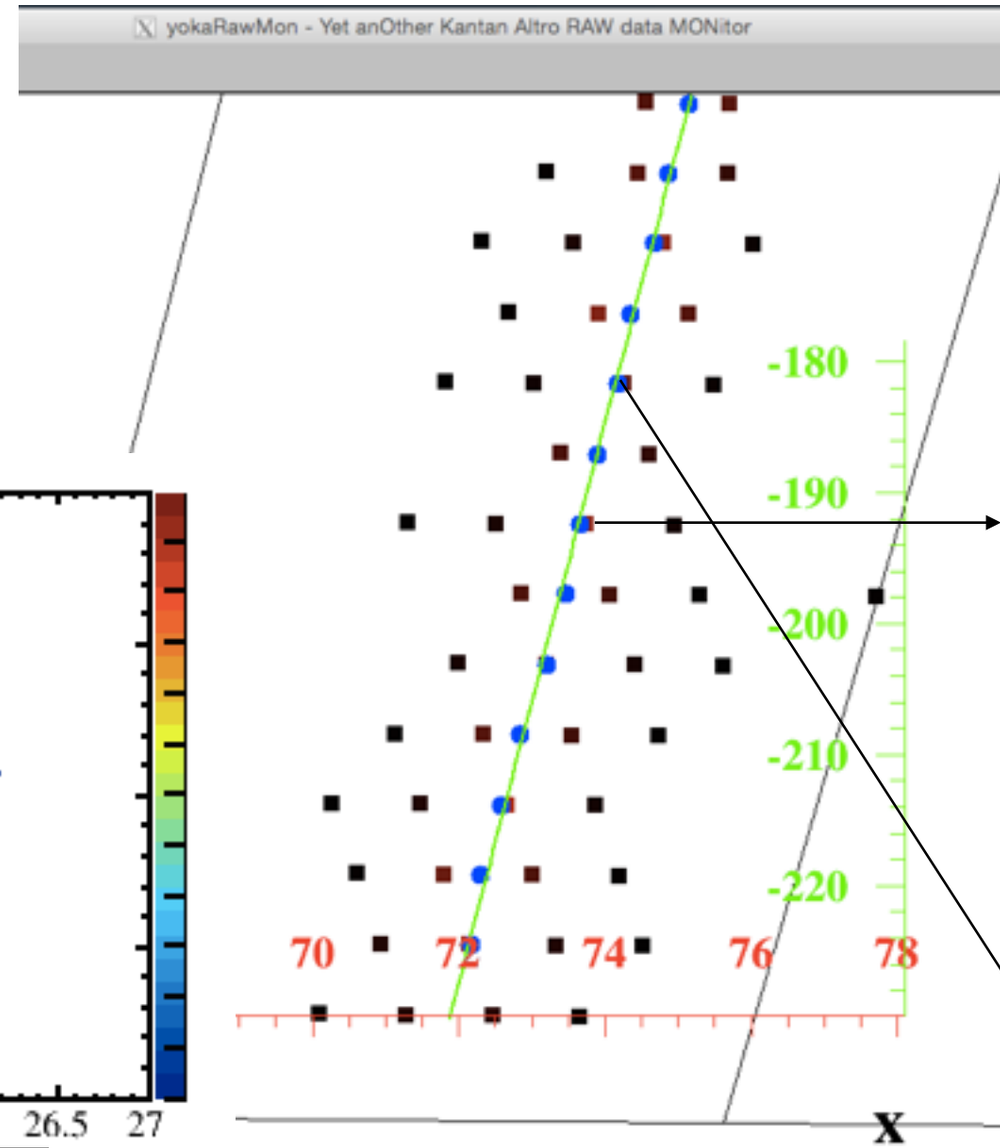
Cluster Time distribution against Pad 91 in Row10

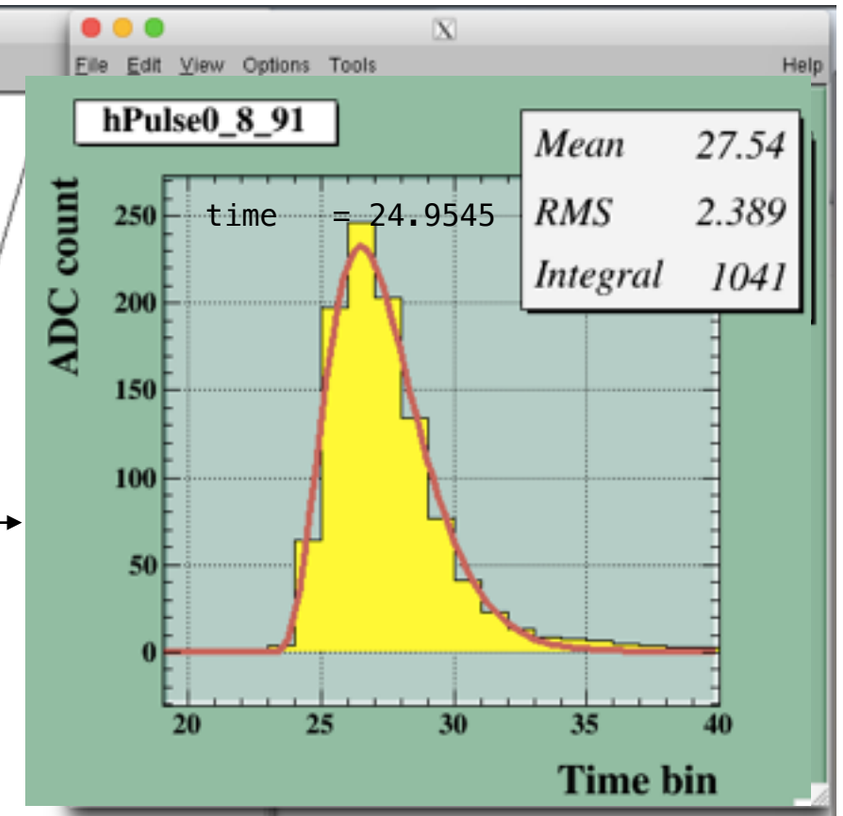


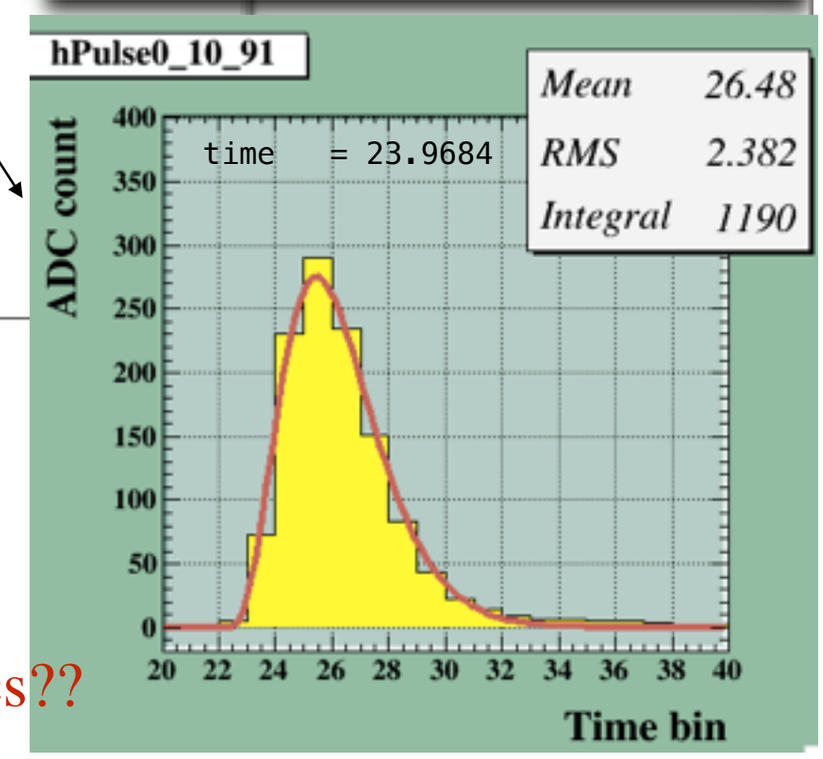
Pick up Specific event & Check Row pulse

Time of Pad 91 in Row8









Event 550

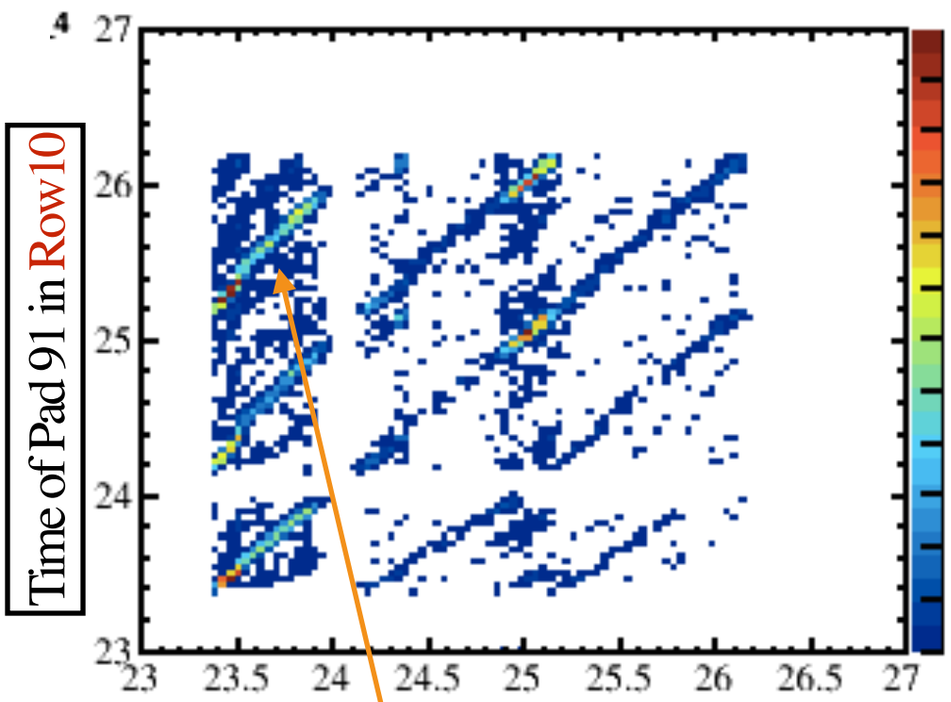
Pulse shape is similar!

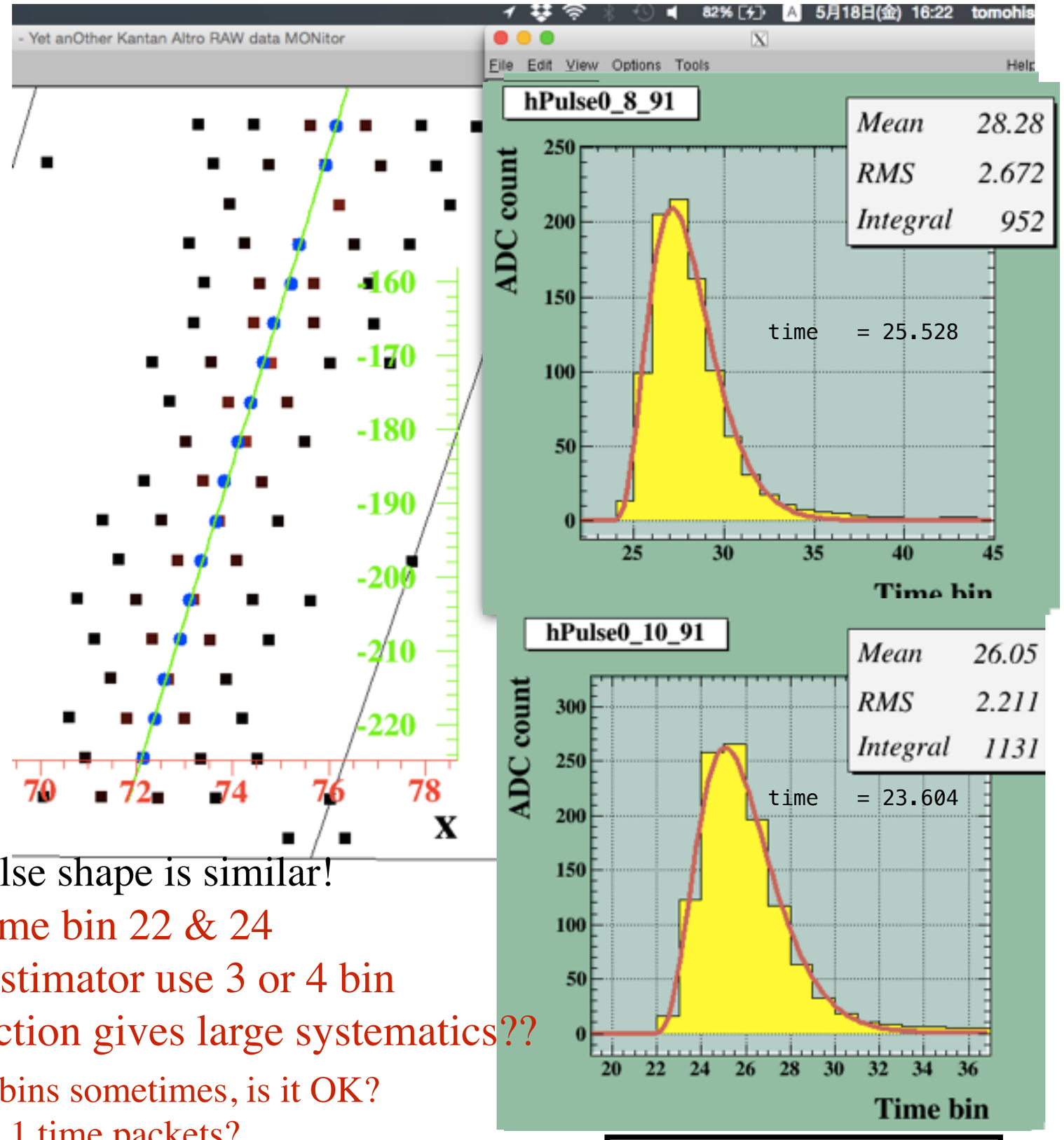
1) Start time bin 22 & 23
2) Time estimator use 3 or 4 bin
   Inflection gives large systematics??

Time of Pad 91 in Row10

Pick up Specific event & Check Row pulse

Time of Pad 91 in Row8





Event548

Pulse shape is similar!

1) Start time bin 22 & 24
2) Time estimator use 3 or 4 bin
   Inflection gives large systematics??

1) Time Estimator use only 3 bins sometimes, is it OK?
2) Electronics unsync. at least 1 time packets?

Need to check beam test data!

Time of Pad 91 in Row10

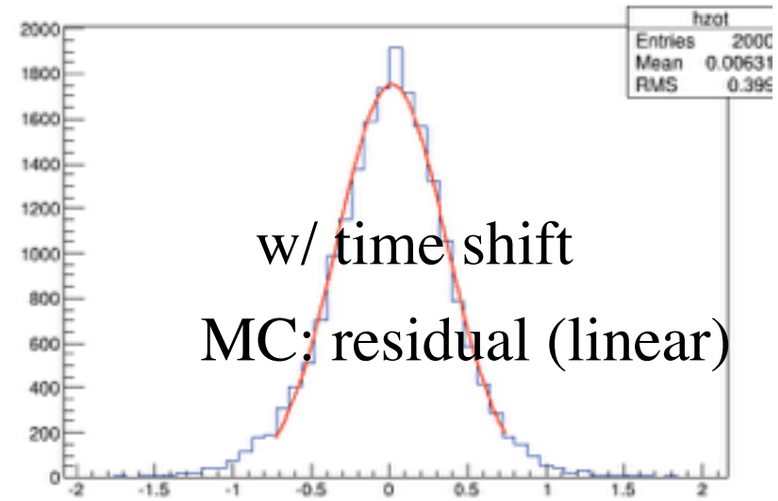
Simulation on Z resolution

Trial !

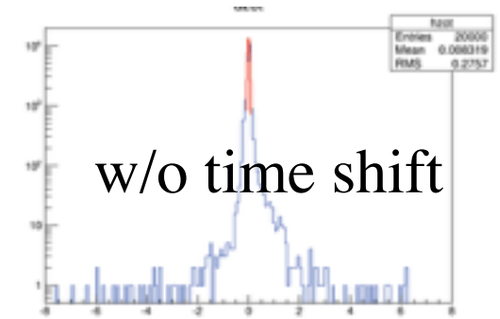
Artificially, randomly,
I include the effects of
1time bin shift in the simulation.

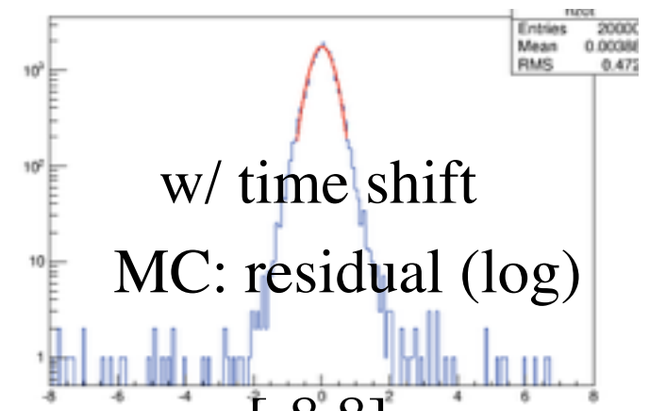
```
int shiftBin = 0.5>gRandom->Uniform(1.) ? 1:0;
```

Z Residual on certain Row



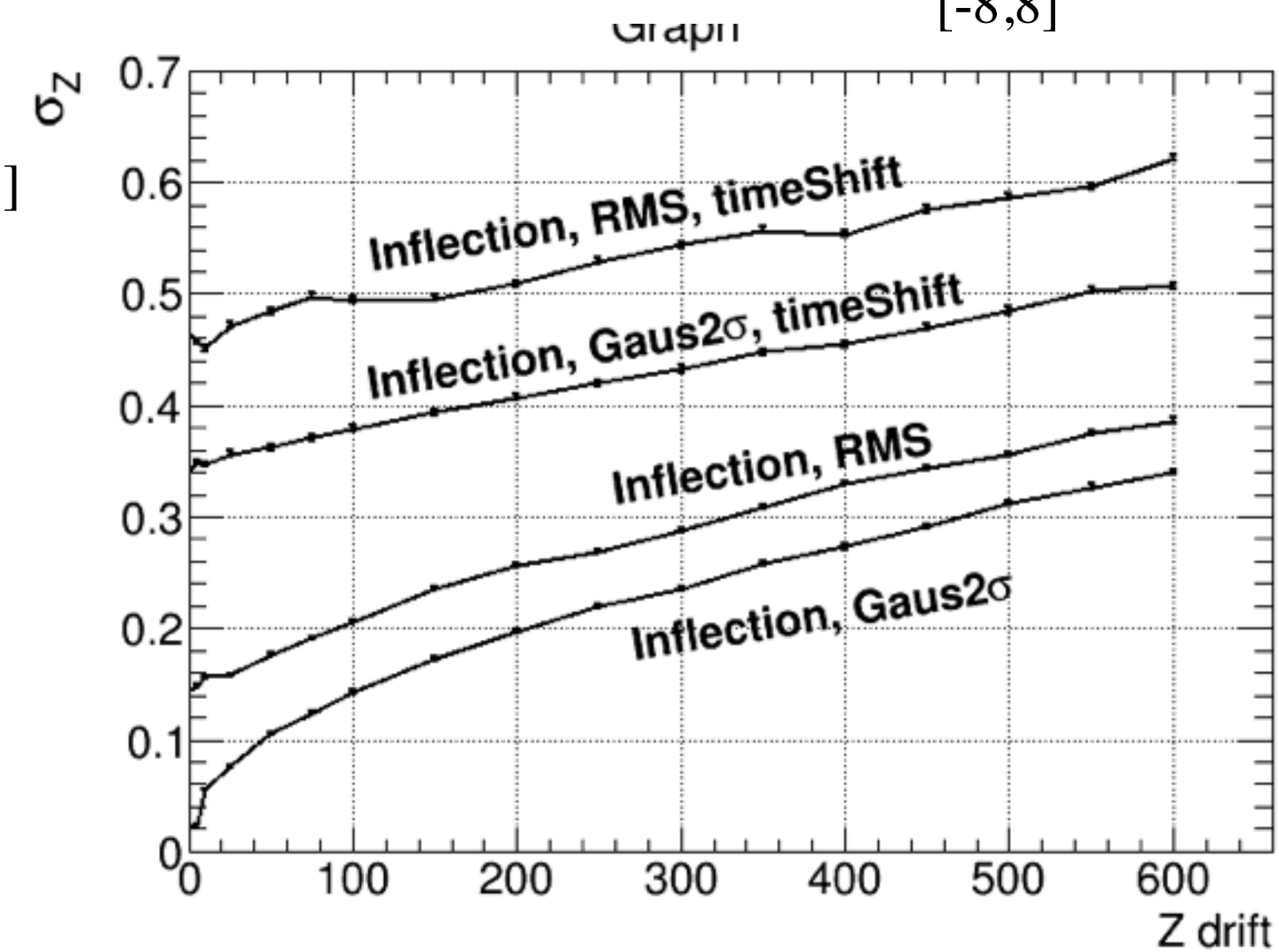
2σ fit (but no Asym shape)





[-8,8]

Time: Inflection
Resolution: Gaus 2 sigma fit
RMS of distributions [-8,8]

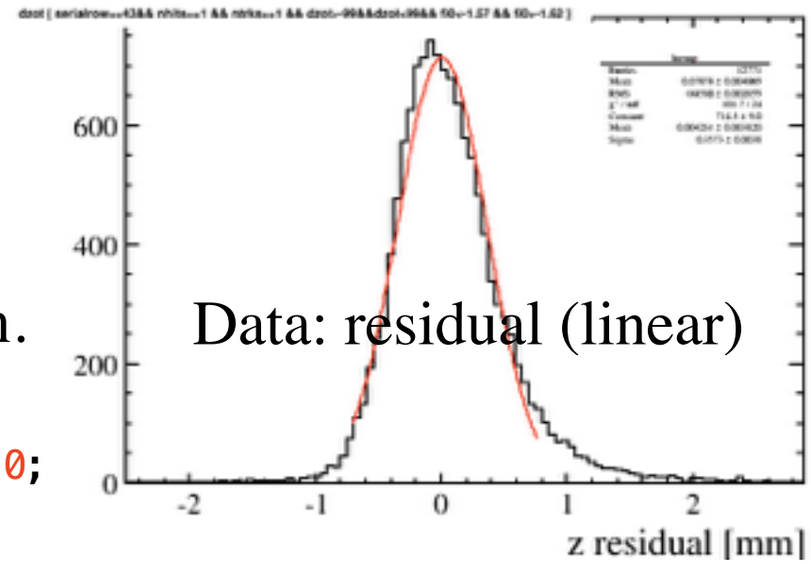


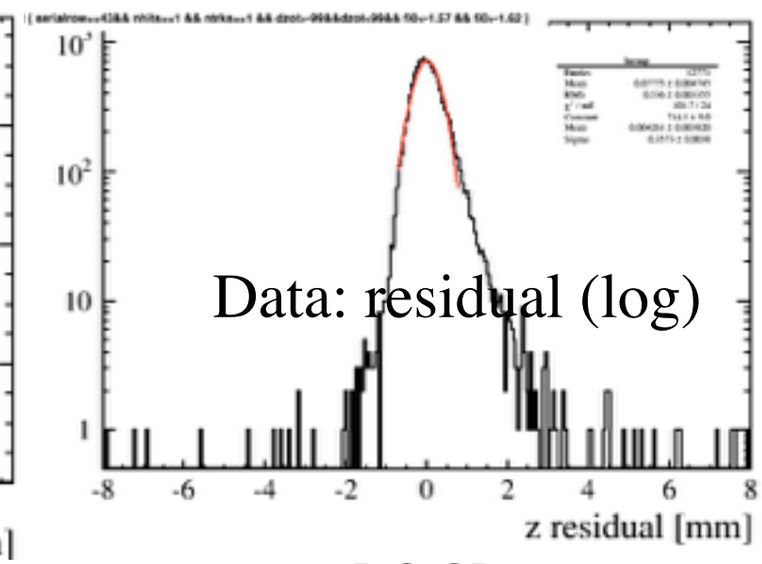
Simulation on Z resolution

Z Residual on Row 15 (field shaper)

Artificially, randomly,
I include the effects of
1time bin shift in the simulation.

```
int shiftBin = 0.5>gRandom->Uniform(1.) ? 1:0;
```





2σ fit (but Asym shape)

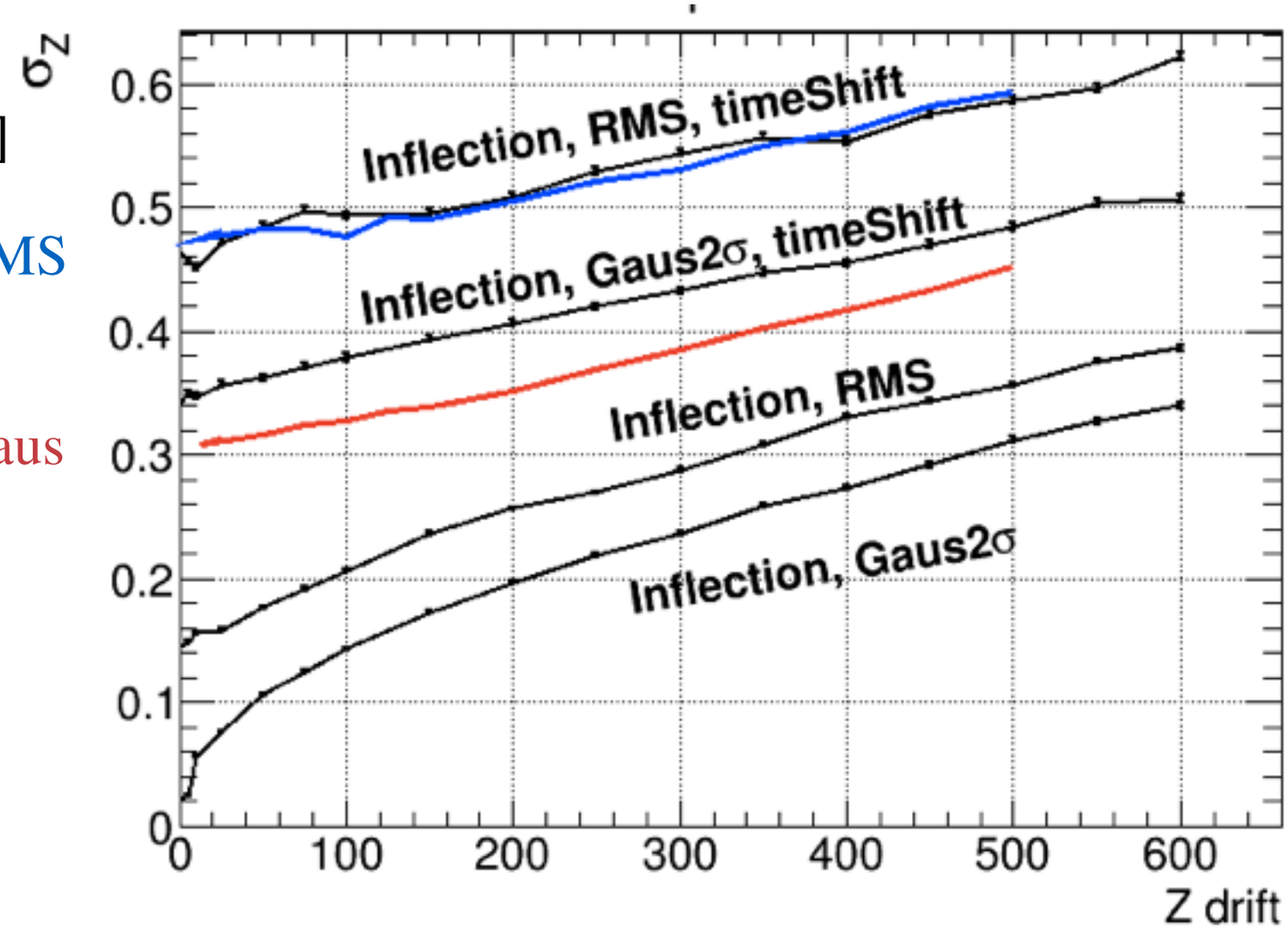
[-8,8]

Time: Inflection
Resolution: Gaus 2 sigma fit
RMS of distributions [-8,8]

2016 Data : Ave. 20Row RMS

2016 Data : Ave. 20Row Gaus
(residual is Asym)

ACCIDENTALLY ?



Summary

- Rough view for Z resolutions using 2016 beam data

  Ratio of the **Ave. Neff** ~ 82.7 ± 3.8 % which is expectation for the aperture

  - **Resolution σ_Z ~ 865 [μm]** with the full drift length of 2.2 m

    Ave. σ0 (w/ the gatingGEM) = 269.7

- Simulation on behavior of the Z resolution (very personal opinion)

  Astrid implied, there is some part in the electronics that dominates over the fact that the charge is spread out in time,

The result I showed is just ACCIDENT?

Question to LCTPC

Q1). Are sampling clocks really synchronized among channels?

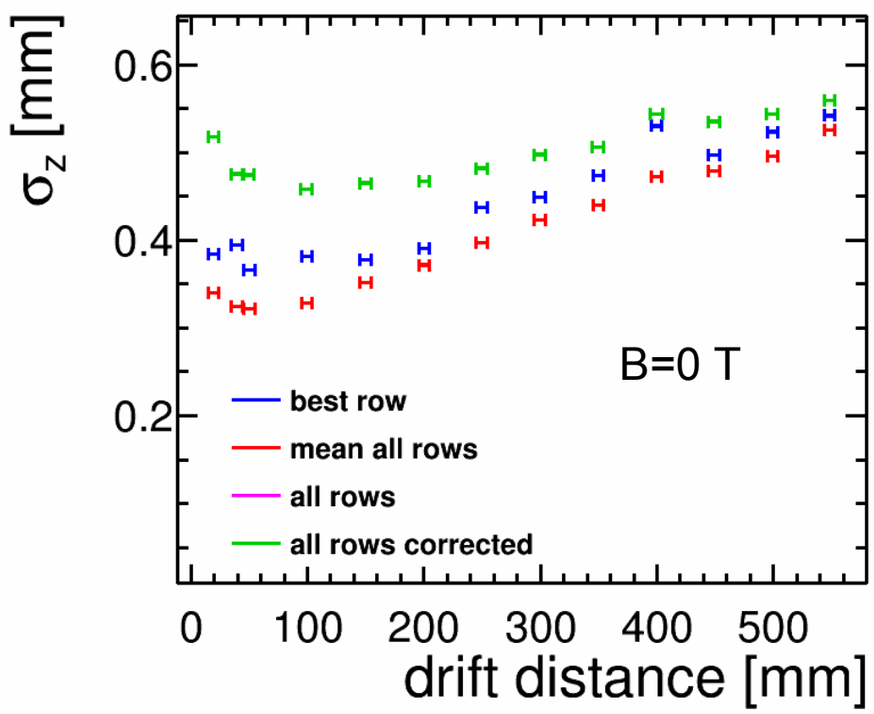
Can any ALTRO users prove it using ALTRO?

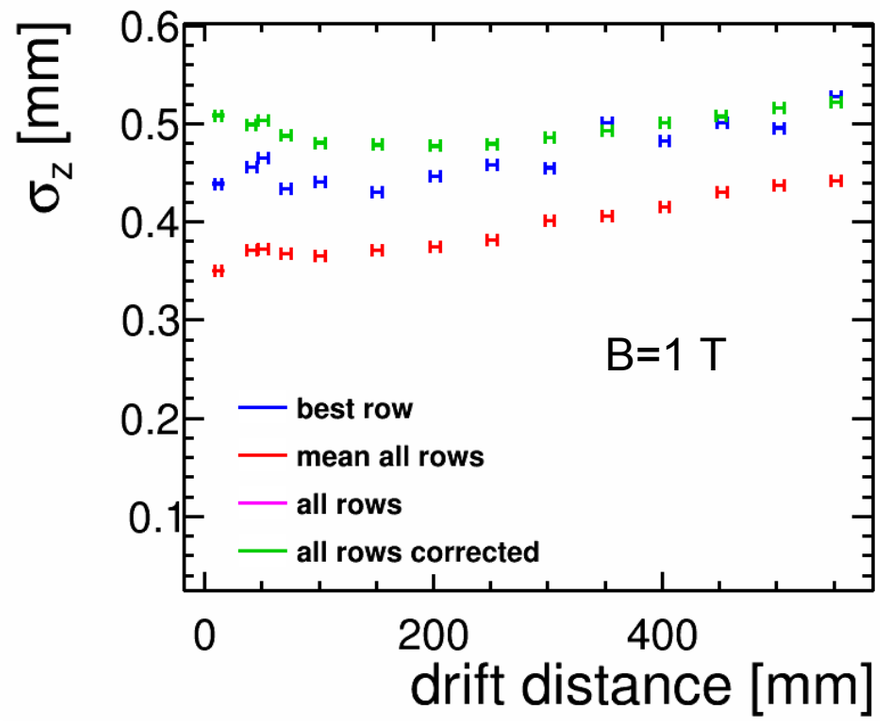
Q2). The method "Inflection point" works well?

Better to re-think the time estimator?

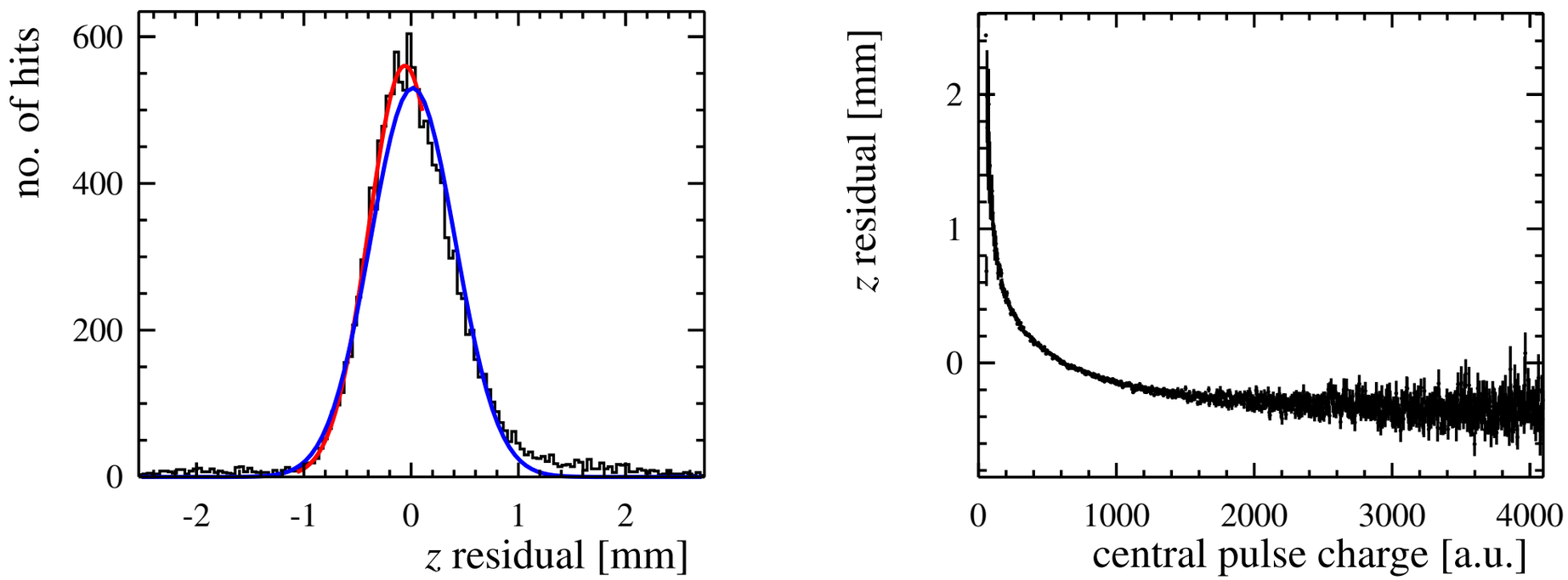
Z Resolution

- The overall resolution drops but the main systematic is still the same
  - Larger rise for 0T data than for 1T data
  - Slightly worse σ_0 for 1T data
- What N_{eff} is expected for z resolution? Same as for rφ resolution?





Felix PhD



(a) exemplary residual distribution

(b) charge dependence of the time estimation

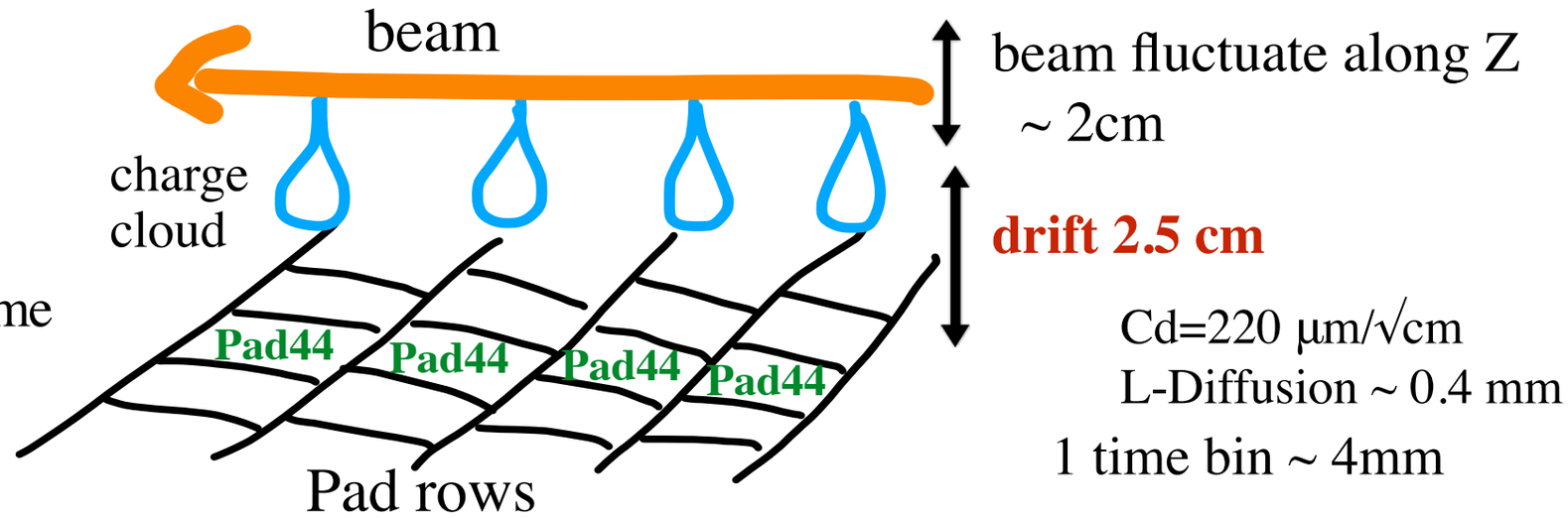
Figure 6.31: a) Example z-residual distribution of one measurement run. A Gaussian fit over the full range and only the left side of the distribution is shown in blue and red, respectively. b) Charge dependence of the time estimation. Smaller total charge of the pulses bias the time estimation to longer drift distances. Therefore, an asymmetric residual distribution in the z direction is observed in figure a). The width of the limited fit serves as input to the resolution estimation using the geometric mean method.

A first look into the longitudinal residual distribution reveals that the expected Gaussian distribution is skewed towards larger values. One example residual distribution is displayed in figure 6.31a. The skewness of the distribution can be explained by the charge dependence of the longitudinal residuals which it is depicted in figure 6.31b. A charge dependence of the time estimation is a typical issue if a constant threshold is used for the time determination. This effect is called timewalk. However, the Gaussian inflexion point method should not suffer from a time walk effect. The other possible explanation could be a non linear response of the readout electronics. Unfortunately, a test bench for the electronics is not available and the hypothesis cannot be verified in the scope of this thesis. In principle, the charge dependence can be extracted from the measured data and applied as a correction. This correction procedure is currently being studied in depth. However, the left hand side of the residual distribution

Cluster time

If every channels synchronously
start sampling, pulse time should be same

especially for very short drift data
and pads located in same pads.

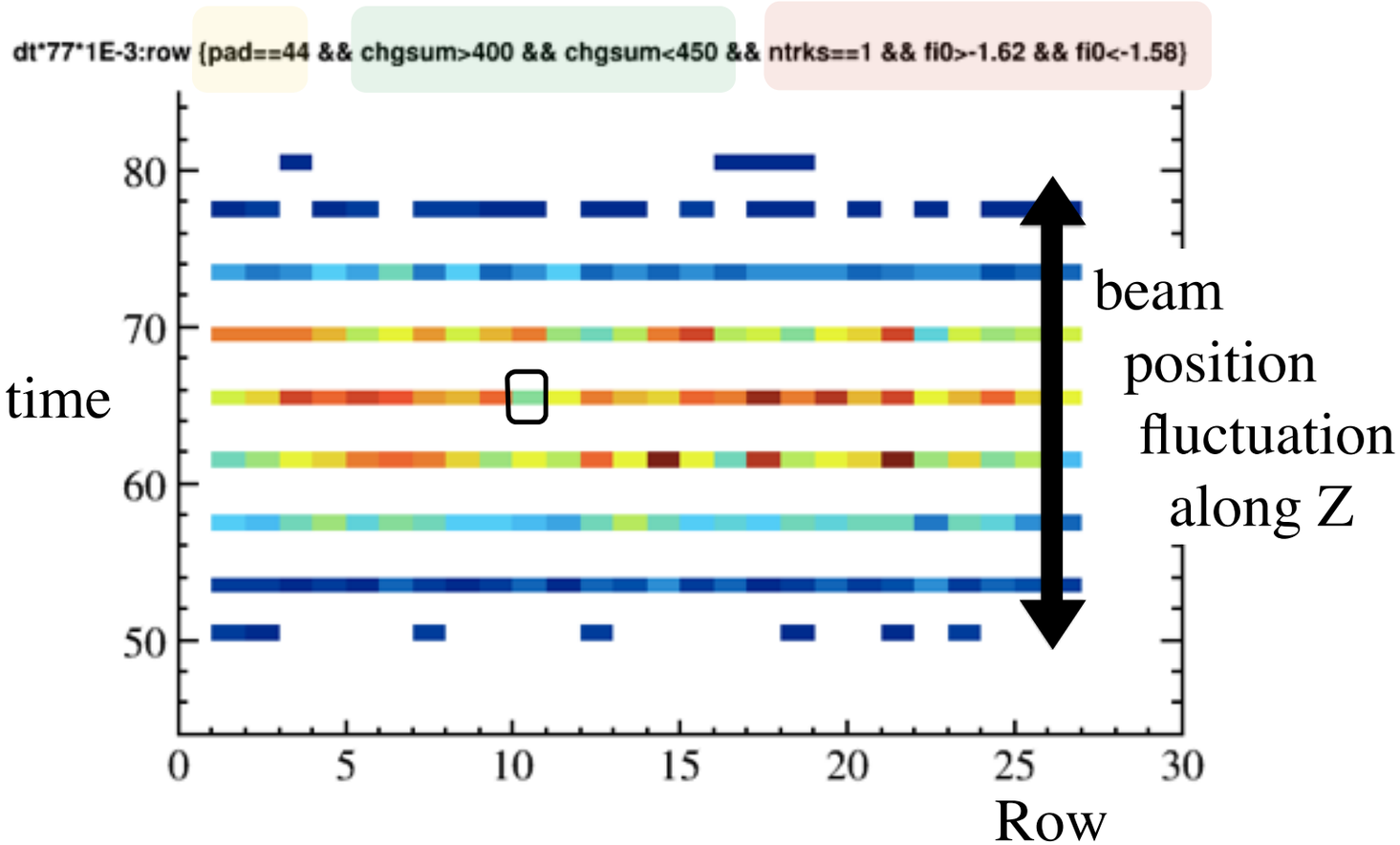


Time vs Pad 44 (of each row)
Notice: time estimator is MaxADCBin

only pad 44 (same position along rϕ)

similar charge distributions
may be similar pulse shape.

track quality cuts



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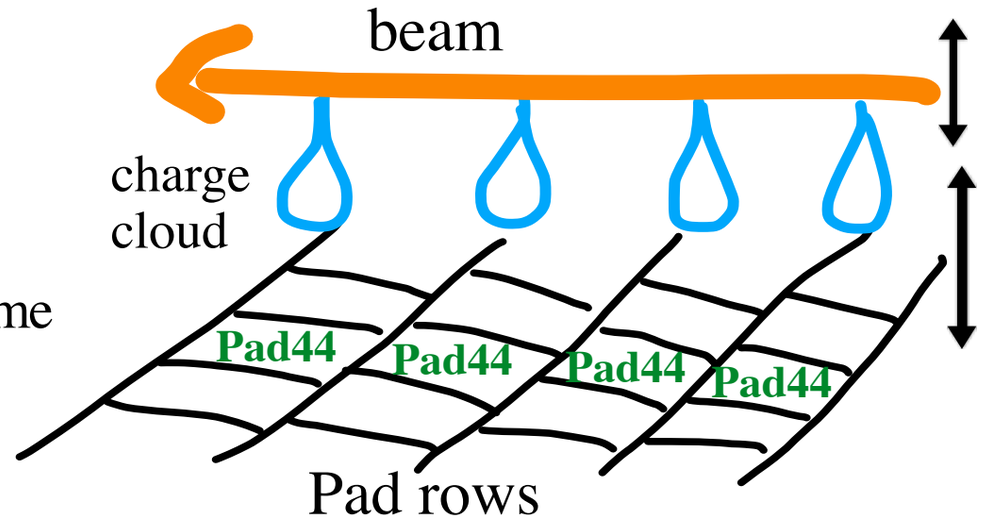


beam fluctuate along Z
~ 2cm

drift 2.5 cm

Cd=220 μm/√cm
L-Diffusion ~ 0.4 mm
1 time bin ~ 4mm

Time vs Pad 44 (of each row)
Notice: time estimator is MaxADCBin

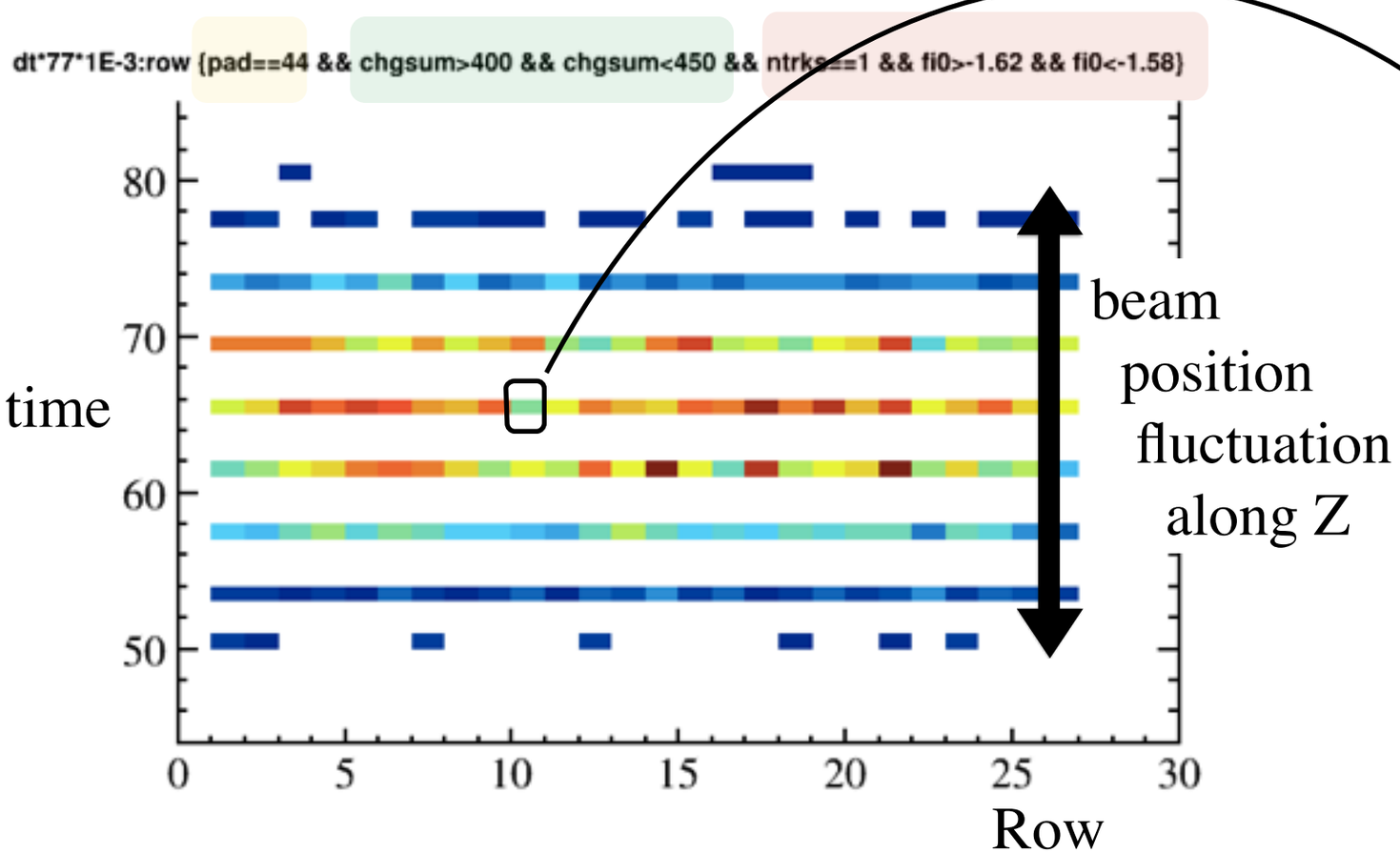
only pad 44 (same position along rϕ)

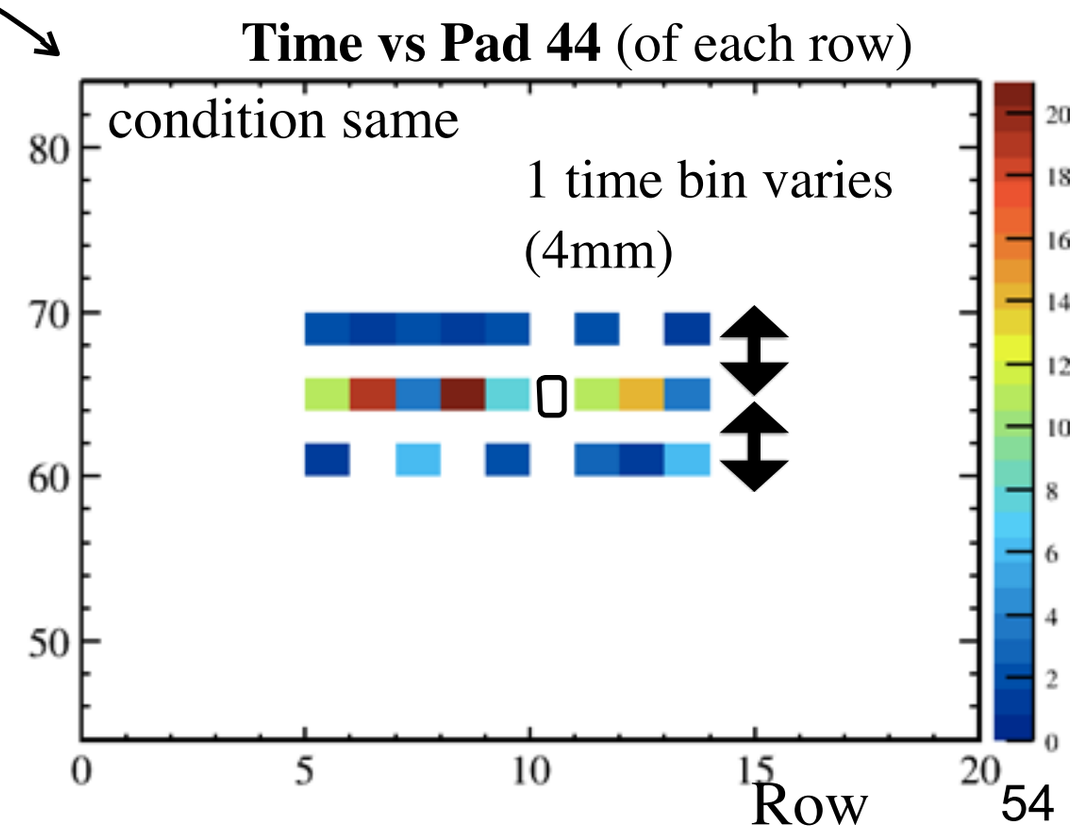
similar charge distributions
may be similar pulse shape.

track quality cuts

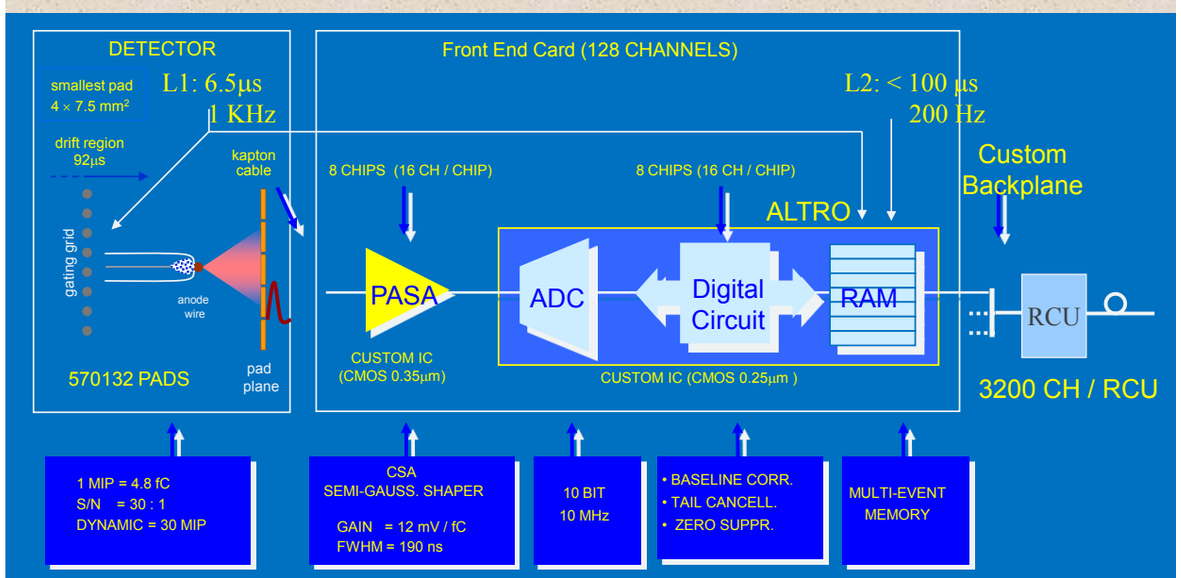
If Time of the pad44 in the row 10 is ▯ ,
the other rows has which time ?

If synchro. (sampling clock chan by chan)
is completed , values can be seen next to ▯ .



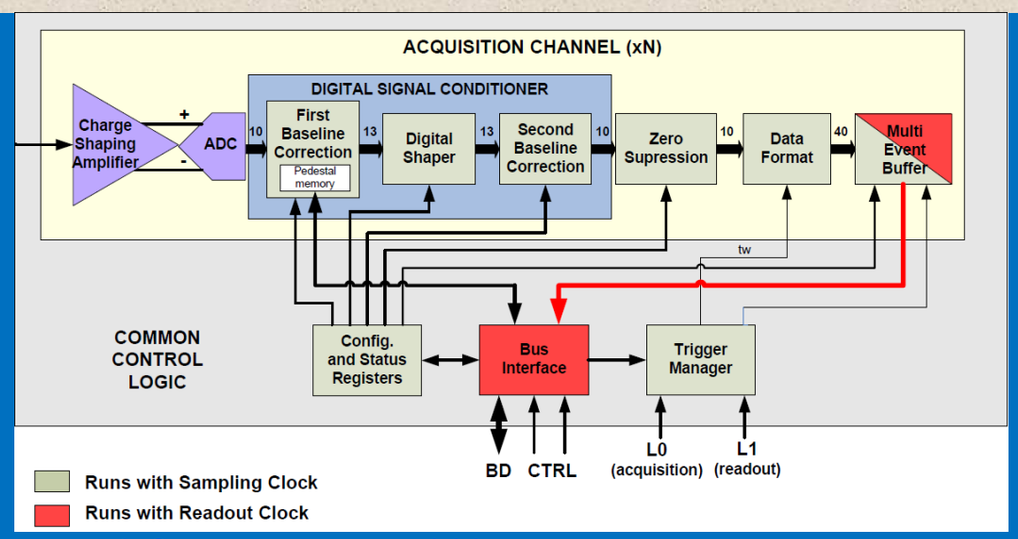


Alice TPC: ALTRO



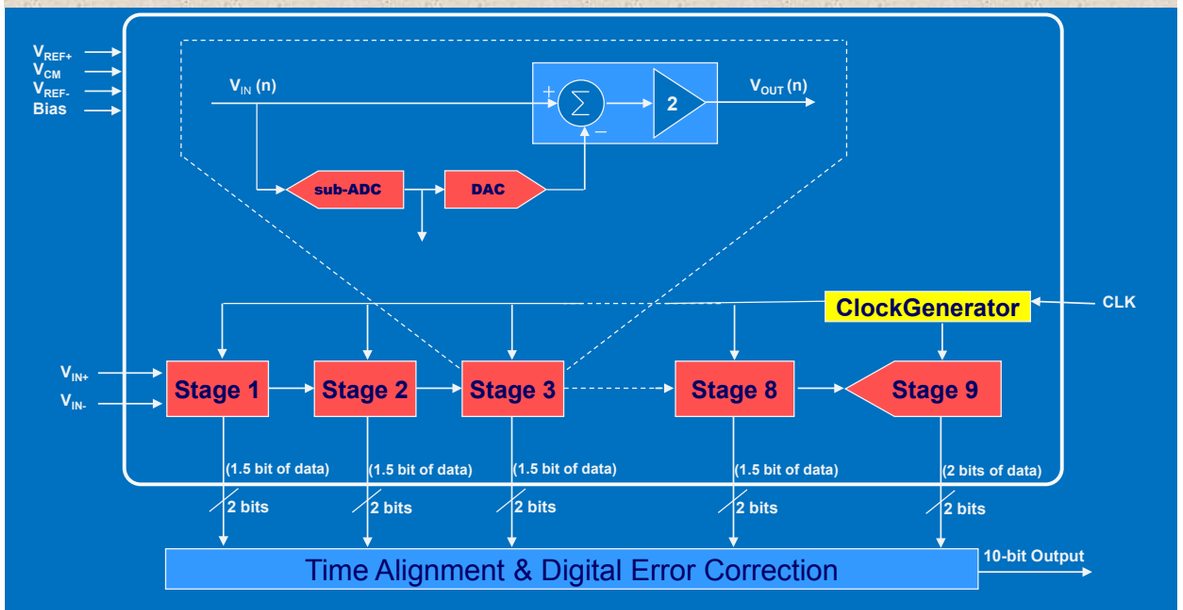
PreAmplifier Shaping Amplifier = PASA
ALice Tpc Read Out = ALTRO
Two-chips system, 4x7.5mm pads

System architecture



Level 1: Starts the data acquisition.
Level 2: Validates data from previous L1.
BD : 40 bit bidirectional bus; 20 bits address + 20 bit data.
CTRL : 6 bits.
Sampling clock : max 40MHz. Readout clock : max 80MHz.

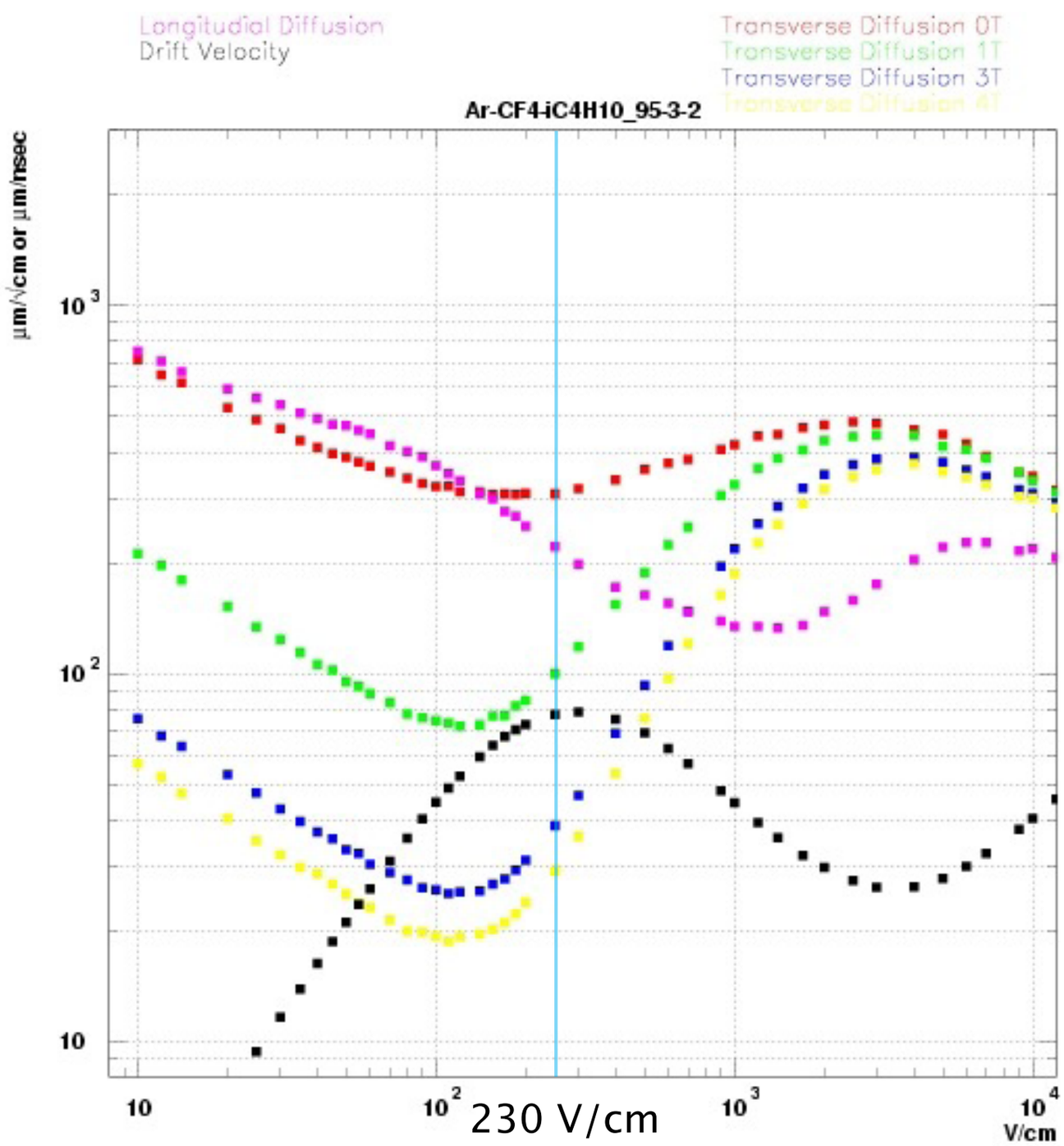
Pipeline ADC



CERN ADC prototype by Hugo França-Santos:

10bit, 40MHz, 1.5V supply, 34mW power, 0.7mm² area

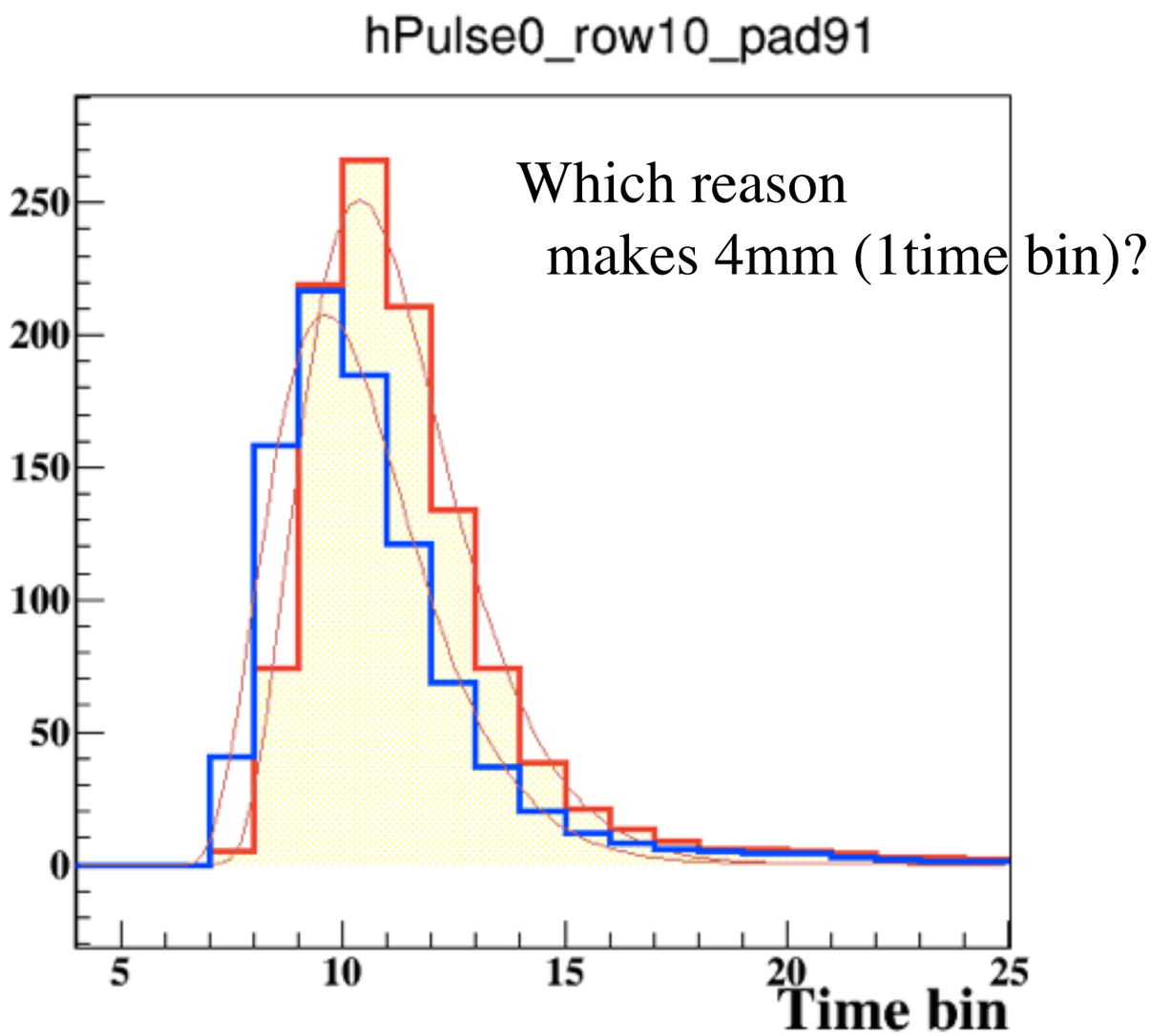
Drift velocity and diffusion (T2K gas)

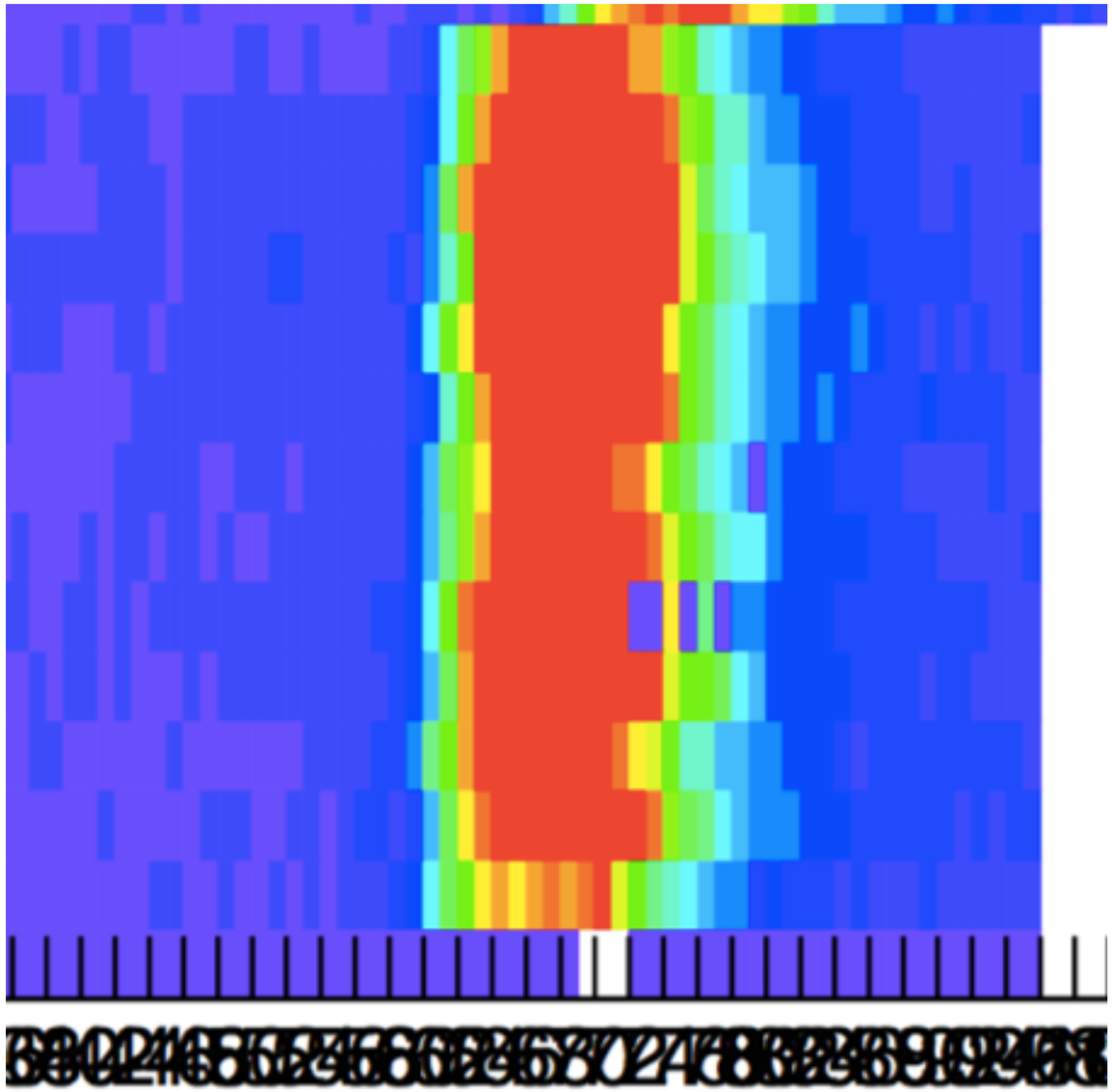


If we require the azimuthal resolution of 100 μm at z = 200 cm the diffusion constant (D), which is essentially the only free (controllable) parameter depending on the choice of gas mixture, needs to be smaller than 30 μm/√cm.

The diffusion constant of drift electrons under the influence of an axial magnetic field (B) is given by $D(B) = D(B = 0)/\sqrt{1 + (\omega\tau)^2}$, where $\omega \equiv e \cdot B/m$, the electron cyclotron frequency, and τ is the mean free time of drift electrons between collisions with gas molecules. Therefore we need a gas mixture in which D(B = 0) is small (cool) and τ is fairly large (fast) under a moderate drift field (E)!

- The diffusion constant D is related to the diffusion coefficient (D^*) through $D2 = 2D^*/W$, where W is the electron drift velocity.
- The electron drift velocity is given by $W = e \cdot E/m \cdot \tau$ with e (m) being the electron charge (mass). A large value of τ, therefore, means a fast gas.


hPulse0_row10_pad91
Which reason
makes 4mm (1time bin)?
250
200
150
100
50
0
5
10
15
20
25
Time bin



along ϕ ~ 15pads ~ *1.2mm ~ 2cm

rφ resolution — Beam test —

○ **Determination of "hit position"**
→ the Charge centroid method.

○ Evaluated Neff for the both module.

Ave. of the central 20 rows.

(Cd is measured with the same terms)

the gating GEM: Neff = 22.8 ± 0.3
the field shaper: Neff = 28.5 ± 0.4

Ratio of the Ave. Neff ~ 80.1 ± 1.2 %

Geometric mean resolution $\sigma_{r\phi} = \sqrt{\sigma_{r\phi(in)}\sigma_{r\phi(out)}}$

https://agenda.linearcollider.org/event/7507/contributions/39322/