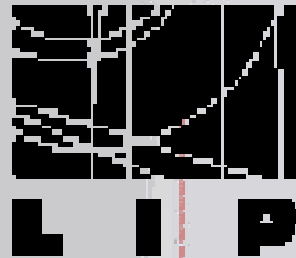


# Performance of the HADES-TOF RPC wall in a Au-Au beam

A. Blanco  
On behalf of HADES RPC Group



Funding:  
**FCT**  
Fundação para a Ciência e a Tecnologia  
MINISTÉRIO DA CIÊNCIA, TECNOLOGIA E ENSINO SUPERIOR



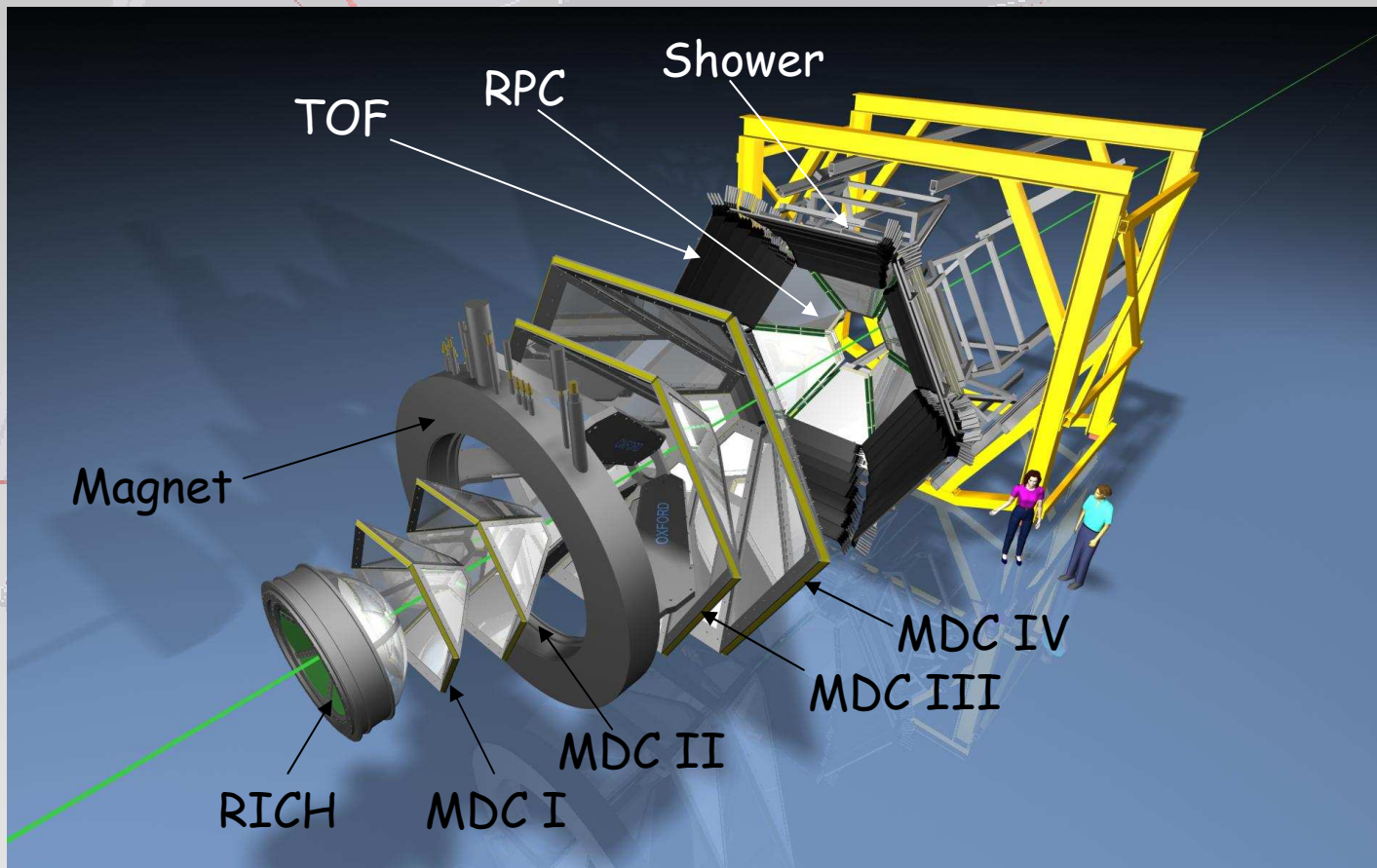
# Outlook

- HADES spectrometer
- RPCs in HADES
- Intrinsic RPC performance in Au + Au beam @ 1.15 AGeV
  - Time resolution, time tails and longitudinal spatial resolution
- Calibration and PID plot

# HADES spectrometer

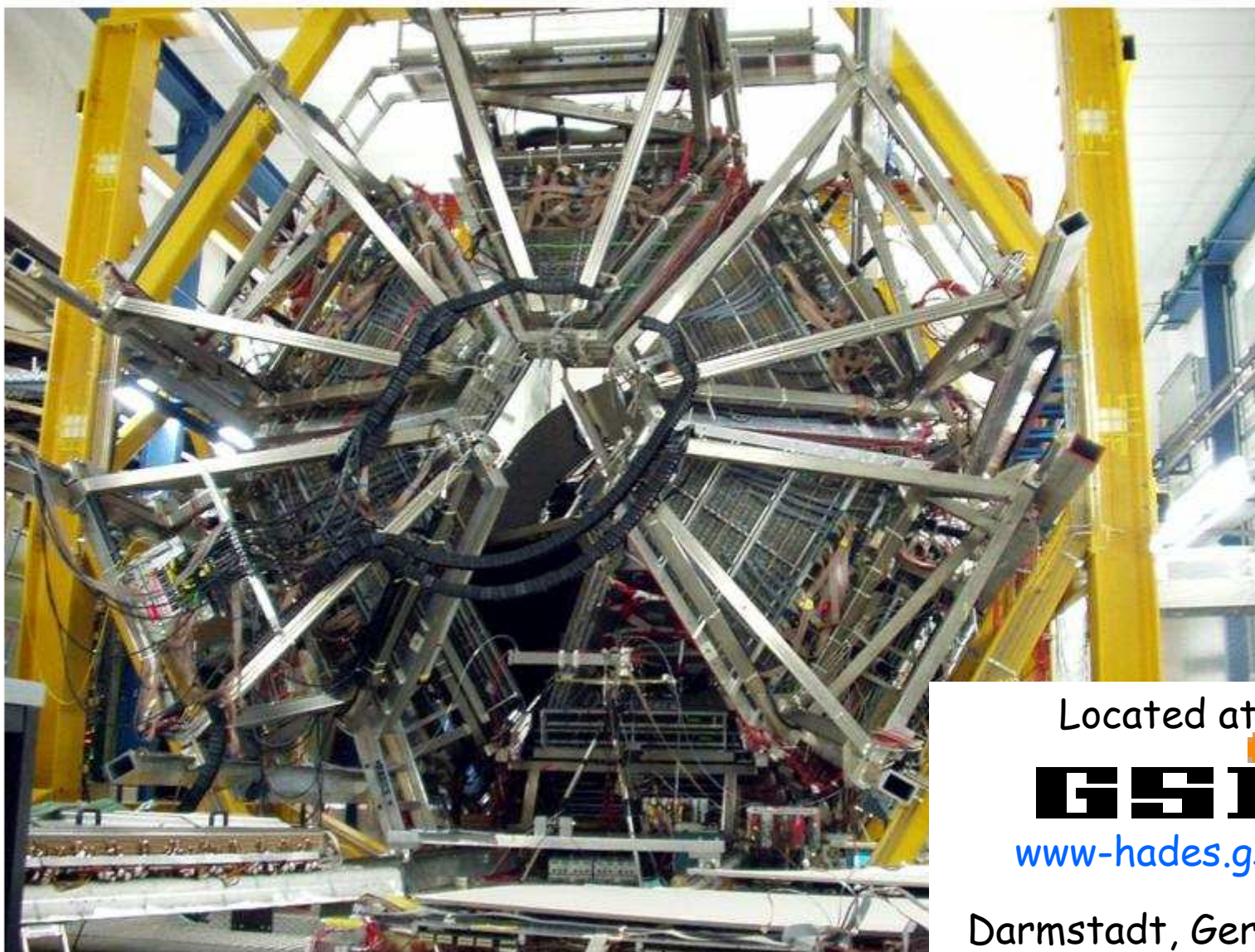
The **investigation of hadron properties inside nuclear matter at normal and high densities** and temperatures is one of the main goals of current nuclear physics studies. Under these conditions, **considerable modifications of basic hadron properties (masses, decay widths, etc.)** are expected.

**Large acceptance, high precision and rate capability**





# HADES spectrometer



Located at:

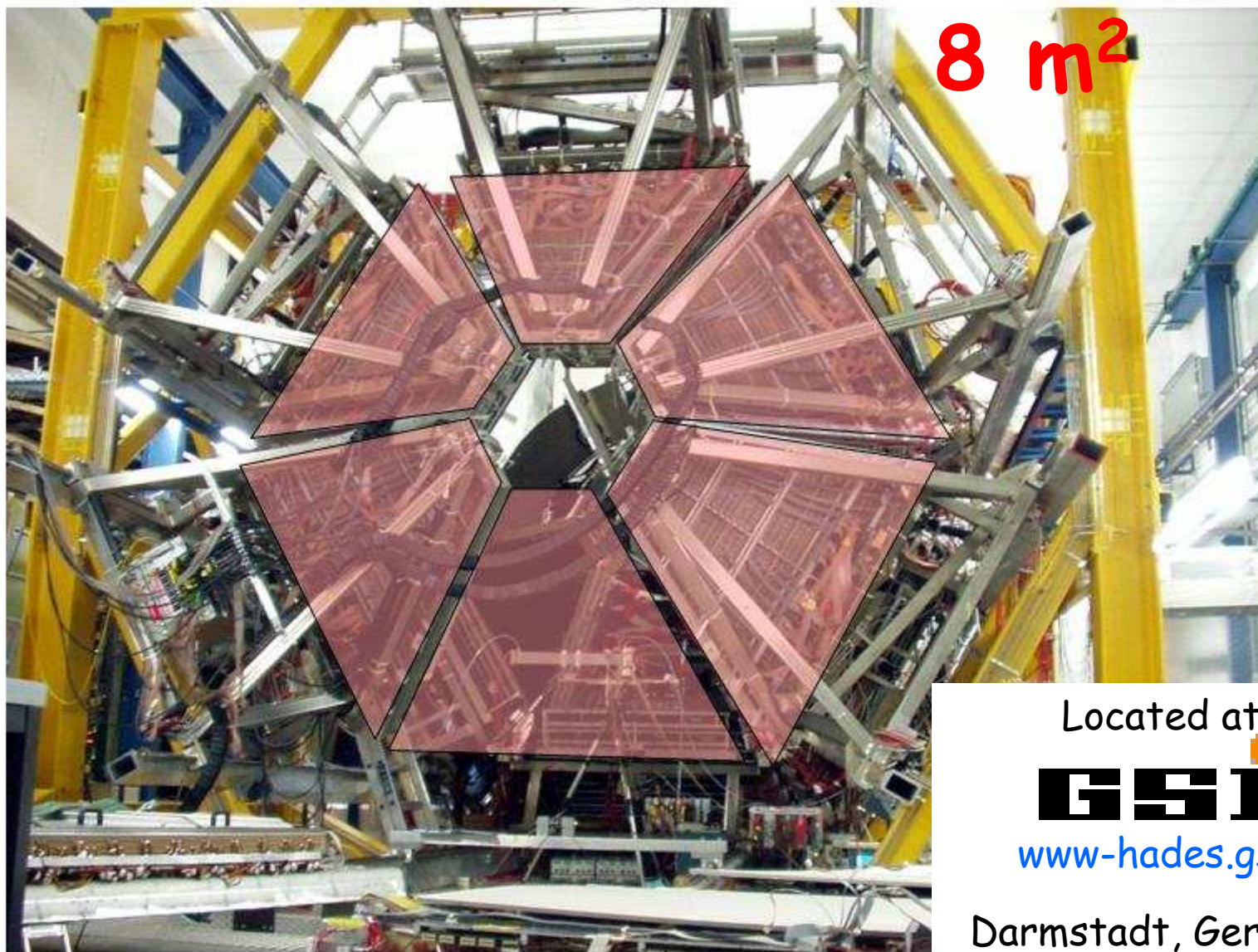
**GSII**

[www-hades.gsi.de](http://www-hades.gsi.de)

Darmstadt, Germany.



# HADES spectrometer. RPC-TOF



Located at:

**GSI**

[www-hades.gsi.de](http://www-hades.gsi.de)

Darmstadt, Germany.

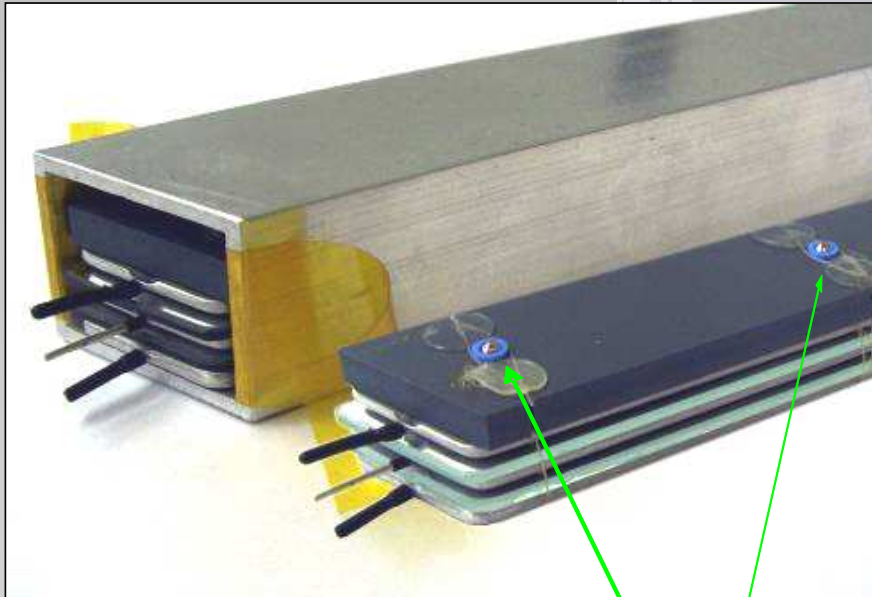
# HADES spectrometer. RPC-TOF

- Multi-hit capability hit-loss probability below 20%
- Time resolution 100 ps ( $\sigma$ ) or better
- Rate capability up to 1 kHz/cm<sup>2</sup> in some areas
- Efficiency above 95% for single hits
- Area  $\sim 8/6$  m<sup>2</sup>/sector

## Fundamental option: shielded detectors, Cells

- Independent hits in terms of timing  $\Rightarrow$  robust multihit performance
- Cluster size  $\sim 1 \Rightarrow$  efficient use of the electronics channels

# The HADES RPC Cells



- 0.27 mm x 4 gaps

Minimum for good efficiency

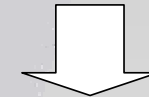
- 2 mm aluminum and glass electrodes

Minimize amount of glass for maximum rate capability

Try to keep good mechanics

- Heat - tolerant materials

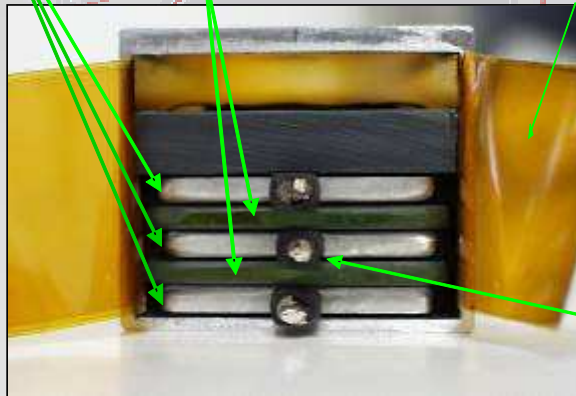
**Fully electrically shielded**



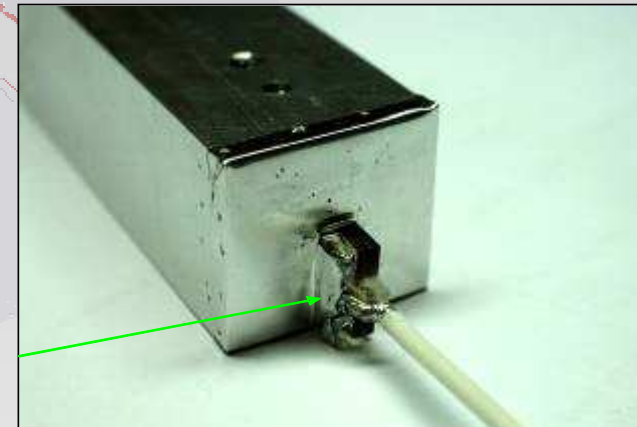
Aluminum

Glass

Spring-loaded pressure plate

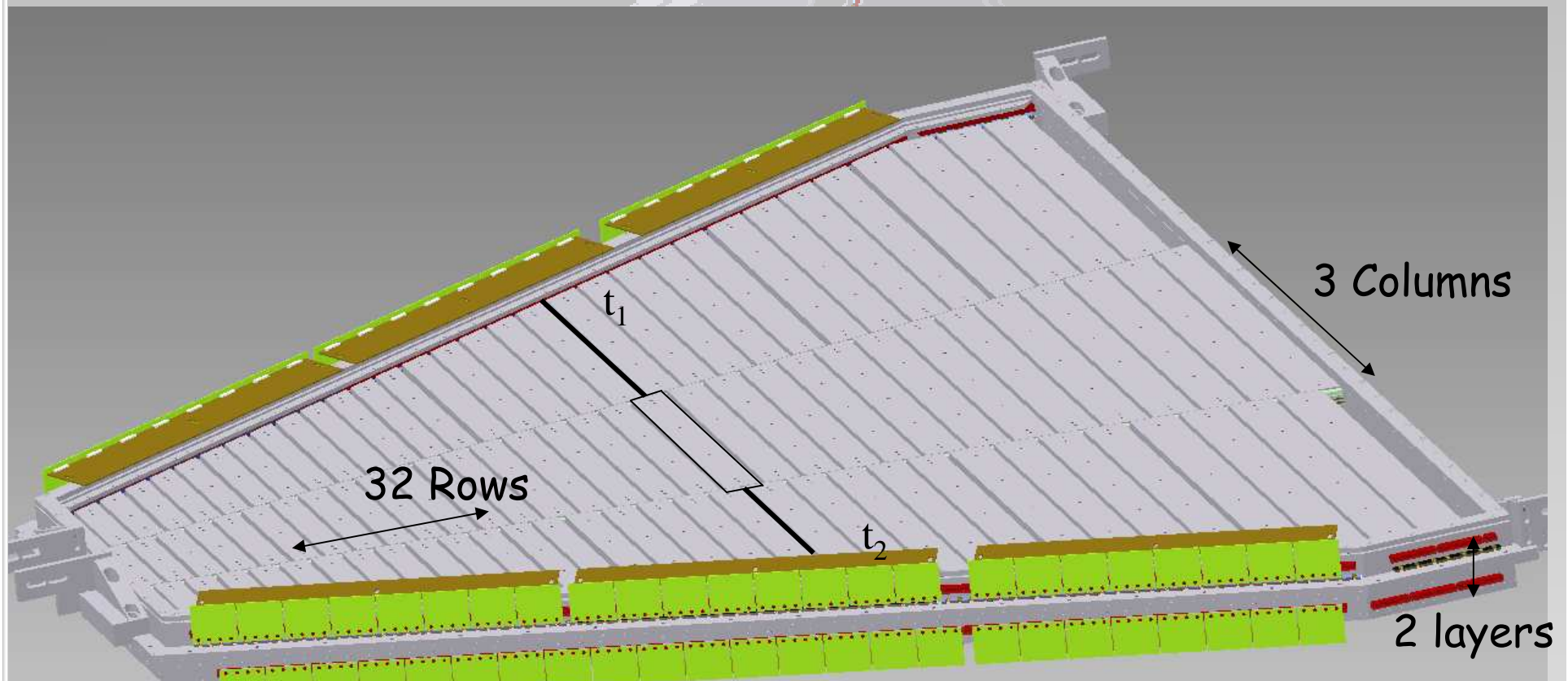


HV & readout in the center





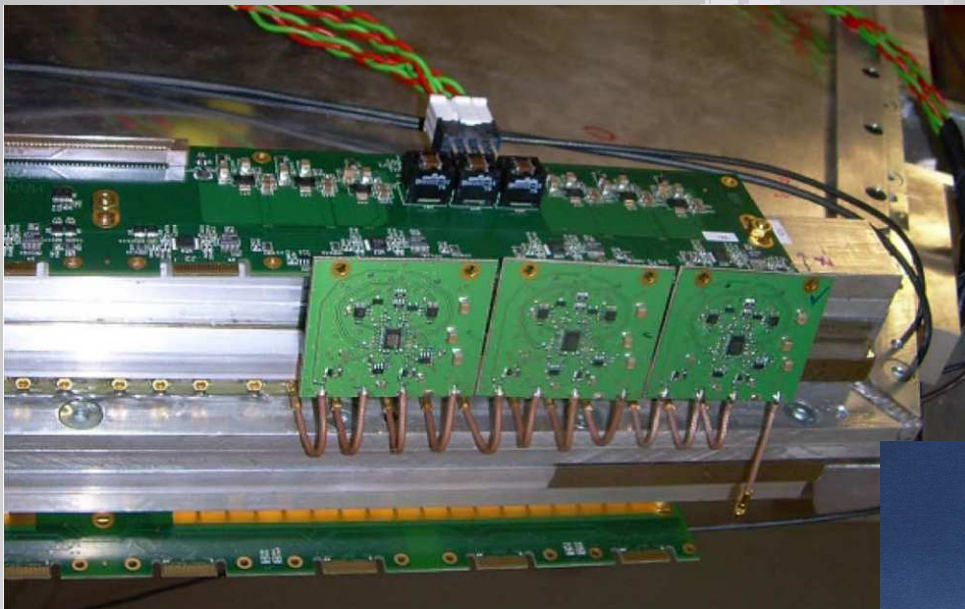
# Sector segmentation



- 186 cells/sector distributed in 32 rows and 6 columns, 3 on top and 3 on bottom (2 layers)
  - 1116 cell in total
  - 124 different cells with variable width, length and shape
  - Read out at both sides
- $$T = (t_1 + t_2)/2 \quad X = t_1 - t_2$$



# FEE and DAQ



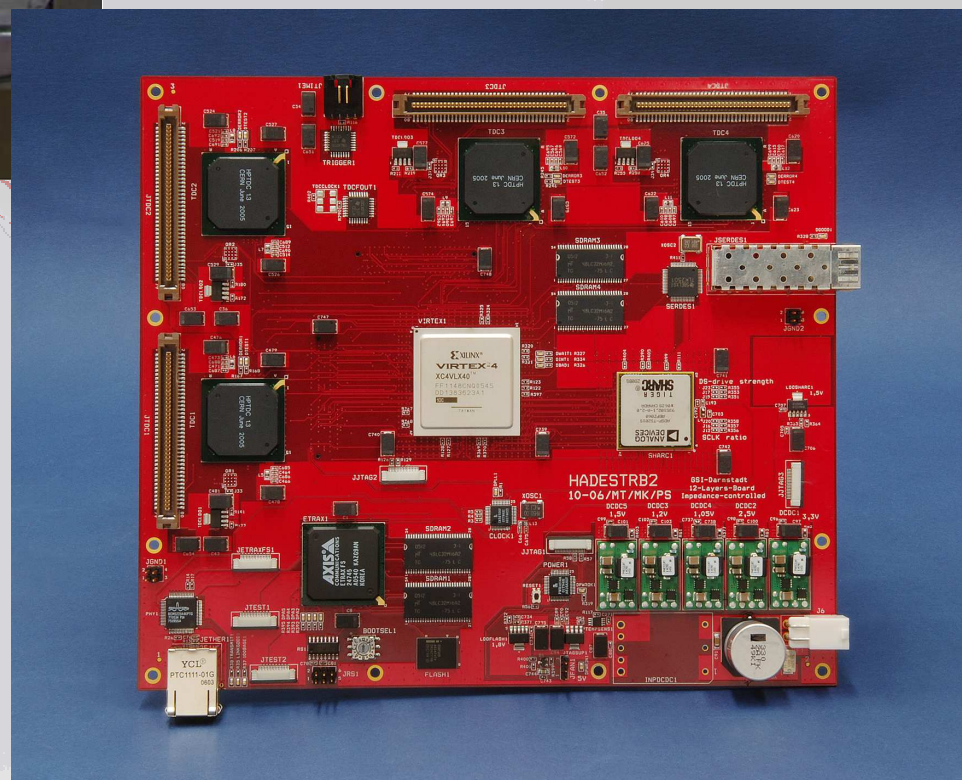
FEE based on Philips BGM1013

$G = 35.5 \text{ dB}$ ,  $BW = 2 \text{ GHz}$ ,  $NF = 4.5 \text{ dB}$

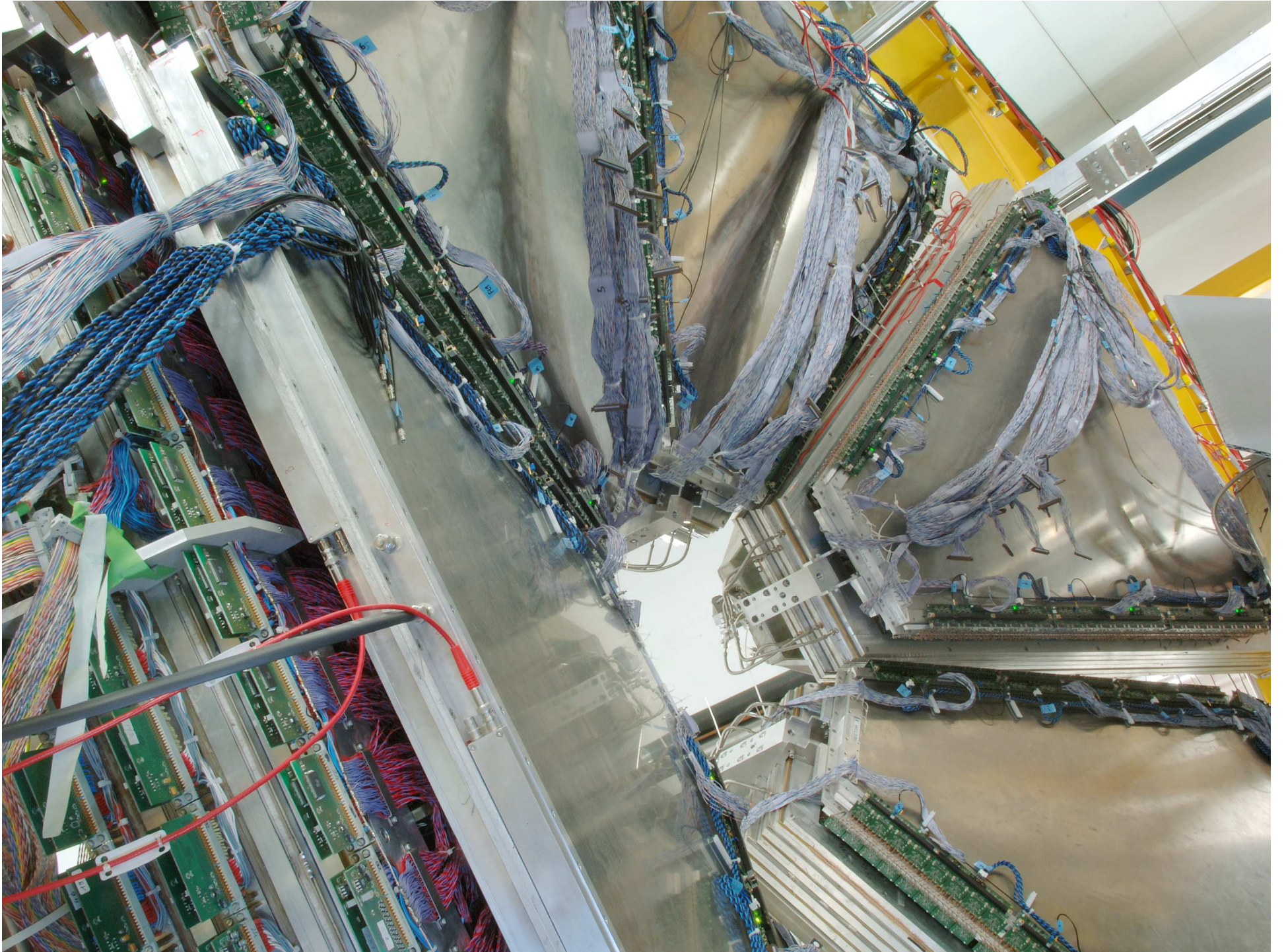
[TNS 57 vol 5 2010, 2848]

DAQ based on a 128 ch  
multihit TDC

[TNS 58 vol 4 2011, 1745]





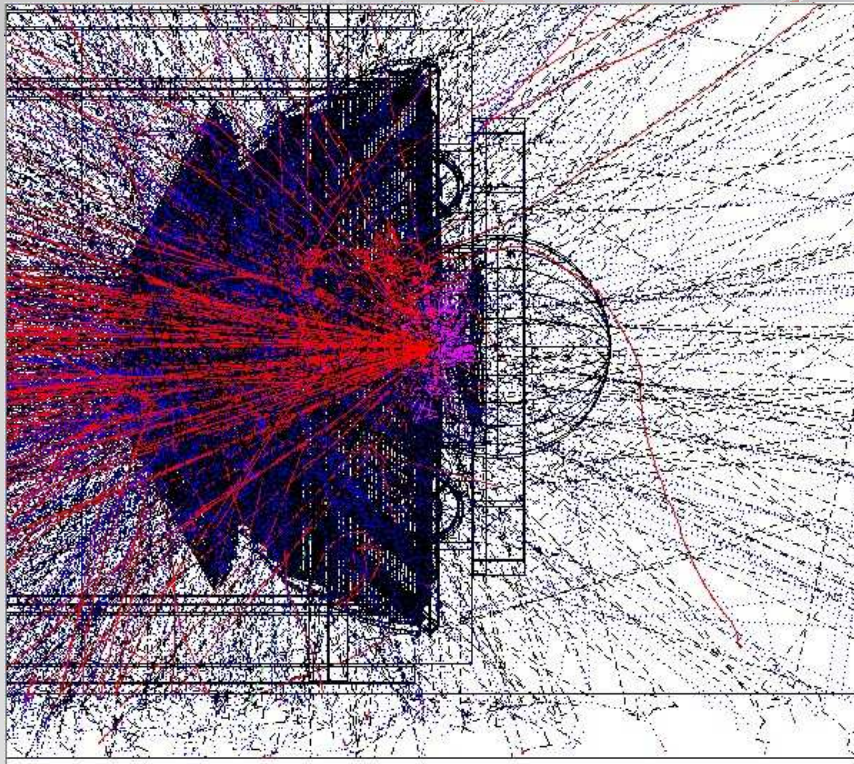




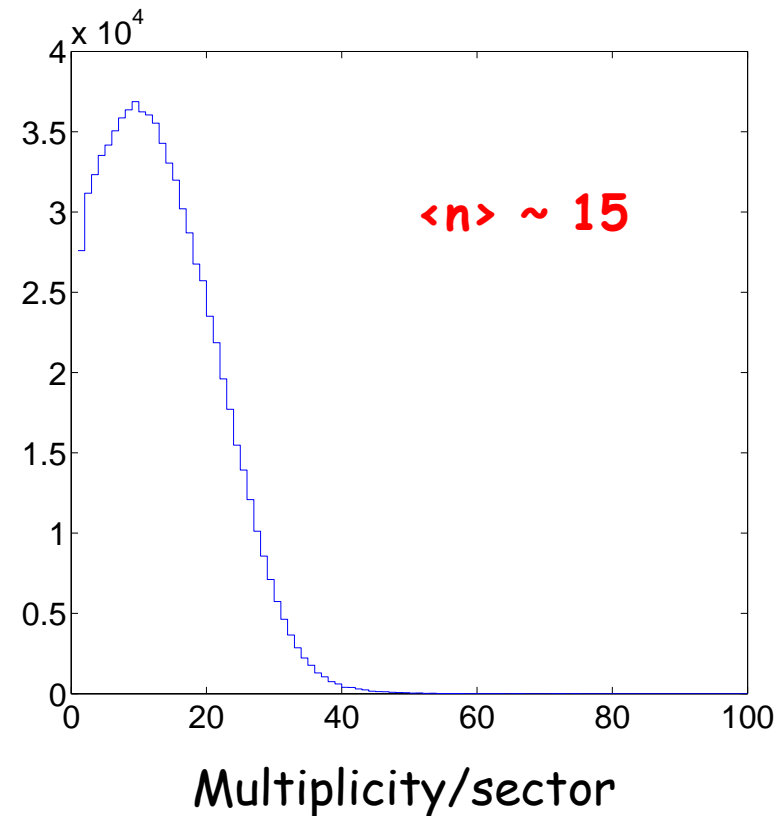
# Intrinsic RPC performance. Au + Au @ 1.15 AGeV

First Au + Au test run in HADES

Multihit environment

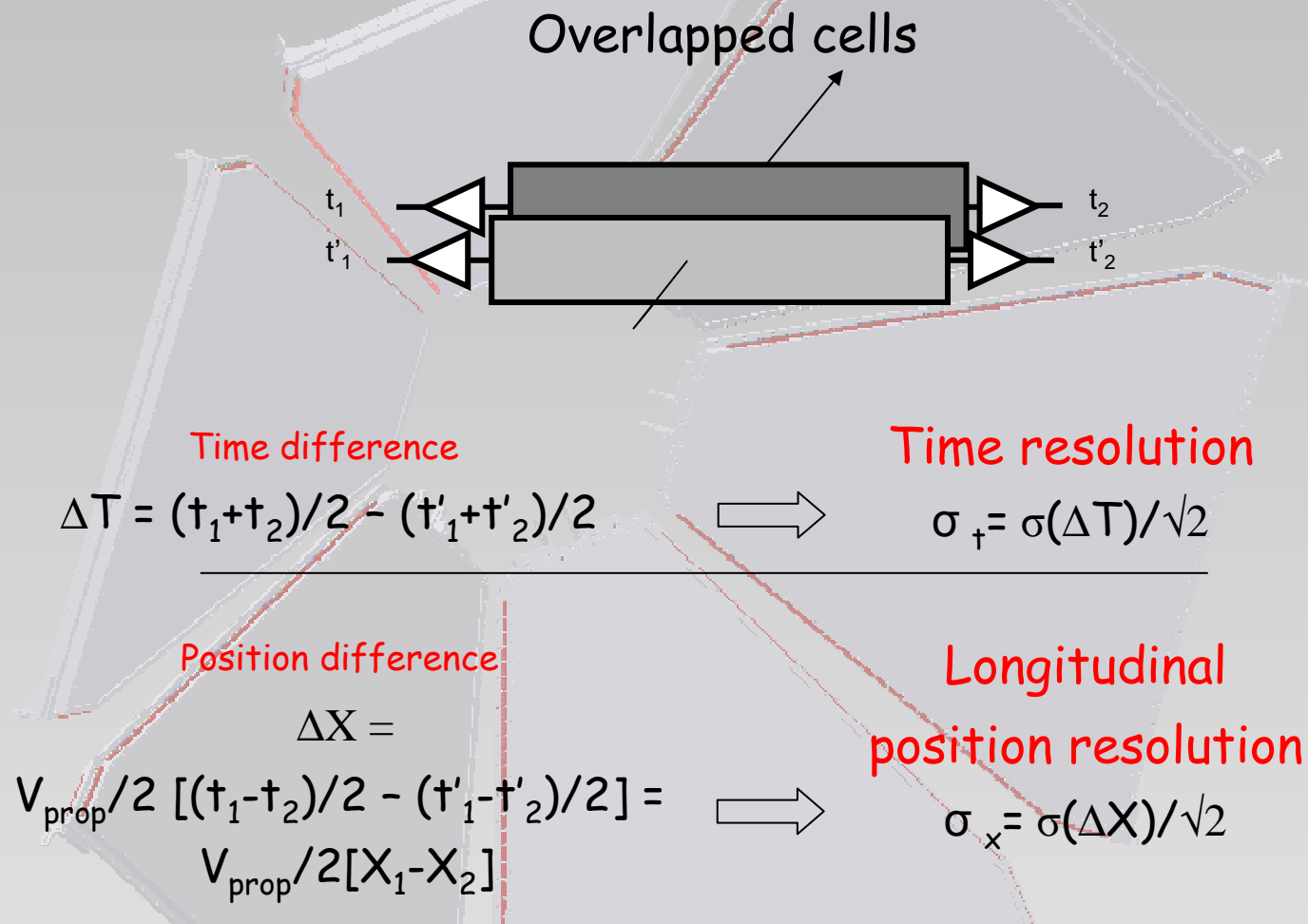


One Au + Au collision from HGeant simulation package



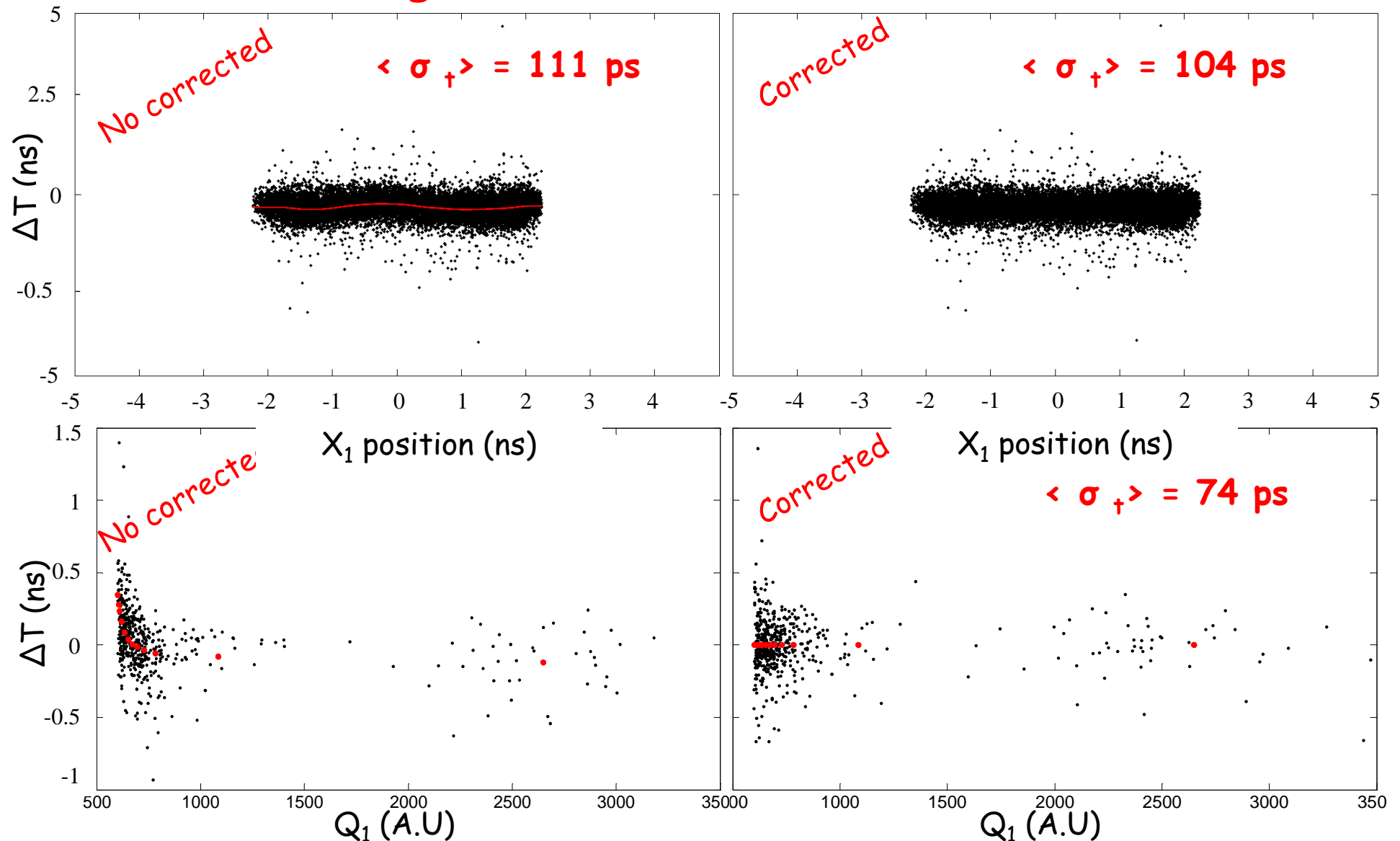


# Intrinsic RPC performance. Analysis



# Intrinsic RPC performance. Time resolution, corrections.

Position and charge information used to correct time

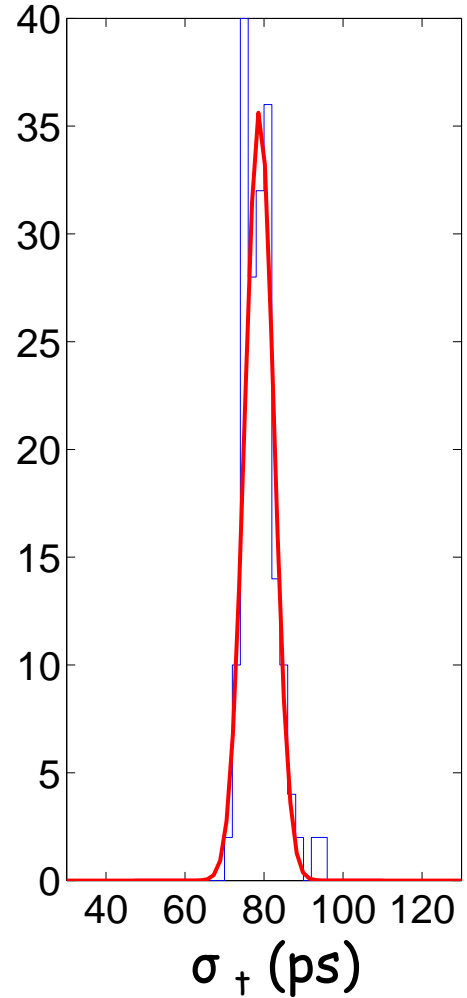
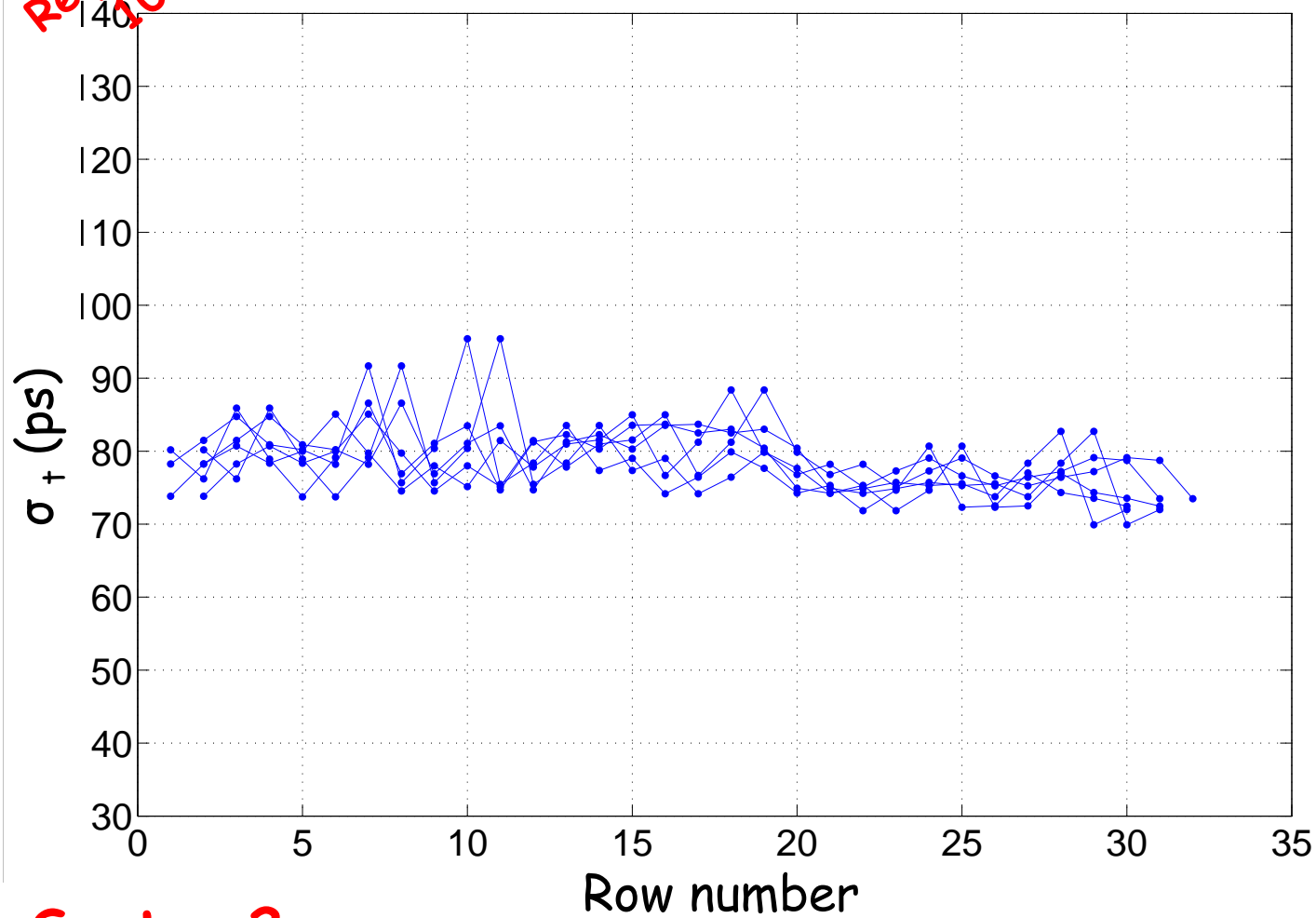


# Intrinsic RPC performance. Time resolution

Requirement  
100ps

Homogeneous time resolution < 100 ps

$\langle \sigma_{\dagger} \rangle = 80$  ps



Sector 2



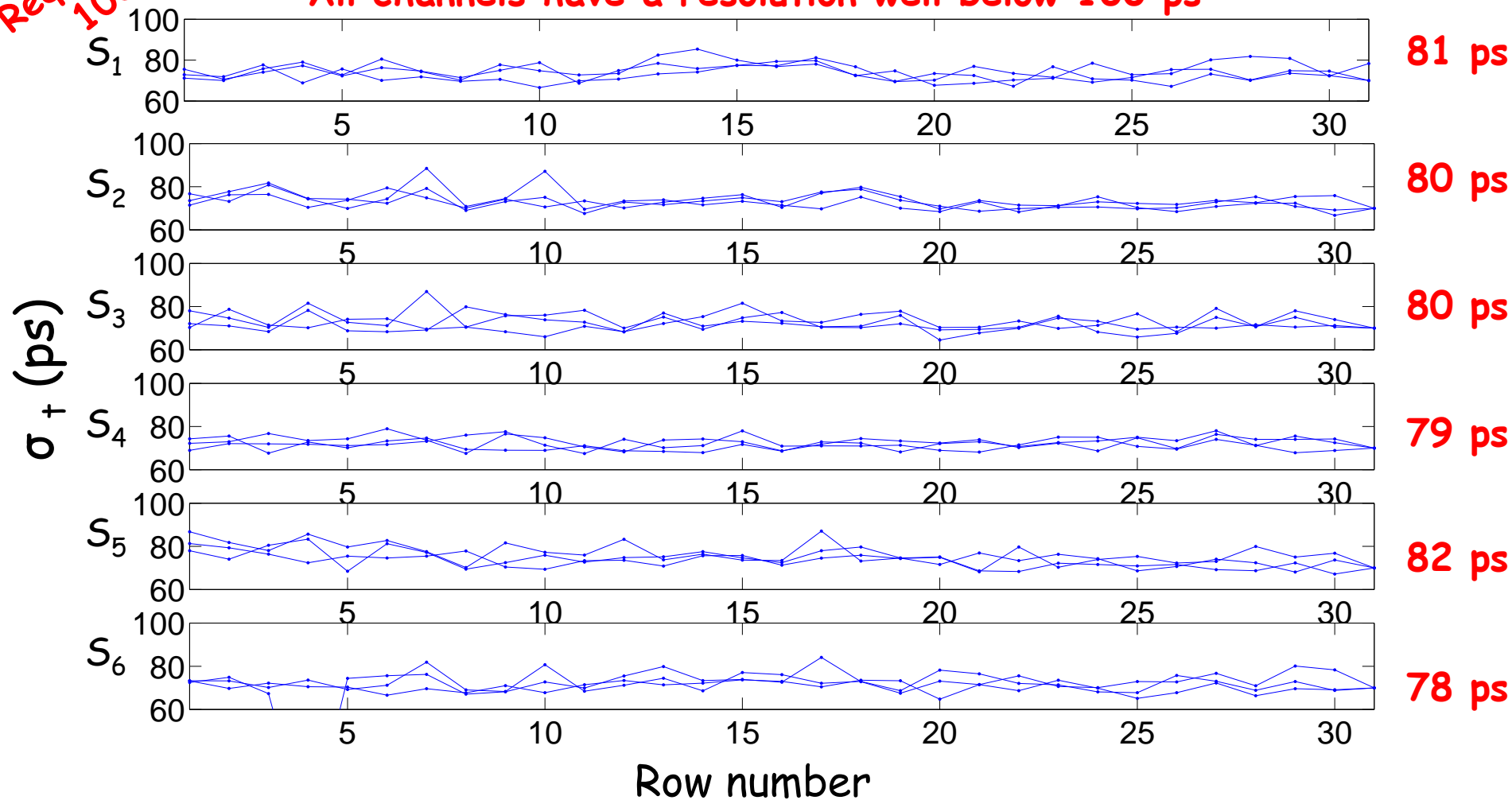
# Intrinsic RPC performance. Time resolution

Requirement  
100ps

$\langle \sigma_{\dagger Global} \rangle = 80 \text{ ps}$

All channels have a resolution well below 100 ps

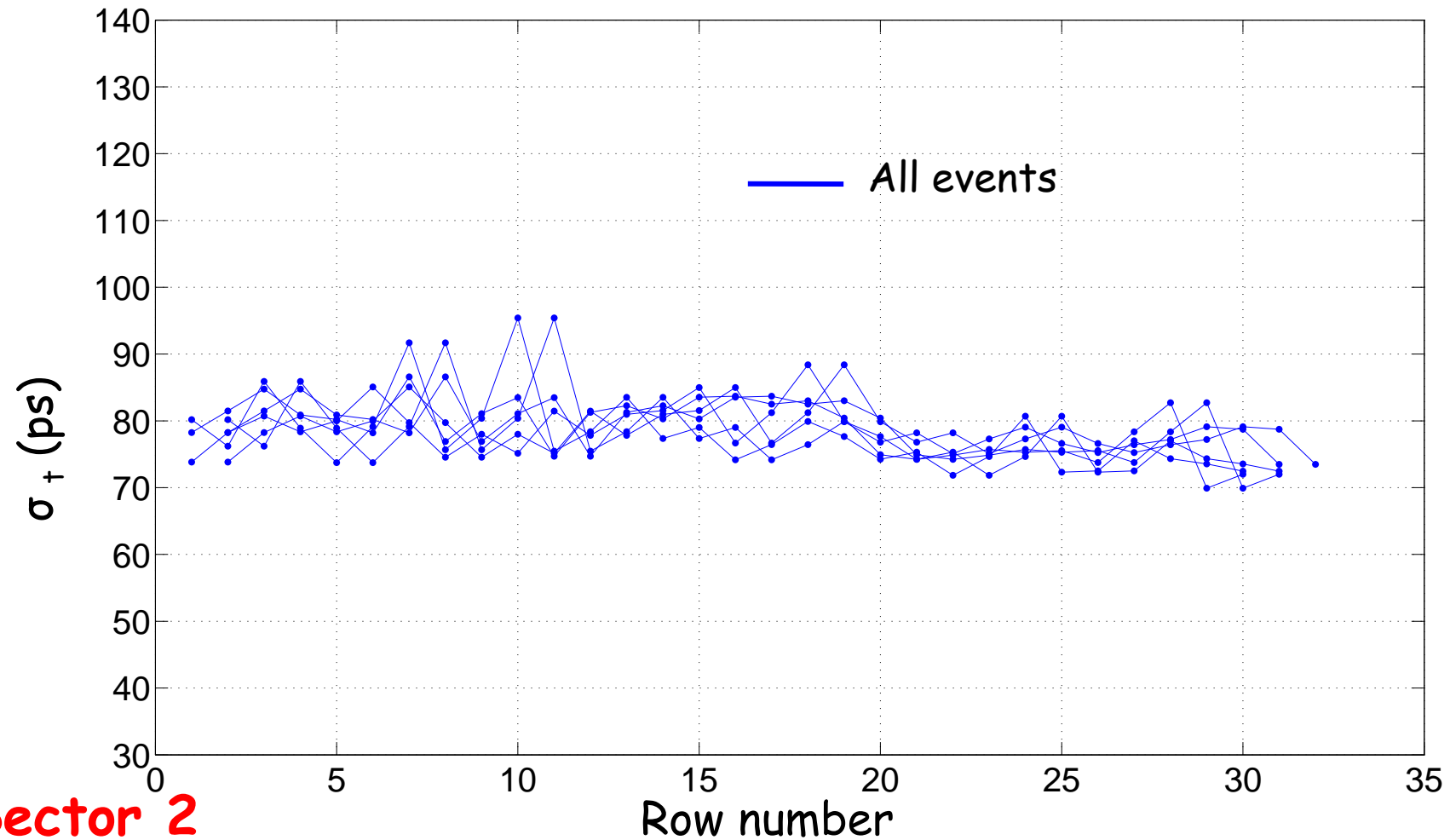
$\langle \sigma_{\dagger} \rangle$



Out of a total of 1116 cell, 1114 are operative along with 2232 FEE

# Intrinsic RPC performance. Time resolution, multihit

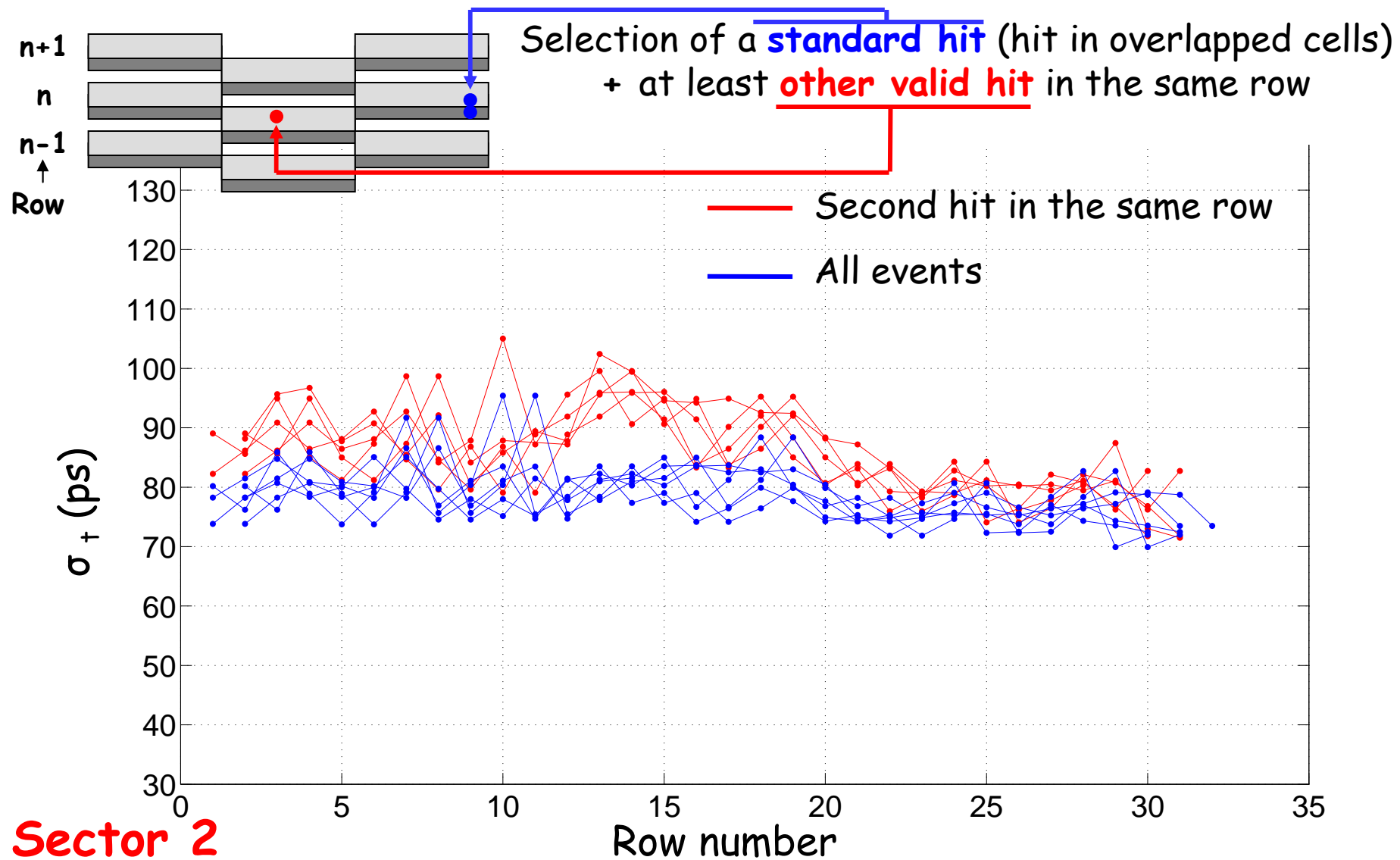
## Multihit time resolution



Sector 2

# Intrinsic RPC performance. Time resolution, multihit

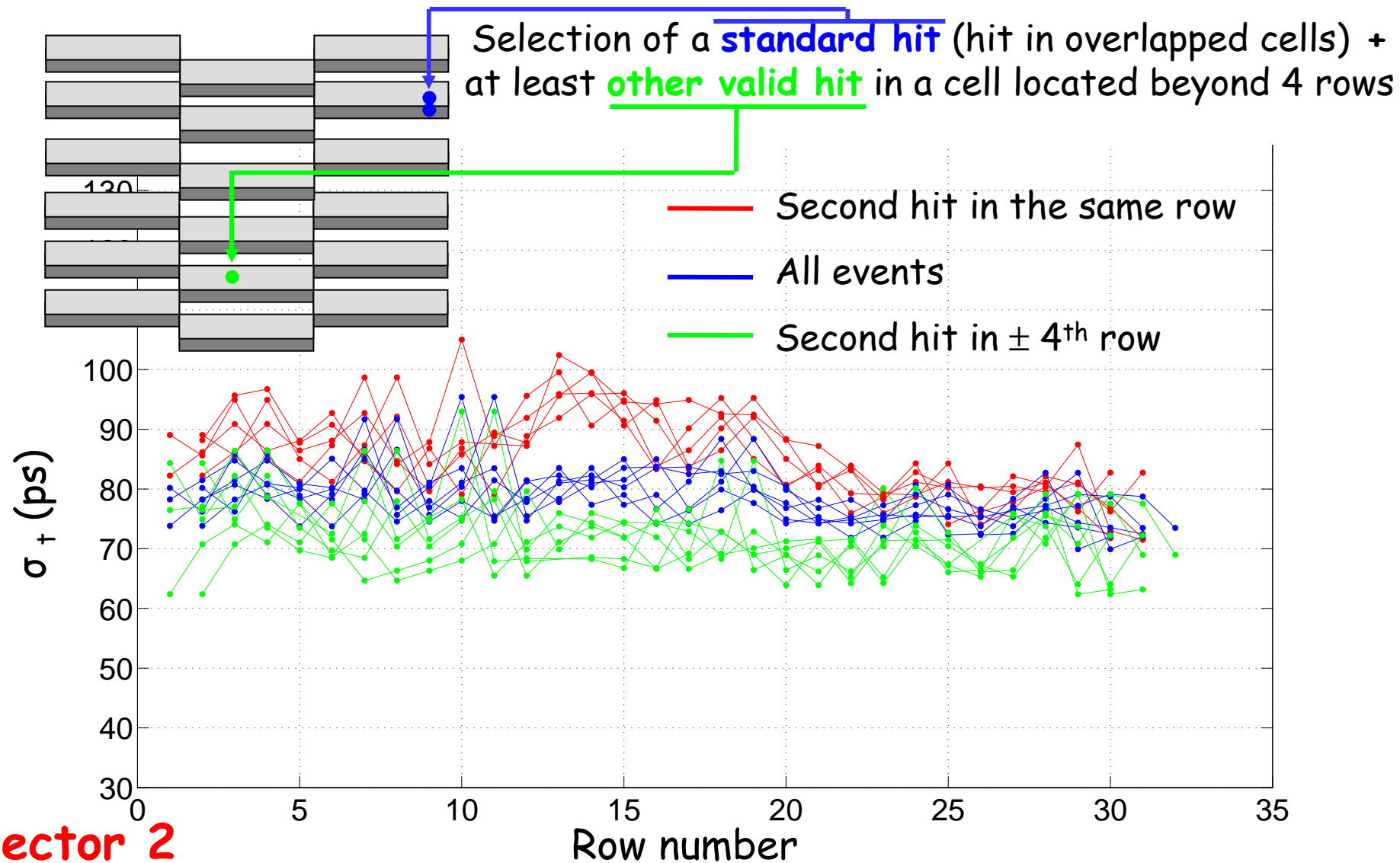
## Multihit time resolution





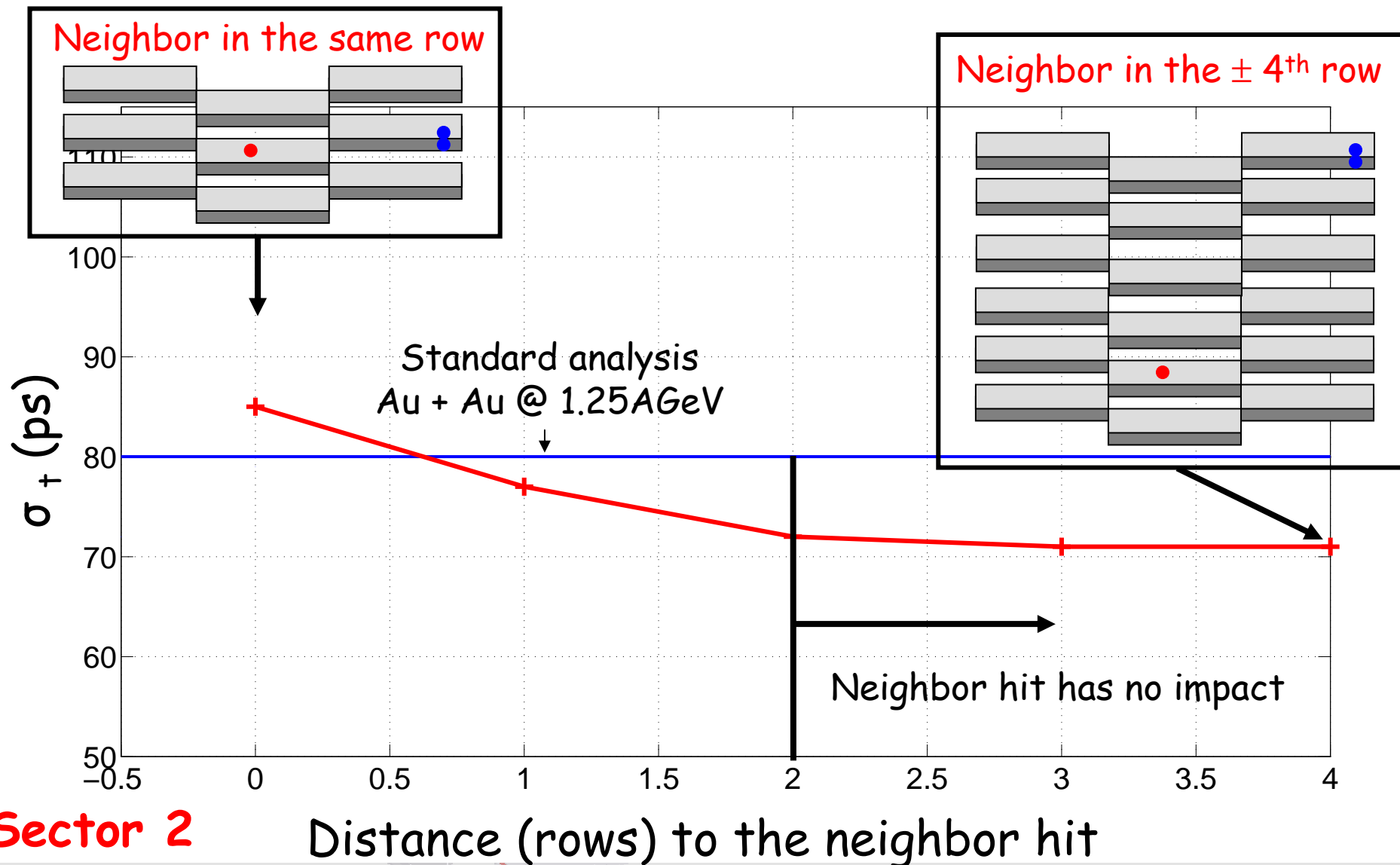
# Intrinsic RPC performance. Time resolution, multihit

## Multihit time resolution



# Intrinsic RPC performance. Time resolution, multihit

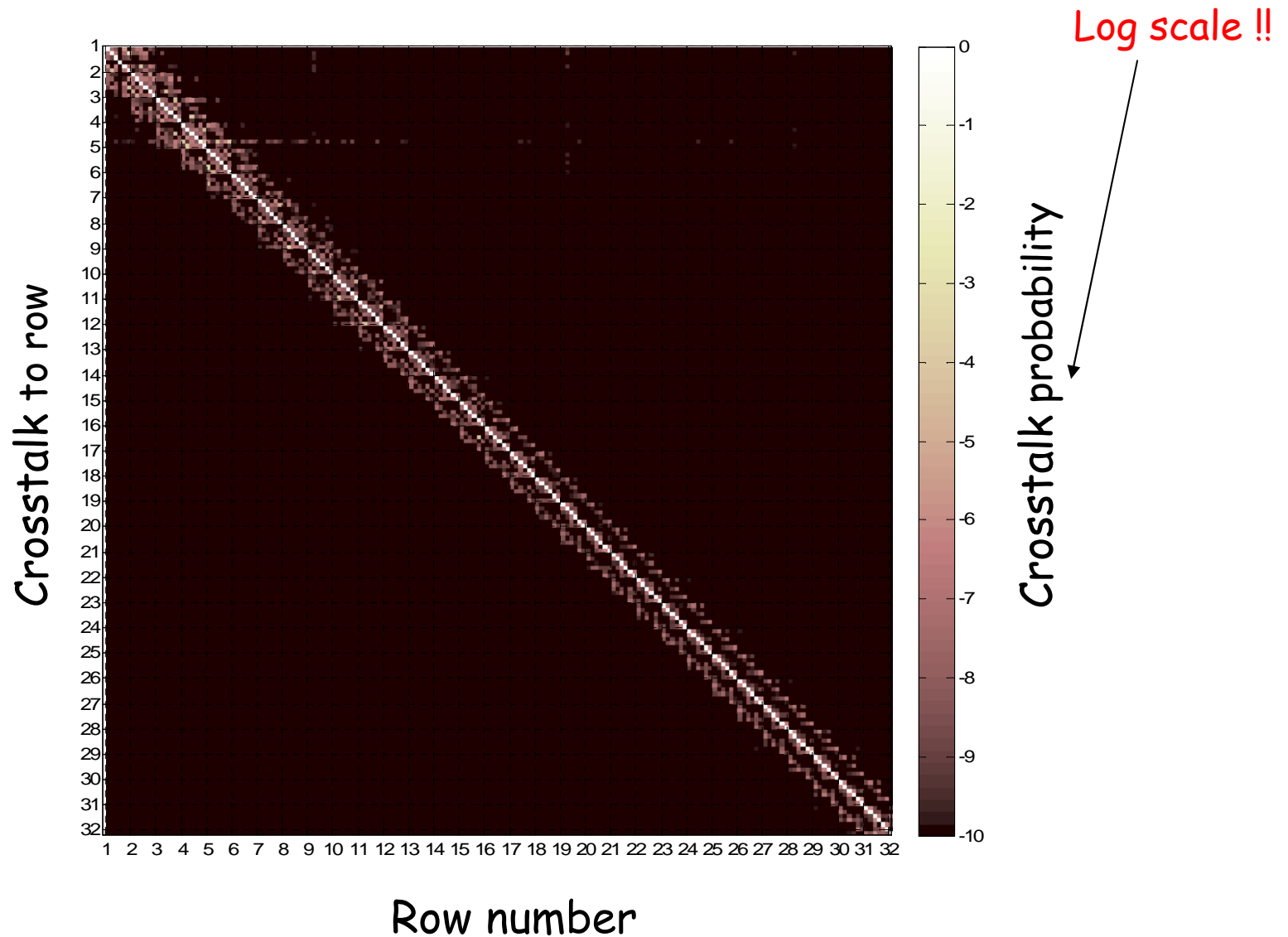
## Multihit time resolution



Sector 2

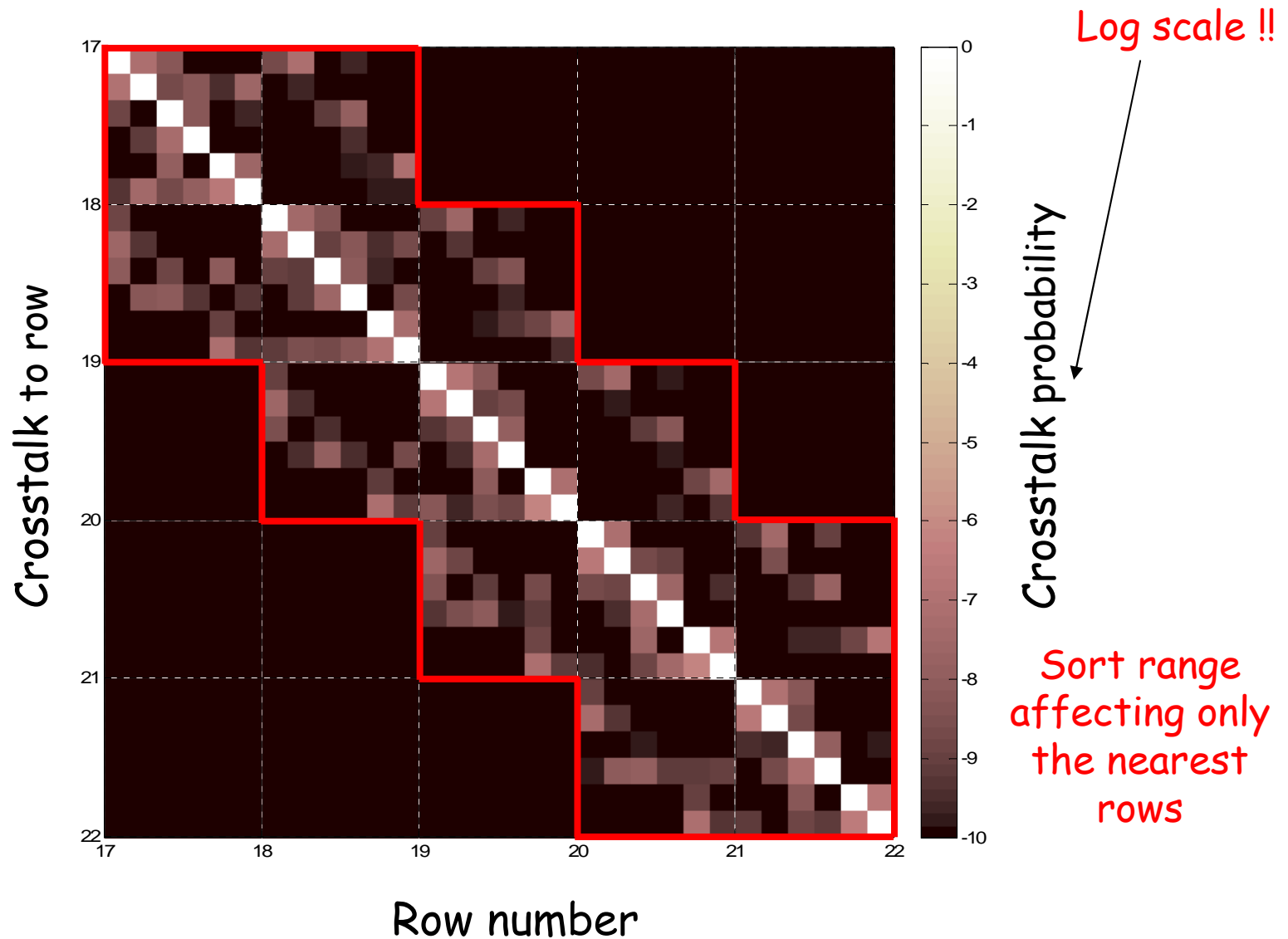
Distance (rows) to the neighbor hit

# Intrinsic RPC performance. Crosstalk



**Sector 2**

# Intrinsic RPC performance. Crosstalk



# Intrinsic RPC performance. Time resolution, $P_{low}$ , $P_{high}$ , $\pi^+$

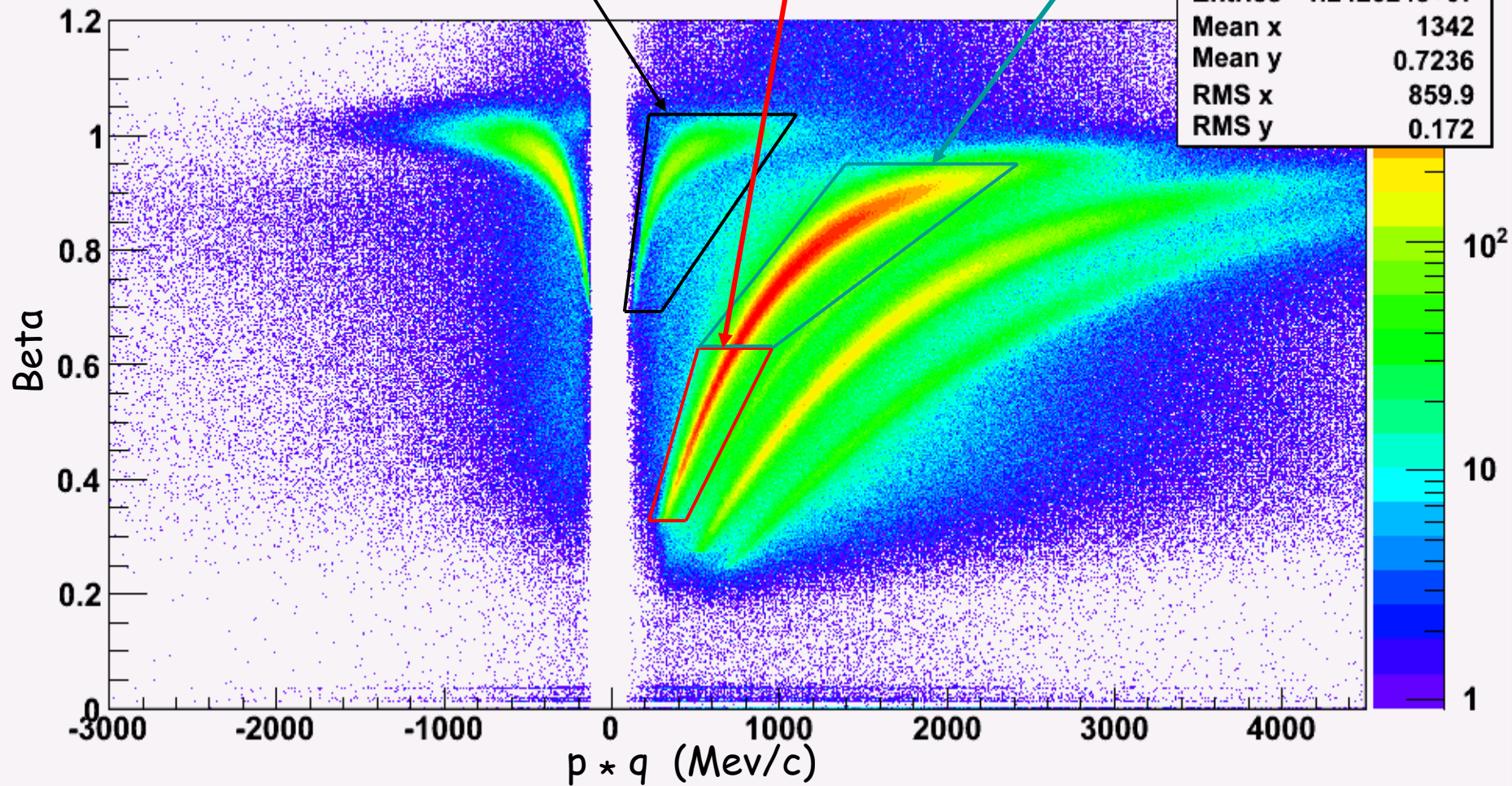
$\pi^+$   
 $\langle \sigma_{\dagger} \rangle = 70$  ps

$P_{low}$  energy  
 $\langle \sigma_{\dagger} \rangle = 50$  ps

$P_{high}$  energy  
 $\langle \sigma_{\dagger} \rangle = 64$  ps

h\_betavsmomallfull

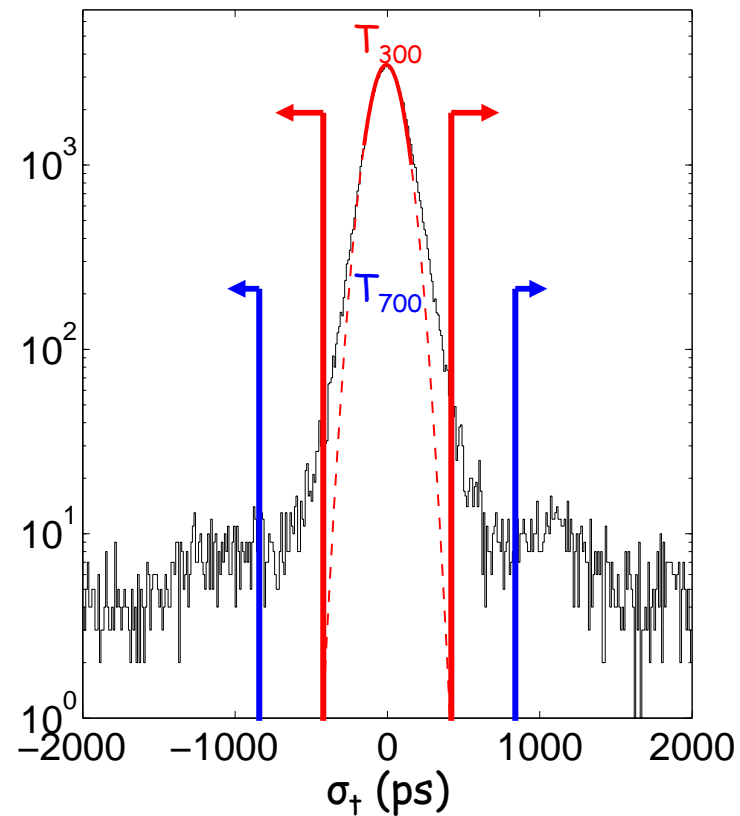
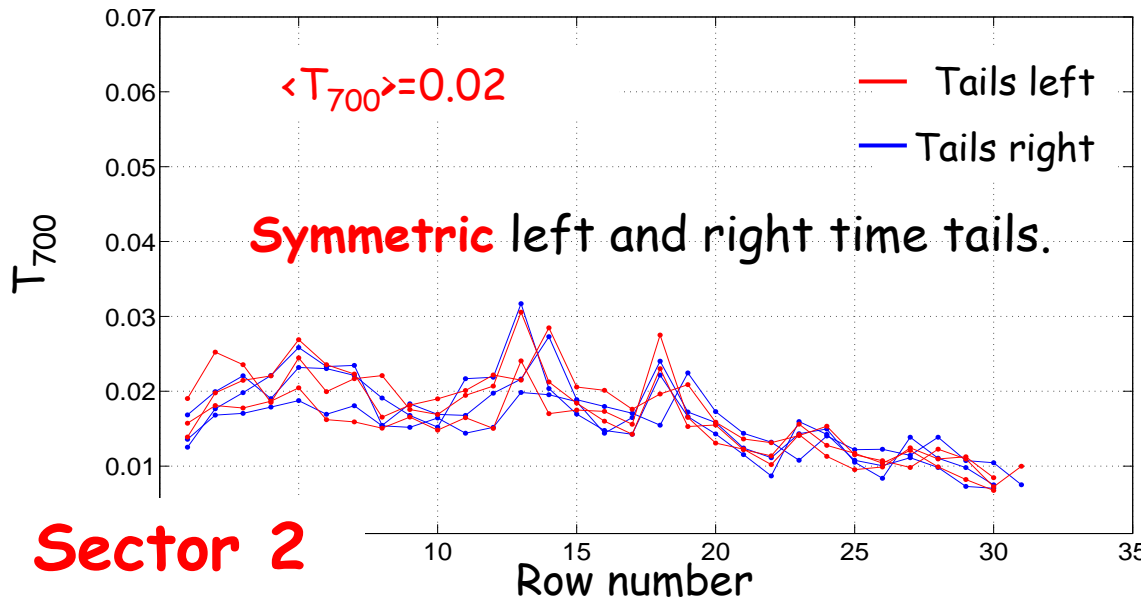
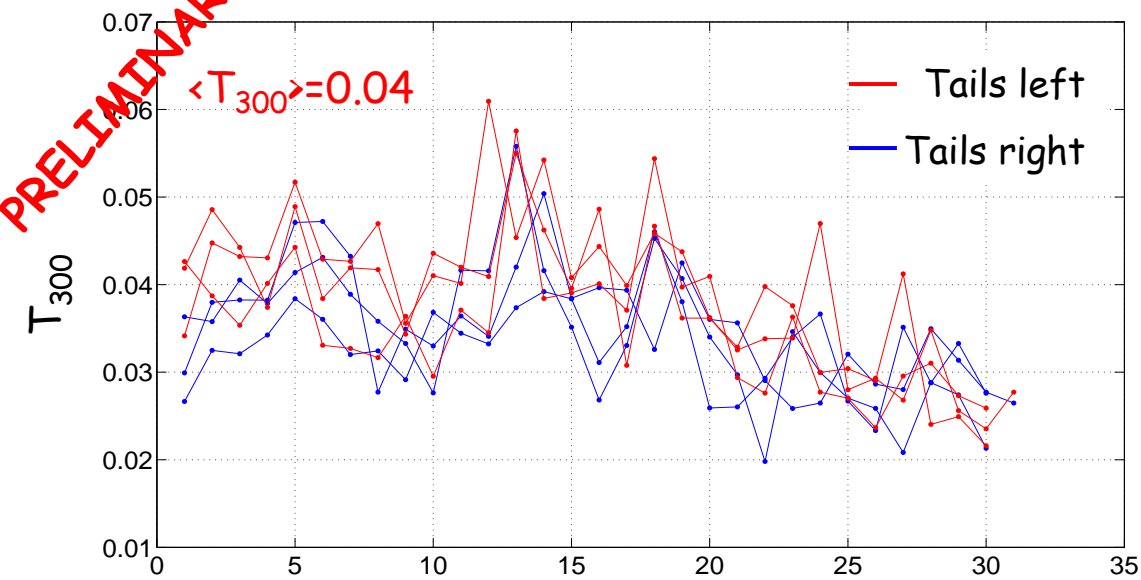
| h_betavsmomallfull |              |
|--------------------|--------------|
| Entries            | 1.242624e+07 |
| Mean x             | 1342         |
| Mean y             | 0.7236       |
| RMS x              | 859.9        |
| RMS y              | 0.172        |





# Intrinsic RPC performance. Time tails

PRELIMINARY !!!



Average for all sectors

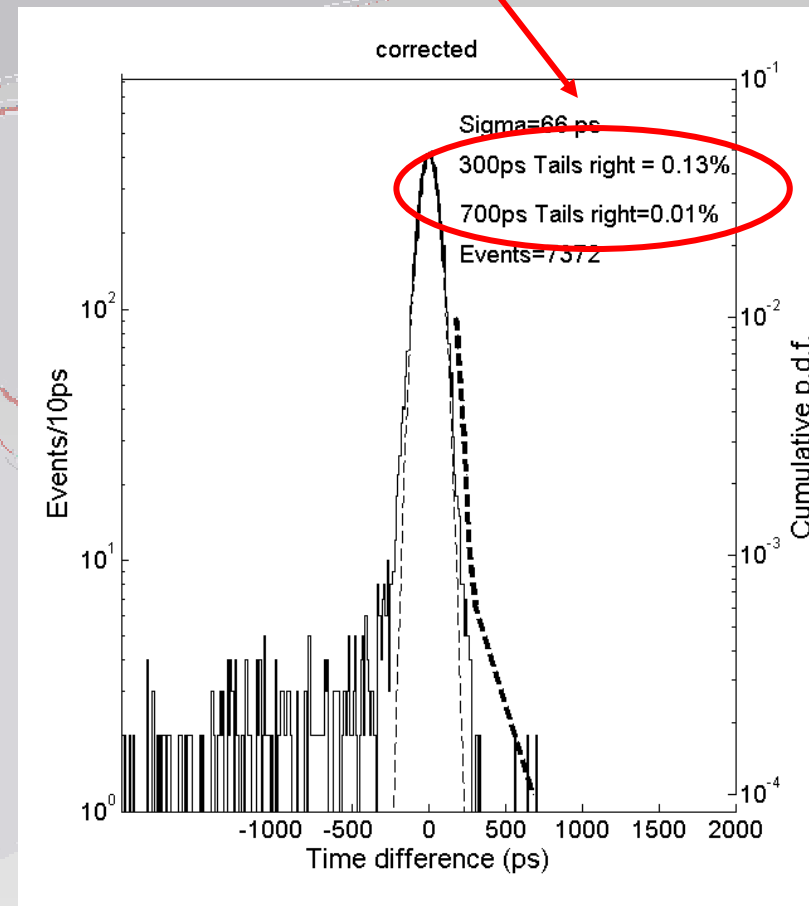
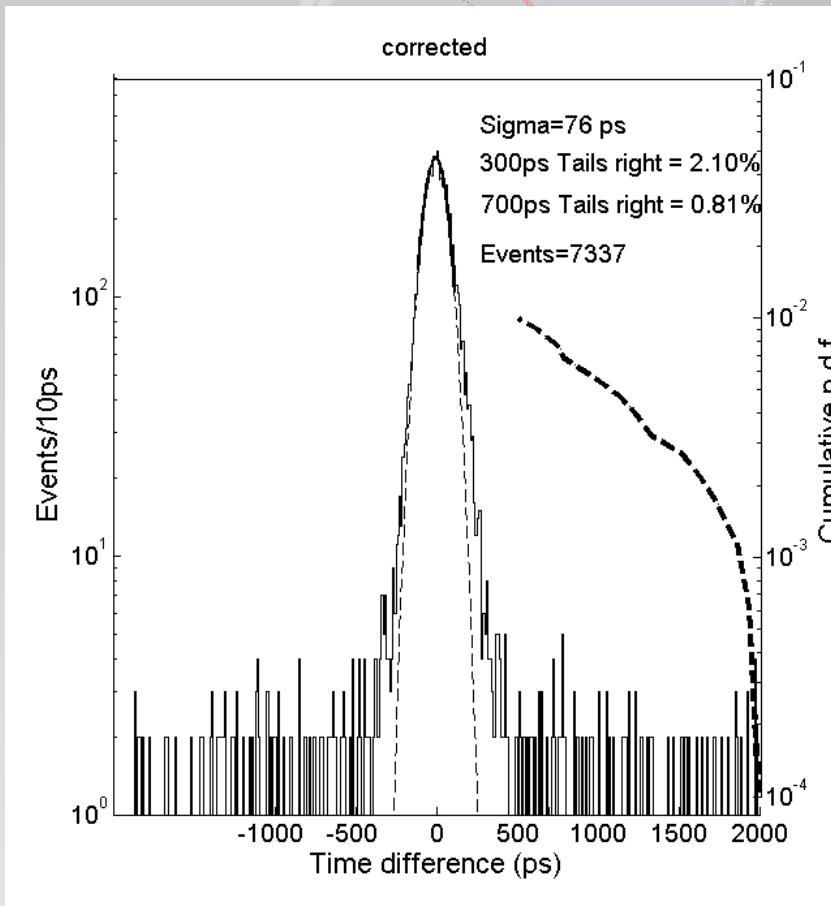
$\langle T_{300} \rangle = 3.6\%$

$\langle T_{700} \rangle = 1.7\%$

# Intrinsic RPC performance. Time tails, double layer advantages

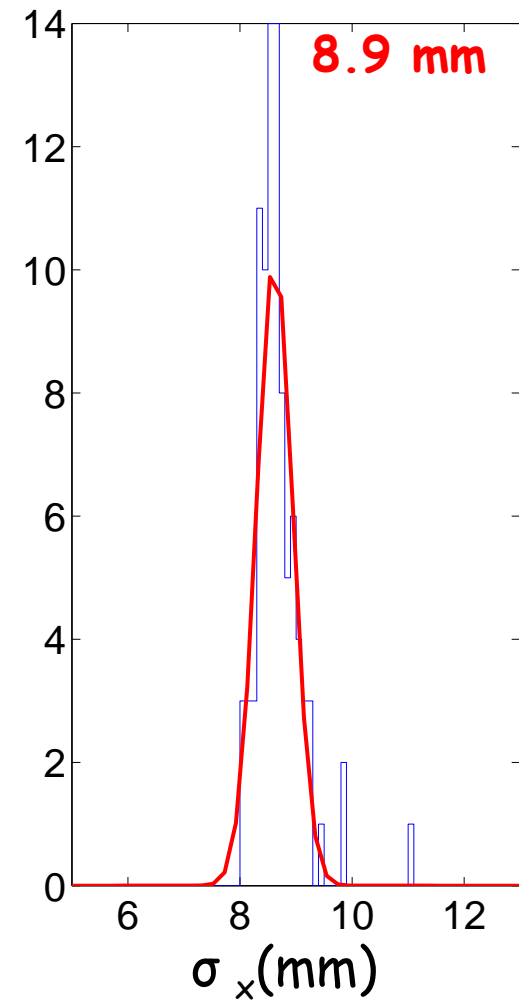
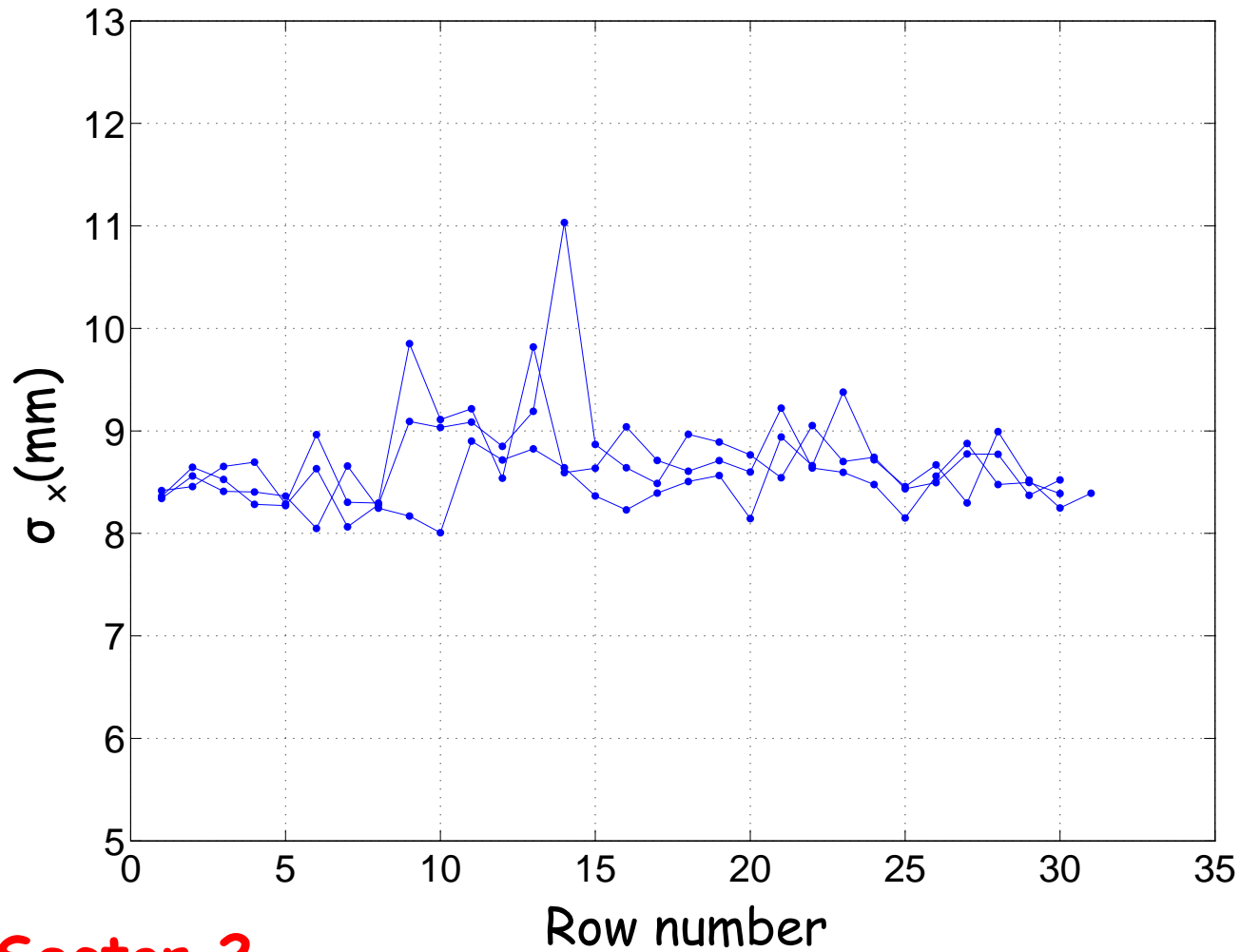
Tail cancellation using redundant information  
(overlapping of cells) at a cost of efficiency

Suppression of the tails in one side



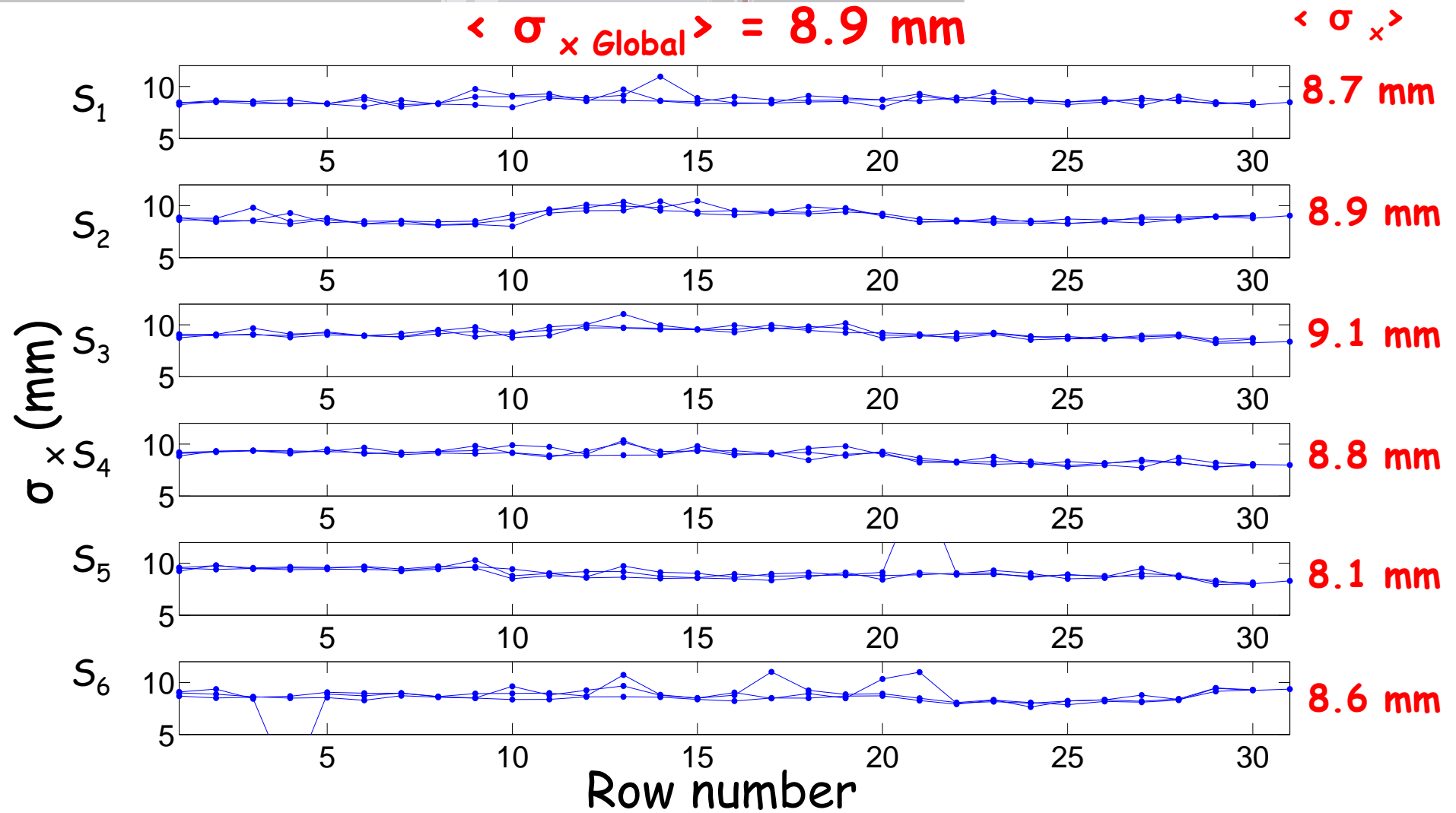
# Intrinsic RPC performance. Spatial resolution

Homogeneous longitudinal position resolution  $< 10$  mm  $\sigma$



Sector 2

# Intrinsic RPC performance. Spatial resolution

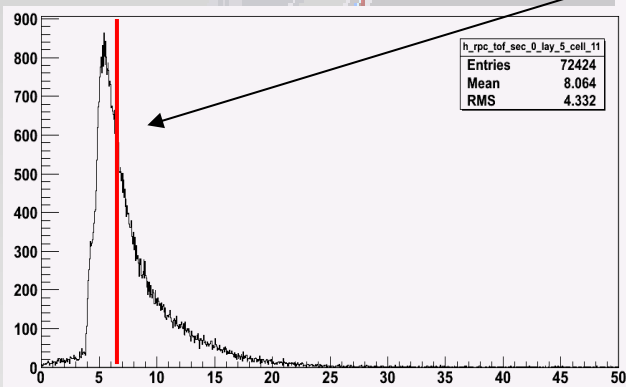


# System RPC performance. Time calibration

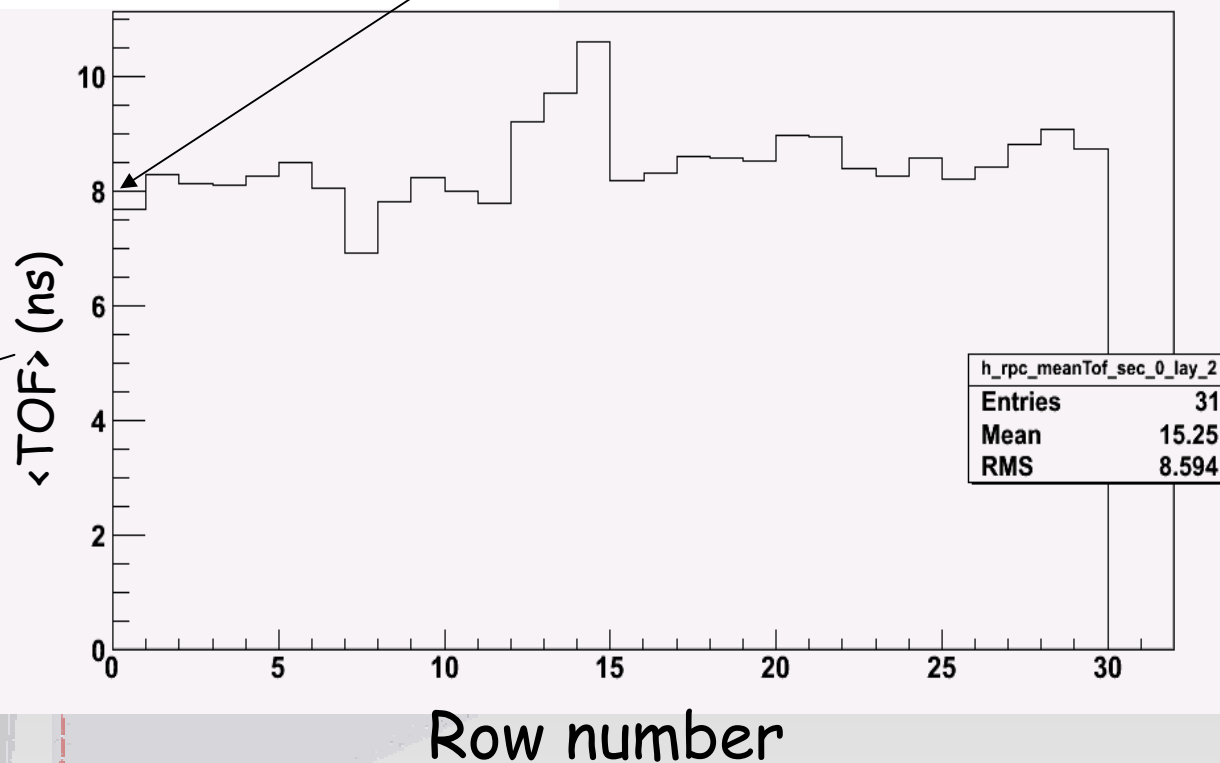
**Different offsets** of individual cells **must be corrected to create a isochronous surface**. Protons are used since covers almost all the detector surface with high statistics.

Raw  $\langle \text{TOF} \rangle$  positioned around 8 ns

Raw calibrated  
TOF from RPC  
 $\text{TOF}_{\text{measured}}$



S2 BC





# System RPC performance. Time calibration

**Different offsets** of individual cells **must be corrected to create a isochronous surface**. Protons are used since covers almost all the detector surface with high statistics.

Raw calibrated  
TOF from RPC  
 $TOF_{\text{measured}}$

Momentum ( $p$ ) and  
path length ( $L$ )  
from tracking

Momentum  
cut at 0.9 GeV  
(avoid Mult.Scatt)

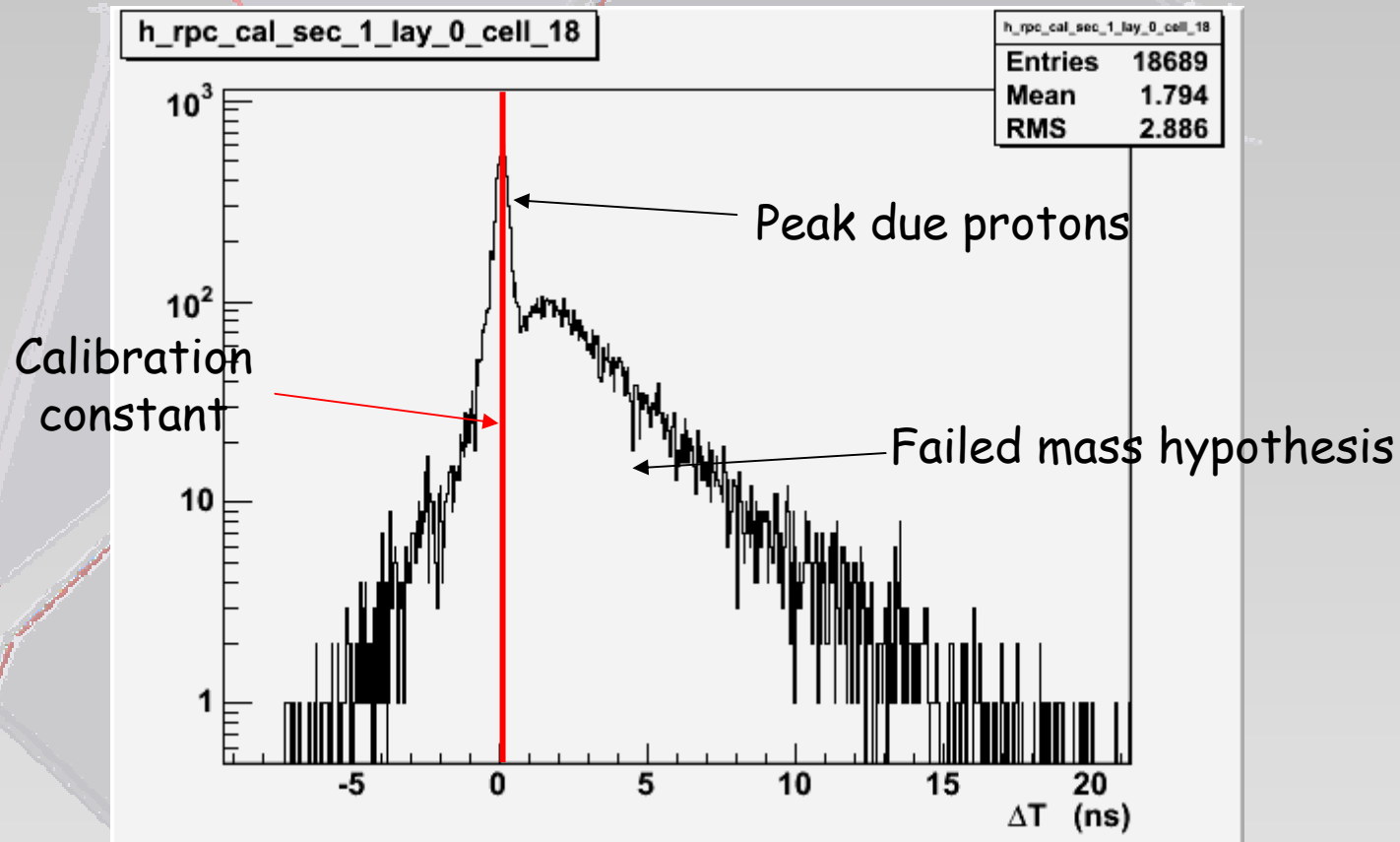
$$TOF_{\text{estimated}}^* = L/v = L \cdot m_p / p$$

\*assuming all particles protons.

ToF  
Calibration  
constant

# System RPC performance. Time calibration

Different offsets of individual cells **must be corrected to create an isochronous surface**. Protons are used since covers almost all the detector surface with high statistics.



$TOF_{\text{measured}} - TOF_{\text{estimated}}$  for one RPC cell

# System RPC performance. Time calibration

**Different offsets** of individual cells **must be corrected to create a isochronous surface**. Protons are used since covers almost all the detector surface with high statistics.

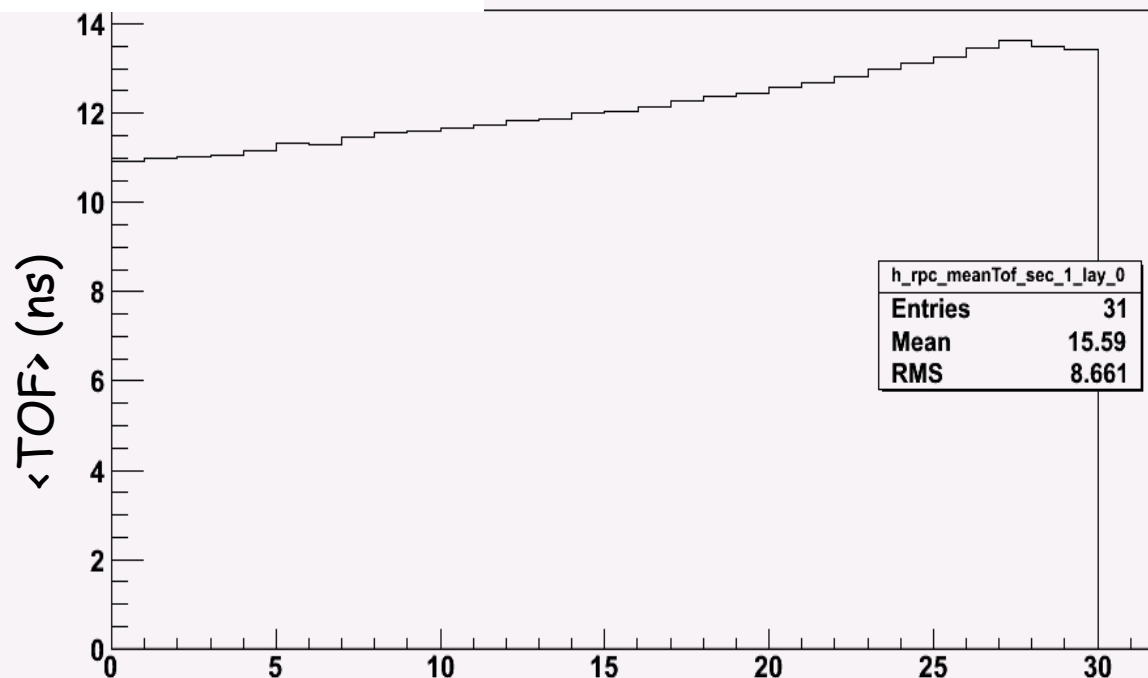
$\langle \text{TOF} \rangle$  after calibration

Raw calibrated  
TOF from RPC  
 $\text{TOF}_{\text{measured}}$

Momentum ( $p$ ) and  
path length ( $L$ )  
from R-K

(a)

S2 BC

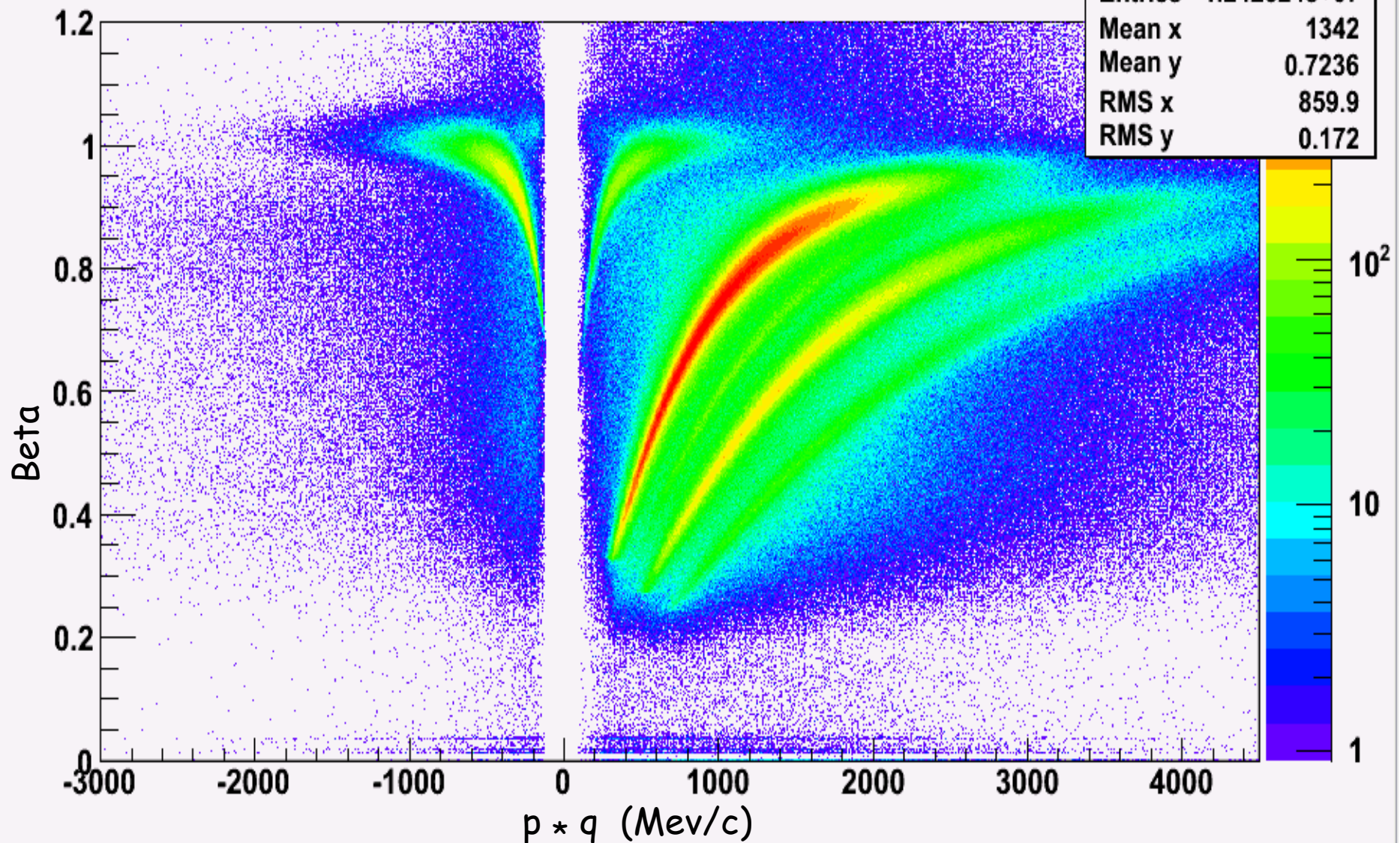


Row number



# System RPC performance. PID

h\_betavsmomallfull



# Conclusions

RPC-TOF fully integrated in the HADES spectrometer  
and commissioned in Au + Au beam

Uniform time resolution  $\langle 80 \rangle$  ps  $\sigma$  in a Au + Au  
environment, fulfilling the desing requirements

Ready for production beam time (April 2012).

# HADES RPC Group

- **GSI**

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- A. Gil