

MINISTERUL CERCETĂRII ȘI INOVĂRII



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PN 19060103

FAZA 14 Septembrie 2022

TITLUL Simulari realiste in cadrul CbmRoot ale prototipului TRD in setup-ul experimental mCBM la rate de interactie de 10 MHz.

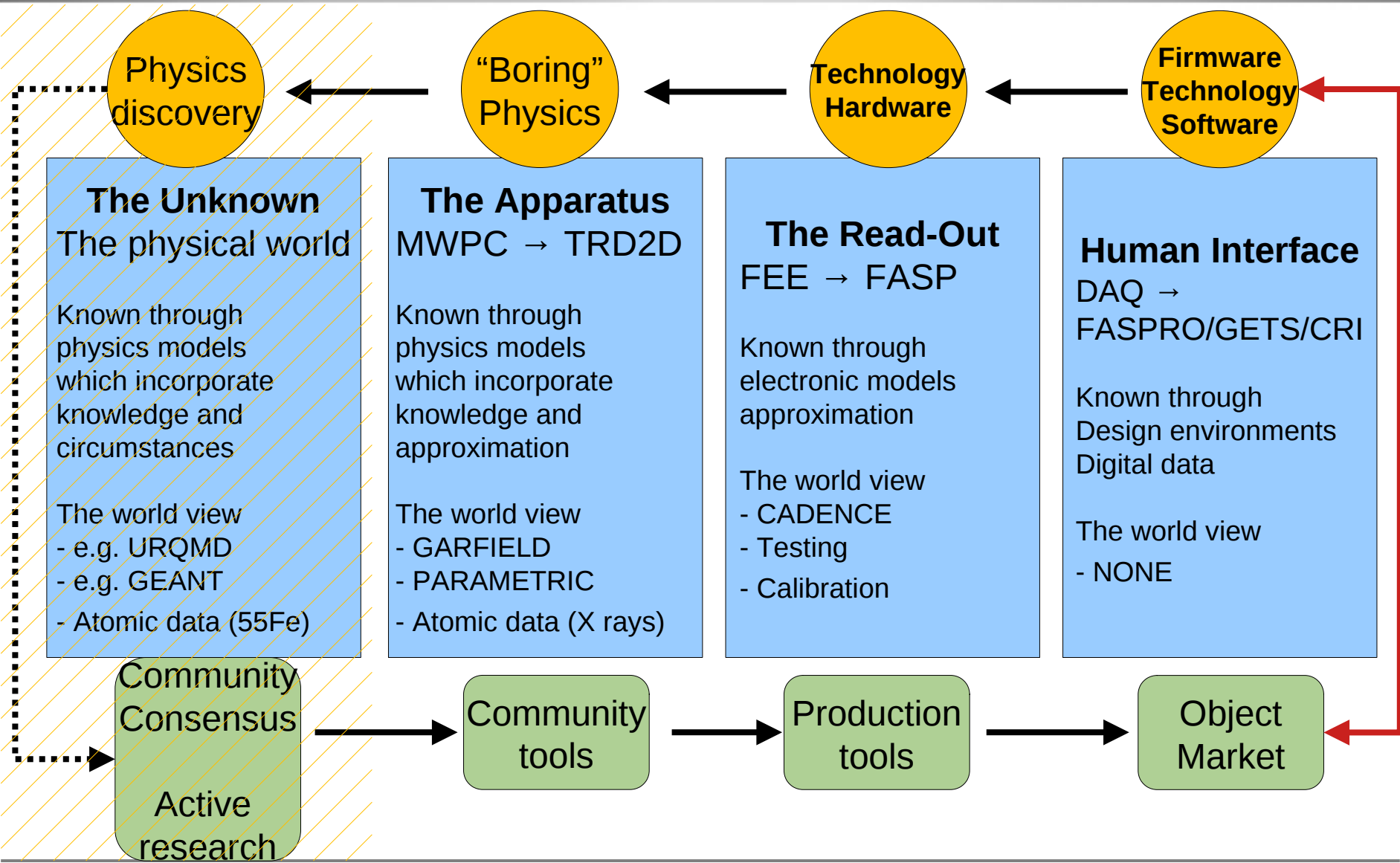
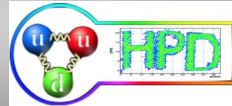
REZULTATE

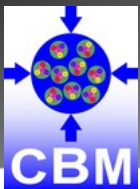
- Producerea semnalelor in detector pentru diferite conditii de operare a acestuia
- Digitizarea semnalelor tinand cont de caracteristicile ASIC-ului frontend FASP
- Constructia de clusteri de semnal in modul de operare free-running
- Determinarea parametrilor de pozitie si energie ale hit-urilor TRD și comparatia cu informatia din MC

Prezinta : Alexandru Bercuci



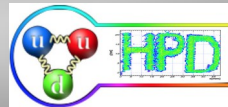
An overview on signal production in MWPC





Particle interaction in the apparatus

Physical signal generation (“Boring” Physics)



Prerequisite

- Segment detector in y-z cells centered on each anode wire
- Use linear track model inside chamber

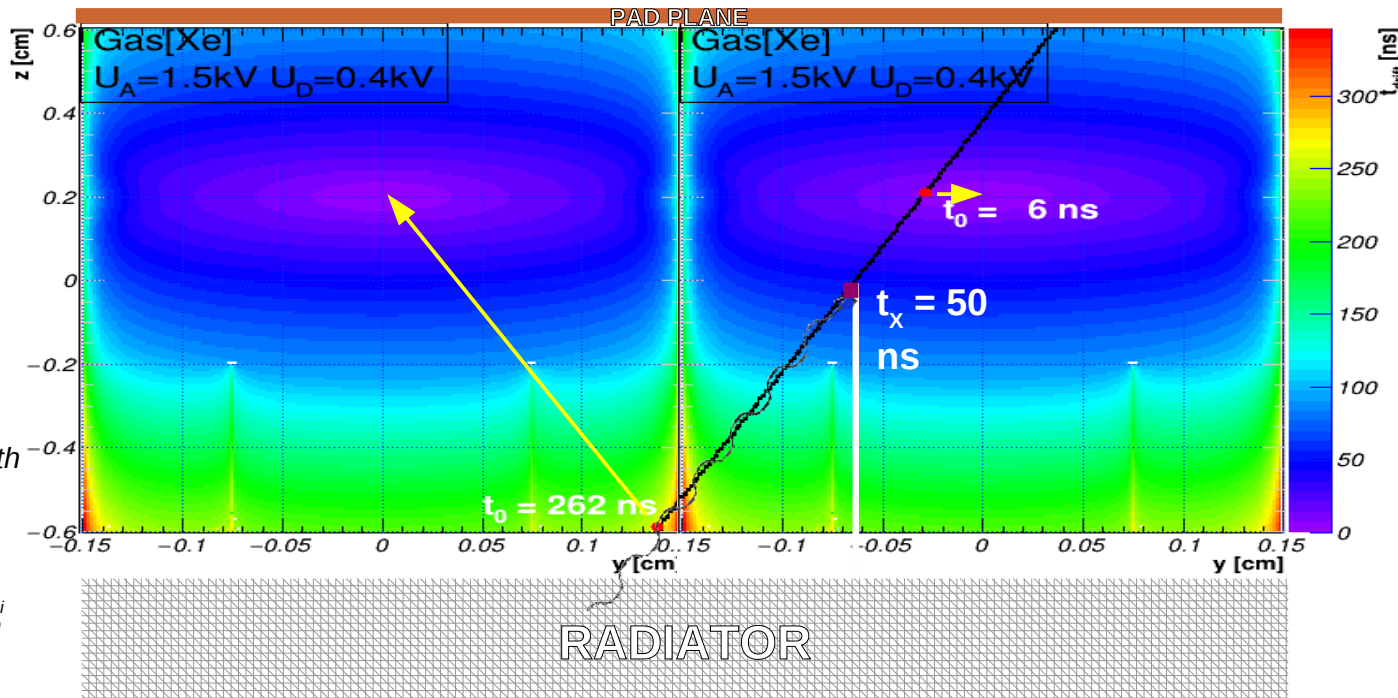
Energy deposit

• Ionization

- Split track on cells; find track length on each cell : dL_i
- Compute minimum drift time for each cell t_0^i
- Compute energy deposit in cell $E_0^i = dL_i * dEdx_{track} / L$

• X-ray interaction

- Compute penetration depth along the track (radiation length)
- Find cell; compute time t_x
- Check process
- For PE compute Auger probability
- Compute energy e.g. Ar
- $E_{PE} = E_x - E_k$; $E_{auger} = E_k - 2E_{L_i}$; $E = E_{PE} + E_{auger}$ (if available)

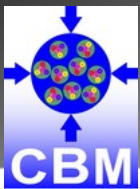


Physical digi (I)

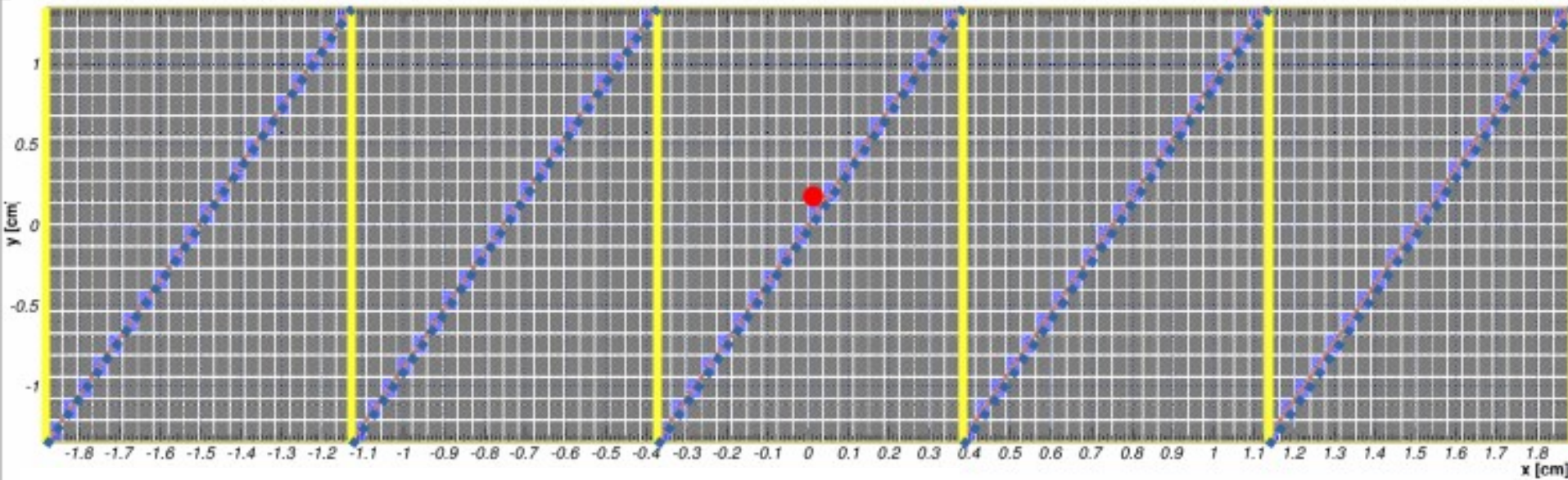
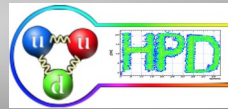
- X → mid of x-y projection in each cell
- Y → mid of the cell (anode wire)
- Z → anode wire
- T → t_0^i
- E → E_0^i

Physical digi (II)

- $Box_{dx}(X-Y) \rightarrow Gauss(X, Y | \sigma_x & dx, \sigma_y)$
- Row → y position on the pad grid
- Col → x position on the pad grid
- Up → triangle selection
- $E(r, c, u) \rightarrow$ energy on the triangle
- $\sum_{r, c, u} E(r, c, u) < E_0^i$ [No energy threshold at this phase as it depends on digi-time topology (neighbor trigger)]
- T → t_0^i



Detector spatial (PARAMETRIC)



$$w = q^{\nabla/\Delta} = \int_{-pw/2}^{pw/2} dx \int_{-k_x}^{k_x} dy \mathcal{G}(x|x_p, \sigma_x) \mathcal{G}(y|y_p, \sigma_y)$$

$$\approx \sum_i \sum_j \mathcal{G}(x_i|x_p, \sigma_x) \mathcal{G}(y_j|y_p, \sigma_y) d\mathcal{A}(i, j)$$

Charge image is calculated for the closest :

- 3 rows
- 5 columns

Neglecting :

- intrinsic time evolution
- ion back-flow correction

Corrections :

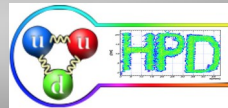
- diffusion
- track inclination
- charge fluctuations/resolution

Approximation :

- PRF = GAUSS
- polar symmetry of charge cloud
- no intrinsic noise generation
- no mechanics effect
(flow, density gradients, etc)

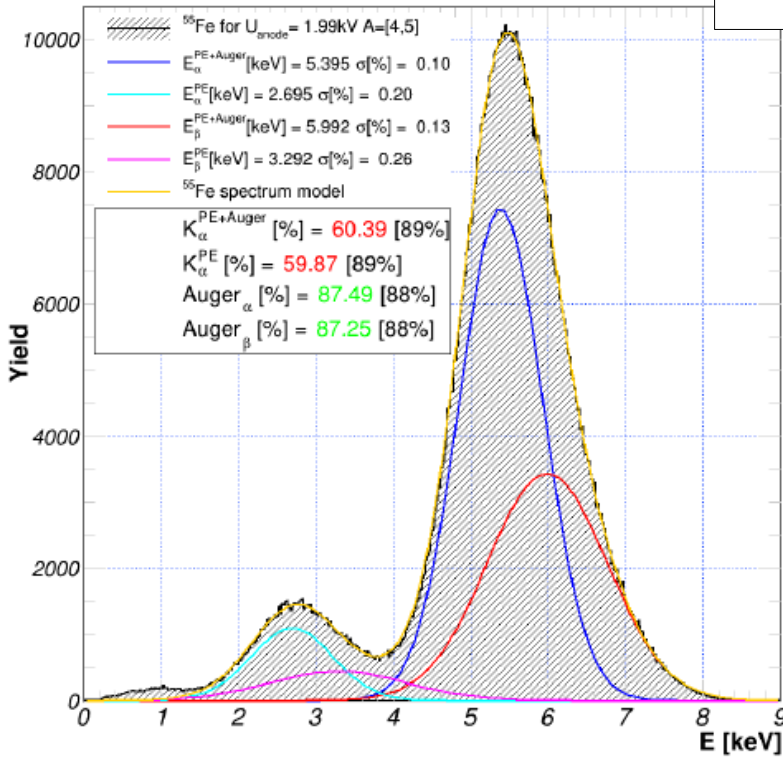


Detector gain (Atomic data)

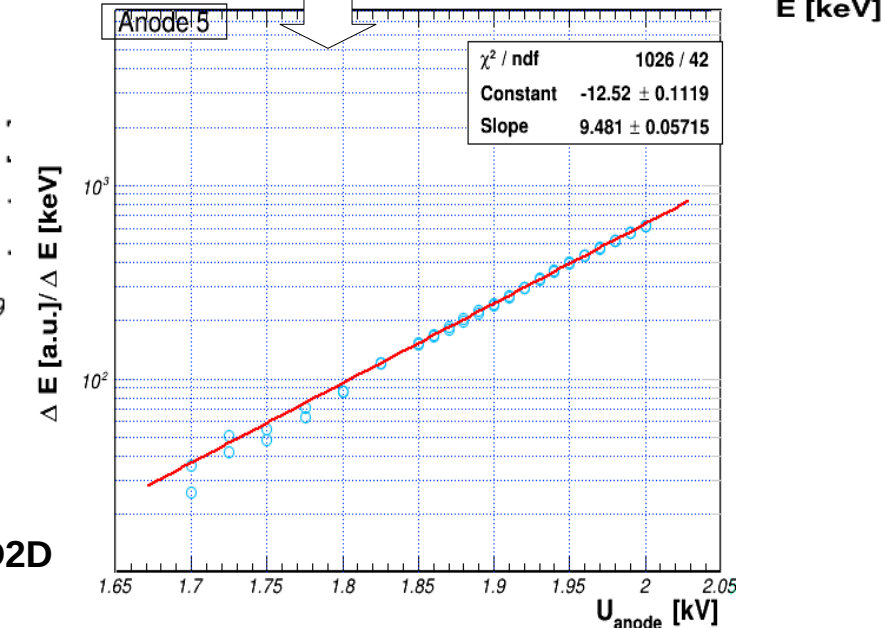
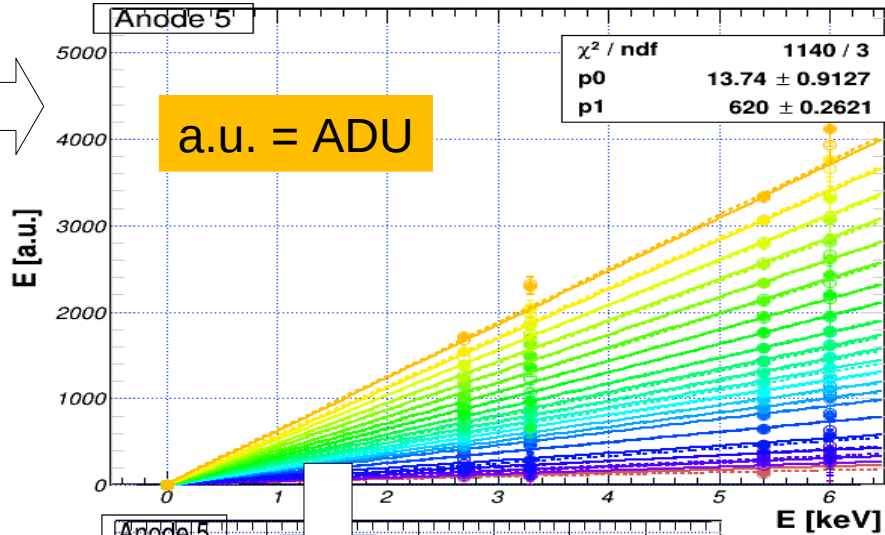


Energy resolution estimation based on fully calibrated cluster reconstruction and anode identification compared with atomic data

Performance estimates for the Inner zone CBM-TRD @ SIS100; CBM-Software Meeting 30th January 2020

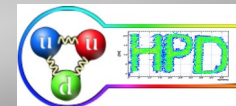


The “measured” gain characteristics of TRD2D as seen on the 5th anode





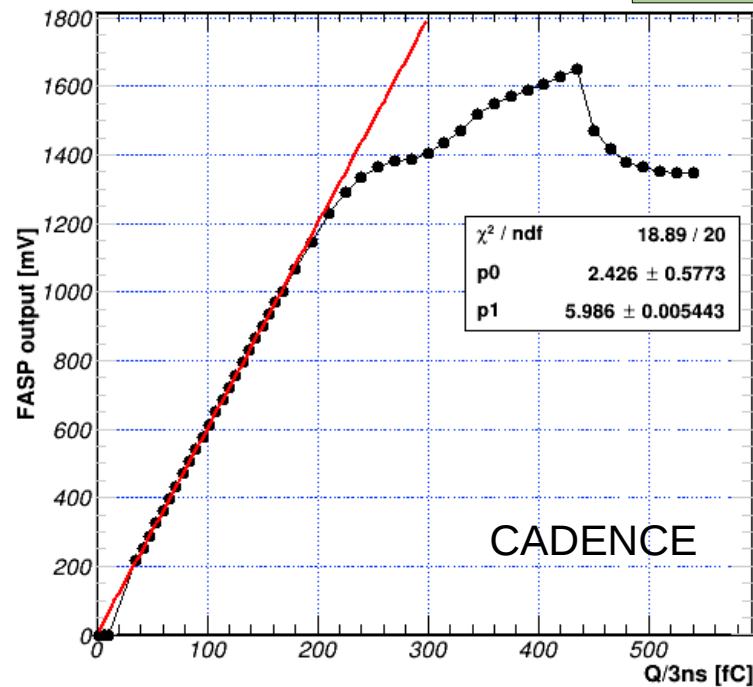
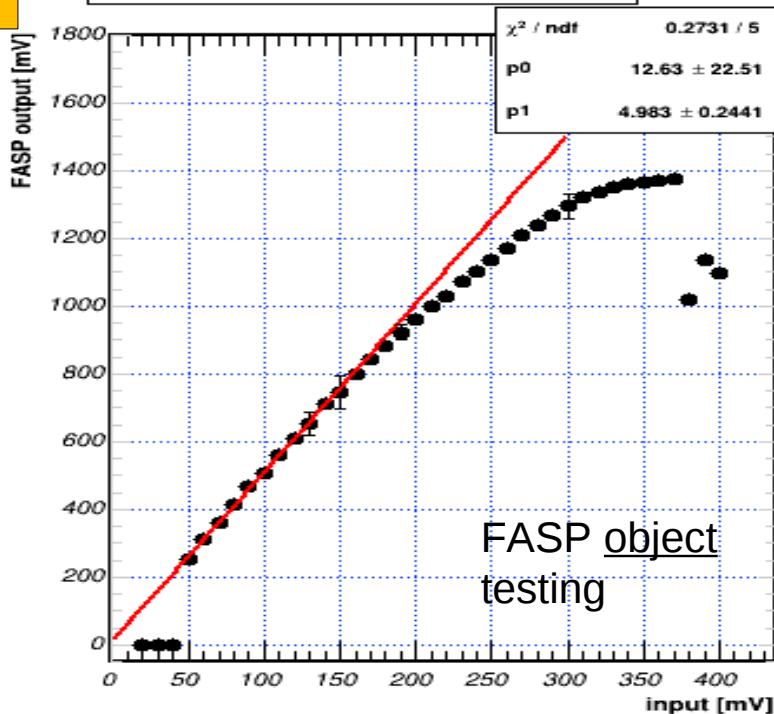
FEE Electric gain (Technology & tools)



ADC response

Th. response

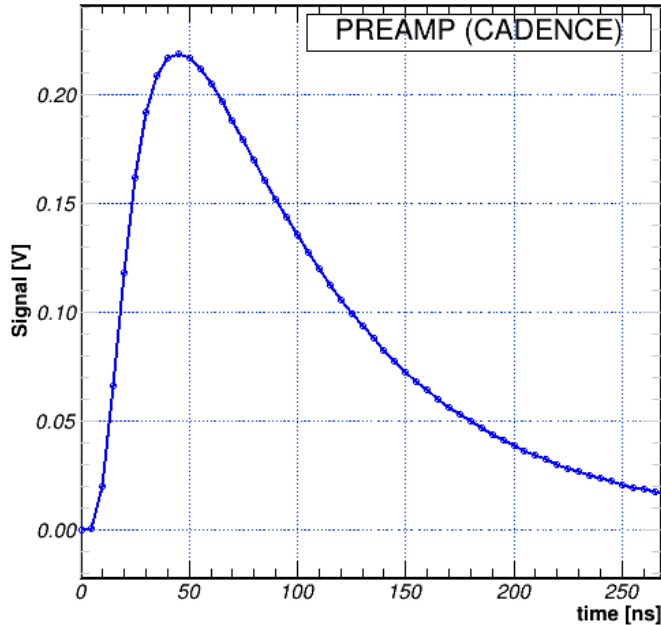
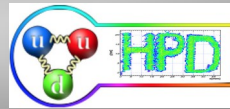
Gain FASPV03 ASIC ID[003] CH[04]



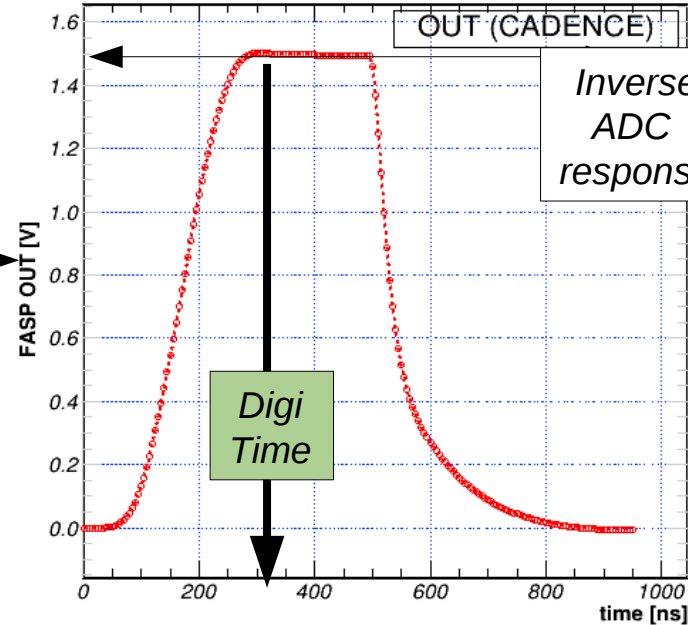
Edep (keV) → Q (fC) → Signal (mV) → Data (ADU)



Electric signal timing / amplification (tools / FW / Technology / SW)



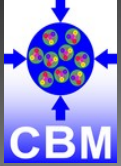
Analytic



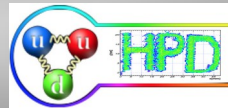
Time-based CbmRoot →

(S,T) → CH(pad) → FASP(FEE) → FASPRO(FEB) → CRI(DAQ) → MS(SW)

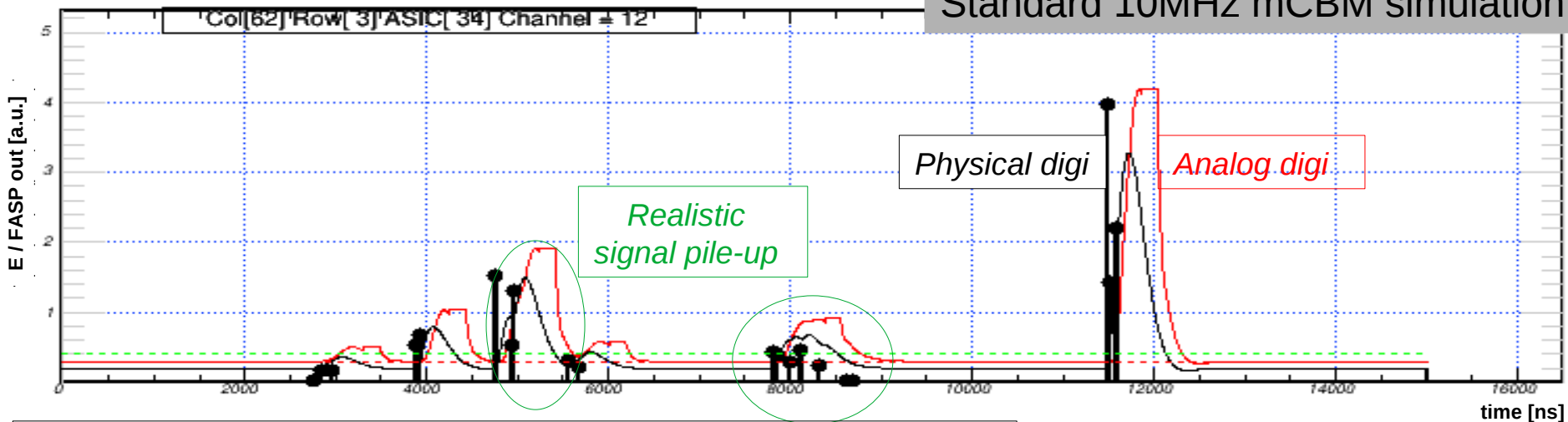
Free-running DAQ →



Adding all up



Standard 10MHz mCBM simulation



Signal-Time simulation for one FASP channel for:

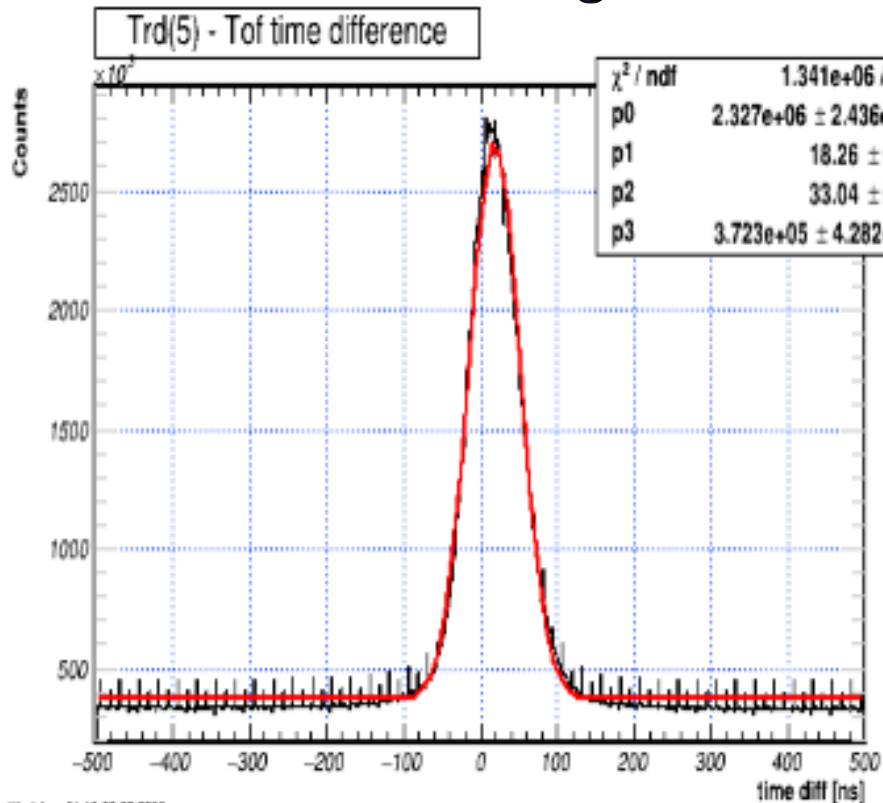
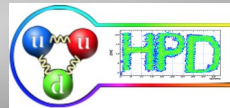
- Au-Au central 10AGeV (URQMD)
- Time-based simulations (CbmRoot/Geant @ 10MHz)
- Standard TRD2D operation (gas, U_{anode} , U_{drift})
- TRD2D Gain extrapolation
- FASP theoretical response

Digi model

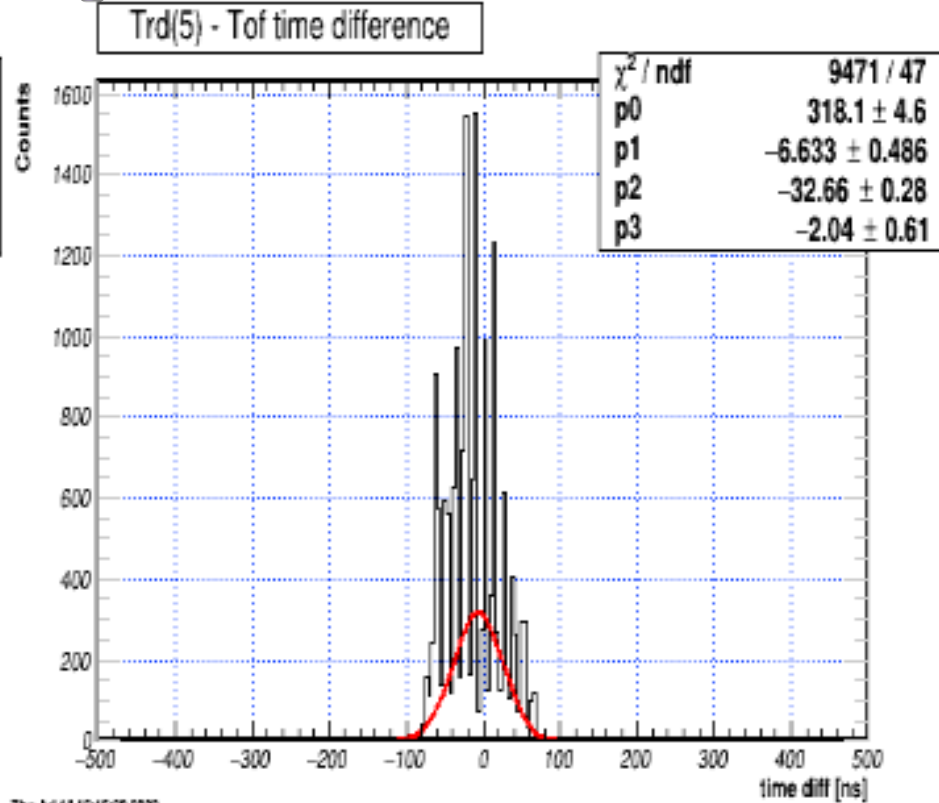
- *CbmTrdDigi* class same for simulation and measurements
- contains all meta data from DAQ
- ***further algorithms treat identical digi independent of their source***



Comparing the results of data taking and modeling chain



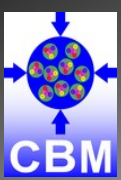
Wed Aug 31 16:32:05 2022



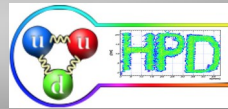
Thu Jul 14 16:15:20 2022

mCBM 2021 @ SIS18 :

Digi time difference between TRD2D, labeled Trd(5), and ToF time tagging for measurements (left) and simulations (right). The time alignment between the two systems is approx. **p₁ = 18+6 ns** which needs fine tuning. The combined time resolution of **p₂ = 33 ns** is nicely reproduced by the simulations while the level of experiment noise is still work in progress. (The ToF has known aging effects not simulated)



Time-Based reconstruction clusters

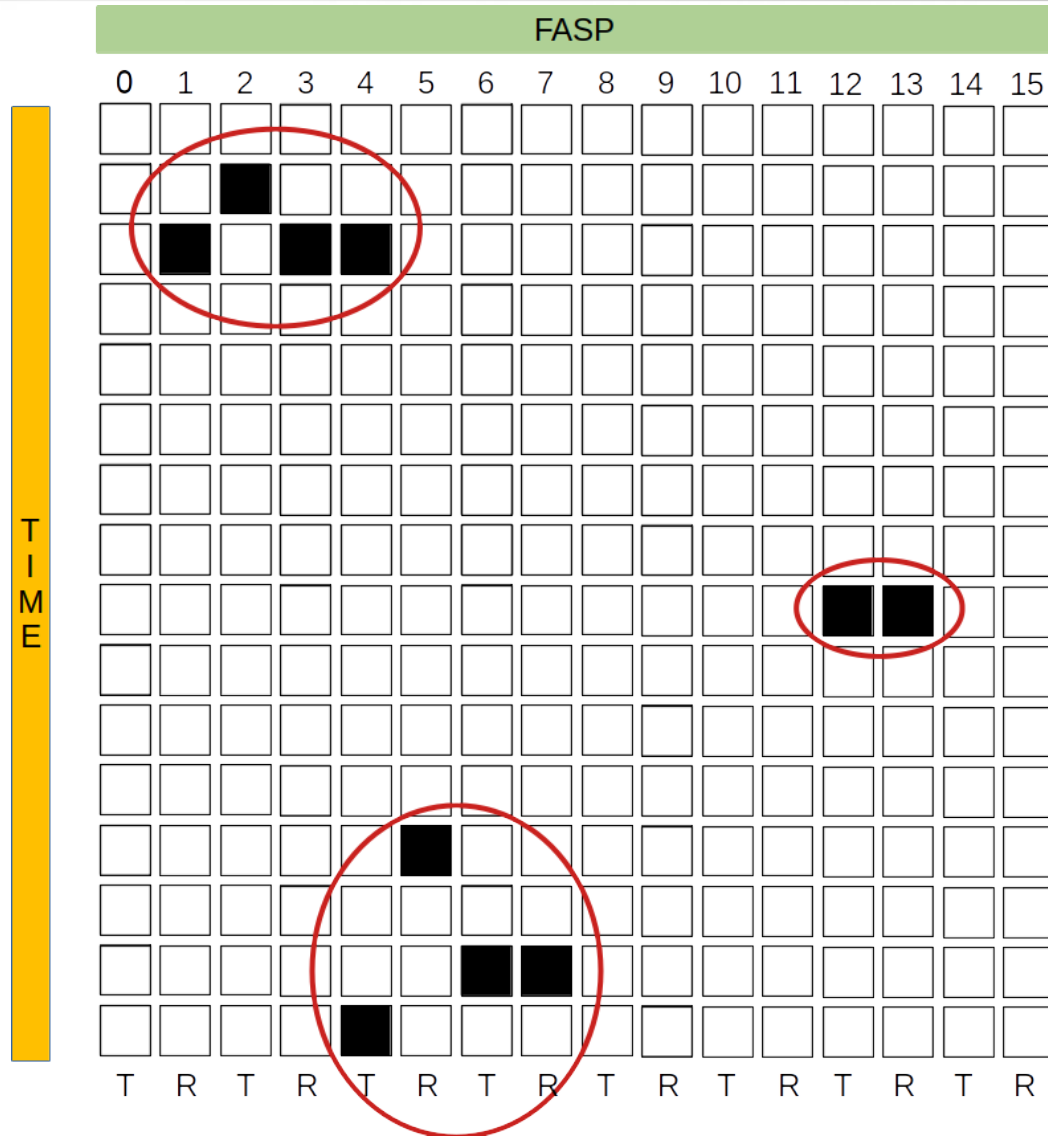
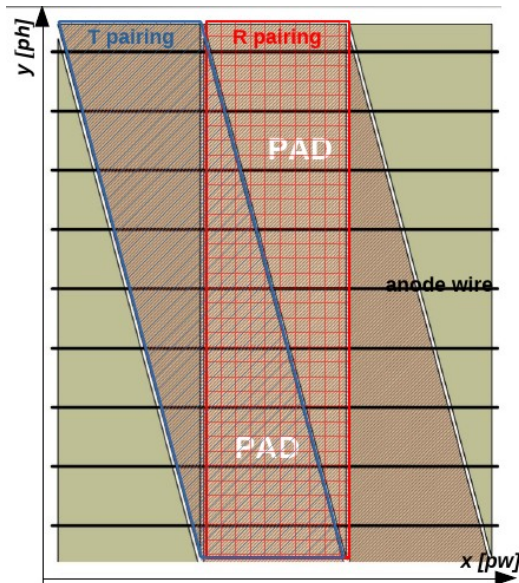


Clusters are

- groups of digi which are
- registered on neighboring pads/channels (without missing pads) and
- a fixed time window (5 clks X 12.5 ns)

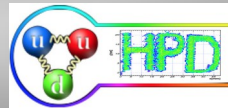
Clusters (CbmTrdCluster) are defined by

- prompt time
- size
- topology (RTRTR)





Time-Based reconstruction hits



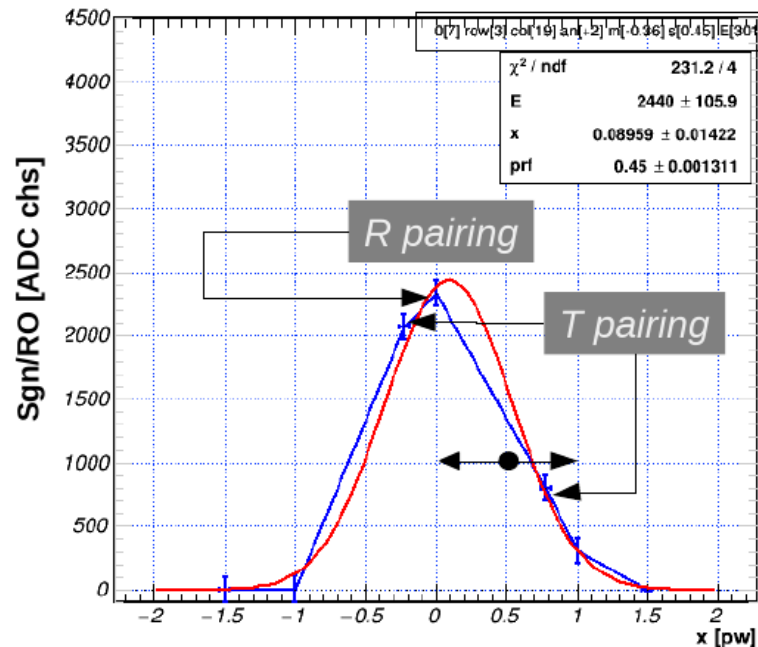
Hits are

- processed info from clusters
- representing best the particle trace
- to be used in tracking

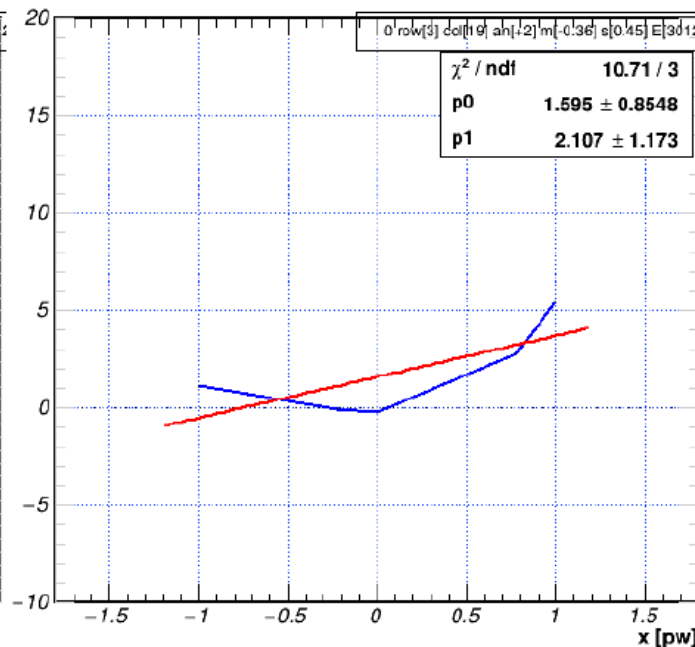
Hits are defined by

- x, y and time information
- error parametrization (covariance matrix)
- energy information
- systematic effects induced by incomplete charge collection

SPACE-CHARGE PROFILE

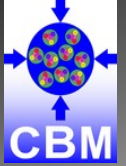


SPACE-TIME PROFILE

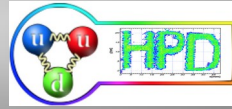


- ✓ For each hit there are 10 anode hypothesis
- ✓ Select on best χ^2/NDF
- ✓ Find x, E, anode id

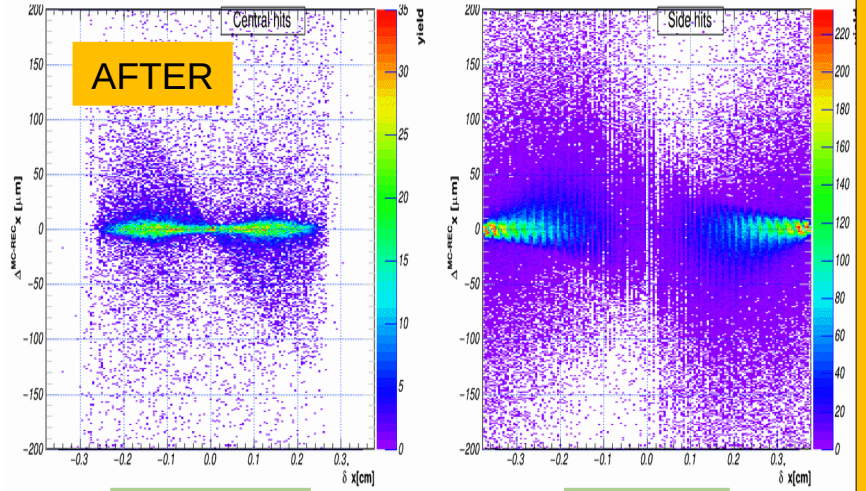
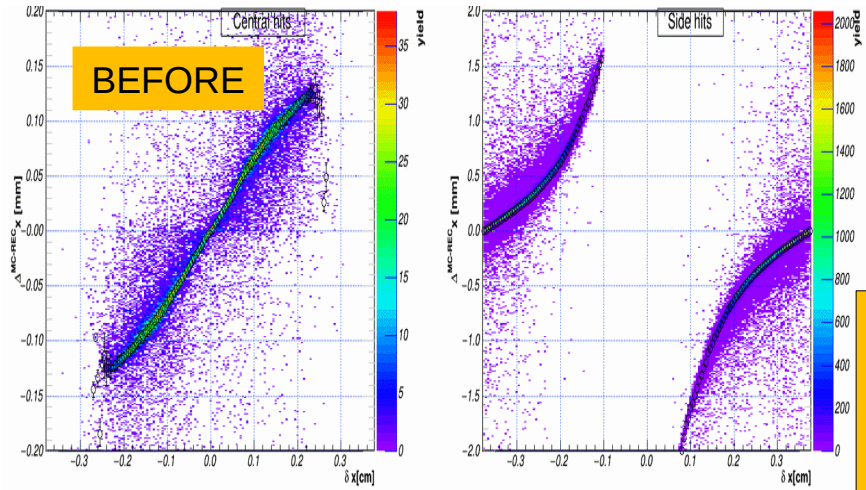
- ✓ For best anode hypothesis
- ✓ Correct for FEE time delay
- ✓ Find time and Δtime (e.g. linear model)



Systematic effects on hit info determination wrt MC info and their correction



Hit-x info

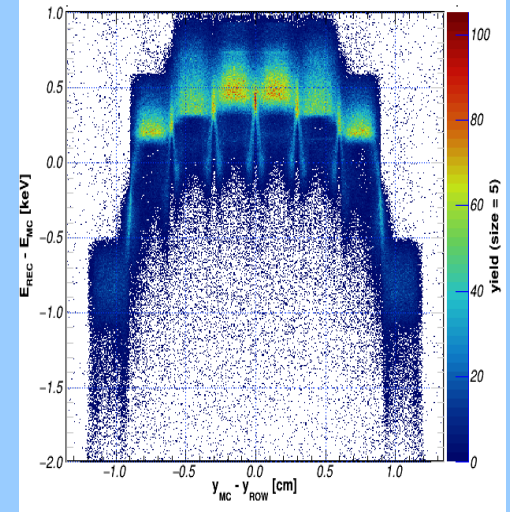
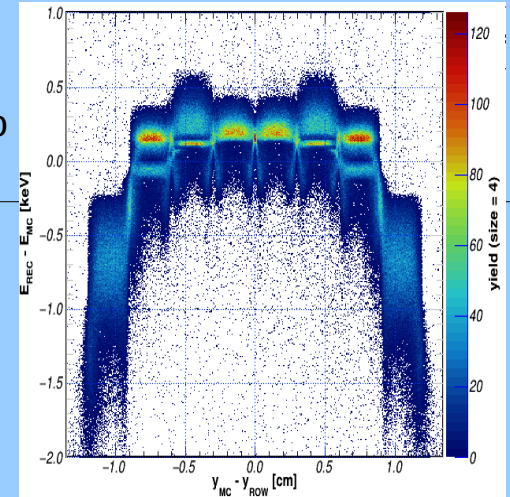


RTRTR

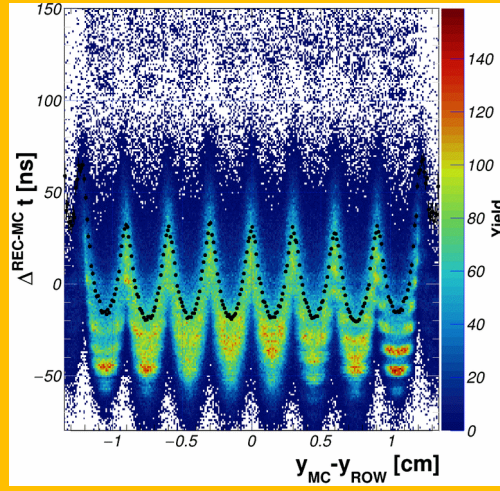
RTRT

estimation of incomplete energy collection by row-cross and its dependence on hit info content (cluster size)

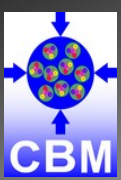
Hit-E info



Hit-t info



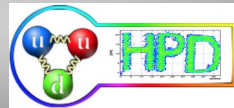
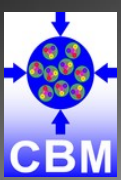
estimation of non-isochronicity and its dependence on hit info content (cluster size)



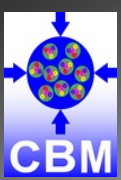
1. S-au definit proceduri pentru folosirea modelelor agreeate de comunitatea in generarea de semnale cu TRD2D:
 - a) Pentru descrierea spatio-temporala a detectorului
 - b) Pentru descrierea energiei depuse (si calibrare pe baza de masuratori si date atomice)
 - c) Pentru descrierea electronicii front-end (FEE)
 - d) Pentru implementarea structurii de date DAQ si procesarea ei
 - e) Pentru gasirea parametrilor de impact ale particulelor si pregatirea pentru tracking
2. Compararea dintre simulari si masuratori obtinute in cadrul setup-ului experimental mCBM la rate mari de interactie (10 MHz) este in buna concordanta.

TRD2D team

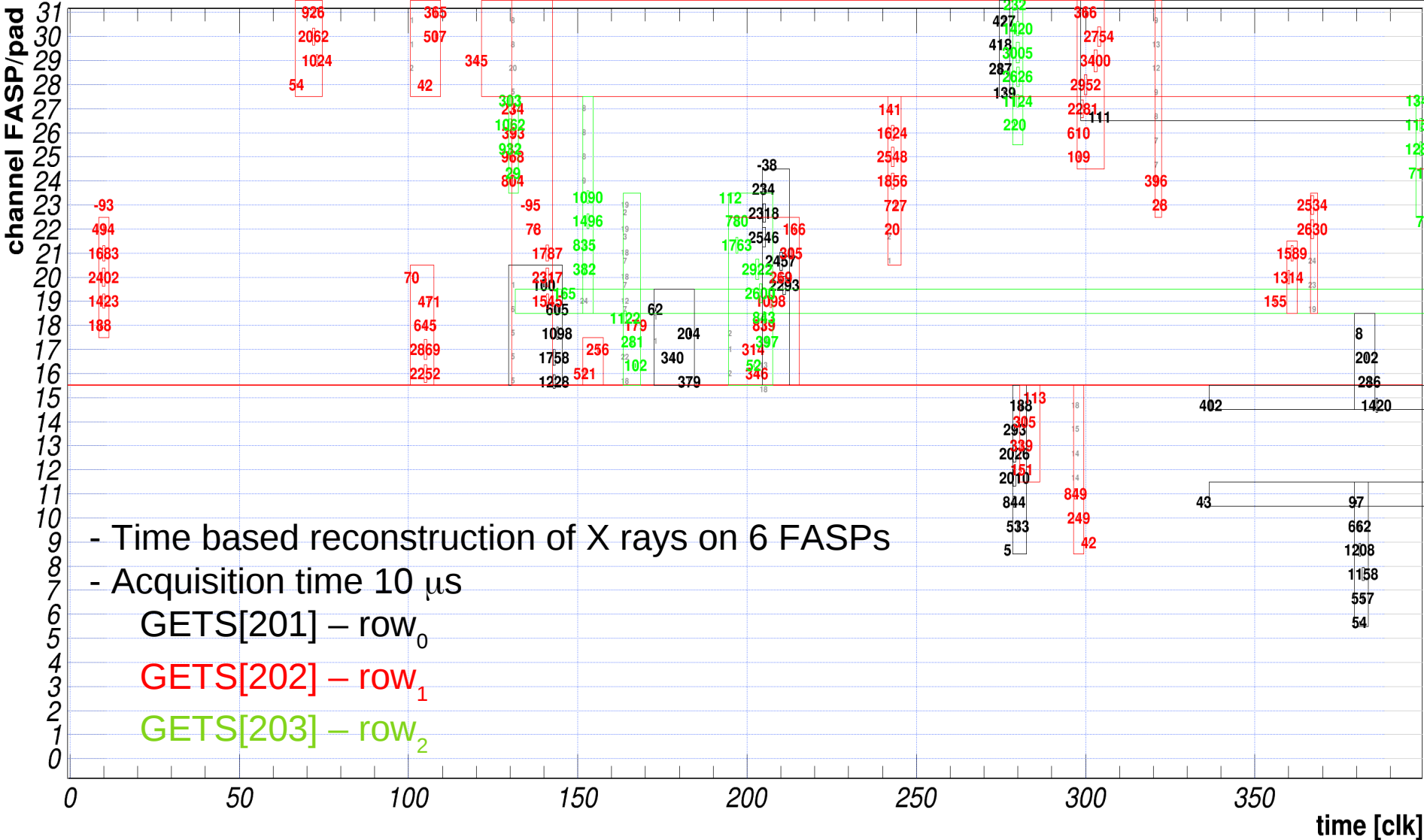
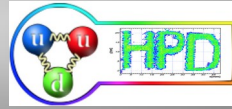
Valerica Aprodu,
Daniel Bartos,
Alexandru Bercuci,
Gheorghe
Caragheorgeopol,
Vasile Catanescu,
Daniel Dorobantu,
Viorel Duta,
Adriana Nan,
Mariana Petris,
Mihai Petrovici,
Lucia Prodan,
Andrei Radu,
Laura Radulescu
Claudiu Schiaua,
(Victor Simion)



BACKUP

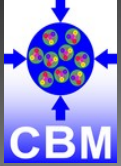


RATE → real life signals @ 100 kHz/cm²



- Time based reconstruction of X rays on 6 FASPs
 - Acquisition time 10 μs
 GETS[201] – row₀
 GETS[202] – row₁
 GETS[203] – row₂

Mon Mar 25 12:22:25 2019



TRD2D dynamics @ CBM

