MINISTERUL CERCETĂRII, INOVĂRII ŞI DIGITALIZĂRII

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The TRD TDR Addendum

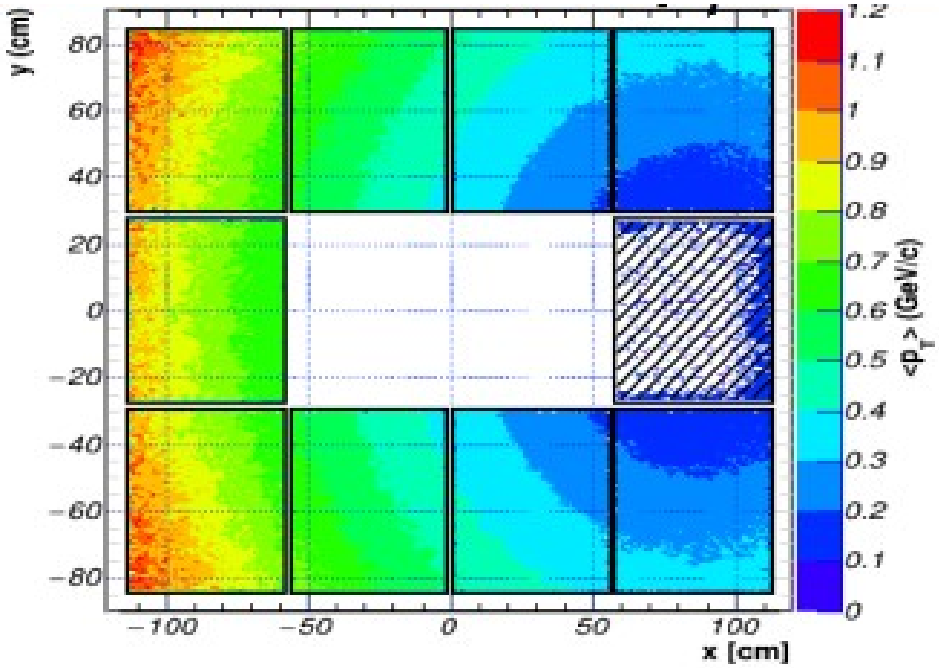
TRD-2D contribution to tracking

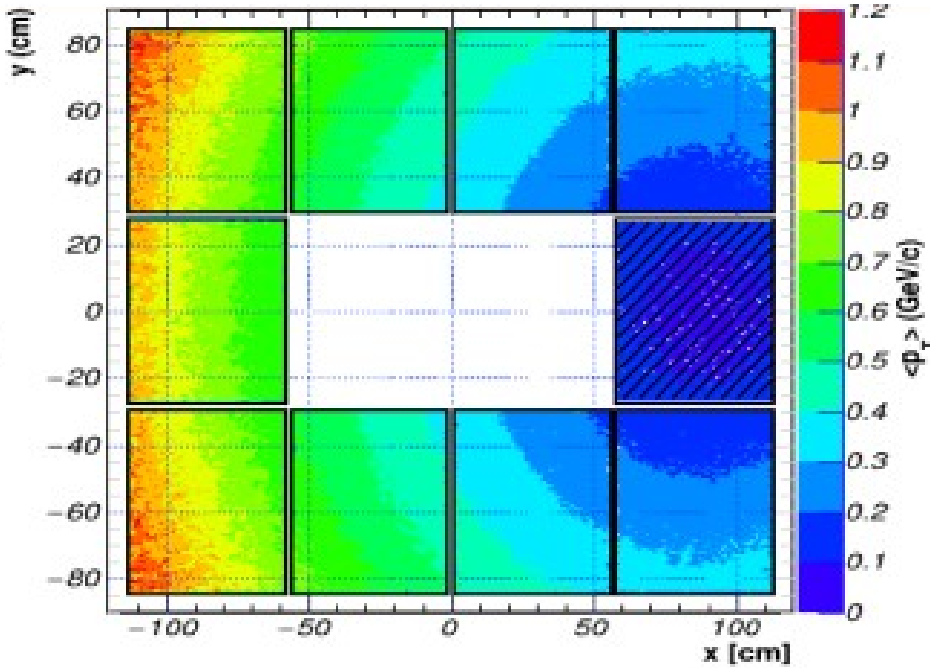
Alex Bercuci

TRD2D weekly meeting
DFH meeting
30th August 2022

Progress of the project

PERFORMANCE



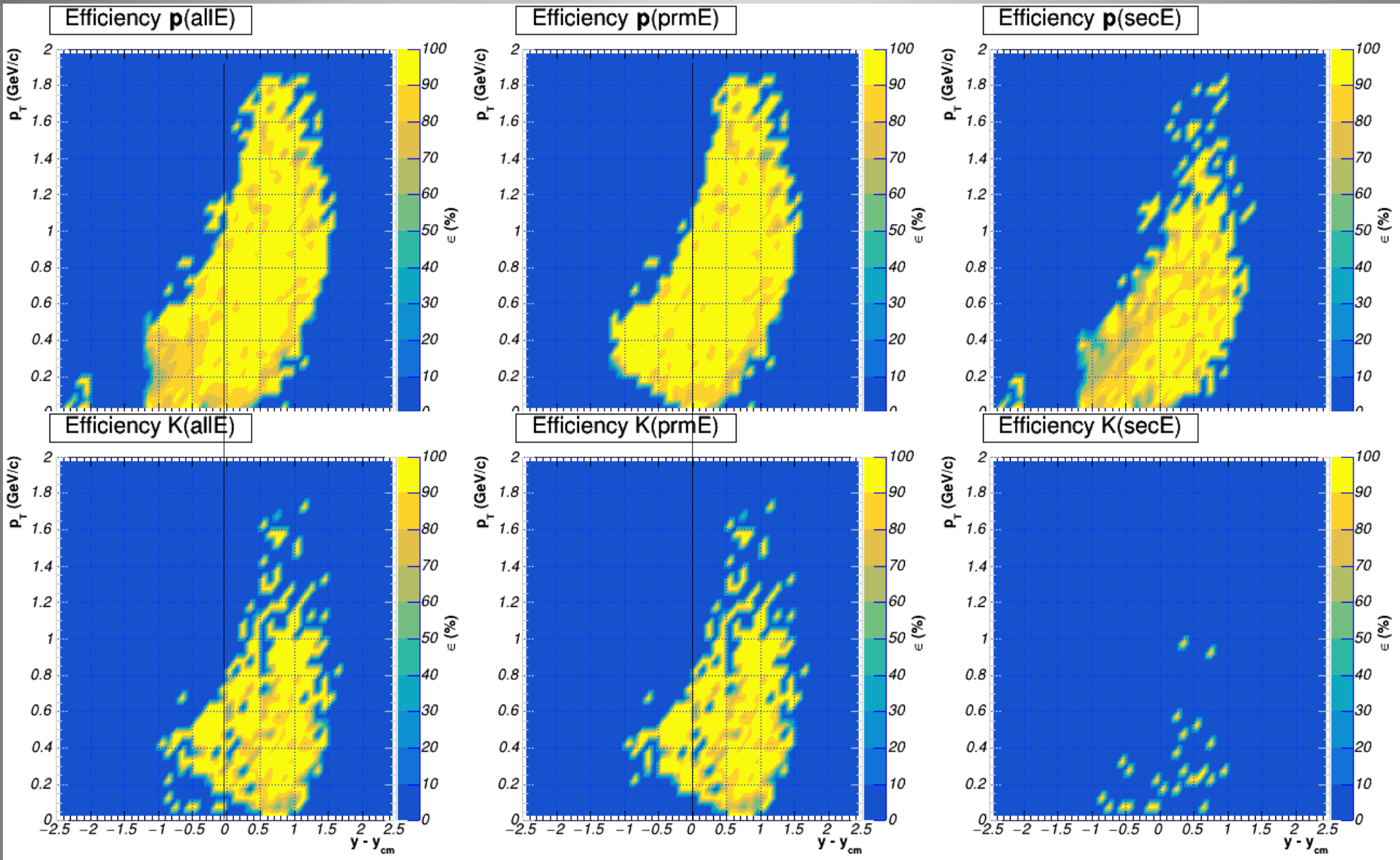


Projection of proton tracks to the first TRD(2D) layer for mid rapidity in the CM.

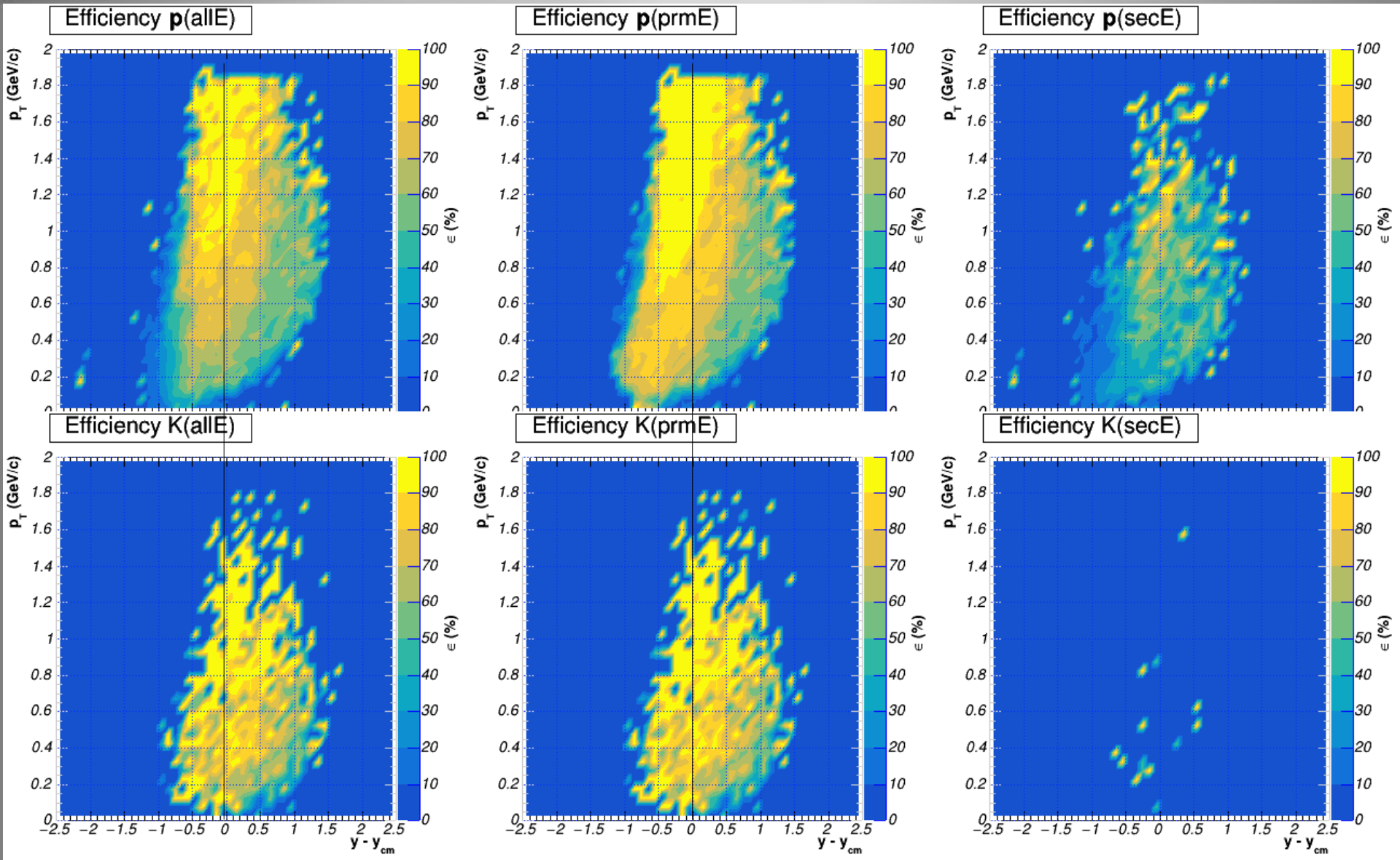
Left : STS defined tracks

Right : Tracks accessible for TRD2D track reconstruction

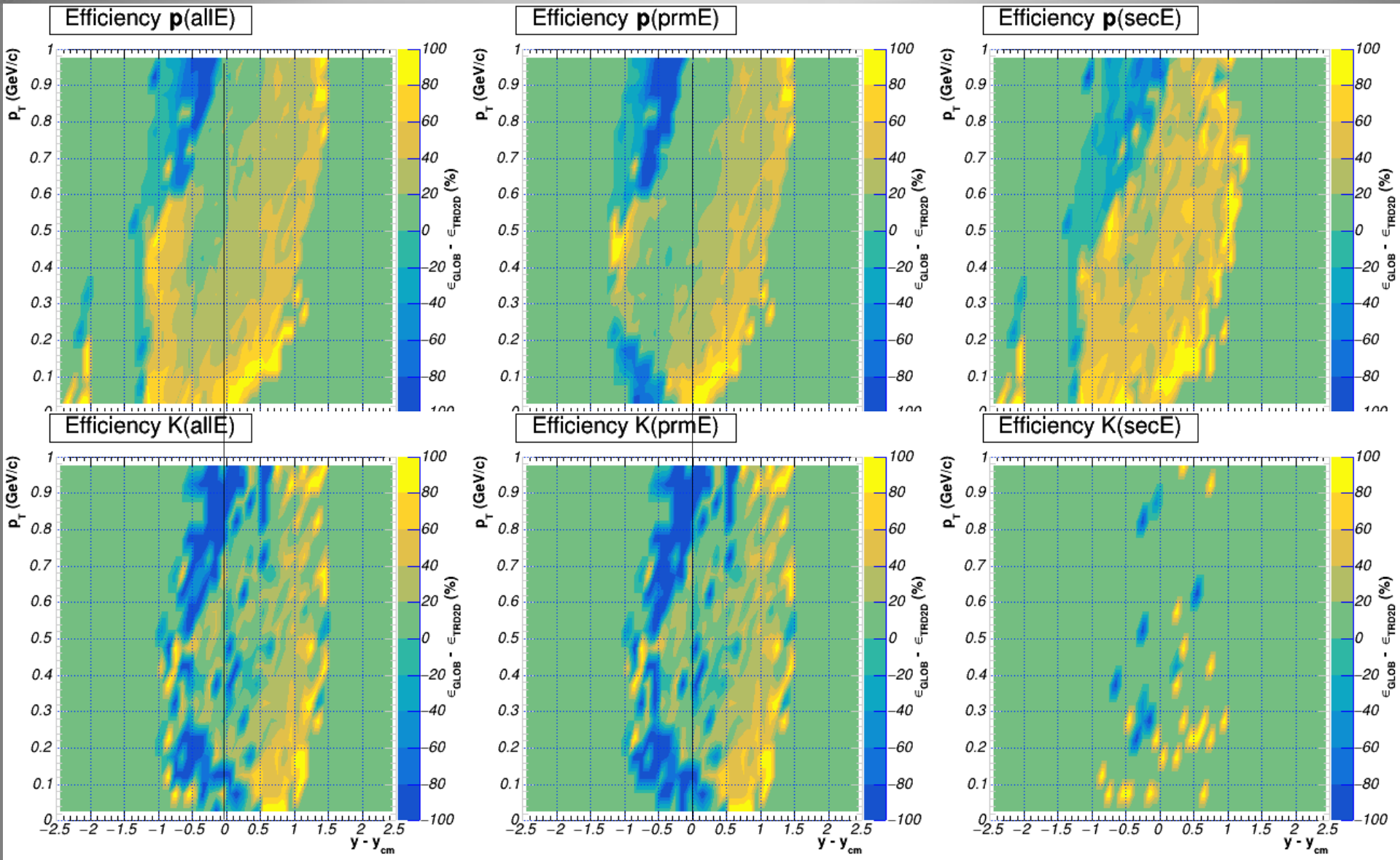
L1 TRD2D tracking (protons and kaons)



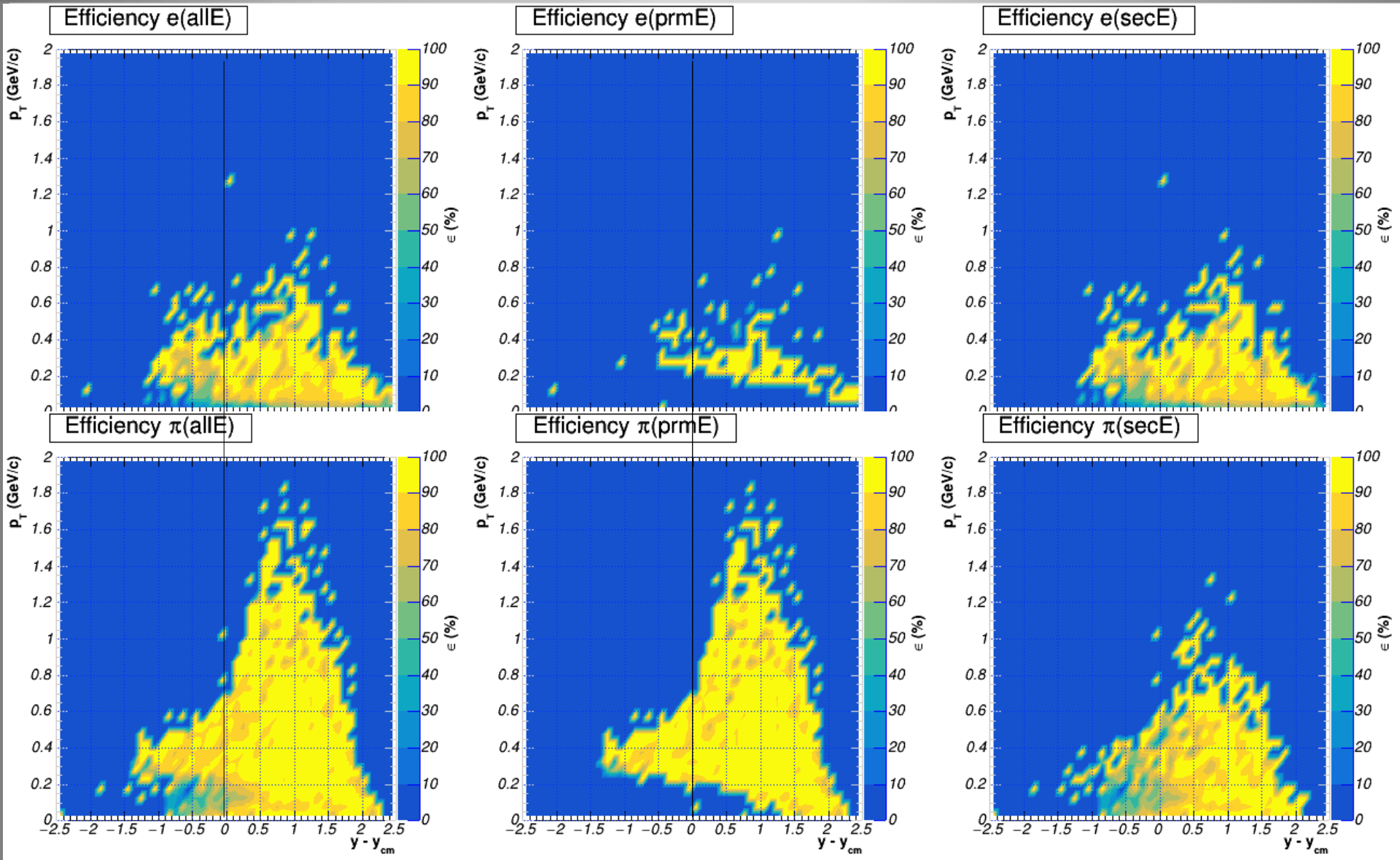
LIT GLOBAL tracking (protons and kaons)



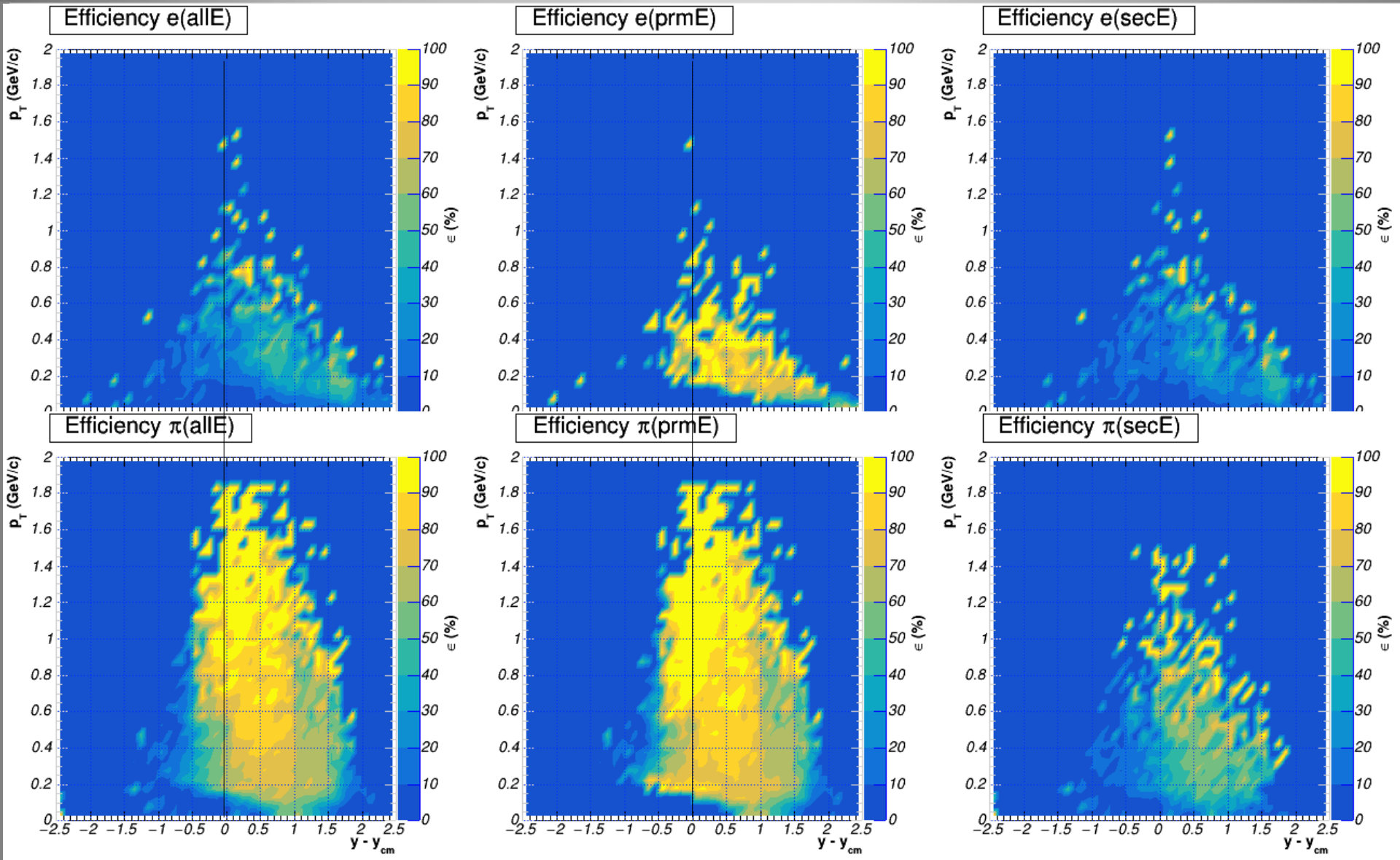
TRD2D extra yield (protons and kaons)



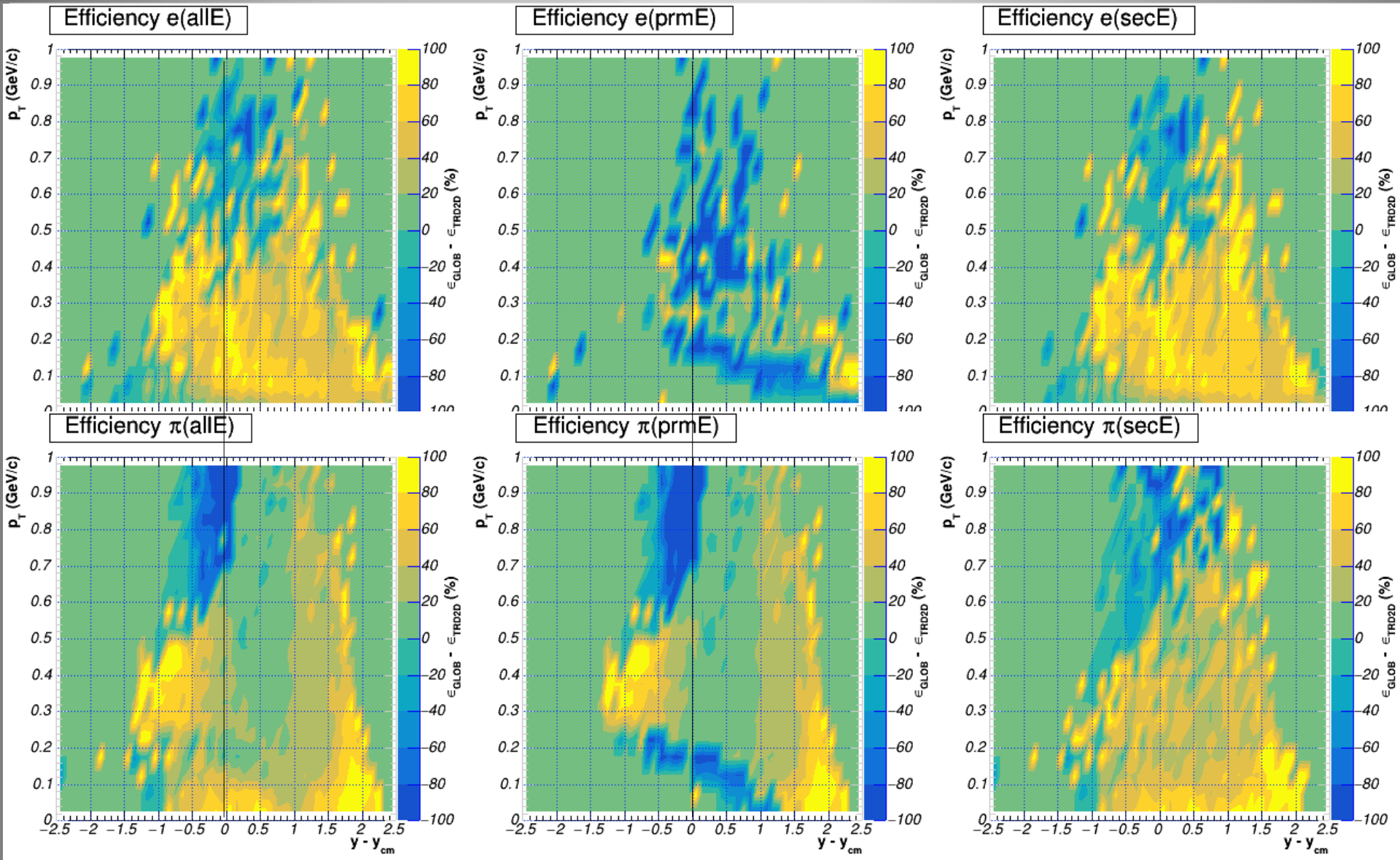
L1 TRD2D tracking (electrons and pions)



LIT GLOBAL tracking (electrons and pions)



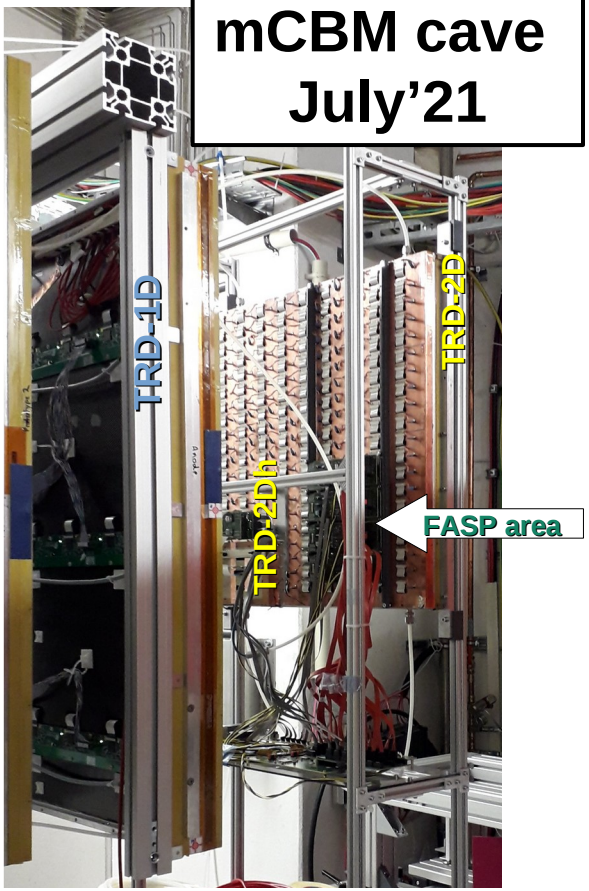
TRD2D extra yield (electrons and pions)



BACKUP

[m]CBM integration

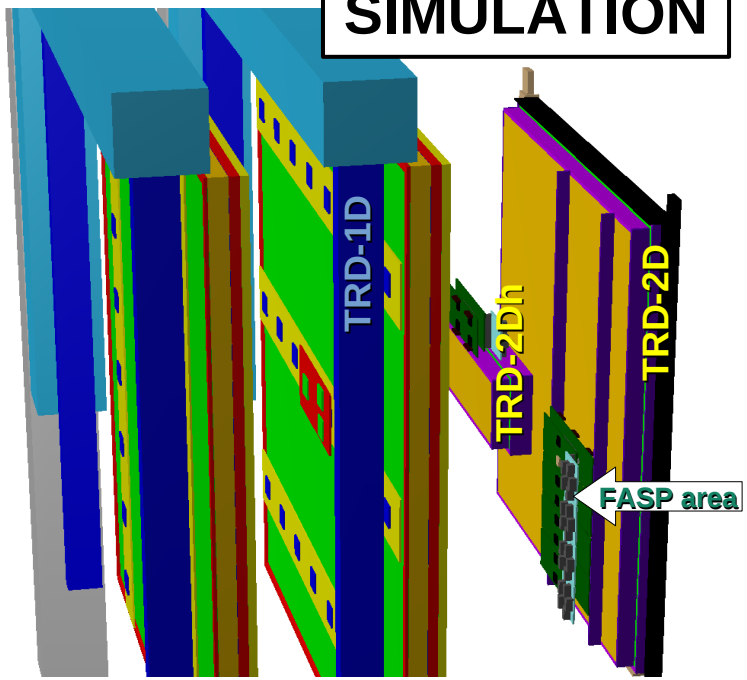
mCBM cave July'21



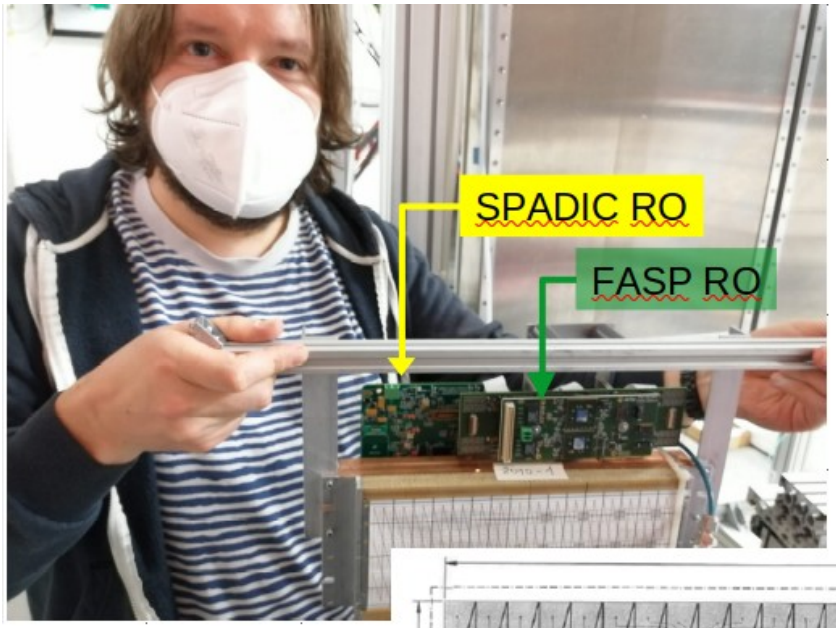
→ **Two TRD-2D** modules were installed in front of **two TRD-1D type 8**
- **TRD-2D** is a close to real size prototype of type 1 TRD module
- **TRD-2Dh** is a hybrid read-out chamber with both SPADIC and FASP connectivity

→ Fully integrated with the **TRD infrastructure** and **CBM DAQ.**
→ Data analysis in **progress** @ **tracking level** (see next slides)
→ **Λ reconstruction** performance for '22. mCBM campaign in progress

SIMULATION



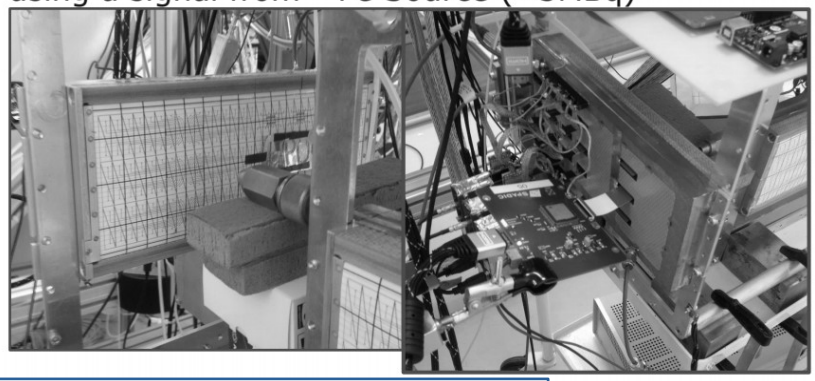
Integration with the TDR baseline solution and back-up solutions



FEE

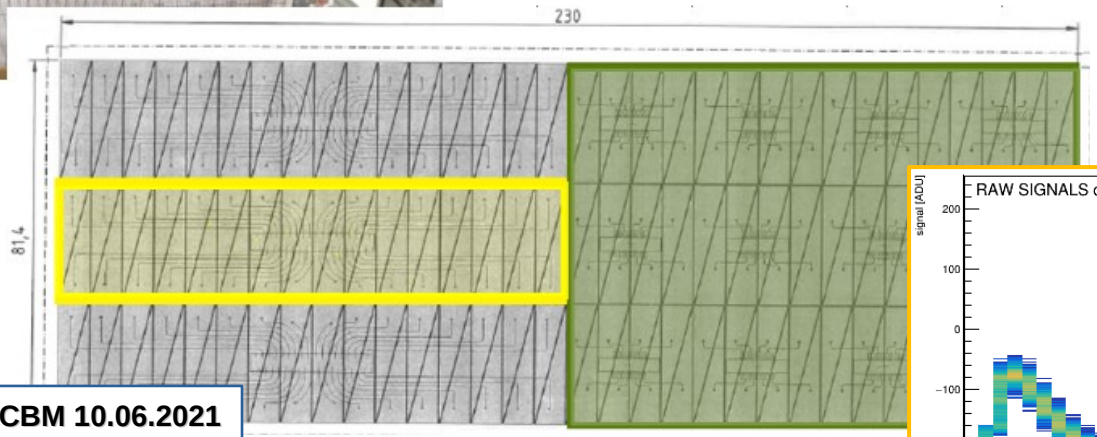
Westfälische Wilhelms-Universität Münster

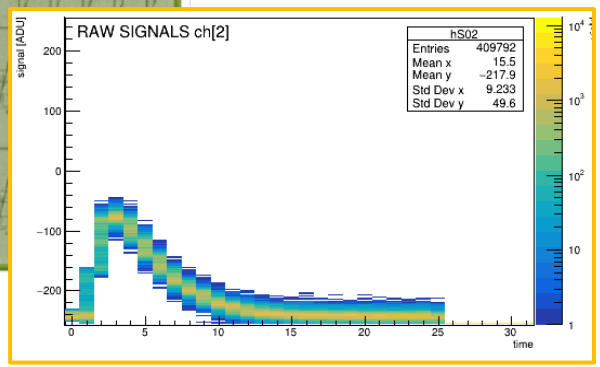
First Readout of Bucharest Prototype with SPADIC1.0 using a signal from ^{55}Fe Source (≈3MBq)



living.knowledge WWU Münster

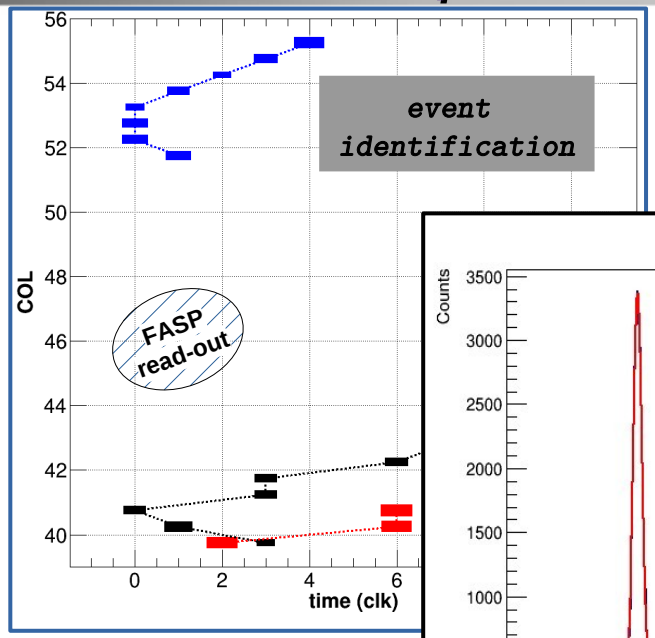
e.g. Martin Kohn, DPG, DA 16.03.2015

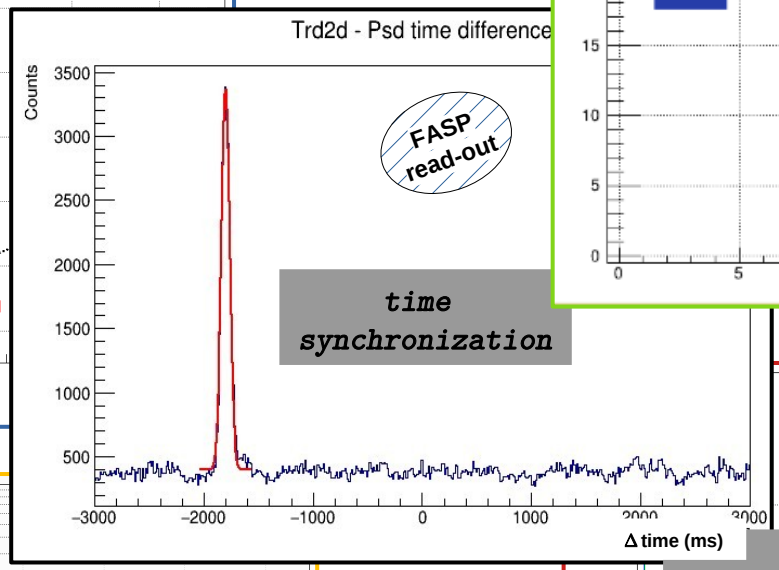


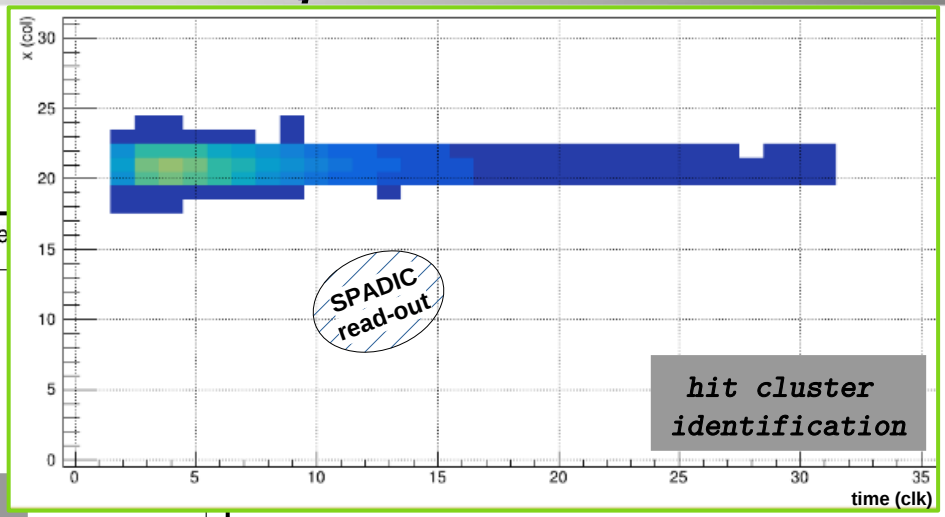


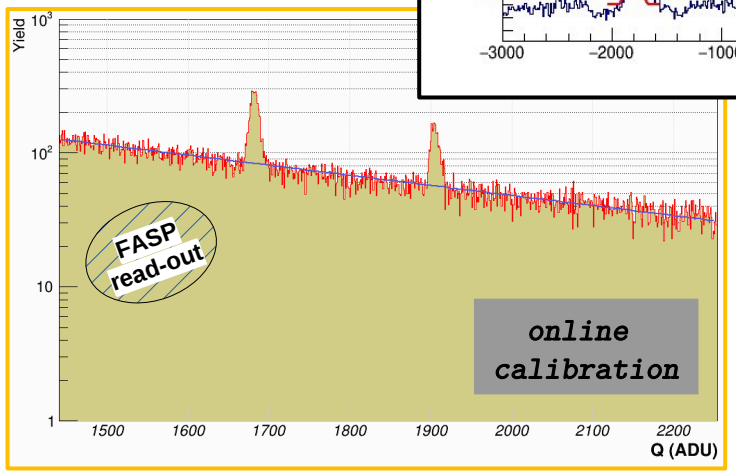
F.Rother, A. Bercuci, mCBM 10.06.2021

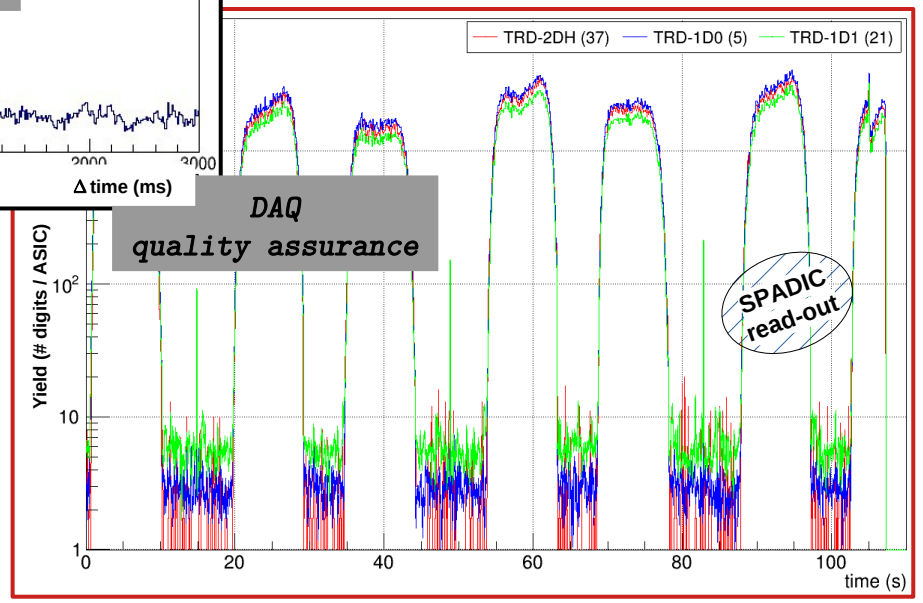
mCBM integration
some preliminary performances plots











Progress towards Physics performance of the TRD-2D

*The performance of TRD-2D in **stand-alone track seeding** for **low p_T** track and **free running** data taking is based on complex software developments tested on **measured data and simulations** for both **mCBM and CBM setups**.*

Global tracking → TRD(2D)

→ *Preliminary results, work in progress*

→ *Isolated TRD-2D part of the global CA tracker, not yet merged with STS*

→ *„Clean input“ from smeared MC points, bypassing digitisation and the local reconstruction*

→ *Only tracks with 4 hits are considered. 100 mbias events at 10 AGeV*

TRD(2D) → Global tracking

→ *realistic simulation of detector and material budget*
→ *unpacking of raw data*
→ *algorithms developed on measured data ported for simulations*
→ *same reconstruction algorithms for both measured and simulated data.*

Efficiency for Primaries, > 1 GeV	**99.1%**
Efficiency for Secondaries, > 1 GeV	**91.4%**
Efficiency for All Tracks > 1 GeV	**97.1%**
Efficiency for All Tracks > 0.1 GeV	**92.4%**
Clone rate	**0%**
Ghost rate	**19.1%**

Conclusions

The TRD-2D DAQ was fully integrated and tested in the new CBM DAQ for the mCBM campaign of July 2021

TRD-2D performance is being confirmed in global CBM measurements wrt to stand-alone laboratory measurements

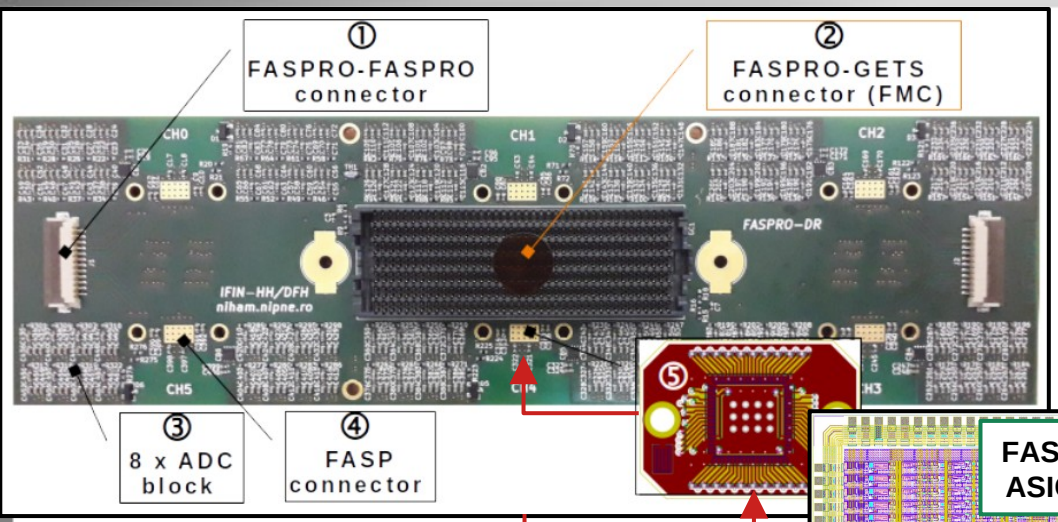
A backup solution for TRD-2D FEE based on SPADIC is being investigated in terms of performance, costs, integration, etc.

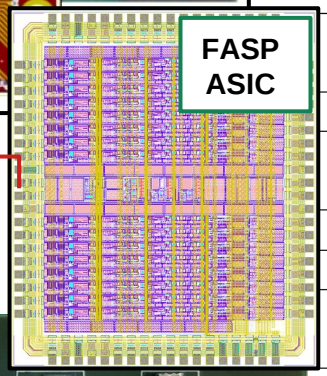
A CBM-wide group was formed to implement the physics program of the TRD-2D for [m]CBM.

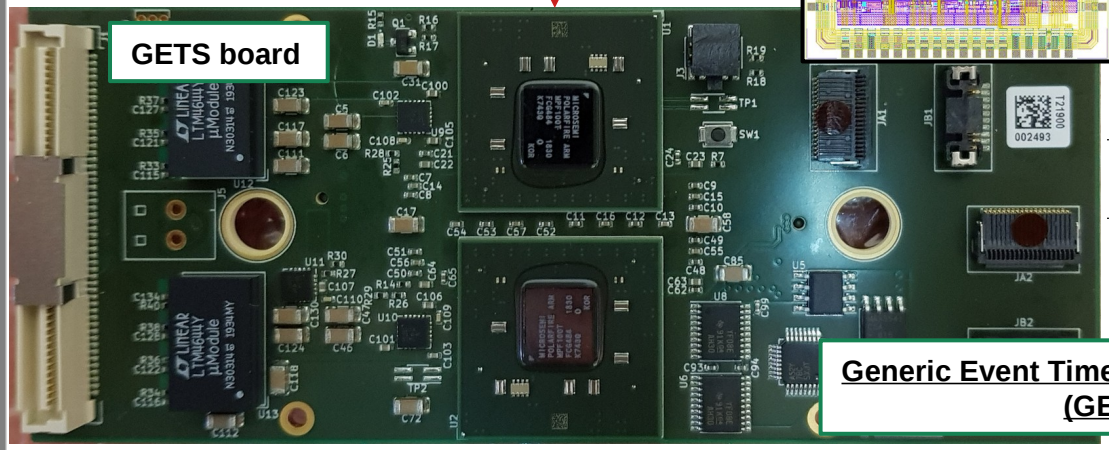
→ Detailed test of radiator, entrance window and FEE impact on PID performance to be performed in a campaign @ CERN-PS late ‘22 by a joint TRD team is under discussion.

→ EDR prototype is being constructed.

TRD-2D specific FEE (FASP+GETS)





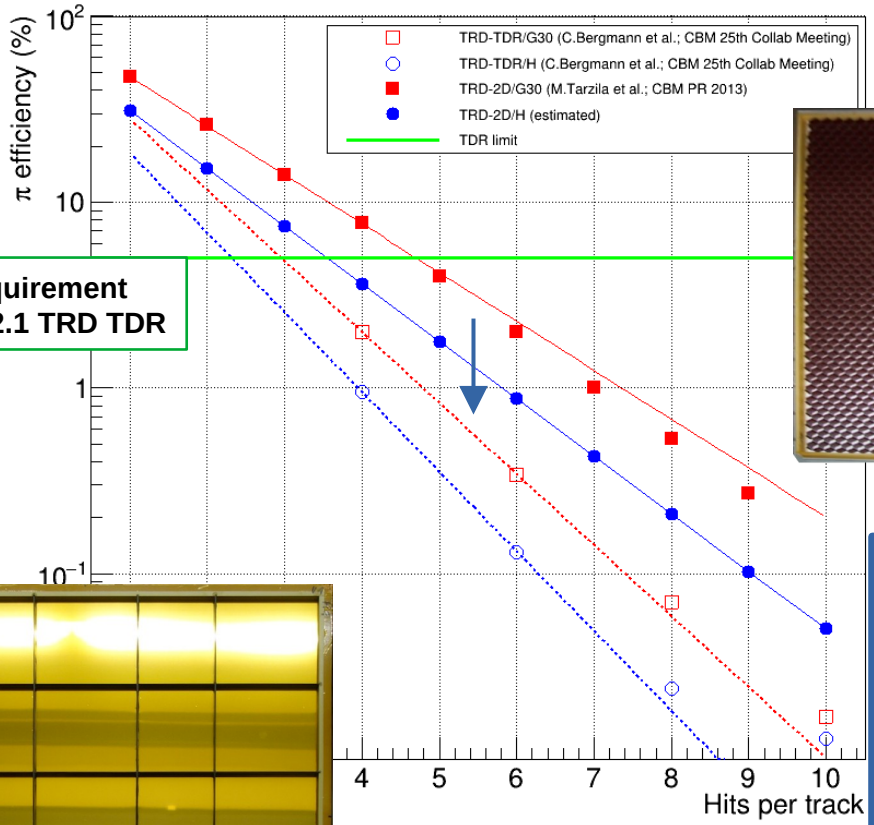


Fast Analog Signal Processor (FASP)

Average pulse rate	0 - 2 MHz
Detector pad capacitance	25 pF
Number of analog channels	16
Input polarity	positive
Adjacent channel pairing	yes
Charge input range	0.15 fC ... 165 fC
Input type polarity	Positive (asymmetric)
Analog output voltage swing	0 ... 1 V
Analog output DC voltage level base line (cont. adj.)	0.2 V ... 1 V
Semi-Gaussian output FWHM	290 ns
Peak-sensing output plateau (time)	14 clk. cycles
Channel ENC (C_{det} = 25 pF)	940 e 1170 e (ST = 20 ns)
Cross-talk (max. signal in only one ch., no signals in others)	0.12 %
Cross-talk (max. signal in 15 ch., no signal in one channel)	0.22 %
Self-trigger capability: variable threshold (cont. adj.)	0 ... 165 fC

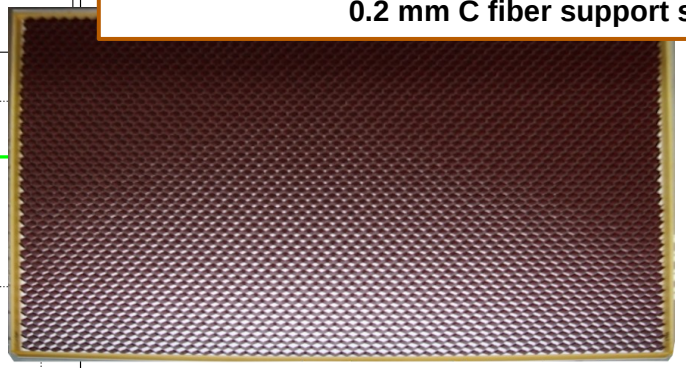
Generic Event Time-stamping Streamer (GETS)

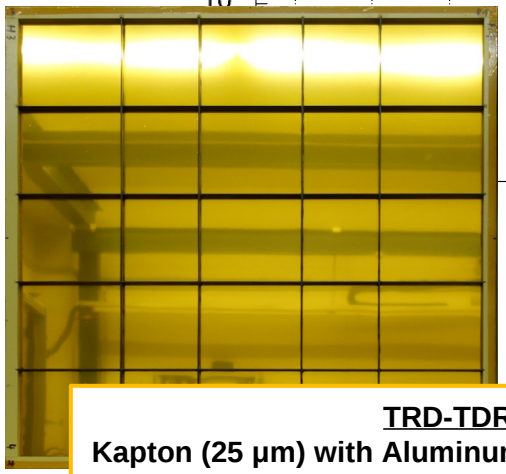
PID performances



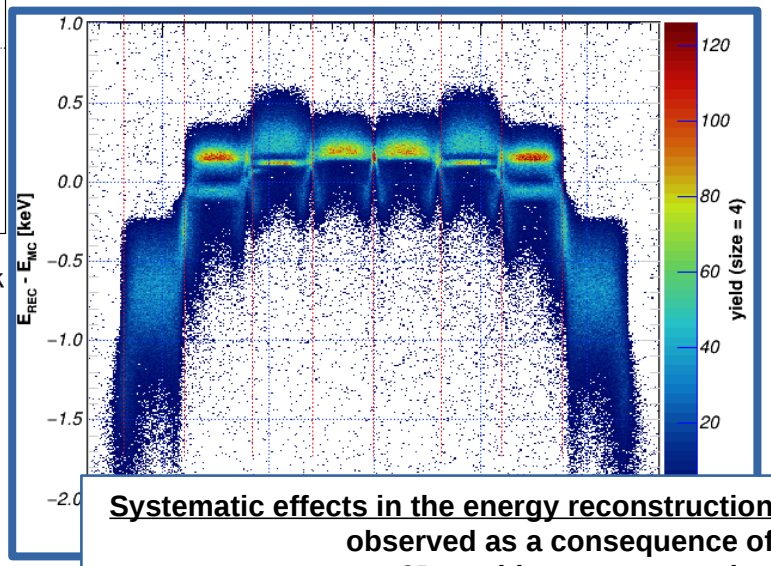
5% design requirement
Tab. 2.1 TRD TDR

TRD-2D entrance window
Honeycomb 9mm with Aluminum coating (12 μm)
0.2 mm C fiber support structure





TRD-TDR entrance window
Kapton (25 μm) with Aluminum coating (50 nm)
Carbon lattice support structure (0.8mm thickness, 10mm height)



Systematic effects in the energy reconstruction observed as a consequence of 2D position reconstruction.

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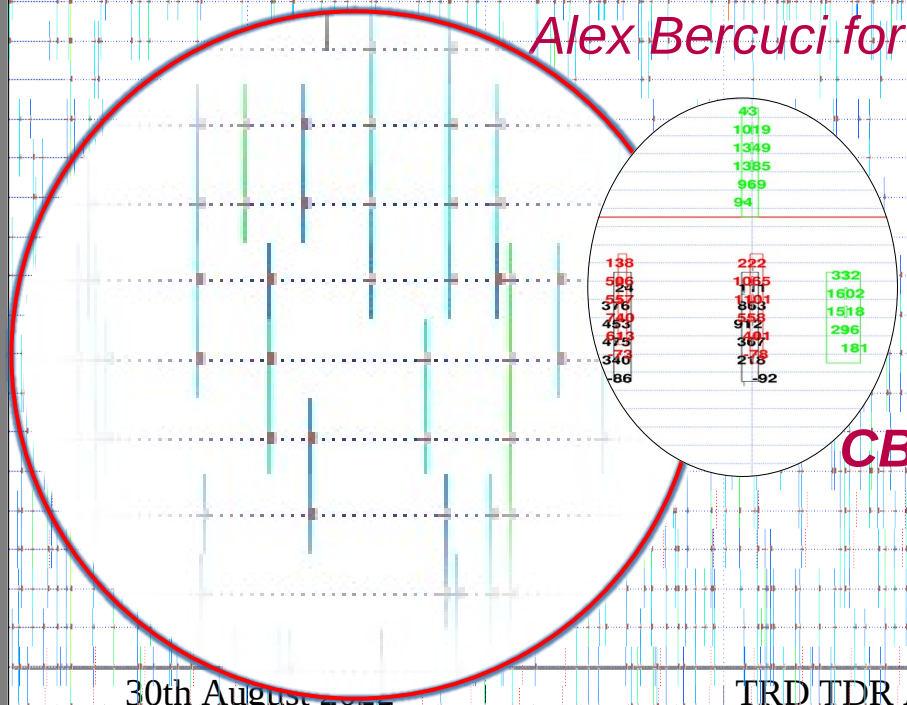
The TRD TDR Addendum

TRD-2D for CBM

Alex Bercuci for the CBM Collaboration



CBM break-out at Joint FAIR ECE 14 and ECSG 05 meeting
31 May 2021

Synoptic comparison between TRD-TDR type 1 and TRD-2D

Table 7.0.1: TRD-2D versus TRD-TDR

Parameter	TRD-2D	TRD-TDR type 1
GENERAL DETECTOR CHARACTERISTICS		
X/X_0 four layers (the inner region only) (%)	35.0	27.4
outer dimensions (mm^2)	567 × 564	570 × 570
active area dimensions (mm^2)	540 × 540	540 × 540
# of pads(read-out channels)/module	2.880	2.560
mean read-out area (cm^2)	1	1.2
amplification/drift (mm)	$(2 \times 4) + 4$	$(2 \times 3.5) + 5$
anode wire / diameter (μm)	20 W(Au plated)	20 W(Au plated)
anode wire pitch (mm)	3.0	2.5
cathode wire / diameter (μm)	80 (Cu-Be)	75 (Cu-Be)
cathode wire pitch (mm)	1.5	2.5
OPERATIONAL PARAMETERS		
Leakage rate (ml/h)	< 1	< 1
Signal-to-noise ratio (MIP)	30 : 1	30 : 1
Maximal signal collection time (μs)	0.3	0.3
Drift field (kV/cm)	1	1
Drift velocity (Xe/CO_2 (85/15)) ($cm/\mu m$)	3	3
Anode voltage (Xe/CO_2 (85/15)) (V)	1950	1850
Anode voltage (Ar/CO_2 (80/20)) (V)	1900	1800
Drift voltage (V)	400 – 800	500
Gas gain	≈ 2000	≈ 2000
Max gas pressure variation (mbar)	± 1.5	± 1
PERFORMANCE		
Position resolution x (across pads) (μm)	15 – 150	250 – 300
Position resolution y (along pads) (μm)	160 – 850	≈ 5000
Energy resolution (^{55}Fe K-line, Ar escape peak) (%)	20	30
Time resolution (ns)	20 – 26	15 – 20
ROC COSTS		
Materials/Processing (€/chamber)	2420 (2020)	2380 (2018)
Time (days/module)	7.5	5
FEE		
Costs (€/channel)	5.18 (2020)	4.15 (2018)
Power (mW/channel)	40 – 50	55
Power (W/module)	115 – 144	140.8
Data volume (Mbps/channel)	20	20
Data volume (Gbps/module)	56.25	50.00

Material budget

Active area

Read-out density

Read-out granularity

Position reconstruction

Energy reconstruction

Time reconstruction performance

ROC price

FEE price

Data volume

Cost Matrix

FEE + ROC

Table 6.4.1: CBM-TRD inner zone core cost

Item	Costs (Euro)
40 Read-out Chambers	96,800
Spare 4 Read-out Chambers	9,680
Read-out Electronics	894,500
Spare 10% Read-out Electronics	58,250
Total	1,059,230

The funding of the production of the TRD-2D chambers and associated read-out electronics for the TRD inner zone is currently split in two parts, according with the 8th CBM Collaboration Resources Review Board (RRB) from November 2018:

→ an in-kind contract between FAIR, IFIN-HH and Romania funding agency/ministry of 752 kEuro (2005)/ 1,080 kEuro (2018),
→ "other Romanian resources" of 482 kEuro (2005)/693 kEuro (2018).

Table 6.4.2: CBM-TRD inner zone core costs with higher integrated FEE.

Item	Costs (Euro)
40 Read-out Chambers	96,800
Spare 4 Read-out Chambers	9,680
Read-out Electronics	597,450
Spare 10% Read-out Electronics	28,545
	732,475

The lower limit for FEE was estimated to 5.18 Euro/channel (2020)

INTEGRATION + SERVICES

6.4.3: CBM-TRD inner zone system integration and services.

Item	Costs (Euro)	Scaling factor
Xe/CO_2(initial filling)	4,500	ROC
HV Power Supplies	14,000	ROC
HV Cables	7,500	ROC
LV Cables	12,000	FEE
DC/DC converters	20,000	market
Gas System	55,000	1 line + design
Cooling	60,000	50 %
Support structure	40,000	ROC
Total	213,000	

TRD-2D in TRD system
→ 115200 FEE chs
→ 40 ROCs
→ 0.95 MEuro(2020)

Project management

Table 6.2.1: List of milestones for TRD-2D.

Milestone	Date
Inner modules EDR	15.12.2021
Inner modules PRR	20.02.2022
Start module production	15.09.2022
All chambers built	15.09.2024

Table 6.3.1: List of milestones for TRD-2D FEE.

Milestone	Date
FEB PRR	30.06.2022
Start FEB production	01.01.2023
End FEB production	30.06.2024

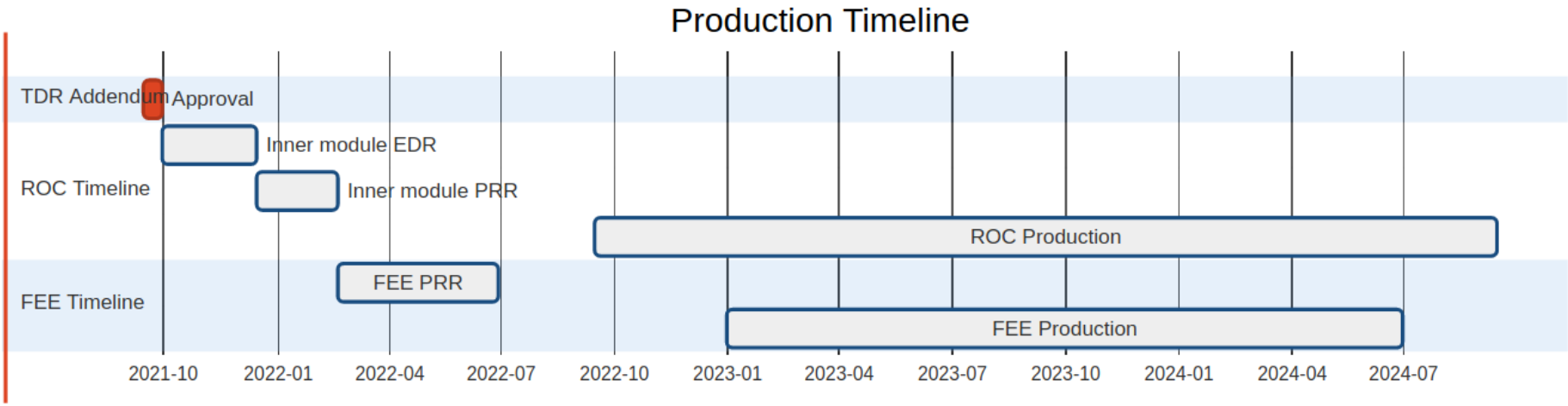


Table 6.1.1: Manpower.

HPD/IFIN-HH	Phys.	Electr. Eng.	Mech. Eng.	Technicians	Msc/PhD
FTEs	2	1.4	1	1.6	0.5/1.5

Conclusions

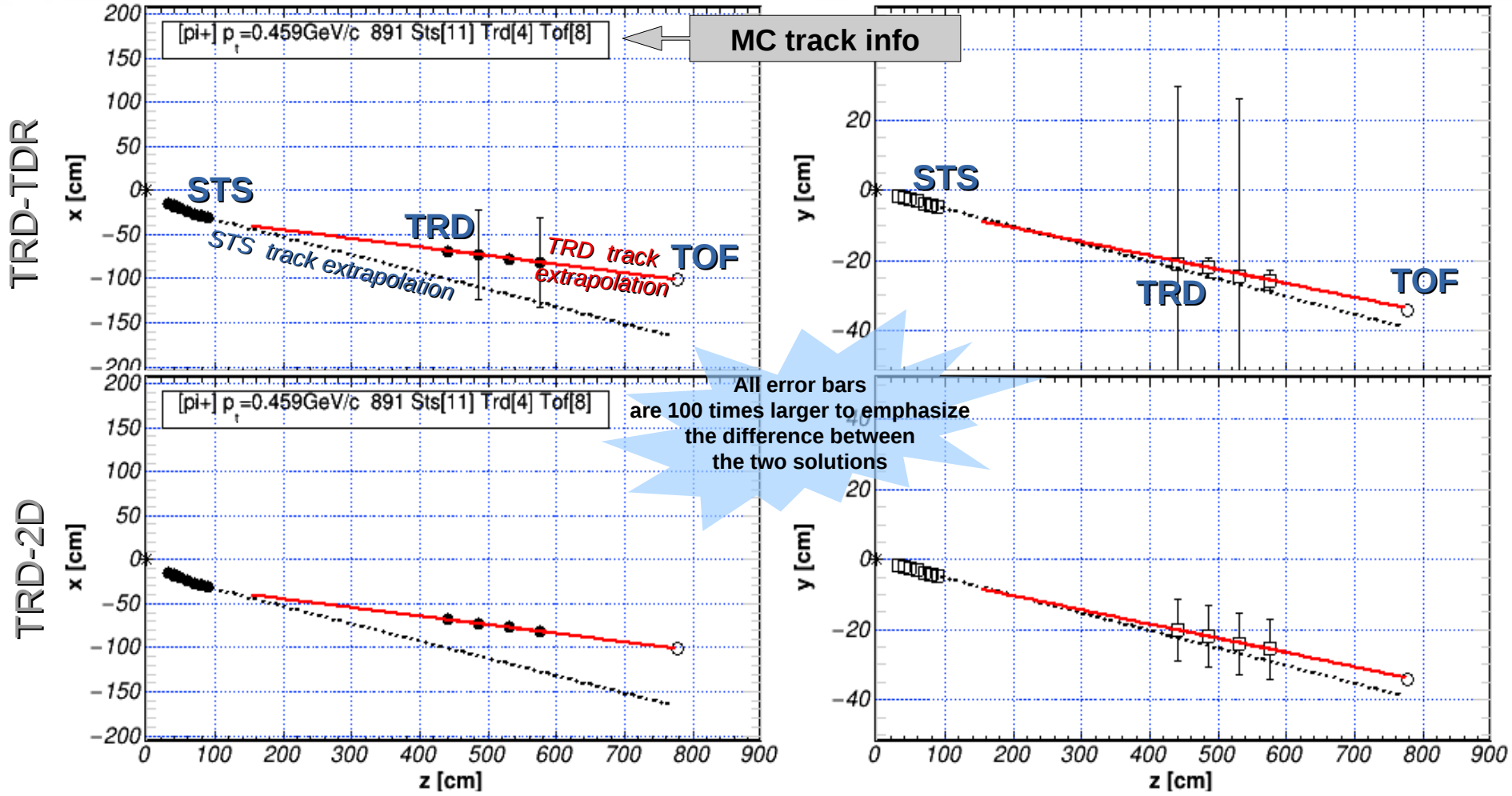
- An improved tracking device is proposed for the inner zone of the TRD system to increase the CBM performance in the p_T < 200 MeV/c range.

- The new inner-zone of CBM-TRD based on TRD-2D presents an alternative to the inner zone described in the TRD TDR. The TRD team identified infrastructure components (services, mechanics, gas) which will be developed in close collaboration, trying to share as many components as possible. Back-up solutions for FEE were also identified

- A cost matrix was put forward out of which approx 61% is covered by in-kind contract committed by Romanian Ministry as part of Romanian contribution to FAIR and 39% by other resources within other projects financed by the Romanian Ministry for Research, Innovation and Digital policy.

Thank You !

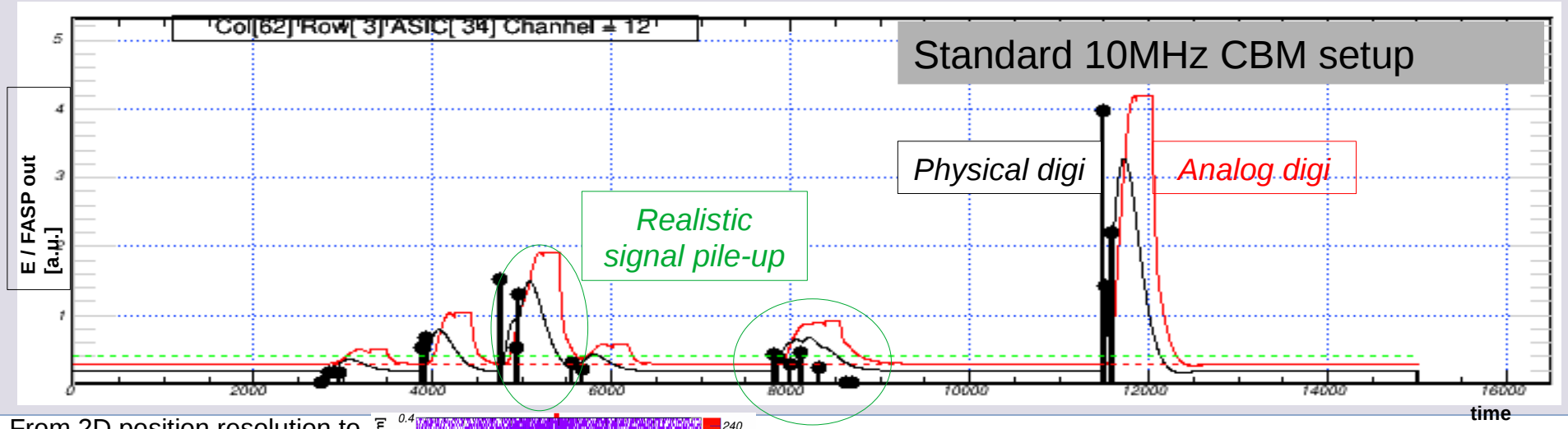
Standalone/complementary TRD tracking



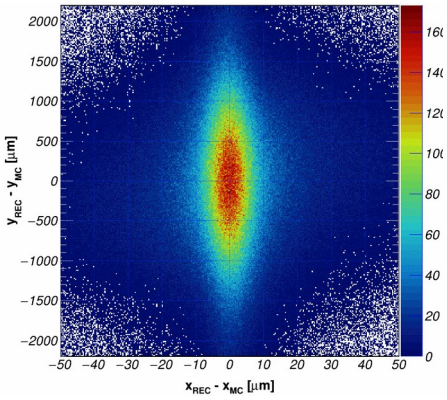
TRD track extrapolation : linear fit of ideally reconstructed TRD hit extrapolated to STS and ToF (z of MC point)

→ see next slide for ideal reconstructed TRD hit definition

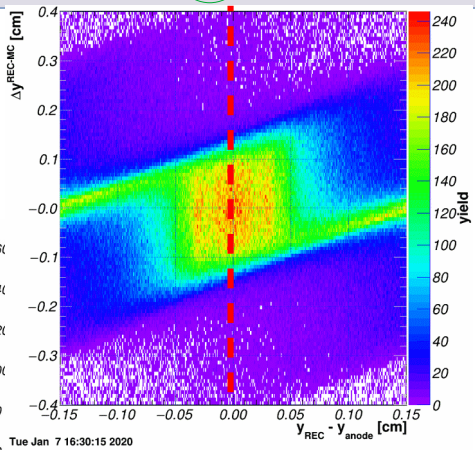
CbmRoot integration : Digitization → Reconstruction → Tracking → *Physics*

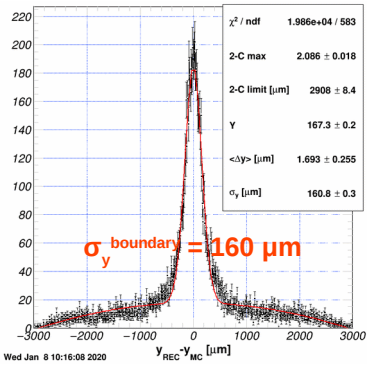


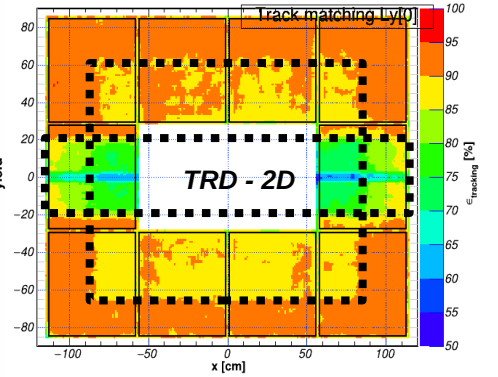
From 2D position resolution to tracking efficiency in SIS100 set-up EbyE simulations.

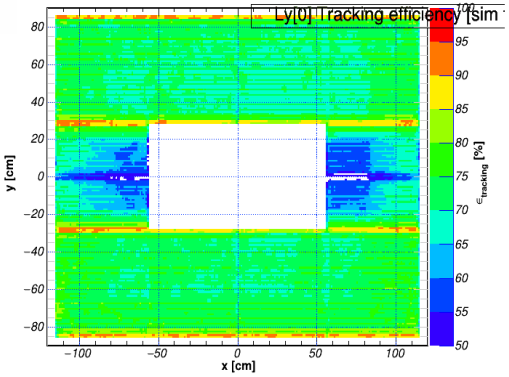


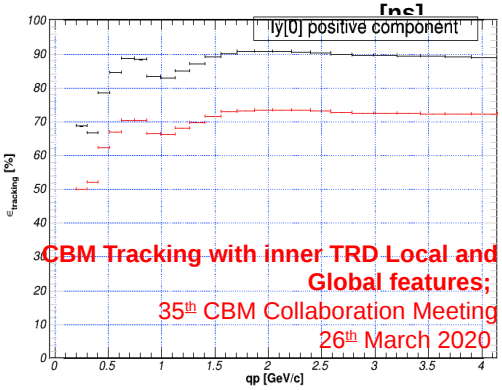
Differential y resolution over the amplification cell with emphasis on the best resolution of σ_y=160µm.



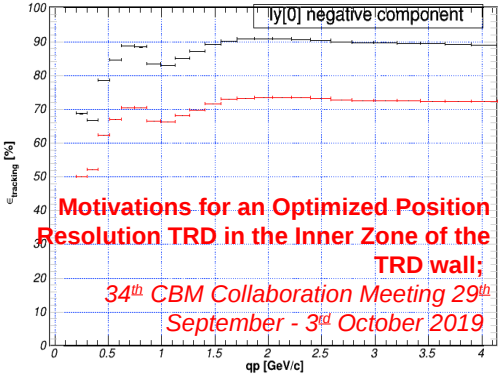








CBM Tracking with inner TRD Local and Global features;
35th CBM Collaboration Meeting
26th March 2020



Motivations for an Optimized Position Resolution TRD in the Inner Zone of the TRD wall;
34th CBM Collaboration Meeting 29th September - 3rd October 2019