TRD project status

Alex Bercuci for the TRD

39th CBM Collaboration Meeting

GSI

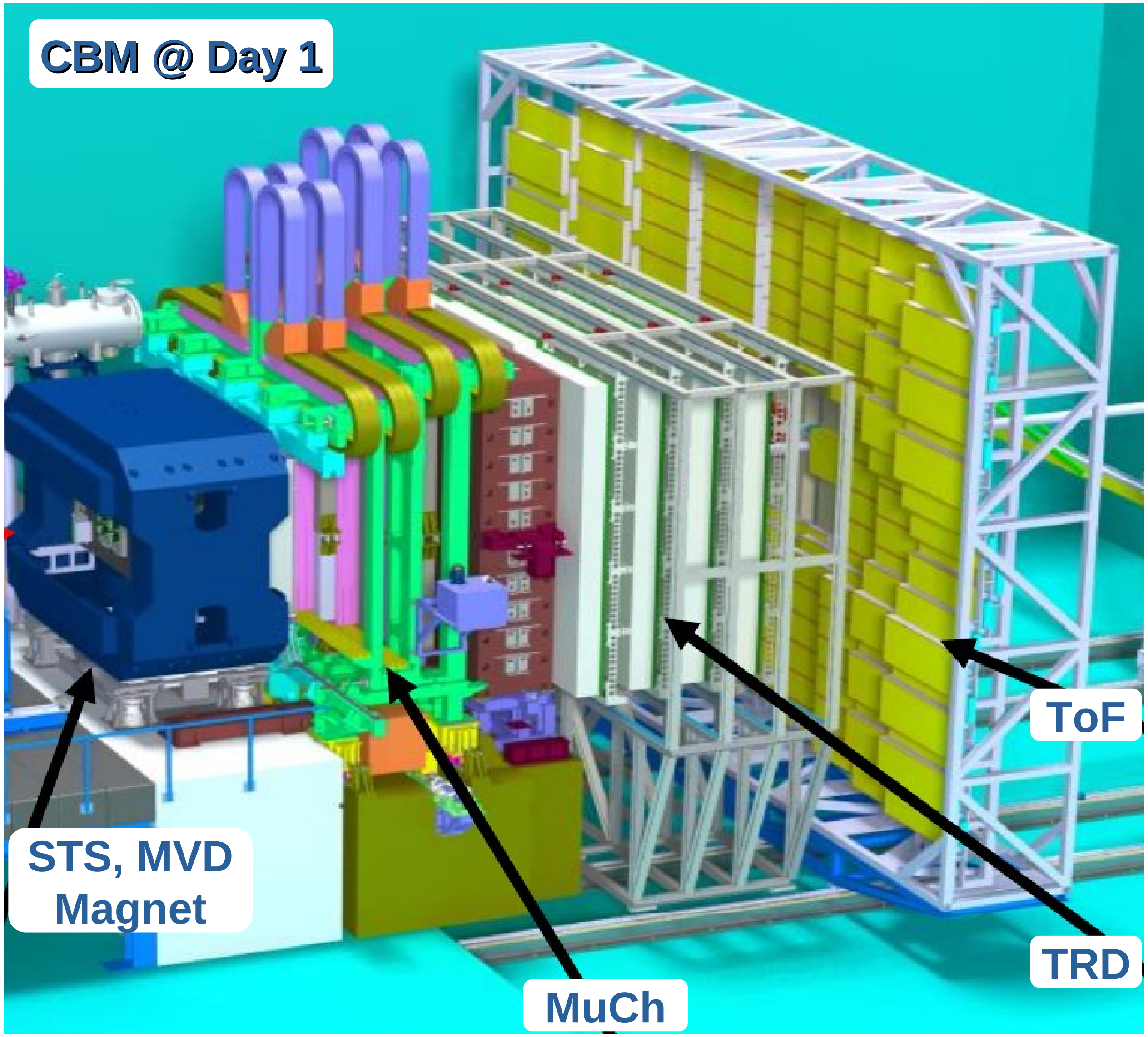
17th May 2022

Overview

- **Milestones of the project**
  → *past & future*

- **Gallery of latest results**
  → *measurements*
  & simulations

- **Outlook**
  → *towards CBM day 1*



N. Herrmann, *CBM Introduction, CBM without Russia;*Joint FAIR ECE 16 and ECSG 07 meeting

Last TODO list

critical

in progress

done

TRD Outlook

C. **Blume**, *TRD: outlook and discussion; 38th CBM Collaboration Meeting 27.09- 1.10 2021*

Essential steps in next months

- Address comments by ECE on TDR-addendum Slide 11
- Start pre-production of five type-5 modules (delayed pad plane) ⟹ Module-FOS Slide *4*
- Finalize SPADIC v2.3 evaluation (v2.3b still to be delivered) ⟹ PRR for v2.4 Slide *8*
- Decision on z-layer-spacing in support structure (⟹ radiator design)
- Construction of test gas system (single line) ⟹ finalize CDR Slide *6*
- Work out final design of LV+HV system (grounding scheme, PS already purchased) Slide *7*
- Continue analysis of mCBM data Slide 13
- Reviews: Slide *10*

  LV+HV EDR (10/21), Module-FOS + PRR-follow-up (12/21), Inner modules EDR (12/21),

  Support + mainframe EDR (12/21), SPADIC PRR + FEB CDR (12/21), Radiator EDR (12/21)

C. Blume, *TRD status; CBM Technical Board Meeting 7.09.2021*

Open issues/risks

- Electronics noise level with next SPADIC generations
- Physics performance studies with TRD-2D (inclusion of TRD-2D in tracking) Slide 12
- Funding: only one gas line currently funded, secure available funds for electronics (BMBF 19-21)

P. Kaehler, *Start of TRD module production; 2021 CBM Progress Report, 2022*

- 35 modules are planned to be produced, 32 + 3 spare
- 5 to be finalized during the 2nd half of 2022
- delay of pad-plane acquisition, modification of the acquisition chain (direct)

Technological steps
1. backpanel carrier
2. backpanel complete (read-out cathode)
3. entrance window frame
4. entrance window complete (drift)
5. wire electrodes layers (anode, cathode)
6. chamber closing

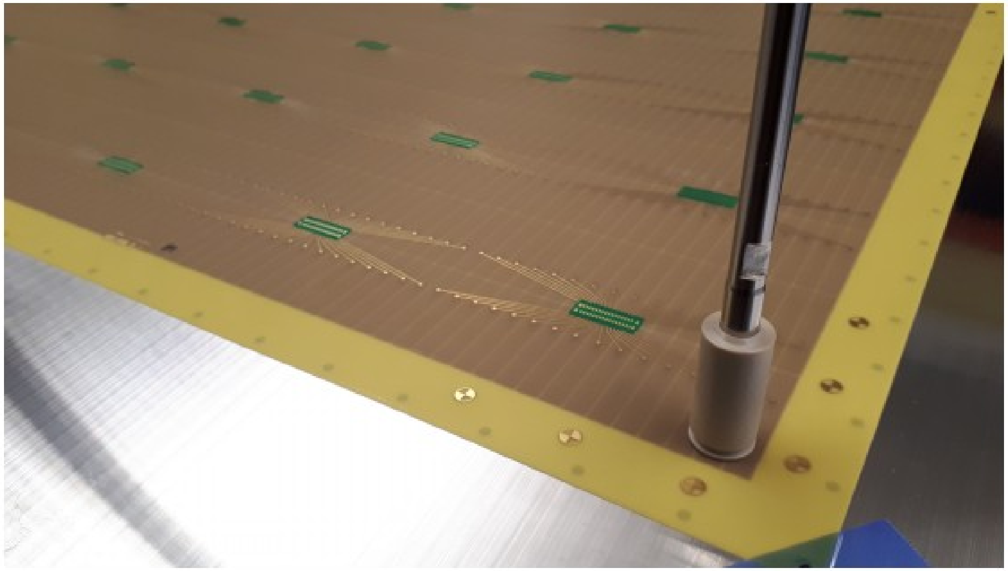
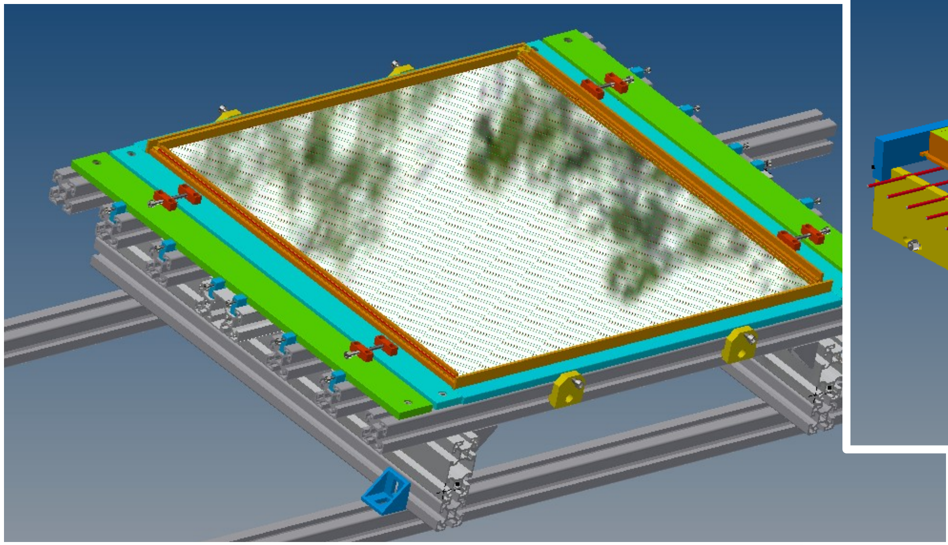


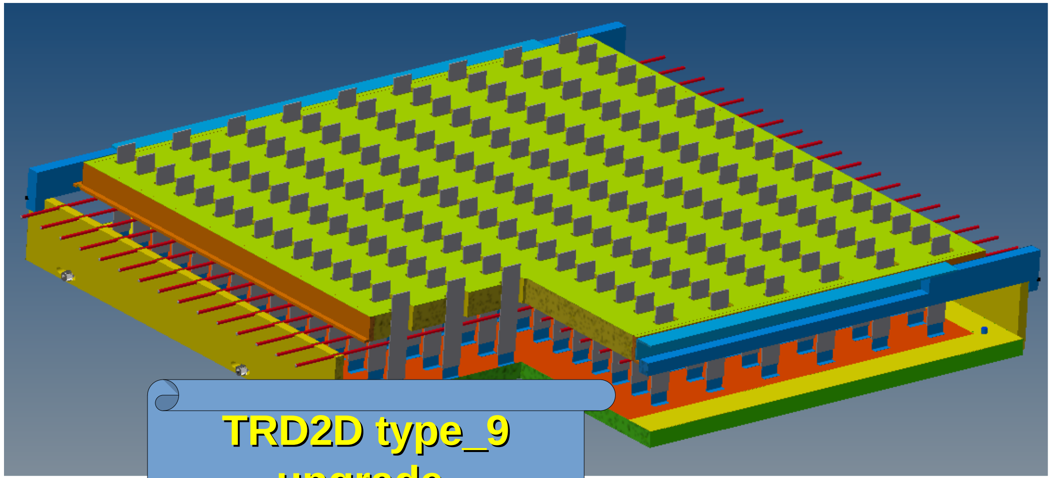
Figure 2: Padplane for the segmented TRD read-out cathode, intrinsically gas-tight connections by 4-layer design.

QA procedures
1. glueing padplane on backpanel carrier
   → planarity better 15 μm, probably even below
2. characterisation of pre-stretched entrance window
   → for characterization w.r.t. to relative detector pressure (Luisa, Felix)
   → good values, given as input for gas system design
3. complete entrance window planarity (prestretched foil+frame) --> full OK for chamber mounting

Construction

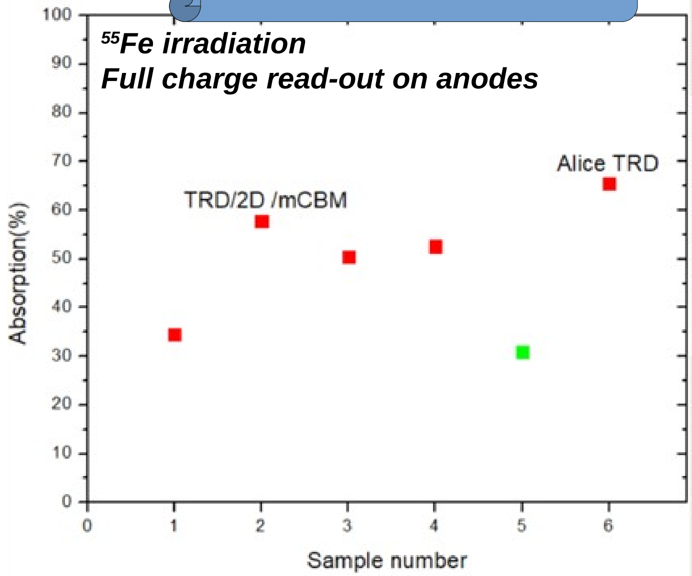
TRD2D_type_9 prototype, TDVs, EW optimization

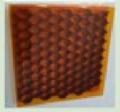
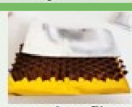
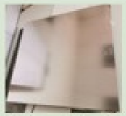
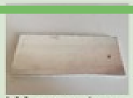




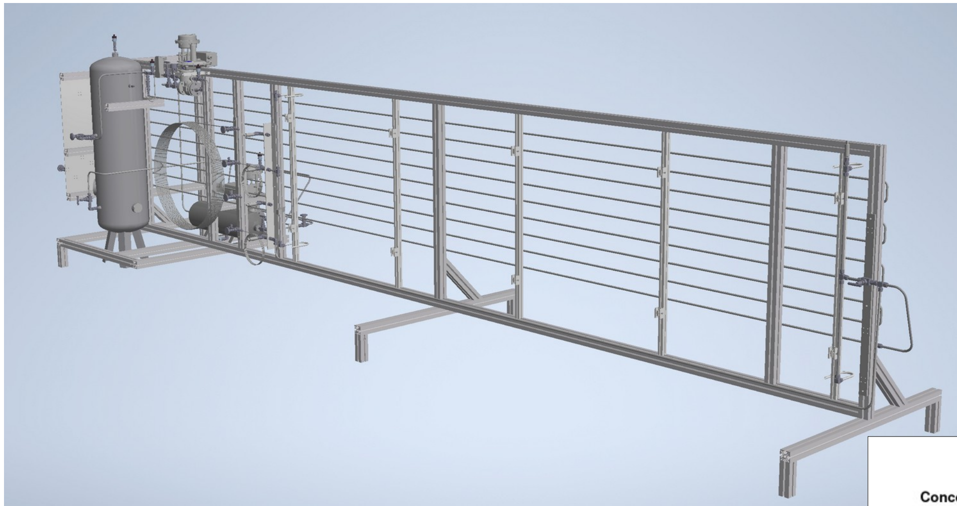
TRD2D type_9 upgrade TRD1D type_1 from TDR

1. **technology steps** for chamber assembly are being defined and *Tools Devices and Verifiers* (TDVs) are devised to assure QA during production.
2. **prototype** all components were prepared and ready (02/22). One TDV is missing (the 1.5 mm wire comb - offer from Uni-Heidelberg)
3. **production** market investigations are being conducted based on price efficiency estimates during prototype phase (A&K wires, honeycomb)
4. **optimization** fine tuning of components to improve material budget (FEB) or TR yield (EW)

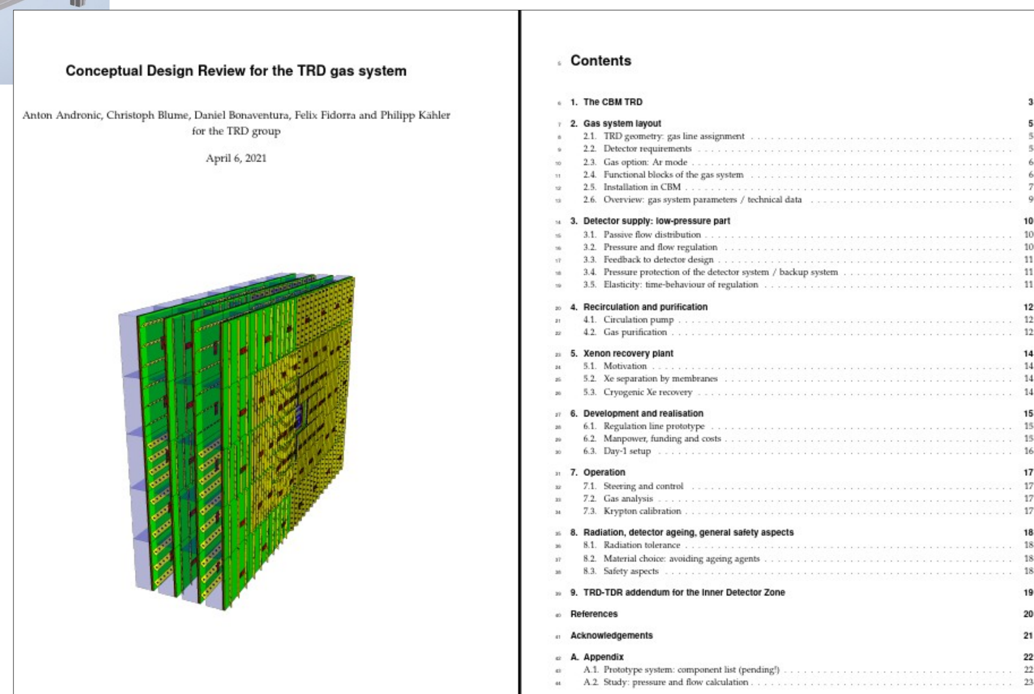


Sample	Sample
1.  2 x 75 µm Kapton foil + 9 mm honeycomb	4.  2 x 170 µm aluminized carbon fiber + 9 mm honeycomb
2.  2 x20 µm aluminized Kapton foil+3 mm Rohacell foam HF71+9 mm honeycomb TRD/2D /mCBM entrance window	5.  135 µm carbon fiber + 25 µm aluminized Mylar foil+9 mm honeycomb + 20 µm aluminized Kapton foil
3.  2 x 0.25 mm aluminized carbon fiber + 9 mm honeycomb	6.  100 µm carbon fiber+25 µm aluminized Mylar foil+ 8 mm Rohacell foam HF71 TRD-ALICE entrance window

GAS system



https://git.cbm.gsi.de/trd/reports/cdr-gas-system



Conceptual Design Review for the TRD gas system

Anton Andronic, Christoph Blume, Daniel Bonaventura, Felix Fidorra and Philipp Kähler
for the TRD group

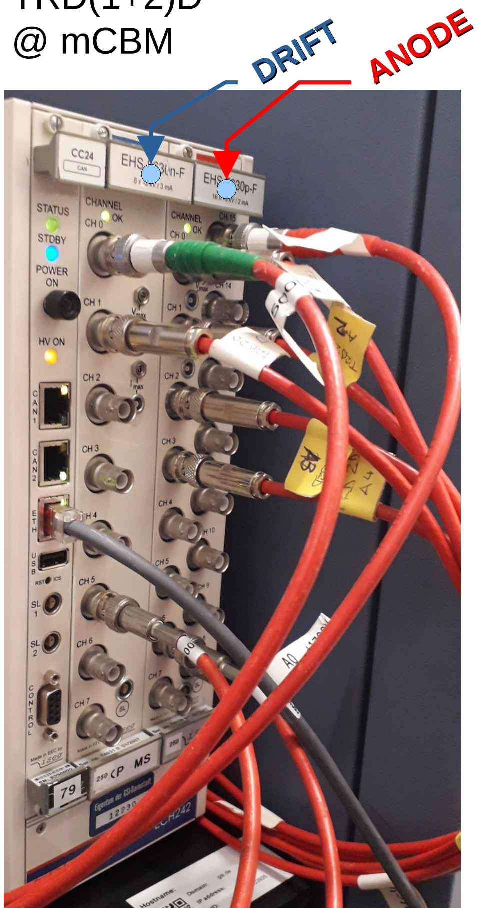
April 6, 2021

Contents

1. **Installation:**
   → first line in Münster. (in progress).
2. **Objectives :**
   → To characterize measurements,
   → Development of regulation routines.
   → Measure characteristic time of regulation with real pipe lengths / chamber volumes.
3. **EDR :**
   → Later 2022
4. **Funds :**
   → First line funded, for the other 4 need to identify resources.

LV & HV system

HV & LV demonstrator for both TRD(1+2)D @ mCBM



HV. 4 anode lines and 1 drift line were rerouted to the HV unit of TRD1D. Anode slots (0-3) Drift slot 2 (see Fig).

1. full calculation for LV system in place.
2. delayed by concurrent activities
   → production preparation (slide 4)
   → mCBM data taking/analysis (slide)

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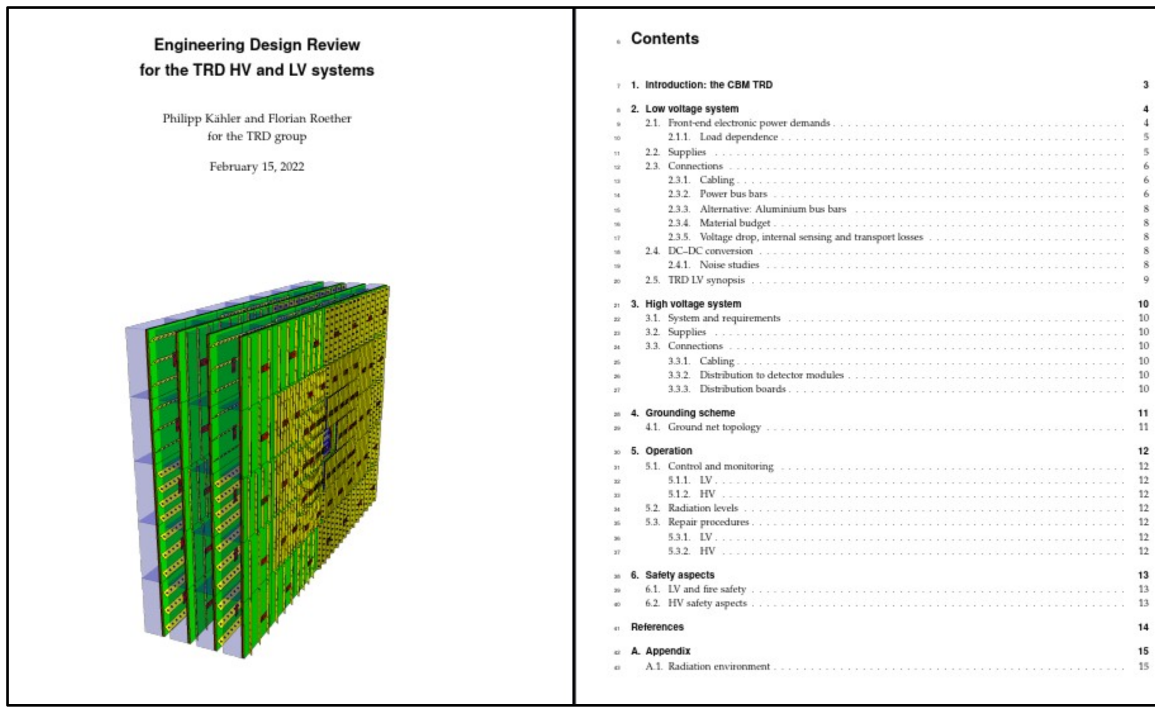
https://git.cbm.gsi.de/trd/reports/edr-hv-lv



Engineering Design Review
for the TRD HV and LV systems

Philipp Kähler and Florian Roether
for the TRD group

February 15, 2022

Contents

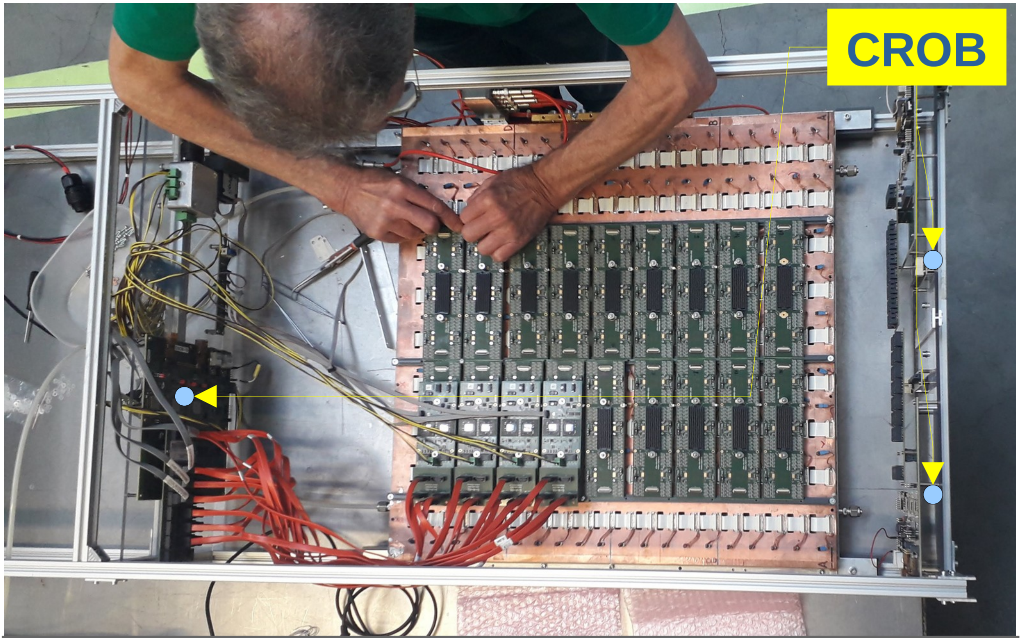
FEE : SPADIC

C. Blume, *TRD status; CBM Technical Board Meeting 7.09.2021*
https://indico.gsi.de/event/13081/contributions/55770/attachments/36880/49242/trd_status_07.09.21.pdf

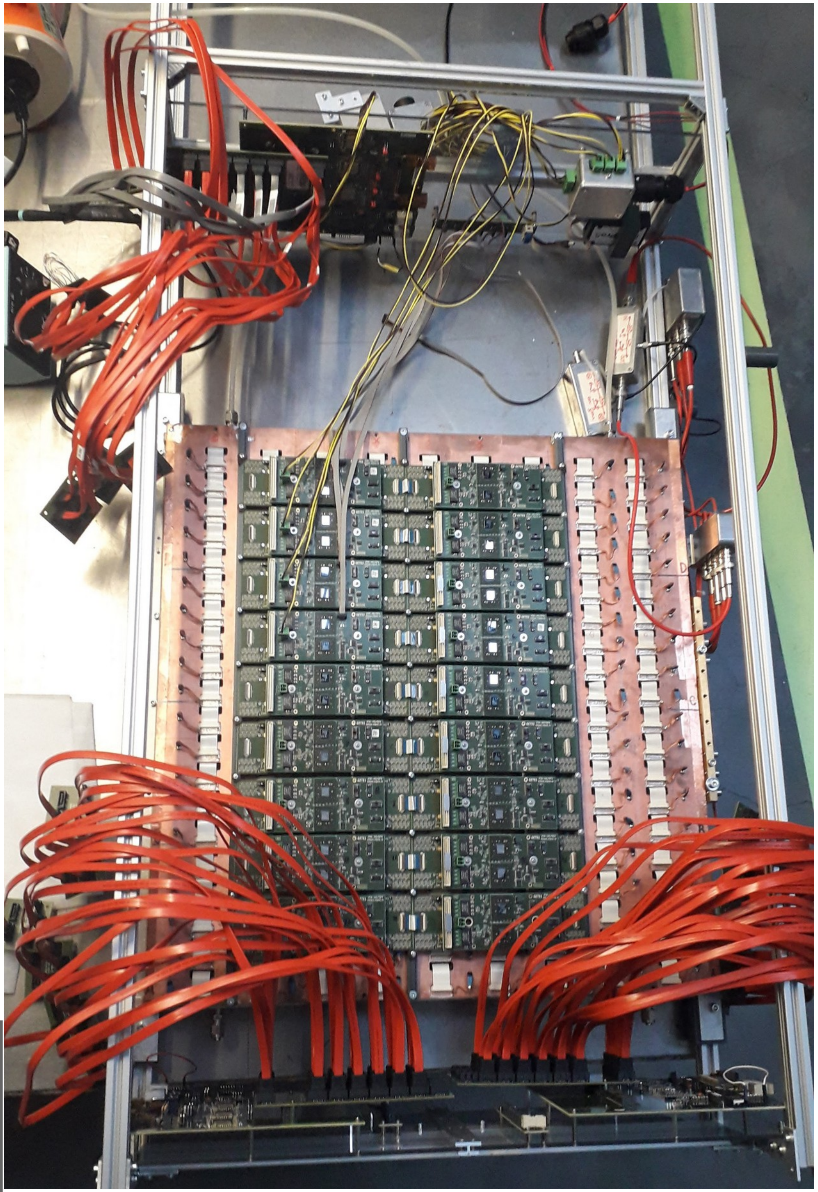
SPADIC v2.3a, v2.3b
→ Both test chips are on FEBs now.
→ Expert team at ZITI is evaluating the chips.

SPADIC v2.4
→ will be designed/configured according to the results of the evaluation. (e.g. choice of input protections).
→ No extra new features

FEE : FASP/GETS



__Mounting the 14 new FASPRO boards on the TRD2D__. The operated region was modified wrt planning as follows (see picture, top to the right):
- from 3 → 2 FASPRO columns
- from 6 → 9 FASPRO rows
→ similar read-out surface
→ more emphasis on low deflection angles (higher multiplicity)
→ matching better with ToF acceptance
→ easier to mount as the old 4 boards were kept in position



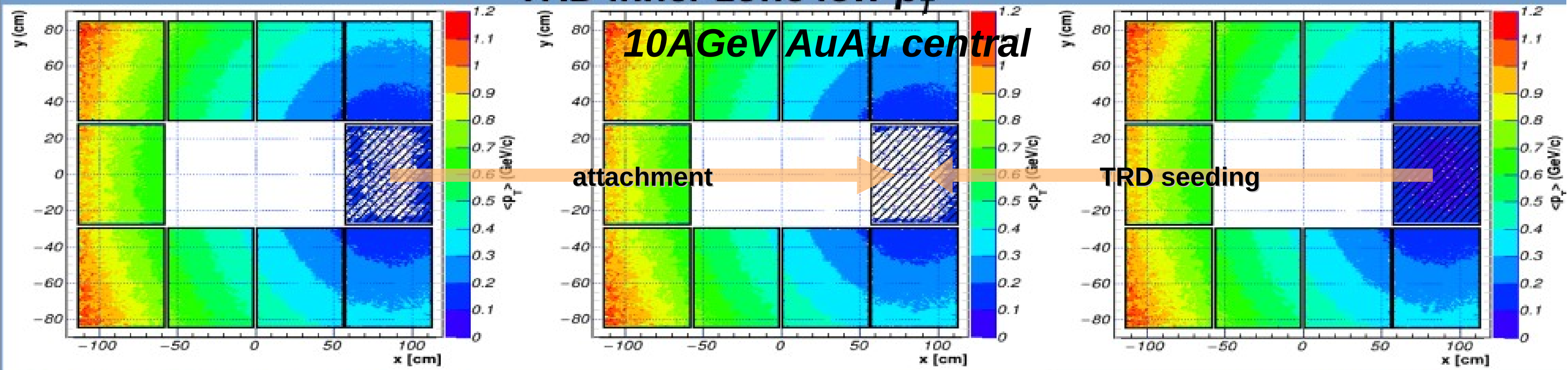
__Mounting the corresponding GETS boards__. The red cables left floating are the connections to the CROB. Due to topological reasons the allocation GETS→CROB will differ from previous runs which will impact the software mapping !

Milestones 2022

JAN	FEB ***LV+HV* EDR** → pending → to be arranged soon	MAR	APR ***LV+HV* PRR** → pending → EDR merged ?
MAY ***Radiator* EDR** → to be arranged soon → layer spacing ***Support*** **+ *Mainframe* EDR** → to be arranged soon → layer spacing	JUN ***TDR Addendum* ECE** → in preparation → need CBM support	JUL ***Gas* EDR** → in preparation **Mod_type_9 (inner)** **start production** → pending (+1y)	AUG
SEP ***Mod_type_9 (inner)*** **EDR** → tentative (old 09/21) ***Support*** **+ *Mainframe* PRR** → depends on	OCT ***Mod_type_5* FOS + PRR** → follow-up	NOV ***SPADIC (v2.4) PRR*** → *tentative (old 05/22)* ***FEB* CDR** → tentative (old 05/22) ***FEB* EDR** ***TDR Addendum*** **approval** → tentative (old 11/21)	DEC

TRD(2D) track seeding

TRD inner zone low p_T



p & K^+ with $|y_{CM}|<0.25$, propagated from STS seeds to last TRD station. Hatched area is a projection of the STS blind spot.

… tracks which attach TRD hits. The hatched area shows a low efficiency !

… tracks which IDEALLY can be reconstructed starting from TRD-2D seeding

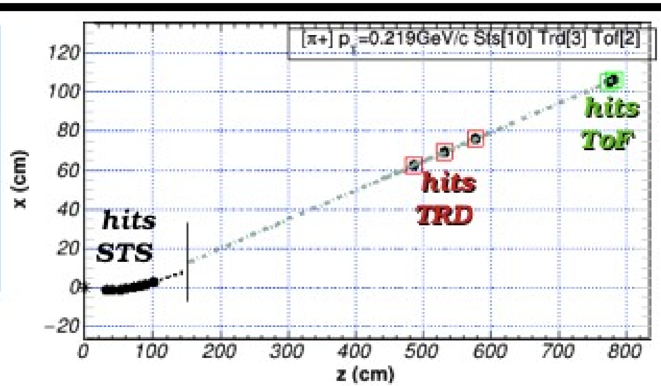
THE PROTONS DISTRIBUTION CAN BE REPRODUCED FOR EACH CHARGED PARTICLE WITH PROPER B FIELD SETTINGS

TRD-2D seeding:

- can be done with at least 2 hits

- x-y resolution independent of missing station !

Once a TRD seed is produced we need only few (2) sparse STS hits to estimate p_T



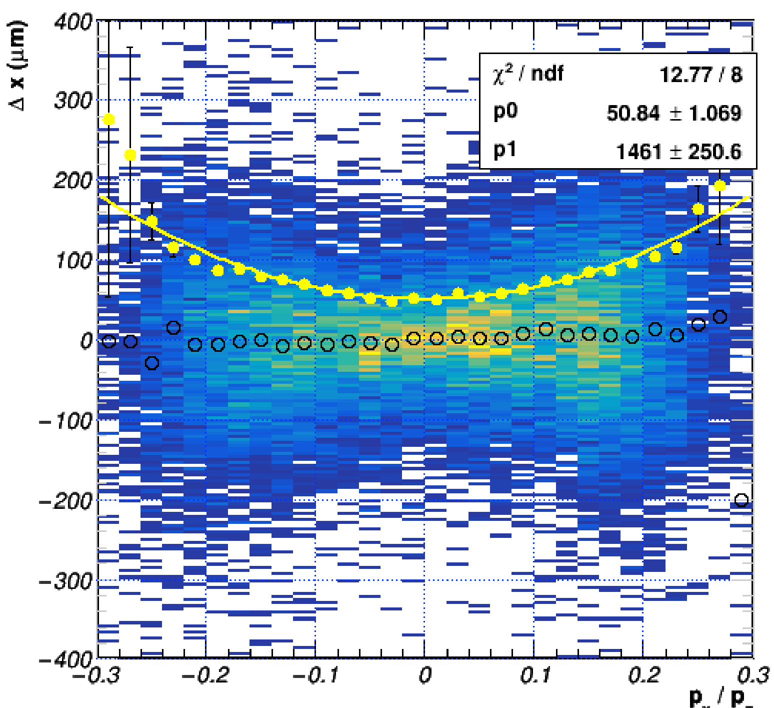
No dedicated list of recommendations from the reviewers so far. A deadline from the collaboration can be asked for June-July

Informal meeting on TRD TDR Addendum 4th May 2022

TRD(2D) track seeding

S. Gorbunov; *private communication*,

Tracker type	PID	Efficiency (%)
TRD2D (4 hits)	any	92,8
	protons and kaons	93,8
	pions	92,2
	electrons	85,7



Δ_x (residuals) between TRD2D hits and MC points as function of $\varphi = p_x/p_z$.
$\sigma_x(\varphi) = p0 + p1 * \varphi^2$; p0 and p1 are expressed in µm

https://git.cbm.gsi.de/computing/cbmroot/-/merge_requests/818

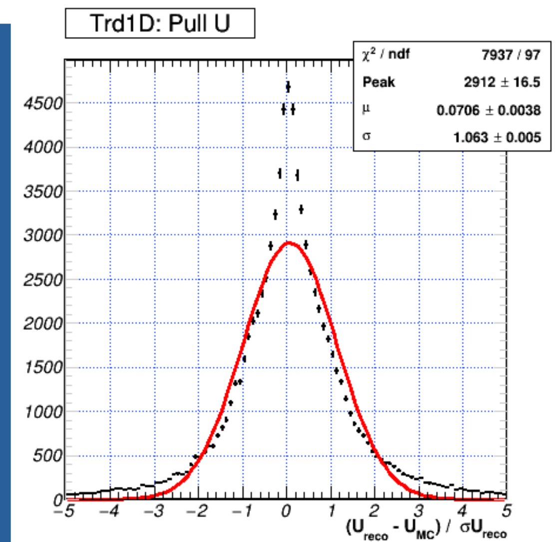
For tracking performance the value of reference is the ration:

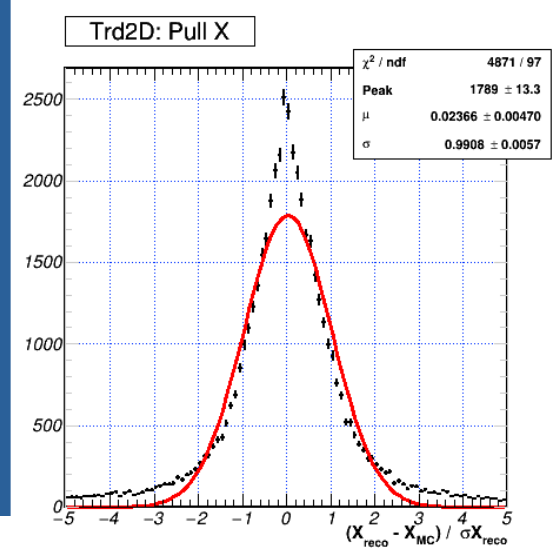
Pull = Δ_x / σ_x

The distribution of this observable has to be Gauss with mean 0 and sigma 1.

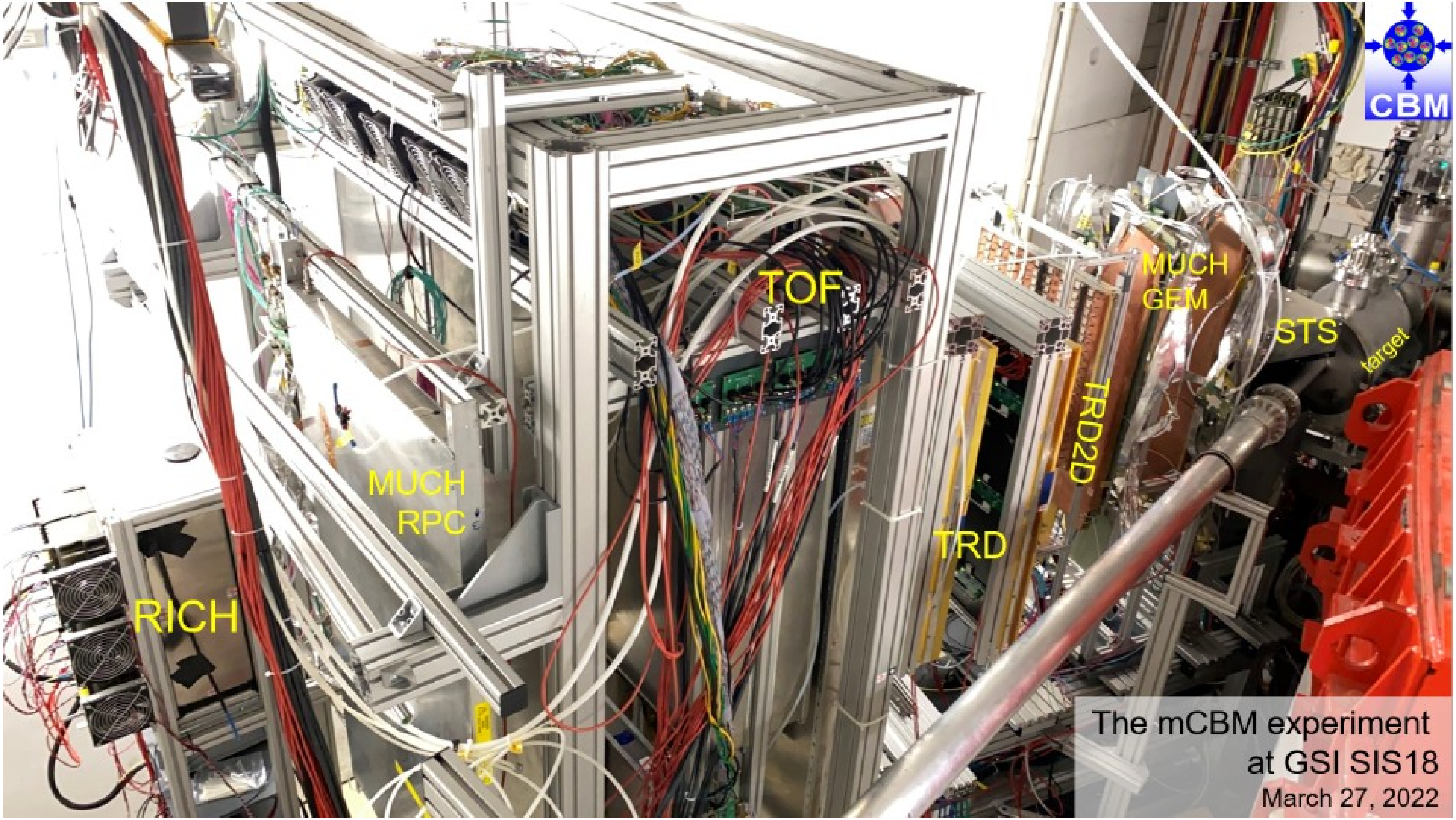
In the figure the pull$_x$ distribution is shown for TRD1D and TRD2D as they are produced by the CbmTrackerInputQaTrd task.

The performance can be improved in terms of χ^2 by improving the error parametrization.

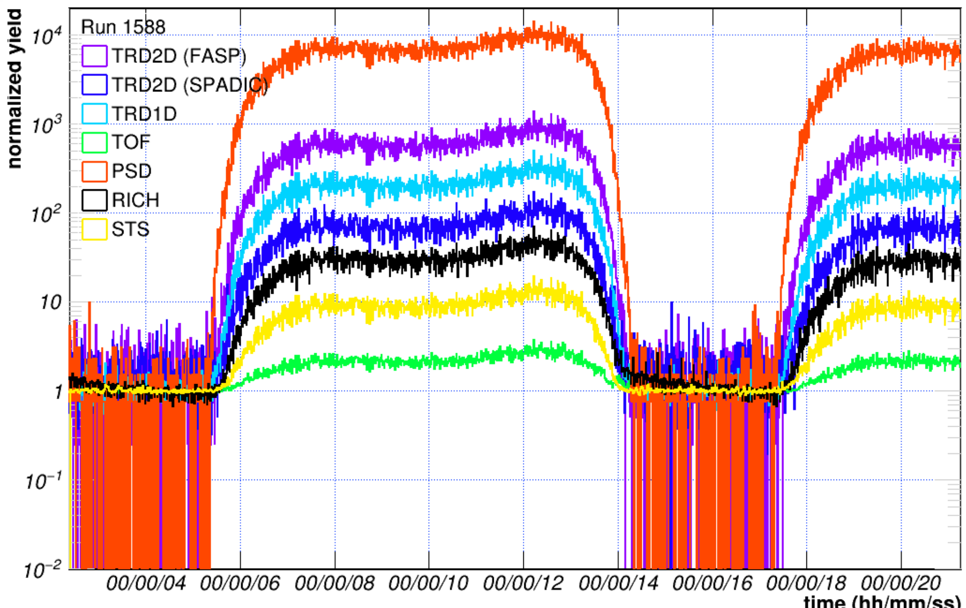




Results, mCBM and beyond

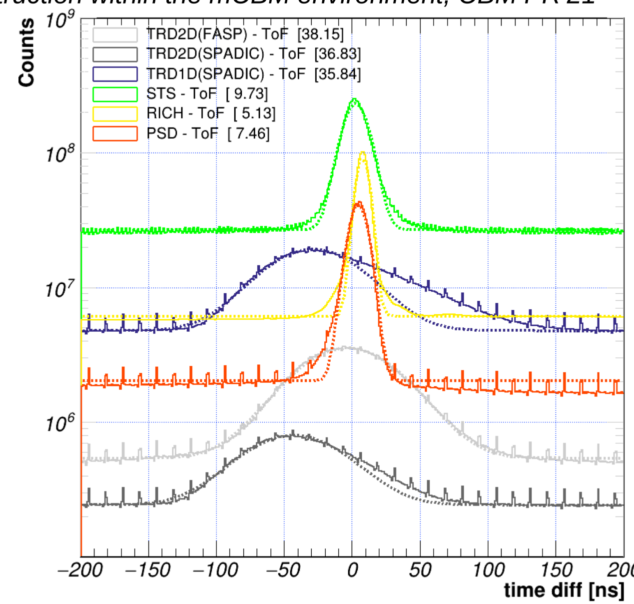


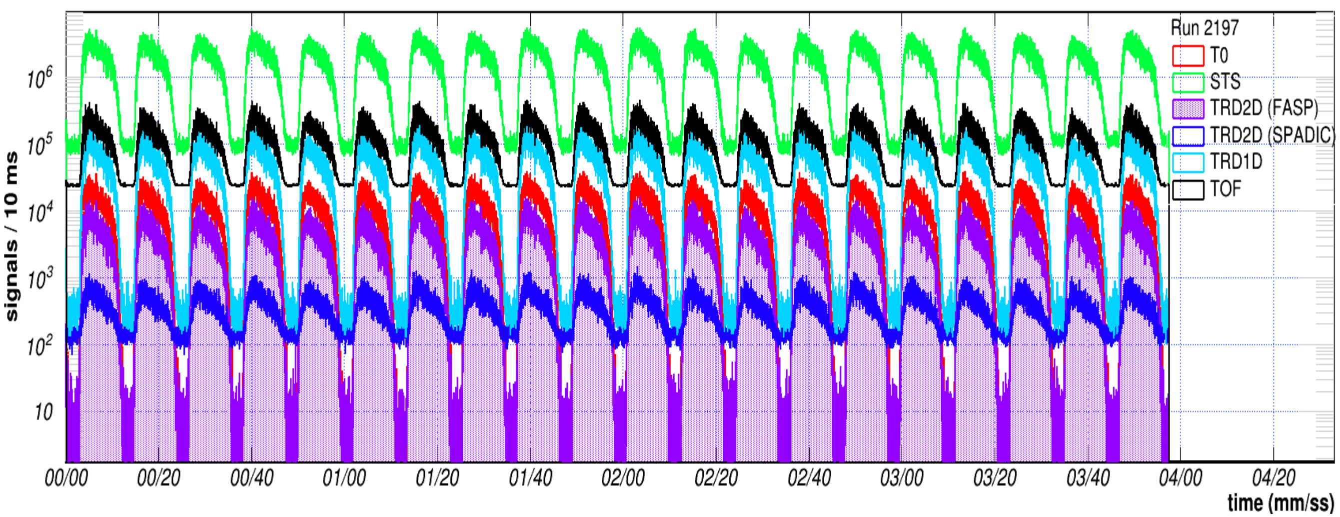
On mCBM data

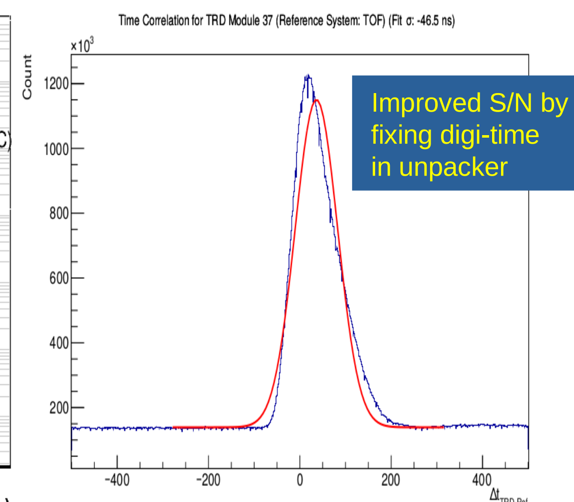


A. Bercuci et al.; *Steps towards integration of the TRD-2D detection system with the CBM experiment, CBM PR'21*

A. Bercuci et al.; *Global space-time correlation of the local TRD reconstruction within the mCBM environment, CBM PR'21*





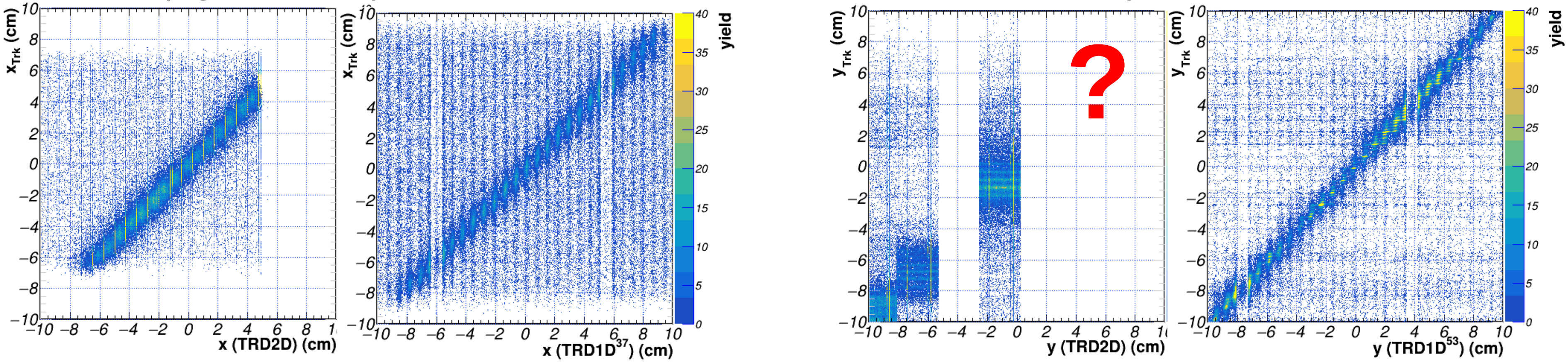


A. Puntke; *private communication*

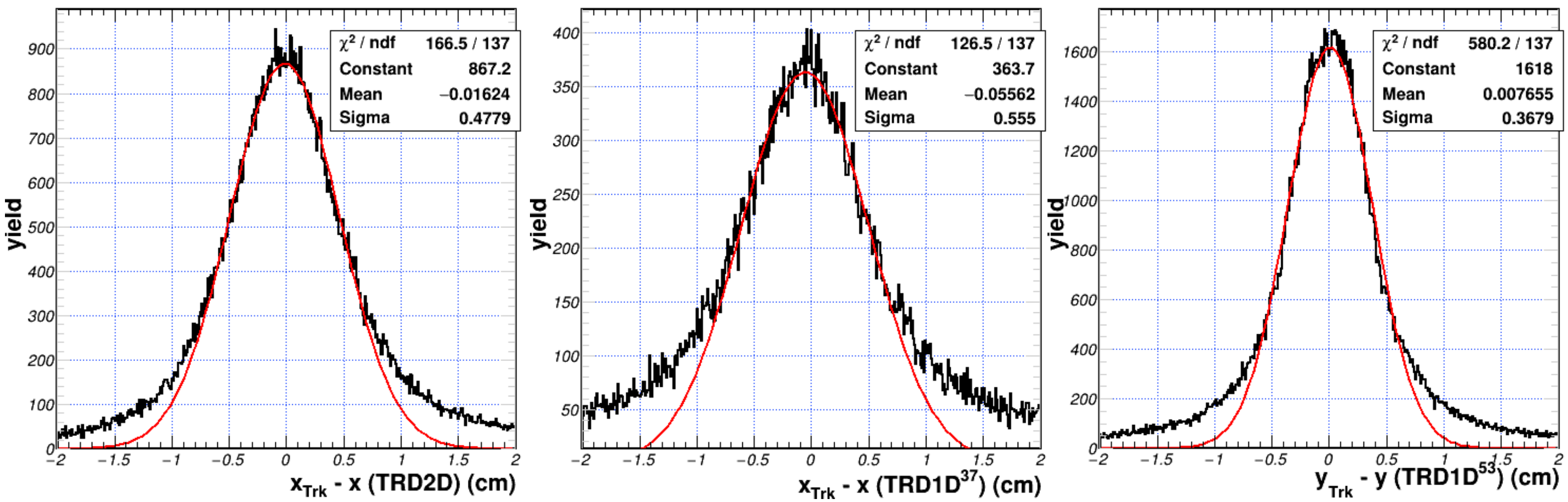
On mCBM correlations

Track definition 2xSTS + 2xToF

x (high resolution) direction *y direction*



A. Bercuci et al.; *Steps towards integration of the TRD-2D detection system with the CBM experiment, CBM PR'21*



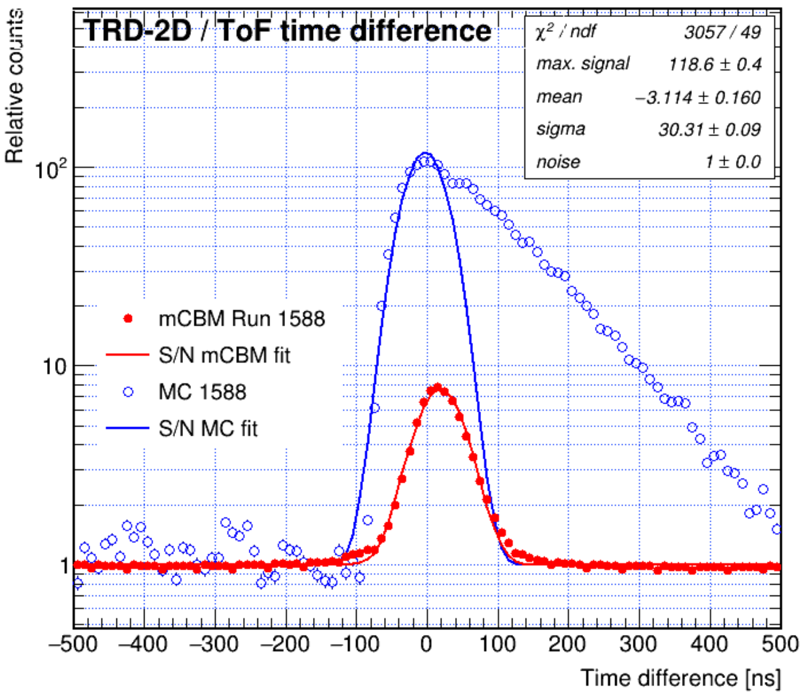
Hit-track resolution is <u>only</u> informative. Calibration, alignment, fixes of mCBM data are work in progress.

Other mCBM results

Time-based Simulations

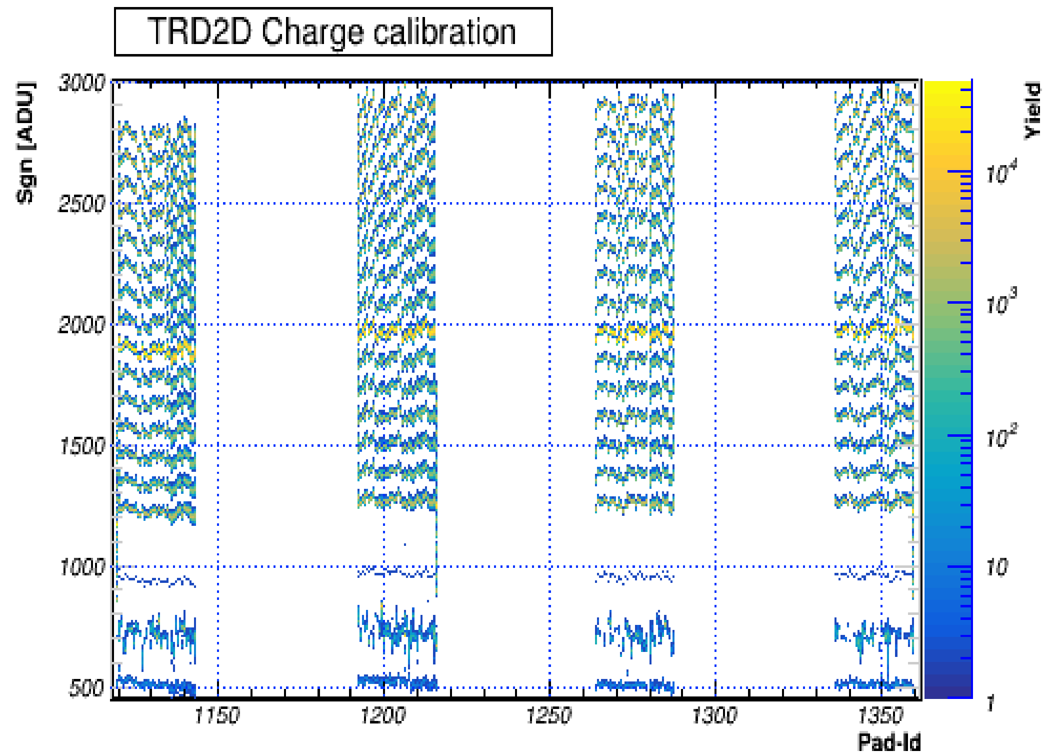
→ O-Ni 2 AGeV mbias

→ Interaction rate @100 kHz:



A. Nan; *AFCO poster presentation, Brasov, ROMANIA*

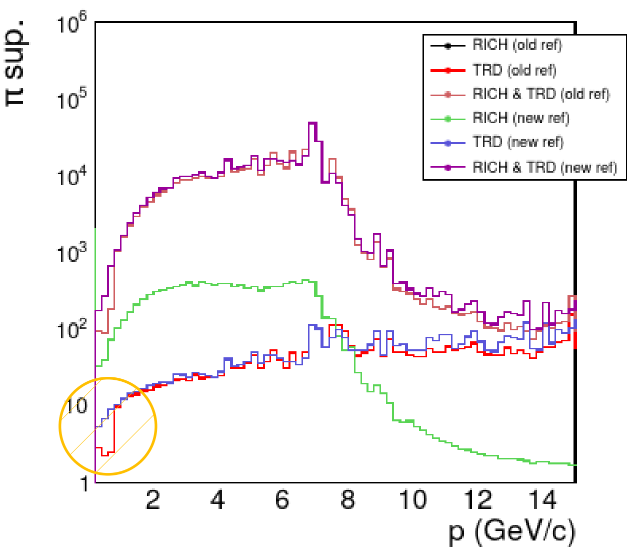
Charge Calibrations



Simultaneous charge calibration of all FASP channels through injection of a standard signal (square, amplitude, frequency) on the anode wires.

CBM simulations

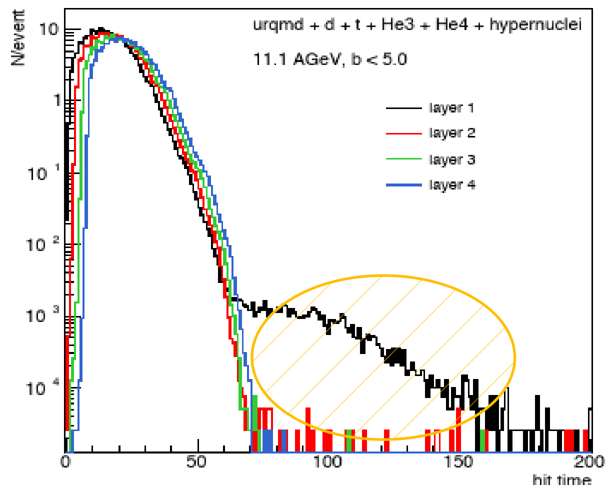
PID references for Di-electron analysis



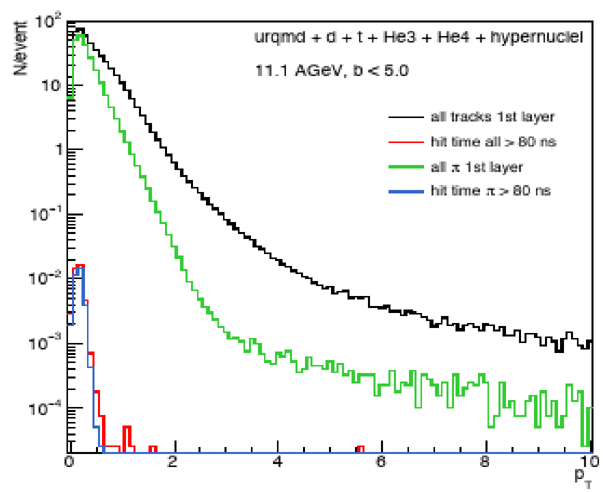
- Electron efficiencies set to:
  - RICH PID: 90%
  - TRD PID: 80%

A. Meyers-Ahrens; *TRD likelihood reference spectra update*, TRD Weekly 11.05.2022

High hit times



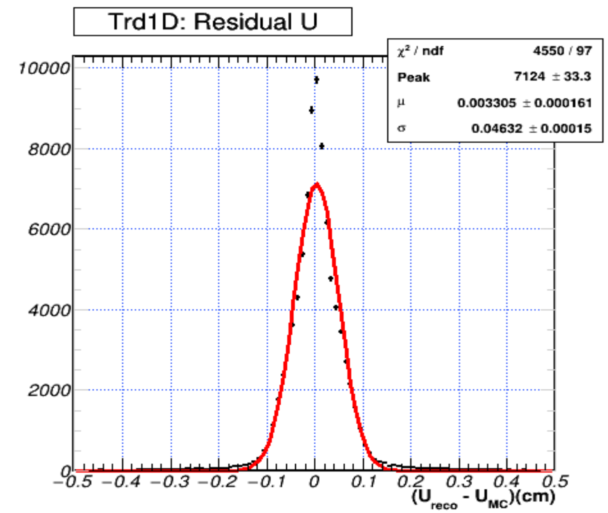
p_T all tracks first layer

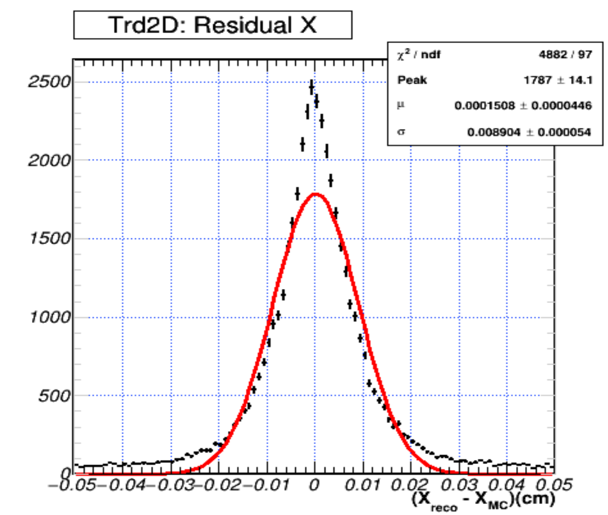


S. Gaessel; *TRD hit times, electron/ligt nuclei input*, TRD Weekly 16.02.2022

Hits QA

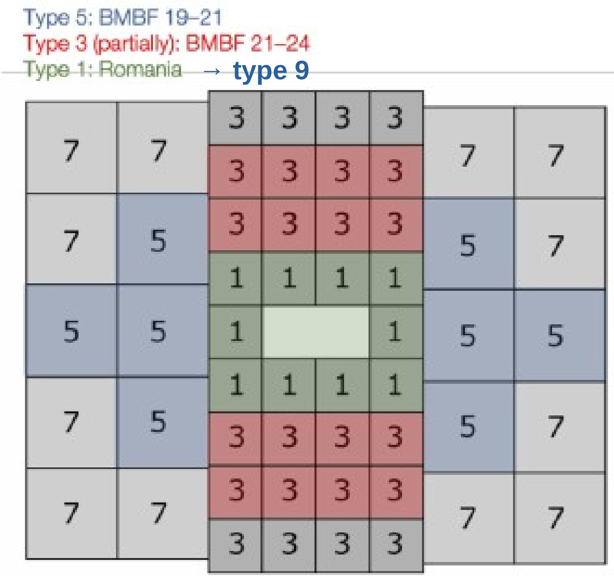
S.Gorbunov, A.Bercuci; https://git.cbm.gsi.de/computing/cbmroot/-/merge_requests/818



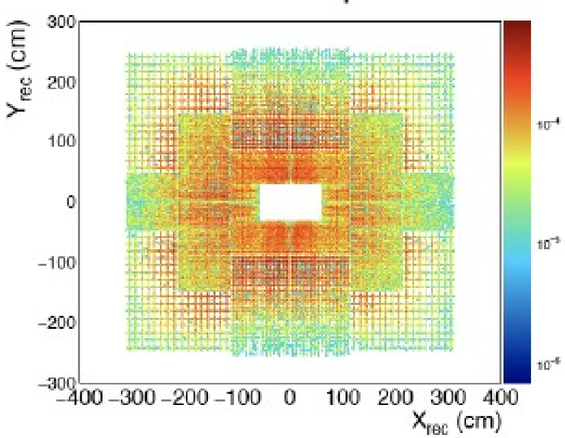


"2024 setup"

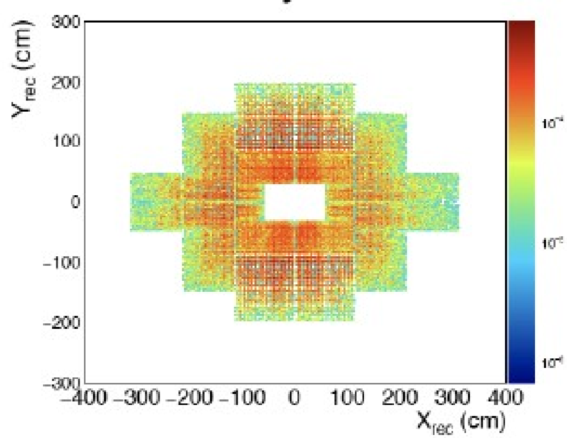
- aiming for full setup in 2025 → **2026 (2027)**
- "2024 setup" scrutinised
  (current funding consent, day-1 scenario)
- funding 2024/2025 open,
  funding further gas system lines open



Full setup



Day 1



Christoph/Etienne, PWG-DIL 14.05.

Milestones 2023

JAN	FEB **Mod_type_5 FAT** → end production **Mod_type_3 FAT** → start production **Gas** PRR → old (07/22)	MAR **Support + Mainframe** FAT **SPADIC 2.4** FAT **FEB(SPADIC)** PRR	APR **Radiator** FAT
MAY	JUN **Mod_type_3 FOS (PRR)** **Mod_type_9 FOS (10)** **FEB(SPADIC)** FOS	JUL	AUG
SEP	OCT	NOV **Gas** FAT	DEC **Mod_type_3 FAT** → end production **FEB(SPADIC)** FAT

BACKUP

TRD – Outer Chambers/modules

Milestone	Date	2019	2020	2021	2022	2023	2024	2025
Outer modules "5"								
Module EDR	10/19							
Module PRR + Start of prod.	10/20							Acceptance on-going
Modules FOS + PRR follow up	~~12/21~~ 10/22							Production on-going
Chambers all built (FAT)	~~07/22~~ 02/23							
Outer modules "3"								
Start of prod.	~~05/22~~ 02/23							
FOS (PRR follow-up if needed)	~~07/22~~ 06/23							
All built (FAT)	12/23							
Outer modules "7"								

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TRD – Inner Chambers/Modules

Milestone	Date	2019	2020	2021	2022	2023	2024	2025
Inner modules (chamber + radiator + FEE)								
TDR-Add internal review	02/21							
TDR-Add submission	05/21							ECE 05/2021
Inner modules "EDR"	~~09/21~~ 01/22					Moved 05/22 ? (should be discussed)		
TDR Addendum approval	11/21							ECE 11/2021
Inner modules PRR	02/22							
Start module production	07/22							
Module FOS (batch of 10)	06/23							
All chambers built	06/24							

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TRD – Radiator box, Services, Mechanics

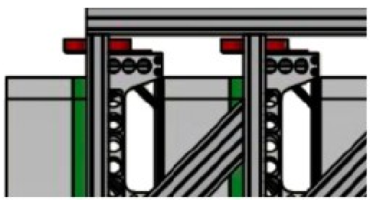
Milestone	Date	2019	2020	2021	2022	2023	2024	2025
				Radiator box				
Radiator EDR	05/22					decision on layer spacing needed		
Radiator PRR	07/22							
Radiator FAT	04/23							
				Gas system				
Gas CDR	04/21					evaluation ongoing		
Gas EDR	~~02/22~~ 07/22					more time for preparation. funding?		
Gas PRR	07/22							
Gas FAT	11/23							
				LV + HV systems				
LV + HV EDR	02/22					being prepared		
LV + HV PRR	04/22					can EDR and PRR be merged?		
LV + HV FAT	09/22							
				Mechanics				
Mainframe CDR	10/20							
Support + Mainframe EDR	05/22					decision on layer spacing needed		
Support + Mainframe PRR	09/22							
Support + Mainframe FAT	03/23							

TRD – ASIC, FEBs

Milestone	Date	2019	2020	2021	2022	2023	2024	2025
SPADIC ASIC + Front-End Boards								
SPADIC 2.2 completed	07/19							
SPADIC 2.3 submission	12/20							
SPADIC 2.4 PRR	05/22					SPADIC 2.3 evaluation on-going, 2.3b just delivered		
SPADIC 2.4 FAT	03/23							
FEB CDR	05/22							
FEB EDR	~~1/22~~ 11/22							
FEB PRR	03/23							
FEB FOS, 1st batch sent	06/23							
FEB FAT, all FEBs sent	12/23							

Layer Spacing

- Options (currently under discussion)

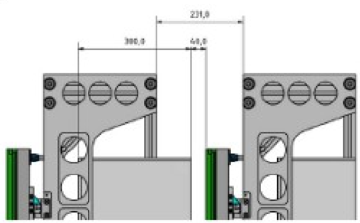


Version 1

Layer spacing: **710 mm**
Radiators mounted
on MWPCs

Reduced acceptance
(# points on track)

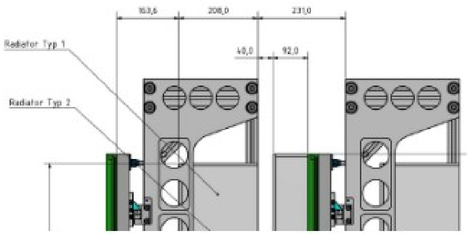
⟹ *PID performance reduced*



Version 2

Layer spacing: **531 cm**
Radiators mounted in
support frame

Air gap between
radiator and MWPC
Reduced size of radiators
⟹ *Radiator perf. reduced*



Version 3

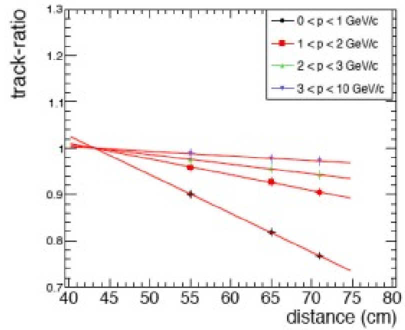
Layer spacing: **531 cm**
Radiators split
into two parts

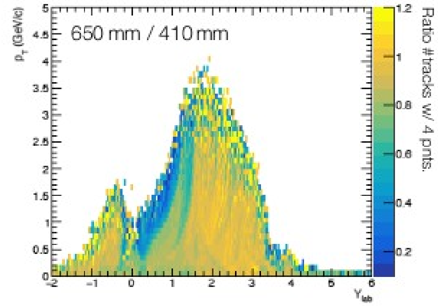
Air gap between
radiator parts

⟹ *Radiator perf. reduced*

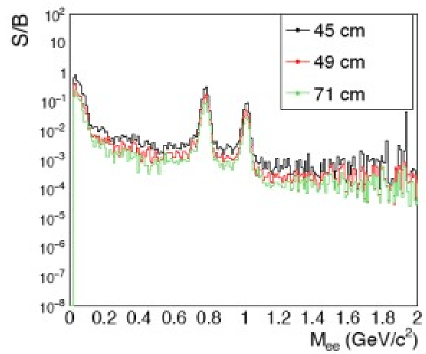
Layer Spacing

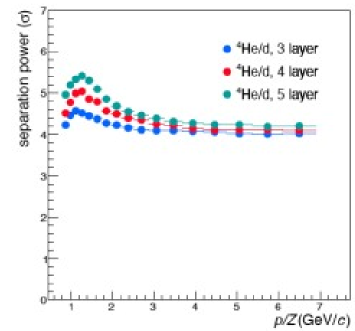
- Reduced acceptance (version 1)
  - # of points decreases with increasing layer spacing
  - Effect prominent in specific areas of phase space





  - Effect on di-electron performance
  - dEdx-performance would also be affected





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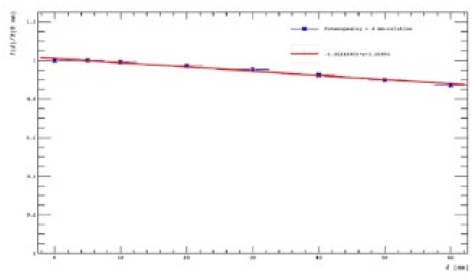
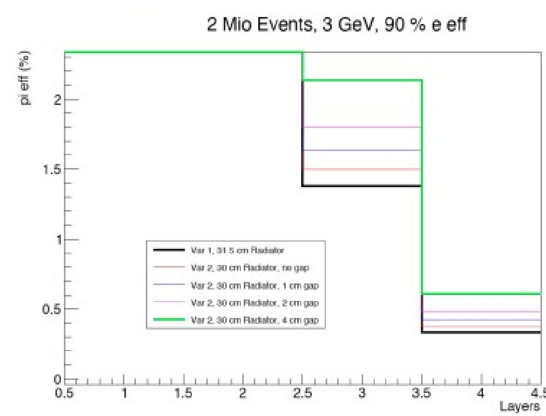
Layer Spacing

- Alternative radiator mounting (version 2 + 3)
  - Air gaps between radiator + MWPC,
    resp. radiator parts, for mechanical clearance
  - Bulging of foam foil stack requires ~ 40 mm
  - Absorption of TR-photons



  - Reduction of radiator performance (up to factor ~ 2)



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Layer Spacing

- Next steps
  - Apparently no clear preference from physics performance point-of-view
  - Other considerations:
    Simplicity of design (radiators, support)
    Ease of maintenance
  - External constraints:
    Short TRD-setup required by general CBM setup?
    Encapsulated radiators needed (fire safety)?
  - Have to come to a decision soon
  - Submit design change request

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