Status and Plans mRICH

Abhishek Anil Deshmukh
Bergische Universität Wuppertal

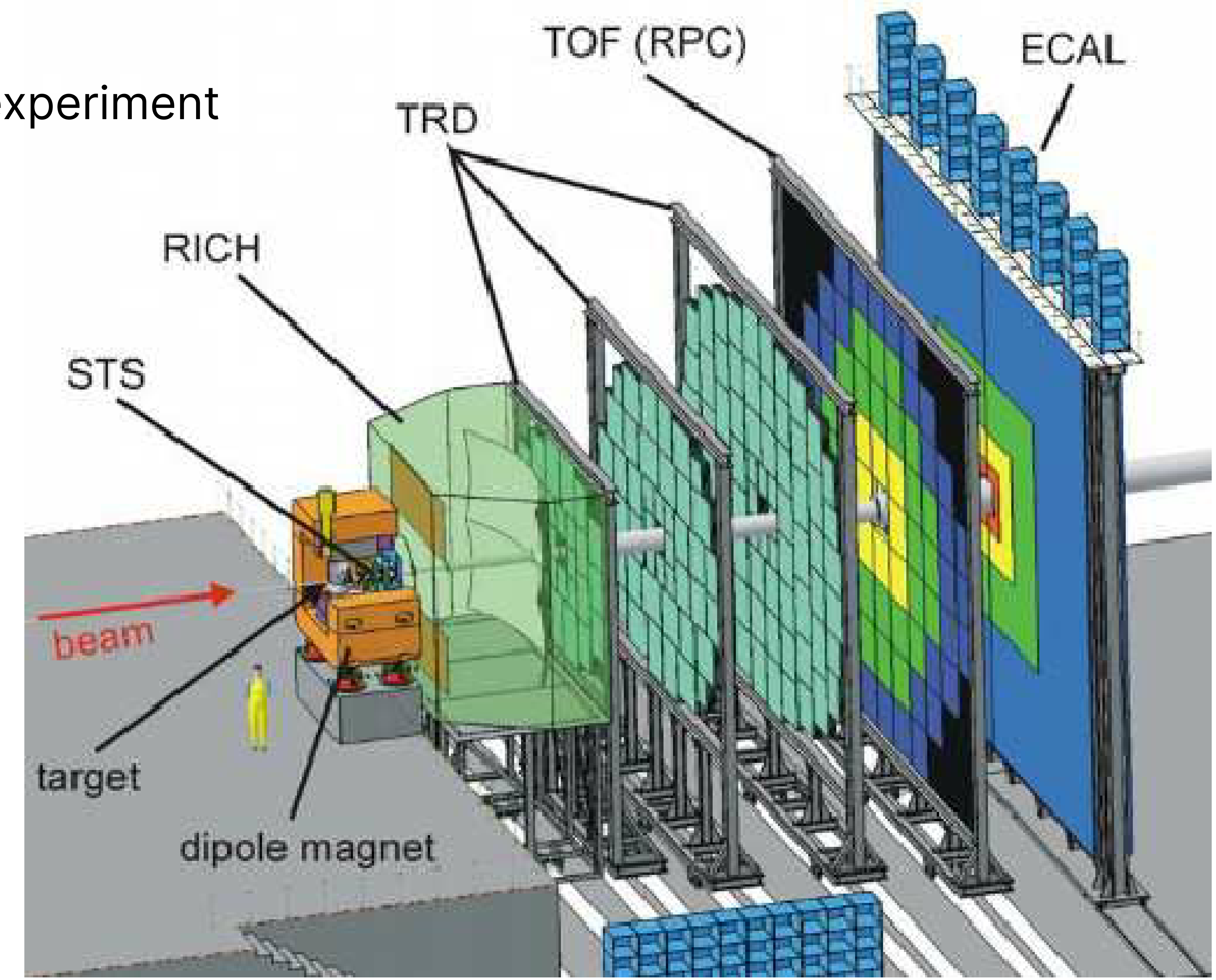
FAIR NExt generation ScientistS, Croatia
25 September 2024

Overview

- What is mCBM?
- What is mRICH?
- You like Aerogel?
- Correlations between detectors
- Buffer conundrum

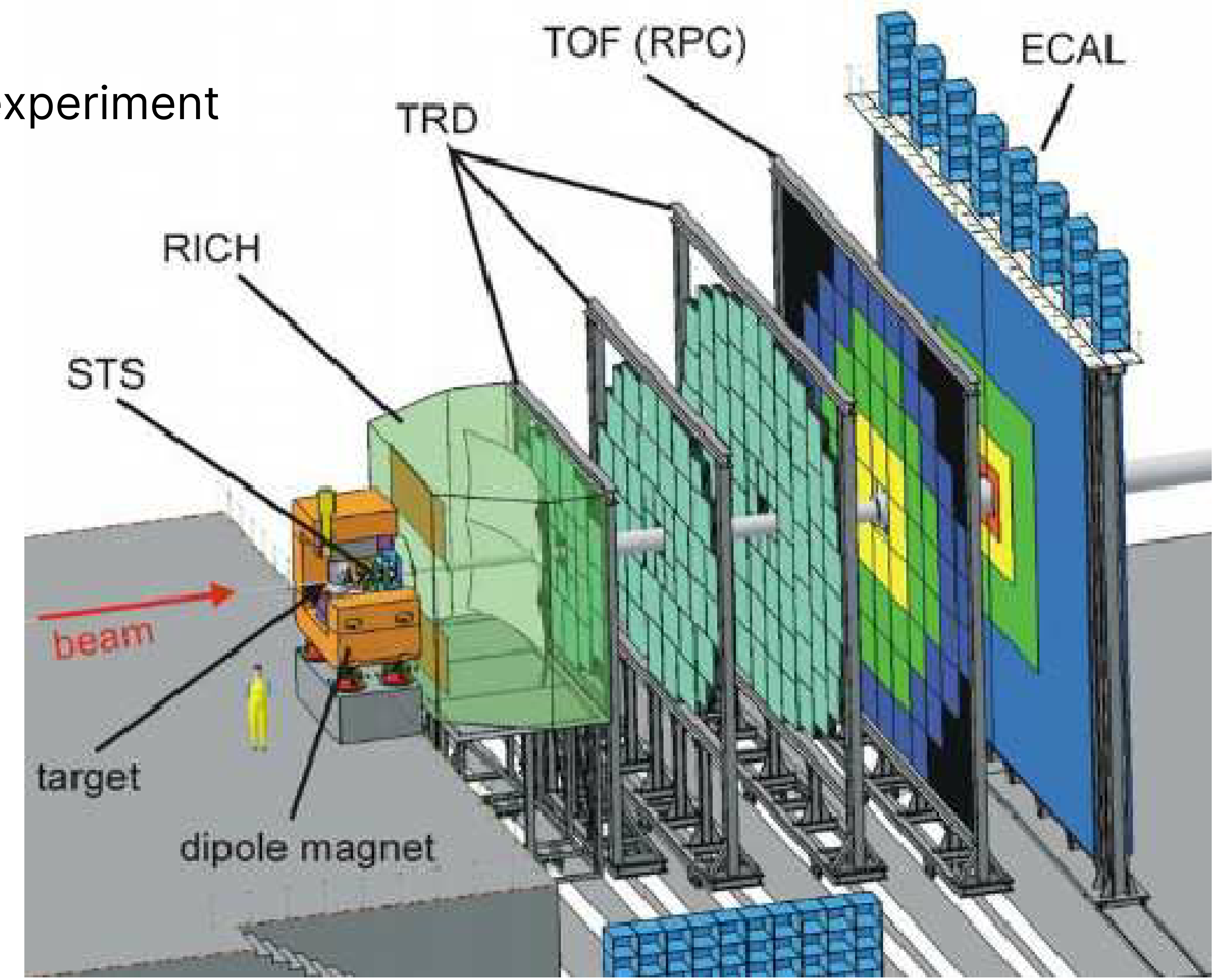
Original Experiment: CBM

Fixed target Heavy-ion collision experiment



Original Experiment: CBM

Future
^Fixed target Heavy-ion collision experiment



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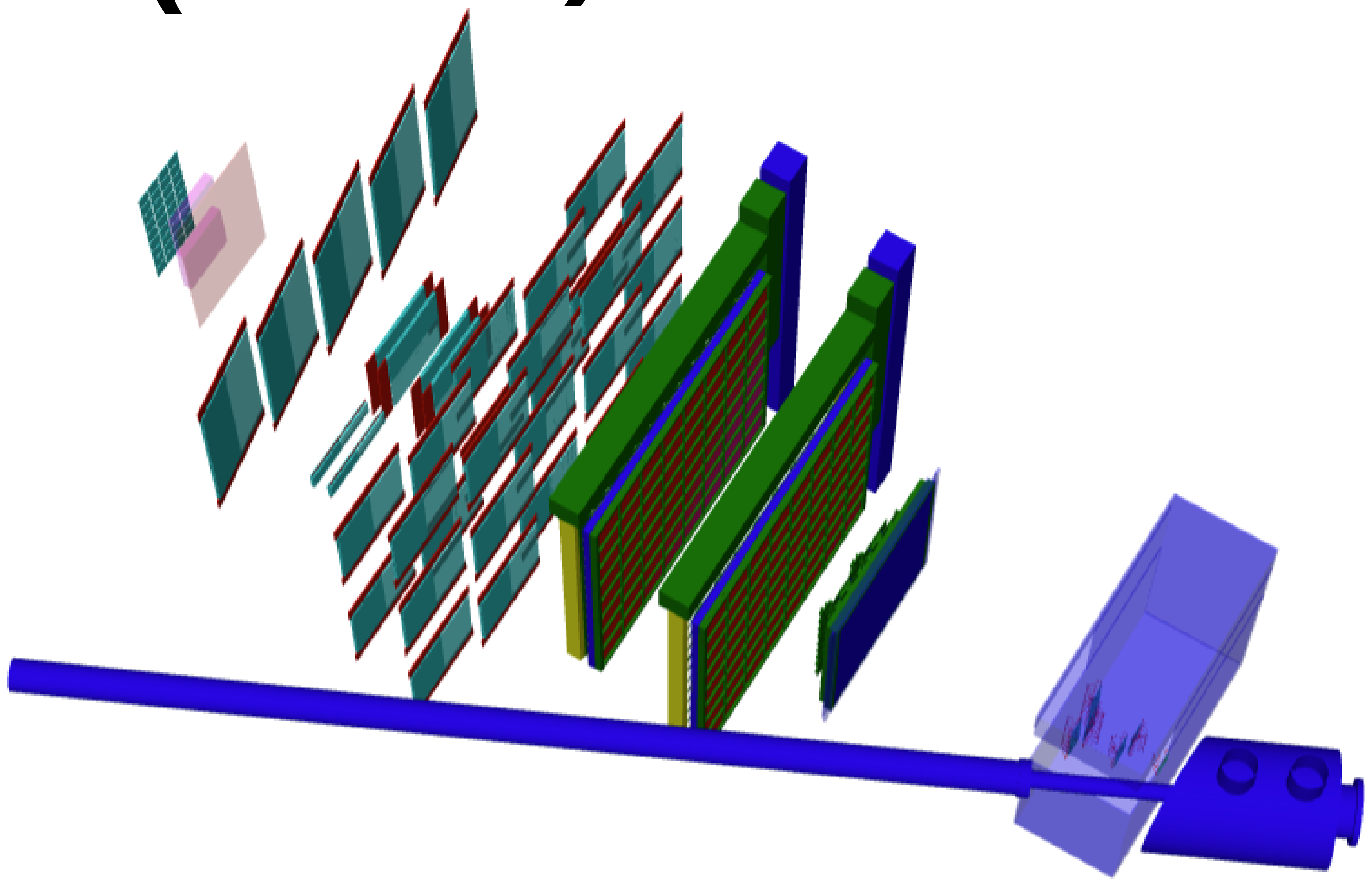
Prototype Experiment: mini-CBM (mCBM)

Present
^ Fixed target Heavy-ion collision experiment

Venue: FAIR, Darmstadt



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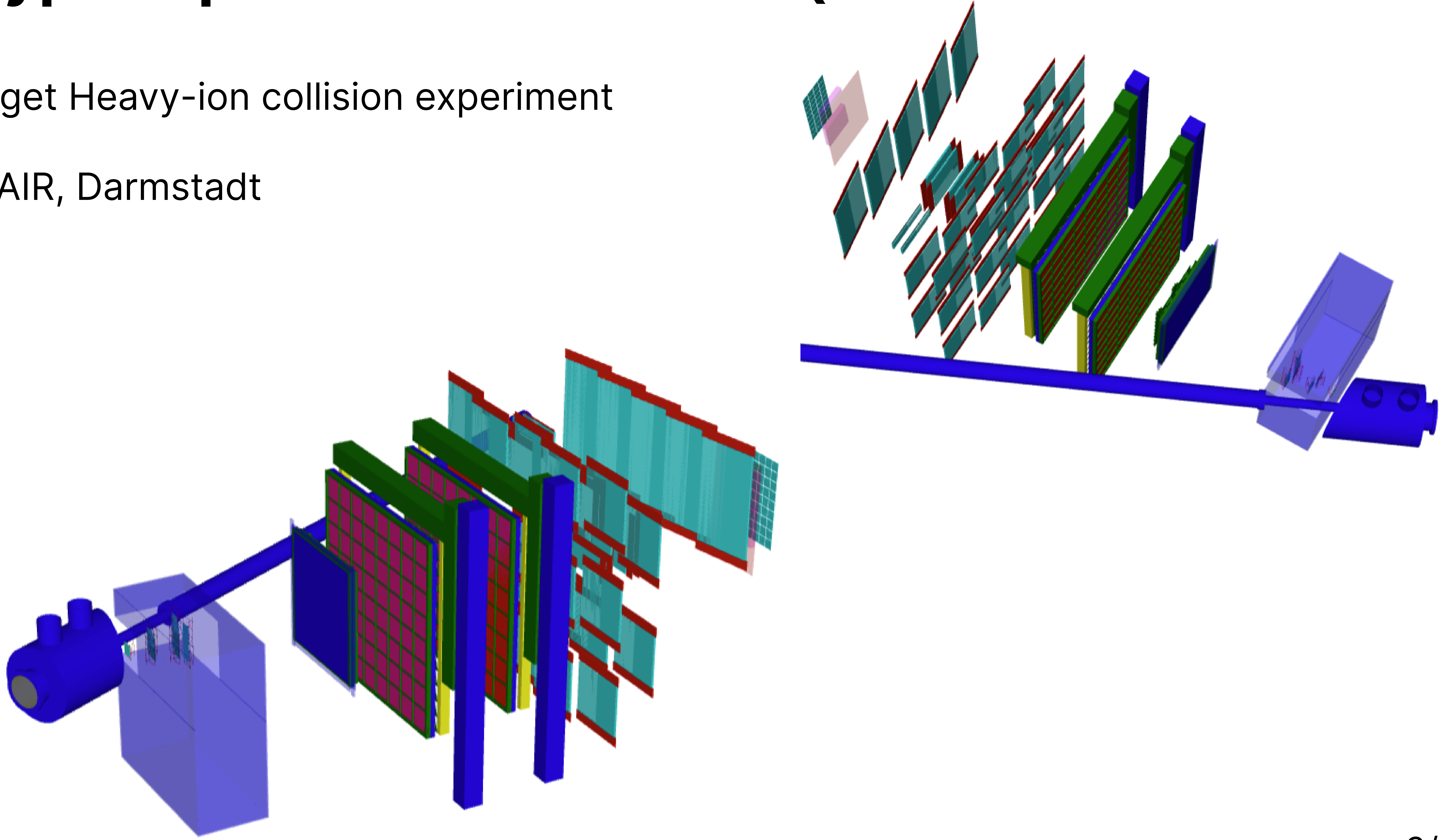

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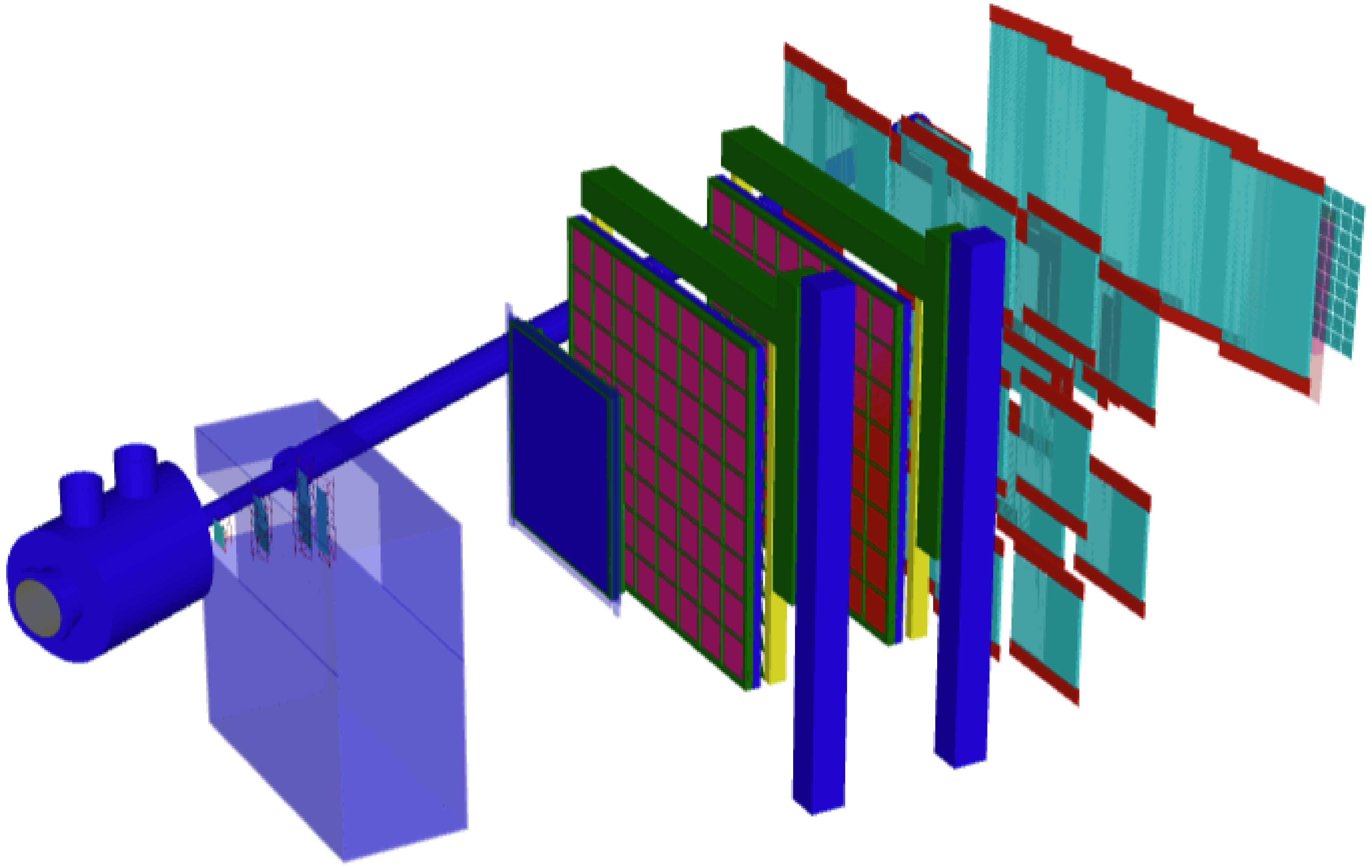

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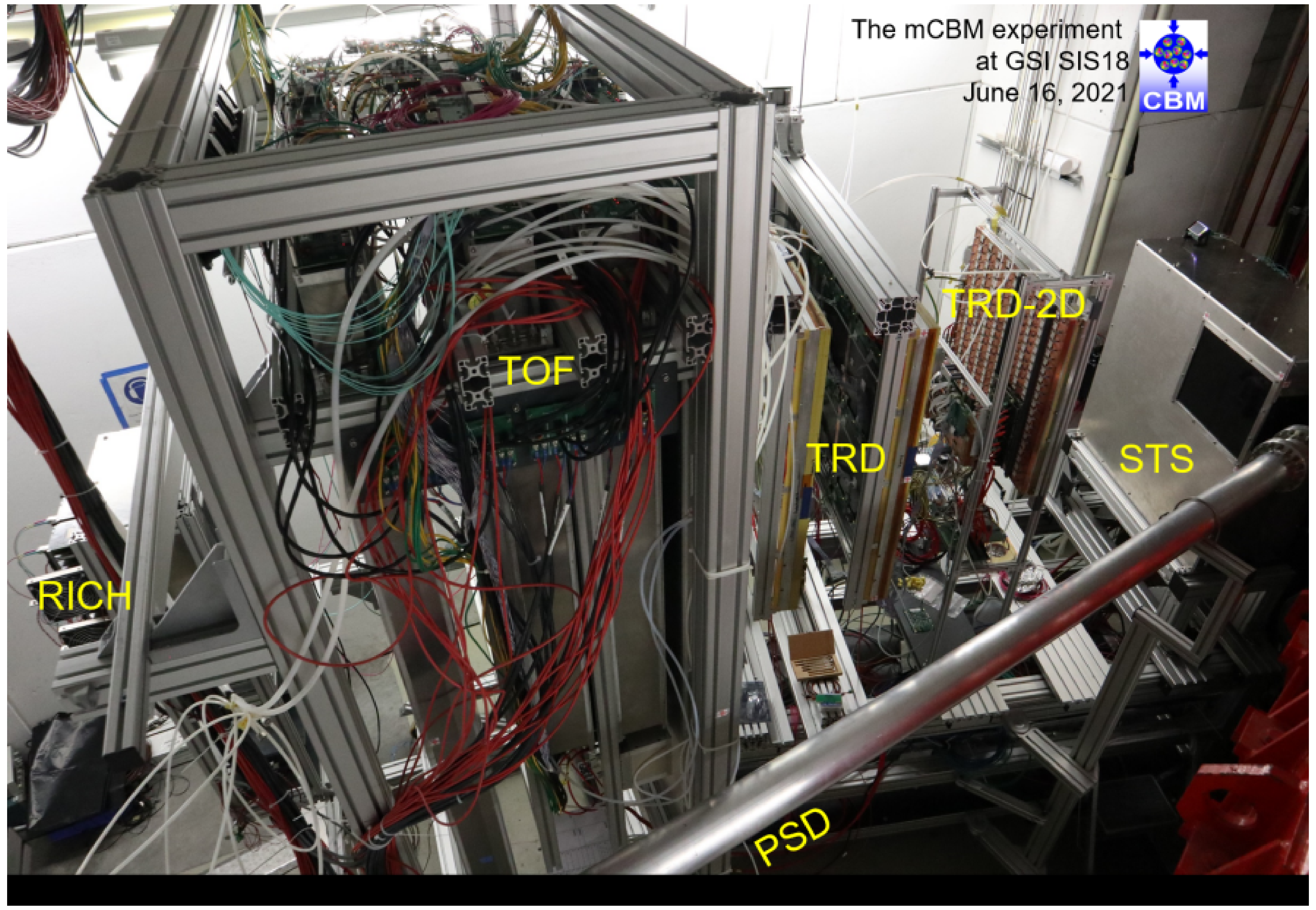
Prototype Experiment: mini-CBM (mCBM)

Present
^Fixed target Heavy-ion collision experiment

Venue: FAIR, Darmstadt

goals:

- get free-streaming readout running
- Testing of the readout electronics
- General working of detectors at high-rate



mRICH

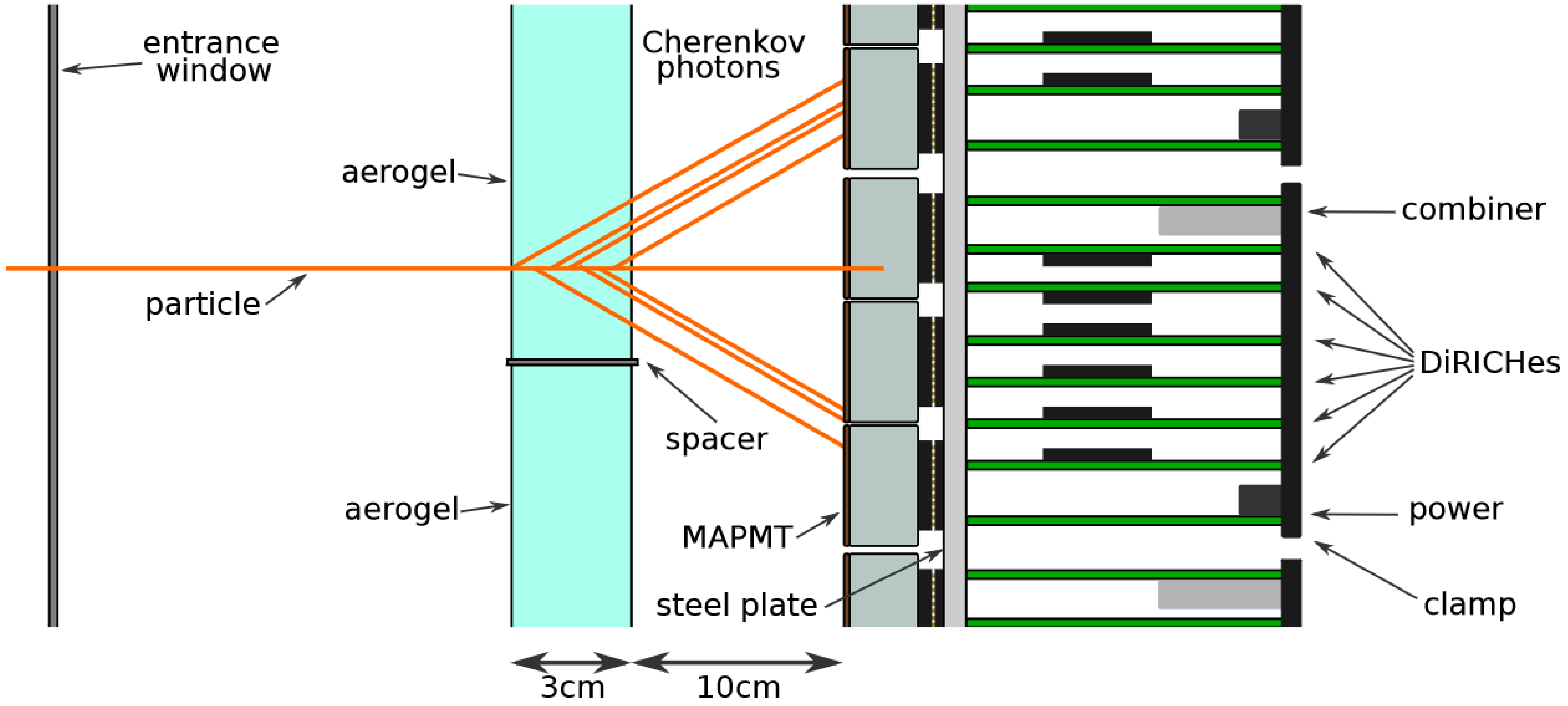
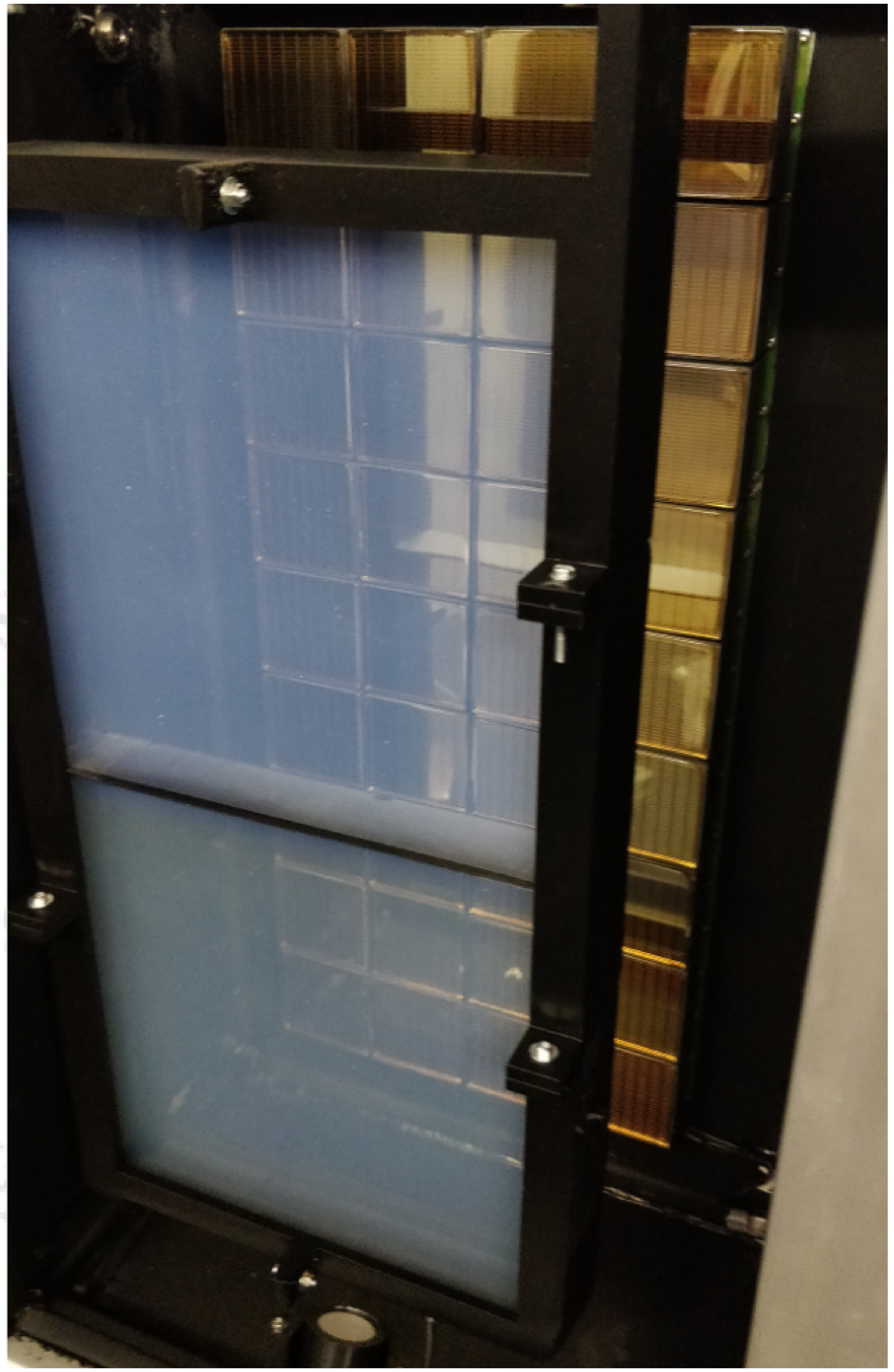


Figure 6.1: Schematic drawing of a side view of the inner mRICH detector. All main parts of the detector as well as the production of Cherenkov photons in the aerogel block are shown.

ref: Adrian Weber



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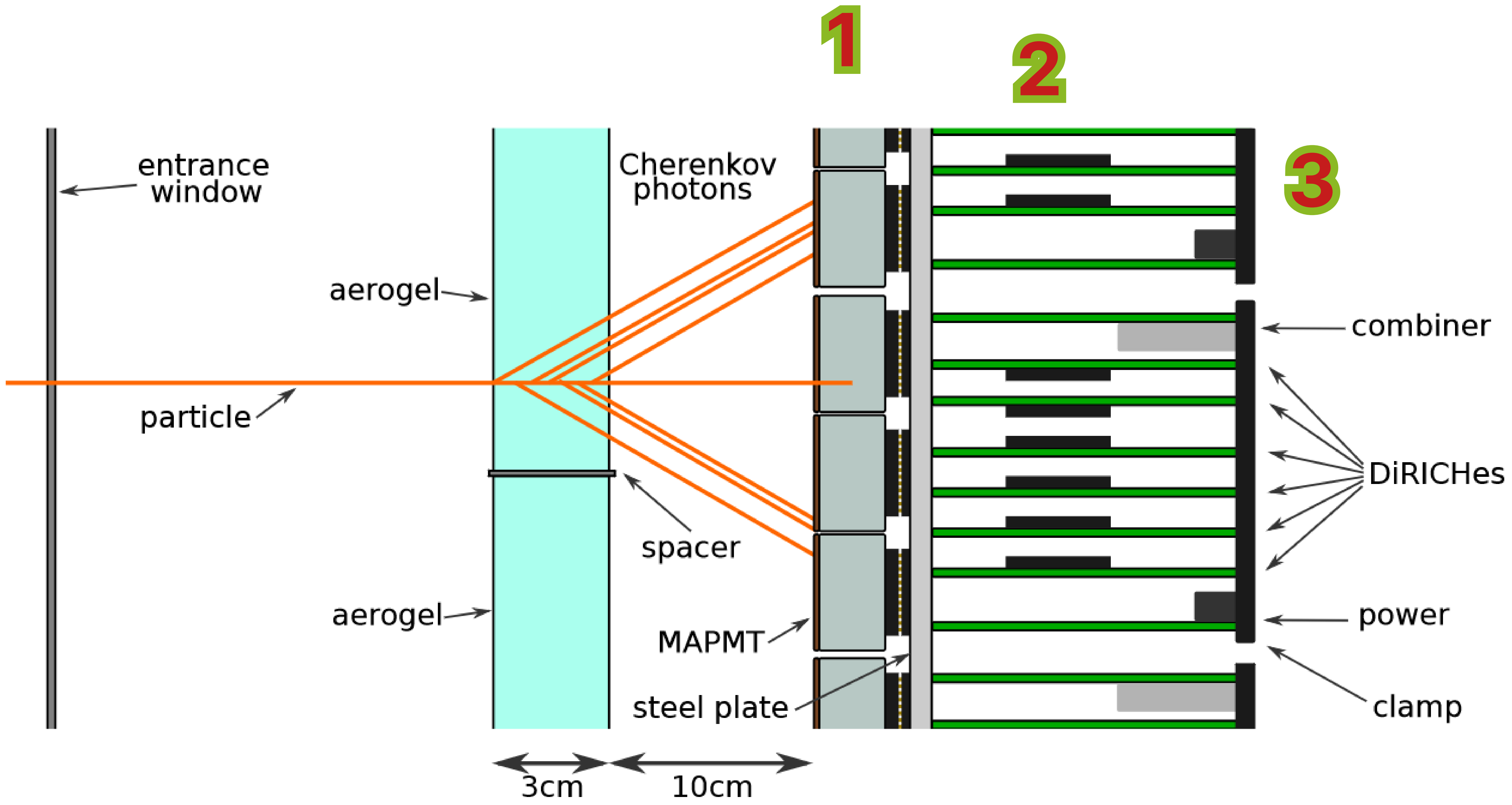
mRICH



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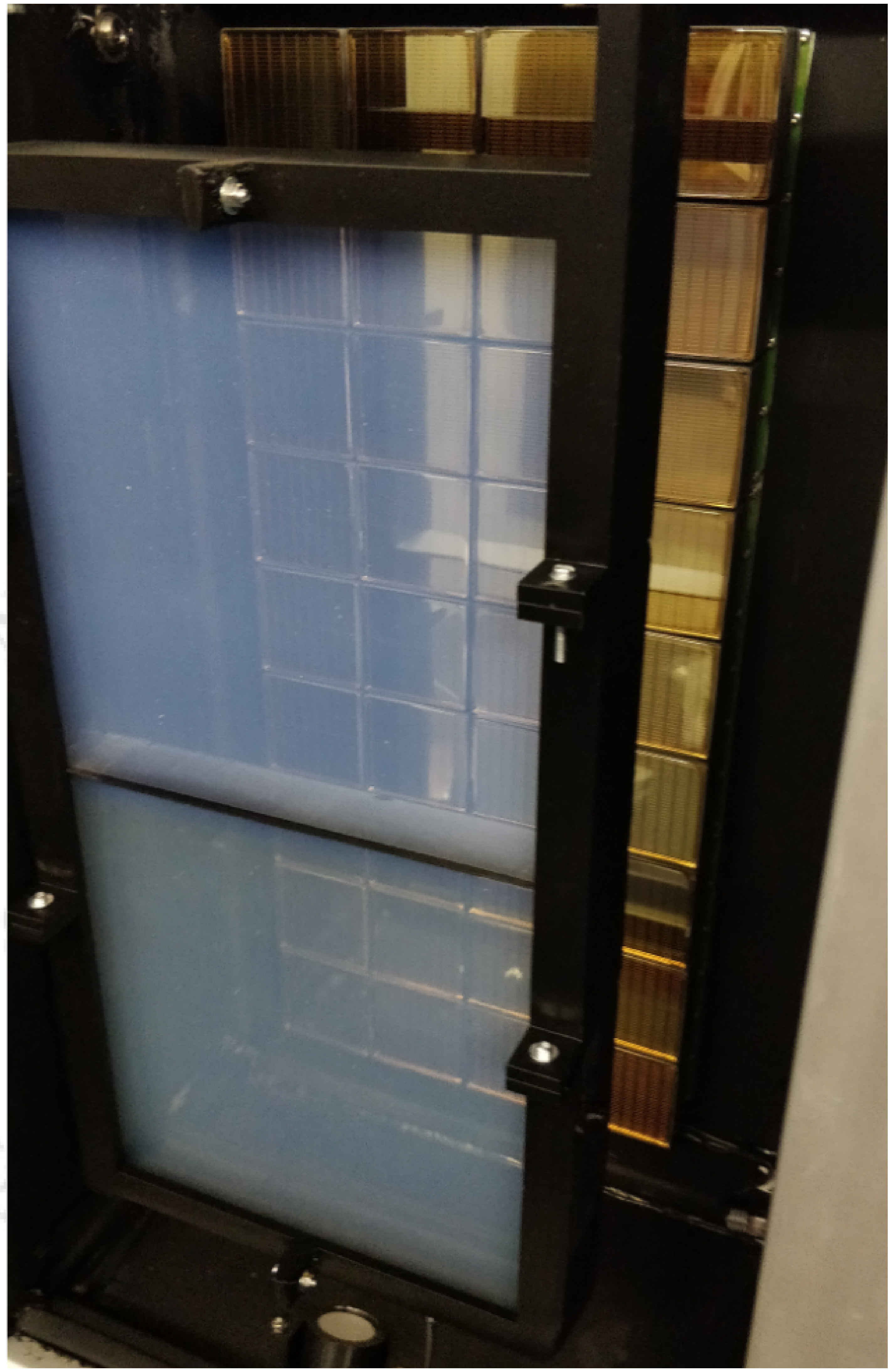

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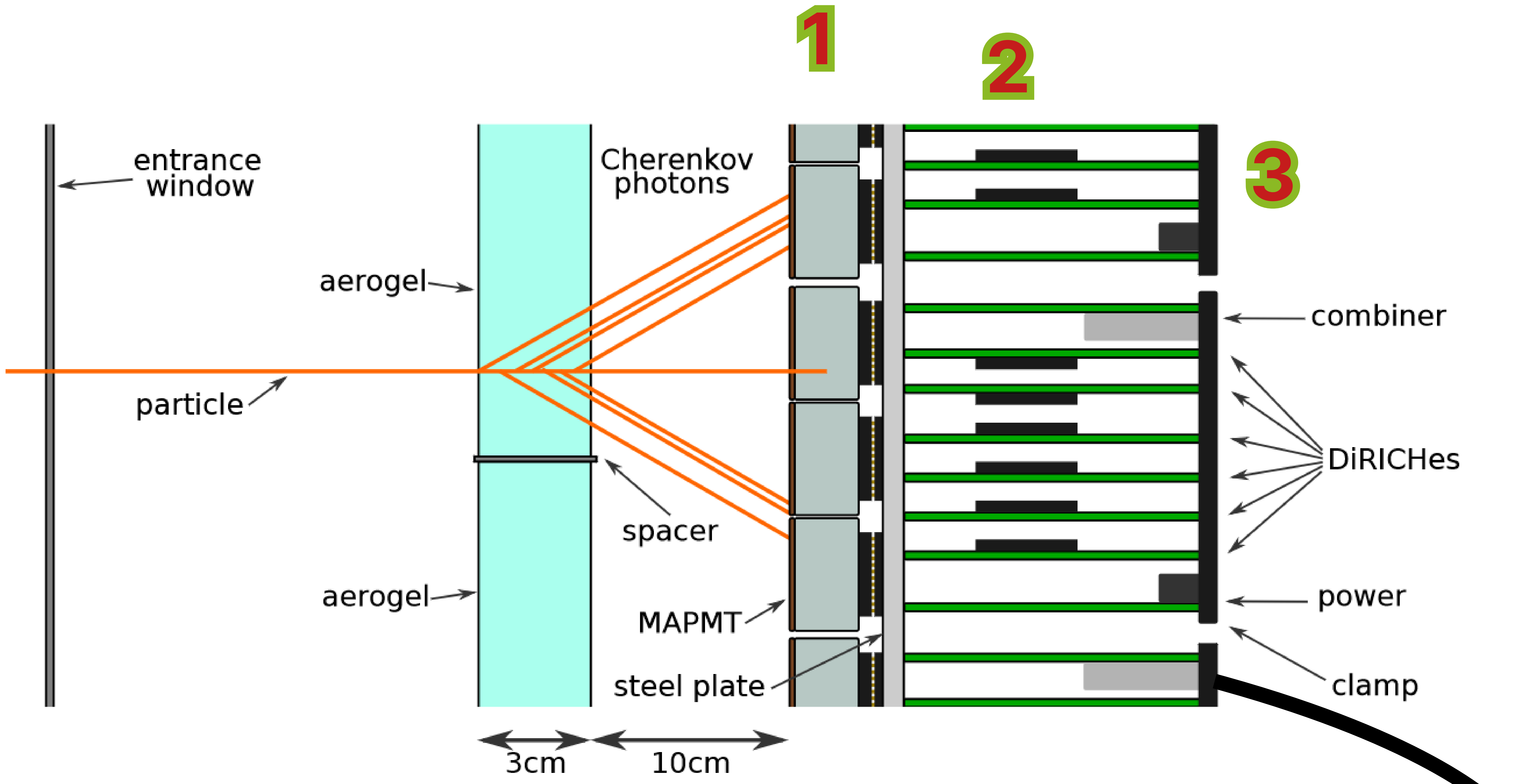
mRICH



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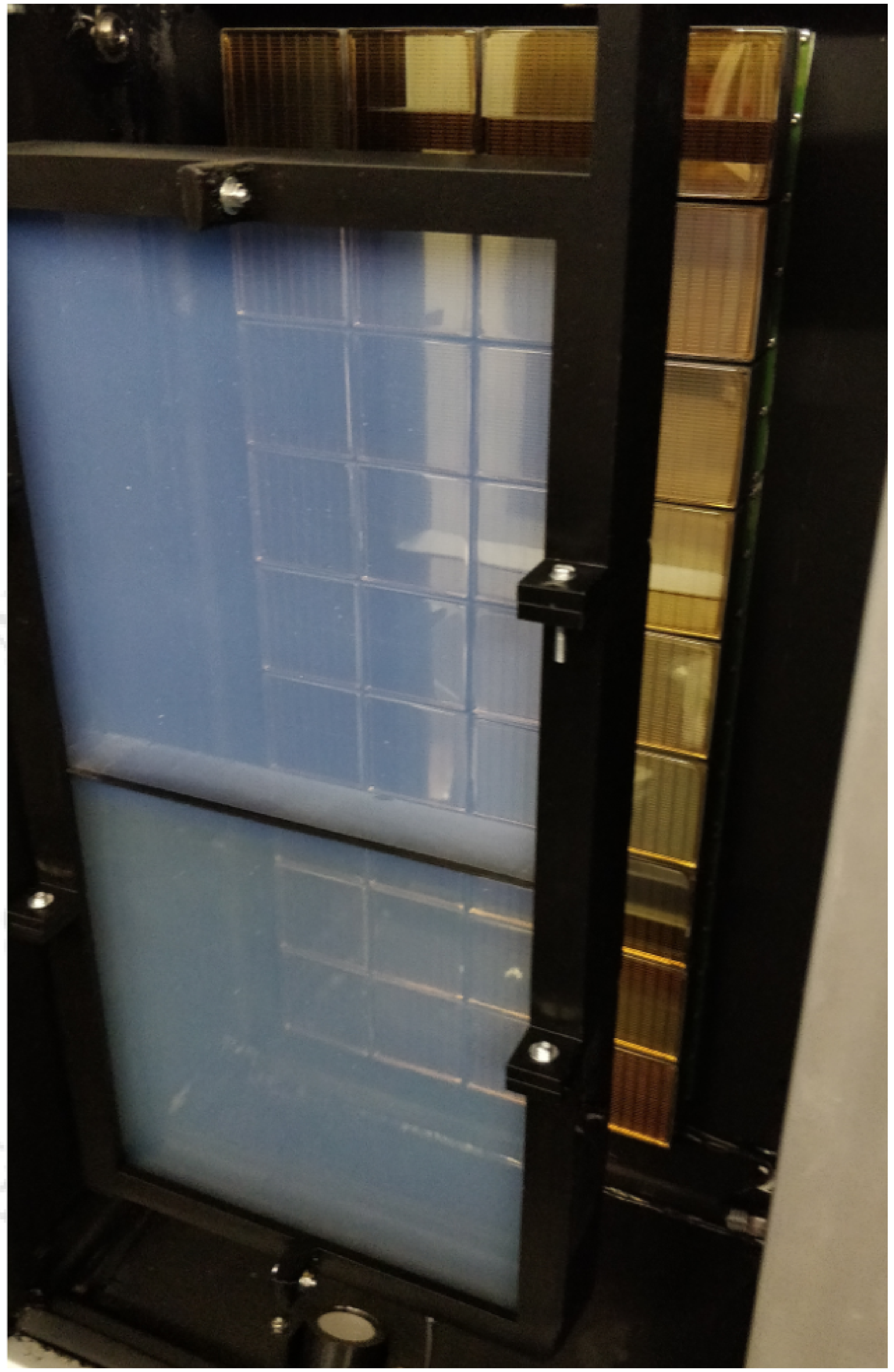
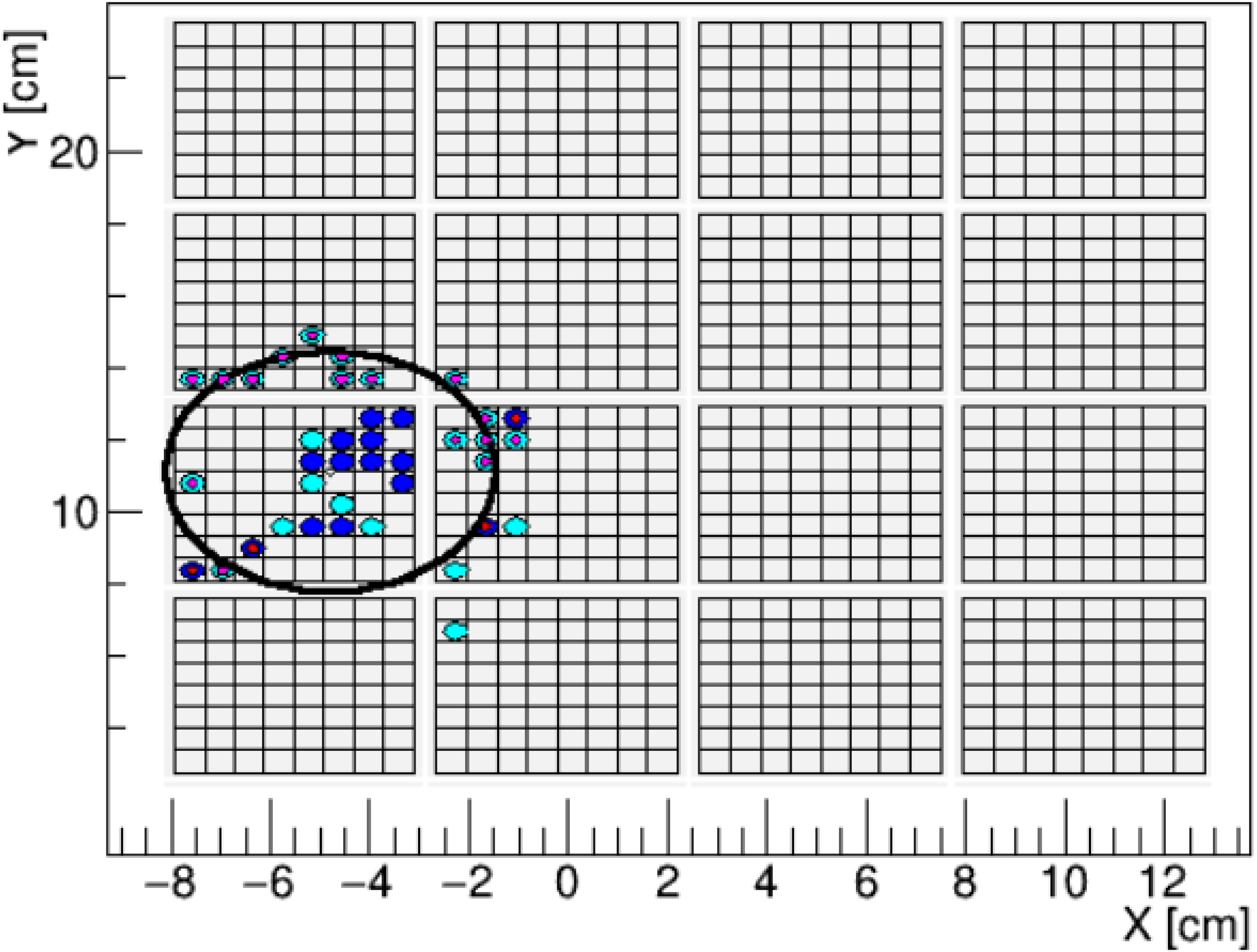
CRI



mRICH ring

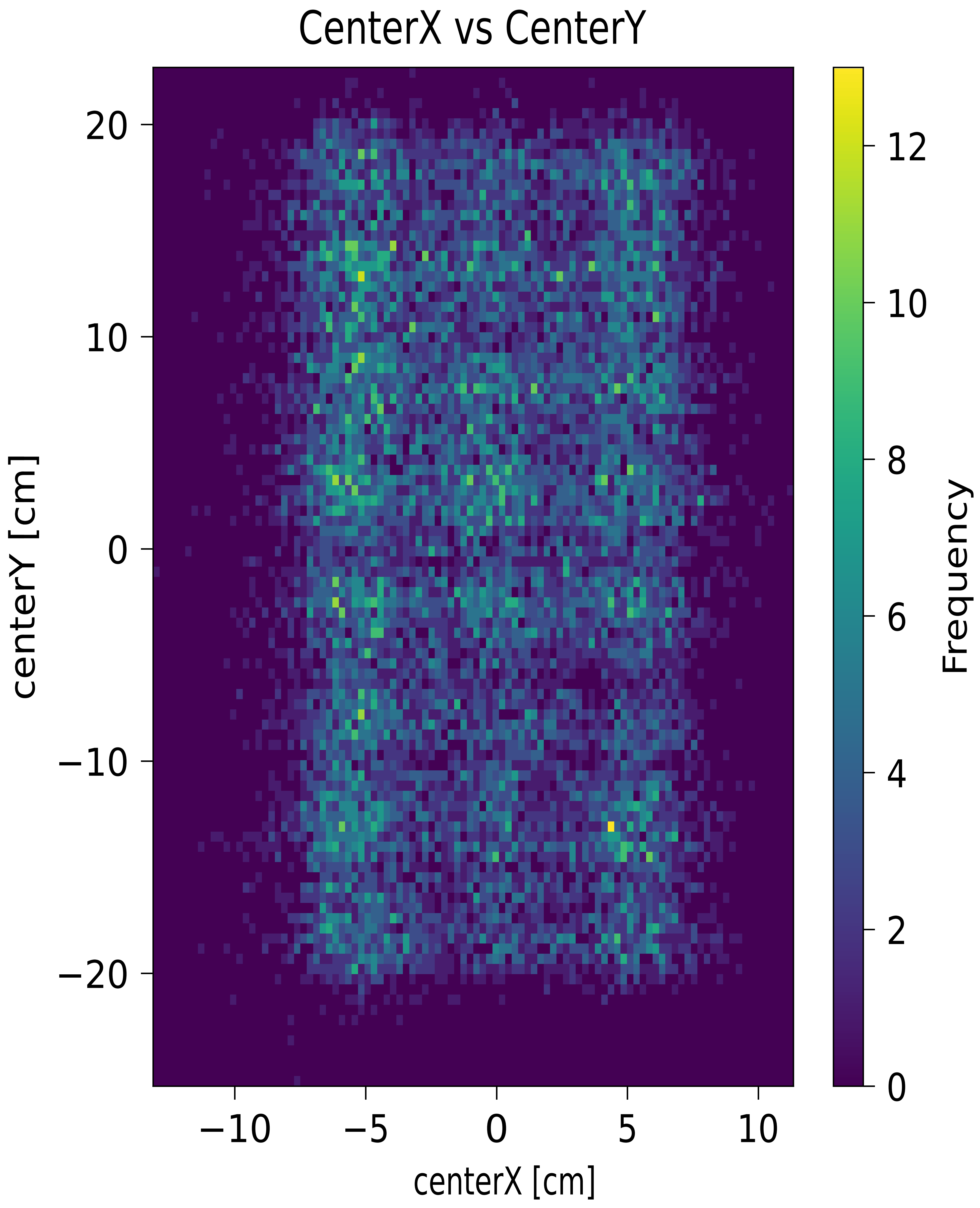


ref: Adrian Weber

2907

New data (all panels)

- Run: 2907
- 2.5mm thickness (thick target)
- Au-Au
- Beam intensity: 2.5e+7 Hz
- Events: 4.7E+6



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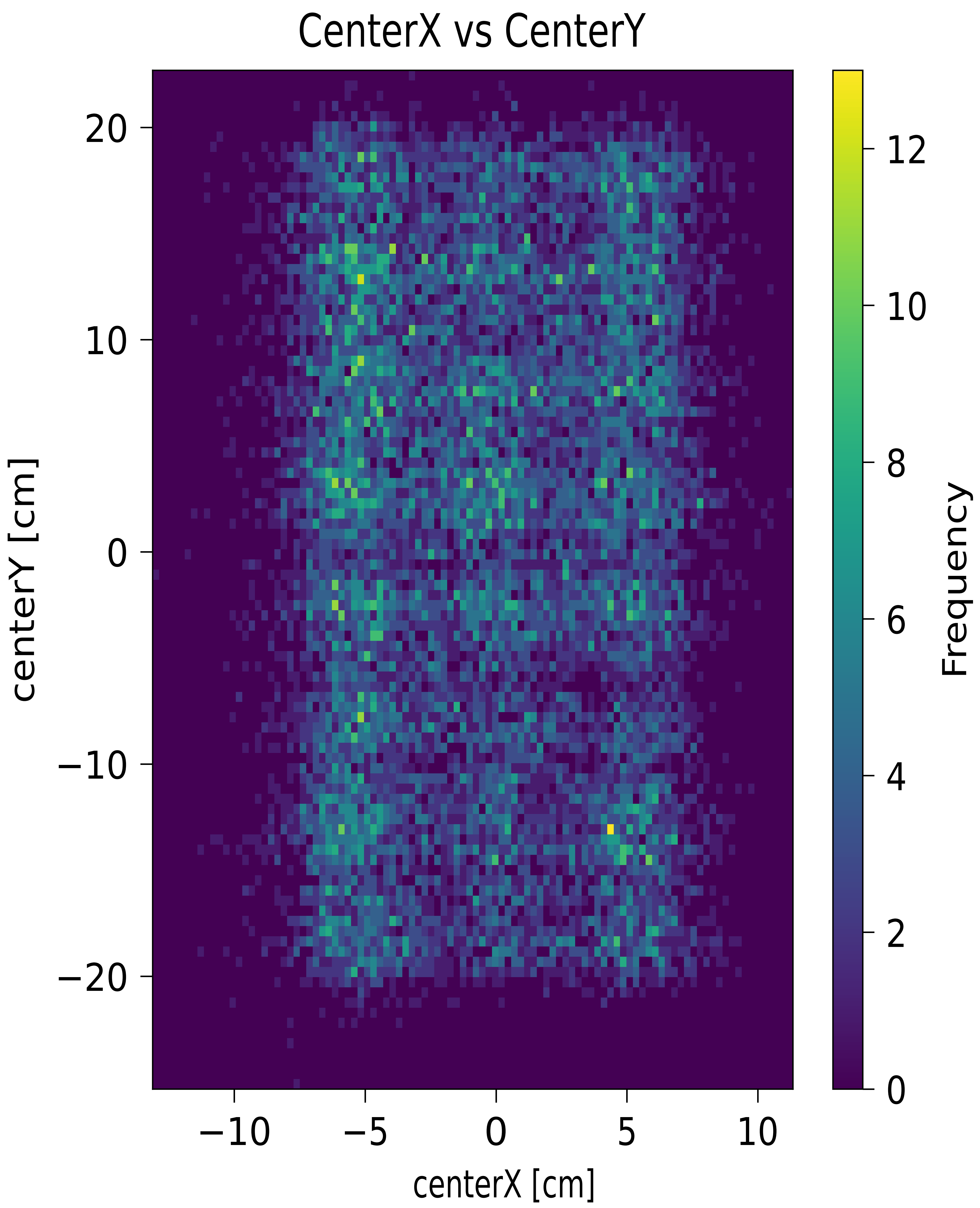

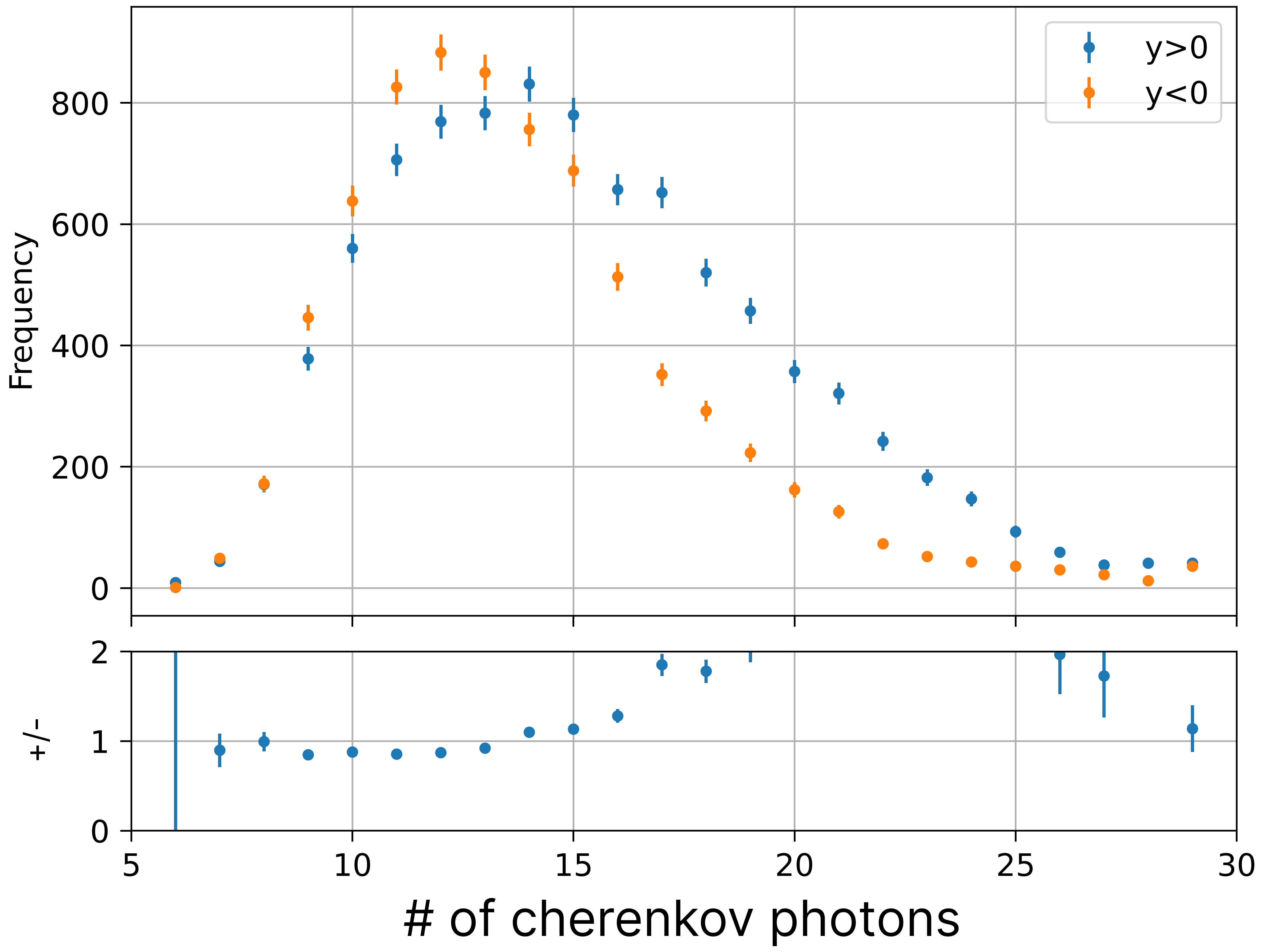

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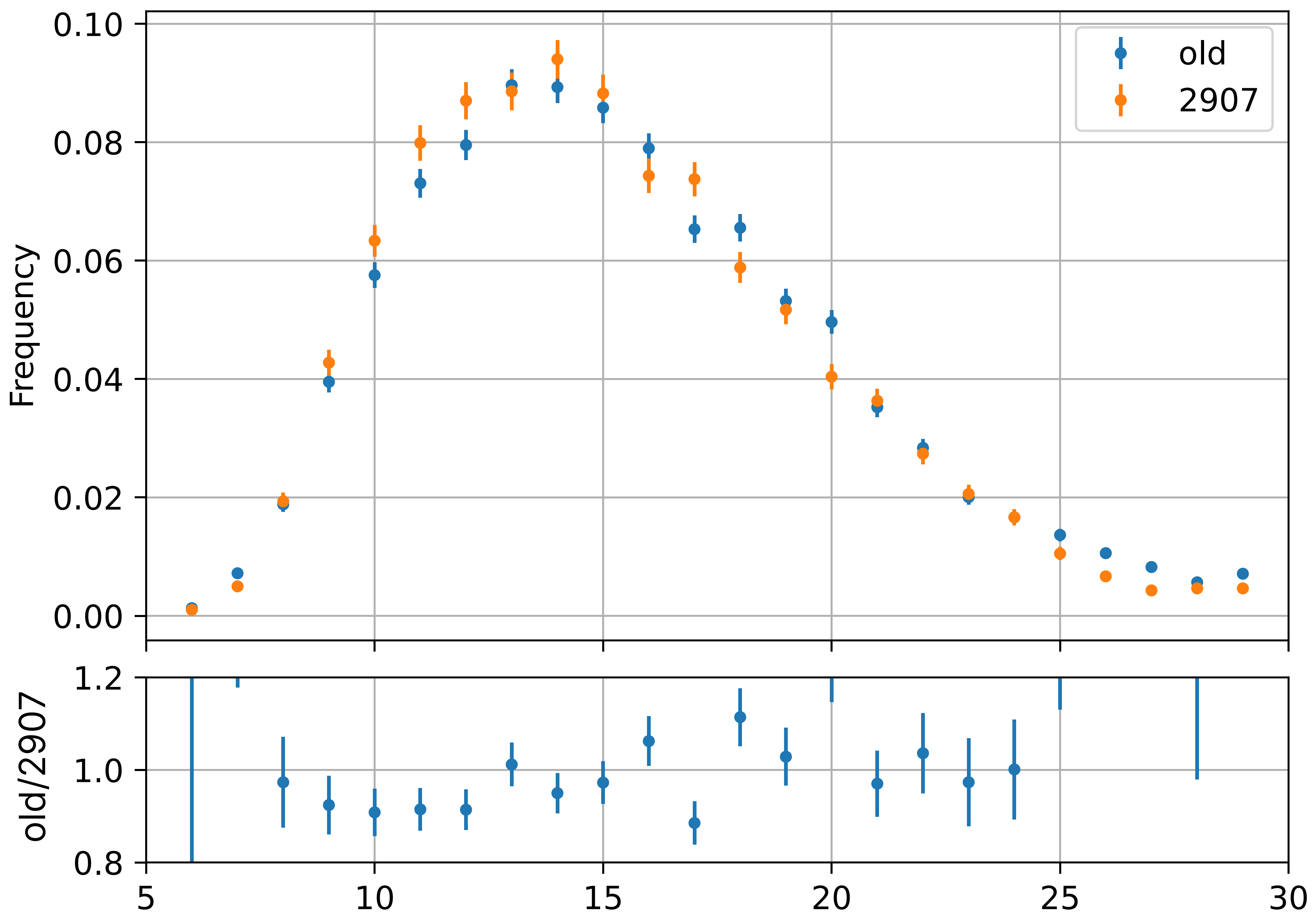
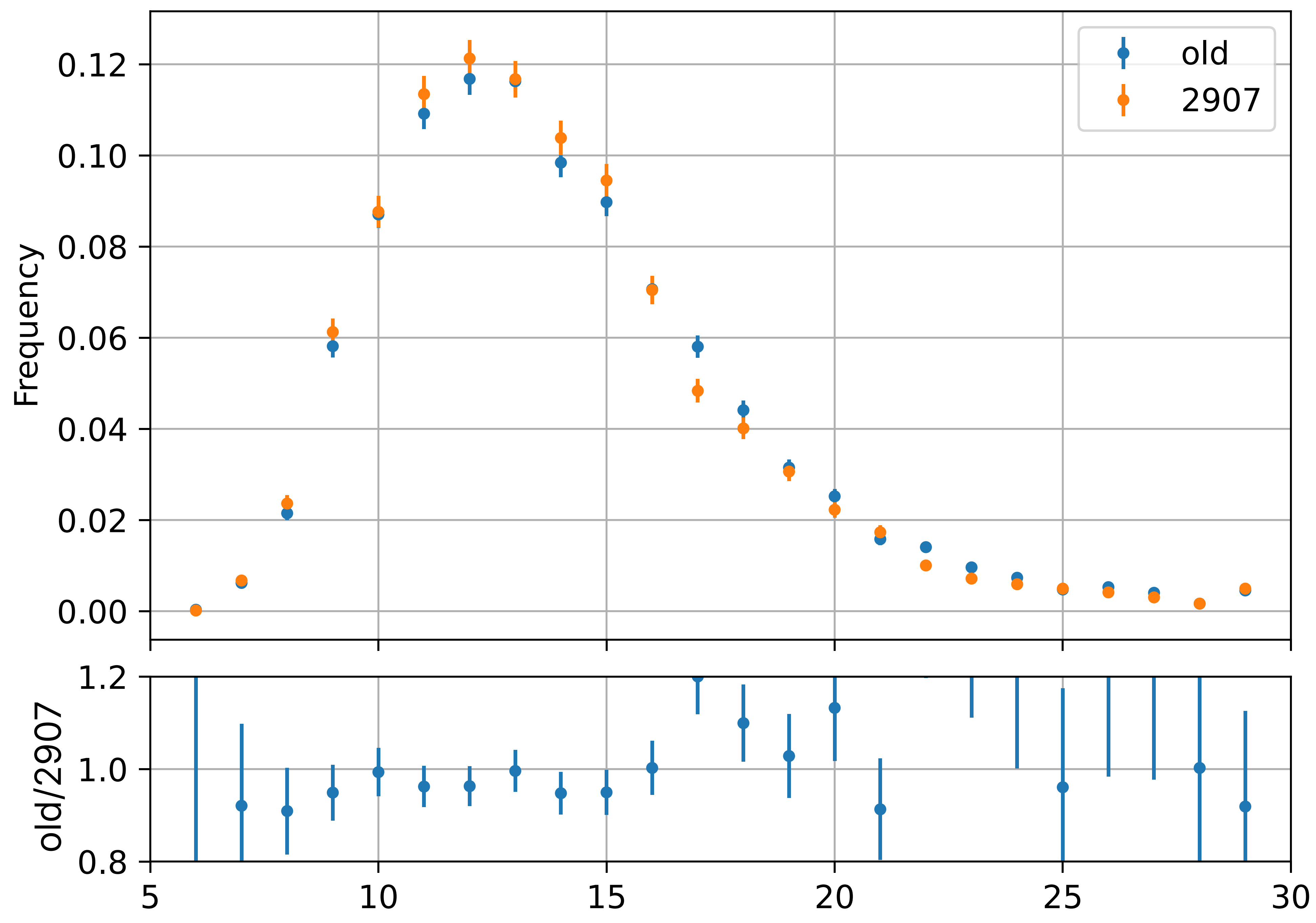
No of Hits/Ring comparing with 2.5 years ago

Upper half



Lower half



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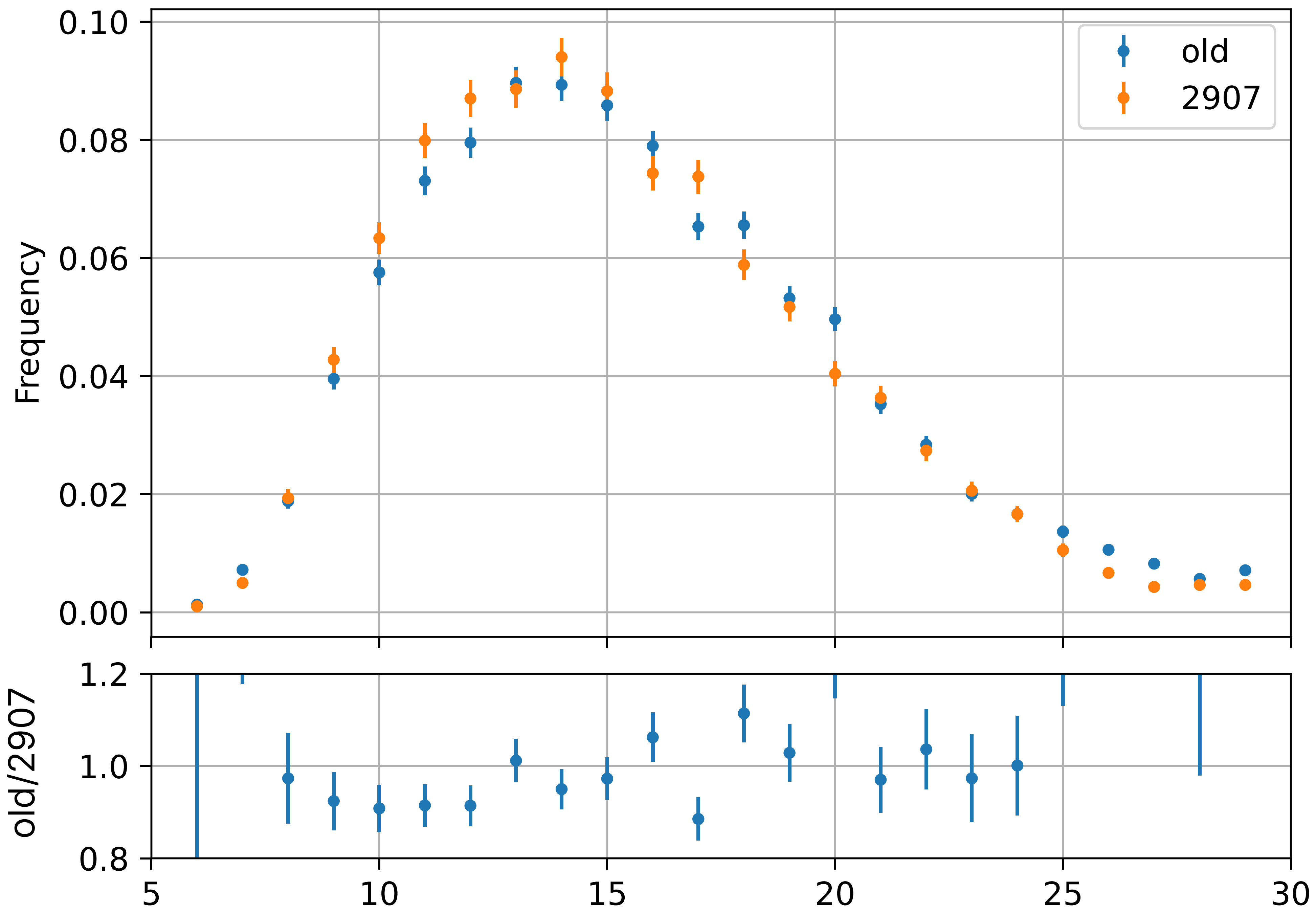
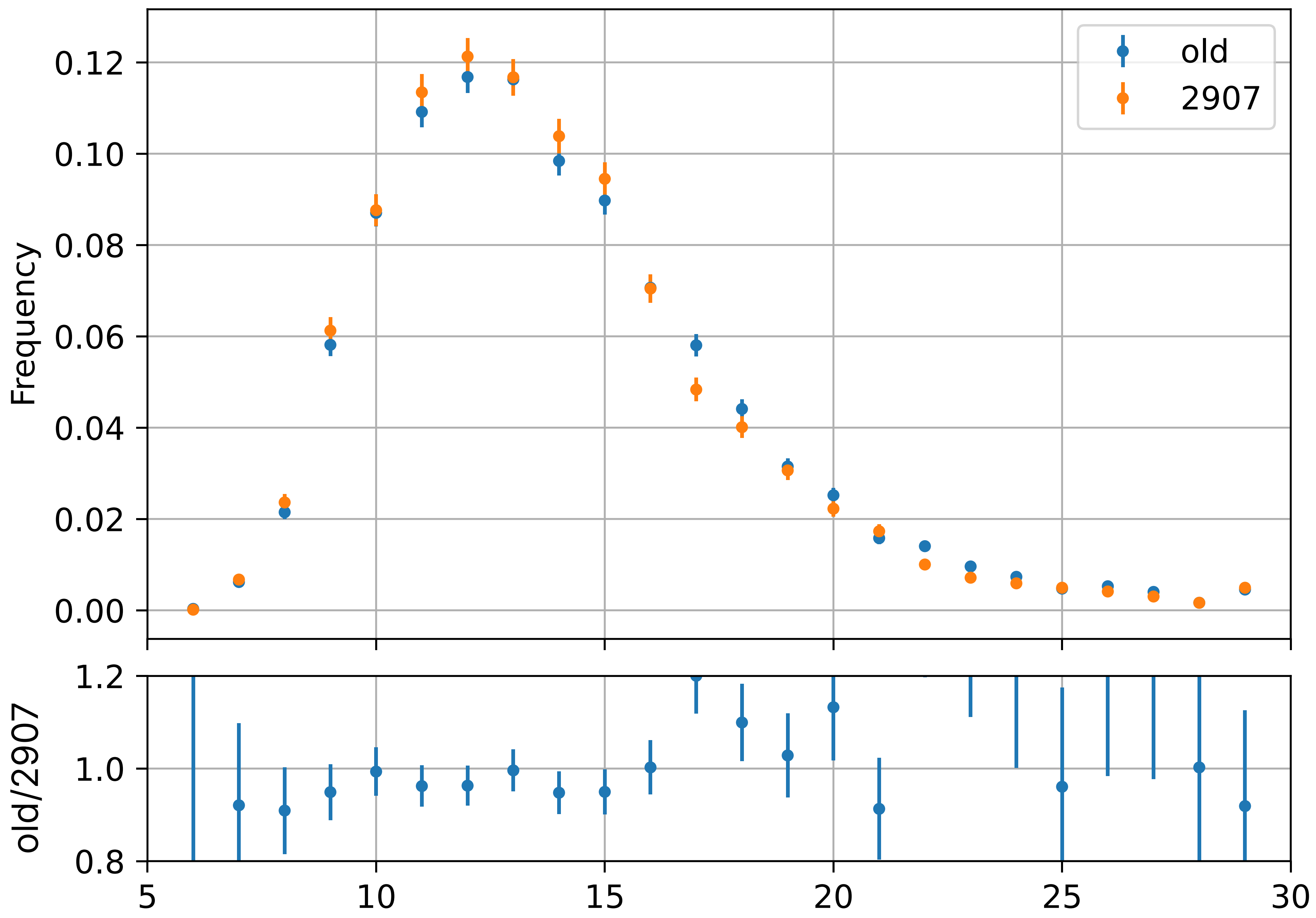


Lower half



Comparing mean value across time

Upper half: $\mu_o = 12.4$, $\mu_n = 12.1$

Lower half: $\mu_o = 11.2$, $\mu_n = 11.1$

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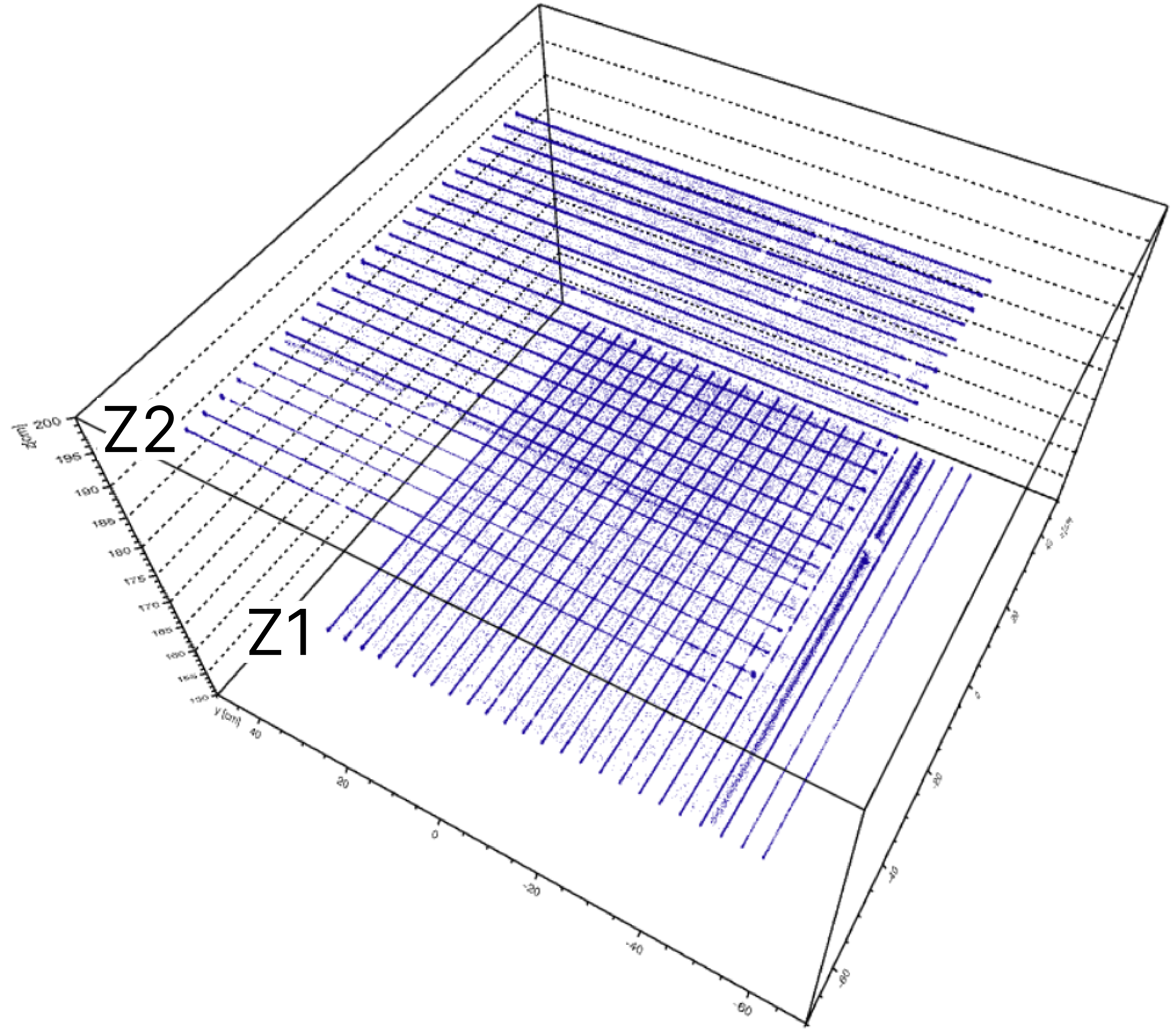
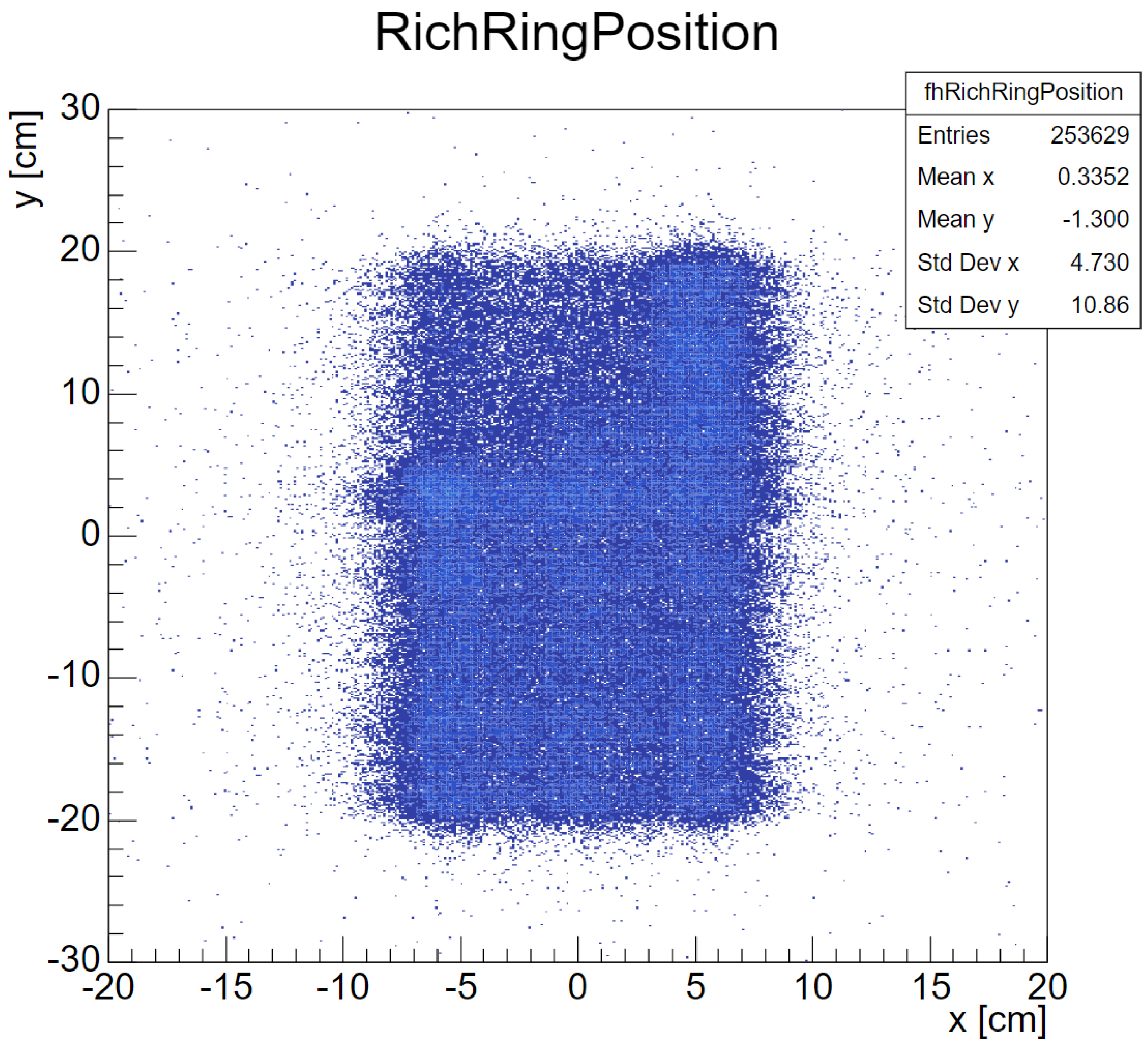
Correlating TRD hits with mRICH rings

TRD hits position



fhTrdHitPosition	
Entries	189473050
Mean x	7.049
Mean y	-3.350
Mean z	164.7
Std Dev x	25.57
Std Dev y	25.94
Std Dev z	18.68



1 TRD hit ⇒ Cluster of TRD readouts

Rich Ring ⇒ Ring of RICH readouts

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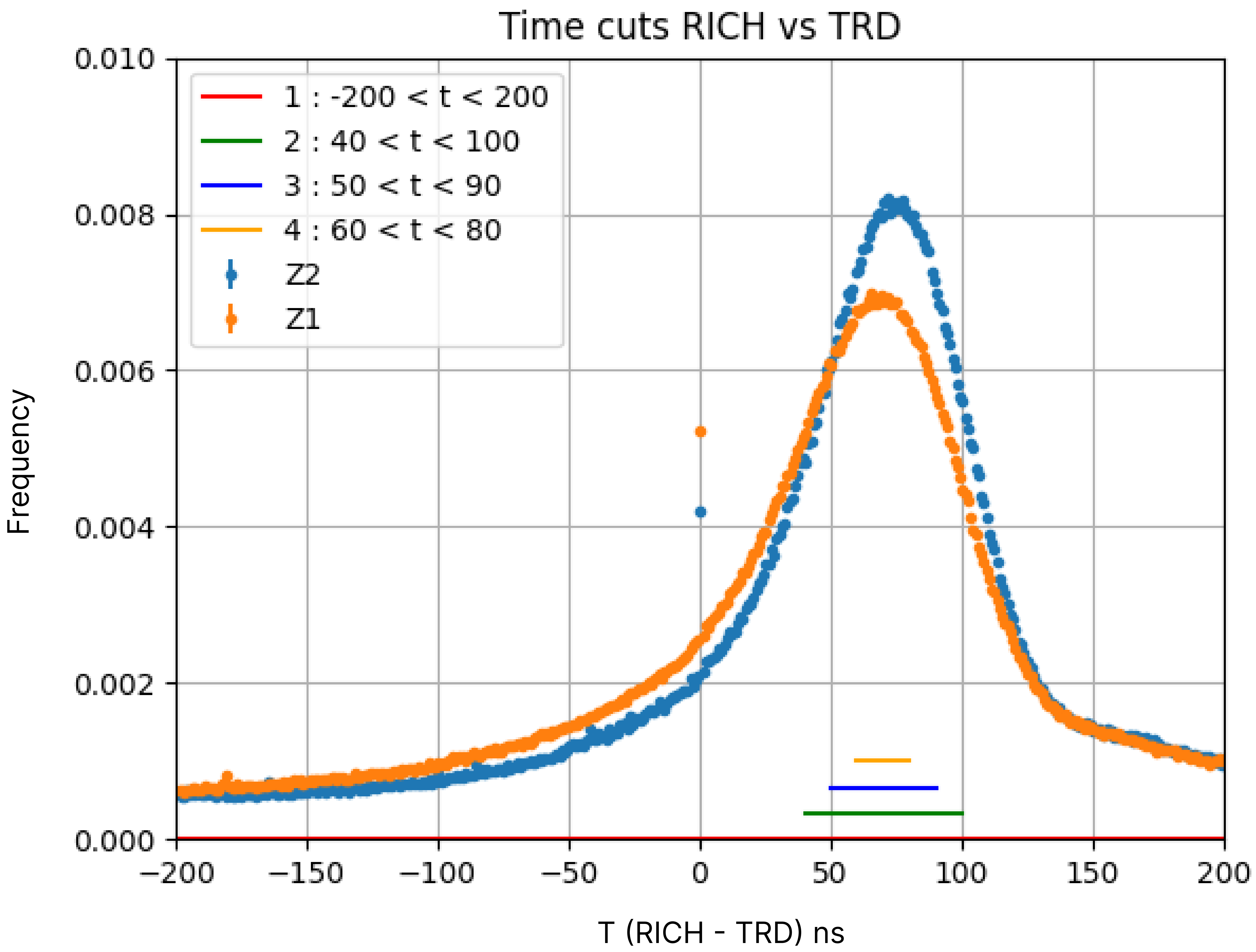
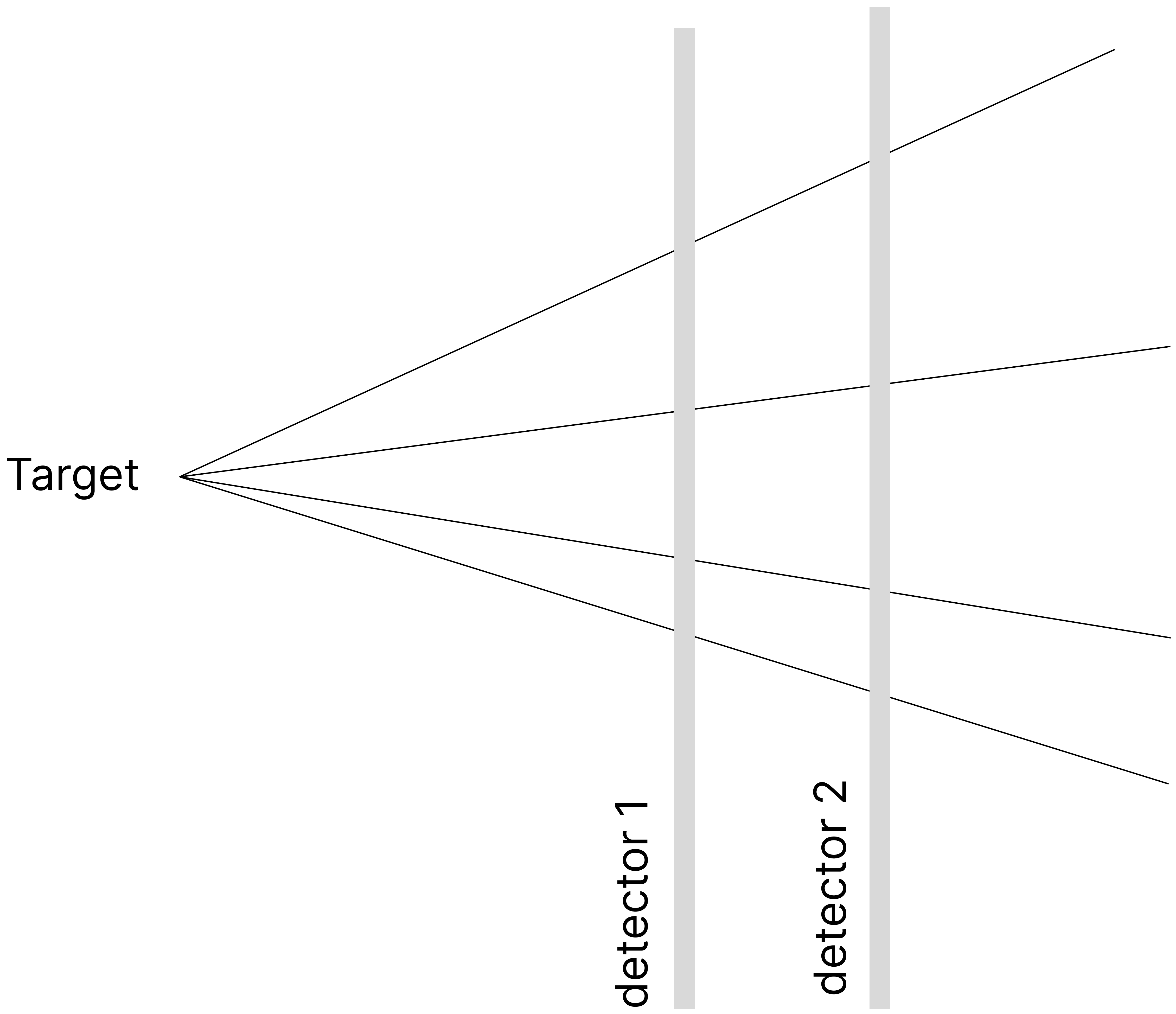
Time correlations



Defined reasonable time cuts

cut index	T_{low}	T_{high}
0	$-\infty$	∞
1	-200	200
2	40	100
3	50	90
4	60	80

Spatial correlations



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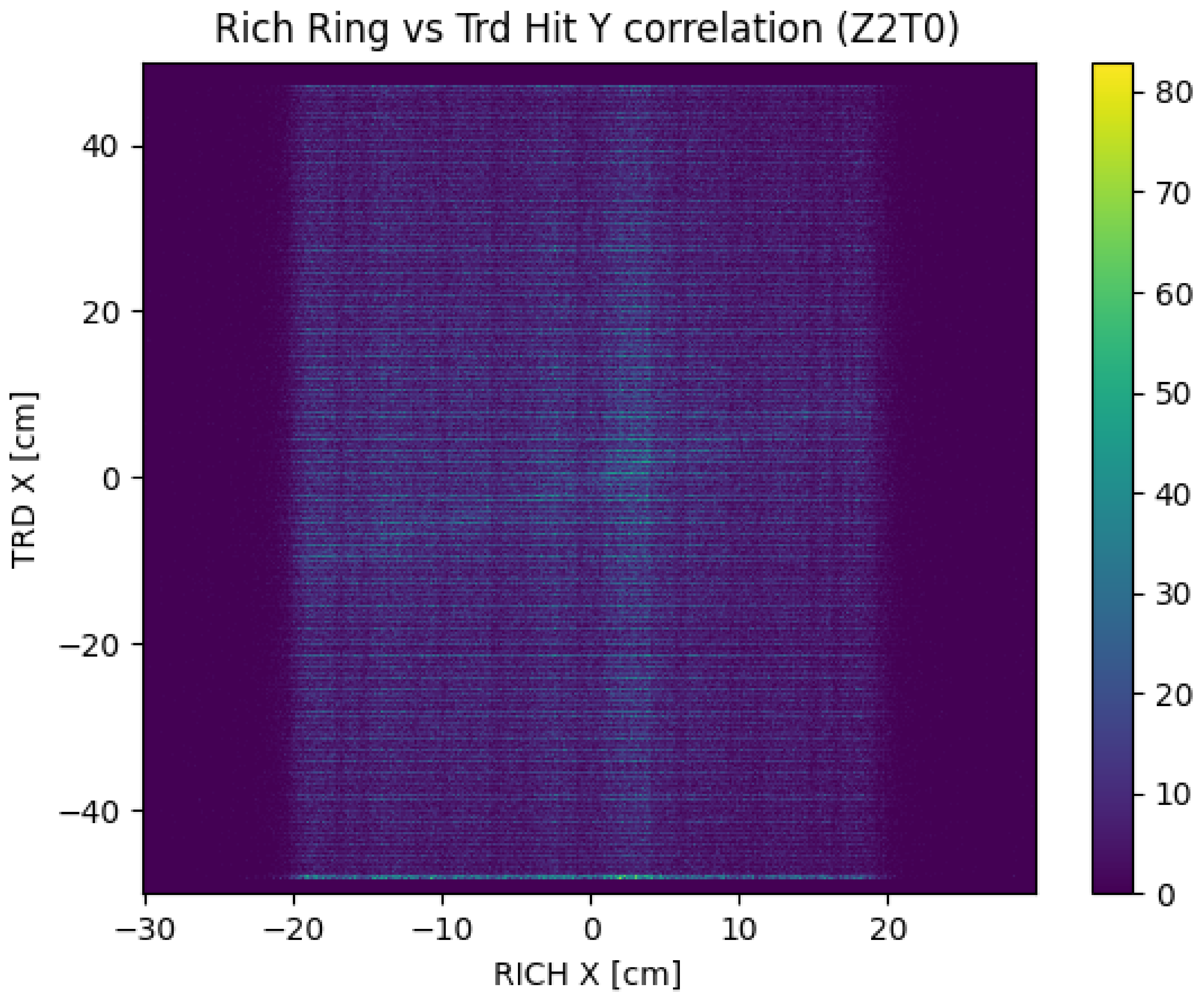
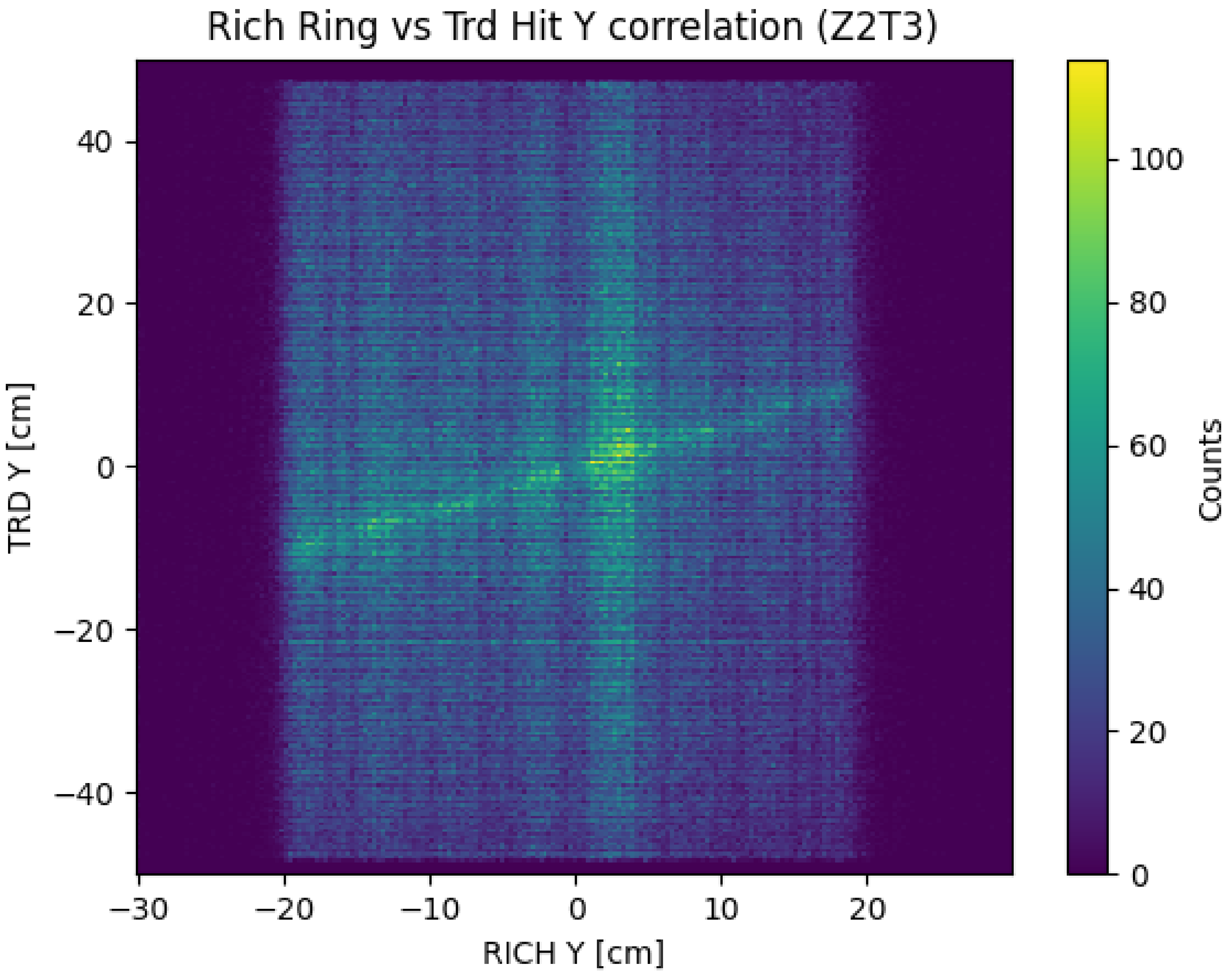
Spatial correlation Y



No cut



Time cut 3

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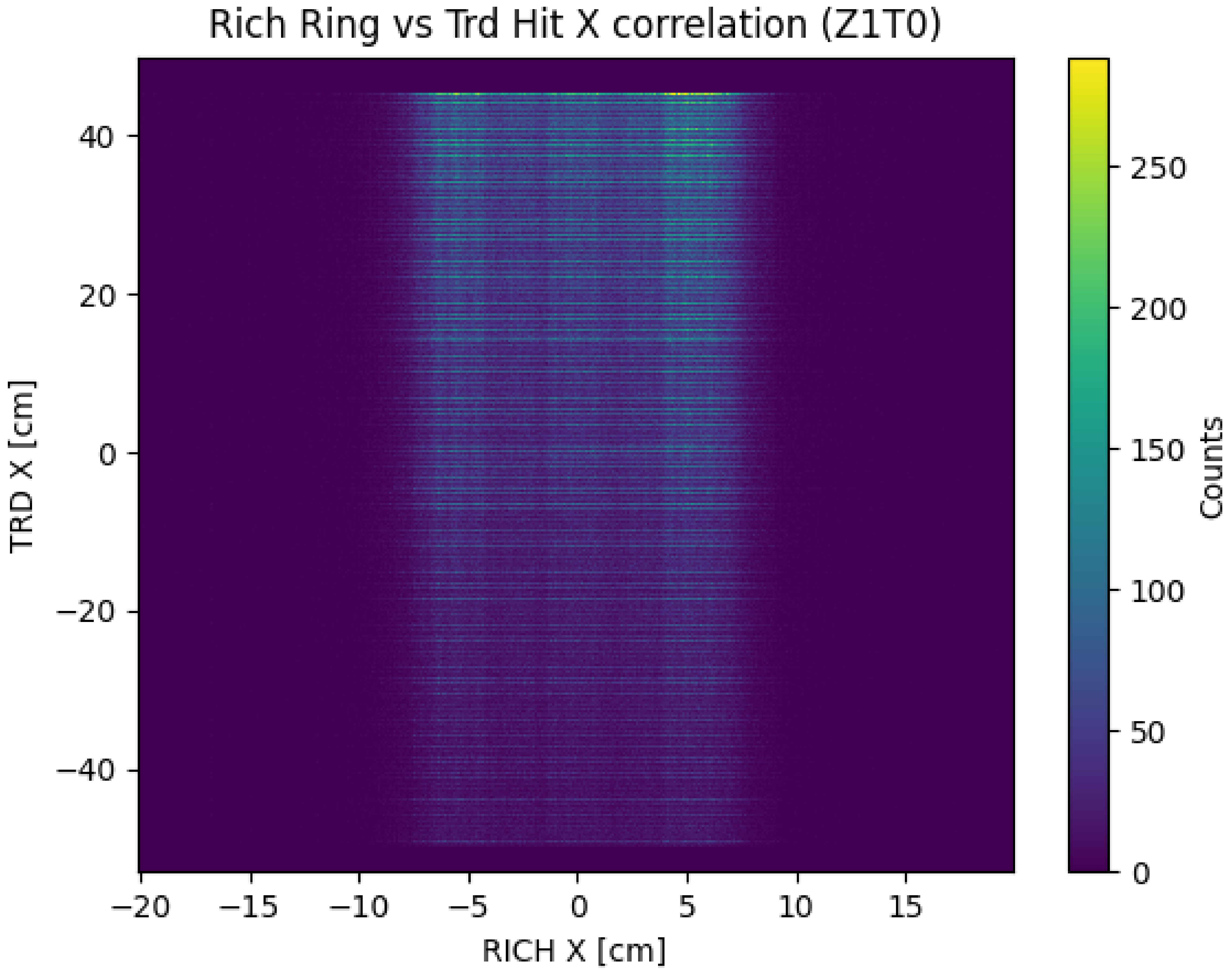
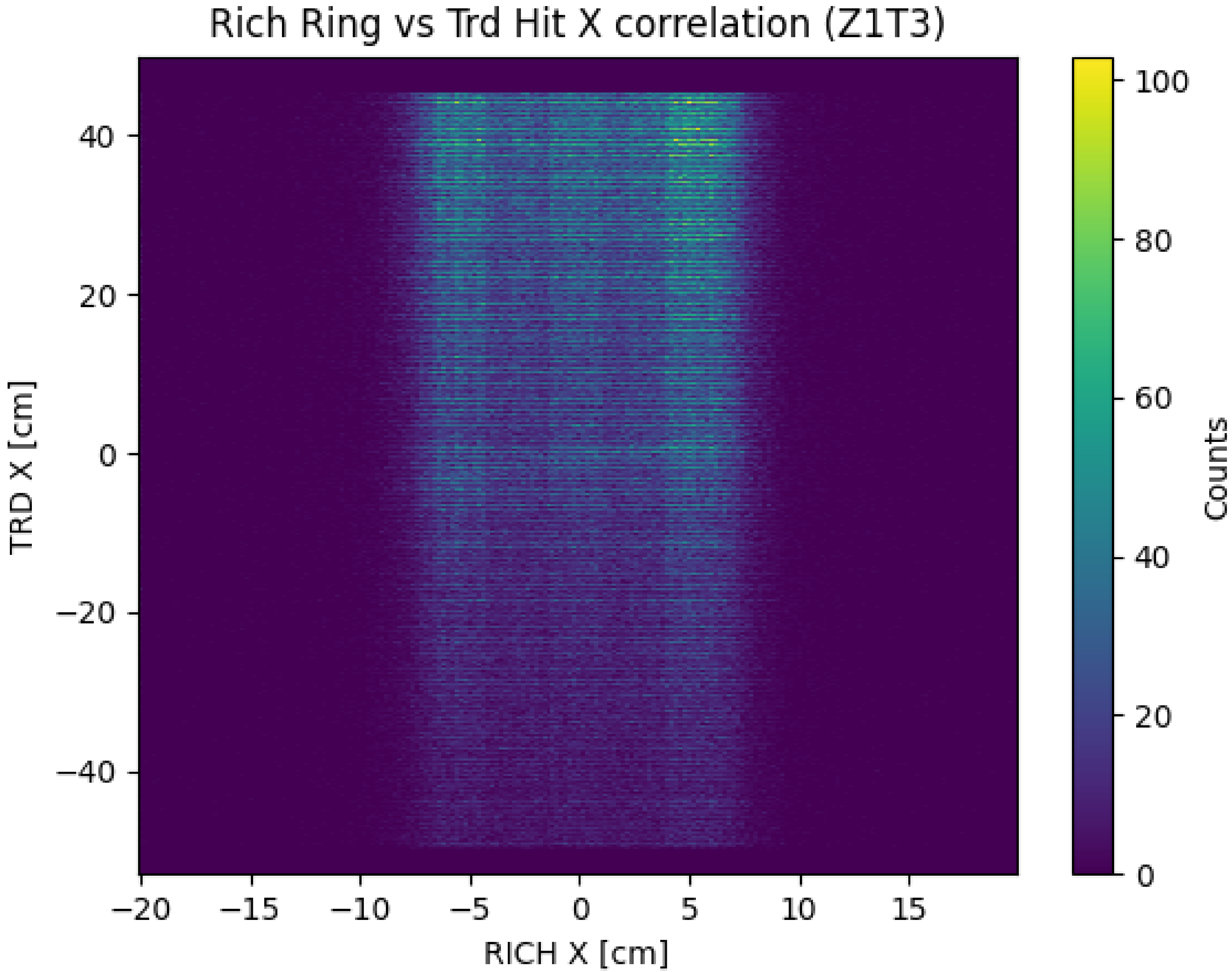
Spatial correlation X



No cut



Time cut 3

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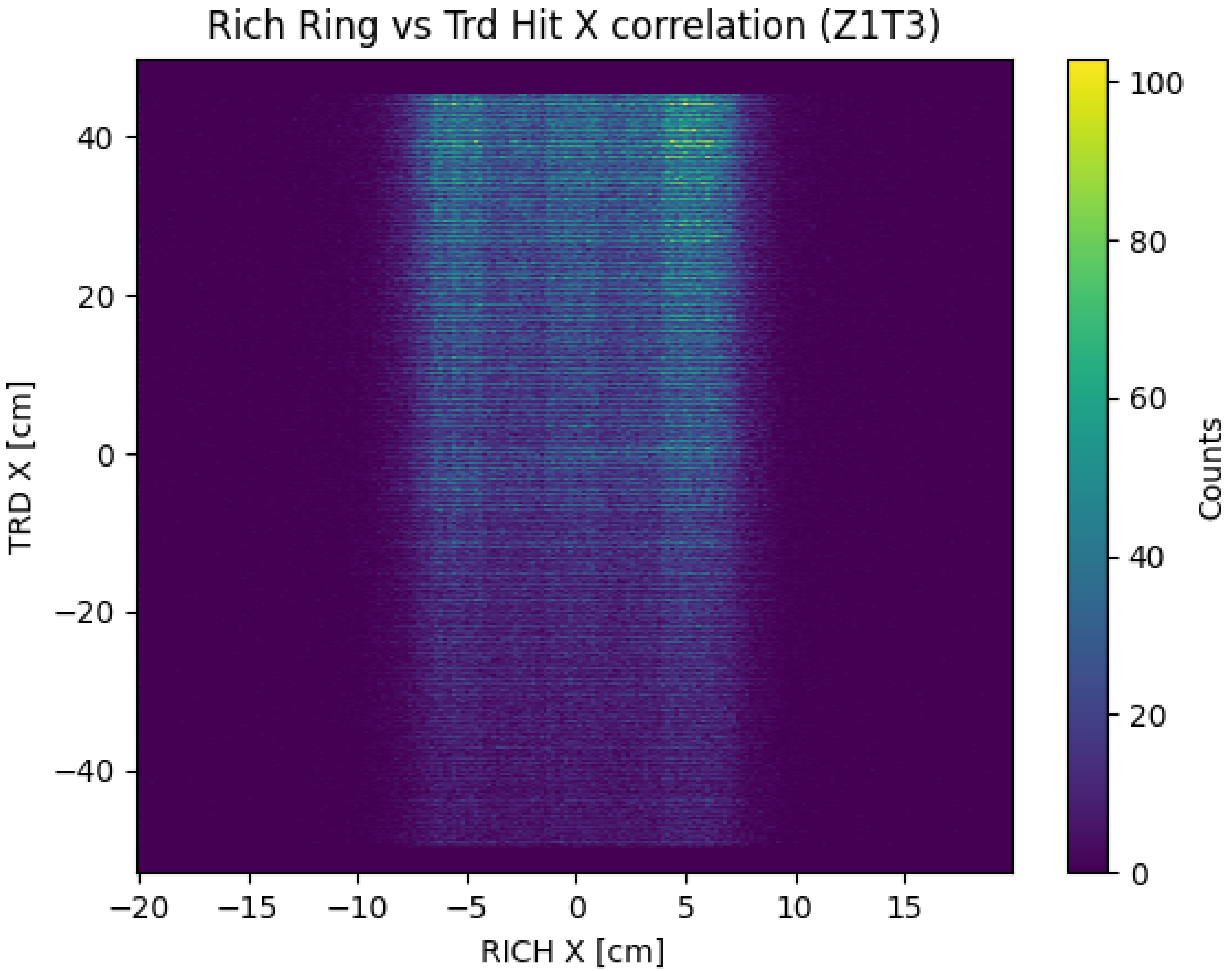
Spatial correlation X

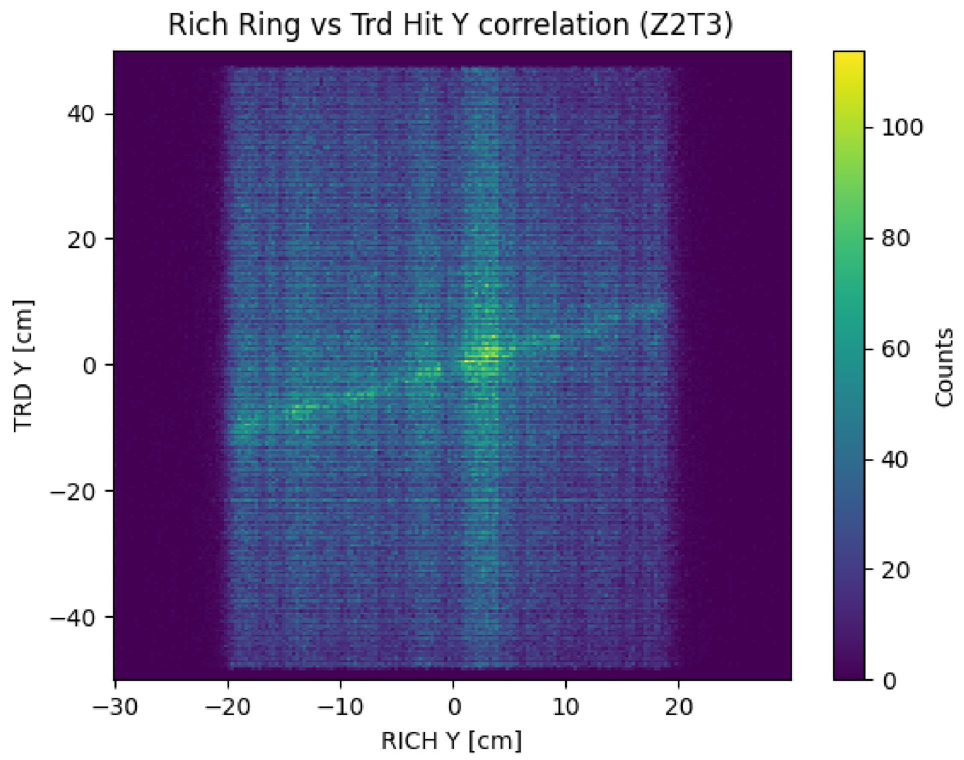


Time cut 3

Since, I can't see a band, lets use the information from the established y-correlation

#newcut

$$\frac{y_{rich}}{2} + 2 > y_{trd} > \frac{y_{rich}}{2} - 2$$



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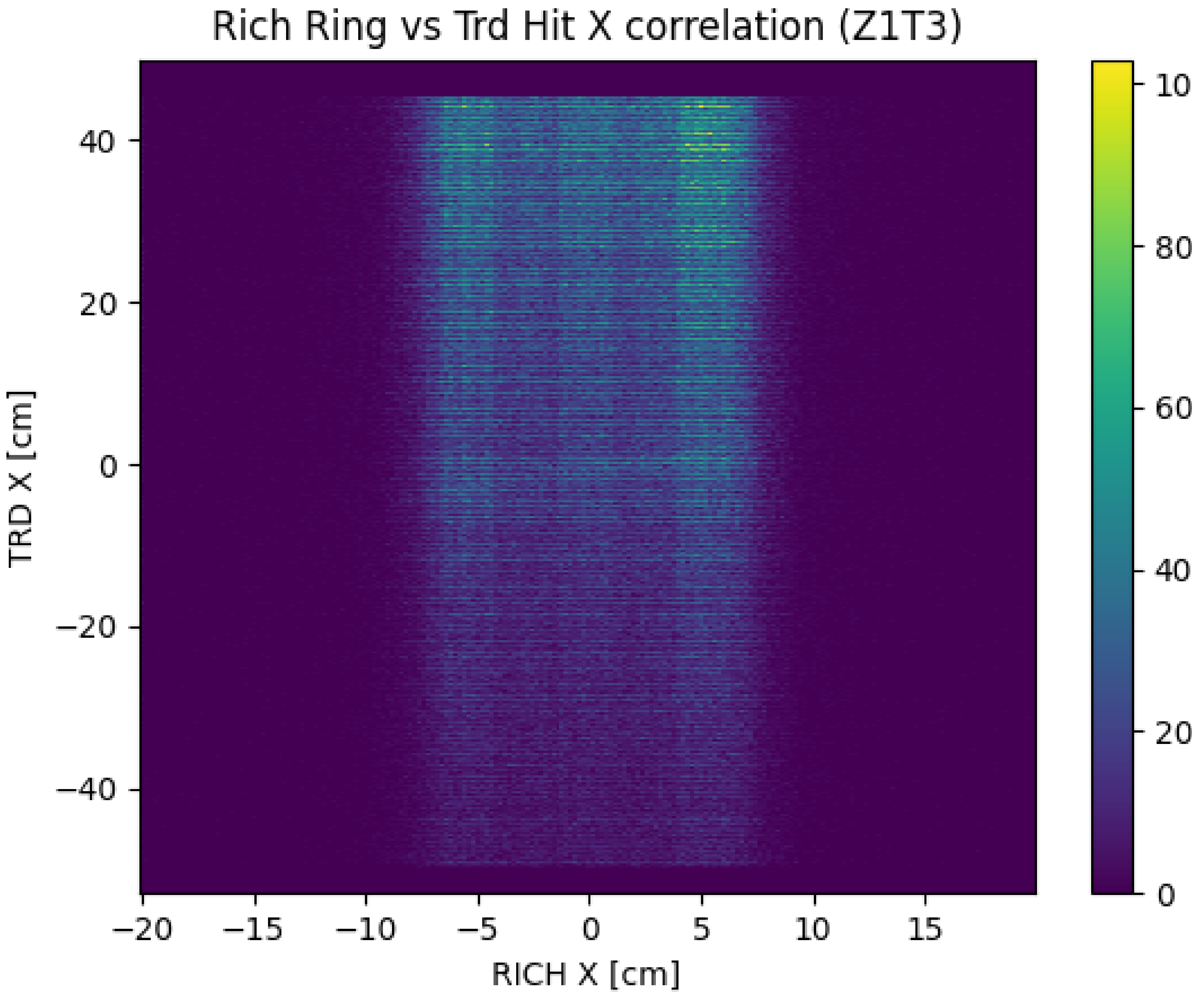
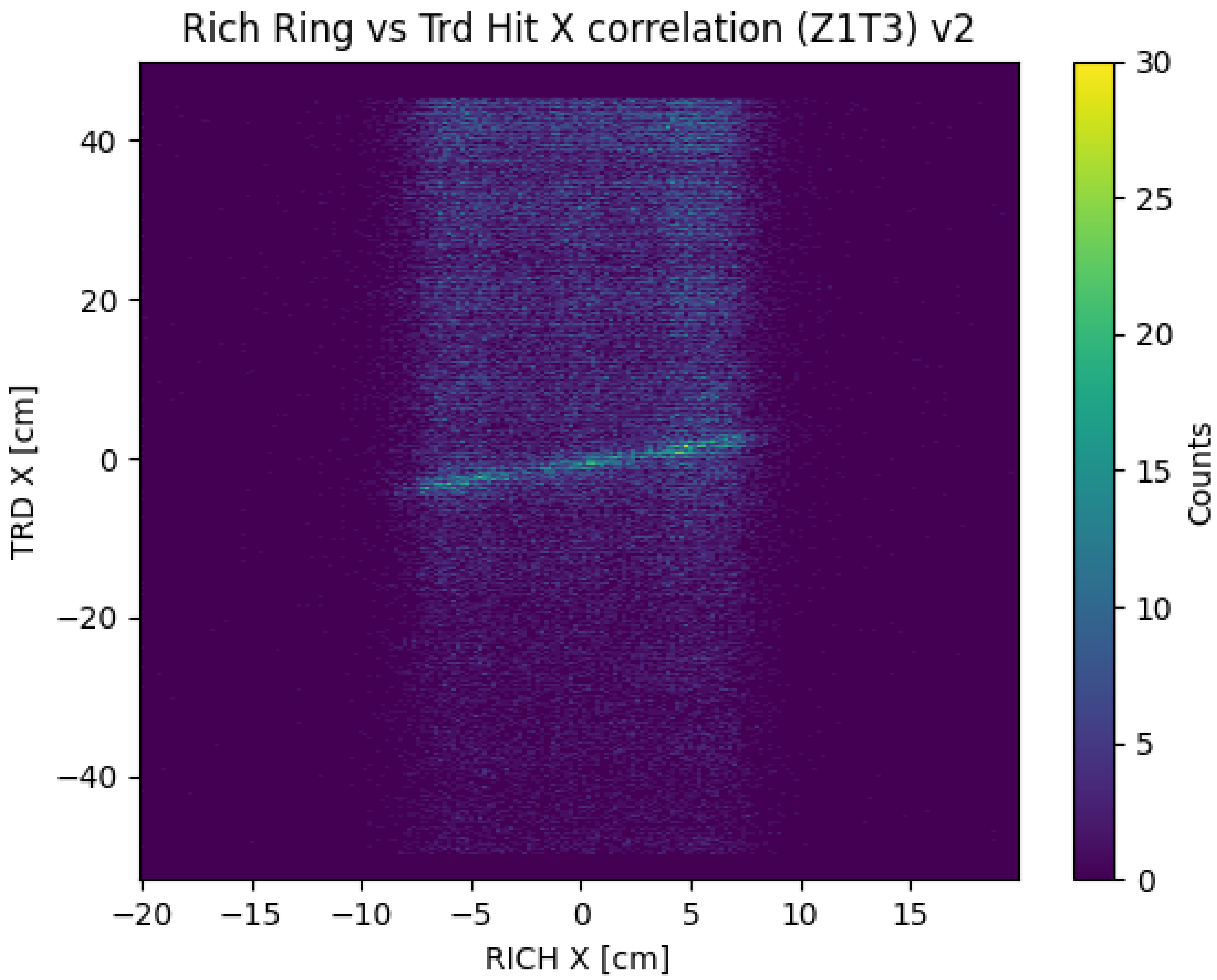
Spatial correlation X



Time cut 3



Time cut 3 + Y cut

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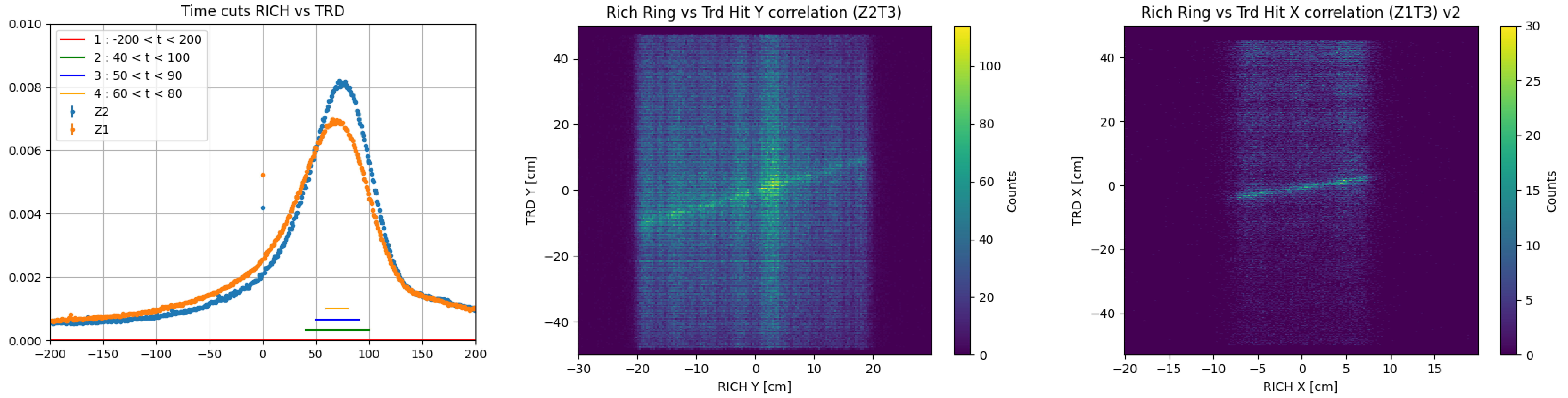
Successfully correlated!!



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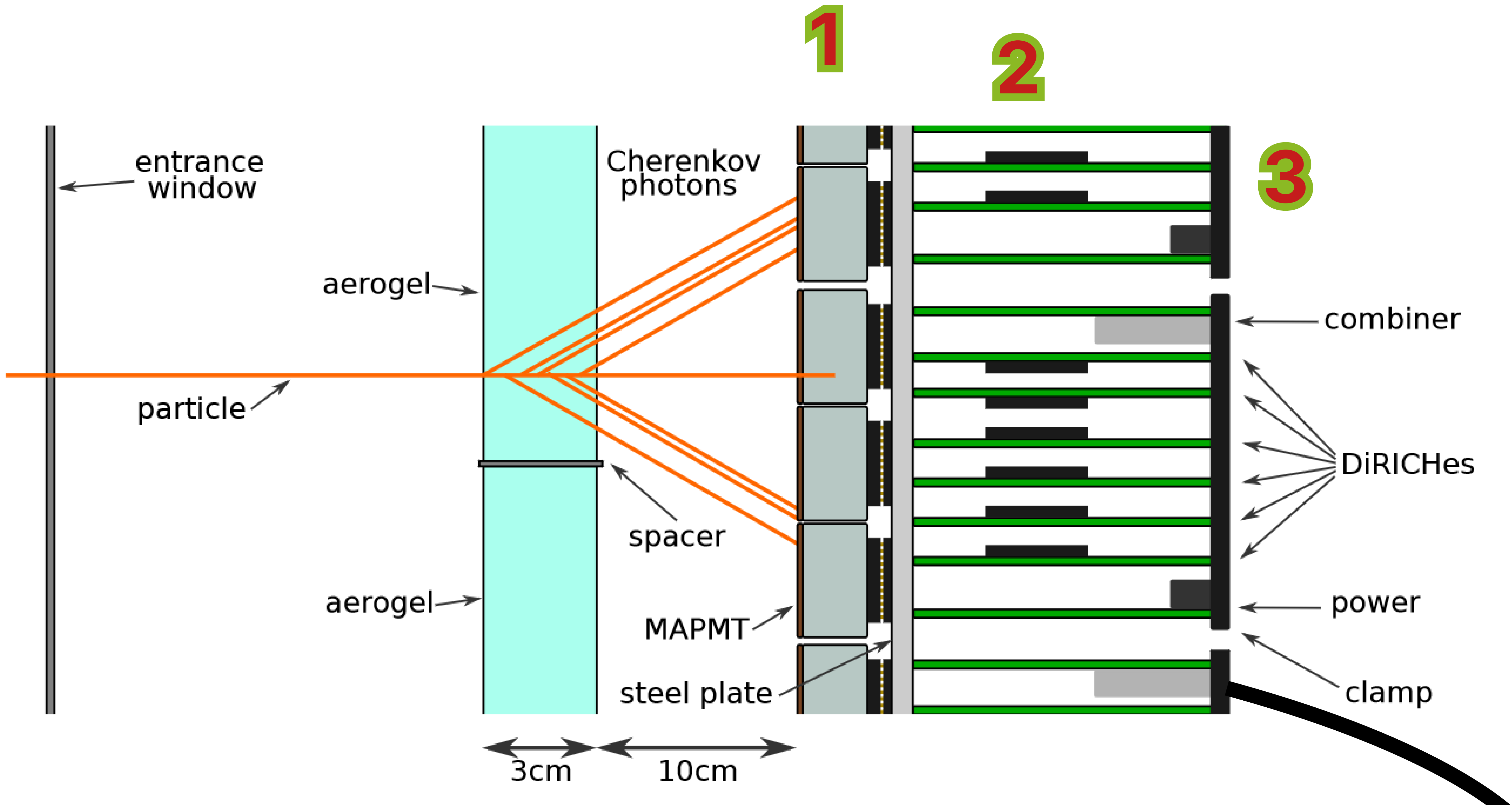
Buffer saturation

1 word = 32 bits

- Each channel on the PMT is assigned a buffer space of 15 words.
- It takes 2 words to express a hit. (also the epoch)
- Each DIRICH has a total buffer space of 499 words.



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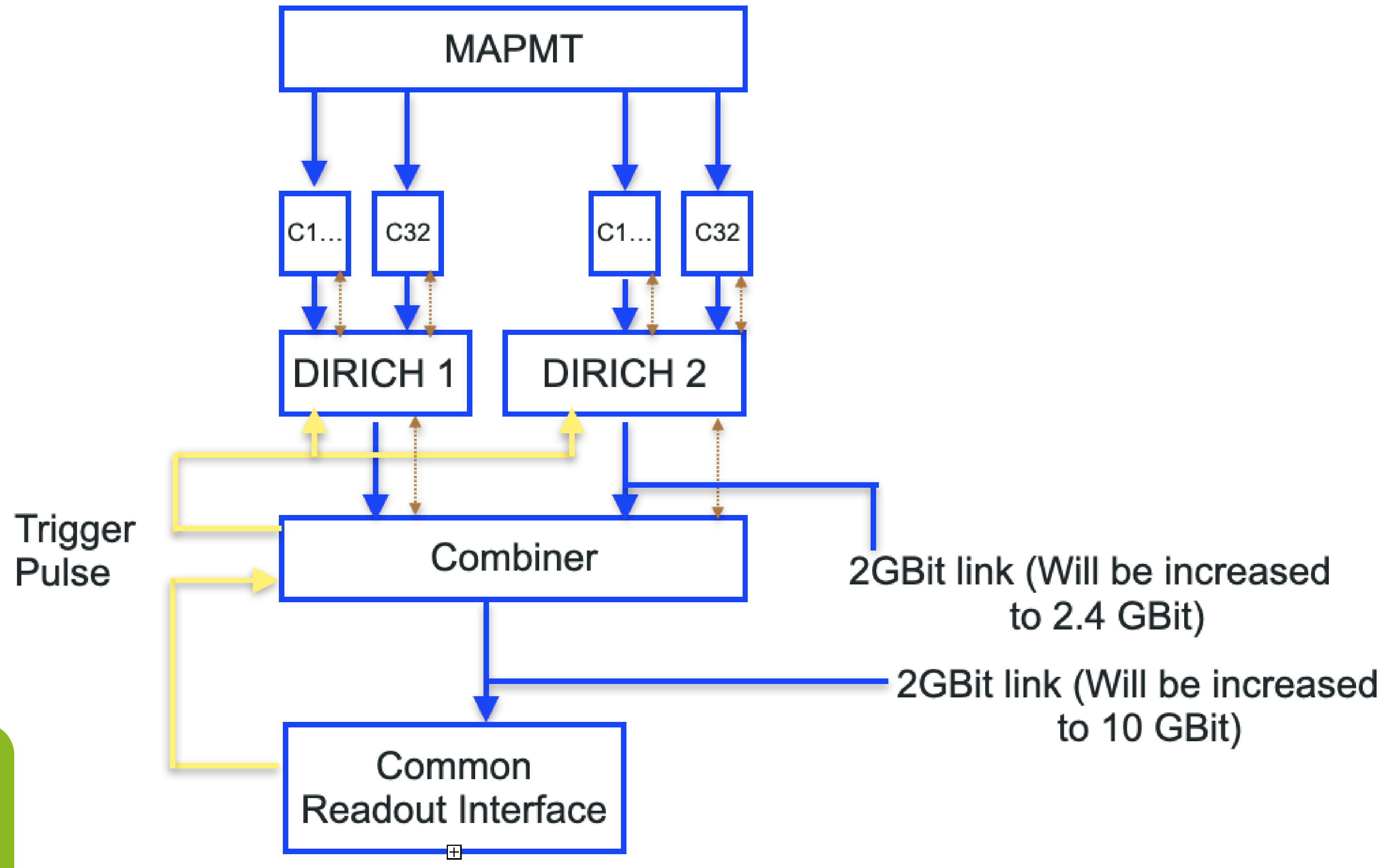

ref: Pavish Subramani

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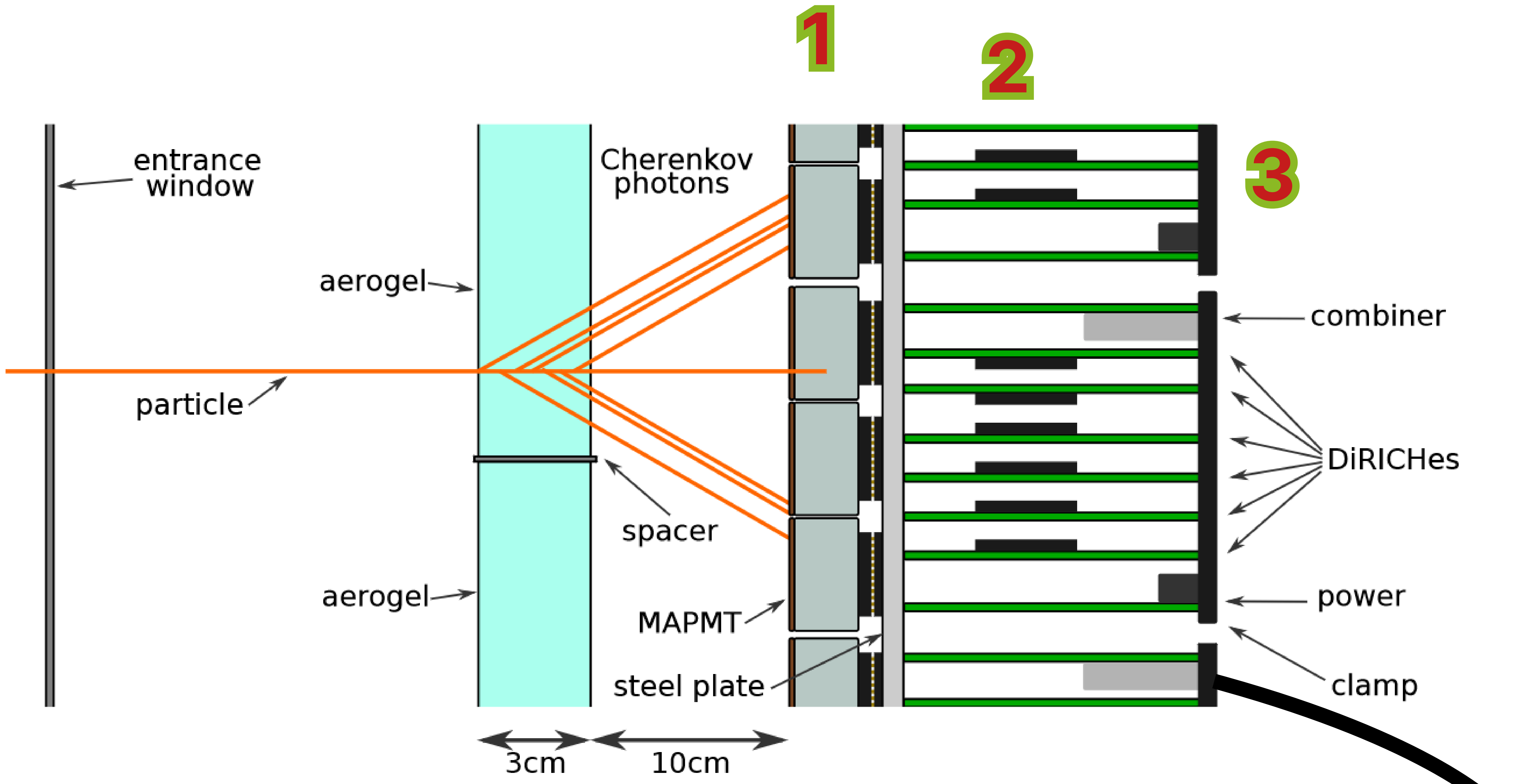
mRICH



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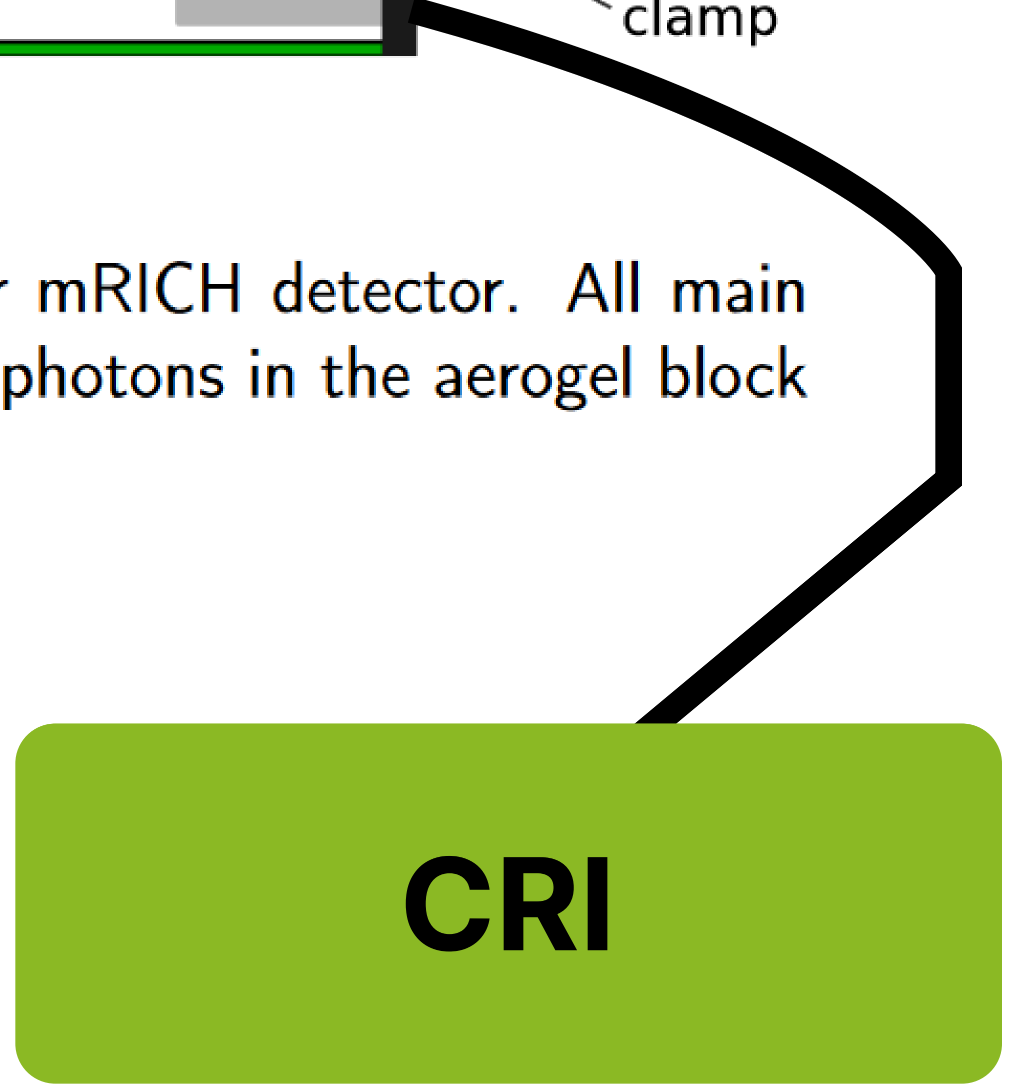

1 word = 32 bits

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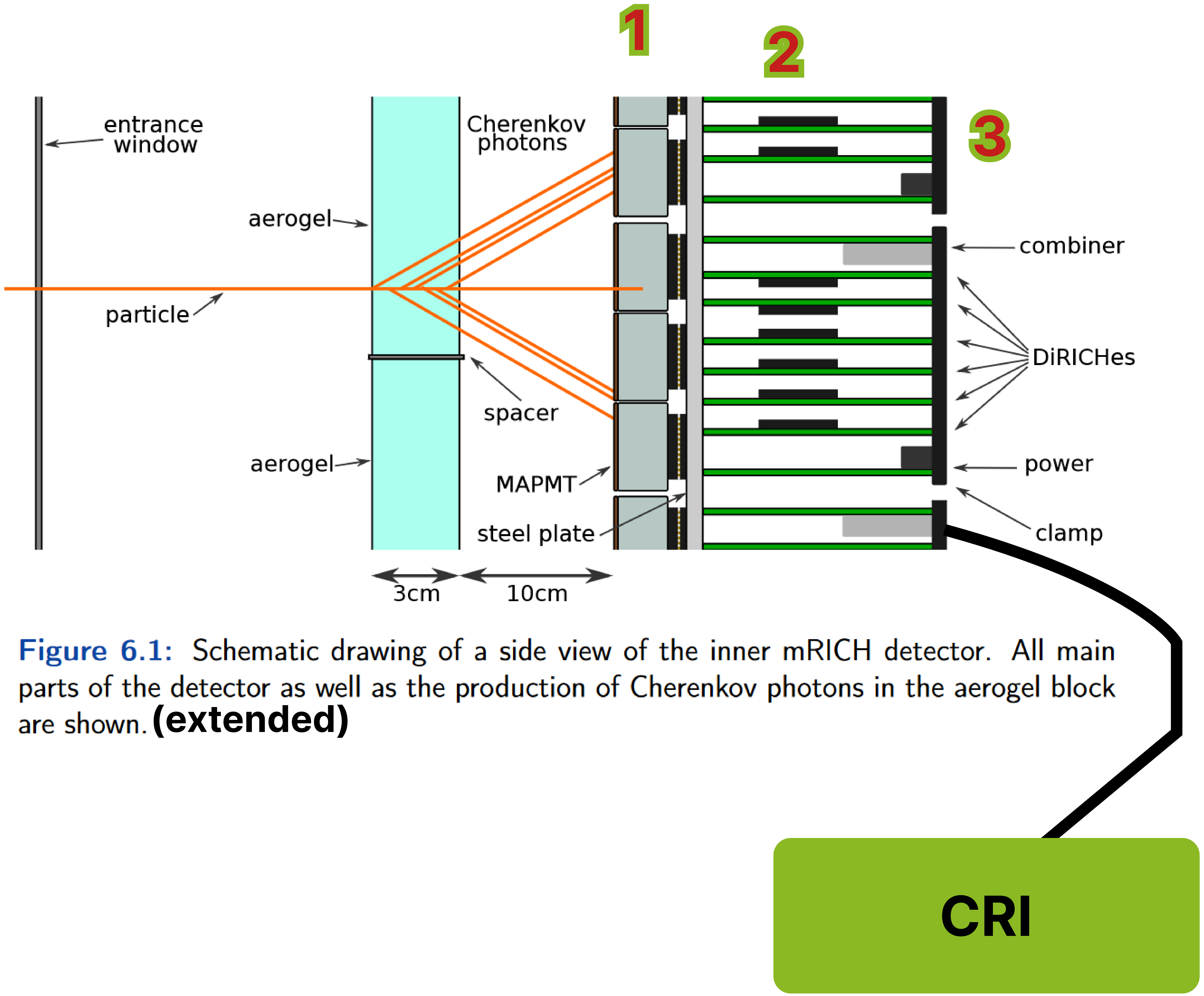
- Each DIRICH has a total buffer space of 499 words.

- So, if each PMT channel can hold 7 hits, there are 64 channels on 1 PMT.

- CRI trigger rate of 3kHz:
  - channels will start loosing data when particle rate > 15kHZ

mRICH



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- CRI trigger rate of 3kHz:
  - channels will start loosing data when particle rate > 15kHZ

- 2 possible solutions
  - Higher CRI rate
  - Larger buffer size

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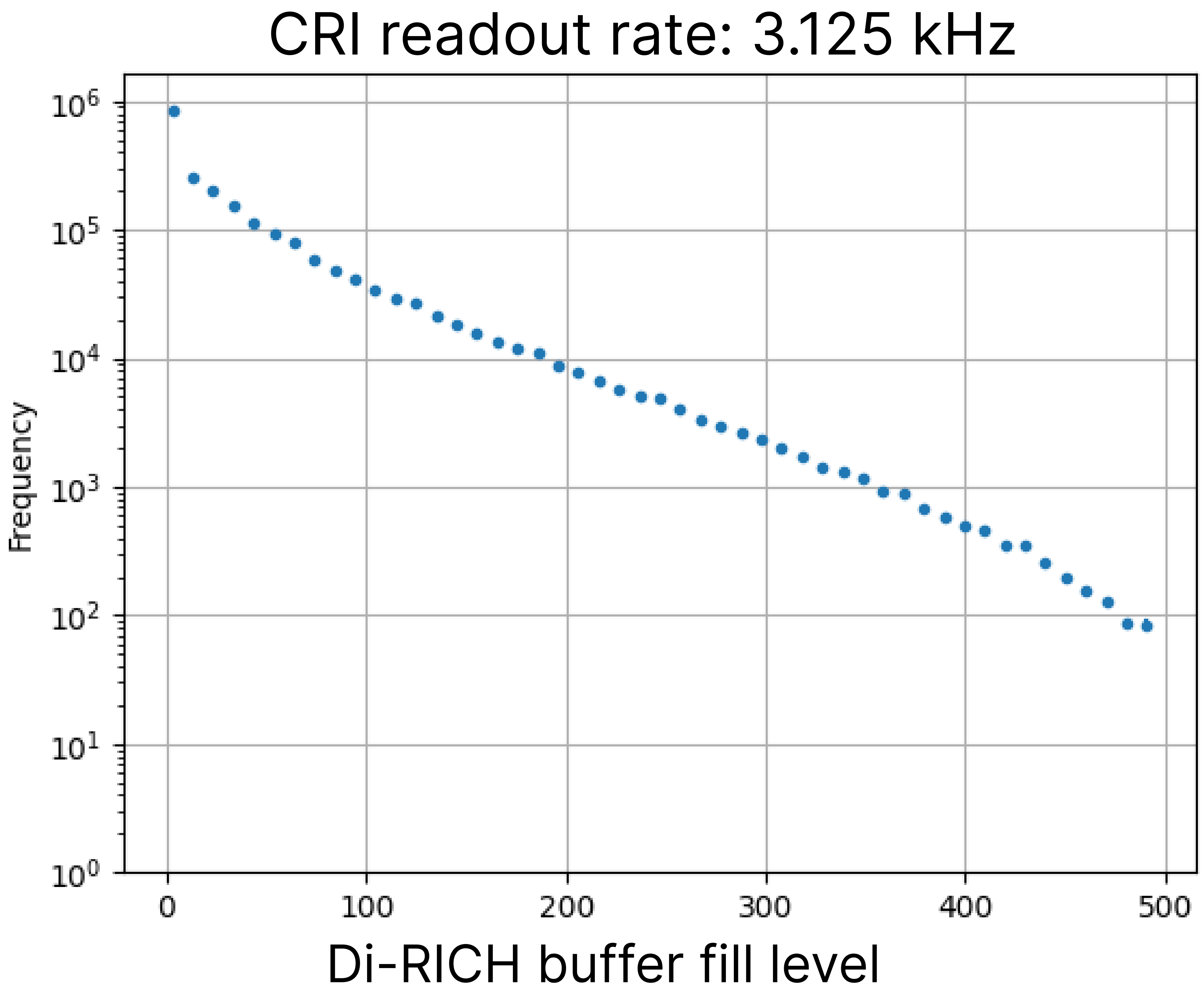
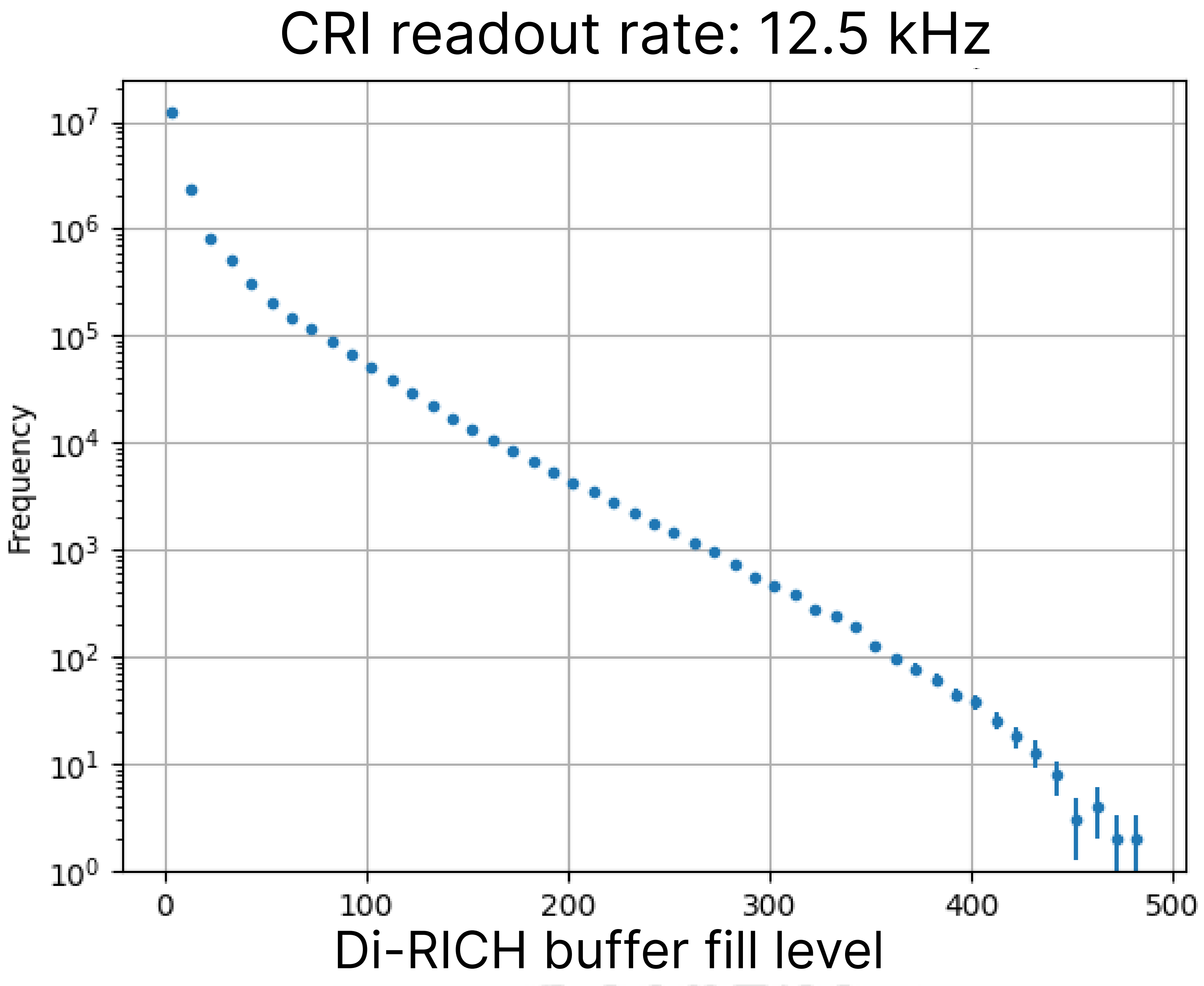
Tested solution: Higher CRI rate



Possible Saturation

2914: Au-Au March 2024



No Saturation (probably)

3096: Ni-Ni May 2024

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Summary and Plans for mini-RICH

Summary

- Successfully revived the mini-RICH detector after a two-year hiatus.
- Verified the functionality of the aerogel plates.
- Established correlations between the mini-RICH and mini-TRD systems.
- Identified and addressed buffer management challenges. (partial solution)

Future Plans

- Integrate the mini-RICH detector into the tracking system.
  - Correlations with mini-STS, mini-TOF, etc (almost done)
- Optimize mini-RICH at high interaction rates.
  - Performance
  - Stability (not the biggest problem in CBM)
- Explore alternative buffer management strategies.
  - Recompile and test the firmware for more buffer (Simon Reiter, Giessen)
- Testing MAPMT ⇒ SIPMs (Jesus Pena Rodriguez, Wuppertal)
- Test a new advanced readout DAQ scheme for the DIRICH modules.
  - Under development
- Working on an alignment procedure for mCBM which can be used in CBM later on.

Backup slides

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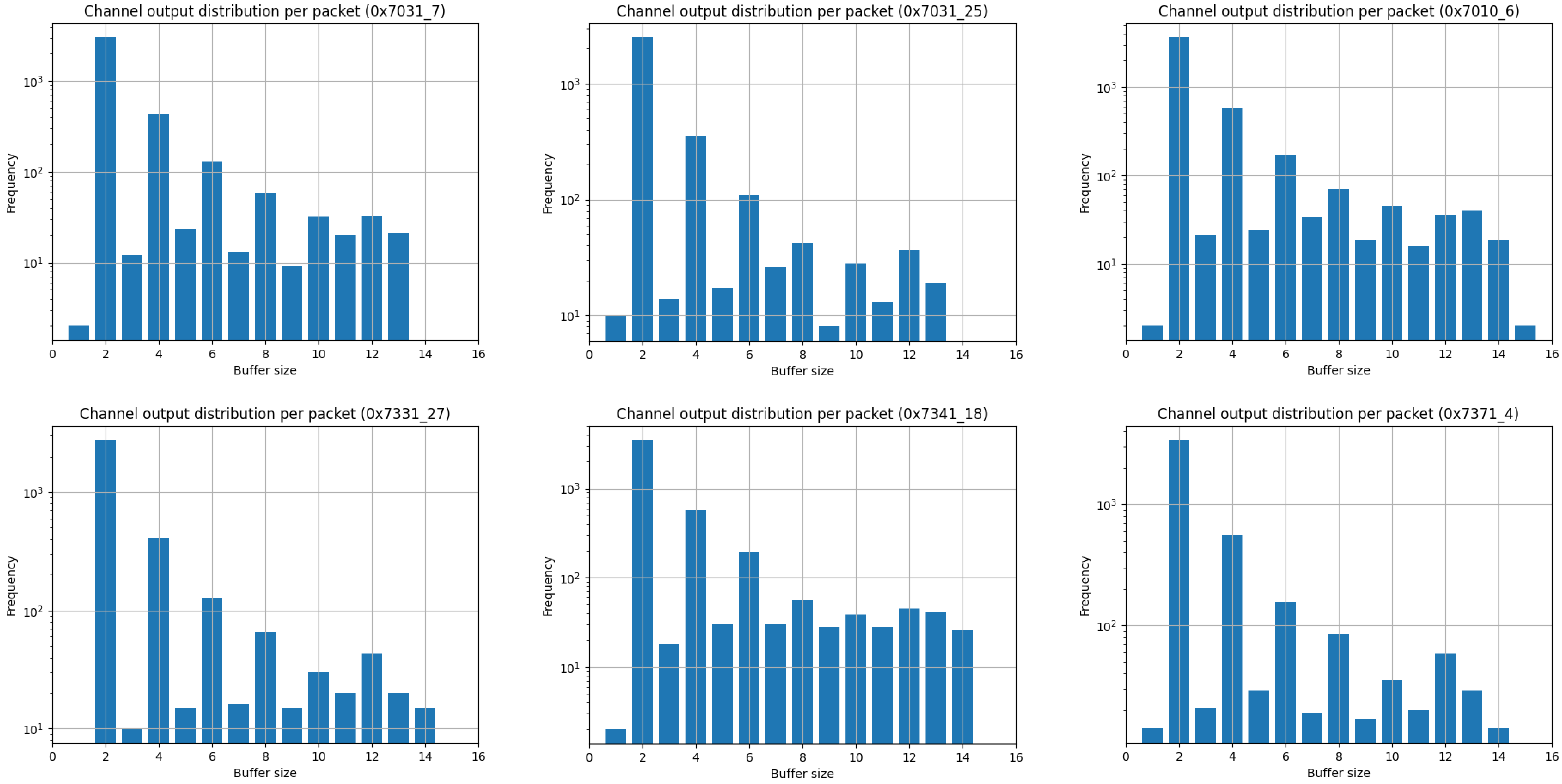
A few random channels



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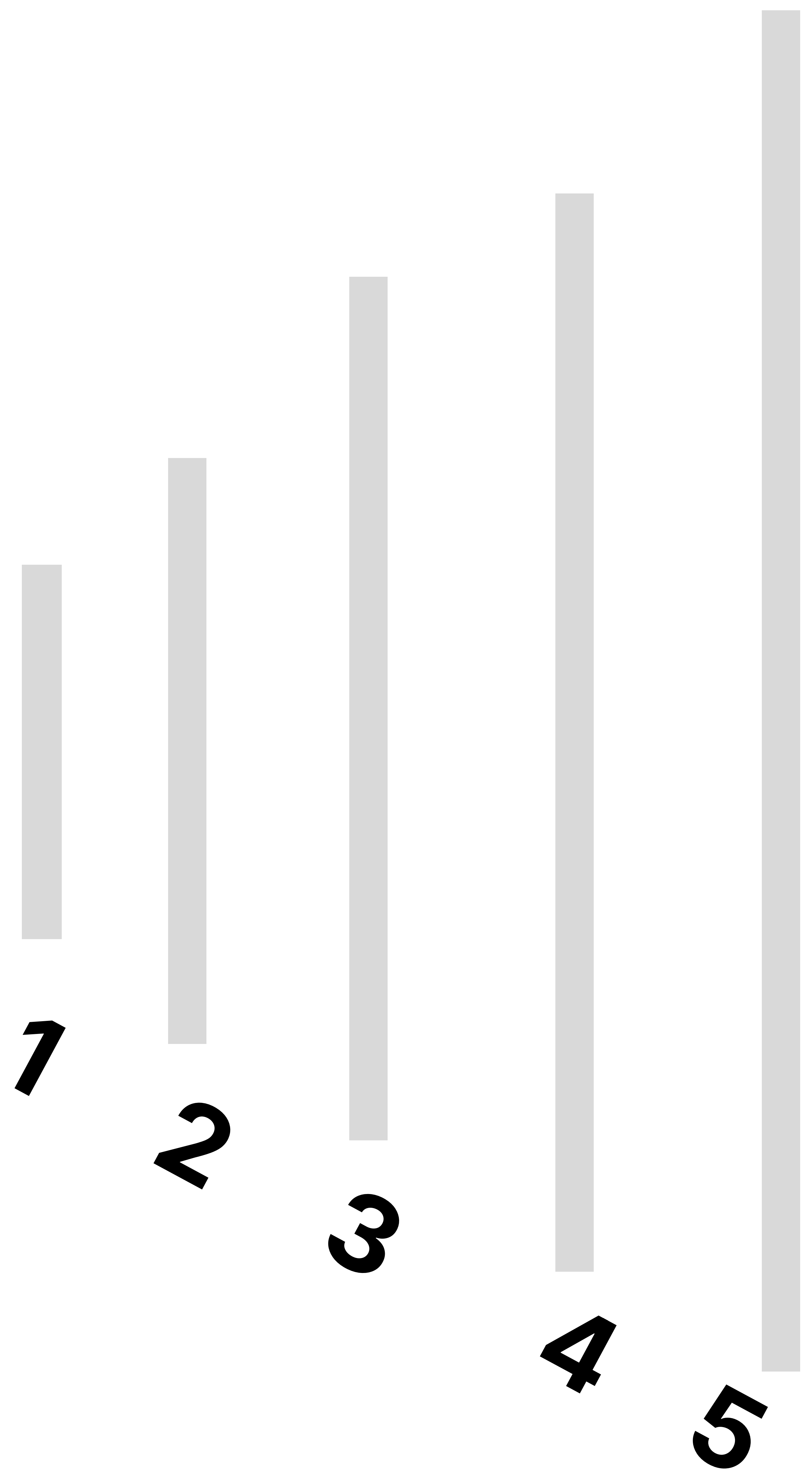
Detector synchronization

- Goal: find a set of time offsets given offsets between detectors along with errors.

- Novel Synchronization Method
- Uses matrix formulation
- Uses Gradient Descent to find a good solution



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Simulation

1. Start with a random offset vector → [a1, a2, a3, a4, a5]
2. Make correlation matrix
3. Add noise [== f(resolution)] to the correlation matrix.
4. find a offset vector
    a. Linear method (read the first row)
    b. Matrix method (Gradient Descent)
5. Put the Loss of both offset vector in histogram
    a. For the original correlation matrix
    b. For the noisy correlation matrix

$$C_{ij} = \alpha_j - \alpha_i$$

	Var1	Var2	Var3	Var4	Var5
Var1	0	-0.08071	0.098675	0.014625	0.06191
Var2	-0.08071	0	-0.10168	0.37678	0.10306
Var3	0.098675	-0.10168	0	0.049934	0.11917
Var4	0.014625	0.37678	0.049934	0	0.00224
Var5	0.061913	0.103062	0.119171	0.002249	0

$$\mathcal{L} = \sum_{i,j} \frac{C_{ij}}{\sqrt{\sigma_i^2 + \sigma_j^2}}$$

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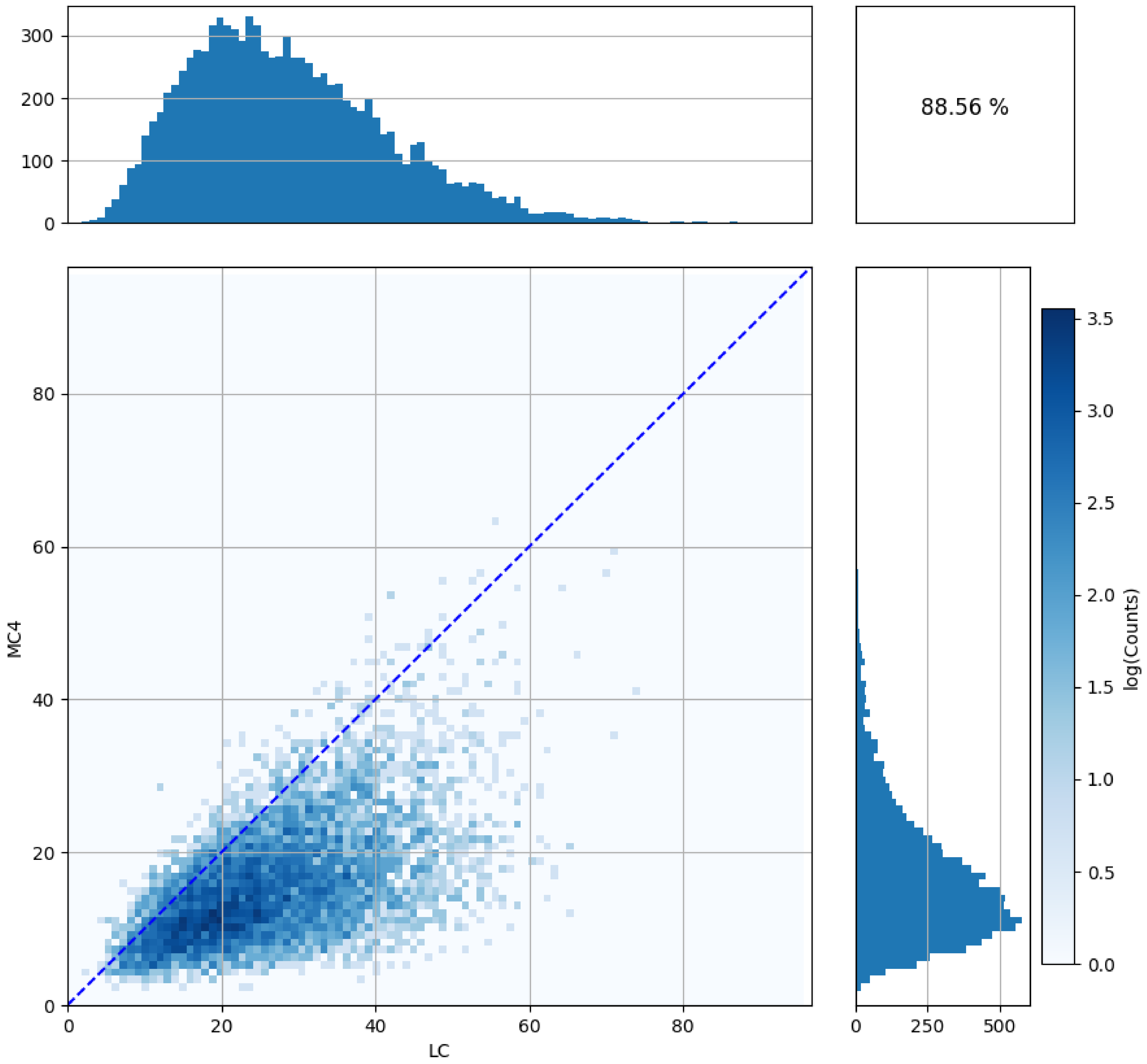
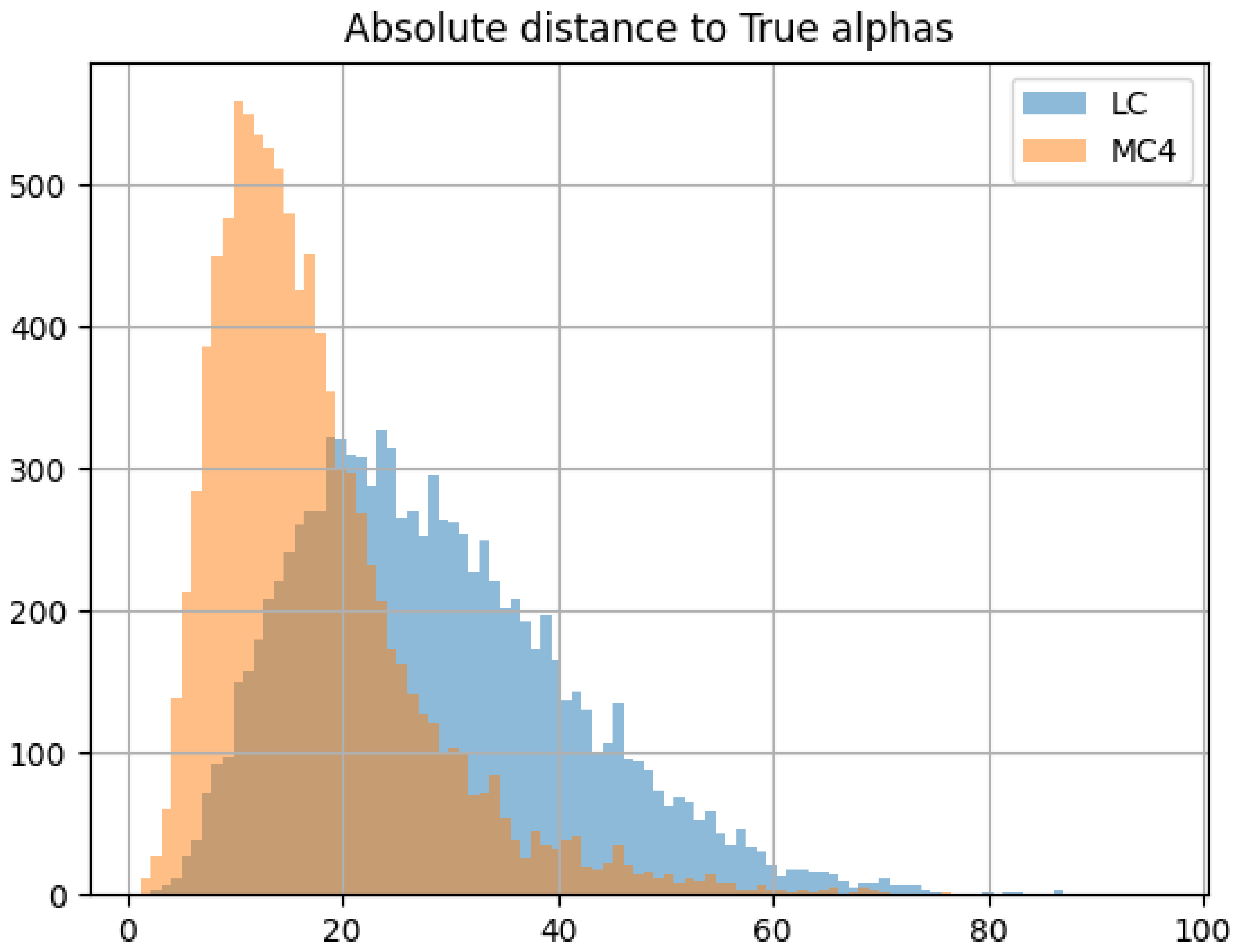
7 detectors with 6 ns resolution





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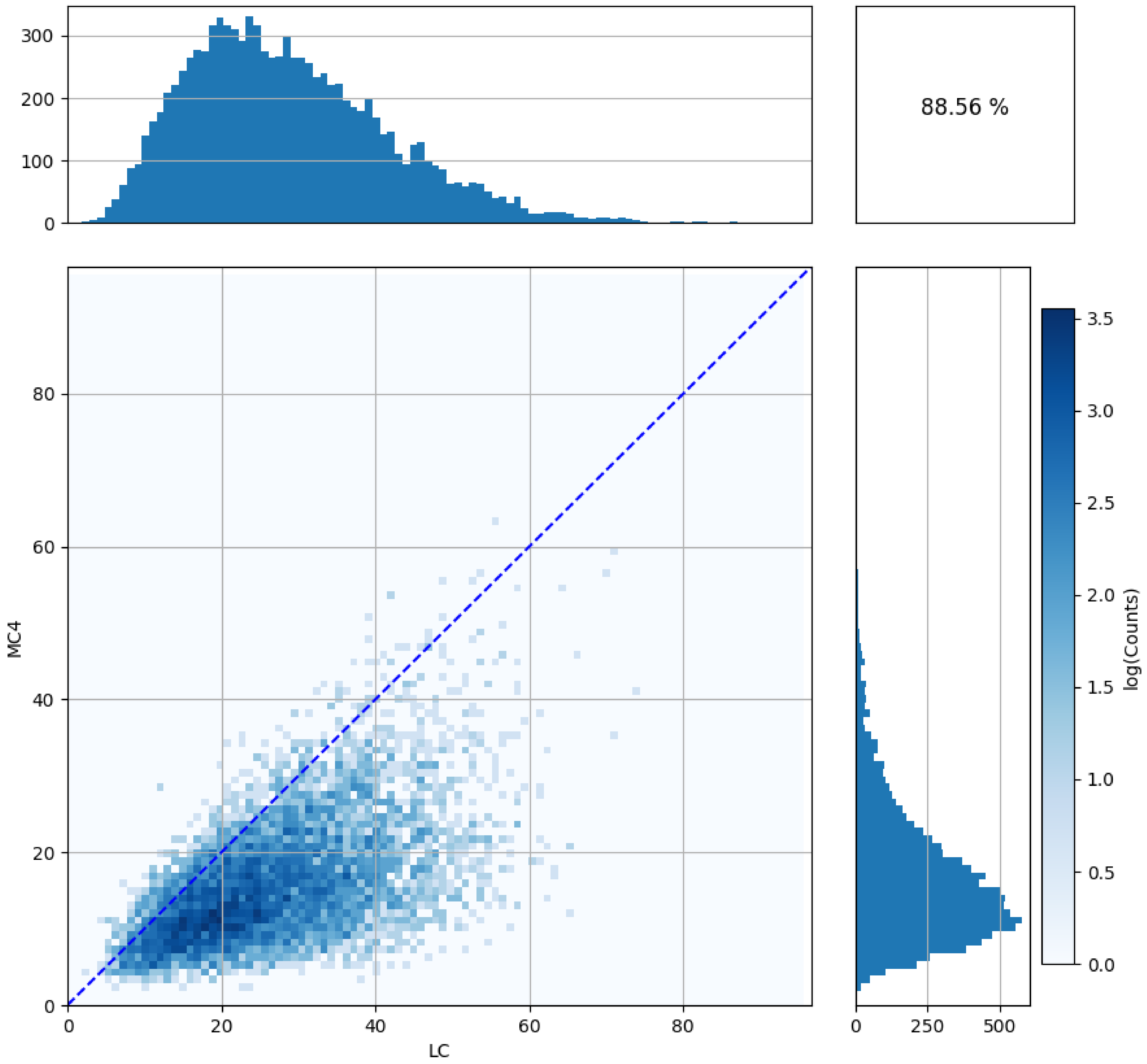
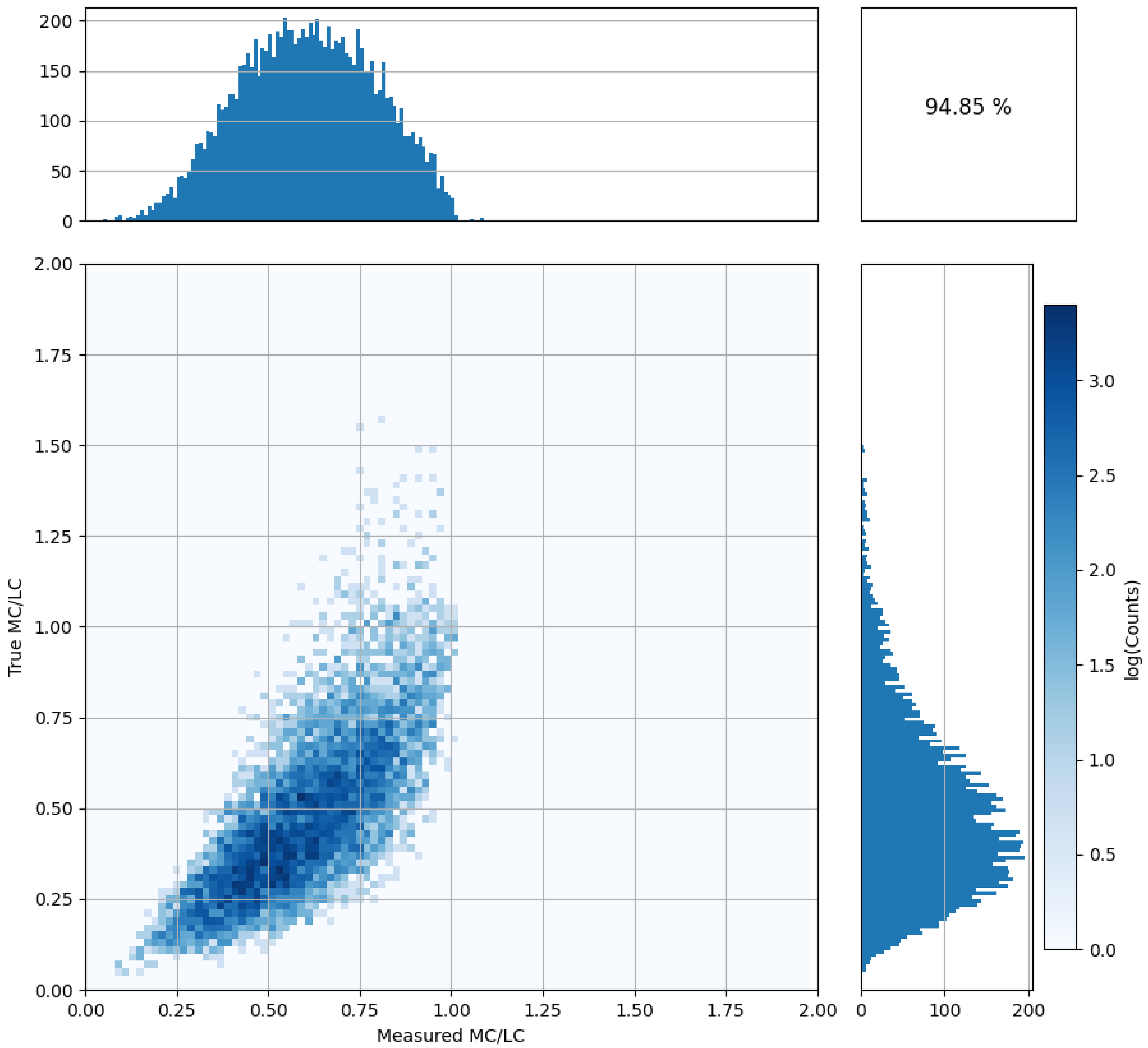
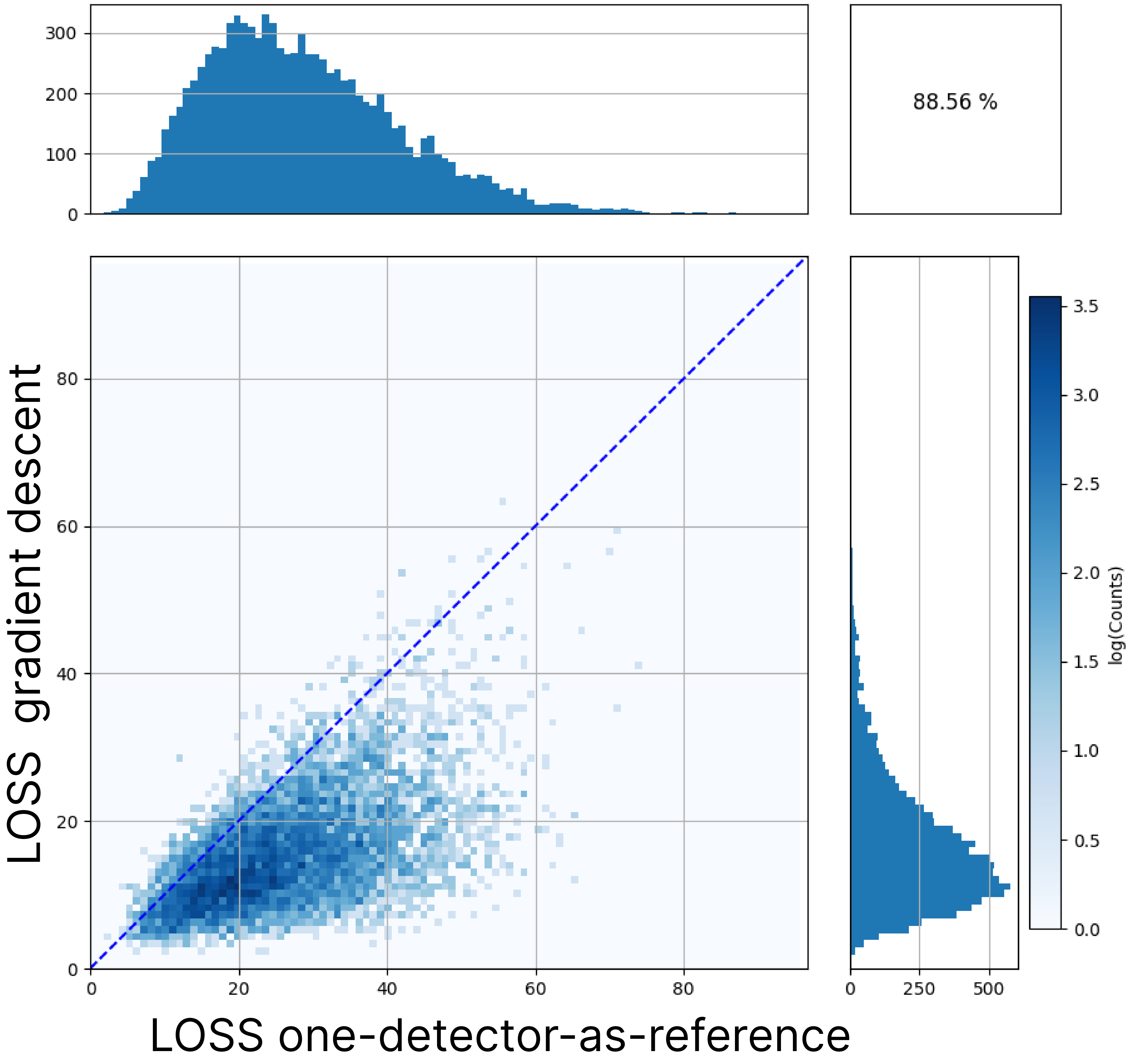
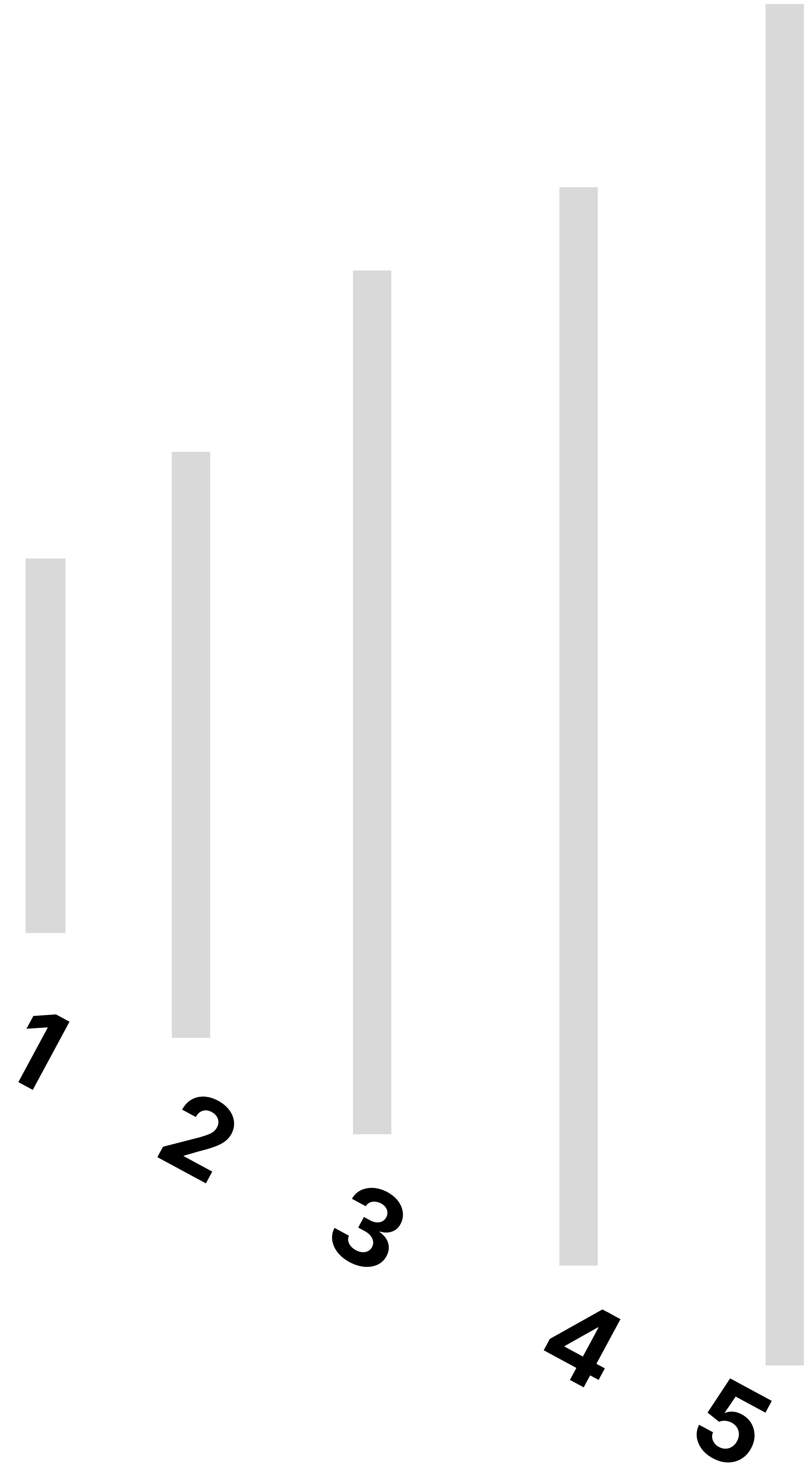


Is alpha same as the original?



Will this alpha make C zero?


88.56 %
log(Counts)
LOSS gradient descent
LOSS one-detector-as-reference



[a1, a2, a3, a4, a5]

5 X 5 Matrix

	Var1	Var2	Var3	Var4	Var5
Var1	0	-0.08071	0.098675	0.014625	0.06191
Var2	-0.08071	0	-0.10168	0.37678	0.1030
Var3	0.098675	-0.10168	0	0.049934	0.1191
Var4	0.014625	0.37678	0.049934	0	0.0022
Var5	0.061913	0.103062	0.119171	0.002249	0

$$\mathcal{L}_1 = \sum_{i,j} |C_{ij}| \qquad \mathcal{L}_2 = \sum_{i,j} C_{ij}^2 \qquad \mathcal{L}_3 = \sum_{i,j} \frac{|C_{ij}|}{\sigma_i + \sigma_j}$$

Gradient Descent

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$$\mathcal{L} = \sum_{i,j} \frac{C_{ij}}{\sqrt{\sigma_i^2 + \sigma_j^2}}$$

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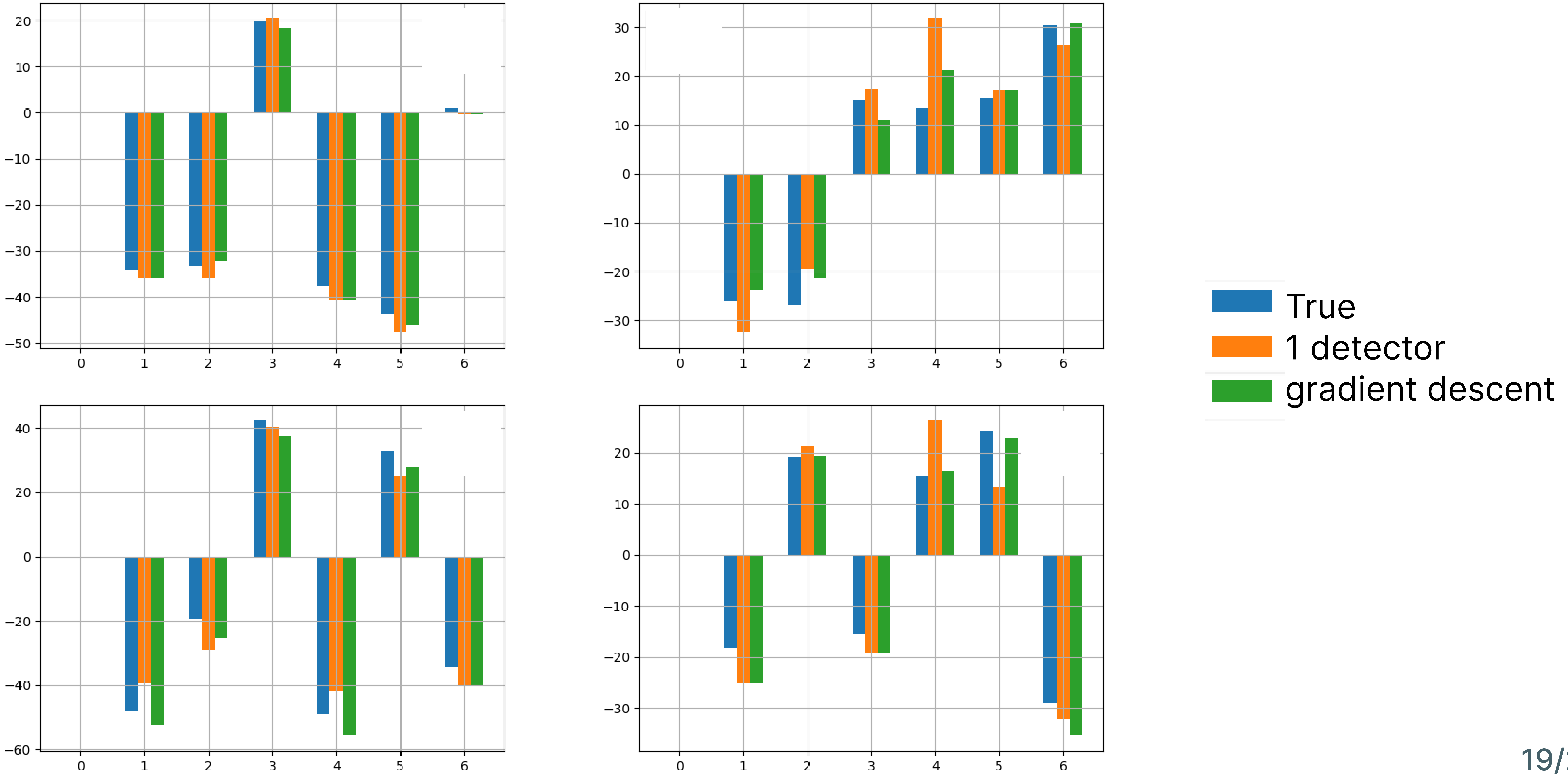
Simulation: 7 detectors with 6 ns resolution



Abhishek Anil Deshmukh