

The new ALICE asynchronous software trigger processing

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for the ALICE Collaboration
EPS-HEP 2025, Marseille 7-11 July 2025



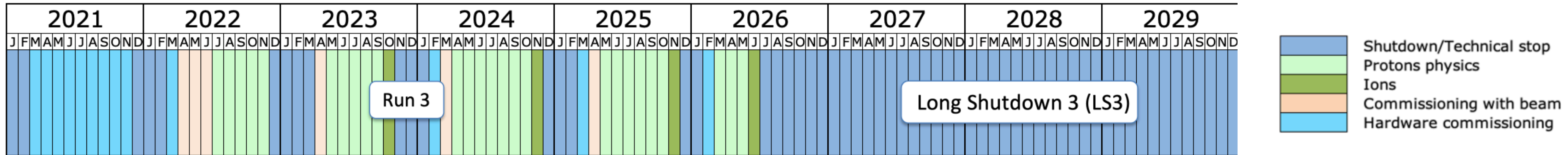
UNIVERSITÄT
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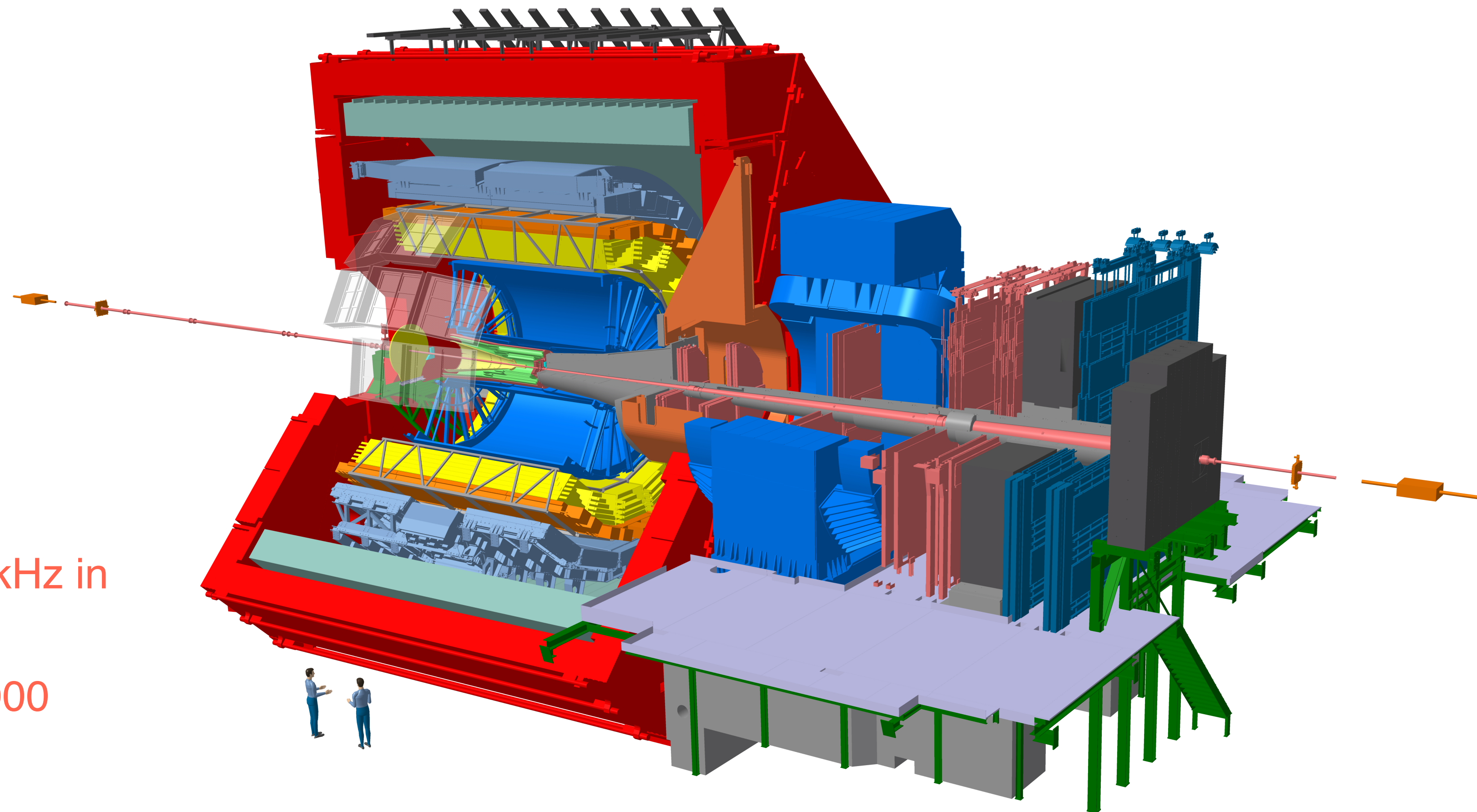
ALICE



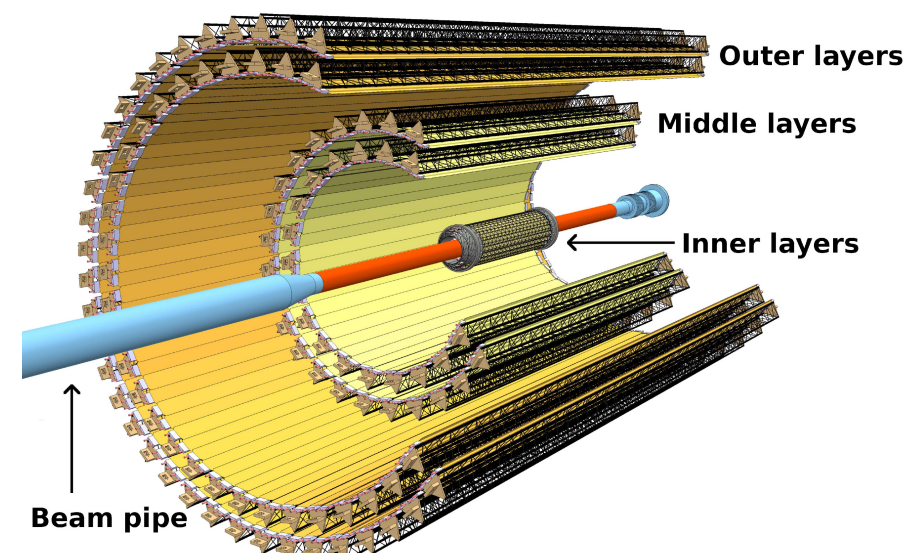
High-precision measurements of quark-gluon plasma (QGP) properties

- Heavy-flavour hadrons and quarkonia at very low p_T
- Vector mesons and low-mass dileptons
- High-precision measurements of light hypernuclei

- ➔ Increased recorded interaction rate 50 kHz in Pb-Pb and up to 5 MHz in pp
- ➔ Collect x100 MB data in Pb-Pb and x1000 data in pp wrt. Run 1 and 2
- ➔ Improved spatial resolution

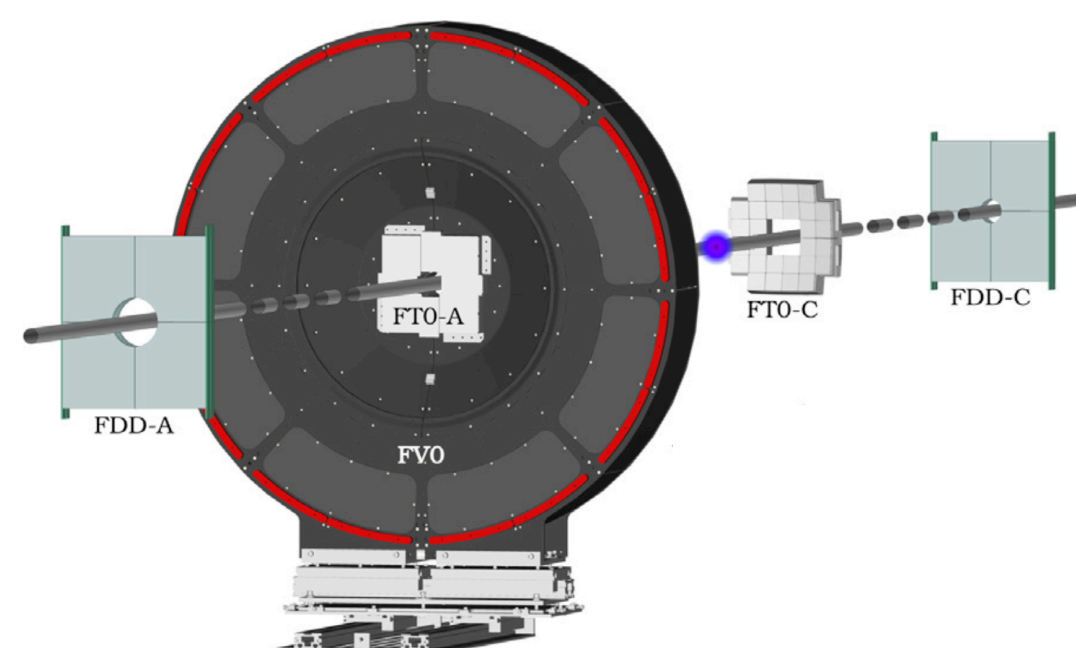


Inner Tracking System 2



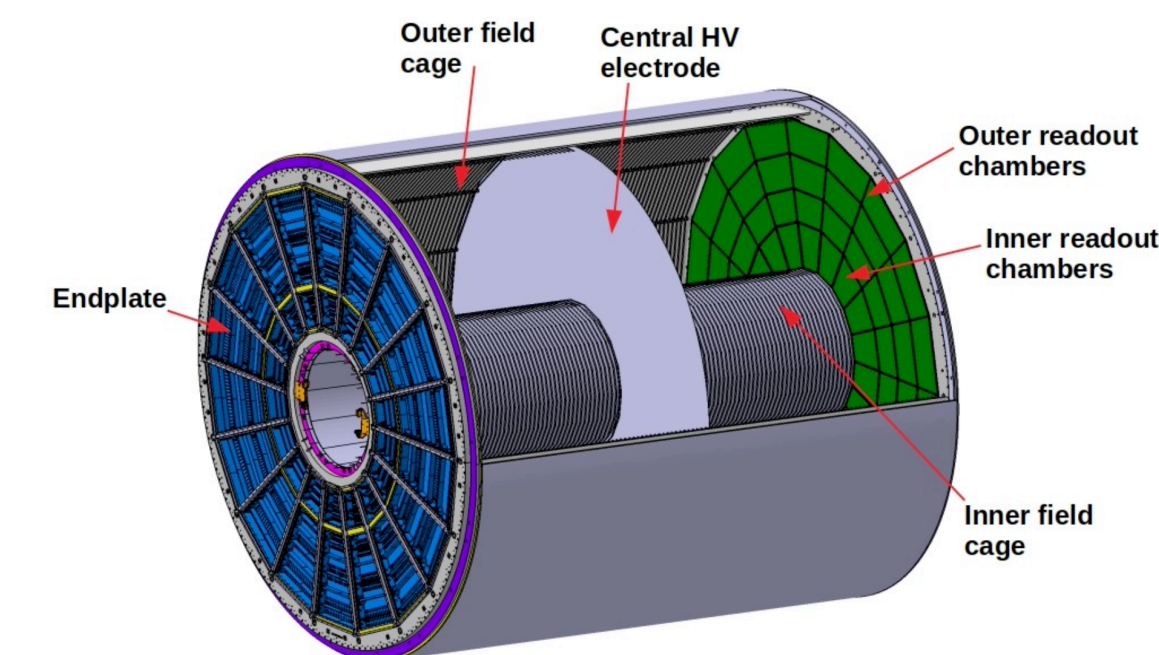
- 7 layers of silicon-pixel detectors
- Low material budget
- 2-5 times better spatial resolution

Forward Interaction Trigger



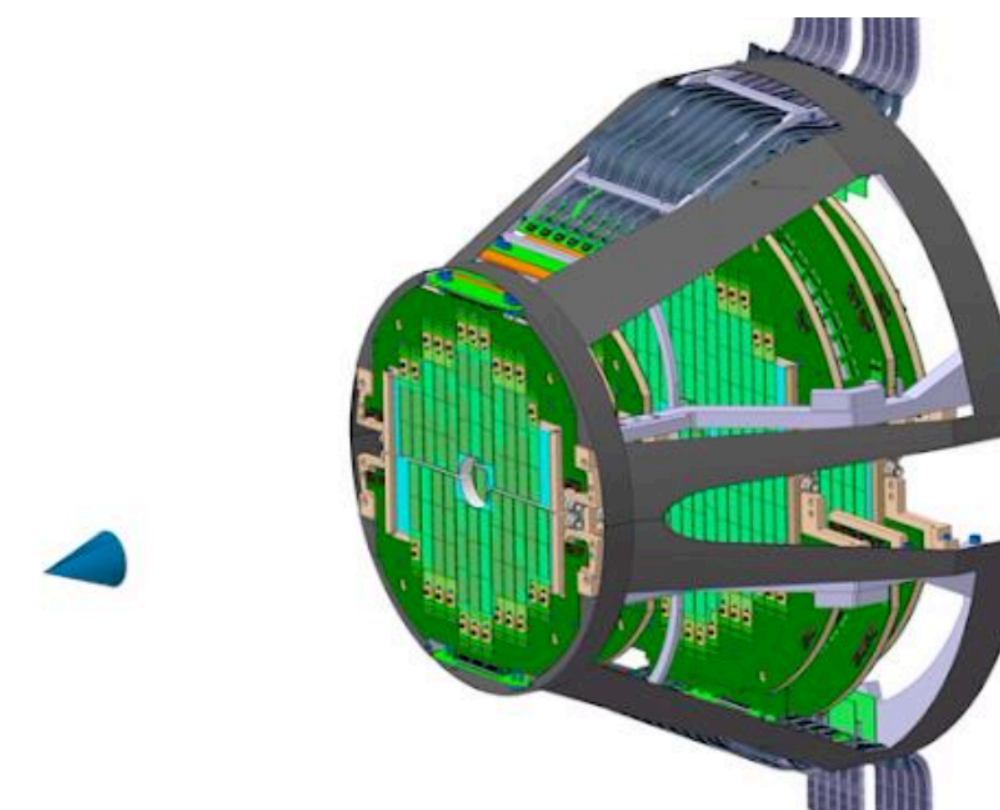
- Fast trigger (latency < 425 ns)
- Low material budget Online luminosity measurement
- Multiplicity and centrality
- Collision time with $\sigma < 50$ ps

Time Projection Chamber

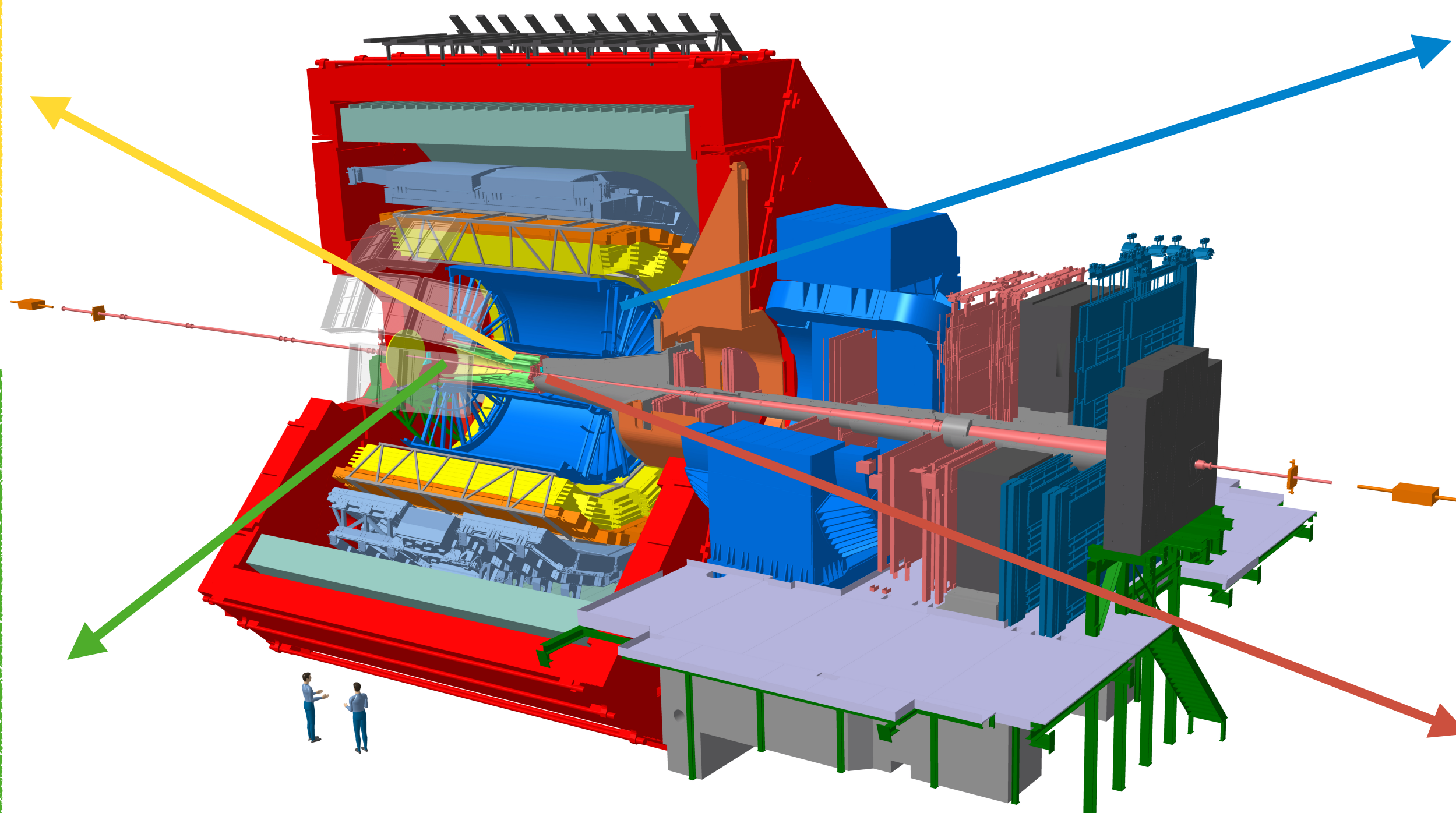


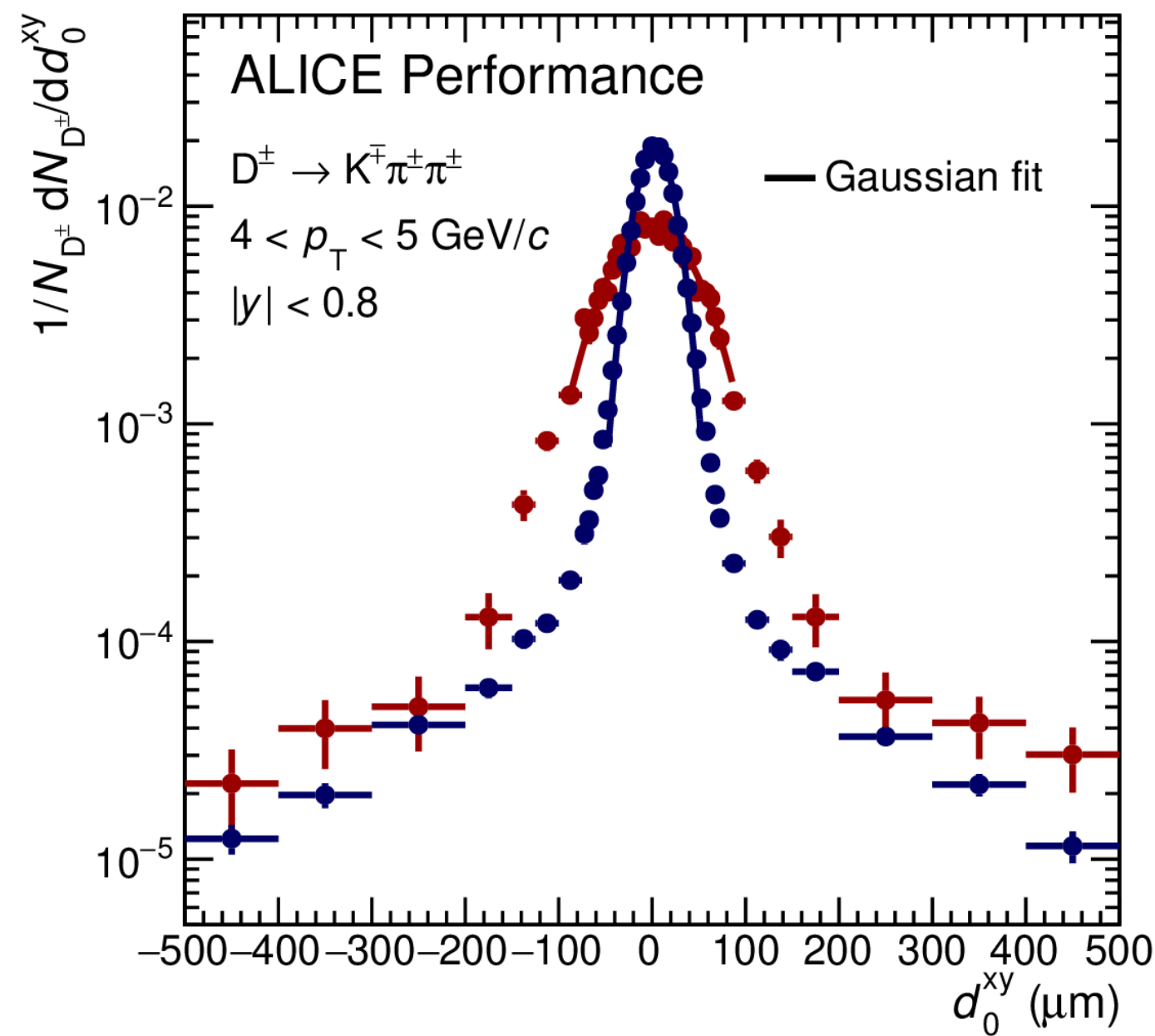
- GEM in place of MWPC
- Continuous readout (~ 50 kHz in Pb-Pb)
- PID capabilities retained

Muon Forward Tracker

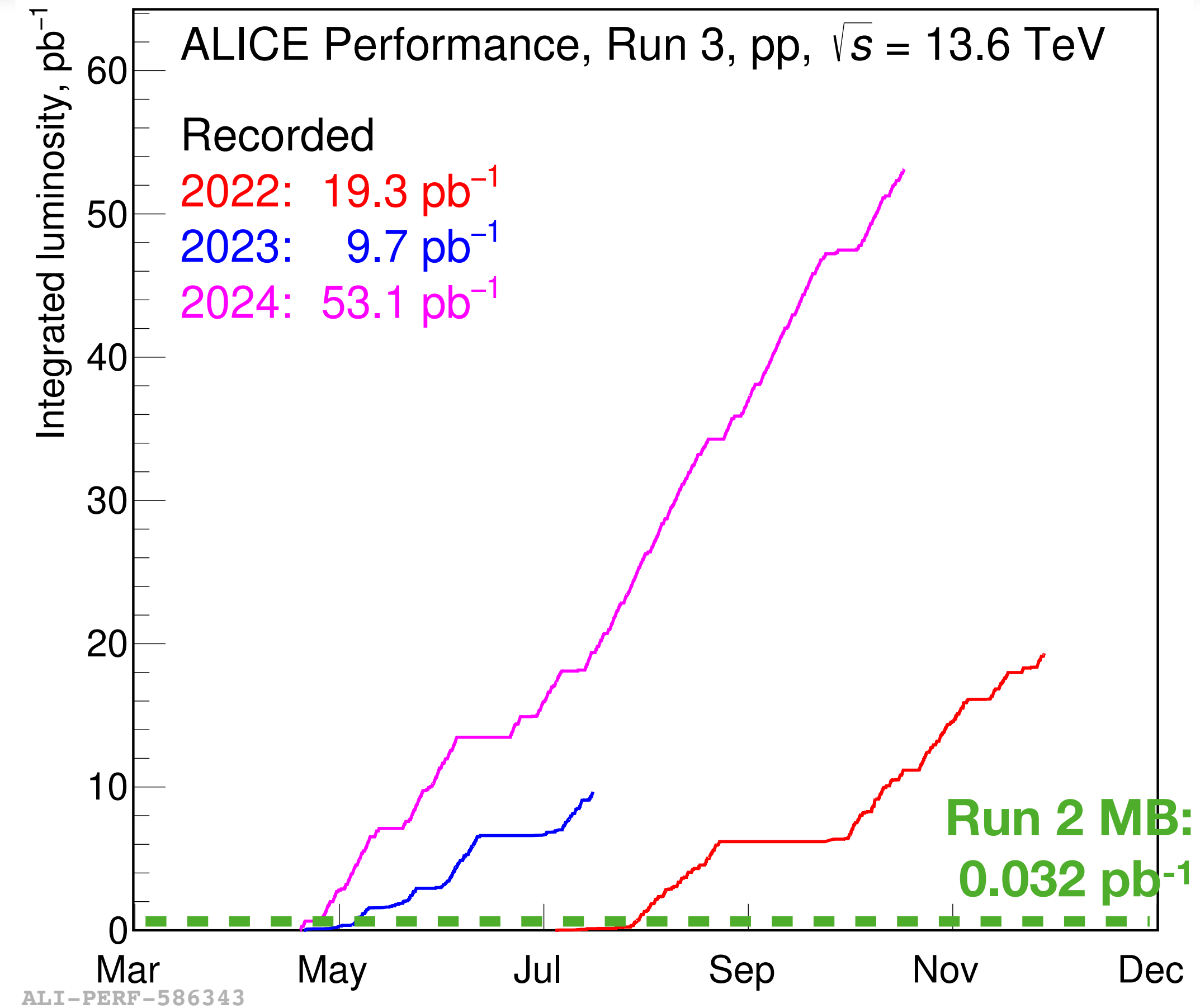
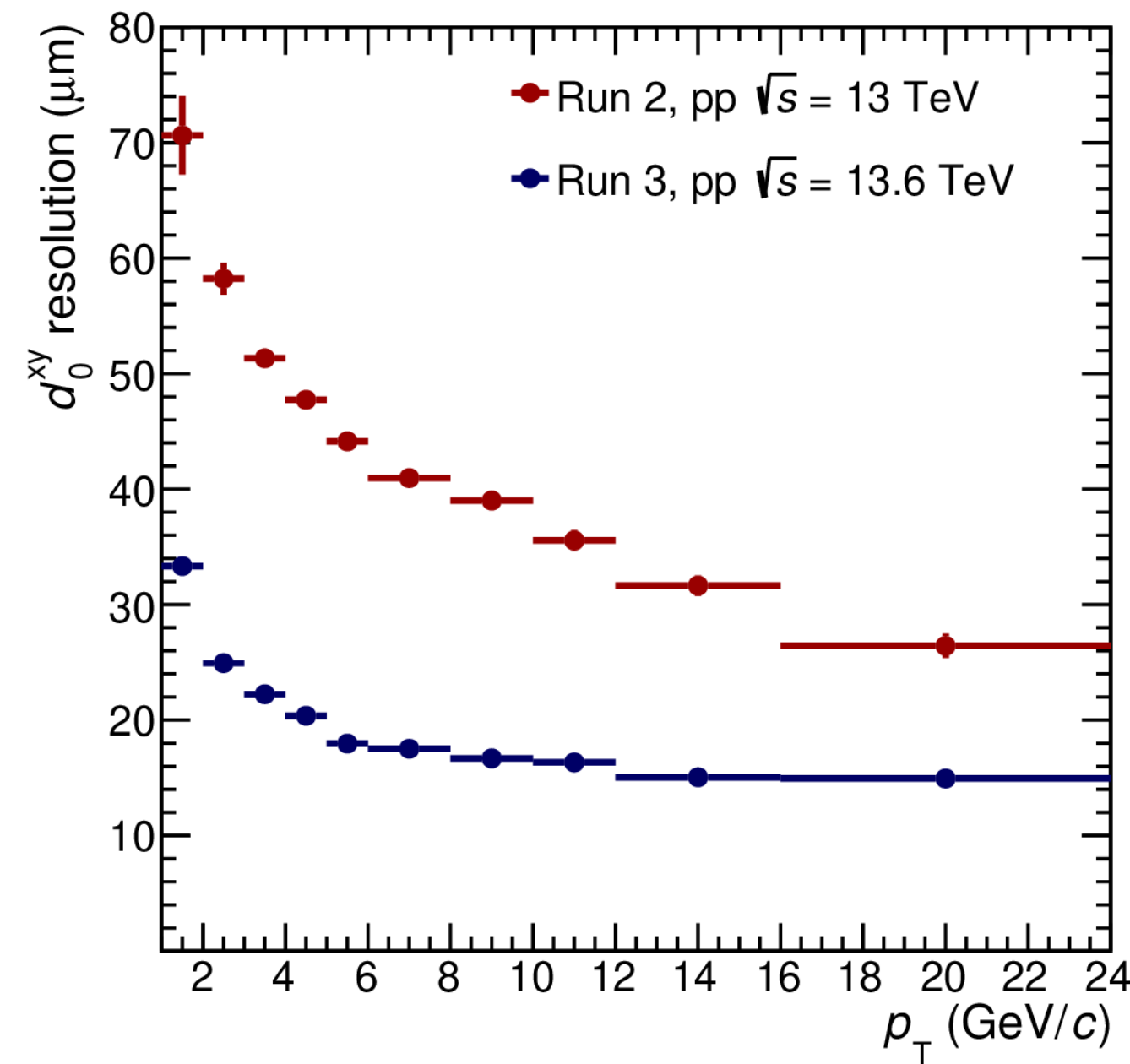


- Prompt vs. non-prompt charmonia separation
- Extended p_T coverage ($p_T > 0$)





ALI-PERF-577966



- ALICE achieved excellent spatial resolution with continuous readout in Run 3
- Full data volume for Pb–Pb collisions (2023-2024) is stored (83 PB)
- Over 4.6 trillion pp events were recorded (2022–2024) at 13.6 TeV with 660 kHz interaction rate, generating 310 PB of data → storing the full pp data volume is not feasible

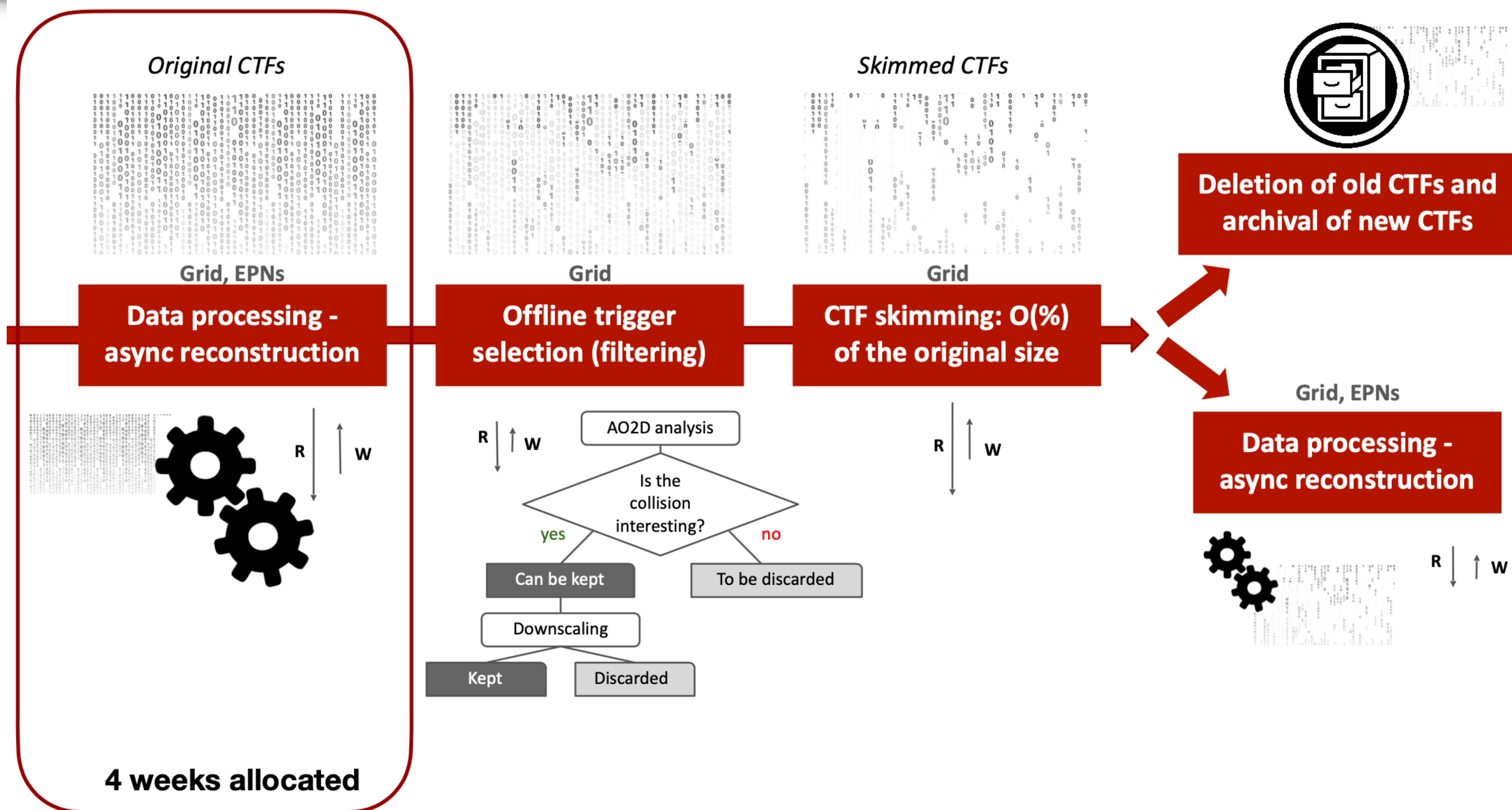
➔ **New ALICE asynchronous software trigger processing**

ALICE asynchronous processing scheme



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CTF: Compressed Time Frame

ALICE asynchronous processing scheme



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Original CTFs



Grid, EPNs

Data processing -
async reconstruction



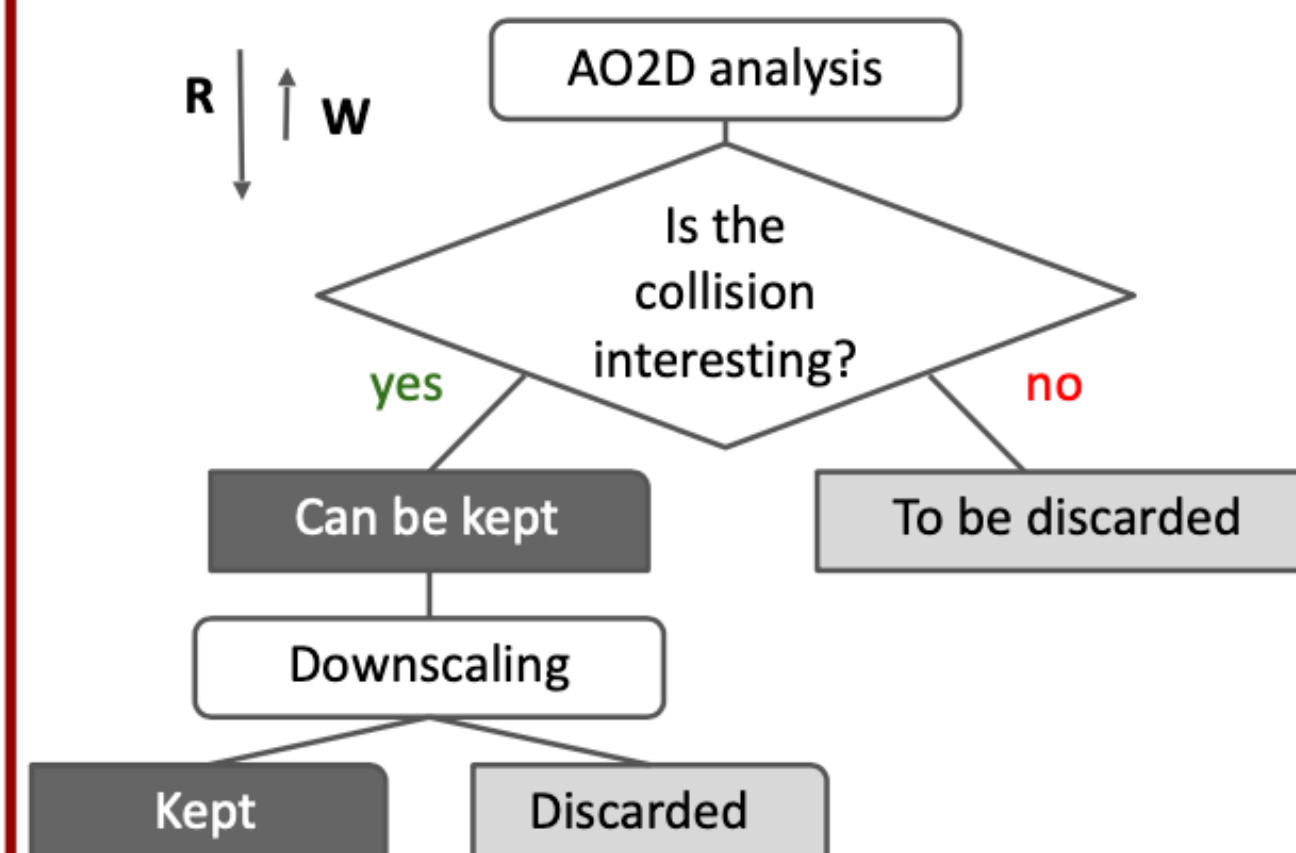
4 weeks allocated

Skimmed CTFs



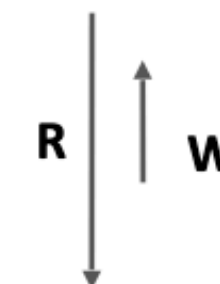
Grid

Offline trigger
selection (filtering)



Grid

CTF skimming: 0(%)
of the original size



4 weeks allocated



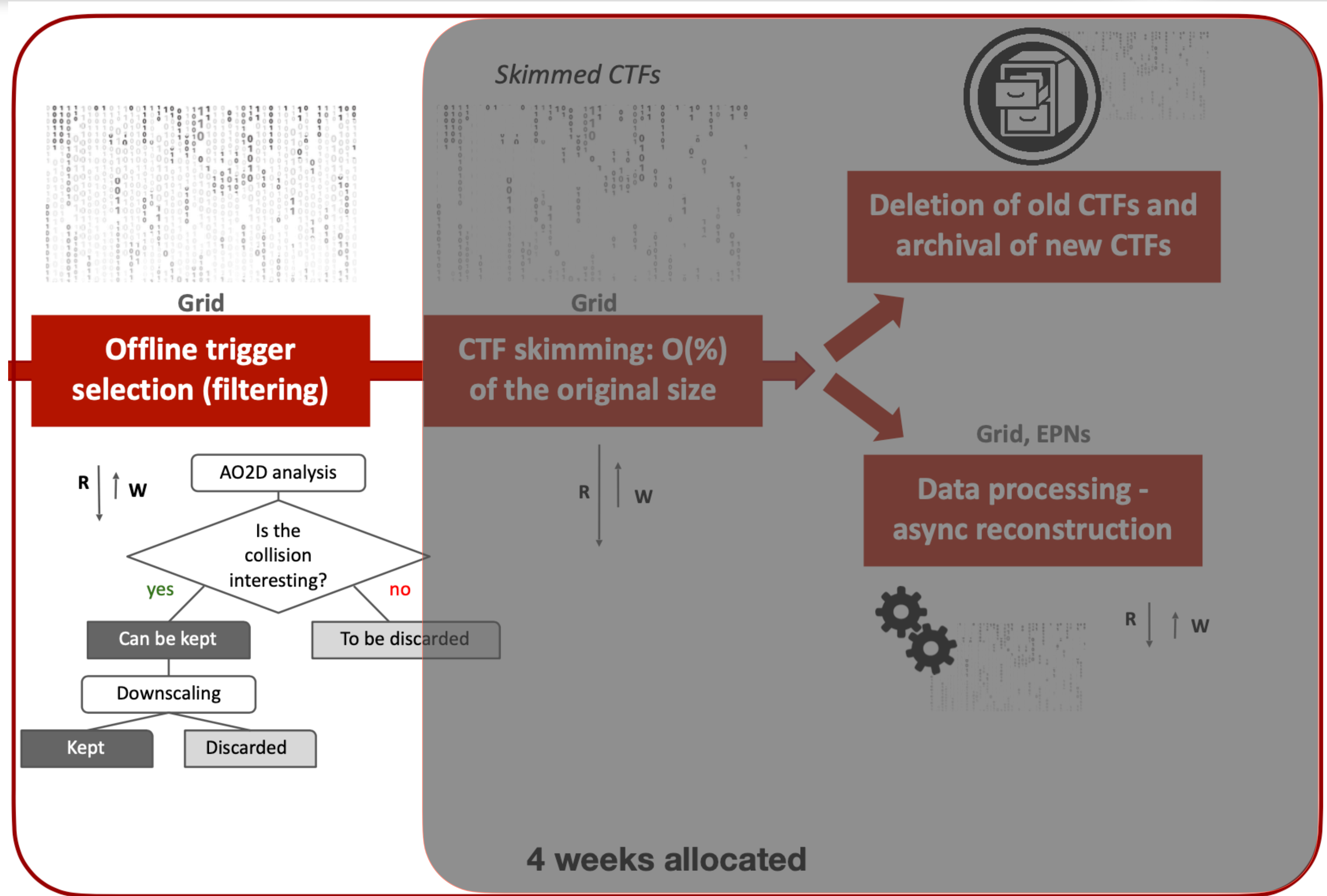
Deletion of old CTFs and
archival of new CTFs

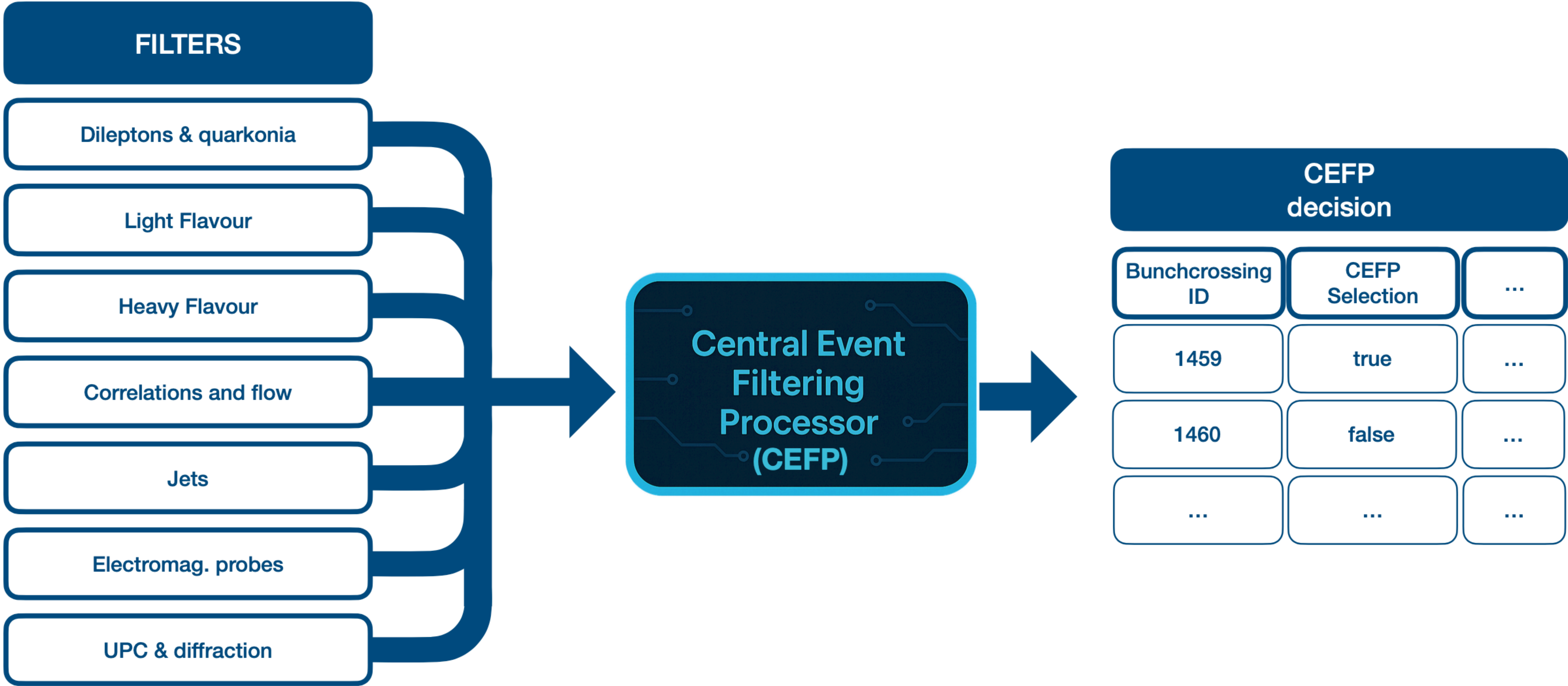
Grid, EPNs

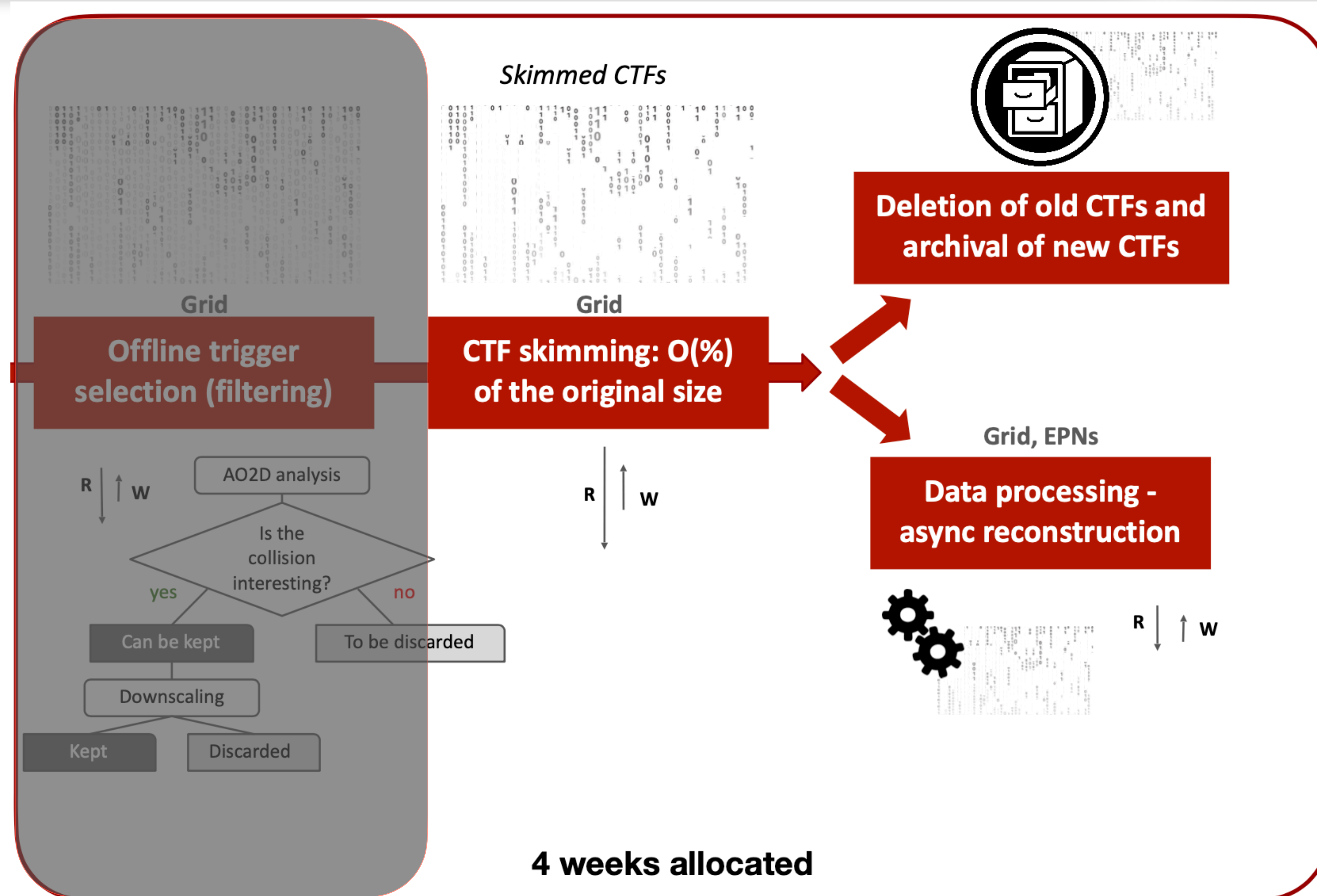
Data processing -
async reconstruction



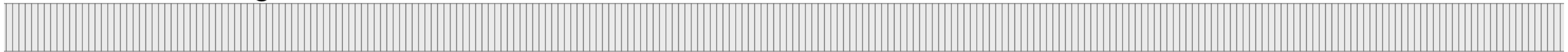
How to do Offline-Trigger Selection Filtering?







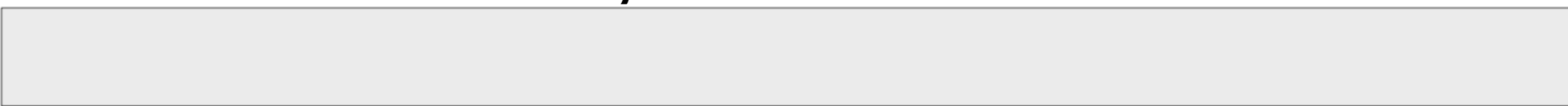
Bunch Crossings



TOF data stream: stream of hits sorted in time



TRD data stream: triggered readout frames of $\sim 3 \mu s$



TPC data stream: time bins of 200 ns



ITS data stream: readout frames of $\sim 5 \mu s$



Sketch of the data stream of 4 barrel detectors

Bunch Crossings

Selected BC

TOF data stream: stream of hits sorted in time

TRD data stream: triggered readout frames of $\sim 3 \mu s$

TPC data stream: time bins of 200 ns

ITS data stream: readout frames of $\sim 5 \mu s$

Sketch of the data stream of 4 barrel detectors

Bunch Crossings

Selected BC

TOF data stream: stream of hits sorted in time

TOF raw time has a constant shift of $\frac{1}{3}$ orbit

TRD data stream: triggered readout frames of $\sim 3 \mu s$

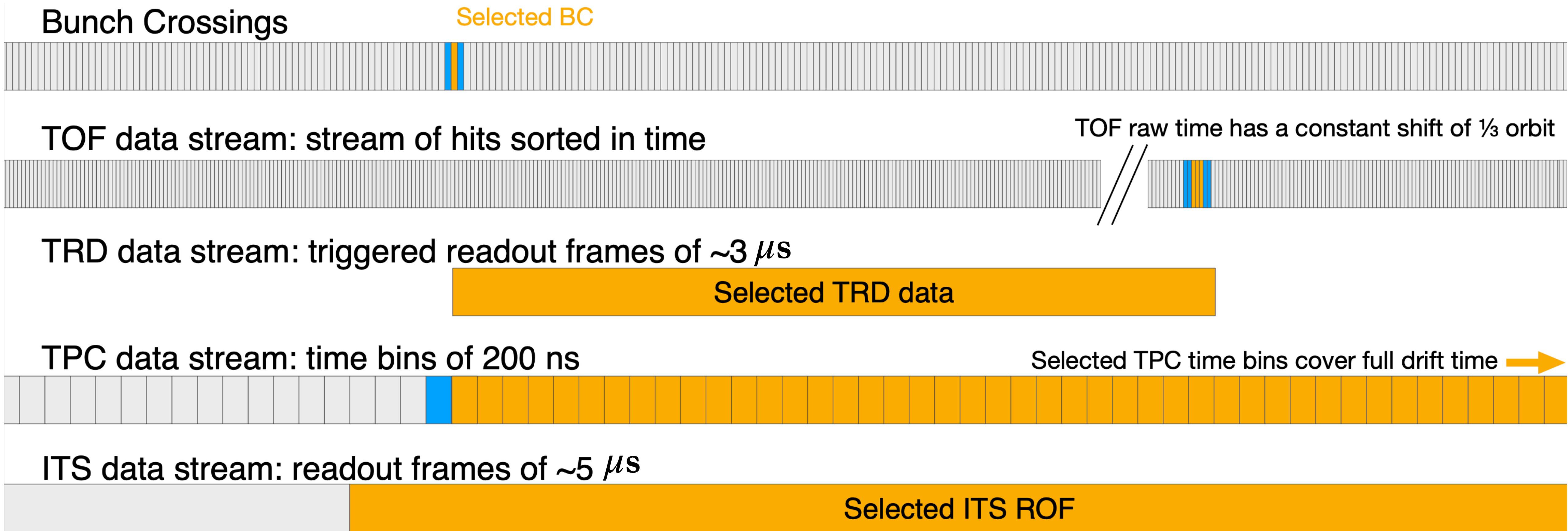
Selected TRD data

TPC data stream: time bins of 200 ns

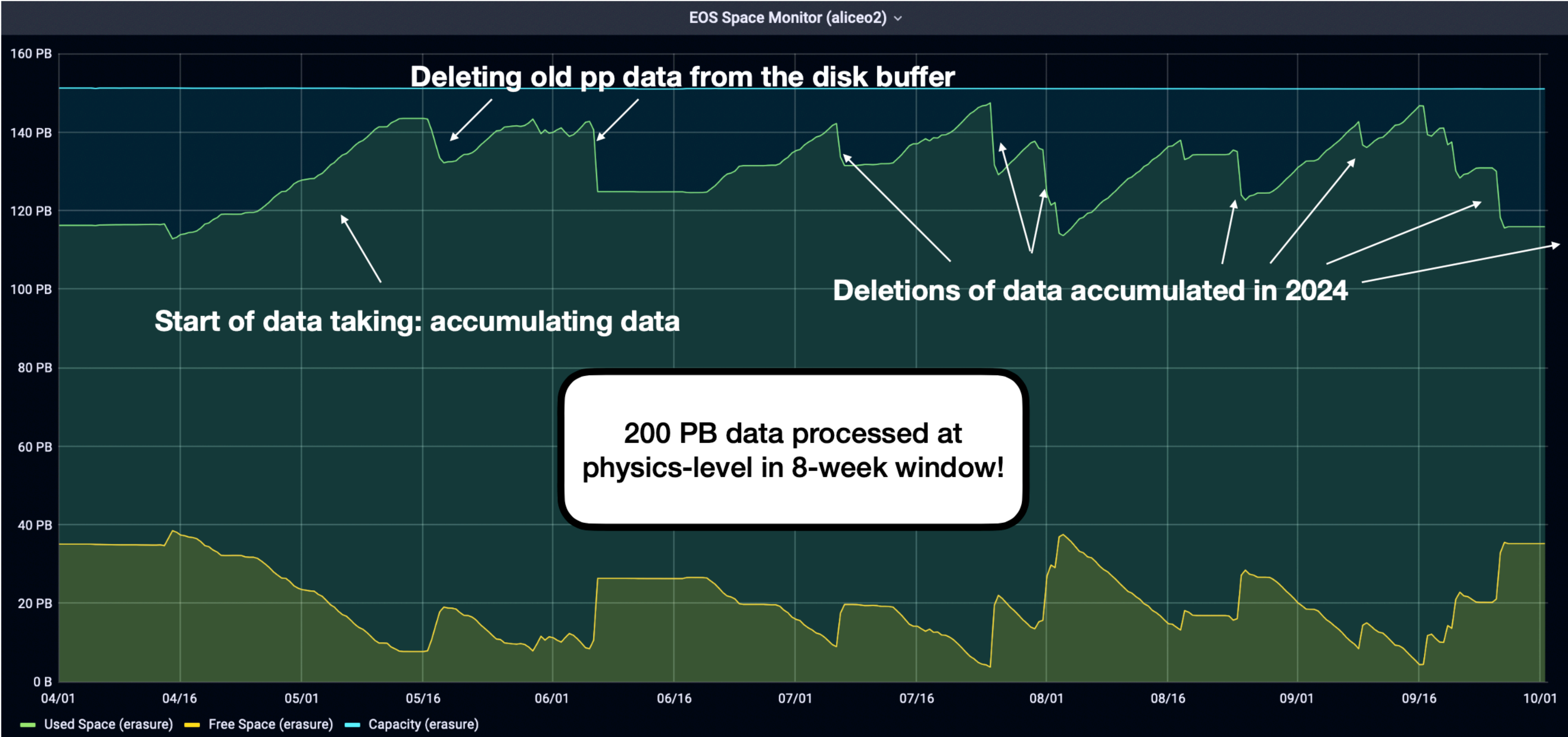
Selected TPC time bins cover full drift time →

ITS data stream: readout frames of $\sim 5 \mu s$

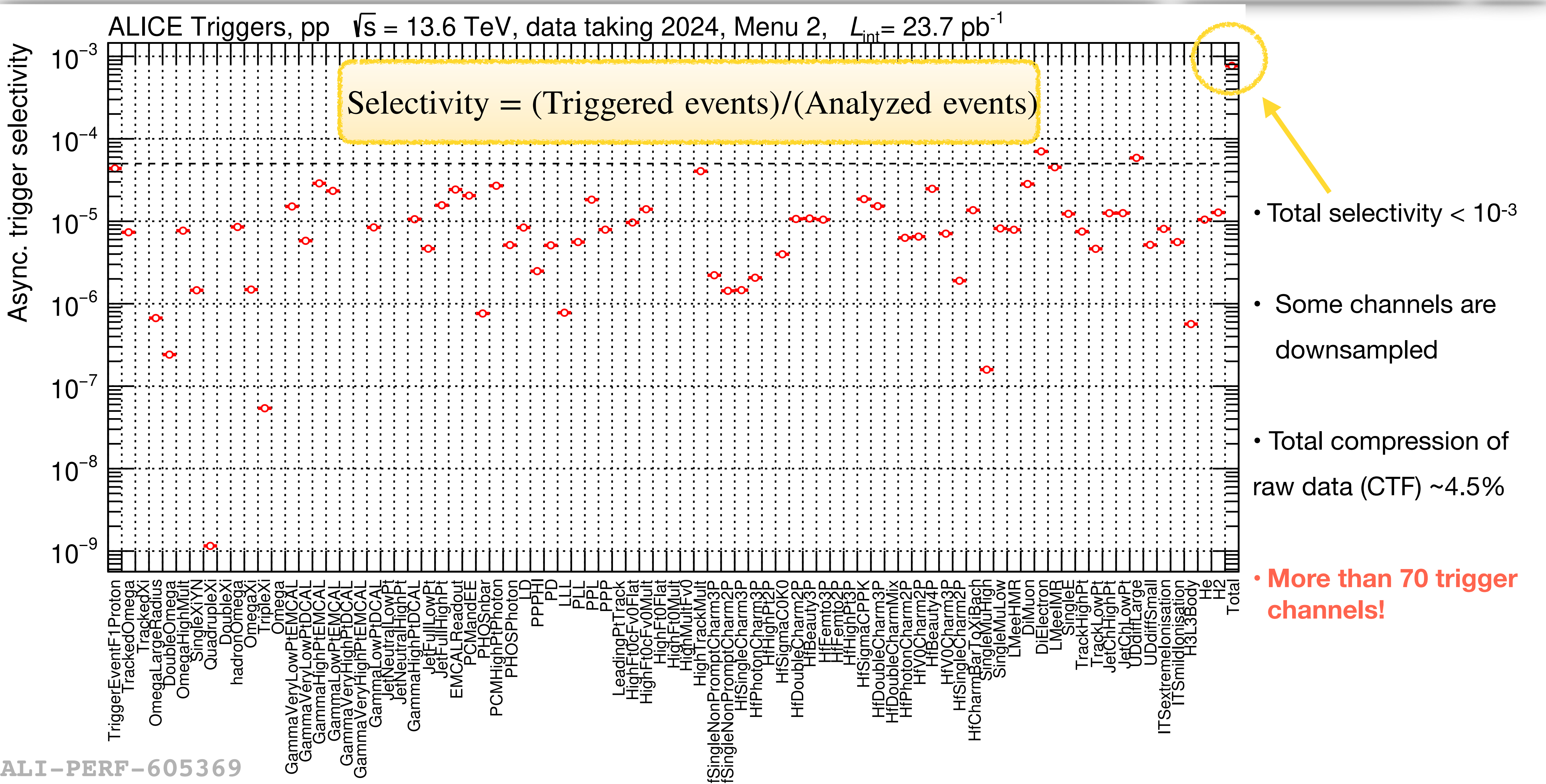
Selected ITS ROF



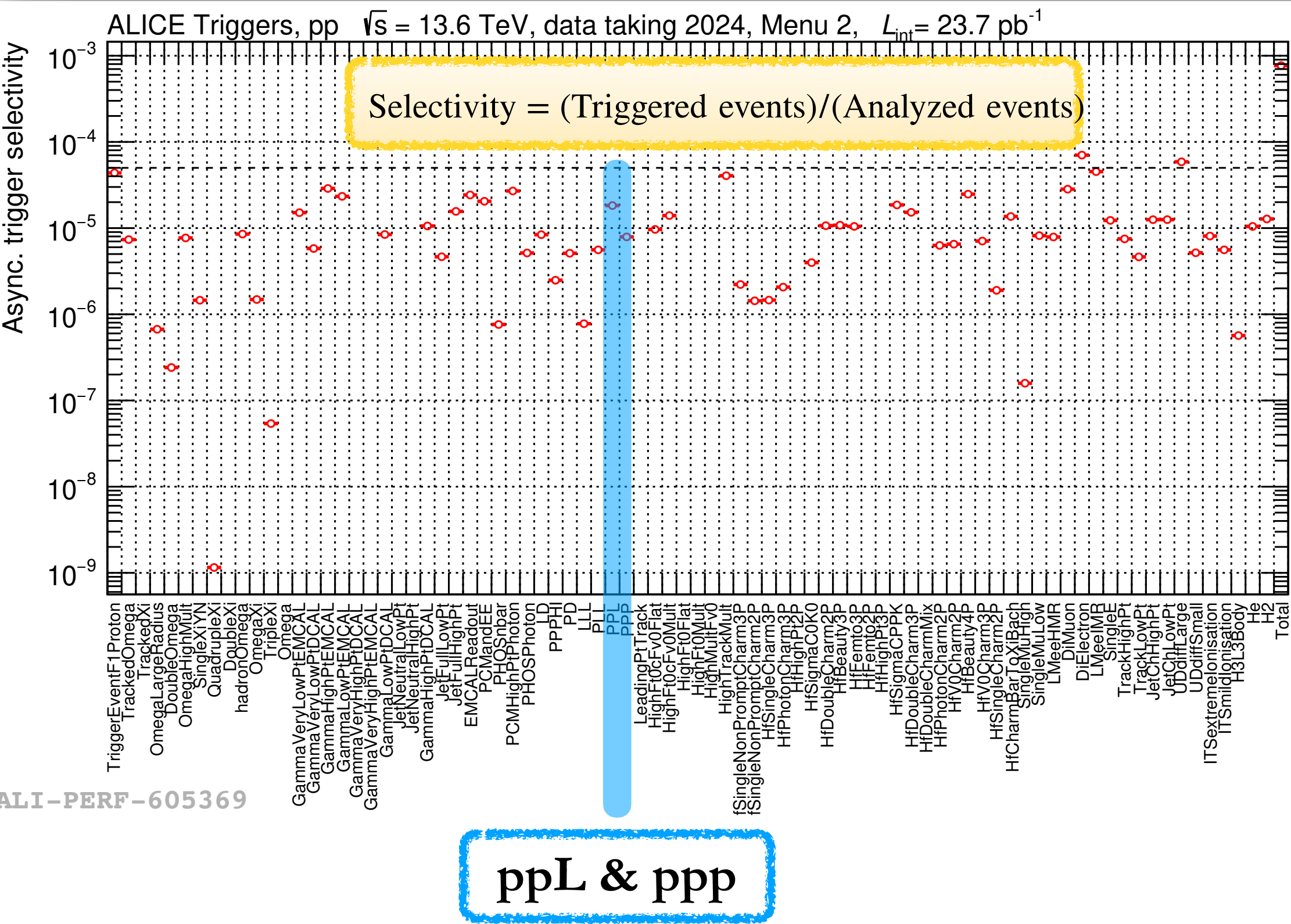
- BC window applied to account for the finite collision time resolution, which can exceed the 25 ns spacing of a single BC
- For pp collisions at 660 kHz, a window of ~ 1000 BCs is used around the selected BC.



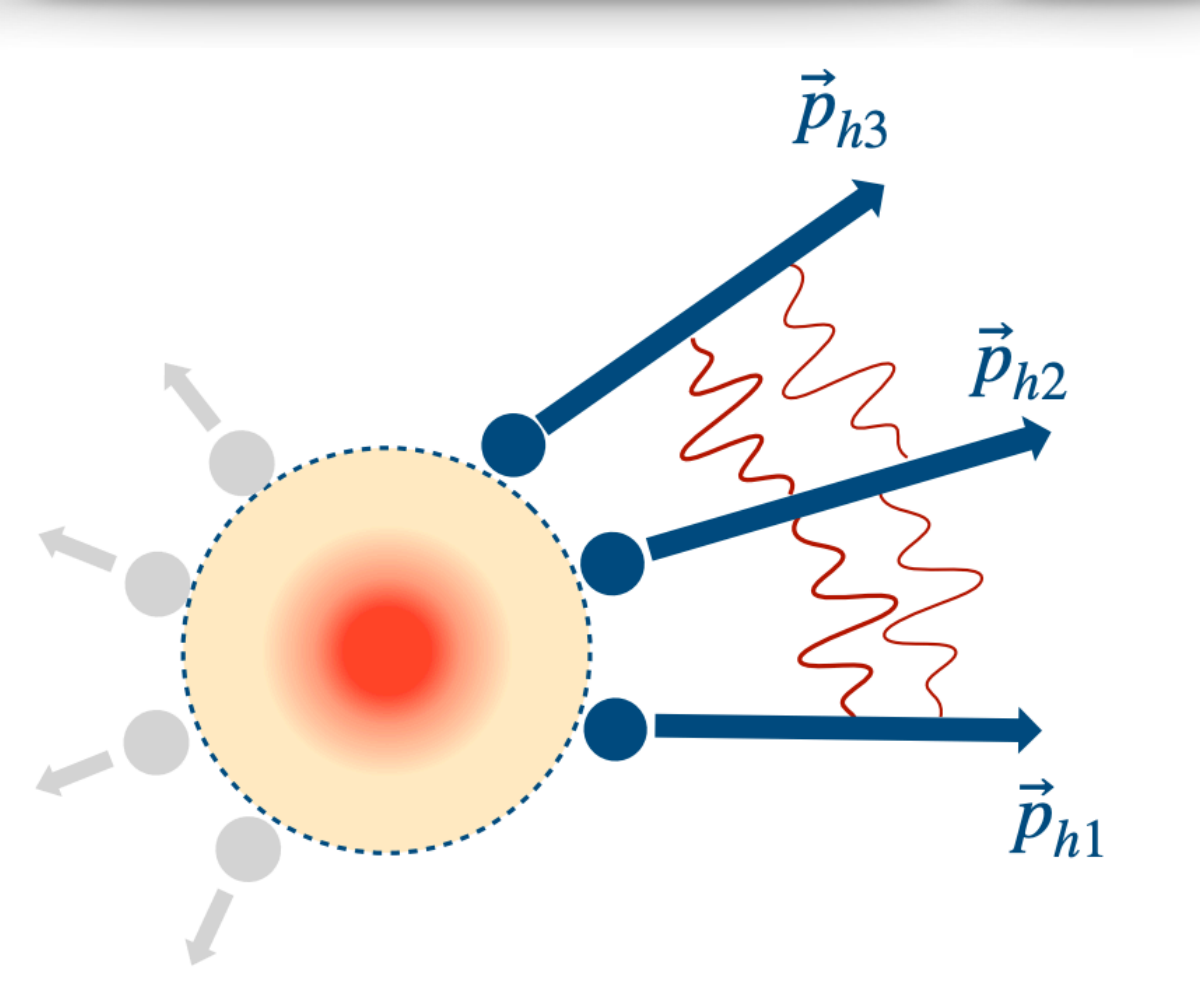
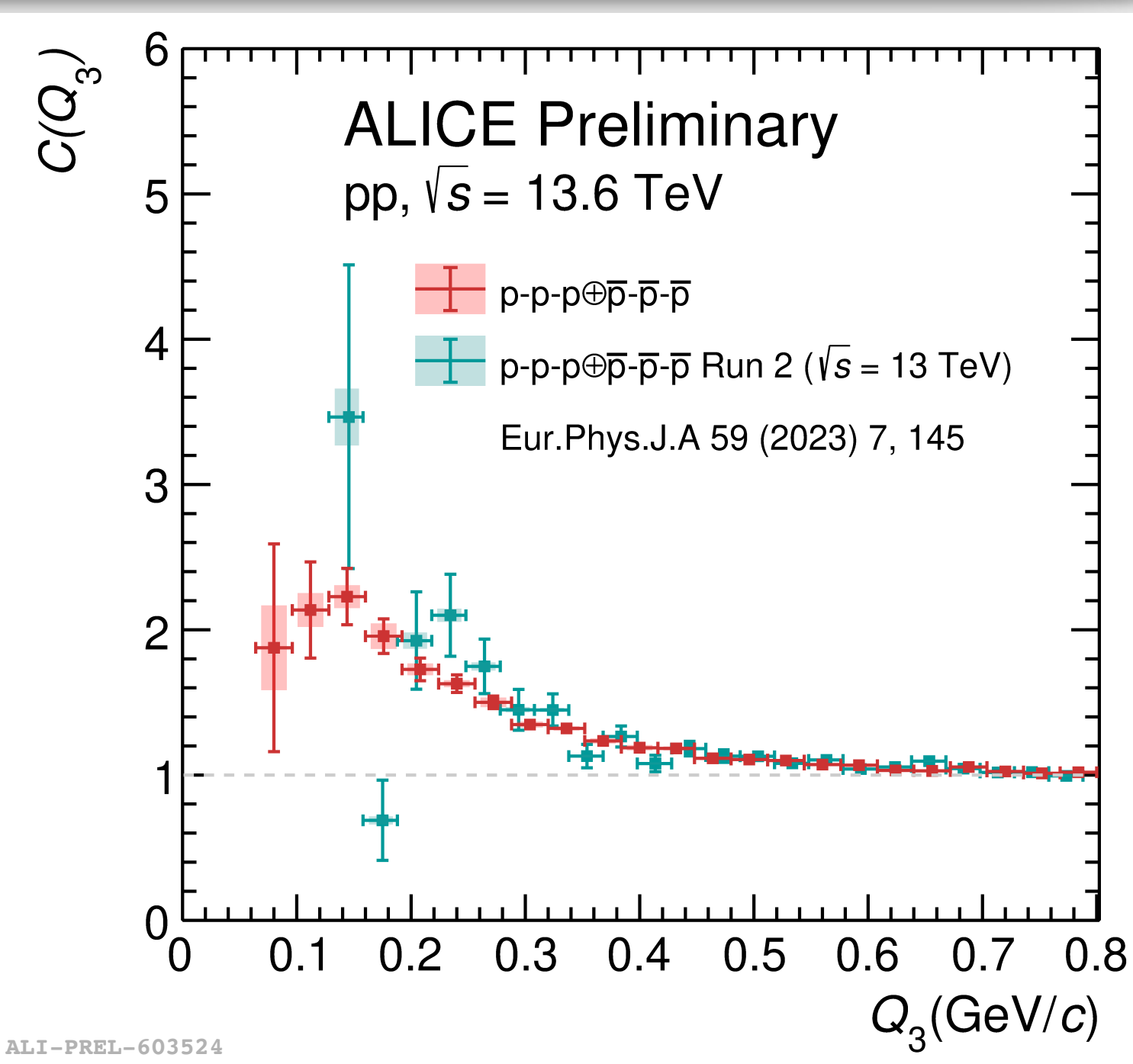
Offline Trigger menu



Offline Trigger menu: 3 body femtoscopy



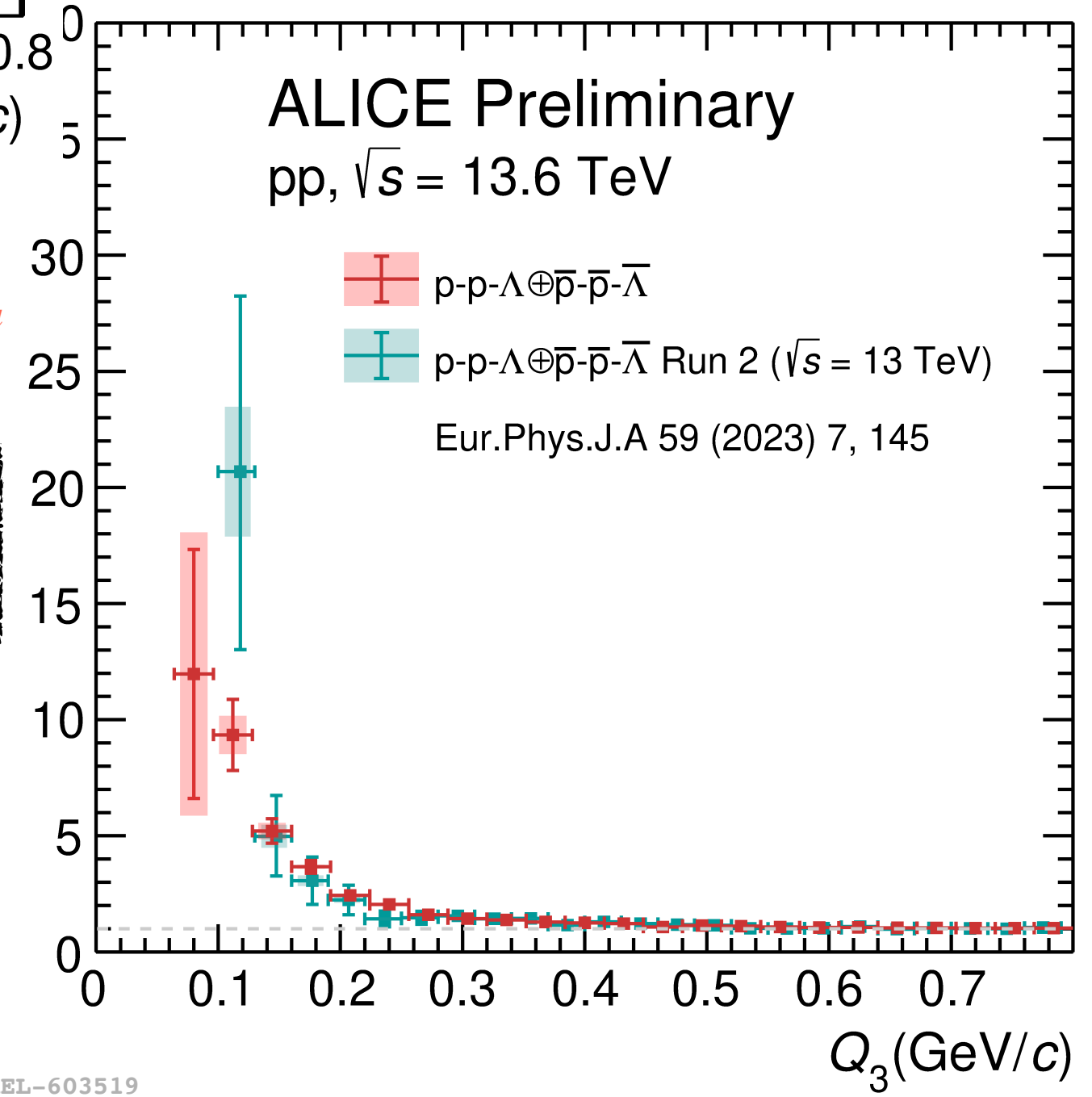
- Up to 40 times more triplets compared to Run 2
- Well explained with full three-body calculations



$$q_{ij}^\mu = (p_i - p_j)^\mu - \frac{(p_i - p_j) \cdot (p_i + p_j)}{(p_i + p_j)^2} (p_i + p_j)^\mu$$

$$Q_3 = \sqrt{-q_{12}^2 - q_{23}^2 - q_{31}^2}$$

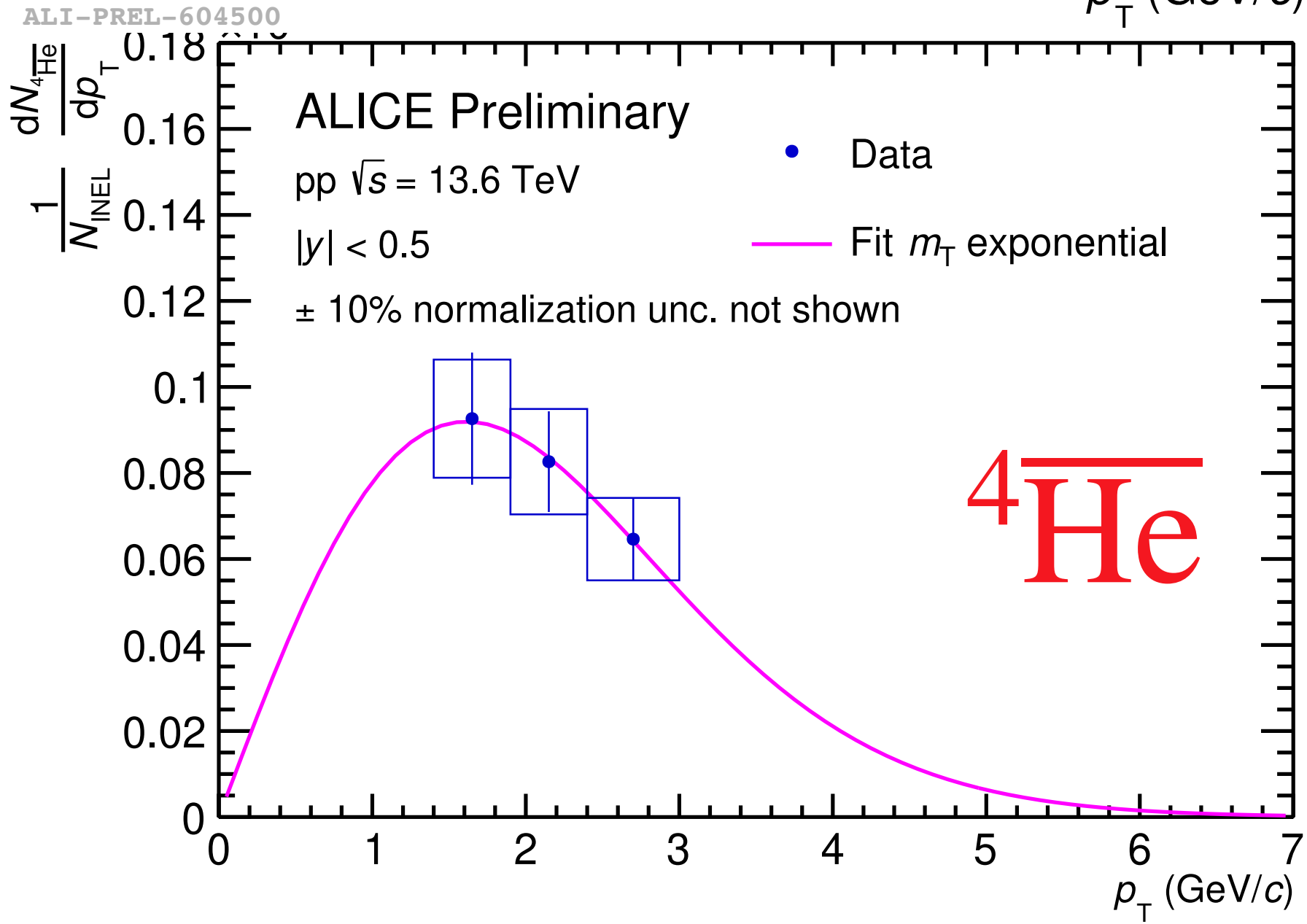
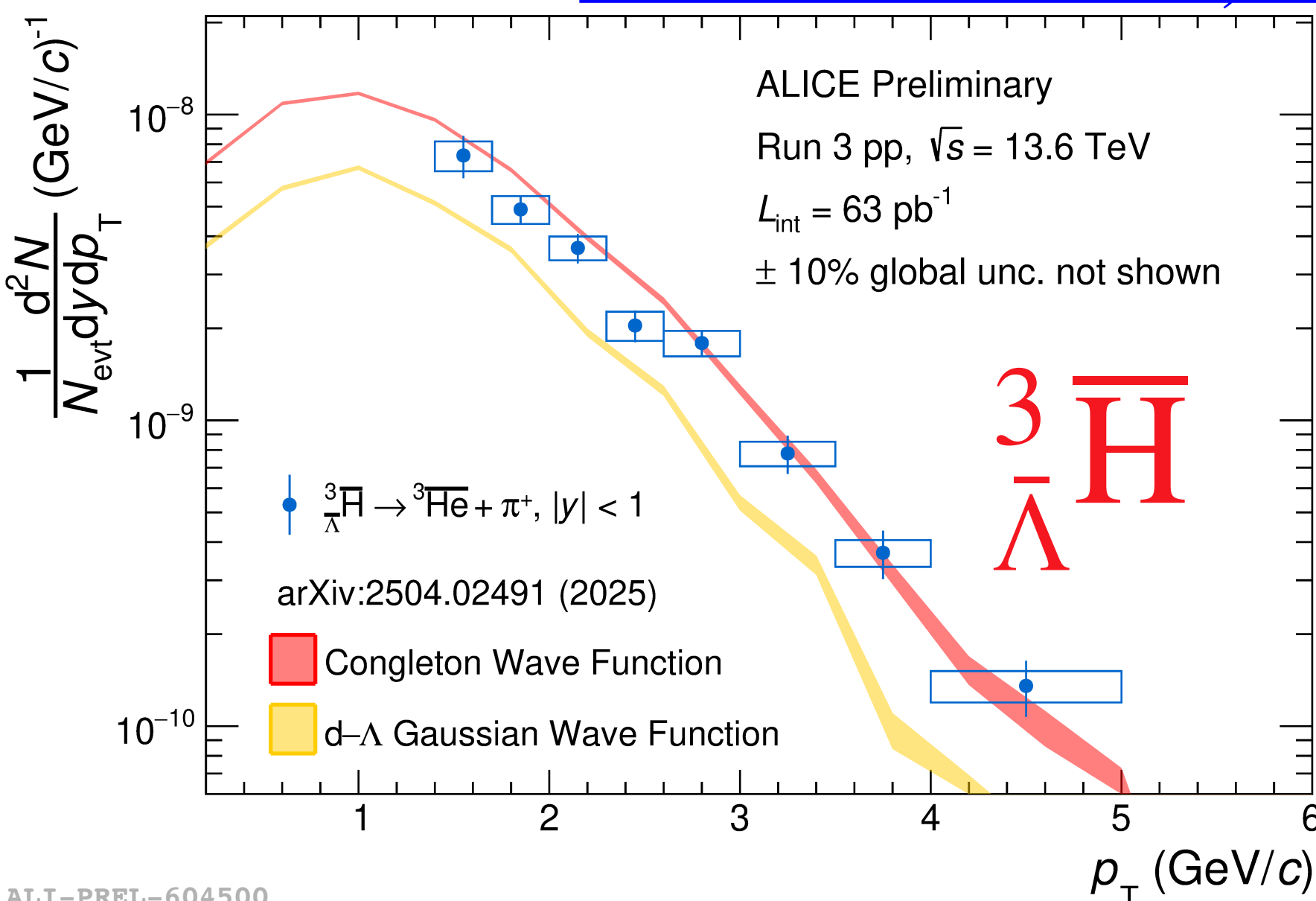
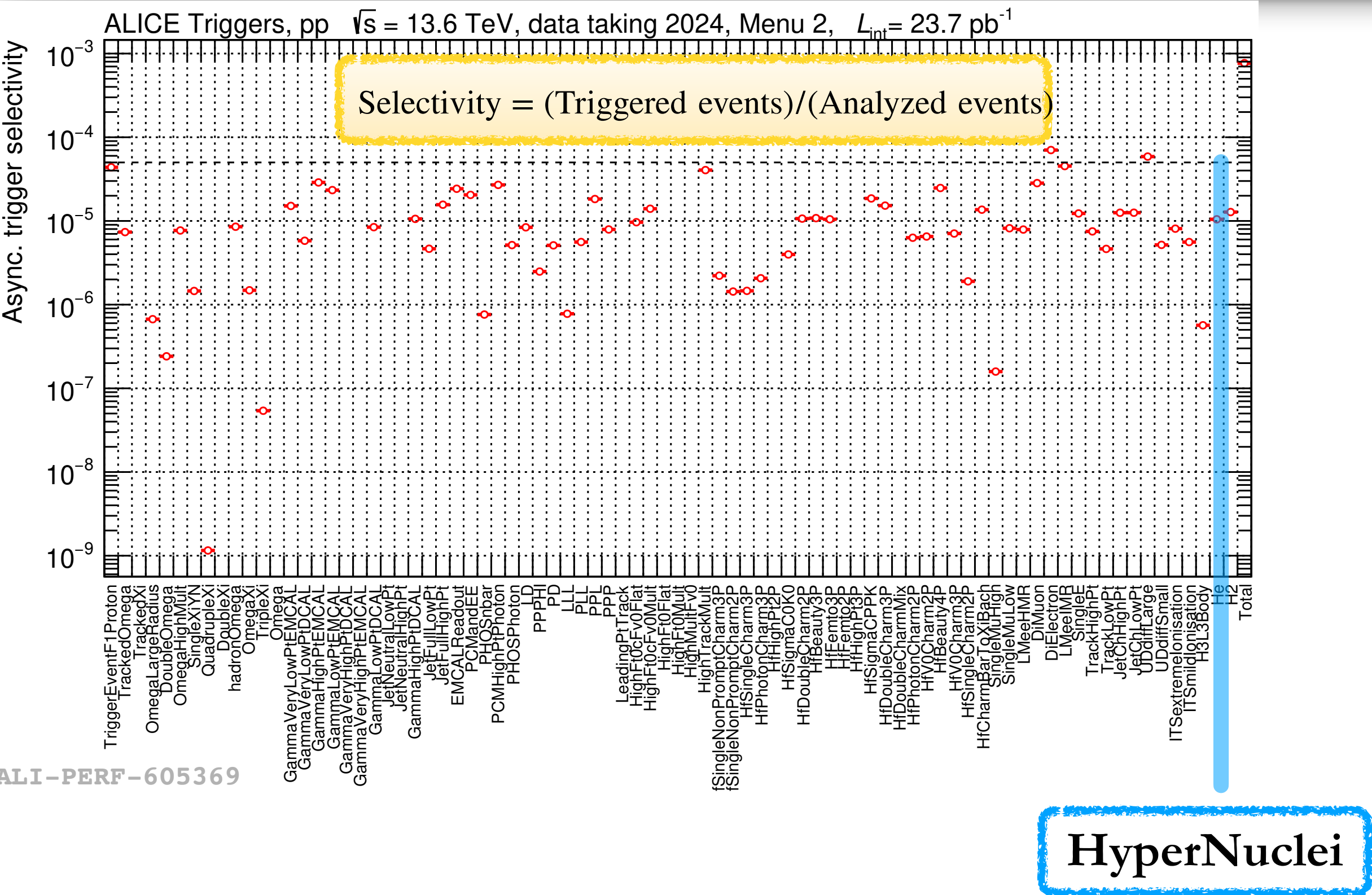
[Anton Albert Riedel's poster, Wed 18:23](#)



Offline Trigger menu: Antinuclei

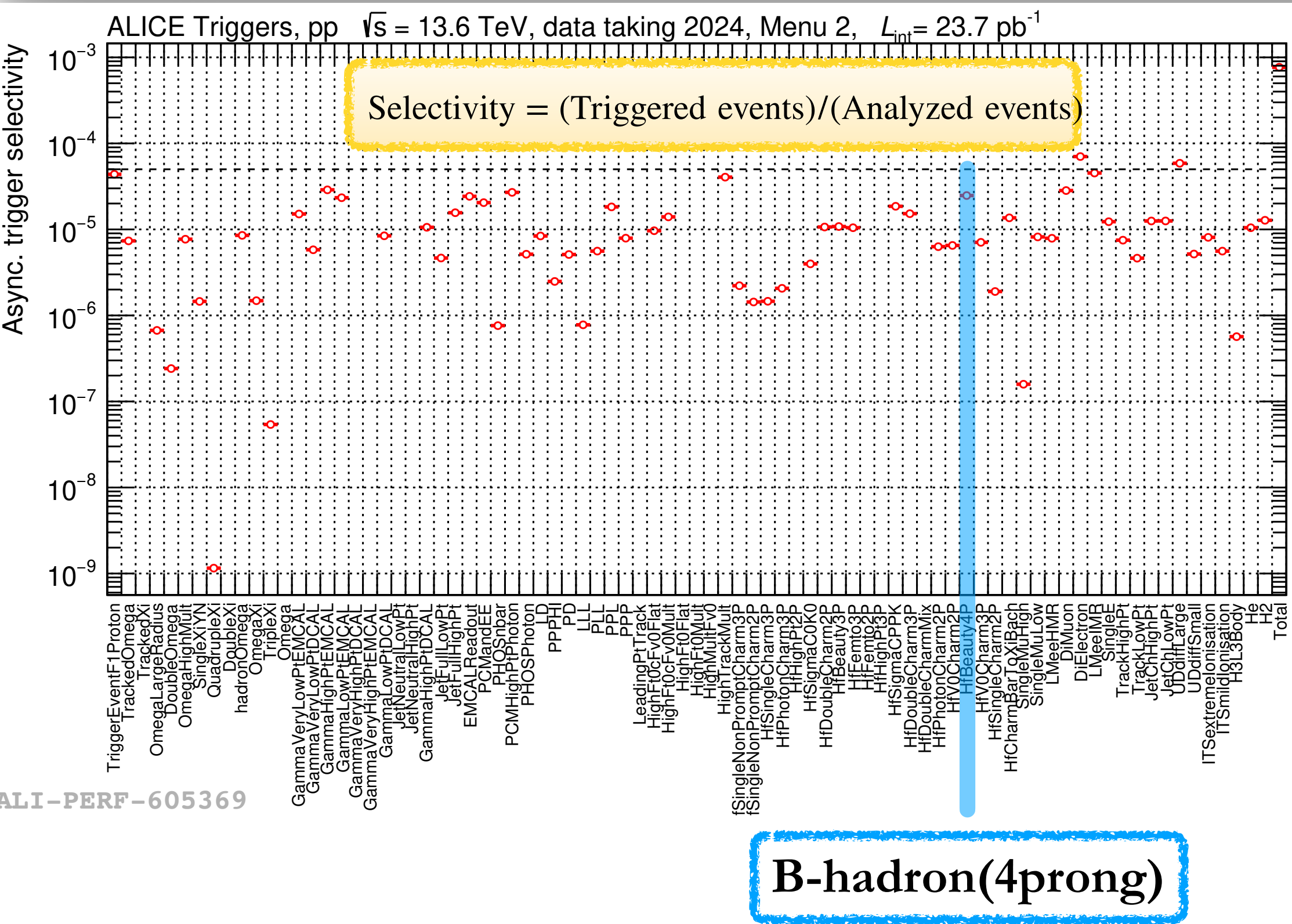


Carolina Anna Reetz, Mon 14:20



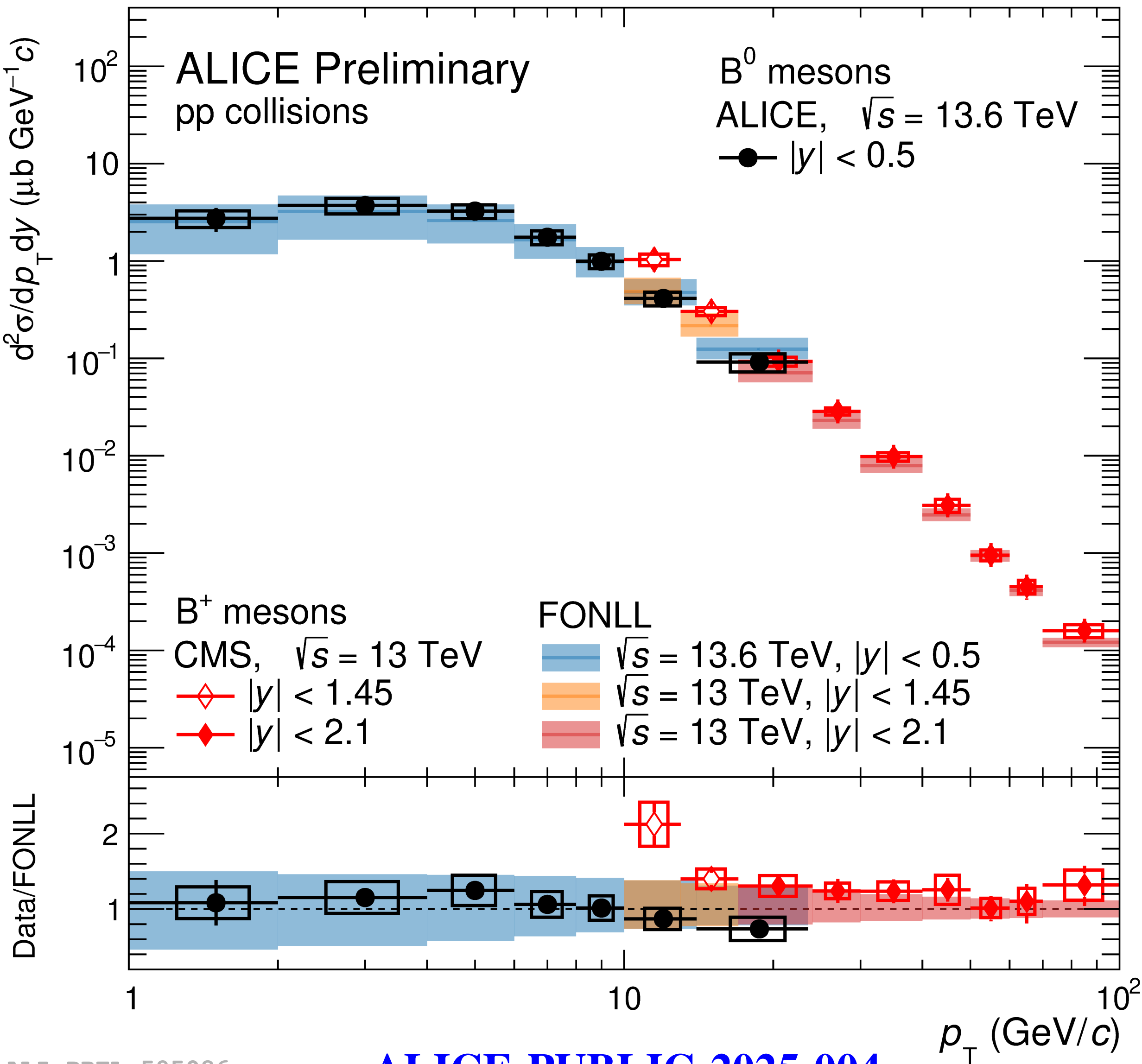
- $3\bar{\Lambda} \text{He}$: ~40 times increase in statistics with respect to Run 2
- First $4\bar{\text{He}}$ observation in pp collisions

Offline Trigger menu: B-hadrons



- First direct observation of B mesons in ALICE using triggered data
- Extended B meson production measurement at midrapidity down to very low p_T

[Antonio Palasciano, Mon 15:40](#)



Upgraded ALICE detector in Run 3 achieved :

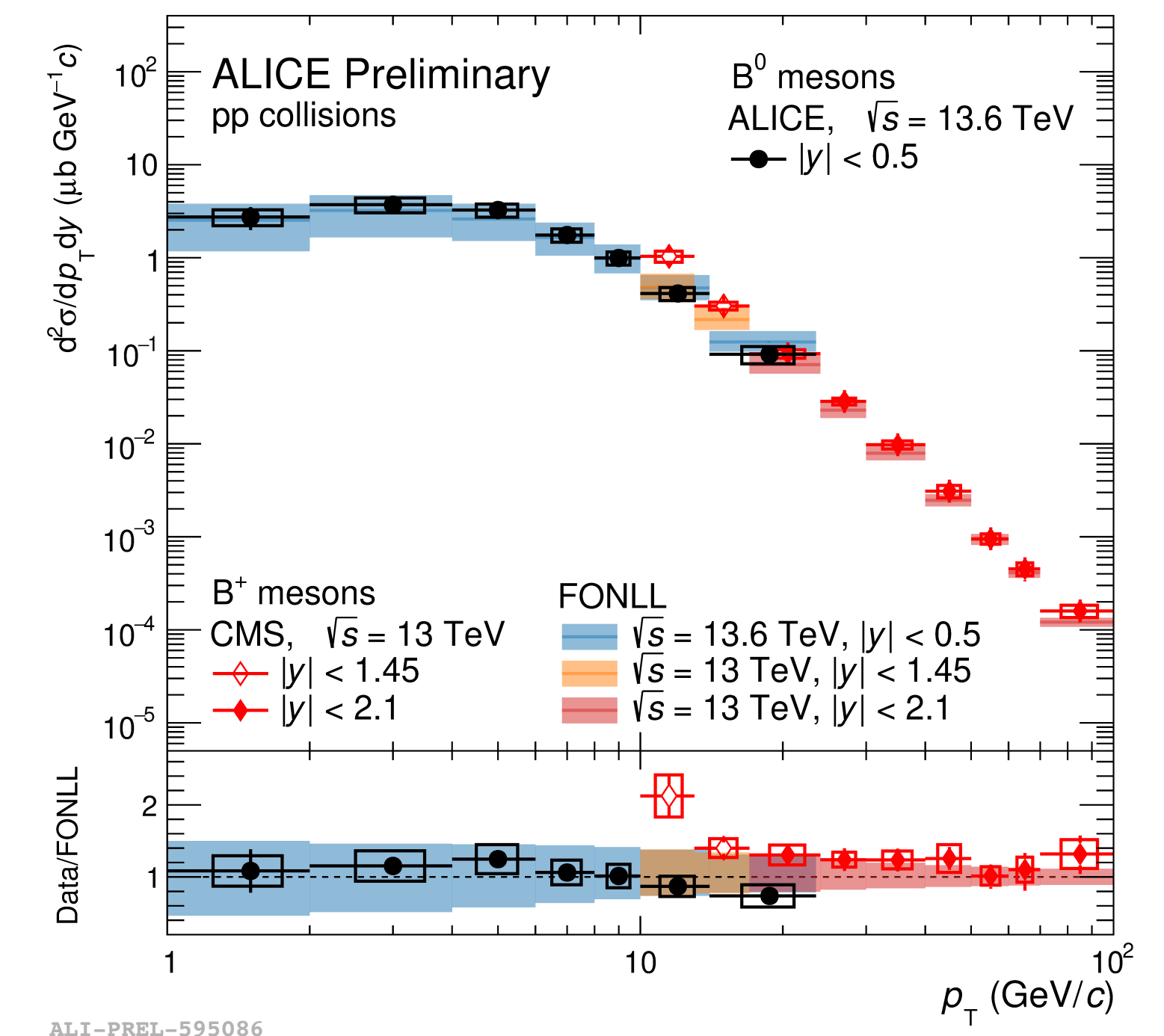
- Continuous readout system: handling ~50 kHz Pb–Pb and up to 5 MHz pp collisions

New ALICE asynchronous software trigger:

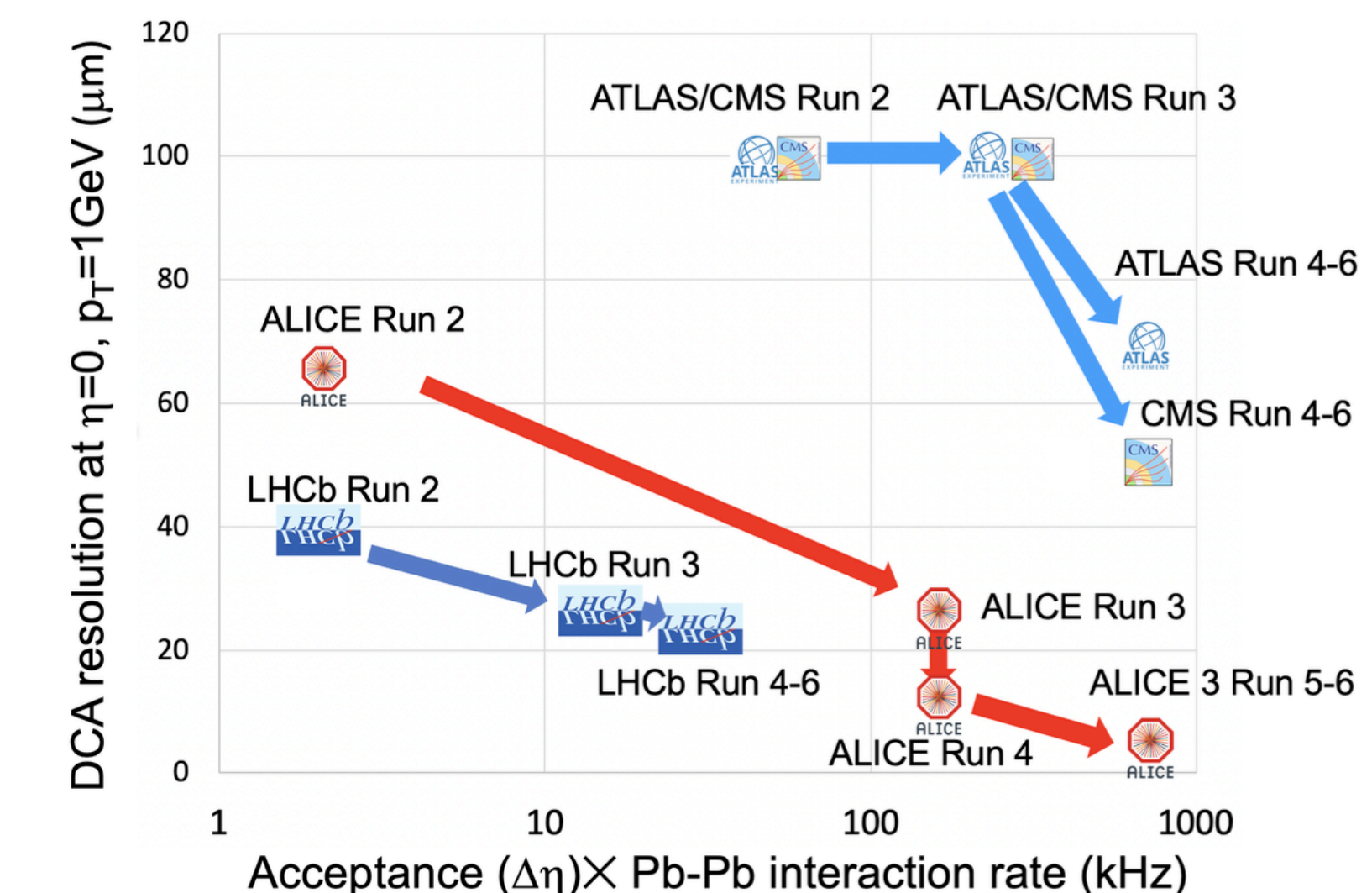
- High-speed and efficient processing enabled the successful inspection of 2000 times more pp collisions compared to Run 2

✓ **New physics results have been obtained from skimmed pp data**

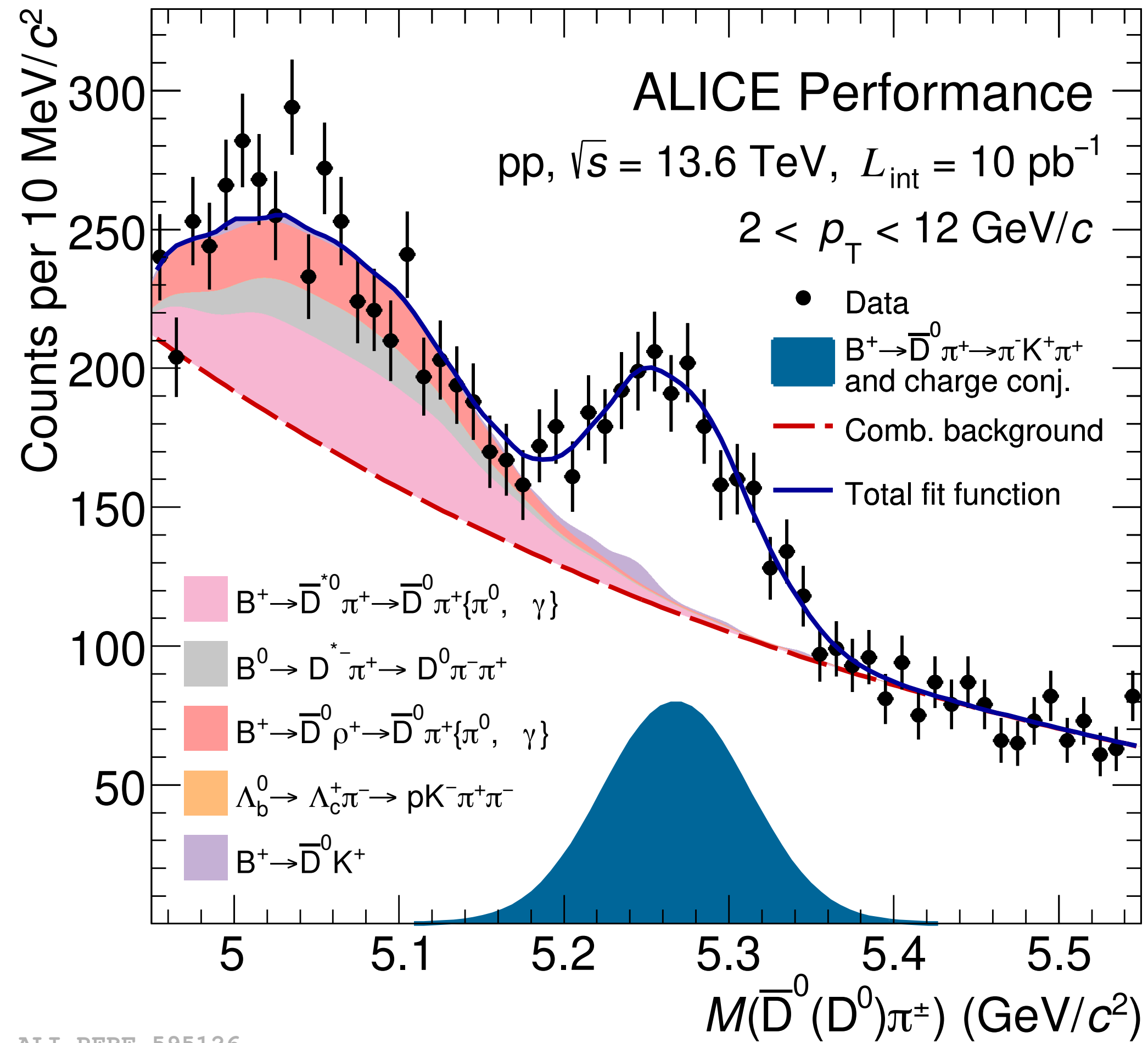
Outlook: More trigger channels will be added for 2025/2026 data processing, further extending the physics reach and improving data handling performance in Run 4!



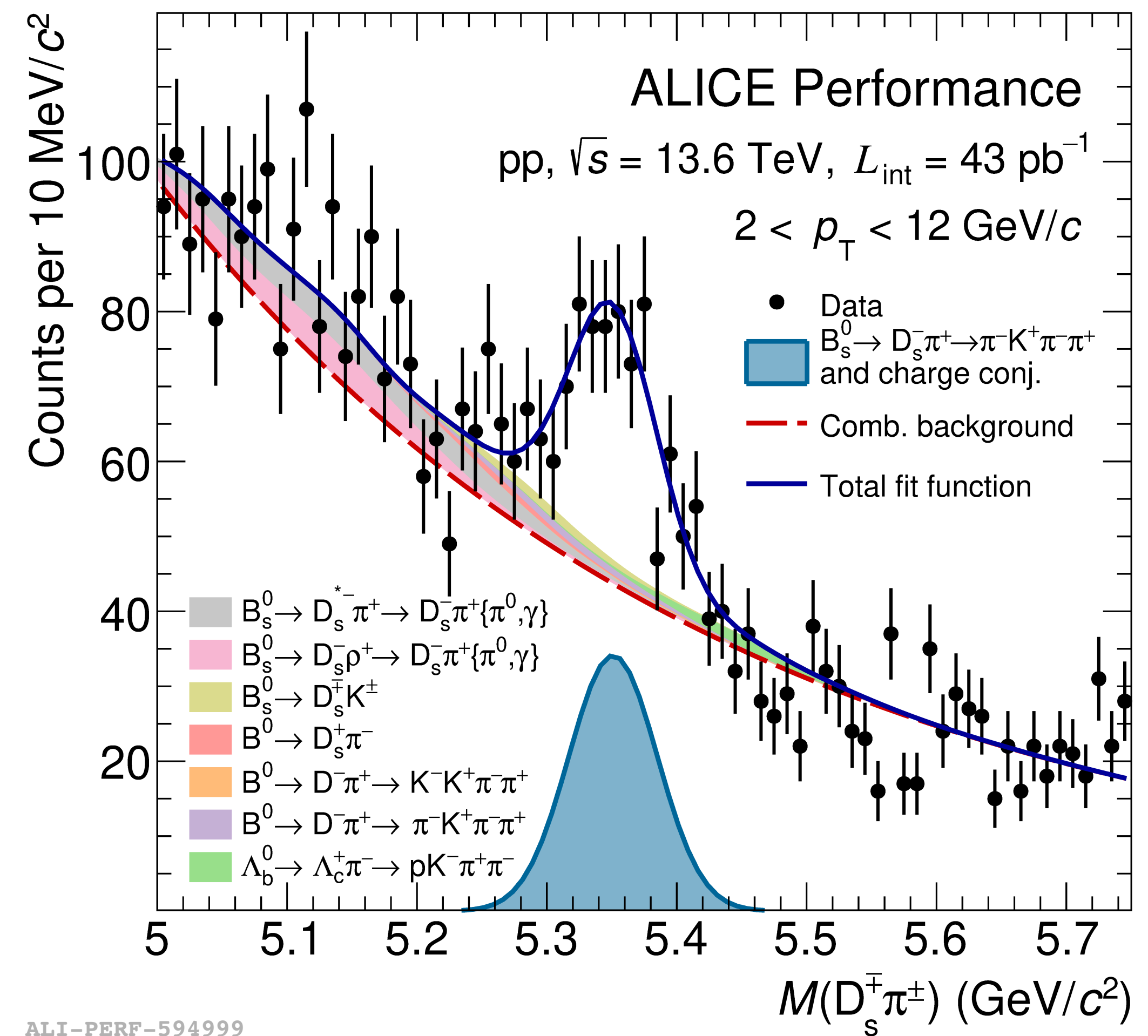
ALI-PREL-595086



Backup slides



ALI-PERF-595126



ALI-PERF-594999

