TPC Reconstruction

David Rohr
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Offline Week

9.11.2017

REMINDER: LAST STATUS

09/11/2017
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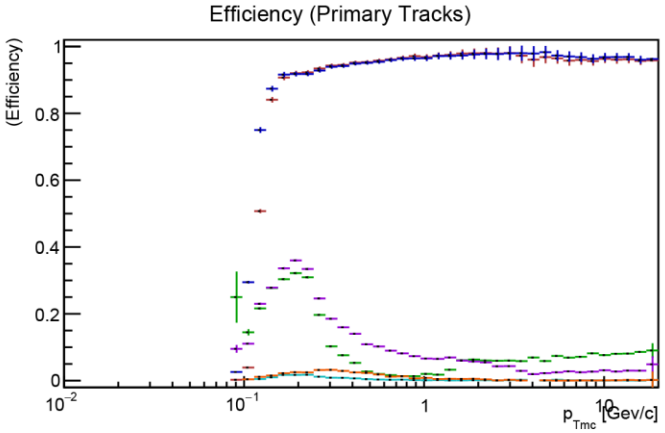
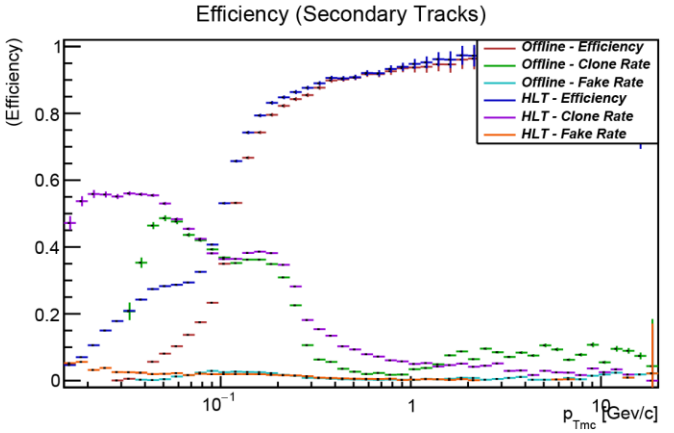
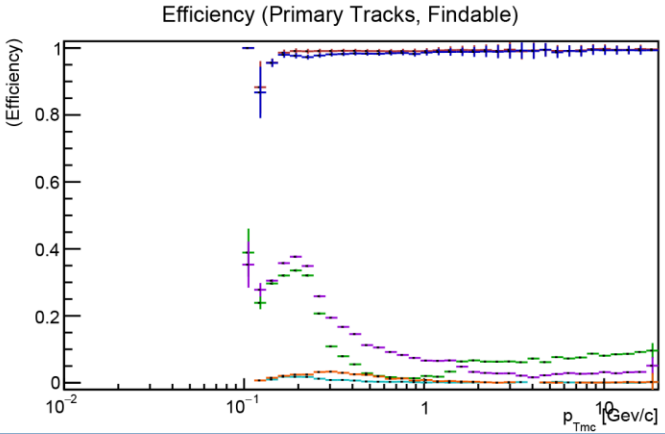
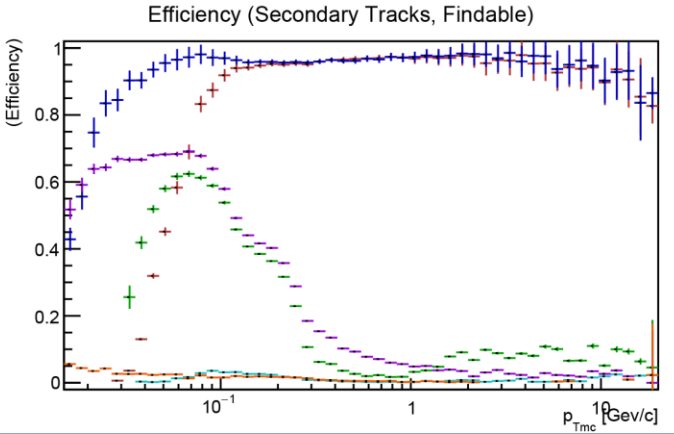
Last status report: Comparison of HLT to Offline tracks (Pb-Pb – LHC15o)

- **Good efficiency for primaries both for findables and for all tracks.**
- **Comparable to offline.**
- **Secondary efficiency comparable down to 200-300 MeV.**
- **HLT better for lower p_T due to new low-p_T settings.**
- **Low-p_T data below 100 MeV in these plots is misleading due to bad track selection: all tracks contain too many tracks not touching the TPC at all while findables is much too strict.**









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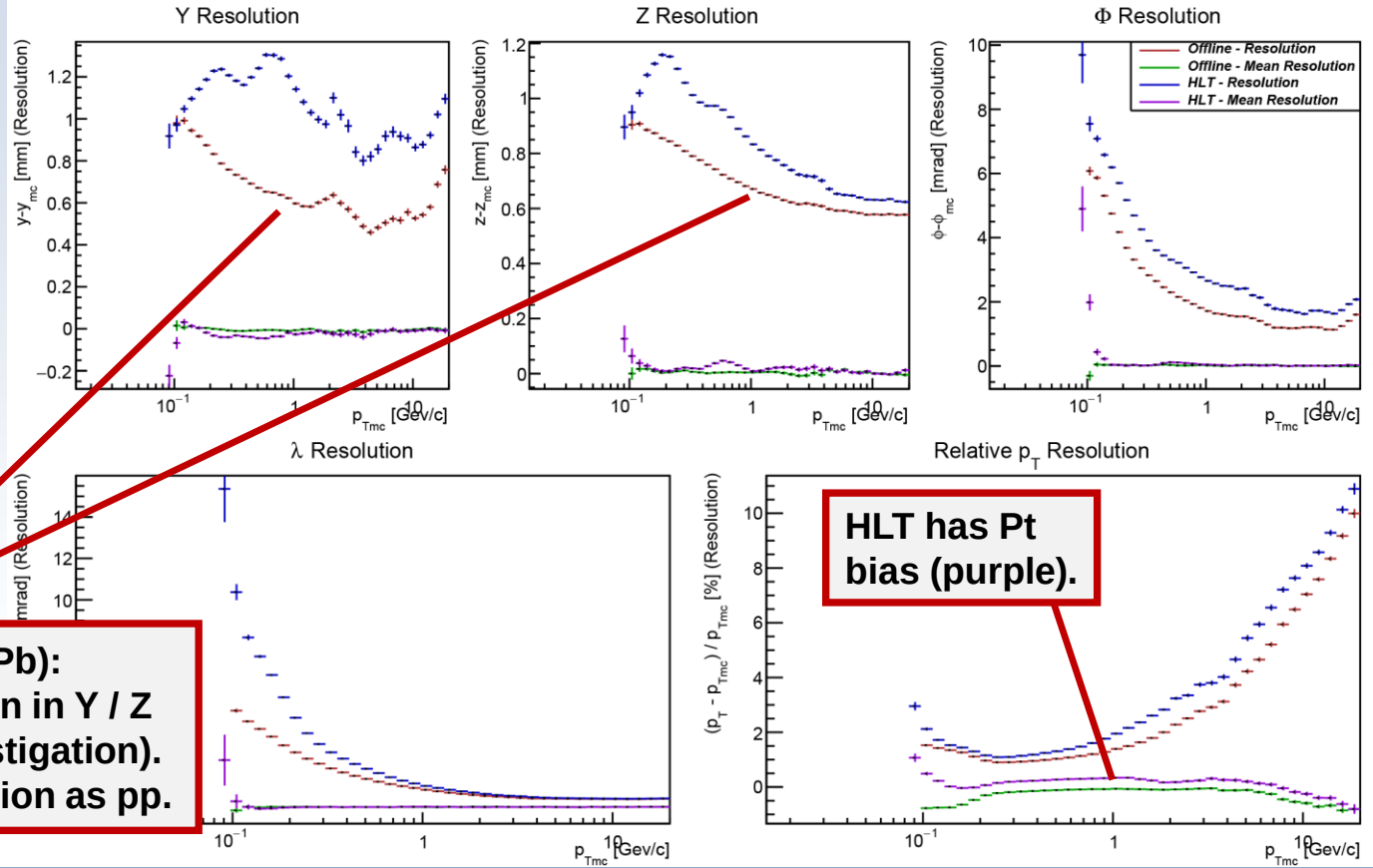
Last status report: Comparison of HLT to Offline tracks (Pb-Pb – LHC15o)

- HLT resolution much worse in Pb-Pb (in particular Y and Z).
- This is unexpected because that should be mostly dominated by cluster coordinates of the innermost rows.

- We have used identical cluster transformation for HLT and offline for these tests.
- Needs additional study.



Summary Resolution (Pb-Pb):

- Significant deterioration in Y / Z resolution (under investigation).
- Otherwise, same situation as pp.

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TRACKING IMPROVEMENTS

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Feature Updates

- **Use Bx / By in fit → cures the Pt bias mostly (Sergey).**
  - Improved polynomial field parameterization.
- **3-way fit like in offline.**
  - Outlier rejection implemented, yet only with a very basic cut, can be tuned.
  - Could add clusters during refit if a row is missing.
- **Storage of TPCOuterParam implemented (needed for TRD extrapolation).**
- **TPC tracking now available in normal O2 build (no special branch)**
- **Fixed merging / refit of low-Pt tracks.**
  - All known issues solved, but the current merging does not cover all cases.
    - In sector merging requires the track to cross the middle of the sector.
    - In-between sector merging can only merge the leg on one side.
    - Cannot merge segments when a leg in between is missing.
- **Seeding improved.**
  - CA seed no longer considered as truth, but can be refined.
  - Operates with eta-window instead of vertex window. (Needed for continuous data, low-Pt legs, deep secondaries.)
- **Tracking can work independent of absolute z. (Needed for continuous data.)**
  - Now, |Z| = 125 assumed for error parameterization, B-field query, etc.
  - Ongoing effort to replace this by reasonable z-estimate (for primaries at least).

- **Still missing:**
  - Additional merging methods for low-Pt, propagation / merging across central electrode, use new O2 data formats, improve cluster rejection.

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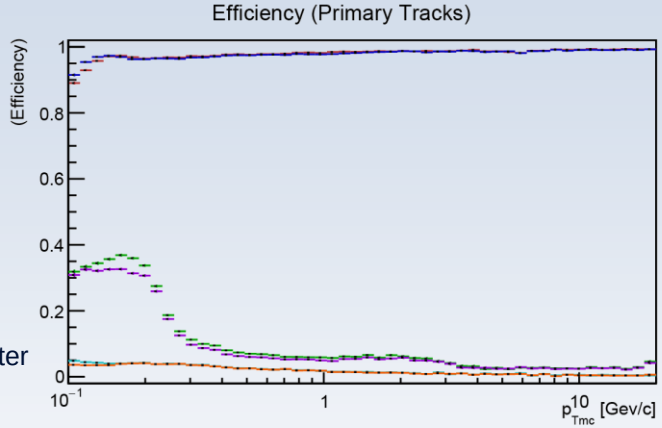
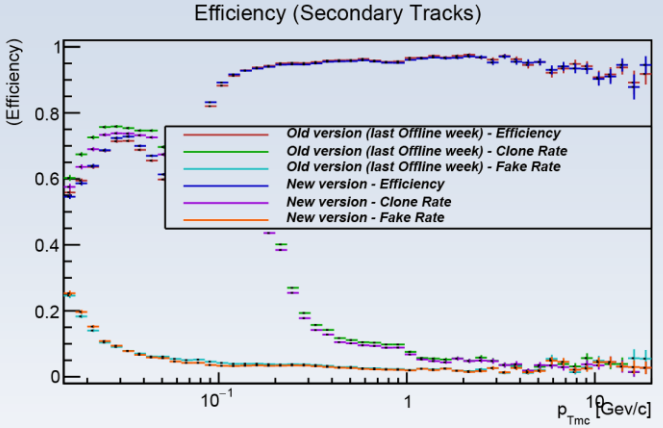
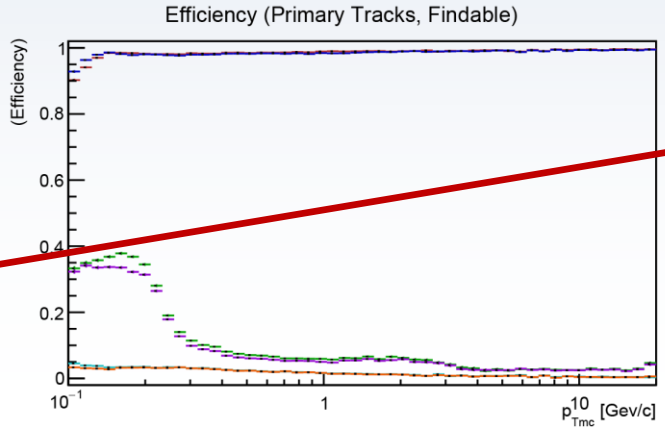
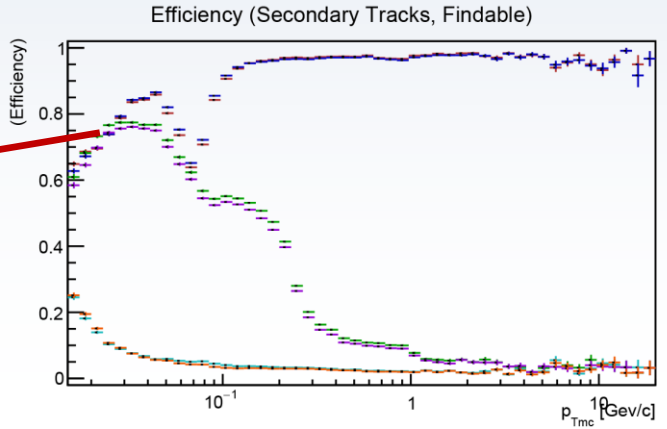
Tracking improvements

- **Low-Pt efficiency improved.**
- **Old version does not require successful track fit in order to mark the track as found, the new version does.**
  - Still, better efficiency.
- **More legs of low-Pt tracks found in new version.**
  - Per se, more clones.
  - Lower net clone rate because of better merging.
- **All tracks:**
  - At least 1 TPC cluster required.
- **Findable:**
  - At least 70 TPC clusters required.









- **80% efficiency at 50 MeV**
- **~60% efficiency at 15 MeV**

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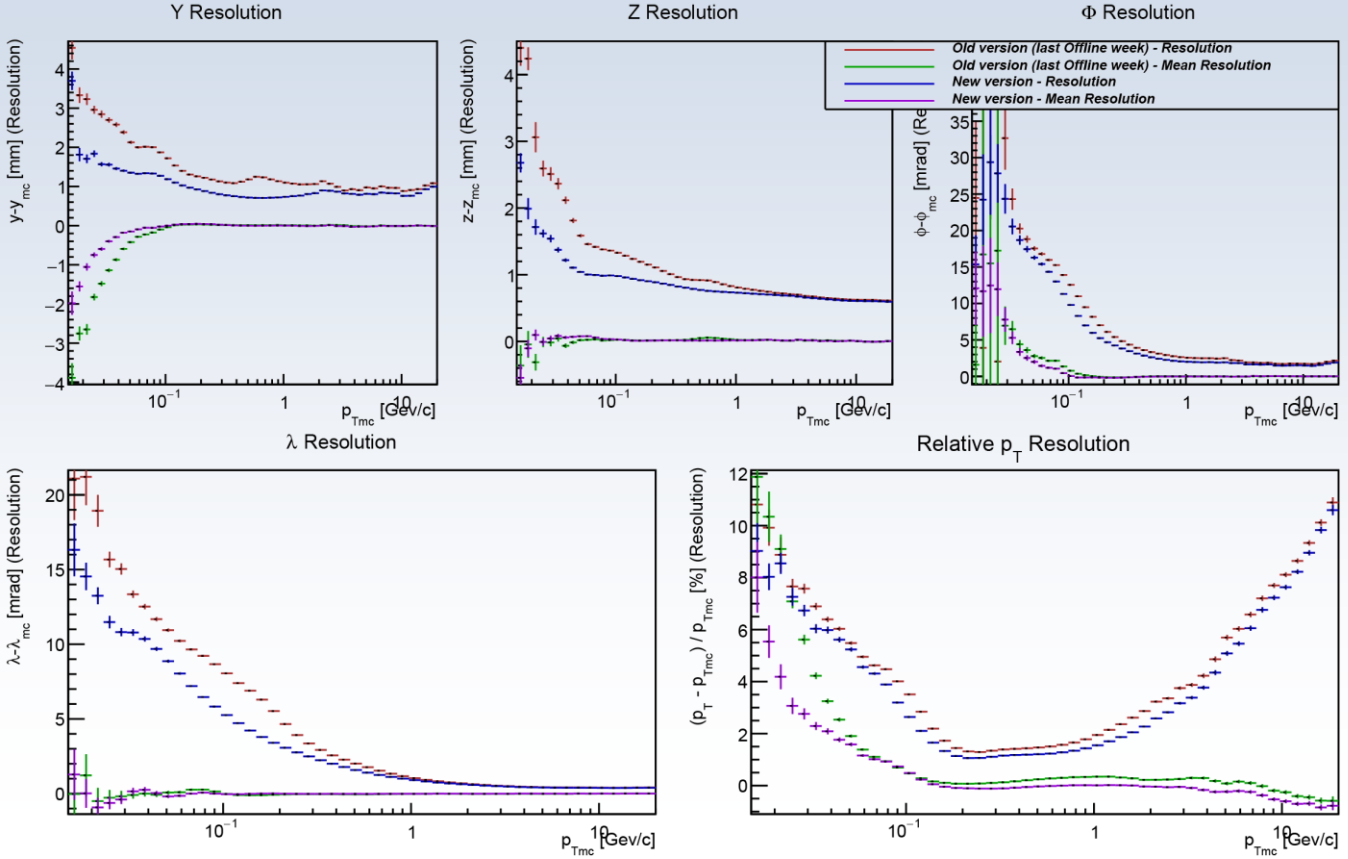
Tracking improvements

- **Generally better resolution in new version.**



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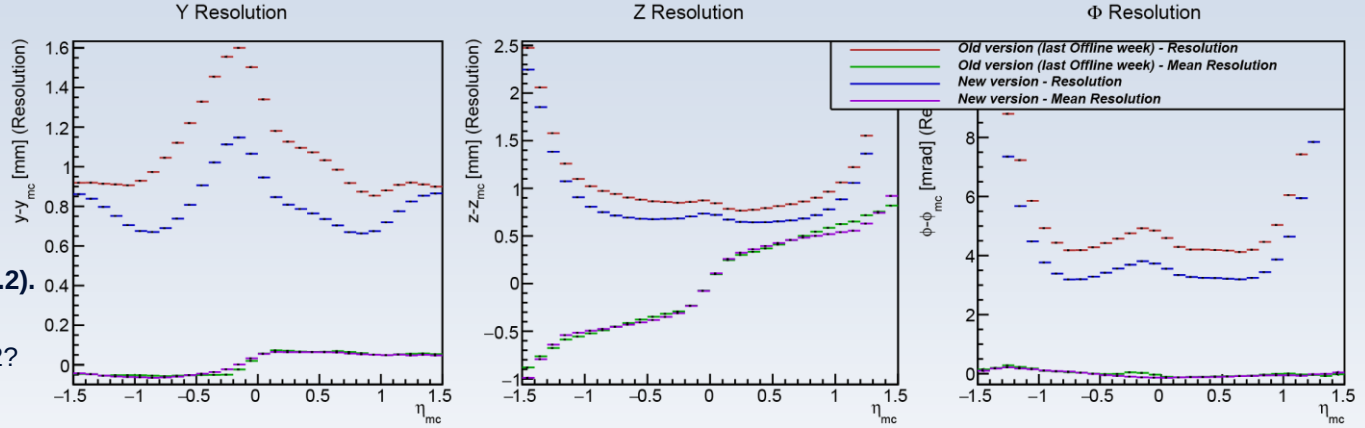
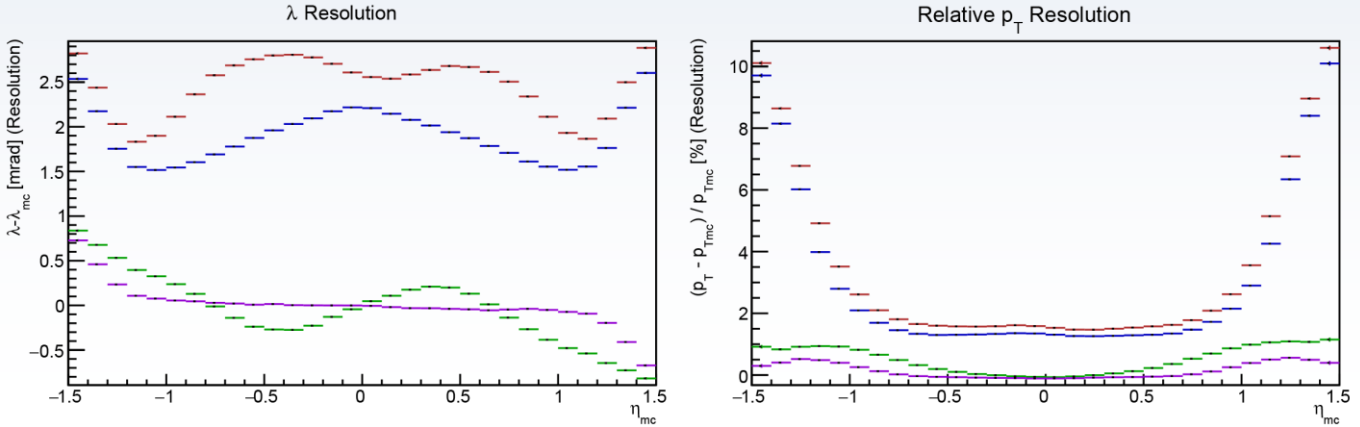
Tracking improvements

- **Eta-dependent bias in Pt resolution mostly cured.**
  - Fit now uses Bx and By field compoenents.
  - Question: Why is there still a bias for eta > 0.7?
- **Eta dependent structure in lambda bias mostly fixed (except for eta > 1.2).**
  - Corrected linearization in 3way fit.
  - Why is there still a bias for eta > 1.2?





- **Still missing:**
  - Some problem with new derivatives introduced in the fit.
  - Repeat comparison to current offline tracking when this is fixed.

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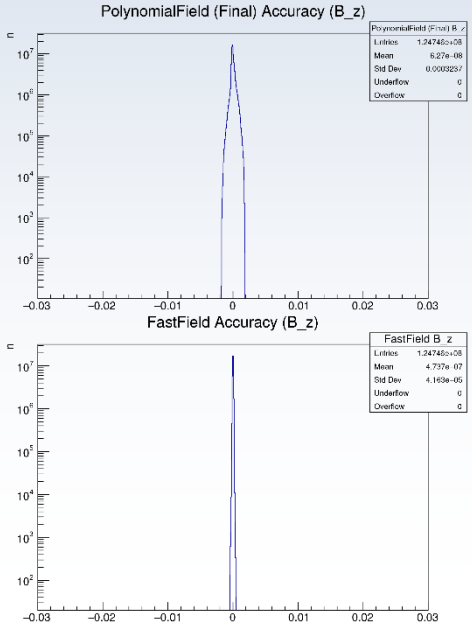
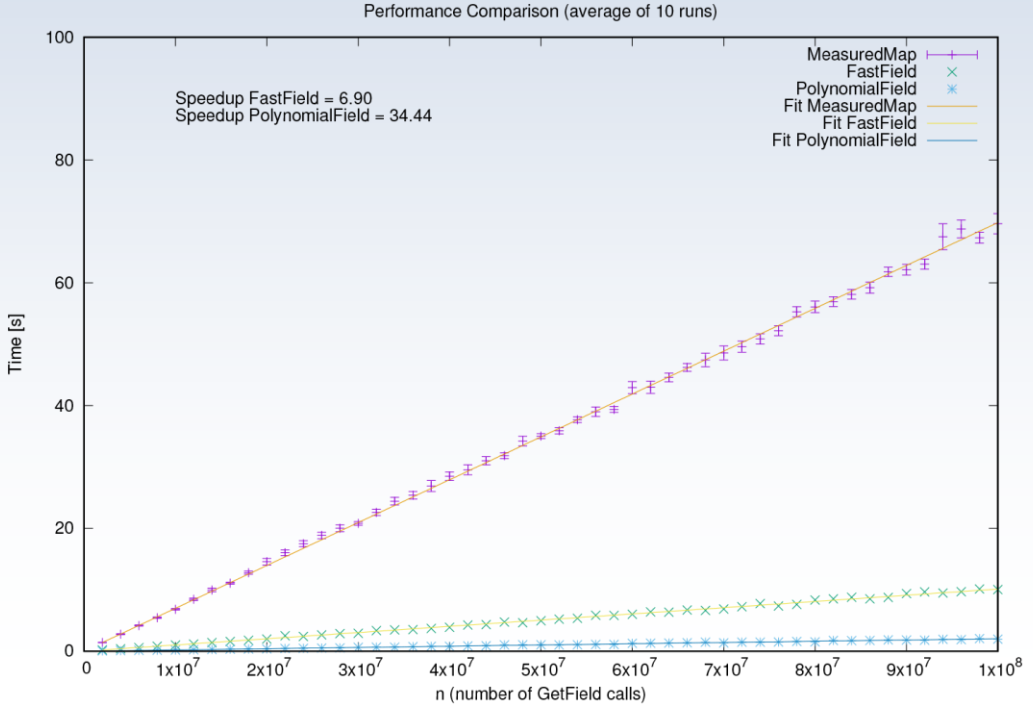
B-Field parameterization.

- **HLT has used polynomial parameterization of magnetic field since a long time.**
  - We have improved that parameterization, and added Bx and By **(Bachelor student supervised by Sergey: Vito Alexander Nordloh)**
  - The new FastField available in AliRoot / O2 is not really suited for GPUs, since it still needs too much memory.
    - Memory consumption: Chebyshev field map: 885 kb, Fast field: 105 kb, HLT polynomials: 120 bytes
  - Several times faster than fast field, less accurate but sufficient.
  - No difference in tracking resolution observed.





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LOW-PT TRACKING

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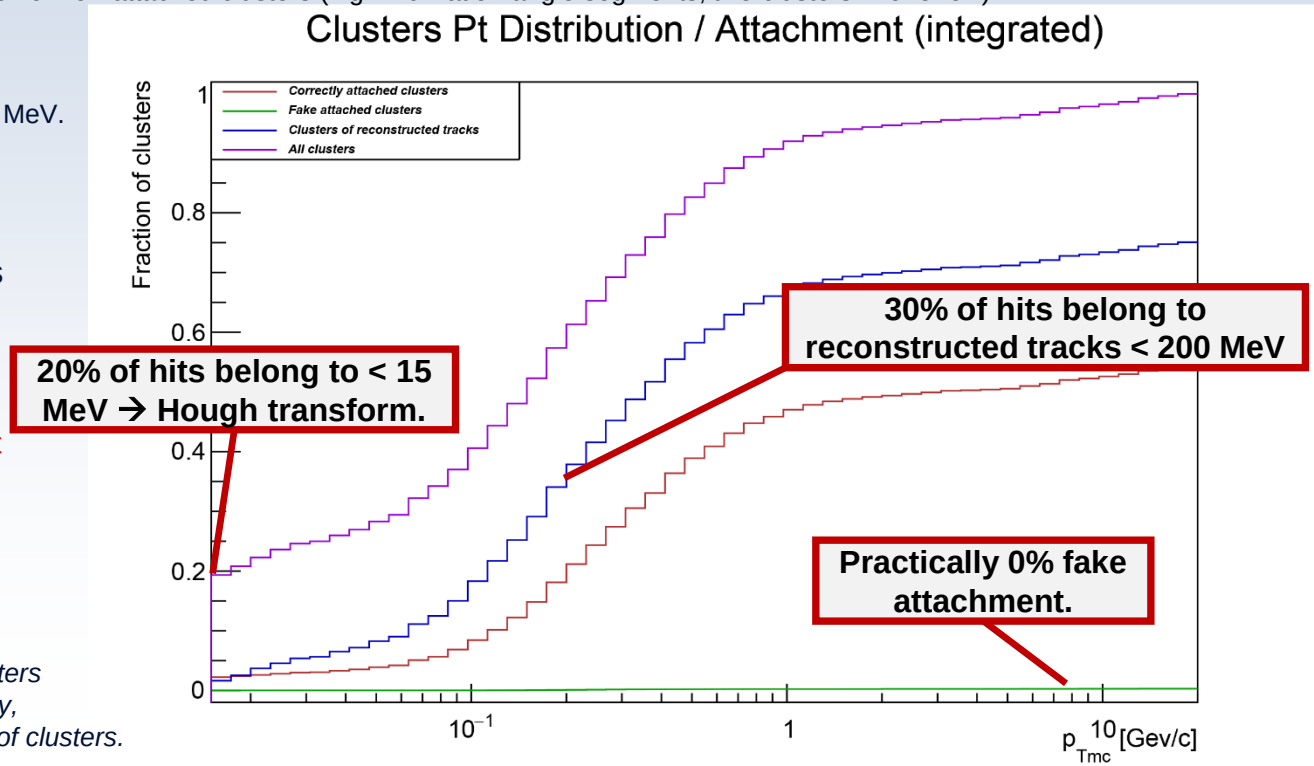
Cluster removal for O2 (should reach 2x compression)

- Strategy: track as low in p_T as possible with relaxed cuts (number of clusters, etc.), merge legs to get sufficient track quality.
  - Use inter-/extrapolation of helix for search of non-attached clusters (high inclination angle segments, two clusters in one row)
- Remove all clusters assigned to
  - Tracks below 50 MeV.
  - Additional legs of tracks below 200 MeV.
  - High incl.-angle track segments.
- Use afterburner (Hough-transform, machine learning) to remove what is left after tracking (masking all hits of good tracks).
- Cluster statistics:
  - Purple: all clusters
  - Red: clusters attached to the correct track.
  - Green: clusters attached to wrong track.
  - Blue: All clusters (if attached or not) of a reconstructed track.
- *Shared clusters and multiple-attached clusters are shown multiple times weighted correctly, so that the integral yields the total number of clusters.*



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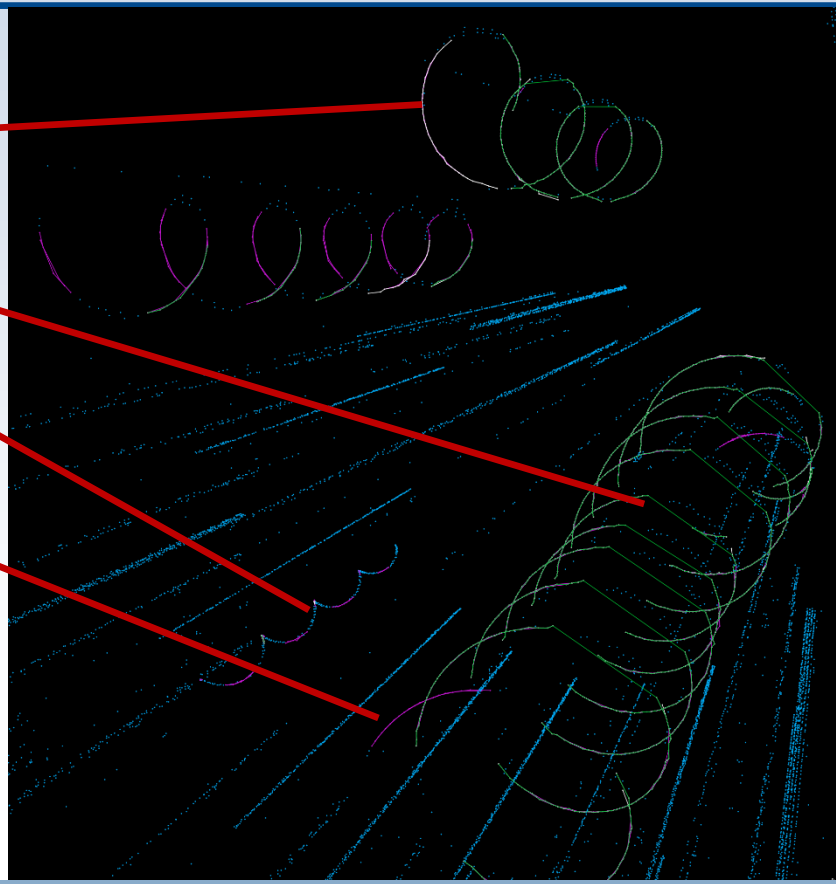
Tracking of low-Pt tracks

- *With improved merging-fit:*
  - *Most legs correctly reconstructed (green)*
  - *Refit fails rarely (only 1 white leg left).*
  - *Most legs merged on at least one side.*
    - *Cannot merge on both sides right now.*
  - *Some seeds left, which do not make it to tracks.*
    - *Many tracks < 15 MeV, could try to extend the tracking, but most such short seeds are garbage in high occupancy Pb-Pb.*
    - *Some cases should still be understood.*
- *Blue: Unused clusters*
- *Purple: Segments found in first CA seeding phase where track prolongation did not find good track.*
- *White: Track prolongation found track, but rejected later (cut, refit, merging).*
- *Green: Final tracks*



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TIMEFRAMES IN RUN 3

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Tracking continuous data in time frames

- **Created a simulation that produced full time frames out of events simulated in AliRoot, including full MC information.**
- **Idea:**
  - Reconstruct the same events as single events like in AliRoot.
  - Reconstruct the same events arranged in a time frame.
  - Compare the results.

- **Simulation done bunch by bunch to yield the correct TPC occupancy distribution (assuming the scenario as in TPC Upgrade TDR).**

- **To be benchmarked:**
  - Performance (tracking time).
  - Efficiency / resolution compared to single events (How much do we loose due to higher occupancy?).
  - Efficiency / resolution w.r.t. to time frame length (To what extent are we independent from z?)

- **Still missing:**
  - Large distortions as in run 3.
  - GEM TPC simulation.
  - This can all be done with the current infrastructure, by simulating the respective events.
  - Will be done when current issues are solved, to have a good baseline, and not to introduce additional complexity.

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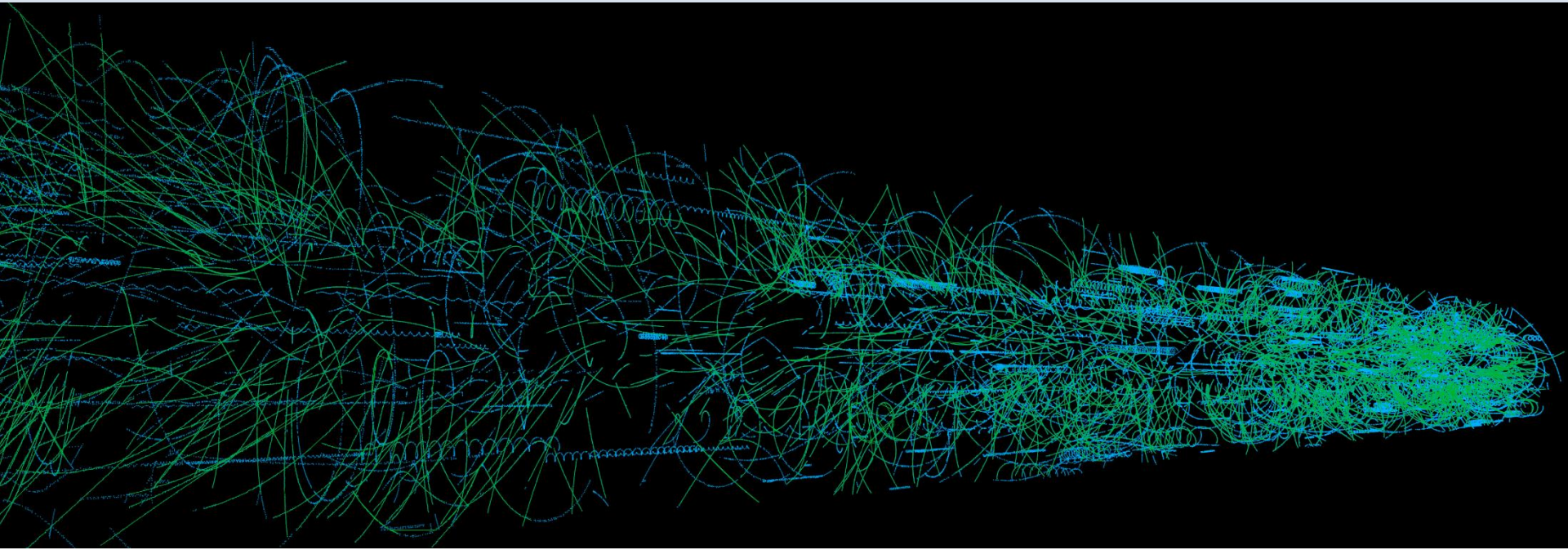
Screenshot, pp, overlaid, 50cm shift



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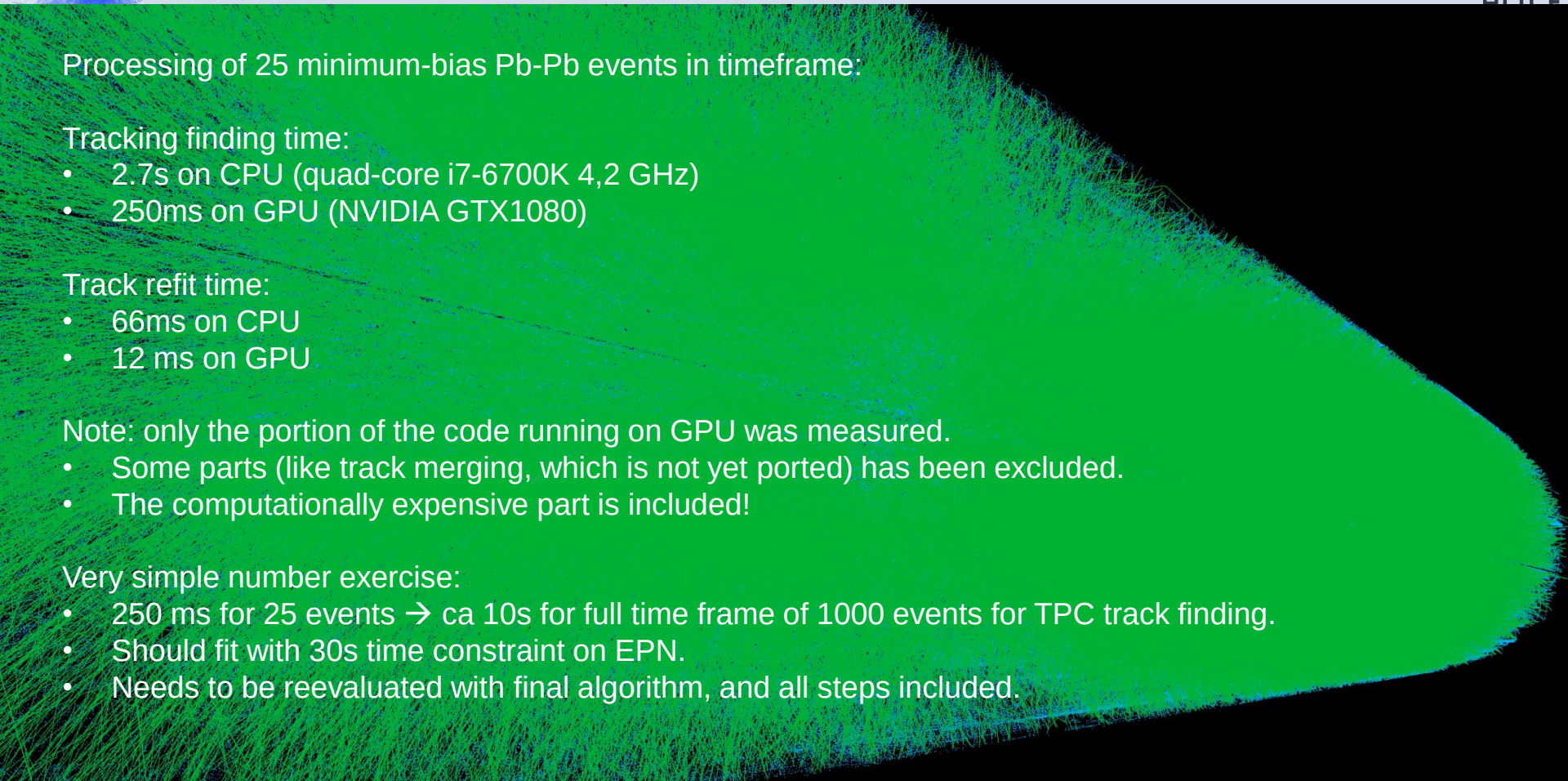
Screenshot, Pb-Pb, overlaid, 50cm shift



Processing of 25 minimum-bias Pb-Pb events in timeframe:

Tracking finding time:
- 2.7s on CPU (quad-core i7-6700K 4,2 GHz)
- 250ms on GPU (NVIDIA GTX1080)

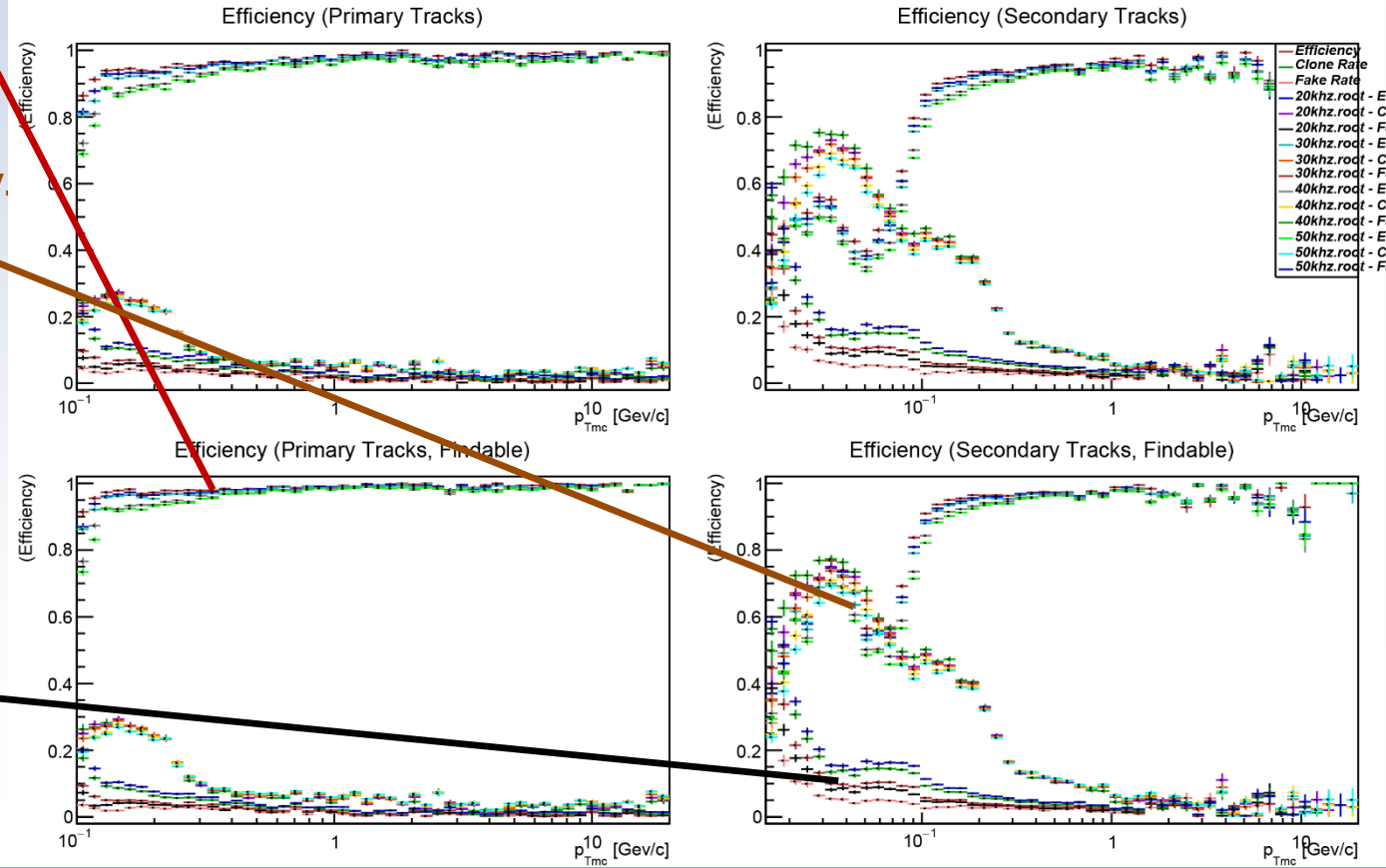
Track refit time:
- 66ms on CPU
- 12 ms on GPU

Note: only the portion of the code running on GPU was measured.
- Some parts (like track merging, which is not yet ported) has been excluded.
- The computationally expensive part is included!

Very simple number exercise:
- 250 ms for 25 events → ca 10s for full time frame of 1000 events for TPC track finding.
- Should fit with 30s time constraint on EPN.
- Needs to be reevaluated with final algorithm, and all steps included.

Realistic O2 scenario (50 kHz, poisson distr.) (efficiency)

- **Deterioration of efficiency below ~400 MeV as > 30kHz.**
- **Good efficiency for secondaries down to 15 MeV.**
  - **Will be used to find clusters of looping tracks.**
  - **Large number of low-p_T clones will go down with improved merging.**
- **Increase of fake rate for low-p_T.**
  - **This should go down with**
    - **Improved merging**
    - **Improved cluster rejection at refit.**



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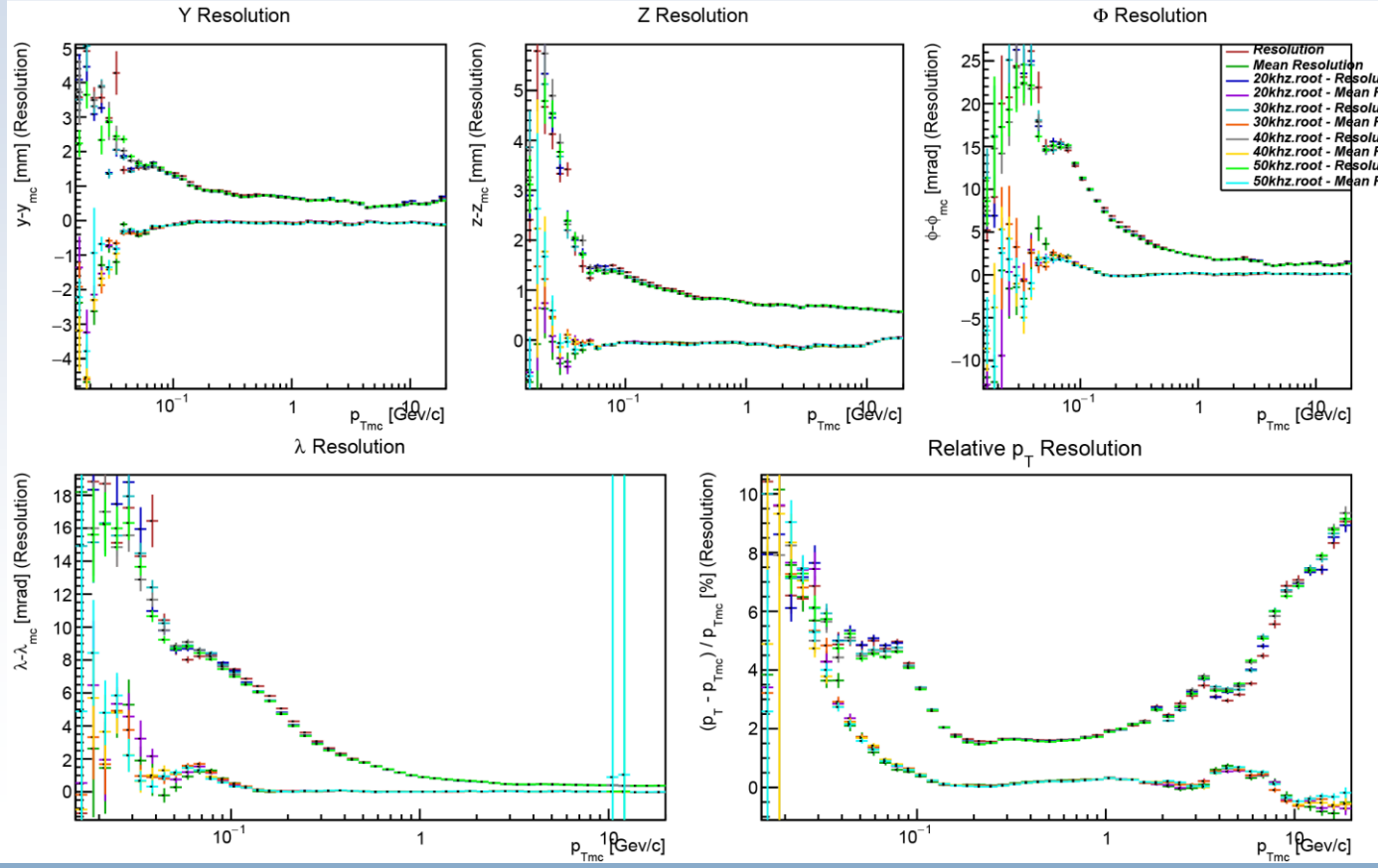
Realistic O2 scenario (50 kHz, poisson distr.) (resolution)

- **Comparable resolution for 8 kHz to 50 kHz.**



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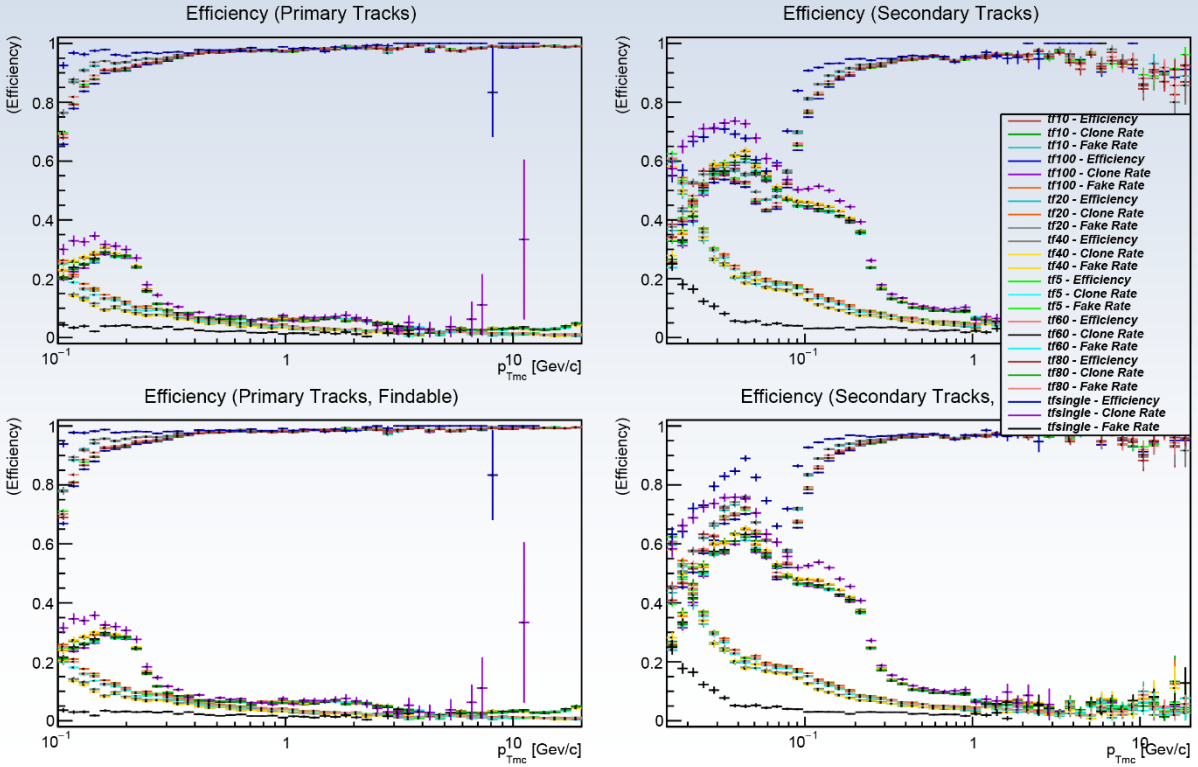
Dependency on time frame length

- **tf10 = time frame with 10 drift times.**
- **Efficiency loss for low-pt compared to single events (tfsingle).**
- **Efficiency loss at > 60 drift times:**
  - Numerical artifacts because float precision is insufficient.
  - Currently working to move the fit to the correct (estimated) z position.
- **Efficiency loss between 2 and 5 drift times:**
  - Not yet understood, but should not be a fundamental problem.



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TPC DATA FORMATS IN RUN 3

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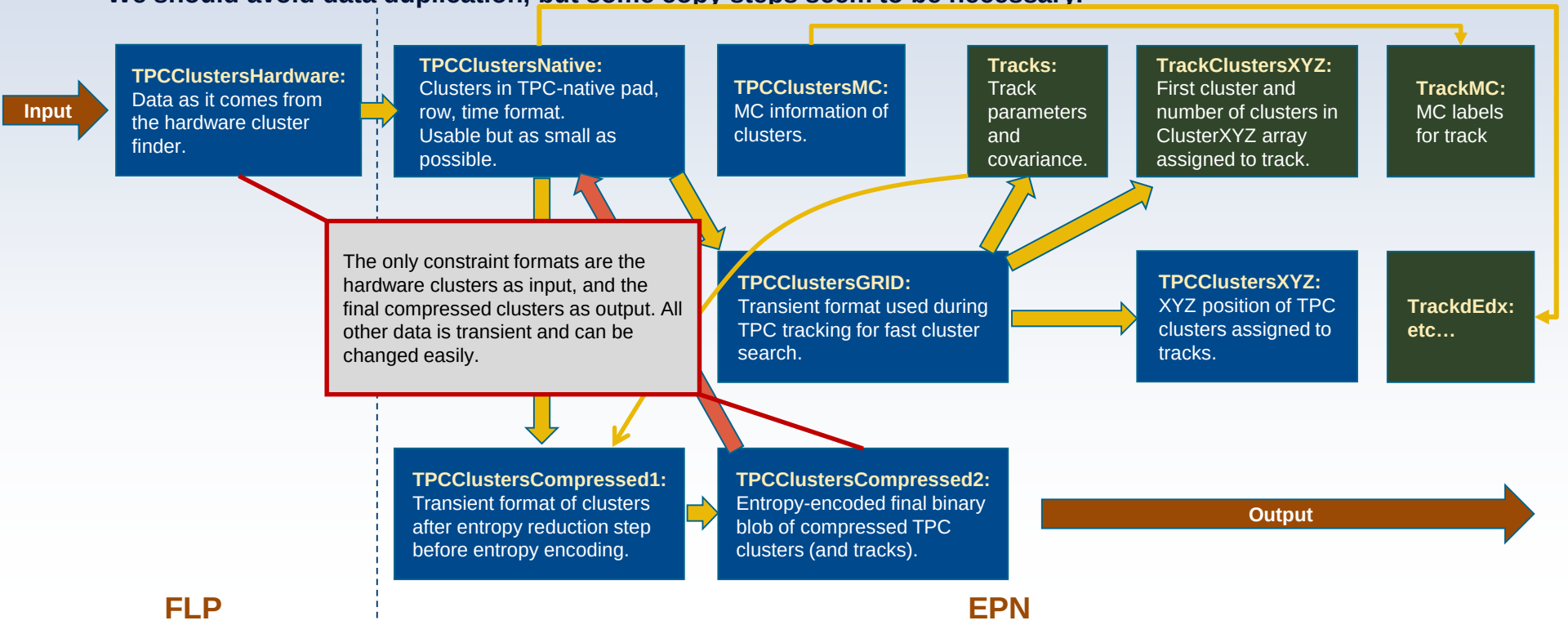
Draft of data types for TPC clustering / tracking / compression in O2

- **TPC produces the bulk of data, so a format that minimizes memory consumption is needed.**
  - **We should avoid data duplication, but some copy steps seem to be necessary.**



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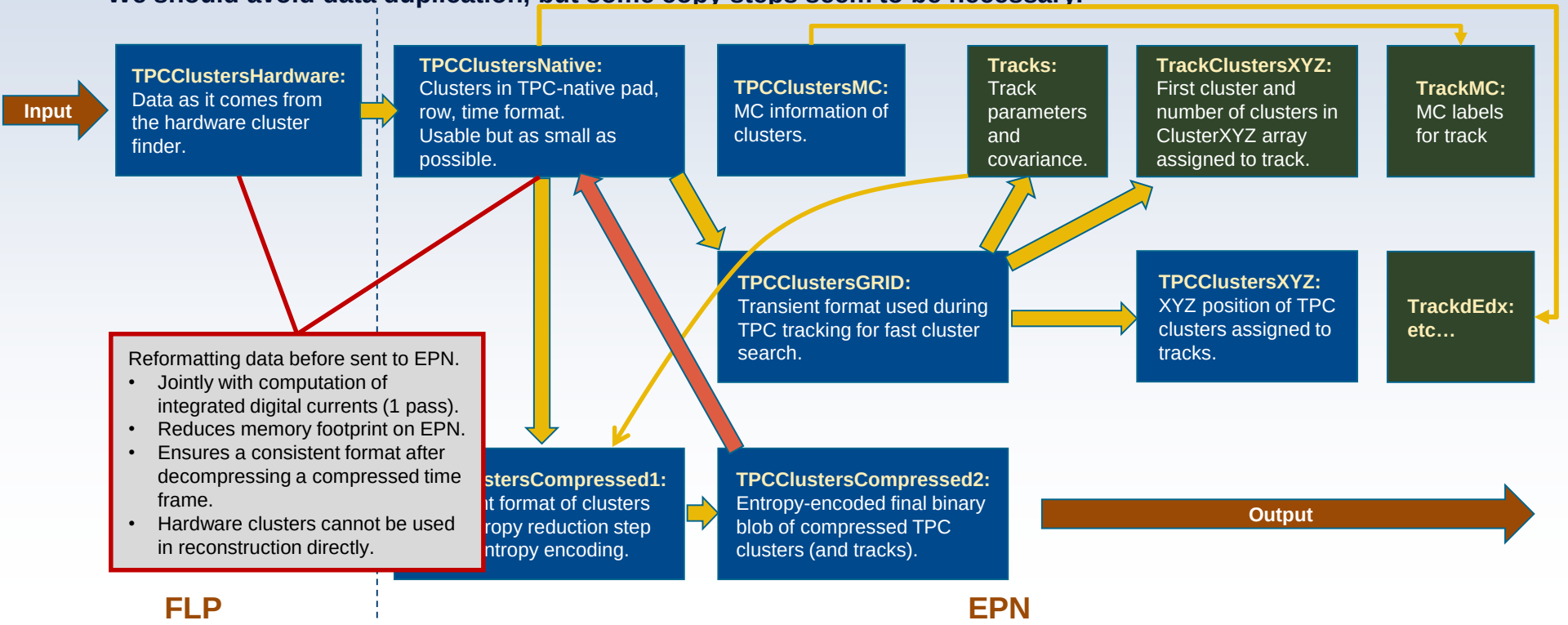

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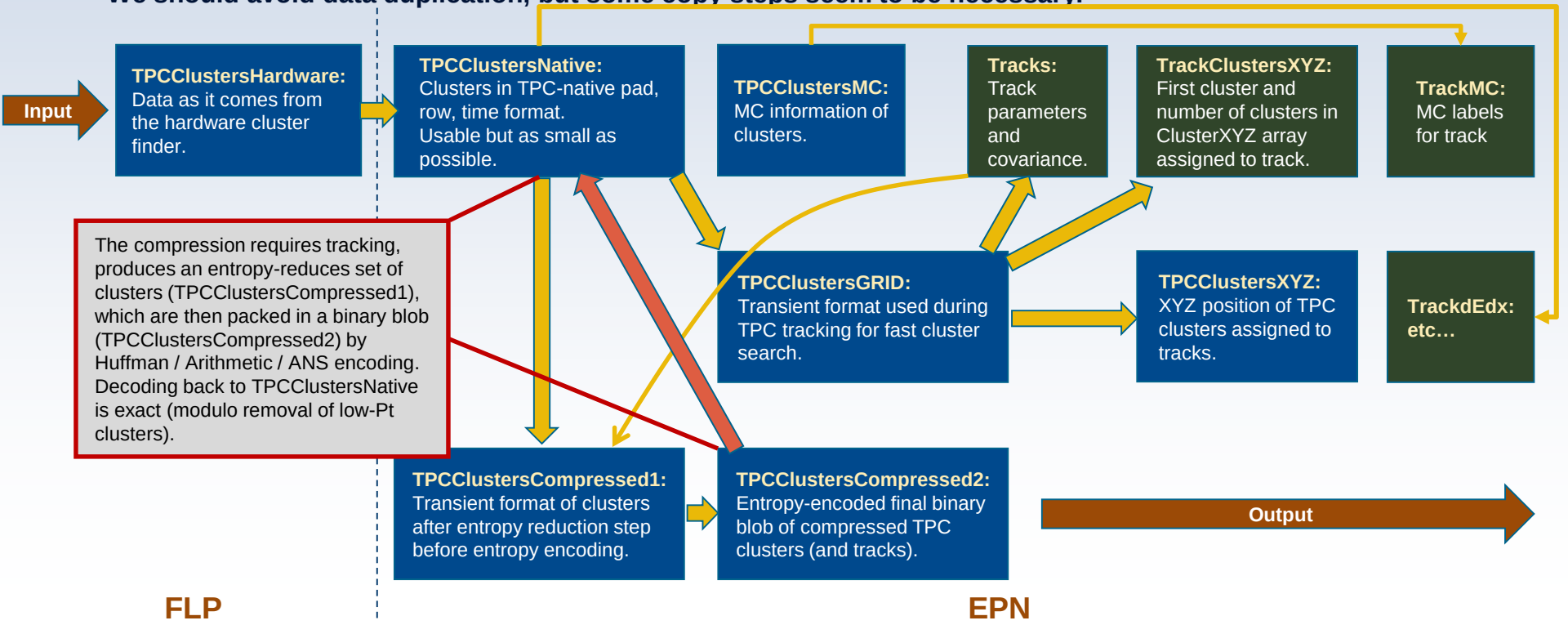

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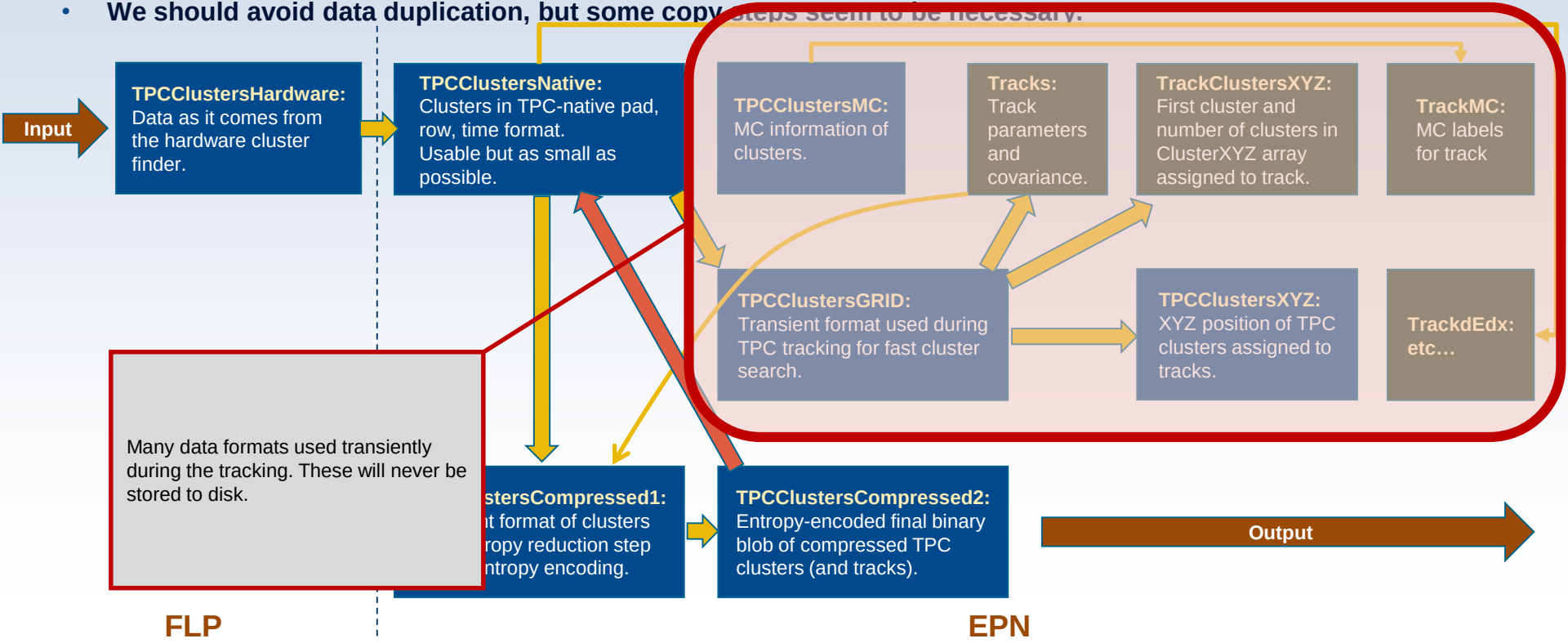

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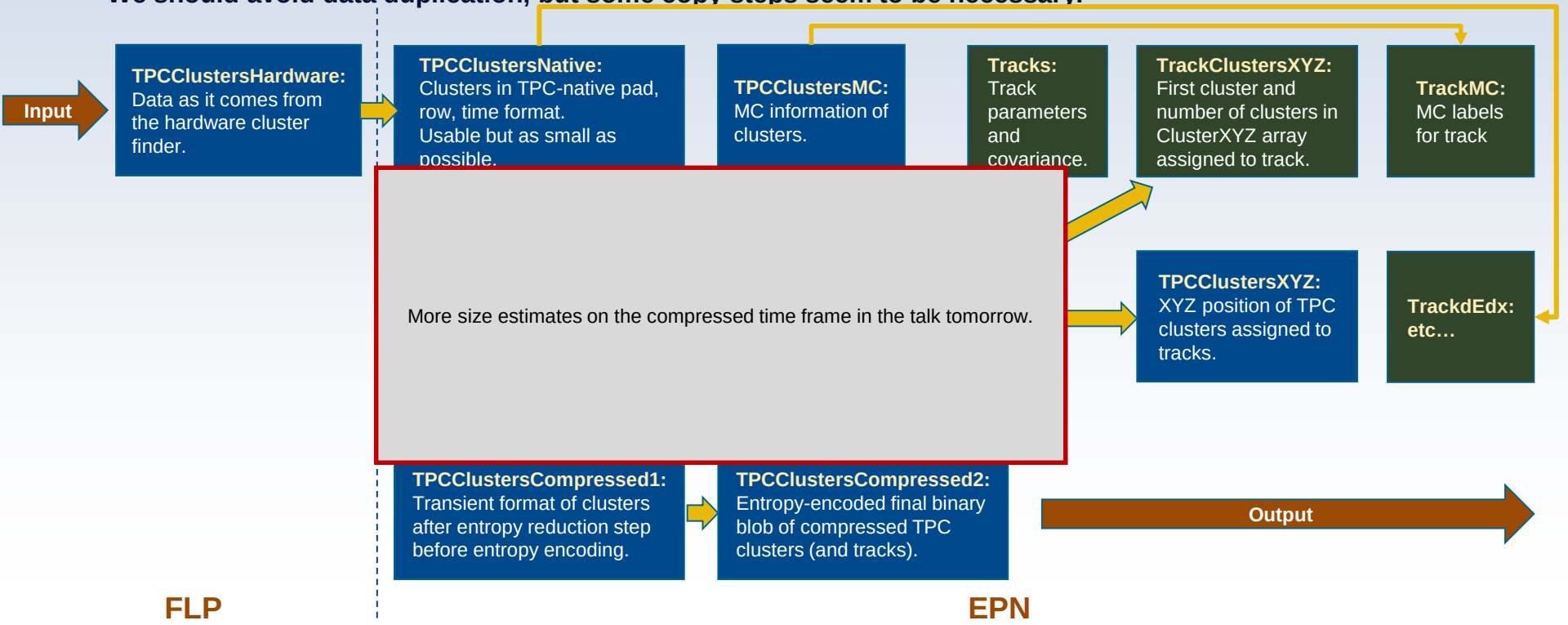

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