



Status on the TPC data sizes and the compression of the compressed TPC time frame

David Rohr drohr@cern.ch, CERN Offline Week 10.11.2017





CLUSTER FINDER COMPRESSION



Cluster finder compression status



- In 2017, we have deployed a new version of the HLT hardware cluster finder and of the cluster compression.
 - Improved noise filtering in the cluster finder.
 - Storing cluster charge and width with less precision.
 - → 23.9% less clusters, 13.7% less bits needed per cluster.
- On top, we have developed some more features to reduce the noise, which are not yet active in the HWCF:
 - Can reduce the number of clusters by additional 1.5% with better noise filtering.
 - We can reduce the clusters by 2.5% by increasing the cut on qMax.
 - → No effect on tracking / dE/dx observed.

Baseline for run 3 compression:

- The run 3 compression prototype, achieves a factor of 9.1 on 2015 Pb-Pb data.
 - This already includes the higher qMax cut, and most but not all of the new HWCF features.
 - The prototype needs in average 36 bits per cluster.
 - → Can expect another 2.5% on top (but still to be verified).





DATA TYPES FOR TPC IN RUN 3





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. **TPCClustersNative:** Tracks: TrackClustersXYZ: **TPCClustersHardware: TPCClustersMC:** Clusters in TPC-native pad, Track First cluster and TrackMC: Data as it comes from row, time format. MC information of MC labels Input number of clusters in parameters the hardware cluster Usable but as small as clusters. for track and ClusterXYZ array finder. possible. covariance. assigned to track. TPCClustersGRID: **TPCClustersXYZ:** Transient format used during XYZ position of TPC TrackdEdx: TPC tracking for fast cluster clusters assigned to etc... search. tracks. **TPCClustersCompressed1: TPCClustersCompressed2:** Transient format of clusters Entropy-encoded final binary Output blob of compressed TPC after entropy reduction step before entropy encoding. clusters (and tracks).

FLP

EPN



Draft of data types



- Draft of members of data types.
- Sizes are sizes for unpadded SOA / padded AOS.

```
TPCClusterHardware: (22 / 24 byte)
float
             pad pre
float.
             time pre
float
             sigmaPad2 pre
float
             sigmaTime2 pre
11in+16
             qMax
11in+16
             qTot
uint.8
             row
uint.8
             flags
```

```
 \begin{tabular}{ll} \textbf{TPCClusterCompressed2:} & (\sim 4.5 \ byte) \\ \textbf{Binary blob} \end{tabular}
```

```
TPCClusterNative: (12 byte)
Uint32 time/flags
uint16 pad
uint8 sigmaTime2
uint8 sigmaPad2
uint16 qMax
uint16 qTot
```

```
TPCClusterCompressed1: (15 / 16 byte)
Uint32
              time
11in+16
             pad
uint8
             sigmaTime2
             sigmaPad2
uint8
uint16
             qMax
             qTot
uint.16
uint.16
             compressionMeta
11 i n t 8
              flags
```

```
TPCTrack:
float pa
```

loat param[], cov[], x, alpha

```
TPCTrackClusters:
uint32     firstCluster
uint16     numClusters
```



Draft of data types



- Draft of members of data types.
- Sizes are sizes for unpadded SOA / padded AOS.

```
TPCClusterHardware: (22 / 24 byte)
float
             pad pre
float
             time pre
                                                 TPCClusterGrid: (10 / 12 byte)
float
             sigmaPad2 pre
                                                 uint16/uint32 z
                                                                                             TPCClusterCompressed2: (~4.5 byte)
float
             sigmaTime2 pre
                                                 uint16
                                                                                             Binary blob
11in+16
                                                 11int32
                                                                clusterId
             qMax
11in+16
             qTot
uint.8
              row
              flags
uint.8
                           Just for reference...
   TPCClusterNative: (1
                                                                                                      clusterXYZ: (18 byte)
                           For details, see
   Uint32
                 time/fl
                                                                                                                Х
   uint16
                 pad
                           https://indico.cern.ch/event/678423/contributions/2778515/attachments/1553617/2
                                                                                                                У
                 sigmaTi
   uint8
                           442101/2017-11-07 HLT TPC Hands on.pdf
   uint8
                 sigmaPa
                                                                                                                clusterId
   uint.16
                 qMax
                                                                                                                sector
   uint.16
                 qTot
                                                                                                                row
```

TPCTrack:

float param[], cov[], x, alpha

TPCTrackClusters:

uint32 firstCluster
uint16 numClusters





- 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. **TPCClustersNative:** Tracks: TrackClustersXYZ: **TPCClustersHardware: TPCClustersMC:** Clusters in TPC-native pad, Track First cluster and TrackMC: Data as it comes from MC information of MC labels Input row, time format. number of clusters in parameters the hardware cluster for track Usable but as small as clusters. and ClusterXYZ array finder. possible. covariance. assigned to track. The only constraint formats are the TPCClustersGRID: **TPCClustersXYZ:** hardware clusters as input, and the Transient format used during XYZ position of TPC TrackdEdx: final compressed clusters as output. All TPC tracking for fast cluster clusters assigned to other data is transient and can be etc... search. tracks. changed easily. **TPCClustersCompressed1: TPCClustersCompressed2:** Transient format of clusters Entropy-encoded final binary Output blob of compressed TPC after entropy reduction step before entropy encoding. clusters (and tracks). **FLP EPN**





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. **TPCClustersNative:** Tracks: TrackClustersXYZ: **TPCClustersHardware: TPCClustersMC:** Clusters in TPC-native pad, Track First cluster and TrackMC: Data as it comes from MC information of MC labels Input row, time format. number of clusters in parameters the hardware cluster Usable but as small as clusters. for track and ClusterXYZ array finder. possible. covariance. assigned to track. TPCClustersGRID: **TPCClustersXYZ:** Transient format used during XYZ position of TPC TrackdEdx: TPC tracking for fast cluster clusters assigned to etc... search. tracks. Reformatting data before sent to EPN. Jointly with computation of integrated digital currents (1 pass). Reduces memory footprint on EPN. Ensures a consistent format after decompressing a compressed time stersCompressed1: **TPCClustersCompressed2:** frame. it format of clusters Entropy-encoded final binary Output Hardware clusters cannot be used blob of compressed TPC ropy reduction step in reconstruction directly. ntropy encoding. clusters (and tracks).

FLP

EPN





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. TPCClustersNative: Tracks: TrackClustersXYZ: **TPCClustersHardware: TPCClustersMC:** Clusters in TPC-native pad, Track First cluster and TrackMC: Data as it comes from MC information of MC labels Input row, time format. number of clusters in parameters the hardware cluster for track Usable but as small as clusters. and ClusterXYZ array finder. possible. covariance. assigned to track. The compression requires tracking, produces an entropy-reduces set of TPCClustersGRID: **TPCClustersXYZ:** clusters (TPCClustersCompressed1), Transient format used during XYZ position of TPC TrackdEdx: which are then packed in a binary blob TPC tracking for fast cluster clusters assigned to etc... (TPCClustersCompressed2) by search. tracks. Huffman / Arithmetic / ANS encoding. Decoding back to TPCClustersNative is exact (modulo removal of low-Pt clusters). **TPCClustersCompressed1: TPCClustersCompressed2:** Transient format of clusters Entropy-encoded final binary Output blob of compressed TPC after entropy reduction step before entropy encoding. clusters (and tracks).

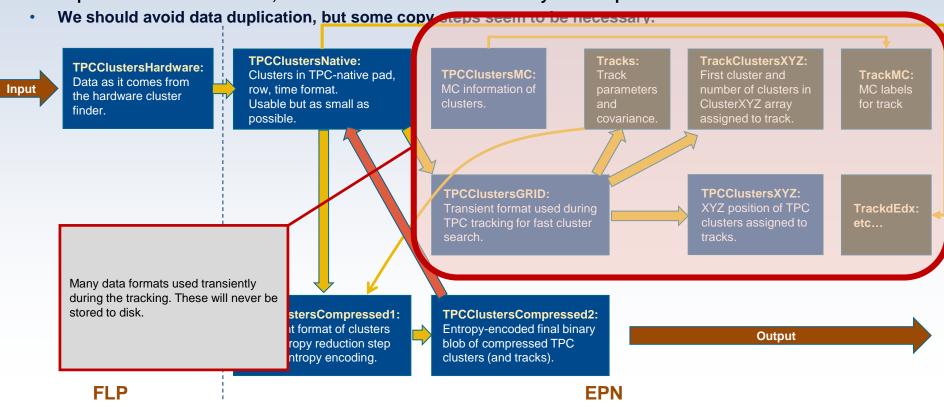
FLP

EPN





• TPC produces the bulk of data, so a format that minimizes memory consumption is needed.





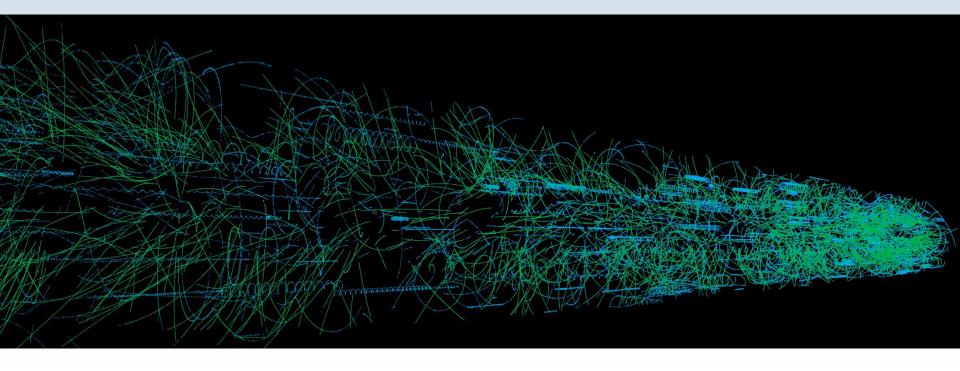


TPC DATA SIZES IN O2



Screenshot, pp, overlaid events, 50 kHz

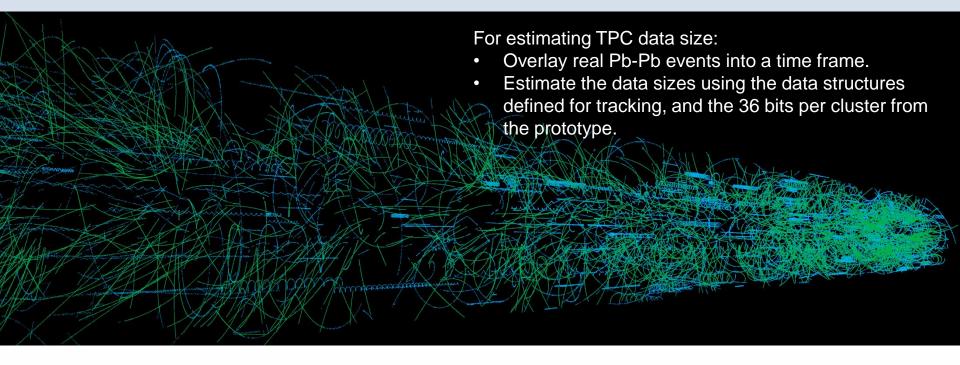






Screenshot, pp, overlaid events, 50 kHz







Data size estimations for run 3



• Estimate the number of clusters per timeframe:

- Ran 2015 Pb-Pb (LHC15o) low-IR (no pile-up) data through new HLT hardware cluster finder.
- Filtered for minimum-bias events only.
- Exclude events with less than 1000 TPC hits (QED interactions, with come on top of the 50 kHz.)
- → In average: 596011 hits per TPC event.
- Assuming a time frame: (11245 orbits / sec, 1 TF = 256 HB frames (orbits), 22.8 ms).
 - 678,429,907 hits per TF in average, 4,390,083 TPC tracks per TF
 - We assume 52% cluster attached to tracks, 40% of clusters can be removed because they are not used for physics.

Data sizes:

- New format yields 12 byte / cluster for the TPC input (most bits already stripped), 36 bit / cluster for the compressed TPC output.
- → TPC Input data size per TF: 7.58 GB (2³⁰ notation).
- → Memory needed during tracking: 12,01 GB + additional temporary memory for track seeds.
- → Size of compressed time frame (all clusters): 2.84 GB.
- → Size of compressed time frame (40% clusters removed): 1.71 GB

Data rates (TPC only):

- Aggregate input (FLP to EPN): 333.05 GB/s (357,61 GB/s (10³ notation)).
- Compressed output rate (all clusters): 124,89 GB/s (134,10 GB/s).
- Compressed output rate (40% clusters removed): 74,94 GB/s (80,46 GB/s).



What is missing / next steps



What was not included in this estimations?

- 2015 Pb-Pb data is with argon, run 3 will be neon → less clusters.
- Run 3 will run a different cluster finder (similar number of clusters assumed as today).
- Recent tracking improvements attach more clusters to tracks.
 - Track model compression should yield a slight improvement.
- Run 3 will run at slightly higher LHC energy than Run 2.

Next steps:

- Develop a wrapper to run current prototype for run 3 cluster finder in AliRoot.
 - Reprocess the mode B data used for HWCF validation with run 3 cluster finder.
 - Run full AliRoot reconstruction and QA on run 3 clusters (as done for HLT HWCF validation).
 - This shall demonstrate the physics performance of the run 3 cluster finder, and will show how many clusters we can expect.
- Rerun the run 3 prototype with the newest improvements to the cluster finder and the tracking, and see how much the factor 9.1 improves (few per cent at most).