Quality Assurance in Xe+Cs(I) run

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The work has been supported by the Ministry of Science and Higher Education of the Russian Federation, Project "Fundamental and applied research at the NICA (JINR) megascience experimental complex" № FSWU-2025-0014

BM@N

НИЯУ МИФИ

BM@N CM, 14/05/2025

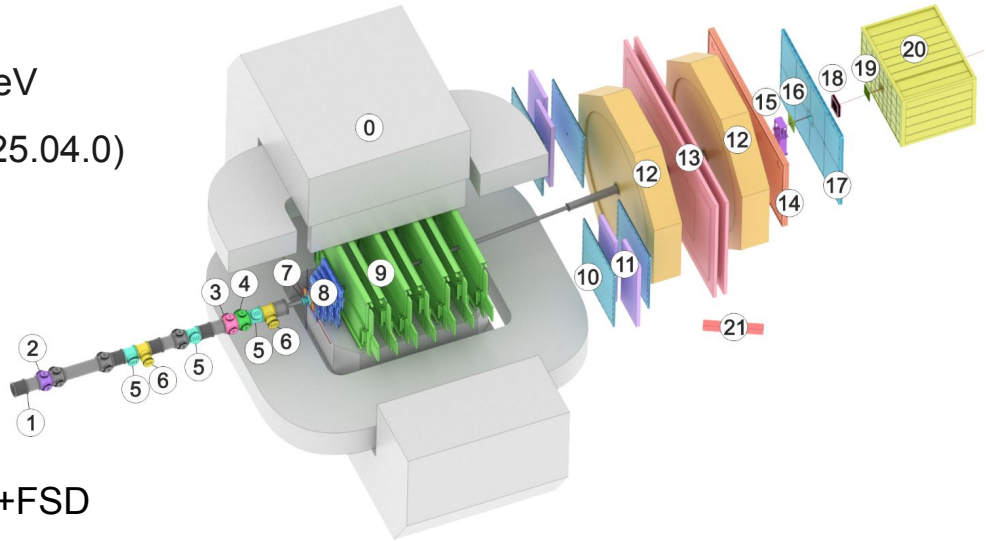
Outline

1. BM@N Experiment
2. Comparisons productions
3. QA framework
4. Conclusions

The BM@N experiment

Data:

- run8 Xe-CsI @3.8*A* GeV (24.04.0, 24.12.0 and 25.04.0)
- VF tracking was used

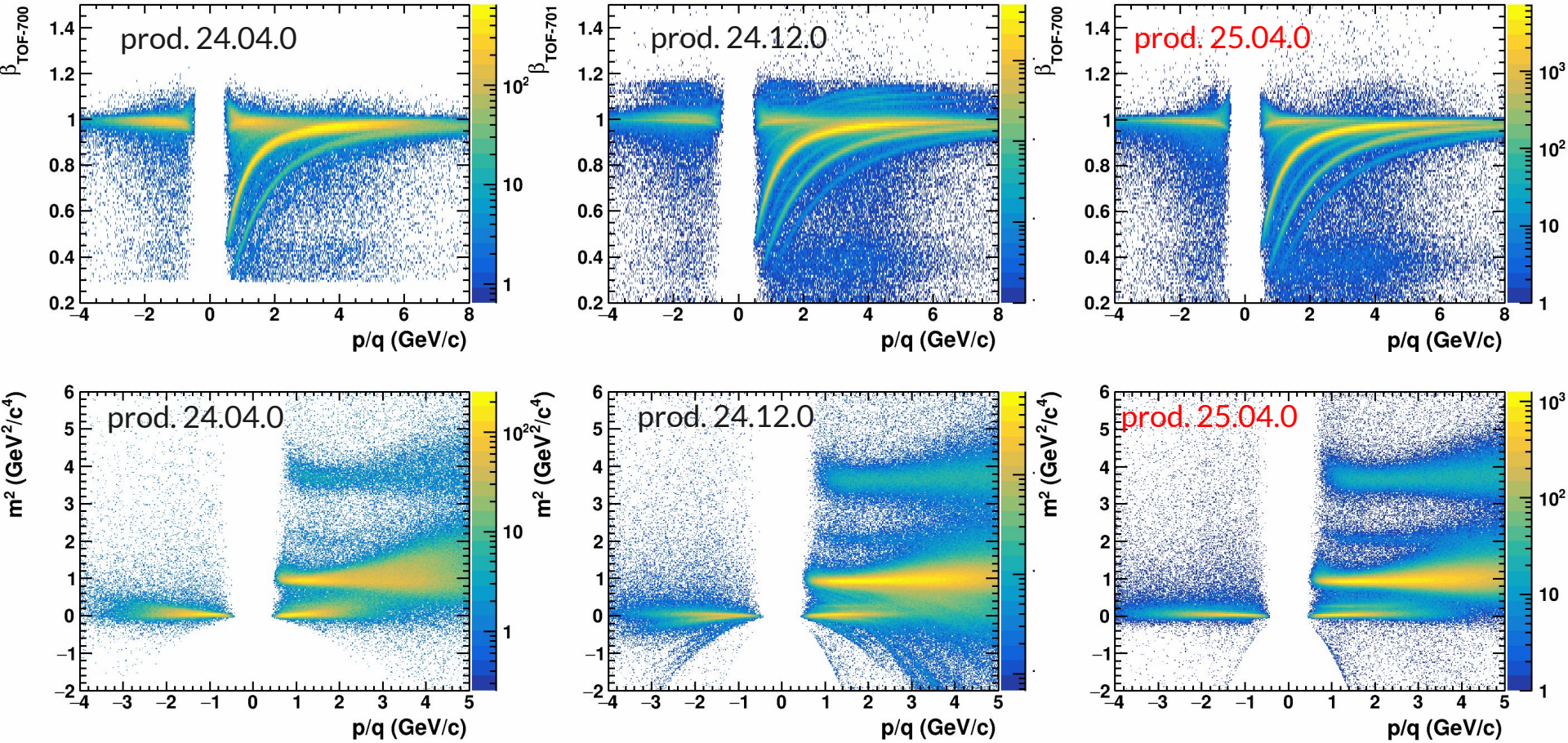


- Magnet SP-41 (0)
- Vacuum Beam Pipe (1)
- BC1, VC, BC2 (2-4)
- SiBT, SiProf (5, 6)
- Triggers: BD + SiMD (7)
- FSD, GEM (8, 9)
- CSC 1x1 m^2 (10)
- TOF 400 (11)
- DCH (12)
- TOF 700 (13)
- ScWall (14)
- FD (15)
- Small GEM (16)
- CSC 2x1.5 m^2 (17)
- Beam Profilometer (18)
- FQH (19)
- FHCal (20)
- HGN (21)

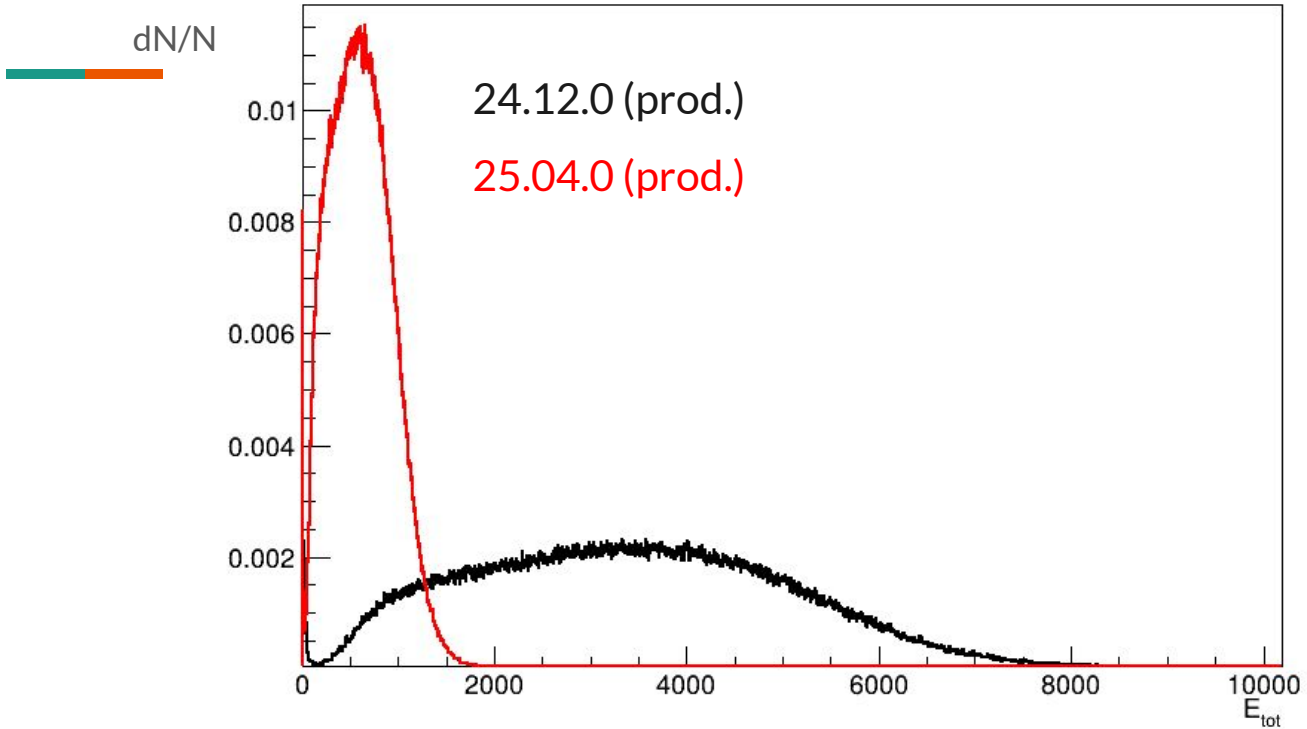
QA Run-by-Run:

- Tracking system GEM+FSD
- BC1, BC2, FD, BD
- FHCal, FQH, ScWall
- TOF-400, TOF-700

Difference between prod: TOF-700 (run 8005)



Difference between prod: FHCal



Change units of energy measurement in FHCal (MeV -> mip)

QA Run-by-Run: runs rejection

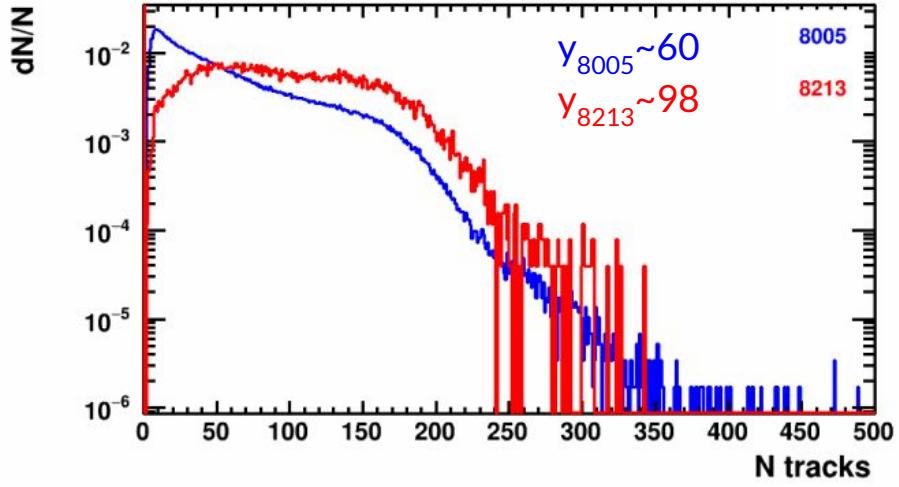
- Physical runs
- CCT2
- More than 1 track in vertex reconstruction

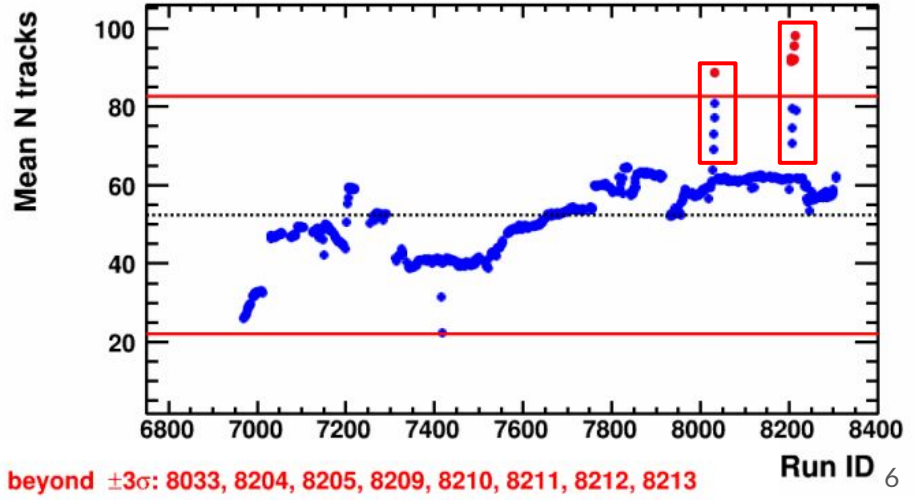
Procedure:

- Averaged (or fit parameters) observables are calculated for each run
- the mean (μ) and standard deviation (σ) are calculated as a function of RunId

$$\mu = \frac{1}{N}\sum_{i=1}^{N} y_i \qquad \sigma = \sqrt{\frac{\sum (y_i - \mu)^2}{N}}$$, where i - RunId number and N - total numbers of runs

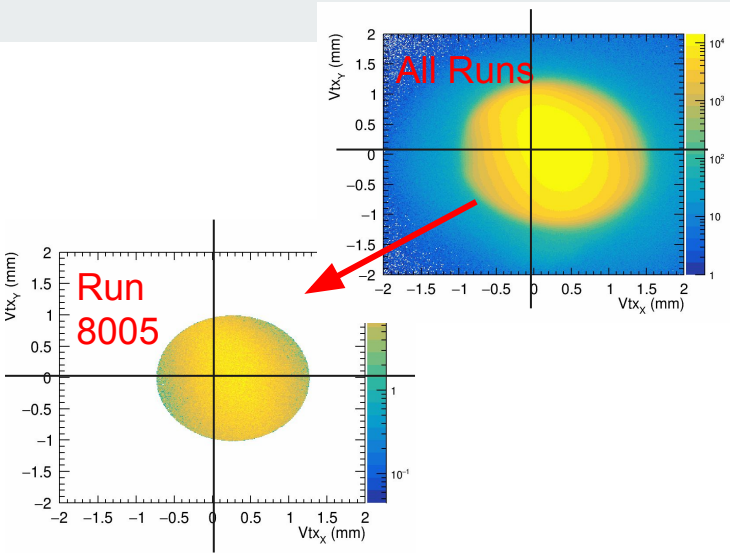
- beyond $\pm 3\sigma$ away from global means - bad runs

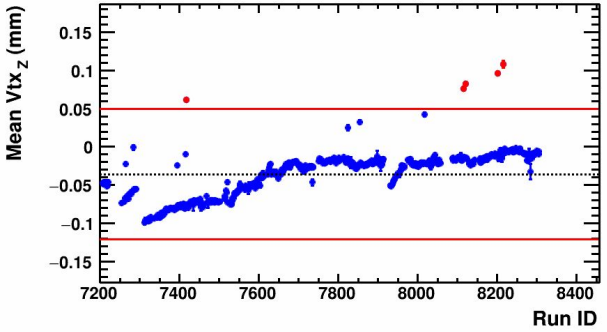


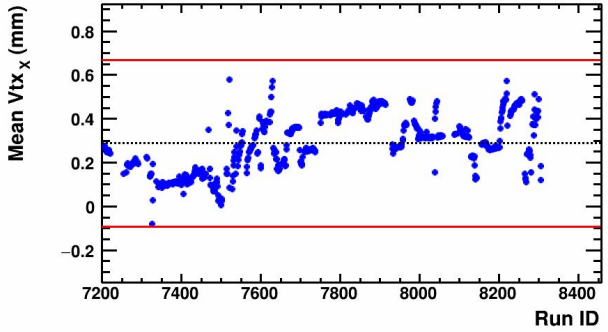


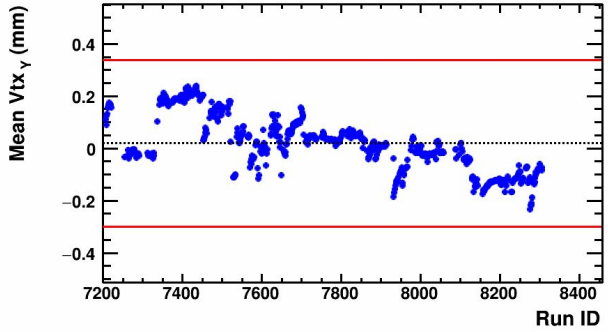
Event selection

- Xe+Cs 3.8 GeV
- Production= last
- Physical runs
- Triggers: CCT2
- Remove BadRuns
- Corrected on <VtxX>, <VtxX>, <VtxZ> for each RunId
- Event selection:
  - More than 1 track in vertex reconstruction
  - VtxR < 1.0 cm (sqrt($VtxY_{corr}^2$ + $VtxX_{corr}^2$) < 1 cm)
  - VtxZ < 0.1 cm
  - Apply graphics cuts
  - Remove pileup (from Oleg Golosov)

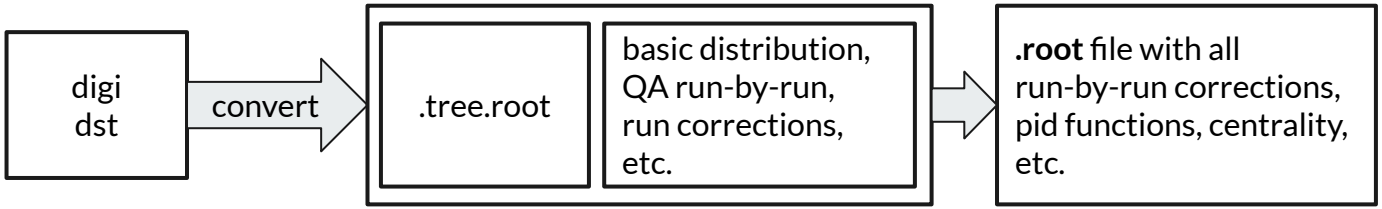








QA framework

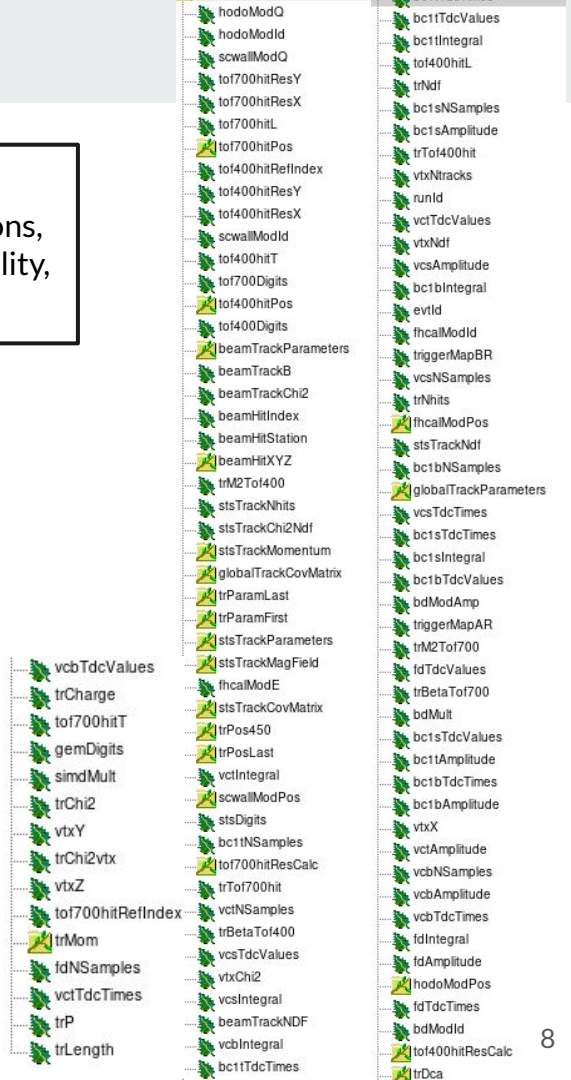


Developed a converter for dst(+digi) format in .tree.root (root TTree):

- variables and selection criteria required for analysis
  (https://github.com/DemanovAE/Final_codes_bmn)

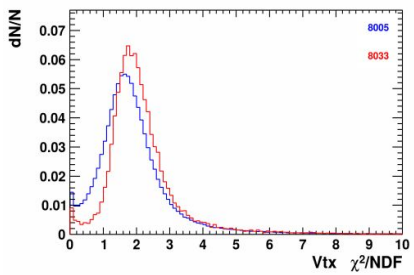
Variables:

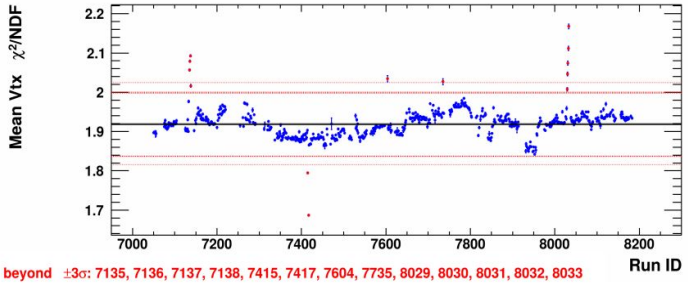
- RunId
- trigger
- Information from bc1, bc2, vcs, fd, bd
- digits: tof400, tof700, gem, fsd
- SiBT: HitXYZ, HitStation, TrackParameters
- Primary Vertex
- GlobalTracks
- fsdTracks
- ScWall, hodo, fhcal
- multiplicity
- .....



QA framework: scripts

- Draw Run-by-Run distributions:

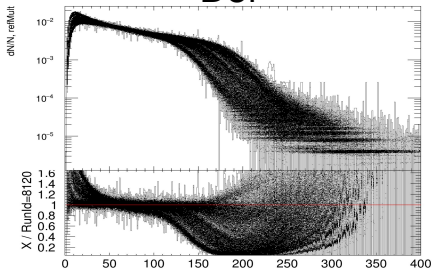




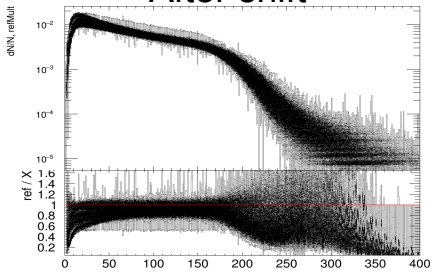
beyond ±3σ: 7135, 7136, 7137, 7138, 7415, 7417, 7604, 7735, 8029, 8030, 8031, 8032, 8033

- Run-by-Run correction of the x, y and z positions of the reconstructed vertex (multiplicity)

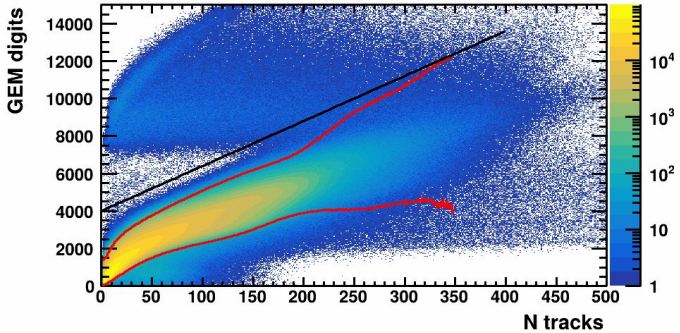
Def



After shift



- Additional cut for pileup run-by-run (GEM digits vs N_{Tr}, FSD digits vs N_{Tr})



More details in
http://indico.oris.mephi.ru/event/315/contribution/1/material/slides/0.pdf

QA framework (example)

QA code: https://github.com/DemanovAE/Final_codes_bmn/tree/main/QA_macro

Selection:

```
auto dd_def = dd
    .Filter("runId < 8312")
    .Filter(PhisRunCut,{"runId"} )
    .Filter(ARCut, {"triggerMapAR"})
    .Filter("vtxNtracks > 1")
```

Define variables:

```
.Define( "track_multiplicity", "return trMom.size();" )
// Global Tracks
.Define( "p",   " ROOT::RVecF p;   for( auto mom : trMom ){ p.push_back( mom.P() ); }     return p; "  )
.Define( "px",  " ROOT::RVecF px;  for( auto mom : trMom ){ px.push_back( mom.Px() ); }    return px; " )
.Define( "py",  " ROOT::RVecF py;  for( auto mom : trMom ){ py.push_back( mom.Py() ); }    return py; " )
.Define( "pz",  " ROOT::RVecF pz;  for( auto mom : trMom ){ pz.push_back( mom.Pz() ); }    return pz; " )
.Define( "pT",  " ROOT::RVecF pT;  for( auto mom : trMom ){ pT.push_back( mom.Pt() ); }    return pT; " )
```

Add 1D histo:

```
////////////////////////////////////////////////////////////////////////////////////////////////////////////////////////////////////
//  {Name histo,        {Name histo,        name of the column in tree, Axis title,                n bins,     min,        max}   //
////////////////////////////////////////////////////////////////////////////////////////////////////////////////////////////////////
const std::map< std::string, HistoParameter > QA_variable{
    {"RunId",           {"RunId",           "runId",                ";Run ID",              RunIdBins,  RunIdMin,   RunIdMax}},
    // Event parametrs
    {"nTracks",         {"nTracks",         "track_multiplicity",   ";N tracks",            1000,       0,          1000}},
    // Global Track variables
    {"tr_px",           {"tr_px",           "px",                   ";p_{x} (GeV/c)",       1000,       -10,        10}},
    {"tr_py",           {"tr_py",           "py",                   ";p_{y} (GeV/c)",       1000,       -10,        10}},
    {"tr_pz",           {"tr_pz",           "pz",                   ";p_{z} (GeV/c)",       1000,       0,          40}},
    {"tr_pT",           {"tr_pT",           "pT",                   ";p_{T} (GeV/c)",       1000,       0,          10}},
    {"tr_p",            {"tr_p",            "p",                    ";p (GeV/c)",           2000,       -40,        40}},
    {"tr_eta",          {"tr_eta",          "eta",                  ";#eta",                1000,       0,          10}},
```

Add 2D histo:

```
const std::vector<std::vector< std::string >> QA_MultDemenPlot{
    {"runId",    "nTracks"},                        // 2d histo
    {"tr_pT",    "Weight:trIsProton"},              // 1d histo with weight
    {"tr_pT",    "tr_phi"},                         // 2d histo
    {"tr_pT",    "tr_phi",    "Weight:trIsProton"}, // 2d histo with weight
```

Conclusions

- Comparison of productions:
  - Incorrect matching for TOF-700 - Solved! (prod. 25.04.0)
  - Change MeV to mip for FHCal
- Draft note and framework for QA are presented

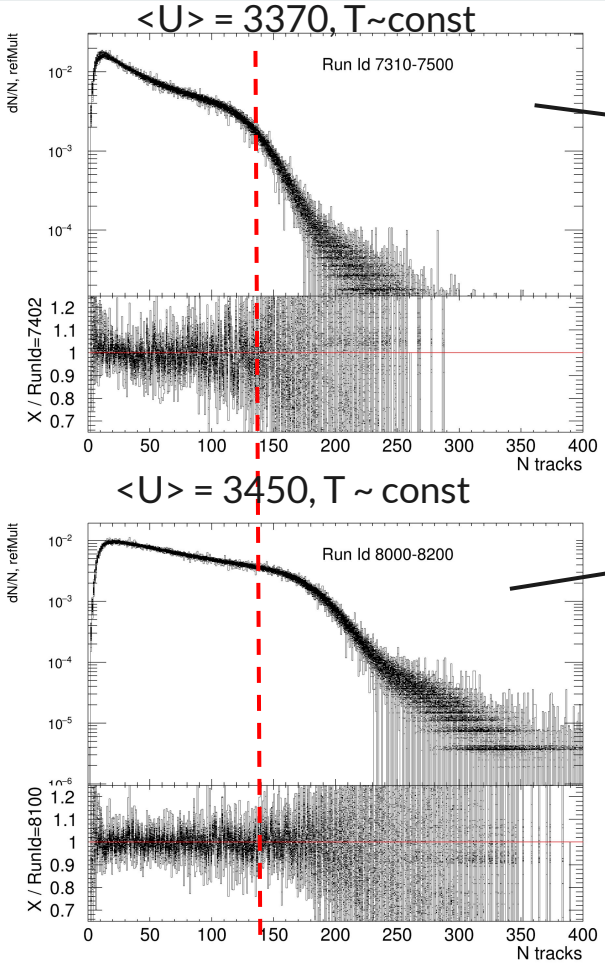
  (https://github.com/DemanovAE/Final_codes_bmn.git and

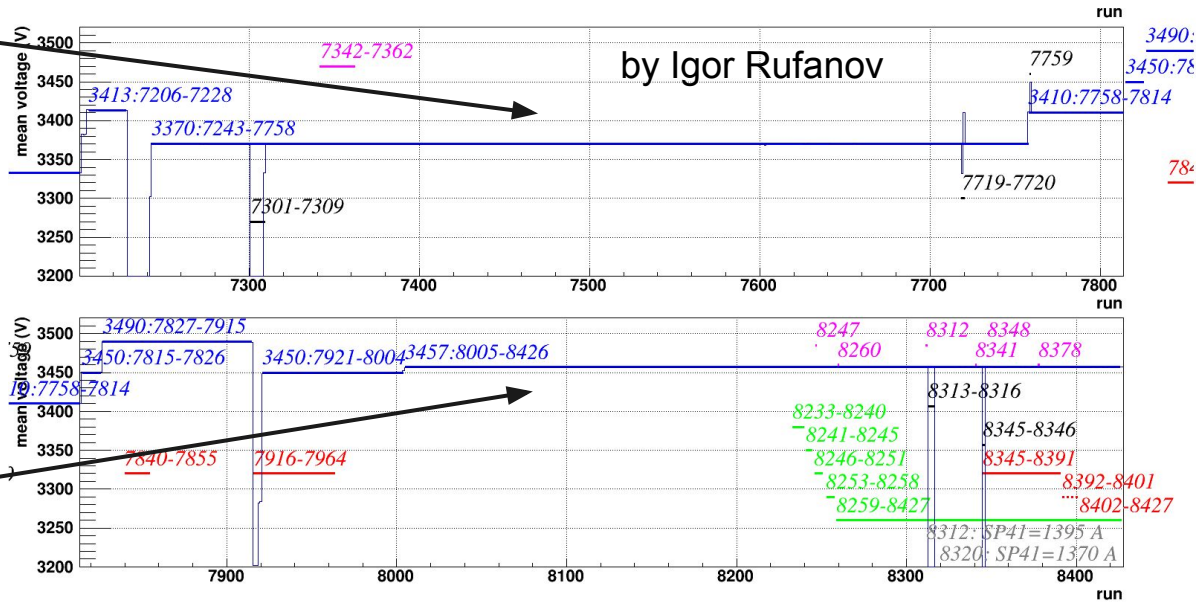
  http://indico.oris.mephi.ru/event/315/contribution/1/material/slides/0.pdf)

Thank you for your attention!

backup

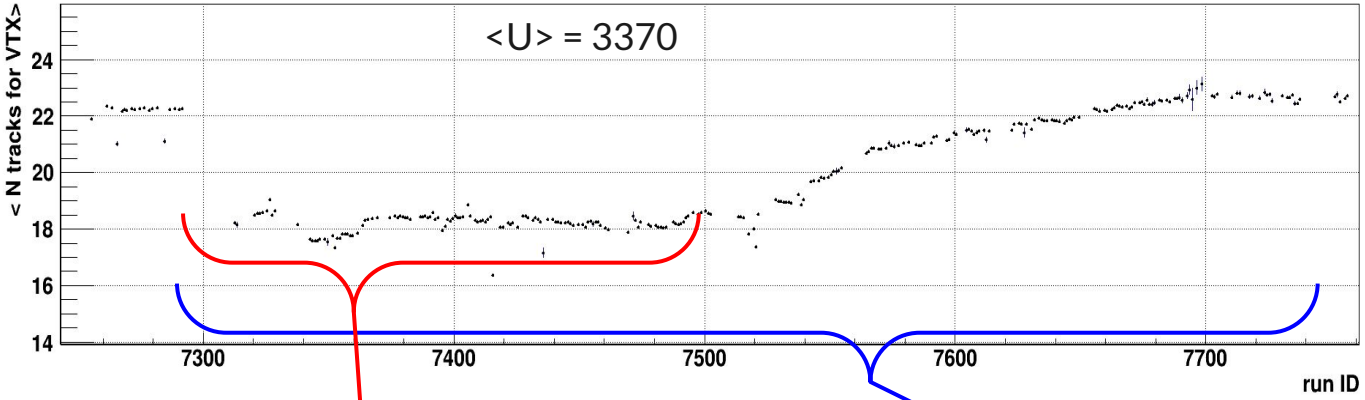
Multiplicity & RunID: Effect of voltage

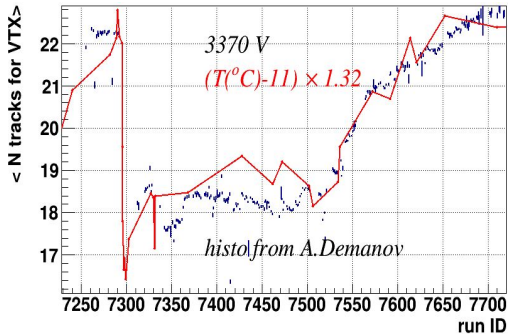


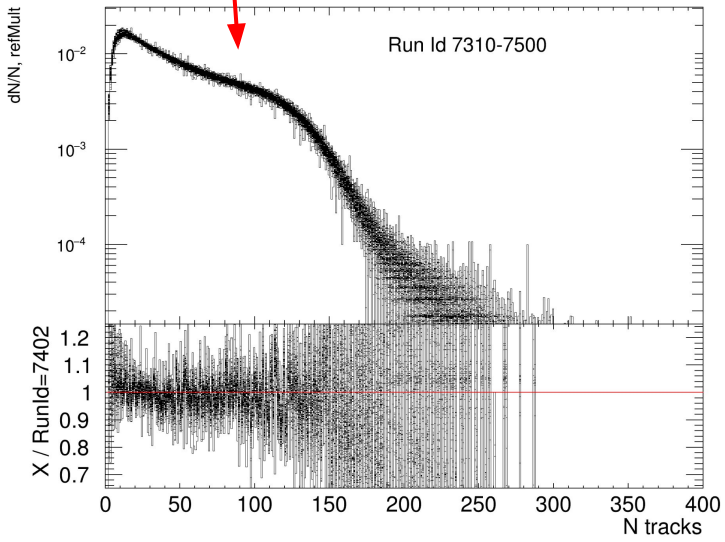


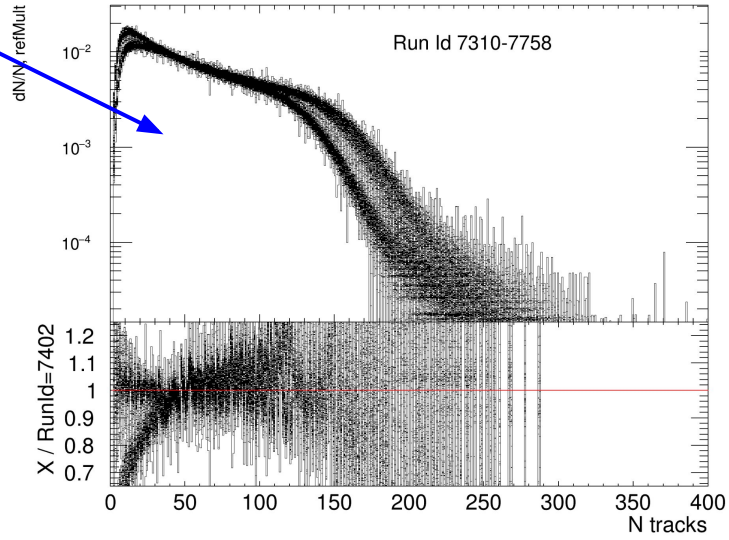
Strong dependence of multiplicity on voltage.
Run-by-run corrections are required!

Multiplicity & RunID: **Effect of temperature**









Mult vs RunId: Shift and re-weight (zero bins eval)

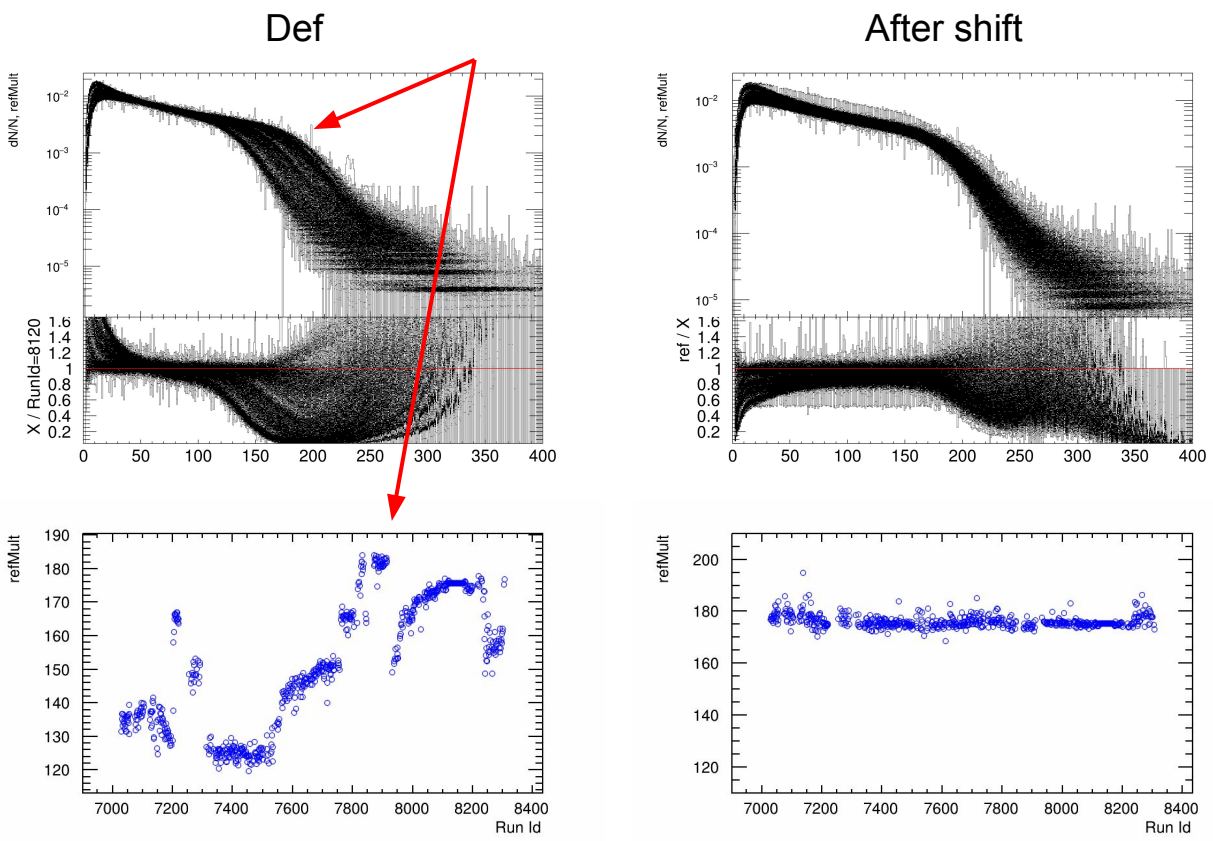
$RunId_{ref}$: 8120-8170

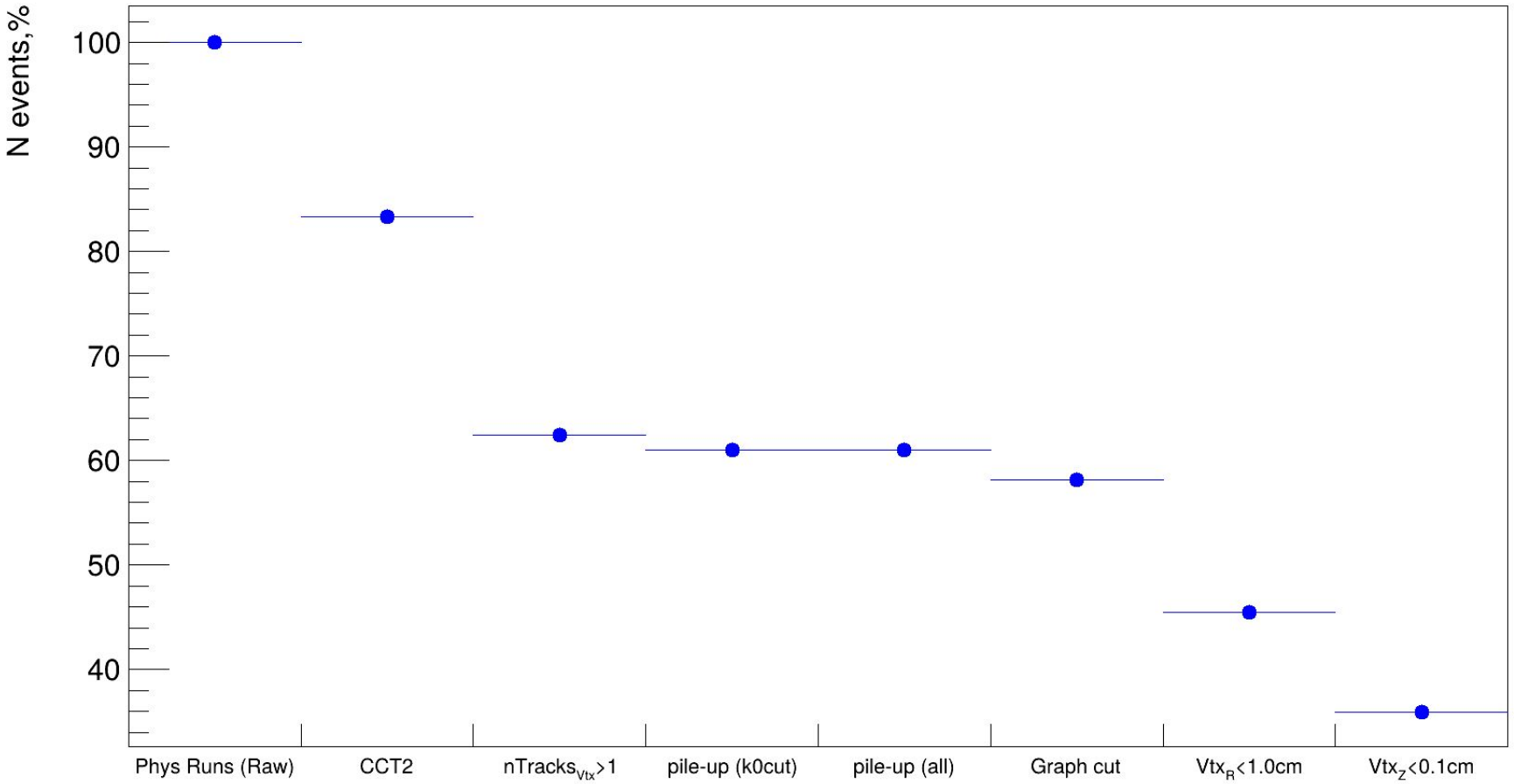
Extract the high-end point of refMult distribution in each RunId via fitting the refMult tail by the function:

f(refMult) = A*Erf(-σ*(refMult-h)) + A

refMult can then be corrected by:

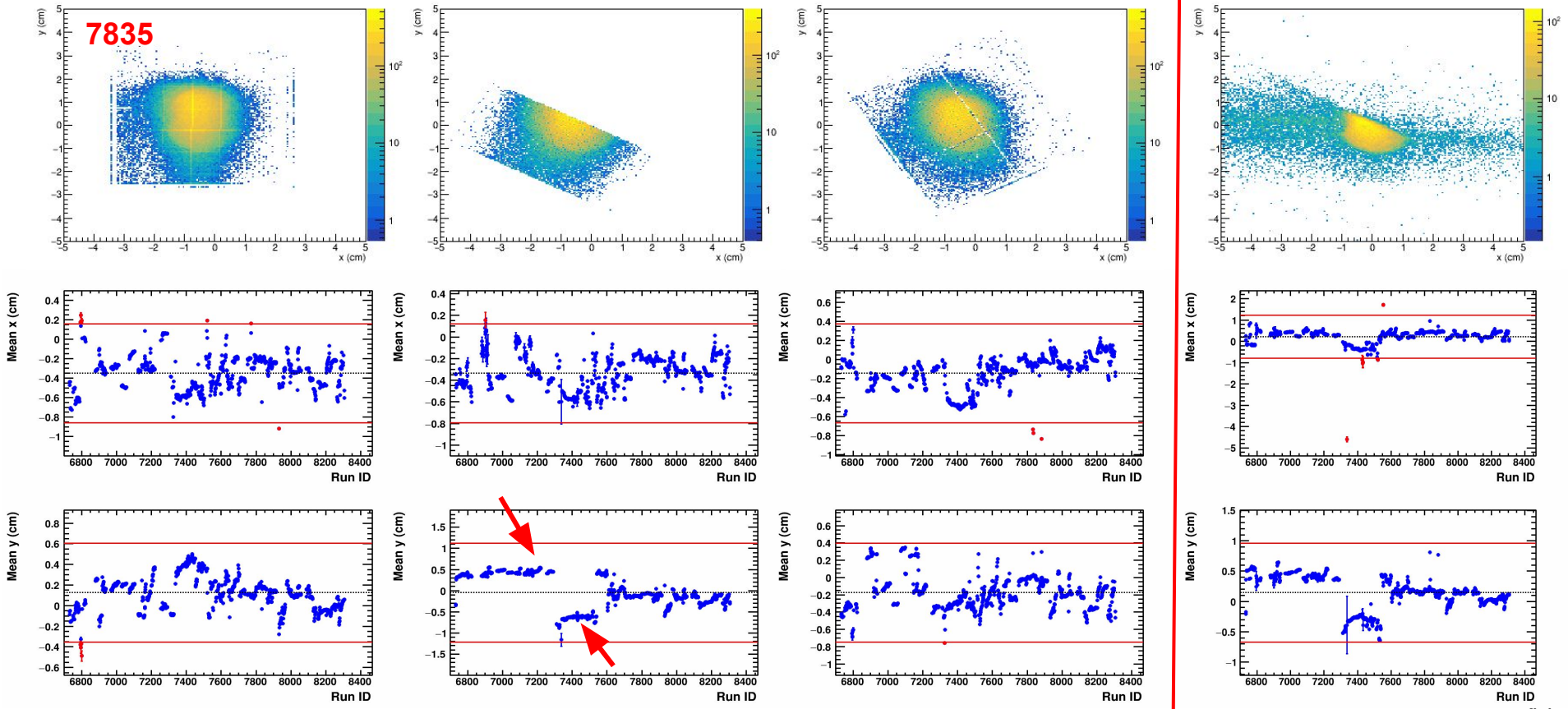
refMultCorr = refMult * h_{ref} / h(RunId)



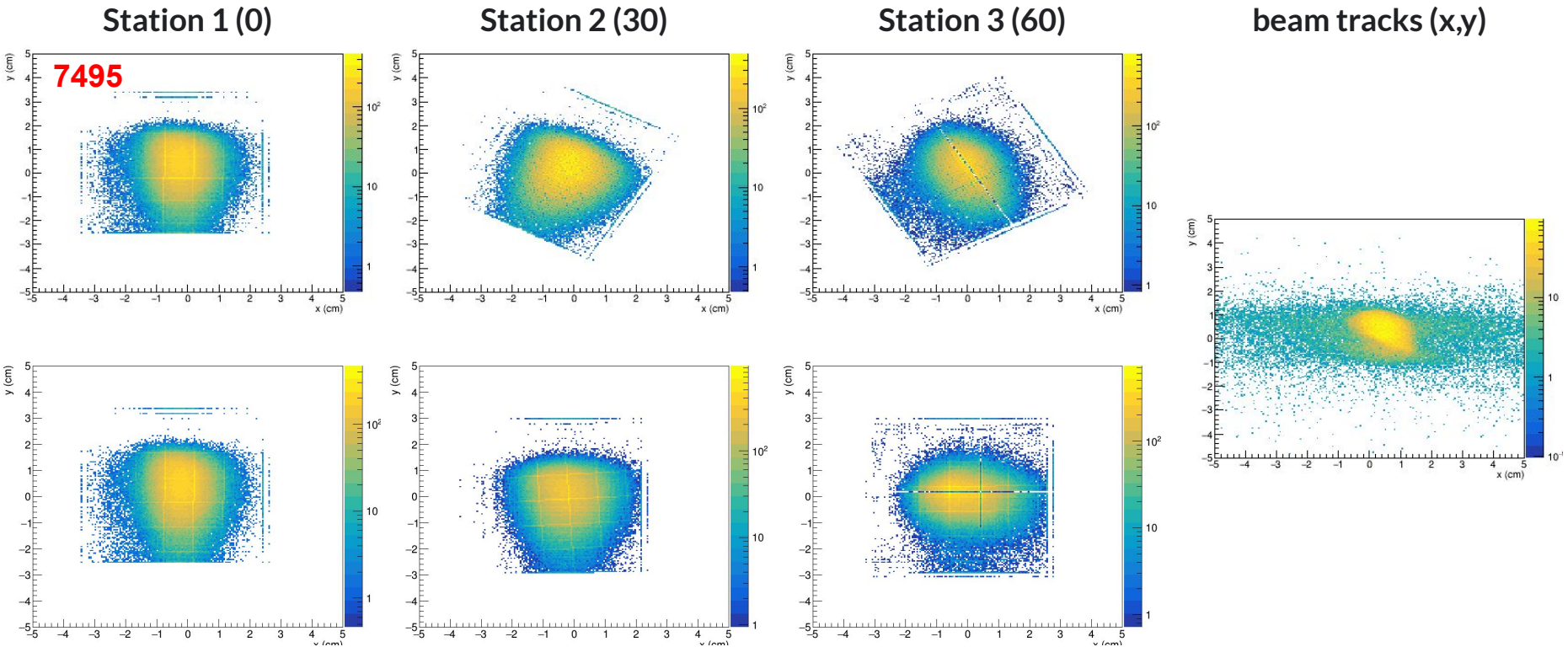

N events,%
100
90
80
70
60
50
40
Phys Runs (Raw)
CCT2
nTracks$_{Vtx}$>1
pile-up (k0cut)
pile-up (all)
Graph cut
Vtx$_R$<1.0cm
Vtx$_Z$<0.1cm

QA Run-by-Run: SiBT (old)

Station 1 (0) | Station 2 (30) | Station 3 (60) | beam tracks (x,y)

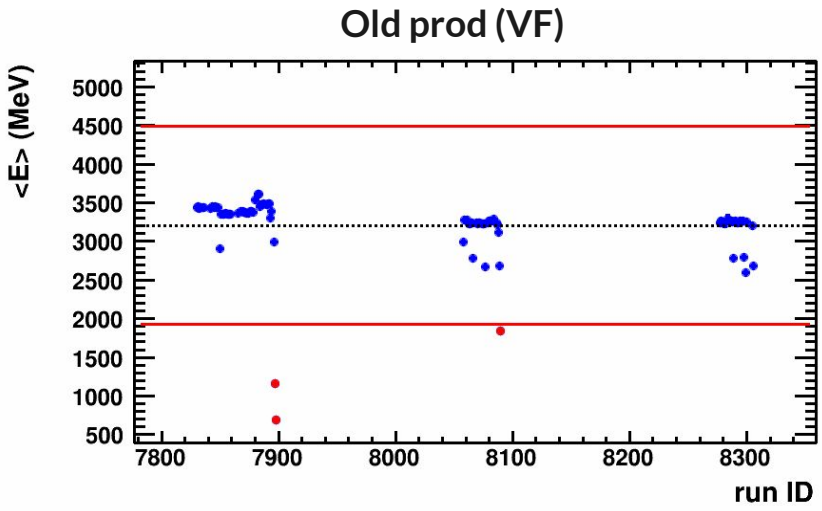


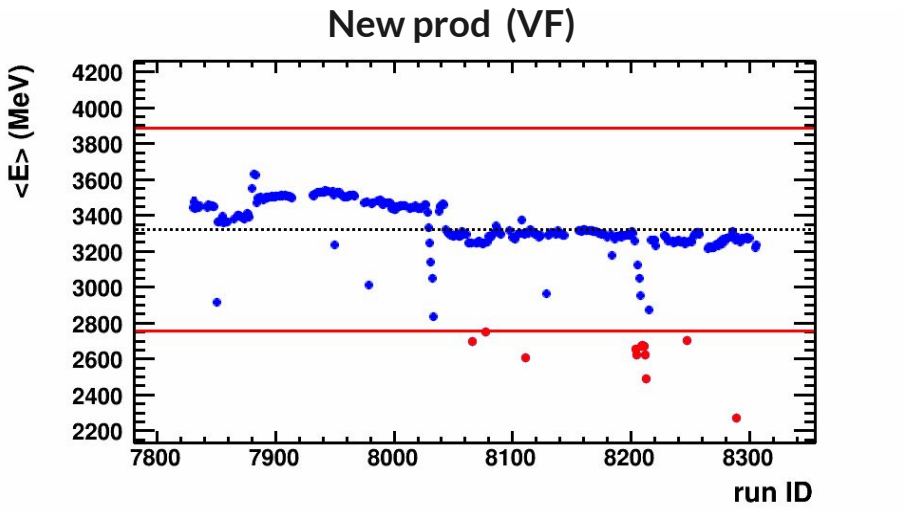
QA Run-by-Run: SiBT

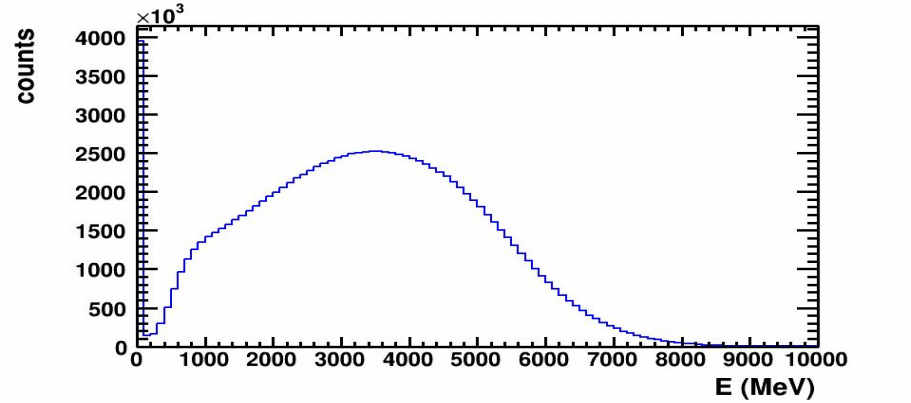


- QA run-by-run the SiBT are in progress

Difference between productions: FHCal (7800-8300)

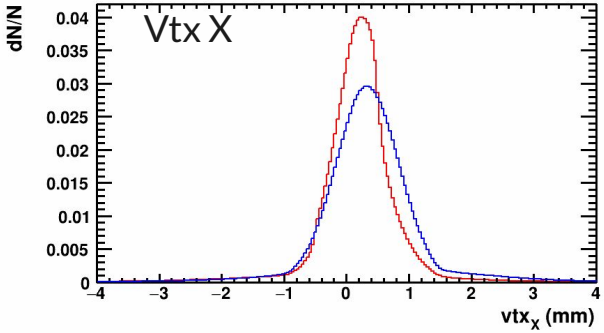


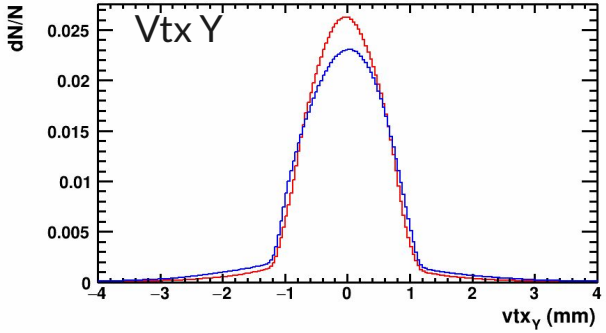


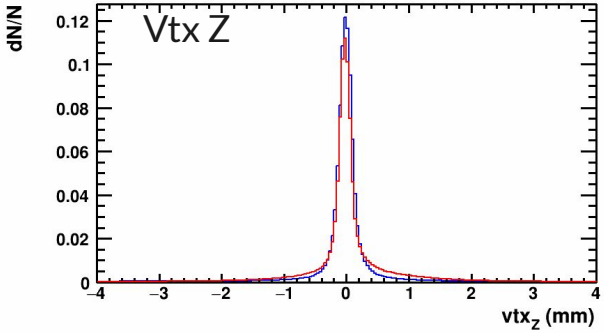


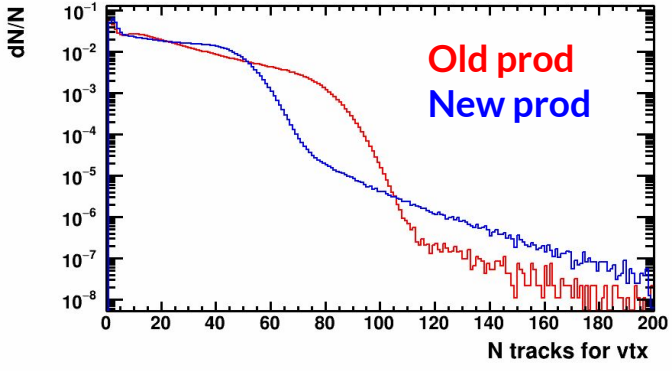
There are problems with the FHCal data when using the VF production - Solved!

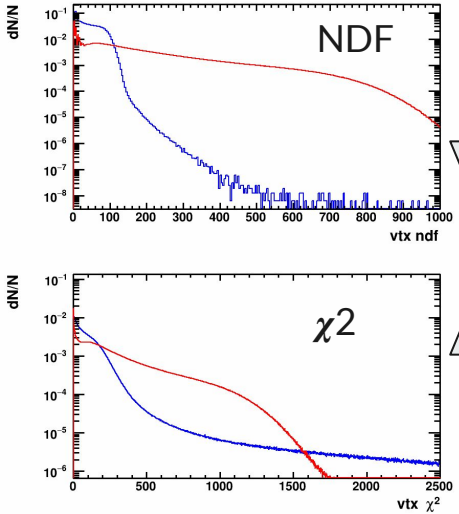
Difference between productions: vertex reconstruction (7800-8300)

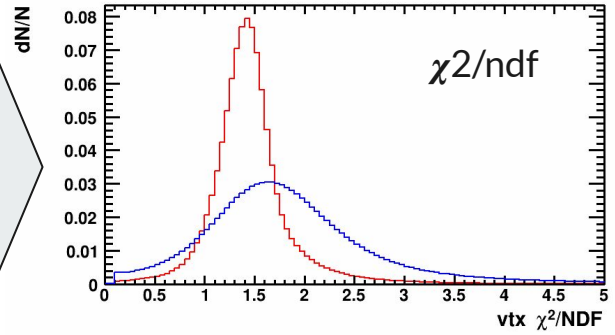






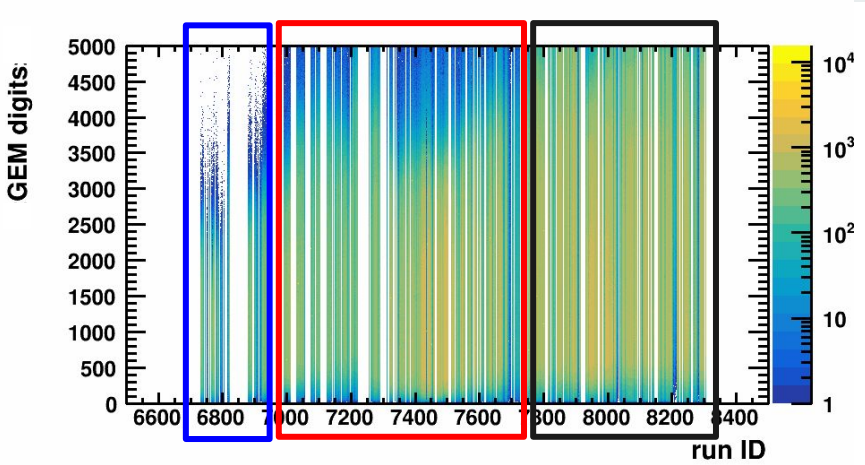


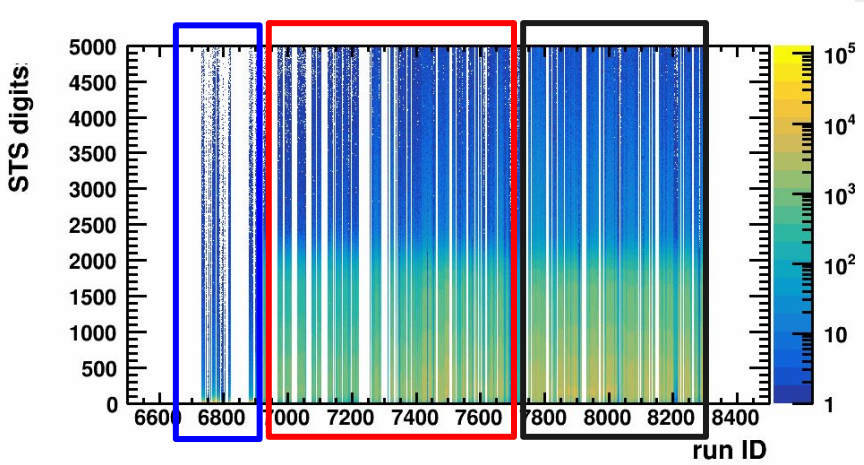


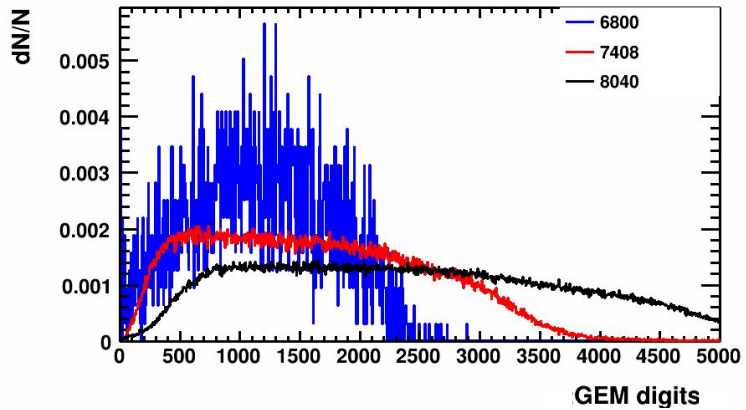


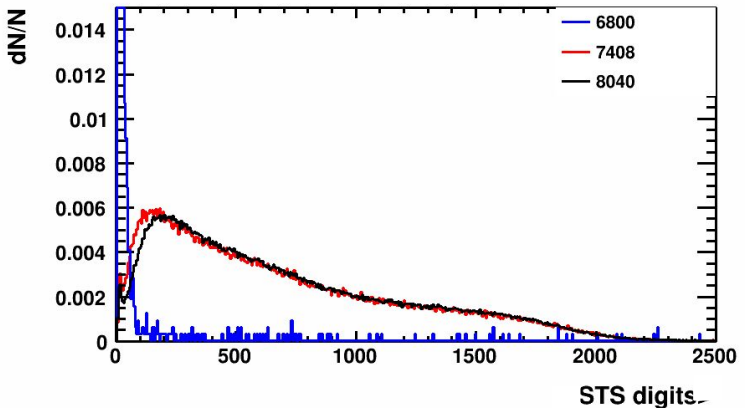
Changes in tracking?

QA Run-by-Run: GEM+FSD



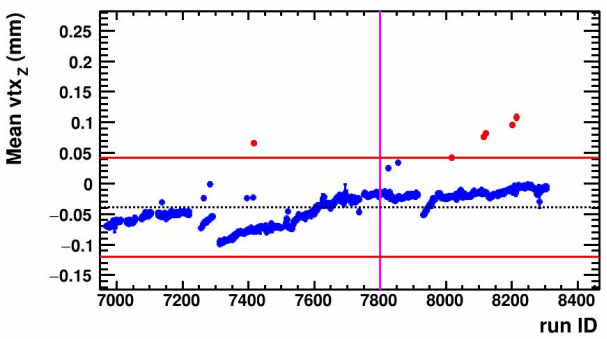


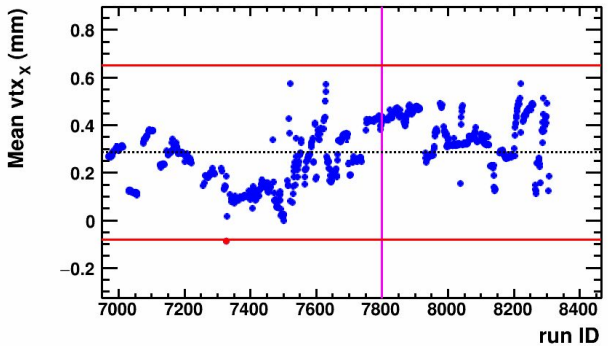


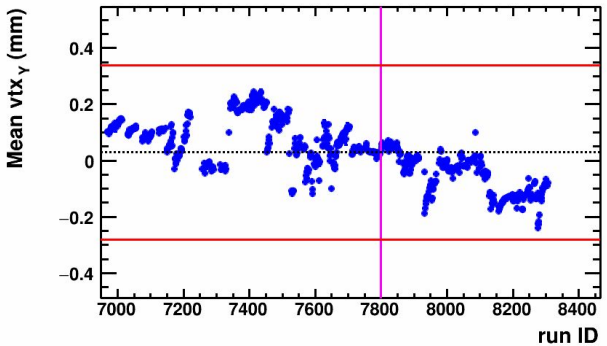


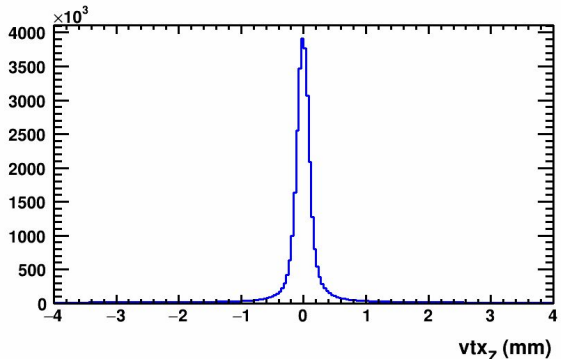
We don't consider Runs below 7000

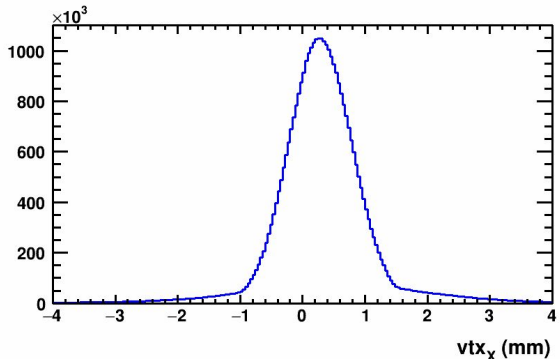
QA Run-by-Run: vertex position

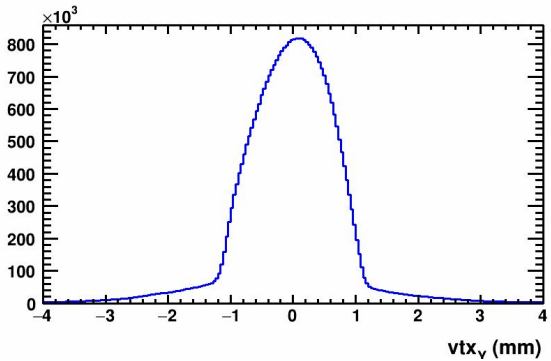






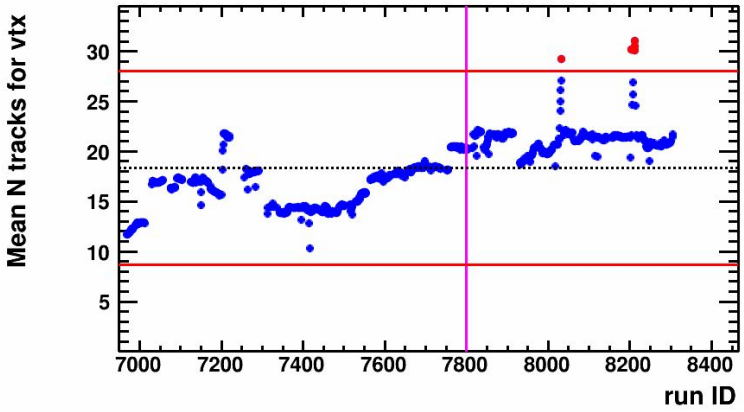


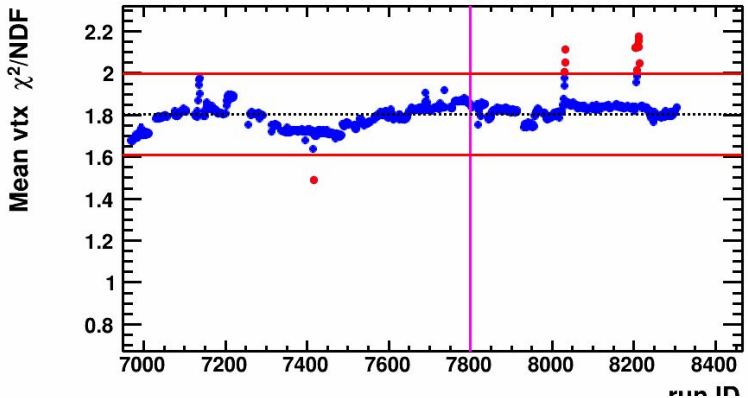


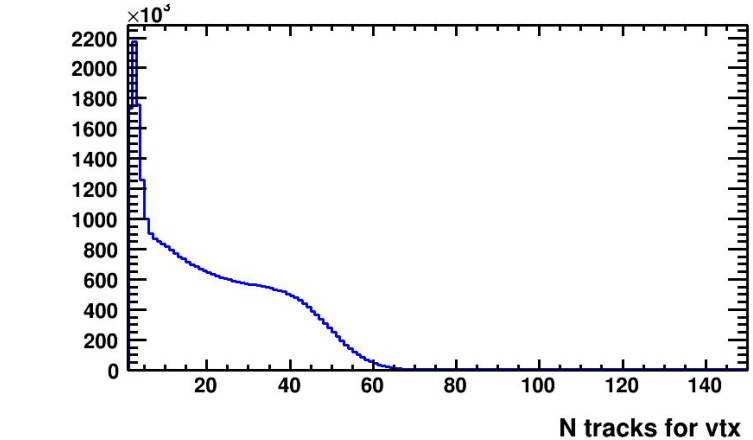


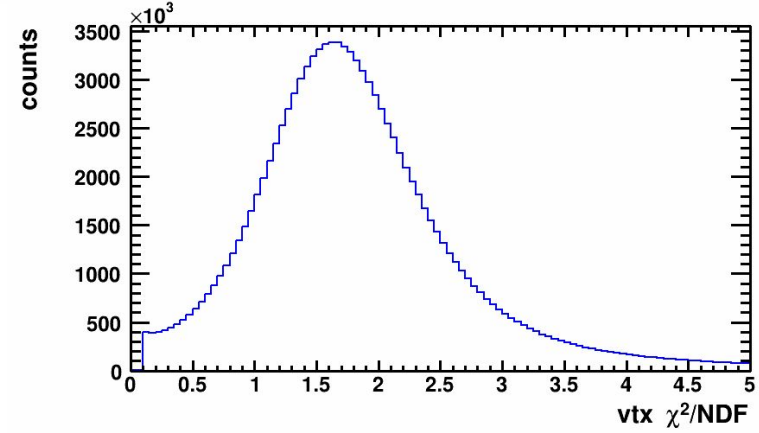
Bad Runs: 7326, 7417, 8201

QA Run-by-Run: vertex quality



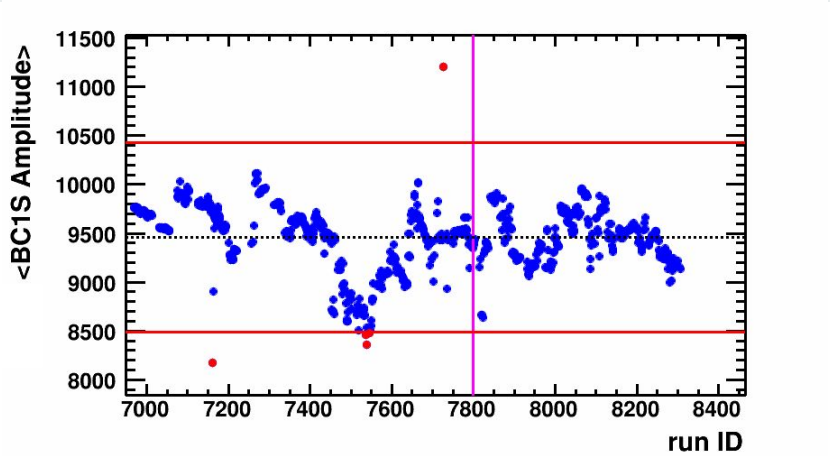


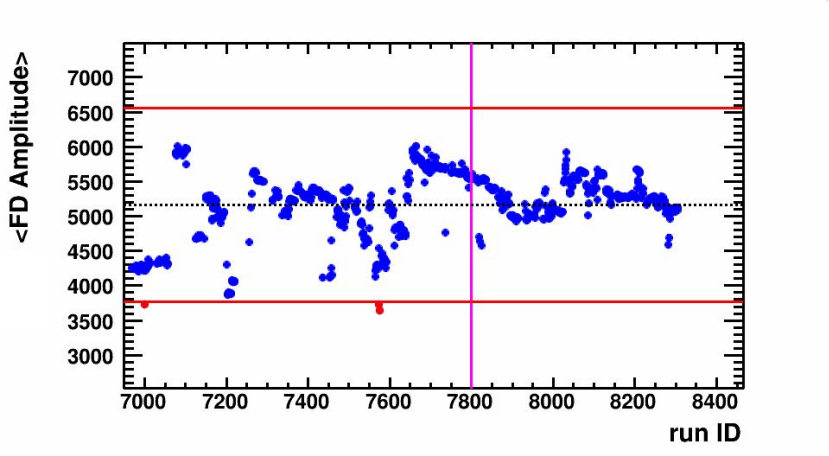


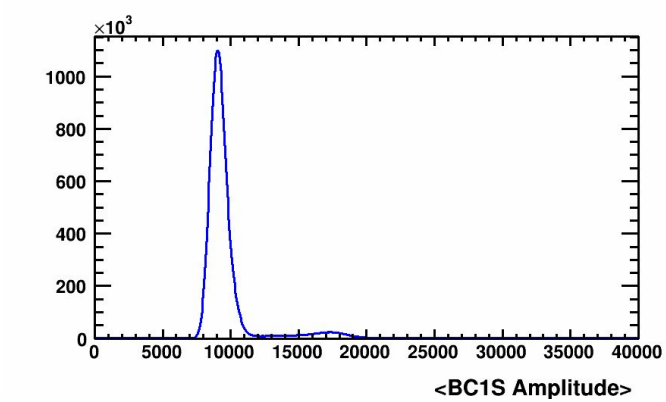


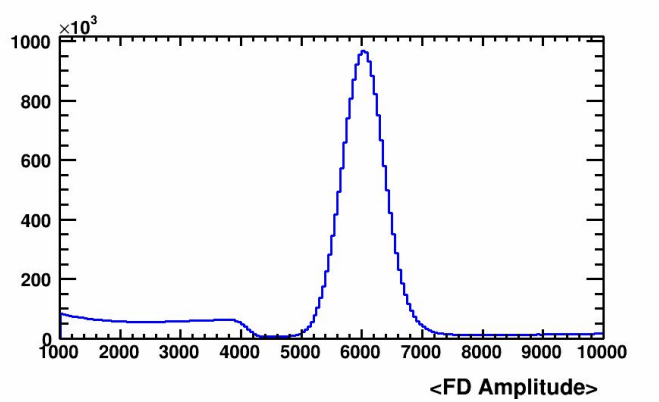
Bad Runs: 78033, 8204, 8205, 8209, 8210, 8211, 8212, 8213

QA Run-by-Run: BC1, FD



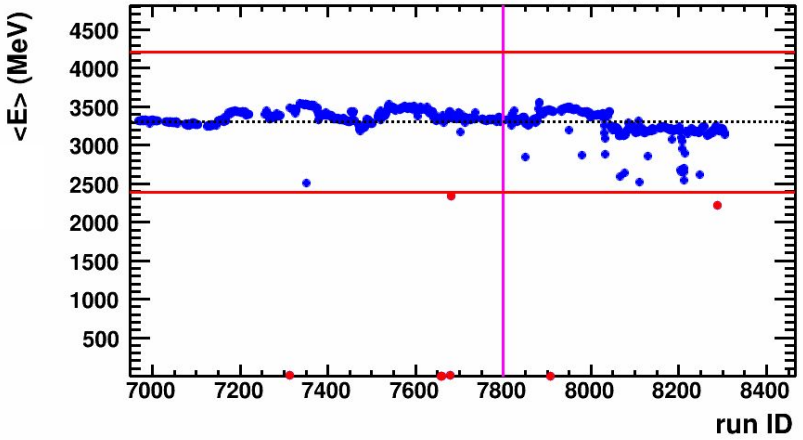


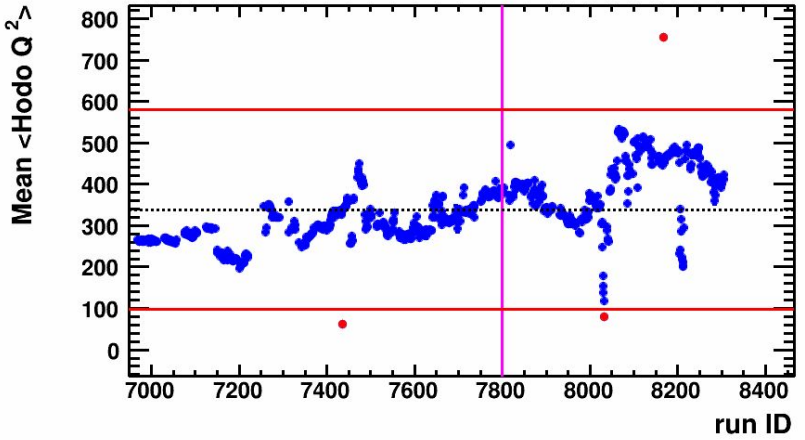


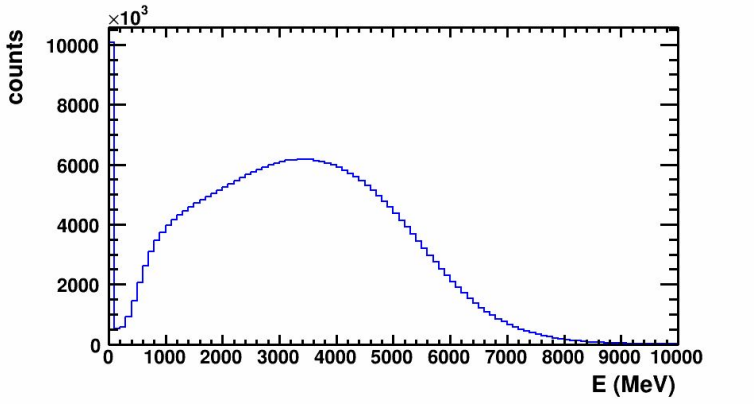


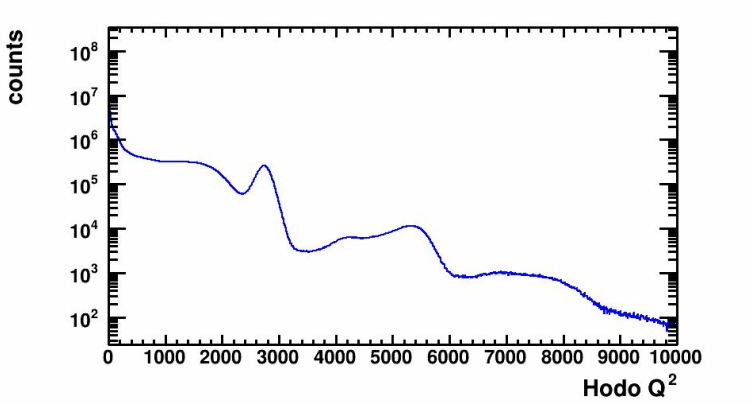
Plans on future: calibrate factor for each RunId

QA Run-by-Run: FHCal and FQH



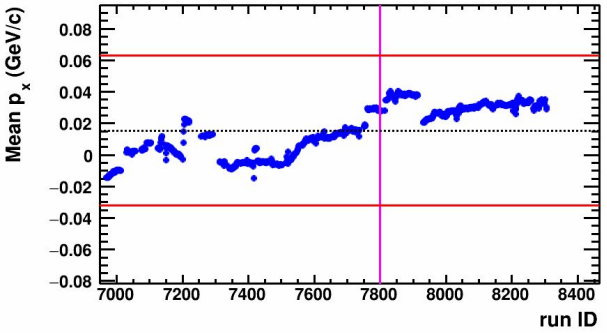


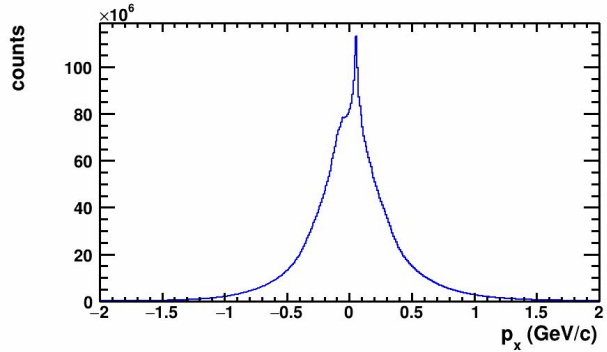




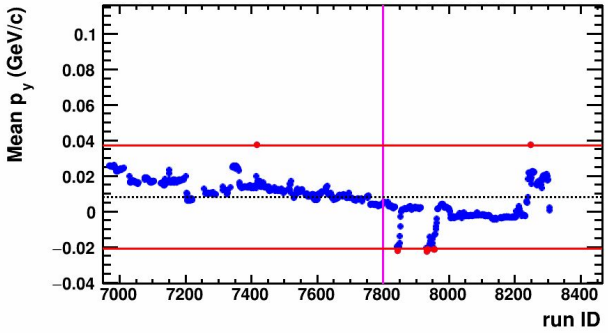
QA Run-by-Run: Tracks

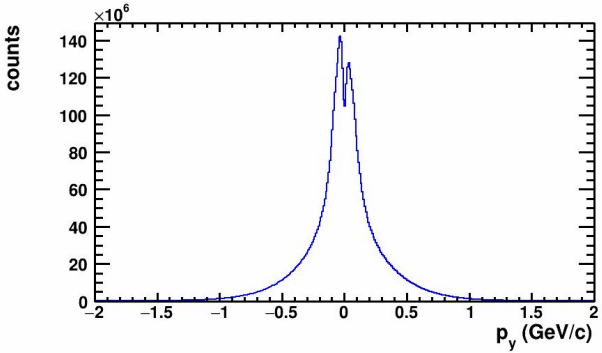
<p_x> GeV/c



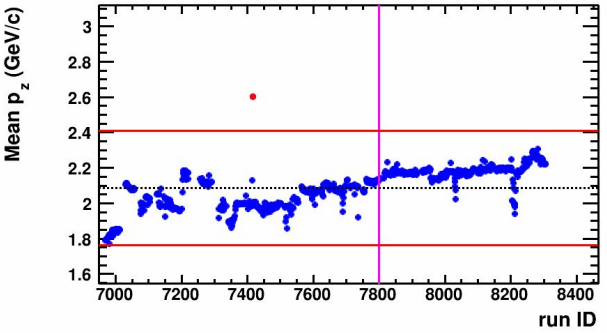


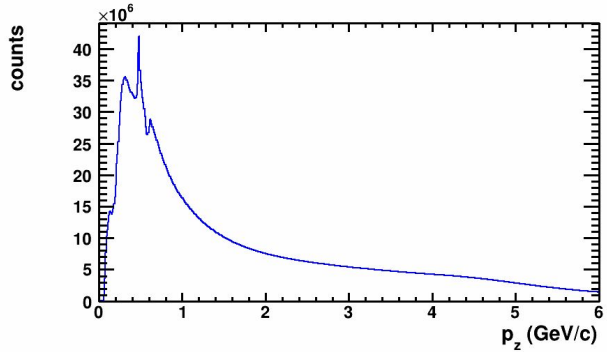
<p_y> GeV/c





<p_z> GeV/c



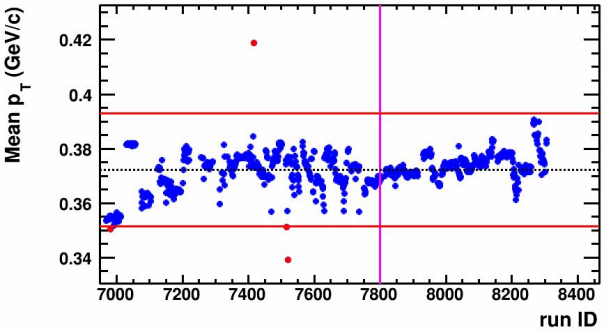


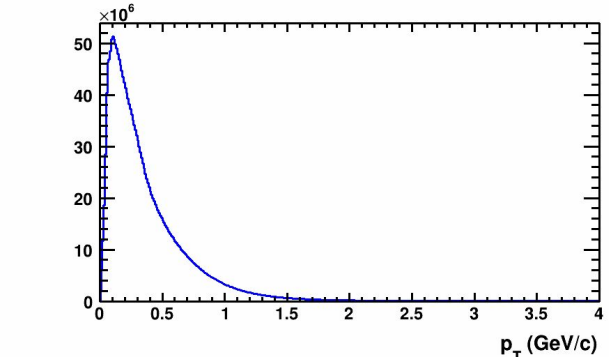
Bad Runs: 7843, 7932, 7933, 7935, 7937, 7954, 7955, 8247

Significant run Id dependence

QA Run-by-Run: Tracks

<p_T> GeV/c





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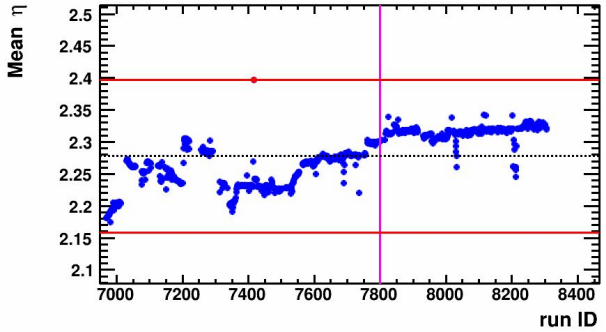

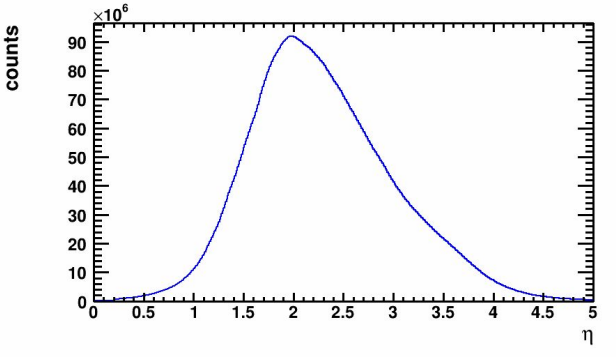

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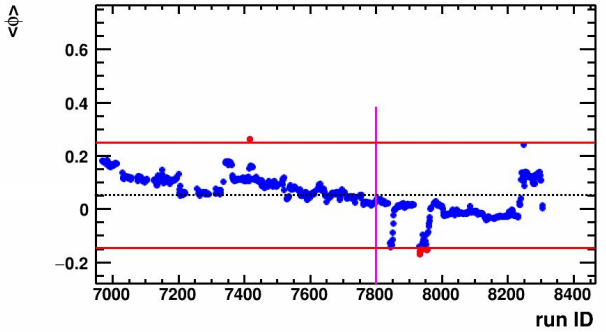
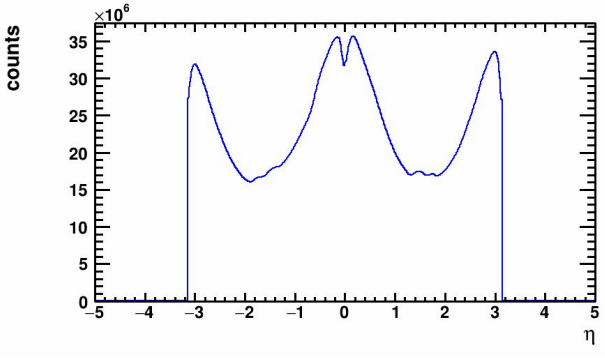
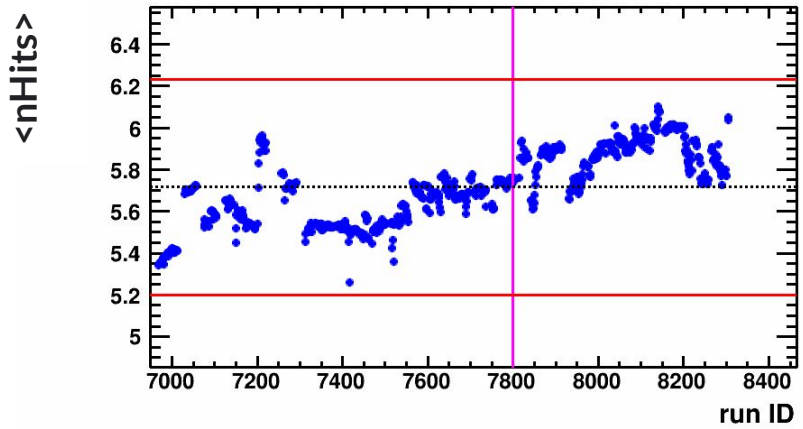


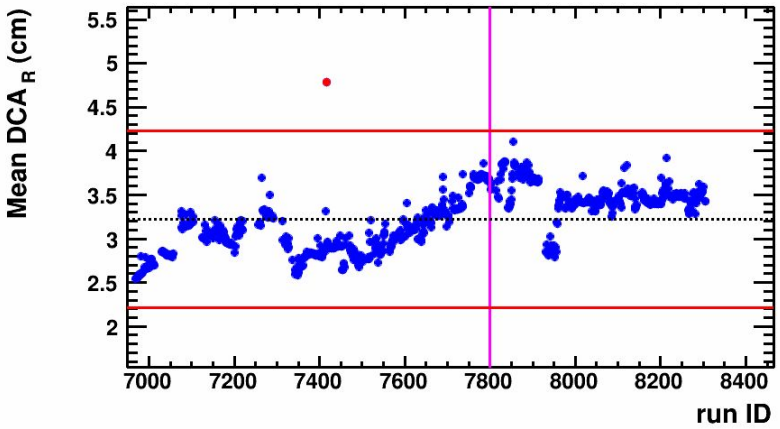


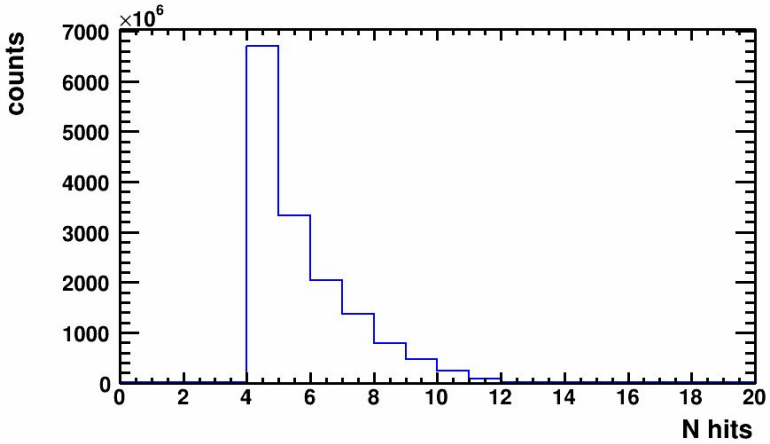
Bad Runs: 6980, 6992, 7417, 7520

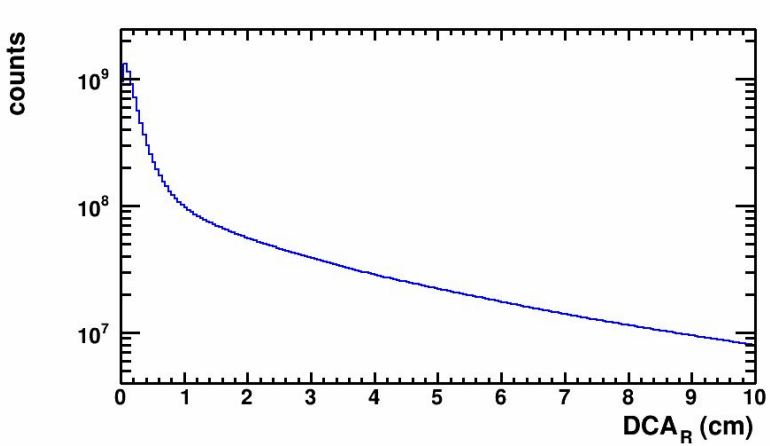
Significant run Id dependence

QA Run-by-Run: Tracks







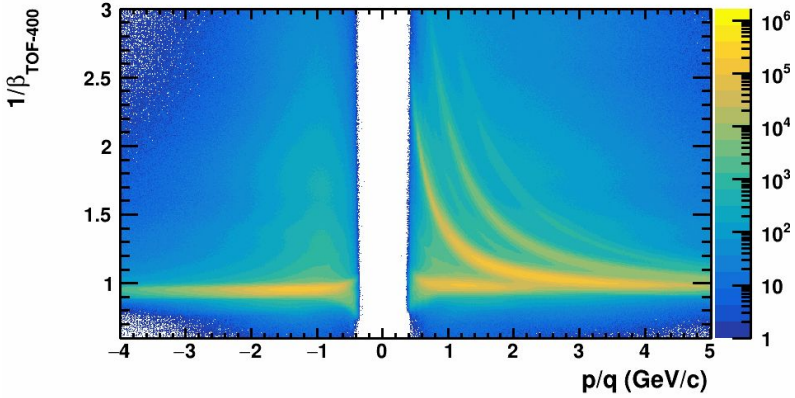


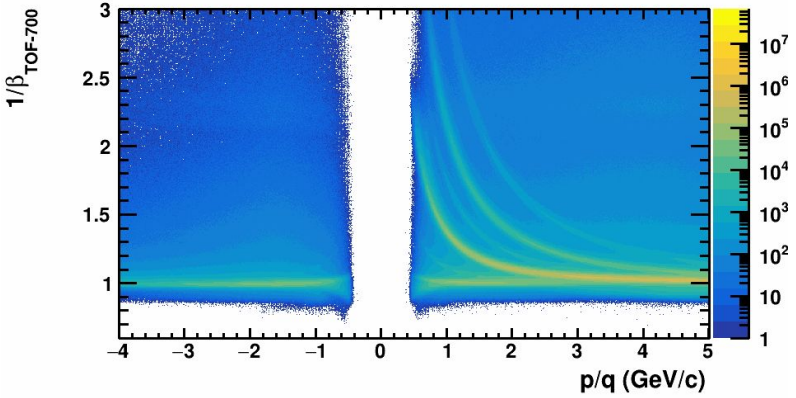
Square mass

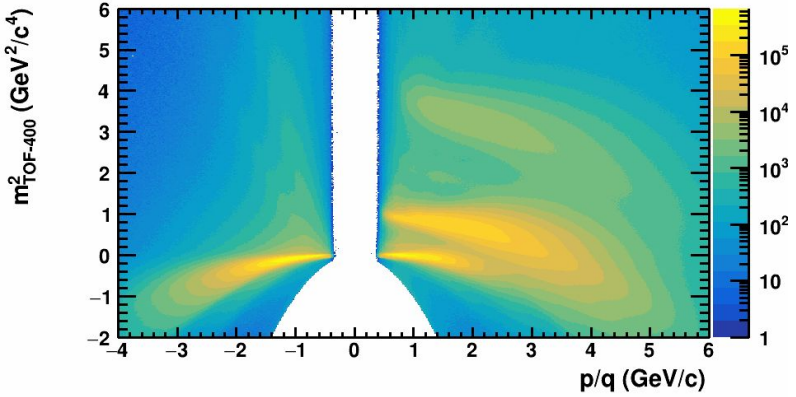
TOF-400

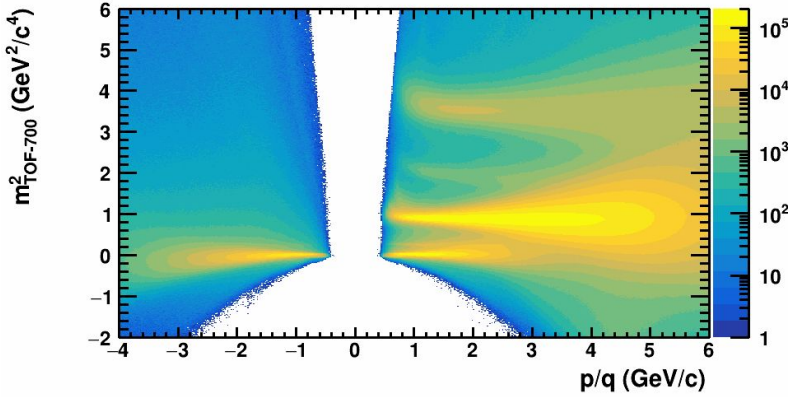
$$m^2 = \frac{(1-\beta^2) * p^2}{\beta^2}$$

TOF-700









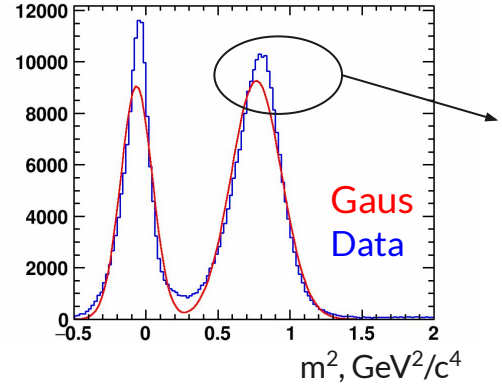
QA Run-by-Run: proton

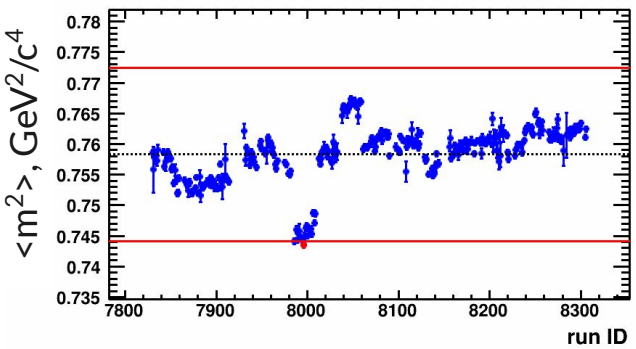
Fit of each run ID with Gaus

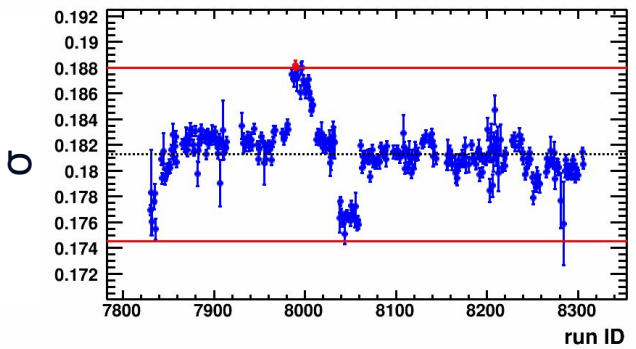
$0.5 < p < 2.0\ GeV^2/c^4$

Runs 7000-7800 are in progress…

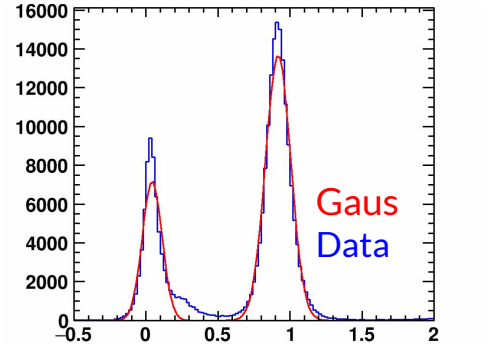
TOF-400

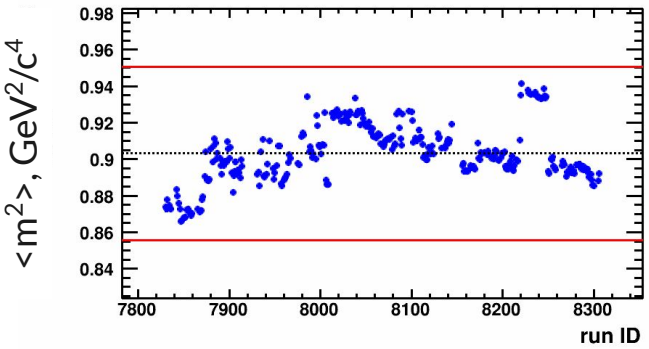


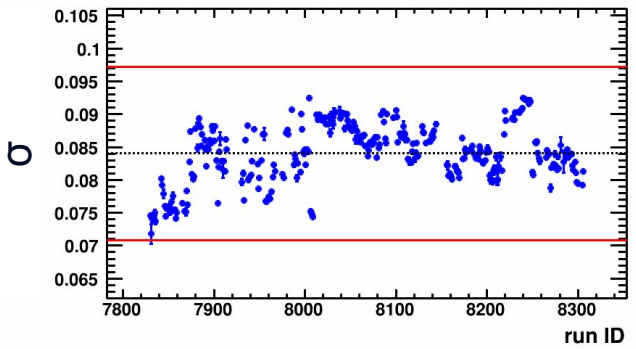




TOF-700







We have a room for improvement after TOF calibration

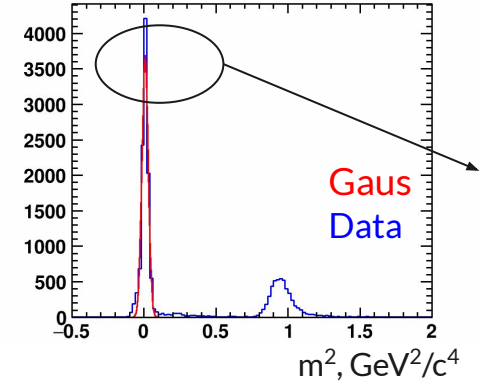
QA Run-by-Run: π^+

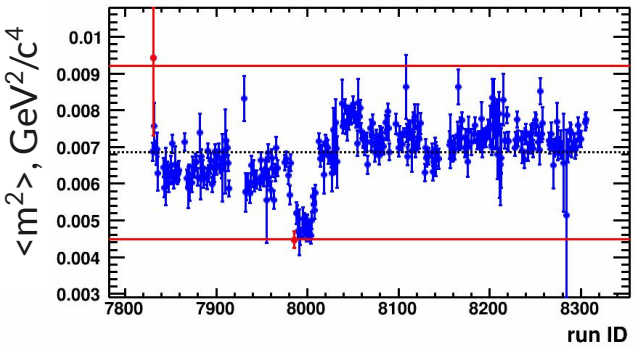
Fit of each run ID with Gaus

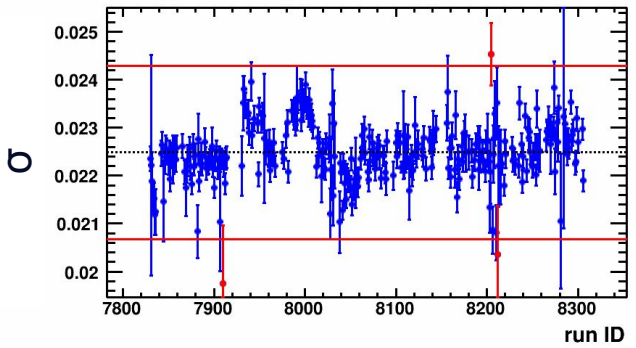
$0.2 < p < 0.7$ GeV^2/c^4

Runs 7000-7800 are in progress…

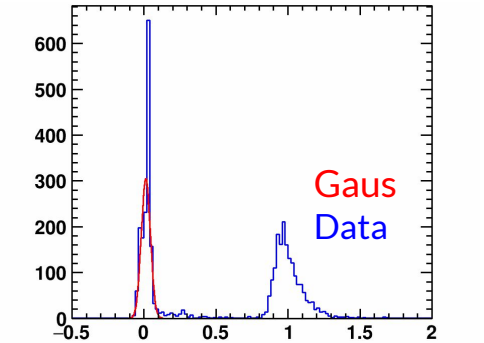
TOF-400

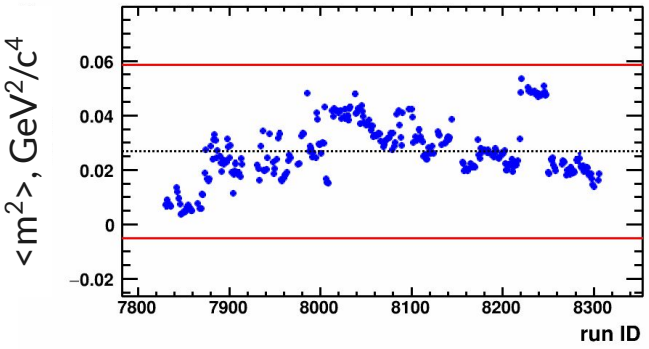


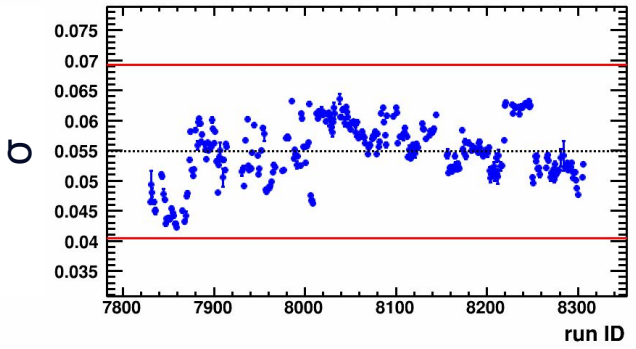




TOF-700







We have a room for improvement after TOF calibration

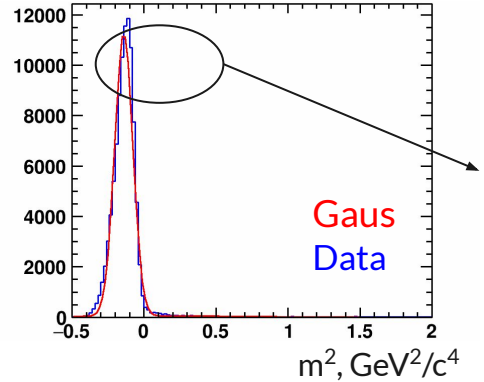
QA Run-by-Run: π^-

Fit of each run ID with Gaus

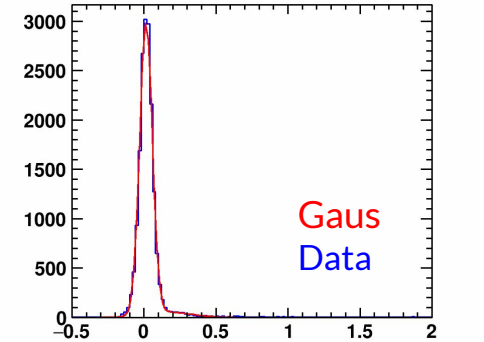
$0.2 < p < 1.5\ GeV^2/c^4$

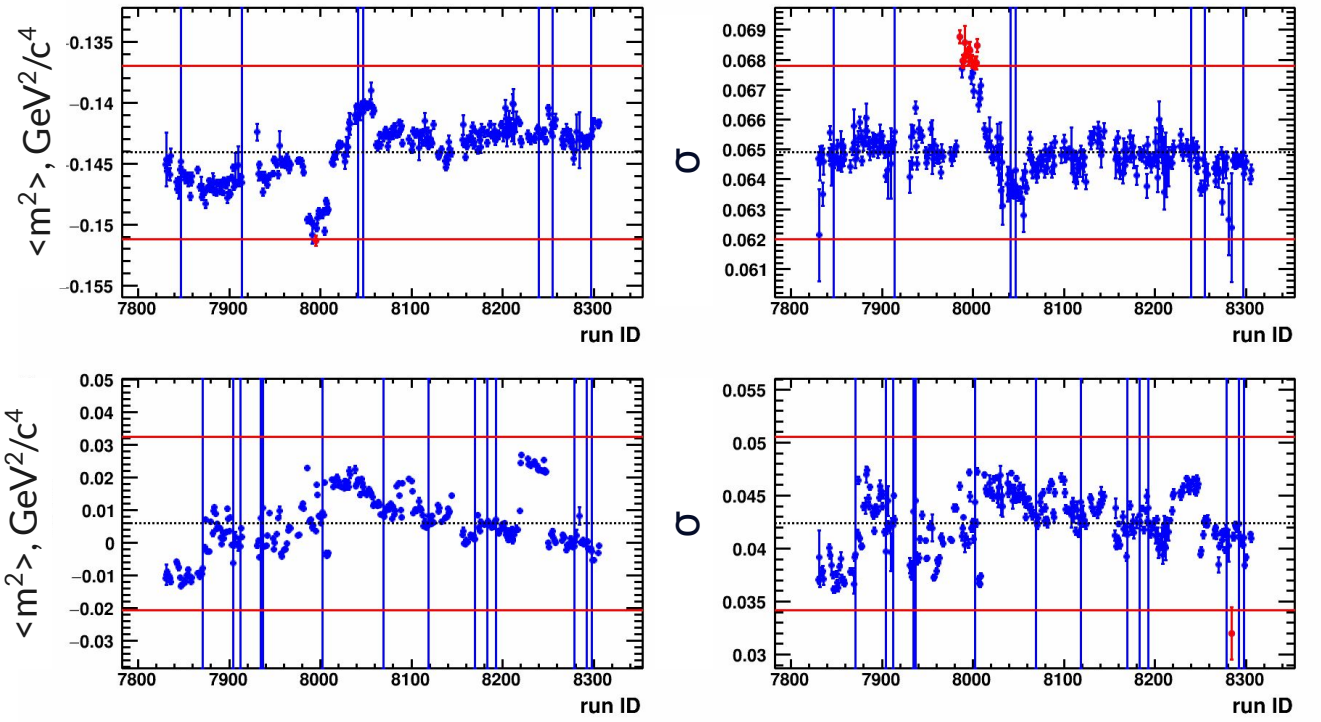
Runs 7000-7800 are in progress…

TOF-400



TOF-700





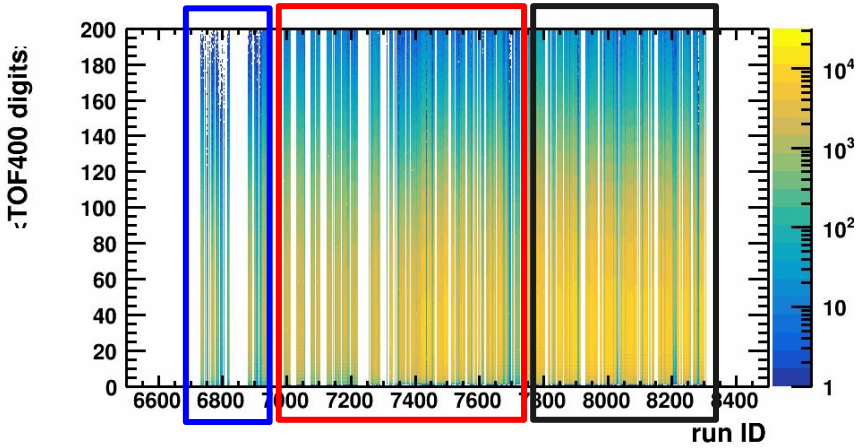
We have a room for improvement after TOF calibration

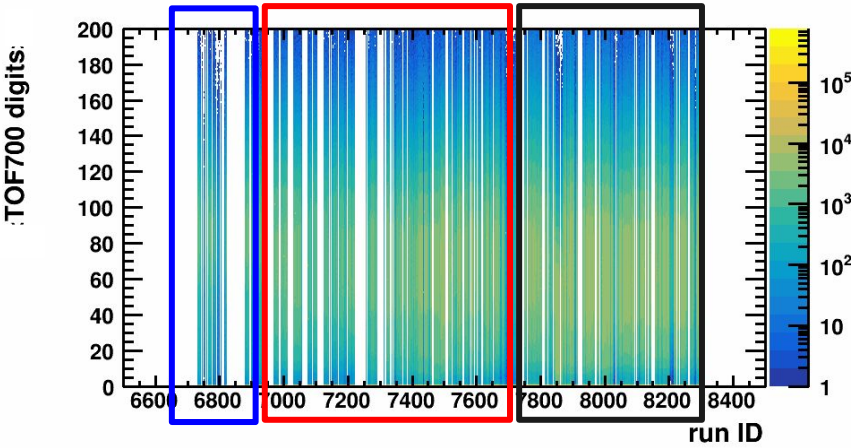
Production information

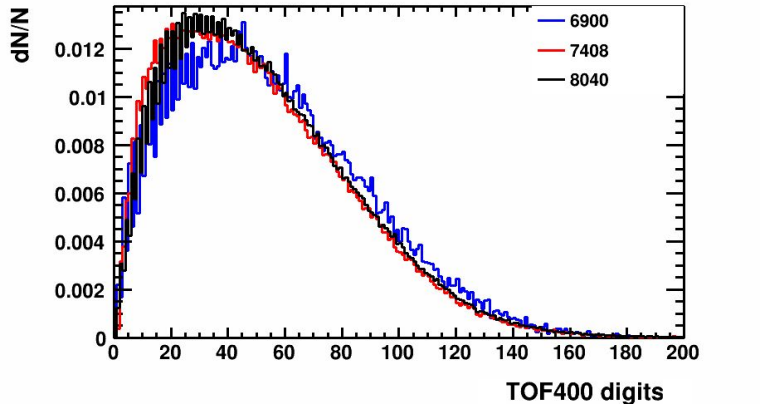
Run8 Xe-CsI @3.8*A* GeV

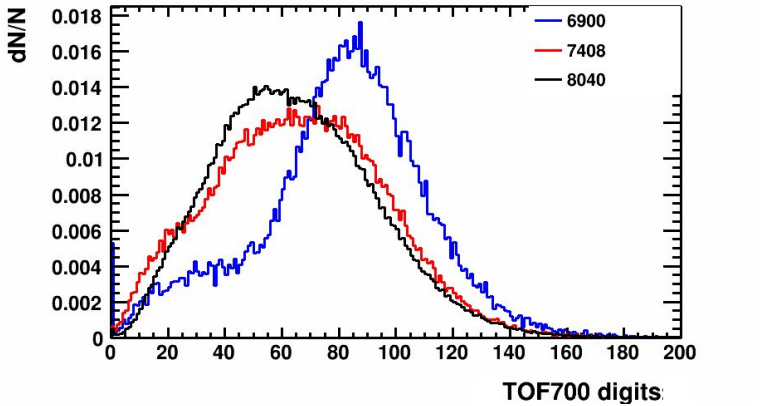
- dev (old):
  - /eos/nica/bmn/exp/dst/run8/dev_vf
  - ~14000 files (7800-8300)
- 24.02.0 (new):
  - /eos/nica/bmn/exp/dst/run8/24.02.0
  - ~29000 files (6600-8300)

QA Run-by-Run: TOF-400 and TOF-700



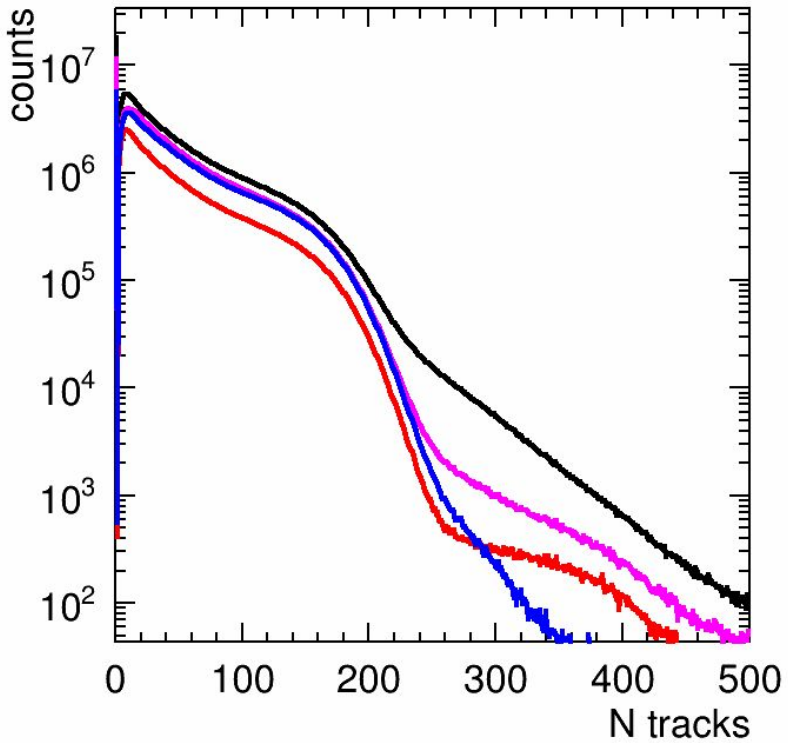






We don't consider Runs below 7000

Basic selection



297.5M (62 %), CCT2 trigger, nTrVtx > 0

128.2M (27 %), 1 ion in BC1 (old)

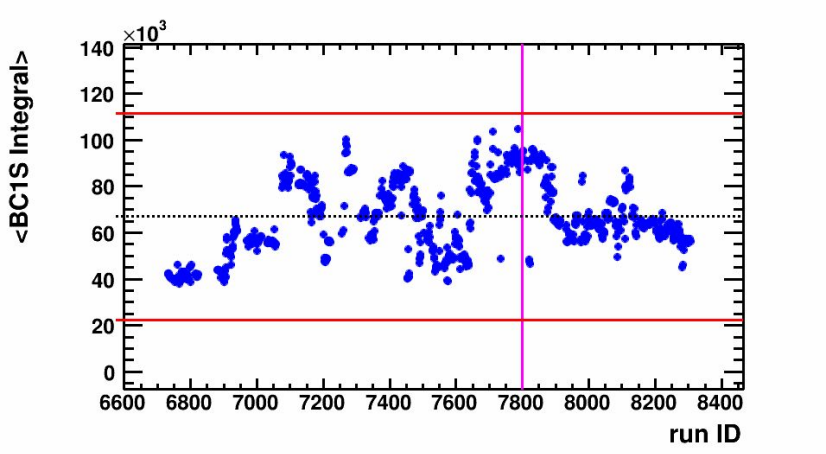
228.4M (48 %), diff between BC1 and FD =1 (new)

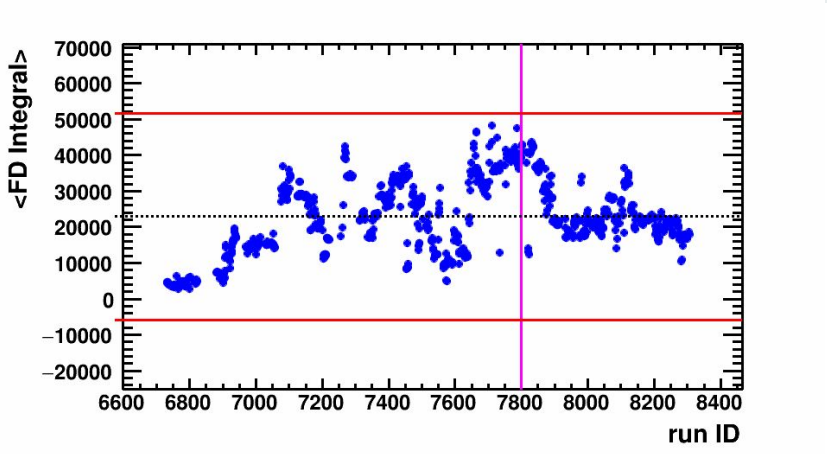
202.5M (42 %), Add cut: StsNTrDiggit vs mult

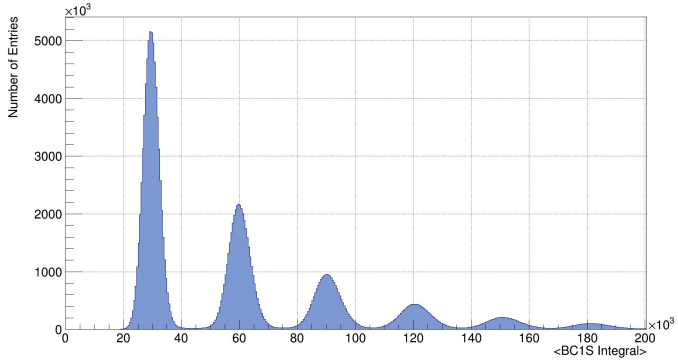
For QA Run-by-run used:

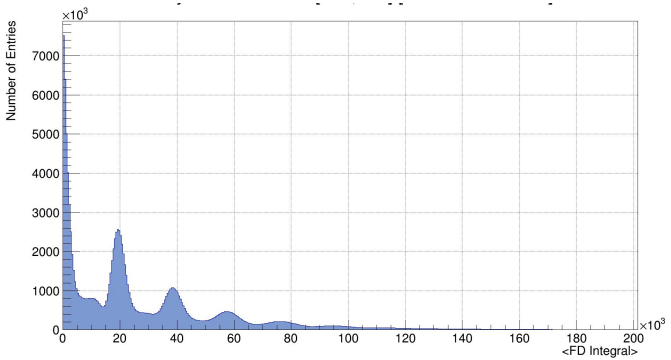
- CCT2
- More than 1 track in vertex reconstruction

QA Run-by-Run: BC1, FD







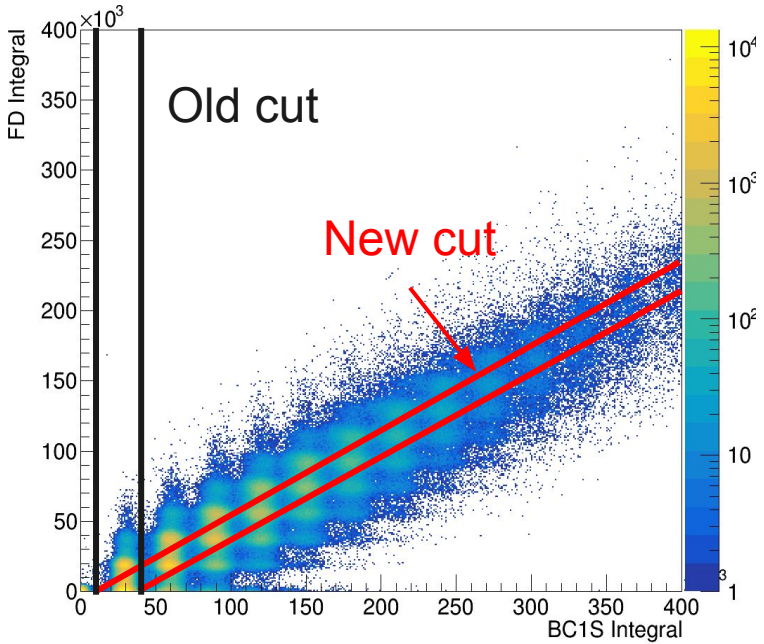


Plans on future: calibrate factor for each RunId

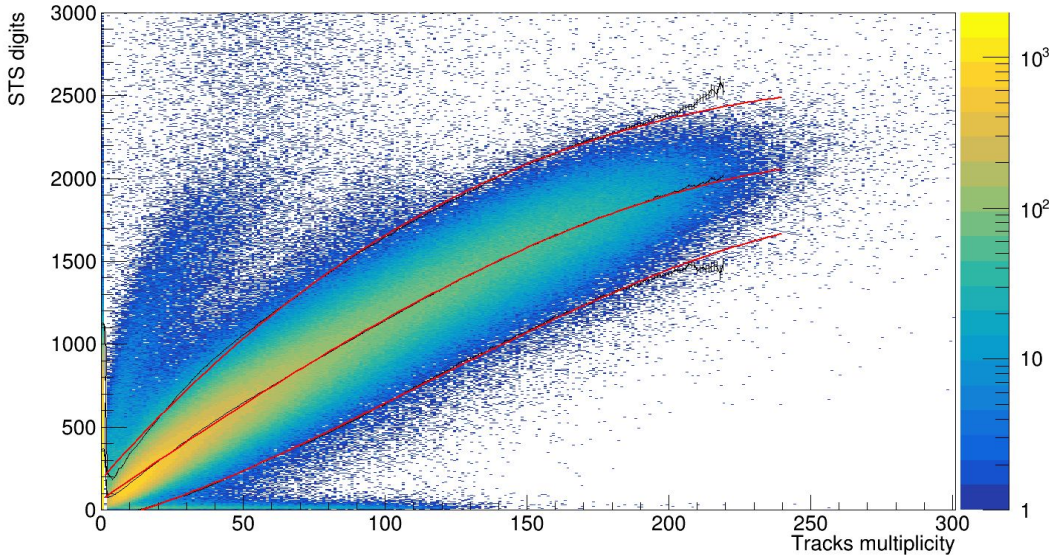
BC1 Integral cut improvement

See the talk of I.Segal for details

- CCT2 trigger
- More than 1 track for vertex reconstruction

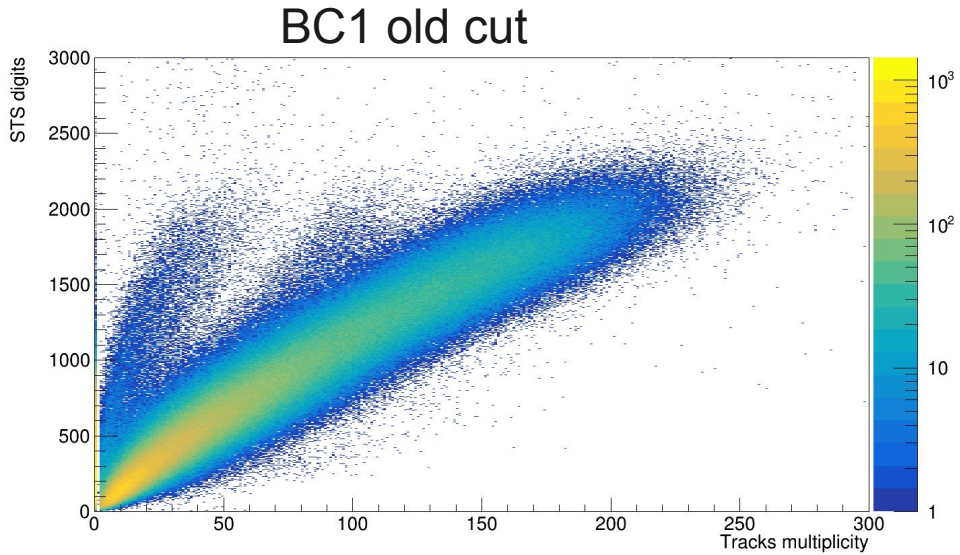


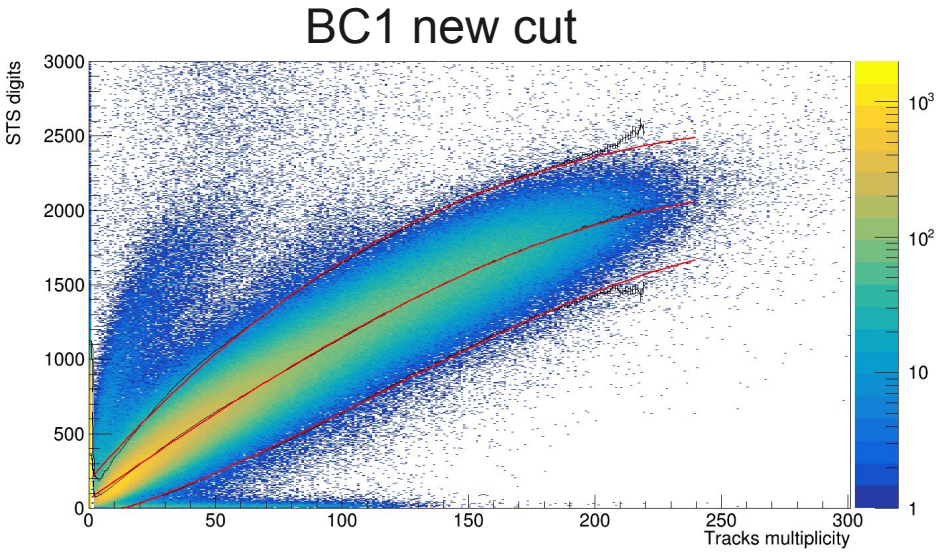
BC1 new cut



We have more events after the New cuts

Additional pileup graphic cut





- Graphic cut was performed to throw out all event unusual behaviour:

  $STS_{max}(N_{tracks})=4.56033e\text{-}05*N^3-0.0518774*N^2+19.4203*N+188.248$

  $STS_{min}(N_{tracks})=-9.62078e\text{-}05*N^3+0.0332792*N^2+4.81632*N-74.0087$

- Difference: