Improving the PID correlator

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What is the PID correlator?

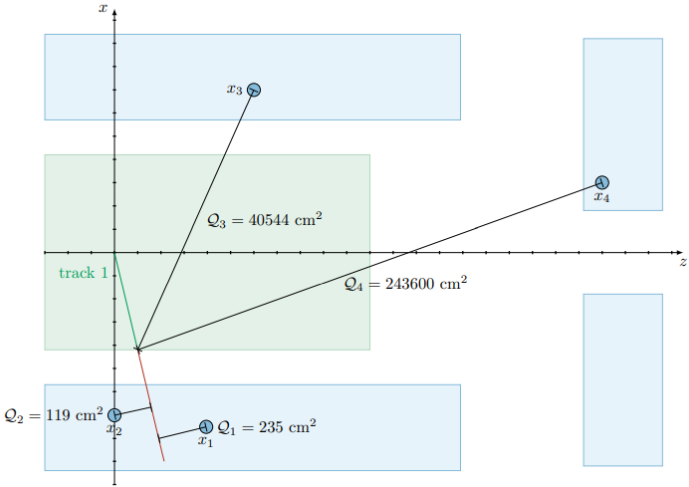
Purpose

- receive reconstructed information from all detector systems
- process and combine all of the information to form neutral and charged particle candidates

Restructuring

- restructured by Sarah Gaiser, to make it more modular and easily manageable
- a few open questions about the inner workings of the PID correlator remained

Matching the emc hits



[Sarah Gaiser]

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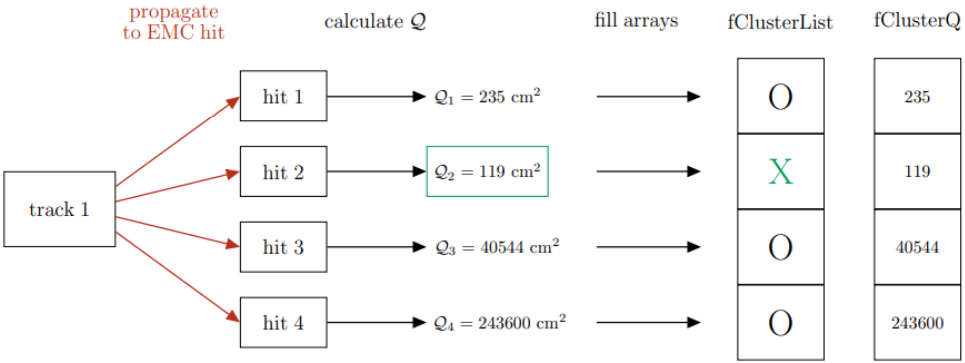

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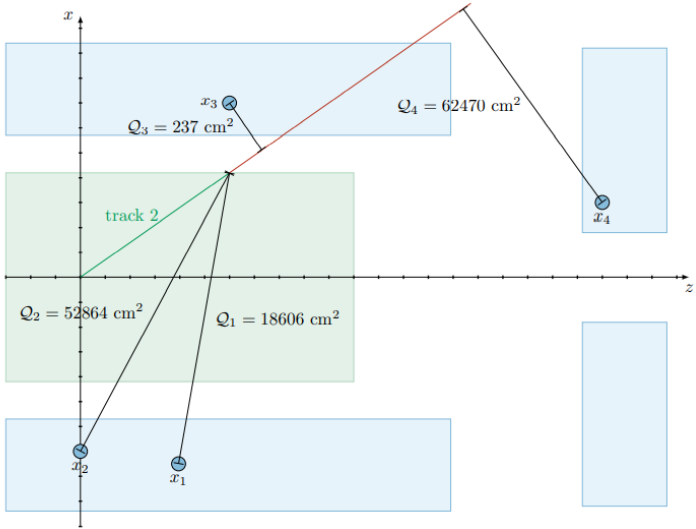

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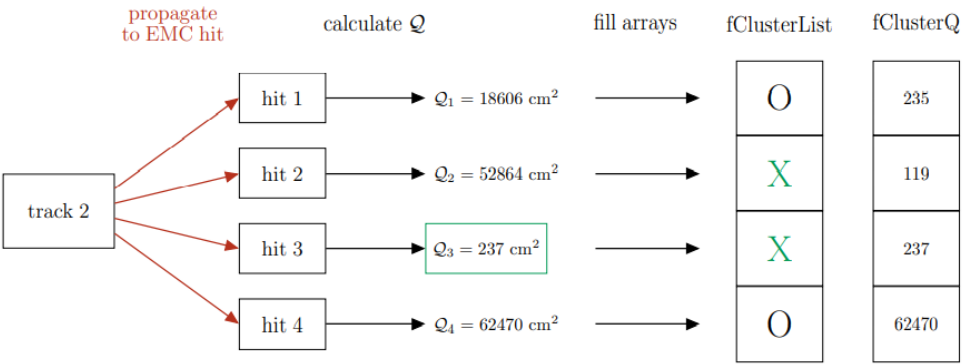

[Sarah Gaiser]

Matching the emc hits

hit	`fClusterList`	`fClusterQ`	neutral cand.?	reason
1	O	235	no	$235\,\mathrm{cm}^2 < 400\,\mathrm{cm}^2$
2	X	119	no	correlated to track
3	X	237	no	correlated to track
4	O	62 470	yes	not correlated, $62\,470\,\mathrm{cm}^2 > 400\,\mathrm{cm}^2$

[Sarah Gaiser]

Emc multi-matches

Issue

- each track is processed completely separately
- $\rightarrow$ each track is matched to the emc hit with the smallest Q, independently of other tracks
- emc hits can be assigned to an unlimited amount of tracks
- $\rightarrow$ emc hits are effectively "multiplied" in the PID output
- within 100k events of $\bar{p}p \rightarrow \pi^0\pi^+\pi^-$ about 19k occurrences

PID correlator - The structure before

```
for (Int_t i = 0; i < fTrackingSystemInfo->GetNTracks(); i++) {
    PndTrack *track = fTrackingSystemInfo->GetTrack(i);
    PndPidCandidate *pidCand = new PndPidCandidate();
    fCalorimeterInfo->GetInfo(track, pidCand);
    for (UInt_t j = 0; j < detectors.size(); j++) {
        (detectors.at(j))->GetInfo(track, pidCand);
    }
}
```

PID correlator - The structure now

```
for (Int_t i = 0; i < fTrackingSystemInfo->GetNTracks(); i++) {
    PndTrack *track = fTrackingSystemInfo->GetTrack(i);
    fCalorimeterInfo->PreprocessTracks(i,track);
    for (UInt_t j = 0; j < detectors.size(); j++) {
        (detectors.at(j))->PreprocessTracks(i,track);
    }
}

for (Int_t i = 0; i < fTrackingSystemInfo->GetNTracks(); i++) {
    PndTrack *track = fTrackingSystemInfo->GetTrack(i);
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    fCalorimeterInfo->GetInfo(track, pidCand);
    for (UInt_t j = 0; j < detectors.size(); j++) {
        (detectors.at(j))->GetInfo(track, pidCand);
    }
}
```

Matching the emc hits - New approach

EmcQ | id

track 1	**260 | 1**	**18 | 2**	**14 | 3**	**2100 | 4**	**450 | 5**	**140 | 6**
track 2	**15 | 1**	**90 | 2**	**165 | 3**	**87 | 4**	**11300 | 5**	**45 | 6**
track 3	**367 | 1**	**740 | 2**	**9 | 3**	**21 | 4**	**429 | 5**	**980 | 6**
track 4	**32450 | 1**	**57 | 2**	**101 | 3**	**245 | 4**	**6 | 5**	**780 | 6**

Matching the emc hits - New approach

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Matching the emc hits - New approach

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Matching the emc hits - New approach

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track 1	18 | 2	140 | 6	260 | 1	2100 | 4
track 2	15 | 1	45 | 6	87 | 4	90 | 2

Matching the emc hits - New approach

EmcQ | id

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EmcQ | id

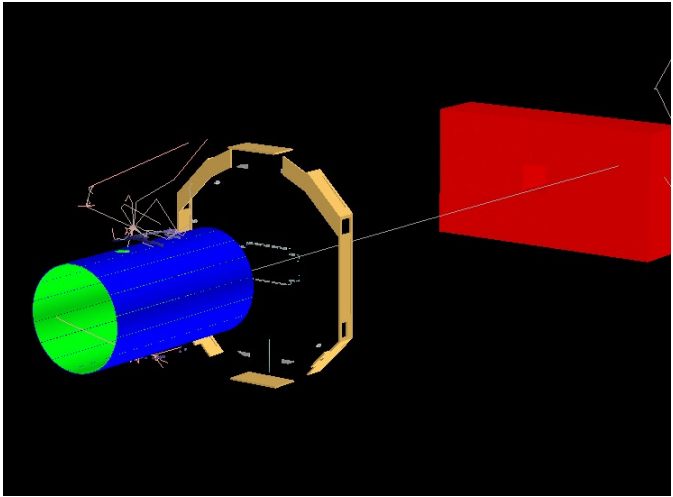
track 1	18 | 2	140 | 6	2100 | 4

PID correlator - Matching requirements

```
if (emcModule < 5) // barrel
{
  if ((emcModule < 3) && (helix->GetZ() > 150.))
    continue; // not consider tracks after EMC barrel for BARREL
  if ((emcModule == 3) && (helix->GetZ() < 165.))
    continue; // consider tracks only from last GEM plane for FWD
  if ((emcModule == 4) && (helix->GetZ() > -30.))
    continue; // consider tracks only ending at the back of STT for BKW
} else        // forward
{
  if (helix->GetZ() < fCorrPar->GetZLastPlane()) {
    continue; // consider tracks only from last FTS plane for FSC
  }
}
```

- certain requirements are set to consider matching tracks and emc hits
- neutral candidates caused by primary charged pions 44k $\rightarrow$ 21k
- multi-matches 400 $\rightarrow$ 6k

Barrel/Forward track containers



- tracks from barrel/forward region handled in separate containers
- tracks involving both are split between the 2 containers
- both tracks are matched to the resulting emc hit

Barrel/Forward track containers

Solution

- rewrote PID to only take a single container, containing all of the tracks as input
- $\rightarrow$ multi-matches eliminated
- BUT tracks are still being split
- $\rightarrow$ simple task combining barrel/forward tracks based on angular difference
- fit information of track with better Chi-Square is retained

Back to the 400 cm^2 cut

hit	fClusterList	fClusterQ	neutral cand.?	reason
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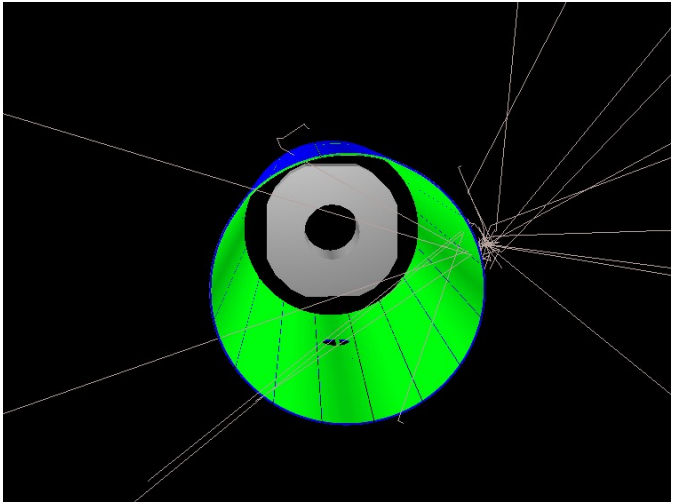
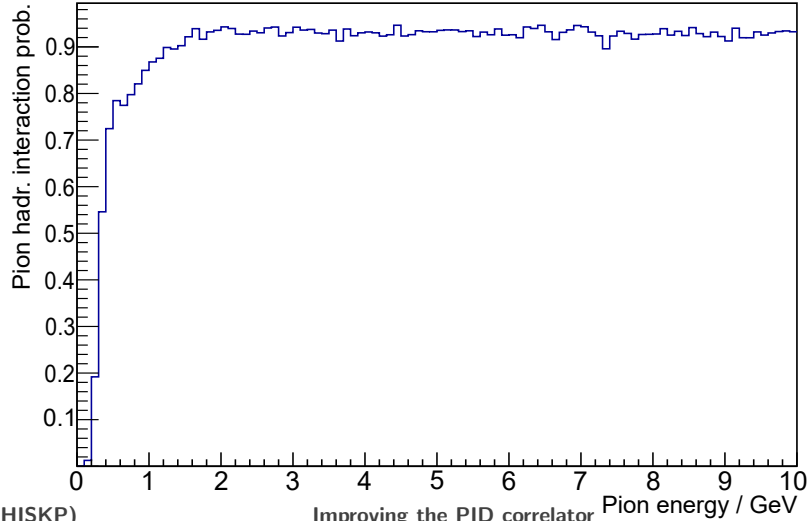
Back to the 400 cm^2 cut



- charged pions hitting the emc induce hadronic reactions
- many charged and uncharged particles are produced
- additional "uncharged hits" created around "charged hit"

Pion hadronic interaction probability - Full Setup

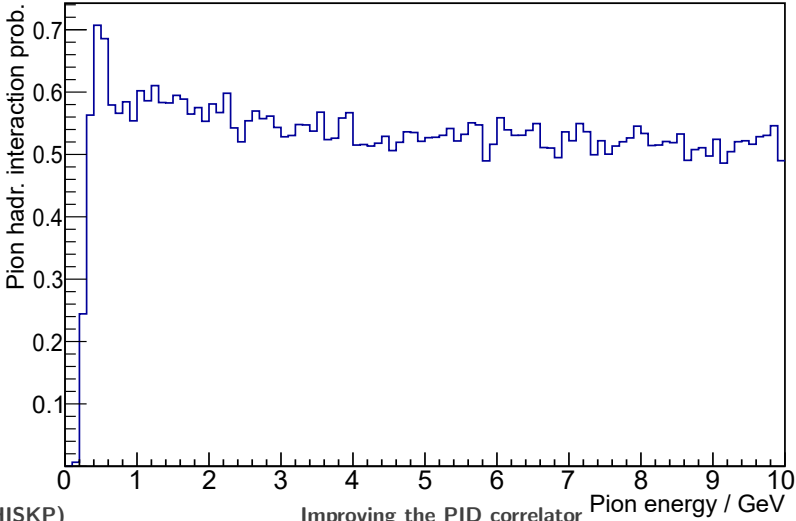


Pion hadronic interaction probability - Theory

Expectation

- PWO "pion interaction length" is 24.04 cm (pdg)
- $exp(-20/24.04) = 43.5\%$
- expect a hadronic interaction in 56.5% of events

Pion hadronic interaction probability - Only Emc



PID correlator - Back to the 400 cm^2 cut

Issues

- not a logical part of the PID process
- cut value appears rather arbitrary
- effectiveness of the cut strongly depends on analysis
- can't easily turn it off, since it's buried in the PID code

PID correlator - Back to the 400 cm^2 cut

```
// Cut hadronic split-offs around charged candidates
PndHadronicSplitOffCut *HadronCorrection = new  PndHadronicSplitOffCut();
this->Add(HadronCorrection);
```

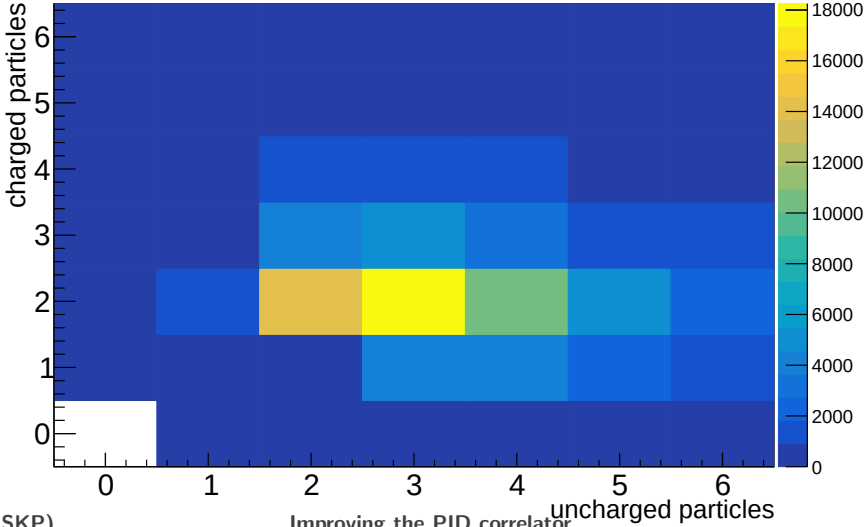
- cut removed from PID correlator
- new task included in the PID master task
- can easily be excluded

Testing the new PID - $\pi^0 \pi^+ \pi^-$

Setup

- very simple analysis as quick measure of the impact of the changes
- 100k events of $\bar{p}p \to \pi^0 \pi^+ \pi^-$
- cut on 2 charged and 2 neutral candidates
- 35 MeV cut around the π^0 mass
- how many mc-truth π^0s can be reconstructed?

Testing the new PID - $\pi^0 \pi^+ \pi^-$ - Old version



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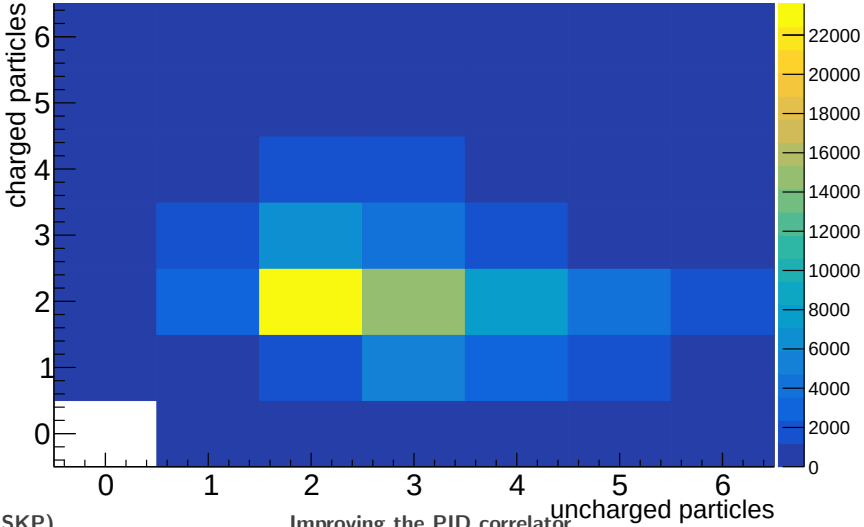

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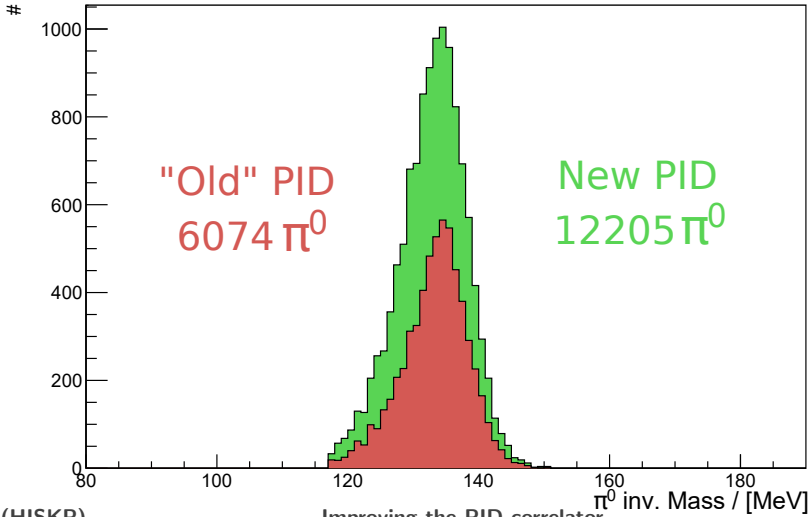

Testing the new PID - $\pi^0 2\pi^+ 2\pi^-$

Setup

- very simple analysis as quick measure of the impact of the changes
- 100k events of $\bar{p}p \to \pi^0 2\pi^+ 2\pi^-$
- cut on 4 charged and 2 neutral candidates
- 35 MeV cut around the π^0 mass
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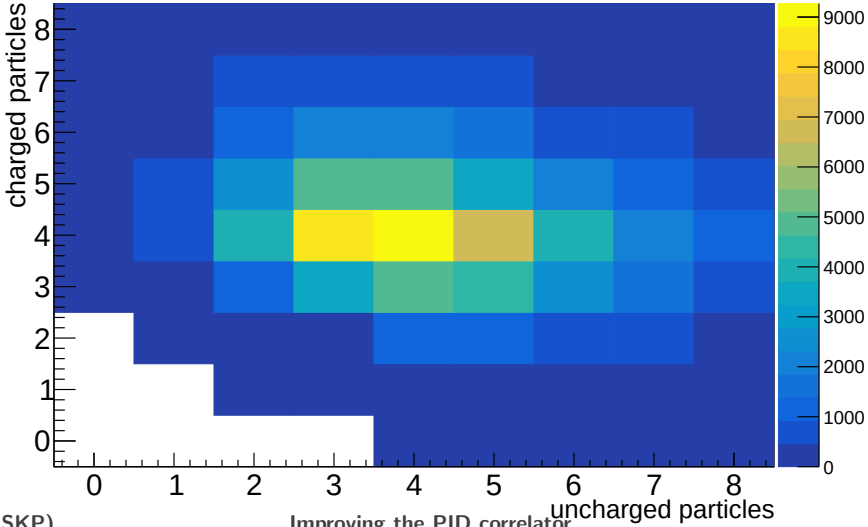
Testing the new PID - $\pi^0 2\pi^+ 2\pi^-$ - Old version



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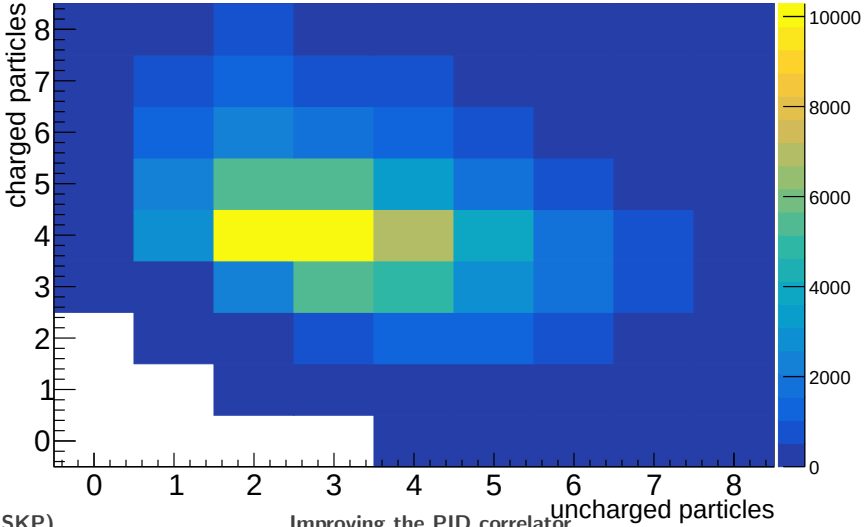

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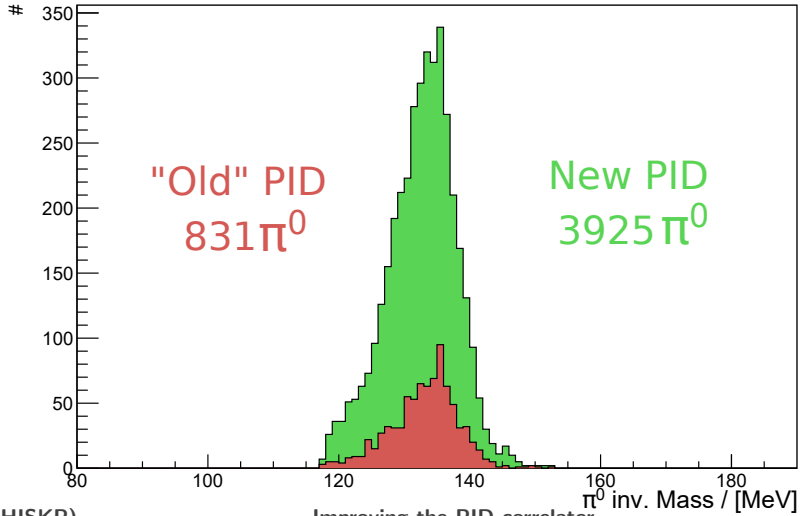

Overview - Issues & Solutions

- multi-matching of emc hits
  → preprocessing stage & table approach implemented
- harsh requirements set for track matching
  → requirements removed from PID
- barrel/forward tracks handled in separate containers
  → PID rewritten to take single container, containing both
- combined barrel/forward tracks being split
  → primitive track matching task implemented
- hadronic correction cut hard-coded and not easily accessible
  → correction moved to easily accessible dedicated task

Thanks for your attention!