

# Tracking validation

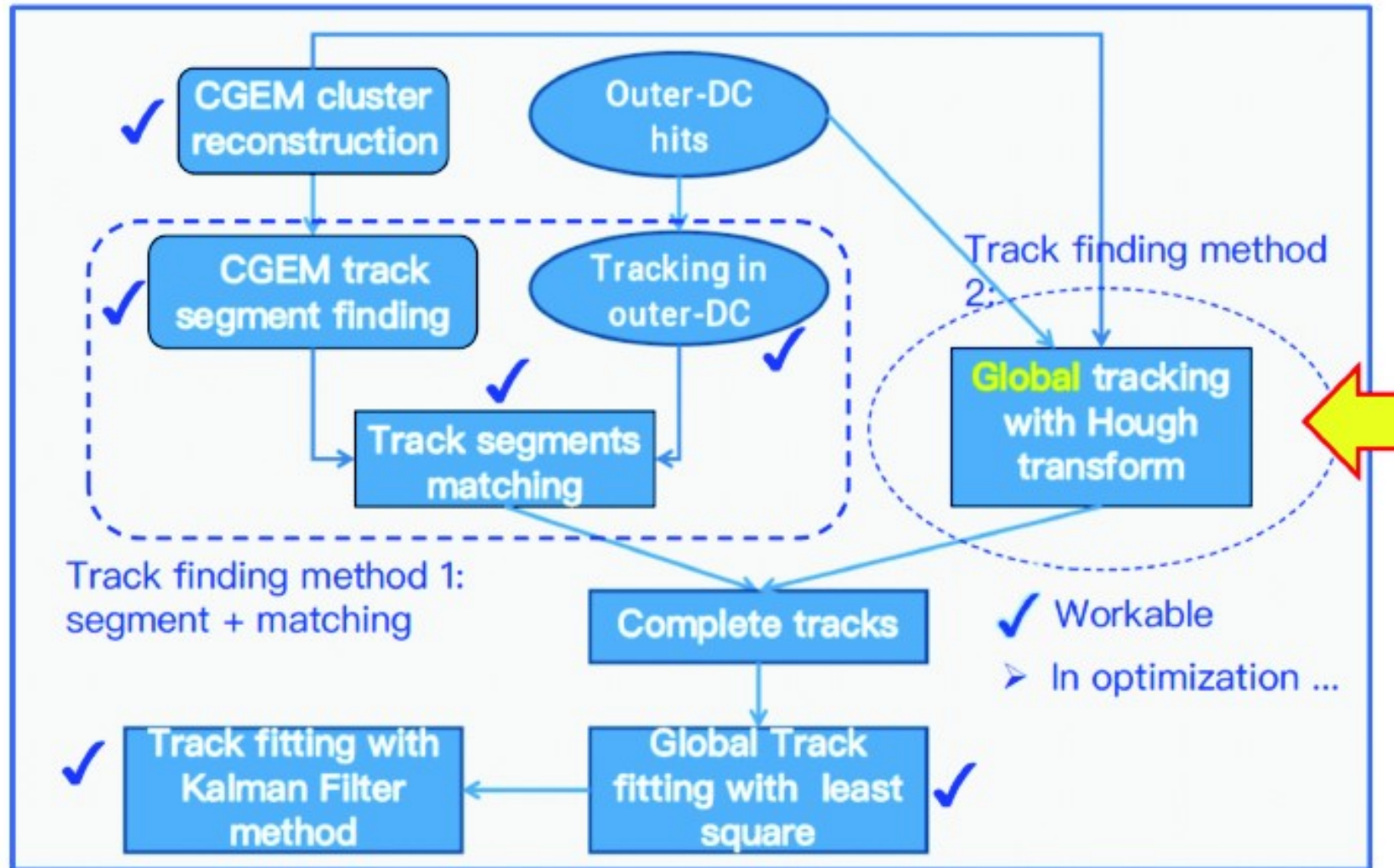
Lia Lavezzi

Università / INFN Torino



Istituto Nazionale di Fisica Nucleare

# Global Tracking



- 1<sup>st</sup> method was segment finder + matching
- 2<sup>nd</sup> method is Hough Transform on CGEM + IDC at once
- 2<sup>nd</sup> method is under optimization

# Latest updates on HT

## Update of global track reconstruction with CGEM+ODC

[ Wang LL, P&S meeting, 03/ 2021 ]

- General status: global track finding with Hough transform, global track fitting with Least-Square (LS), track fitting with Kalman Filter implemented and now in optimization with simulated events
- Updates
  - ✓ new global track fitting with LS implemented and used
    - circle fitting rejects hits with large  $\chi^2$
    - helix fitting rejects outermost hits if  $\chi^2$  is large
      - => tend to keep hits/clusters near IP
      - => better track parameters at IP
  - ✓ Global track finding (HoughTransAlg) tuned for  $\pi^-$  with  $p_T=50$  MeV/c
    - Circle search/reconstruction criteria loosen => keep efficiency high
    - A recursive V-hits association procedure is modified to an iterative one
    - Latest version: HoughTransAlg-00-00-18

outliers rejection

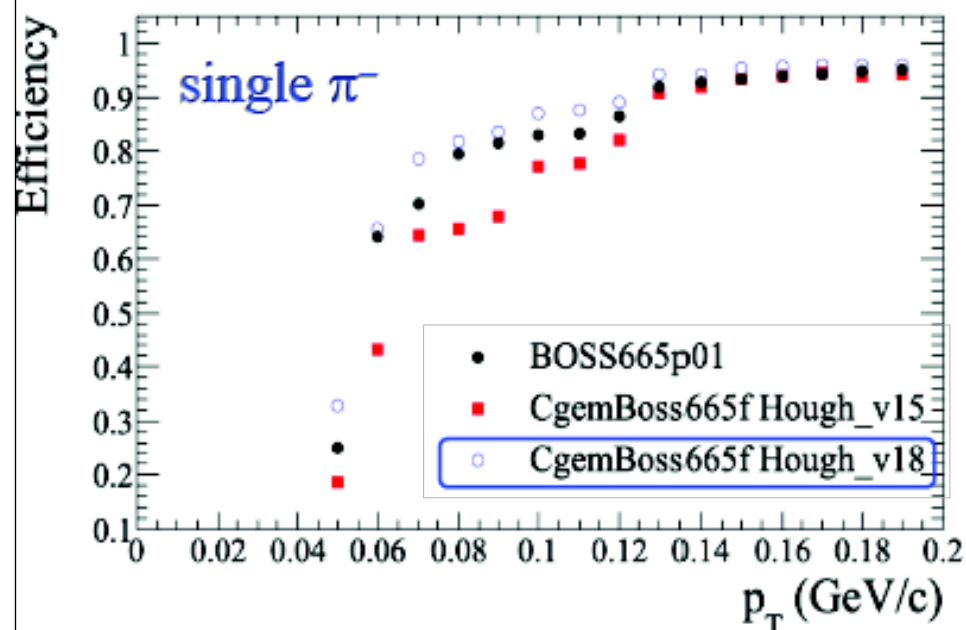
tuning for low momenta

And earlier (already shown @ last BESIII Italia meeting)

- Recently: fix a sign issue in an angle calculation (to be used in Kalman Filter)
- Success rate of Kalman Filter for single pion with CGEM+ODC is good generally with a sag between 70&120 MeV/c (likely due to multi-loops)

# Latest updates on HT

Improved pion efficiency at low  $p_T$



Improved efficiency for  
 $\psi(3686) \rightarrow \pi^+ \pi^- J/\psi \rightarrow \pi^+ \pi^- e^+ e^-$

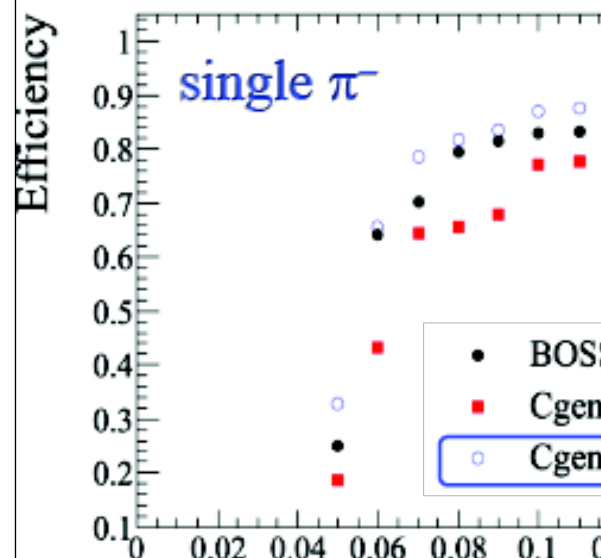
Event selection flow for $\psi(3686) \rightarrow \pi^+ \pi^-$ $J/\psi \rightarrow \pi^+ \pi^- e^+ e^-$	Hough v15	Hough v18
Ntrack $\geq 4$	69.09%	72.33%
$\pi^+ + \pi^- + e^+ + e^-$ selection	53.55%	56.27%
Loose $J/\psi$ mass cut	50.86%	53.15%
4C fit ( $\chi^2 < 60$ )	32.08%	33.42%

[ Wang LL, P&S meeting, 03/ 2021 ]

- Efficiency on pion **single** tracks
- **Last tag of HT** shows an efficiency compatible with full-MDC
- **Improvements** in efficiencies for the **physics channel** reconstruction w.r.t. previous tag

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- Efficiency on pion **single** tracks
- **Last tag of HT** shows an efficiency compatible with full-MDC
- **Improvements** in efficiencies for the **physics channel** reconstruction w.r.t. previous tag
- **But still not as good as full-MDC**
  - also because full-MDC is not with **ideal** resolution/efficiency
  - while for **CGEM** efficiency = 100% / resolution = 130  $\mu\text{m}$

# Quality Assurance for tracking

- suggested in january 2019

study the tracks coming from Hough transform, before the Kalman fit

**SINGLE TRACK**  
→ **Defined on hits**

$$\text{EFFICIENCY} = \frac{\# \text{ CORRECTLY ASSIGNED HITS}}{\# \text{ MC POINTS}}$$

$$\text{PURITY} = \frac{\# \text{ CORRECTLY ASSIGNED HITS}}{\# \text{ RECO HITS}}$$

**SINGLE EVENT**  
→ **Defined on tracks**

$$\text{EFFICIENCY} = \frac{\# \text{ TRACKS WITH SINGLE TRACK EFF} > 80\%}{\# \text{ MC RECONSTRUCTABLE * TRACKS}}$$

@Panda

\*reconstructable means:

- ☐ 3 hits for  $xy$
- ☐ 2 hits for  $z\phi$

A **connection** between the hit used in PR and the MC point from which it was generated is necessary to:

- check if it is correctly assigned to the track
  - check if it comes from noise
  - check if it comes from background (when bk will be added)
- it is necessary to evaluate efficiency/purity of the found track candidate

A match between the reconstructed and MC track is also important to evaluate the number of **reconstructable** tracks, i.e. tracks which leave a minimum number of MC points in the trackers

- efficiency / purity must be evaluated vs (transverse) momentum, angle ...
- define “reconstructable” in a proper way

# CgemBoss Algorithm → Service

- added to the algorithm class TestHoughTrack
- functions to associate MC ↔ reco MDC / CGEM points / tracks
- will be ported to a service class (now it is not in CVS)

```
int GetMdcRecoHitID( int mc_point_id, SmartDataPtr< Event::MdcMchHitCol > mdc_MC_point_Col,  
                    SmartDataPtr< MdcDigiCol > mdc_digi_Col,  
                    SmartDataPtr< RecMdcHitCol > mdc_hit_Col);
```

MDC

```
int GetMdcMCHitID( int reco_hit_id, SmartDataPtr< Event::MdcMchHitCol > mdc_MC_point_Col,  
                  SmartDataPtr< MdcDigiCol > mdc_digi_Col,  
                  SmartDataPtr< RecMdcHitCol > mdc_hit_Col);
```

```
int GetMdcRecoHitID( RecMdcHit *hit_in_vector, SmartDataPtr< RecMdcHitCol > mdc_hit_Col);
```

```
int GetCgemMCHitID( int cluster2d_id,  
                   SmartDataPtr< Event::CgemMchHitCol > cgem_MC_point_Col,  
                   SmartDataPtr< RecCgemClusterCol > cgem_cluster_Col);
```

CGEM

```
int GetCgemCluster2dID( int mc_point_id,  
                       SmartDataPtr< Event::CgemMchHitCol > cgem_MC_point_Col,  
                       SmartDataPtr< RecCgemClusterCol > cgem_cluster_Col);
```

```
int GetMCTrack( RecMdcTrack *hough_track,  
               SmartDataPtr< Event::MdcMchHitCol > mdc_MC_point_Col,  
               SmartDataPtr< MdcDigiCol > mdc_digi_Col,  
               SmartDataPtr< RecMdcHitCol > mdc_hit_Col,  
               SmartDataPtr< Event::CgemMchHitCol > cgem_MC_point_Col,  
               SmartDataPtr< RecCgemClusterCol > cgem_cluster_Col,  
               std::vector< int > &associated_mc_track,  
               std::vector< int > &associated_nmdc,  
               std::vector< int > &associated_ncgem);
```

track

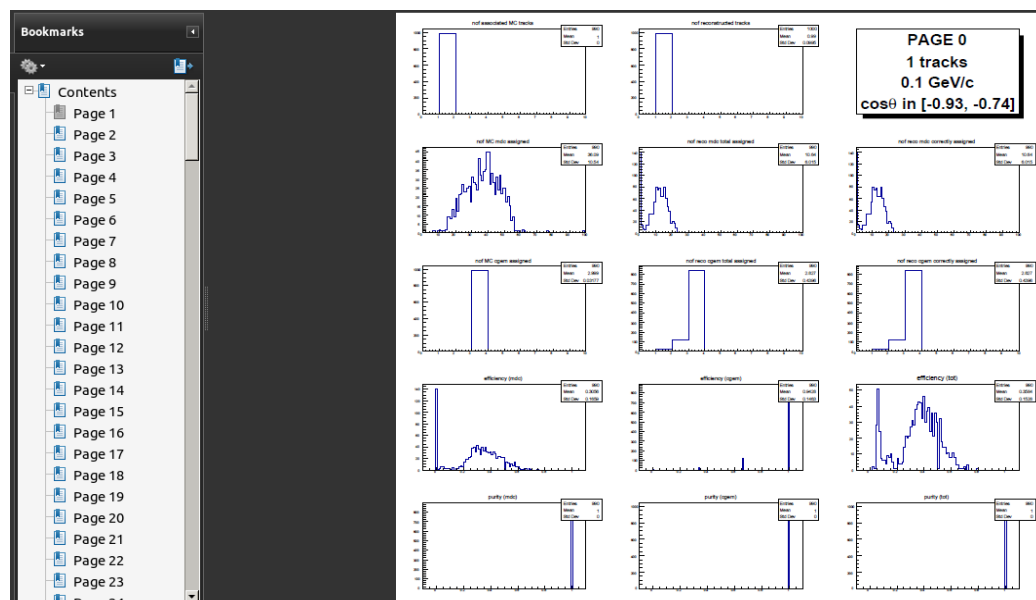
# Testing sample

muons @ fixed transverse momentum

- multiplicities = 1, 2, 3, 4 tracks/event
- transverse momentum = 0.1, 0.3, 0.5, 0.7, 1 GeV/c
- $\cos(\theta)$  in  $[-0.93, 0.93]$  in steps of 0.186

A total of  $4 \times 5 \times 10$   
= 200 scan points

For each scan step  
a series of 14 histos is filled

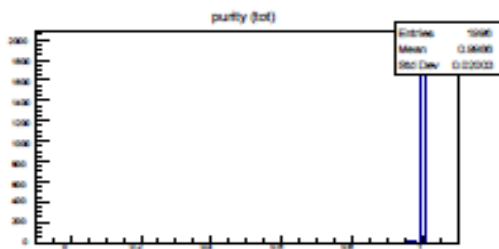
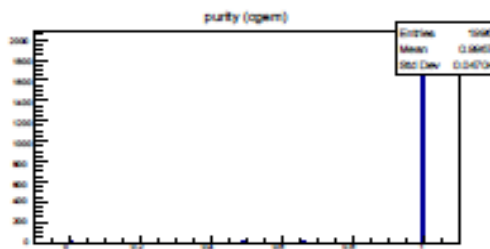
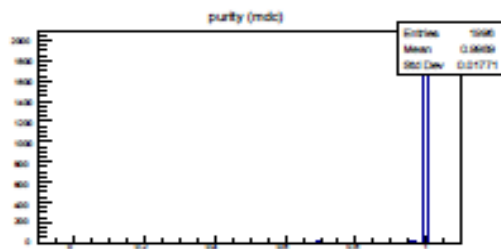
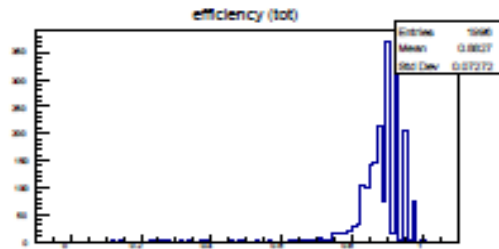
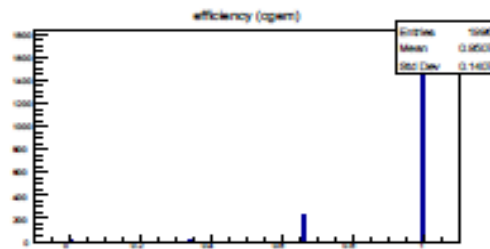
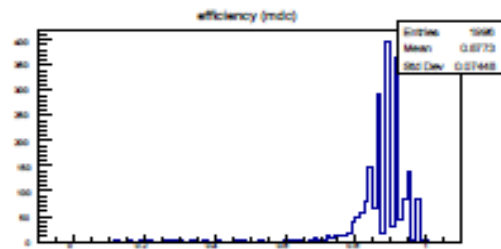
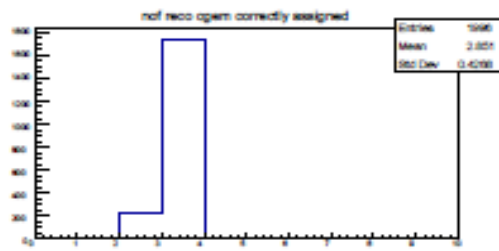
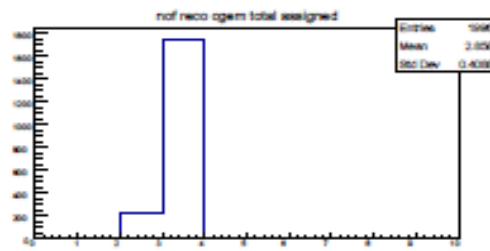
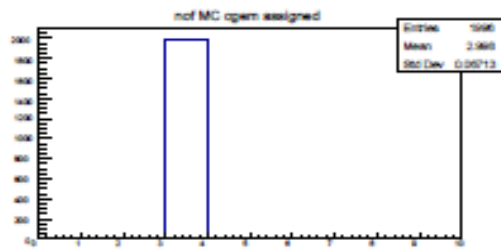
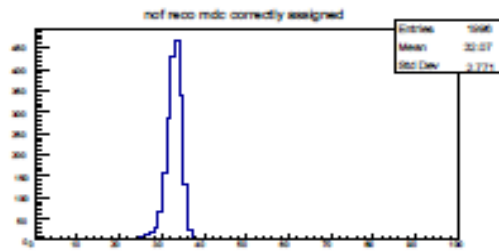
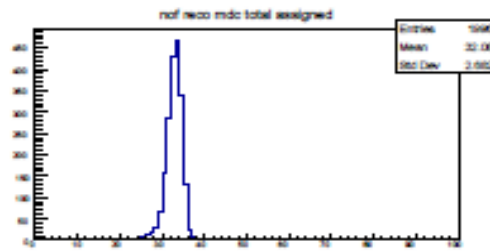
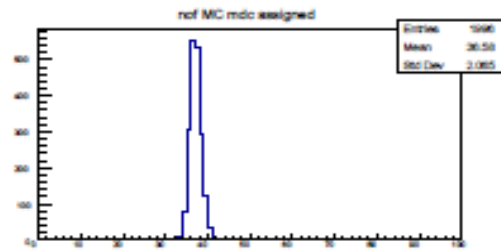
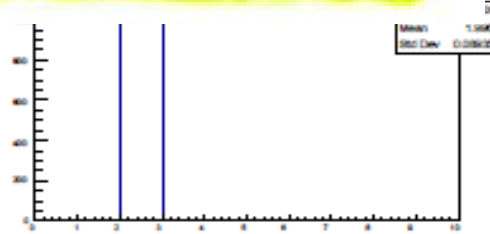
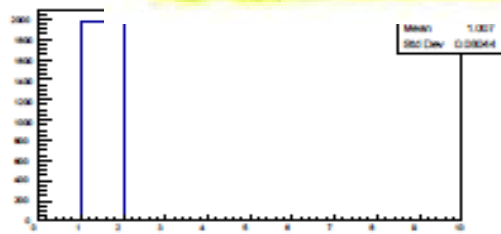


For now:

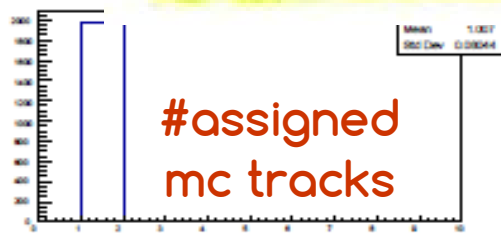
- no “reconstructable” track definition
- The reco track is associated to the MC track with which it shares the majority of the hits – no “80%” limit (or other) is set

# Very preliminary results

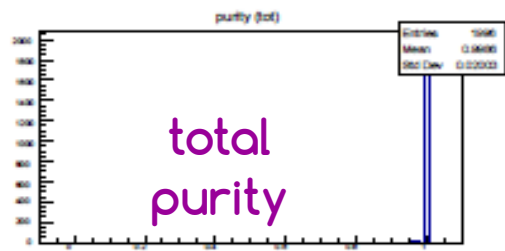
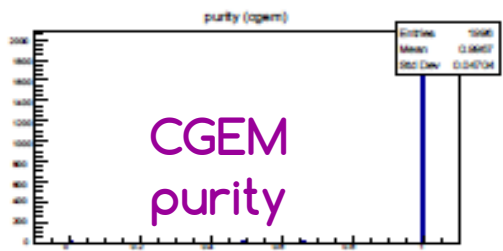
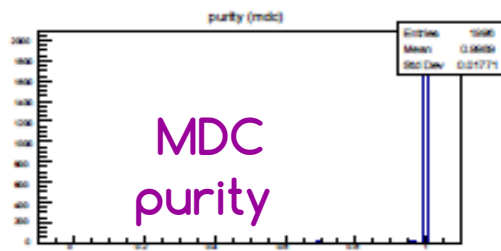
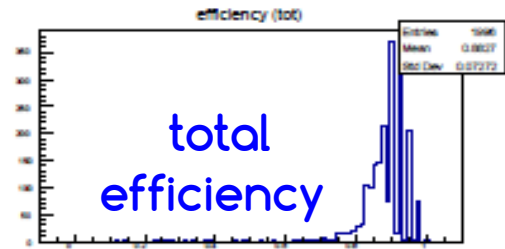
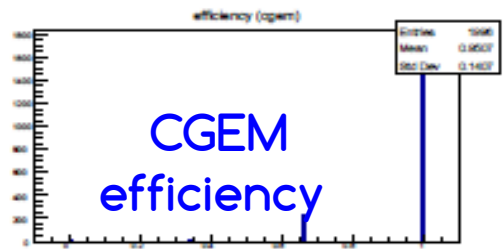
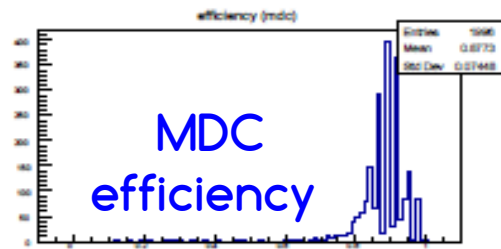
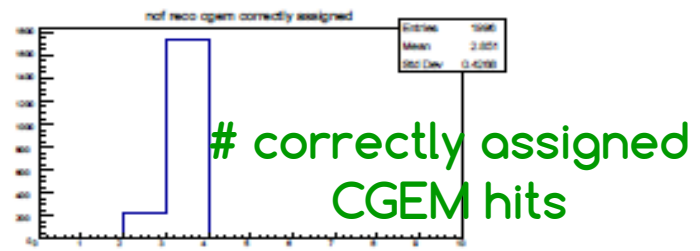
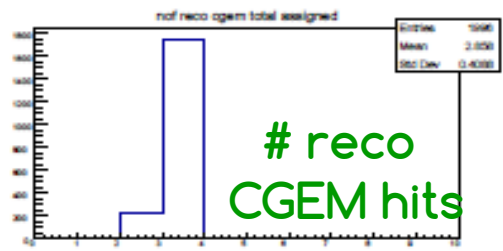
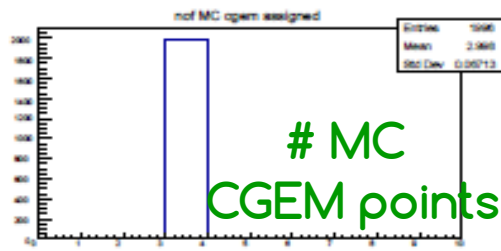
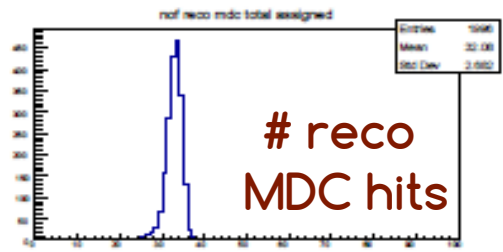
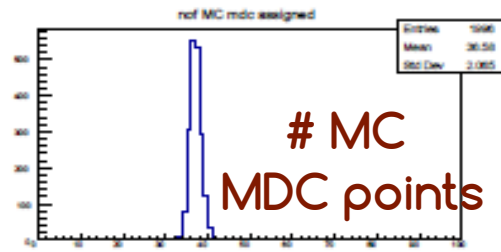
**PAGE 88**  
**2 tracks**  
**0.7 GeV/c**  
 **$\cos\theta$  in [0.56, 0.74]**



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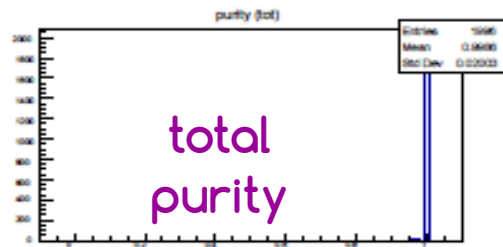
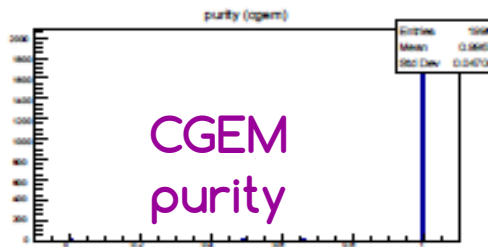
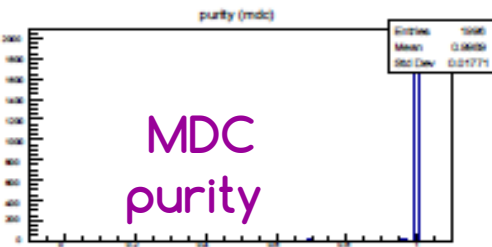
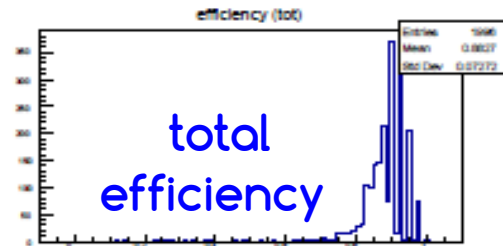
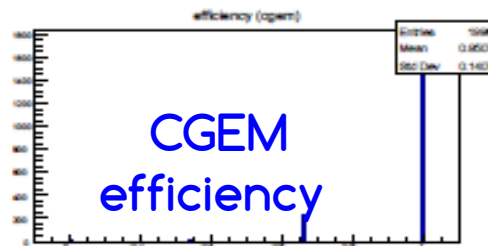
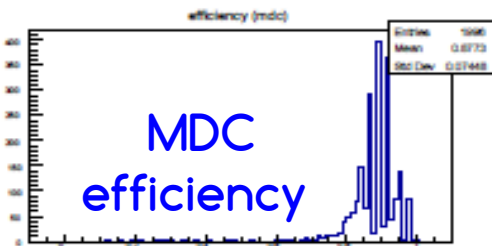
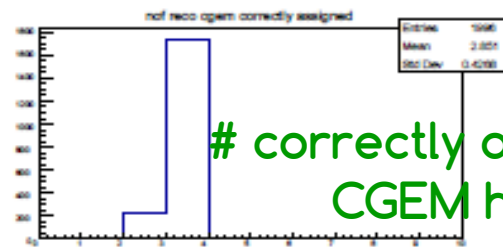
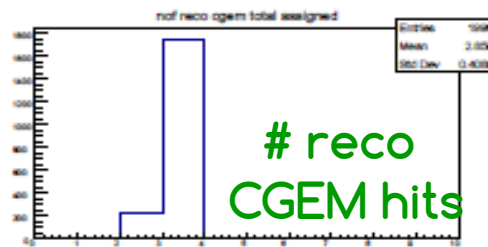
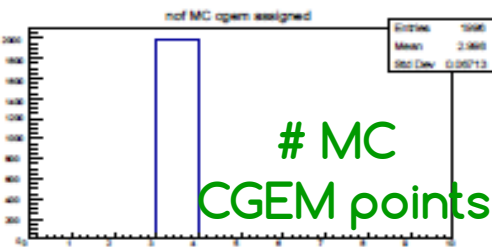
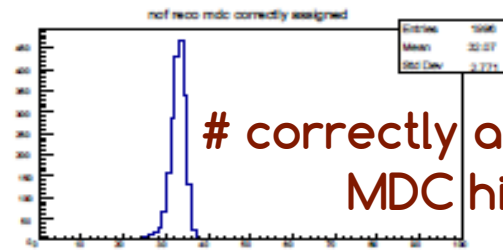
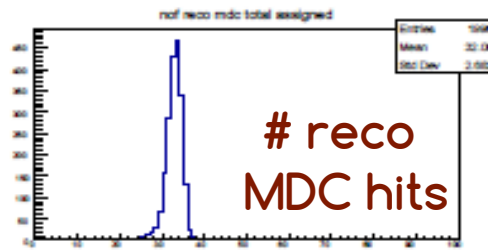
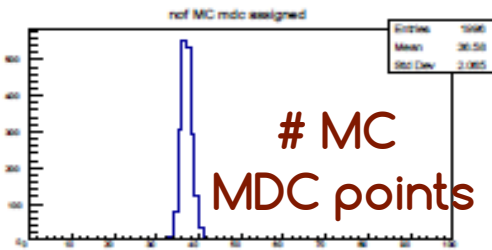
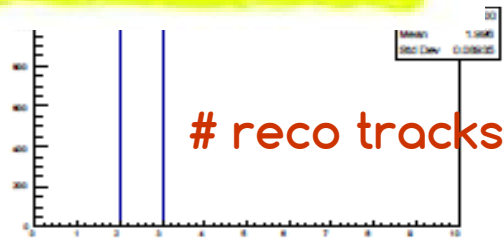
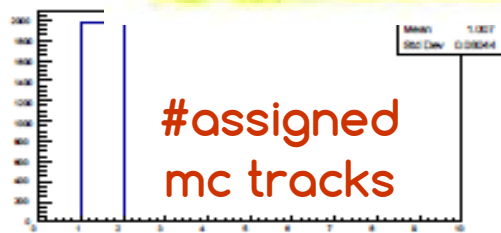


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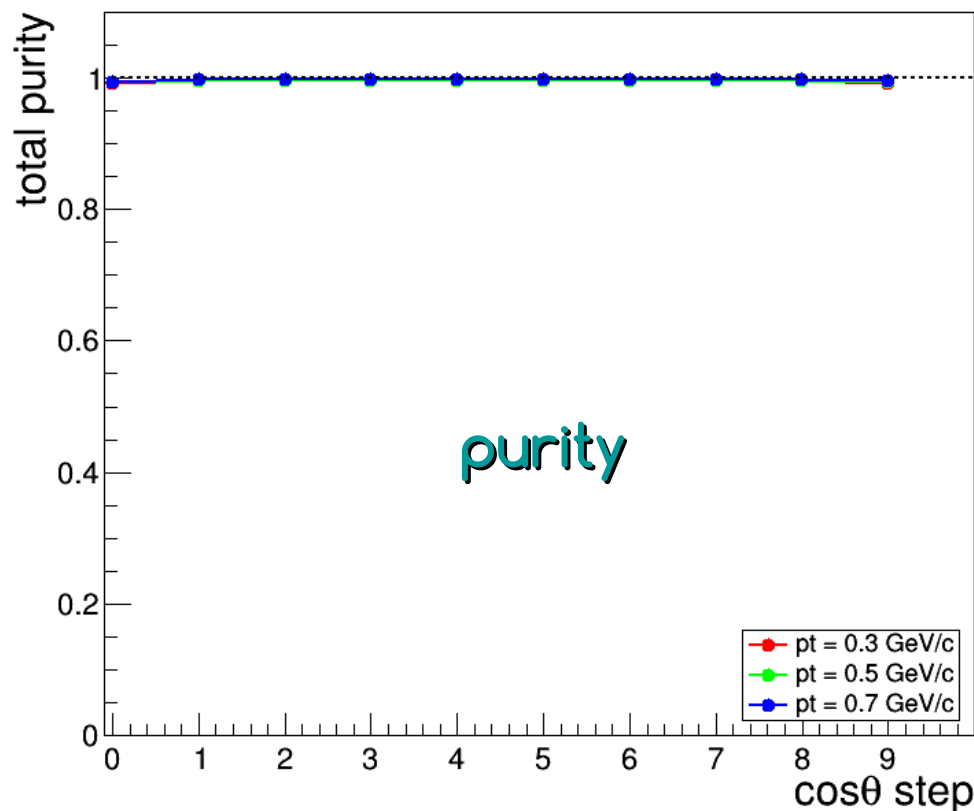
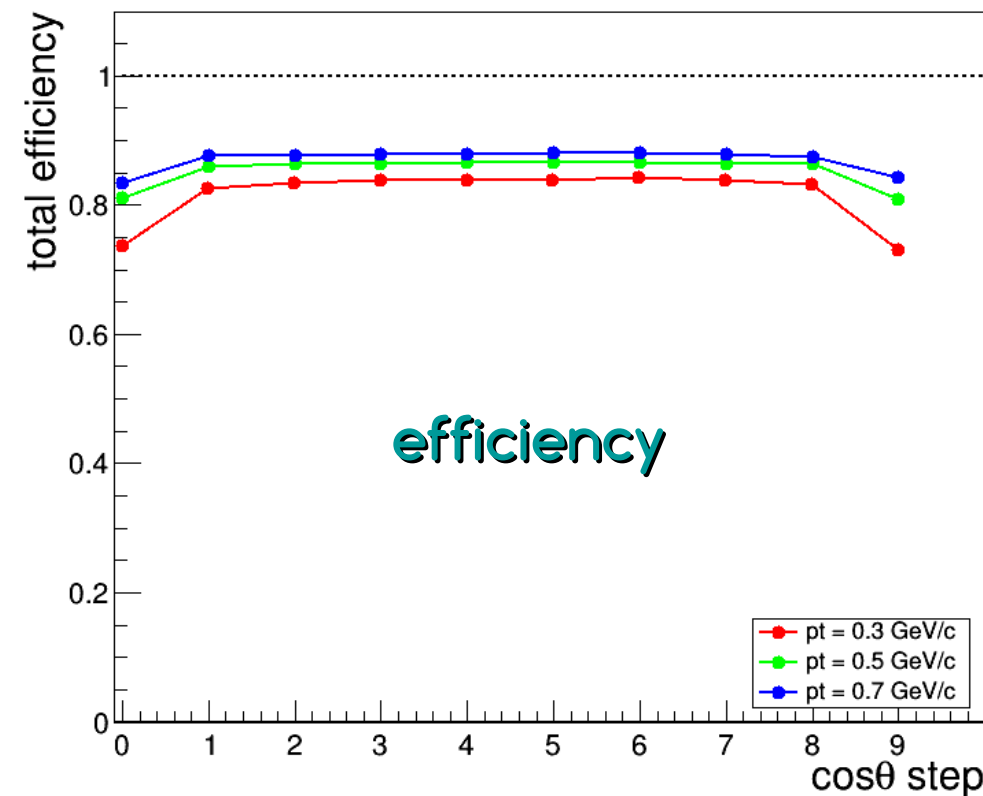


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3

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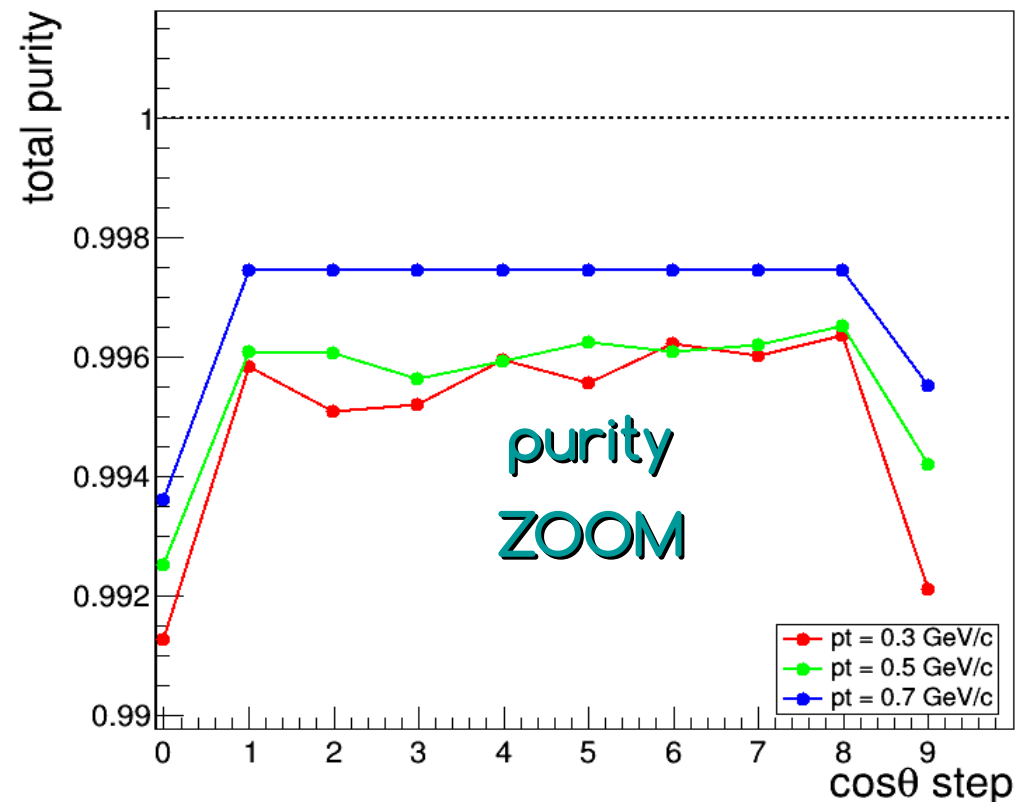
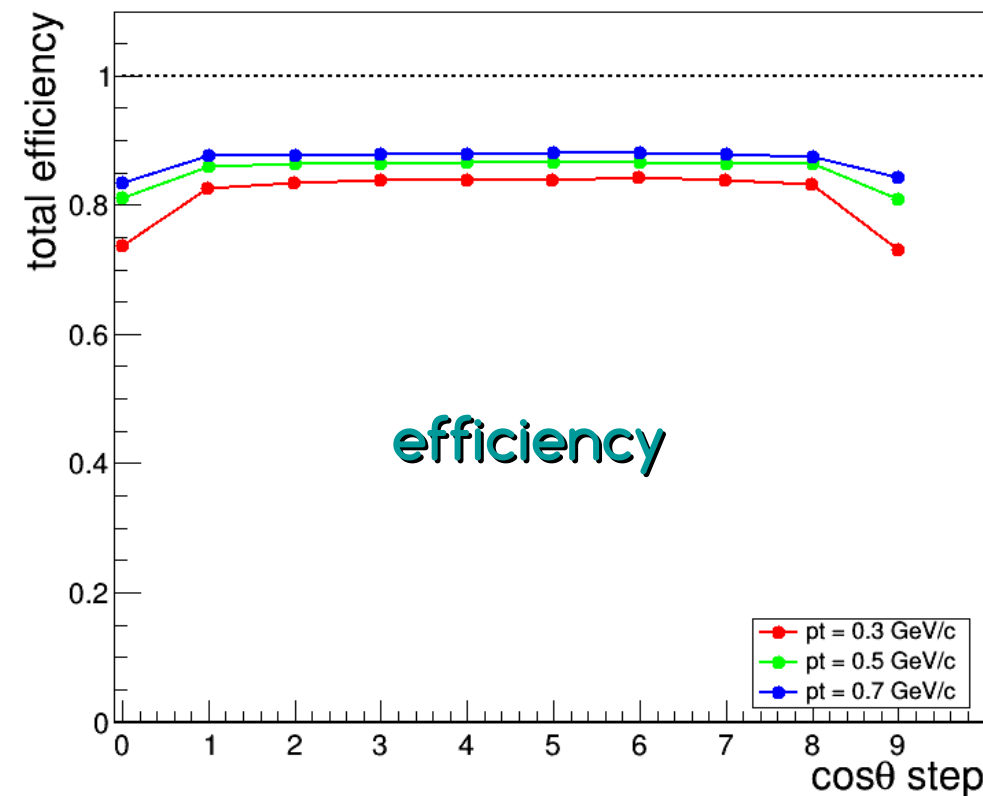


efficiency / purity lower with decreasing  $pt$   
efficiency / purity lower fwd / bwd

- skipped two  $pt$  steps:
  - $pt = 0.1$  GeV/c has loopers  $\rightarrow$  need to increase the range of histos
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- The machinery for track validation is ready
- (possibly) will share the functions in a service class on CVS
- I already tested it on the whole sample, but need to fix some bugs before plotting the graphs for QA for all the points (e.g. 0.1 GeV/c)
- need to add the correct definition for “reconstructable” track
- add pull distributions of track parameters

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*Thank You!*

# Backup

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[ Wang LL, P&S meeting, 03/ 2021 ]

①  $\pi^+ + \pi^- + e^+ + e^-$  selection: PID by momentum,  $p < 0.8 \text{ GeV} \rightarrow \text{pion}$ ,  $p > 0.8 \text{ GeV} \rightarrow \text{electron}$ ,  
 $|\text{dr}| < 1.0 \text{ cm}$ ,  $|\text{dz}| < 10 \text{ cm}$ ,  $|\cos\theta| < 0.93$ , total charge = 0

② Loose  $J/\psi$  mass cut:  $m_{ee}$  in (2.5, 4.0)  $\text{GeV}/c^2$ ,  $m_{\pi\pi\text{-recoil}}$  in (2.5, 4.5)  $\text{GeV}/c^2$ ,  $m_{\text{total}}$  in (3, 5)  $\text{GeV}/c^2$