K_S Daughters Reconstruction Efficiency

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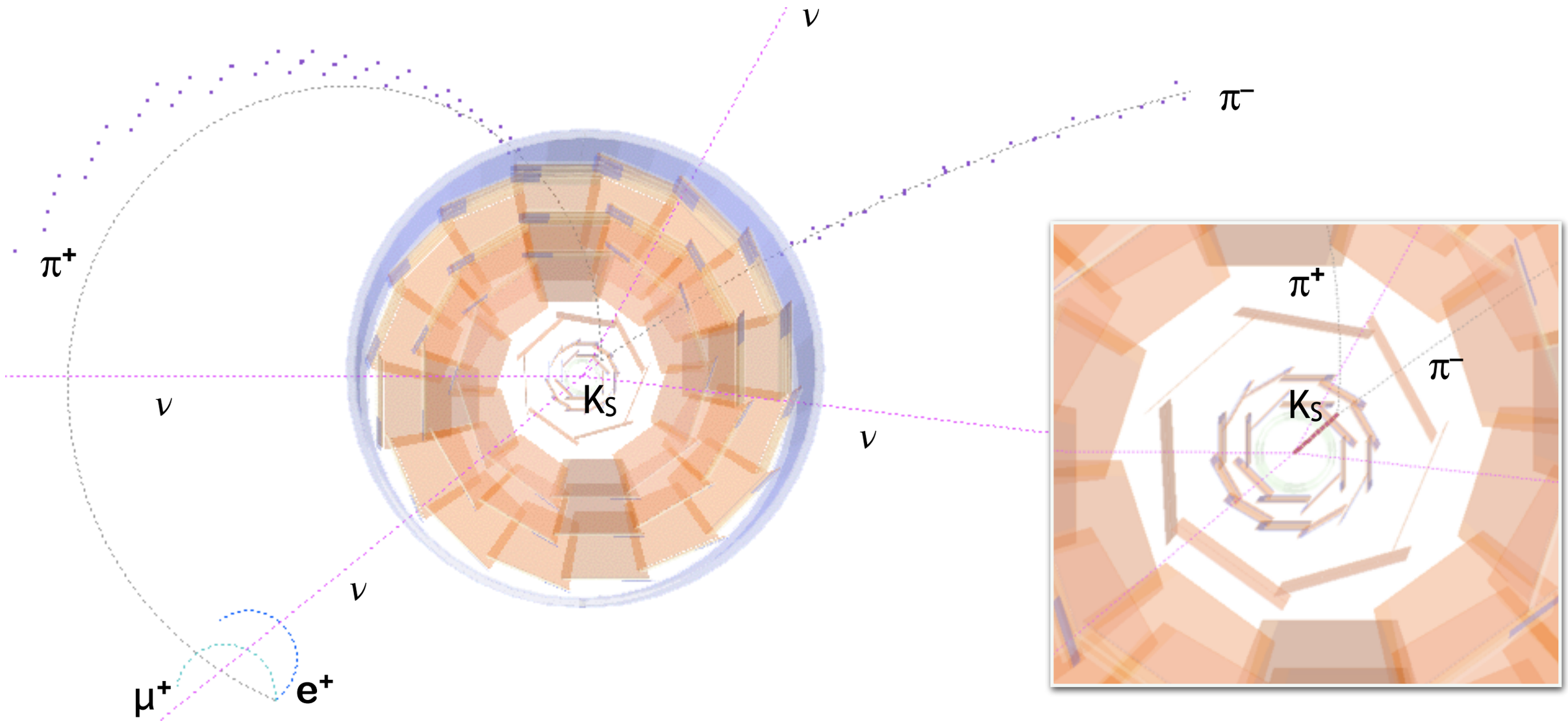
Outline

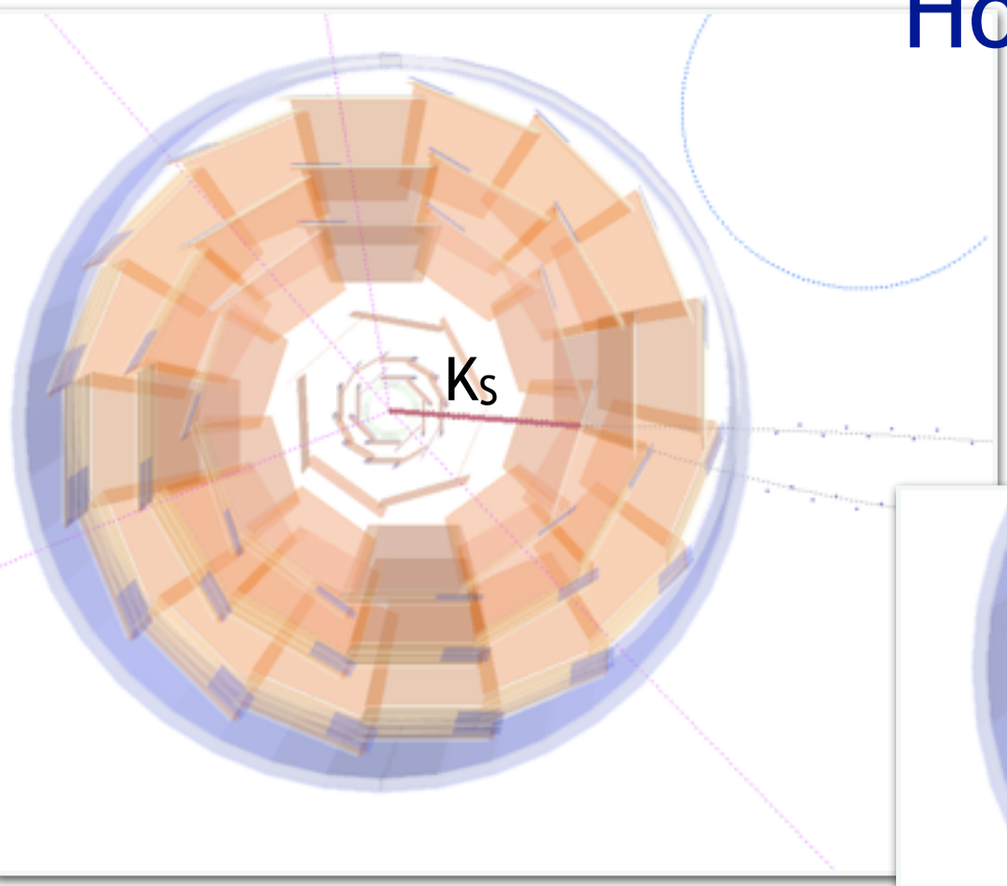
- ➡ Motivation of the Study
- ➡ Performances of the pattern recognition of pions from K_S
  - ‣ results on a dedicated generated sample $B \rightarrow J/\psi\ K_S$ events:
    - ◉ VXD only reconstruction, CDC only reconstruction
    - ‣ comparison with the results obtained on a generic B decays sample
- ➡ Conclusions & Future Plans

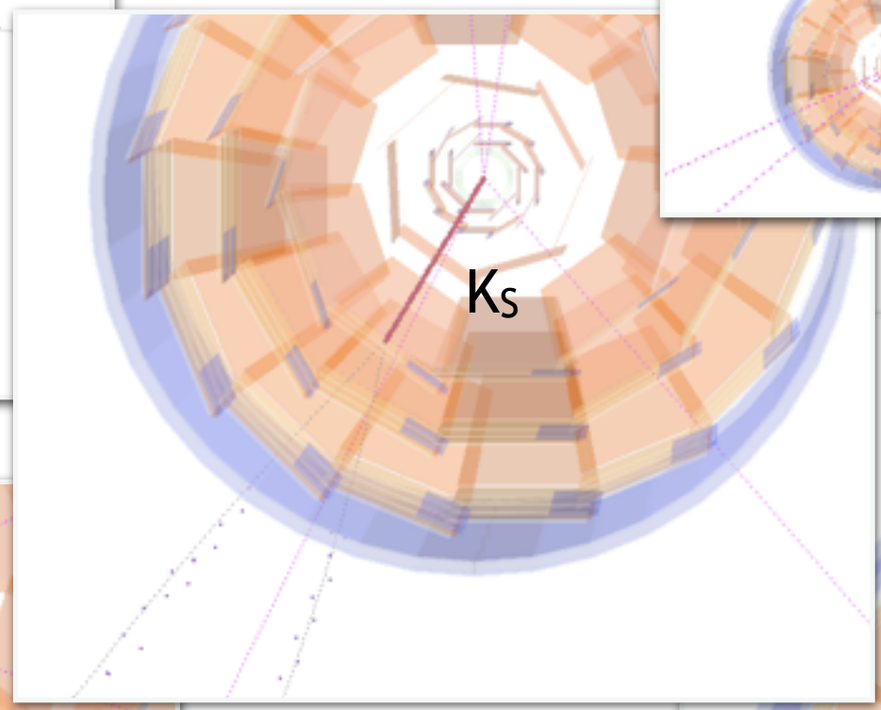
Motivation

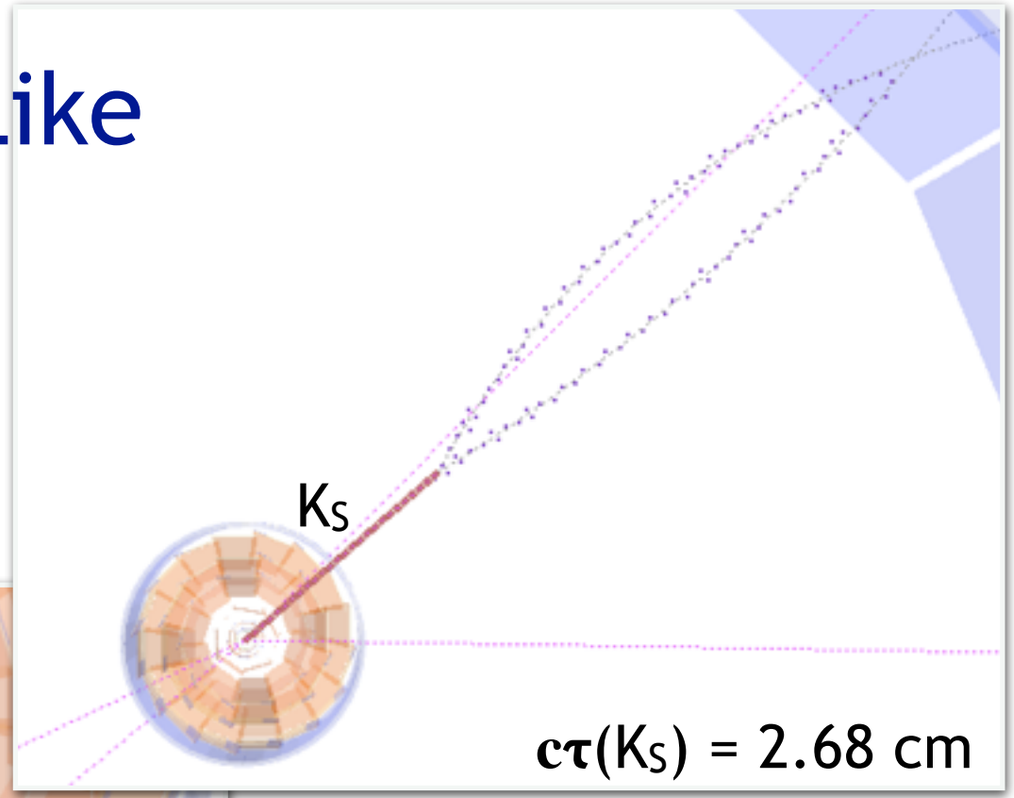
- We need an *accurate* and *efficient* K_S reconstruction for physics analysis
  - $B \rightarrow J/\psi\, K_S$, $B \rightarrow \varphi\, K_S$, $D^0 \rightarrow K_S\pi\pi$, …
- Evaluate the efficiency of the pattern recognition for K_S daughter tracks and find the critical points and where it can be improved.

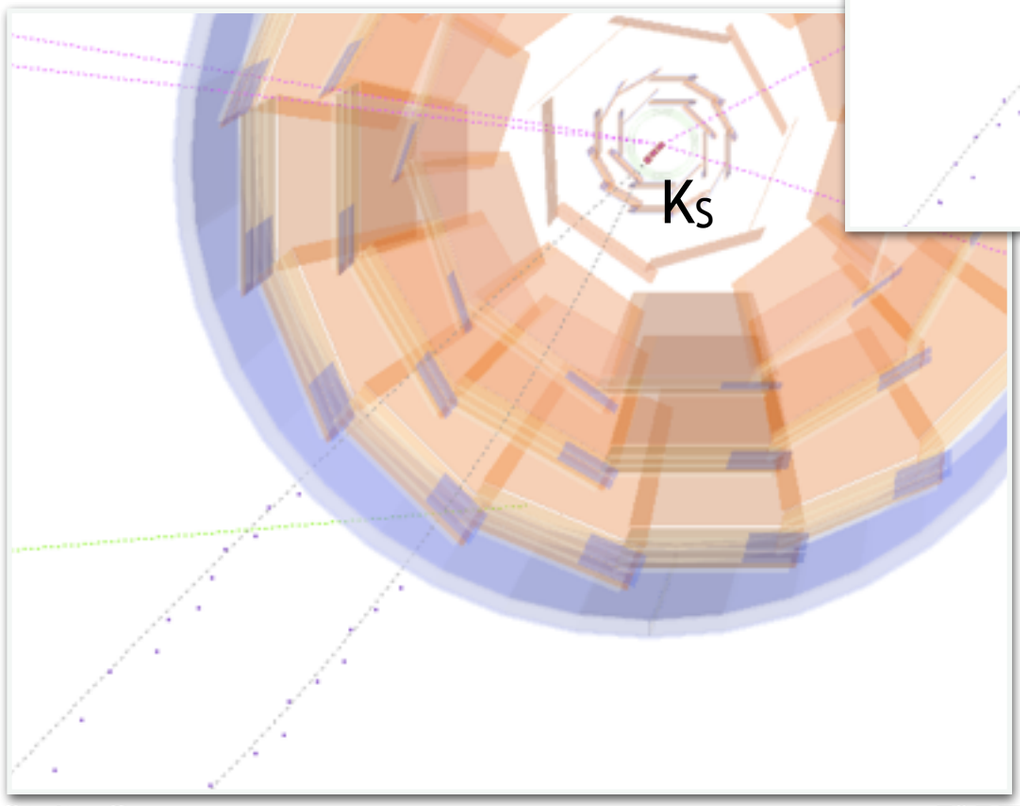


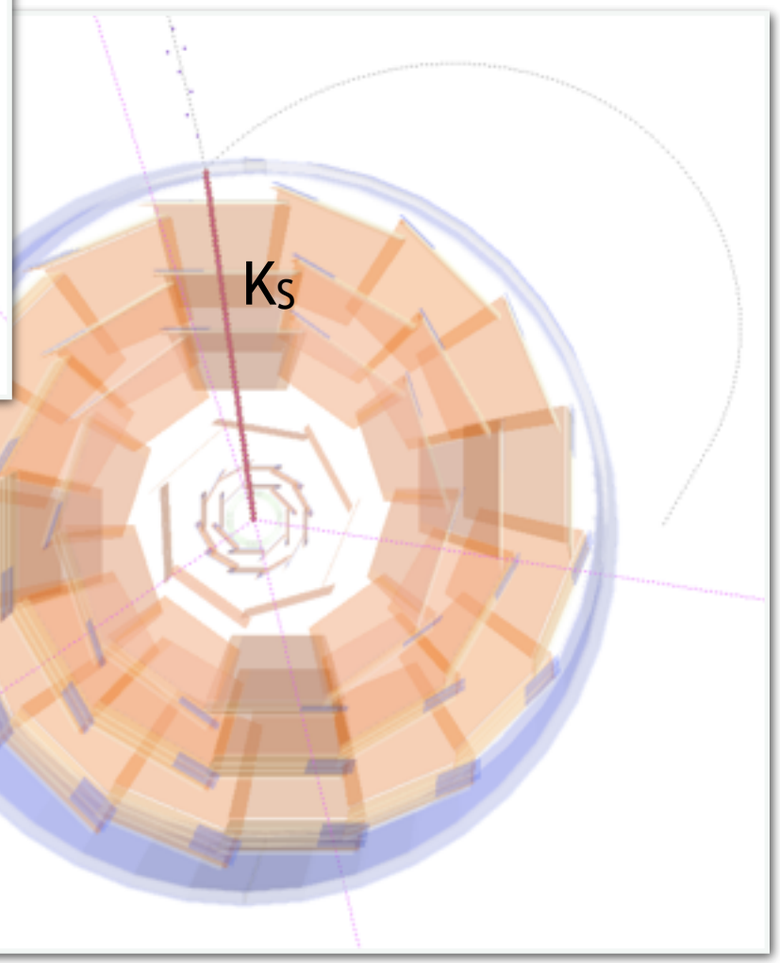
How K_S Look Like





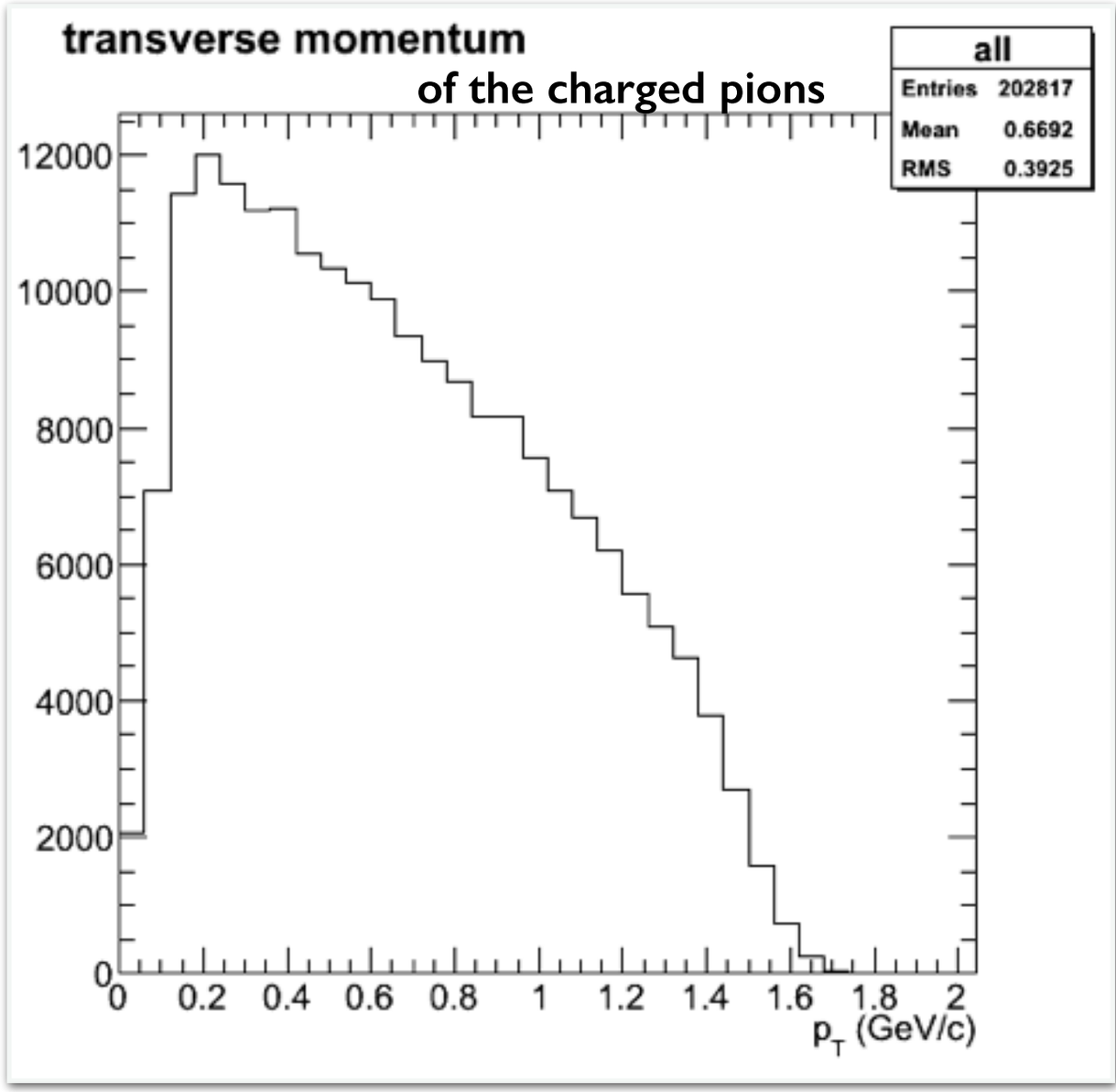


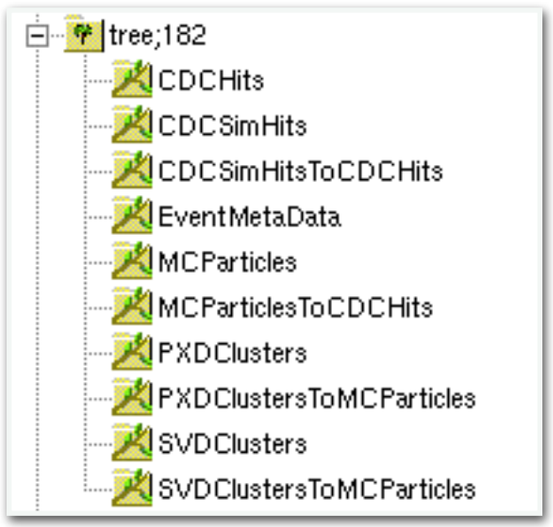




The Simulation

- used the standard Belle II full simulation, no background (build-2014-04-11)
- simulated 100k Y(4S) events:
- Y(4S) → B $\bar{B}$
  - B → $\nu\ \bar{\nu}$
  - $\bar{B}$ → J/ψ K_S
    - J/ψ → $\nu\ \bar{\nu}$
    - K_S → $\pi^+\pi^-$
- The output of the simulation is saved in a rootfile and then analysed with different reconstruction algorithms.





~ 6.8 kb/evt
5.2 Gb on disk

The Reconstruction

- Use the *standard* reconstruction script in the reconstruction package (build-2014-04-11):
  - CDC Track Finder: Trasan
  - VXD Track Finder: VXDTF
  - Track Merging: MCTrackCandCombiner(*)
  - [MC Track Finder: TrackFinderMCTruth, need by MCTrackMatcher Module]
- Add the MCTrackMatcher module to set the McTrackId for the TrackCand
- Run different reconstruction configurations and compare the results of the performances on the *same* set of simulated events:
  - CDC only
  - VXD only
  - [VXD+CDC(*)]

(*) *use MC Truth information*

The Analysis Skeleton

In the event():

```
for (int j = 0; j < mcParticles.getEntries(); j++) {
  mother = aMcParticle->getMother();


 if ( (abs(aMcParticle->getPDG() ) != 211 )
       || ( abs(mother->getPDG() ) != 310) )
    continue;


 [. . .]
```

```
for (int i = 0; i < trackCands.getEntries(); i++)
    if (ID == trackCands[i]->getMcTrackId())
      matched = true;

 if (matched) {

[. . .]

}
  else {

[. . .]

 }
}
```

- loop on MCParticles
  - select pions from K_S only
  - compute the relevant variables (p_T, d_0, # CDC hits, # PXD/SVD clusters)
  - fill the histos of "*all*" the particles
  - loop on TrackCands
    - check whether any of the TrackCand matches the MCParticle
    - if matched, fill the histos of "*matched*" particles with the infos of the matched MCParticle
    - if not matched, do something else

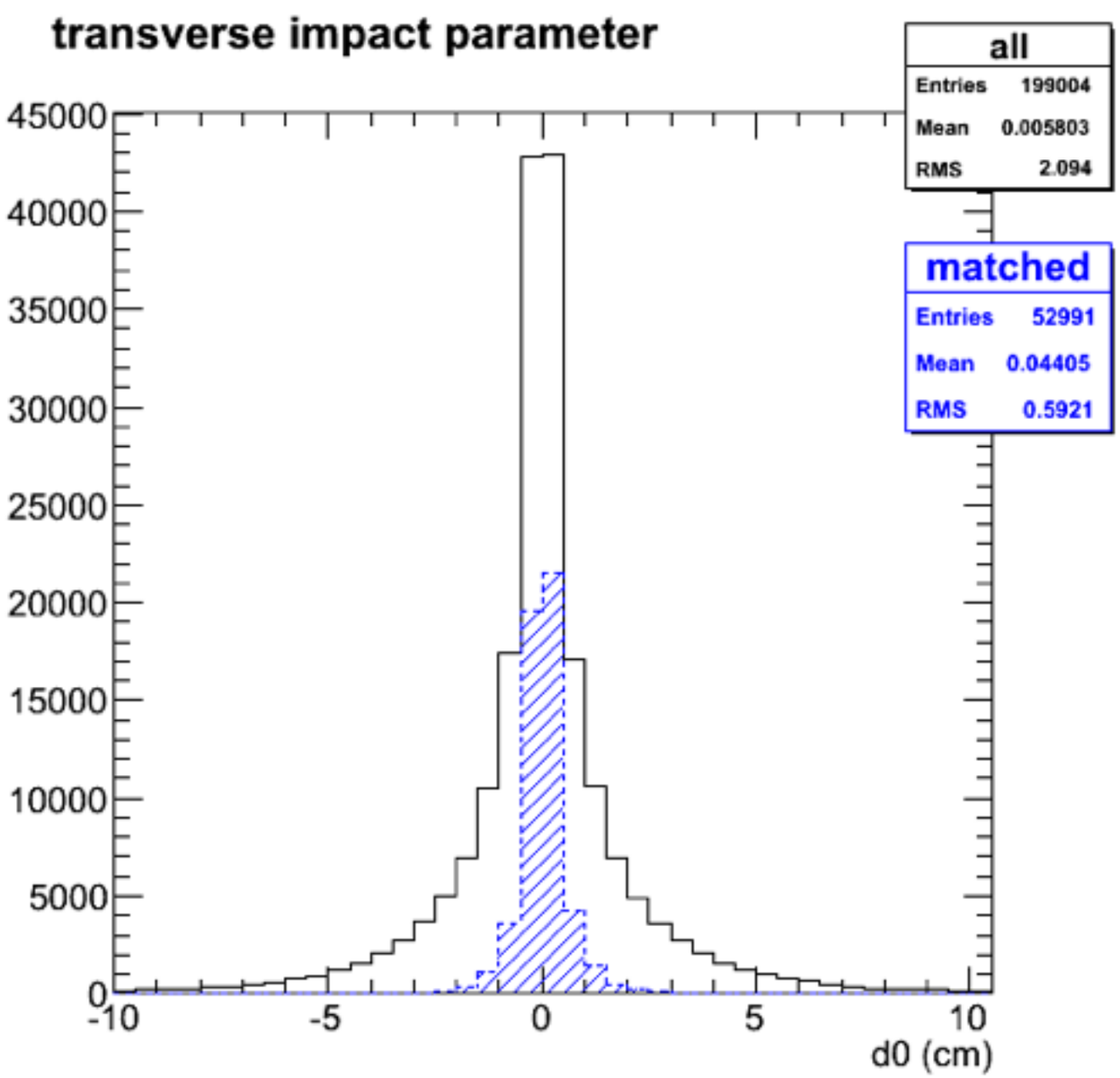
Integrated Efficiencies

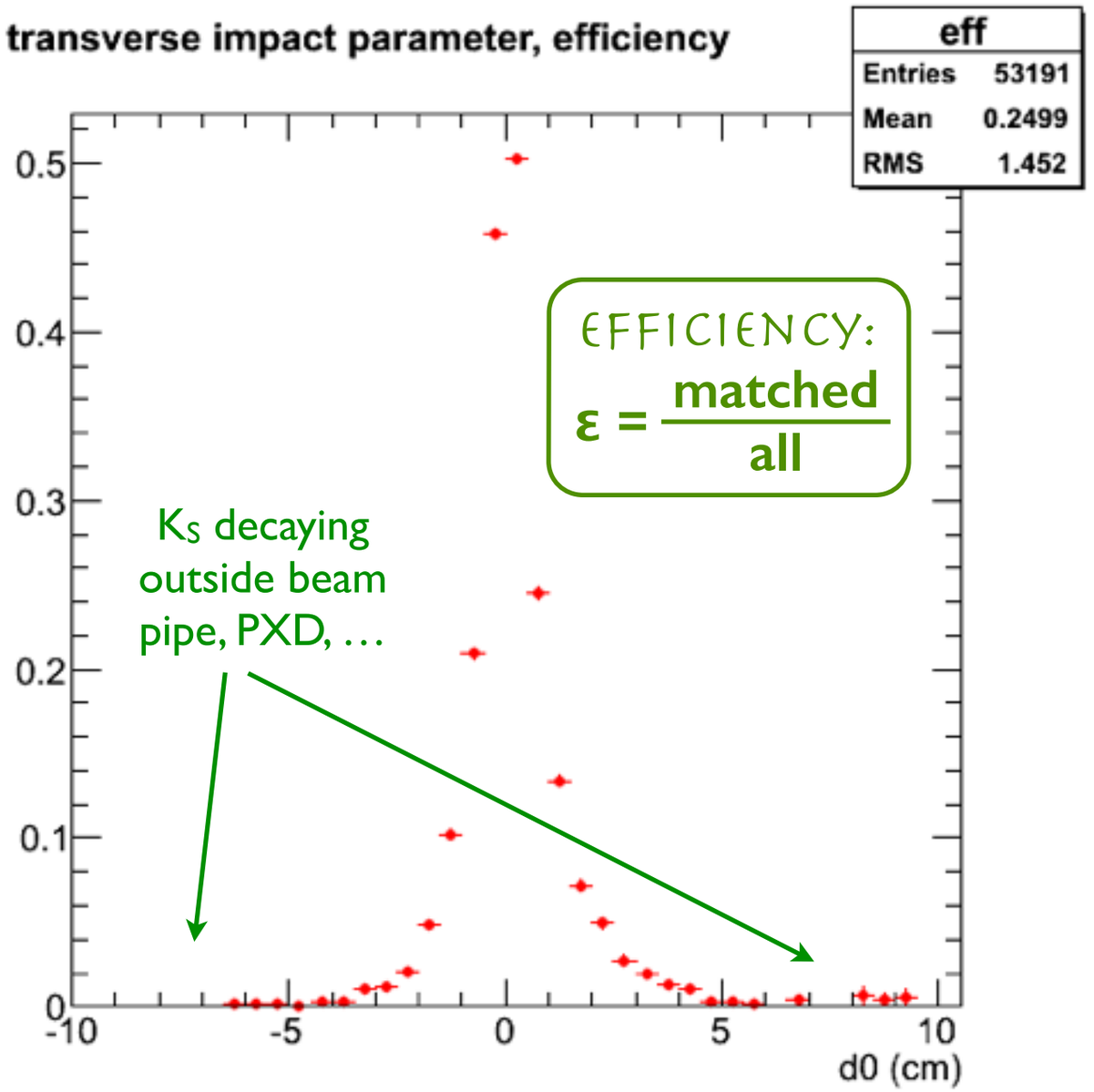
- 199004 simulated charged pions (MCParticle) from K_S decays
  - missing 0.5% pions: not compatible with K_S decaying outside active volume, may be an effect of K_S-K_L mixing?
- 188884 MC TrackCand, 94.9% of the simulated ones (geometrical acceptance)

		VXD	CDC	CDC+VXD
	TrackCand	54146	184889	176685
PURITY:	**$\frac{\text{matched}}{\text{TrackCand}}$**	(97.87±0.06)%	(93.24±0.06)%	(99.93±0.01)%
EFFICIENCY:	**$\frac{\text{matched}}{\text{MCParticle}}$**	(26.6±0.4)%	(88.63±0.07)%	(88.72±0.08)%

(*) *use MC Truth information*

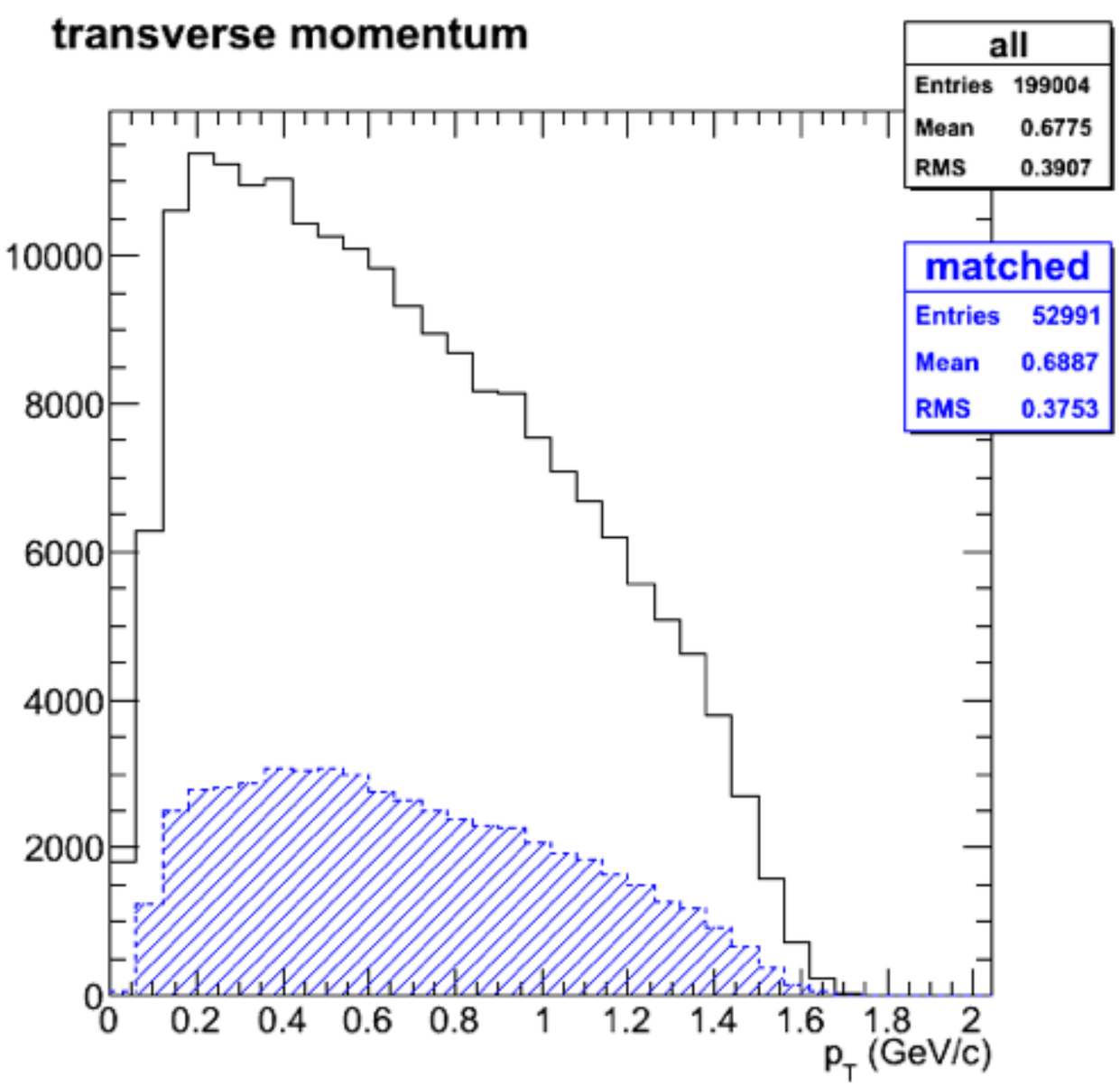
VXD only: transverse impact parameter

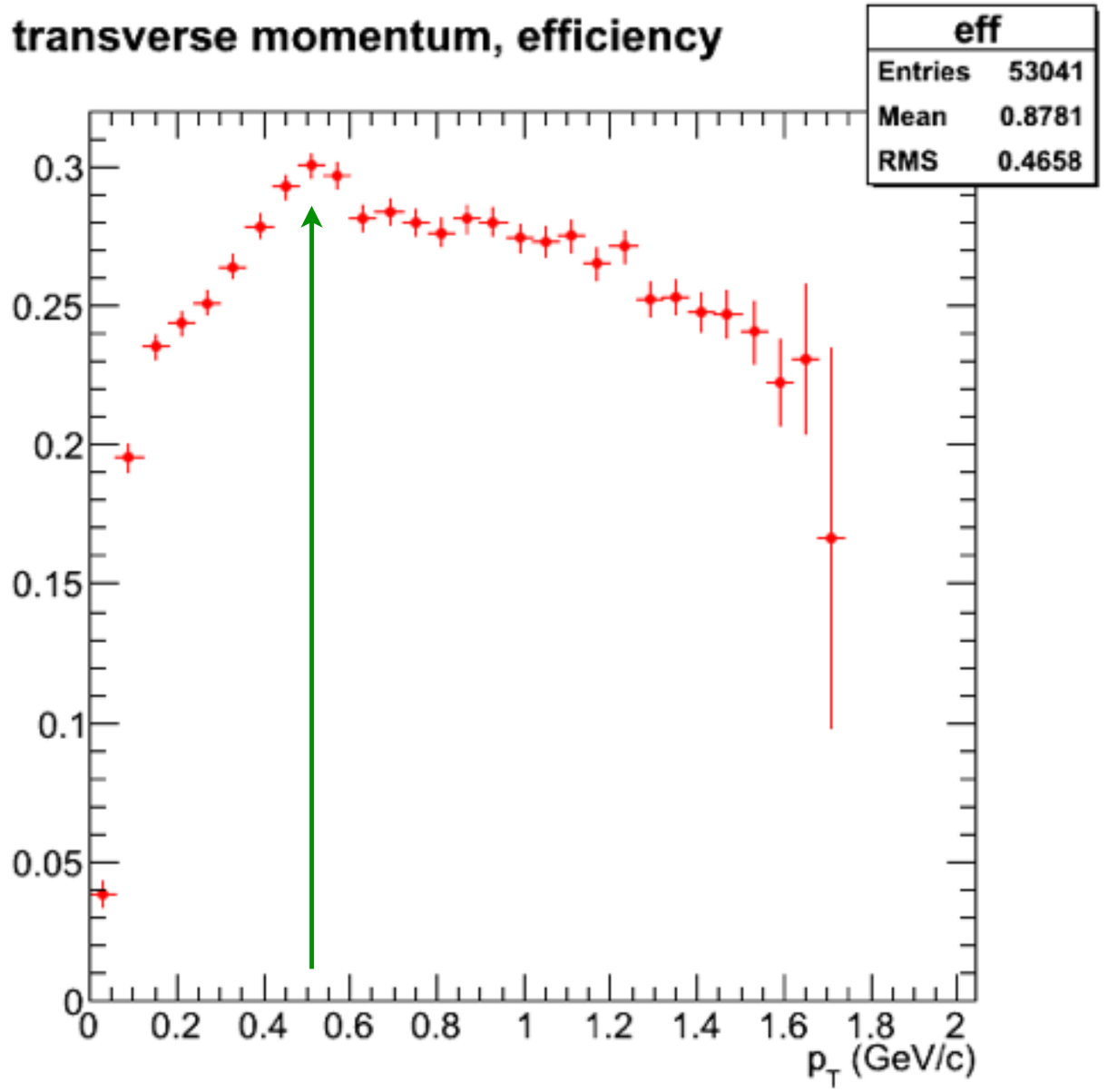




- Clear dependence on the transverse impact parameter (d_0)
- Maximum efficiency ~ 50% (with bin width = 1mm, ε goes up to 60%)

VXD only: transverse momentum

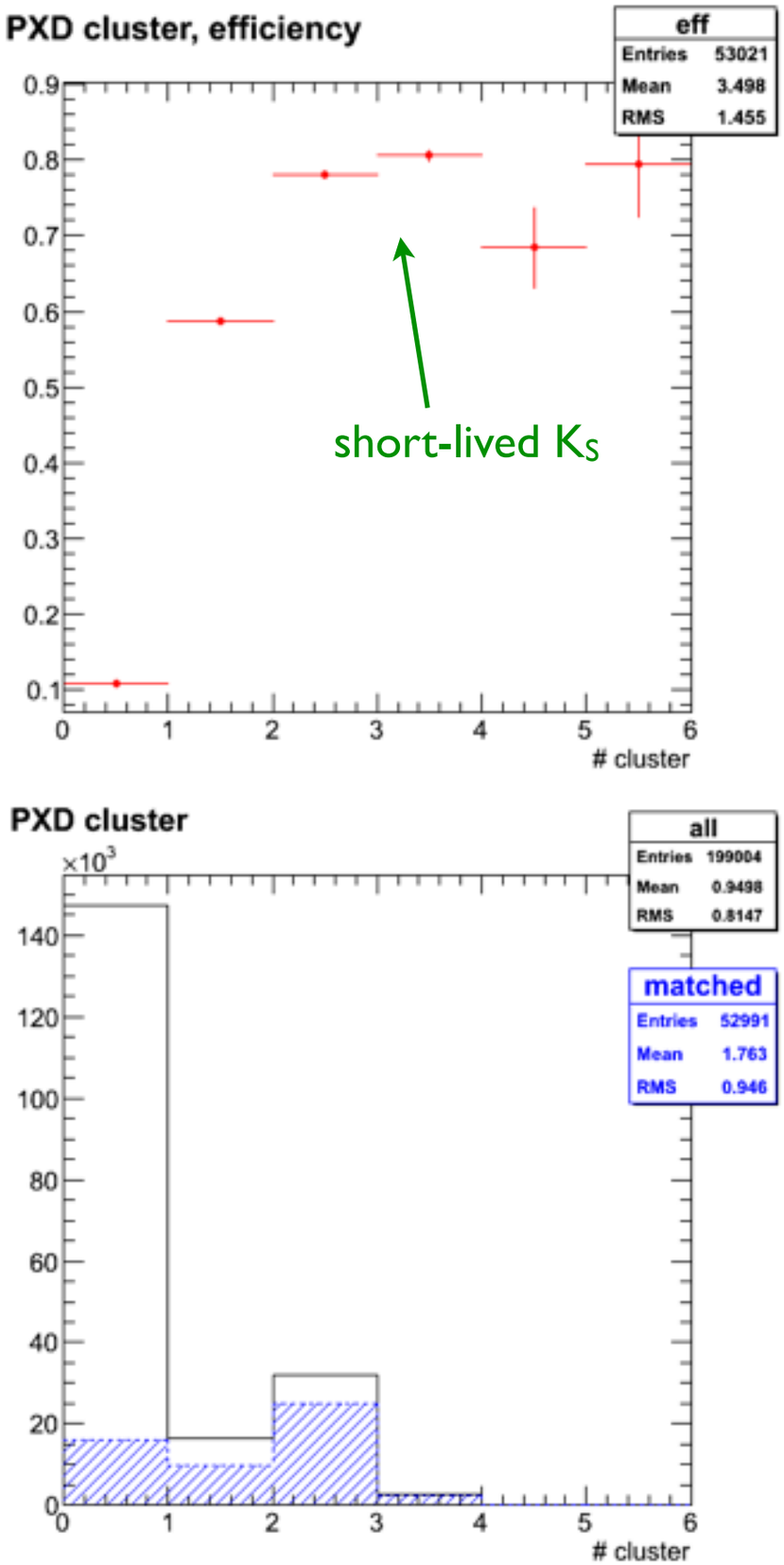


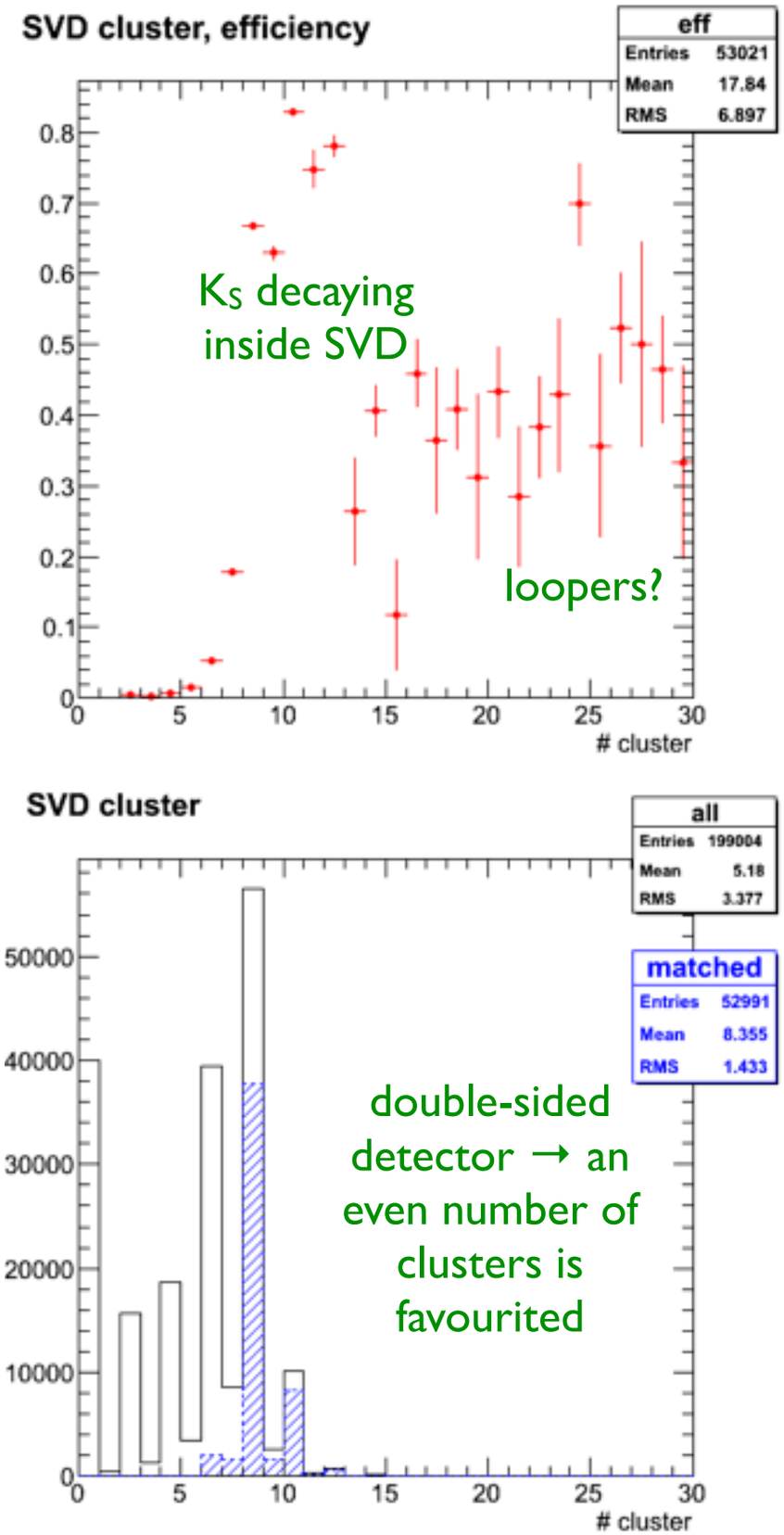


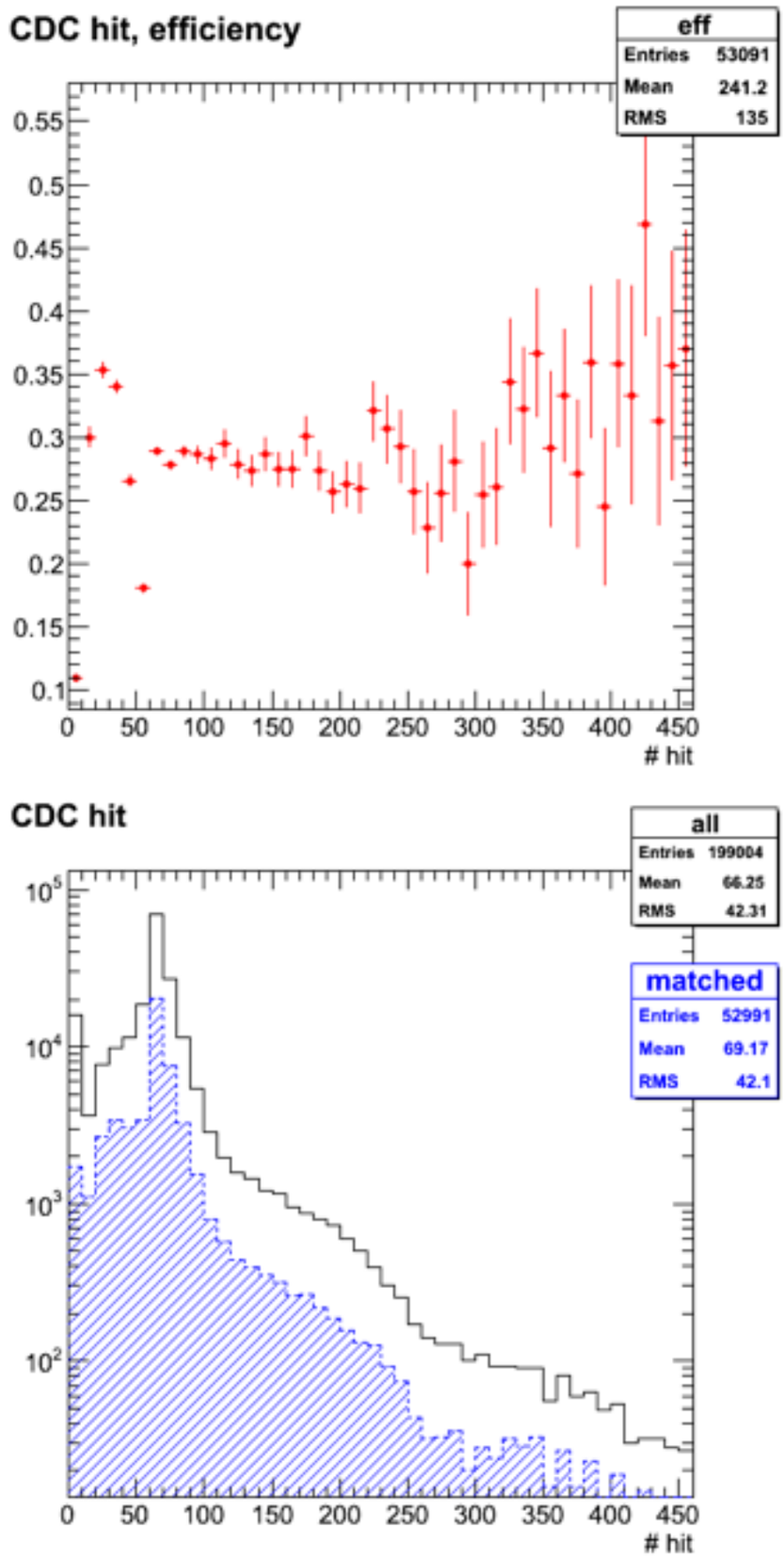
➡ Maximum efficiency (30%) at 500 MeV/c transverse momentum tracks

- lower p_T tracks: harder to track them in general + tracks not coming from the IP
- higher p_T tracks come from K_S with larger boost that travel outside the VXD

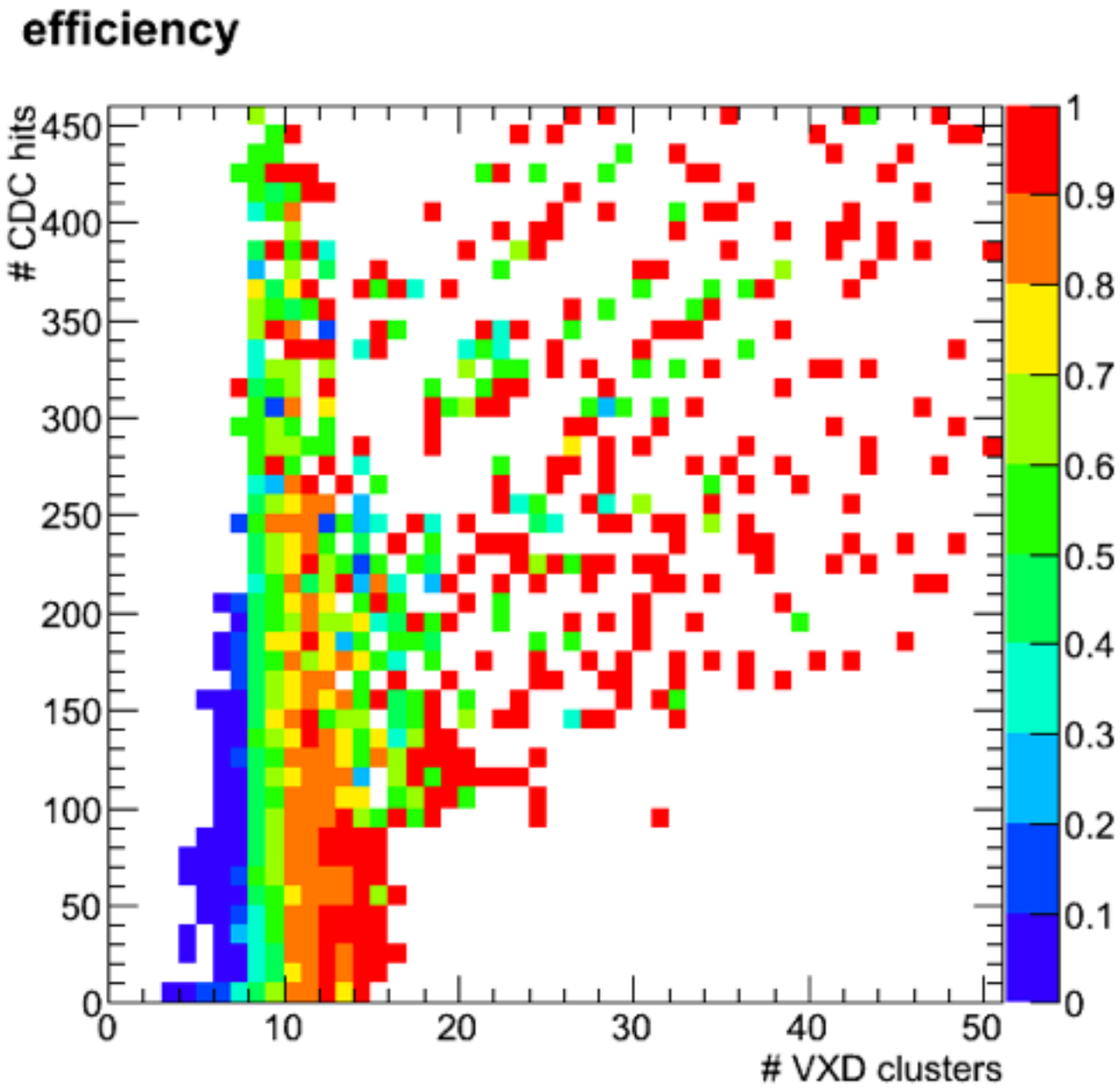
VXD only: VXD clusters and CDC Hits

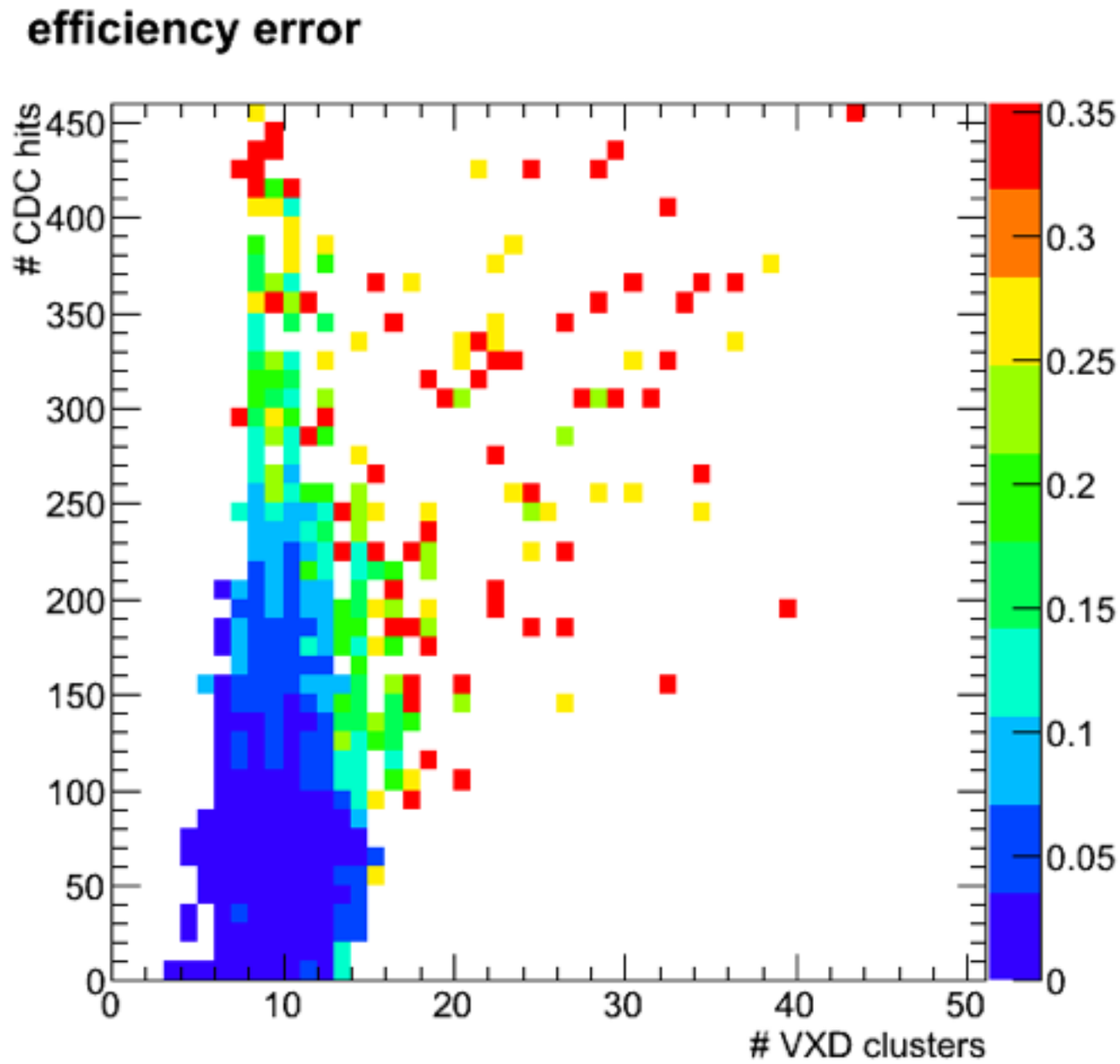






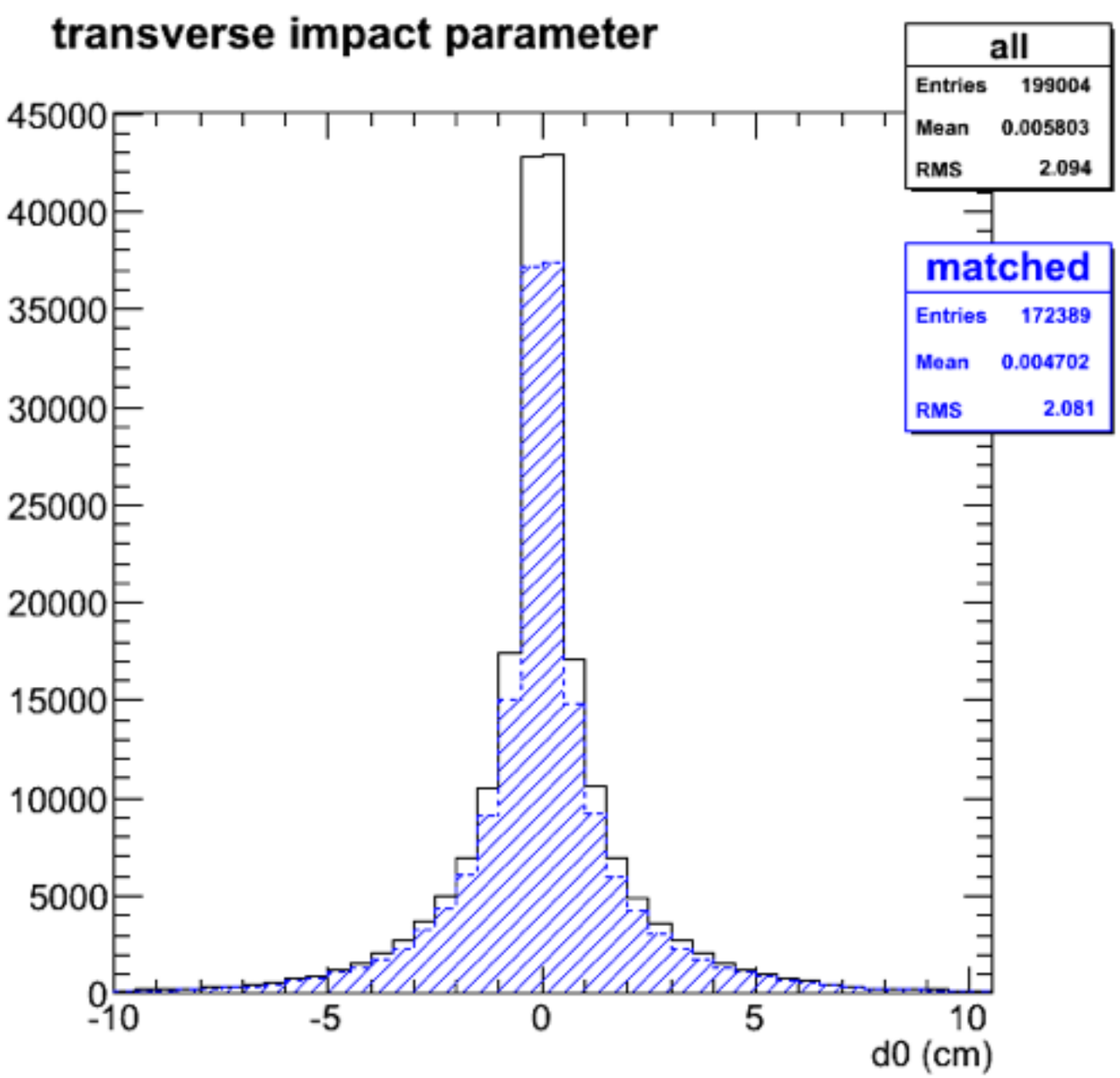
VXD only: CDC hits vs VXD clusters

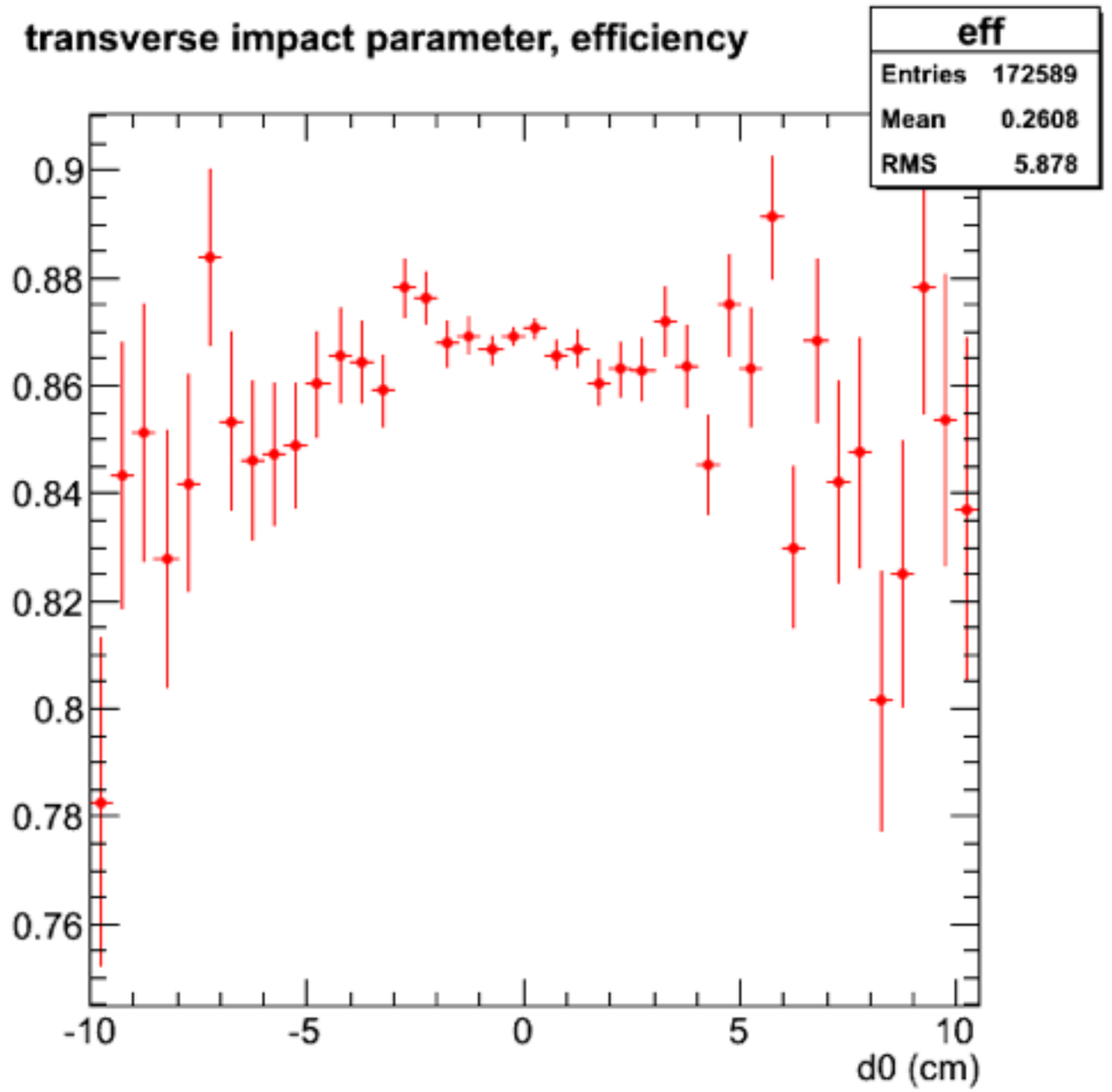




➡ Efficiency does not depend on the number of CDC Hits (as expected)

CDC only: transverse impact parameter

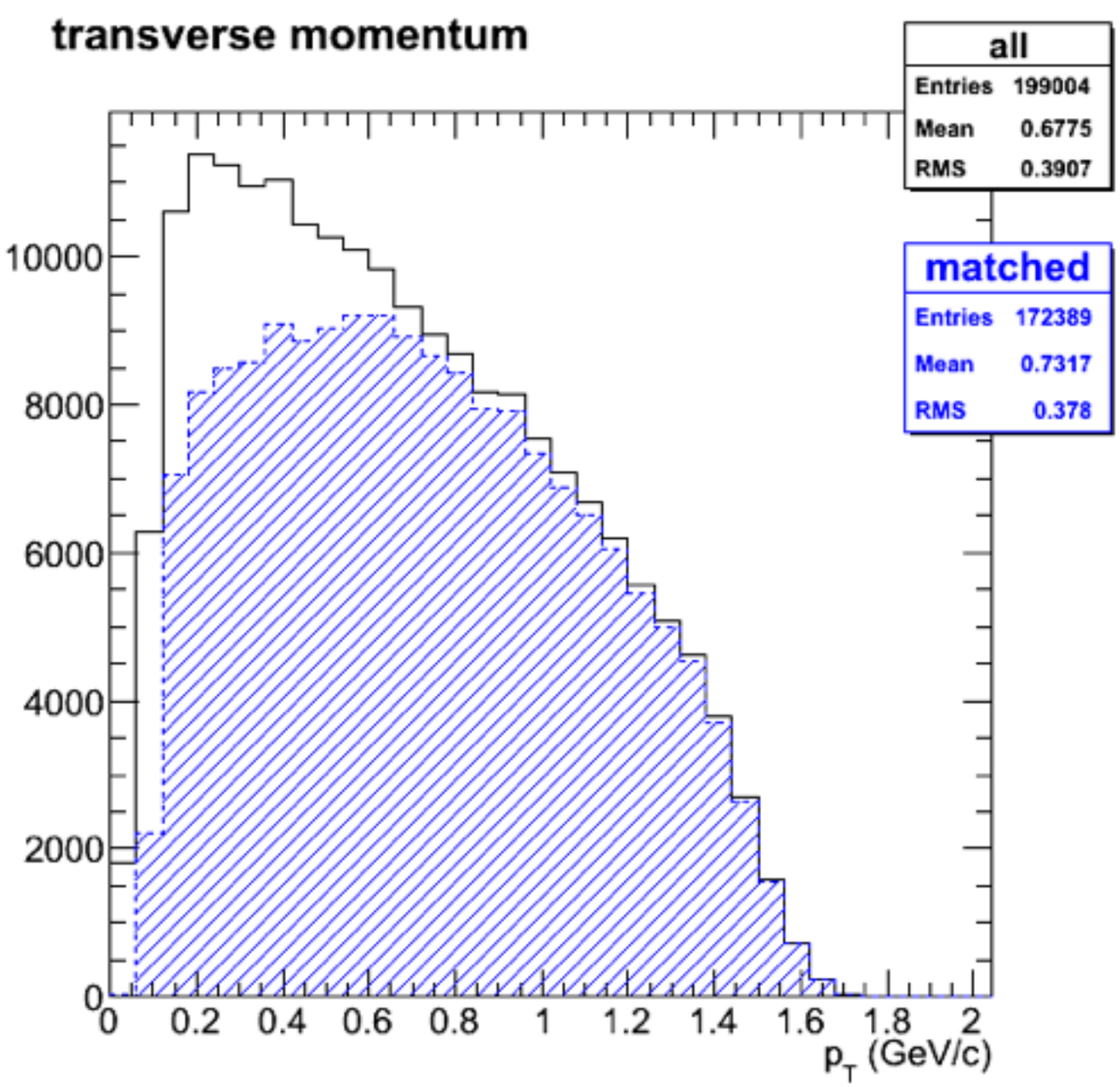


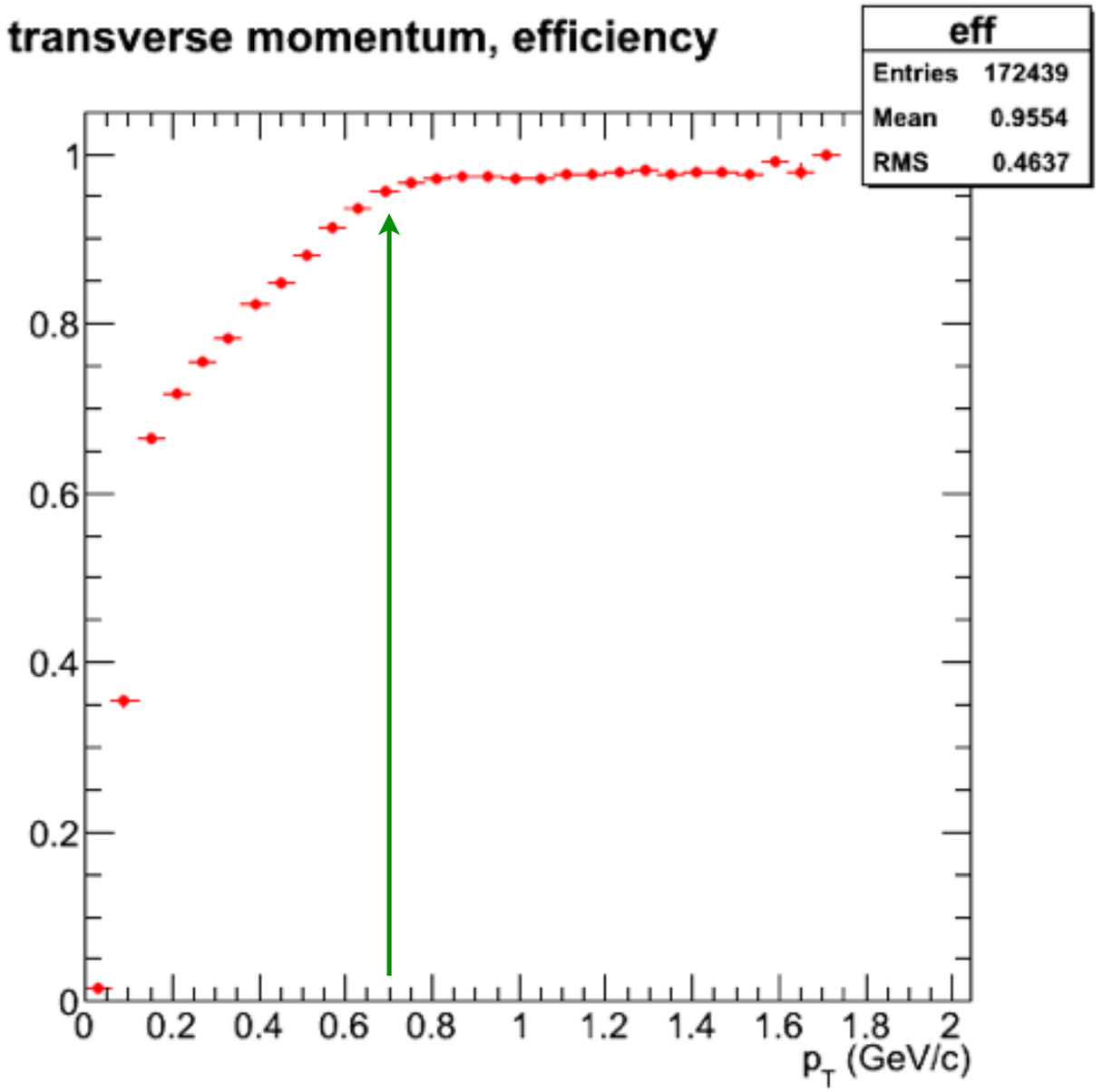


➡ No strong dependence on the transverse impact parameter (d_0)

- most of the K_S decay inside the VXD

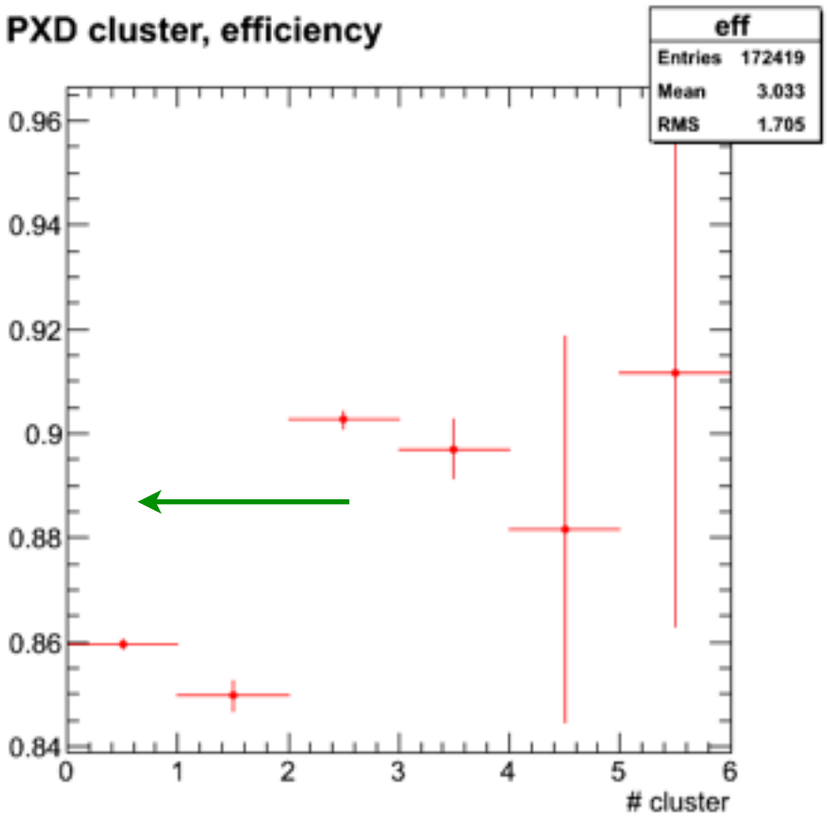
CDC only: transverse momentum

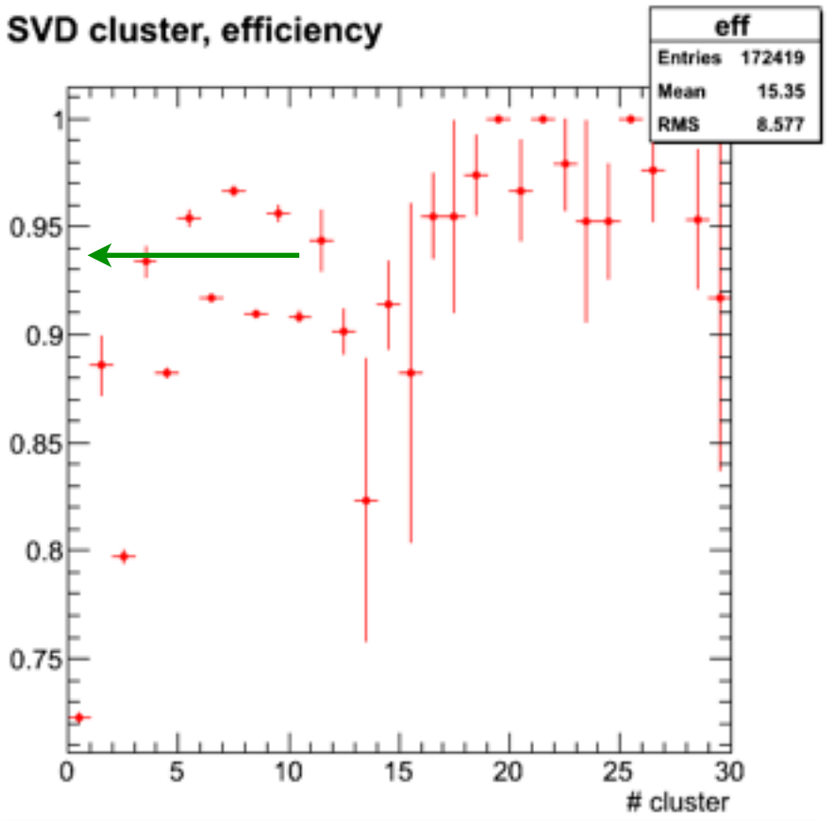


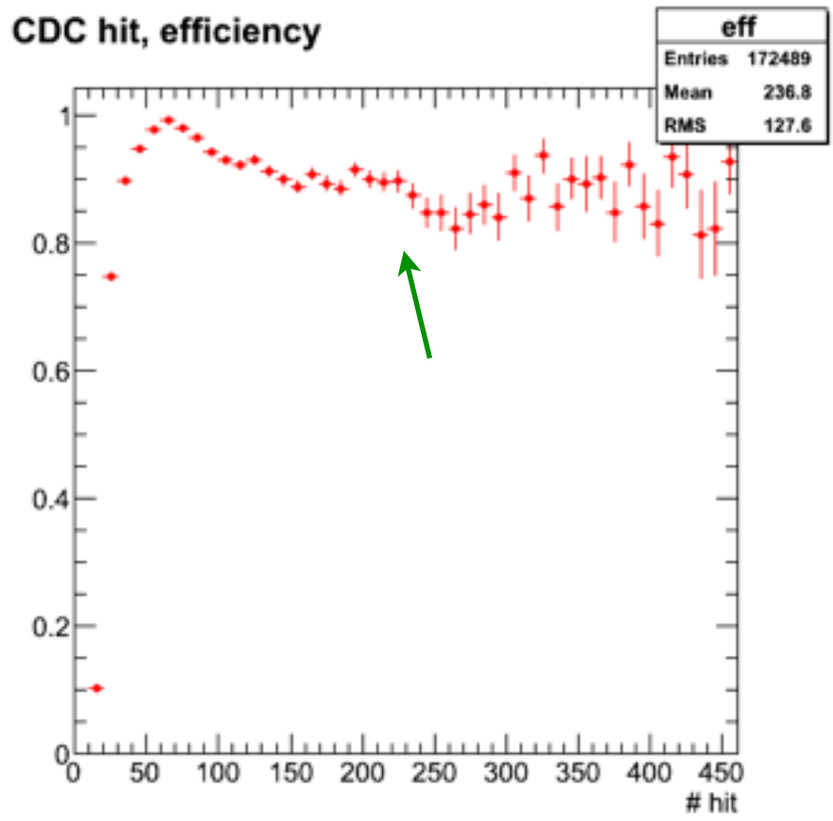


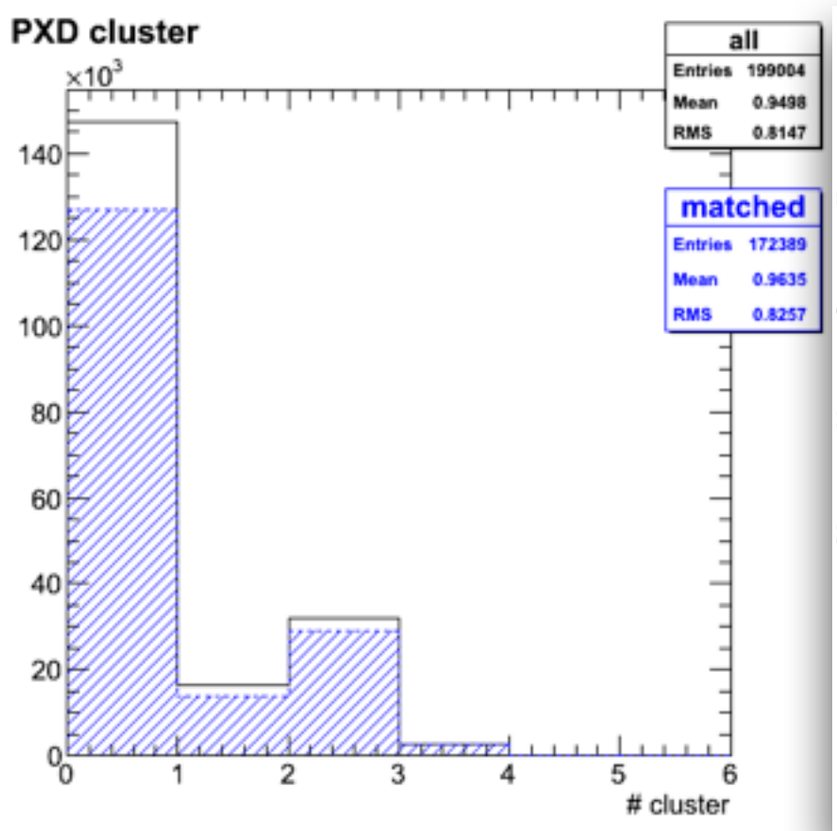
➡ Missing “low” (up to 700MeV/c!) transverse momentum tracks

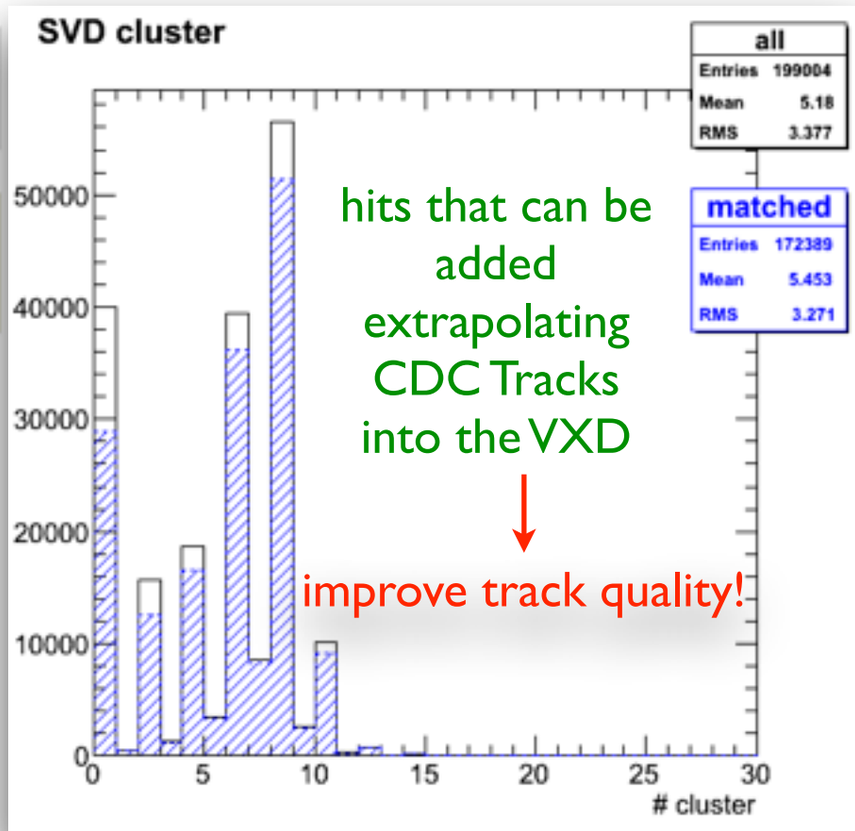
CDC only: VXD clusters and CDC Hits







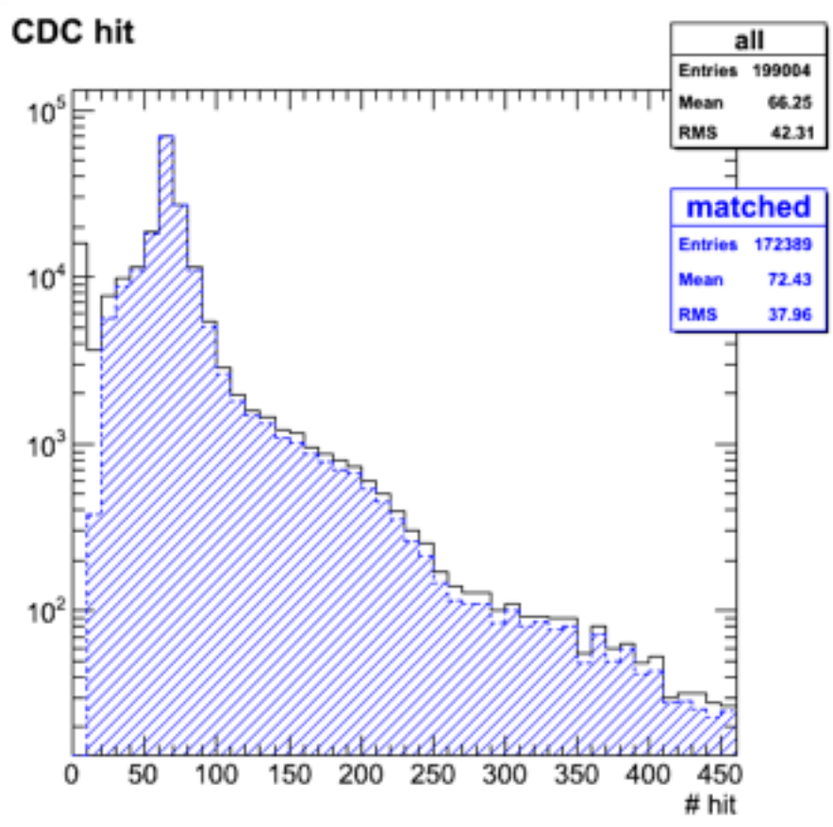




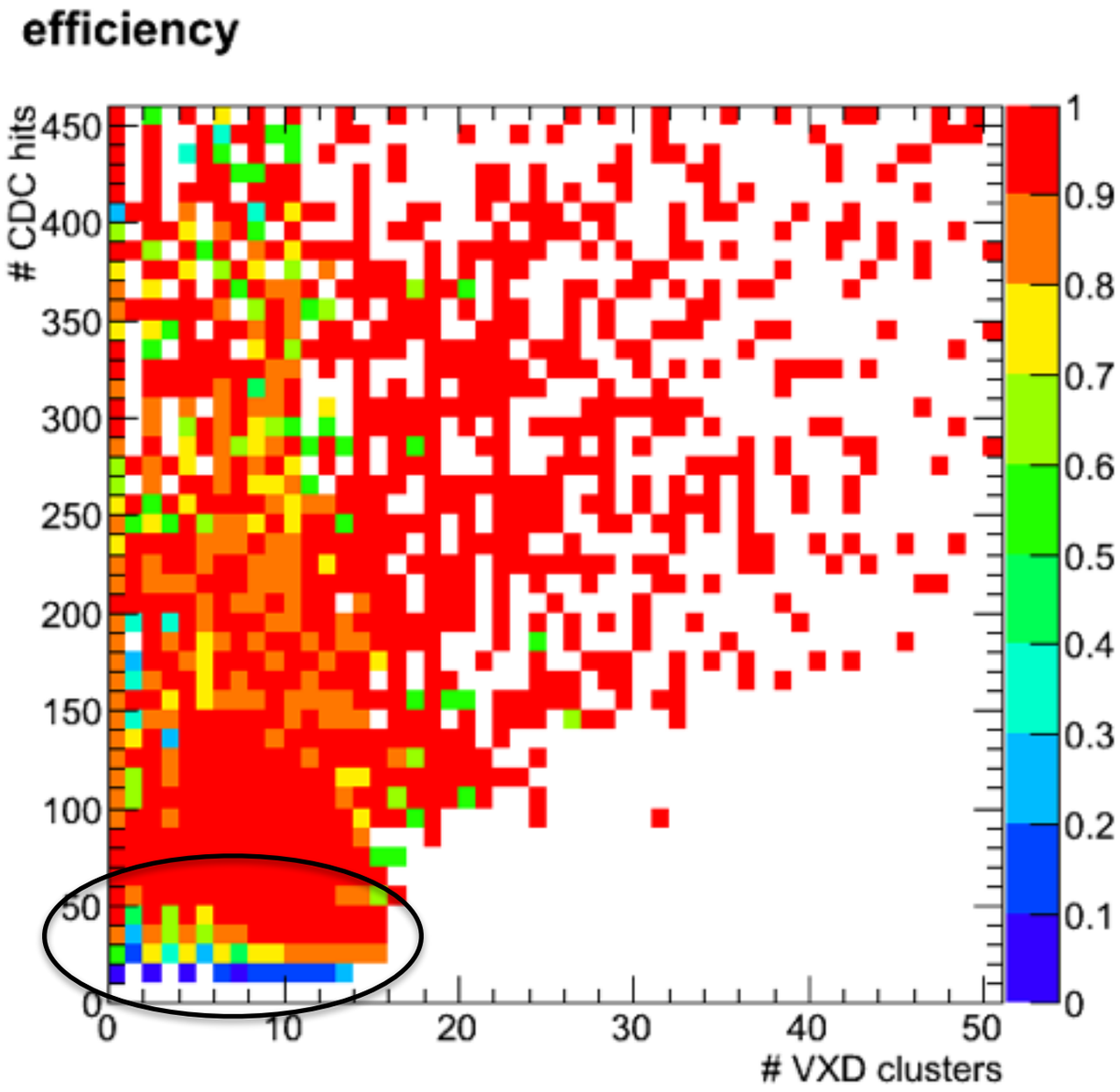
hits that can be added extrapolating CDC Tracks into the VXD

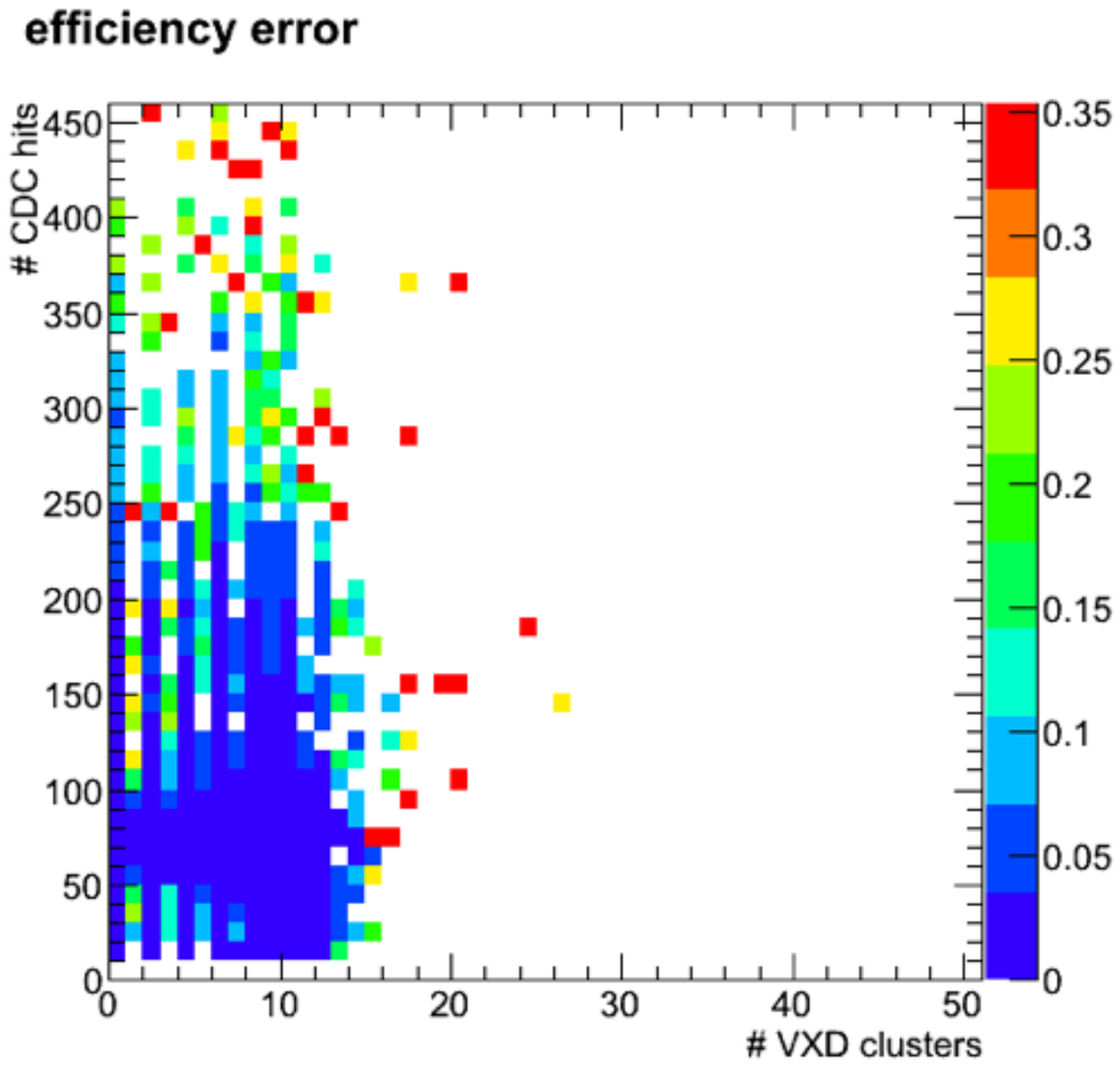
↓

improve track quality!



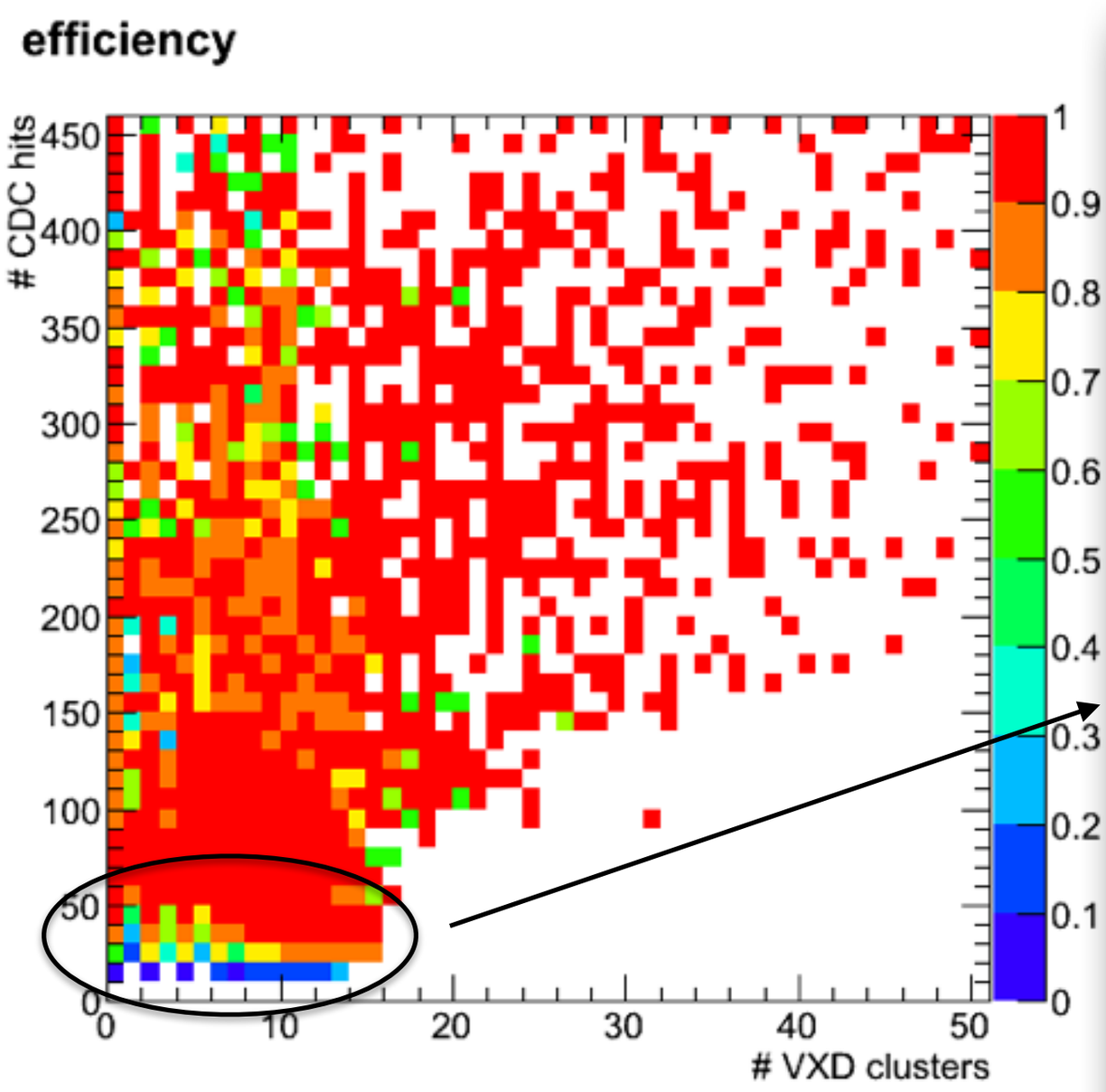
CDC only: CDC hits vs VXD clusters

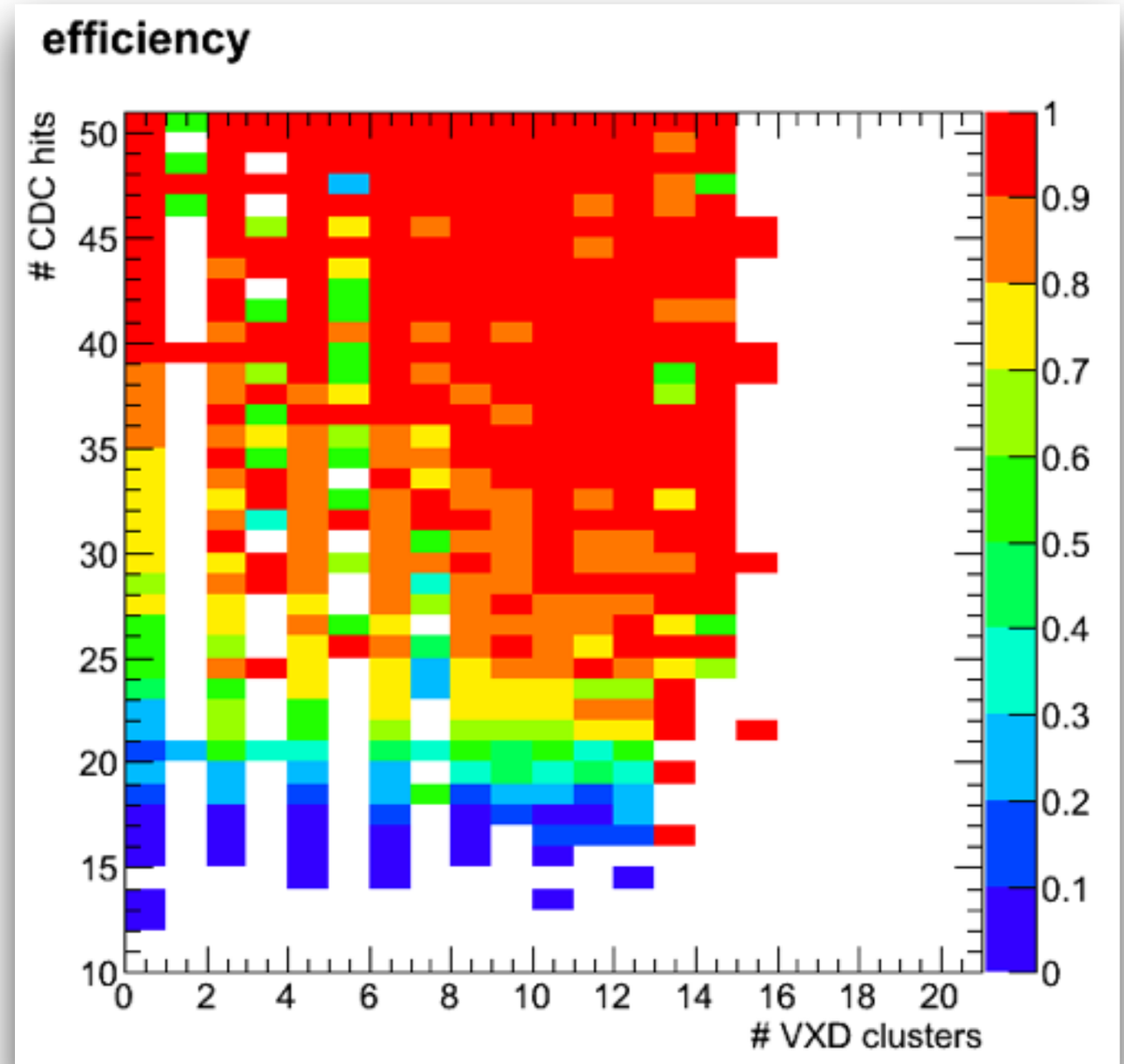




➡ hint of a correlation between CDC hits and VXD clusters?

CDC only: CDC hits vs VXD clusters





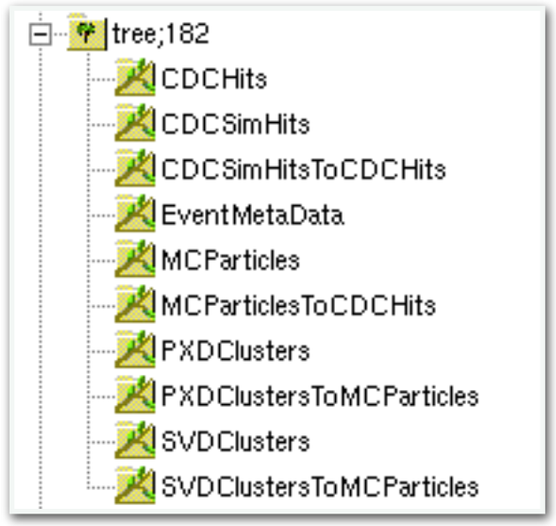
➡ hint of a correlation between CDC hits and VXD clusters?

- in the region # CDC hits < 50 it seems that there is an increase of efficiency for larger number of VXD clusters

What about K_S from generic B decays?

The Simulation, Reconstruction and Analysis

- used the standard Belle II full simulation, no background simulated
- simulated 10k Generic Υ(4S) events
  - softer transverse momentum distribution
- the output of the simulation is saved in a rootfile and then analysed with different reconstruction algorithms.



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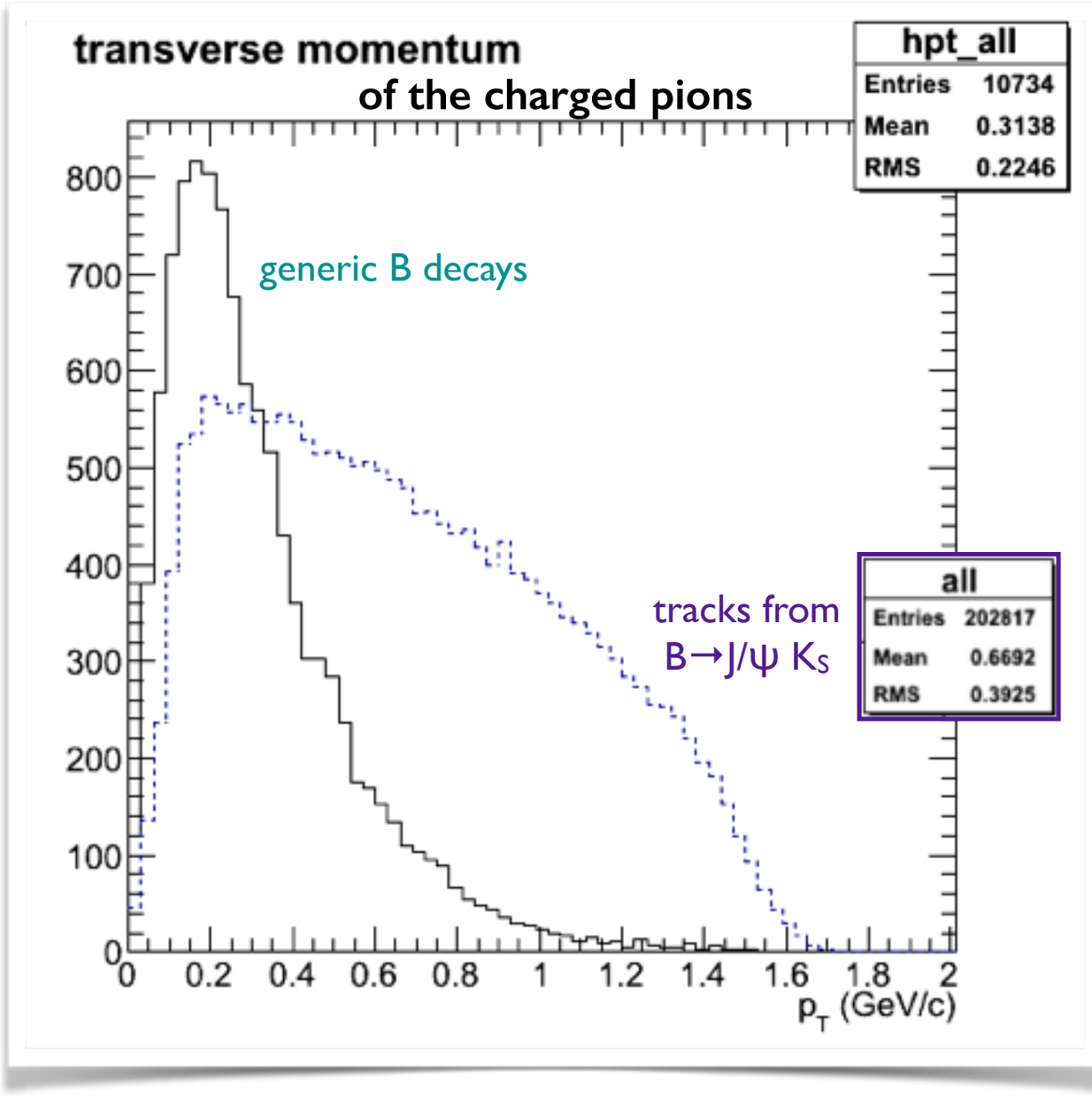


- reconstruction and analysis are unchanged.

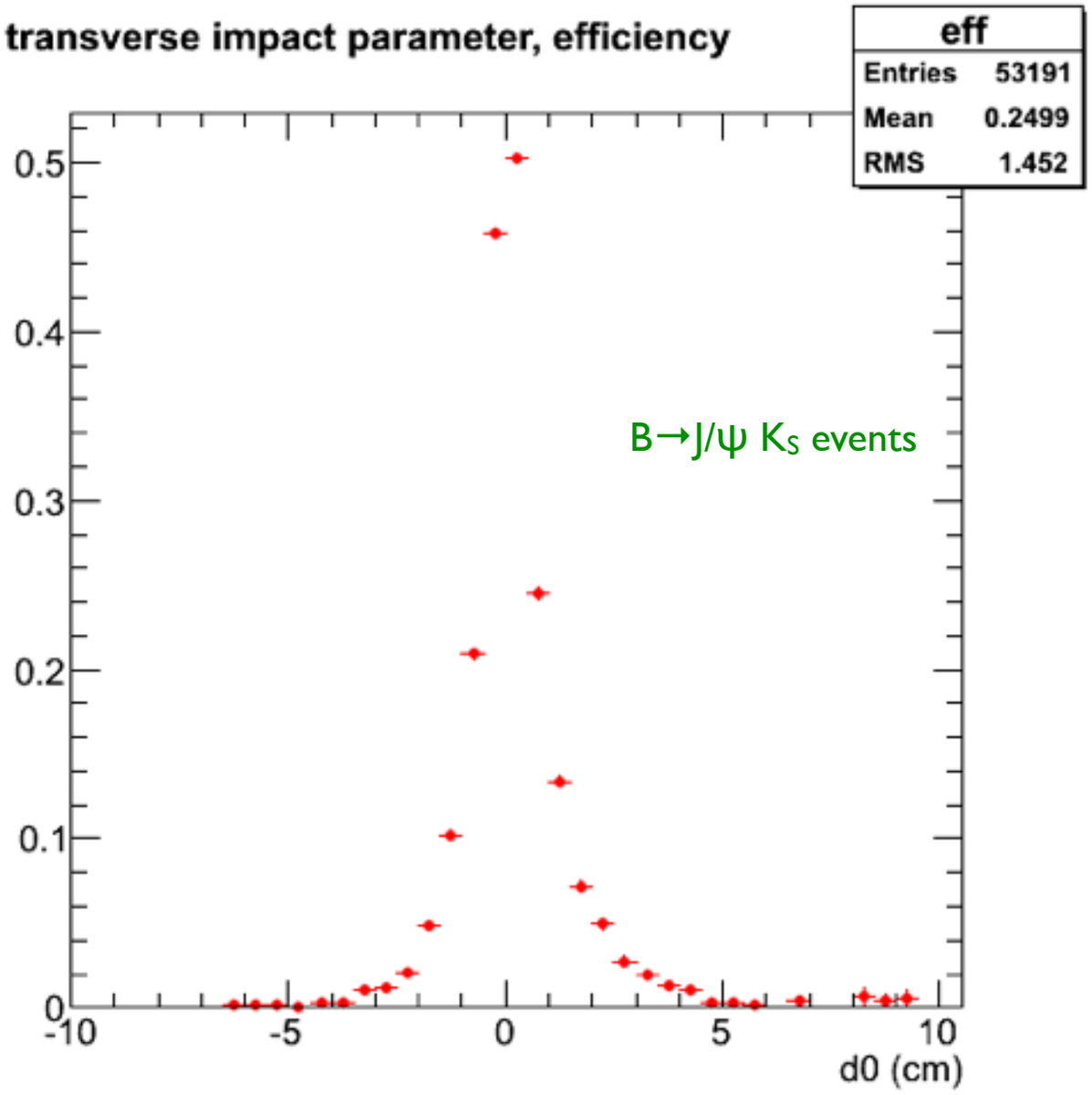
Integrated Efficiencies for Generic B decays

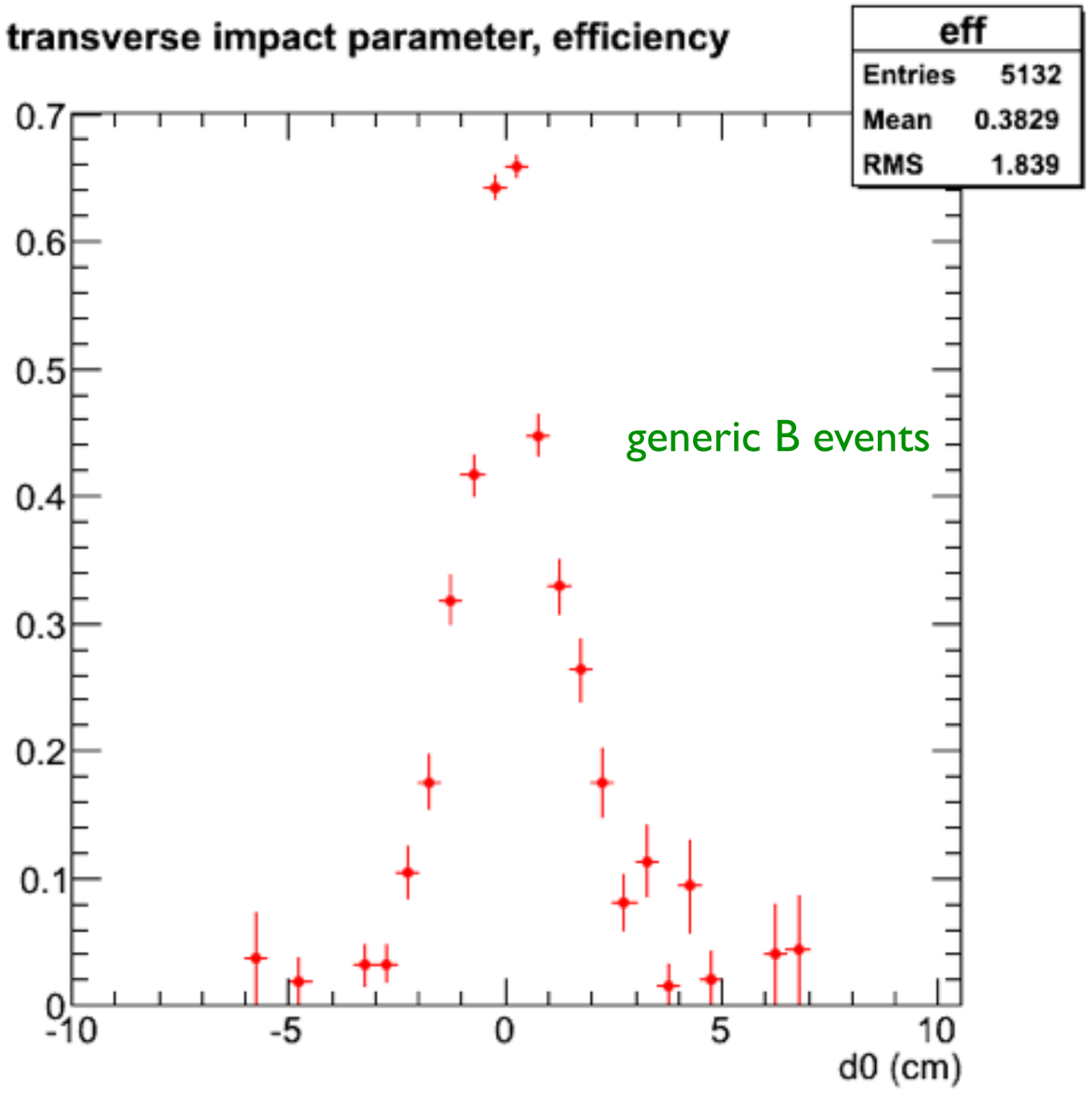
- 10724 simulated charged pions (MCParticle) from K_S decays in generic B decays
- 10242 MC TrackCand, 95.5% of the simulated ones (geometrical acceptance)

		VXD	CDC	CDC+VXD	
	TrackCand	54146	184889	176685	$B \to J/\psi\ K_S$
	TrackCand	5132	10507	9189	generic B decays
PURITY:	$\frac{\text{matched}}{\text{TrackCand}}$	(97.87±0.06)%	(93.24±0.06)%	(99.93±0.01)%	
	$\frac{\text{matched}}{\text{TrackCand}}$	(96.1±0.3)%	(81.0±0.4)%	(99.89±0.03)%	
EFFICIENCY:	$\frac{\text{matched}}{\text{MCParticle}}$	(26.6±0.4)%	(88.63±0.07)%	(88.72±0.08)%	
	$\frac{\text{matched}}{\text{MCParticle}}$	(46±1)%	(79.4±0.4)%	(85.6±0.4)%	

(*) *use MC Truth information*

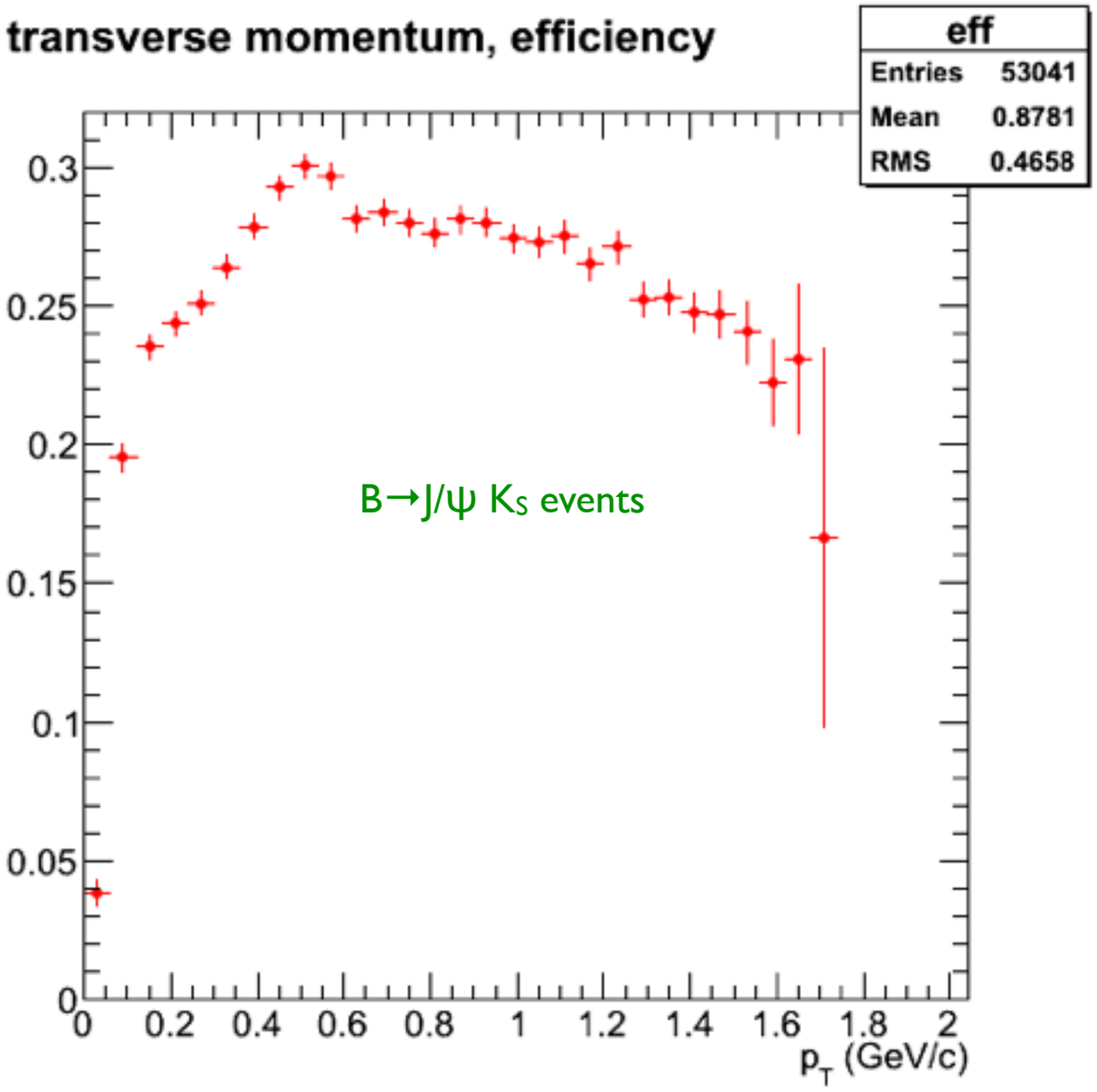
VXD only: transverse impact parameter

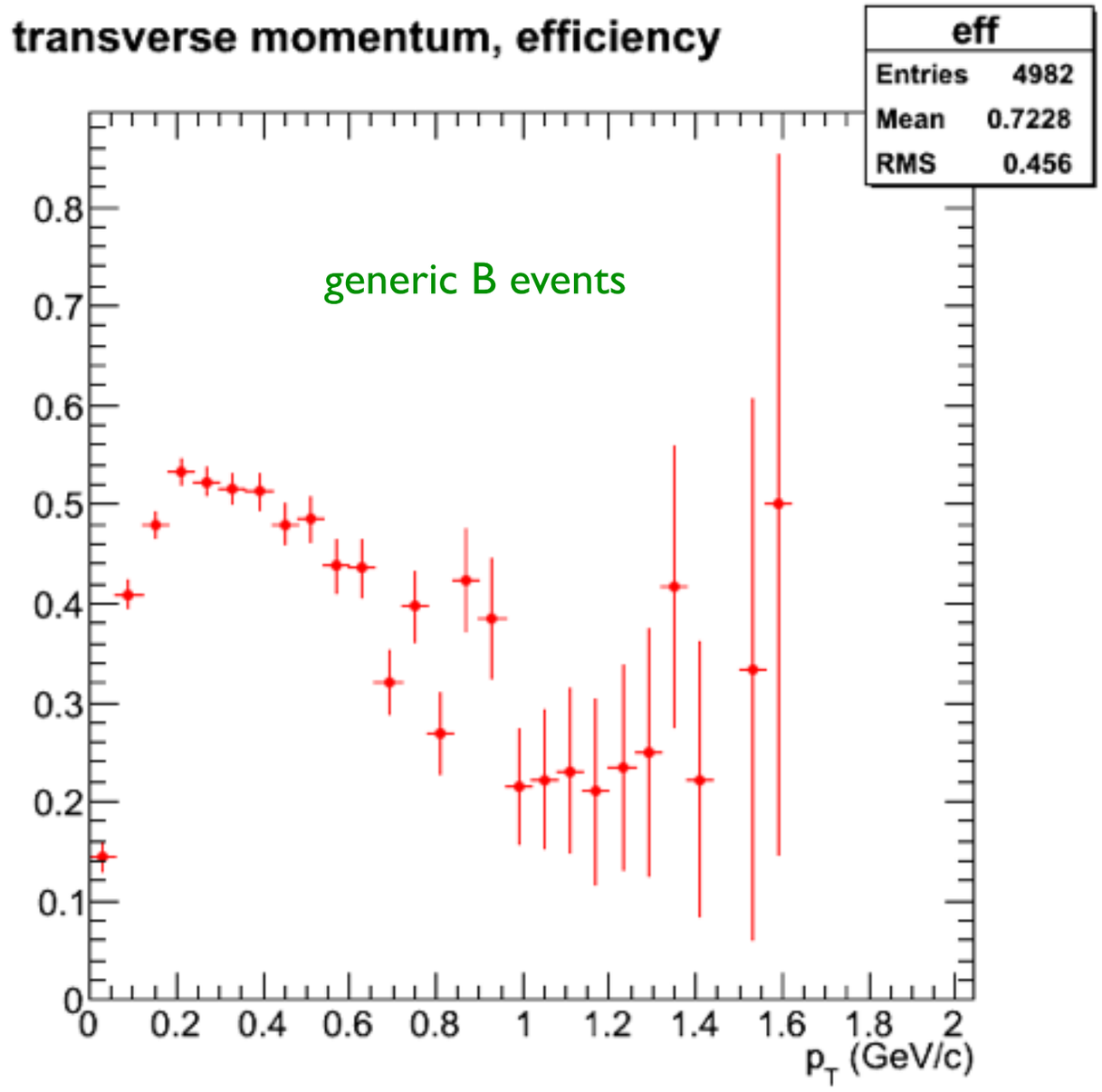




➡ Similar dependence but in general higher efficiencies for the generic B sample (as shown in the integrated efficiency table)

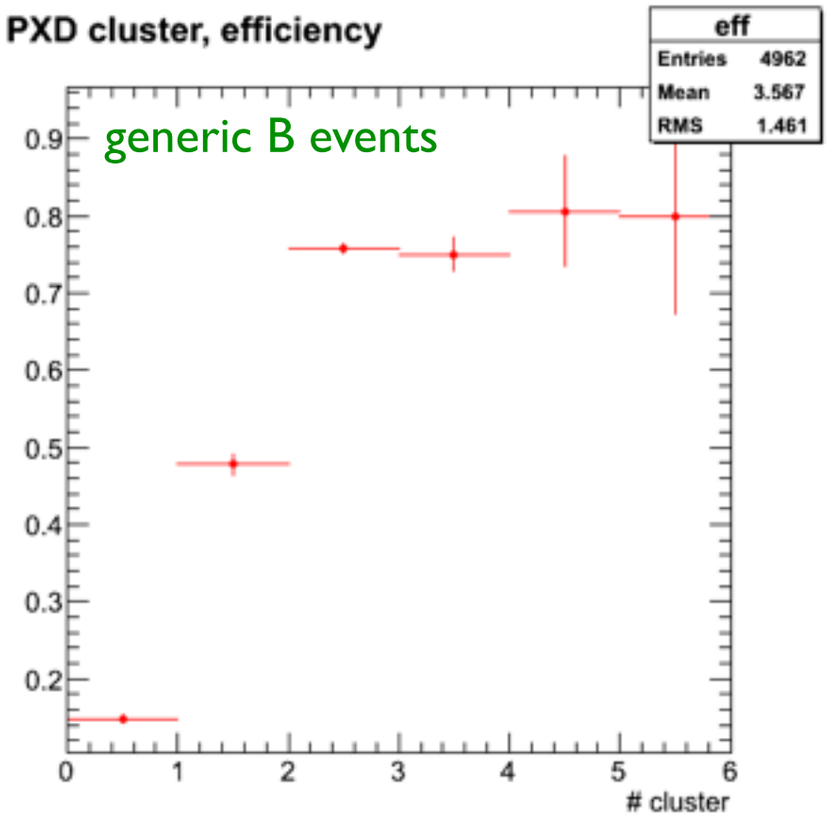
VXD only: transverse momentum

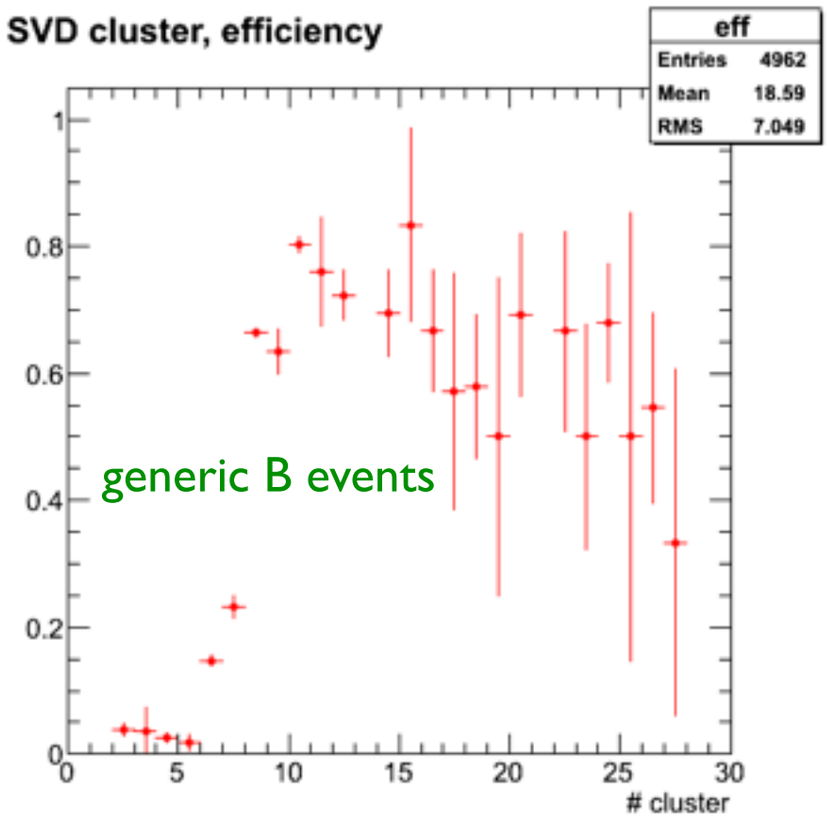


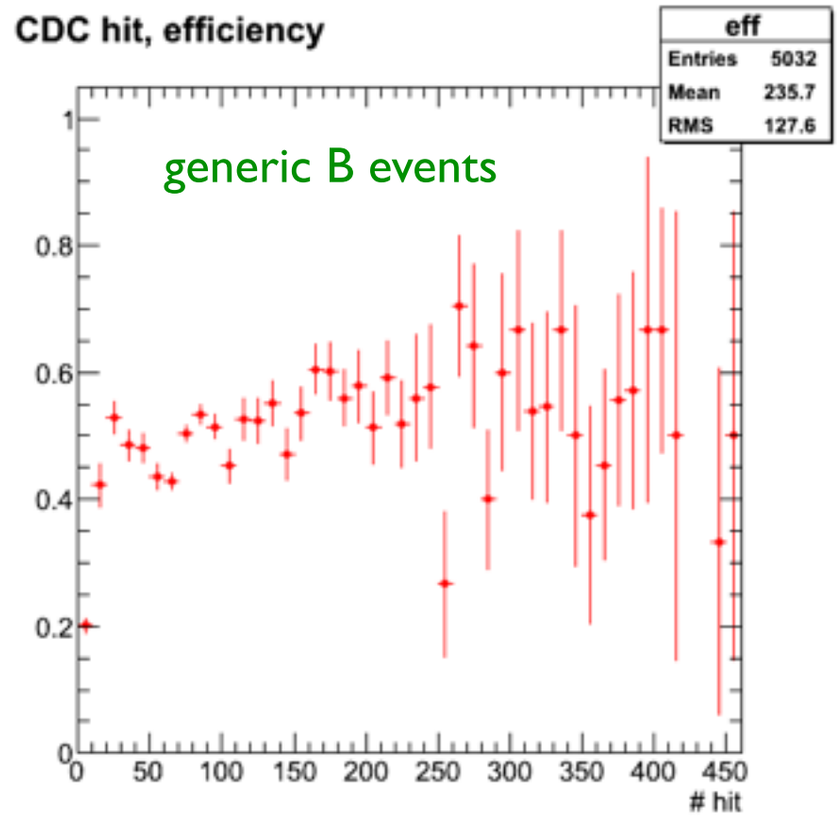


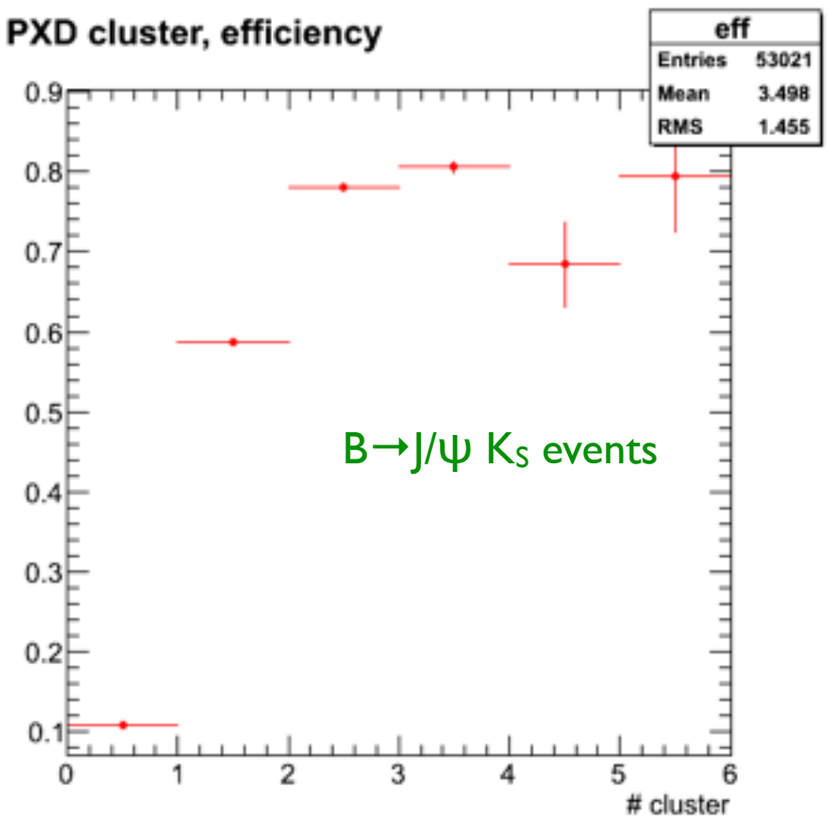
➡ Similar dependence but in general higher efficiencies for the generic B sample (as shown in the integrated efficiency table)

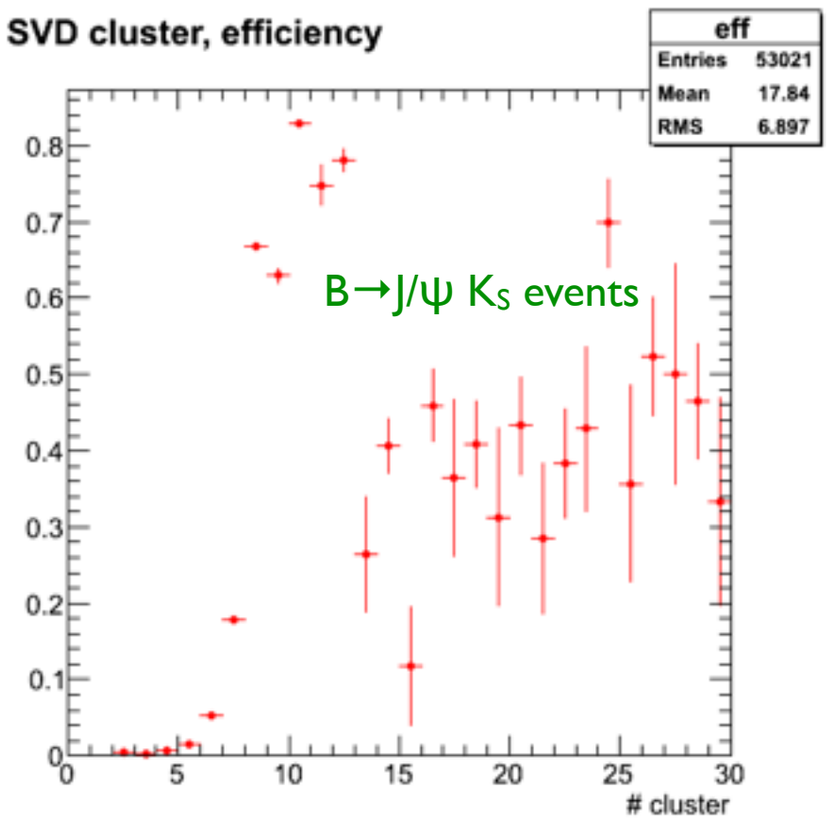
VXD only: VXD clusters and CDC Hits

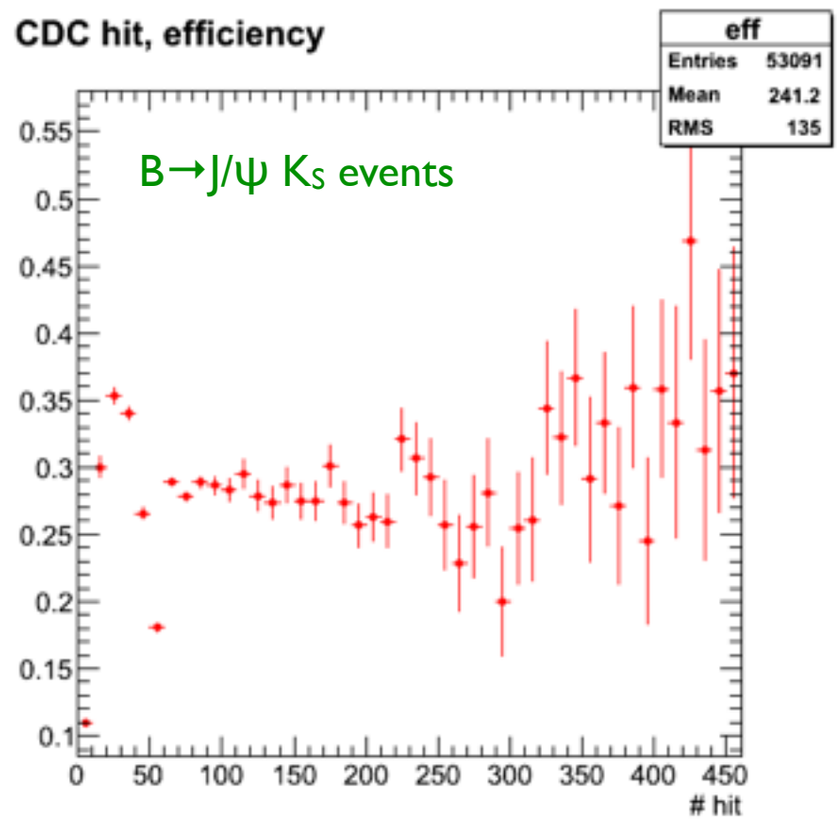




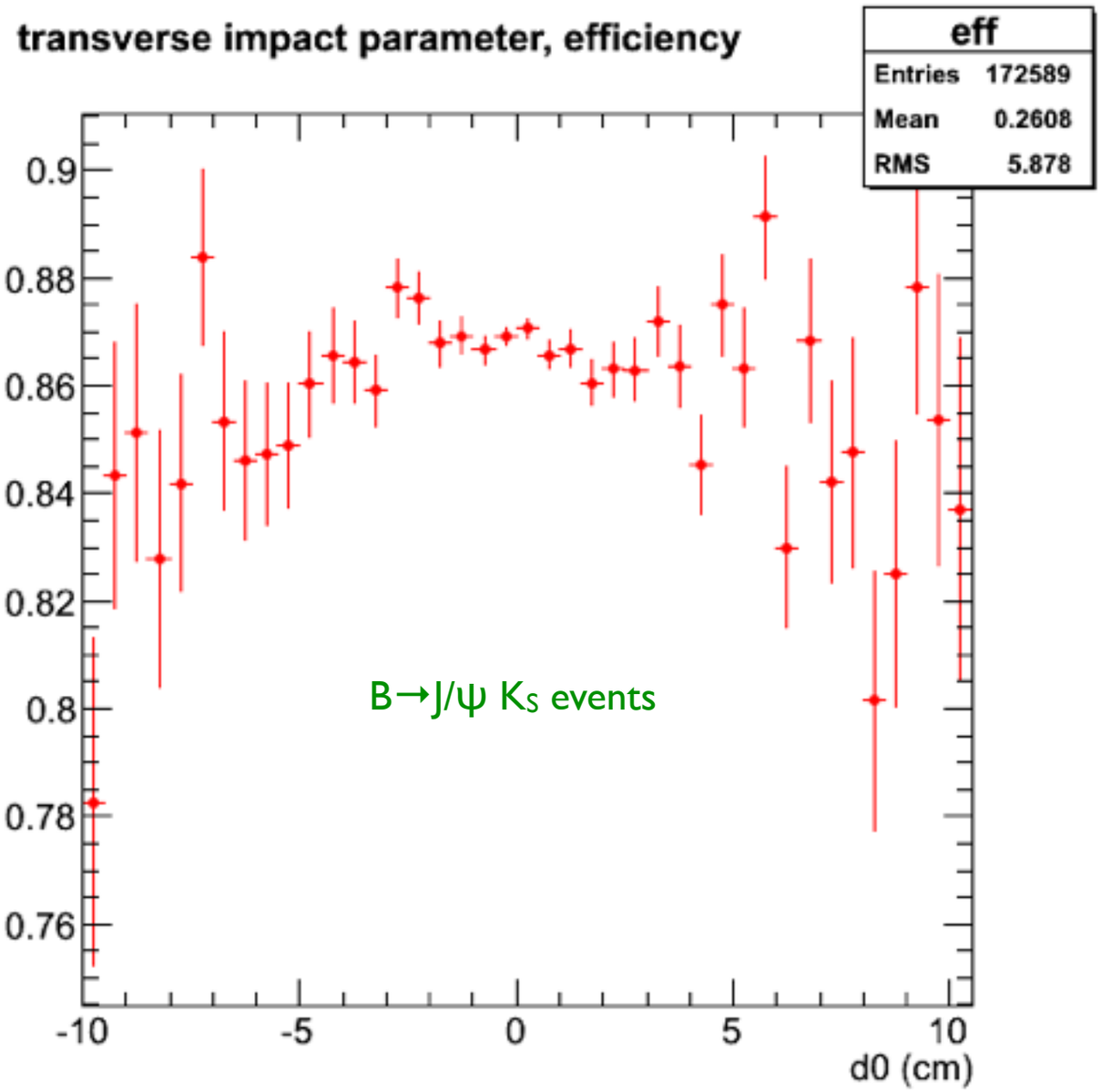


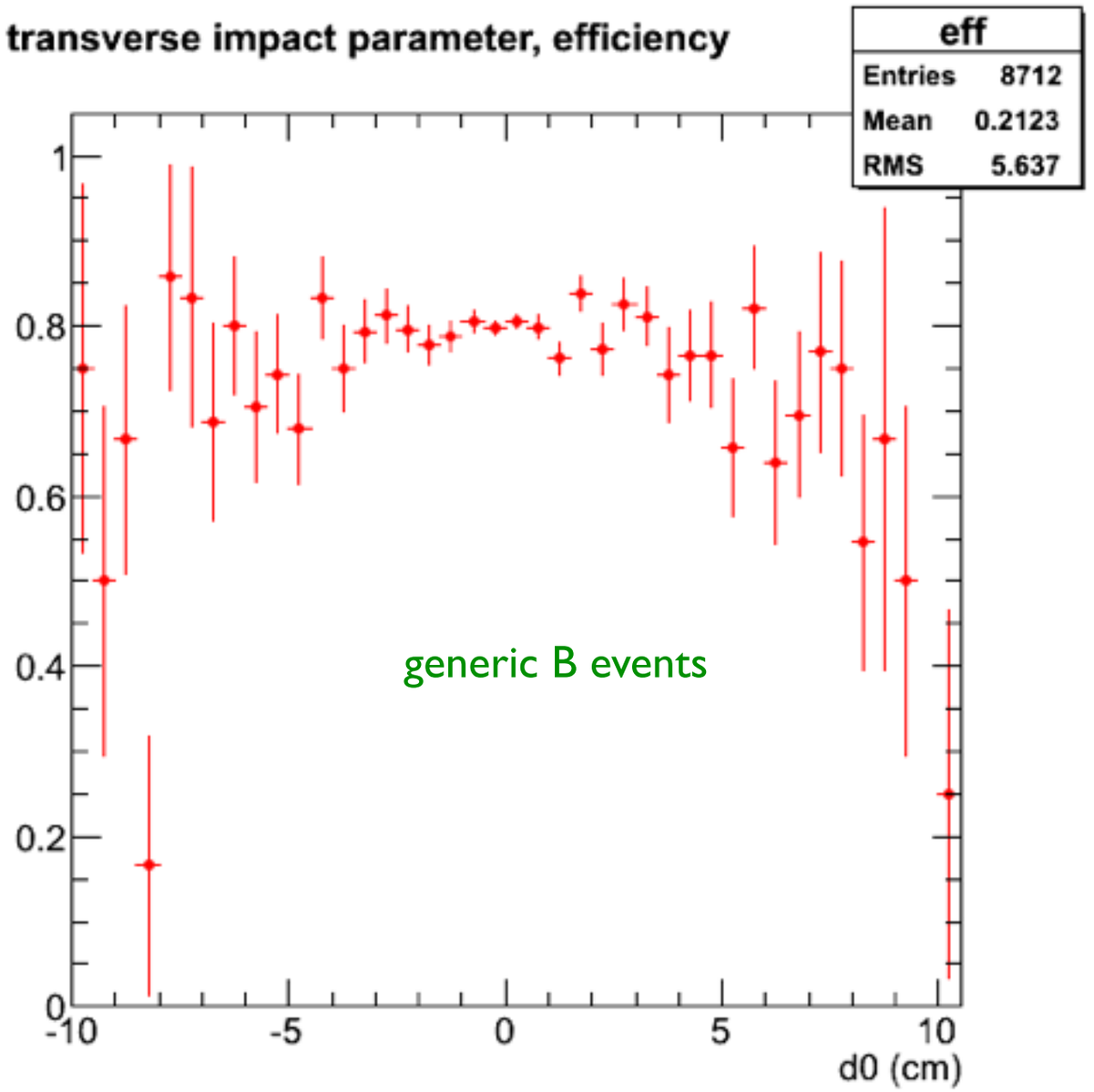






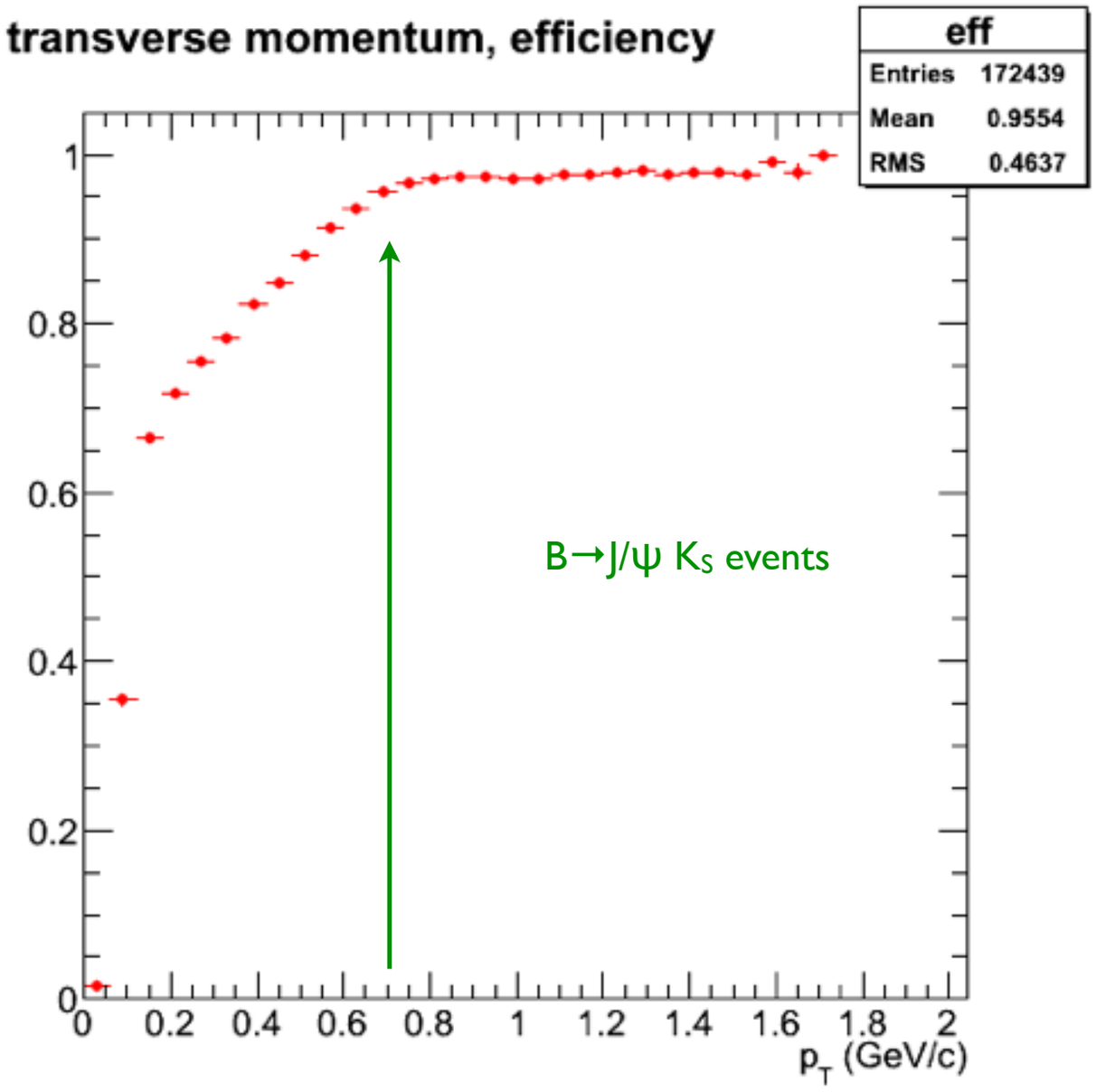
CDC only: transverse impact parameter

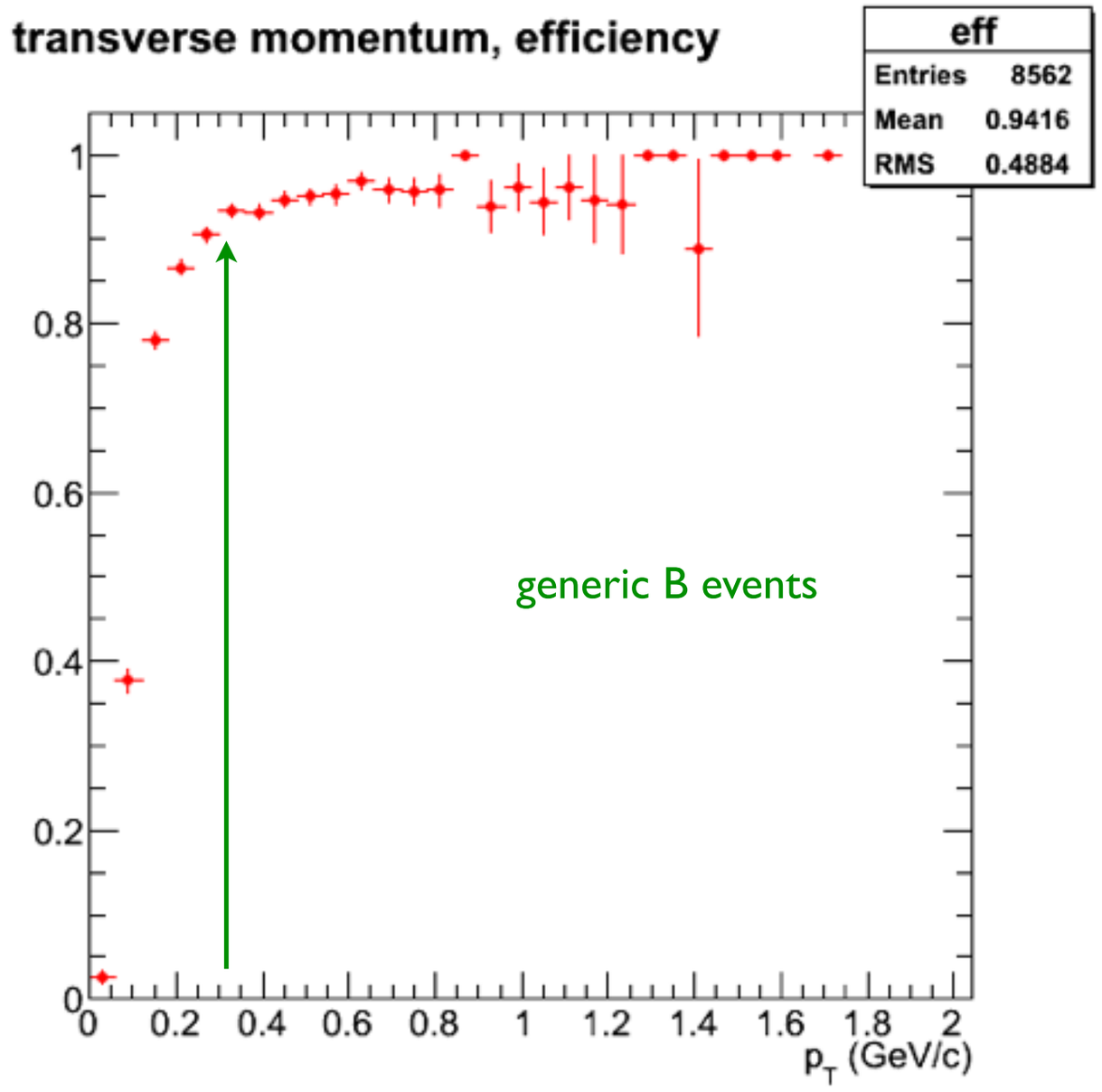




➡ No significant differences

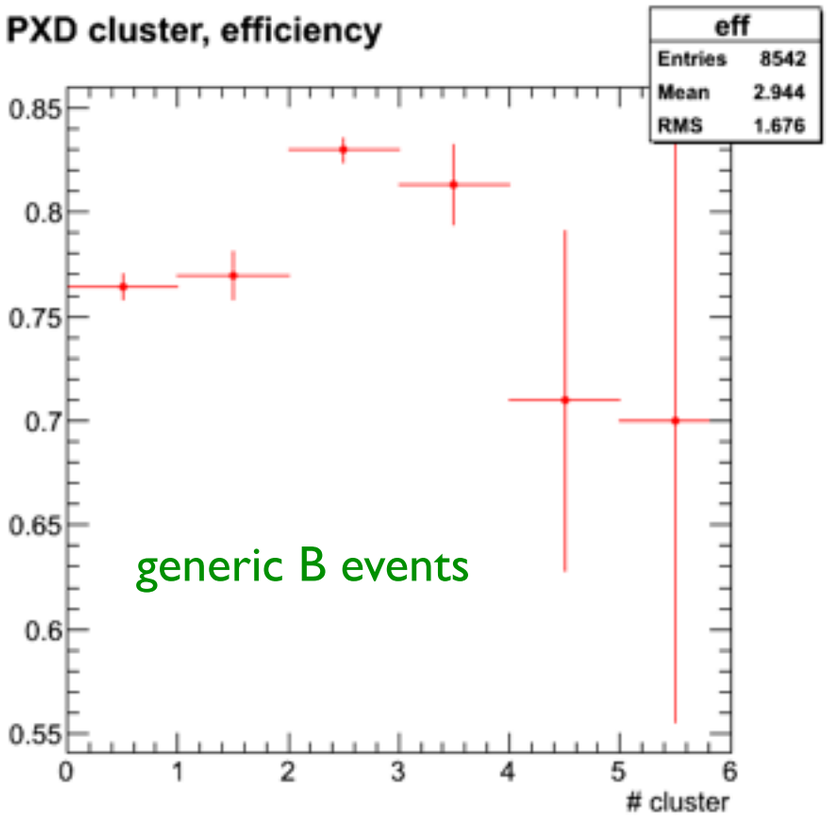
CDC only: transverse momentum

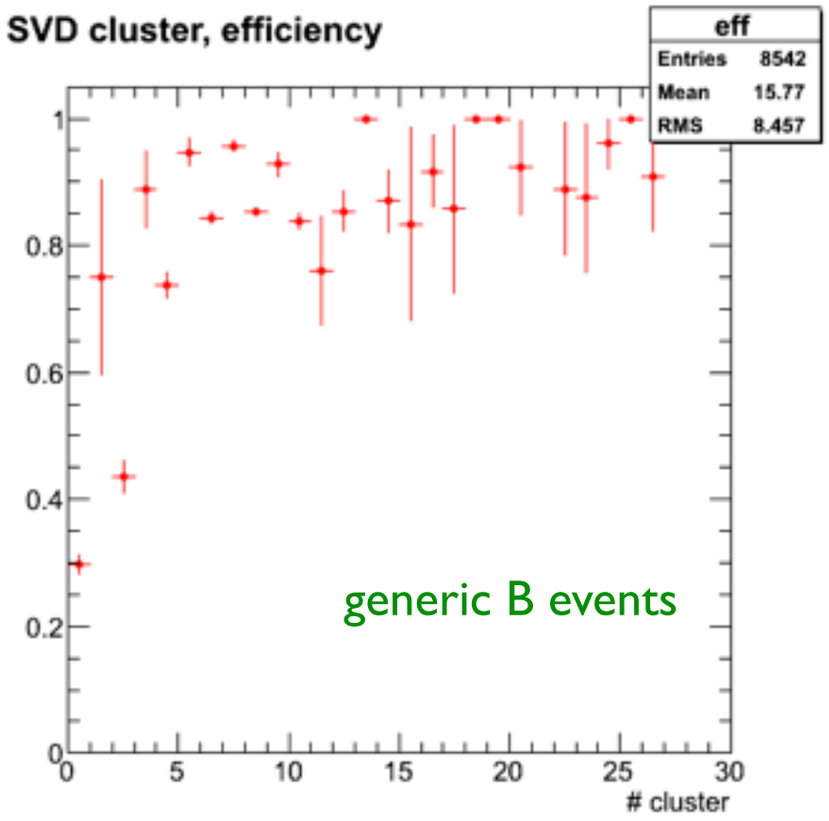


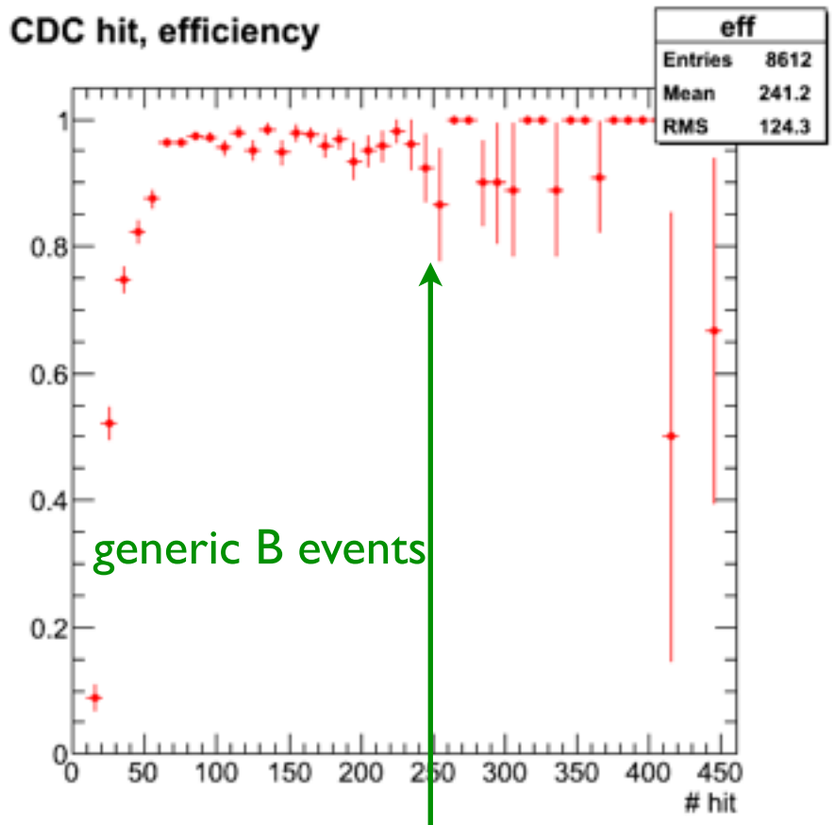


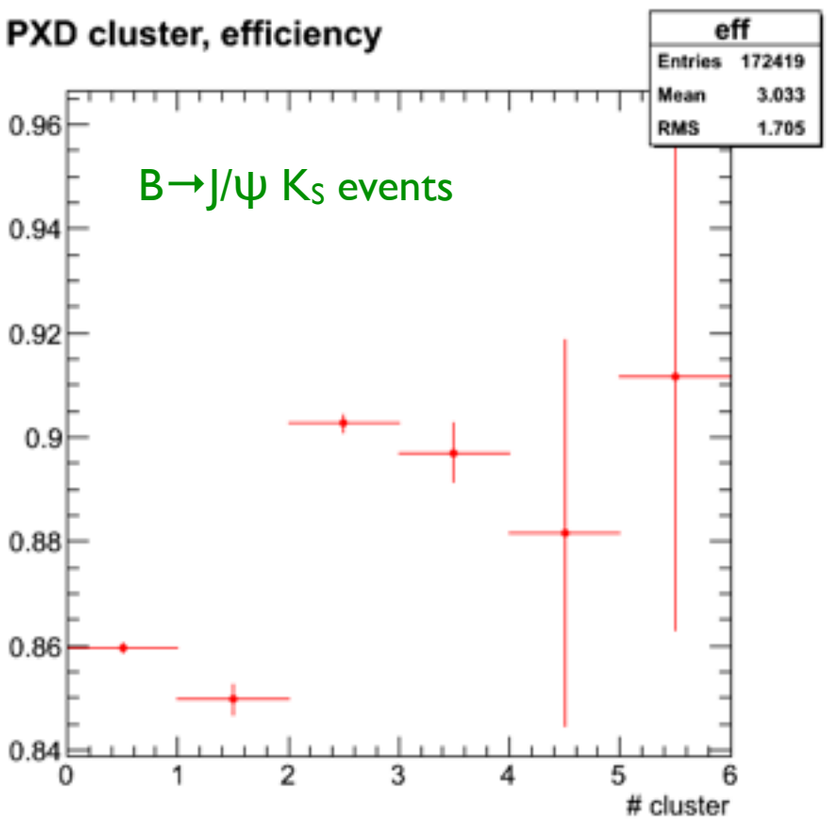
➡ In generic B events the knee comes at lower p_T

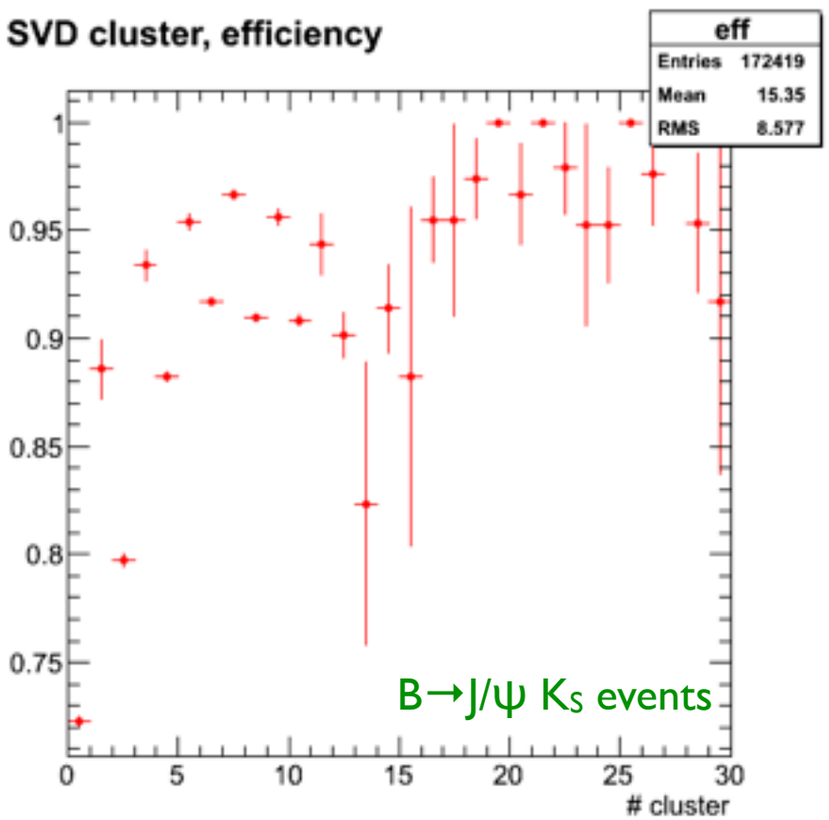
CDC only: VXD Clusters and CDC Hits

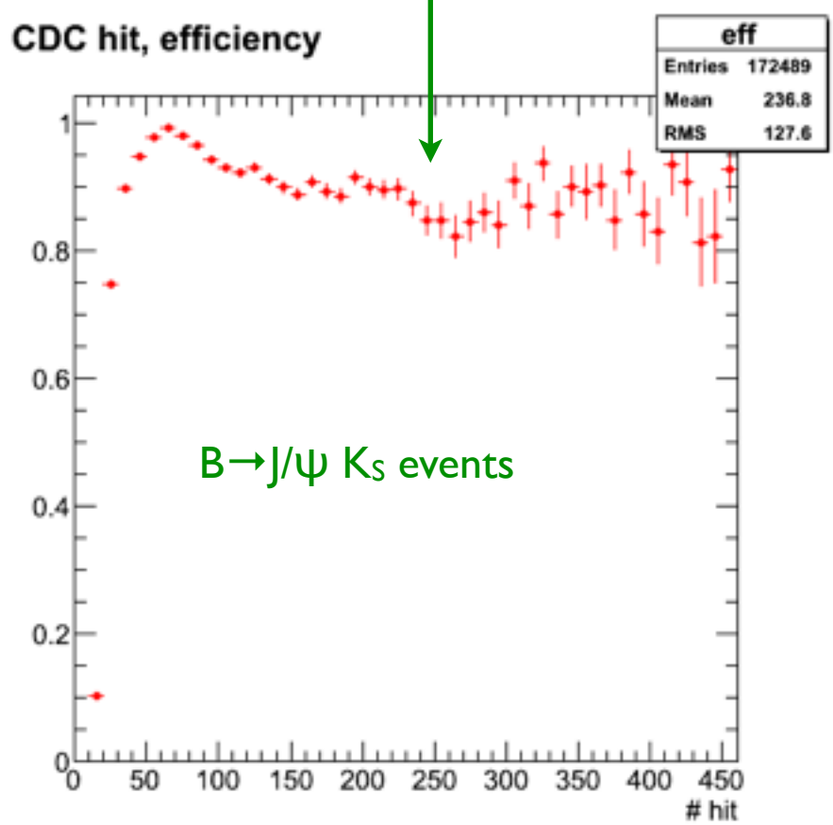












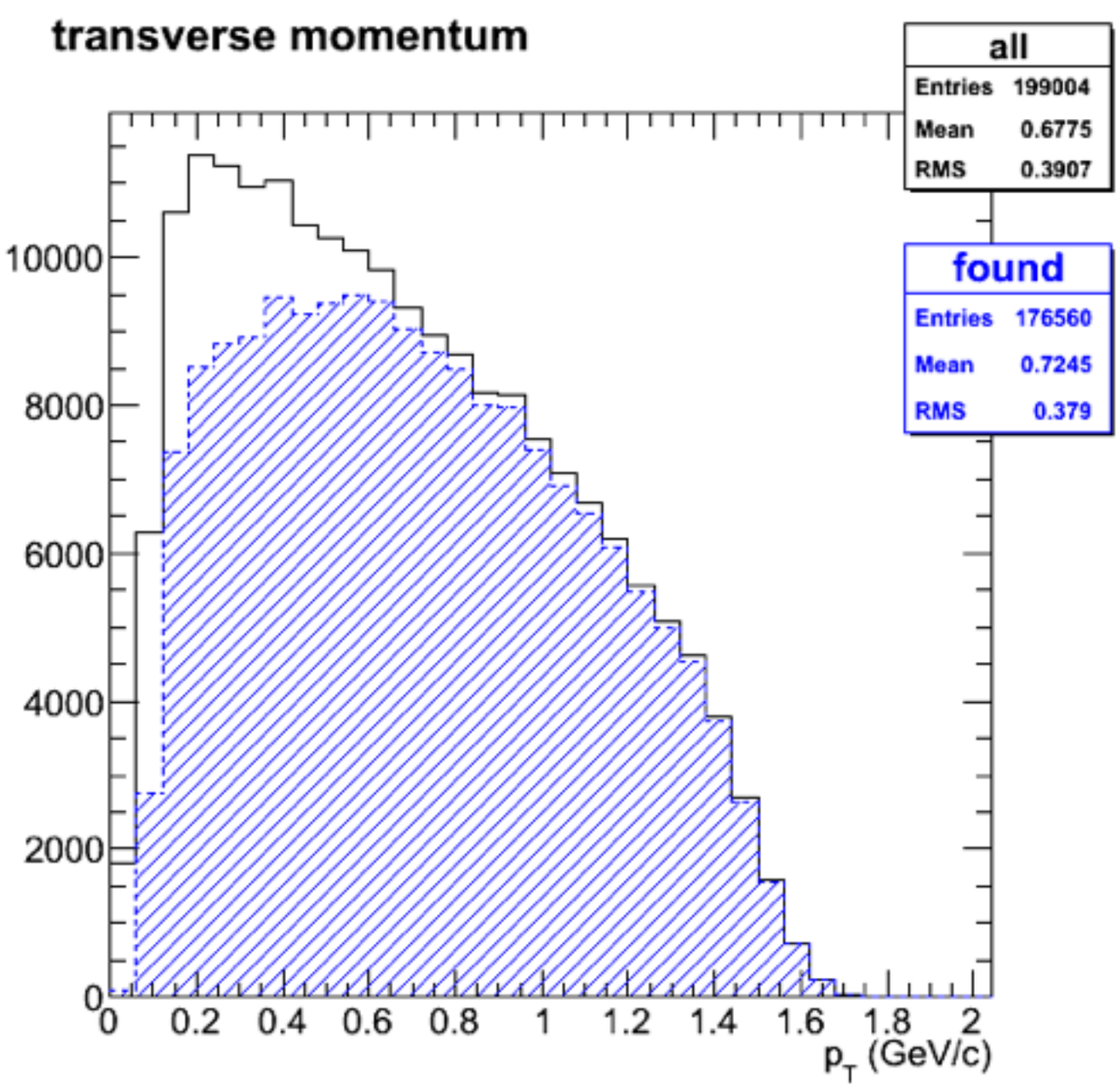
Conclusions & Future Plans

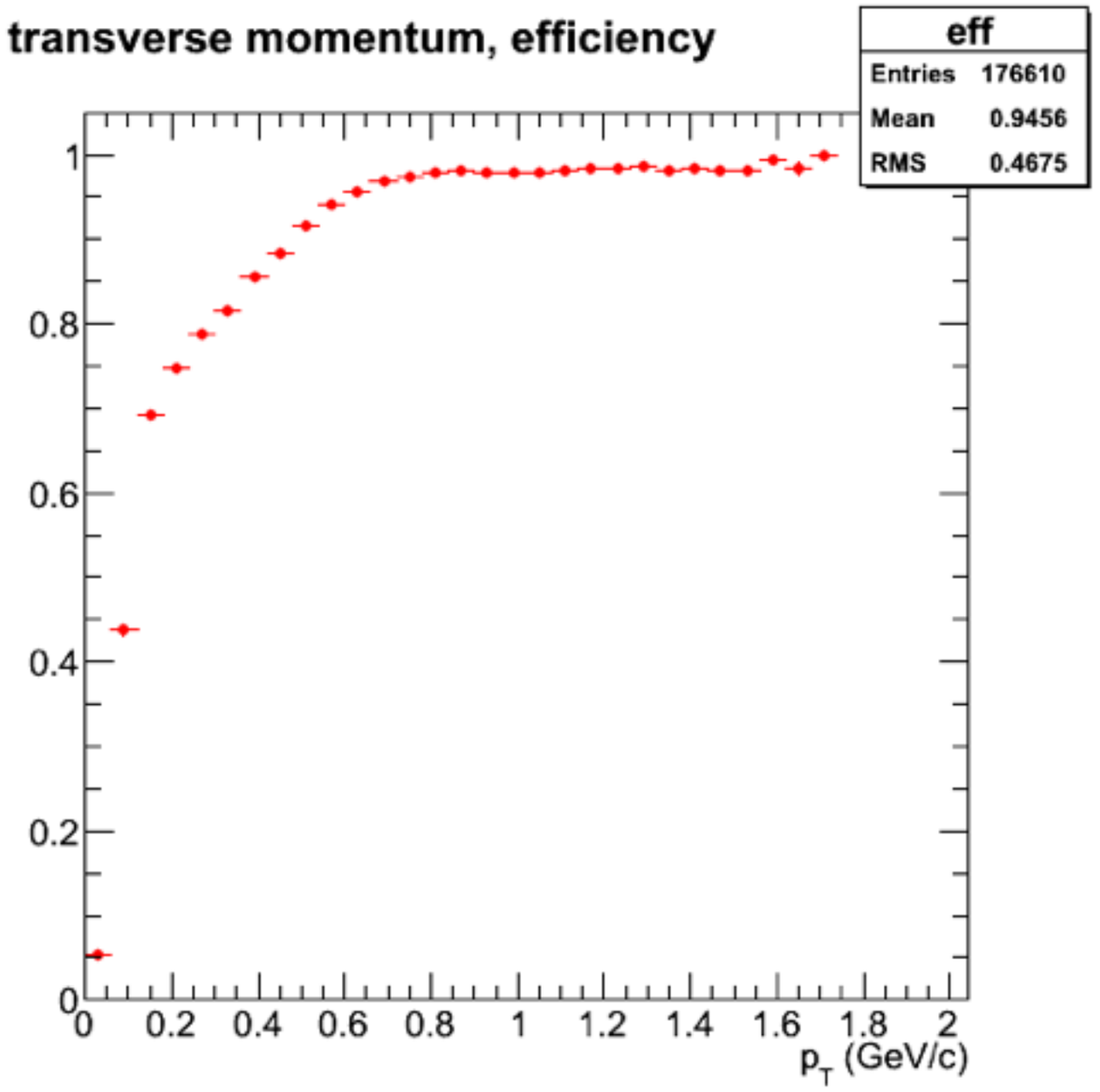
- First results have been presented, some features still to be understood
- There is room for improvement in both efficiency and accuracy:
  - improvements of the single track finders
  - track-quality improvement with the addition of VXD hits to CDC tracks (and vice-versa). [to be quantify
- Repeat the study (reconstruction + analysis) on the same set of simulated events with the improved versions of the tracking package (new CDC TrackFinder, Track Combiner module, …)
- Use the analysis module to perform similar studies on other particular types of tracks:
  - soft pions from D* decays
- Present the results to the physics meeting or at next B2GM

Thank You!

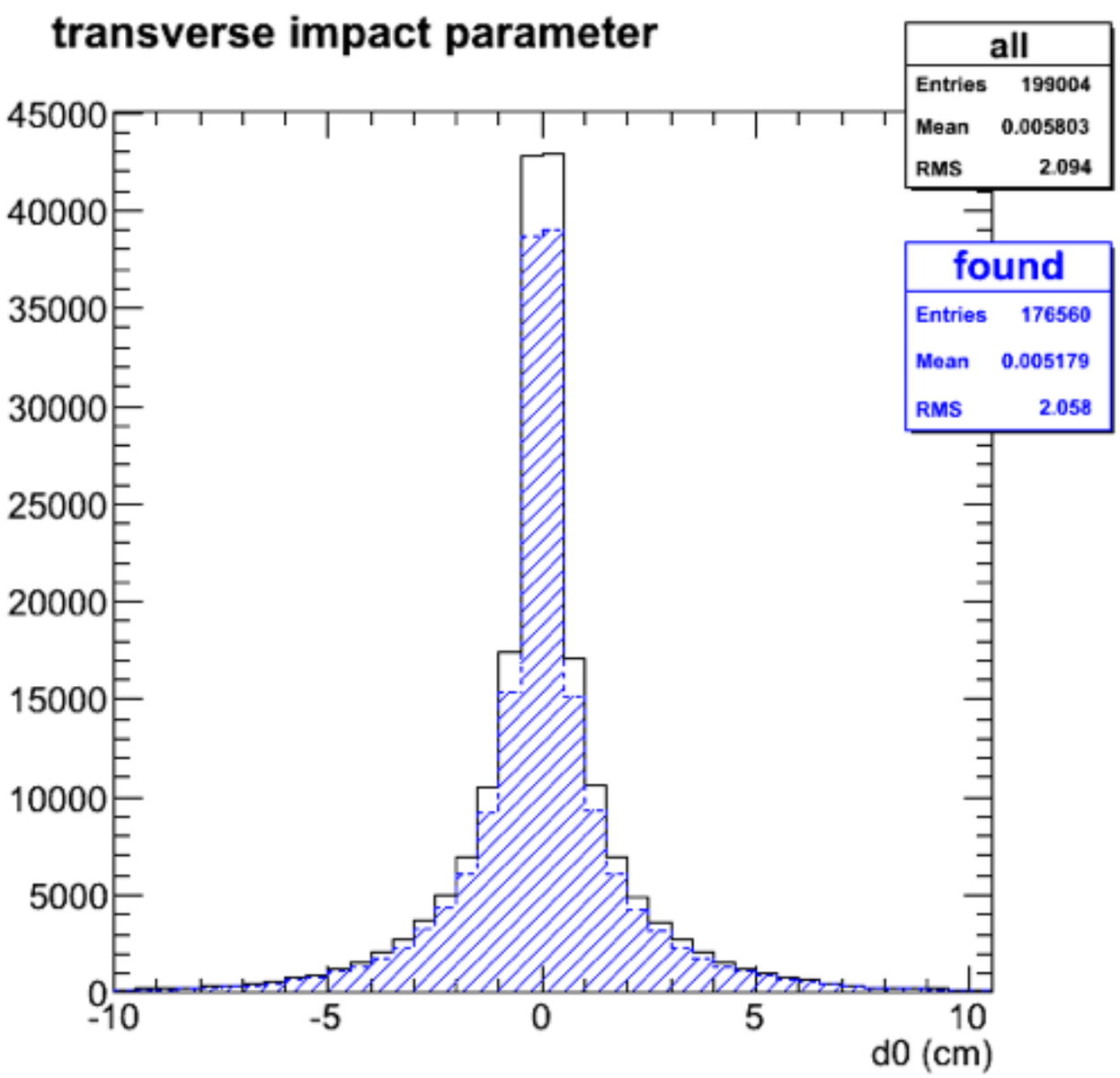
backup slides

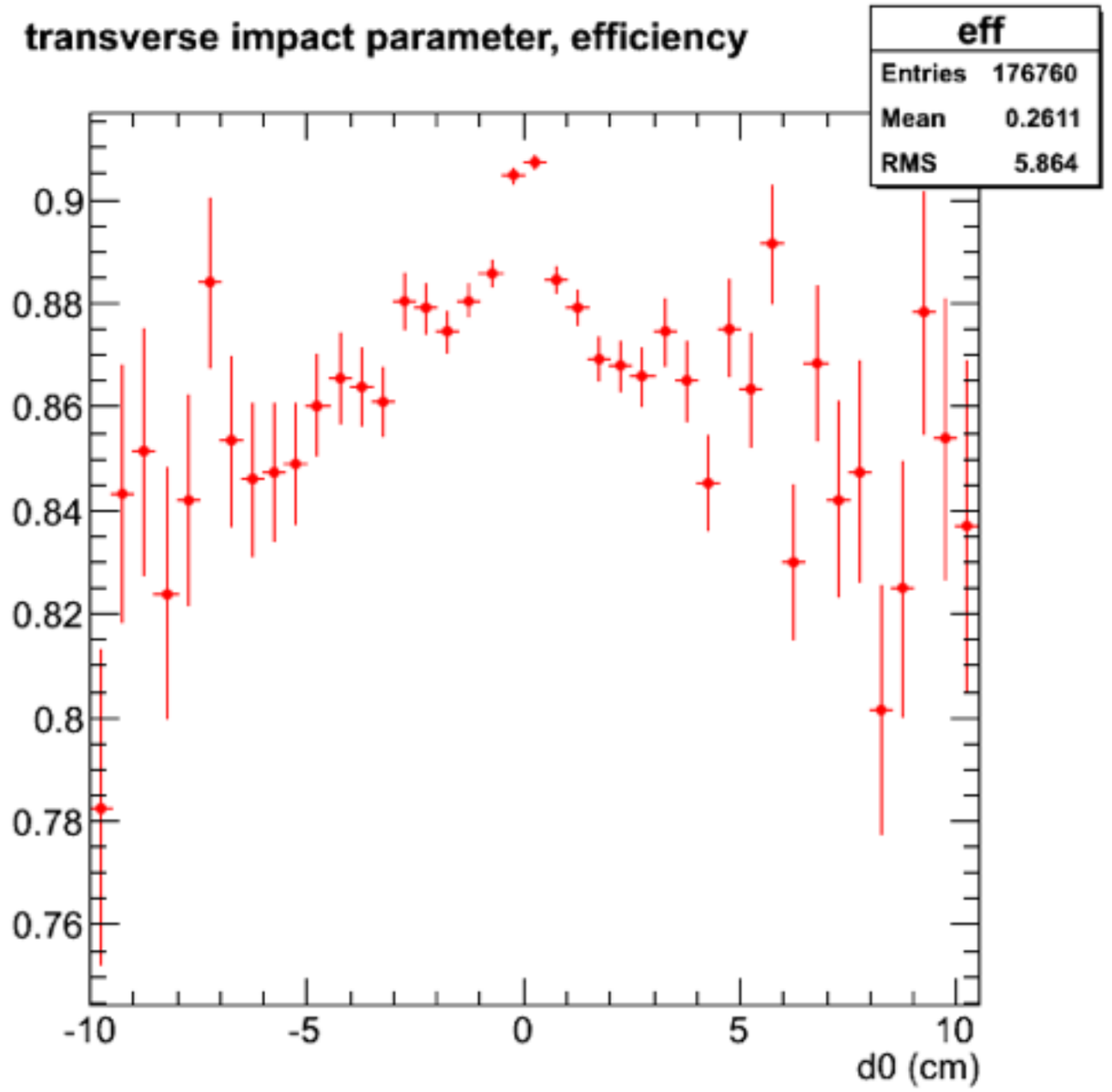
VXD+CDC: transverse momentum





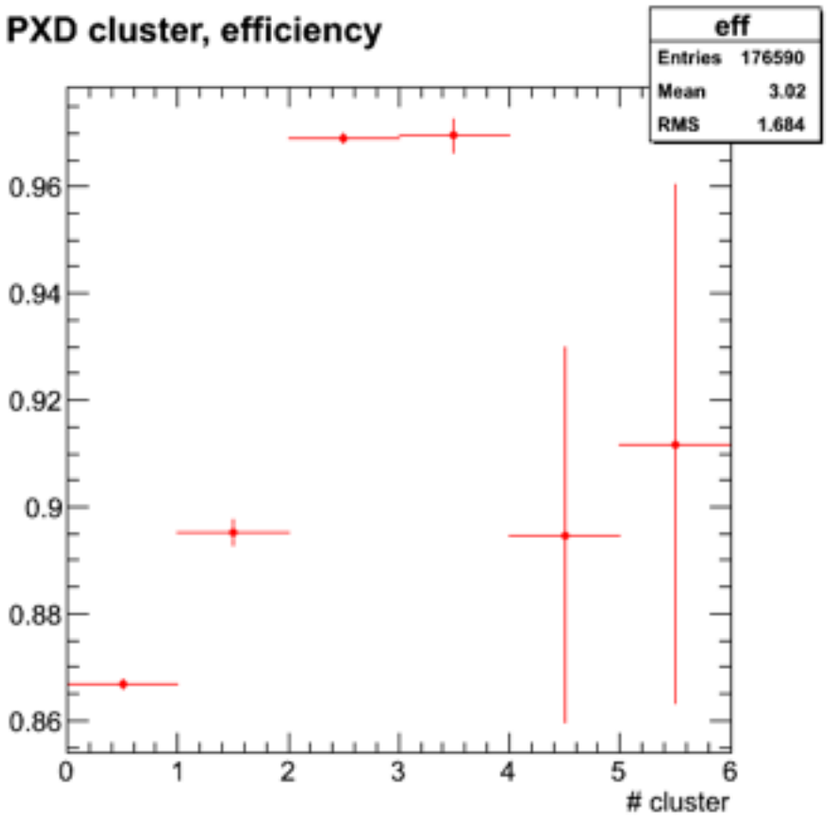
VXD+CDC: transverse impact parameter

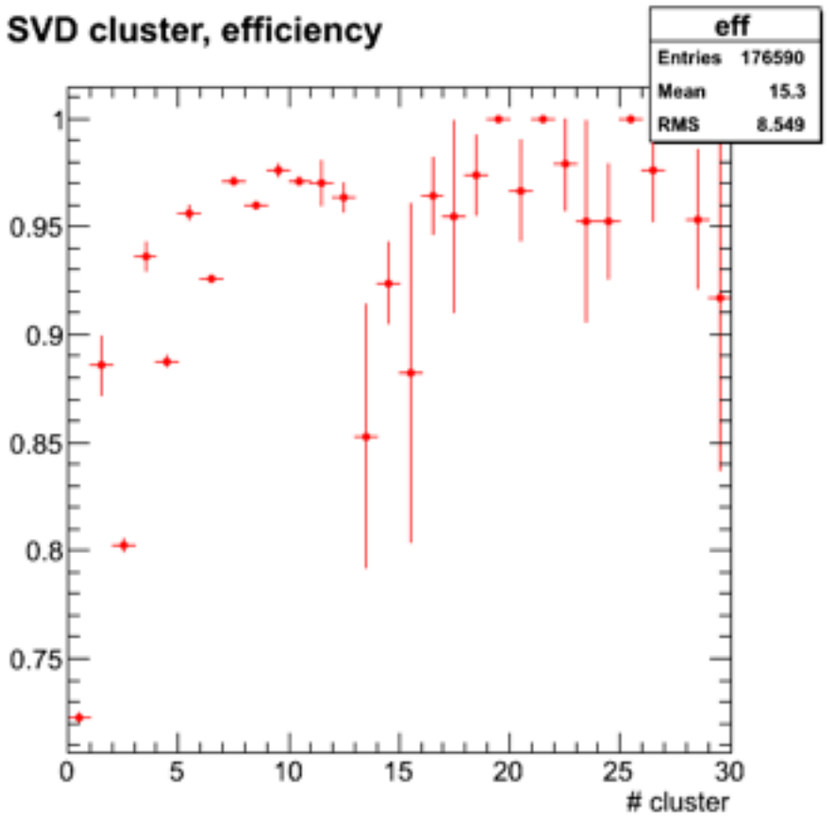


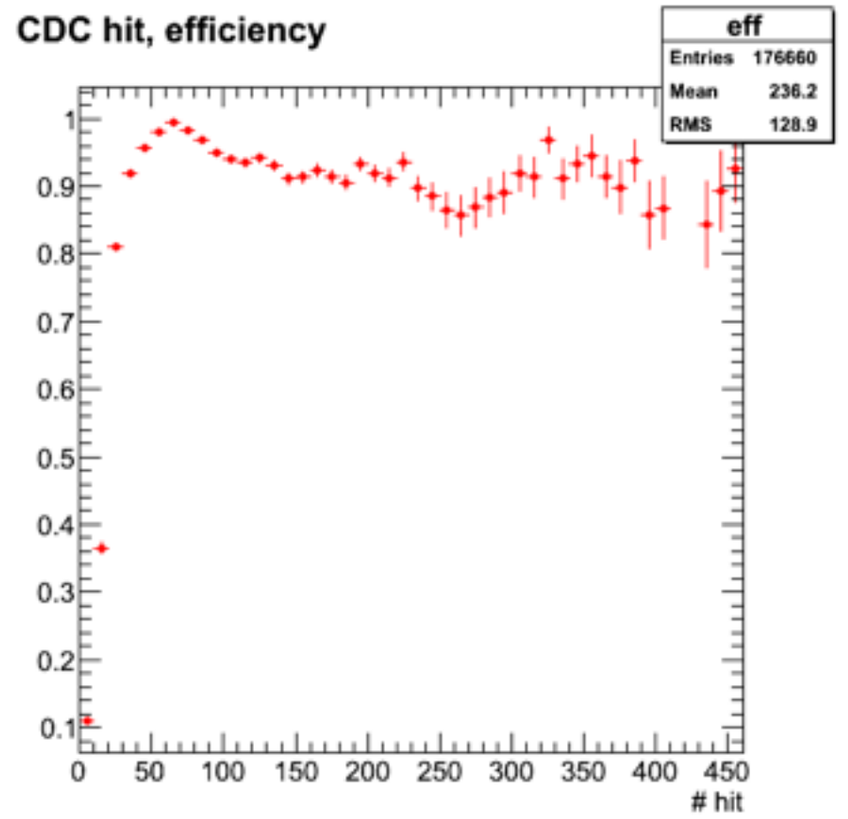


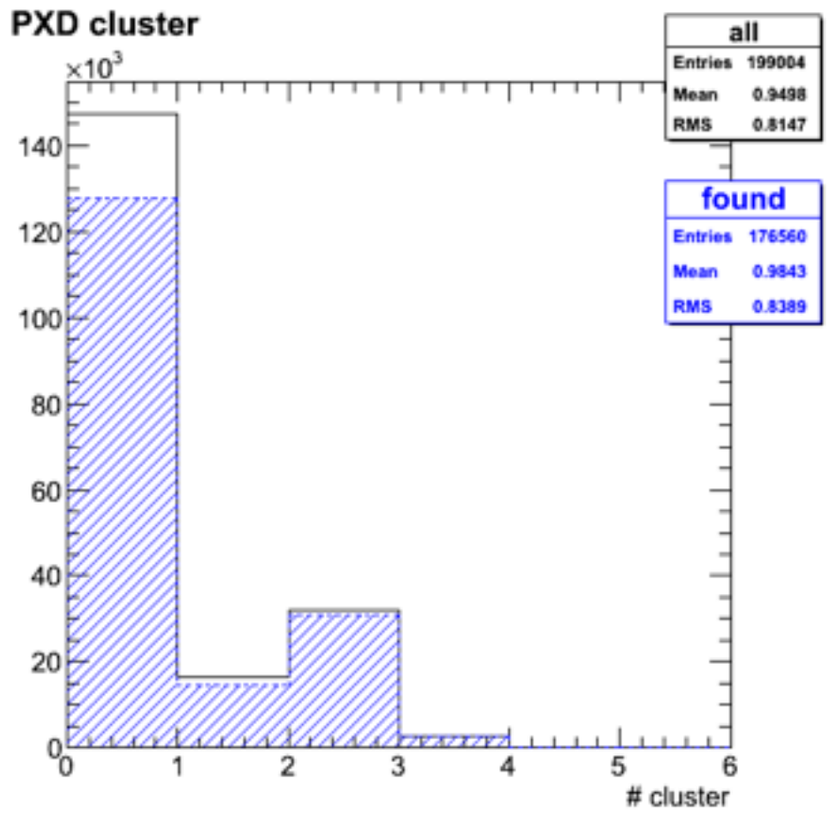
VXD+CDC: CDC Hits and VXD clusters

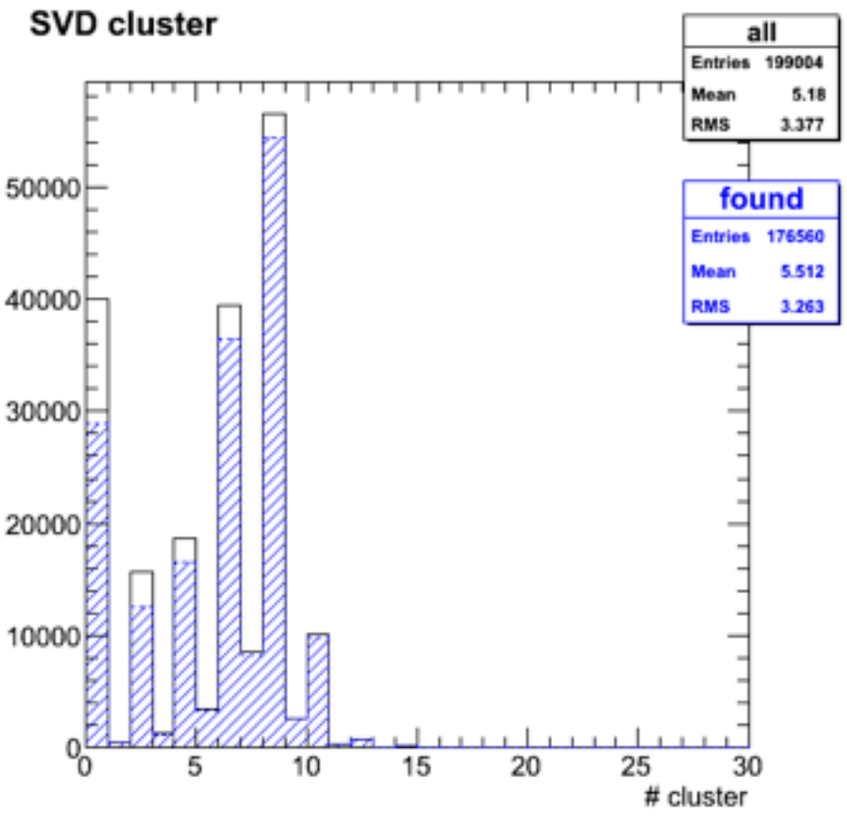
$B \rightarrow J/\psi\ K_S$ events

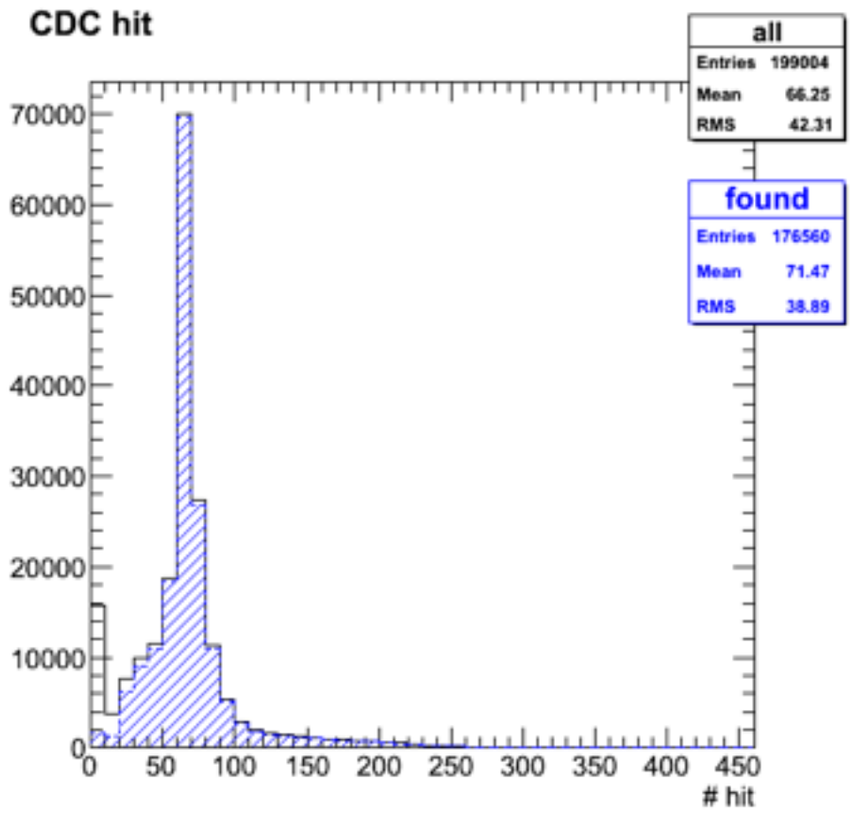




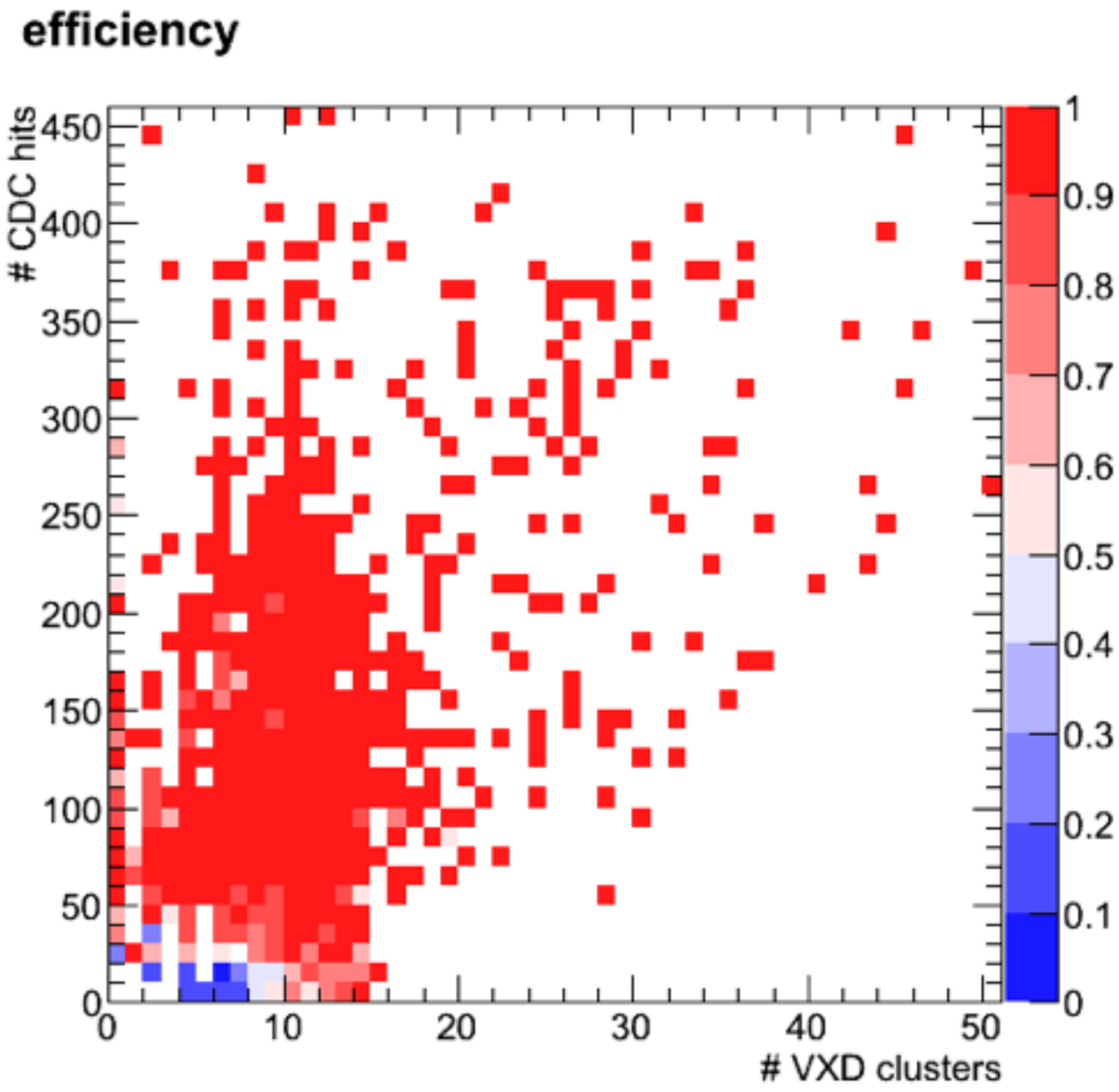


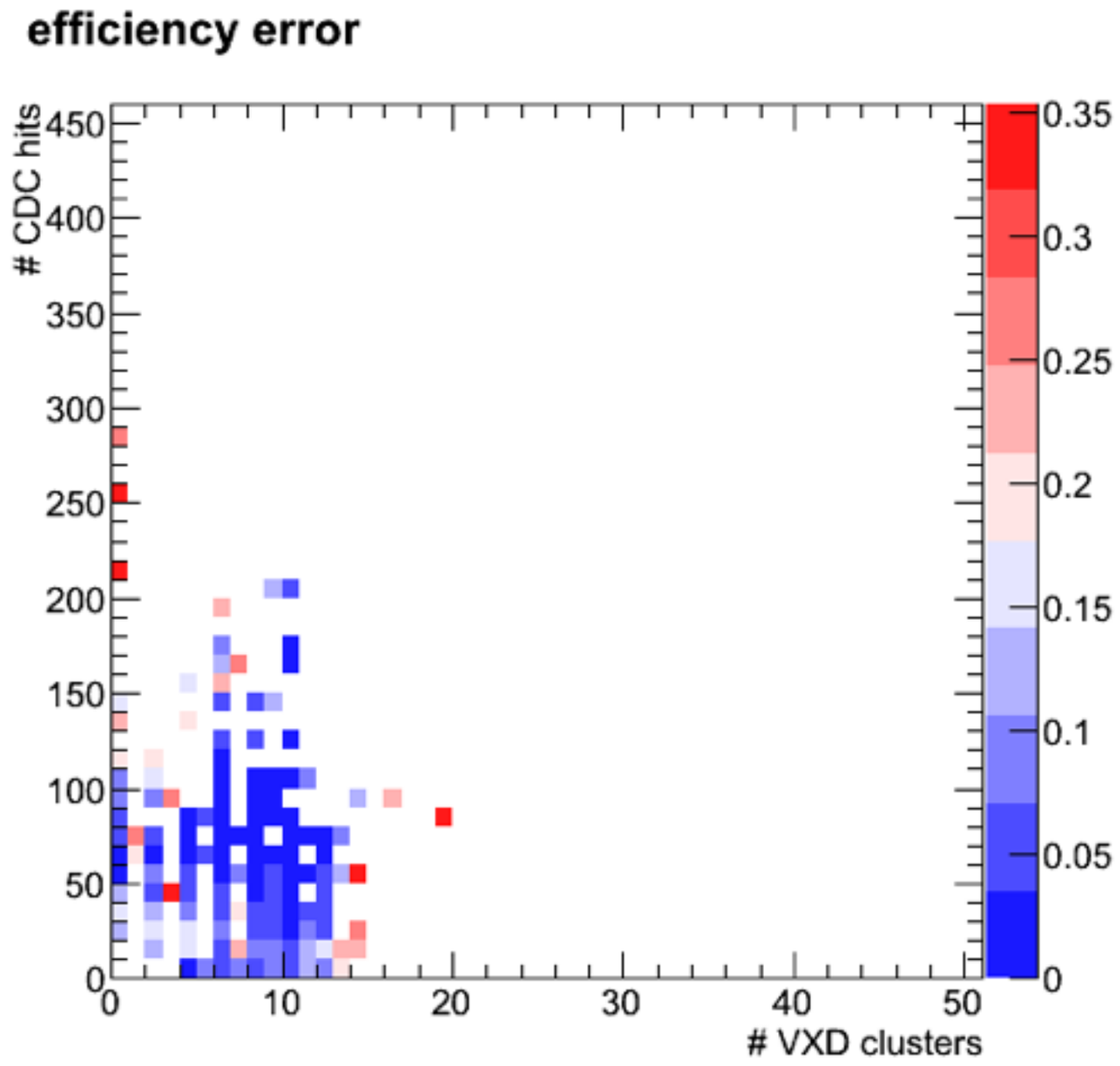




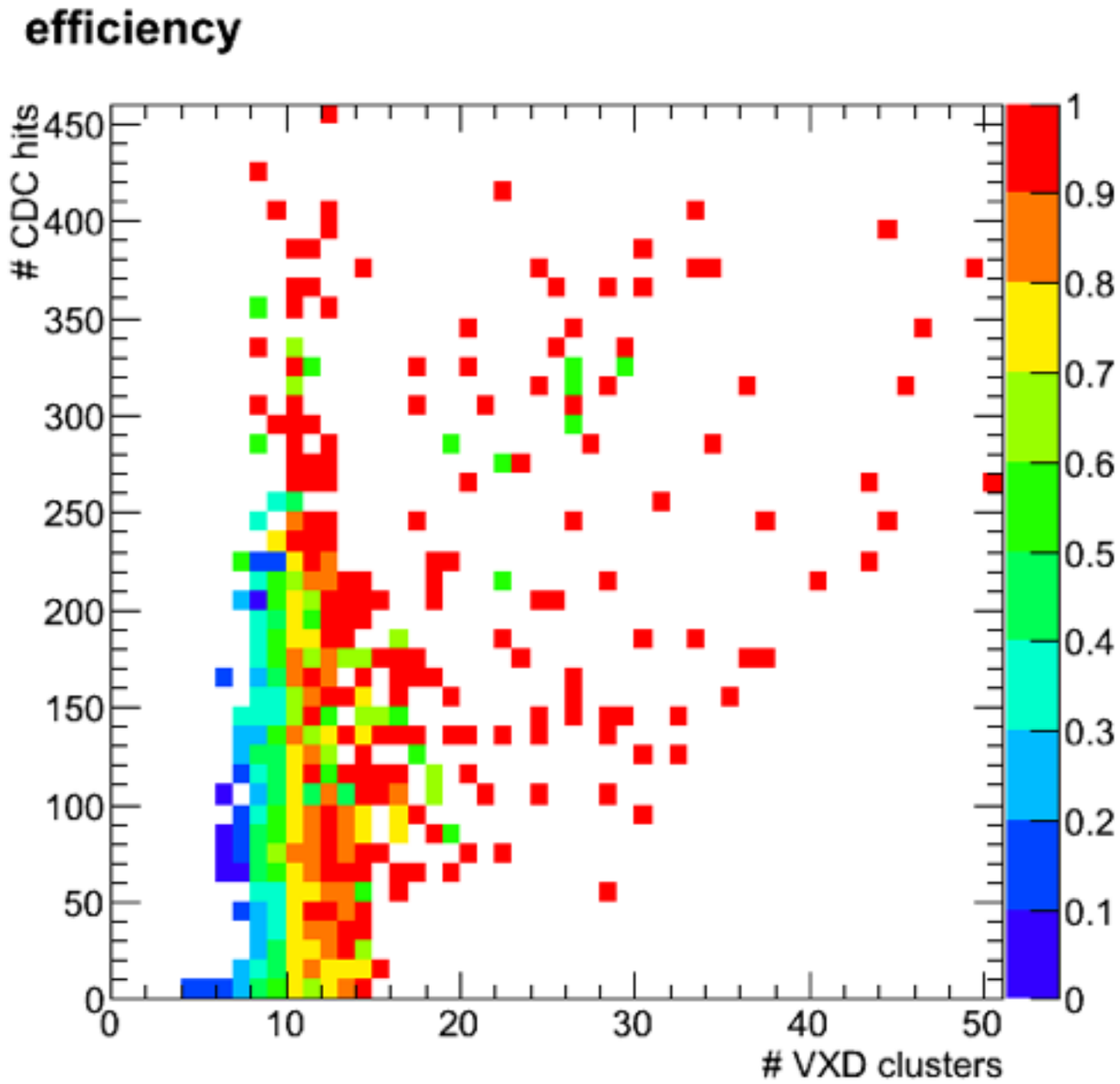


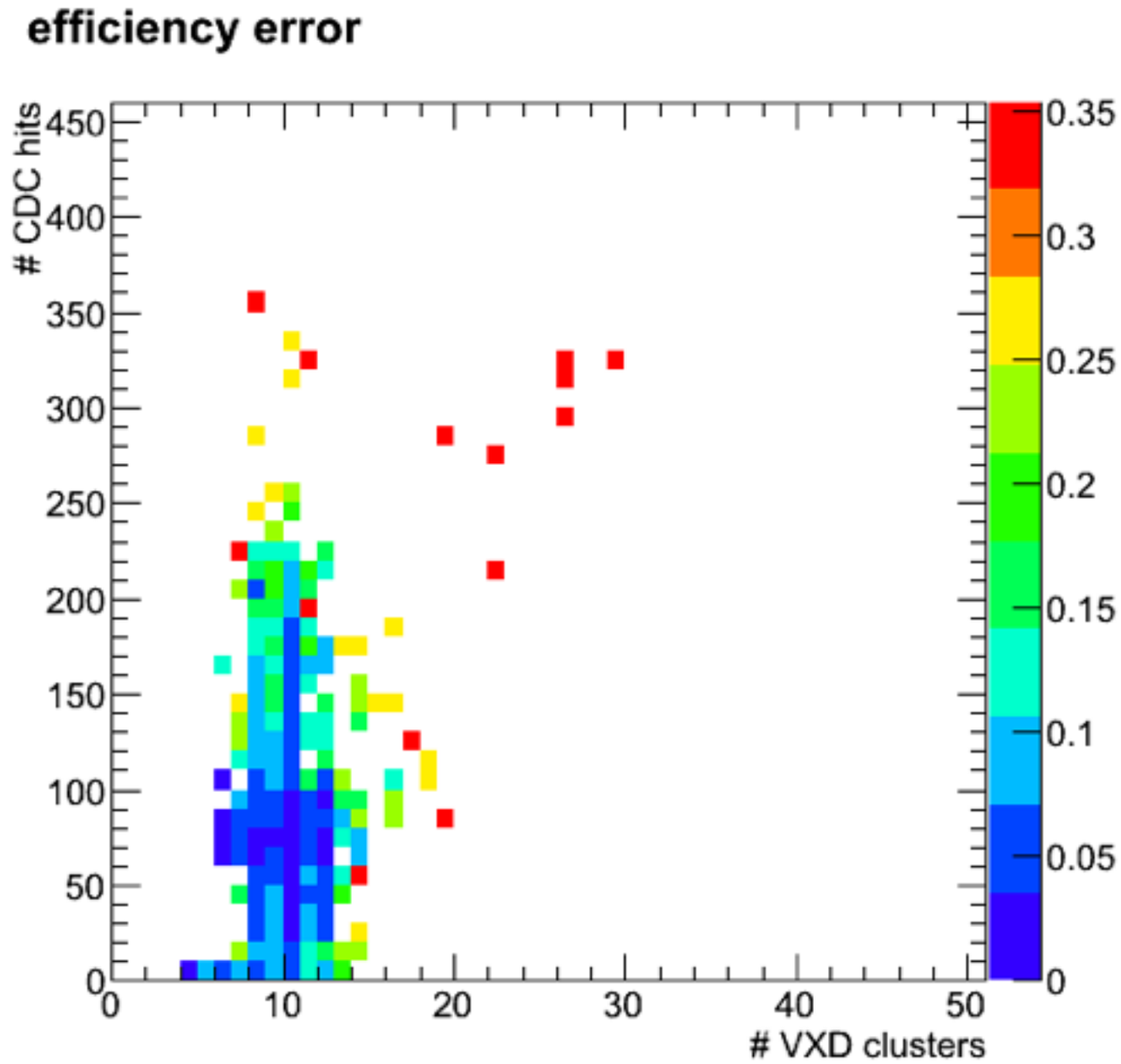
VXD+CDC: CDC Hits and VXD Clusters





VXD only: CDC hits vs VXD clusters

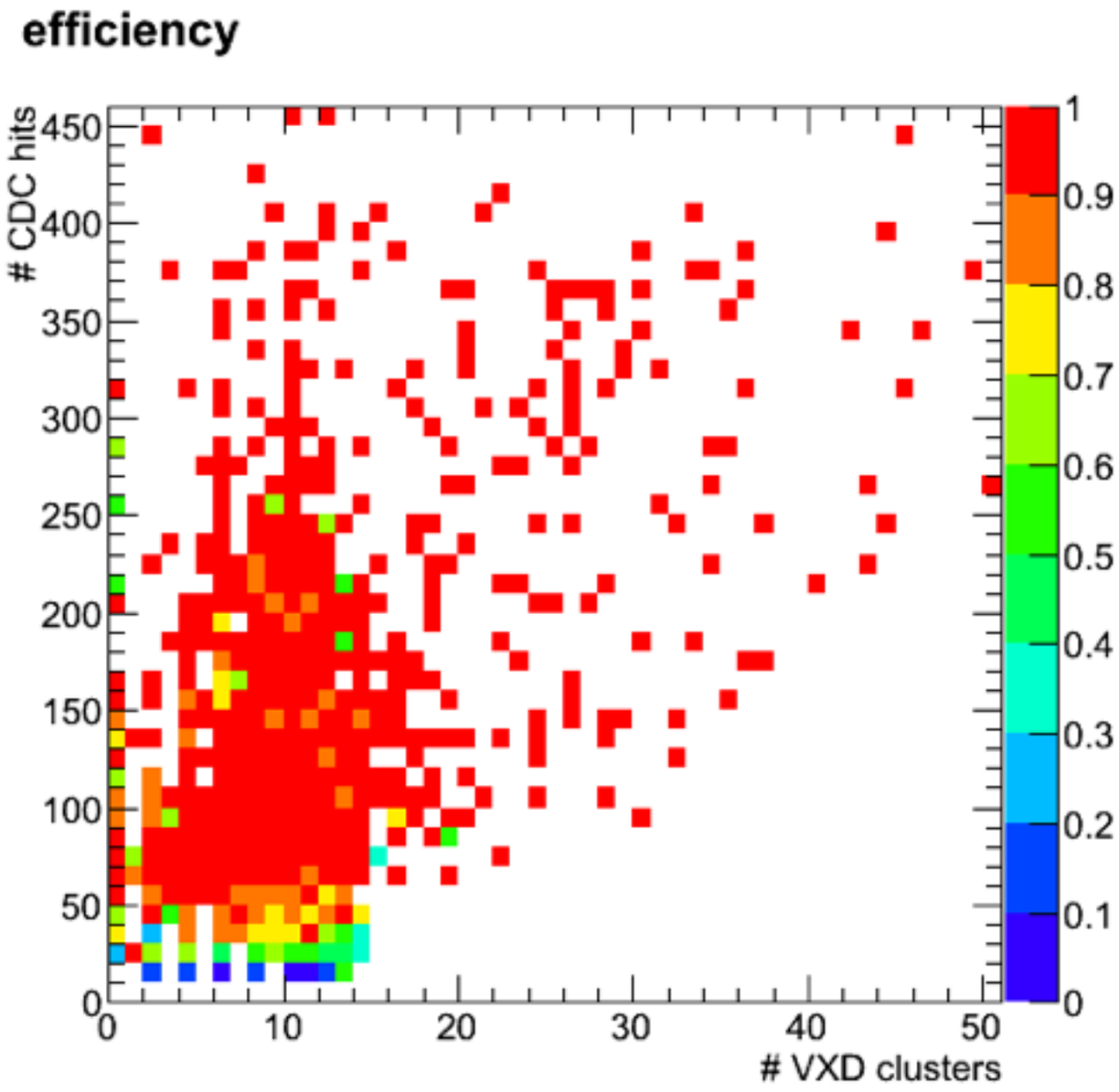


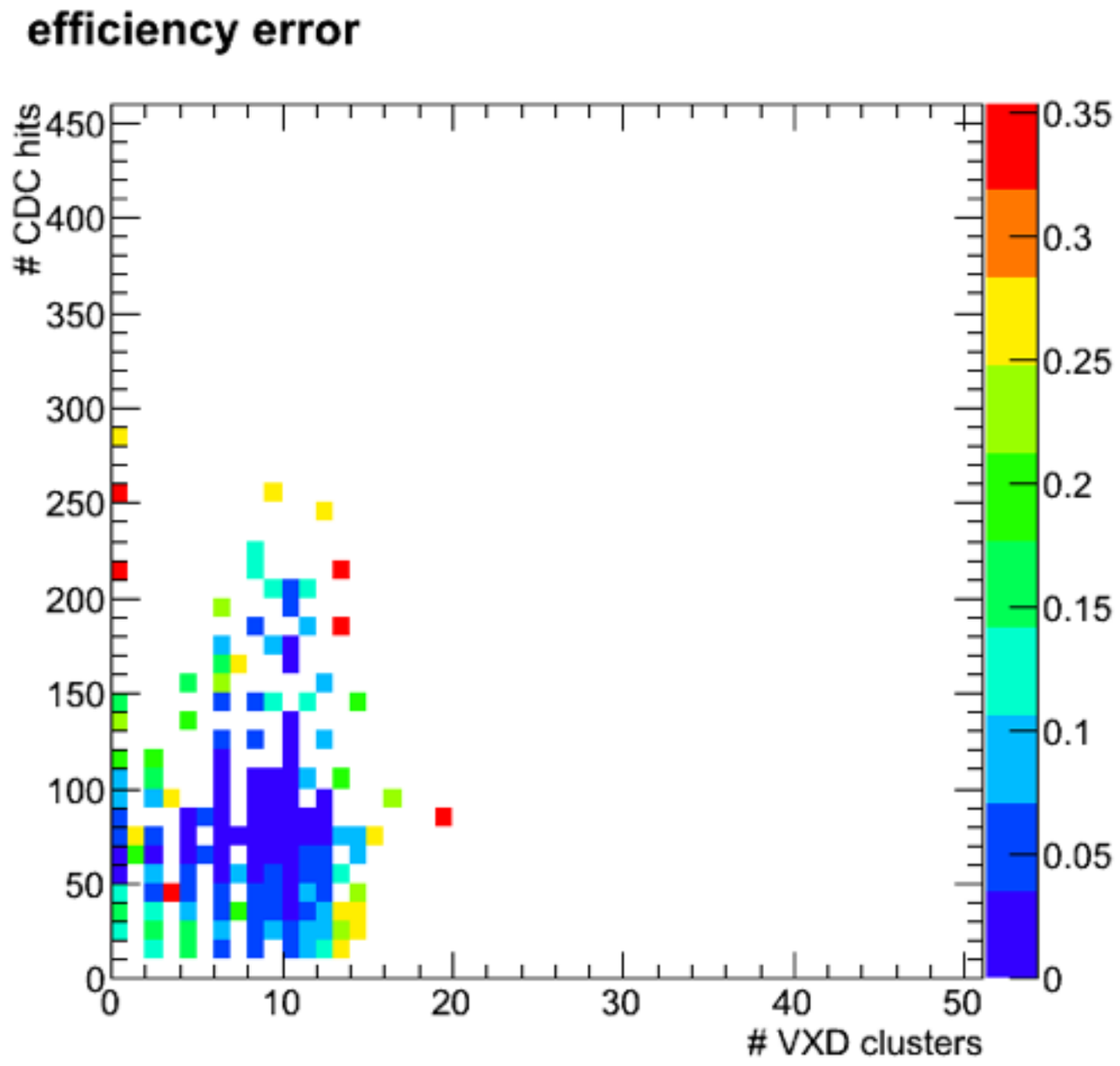


➡ Efficiency does not depend on the number of CDC Hits (as expected)

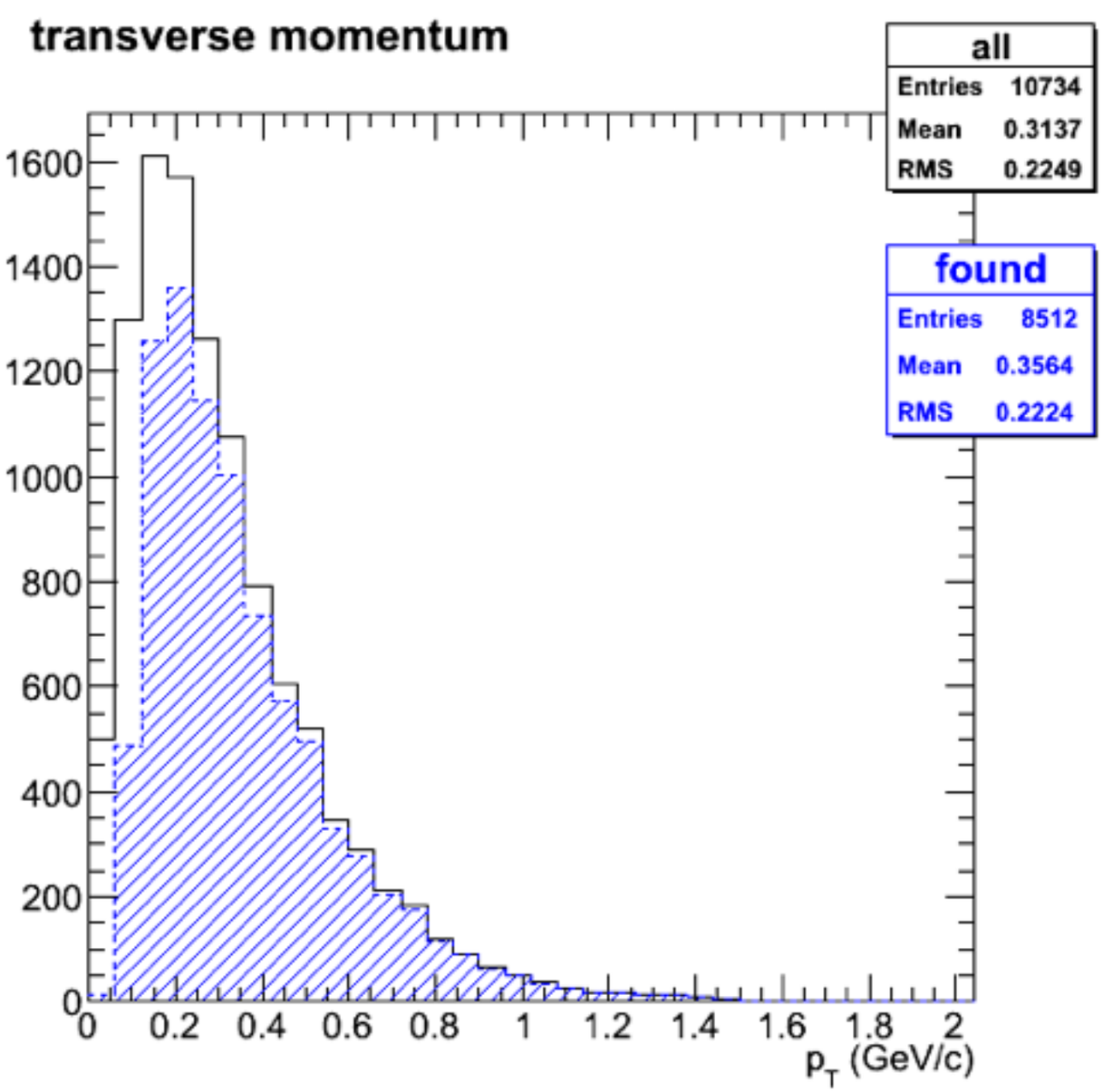
- no differences wrt 100k K_S simulated sample

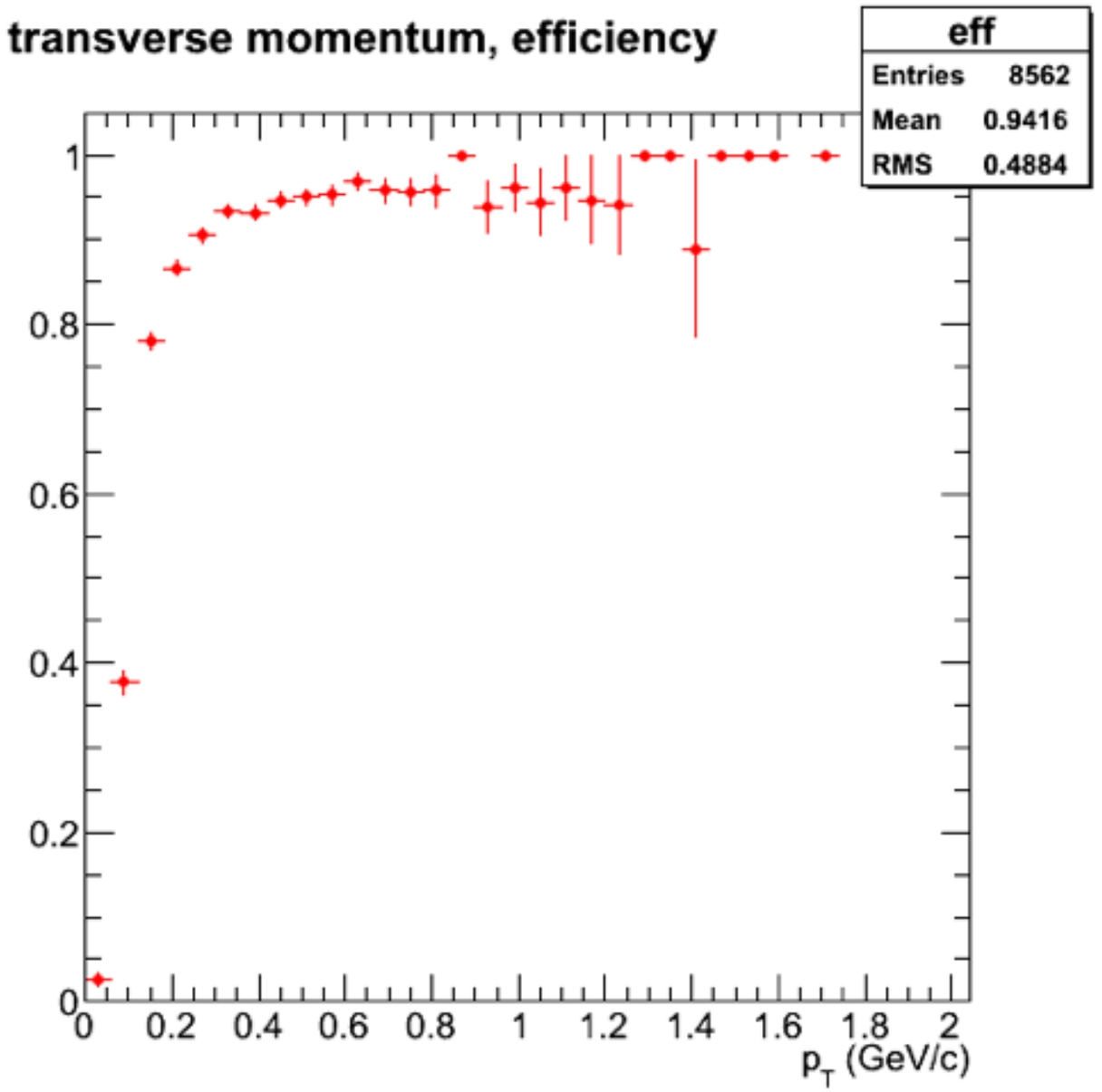
CDC only: CDC hits vs VXD clusters



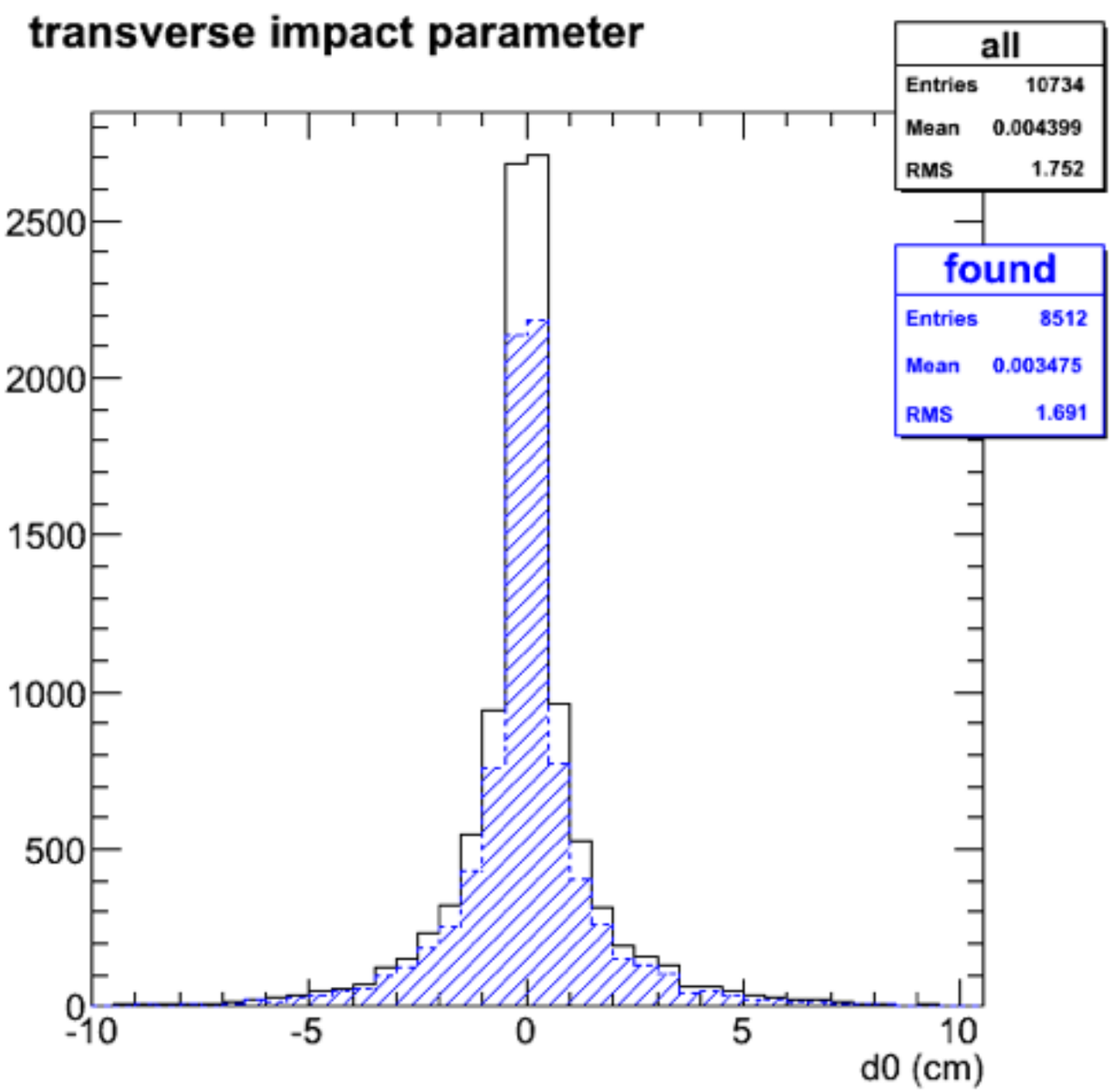


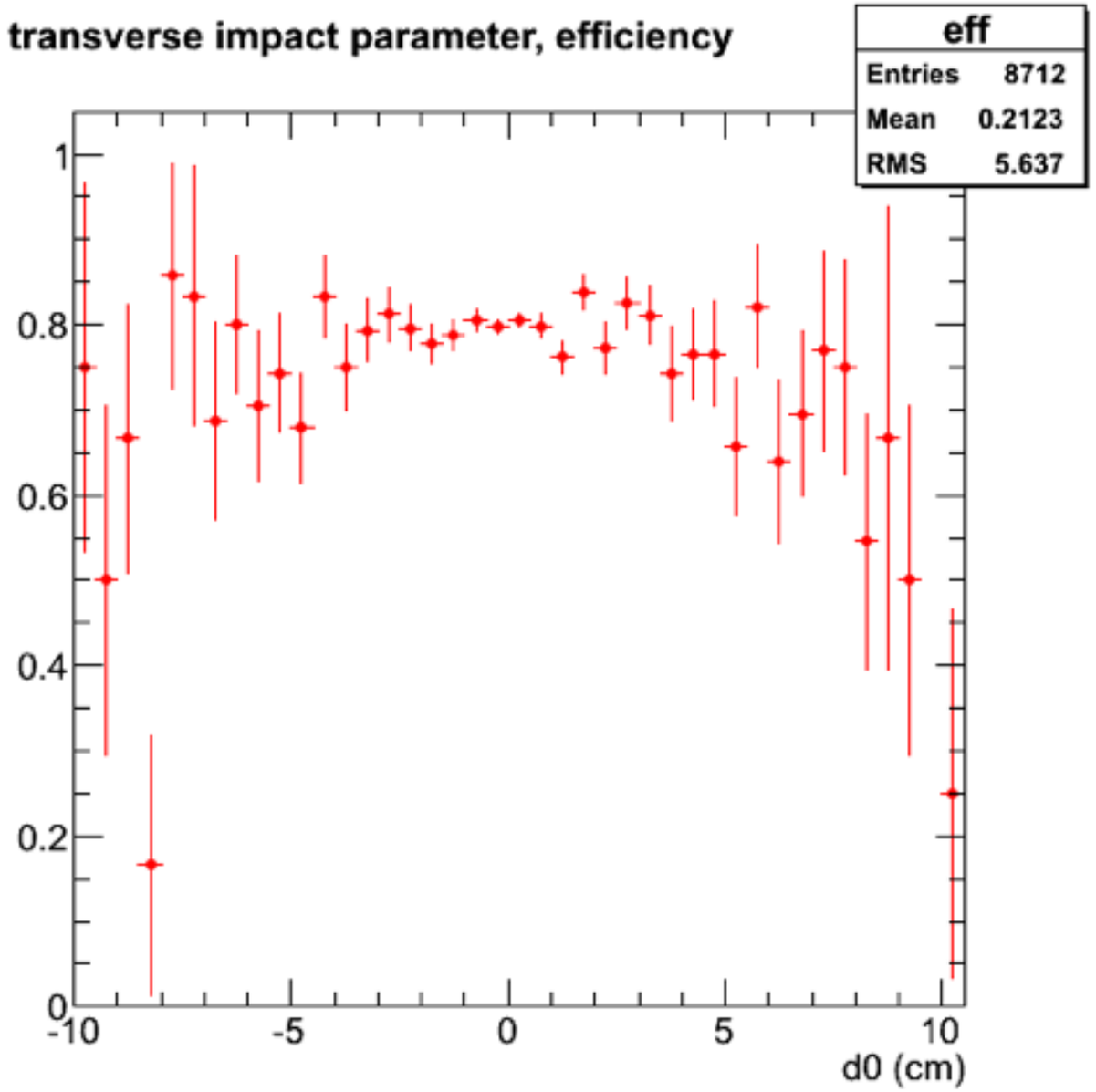
CDC only: transverse momentum



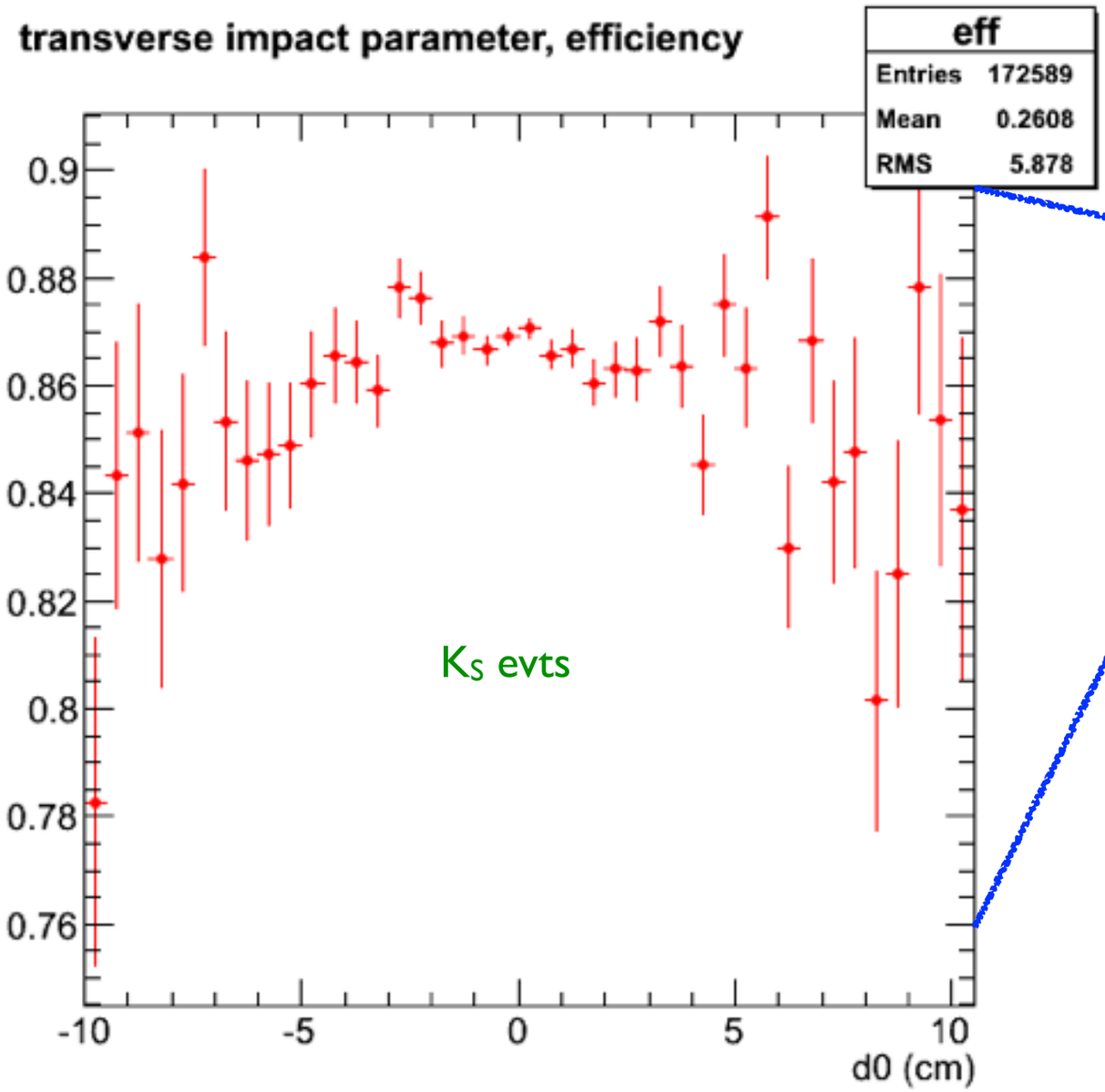


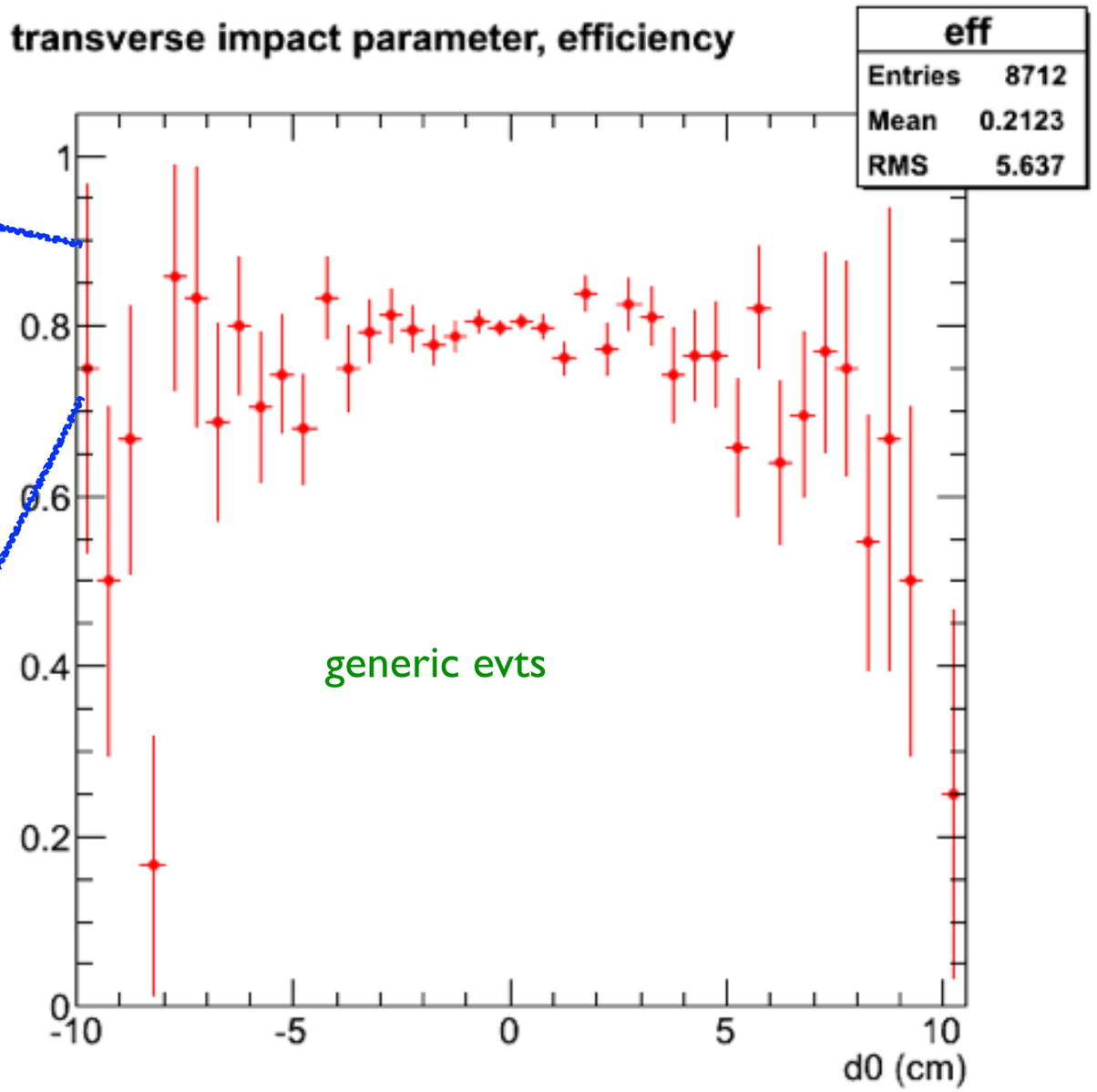
CDC only: transverse impact parameter





CDC only: transverse impact parameter





generic B events

CDC: CHC Hits and VXD Clusters