

Tracking Validation

outline

- ★ Current Performances
 - Overall Efficiency & Purity
 - Track Quality
 - Pattern Recognition
- ★ How Jakob Fix Looks Like

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Face2Face Tracking Meeting

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Current Performances



- ➔ used release r14908 (except otherwise stated), TrackingPerformanceEvaluation Module
 - Belle CDC pattern recognition (Trasan)
 - Merger of VXD TrackCand + CDC TrackCand uses MC truth information
 - no extrapolation from CDC to VXD and vice-versa

Integrated Efficiency & Purity

<i>tracking</i> ^(*)	VXD only <i>(r14200)</i>	CDC only <i>(r14200)</i>	VXD+CDC
purity (%)	95.72±0.08	77.1±0.1	-
$\epsilon =$ efficiency (%)	68.4±0.2 <i>not updated see next slide</i>	75.3±0.1 <i>not updated</i>	82.0±0.1
$\epsilon' =$ efficiency' (%)	77.8±0.1	91.1±0.1	91.8±0.1

() numbers and plots shown are based on 8k Y(4S) events*

purity = probability to find an MCParticle associated to a Track, given a Track

$$\epsilon = \frac{\text{\# MCParticles with at least one associated Track}}{\text{\# MCParticles}}$$

physical efficiency

$$\epsilon' = \frac{\text{\# MCTrackCands with at least one associated Track}}{\text{\# MCTrackCands}}$$

geometrical acceptance and detector efficiency are factored out

Reconstruction run-time errors related to tracking

→ **r14908**, during this study, after a few events, basf2 exited with this error:

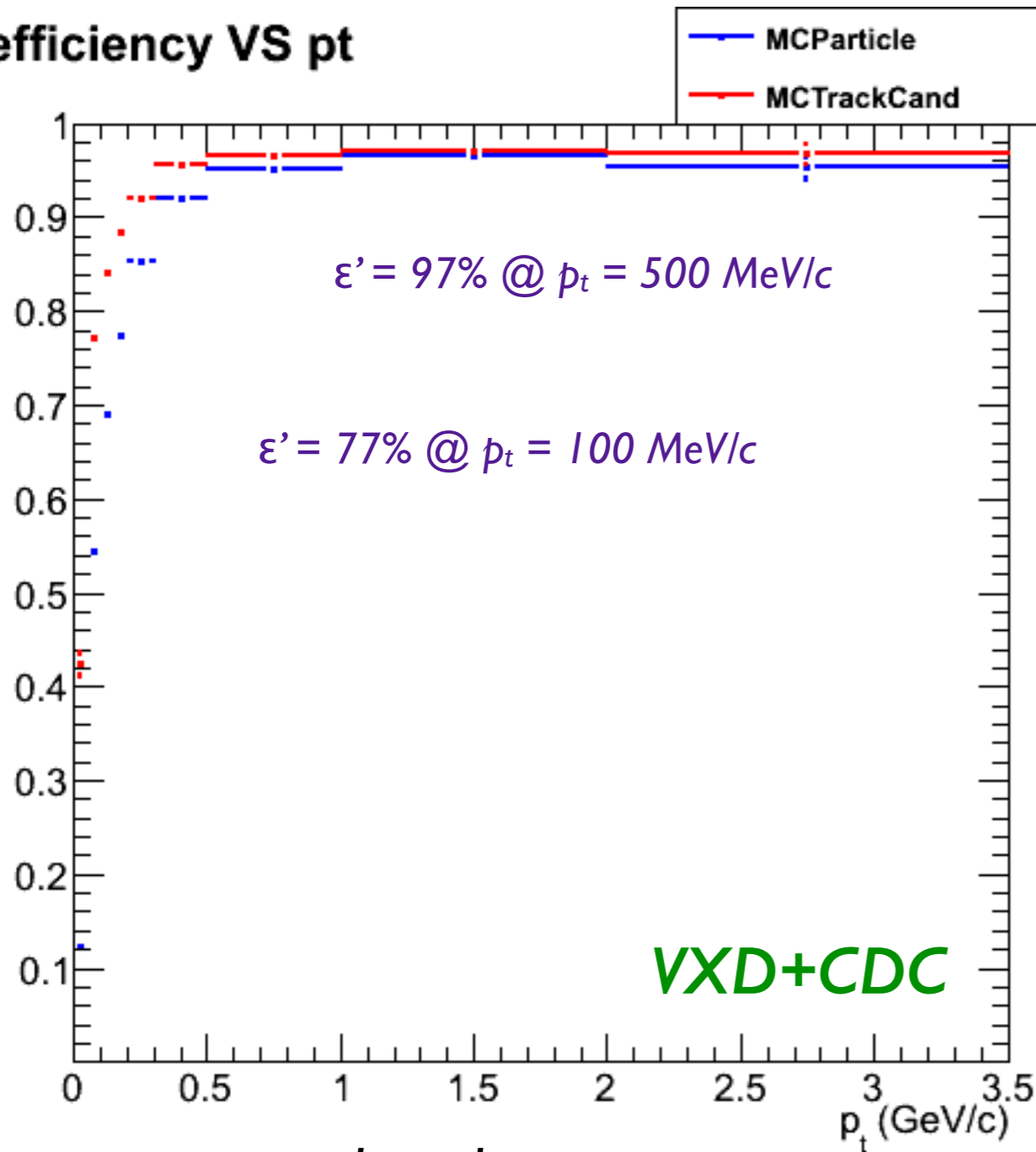
```
[ERROR] Uncaught exception encountered: Out-of-range access in StoreArray::operator[], for array
'TrackCands' (durability: event) { module: MCTrackMatcher }
Traceback (most recent call last):
  File "/gpfs/home/belle2/casarosa/releases/rValidation2/workdir/./tracking/validation/
a02_trackingEfficiency_runTracking.py", line 85, in <module>
    process(path)
  File "/gpfs/home/belle2/casarosa/releases/rValidation2/lib/Linux_x86_64/debug/basf2_def.py", line 155,
in process
    fw.process(path)
IndexError: Out-of-range access in StoreArray::operator[], for array 'TrackCands' (durability: event)
```

→ **build-2014-10-18**, Skimming MC-4.5 failed jobs are almost all due to:

```
[ERROR] Uncaught exception encountered: Out-of-range access in StoreArray::operator[], for array
'TrackFitResults' (durability: event) { module: ParticleLoader }
Traceback (most recent call last):
  File "/home/belle2/casarosa/releases/build-2014-10-18/workdir/scripts/skim.py", line 85, in <module>
    process(analysis_main)
  File "/sw/belle2/releases/build-2014-10-18/lib/Linux_x86_64/debug/basf2_def.py", line 153, in process
    fw.process(path)
IndexError: Out-of-range access in StoreArray::operator[], for array 'TrackFitResults' (durability:
event)
```

Efficiency VS Transverse Momentum

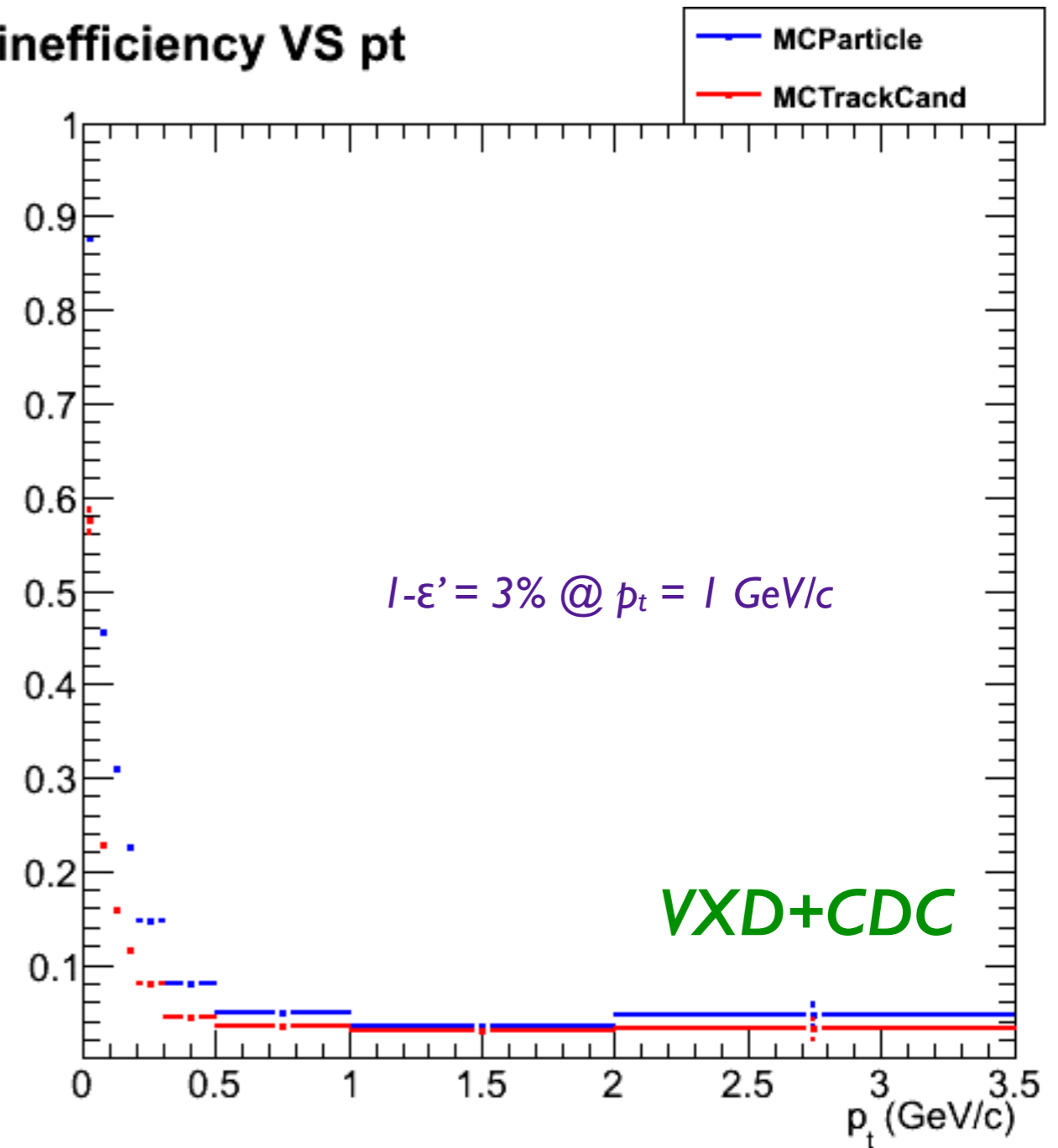
efficiency VS pt



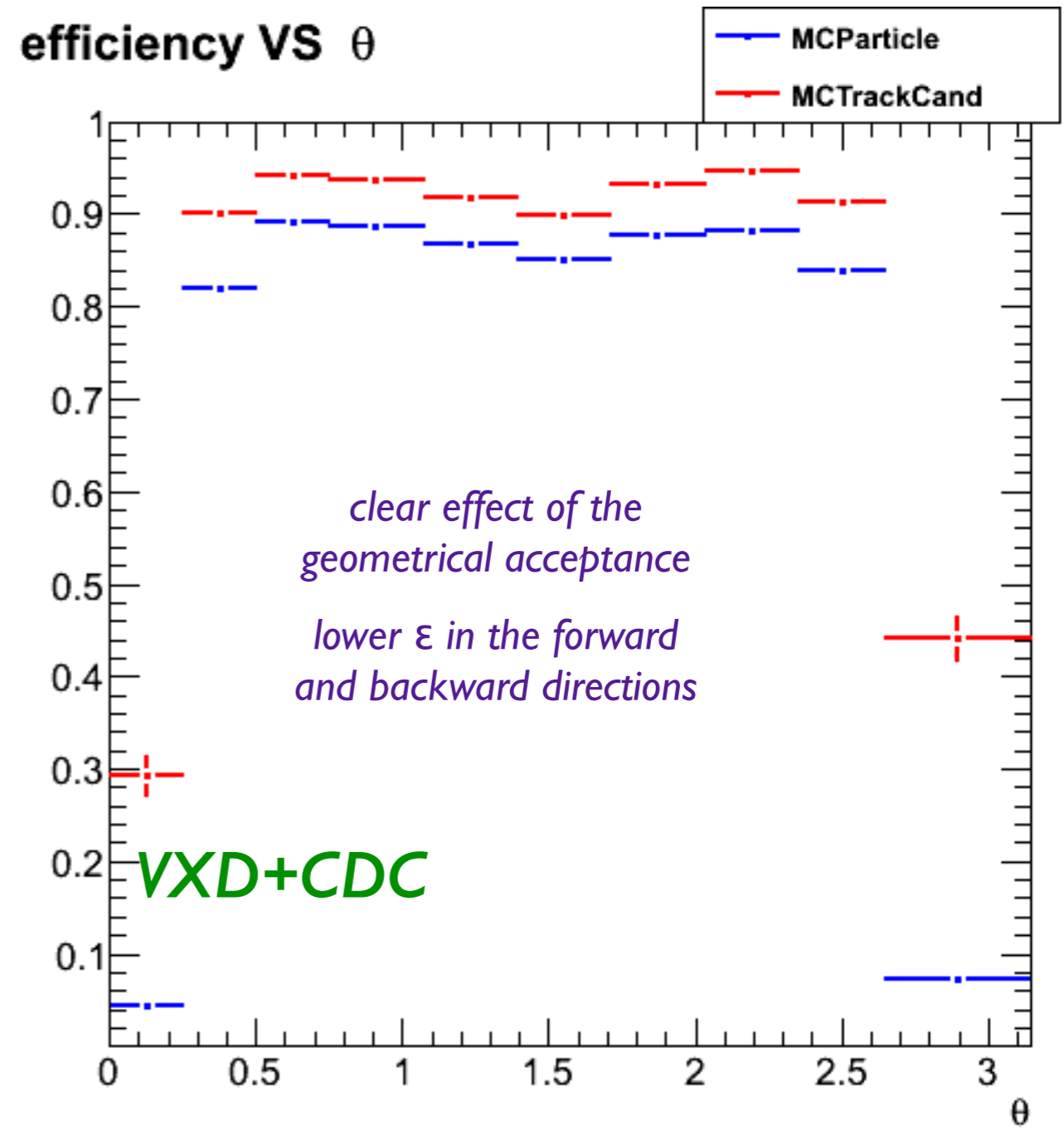
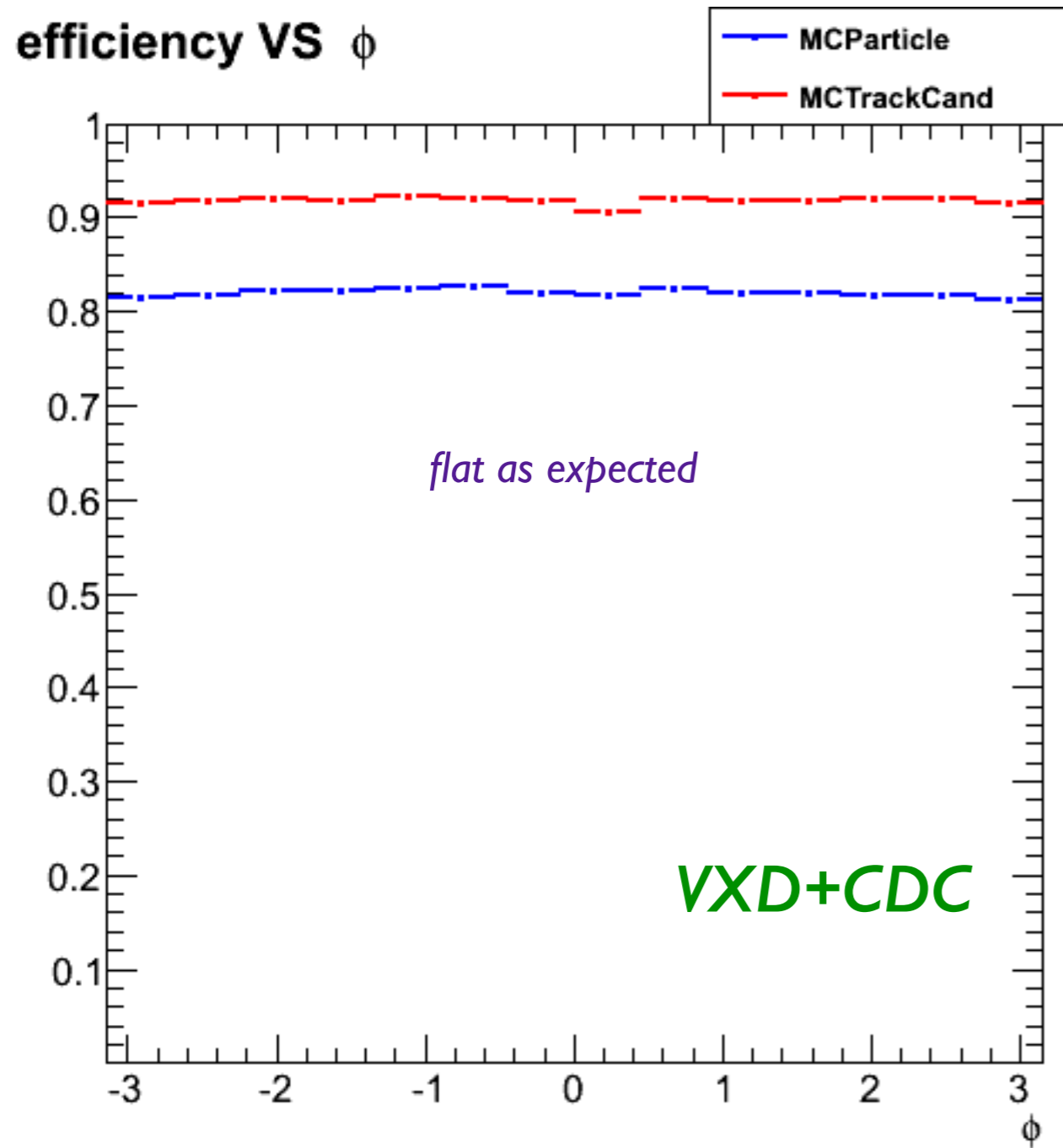
legend:

- ϵ , physical efficiency
- ϵ' , geometrical acceptance and detector efficiency factored out

inefficiency VS pt



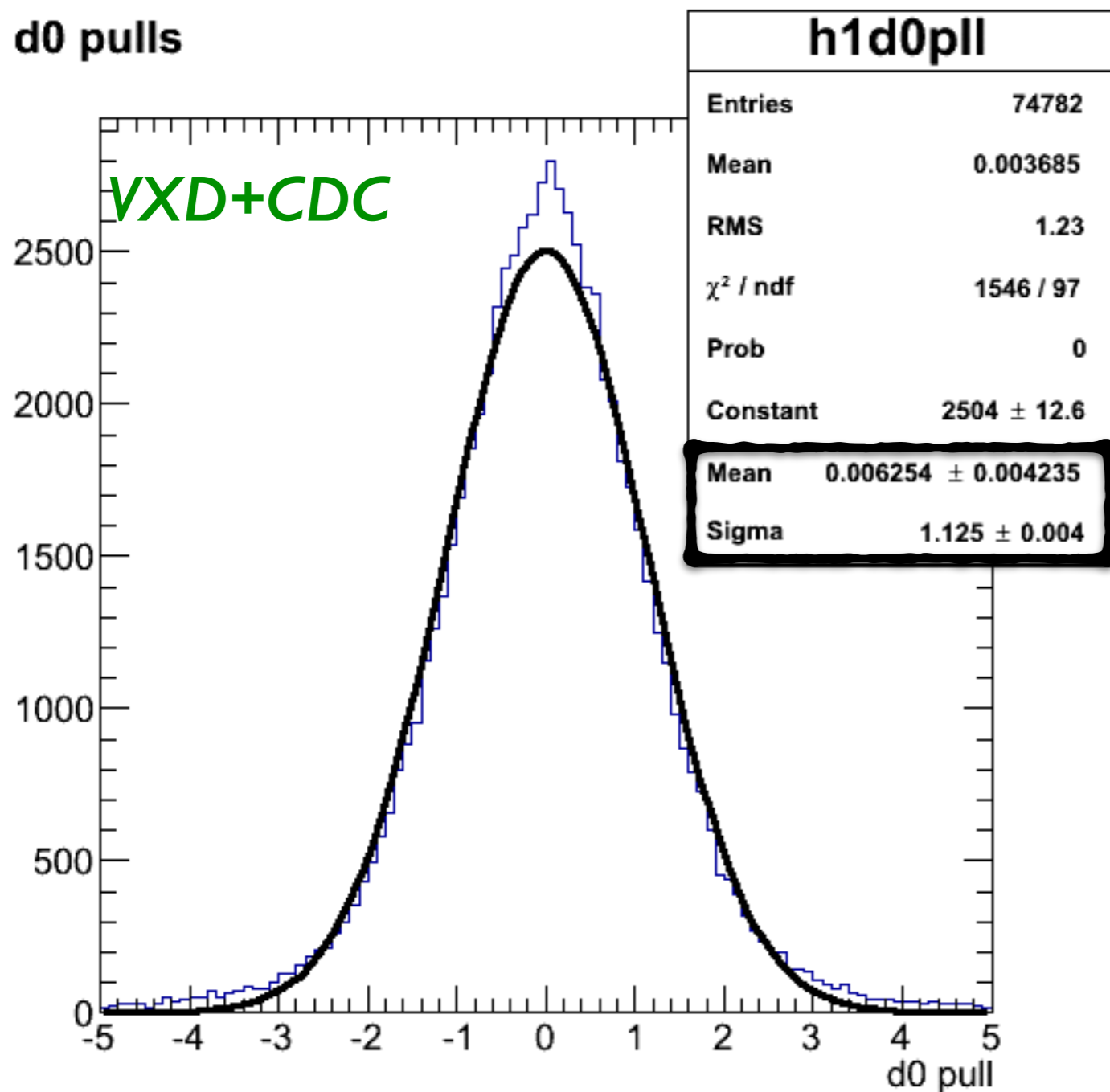
Efficiency VS Polar and Azimuthal Angles



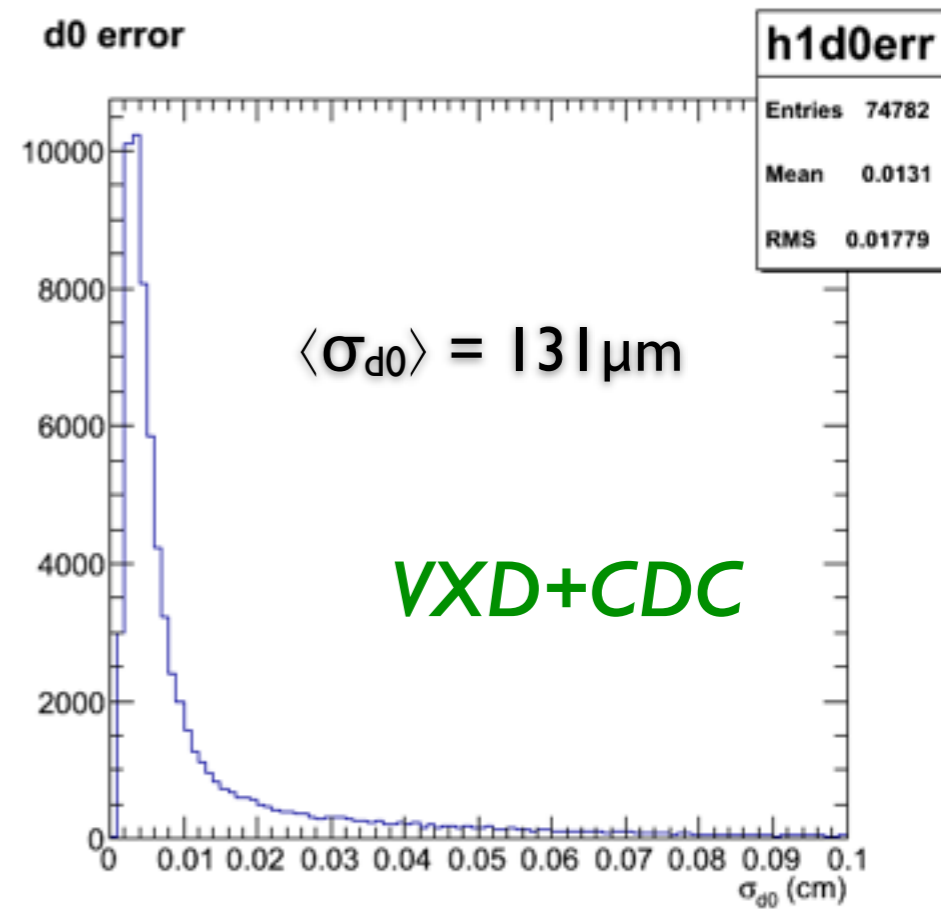
legend:

- ϵ , physical efficiency
- ϵ' , geometrical acceptance and detector efficiency factored out

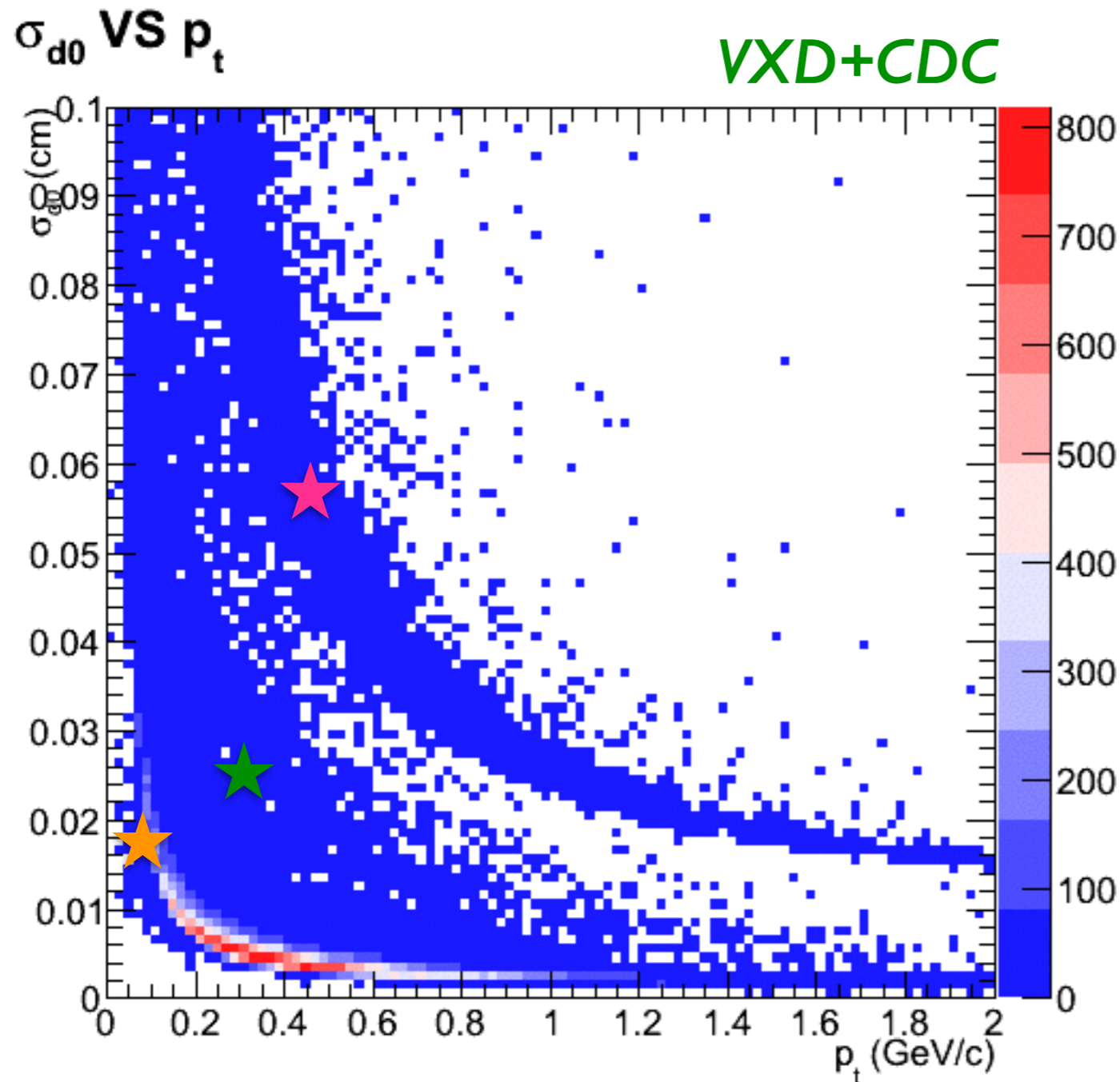
Transverse Impact Parameter



→ almost gaussian pulls distribution



σ_{d0} VS transverse momentum



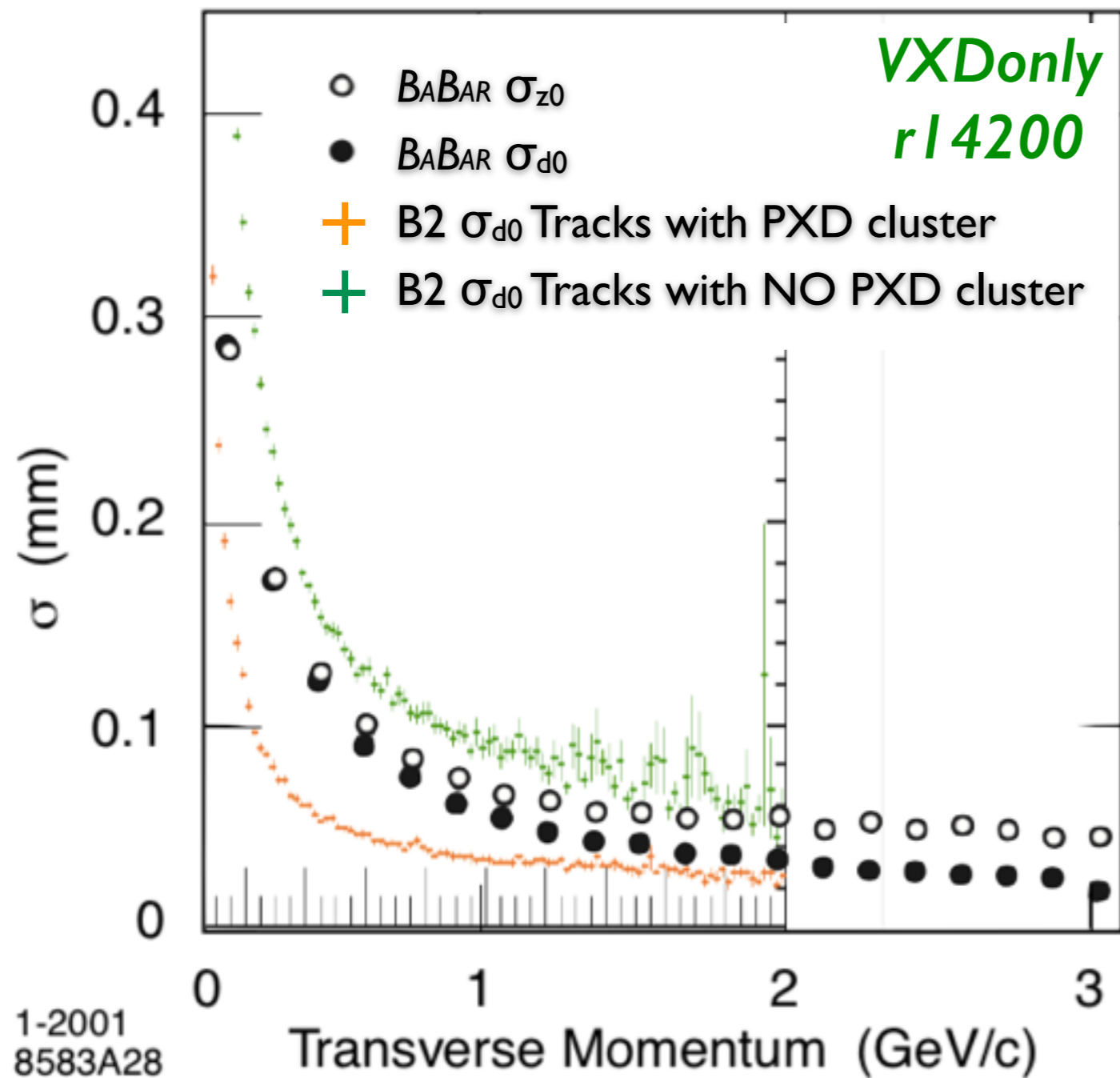
→ 3 families of tracks:

★ CDC only tracks

★ tracks with no PXD clusters attached

★ tracks with PXD clusters attached

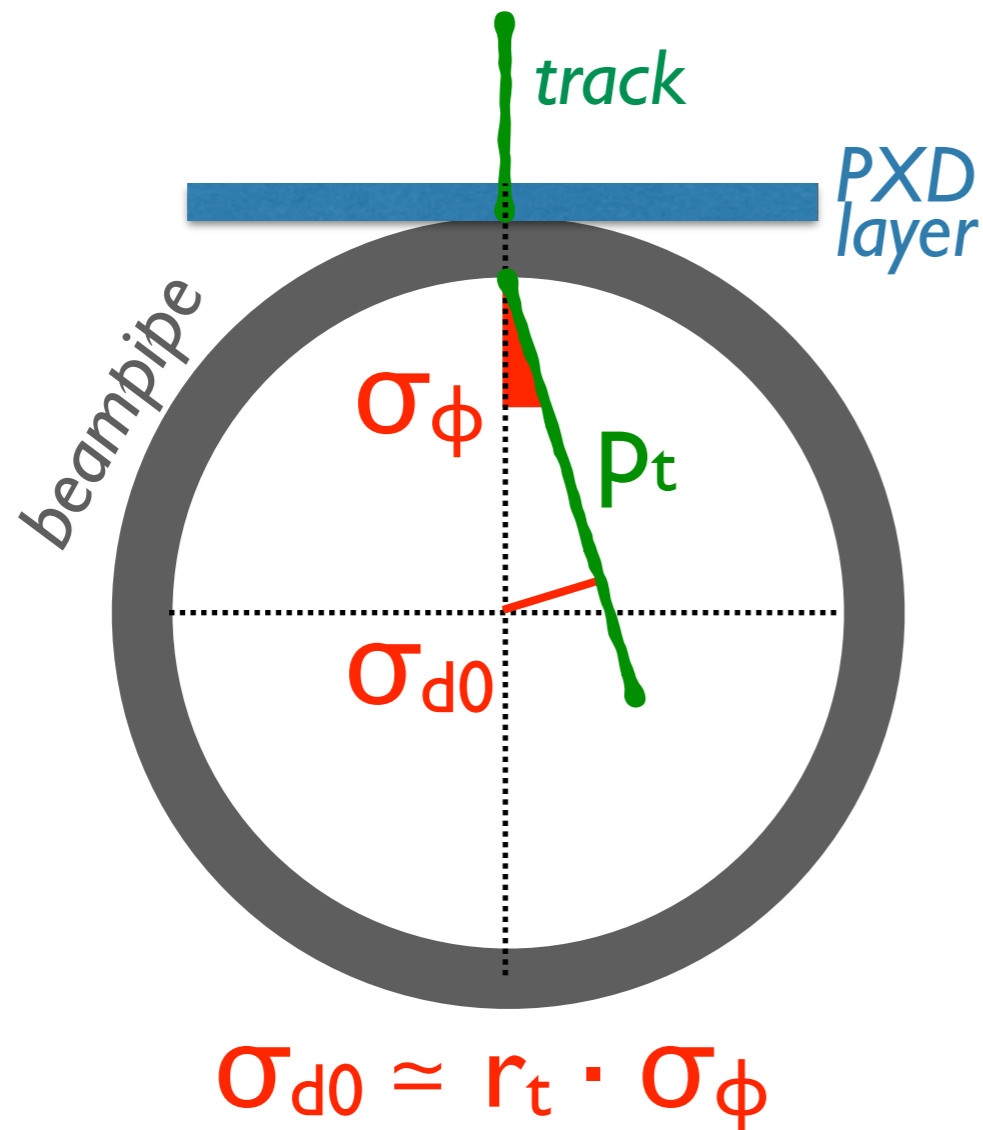
Comparison with *BABAR* Tracking



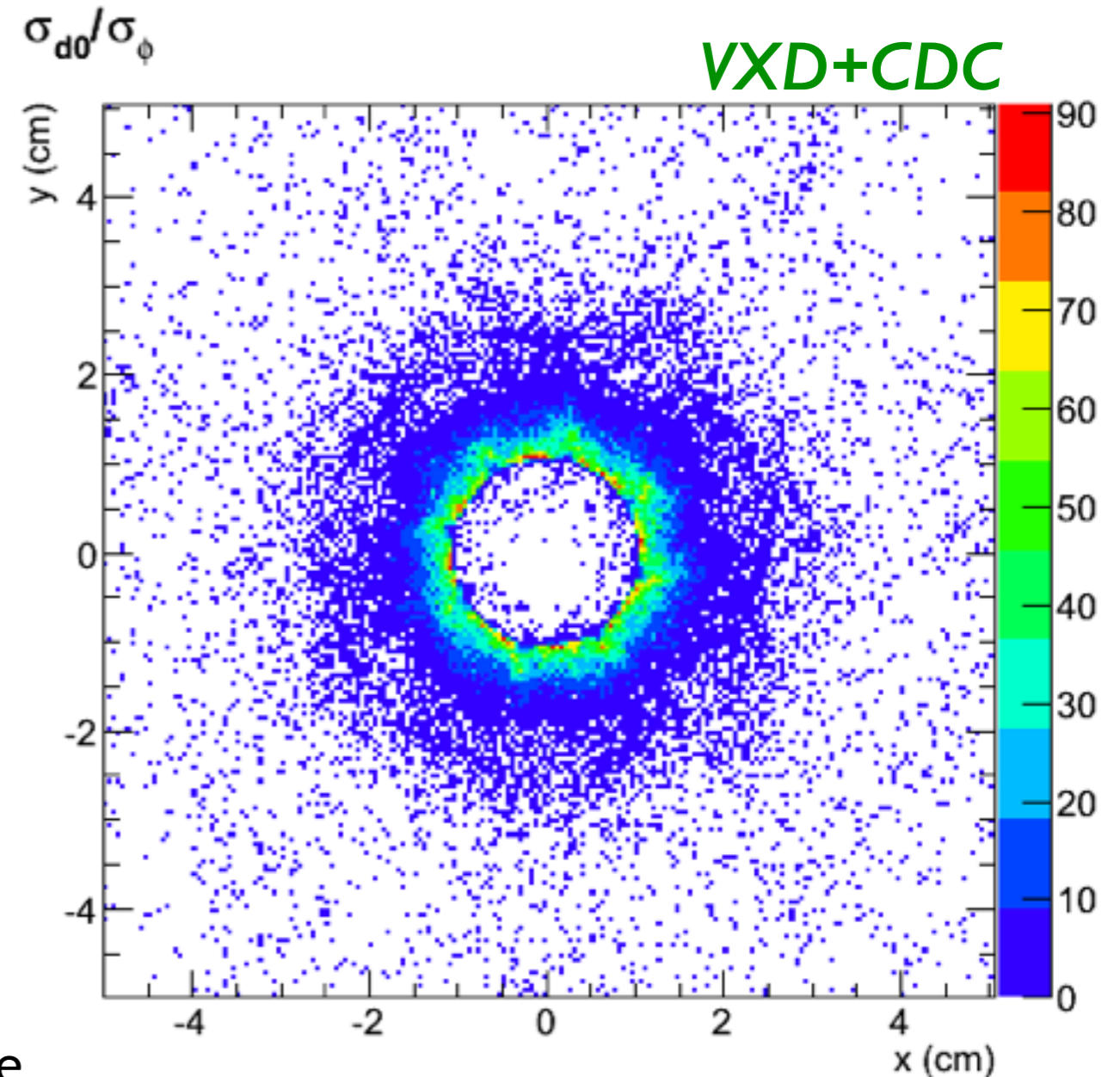
- Belle2 VXD Tracking when PXD clusters are used in the track fit performs better than *BABAR*
- Belle2 Tracking when no PXD clusters are used in the track fit performs worse than *BABAR*

Relating Track Parameters Errors (1)

- Can relate the errors on d_0 and ϕ and estimate the distance between the origin and the nearest hit (i.e. the hit that has more weight in the d_0 estimation)



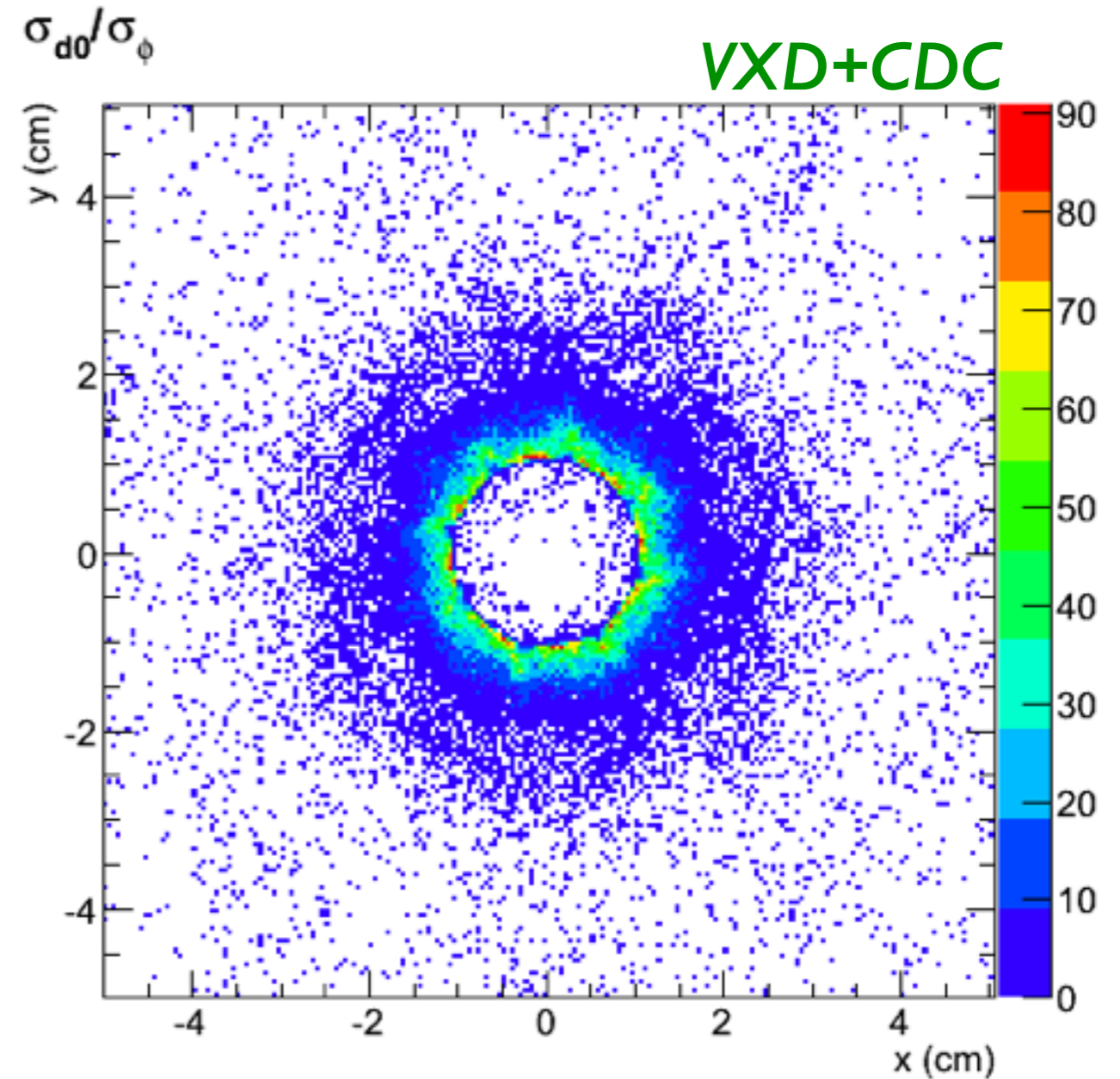
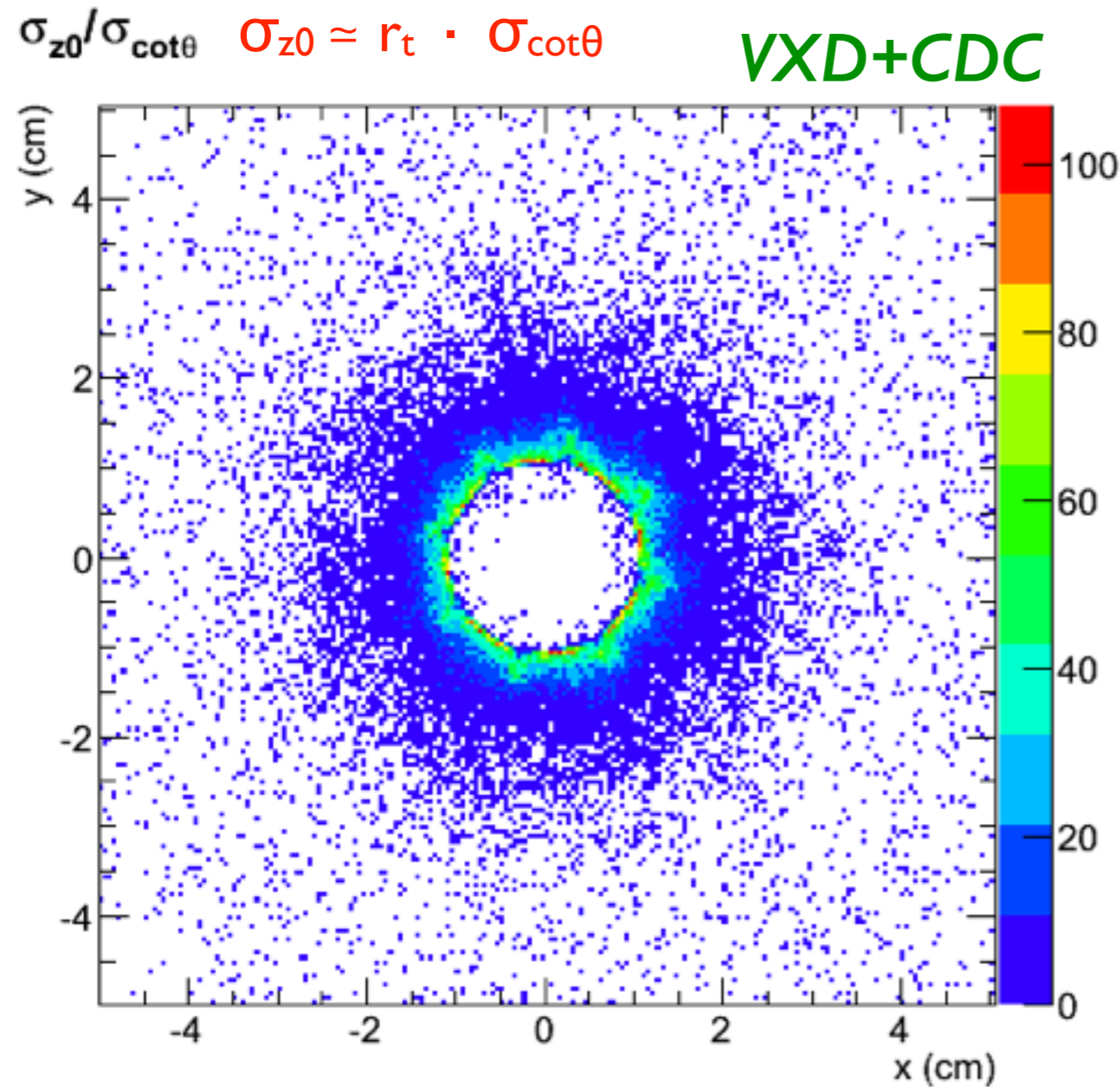
- valid when first hit is near the beam pipe
- neglecting detector hit resolution



MC-truth-information free plot!

Relating Track Parameters Errors (2)

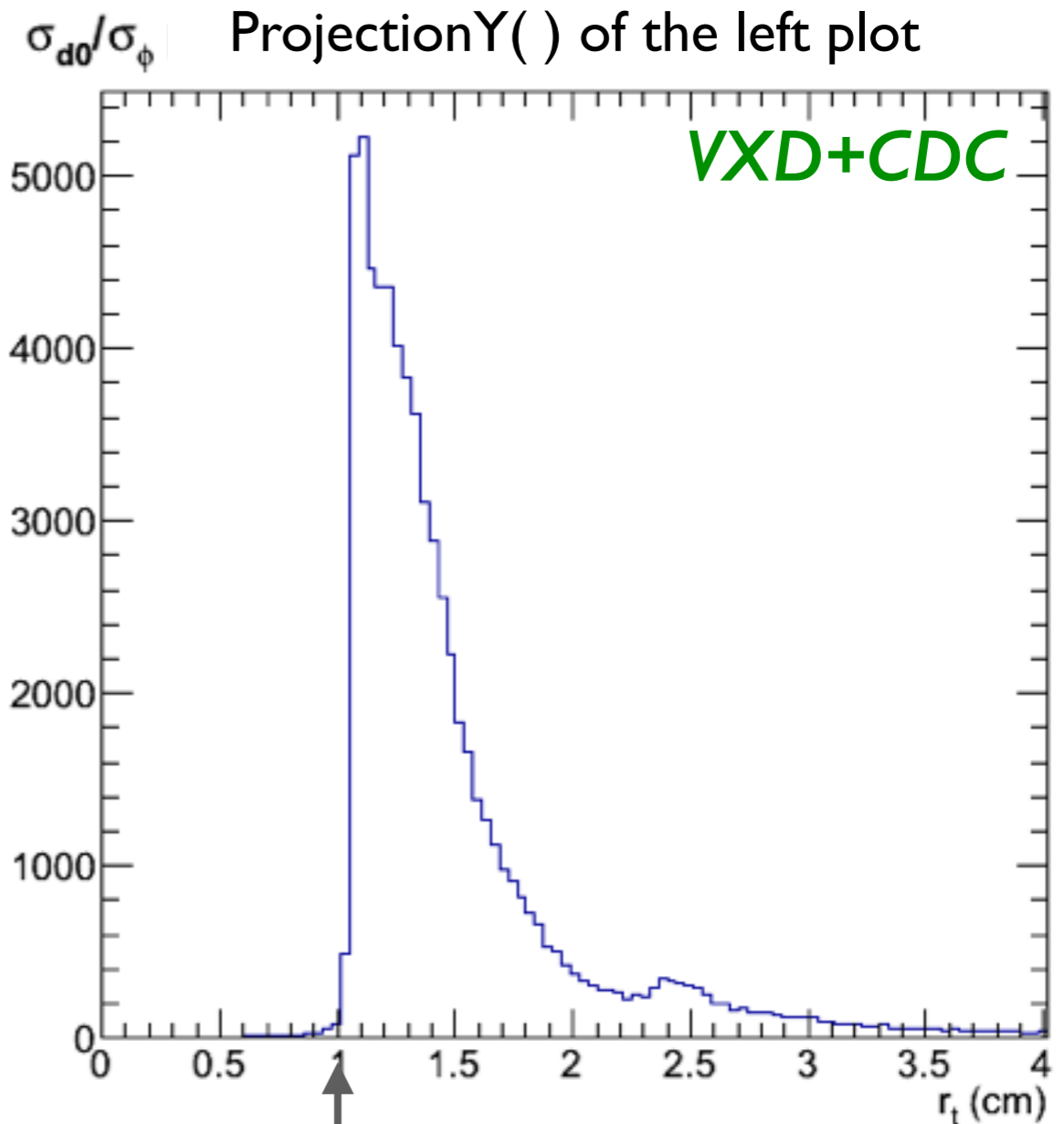
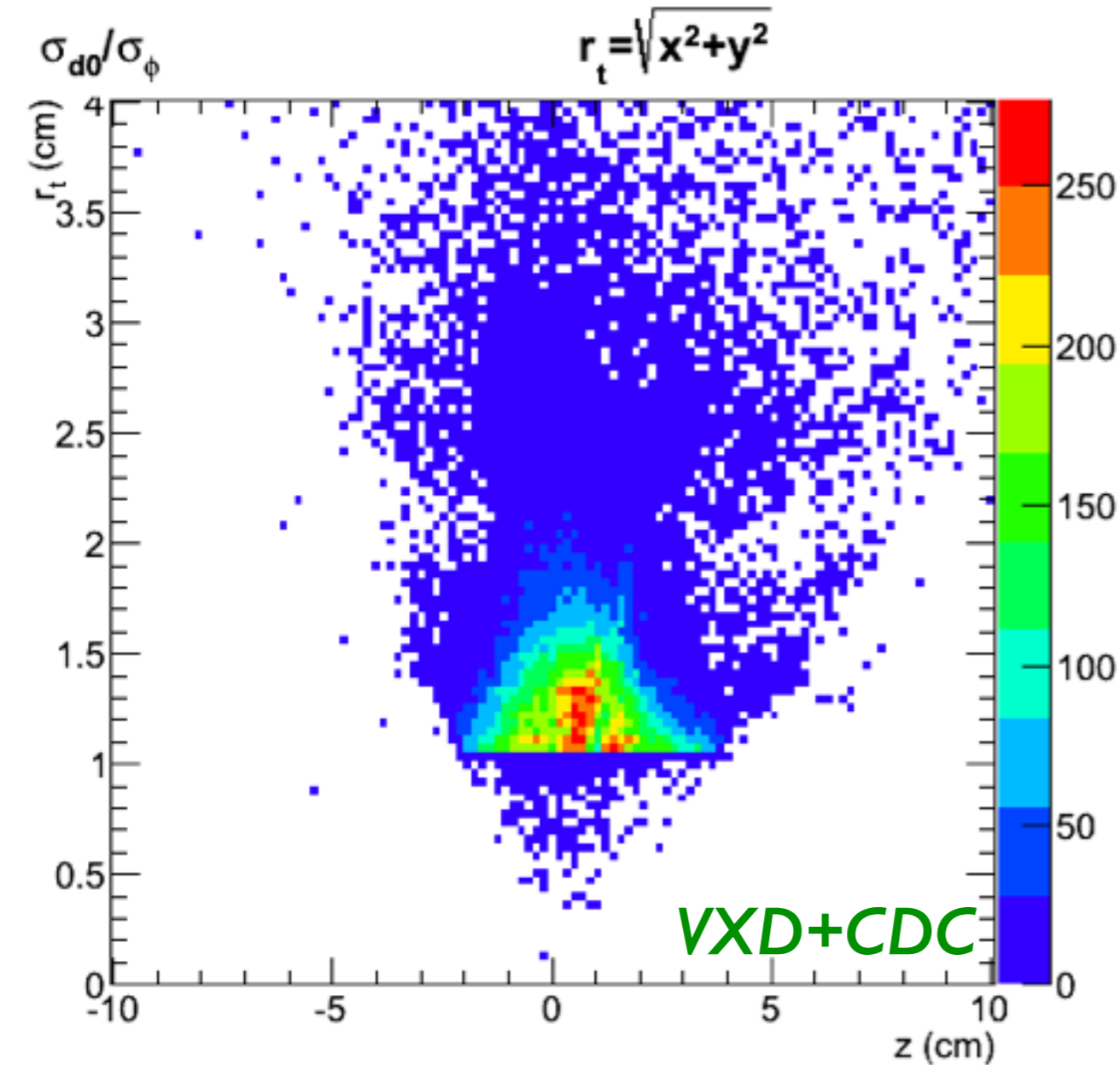
- Can also use the errors on z_0 and $\cot\theta$ to estimate the distance between the origin and the nearest hit (i.e. the hit that has more weight in the z_0 estimation)



MC-truth-information free plot!

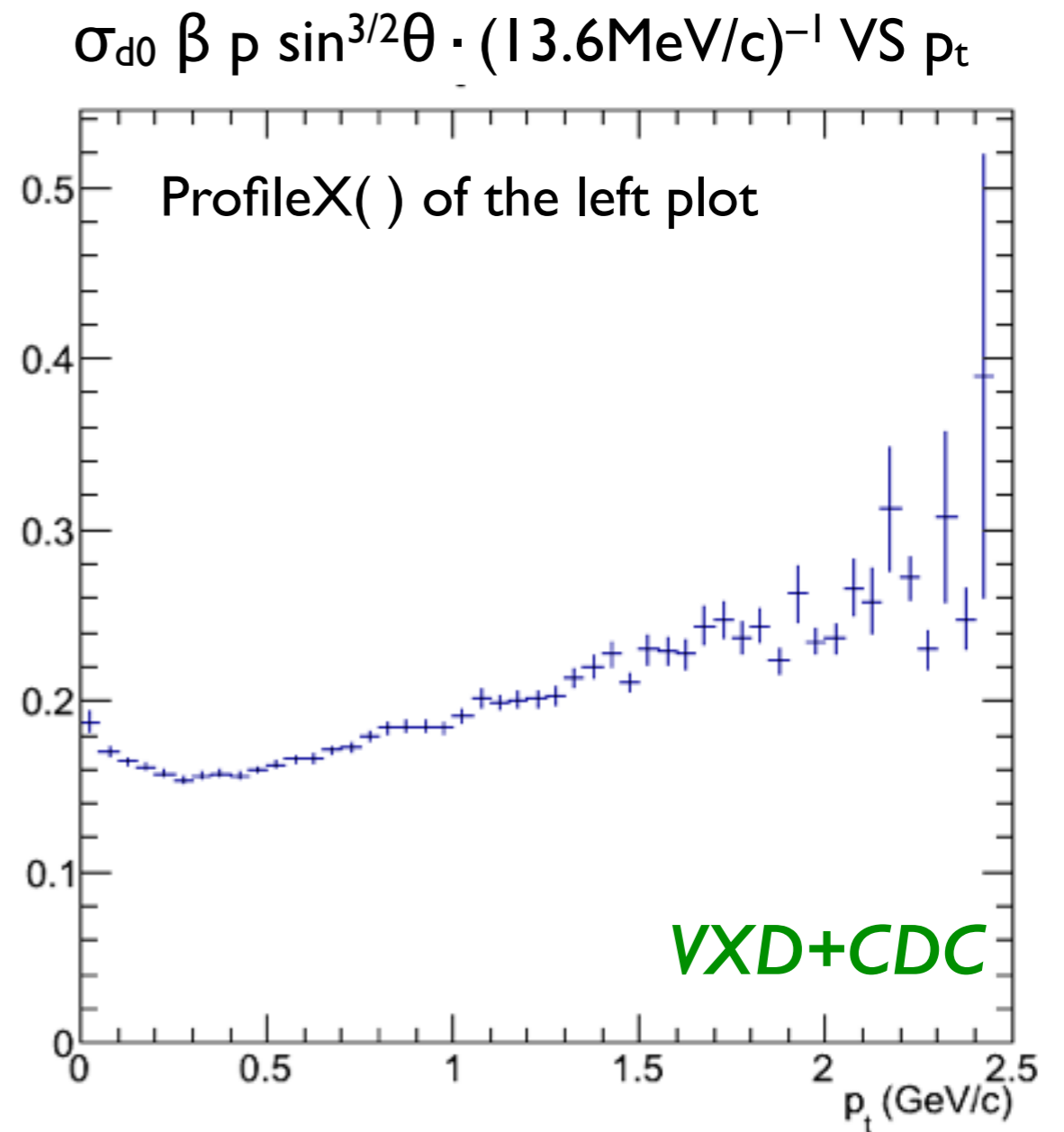
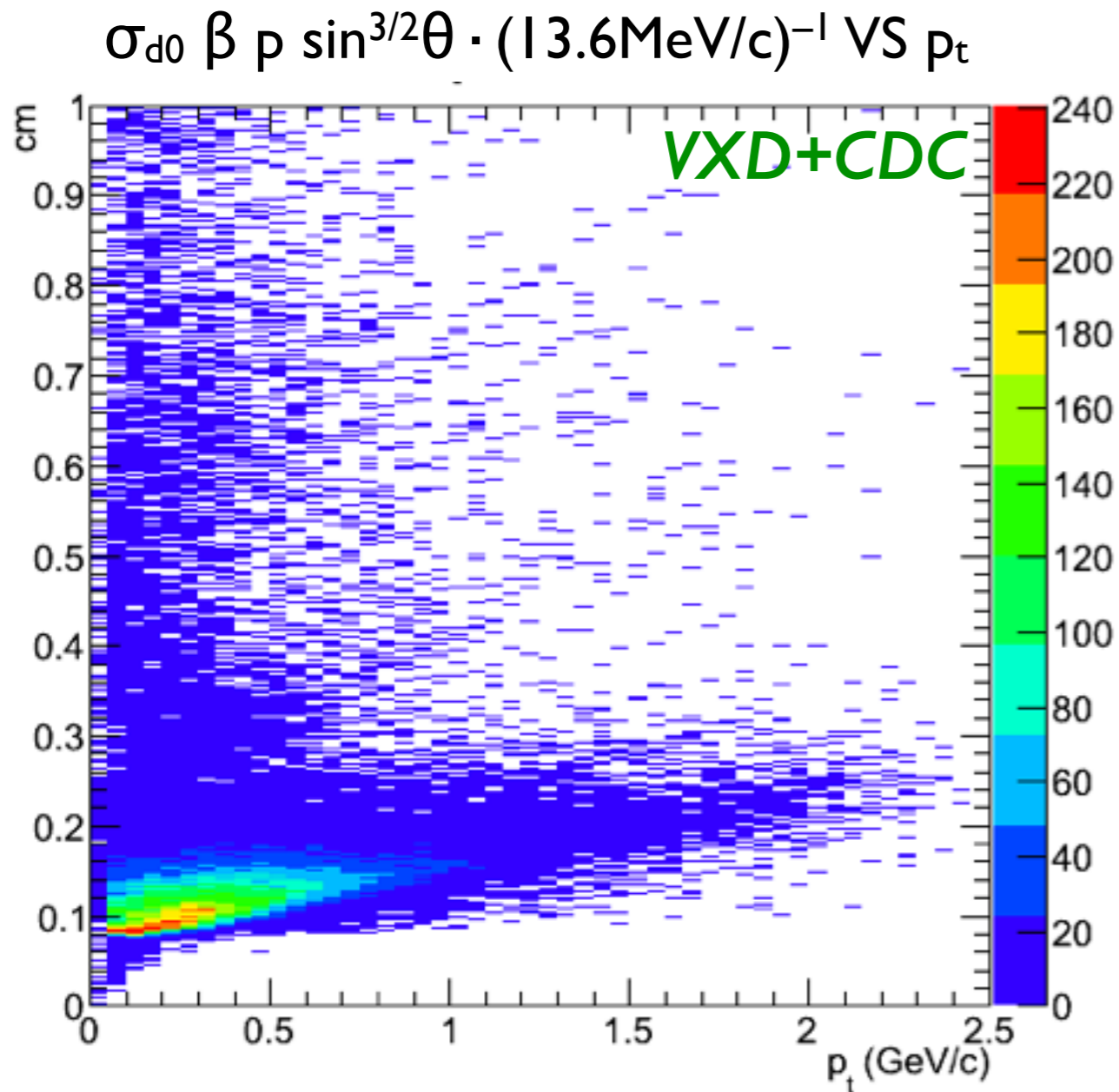
Relating Track Parameters Errors (3)

- Can also look at the longitudinal view and plot the distance between the origin and the nearest hit to the origin.



MC-truth-information free plots!

Effect of Multiple Scattering



→ taking into account the error introduced by the multiple scattering of the first layer crossed by the track:

$$p_t \cdot \sigma_{d0} \beta p \sin^{3/2}\theta = \text{const}$$

Pattern Recognition Efficiency & Purity

not updated

<i>Pattern Recognition</i>	VXD only	CDC only	VXD+CDC
purity (%)	94.88±0.08	75.5±0.1	-
$\epsilon =$ efficiency (%)	79.3±0.2	91.3±0.1	94.3±0.1

not updated

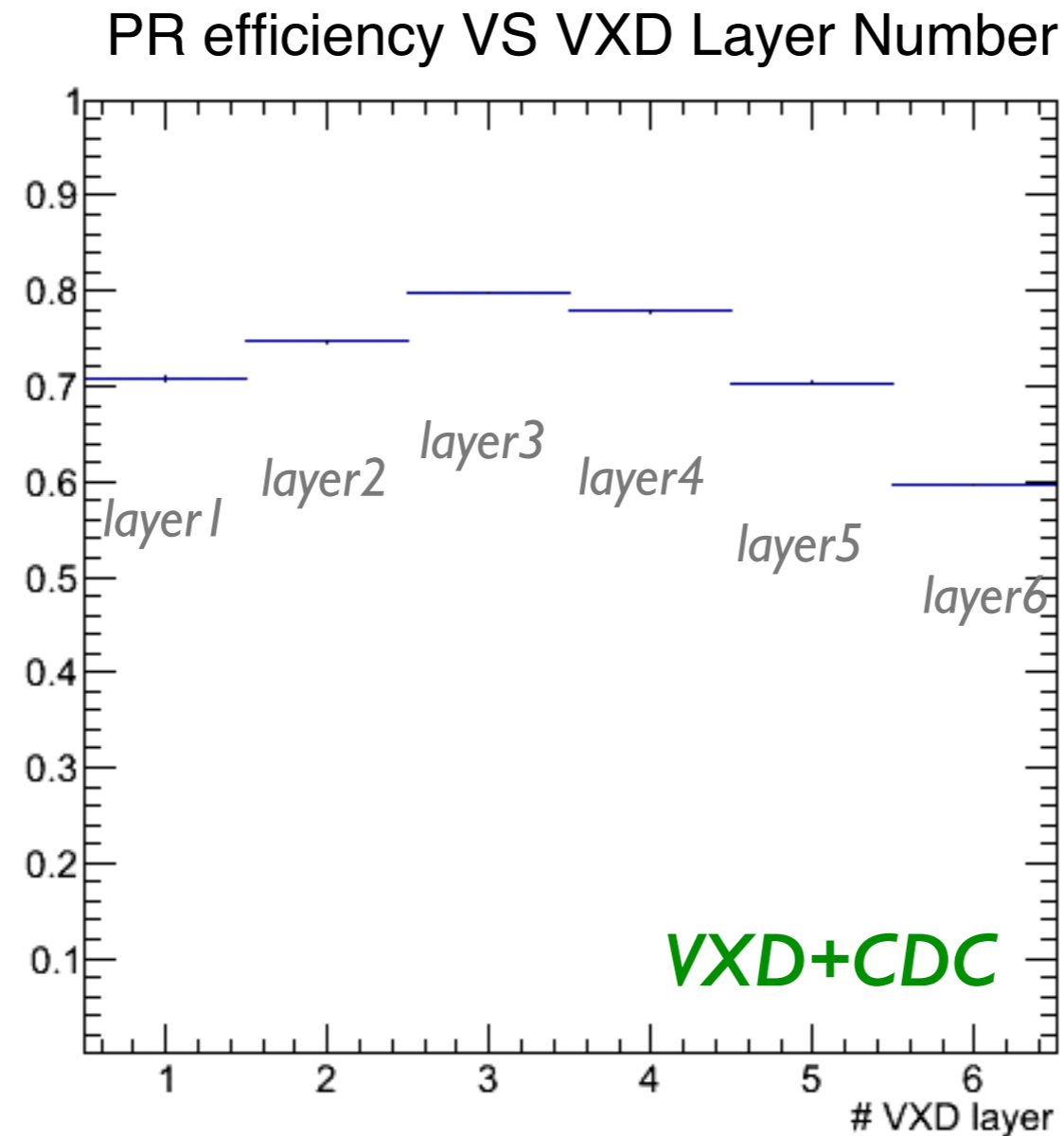
→ above numbers are relative to release r14200

- VXD only PR efficiency increased to 85% with the patch, same purity
- VXD+CDC PR efficiency increased to 96.1% with the patch

purity = probability to find an MCTrackBar associated to a TrackCand, given a TrackCand

$$\epsilon = \frac{\# \text{ MCTrackBar with at least one associated TrackCand}}{\# \text{ MCTrackBar}}$$

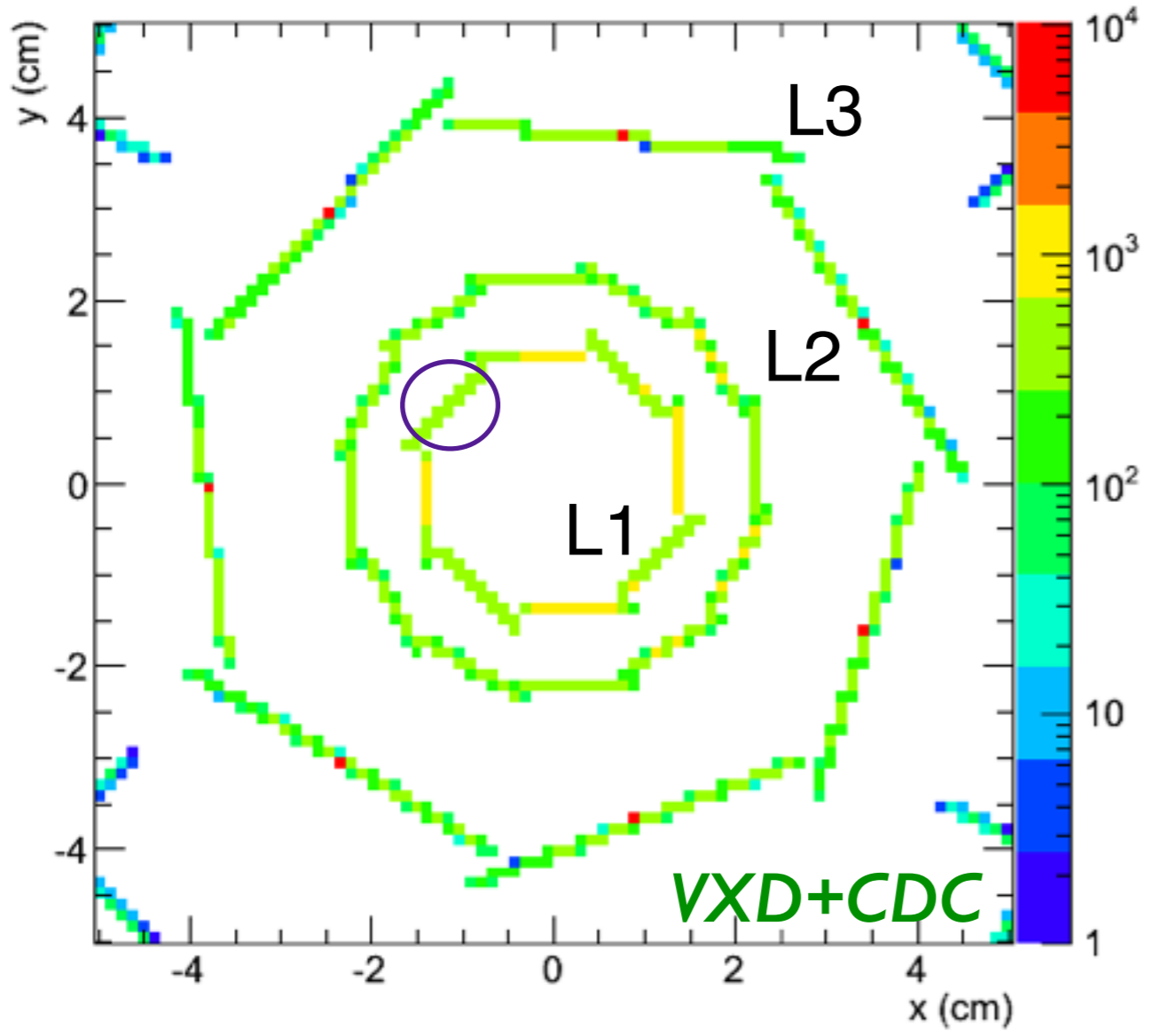
PR Efficiency on VXD Layers



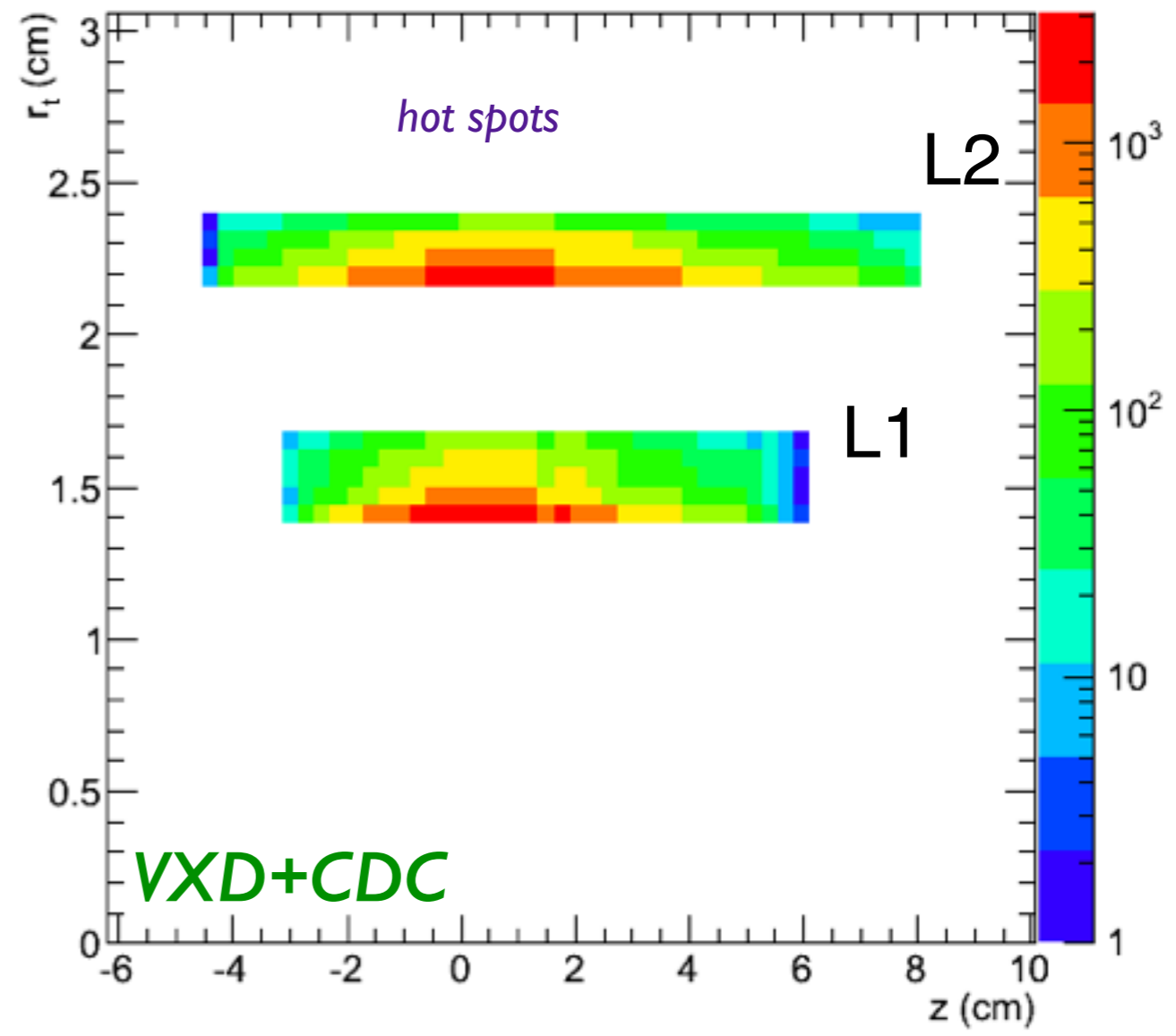
- Efficiency is maximum on layer3 (80%)
- Efficiency decreases from inner to the outer layers (70% on layer1, 60% on layer6)

VXD Clusters used in the Track Fit

hits used in the Track Fit: transverse view



hits used in the Track Fit: longitudinal view



lower efficiency in PXD slanted ladders?

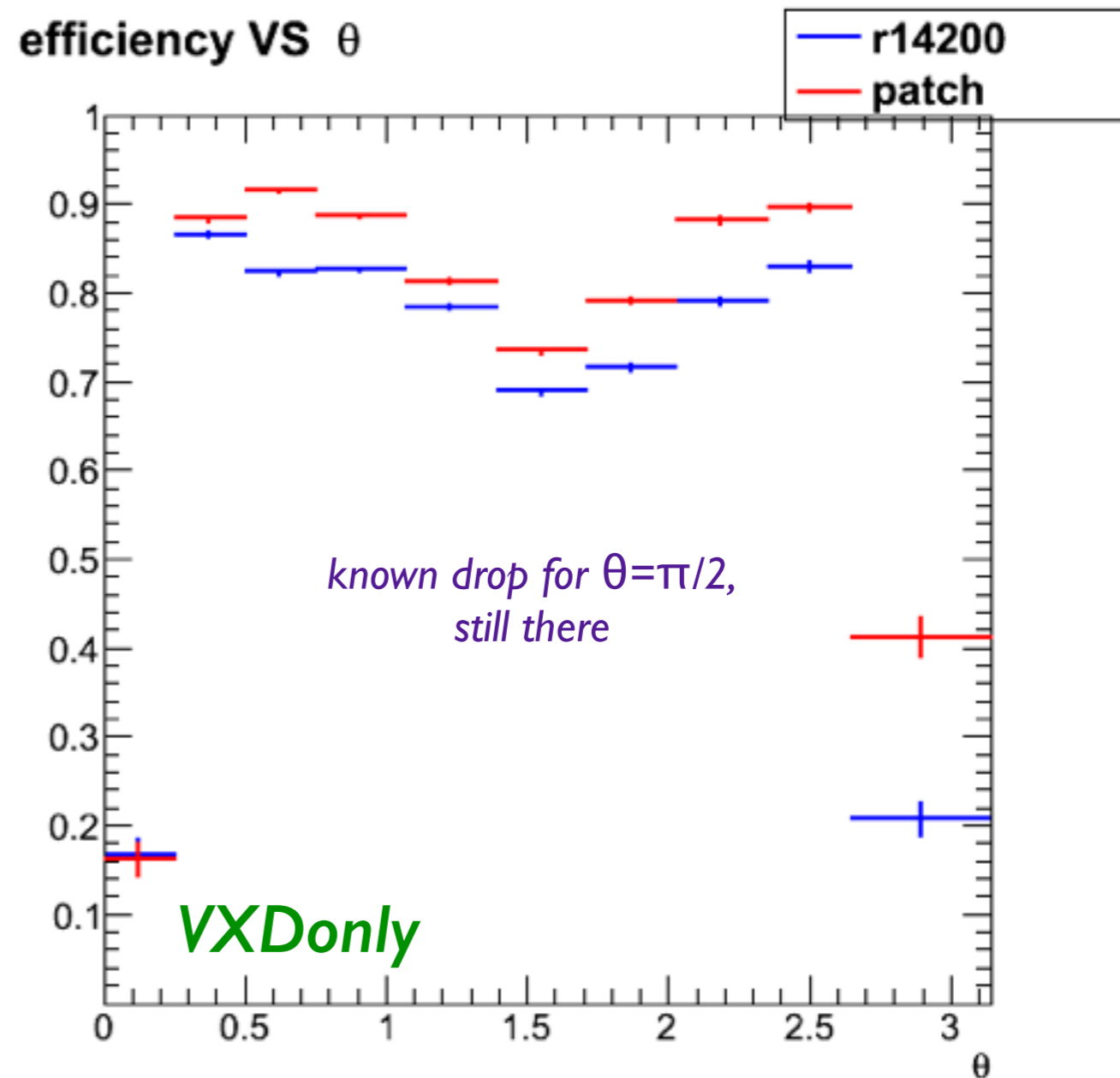
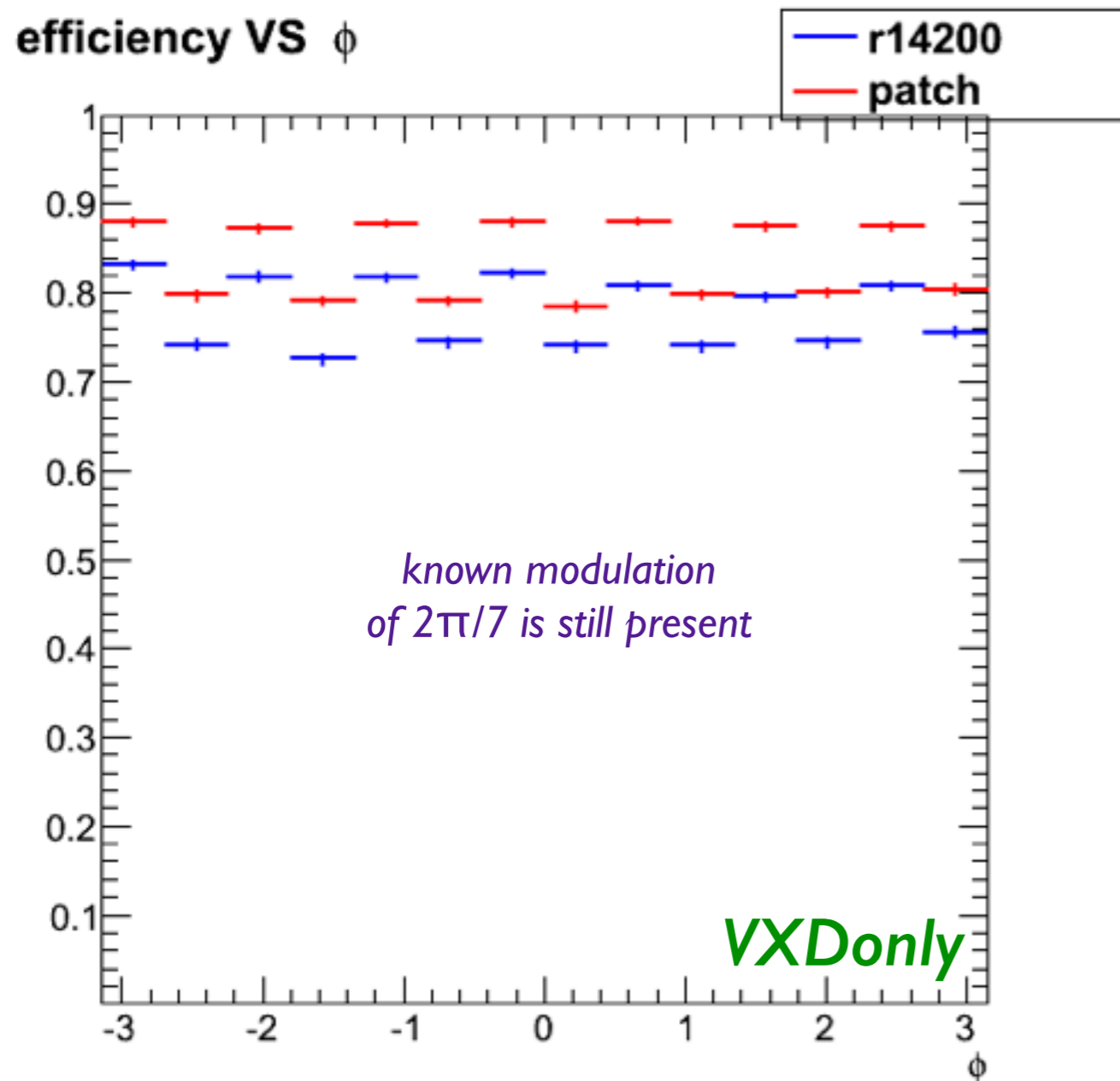
How Jakob Fix Looks Like

➔ compare **VXD only tracking** in **r14200** (before the patch) and **r14200+patch**

patch = svn update of:

- tracking/modules/VXDTF/{include,src}/VXDTFModule.{h,cc}
- tracking/modules/VXDTFHelperTools/{include,src}/FilterCalculatorModule.{h,cc}
- tracking/spacePointCreation/{include,src}/spacepoint.{h,cc}
- tracking/vectorTools

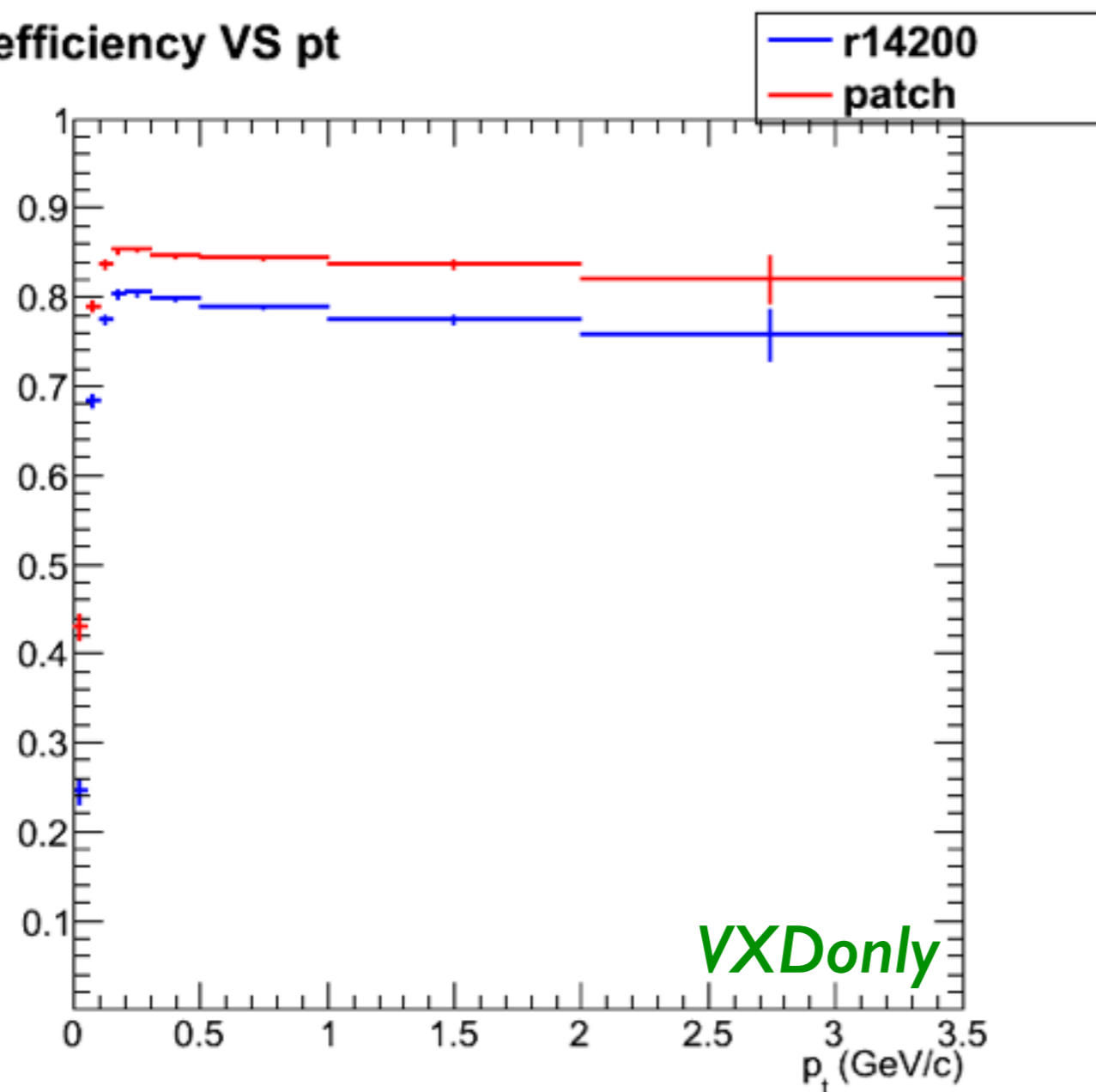
Efficiency VS Polar and Azimuthal Angles



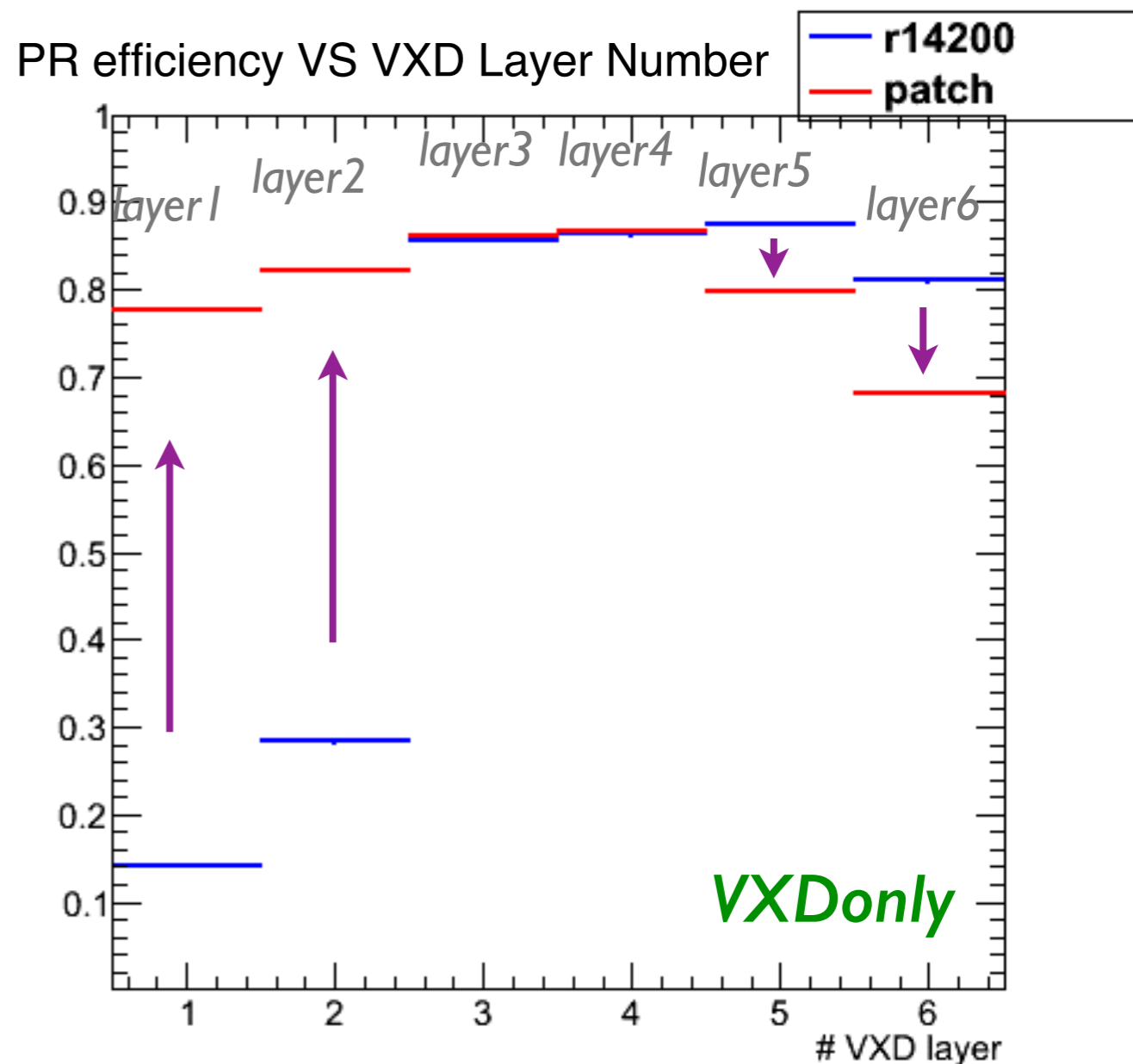
➔ improvement in efficiency but undesired feature are still present

Efficiency VS p_t and VXD Layers

efficiency VS p_t



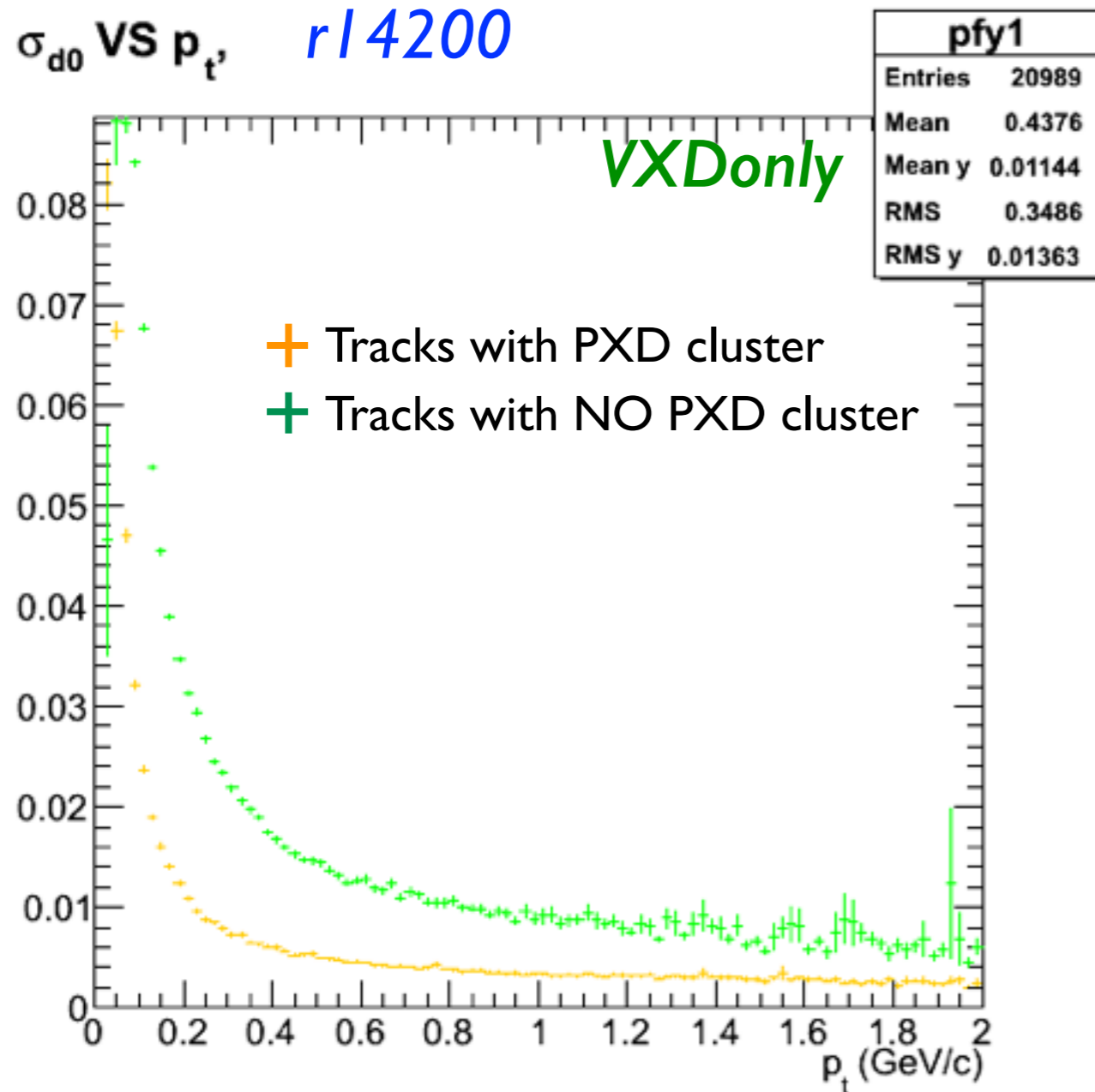
PR efficiency VS VXD Layer Number



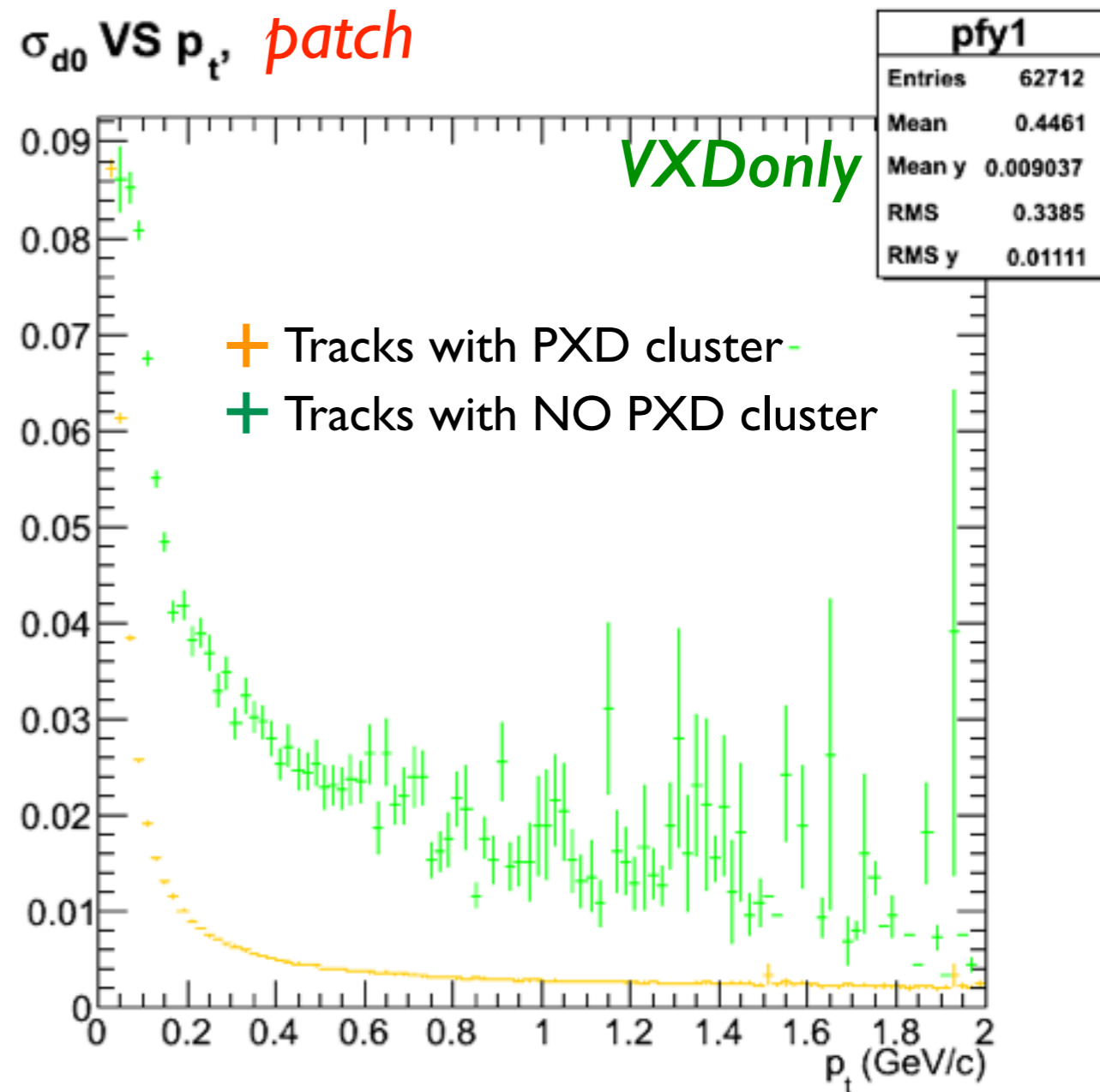
- ➔ improvement in efficiency VS p_t
- ➔ huge increase of the efficiency on layers 1 and 2, but an undesired 10% decrease on outer layers shows up

Transverse Impact Parameter Resolution

σ_{d0} VS p_t , *r/4200*

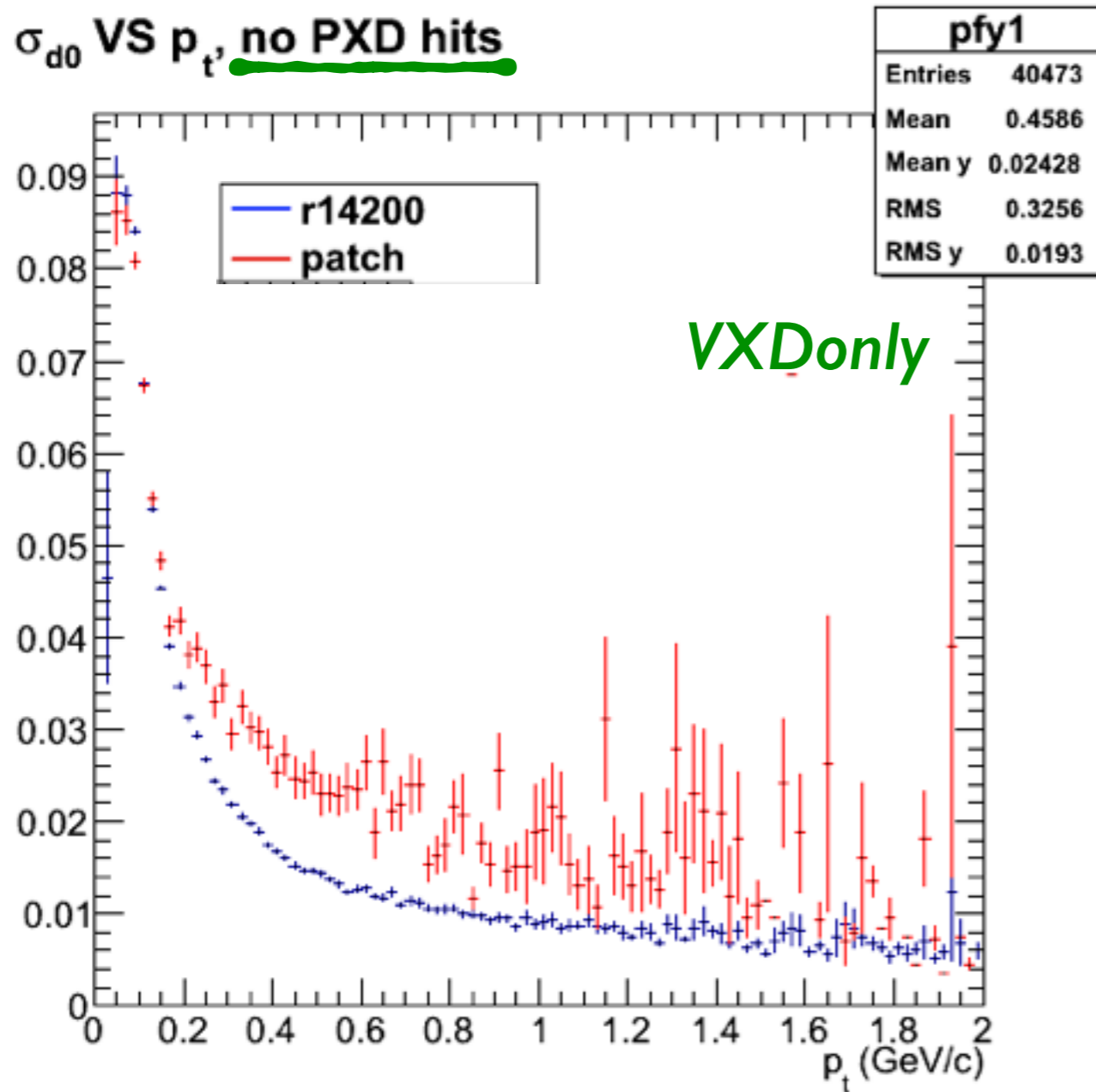


σ_{d0} VS p_t , *patch*

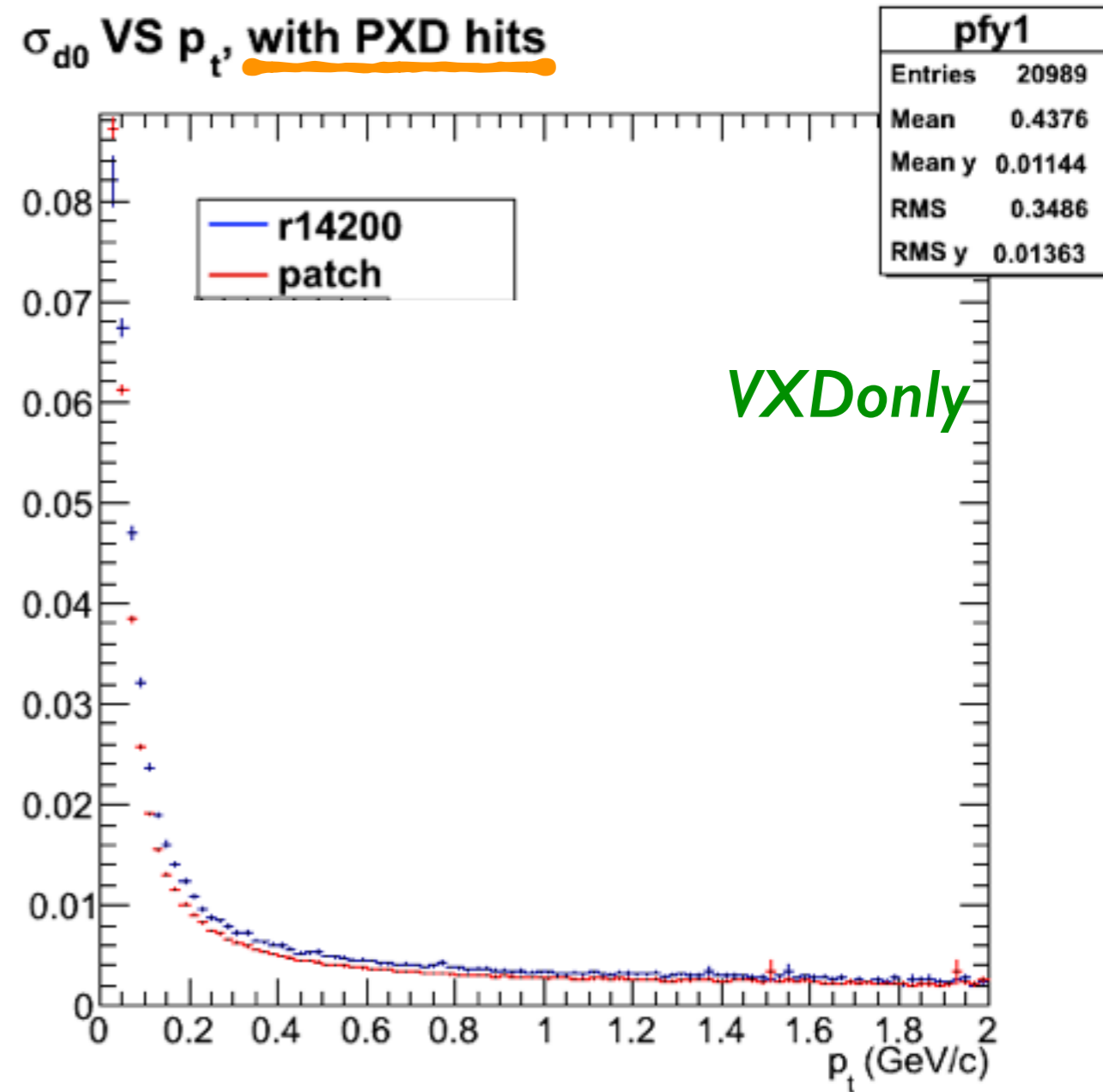


σ_{d0} with and without PXD clusters

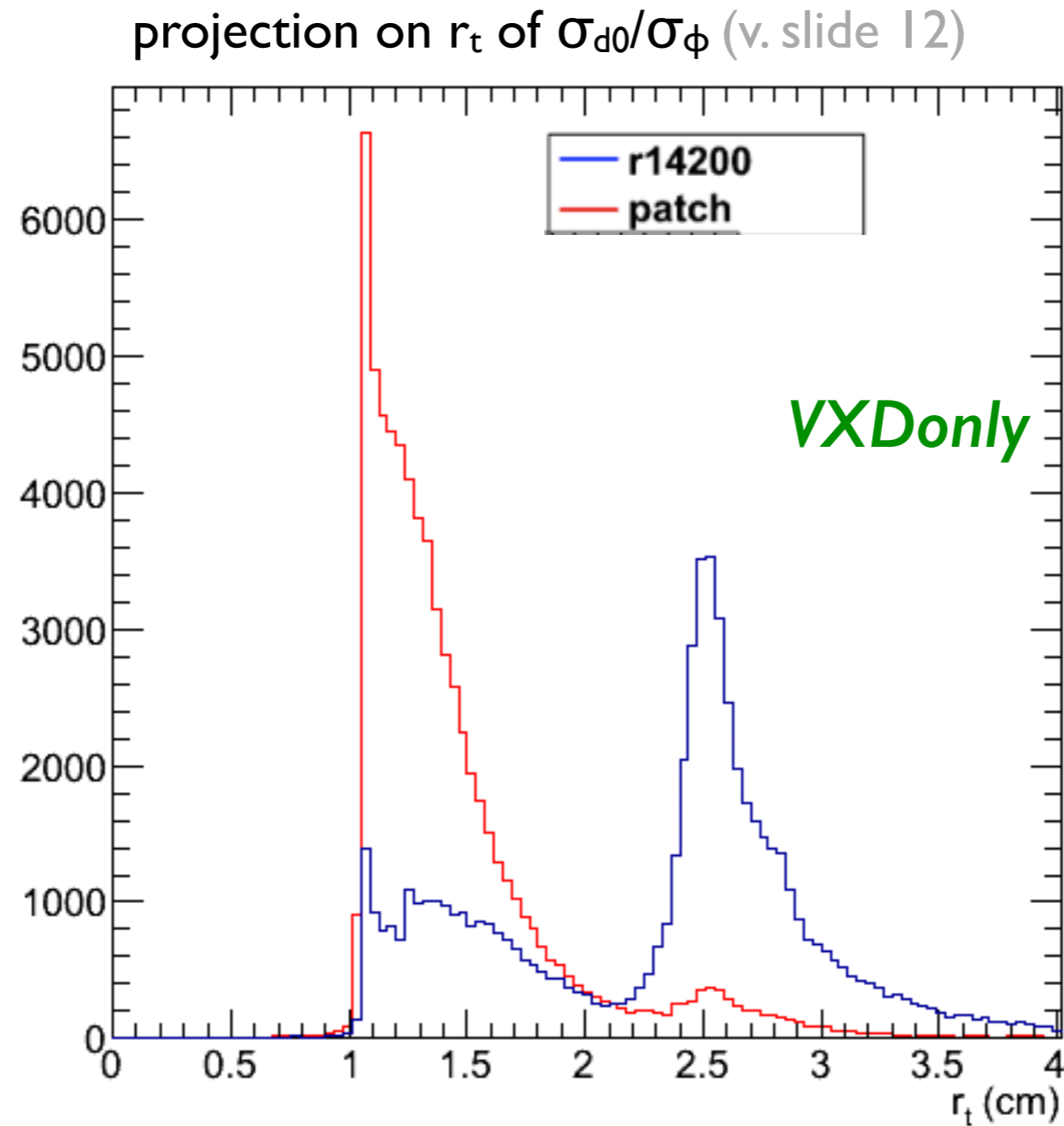
σ_{d0} VS p_t , no PXD hits



σ_{d0} VS p_t , with PXD hits



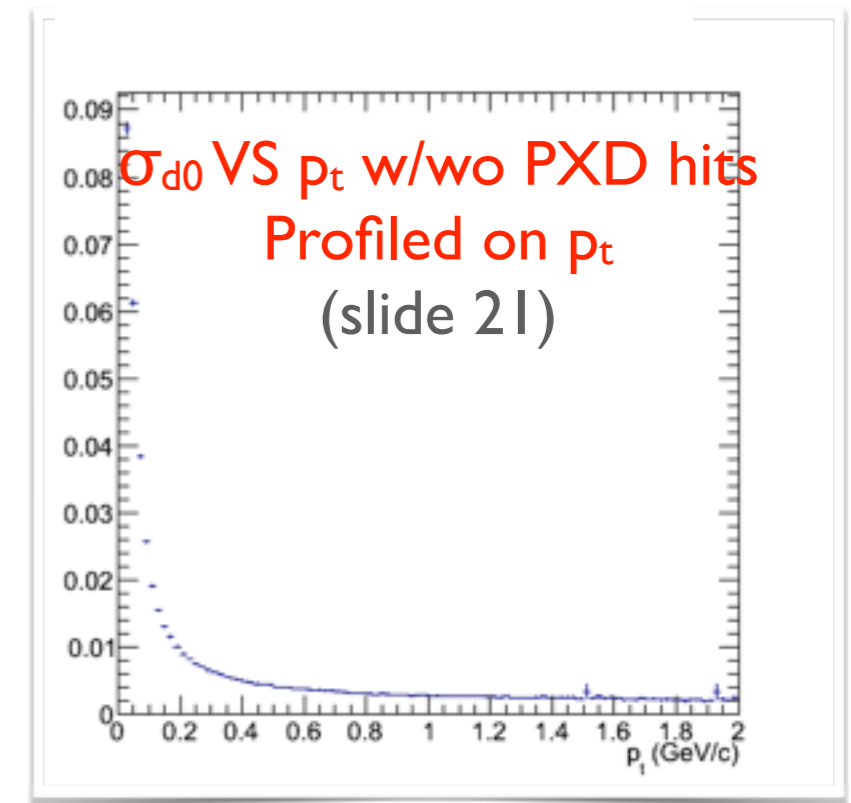
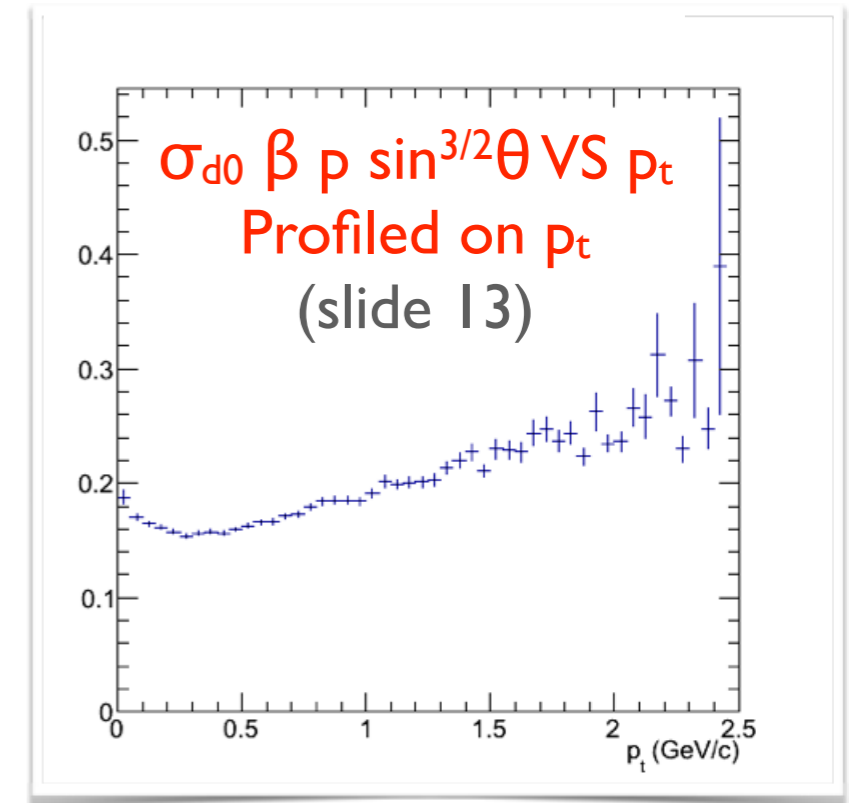
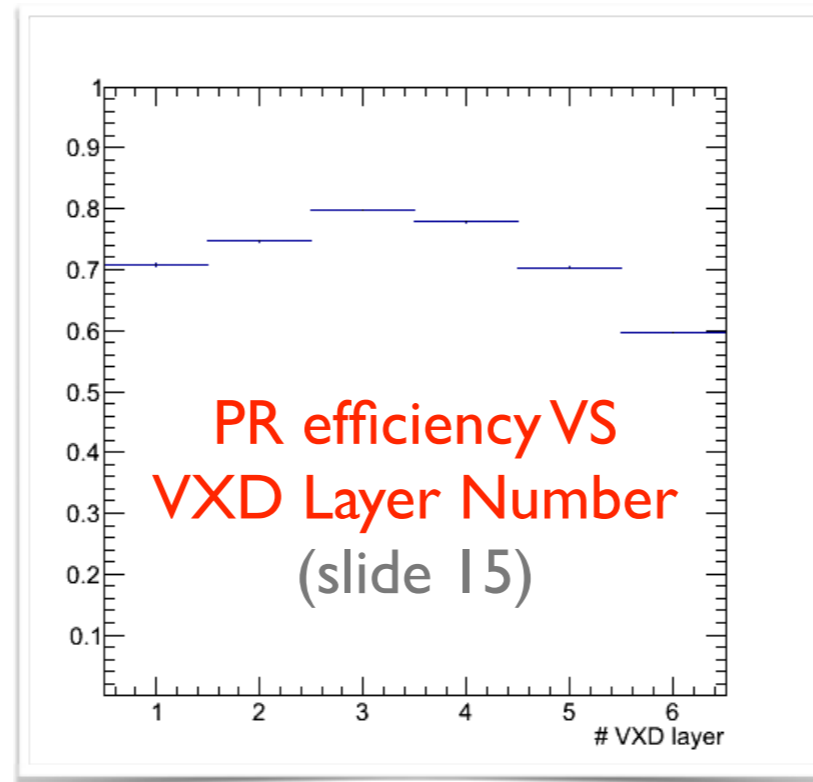
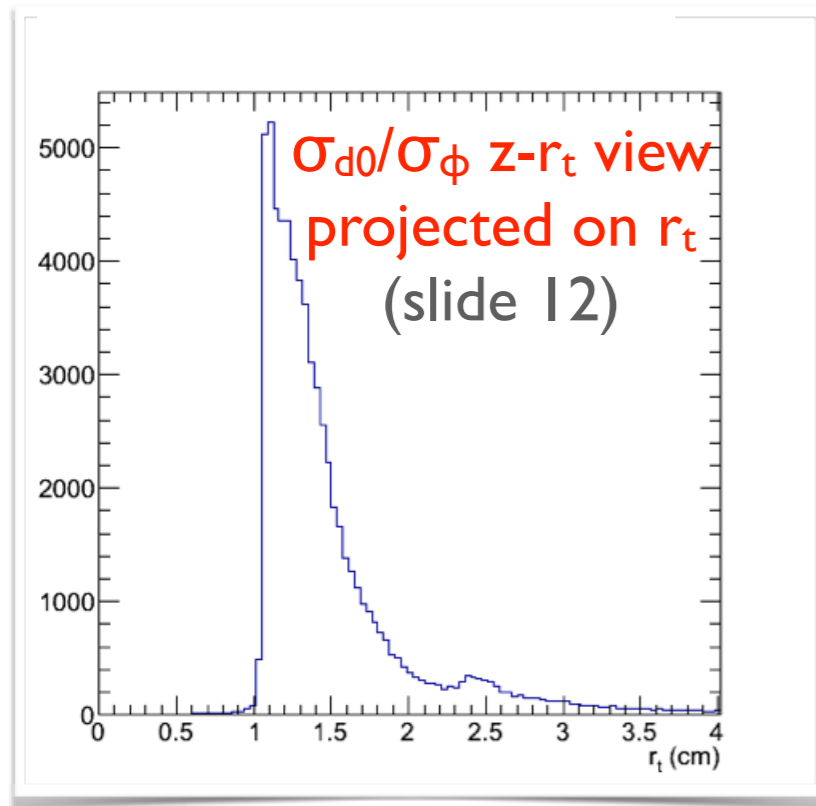
Relating Track Parameters Errors



→ striking difference between the two curves

Conclusions

- ➔ Good improvements in the tracking performances after Jakob Fix!
- ➔ Some plots that may be implemented in our new validation:



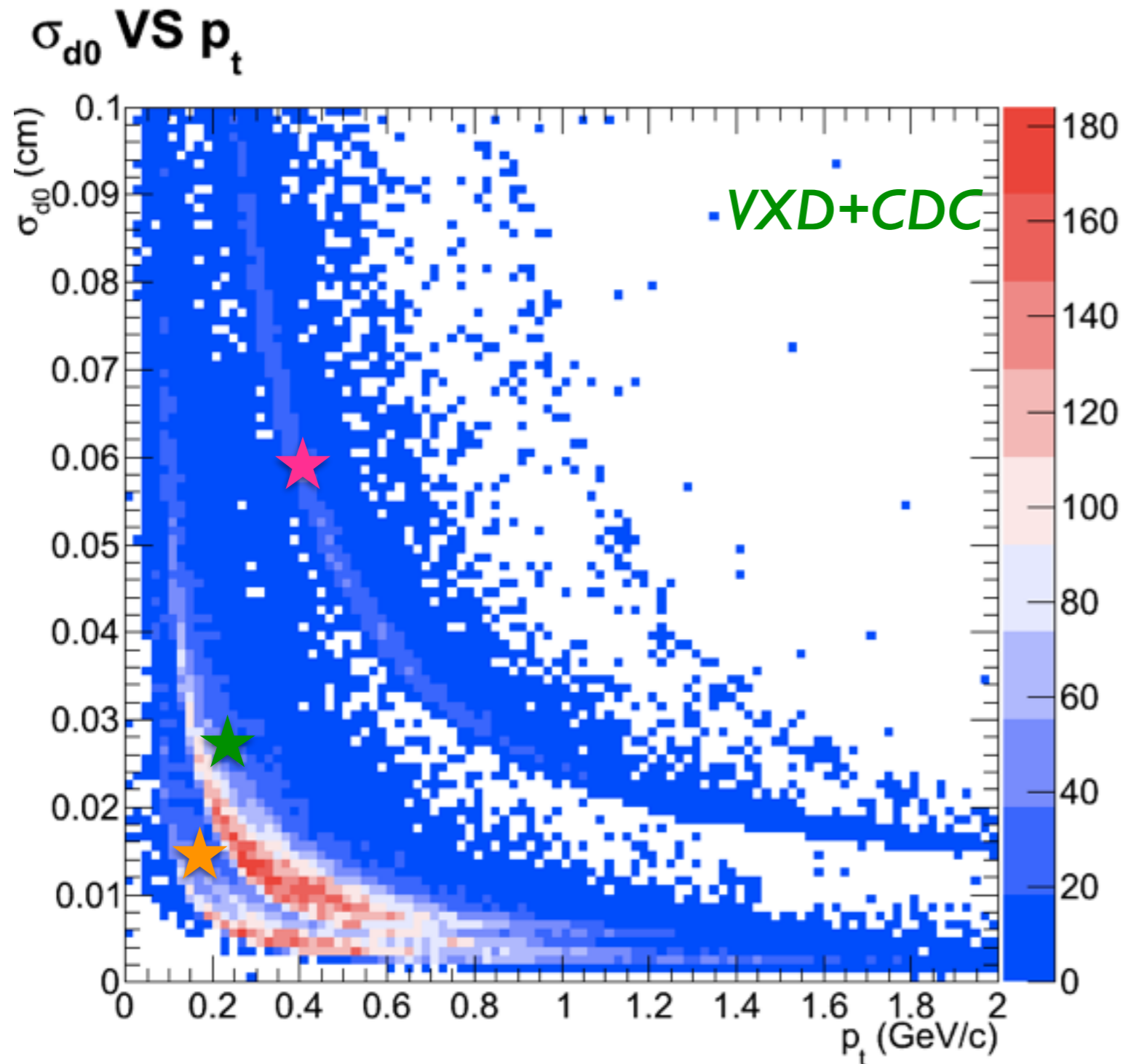
Thank You!

backup slides



r14200 validation plots here:

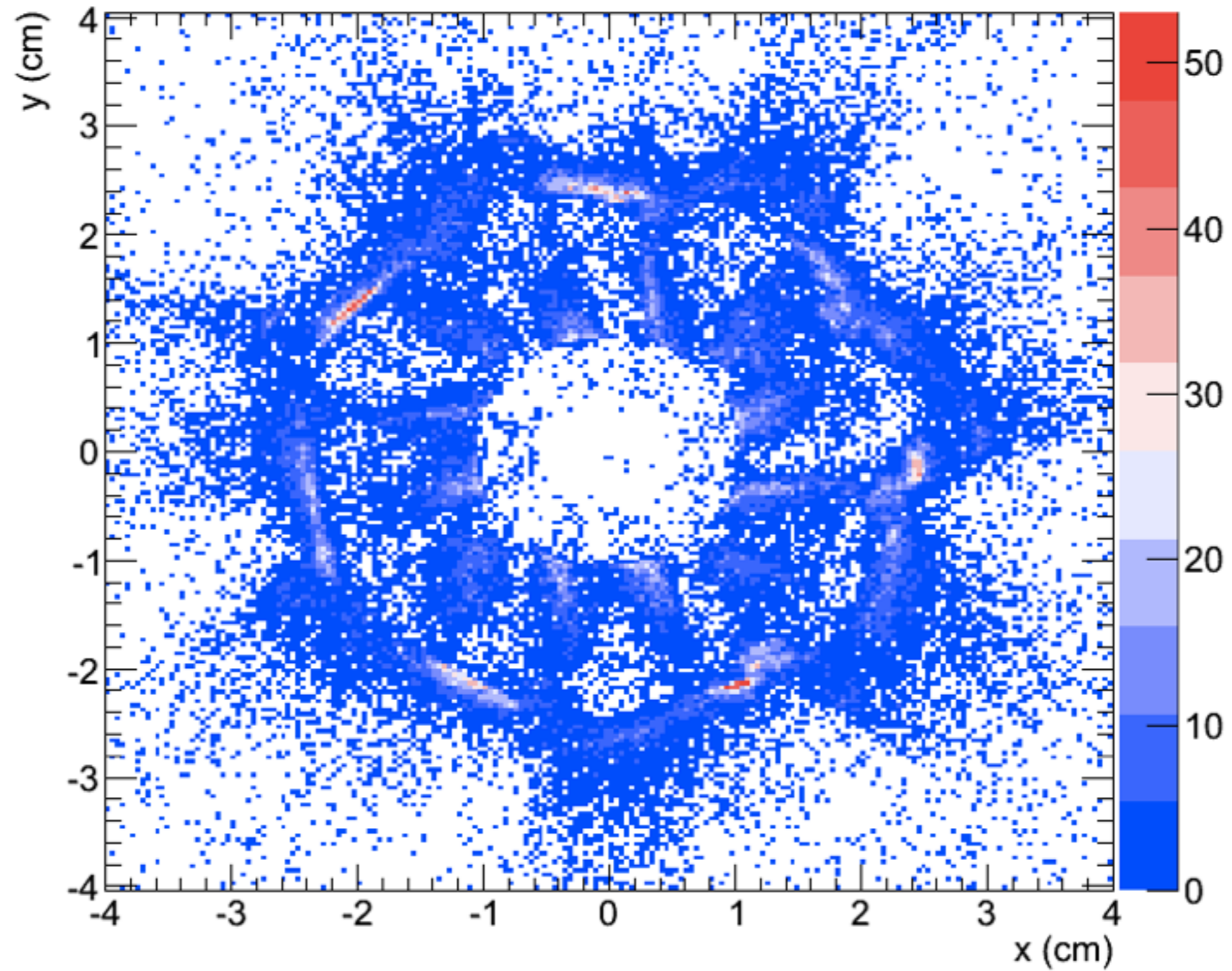
<https://agenda.infn.it/getFile.py/access?resId=0&materialId=slides&contribId=7&sessionId=3&subContId=1&confId=8680>

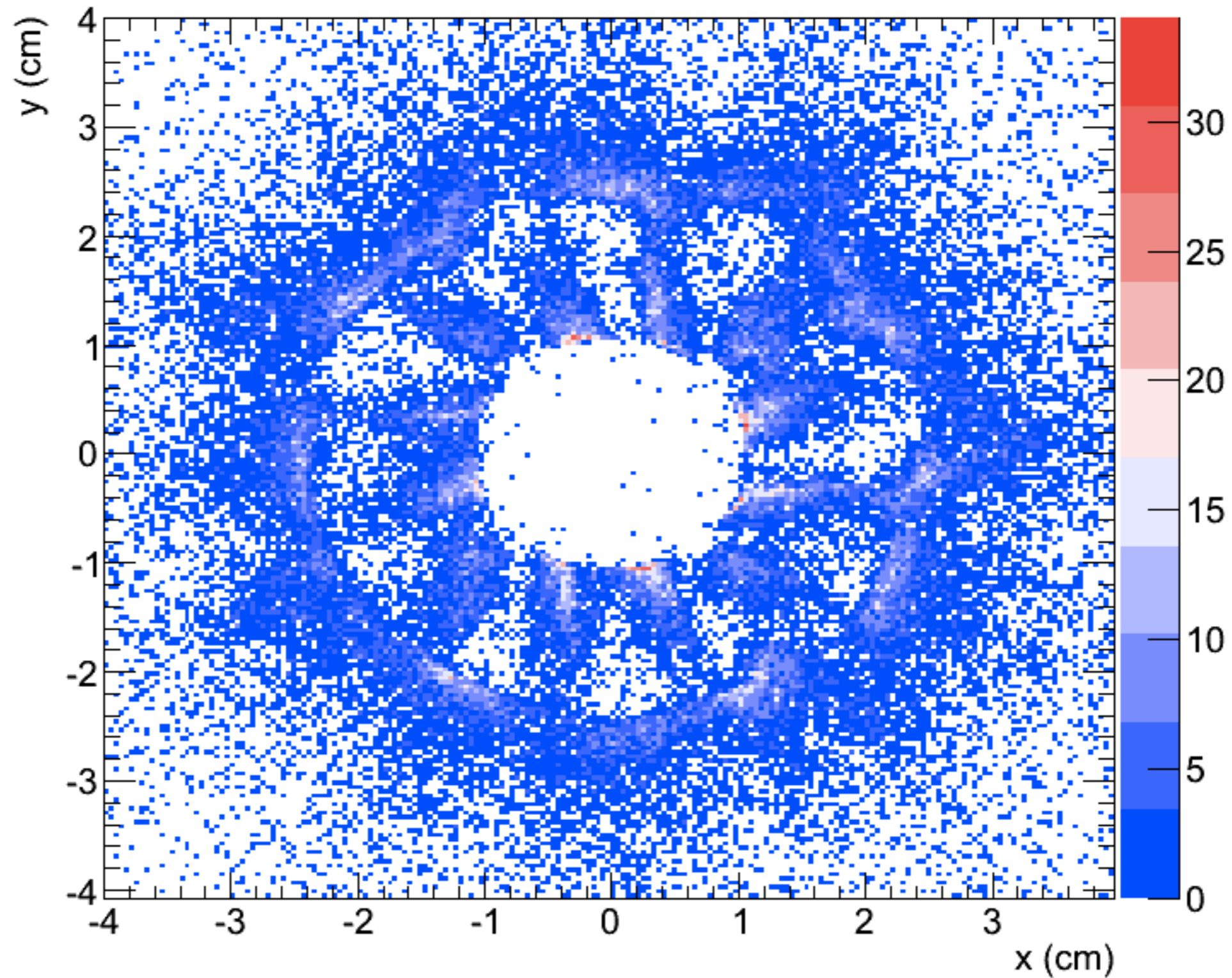
σ_{d0} VS transverse momentum

→ 3 families of tracks:

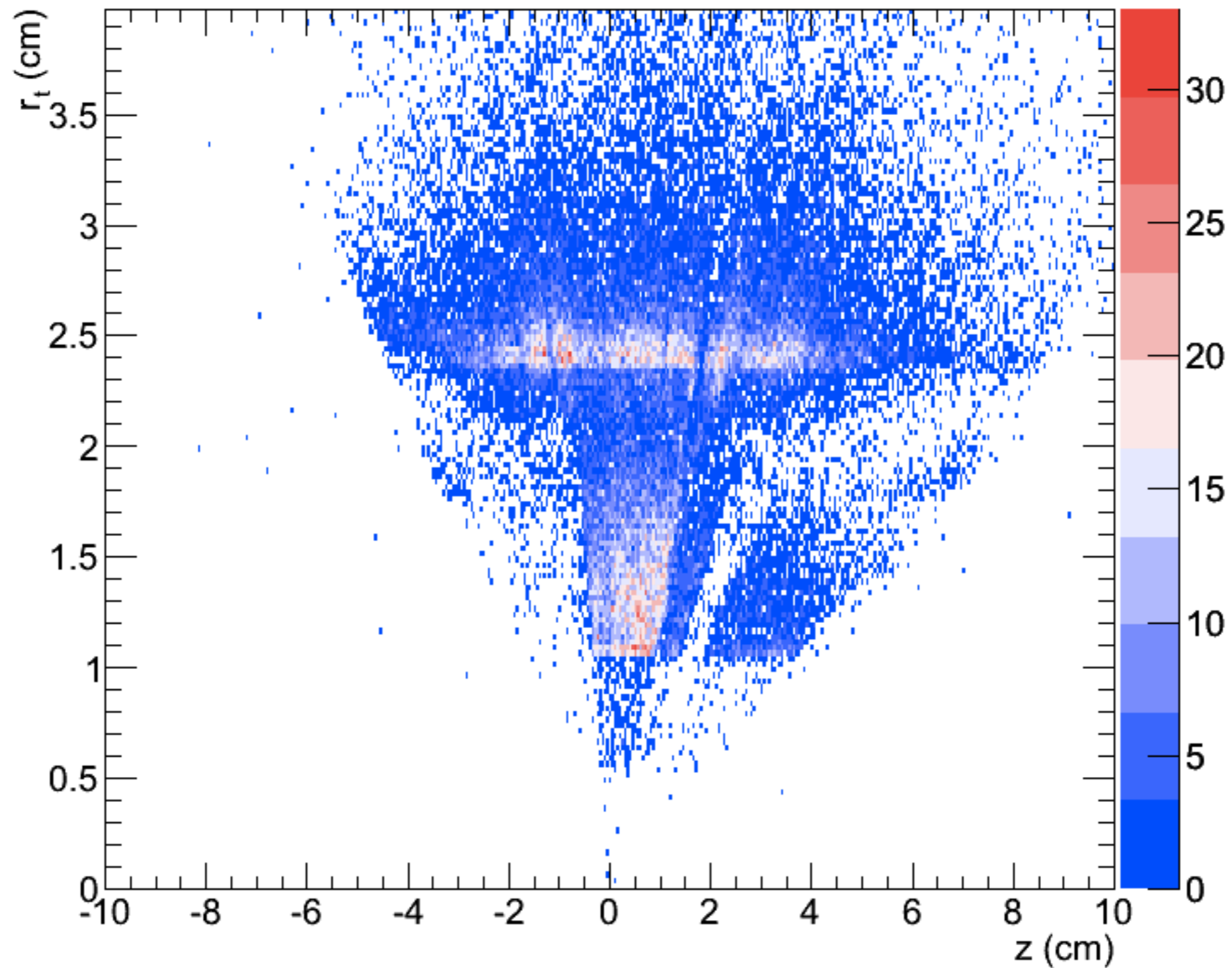
- ★ CDC only tracks
- ★ tracks with no PXD clusters attached
- ★ tracks with PXD clusters attached

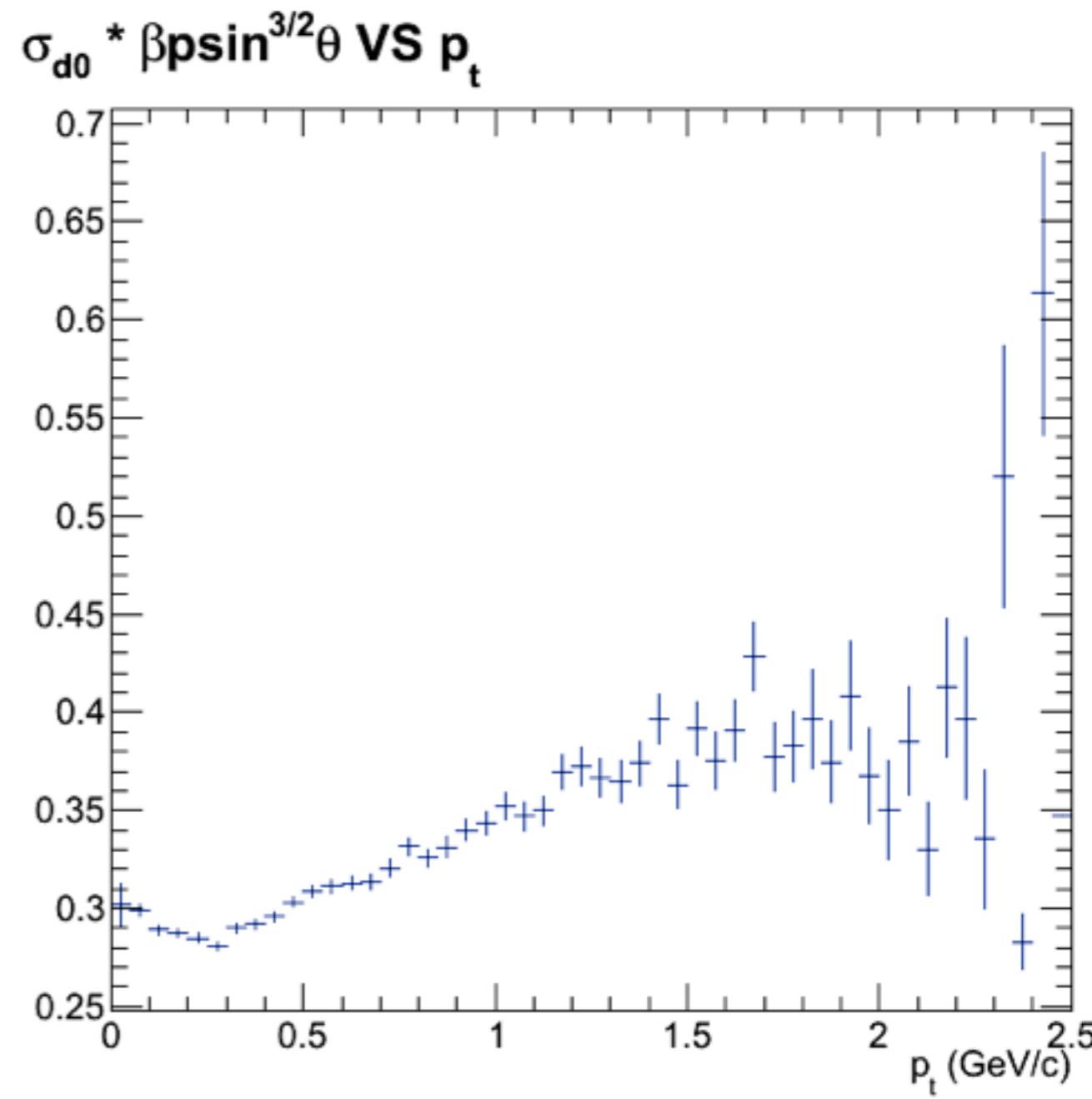
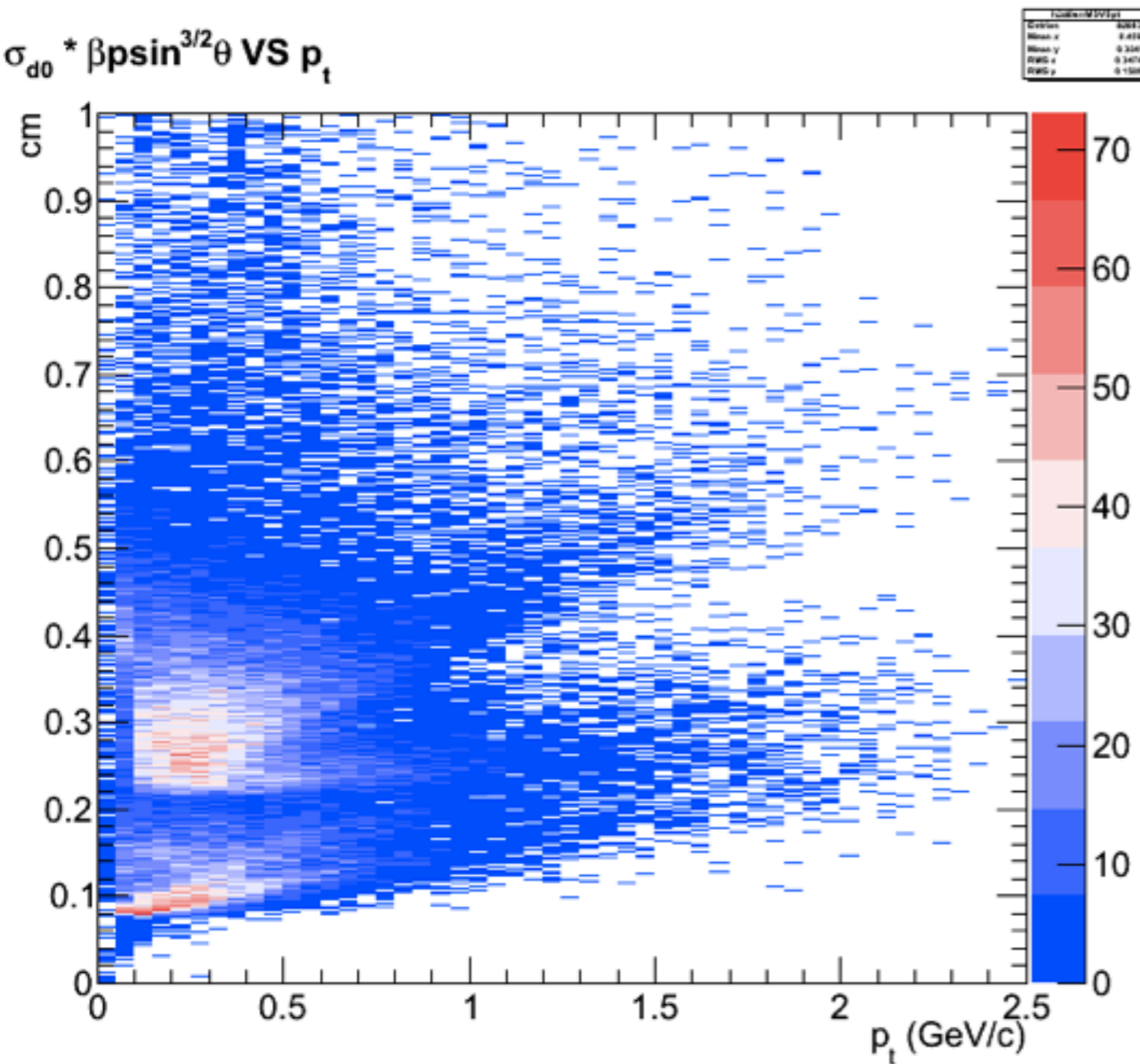
σ_{d0}/σ_ϕ projected on x,y



$\sigma_{z0}/\sigma_{\cot\theta}$ projected on x,y

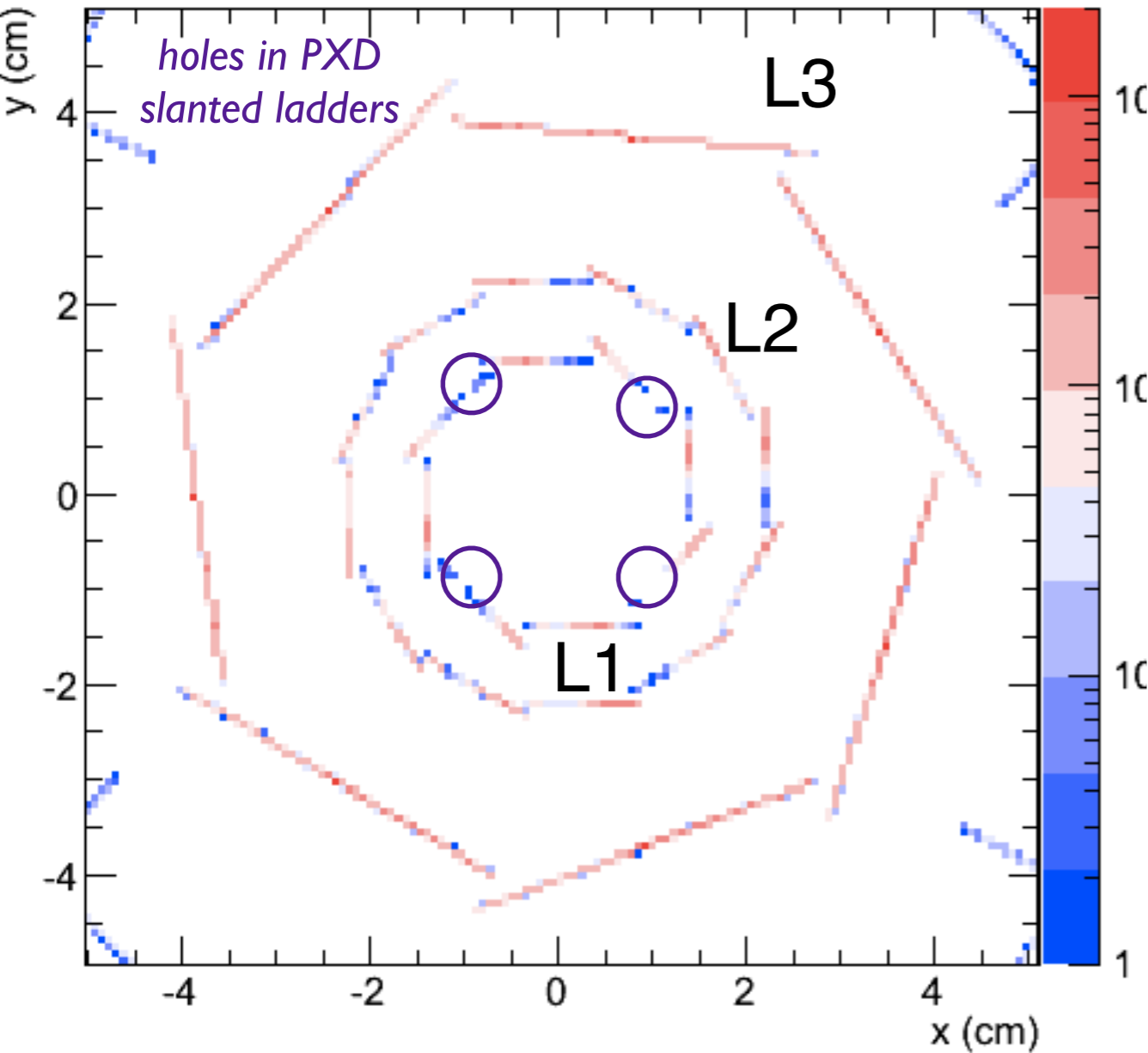
σ_{d0}/σ_ϕ projected on z and $r_t = \sqrt{x^2+y^2}$





VXD Clusters used in the Track Fit

used in the Track Fit: transverse view



hits used in the Track Fit: longitudinal view

