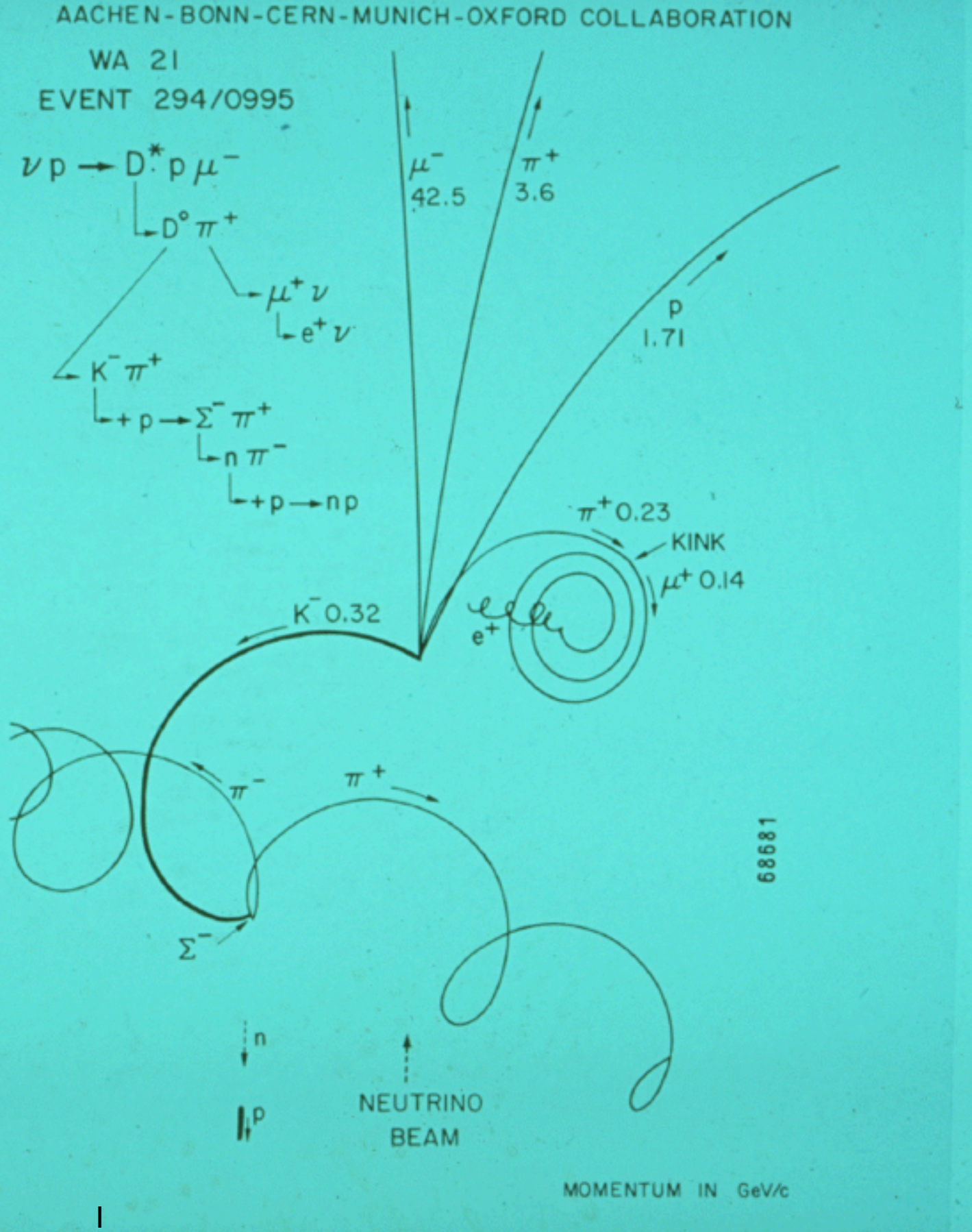
Tracking

E. P.

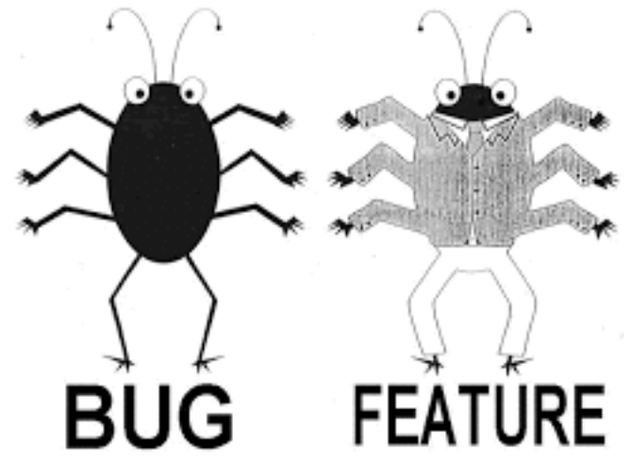
INFN & Università di Pisa

for the Tracking Group



BASF2 Release 1.00

BASF2 Release 1 New Features



- VXDTF2 ON STAGE!
  - bug fixes, new filters, SVD timing cuts, early removal of bad candidates, better training.
- Fit with multiple mass hypothesis (pion, kaon, proton)
- More V0 candidates stored on MDST: Ks, Lambdas, photon conversions
- Combinatorial Kalman Finder (find, extrapolate, attach)
- CDC t_0 finders.

CDC Tracking

- We are learning from the CDC cosmic data sample
  - Track parameters resolution and error estimate correctness
  - CDC based t_0 finding
- We need a dedicated task force and a better communication with the CDC, the L1 and the HLT teams

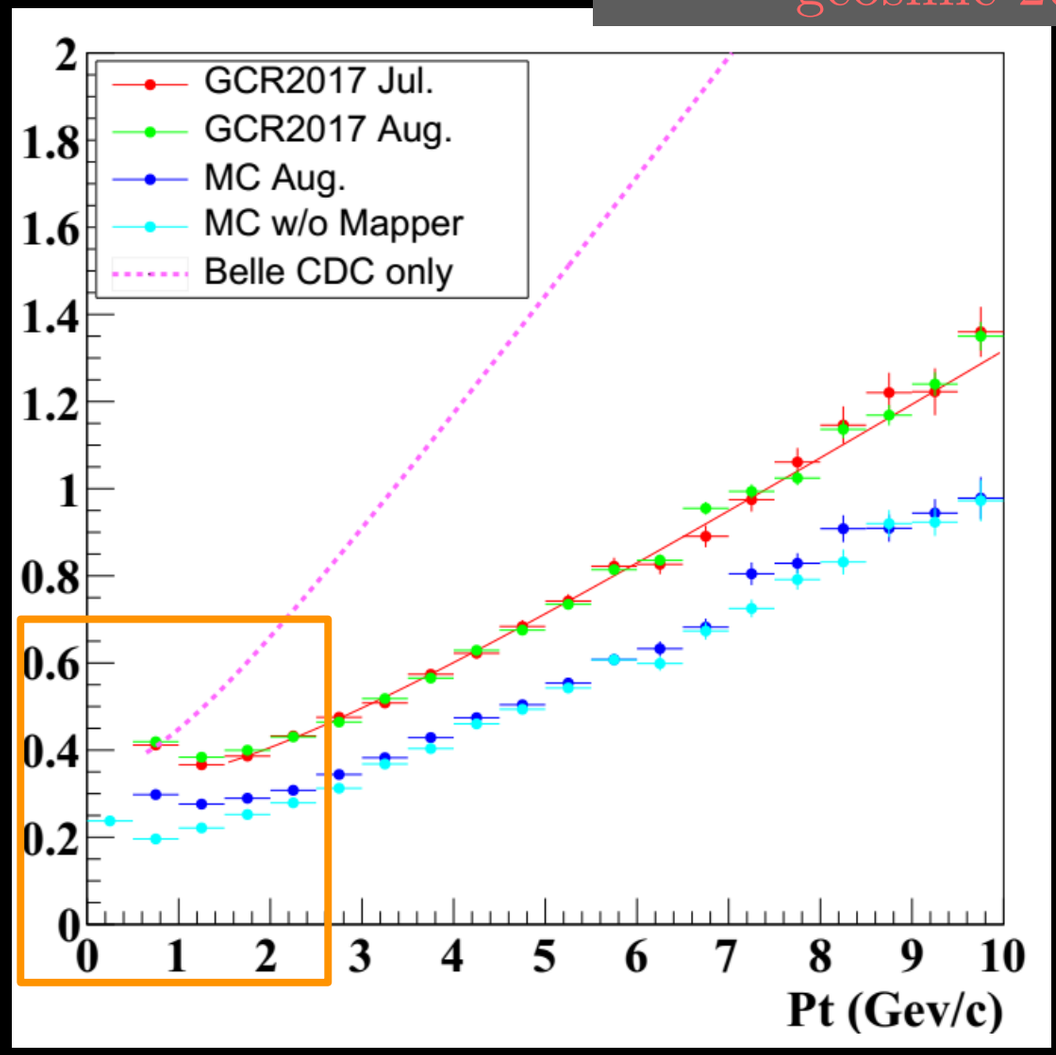
D. V. Thanh (Soken,KEK)
M. Uchida (TIT)

Pt resolution

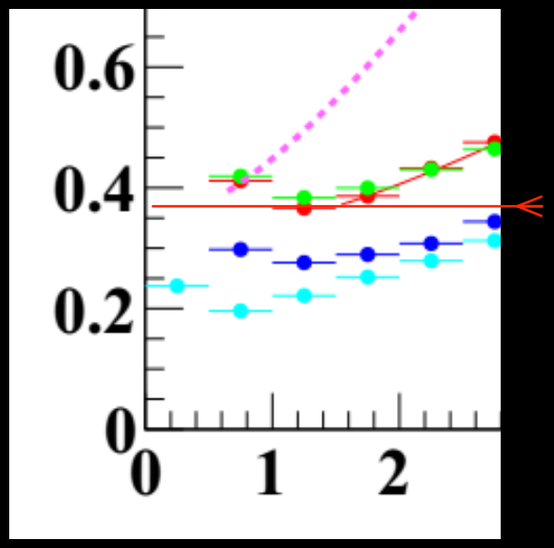
Belle CDC only (cosmic) $\sim 0.28P_t \oplus 0.35$

gcosmic 2017 July $\sim 0.13P_t \oplus 0.31$

Pt resolution (%)



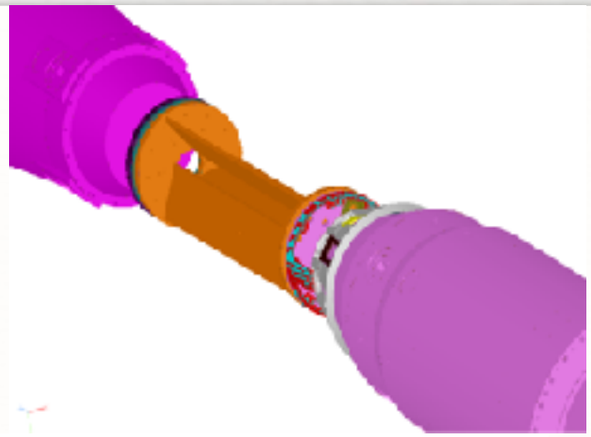
0.38% at 1.5GeV/c

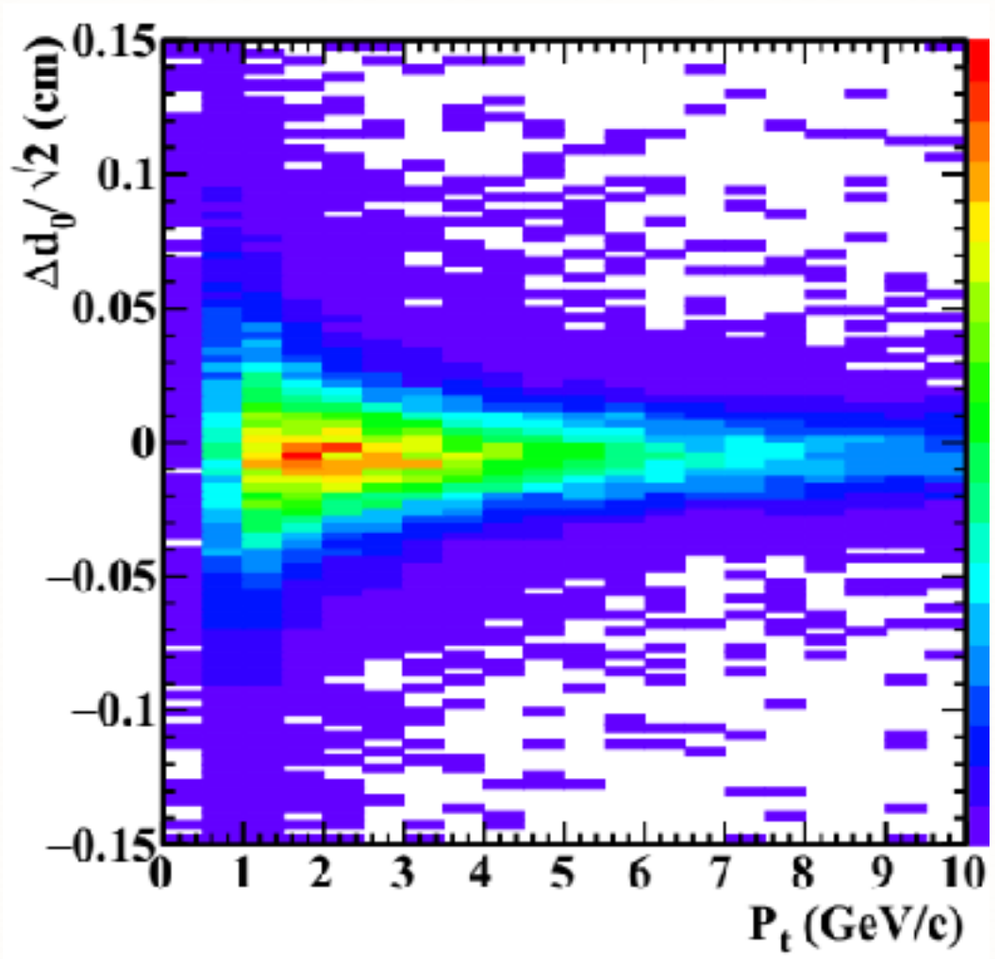


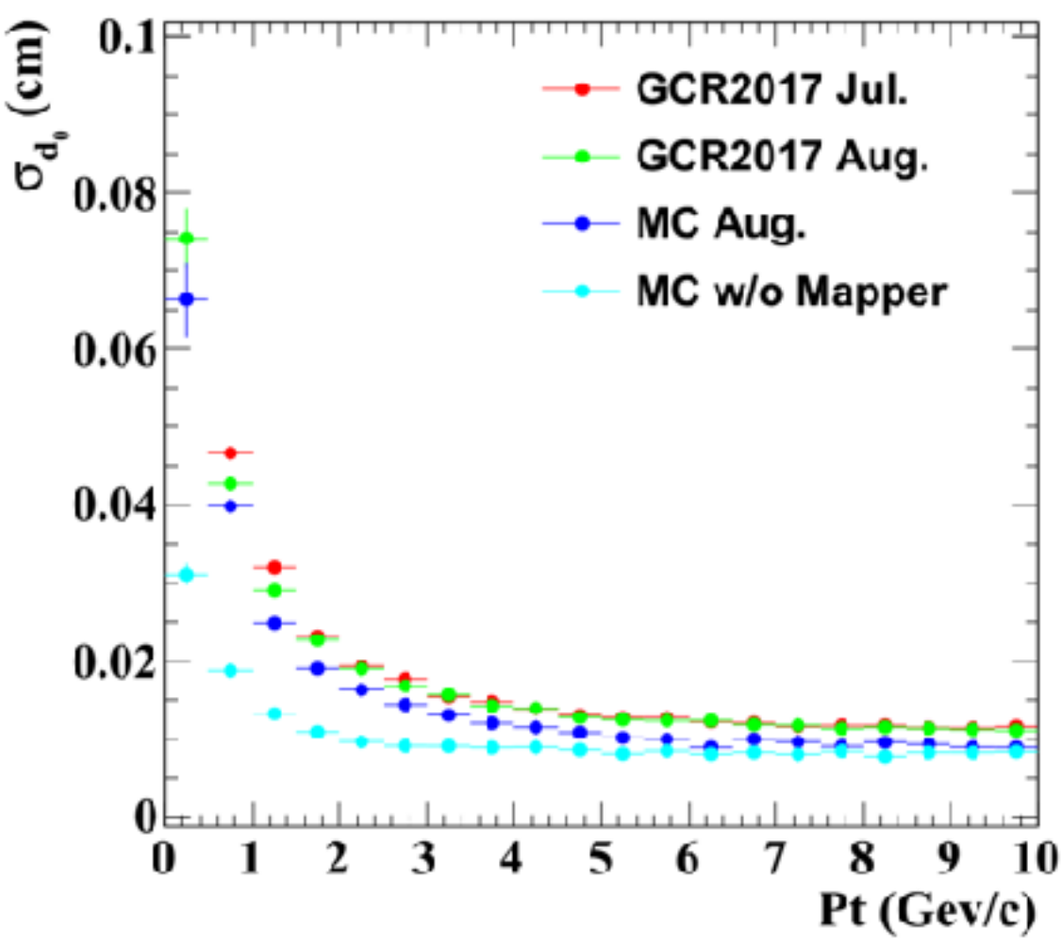
- much improvement by better calibration and alignment
- improvement in high momentum region because of longer lever arm compared with Belle CDC as expected
- we will take local cosmic run to correct remaining mis-alignment
  - large data is necessary for wire-by-wire alignment

d_0 resolution studies

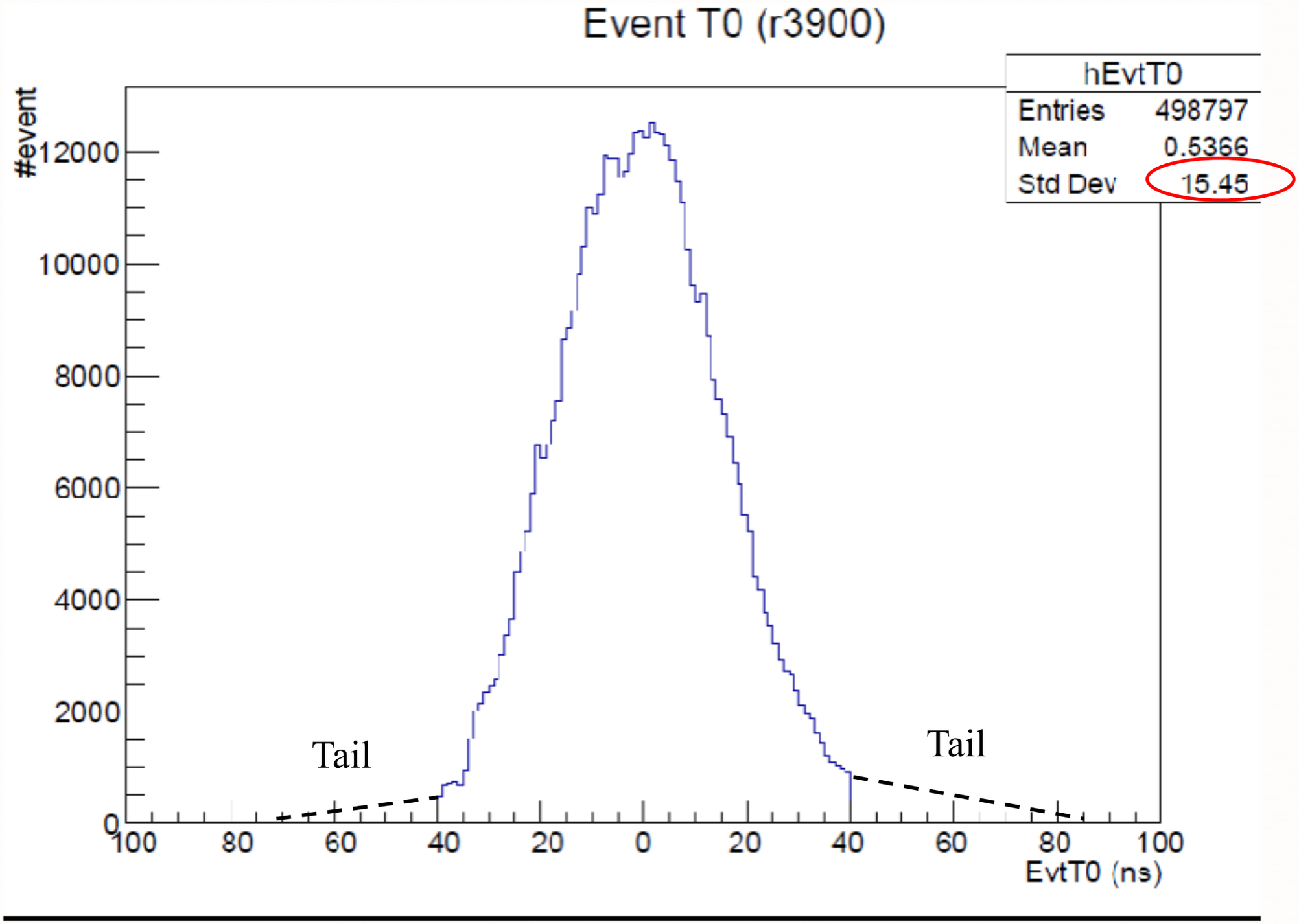
- Additional material from the field mapper:
  3 slabs of Aluminum 1.2 cm thick





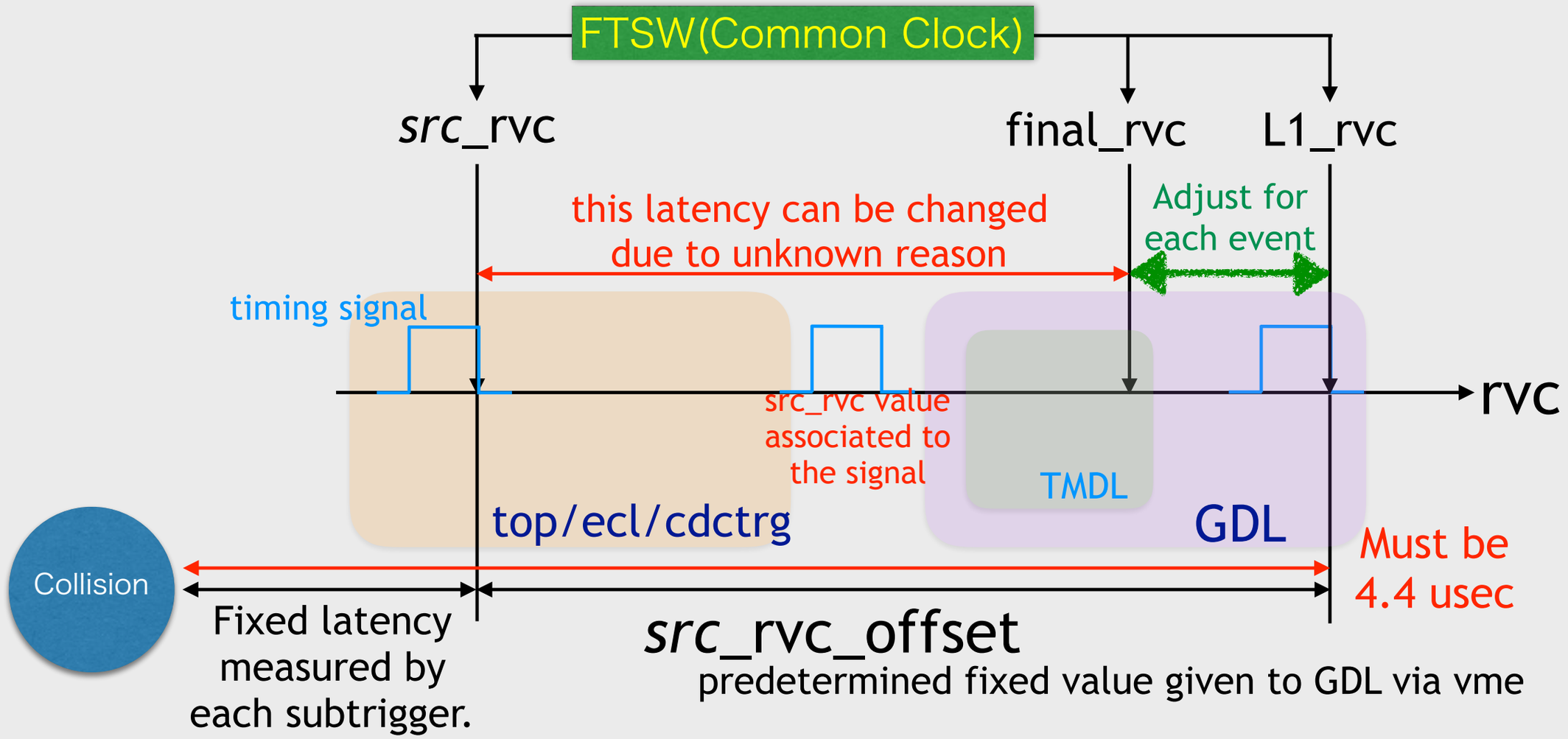


T0 Determination



To From L1 (Nakazawa B2GM Oct 2017)

Timing Adjustment using rvc (revolution clock)

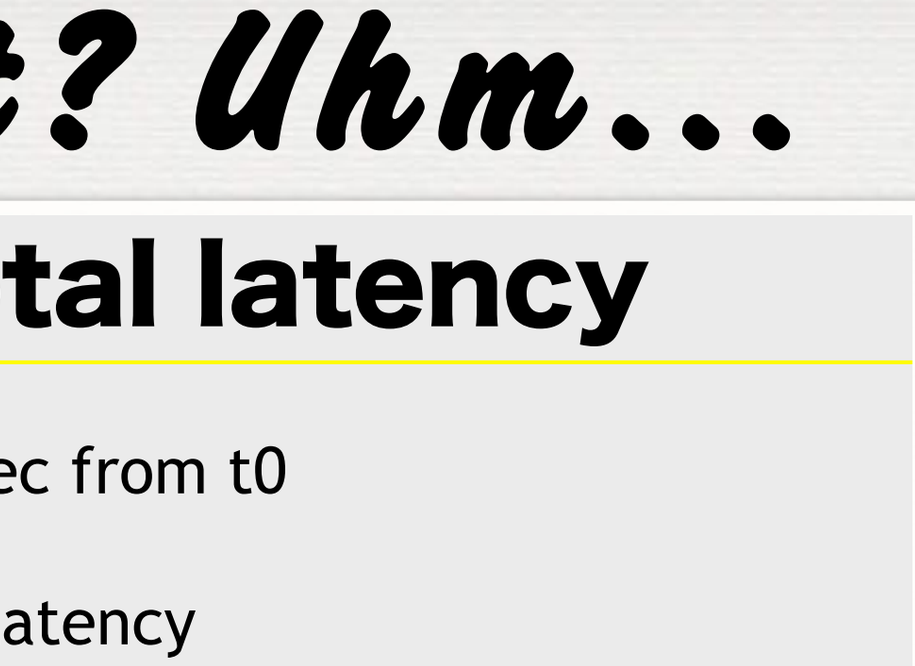


⟷ is calculated event by event on GDL as
src_rvc + src_rvc_offset - final_rvc

Clear, Isn't It? Uhm...

Comments on total latency

- We are not sure
  - if GDL generates L1 at 4.4 usec from t0
- We are sure that
  - GDL generates L1 with fixed latency
  - common L1 is given to CDCFEE after ~5 usec from t0
- ~5 usec is not the final value
  - Serious latency study has not started yet



nkzw 10 B2GMCDC201710

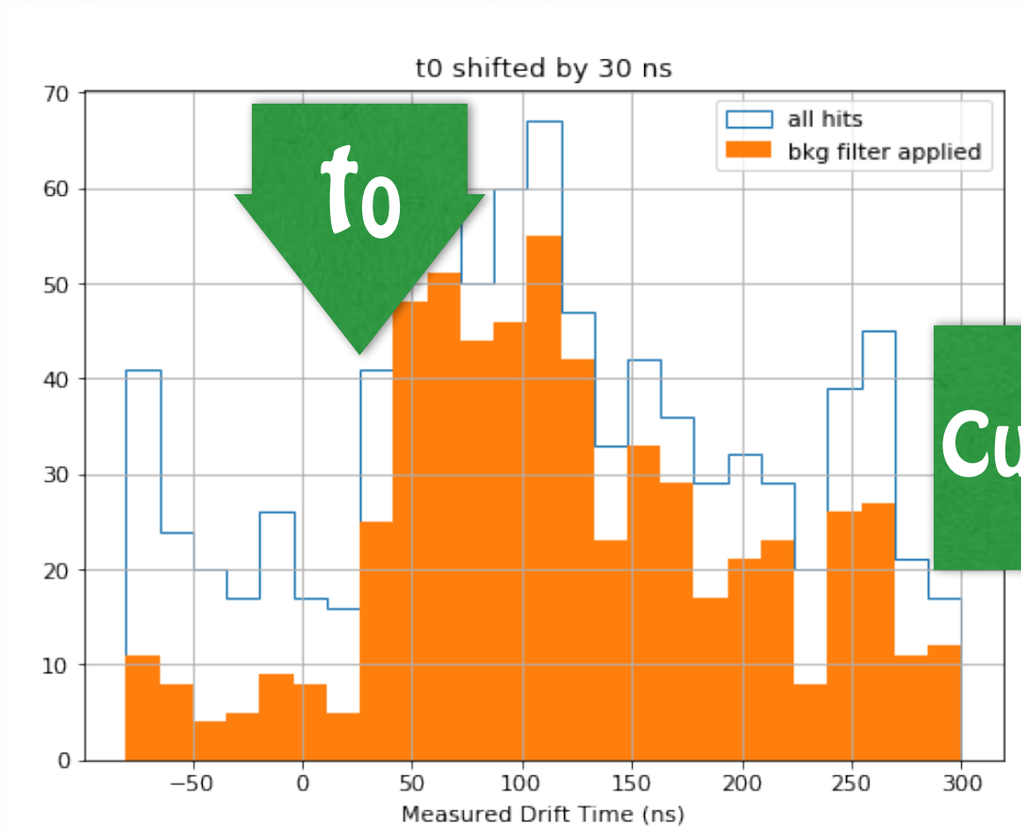
The Quest For The Holy To

- Apparently we are realizing only now that we have to determine the t_0
  - SVD: L1 trigger RMS jitter few ns
  - CDC: few ns during reconstruction
  - CDC: few ps during reconstruction
  - ECL: few ns during reconstruction
- Meeting last week to find a common strategy for the HLT and the final reconstruction

"I got it on eBay."

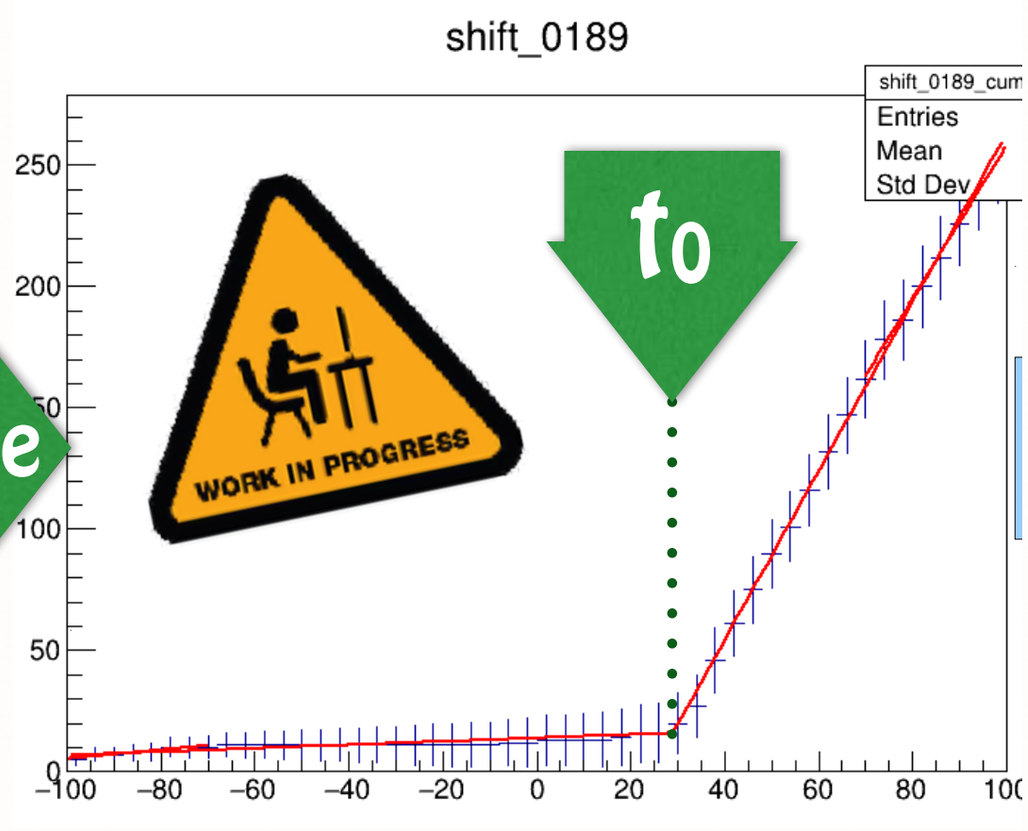
Cdc T_0 Determination

- Fast rough determination of the t_0 from the CDC hits
- Look for a sudden jump on the # CDC hits
- 4 ms/event can be executed on the HLT



to

Cumulate

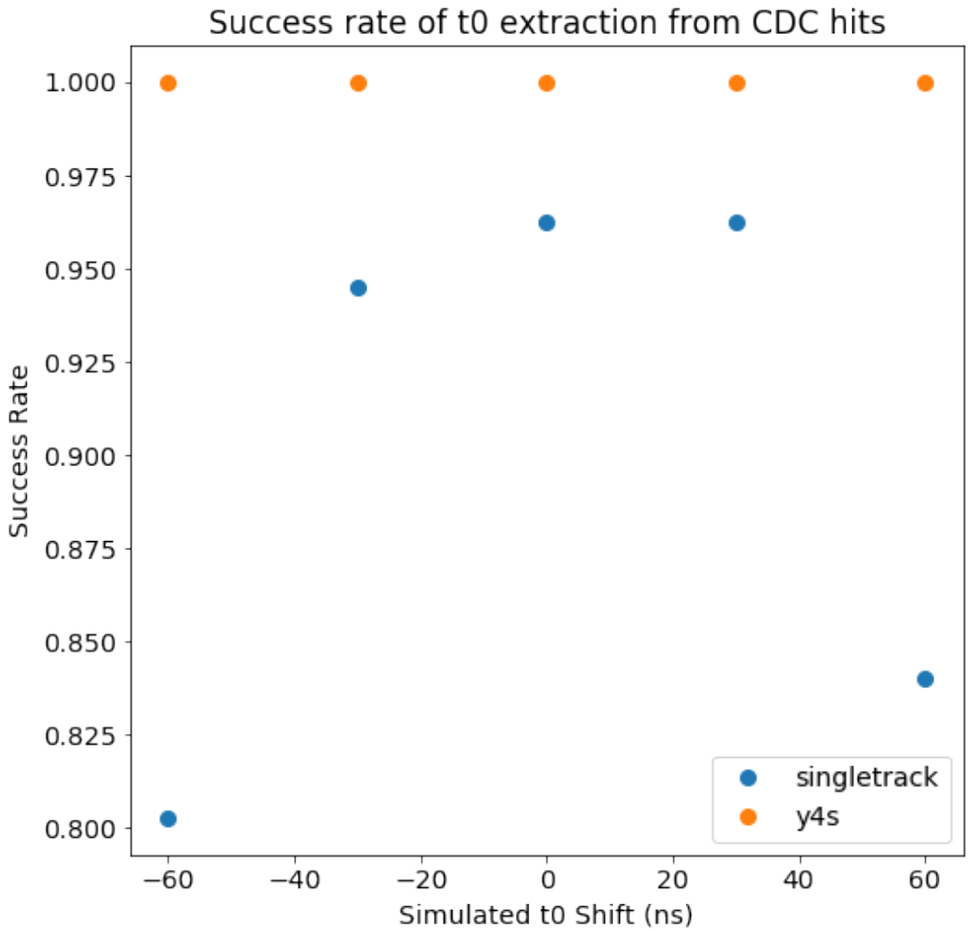


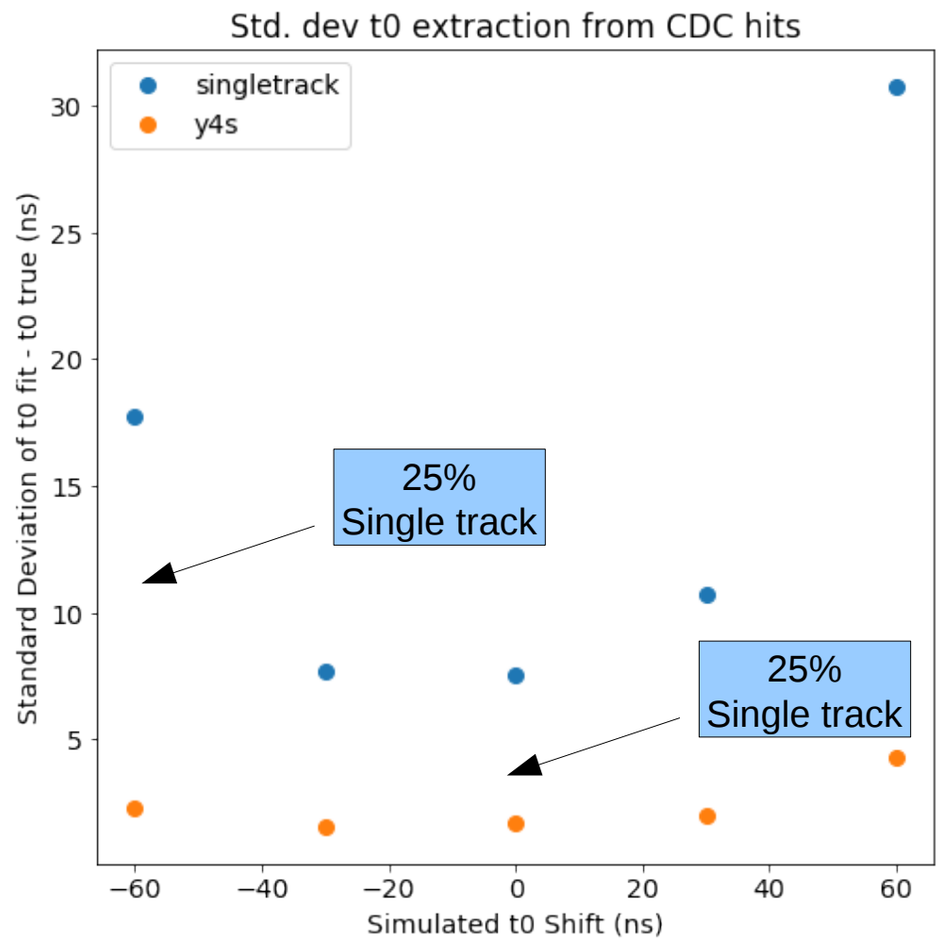
to

To Success Rate And Resolution

Full Phase III Background

- Still working very well
- The uncertainty on the extracted t0 is large for single track, esp. for large t0 shifts





VXDTF2: Finally on Your Screens!

- The VXDTF2 will be the default SVD track finder in release 1.0.
  - We are still tuning its filters and the training procedure (cfr Valerio's talk)
  - We would like to collect users comments to improve its performances (cfr. Alessandro Gaz B-> Φ Ks)

Users Perspective (release 9)

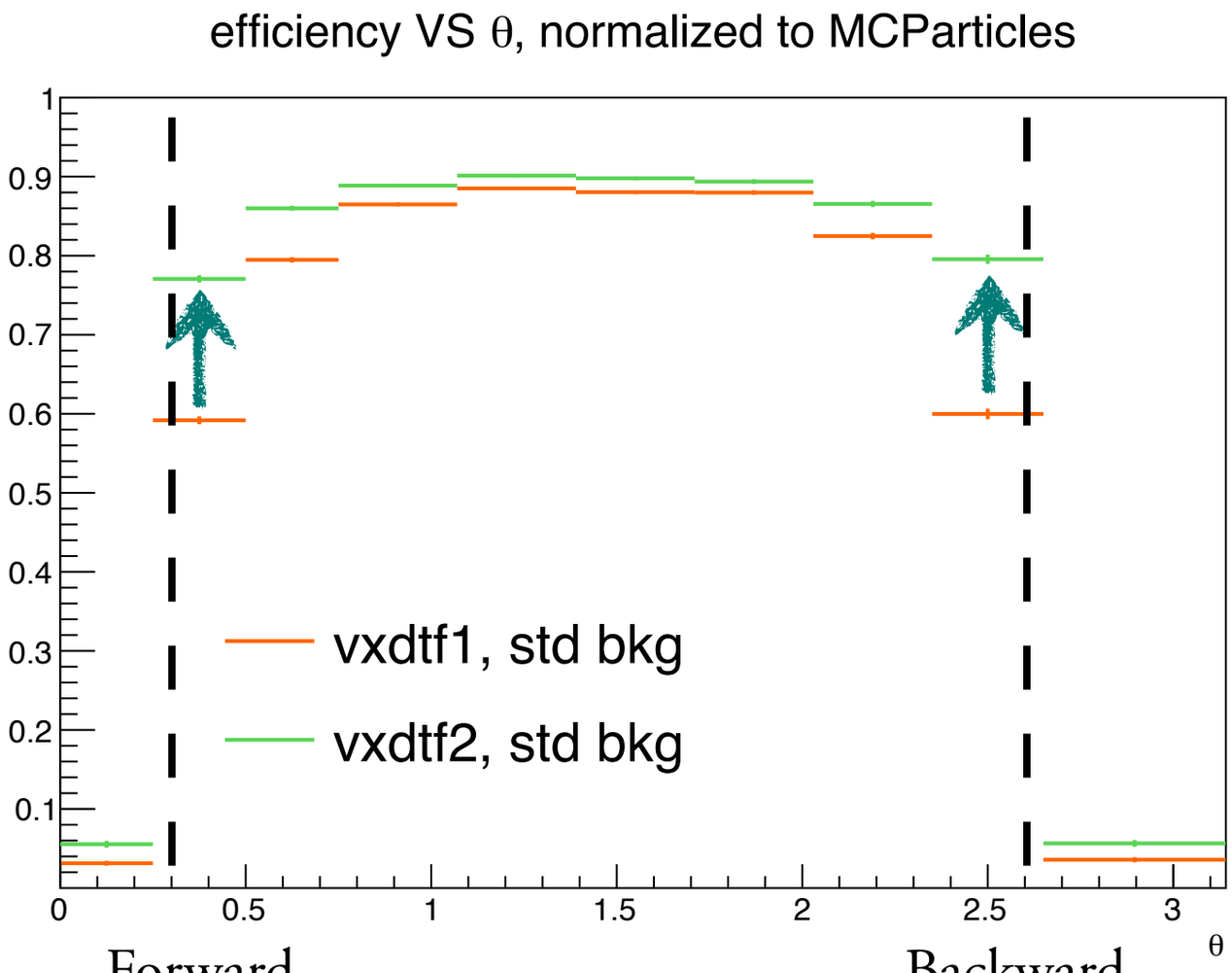
Tracking efficiency on Y(4S) generic events with (without) the expected background at full luminosity.

INTEGRATED EFFICIENCIES	vxdtf version	tracking ε	ε factoring out geom accept	vxdtf ε
noBKG	VXDTF1	(84.8 ± 0.1)%	(94.9 ± 0.1)%	(87.8 ± 0.1)%
	VXDTF2	(86.0 ± 0.1)%	(96.2 ± 0.1)%	(88.9 ± 0.1)%
stdBKG	VXDTF1	(77.5 ± 0.1)%	(86.9 ± 0.1)%	(78.3 ± 0.1)%
	VXDTF2	(82.4 ± 0.1)%	(92.4 ± 0.1)%	(82.6 ± 0.1)%

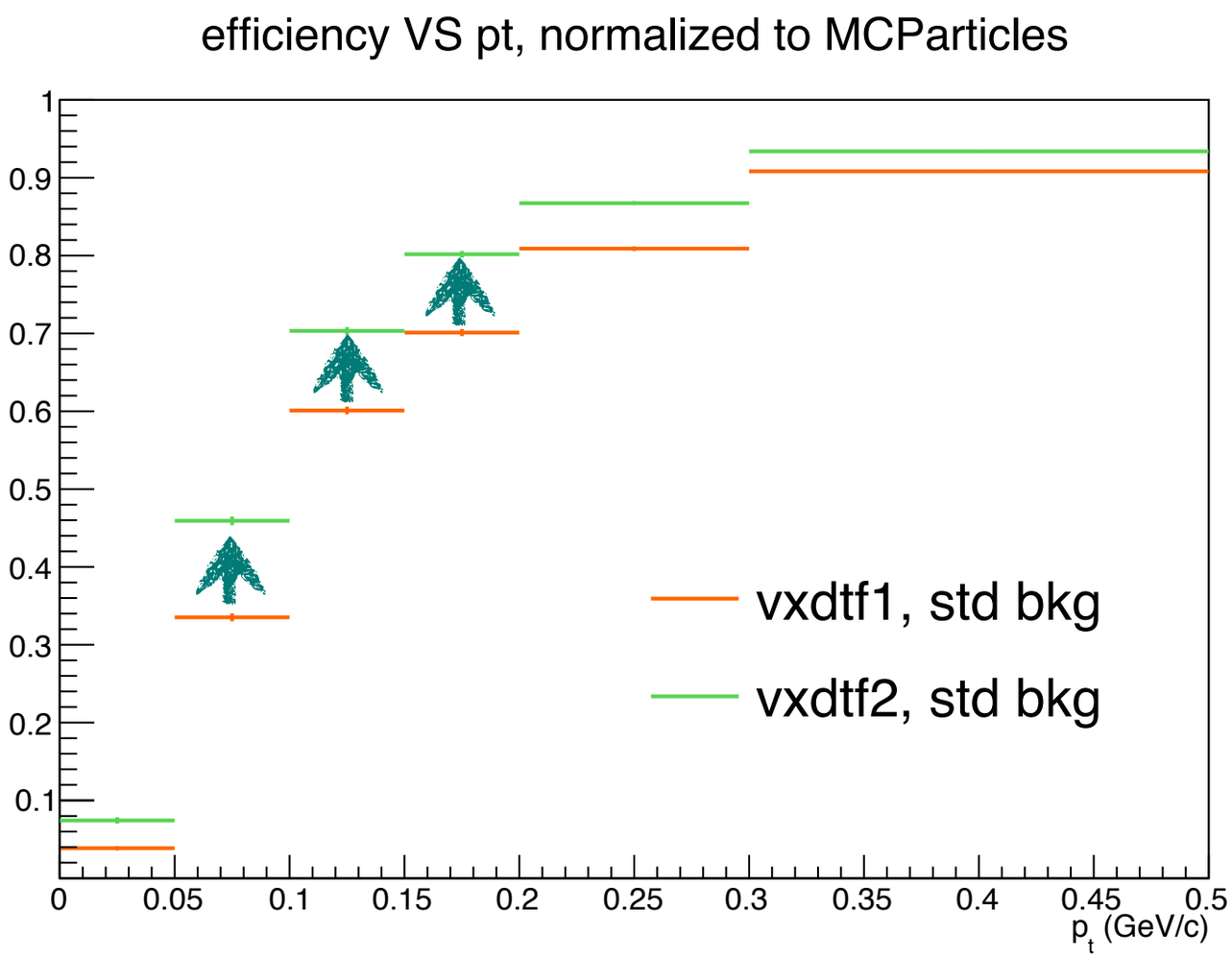
Overall we are delivering
an additional 5% of good tracks to the user

We are gaining at the edge of the acceptance boundary

- Overall tracking efficiency (VXD+CDC, pattern recognition & fitting) on Y(4S) events with nominal background conditions.



Polar angle



Transverse momentum

Users Perspective (release 9 no background): B -> ϕ K_s

ϕ[K^+K^-] $K_S[\pi^+\pi^-]$ efficiency breakdown

BGx0 **VXDTF1** **VXDTF2**

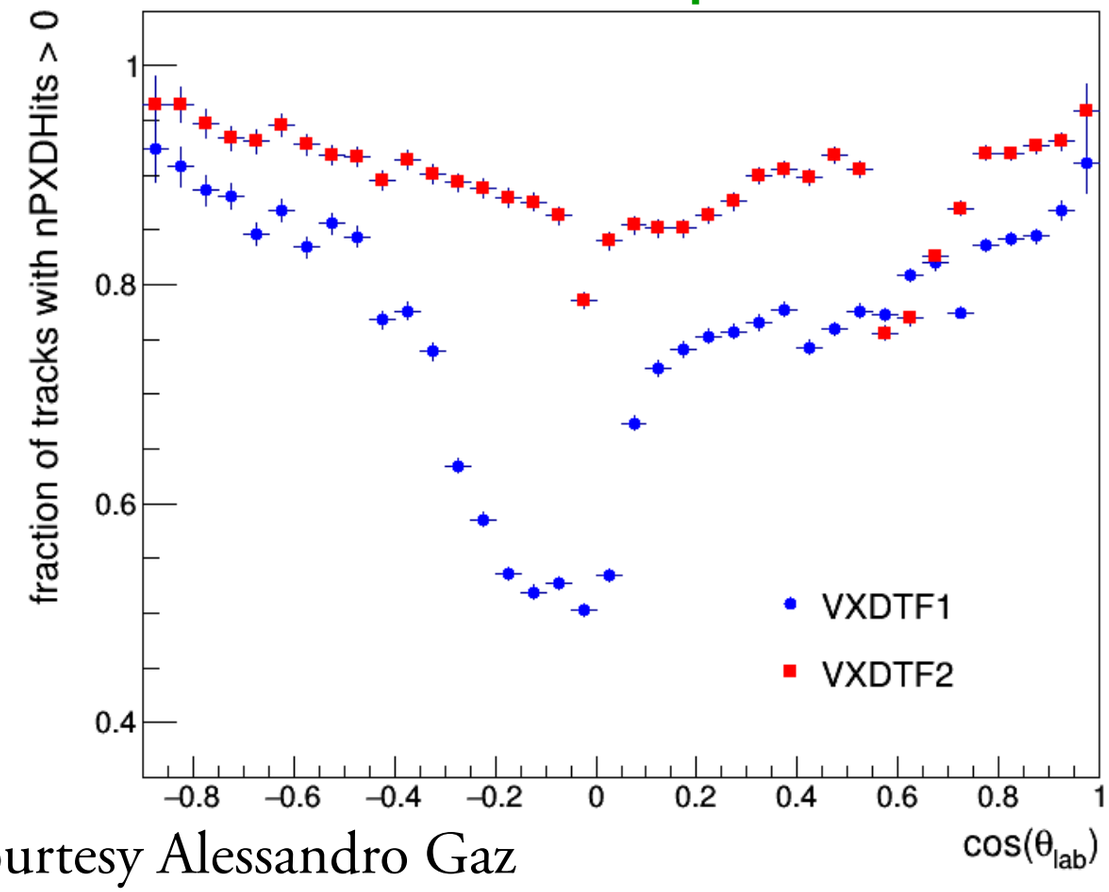
	Efficiency	Rel. efficiency	Efficiency	Rel. efficiency
Reconstructed (M_{bc} > 5.25, |ΔE| < 0.2)	47.5%	47.5%	49.9%	49.9%
M(ϕ) cut	45.7%	96.1%	47.9%	96.1%
d_0(K) cut	43.3%	97.0%	46.4%	96.9%
z_0(K) cut	44.3%	97.7%	45.5%	98.1%
PID(k)	39.0%	90.2%	41.1%	90.3%
K PXD hits cut	26.8%	68.6%	33.7%	82.0%
K_S VtxProb	26.4%	98.5%	33.2%	98.6%
ϕ VtxProb	25.9%	98.3%	32.8%	98.6%
B VtxProb	24.0%	92.6%	30.1%	91.8%

ϕ[$\pi^+\pi^-\pi^0$] $K_S[\pi^+\pi^-]$ efficiency breakdown

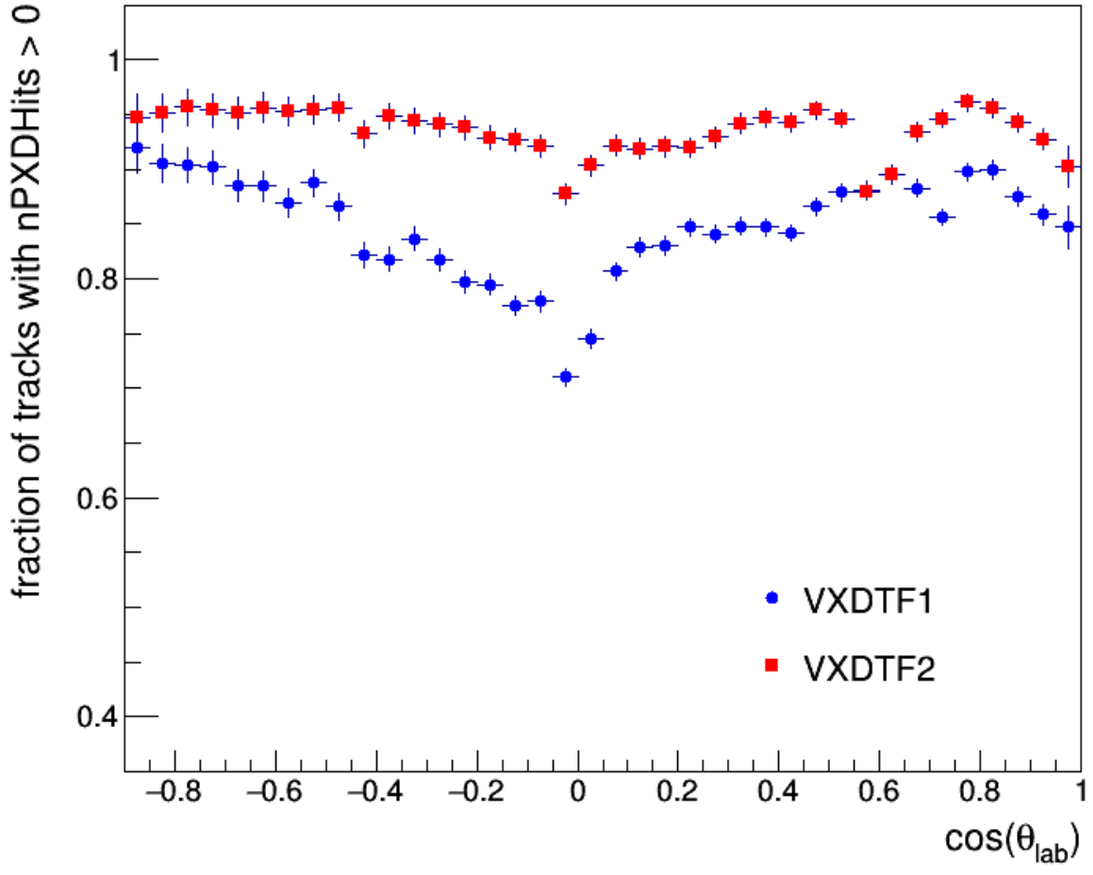
BGx0 **VXDTF1** **VXDTF2**

	Efficiency	Rel. efficiency	Efficiency	Rel. efficiency
Reconstructed (M_{bc} > 5.25, -0.1 <ΔE < 0.2)	30.9%	30.9%	31.8%	31.8%
M(π^0) cut	30.2%	97.5%	31.0%	97.5%
E(π^0) cut	27.1%	90.0%	27.8%	89.7%
M(ϕ) and M(K_S) cut	25.6%	94.3%	26.3%	94.5%
d_0(π) cut	24.3%	94.8%	25.1%	95.5%
z_0(π) cut	23.9%	98.4%	24.8%	98.8%
π PXD hits cut	18.8%	78.9%	23.0%	92.7%
K_S VtxProb	18.5%	98.3%	22.6%	98.4%
ϕ VtxProb	18.4%	99.3%	22.5%	99.9%
B VtxProb	18.1%	98.3%	22.0%	98.0%

Kaons from ϕ → K^+K^-



Pions from ϕ → $\pi^+\pi^-\pi^0$



Courtesy Alessandro Gaz

Memory Footprint Issue: To run on the < 2 GBytes

- ***VXDTF2 steps***

1. Find good triplets of space points using the Sector Map
2. Join the triplets using a Cellular Automaton
   - Seldom the number of candidates harvested by the Cellular Automaton exceeds 10^6
3. Solve the overlaps and find the best candidates
   - Overwhelming task if the candidates are order of 10^6

- ***How to reduce the number of candidates from the CA?***

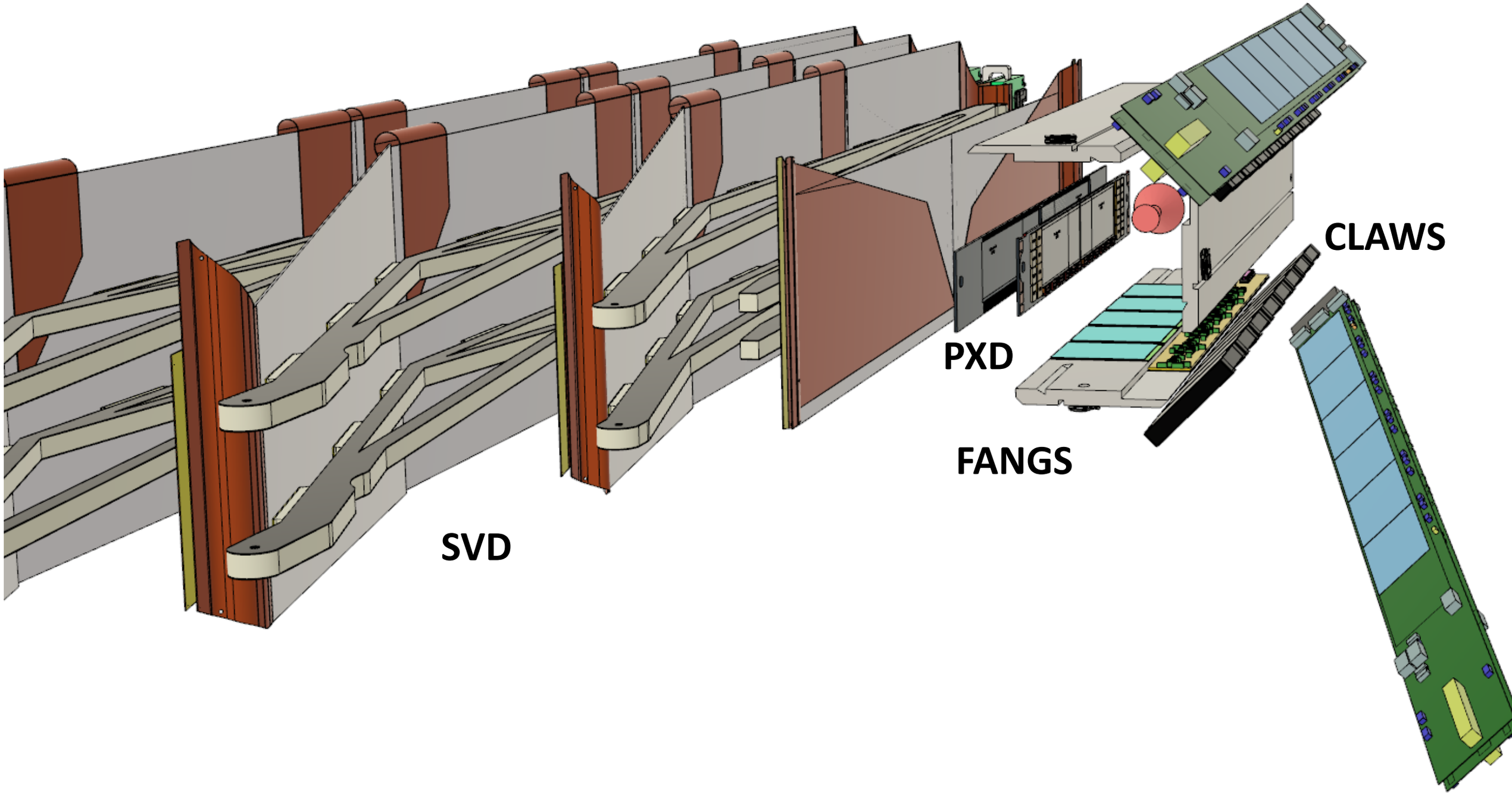
A. With a tighter time window for the SVD signals (120ns -> ~ 40ns)

B. With a slimmer Sectormap.

C. With a clever preselection of the good candidates from the CA.

- ***The code for A, B and C is available in release 1. We are tuning their parameters.***

Phase 2 Readiness



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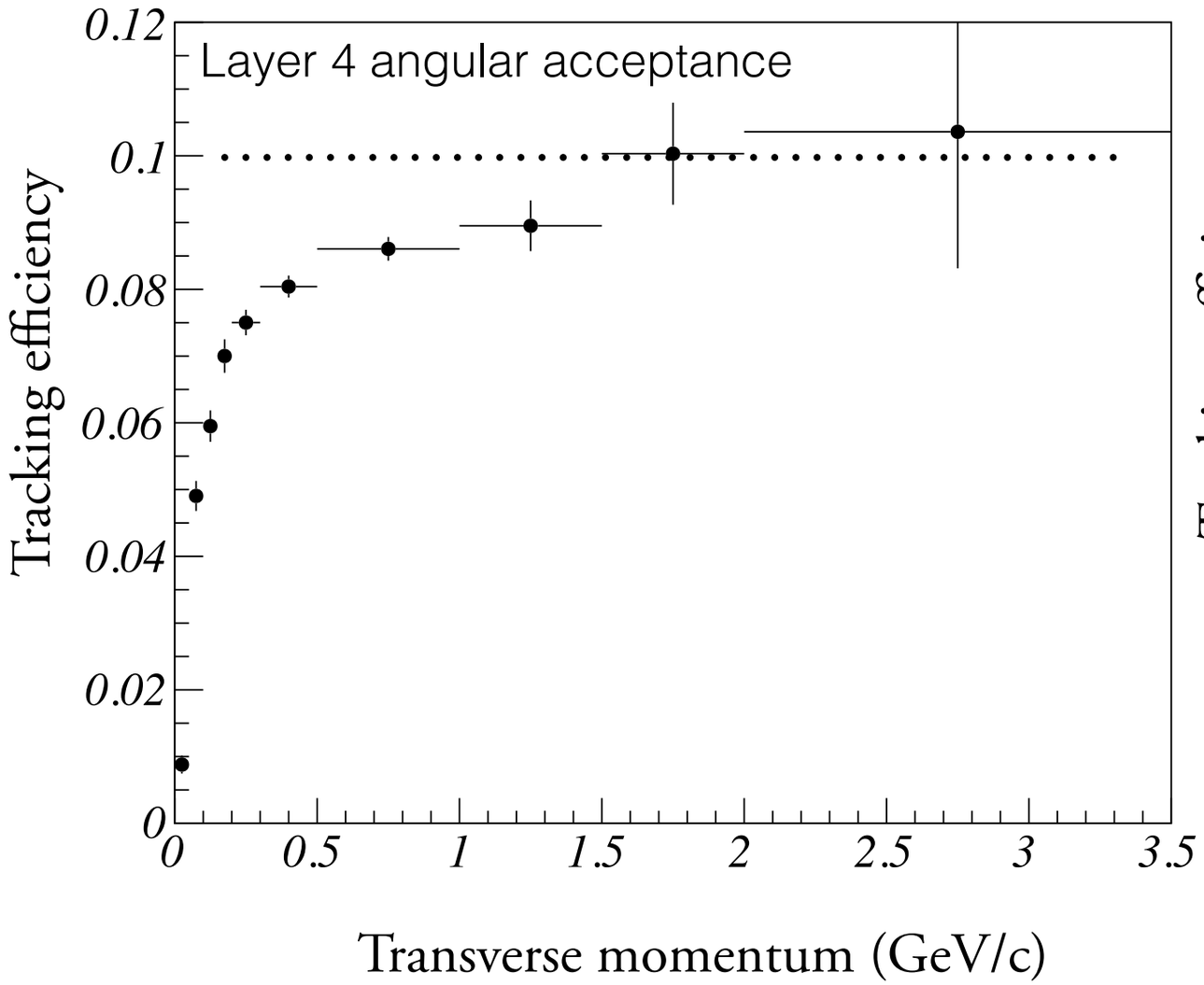
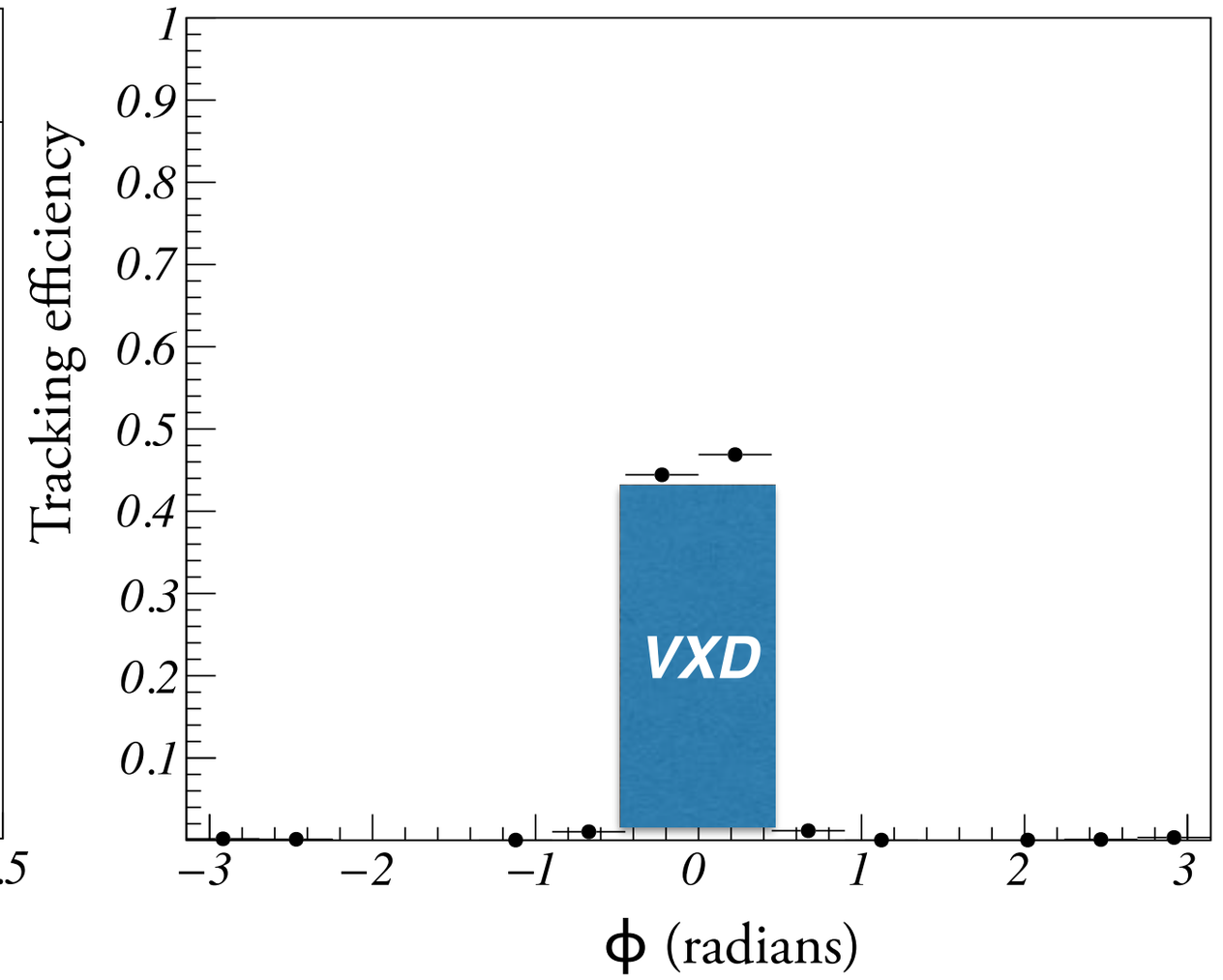
Phase 2

- ✦ Phase 2 geometry is quite different with respect to the one showed so far
- ✦ Same geometry used in the test beam:
  - 6 layers
  - one single ladder per layer
  - no pin wheel geometry

Overall tracking efficiency VXDTF2 in phase 2

- ✦ Yes, we are still able to find tracks by ourselves

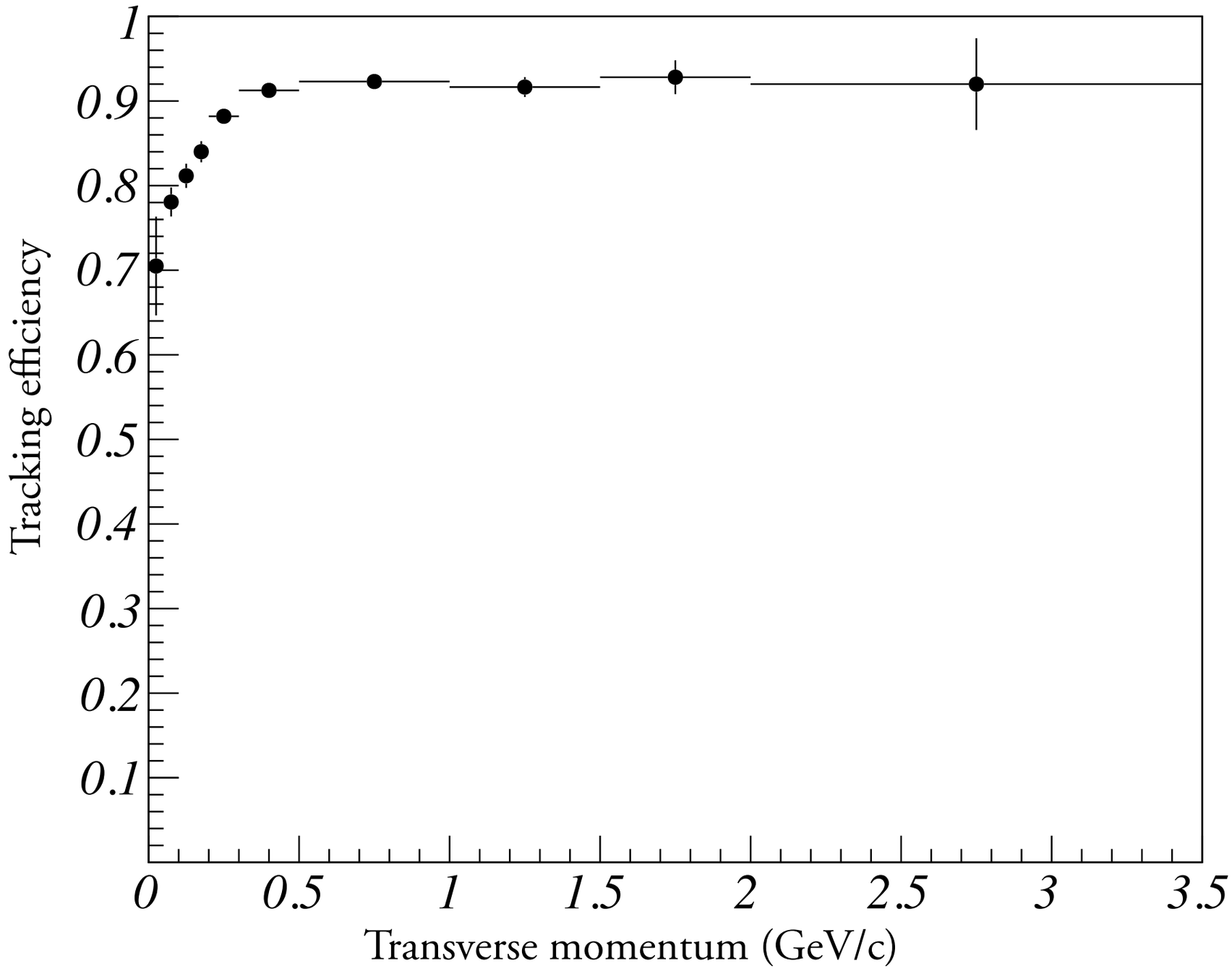




Phase 2 VXD used as a stand alone track device

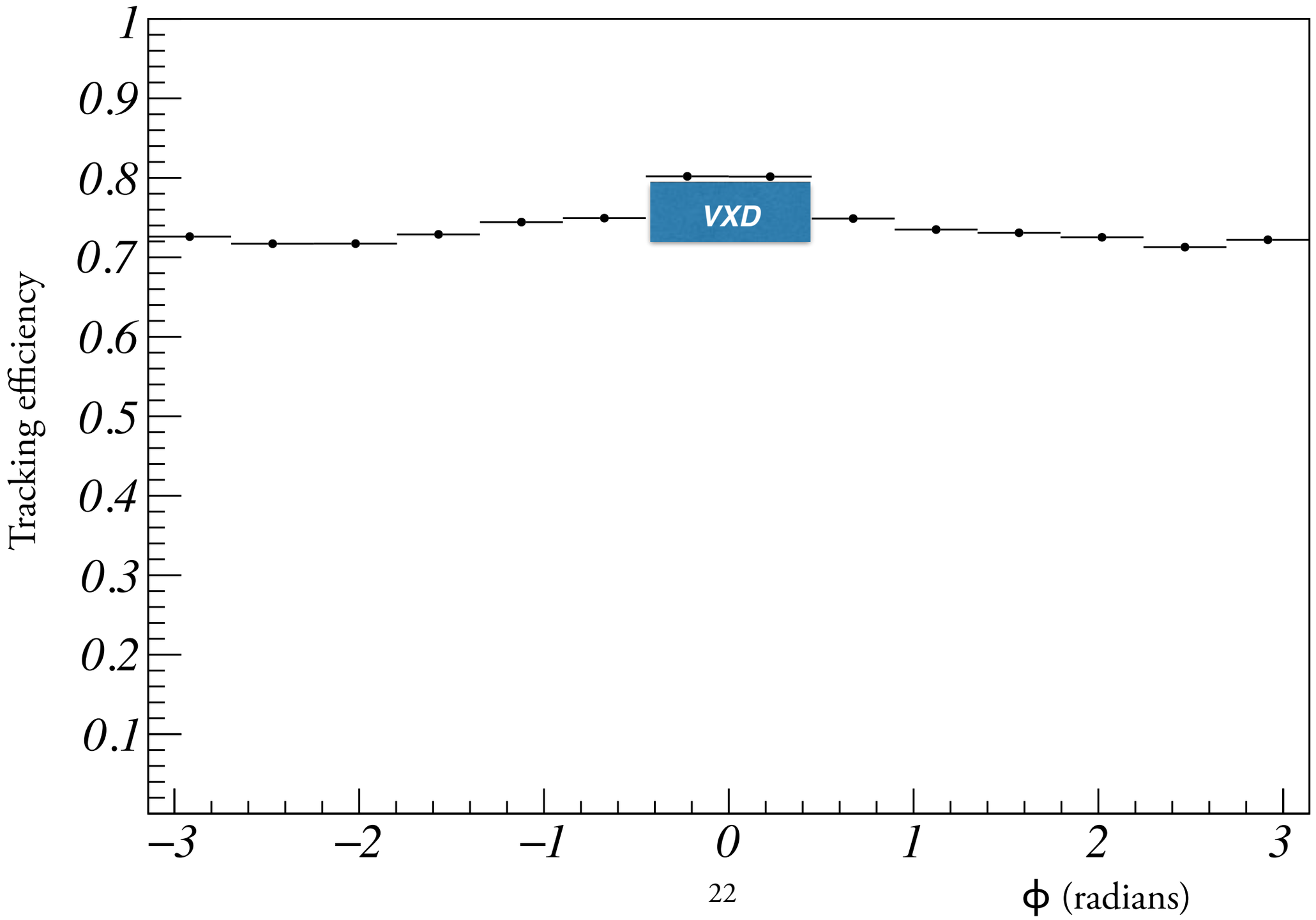
Efficiency normalized to "Trackable" tracks

- ✦ "Trackable": 3 or more sensors hit by the particle

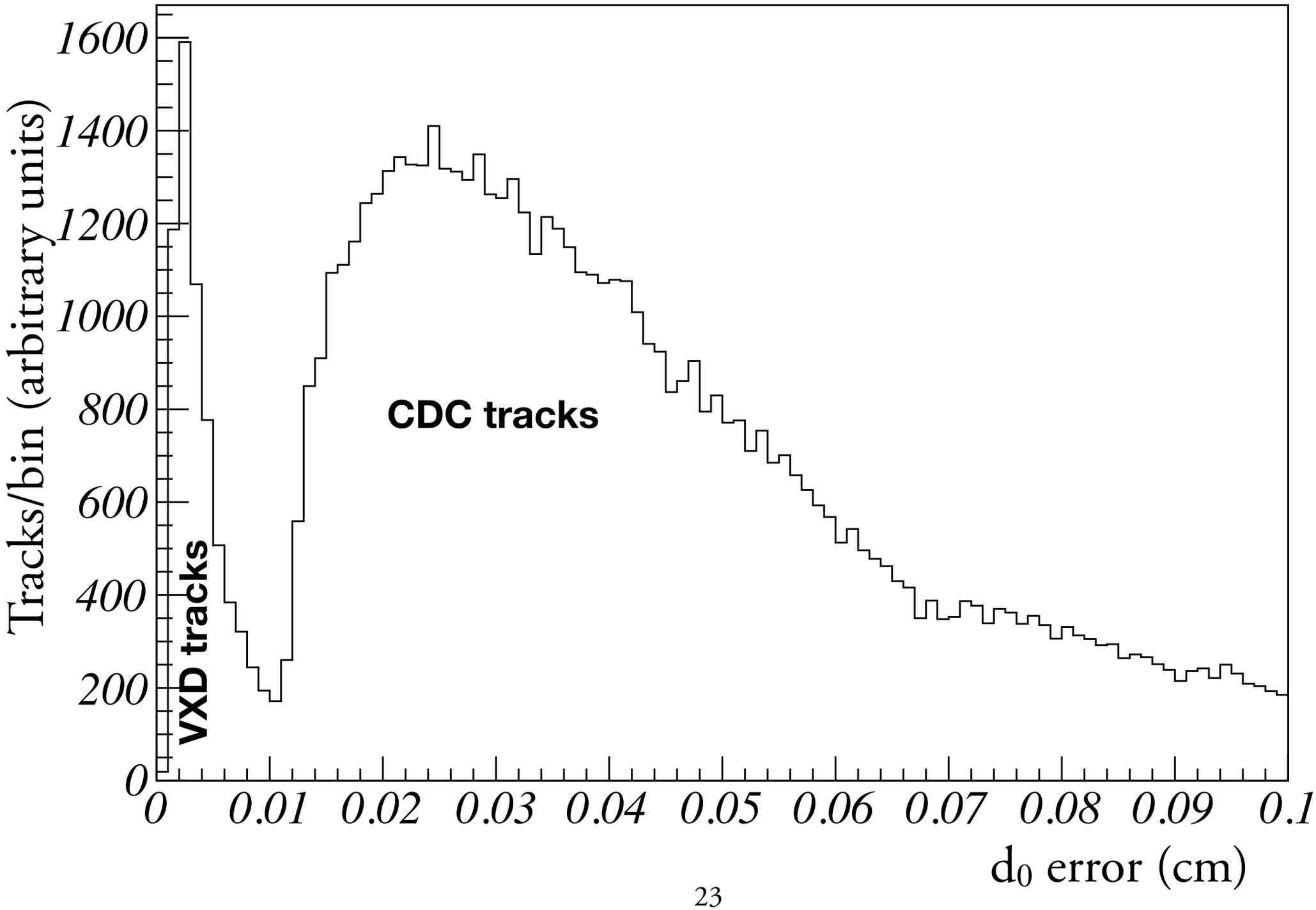


Overall Track Finding Efficiency (including CDC)

- ✦ We do really improve tracking performances

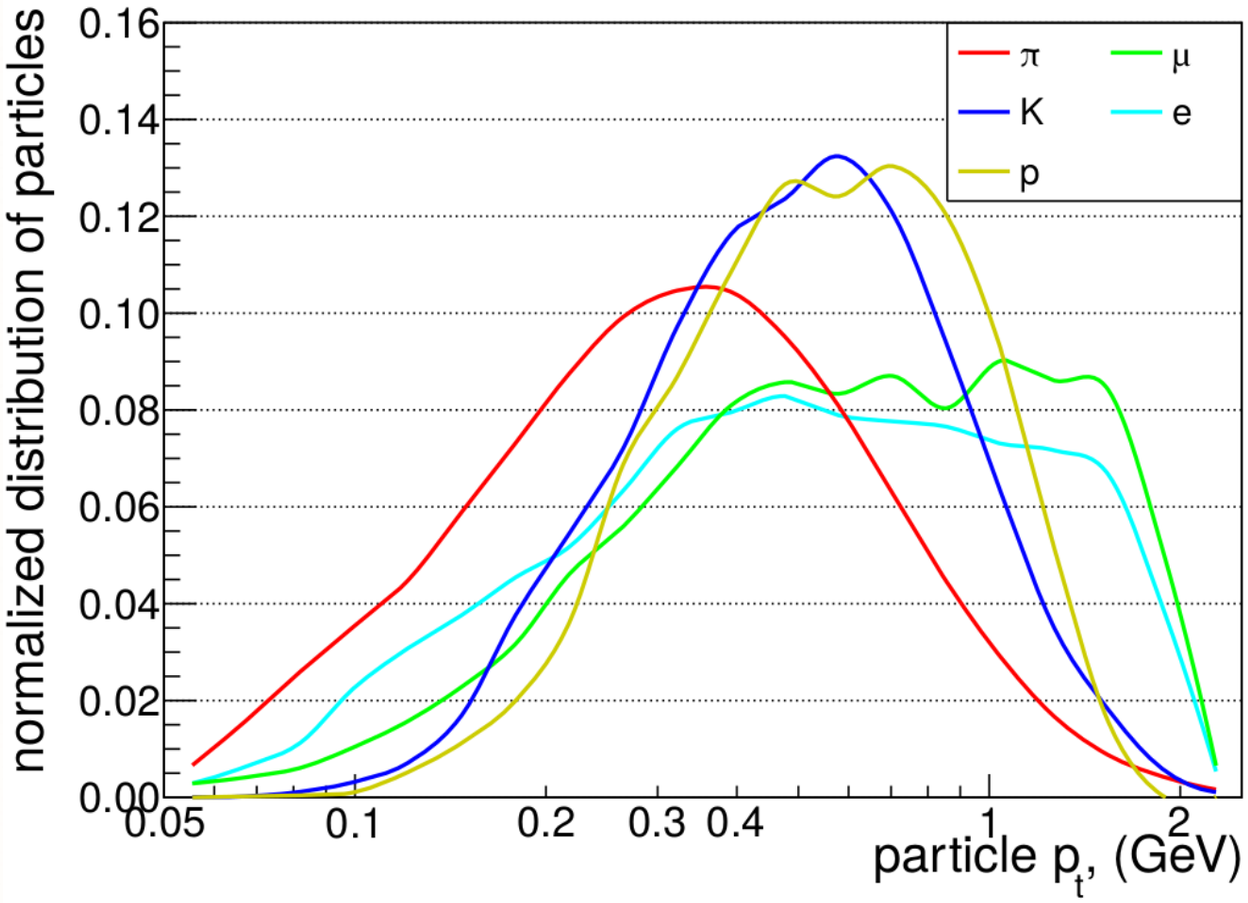


Error on the transverse impact parameter

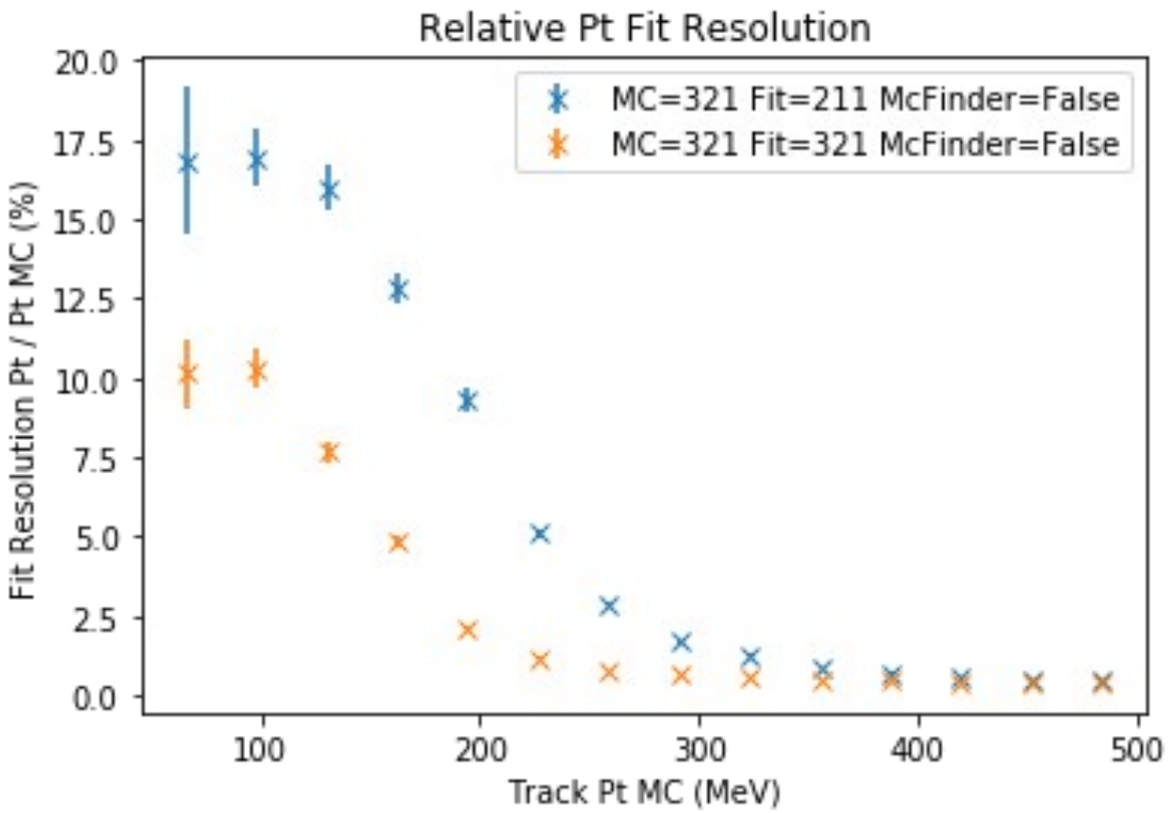


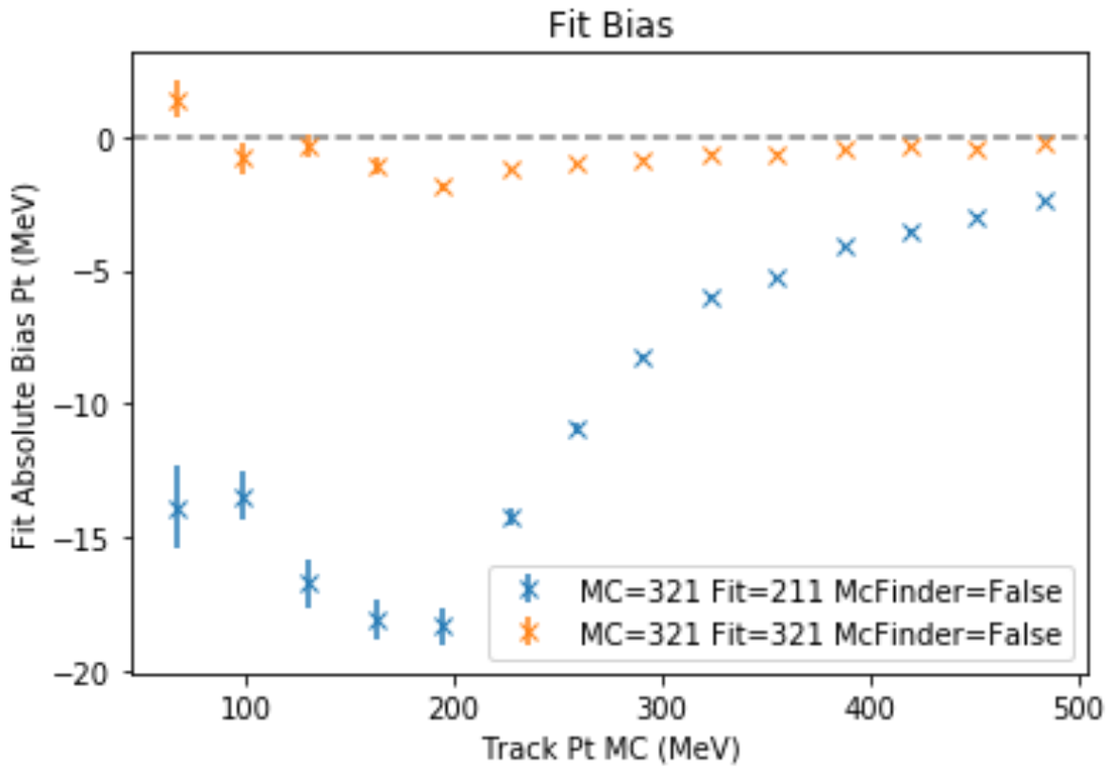
Multiple Mass Fit Hypothesys

Particle type	Average fraction	PDG Id
$\pi^{\pm}$	72.8%	211
$K^{\pm}$	14.9%	321
$e^{\pm}$	5.8%	11
$\mu^{\pm}$	4.7%	13
$p^{\pm}$	1.8%	2212



Kaons



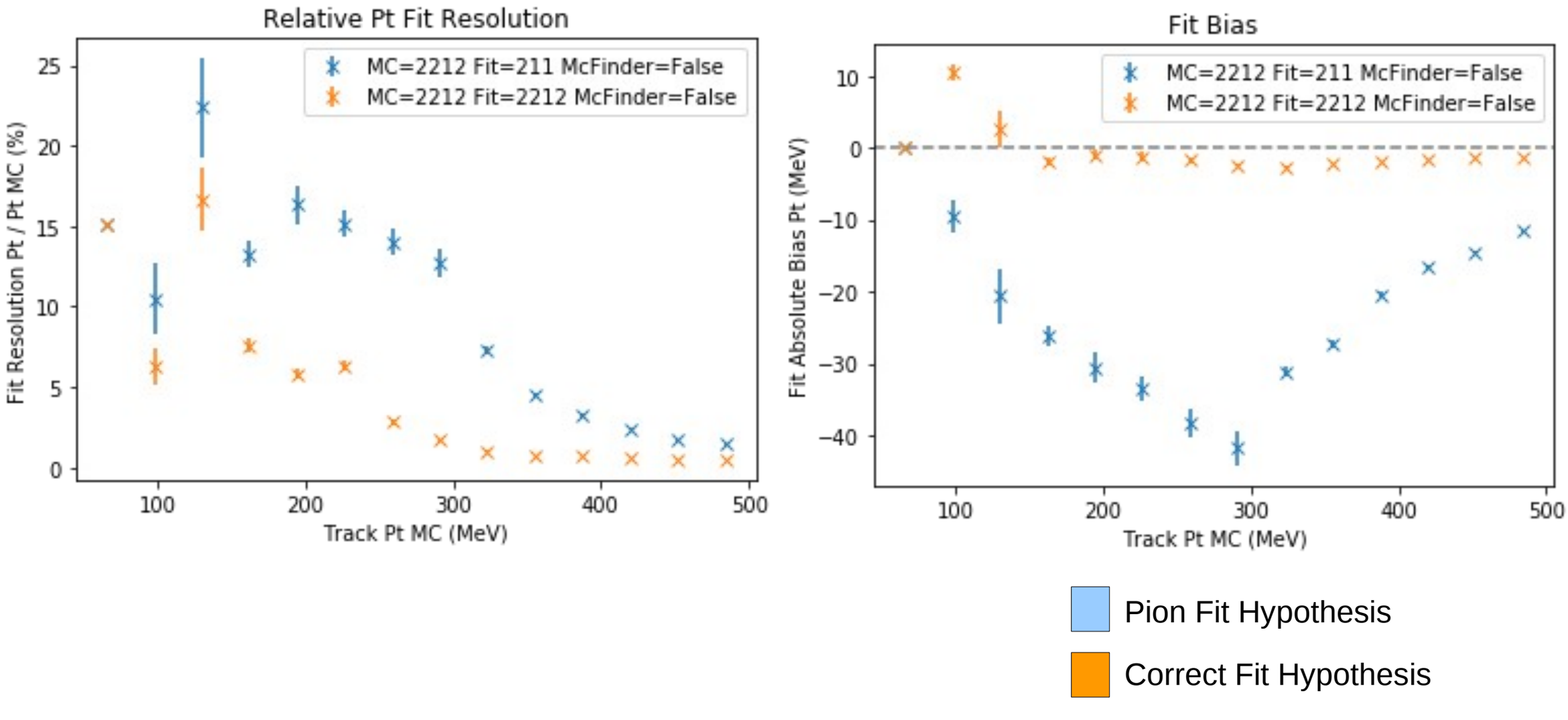


Pion Fit Hypothesis

Correct Fit Hypothesis

- **Fitting with correct Hypothesis improves the Fit Bias and the Resolution in all Pt ranges**

Protons



- **Fitting with correct Hypothesis improves the Fit Bias and the Resolution in all Pt ranges**
- **Big improvement with Proton hypothesis as expected due to the large mass difference btw. Proton and Pion**

Conclusions 1

- Release 1 is in the validation phase.
- VXDTF2 is the standard silicon stand alone track-finder.
  - We are tuning and training it.
  - Freeze-out of the parameters within two weeks.
- We are able to reconstruct tracks in Phase 2 (even with the VXD alone)
- We are going to store additional fit results for kaons and protons mass hypothesis

Conclusions 2

- We are entering in the phase of tuning, commissioning and maintenance of the track reconstruction software.
  - We will appreciate feed backs from the users
  - We will highly appreciate your help on systematic/ performance studies
- We will discuss these in the forthcoming Face 2 Face tracking meeting here in Pisa in two weeks from now: December the 5th - December the 7th.