Training Sample selection performances

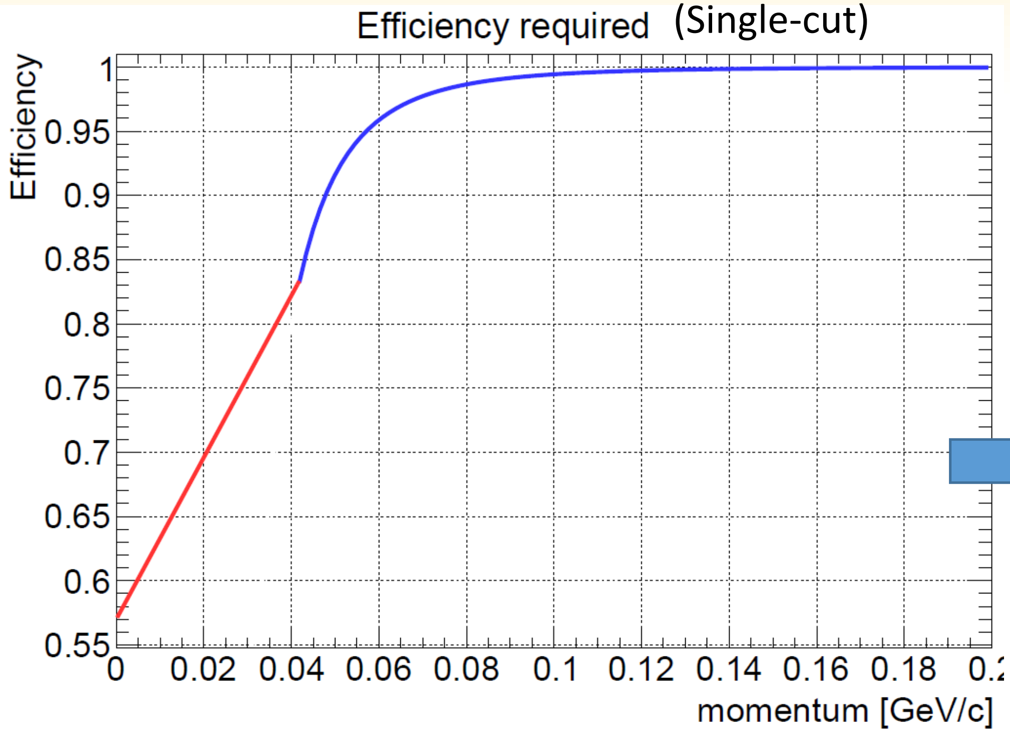
Valerio Bertacchi
Università di Pisa & INFN Pisa
Face To Face Tracking Meeting
18 Semptember 2017

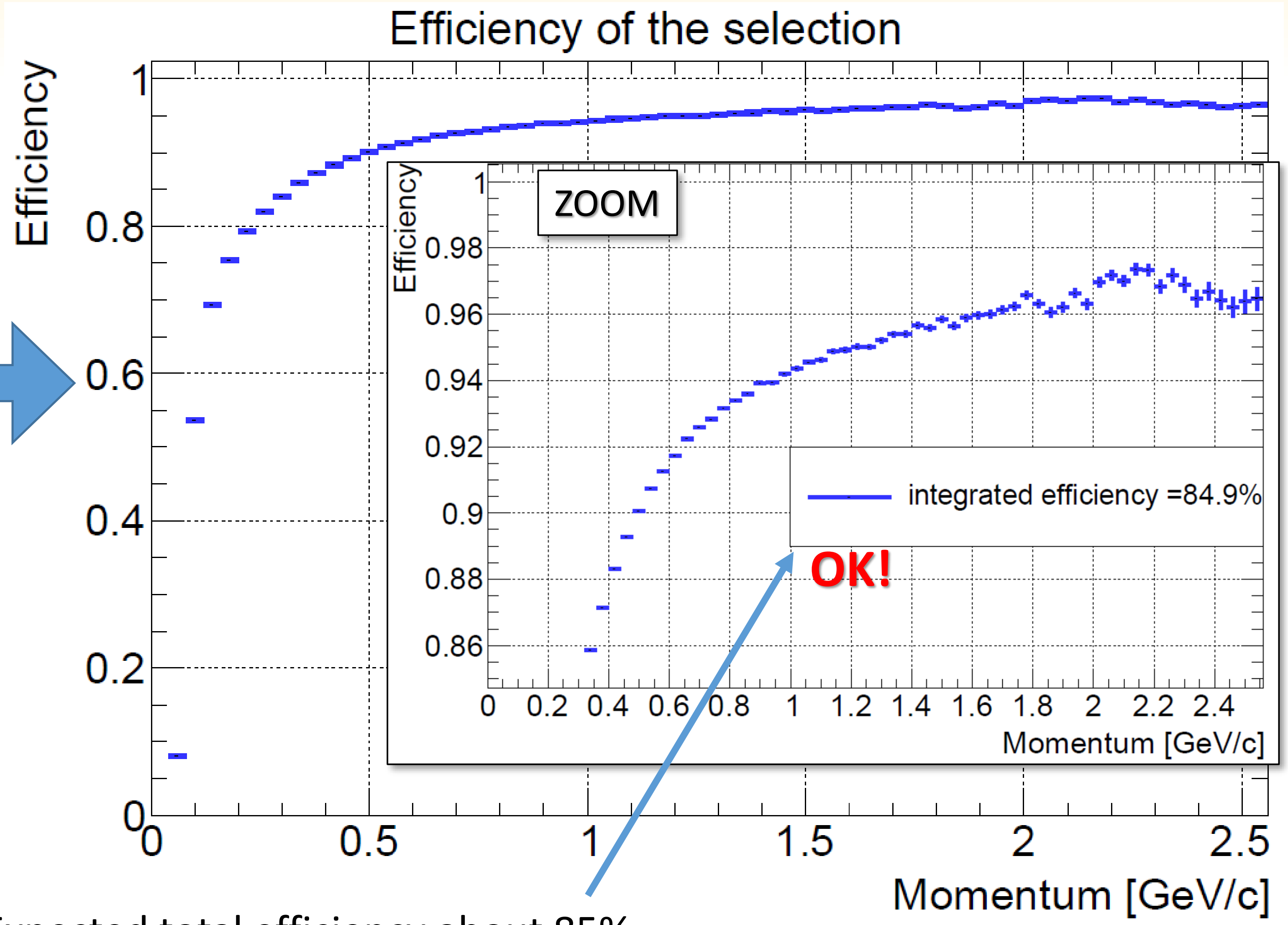
Strategy of the selection - reminder

- **Idea**: remove from training sample tracks which have strong interaction with material (multiple scattering) because:
  - They increse Sector Map complexity
  - They increse CPU time
  - They allow the selection of pattern mostly rejected in fitting phase
  - They increase the fake rate of VXDTF2
- **How to idetify these tracks**?
  - Track parameters should be constant along the track
  - Strong variation of a Track parameter in a single layer crossing is a signature of a strong interaction ⟹ ΔX used as a rejection tag (X=track parameter)
- **Implementation**
  - definition of cuts from simulated ΔX distributions, in function of momentum, polar angle, and specific layer crossing (beam pipe, layer 1-6).
  - NB: amplitude defined on single-cut efficiency a priori requirement (*set by hand*)
  - Filter during TrainingSamplePreparation: a track it is selected only if each segment (pair of consecutive hit) has $-\Delta X_{cut} < \Delta X < \Delta X_{cut}$ for each track parameter

Effects on training sample - efficiency

$$\varepsilon(p) = \frac{N_{\text{track pass}}(p)}{N_{\text{track tot}}(p)}$$

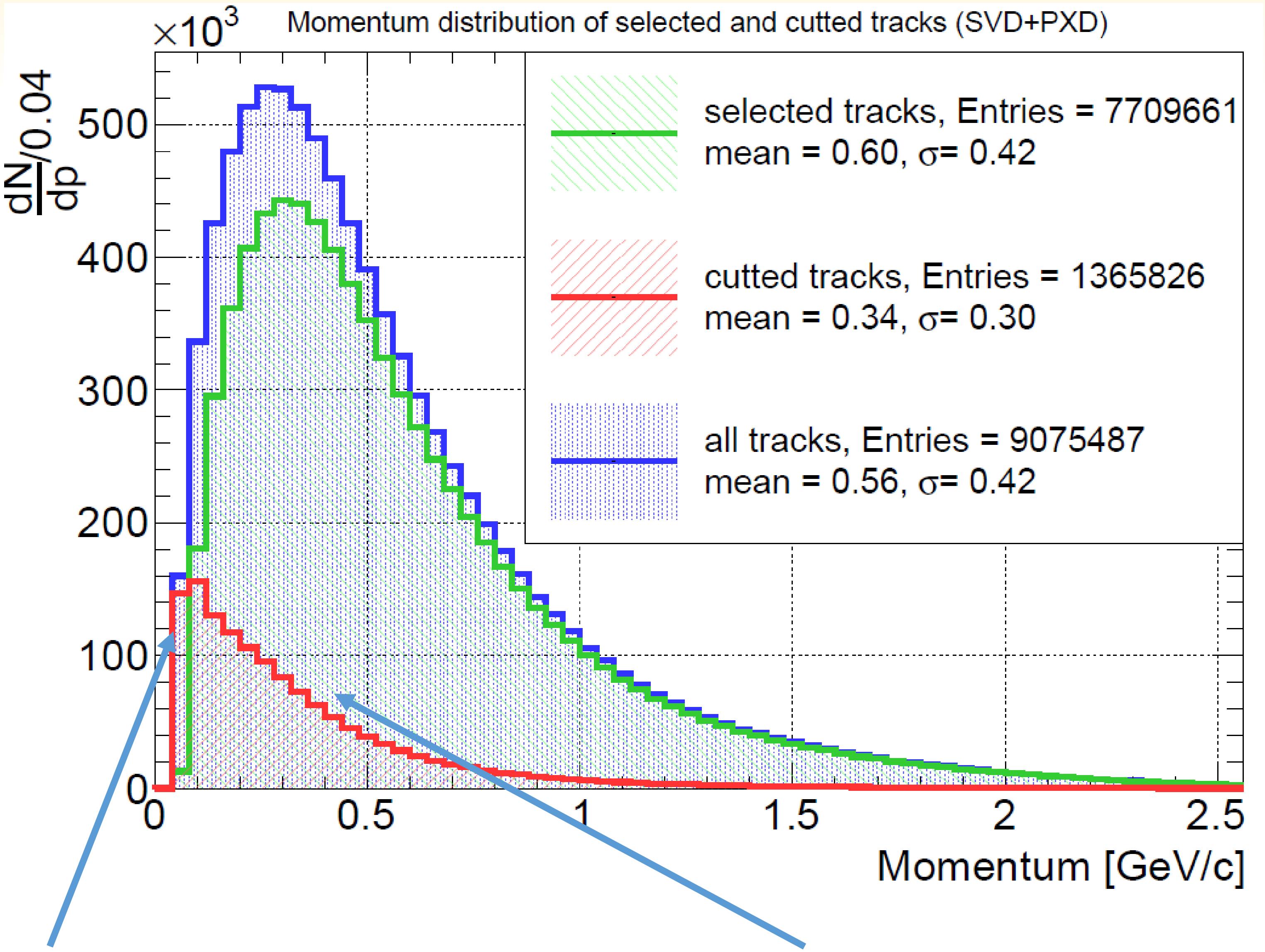




- Over each track are applied up to 60 cuts (up to 12 layers, 5 parameters) and each cut allow inefficiency <0.001
- Preliminary «global» cuts (flat in angle, layer momentum) remove 10% of the track

Expected total efficiency about 85%

Effects on training sample - momentum



Range:

- Global cuts are momentum-independent
- Specific cuts are applied under 2 GeV/c

Dominant under 75 MeV/c

Slope higher than intrinsic distribution

Effects on the Sector Map

(same original sample, 0.9M Y(4S) events)

- **Dimension** of the sector map:
  - Fast Reco (SVD-Only): 12.3 MB (default), 5.1 MB (selected)
  - Full Reco (VXD): 21.0 MB (default), 8.3 MB (selected)

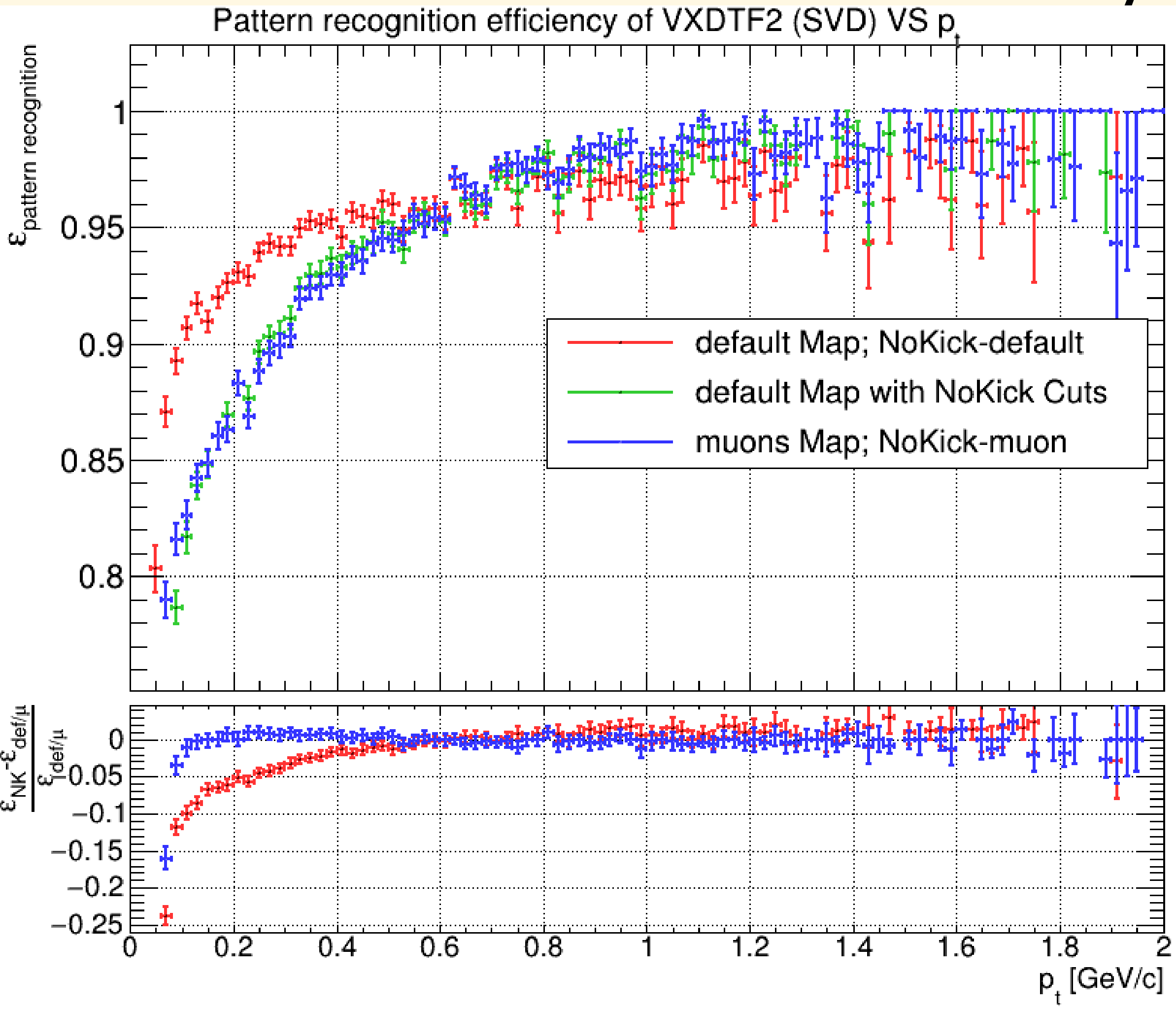
60% ligther with 15% tracks removed only!

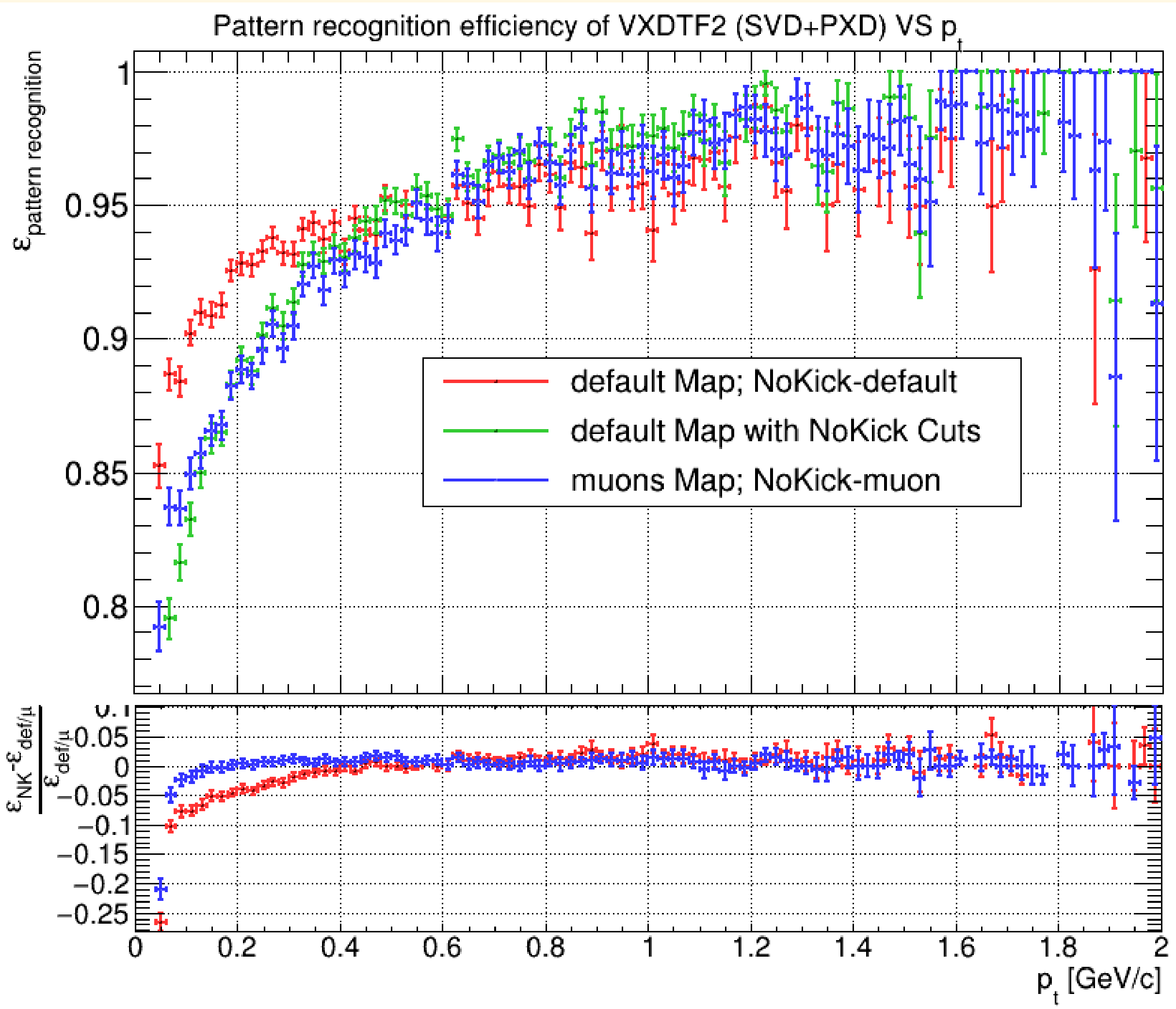
- **Complexity:** More studied needed to quantify the complexity reduction in term of connections of the Sector Map
- **Loops:** unfortunately still presents…

Effects on tacking performances

- Test VXDTF2 with:
    - Default Maps (SVD-only and VXD)
    - Selected Maps aka NoKick Cuts Maps (SVD-only and VXD)
    - Maps from 10-muons events (SVD-only and VXD) produced by *KIT* group
- Analyzed VS momentum and polar angle:
    - Pattern recognition efficiency
    - Fitting Efficiency
    - (total efficieny= P.R.+Fit)
    - Fake Rate
    - CPU time

Pattern Reco. Efficiency - pt

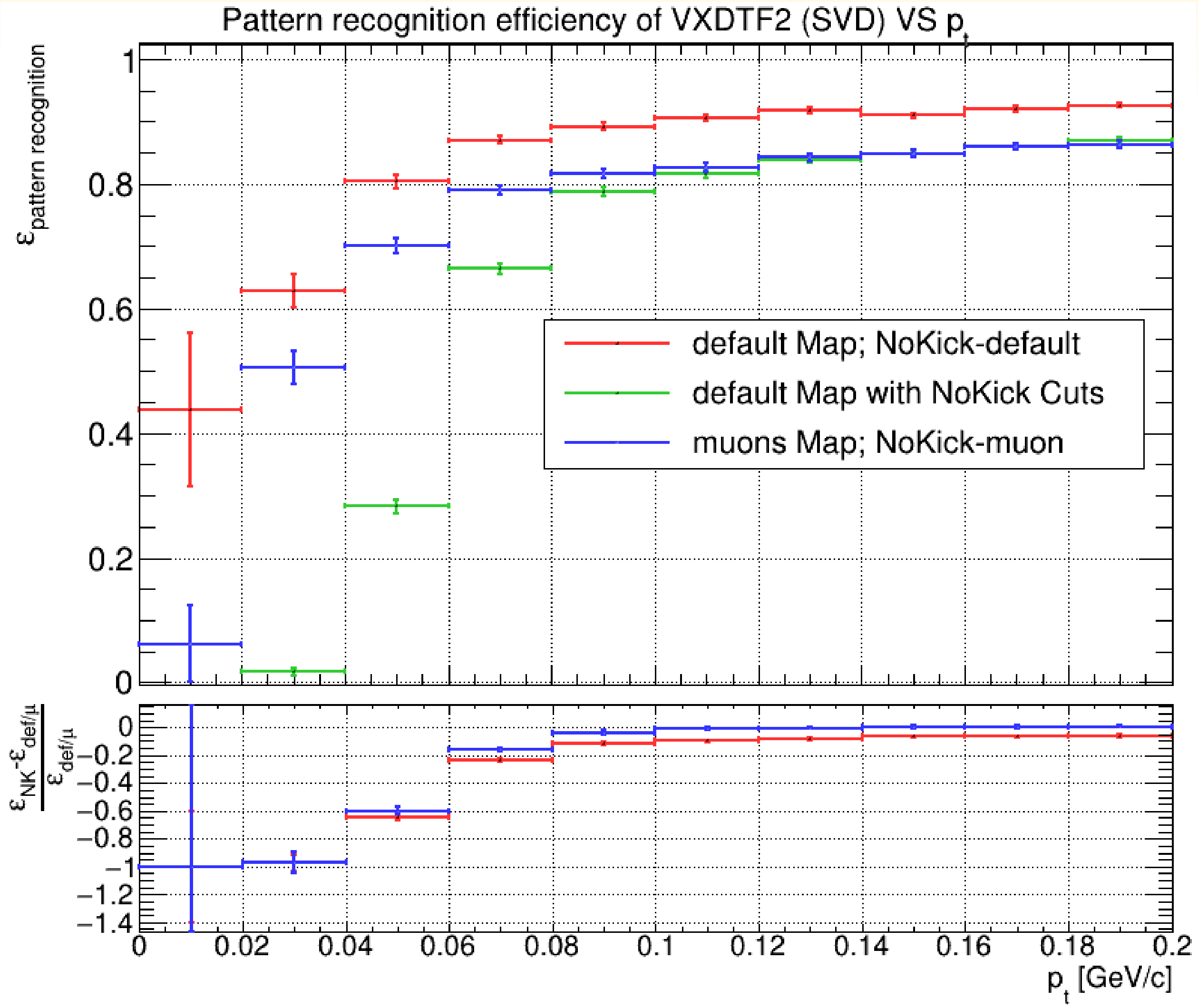


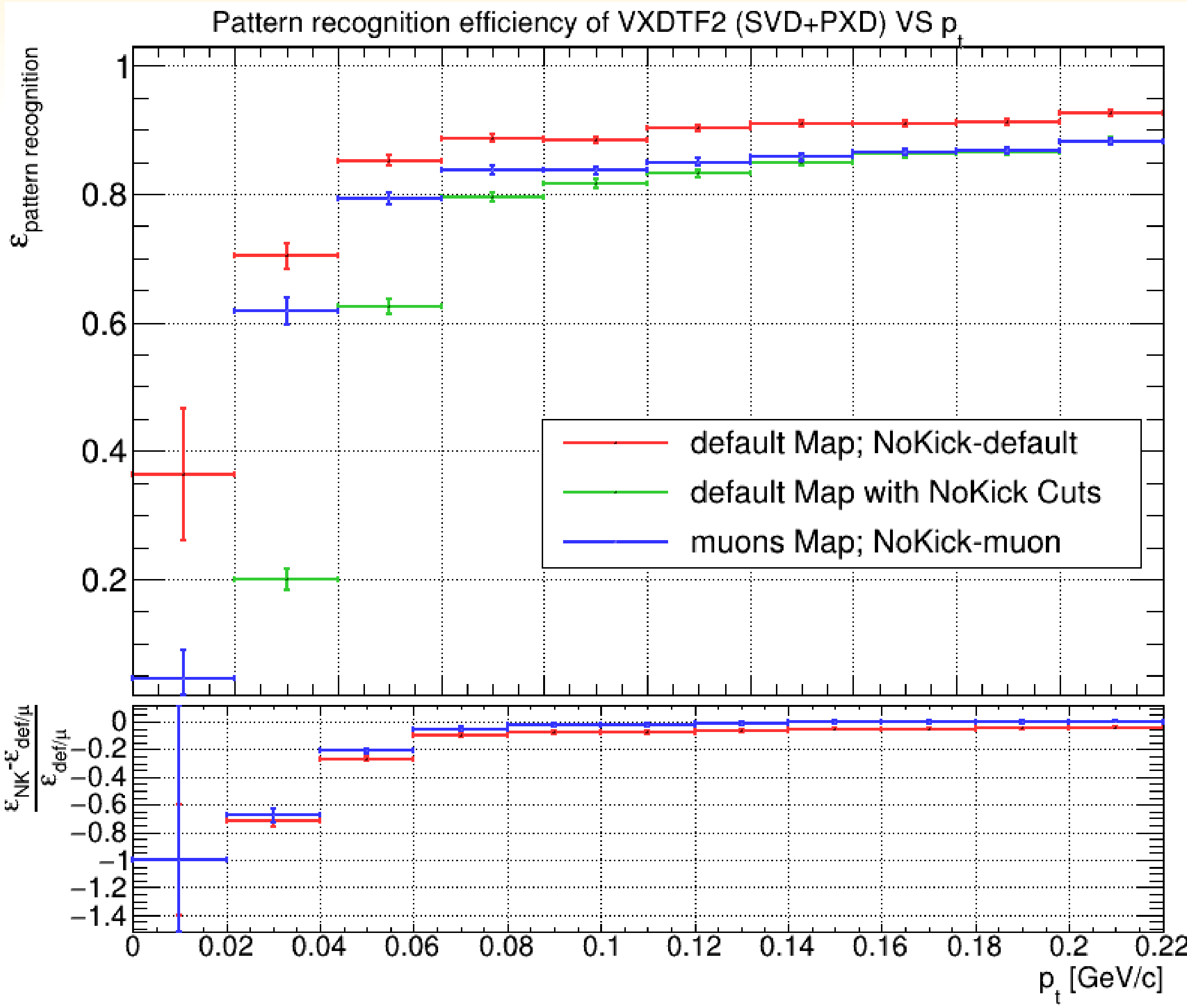


- **VS Default**: degradation (up 10%) under 500 MeV/c
- **VS Default**: increase (up to 2-3%) over 800 MeV/c (C.A.?)
- **VS Muon**: quite same except very low p

- **Adding PXD:** degradation reduced

Pattern Reco. Efficenty – very low p_t

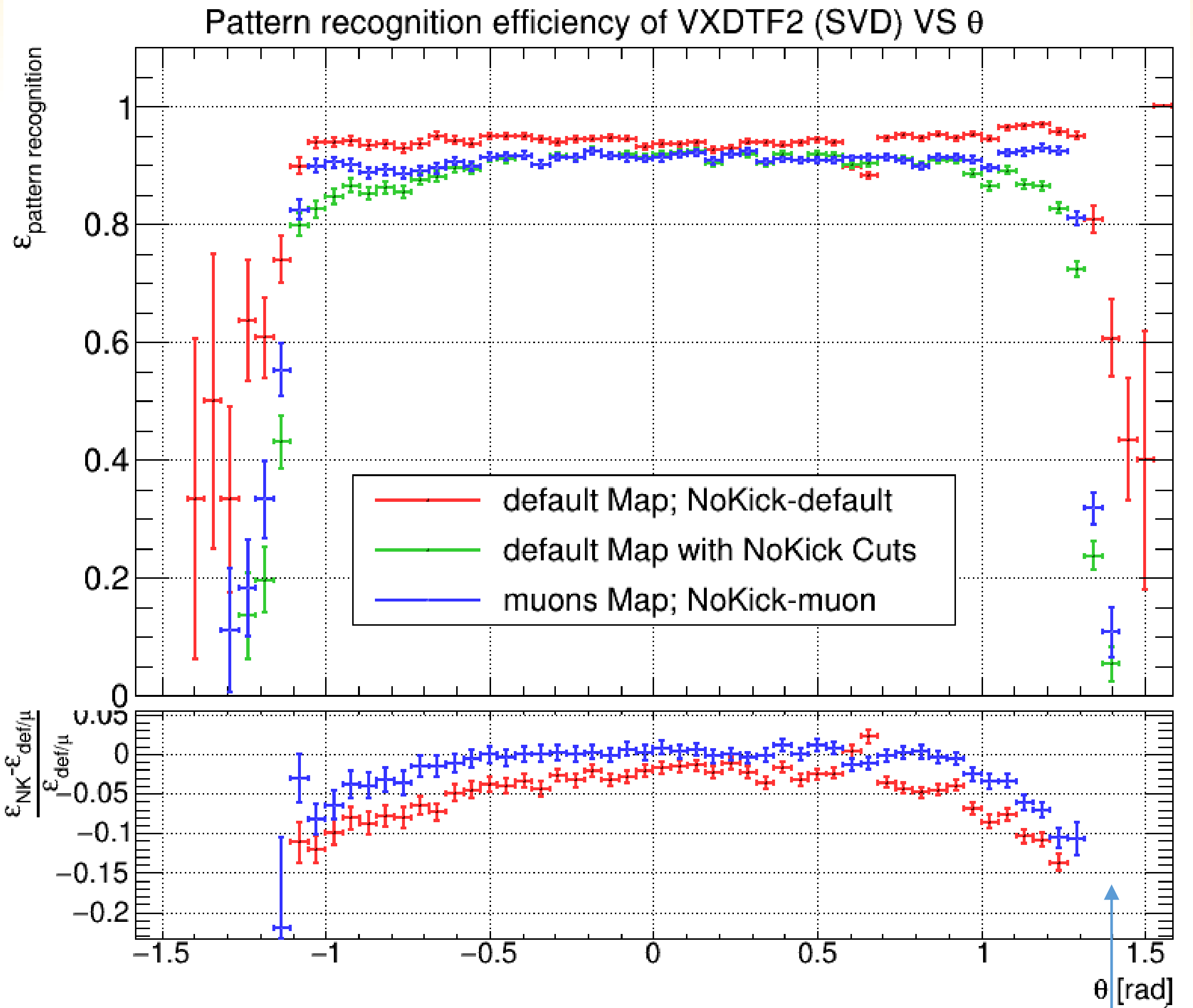


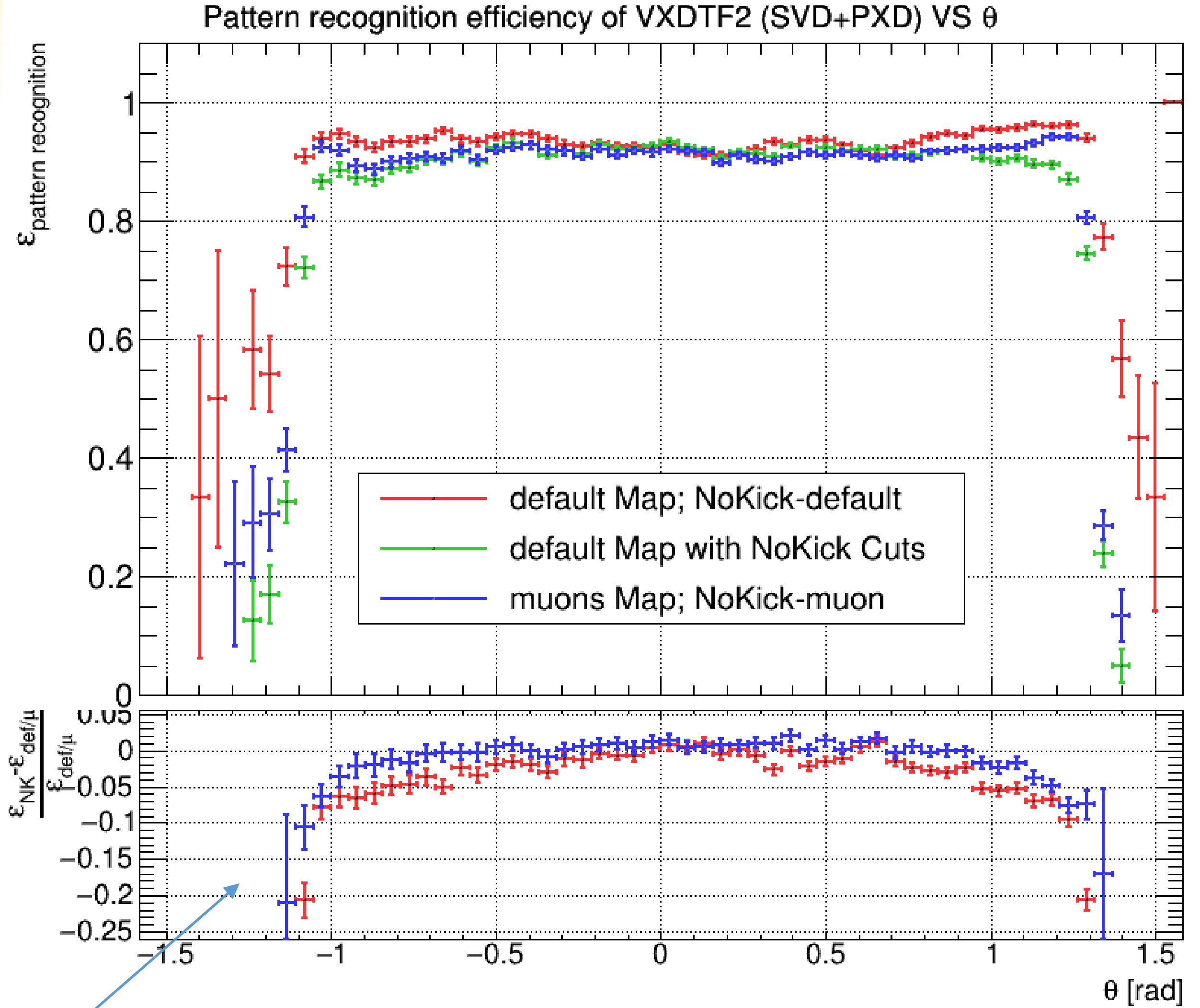


- **VS Default:** strong degradation under 100 MeV/c (up to 40%)
- **VS Muon:** quite the same of default

- **Adding PXD:** degradation reduced

Pattern Reco. Efficiency - theta



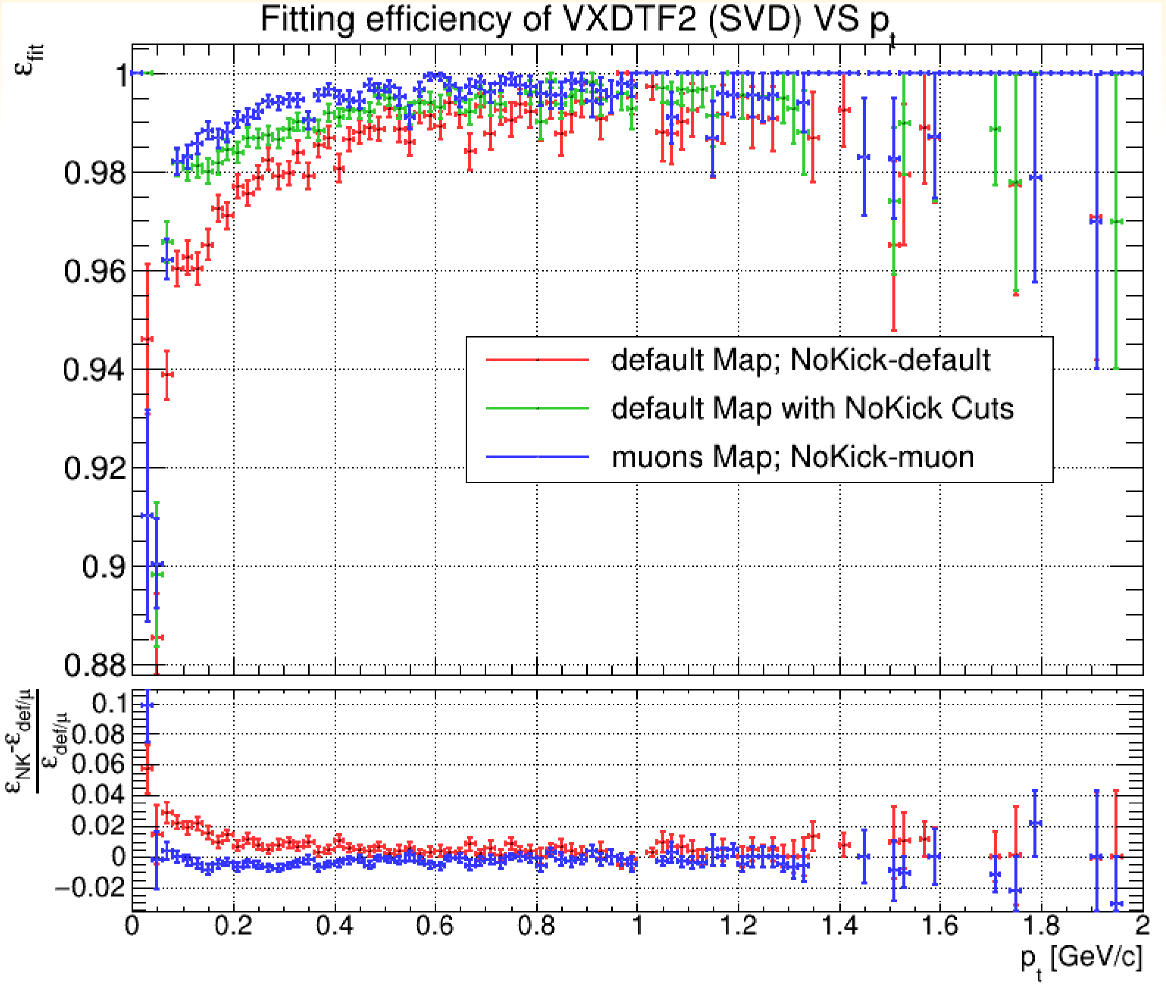


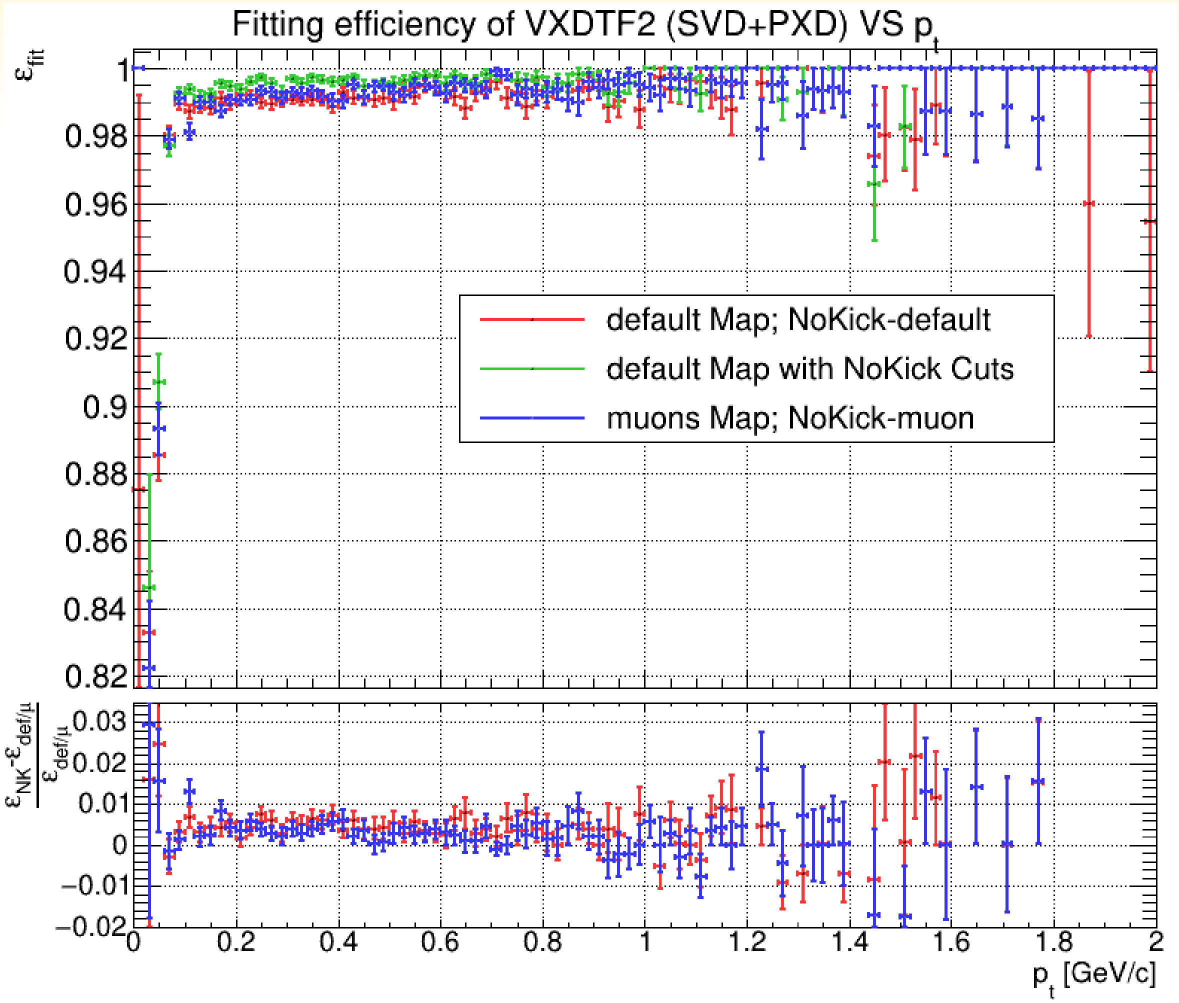
- **VS Default:** : degradation up 10 % (coherent with $\varepsilon(p_t)$)
- **VS Default:** High angle strong degradation
- **VS Muon:** reduced degradation (0 to 5%)

- **Adding PXD**: degradation reduced (compatible with muon)
- **Adding PXD:** high efficiency range extended

NB: not plotted high angles

Fitting efficiency - pt

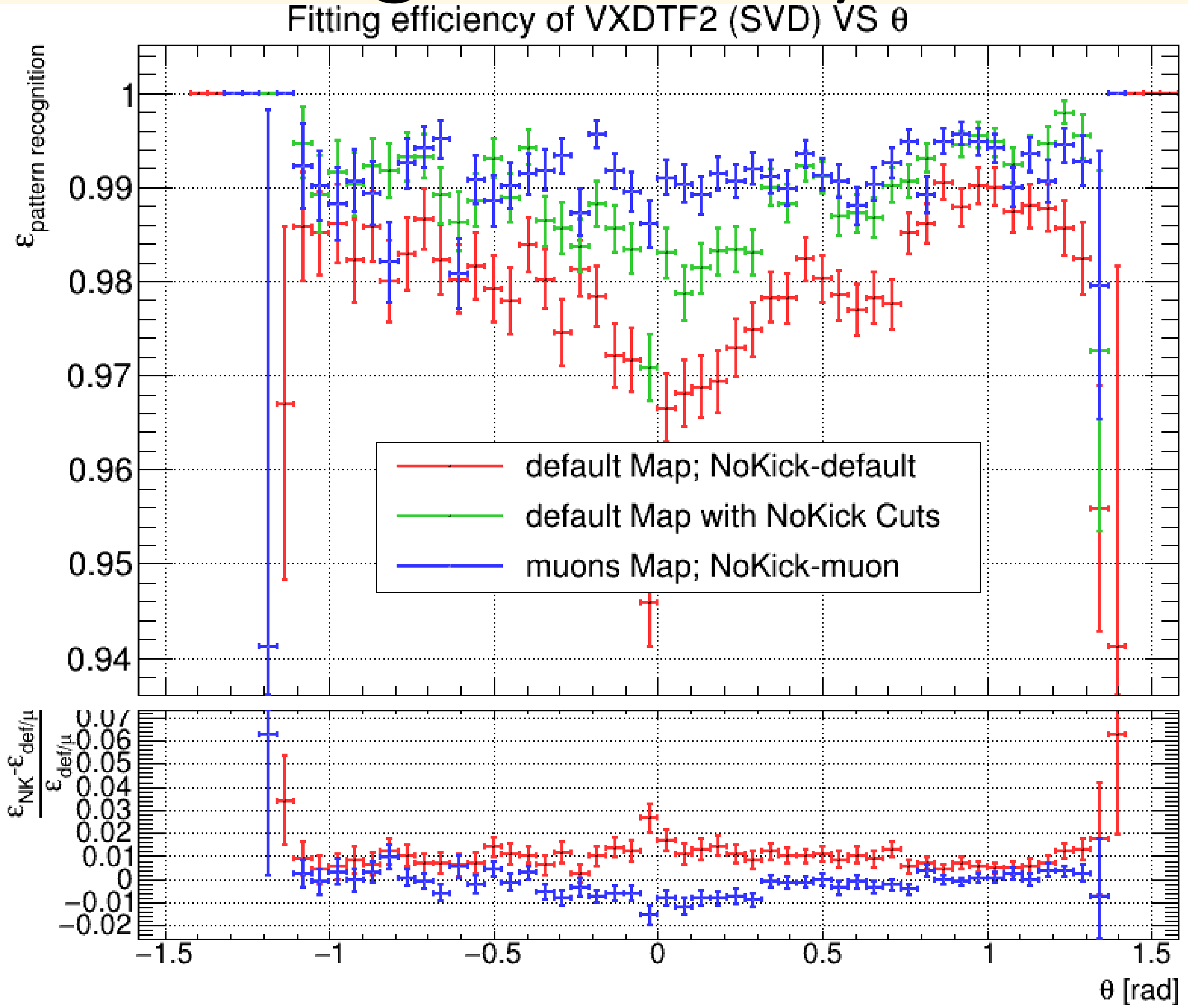


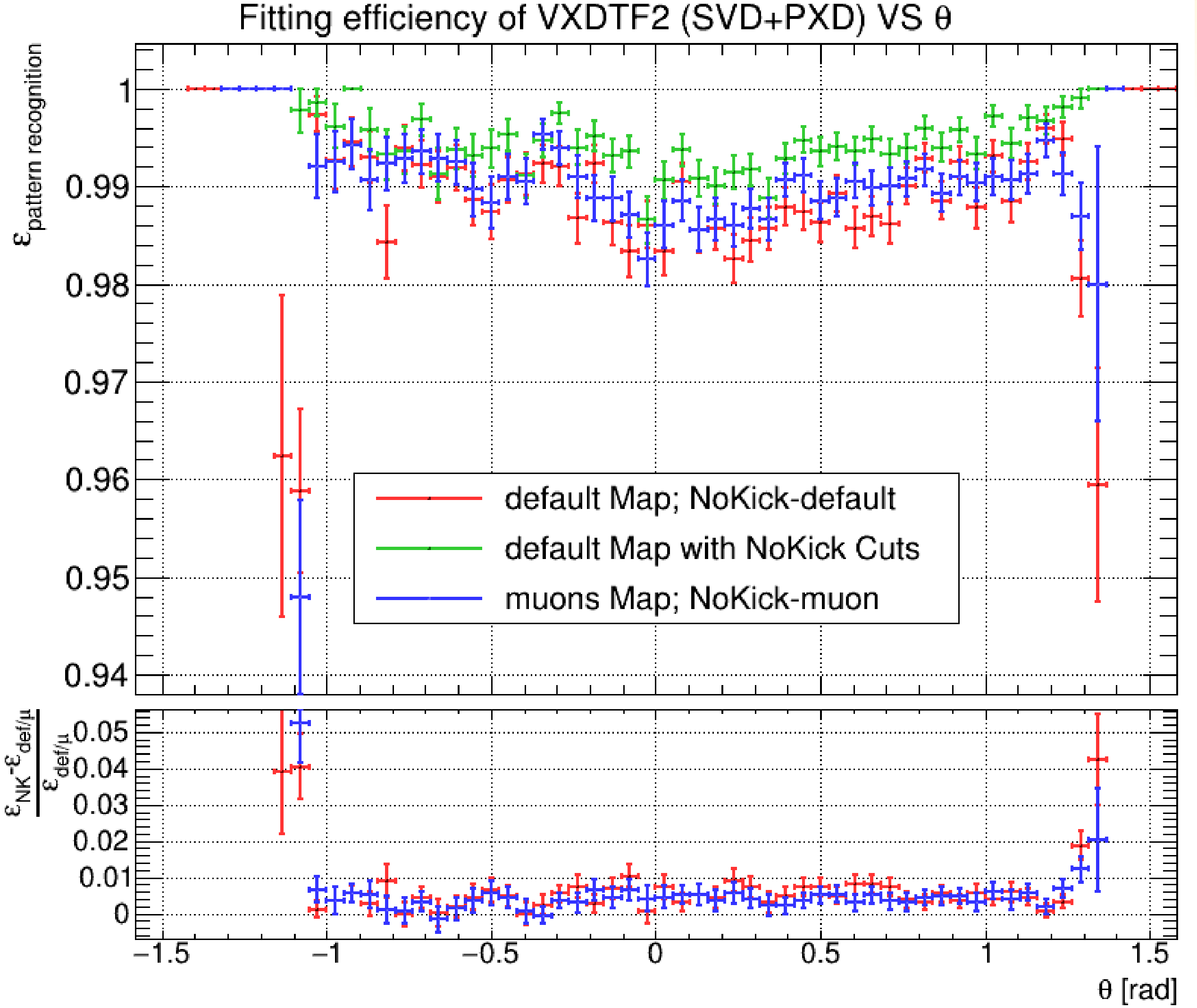


- **VS Default:** increased eff. in all the range, up to 4% at low pt
- **VS Muon:** slightly decreased eff. In low p (under 1%)

- **Adding PXD:** increaded eff. In all the range (up to 1% except very low pt)
- **Adding PXD:** muon and default have same eff.

Fitting efficiency - theta



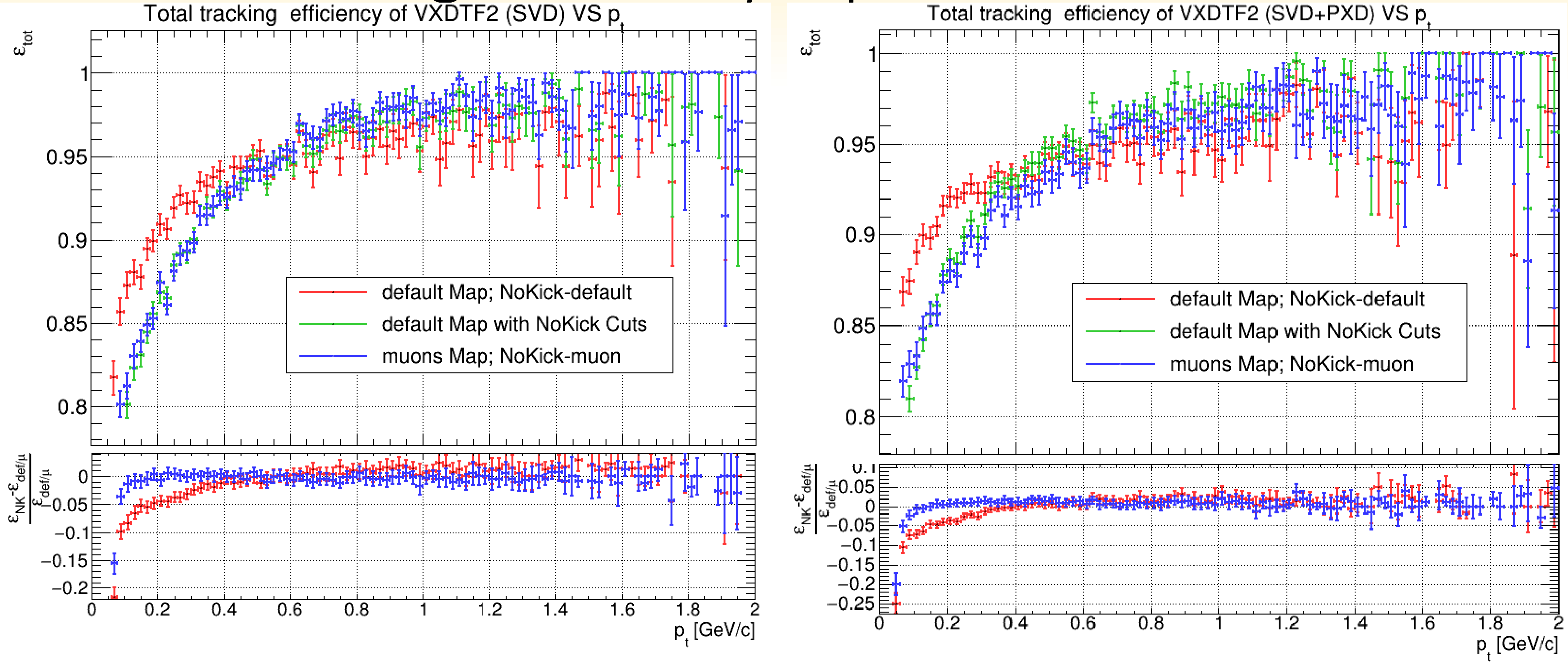


More evident the previous described behaviour:

- **VS Default:** NoKick is more efficient (1-3%)
- **VS Muon:** Nokick is less efficient (1%)

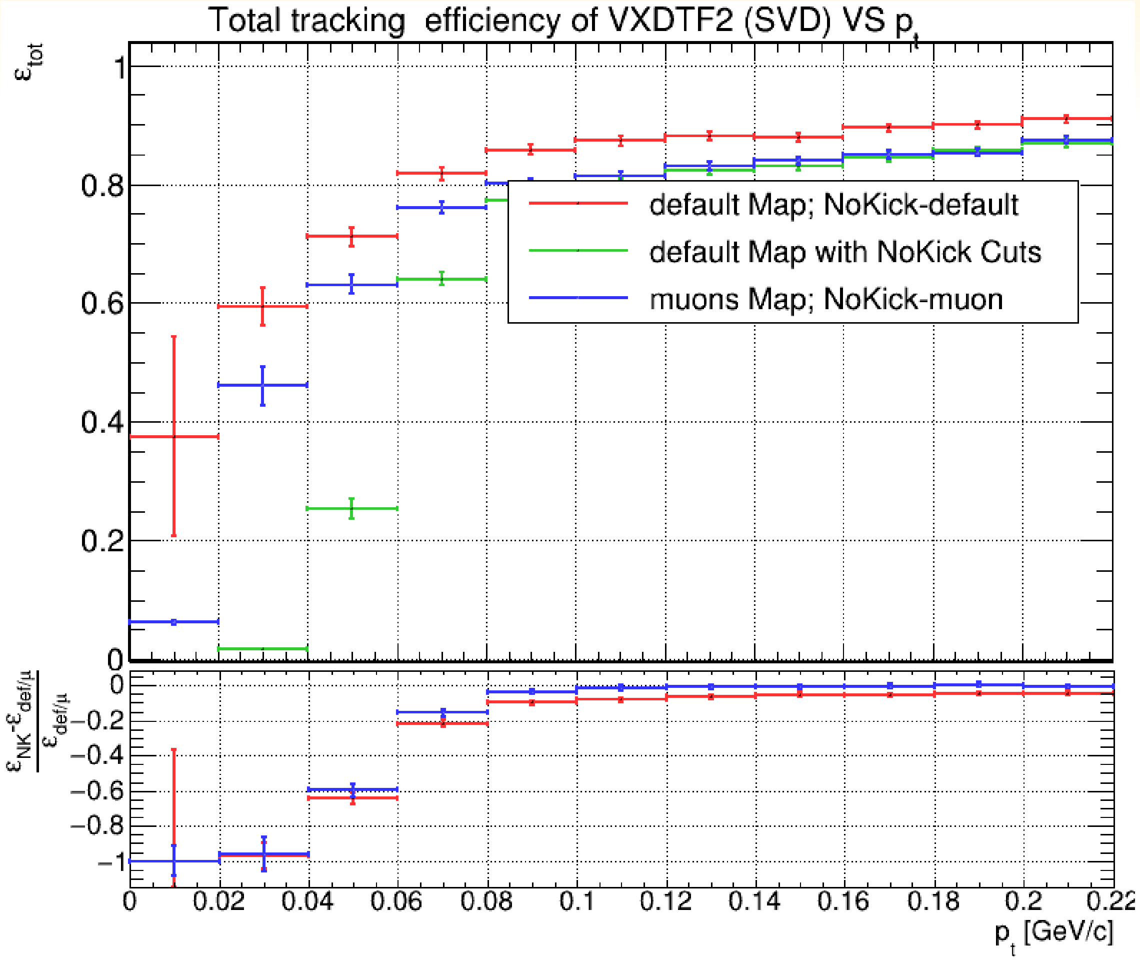
- **Adding PXD:** Nokick more efficient up to 1% with respet both maps, in particular at high angle

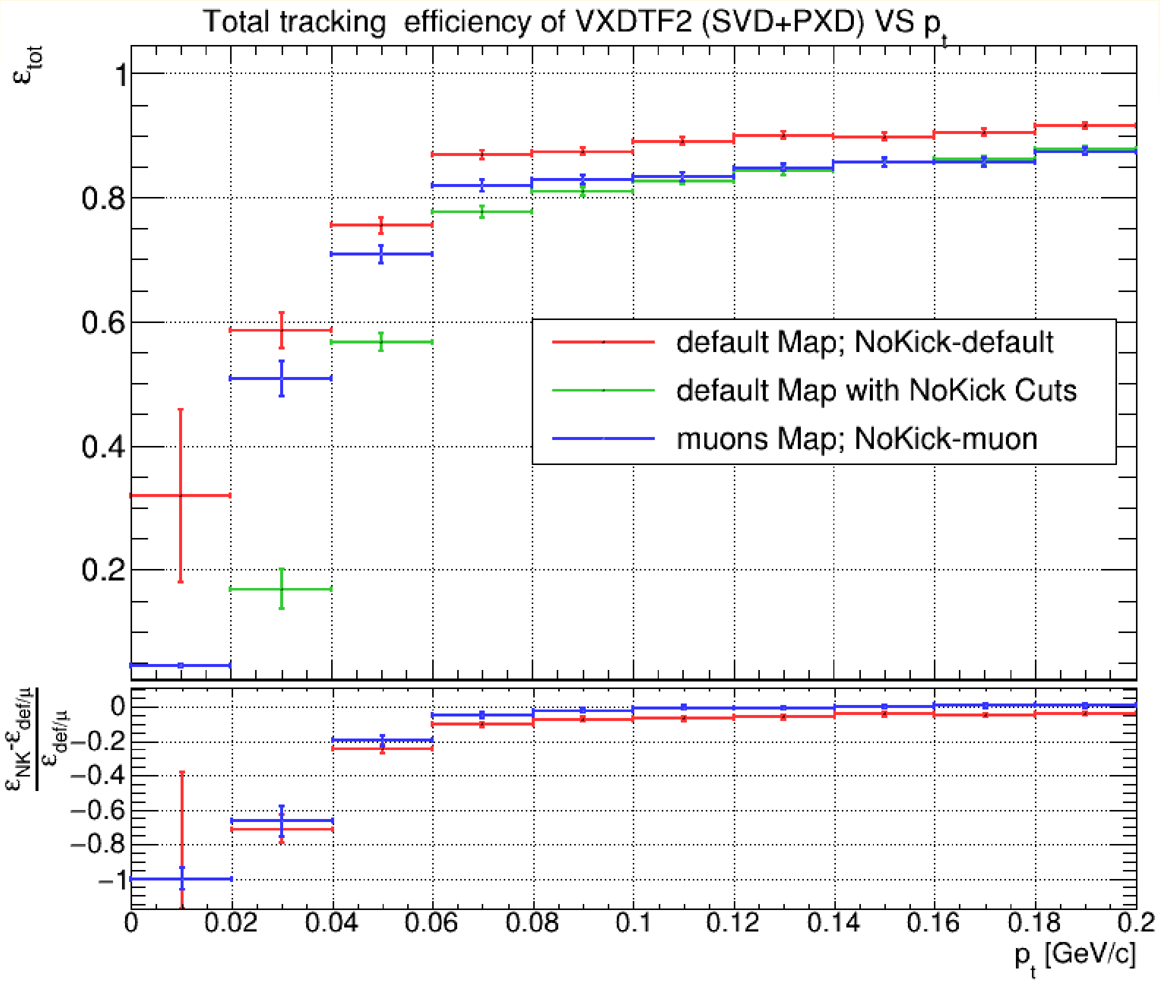
Total Tracking efficiency – pt



- Increased fitting eff. doesn't compensate completely the degradation of P.R. eff.
- Residual degradation up to 10% with respect to Default map (muon and NoKick have the same total eff.)

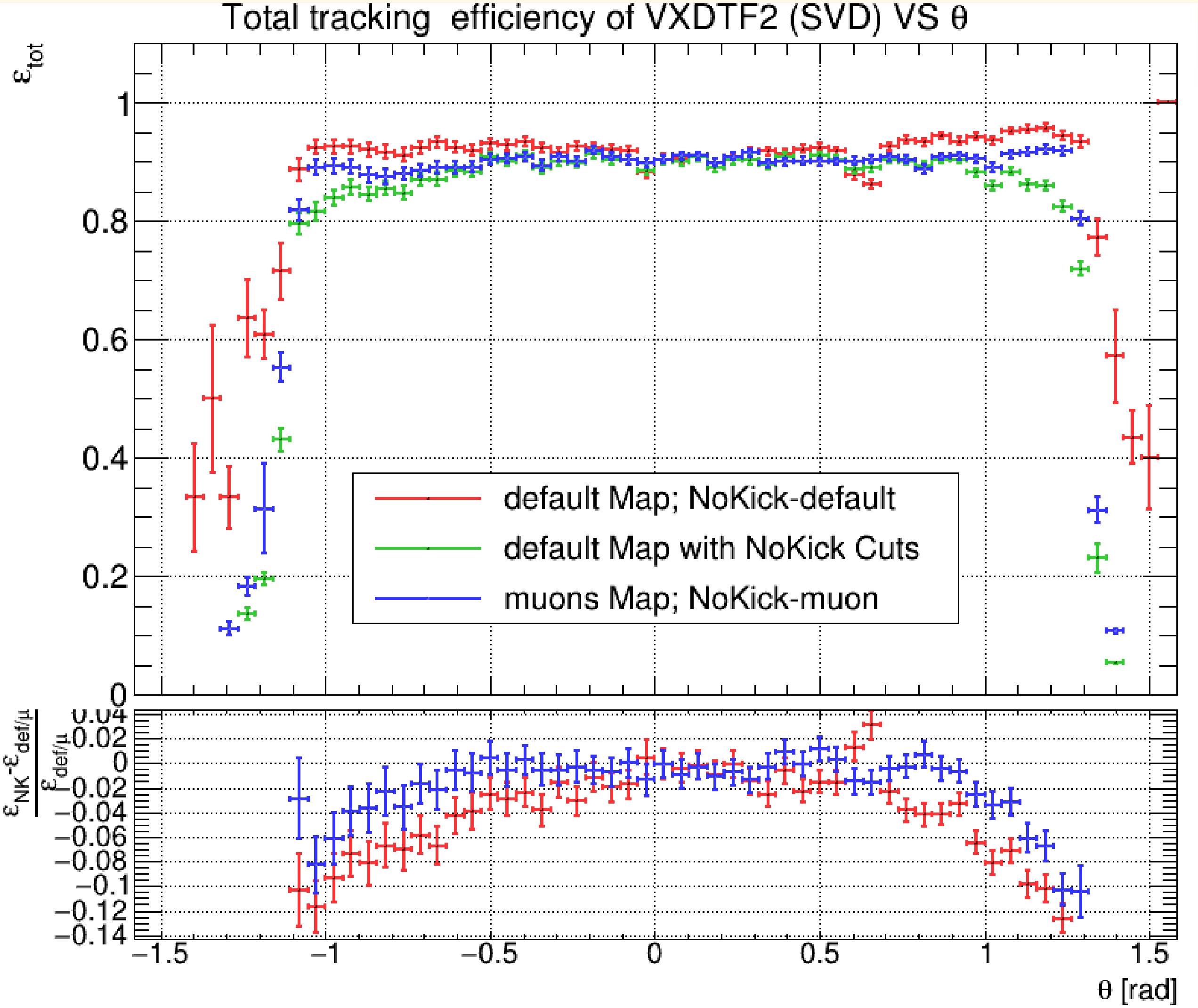
Total Tracking efficiency – very low pt

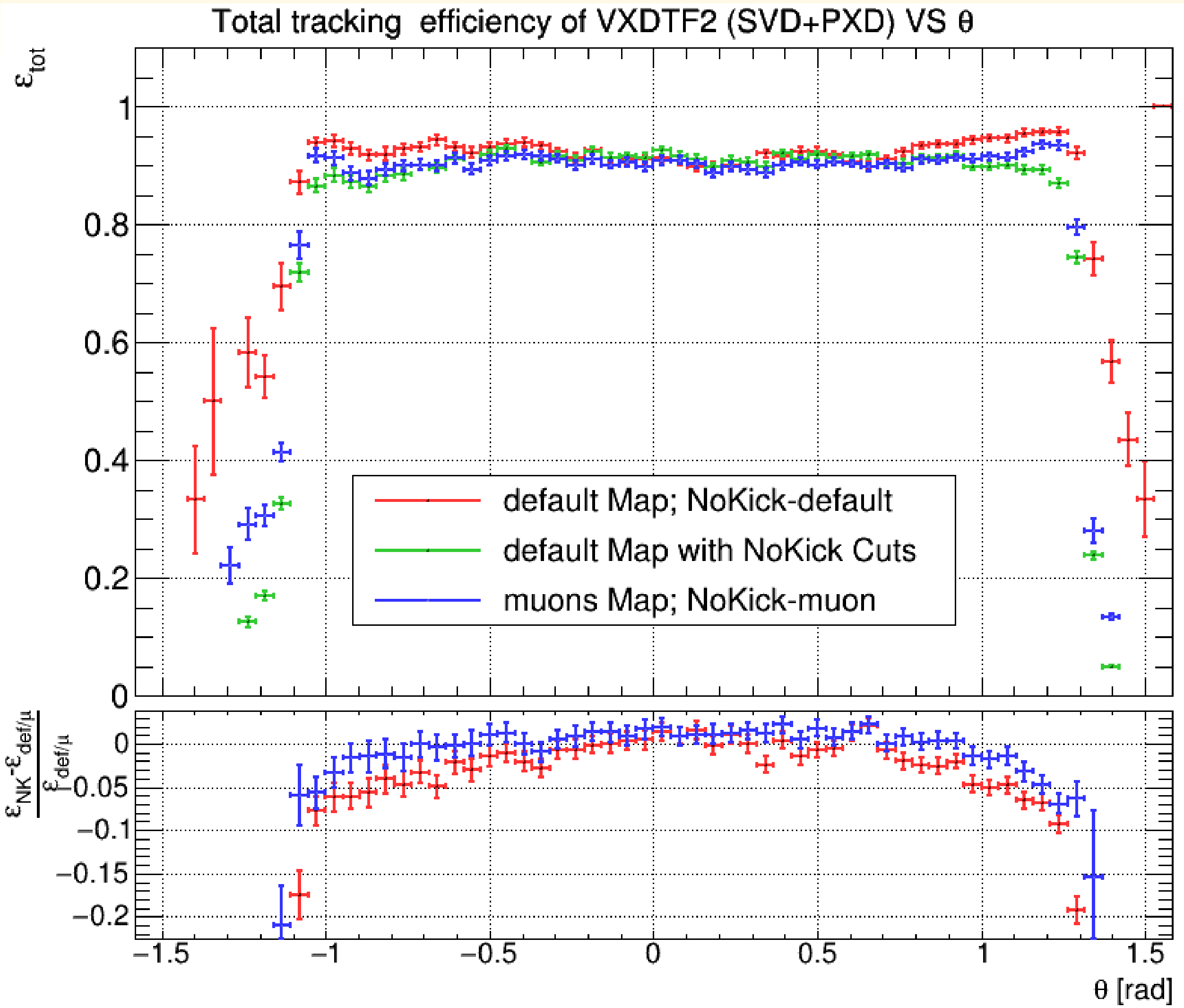




- Strong degradation under 100 MeV/c
- **Adding PXD:** degradation reduced

Total Tracking efficiency - theta



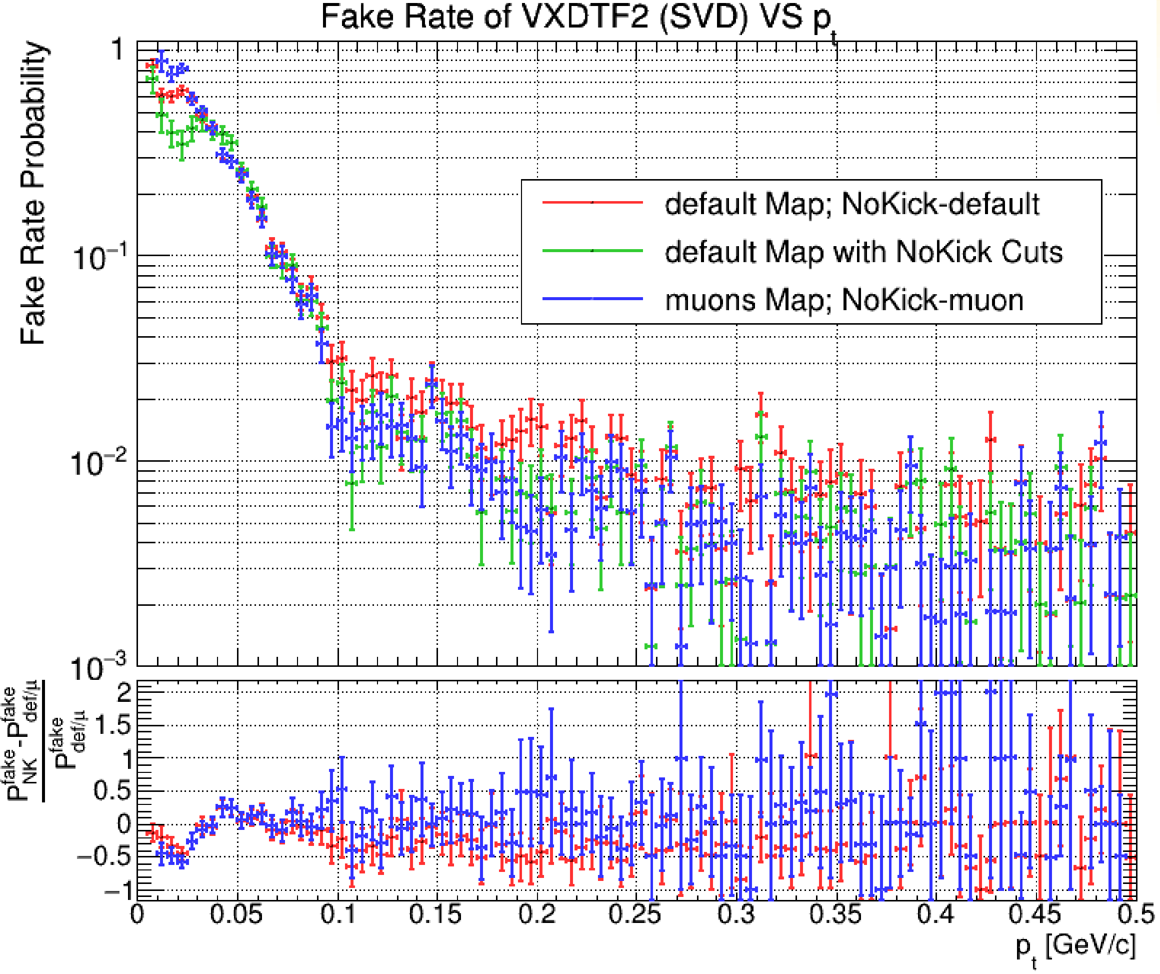


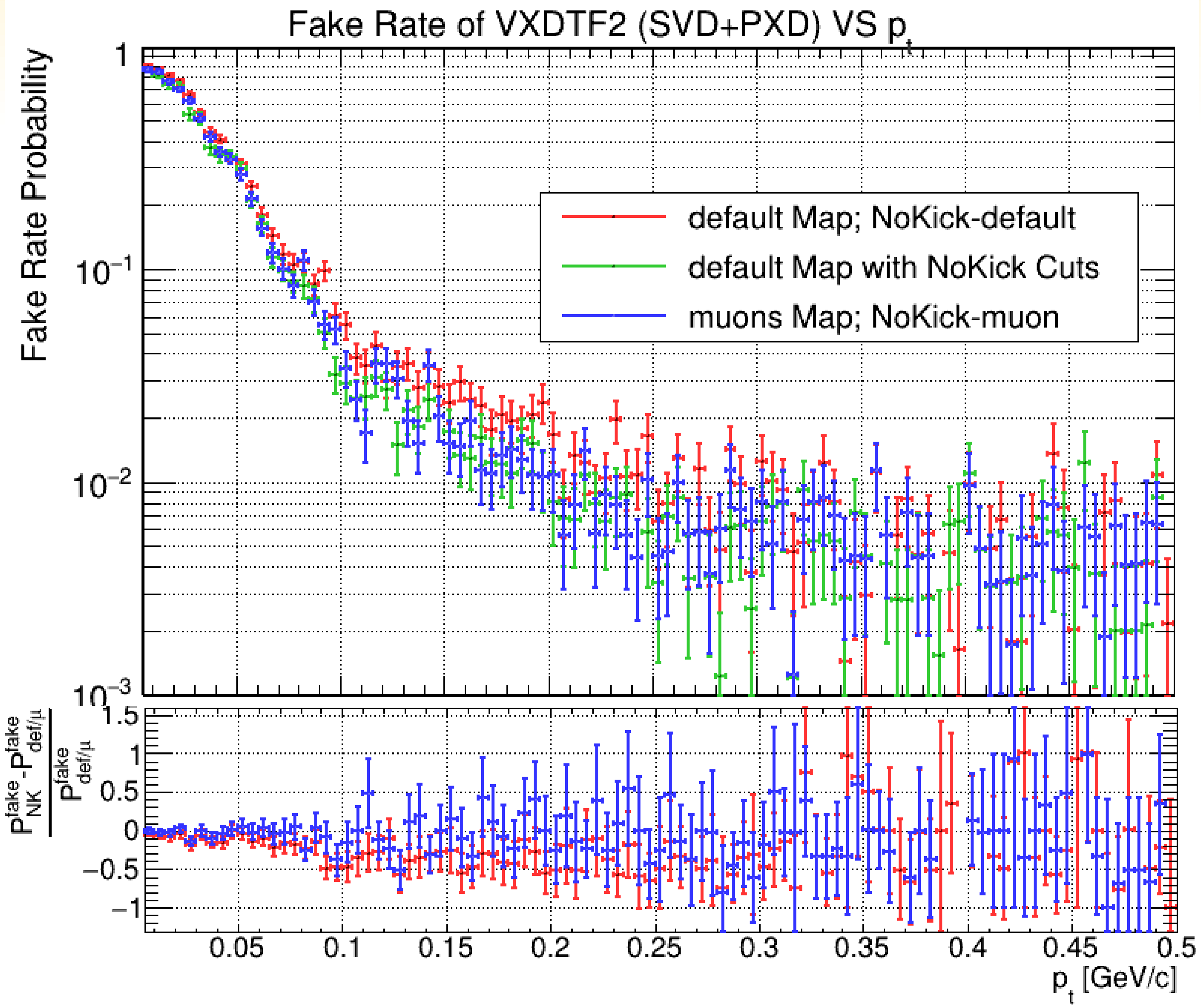
- VS Default: degradation up to 10% at high angles
- VS Muon: similar result

Adding PXD: Halved degradation with both maps

Adding PXD: At low angles small increase in efficiency (1-3%)

Fake rate - pt

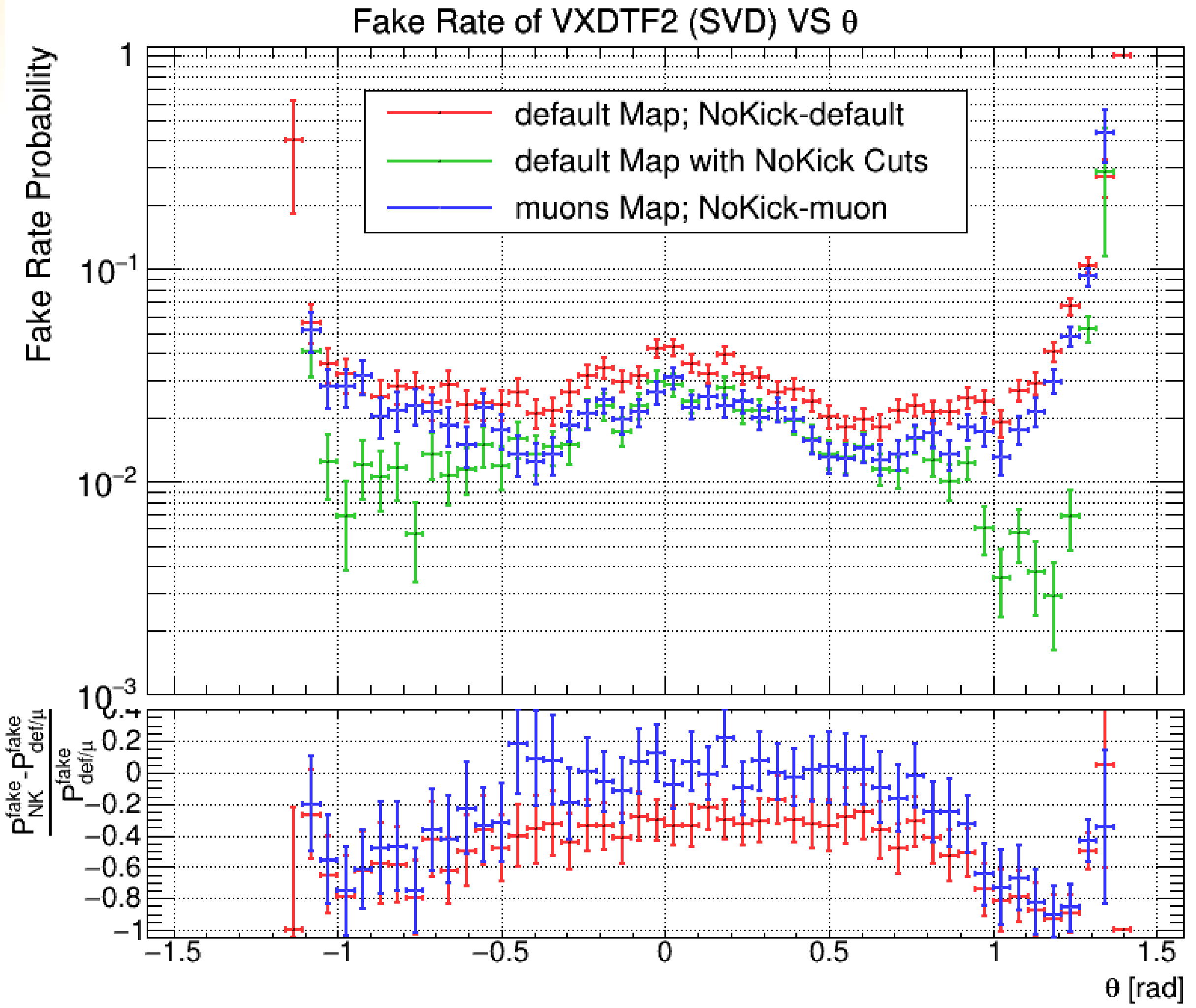


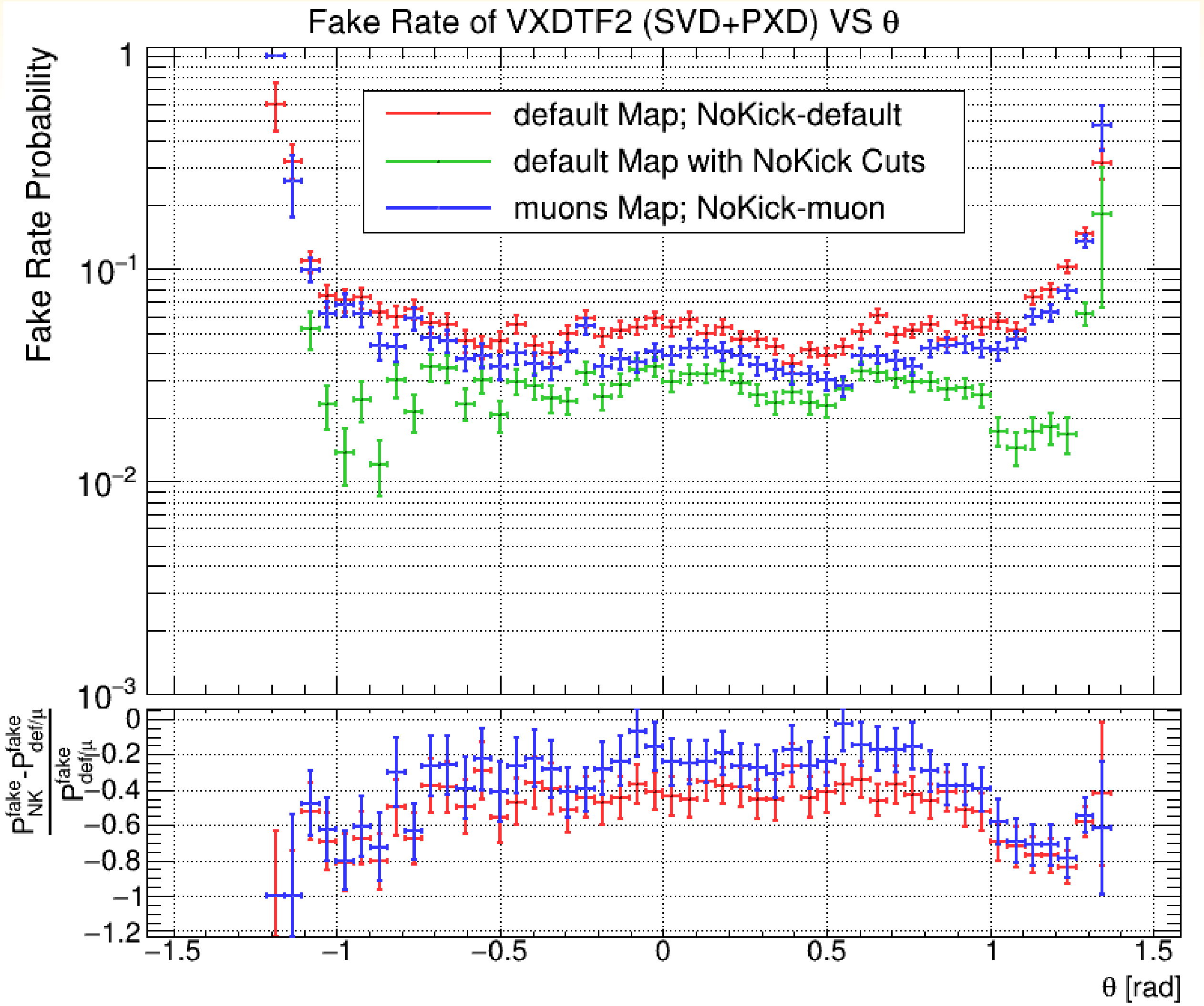


- **VS Default:** fake rate halved at low momentum and reduced in all the range
- **VS Muon:** fake rate halved under 50 MeV/c and quite the same over 50 MeV/c

- **Adding PXD**: increased fake rate for all the maps, thus same situation of SVD-only

Fake rate - theta





- **VS Default:** fake rate reduced in all the range about 40-80%
- **VS Muon:** the same at low angle, reduced of 40%-60% at high angle

- **Adding PXD, VS Default:** quite as SVD-only
- **Adding PXD, VS Muon:** reduced at low angle too (20%)

Effects on tacking - CPU Time

Default Map
- 10.6 ms/ev (Fast)
- 32.3 ms/ev (Full)
- VXDTF1: 3.6 (Fast)9.3 (Full) ms/ev
- 20-40 % Overlap Rem, 50-30% SegNetProd, 15% C.A.

Muon Map
- 3.2 ms/ev (Fast)
- 12.4 ms/ev (Full)
- 9-20% Overlap Rem, 50% SegNecProd, 5-10% C.A

NoKick Map
- 4.5 ms/ev (Fast)
- 9.58 ms/ev (Full)
- 16-20 % Overlap Rem,. 60-45% SegNetProd, 9-8% C.A

- NoKick Map gives the best result in Full Reco
- Muon Map gives the best result in Fast reco
- Both reduce of a factor 3 the CPU time
- Gain mainly in Overlap Remover and SegNetProd

Summary

- Cuts works as expected on the training sample
- Cuts are not able to remove all the loops inside the SecMap, they have a different physical source
- With the NoKick maps the fake rate is halved, with 3-10% degradation in efficiency.
- The CPU time is reduced of factor 3
- The Muon map has similar result, slighty higher efficiency but higher fake rate
- The PXD strongly increase the performances in NoKick case

Next steps

- NoKick Cuts are not optimized → large rooms of improvement:
  - Define the single-cut efficiency requirement from a figure of merit (from final performances in term of Efficiency, Fake Rate, CPU time)
  - Probably long work
- Identified a way (from Martin Ritter software advice) to increase the performance of the cuts, maybe removing the global cuts
  - Currently cuts and validation under production (NoKick_upgrade)
  - Results in few days

BACKUP SLIDES

Track Parameters

$$\omega \to \frac{B_3 q}{\sqrt{P_1^2+P_2^2}} \qquad (1)$$

$$\tan\lambda \to \frac{P_3}{\sqrt{P_1^2+P_2^2}} \qquad (2)$$

$$d_0 \to \operatorname{sgn}(B_3 q)\left(\sqrt{\left(\frac{P_2}{B_3 q}+X_1\right)^2+\left(X_2-\frac{P_1}{B_3 q}\right)^2}-\sqrt{\frac{P_1^2+P_2^2}{B_3^2 q^2}}\right) \qquad (3)$$

$$\chi \to \tan^{-1}\left(\operatorname{sgn}(B_3 q)\left(\frac{P_1^2+P_2^2}{B_3 q}+P_2 X_1-P_1 X_2\right), (-P_1 X_1-P_2 X_2)\operatorname{sgn}(B_3 q)\right)$$

$$\varphi_0 \to \tan^{-1}(P_1, P_2)-\chi \qquad (4)$$

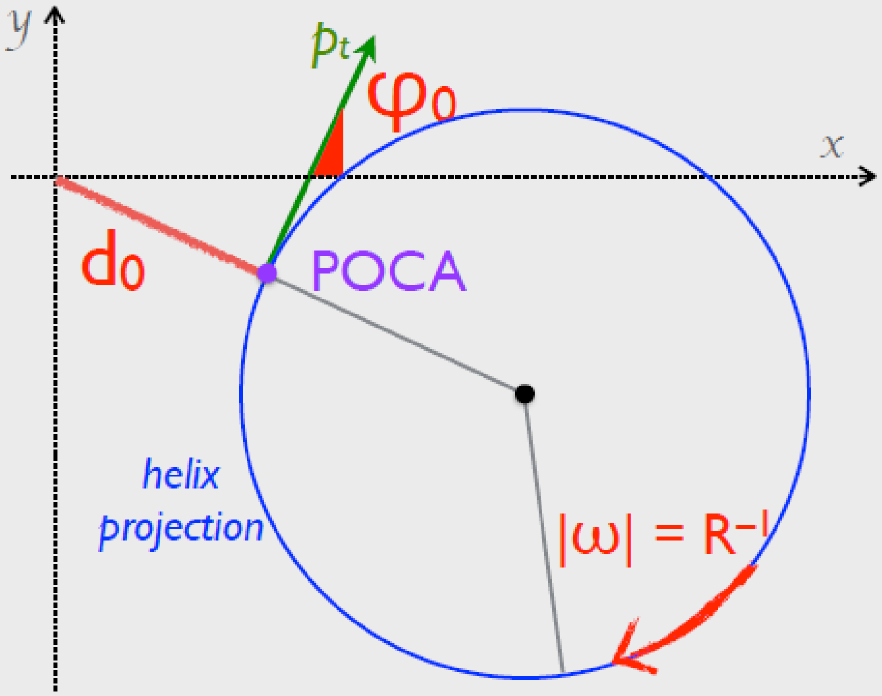
$$z_0 \to \frac{P_3 \chi}{B_3 q}+X_3 \qquad (5)$$

$$s \to -\frac{\sqrt{P_1^2+P_2^2}\,\chi}{B_3 q}$$

[Eugenio, Oliver, Tobi,
helices:the nitty-gritty of their Parametrization, B2GM 2015]

Track Parameterisation

TRANSVERSE PLANE



- POCA = Point Of Closest Approach
- d_0 is the 2d signed distance of the POCA from the z axis, the sign depends on the angular momentum of the track (>0 in the fig.)
- φ_0 is the angle between p_t and the x axis at the POCA, $\varphi_0 \in [-\pi, \pi]$
- the sign of ω, the curvature, is the same as the charge of the track (>0 in the fig.)

LONGITUDINAL VIEW

- $\tan\lambda$ is the ratio of p_z and p_t, $\lambda \in [-\pi, \pi]$
- z_0 is the signed distance of the POCA from the transverse plane