МФТИ

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PNPI

Prospects for the study of the hot QCD matter with heavy-flavor probes at ALICE-3 (HL-LHC)

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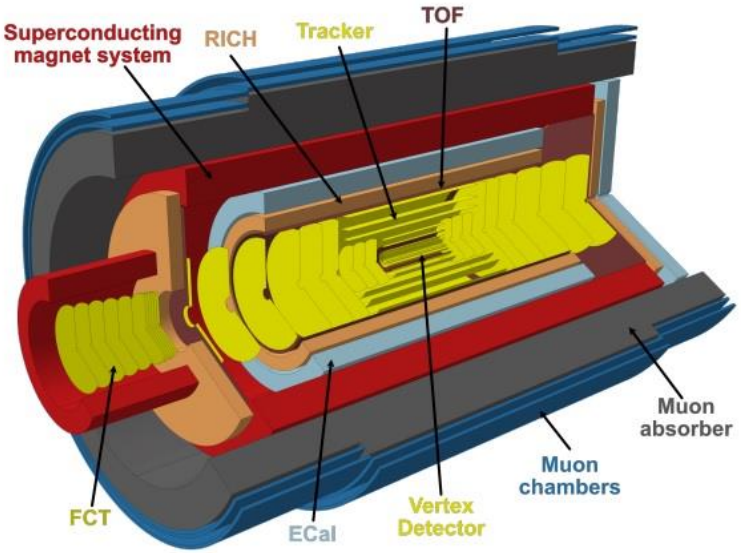
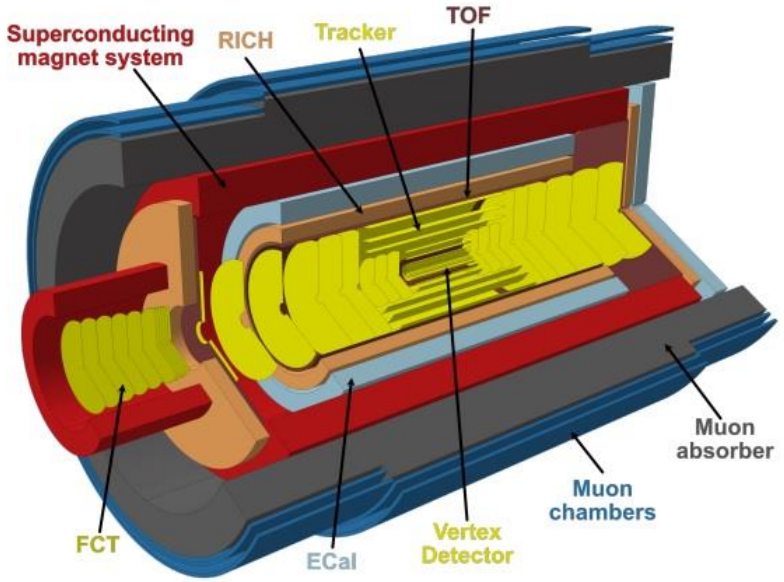


* This work was supported by RSF according to the research project № 22-42-04405

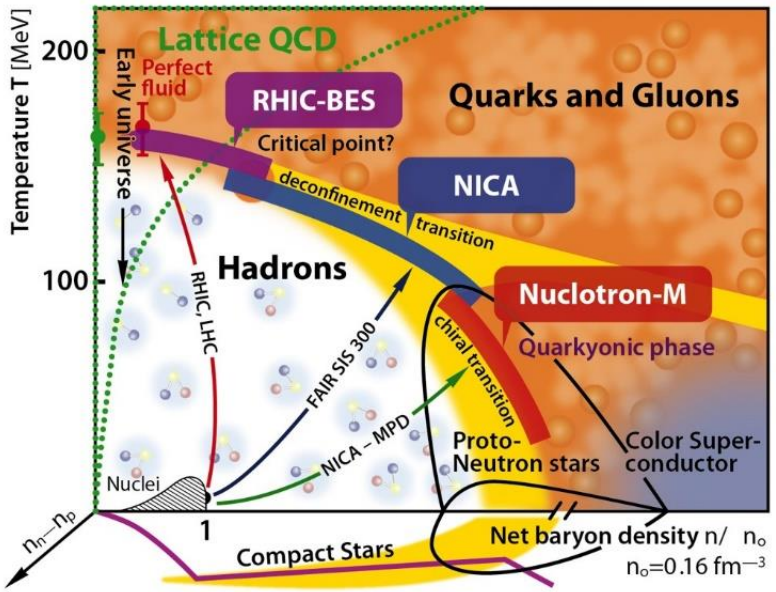
Introduction

Advanced detector:

- Compact all-silicon tracker with high-resolution vertex detector
- Superconducting magnet system
- Particle Identification over large acceptance:
- muons, electrons, hadrons, photons
- Fast read-out and online processing

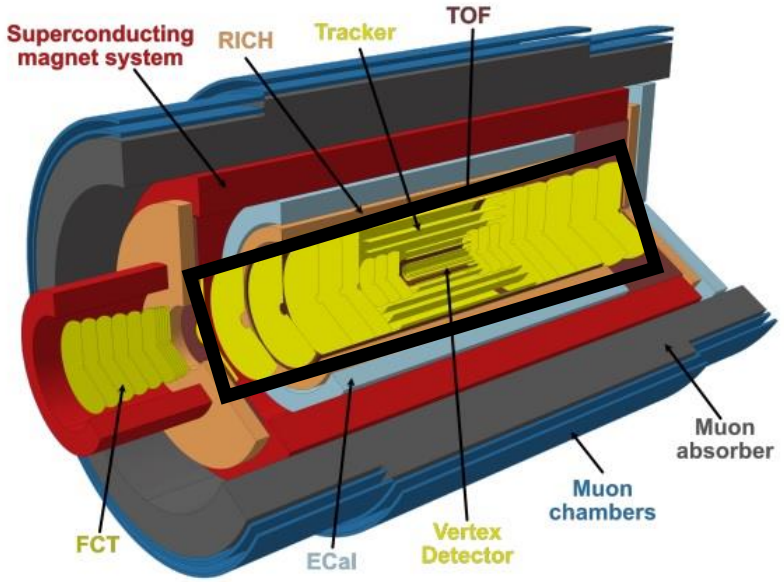


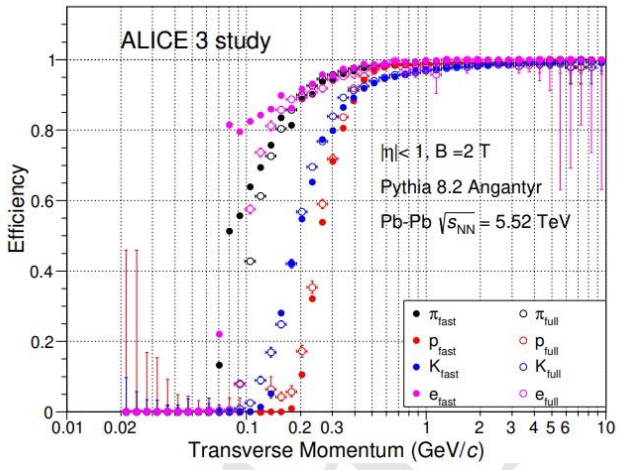
- ✓ Heavy quarks, like charm and beauty, are sensitive probes to investigate the colour-deconfined medium created in high-energy heavy-ion collisions
- ✓ Because of their large mass, heavy quarks are mainly produced in the early times of the collision, before the formation of the QGP
- ✓ High p_T – in-medium parton energy loss
- ✓ Comparison to light-flavor – dependance of the energy loss on the color charge and quark mass
- ✓ Hadronisation mechanisms studies

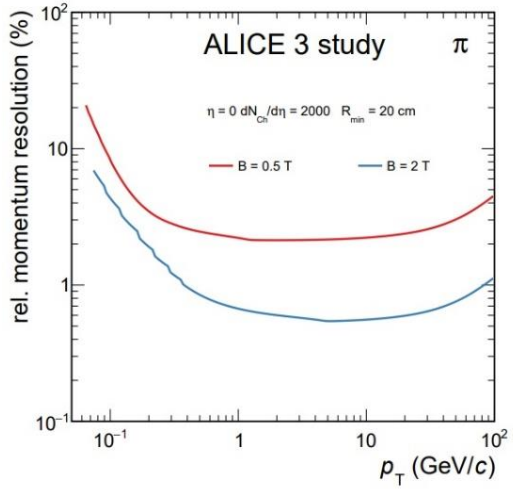


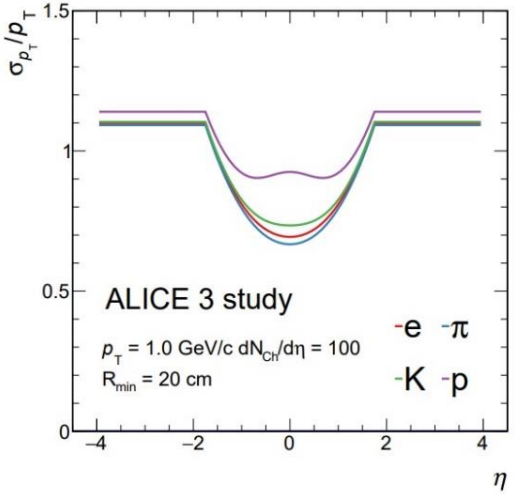
ALICE3 concept: tracker

Layer	Material thickness ($\%X_0$)	Intrinsic resolution (μm)	Barrel layers Length ($\pm z$) (cm)	Barrel layers Radius (r) (cm)	Forward discs Position ($\lvert z\rvert$) (cm)	Forward discs R_{in} (cm)	Forward discs R_{out} (cm)
0	0.1	2.5	50	0.50	26	0.50	3
1	0.1	2.5	50	1.20	30	0.50	3
2	0.1	2.5	50	2.50	34	0.50	3
3	1	10	124	3.75	77	5	35
4	1	10	124	7	100	5	35
5	1	10	124	12	122	5	35
6	1	10	124	20	150	5	80
7	1	10	124	30	180	5	80
8	1	10	264	45	220	5	80
9	1	10	264	60	279	5	80
10	1	10	264	80	340	5	80
11	1				400	5	80





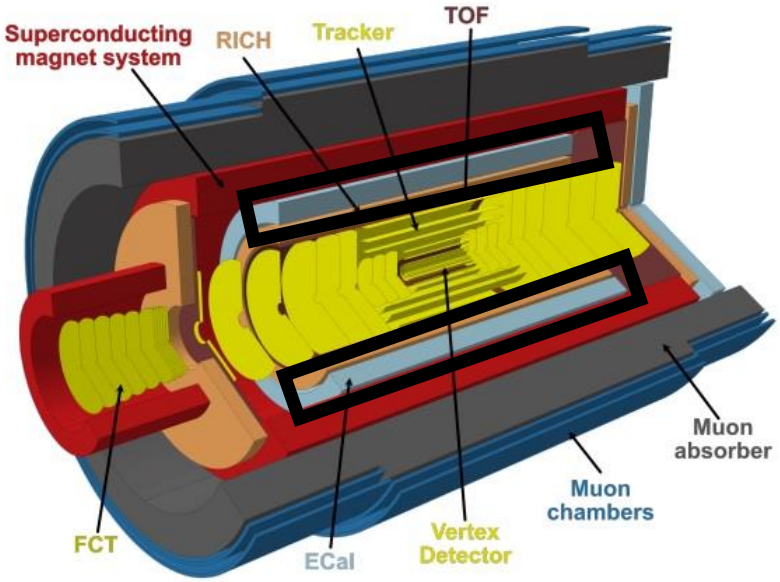




ALICE3 LOI - 2211.02491.pdf (arxiv.org)

ALICE3 concept: ECAL

- The Electromagnetic Calorimeter (ECAL) is planned to cover the full central barrel region and one forward region, i.e. the rapidity range of $-1.6 < \eta < 4$
- Most of the rapidity range will be instrumented with a samplin calorimeter (ECAL)
- A fraction of the central barrel will be covered by existing $PbWO_4$ crystal for the high precision measurements



ECAL energy resolution:

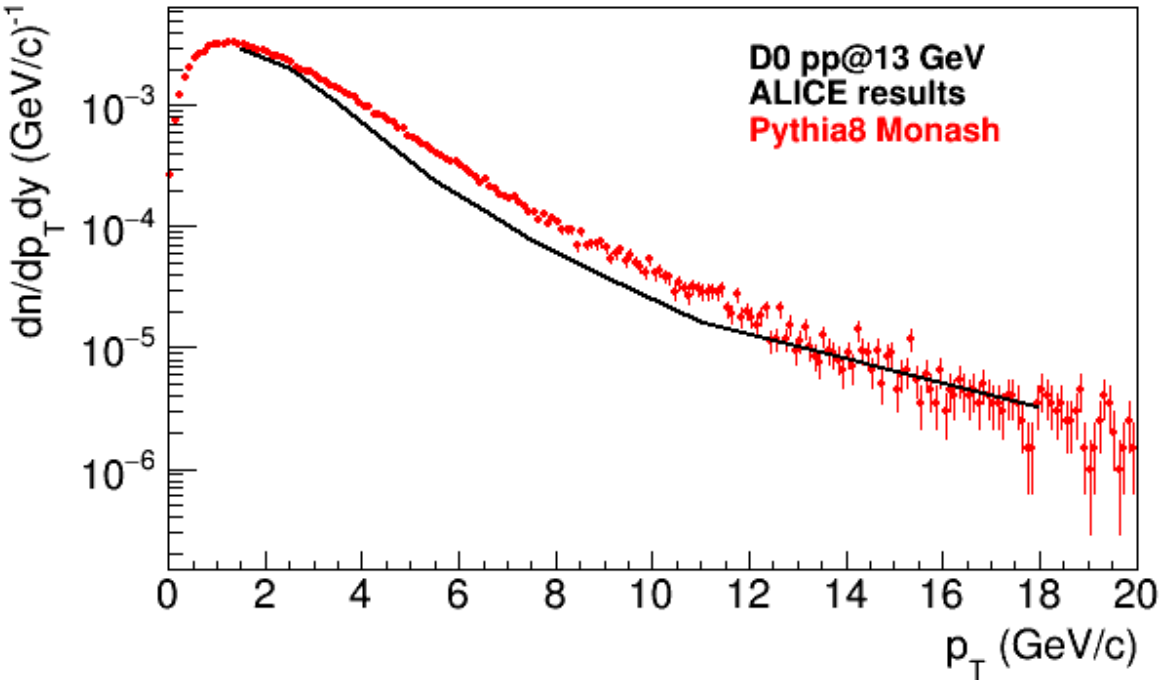
$$\frac{\sigma_E}{E} = \frac{a}{E} \oplus \frac{b}{\sqrt{E}} \oplus c$$

ECal module	Barrel sampling	Endcap sampling	Barrel high-precision
acceptance	$\Delta\varphi = 2\pi$, $\lvert\eta\rvert < 1.5$	$\Delta\varphi = 2\pi$, $1.5 < \eta < 4$	$\Delta\varphi = 2\pi$, $\lvert\eta\rvert < 0.33$
geometry	$R_{in} = 1.15$ m, $\lvert z\rvert < 2.7$ m	$0.16 < R < 1.8$ m, $z = 4.35$ m	$R_{in} = 1.15$ m, $\lvert z\rvert < 0.64$ m
technology	sampling Pb + scint.	sampling Pb + scint.	$PbWO_4$ crystals
cell size	30×30 mm^2	40×40 mm^2	22×22 mm^2
no. of channels	30 000	6 000	20 000
energy range	$0.1 < E < 100$ GeV	$0.1 < E < 250$ GeV	$0.01 < E < 100$ GeV

ALICE3 LOI - 2211.02491.pdf (arxiv.org)

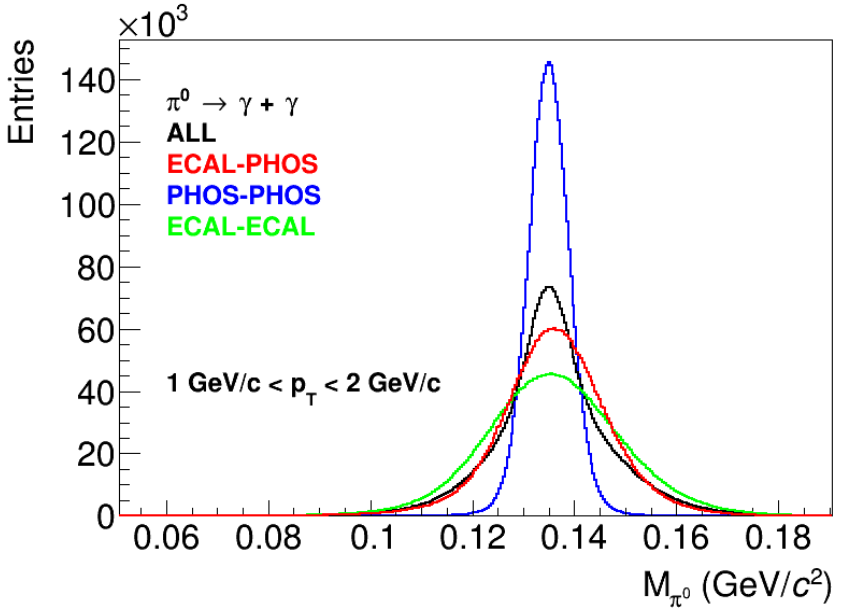
Simulation

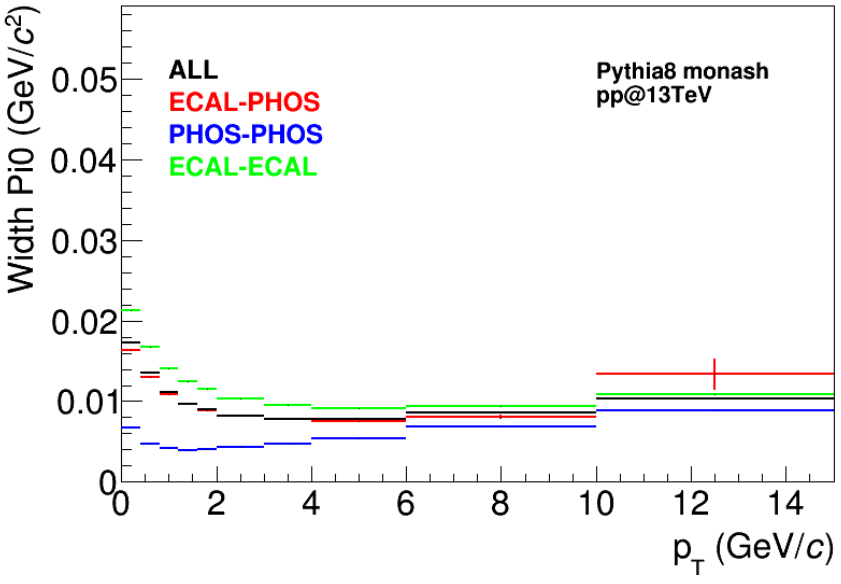
- Pythia8 (Monash 2013 tune) pp@13TeV
- $D^0 \rightarrow \pi^{\pm} + K^{\pm} + \pi^0 (\pi^0 \rightarrow \gamma + \gamma)$ (BR ~ 14%)
- $D(2007) \rightarrow D^0 + \gamma$ (BR ~ 38%)
- $D(2010)^{\pm} \rightarrow D^0 + \pi^{\pm}$ (BR ~ 68%)

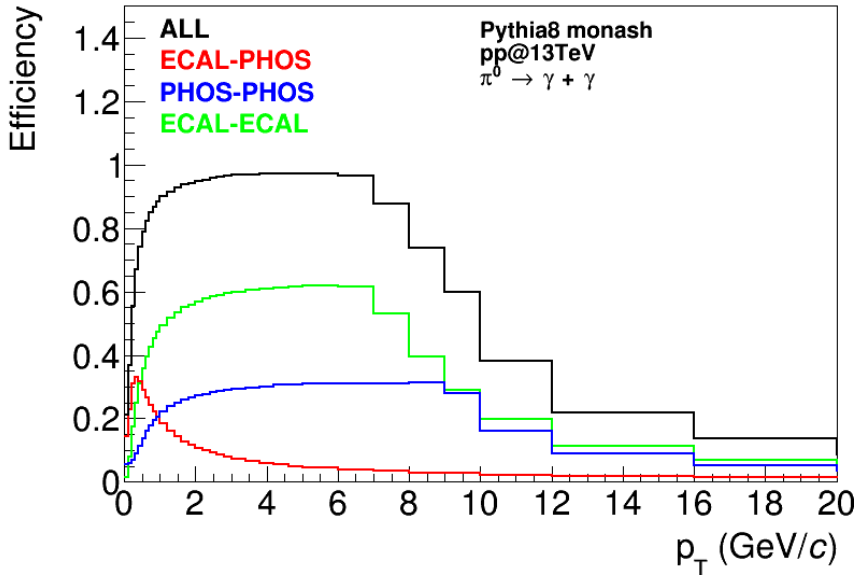


Detector resolution estimation: π^0

- $D^0 \rightarrow \pi^{\pm} + K^{\pm} + \pi^0 (\pi^0 \rightarrow \gamma + \gamma)$
- 2 γ in High precision part of the calorimeter – PHOS-PHOS
- 2 γ in ECAL acceptance – ECAL-ECAL
- 1 γ in high precision part and 1 outside – ECAL-PHOS







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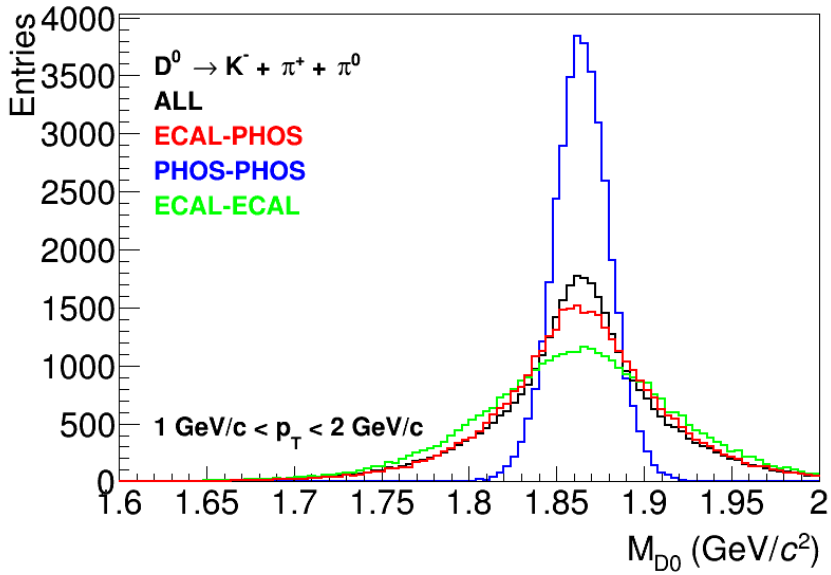
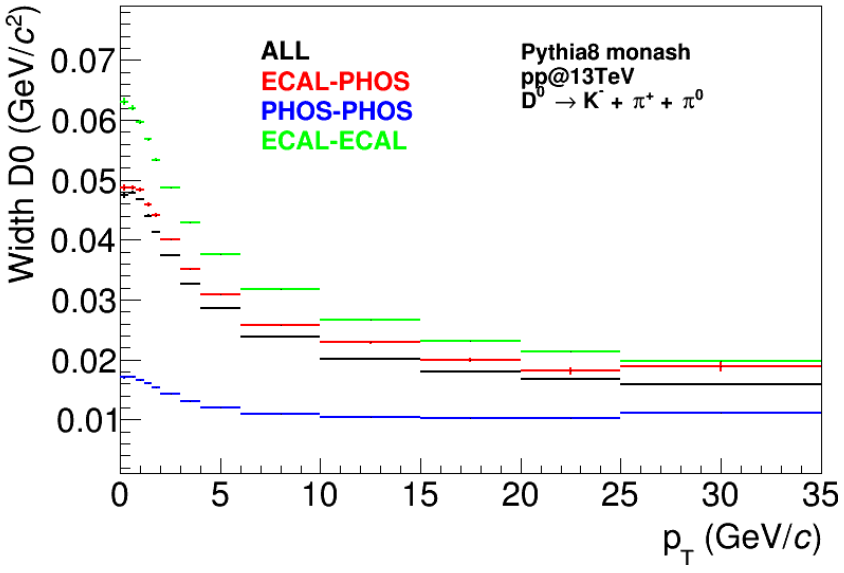
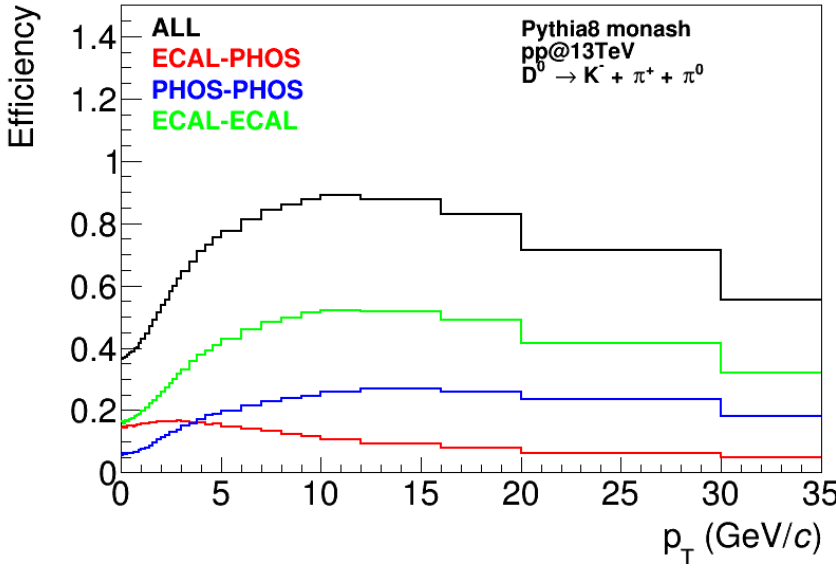
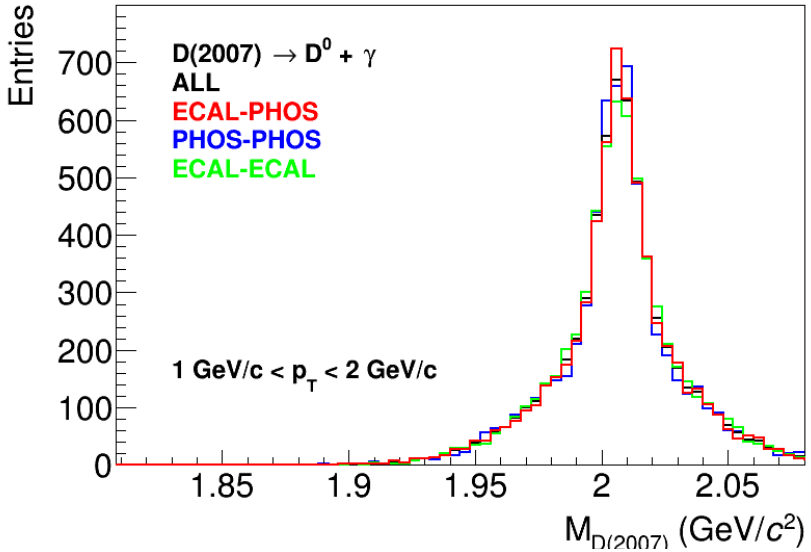
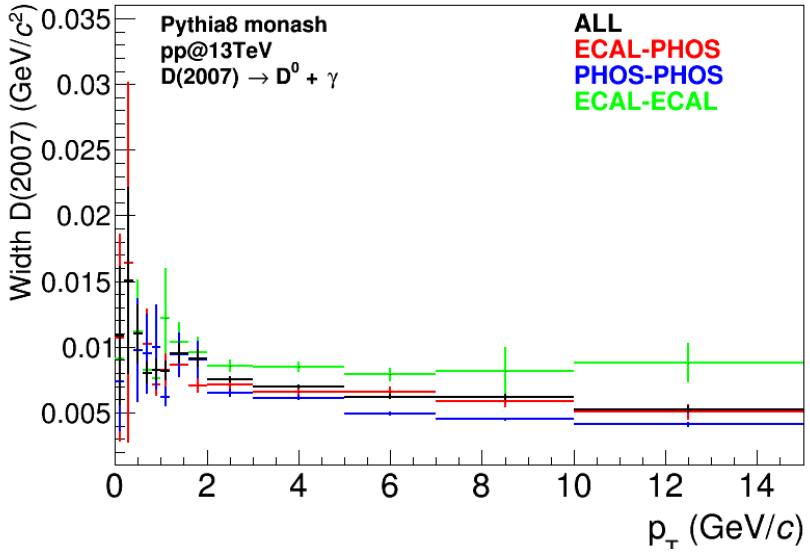


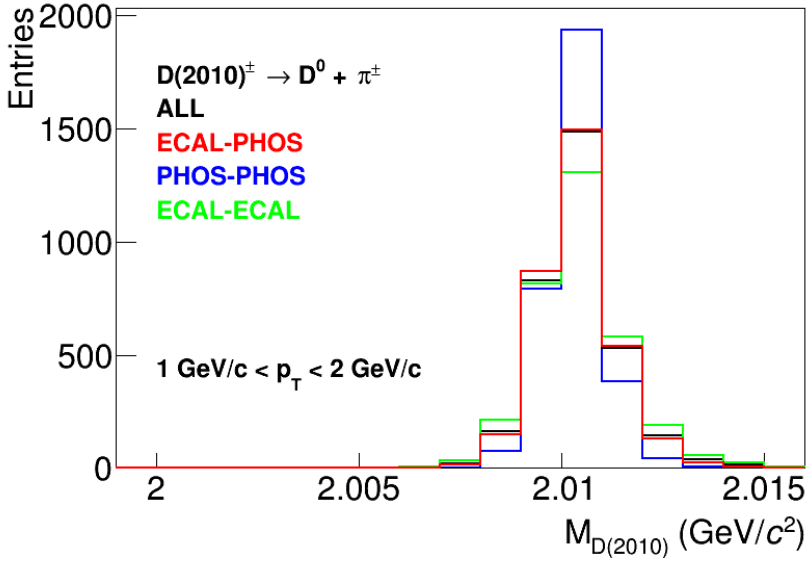


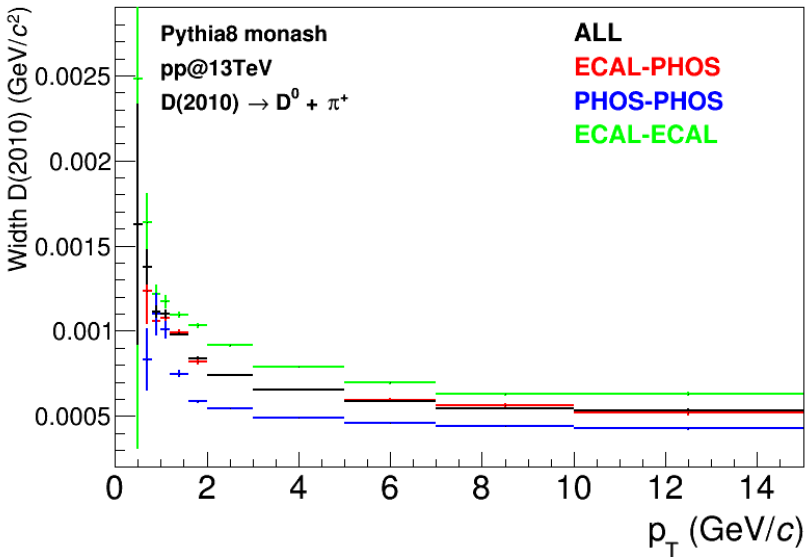


Detector resolution estimation: D(2007) & D(2010)

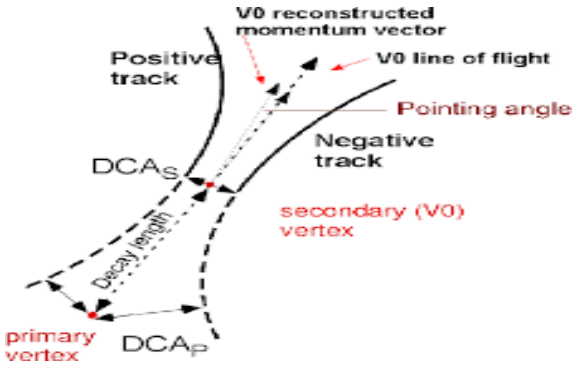


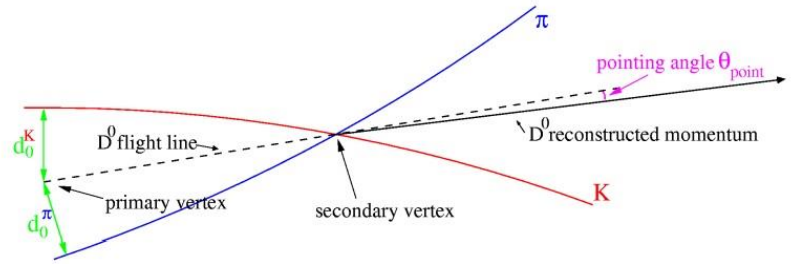






Cut optimization: DCA & Distance between tracks cuts



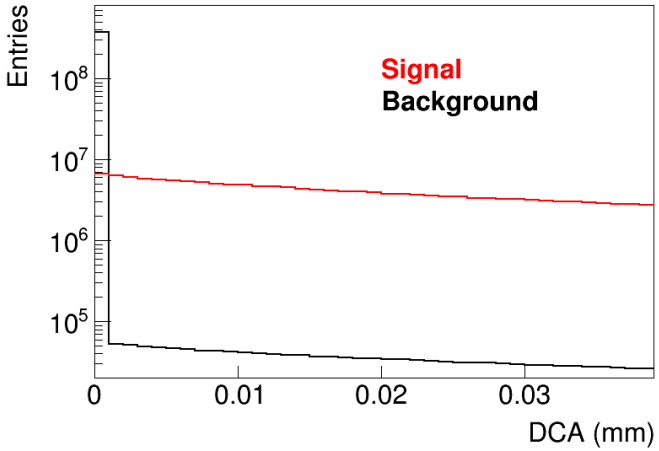


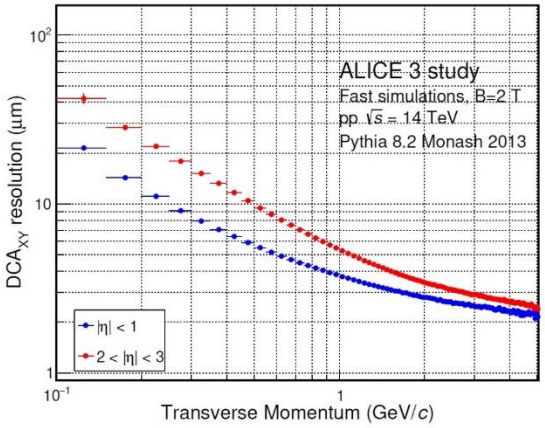
DCA (distance of closest approach) cut:

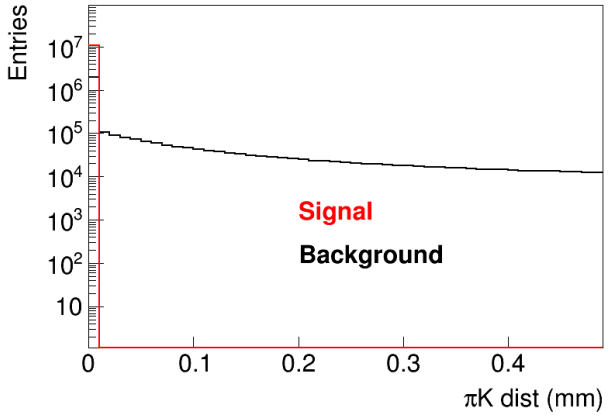
- All prompt particles go from 0 (primary vertex)
- Tracks from D0 decay have non-zero DCA
- p_T dependent cut equal to DCA resolution estimation (2211.02491.pdf (arxiv.org)))

Distance cut:

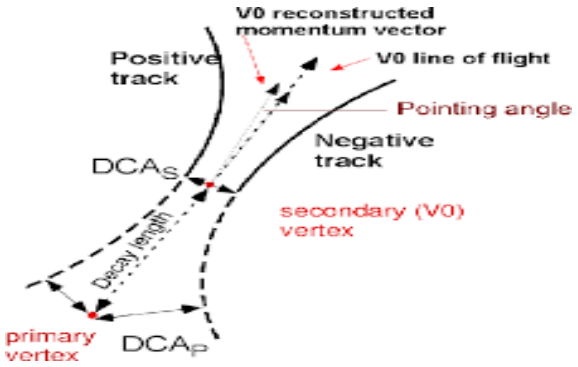
- Signal - distance between tracks always 0
- Background - pairs distributed in wide range
- Distance < 50 μm

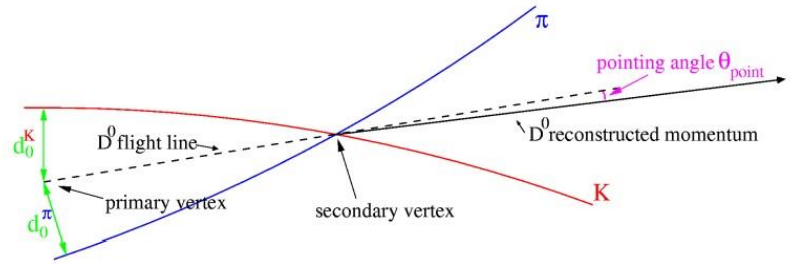






Cut optimization: Pointing angle & Decay length cuts



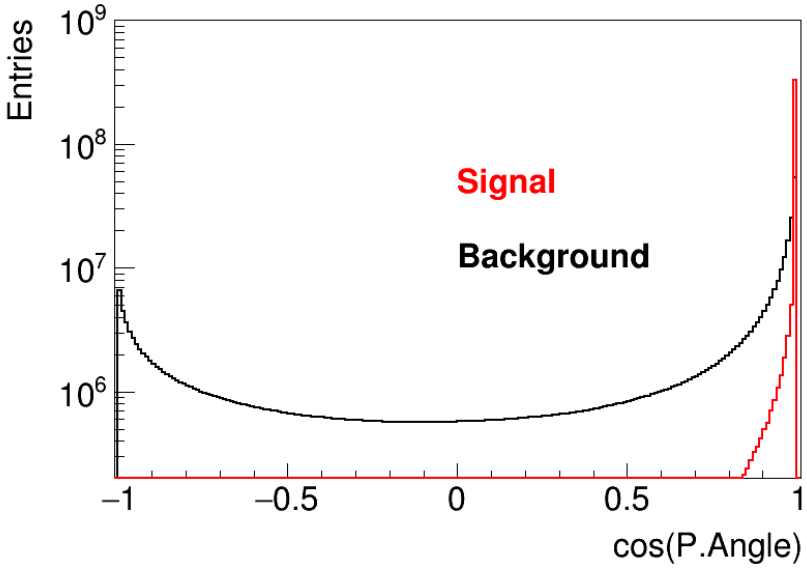


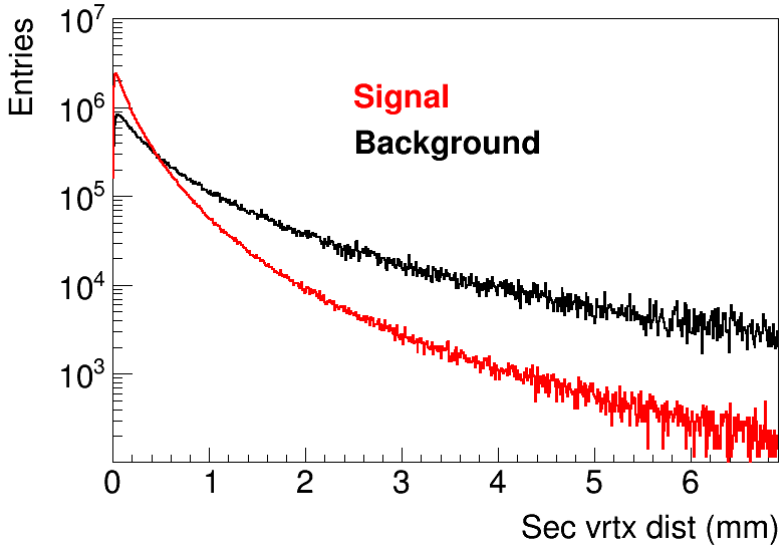
Pointing angle cut:

- Signal – close to 1
- Background – from -1 to 1
- Cos(p.angle) > 0.9

Decay length cut:

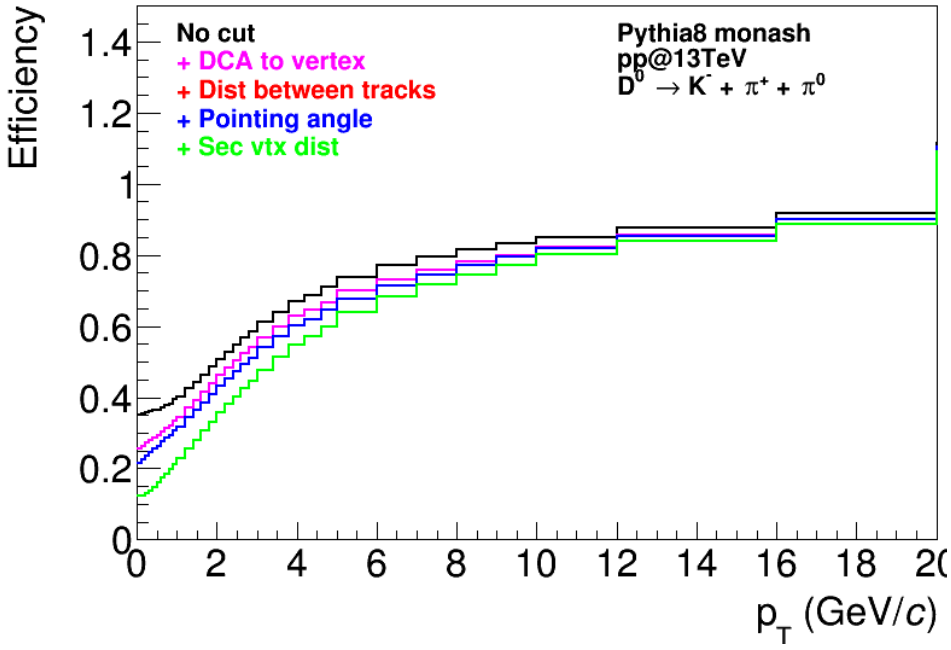
- Depends on the resolution of the secondary vertex reconstruction
- Does not improve signal to background ratio
- 100 μm for check

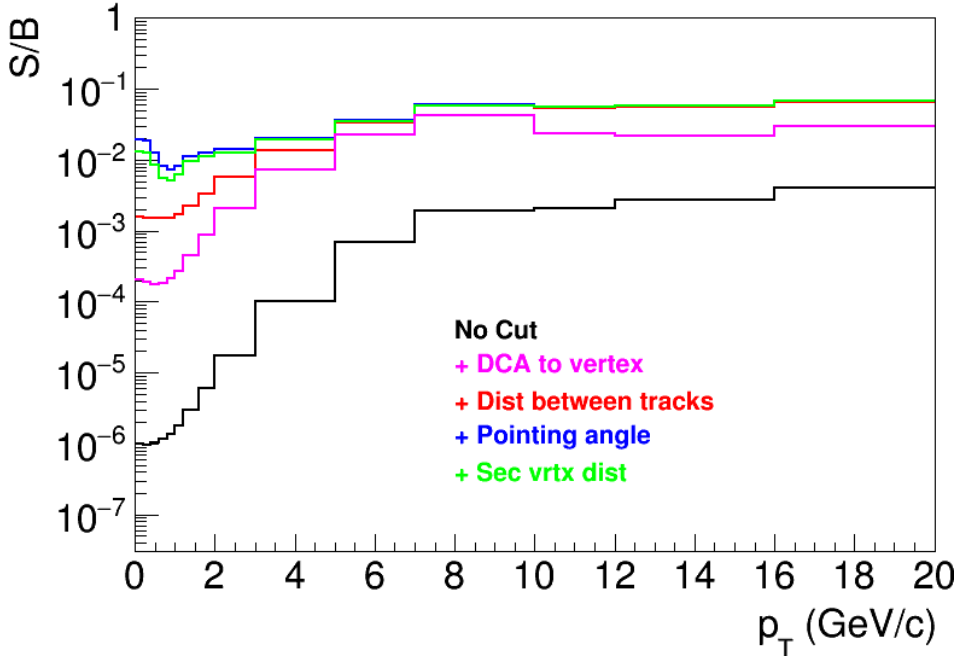




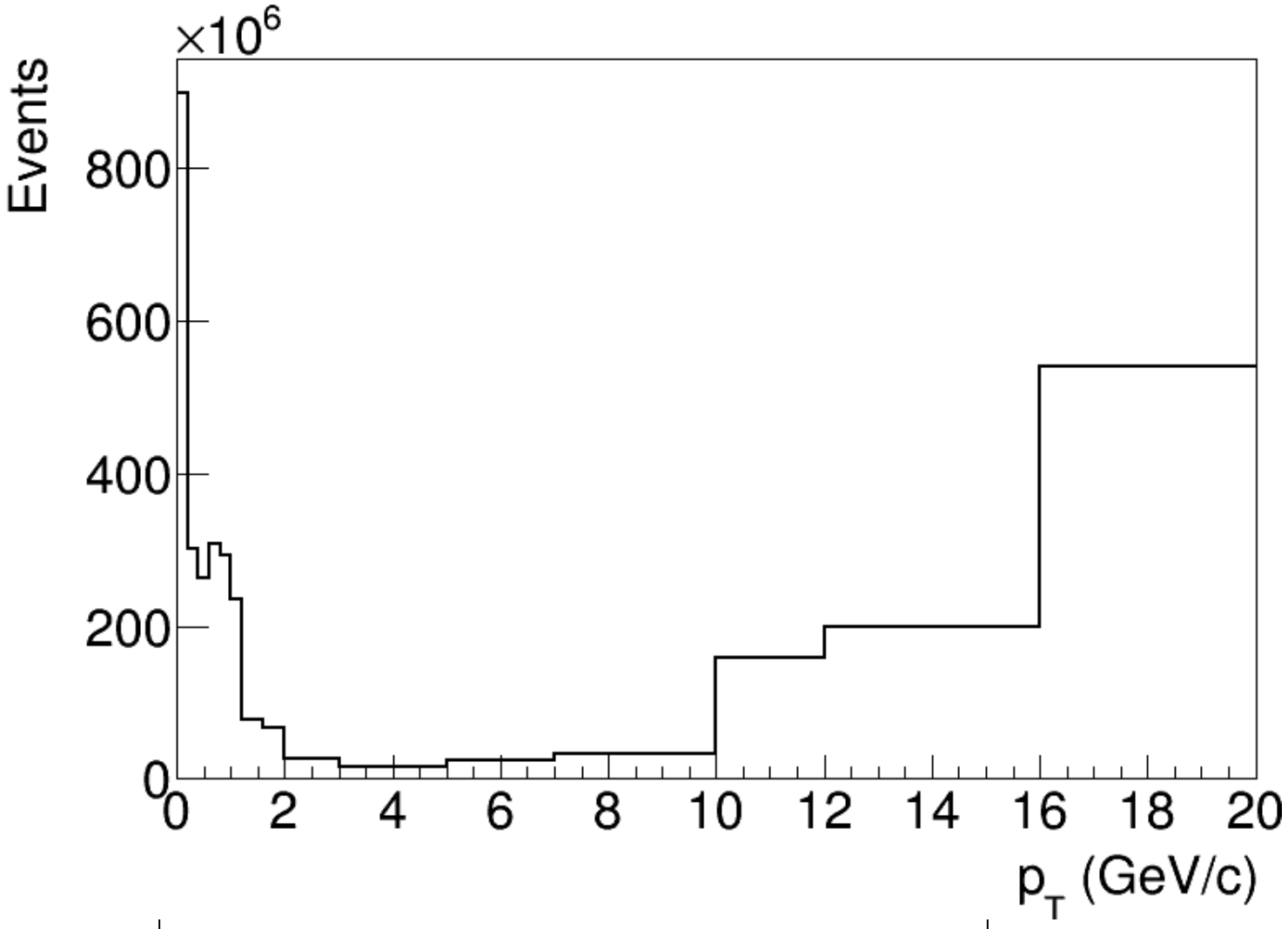
Cuts efficiency

- First rough estimation
- No dramatic losses of signal due to cuts
- Considerable gain in signal to background due to cut implementation
- Main contribution form DCA cut
- Work in progress





Statistic estimation



- Estimation for significance equal to10
- Low p_T reach – signal/background improvement
- High p_T reach – limited only by statistic

Summary

- Measurement of heavy quarks will contribute to the ALICE3 physical program
- $D^0 \rightarrow \pi^{\pm} + K^{\pm} + \pi^0$ advantages in relatively large BR (~14%) and electromagnetic calorimeter usage
- First estimations of detector resolution, reconstruction efficiency and cuts efficiency provided
- Principal possibility for D0 mesons reconstruction in ALICE3 experimental setup demonstrated
- High p_T reach is limited only by available statistic
- Work in progress

This work was supported by RSF according to the research project № 22-42-04405

Backup slides

Detector resolution estimation: D(2007) & D(2010)