

Progress update on muon combinatorial background

Oliver Lantwin , Kostas Petridis

11th SHiP Collaboration Meeting, CERN

[oliver.lantwin@cern.ch]

8th June 2017



Update of combinatorial background studies with

- ▶ New detector geometry and shield
- ▶ Updated kinematics for toy generator

Introduction

Muons from Muon Background

Study of muon kinematics at the tracking stations

Toy-MC

Results

Conclusion

Simulation procedure



NB: Closely following [Kostas's](#) procedure used for TP with some recent departures (see later slides)

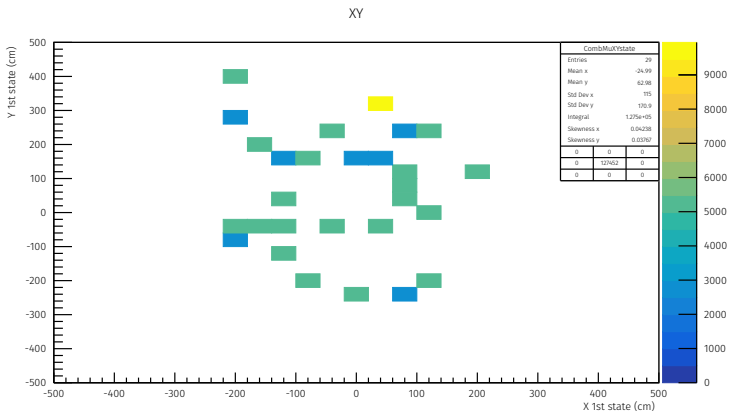
- ▶ Use muons with [well-reconstructed](#) tracks from muon background
- ▶ Form all possible combinations
- ▶ Use distributions of position, momenta to seed a fast simulation
 - ▶ Use data-driven methods to estimate kinematics
 - ▶ Generate according to these kinematics

Muons pairs used as seed

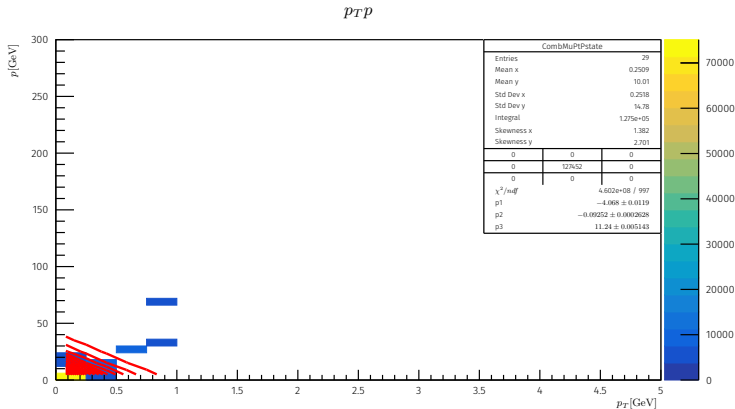


- ▶ Updated to 10× the full muon sample (9× with randomised ϕ)
 - ▶ 29 muons → 406 combinations
- ▶ Current geometry
- ▶ Current reconstruction

Hit distribution of muons (used as seed)



p_t - p distribution of muons (used as seed)



- ▶ Simple 2D Exponential fit (no cross-terms, assume p , p_t uncorrelated)
- ▶ Fit function chosen for TP because of lack of statistics → investigate using something more realistic now?

The toy-MC



- ▶ Sample muon positions from histogram of seed muons
- ▶ Sample muon momenta from fit
- ▶ Randomise ϕ of muon direction \rightarrow Uniform distribution? [Assumption justified?](#)

\rightarrow Study kinematics more closely!

Setup



- ▶ Generate 10 000 000 muons with particle gun, uniform in $3 < \eta < 8$ and $2 \text{ GeV} < p < 400 \text{ GeV}$ and $-\pi < \phi < \pi$
- ▶ Hans's shield configuration
- ▶ Study ϕ as a function of p , p_T for muons hitting the tracker

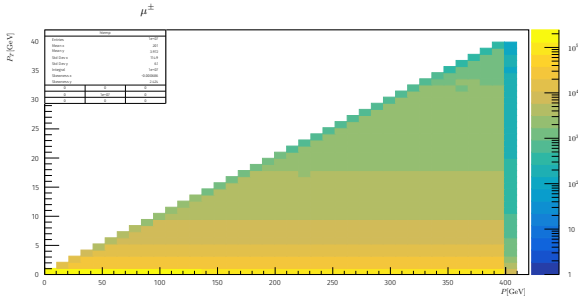


Figure: Generated momentum distribution

- ▶ NB: significantly higher momenta and transverse momenta than in actual muon spectrum, beyond kinematic limit

p - p_T distribution before and after shield

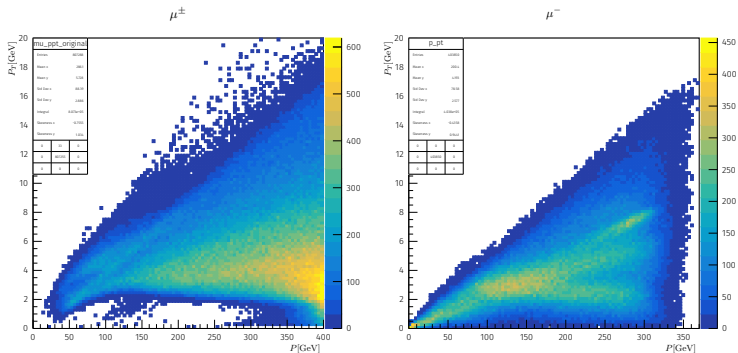
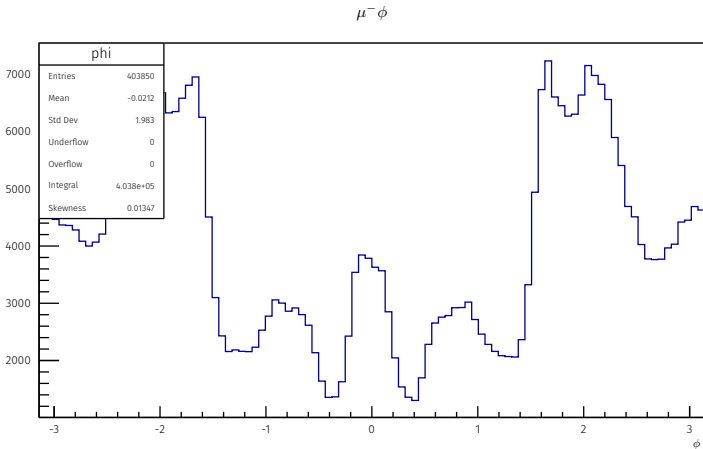


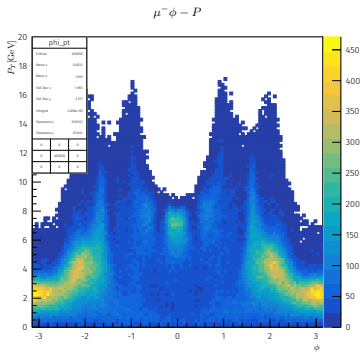
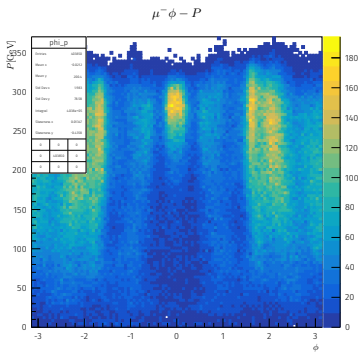
Figure: Momentum and transverse momentum of muons creating hits in the tracking station: left: at generation; right: at the tracking station

ϕ distribution



- ▶ Results for muons, for anti-muons results are virtually the same with ϕ shifted by π
- ▶ ϕ distribution clearly not uniform

ϕ - p_T and ϕ - P distributions



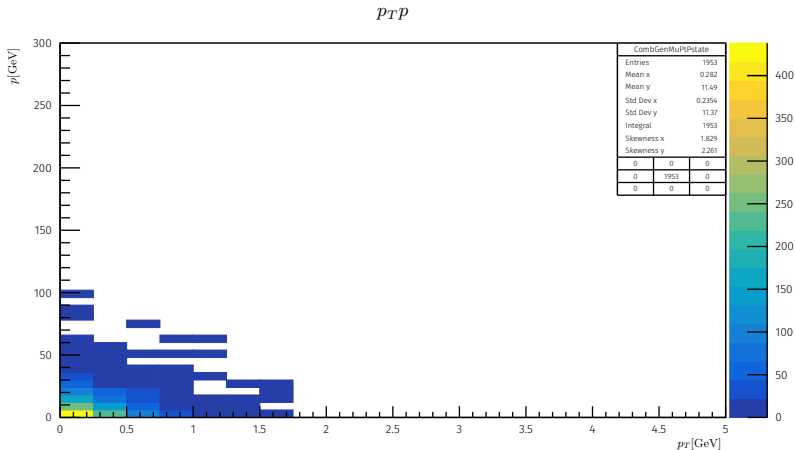
- Some clear hotspots visible.



- ▶ Sample muon positions from histogram of seed muons
- ▶ Sample muon momenta from fit
- ▶ Sample ϕ from p - p_t - ϕ histogram in slice corresponding to generated p - p_t
→ further studies into implicit assumptions ongoing
- ▶ Generate 1958* muons → 1915903 pairs

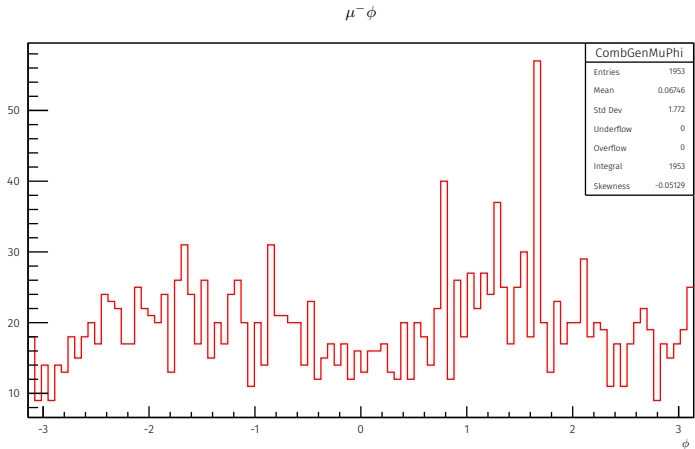
*2 events are discarded because their $p_t > p$

Generated p_t - p distribution of muons (from toy-mc)

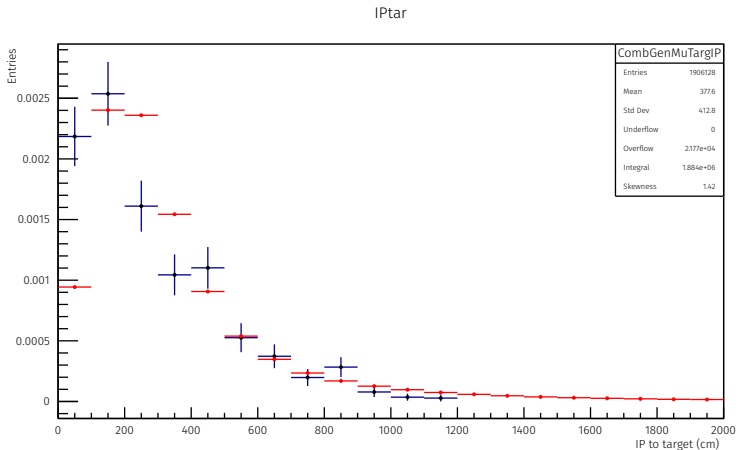


- Note: Sample muon momenta from fit (i.e. interpolate histogram) up to 100 GeV

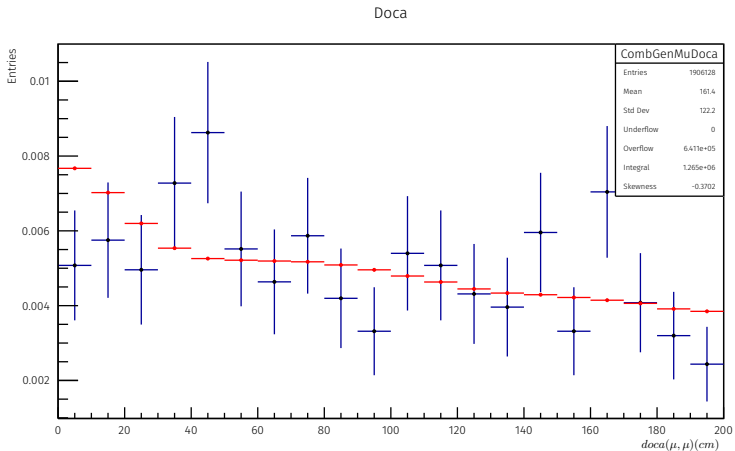
Generated ϕ distribution of muons (from toy-MC)



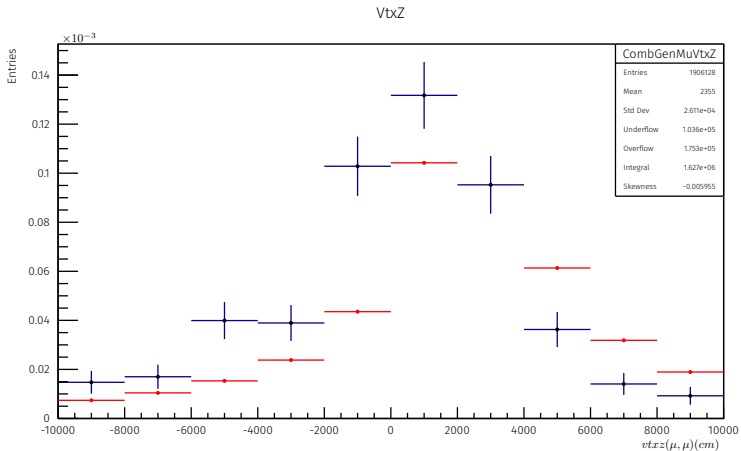
Comparison of seed muons vs. toy-MC muons



Comparison of seed muons vs. toy-MC muons



Comparison of seed muons vs. toy-MC muons



Conclusion



Update of combinatorial background studies with

- ▶ New detector geometry and shield
- ▶ Updated kinematics for toy generator

TODO

- ▶ Study relation between muon kinematics at generator and tracker to prove that method used to sample ϕ OK
- ▶ Cross-check by combining muons from different HNL decays
- ▶ Comparison with HNL signal
- ▶ Scale results and look at efficiency of cuts

Estimation of computing time:

- ▶ Bottleneck: muon generation for seeding the toy-MC \rightarrow a few days
 - ▶ Done, unless we want even more statistics, but randomising ϕ only gets us so far
- ▶ Toy-MC: \mathcal{O} (minutes)