Single muon analysis for d+Au collision at RHIC

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This is very introductory talk!

Outline

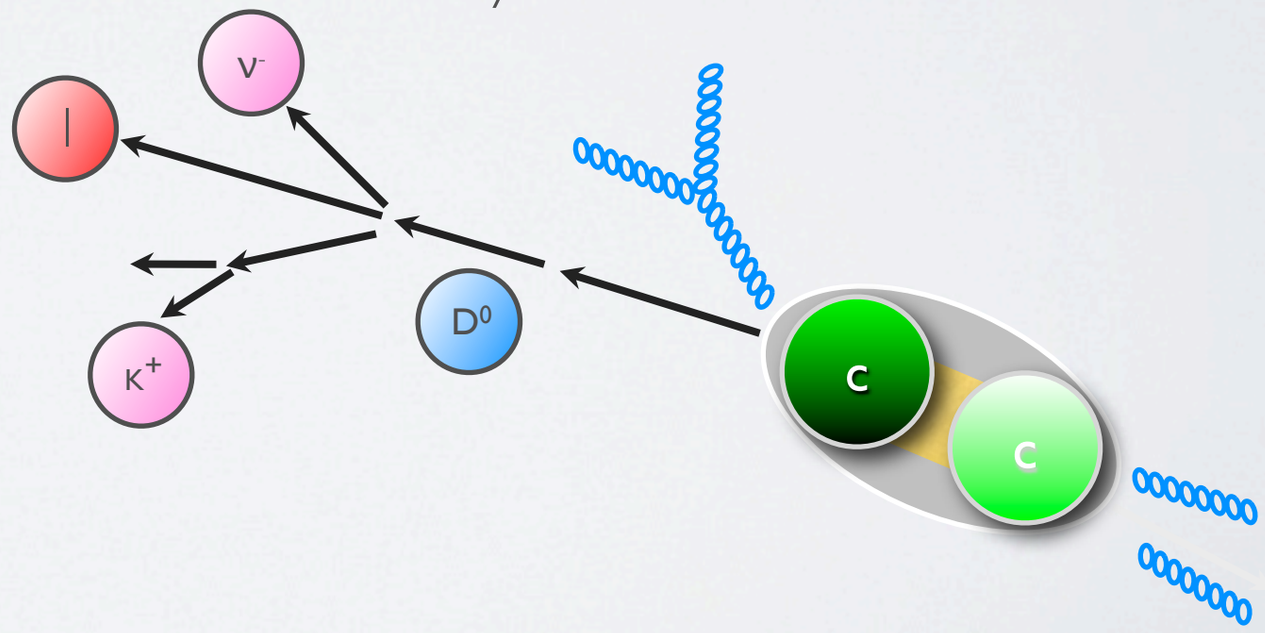
- ***Single muons*** in ***forward rapidity*** from ***d+Au collisions***

- How to the ***extract muons of open heavy flavor*** from hidden backgrounds

- Current status...

Single muons...

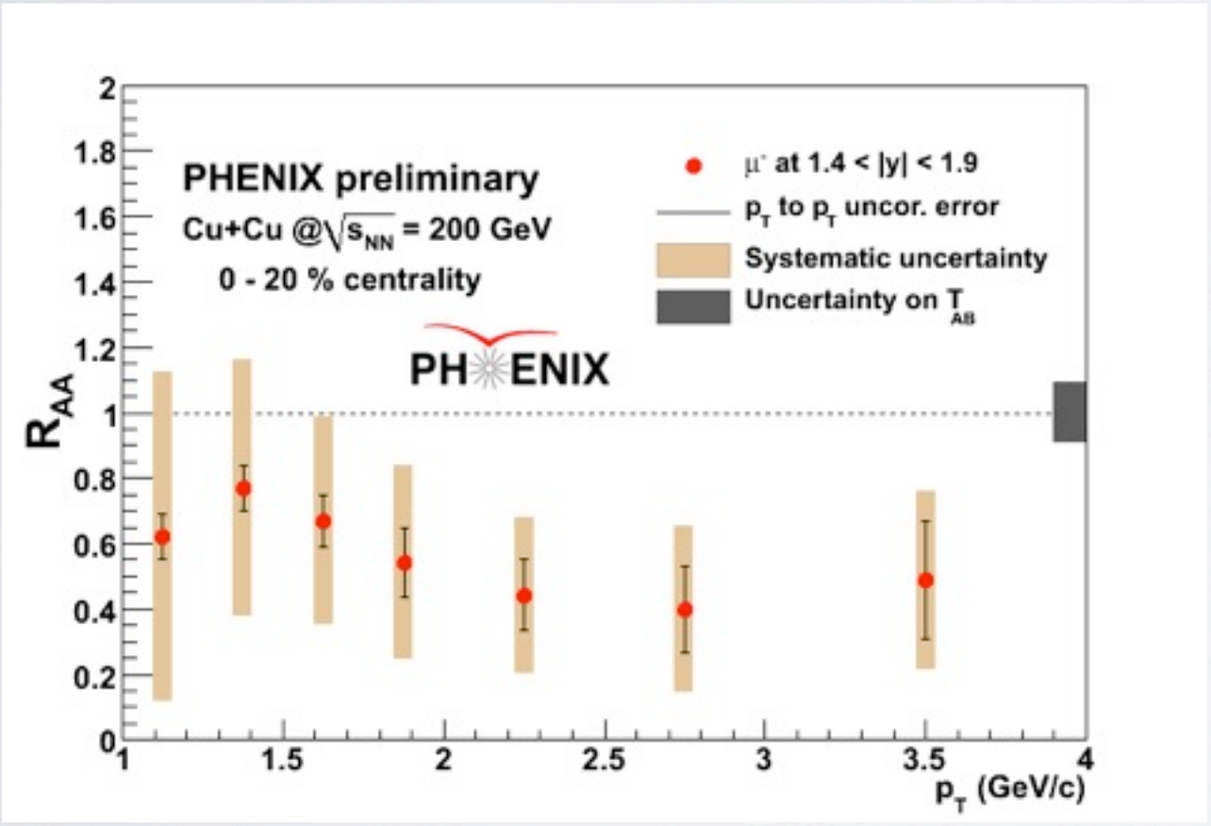
- In p+p
  - Measurement of heavy flavor production cross section
  - Reference for heavy-ion and deuteron-gold collision
  - Comparison with pQCD calculation
- In heavy ion
  - Measurement of heavy flavor production in heavy ion collisions
  - Study of medium effect

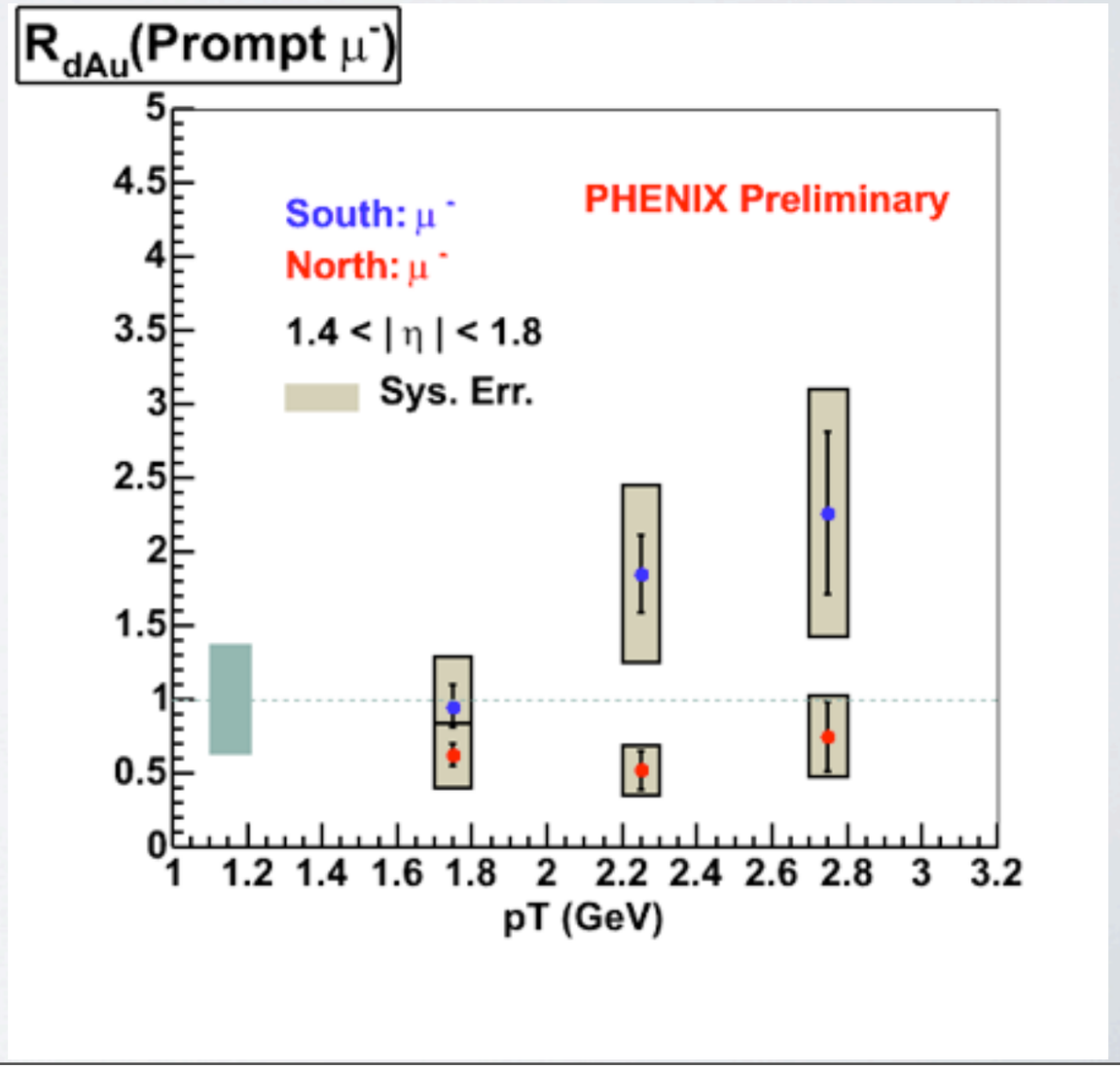


Nuclear modification factor

- Suppression in the most central Cu+Cu collisions
- Toward better results for d+Au collisions
  - reduce statistical errors and expand p_T region

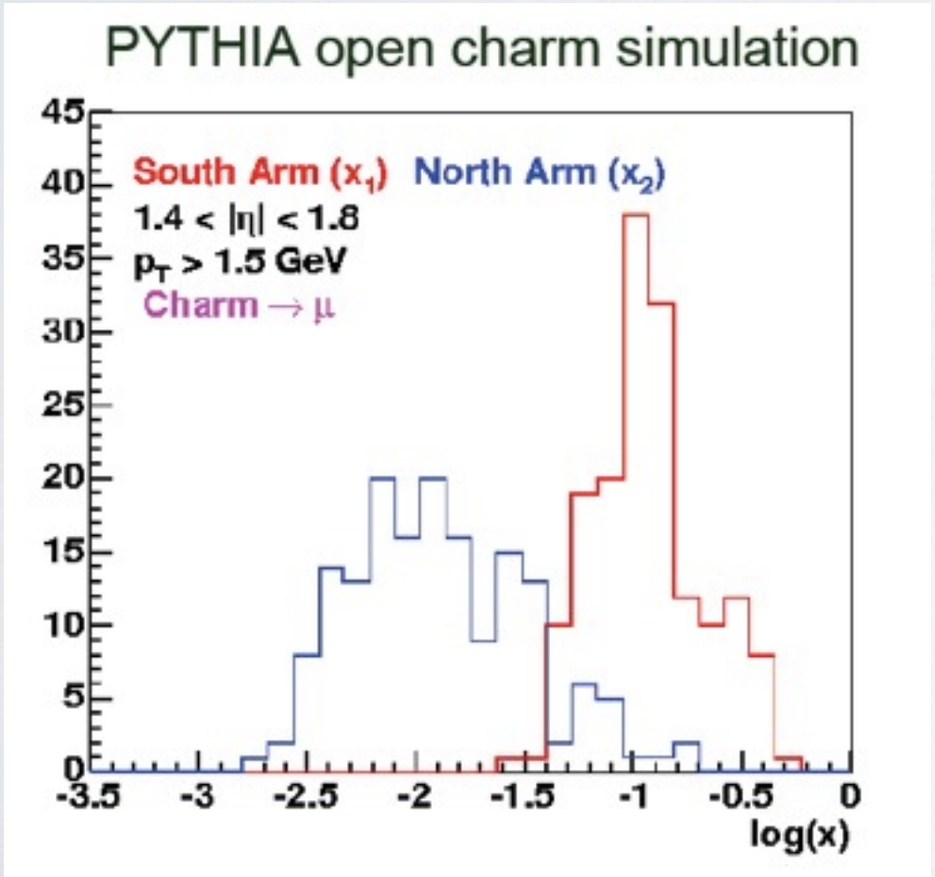
$$R_{AA}(p_T) = \frac{\frac{d^2 N^{AA}}{dp_T d\eta}}{< N_{coll} > \frac{d^2 N^{pp}}{dp_T d\eta}}$$

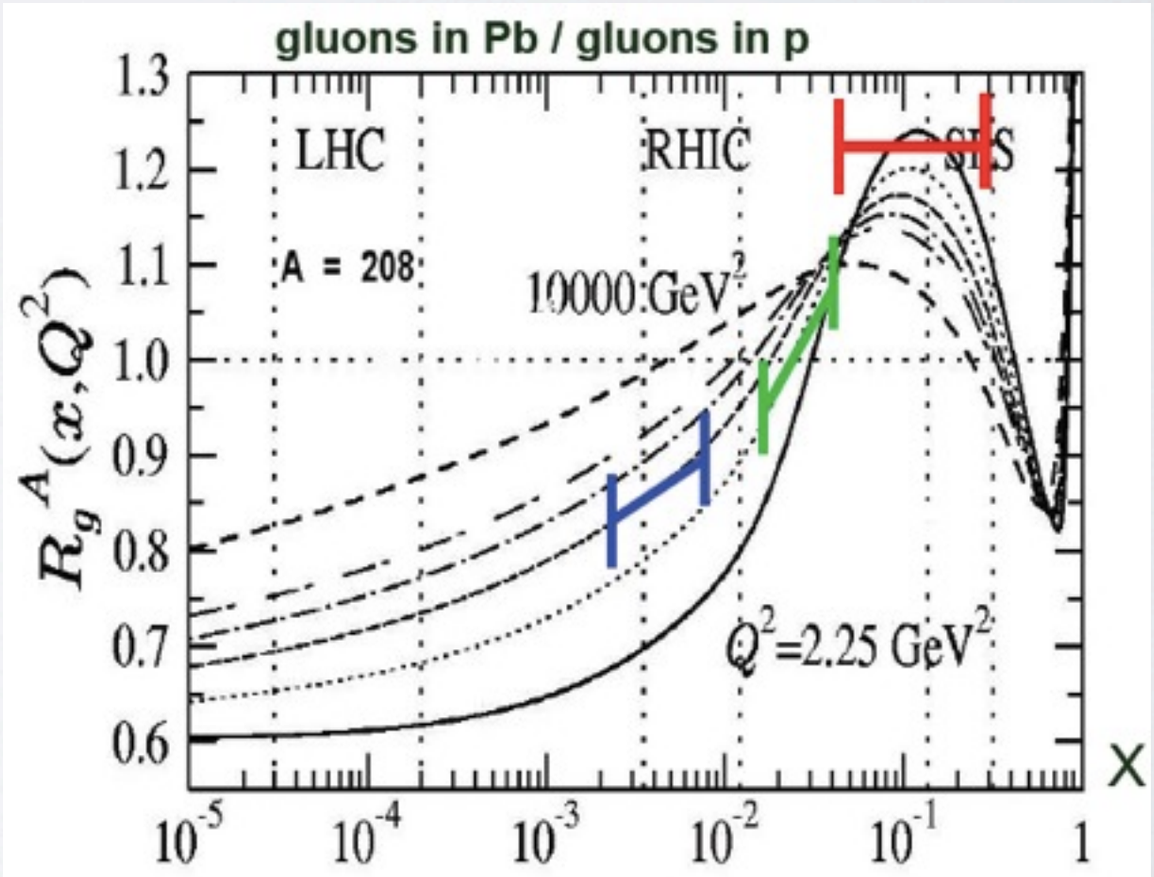




Forward rapidity in d+Au collisions

- Particle production in the forward rapidity region(d going side) is sensitive probe of the small-x partons in the gold nuclei
  - SOUTH ($y < -1.2$) : large $x \sim 0.09$ (Anti-shadowing/Cronin regime)
  - NORTH ($y > 1.2$) : small $x \sim 0.005$ (Shadowing/suppression regime)





from Eskola, Kolhinen, Vogt
Nucl. Phys. A696 (2001) 729-749

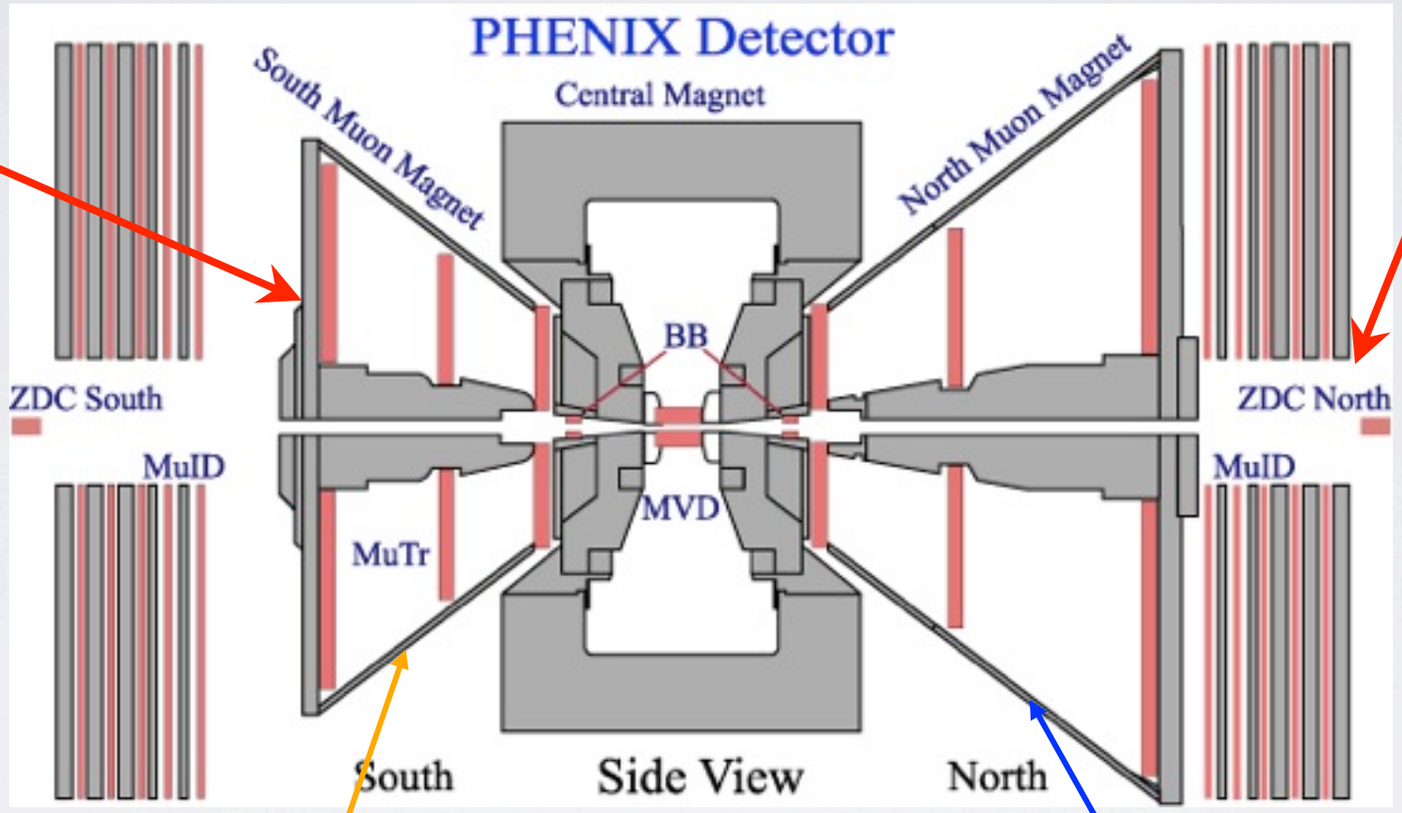
PHENIX Muon Detectors

deuteron → ✸ ← *gold*

Muon Tracker

Momentum measurement

3 station inside Muon Magnet



Muon Identifier

hadron/muon separation

5-layer sandwich of chamber and steel

Local Level 1 trigger

South Muon arm : $-2.2 < \eta < -1.2$

North Muon arm : $1.2 < \eta < 2.4$

Source of tracks in the muon arm

Muon from heavy flavor (the signal)

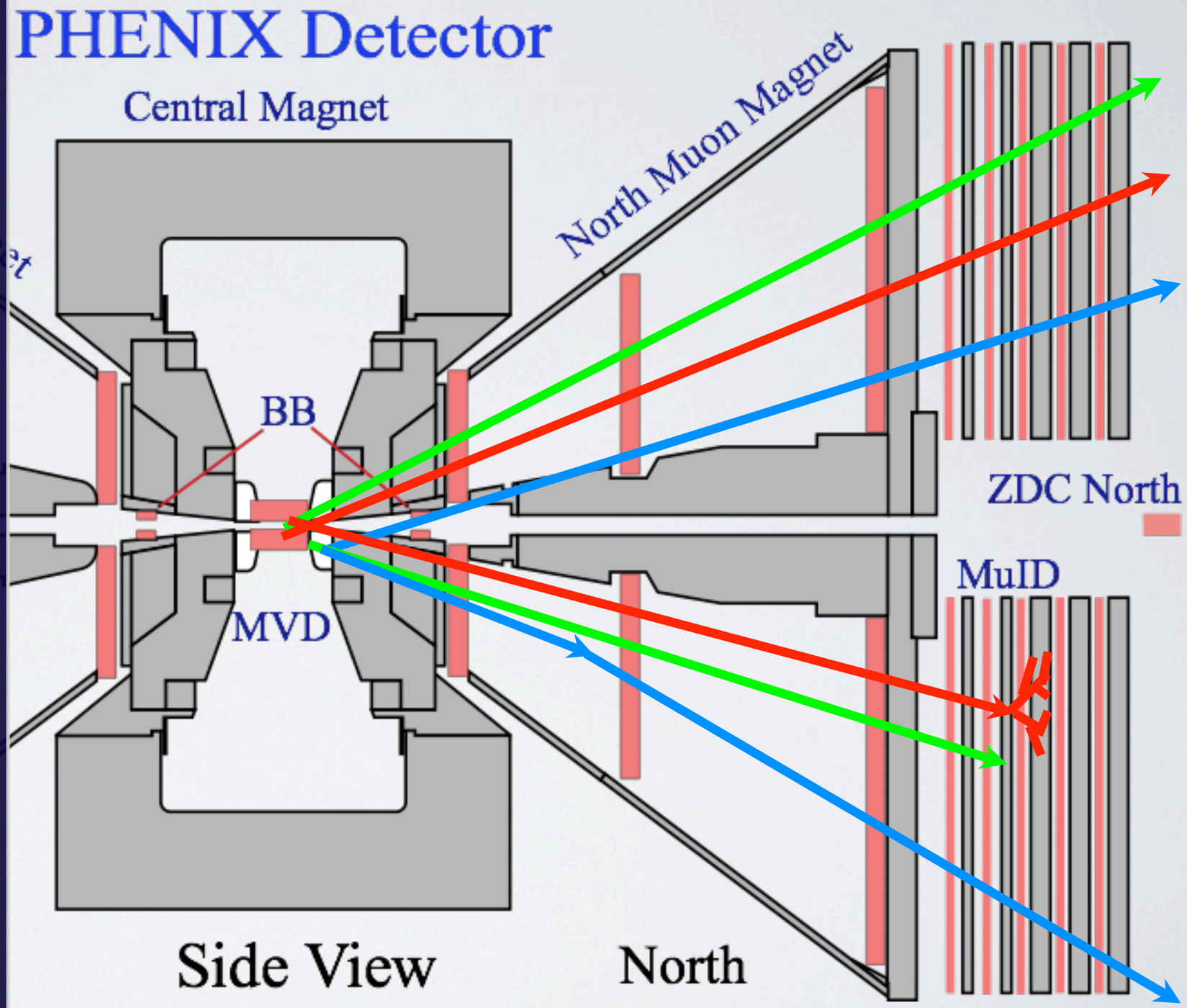
Hadron Punch through

Decay muon from light meson

Stopped hadron

Stopped muon

Other background
Decaying in track volume

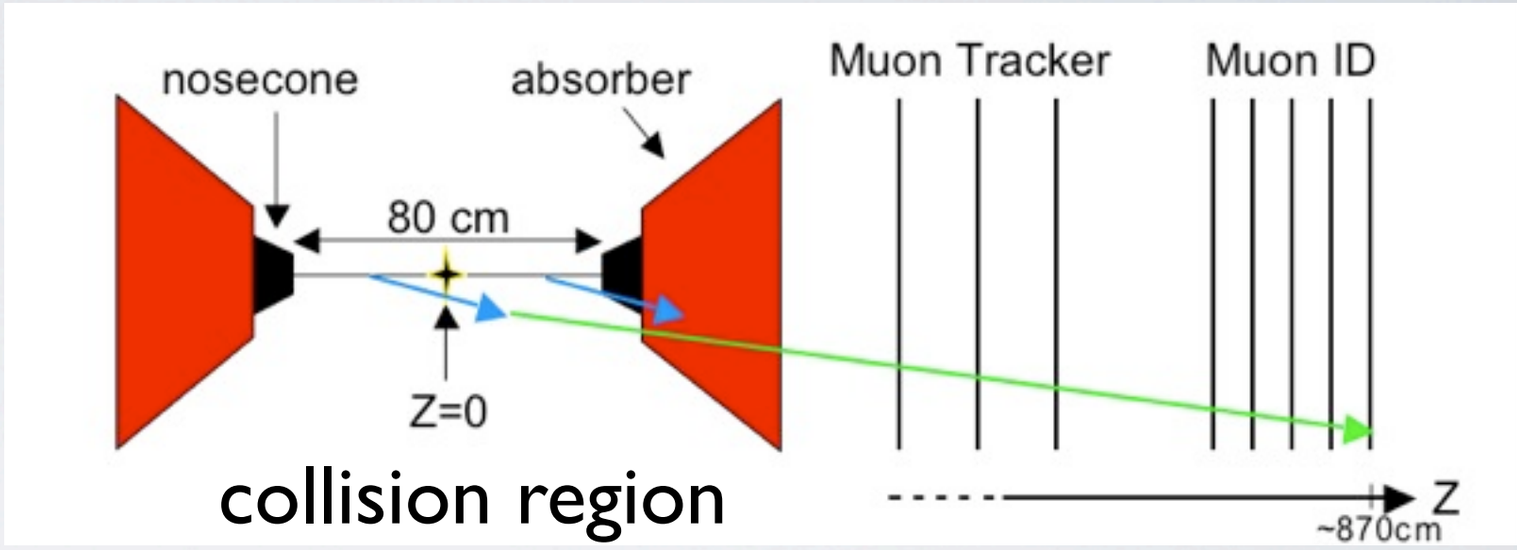


Source of tracks - Decay muon from light hadron

π's : $c\tau$ = 780 cm

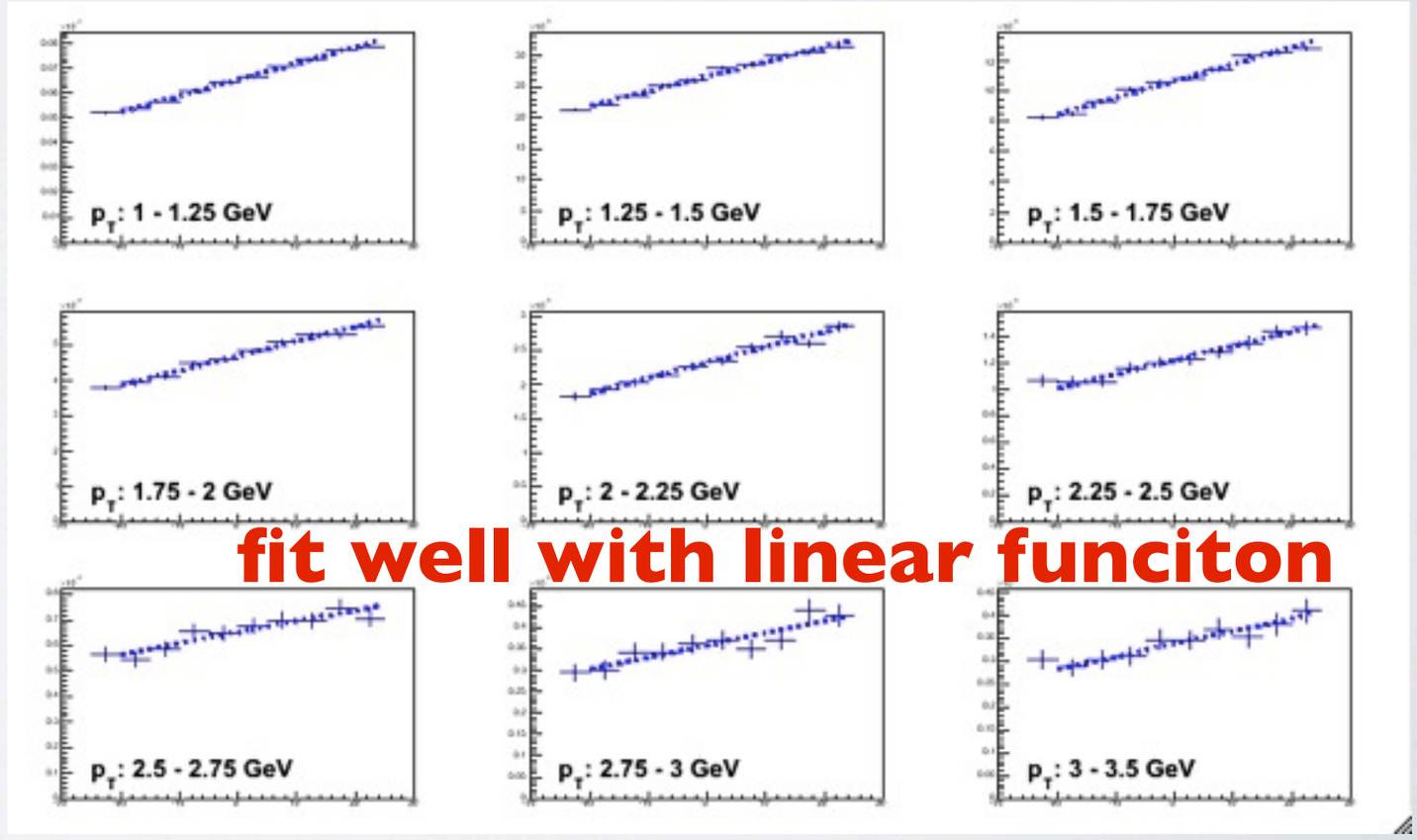
K's : $c\tau$ = 371 cm

Muons from hadronic decays exhibit a characteristic linear vertex dependence.



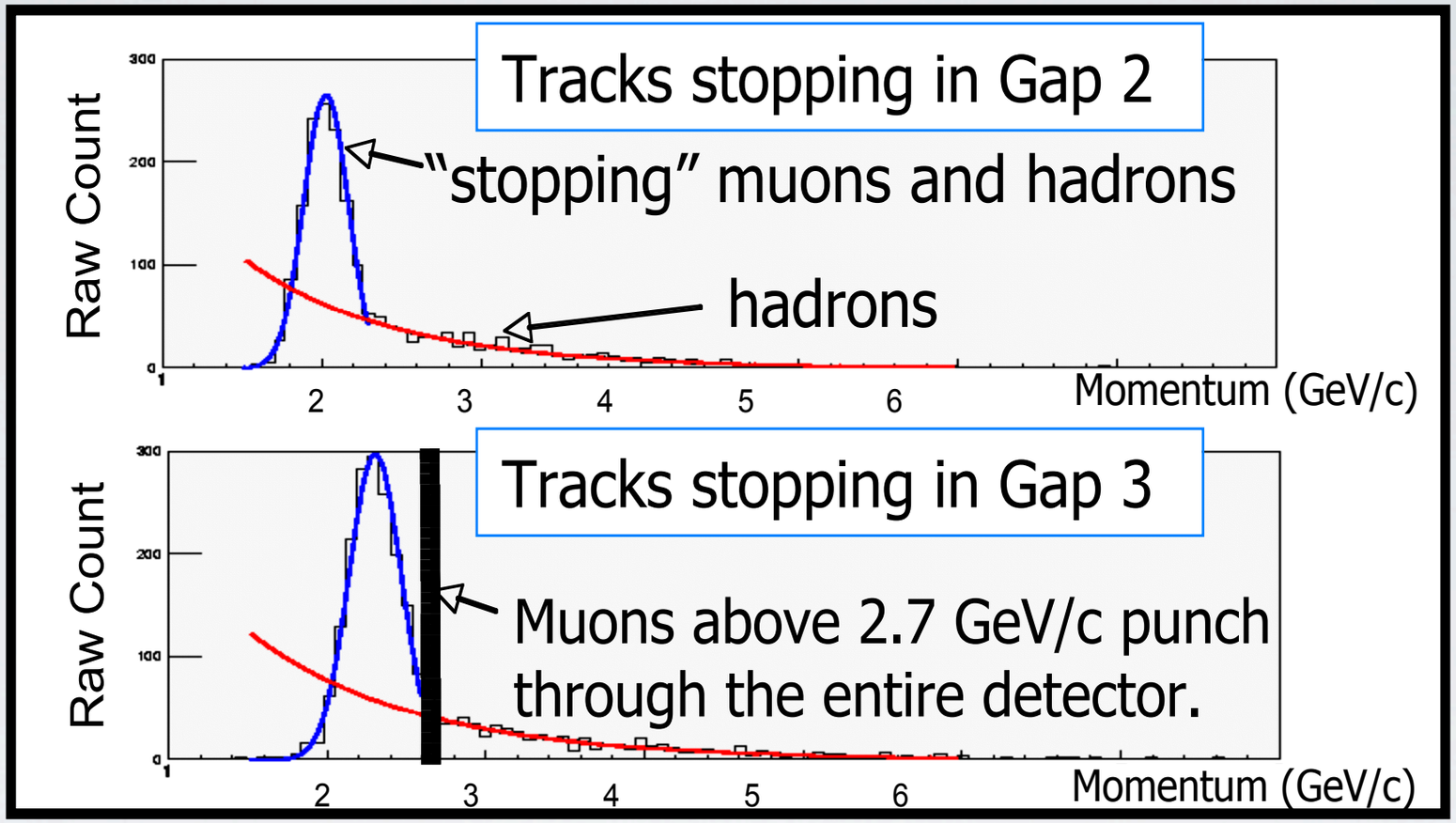
Probability of the hadron decay

$$P(\Delta z) = 1 - e^{-\frac{\Delta z}{\gamma c\tau}} \approx \frac{\Delta z}{\gamma c\tau}$$



fit well with linear funciton

Source of tracks - Stopped hadron and muon



- Most of tracks having low momentum are muons from hadronic decay
- After p_z cut, pure stopped hadrons are left

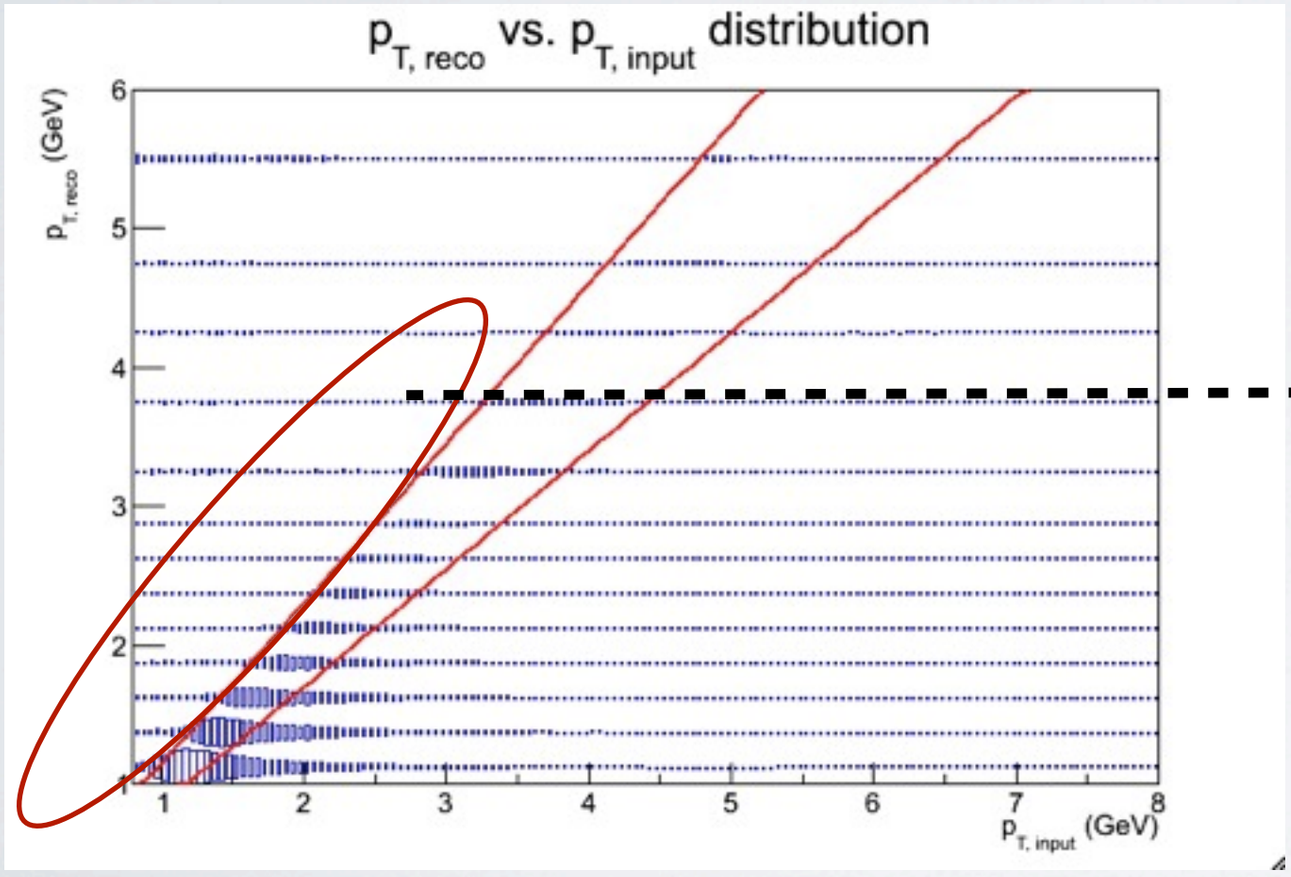
  =>Hadrons at Gap2 and Gap3 important components for matching simulation and data

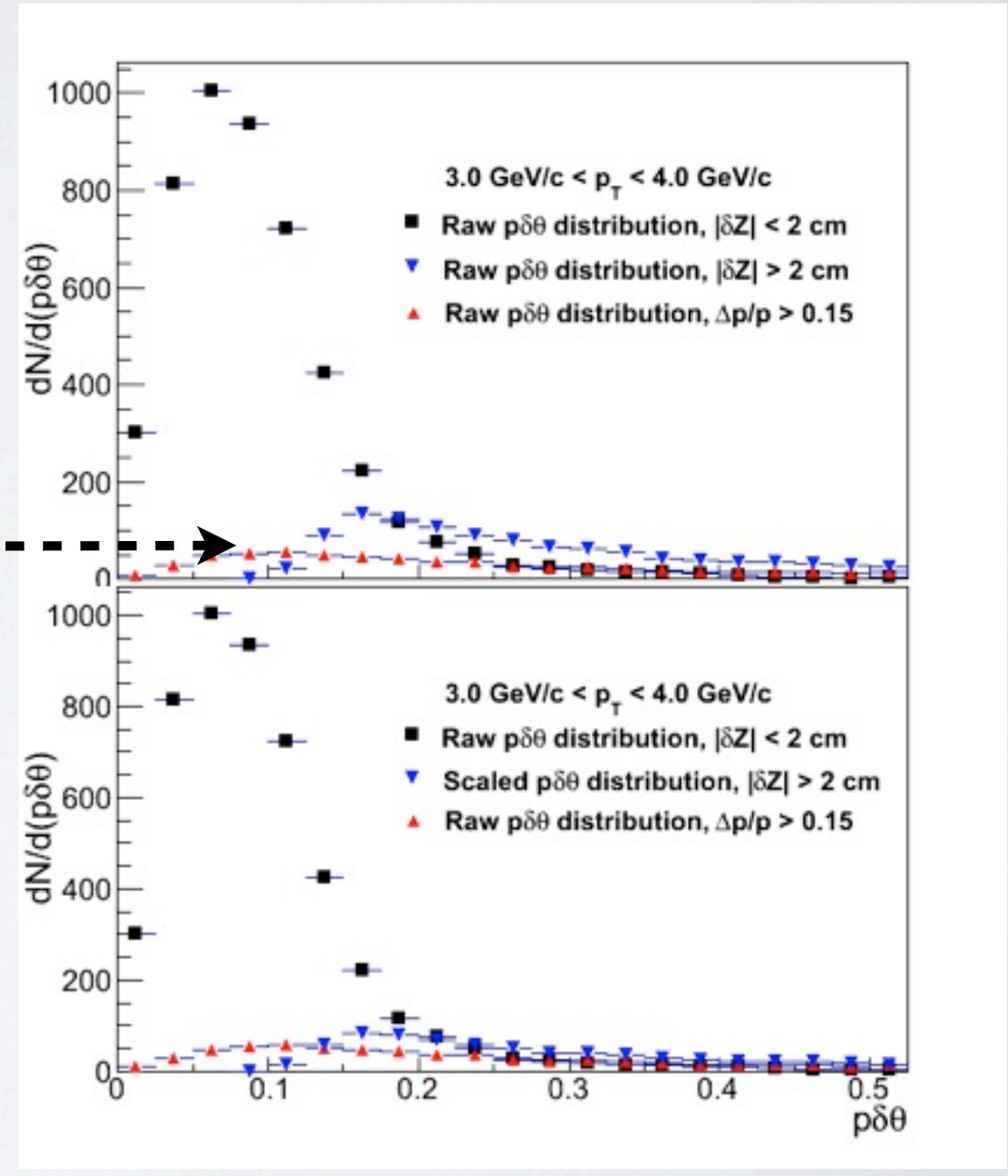
Source of tracks - Hadron punch-through

- Survived hadrons against ~10λ absorber
  - Dominant than decay muons over p_T > 3 GeV
  - vertex independent
- Estimation of hadron punch-through is the key to reaching the signal
  - No light hadron measurement in this rapidity window ~ <y>=1.7
  - Stopped hadron just give limited information
  - Massive hadron simulation with reasonable hadron input spectra

Source of tracks - Decay in track volume

- Muons decaying in tracking volume can be reconstructed high p_T tracks
  - Using hadron simulation, the $p\delta\theta$ distribution of background tracks can be estimated





How to extract signal?

- Basically, after removing all sources of background, only muons from heavy flavor decay will remain.
  - After background subtraction, just do one reconstruction efficiency correction for prompt muon

$$N_{prompt} = N_{inclusive} - N_{decay} - N_{punchthrough} - N_{background}$$

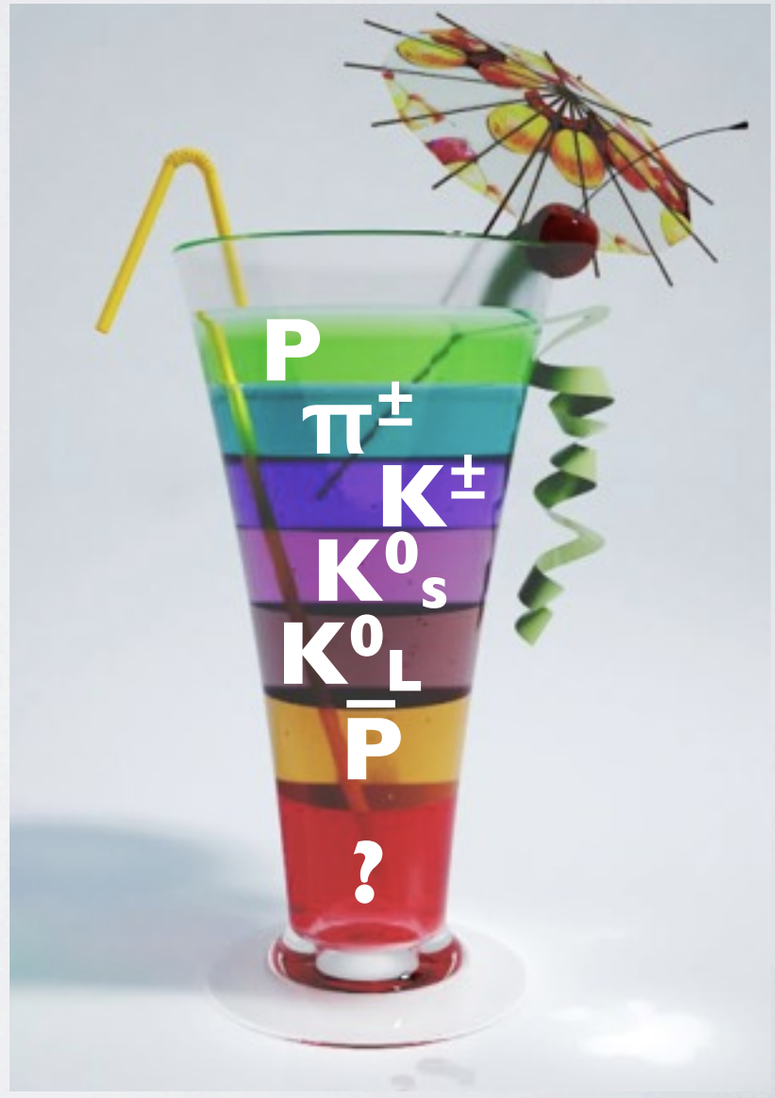
ONLY IF simulation fits and works perfectly

Hadron cocktail

- Hadron cocktail
  - limited hadron results in the forward and backward region
  - light hadron spectra study of event generator (PYTHIA for p+p, HIJING for d+Au)
  - LAST ingredient for blending => Hadron shower code

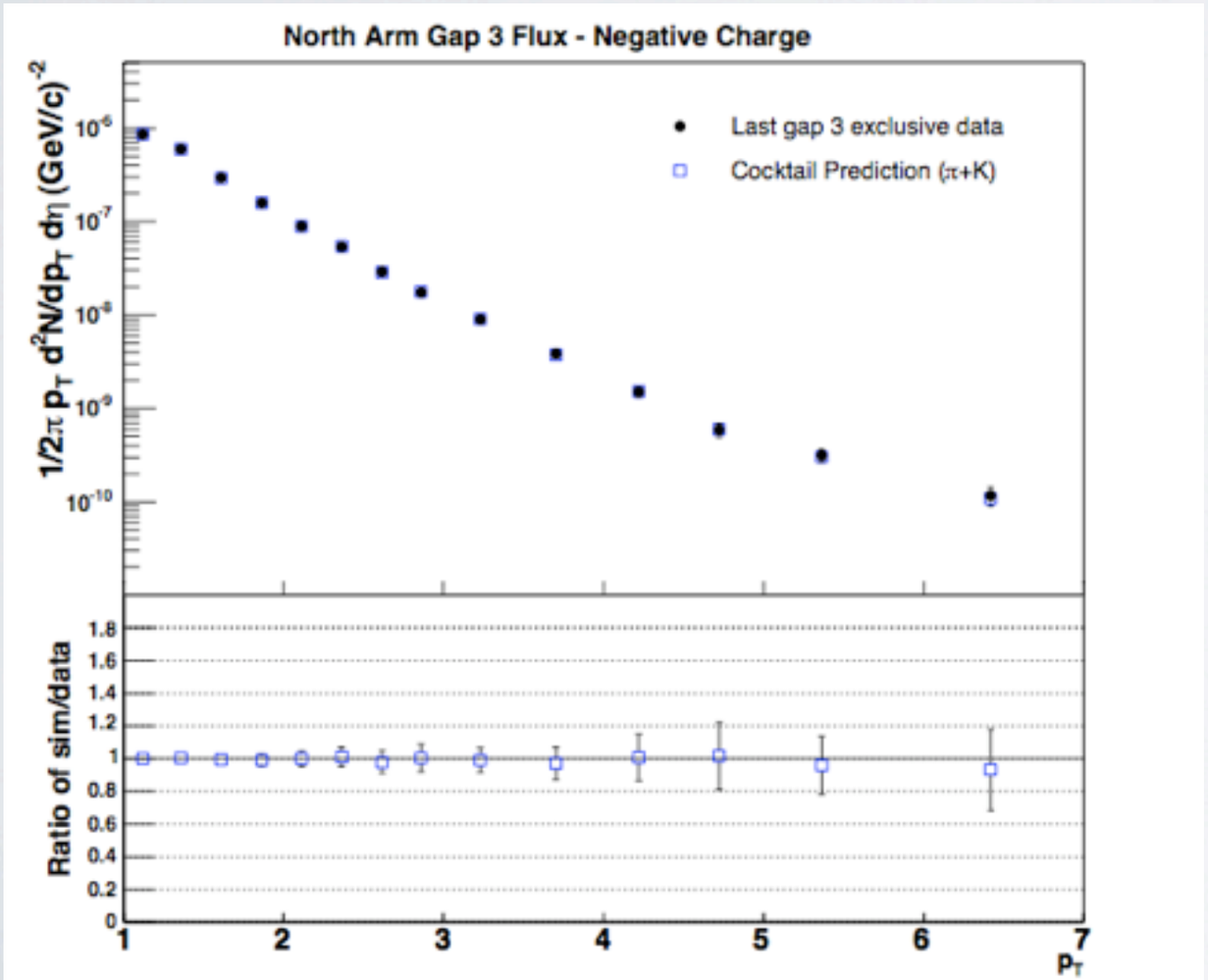
FLUKA & GHEISHA

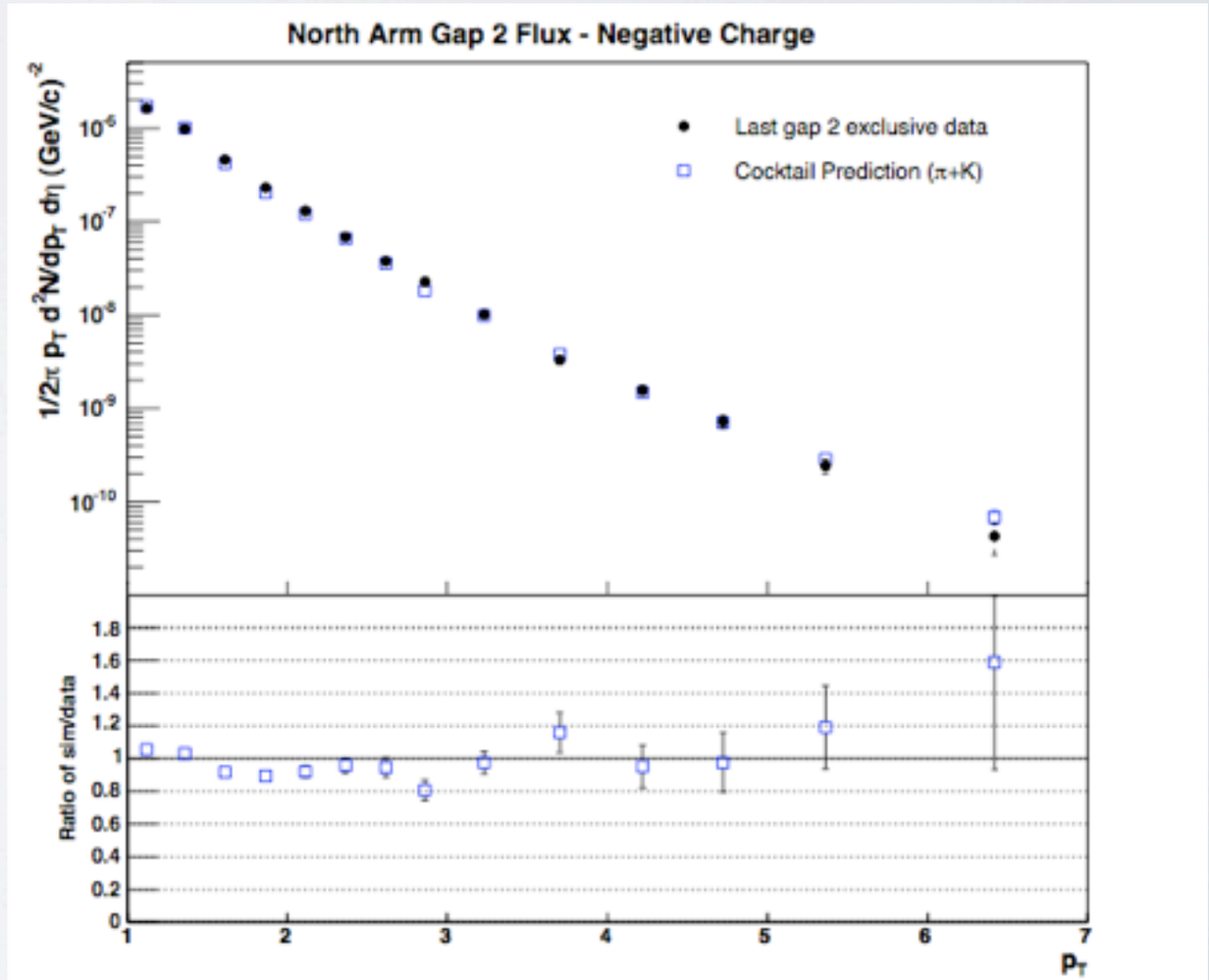
- From previous single muon analysis in PHENIX, the overall flux of particle for GHEISHA is half of that for FLUKA
- Adjusting hadron interaction cross section separately for each hadron shower code and find out BEST combination for background estimation



Tuning the cocktail

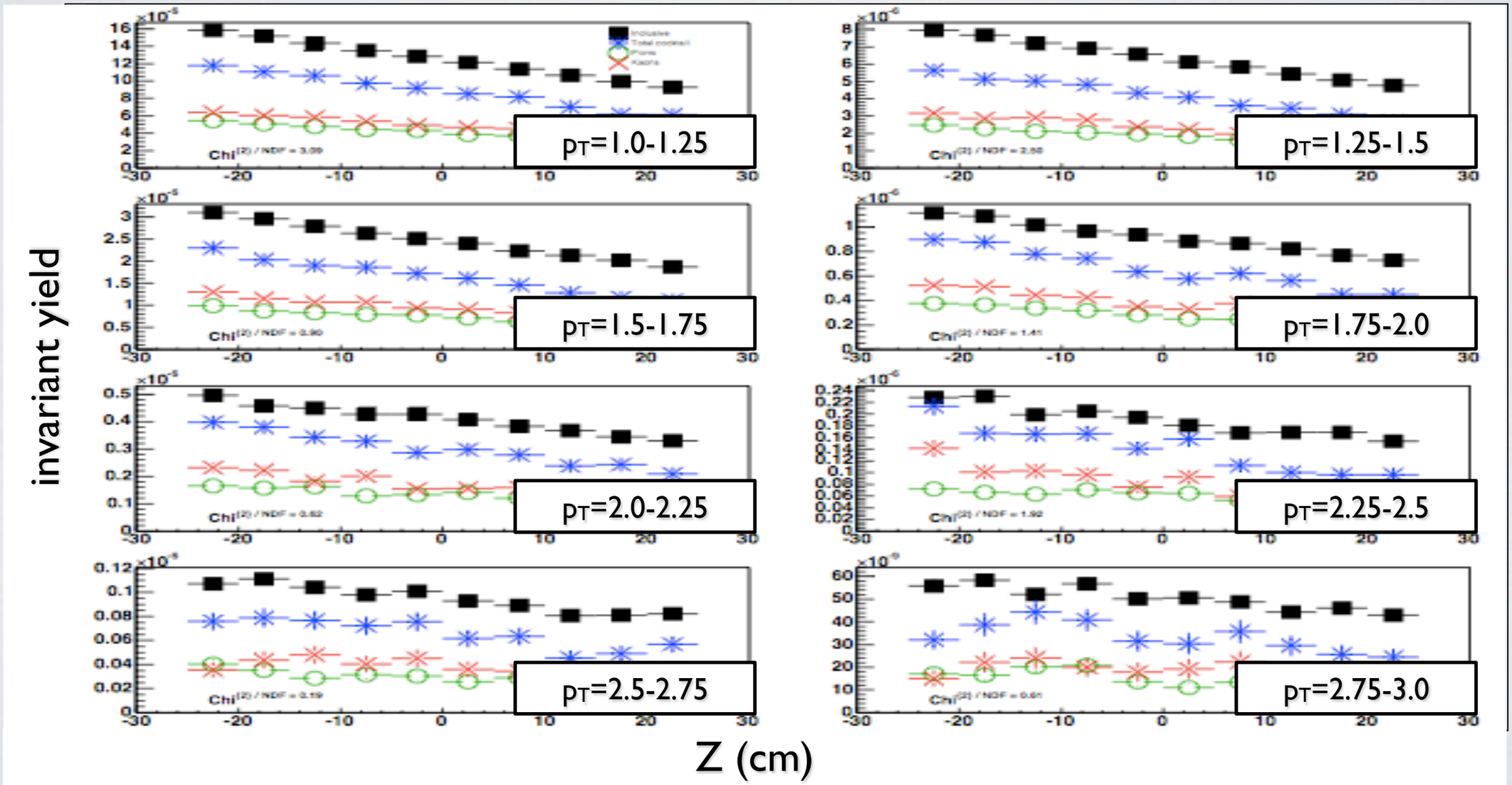
- The results of hadron cocktail are normalized to the measured gap 3 stopped hadron yield
  - check the each hadron package well matched to gap 2 stopped hadron yield after tuning





Check the z-vertex of muon candidates

- Last gap tracks from hadron cocktail contain hadron punch-through and decay muon => tendency of z-vertex should be matched

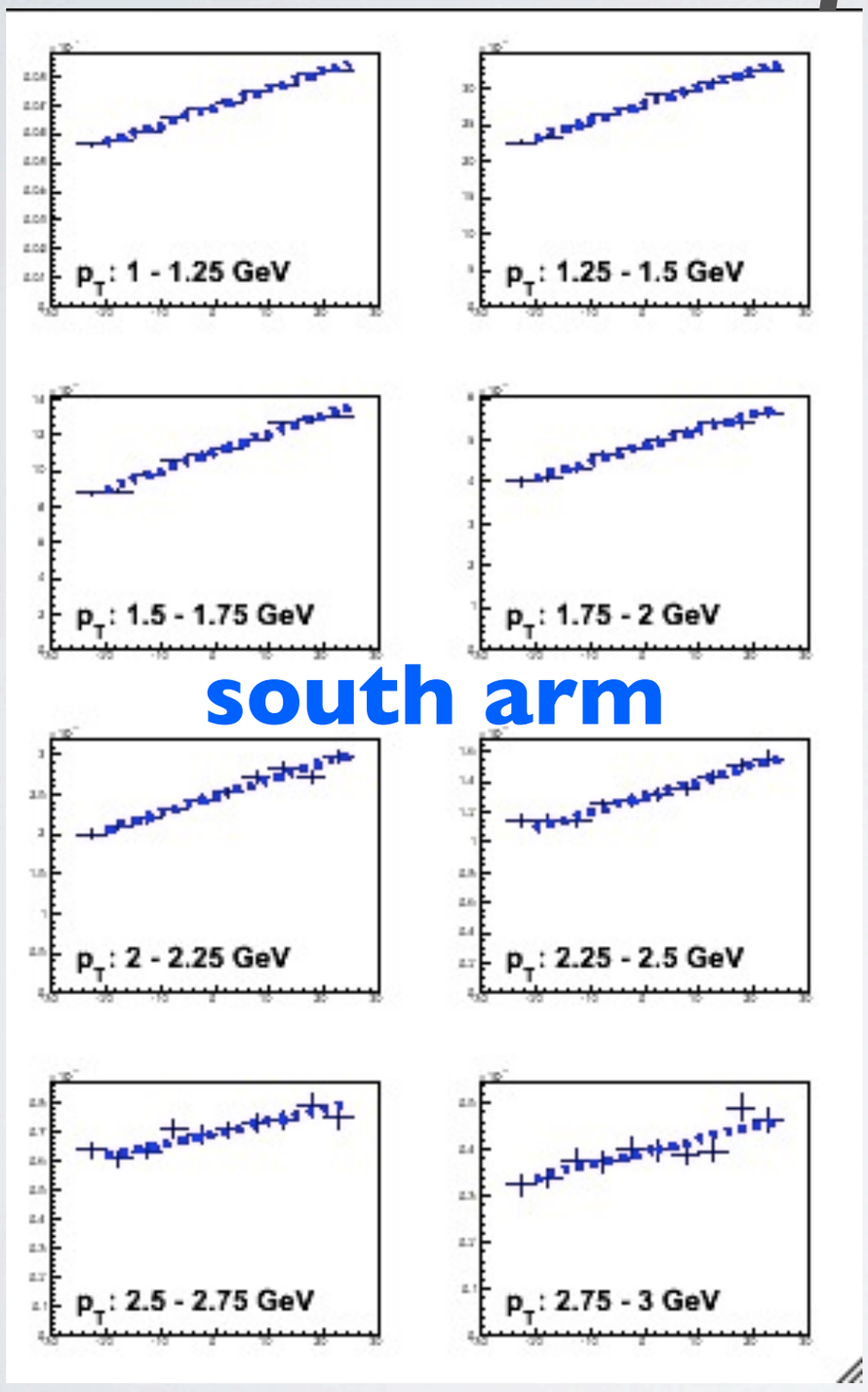


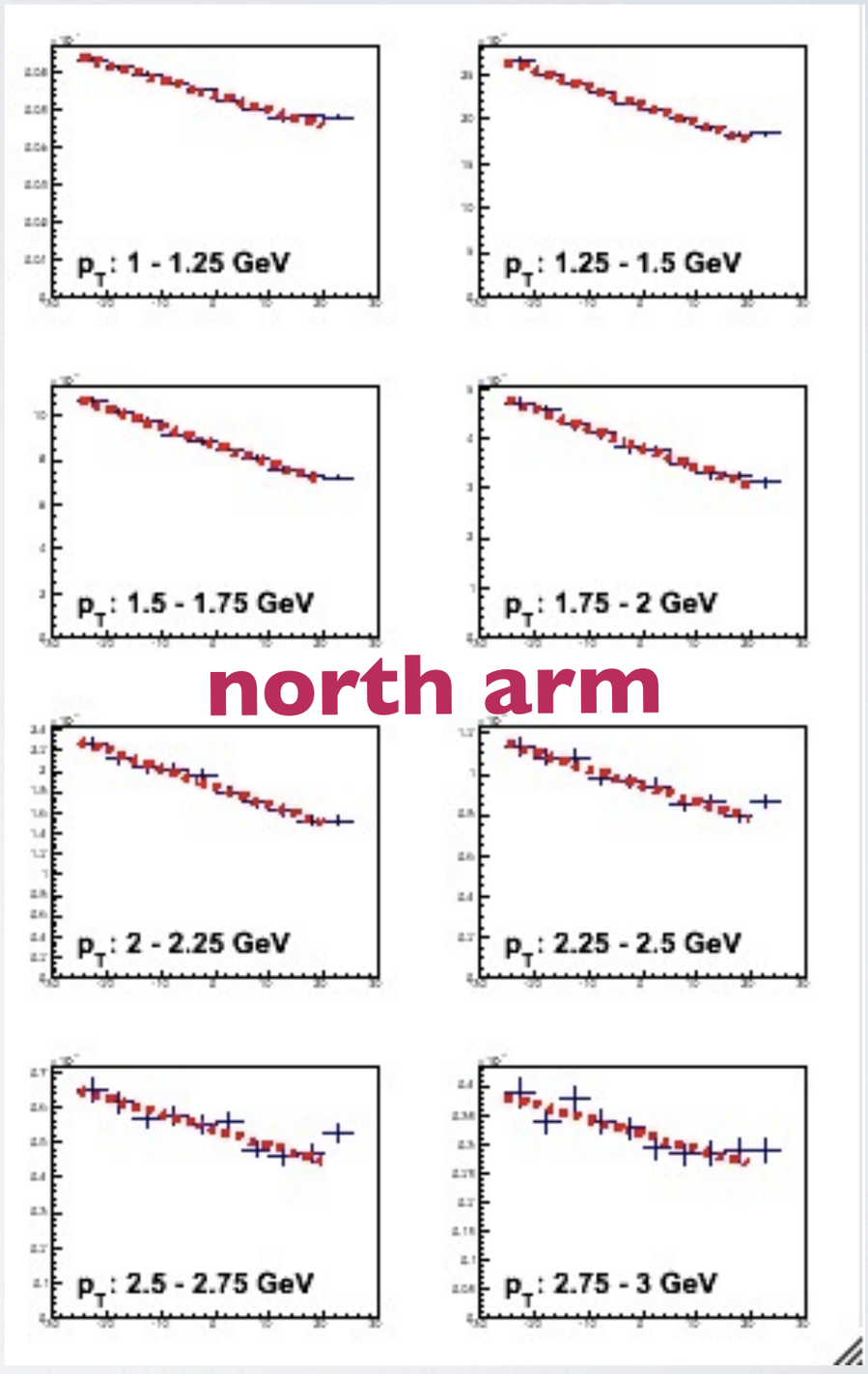
Do Step by Step...

- Data production and basic quality check are completed.
- Study of track quality cuts and reconstruction efficiency are almost completed
- Input hadron spectra study is still going
  - HIJING estimates well the light hadron in d+Au collisions
  - PYTHIA for p+p will be checked soon
- Massive hadron simulation
  - At first, test hadron packages(modified hadron cross section) used for previous single muon analysis

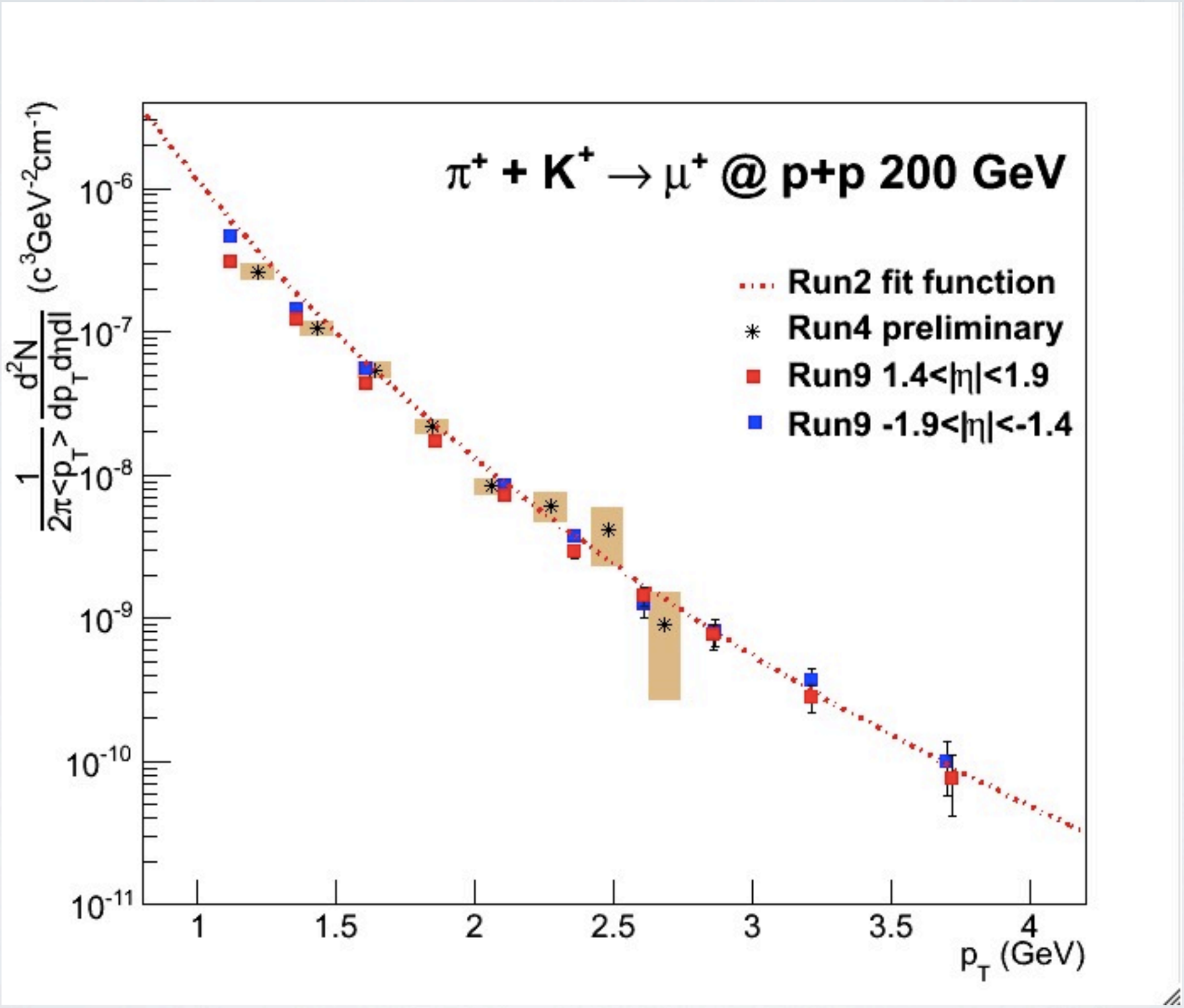
Midterm check - Decay muons

Run9 p+p 200 GeV



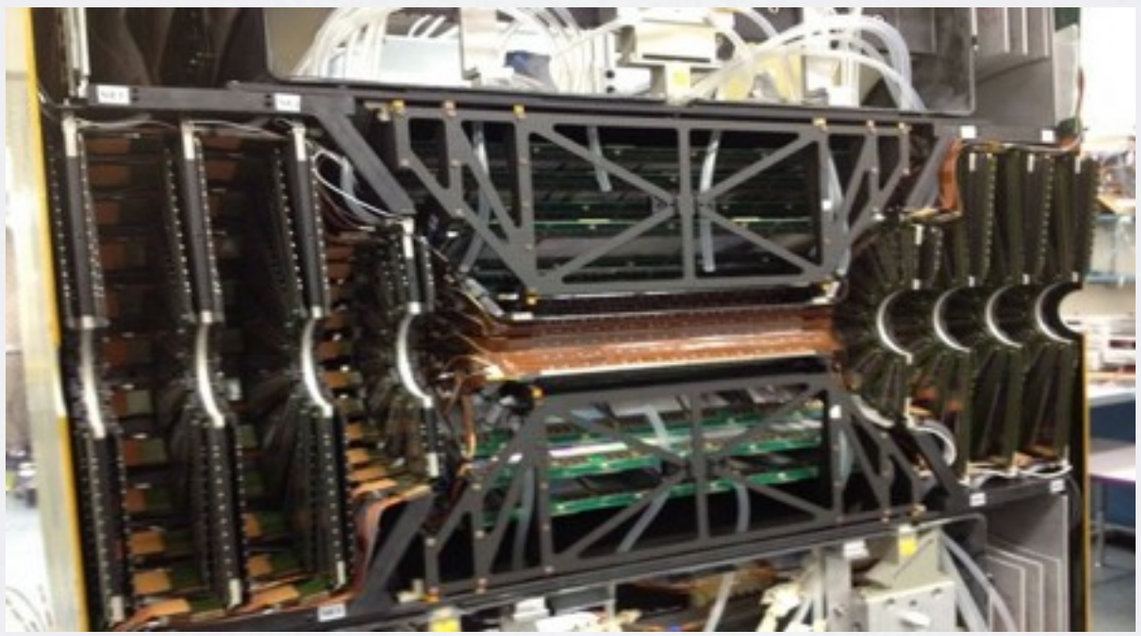


Midterm check - Decay muons

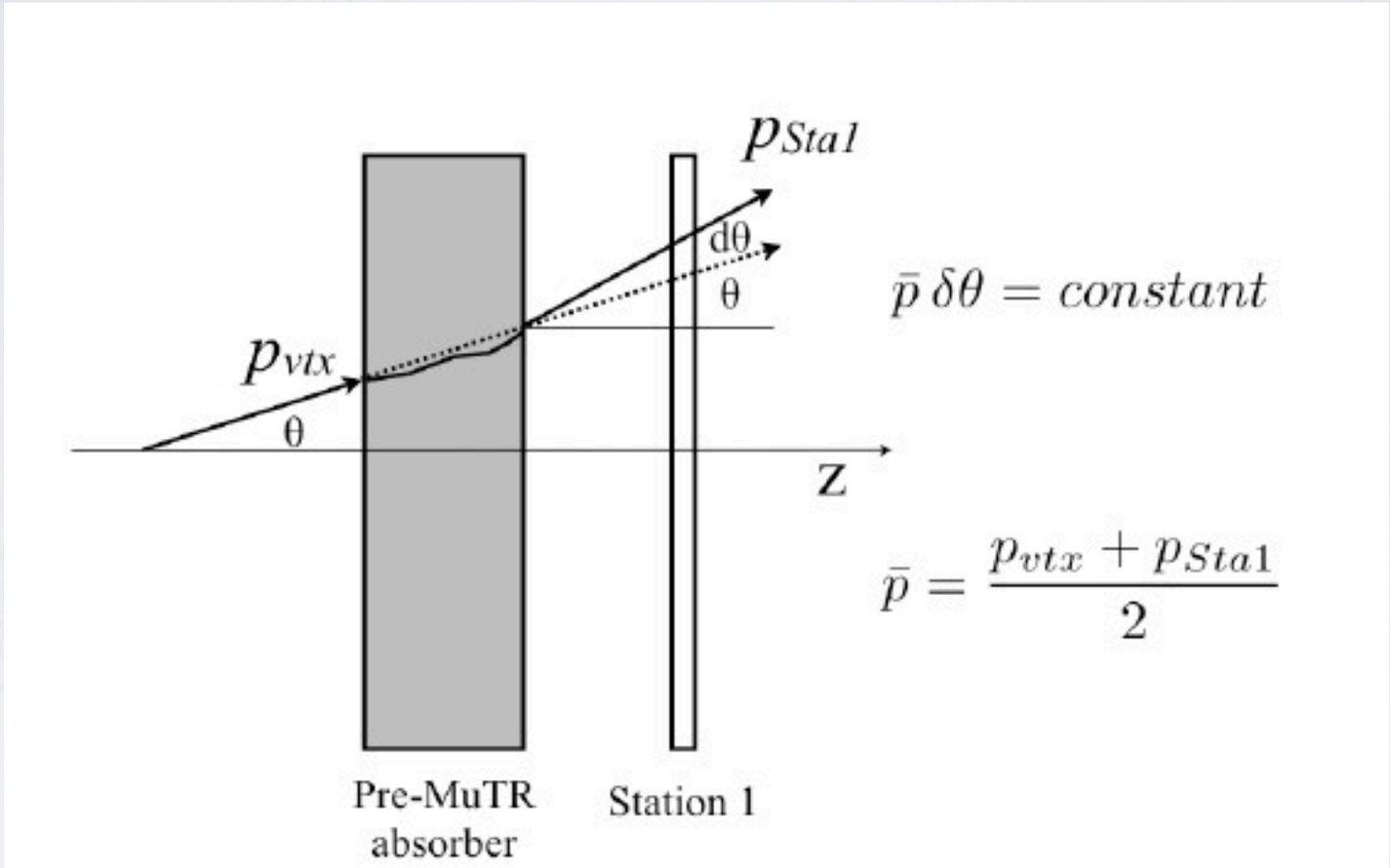


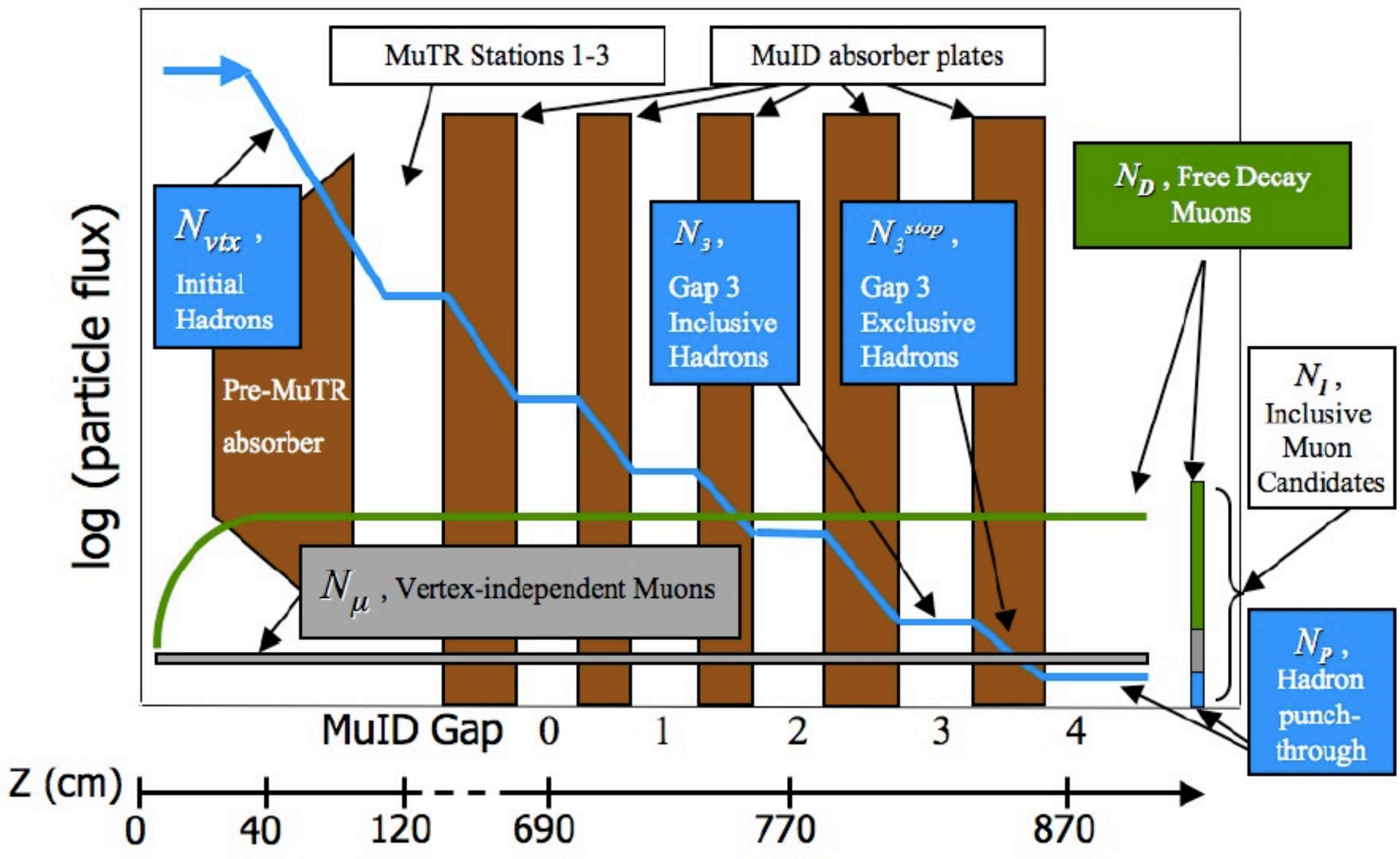
Summary & outlook

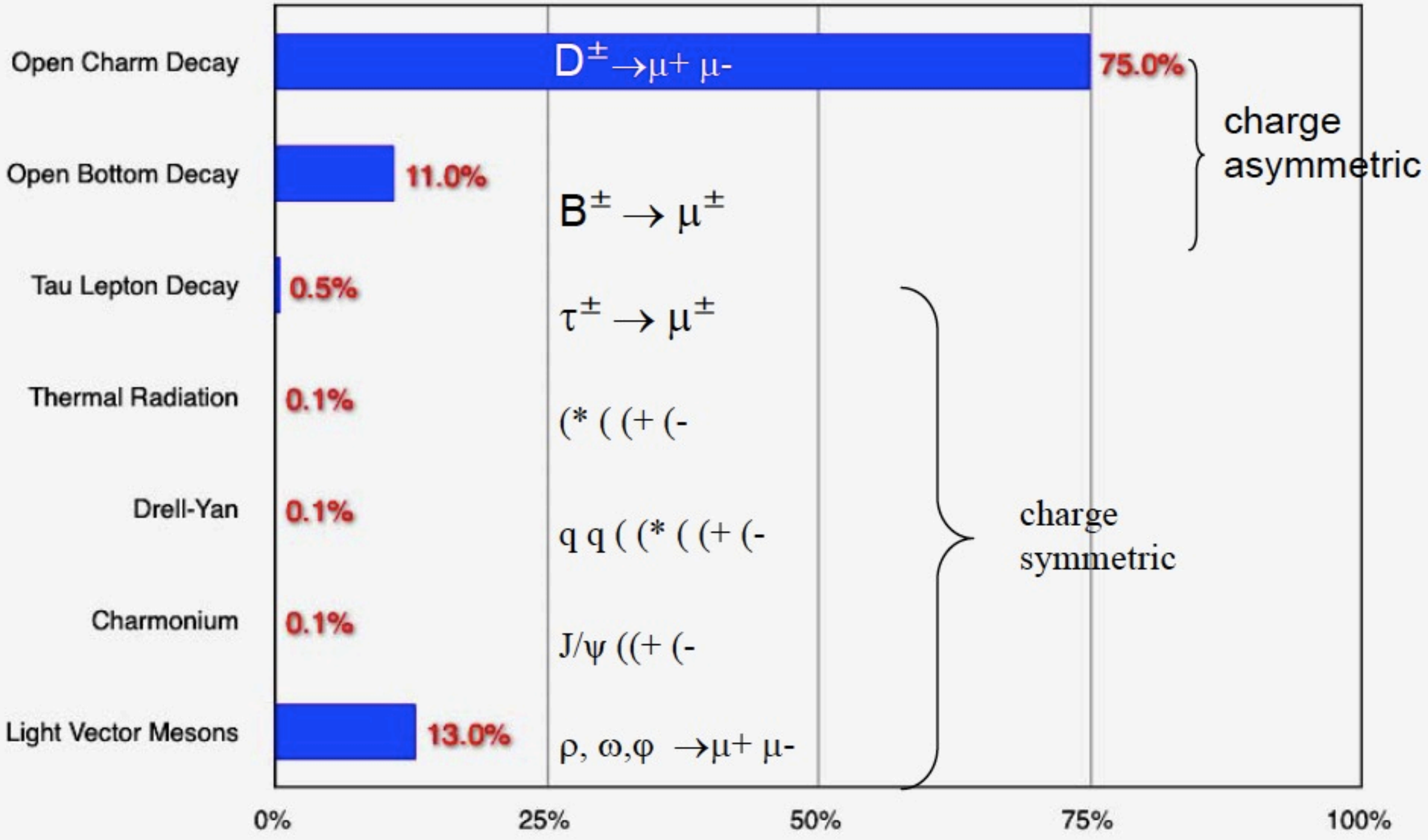
- Single muon measurement from open heavy flavor in d+Au collisions is expected to be a good probe searching for cold nuclear matter
  - Statistical error would be reduced with d+Au data in Run8
  - Good comparison to Cu+Cu results
- New subsystem in PHENIX, FVTX starting from this run is expected to help background reduction and Charm and Bottom separation



Back up


p_{Sta1}
dθ
θ
p_{vtx}
θ
z
Pre-MuTR
absorber
Station 1
$\bar{p}\,\delta\theta = constant$
$\bar{p} = \frac{p_{vtx} + p_{Sta1}}{2}$


MuTR Stations 1-3
MuID absorber plates
N_{vtx} , Initial Hadrons
Pre-MuTR absorber
N_3 , Gap 3 Inclusive Hadrons
N_3^{stop} , Gap 3 Exclusive Hadrons
N_D , Free Decay Muons
N_I , Inclusive Muon Candidates
N_μ , Vertex-independent Muons
N_P , Hadron punch-through
log (particle flux)
MuID Gap 0 1 2 3 4
Z (cm)
0 40 120 690 770 870


Open Charm Decay
$D^{\pm} \rightarrow \mu+ \mu-$
75.0%
charge asymmetric
Open Bottom Decay
11.0%
$B^{\pm} \rightarrow \mu^{\pm}$
Tau Lepton Decay
0.5%
$\tau^{\pm} \rightarrow \mu^{\pm}$
Thermal Radiation
0.1%
(* (((+ (-
Drell-Yan
0.1%
q q ((* (((+ (-
charge symmetric
Charmonium
0.1%
J/ψ ((+ (-
Light Vector Mesons
13.0%
ρ, ω,φ →μ+ μ-
0%
25%
50%
75%
100%