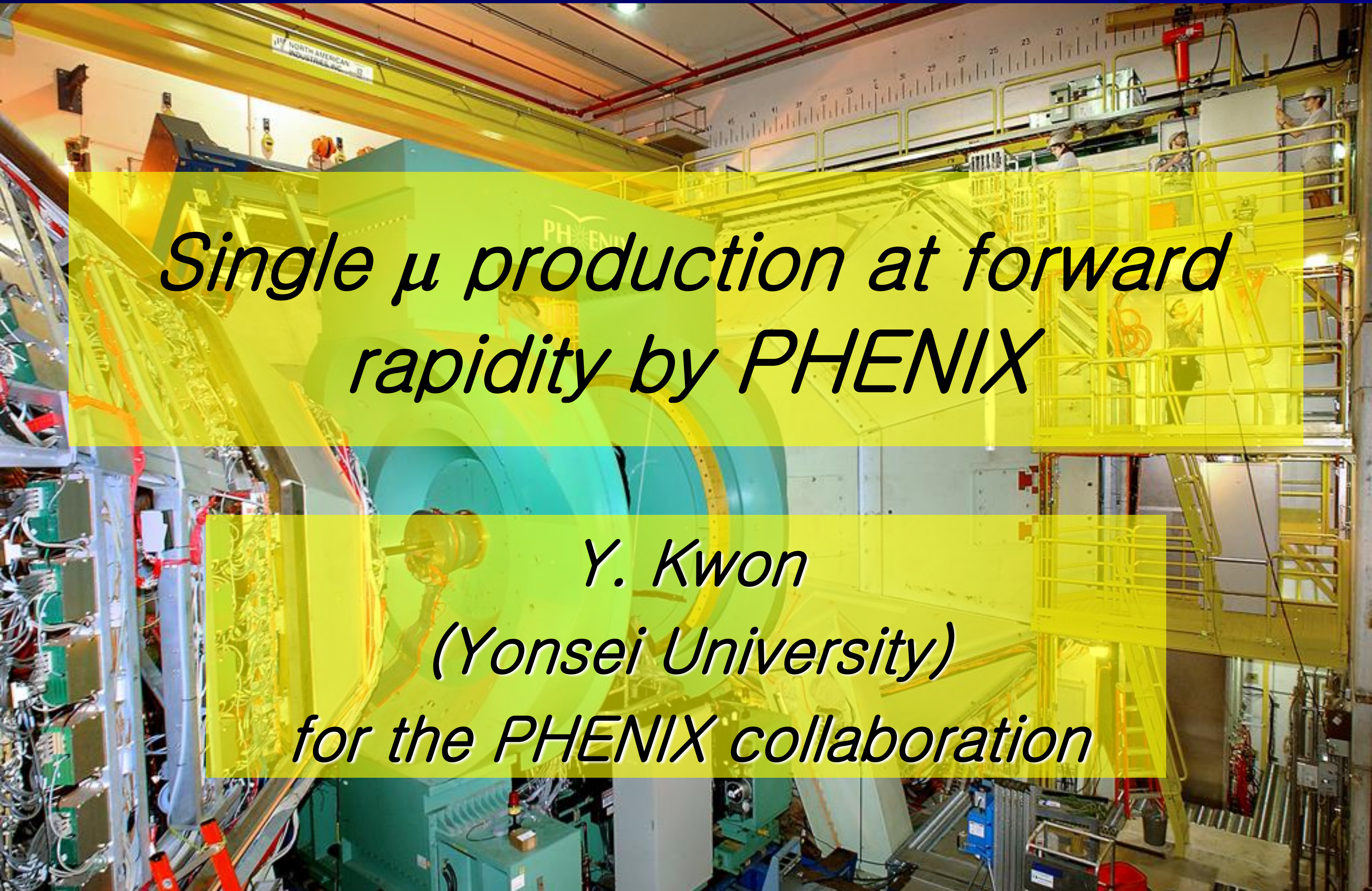


Single μ production at forward rapidity by PHENIX

Y. Kwon
(Yonsei University)
for the PHENIX collaboration

Contents

- Motivation : why forward lepton(μ)?
- Detector Setup : how to detect μ?
- Analysis :
  how to separate signal/background?
- Results :
  Forward μ production,
  p+p, d+Au & Au+Au @ 200A GeV
- Conclusion & outlook

Why forward lepton(μ)?

- *Experimental*
  - *Lepton :* $\frac{l}{h} \approx 10^{-3} \sim 10^{-4}$

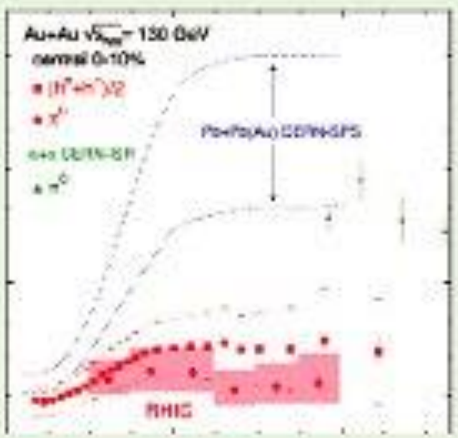
    → *Probe of **rare signals***
  - *Forward?*

    → *Completes measurement at mid-rapidity (**unique to PHENIX at RHIC**)*

PHYSICAL REVIEW LETTERS

14 January 2002

Volume 88, Number 2

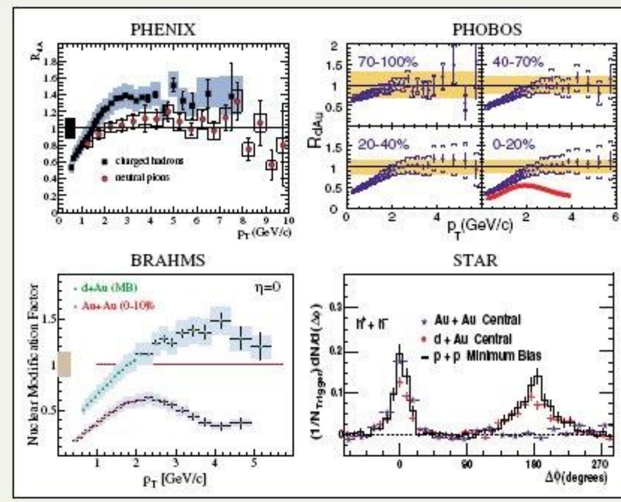


APS Published by The American Physical Society

PHYSICAL REVIEW LETTERS

Articles published week ending
15 AUGUST 2003

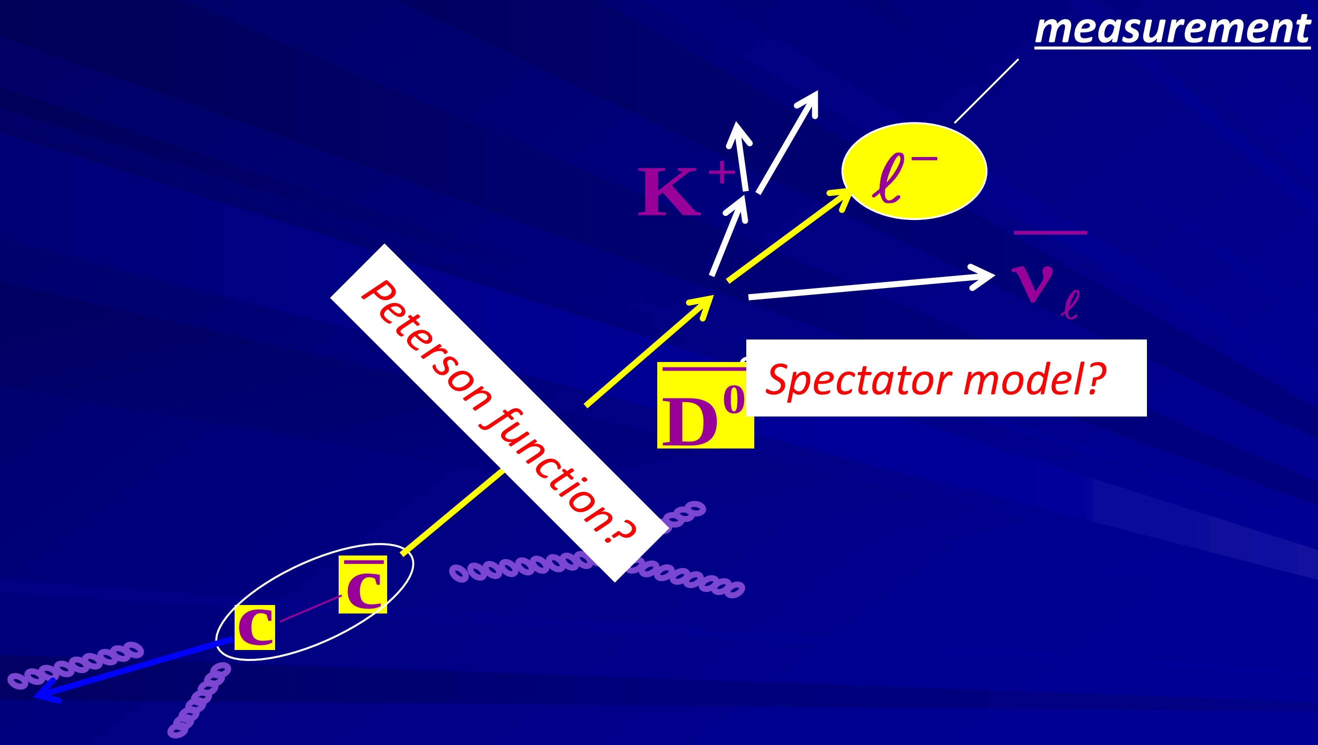
Volume 91, Number 7



APS Published by The American Physical Society

Heavy flavor to leptons? → Major source of hard prompt leptons

Semi-leptonic decays contribute to single lepton spectra!



Hard Processes?

Factorization theorem

$$d\sigma\,[A+B\rightarrow H+X] = \Sigma_{ij}\, f_{i/A} \otimes f_{j/B} \otimes d\hat{\sigma}\,[ij\rightarrow c\bar{c}+X] \otimes D_{c\rightarrow H} + \ldots$$

$f_{i/A,}\ f_{j/B}$: distribution fuction for parton ij

$D_{c\rightarrow H}$: fragmentation function for c

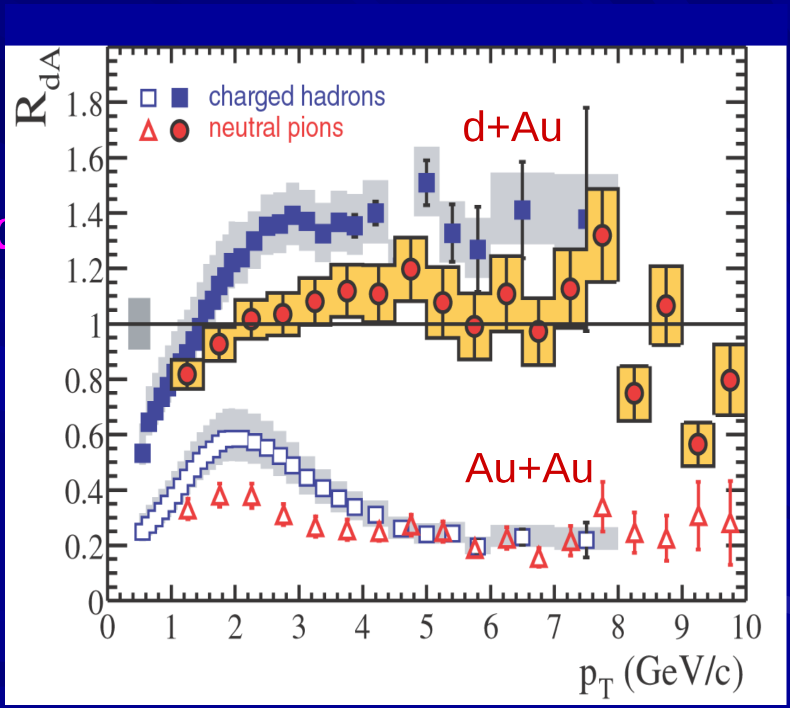
$d\hat{\sigma}\,[ij\rightarrow c\bar{c}+X]$: parton cross section

$+\ldots$: higher twist (power suppressed by $\Lambda_{QCD}/m_{c,}$ or Λ_{QCD}/p_t if $p_t \gg m_c$) : e.g. "recombination"

Application to nuclei:

$f_{i/Au} \approx 79\, f_{i/p} + 118\, f_{i/n} \approx 197\, f_{i/N}$

$f_{i/d} \approx f_{i/p} + f_{i/n} \approx 2\, f_{i/N}$

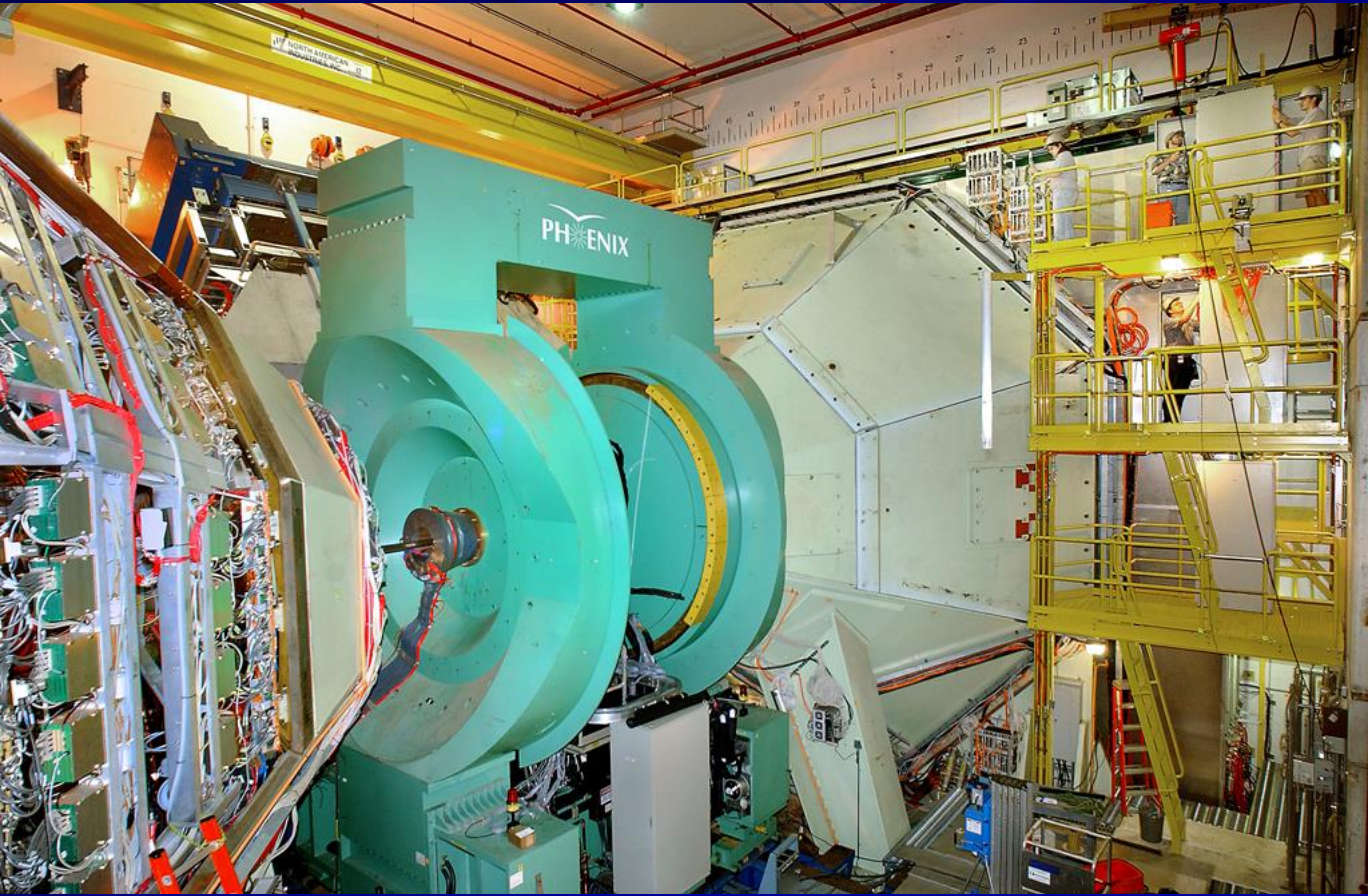


Binary scaling not working

for high pt particles in central AuAu collisions

PHENIX: PRL, 91, 072303 (2003)

how to detect μ?

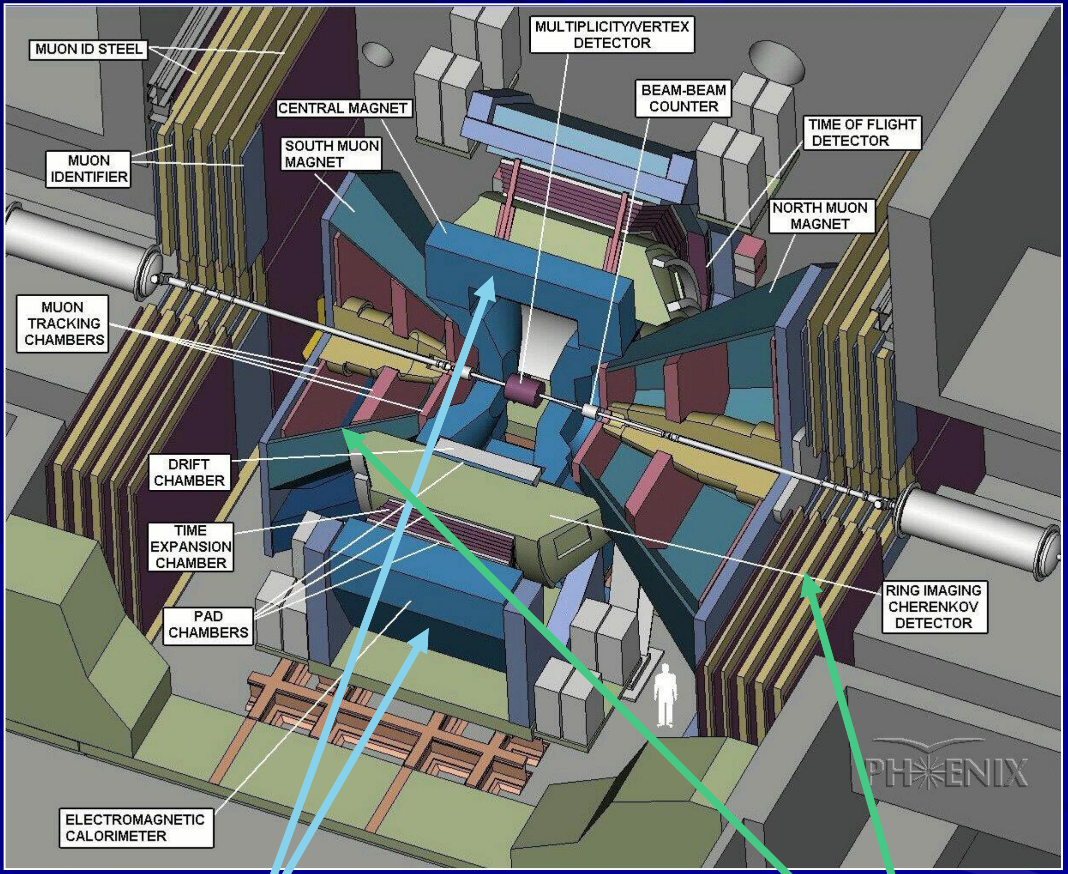


PHENIX

Optimized for Rare probes

- **$e^{\pm}$, γ, h :** ***central arms***
  - ***measurement range*:**
    $|\eta| \leq 0.35$
    $p \geq 0.2$ GeV/c

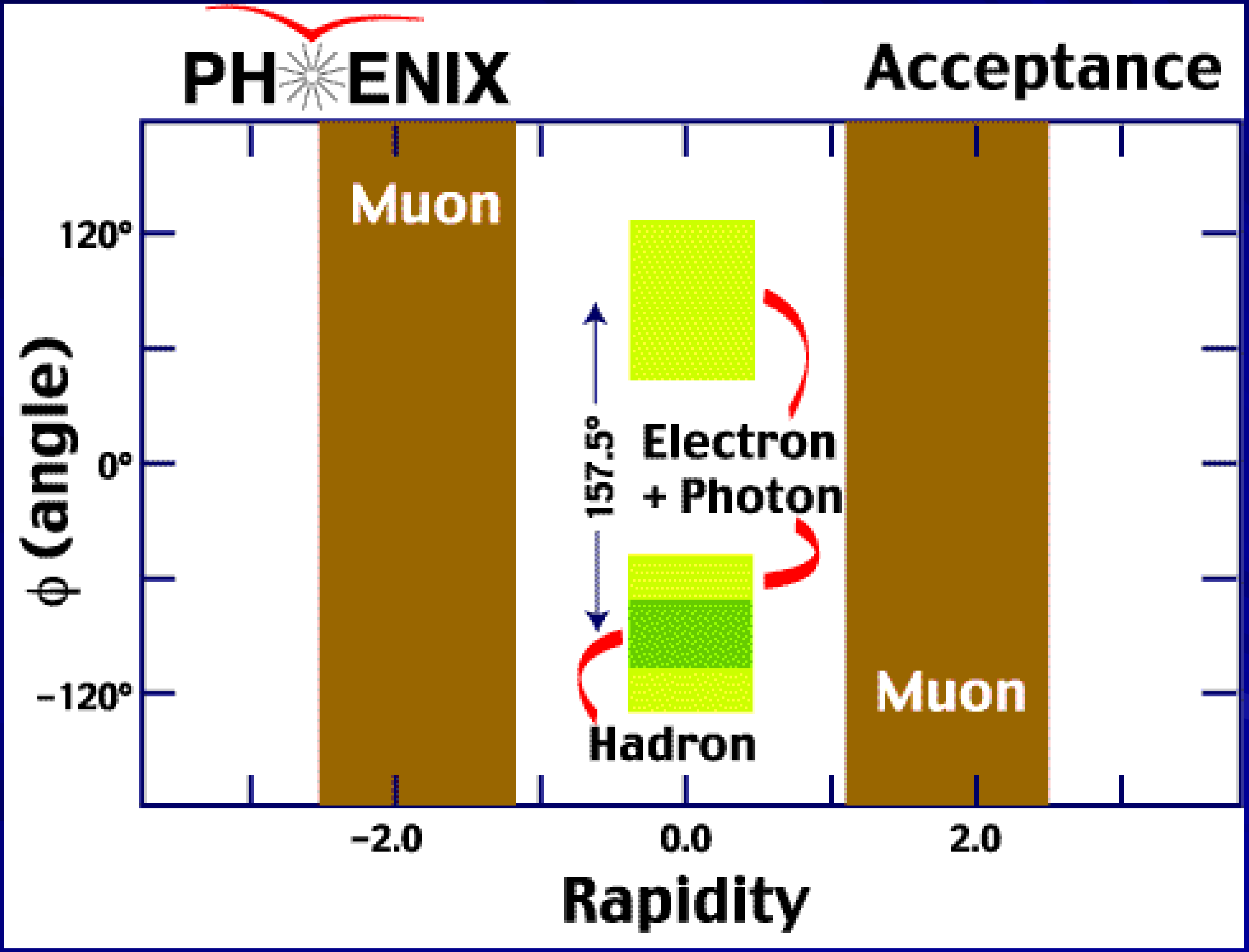
- **$\mu^{\pm}$, h :** ***forward arms***
  - ***measurement range*:**
    $1.2 < |\eta| < 2.4$
    $p \geq 2$ GeV/c



two central electron/photon/hadron spectrometers

two forward muon spectrometers

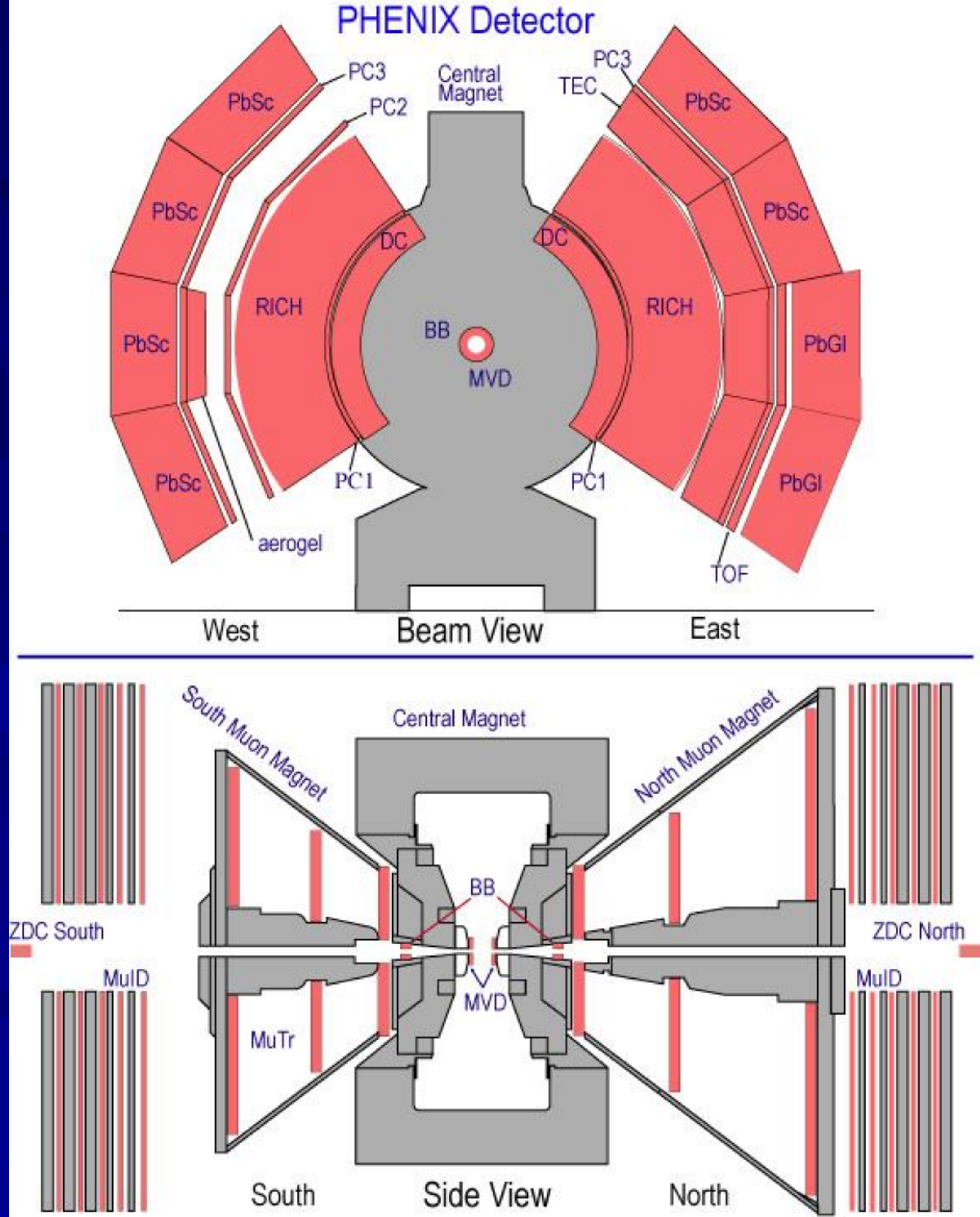
Acceptance


PHENIX
Acceptance
Muon
120°
0°
−120°
φ (angle)
157.5°
Electron
+ Photon
Hadron
Muon
−2.0
0.0
2.0
Rapidity

Detector schematics

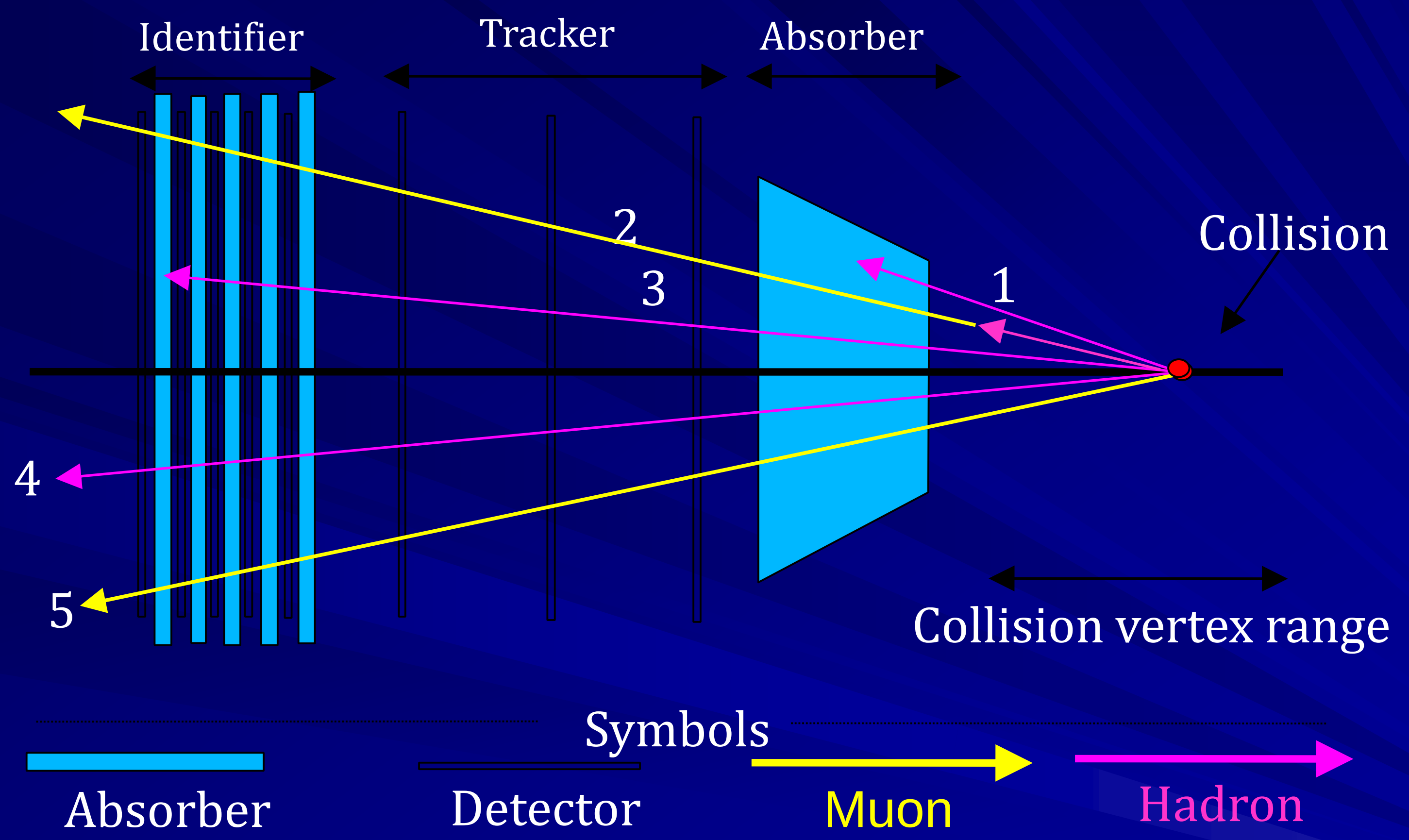
Top : central arm

Bottom : muon arm



How to separate signal/background?

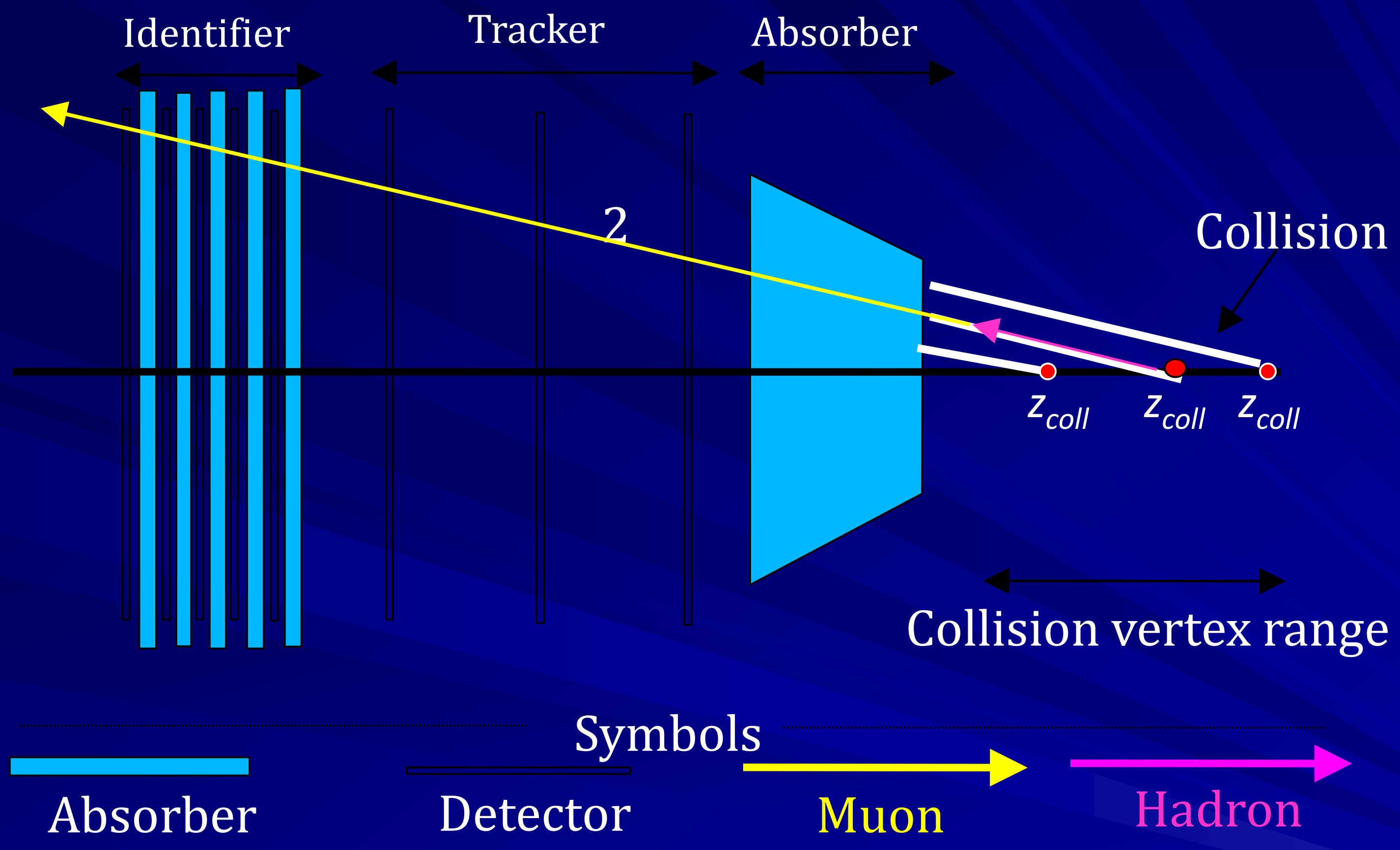
μ-measurement, Sources



1 : Hadrons, interacting and absorbed (98%),
2 : Charged π/K's, "decaying into μ" before absorber (≤1%),
3 : Hadrons, penetrating and interacting ("stopped")
4 : Hadrons, "punch-through",
5 : Prompt μ,"desired signal"

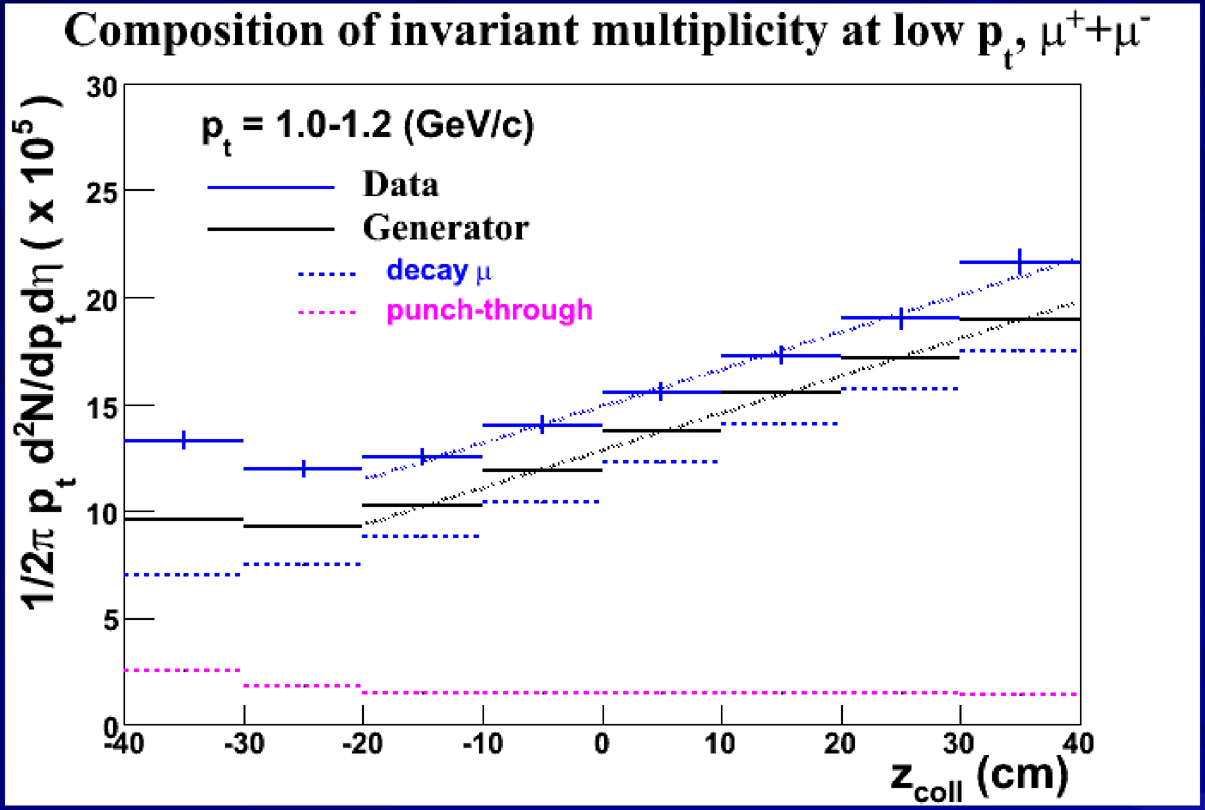
Decay μ's & Punch-through's?

μ-measurement, Sources



2 : Charged π/K's, "decaying into μ" before absorber (≤1%),

μ−measurement, Signal composition

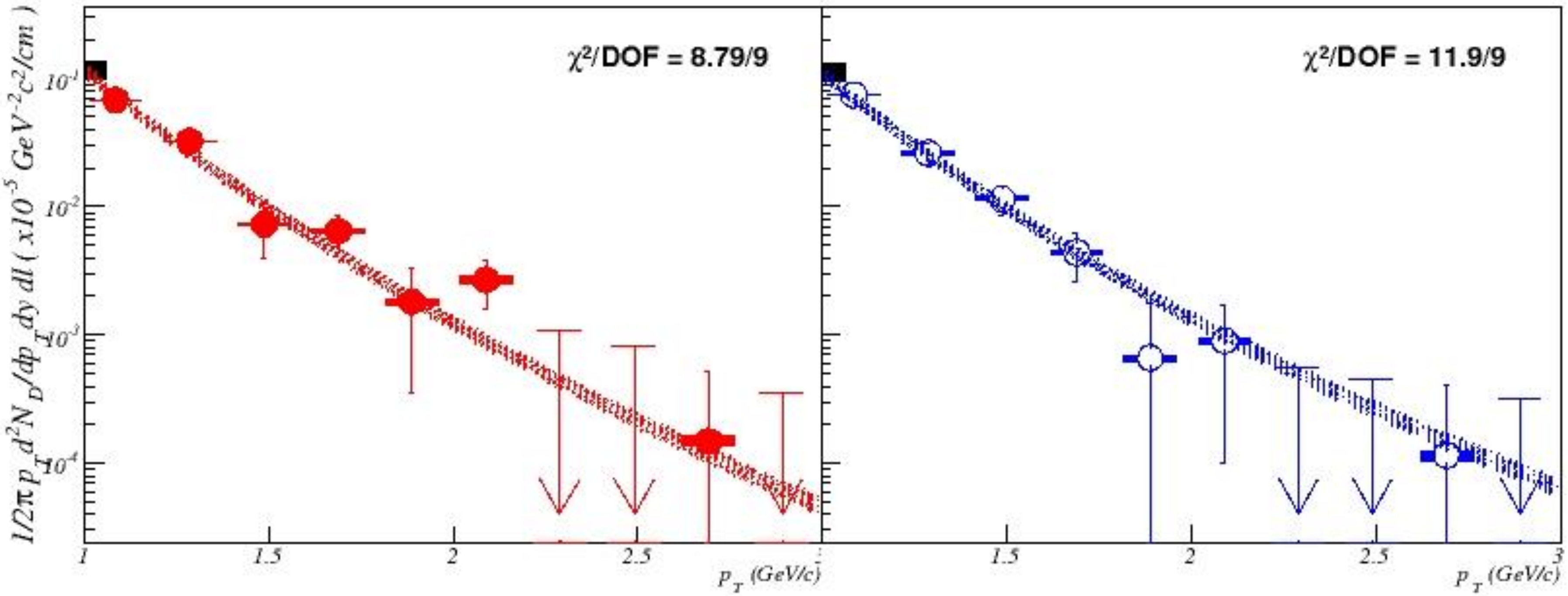


Generator (Decay μ + punch-through)

1. *Light hadron measurement by PHENIX central arm (y = 0)*
2. *Gaussian extrapolation in rapidity to muon arm acceptance (σ = 2.5)*
3. *Simplified spectrometer geometry.*

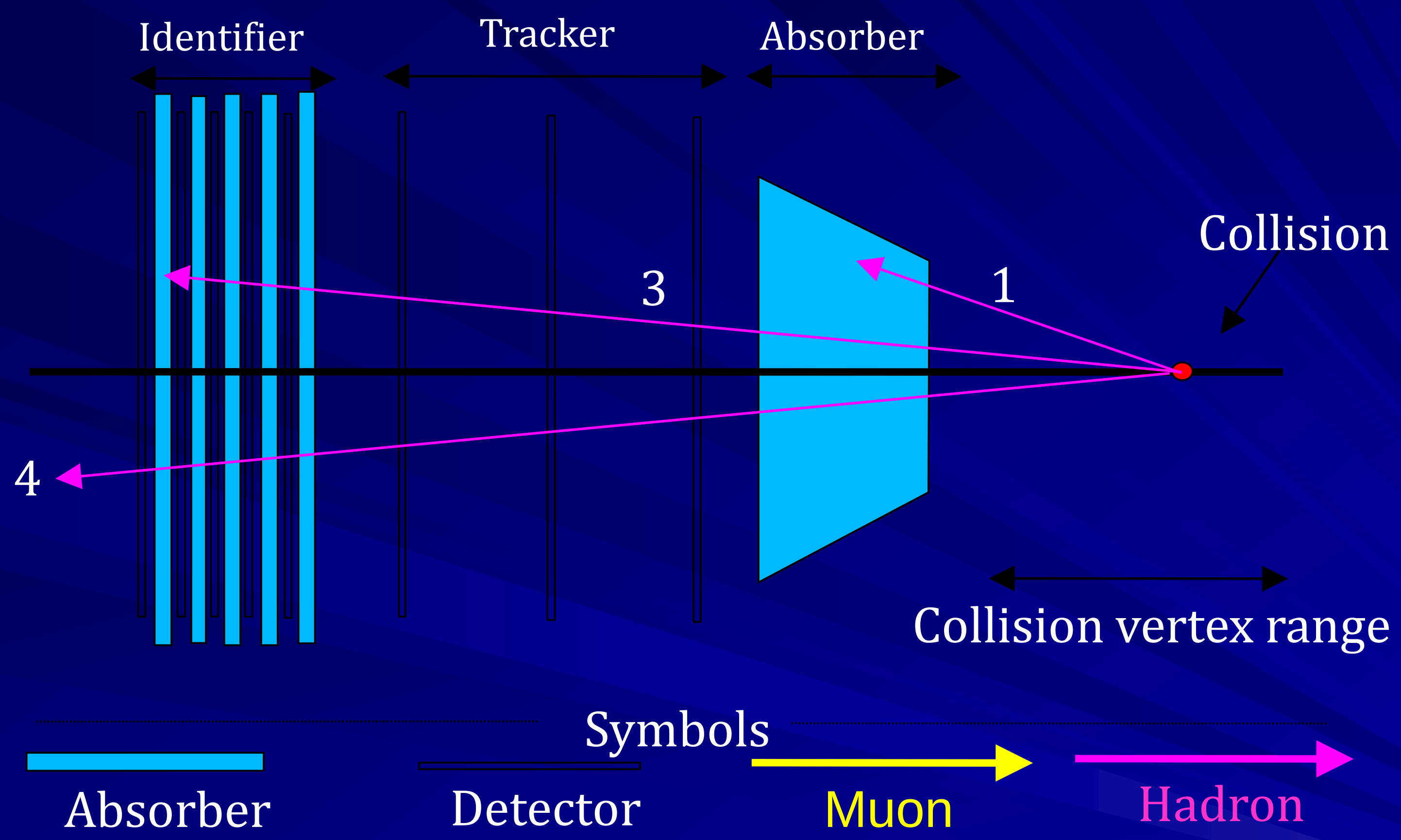
Decay μ spectra

p + p @√s = 200 GeV, η = 1.65, RUN2 FINAL



10 data points for μ^+ and for μ^- *correspond to the slopes for 10* p_T *bin (* $1 < p_T < 1.2$, $1.2 < p_T < 1.4$, … , $2.8 < p_T < 3.0$ *GeV/c). Each slope represents amount of decaying light hadrons, and good match occurs between the generator prediction and the measurement up to absolute normalization (5%). Hence we can determine decay μ component precisely.*

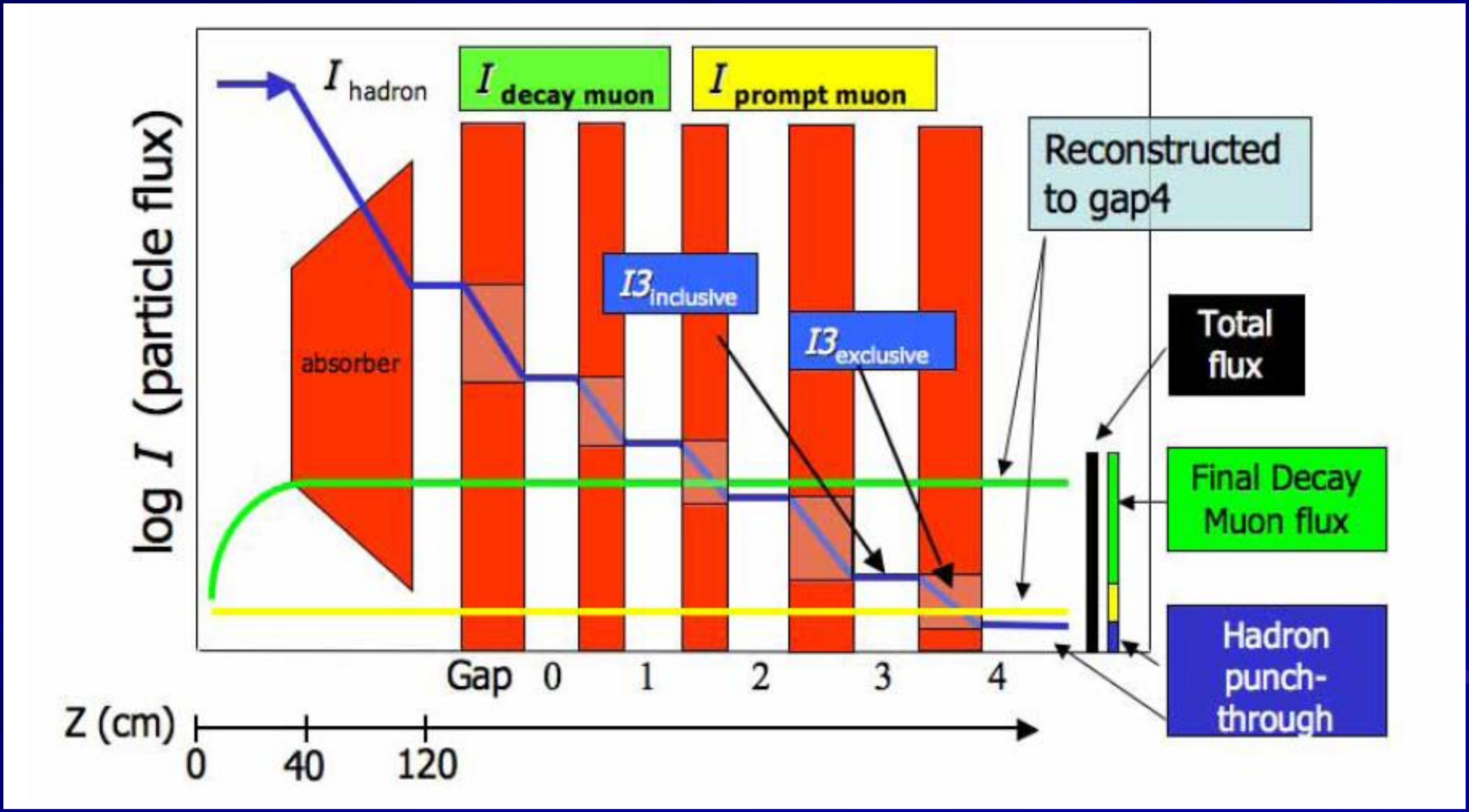
μ-measurement, Sources



1 : Hadrons, interacting and absorbed (98%),

3 : Hadrons, penetrating and interacting ("stopped")
4 : Hadrons, "punch-through",

Flux of hard muons in μ spectrometer

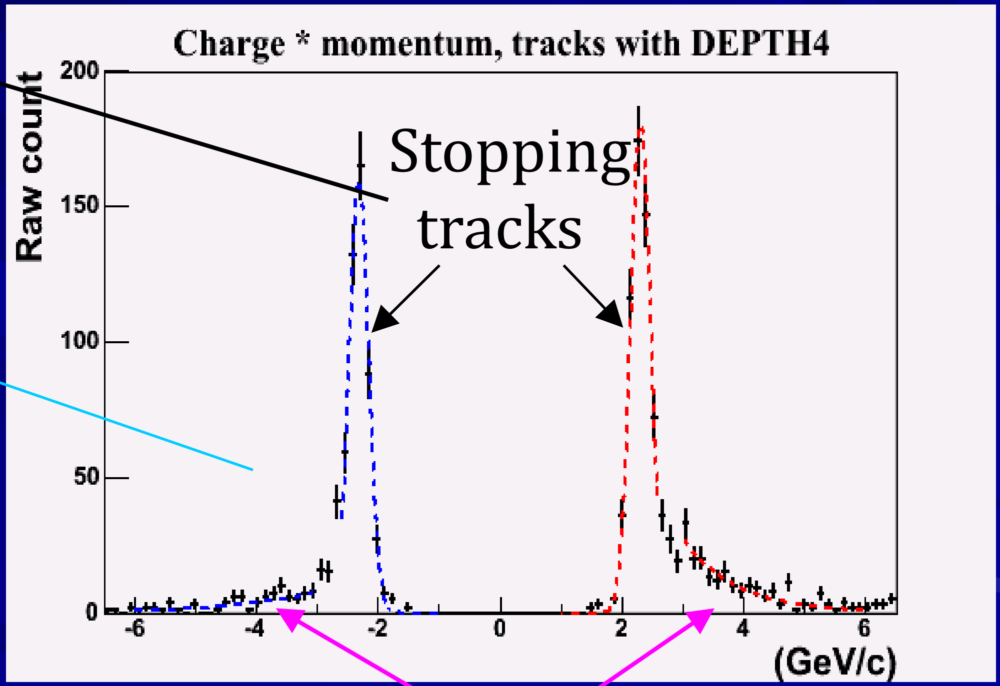


Hadrons, penetrating and interacting ("stopped")

Momentum distribution of the tracks with DEPTH 4

All energy lost to ionization

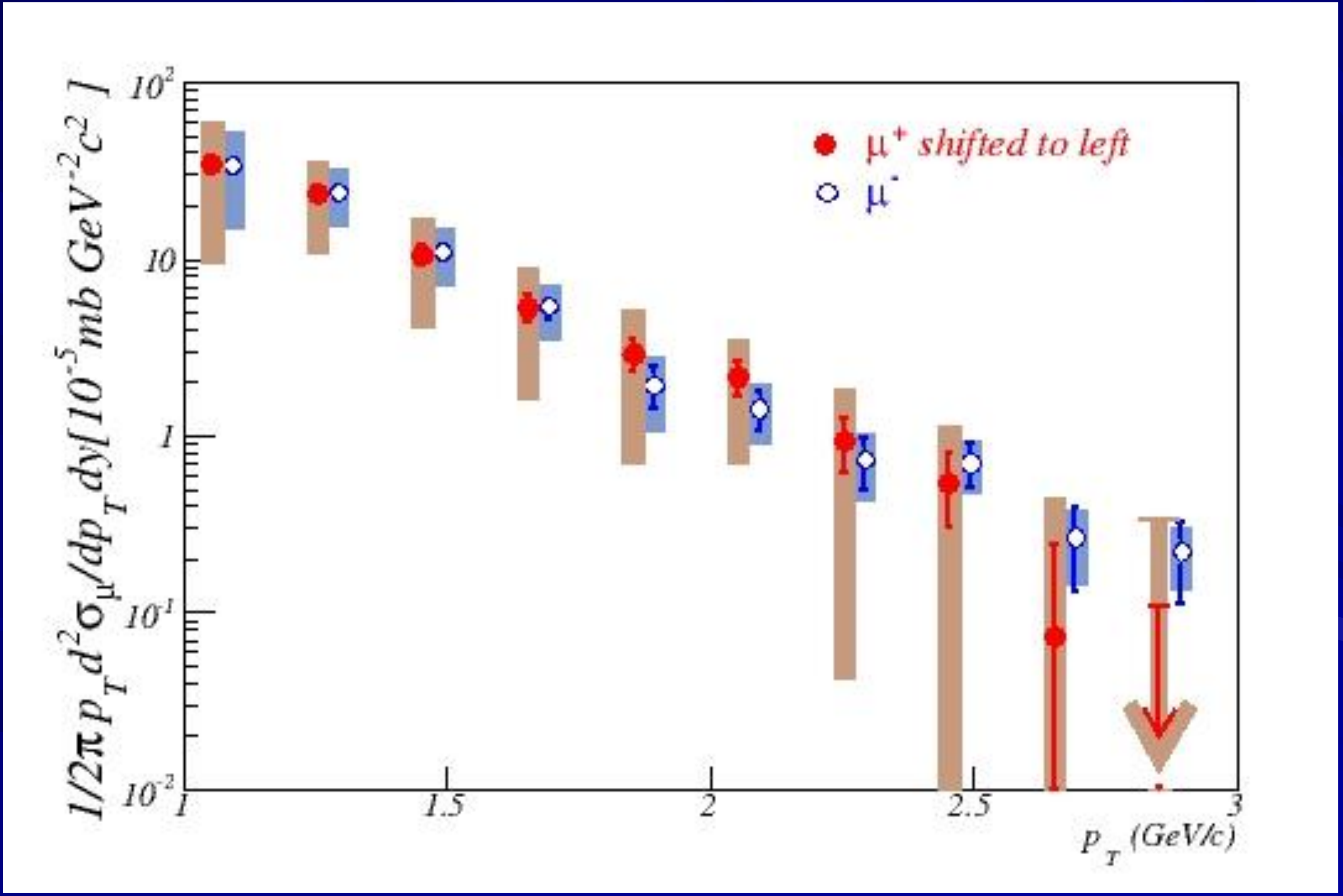
*Large momenta to reach the last MuId layer, **but hadron interaction in the last absorber layer** to stop before last MuId layer.*



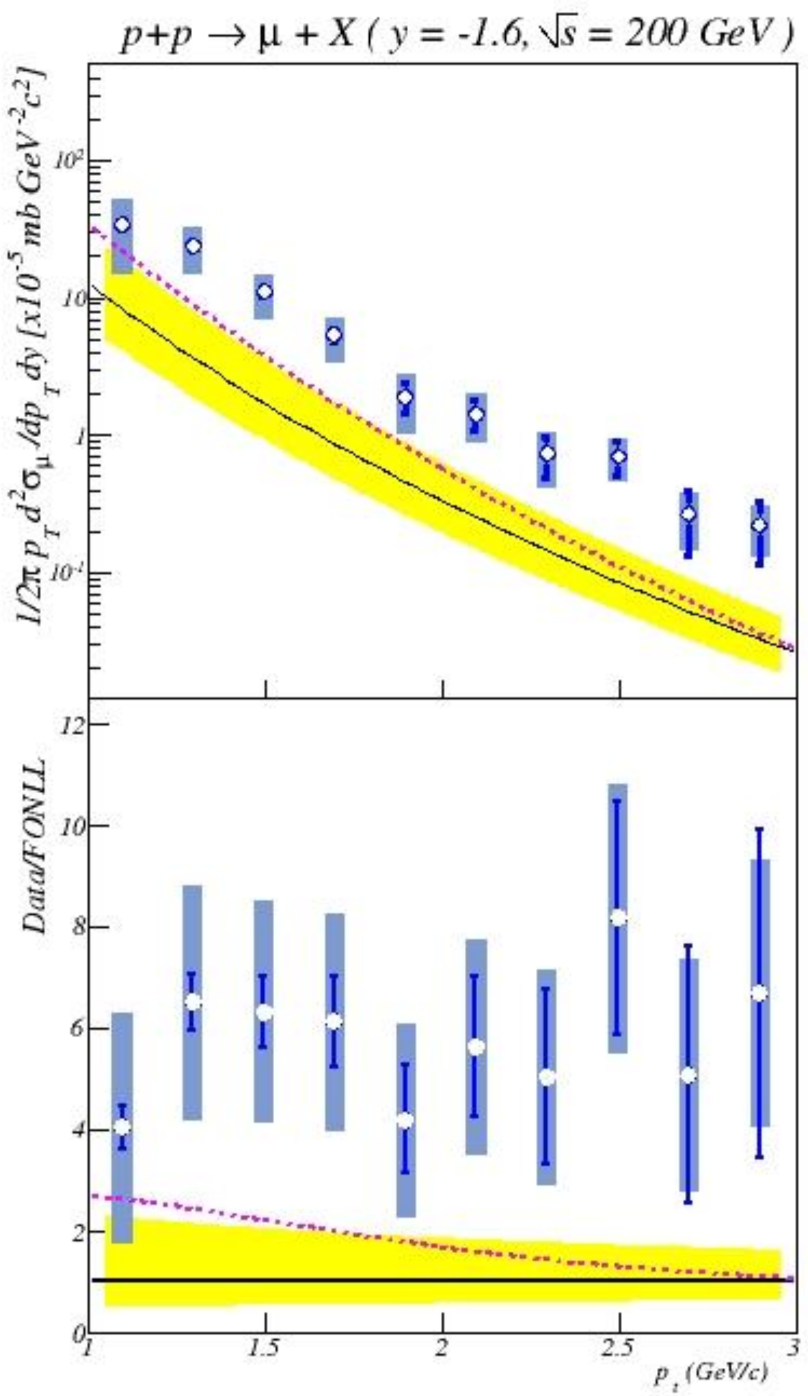
Forward μ production, p+p & Au+Au @ 200A GeV

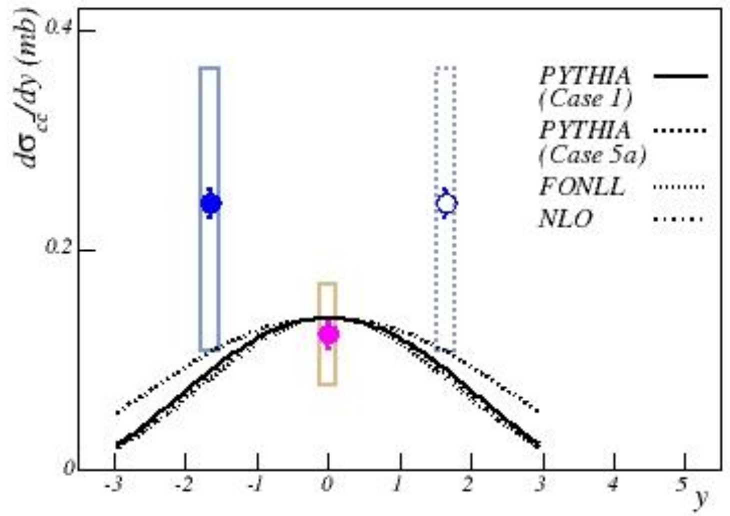
Obtained prompt μ spectra

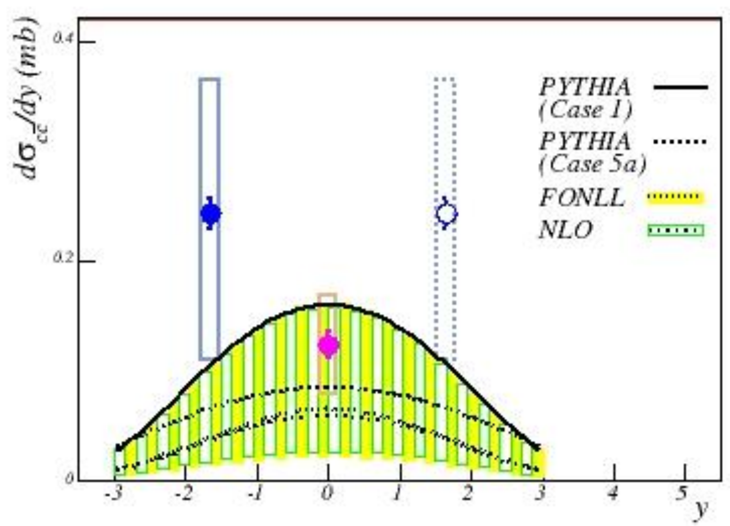
y = 1.65, p+p @ √s = 200 GeV, RUN2 FINAL



Comparison : FONLL





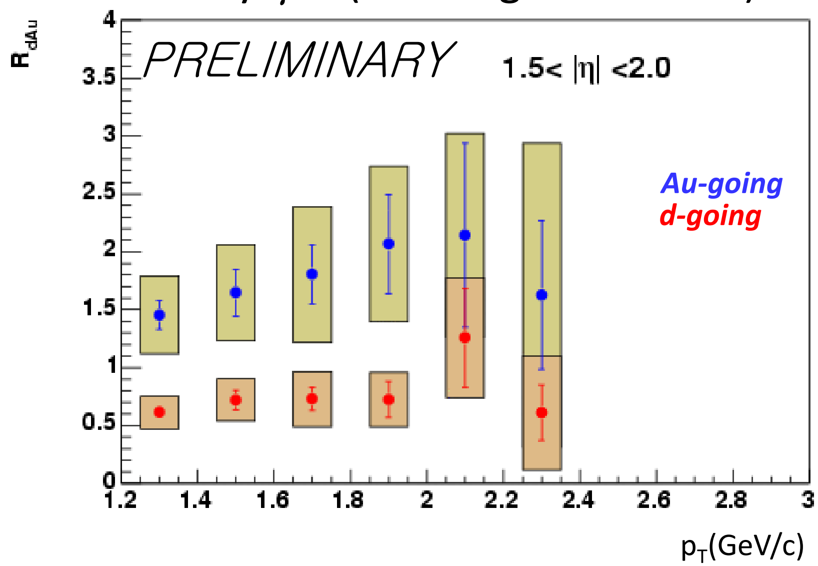


$\mu^{\pm}$ & NMF, d+Au at $\sqrt{s_{NN}}$ = 200 GeV

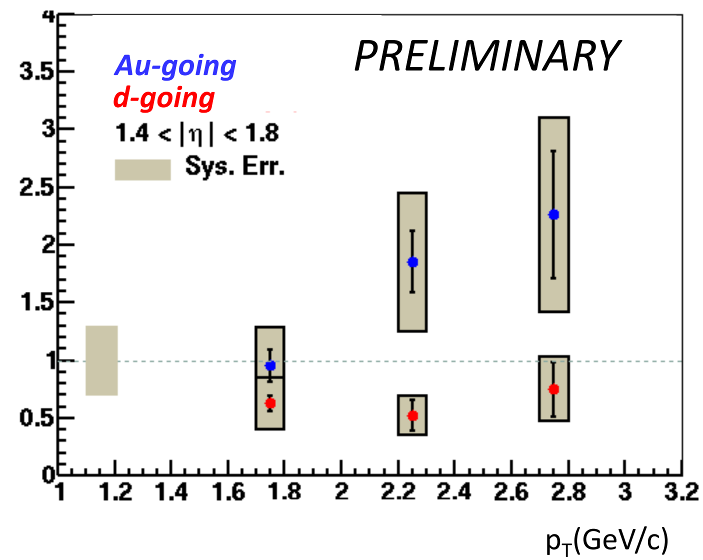
$$R_{dAu}(p_T,\eta) \equiv \frac{\dfrac{1}{2\times 197}\dfrac{d^2\sigma^{d+Au\to\mu+X}}{dp_T d\eta}}{\dfrac{d^2\sigma^{p+p\to\mu+X}}{dp_T d\eta}}$$

South : Au-going direction,
North : d-going direction

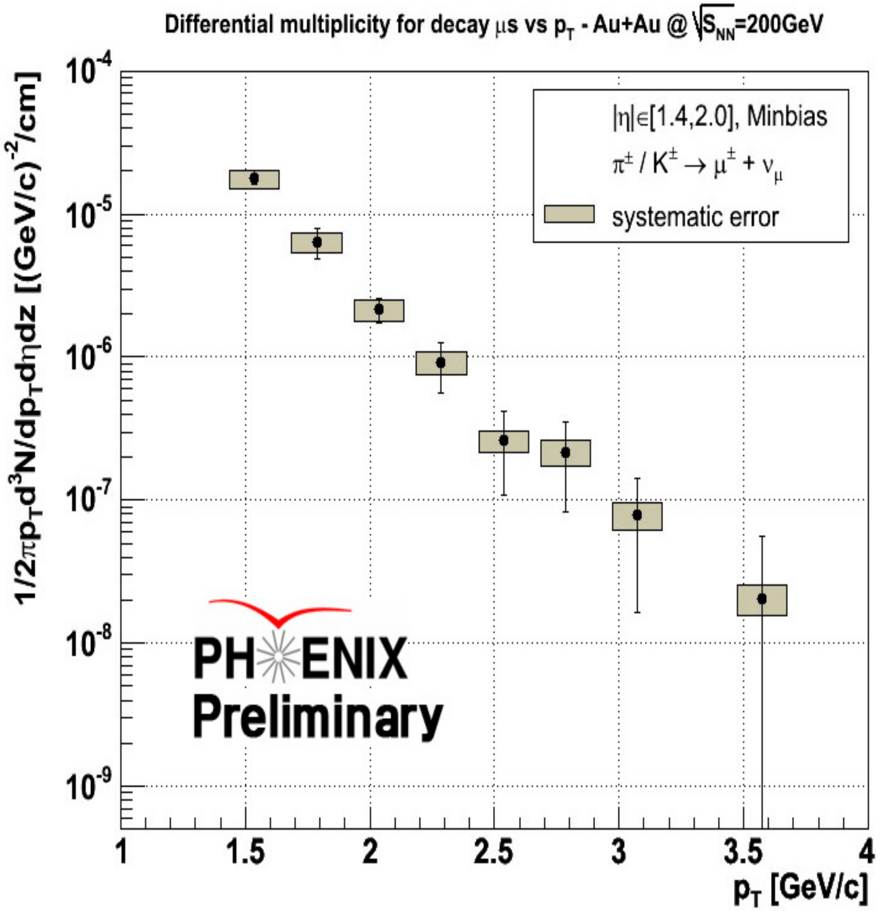
Decay μ's (from light hadrons)

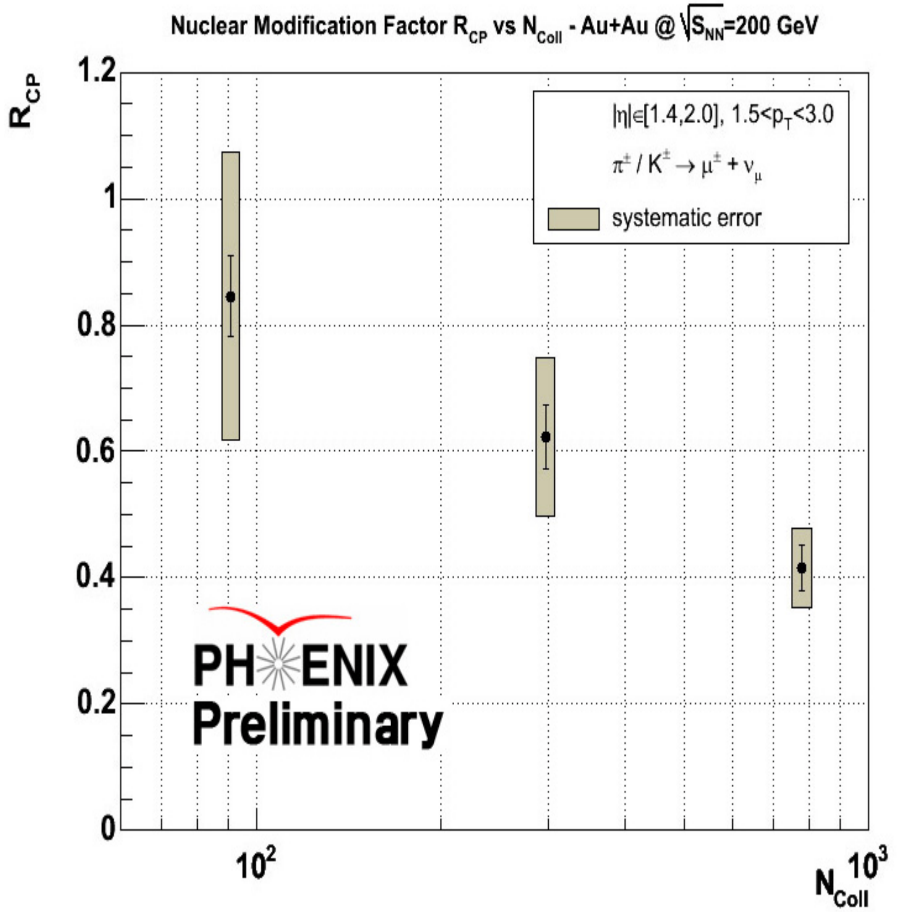


Prompt μ's (from heavy quarks)

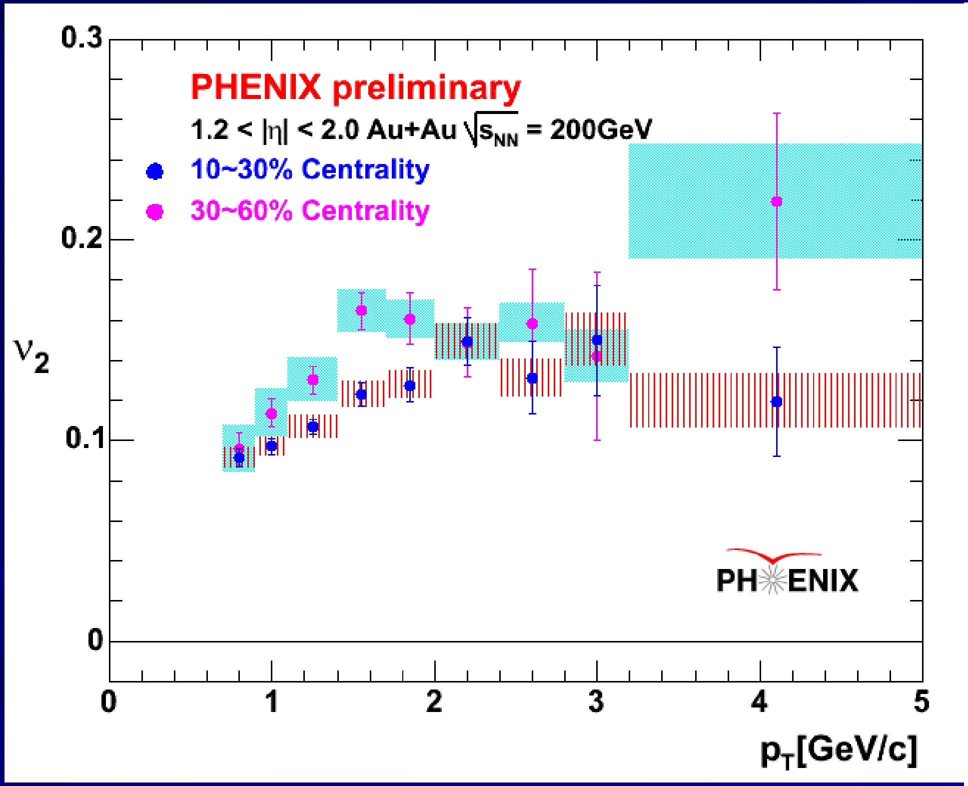


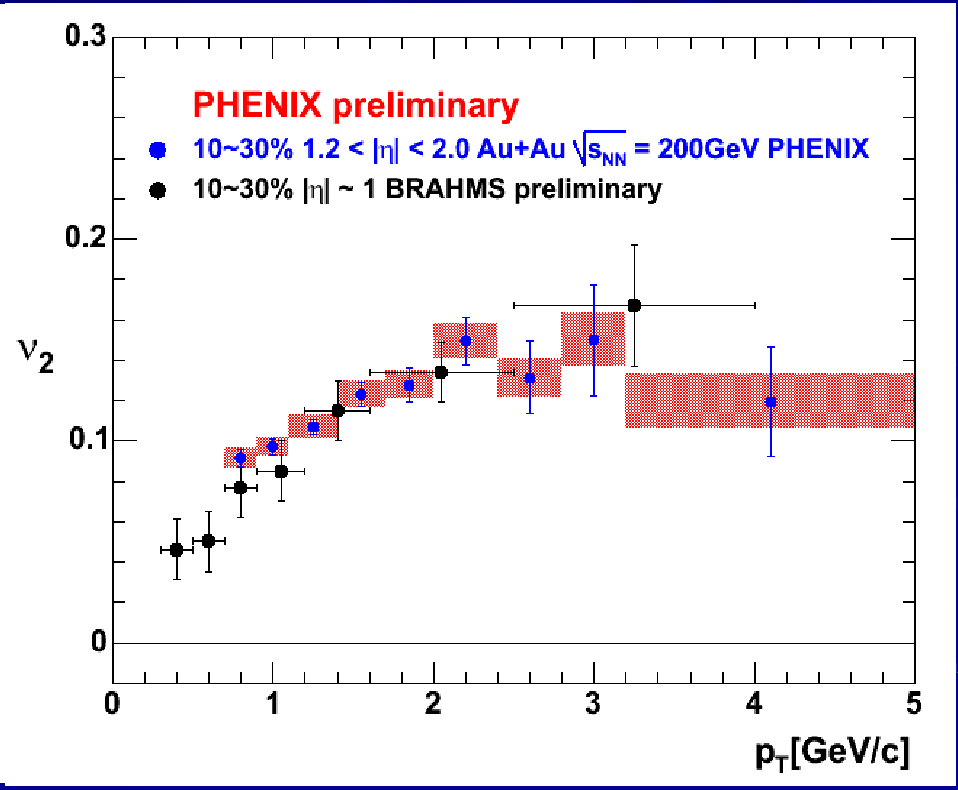
$Decay\ \mu,\ Au + Au\ @\sqrt{s_{NN}} = 200GeV$





Inclusive (Decay/Prompt μ & Punch-through), v_2



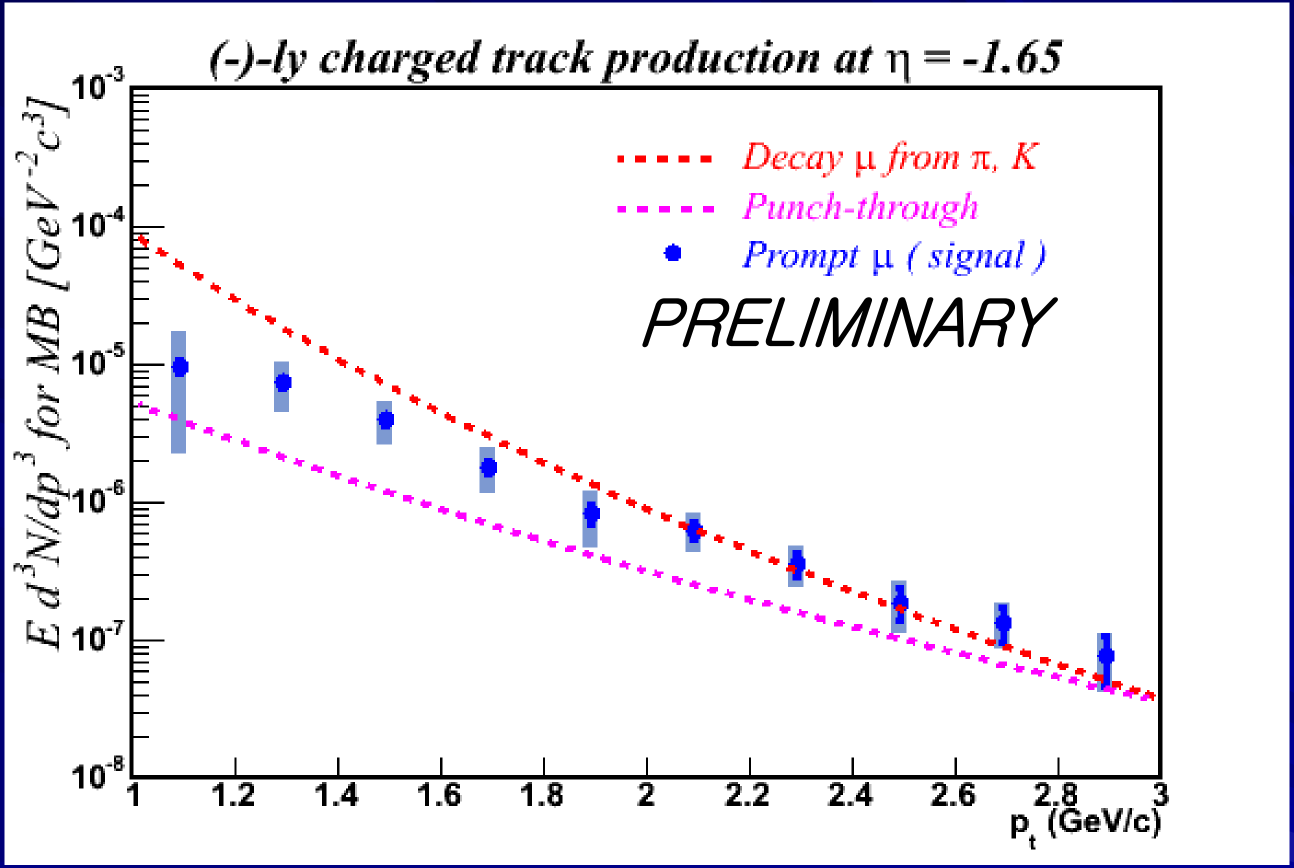


Conclusion & outlook

- New forward lepton measurements are emerging at RHIC.
- Study of forward light/heavy flavored hadron production is possible from the measurement.
- FONLL underpredicts forward prompt lepton production within marginal significance.
- First (limited) results on R_{dAu}, R_{CP} and v_2 shown.

Backup

Signal/Background



Sources of μ candidates

1. *Decay μ's is important at all p_T.*
2. *Punch-through is small, but important due to large uncertainty.*
3. *Prompt μ signal comparable to decay μ when $p_T \sim 2(GeV/c)$.*