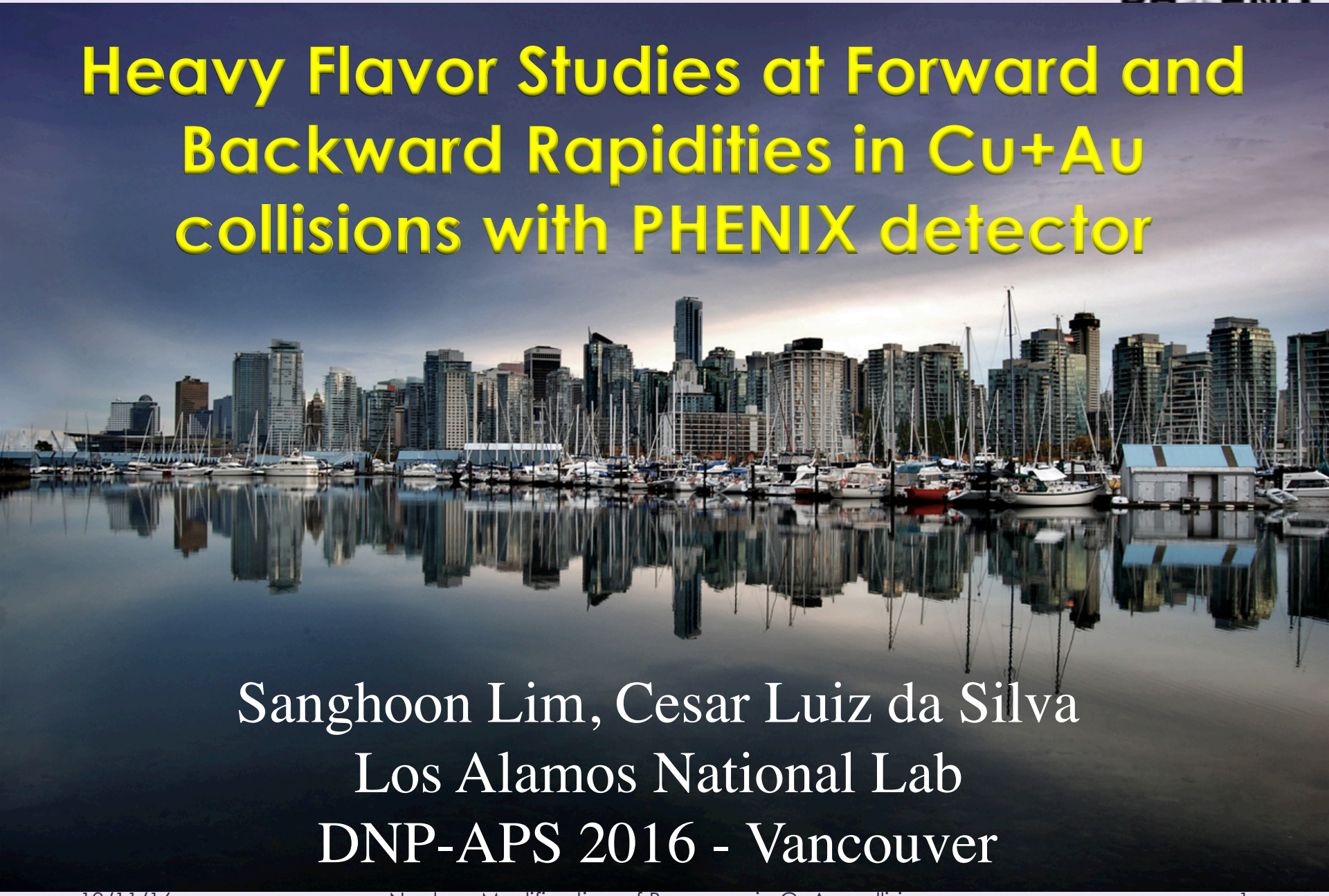
Heavy Flavor Studies at Forward and Backward Rapidities in Cu+Au collisions with PHENIX detector

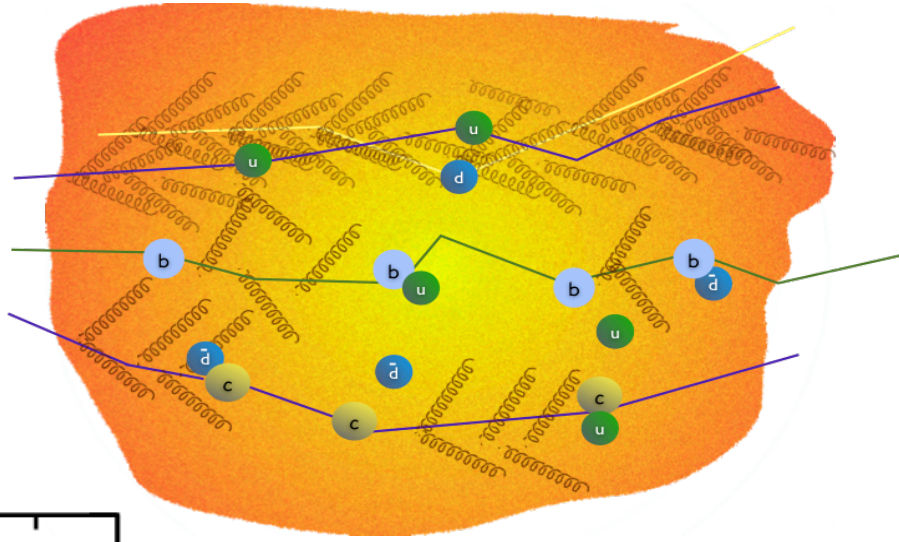


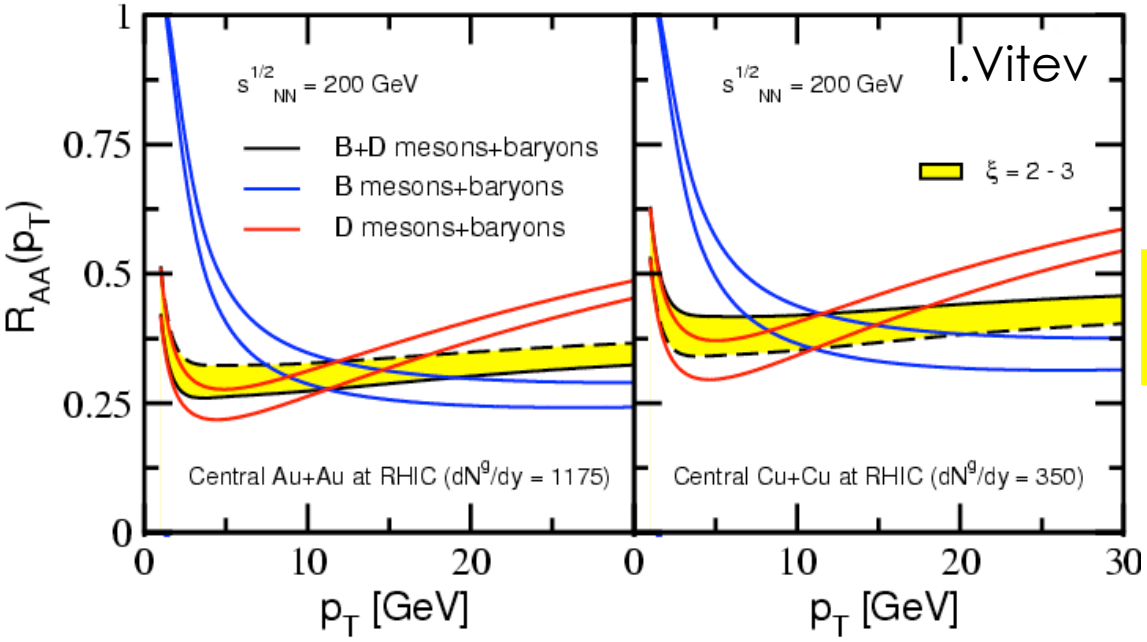
Sanghoon Lim, Cesar Luiz da Silva
Los Alamos National Lab
DNP-APS 2016 - Vancouver

Light, Charm and Bottom Quarks crossing QGP

Energy loss:

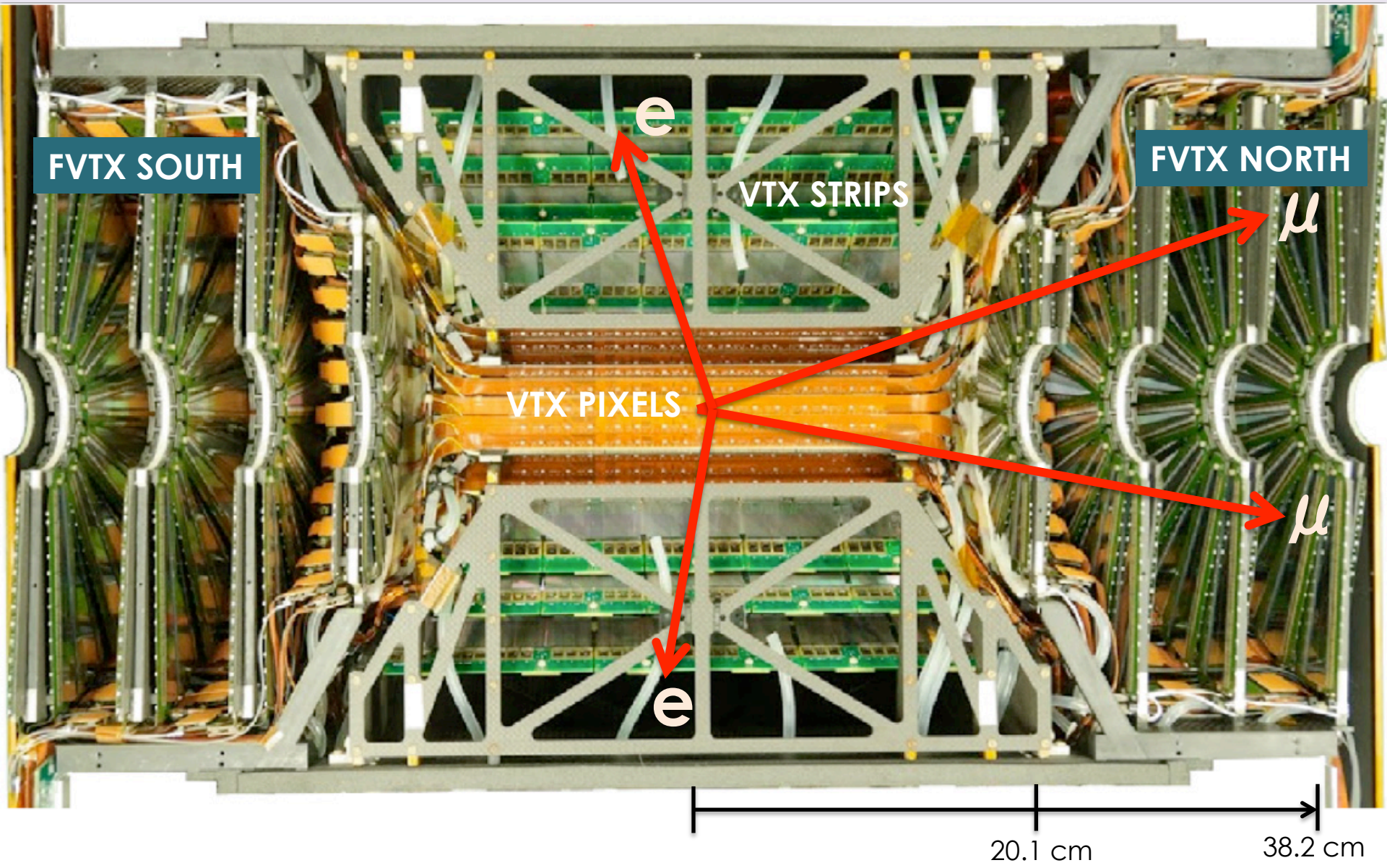
- Gluon radiation
- elastic collisions
- Gluon radiation suppressed for θ <M/E
- Heavy quarks hadronize quickly crossing the medium as mesons or dissociated quarks





Quark mass dependency more pronounced at small p_T

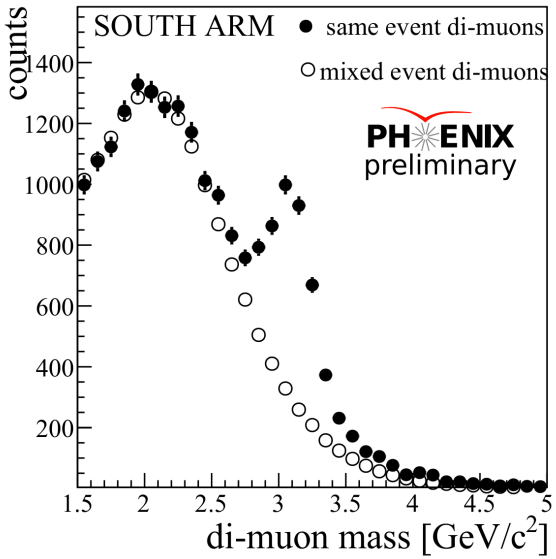
Vertex Detectors in PHENIX



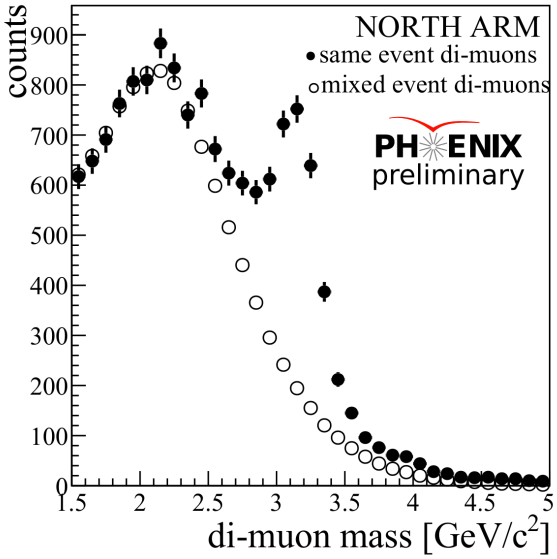
B-mesons at RHIC

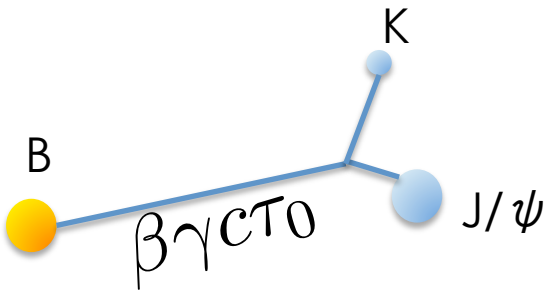
Inclusive J/ψ

-2.2<y<-1.2



1.2<y<2.2





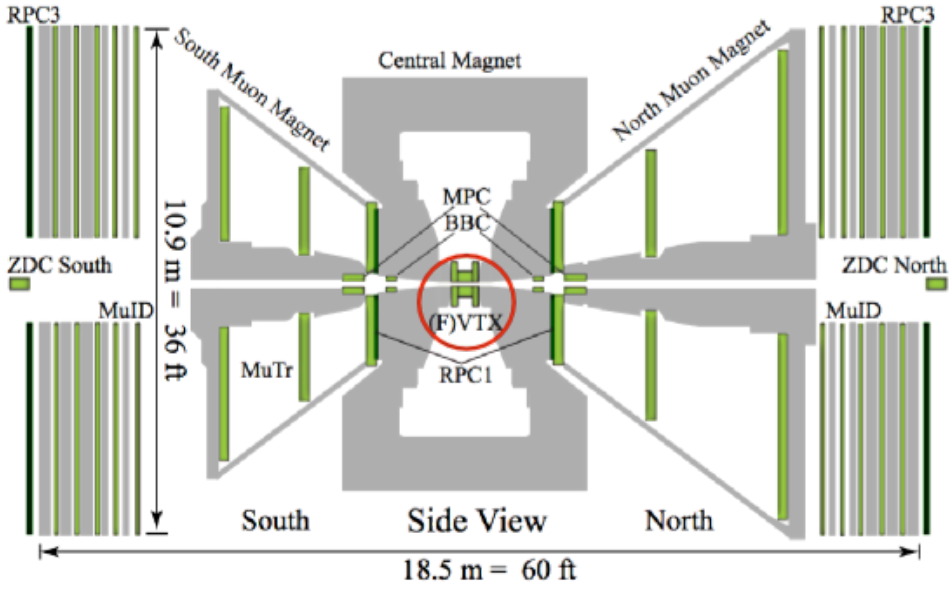
$$c\tau_0 \sim 450\mu m$$

$$\gamma = \frac{\sqrt{p_z^2 + p_T^2 + M^2}}{M}$$

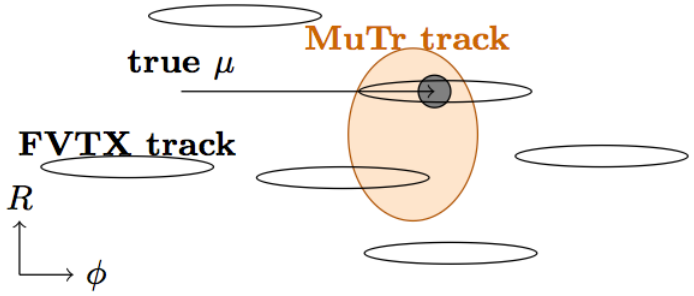
- Look for non-prompt J/psi using the new forward vertex detector (FVTX)
- Decay length is boosted at large rapidities (p_Z>>0) allowing to identify non-prompt particles down to p_T=0

Muon Reconstruction

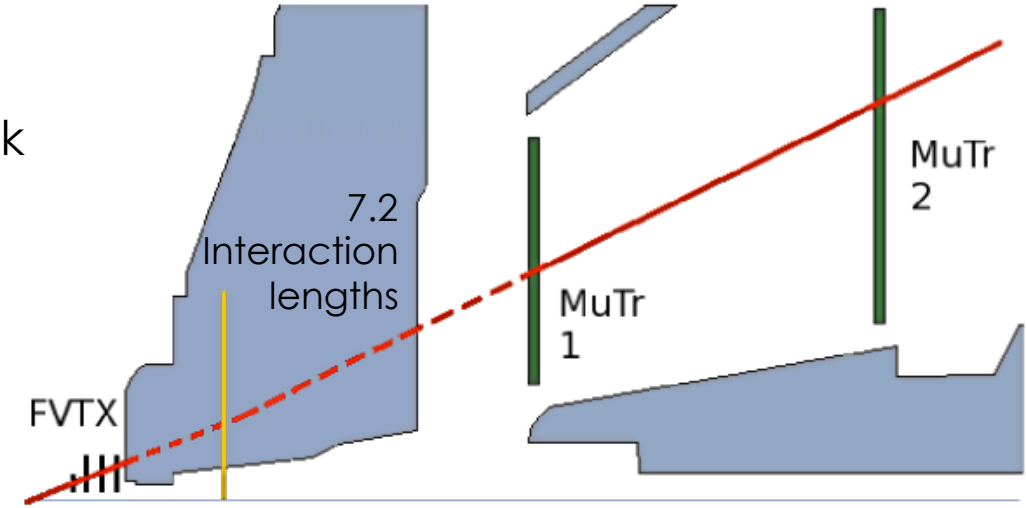
1.2<|y|<2.2
2π azimuthal coverage



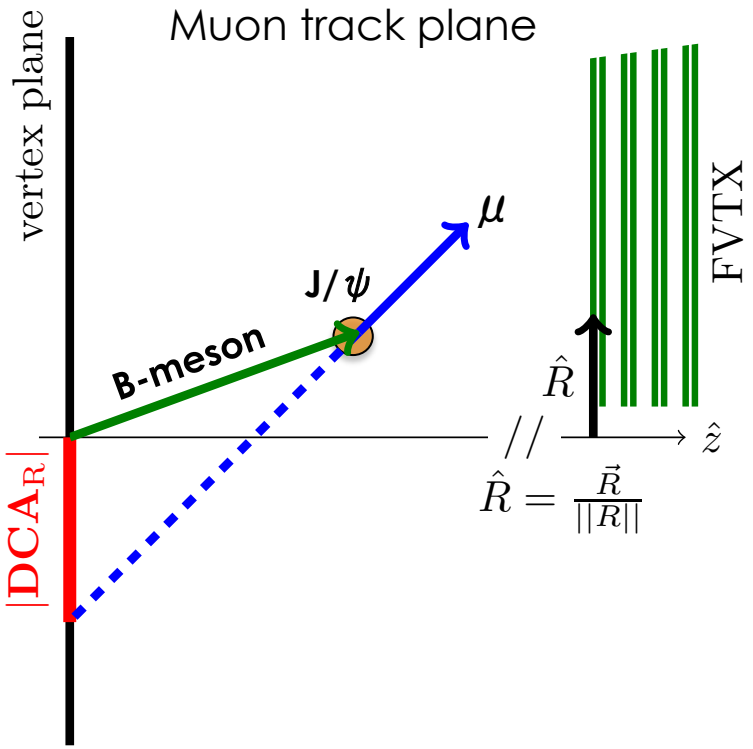
Projections at one of the FVTX planes



- MuTr track can match >1 FVTX track because of multiple scattering projection
- Analysis use all 3σ matchings and statistically subtract mismatches using event mixing technique

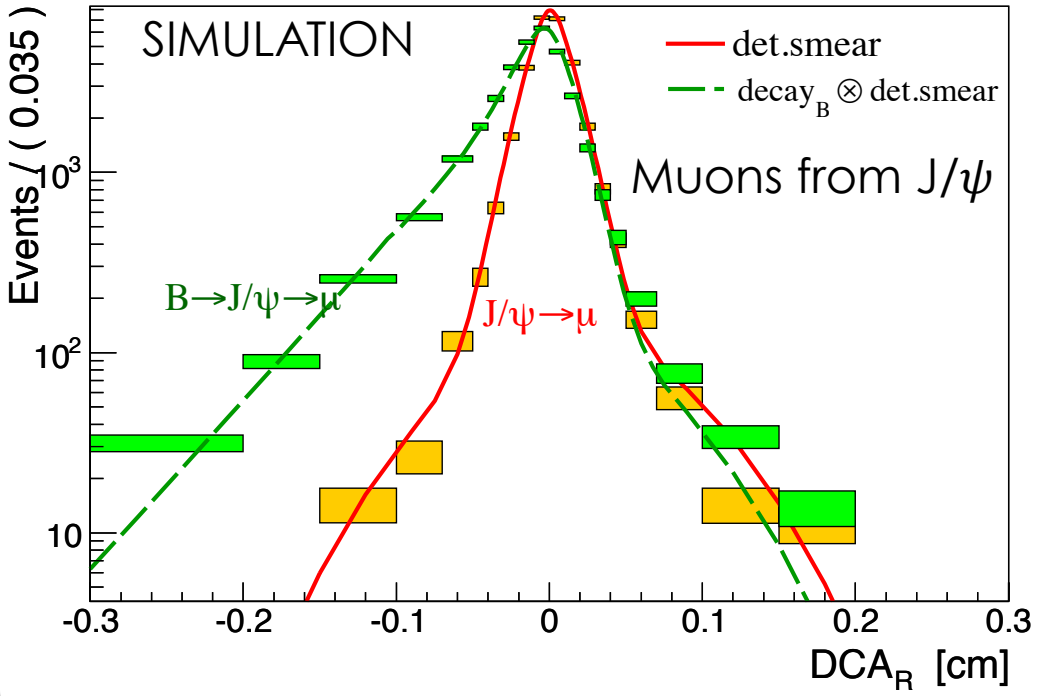


Identifying B-meson decays



Decays from HF produce additional asymmetric tails because of the decay lever arm.

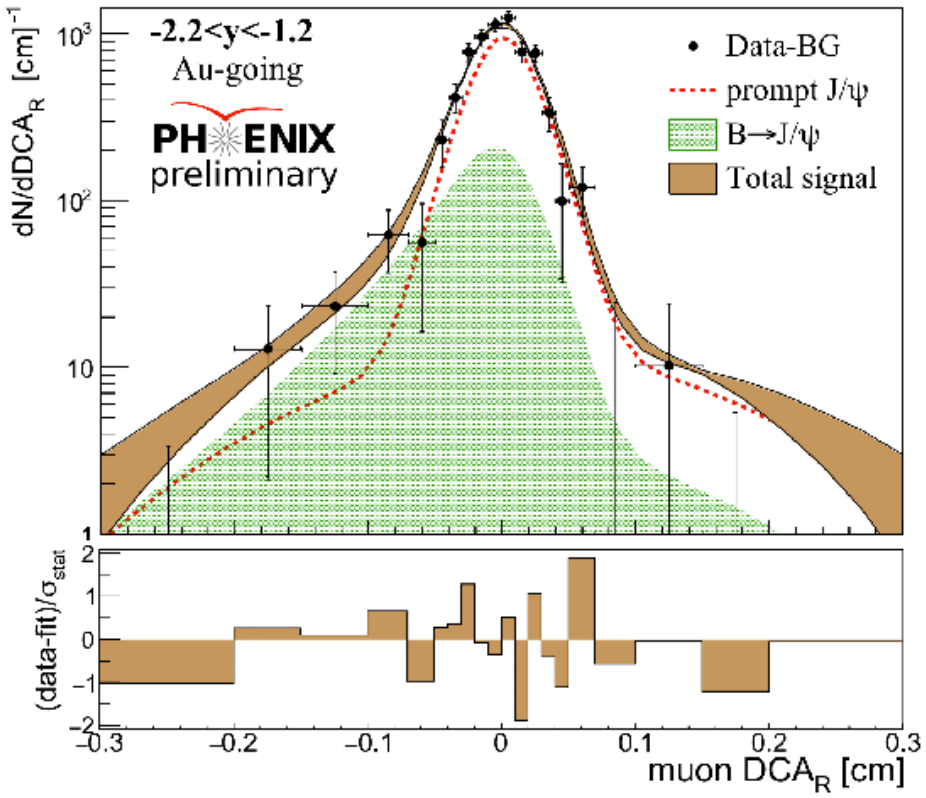
Detector smearing obtained from large and clean sample of prompt pions and kaons.

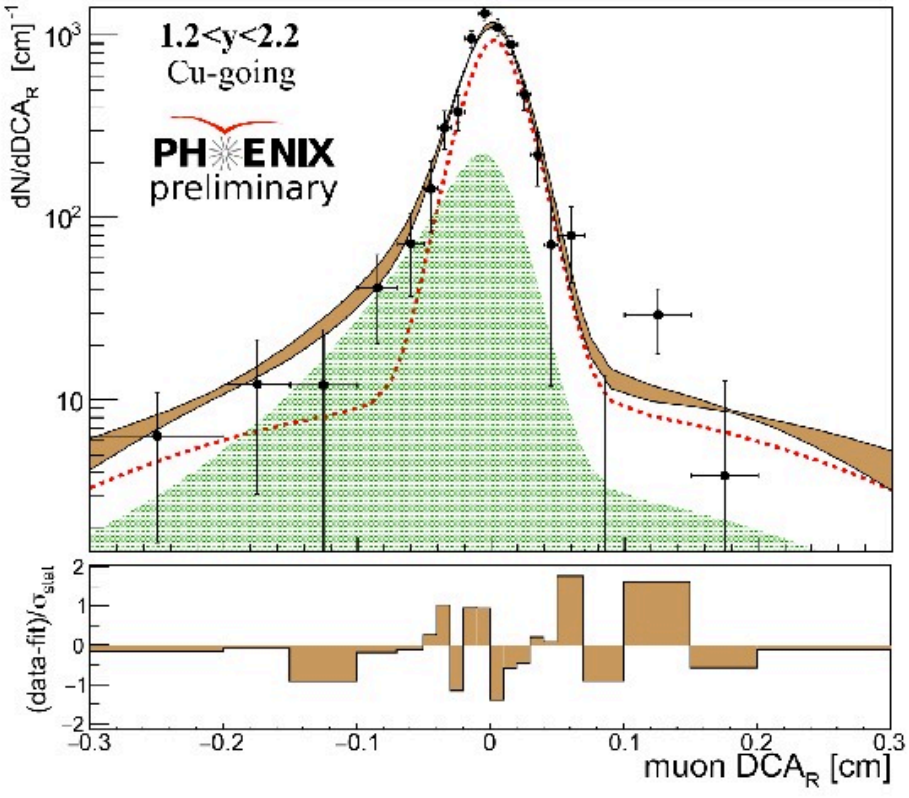


B→J/Ψ decays

Cu+Au @ 200 GeV

Integrated Centrality and p_T.



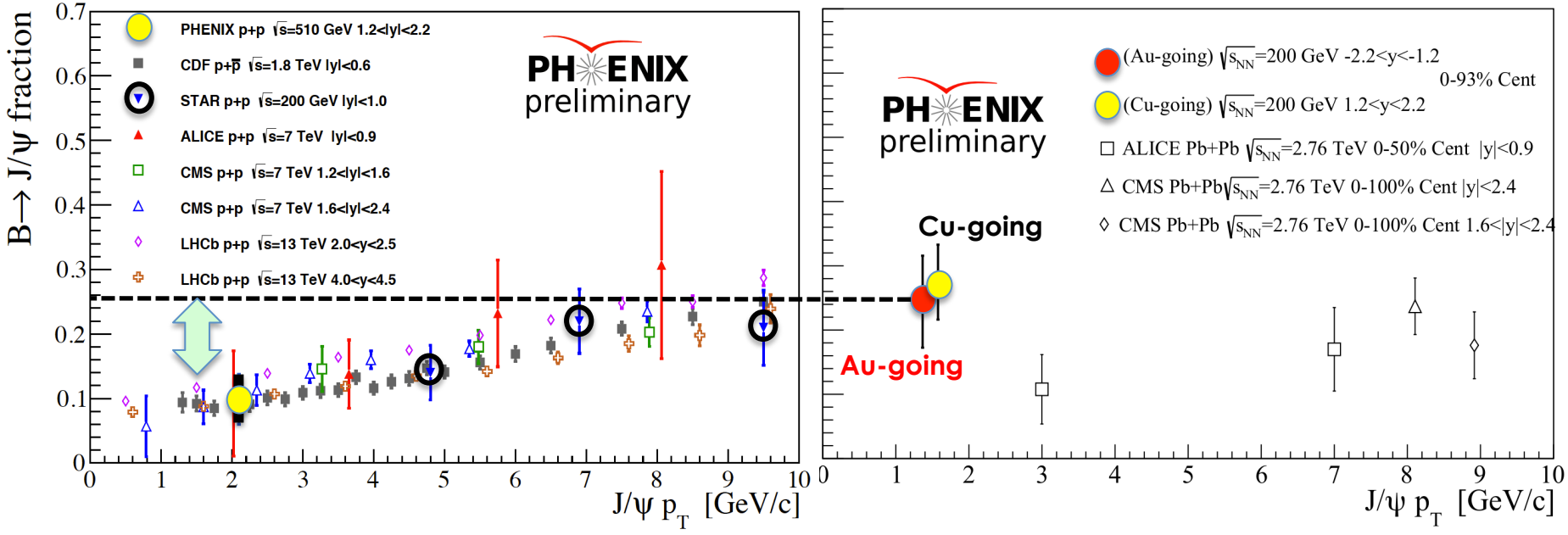


Di-muon combinatorial and FVTX-MuTr mismatch backgrounds not shown for clarity, but considered in the likelihood fit.

B→J/Ψ fraction results

PHENIX results are p_T and centrality integrated. Data points placed at average J/ψ p_T.

Cu+Au 200 GeV 1.2<|y|<2.2



B-fraction in Cu+Au data enhanced compared to world p+p data at the same average p_T.

Indicates B-meson is less suppressed than prompt J/ψ in Cu+Au collisions.

p+p reference at 200 GeV coming soon to obtain nuclear modification factor R_{AA}.

Summary and Next Results

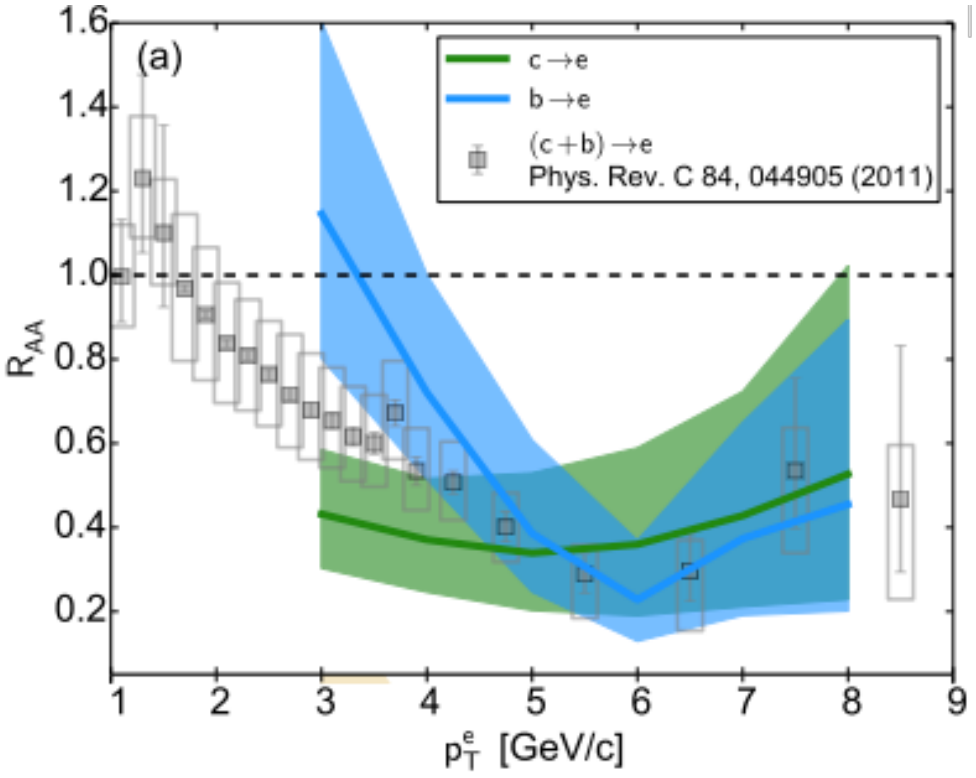
- Forward B->J/ψ at PHENIX has unprecedented access to B-mesons at p_T>0, where quark mass is relevant for energy loss.
- B-meson fraction in J/ψ is enhanced in Cu+Au collisions compared to world data, indicating the B-meson is less suppressed than prompt J/ψ
- p+p at 200 GeV B->J/ψ reference coming soon allowing the quantification of R_{AA}
- p+Au at 200 GeV B->J/ψ result also coming soon providing information on initial state effects
- Inclusive single muon DCA_R analysis will bring more statistics to the D- and B-meson measurement allowing R_{AA} vs. p_T in Cu+Au
- ~30x more statistics from run14+run16 coming up, it will provide a final word on the mass hierarchy of the energy loss mechanism in QGP

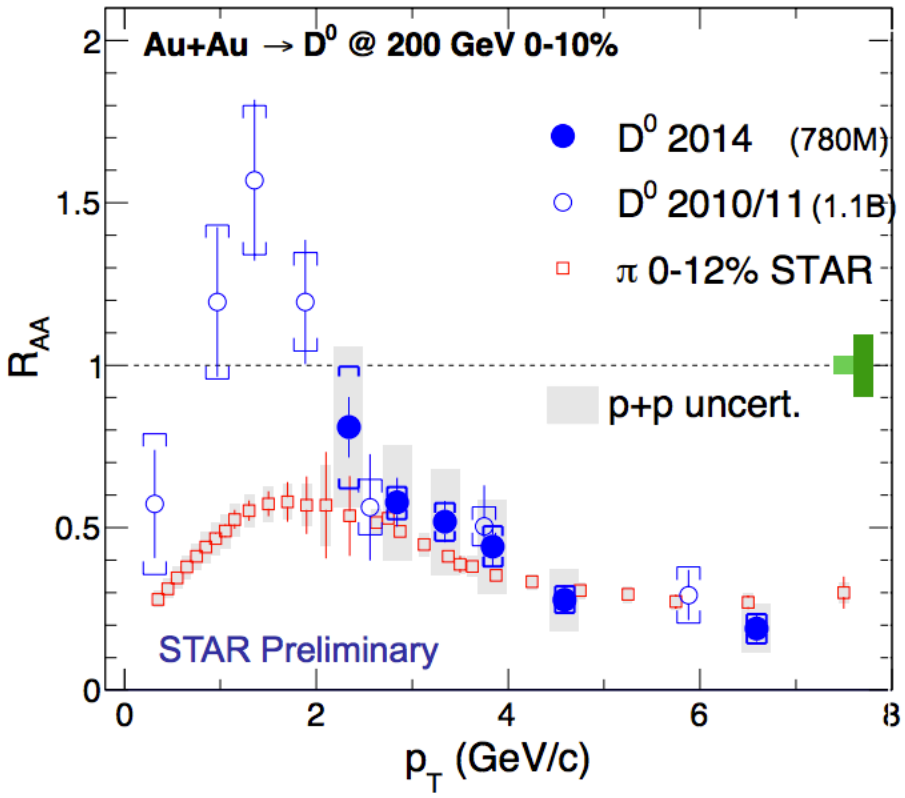
2017
Jets and heavy flavor workshop

- Second in a series of workshops to bring the NP and HEP communities working on jets and heavy flavor, with emphasis on QCD and SCET

BACKUP

Separating charm and bottom



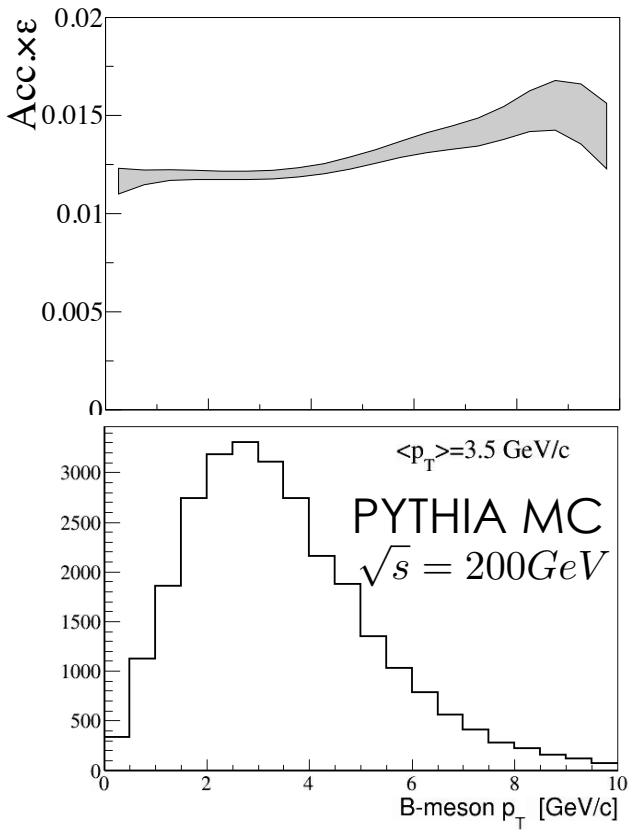


First results at mid-rapidity using

- Displaced vertex of semi-leptonic decays
- Reconstructed D^0

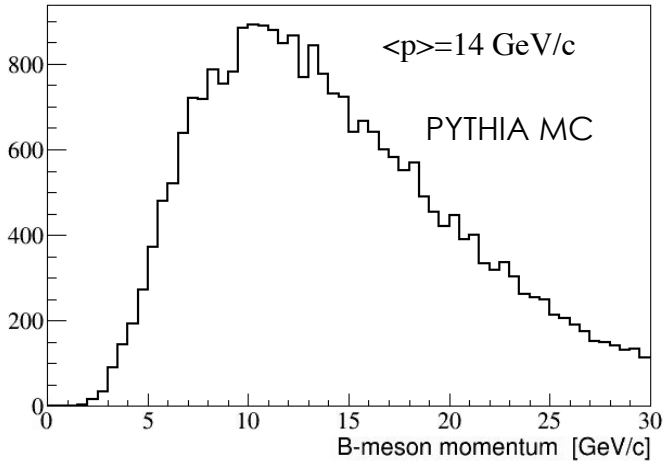
B-mesons Acceptance

$$B \rightarrow J/\psi \rightarrow \mu$$



Flat detector acceptance in small p_T region.

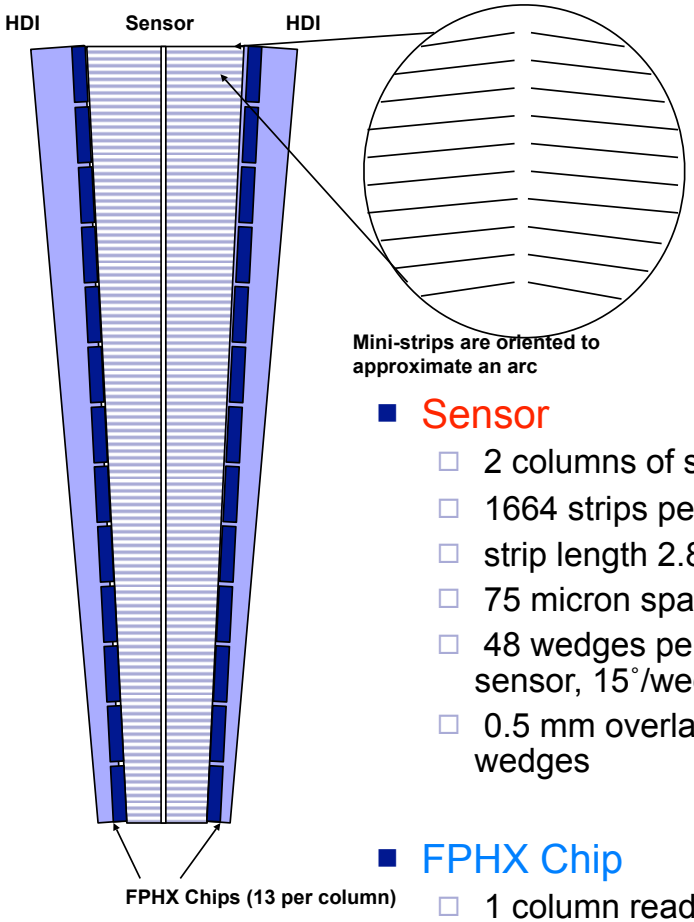
Clean access to small p_T B-mesons.



Boosted B-mesons :

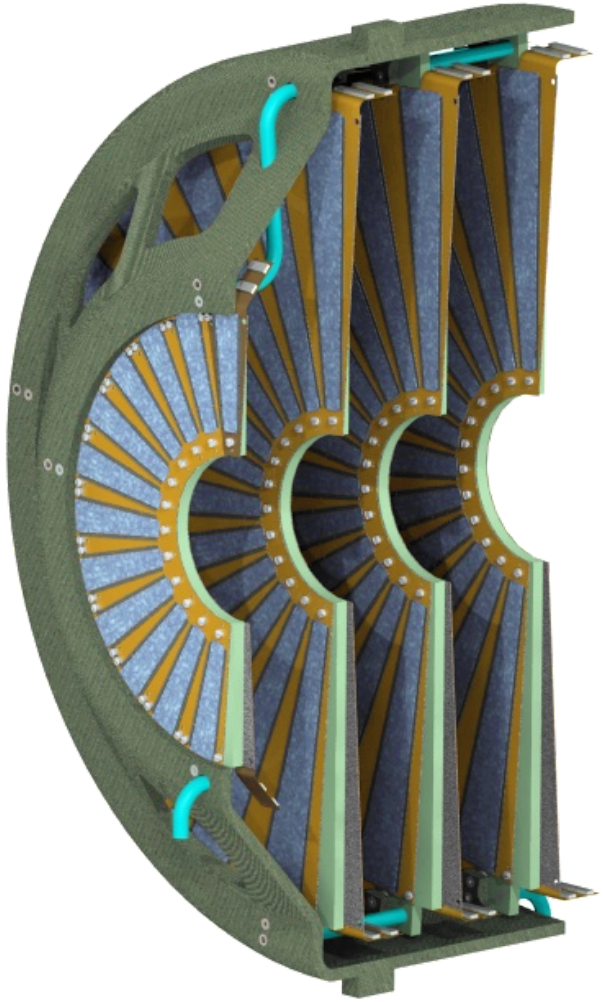
- longer decay length
- may also have physics implications on path length until hadronization

The Forward Vertex Detector (FVTX)



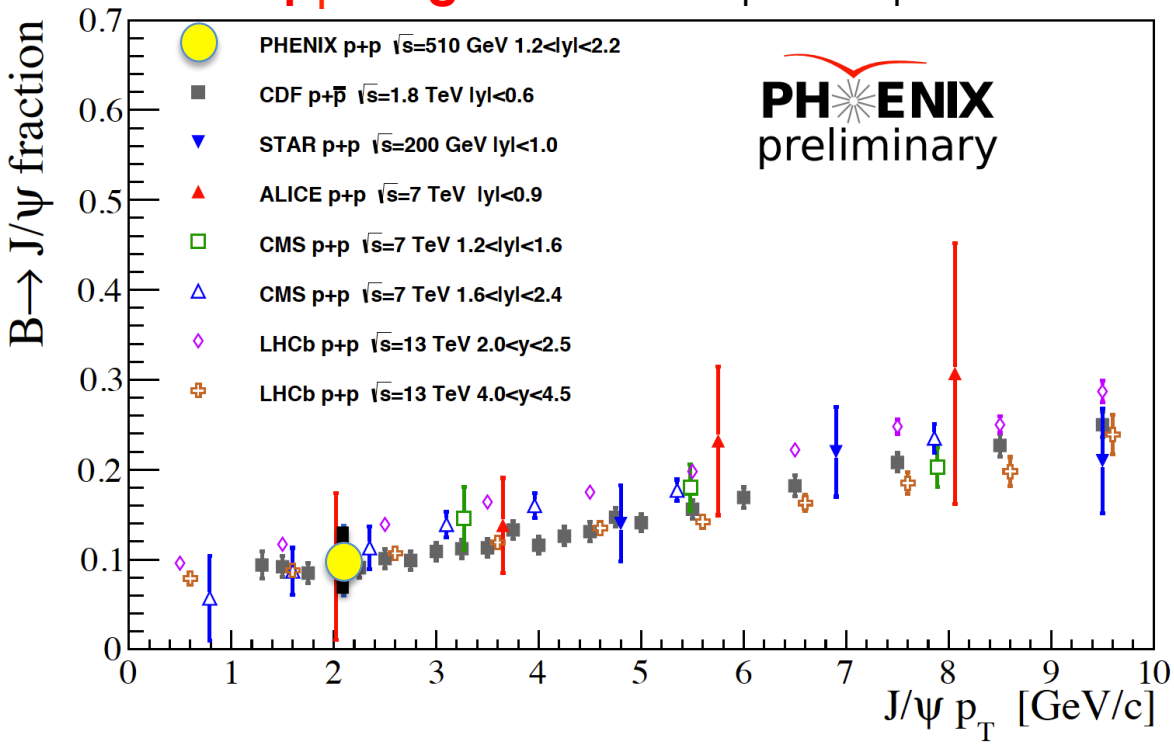
75 μm radial segmentation

- Sensor
  - 2 columns of strips
  - 1664 strips per column
  - strip length 2.8 to 11.2 mm
  - 75 micron spacing
  - 48 wedges per disk (7.5˚/ sensor, 15˚/wedge)
  - 0.5 mm overlap with adjacent wedges
- FPHX Chip
  - 1 column readout
  - 128 channels
  - ~ 70 microns channel spacing
  - Dimensions –9mm x 1.2 mm



B→J/Ψ fraction results

PHENIX results are **p_T integrated**. Data points placed at average J/ψ p_T.

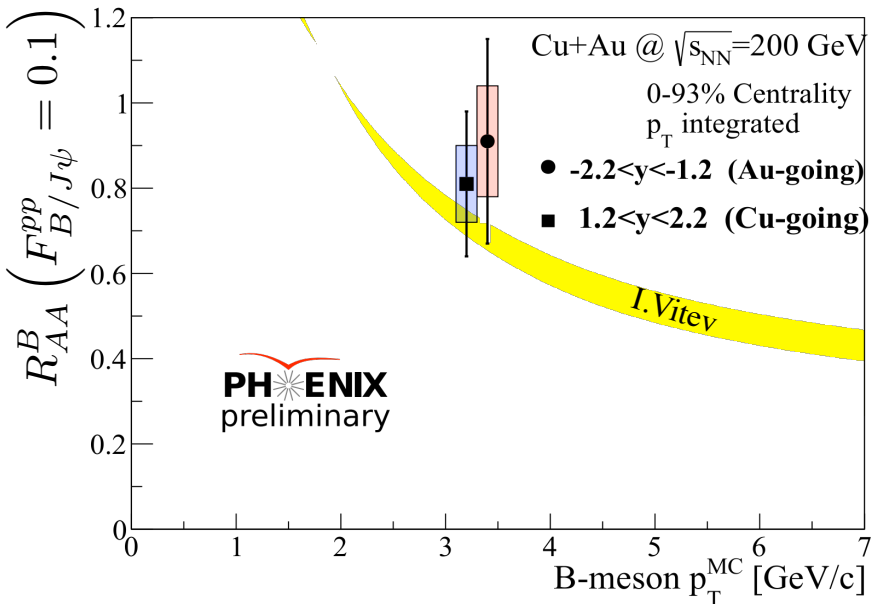


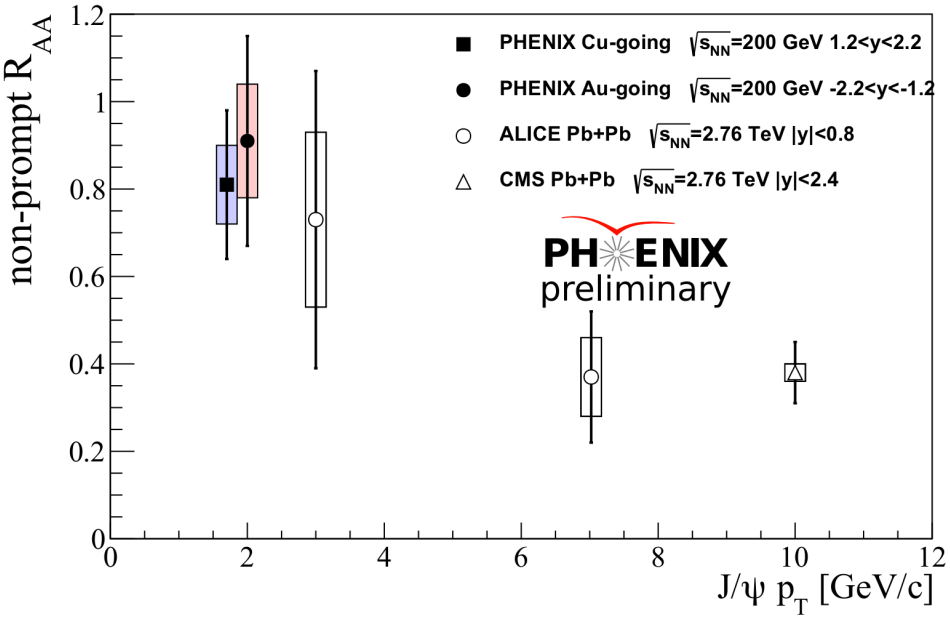
- Despite expected reduction of $b\bar{b}/c\bar{c}$ ratio at 510 GeV, fraction of B-meson decays in inclusive J/ψ yield is consistent with higher energy results
  - Larger fraction in PHENIX rapidity range ? (as observed by CMS and LHCb)
  - Compensation from larger (J/ψ)/$c\bar{c}$ at higher energies ?

B-meson R_{AA}

Cu+Au 200 GeV 1.2<|y|<2.2

$$R_{AA}(B-meson) = \frac{F^{CuAu}_{B/J\psi}}{F^{pp}_{B/J\psi}=0.1} R_{AA}(incl.J/\psi)$$



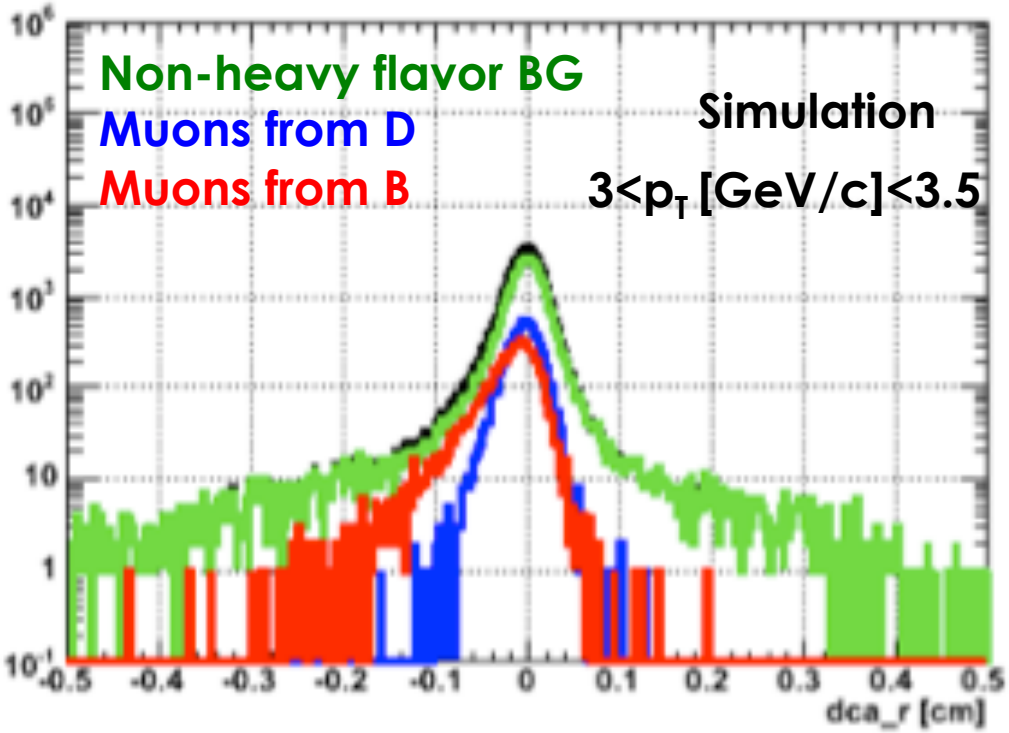


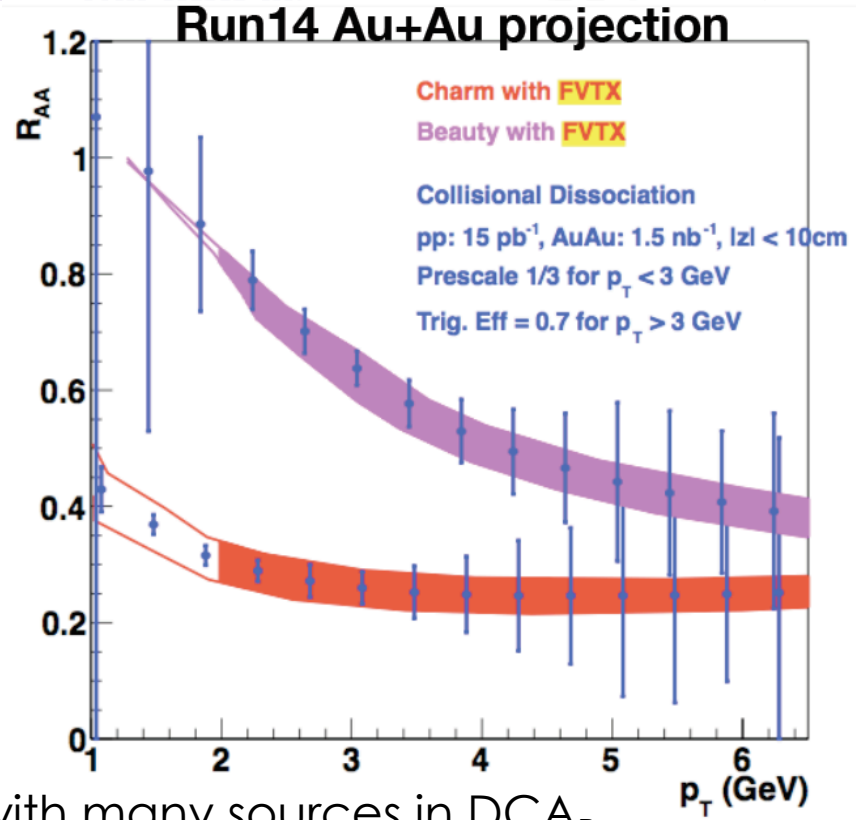
No pp reference at 200 GeV in the same p_T and rapidity at this moment.

Assuming $F_{B/J\psi}$ (pp)=0.1 from world p+p data at J/ψ p_T=1.5 GeV/c.

In this assumption, R_{AA} from Cu- and Au-going data consistent to binary scaling of B-mesons: no B-meson destruction, no thermal production in the QGP

Charm and Bottom from inclusive single muons





- Provides high statistics but needs to deal with many sources in DCA_R distribution.
- Very careful analysis underway with Cu+Au and p+p data sets to minimize systematics.

Opportunity in many data samples for R_{AA} and flow measurements.