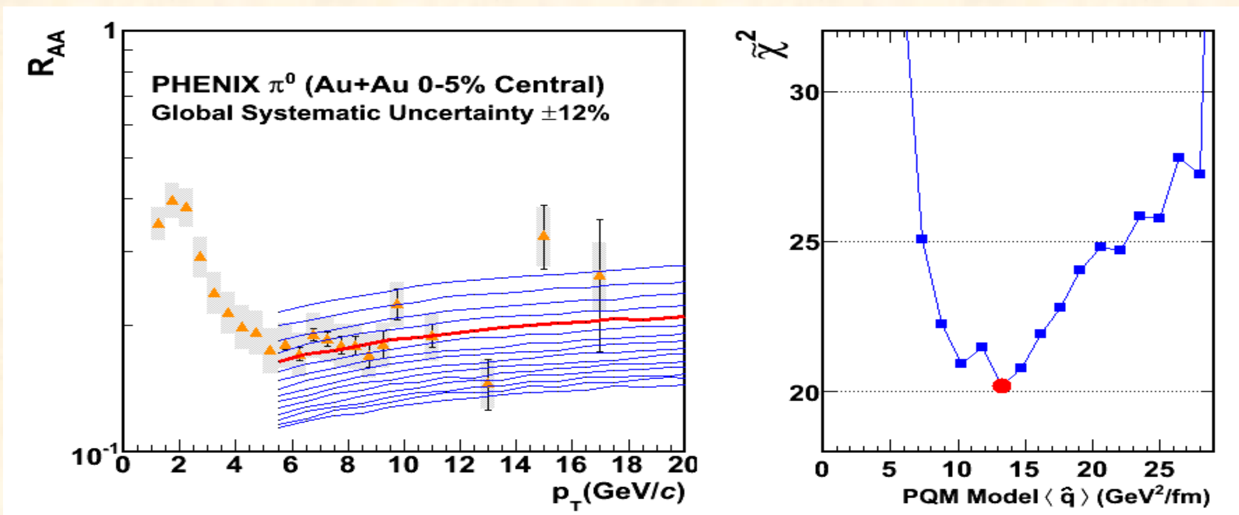
High p_T hadron production and its quantitative constraint to model parameters

Takao Sakaguchi
Brookhaven National Laboratory
For the PHENIX Collaboration

High p_T single hadrons at RHIC

- They are typically leading fragments of a jet. A strong probe to explore the interaction of hard scattered partons and medium
  - We have particular interest on high p_T π^0
- Quantitative comparison of R_{AA} between data and models has been carried out
  - Some models survived comparison
  - Constrained model parameters (<qhat>, dN^g/dy…)
- Are we happy enough? Maybe not!
  - We want much more precise data and higher p_T extension.
  - One of the problems on higher p_T π^0 is merging of γ's decaying from it

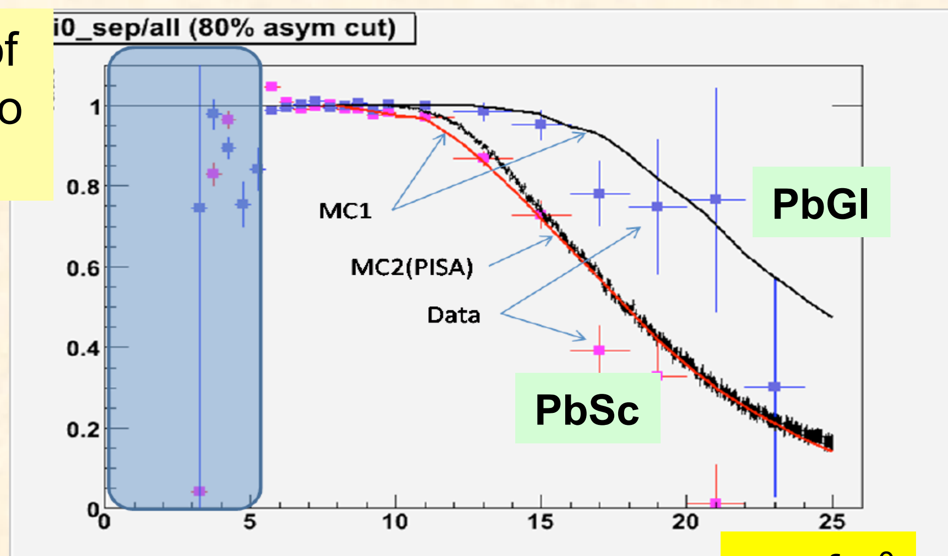


Model Constraint: Phys. Rev. C 77, 064907 (2008), arXiv:0910.1823 (nucl-ex)

What is the merging effect?

- Because of limited granularity of the detector, two γ's from π^0 can not be resolved at very high p_T (γ's merged. mass can not be reconstructed).
  - Opening angle: $\theta \sim mass/p_T$
- We corrected for the inefficiency due to merging, but also introduced a large systematic error.

Probability of detecting two γ's from π^0



p_T of π^0

How can we offer better data?

- How about η? The next lightest meson in the world
  - Pros: p_T reach will be extended by $M\eta/M\pi$=~4, because of a larger opening angle.
  - Cons: one has to assume that η is produced from light quark or ssbar is suppressed the same amount as light quarks.

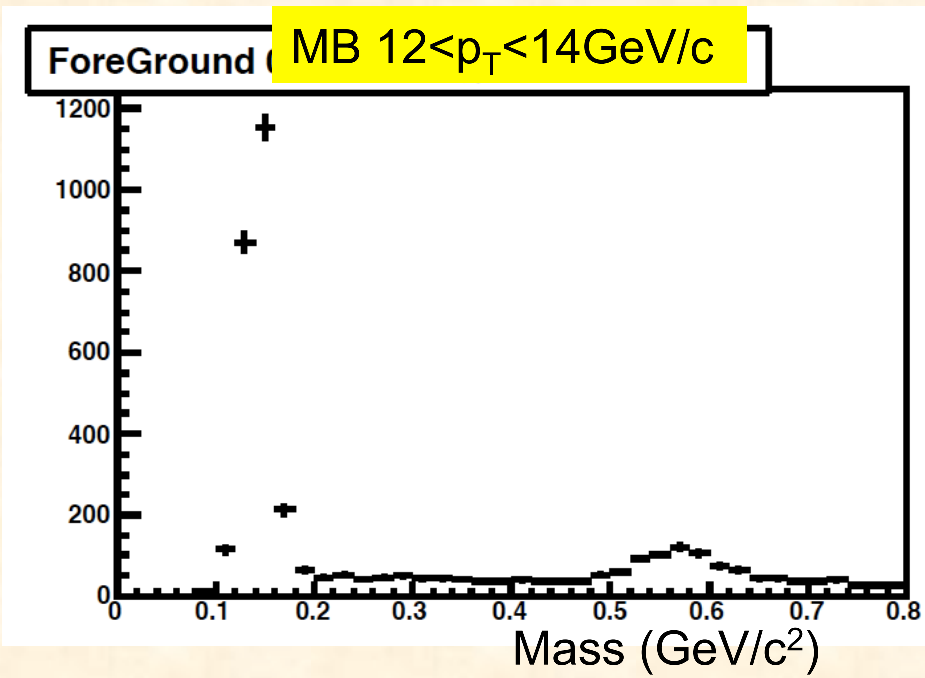
- Name: π^0
- Mass: 0.1350MeV/c^2
- $\Gamma(\pi \to\gamma\gamma)/ \Gamma(\pi \to X)$: 0.988
- Wave function:
  - (uubar-ddbar)/√2

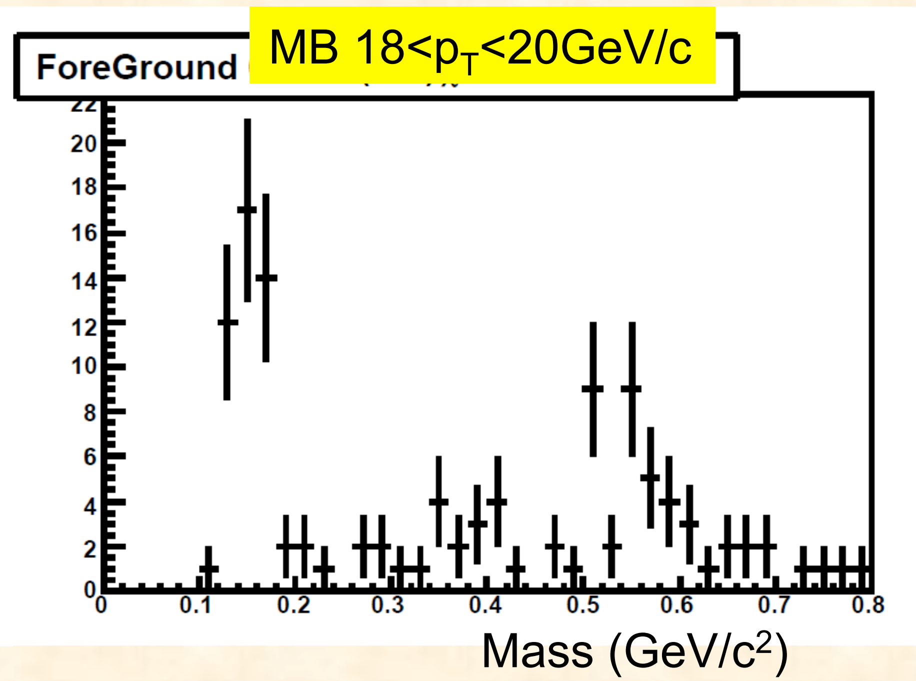
- Name: η
- Mass: 0.5479 MeV/c^2
- $\Gamma(\eta\to\gamma\gamma)/ \Gamma(\eta\to X)$: 0.393
- Wave function:
  - (uubar+ddbar)/2+ssbar/√2

η/π^0 = ~0.5 (measured at high pT)

$\gamma\gamma$ invariant mass distributions

- Successfully reconstructed π^0 and η in RHIC Year-7 Au+Au
  - 3.9B events (80% of recorded events), PbSc EMCal only. ¾ of whole EMCal. (We have two calorimeters: PbSc and PbGl)
- Even by eye-ball, we can see that reconstructed η to π^0 ratio increases as a function of p_T
- Number of reconstructed π^0 is decreased





Systematic errors

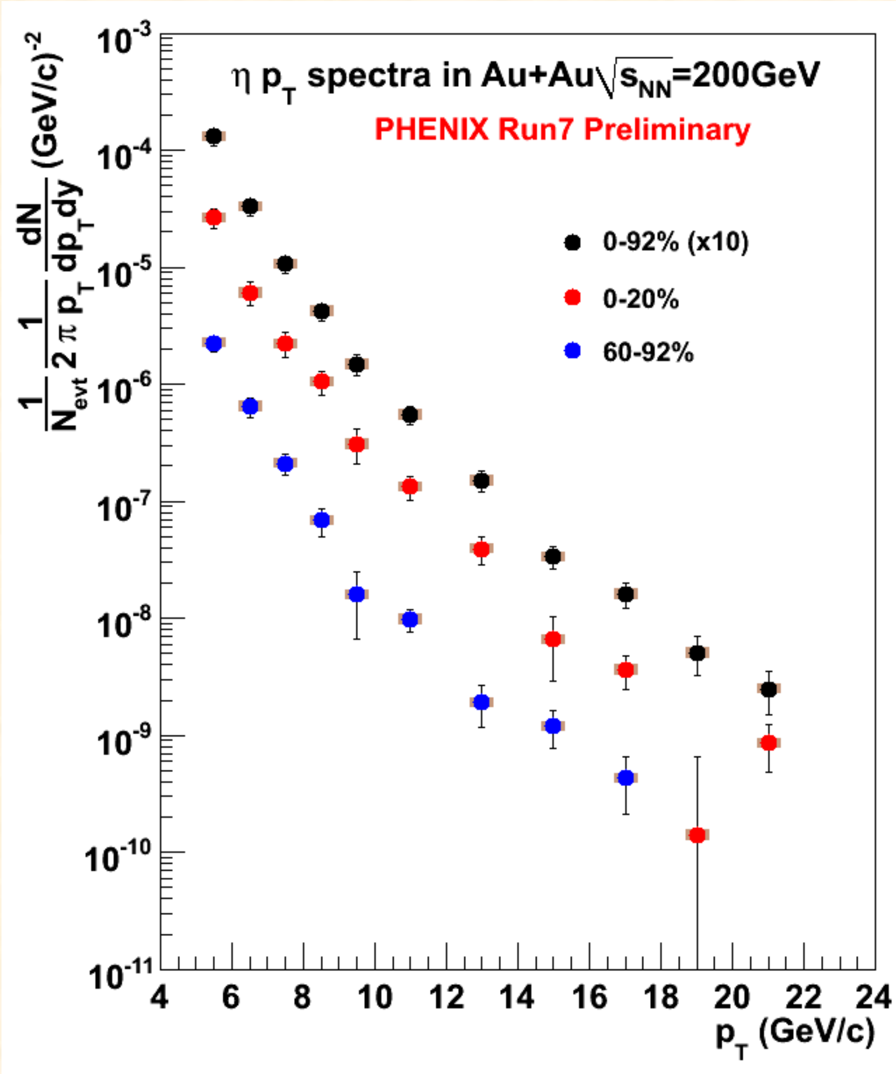
- Conservative estimate this time
  - Type A: point-by-point fluctuating errors (similar to statistical error)
    - Will be summed with statistical error
  - Type B: p_T-correlated errors
  - Type C: overall normalization errors
- No error from merging effect (~ 30% for p_T>16GeV for π^0 case)
- Errors will become smaller in the final publication

Table 2: Systematic Error table for η (p_T >5 GeV/c)

source	Type	Values
Peak extraction	A	11 %
Acc+Eff fit error	A	10 %
Acceptance error	B	1.5 %
energy scale (EMCal position & E. cluster)	B	8 %
PID	B	3 %
Conversion Correction (HBD loss)	C	1.3 %
Conversion Correction (other loss)	C	5 %
Sum Of A	A	14.9 %
Sum Of B and C	B+C	10.1 %

Invariant p_T spectra

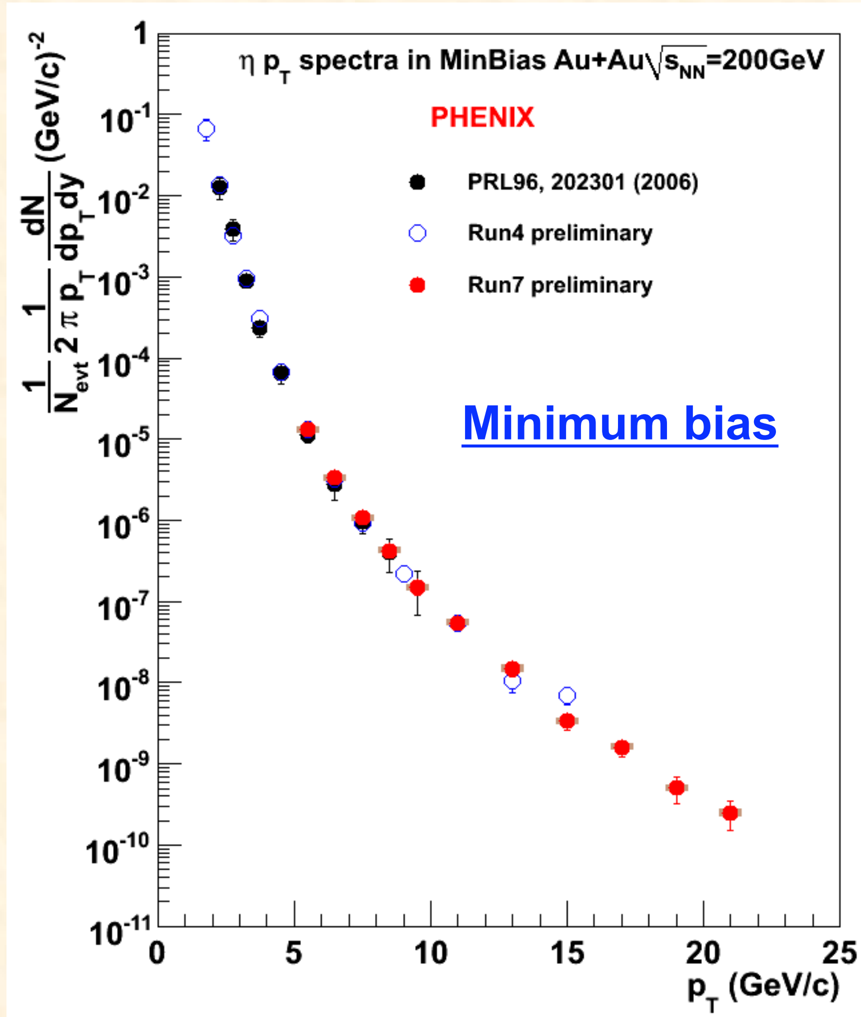
- Used 3.9B MB events from RHIC Year-7 Au+Au Run
  - 80% of recorded events
- Used ¾ of whole electro-magnetic calorimeters (PbSc)
- 0-20, 60-92% centrality and MB (0-92%)
- Reached up to p_T=21GeV/c
- Error bars: Statistical + point-by-point fluctuating (type A) systematic errors
- Error box: Other systematic errors (Type B + C)



![APS JPS logo]

Plotting with previous results

- Good agreement between published Run2 results, Run4 preliminary and this work.
- Nice power-law shape from ~5GeV/c
- Error bars:
  - Statistical + point-by-point fluctuating systematic errors for Run7 preliminary
  - Combined statistical and systematic errors for Run2 published and Run4 preliminary
- Error box: other systematic errors for Run7 preliminary



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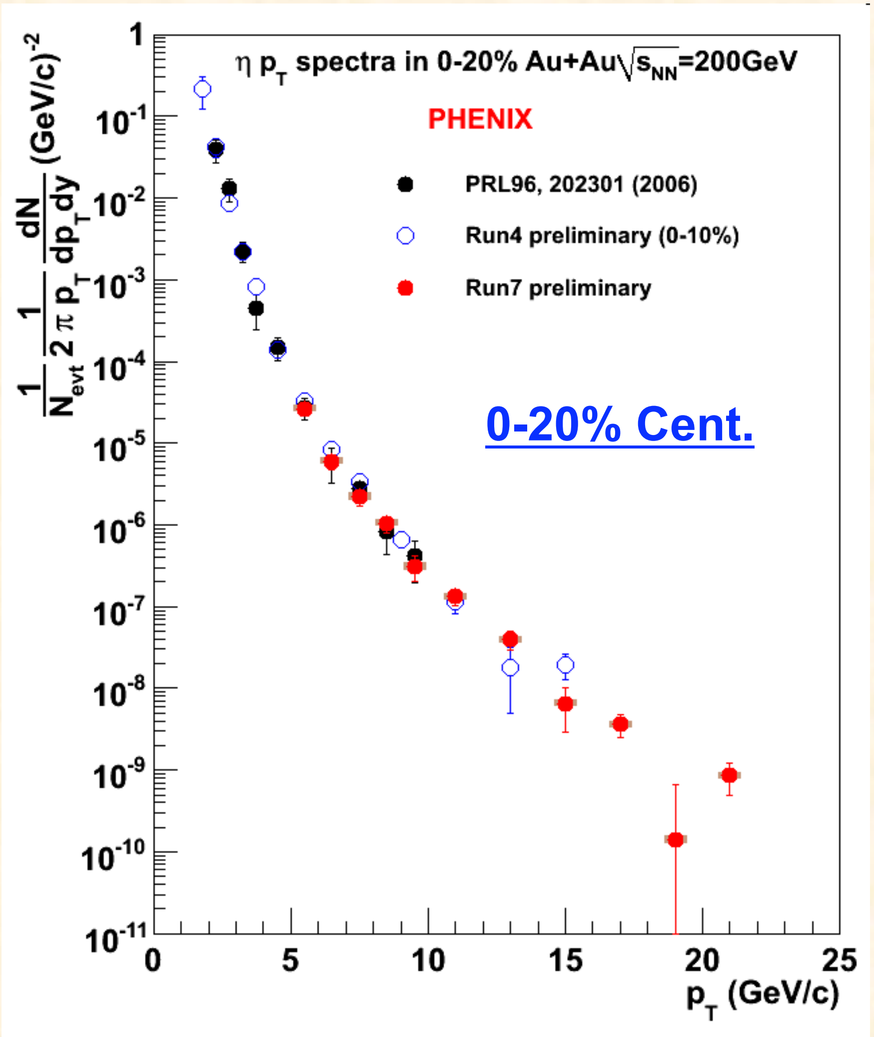

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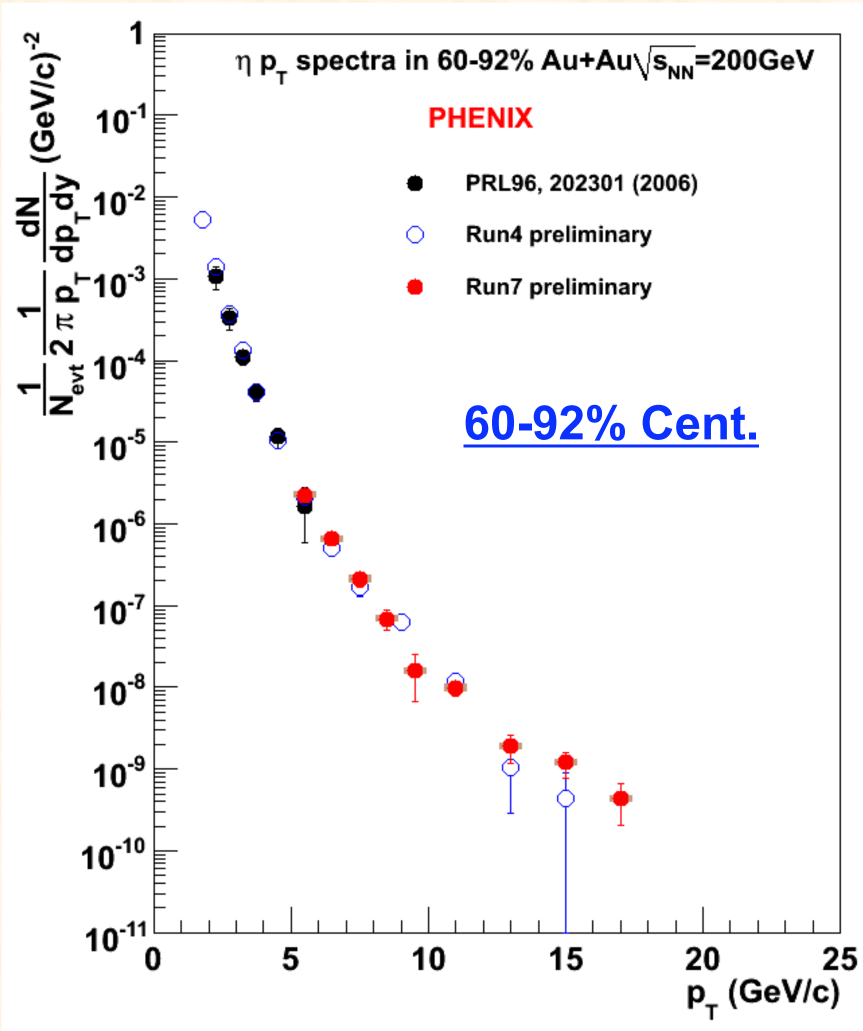
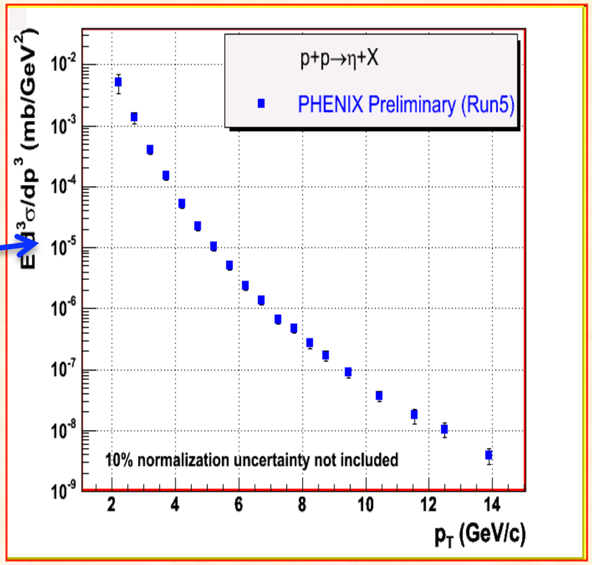
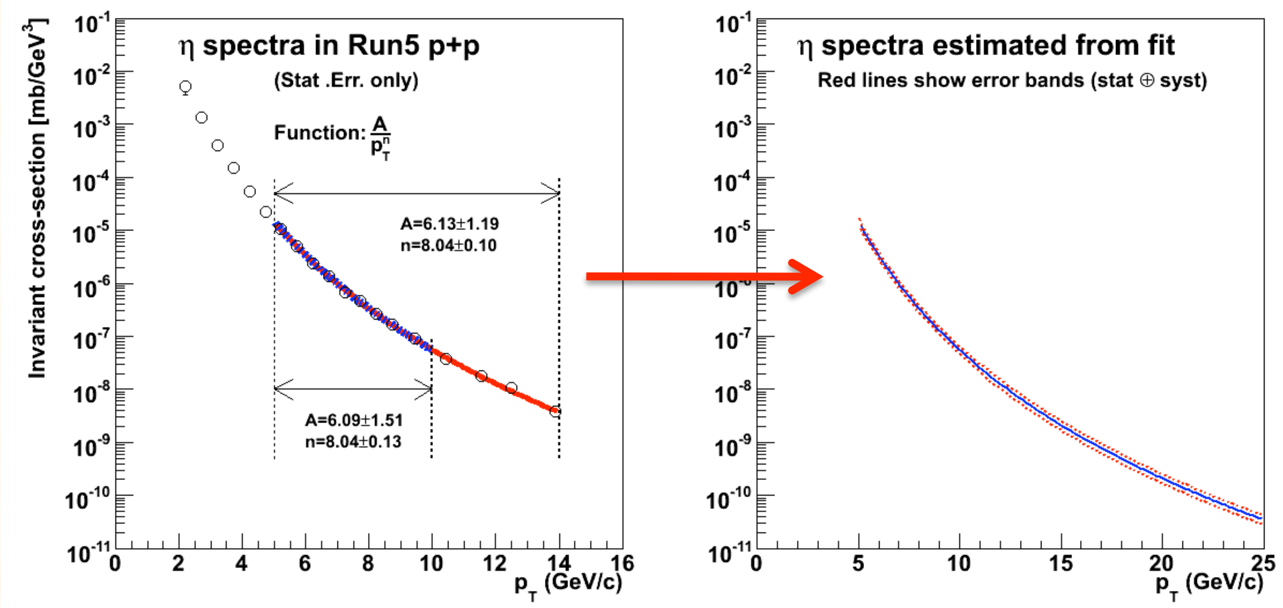


p+p baseline

- Need p+p baseline to calculate a nuclear modification factor (R_{AA})
- However, currently, data are not available above p_T=14GeV/c (from RHIC Year-5 Run)
- We fitted the spectra and extended to higher p_T
  - Tested the reliability of the extension
  - Statistical and systematic error of p+p data is propagated into the systematic error of R_{AA}



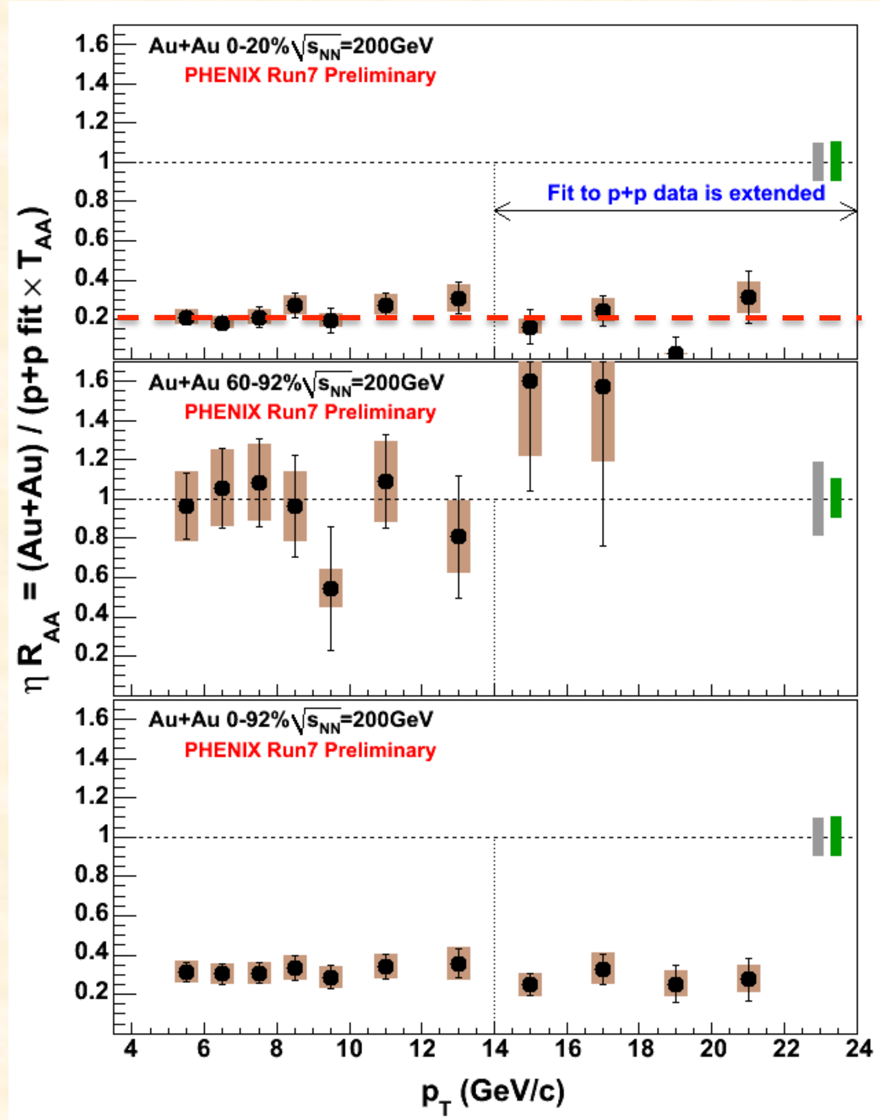


Systematic errors

- Peak extraction error: 8% (3-11GeV/c), and 15% (>11 GeV/c)
- Energy scale error: 13%
- Global scale uncertainty: 10%

Nuclear modification factor (R_{AA}) and model constraint

- R_{AA} extends to 21GeV/c
- Values consistent with what we saw in π^0 in the quoted uncertainty
- Flat over the p_T region observed
  - "Eye-ball" model fitting tells that the flat line can nicely describe the data
  - *Suggesting constant fractional energy loss: $\Delta E = \alpha E$*

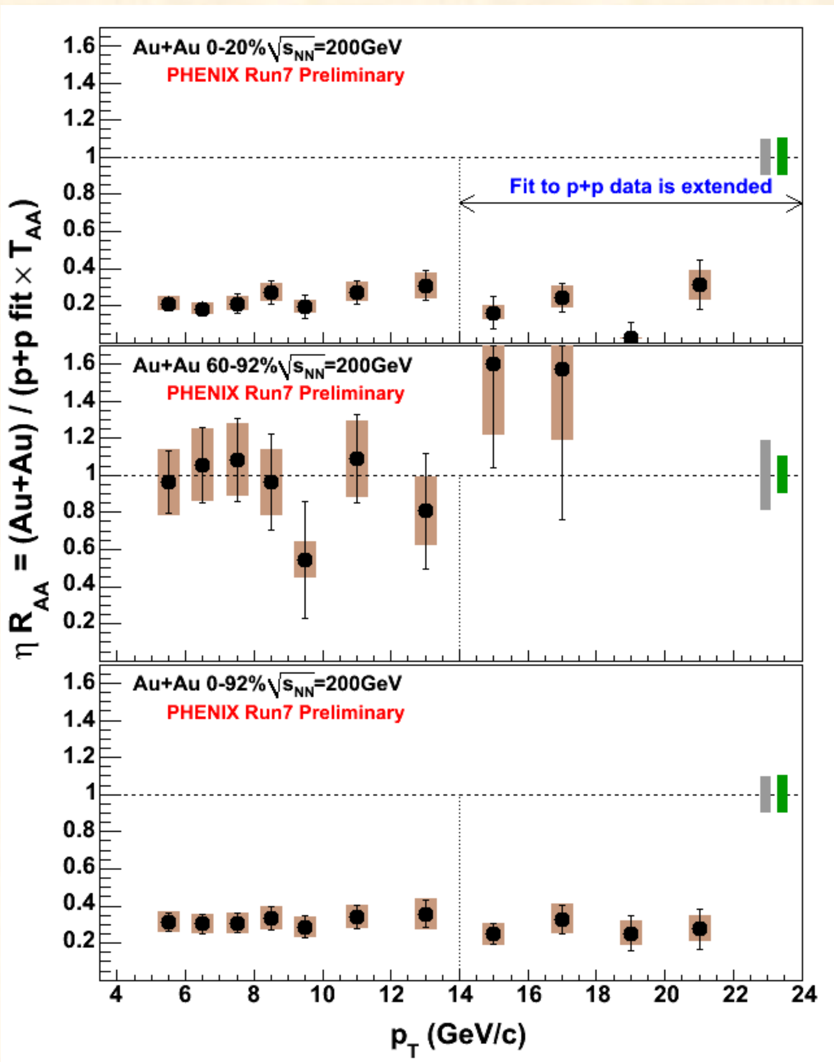


Summary and Question

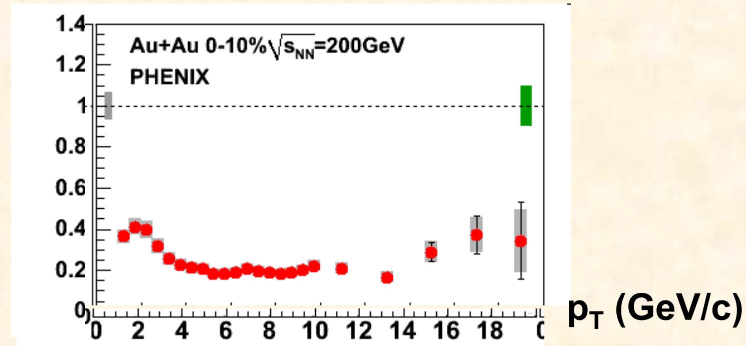
- η is measured up to 21GeV/c using RHIC Year-7 Au+Au data
  - Absence of merging effect in η lead us to smaller systematic uncertainty and higher p_T reach
- p+p baseline established based on existing data (Year-5 Run)
- R_{AA} is flat in the p_T region observed.
  - Result is consistent with what we saw in π^0
  - Suggesting constant fractional energy loss scenario ($\Delta E = \alpha E$)
- *Question*: we would like to know if the η measurement helps constraining energy loss model parameters
  - η includes strangeness component. Need help from theorists!

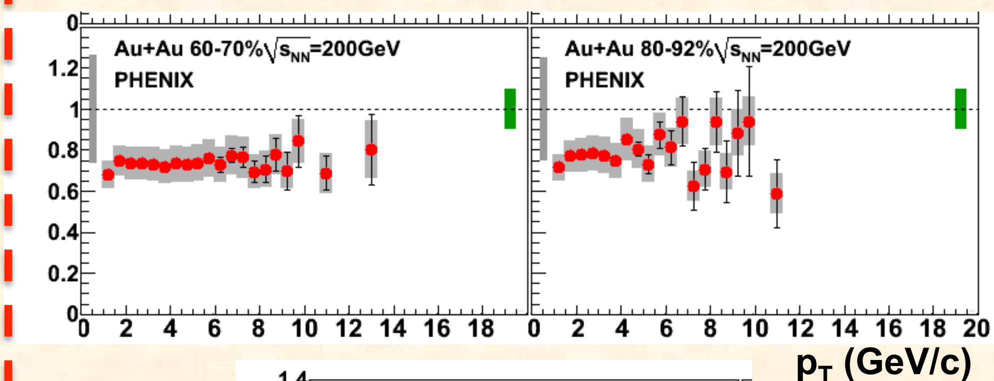
Comparison..

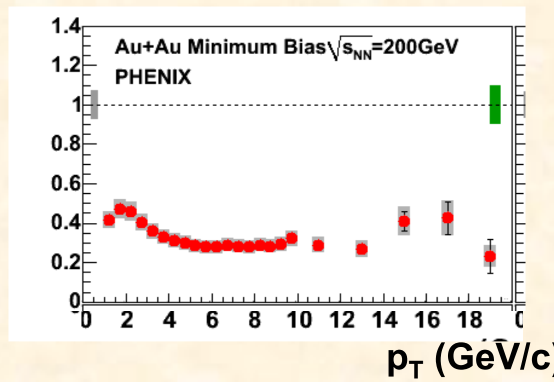
η from Run7 preliminary



π⁰ from PRL101, 232301 (2008)







Backup

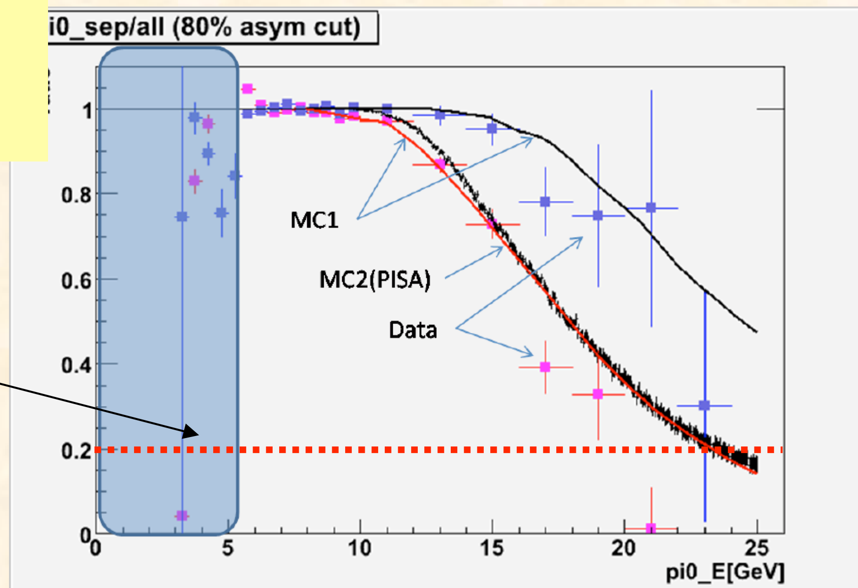
Experimentally, nice!

- "visible" η yield exceeds "visible" π^0 yield above pT~23GeV/c.
- Systematic error on η yield should much be smaller for pT>12GeV/c, because we don't need to take care of merging

η/π^0 = ~0.5 (measured at high pT)

Probability of detecting two γ's from π^0

0.393*0.5=0.1965



Review ~single hadrons~

- Phys. Rev. Lett. 101, 232301 (2008)