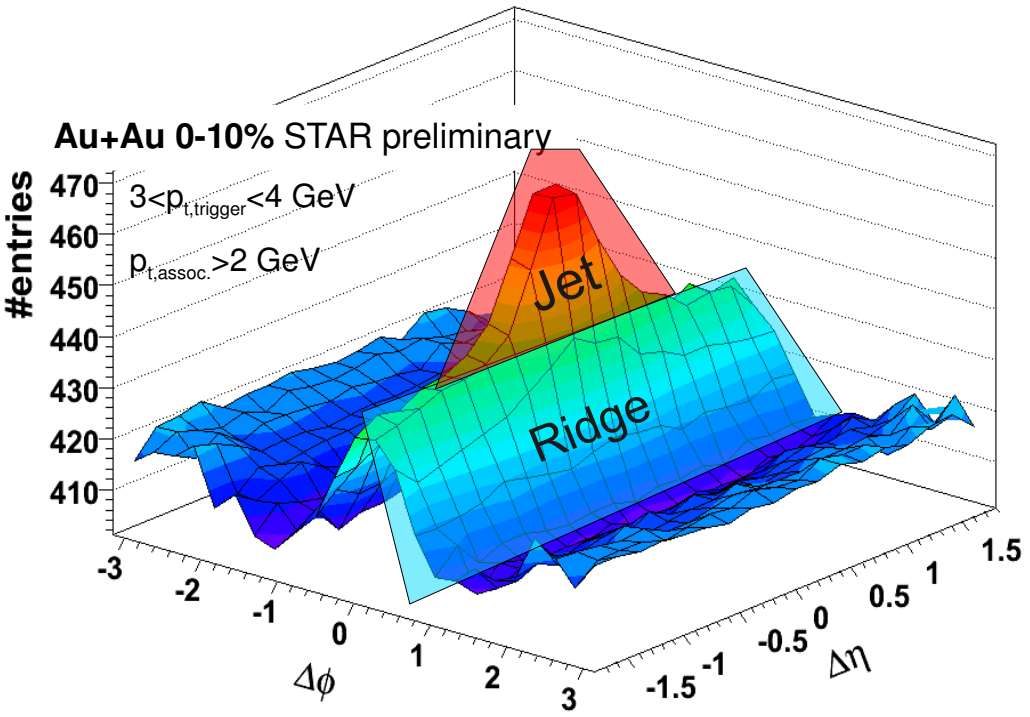
System size and energy dependence of high-p_T triggered correlations in STAR

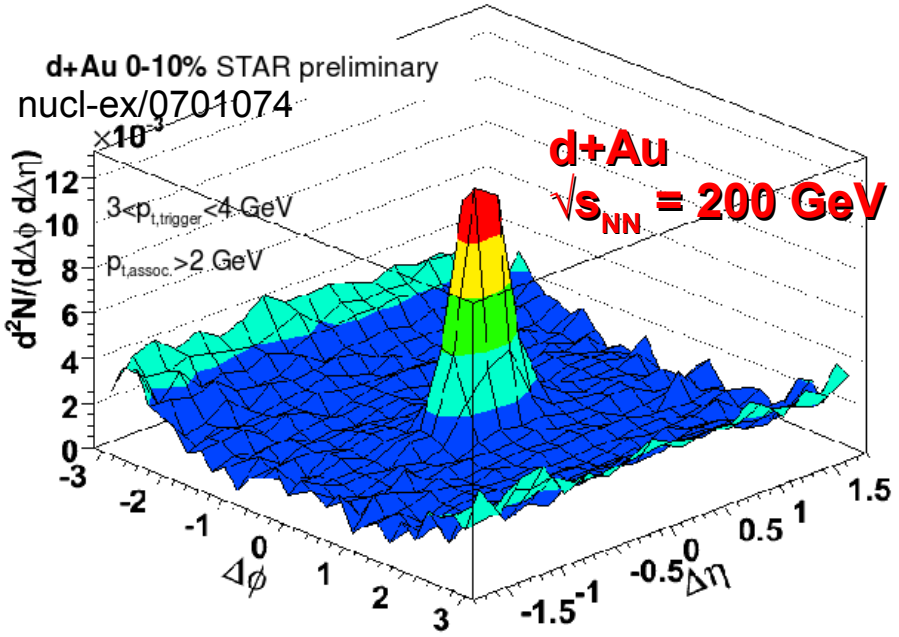
Christine Nattrass (Yale) for the STAR Collaboration

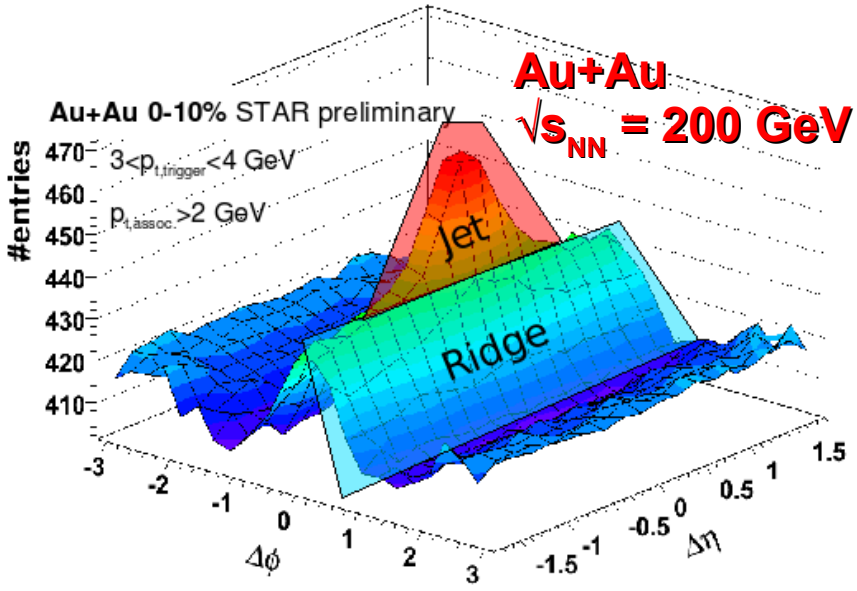
Outline

- Introduction
- The *Jet*
- The *Ridge*
- Theory
- Conclusions



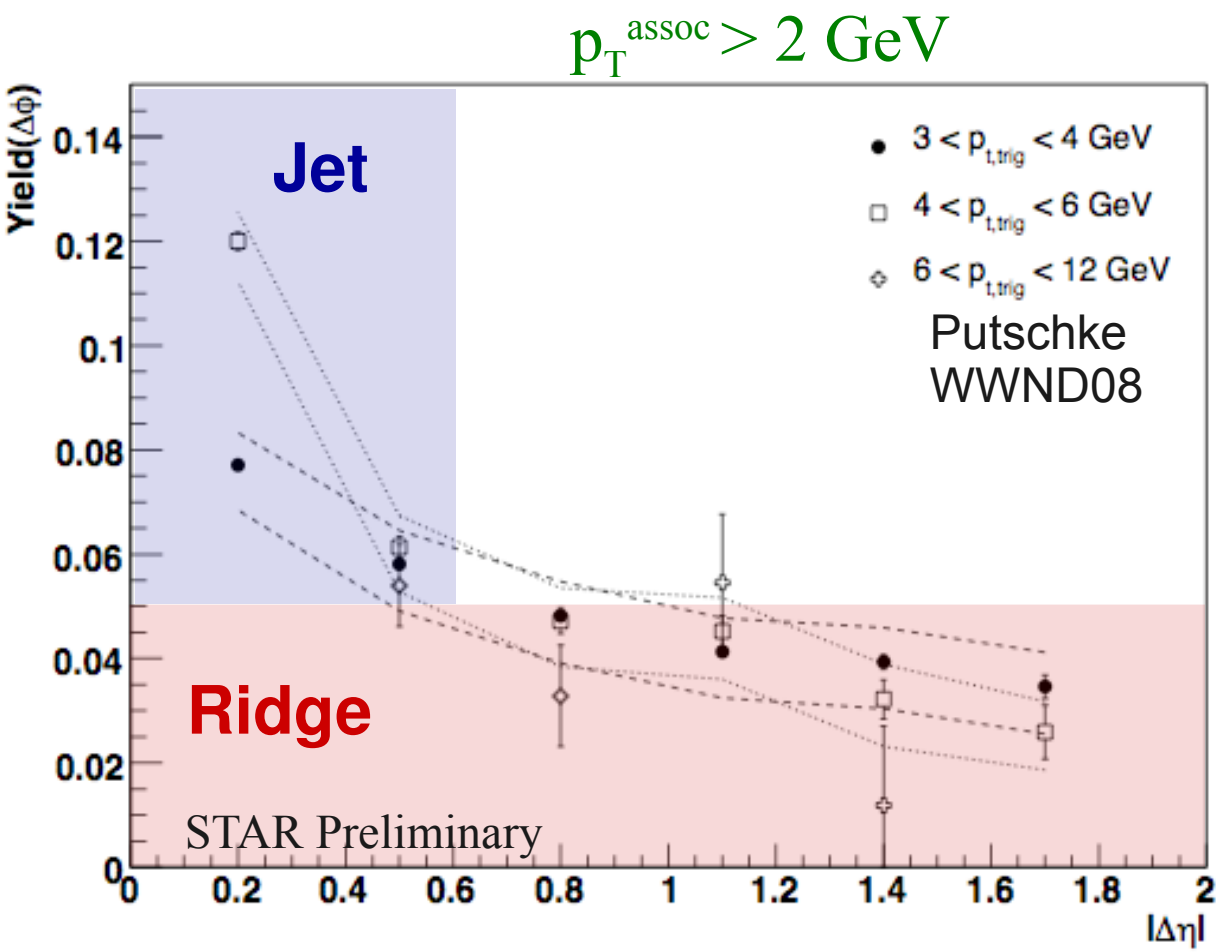
Motivation – *Jet* and *Ridge*





- In d+Au narrow peak narrow in $\Delta\Phi$, $\Delta\eta$ even for small $p_T^{trigger}$
- Long-range pseudorapidity ($\Delta\eta$) correlations observed by STAR in Au+Au at intermediate p_T
- Significant contribution to the near-side yield in central Au+Au at intermediate p_T^{assoc},$p_T^{trigger}$
- Yield/trigger – number of particles in p_T^{assoc} range associated with trigger particle with $p_T^{trigger}$ range

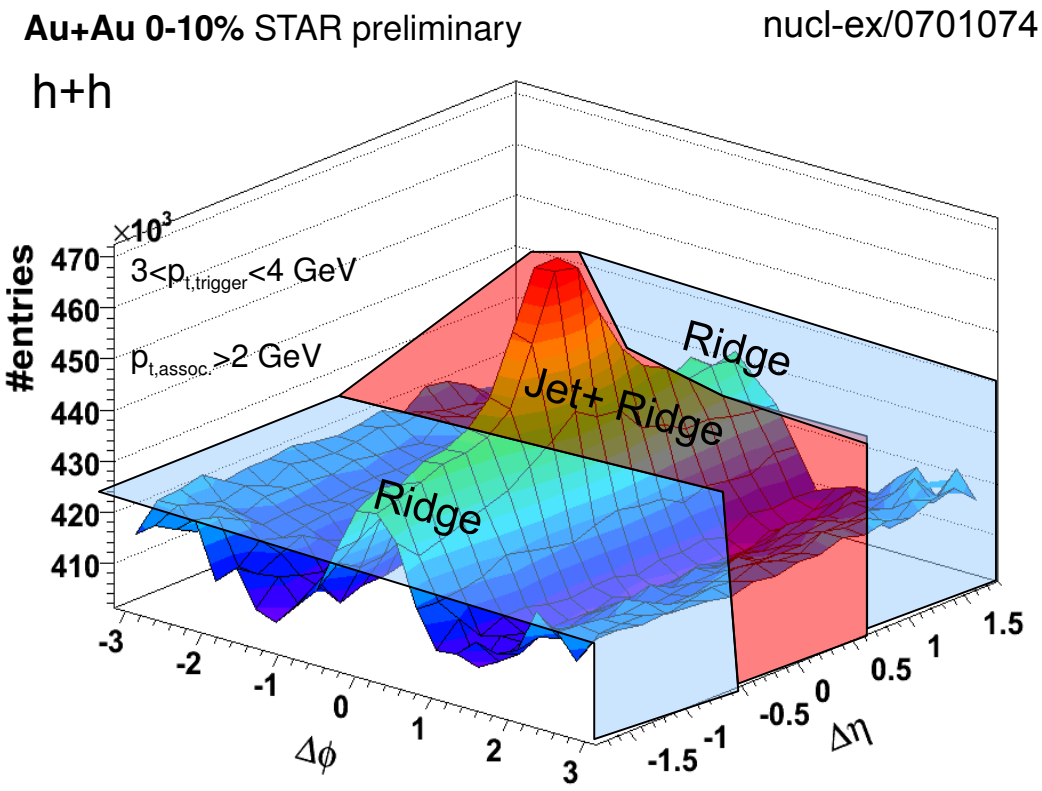
Extent of *Ridge* in $\Delta\eta$



- *Ridge* yield approximately independent of $\Delta\eta$ in STAR acceptance
  - PHOBOS (arXiv:0804.3038v3) showed independence on $\Delta\eta$ out to $\Delta\eta = 4$
- *Jet* increases with $p_T^{trigger}$, *Ridge* roughly constant

Method: Yield extraction

- *Ridge* previously observed to be independent in Δη in Au+Au
- To determine relative contributions, find yields for near-side (-1<ΔΦ<1), take ΔΦ projections in



Method: Yield extraction

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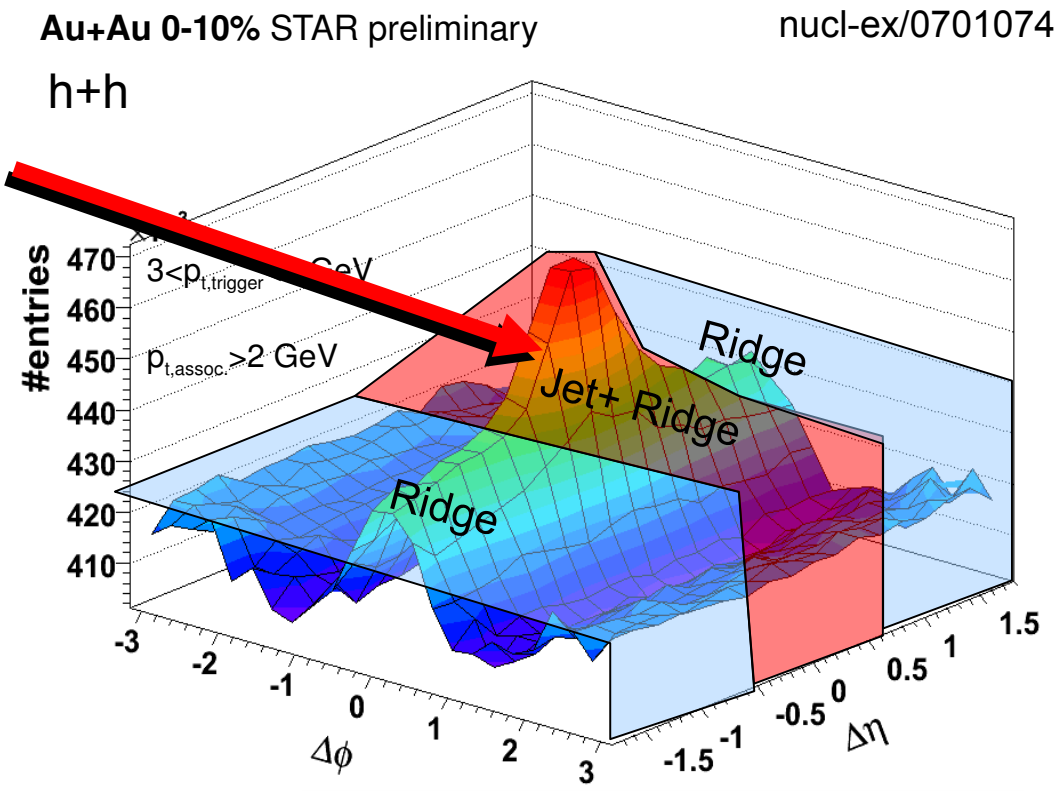
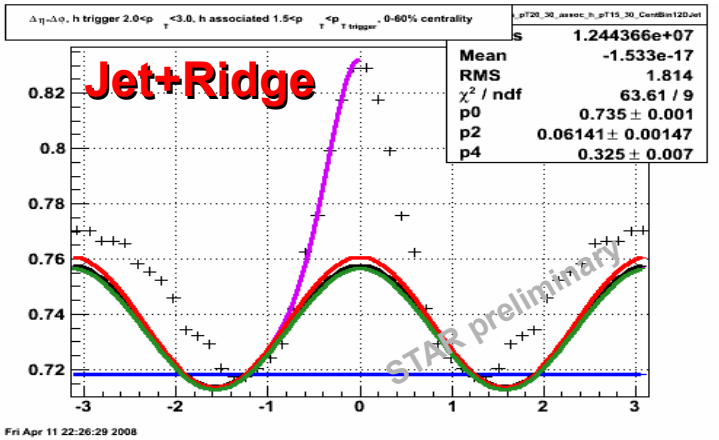
  - -0.75<Δη<0.75 ***Jet + Ridge***





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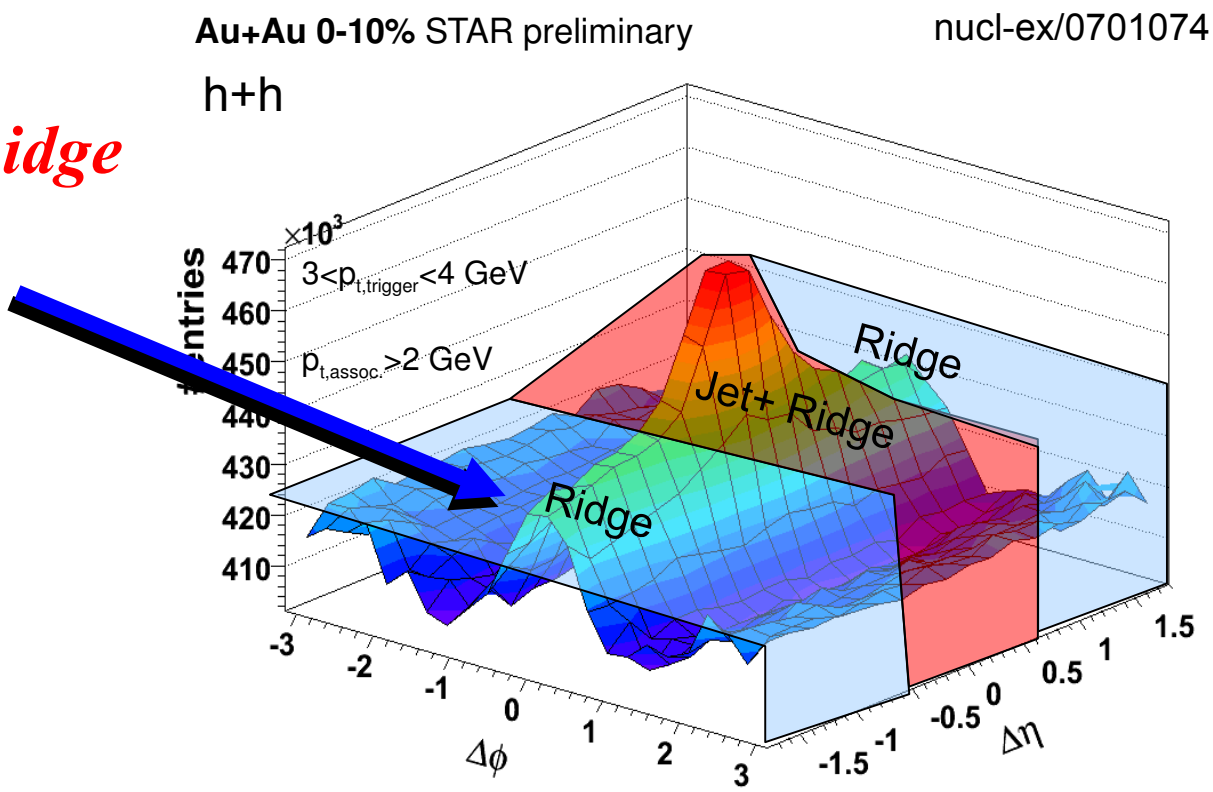

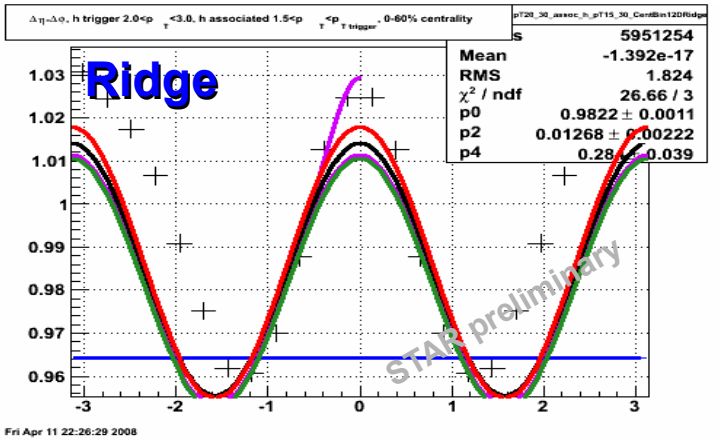

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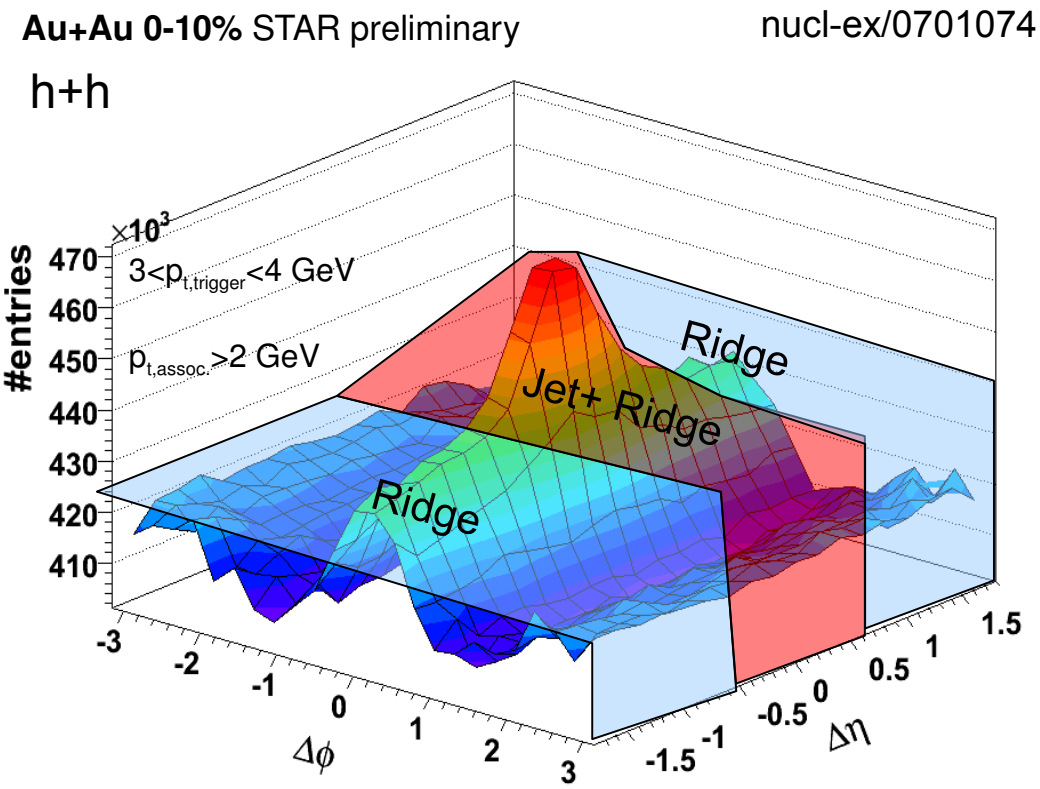

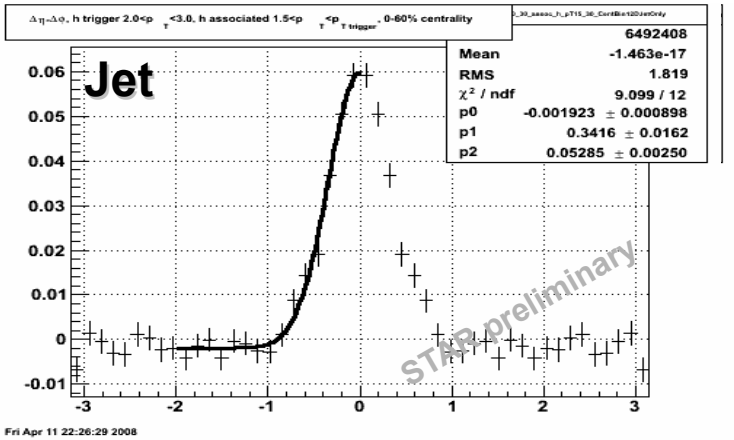

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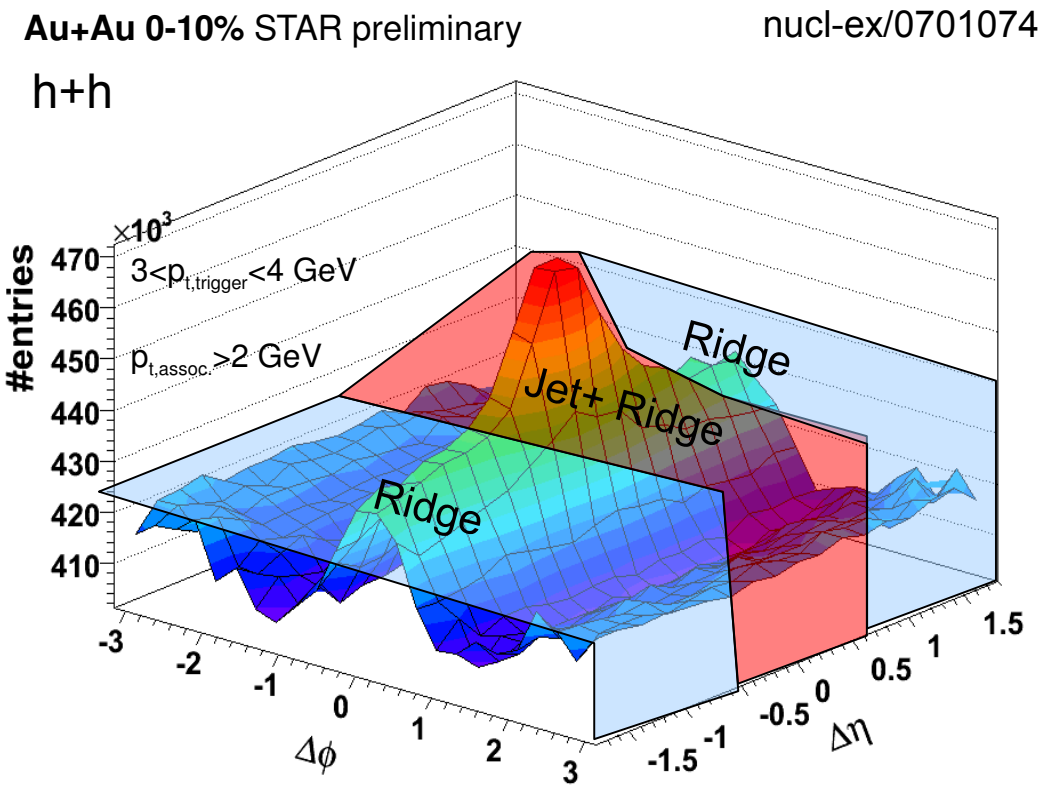

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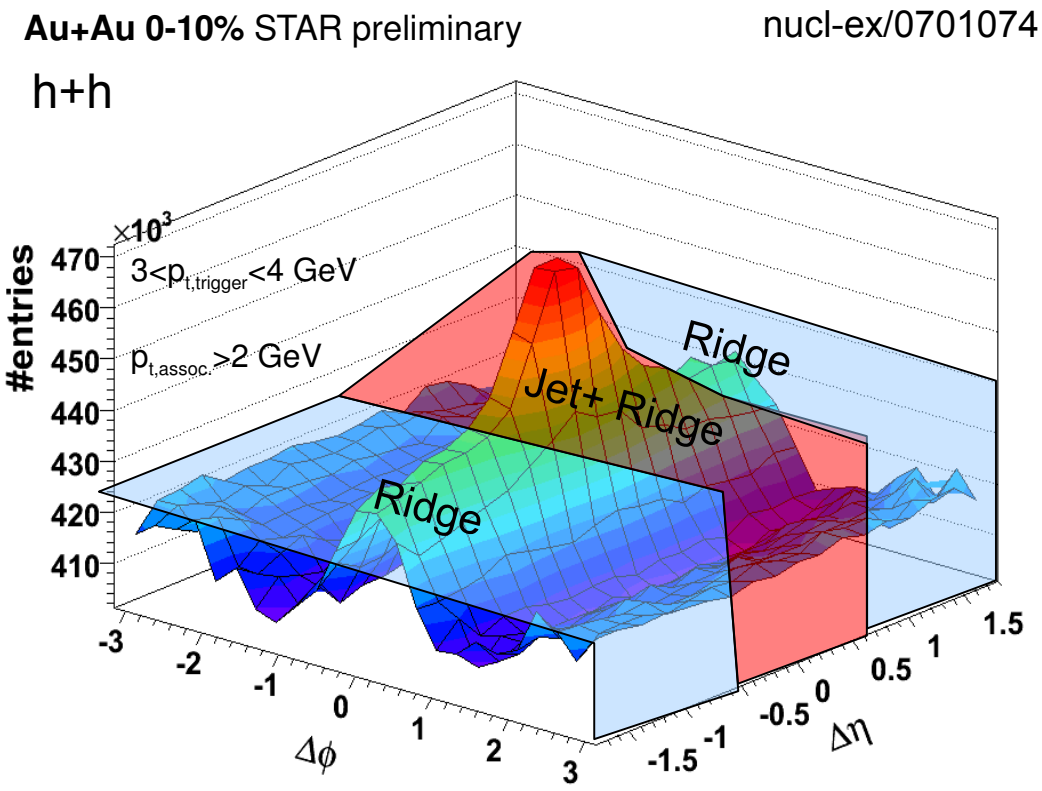
- Flow contributions to *Jet* cancel
  - v_2 independent of η for |η|<1
    - Phys. Rev. C72, 051901(R) (2005), Phys. Rev. Lett. 94, 122303 (2005)



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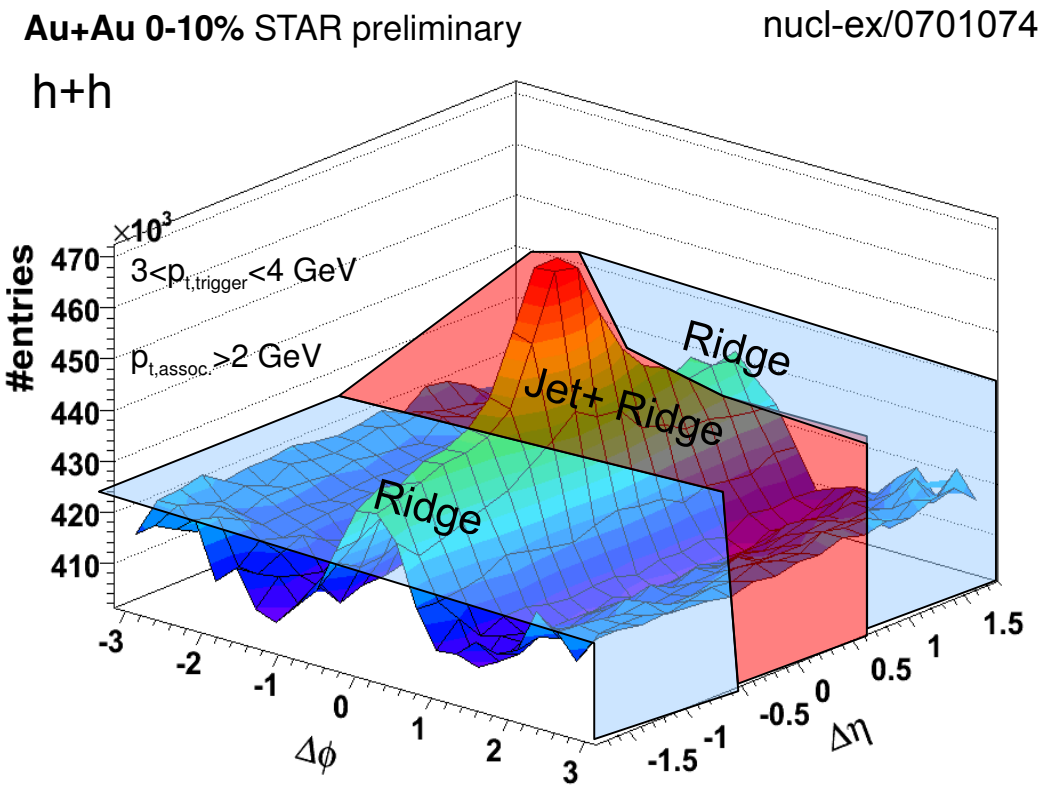
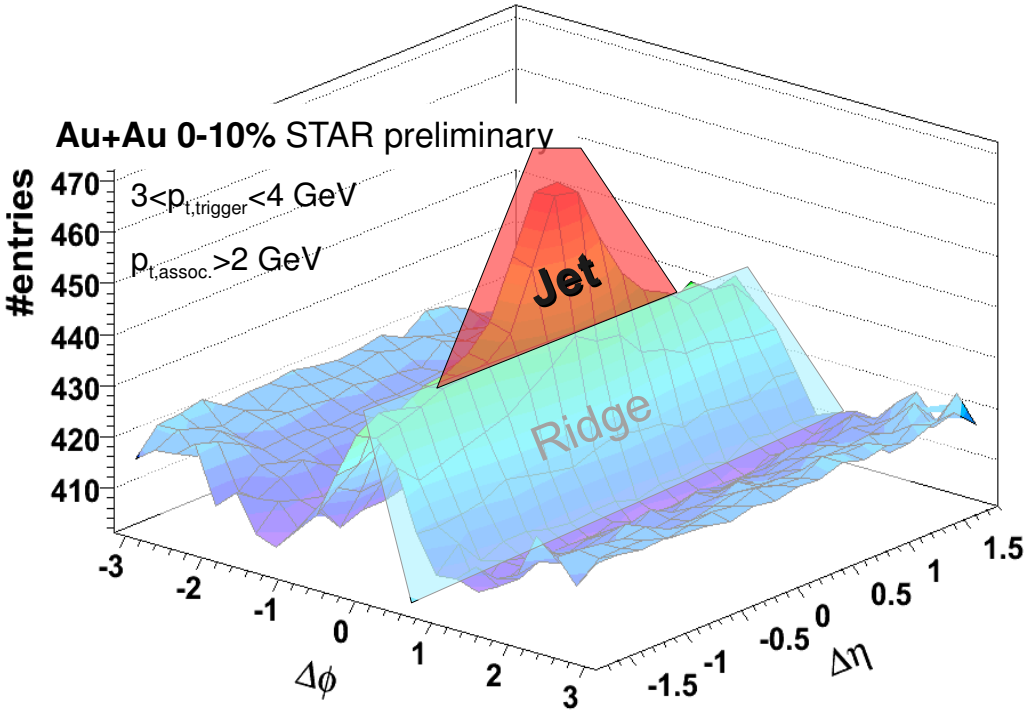
- $3.0<p_T^{trigger}<6.0$ GeV/c; $p_T^{assoc}>1.5$ GeV/c unless otherwise stated



The *Jet*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3<p_t,trigger<4 GeV
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#entries
470
460
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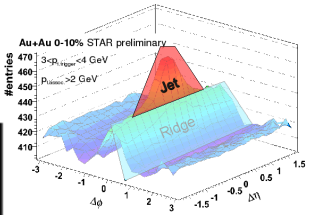
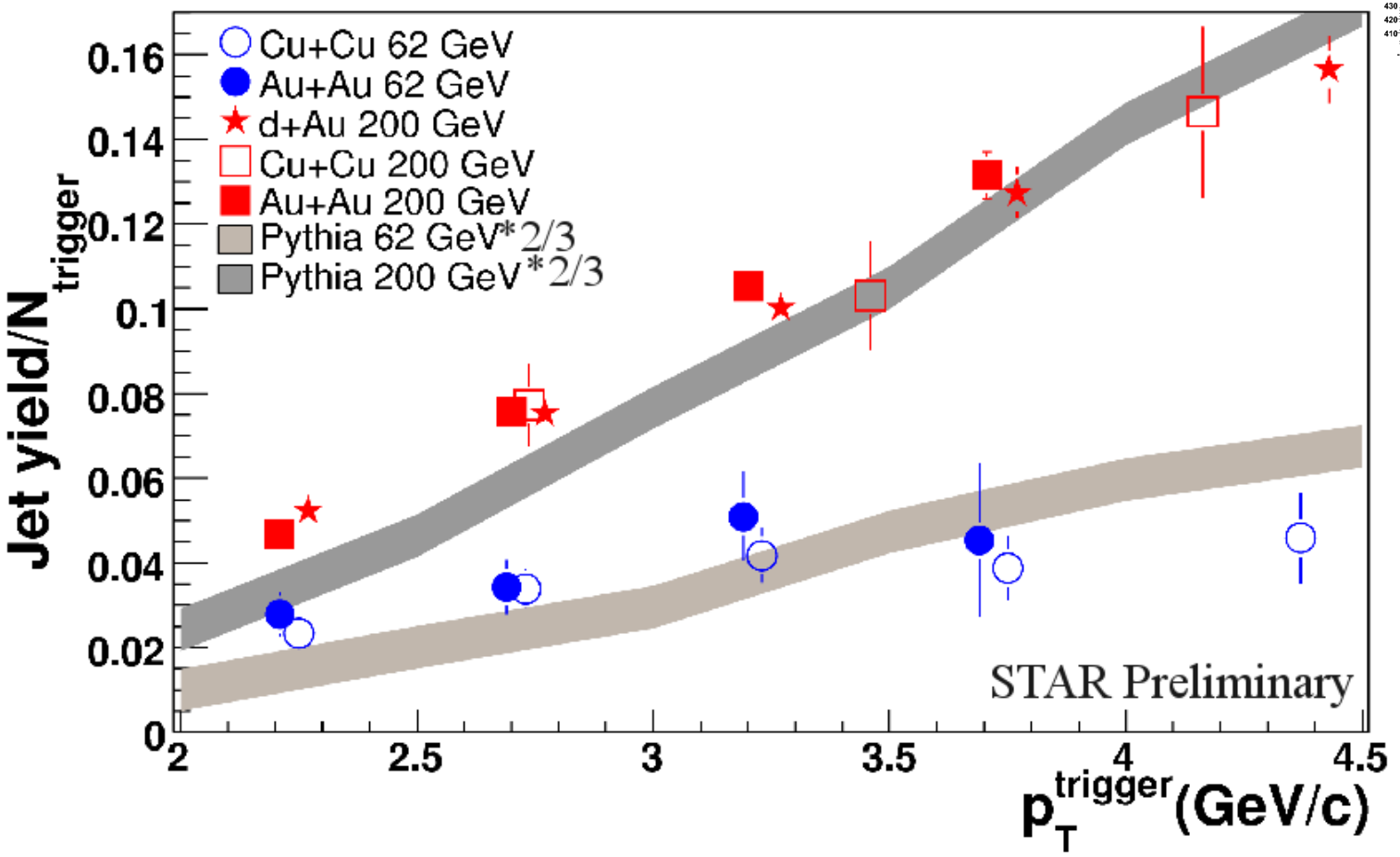
410
Jet
Ridge
-3
-2
-1
0
1
2
3
Δφ
1.5
1
0.5
0
-0.5
-1
-1.5
Δη

$p_T^{trigger}$ dependence

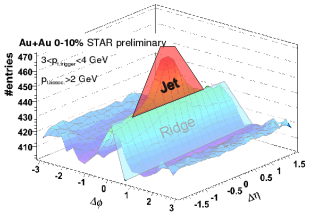


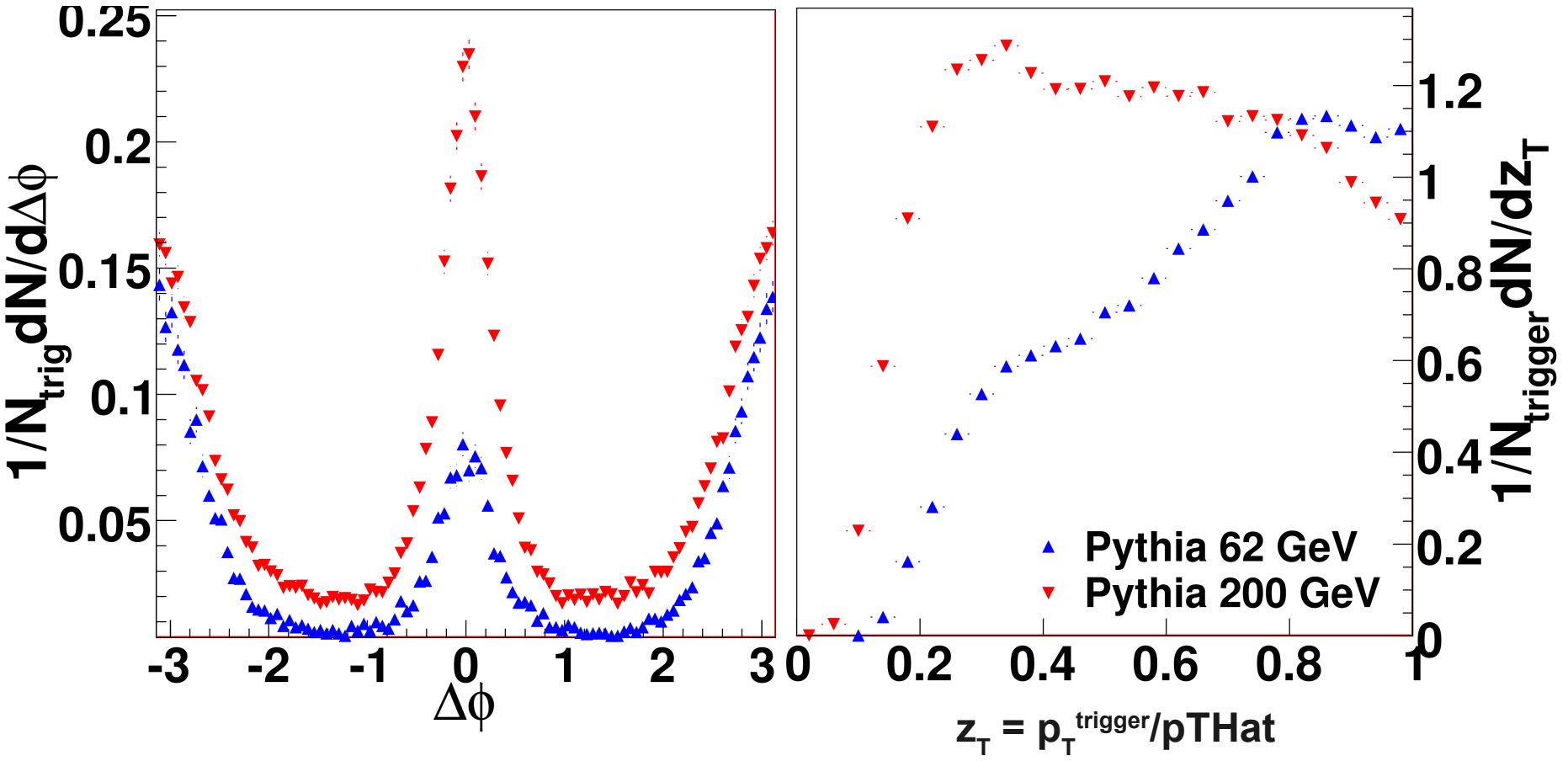


- Pythia 8.1 describes trends in data up to a scaling factor
  - Gets energy dependence right → this is a pQCD effect
  - Stronger deviations at low $p_T^{trigger}$, as expected

J. Bielcikova (STAR), arXiv:0806.2261/nucl-ex
C. Nattrass (STAR), arXiv:0804.4683/nucl-ex

Pythia comparisons





- What can Pythia tell us?
  - Higher z_T (lower jet energy) in 62 GeV for same $p_T^{trigger}$

pTHatMin = the parameter in Pythia for the minimum transverse momentum in the hard subprocess

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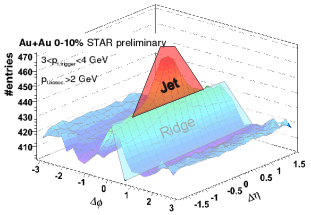

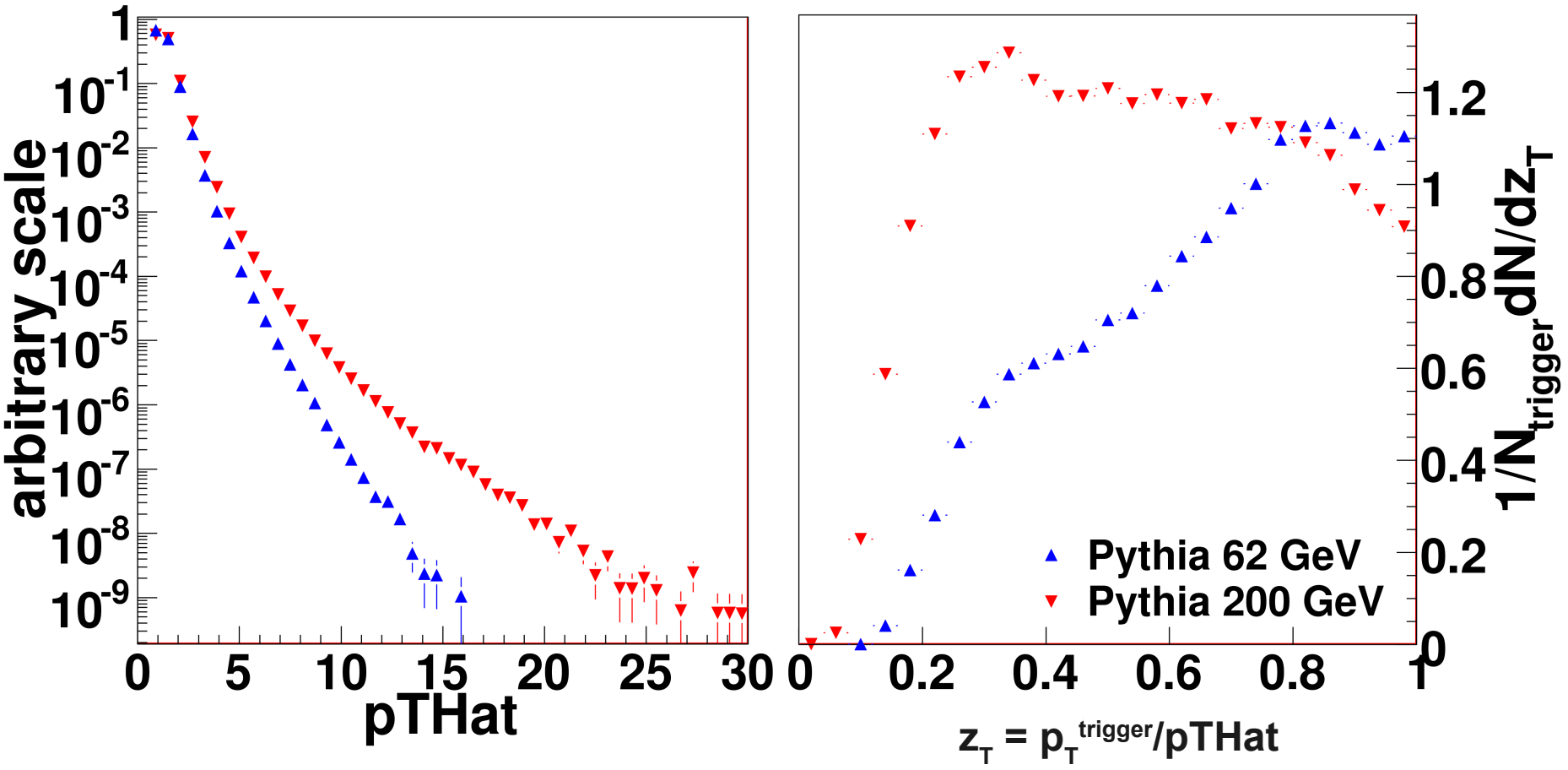

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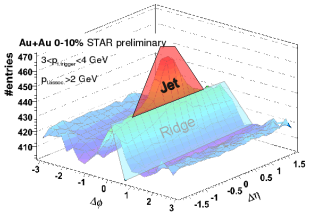
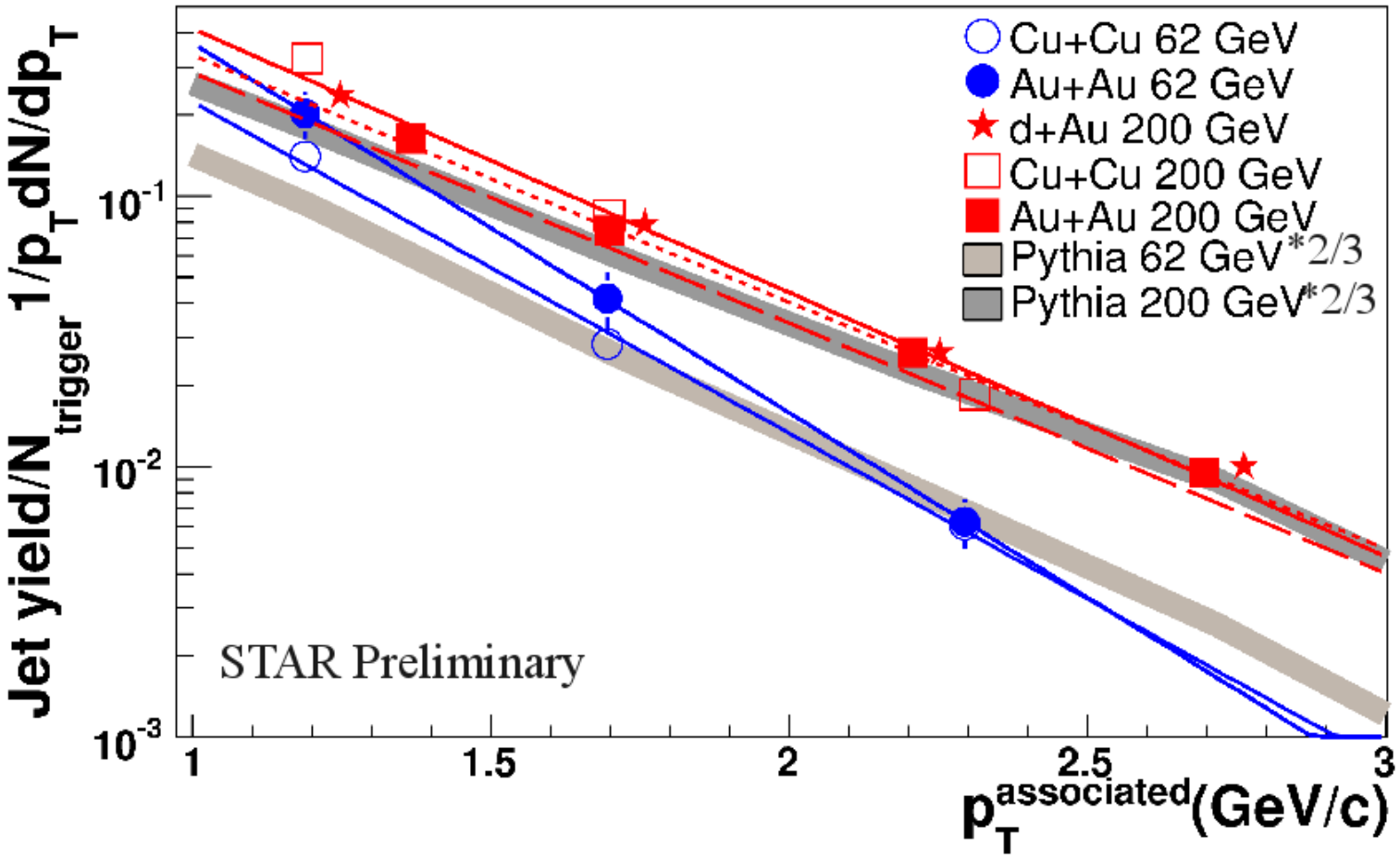
$p_T^{associated}$ dependence





- No system dependence
- Pythia 8.1 slightly harder than data
- Diverges slightly from Pythia 8.1 at lower $p_T^{associated}$

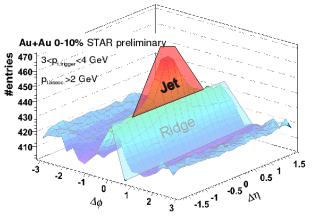
Inverse slope parameter

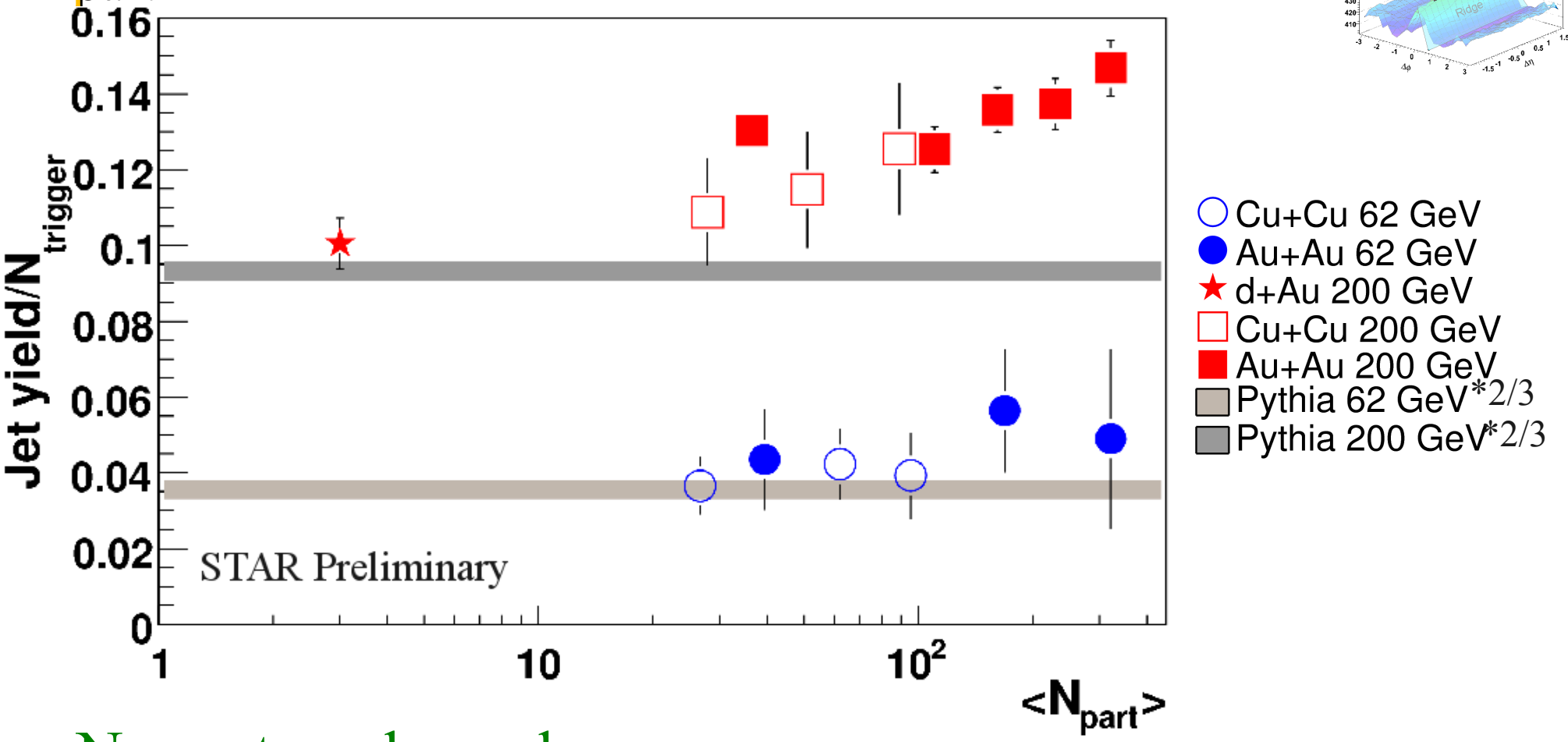
	$\sqrt{s_{NN}}$ = 62 GeV	$\sqrt{s_{NN}}$ = 200 GeV
Cu+Cu	317 ± 26	445 ± 20
Au+Au	355 ± 21	478 ± 8
d+Au		469 ± 8
Pythia	417 ± 9	491 ± 3

Statistical errors only

J. Bielcikova (STAR), arXiv:0806.2261/nucl-ex
C. Nattrass (STAR), arXiv:0804.4683/nucl-ex

N_{part} dependence

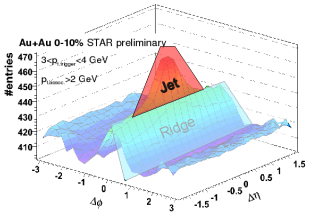


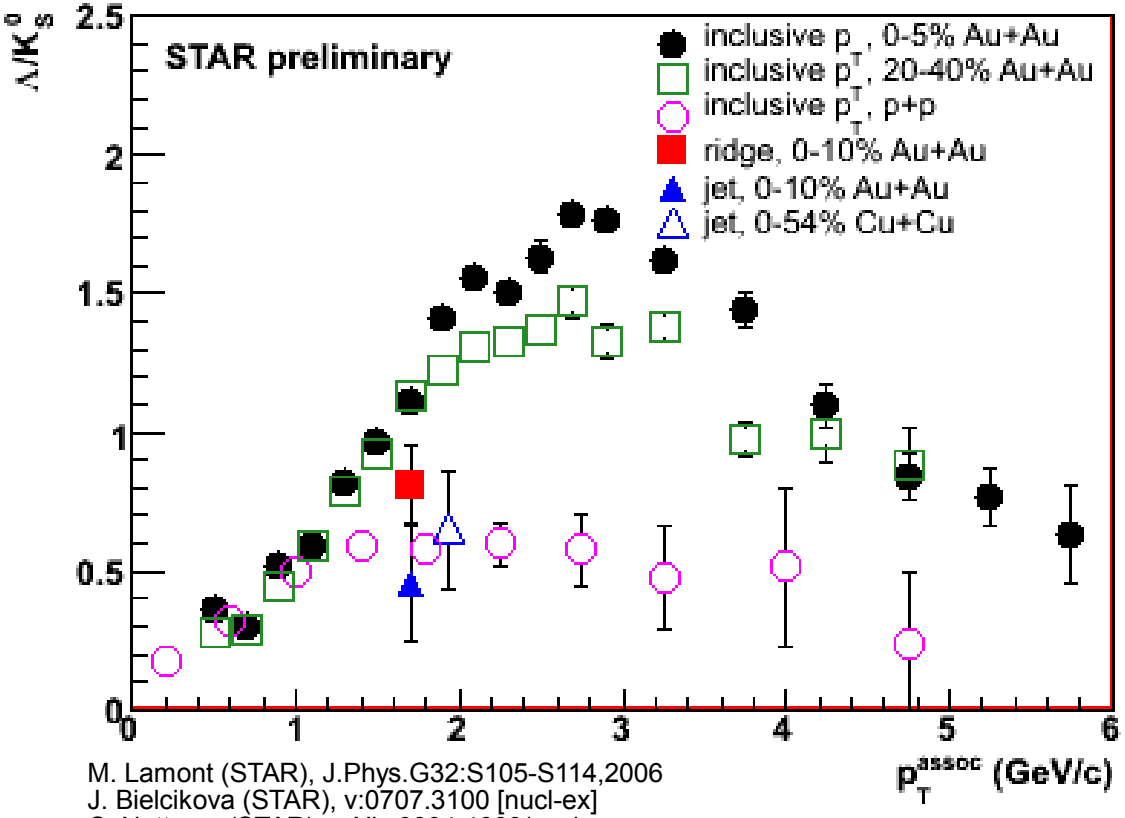


- No system dependence
- Some deviations from Pythia 8.1 with increase in N_{part}
  - Incomplete *Ridge* subtraction?
  - Jet modification at low p_T?

J. Bielcikova (STAR), arXiv:0806.2261/nucl-ex
C. Nattrass (STAR), arXiv:0804.4683/nucl-ex

Jet composition





M. Lamont (STAR), J.Phys.G32:S105-S114,2006
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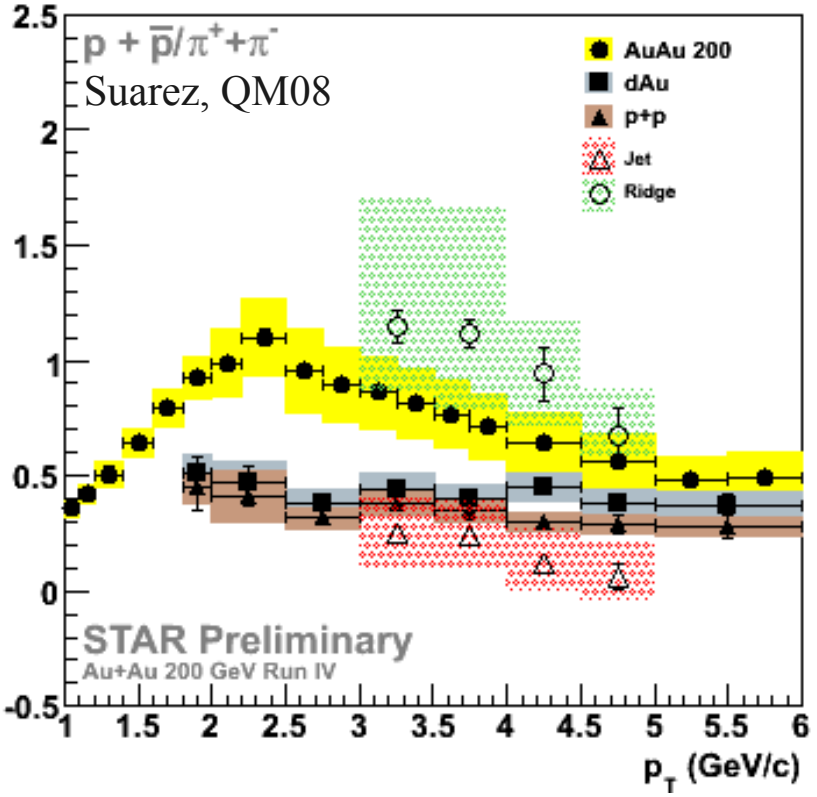
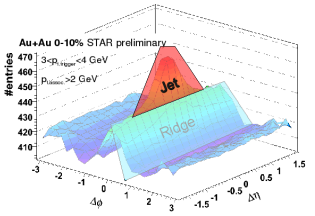


- Baryon/meson ratios in *Jet* in Cu+Cu and Au+Au similar to p+p for both strange and non-strange particles

Conclusions: *Jet*

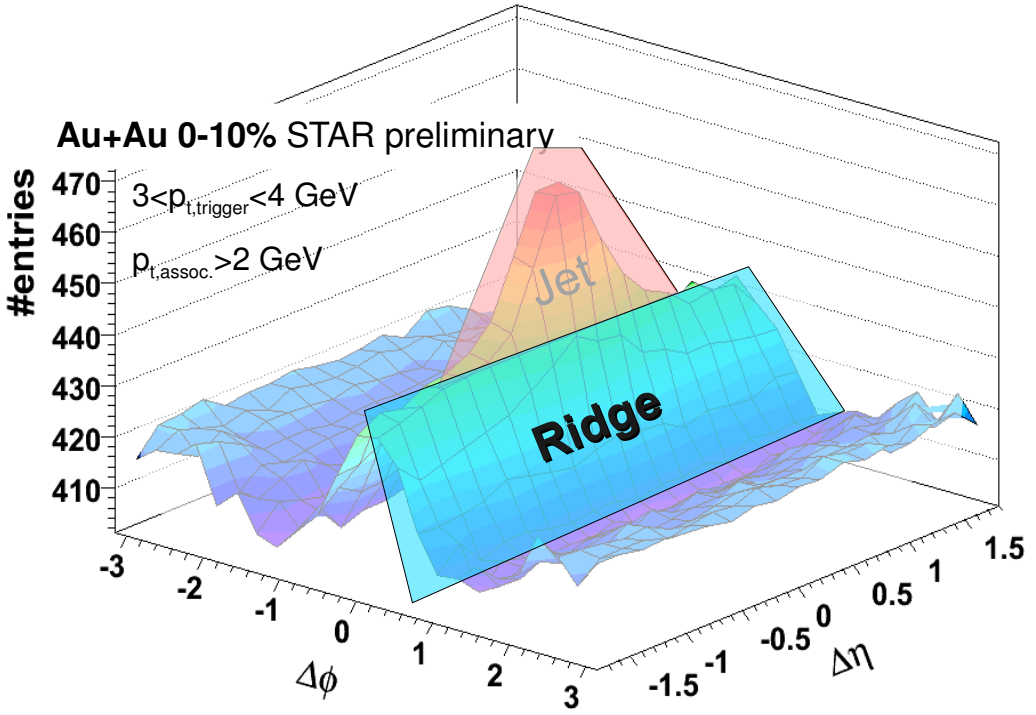


- Pythia describes data well
  - Scaling factor needed but Pythia 8.1 is not as tuned as earlier versions
  - Energy dependence in *Jet* is pQCD effect
  - Trends for $p_T^{trigger}$, p_T^{assoc} dependence right
- Particle ratios similar to p+p

→ *Jet* production mechanism dominated by fragmentation

  - Separation of *Jet* and *Ridge* works

The *Ridge*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Δφ
-1.5
-1
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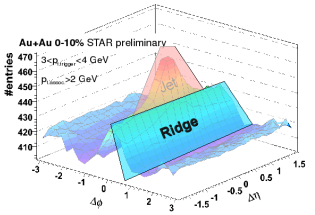
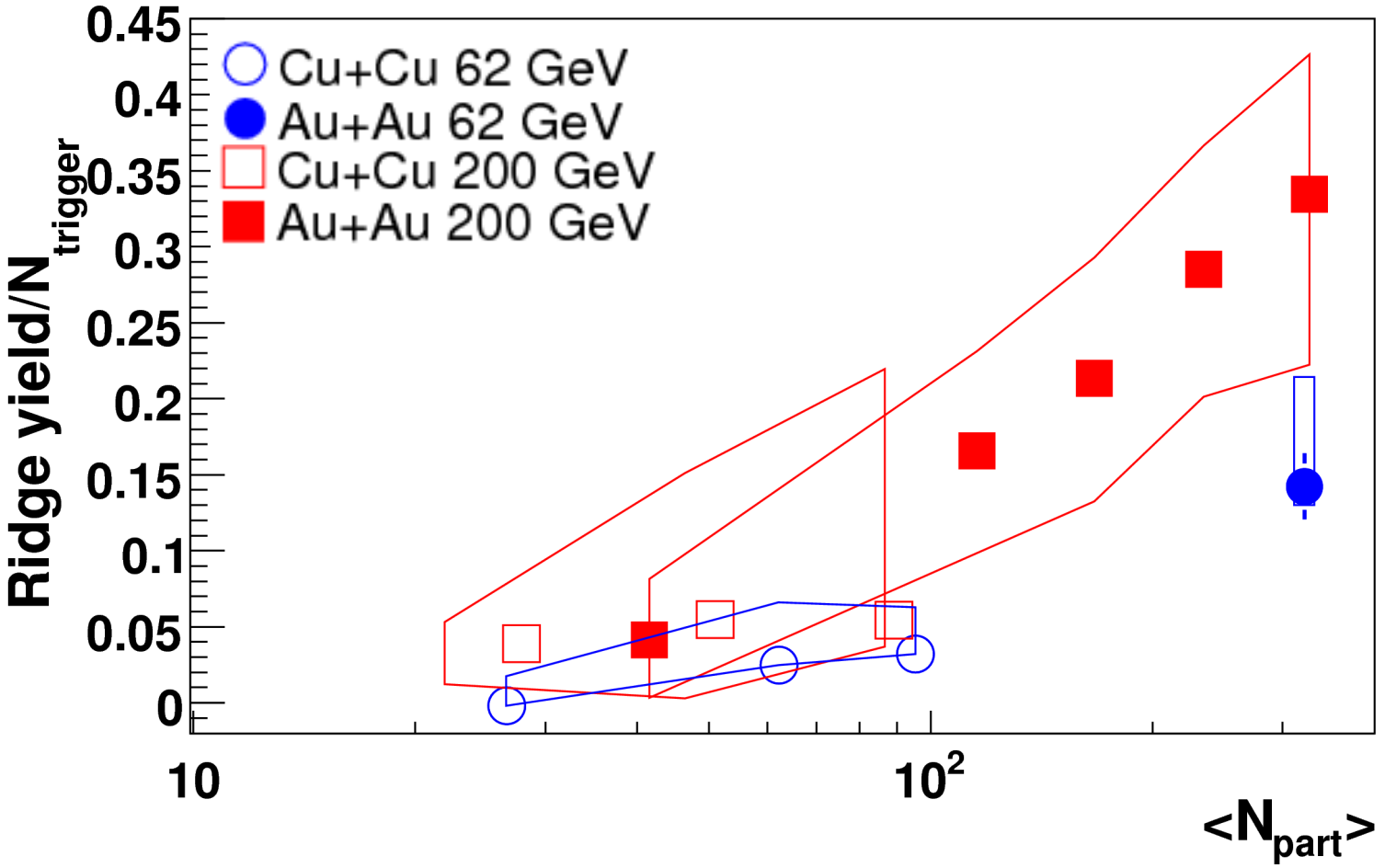
0
0.5
1
1.5
Δη

Ridge vs N_{part}

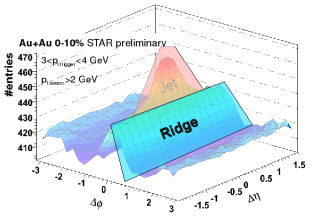


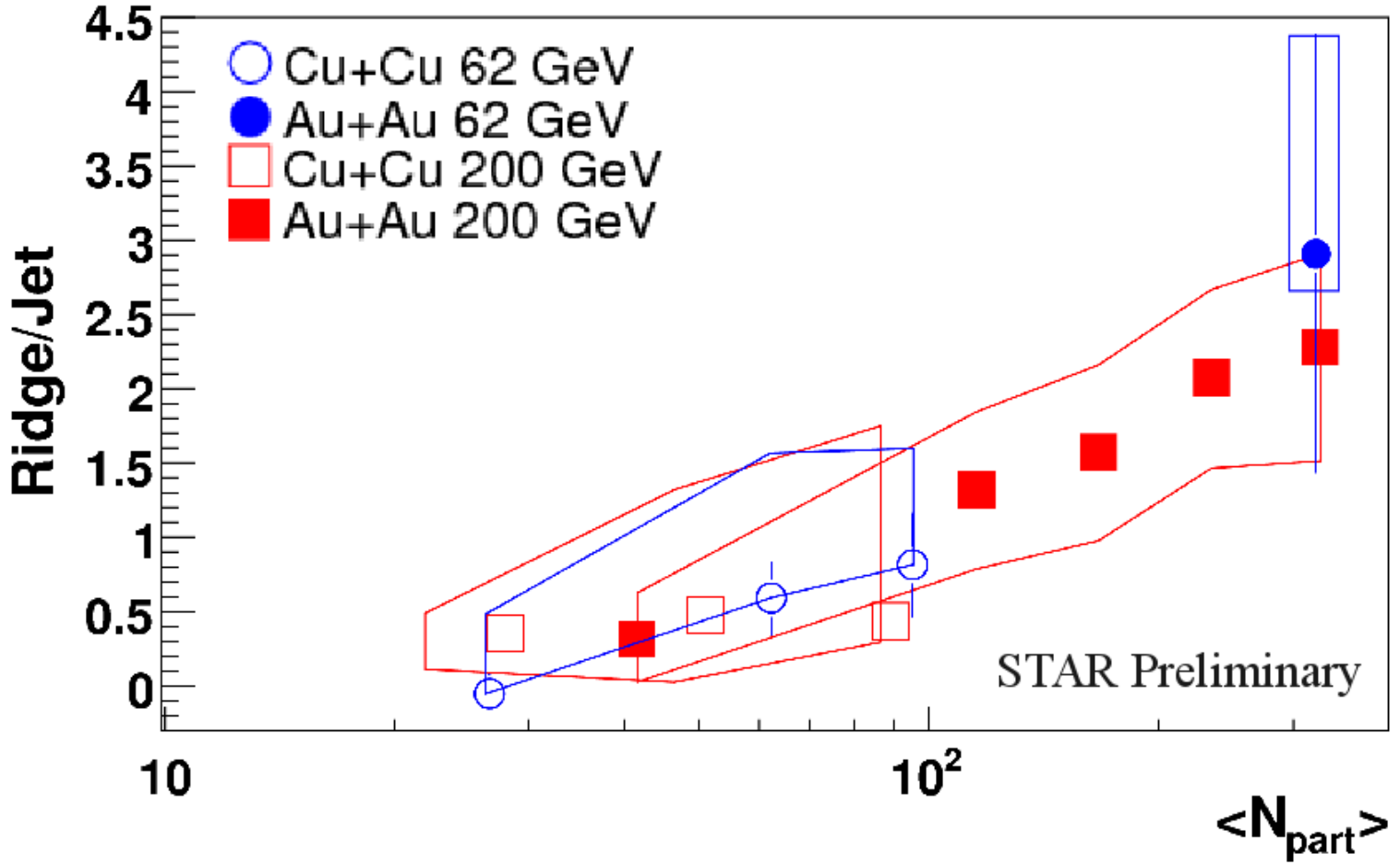


- No system dependence at given N_{part}

J. Bielcikova (STAR), arXiv:0806.2261/nucl-ex
C. Nattrass (STAR), arXiv:0804.4683/nucl-ex

Ridge vs N_{part}

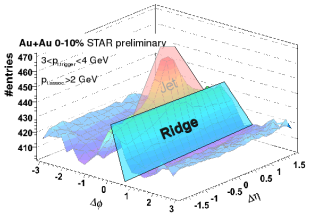


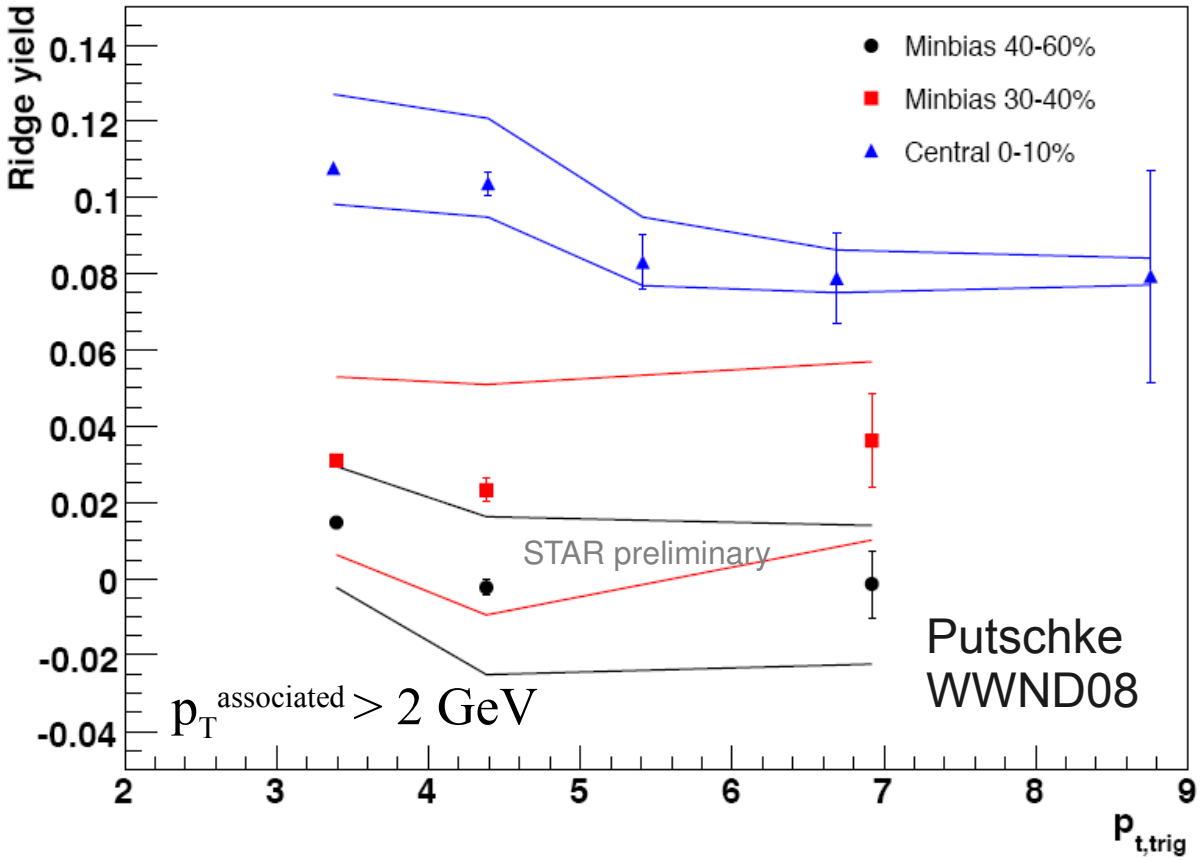


- No system dependence at given N_{part}
- *Ridge/Jet* Ratio independent of collision energy

J. Bielcikova (STAR), arXiv:0806.2261/nucl-ex
C. Nattrass (STAR), arXiv:0804.4683/nucl-ex

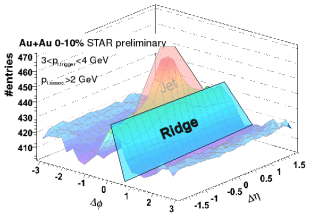
Ridge yield vs. $p_T^{trigger}$ in Au+Au

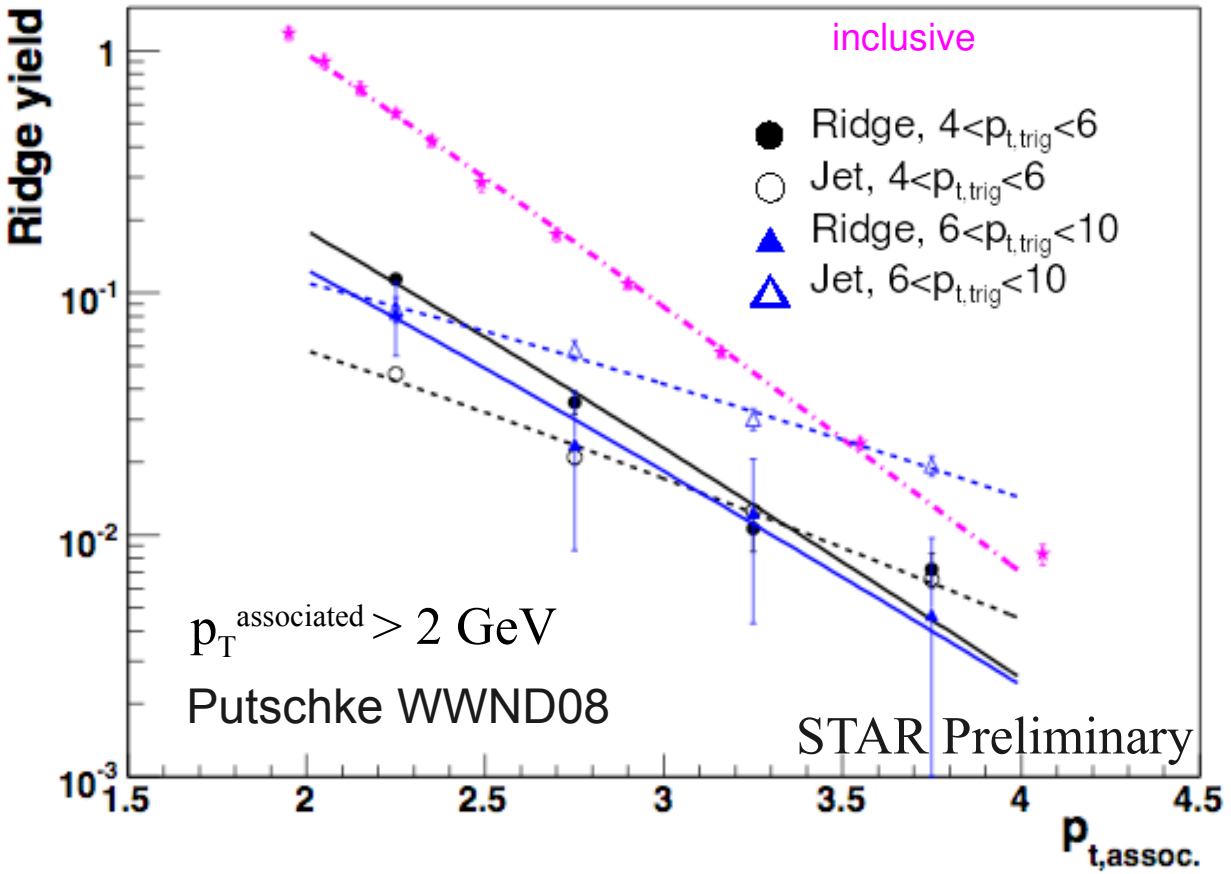




- *Ridge* yield persists to high $p_T^{trigger}$

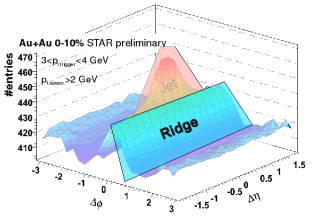
Ridge yield vs. $p_T^{associated}$ in Au+Au

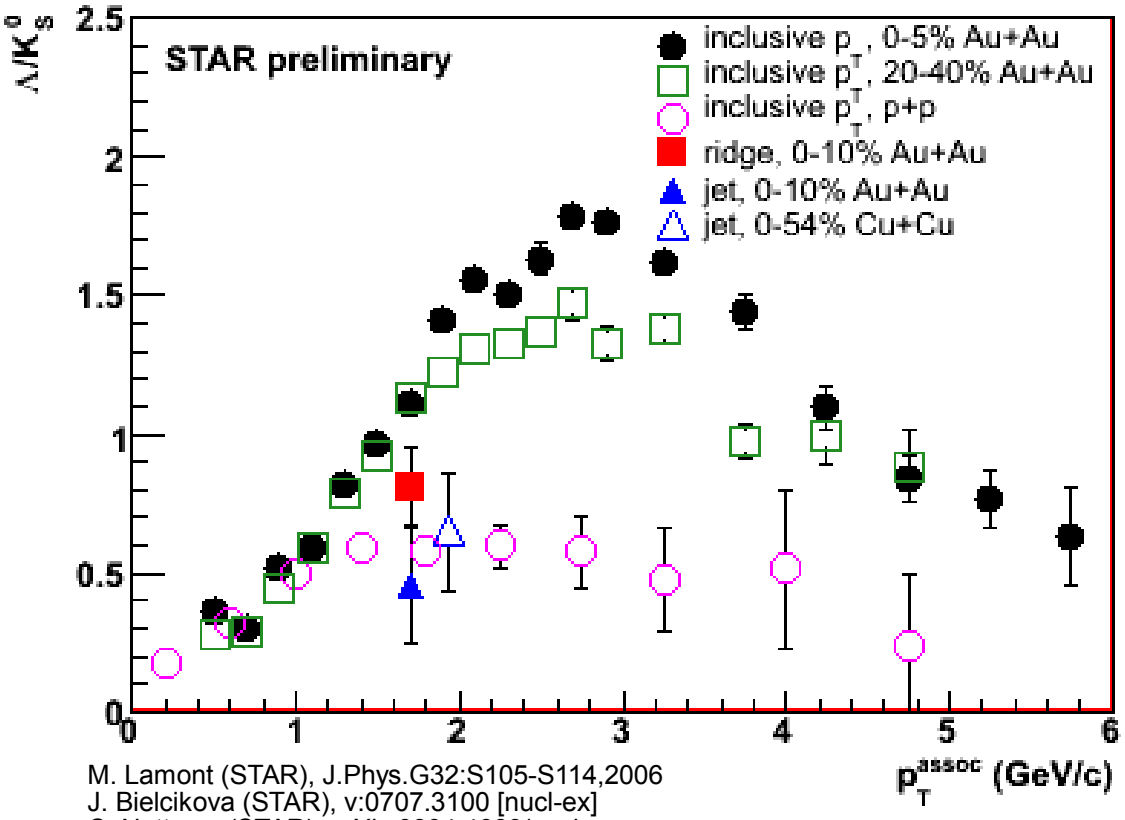




- Spectra of particles associated with *Ridge* similar to inclusive

Ridge composition





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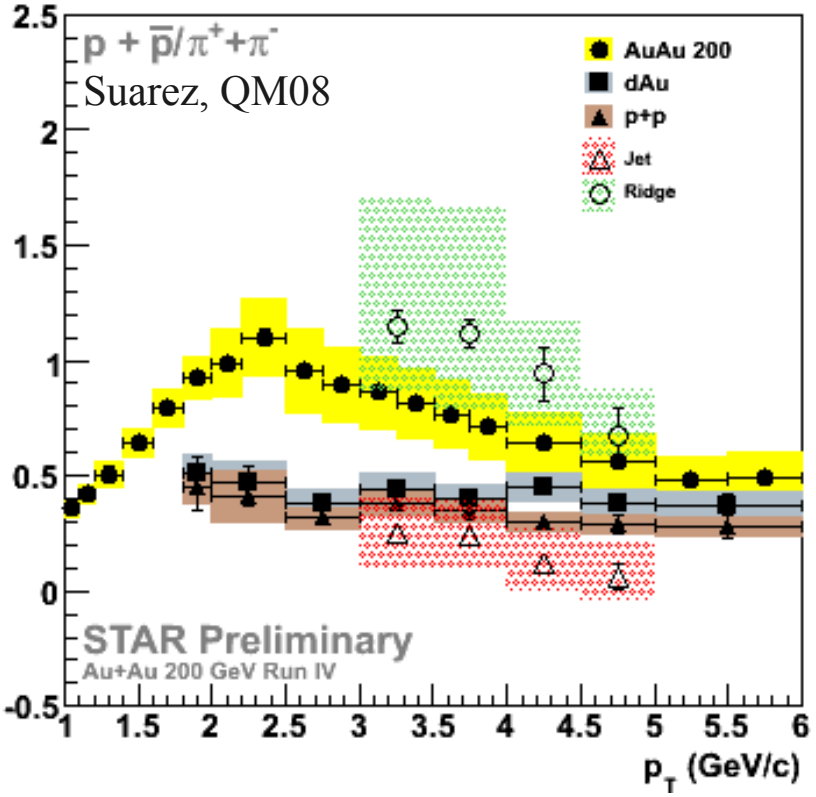
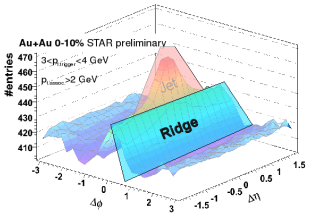


- Baryon/meson ratios in *Ridge* similar to bulk for both strange and non-strange particles

Conclusions: *Ridge*



- Extensive data on Ridge
  - Cu+Cu, Au+Au consistent at same N_{part}
  - *Ridge/Jet* ratio independent of energy
  - Persists to high $p_T^{trigger}$
  - *Ridge* looks like bulk
    - $p_T^{associated}$ dependence, particle composition
  - *Ridge* larger in plane (not shown, arXiv:0807.4606v1)
  - Particles in *Ridge* not correlated with each other in $\Delta\eta$ (not shown, arXiv:0804.4417v1)
- *Jet* agreement between different systems, with scaled Pythia
  - Simulations can be used to approximate z_T distribution for comparisons of data to models
  - More steeply falling jet spectrum in 62 GeV → stronger bias towards unmodified/surface jets
    - Could explain smaller Ridge yield in 62 GeV

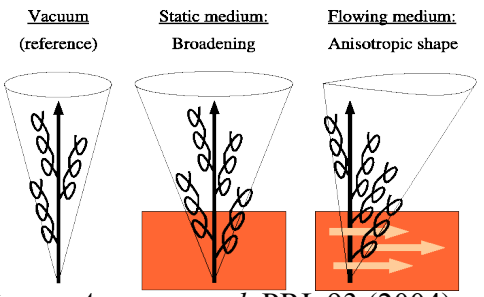
Models

Models

- Radiated gluons broadened in pseudorapidity

Longitudinal flow, Armesto et al, PRL 93 (2004)
QCD magnetic fields, Majumder et al,Phys.Rev.Lett.99:042301,2007
Anisotropic plasma, P. Romatschke, PRC,75014901 (2007)

  - So far unable to make enough *Ridge*



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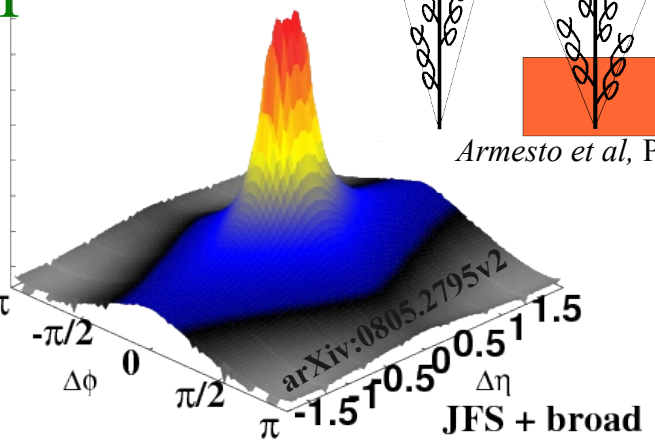

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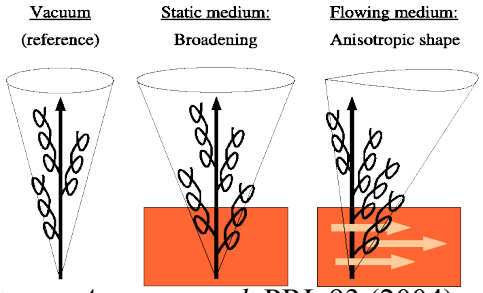

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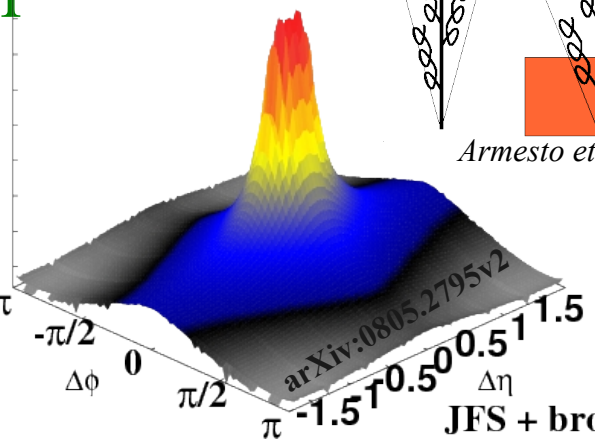
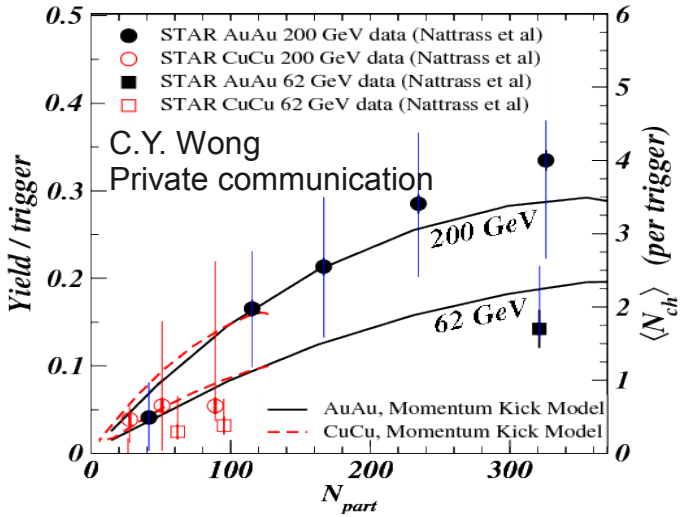


- Interaction of jet+medium

Momentum kick from jet, C.-Y. Wong , Phys.Rev.C76:054908,2007
Medium heating + recombination, Chiu & Hwa, PRC72, 034903

  - Agrees with data but lots of fits to the data



N$_{part}$

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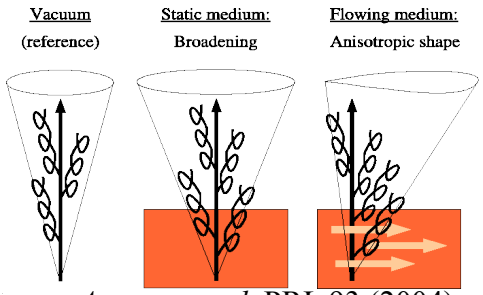

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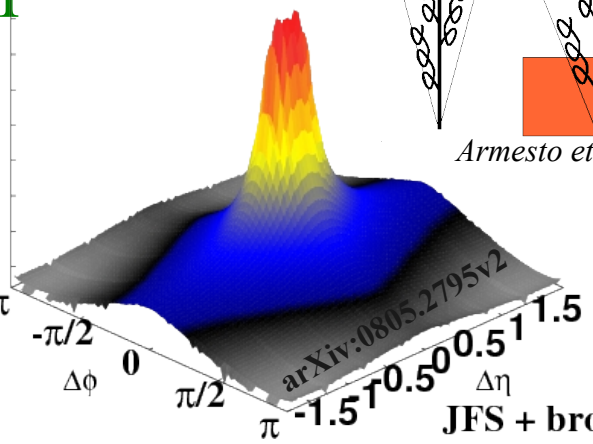

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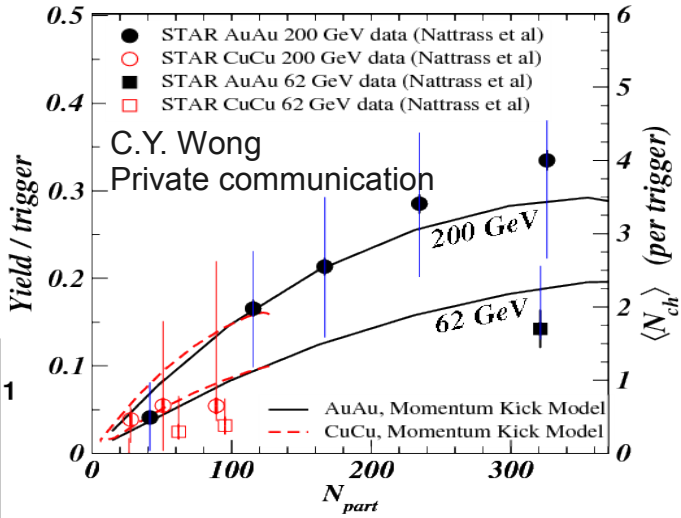

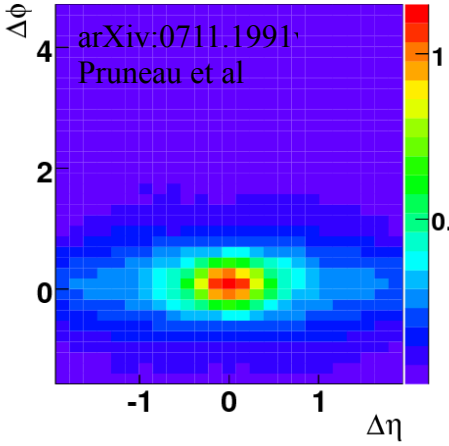

- Radial flow+trigger bias

  S. Voloshin, nucl-th/0312065, Nucl. Phys. A749, 287
  C.. Pruneau, S. Gavin, S. Voloshin, arXiv:0711.1991v2
  E. Shuryak, *Phys.Rev.C76:047901,2007*

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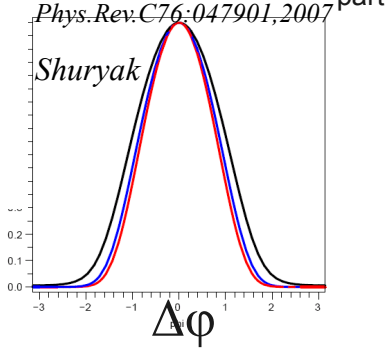

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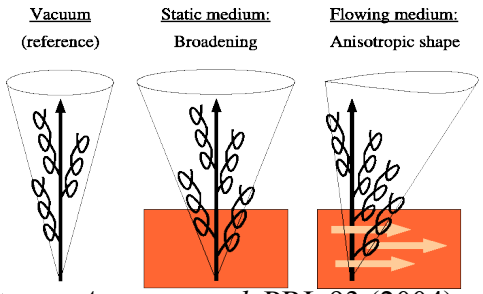

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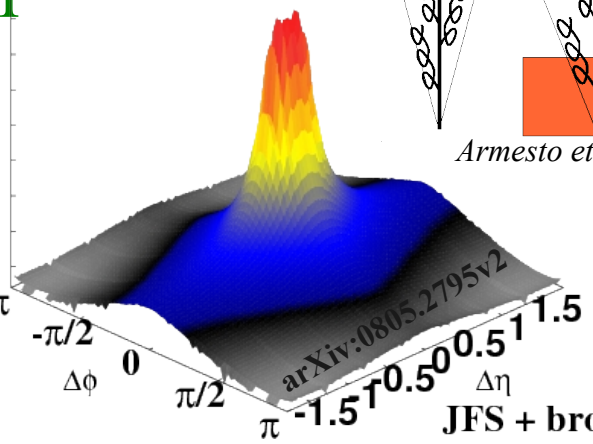

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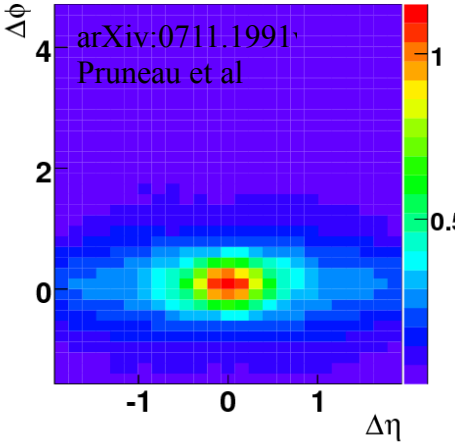

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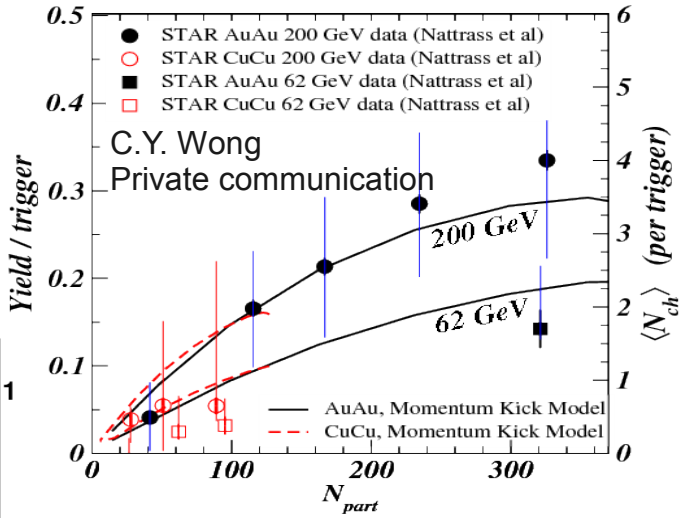
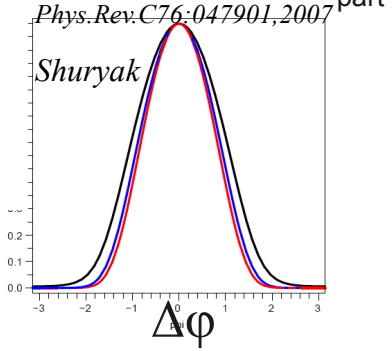
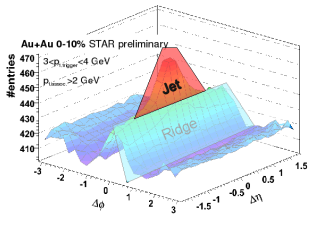




→ No preferred model

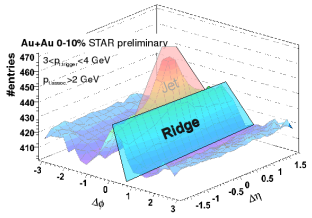
Conclusions

Jet



- Pythia explains trends in data well
  - Needs scaling factor but amazing it does so well
  - Energy, $p_T^{trigger}$, $p_T^{associated}$ dependence
- Separation of *Jet* and *Ridge* works well
- *Jet* production dominated by fragmentation
- Deviations from fragmentation/Pythia indicate modification of jet

Ridge



- Extensive experimental data
- Models need more rigorous comparisons to data, more signatures to distinguish production mechanism
- Reasonable agreement of *Jet* with Pythia

  → simulations can be used to convert from $p_T^{trigger}$ to distribution of jet energies

  → Greater surface bias in 62 GeV could explain lower *Ridge* yield

STAR Collaboration

Argonne National Laboratory - University of Birmingham - Brookhaven National Laboratory - California Institute of Technology - University of California, Davis - University of California - University of California, Los Angeles - Carnegie Mellon University - University of Illinois at Chicago - Creighton University - Nuclear Physics Institute Prague - Laboratory for High Energy (JINR) - Particle Physics Laboratory (JINR) - University of Frankfurt - Institute of Physics, Bhubaneswar - Indian Institute of Technology, Mumbai - Indiana University, Bloomington - Institut de Recherches Subatomiques - University of Jammu - Kent State University - Institute of Modern Physics, Lanzhou - Lawrence Berkeley National Laboratory - Massachusetts Institute of Technology - Max-Planck-Institut fuer Physik - Michigan State University - Moscow Engineering Physics Institute - City College of New York - NIKHEF and Utrecht University - Ohio State University, Columbus - Panjab University - Pennsylvania State University - Institute of High Energy Physics, Protvino, Russia - Purdue University - Pusan National University, Pusan, Republic of Korea - University of Rajasthan, Jaipur - Rice University - Universidade de Sao Paulo - University of Science & Technology of China - Shanghai Institute of Applied Physics - SUBATECH, Nantes, France - Texas A&M University - University of Texas - Tsinghua University - Valparaiso University - Variable Energy Cyclotron Centre, Kolkata, India - Warsaw University of Technology - University of Washington - Wayne State University - Institute of Particle Physics, CCNU (HZNU), Wuhan - Yale University - University of Zagreb