

STAR's progress on physics analyses



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Yale

BNL-PAC
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- Overview of STAR's activities since last PAC
- Highlights
 - publications since last PAC
 - preliminary results since last PAC
- Computing progress highlights
- Summary



State of STAR

Collaboration meeting May '17 :

Co-spokesperson's elected: Helen Caines and Zhangbu Xu

New management begins July 1, 2017

3 new institutions applied to join:

Fudan - China, Lead rep.: Chuan Zheng

Heidelberg - Germany, Lead rep.: Norbert Herrmann

Rutgers - U.S.A., Lead rep.: Sevil Salur

From 2014-2017 (Zhangbu's first term) :

45 refereed publications (18 PRL, 2 Nature)

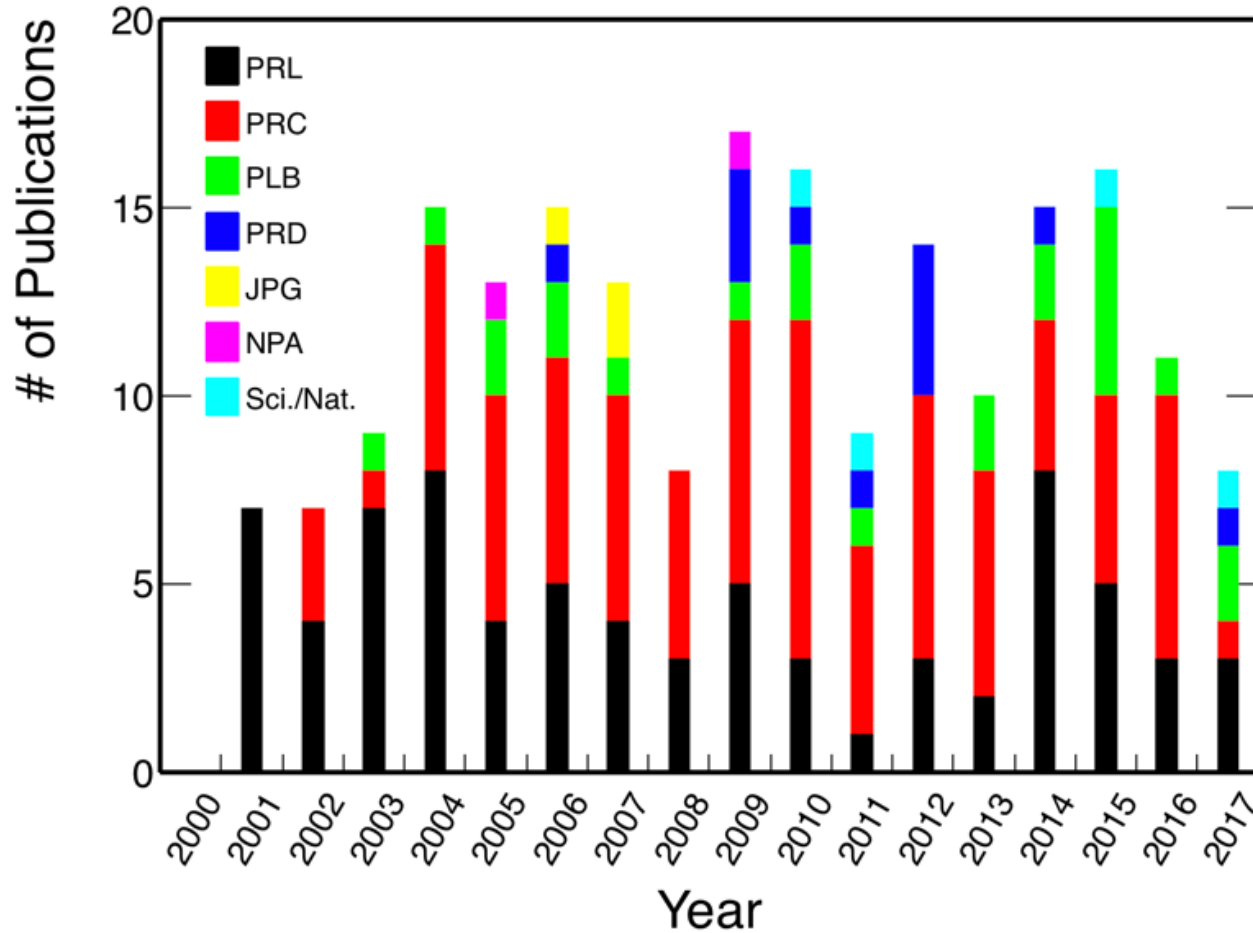
50 Ph.D. Theses (18 since last PAC meeting)

14 new institutions

6 upgrades installed or under construction



STAR publications



2016:
11 publications
(3 PRL, 1 PLB, 7 PRC)

2017:
4 publications
3 accepted
(2 PRL, 2 PLB, 1 PRC,
1 PRD, 1 Nature)

6 papers in journal review

Continued strong publication record

HEPData: STAR's footprint has increased from 7 to 35 papers
submission now included in STAR's paper publication process
working ongoing supplying data from previous papers



Publications since last PAC

- Elliptic flow of electrons from heavy-flavor hadron decays in Au+Au collisions at $\sqrt{s_{NN}} = 200, 62.4, \text{ and } 39 \text{ GeV}$
 - Subm: 5/23 '14; Acc: 3/17' 17
 - [Phys. Rev. C 95 \(2017\) 034907](#)

HF
- Measurement of elliptic flow of light nuclei at $\sqrt{s_{NN}} = 200, 62.4, 39, 27, 19.6, 11.5, \text{ and } 7.7 \text{ GeV}$ at RHIC
 - Subm: 1/26; Acc: 9/23 2016
 - [Phys. Rev. C 94 \(2016\) 034908](#)

BulkCorr
- J/ψ production at low transverse momentum in p+p and d+Au collisions at $\sqrt{s_{NN}} = 200 \text{ GeV}$
 - Subm: 2/6; Acc: 9/23 2016
 - [Phys. Rev. C 93 \(2016\) 064904](#)

HF
- Measurement of the cross section and longitudinal double-spin asymmetry for di-jet production in polarized pp collisions at $\sqrt{s} = 200 \text{ GeV}$
 - Subm: 10/24 '16; Acc: 4/28 '17
 - [Phys. Rev. D 95 \(2017\) 71103](#)

Spin
- Near-side azimuthal and pseudorapidity correlations using neutral strange baryons and mesons in d+Au, Cu+Cu and Au+Au collisions at $\sqrt{s_{NN}} = 200 \text{ GeV}$
 - Subm: 3/17; Acc: 7/28' 16
 - [Phys. Rev. C 94 \(2016\) 014910](#)

JetCorr
- Jet-like Correlations with Direct-Photon and Neutral-Pion Triggers at $\sqrt{s_{NN}} = 200 \text{ GeV}$
 - Subm: 4/7; Acc: 7/22 2016
 - [Physics Letters B 760 \(2016\) 689](#)

JetCorr

- Charge-dependent directed flow in Cu+Au collisions at $\sqrt{s_{NN}} = 200 \text{ GeV}$
 - Subm: 8/13 2016; Acc: 1/5 2017
 - [Phys. Rev. Lett. 118 \(2017\) 012301](#)

BulkCorr
- Upsilon production in U+U collisions at 193 GeV with the STAR experiment
 - Subm: 8/24; Acc: 12/15 2017
 - [Phys. Rev. C 94 \(2016\) 064904](#)

HF
- Direct virtual photon production in Au+Au collisions at $\sqrt{s_{NN}} = 200 \text{ GeV}$
 - Subm: 7/6 '16; Acc: 4/28 '17
 - [Physics Letters B 770 \(2017\) 451](#)

LFSUPC
- Measurement of D^0 azimuthal anisotropy at mid-rapidity in Au+Au collisions at $\sqrt{s_{NN}} = 200 \text{ GeV}$
 - Subm: 1/23 '17; Acc: 4/28 '17
 - [Phys. Rev. Lett. 118 \(2017\) 212391](#)

HF
- Energy dependence of J/ψ production in Au+Au collisions at $\sqrt{s_{NN}} = 39, 62.4, \text{ and } 200 \text{ GeV}$
 - Accepted by PLB (subm: 7/26 '16)

HF
- Global Lambda hyperon polarization in nuclear collisions: evidence for the most vortical fluid
 - Accepted by Nature (subm: 1/21 '17)

BulkCorr
- Di-jet imbalance measurements at $\sqrt{s_{NN}} = 200 \text{ GeV}$ at STAR
 - Accepted by PRL (subm: 9/15 '16)

JetCorr

+7 Submitted: 2 LFSUPC, 3 BulkCorr, 1 JetCorr, 1 HF

All PWGs active and publishing



Citesummary excluding self-citations or RPP citations

Generated on 2017-06-12

200 papers found, 200 of them citeable (published or arXiv)

Citation summary results

	Citeable papers	Citeable papers excluding self cites
Total number of papers analyzed:	<u>200</u>	<u>200</u>
Total number of citations:	25,111	16,730
Average citations per paper:	125.6	83.7
Breakdown of papers by citations:		
Renowned papers (500+)	<u>11</u>	<u>4</u>
Famous papers (250-499)	<u>14</u>	<u>12</u>
Very well-known papers (100-249)	<u>42</u>	<u>26</u>
Well-known papers (50-99)	<u>43</u>	<u>39</u>
Known papers (10-49)	<u>70</u>	<u>80</u>

(2005 white paper: 2513)

Renowned and Famous Papers:

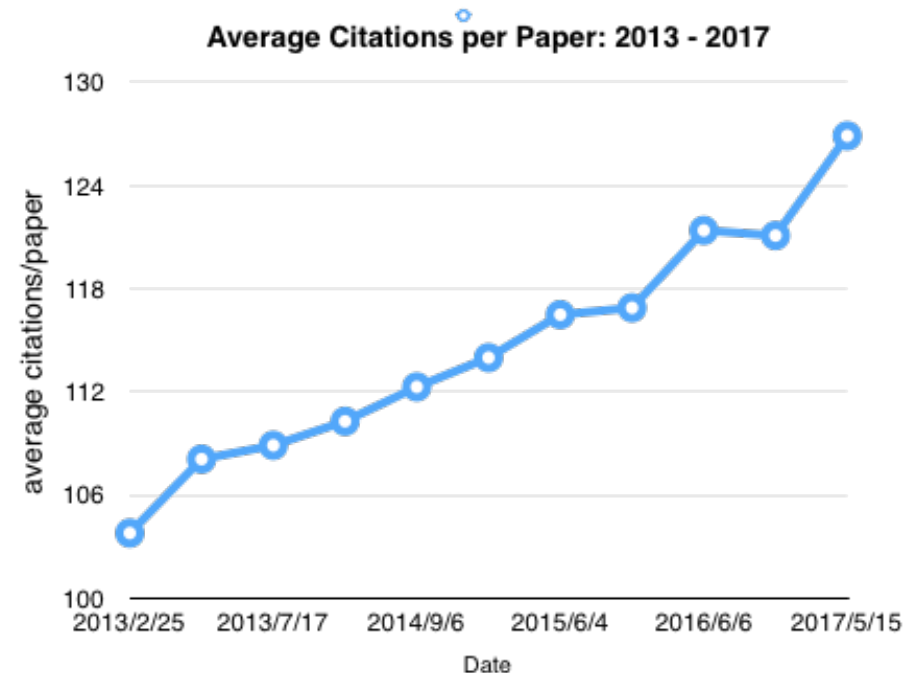
2017: 11 + 14

2016: 11 + 11

2015: 9 + 10

2014: 6 + 9

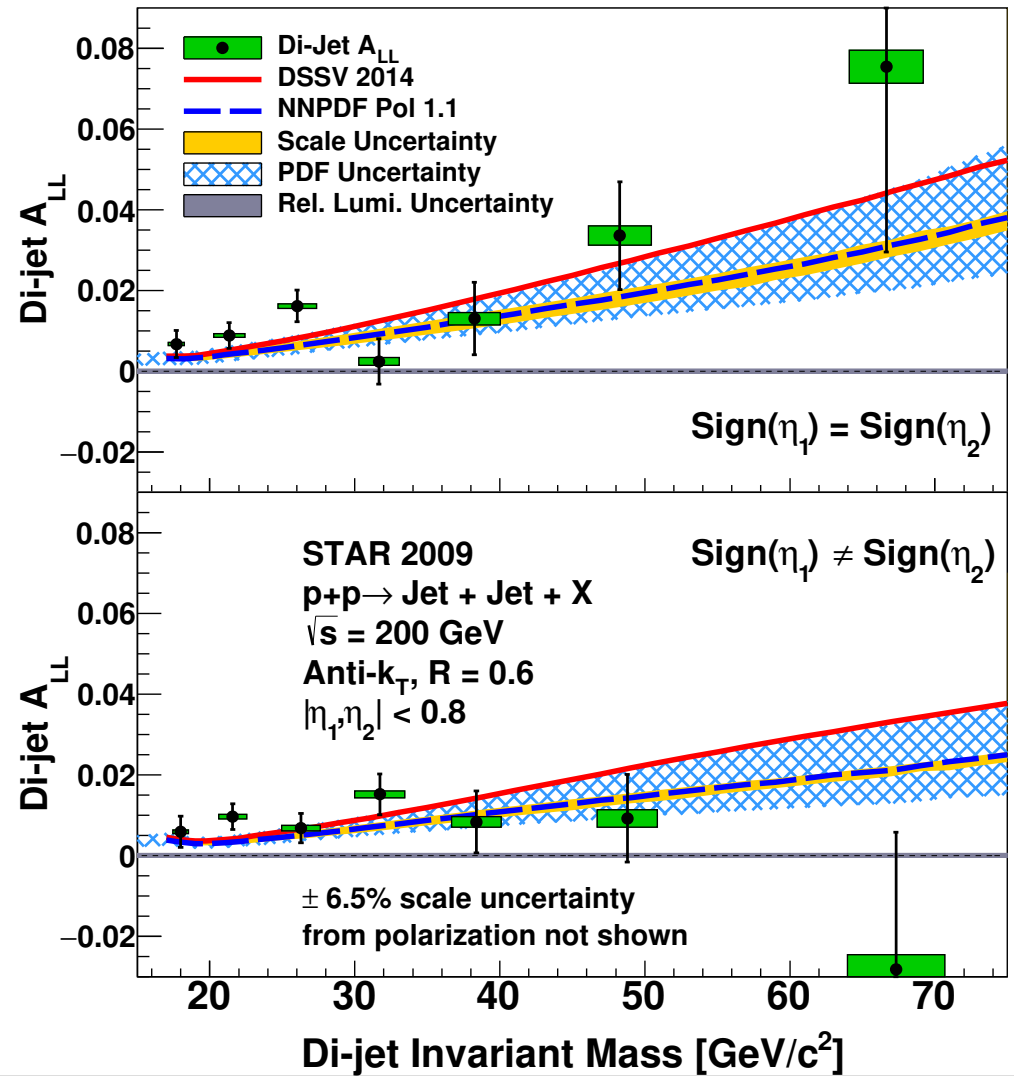
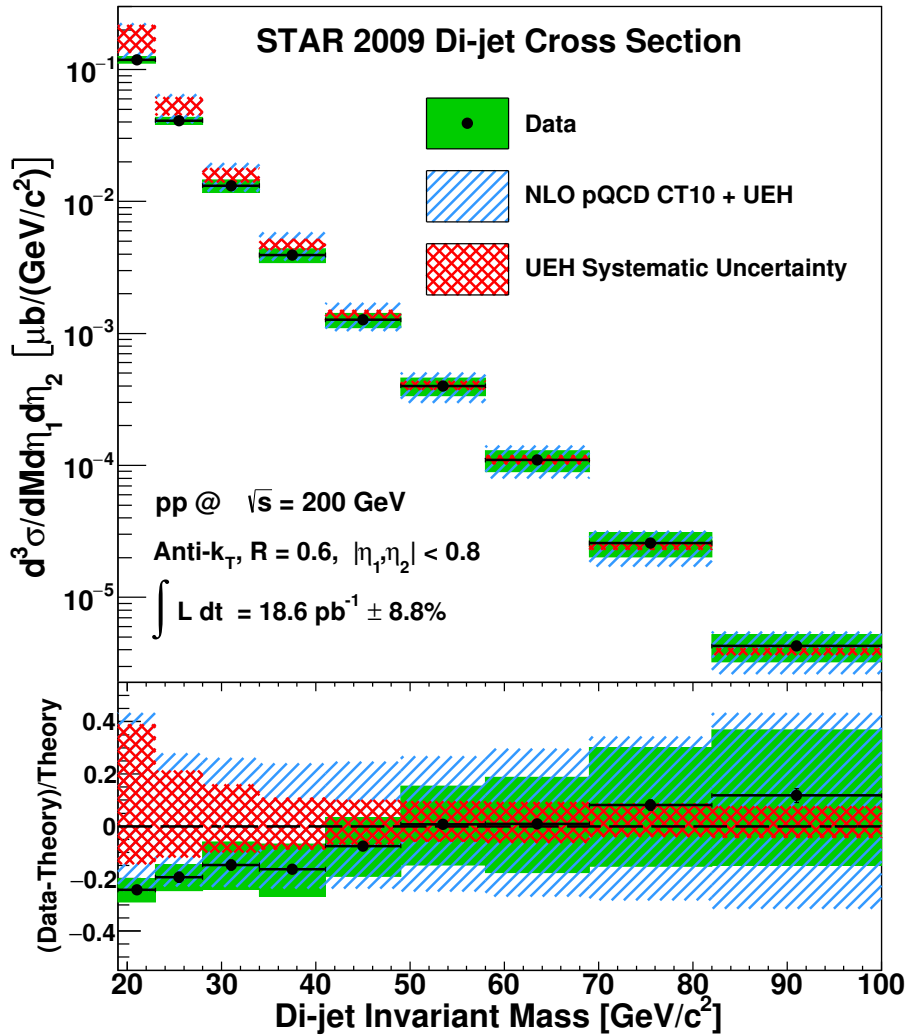
Citation rate per paper continues linear trend



Constraining polarized gluon distribution

Rapid Communications PRD

Run 9 Longitudinal p+p at 200 GeV



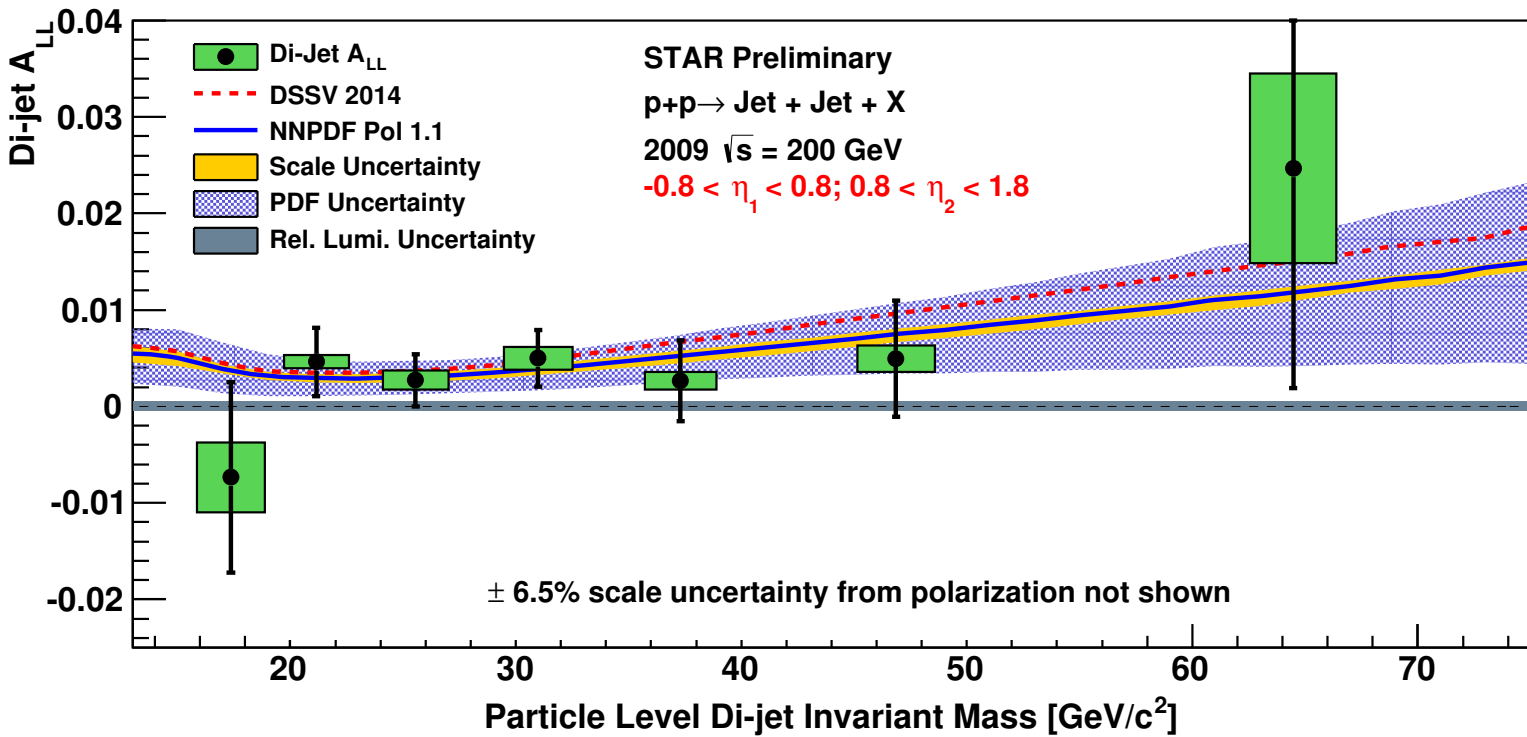
STAR's first mid-rapidity di-jet publication

Gluon polarization 0.2 for $x > 0.05$

Extending to lower x

Preliminary release

Run 9 Longitudinal p+p at 200 GeV



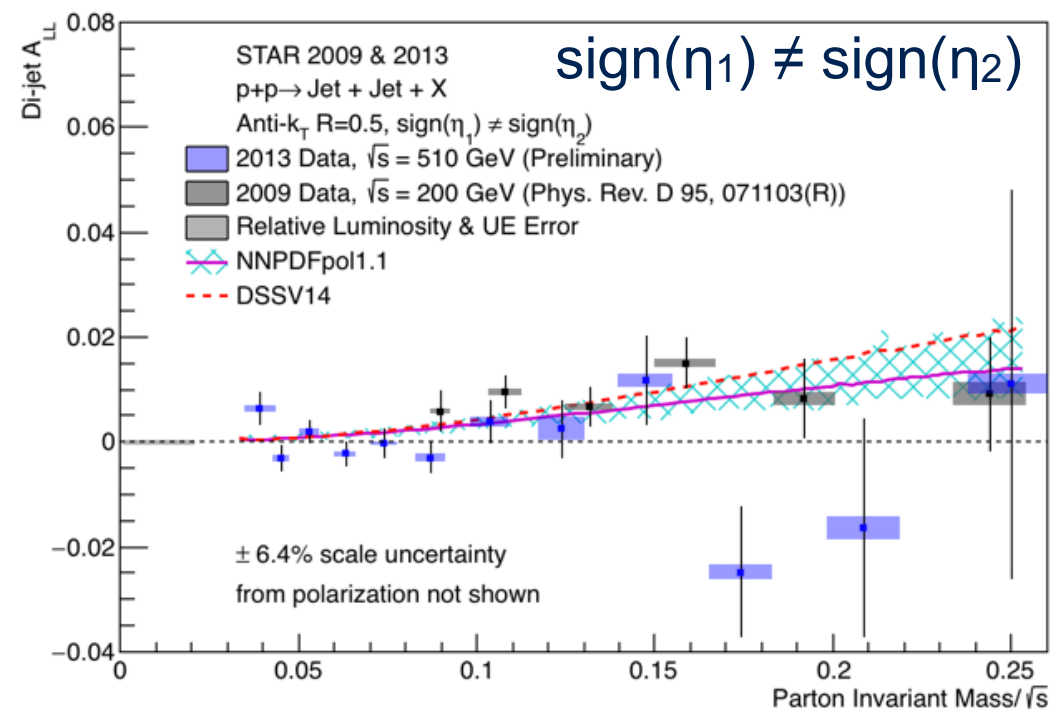
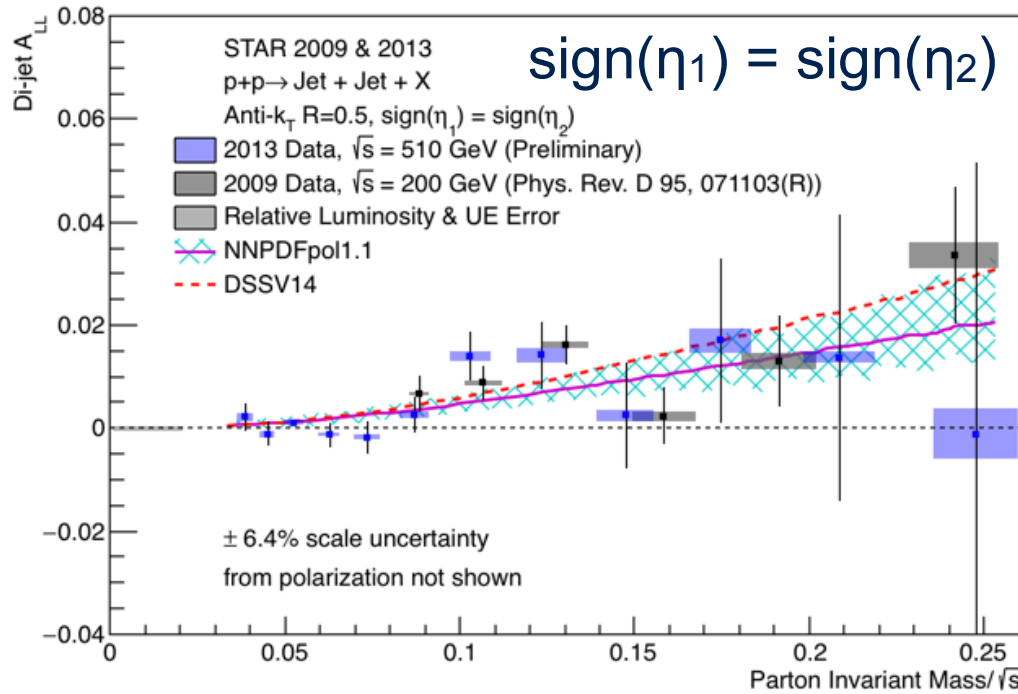
First forward di-jet A_{LL} result
Access to lower x

Good agreement with DSSV & NNPDF NLO QCD global analyses

And even lower x

Preliminary release

Run 13 Longitudinal p+p at 510 GeV



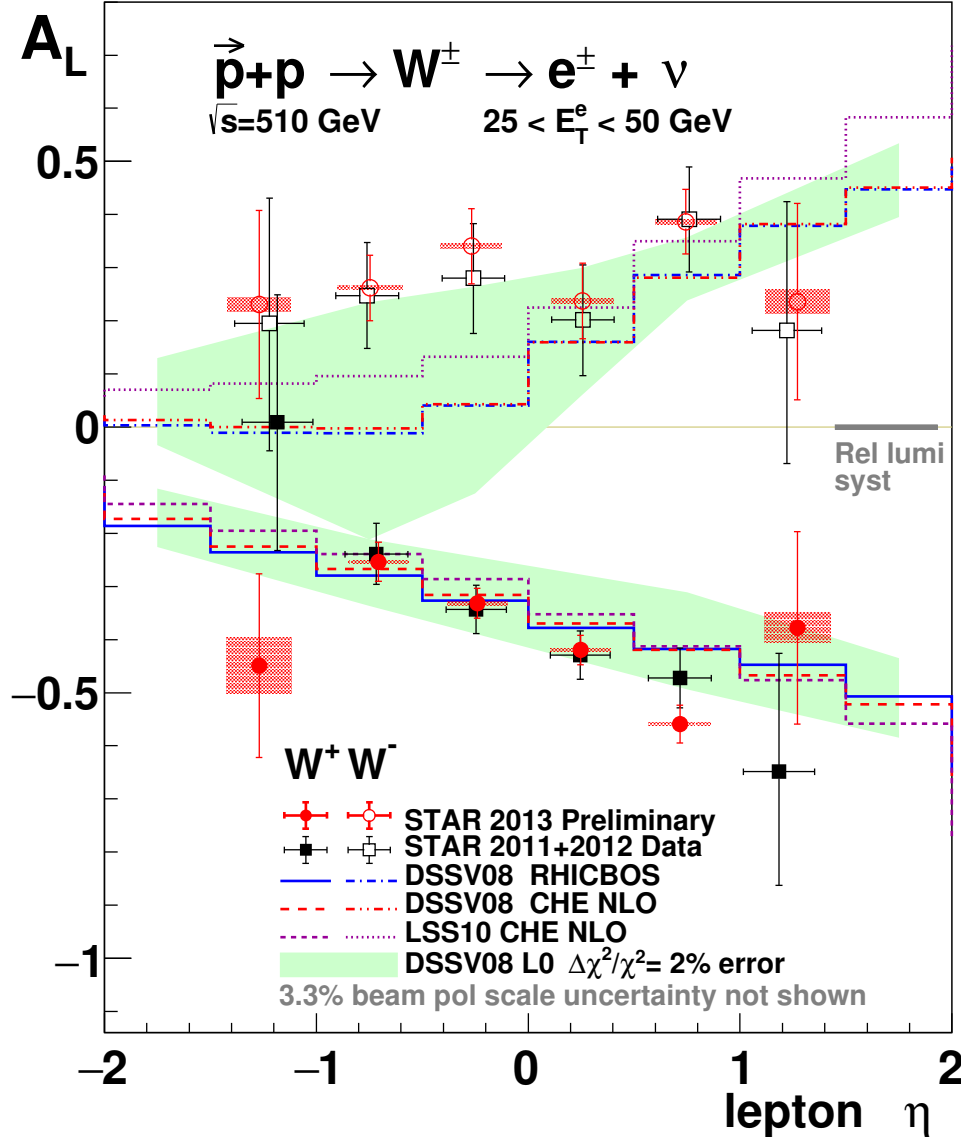
Run 13 data: largest impact $0.02 \leq x \leq 0.05$
 Good agreement between 200 and 510 GeV data
 A_{LL} indicates positive trend with invariant mass

Further constraining ΔG via higher statistical precision

Probing sea quark polarization

Preliminary release

Run 13 Longitudinal p+p at 510 GeV



$W A_L$:
 Good agreement with previous results
 Statistical precision improved by 40%

Measured asymmetry larger than that expected from DSSV fits

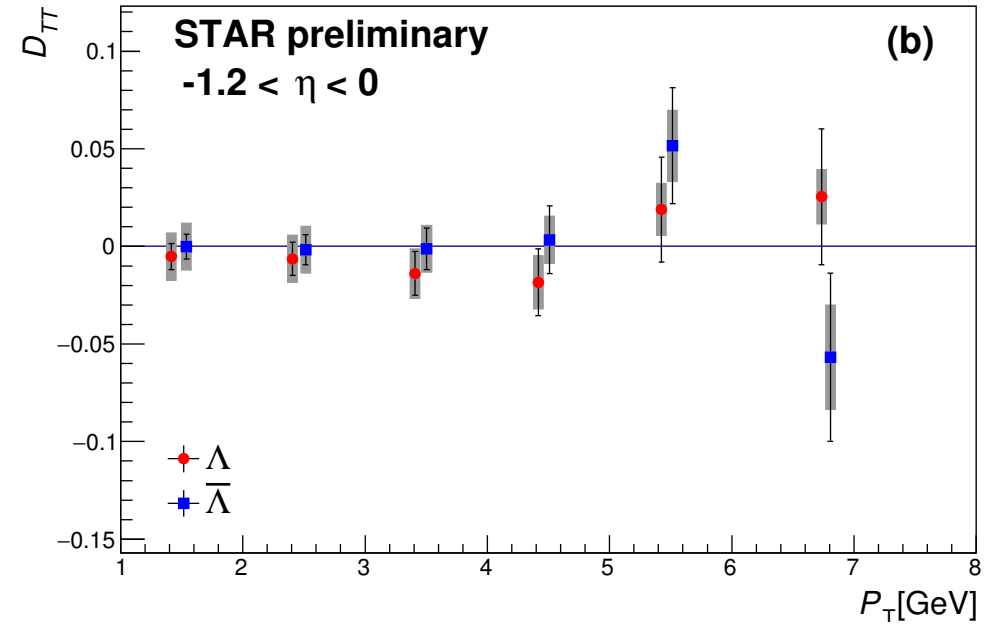
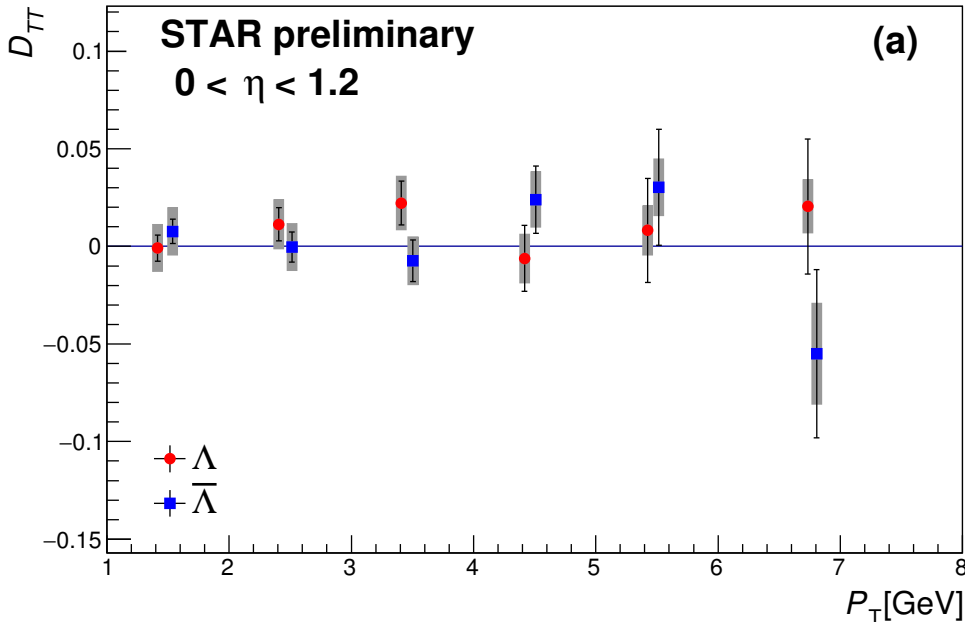
Results already impactful in reweighting NNPDF fits (E. Nocera, arXiv:1702.05077)

Tightest constraints to date on $\Delta\bar{u}$ and $\Delta\bar{d}$ distributions

Λ ($\bar{\Lambda}$) transverse spin transfer

Preliminary release

Run 12 Transverse p+p at 200 GeV



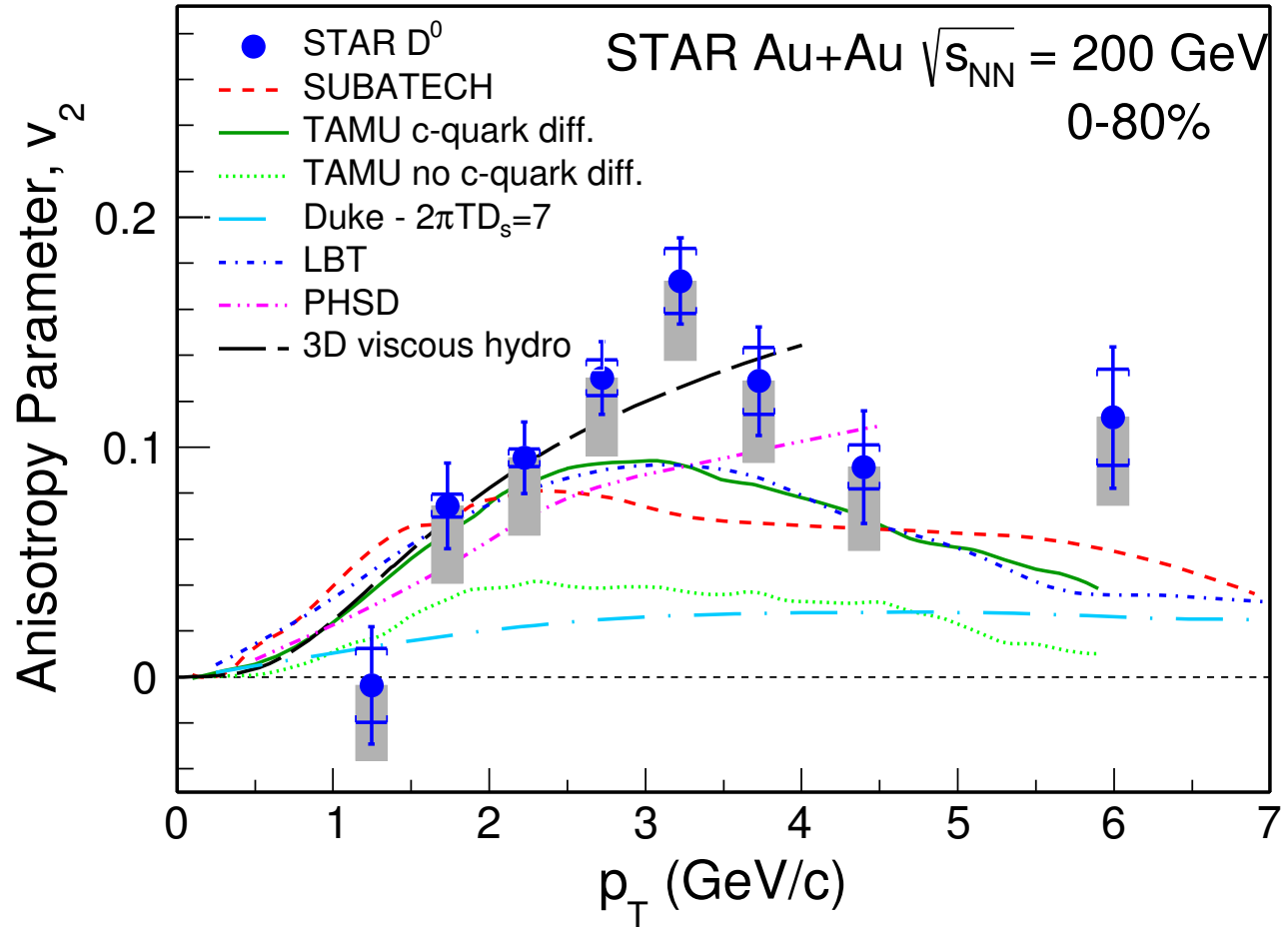
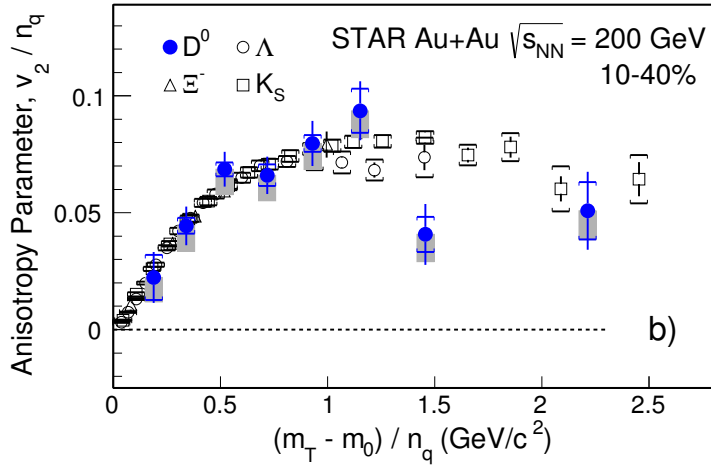
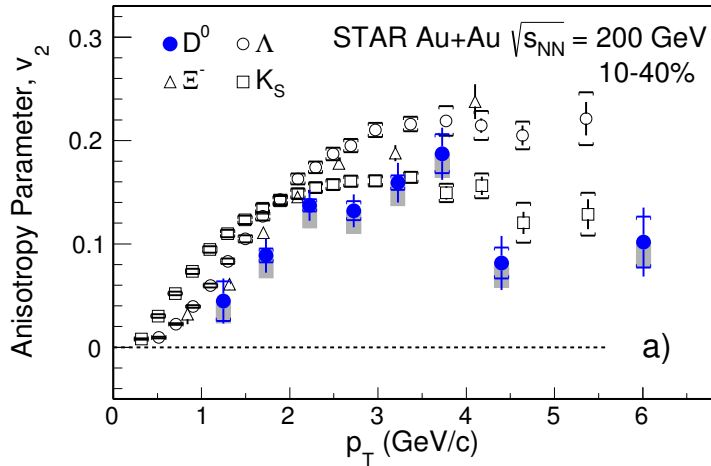
D_{TT} : Sensitive to (anti-)s-quark transversity **and** spin dependent fragmentation distributions

First measurement of mid rapidity Λ D_{TT} in p+p collisions

HFT: Charm flow

PRL

Run 14 Au+Au at 200 GeV



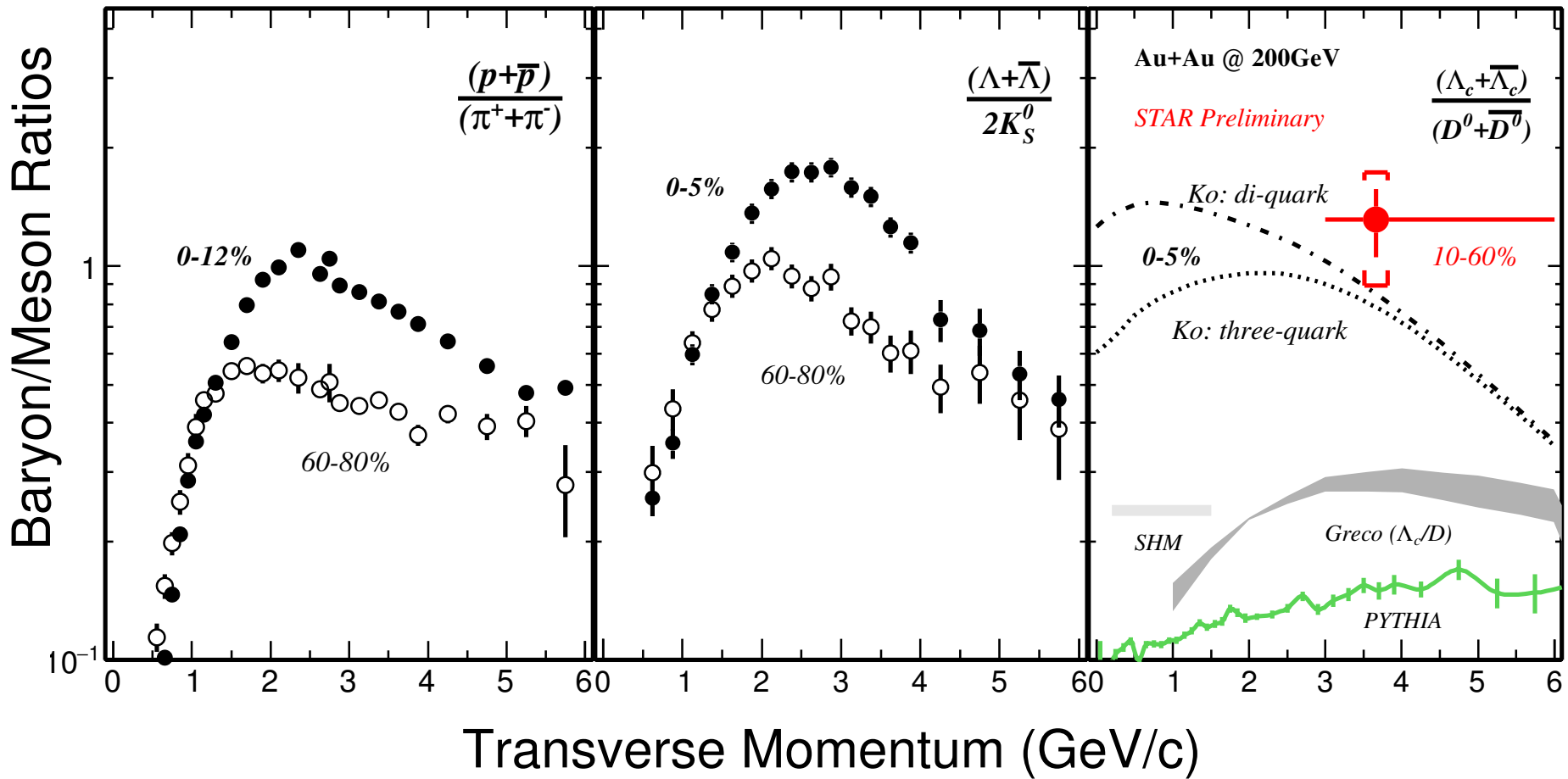
Clear mass ordering $p_T < 2$ GeV/c
Consistent with NCQ scaling

Thermalization of charm

HFT: Enhanced charm baryons

Preliminary release

Run 14 Au+Au at 200 GeV



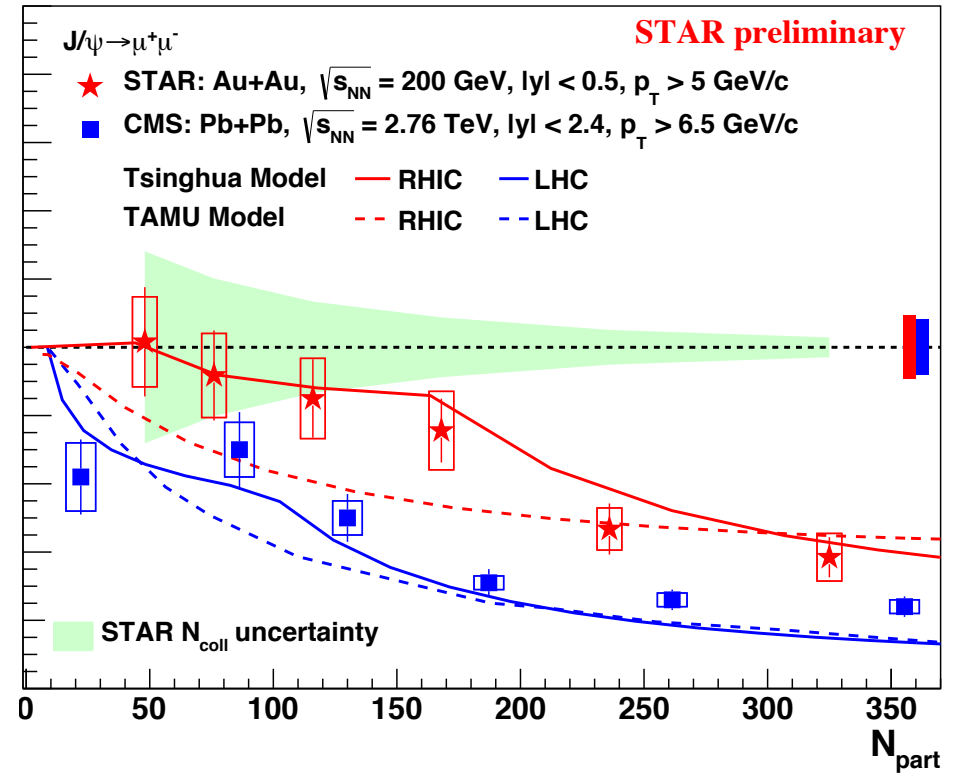
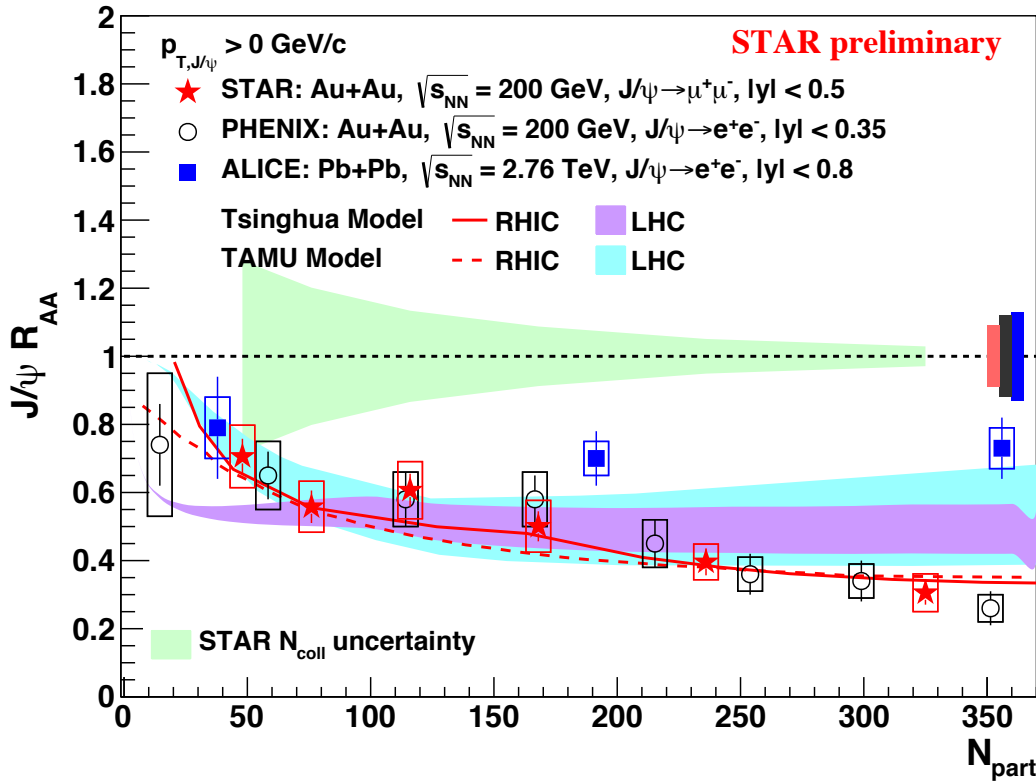
Charm B/M ratio similar to light and strange species
Coalescence of charm?

First charm baryon measurement in HI

MTD: Charmonia

Preliminary release

Run 14 Au+Au at 200 GeV
Run 15 p+p and p+Au



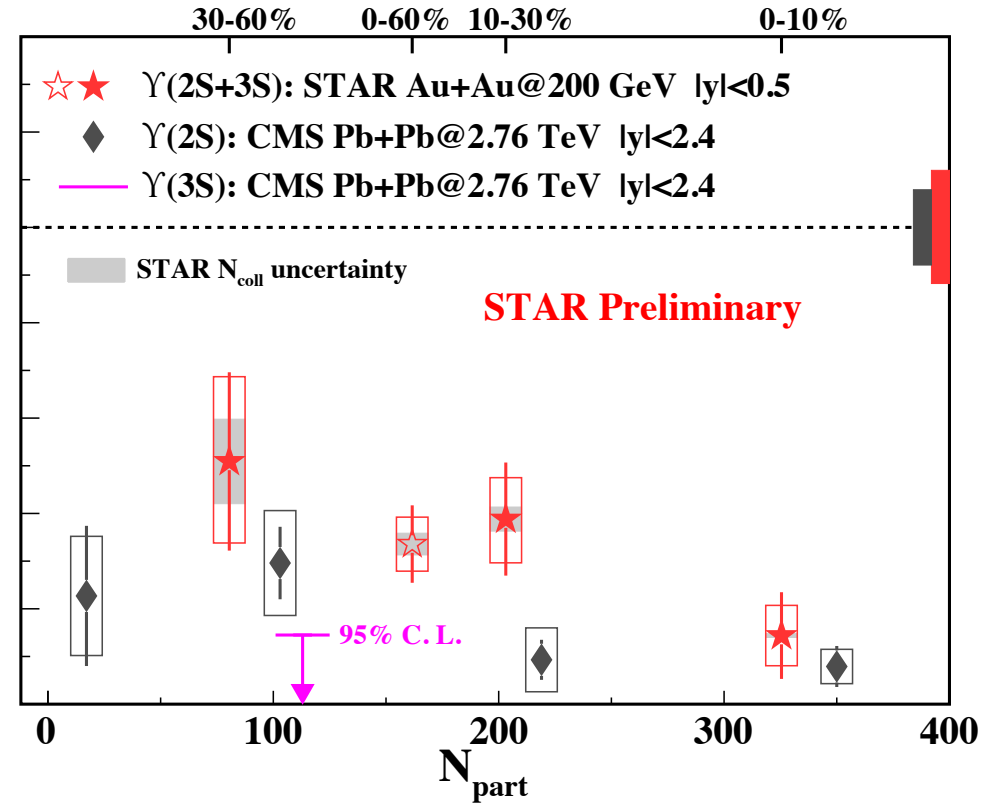
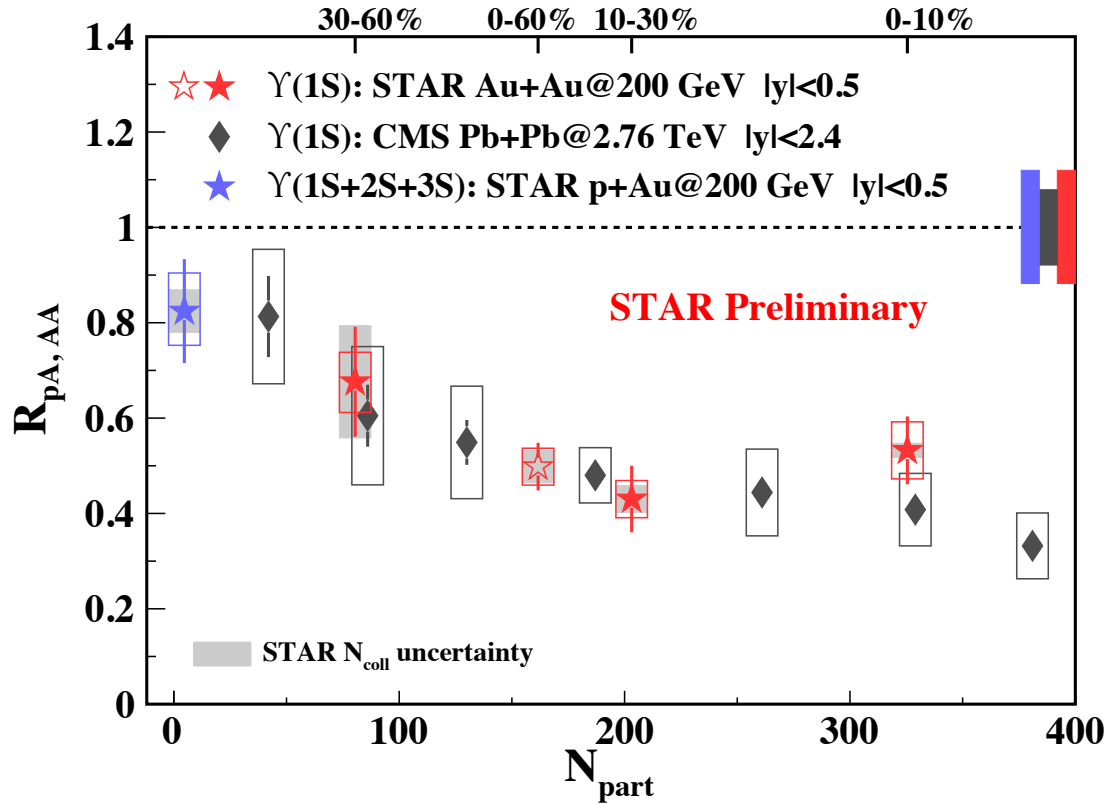
Low p_T : RHIC < LHC \rightarrow Less regeneration at RHIC
High p_T : RHIC > LHC \rightarrow Less color screening at RHIC

Lower temperature QGP at RHIC

MTD: Bottomonia

Preliminary release

Run 14 Au+Au at 200 GeV
Run 15 p+p and p+Au



First measurement: $Y(2S+3S)$
 $R_{AA} Y(1S)$: LHC ~ RHIC
 $R_{AA} Y(1S) > R_{AA} Y(2S+3S)$

Results consistent with sequential melting

Hardcore jet quenching

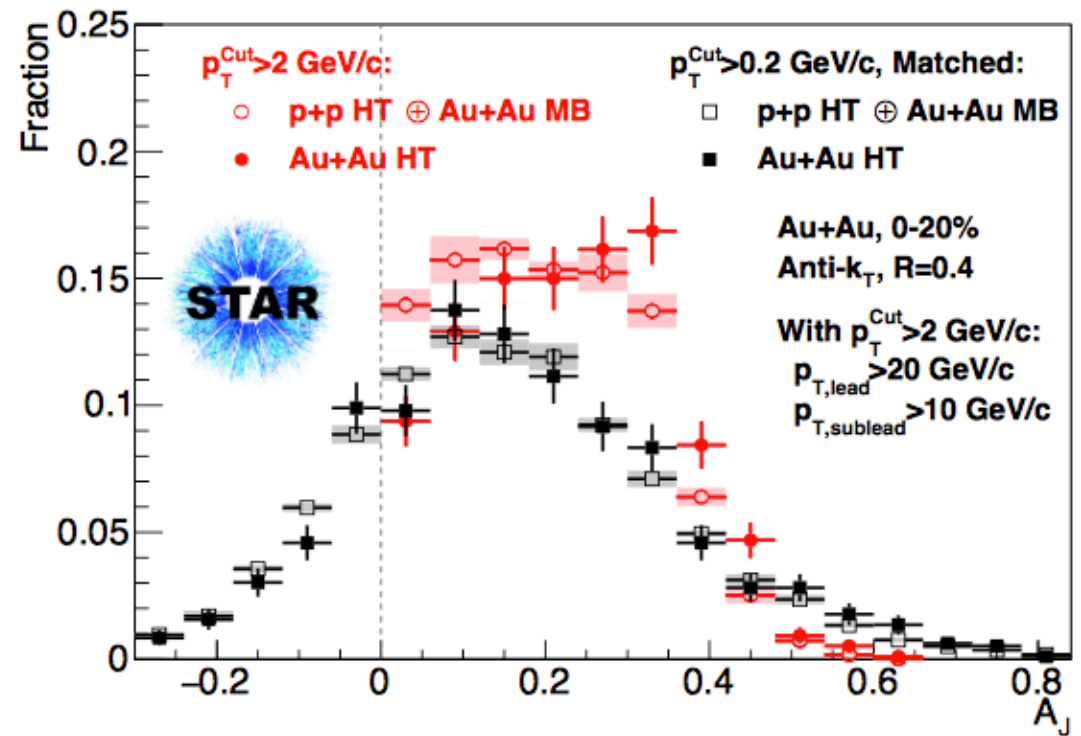
PRL - Editors choice

Preliminary release

Dijet asymmetry

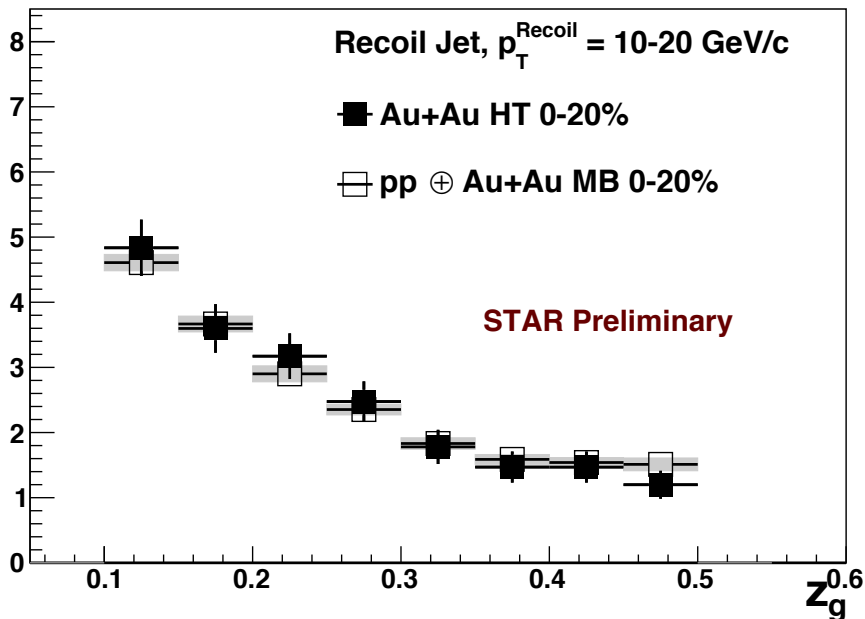
p+p balance recovered for $R=0.4$ (not $R=0.2$) when soft particles included

Run 6 Au+Au at 200 GeV



z_g related to parton splitting function
: not modified for hardcore jets

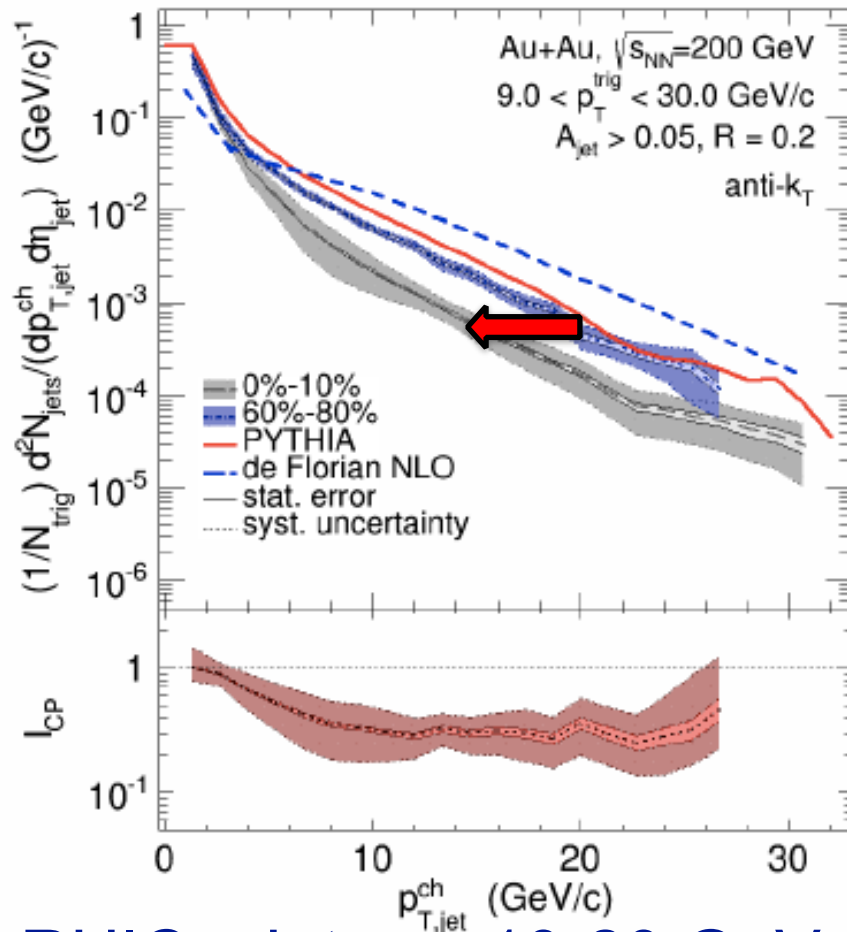
Jets are quenched but lost energy can be recovered and first hard splitting not modified



Recoil jet quenching

PRC - Submitted

Run 11 Au+Au at 200 GeV



Examine jets recoiling of high p_T charged hadron

Removal of combinatorial jets via event mixing allows access to low p_T jets

Recoil jets highly suppressed

RHIC: Jet $p_T = 10-20$ GeV

$R=0.2$: $p_{T,\text{Shift}} \sim -4.4 \pm 0.2 \pm 1.2$ GeV

$R=0.5$: $p_{T,\text{Shift}} \sim -2.8 \pm 0.5 \pm 1.2$ GeV

LHC: Jet $p_T = 60-100$ GeV

$R=0.5$: $p_{T,\text{Shift}} \sim -8 \pm 2$ GeV

Larger energy loss at LHC

BES-I results

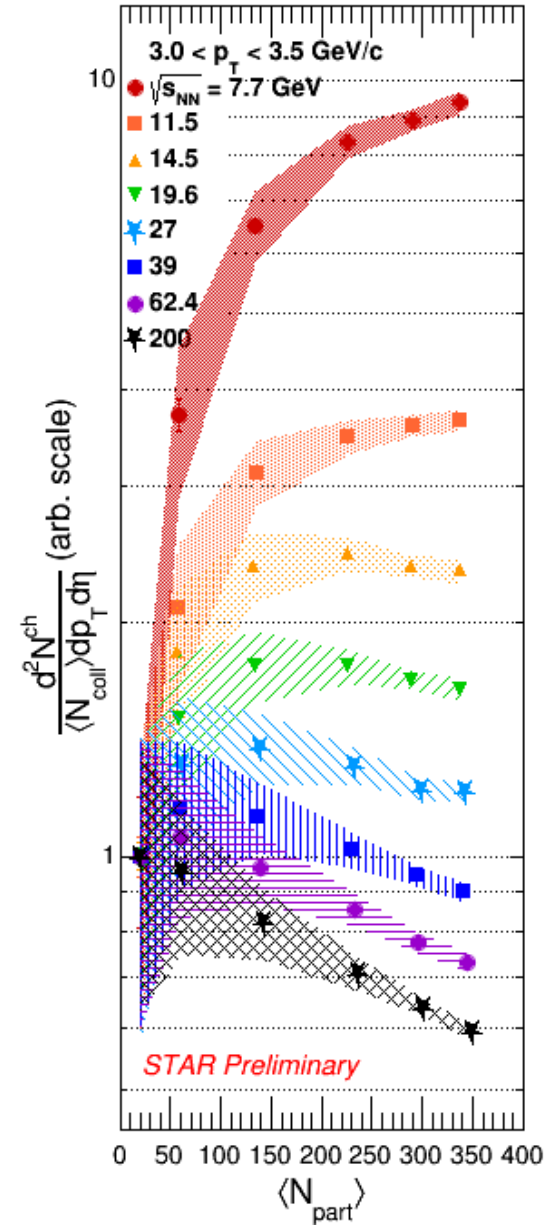
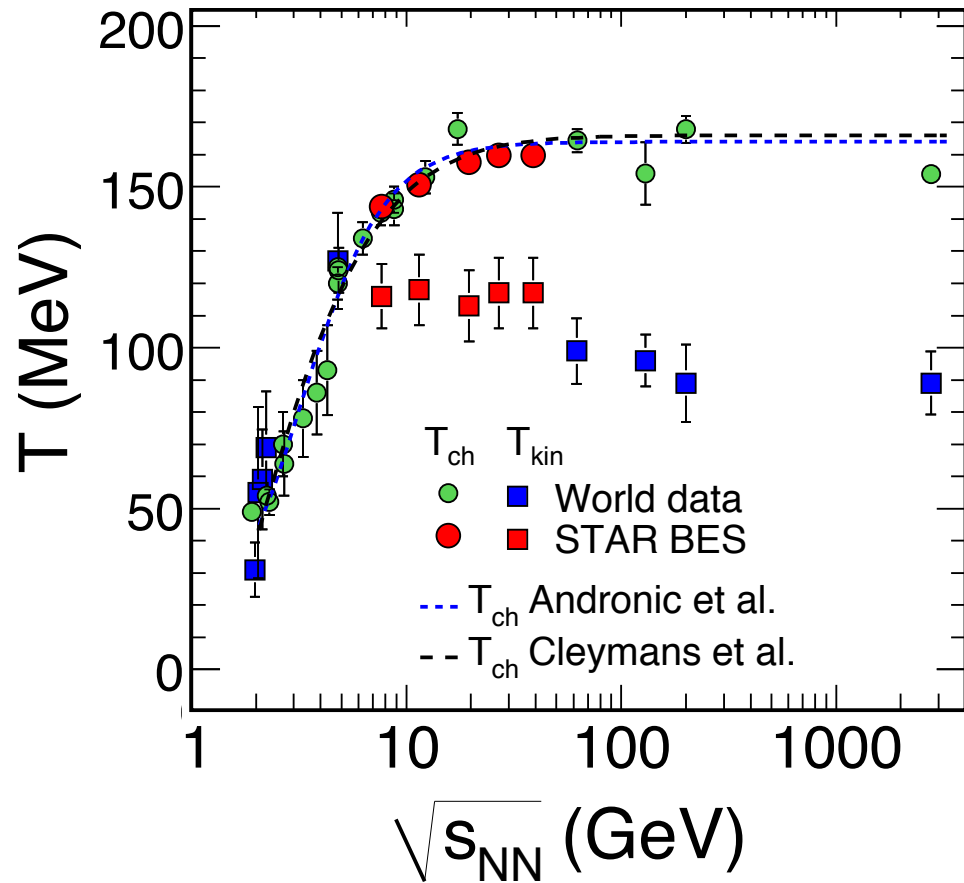
Spectra: Submitted PRC

R_{cp} : Submission PRL this week

BES-I data including 14.5 GeV

Chemical, kinetic, and high p_T analyses of BES-I data completed

Strangeness analysis nearly ready for submission to journal



Most BES-I results (close to being) published

Global Λ polarization

Accepted by Nature

BES-I data including 14.5 GeV

(still under embargo)

Unpredicted BES-I analysis

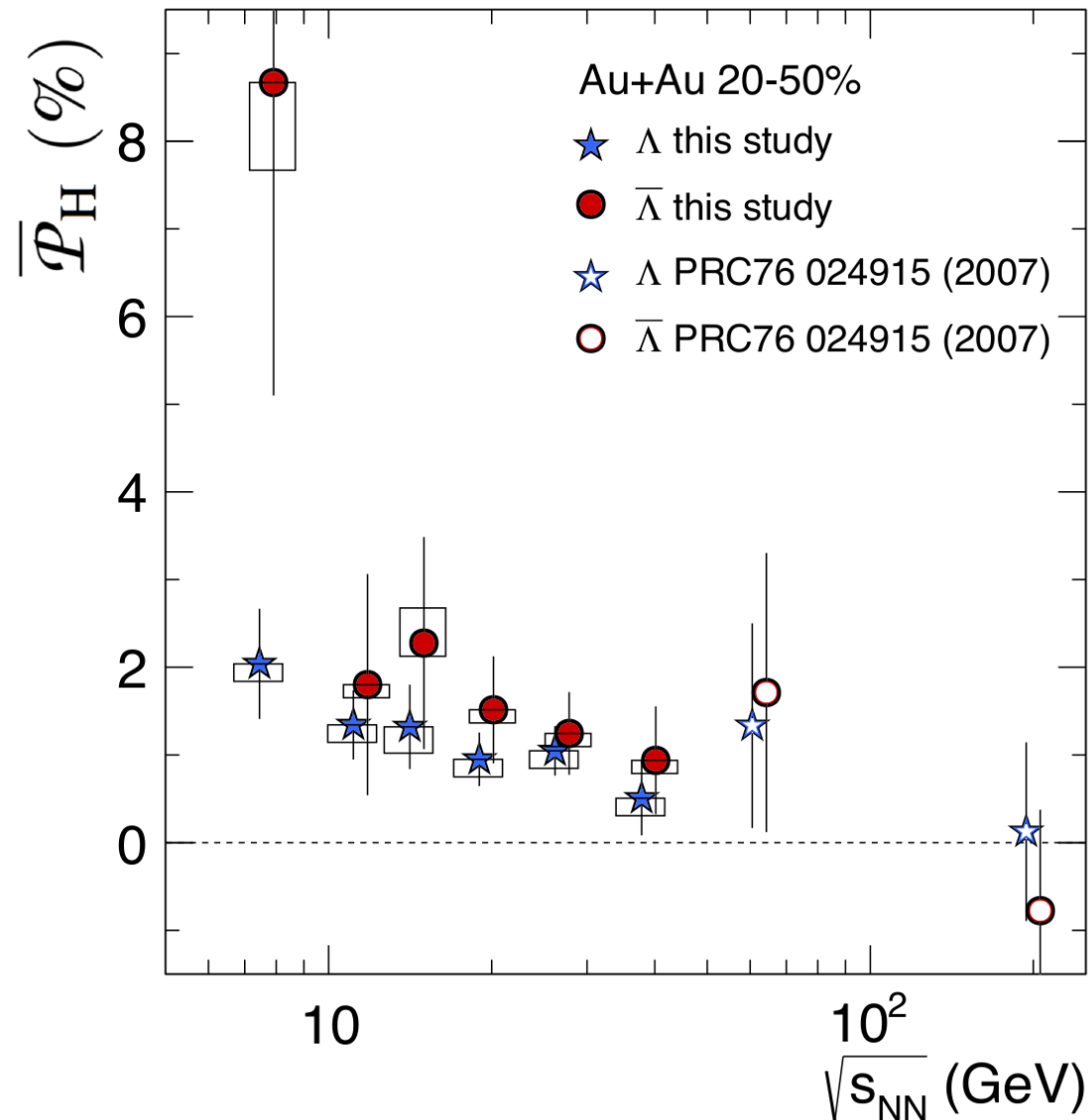
Both Λ and $\bar{\Lambda}$ polarized

Hint that polarization different for anti-particle

Due to coupling to magnetic field?

Need better statistics

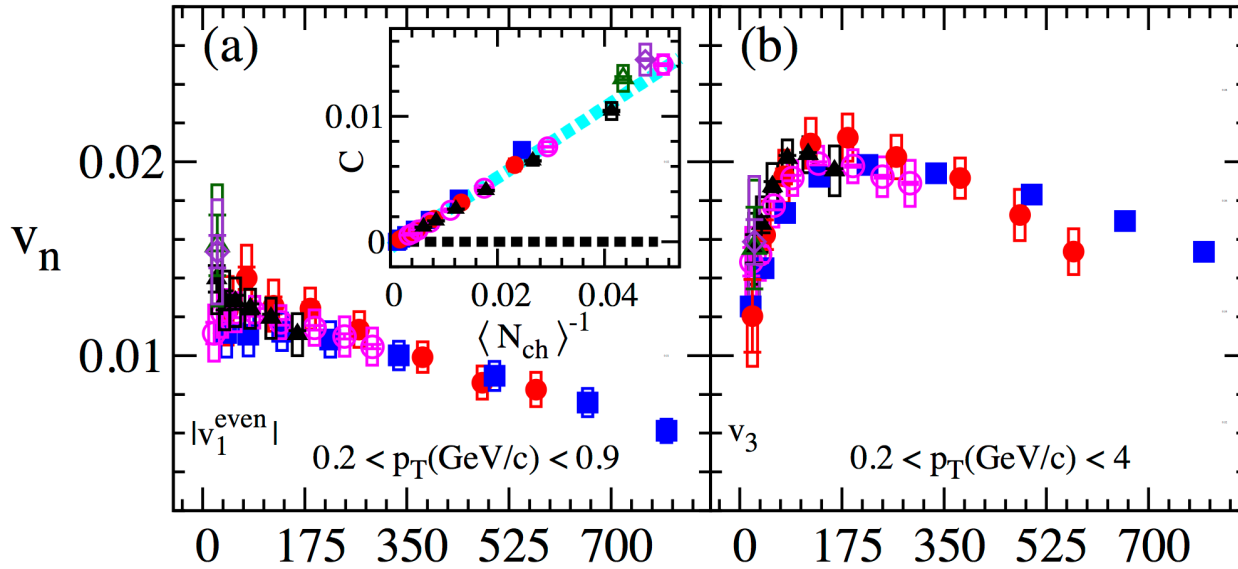
Most vortical system ever



Flow in small system

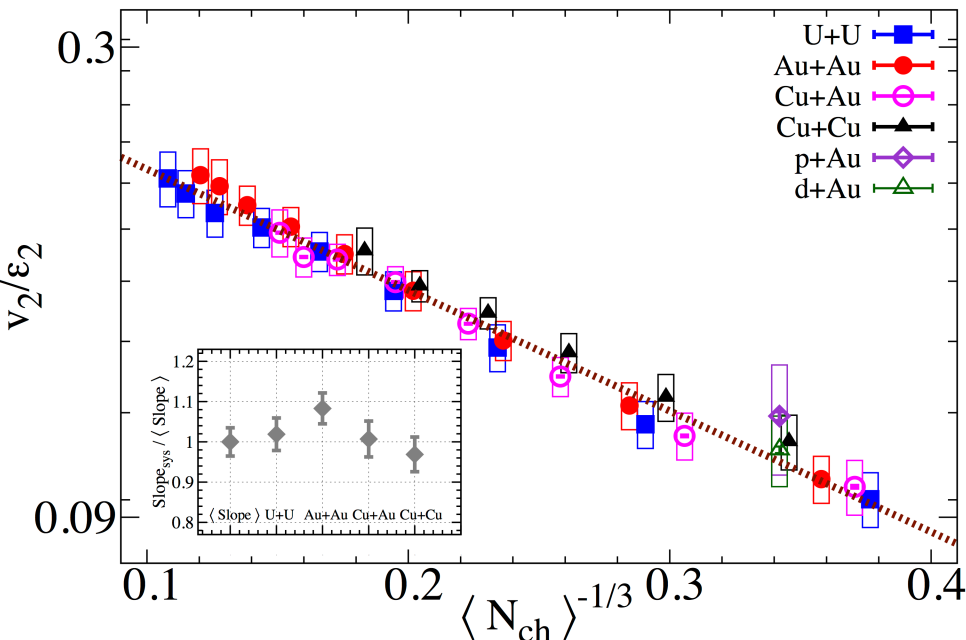
Preliminary release

p+Au, d+Au, Cu+Cu, Cu+Au, Au+Au, U+U at 200 GeV



$v_{1\text{even}}$ and v_3 system independent

$|\eta| < 1$ and $|\Delta\eta| > 0.7$



$\ln(v_2/\epsilon_2)$ scales with $N_{\text{ch}}^{-1/3}$ for all systems

$$v_n/\epsilon_n \propto e^{-A\left(\frac{\eta}{s} \frac{n^2}{S}\right)}$$

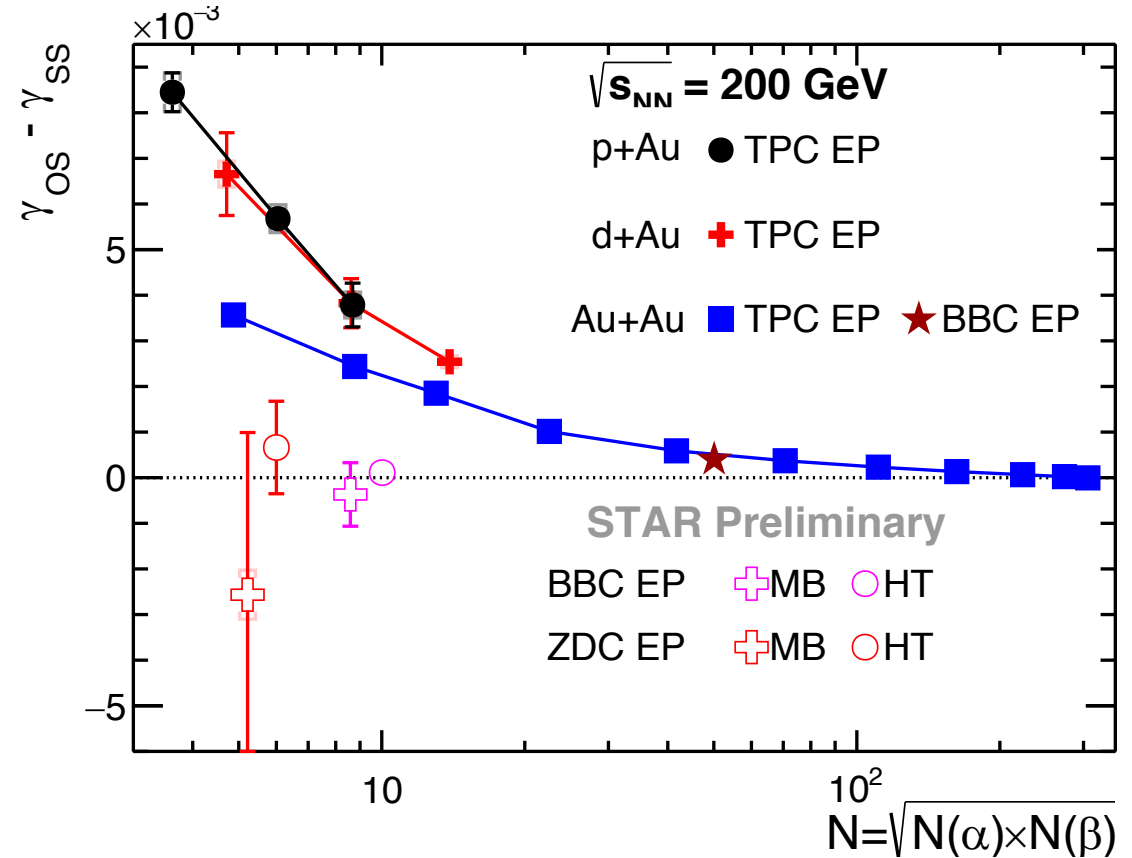
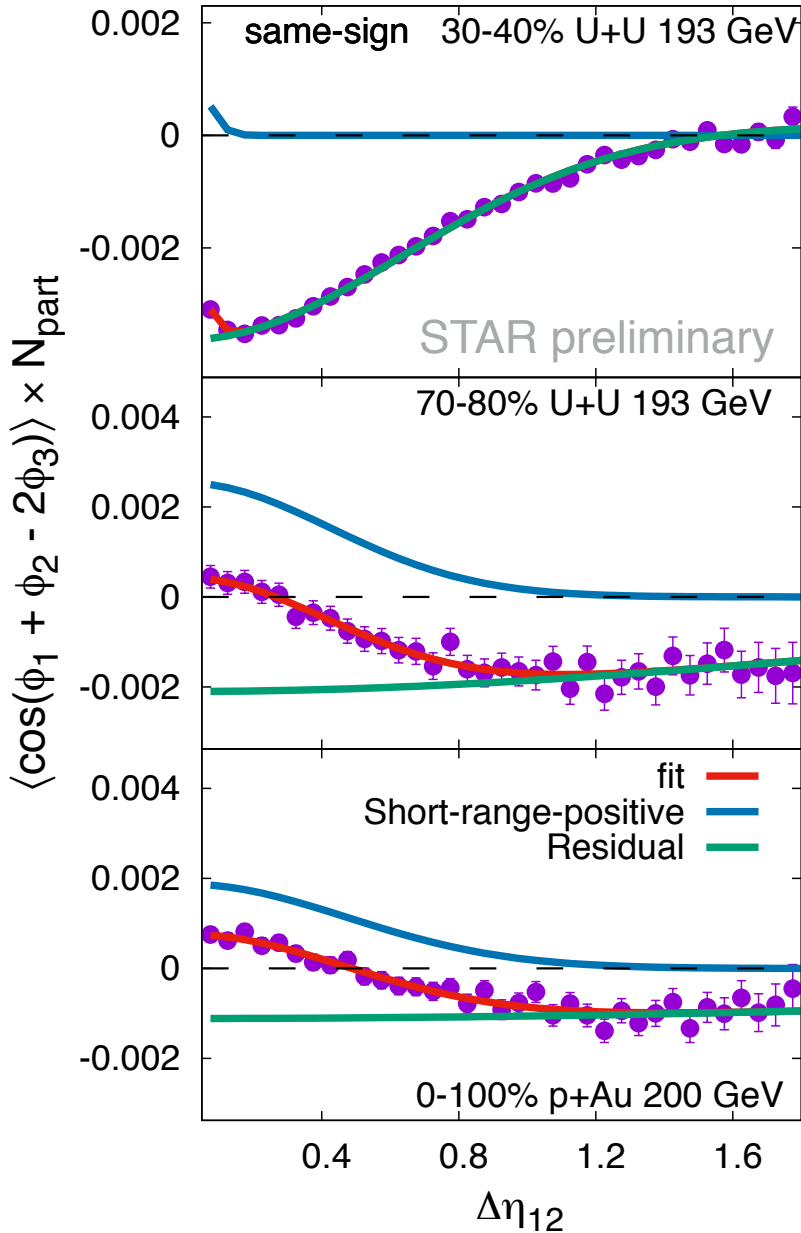
All systems have similar η/s ?

Chiral magnetic effects

Preliminary release

Run 15 p+Au at 200 GeV

Same-sign



Charge separation variable has dependence on correlation conditions

Offline production summary



	Species	Total #of events (M)	% tage events completed	Estimate time to delivery (months)	% tage time to completion
Run 16		9126.46	70.15	2.95	69.76%
	Au+Au 200GeV	6543.26	72.22	2.43	
	d+Au 200GeV	1181.10	32.15	0.44	
	d+Au 62GeV	357.91	90.81		
	d+Au 39GeV	642.12	91.42	0.08	
	d+Au 20GeV	402.08	95.74		
Run 15		10997.37	95.26	0.23	95.68%
	p+p 200GeV	6329.66	96.81	0.10	
	p+Au 200GeV	3647.70	93.29	0.10	
	p+Al 200GeV	1015.11	92.62	0.03	
	Fixed Target 2015	4.76	100.00	0.00	
Run 14		6718.09	84.66	0.39	90.85%
	Au+Au 200GeV	5045.59	96.79	0.22	
	He3+Au 200GeV	1260.30	31.29	0.18	
	Au+Au 14.6GeV	412.20	99.38	0.00	

Production of all past dataset essentially completed

Use of Cori more efficient than use of unused PHENIX CPU cycles

Updated since BUR

Progress towards picodsts



Run 16 data produced in picots format
HFT analysis uses picodsts exclusively

Picodsts development nearly finalized for adoption by whole collaboration

Most recently adding FMS, EMCaI, EPD data

In process of converting “active” older datasets

Since jobs are short and self-contained could be opportunity to use unused PHENIX CPU cycles

Microdst preserved and written directly to tape

Factor 5-7 larger than picodsts

Can (re)make picodsts from microdsts



Summary

12 papers published/accepted since last PAC meeting
including 1 Nature and 3 PRL

18 active GPCs

6 submitted to journals

5 PWGC-previewed paper drafts in PWGs + 35 analyses expected for preview
within ~12 months

Published or preliminary results from most datasets in circulation

37 (55) invited talks in 2017 (2016)

> 60 talks and posters at SPIN16, DIS17, SQM16, HP16, QM17

Essentially all previous datasets produced

Conversion to picodsts begun

Significant allocation granted to run on NERSC/Cori

Successfully running production, and simulation, on HPC resources

Run 17 p+p data mostly calibrated during run

Final calibration underway before production starts

Another very productive year