Ω production in p+p, Au+Au and U+U collisions at STAR

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For the STAR Collaboration

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XXIV QUARK MATTER
DARMSTADT 2014

Outline

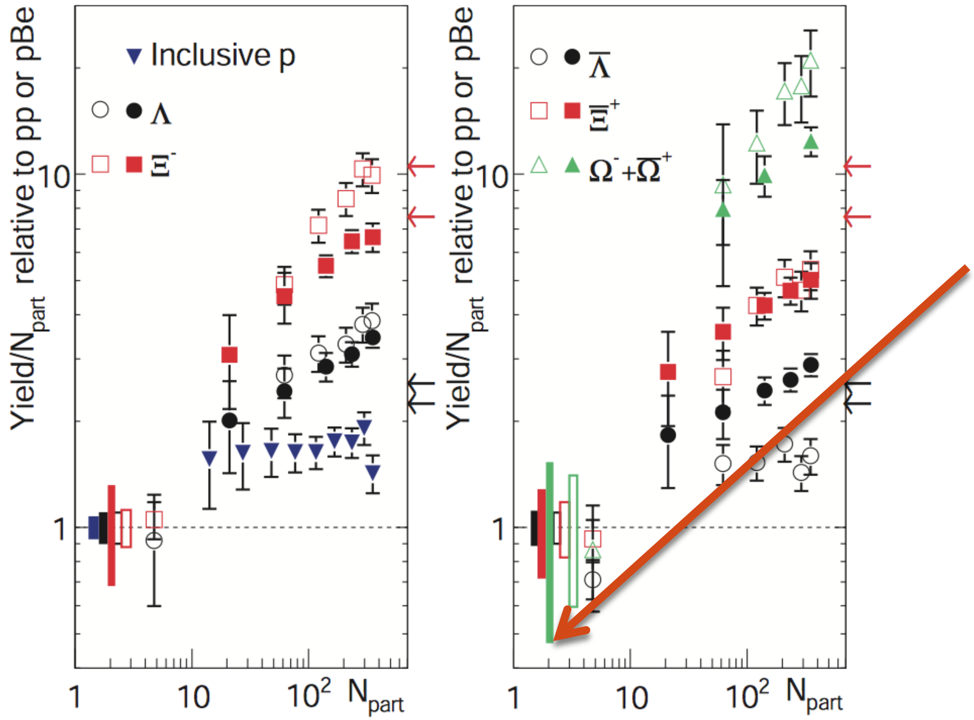
- Motivation
- STAR detector and Ω reconstruction
- Ω spectra
- Strangeness enhancement factors
- Particle ratios
- Nuclear modification factors
- Summary

Motivation

- Strange quark
  - current mass ~100 MeV < T_c
  - pair produced in heavy-ion collisions (total $S = 0$)
- Baryon with **only** strange quarks: **Ω (sss), $\bar{\Omega}(\bar{s}\bar{s}\bar{s})$**
  - small hadronic cross section
  - no feed down from excited states
  - sensitive to the early stage dynamics of the medium
- Key observables:
  - Strangeness enhancement factors – canonical suppression
  - Particle ratios – chemical equilibration
  - Nuclear modification factors – interplay of strange quark energy loss and recombination/coalescence

Motivation

- Ω in p+p 200 GeV
  - provide the baseline for strangeness enhancement study



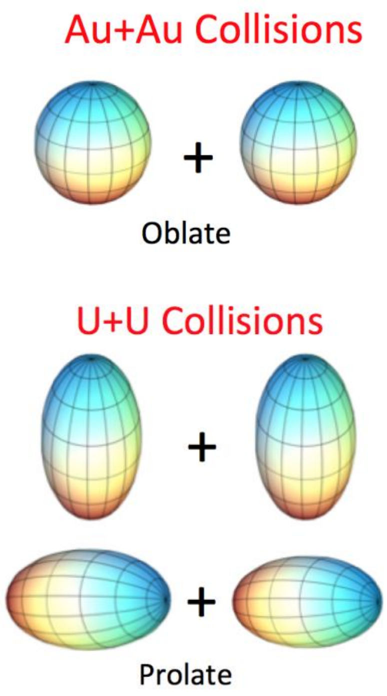
Large errors (2001-2002 data)

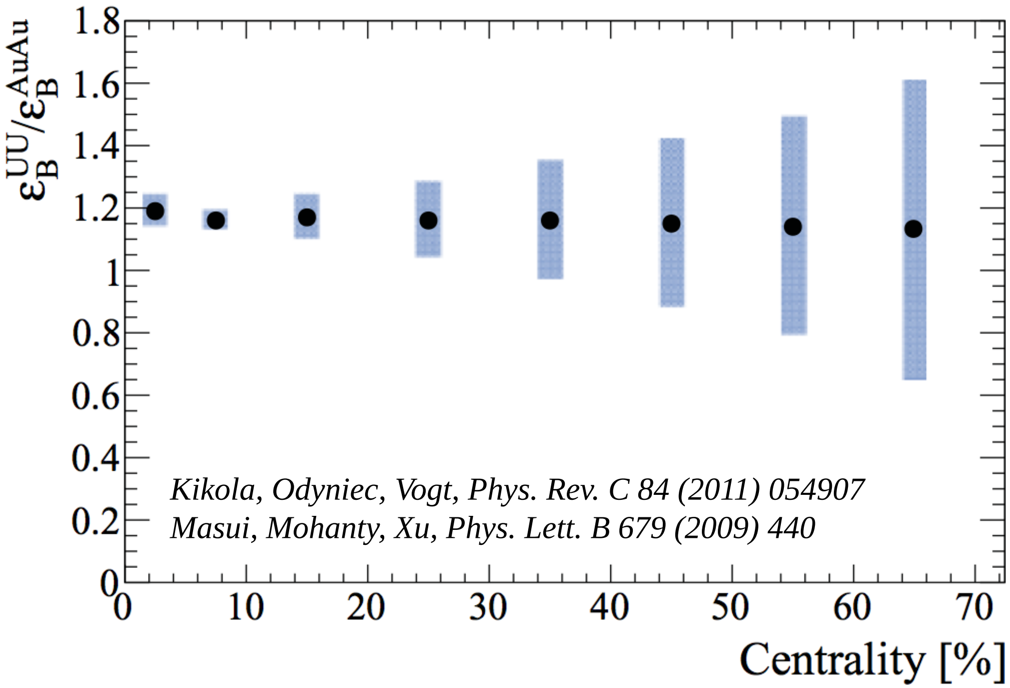
~**18 times** more p+p data were taken in year 2009!

STAR, Phys. Rev. C **77** (2008) 044908

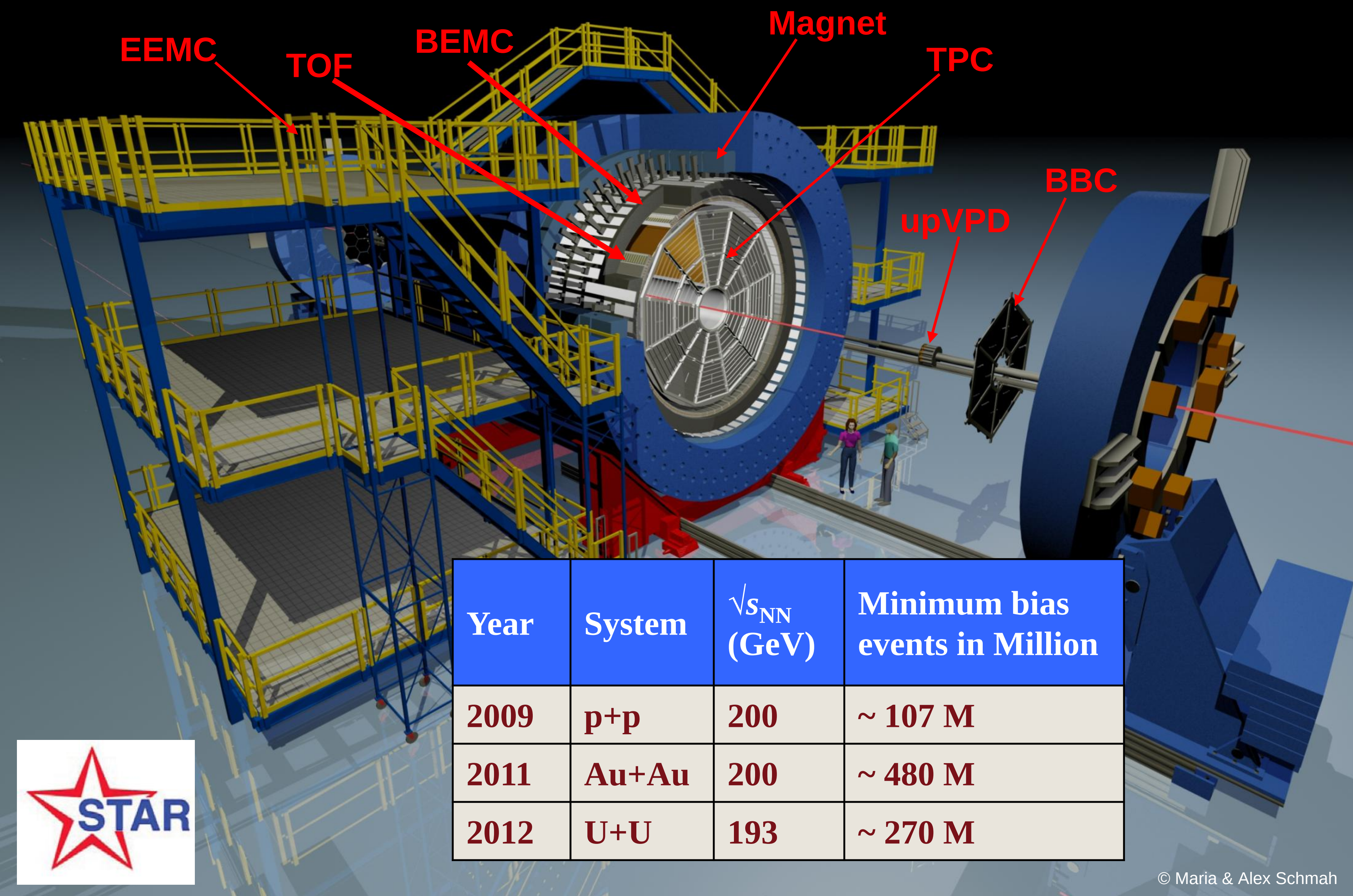
Motivation

- Ω in **Au+Au** vs in **U+U**
  - U+U collisions expected to have **20% higher** energy density
  - How is the Ω enhancement in U+U?
  - Ω yield suppressed at high p_T in Au+Au?
    and even more suppressed in U+U?





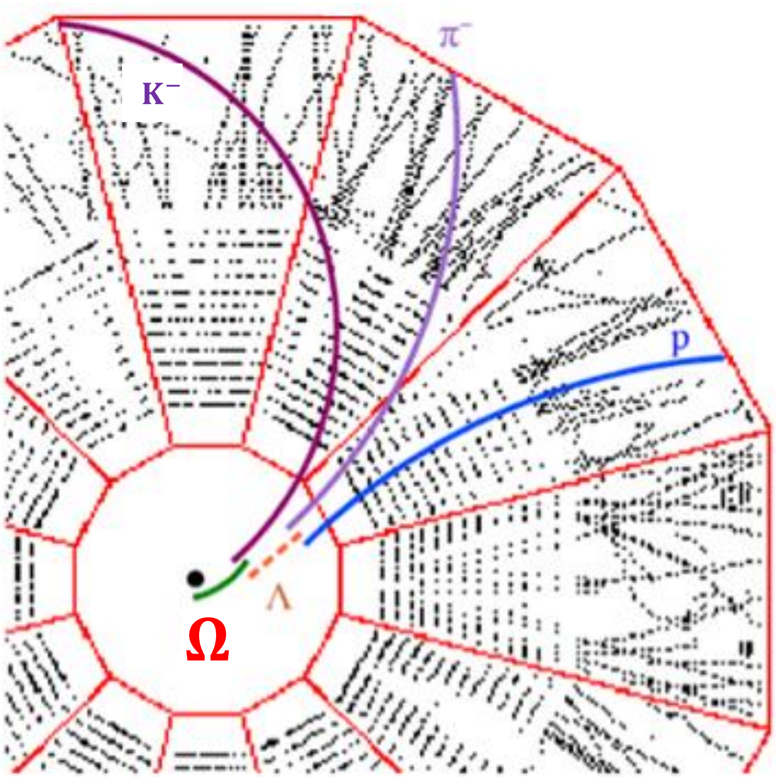
The Solenoidal Tracker At RHIC (STAR)

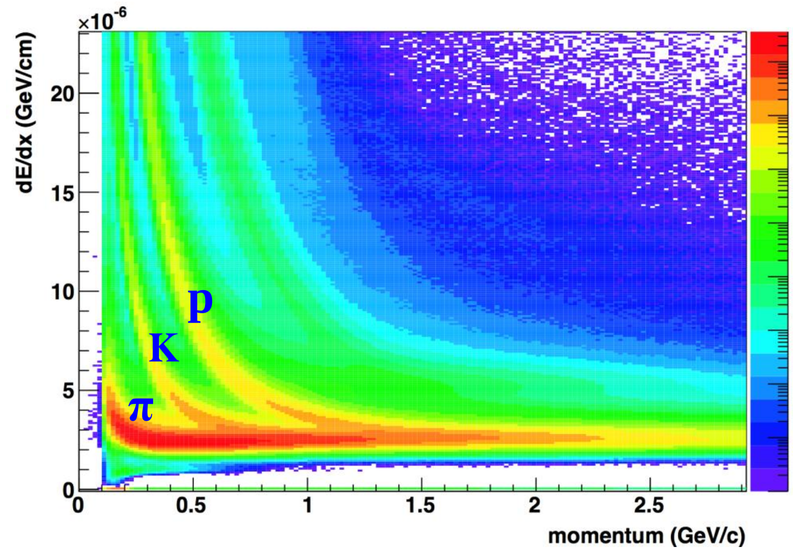


Year	System	$\sqrt{s_{NN}}$ (GeV)	Minimum bias events in Million
2009	p+p	200	~ 107 M
2011	Au+Au	200	~ 480 M
2012	U+U	193	~ 270 M

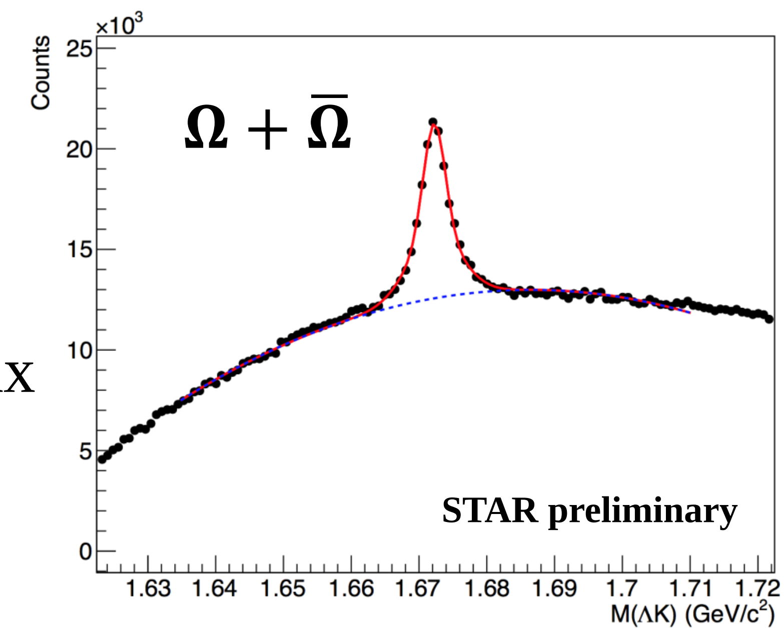
STAR

Ω reconstruction in STAR



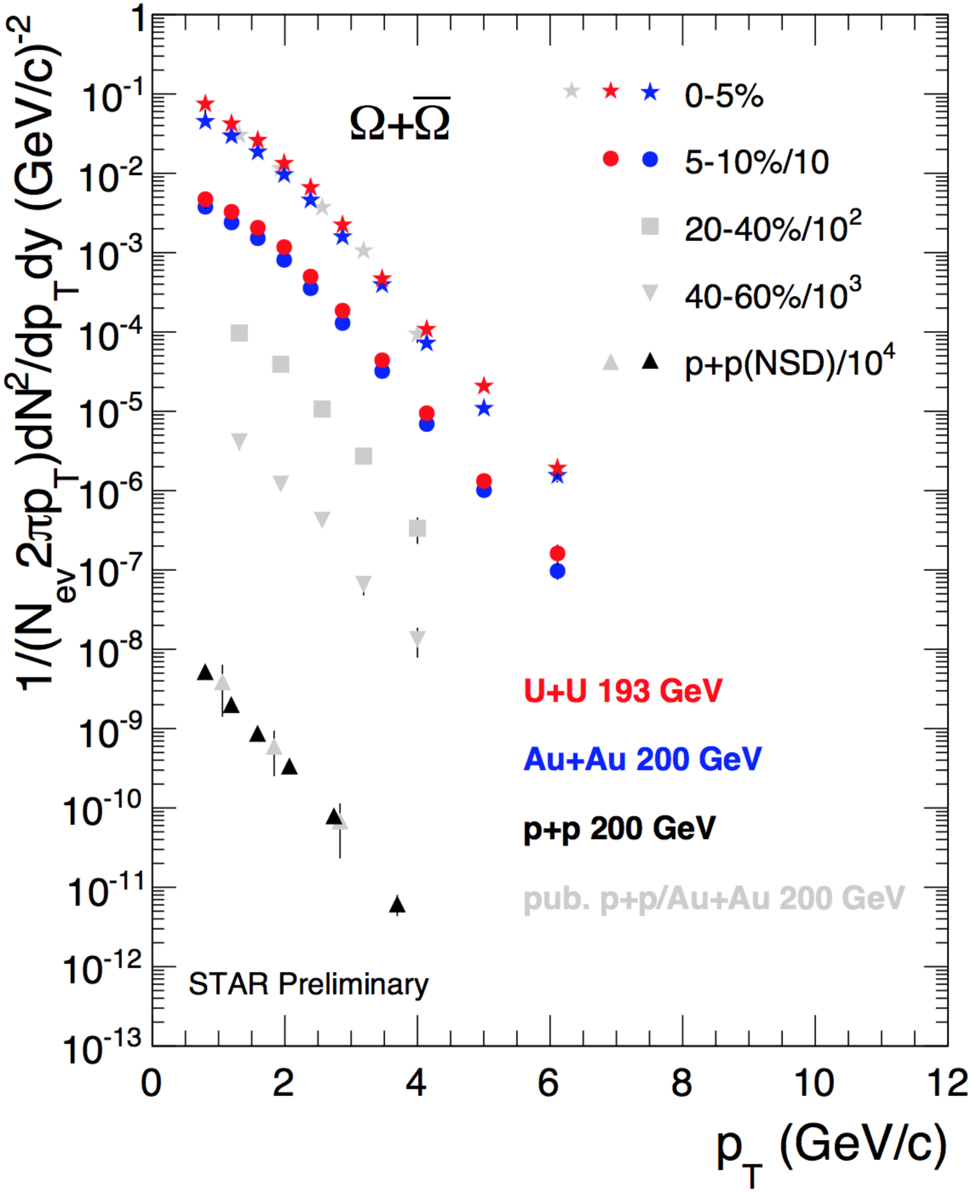


$\Omega+\bar{\Omega}$, Au+Au 200 GeV, 0-5%, p_T 0.6-7.0 GeV/c



- $\Omega \rightarrow \Lambda + K \rightarrow (p+\pi) + K$
- π ,K, p are identified with TPC dE/dx
- reconstruct the secondary vertex

p_T spectra



* $|y|<0.5$, *statistical error only*

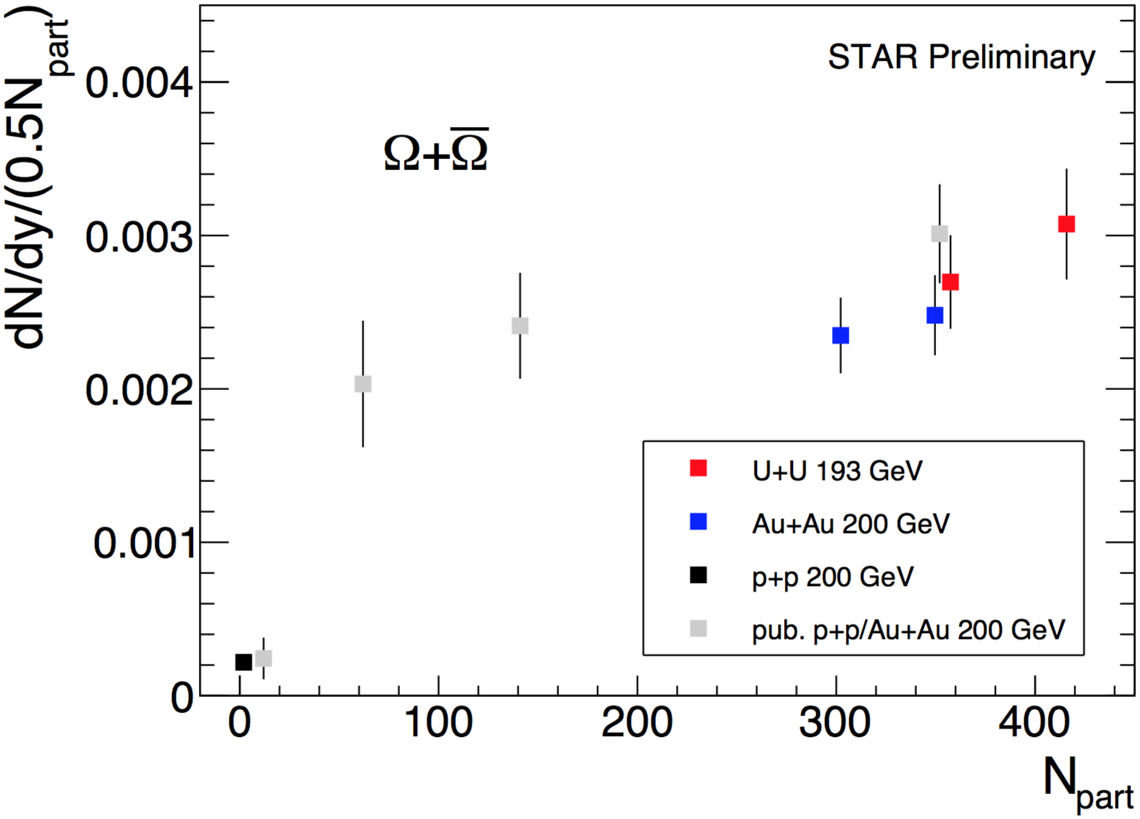
STAR, Phys. Rev. C 75 (2007) 064901

STAR, Phys. Rev. Lett. 98 (2007) 062301

* *only central (0-5, 5-10%) new Au+Au and U+U data available so far*

- Maximum p_T ~ 6 GeV/c for both Au+Au and U+U central collisions
- Yields (U+U > Au+Au)

Centrality dependence of yields



|y|<0.5 for new p+p, Au+Au and U+U data

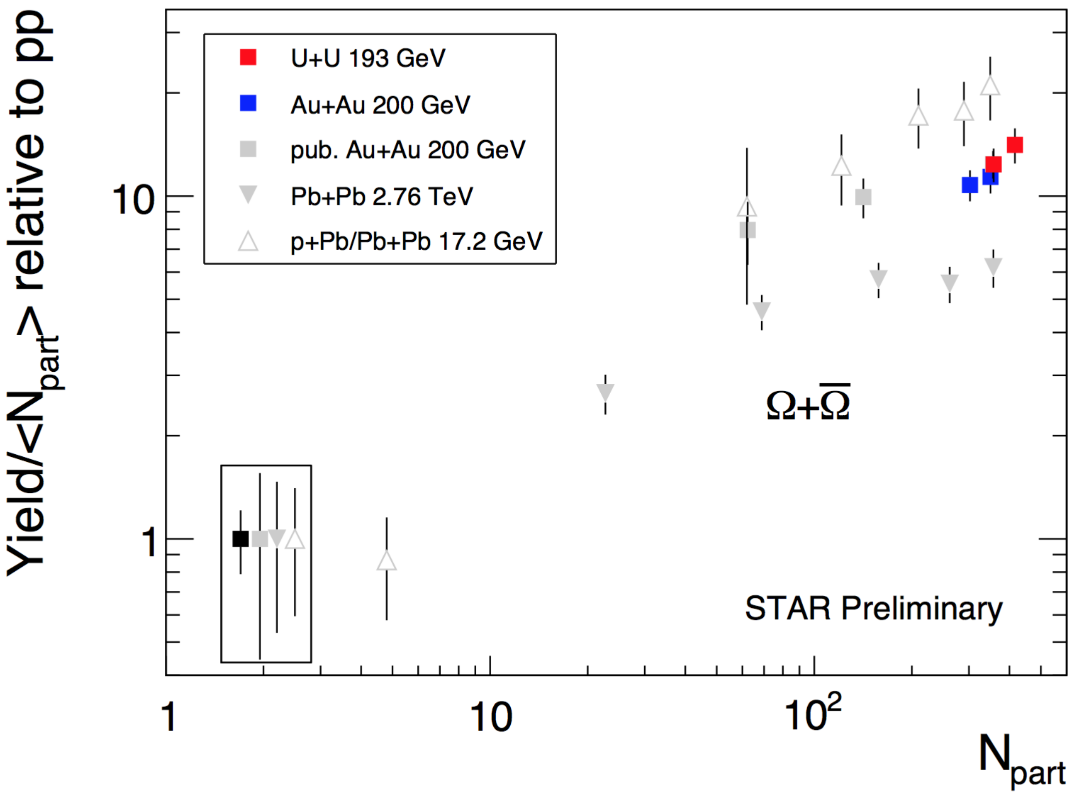
Systematic errors dominate

STAR, Phys. Rev. C 75 (2007) 064901

STAR, Phys. Rev. Lett. 98 (2007) 062301

- Ω baryon yield per participant increases with N_{part}

Strangeness enhancement factor



New p+p 200 GeV data as reference for both new Au+Au 200 GeV and U+U 193 GeV

ALICE, Phys. Lett. B 728 (2014) 216

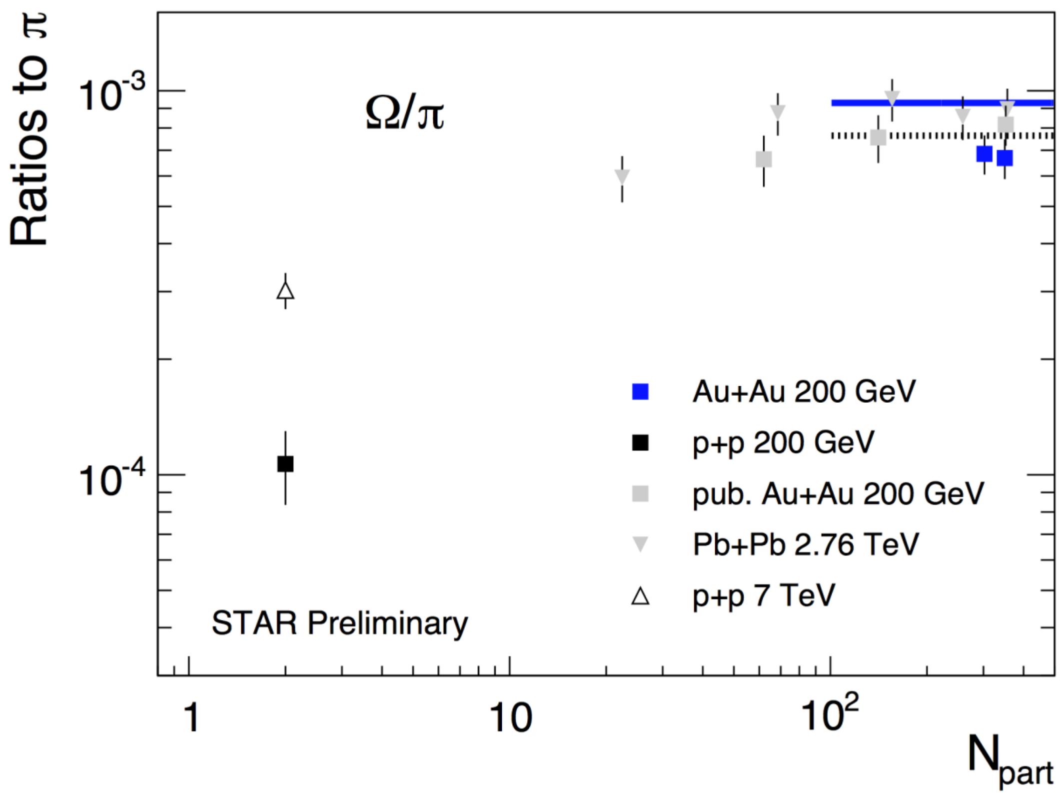
NA57, J. Phys. G 32 (2006) 427;

NA57, J. Phys. G 37 (2010) 045105

STAR, Phys. Rev. C 77 (2008) 044908

- Significantly reduced reference uncertainty at RHIC
- Larger enhancement than LHC, lower than SPS
- Larger enhancement in central (0-5%) U+U than in central (0-5%) Au+Au (strangeness enhancement not saturated)

Ratios to pion



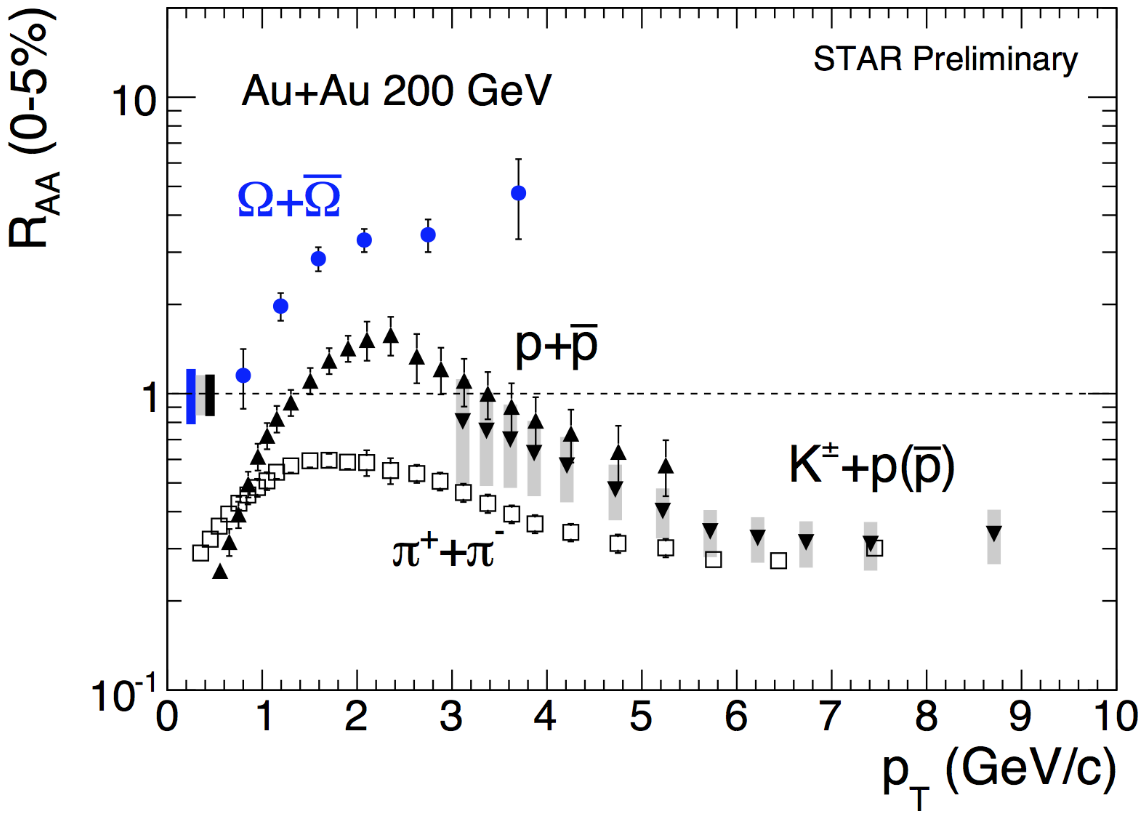
Thermal models:

Fitting to RHIC, *Andronic, et al., Phys. Lett. B 673 (2009) 142; Phys. Lett. B 678 (2009) 516*

Fitting to LHC, Stachel, et al., arXiv: 1311.4662

- RHIC data is lower than LHC
- Lower than thermal model fitting results for RHIC
- Ω/π (LHC>RHIC) in p+p, canonical suppression

Nuclear modification factor (R_{AA})



$$R_{AA} = \frac{\sigma_{NN}^{\text{inel}}}{N_{\text{bin}}^{AA}} \frac{d^2N_{AA}/dyd\,p_T}{d^2\sigma_{pp}/dyd\,p_T}$$

Statistical error only for Ω

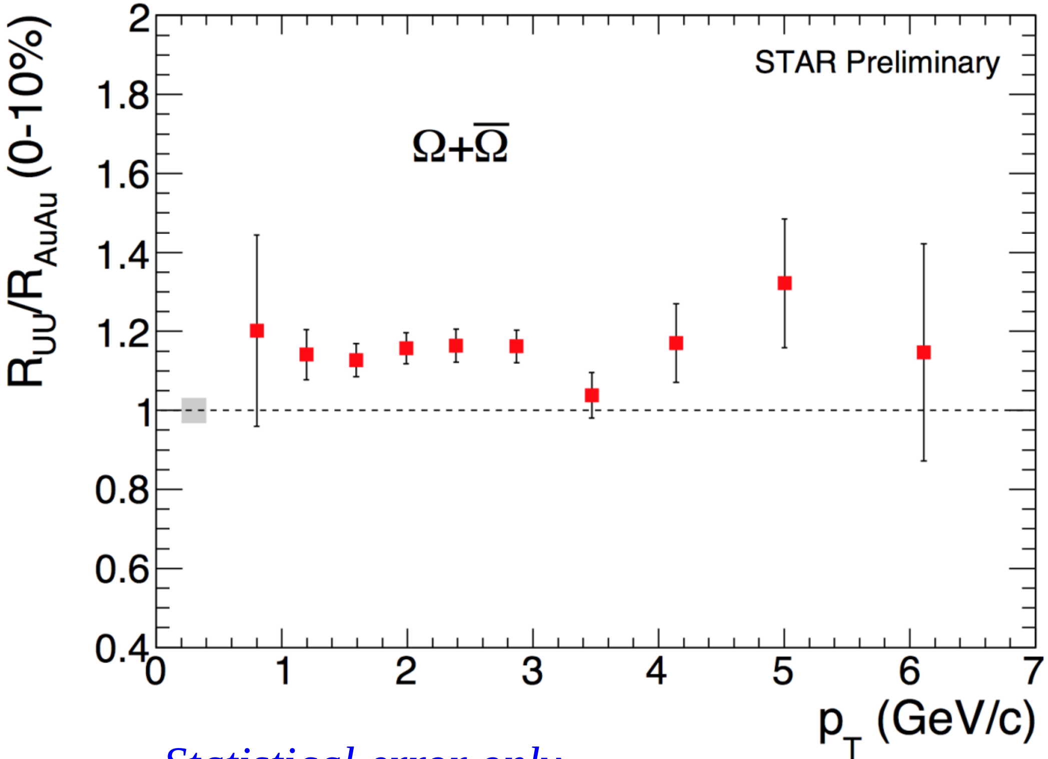
$\pi^+ + \pi^-$ and $p + \bar{p}$: *0-12%,*
STAR, Phys. Rev. Lett. 97 (2006) 152301
STAR, Phys. Lett. B 637 (2006) 161
STAR, Phys. Rev. C 81 (2010) 054907

$K^{\pm} + p(\bar{p})$: *0-12%,*
STAR, Phys. Rev. Lett. 108 (2012) 072302

- Ω baryon R_{AA} much larger than proton/pion up to 4 GeV/c

  → Interplay of strange quark energy loss and coalescence or recombination

Ratio of nucl. mod. factors (R_{UU}/R_{AuAu})



Statistical error only

Higher energy density

→ Jet more quenched

R_{UU}/R_{AuAu} < 1 at high p_T

→ Strangeness enhancement

(Coalescence?)

R_{UU}/R_{AuAu} > 1 at intermediate p_T

** Au+Au 200 GeV 0-10%*

N_{part} = 325 ± 4; N_{bin} = 941 ± 26

** U+U 193 GeV 0-10%*

N_{part} = 387 ± 4; N_{bin} = 1151 ± 18

The energy density in central U+U is expected to be 20% higher, but N_{bin}-scaled high p_T Ω yield is not suppressed

→ Ω formed through coalescence/recombination up to p_T ~ 6 GeV/c ?

Summary

- Precision measurement for Ω was made at STAR with high statistics p+p, Au+Au, U+U at top RHIC energies
- Ω enhancement factors from RHIC are in between SPS and LHC
- Ω canonical suppression may still remain in central Au+Au collisions
  - Larger strangeness enhancement in central U+U
  - Lower Ω/π ratio than LHC and thermal model
- Ω R_{AA} (0-5%) is above 3 up to 4 GeV/c and R_{UU}/R_{AuAu} (0-10%) does not show suppression up to 6 GeV/c
  → Ω formation in central collisions may be dominated by strange quark coalescence/recombination up to p_T ~ 6 GeV/c