4th International Conference on New Frontiers in Physics ICNFP 2015

STAR heavy-ion highlights

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Outline

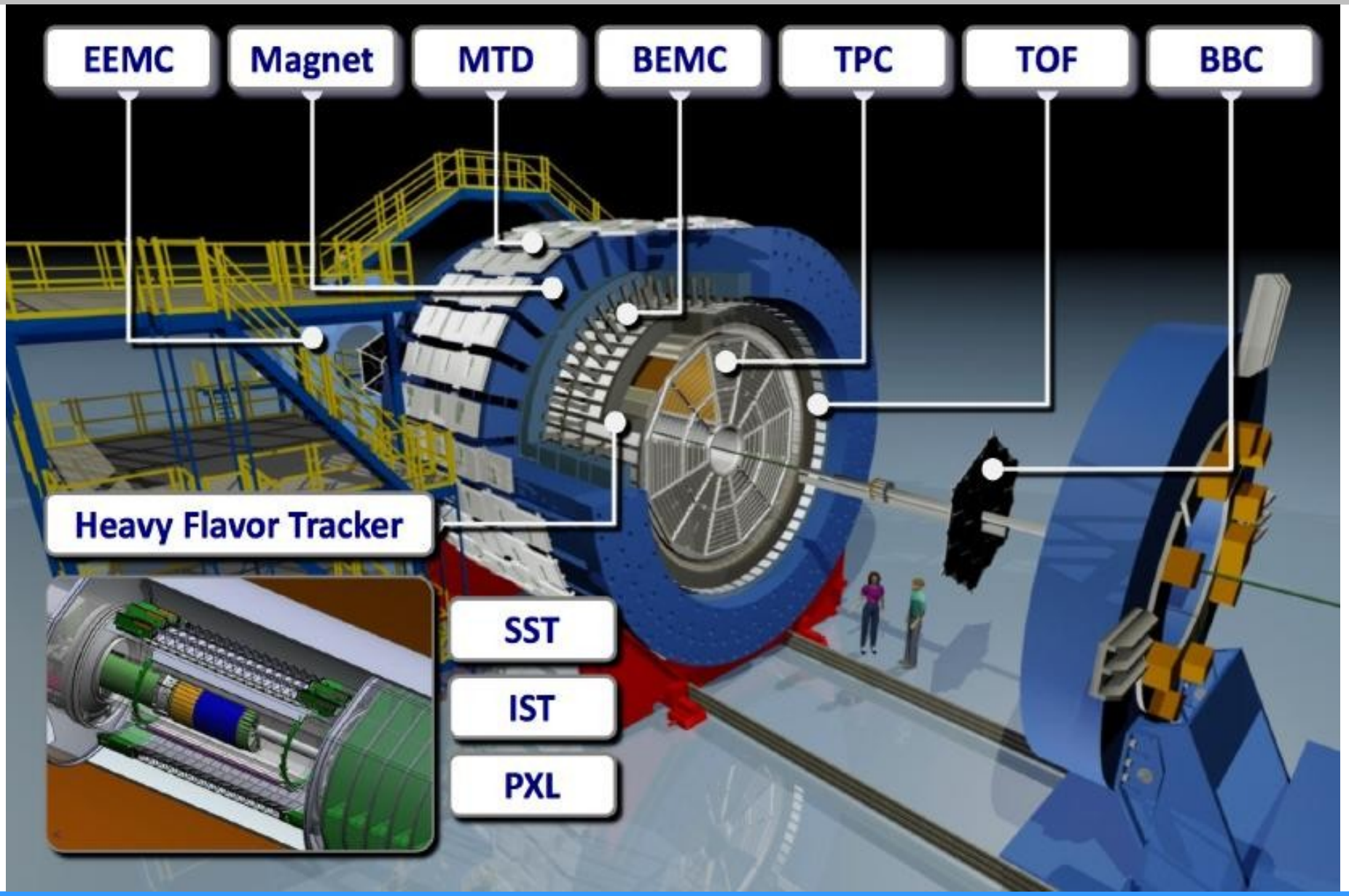
- Jet measurement: Semi-Inclusive recoil jet spectrum
- BES I program and BES II plan and upgrade
- Quarkonium measurements: J/ψ
  ϒ in Au+Au and U+U collisions
- D^0 with HFT
- STAR future plan

Quarkonia with STAR at RHIC
Sonja Kabana **TH 17:00**

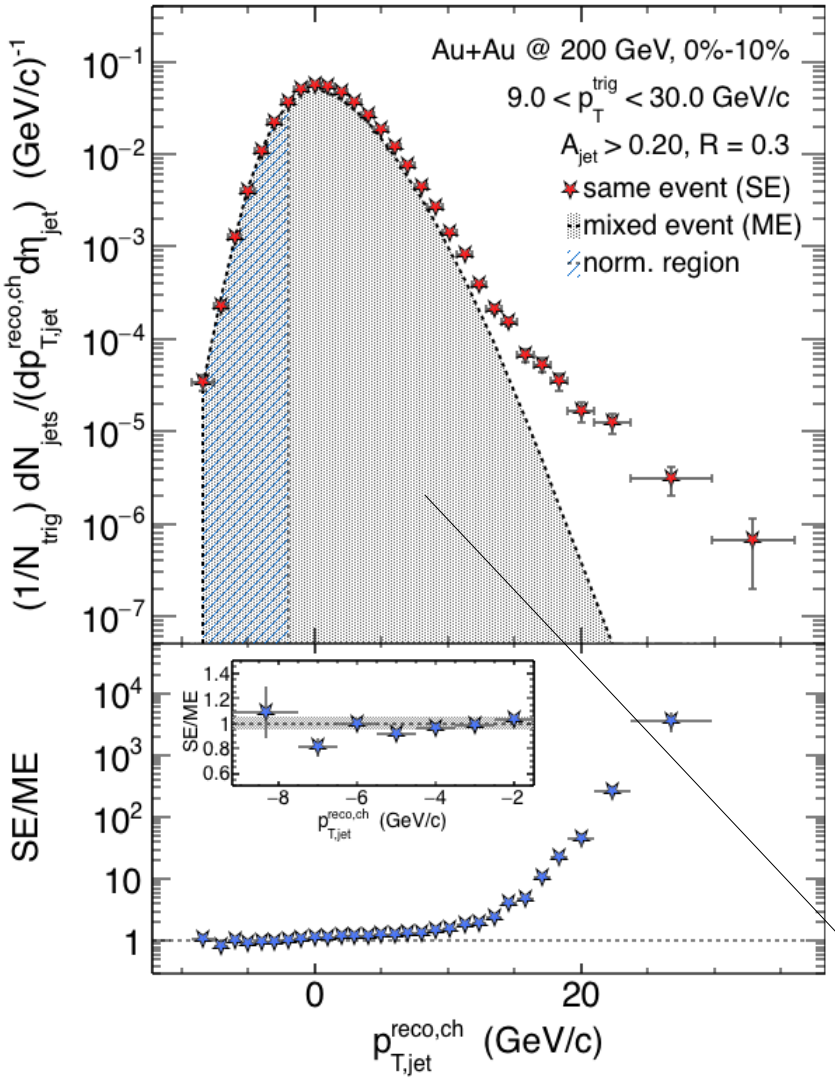
Non-photonic electrons at STAR
Katarina Gajdošová **WE 18:05**

Femtoscopy at STAR
Jindřich Lidrych **Poster session**

STAR detector system

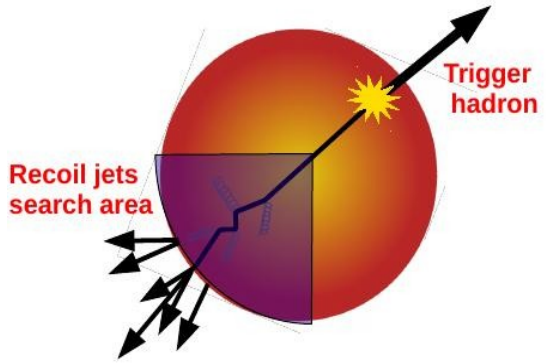


Semi-Inclusive Recoil Jet Spectrum



Trigger: high-p_T hadron → selection of hard processes

Recoil side: all jet candidates within ± 45°

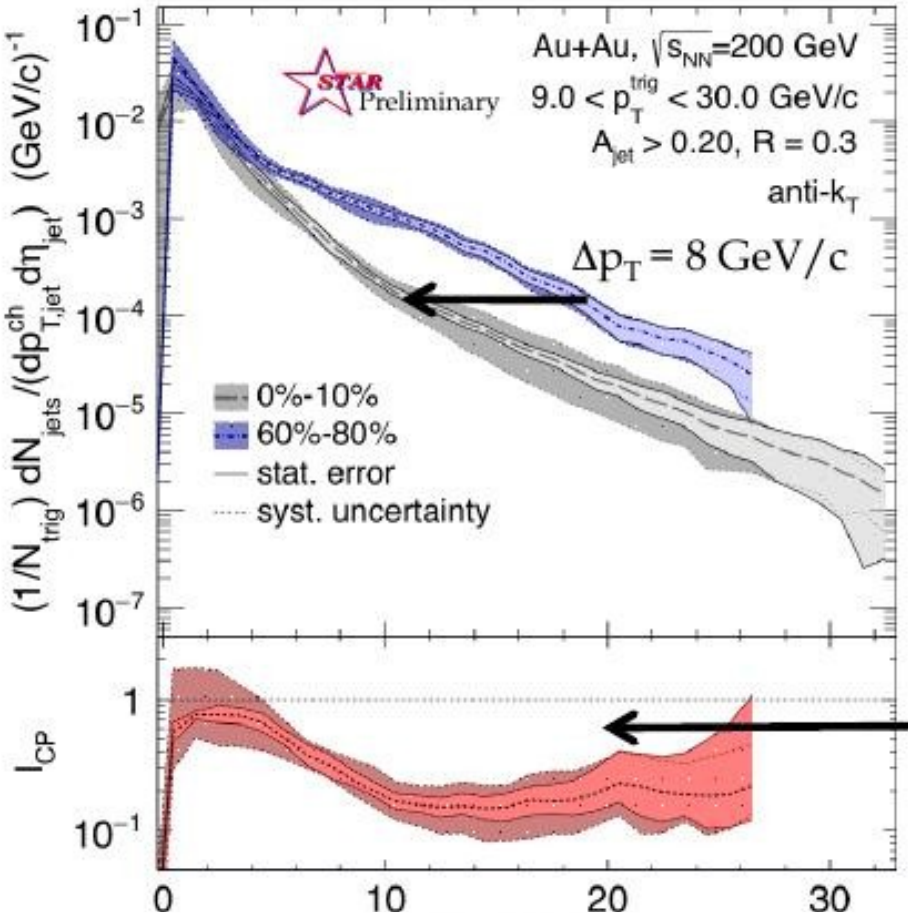


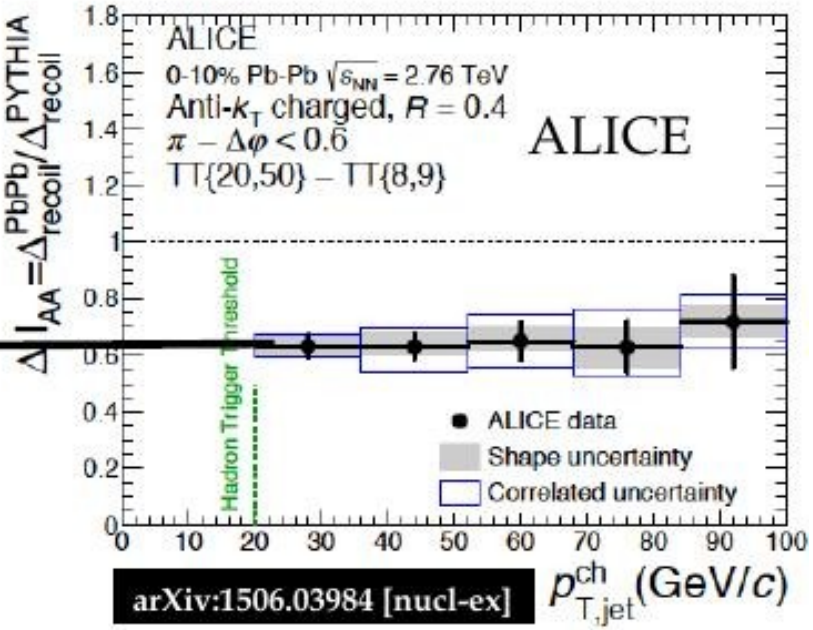
- **Combinatorial background -> fake jets -> described by mixed event background**
- Excelent description of low p_T SE spectrum with ME spectrum.
- Significant jet signal at $p_T^{reco}=p_T-\rho A$ > 10GeV/*c*

Combinatorial jet background – described statistically by mixed event technique.

Central to peripheral - I_{CP}

- Significant suppression at p_T>10 GeV/c
- I_{CP} close to 1 at low p_T
- **Larger suppression compared with ALICE.** (different R, different background, different reference, subtraction method, but similar shift in Δp_T)



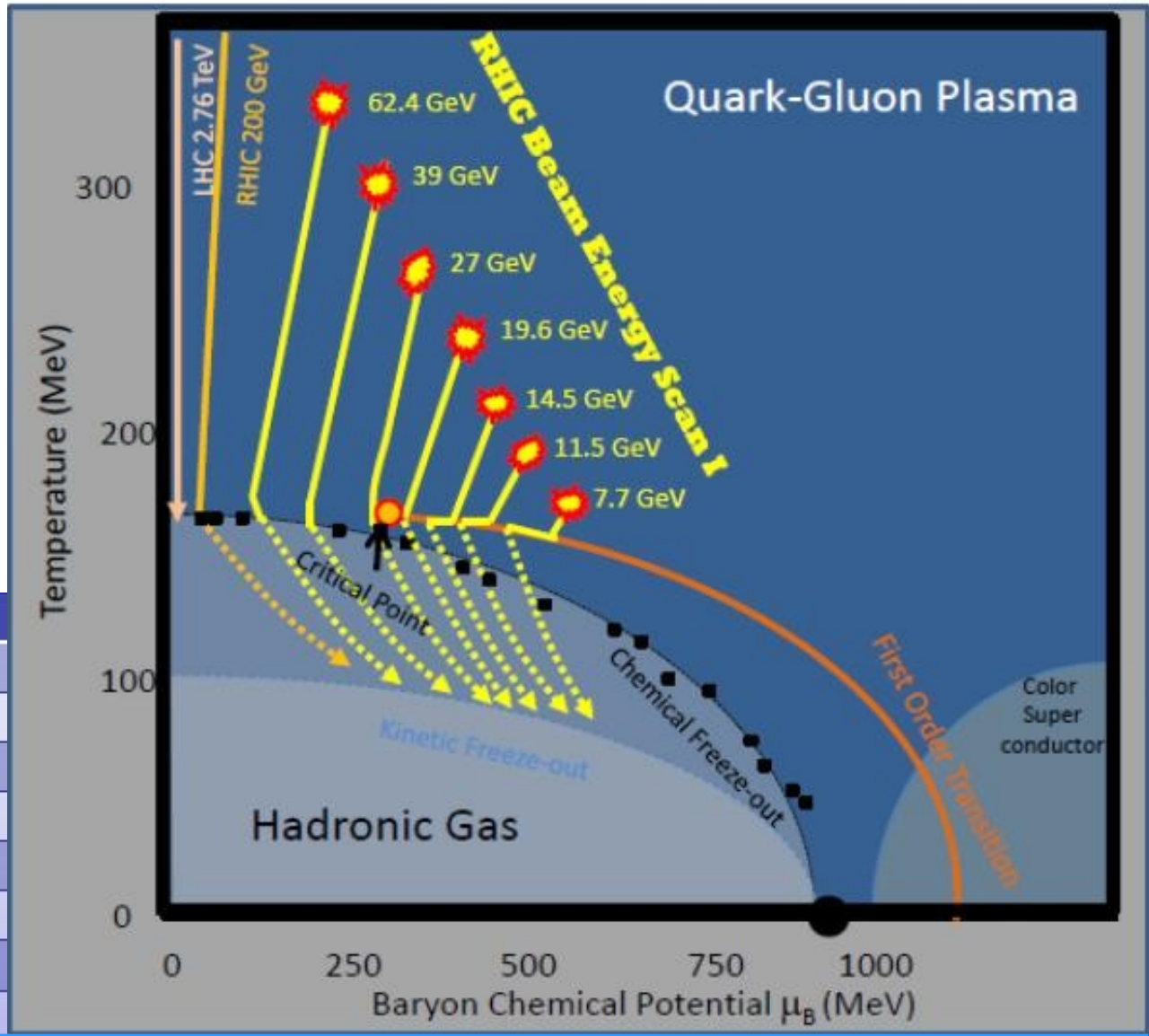


STAR Beam Energy Scan Program

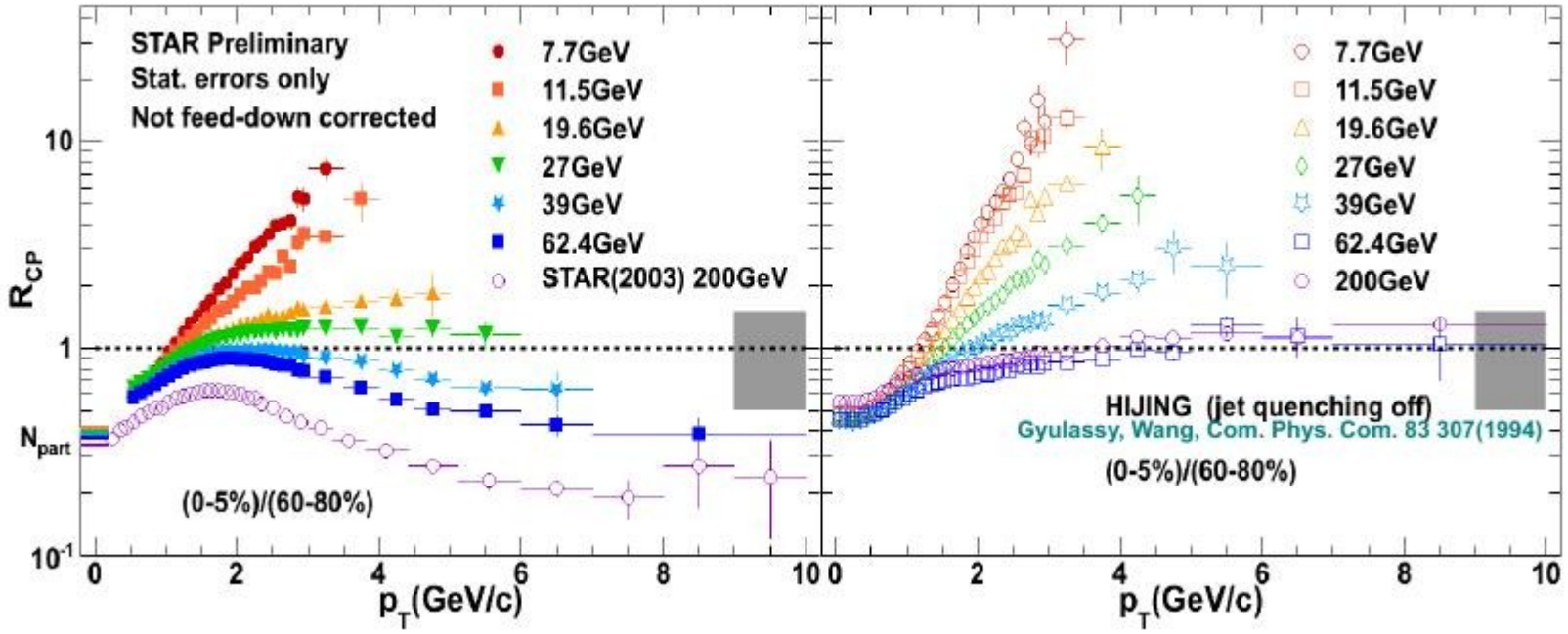
Main goals of BES I and BES II:

- *1st order phase transition?*
- *The QCD critical point?*
- *Chiral symmetry restoration?*
- *Turn-off of QGP signatures*

$\sqrt{s_{NN}}$ (GeV)	μ_B (MeV)	#Events	#Weeks	Year
200	20	350 M	11	2010
62.4	70	67 M	1.5	2010
39.0	115	130 M	2	2010
27.0	155	70 M	1	2011
19.6	205	36 M	1.5	2011
14.5	260	20 M	3	2014
11.5	315	12 M	2	2010
7.7	420	4 M	4	2010



Nuclear modification factor R_{CP}



- R_{CP} suppression at high p_T for $\sqrt{s_{NN}}$ >= 39 GeV → signature for partonic energy loss.
- R_{CP} is increasing towards lower energies → change of energy loss?

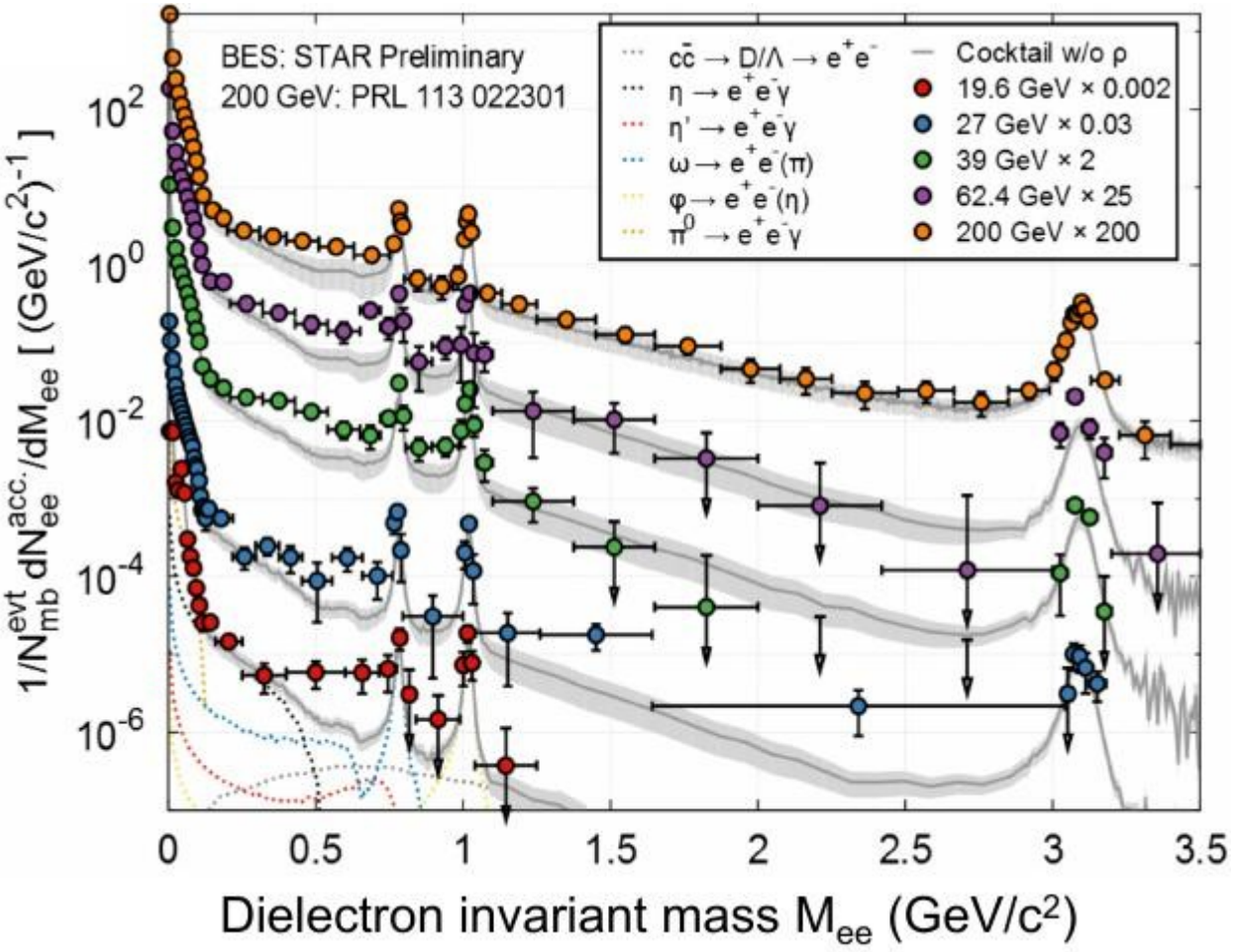
- Radial flow is widely changing over the BES energy range
- Hijing calculation with Cronin effect but without partonic energy loss shows similar trends
- Indicates high pT high energy suppression is due to jet quenching.

Di-electron spectra in BES I

- Systematic study of di-electron production at energies 19-200 GeV.
- Agreement of di-electron data and cocktail w/o ρ meson over the whole mass range for all energies.

BES II - plan

- High statistics at energies below 20 GeV nedded
- Study of chiral symmetry restoration at low μ_B



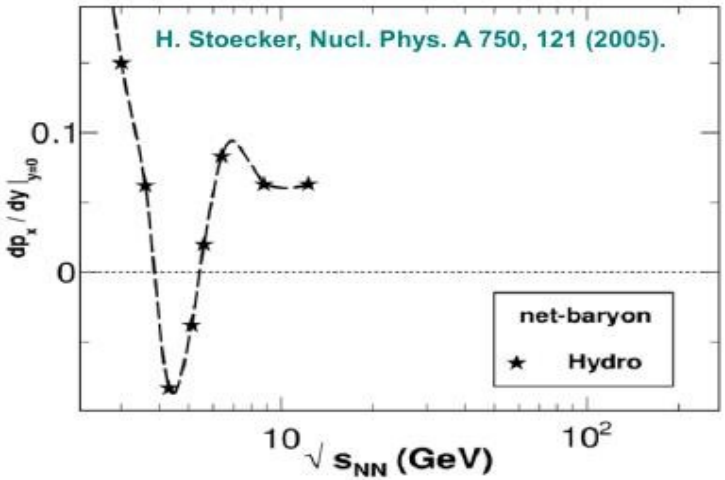
Net Proton v_1 slope

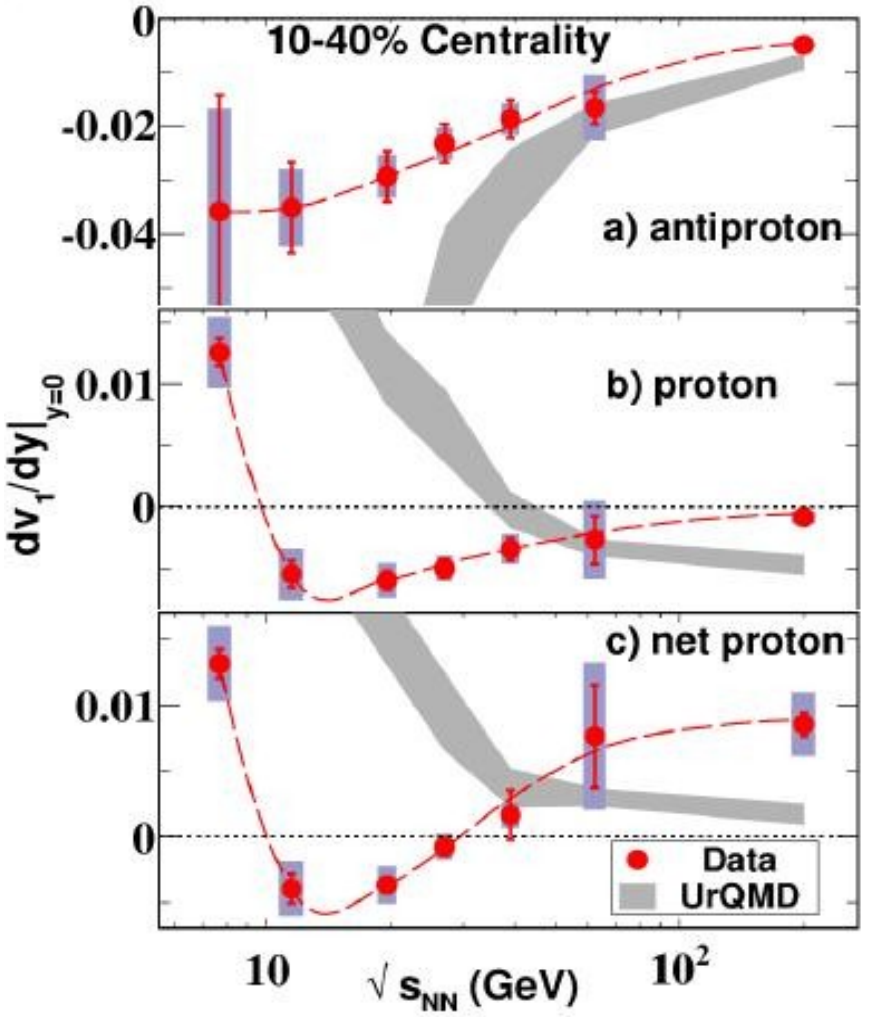
v_1 slope as a function of beam energy

Net-proton double sign change

→ Dip in net-proton dv_1/dy reproduces theory prediction (but in different location)
→ *Softest point of EoS?*

***Is there a first order phase transition and where* is it?**





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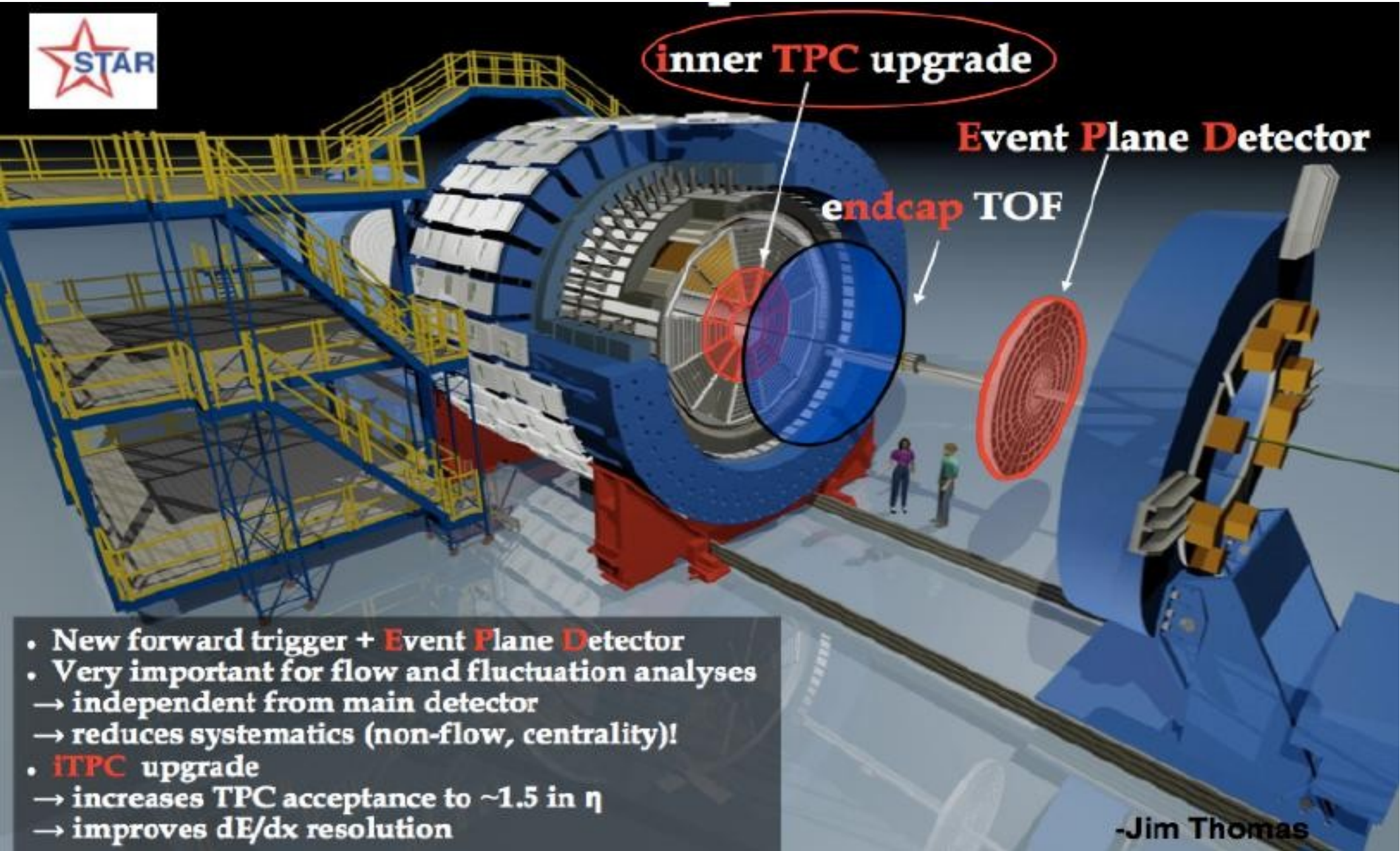
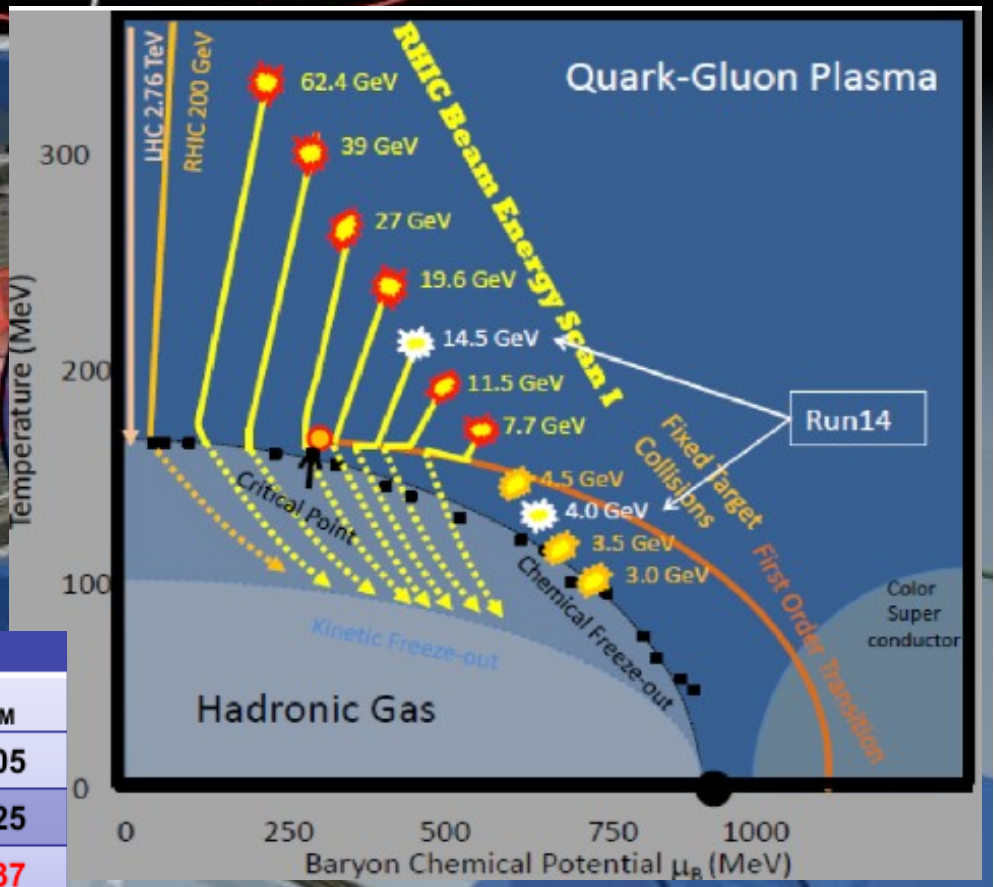
STAR upgrades for BES II



Fixed target program at STAR

- Fixed target program extends STAR's physics reach to region of compressed baryonic matter
- Simultaneous run with collider mode (ions from the halo, main program will not be affected)

Collider mode $\sqrt{s_{NN}}$ (GeV)	Fixed target		
	$\sqrt{s_{NN}}$ (GeV)	μ_B (MeV)	y_{CM}
7.7	**3.0**	720	**1.05**
11.5	**3.5**	670	**1.25**
14.5	**3.9**	633	**1.37**
19.6	**4.5**	585	**1.52**



- New forward trig
- Very important fo
  → independent fro
  → reduces systematics (non-flow, centrality)!
- iTPC upgrade
  → increases TPC acceptance to ~1.5 in η
  → improves dE/dx resolution

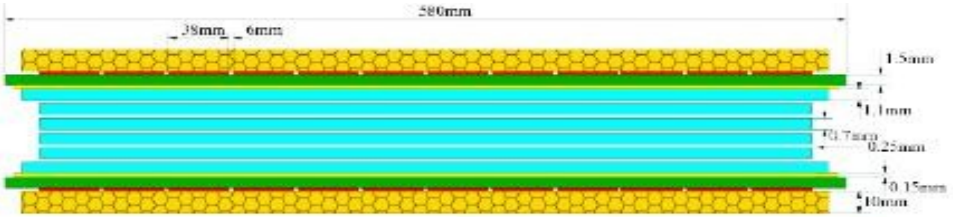
-Jim Thomas

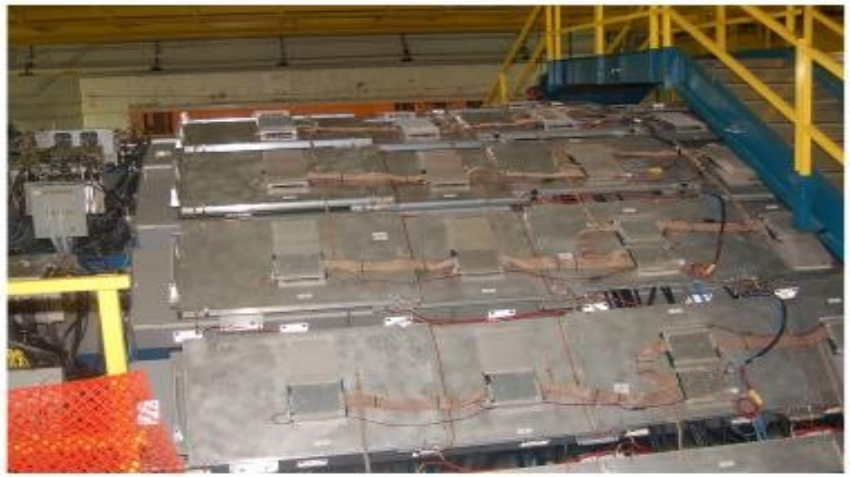
J /ψ with Muon Telescope Detector

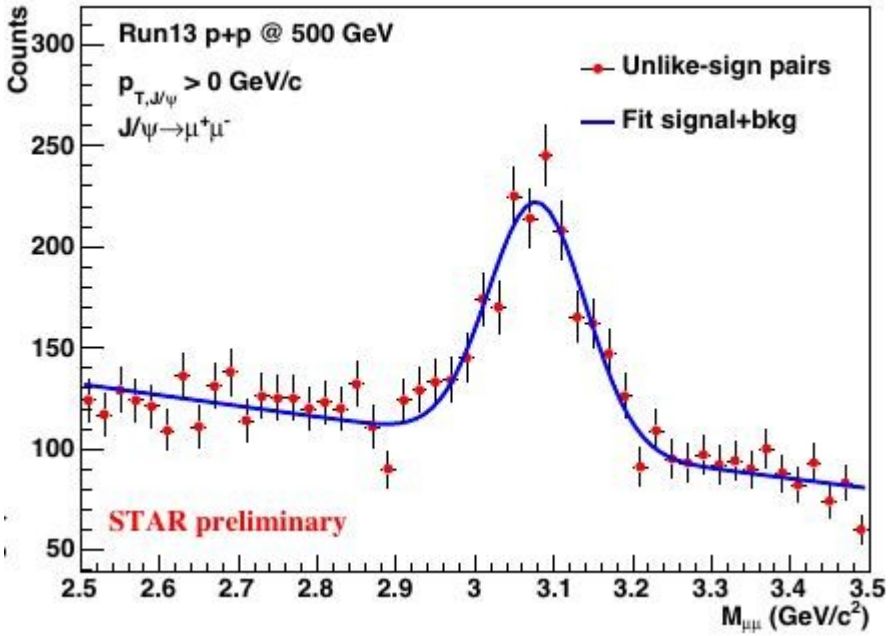
Multi-gap Resistive Plate Chamber technology.

- Precise timing (~95 ps)
- Accurate hit position (~1 cm)

Muon identification: TPC track and MTD hit match



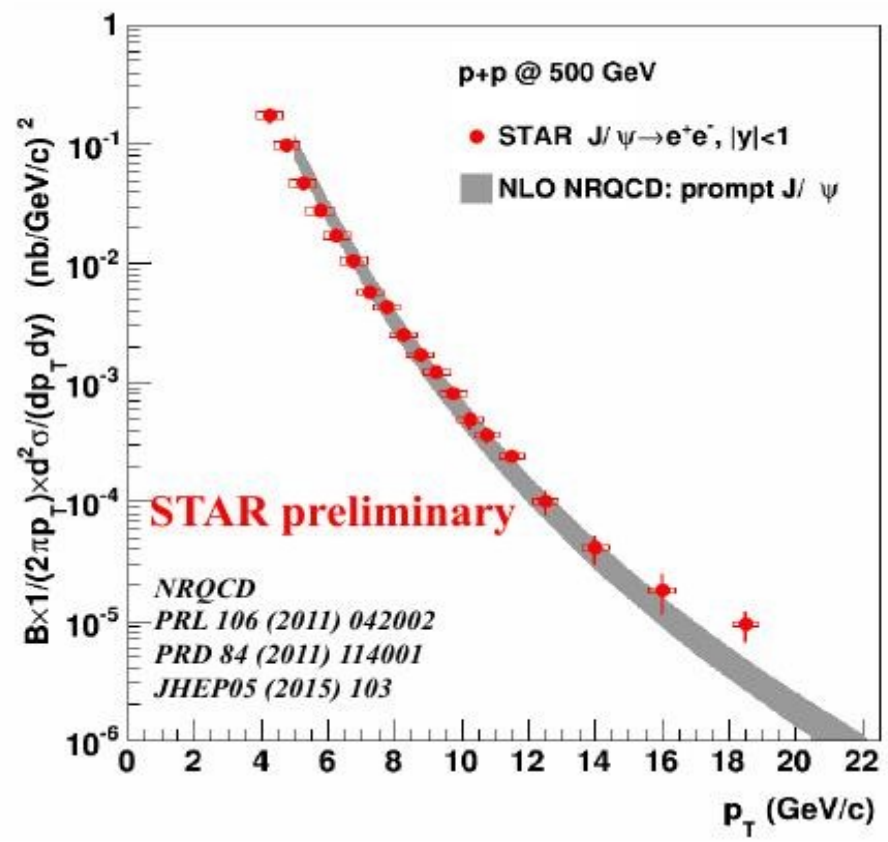


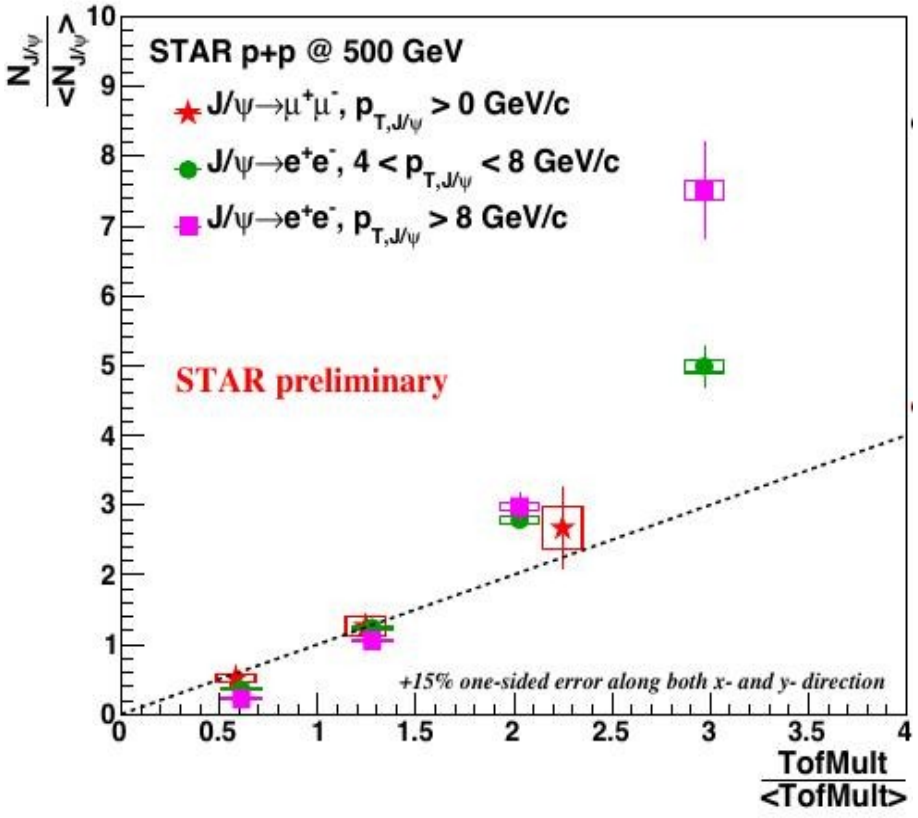


$J/\psi \rightarrow \mu^+\mu^-$: J/ψ was reconstructed via di-muon channel at STAR for the first time

- p+p collisions at 500 GeV, Run 2013
- MTD dimuon trigger → two hits in MTD

J/ψ measurements

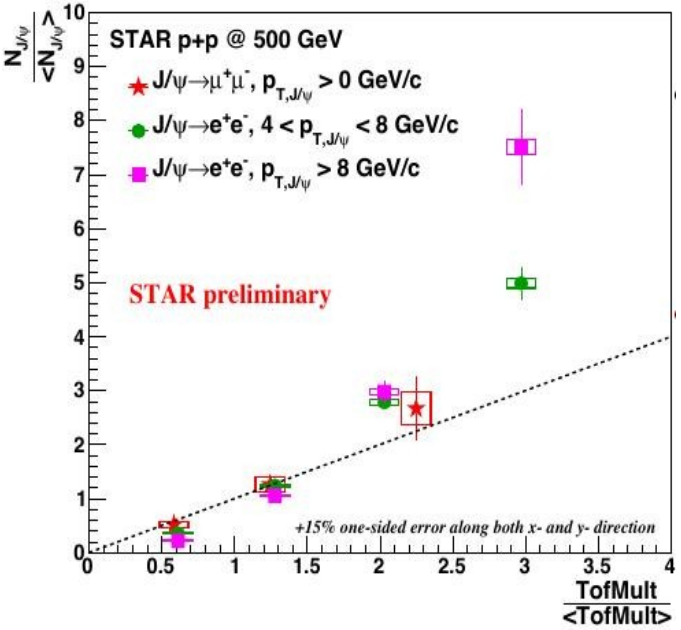


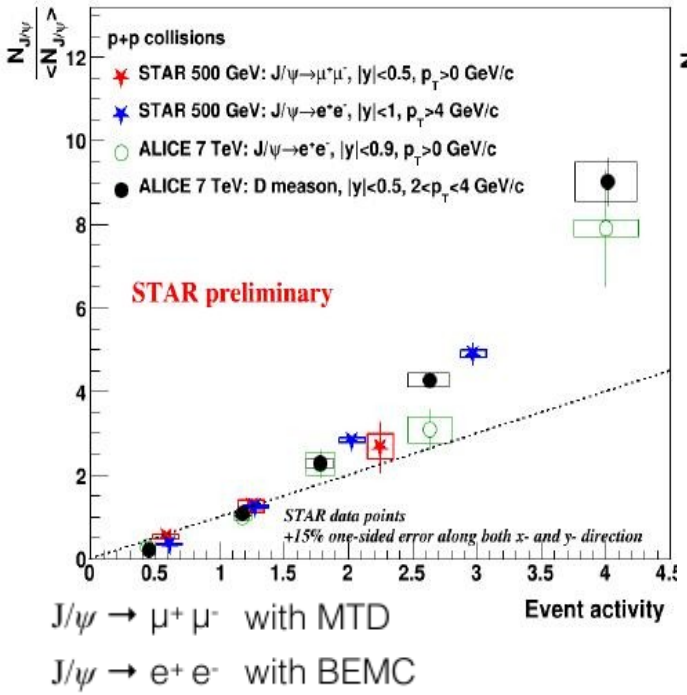


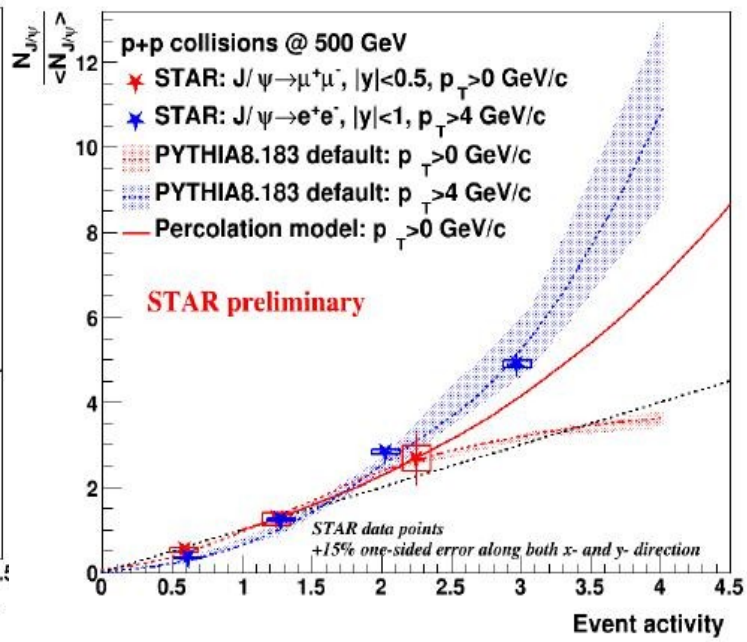
- J/ψ cross section measured in p+p collisions at 500 GeV within $4 < p_T < 20$ GeV/*c*
- NLO NRQCD prediction agrees well with data.
- Event activity – multiplicity of TOF matched tracks

J/ψ → $\mu^+\mu^-$ 2013
J/ψ → e^+e^- 2011

J/ψ yield versus event activity

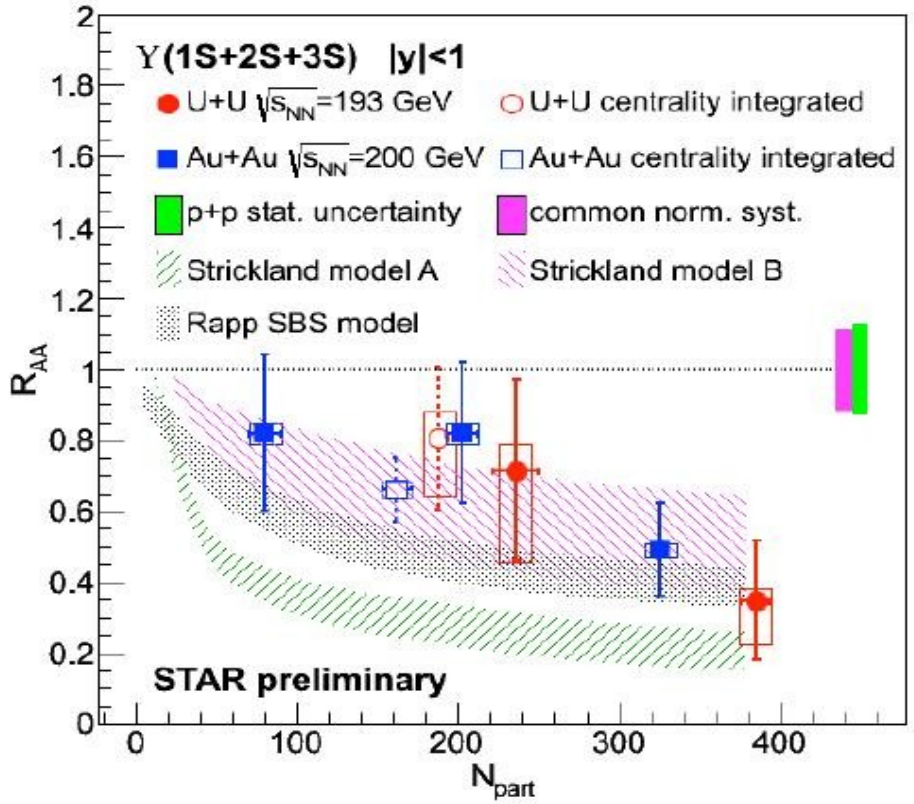


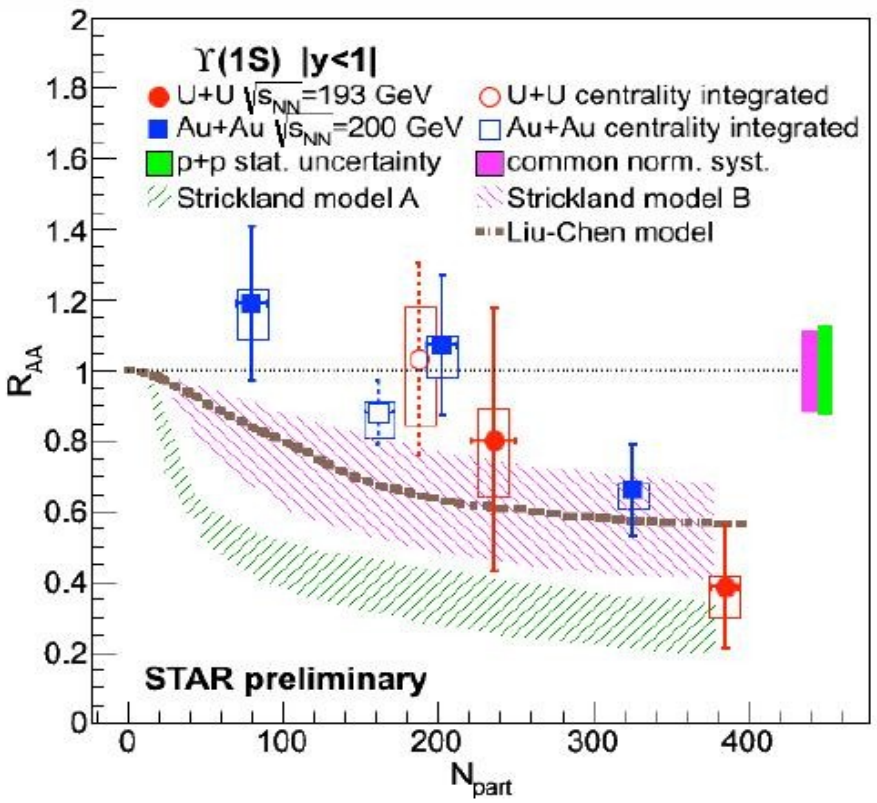




- Clear correlation between yield and multiplicity in p+p collisions.
- Different trends for J/ψ yield versus event activity at low-p_T (di-muon) and high-p_T (di-electron)
- Both rising trends can be reasonably well described by PYTHIA.

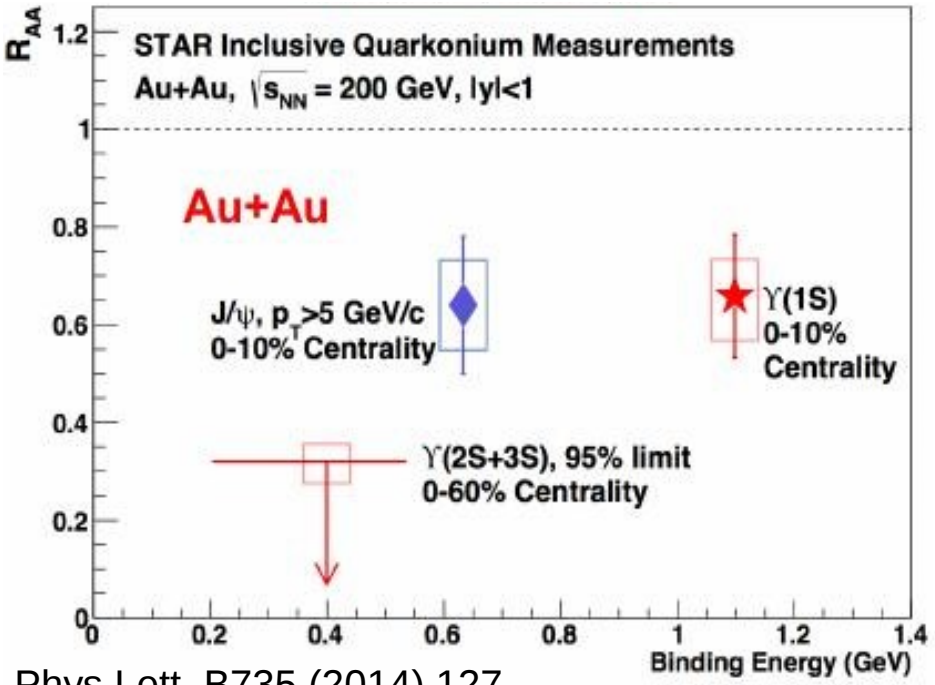
ϒ measurement





- **U+U collisions:** higher energy densities (~20% more in central collisions) → extended Au+Au results to higher Npart
- **Central collisions:** significant suppression sequential melting
- **Peripheral collisions:** consistent with no suppression

Excited ϒ states



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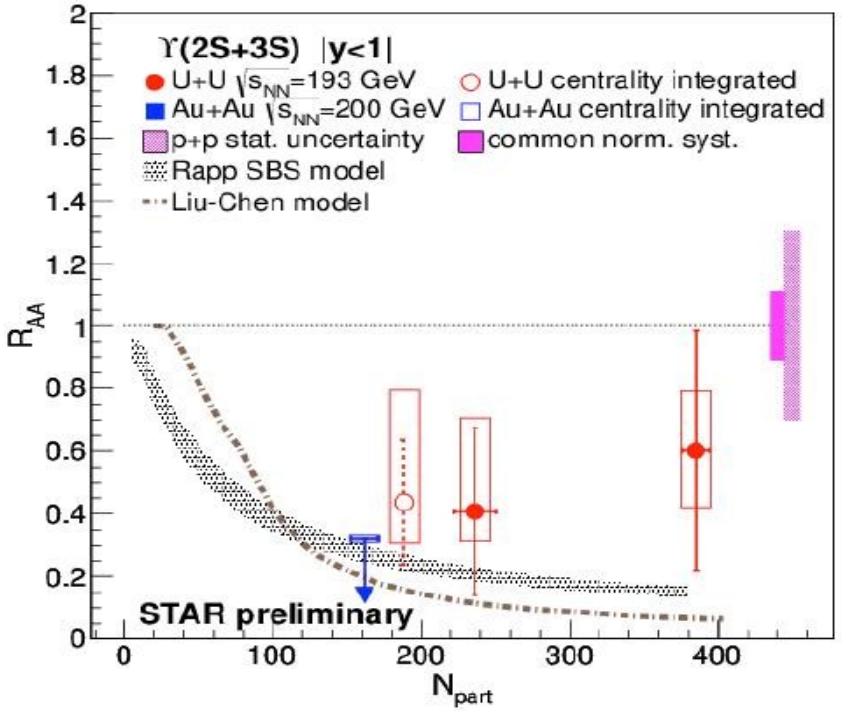
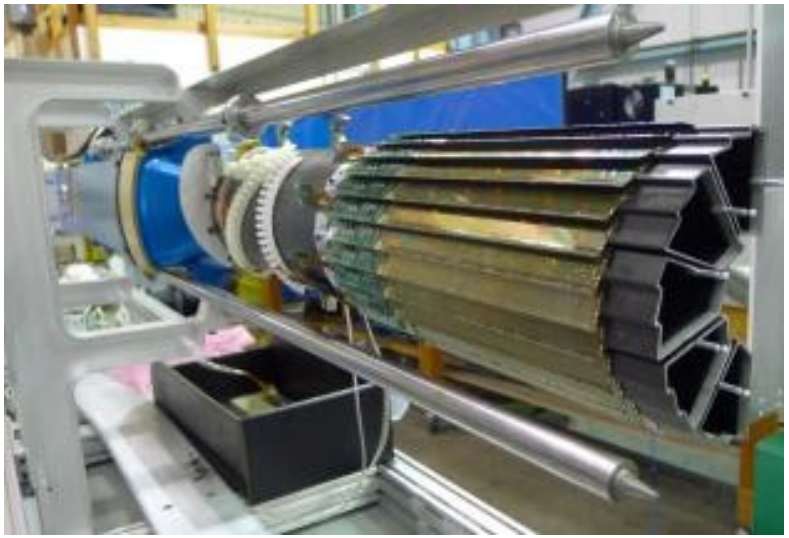
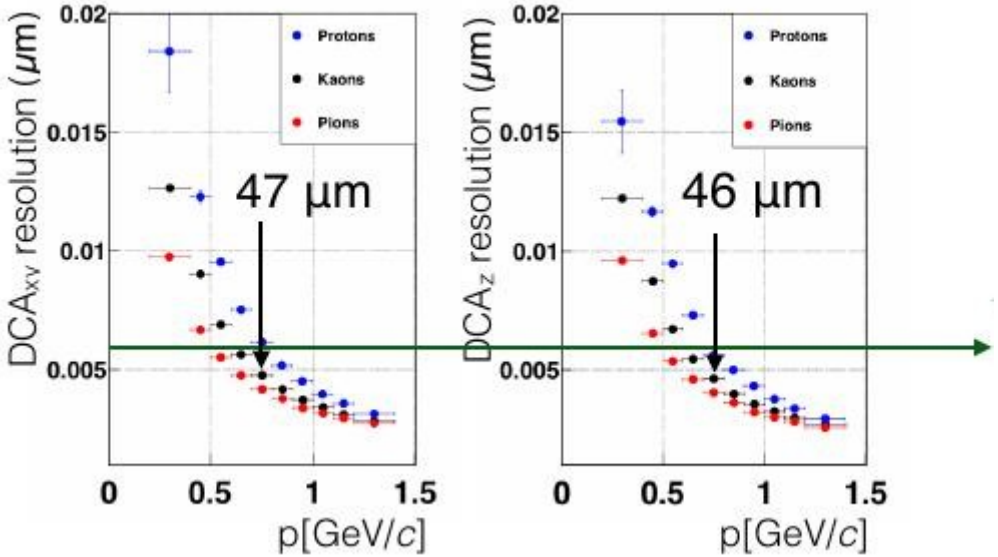


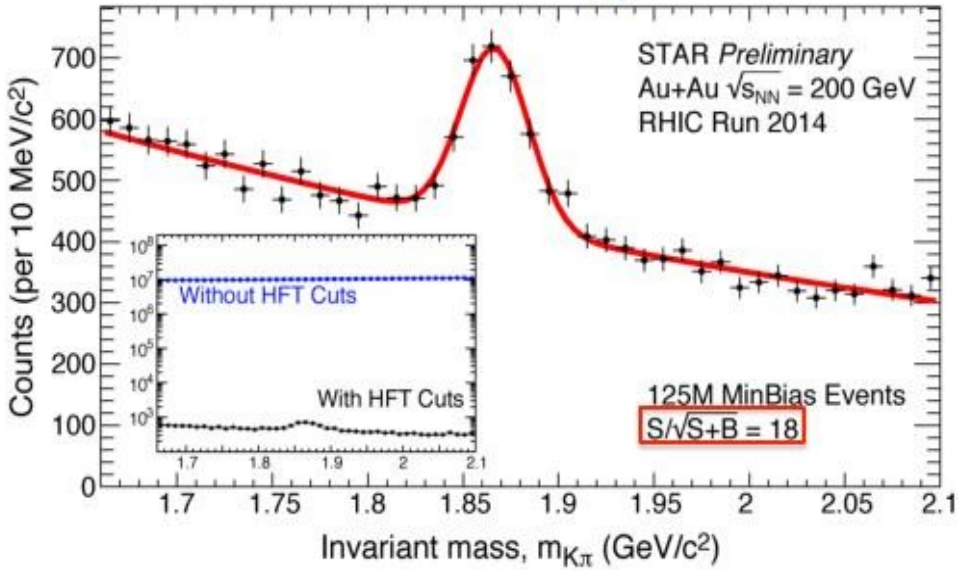
- Excited states ϒ(2S) and ϒ(3S) consistent with complete melting in central Au+Au collisions.
- **But: indication of ϒ(2S+3S) in central U+U collisions (1.8σ effect)**

D^0 with Heavy flavor tracker





10% 2014 Au+Au data

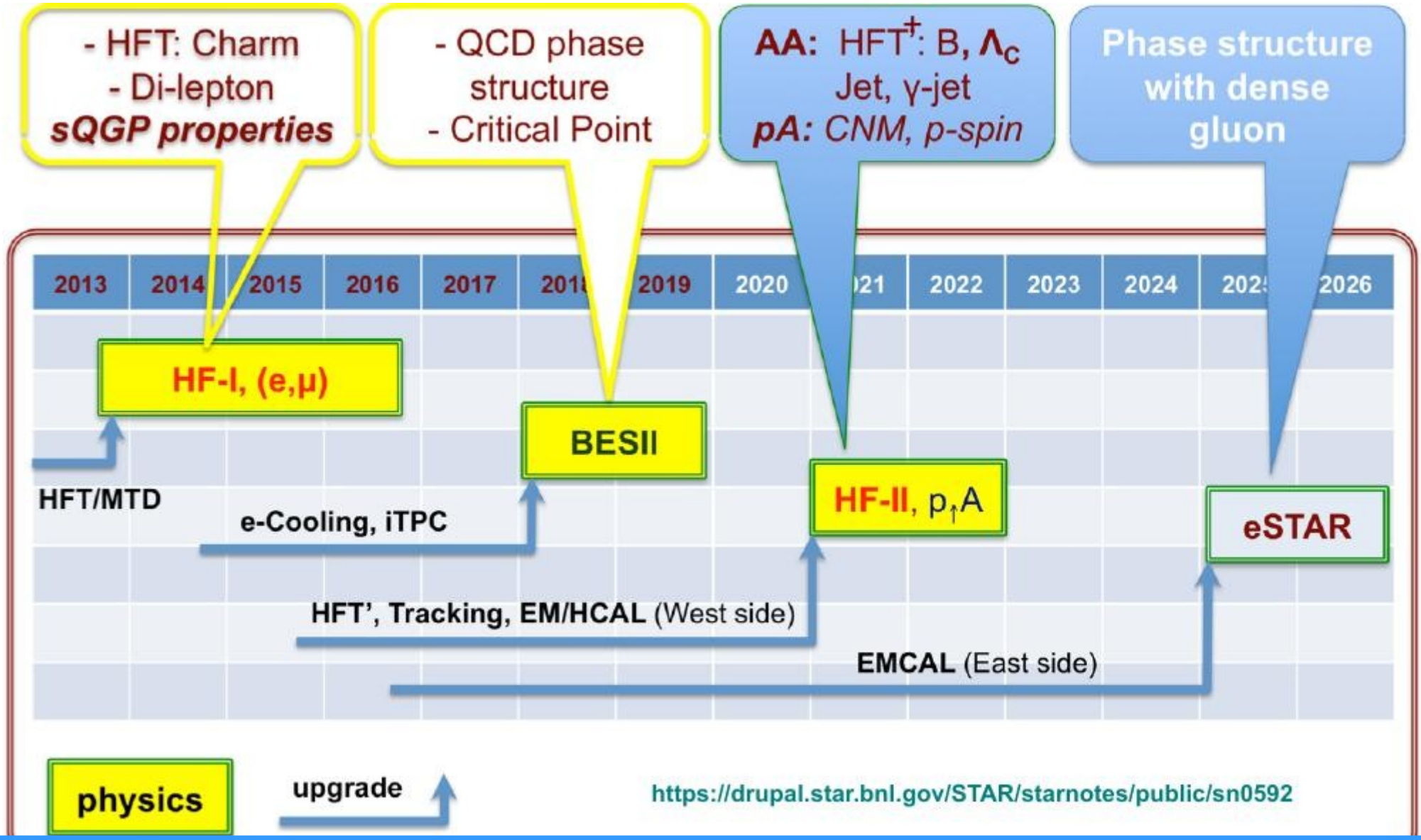


HFT – 3 kinds of sillicon detector (PXL, IST, SSD)

- High resolution of decay vertex reconstruction
- Exceeded DCA resolution design goal

- **First D^0 signal with HFT**
- Significance greatly enhanced
- Background suppressed by HFT topology cuts

STAR – long-term plan



Summary

Jets → New mixed event technique, successful reproduction of combinatorial jet background
→ Suppression at 20 GeV/c (~0.2) is larger compared to LHC energies

STAR Upgrades → First results from HFT (D0 signal) and MTD (J/ψ yield)

Quarkonia → Suppression of central ϒ(1S) confirmed in Au+Au and U+U
→ Indication of ϒ(2S+3S) presence in 0-60% U+U data (1.8σ)
→ The relative J/ψ yield grows rapidly with event multiplicity

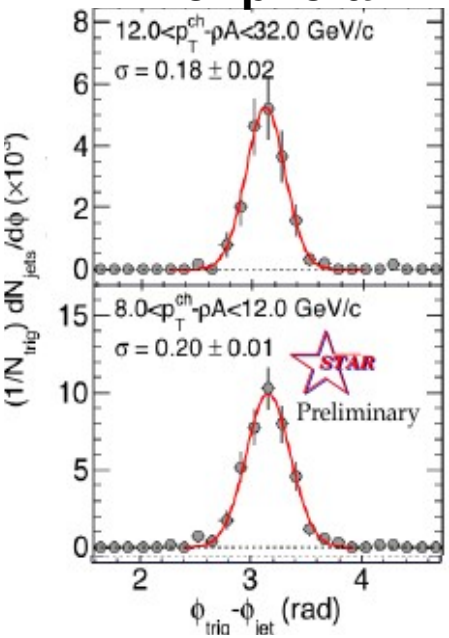
BES I key questions for BES II program (2019-2020)
→ Is there a first order phase transition and where is it?
→ Study of QGP radiation and chiral symmetry restoration for different μ_B

Thank you :-)

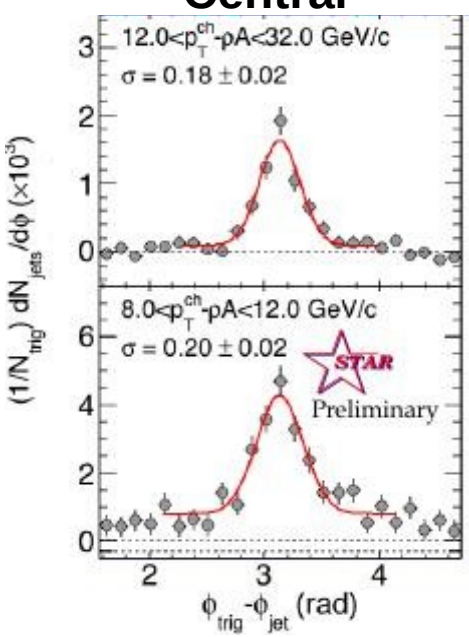
BACKUP

Large angle scattering

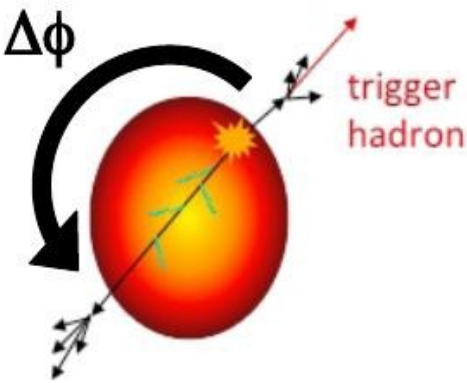
Peripheral



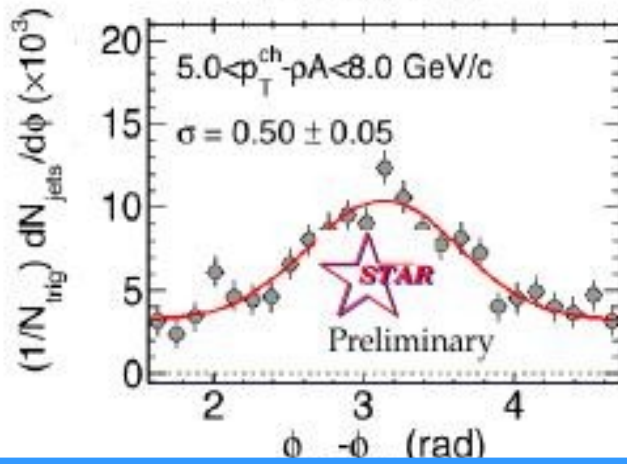
Central



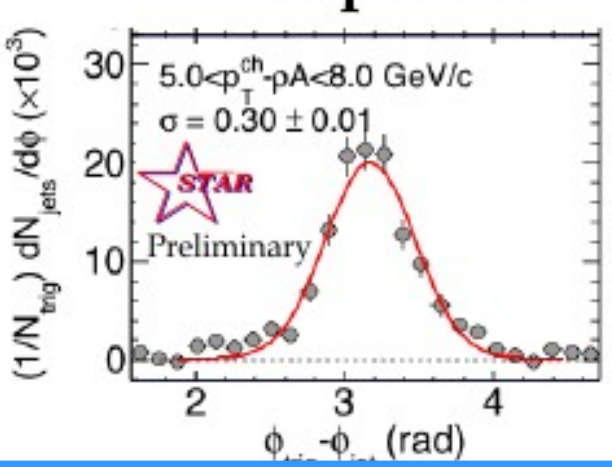
- Scattering probability can give us important information about coupling → strongly/weakly coupled QGP.
- No centrality dependence at high p_T



Central



Peripheral



Significant difference at $5 < p_T^{reco} < 8$ GeV/*c*

- *Flow?*
- *Φ dependent normalization needed?*
- *Background from multiple interactions?*
- **Needs more study!**