# BNL STAR Group Efforts RHIC S&T review 2014

*Flemming Videbæk*

*BNL*

BROOKHAVEN NATIONAL LABORATORY

*a passion for discovery*

U.S. DEPARTMENT OF ENERGY | Office of Science

# Overview

- Group Composition and Responsibilities
- Operations support
- Science Highlights
- Upgrade Involvement and Leadership
- Research relevant to EIC science case
- Summary

# BNL STAR Heavy Ion Group

BNL STAR group dual mission:

- Support for the existing detector systems, along with development of new detector technology
- Ground-breaking scientific research to utilize these systems to their fullest potential, taking advantage of detailed expertise and knowledge of the detector capabilities
  - Ratio research : operations (10.8 FTE : 27.1 FTE)

BNL STAR group plays central and critical role to the success of the STAR experiment in all of these areas

# The researchers and their roles in STAR

STAR Council
59 institutions,
12 countries
Chair; G. Westfall
BNL Rep: F. Videbaek

STAR Spokesperson
Z. Xu
Deputy Spokespeople
Caines,Fatima,Sichterman

STAR mgt
Geurts (PA)
Lauret (S&C)
Van Buren (S&C)
Christie (ops)
Videbaek (upgrade)

STAR Physics Working Groups
Physics Analysis Coordinator: Geurts
Bulk Correlations: Shi, Wang
Heavy Flavor: Kikola, Ye Zhang
Jet-like Correlations: Mioduszewski, Wang
Light Flavor Spectra: Kumar, Huang
Spin: Drackenberg, Vossen
UPC: Seger, Guryn

BES Focus Group: Sorensen, Keane, Odyniec

STAR Group Leader: Z.Xu

## STAR Operations

Detector Support Group
Leader: Christie
DAQ: Ljubicic, Landgraf
TPC: Lebedev
Trigger: Crawford
HLT: Tang, Ljubicic
Magnet: C-AD
Slow ControlCrls: Cherney
BEMC: Tsai
EEMC: Jacobs
Laser: Lebedev
ZDC: Z. Xu, Tang
BBC: Ogawa
FMS: Trentalange
TOF : Ruan, Eppley, Llope
MTD : Ruan, Eppley, Llope

Technical Support Group

S.Valentino Head EE
Soja MT
Sexton MT
Scheblein Designer
Kuzcewski ET
Camerada ET
Tkatchev ET
Scheetz EE, DAQ,iTPC
Hammond ET

Software & Computing
Lauret Leader
Van Buren Co-Leader
Didenko Production
Webb Simulation
Perevotchikov Simulation
Fisyak Reco Leader
Arkhipkin Online/Database
Smirnov gen software
Betts, poat Real Time Support
Zhu Embedding
Witt,Mustafa TPC calibration
Hajdu Grid Development

BNL Scientific Staff;
BNL Professional Staff;
Non-BNL Staff

# STAR Operations Group

- Key experimental support in STAR Technical support Group
  - Essential for maintenance and installation of new detectors

  Leader: Christie

  Mechanical Enginer Sharma

  Facility Manager Soja

  Mechanical Tech Soja, Sexton

  Mechanical Designer for modification new detectors Scheblein

- Electronics development, support and repair for STAR sub systems

  Electronics Engineers Valentino (head) Scheetz

  Electronics Technicians: Camarada, Hammond, Kuzcewski, Tkatchev

# Electronics Group Activities

## 2014 & 2015 activities

- FPS Electronics, Rack and cabling.
- Replacement Digitizer Cards for BEMC
- Gating Grid Card
- iTPC R&D
  - Pad Plane
  - iFEE card.
  - iRDO card
- New TAC card
- New QT8 card
- BSMD Electronics Upgrade (long term)
  - Will re-evaluate plan, cost and effort in 2015
  - Installation targeted for run 18.
- Barrel and Endcap EMC electronics upgrade (long term).
- DSM2 board production and test.

## 2013 Installation Activities

- BEMC tower crate relocation (relocated digitizer crates, communication boxes and installed new cabling).
- SSD installation (installed crates, power supplies and cables).
- MTD installation (installed power supplies and cables).
- IST installation (installed crates, power supplies, cables and revision of ARC-II RDO board).
- PXL installation (installed crates, power supplies, cables and remote monitor/ control of cooling unit).
- Bit checker for Trigger group (Alex).

**Installed for 2013 run.**

- JTAG Programming over trigger cable boards.

# Software And Computing (S&C) Team Composition

## Core team

- Leader: Jérôme Lauret
- Co-Leader: Gene V. Buren
- Simulation co-leaders: Victor Perevoztchikov & Jason Webb
- Reconstruction Leader: Yuri Fisyak
- Database Leader: Dmitry Arkhipkin
- General offline software & sub-system software integration support: Dmitri Smirnov
- Data production coordinator and software librarian: Lidia Didenko
- Distributed production, Grid technology and online tool support: Levente Hajdu
- Real-time, Online and user support: Wayne Betts and Michael Poat
- Grid Operation point of contact: Wayne Betts
- Web Master: Hongwei Ke

# Software And Computing (S&C) Responsibilities

- The S&C team is responsible for
  - The STAR specific infrastructure (online resources, online networking, Meta-Data archiving, …) in support of the data taking, run monitoring as well as STAR specific user support (real-time support)
  - The development of core framework components, tools and techniques in support of the scientific program. This includes framework development, simulation and modeling, global tracking, global calibration, efficient access to database, efficient retrieval of data from mass storage, …
  - The data reduction and production to physics usable quantities to sustain the experiment's Physics analysis (local and distributed data production)

- The Core team provides technical expertise critical for timely and correct physics results and to ensure data quality as it is recorded – it coordinates activities sustained by external workforce.

- Due to increase workload (more complex datasets, more sub-system), workforce was refocused on software support . At constant staffing, the following activities are no longer sustained by active and dedicated workforce: Event Display and visualization, ROOT framework support, Grid activity overall coordination (presence on the OSG is at "best effort" basis)

# Activity Highlights

In addition to operational activities the S&C group members are involved in work aimed at improving efficiency, scalability, stability and precision. This work is crucial to keep up with the increasing demand on computing in the high luminosity RHIC era

- Planning for distributed workflows using Constraint Programing techniques. PhD in CS, Prague (advisor: J. Lauret) – initial study shows a 50% improvement over simple heuristic with 2 site job submission (presented ACAT 2014) – optimized usage of distributed computing resources
- Remote Grid based real-data production @ KISTI / Korean – leveraging remote resources
- Cloud collaboration with ANL and FNAL (evaluation of best strategies and approach). Funded through the "*Infrastructure Strategy to Support Collaboration*" proposal (ASCR/NP) – access to on-demand resources

- Evaluation of distributed file system for online use – potential provisioning of large storage space at low (to no) cost
- Use of modern configuration management and monitoring tools (CFEngine, Nagios, …) – managed and monitored reliable online infrastructure consistent with Cyber-Security (increasing) requirements
- Message Queuing online system for scalable MetaData collection, archiving, monitoring and alarm handling. Extending to (remote) control capabilities (presented @ ACAT 2014) – deliver modern and scalable online framework to sustain higher data taking demands
- Calibration R&D: Development of an innovative technique for in situ measurements of misalignment between electric and magnetic fields within typical TPCs using delta electrons - precision alignment in the HFT era
- Calibration R&D: Effort was also given to understanding dynamical TPC distortions due to added materials in STAR and asymmetrical colliding systems – more accurate measurement of distortions in asymmetrical systems (Cu+Au, He3+Au, …)

- Collaborative work with the RCF personnel – GPFS testing and deployment – efficient and scalable central storage to sustain user analysis

# Group Hardware Operational Responsibilities

TPC Hardware: Lebedev

Magnet: Christie

DAQ Ljubicic, Landgraf

Trigger: Berkeley

ZDC: Z.Xu, Tang

TOF- MTD Ruan

HLT Ljubicic:, Tang, Ke

RP-II Guryn, Pak

HCAL pixelation R&D: Bland

# Publication, Leadership & Awards

STAR had 10 publications in FY13, 12 in FY14 and 9 submitted.

The BNL group had 9 GPC chairs, and 15 PA's on these papers

Chair of RHIC/AGS users group: Sorensen

Co- Chairing of EIC science task force: Ullrich

Awards

- **L.Ruan** recipient of 2013 DOE early career Award
- R.Ma awarded BNL Goldhaber fellowship

# Research Highlights

Tightly coupled responsibilities for hardware, software, and analysis provide the BNL STAR group a uniquely fertile ground for new uses of the STAR detector

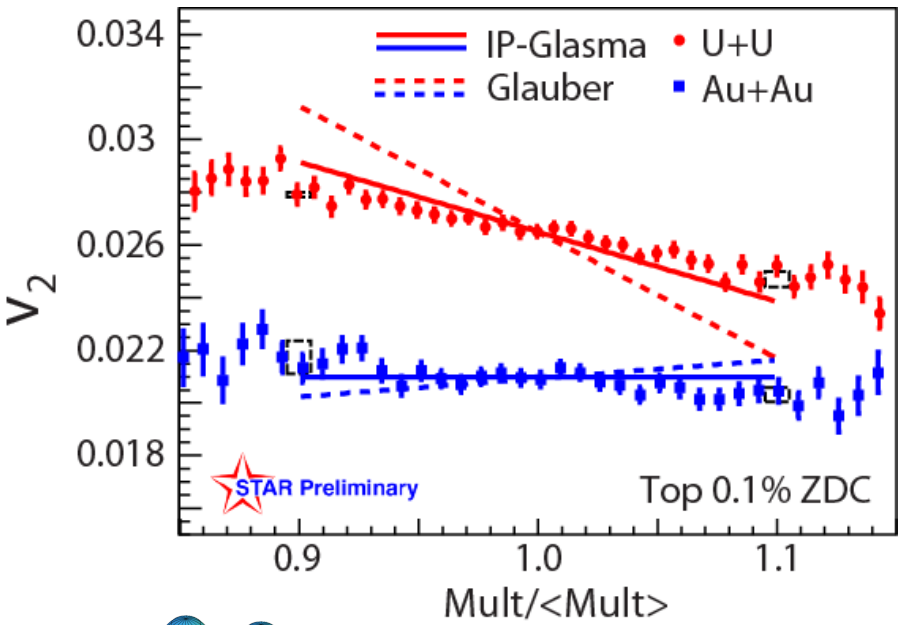
Focus of local researchers

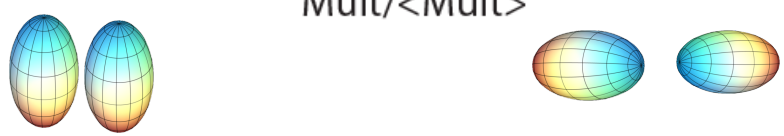
- Heavy flavor, exotics, and dileptons
  - Utilizing RHIC II luminosity and upgrades
    - Z. Xu, Tang, Ullrich, Ruan, Huang, Ma, Chakabera,, Videbaek, Dunlop
- Flow: utilizing RHIC flexibility
  - Energy and beam species to constrain system properties with flow phenomena
    - Initial state fluctuations, viscosity, equation of state
      - Sorensen, Wang, Tang, Ke
- Elastic scattering, hard diffractive processes, UPC
  - Debbe, Lee, Guryn

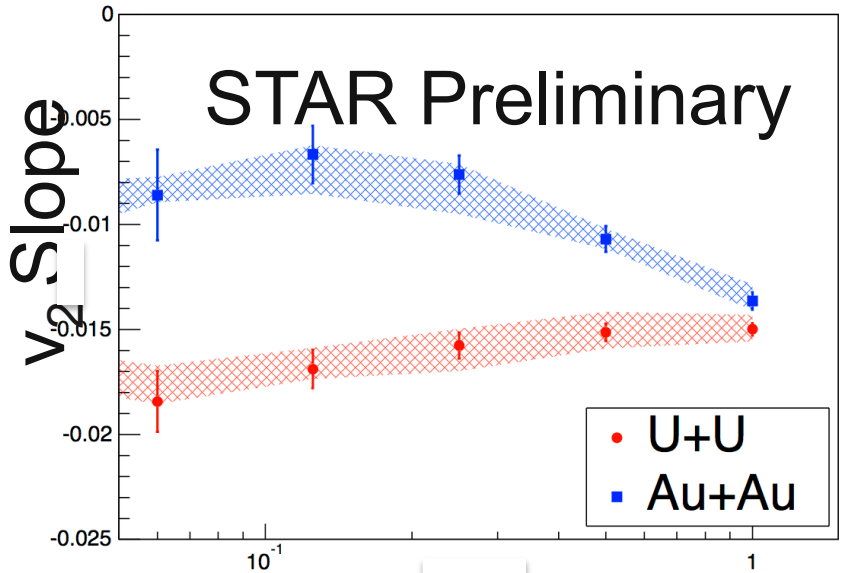
Extremely important for the collaboration:

Pool of local expertise for supervision of visiting students, post-docs

# Shape Matters: U+U Collisions





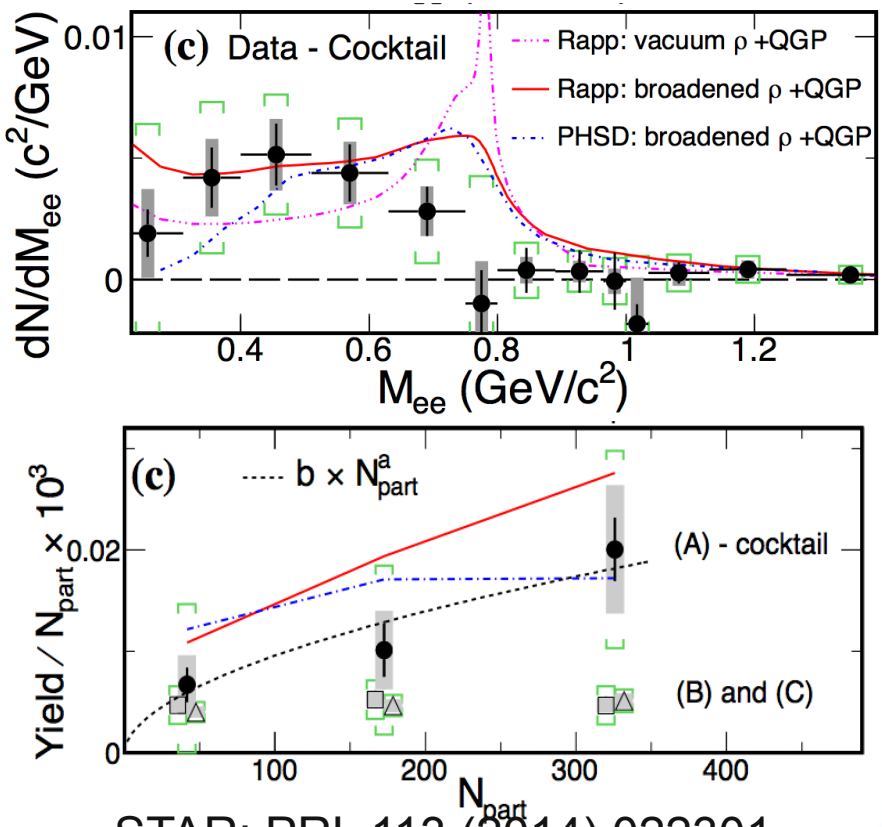

Collision centrality (ZDC)

Paul Sorensen Hui Wang

1) RHIC delivered the U+U collisions in order to study geometry effects. Model expectation: 20% increase in energy density in very central collisions
2) Tip-tip and body-body enhanced samples selected via ZDC-mult cut
3) IP-Glasma model consistent with the observation: implying CGC type of initial condition at RHIC

*- Bjoern Schenke, et al. arXiv:1403.2232*
*- Maciej Rybczyński, et. al. PRC87,044908(13)*

# Excess di-electron spectra

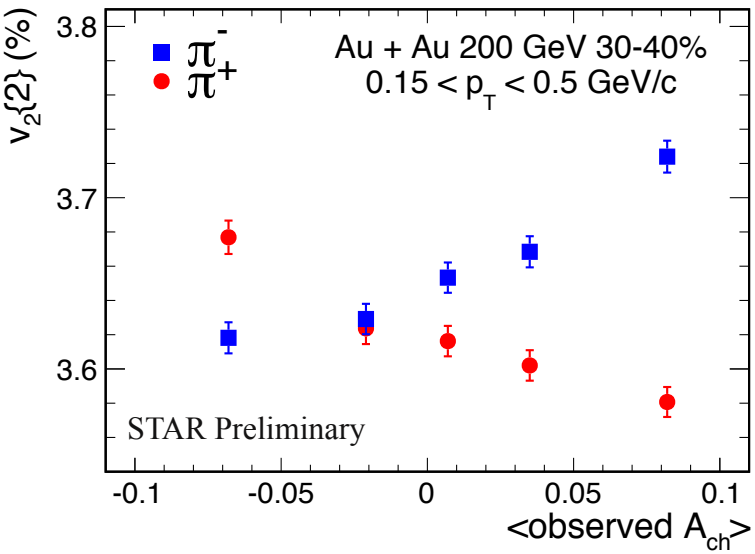


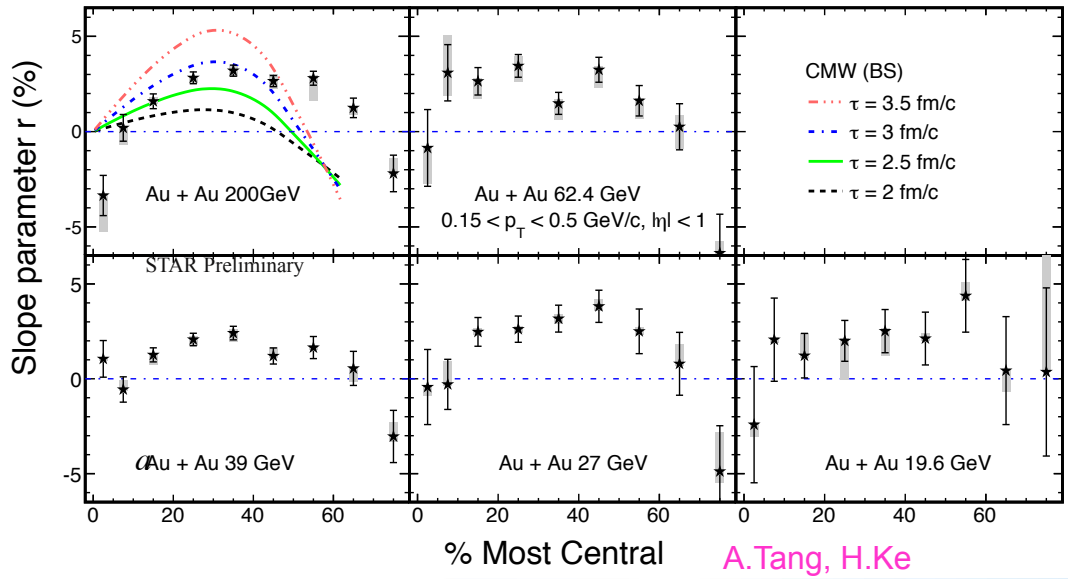

STAR: PRL 113 (2014) 022301.

B. Huang, L. Ruan

Excess dielectron mass spectrum in the mass region 0.3-0.76 GeV/c2 in 200 GeV Au+Au collisions follows Npart*1.54±0.18 dependence.

# Charge Asymmetry Dependence of $\pi^+(\pi^-)$ Elliptic Flow

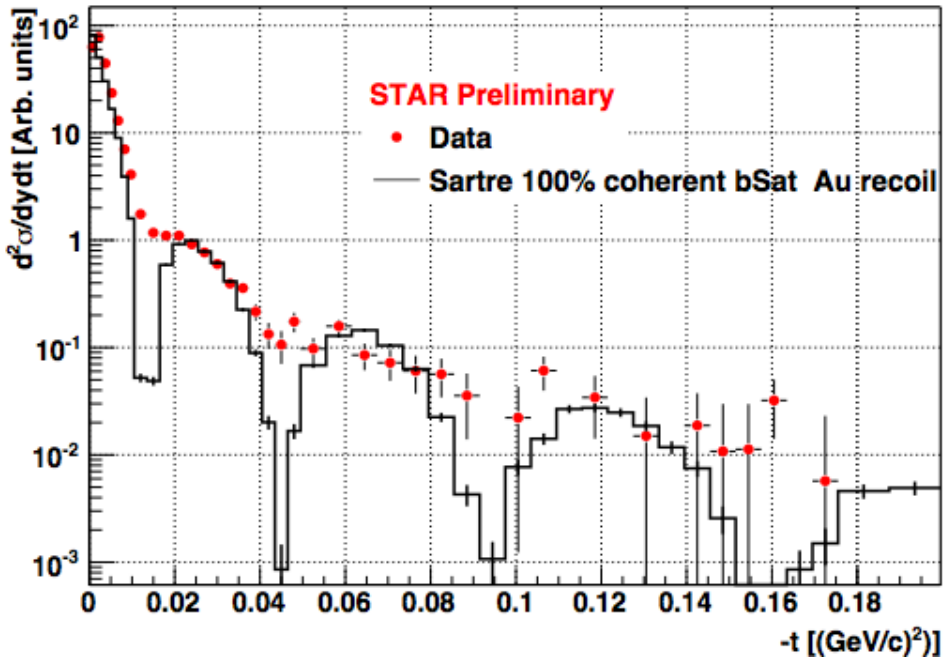



- The difference between $v_2(\pi^-)$ and $v_2(\pi^+)$ shows a linear dependency on charge asymmetry in Au + Au collisions at $\sqrt{s_{NN}}$ = 200, 62.4, 39 and 27 GeV.
- As a function of collision centrality, the slope parameter $r$ for $\pi^\pm$ shows a rise and fall feature from central to peripheral collisions and the energy dependence seems weak.
- The centrality dependency of the $\Delta v_2(\pi)$ slope shows a similar trend of the calculations based on Chiral Magnetic Wave .

# $\rho^0$ diffraction pattern in Ultra-Peripheral Au+Au Collisions

Au + Au $\sqrt{s_{NN}}$ = 200 GeV




Debbe, (Schmidke) arXiv:1209.0743 [nucl-ex]

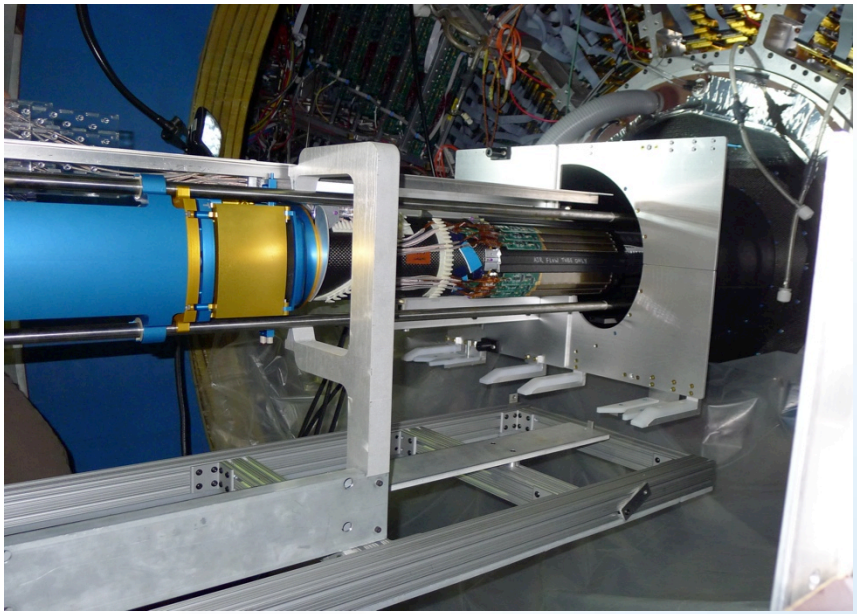
UPC events triggered by small activity in TPC, BBC veto and 1 to 6 neutrons in ZDC (Giant Dipole Resonances).
Exchanged photon fluctuates into $\rho^0$ meson which then scatters elastically off entire Au nucleus.

Distribution of Mandelstam invariant t (~$-p_T^2$) of $\rho^0$ mesons may be related to the glue form factor of Au thru exchange of soft Pomerons

Testing ground for similar measurements at future Electron Ion Collider

# Upgrade Involvement - Heavy Flavor Tracker (HFT)

- HFT was installed summer, fall 2013. 450Mpixel MAPS detector. First in collider
- Took data in run-14
- ESAAB eq. CD-4 review scheduled for September 25
- BNL group leadership with videbaek as Contract project manager and STSG for installation



Institutions: BNL, UCLA, Kent State, MIT, LBNL, Purdue, UIC, UT Austin; France: Subatech,IPHC; Czech Republic: CTU, NPU c

# Upgrade Involvement - Muon Telescope Detector (MTD)

- The last 47 ( of 122) MTD modules were installed for Run-14 completing the project on schedule
- BNL group leadership with Ruan as project manager, US-China-India Collaboration: Z. Xu
- Postdoc Huang and students instrumental in installation, testing and operations of MTD

Institutions: BNL,UC Berkeley/SSL,UC Davis,Texas A&M,UT Austin; China: USTC,Tsinghua; India: VECC

# Ongoing STAR Upgrades

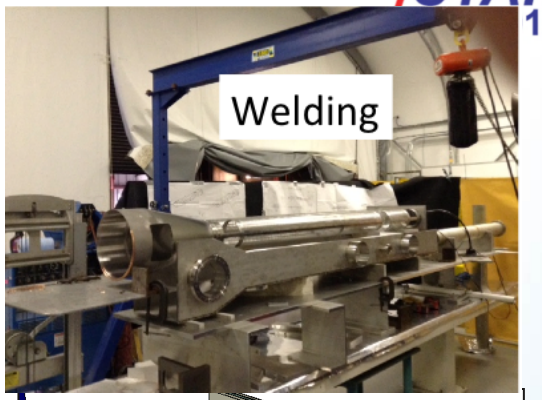
Roman Pot Phase-II*

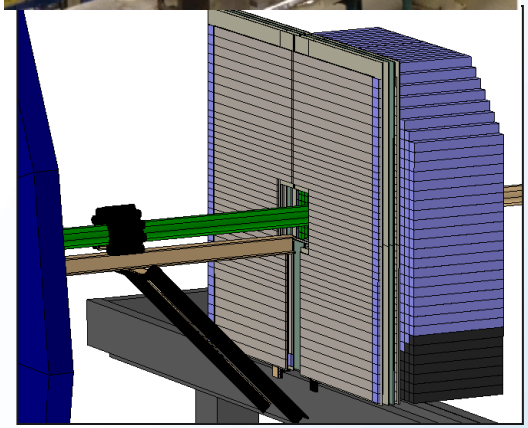
- Modest upgrade, extending t range and allowing concurrent operation with high luminosity operation for $A_N$ and exotic states
- Testing ground for applications at the EIC
- Star HI Group Guryn, Debbe, Lee + STSG+ (BNL ME)
- On target for readiness for Run-15

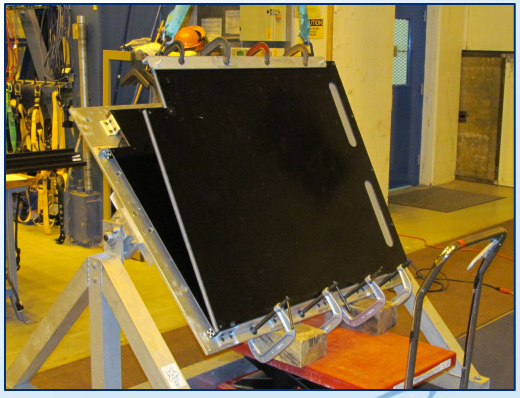
FMS is being refurbished

FMS pre-shower

- Direct photon measurements at forward rapidities
- 3 layer hodoscope. In fabrication
- BNL Medium Energy group and STSG
- Will be ready for run-15





# Beam Energy Scan-II

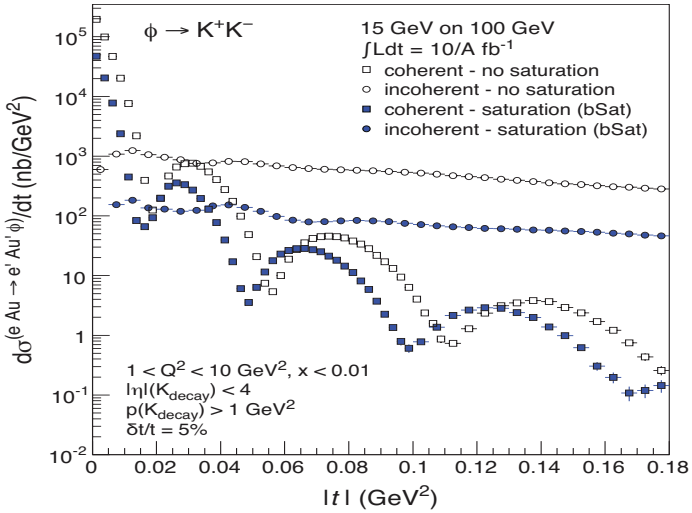
- STAR is preparing for the BES-II program, and the BNL group provides strong physics leadership by P.Sorensen

- The group is involved the iTPC development and proposal.
  - Collaboration with Shandong U. Z.Xu
  - Proposal Z.Xu, Videbaek
  - Electronics development Ljubicic, Scheetz,
  - Simulations Chakaberia

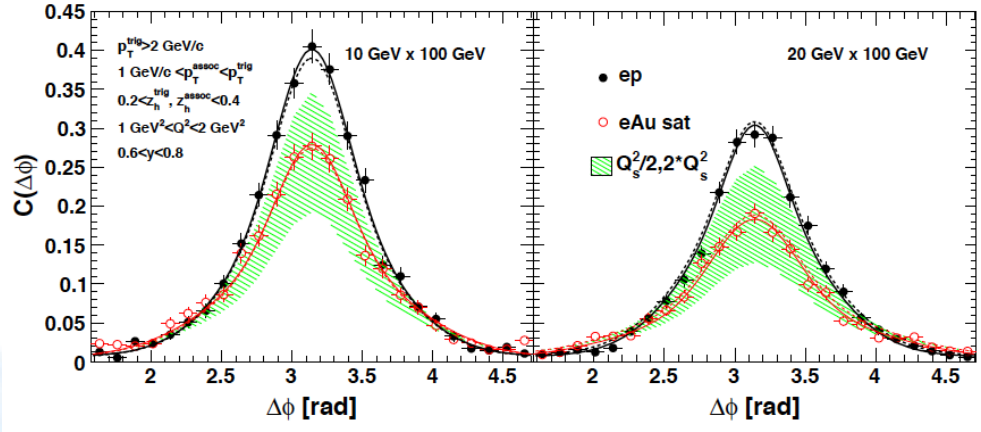
# Research relevant to EIC science

- Strong involvement in BNL EIC task force
  - Ullrich (co-leader with Aschenauer)
  - Lamont
  - Lee
  - Toll (left 8/14)
- Strong collaborative effort with Medium Energy Group
- Research Efforts
  - Structure function particular in eA, $F^A_L$
  - Diffractive Physics
  - Di-Hadron correlations
  - Tagging event geometry in eA

# Two Highlights




Dipole model Event generator **Satre** develop by Ullrich, Toll
Comp.Phys.Comm 185 (2014) 1835
Phys.Rev.C87 (2013) 024913




Probing gluon saturation through di-hadron correlations.
Lee
Phys.Rev.D89 (2014)074037
arXiv:1407.8055

# eSTAR

- Group is involved in work for using STAR at eRHIC
- We have produced an eSTAR letter of Intent with group efforts from
  Ulrich, Z.Xu, Videbaek,  Lee, Lamont, Dunlop
- Working on R&D via EIC R&D on Transition Radiation Detector: Z.Xu and students

# Summary

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