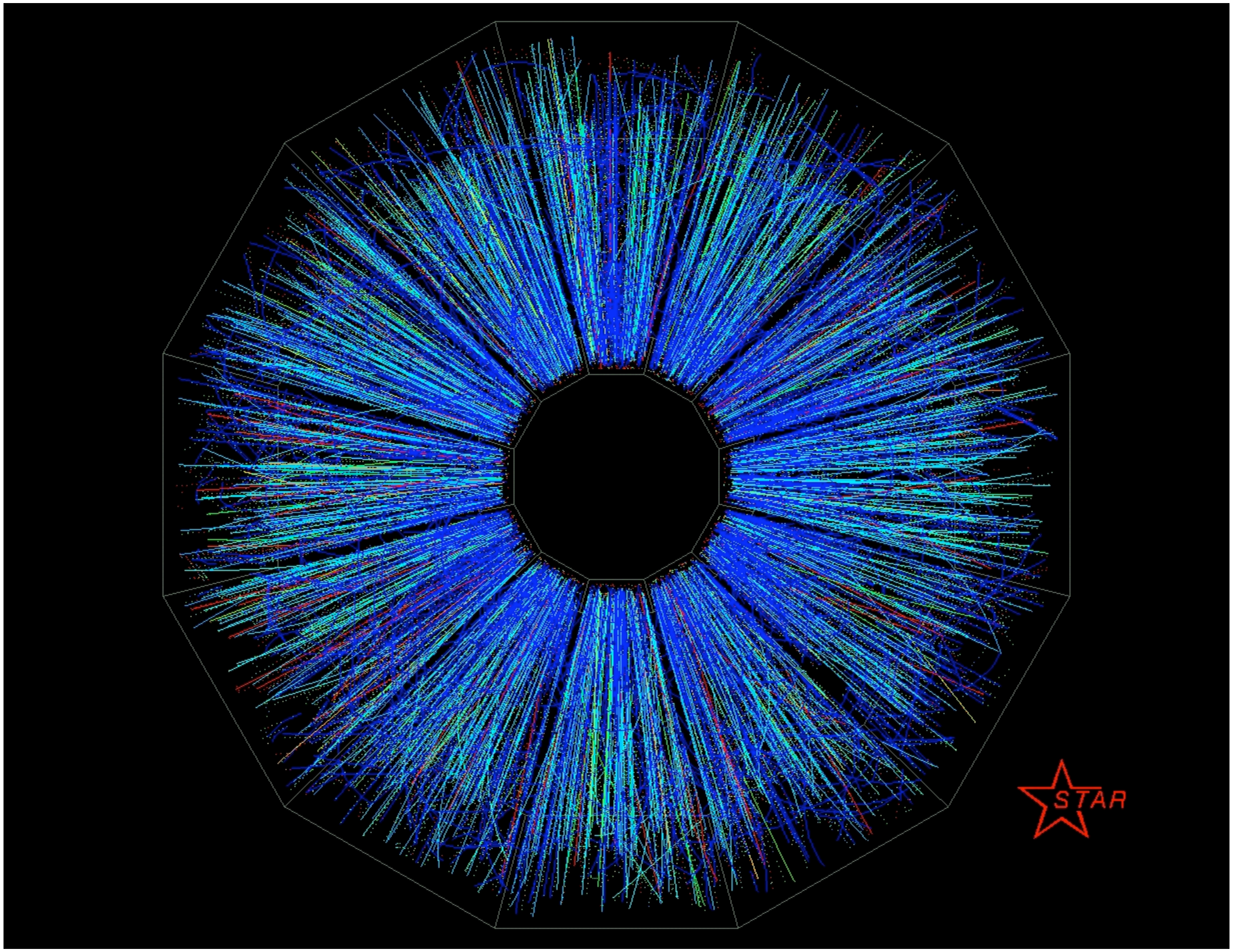
STAR Decadal Plan Status



1st Collision
June 12, 2000

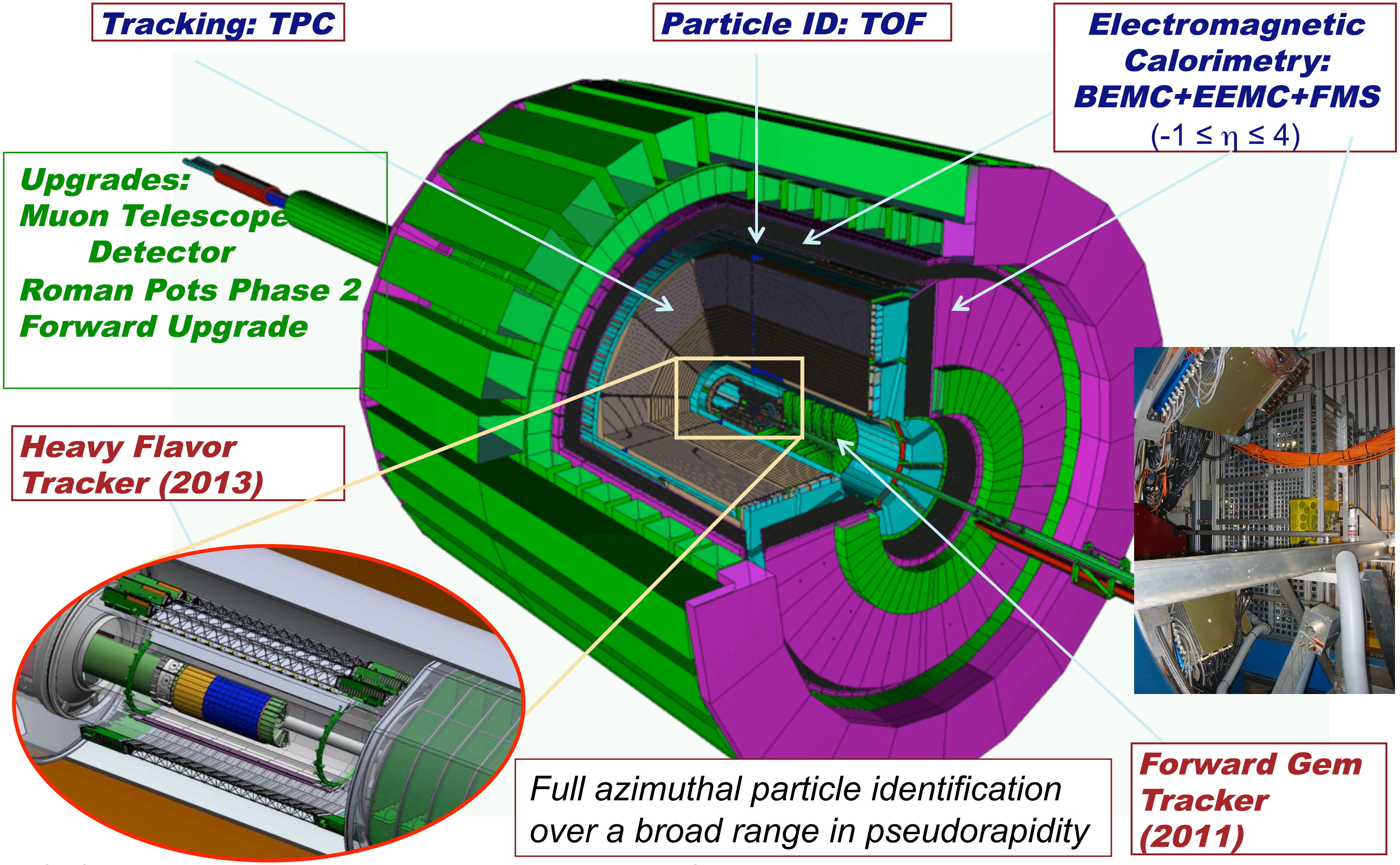
James Dunlop

Introduction

STAR's philosophy

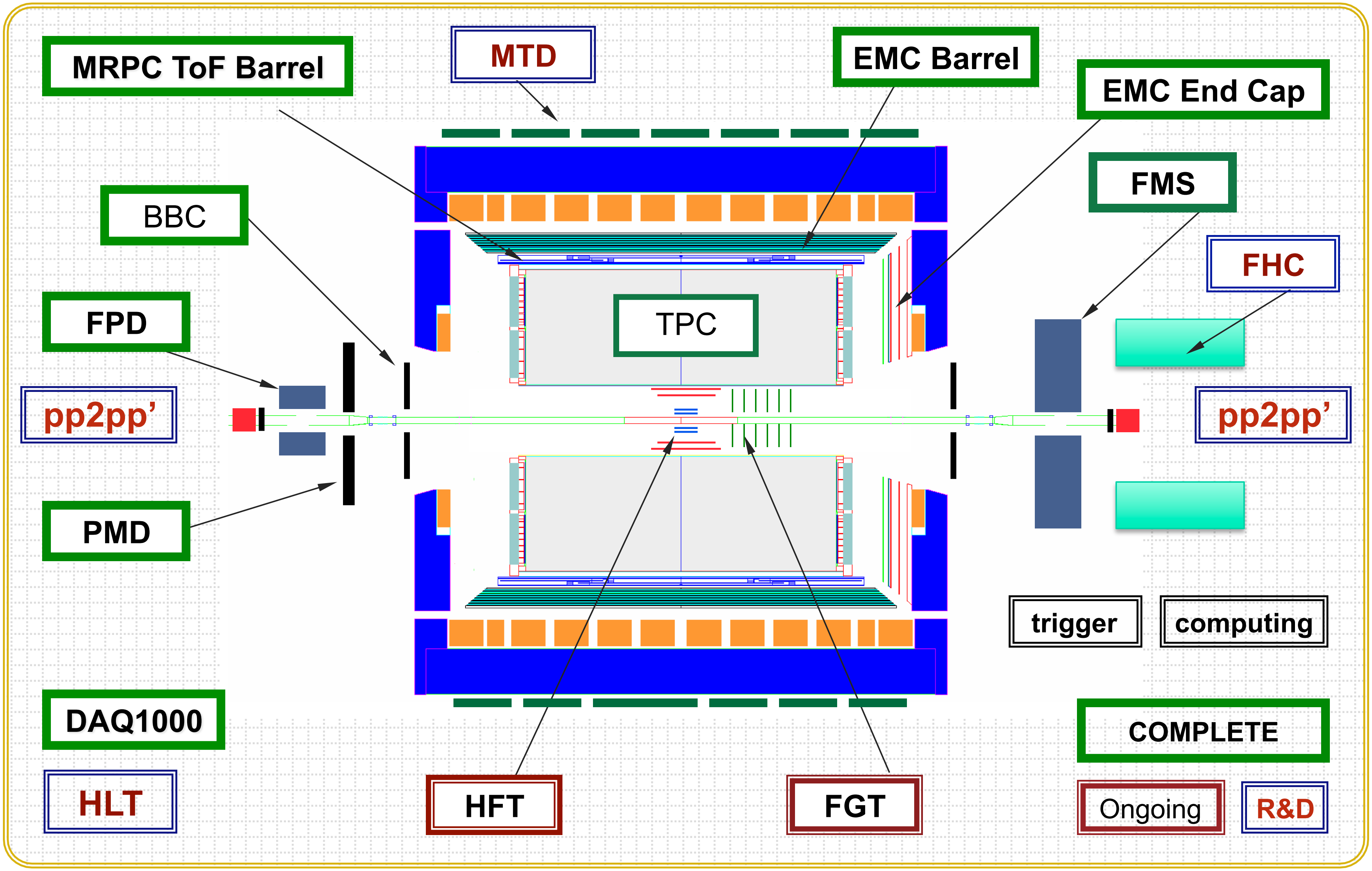
- Use the full flexibility of RHIC
  - A+A: full range of A and E to characterize QCD matter
  - polarized p+p: broad study of spin structure of matter
  - p+A: understand the A in A+A
  - e+A: precisely quantify the A in A+A
  - e+p: precisely quantify the spin structure of matter
- Build on our strengths
  - Keep using (and refurbish as necessary)
  - existing and proven detector systems
- Add fundamentally new capabilities
  - heavy flavor, muons, forward direction

STAR: A Correlation Machine

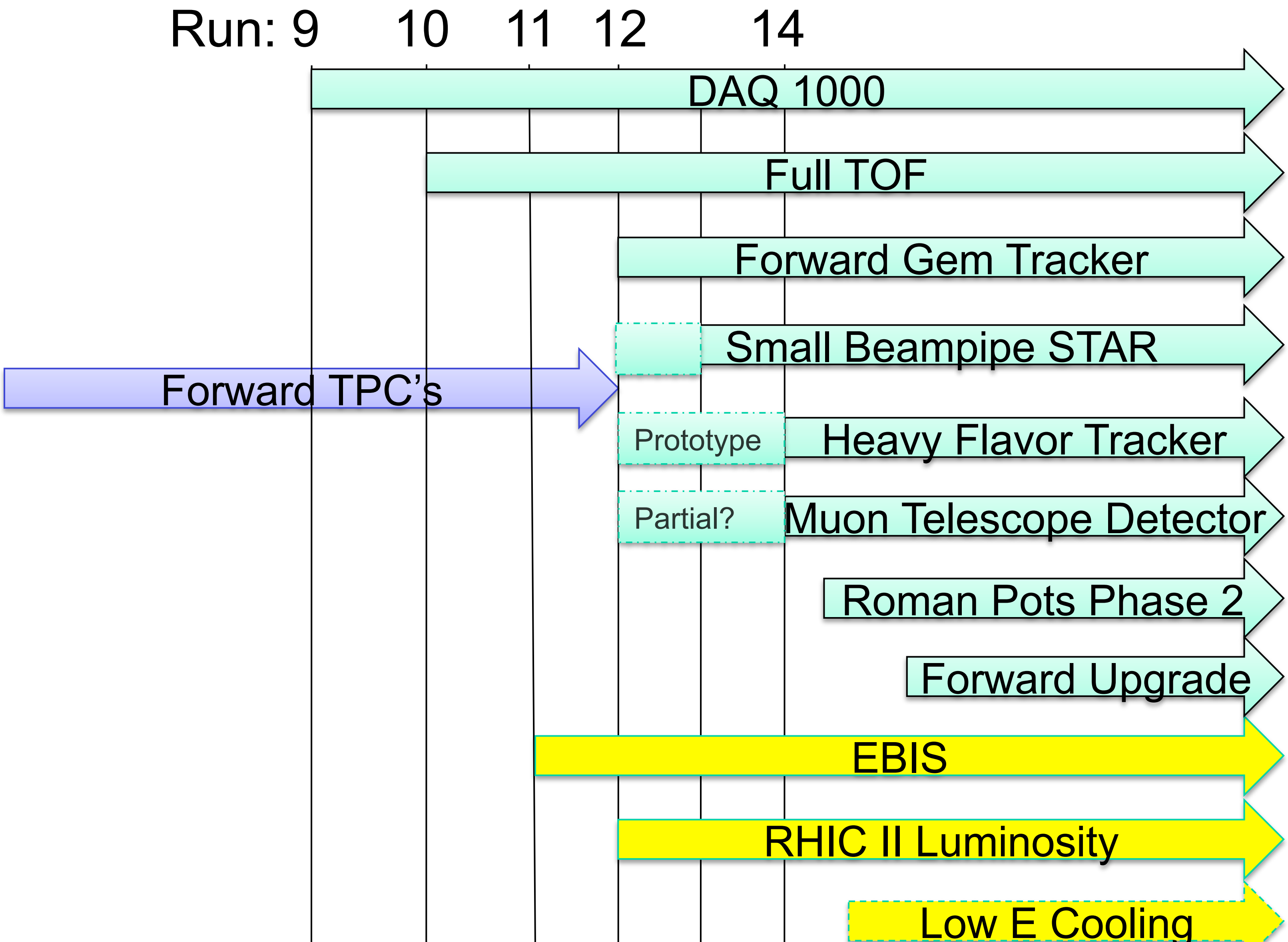


Full azimuthal particle identification over a broad range in pseudorapidity

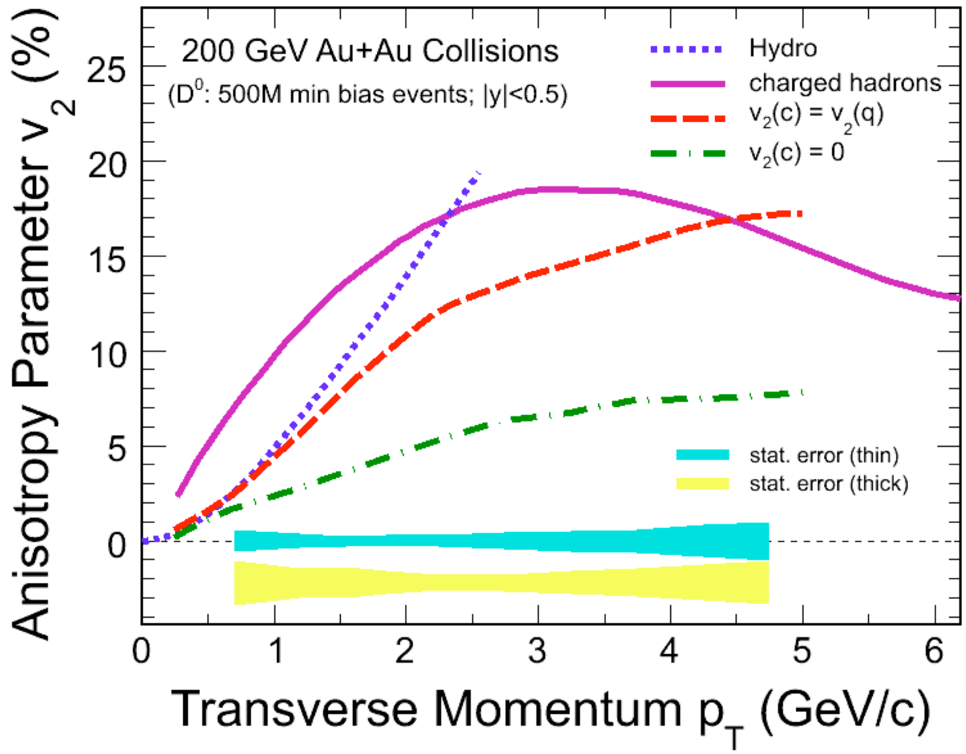
STAR Experiment

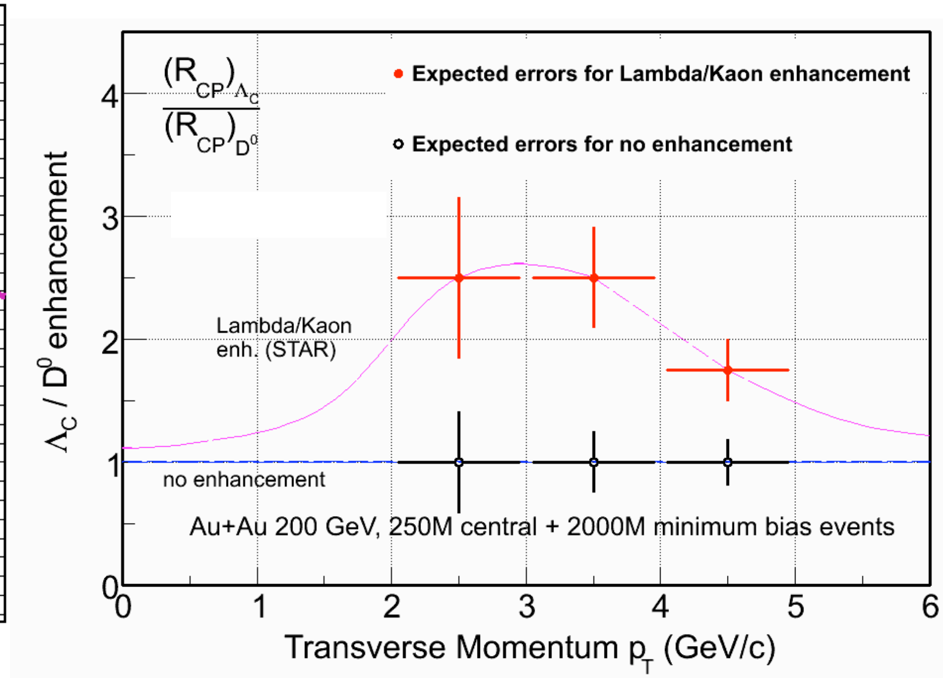


Timeline


Run: 9
10
11
12
14
DAQ 1000
Full TOF
Forward Gem Tracker
Small Beampipe STAR
Forward TPC's
Prototype
Heavy Flavor Tracker
Partial?
Muon Telescope Detector
Roman Pots Phase 2
Forward Upgrade
EBIS
RHIC II Luminosity
Low E Cooling

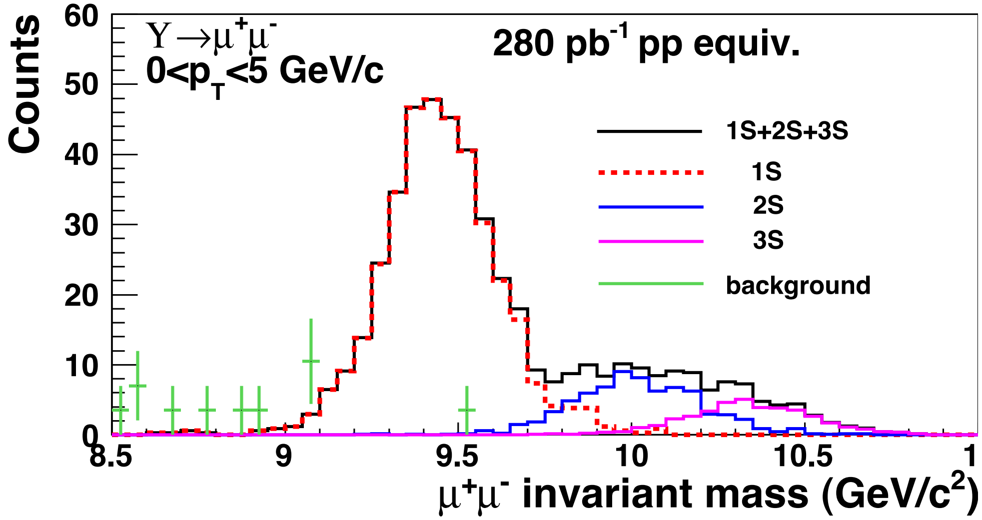
New Capabilities: Heavy Flavor Tracker

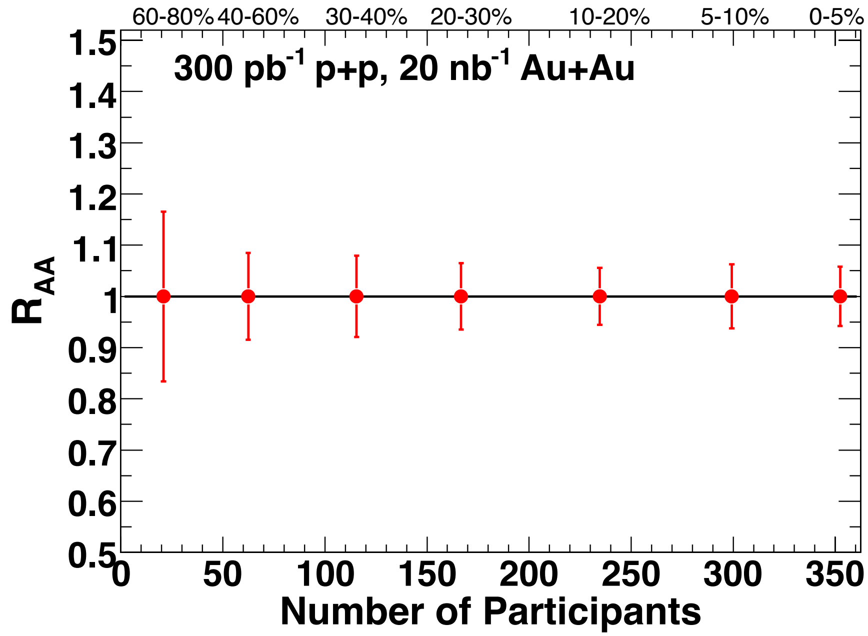




- Uniquely thin vertexer, with focus on fully reconstructed charm
  - Run 14: does charm flow (in the hydrodynamic regime)?
  - Run 15: reference data in p+p 200 GeV
  - Run 16: baryonic composition (is there a baryon/meson anomaly?)
    - Will lead to a revisit of the interpretation of NPE: branching ratios

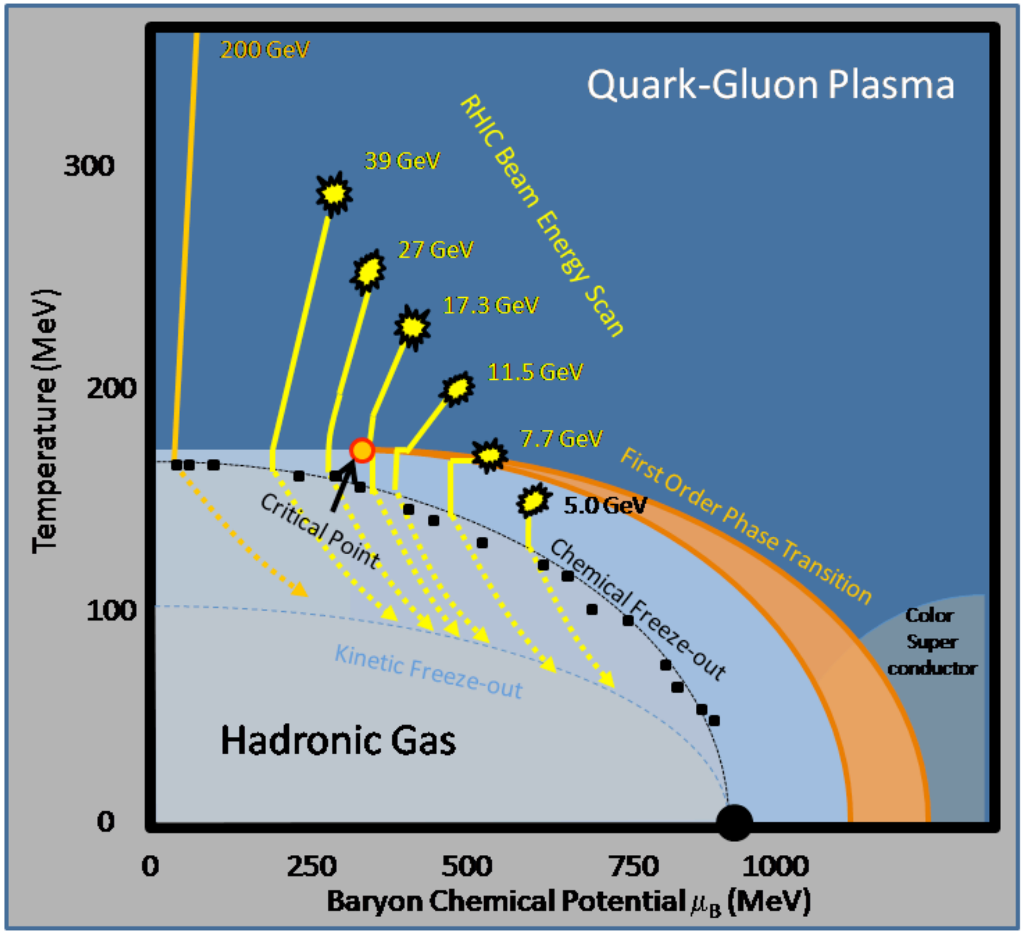
New Capabilities: Muon Telescope Detector





- Muons at mid-rapidity: dileptons of a different flavor
  - Effective trigger to sample entire RHIC luminosity
  - No Bremsstrahlung tails: separation of states
- High precision Upsilons, J/Psi, …
- Possibility of Phase 2 upgrade in latter part of the decade to increase coverage, selectivity

Flexibility: Critical Point Search



- Phase 1: Runs 10 and 11

~5M events/energy initially

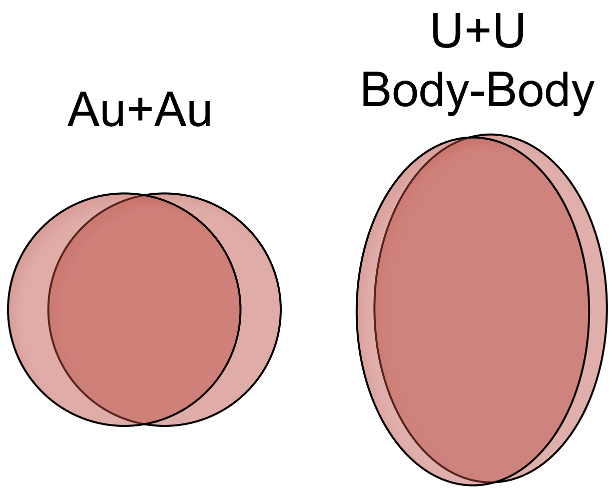
Fluctuations, LPV, NCQ, HBT

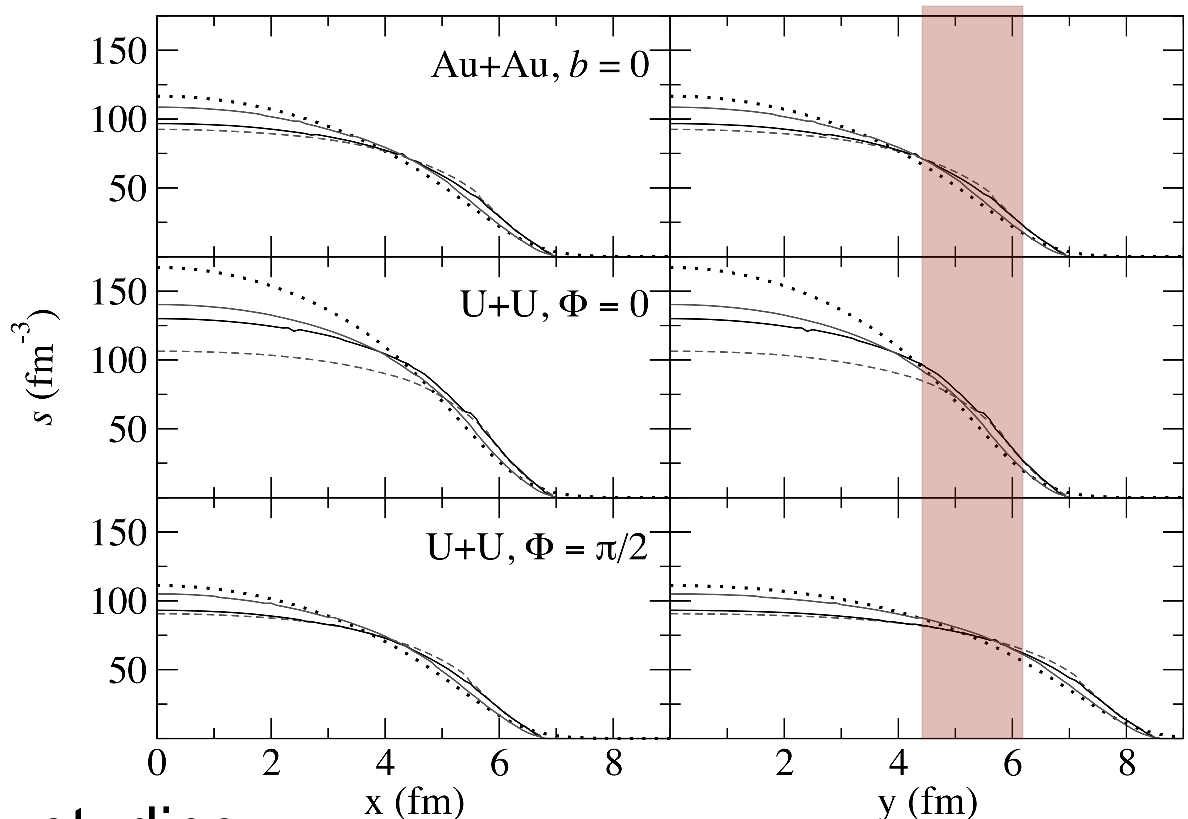
- Phase 2: Run >14
  - Luminosity improvement with electron cooling
  - Scan to lower energies, increased event count at other energies (dileptons…)

- Working hard on data taken this year to provide further guidance

Flexibility: U+U

A. Kuhlman, U. Heinz, Y.V. Kovchegov, Phys. Lett. **B638**, 171(2006

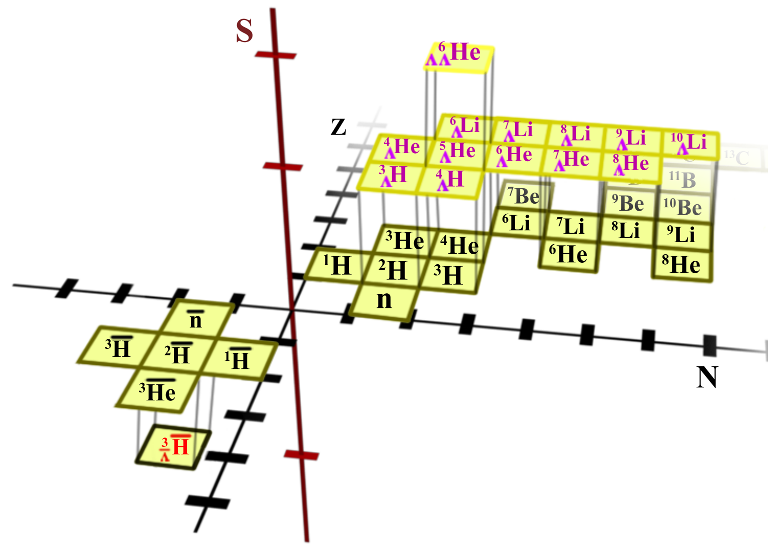


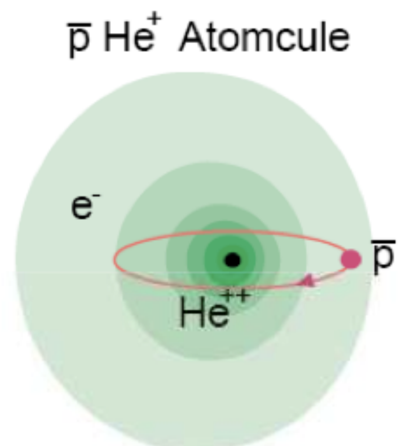


- Run 11: first feasibility studies
- Run 12 and later: high luminosity studies
- Unique: pathlength dependence of quenching (50% more L)
  - Full range of measurements: γ-jet, b and c, jets, Upsilons, …

Techniques: Spectroscopy

- STAR is the best place in the world for anti-hypernuclei
- Atomcule program started in Run 10: tests of CPT
- Beginning investigation of possibilities in μ-mesic atoms (μ-π, μ-K, μ-p)
- Exotica in Ultra-Peripheral Collisions and using Roman Pots Phase 2 in pp collisions
  - High luminosity = wide range of final states available

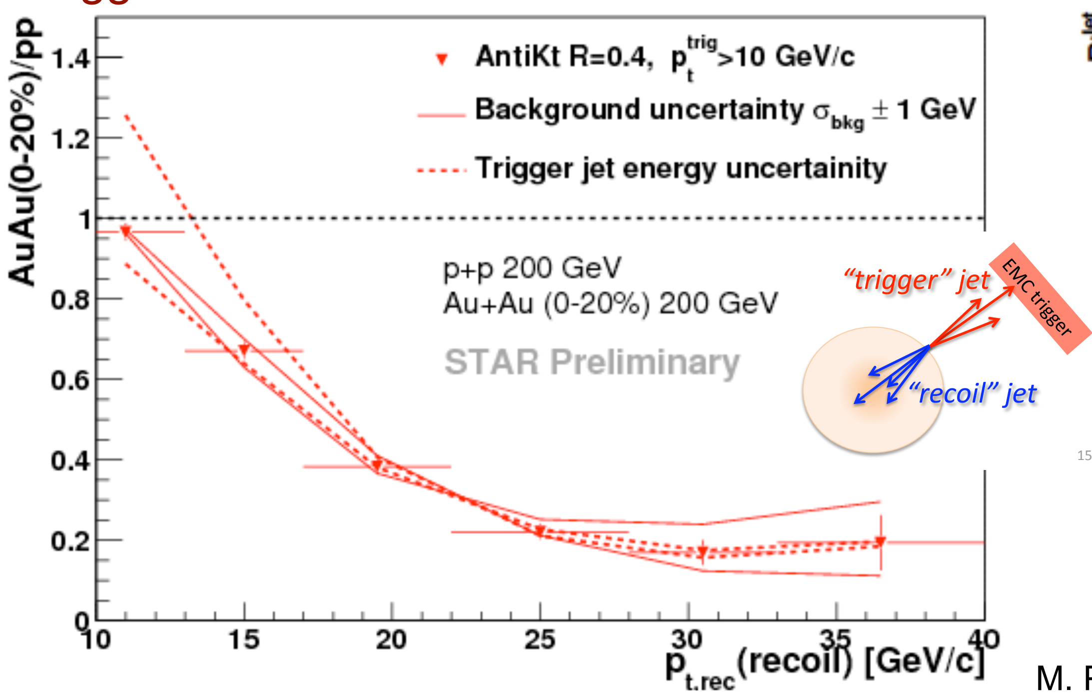




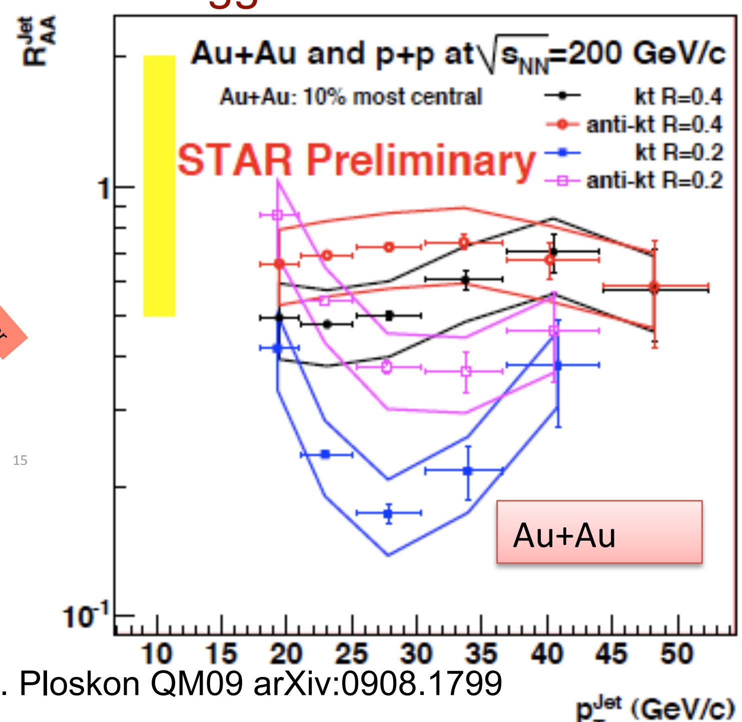
Unique to RHIC: Antinuclear (A>antiproton) atomcules

Techniques: Jets

Triggered di-Jet: ~0.3 nb^{-1}



Untriggered inclusive: ~0.01 nb^{-1}



M. Ploskon QM09 arXiv:0908.1799

Beginning results from Run 7 indicative, but in no way final word

Huge increases in significance with trigger upgrades+luminosity

- To do: investigate b-tagging with HFT

Complementary to LHC: only place to do jets < ~50 GeV

- RHIC: quark jets LHC: gluon jets (+b-tagging)

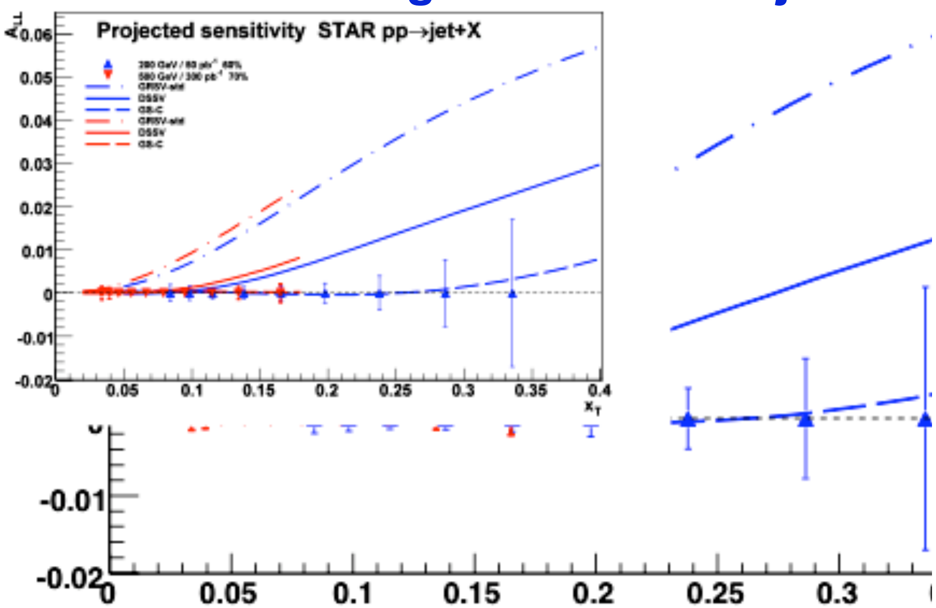
Spin: the broad array

- **Elucidate the partonic structure** of the proton
  - Gluon polarization
  - Flavor-separated quark and anti-quark polarizations
  - TMDs and twist-3 correlations
  - Transversity

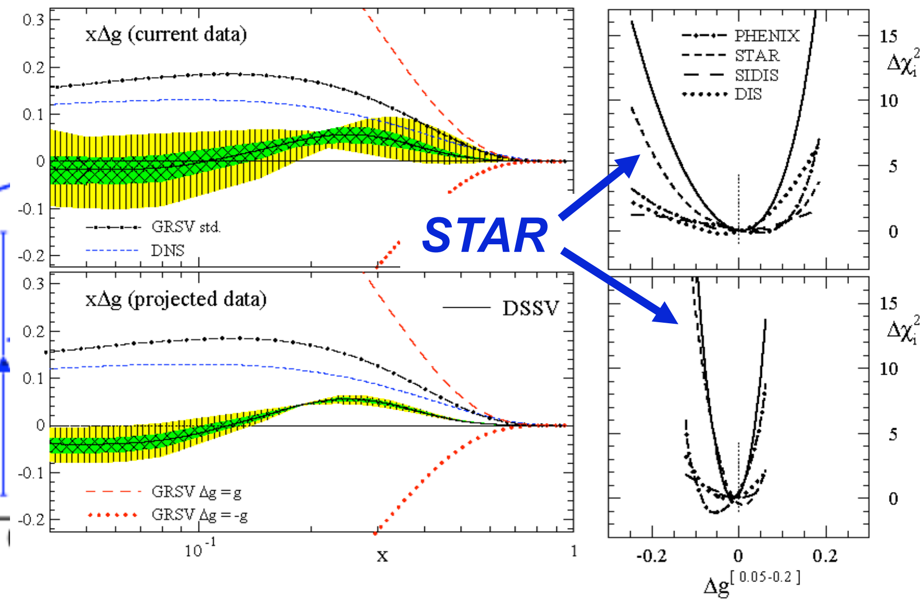
- **Explore the dynamics** that underlie spin-dependent hadronic interactions
  - Origins of the large transverse single-spin asymmetries
  - Diffractive interactions

Remaining goals from Run 9: Inclusive jet A_{LL}

STAR **Run 9 goal – inclusive jets**



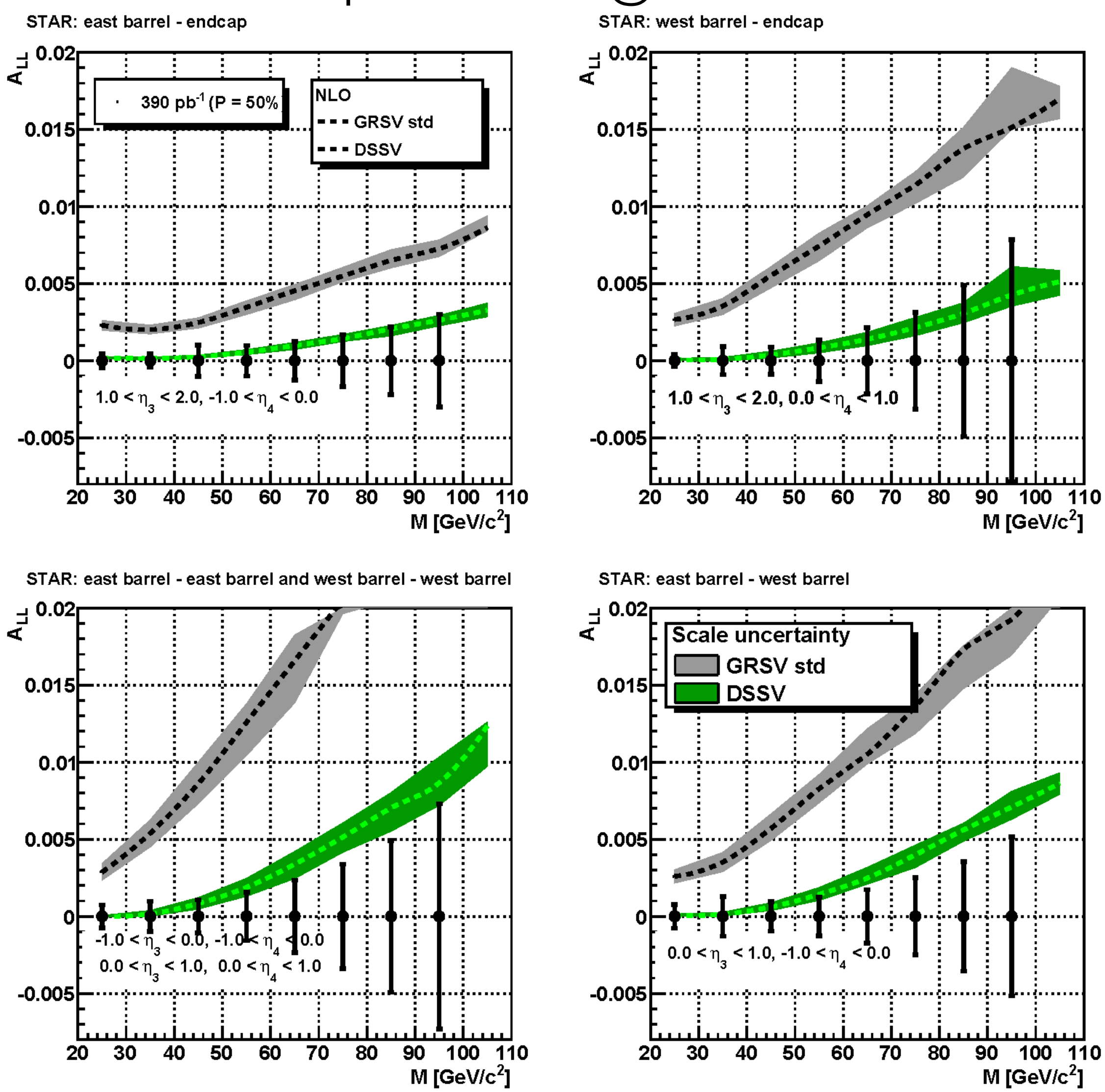
Projected improvement in $x\Delta g$ had we achieved the goal



- Goal for the Run 9 200 GeV run:
  - 50 pb^{-1} @ 60% pol – reduce A_{LL} uncertainties a factor of ~4
  - Provide strong constraints on gluon polarization
- Ended up sampling only 1/3 the desired Figure-of-Merit
- ***STAR*** is **not done** with gluon polarization studies at 200 GeV

Projected sensitivity for di-jets at 500 GeV

Assumes 600 pb^{-1} delivered @ P = 50%



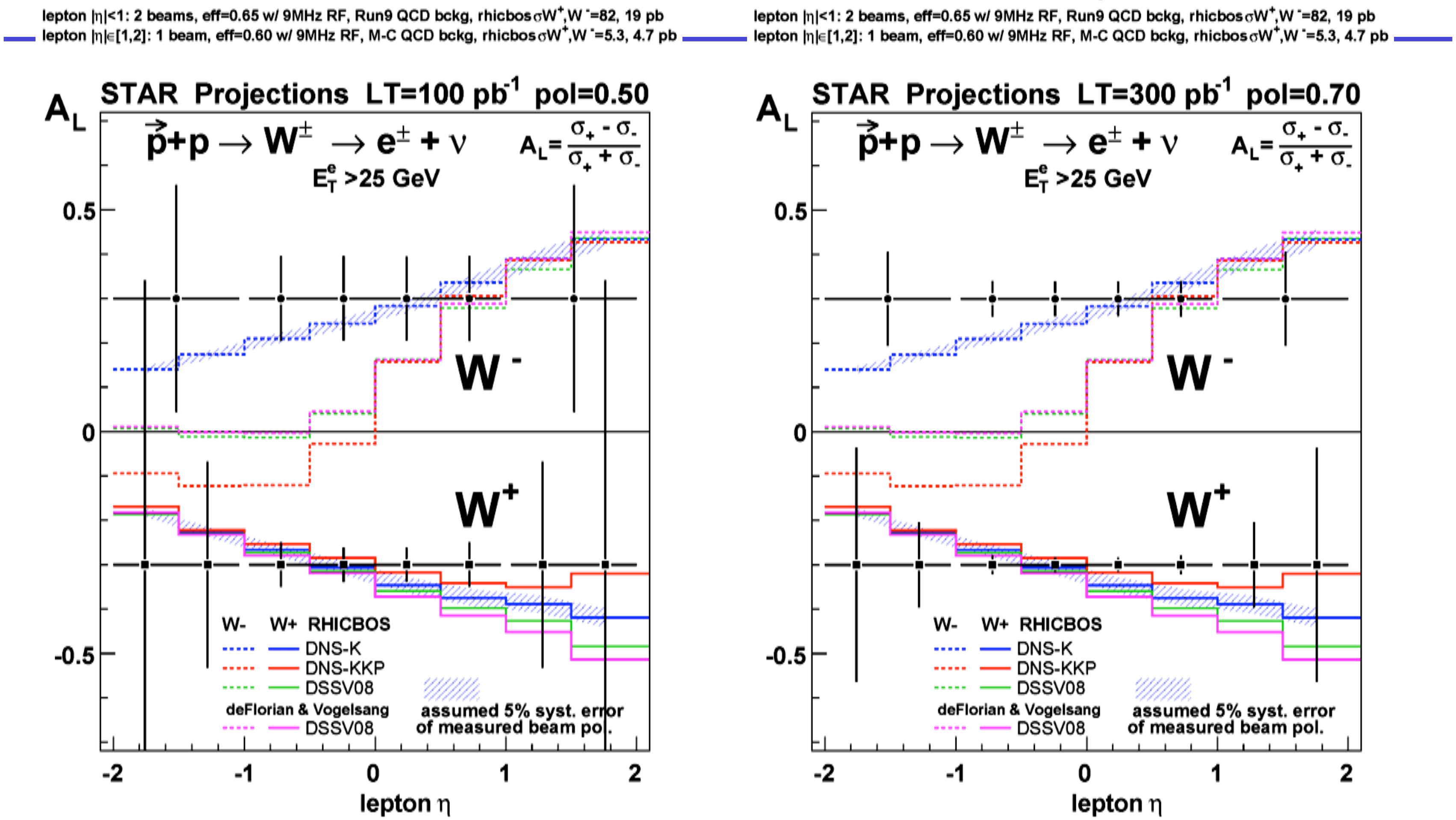
Includes information on trigger rates, etc., from Run 9

Uncertainties shown are purely statistical

Must push the relative luminosity systematic uncertainty down

- **High polarization essential** to minimize this sensitivity!

W sensitivities in upcoming runs



- Will significantly reduce uncertainties on antiquark polarizations
- Both high luminosity and high polarization are **essential**
  - Precision of beam polarization measurements also important for mid-rapidity W^+ asymmetries

Transverse spin measurements

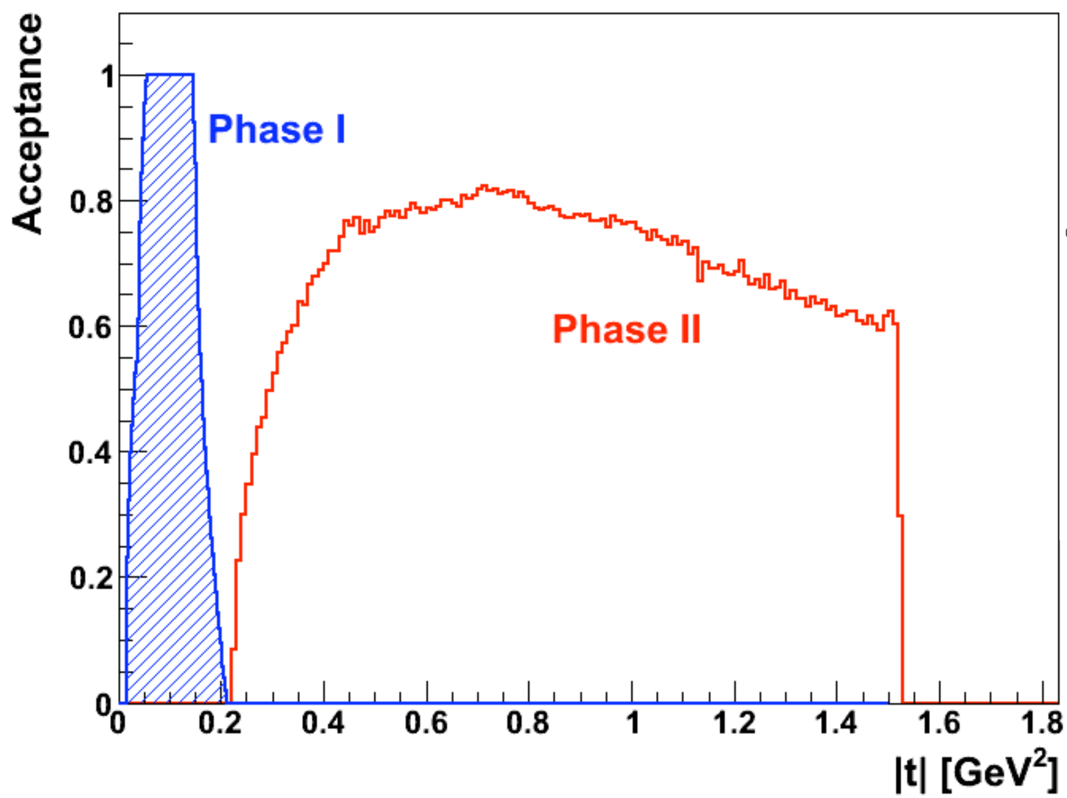
- Next few years:
  - A_N for π^0 and η with high precision over a broad range in (x_F, p_T)
    - Important on their own
    - Essential inputs to constrain the backgrounds for direct photons
  - A_N for photons and γ + jet
  - A_N for jets or jet-like events
  - Forward Lambdas
    - Also very interesting with longitudinal beams

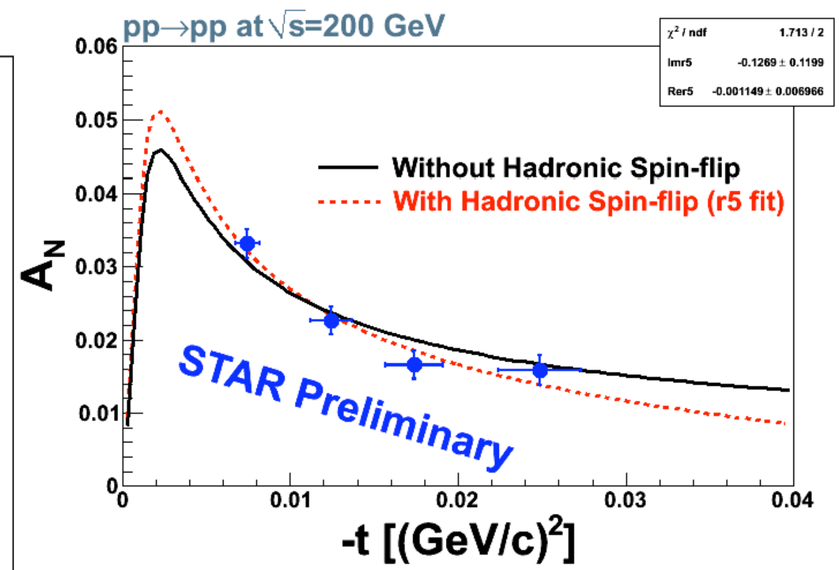
→ Forward Hadron Calorimeter: Inexpensive bridge to full forward upgrade

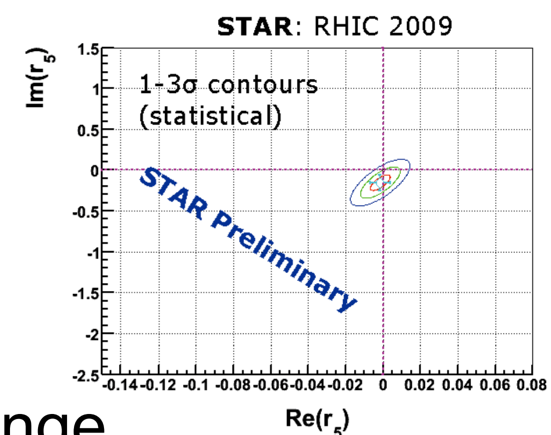
- Further future:
  - Drell-Yan
  - Polarized ^{3}He

→ Forward Upgrade
Tracking: Solenoid is likely enough, but need high precision spacepoints
Calorimetry: granularity, e/h

New Capabilities: Roman Pots Phase 2

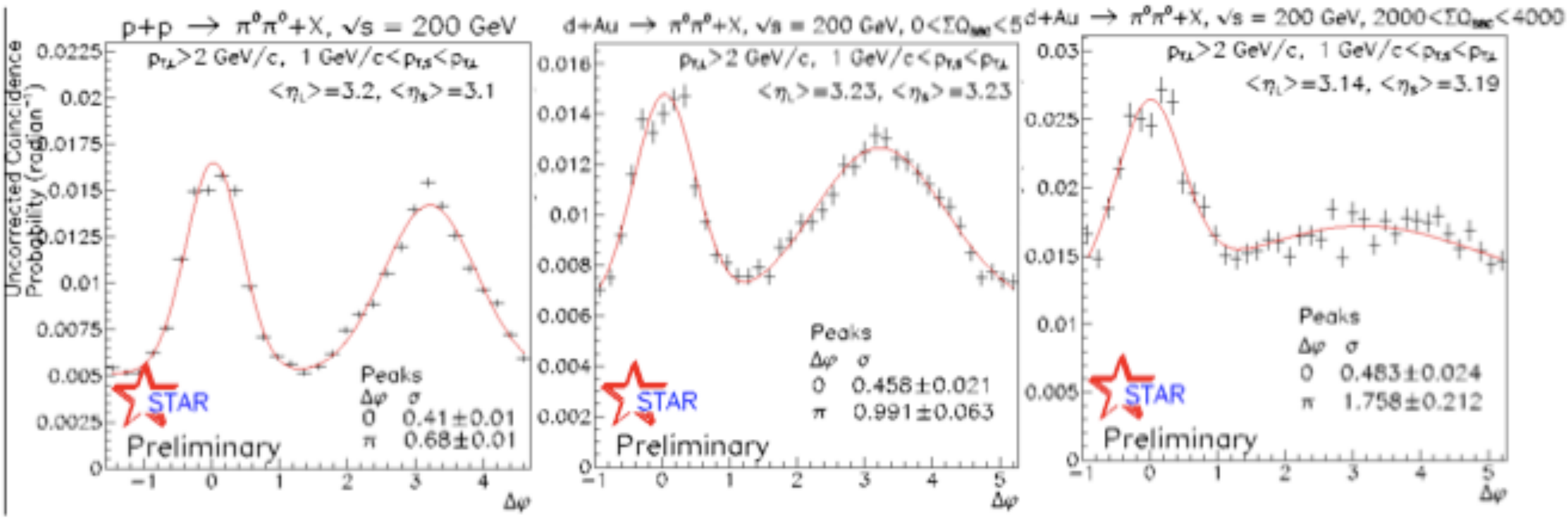






- Extend t acceptance, run concurrently
- Glueball search in double Pomeron exchange
- Future: critical for diffractive physics at eRHIC

p+A: Saturation

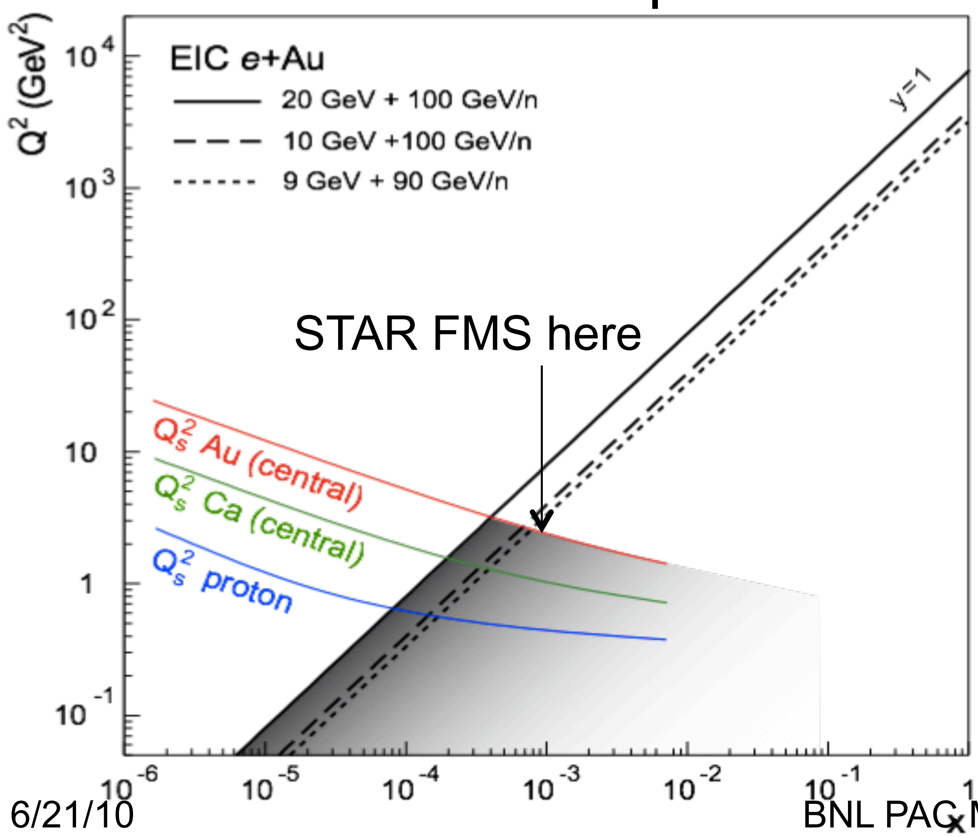


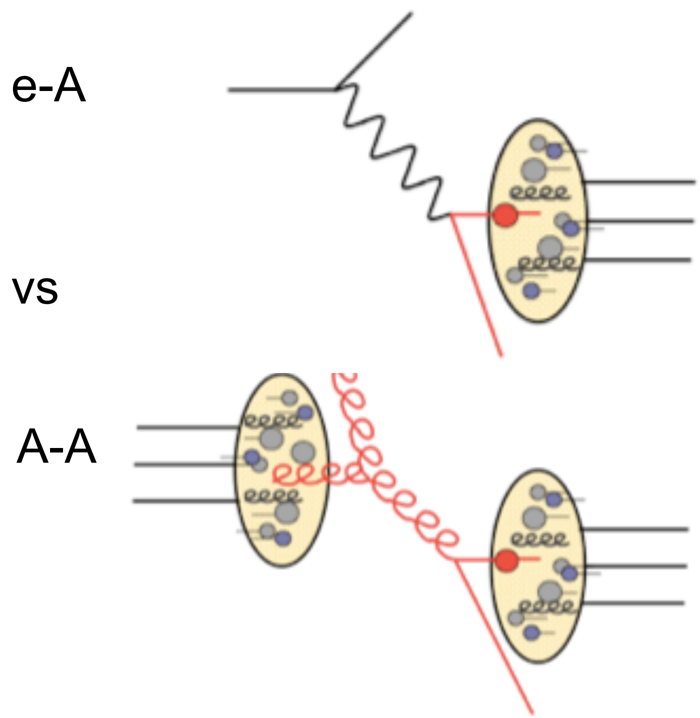
pp ***d+Au (peripheral)*** ***d+Au (central)***

- Indications of saturation in Run 8 from decorrelation
- Compelling and necessary further measurements in future
  - Go as electromagnetic and factorizable as possible: Drell-Yan, photons
  - Likely want p+A, rather than d+A, for cleanest results
- RHIC provides unique access to the onset of saturation

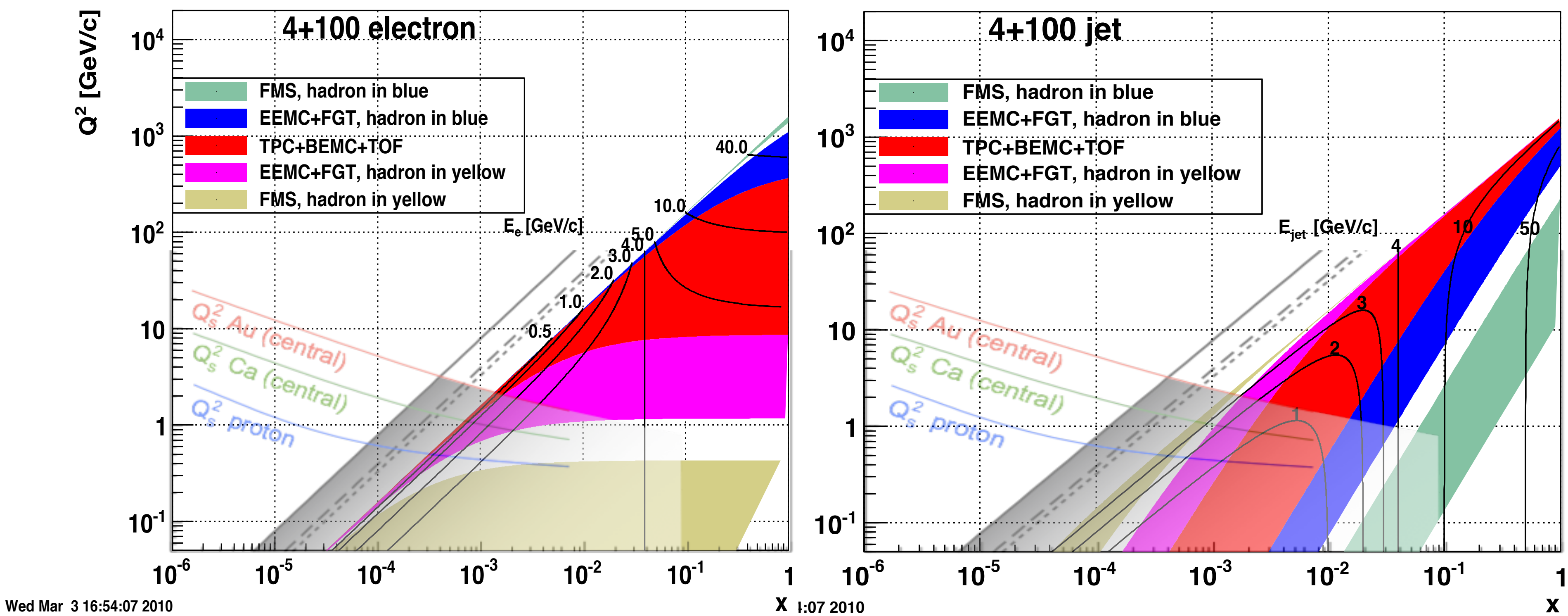
Connections: A+A to p+A to e+A

- e-A: Precise understanding of A in A+A
  - Initial state: saturation and more generally nuclear PDF's
  - Energy loss in cold nuclear matter
- Precise control of kinematics, map independently x and Q^2
- Factorization: initial probe via QED rather than QCD



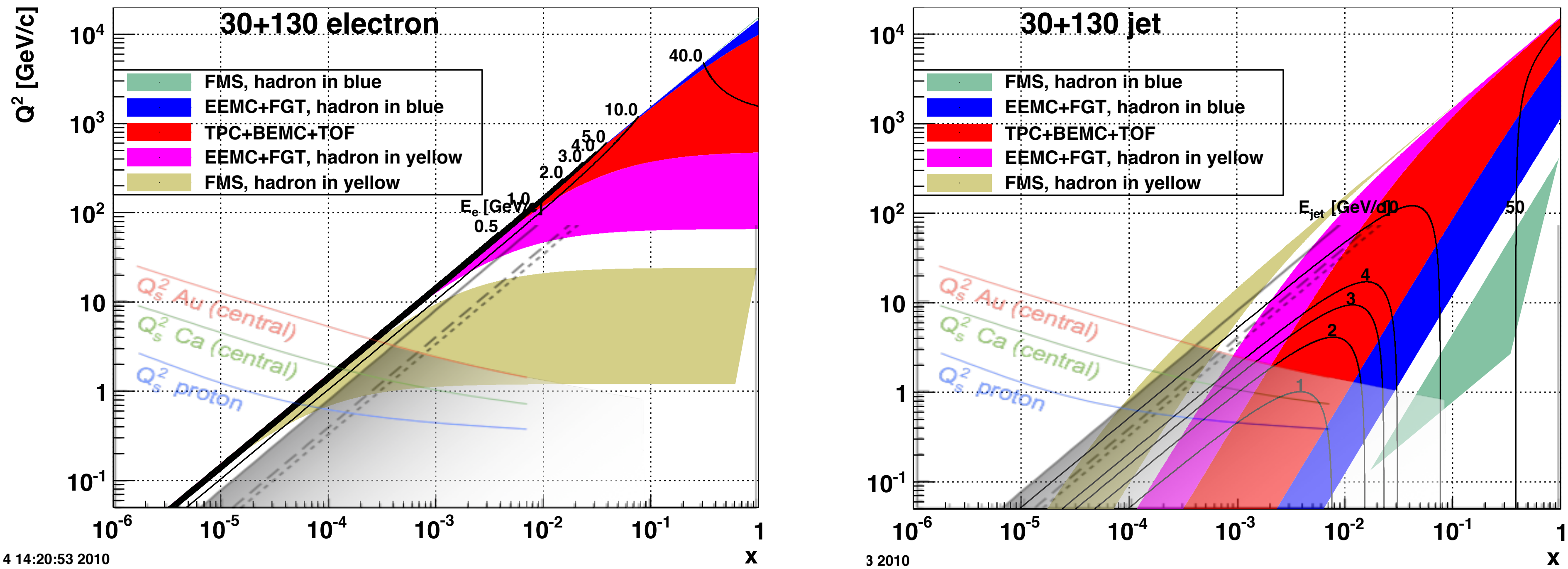


STAR and meRHIC



- Current detector matches quite well to kinematics of meRHIC
  - Particle ID, sufficent p_T resolution, etc. at mid-rapidity
  - Upgrades in forward direction: increase capability at lower momentum
- Developing plan for effective and compelling use of e+A

Longer term: STAR and eRHIC



- Forward region critical for higher energy options
- Major upgrades in forward direction needed
  - Either in STAR, keeping mid-rapidity capability intact, or in a completely new detector somewhere else

Summary

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  - A+A: full range of A and E
  - polarized p+p: broad study of spin structure of matter
  - p+A: understand the A in A+A
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- Build on our strengths
  - Keep using (and refurbish as necessary)
  - existing and proven detector systems
- Address our weaknesses
  - Add fundamentally new capabilities
    - heavy flavor, muons, forward direction