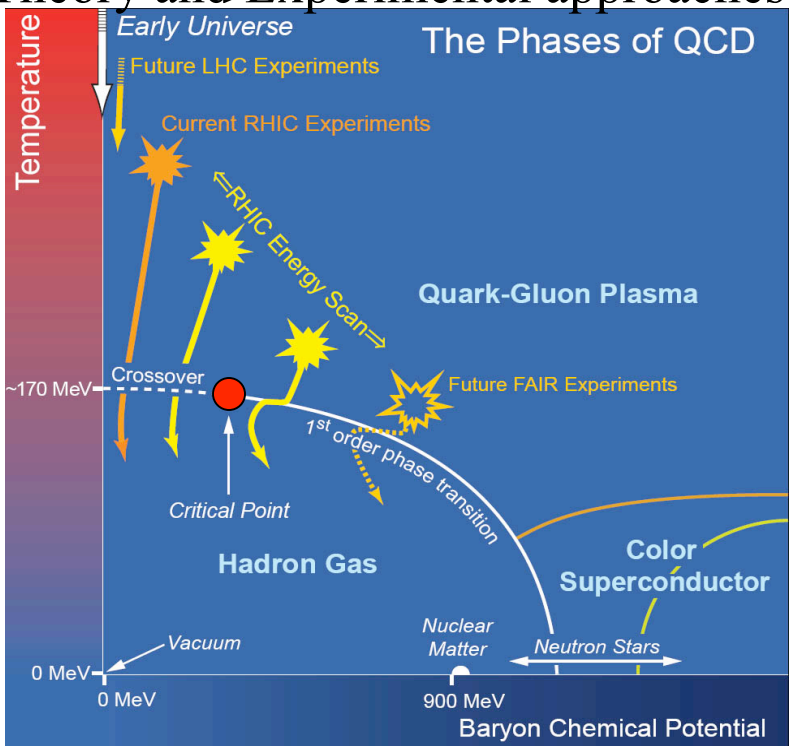
3 Years

2008 - 2010/11

Three exciting physics observations
Three exciting physics programs
Three new beam energies data
Three Quark Matters
Three publication milestones
Three challenges
Three support from collaboration
Three important future programs

QCD (Hadrons -- Partons)
Theory and Experimental approaches

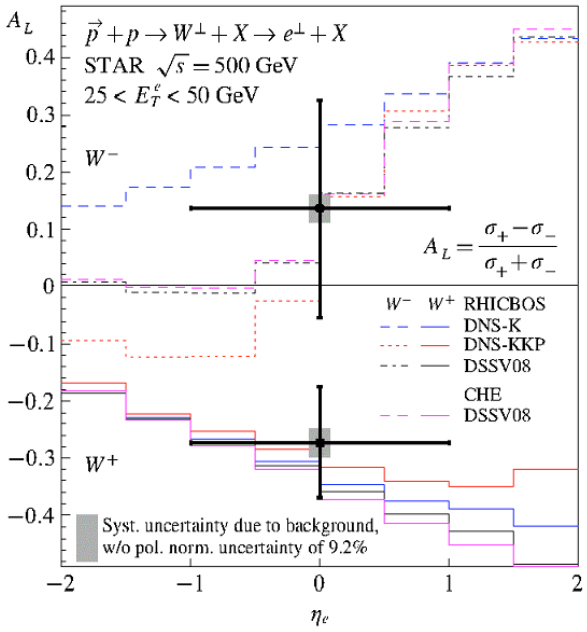


Bedanga Mohanty

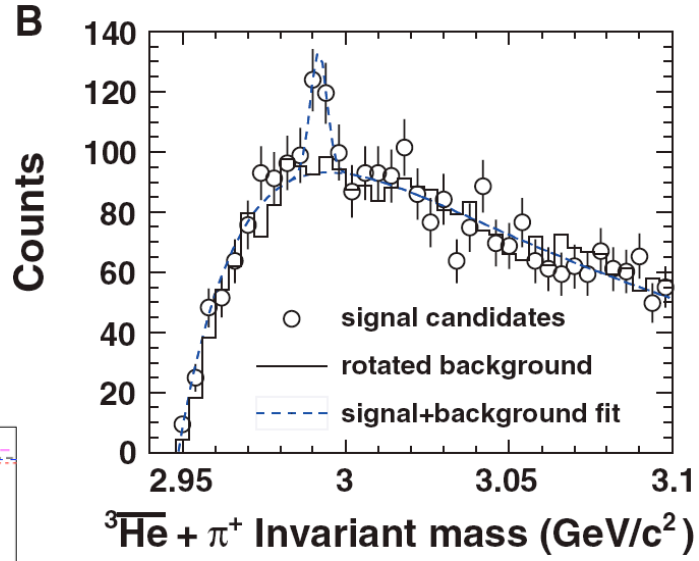
Three Exciting Physics Observations

Anti-Hypertriton
Anti-alpha
W- spin asymmetry

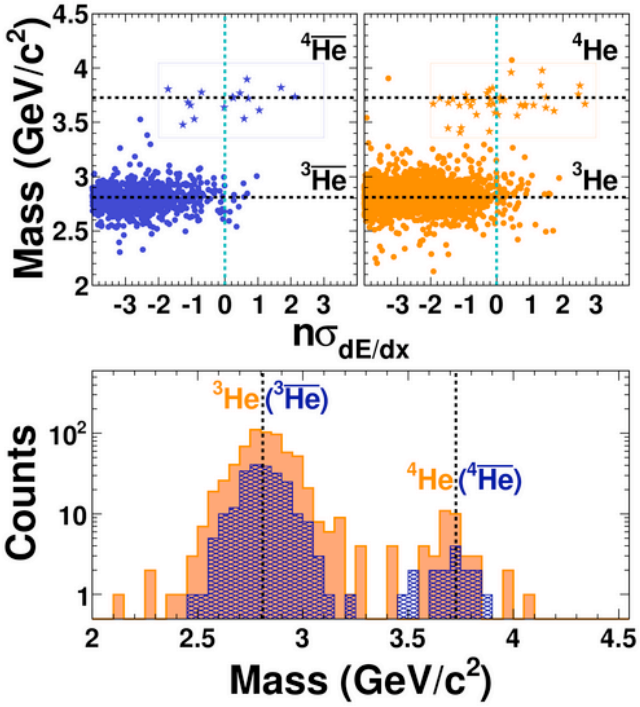
Physical Review Letters



Science



Submitted to Nature



Once in a lifetime opportunity to be an experiments physics coordinator and guide results towards a discovery!

Antimatter - Ideas

Nature 58, 367 (18 August 1898) Potential Matter.- A Holiday Dream - by Arthur Schuster

"Surely something is wanting in our conception of the universe. We know positive and negative electricity, north and south magnetism, and why not some extra terrestrial matter related to terrestrial matter as the source is to sink …….

Worlds may have been formed of this stuff, with elements and compounds possessing identical properties with our own, undistinguishable in fact from them until they are brought into each other's vicinity." *(Matter-Anti-matter asymmetry)*

"If there is negative electricity, why not negative gold, as yellow and as valuable as our own, with same boiling point and identical spectra lines; different only in so far that if brought down to us it would rise up into space with an acceleration of 981." *(CPT)*

"Whether such thoughts are ridiculed as inspirations of madness or allowed to be serious possibilities of a future science … Astronomy, the oldest and yet most juvenile sciences, may still have some surprises in store….. But I must stop - … we must return to sober science, and dreams must go to sleep till next year.

Do dreams ever come true ?" Yes!

Three Exciting Physics Programs

Beam Energy Scan Program:

(a) Demonstrate STAR work below injection energy

(b) Provide an observable for CP search

(c) QCD Phase Diagram

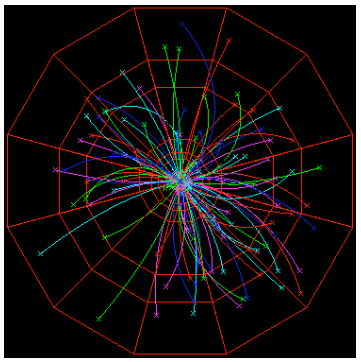
Di-lepton Physics:

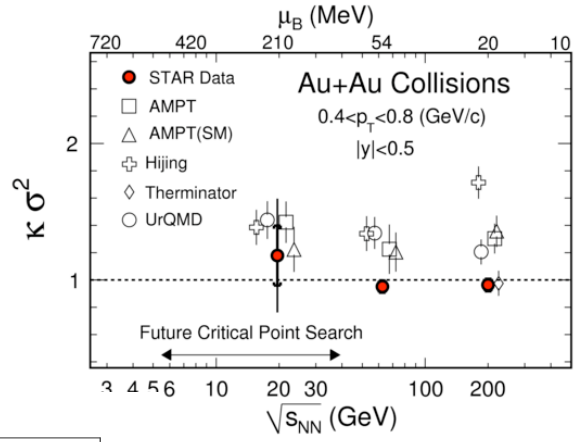
New detector in STAR: ToF

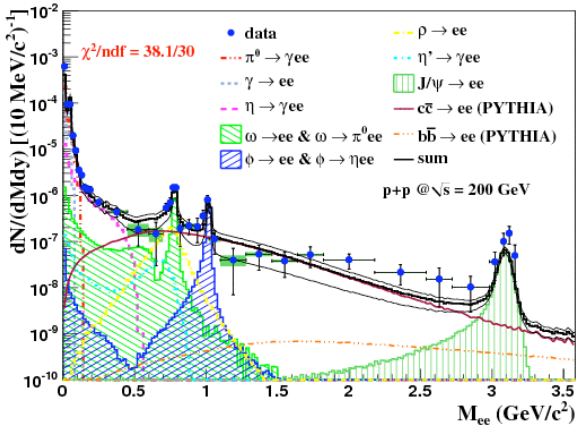
A completely new area of physics open for research

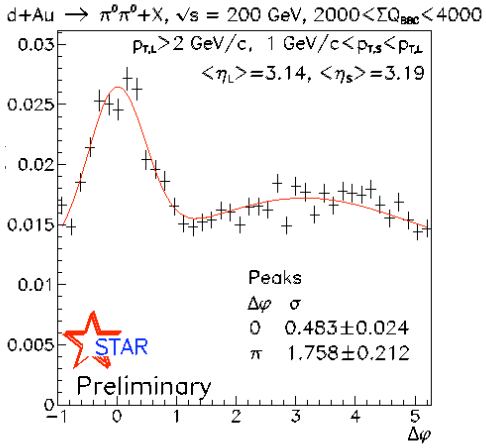
Forward physics:

W production, CGC studies and pp2pp









Three New Beam Energies

7.7 GeV
11.5 GeV
39 GeV

Goals:

A search for turn-off of new phenomena already established at higher RHIC energies.

A search for signatures of a phase boundary and a critical point.

History Behind BES Program

STAR: Beam User Request 2008:

"Start the energy scan program within root(s_NN) = 39 - 6.1 GeV. This is to search for the QCD phase boundary and the possible critical point in the diagram."

Nuclear & Particle Physics Program Advisory Committee
STAR request not accepted:

http://www.bnl.gov/npp/docs/pac0508/Final%200508%20PAC%20Recommendations_sv_edited.pdf

(A) "…the experimental capabilities, in particular at sub-injection energies (i.e. below the normal AGS injection energy), are quite different for the two experiments, due to overall acceptance and triggering issues." --- *Demonstrate STAR (designed for 200 GeV) can run at low energy*

(B) "To date, however, the PAC has not seen a compelling presentation of the key observables and their potential physics impact for this measurement program. …..observables need to be identified, their measurements simulated and luminosity requirements established." -- Establish a proper observable

History Behind BES Program

PHYSICAL REVIEW C 81, 024911 (2010)

Identified particle production, azimuthal anisotropy, and interferometry measurements in Au + Au collisions at $\sqrt{s_{NN}} = 9.2$ GeV

We present the first measurements of identified hadron production, azimuthal anisotropy, and pion interferometry from Au + Au collisions below the nominal injection energy at the BNL Relativistic Heavy-Ion Collider (RHIC) facility. The data were collected using the large acceptance solenoidal tracker at RHIC (STAR) detector at $\sqrt{s_{NN}} = 9.2$ GeV from a test run of the collider in the year 2008. Midrapidity results on multiplicity density dN/dy in rapidity y, average transverse momentum $\langle p_T \rangle$, particle ratios, elliptic flow, and Hanbury-Brown–Twiss (HBT) radii are consistent with the corresponding results at similar $\sqrt{s_{NN}}$ from fixed-target experiments. Directed flow measurements are presented for both midrapidity and forward-rapidity regions. Furthermore the collision centrality dependence of identified particle dN/dy, $\langle p_T \rangle$, and particle ratios are discussed. These results also demonstrate that the capabilities of the STAR detector, although optimized for $\sqrt{s_{NN}} = 200$ GeV, are suitable for the proposed QCD critical-point search and exploration of the QCD phase diagram at RHIC.

PhD thesis - Lokesh Kumar

Ex-PHENIX spokesperson - W. Zajc : Congratulates STAR at SQM2008 Summary talk

Referee: “The collaboration is to be commended for the beautiful data….”

History Behind BES Program

PRL 105, 022302 (2010) PHYSICAL REVIEW LETTERS week ending 9 JULY 2010

Higher Moments of Net Proton Multiplicity Distributions at RHIC

at μ_B values $\lesssim$200 MeV in the QCD phase plane. The RHIC beam energy ($100 < \mu_B < 550$ MeV) scan will look for nonmonotonic variation of $\kappa\sigma^2$ for net protons as a function of $\sqrt{s_{NN}}$ to locate the CP.

Data Paper Referee A : “An excellent paper, very well written and it has a clear message.”
Data Paper Referee B : “The paper reports one of the most interesting measurements to come out of RHIC recently, and addresses the question of the location of the QCD critical point. As such it is of wide interest.”

http://drupal.star.bnl.gov/STAR/starnotes/public/sn0493

Experimental Study of the QCD Phase Diagram and Search for the Critical Point: Selected Arguments for the Run-10 Beam Energy Scan at RHIC
The STAR Collaboration (B. I. Abelev et al.)

We present an overview of the main ideas that have emerged from discussions within STAR for the Beam Energy Scan (BES).

BES Program Approved by PAC

QM2009: Summary Talk -

"Exploring the QCD phase diagram needs to be vigorously pursued to know properties of basic constituents of matter under extreme conditions."

"To make the QCD phase diagram a reality equal attention needs to be given to high baryon density region."

15-16 June 2009

Nuclear & Particle Physics Program Advisory Committee

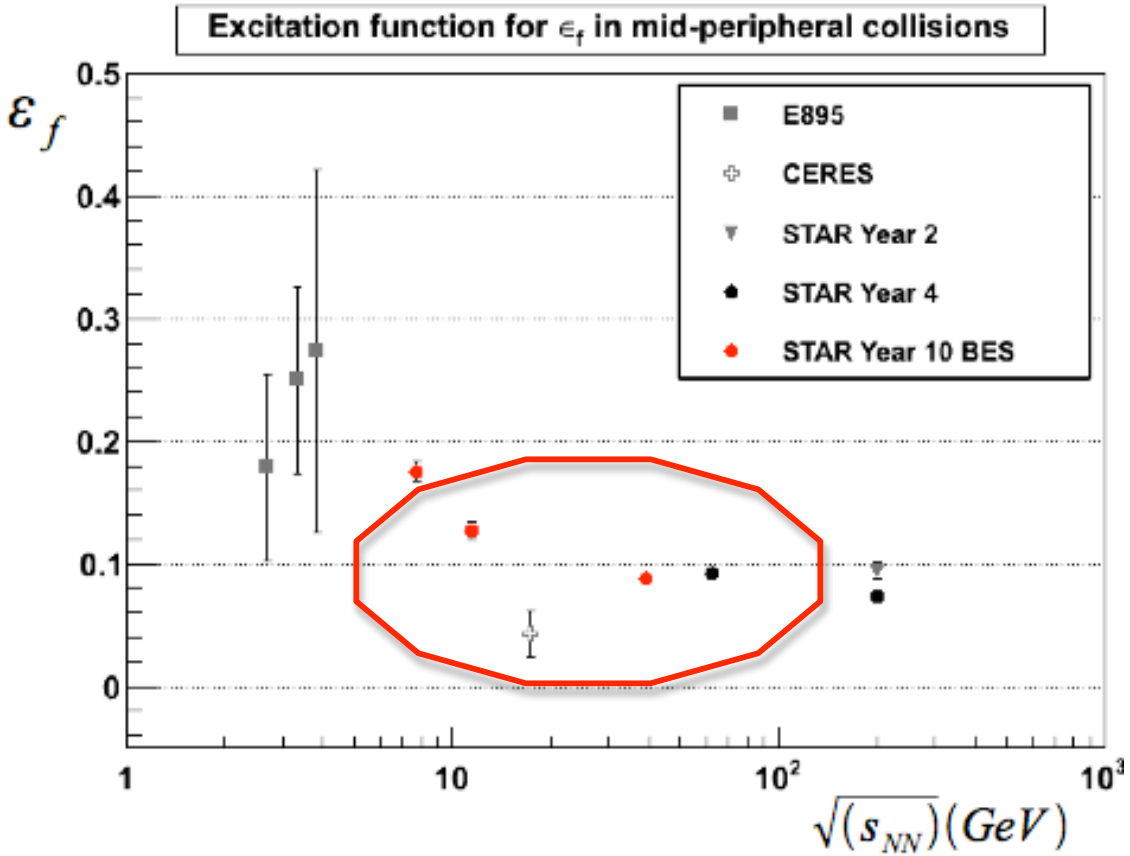
For Run 10 the PAC recommends

http://www.bnl.gov/npp/docs/pac0609/Final%20Recommendations%20(2).pdf

….. 12 weeks for a beam energy scan (BES) with Au-Au collisions.. The use of only one of the two major detectors during the latter period is justified by the strong attention given in the RHIC community to the potential for a landmark observation in this energy range…… In arriving at its recommendations for the BES, the PAC has given priority to careful measurements of the energy dependence of fluctuation and correlation observables associated with the CEP search,……

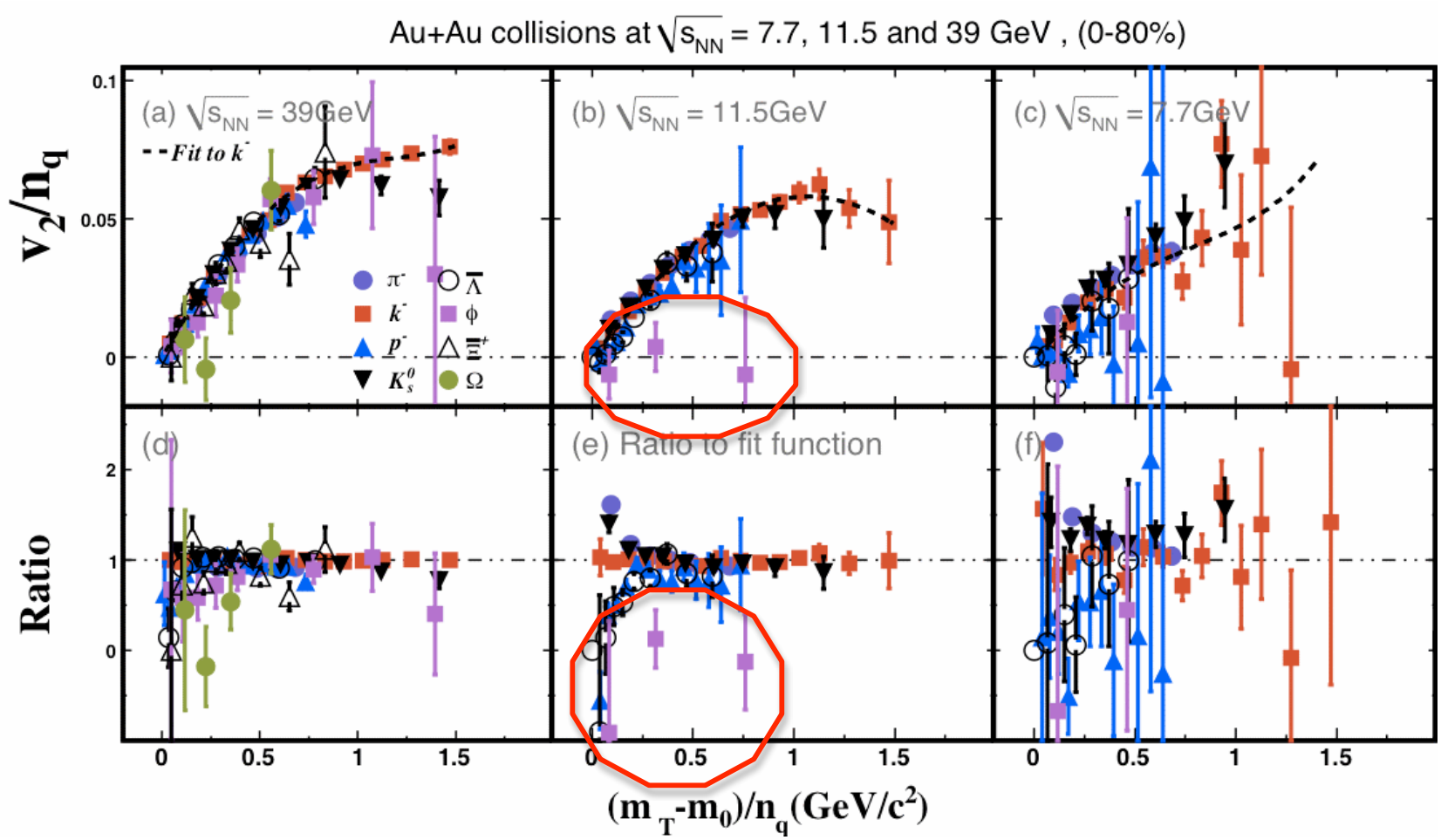
Rich Physics Results - HBT

STAR: 10-30%
NA45: 10-25%
E895: 8-28%



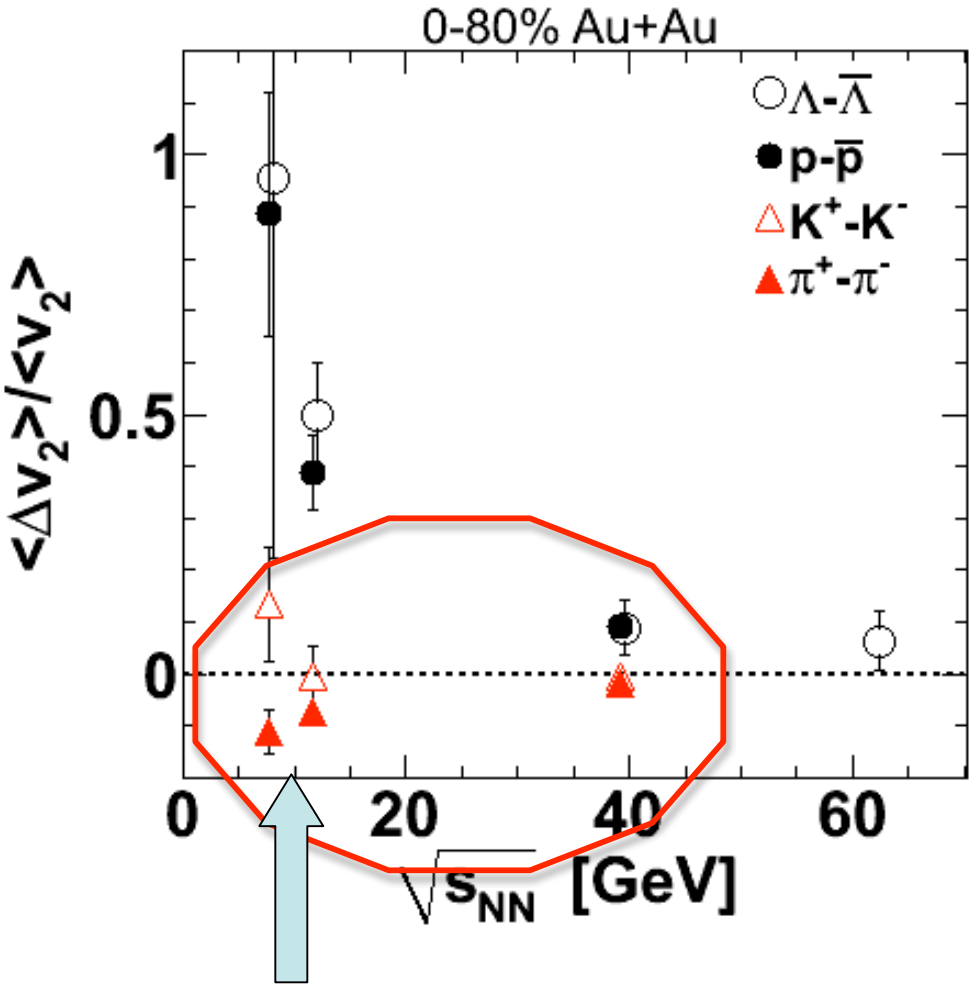
1) Measured eccentricity at freeze-out
2) NA45 data point seems lower than usual: the 'softest point' in EOS?
3) Need data from Au+Au collisions at 18 and 27 GeV

Rich Physics Results - v_2



1) At 200 GeV, the NCQ scaling in v_2 is one of the evidences for the formation of sQGP in Au+Au collisions at RHIC
2) At 11.5 GeV, ϕ-mesons seems to drop from the scaling. Note that ϕ-mesons do not interact in hadronic environment.
3) Need high statistics data at 18 and 27 GeV

Rich Physics Results - v_2



1) At 200 GeV, the NCQ scaling in v_2 is one of the evidences for the formation of sQGP in Au+Au collisions at RHIC

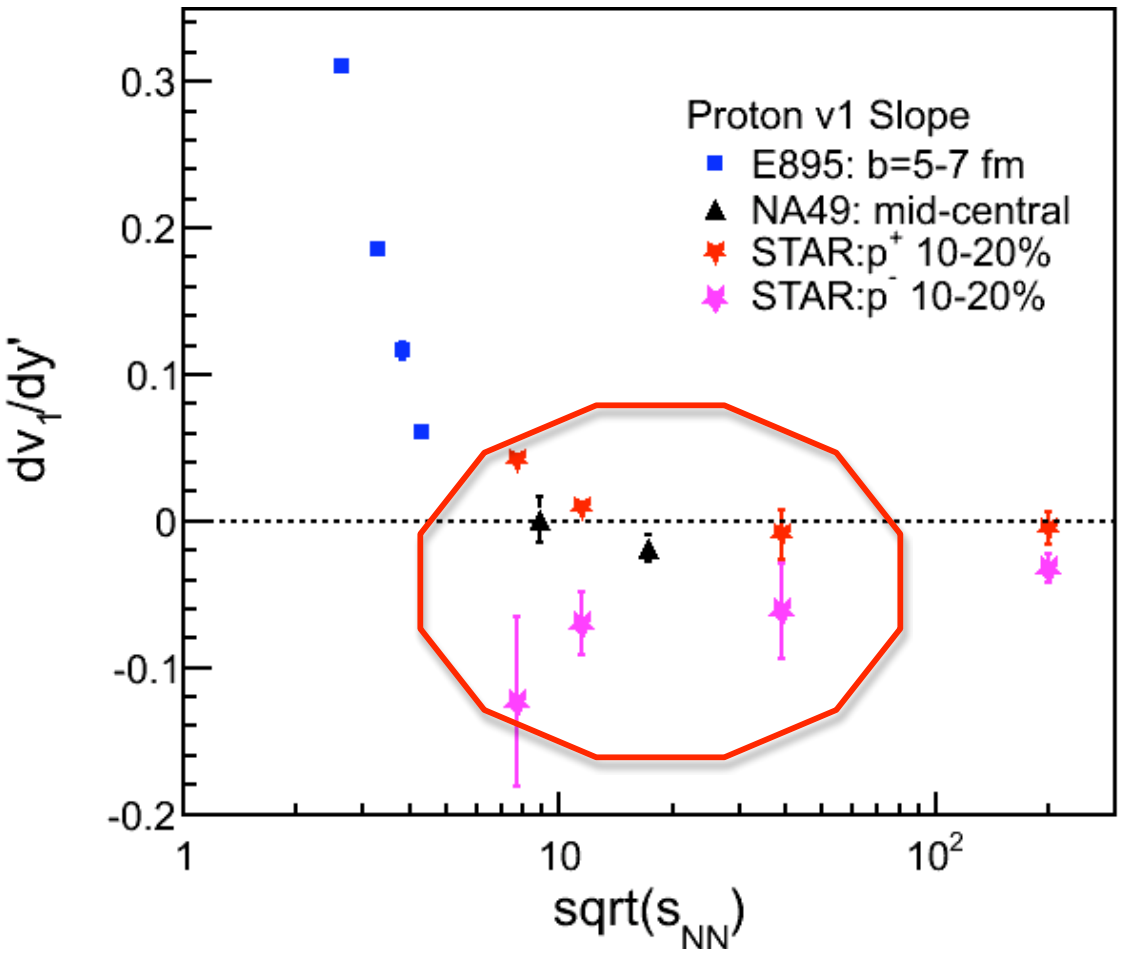
2) At 7.7 and 11.5 GeV, the v2 of anti-p and anti-Λ are much lower than their corresponding particles: indicating the hadronic interactions become dominant.

Partonic => Hadronic !

3) Need high statistics data at 18 and 27 GeV to see where does the change occur

CME effect ??

Rich Physics Results - v_1



1) The slope ***dv_1/dy'*** represents the transverse side motion relative to the beam direction.

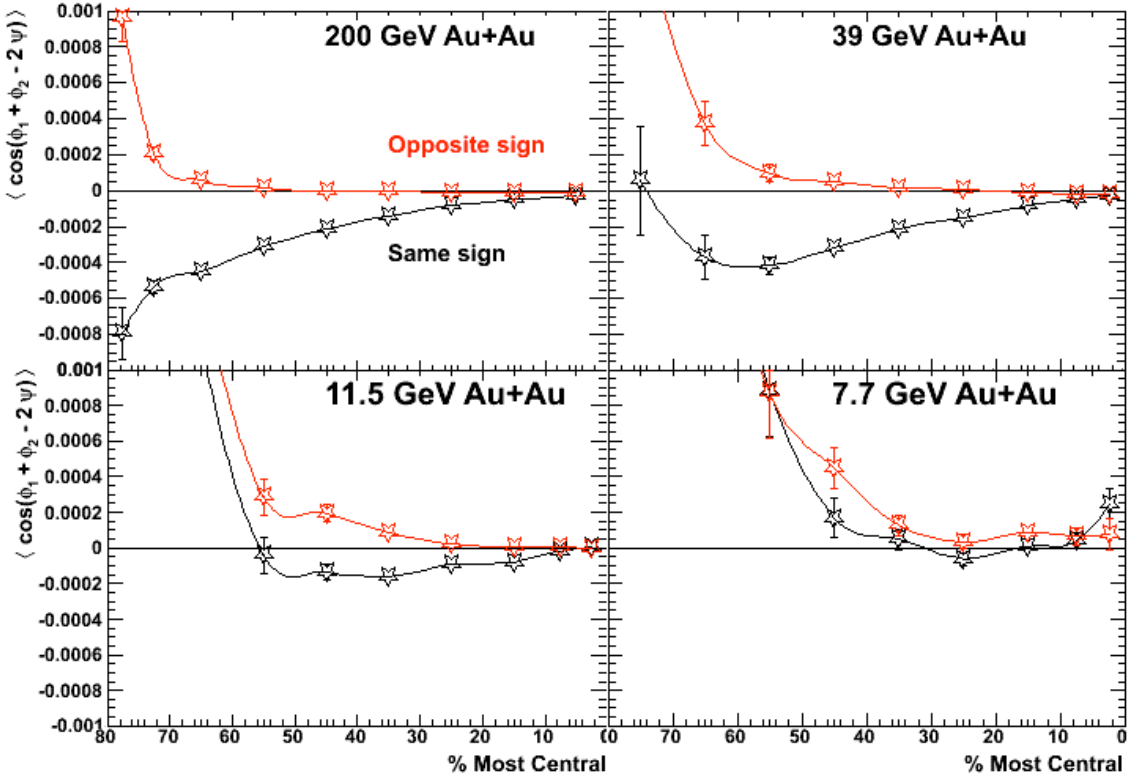
2) The mid-rapidity slope changes sign between 11.5 and 39 GeV:

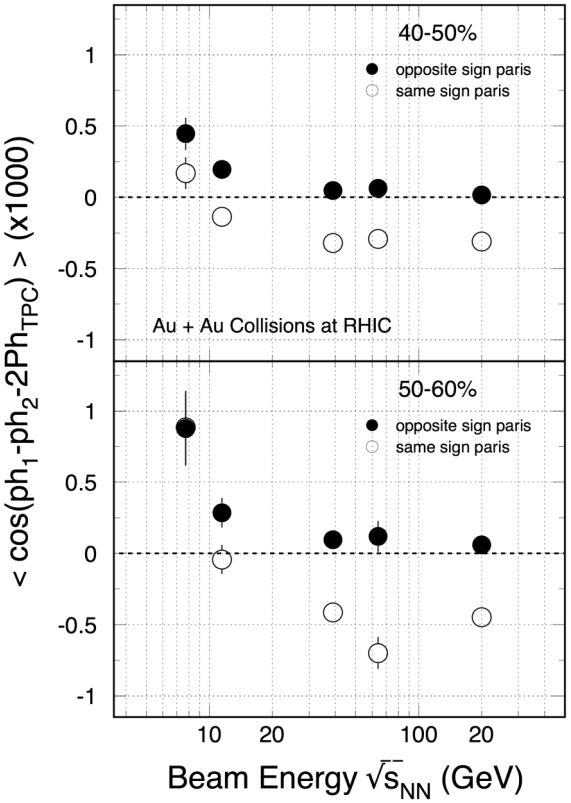
   Change of EOS?

3) Need 18 and 27 GeV data to understand the evolution.

Reduced rapidity: **$y'=y/y_{beam}$**

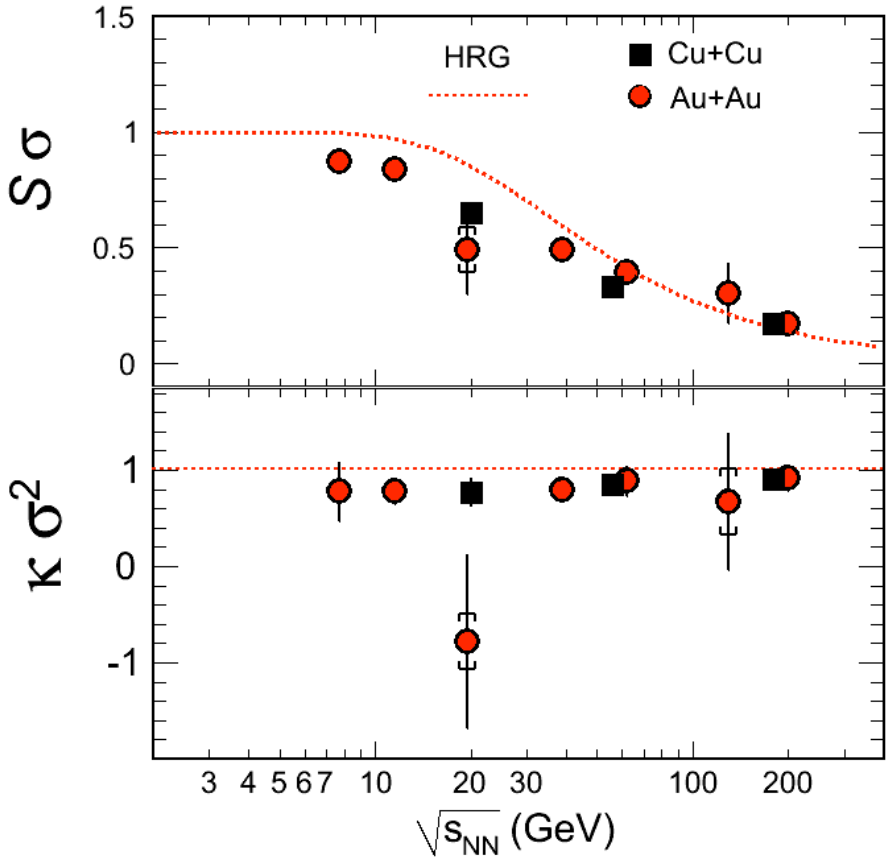
Rich Physics Results - CME





1) At 200GeV, observed charge separated correlation is consistent with CME: Strong B-field, de-confinement, and Chiral symmetry restoration.
2) Such separation seems disappeared at 11.5 and 7.7 GeV.
3) Need data at 18, 27 GeV.

Rich Physics Results - Fluctuations



1) In thermodynamics, high order correlations are sensitive to the correlation scale of the system thus to the structure of matter under study.

2) At 200, 130, 62 GeV, data are consistent with thermal model predictions.

3) Deviation from HRG predictions at 19.6, 11.5 and 7.7 GeV.

4) Need data at 18, 27 GeV

Three Quark Matters

QM2008: 24 Talks + 2 Plenary

QM2009: 21 Talks + 4 Flash Talks + 2 Plenary Talks

QM2011 +1 Plenary Talk

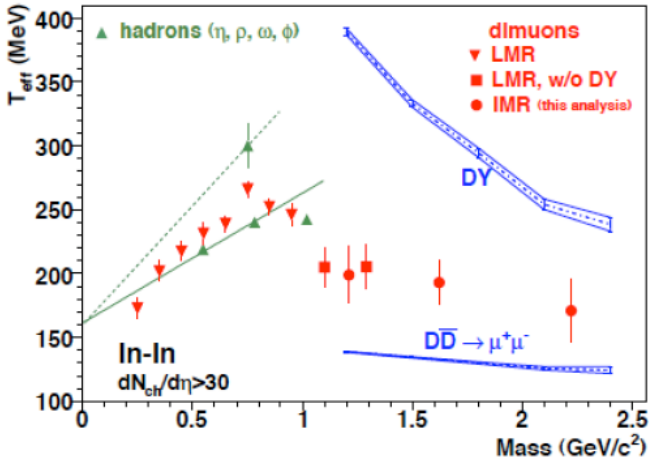
Conversion to papers: QM2009 - 12 papers
QM2008 - 15 papers

PWG	Proposed	Analysis Mtg.	Submission
LFSpectra	9 Talks, 3 Posters	5* Talks	
Bulk Corr	29 Talks, 2 poster	9 Talks	
Jet Corr	8 Talks, 1 Poster	4* Talks	
Heavy Flavor	12 Talks	6* Talks	
UPC	1 Talk	1 Talk	

QM2011

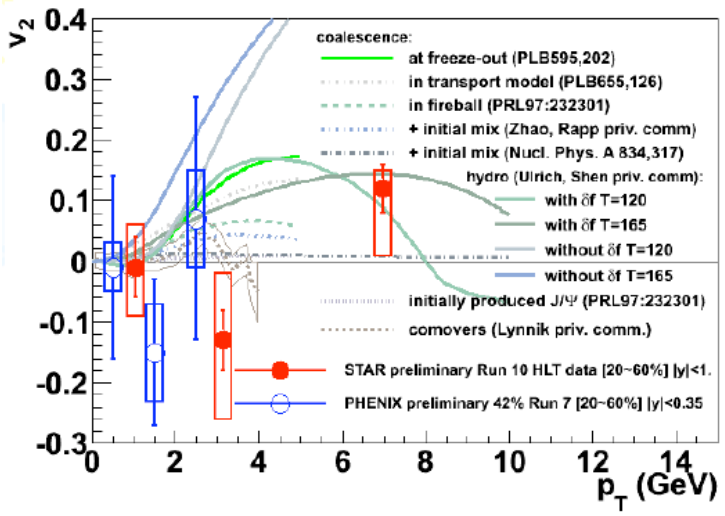
Proposed abstracts for talk following PWGC discussion March 14, 2011 and presentations on March 17, 2011

Light Flavour Spectra - 5 Talks
-- dileptons Low Mass Region
-- dileptons Intermediate Mass Region
-- BES PID spectra and freeze-out conditions
-- BES Strangeness enhancement and B/M ratio
-- Anti-alpha



Embeddings crucial

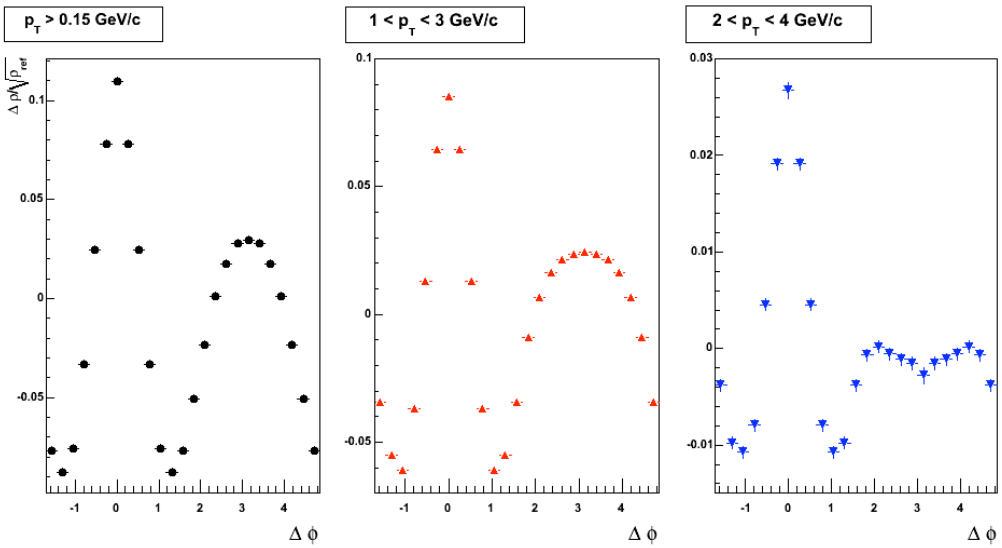
Heavy Flavour - 5 Talks
-- Upsilon
-- NPE (correlation, spectra, v_2)
-- Open charm
-- J/Psi (AA)
-- J/Psi (pp)

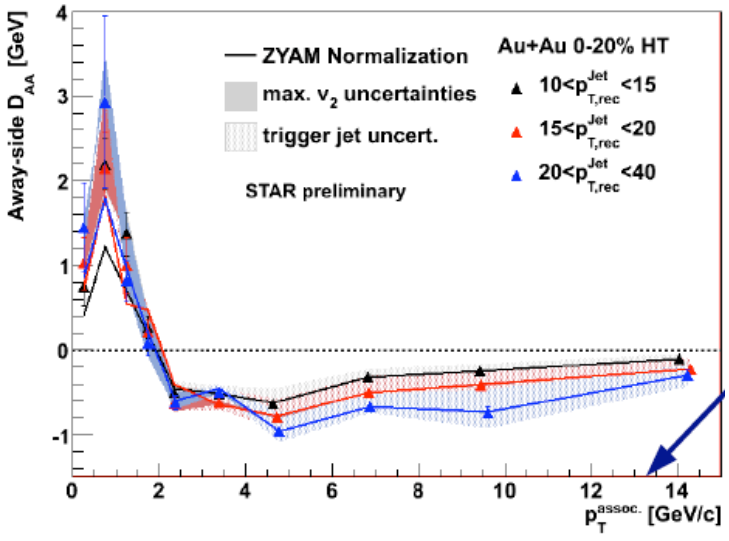


QM2011

UPC - 1 Talk
Ratio of J/Psi to Rho0 photo prodction

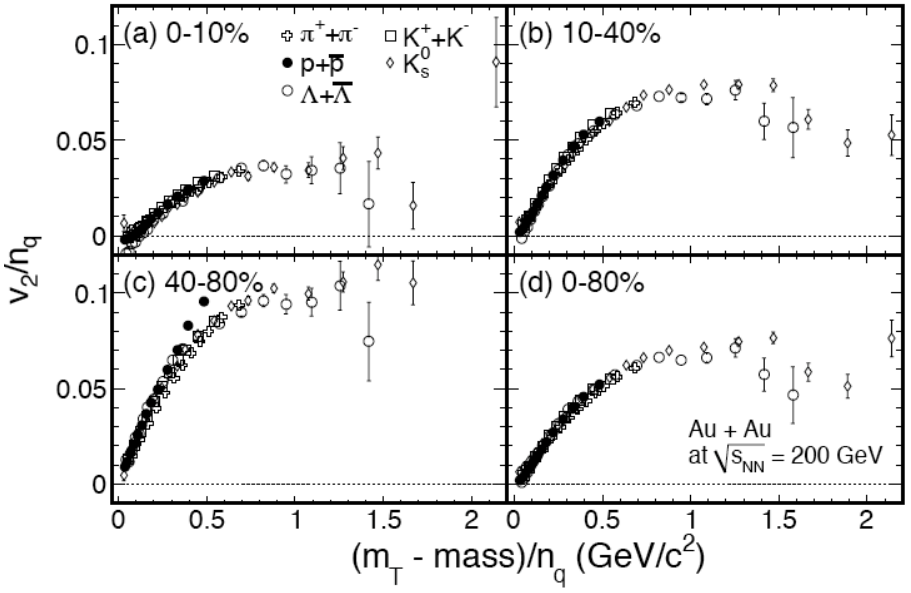
Jet-like correlations - 4 Talks
-- Jet studies reconstruction*
-- Un-triggered correlations
-- Jet-hadron correlations
-- PID correlations

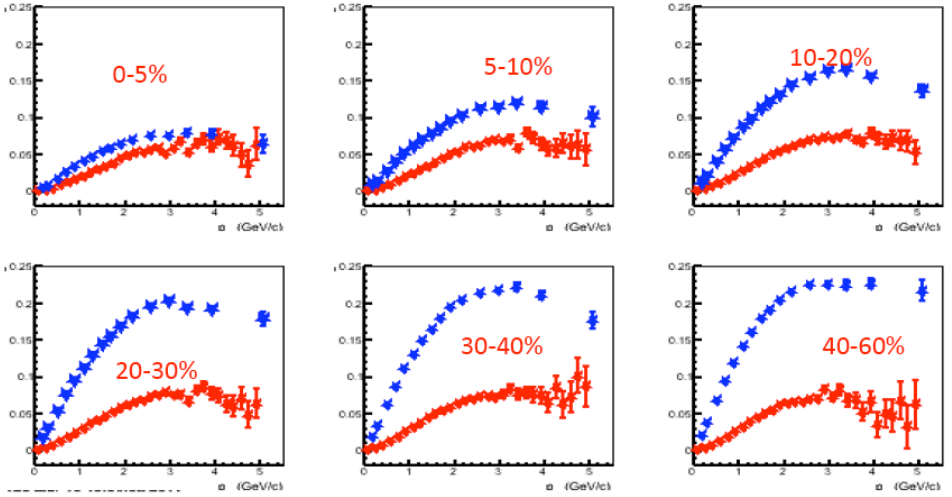




QM2011

Bulk Correlations - 9 Talks
-- Fluctuations higher moments
-- Fluctuations particle ratio
-- Balance function and LPV
-- Directed flow
-- Triangular flow
-- BES PID elliptic flow
-- BES inclusive charged hadron flow
-- Elliptic flow for 200 GeV
-- HBT studies





Instrumentation - 1 Talk
-- HLT+HFT+MTD

Three Publication Milestones

Number of PRLs crossed 50
Number of Physical Reviews crossed 50
STAR white paper crossed 1000 citations

50 publications submitted/published
11 PRL published and 2 submitted
1st submissions to interdisciplinary journals
Science and Nature from heavy-ion experiments

16+ PhDs - 2010
15+ PhDs - 2009
20+ PhDs - 2008

150 Talks - 2010
150 Talks - 2009
140 Talks - 2008

Three challenges

New PWG structure and transparent PWGC functioning
STAR publication policy (Implementing STAR note and codes in CVS, talks and abstract QA).

Get BES Program for STAR, Decadal plan, BUR, S&T, Priorities (Data/simulation) …forums for physics discussions, topical sessions in STAR Meetings to channel physics goals, etc ….

Solution to NPE issue.

Three things from Collaboration

Great place for physics analysis results/discussions

Tremendous support during paper and presentation QA

Great team of PWGC

Three important future programs

BES: Complete the proposed study of QCD phase diagram

Heavy flavor + Dilepton era in STAR (…ToF, HFT, MTD, HLT)
Details of medium properties (Temperature, time evolution
of collectivity, thermalization..)

Complete proposed spin program
(Logitudinal+ Transverse, …+FMS+FGT)

Further future: focus on forward physics (New detectors @ eSTAR)

RHIC will continue to provide landmark observations

Concluding Remarks …..

Louis Pasteur: *"In the field of observation, chance only favours those minds which have been prepared"*

Let us be prepared in highly competitive environment…..

"I am reminded of a famous remark of Napoleon. Whenever he was presented with a young man for military advancement, he invariably asked the question: Is he lucky?

This was by no means a casual inquiry. The important quality for which he was seeking was does this man put himself in a situation where he can be lucky? If you fail to put yourself in a situation where it is possible to have good fortune then you cannot have any success; if you do, you may.

-- Powell in after dinner talk at St. Cergue after-may."

Yes! STAR is lucky to have several such lucky physicists ….