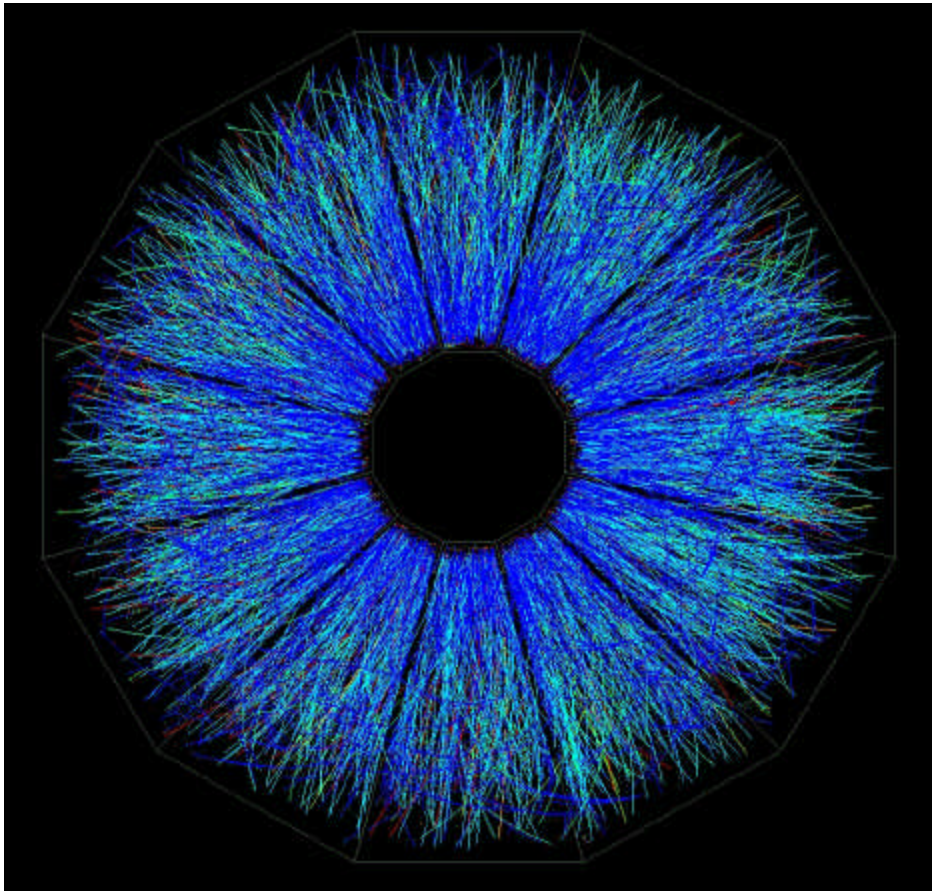
The BNL STAR Group



The BNL STAR Group

The BNL STAR Group's Mission

Research Effort

- **To perform forefront research and advance the state of knowledge in relativistic heavy ion physics**
  - **Form a core effort to strengthen STAR overall scientific program**
  - **Tie analysis strongly to knowledge of detector performance**
  - **Optimize the physics performance of the detector**

Operations Team

- **To insure quality operation of the STAR detector and provide an environment strongly supportive of STAR users**

The BNL STAR Group

Role of the BNL STAR Group

Lead responsibilities of the local BNL group

Research:

- **STAR Physics Analysis Coordinator**
- **STAR HBT Co-convenor**
- **STAR Spectra Physics Co-convenor**
- **STAR Heavy Flavor Co-convenor**
- **STAR Spokesperson**

Operations:

- **STAR Operations Leader**
- **STAR Technical Support Group Leader**
- **STAR Software and Computing Leader**
- **STAR Data Acquisition Leader**
- **STAR Simulations Leader**
- **STAR SVT Sub-system Manager**
- **STAR FTPC Sub-system Manager**
- **STAR Chief Electronics Engineer**
- **STAR Data Production Manager**
- **STAR Magnet sub-system Manager**
- **STAR Safety Representative**
- **STAR ZDC Sub-system Manager**
- **STAR Conventional Systems / Global Interlocks Manager**

The STAR Council Chair
is also a member of the BNL STAR Group
(W. Christie)

The BNL STAR Group

BNL STAR Group Operations Responsibilities

- **STAR Systems (The Overall Scope of Operations in STAR) -**

  - TPC, Magnet, SVT, Slow Controls, EEMC, BEMC, Trigger, FTPC, SSD, TOFp, TOFr, ZDC, FPD, PMD, BBC, Soft& Comp, DAQ, LVL III, Run Control, Conventional Systems

- **Coordination of all detector operation and maintenance.**
  - *- Coordination of Detector commissioning*
  - *- Scheduling*
  - *- Budget preparation and tracking*
  - *- Coordination with C-AD*
  - *- Safety & environmental compliance*
  - *- Allocation and tracking of User Support*

- **Coordination of STAR Software effort**
  - *- Offline Software*
  - *- Maintenance of Software libraries*
  - *- Design and maintenance of databases*
  - *- Design, maintenance, and running of data production*
  - *- Computer support for operations*
  - *- Coordination with RCF*
  - *- Development of next generation tracker*

The BNL STAR Group

BNL STAR Group Operations Responsibilities

- **Engineering and Technical Support**
  - *Engineering oversight and design reviews for new and upgraded systems*
  - *Designer support and archiving of existing and new system engineering drawings*
  - *Installation management for new systems*
  - *Technical support for operations*
  - *Sub system procurement support*
- **Subsystem responsibility for:**

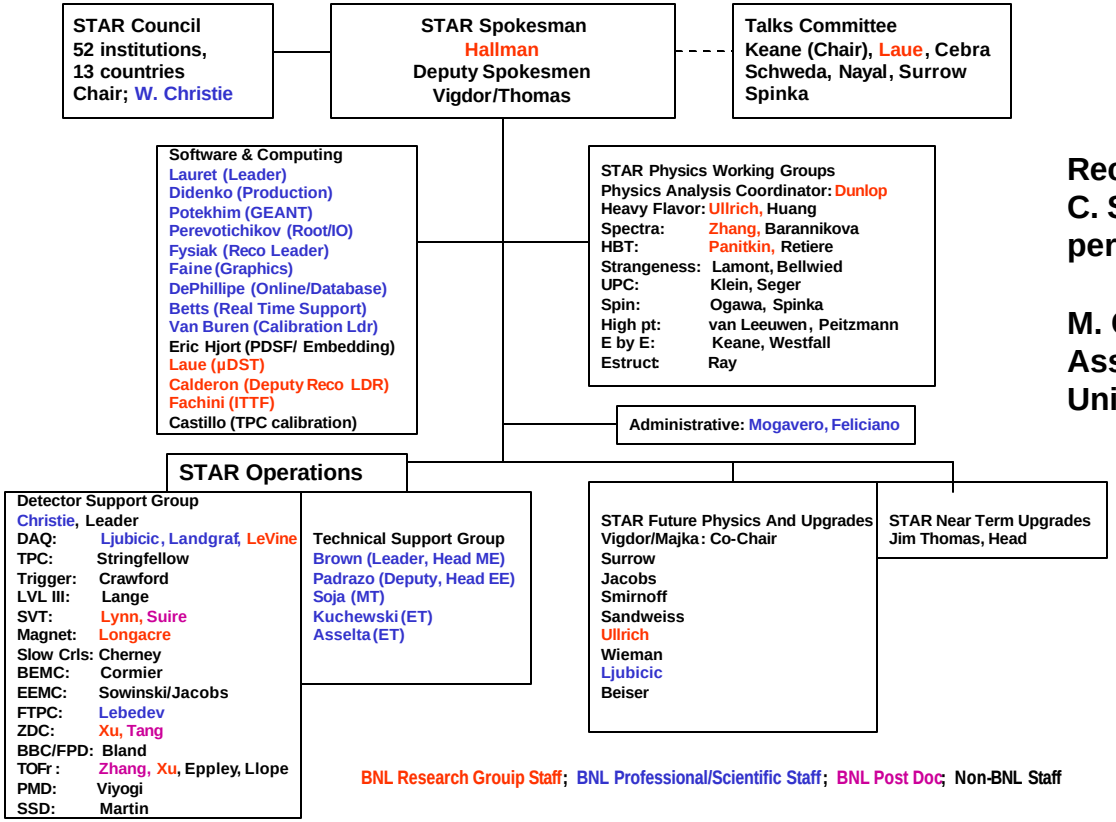
  DAQ, Run Control, SVT, Magnet, Online and Offline software, Conventional systems, STAR Global Interlock System, ZDCs, BBC, FPD, FTPC
- **Recent accomplishments:**
  - **Completion of Endcap Electromagnetic Calorimeter**
  - **Barrel Electromagnetic Calorimeter**
    - *Completion of mechanical installation, tower readout for full barrel*
    - *Installation of remote power supplies to increase stability*
    - *Shower Maximum and Preshower readout on East half summer 2005*
  - **Installation of the complete Silicon Strip Detector**
  - **Installation of the complete Photon Multiplicity Detector**
  - **Installation of Shower Maximum Detector into Zero Degree Calorimeters**
  - **Highly successful operation of the detector in Run V**

The BNL STAR Group

BNL STAR Research Group

Research personnel supported:

J. Dunlop (75%); P. Fachini (75%); T. Hallman (25%); F. Laue (75%); M. LeVine (85%); R. Longacre (85%); S. Panitkin (50%); T. Ullrich (100%); Z. Xu (70%); H. Zhang (100%); A. Tang (100%); Support: C. Feliciano (88%)



Recent departures:
C. Suire, Jan 2004 to permanent position, IN2P3

M. Calderon, Aug. 2004 to Assistant Professor, Indiana University

The BNL STAR Group

Uniqueness of the research group's capabilities:

The BNL STAR research group serves a unique role as a core STAR research group due to its proximity to detector and software/analysis

Quality of leadership both nationally and internationally:

- STAR Spokesperson (Hallman)
- STAR Physics Analysis Coordinator (Dunlop)
- STAR HBT Co-convenor (Panitkin)
- STAR Spectra Physics Co-convenor (Xu until May, 2005; Zhang after May, 2005)
- STAR Heavy Flavor Co-convenor (Ullrich)

Member RHIC II Upgrades Steering Committee (Ullrich, Xu)

RHIC II Electromagnetic Probes Working Group Co-convenor (Xu)

RHIC II Heavy Flavor Working Group Co-convenor (Ullrich)

Presidential Early Career Award for Scientists and Engineers 2004 (Xu)

Organizing Committees QM01 (Hallman/Ullrich), SQM03 (Ullrich), CIPANP (Hallman), Hot Quarks '04/'06(Ullrich), RHIC-II at Panic05(Ullrich), Heavy Ion co-convenor ICHEP 2006 (Hallman)

- International Committees: SQM04/06 (Hallman/Ullrich), Hard Probes '04, '06 (Ullrich), QM05 International Advisory Committee (Hallman)
- DNP Program Committee: (Hallman)
- Chair of Dubna Program Advisory Committee for Particle Physics: (Hallman)
- Chair of BNL Nuclear Physics Planning Group, Sept. 2003-Oct. 2004: (Ullrich)
- Member NSAC ('99-'01); Member NSAC Subcommittee on Education ('03-'05) (Hallman)

The BNL STAR Group

Demonstrated competency and future promise of research personnel:

Total STAR impact: 28 PRL, 15 PRC, 4 PLB published or in press
2692 citations on Spires: 11 papers have >100 citations, 18 >50

BNL STAR research group had a leading role in 11 of 28 STAR PRL's, 6 of 15 STAR Phys Rev C's, and 1 of 4 STAR Phys. Lett. B's

Additional Measures:

S. Panitkin,	Summary Speaker QM 2001
T. Ullrich,	Summary Speaker QM 2002
P. Fachini, Z. Xu	Parallel Talk QM2002
T. Hallman,	NSAC Initiatives (RHIC/e-RHIC) Prioritization, Rutgers 2003
T. Ullrich,	Student Lecturer QM2004
P. Fachini,	Summary Talk QM2004
Z. Xu,	Rapporteur Summary QM2004
A. Tang,	Parallel Talk QM2004
J. Dunlop,	RHIC Summary Plenary ICHEP 2004
T. Hallman,	Heavy Ion Summary Plenary ICPAQGP 2005
Z. Xu	Presidential Early Career Award for Scientists and Engineers 2004
J. Dunlop	Plenary Talk QM2005
J. Bielcik, F. Laue, H. Zhang	Parallel Talk QM2005

The BNL STAR Group

Quality of leadership both nationally and internationally:

Out of 71 STAR papers published or in preparation, members of the group have been:

- Chair of the God Parent Committee (GPC): Ullrich (2), Panitkin (3)
- Principal Authors on 25 papers 46 times: Christie (1), Calderon (3), Dunlop (3), Fachini (5), Laue (6), Longacre (2), Panitkin(1),Tang (8), van Buren (1), Ullrich (2), Xu (11), Zhang (3)
- Members of a GPC other than Principal Author on 34 papers 39 times: Christie (2), Calderon(2), Dunlop(1), Fachini(1), Laue(1), Lauret (1), Longacre (1), Panitkin(6), Tang(3), Ullrich(8), van Buren(1), Xu (8), Zhang (4)

Creativity and innovation that engender new opportunities to advance the field:

Leading contributions resulting in major advances in

Open charm: initial conditions; heavy quark thermalization; heavy quark energy loss

Resonances: evolution between chemical and thermal freeze-out; medium modification

HBT, Flow: dynamics, collective behavior

MRPC TOF Tech: PID'd Cronin Enhancement (initial state momentum broadening), open charm and resonances (see above)

The BNL STAR Group

Impact of BNL group on education and training of the next generation of scientists

(students receiving Ph.Ds with group; teaching by group members)

1. Haibin Zhang Yale University/BNL, Thesis topic: "K* resonance and Open Charm production in Au+Au and pp collisions at RHIC", Co-advisors: Prof. Jack Sandweiss, Dr. Zhangbu Xu
2. Lijuan Ruan USTC (China)/ BNL, Thesis topic: "Pion, Kaon and proton spectra in d+Au and pp collisions and Cronin Effect at RHIC", Co-advisors: Prof. Hongfang Chen, Dr. Zhangbu Xu
3. Xin Dong USTC (China)/LBL Thesis topic: "Electron Spectra and Open Charm Production at RHIC", supervision at BNL, Dr. Zhangbu Xu
4. Shengli Huan from USTC (China) Thesis topic: "Soft and Hard events and their properties in pp collisions at RHIC", Co-advisors: Prof. Hongfang Chen, Dr. Zhangbu Xu
5. Johan Gonzalez UCLA Analysis for published Phys. Rev. C, "Pseudorapidity asymmetry and centrality dependence of Charged Hadron Spectra in d+Au Collisions at sqrt(sNN) = 200 GeV", supervision at BNL, Dr. Zhangbu Xu
6. Dipak Kumar Mishra from Bhubaneswar (India) Thesis topic: "Delta production and properties in d+Au", supervision at BNL, Dr. Zhangbu Xu
7. Haidong Liu from USTC (China) Thesis topic: "PID Spectra in Au+Au collisions", Co-advisors: Prof. Hongfang Chen, Dr. Zhangbu Xu
8. Brandon Szeliga from Wayne State University Summer undergraduate student, PA on proposed paper "Strangelet search at RHIC", supervision at BNL Dr. Aihong Tang

T. Ullrich, Adjunct Professor, Yale University

T. Hallman, NSAC Education Sub-panel Survey of Postdocs in Nuclear Science

T. Hallman, Guest Professor: Huazhong Normal University, Wuhan, China; USTC Hefei, China; Tsinghua University, Beijing, China

T. Hallman, Johns Hopkins Society of Scholars; Honorary Doctor of High Energy Physics, Dubna International University; Honorary Doctor of Joint Institute for Nuclear Research, Dubna

The BNL STAR Group

Scientific and Technical Achievements

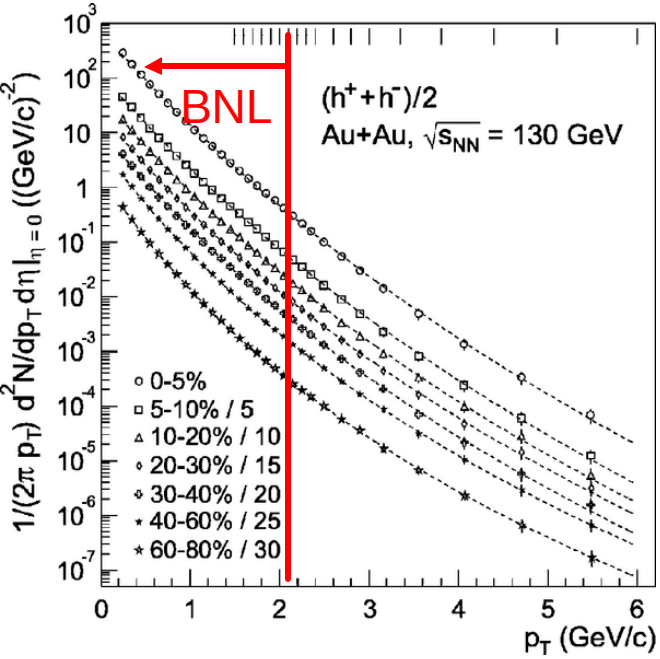
Covers work (selected highlights) by:

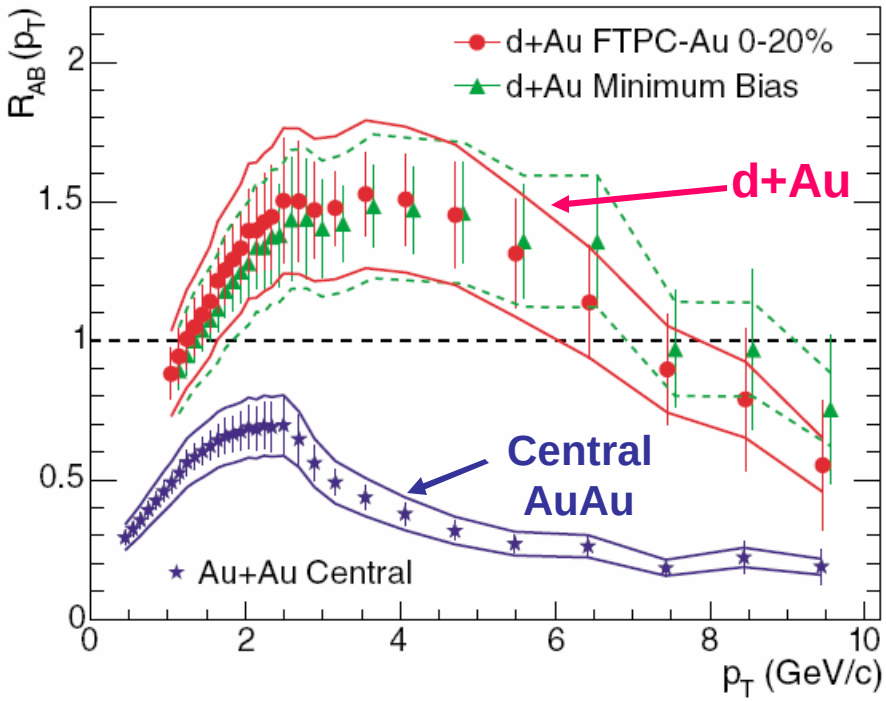
1. Dunlop (high p_T (and all STAR analysis))
2. Fachini (resonances)
3. Laue (spectra, charm flow)
4. LeVine (Next Generation DAQ)
5. Longacre (fluctuations, correlations)
6. Panitkin (HBT)
7. Tang (directed, elliptic flow, and higher harmonics)
8. Ullrich (charm, high p_T, spectra)
9. Xu (open charm, resonances, spectra)
10. Zhang (strange resonances, open charm)

The BNL STAR Group

High-p_T Hadrons: Key contributions

Calderon
Dunlop
Fachini
Laue
Ullrich
Xu





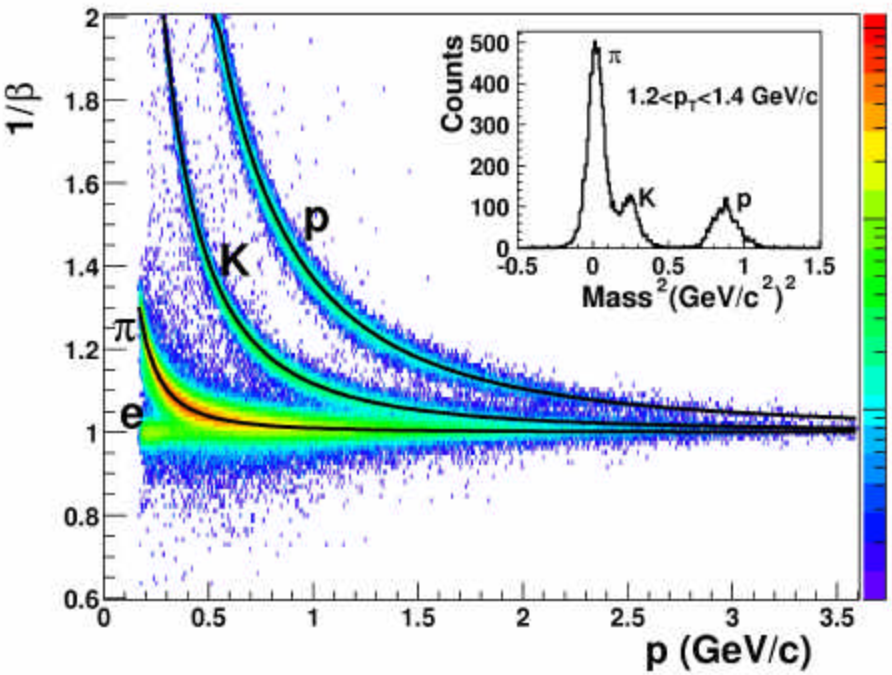
130 GeV: Phys. Rev. Lett. **89** (2002) 202301
Dunlop, Laue
200 GeV Au+Au: Phys. Rev. Lett. **91** (2003) 172302
Dunlop, Xu
200 GeV d+Au: Phys. Rev. Lett **91** (2003) 072304
Dunlop, Fachini, Xu

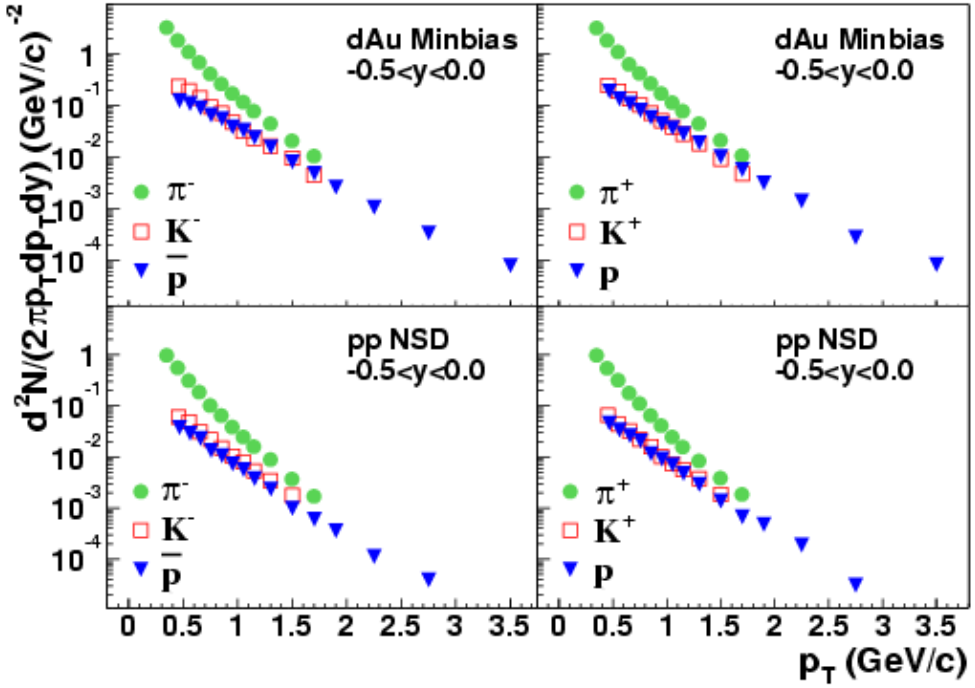
Clear evidence for high p_T hadron suppression in central nuclear collisions: Due to jet quenching in produced matter at high density

The BNL STAR Group

Xu

Beyond unidentified hadrons: PID Capabilities with TOF





Student: Lijuan Ruan

Phys. Lett. B 616 (2005) 8

- MRPC TOF is a cost-effective solution for large area time-of-flight system
- Spectra from p+p, d+Au obtained with first-year prototype

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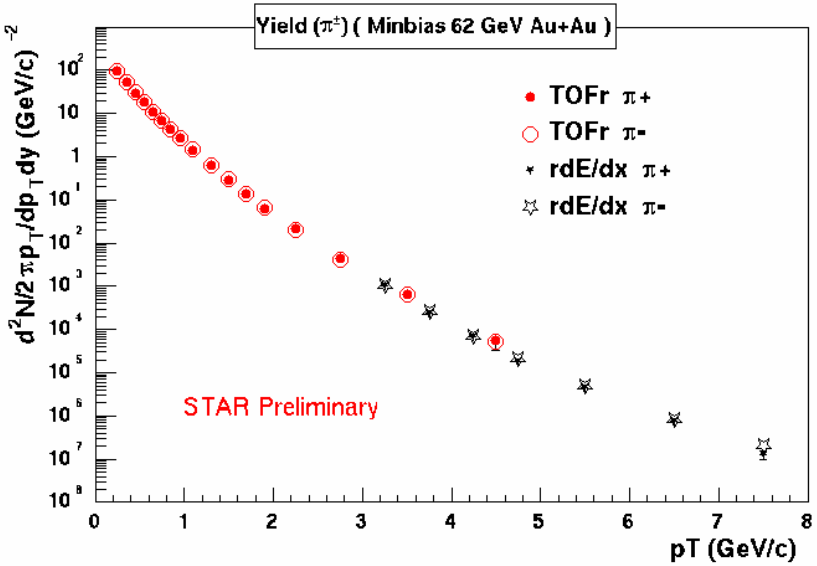
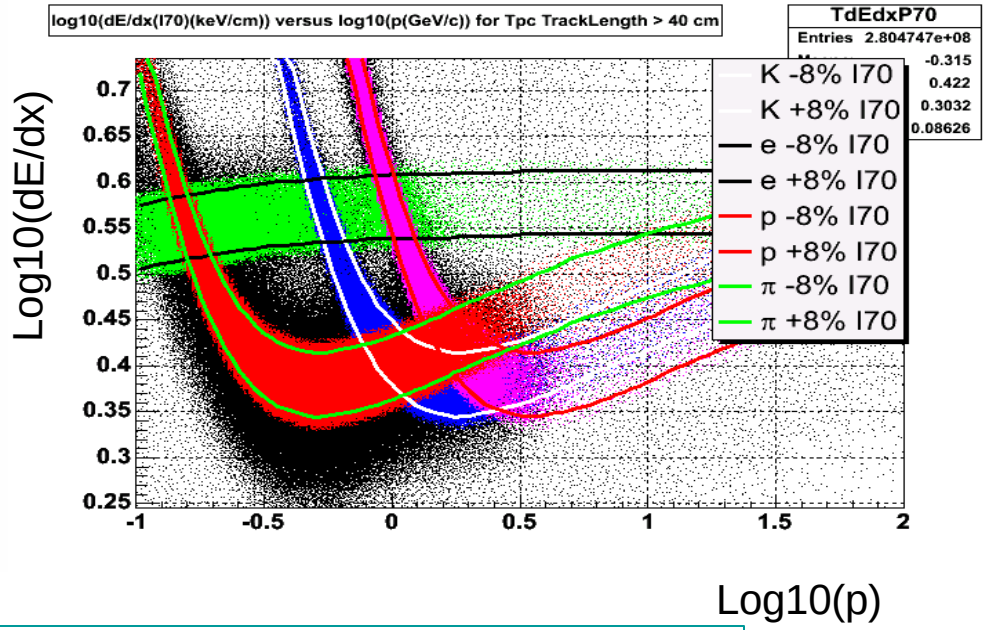
Xu

Extending particle ID capabilities to ultimate limits





Methods paper submitted to NIM A, nucl-ex/0505026. Fisyak, Xu

- TPC:
  - Pion: 0-~0.6GeV/c
  - Kaon: 0.2-~0.6GeV/c
  - Proton: 0.2-~1 GeV/c
- TOF:
  - Pion: 0.2-~1.6GeV/c
  - Kaon: 0.2-~1.6GeV/c
  - Proton: 0.2-~3 GeV/c
- TPC+TOF:
  - Pion: 0.-~10 GeV/c
  - Kaon: 0.2-~3GeV/c
  - Proton: 0.2-~? GeV/c

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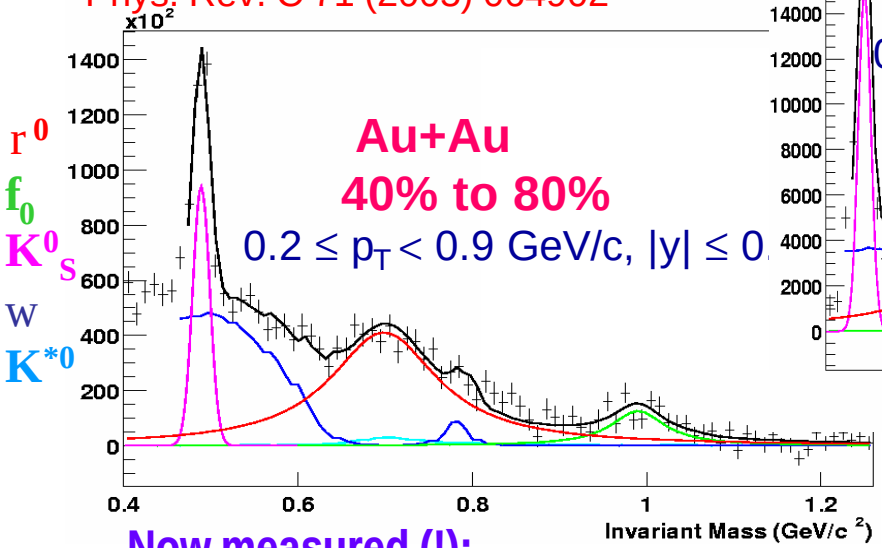
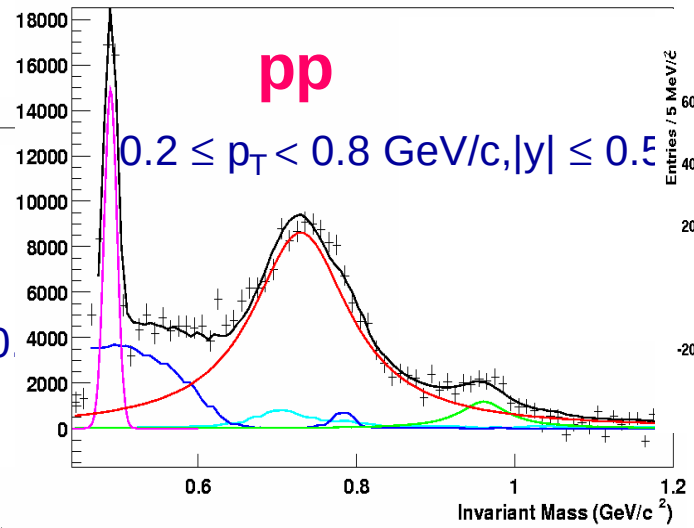
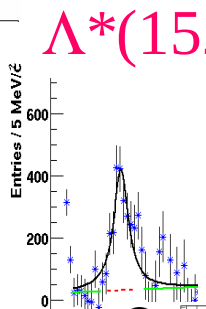
Establishing a new probe of the medium: Resonances

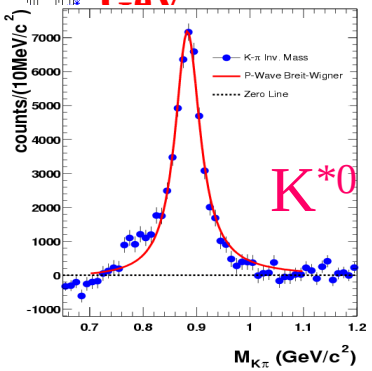
Fachini
Laue
Longacre
Xu
Zhang

Phys. Rev. C 66 (2002) 061901
Phys. Rev. Lett. 92 (2004) 092301
Phys. Rev. C 71 (2005) 064902

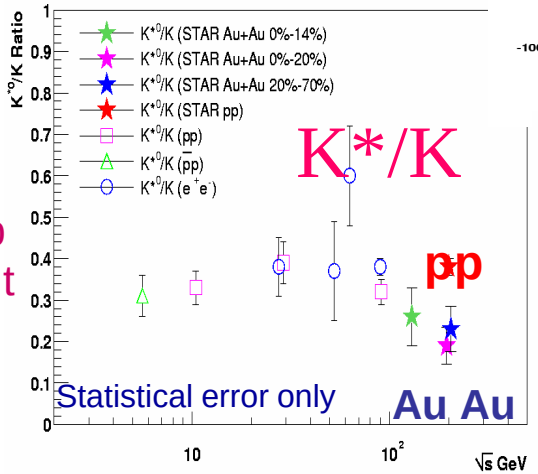


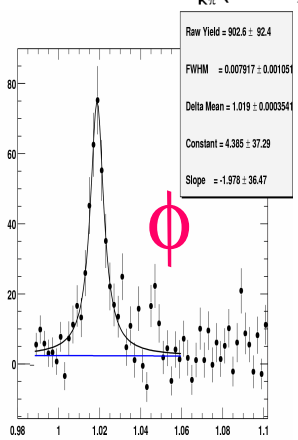






Now measured (!):
r, D, K*(892), S*(1385), L*(1520), f, D*



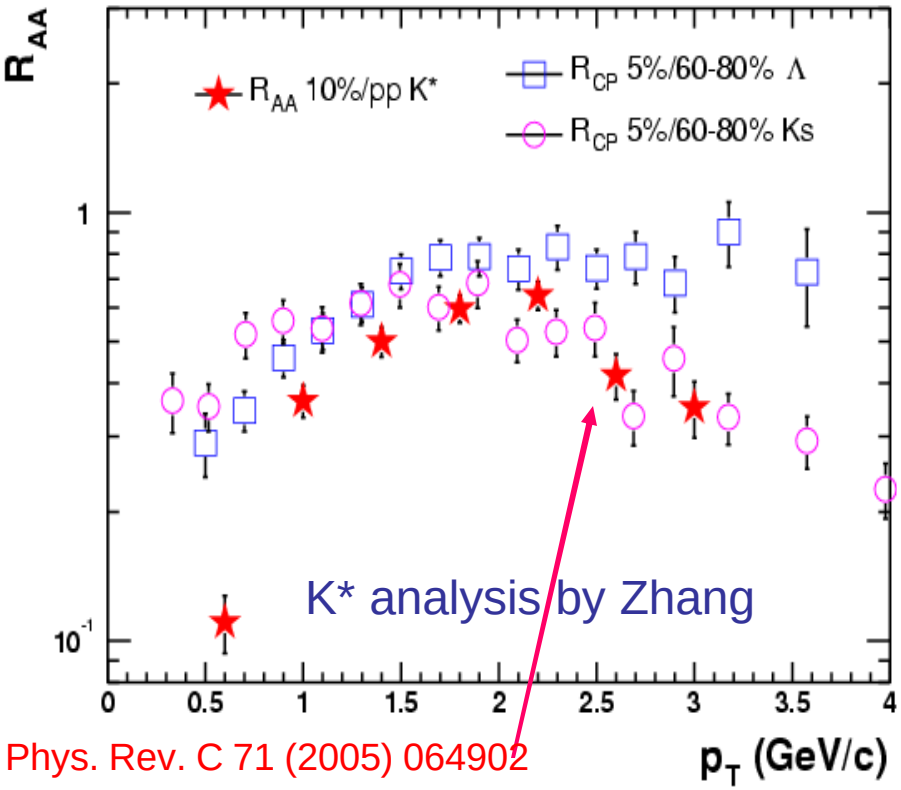


- Short-lived resonances probe the medium and map the history wrt rescattering after chemical freezeout
  - Destruction of signal in hadronic channel
  - Regeneration in "elastic" scattering stage

The BNL STAR Group

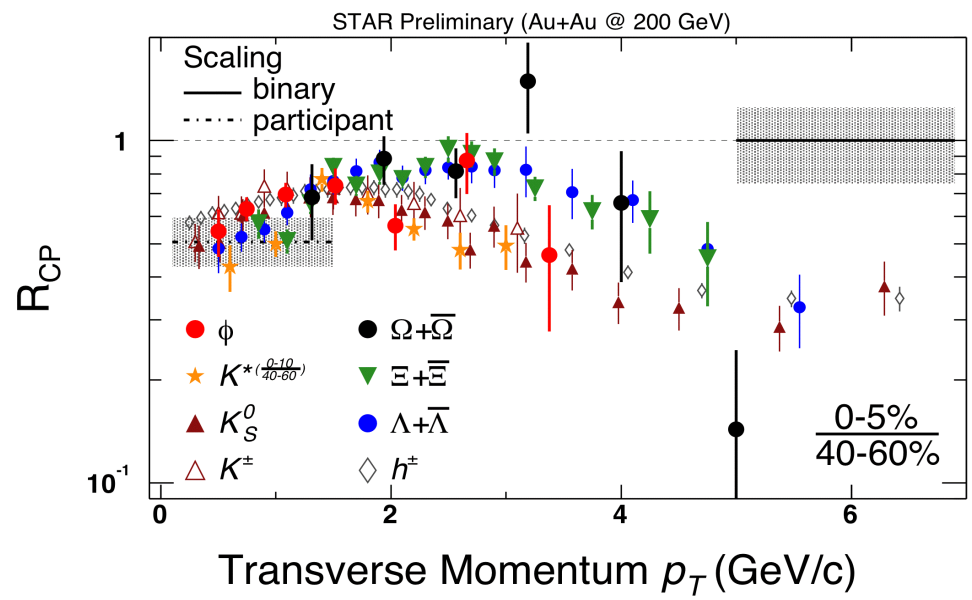
Zhang

Resonance Nuclear Modification Factor



Phys. Rev. C 71 (2005) 064902

- K* R_{AA} @ $p_T > 1.5$ GeV/c ⇒ The K*(892) is close to the K_S^0, and different from the Λ



Clearest evidence yet that at intermediate p_T there is a meson/ baryon difference as opposed to a mass difference: quark coalescence?

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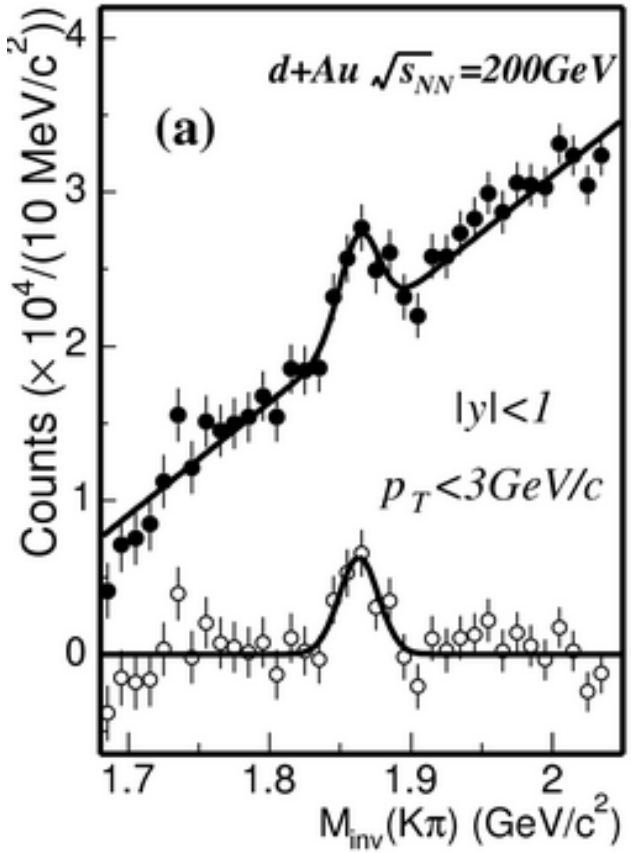
Ullrich
Xu
Zhang

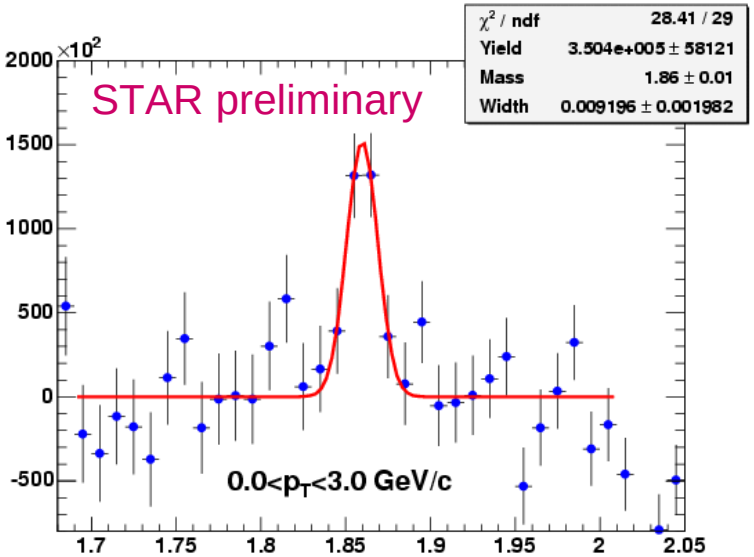
Open charm: Direct reconstruction in STAR

No secondary vertex, Treated as “heavy K*”

d+Au: Phys. Rev. Lett. 94 (2005) 062301



Au+Au: Clear signal for QM05
Contributed talk by Zhang



hadronic channel: $D^0 \rightarrow K^- \pi^+$
(B.R. 3.80%±0.09%)

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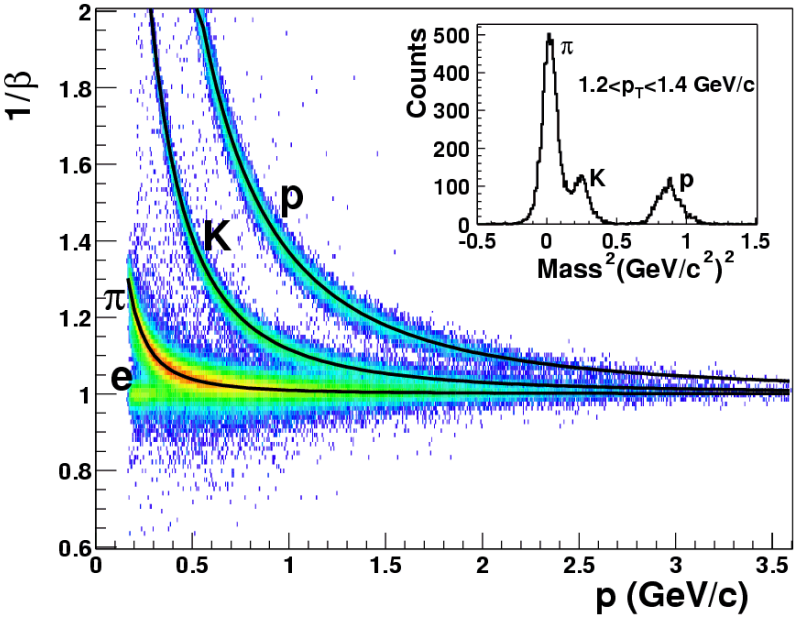
Xu Zhang

New Electron Identification Capability in STAR: MRPC ToF

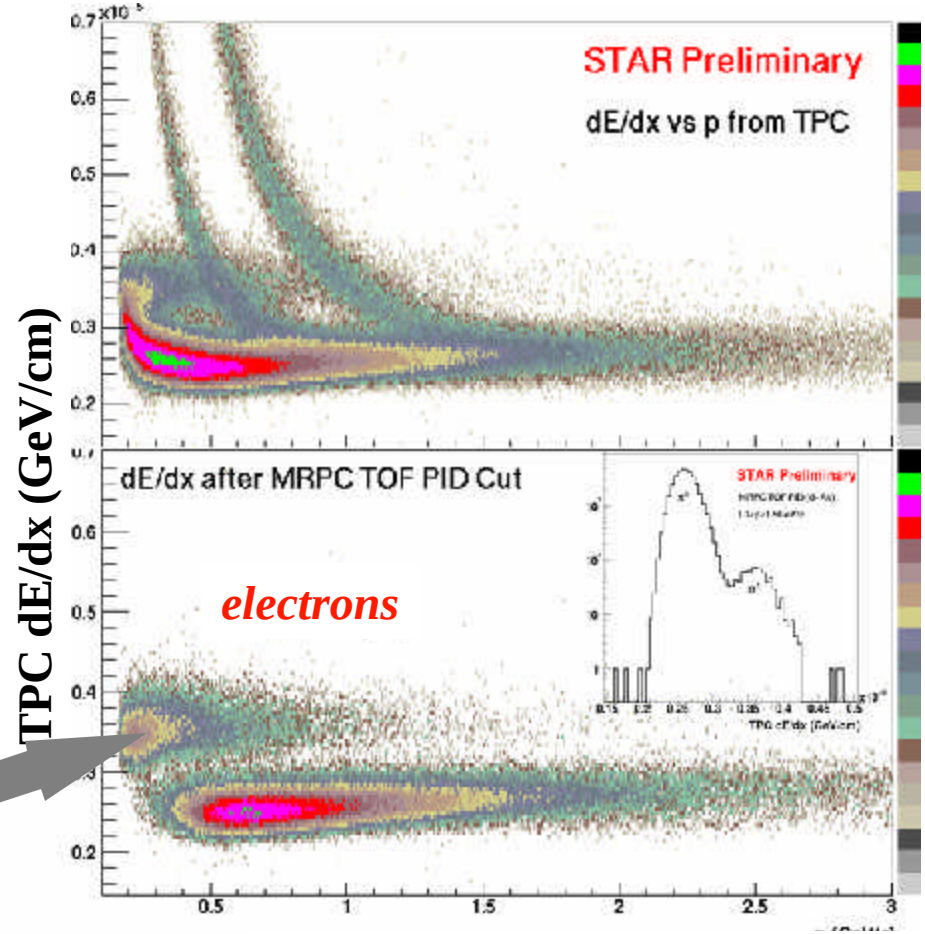


Phys. Rev. Lett. 94 (2005) 062301
Phys. Lett. B 616 (2005) 8.

Electron identification:

TOFr |1/ß-1| < 0.03

TPC dE/dx electrons!!!



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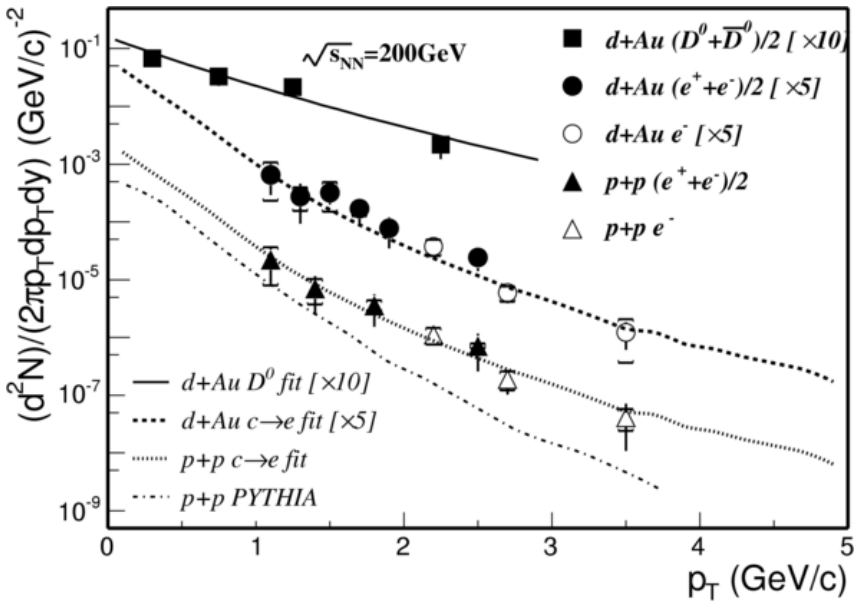
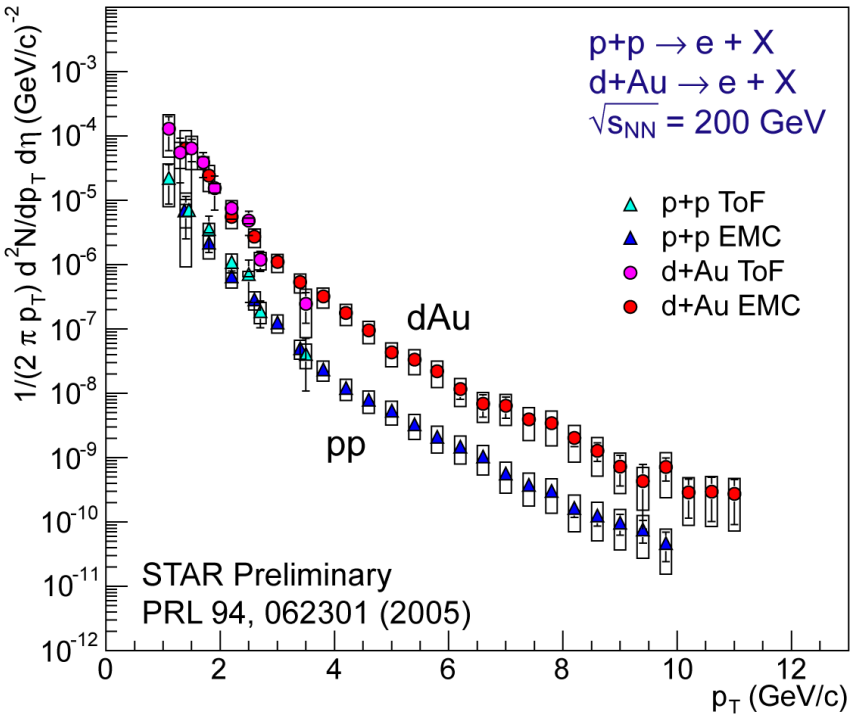
D meson and electron spectra from STAR

Bielcik
Ullrich
Xu
Zhang



Phys. Rev. Lett. 94 (2005) 062301



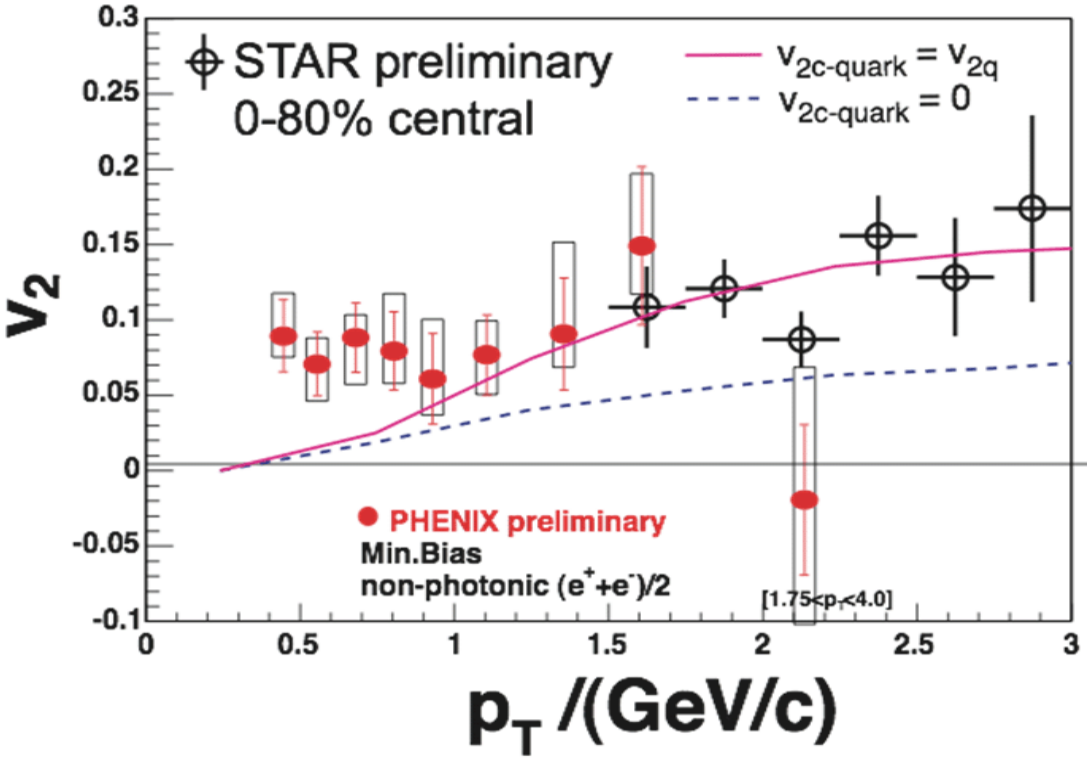
Consistency in d+Au between three methods of electron ID and direct reconstruction of D mesons

Contributed talks at QM05: Bielcik, Zhang results from Au+Au

The BNL STAR Group

Laue

Charm flow from non-photonic electrons

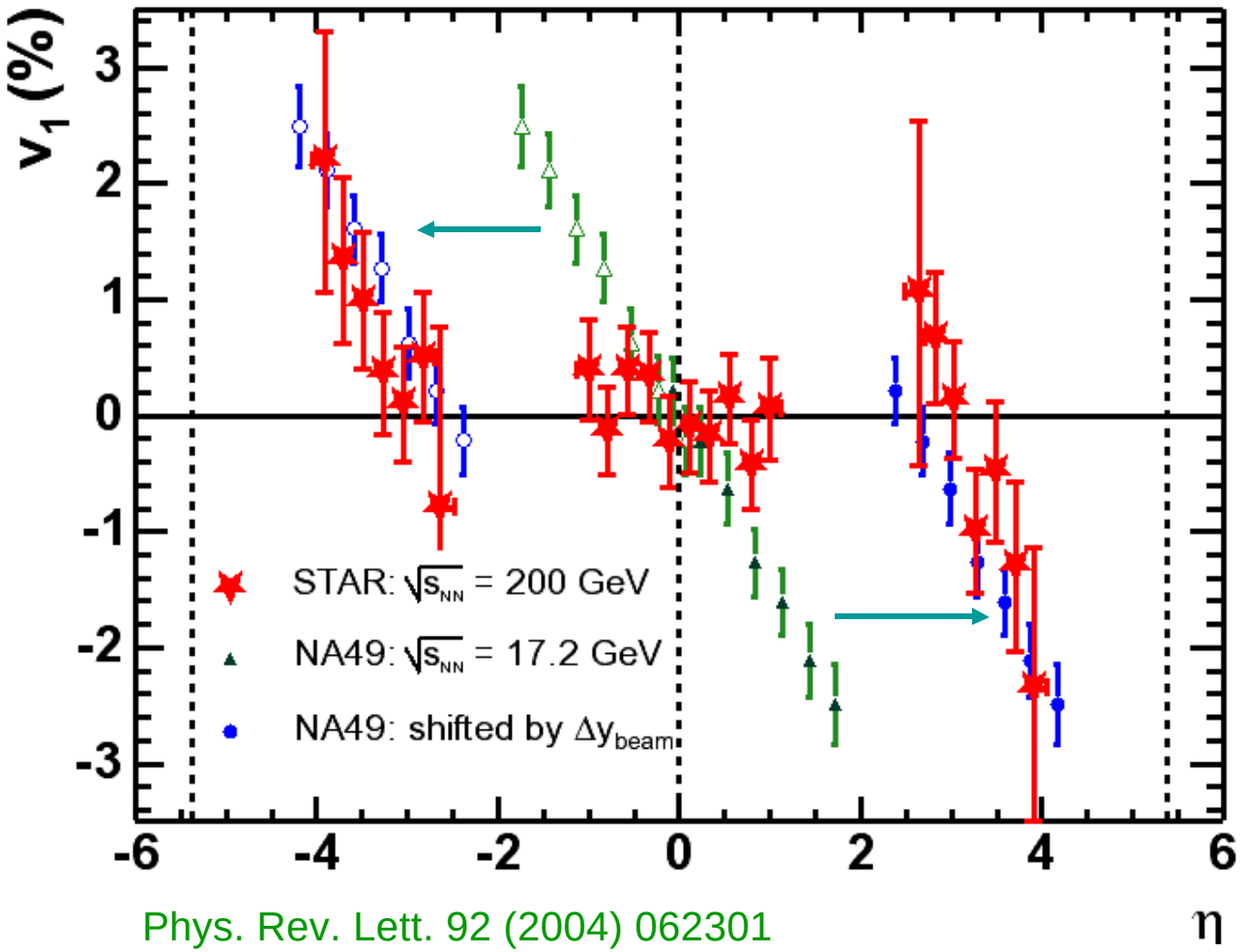


Indications that charm quark flows as others: high degree of collectivity
Contributed QM05 talk: Laue

The BNL STAR Group

Tang

Directed flow at RHIC



Phys. Rev. Lett. 92 (2004) 062301

First measurement of v_1 at RHIC!

Collective behavior over 6-8 units of pseudo-rapidity

⇒v_2 is positive: first direct evidence of *in-plane* elliptic flow

⇒ZDC SMD instrumented for year 4 allows to obtain sign of v_1

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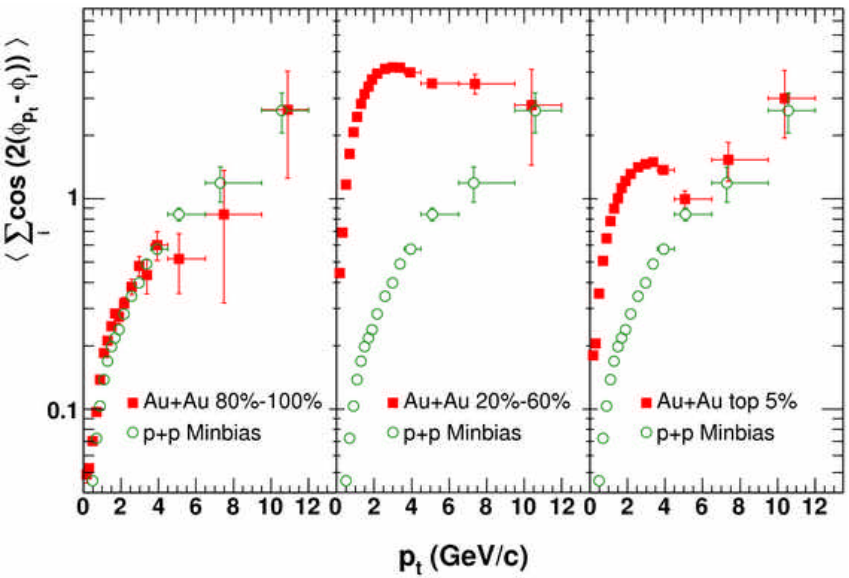
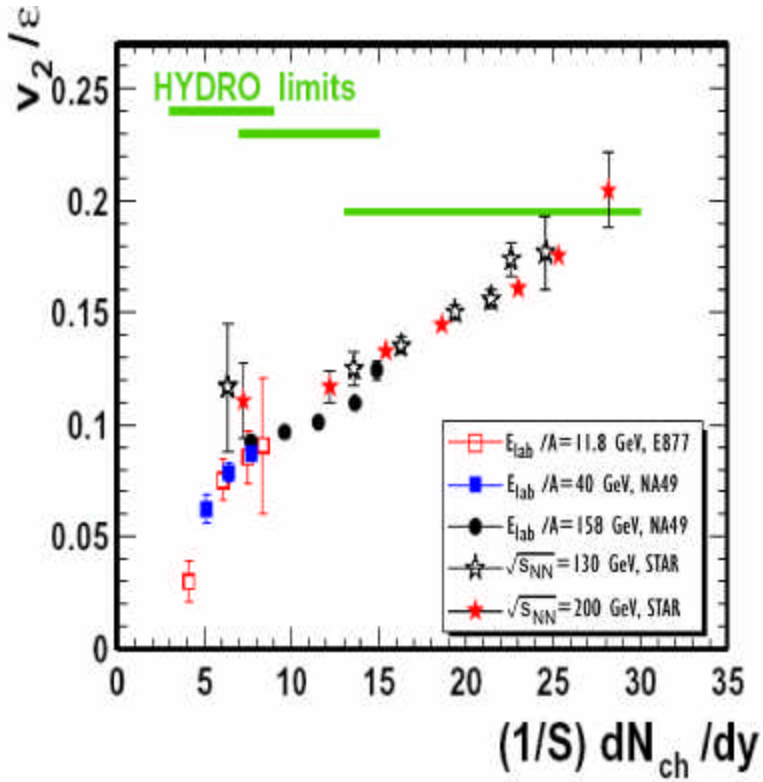
Continuing development of v2 measurement technique

Tang

nucl-ex/0409033, Phys. Rev. C in press
Phys. Rev. Lett. 93 (2004) 252301
Phys. Rev. C 66 (2002) 034904





Large measured value of v_2 pillar of RHIC physics: "perfect fluid"

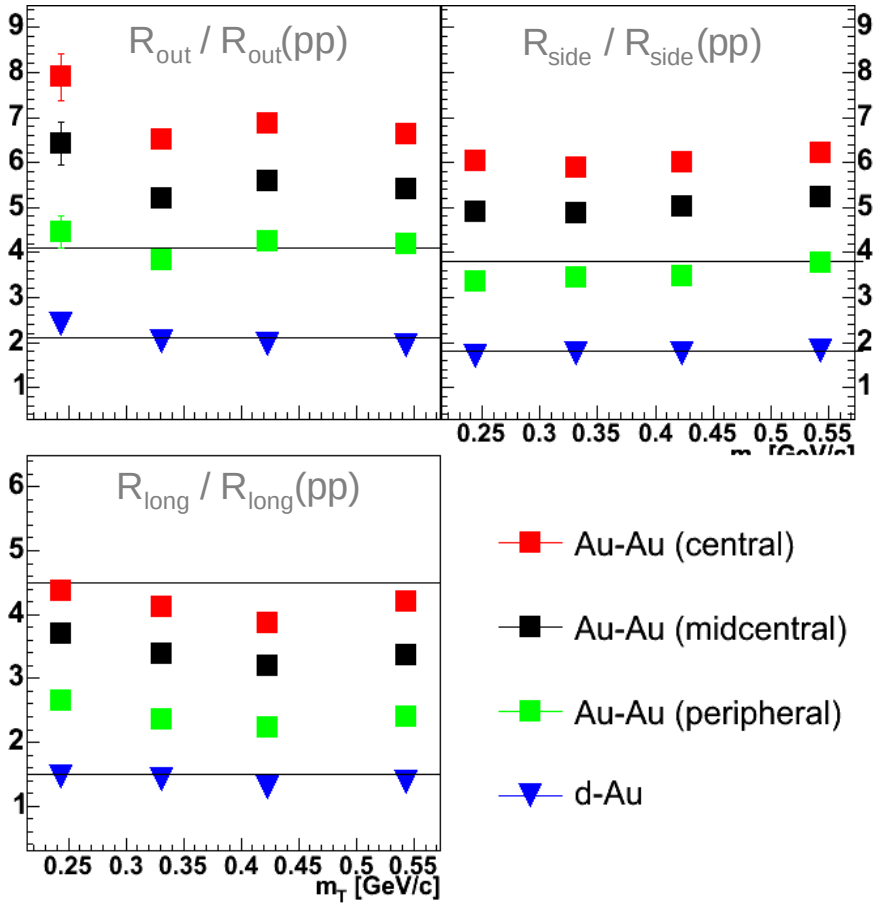
Leading edge of techniques to reduce systematic uncertainties in v_2 measurement from correlations unrelated to the reaction plane: subtraction of p+p correlations, higher-order cumulants, separation in rapidity

The BNL STAR Group

Panitkin

Another puzzle in HBT: p+p ? d+Au ? Cu+Cu ? Au+Au

preliminary



All four systems exhibit similar kT dependence. Why?

Is the standard Interpretation of the m_T dependence in terms of flow mistaken?

– Rapid turnaround analysis of Cu+Cu @62, 200 GeV, Au+Au @62 GeV

The BNL STAR Group

Next Generation STAR DAQ

- cluster-finding and tracking in real time @1KHz event rates requires:

  highly parallel pre-processing
  delivery of data from each TPC pad to pertinent pre-processing node

- cluster-finding: must process an entire padrow in one place
- farm of several hundred tracking nodes

➘ network for delivery of ADC data to cluster-finder nodes, cluster results to tracking node

➘ fine-grained parallel processing (hardware-assisted) to meet throughput requirements for cluster-finding

- **LHC Trigger-DAQ Test-Bed**:
  - 1600 data sources
  - 200 LVL2 processing nodes
  - 100 event builders

all tied together with switched Gigabit Ethernet

The BNL STAR Group

LeVine

Next Generation STAR DAQ

- **STAR** is participating in implementing these tests, specifically highly parallel processing in programmable hardware (FPGAs).

- Both technologies are directly applicable to STAR. Switched Ethernet is a viable candidate for the STAR upgrade network; FPGAs will be necessary to implement the parallel cluster-finding

- Experience from the LHC context can directly shorten the learning curve in the STAR implementation

The BNL STAR Group

Future research plan; feasibility of the plans for the proposed research:

Continued research on proven directions

- Resonances (including ultimately e+e- decays using TOF):
  In-medium modification of resonances; mapping the late evolution of the matter
- Heavy flavor (yields and spectra):
  Heavy quark production/propagation (energy loss)
- Elliptic flow/ other harmonics for broad range of momenta/species
  Understanding (in detail) the collectivity of the matter
- Identified nuclear modification factor
  Partonic energy loss, quark coalescence

Further progress from critical upgrades

Bottomonium, charmonium program

Completion of barrel EMC; barrel TOF, increased luminosity

Full possibilities in particle identification with full barrel TOF

The BNL STAR Group

BNL STAR Operations Group

Concerns

- **The local group is finding it necessary to take on additional scope:**
  - **Forward Time Projection Chambers (Lebedev now subsystem leader)**
  - **Barrel EMC (need for resident expert stressed by Subsystem Manager , Tom Cormier)**
  - **Local Trigger expert needed to augment present trigger and DAQ efforts which have minimal staffing.**
  - **Software effort needs some re-building after attrition at BNL and elsewhere**
- **Constant dollar budgets** Þ
  - **Reduction in staff to try to maintain adequate MST**
  - **Inability to meet the needs above**
  - **Operations crew stretched thinner; reduced response time; less efficient use of beam time.**

The BNL STAR Group

BNL STAR Research Group

Concerns

Constant-dollar funding

- Challenge to maintain core competency of the group in the research areas to which we contribute
- Important issue not only for the local group, but for the wider STAR program
  - Example

    We will reduce by one FTE in the coming year

    The group will no longer have a leading interest in the STAR HBT program

    This impacts a leader (convenor) of the STAR HBT effort, and through that the entire STAR HBT effort

The BNL STAR Group

Conclusions

- The BNL STAR Group is a highly effective, productive group of aggressive researchers which is pioneering new directions in heavy ion research. The pace of progress has been breathtaking!
- The efforts of the group are having a high impact on the ongoing heavy ion research effort
- The Group is pioneering new technology which has/will open entirely new research directions in the field
- The members of the group who are developing their careers show outstanding promise, and are already in important positions of scientific leadership, both within STAR and in the wider community
- The group is playing a proactive role in educating the next generation of scientists in the field.