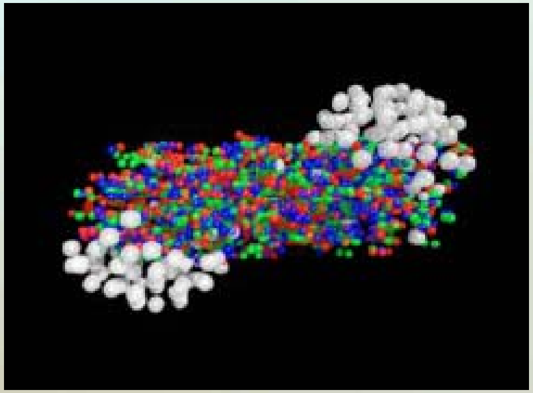
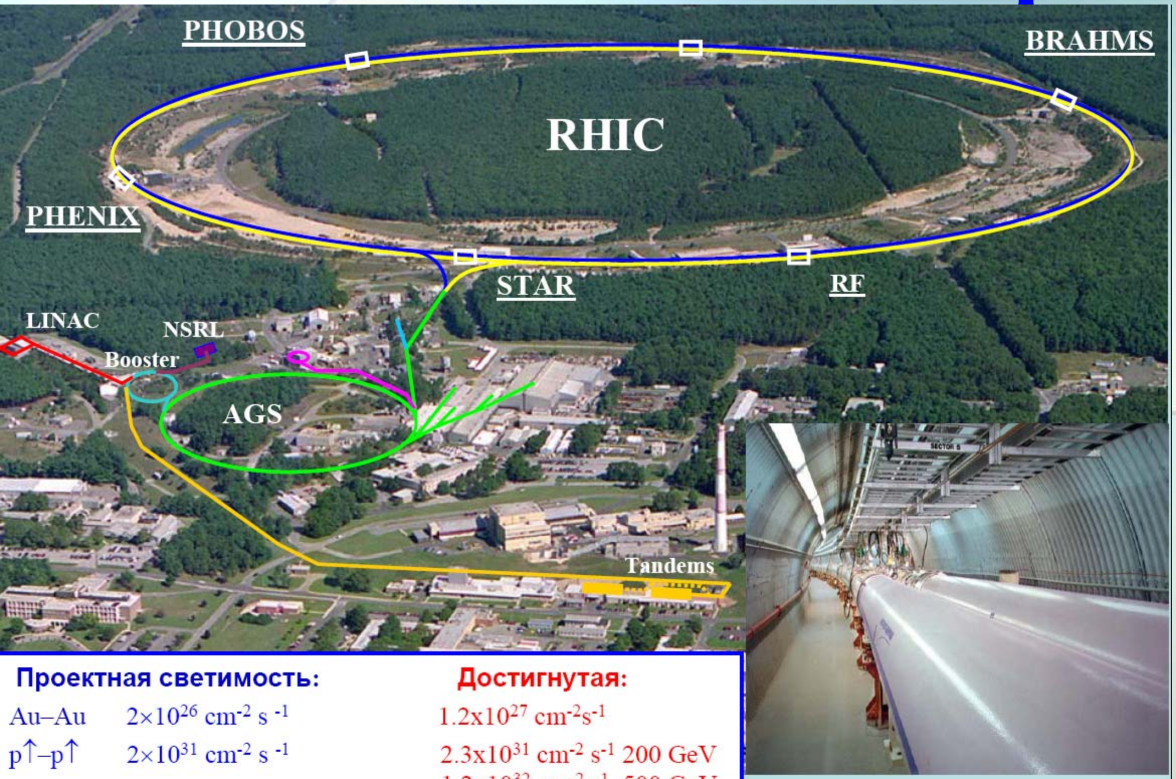
Эксперимент ФЕНИКС

В. Рябов (ЛРЯФ)



Коллайдер RHIC



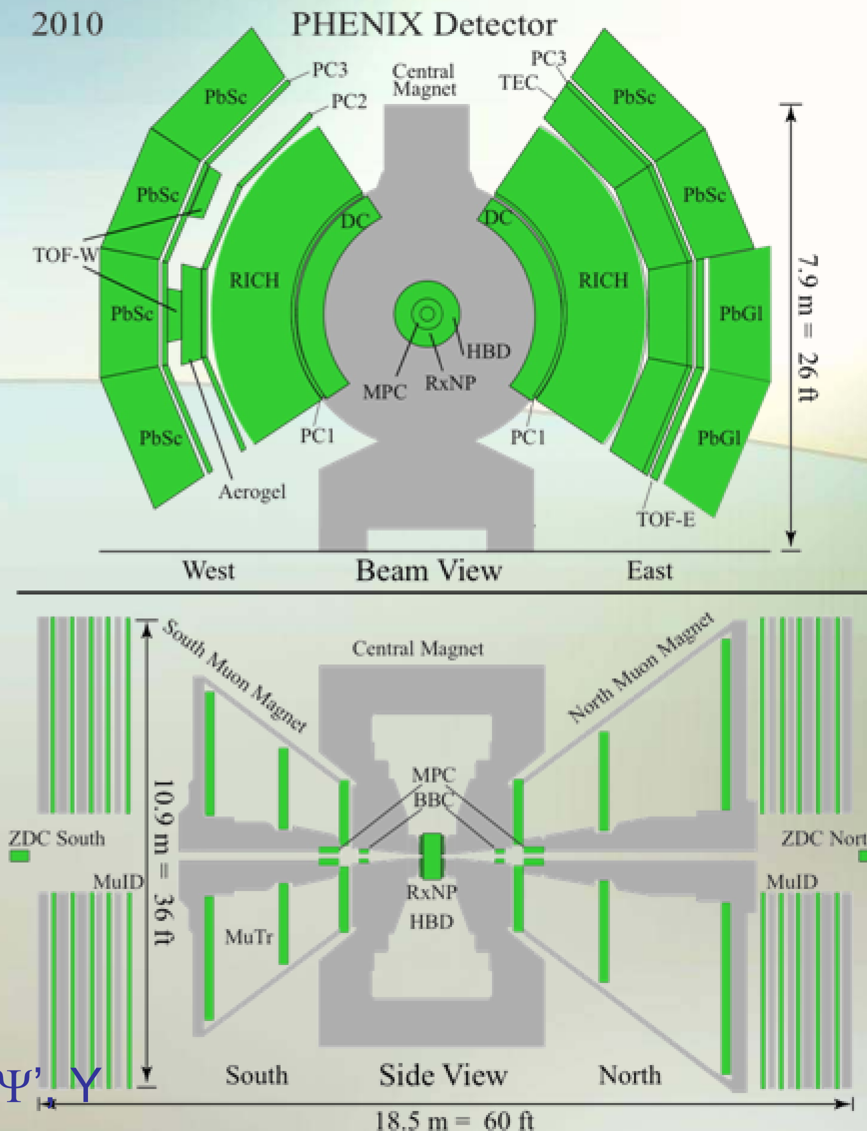
Проектная светимость:		Достигнутая:
Au–Au	2×10^{26} cm^{-2} s^{-1}	$1.2\text{x}10^{27}$ cm^{-2}s^{-1}
p↑–p↑	2×10^{31} cm^{-2} s^{-1}	$2.3\text{x}10^{31}$ cm^{-2} s^{-1} 200 GeV $1.2\text{x}10^{32}$ cm^{-2}s^{-1} 500 GeV

System	$\sqrt{s_{NN}}$, GeV
Au+Au	7, 9, 39, 62, 130, 200
d+Au	200
Cu+Cu	22, 62, 200
p↑+p↑	22, 62, 200, 500

- p+p: reference to HI collisions, particle production in elementary hadronic collisions
- d+Au: CNM effect (nPDF, Cronin, hadron final state interactions etc.)
- Au+Au/Cu+Cu: study of hot and dense medium;
- Low energy runs: detailed study of medium properties and search of critical point

Эксперимент ФЕНИКС - 2010

- Global detectors:
  - ✓ BBC/ZDC provide minimum bias trigger and centrality determination
- Central arms:
  - ✓ Tracking system (DC, PC1, PC2, PC3, TEC)
  - ✓ PID detectors (TOF, RICH, AGEL, HBD, TEC)
  - ✓ EMCal (PbSc and PbGl), MPC
- Muon arms:
  - ✓ Three layers of muon tracker (MuTr)
  - ✓ Five layers of absorbers and muon identification chambers (MuID)

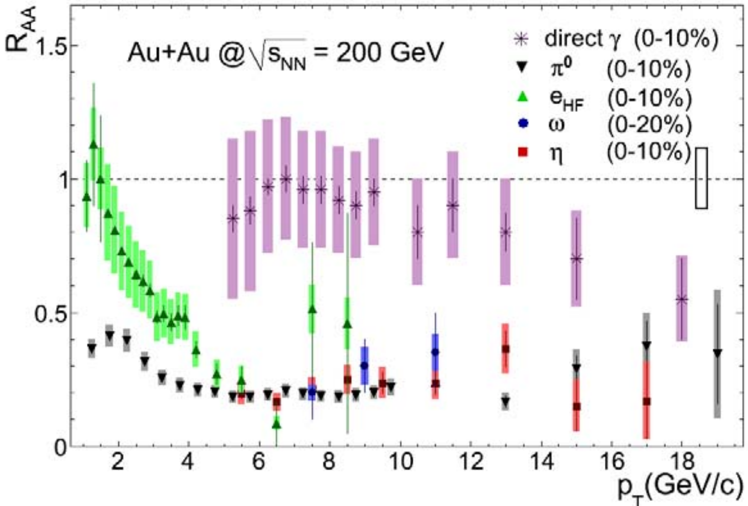


Российский вклад:

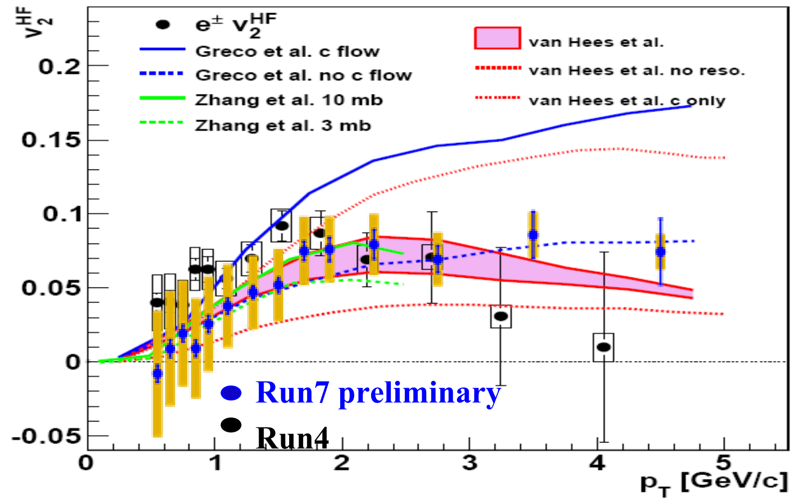
- Центральный магнит (Ижорский завод)
- Дрейфовые камеры (ПИЯФ, Гатчина)
- Электромагнитный калориметр:
  - PbSc (ИТЭФ, Протвино)
  - PbGl (РНЦ "Курчатовский институт")
- AGEL (ОИЯФ, Дубна)

γ, e, μ, h±, π, K, η, ω, K*, η', φ, p, Λ, J/Ψ, Ψ', Y ...

Основные результаты ФЕНИКС



The matter is dense



The matter is strongly coupled

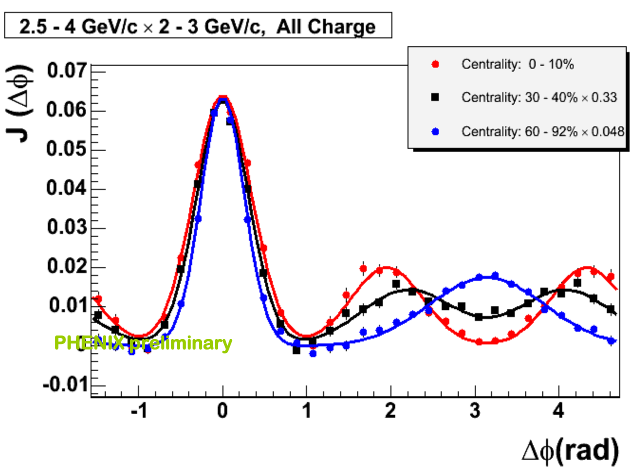
ε > 15 GeV/fm^3

dN_g/dy > 1100

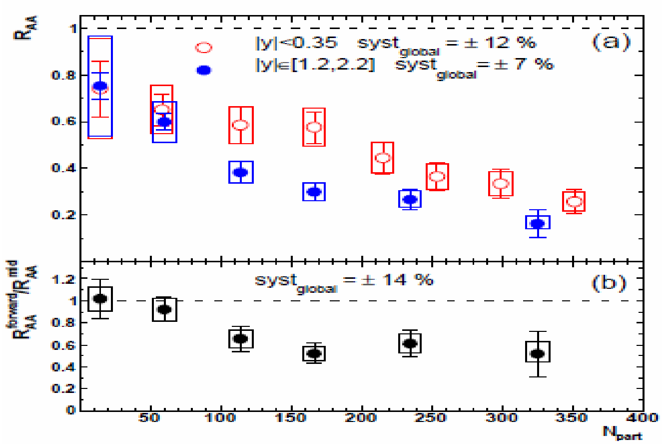
τ_0 < 1 fm/c

T = 300 - 600 MeV

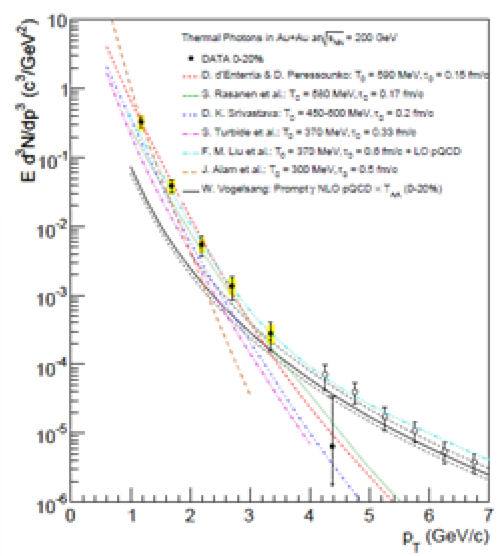
Partonic dof



The matter modifies jets



The matter may melt and regenerate J/ψ's

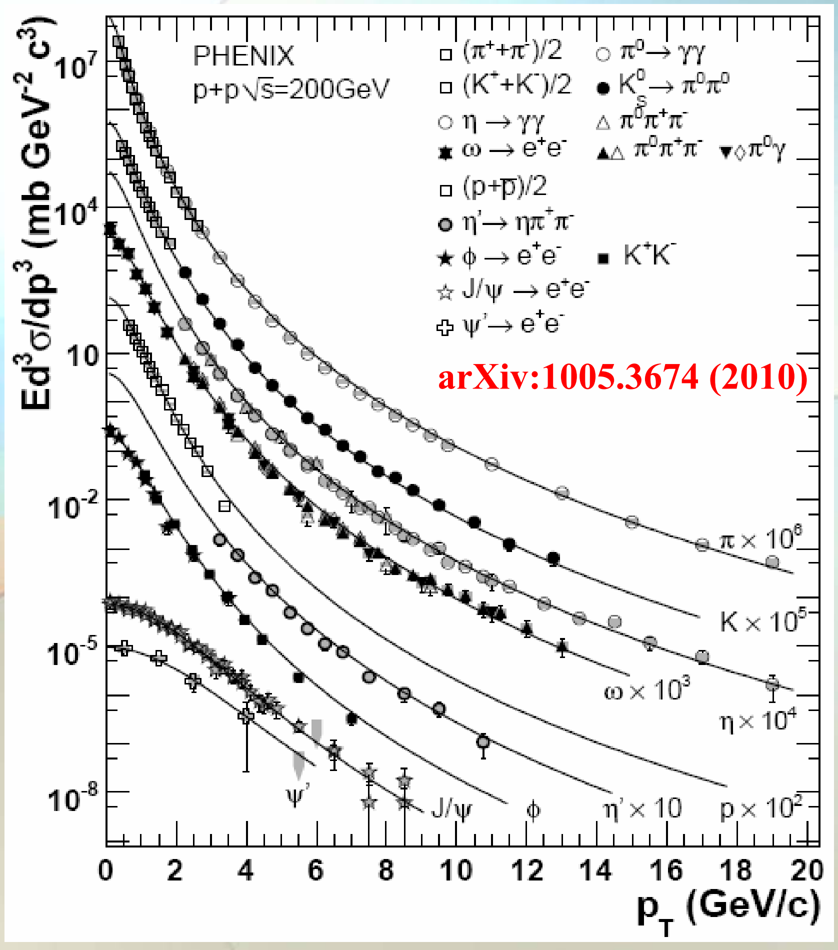


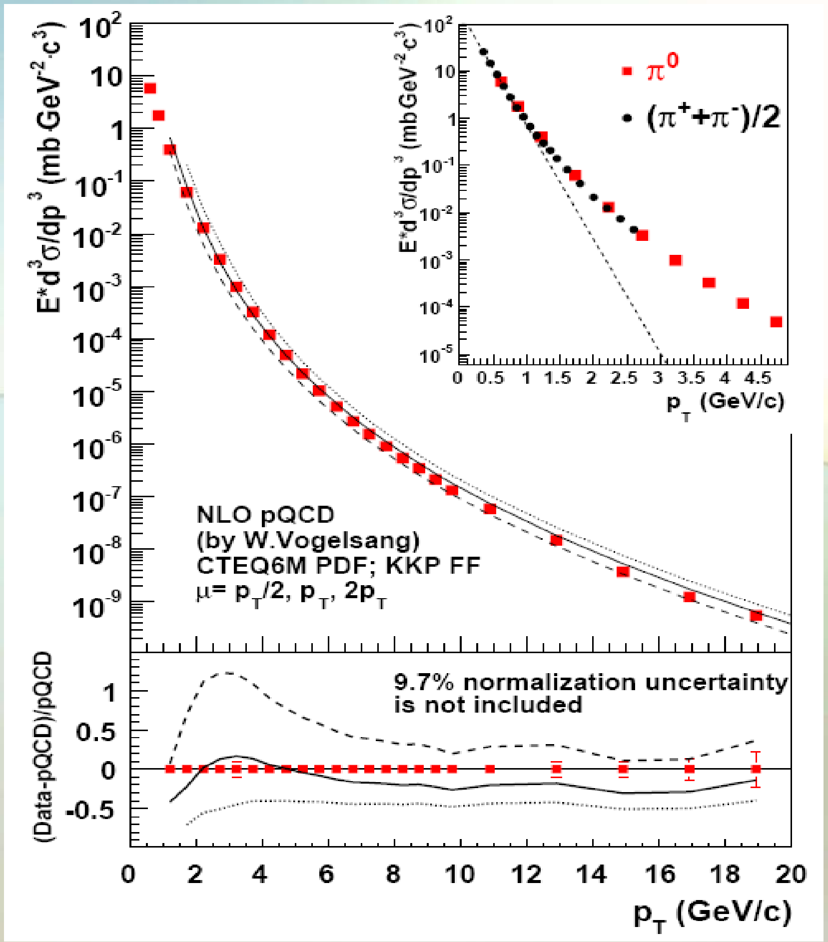
The matter is hot

Рождение адронов в p+p и d+Au

- Больше частиц
- Шире диапазон измерений
- Меньшие неопределенности

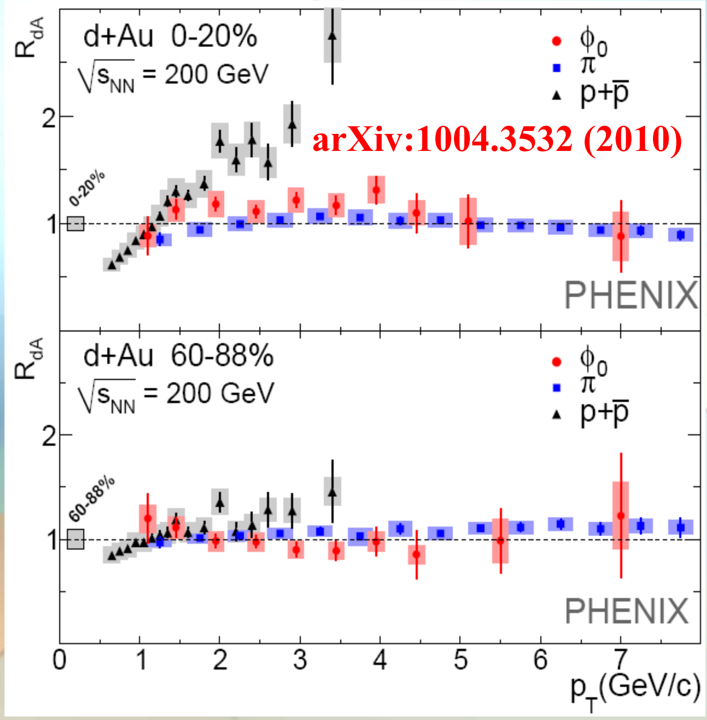
p+p, differential cross sections

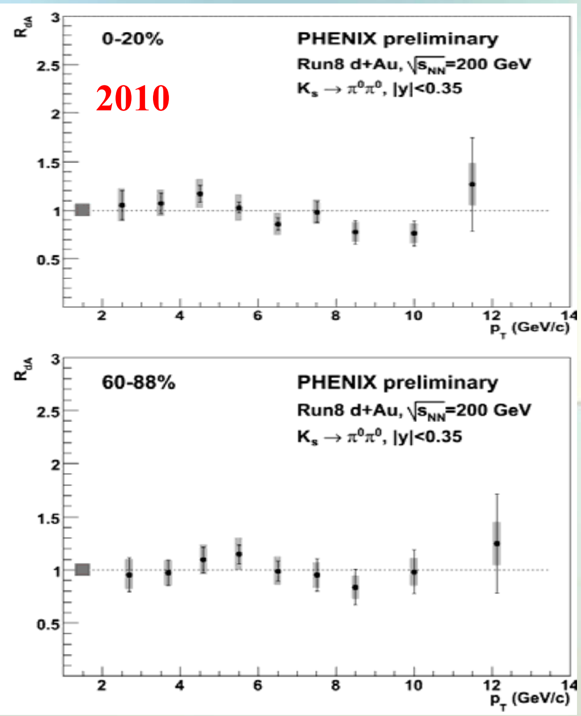


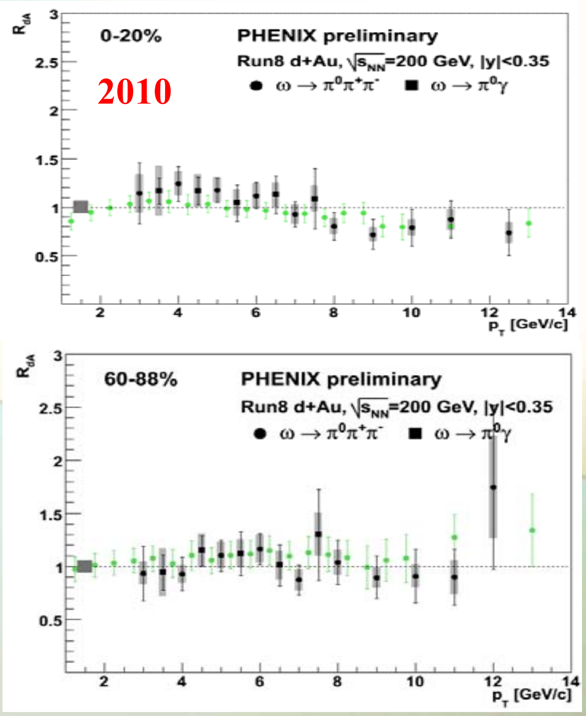


- Serve as a reference for heavier collision systems
- Precision tests for pQCD calculations at $p_T > 2$ GeV/c
- Used to study universal scaling properties in particle production

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







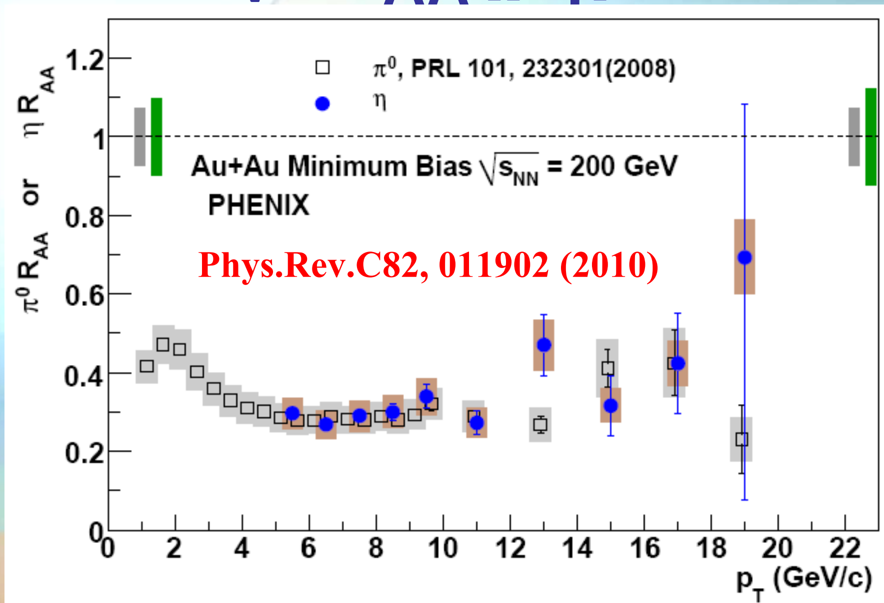
- In peripheral d+Au production of hadrons ~ follows binary scaling
- In central d+Au production of hadrons is enhanced at intermediate p_T:
  - very similar for all mesons
  - statistically significant difference between baryons and mesons

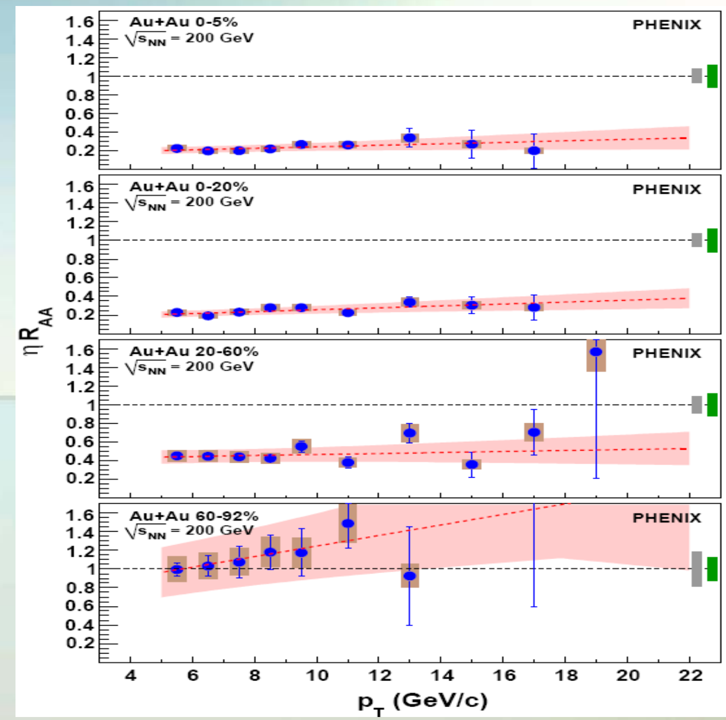
→ Hard to reconcile with explanation of Cronin effect as from soft multiple rescattering in the initial state (R.Hwa et al., Phys.Rev.Lett 93, 082302 (2004))

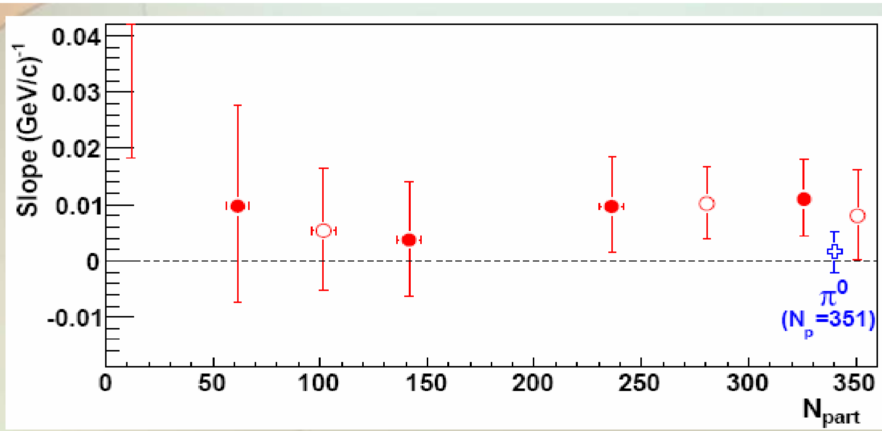
Гашение струй: $R_{AA}(p_T,\varphi)$, $v_2(p_T)$

- Более дифференциальные измерения
- Больше частиц и более широкий диапазон измерений
- Меньшие неопределенности

π^0, η, $R_{AA}(p_T)$, Au+Au, $\sqrt{s_{NN}}$ = 200 GeV



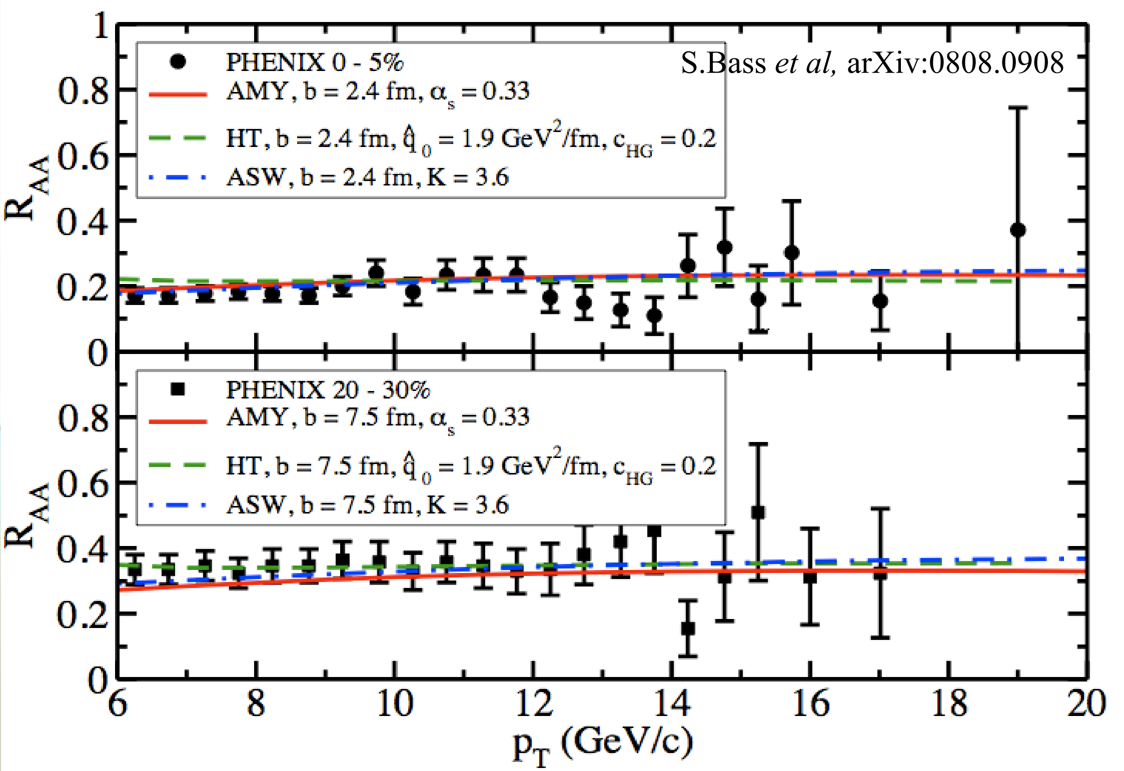




- New η measurements at high $p_T \rightarrow$ smaller uncertainties from γ-cluster merging in the EMCal (larger opening angle)
- R_{AA} for π^0 and η agree within uncertainties

- Linear fits to R_{AA} vs. p_T indicate that R_{AA} is consistent with constant at all centralities
- Slow rise (0.01 c/GeV) of R_{AA} with increasing p_T cannot be excluded

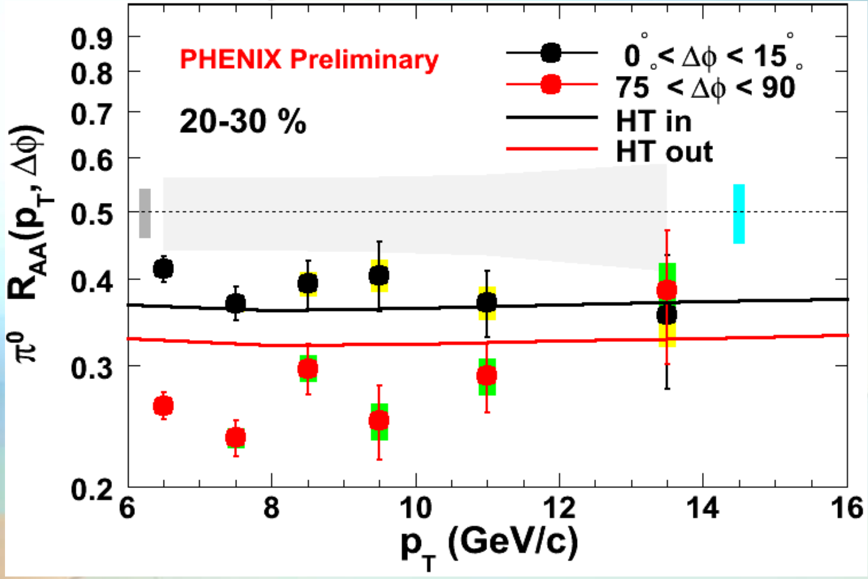
π^0, $R_{AA}(p_T)$, Au+Au, $\sqrt{s_{NN}}$ = 200 GeV, models

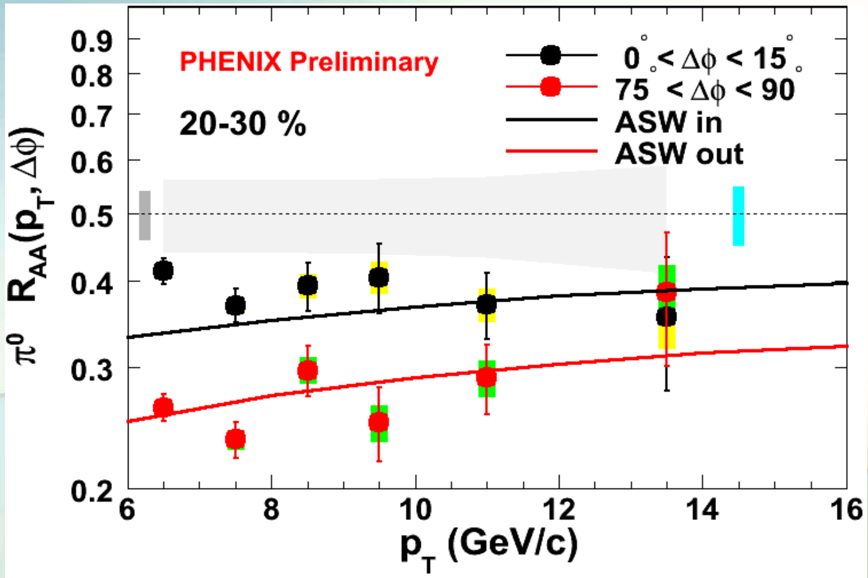


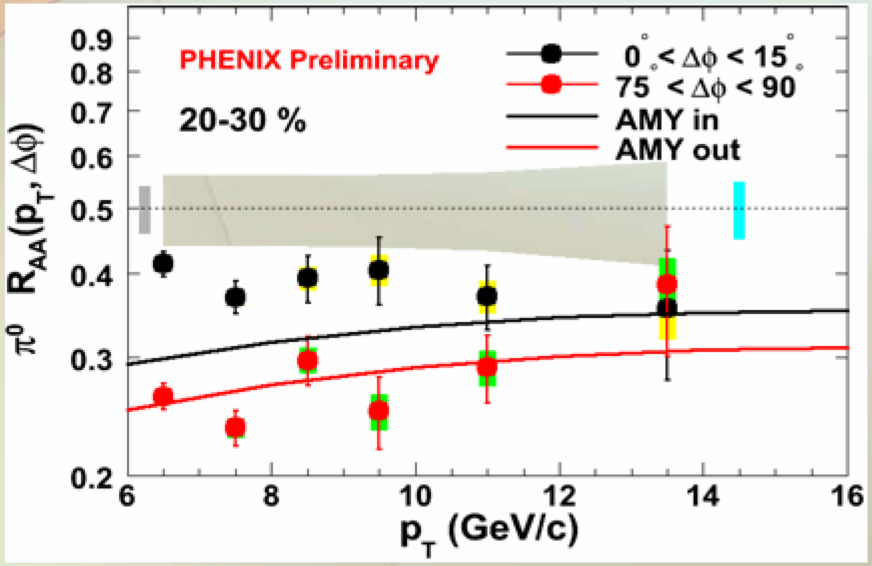
- Model calculations describe measured $R_{AA}(p_T)$ at high p_T using different assumptions about collision geometry, time evolution of interacting system, energy loss approximations

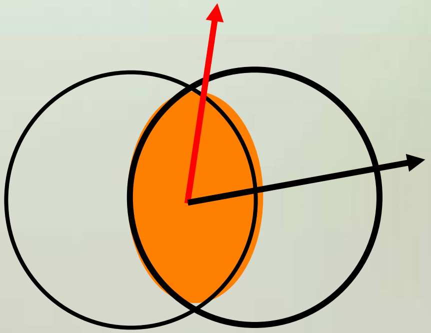
→ discriminating power of R_{AA} is not sufficient

π^0, $R_{AA}(p_T,\varphi)$, Au+Au, $\sqrt{s_{NN}}$ = 200 GeV, models



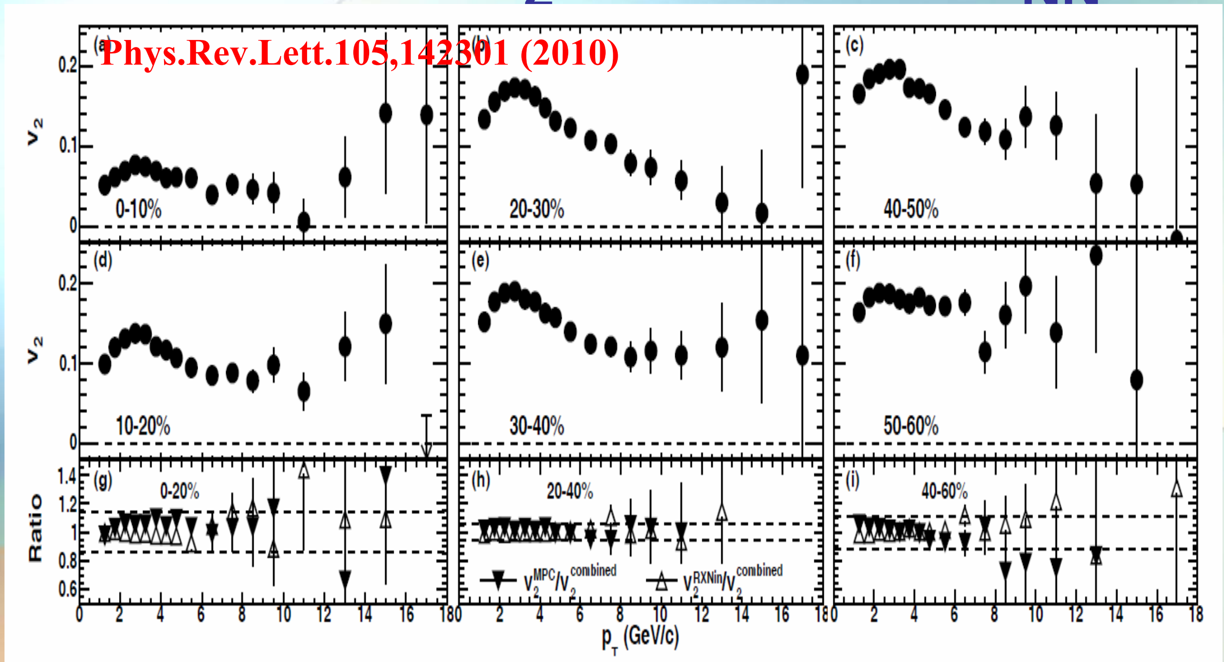


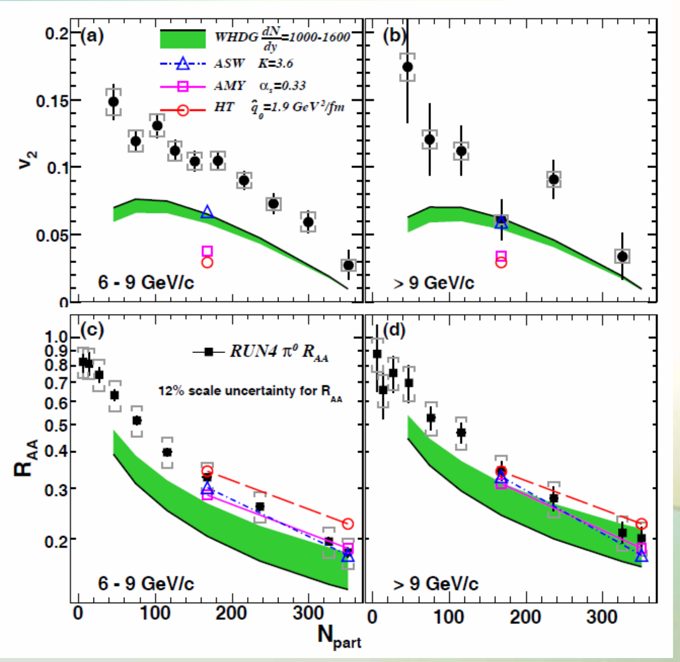




- Description of data is problematic
- ASW suggests q-hat > 10 GeV^2/fm

π^0, v_2, Au+Au, $\sqrt{s_{NN}}$ = 200 GeV





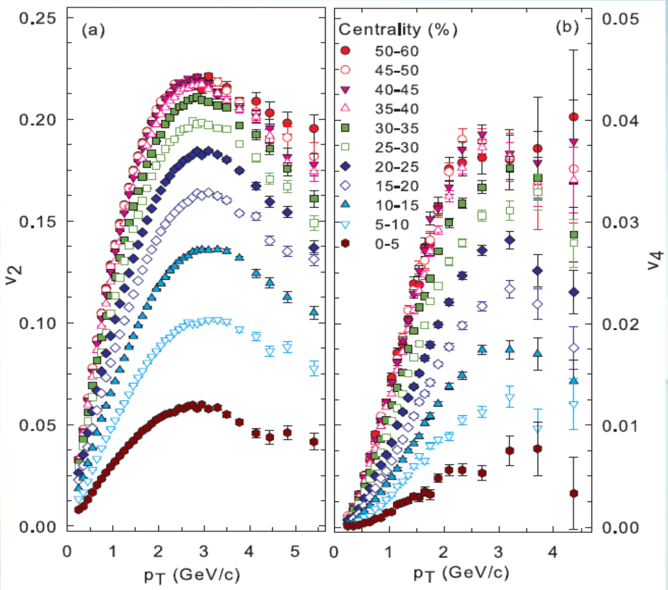
- If elliptic flow is dominant source of yield vs $\Delta\varphi = (\varphi - \Psi_{RP})$ variation: $\frac{dN}{d\Delta\phi} = N_0(1 + 2v_2^{meas}\cos 2\Delta\phi)$
- Measurements are extended up to 18 GeV/c in p_T
- v_2 rapidly increases at low p_T, reaches maximum at 2-3 GeV/c, then decreases with p_T
- Weak dependence on p_T at p_T>5-7 GeV/c
- Results for η are consistent with π^0 at high-p_T → no mass dependence
- The magnitude of v_2 is under-predicted by current pQCD energy-loss model calculations, an estimate of the increase in v_2 expected from gluon saturation effects and fluctuations is insufficient to account for this discrepancy.

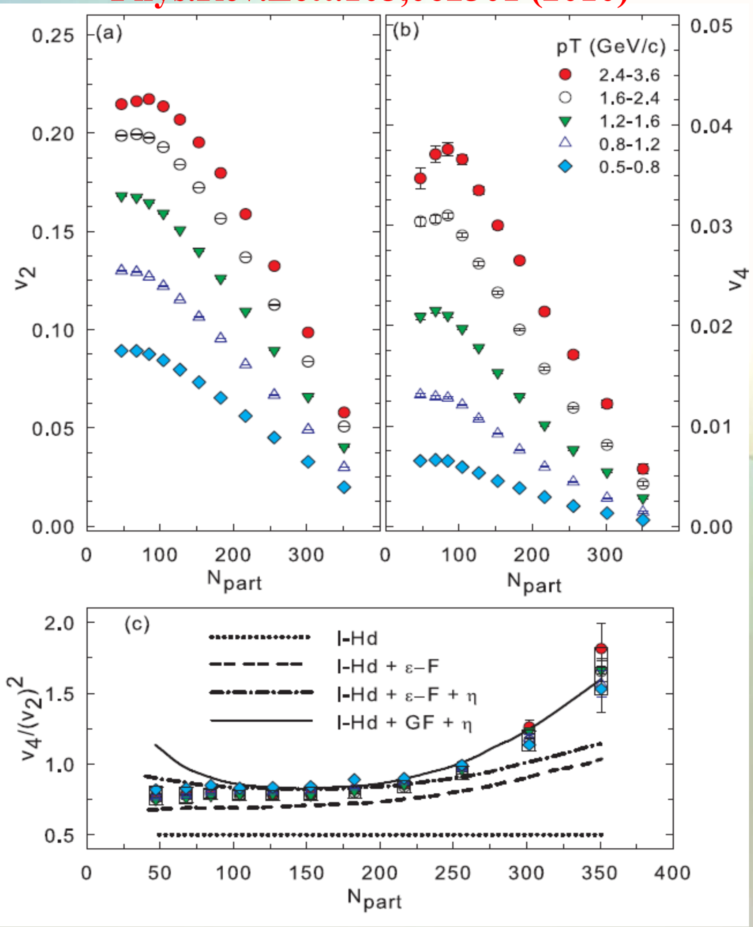
Азимутальная анизотропия

- Измерение v_2 и v_4
- Существенное улучшение в разрешение RP
- Меньшие неопределенности

v_2 and v_4 for $h^{\pm}$, Au+Au, $\sqrt{s_{NN}}$ = 200 GeV

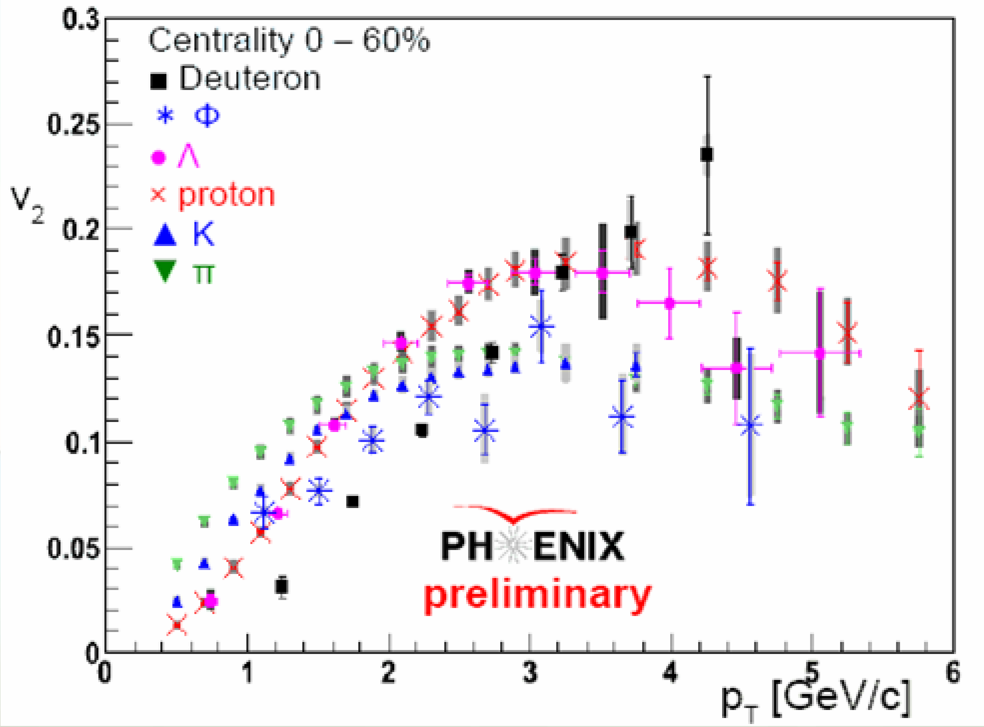
Phys.Rev.Lett.105,062301 (2010)





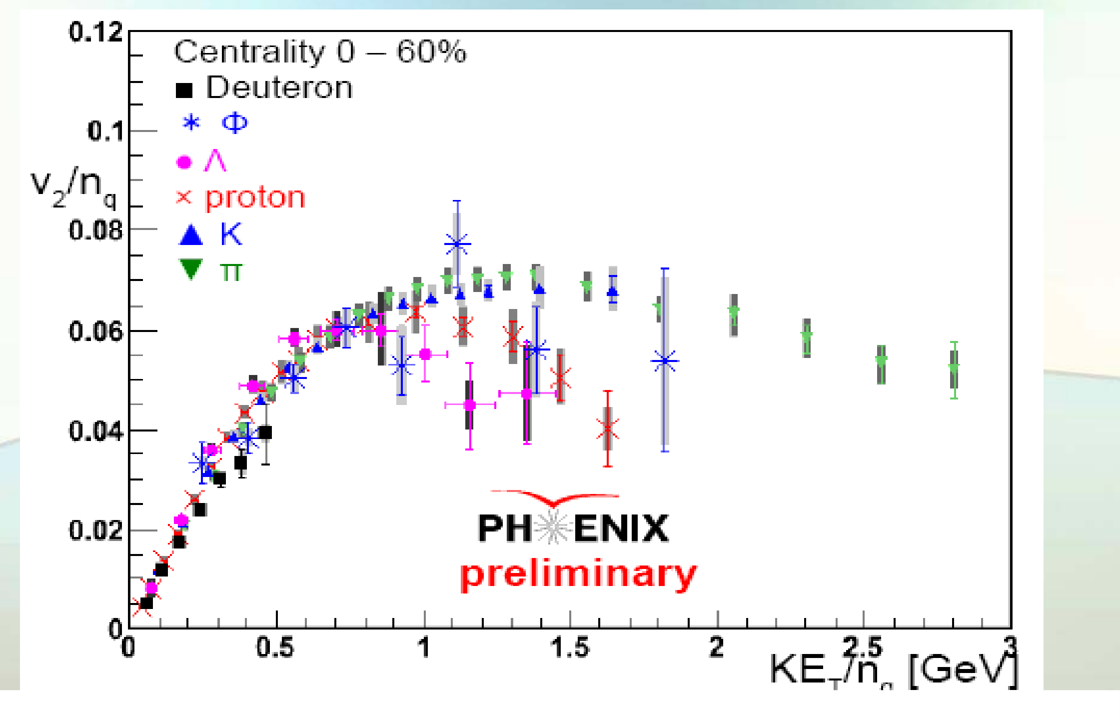
- v_2 and v_4 signal have similar shape
- $v_4/(v_2)^2$ ratio is independent of p_T, 0.5-3.6 GeV/c
- $v_4/(v_2)^2 \approx 0.8$ for N_{part}<200
- Adding eccentricity fluctuations within hydro model fits data better (dash-dash)
- Even better agreement when η added to hadron gas phase and small η added to QGP phase (dot-dash)
- $v_4/(v_2)^2$ ratio significantly increases at N_{part} > ~200ations (solid)
- Fit to data implies small η/s

v_2, identified hadrons, Au+Au, $\sqrt{s_{NN}}$ = 200 GeV



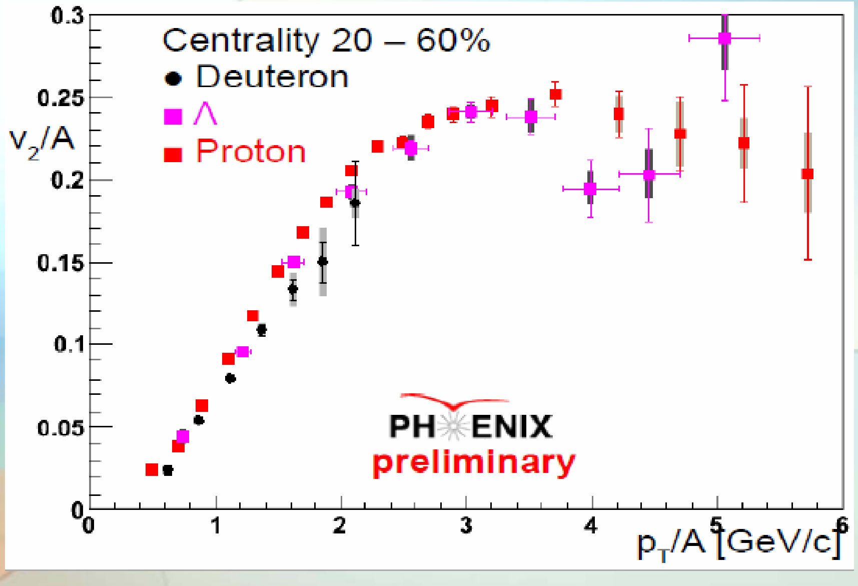
- Clear mass ordering at p_T < 2 GeV/c → consistent with hydro calculations
- At 2-4 GeV/c departure from mass ordering; v2 is more strongly dependent on the quark composition of the particles → dominance of the quark coalescence mechanism
  - Λ is consistent with p
  - φ is consistent with lighter mesons (π, K)
  - D is somewhat higher then p
- v_2 for all hadrons seem to approach the same value at very high p_T

v_2 for identified hadrons, Au+Au, $\sqrt{s_{NN}}$ = 200 GeV



- Universal quark number scaling at kE_T/n_q < 0.8-1.0 GeV
  → indication of the inherent quark-like degrees of freedom
- Scaling breaks at higher kE_T/n_q with separation of mesons and baryons
  → change in particle production mechanisms

v_2 for identified hadrons, Au+Au, $\sqrt{s_{NN}}$ = 200 GeV



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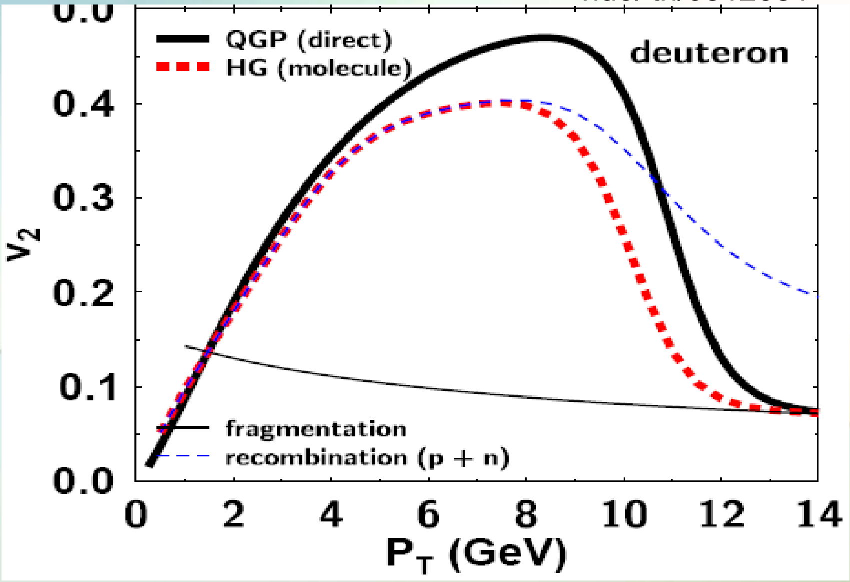
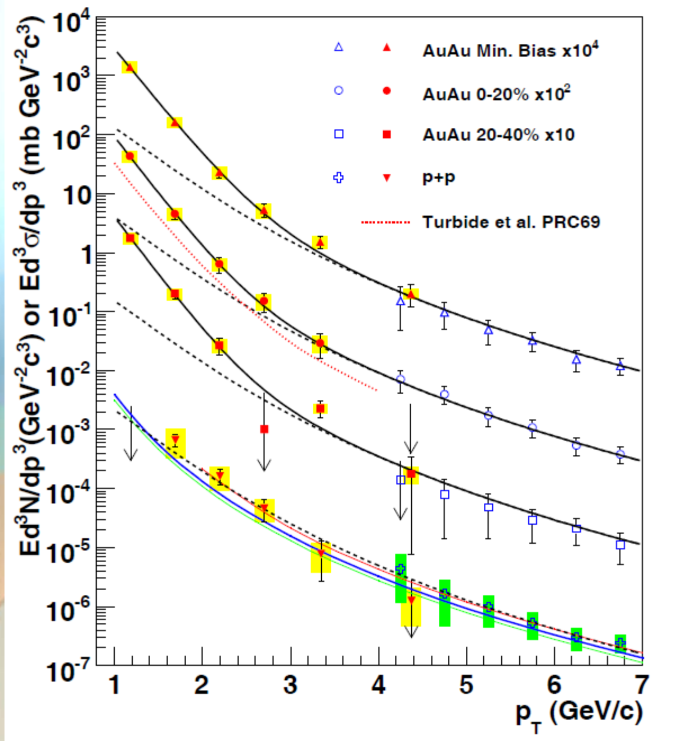


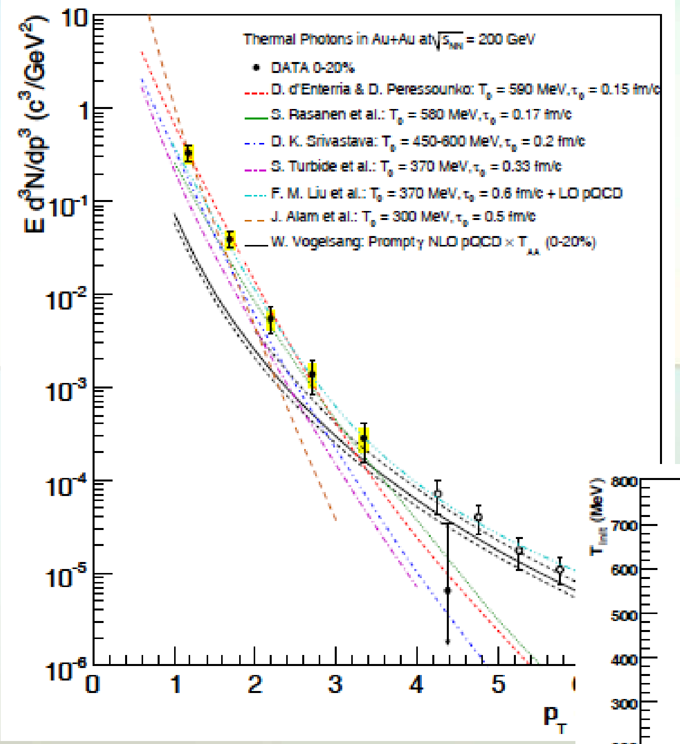
- D and p follow the p_T/A scaling
  → suggests similar flows for p and n
- D meson is produced as a result of coalescence of 6 quarks or p and n ???

Тепловые прямые фотоны

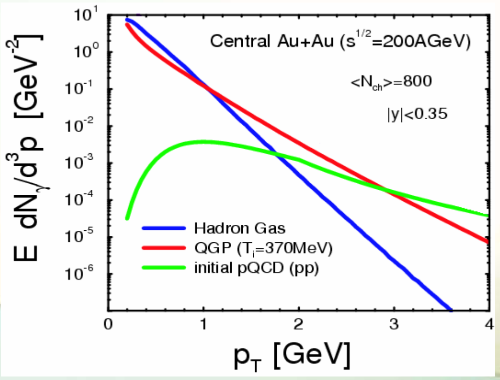
Прямые фотоны, Au+Au, $\sqrt{s_{NN}}$ = 200 GeV

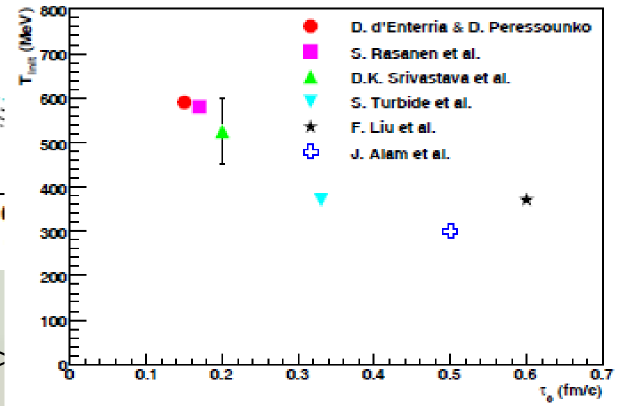
Phys.Rev.C81,034911 (2010); Phys.Rev.Lett.104,132301 (2010)





S.Turbide *et al* PRC 69 014903

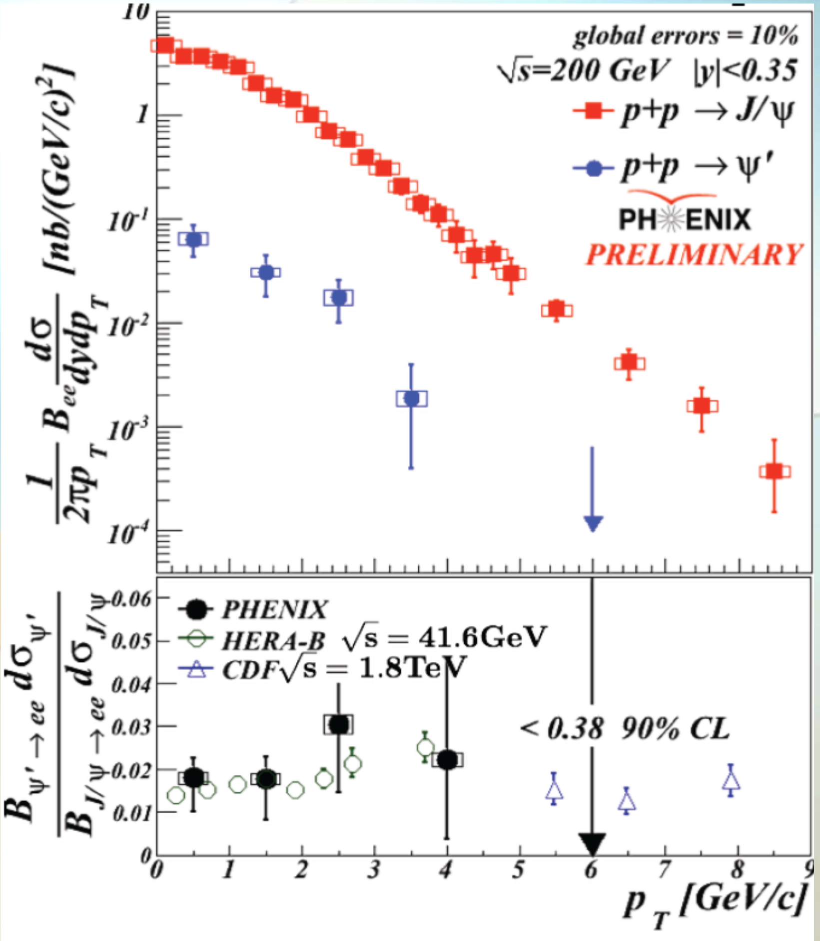


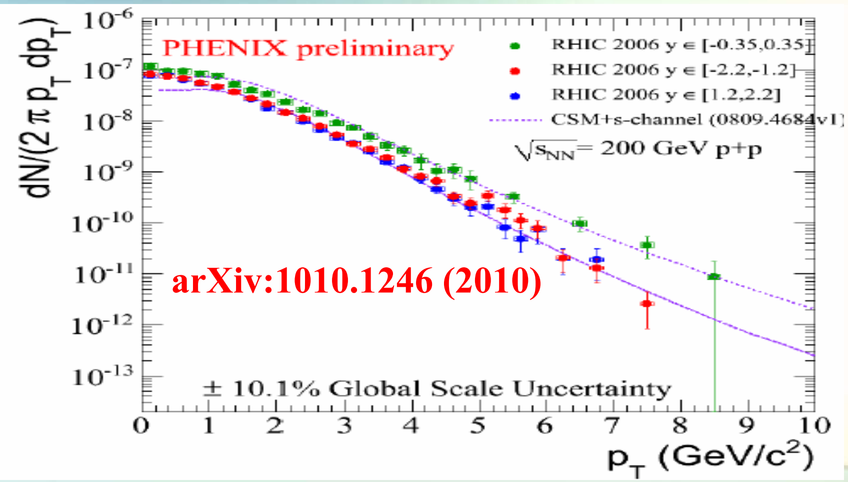


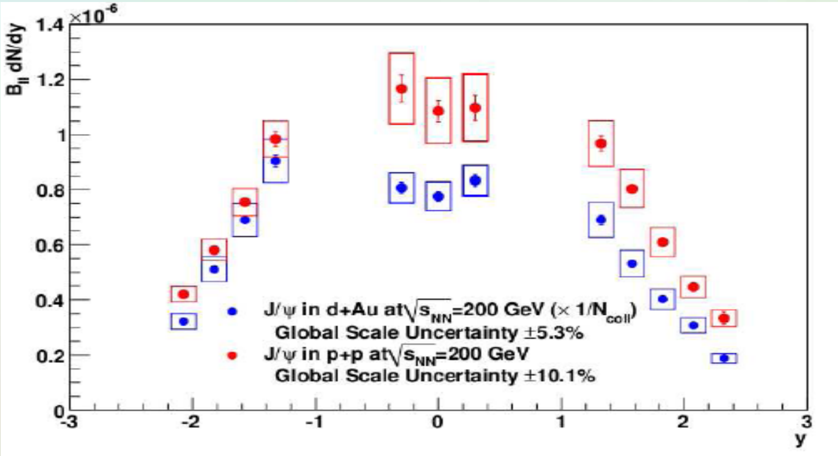
- В p+p спектр рождения описывается pQCD при p_T >
- В Au+Au наблюдается избыточный выход прямых фотонов при p_T < 4 ГэВ/с
- Аппроксимация экспонентой: T ~ 220 МэВ
- Гидродинамические расчеты: T ~ 300-600 МэВ

J/Ψ

J/Ψ, p+p/d+Au, $\sqrt{s_{NN}}$ = 200 GeV

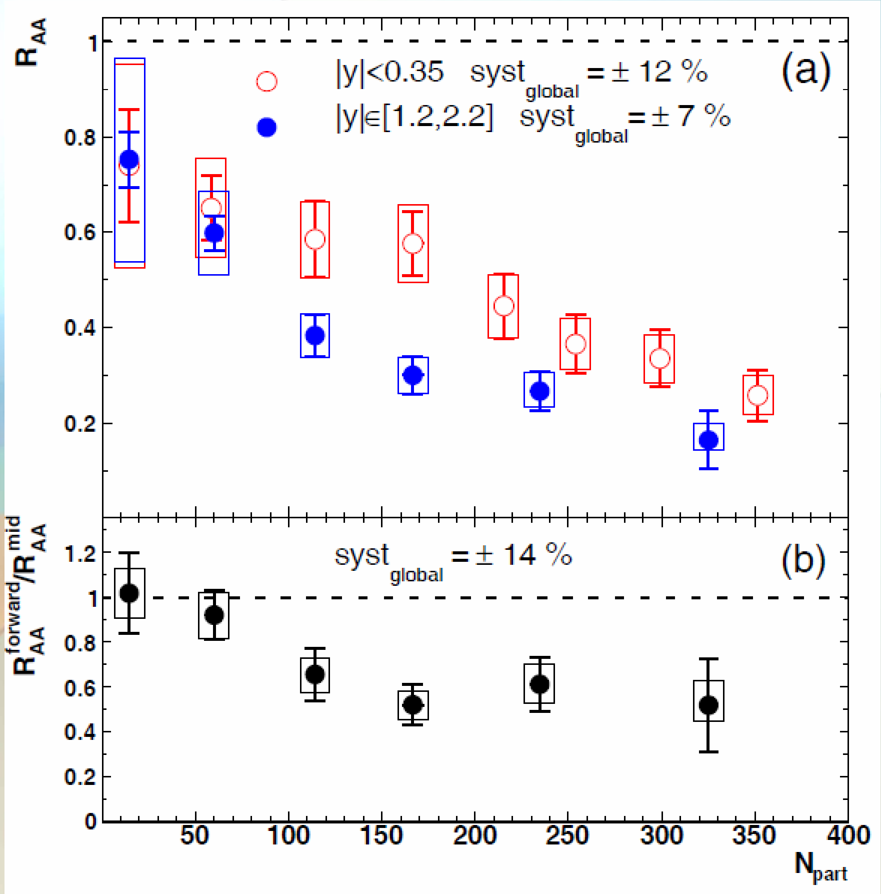


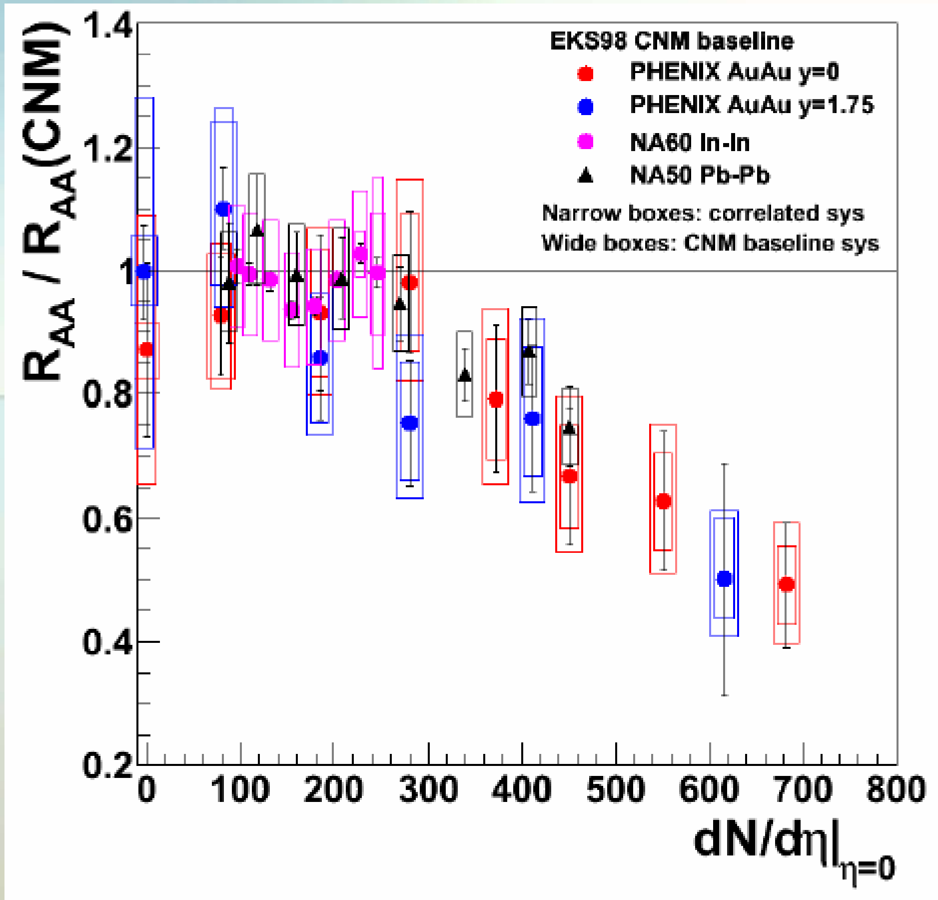




- FD(Ψ') = 8.6 ± 2.5 %; FD (Chic) < 42% (90% CL)
- Рождение J/Ψ подавлено в d+Au взаимодействиях при y>0

J/Ψ, Au+Au, $\sqrt{s_{NN}}$ = 200 GeV





A. Adare *et.al.*, arXiv:1010.1246.
N. Brambilla, *et.al.*, arXiv:1010.5827.
J. L. Nagle *et.al.*, arXiv:1011.4534.

Участие ЛРЯФ (2010)

- ДК
- Закончен цикл работ по измерению инвариантных спектров рождения по поперечному импульсу и факторов ядерной модификации для легких адронов в различных сталкивающихся системах:
  - ✓ $\varphi \to K^+K^-$ в p+p, d+Au, Cu+Cu и Au+Au при $\sqrt{s_{NN}} = 200$ ГэВ
  - ✓ $\varphi \to$ K+K- в p+p, Cu+Cu и Au+Au при $\sqrt{s_{NN}} = 62$ ГэВ
  - ✓ $\omega \to \pi^0\pi^+\pi^-$ $(\pi^0\gamma)$, $K_s \to \pi^0\pi^0$ в d+Au, Cu+Cu и Au+Au при $\sqrt{s_{NN}} = 200$ ГэВ

- Была защищена кандидатская диссертация:
  - ✓ Д. Котов, “Рождение φ-мезонов в p+p, d+Au, Cu+Cu и Au+Au взаимодействиях при энергиях √sNN = 62.4 и 200 ГэВ в эксперименте ФЕНИКС”

- Приняли участие в 6 конференциях:
  - ✓ VII конференция по физике высоких энергий, ядерной физике и ускорителям, Харьков.
  - ✓ Ядро 2010, Петергоф.
  - ✓ RHIC & AGS Users meeting, BNL.
  - ✓ XIV Всероссийская конференция «Фундаментальные исследования и инновации в национальных исследовательских университетах», С.-Петербург.
  - ✓ Конференция по физике и астрономии, С.-Петербург.
  - ✓ HSQCD-2010, Гатчина.

- Подготовили несколько коллаборационных публикаций.

Ближайшие планы (2011)

- Run-11 (январь-июнь, 2011)
- Новый цикл анализов с использованием HBD и (F)VTX:
  - ✓ ЛВМ
  - ✓ Сектор тяжелых ароматов
- Окончание текущих анализов, публикация результатов, защита диссертаций

PHENIX

14 Countries; 71 Institutions

Universidade de São Paulo, Instituto de Física, Caixa Postal 66318, São Paulo CEP05315-970, Brazil
Institute of Physics, Academia Sinica, Taipei 11529, Taiwan
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Peking University, Beijing, People's Republic of China
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Kyoto University, Kyoto 606-8502, Japan
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Chonbuk National University, Jeonju, Korea
Ewha Womans University, Seoul 120-750, Korea
Hanyang University, Seoul 133-792, Korea
KAERI, Cyclotron Application Laboratory, Seoul, South Korea
Korea University, Seoul, 136-701, Korea
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Department of Physics and Astronomy, Seoul National University, Seoul, South Korea
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IHEP Protvino, State Research Center of Russian Federation, Institute for High Energy Physics, Protvino, 142281, Russia
Joint Institute for Nuclear Research, 141980 Dubna, Moscow Region, Russia
Russian Research Center "Kurchatov Institute", Moscow, Russia
PNPI, Petersburg Nuclear Physics Institute, Gatchina, Leningrad region, 188300, Russia
Saint Petersburg State Polytechnic University, St. Petersburg, Russia
Skobeltsyn Institute of Nuclear Physics, Lomonosov Moscow State University, Vorob'evy Gory, Moscow 119992, Russia
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University of Colorado, Boulder, CO 80309, U.S.
Columbia University, New York, NY 10027 and Nevis Laboratories, Irvington, NY 10533, U.S.
Florida Institute of Technology, Melbourne, FL 32901, U.S.
Florida State University, Tallahassee, FL 32306, U.S.
Georgia State University, Atlanta, GA 30303, U.S.
University of Illinois at Urbana-Champaign, Urbana, IL 61801, U.S.
Iowa State University, Ames, IA 50011, U.S.
Lawrence Livermore National Laboratory, Livermore, CA 94550, U.S.
Los Alamos National Laboratory, Los Alamos, NM 87545, U.S.
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Morgan State University, Baltimore, MD 21251, U.S.
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New Mexico State University, Las Cruces, NM 88003, U.S.
Oak Ridge National Laboratory, Oak Ridge, TN 37831, U.S.
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RIKEN BNL Research Center, Brookhaven National Laboratory, Upton, NY 11973-5000, U.S.
Chemistry Department, Stony Brook University, SUNY, Stony Brook, NY 11794-3400, U.S.
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Vanderbilt University, Nashville, TN 37235, U.S.

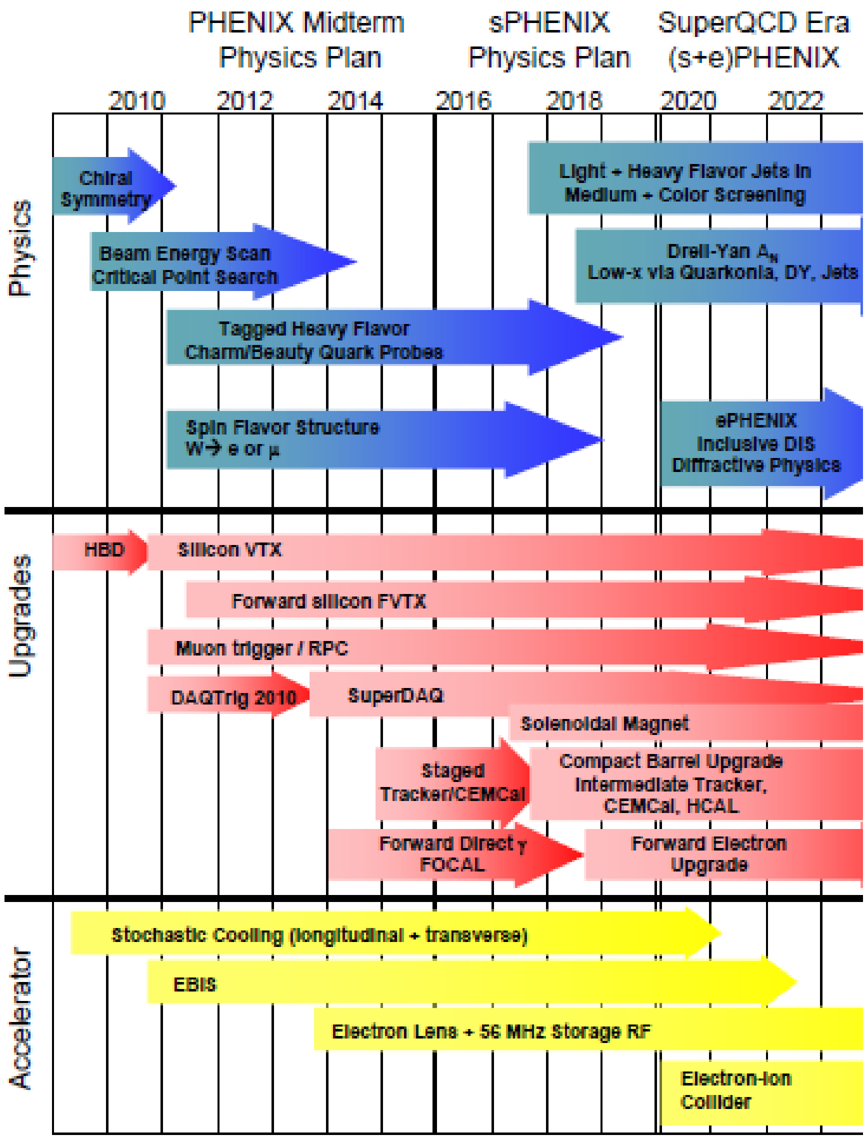

Figure 1: Timeline indicating the physics topics, detector upgrades, and accelerator upgrades over the next decade.