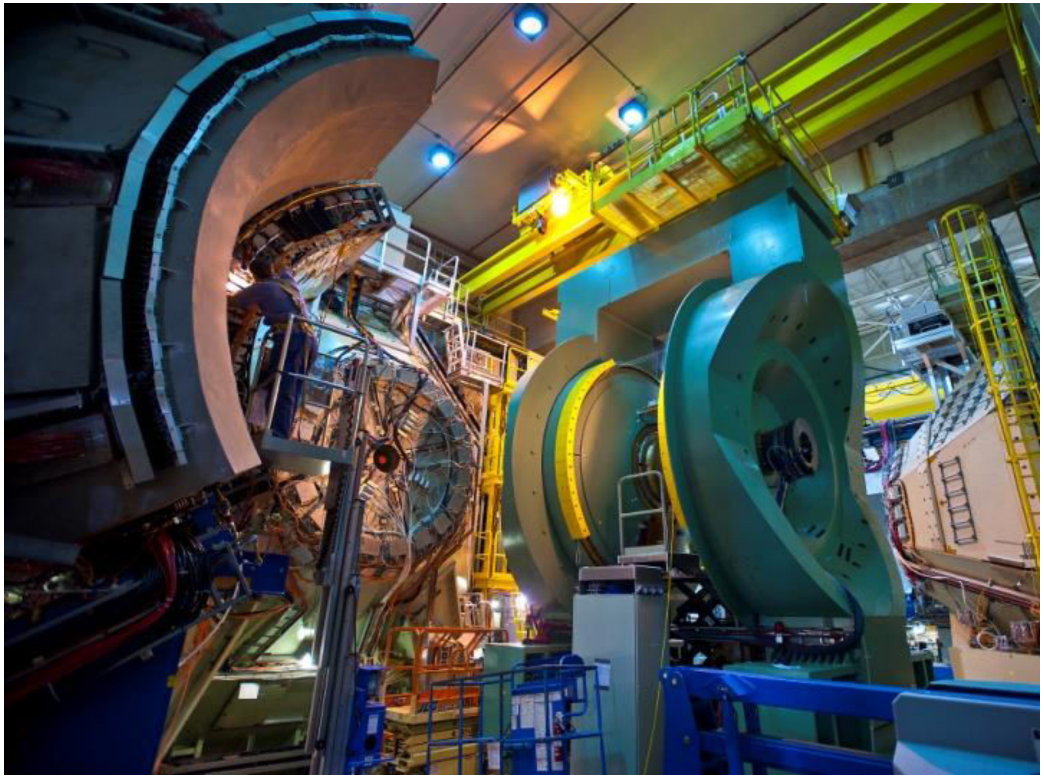
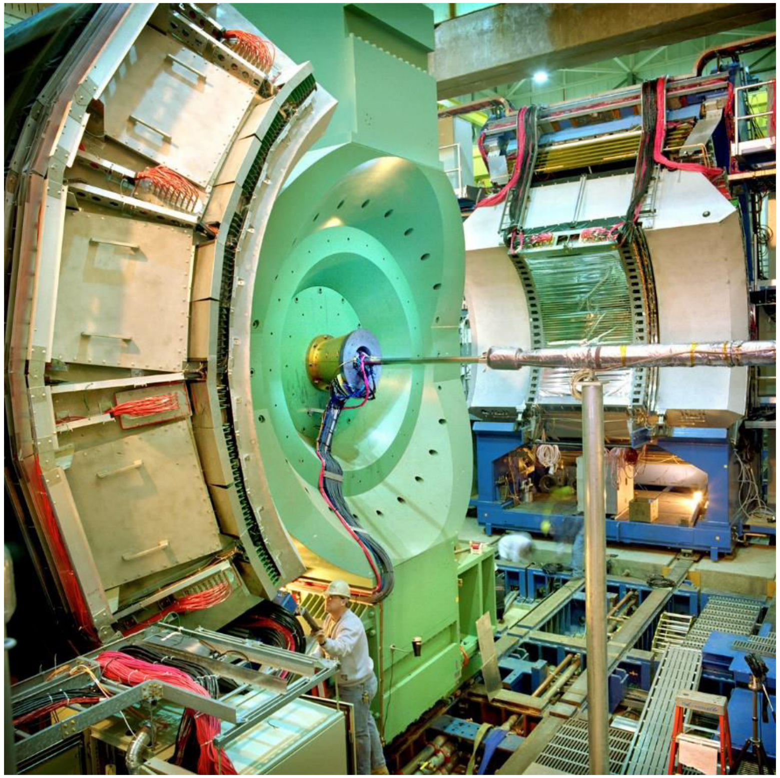
Эксперименте ФЕНИКС

В. Рябов, ЛРЯФ ОФВЭ





Текущее состояние - I

~ 1997 год

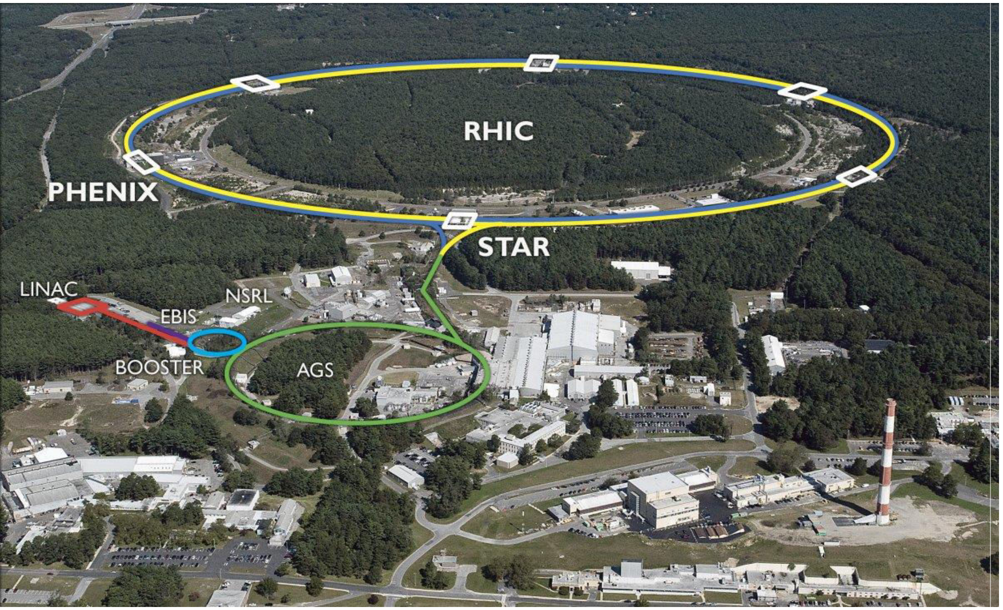
~ сегодня

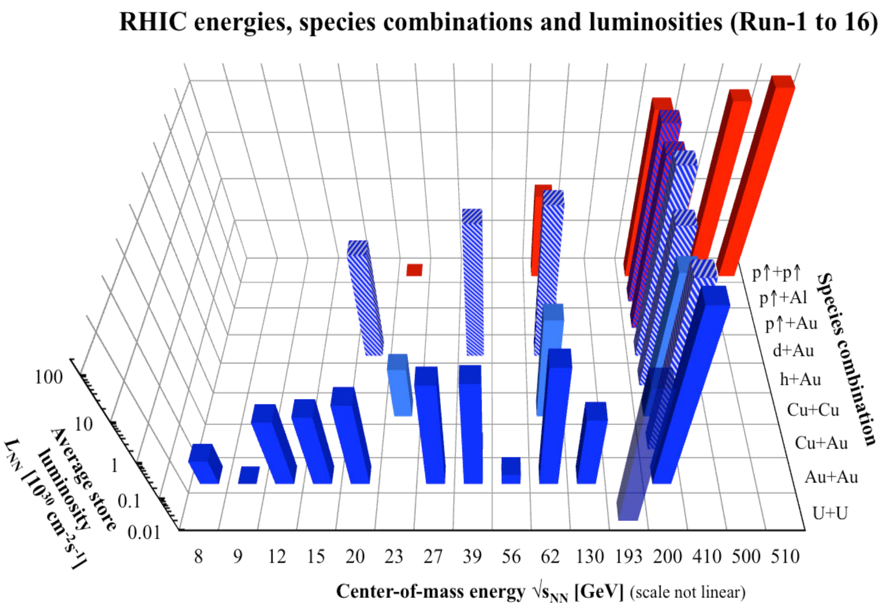
Текущее состояние - II

Дрейфовые Камеры сегодня

DC.W sitting in the sun outside 1008 and ready for a loooong vacation

Relativistic Heavy-Ion Collided (RHIC)





- 2000-2016, обширная физическая программа:
  - ✓ p+p, p+A, A+A при максимальной энергии $\sqrt{s_{NN}}$ = 200 ГэВ (9 комбинаций)
  - ✓ программа сканирования по энергии взаимодействия (13 энергий)
  - ✓ единственный коллайдер пучков поляризованных протонов, P ~ 70%

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Joint Institute for Nuclear Research, 141980 Dubna, Moscow Region, Russia
National Research Nuclear University, MEPhI, Moscow Engineering Physics Institute, Moscow, 115409, Russia
Russian Research Center "Kurchatov Institute", Moscow, Russia
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Saint Petersburg State Polytechnic University, St. Petersburg, Russia
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Ewha Womans University, Seoul 120-750, South Korea
Hanyang University, Seoul 133-792, South Korea
Korea University, Seoul, 136-701, South Korea
Accelerator and Medical Instrumentation Engineering Lab, SungKyunKwan University, 53 Myeongnyun-dong, 3-ga, Jongno-gu, Seoul, South Korea
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Department of Physocs and Astronomy, Seoul National University, Seoul, South Korea
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14 countries, 75 institutions, Jan 2015

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Vanderbilt University, Nashville, TN 37235, U.S.
Department of Physics and Astronomy, Howard University, 2355 6th St. NW, Washington, DC 20059, U.S.

Участие ПИЯФ, 2017

- ✓ В. Самсонов, д.ф.-м.н., зав. ЛРЯФ
- ✓ В. Баублис, к.ф.-м.н., снс
- ✓ Д. Иванищев, к.ф.-м.н.нс
- ✓ Б. Комков, снс
- ✓ Д. Котов, к.ф.-м.н., снс
- ✓ М. Малаев, к.ф.-м.н., нс
- ✓ В. Рябов, д.ф.-м.н., внс
- ✓ Ю. Рябов, к.ф.-м.н., снс
- ✓ А. Ханзадеев, д.ф.-м.н., внс

- Участие в работе международной физической группы PWG-LF
- Участие в PSB (PHENIX Speaker Bureau)
- Участие во многочисленных PPG, IRC
- Физический анализ экспериментальных данных (легкие адроны)

Конференции

- Международная сессия-конференция Секции ядерной физики ОФН РАН "Физика фундаментальных взаимодействий", 6-8 июня 2017 года, Кабардино-Балкарский Государственный Университет, г. Нальчик
  «Light meson production in heavy ion collisions in PHENIX experiment»

- 6th International Conference on New Frontiers in Physics (ICNFP 2017). Aug 17-26 in Kolymbari, Crete (Greece).
  «Recent PHENIX results on high-p_T light hadron production»

Публикации

1. Measurement of emission angle anisotropy via long-range angular correlations with high p_T hadrons in d+Au and p+p collisions at $\sqrt{s_{NN}}$=200 GeV, arXiv:1711.09003
2. Measurements of mass-dependent azimuthal anisotropy in central p+Au, d+Au, and ^{3}He+Au collisions at $\sqrt{s_{NN}}$=200 GeV, arXiv:1710.09736
3. Measurement of ϕ-meson production at forward rapidity in p+p collisions at $\sqrt{s}$=510 GeV and energy dependence of $\sigma\phi$ from $\sqrt{s}$=200 GeV to 7 TeV, arXiv:1710.01656
4. L'evy-stable two-pion Bose-Einstein correlations in $\sqrt{s_{NN}}$=200 GeV Au+Au collisions, arXiv:1709.05649
5. Measurements of azimuthal anisotropy and charged-particle multiplicity in d+Au collisions at $\sqrt{s_{NN}}$=200, 62.4, 39, and 19.6 GeV, arXiv:1708.06983
6. Measurements of multiparticle correlations in d+Au collisions at 200, 62.4, 39, and 19.6 GeV and p+Au collisions at 200 GeV and implications for collective behavior, arXiv:1707.06108
7. BB-meson production at forward and backward rapidity in p+p and Cu + Au collisions at $\sqrt{s_{NN}}$=200 GeV, Phys.Rev. C96 (2017) no.6, 064901
8. Measurements of e+e− pairs from open heavy flavor in p+p and d+A collisions at $\sqrt{s_{NN}}$=200 GeV, Phys.Rev. C96 (2017) no.2, 024907
9. Measurements of $B\to J/\psi$ at forward rapidity in pp collisions at $\sqrt{s}$=500 GeV, Phys.Rev. D95 (2017) no.9, 092002

Основные результаты 2017

Geometry engineering and energy scan

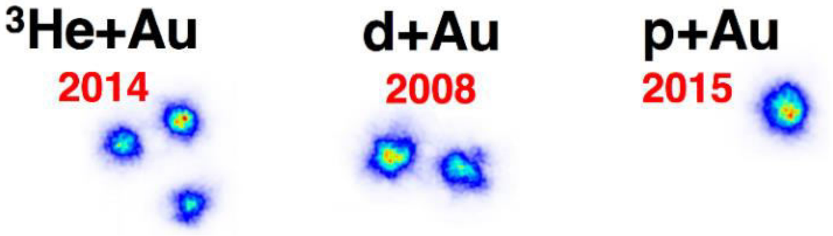
- Поиск коллективных эффектов во взаимодействиях малых систем
- Связь потоков с геометрией области перекрытия ядер → **geometry scan**
- Связь потоков с плотностью энергии → **energy scan (d+Au)**

√s [GeV]	p+p	p+Al	p+Au	d+Au	^{3}He+Au
200	✓	✓	✓	✓	✓
62.4	✓			✓	
39				✓	
20				✓	

2016 Data

Geometry engineering - I

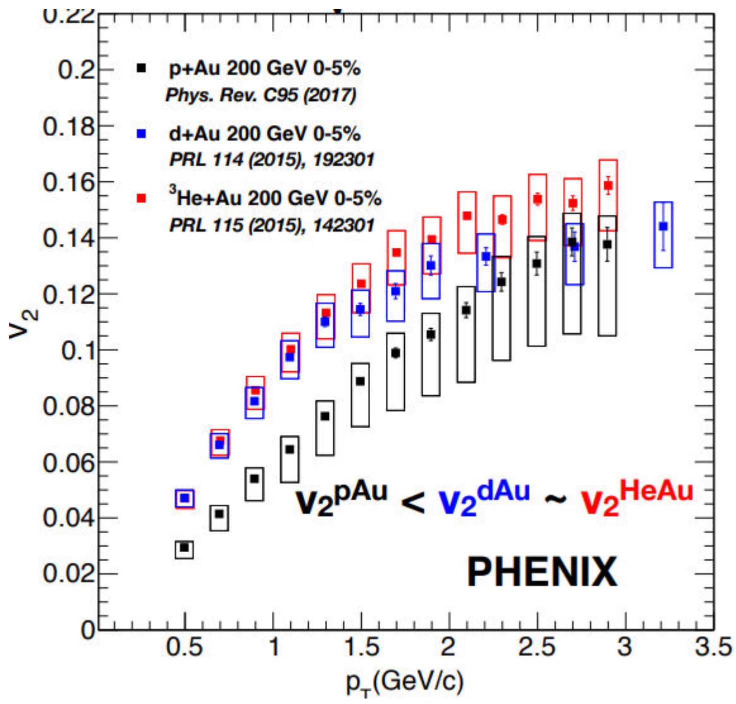
- Geometry engineering is a unique capability of the RHIC

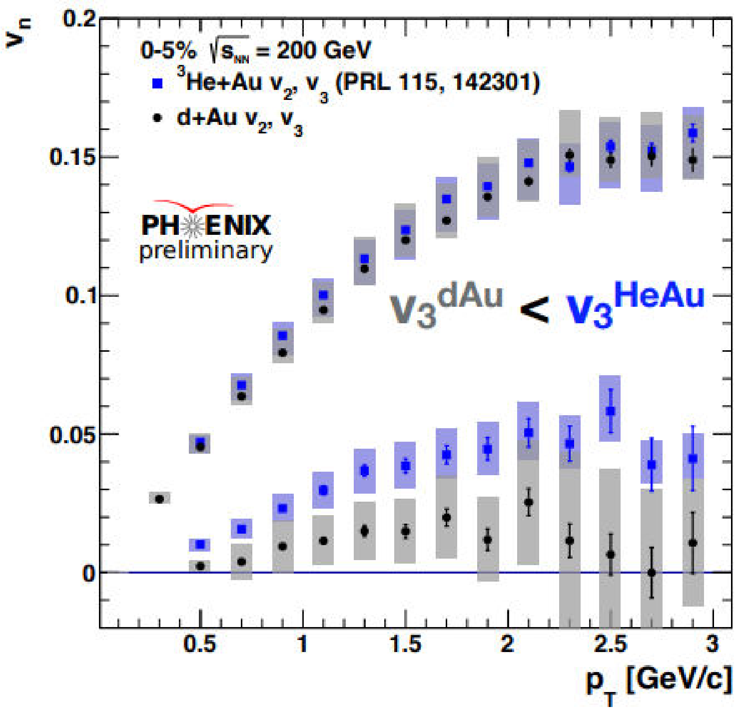


$\varepsilon_2^{pAu} < \varepsilon_2^{dAu} \sim \varepsilon_2^{HeAu}$

$\varepsilon_3^{dAu} < \varepsilon_3^{HeAu}$

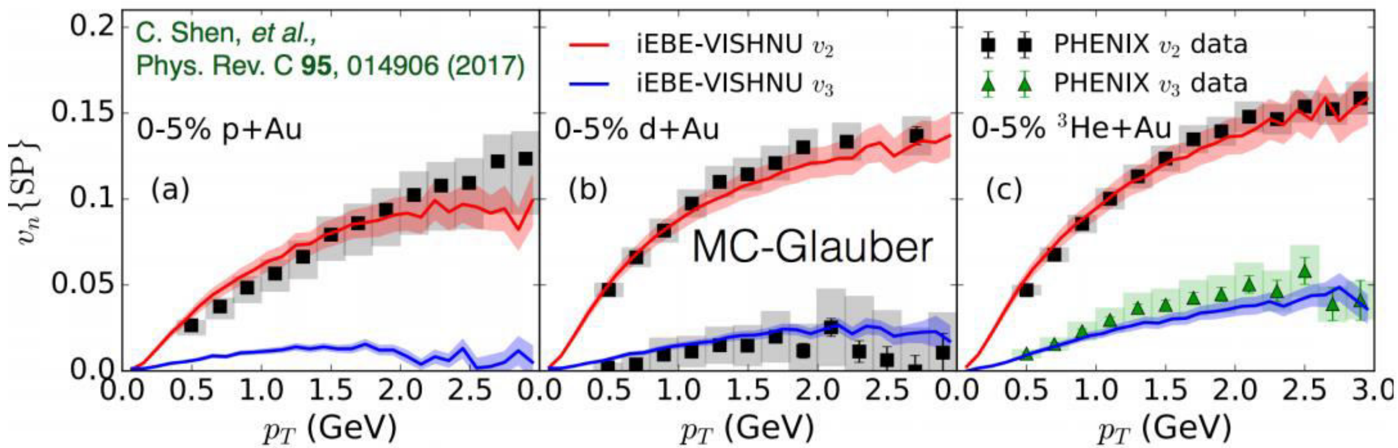
- v_2 & v_3 for charged hadrons in central p+Au, d+Au, 3He+Au at $\sqrt{s_{NN}}$ = 200 GeV

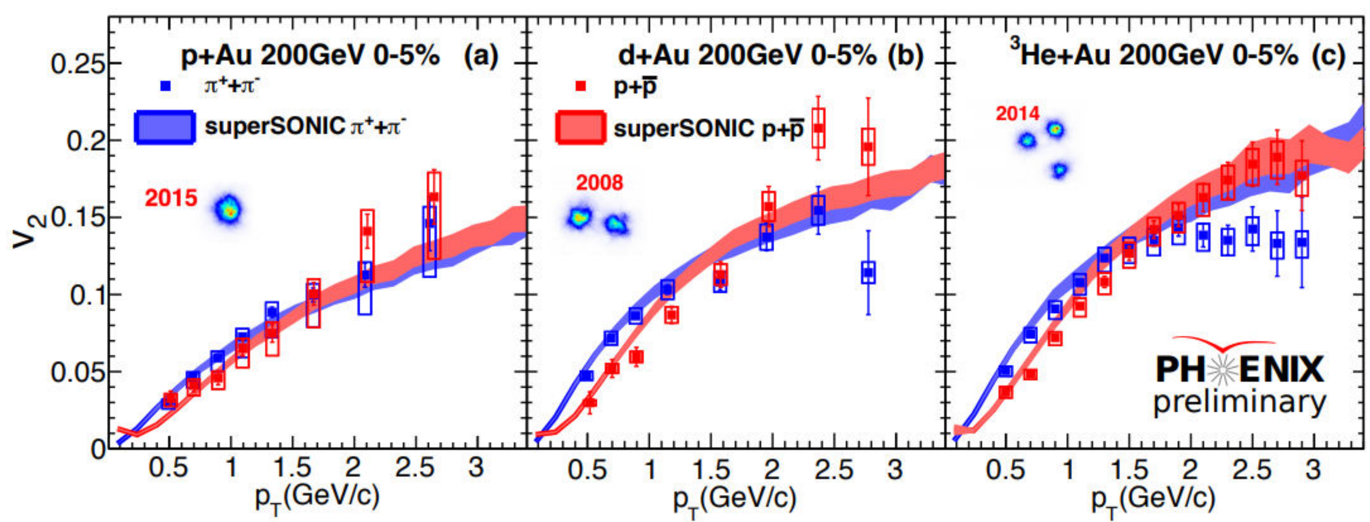




Geometry engineering - II

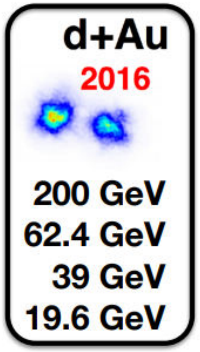
- v_2 & v_3 well described by hydrodynamics
- System dependence described by hydro
- Mass ordering for π/K/p in p/d/^{3}He+Au described by hydro
  → Final State Anisotropy = Initial Geometry + Final State Interactions

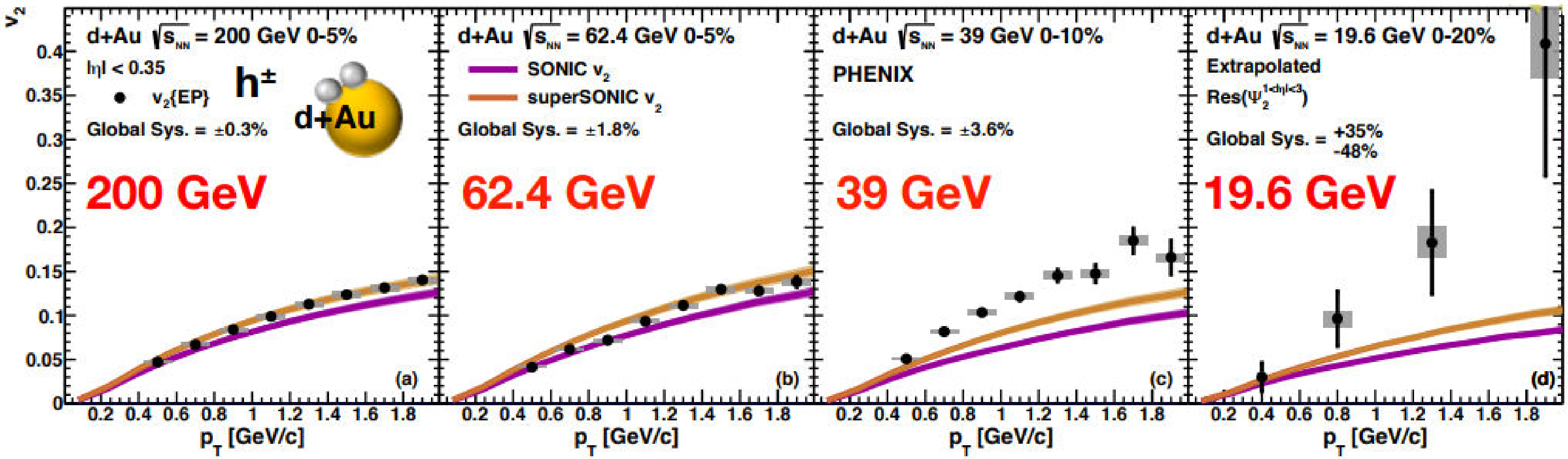




Energy scan - I

- How does the flow depend on collision energy?
- Significant v_2 signal at all 4 energies!
- Hydro in good agreement at 200 & 62.4 GeV
- Hydro under predicts data at 39 & 19.6 GeV --> Nonflow contributions?



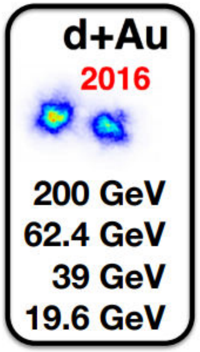


Energy scan - II

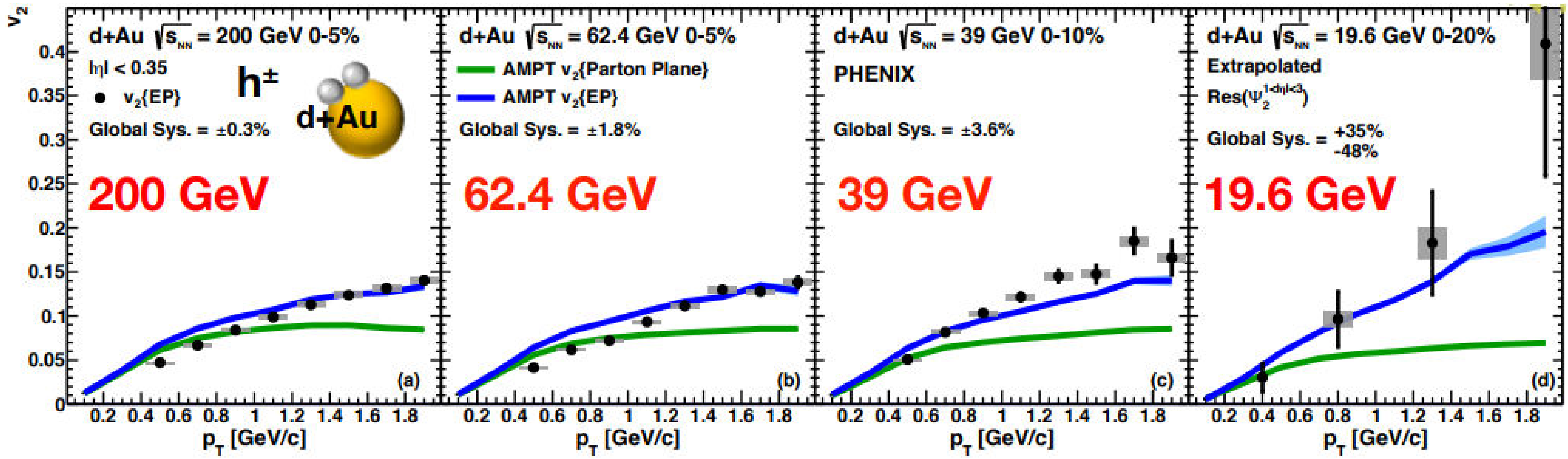
- Comparison to AMPT:
  - **AMPT v2{Parton Plane}: ← Flow**
  - **AMPT v2{EP}: ← Flow ⊗ Nonflow**
- Expectations:

  difference is small at low-p_T and grows at high-p_T

  difference grows with decreasing collision energy



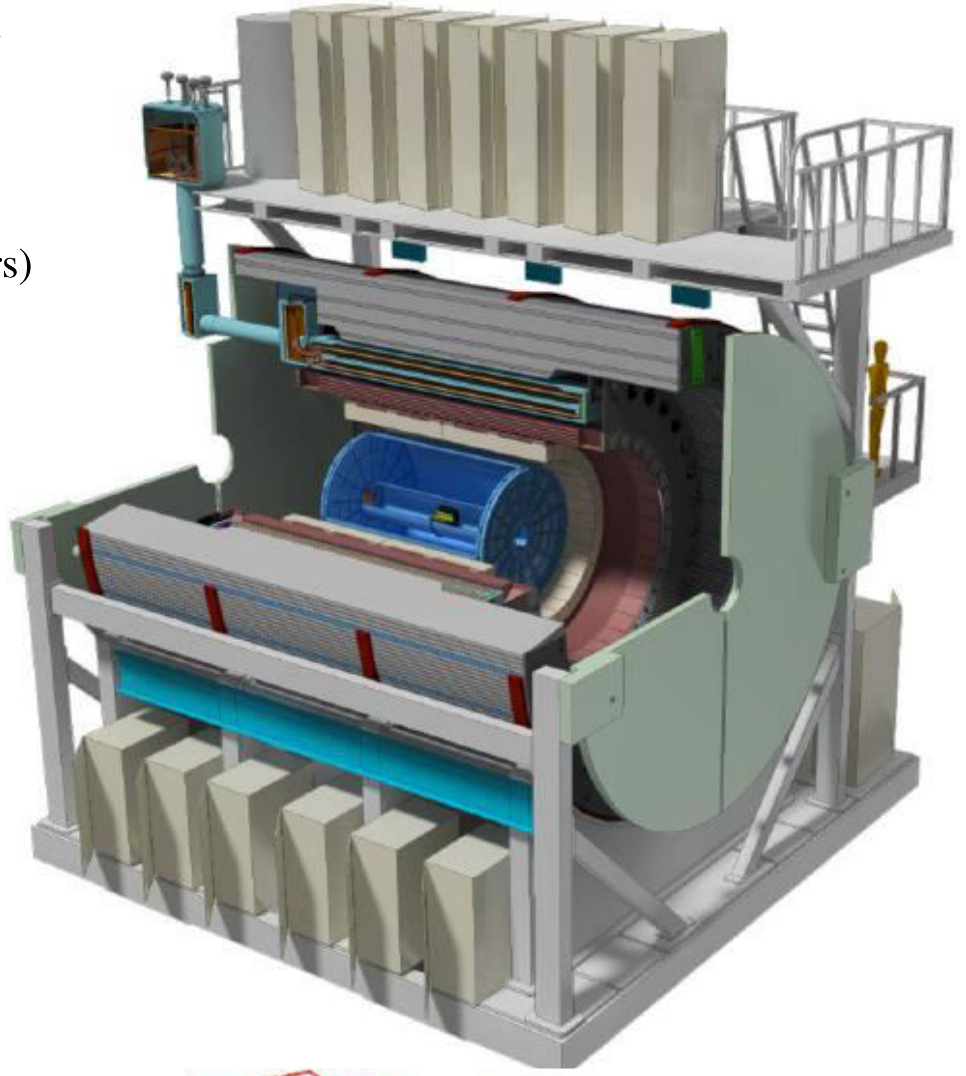
→ Strong v2 signal even at 19.6 GeV … interpretation is complicated by nonflow



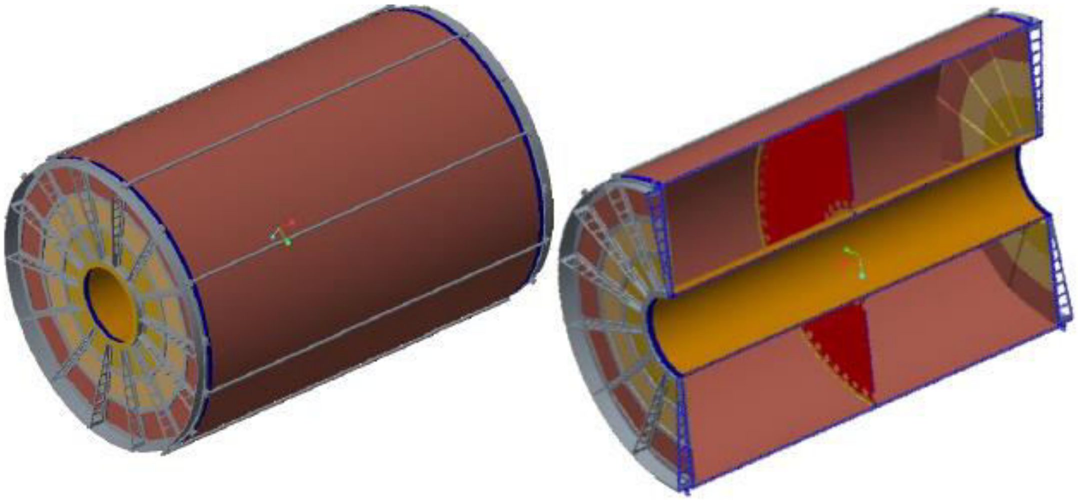
Будущее (s)PHENIX

Концепция sPHENIX

- Однородный аксептанс: $0 < \phi < 2\pi$; $|\eta| < 1.1$
- 1.5 Т сверхпроводящий соленоид (BaBar)
- Трекинг (0.2 - 40 ГэВ/c):
  - ✓ VTX: MAPS (Monolithic Active Pixel Sensors)
  - ✓ Промежуточный трекер: silicon strips
  - ✓ Внешний трекер: TPC
- Калориметрия:
  - ✓ EMCal: tungsten-scintillating fiber (W/ScFi)
  - ✓ Внутренний адронный калориметр
  - ✓ Внешний адронный калориметр; также используется как возвратное ярмо
- Возможность добавления мюонного плеча, fsPHENIX
- Коллаборация sPHENIX создана на основе коллаборации PHENIX, большой опыт и поддержка
- Первые данные ожидаются в 2022 году



Возможный вклад ПИЯФ



❖ Трековые станции разбиты на три сектора по радиусу и 12 секторов по азимутальному углу

❖ Активно ведутся работы по оптимизации конструкции детектора, GEM структуры и геометрии падов

❖ ПИЯФ официально числится участником проекта, предполагается участие в производстве и наладке трековых станций

Заключение

- Эксперимент ФЕНИКС прекратил свое существование
- Дальнейшее участие в обработке данных → защиты, статьи, конференции ...
- Участие в обновление установки до sPHENIX

С Новым годом!

Январь

пн	вт	ср	чт	пт	сб	вс
1	2	3	4	5	6	7
8	9	10	11	12	13	14
15	16	17	18	19	20	21
22	23	24	25	26	27	28
29	30	31				

Февраль

пн	вт	ср	чт	пт	сб	вс
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26	27	28				

Март

пн	вт	ср	чт	пт	сб	вс
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19	20	21	22	23	24	25
26	27	28	29	30	31	

Апрель

пн	вт	ср	чт	пт	сб	вс
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30						

Май

пн	вт	ср	чт	пт	сб	вс
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28	29	30	31			

Июнь

пн	вт	ср	чт	пт	сб	вс
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25	26	27	28	29	30	

Июль

пн	вт	ср	чт	пт	сб	вс
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23	24	25	26	27	28	29
30	31					

Август

пн	вт	ср	чт	пт	сб	вс
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20	21	22	23	24	25	26
27	28	29	30	31		

Сентябрь

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Октябрь

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29	30	31				

Ноябрь

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19	20	21	22	23	24	25
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Декабрь

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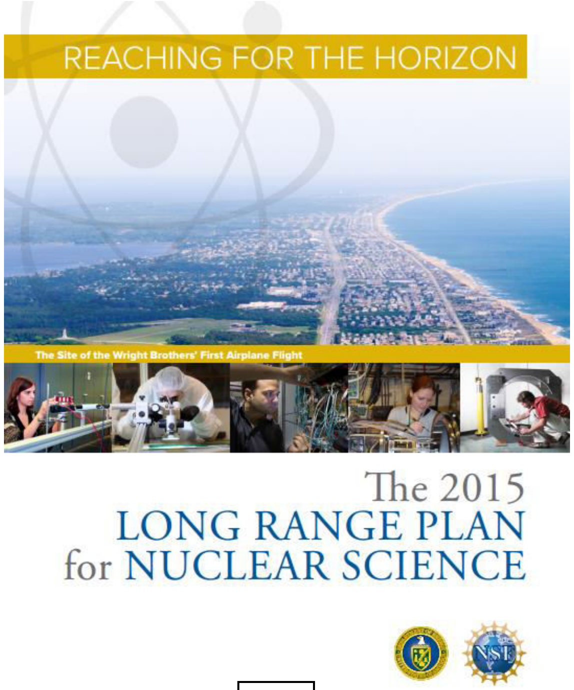
10	11	12	13	14	15	16
17	18	19	20	21	22	23
24	25	26	27	28	29	30
31						

BACKUP

Новые физические задачи

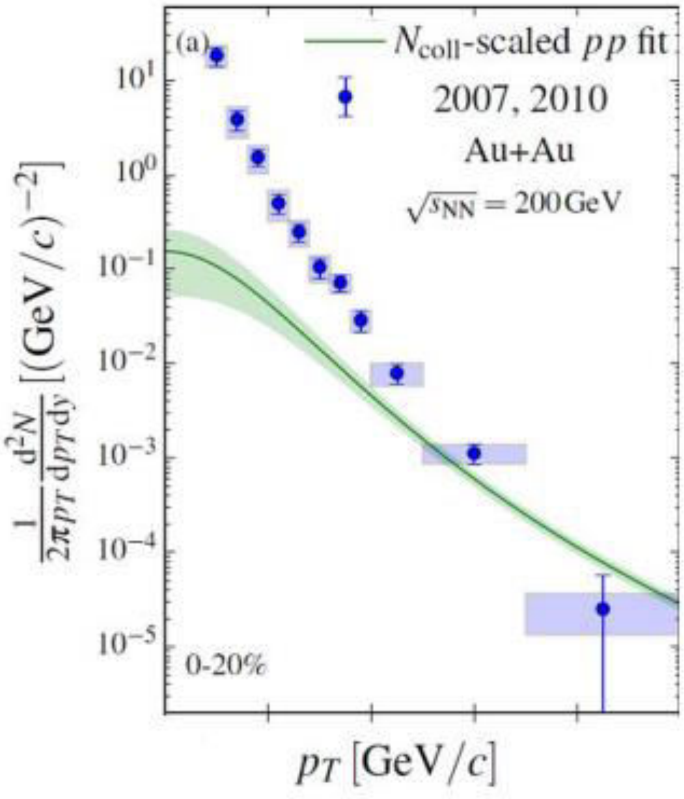
- ❖ Исследование микроскопической структуры КГП
- ❖ Изучение струй:
  - ✓ подавление струй и лидирующих адронов
  - ✓ HF-tagged струи
  - ✓ измерение выхода γ_{diret} и γ_{direct}-jet корреляций
  - ✓ функции фрагментации при $z_T \sim 1$
- ❖ Тяжелые ароматы:
  - ✓ выход c и b при $p_T >> 1$
  - ✓ Подавления боттомония
- ❖ Измерения необходимы в p+p, p+Au и Au+Au столкновениях @ 200 ГэВ

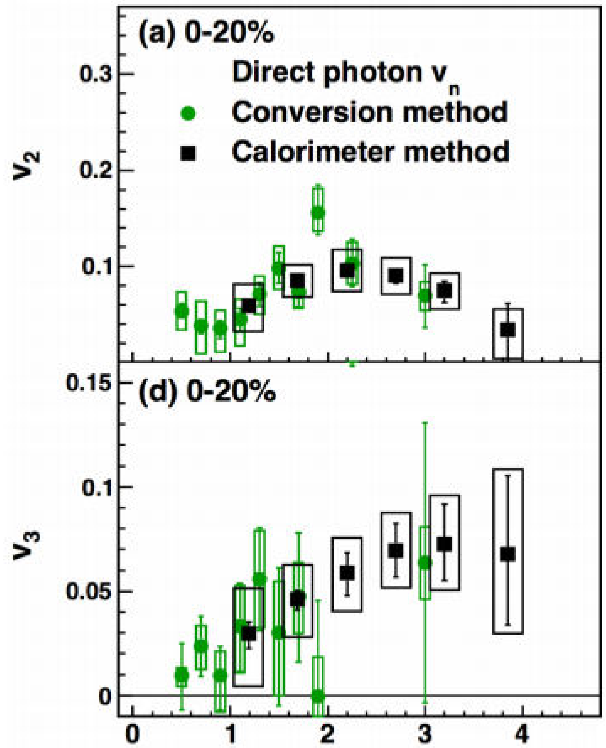


There are two central goals of measurements planned at RHIC, as it completes its scientific mission, and at the LHC: **(1) Probe the inner workings of QGP by resolving its properties at shorter and shorter length scales. The complementarity of the two facilities is essential to this goal, as is a state-of-the-art jet detector at RHIC, called sPHENIX. (2) Map the phase diagram of QCD with experiments planned at RHIC.**

Soft direct photons, Au+Au at $\sqrt{s_{NN}} = 200$ GeV

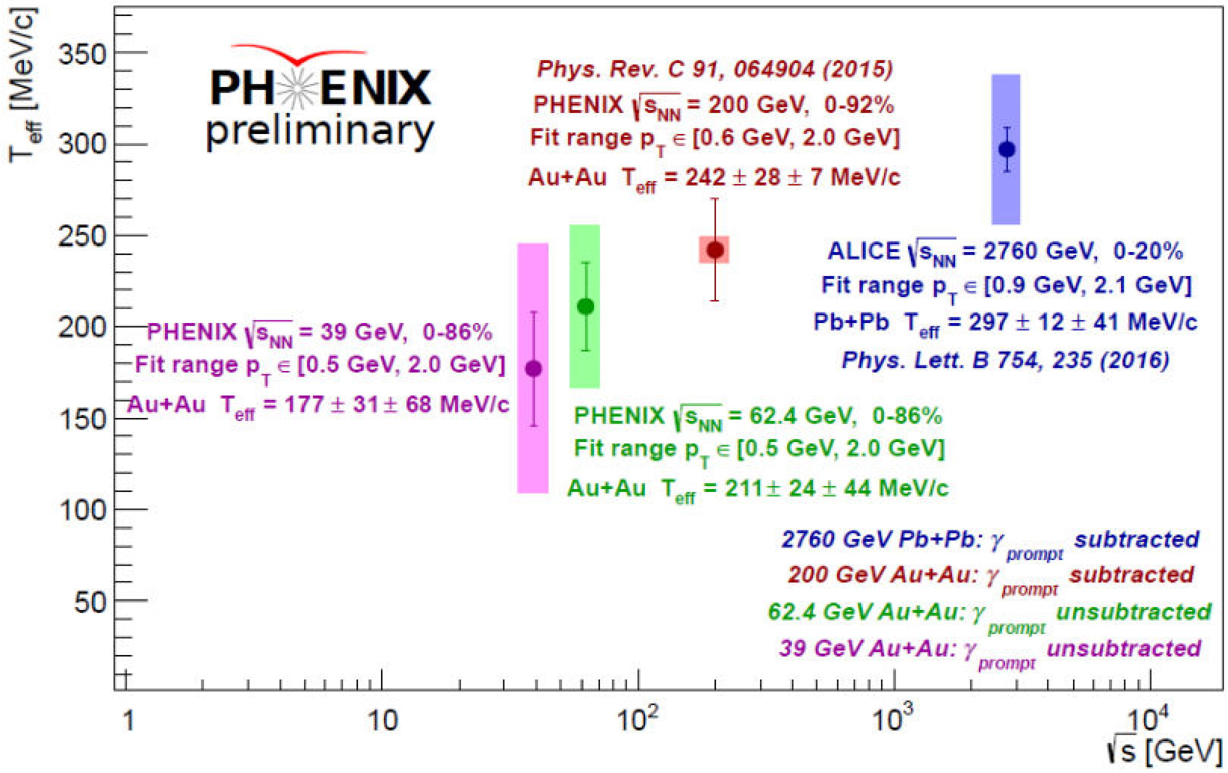
- Observed large yield of soft direct photons in central collisions → QGP radiation
- $T_{eff} \sim 240$ MeV >> T_c
- Results for yields and v_2 & v_3 can not be explained within the same models





Soft direct photons, Au+Au energy scan

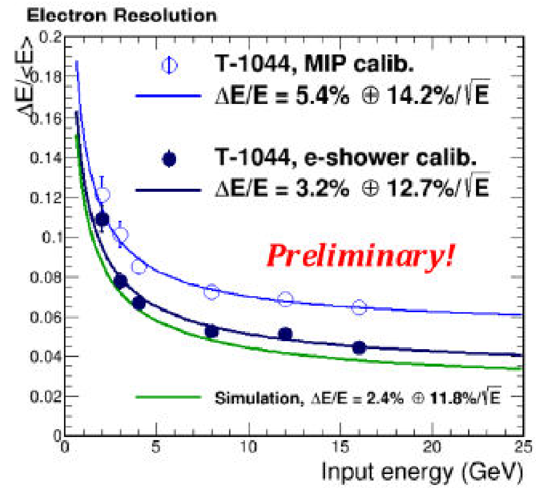
❖ T_{eff} in collision energy range 39-2760 GeV

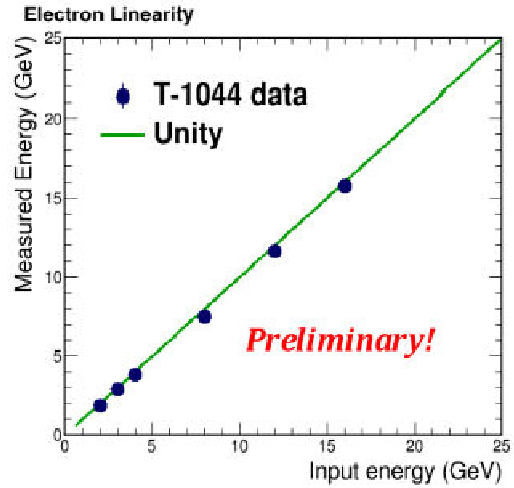


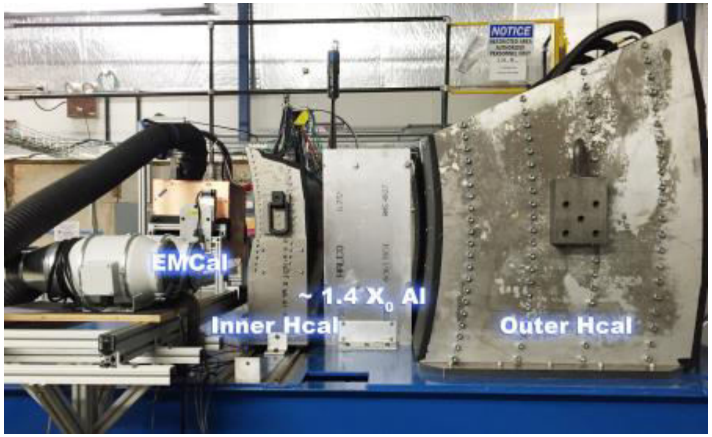
Projected Future sPHENIX Schedule

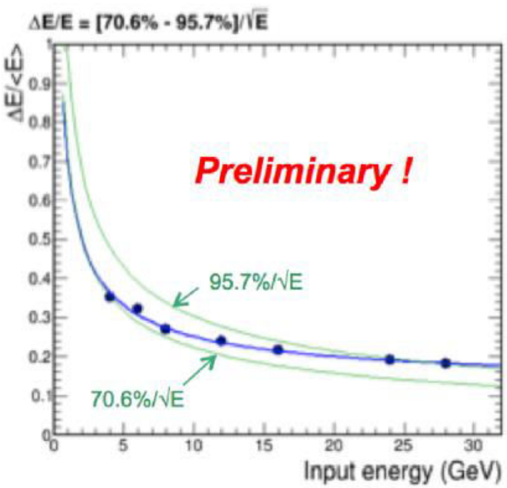
CD-0	Fall 2016
Director's Cost and Schedule Review	Nov-Dec 2016
Test Beam at FNAL(2nd round prototyping)	Jan 2017
OPA-CD-1/CD-3a Review	May-Jun 2017
CD-1/CD-3a authorization	Nov-Dec 2017
All Preproduction R&D and Design complete	May-Jun 2018
OPA- CD-2/CD-3b review	May-Jun 2018
CD-2/CD-3b authorization	Jul-Aug 2018
sPHENIX Installed, cabled, ready to commission	Apr 2021
First RHIC beam for sPHENIX	Jan 2022

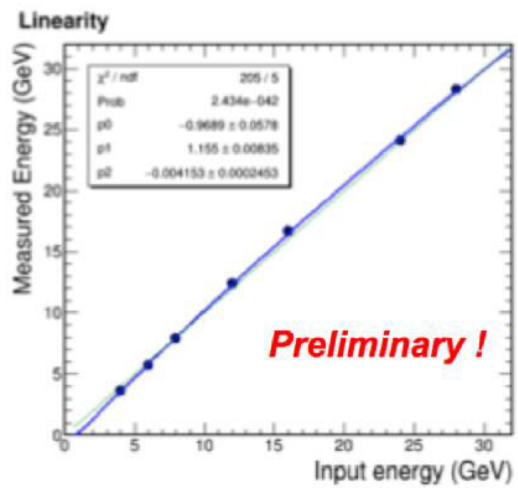
Тестирование EMCal и HCal пучках









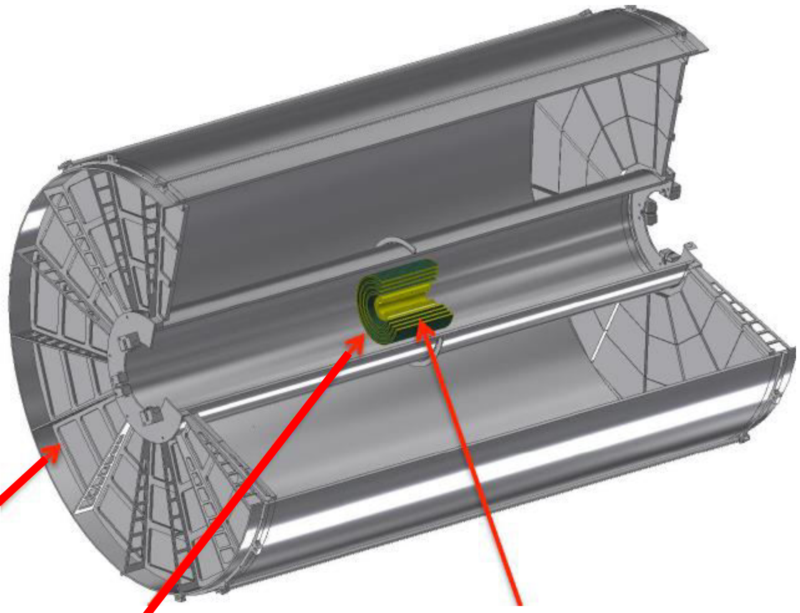


- 8x8 башни EMCa
- 4x4 башни HCal
- 4 недели пучкового времени, FNAL Test Beam Facility

- Достигнуты и превышены проектные значения по разрешению и линейности
- Измерения в основном подтвердили результаты Монте-Карло моделирования

Центральный трекер

- Восстановление треков: $\Delta\phi < 2\pi$, $|\eta| < 1.1$, $0.2 < p_T$ (ГэВ/с) < 40
- DAQ ~15 кГц
- Υ разрешение по массе ~ 1%
- Прозрачность
- $DCA_{xy} < 70$ мкм

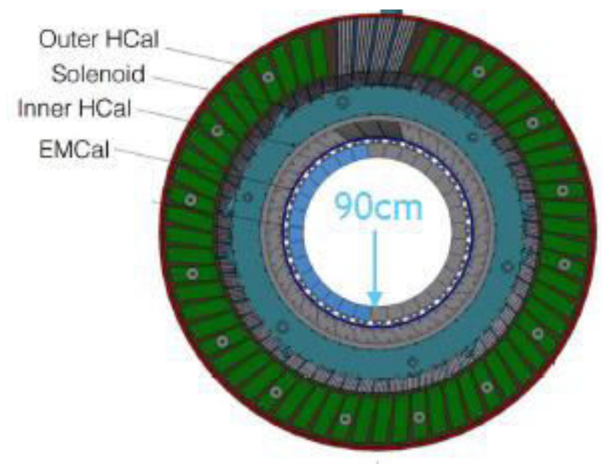


TPC:
- непрерывное считывание
- R = 20-78 см
- BNL & SUNY funding for development

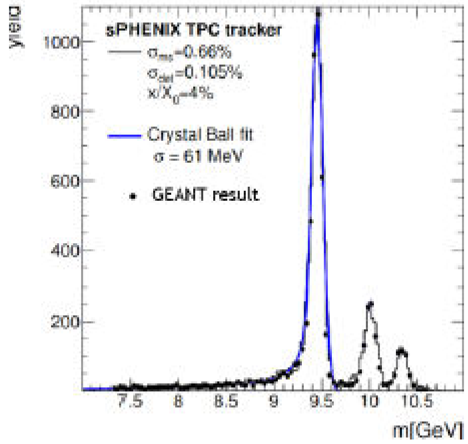
VTX:
-MAPS (ALICE ITS IB: ALPIDE sensors, 28x28 um pitch, 99.9% efficiency, 2-4 usec integration time)
- 3 слоя: 2.3, 3.1, 3.9 см
- LANL funding for development
- funded by consortium

Промежуточный трекер:
- silicon strips: FPHX Chip
  (108 identical ladders each 2x24 cm^2,)
- 4 слоя: 6, 8, 10, 12 см
- In kind contribution from RIKEN

Концепция TPC



- ❖ Механические требования:
  - ✓ EMCal, R_{min} = 90 см
  - ✓ $|\eta| < 1.1$;
  - ✓ Length ~ Diameter
- ❖ Физические требования:
  - ✓ 1% разрешение по массе → $\sigma_{r\phi} < 250$ мкм
- ❖ Набор данных:
  - ✓ максимальные светимости RHIC-II
  - ✓ 50-100 кГц, 15 кГц при $|z_{vrtx}| < 10$ см

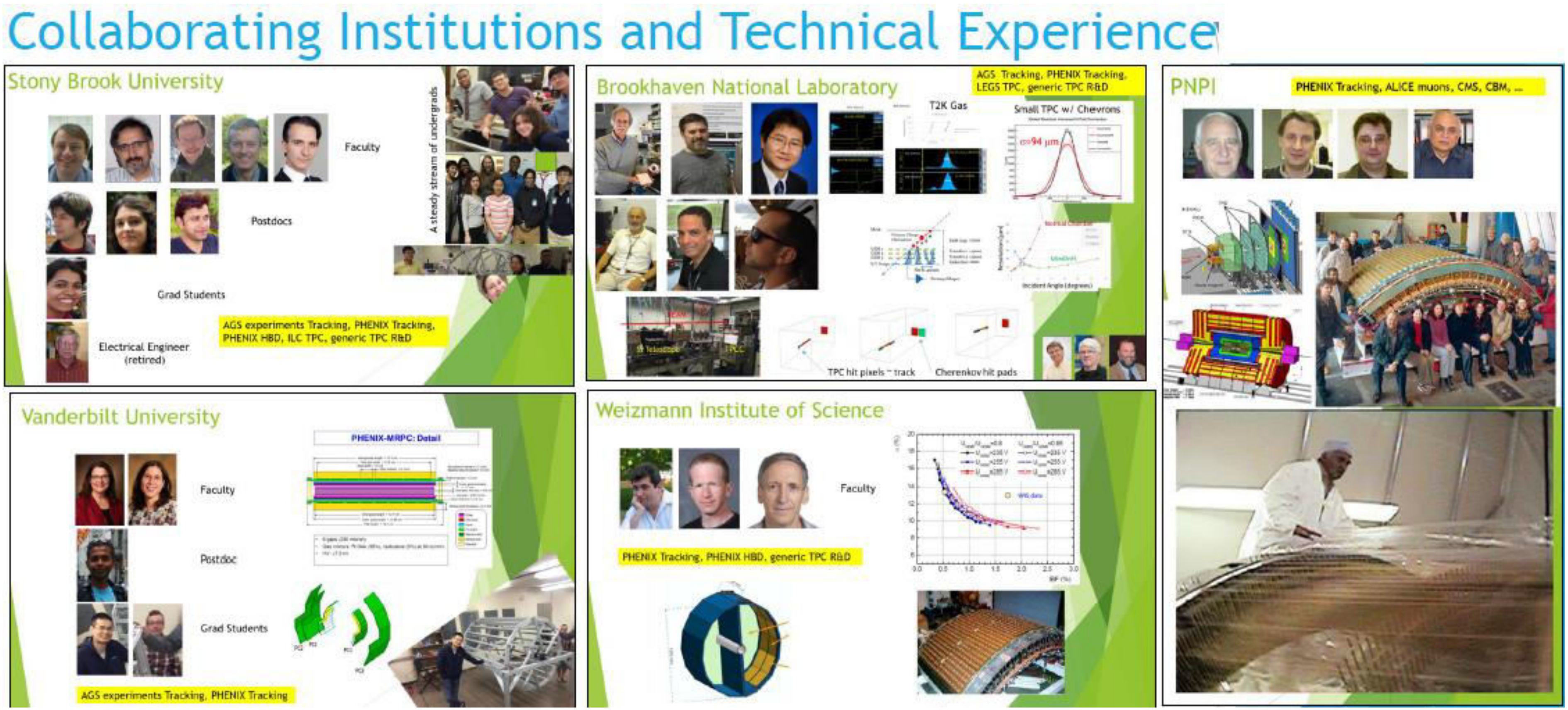


→ *Gateless TPC*

→ *Координатные детекторы с минимальным IBF (MPGD), быстрые смеси (Ne, He)*

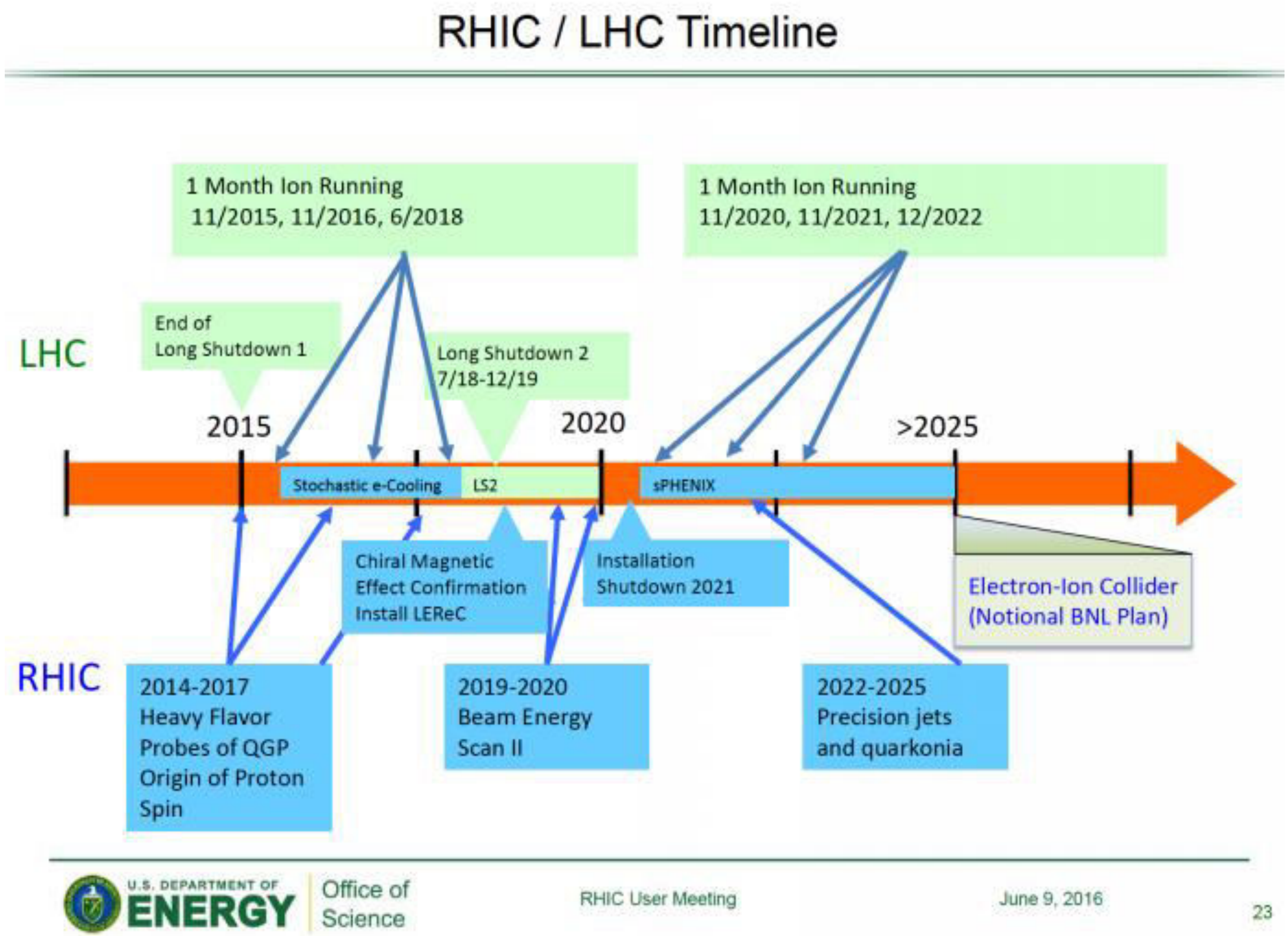
→ *Непрерывное считывание (границы событий определяются офлайн)*

Коллаборация TPC



"...we anticipate that the features and experience gained with this device might provide the basis for a "day-1" detector at a future EIC, independent of where the new facility will be sited. It is envisioned that this new collaboration will consider the possible evolution toward such a detector as part of its mission."

--Berndt Mueller

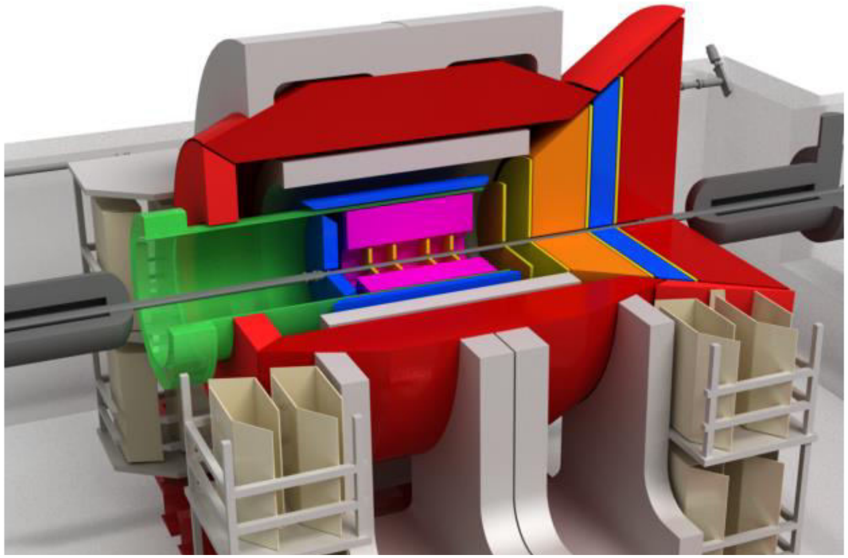


Фундаментальные задачи eIC

The EIC is designed to address several important question that are described in detail in the recent EIC White Paper [3]. Quoting from the White Paper, these questions are reproduced here:

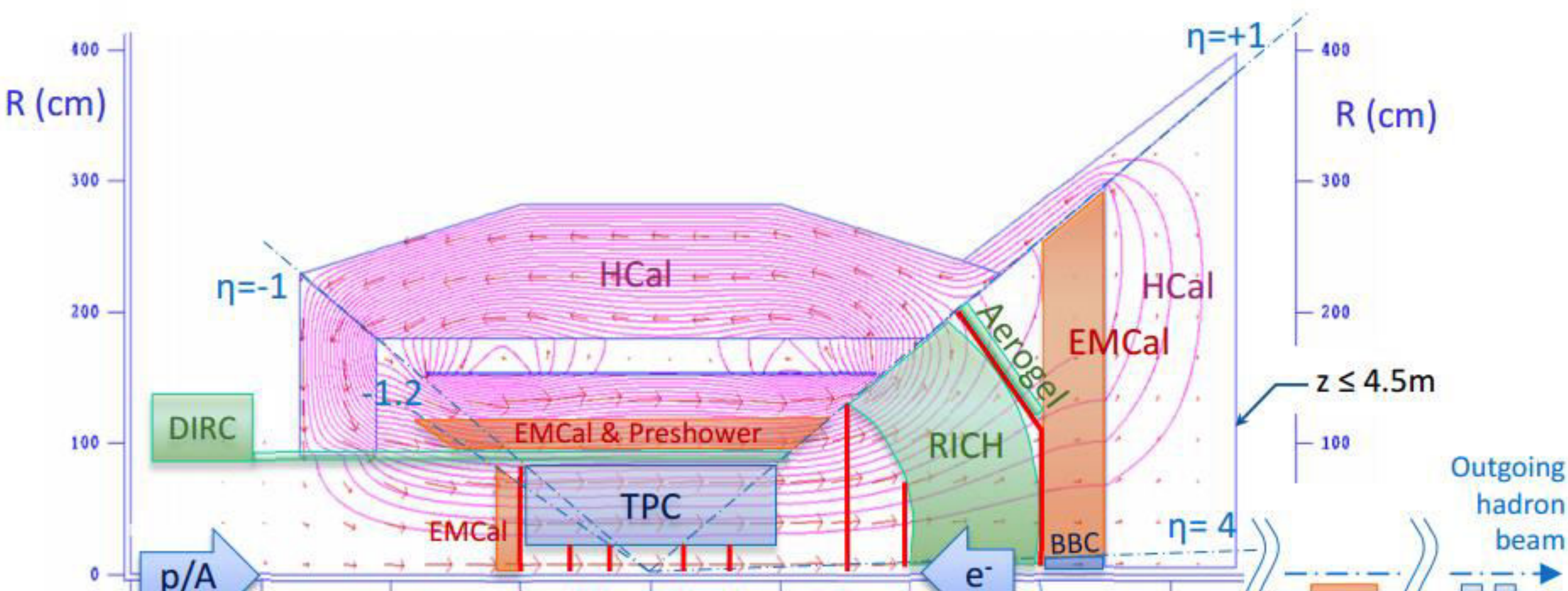
- **How are the sea quarks and gluons, and their spins, distributed in space and momentum inside the nucleon?** How are these quark and gluon distributions correlated with overall nucleon properties, such as spin direction? What is the role of the orbital motion of sea quarks and gluons in building the nucleon spin?
- **Where does the saturation of gluon densities set in?** Is there a simple boundary that separates this region from that of more dilute quark-gluon matter? If so, how do the distributions of quarks and gluons change as one crosses the boundary? Does this saturation produce matter of universal properties in the nucleon and all nuclei viewed at nearly the speed of light?
- **How does the nuclear environment affect the distribution of quarks and gluons and their interactions in nuclei?** How does the transverse spatial distribution of gluons compare to that in the nucleon? How does nuclear matter respond to a fast moving color charge passing through it? What drives the time scale for color neutralization and eventual hadronization?

Концепция ePHENIX

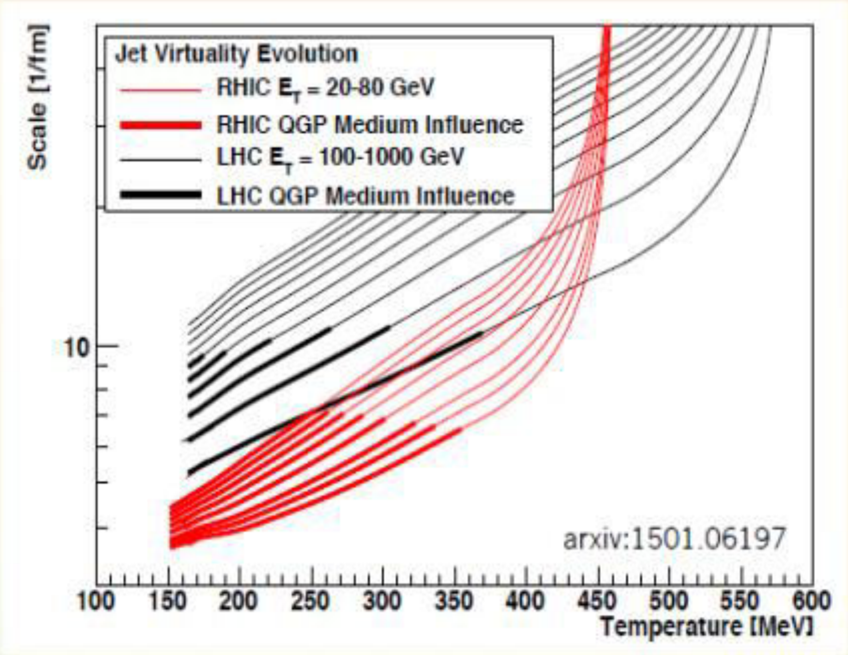


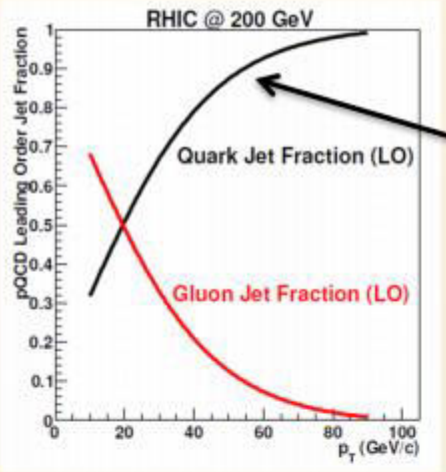
❖ ePHENIX детектор построен на основе sPHENIX с добавлением форвардного плеча

❖Участие в sPHENIX может стать мостом к участию в дальнейших обновлениях укорителя и экспериментальной базы

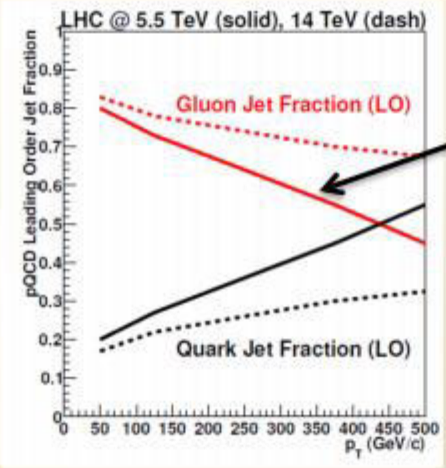


Using Jets to Probe the QGP





Higher quark-jet fraction at RHIC

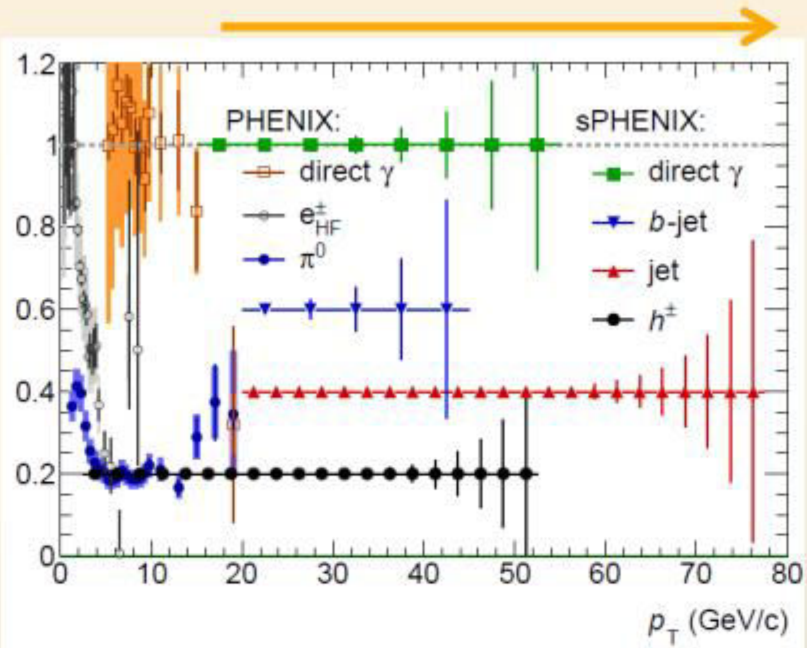


Gluon-jets dominate at LHC

Lower energy jets at RHIC have increased sensitivity to QGP interactions

Kinematic Reach

Extends range at RHIC



Overlaps with LHC