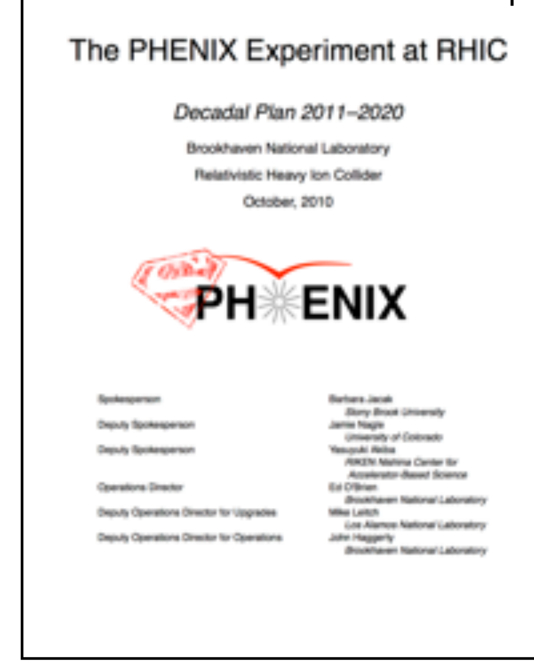
e/sPHENIX update

Dave Morrison

timeline of the story so far ...

- charge from ALD Steve Vigdor to PHENIX and STAR for decadal plans, December 2009
- presentation to PAC of progress on decadal plan, June 2010
- decadal plan submitted to ALD Steve Vigor, September 2010
- presentation to PAC of decadal plan, June 2011
- met with DOE/ONP to describe sPHENIX concept, May 2012
- presentation to PAC of sPHENIX plans, June 2012
- initial MIE submitted to ALD Steve Vigdor, June 2012
- BNL administered review, October 2012
- updated MIE submitted to ALD Berndt Mueller, March 2013
- MIE sent to DOE/ONP by BNL, April 2013

PHENIX decadal plan


The PHENIX Experiment at RHIC

Decadal Plan 2011–2020

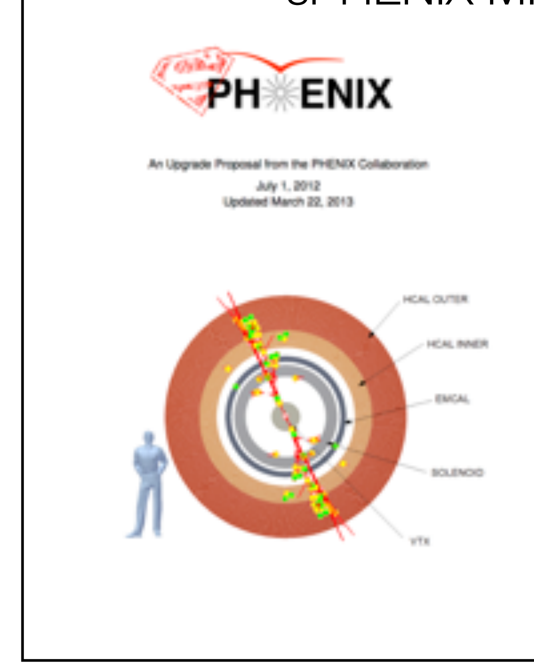
Brookhaven National Laboratory

Relativistic Heavy Ion Collider

October, 2010

PHENIX

sPHENIX MIE


PHENIX

An Upgrade Proposal from the PHENIX Collaboration

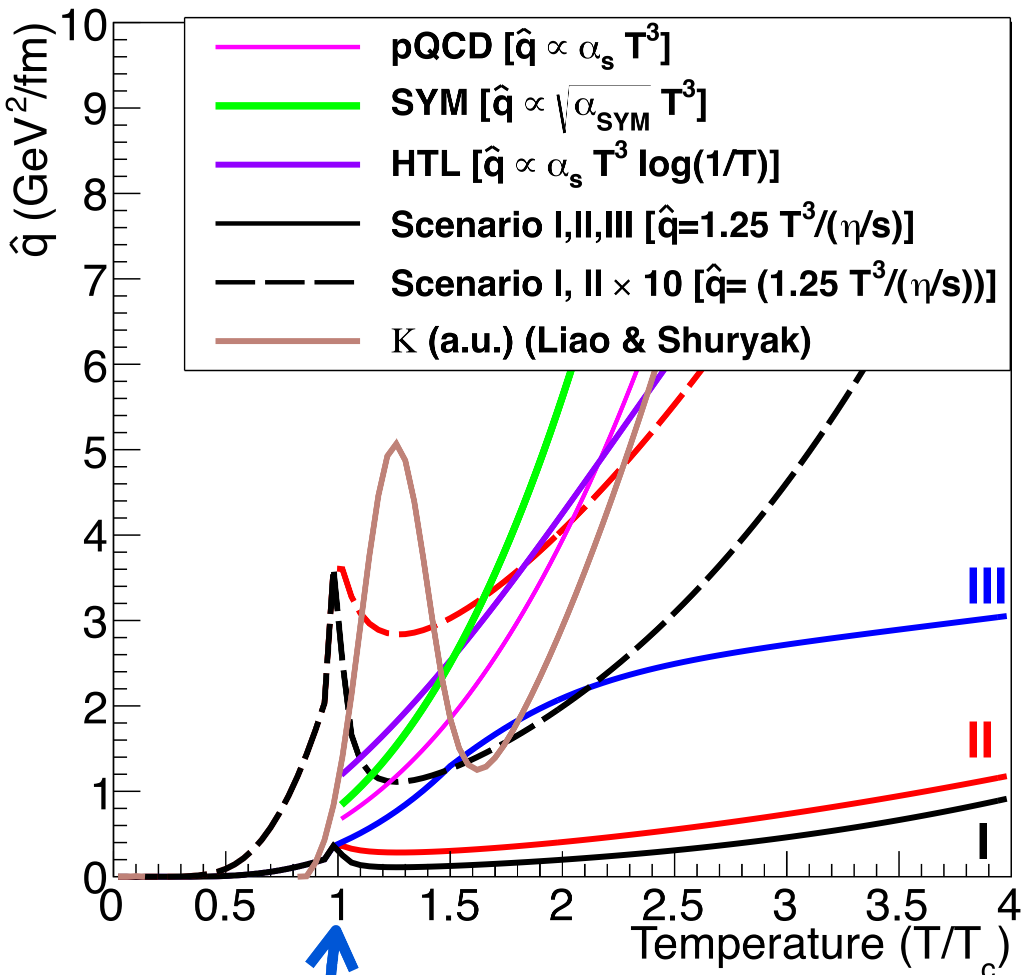
July 1, 2012

Updated March 22, 2013

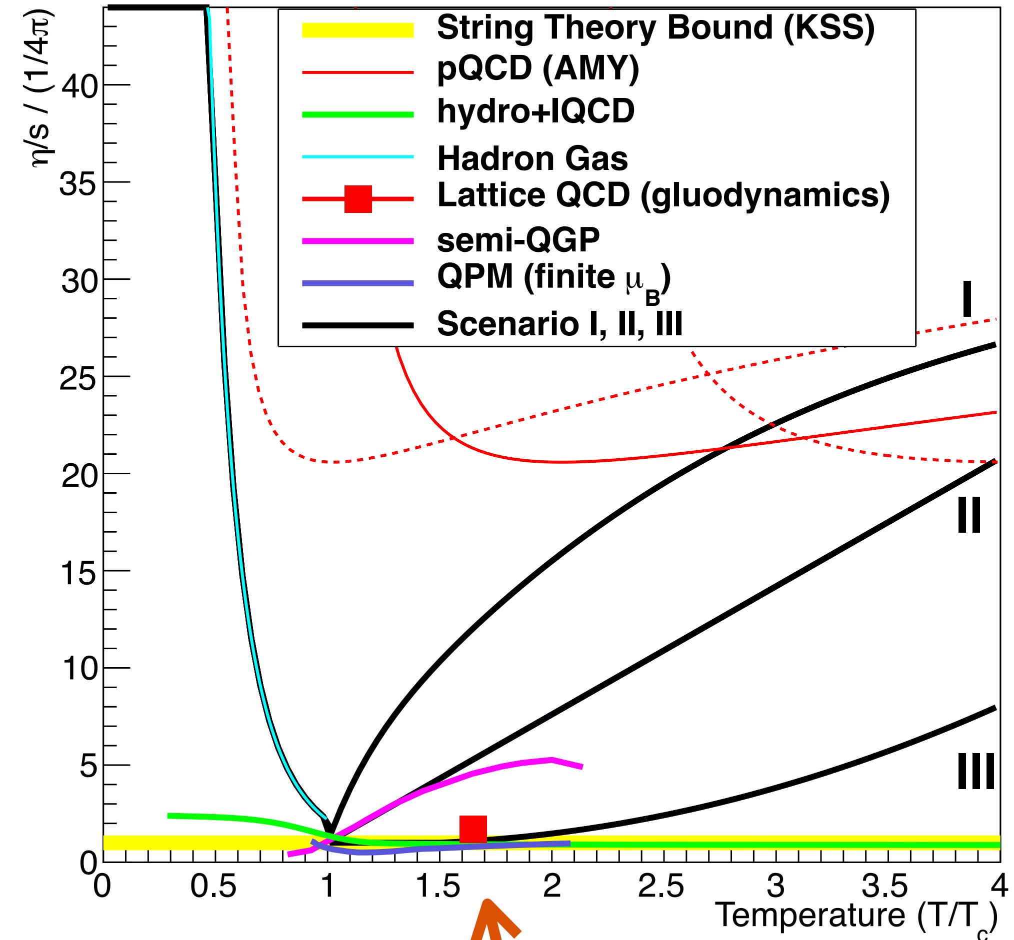
What *is* the nature of the strongly coupled QGP?

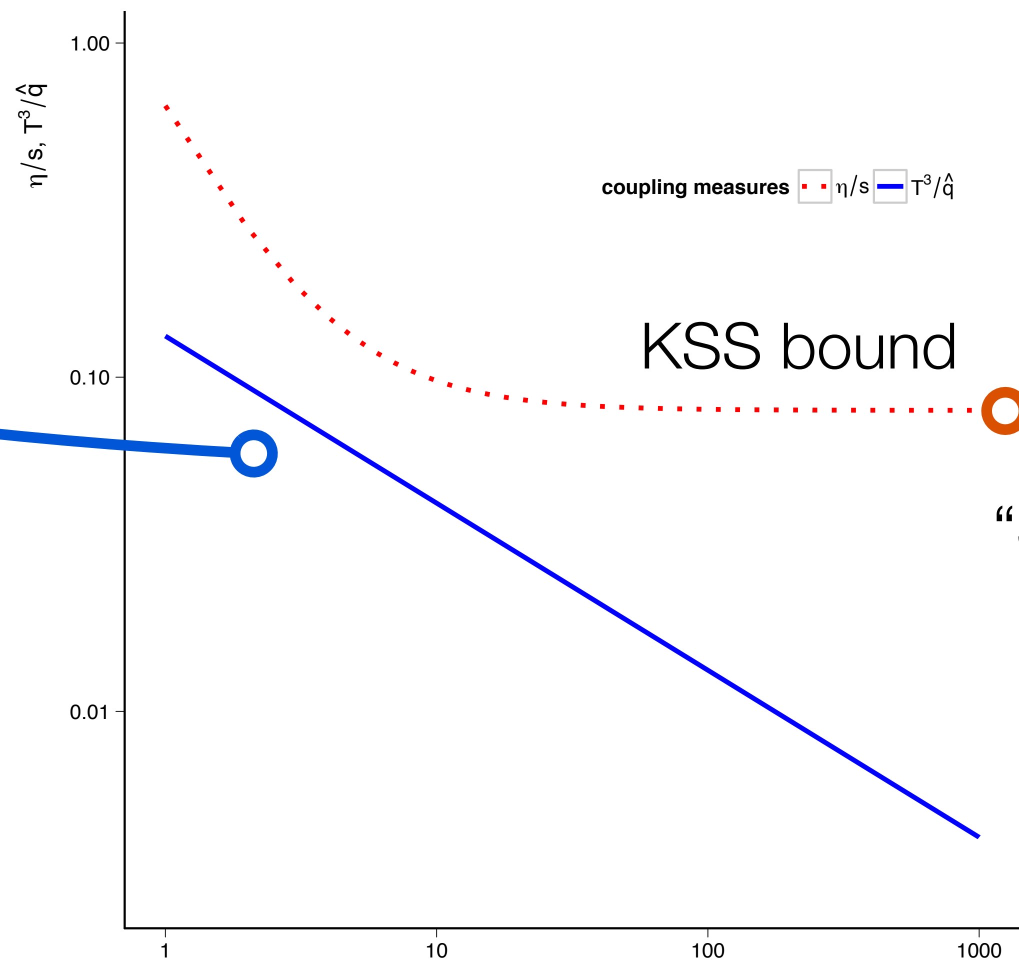
- What are the inner workings of the sQGP?
- Are the key degrees of freedom quasi-particles? excitations? other?
- How do these degrees of freedom depend on the scale of the probe?
- How does the sQGP itself evolve along with the parton shower?
- What are the dynamical and other underlying changes to the medium as one crosses the RHIC to LHC temperature expanse?

Use jets as a tool to investigate the constituents and dynamics of the sQGP in the region of strongest coupling through its transport coefficients



$$\hat{q} \stackrel{?}{=} \frac{1.25T^3}{\eta/s}$$





$\hat{q}$ retains sensitivity even when coupling is strong

KSS bound

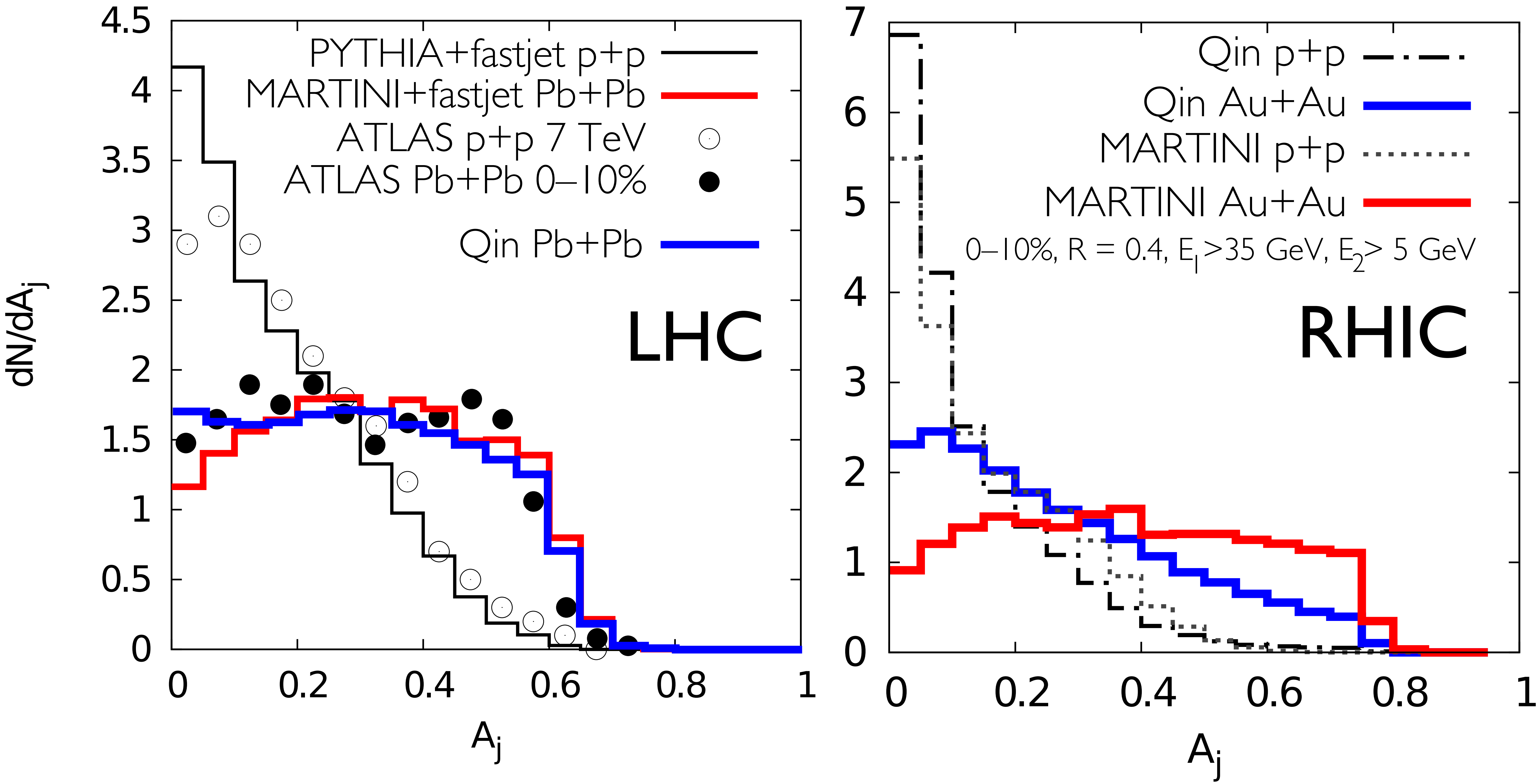
η/s saturates when coupling is strong

"[We find] the jet quenching is a few times stronger near T$_C$ relative to the QGP at T > T$_C$."
Liao, Shuryak, PRL (2009)

"Small shear viscosity implies strong jet quenching"
Majumder, Mueller, Wang, PRL (2007)

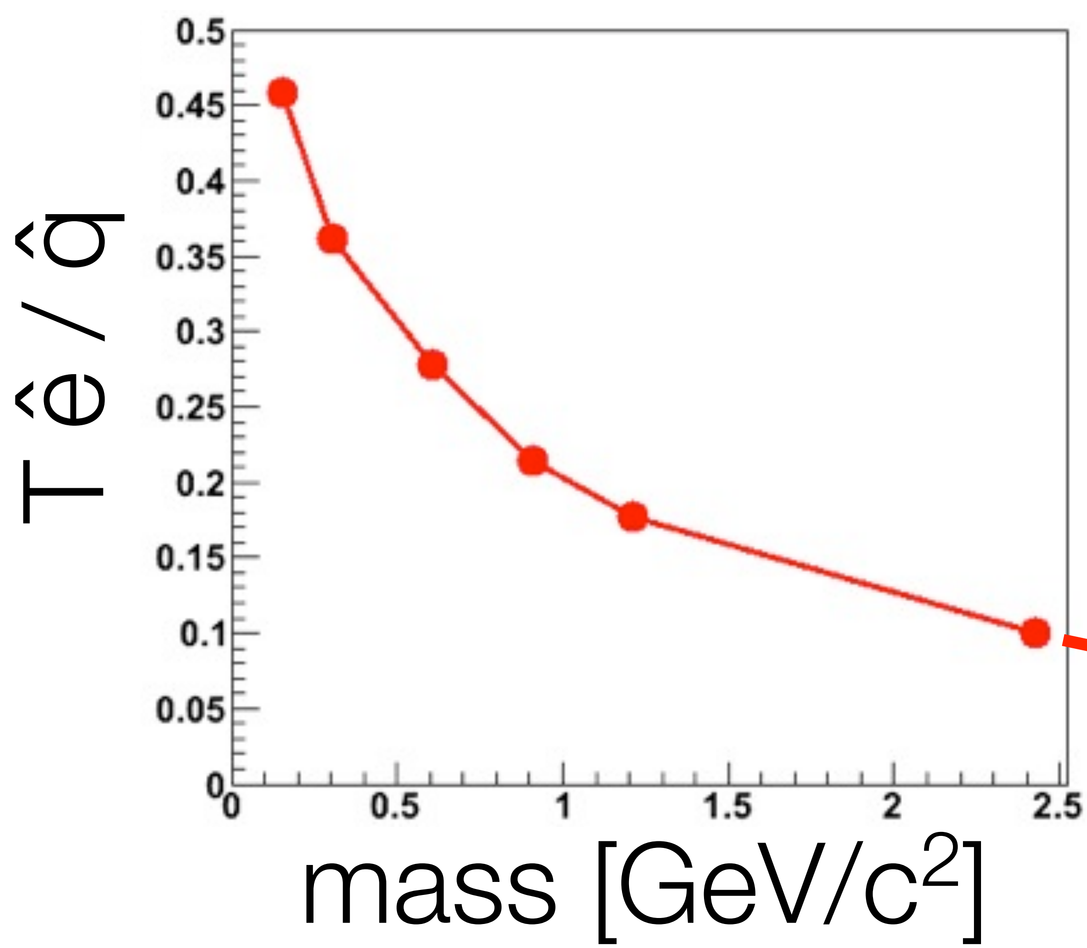
't Hooft coupling

same at the LHC, different at RHIC



C. Young, B. Schenke; G-Y Qin, Berndt Mueller

what are the jet partons scattering from?



Limit of infinitely massive scattering centers yields all radiative e-loss.

http://arxiv.org/abs/arXiv:1209.3328

collaboration focus on e/sPHENIX

- John Haggerty (BNL) is sPHENIX project leader
- productive series of workfests

May 21–25, Santa Fe

September 2011 - Brookhaven workfest

December 2011 – Boulder workfest

January 2012 - Tennessee workfest

February 2012 - Columbia workfest

March 2012 - Florida State collab. meeting

April 2012 - Boulder workfest

May 2012 - Brookhaven/Boulder writing

November 2012 - Boulder workfest

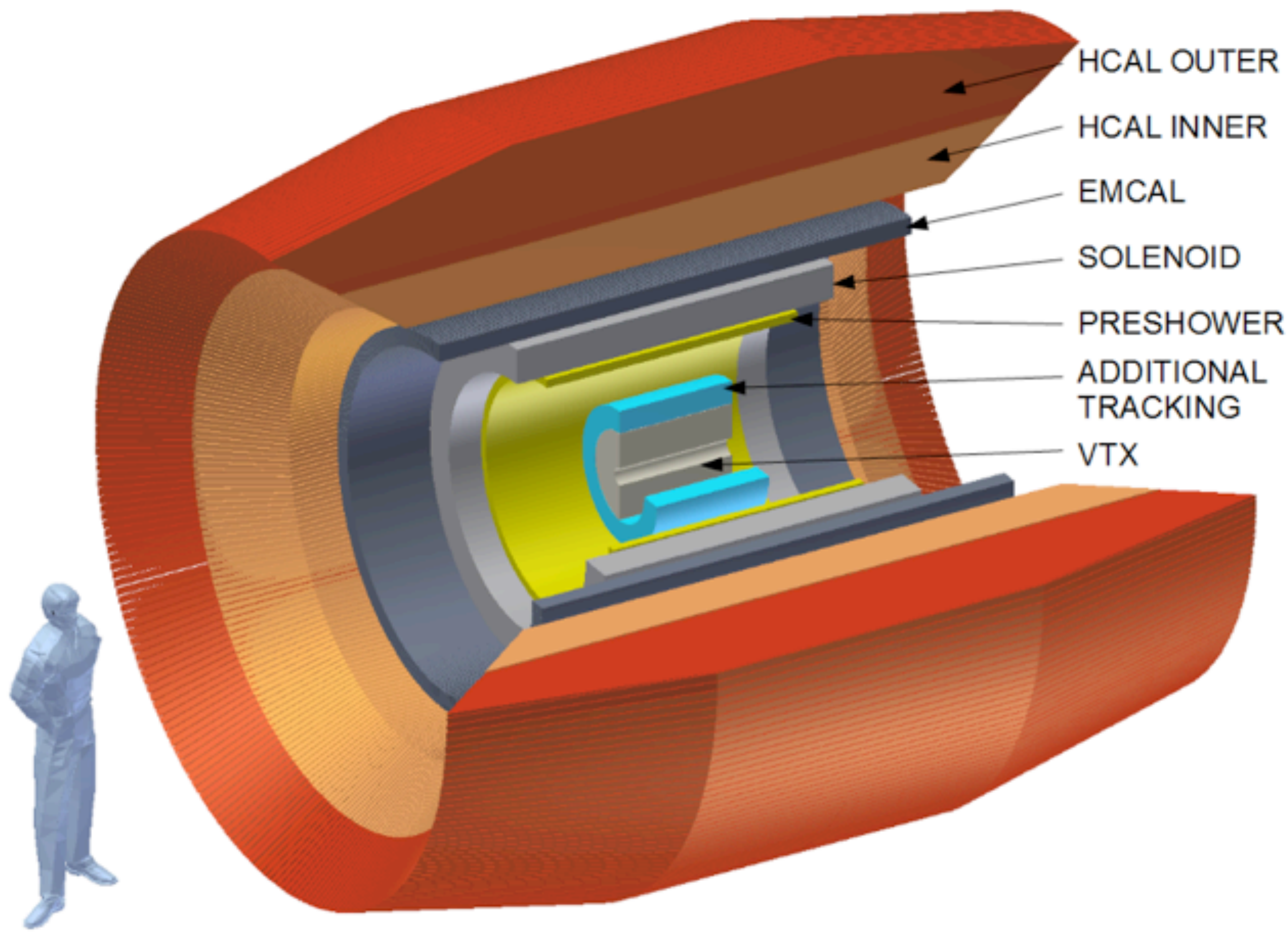
January 2013- Brookhaven workfest

February 2013 - BNL Calorimeter workfest

May 2013 - Santa Fe workfest

July 2013 - ePHENIX workfest: Japan/RIKEN

sPHENIX detector concept



BNL review of sPHENIX MIE, October 5–6, 2012

- committee members: John Harris, Mike Harrison, Miklos Gyulassy, Jimmy Proudfoot, Raju Venugopalan, Bolek Wyslouch, Xin-Nian Wang
- about the physics: “The Committee therefore strongly endorses the science case for this program.”
- several recommendations to strengthen proposal. E.g.,
  - move discussion of non-DOE funded additional tracking and EMCal pre-shower from appendix to main body of MIE to underscore how they broaden the physics case
  - further GEANT studies
  - increase contingency on solenoid to reflect current-day challenges in procuring superconducting magnets

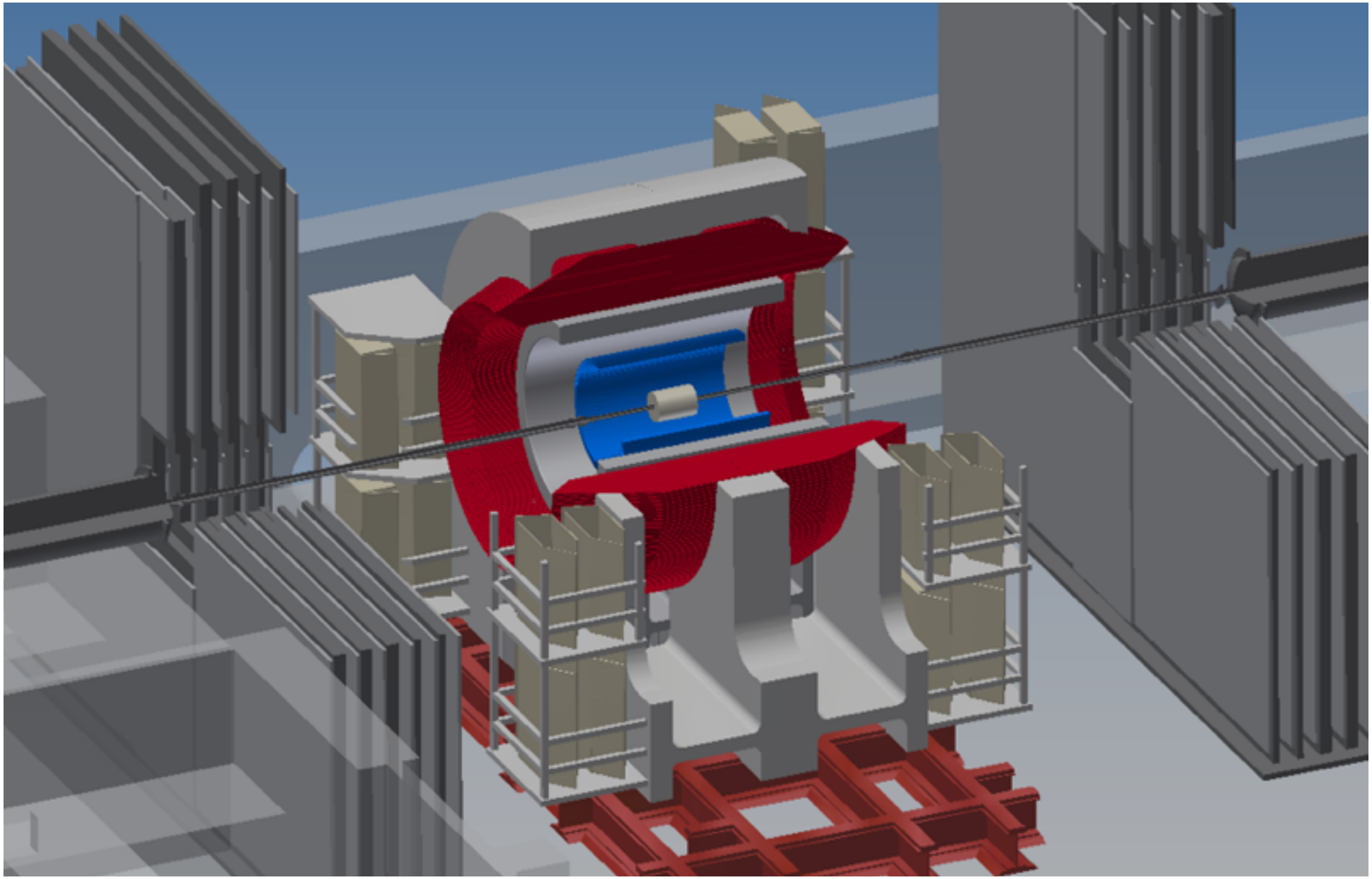
an interesting development ...

- cancelation of SuperB has made BaBar solenoid potentially available
- magnet already extracted from BaBar and made ready for shipping
- indications are it would made excellent foundation for sPHENIX/ ePHENIX: inner radius 140 cm, field 1.5 T
- at ALD's request, drafting an official letter to express interest in acquiring the magnet

BaBar solenoid in its transfer frame

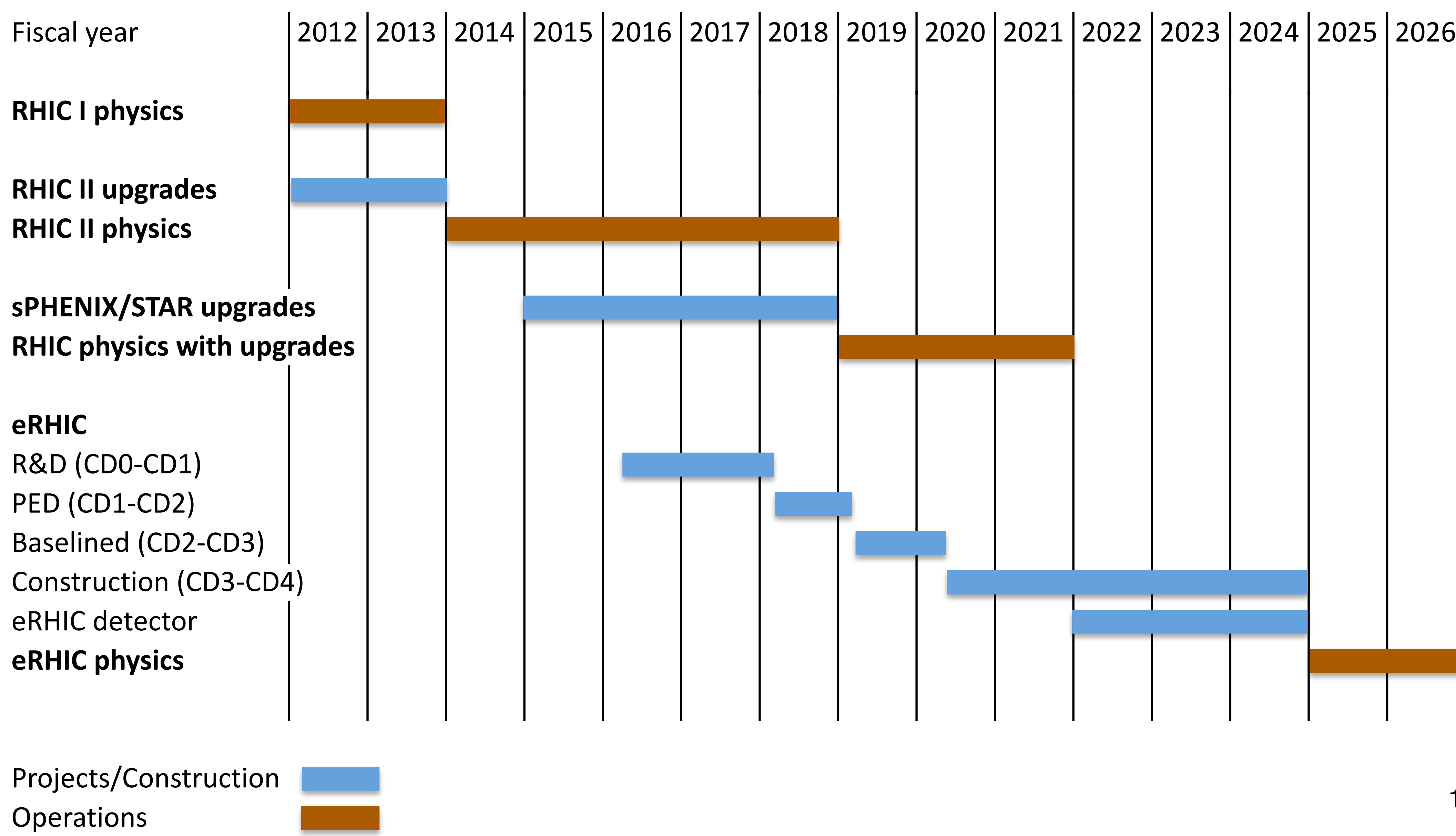
May 17, 2013

sPHENIX detector in situ



increasing emphasis on evolution to ePHENIX

- the BNL plan is ePHENIX/eSTAR for the first stage of eRHIC
- current BNL schedule, as shown to NSAC committee on scientific facilities

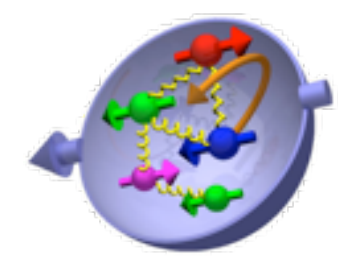


ePHENIX letter of intent

- progress toward CD-0 for sPHENIX requires ePHENIX/eSTAR LOIs for “stage 1” eRHIC (5–10 GeV electron beam, L ~ 10^{33}) with description of physics, detectors and cost
- due to DOE by end of September – in time to allow potential FY’16 f unding
- ePHENIX LOI writing team formed: Sasha Bazilevsky (Chair), Kieran Boyle, Abhay Deshpande, Tom Hemmick, Jin Huang, Itaru Nakagawa, Craig Woody
  - develop and then focus on one “strawman” design
  - detector concept needs to be detailed enough to enable solid cost estimate
- engaging the EIC task force to get input on physics case

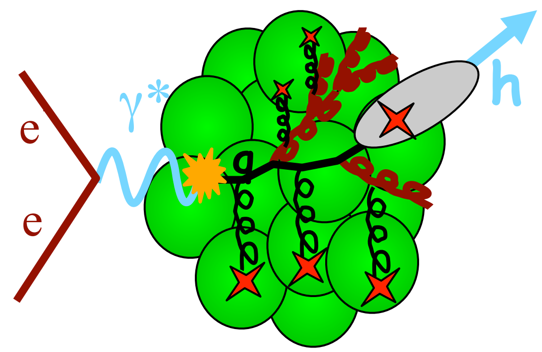
stage 1 eRHIC physics

Distribution of quarks and gluons and their spins in space and momentum inside the nucleon



Nucleon helicity structure
Parton transverse motion in the nucleon
Spatial distribution of partons and parton orbital angular momentum

QCD in nuclei

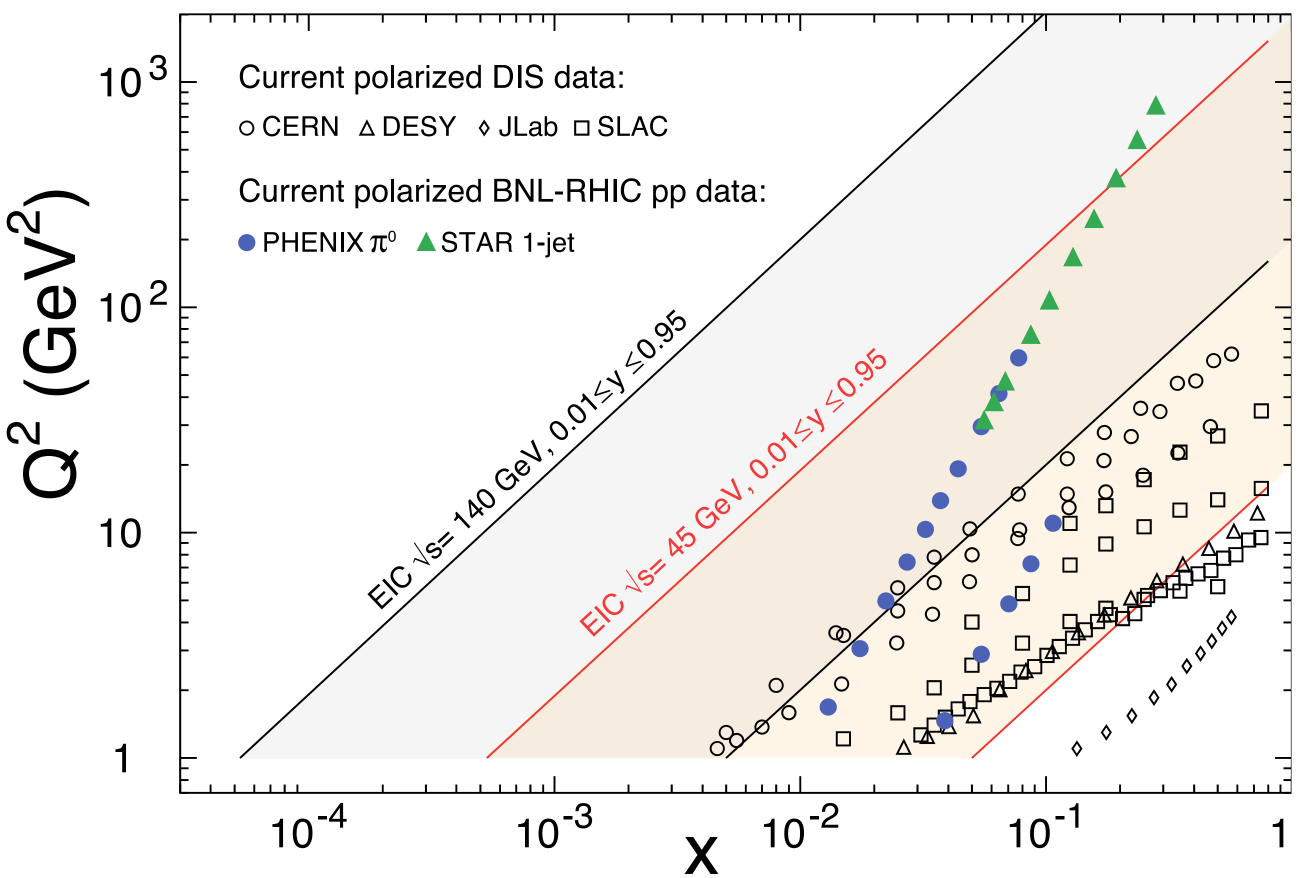


Nuclear modification of parton distributions
Propagation/Hadronization in nuclear matter
Gluon saturation

~~Weak interactions & beyond standard model~~

Require highest energy and lum. $\Longrightarrow$ not for stage I eRHIC

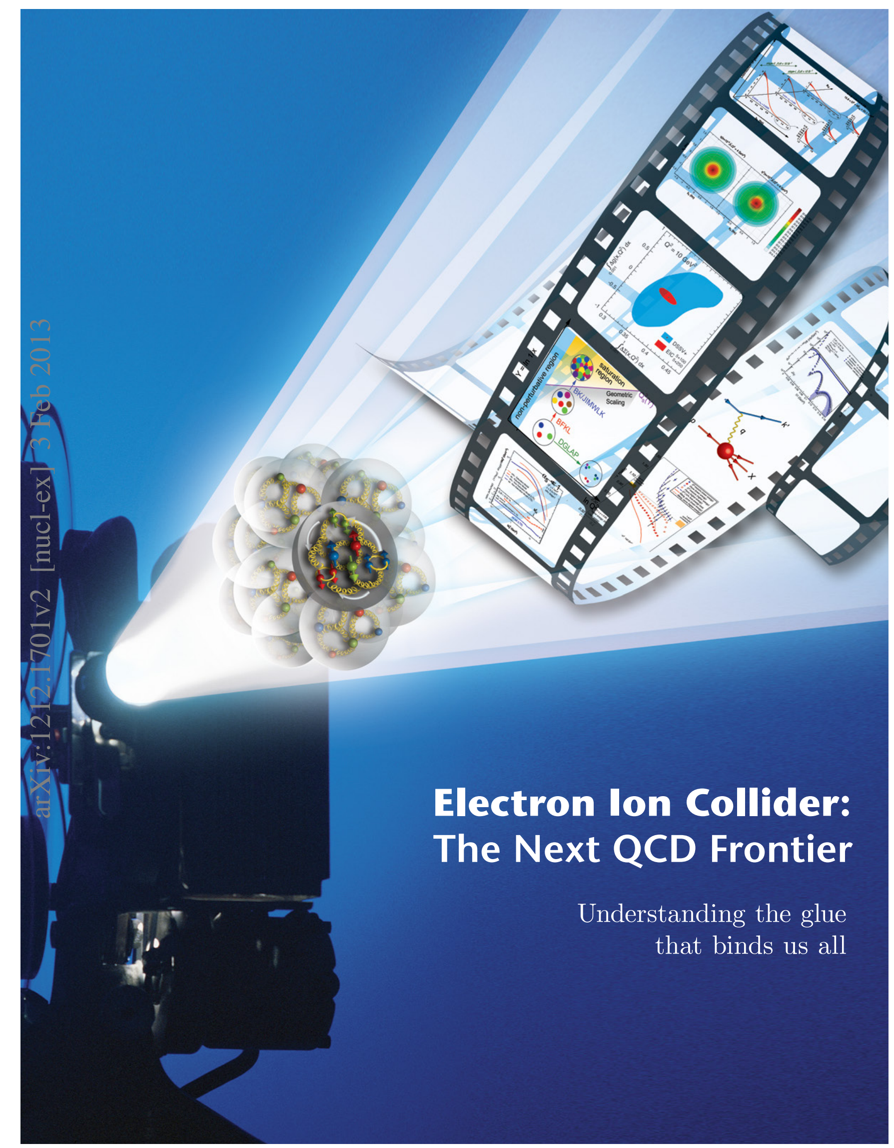
one example: nucleon spin structure



Inclusive and semi-inclusive DIS

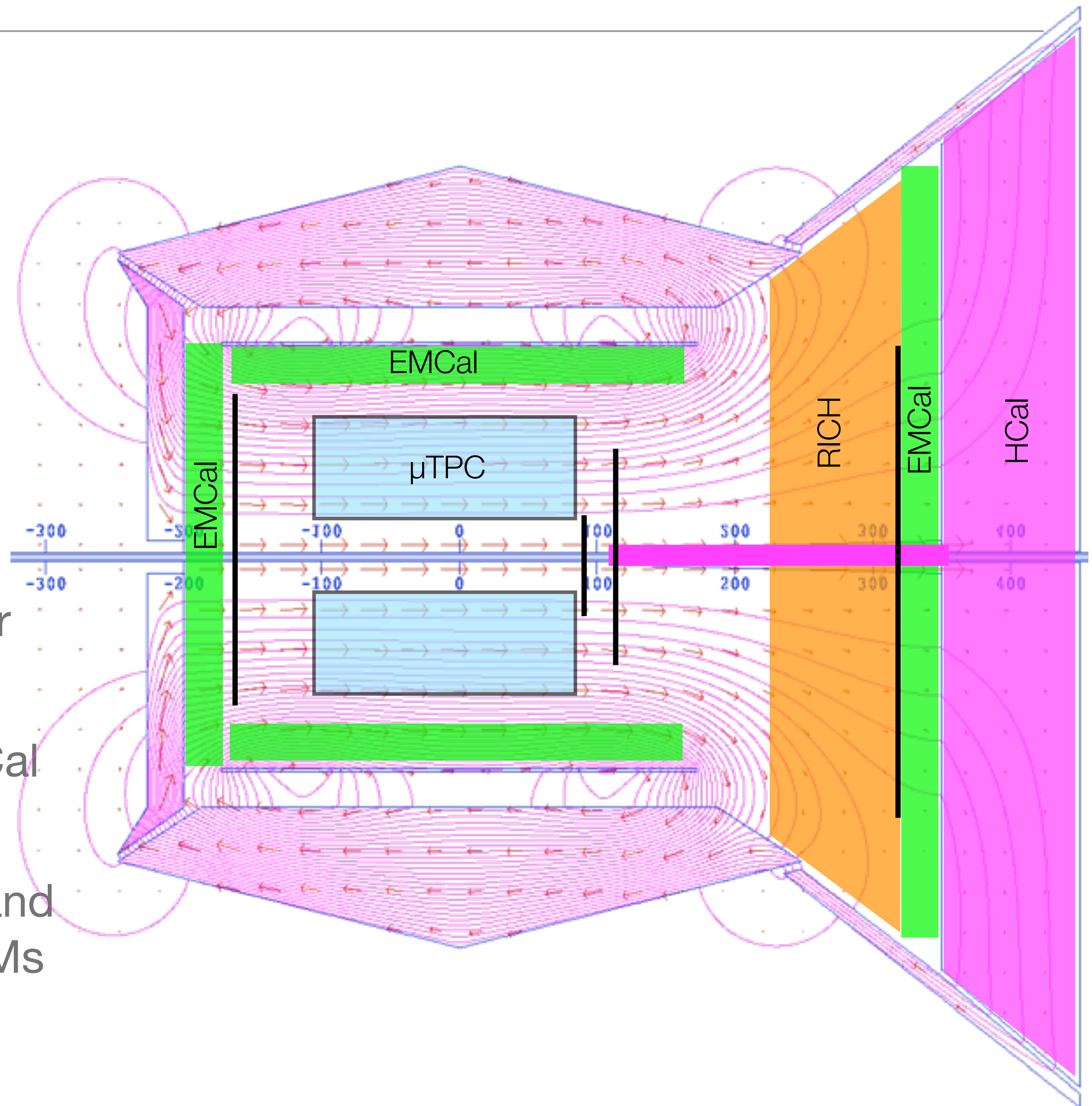
Detector requirements:

- Electron measurements in e-going direction and barrel
- PID-ed hadron measurements in barrel and h-going direction

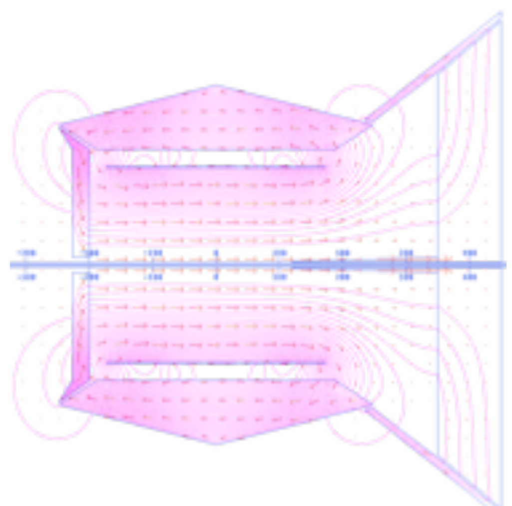


ePHENIX strawman detector concept

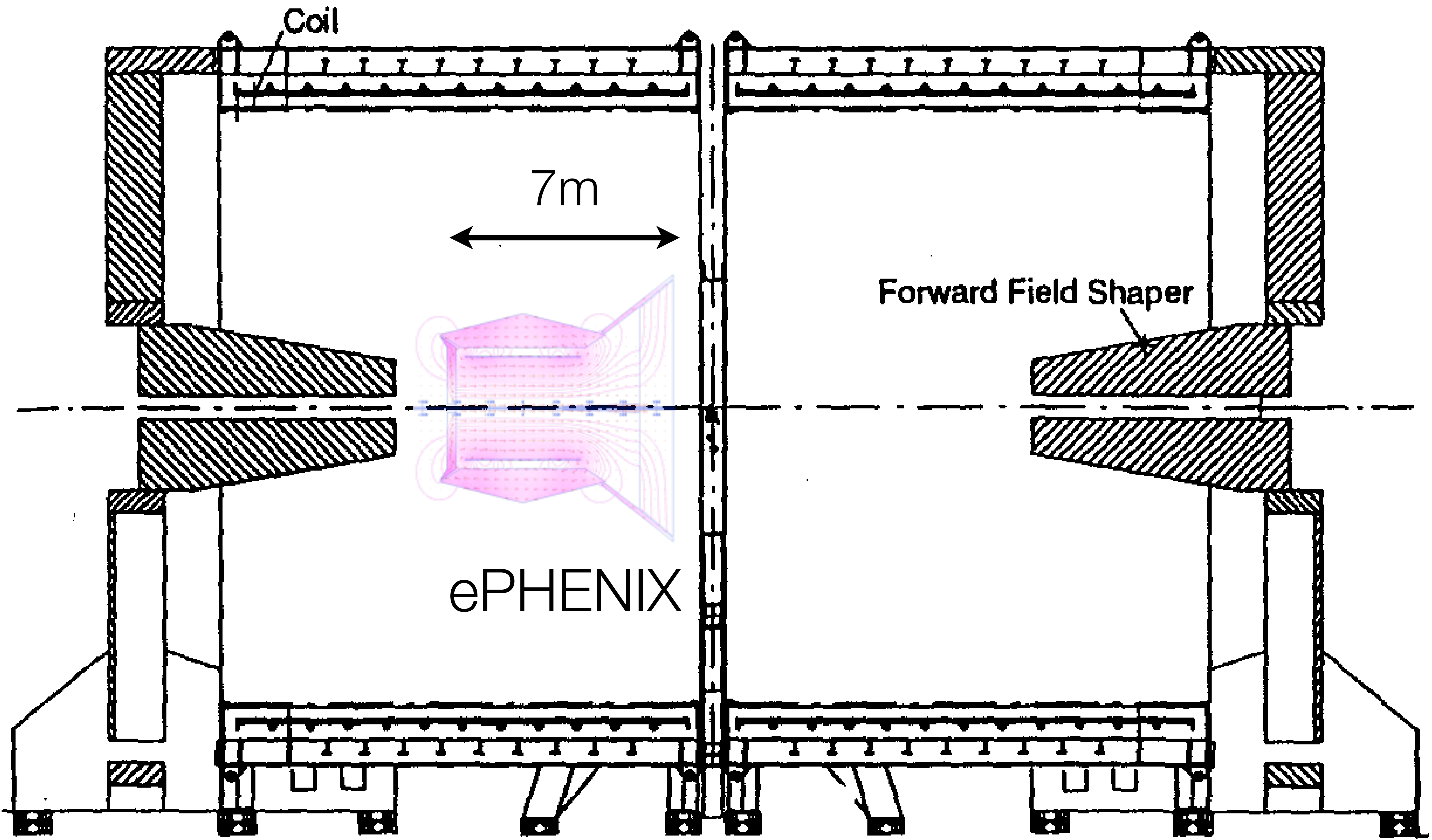
- passive shaping of solenoid fringe field
- “sleeve” of high magnetic saturation material around beam pipe to act as forward field shaper for 3 < η < 4
- e-direction: PWO calorimeter
- h-direction: RICH/EMCal/HCal
- low mass tracking in barrel and forward/backward: TPC/GEMs



7m

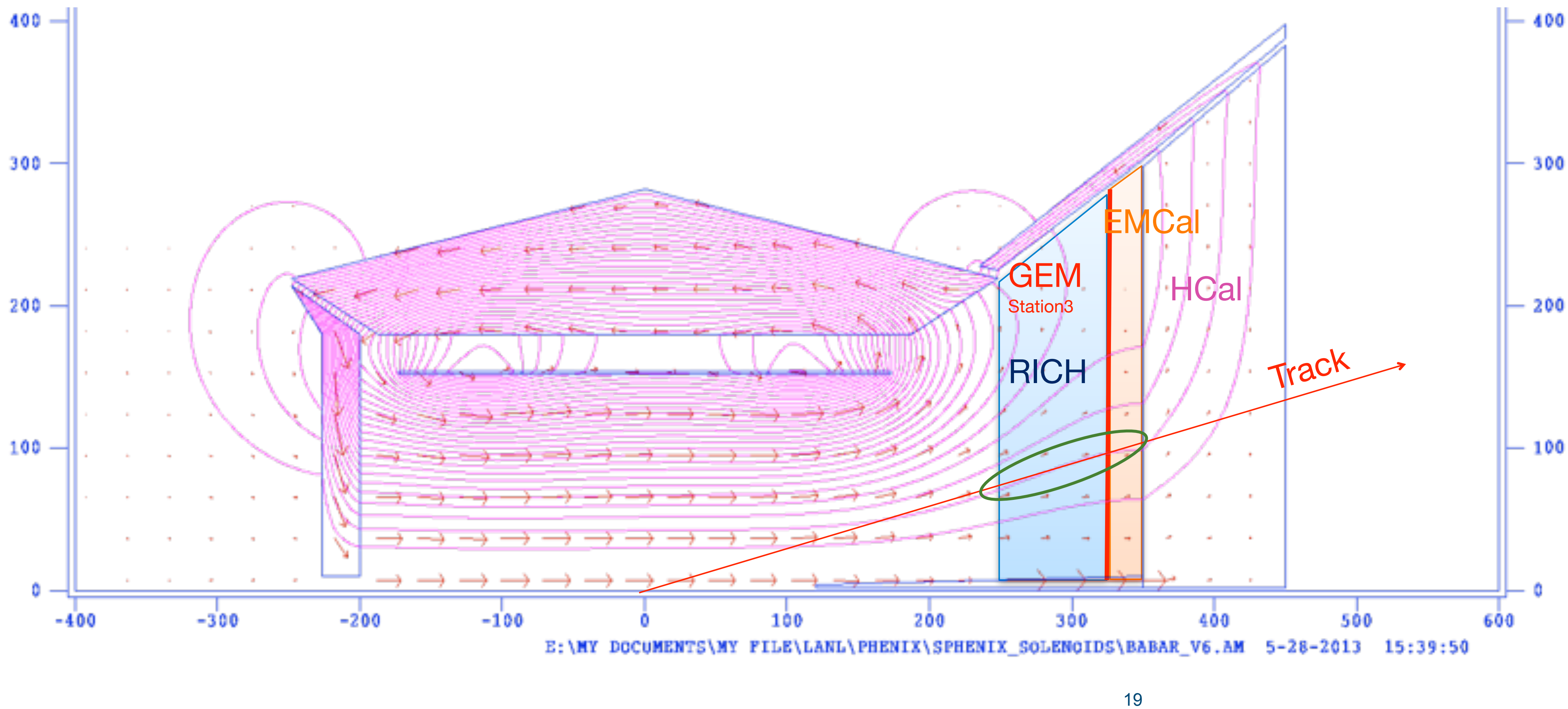


ePHENIX



GEM@SSC

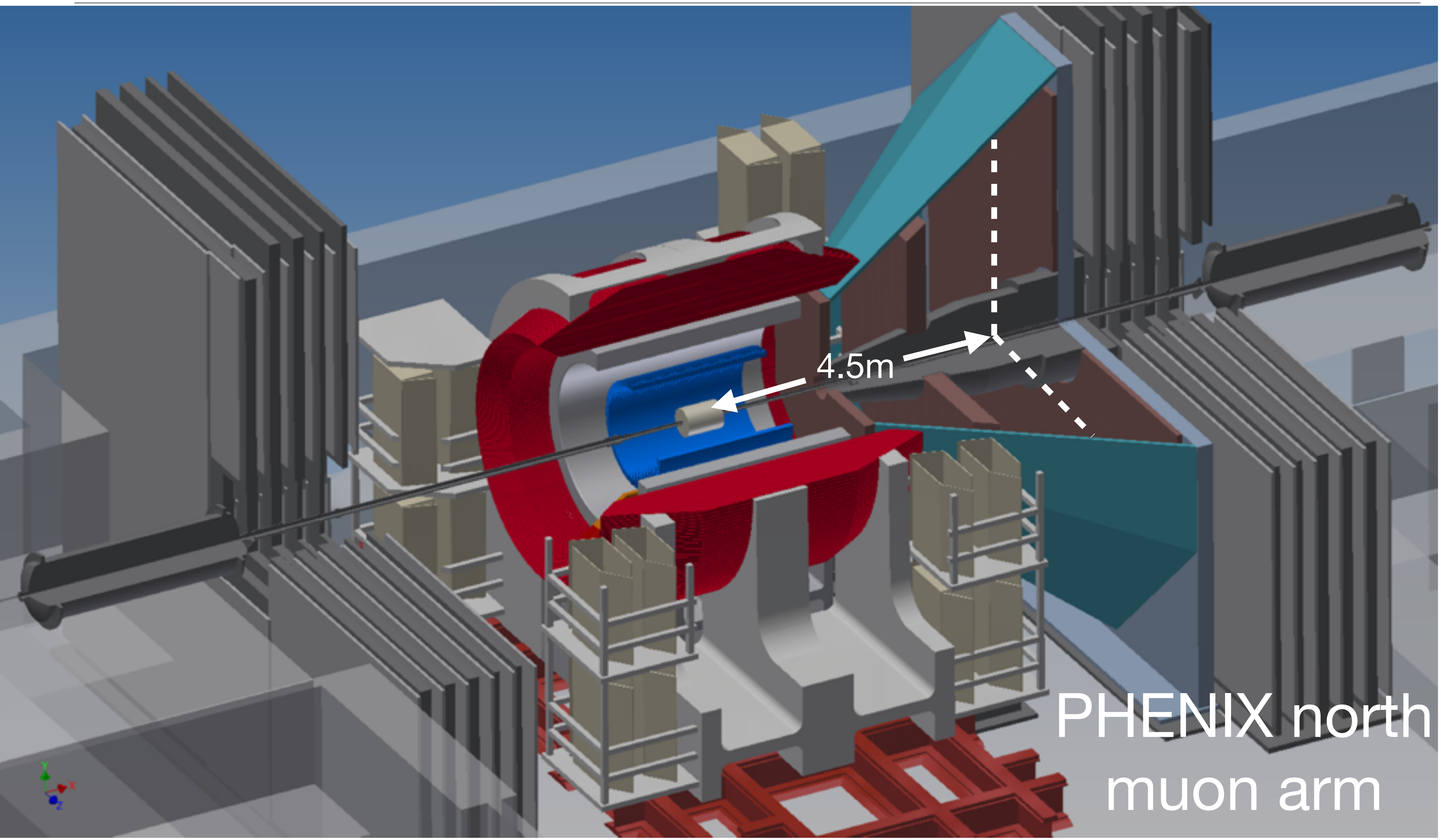
more involved magnetic field considerations



bending of track inside volume of RICH can lead to sweeping beam of Cerenkov light and blurring of ring

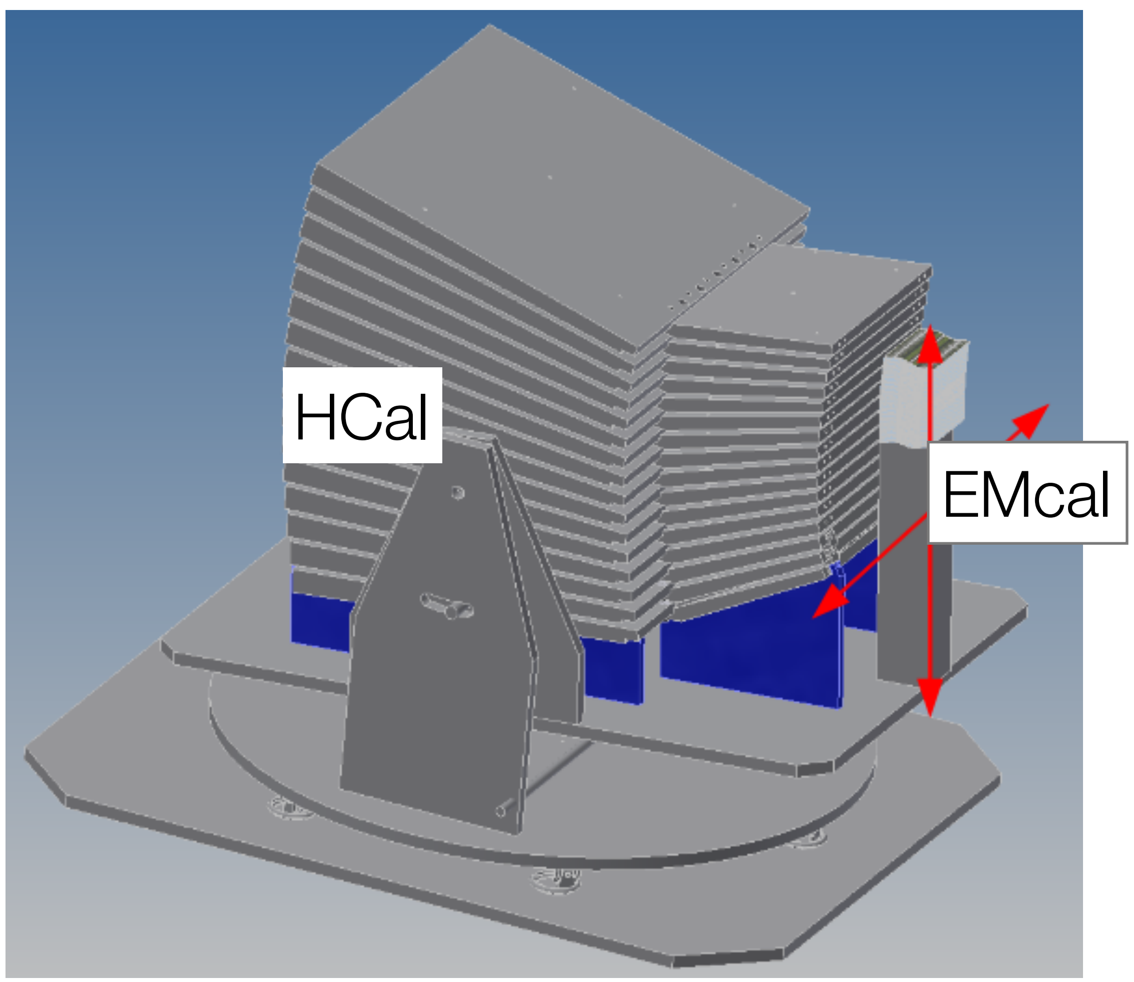
field shaping plus careful location of RICH produces field lines roughly parallel to tracks in RICH volume: blurring doesn't appear to be dominant effect

a visual approximation to ePHENIX concept in situ

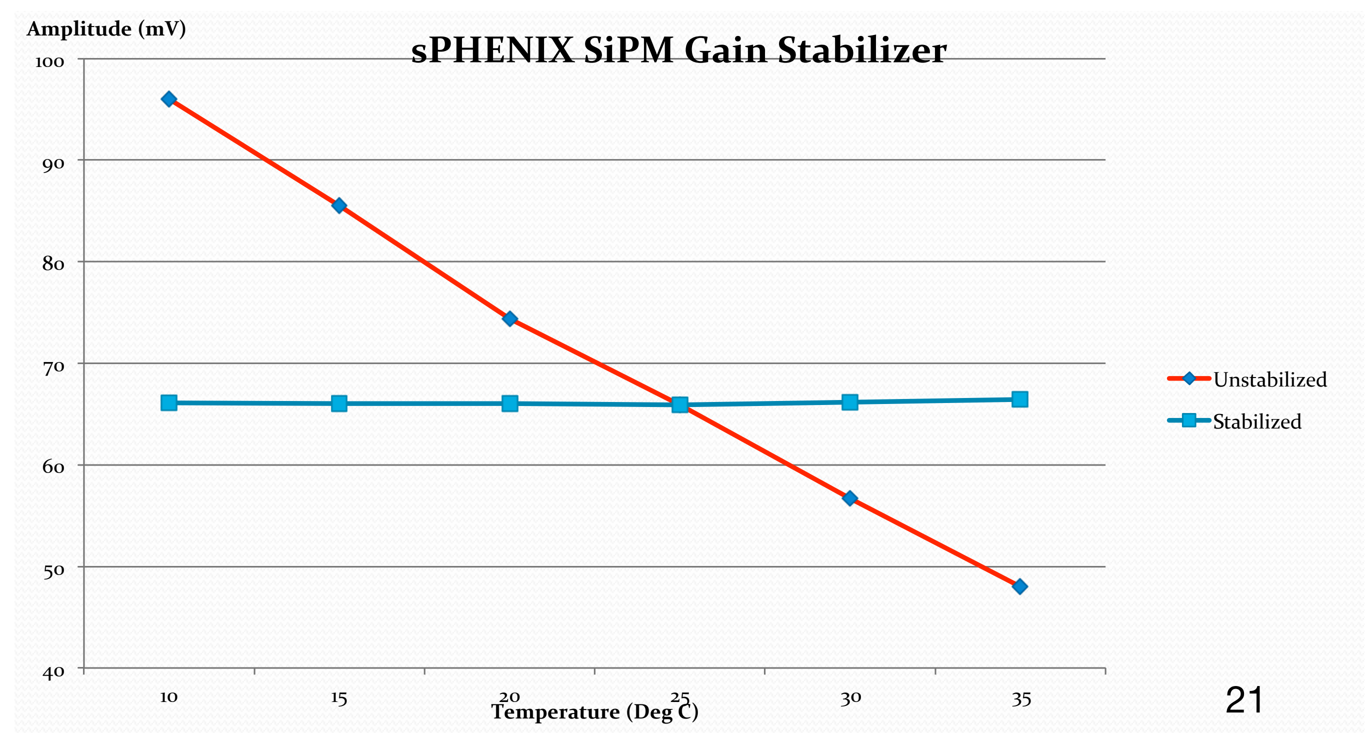


e/sPHENIX R&D

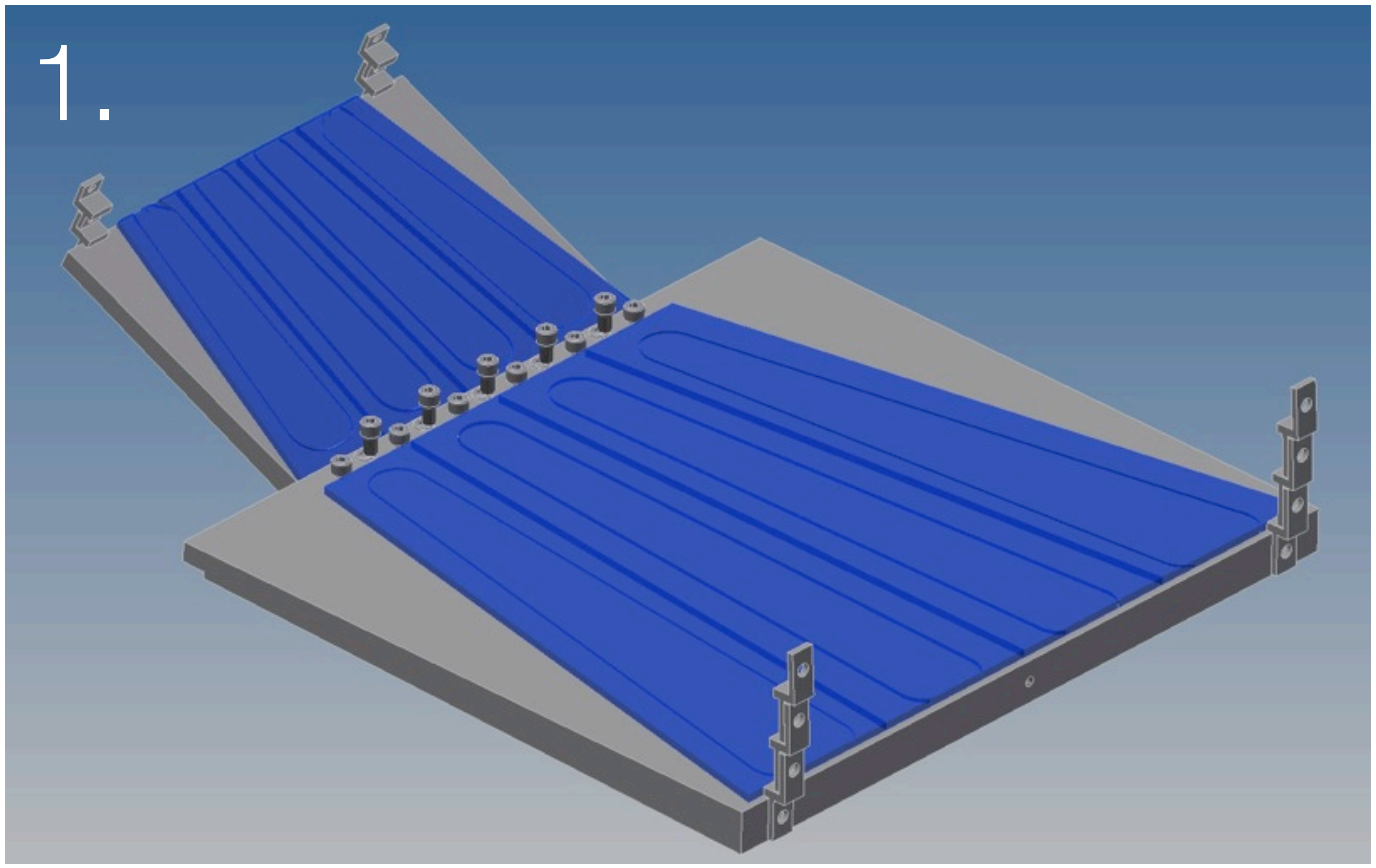
- planning for several ton-scale combined EMCal/HCal prototype to see test beam at Fermilab this year

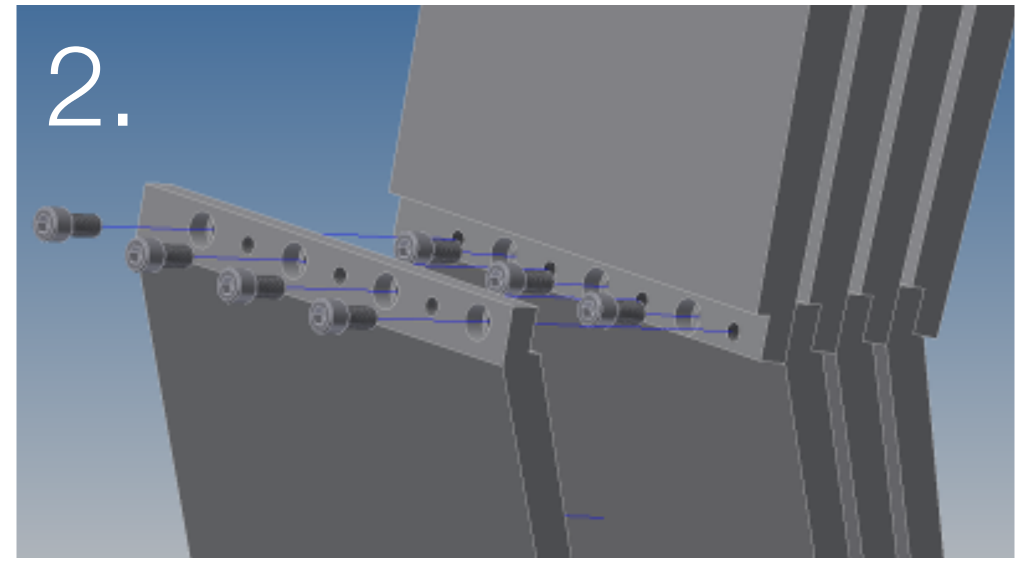


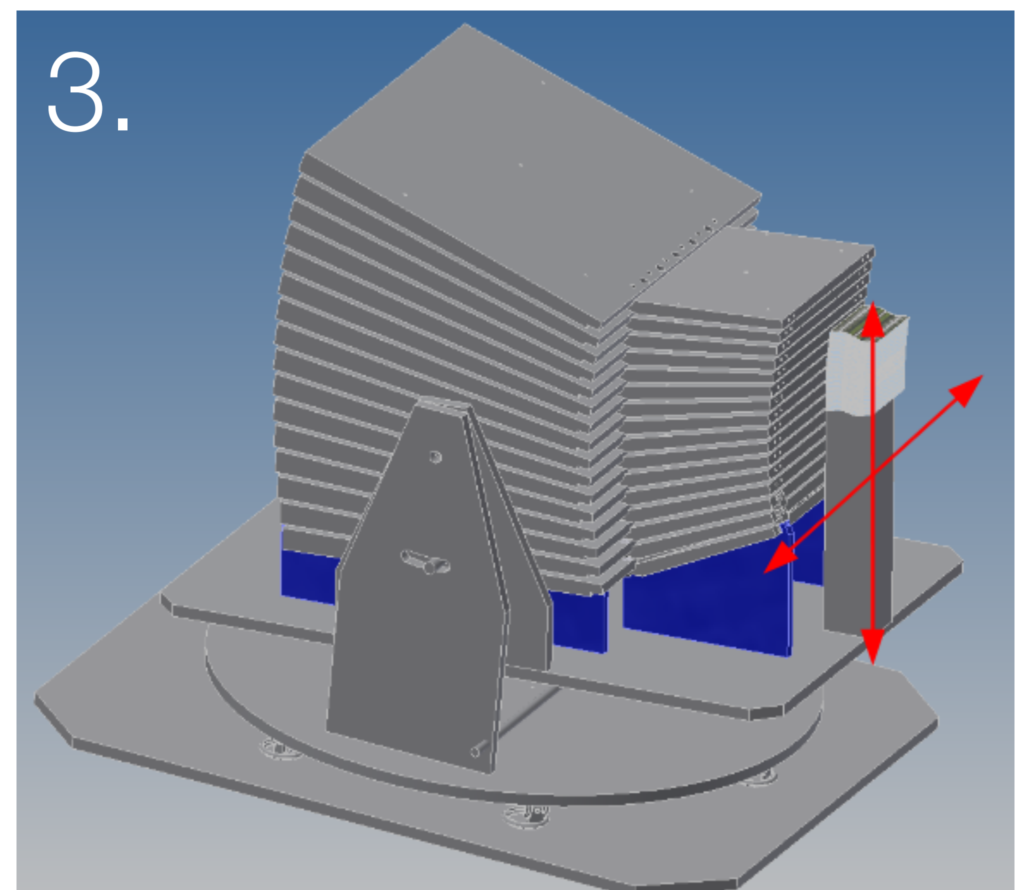
- completed Phase I SBIR with Tungsten Heavy Powder, Inc. on development of W/Scint EMCal
- submitted LDRD concerning magnet design for ePHENIX
- testing light collection strategies for matching fibers to SiPMs
- evaluate temperature dependent gain control of SiPMs



HCal assembly instructions

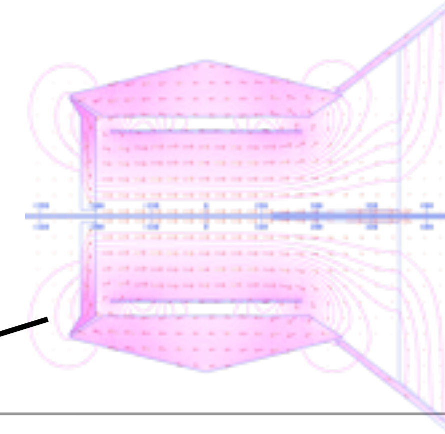


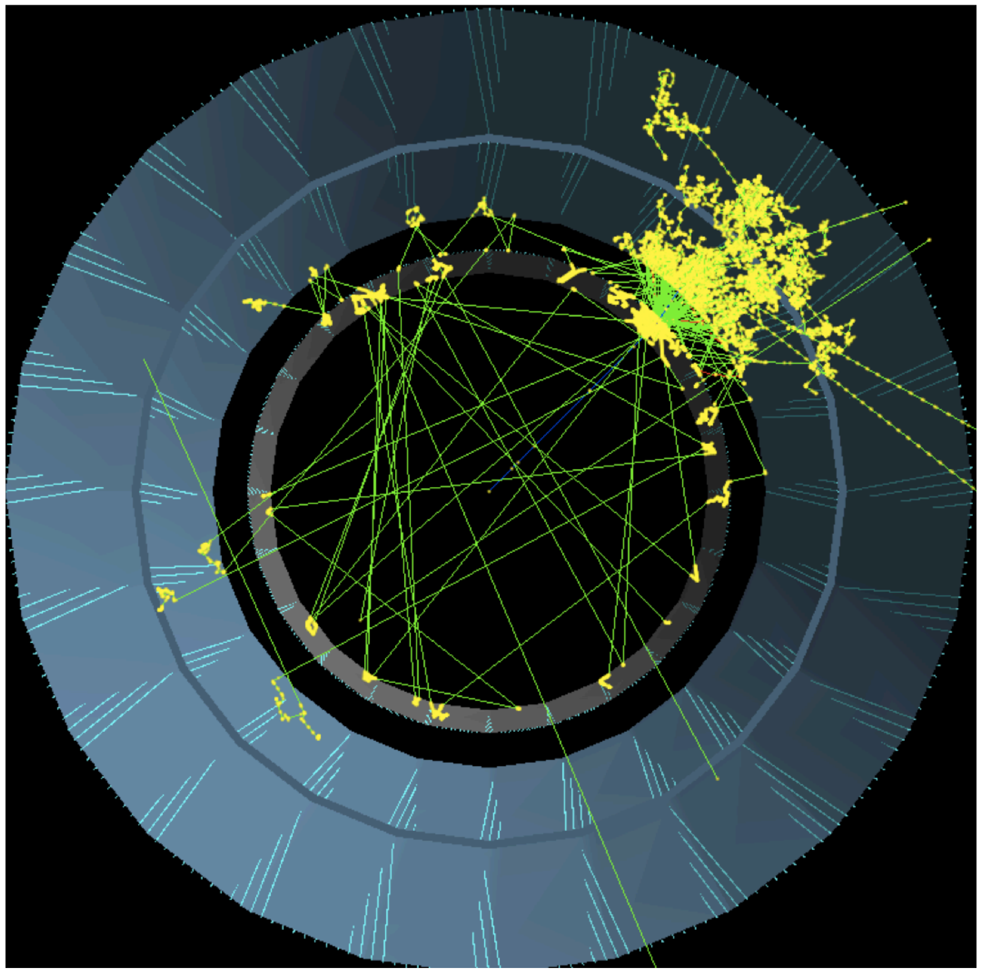




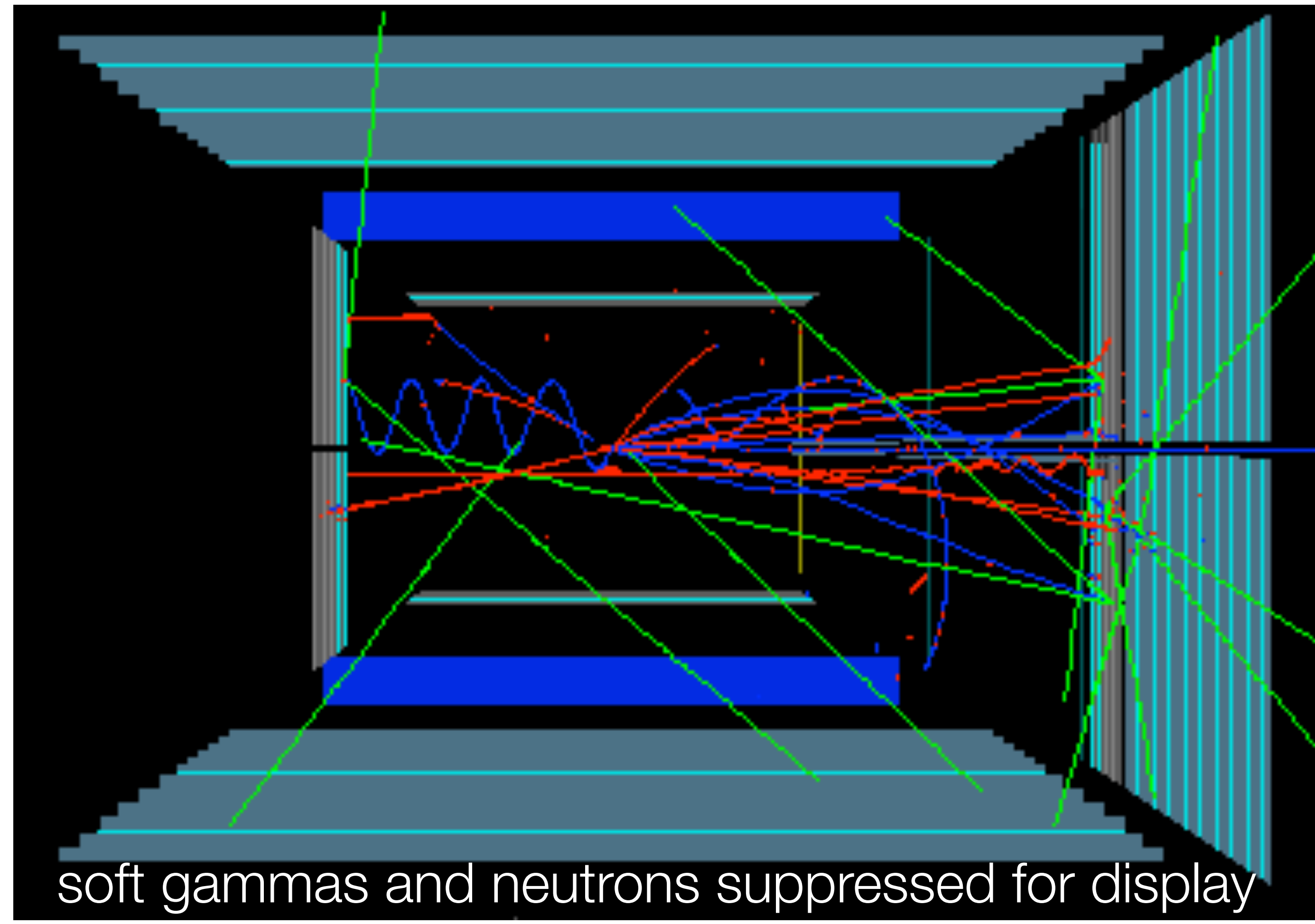
scintillator, segmented in η, with groove for light collecting fiber sandwiched between steel plates. similar to design in use in T2K experiment.

simulations





GEANT4 implementation of sPHENIX MIE calorimeters. Being used to evaluate different absorber/scintillator geometries, uniformity of response, and to verify that energy resolution meets MIE specs



Initial GEANT4 implementation of ePHENIX strawman detector. Shown with PYTHIA e+p event (5 + 50 GeV, $Q^2 > 1$ GeV^2). Magnetic field map from OPERA calculations (includes, e.g., field shaping effects of lampshade and piston)

summary and next steps

- sPHENIX MIE, updated to reflect very helpful guidance from October 2012 review, submitted by BNL to DOE
- collaboration is energized about the physics potential and is very active; attendance at workfests has been consistent at about two dozen people
- ePHENIX LOI team formed and is moving very quickly to a strawman design addressing eRHIC stage I needs and will develop a solid cost estimate for LOI
- have arranged face-to-face meeting at DOE for July 1
- submit LOI to ALD at end of August
- looking forward to a timely (and positive) CD-0 decision!

request for ePHENIX letter of intent

Charge for LOI from ALD Berndt Mueller

Provide specific plans (i.e. Letters of Intent) to upgrade/reconfigure the detectors from their present form to first-generation eRHIC detectors. These Letters of Intent (LOI) will be an important part of BNL's strategic planning as we move toward the next Nuclear Physics Long Range Plan. They should include an assessment of how the collaborations may evolve through this transition, and of the size and breadth of the scientific staffing required to carry out these plans.

In preparing these LOI the collaborations should assume an eRHIC machine with an electron beam energy up to 10 GeV, hadron beam energies as provided by the current RHIC machine (255 GeV for p and 100 GeV/nucleon for Au), and design luminosities of 10^{33} cm^{-2} s^{-1} for 10 GeV on 255 GeV ep collisions and the equivalent of 6×10^{32} cm^{-2} s^{-1} for 10 GeV on 100 GeV/ nucleon eA collisions.

The LOI should include a description of the physics reach of the upgraded detectors, based on their detection capabilities, taking into consideration the key measurements identified in the EIC White Paper for Stage 1 (but now for 10 GeV electrons instead of 5 GeV).

The technical details of the proposed upgrades should be given in sufficient detail to make a preliminary cost estimate. We assume that the upgrades may come in stages, with some elements implemented during the on-going RHIC heavy ion operations. Sufficient detail should be provided for each step to allow a rough outline of the overall construction schedule, assuming a 2-3 year shut-down of collider operations before the commencement of eRHIC operations, and an estimate of the required funding profile.

The Letters of Intent should be submitted by September 30, 2013.