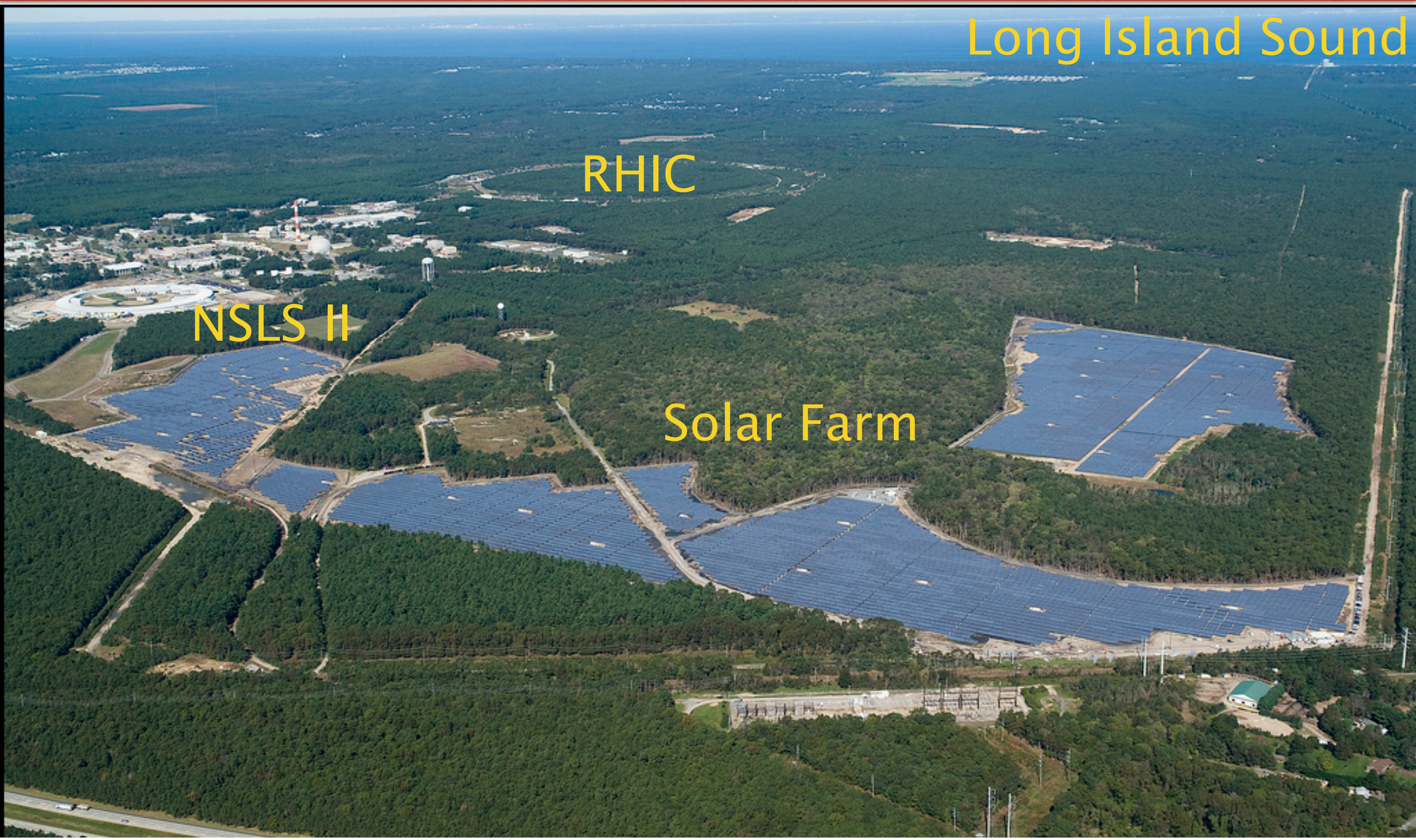
Future upgrades for the PHENIX Experiment at RHIC

From PHENIX to sPHENIX and beyond

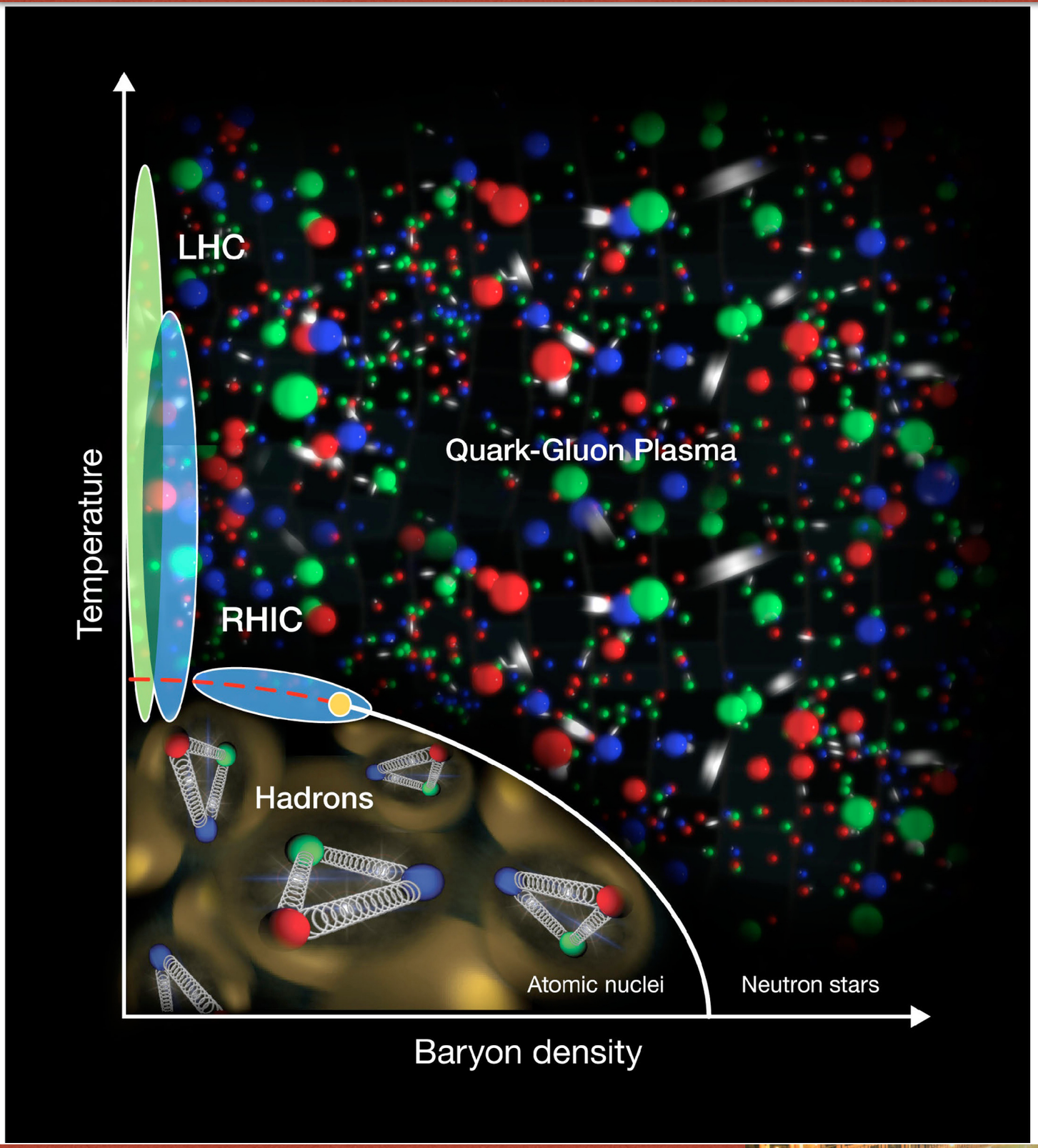
Achim Franz
Physics Department
Brookhaven National Laboratory, Upton NY

achim@bnl.gov

Brookhaven National Laboratory



matter phase diagram



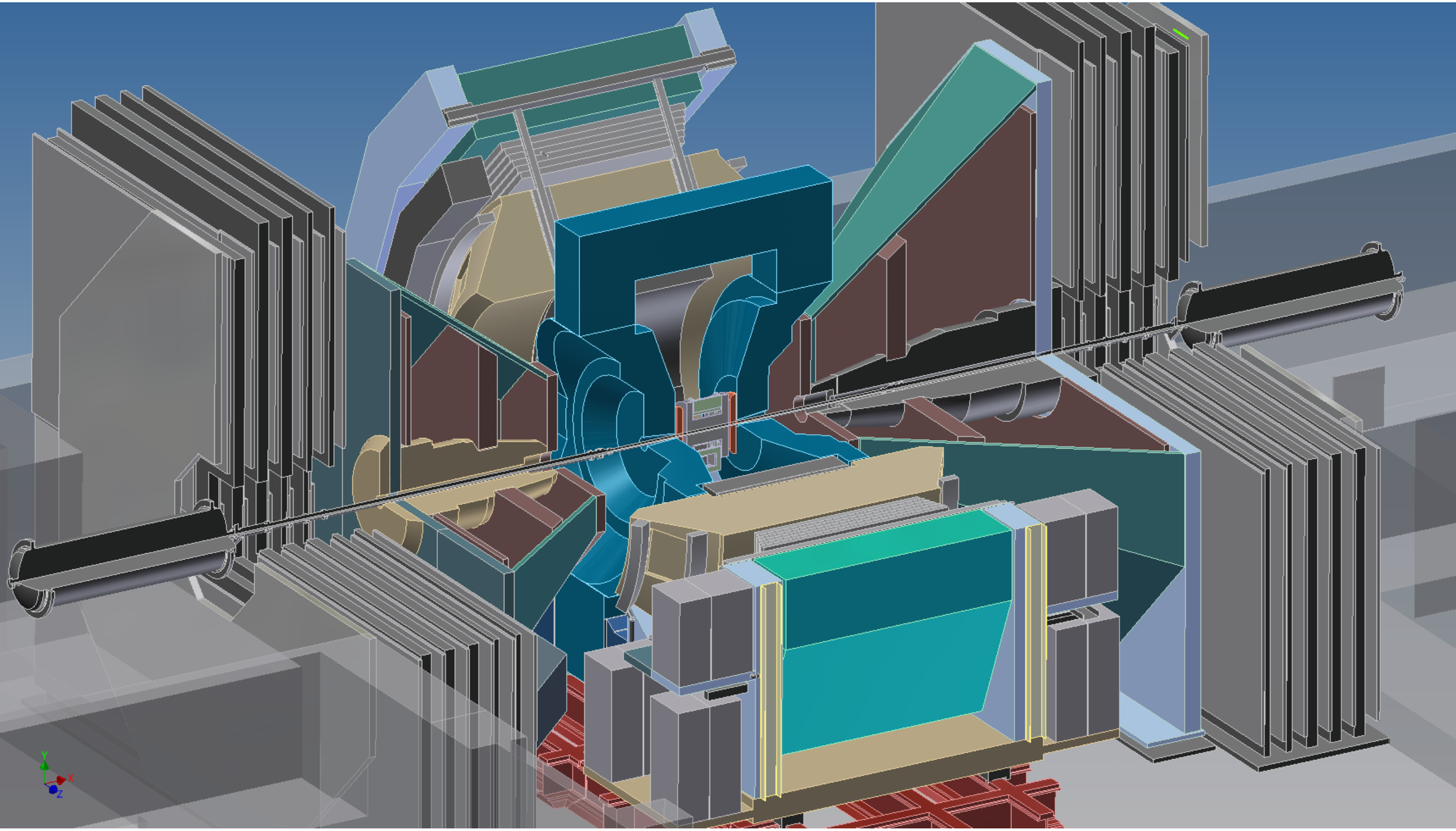
RHIC has
unique capabilities
to explore
phase transition

- range in energies
- projectile–targets
- p→U, 5.5→510GeV

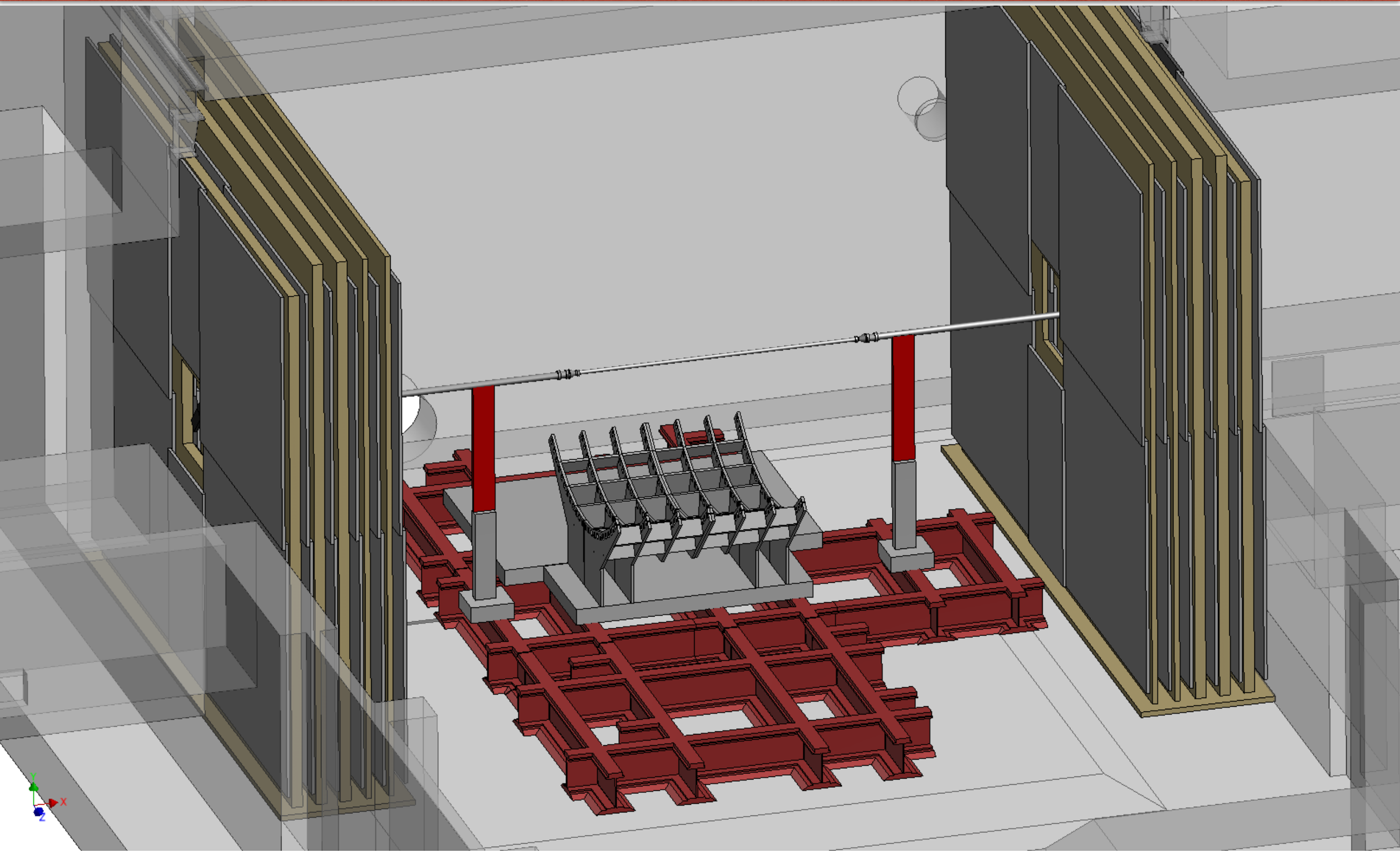
Tools

- jets
- flow
- heavy flavor
- melting quarkonia

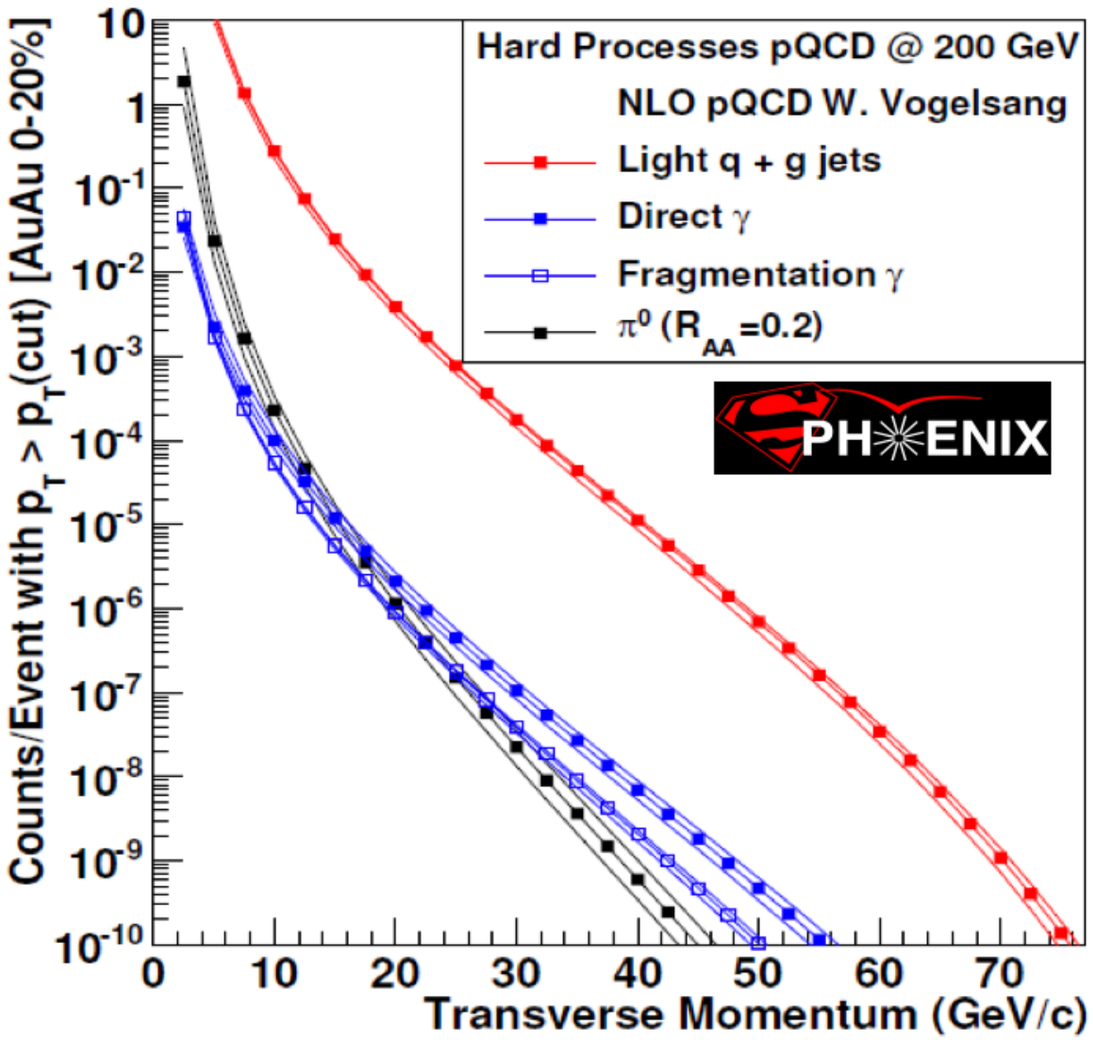
current PHENIX detector



what we need to do



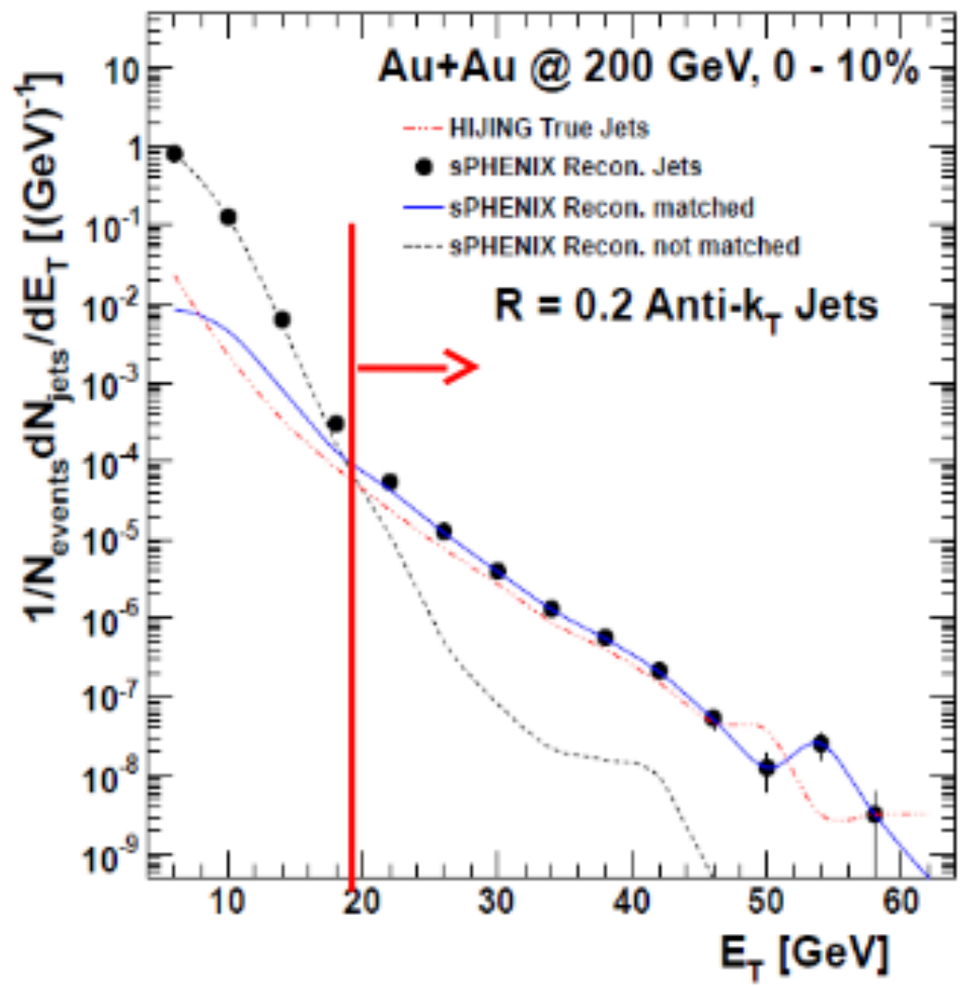
Jet Rates



Event rates per year

10^7 jets p_T > 20 GeV
10^6 jets p_T > 30 GeV
80% are dijet events

10^4 direct γ events with p_T > 20 GeV



requirements

Physics	Detectors	Requirements
Full jet reconstruction	EMCal	$\sigma/E < 20\%/\sqrt{E}$
	HCal	$\sigma/E < 100\%/\sqrt{E}$
		$\Delta\eta \times \Delta\phi \sim 0.1 \times 0.1$
		uniform within $\lvert\eta\rvert < 1$
Direct γ, $p_T > 10\,\mathrm{GeV}/c$	EMCal	$\sigma/E \simeq 15\%/\sqrt{E}$
		$\Delta\eta \times \Delta\phi \sim 0.03 \times 0.03$
Jet-hadron	VTX 4 layers	tracking $p_T < 4\,\mathrm{GeV}/c$
	Solenoidal field	

http://www.phenix.bnl.gov/phenix/WWW/publish/dave/PHENIX/sPHENIX_MIE_09272013.pdf

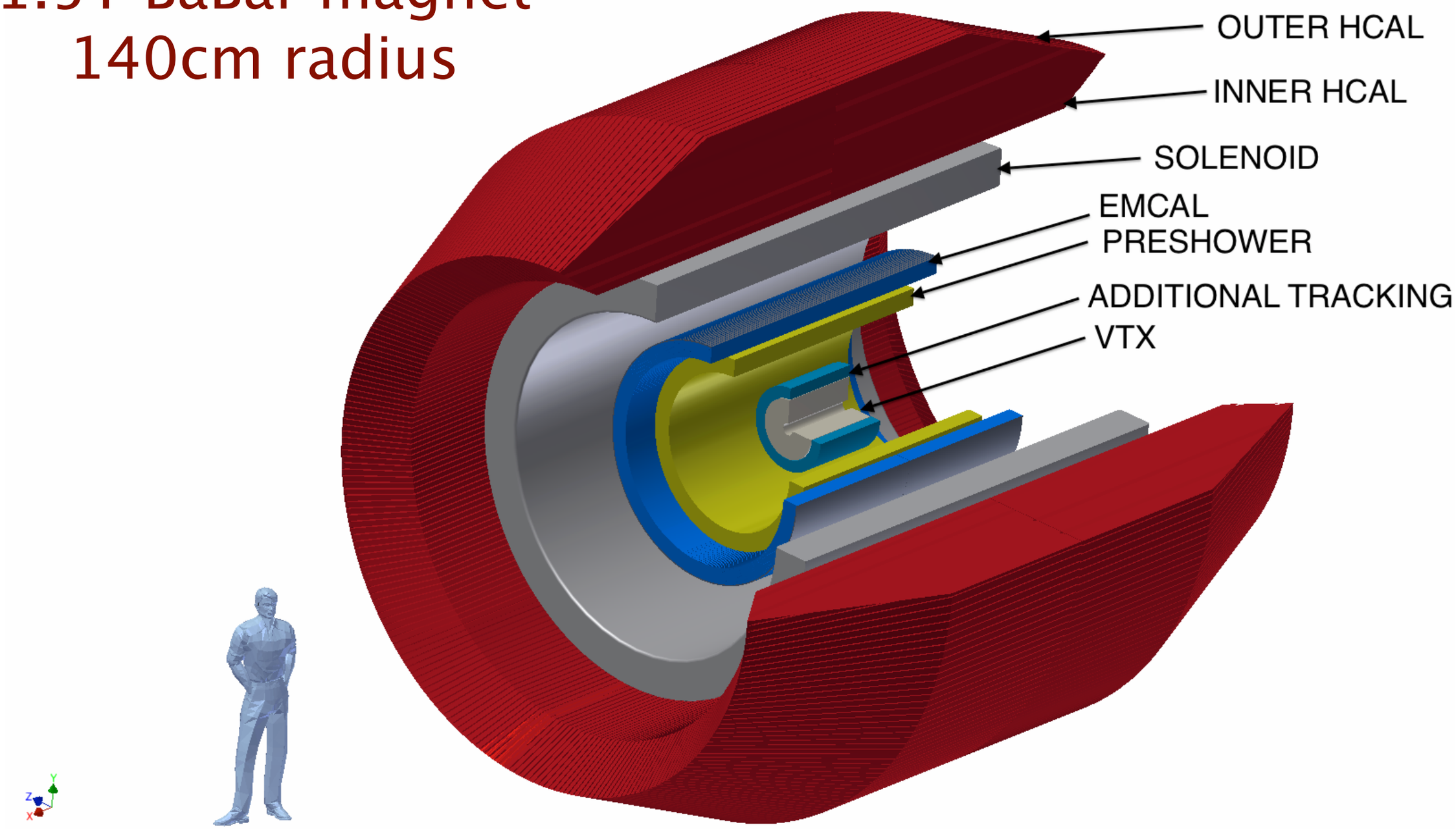
requirements cont'd

Physics	Detectors	Requirements
Tagged HF jets	Jets as above	EMCal and HCal
	DCA capability	Current PHENIX VTX
	Tracking	$\Delta p/p \simeq 0.2\% \cdot p$
Heavy quarkonia	Electron ID	
	EMCal	$\sigma/E \simeq 15\%/\sqrt{E}$
		$\Delta\eta \times \Delta\phi \sim 0.03 \times 0.03$
Separation of Y states	Preshower	e/π rejection
		fine segmentation
	Tracking	$B = 1.5T$
		$\Delta p/p \simeq 0.2\% \cdot p$

1.5T superconducting BaBar magnet

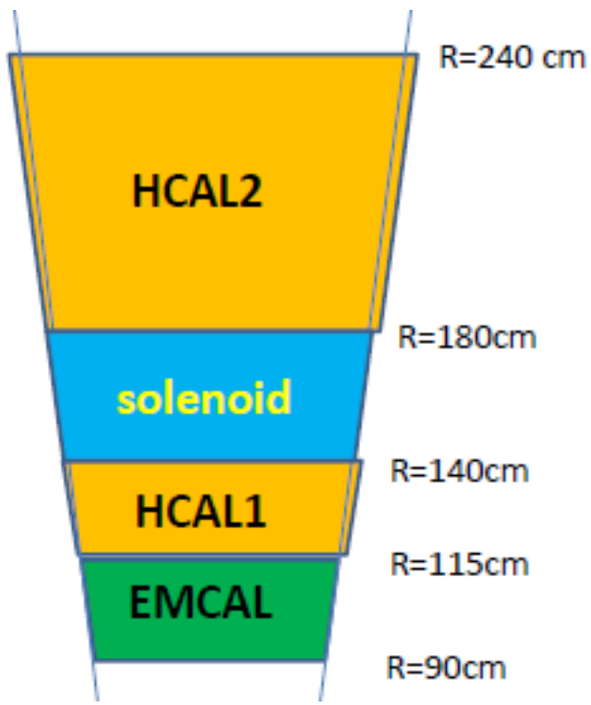
sPHENIX concept

1.5T BaBar magnet
140cm radius



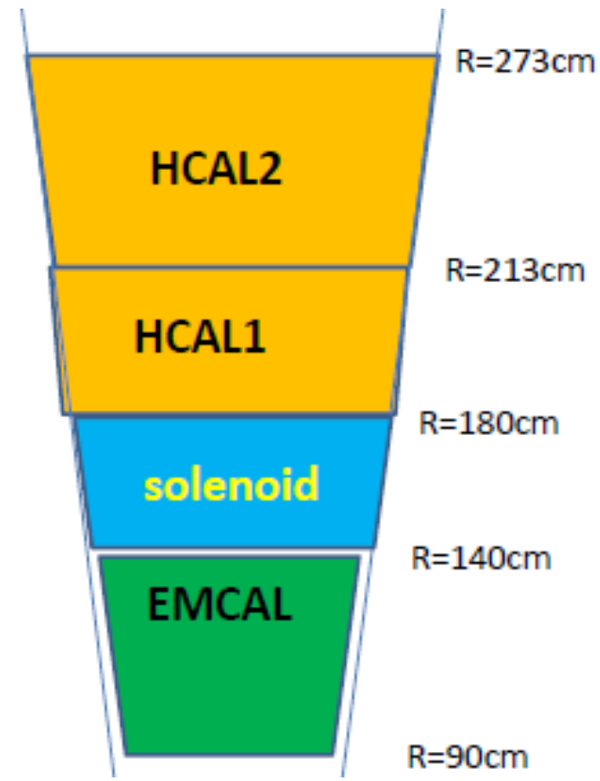
calorimeter options

Compact EMCAL
Thin section of HCAL inside magnet



- Smaller Molière radius better for HI collisions
- Thin HCAL section can be used for e/h separation
- Smaller overall HCAL

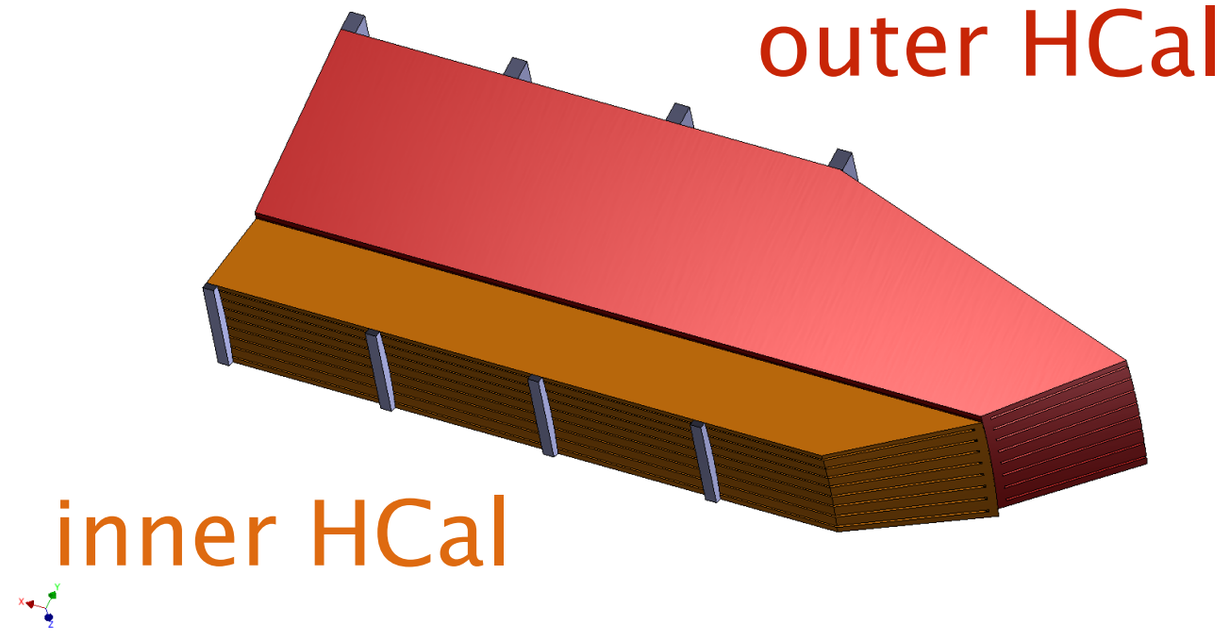
Lower density EMCAL
Both sections of HCAL outside magnet



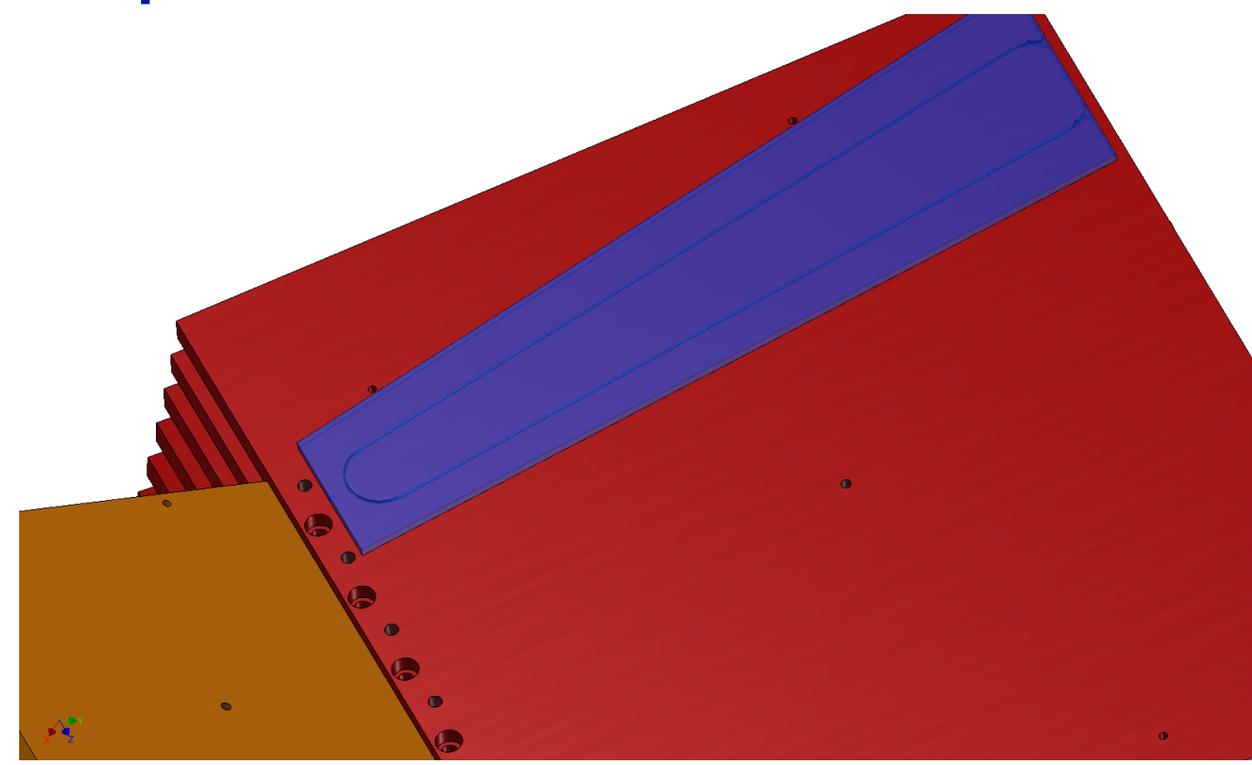
- Larger Molière radius worse for HI collisions
- EMCAL can be Pb/Sc

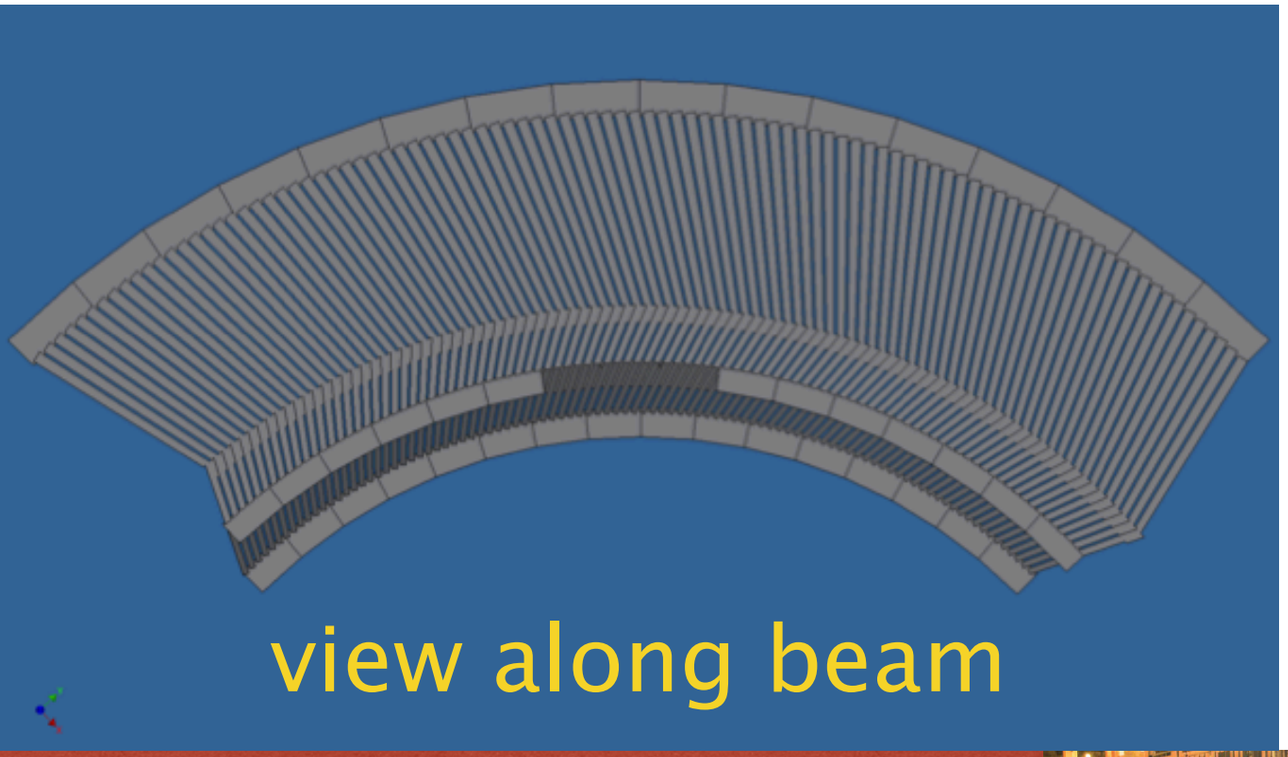
- Overall HCAL larger

unique HCal design, tilted plates



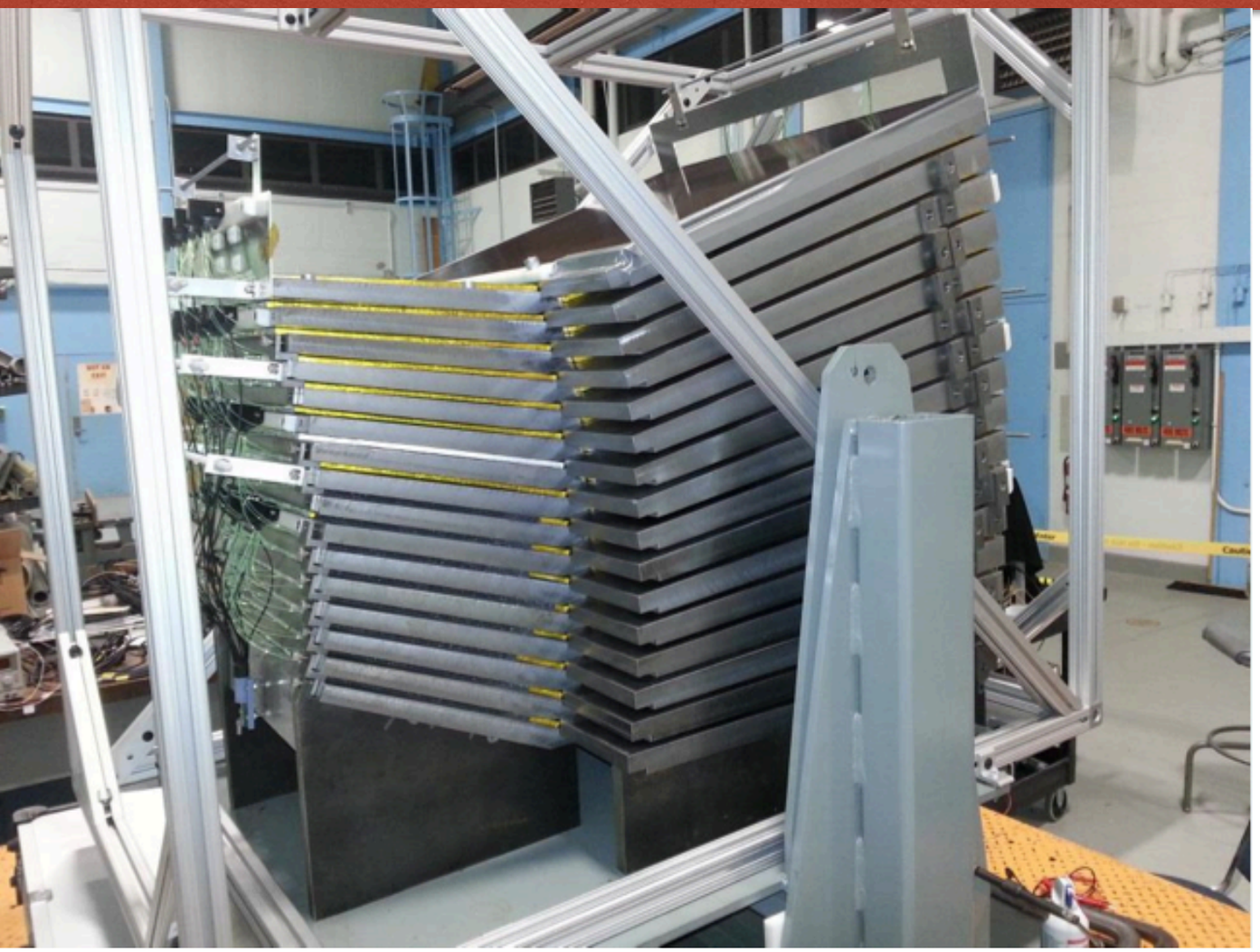
scintillator
plates with fiber readout





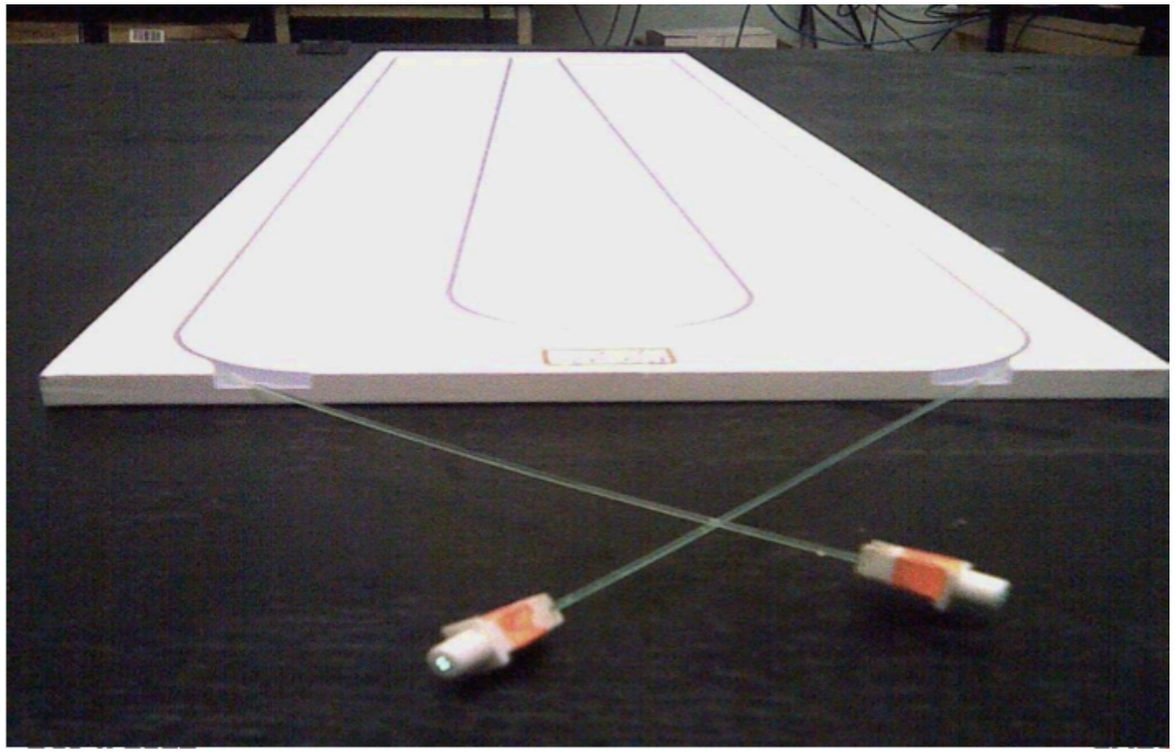
HCal provides magnetic field flux return

HCal Scintillator

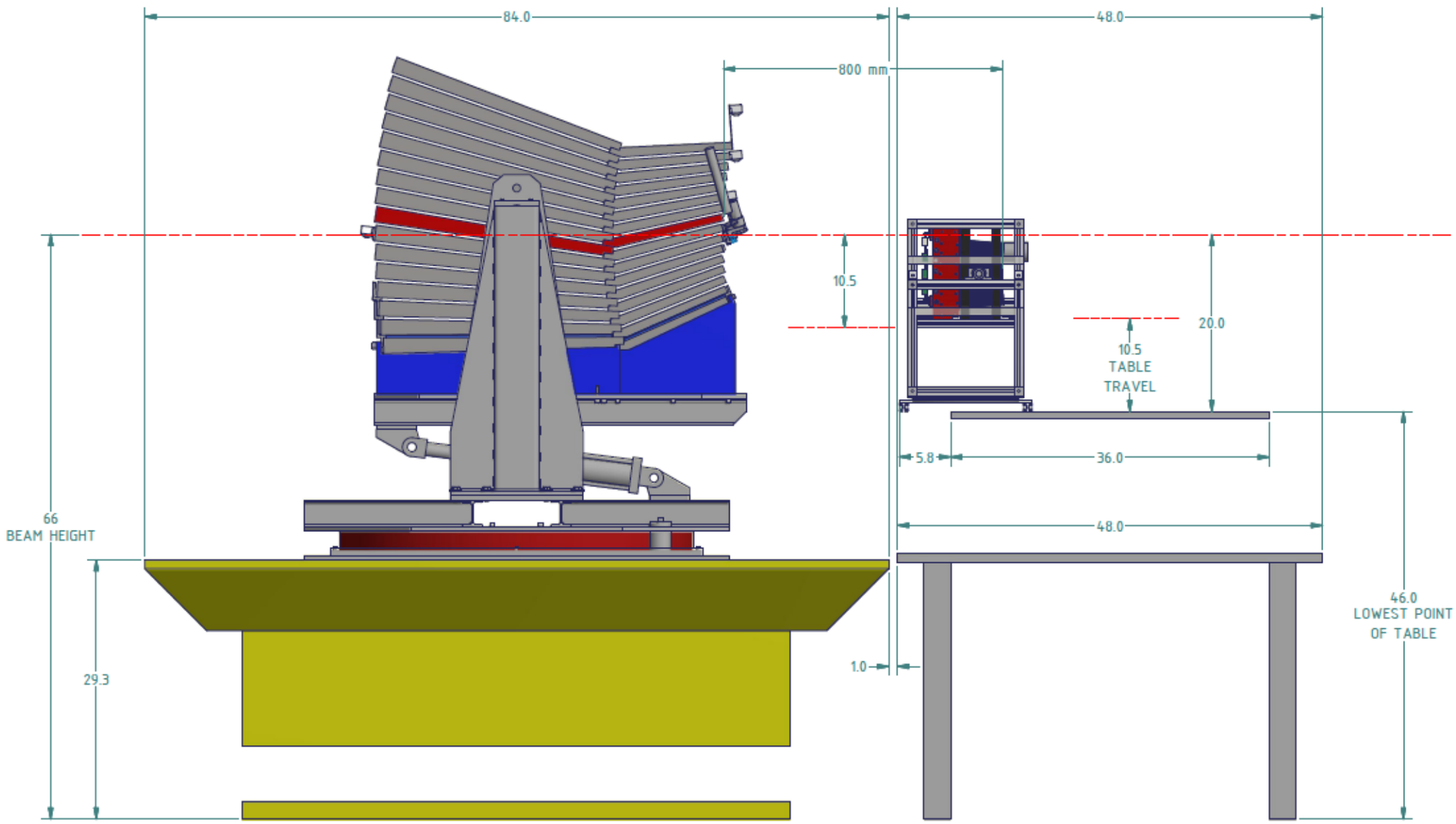


prototype in FNAL test beam

scintillator readout
via imbedded fibers
bundled together
and read by a SiPMs
and waveform digitizers

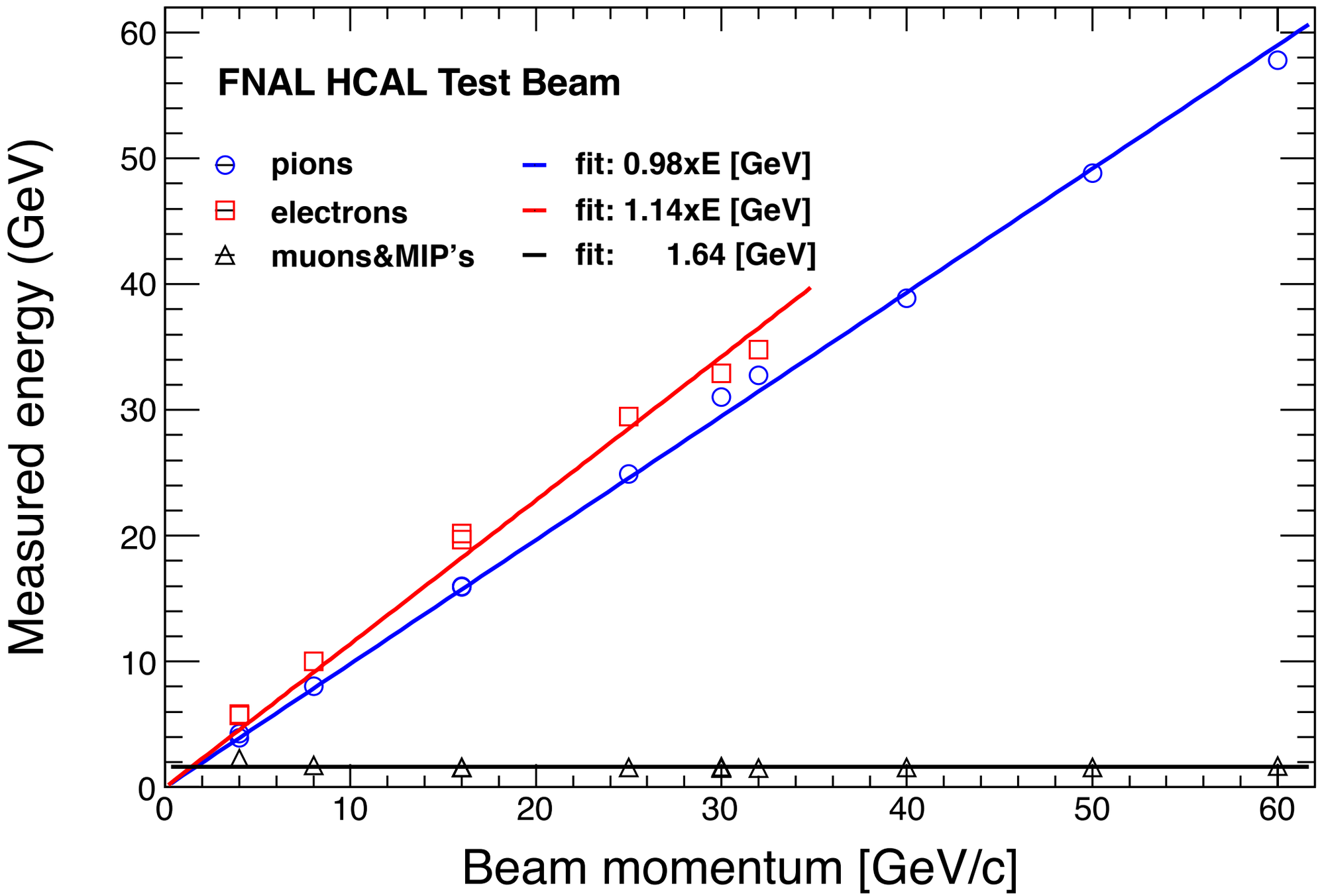


Calorimeter test beam @ FNAL

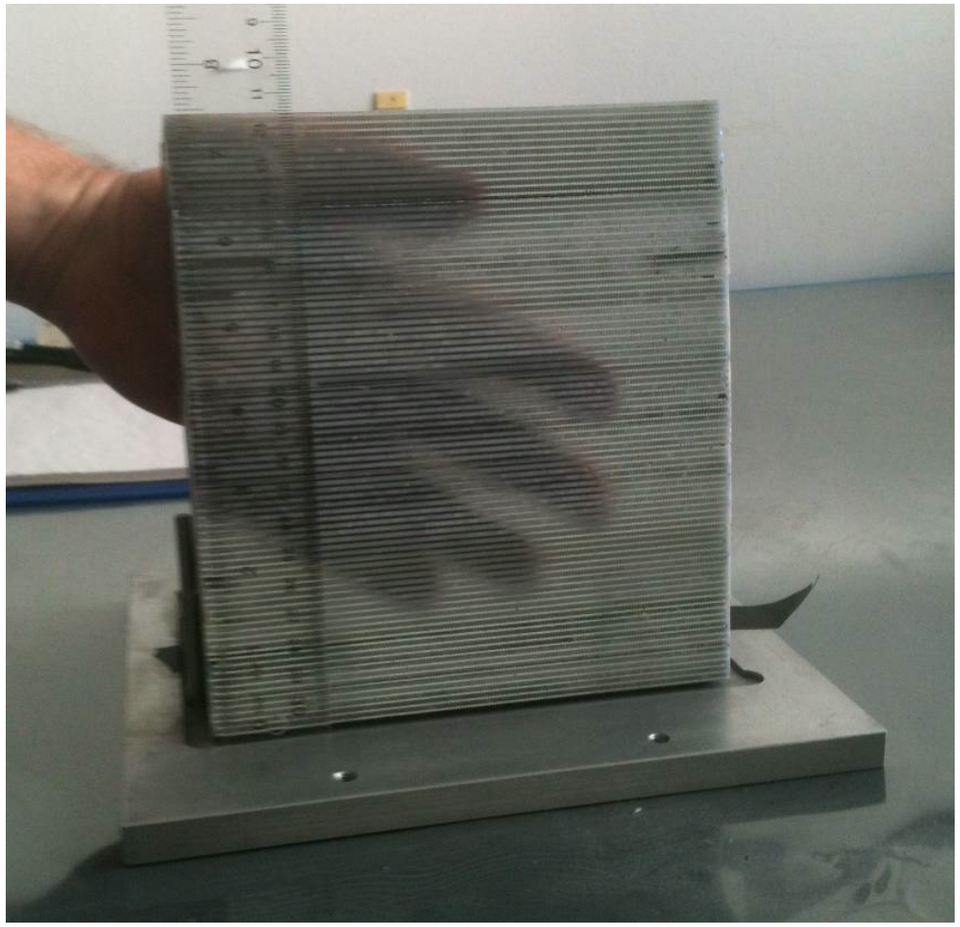


Test of combined EMCAL and HCAL prototypes at Fermilab in Feb 2014
(sPHENIX 2/5-2/25, STAR 2/26-3/18)

current state of HCal analysis

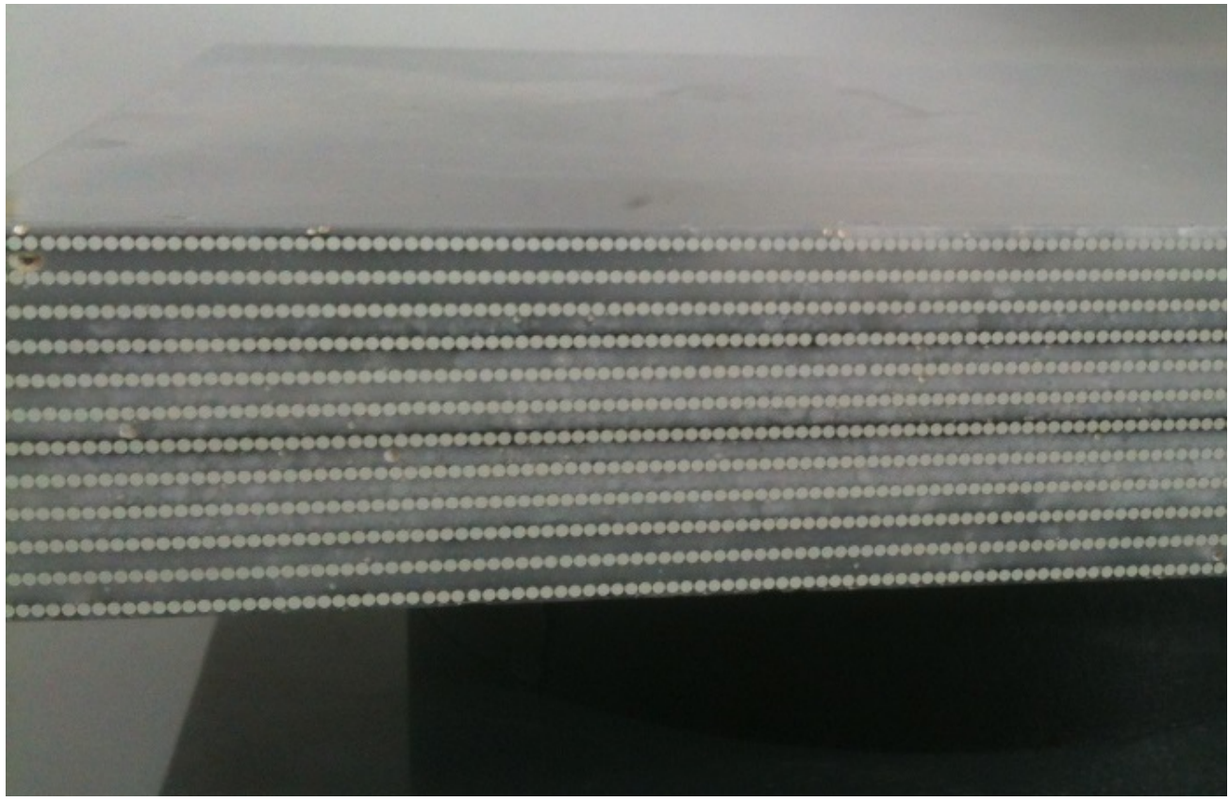


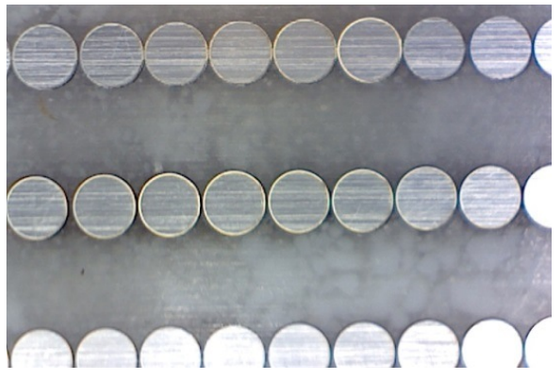
EMCal prototype, flat tapered plates



Looking through absorber stack

Readout end of absorber stack

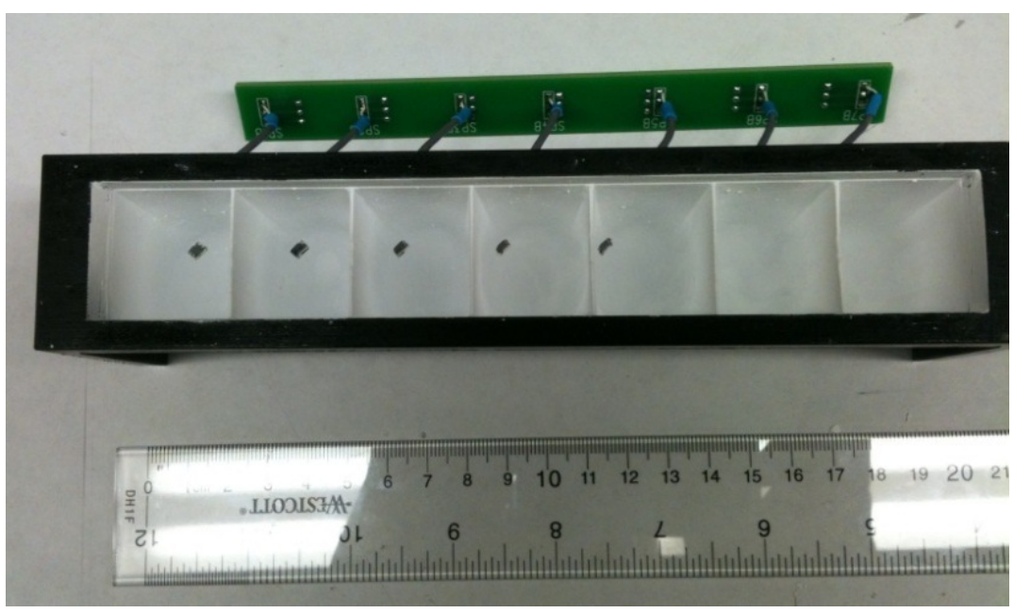


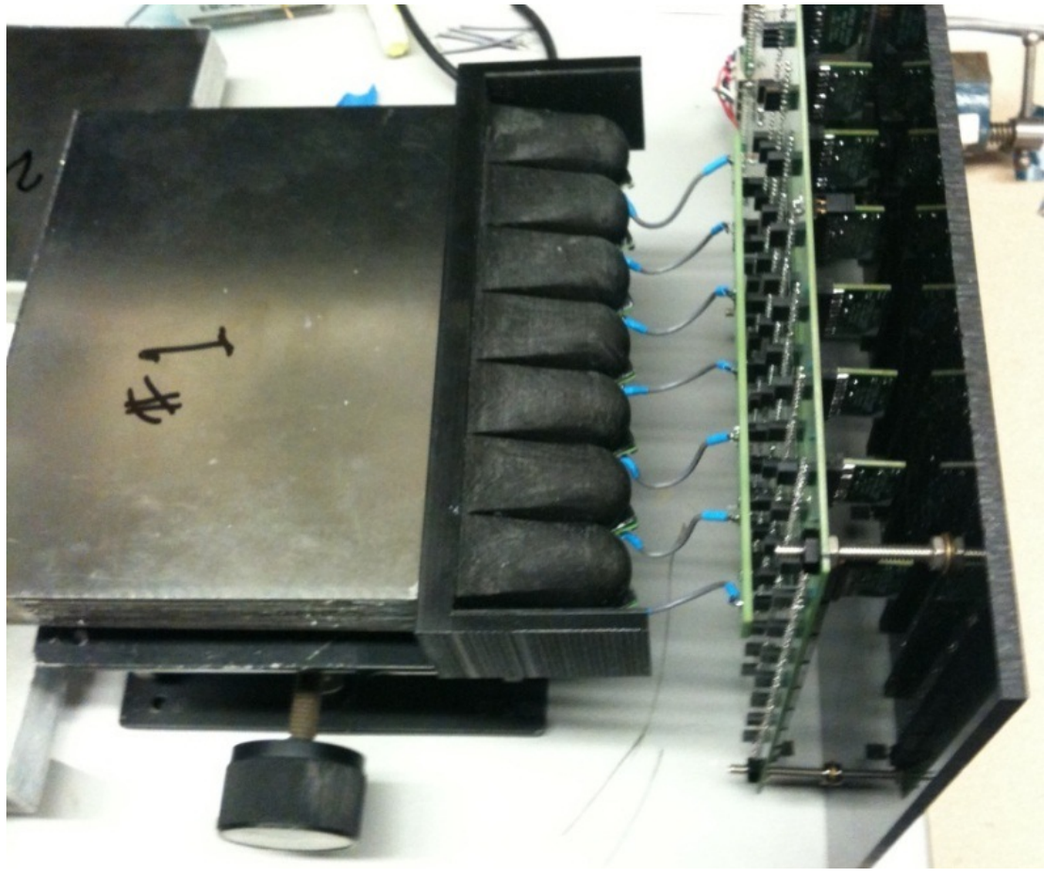


Readout end of module is potted with white reflecting epoxy.
Other end is covered with 3M ESR reflector

EMCal readout for prototype

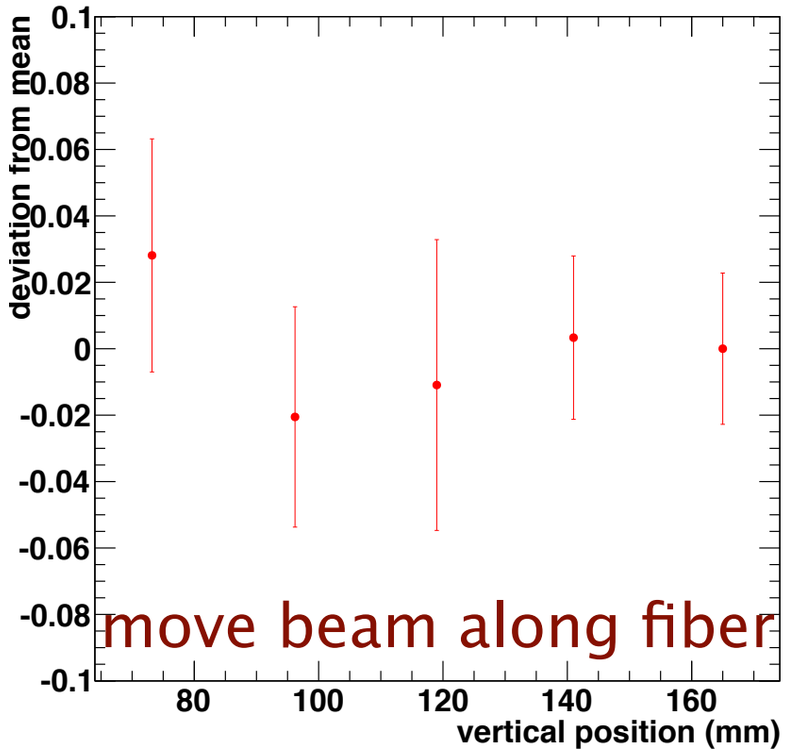
- Plastic collector boxes are 3D printing
- Cavities are coated with a white diffusing reflector
- SiPMs can be mounted to the top or sides of the cavities

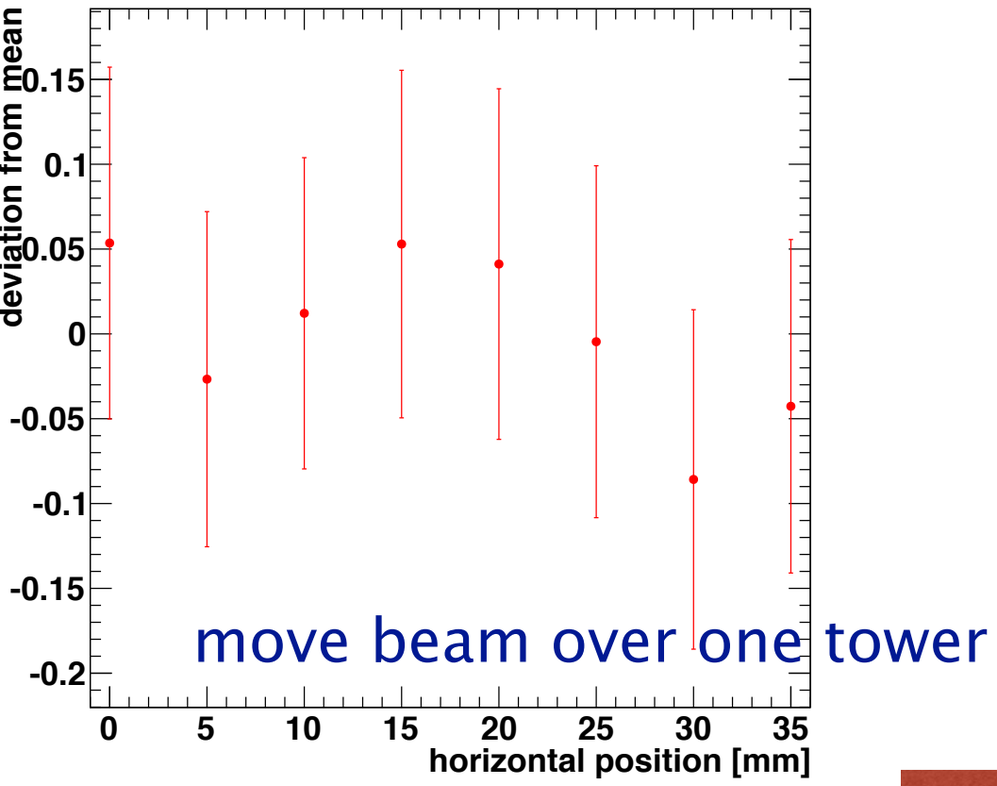




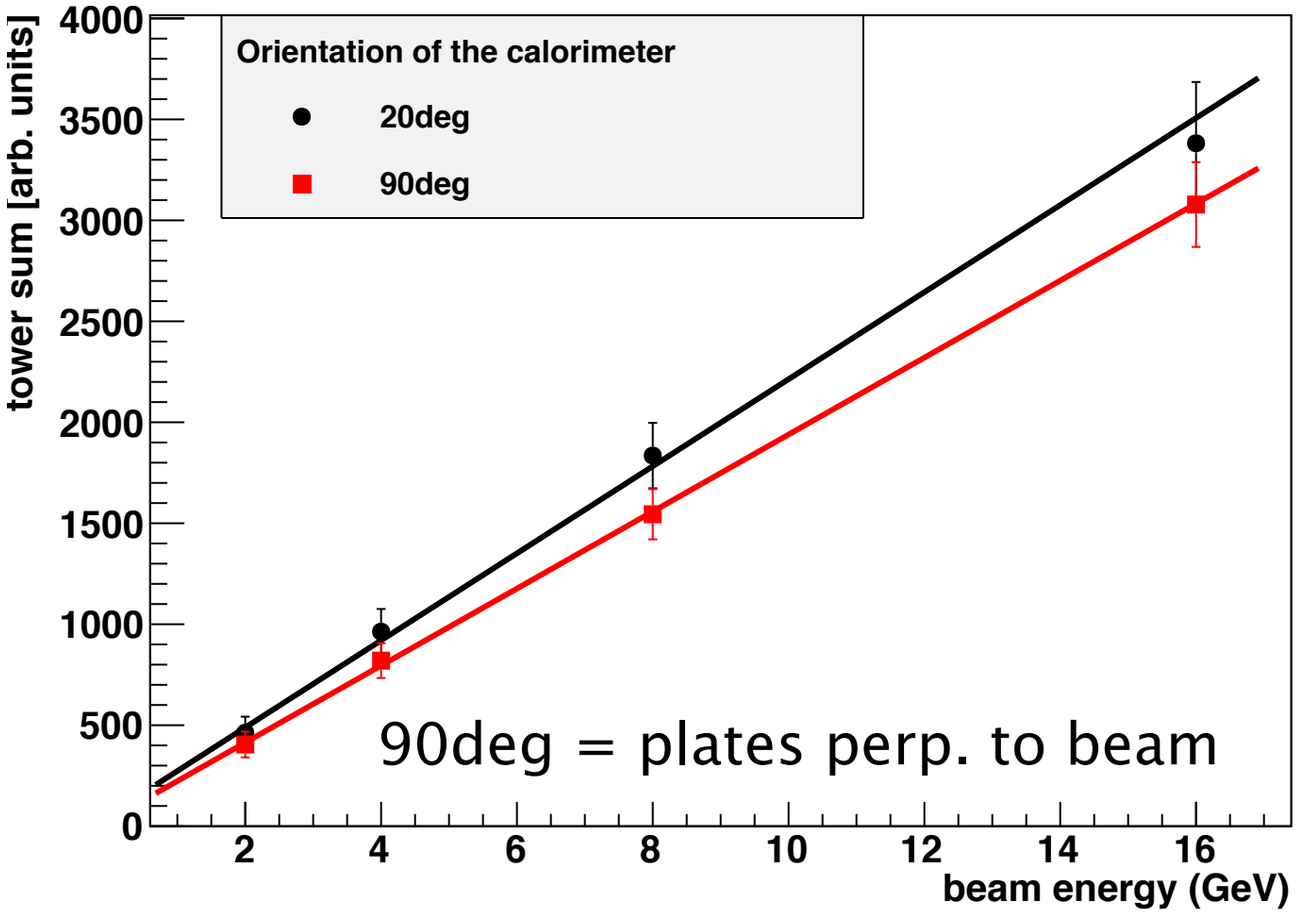
Seven rows of seven cavities mounted to a frame and readout boards are connected at the back again to waveform digitizers

preliminary EMCal test beam data

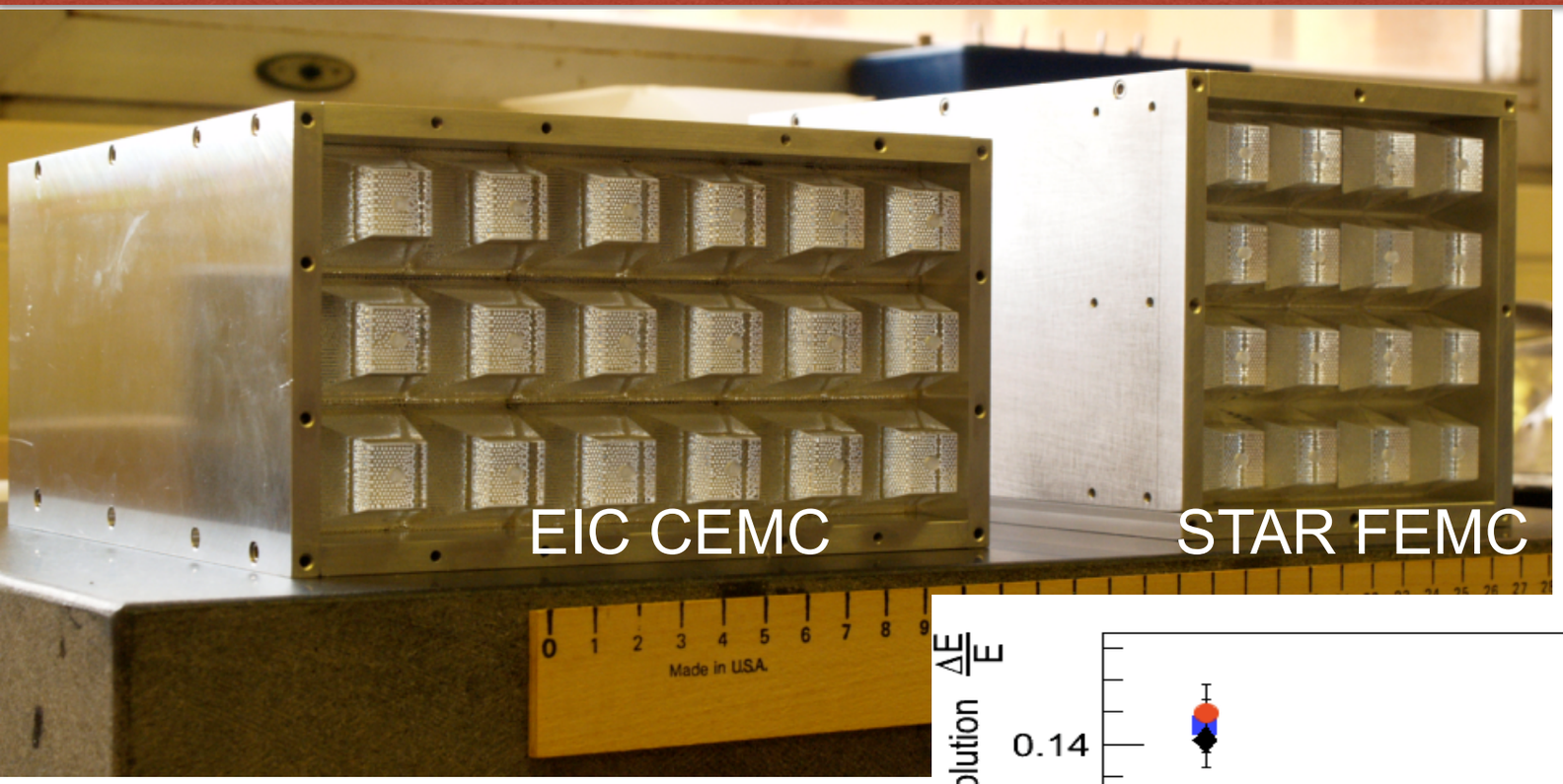




EMCal response
individual towers not calibrated
work in progress

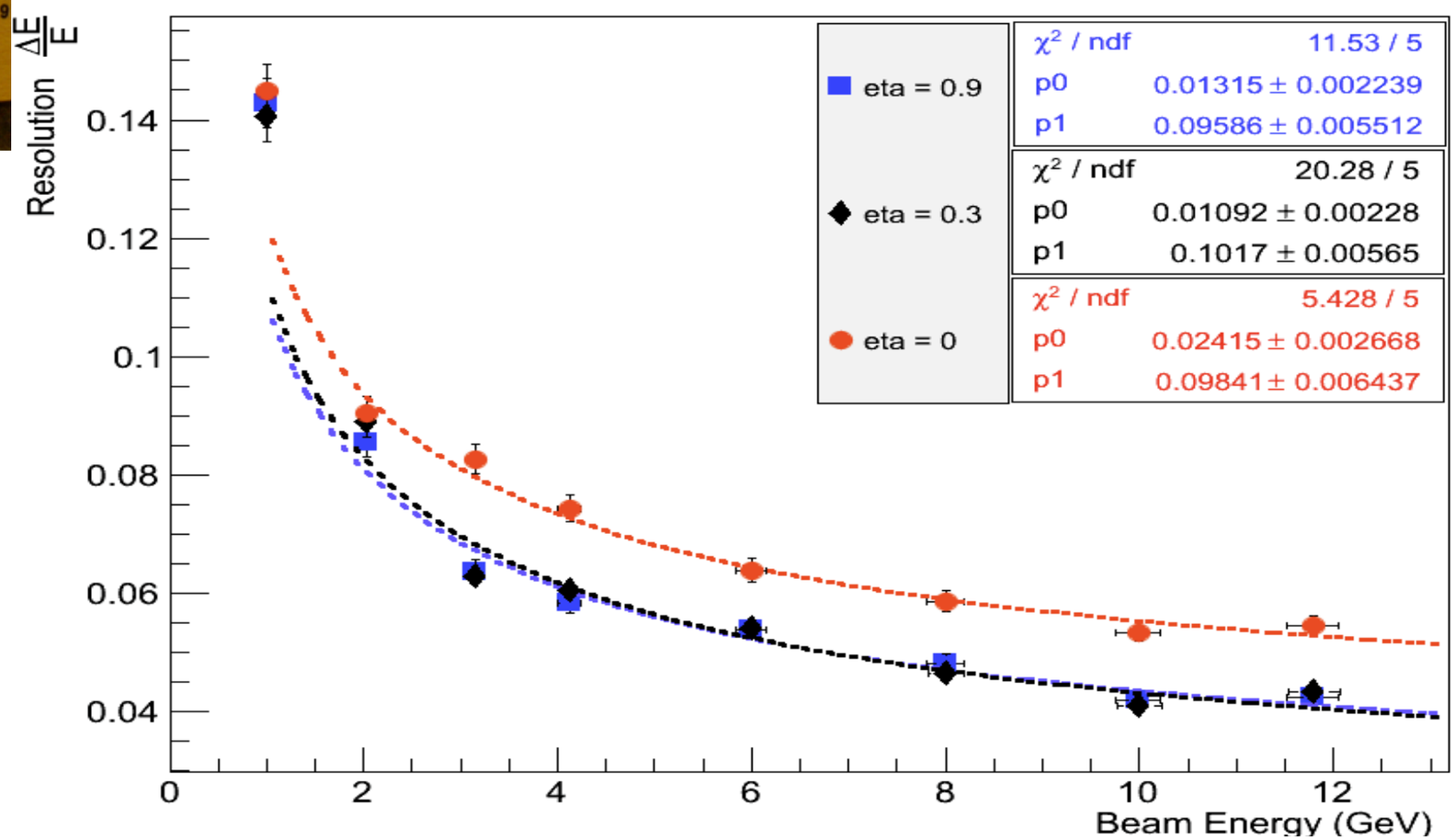


UCLA W–Fiber calorimeter

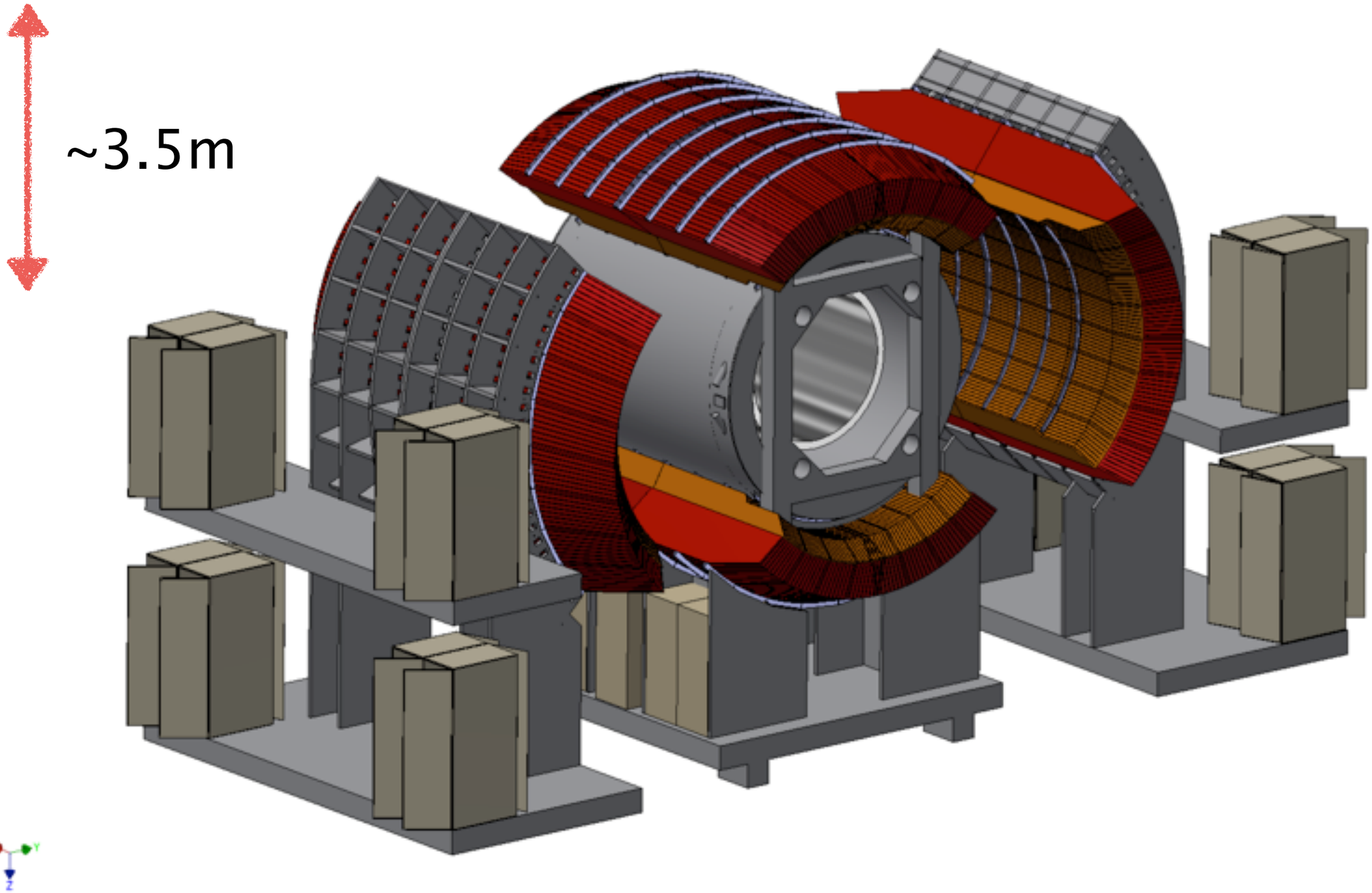


Courtesy:
A.Kiselev (BNL) DIS2014
O. Tsai (UCLA) CALO2014

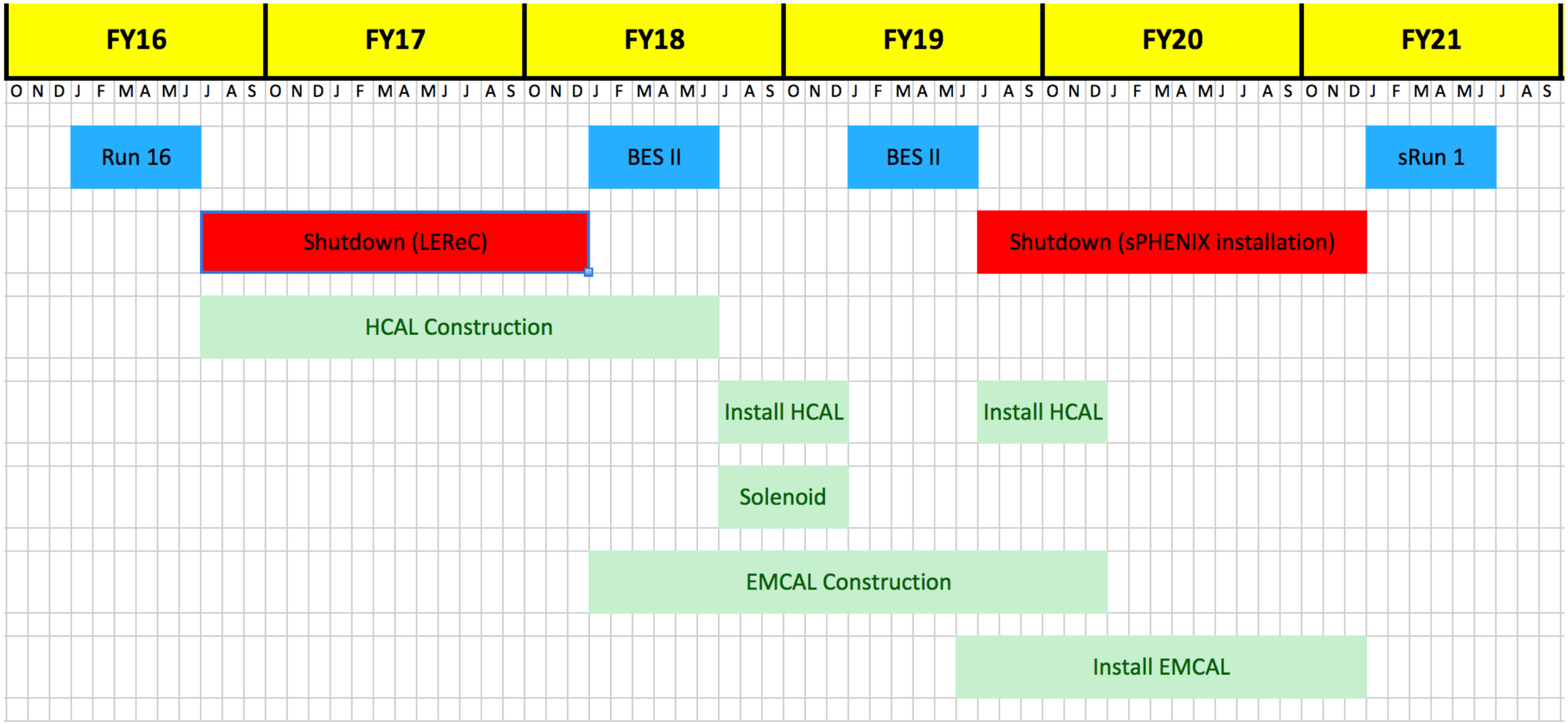
several years of development mature design, possible candidate



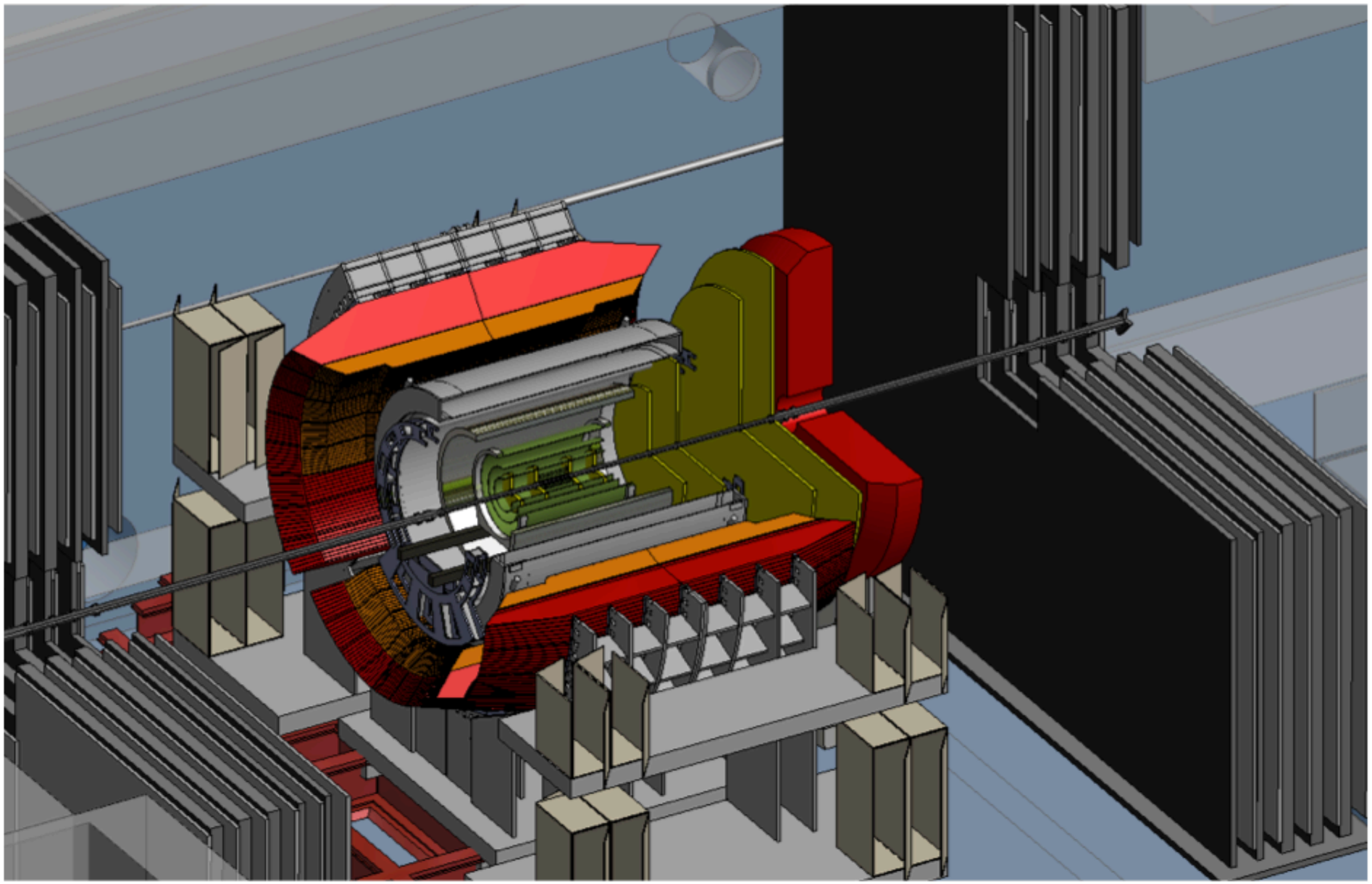
sPHENIX concept



sPHENIX timeline



fsPHENIX concept add forward physics



RHIC unique as a source of polarized protons beams

jet production in transversely spin-polarized *p*+*p* and *p*+A collisions

probe of the parton densities in nuclei at small-*x*

forward-central jet correlations

summary

- concept for sPHENIX
- MIEs submitted, available from PHENIX website, http://www.phenix.bnl.gov/plans.html
- few decisions on technologies still pending, e.g. might adopt the UCLA EMCal design
- several physics and PM review in the coming months
  e.g. DOE science review is planned for July 2014
- this is really a new experiment based on PHENIX infrastructure so new collaborators are welcome
- http://www.phenix.bnl.gov/phenix/WWW/publish/dave/PHENIX/sPHENIX_MIE_09272013.pdf
- http://www.phenix.bnl.gov/phenix/WWW/publish/dave/sPHENIX/pp_pA_whitepaper.pdf