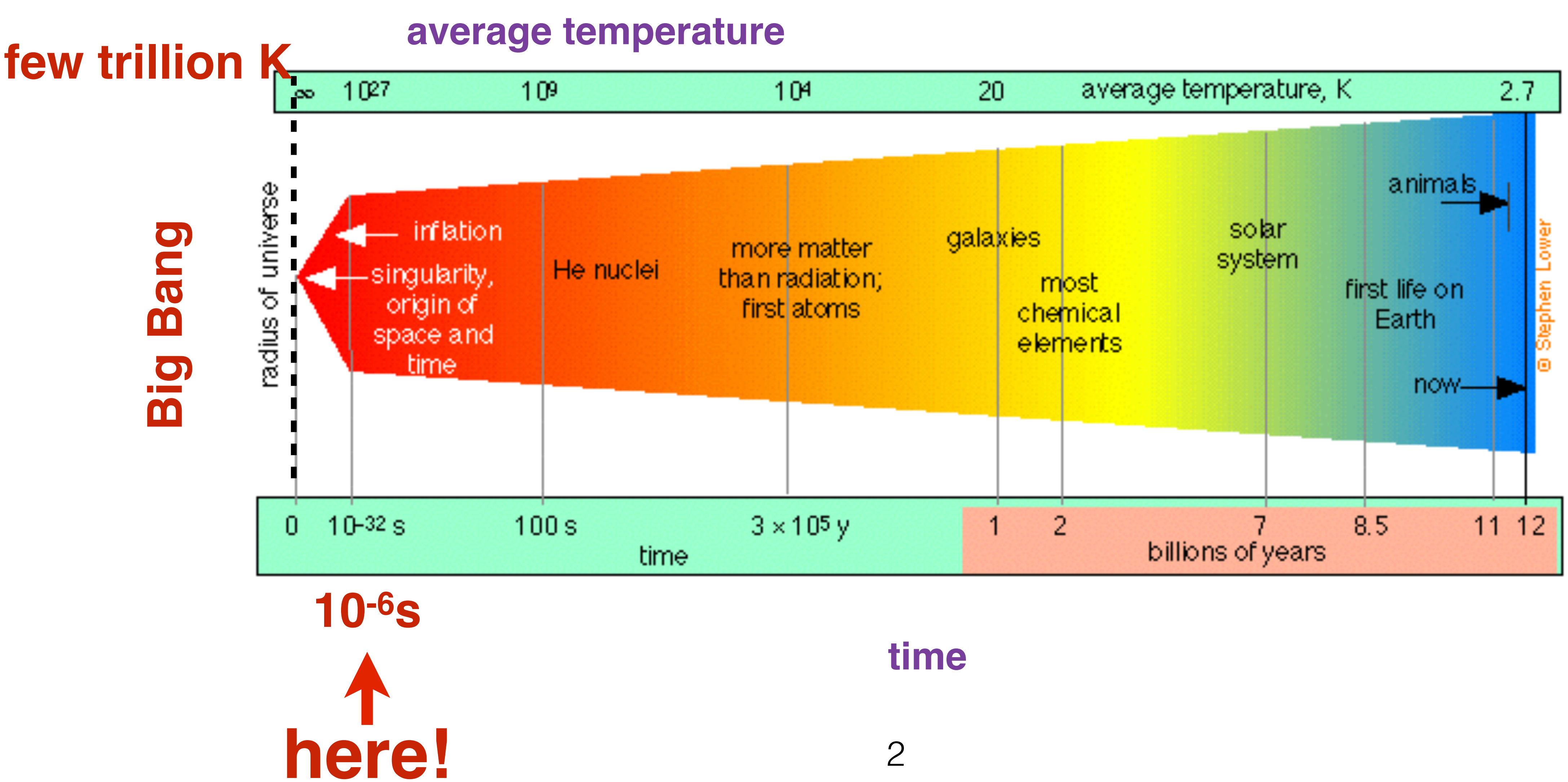
Preliminary Results of a Tungsten Powder Epoxy Scintillating Fiber EMCAL for sPHENIX

Vera Loggins
University of Illinois Urbana Champaign
Sept 27, 2016

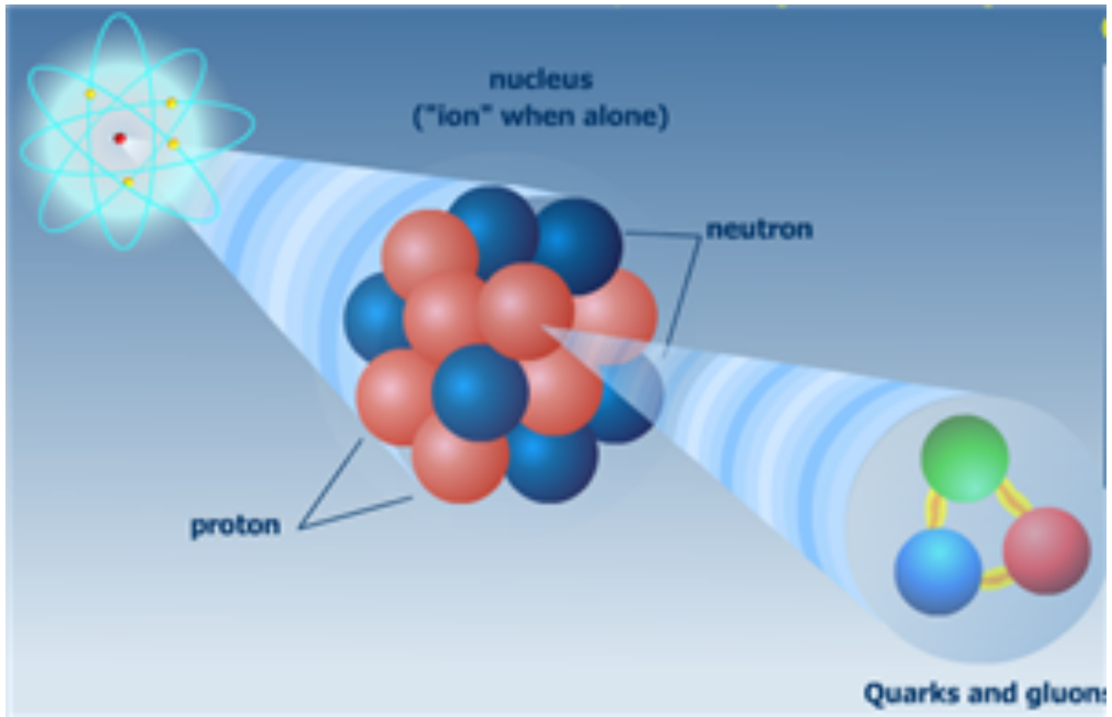
22nd International Spin Symposium

Motivation of Research

- Presently, the understanding is that all matter and energy of the universe sprang from a single point.
- We recreate the conditions of the early Universe, in particular a form of medium created, the Quark Gluon Plasma (QGP).
- As the universe cools down, almost all the mass of visible mater sits in nucleons.
- Therefore is important to study QCD in both phases, the QGP and the nucleon.

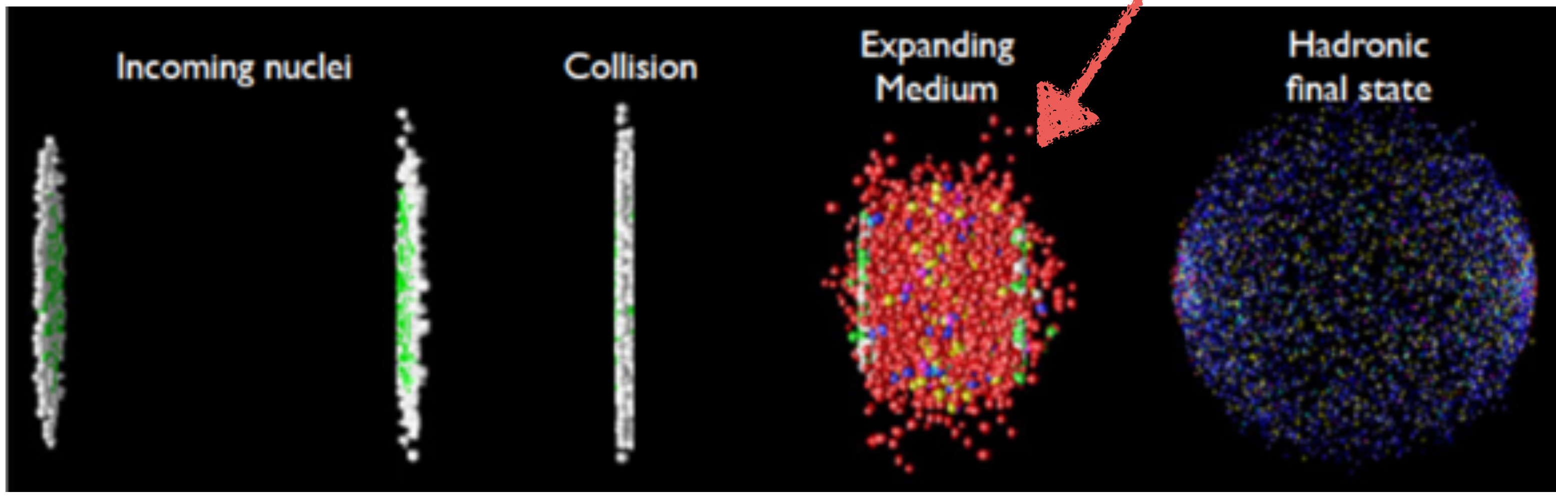


Motivation of Research

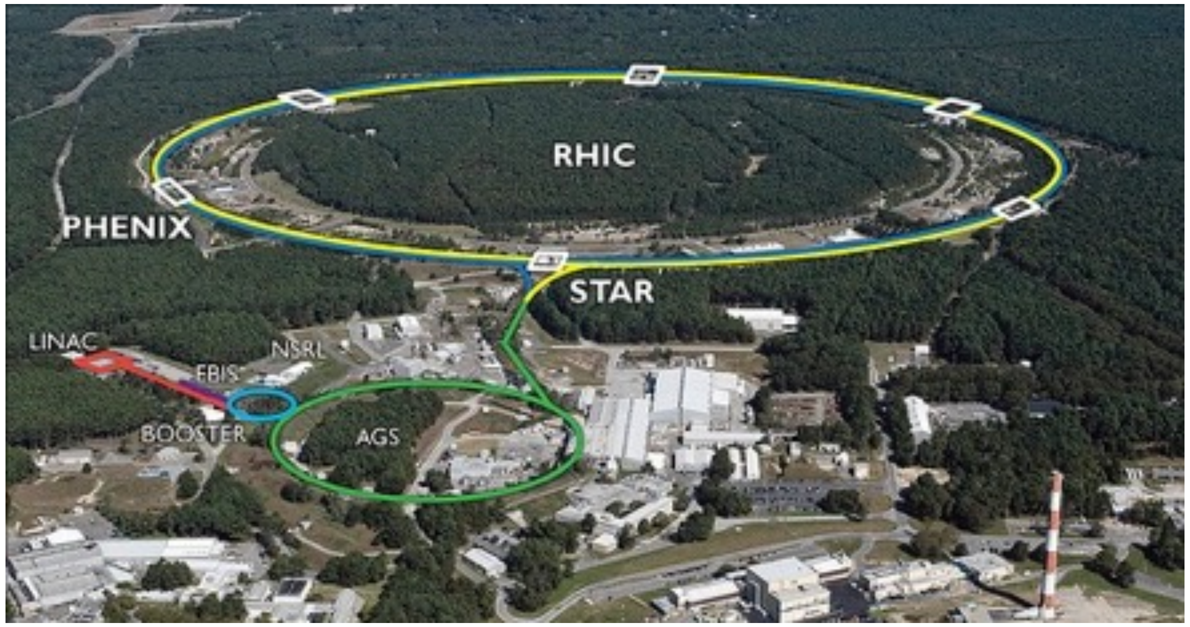


Stages of a large nuclei collision

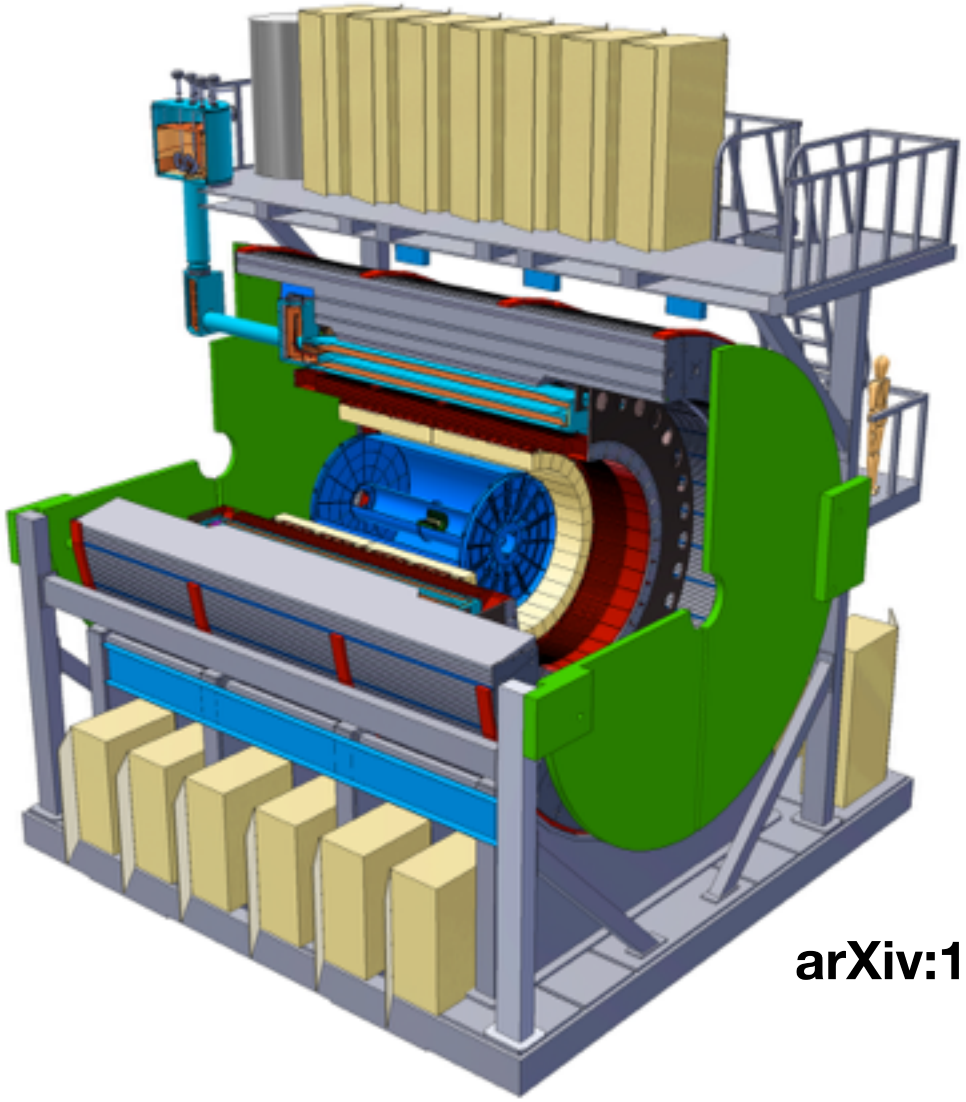
Quark Gluon Plasma

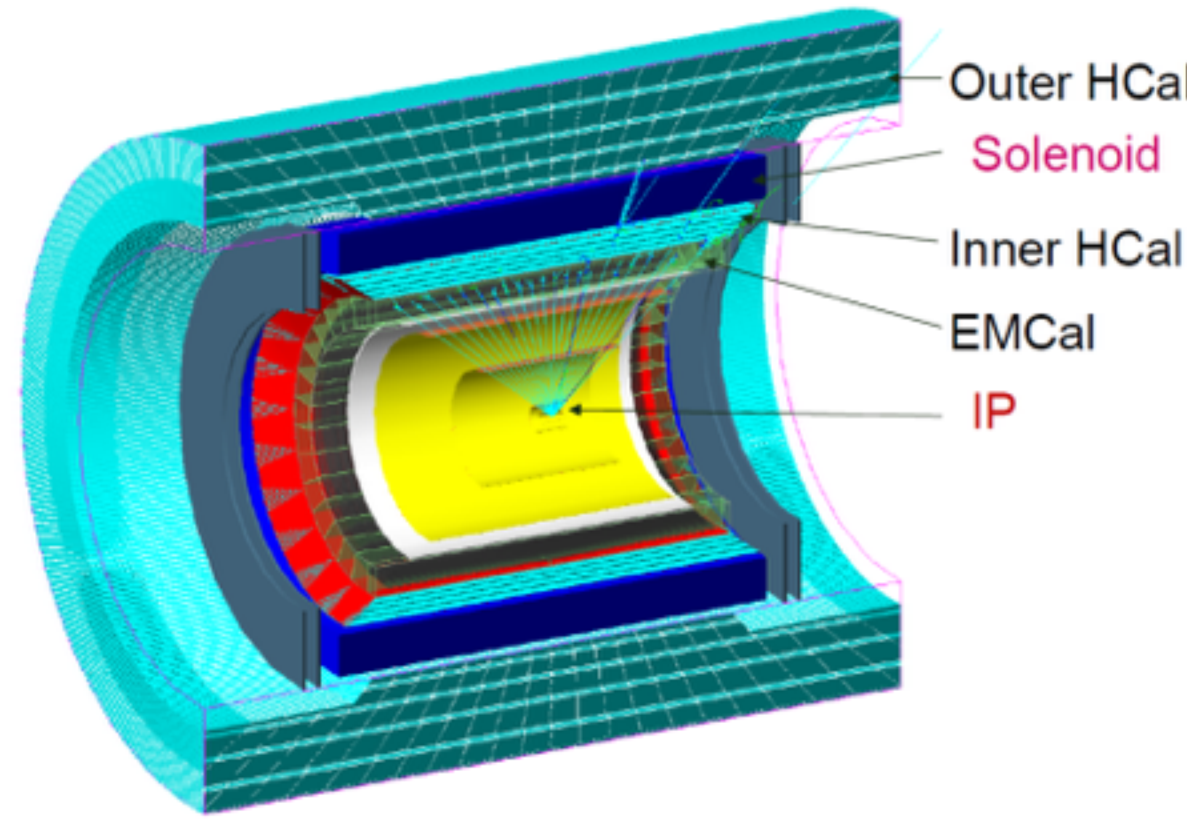


Besides heavy ion physics, RHIC is also the world's only polarized proton collider, which provides a unique window into the nucleon spin structure.



sPHENIX





arXiv:1501.06197

- sPHENIX is a proposed new detector at the Relativistic Heavy Ion Collider which will take data in early 2020s.
- sPHENIX focuses on jet and hard probes as well as quarkonia to address the fundamental questions about the nature of the strongly coupled quark-gluon plasma (QGP).
- sPHENIX also open up opportunities for further spin measurements with polarized proton collisions using the pi0, direct photon and jet production channels. - See talks in H.W. Yu (session Helicity) and J. Lajoie (session Future)
- The letter of intent to use sPHENIX as a foundation for a day-1 electron ion collider detector (EIC). arXiv:1402.1209

sPHENIX Requirements

Physics:

- Measure jets, γ-jets, and direct single γ's up to high p_T.
- Identify electrons and measure their energies for measuring Υ's.
- Kinematic range will have more overlap with the LHC.
- jet energy resolution:

−single particle: $\sigma / E < 100\% / \sqrt{E}$

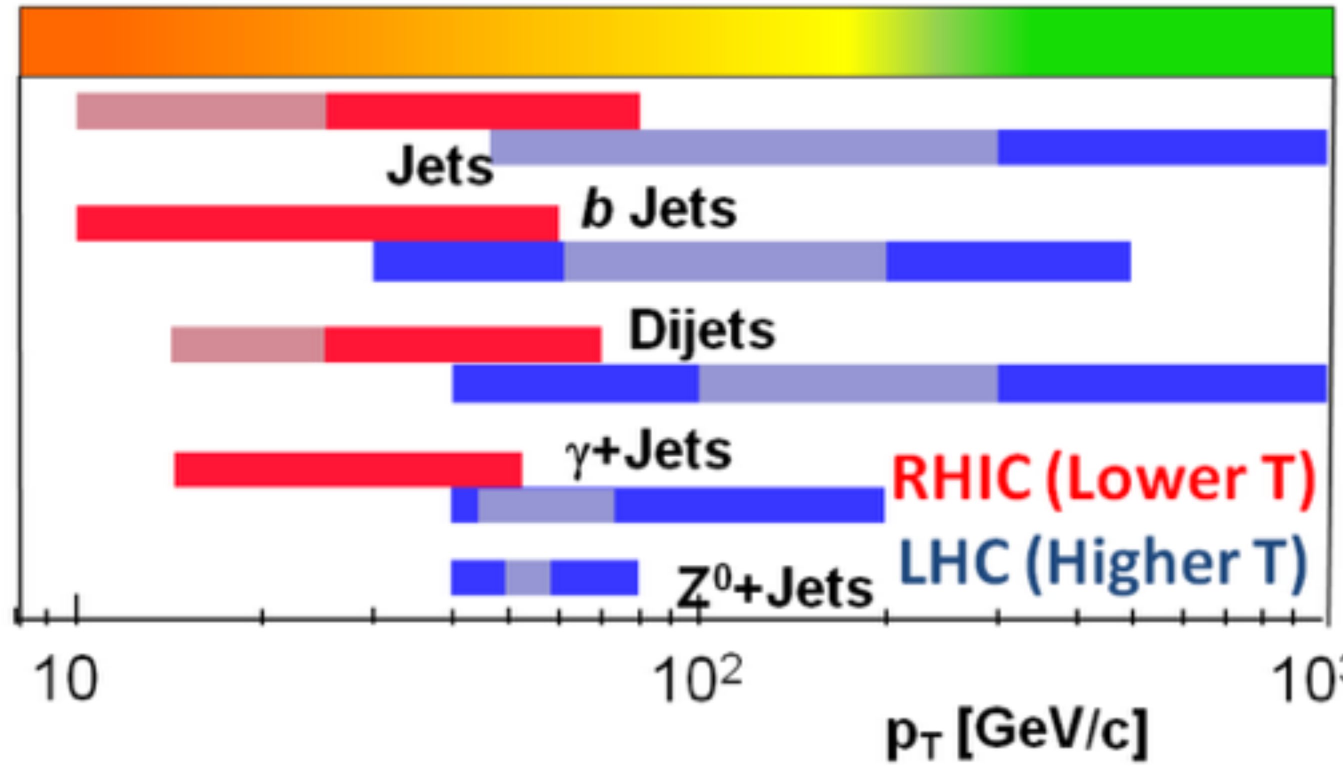
−jet : $\sigma / E < 120{,}150\% / \sqrt{E}$

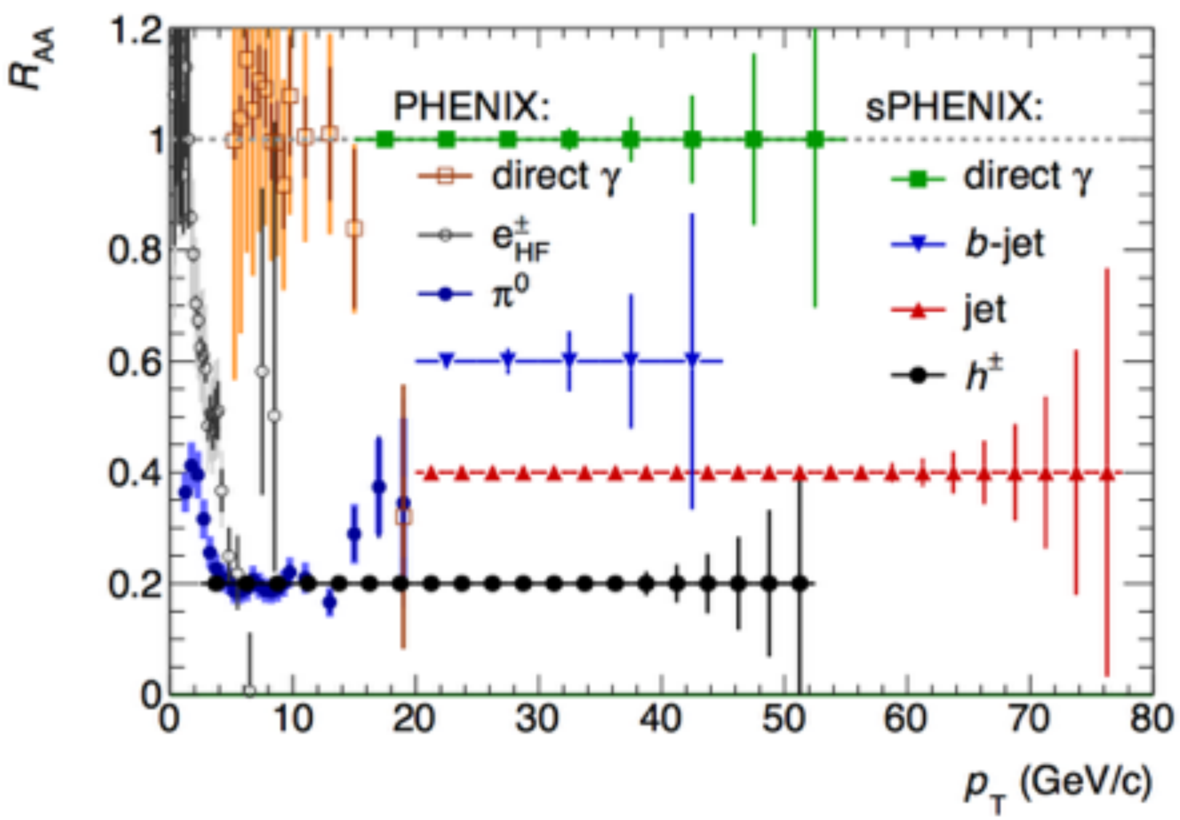
- gamma-jet emcal energy resolution:

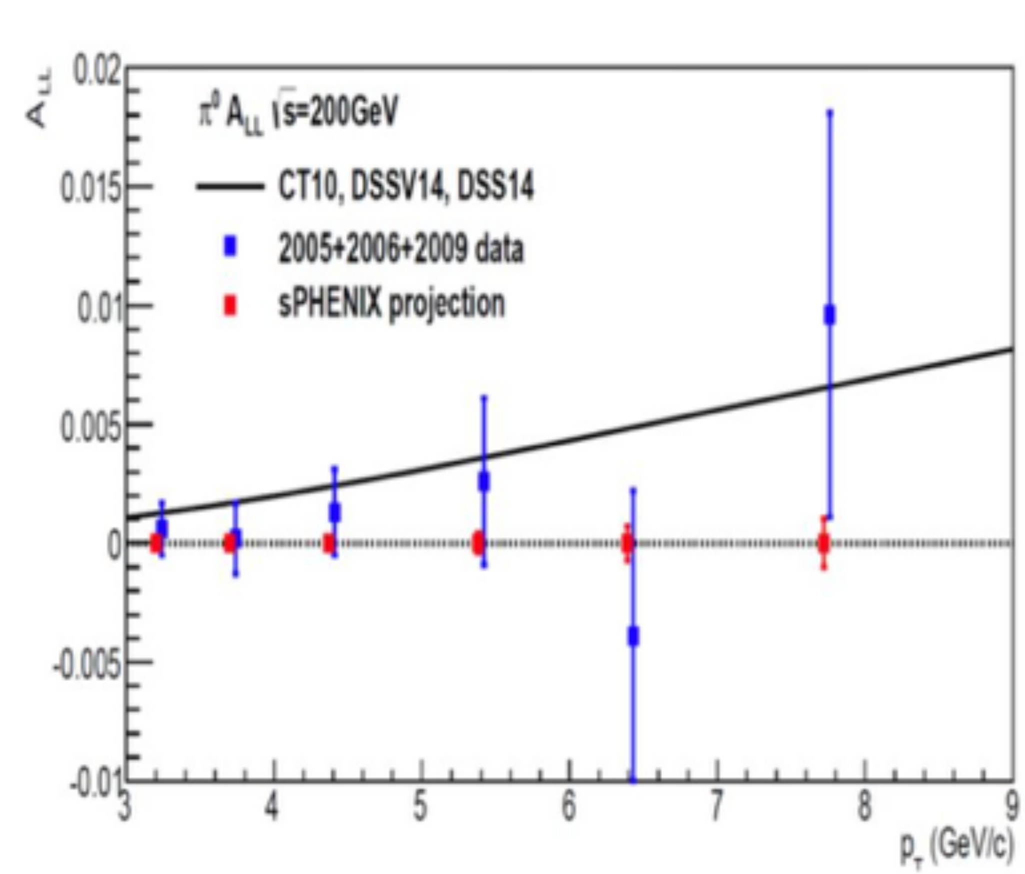
$-\sigma / E < 15\% / \sqrt{E}$

Detector:

- Large solid angle coverage (± 1.1 in η, 2π in ϕ)
- good energy resolution
- Fit inside the BaBar magnet
  - minimal radial space (dense)
  - compact (short X_0, small R_M)
  - high segementation for heavy ion physics

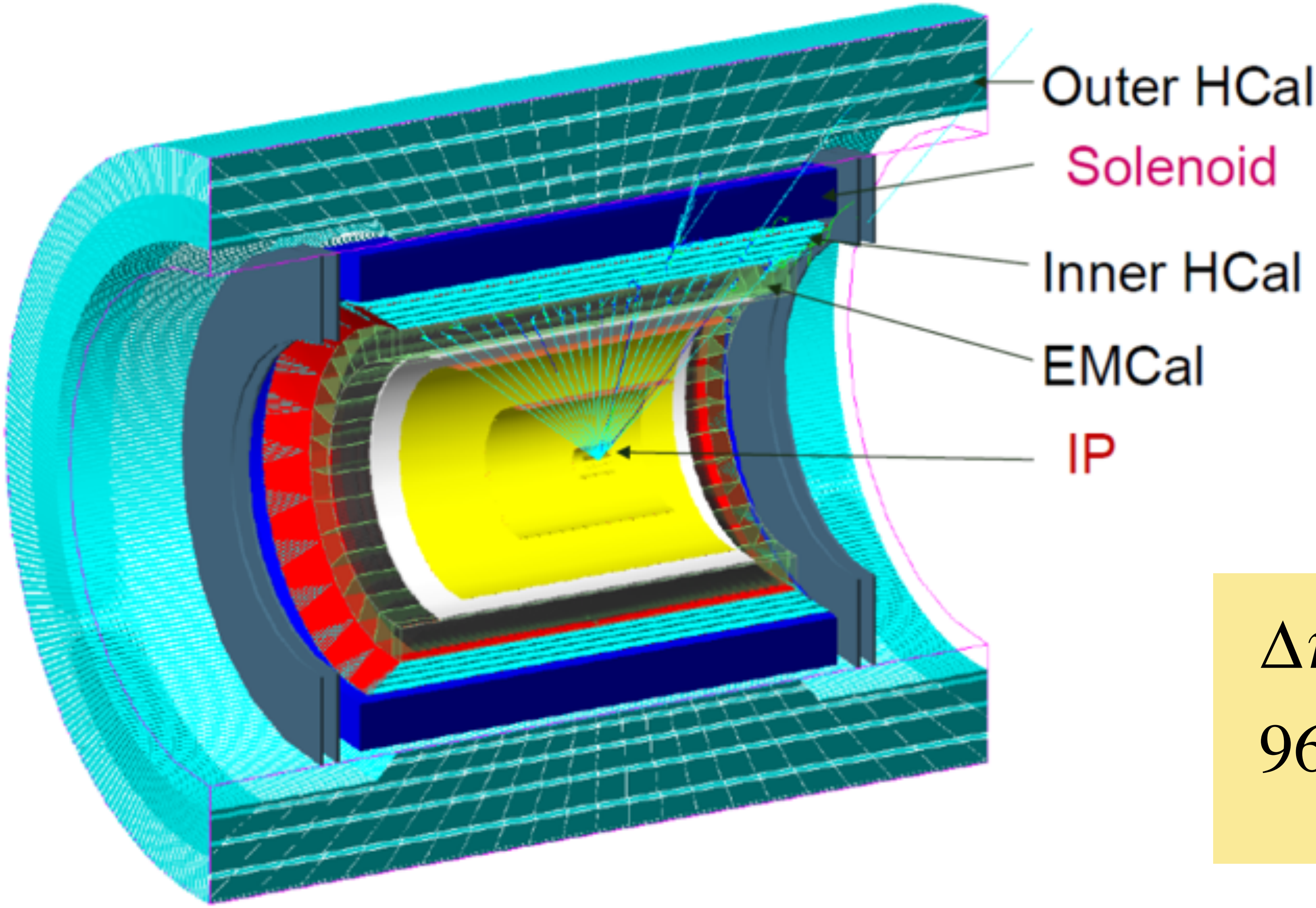




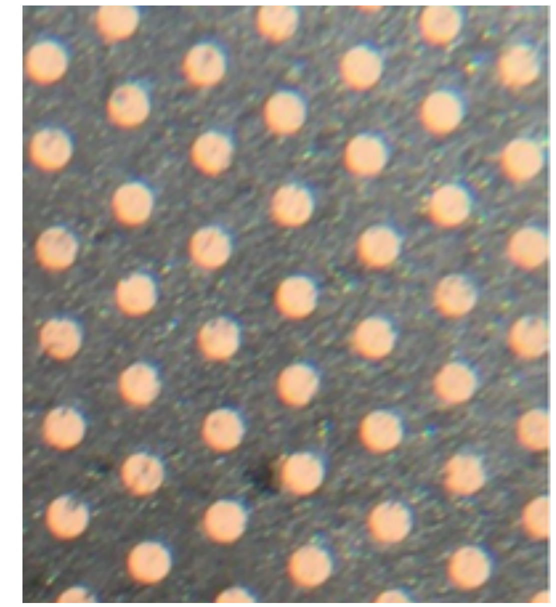


See talks in H.W. Yu (session Helicity)

sPHENIX EMCal



tungsten-fiber block



$$\Delta\eta \times \Delta\phi \approx 0.025 \times 0.025$$

96×256 readout channels

inner radius must be ~ 90 cm for tracking & particle ID

Inner radius must be small

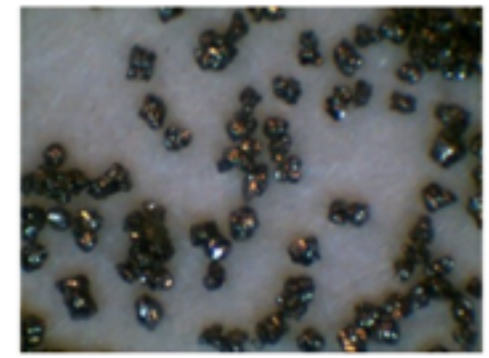
$\Delta R = 116$ cm - 90 cm (26cm)

EMCal tower

EMCAL Materials

Absorber

Matrix of Tungsten powder and epoxy w/embedded scintillating fibers

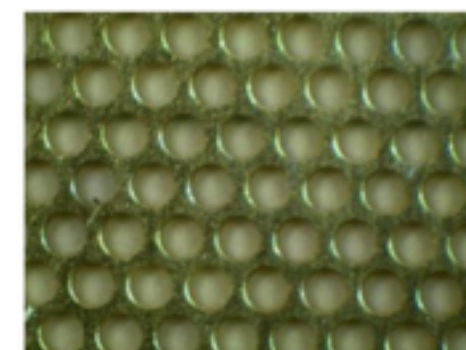


magnified view of powder

Scintillating Fiber (Kuraray SCSF78)

Diameter 0.47 mm, spacing 1mm

scintillating fibers



mesh to hold fibers

Calorimeter Specs

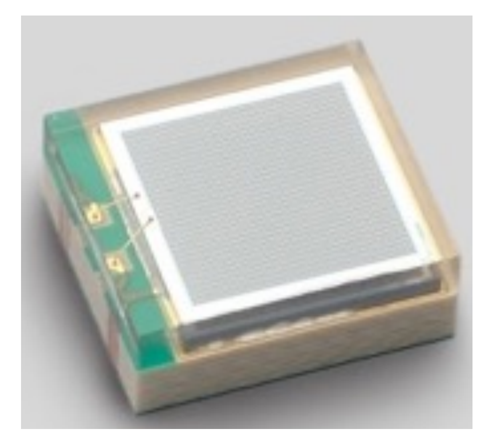
Density ~ 10g/cm^3

X_o ~ 7mm (18 X_o total), R_M~2.3 cm

Readout

Silicon Photomultipliers (SiPMs)

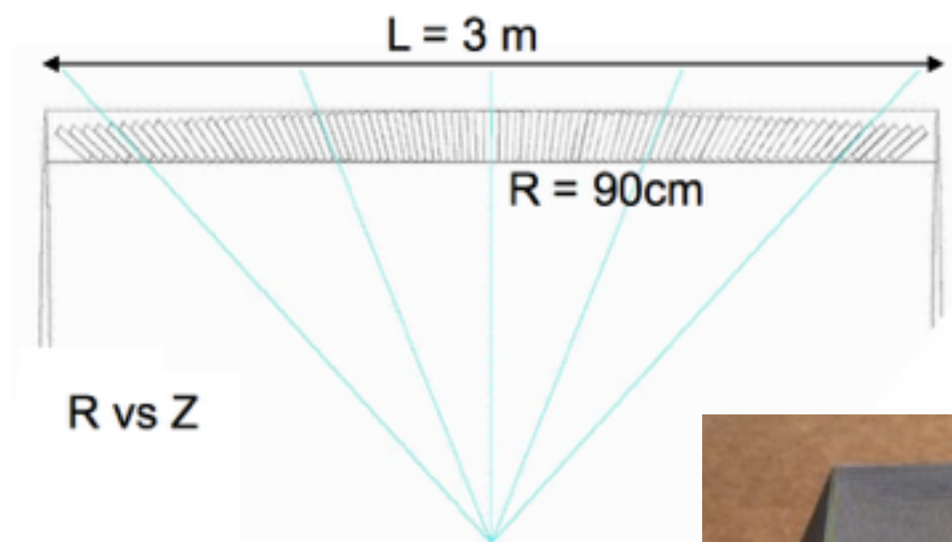
Works inside magnetic field

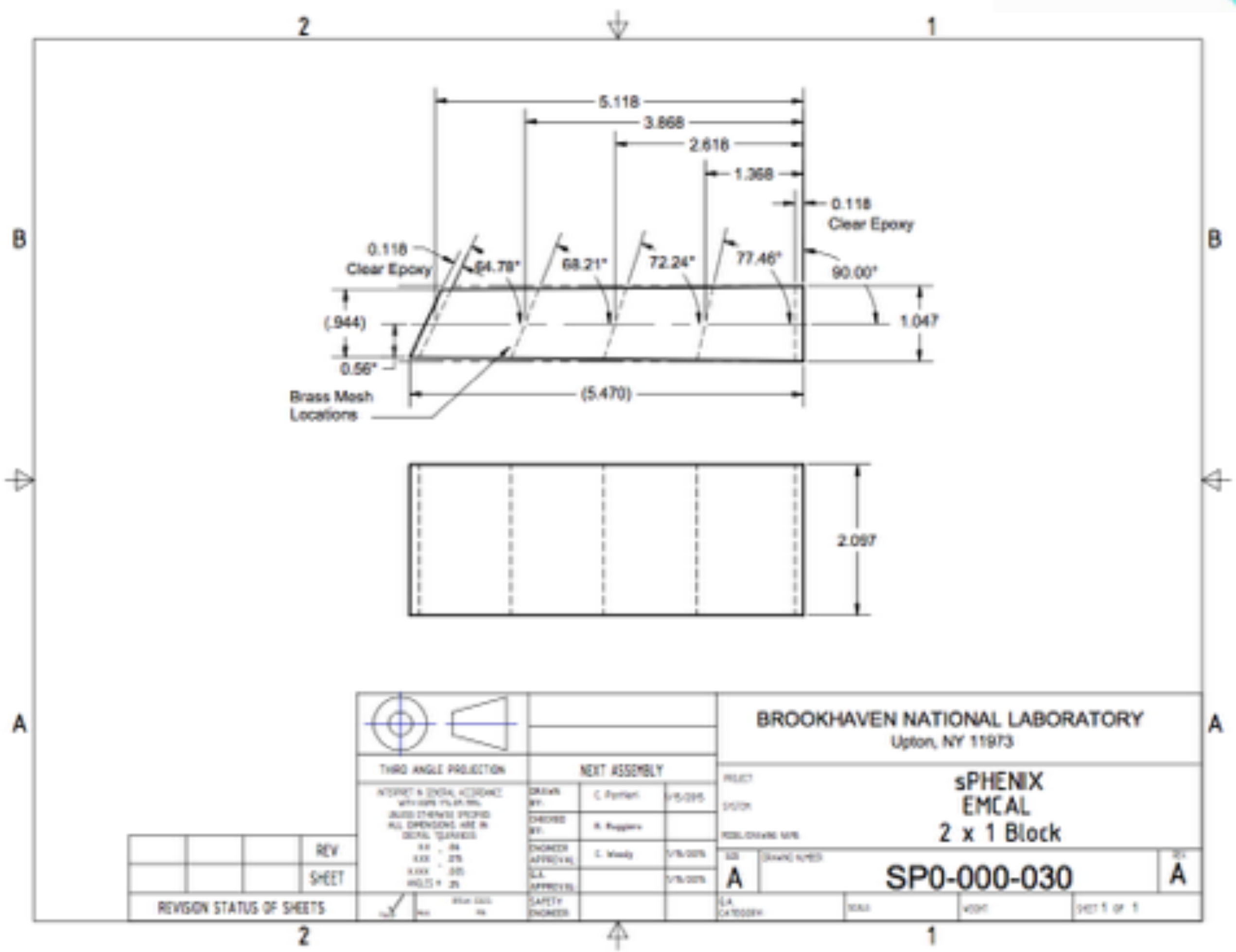


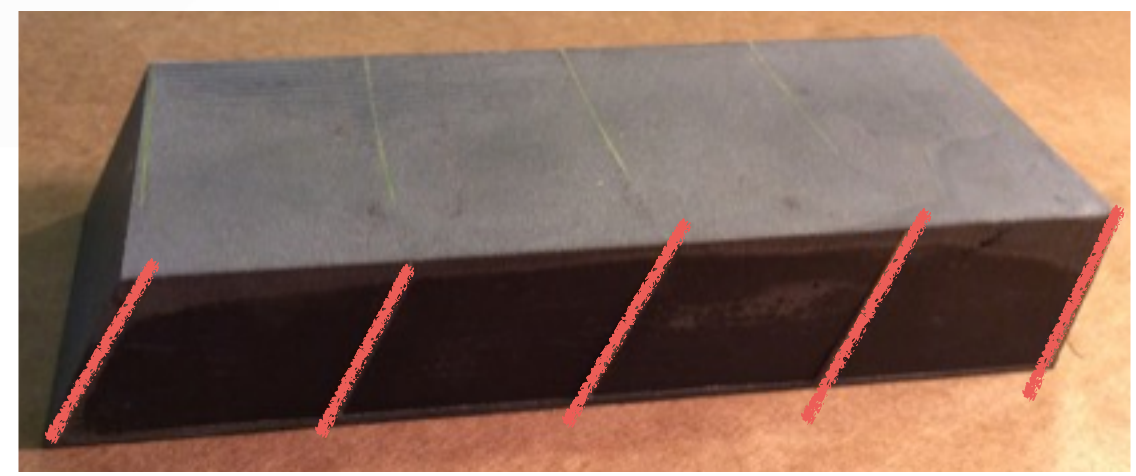
Hamamatsu S12572-015P

Projectivity

The reason for a 2D (fully) projective design is due to the high multiplicity in central heavy ion collisions.





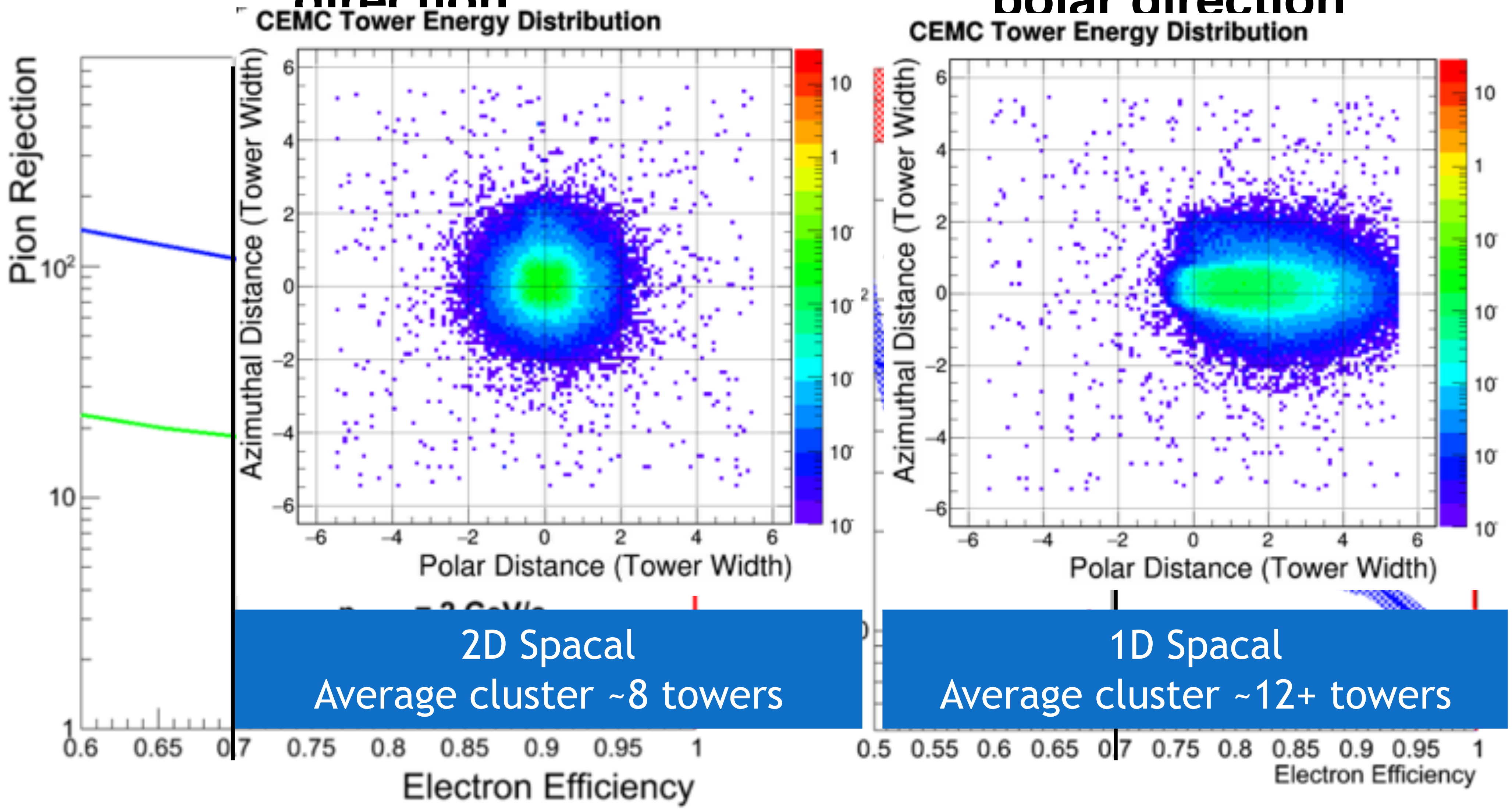


The first way to make the fibers projective was to tilt them in 1D.

Projectivity

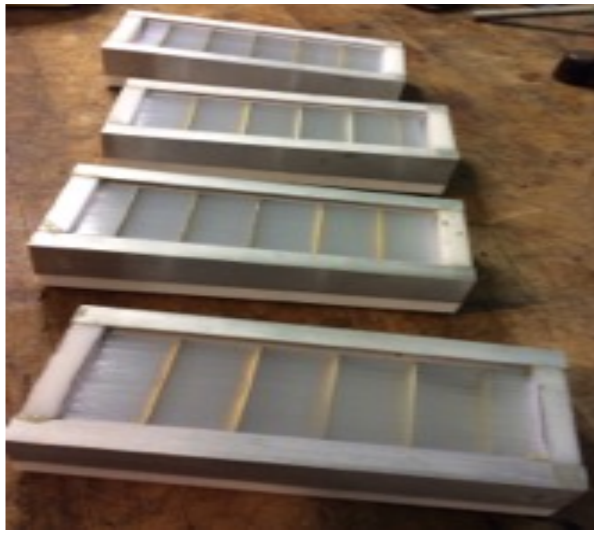
Pion Rejection vs. Electron Efficiency

Projective in polar direction | **Non-Projective in polar direction**



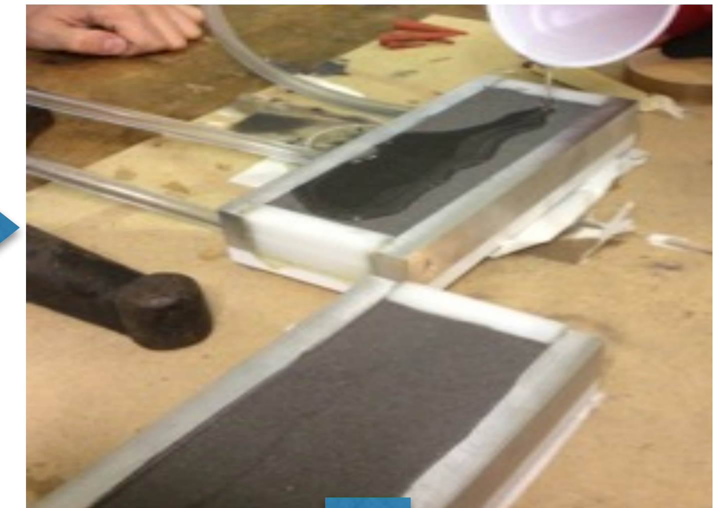
Pion rejection is considerably lower for the non-projective case. This is problematic for Υ measurements which are already rare probes.

sPHENIX EMCal 1D Production @UIUC

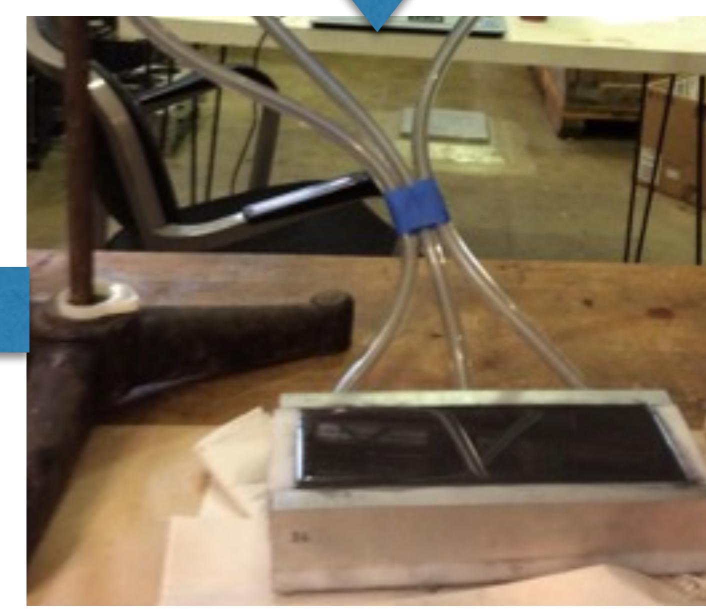


fibers & meshes

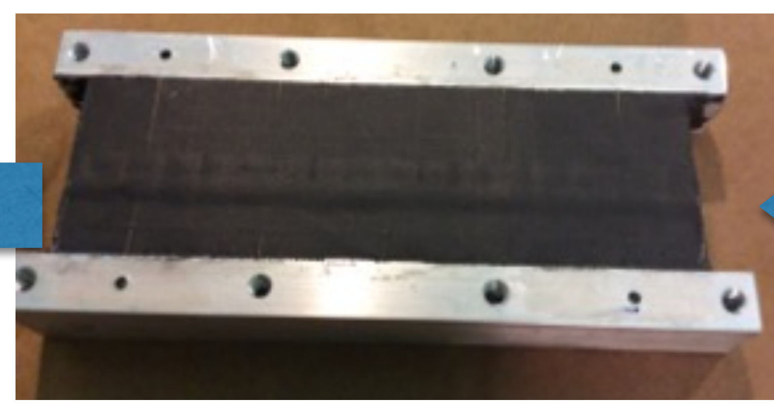
fibers, meshes,
& tungsten



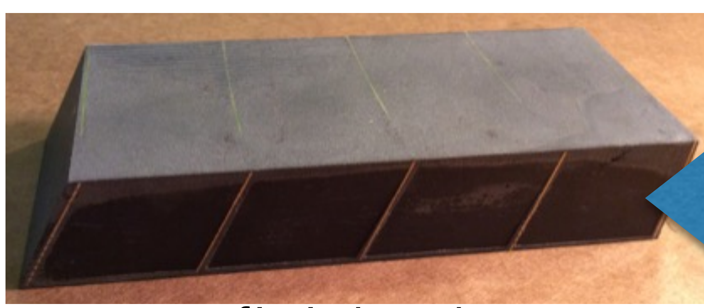
epoxy added



epoxy drying for 24 hours



module ready to be machined



finished

Collaborate with Brookhaven National Laboratory for assembly

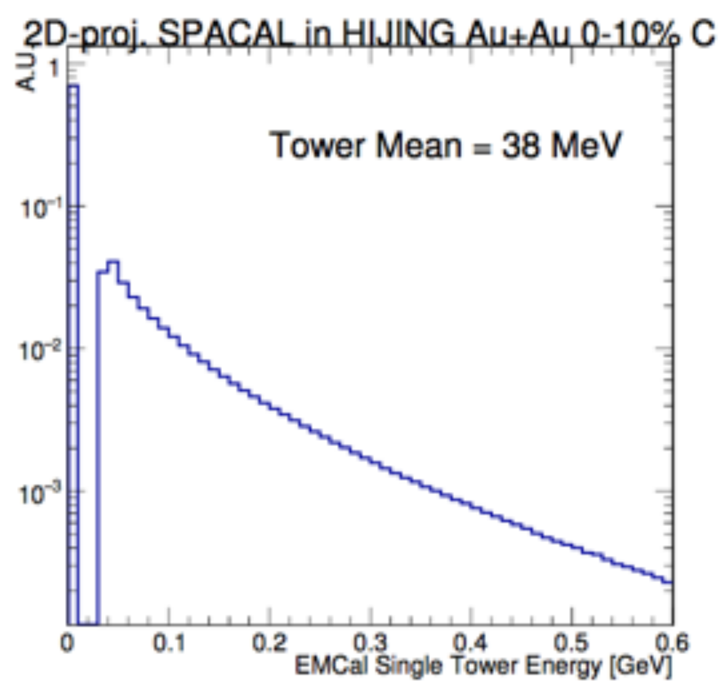
Segmentation Requirement

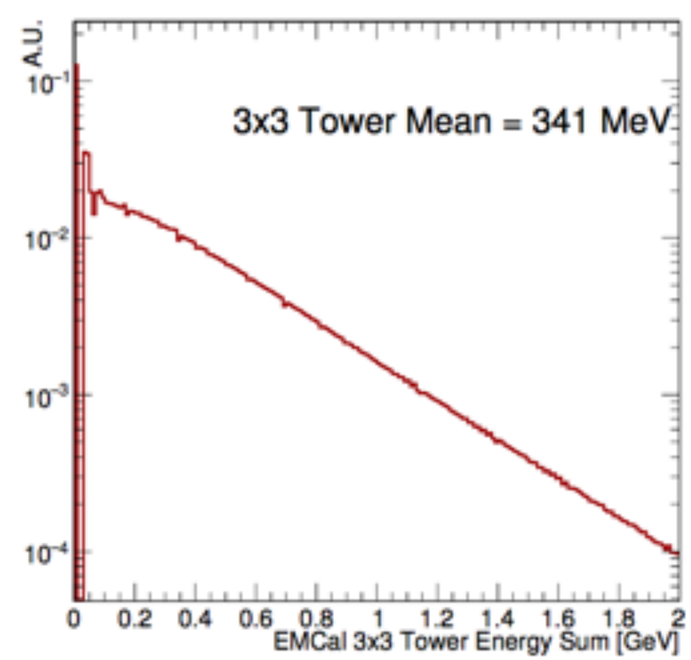
The goal is for detector resolution and segmentation to be better than the limitations on photon reconstruction due to the underlying event background in a heavy ion event.

Hijing Central Au+Au

Average energy per tower ~38 MeV

Energy in a 3x3 tower sum ~341 MeV

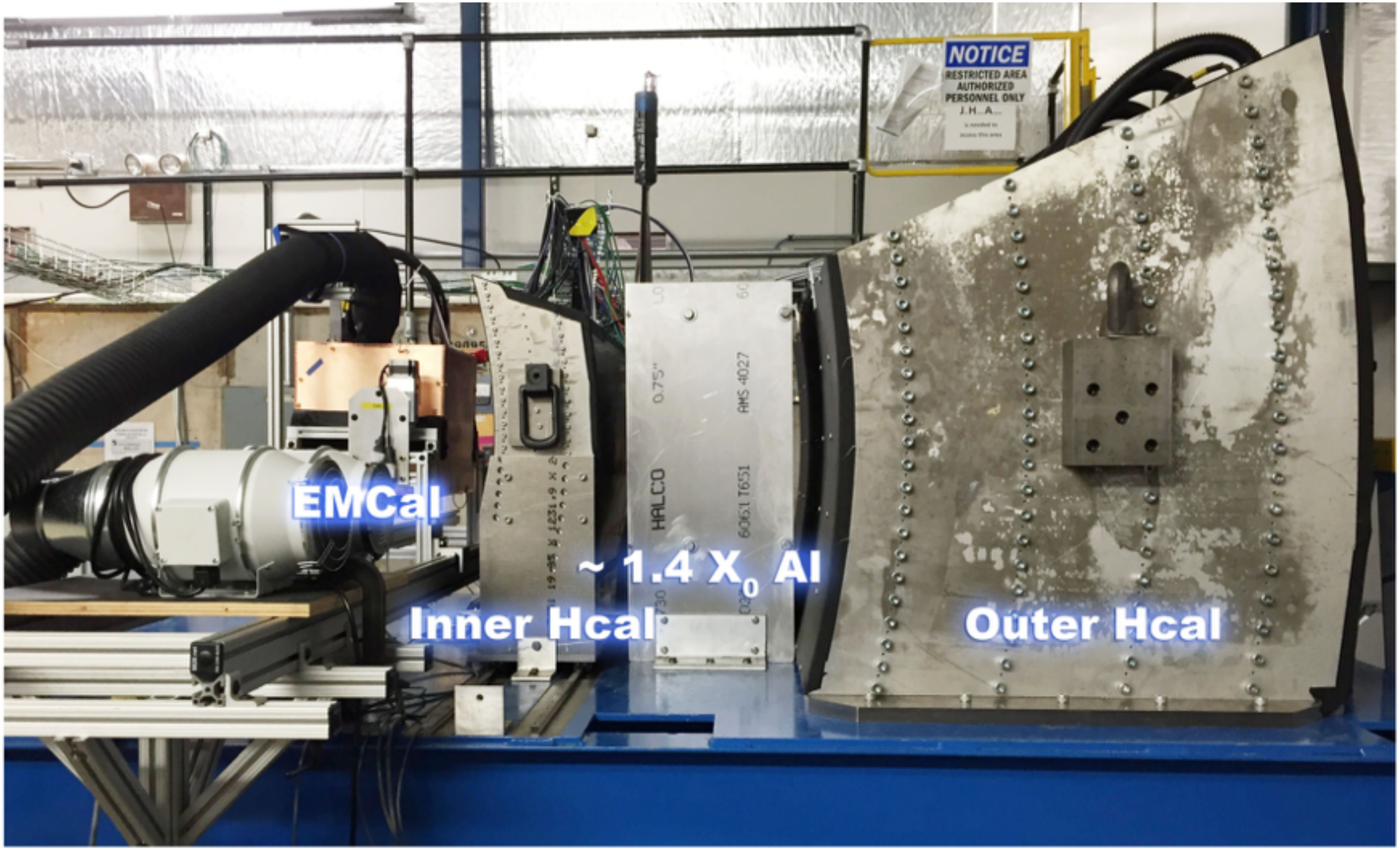




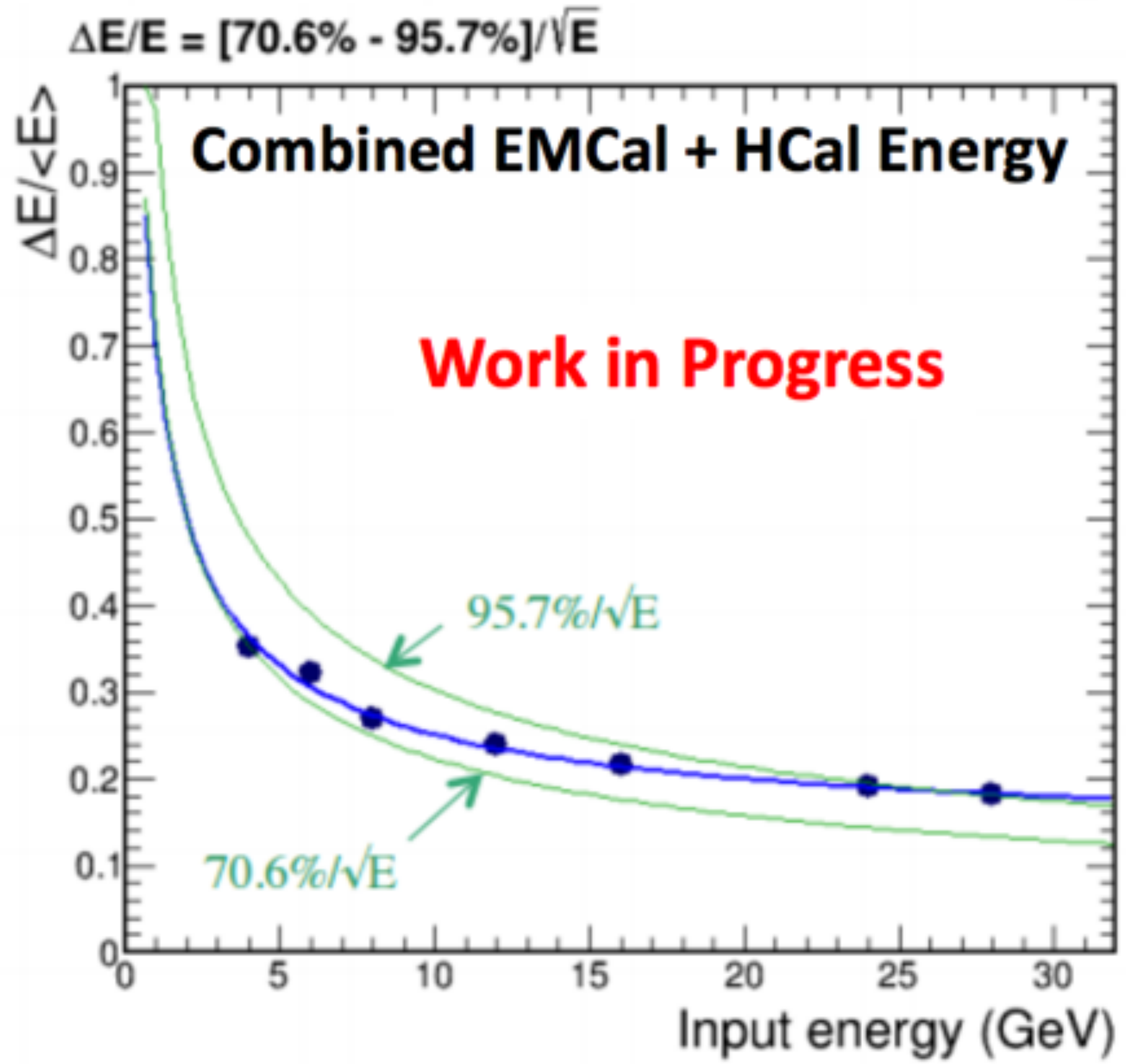
3x3 tower~size of single photon cluster

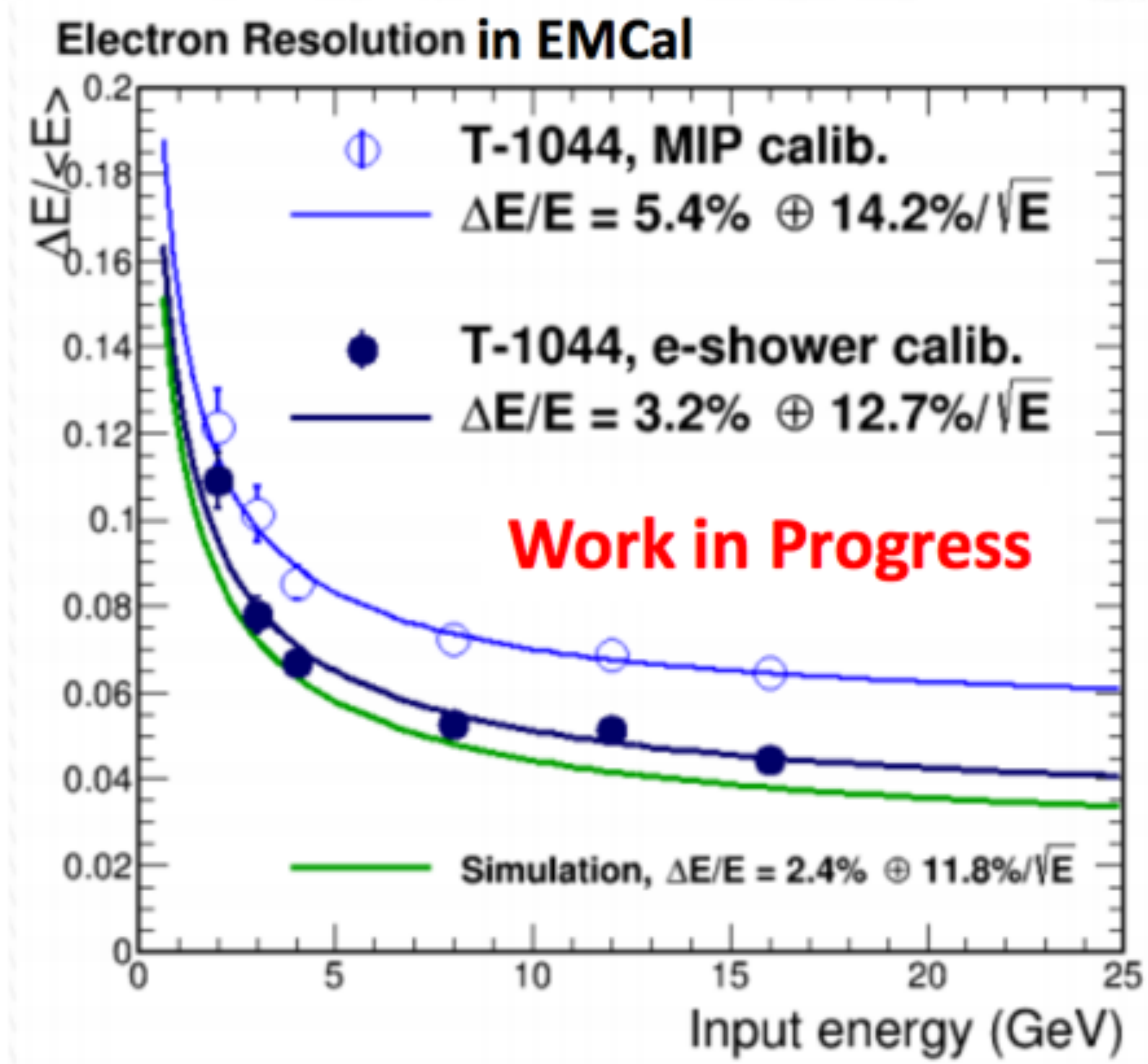
Average energy of tower~341 MeV from the underlying event in central Hijing Au+Au event.

Fermilab Test Beam 2016



Fermilab Test Beam 2016





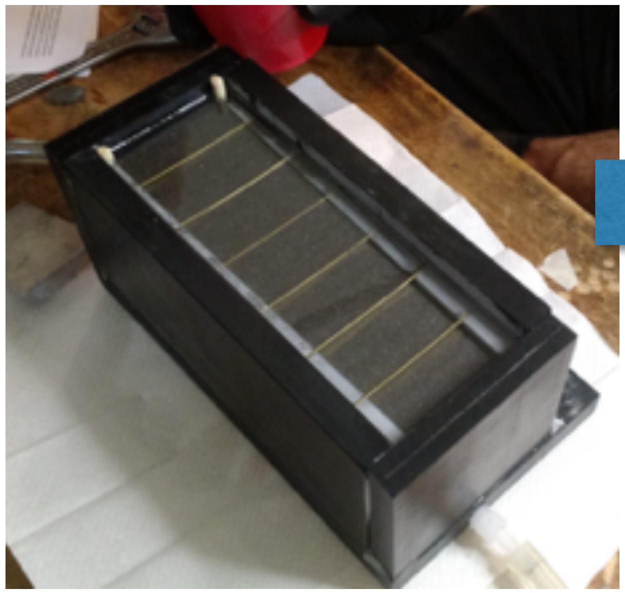
Meets design goals of <100%/√E and <15%/√E for EMCal

RHIC/AGS User's Meeting June 2016

https://www.bnl.gov/aum2016/content/workshops/Workshop_2b/campbell_sarah.pdf

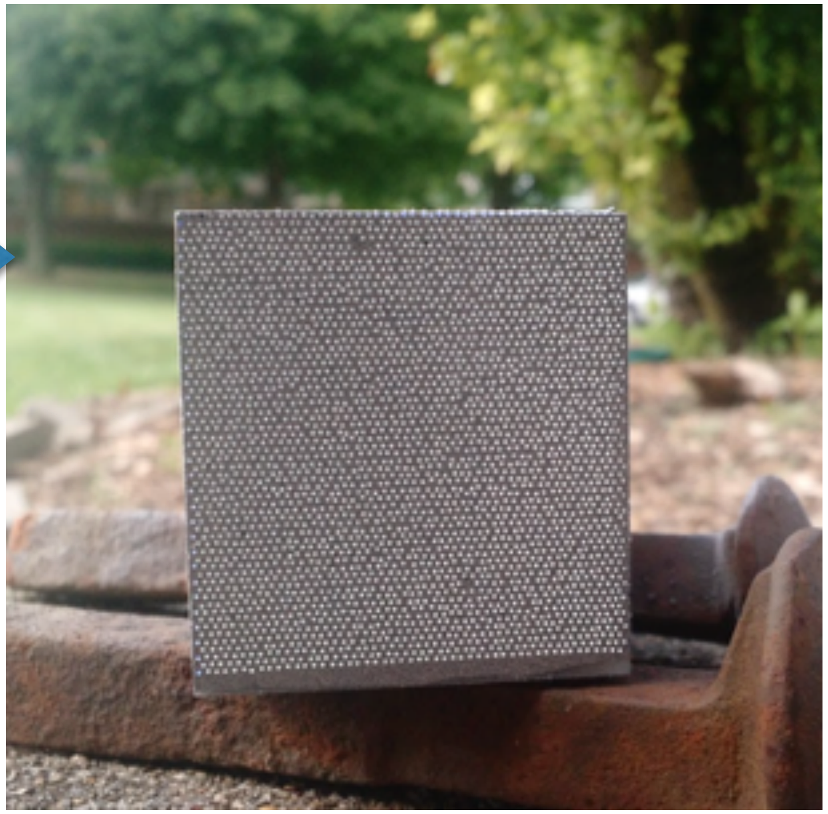
sPHENIX EMCal 2D Production @UIUC

…for next Test Beam!

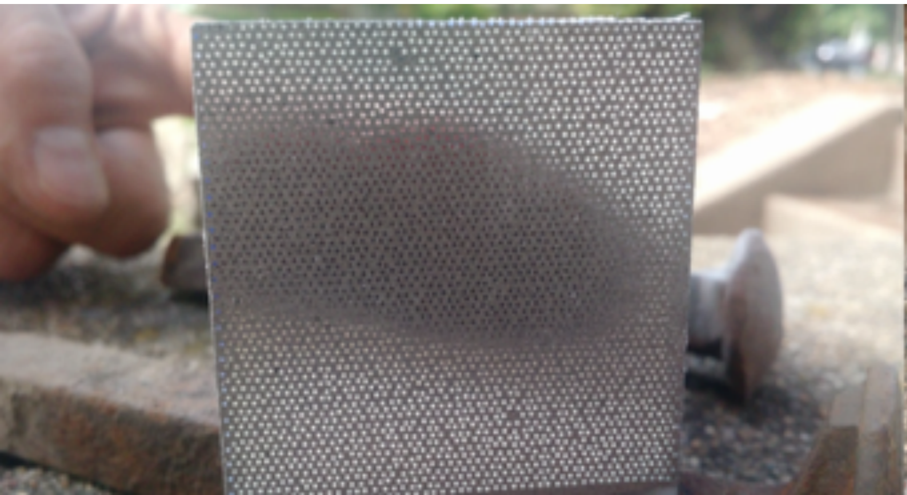


fibers, meshes,
& tungsten

2D module ready
to be machined



final 2D module



Summary/Future Plans

- We have completed the first Test Beam with EMCal prototype version 1 8x8 towers of 1D projective blocks.
- Results are consistent with design goals.
- Version 2 prototyping of *2D* projective blocks is underway.
- sPHENIX is part of plans for BNL after a final PHENIX run in 2016.
- First Draft of sPHENIX Test Beam Paper is completed, plan to publish this fall 2017.
- We look forward to Physics in 2021.
- Second Test Beam in Jan-Feb 2017!