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

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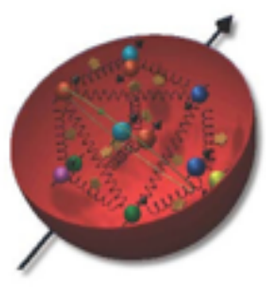
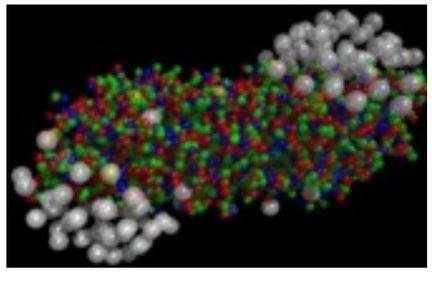
22nd International Spin Symposium

Studying QCD at RHIC

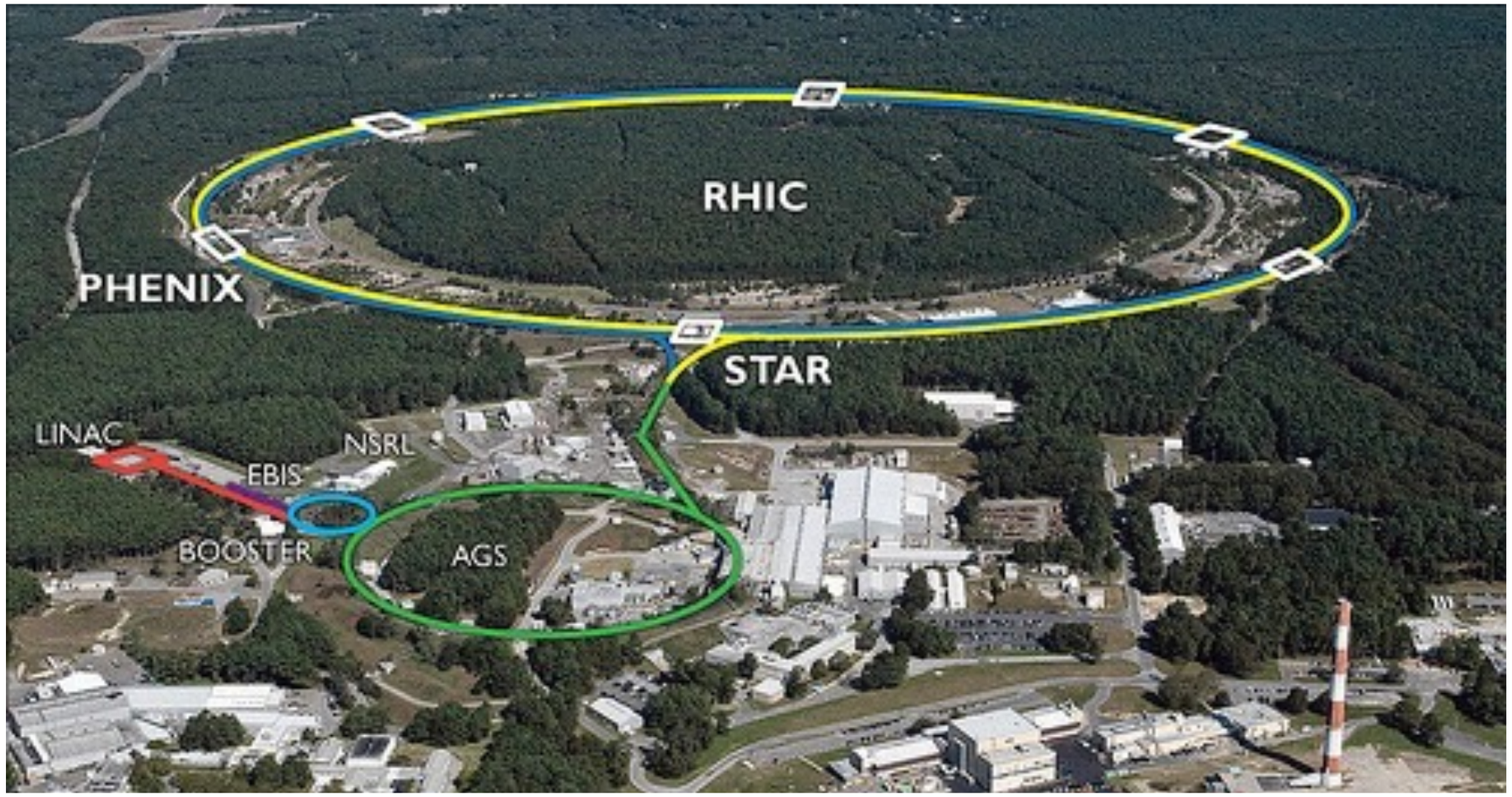
RHIC the most versatile hadron collider in the world, designed to study

- Simple QCD bound states - the proton
- Collections of QCD bound states - nuclei
- QCD deconfined - Quark-Gluon Plasma

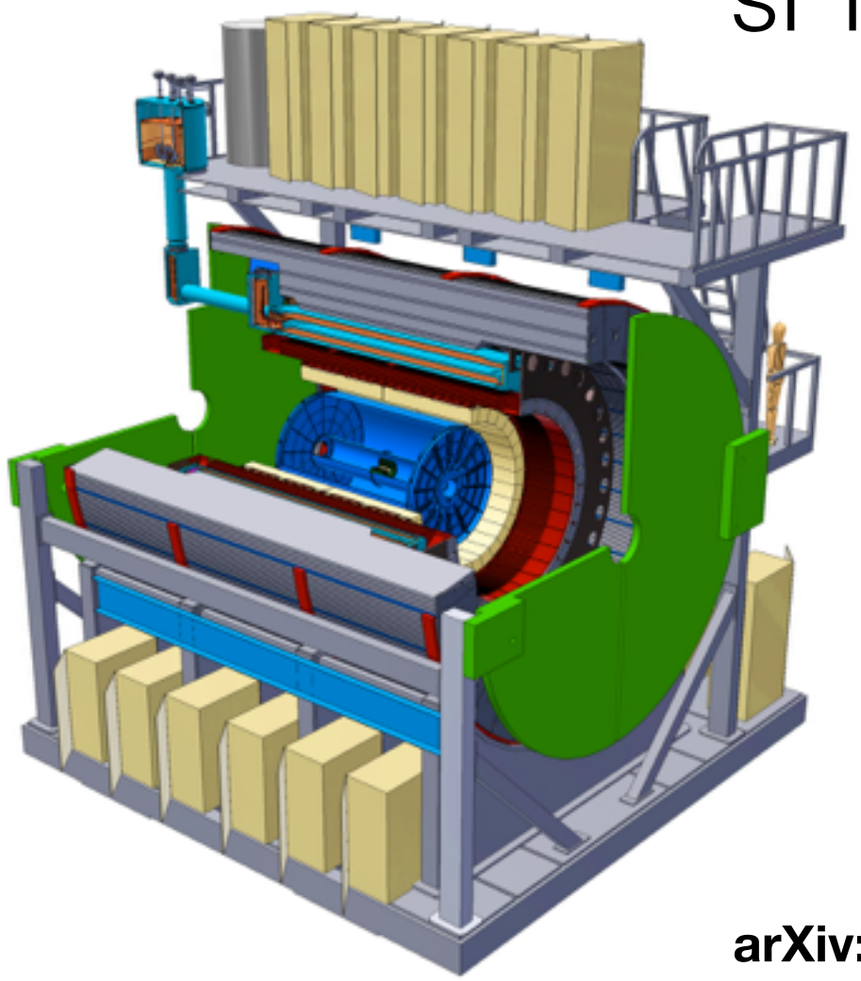


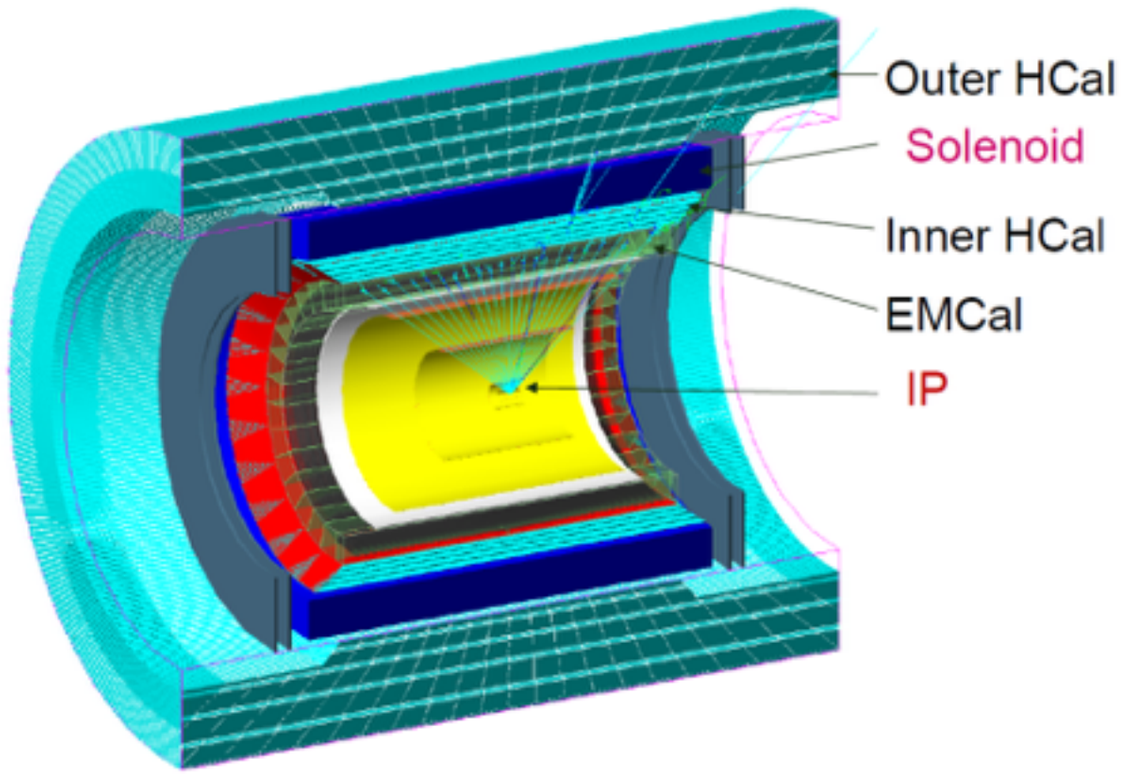


A single facility capable of nucleus-nucleus, proton-nucleus, and proton-proton collisions. World's only polarized p+p collider!



sPHENIX





arXiv:1501.06197

sPHENIX focuses on jet and hard probes as well as quarkonia

- Dijet and photon-jet correlation measurements will constrain x for polarized pdf measurements and can provide sensitivity to nonperturbative transverse momentum effects
- Diphoton measurements will offer a Drell-Yan-like process to study transverse-momentum-dependent pdfs
- Heavy quarkonium will provide sensitivity to gluon distributions
- See talks by H.W. Yu (session Helicity), R. Fatemi (session Future), and J. Lajoie (session Future)
- RHIC Cold QCD Plan: arXiv:1602.03922
- Letter of Intent to use sPHENIX as a foundation for a day-1 Electron Ion Collider detector: 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: $\sigma / E < 100\% / \sqrt{E}$

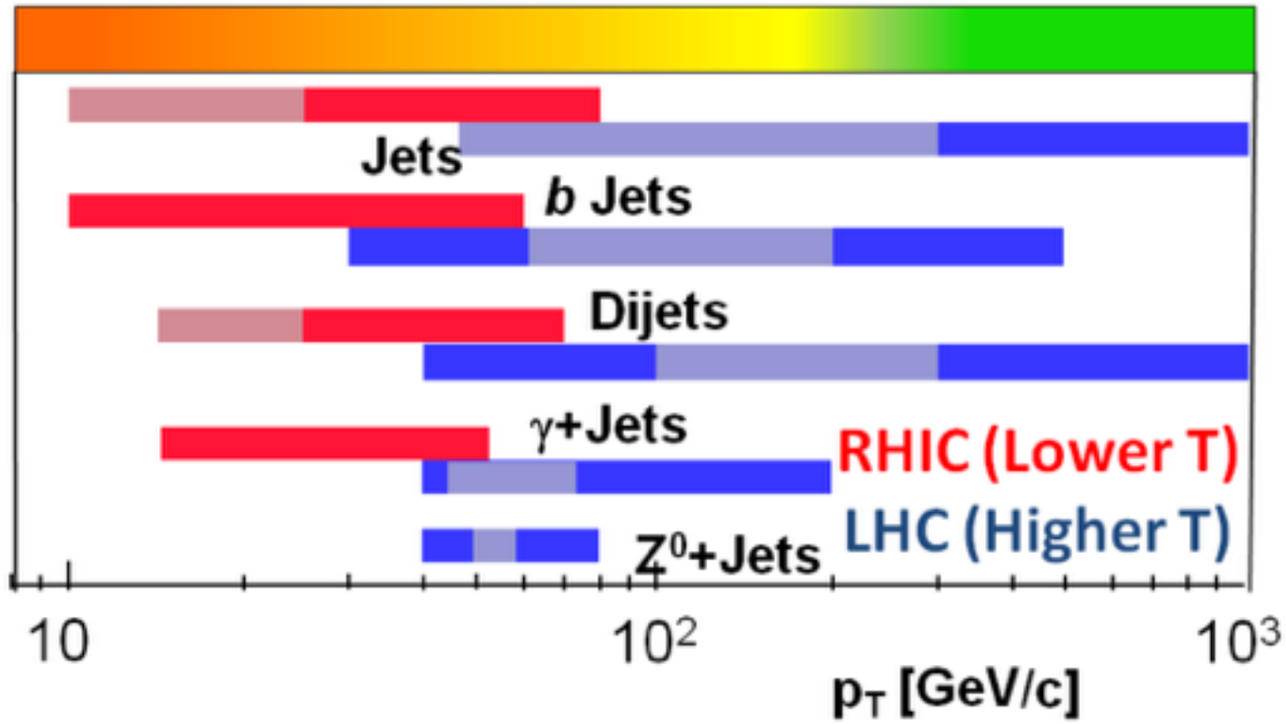
– jet : $\sigma / E < 120,150\% / \sqrt{E}$

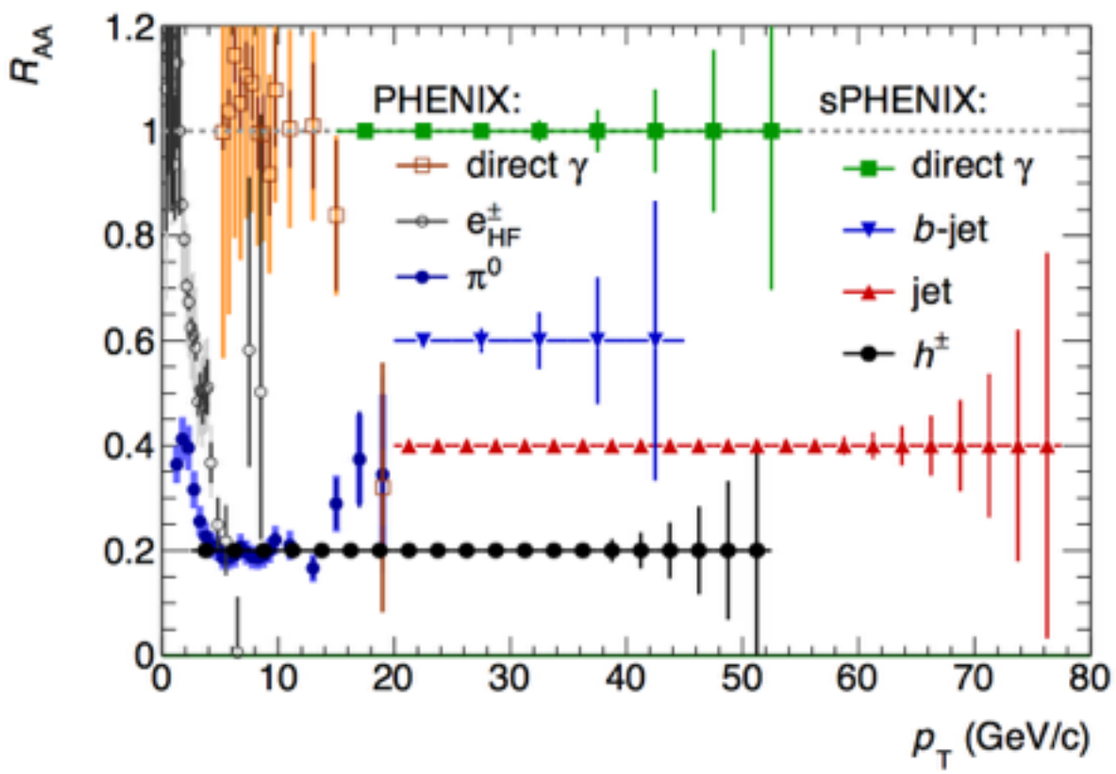
- gamma-jet emcal energy resolution:

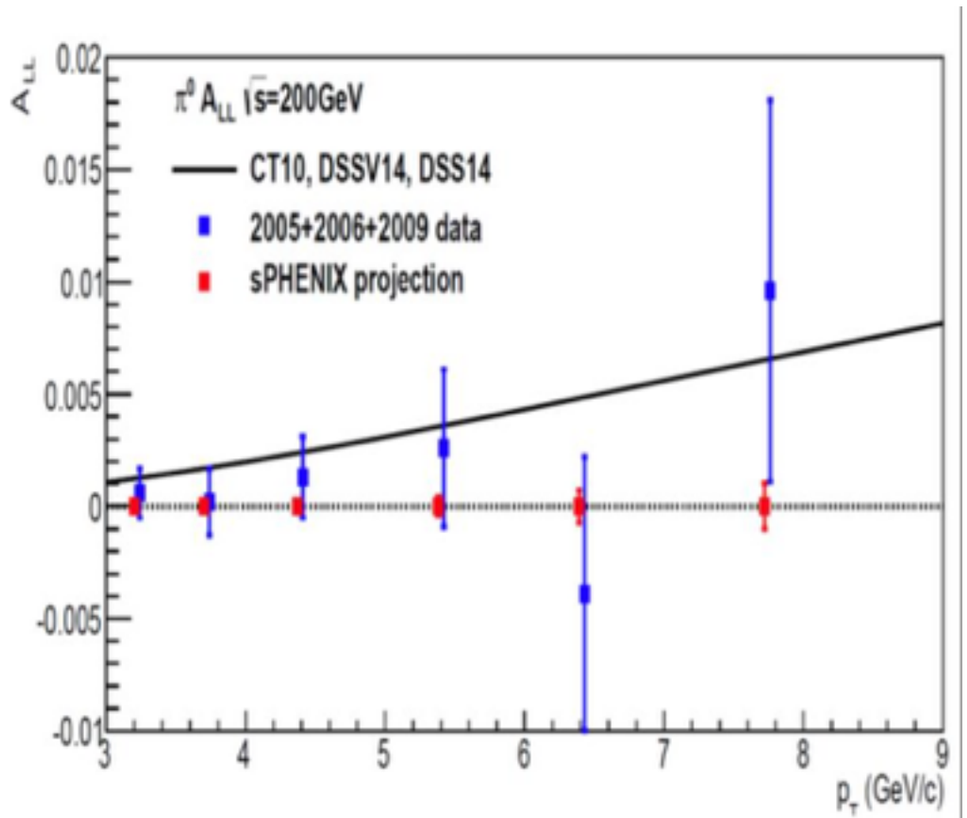
$-\sigma / E < 15\% / \sqrt{E}$

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

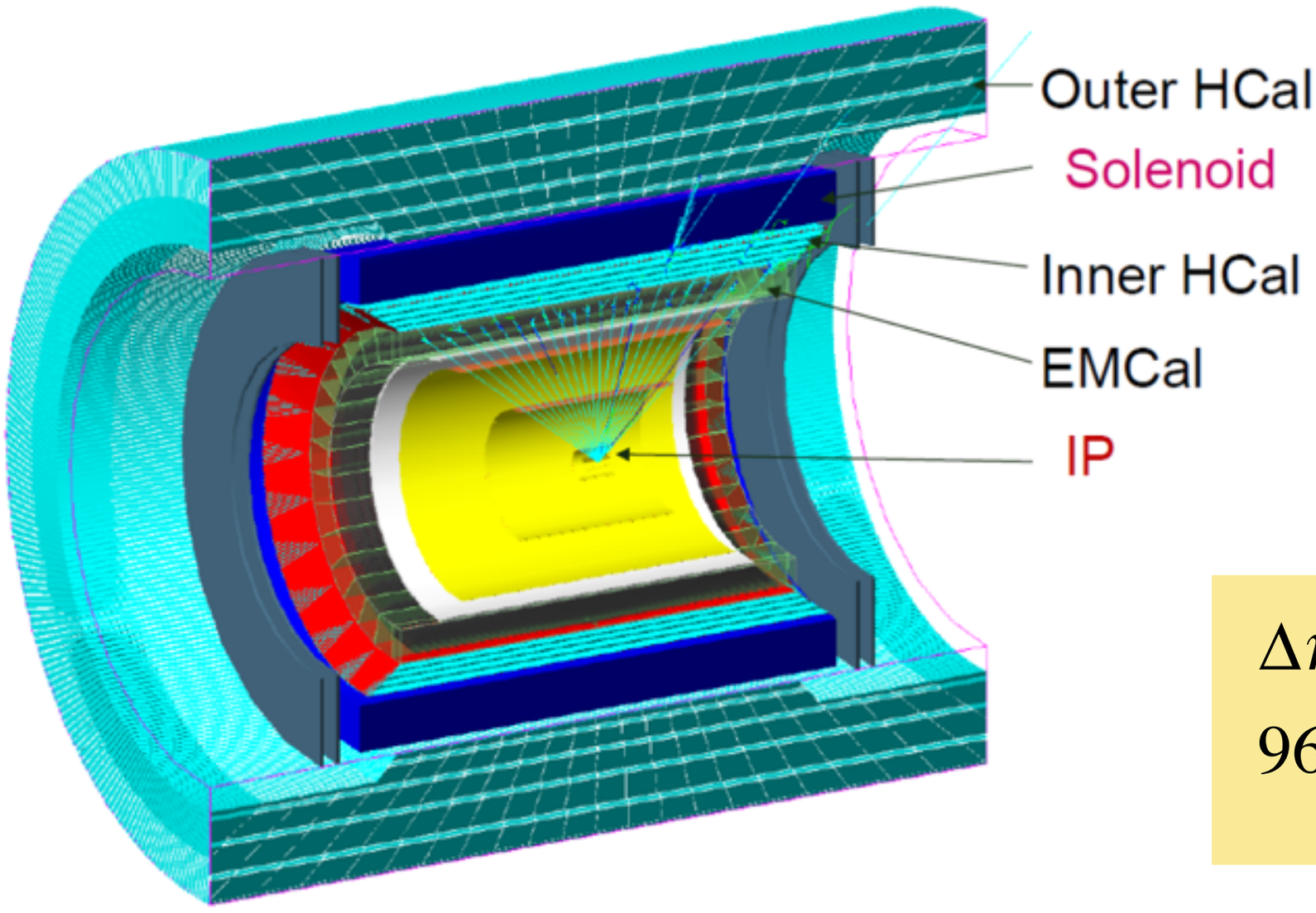




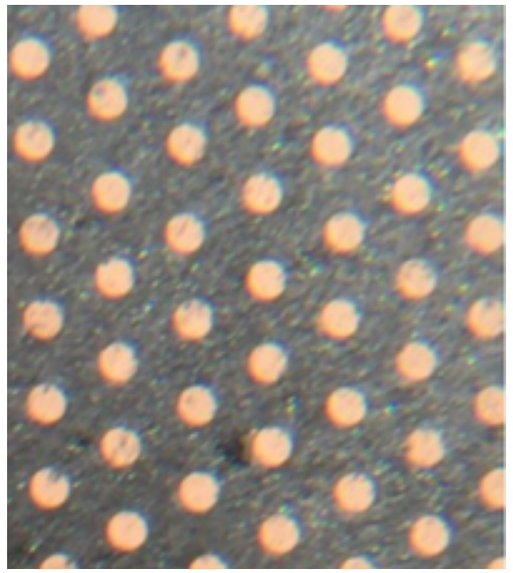


See talks in H.W. Yu (session Helicity)

sPHENIX EMCal



tungsten-fiber block



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

$$96 \times 256 \text{ readout channels}$$

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

Inner radius must be small

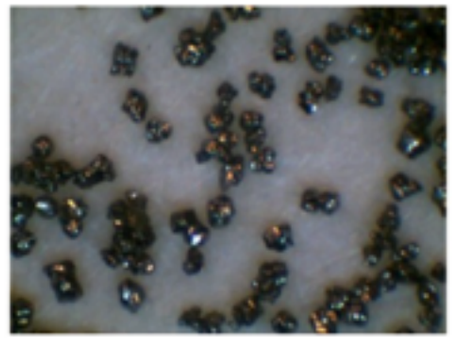
ΔR=116 cm - 90 cm (26cm)

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

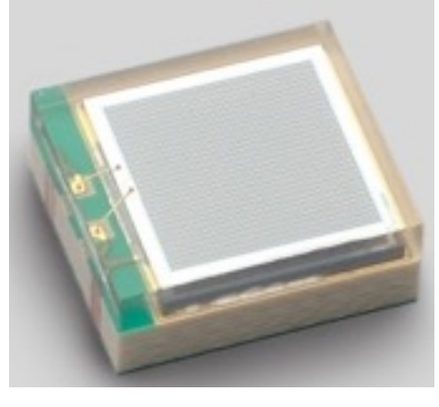
Density ~ 10g/cm^3

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

Readout

Silicon Photomultipliers (SiPMs)

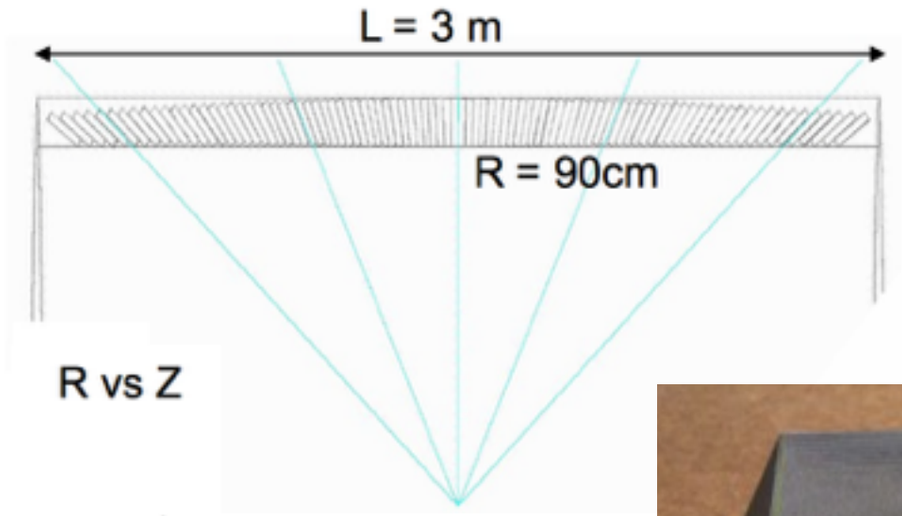
Works inside magnetic field

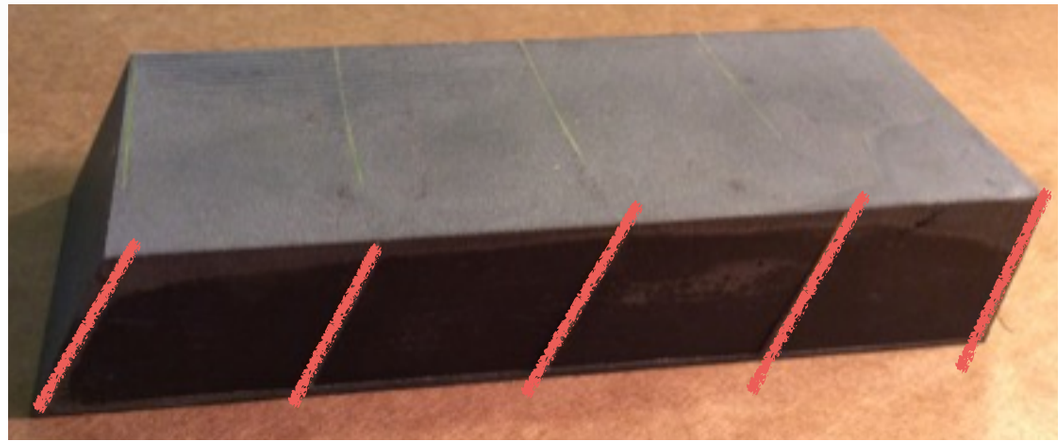


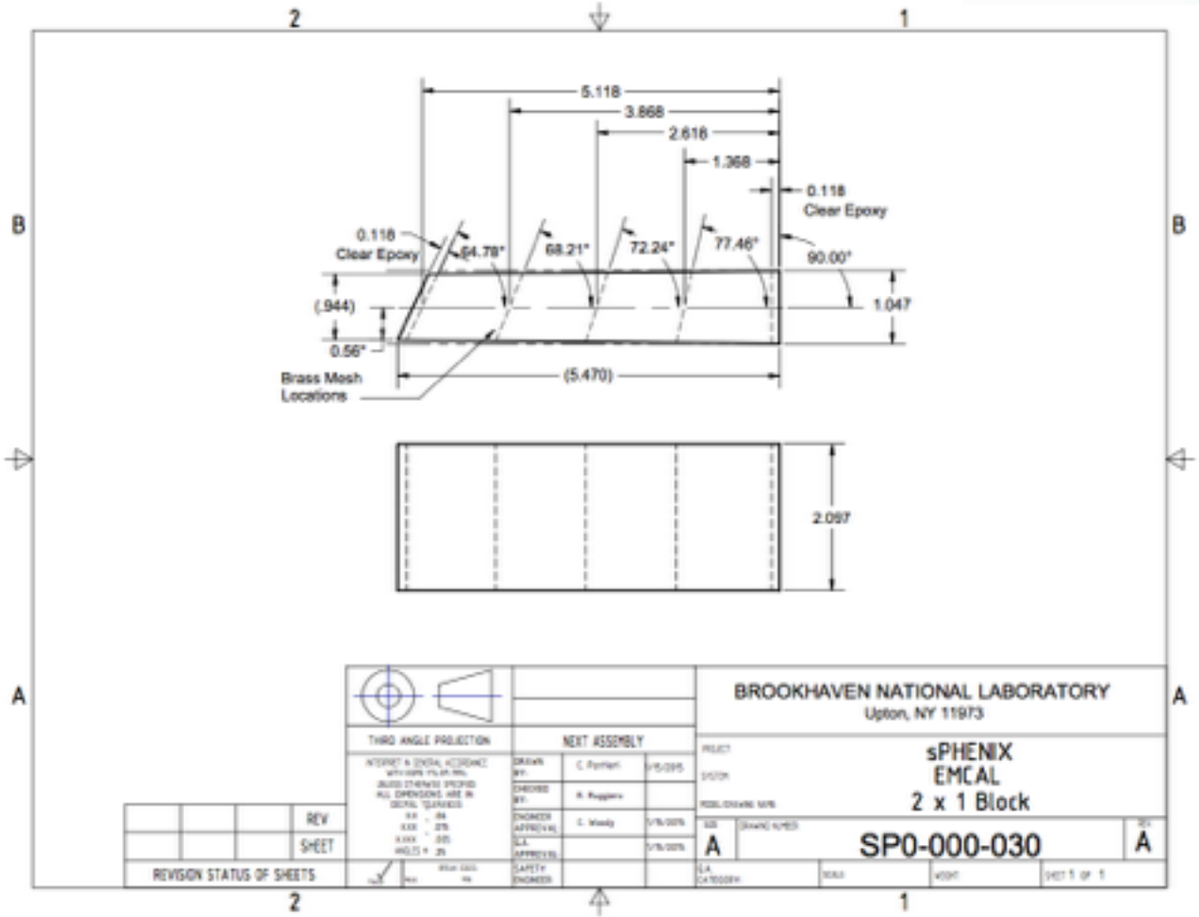
Hamamatsu S12572-015P

Projectivity

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



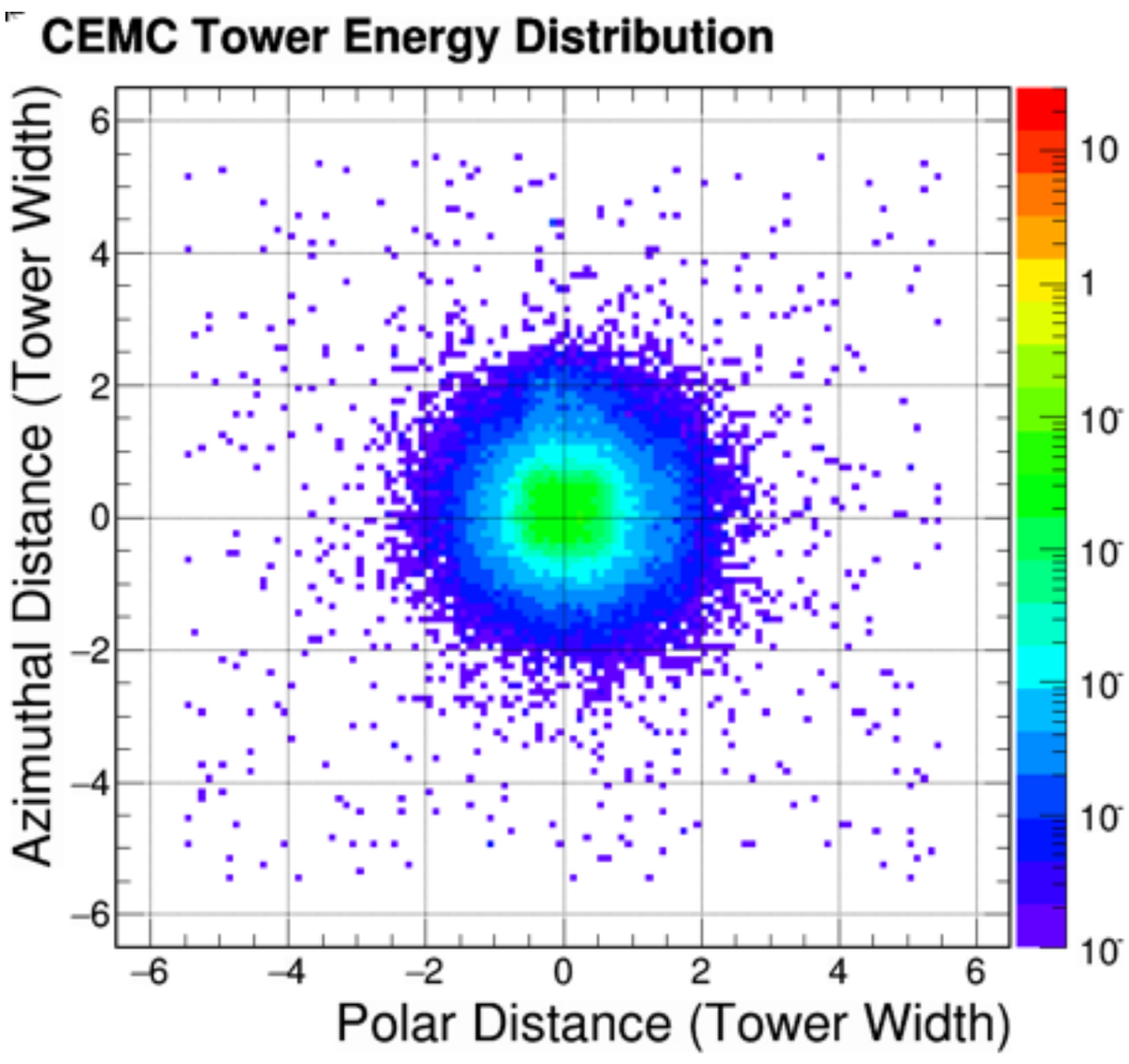




The first way to make the fibers projective was to tilt them in 1D.

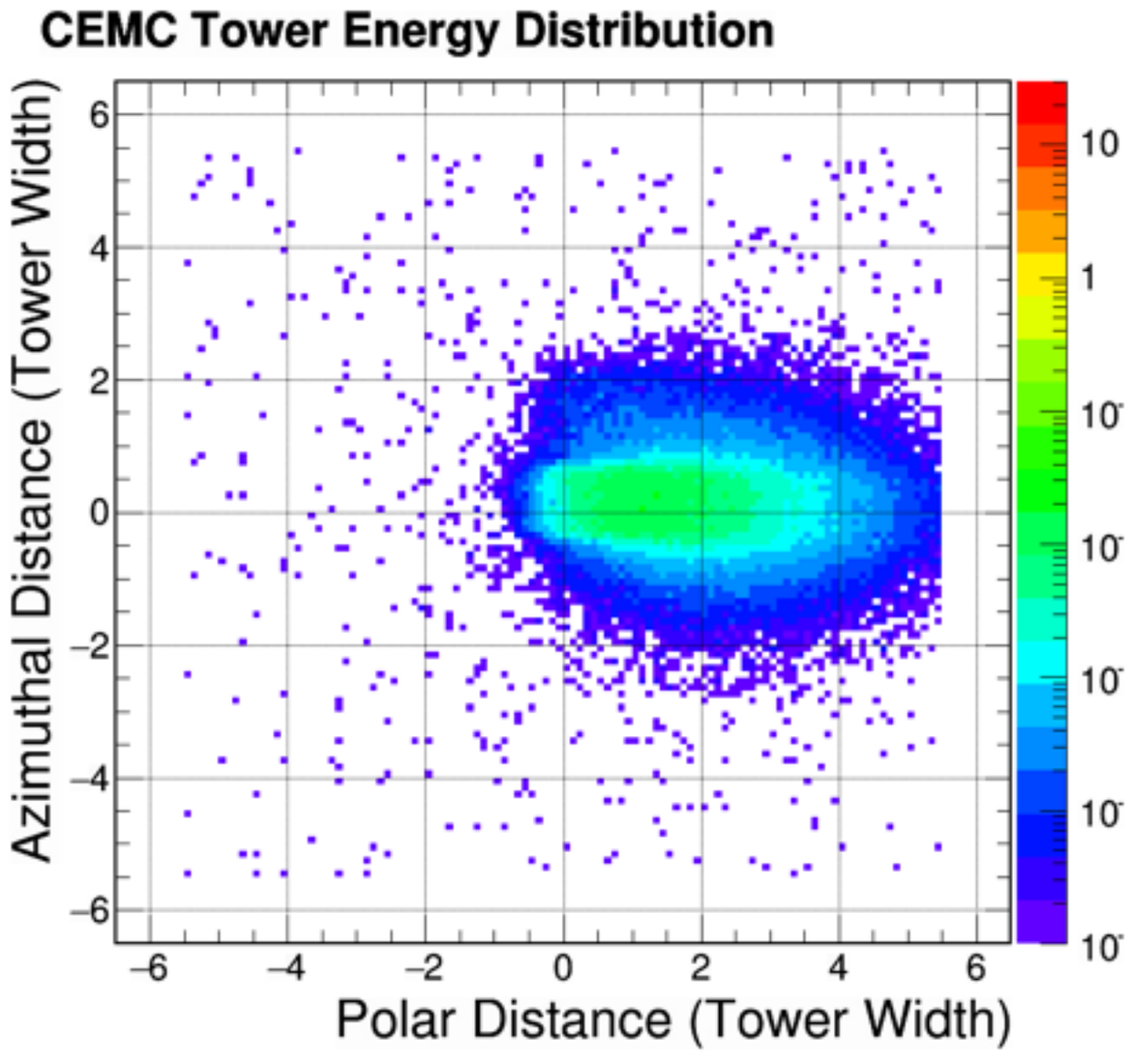
Projectivity: 1D vs. 2D

Projective in polar direction



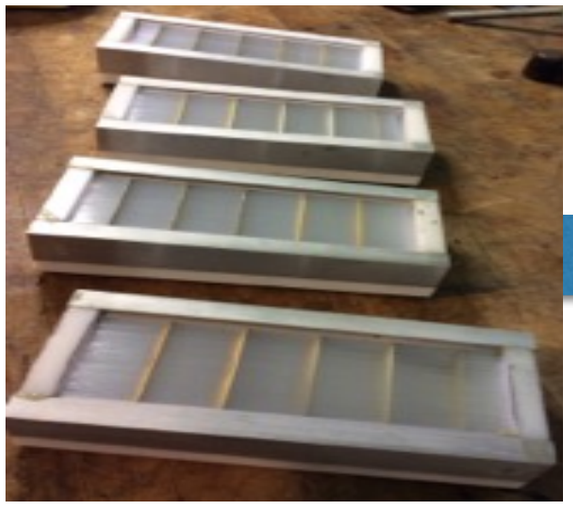
Average cluster ~8 towers

Non-Projective in polar direction



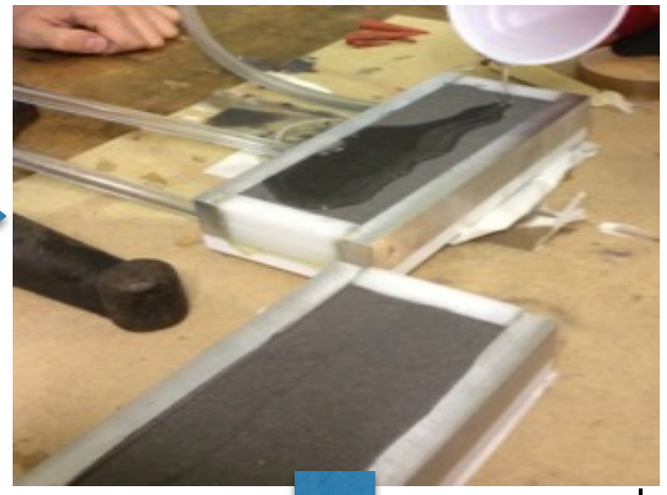
Average cluster ~12+ towers

sPHENIX EMCal 1D Production @UIUC

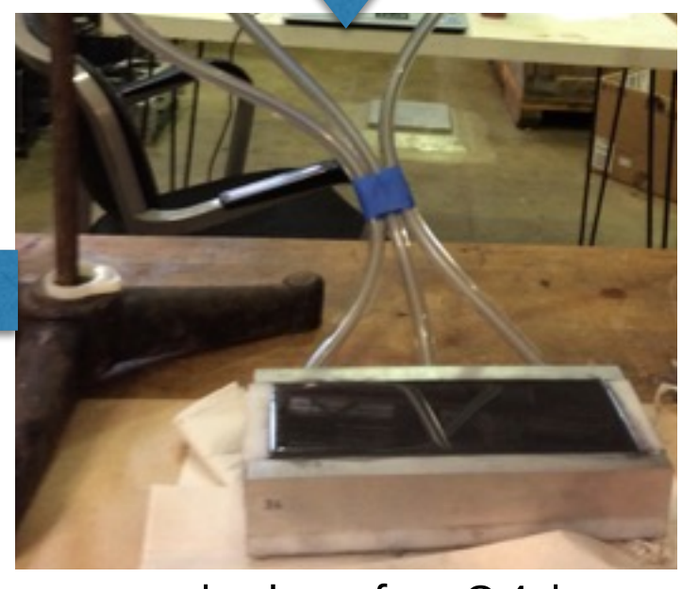


fibers & meshes

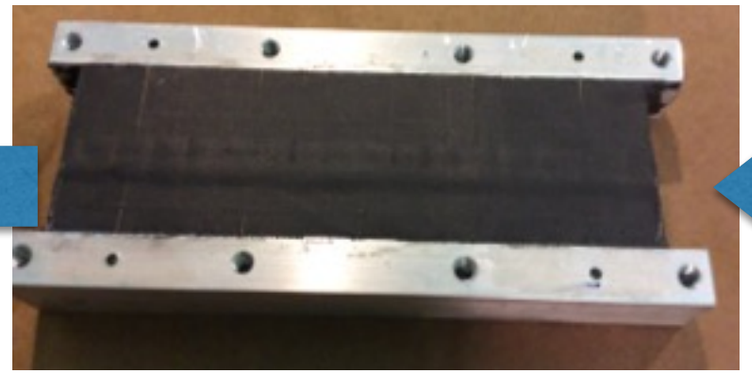
fibers, meshes, & tungsten



epoxy added



epoxy drying for 24 hours



module ready to be machined

finished

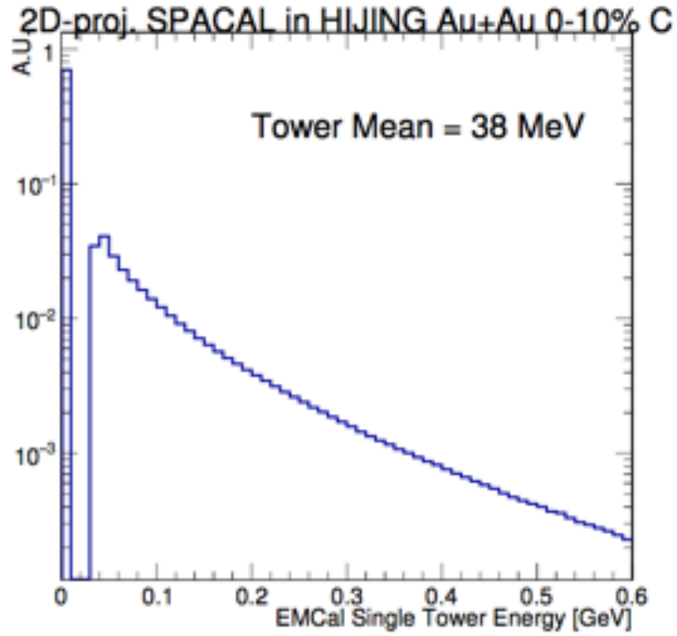
Collaborate with Brookhaven National Laboratory for assembly

Segmentation Requirement

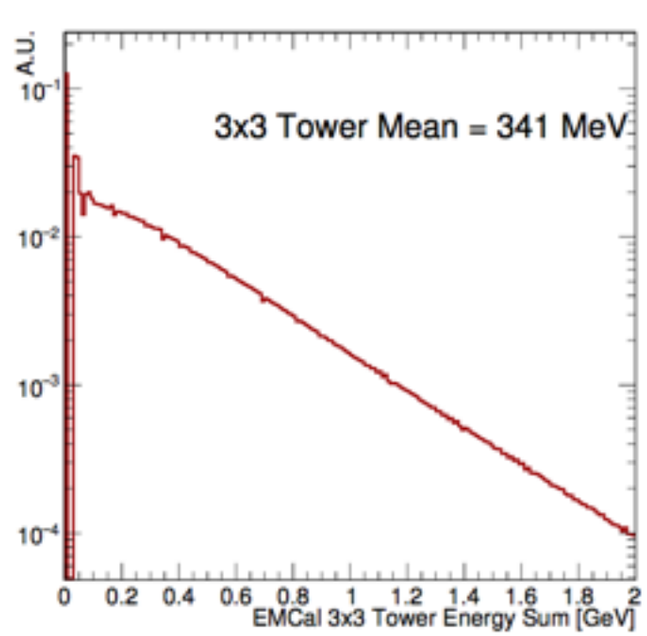
The goal is for detector resolution and segmentation to be better than the limitations on photon reconstruction due to the underlying event background in a heavy ion event.

Hijing Central Au+Au

Average energy per tower ~38 MeV



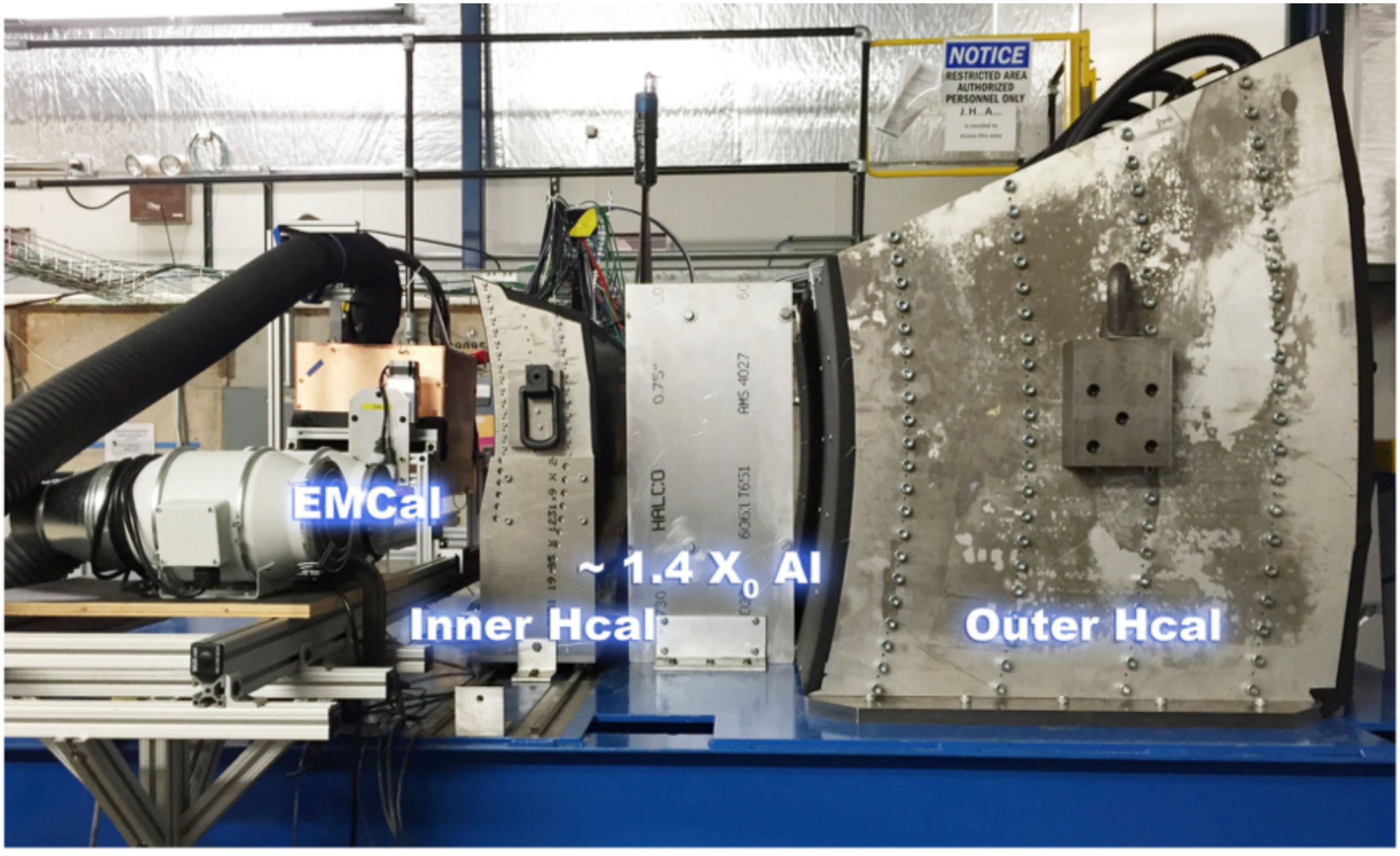
Energy in a 3x3 tower sum ~341 MeV



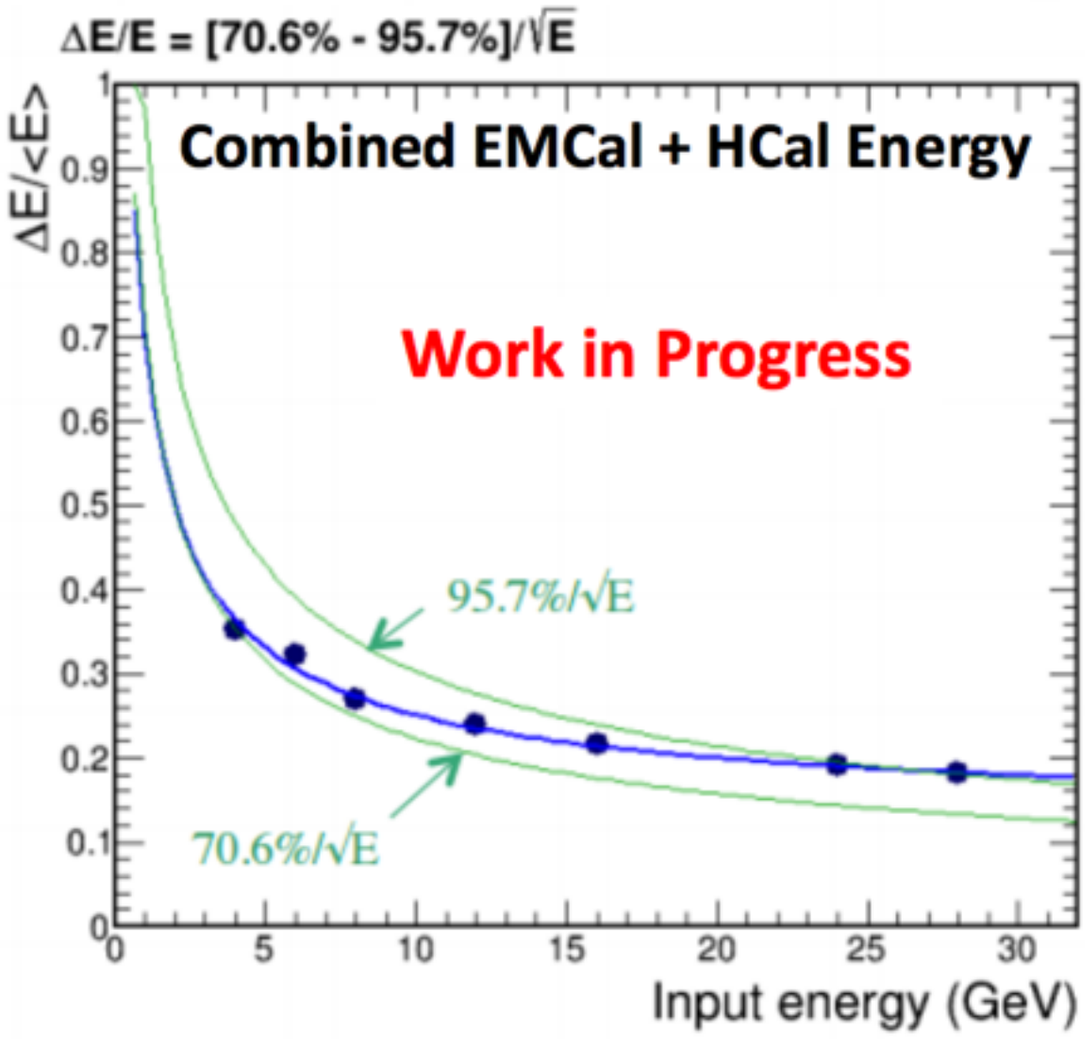
3x3 tower~size of single photon cluster

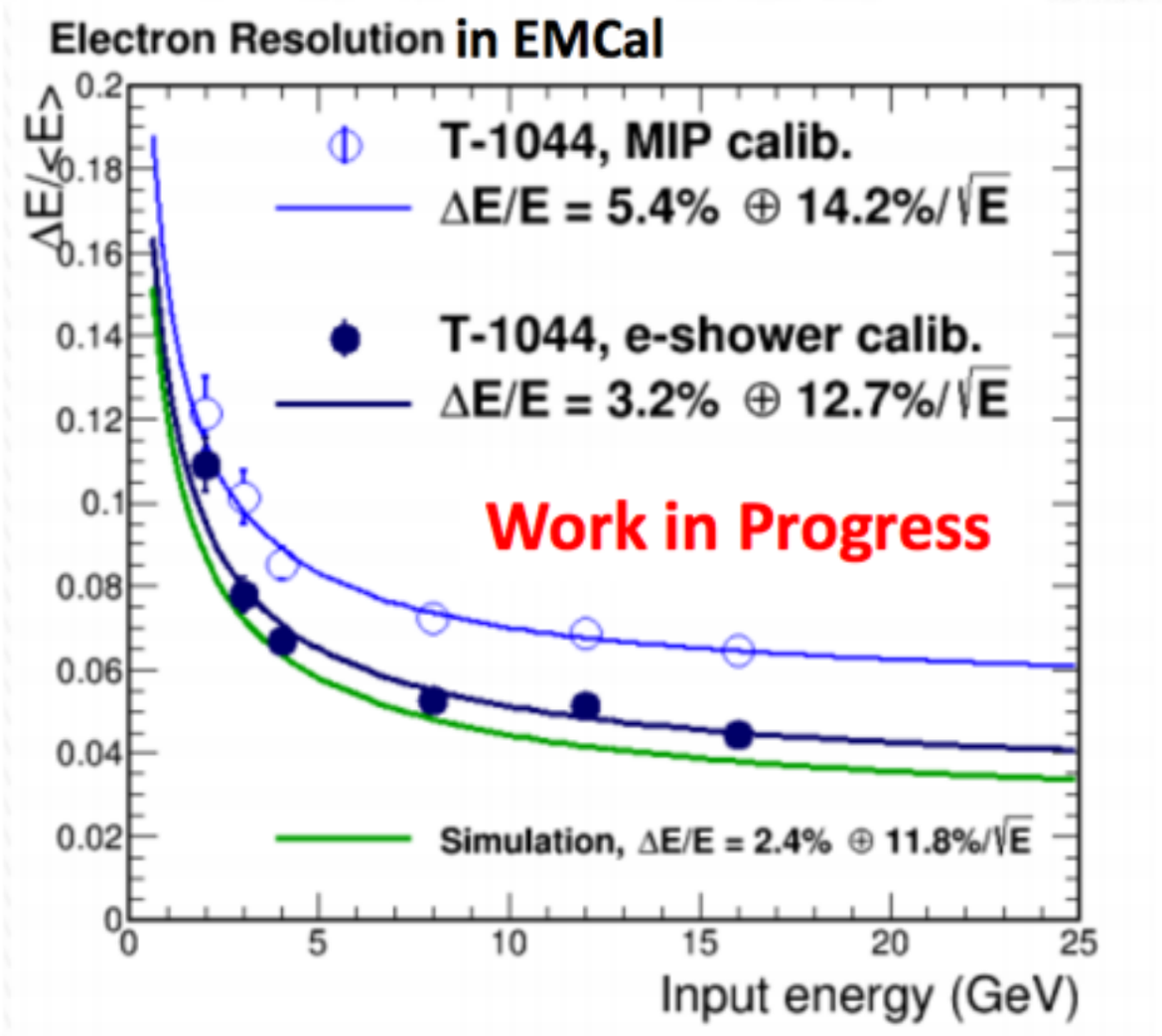
Average energy of tower~341 MeV from the underlying event in central Hijing Au+Au event.

Fermilab Test Beam 2016



Fermilab Test Beam 2016





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

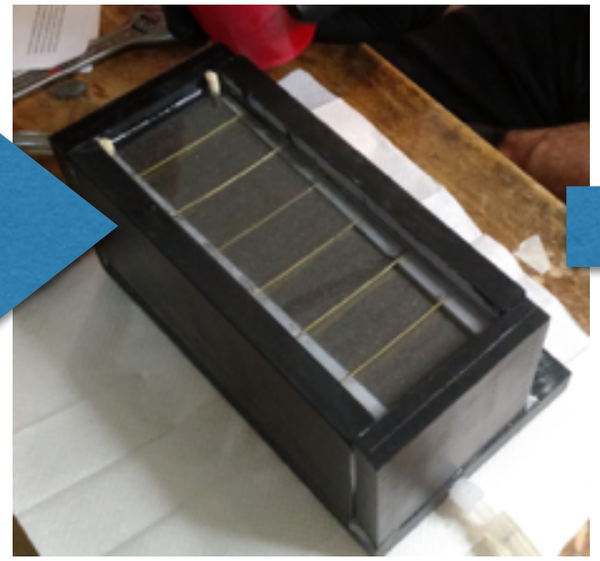
RHIC/AGS User's Meeting June 2016

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

sPHENIX EMCal 2D Production @UIUC

…for next Test Beam!

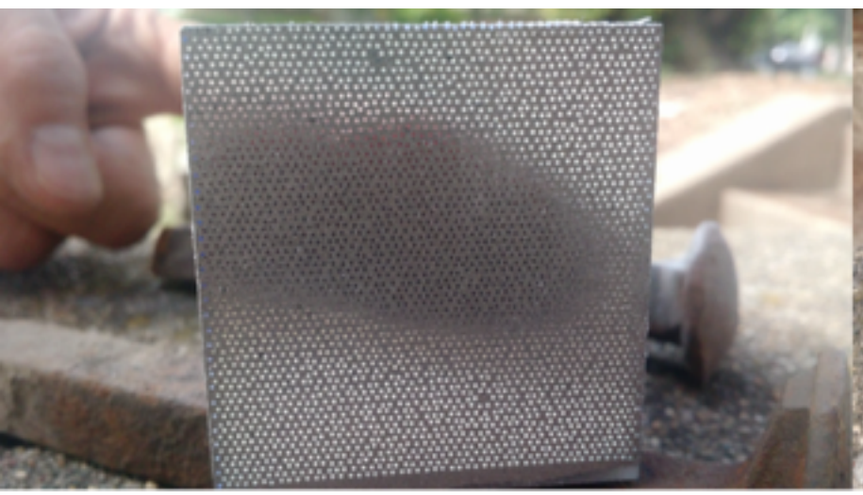
fibers & meshes,



fibers, meshes,
& tungsten

2D module ready
to be machined

final 2D module



V. Loggins UIUC

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 the completed final PHENIX run in 2016.
- First Draft of sPHENIX Test Beam Paper is completed, plan to publish this fall 2016.
- We look forward to Physics in 2022.
- Second Test Beam in Jan-Feb 2017!