A Tungsten Powder Epoxy Scintillating Fiber EMCAL for sPHENIX

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2015 Fall Meeting of the APS Division of Nuclear Physics
Santa Fe, New Mexico
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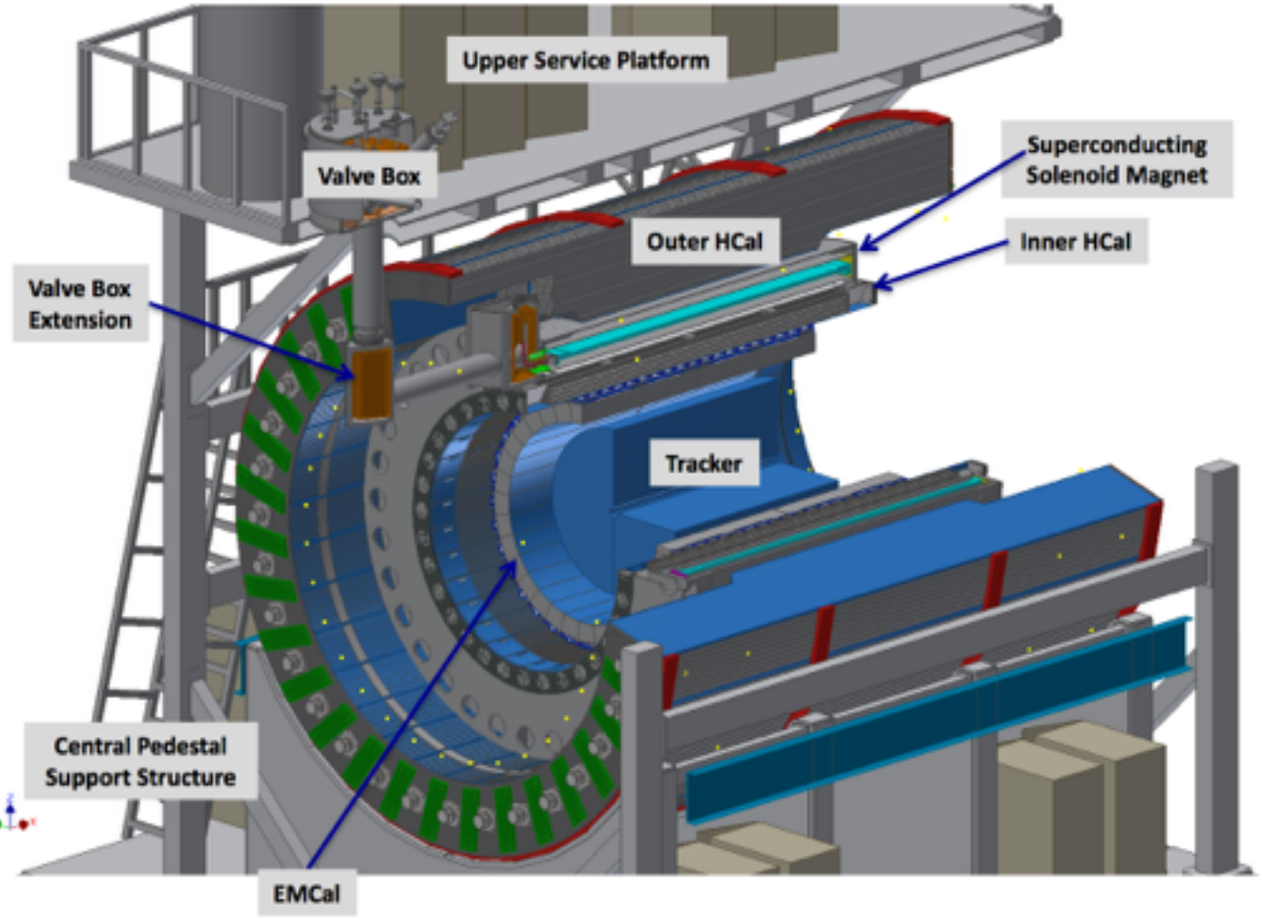
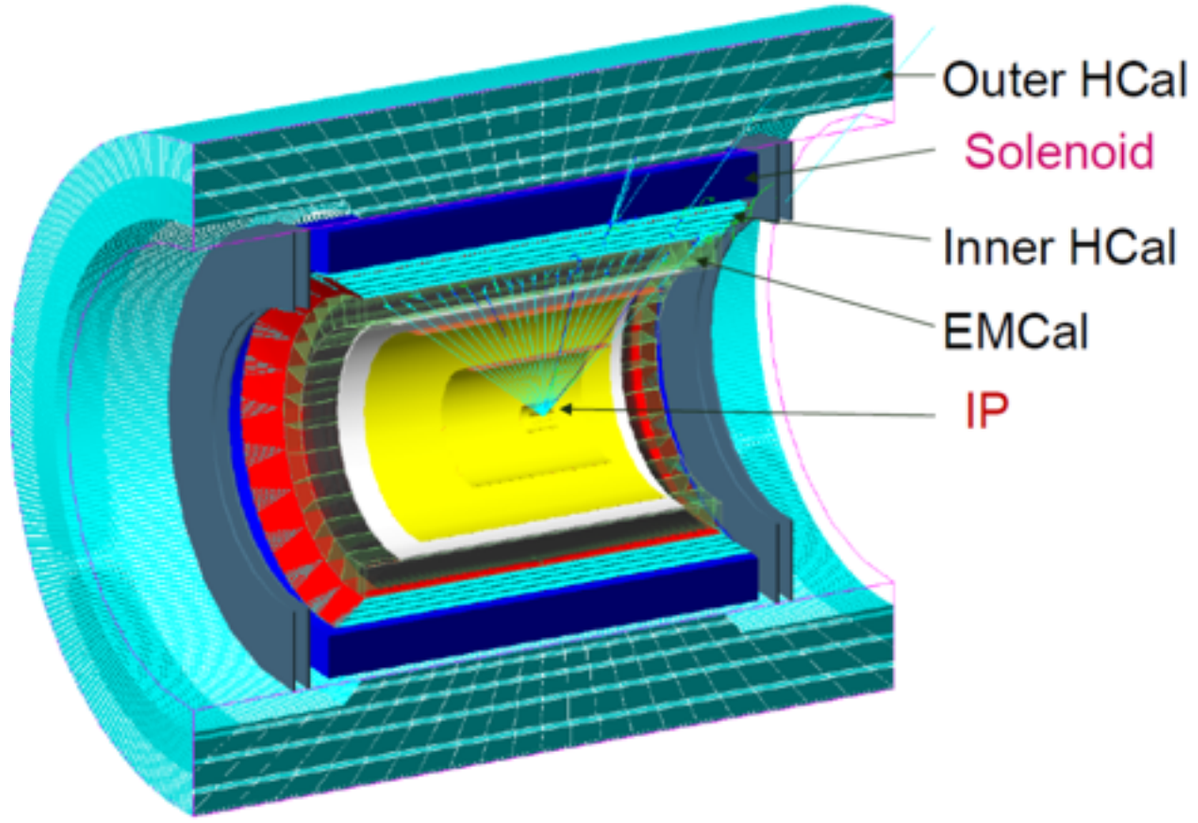
sPHENIX





- sPHENIX is an upgrade to the PHENIX detector at the Relativistic Heavy Ion Collider.
- 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).

http://www.phenix.bnl.gov/phenix/WWW/publish/documents/sPHENIX_proposal_19112014.pdf

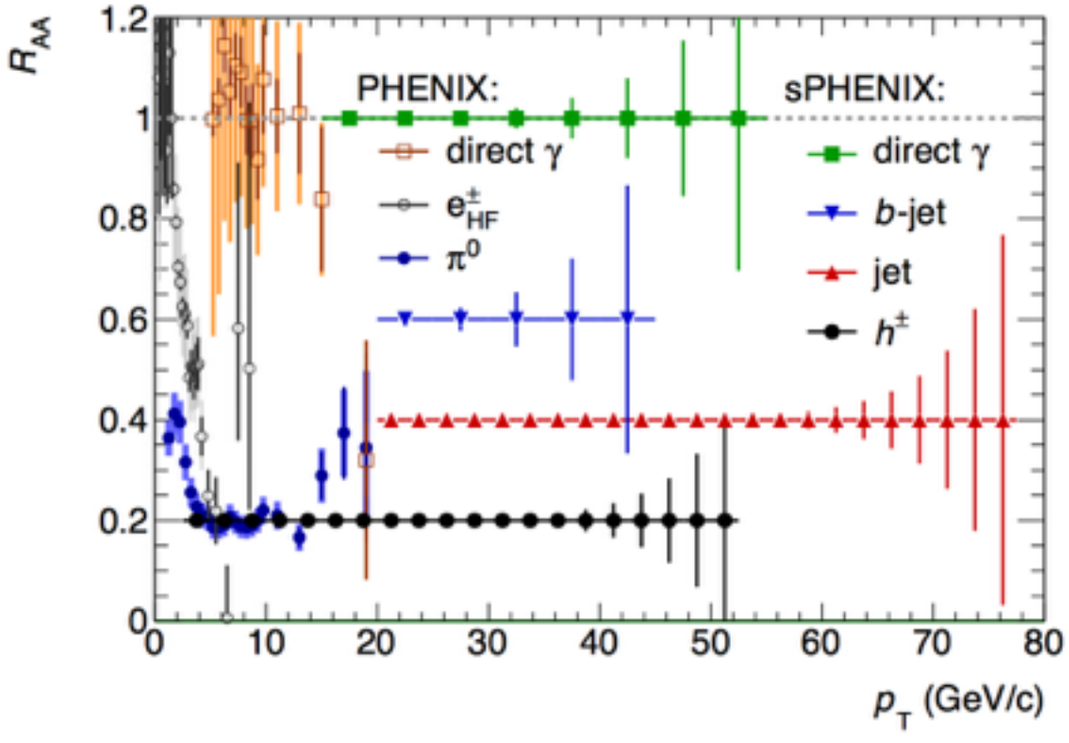
sPHENIX Requirements

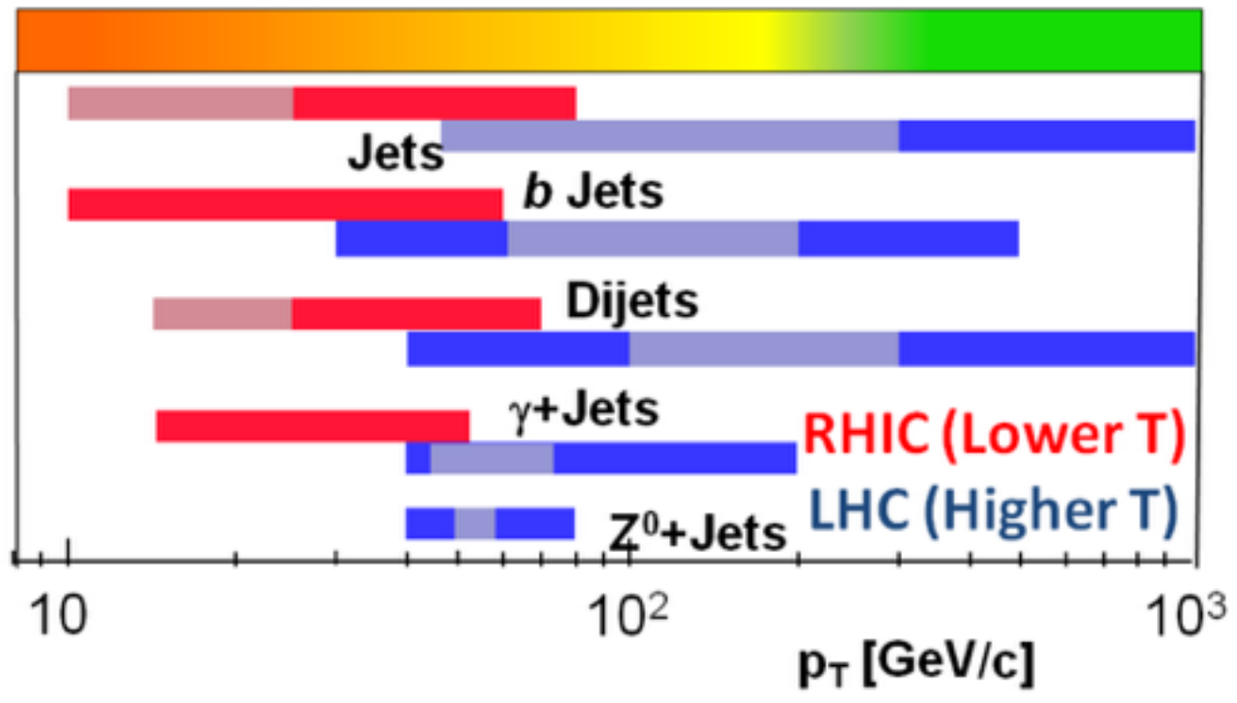
Physics:

- 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.

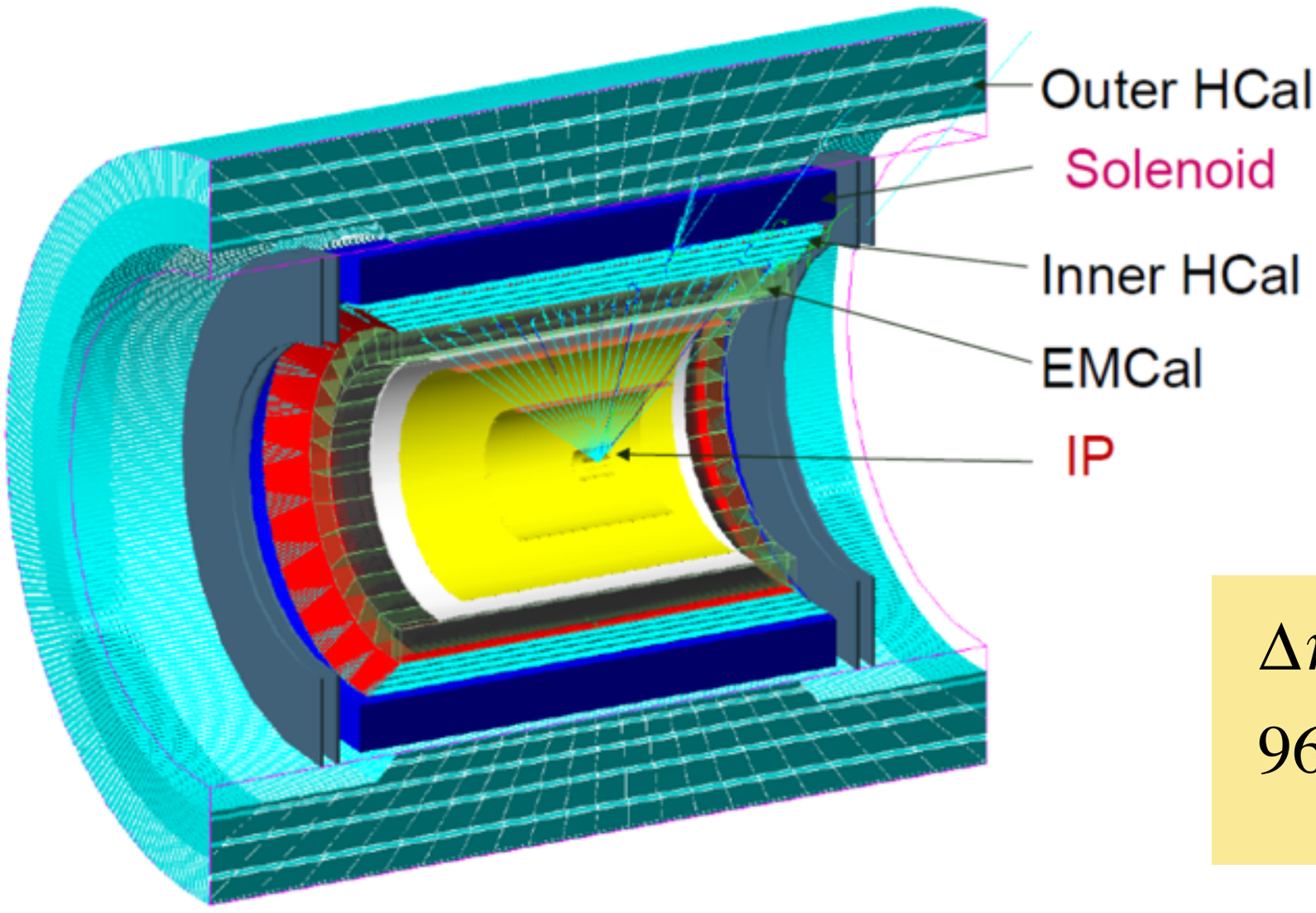
Detector:

- 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

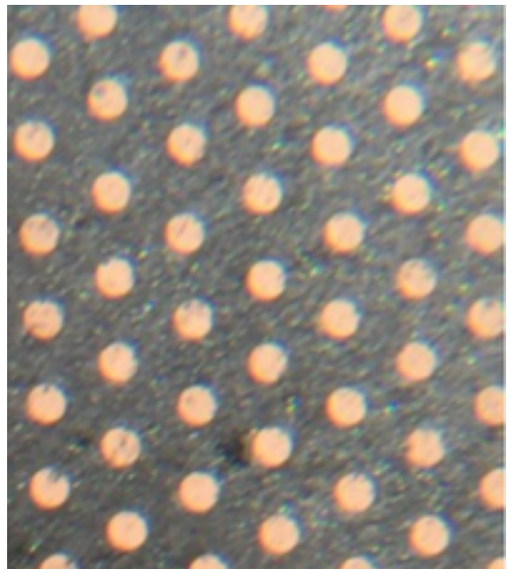




sPHENIX EMCAL



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

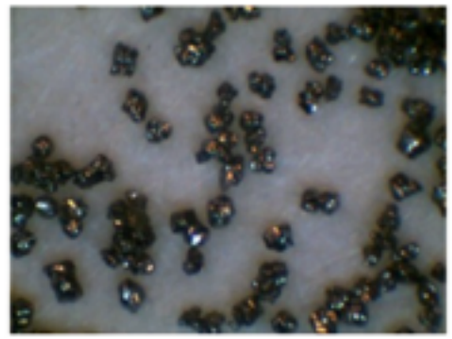
Inner radius must be small

ΔR=116 cm - 90 cm (26cm)

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

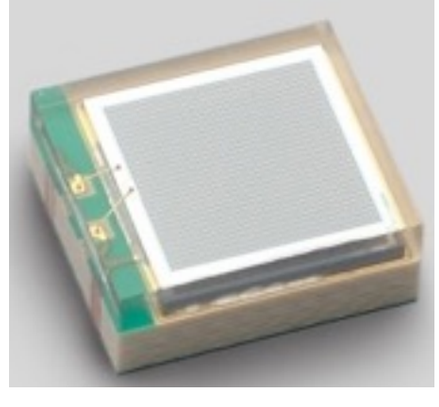
Density ~ 10g/cm^3

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

Readout

Silicon Photomultipliers (SiPMs)

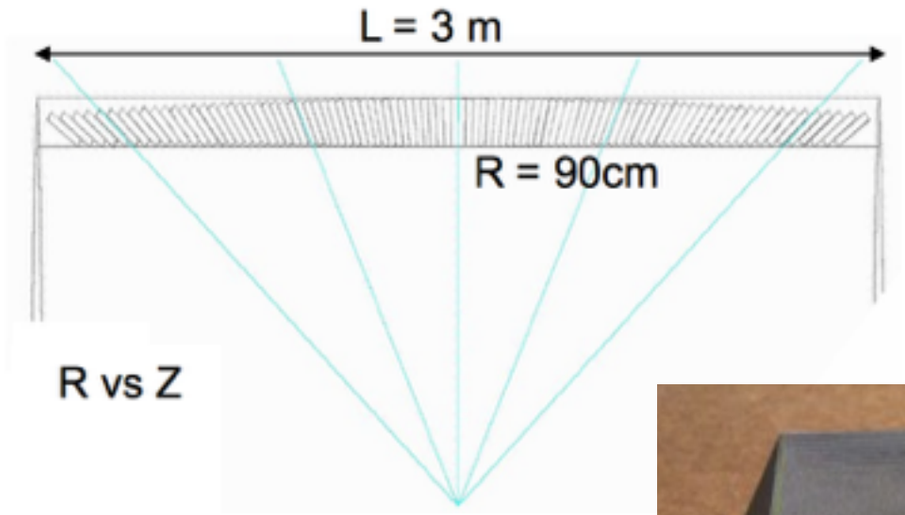
Works inside magnetic field

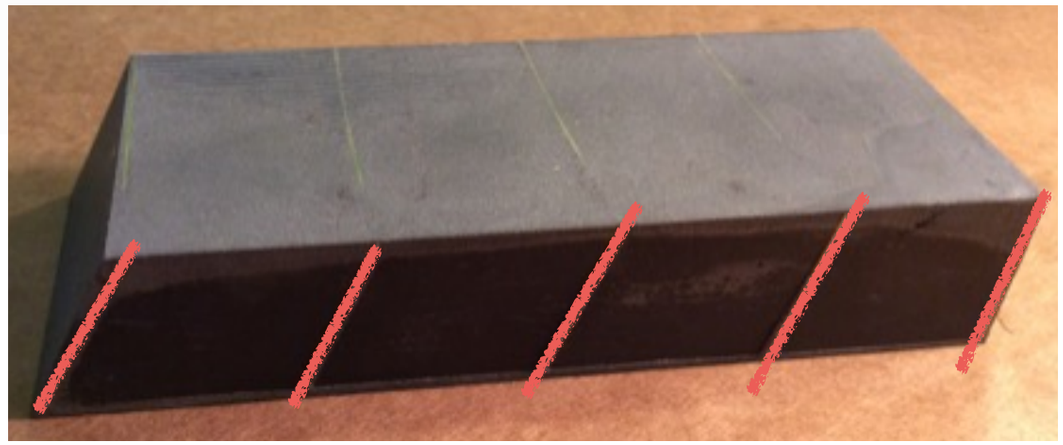


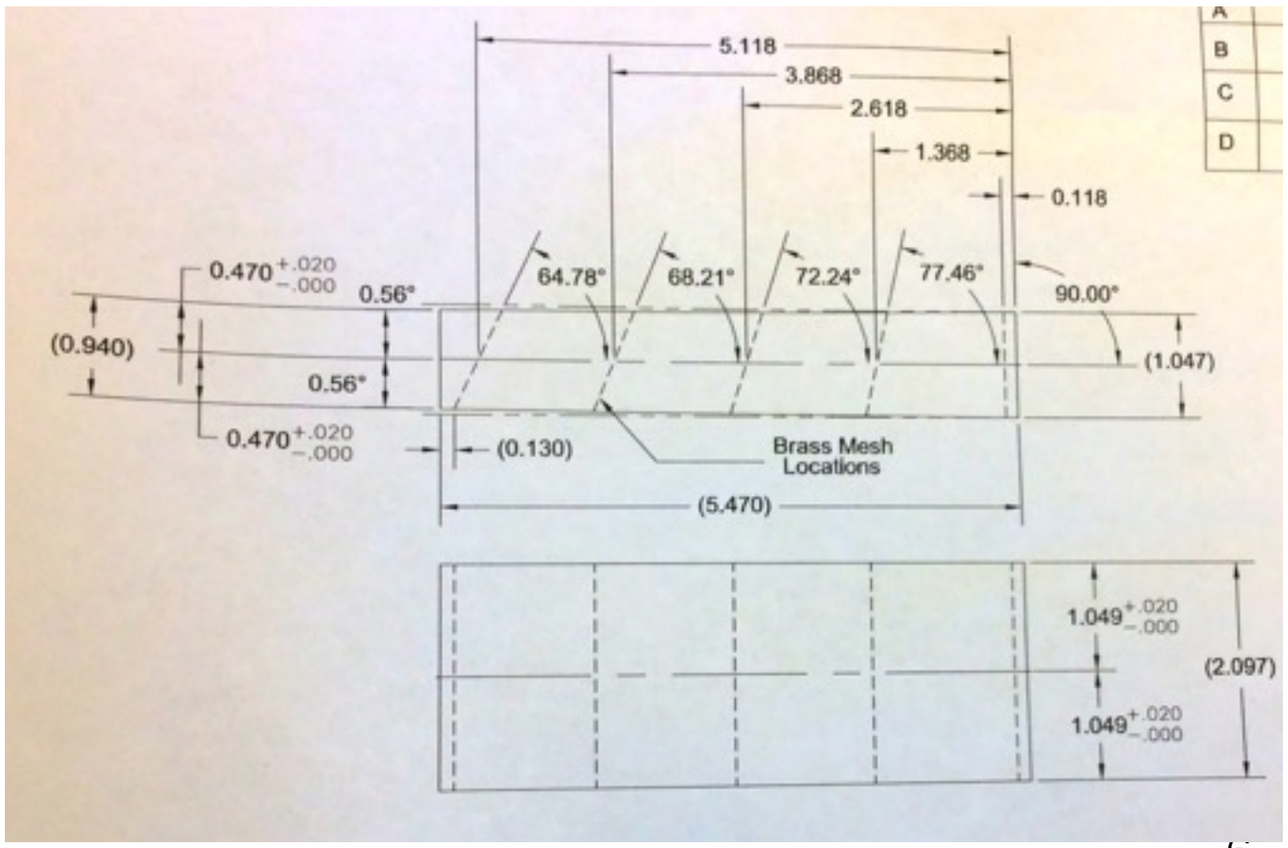
Hamamatsu S12572-015P

Projectivity

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





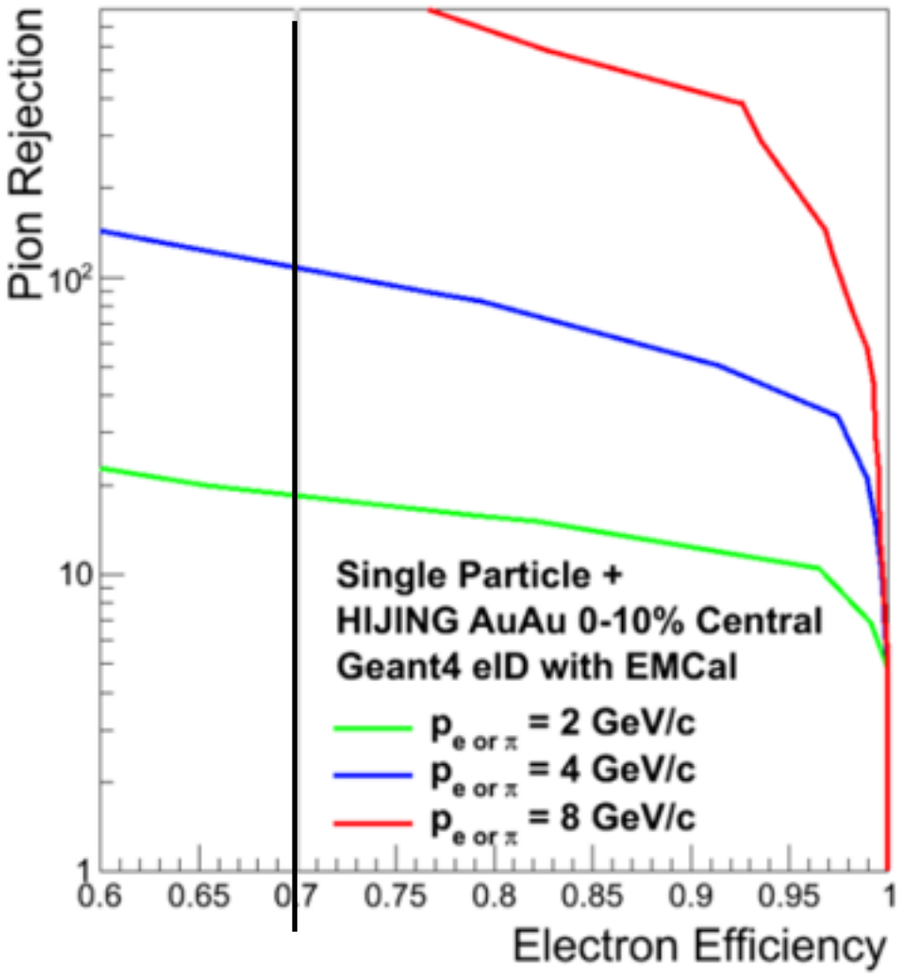


The first way to make the fibers projective was to tilt them in 1D.

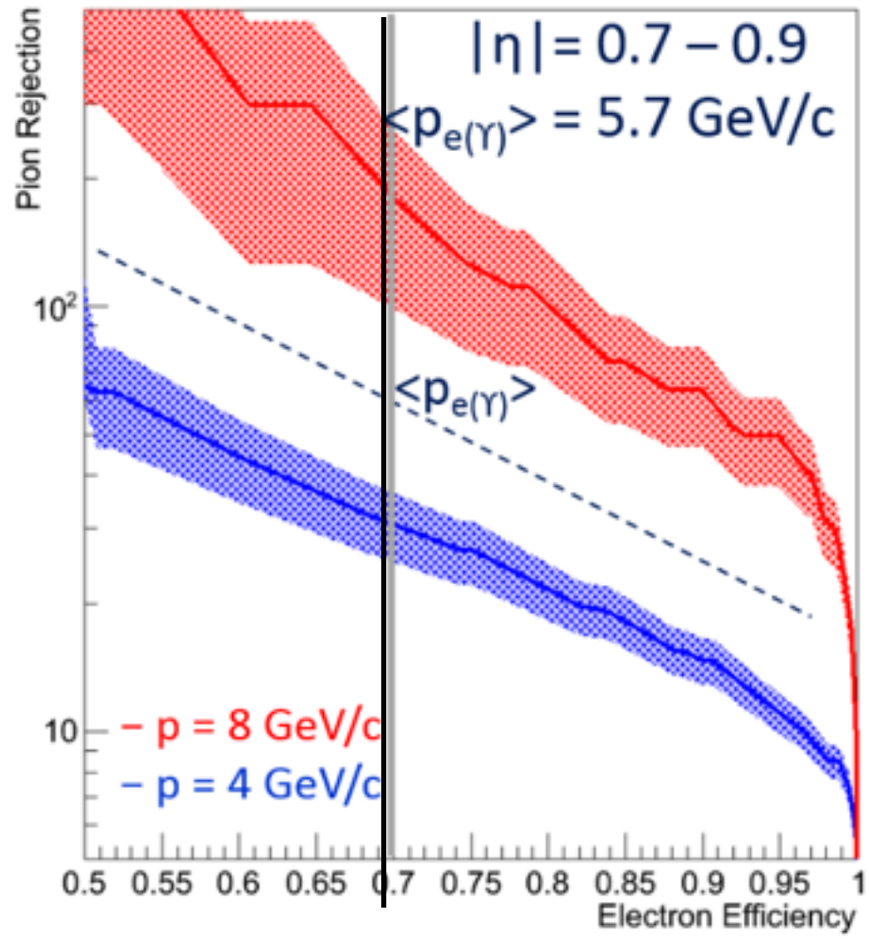
Projectivity

Pion Rejection vs. Electron Efficiency

Projective in polar direction



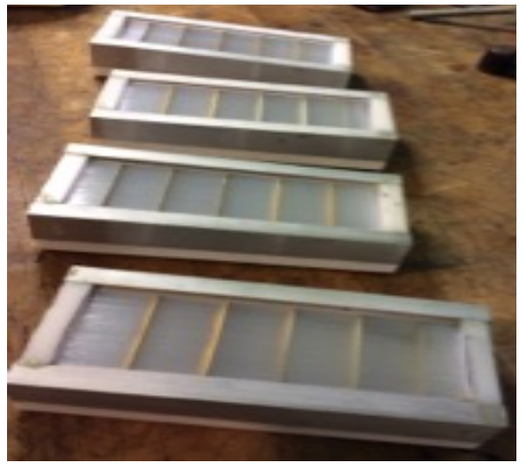
Non-Projective in polar direction



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

EMCAL Module Construction: "Bathtub" Approach

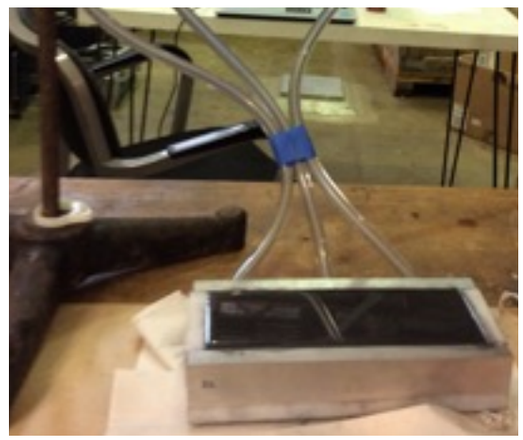
1. Fill the brass meshes with fibers, and place in mold



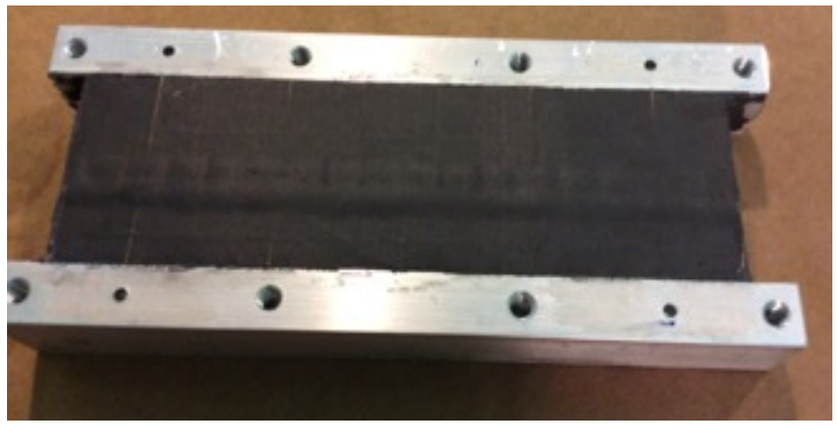
2. Add Tungsten powder (use vibration table)

3. Pour epoxy from the top of the mold (use light vacuum until the epoxy comes through the bottom of the mold)

4. allow the epoxy to dry for 24 hours

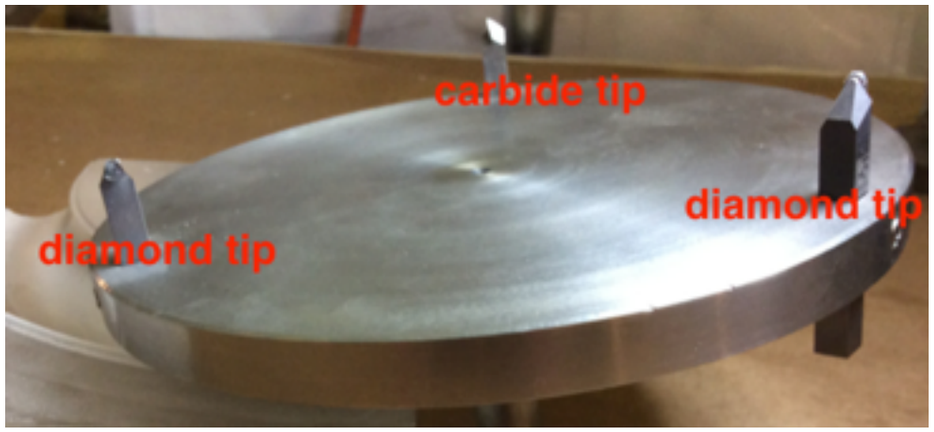


5. final module before machining



Note:
3D printing mold bottoms!

EMCAL Module Construction: Bathtub Approach

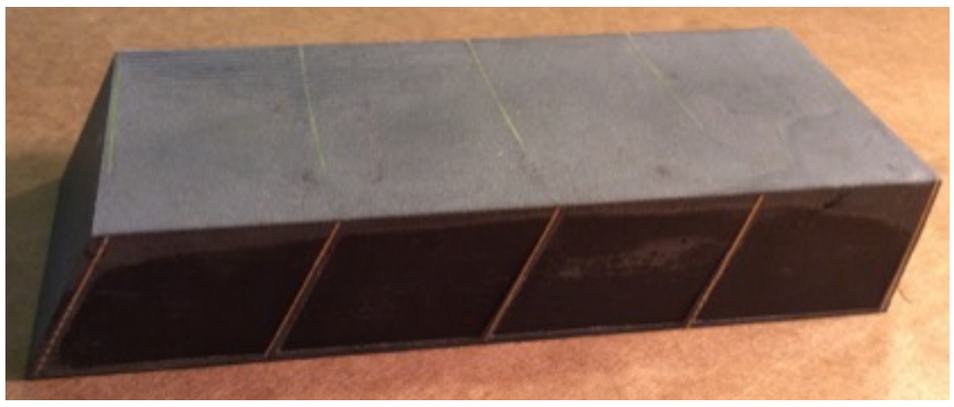


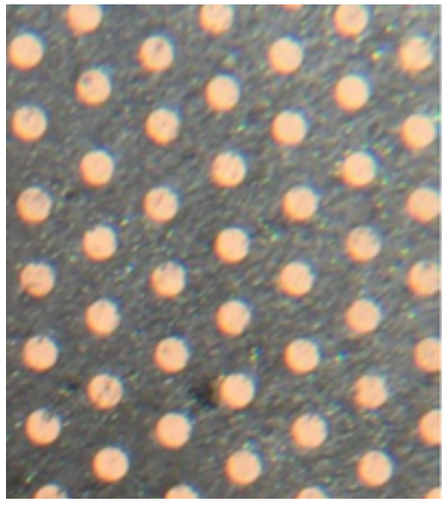
diamond cutter used for machining the modules

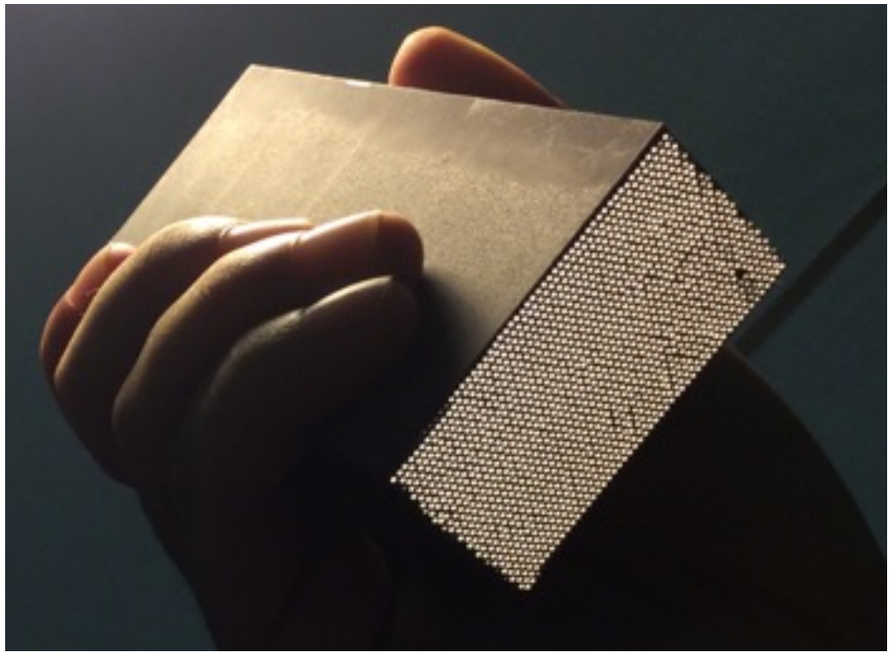
carbide tip

diamond tip

5. final module after machining the ends

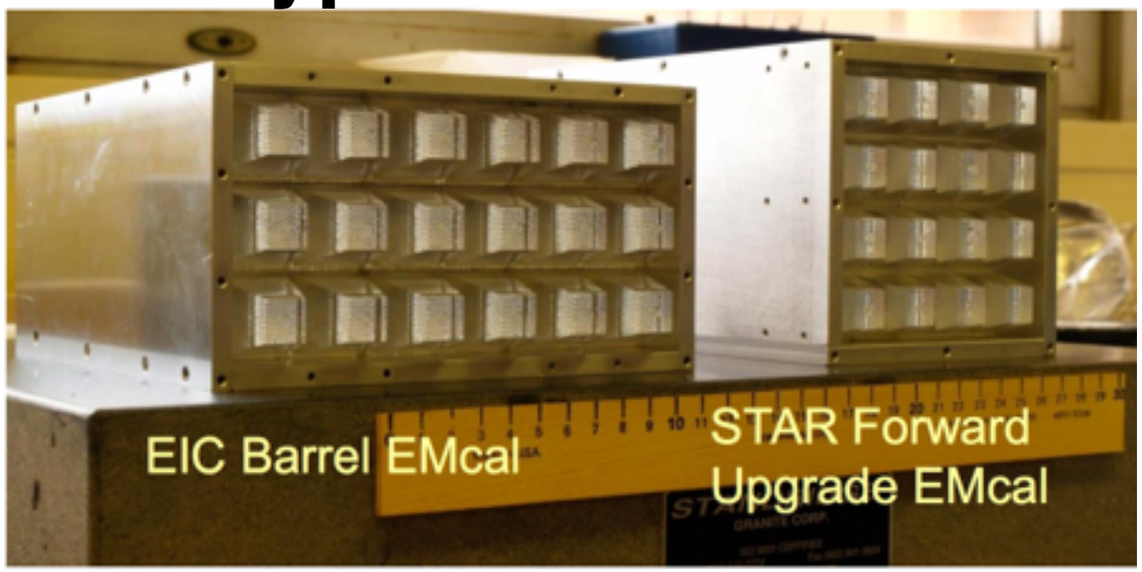






Fermilab test beam 2014 results

Prototype Calorimeters

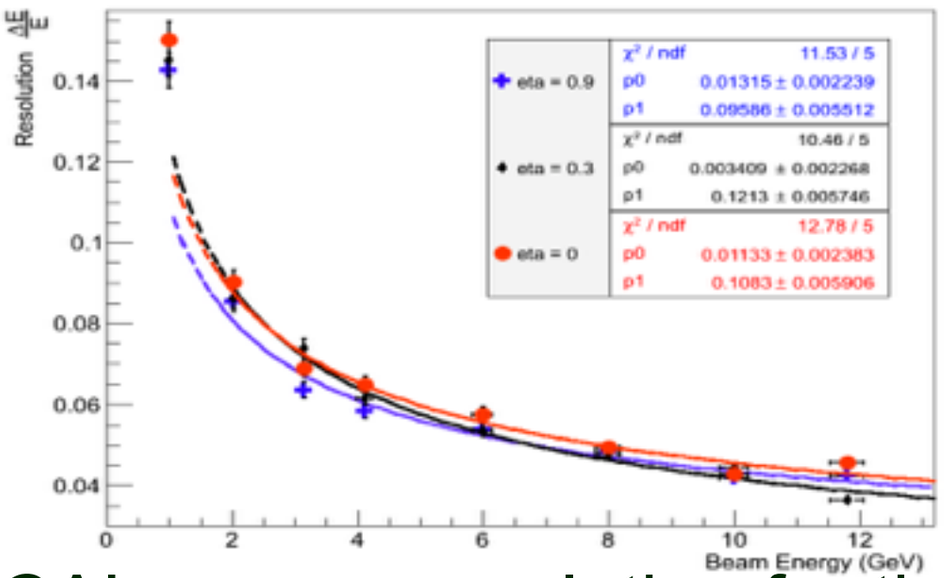


EIC Barrel EMCAL
-semi-projective modules

STAR Forward Upgrade
-non-projective modules

Developed at UCLA

Energy Resolution



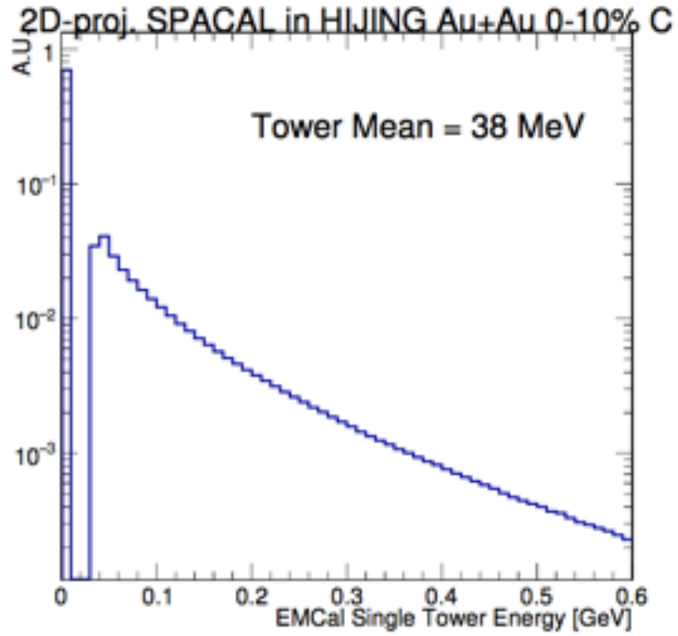
The measured EMCAL energy resolution for three different rapidities.

Segmentation Requirement

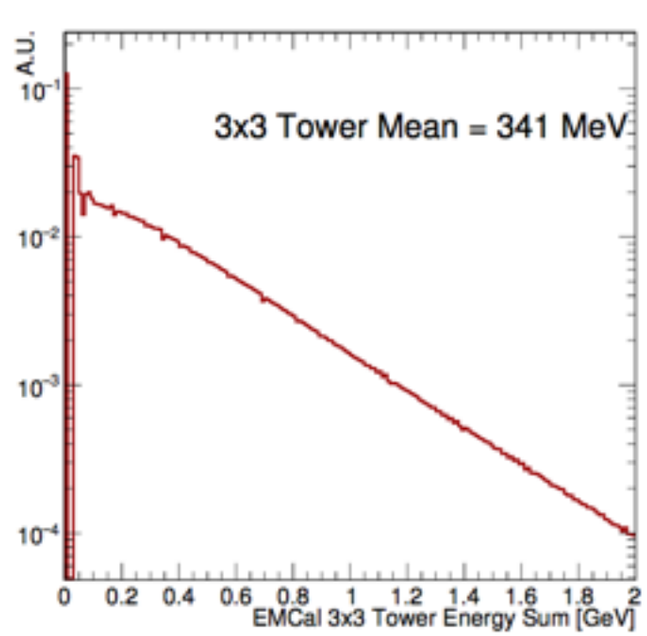
The goal is for detector resolution and segmentation to be better than the limitations on photon reconstruction due to the underlying event background in a heavy ion event.

Hijing Central Au+Au

Average energy per tower ~53 MeV



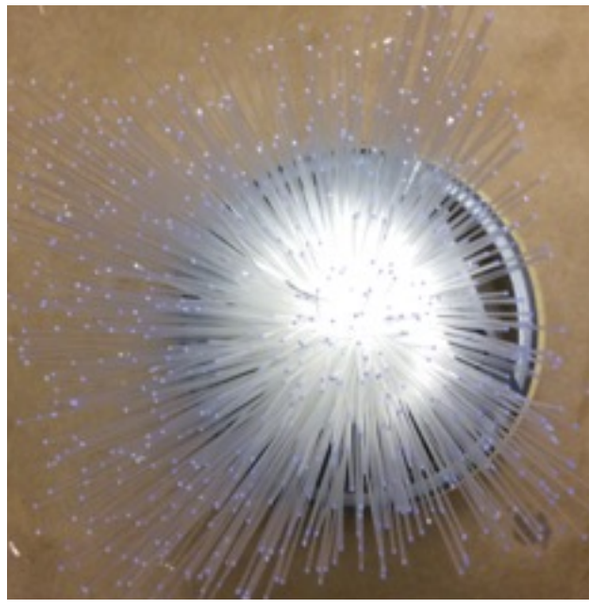
Energy in a 3x3 tower sum ~341 MeV



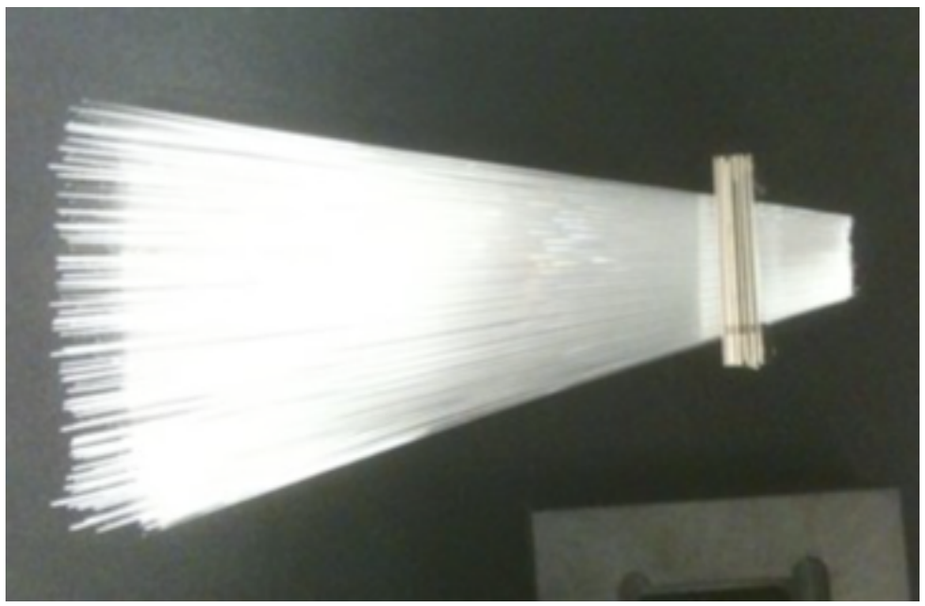
3x3 tower~size of single photon cluster

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

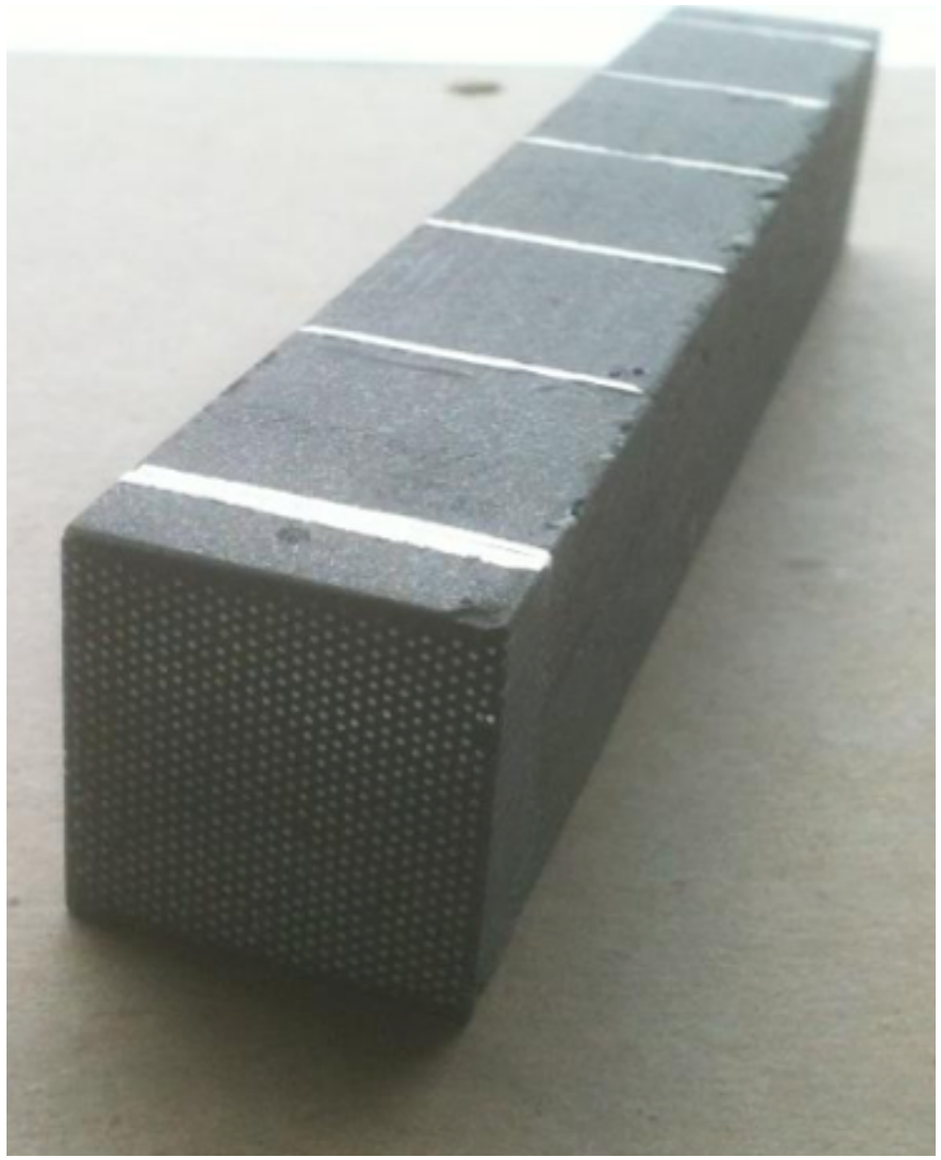
sPHENIX 2D Projective model



2D projective meshes holding fibers



2D projective design is challenging!



2D projective module by BNL

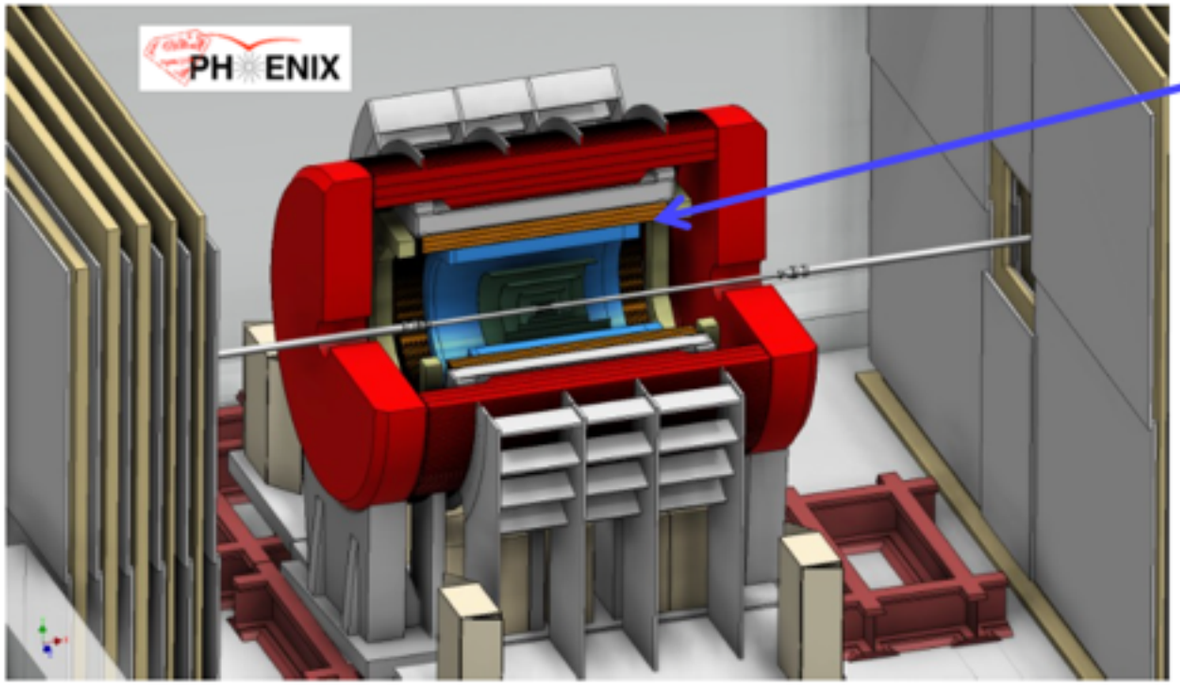
Future Plans

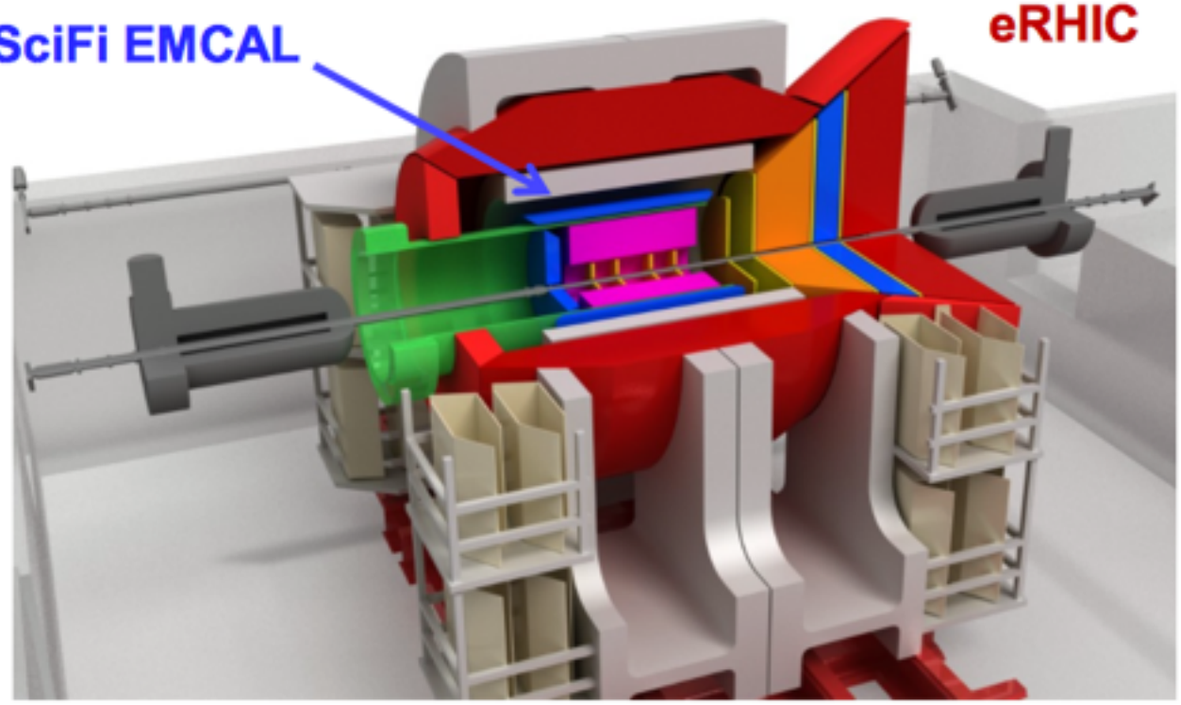
- We are really excited about sPHENIX!
- DOE Panel accepted science case at reviews completed in May 2015!
- We are actively prototyping version 1 8x8 towers of 1D projective blocks.
- Version 2 prototyping of 2D projective blocks is underway.
- sPHENIX is part of plans for BNL after a final PHENIX run in 2016.
- We look forward to Physics in 2021.
- First Collaboration meeting to take place Dec 10-12, 2015 at Rutgers University, see you there!

https://indico.bnl.gov/conferenceDisplay.py?ovw=True&confId=1376

Backup slide

Future Plans: sPHENIX to EIC





The calorimeter requirements are different from sPHENIX to EIC, but there are many similarities such that the sPHENIX EMCAL can satisfy both experiments.