Poster 298

The Tungsten-Scintillating Fiber Accordion Electromagnetic Calorimeter for the sPHENIX Detector

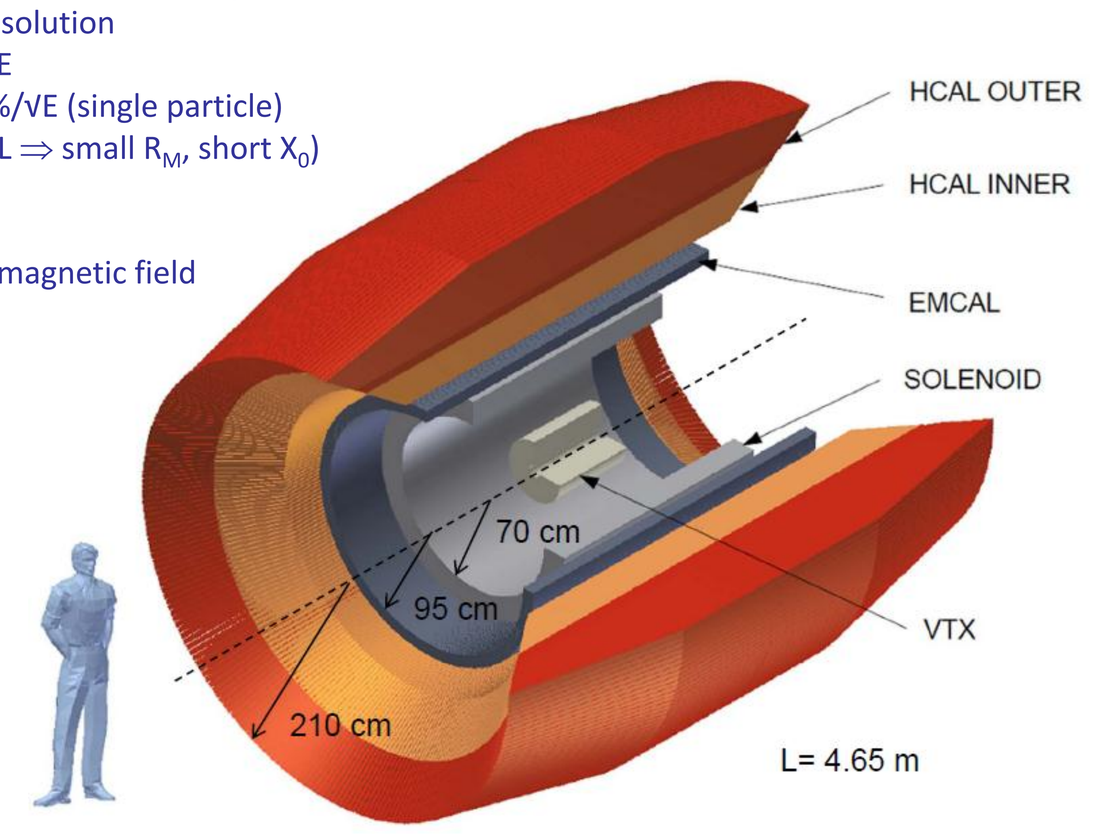
Craig Woody, for the PHENIX Collaboration
Physics Department, Brookhaven National Lab
Upton, NY 11973

Abstract: The PHENIX Experiment at RHIC is planning a major upgrade to enhance its capabilities to measure jets in heavy ion collisions, as well as in p+A, polarized proton, and eventually e-A collisions at the Electron Ion Collider. One major new component of this upgrade will be a new compact electromagnetic calorimeter covering ±1.1 units in η and 2π in ϕ. It will consist of a matrix of tungsten plates, tungsten powder, scintillating fibers and epoxy formed into an accordion structure that will have a small Moliere radius and short radiation length, thus enabling the calorimeter to have a high degree of segmentation for measuring jets at a relatively small radius and allowing a compact design for the sPHENIX detector.

The sPHENIX Central Detector

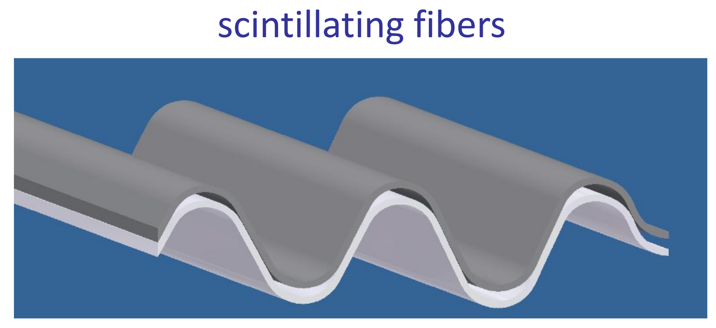
Detector Requirements

- Large solid angle coverage (± 1.1 in η, 2π in ϕ)
- Moderate energy resolution
  - EMCAL ~ 15%/√E
  - HCAL ~ 50-100 %/√E (single particle)
- Compact (for EMCAL ⇒ small R_M, short X_0)
- Hermetic
- Projective
- Readout works in a magnetic field
- Low cost

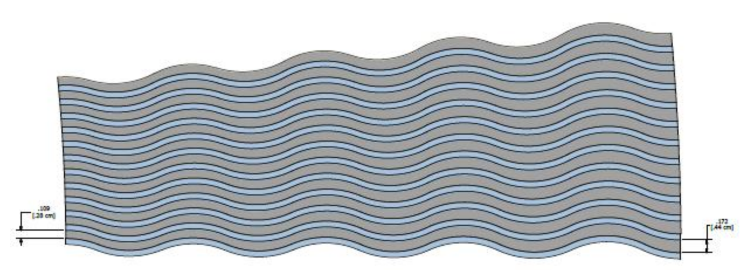


The Optical Accordion

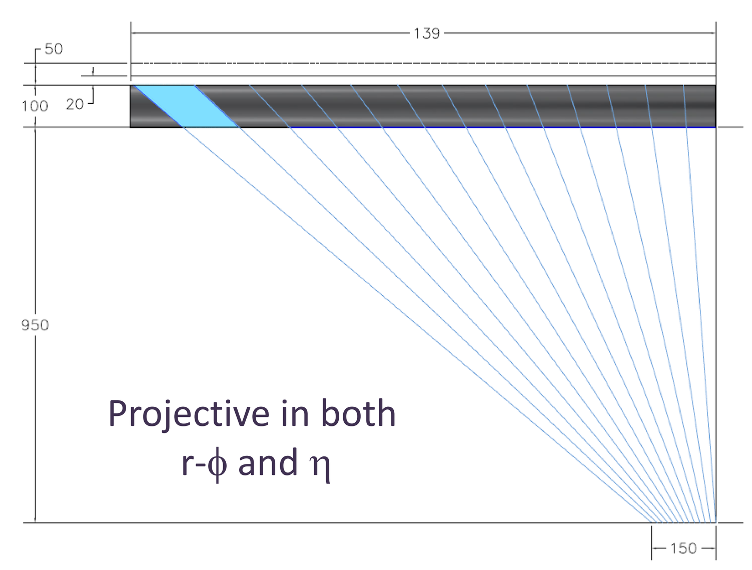
Layered accordion of tungsten plates and scintillating fibers

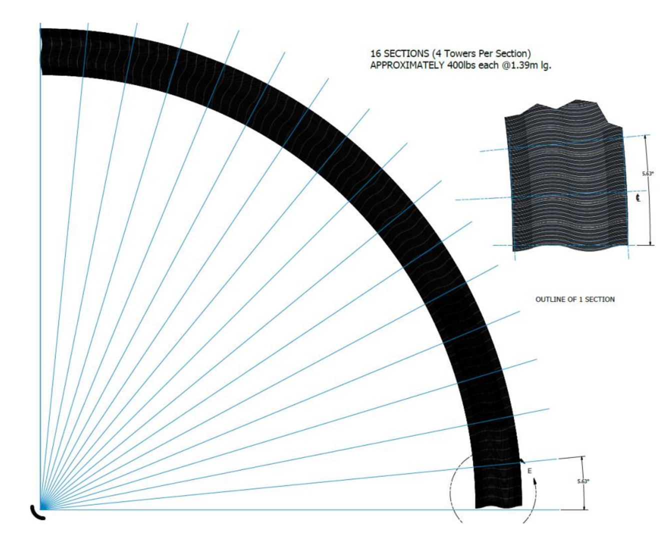


- Volume increases with radius
- Scintillator thickness doesn't increase with radius, so either tungsten thickness must increase or the amplitude of the oscillation must increase, or both
- Plate thickness cannot be totally uniform due to the undulations
- Small amplitude oscillations minimize both of these problems



- 24,576 towers (256 ϕ x 96 η)
- Modules assembled in groups to form sectors
- 64 sectors arranged azimuthally to cover 2π (x2 for both sides)

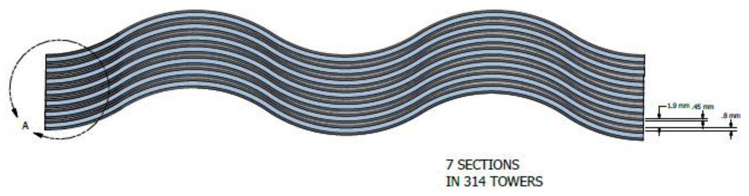




Tungsten-SciFi Epoxy Sandwich

Uniform thickness, thin pure tungsten metal sheets with wedge shaped SciFi + tungsten powder epoxy layer in between

Can be made into large modules (L > 1m) and fabricated in industry



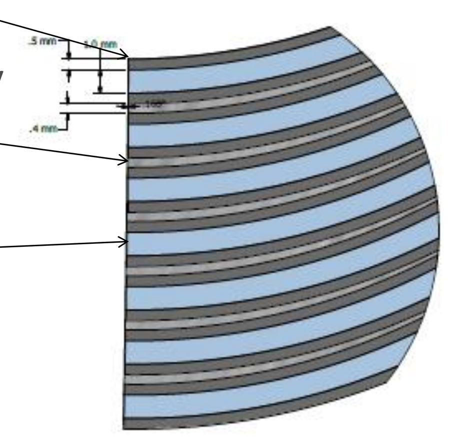
Sandwiches are cast together in 7 layers to form a module with ~ 2 cm² towers in r-ϕ, 10 cm deep, and 1.4 m long

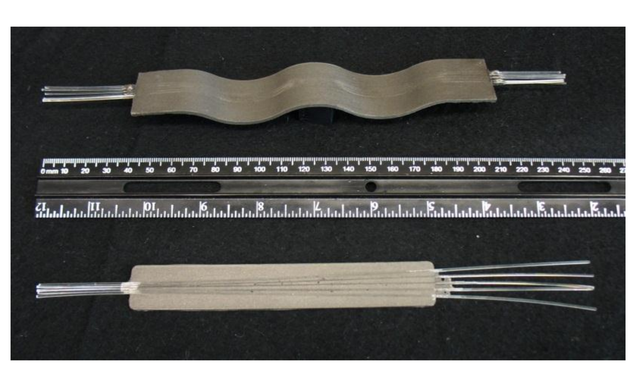
Pure tungsten metal sheet (ρ ~ 19.3 g/cm³)
Thickness: 2x1.0 mm

Tungsten powder epoxy (ρ ~ 10-11 g/cm³) 0.08-0.2 mm

Scintillating fibers 1.0 mm

X_0 = 5.3 mm
R_M = 15.4 mm

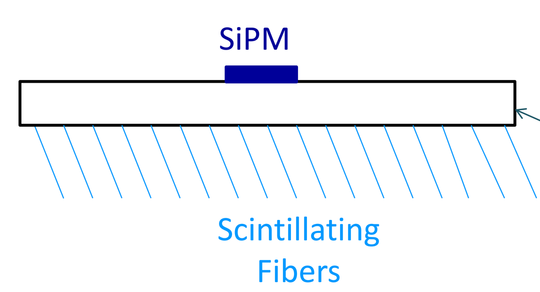




Light Yield and Readout Devices

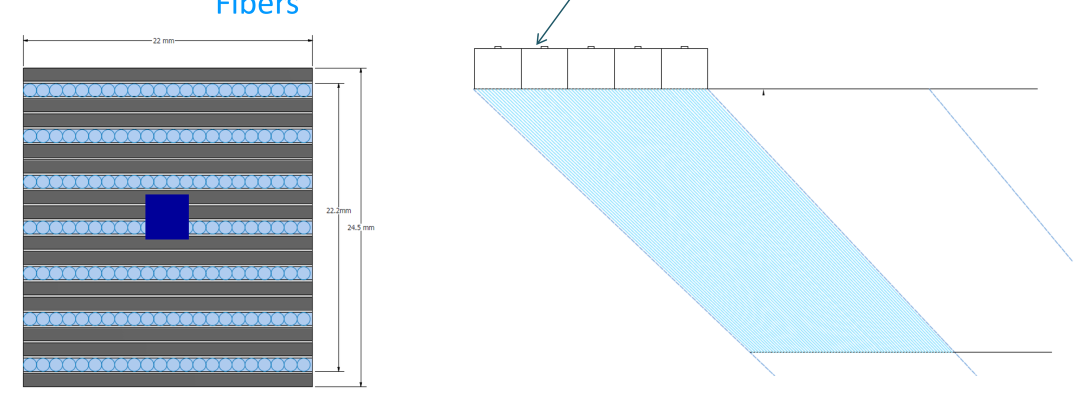
Want to have small photostatistics contribution to the energy resolution

Need sufficient light output from fibers to allow randomizing and collecting the light onto a small readout device



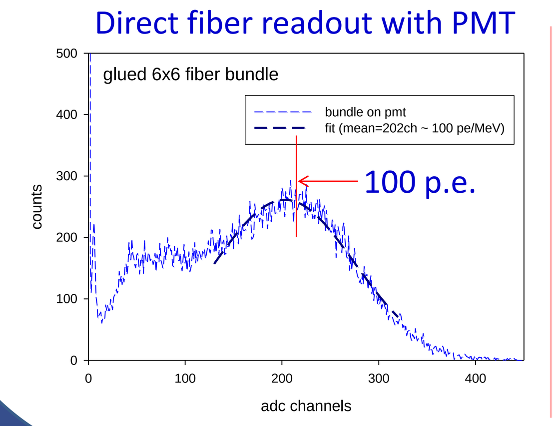
Possible Readout Schemes

Small reflecting cavity or wavelength shifting block



Need to match ~150 1 mm diameter fibers onto a single 3x3 mm² SiPM with good efficiency and uniformity (ε_{area} ~ 2%)

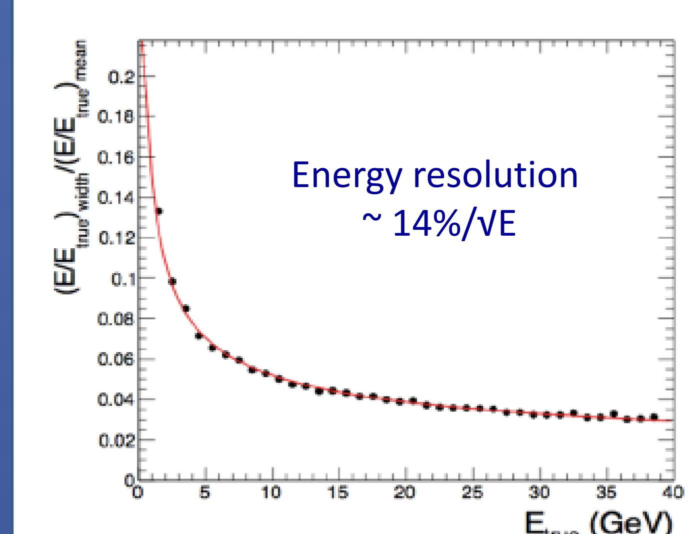
Direct fiber readout with PMT

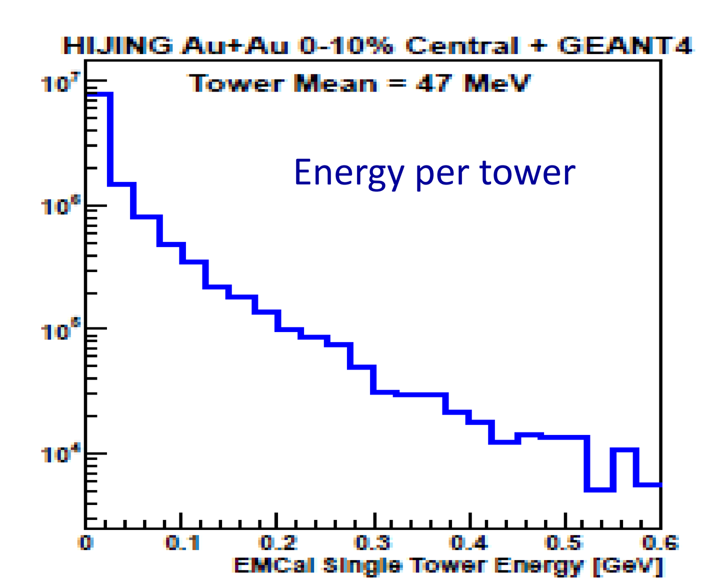


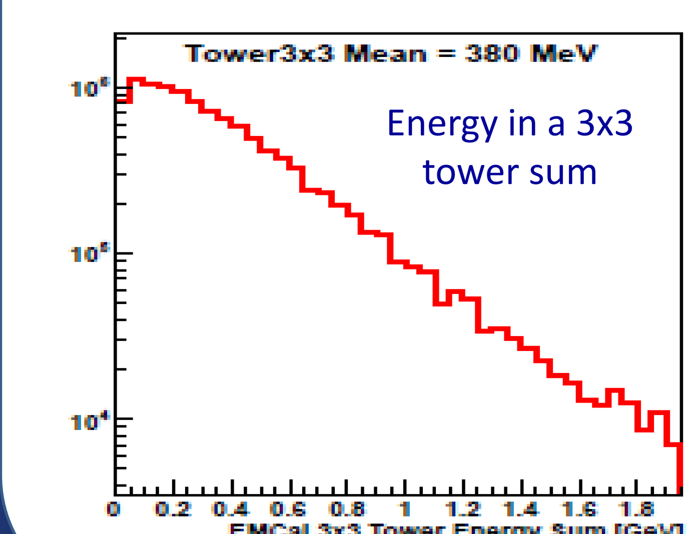
With a sampling fraction of 4%, 100 p.e./MeV in scintillator (direct readout with PMT) ⇒ 4000 p.e./GeV of energy deposit in the calorimeter

Assuming only geometrical light collection of 2% and 2.5x higher QE for SiPM ⇒ 200 p.e./GeV photostatistics

Monte Carlo Results







Related posters:

- 391 - Hadronic Calorimetry in the sPHENIX Upgrade Project at RHIC
- 288 - A Silicon Photomultiplier (SiPM) Based Readout for the sPHENIX Upgrade
- 382 - Photon Reconstruction in the sPHENIX Electromagnetic Calorimeter
- 258 - Jet Physics Simulations for the sPHENIX Upgrade
- 323 - sPHENIX Jet Reconstruction Performance
- 271 - sPHENIX Jet Upgrade Program: Unraveling Strong vs Weak Coupling
- 353 - The sPHENIX Barrel Upgrade: Jet Physics and Beyond

Preprint: sPHENIX: An Upgrade Concept by the PHENIX Collaboration, arXiv:12076378

Calorimeter development is being supported by a Phase I SBIR with Tungsten Heavy Powder, Inc. San Diego, CA

This work is supported by U.S. Department of Energy Contract DE-AC02-98CH10886.