sPHENIX EMCal design, construction and test beam results

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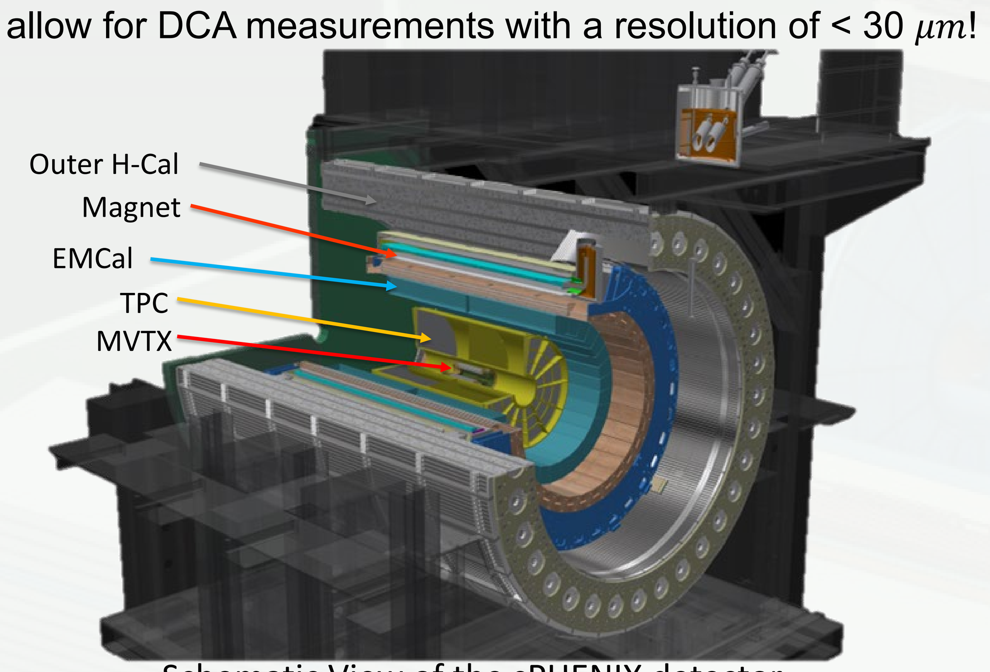
Abstract

The sPHENIX detector at BNL's Relativistic Heavy Ion Collider (RHIC) is designed to accurately study proton-proton, proton-nucleus, and nucleus-nucleus collision systems. The design of sPHENIX, including full azimuthal calorimeter coverage, will allow it to precisely study properties of the Quark Gluon Plasma through open heavy flavor production, jet modification, and Upsilon measurements. It will also perform a variety of cold QCD studies. Helping to enable the broad measurement capabilities of sPHENIX is the Electromagnetic Calorimeter (EMCal), which is the primary detector for identifying and measuring the energy of photons and electrons. The EMCal is constructed of scintillating fibers embedded in blocks of tungsten powder in an epoxy matrix, with the emitted light collected with acrylic light guides and read out through Silicon Photomultipliers (SiPMs). This poster will discuss the design and construction of the EMCal as well the results from a 2018 Beam Test.

sPHENIX

The sPHENIX detector will be located at the Relativistic Heavy Ion Collider and designed with the stated goal of studying the Quark Gluon Plasma by providing accurate jet measurements as well as heavy flavor measurements.

- Full 2π azimuthal and $|\eta| < 1.1$ acceptance
- Electromagnetic calorimeter tower granularity of 0.024x0.024 in η x ϕ
- First Hadronic Calorimeter at RHIC allowing measurement of hadronic component of jets!
- Tracker will allow for DCA measurements with a resolution of < 30 μm!



Schematic View of the sPHENIX detector

EMCal Design

The EMCal consists of 24,576 towers constructed into 6,144 blocks arranged in a cylindrical pattern around the interaction region

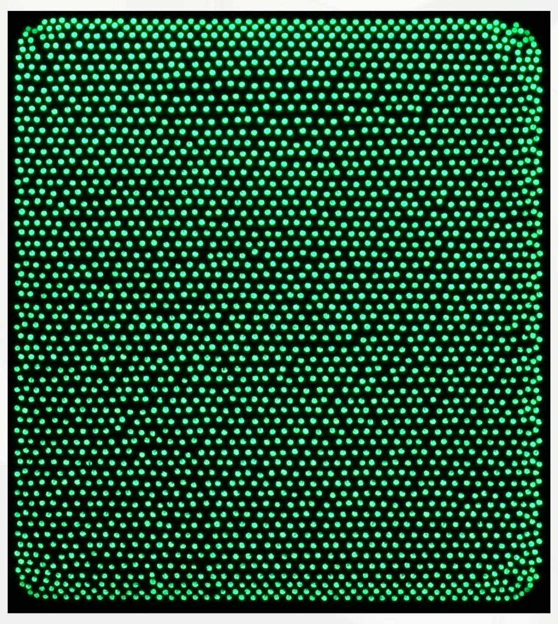
Blocks are tapered in two dimensions allowing for the fibers to be projective in both η and ϕ

The block consists of 2668 scintillating fibers embedded into a tungsten powder and epoxy matrix

Mounting end of the block is attached to a reflective plate, and the instrumented side is equipped with light guides

Collected Light signal is readout using 4 SiPMs per tower

Block with reflector, light guides and SiPMs mounted



Readout end of block illuminated with green light from the reflector end as used to count the number of fibers

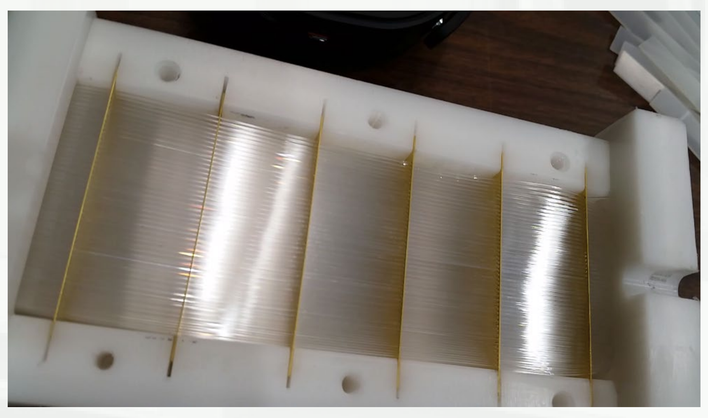
EMCal Block Production

Blocks are produced at UIUC in 4 main stages:

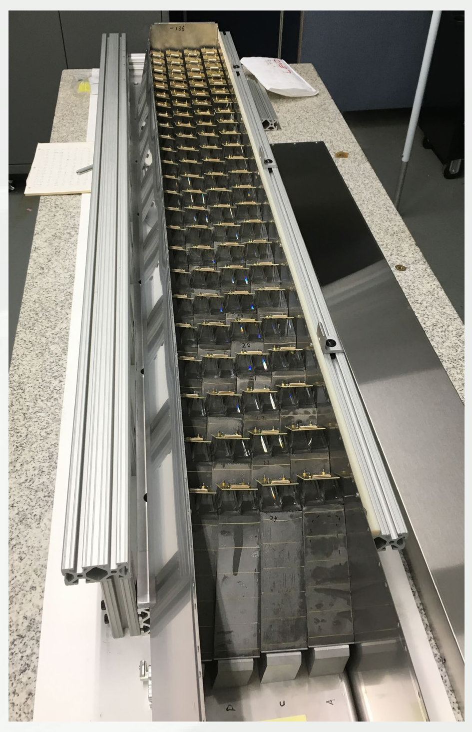
1. 2668 scintillating fibers inserted through 6 brass screens (fiber set) and placed into mold
2. Tungsten Powder (TP) added to the mold using a vibration table.
3. Epoxy is pulled through the TP using a vacuum pump
4. Machining to final dimensions and finished surfaces

More than 30% of the fiber sets for the EMCal have been produced

1 of 64 sectors completed



Sample Fiber Set in Mold

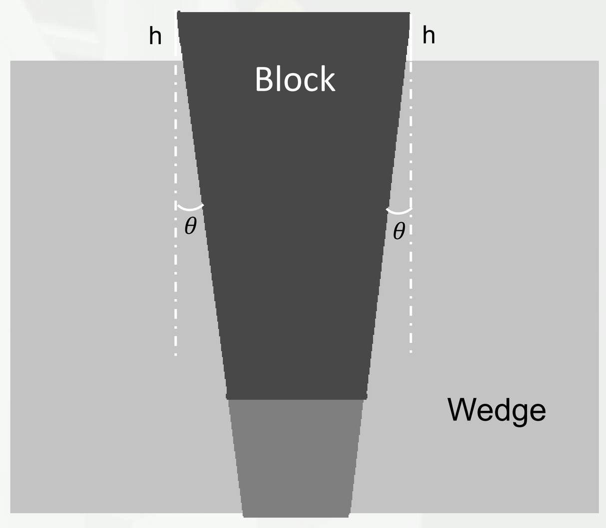


First assembled sector

EMCal Block Testing

Produced blocks are evaluated for quality based on four tests:

- Dimensionality: Evaluated using a wedge based technique using the angles in the block to maximize accuracy.
- Density: Ensure that the produced block has a density above 8.8 $\frac{g}{cm^3}$
- Light Transmission test to verify fiber count
- Scintillation test to verify functionality of the fibers



Schematic view of the Wedge system used to evaluate dimensionality

Test Beam and Results

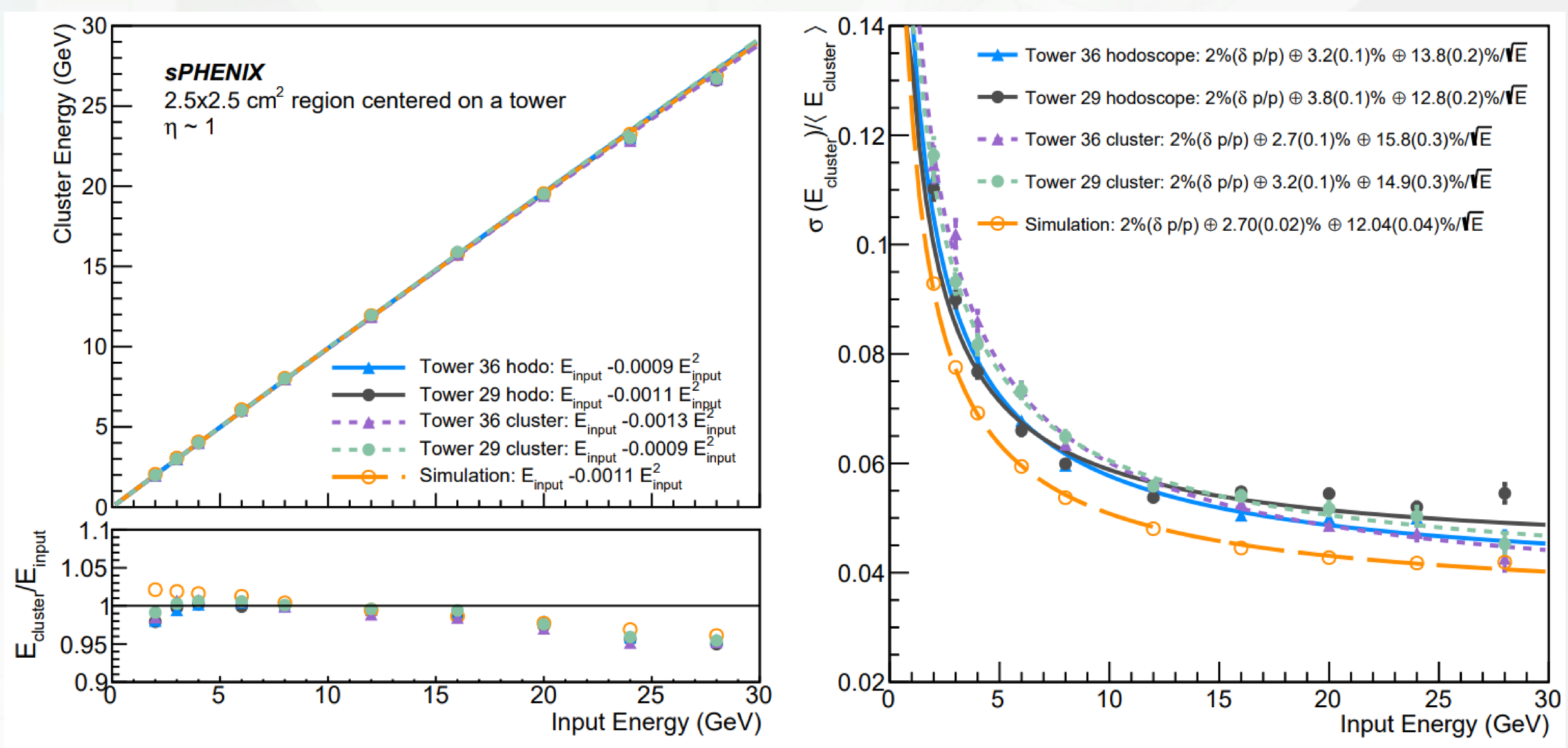
In 2018 a 4x4 block matrix prototype, 1/6th of a sector, was tested at the Fermilab Test Beam facility

Energy scan over the range of 2 to 28 GeV completed targeting two towers on two different blocks

Used a Cerenkov detector for EID, and a hodoscope to provide 0.5x0.5 cm position resolution

In order to account for beam position dependent effects due to nonuniformity and tower boundaries a position dependent calibration is applied

Resulting energy resolution meets the design goals for the sPHENIX EMCal



Linearity and resolution of the EMCal Prototype measured for two towers shown with two positional dependence calibration techniques. Hodoscope method best reflects what is expected in the full detector system due to the tracking detectors

Thanks to the 4 technicians, 2 graduate and 35 undergraduate students working on this project at UIUC, without whom it would not be possible.

Special Thanks to Emily Pasetes, Mason Housenga, and Saad Altaf who have each filled over 800,000 fibers equating to more than 300 blocks

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