sPHENIX EMCal Design, Construction and Test Beam Results

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Learn more at https://arxiv.org/pdf/2003.13685.pdf

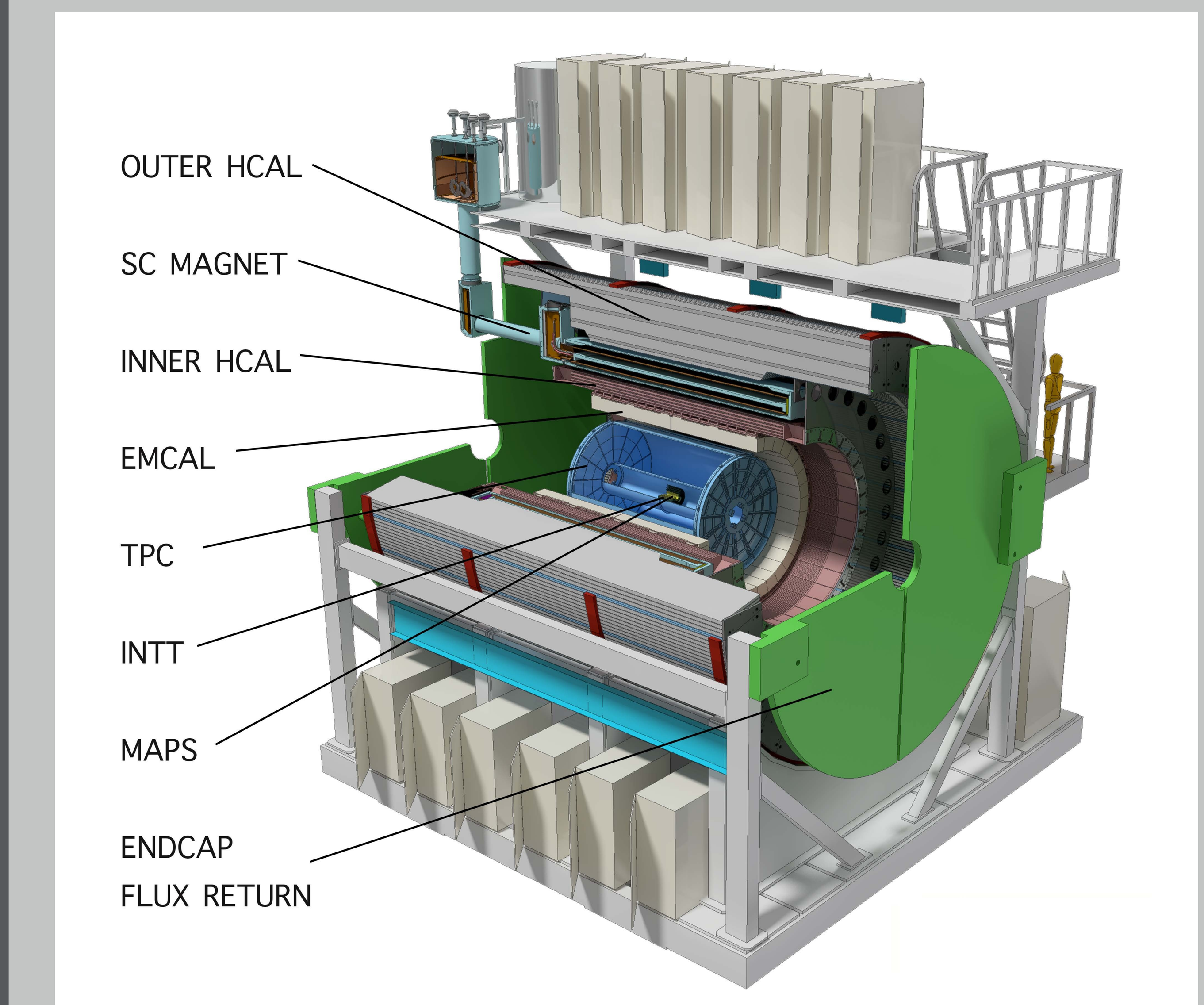
Abstract

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. This poster will discuss the design and construction of the EMCal as well the results from a 2018 Beam Test.

sPHENIX Detector Overview

The sPHENIX detector at RHIC is designed to provide accurate jet measurements as well as heavy flavour measurements.

- EMCal tower granularity of 0.025×0.025 in $\Delta\eta \times \Delta\phi$.
- First Hadronic Calorimeter at RHIC! Angular ranularity of 0.1×0.1.
- large acceptance: over the full 2π azimuthal and $|\eta| < 1.1$
- High resolution vertexing and precision tracking.
- high rate: a readout rate of 15 kHz for all sub-detectors.



EMCal Design and Block Production at UIUC

- 24576 towers constructed into 6144 blocks arranged in a cylindrical pattern around the interaction region.
- each block tapered in both η and ϕ direction such that the fibers point approximately to the center of sPHENIX detector.

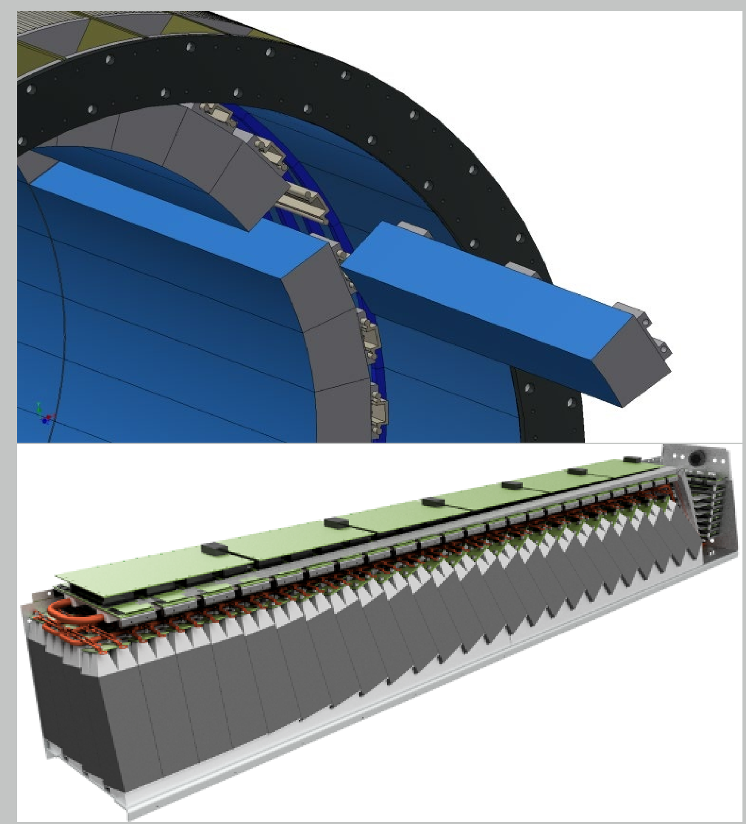


Figure: One EMCal sector in sPHENIX detector and its structure

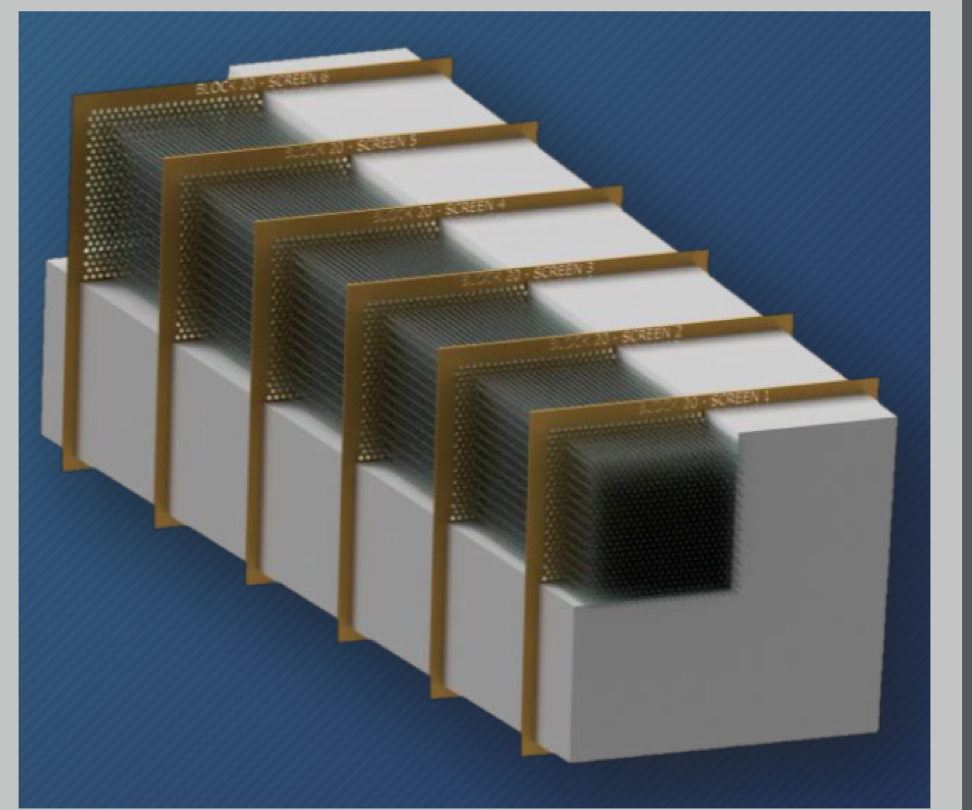


Figure: An EMCal block with light guides and readout electronics installed

The production of a block is in 4 main stages:

1. 2668 scintillating fibers inserted through 6 brass screens (fiber set) and placed into mold
2. Tungsten Powder (TP) is added to the mold
3. Epoxy is pulled through the TP using a vacuum pump
4. Dried block is machined to final dimensions
   - Qualified blocks are then shipped and assembled at BNL.

- Percentage of filled UIUC sets: 71%
- Percentage of finished UIUC blocks: 13.35%

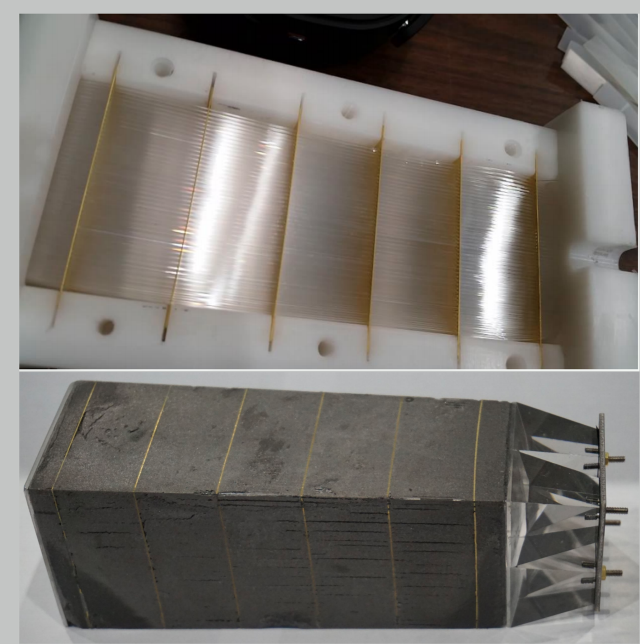


Figure: A filled fiber set in mold

Block Testing

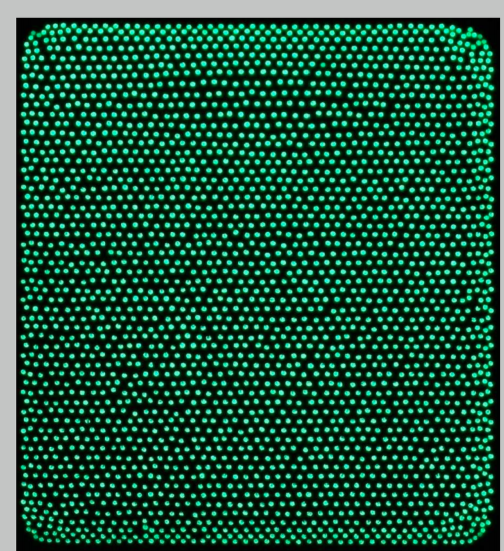


Figure: Light transmission test

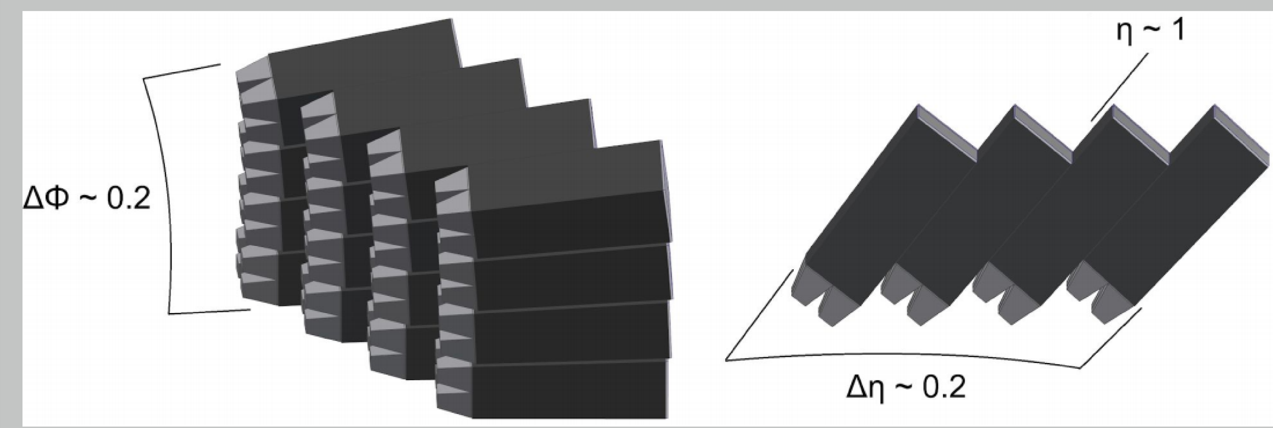
The production of EMCal blocks at UIUC are tested and selected to meet performance expectations from the following perspectives before assembly

- Dimensional compliance and density
- Counts of fibers that transmits light
  - For example, shown left is the picture taken at the end of a block with green lights shine from the opposite end. A custom written script was used to analyze each fibers' light transmitting.
- scintillation response of block

2018 Prototype and Beam Test: Overview & Technicality

An EMCal prototype, corresponding to a slice $\Delta\eta \times \Delta\phi = 0.2 \times 0.2$ centered at $\eta = 1$, was tested at the Fermilab Test Beam Facility in Spring 2018.

- Studied the prototype's energy resolution
- Calibrated effects of relative position to beam as well as tower boundaries



Schematic view of the EMCal prototype.

Techinicality:

1. Two Cherenkov counters for trigger only on electron signals.
2. A hodoscope to determine beam position to a resolution of 0.5×0.5 cm^2.
3. Scanned energy resolution from 2 GeV to 28 GeV.

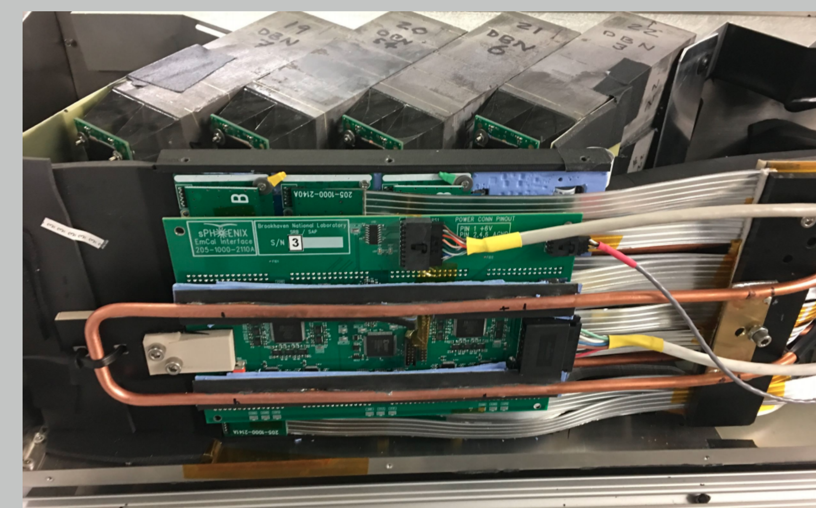


Figure: Picture of the EMCal prototype.

Analysis and Results

Three sources of calibrations were determined using input energy of 8 GeV.

- Two position dependent corrections: by hodoscope and by the prototype (cluster-based).
- Transverse beam profile of the beam at different energies.

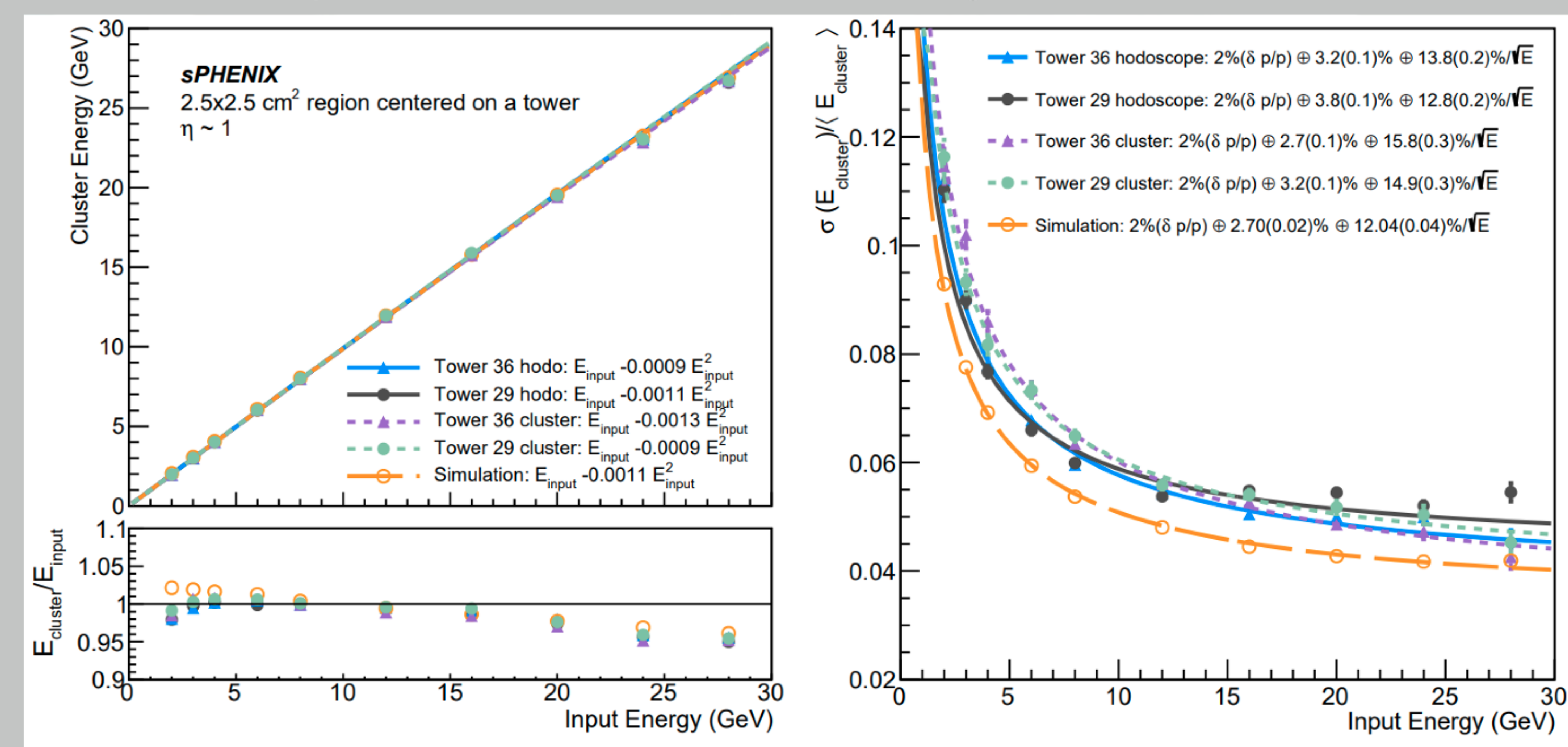


Figure: EMCal energy linearity and resolution.

The energy resolutions obtained for this 2D projective EMCal prototype meet the sPHENIX physics requirements.

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