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

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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 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
**Physics:**
- Measure jets, $\gamma$-jets, and direct single $\gamma$'s up to high $p_T$.
- Identify electrons and measure their energies for measuring $\gamma$'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 ($\pm 1.1$ in $\eta$, $2\pi$ in $\phi$)
- good energy resolution
- Fit inside the BaBar magnet
  - minimal radial space (dense)
  - compact (short $X_0$, small $R_M$)
  - high segmentation 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 readout channels

Inner radius must be \( \sim 90 \) cm for tracking & particle ID
Inner radius must be small
\( \Delta R = 116 \) cm - 90 cm (26cm)

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Absorber
Matrix of Tungsten powder and epoxy w/embedded scintillating fibers

Scintillating Fiber (Kuraray SCSF78)
Diameter 0.47 mm, spacing 1mm

Calorimeter Specs
Density \(\sim 10\text{g/cm}^3\)
\(X_0 \sim 7\text{mm}\) (18 \(X_0\) total), \(R_M\sim 2.3\text{ cm}\)

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

Non-Projective in polar direction

Average cluster ~8 towers

Average cluster ~12+ towers
Collaborate with Brookhaven National Laboratory for assembly

fibers & meshes

fibers, meshes, & tungsten

epoxy added

epoxy drying for 24 hours

module ready to be machined

finished

sPHENIX EMCal 1D Production @UIUC

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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** \( \sim 38 \text{ MeV} \)
- **Energy in a 3x3 tower sum** \( \sim 341 \text{ MeV} \)

3x3 tower \( \sim \) size of single photon cluster

Average energy of tower \( \sim 341 \text{ MeV} \) from the underlying event in central Hijing Au+Au event.
Fermilab Test Beam 2016
Fermilab Test Beam 2016

Meets design goals of $<100%/\sqrt{E}$ and $<15%/\sqrt{E}$ for EMCal

RHIC/AGS User’s Meeting June 2016
https://www.bnl.gov/aum2016/content/workshops/Workshop_2b/campbell_sarah.pdf
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sPHENIX EMCal 2D Production @UIUC

...for next Test Beam!

fibers & meshes,
fibers, meshes, & tungsten
2D module ready to be machined

final 2D module
• 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!