

# The RHIC zero-degree calorimeters

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## Abstract

The RHIC zero-degree calorimeters provide common event characterization in the four heavy ion experiments which recently completed their first data taking run. Here, we describe simulations which lead to the design of these devices, testbeam performance and initial experience at RHIC. © 2001 Elsevier Science B.V. All rights reserved.

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## 1. Introduction

High-energy collisions of nuclei usually lead to the emission of evaporation neutrons from both “beam” and “target” nuclei. At the RHIC heavy ion collider with 100 GeV/*u* beam energy, evaporation neutrons diverge by less than 1 mrad from the beam. Neutral beam fragments can be detected downstream of RHIC ion collisions (and a large aperture accelerator dipole magnet) if  $\theta \leq 4$  mrad but charged fragments in the same angular range are usually too close to the beam trajectory.

The purpose of the RHIC zero-degree calorimeters (ZDCs) is to detect neutrons emitted within this cone along both beam directions and measure their total energy (multiplicity). The ZDC

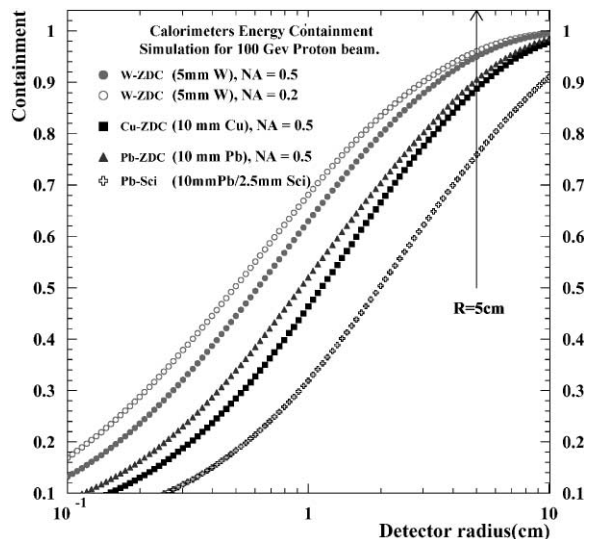


Fig. 1. The fraction of the calorimeter signal (photons transported in the scintillator or C fiber) produced as a function of radius from 100 GeV *n*'s impact.

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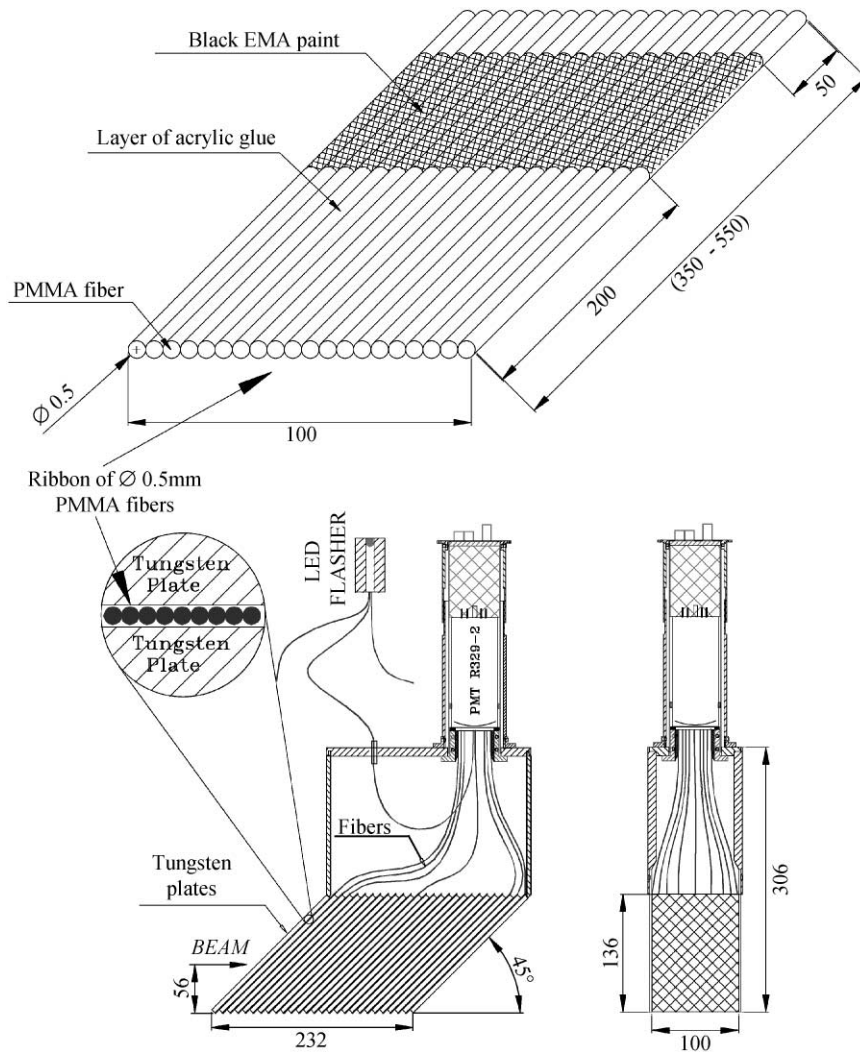


Fig. 2. Mechanical design of the production tungsten modules.

coincidence of the two beam directions is a minimal bias selection of mutual beam interactions. This makes it useful as an event trigger and a luminosity monitor [1,2]. The neutron multiplicity is also known to be correlated with event geometry [3].

The RHIC ZDCs are hadron calorimeters. The most stringent constraint on their design follows from the limited available space between the RHIC beams. The total width of the calorimeters is only 10 cm (equal to  $A_I$  in tungsten).

## 2. Simulations, construction, beamtest results

We simulated shower development, light production and transport in the optical components using Geant 3.21 for two basic sampling calorimeter designs: (1) Pb absorber with scintillator sampling (2) Pb, Cu or  $W$  absorber, each with ribbons of commercial, PMMA-based<sup>1</sup> commu-

<sup>1</sup>Raytella fiber, Toray Industries, 600 Third Avenue, NY 10016, USA.

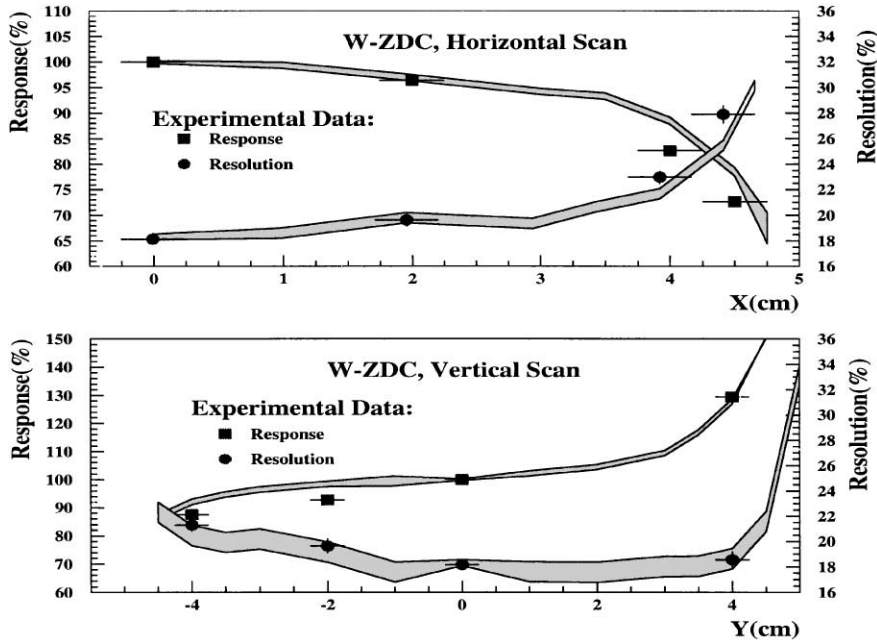


Fig. 3. Response map of the calorimeter.

nication grade optical fiber in the sampling layer. In Fig. 1, we see the main advantage of the zdc vs. scintillator sampling technique.

For 10 cm wide modules with 5 mm absorber plates, a convenient longitudinal segmentation is 1 module per 2 nuclear interaction lengths of absorber. For the production modules, we obtained machined plates of tungsten alloy<sup>2</sup> (See Fig. 2).

In Fig. 3, we plot the calorimeter response vs. impact position for both *W* and Cu prototype module types. In the vertical scans, there is an abrupt increase in response near the upper edge of the modules. Our simulation reproduces this edge effect. It can be traced to shower leakage into the fibers above the absorber. We increased the height of the module in our final production design from 10 to 13.6 cm.

<sup>2</sup>Kulite Tungsten Corp., 160 E. Union Avenue, E. Rutherford, NJ 07073, USA.

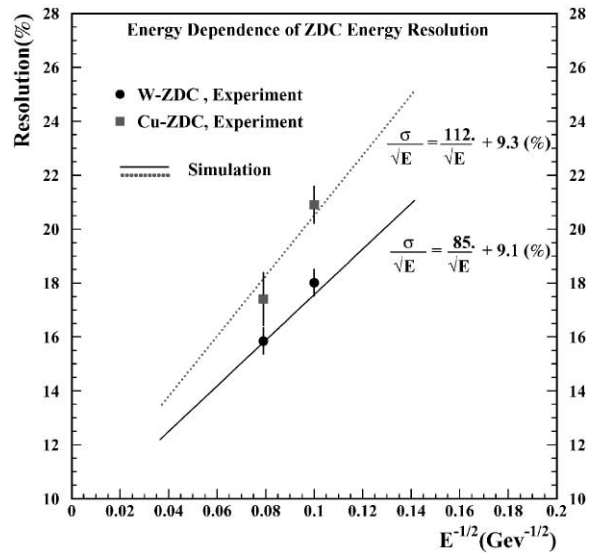


Fig. 4. Measured resolution ( $\sigma/\text{mean}$ ) for both 8  $A_1$  prototypes at 100 and 160 GeV compared to simulation. Note that the simulation results are best represented by a linear sum of the stochastic and constant terms.

The tungsten calorimeter uniformity and energy resolution were essentially unchanged when the energy deposited in the fourth module was neglected. Typically 1–2% of the energy is seen in this module. The energy resolution at 100 GeV changes from 17.6% to 19% when it is removed (Fig. 4).

## References

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