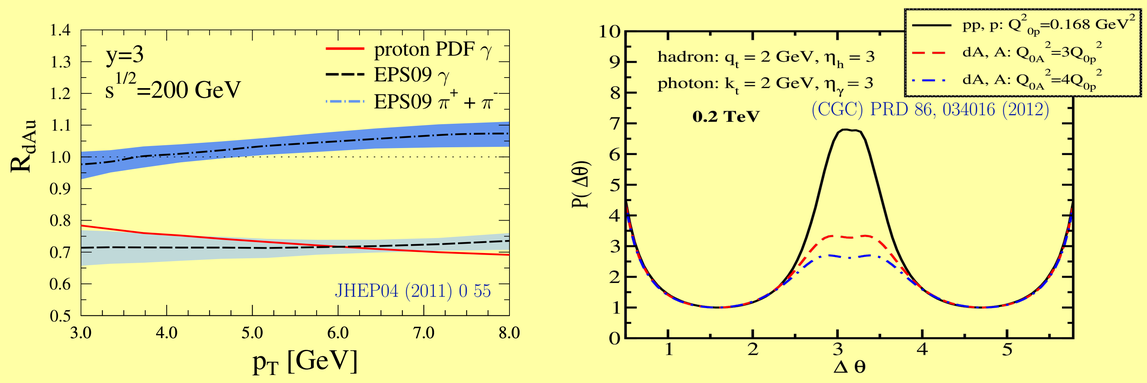
Forward Photons in d+Au Collisions at $\sqrt{s} = 200$ GeV

Carlos E. Pérez Lara for the PHENIX collaboration

Physics Motivation

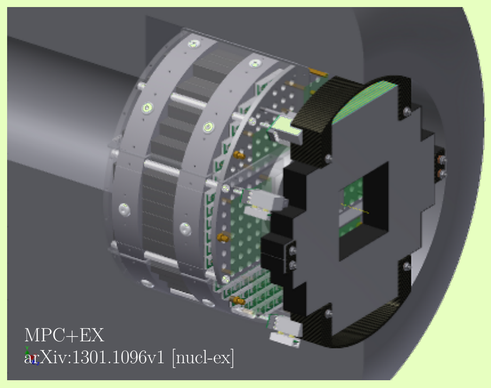
A strong suppression of hadron yields in d+Au collision has been seen at forward rapidities at RHIC which would be connected to gluon saturation or modification of the underlying PDFs in the nuclear enviroment. Direct photons provide complementary insight towards the physical nature of these effects since they are directly sensitive to the gluon density and their final state interactions are small. Furthermore they allow for direct access to the gluonic component of nPDF at low x which is currently not well understood.



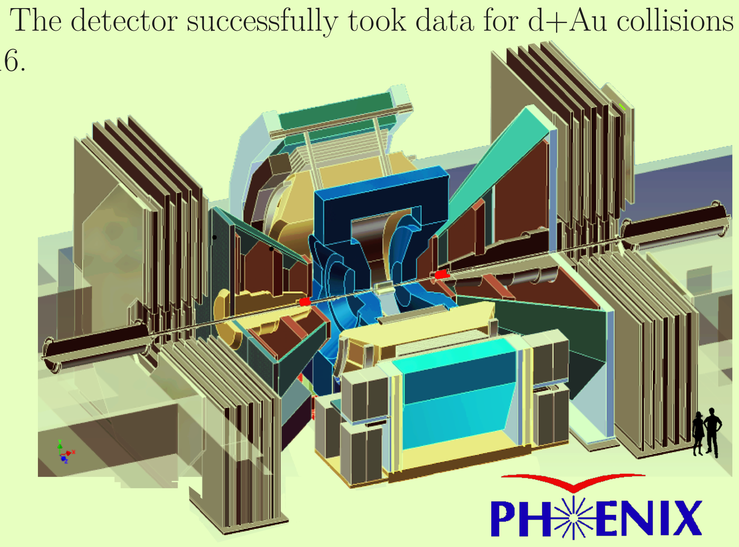
γ Nulcear Modification Factor and γ-h Relative Azimuthal Correaltion Modification predicted for RHIC energies.

Experimental Setup

The detector setup consists of an array of 416 PbWO4 crystals installed in the PHENIX detector on both sides of the interaction point ($-3.8 < \eta < -3.1$ and $3.1 < \eta < 3.9$). The crystals are preceded by a pre-shower stage formed by eight layers of 24 SiW micromodules. Each micromodule has a 2 mm thick W plate attached to 128 Si minipads with cross section $2 \times 15\ \mathrm{mm}^2$ suitable for direct photon identification. The detector successfully took data for d+Au collisions at $\sqrt{s} = 200$ GeV during May-June 2016.

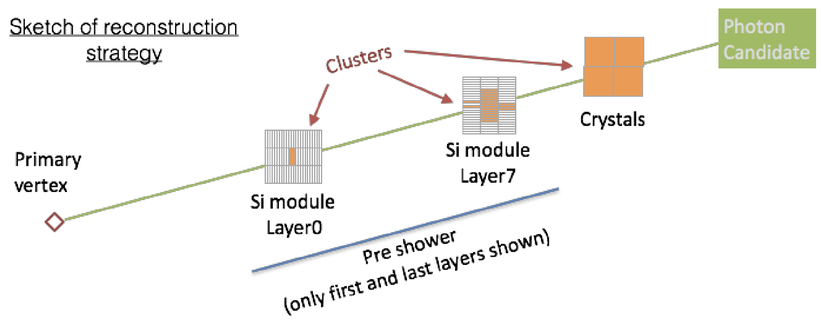


Mechanical rendering of the forward calorimeter



Photon Identification Strategy

Sketch of Reconstruction



The array of long crystals is suitable for high resolution energy measurement, while the highly granular silicon minipads allows for accurate shower centre measurement, which is a key feature for background ($h \to \gamma\gamma$) rejection, and provides complementary energy measurement.

Method A: Hough Transform

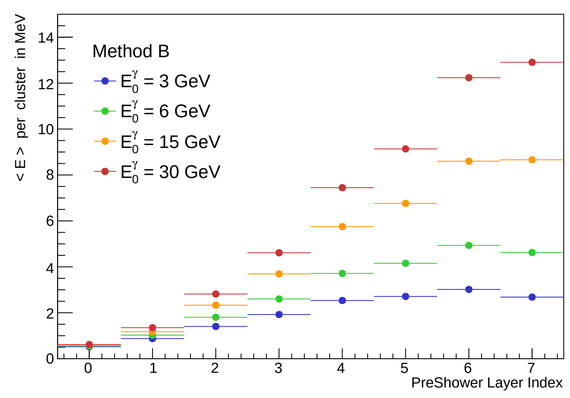
- Hit minipads are ordered by energy (in an arm)
- Starting with the highest energy minipads, a track is formed in Hough space by grouping hits in a fixed cone (x/z, y/z) that corresponds to a radius of approximately 0.8 cm at the front of the preshower and 1.6 cm at the back.
- The axis of the cone is iterated as hits are added until stable
- The cone is expanded by 30% in radius and additional hits are added until the change in energy is $\leq 2\%$ or a max of four expansions

Method B: Cluster & Align

- Local clustering: accumulate hits around local maxima within SiW padrow, where charge sharing is evaluated based on weighted distance
- Global clustering: local clusters are merged based on a per layer analysis of dead minipads and micromodule edges
- Alignment: cluster are aligned in phi theta space to primary vertex
- Alignment algorithm seeds in the 6th layer of the preshower detector and attaches clusters as it moves towards the primary vertex
- Once the vertex is reached the procedure is reversed towards the crystals
- Axis of the shower is recomputed via χ^2 fit of the clusters and vertex

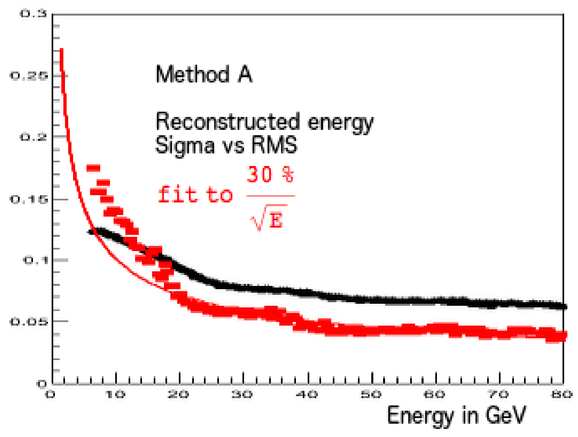
Performance in the MonteCarlo Simulation for Single Photons

Energy in PreShower



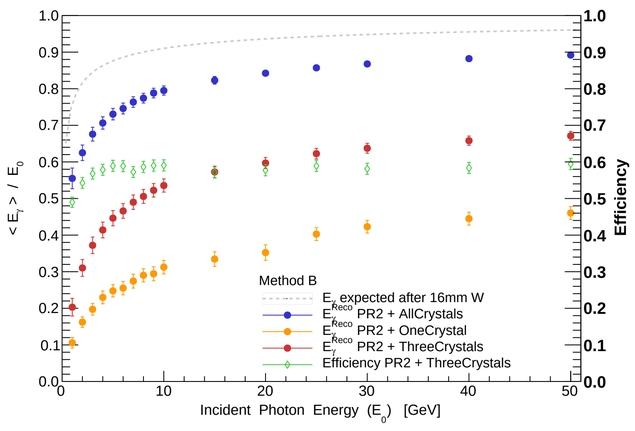
- Average energy of cluster attached to reconstructed photons in the preshower detector. Plot shows the shower development as the photons traverse the tungsten.

Energy Resolution



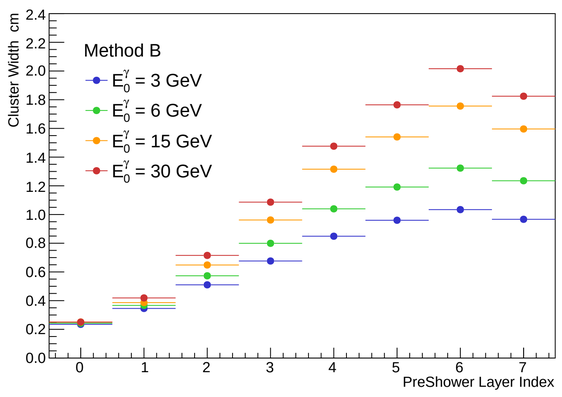
- Energy resolution for photon candidates from fit to energy distribution and direct RMS. Material budget was used to compute proper sampling fraction. Difference found is due to large tails in the distribution from sampling in the preshower detector.

Energy in Crystals



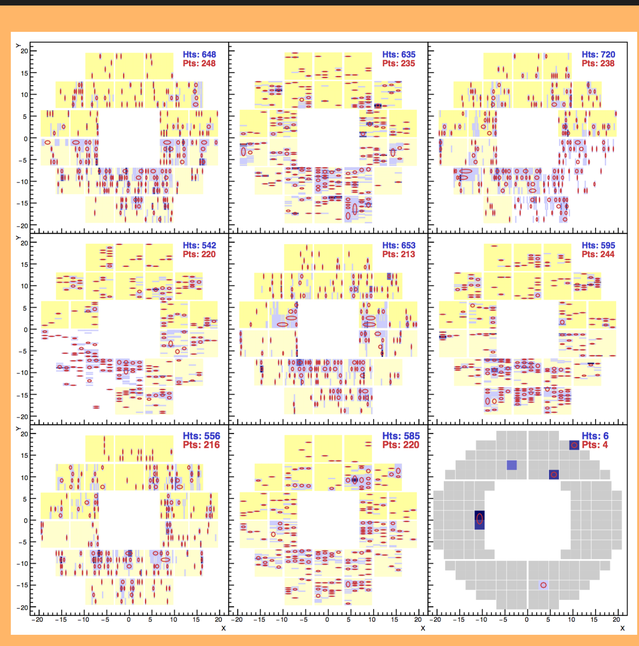
- Average energy reconstructed solely in the crystals after photon candidate was identified using the preshower detector. Plot shows the quick buildup in energy as the cluster size formed by the crystals increases.

Transverse Profile

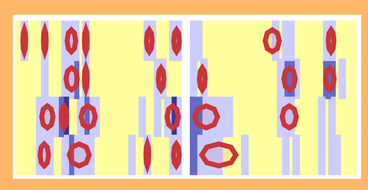


- Average width of clusters attached to reconstructed photon. The width is measured as the distance from the cluster centre to the hit where the energy contained is at least 70% of the total cluster energy.

Data: d+Au $\sqrt{s} = 200$ GeV



- Display of one d+Au data for the Au-going direction arm. The first eight plots show the hit intensity in each layer of the preshower detector; the last plot, in the crystals.



- Zoom in to two adjacent micromodules for layer 6 showing the separation power for adjacent showers. Red blobs show local clusters.

List of Asociated Posters

480 J. Bryslawskyj. Single-track π^0 Identification
435 J. Do. Photon and Neutral Separation
541 M. Patel. Hardware Timing Setup for Run16