Technical Note
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A Description of the Jetset Barrel Gamma Veto

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Abstract

In its phase-I implementation, the photon coverage in the Radphi experiment is confined to angles forward of 40^o in the lab. These forward angles are the most important for reconstructing the final states of interest to this experiment. However our lack of knowledge about what photons were produced at larger angles has an important effect on our ability to reject background events in our sample. Discussion is underway with David Hertzog at the University of Illinois concerning the possible loan of the barrel gamma veto (BGV) spaghetti calorimeter modules from the Jetset experiment at LEAR for use as a photon multiplicity counter in the Radphi experiment. In addition to providing a veto on events with large-angle photons, it could also provide medium-resolution calorimetry for low-energy showers. In combination with a barrel scintillator array (barrel CPV) it could also provide information on the number and angles of charged-particle tracks. This report summarises the design and features of the BGV, and shows some of the data from the Jetset experiment which give an indication of its performance. Many of the figures contained in this report are taken from the thesis of Johannes Ritter.

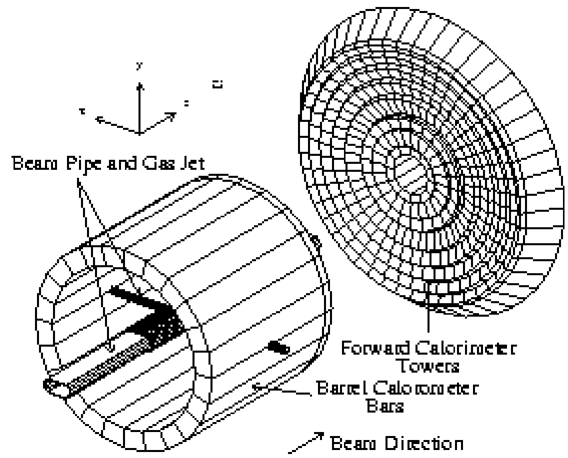


Figure 3.13: Forward and barrel calorimeter. For clarity, the forward and barrel detectors have been moved apart in this drawing.

Work is now underway to implement a more advanced trigger in the Radphi experiment that could work without a fast signal from the recoil proton. With the RPD out of the trigger, it would be possible to completely replace it with a larger acceptance barrel detector. The present discussion is focused on the possibility of adding barrel coverage for both charged particles and neutrals. This would greatly enhance our ability to reject false 5γ events that currently feed into our sample from higher multiplicity channels. For example, the decay $\phi \to \gamma\eta$ where the η decays to $3\pi^0$ appears as a 7γ final state, a certain fraction of which will produce two soft photons outside the acceptance of the lead glass wall and improperly reconstruct as a $\phi \to 5\gamma$ event. With the $\phi \to \gamma\eta$ decays two orders of magnitude more abundant than the rare decays for which we are searching, we would like to suppress such events as much as possible.

A device with a very similar purpose was built by David Hertzog and collaborators at the University of Illinois for the Jetset experiment at LEAR, which took data between the years 1990-1994. David has indicated that he might allow us the use of this detector for Radphi. It is presently in storage at CERN, and it would be up to us to transport, mount and instrument it with high voltage and whatever else. Since the whole procedure of overseas transport, building a mounting frame, testing and installing it must fit into the narrow time frame of the next few months, it is important that we make a timely decision as to its desirability for our purposes. In this report I describe the geometry and performance of this detector, making liberal use of the figures from the thesis of Johannes Ritter (May 1998). I thank Johannes for making these available.

1 Calorimetry in Jetset

Johannes shows an overview of the Jetset electromagnetic calorimetry in his Fig. 3.13 shown below. Both barrel and forward counters are composed of a matrix of lead and scintillating fibres, with the fibres pointing toward the target in the forward region and along the z-axis in the barrel. Just upstream of the forward wall and inside the barrel counters is a three-layer scintillator hodoscope built by the group of Walter Oelert of KFA Jülich to tag charge particles entering the calorimeter. The geometry of the hodoscopes are shown by Johannes in his Fig. 3.9 shown below. A horizontal hole a few cm in radius extending through the barrel counters provided space for the entrance and exit of the internal gas jet target for the Jetset experiment.

The basic parameters of the blocks are as follows. The composition by volume is 50% lead alloy, 35% scintillating fibre, and 15% epoxy. The measured density is 4.58g/cm^3. The radiation length is 1.61cm and the barrel blocks are 9.6cm thick, about 6 radiation lengths.

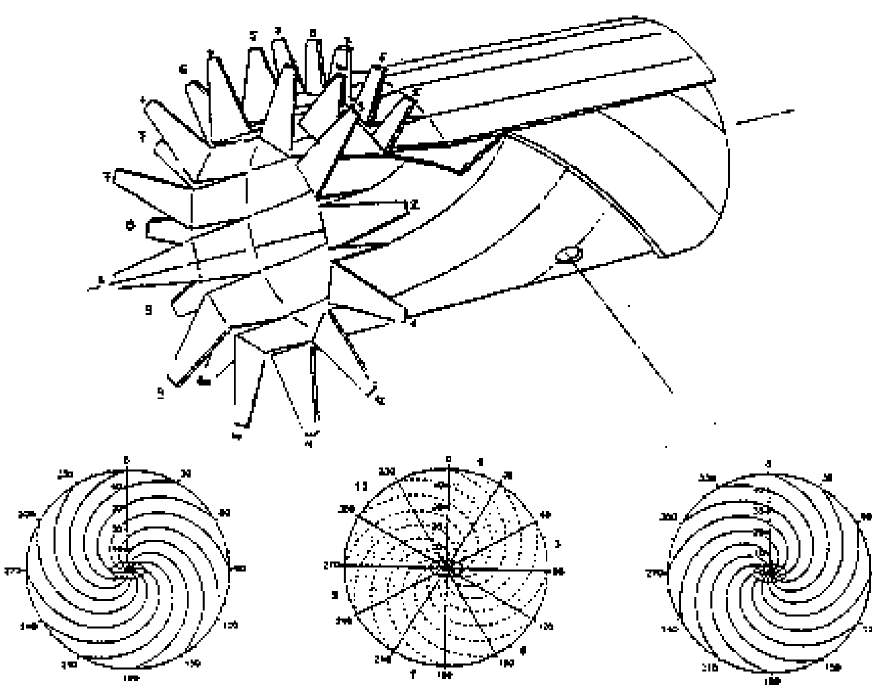


Figure 3.9: Schematic drawing of the outer scintillators. The barrel system is shown on top, the forward system on the bottom.

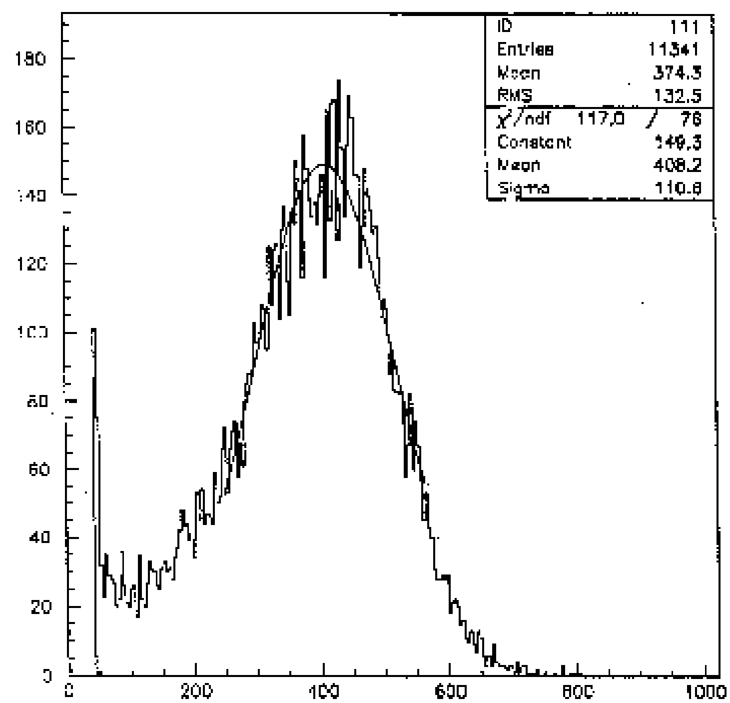


Figure 3.14: A typical Energy Resolution in BEC block. The energy resolution for an electron of 750 MeV incident at $\theta = 67.5°$ on a BEC block. The data were taken at a BNL test beam [56]. The number of events is shown as a function ADC channel.

2 Performance of the barrel counters

Being only 6 radiation lengths thick, the energy resolution of the barrel counters is limited by shower leakage out the back of the blocks. Resolution is best for showers of energy around 500MeV and does not follow the $\sqrt{E}$ scaling law. It also depends on the incidence angle. Johannes shows the electromagnetic response of a block to 750MeV electrons 22.5^o from normal incidence in Fig. 3.14. Although the resolution is not great, Johannes showed that it is still possible to reconstruct 2γ mesons from pairs of showers in the barrel. In his thesis he presents results on the differential cross section for 4γ final states (see Fig. 4.2) where one of the final-state mesons was entirely reconstructed in the barrel, as shown below. A very clear η signal is seen in the 2γ invariant mass spectrum in the forward system, with an r.m.s. width of 30MeV. Selecting around this mass peak in the forward system, and looking at the invariant mass of the barrel pair *following a 2C kinematical fit of the entire event* leads to the following mass spectrum. A signal is seen for both π^0 and η albeit with limited resolution. The BV blocks are equipped with readout on both ends. The bulk of the light yield comes from the upstream end, but the downstream signal is useful to reduce the singles rates and to provide a time signal that can be used in combination with the upstream timing to estimate the z-position of the hit. A resolution of about 7cm r.m.s. was obtained in this way, as Johannes shows in his Fig. 4.28.

3 Mechanical figures for the blocks

The best mechanical drawing I have found so far is Fig. 4.26 from Johannes' thesis. It is reproduced below. Printing the postscript file of the thesis gives a better rendering than you see below. Information about the length of the block can be extracted by remembering that the forward bevel on the blocks is at 45^o with respect to the origin. There is a possibility that the barrel support that served the Jetset experiment may be available for the use of Radphi. The question of how much of the system can be made available for our

$\overline{p}p \rightarrow 4\gamma$

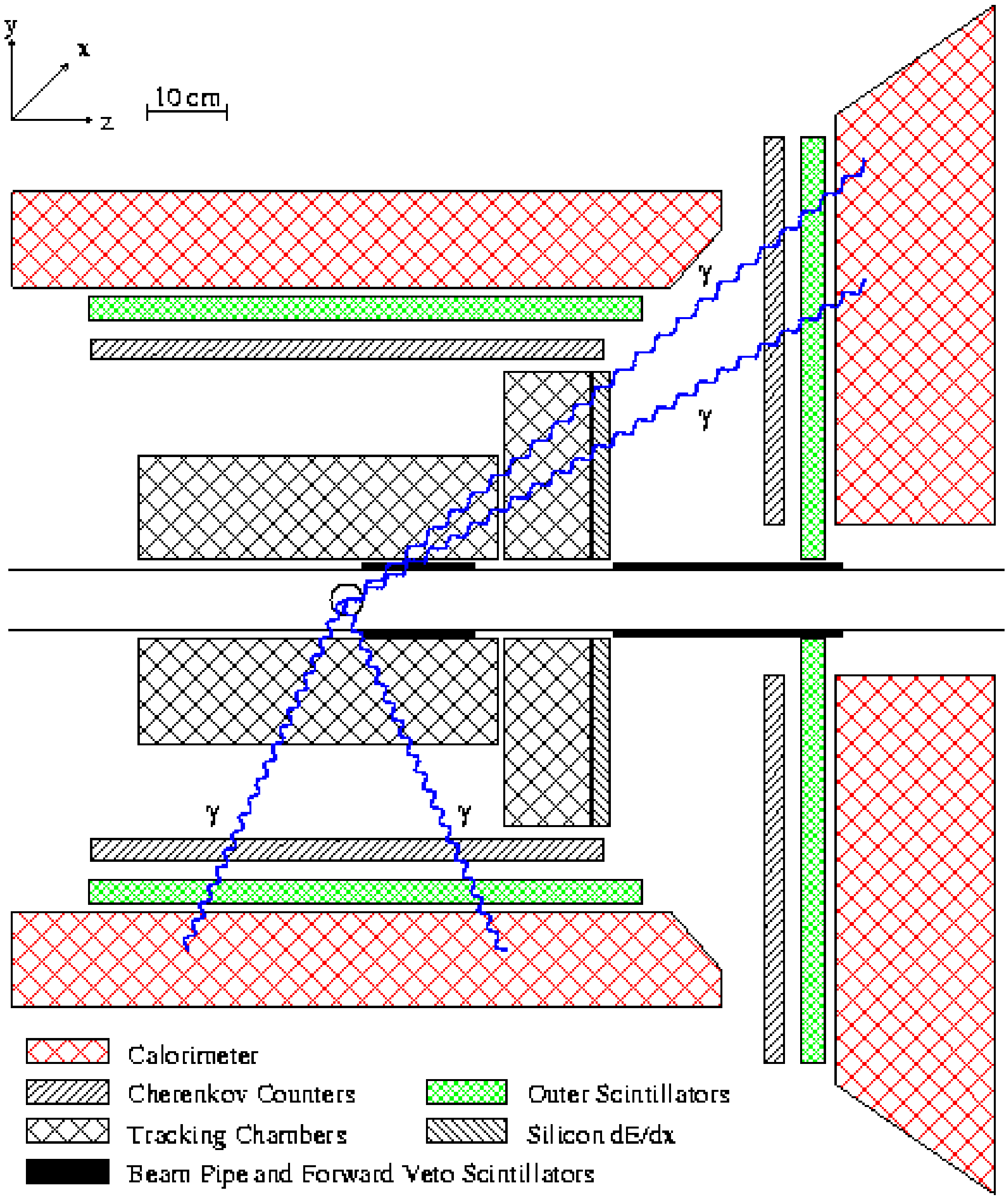
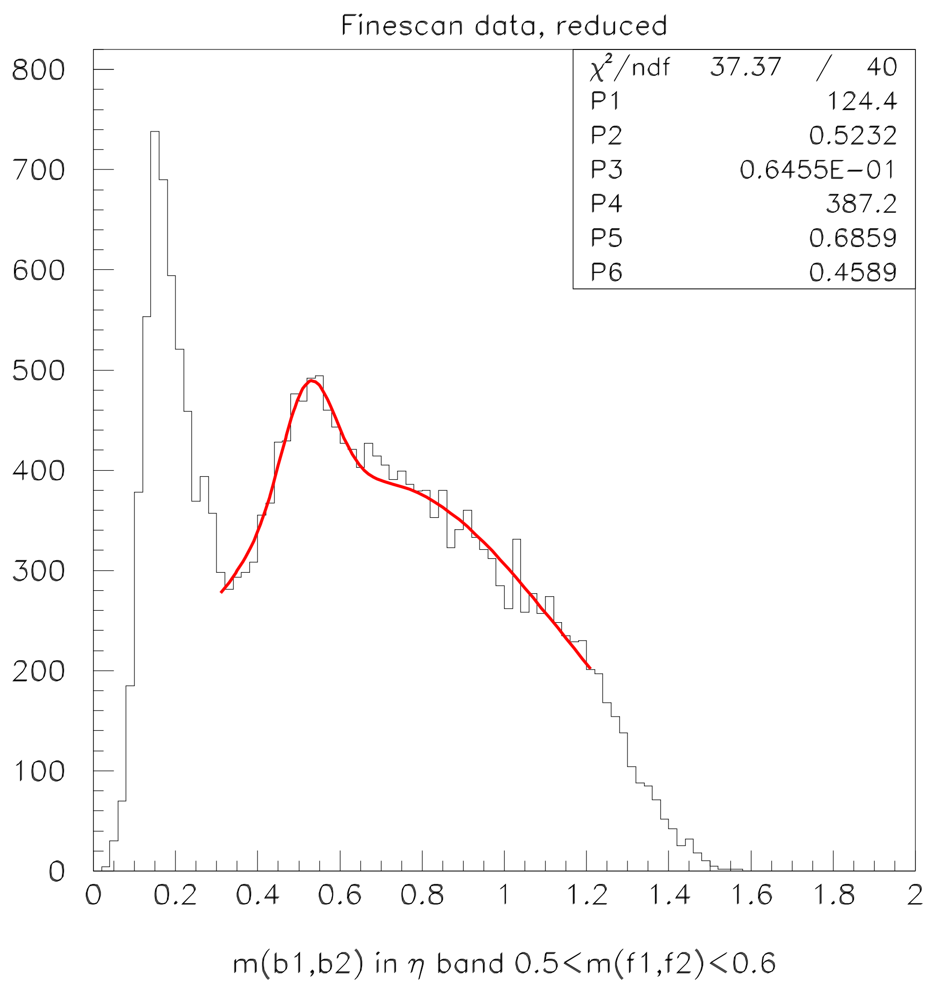


Figure 4.2: A typical $\overline{p}p \rightarrow 4\gamma$ event in the Jetset detector.


Finescan data, reduced
χ²/ndf 37.37 / 40
P1 124.4
P2 0.5232
P3 0.6455E-01
P4 387.2
P5 0.6859
P6 0.4589
800
700
600
500
400
300
200
100
0
0 0.2 0.4 0.6 0.8 1 1.2 1.4 1.6 1.8 2
m(b1,b2) in η band 0.5<m(f1,f2)<0.6

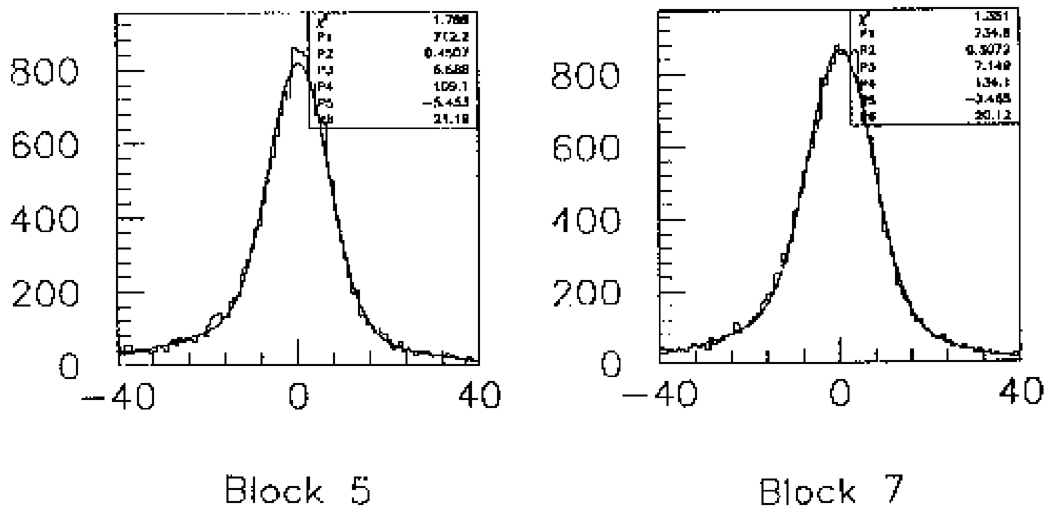


Figure 4.28: The z-position-distribution (cm) as obtained from the time difference in the BEC for two sample blocks (z = 0 corresponds to θ = 90°). Charged particle triggers have been used for this calibration.

use is still under investigation.

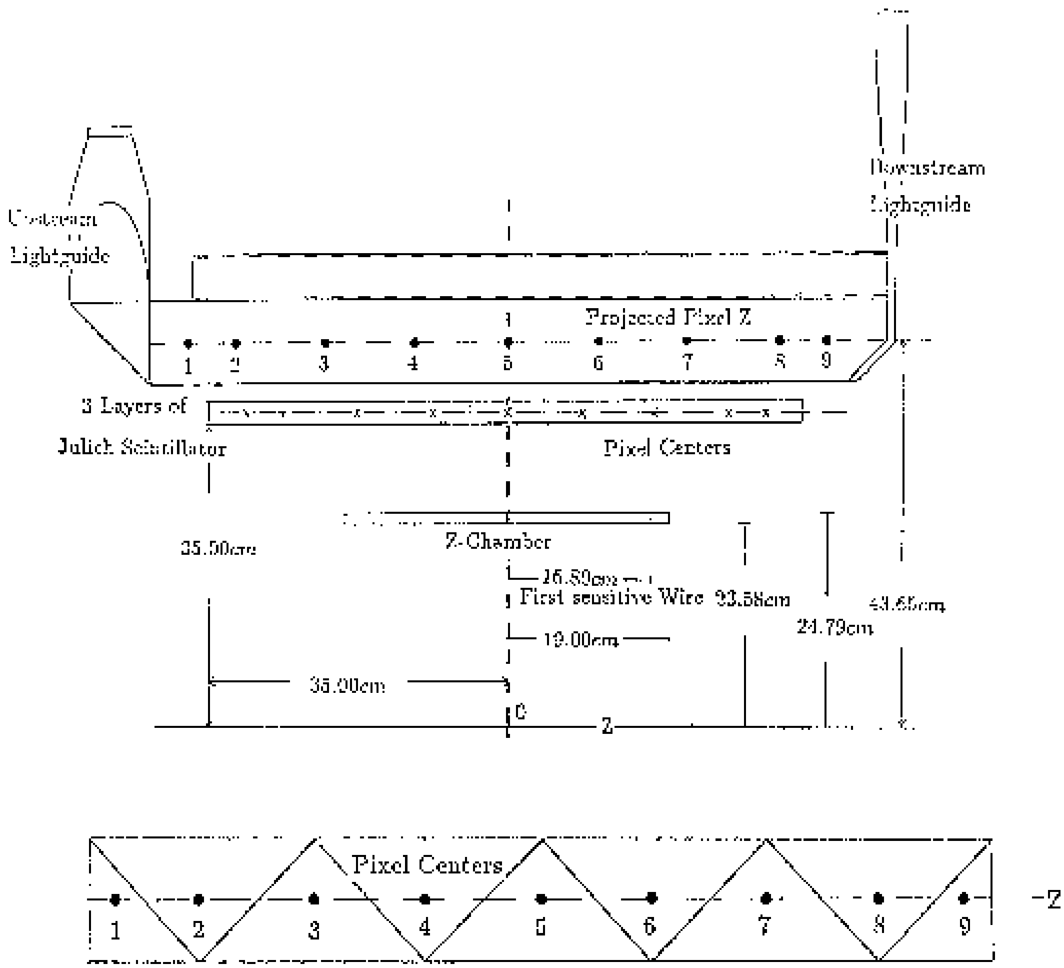


Figure 4.26: Diagram of a BEC block with z-chamber and pixel location.