HERMITICITY STUDIES IN SSC TYPE CALORIMETERS

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Abstract

We examine the effect of both dead material and missing material on the hermiticity of calorimetry for the type of detector proposed for the SSC. Using a simulation of the D0 detector based on the Cern Monte Carlo program Geant [1], we study the effects of cracks and cryostat dead material on missing E_T. An improved version of the Isajet program [2] that incorporates initial state Bremstrahlung is used to investigate the contribution due to missing E_T from energy disappearing down the beam pipe.

Dead material Effects

Since the exact geometry of the SSC calorimeter is not yet specified, we quote here work done on the D0 calorimeter which will be the first 4π detector using Uranium-liquid argon calorimetry. This work is described in greater detail in reference 1. We consider two types of dead material;that due to steel skins and dead Uranium in cracks between calorimeter modules, and that due to steel cryostat walls between the Central calorimeter and the End Cap calorimeter.

In order to do a proper study of the effect of dead material, one needs to study the tails of the energy loss distributions of hadronic showers. The density of the dead material regions will in general be different from that of the calorimeter proper. Full shower simulation, as opposed to parametrizations of showers, is necessary to give a good description of the tails of the energy deposition in regions of varying density. Full simulation, by its very nature, is expensive in terms of computing time. Estimates of computing time needed to push through a million Isajet events through Geant with the Gheisha full shower algorithm are quite mind boggling. In its stead, we have had to take a more approximate approach which gives us a measure of the relative effects of various dead material regions on missing E_T.

It can be shown [3] that for minimum bias events,where particle correlations can be neglected, the average missing E_T due to an aggregate of dead material is proportional to

$$QF \equiv \int d\eta d\phi (\Delta E/E)$$

where η and ϕ are the pseudo-rapidity and azimuth angle describing a point belonging to the dead material region and ΔE is the average energy loss suffered by a pion of energy E aimed at the point η, ϕ in the dead material. The variable QF we introduce here is a kind of quality factor for the dead material. The greater QF, the worse the effect of the dead material. By comparing QF for various dead material regions, we get an idea of the relative importance of these regions. If instead of minimum bias physics, we input say two jet physics, the relative ordering of dead material regions is unlikely to change. It must be pointed out that for small values of ΔE, the missing energy can be calibrated away on average by active elements placed downstream of the dead material. Nevertheless, an ordered list of QF values for the dead material allows one to minimize the effects due to cracks at design time. Table 1 is the list of QF values for the D0 detector dead material, obtained by using Geant and Gheisha. The cracks between calorimeter modules were modelled as containing dead material of uniform density with a value roughly half that of the calorimeter proper. The position of these cracks is evident from Figure 1. It is clear that the most important dead material resides in the transition region between the Central and End cap calorimeters in the cryostat walls.

Beam Hole Effects

The contribution to missing p_t by the beam holes was studied generating QCD jet-events with Isajet in the range of 30 to 100 GeV in p_t at 40 TeV. The effect of the beam holes was calculated by simply adding the momenta of particles inside some small cone. This calculation, of course, only gives the contribution of particles that are never seen by the detector, it tells us nothing about the effect of mismeasurements near the beam pipe. The effect due to beam holes was calculated during Snowmass '84 using the same methods [4] , however at that time Isajet could not simulate the effects of initial state radiation and it was understood that the calculation was likely to grossly underestimate the contribution of the beam holes to the missing p_t. The new results are shown in Fig.3 for coverages down to 1.5° , 1.0° and 0.5° . One can see immediately that adding initial state radiation has enormously increased the beam holes contribution, which was to be expected since initial state radiation tends to produce jets close to the beam directions. Even down to 0.5° the effects due to the holes now exceed those calculated previously assuming a hole of 1.5° and are far above the contribution

Dead Material	Quality Factor.
I)CC/EC Transition region.	~200
II)Central Calorimeter EM crack.	8.59
III)Insert Plug/Middle Fine Hadronic crack.	5.43
IV)Crack between CC Fine Hadronic Modules	3.73
V)Crack between CC coarse Hadronic modules	3.47
VI)Crack between Middle Fine Hadronic End Cap modules.	2.56
VII)Crack between EC Middle Fine Hadronic and Outer Coarse hadronic modules	1.83
VIII)Crack between EC Outer Coarse hadronic modules.	0.98

Table 1: Ordered list of Quality Factors for the D0 detector

from neutrinos. The present study was not carried sufficiently far in p_t to see when the contribution from neutrinos to missing p_t exceeds that of the beam holes, but from the curves in Fig.2 it is unlikely to occur before the missing p_t is greater than 100 GeV (assuming good coverage down to 0.5° .).

An unfortunate characteristic of initial state radiation is that the higher the Q^2 of the process the stronger the initial state radiation. Thus the contribution to missing p_t increases as the p_t of the jets increase. As an example we generated 500 events with

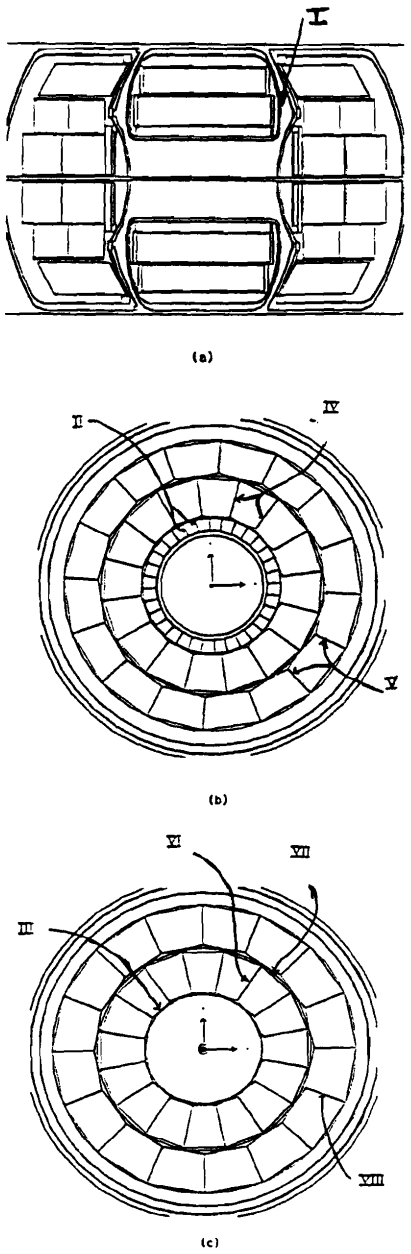

Figure 1: Geometry of the D0 detector. a) Cut View of the detector along the plane containing the beam pipe and the vertical. b) Cut view of the Central calorimeter c) Cut view of the End cap Calorimeter. The Roman numerals indicate regions of dead material refered to in table 1

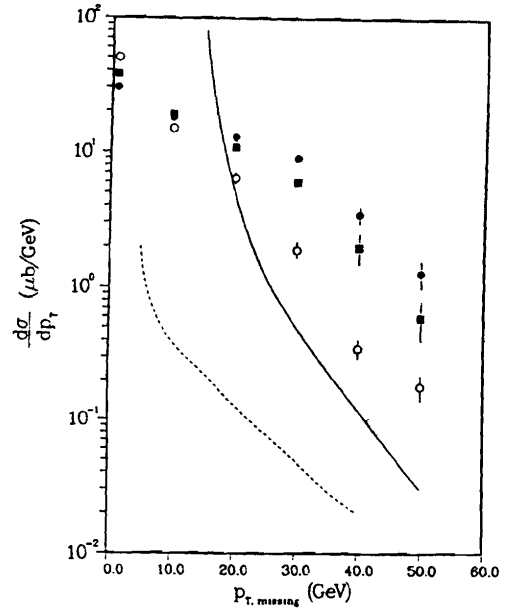

Figure 2: Missing p_t (Isajet 5.22) requiring $30 < p_t < 100$ GeV: solid circles below 2° , solid squares below 1° and open circles below 0.5° . The solid line is the missing p_t below 1.5° calculated at Snowmass '84 (Isajet 4.0) The dotted line is missing p_t contribution from neutrinos.

Isajet requiring $1.0 > p_t > 1.2$ TeV. The resulting contributions to missing p_t from the holes and from neutrinos are shown in Fig. 3. The neutrinos come from the decay of heavy quarks. It is clear from the distributions that even down to 0.5° the holes dominate at least up to 100 GeV of missing p_t and are comparable to the neutrino contribution up to 200 GeV. One should note that Isajet does not include the possibility of radiating W's or Z's from the final partons, the contribution to missing p_t at high Q^2 of these processes may be substantial.

The message is clear: coverage down to very small angles is critical to do missing p_t physics with events which have topologies similar to common QCD-jet events.

References

[1] User's Guide to GEANT 3.10, R.Brun et al, CERN DD-EE-84-1

[2] ISAJET v. 5.22, A Montecarlo Event Generator for $\bar{p}p$ and pp Interactions, F.E. Paige and S.D. Protopopescu, BNL-38034

[3] R.Raja, D0 Note 461.

[4] P. D. Grannis and H. A. Gordon, Proceedings of 1984 Summer Study on the Design and Utilization of the SSC, Snowmass, Colorado, p. 541 (1984), eds. R. Donaldson and J.G. Morfin.

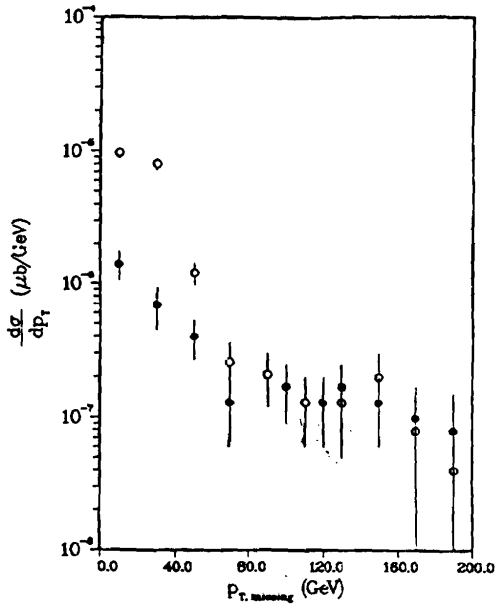

Figure 3: Open squares: contribution to missing p_t from 0.5° holes for 1 TeV jets. Solid circles: neutrino contribution to missing p_t from heavy quark production in 1 TeV jets.