Real Photon Collaboration Technical Note RPC-15
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BETHE HEITLER PAIRS FOR E161

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Abstract

I have studied the impact of Bethe-Heitler μ pairs on E161. One of the muons goes into the acceptance region of $5 < P < 15 GeV$, $0.5 < P_T < 1.6$. Where does the other muon go so that the pair can be vetoed?

METHOD

A Monte-Carlo program bh_fermi_wt_xm0.f: produces either elastic or quasielastic Bethe-Heitler muon-pairs. For inelastic Bethe-Heitler the Monte Carlo program bh_inelastic.f: is used. They write the kinematics and weights for each pair onto a binary file. There is a cut that P_t of one of the muons must be greater than 0.2 GeV This file is in /nfs/slac/g/esa/e161 Rates for elastic and quasi-elastic per NUCLEUS while for inelastic rates are per NUCLEON.

The program bh_read_vec reads the data produced above and makes tables. There is a separate output for elastic, quasi-elastic, inelastic. The program bh_sum_ccorrelations reads the three files above and combines the results and produces tables and plots for the total B-H production.

The detector is the one described in the proposal with three different operating conditions.

- No absorber, No Magnet field
- No absorber, Magnet ON
- Absorber in, Magnet ON

Particles starting at the target where bent in the magnetic field and multiple scattered in the absorber depending on the operating conditions. The magnet center is 1.8 meters from the target and the total Bdl=2.5Tm. I assume one bend in the center of the magnet. The absorber is 39 radiation lengths of Alumina. The multiple scattering is done using a monte-carlo, independently of the bending. I assume that the resolution of the detectors is much better than the smearing due to multiple scattering and does not contribute to the errors. The first hodoscope is at the end of the Alumina at 3.3 m from the target There are two other hodoscopes at 4.7 and 7.0 m.

EXPERIMENTAL PROCEDURE

There will be runs with the diamond crystal oriented to produce the coherent peak, and also oriented to produce only Bremmstrulung spectrum. The difference between these spectrum has only the coherent peak. B-H pairs can be studied under both conditions.

After the subtraction, only the pairs from the coherent peak will remain. The diamond is 7E-4 radiation lengths. The electron beam intensity is 2E10/spill. This produces 1.4E-7 Equivalent Quanta/spill. For the coherent beam there is about a factor of 2 enhancement above the Bremmstrulung background giving a beam of 2*EQ*log(40/30) = 0.6 EQ as the number of coherent photons after the Bremmstrulung subtraction.

RESULTS

POSITION RESOLUTION

Table 1 shows the position resolution(σ) due to momentum scattering for different values of the muon momentum at different distances from the target.

TABLE 1 –Position resolution due to multiple scattering in cm for several μ momentum and 3 different distances from target.

P	z=3.3m	4.7m	7.0m
6.0	3.1	2.5	4.4 (cm)
8.0	2.3	1.8	3.3
10.0	1.8	1.4	2.6
12.0	1.5	1.2	2.2
14.0	1.3	1.0	1.8

Note the weird behavior where the resolution is better at 4.7m then closer and further away due to partial cancellation of two multiple scattering terms.

From these numbers, the bin width of the hodoscope fingers should be about 1.5 cm ($\sigma = .4cm$) to have negligible influence on resolution at all momentum used in E161.

P_T RESOLUTION

Multiple scattering causes the reconstructed P_T value , on average, to be offset from the value at the target and there is also a spread. Table II. shows this offset and spread as a function of P_T. The offset is caused by the shape of the BH spectrum which decreases exponentially with increasing P_T.

TABLE 1 –P_T offset and resolution

PT	OFFSET	SIGMA
0.55	0.033	0.098
0.65	0.037	0.104
0.75	0.041	0.112
0.85	0.044	0.121
0.95	0.046	0.131
1.05	0.048	0.140
1.15	0.049	0.152
1.25	0.050	0.163
1.35	0.052	0.171

The resolution is close to the value of 0.12 in the E161 proposal, but is lower at low P_T and higher at high P_T. This is probably the cause of the increasing offset with P_T.

CORRELATIONS BETWEEN PAIRS

If one of the μ is within the physics acceptance region of $5 < P < 15$ GeV and $0.5 < P_T < 1.5$ GeV we want to determine where the second μ will be at various distances from the target. Figures 1 and 2 show the fractional number of the second muon detected as a function of the inner radius of the hodoscopes, when the hodoscope is located at three different distances from the target. For Fig. 1 the photons are in a coherent peak at 45 GeV (after Bremmstrulung subtraction), while Fig. 2 has a Bremmstrulung with peak energy 48 GeV.

The 45 GeV coherent peak produces accompanying μ very close to the beam pipe. To detect (and veto) 90% of these particles it is necessary to have the first hodoscope (3.3 m) within 7cm of the beam line. A hodoscope 7 m away from the target need only be 14 cm from the beam line. Fortunately, over 99% of these μ have $P > 20$ GeV and thus one can put lots of absorber in front of them to get rid of low energy particles near the beam pipe. The elastic and quasi-elastic B-H have their second μ closer to the beam pipe than the inelastic. Unfornately, the elastic scattering which is almost 50% of the total, may be the most difficult to calculate due to the quadropole moment of 6Li.

The Bremmstrulung beam produces accompanying μ at much larger distances from the beam pipe. Here the problem may be detecting the μ very far from the beam pipe. Approximately half are more than 40 cm from the beam pipe at 3.3 meters from the target. Approximately 8% have momentum < 2 GeV and will not get through the absorber while another 4% have $2 < P < 2.5$ GeV and might not make it through the absorber since they are at large angles.

P_T RATES

The absolute rates from a 45 GeV coherent beam with an enhancement of a factor of 2 above the Bremmstrulung "background" and the rates from the Bremmstrulung beam are shown in Fig. 3. The Bremmstrulung beam rates are higher than for the coherent peak alone. Within the standard acceptance of $5 < P < 15$GeV and $0.5 < P_T < 1.6$. GeV and for the scattering angle greater than 40 mr, the single μ rate is 3.6E-2 for the coherent beam (Bremmstrulung subtracted) and 9.7E-2 for the Bremmstrulung beam. This is to be compared to the single muon rate from photon gluon fusion of 1.3E-2 from the proposal. Thus it is necessary to 1) Do a subtraction to eliminate the B-H pairs from the Bremmstrulung beam. 2) Detect the 2nd muon at least 90% of the time and then veto. This will still give a 25% background from the unvetoed B-H muons which will have to be calculated. The polarization will have to be calculated in the particular corner of the phase space they occupy.

CONCLUSIONS

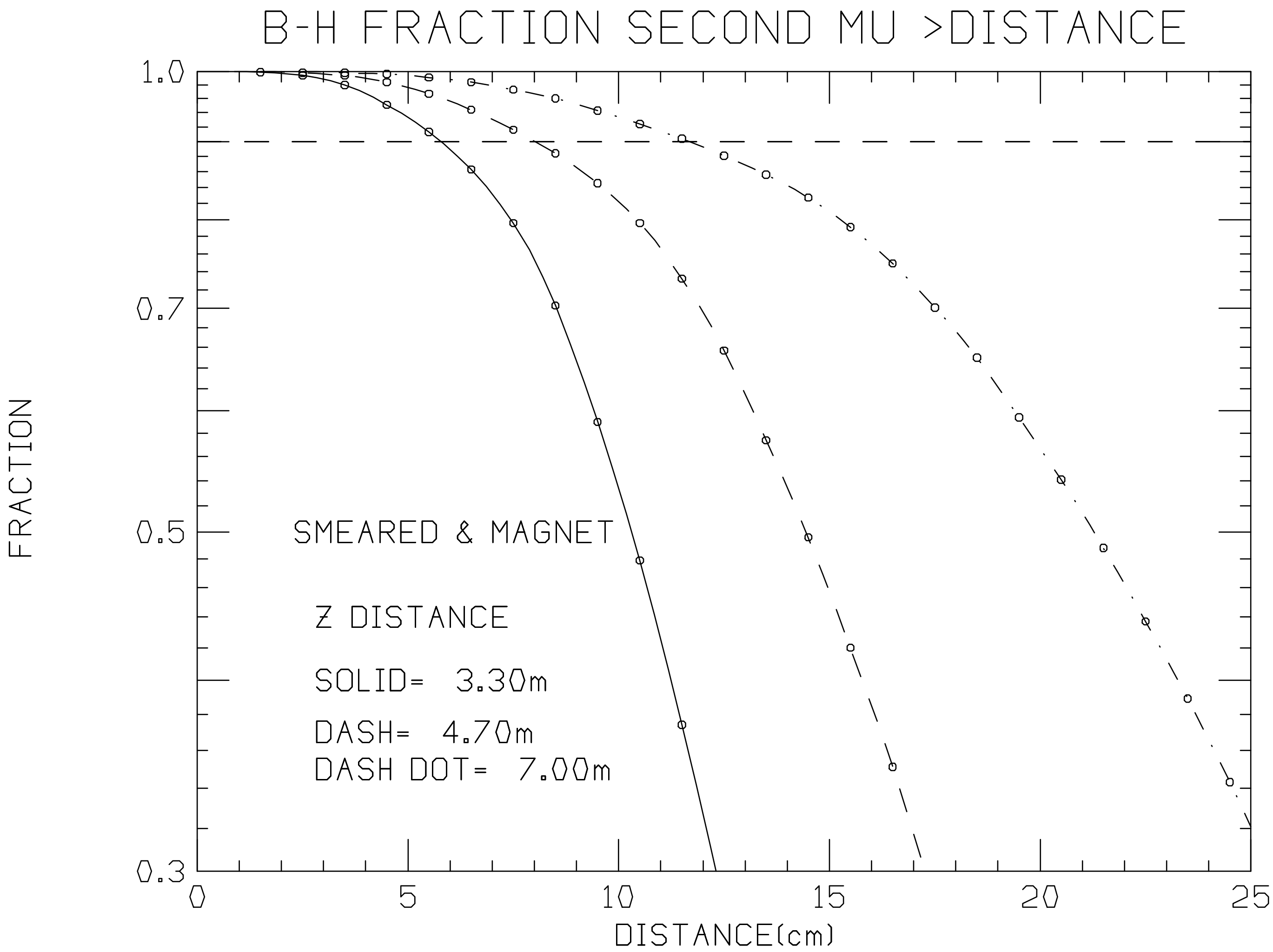

Figure 1: Fraction of the second μ detected as a function of the detector distance from the beam pipe at 3 different distances from the target. The first μ is within the detector acceptance region $5 < P < 15$ and $0.5 < P_T < 1.5$. The photon beam is a coherent 45 GeV peak (after Bremmstrulung subtraction).

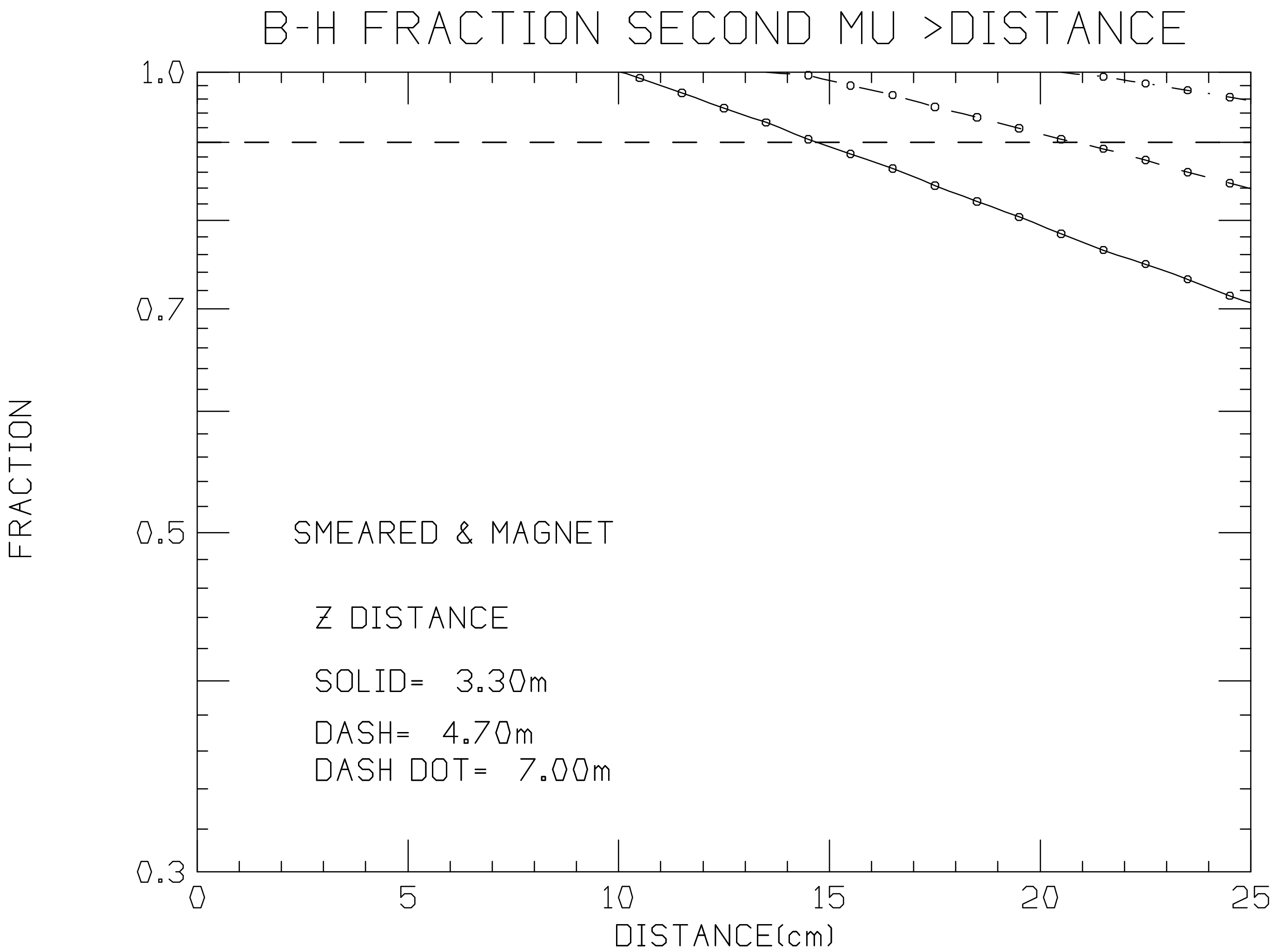

Figure 2: Fraction of the second μ detected as a function of the detector distance from the beam pipe at 3 different distances from the target. The first μ is within the detector acceptance region $5 < P < 15$ and $0.5 < P_T < 1.5$. The photon beam is a Bremmstrulung beam with maximum energy of 48 GeV.

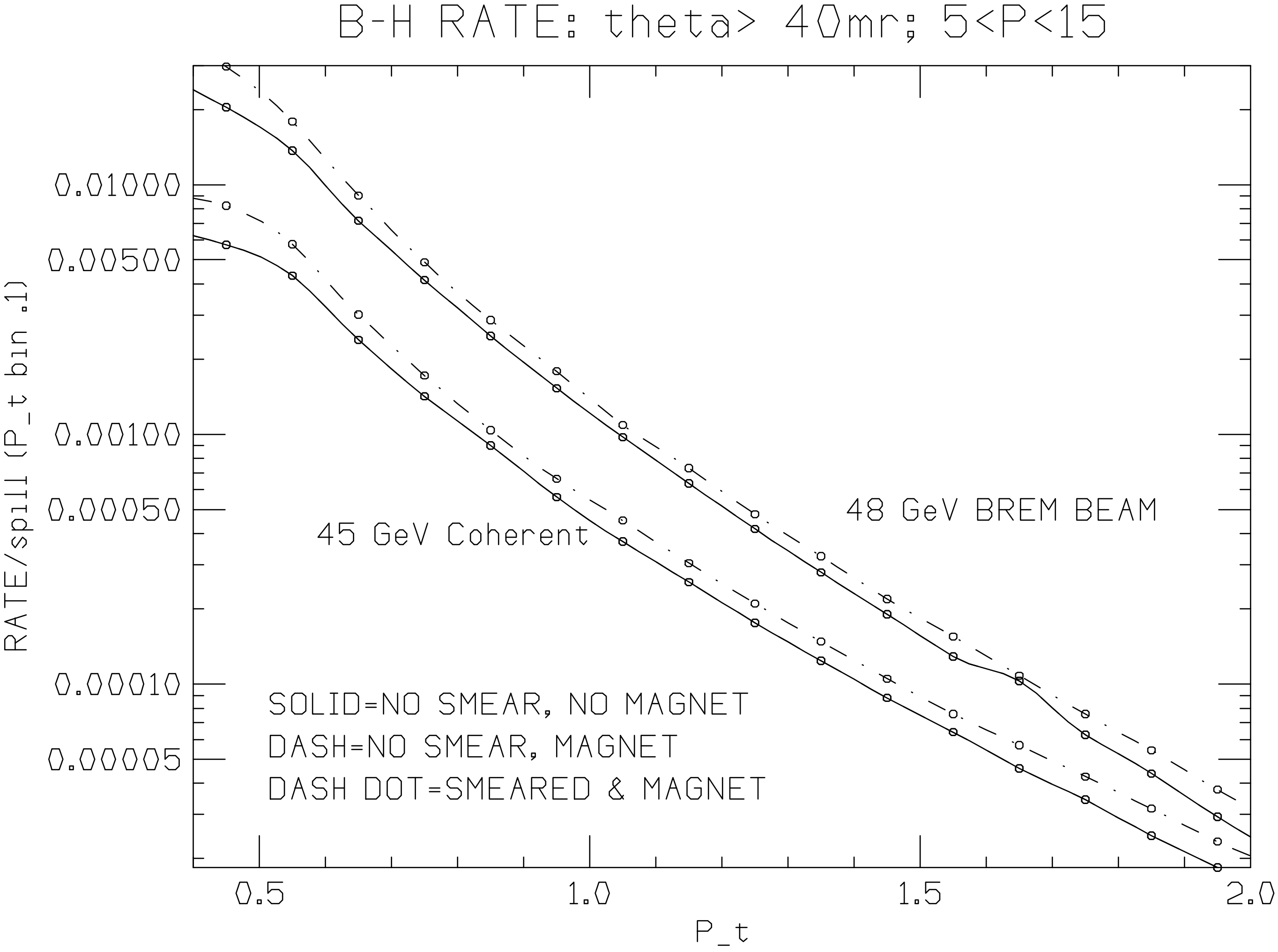

Figure 3: B-H rates as a function of P_T for $5 < P < 15$ GeV. The upper curves are from a 48 GeV Bremmstrulung Beam and the lower curves are for a coherent 45 GeV peak (after Bremmstrulung subtraction).

- P_T resolution is about .12 GeV as in proposal
- Radial Resolution is a couple of cm and varies with distance
- Second μ is close to the beam pipe (7cm at z=3.30- meters
- B_H rates from Bremmstrulung beam are much higher than from Coherent Beam $\Rightarrow$ Incoherent subtraction.
- Must Veto $>$ 90% of BH