Options for Energy Upgrade of the Hall-B Tagger*

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1 Introduction

Four options for an energy upgrade of the present Hall-B Tagger have been considered. These are

1. Boost the magnetic field in the present Tagger,
2. Replace the Tagger with a new Tagger system,
3. Install a pre-Tagger magnetic chacain, and
4. Use the present Tagger as part of the beam dump.

In this document each of these options is described briefly, the advantages and disadvantages of each are presented, and a very rough cost of implementation is suggested.

2 Options for an energy Upgrade

2.1 Boost the magnetic field in the present Tagger

In the present Tagger, described more fully in a CLAS Note,[1] full energy electrons have a bend radius of 11.7 m. At the present maximum momentum of 6.05 GeV/c, the field in the magnet is 1.7 T with a current in the coils of 2400 A. Under these conditions the iron in the pole and yoke is already showing considerable saturation. The current in the coils could be increased to around 3000 A, limited by the ability to cool the coils. However, this 56% increase in power is expected to yield a maximum momentum of around 6.4 GeV/c, only a 6% increase in field.

A second approach is to narrow the gap in the magnet with the use of pole shims. At higher energies the present gap of 6 cm is larger than needed, so a 3 cm gap would be adequate. However, because the iron is already in saturation the gain in field is only modest. It is estimated that this re-gapping effort would increase the maximum momentum to around 7 GeV/c. With the combination

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of a narrow gap and increased current a maximum momentum of approximately 7.4 GeV might be obtained.

A rough estimate of the cost of this option is $100 k, mostly for the power supply. It has the advantage that the present full range detector could be used, with somewhat degraded resolution because of the extensive fringe field beyond the magnet gap. It has the disadvantage that it fails completely to achieve a momentum compatible with the planned energy upgrade of CEBAF.

2.2 Replace the present Tagger magnet with a new Tagger System

In order to bend the electron beam so that it is deposited in the tagger dump, the electron beam must be bent through an arc of 30^0 in the physical space available. The present magnet does this for a 6 GeV beam with a magnetic field greater than 1.7 T. At this field the iron of the pole and the yoke is very nearly saturated. Thus to bend an 11 GeV beam a much bigger iron core magnet would be needed. Scaling up the present magnet to the appropriate dimensions shows that such a magnet would not fit in the space available. In addition, even if it could be made to fit with appropriate excavation, the magnet would weigh over 450,000 kg and would be very expensive both to purchase and to operate.

A more rational solution would be to replace the present magnet with a similar shape superconducting magnet capable of supplying the necessary 3.2 T field. Such a solution would have the advantage of maintaining the present high-resolution, broad-band detection system. It has the disadvantage of being the most expensive of the options considered, with an estimated cost of $3 M.

2.3 Install a pre-Tagger magnetic chacain

Even at beam energies higher than 6 GeV the Tagger would still be able to tag electrons with energies greater than 300 MeV, those corresponding to the interesting higher-energy portion of the bremsstrahlung spectrum. An achromatic chicane positioned considerably upstream of the Tagger has been considered. This system would be capable of transporting these lower energy electrons to the tagger, while separately dumping the main part of the beam. Conceptually this system is shown in Fig. 1. The main beam is deflected 3^0 by the first magnet and then an additional 3^0 by the third magnet. The electrons that have lost energy in the bremsstrahlung process are bent through a greater angle by the first magnet, and then bent back toward the main beam line by the second magnet in the achromatic set. The main beam is then dumped before reaching the Tagger. This system has the advantage that it would make use of the present Tagger, which would then operate in a more restricted energy range from approximately 50% to 10% of the incident electron energy (corresponding to the photon energy range from 50 to 90% of the incident energy). It has the disadvantage that it would take almost all of the available space between the last beam line magnet and the Tagger, thus making it difficult to install the Möller Quadrupoles and other beam line devices. In addition a new access way

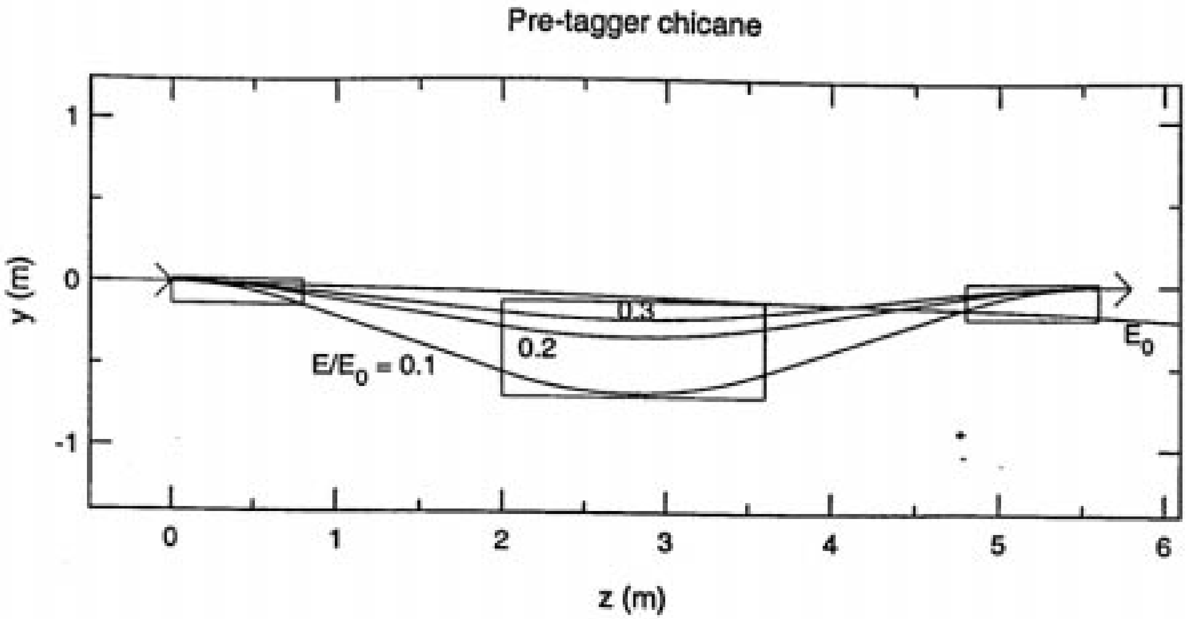

Figure 1: Schematic view of the three-magnet achromatic, pretagger chacane. The rectangular boxes inticate regions of constant magnetic field. The axis labeled "y" indicates the verticle dimension; the axis labeled "z" indicates the horizontal dimensions along the beam direction

into the tunnel would have to be established in order to get these physically large and heavy chicane magnets in place. The estimated cost of such a system is $500 k.

2.4 Use the present Tagger as part of the beam dump

If the Tagger where to be run at one-half the field associated with the incident electron energy, the primary beam would follow an orbit with twice the radius (or about 23.7 m) as long as the beam remained in the constant field region of the magnet. The larger radius would cause the beam to move to the edge of the magnetic field where it would exit through the 0.48-cm thick stainless steel vacuum wall on the inside of the magnet. It would then pass between the current coils and be deposited into the yoke of the magnet.

At this point the remaining yoke provides more than 2 m (or more than 100 radiation lengths) of iron in which to develop and absorb the electromagnetic shower before the CLAS detector. Thus the effect of dumping a relatively low power (a few hundred watts) in the yoke should have only a negligible effect on the operation of CLAS. A more serious potential problem is the large number of photons generated as the beam passes with a shallow angle through the relatively thick vacuum wall. The tagger detectors are positioned to look directly through the magnet gap at this source. While the photons will approach the detector at the wrong angle to provide E-T coincidences, there may be too much background produced in the Tagger detectors. Fortunately the operation of the Tagger in this mode can be checked with a low intensity 100 pA beam as a test of principle.

The advantage of this solution is that it uses the present Tagger and has costs only associated with additional shielding that might be needed. Thus it is the most economical of the solutions yet considered. The tagging range will be somewhat reduced, tagging photons with energies from 0.4 to 0.975 times the incident electron energy.

References

[1] D.I. Sober, CLAS Note 91-012.