# A Proposal for Calibration and Testing of a Transition Radiation Detector for Space Applications

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**Abstract**

We plan to use transition radiation detectors (TRD) for the measurement of the Lorentz factor ($\gamma$) of high energy cosmic ray nuclei on spacecraft and high altitude balloons. These are designed to provide response over a range of particle energies from $\gamma$ ~500 to $\gamma$ ~10000. Since the absolute response of a TRD is difficult to accurately predict from calculation the calibration of a test unit with particles of known $\gamma$ is essential to verify performance. We propose to use a suitably instrumented calibration beam at FNAL for this purpose. With auxilary detectors we plan to identify $p$,$\mu$,$\pi$, and $e$ in the beam and use this tagging to determine the response of the TRD for particles of different $\gamma$. For a beam with particle momenta somewhere in the range 100-500GV we expect to collect an adequate number of data points for a calibration. Although it is desirable to collect as many data ponts as possible a minimum test would consist of determining the response for a low $\gamma$ value (likely from $p$) and for a high $\gamma$ (from e). Even this small amount of information would be useful to test the calculated response.

## 1 Introduction

The variation of the elemental abundances of cosmic ray nuclei as a function of energy has long been viewed to be a crucial measurement for the origins of cosmic rays. While much progress has been made in this area, elemental composition measurements at energies above ~100GeV exist only for the more abundant species and disappear altogether above 100TeV. Although many cosmic rays have been measured at these and higher energies, the elemental composition is not known. The TRDs discussed in this proposal are designed to fly on NASA missions to investigate the elemental composition at high energies by a determination of $\gamma$ for high energy cosmic ray nuclei. They use plastic fiber TR radiators and detectors filled with xenon gas. A novel aspect of this TRD is the use of thin proportional tube detectors which can be operated in external vacuum. Previous TRD systems flown in space have used multiwire proportional chambers as detectors. Since no pressure shell is required for the new design there are significant savings in weight and complexity for this new type of TRD in space.

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## 2 Missions

The TRDs being developed are scheduled to fly on the Advanced Cosmic ray Composition Experiment (ACCESS) for the International Space Station, which is scheduled for launch in 2006. A more detailed description of the scientific goals can be found at http://hep.uchicago.edu/~swordy/access.html, The more technical aspects of ACCESS are discussed at http://www701.gsfc.nasa.gov/access/access.htm. As a precursor to the ACCESS mission we are also planning fly these TRDs on long duration high altitude balloon payloads. These are TRACER, described at http://uchuusen.uchicago.edu and CREAM discussed in http://cream.phys.psu.edu. All of these payloads are directed toward the determination of cosmic ray elemental composition at high energy.

## 3 Proposed Beam Setup

The proposed beamline setup for this calibration is shown in Figure 1. As discussed above, a beam momentum range of 100-500GV would be ideal for these tests. The particle beam momentum definition requirements are relatively loose, a knowledge of the momentum to an accuracy of ~5% wil be adequate for the calibration. Beam collimation at the TRD should produce a spot size of diameter ~10cm. During the beam spill the particle rates at the TRD should be fairly low, less than 1000 events/second.

After the momentum definition and focussing the beam passes through a gas Cherenkov detector, hopefully provided by FNAL. Ideally this is capable of being filled with He or N2. The beam defining counters s1 and s2 will be provided by the University of Chicago (UC) as will the TRD apparatus and a small electron tagging calorimeter downstream of the TRD. If possible, it will be of great help to have a relatively large absorber (~1000g/cm$^2$ concrete) downstream of the setup for identification of muons via the counter s3 (UC provided). The basic tagging scheme is outlined in table 1.

The physical dimensions of the beam setup area are not large. About 3m along the beam direction are required for s1, s2, TRD and the EM calorimeter. Perpendicular to the beam a distance of about 50cm each side provides adequate clearance. The other components shown in Figure 1 will depend on the specific area and devices used.

A summary of the desired beam properties is given in table 2. This calibration can also be run with a subset of the desired particles and a smaller range of particle momenta. It will simply sample fewer places on the response curve.

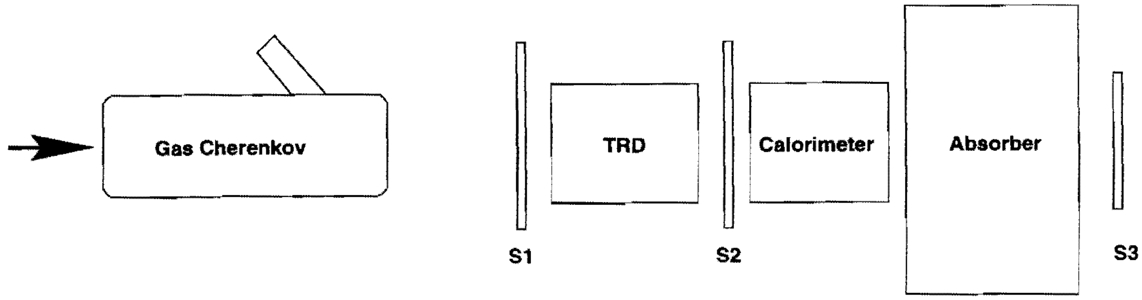


Fig. 1. *Calibration Beam Proposd Setup*

Table 1
Preliminary Tagging Scheme

| Particle | Cherenkov | Calorimeter | S3 |
|---|---|---|---|
| $p$ | no | single particle | no particle/shower tail |
| $\mu$ | yes | single particle | single particle |
| $\pi$ | yes | single particle | no particle/shower tail |
| $e$ | yes | em shower | no particle |

Table 2
Desired Beam Properties

| | |
|---|---|
| Beam Contents | $p, \mu, \pi, e$ |
| Beam Momentum | tunable 100-500 GV |
| Momentum Resolution | <5% |
| Space Required: | |
| Along Beam | 3m |
| Perpendicular to Beam | ± 0.5m |
| Beam Time Desired | 100 hours |
| Minimum Beam Time | 10 hours |

Any reasonable calibration ooportunity will be considered for these tests since to some extent the development of the TRD and quantifying the response is an important schedule-driver for the projects discussed above.

The required beam time depends on the quality of the beam, level of various particle contents, etc. Experience in these kinds of calibration has shown that a reliable calibration requires several hours of good beam at a particular momentum and Cherenkov threshold setting. To complete a full program of calibration with different particles, beam momenta, etc will probably take 100 hours of beam time. For the minimum useful calibration about 10 hours are required. Since significant time is spent in setup and initial testing we would expect to have a low level presence at FNAL for about 2 months.