# Charge Zero (CHG0): Internal Review on Detector Specifications
# January 25, 2021

## Charge

The goal for the current internal review is to focus on the detector and tunnel installation, so that the project can move forward on the purchase of the detector and installation stands. We would like the committee to comment and provide any recommendations concerning the suitability of the selected detector for the Booster beam current monitor. Additionally, we would like the committee to consider the following three charge questions

## Charge Questions

1. Have the requirements for the replacement Booster beam current detector been sufficiently spelled out? *Yes. The hardware requirements are sufficiently spelled out. The way the hardware requirements match to the physics and operations requirements was not.*
2. Does the selected unit meet the specifications? *Yes.*
3. Does the installation hardware look appropriate? *Yes.*

## Background

During the PIP-II era, the Booster will be running higher intensity and higher frequency. With a premium on losses, a good understanding of transmission efficiency is required. The existing current measurement hardware is not up the to future requirements, so an upgraded system is necessary. This review is to judge readiness of the detector procurement and installation plan.

## Findings

- There are 2 Pearson E3100 current transformers currently installed in the Booster, 1 at L20 and a spare at L10. A normalizer box, with the LLRF frequency, converts the current to number of protons. There are a number of issues with the system – effects of nearby magnets, PS switching noise, resolution - that make it inadequate for future use.
- The transfer efficiency from injection to extraction is expected to be in the 98% range during the PIPII era and so the beam current measurement accuracy will have to better than 0.1% for the entire Booster ramp.
- NPCT must work in PIP and PIPII intensities and low current for tuning with accurate measurement of current at 0.1% at HEP intensities.
- Peak currents occur at transition (due to bunch narrowing) and will approach 20 A during the PIP-II era.

- Bergoz makes an NPCT that meets Booster vacuum specs, has 0.1% accuracy at full scale, radiation resistant sensors (and optionally cable).
- The rad hard cable is ~$25/m more expensive than standard cable.
- Bergoz provides the vacuum insert, cable, shaping electronics, and power supply. It is the combined system which is calibrated and provides an output signal which represents the beam current. This output signal would then go to lab designed electronics to convert to number of protons and interface to the control system.
- Proposed installation is in the Long 10 straight section, using a modified version (for beam pipe height) of an existing MI stand. Spool pieces and bellows will be required.
- Goal is to install the instrument in the Booster tunnel during the summer 2021 shutdown. There is a 14 week lead time from purchase to delivery. Procurement is waiting on the project receiving CD-3a. If all goes according to schedule, delivery is in early August with installation in late August.

## Comments

- There was good discussion between the committee and the proponents on the meaning of the 0.1% accuracy. It is understood that this accuracy is on the beam current measurement at the output of the Bergoz shaping electronics. The implications for the lab designed electronics and efficiency measures need to be spelled out in more detail to understand how the efficiency measurement results. These are physics requirements outside the direct scope of this review.
- The rad hard cable is about $1500 more than the standard cable. Given possible future costs to pull it out and replace, rad hard cable would be a good option.
- The Bergoz instrument is probably the best available on the market. It does appear that the project hardware specs were written to match the instrumentation capabilities. The project does need to be sure that desired physics and operations measurements can be met with this device.
- There were options identified in discussion that should be brought up with Bergoz (hardware options to minimize effects of the Booster notch and frequency sweep, early cable delivery) during the procurement process.
- The mechanical details look appropriate. The device has a 3.78" ID which is not an aperture restriction. Modification of existing MI stands is a good idea. Detailed design work does have to get started to be ready for a summer installation.
- The procurement schedule is tight. Any slips would miss the summer shutdown window. The ongoing prep work with procurement is commended.

## Recommendations

- Pursue the procurement radiation hard cable.
- Proceed with procurement of the Bergoz NPCT as described.

## Committee:

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## Website:

https://indico.fnal.gov/event/47392/