NMLTA Protection System Update
-Loss Monitors-

Arden Warner October 13th, 2010

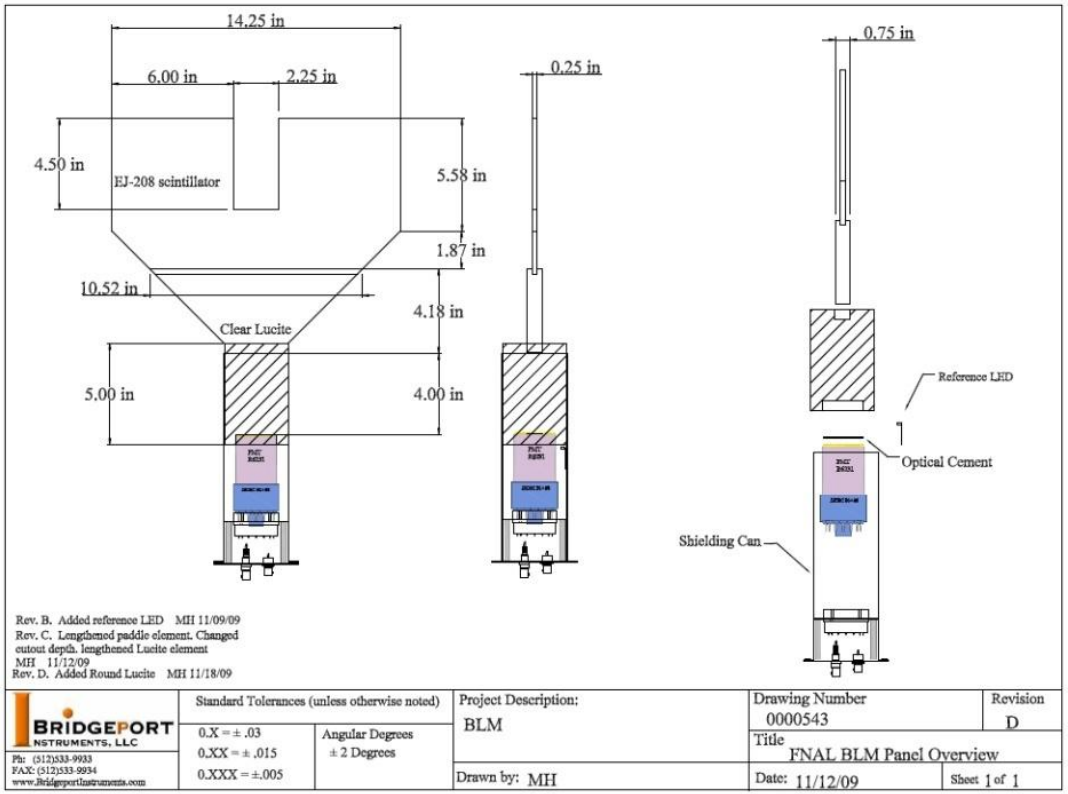
Status of loss monitors

Two FBLMs were designed at FNAL and manufactured by Bridgeport Instruments and Elgen Technology. Both prototypes installed at A0 photo-injector.

- Paddles designed to have ~ 40% less scintillator material than that used at DESY
- Hamamatsu and ET Enterprise PMTs with comparable specifications
  - See properties in table below:

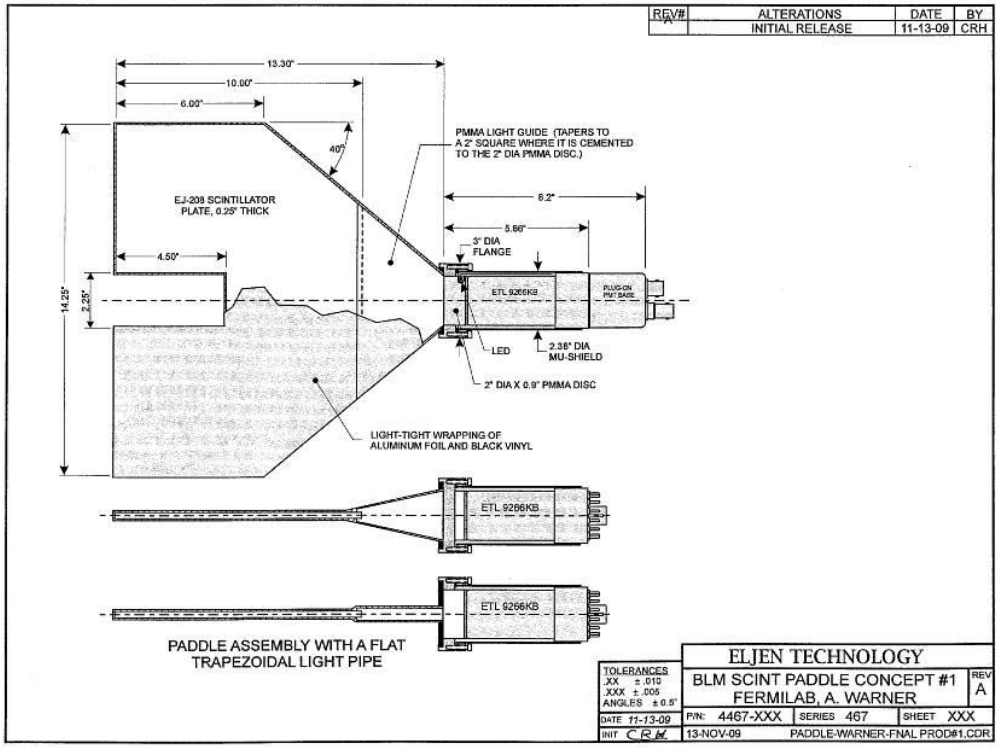
EJ208 Scintillator properties	**Value**
Rise time	1.0 ns
Scintillator Brightness	76 p.e./ MeV
Wavelength of max emission	435 nm
Detector sensitivity	7.0 pC/Mev
Decay time	3.3 ns
Density	1.023 g/cc
Light attenuation length 1/e	210 cm
Number of electrons	$3.37/cm^3$
PMT Specifications	
Rise time	3-5 ns
Gain (min)	2.7×10^5
Supply voltage (max)	2000 volts
Sensitivity	0.1 – 200 A/lm

Fast Beam Loss Monitor Design (BI prototype)



Cost : Bridgeport Instruments
1 ea. $2350 each
40 ea. $1300 each

Fast Beam Loss Monitor Design (EL prototype)



Cost : Elgen Tech
1 ea. $1878 each
50 ea. $1545 each

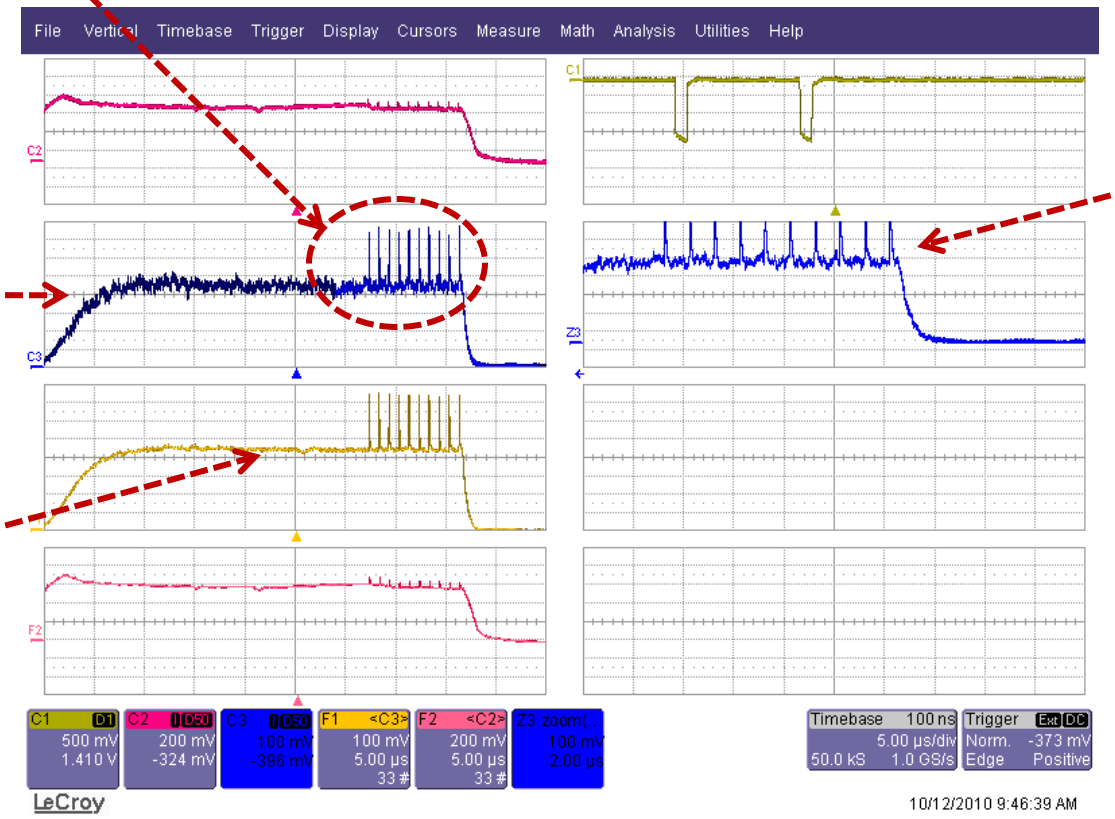
FBML Measurements (BI prototype)

10 bunches to radio-beam dump. Cross 6 inserted

Detector located downstream of cross8 115mm from DIAX07 cross. (-500 volts on divider)

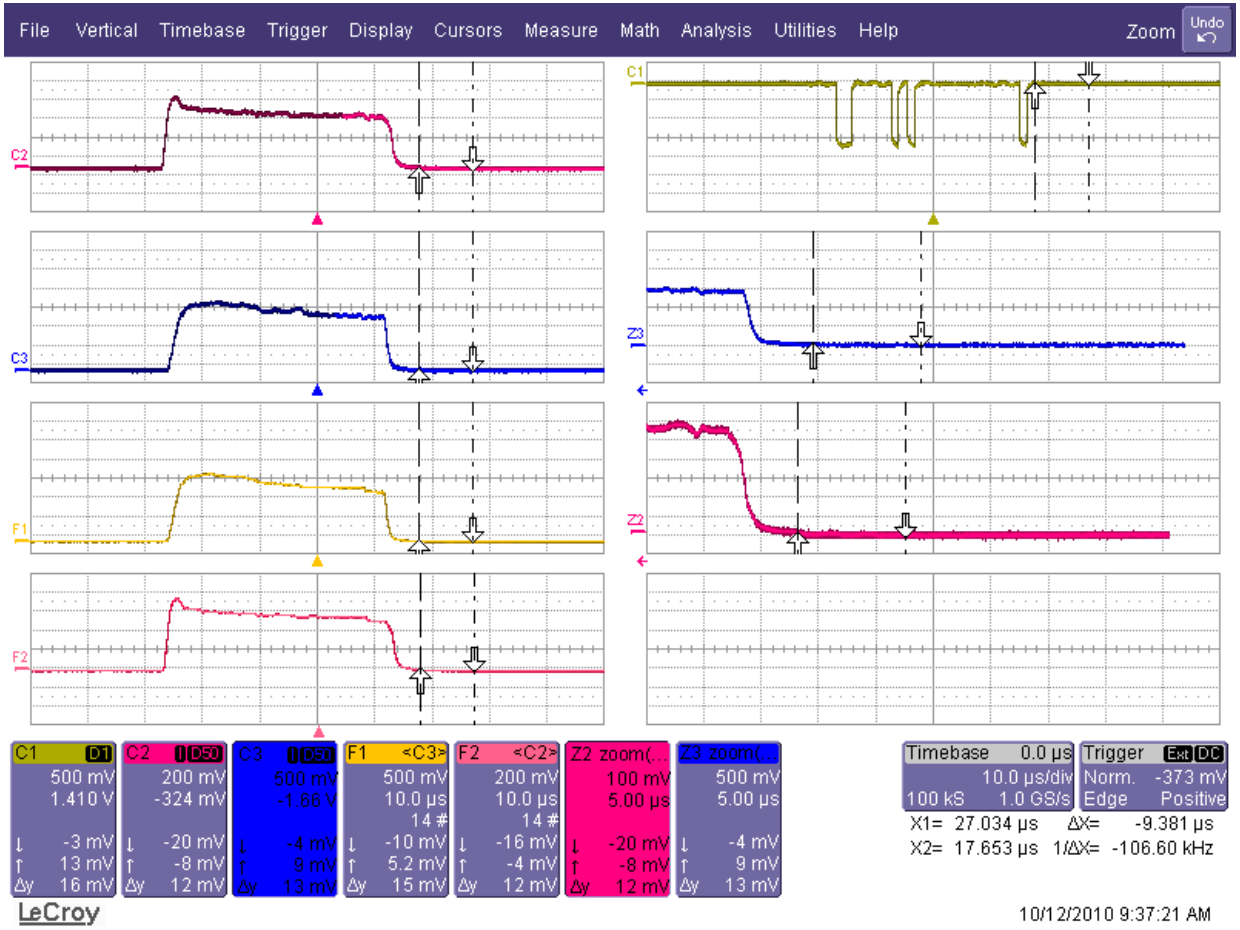
Same signal with averaging turned on

Zoom on bunches 250 pC/bunch



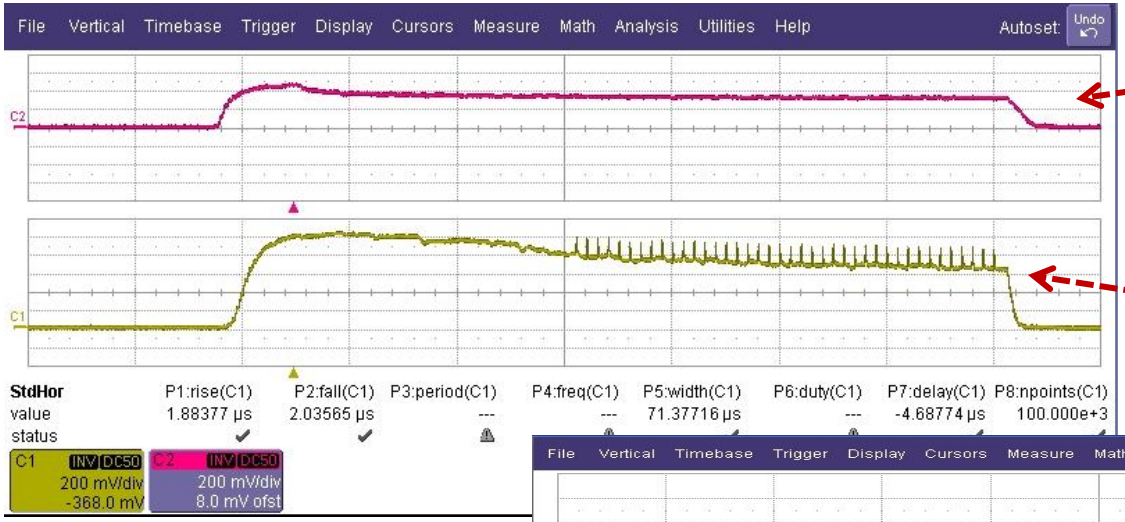
FBLM Measurements (BI prototype)

Corresponding dark current background with no photoelectrons



FBML Measurements (BI prototype)

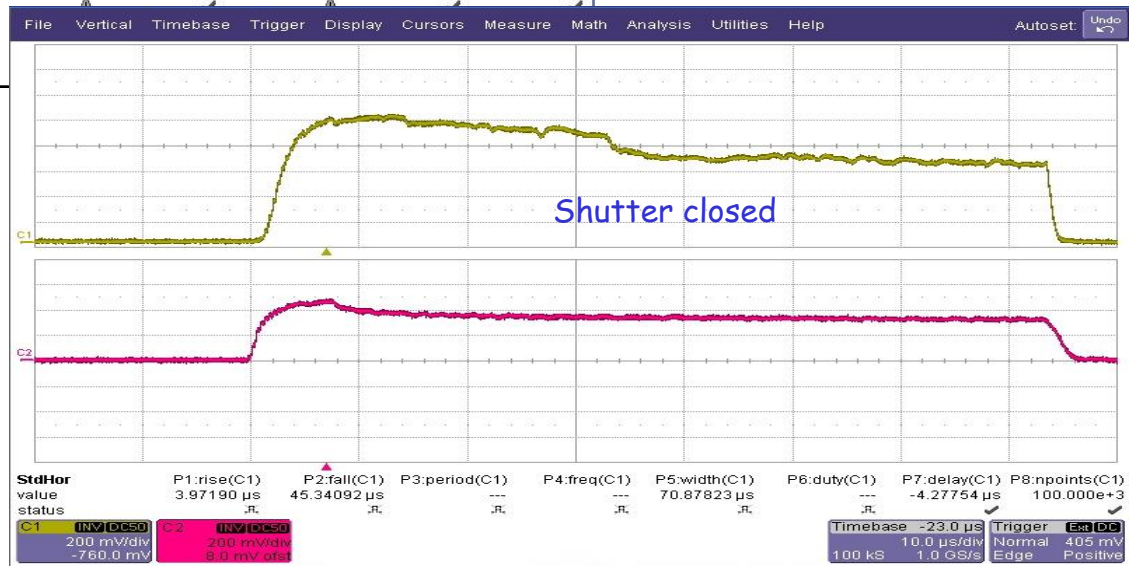
40 bunches, 400 pC, cross4 OTR inserted



Dark current upstream of beam loss at exit of capture cavity 25mm from GV2

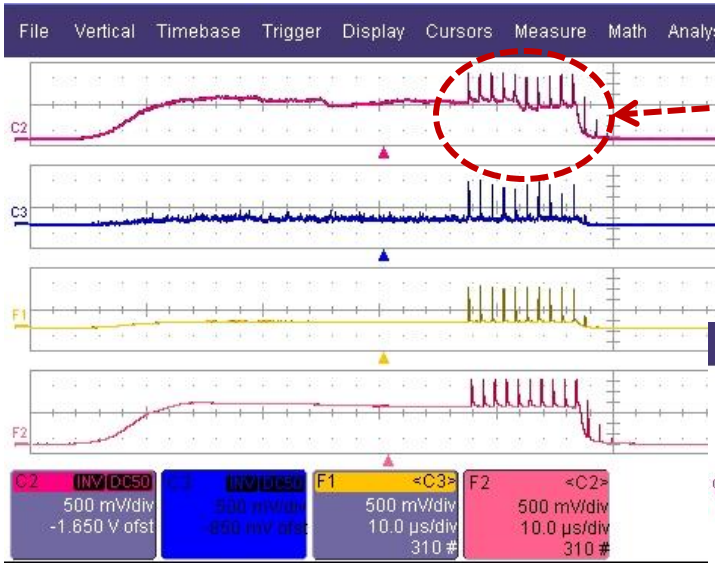
Cross8 FBLM showing Loss photo-electrons + dark current

Dark current/photo-electron beam = 5/1 in this case.



FBLM Measurements (BI prototype)

Dark current background varies with machine tuning and 9cell on/off as expected

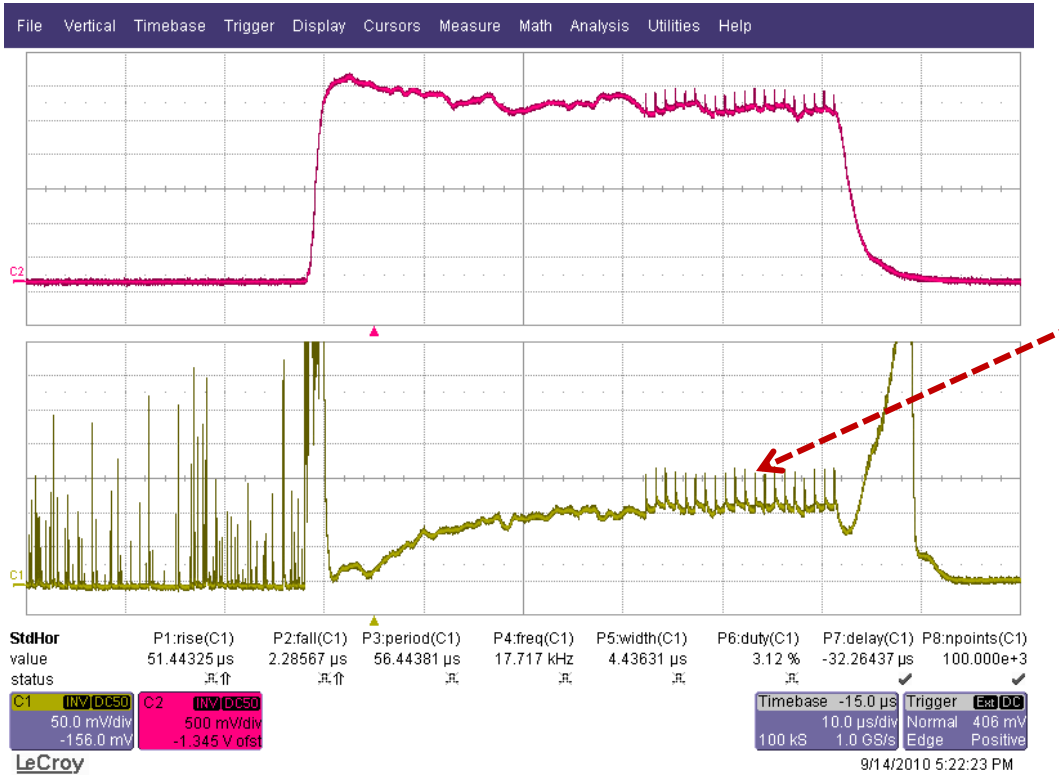


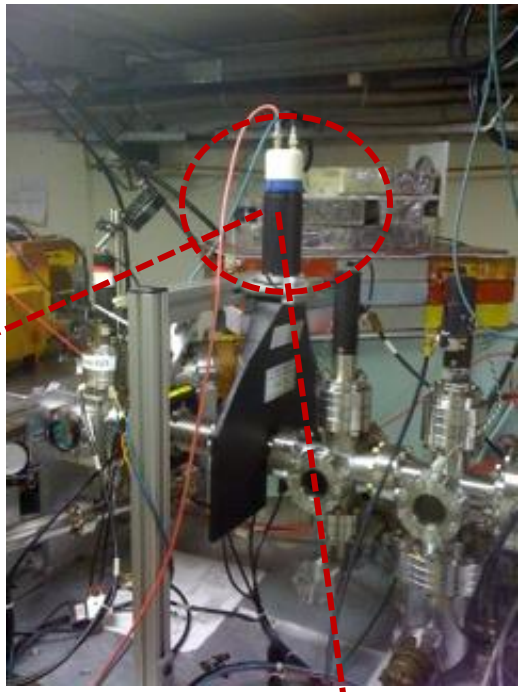
10 intended bunches, last 2 bunches near end of rf cycle

Signal rise time ~40 ns

Measured dark current to faraday cup:
220mV/50 ohms = 4.4 mA

FBLM Measurements (Elgen prototype)





Lots of noise outside of rf pulse. The amount of required EMI and mu-mental shield can tested tested.

ET Enterprise PMT. No mu-mental shield and no iron

Cryogenic Ionization chamber

Type : Cryogenic beam loss monitors can be operate from inside the cryomodules from 5k to 350k.

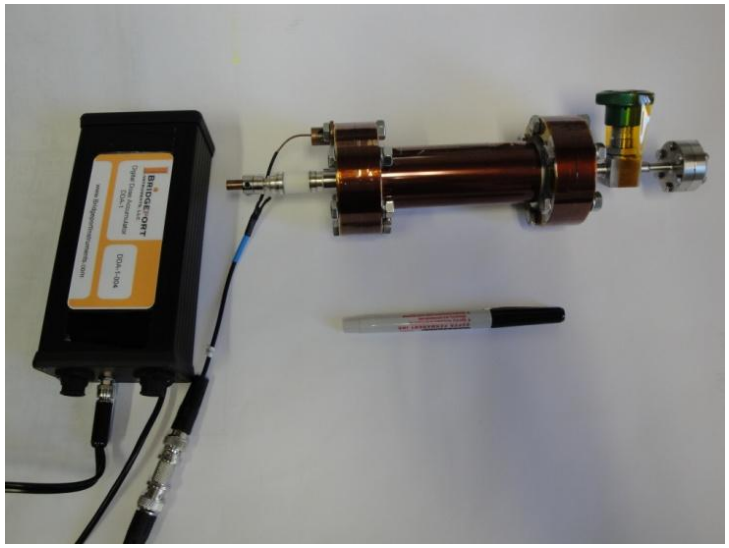
Design Properties:

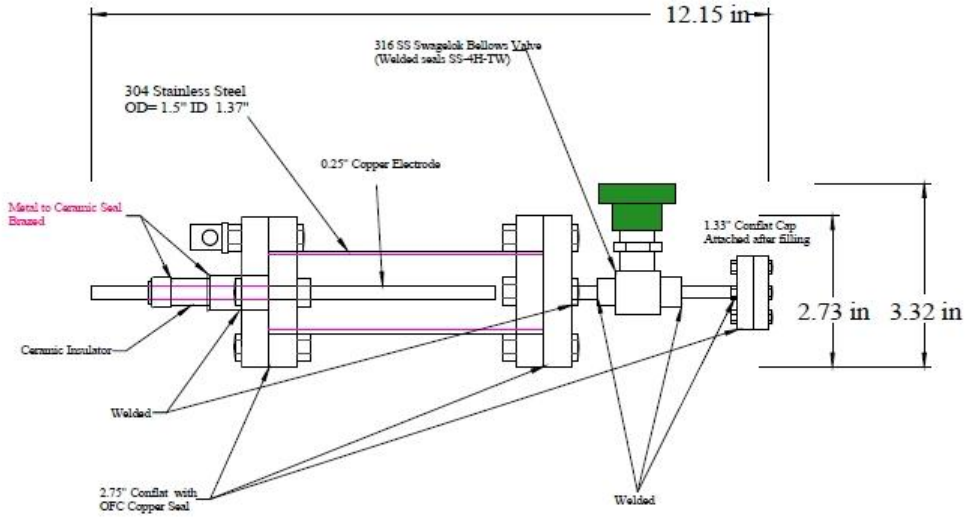
- Stainless steel vessel, 120 cm3 filled with He-gas.
- He-gas pressure of 1 bar (0.98 atm)
- Sensitivity 1.9 pA/(Rad/hr)
- Readout via current-to-frequency converter (1.9Hz/(Rad/hr)
- Range: up to 30 kRad/hr
- Pulses can be sent through long cables

Installation requirements:

- BNC feed through (-95 volts)
- Electrically isolated

Cryogenic Ionization chamber 5k – 350K





It is a helium-filled ionization chamber. It's current is proportional to the dose rate.

- The signal current is processed by a current to frequency converter to achieve a wide dynamic range and quick response dose rate excursions.
- All materials used are know to be radiation hard and suitable for operation at 5K.
- The electronics is self-contained and requires no computer to operate.

Cryogenic Loss Monitor operation

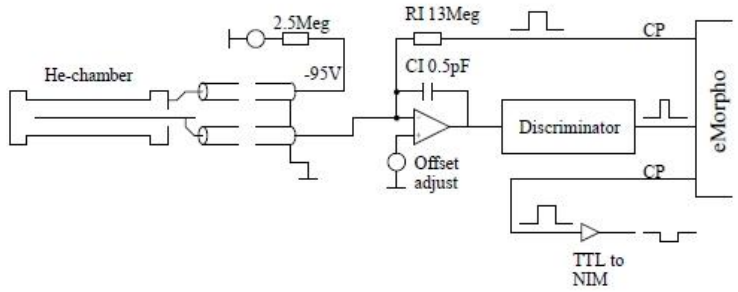
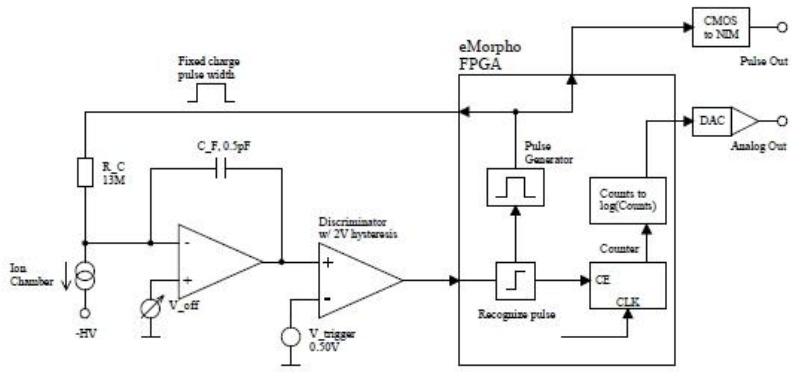


Figure 1: Schematic view of the dose rate monitor.



Drawing 1: Simplified schematics of the digital dose accumulator using a recycling inegrator and the eMorpho platform. Future versions may use a lower-cost platform.

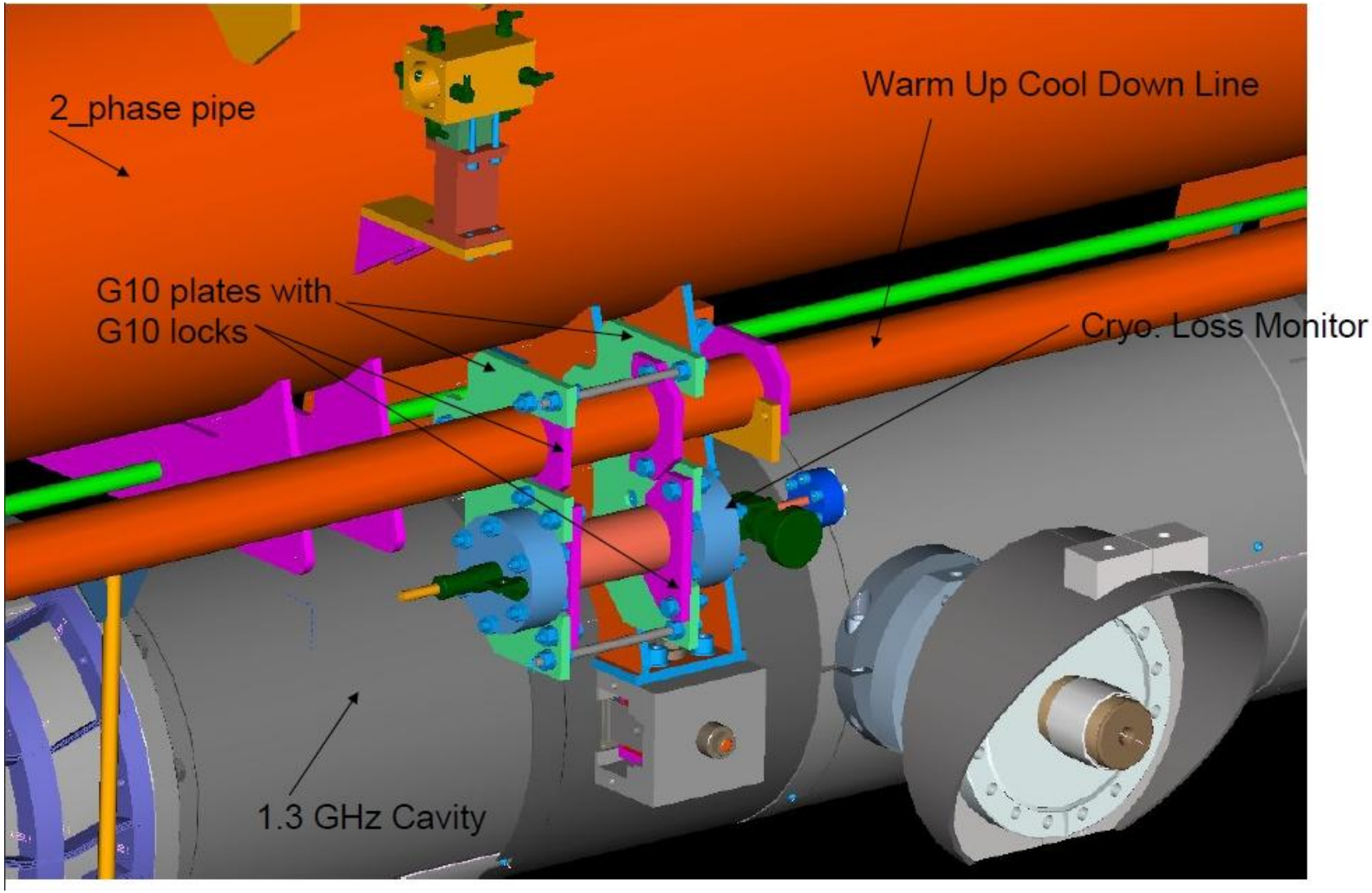
The chamber housing is held at negative potential and negative charge is collected on the center electrode. The HV is -95 V and is kept well below the minimum breakdown voltage of 156V in Helium.

The electronics uses a recycling integrator as a current to frequency converter with a wide dynamic range. The charge per pulse is 1.63pC or 238μR at 1 atm (room temp) of He.

The recycling integrator consist of a charge integrating amplifier with a 0.50 pF capacitance followed by a discriminator which senses when the capacitor is fully charged.

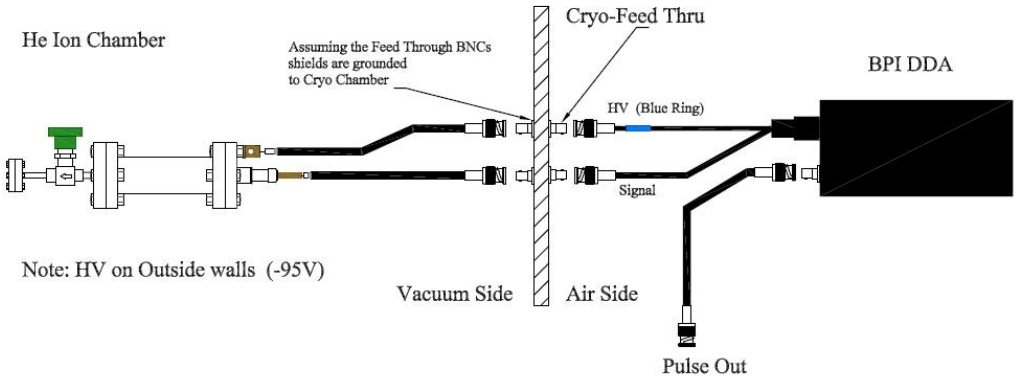
The FPGA generates a fixed-width (1.2μs) discharge pulse with an amplitude of 3.3V. It connects to the amplifier input via a 13 MΩ resistor, creating a 254 nA discharge current

Cryogenic Loss Monitor proposed installation in CM2

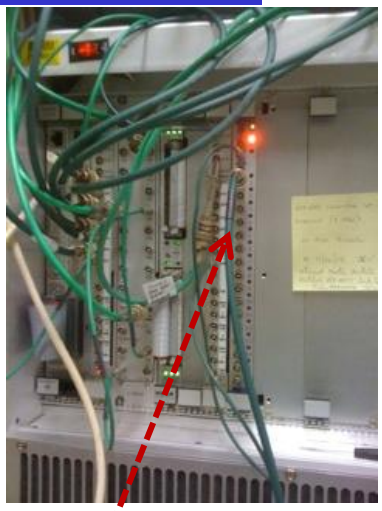


Cryogenic Loss Monitor

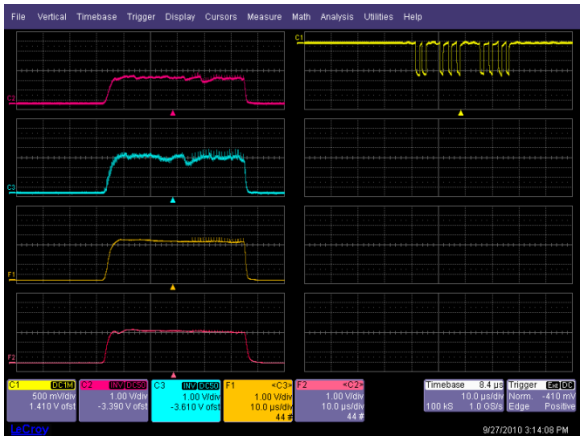
Counter/timer show 630 counts = 150 mR

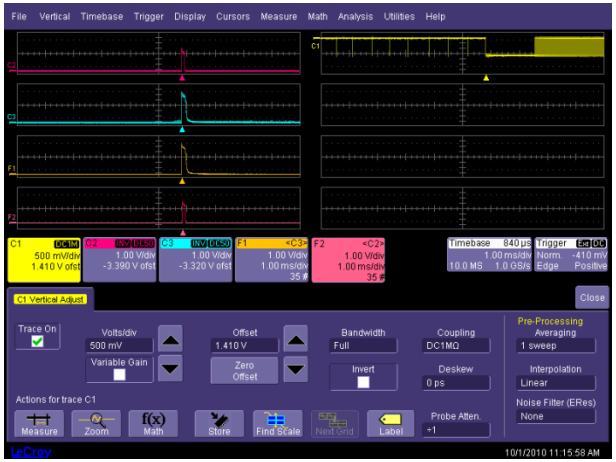


HTS installation



VME based counter/Timer board





Conclusion on FBLM studies

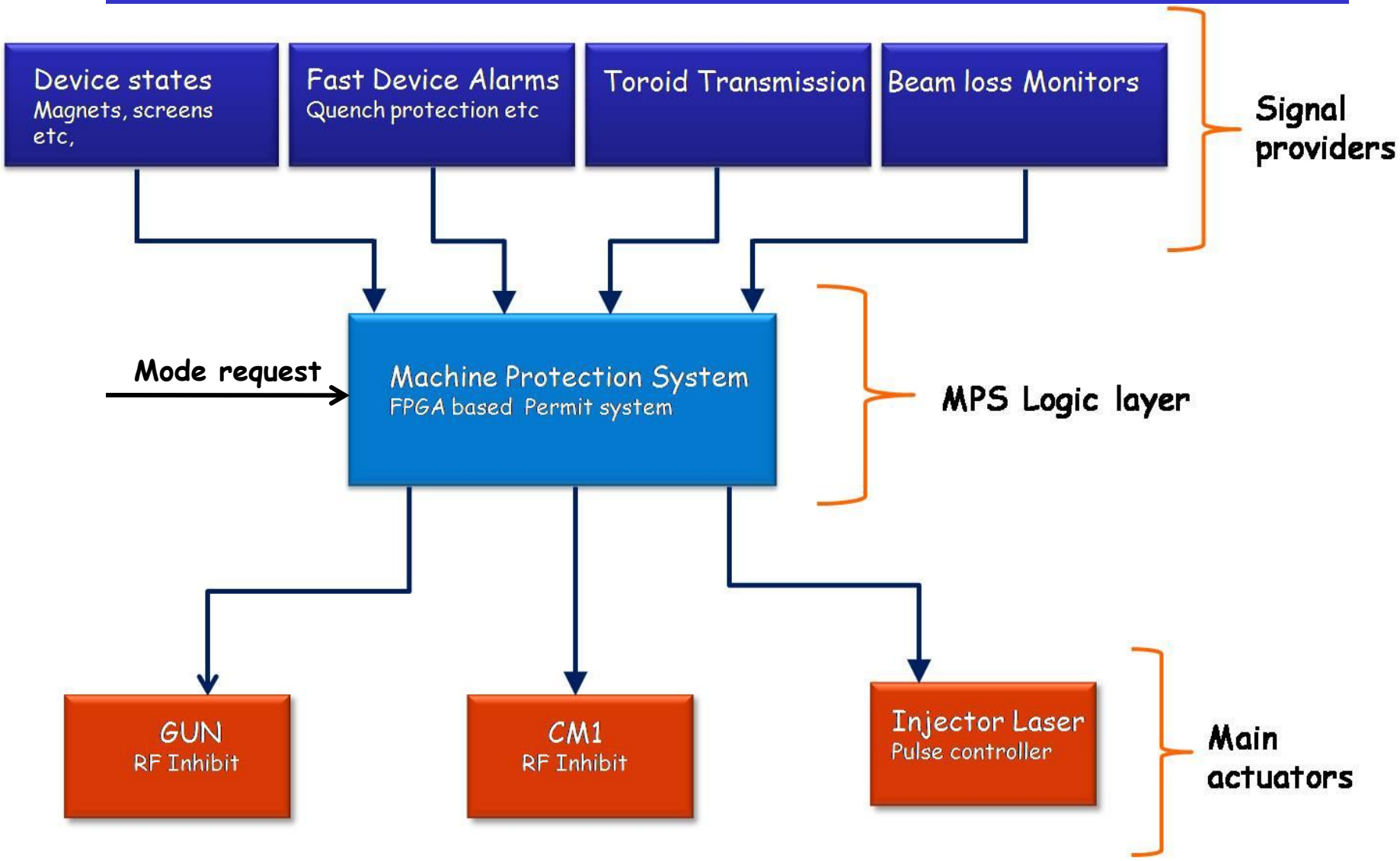
Bridgeport Design

- The FBLMs manufactured by Bridgeport Instruments are well constructed and show good response.
  - The Hamamatsu R6231 PMT is linear and stable but some systematic studies with A0 beam conditions is needed.
  - Adequate shielding can be added to the design to reduce noise and shield from magnets. Provision was made in the design to include this.
  - A few minor modifications to accommodate the beam line can also be added.

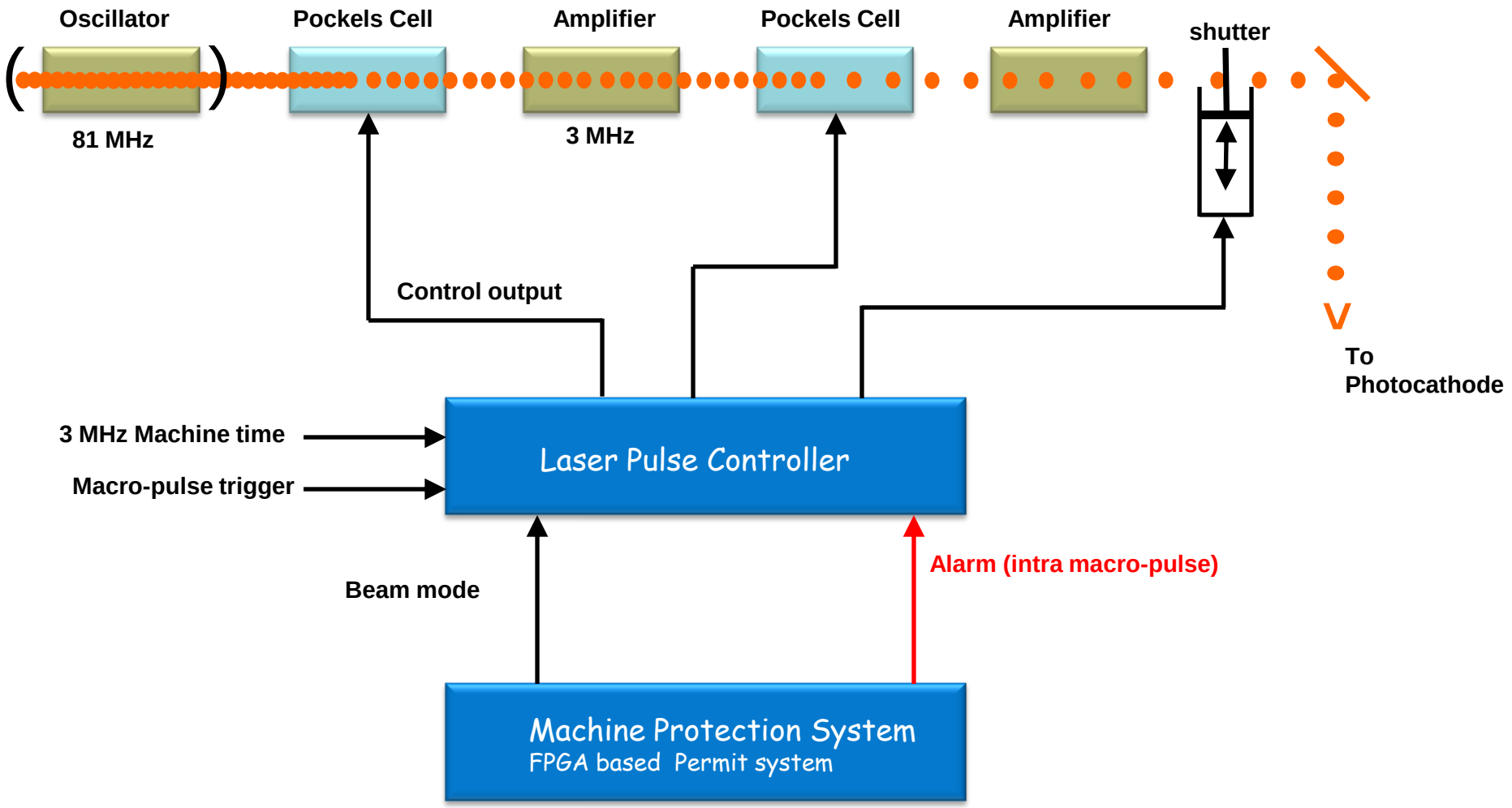
Elgen Design

- Shielding needs to be included to finalize
- PMT adequate but the assembly and connections were not done well.
- Not happy with the construction and response.

Machine Protection System for NML



MPS Laser pulse control



- Block the Pockels cell based pulse kickers as long as the MPS input is in an alarm state.
- Enforce the limit on the number of bunches as given by the currently selected beam mode.
- Close the laser shutter on request of the MPS. This may happen when there is no valid operational mode or when some combination of loss monitors exceed thresholds which trigger a dump condition.