Beam Loss Monitoring Using IDX Detectors at CEBAF

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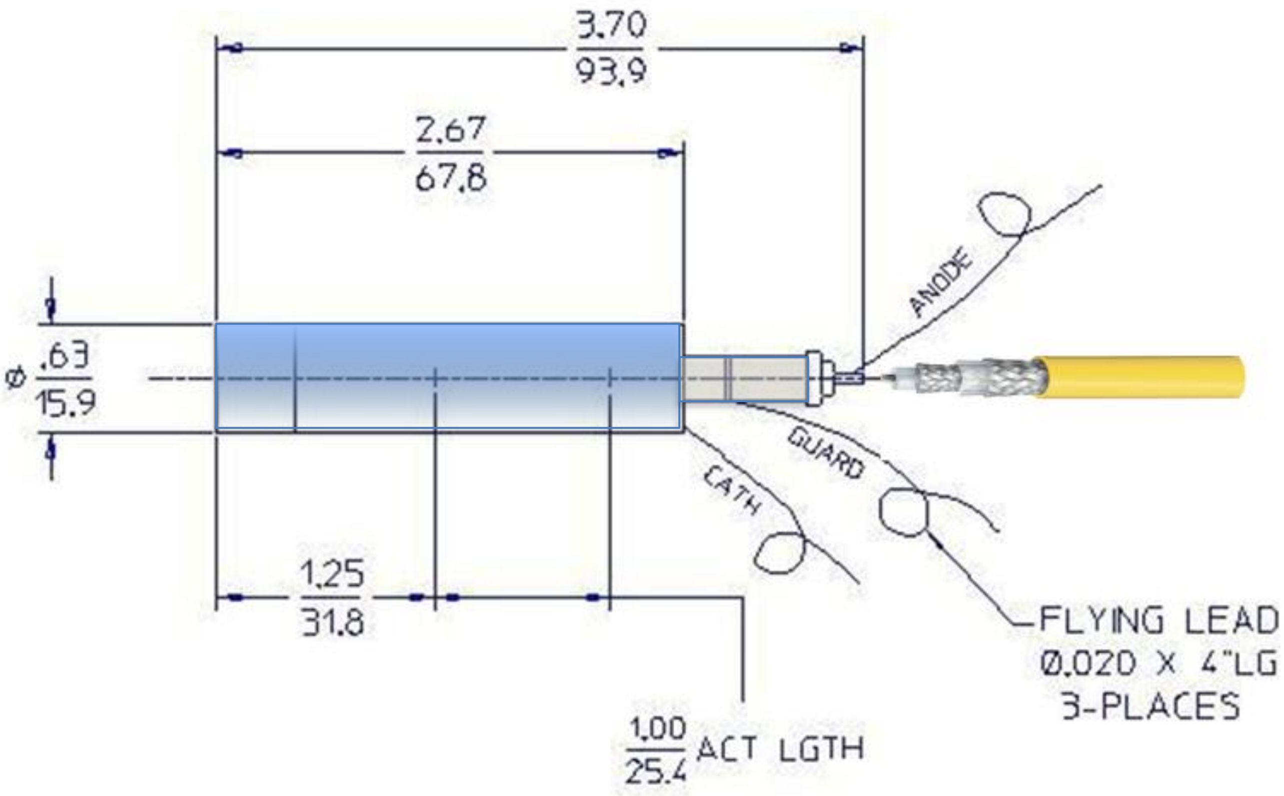
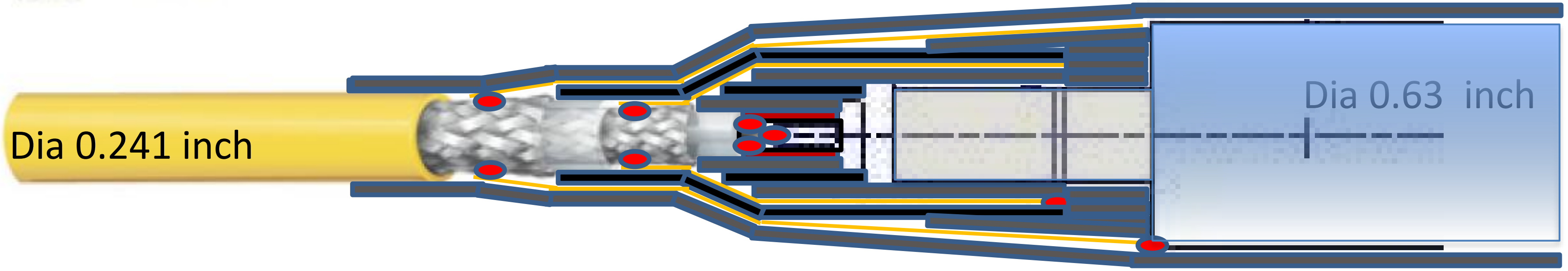
NDX / IDX Dose Rate Monitors

- NDX / IDX stand for (Neutron) / (Ionizing Radiation) Dose Rate Meters with Extended Capabilities
- Common features:
  - Small ion chambers filled with inert gas
  - Long triaxial connection cables (not radiation hard at this point)
  - Super sensitive and stable (~0.1 pA) I400 PTC electrometers with wide switchable dynamic range, using variable integrating capacitor and time
- IDX Differences:
  - Smaller IC, filled with Xe at lower pressure and lower HV
  - Single triax cable used both for HV supply and current readout – no dedicated HV cable needed
  - Open geometry, no moderator shielding

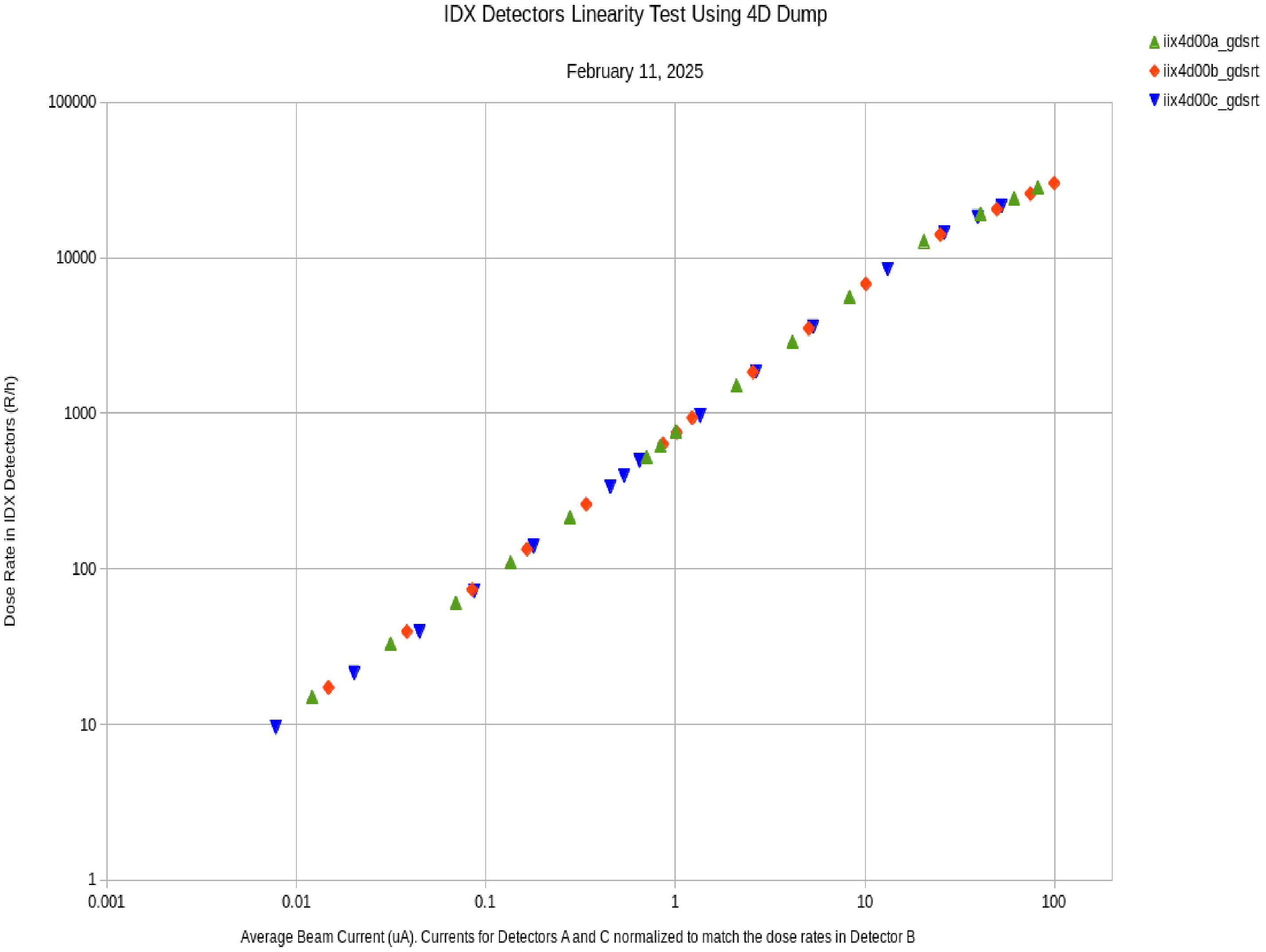
IDX: LND Ion Chamber Connections



- Three layers of conductors
- Soldering and shrink tubing
- Need to guard the center conductor from all leakages
- Joint design with Keith Cole's group

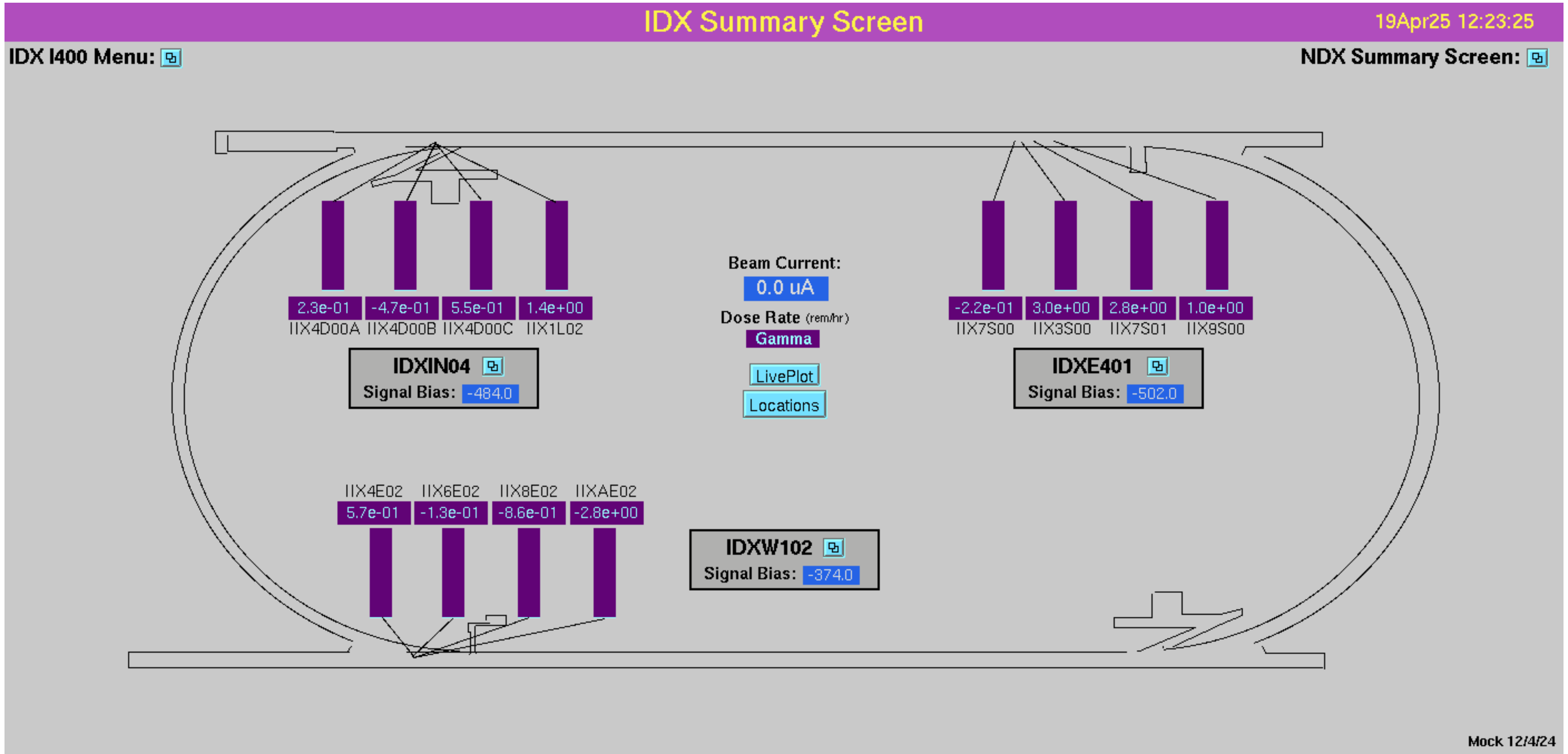


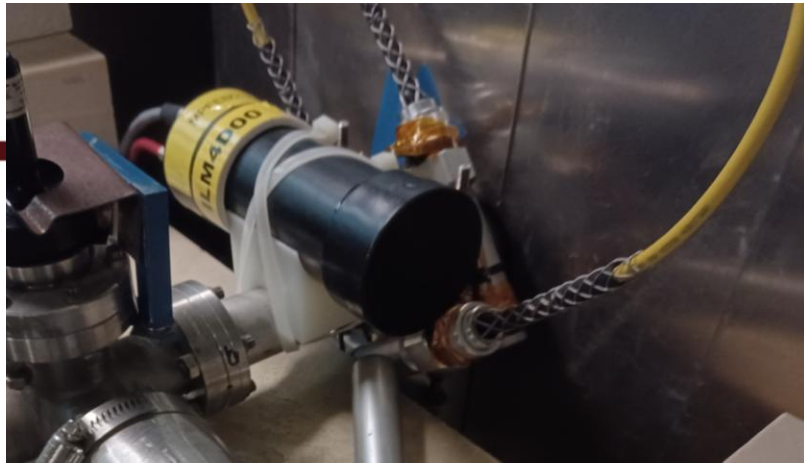
IDX: Calibrations at B1000 and at 4D Dump

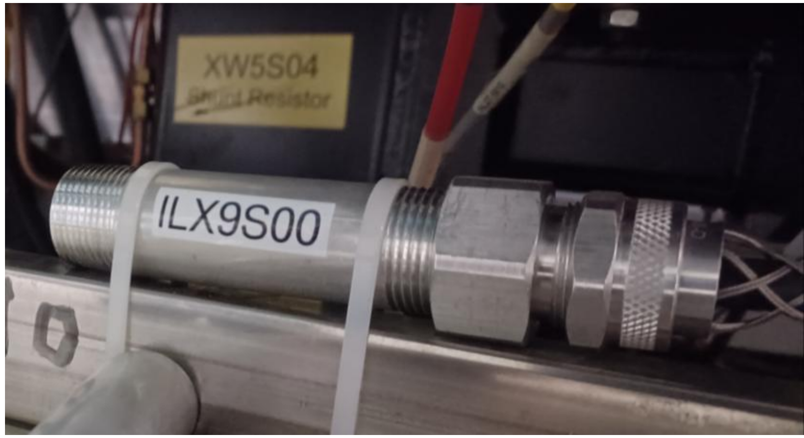


IDX Monitors

- Currently installed 12 IDXs at CEBAF







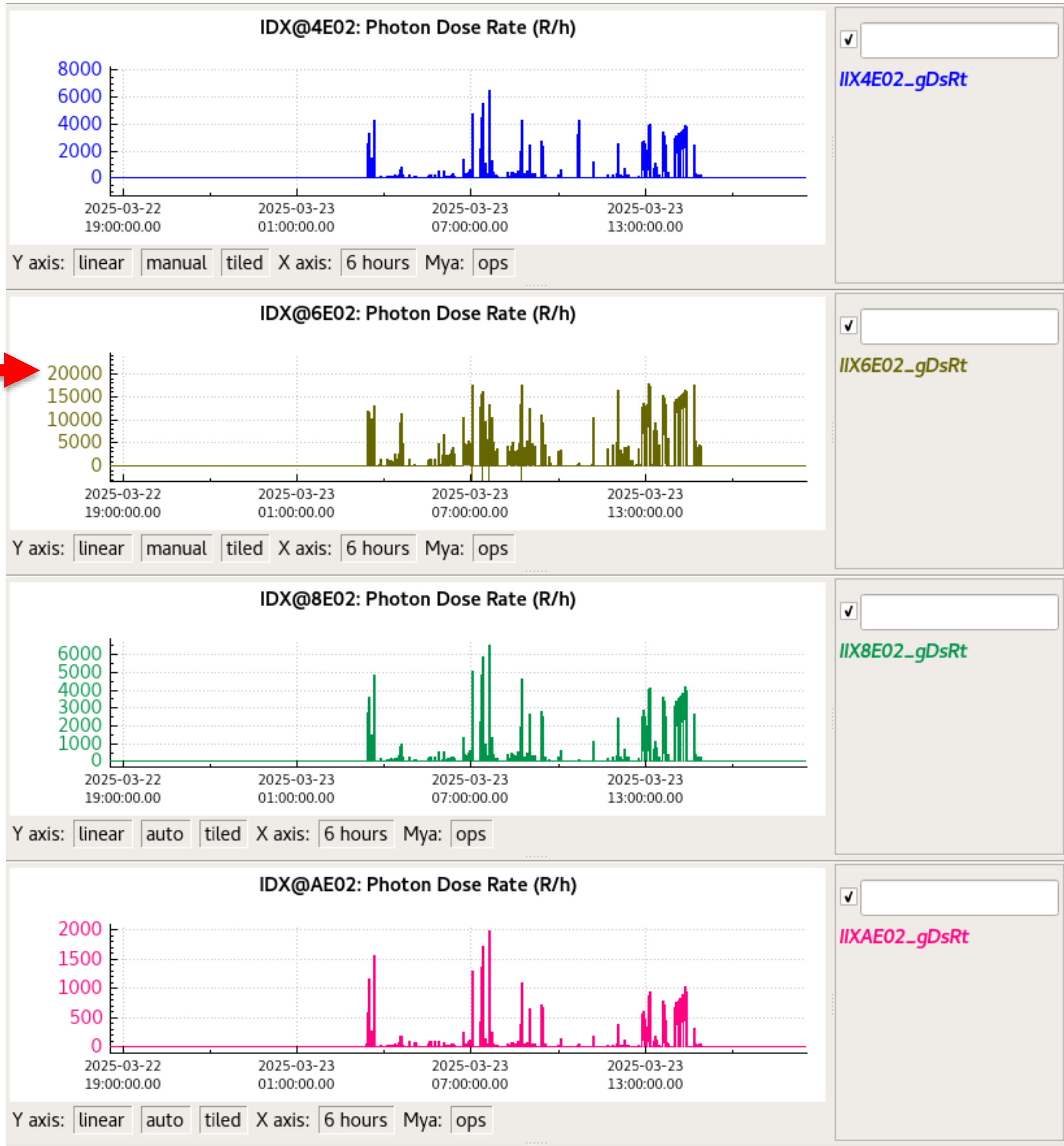
IDX Use at CEBAF

- Strategy
  - Test deployment in critical locations
  - Learning the capabilities
  - Find useful applications
- Beam tune trying to avoid beam losses
- Calibration of the standard BLMs
- Help to solve beam transport puzzles

Threading the Beam through the Machine

First Pass

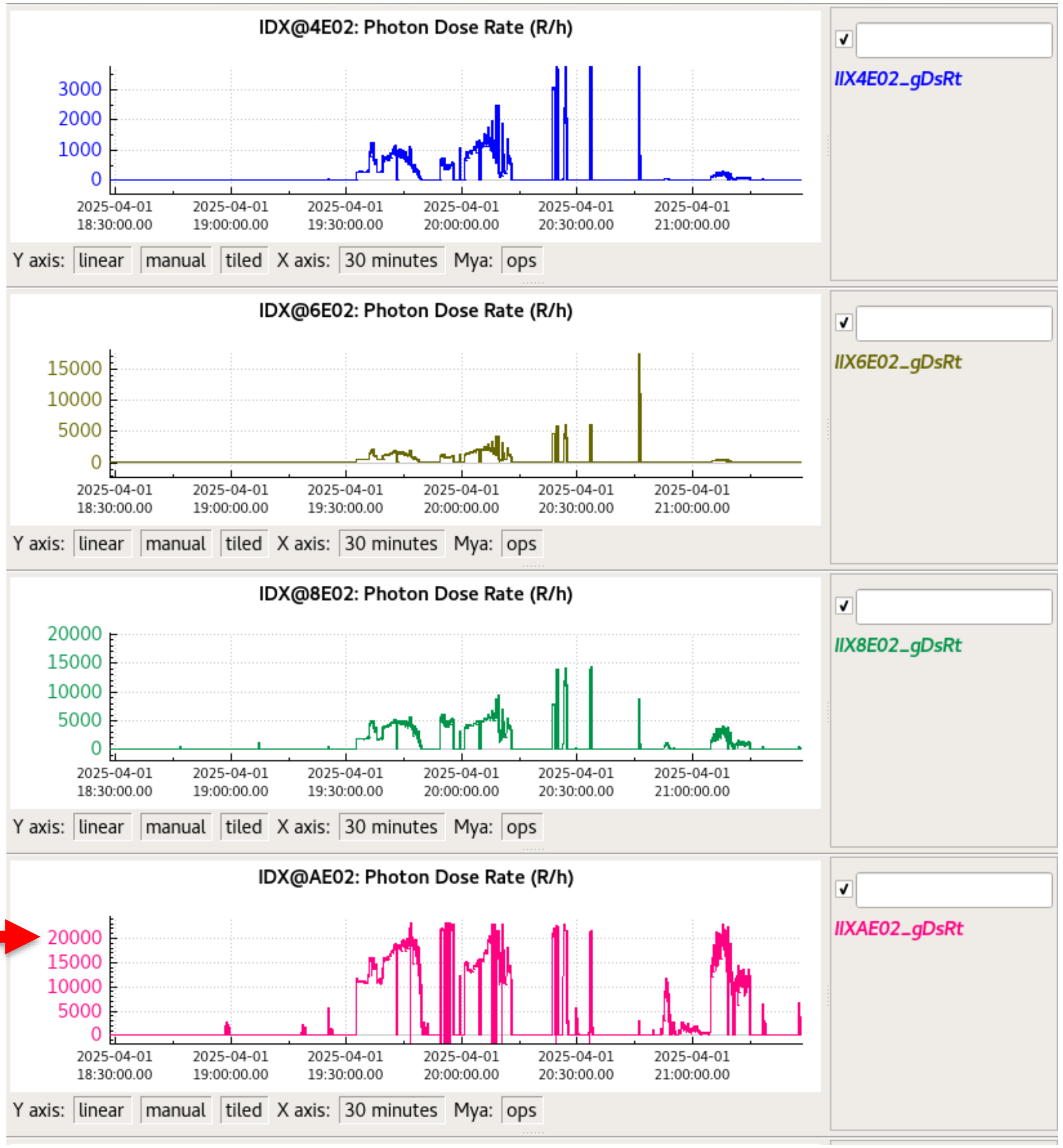
Second Pass



Threading the Beam through the Machine

Third Pass

Fifth Pass



IDX Monitoring System at this Point

- Still a relatively new technology, but relying on the 5+ years of NDX
- The HV supply combined with the signal in a single cable works good
- The sensitivity, linearity, and dynamic range match the needs
- Time response good for monitoring (~1 Hz)
- Cost is roughly $2-3k per channel (IC cost ~$1k)
- Would work well for the continuation of the strategy to gradually deploy new units in critical locations
- In the ARCs the new IDX sets of four may be placed between the beam lines; relative values will characterize the problem line
- Faster reactions are possible, but need new hardware and testing

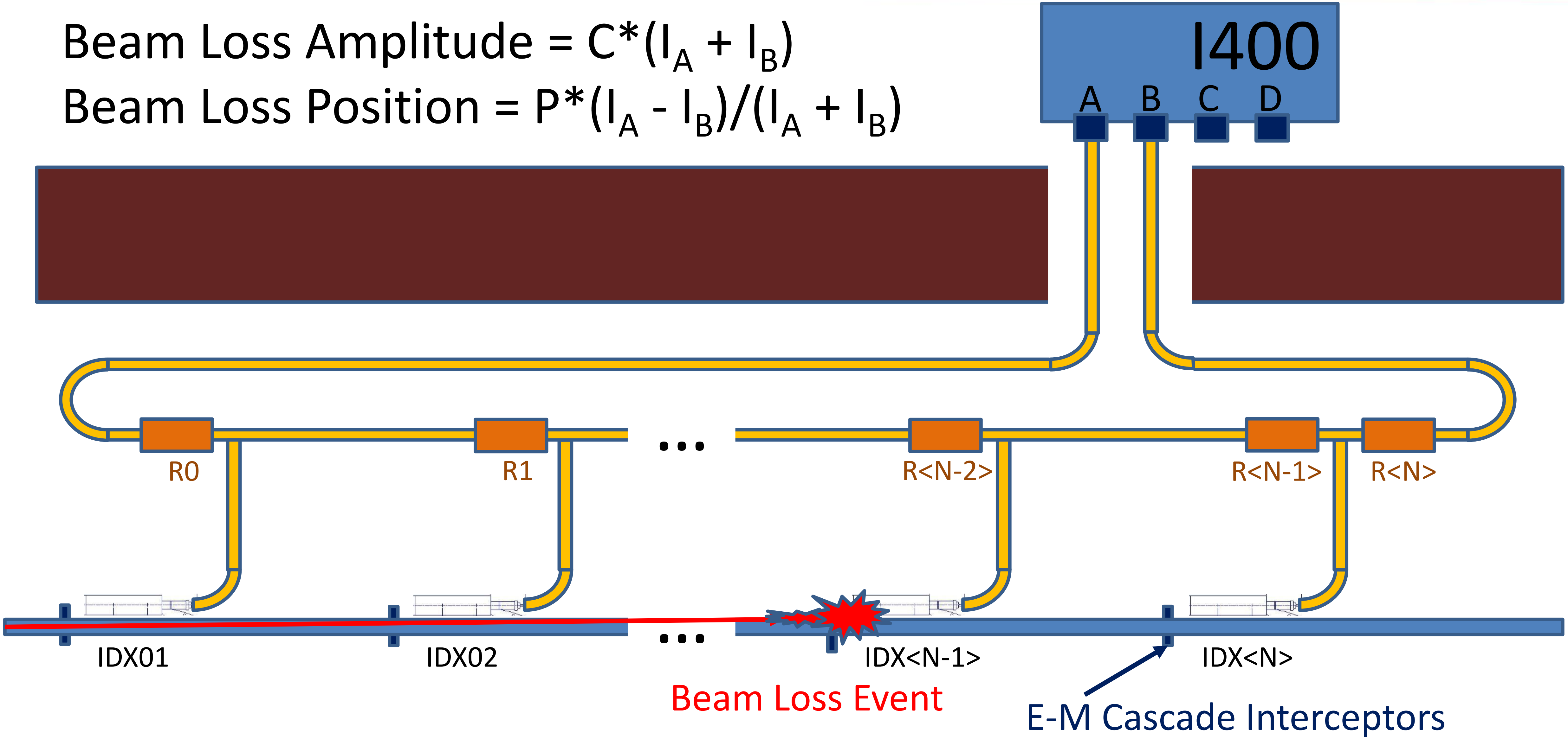
"Beam Loss Imaging"

- In a way similar to the standard radiation imaging solutions, the readout from the array of the IDX detectors can be combined into the dedicated resistive matrix capable of extracting the weighted coordinates of each beam loss event
- 1-dimensional linear arrangement: several detectors in a horizontal or vertical chain -> loss amplitude and X-coordinate
- 2-dimensional arrangement : a matrix of, say, 5 by 10 detectors placed in the ARC one string along each of the beam lines, read out by a single I400 electrometer -> loss amplitude and weighted (X,Y) coordinates of current average loss position

One-Dimensional IDX Array

Beam Loss Amplitude = $C*(I_A + I_B)$

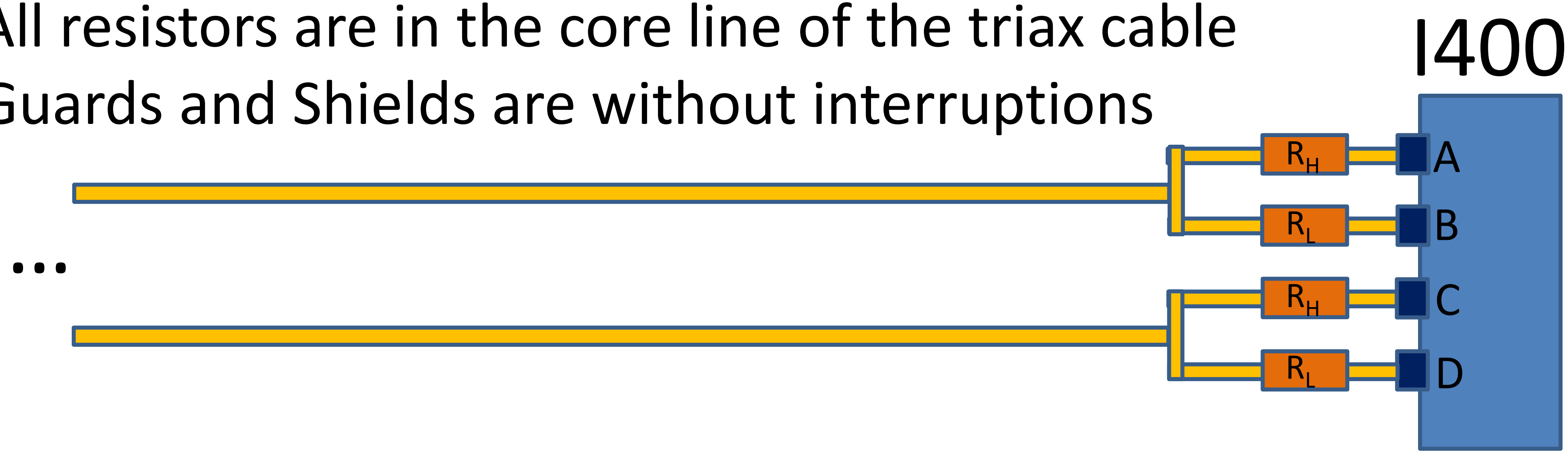
Beam Loss Position = $P*(I_A - I_B)/(I_A + I_B)$



Increasing “Always On” Dynamic Range

All resistors are in the core line of the triax cable

Guards and Shields are without interruptions



High Sensitivity Amplitude = $C*(I_A + I_C)$

High Sensitivity Position = $P*(I_A - I_C)/(I_A + I_C)$

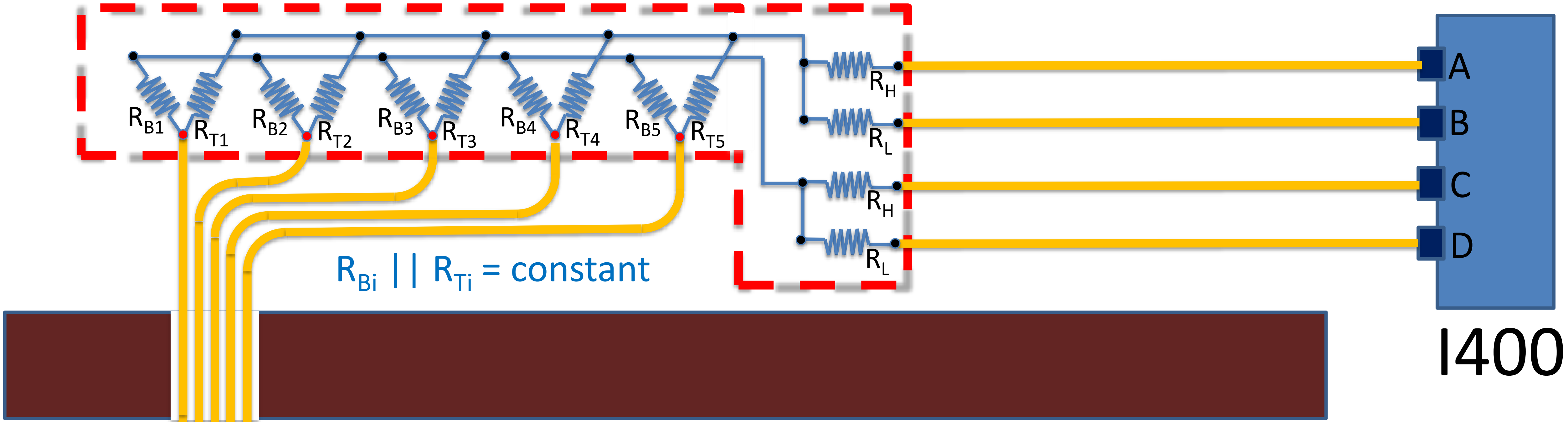
Low Sensitivity Amplitude = $C*(I_B + I_D)$

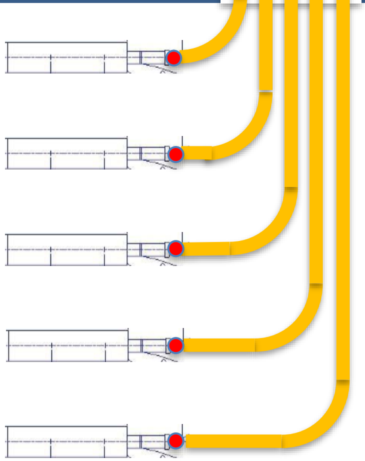
Low Sensitivity Position = $P*(I_D - I_D)/(I_B + I_D)$

$R_L / R_H = 100$

or as needed

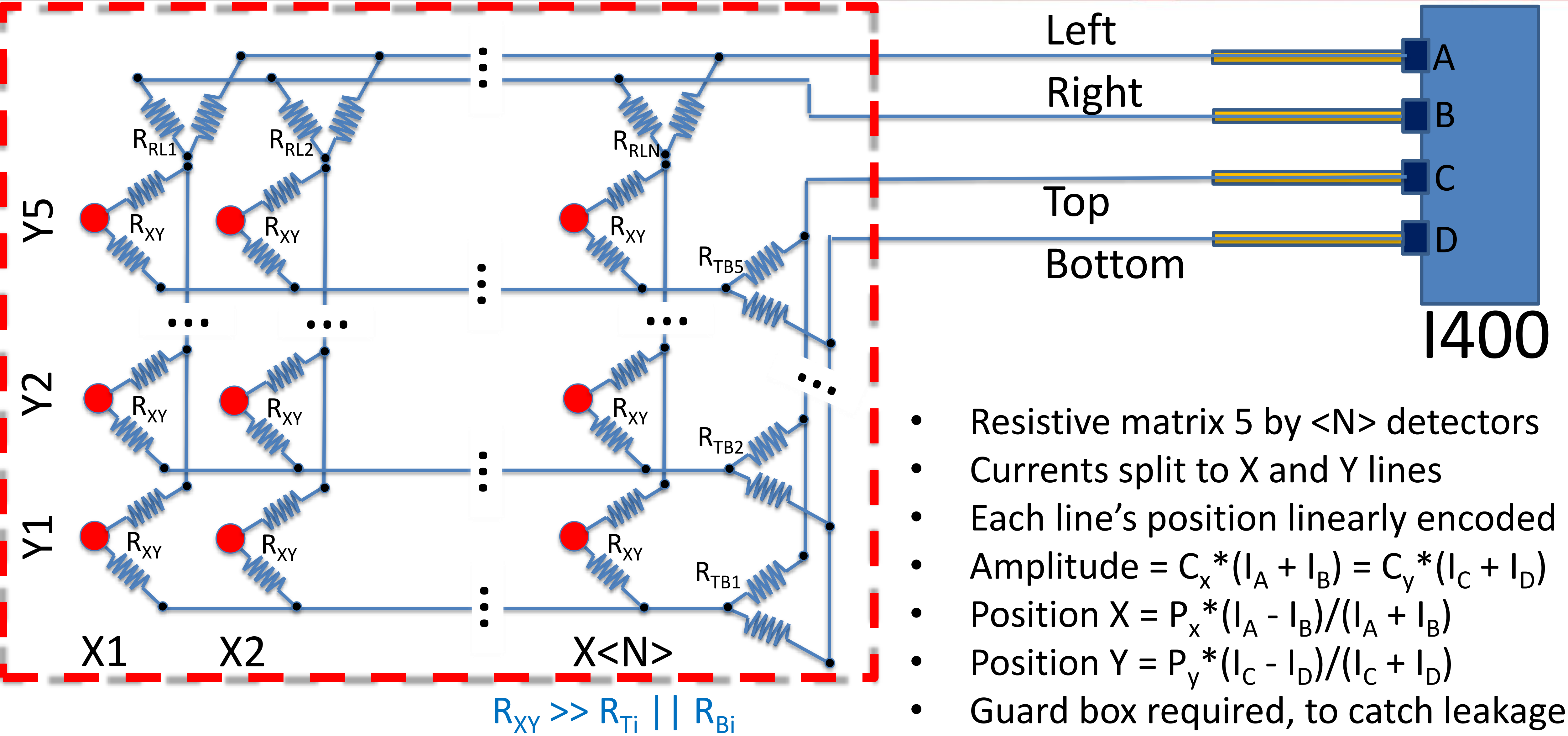
Possible Conceptual Test: Vertical IDX Array in ARC





- Vertical chain in one ARC location
- Combines the loss position and the extended immediate range
- Triax cables go upstairs into the splitter box and then go to I400
- Amplitude = $C_H*(I_A + I_C)$ <and/or> $C_L*(I_B + I_D)$
- Position Y = $P_H*(I_A - I_C)/(I_A + I_C)$ <and/or> $P_L*(I_B - I_D)/(I_B + I_D)$
- The guard layer of the box must be at the same HV as the cable guard

Two-Dimensional IDX Array



- Resistive matrix 5 by <N> detectors
- Currents split to X and Y lines
- Each line's position linearly encoded
- Amplitude = $C_x*(I_A + I_B) = C_y*(I_C + I_D)$
- Position X = $P_x*(I_A - I_B)/(I_A + I_B)$
- Position Y = $P_y*(I_C - I_D)/(I_C + I_D)$
- Guard box required, to catch leakages

Beam Loss Imaging: pro and contra

- Pluses
  - Savings on the number of the DAQ readout channels
- Minuses
  - Loss of individual detector information, only averages available
  - No redundancy
  - More complexity
  - Could be difficult to deal with multi-channel troubleshooting – there will be a learning curve

Overview: IDX System for BLM

- Operational detectors installed in few critical places
- Currently used for beam tuning and troubleshooting
- The technology is stable, covering needed range of losses
- We may continue to install them in new locations
- "Beam Loss Imaging" is possible, saving costs of readout channels at the expense of losing individual detector information - would require R&D efforts and testing
- Could use chains of 4 IDXs in the ARCs with extended "always on" dynamic range and vertical position information
- Using the IDX readouts to trigger FSDs may be studied