BEASTII PIN Diode Radiation Monitor System

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Outline

- Introduction: System Goals
- CLEO Experience
- Belle II Work and Plans
  - Prototype based on Cremat Inc. electronics
  - Location within BEAST II
  - Multichannel System
  - DAQ Plans
  - Remaining Issues
- Plans and Timeline

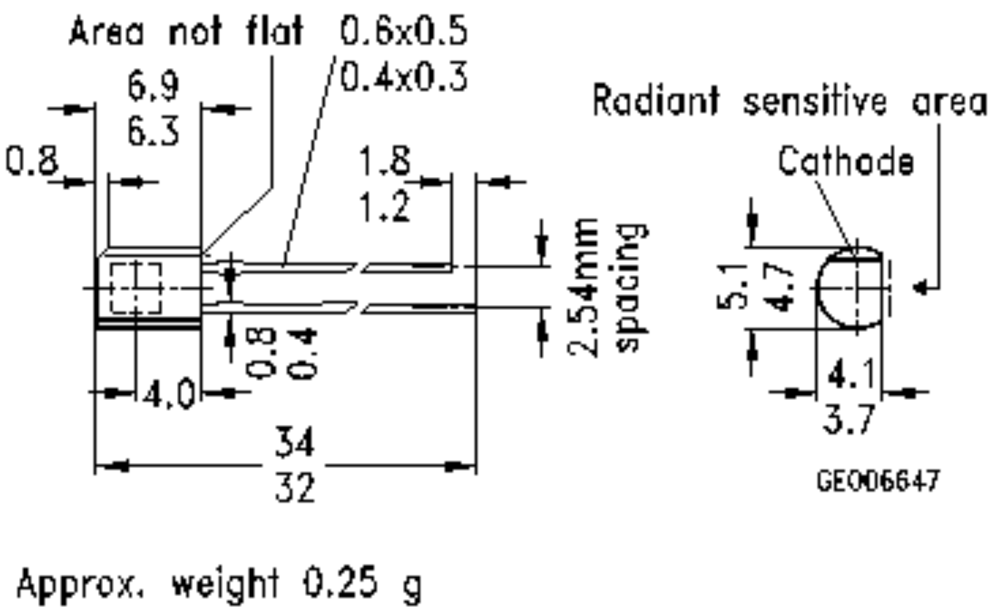
System Goals

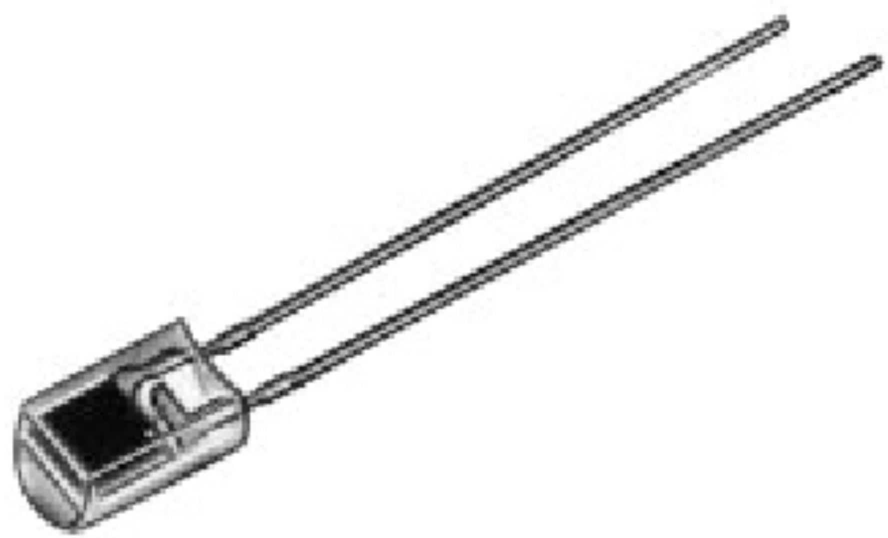
- Robust, simple system to monitor ionizing radiation
  - The starting point of all e+e- machine radiation (all others derive from it)
  - Minimal complication so that it can be always on
  - Easy to change, location or gain, in response to changing conditions or for targeted machine studies
- Candidate for feedback for mask control system
- Minor goal is to shadow TPC's to validate their measured non-neutron dose

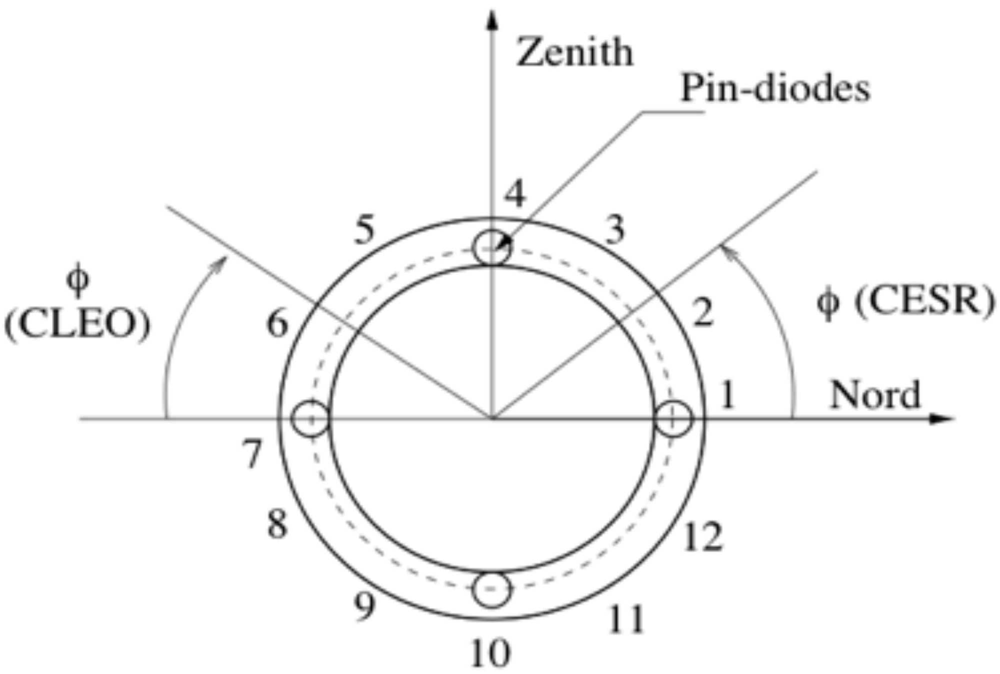
CLEO-III/-c Radiation Monitor Diodes

David Cinabro, Wayne State, Mikhail Dubrovin, now SLAC

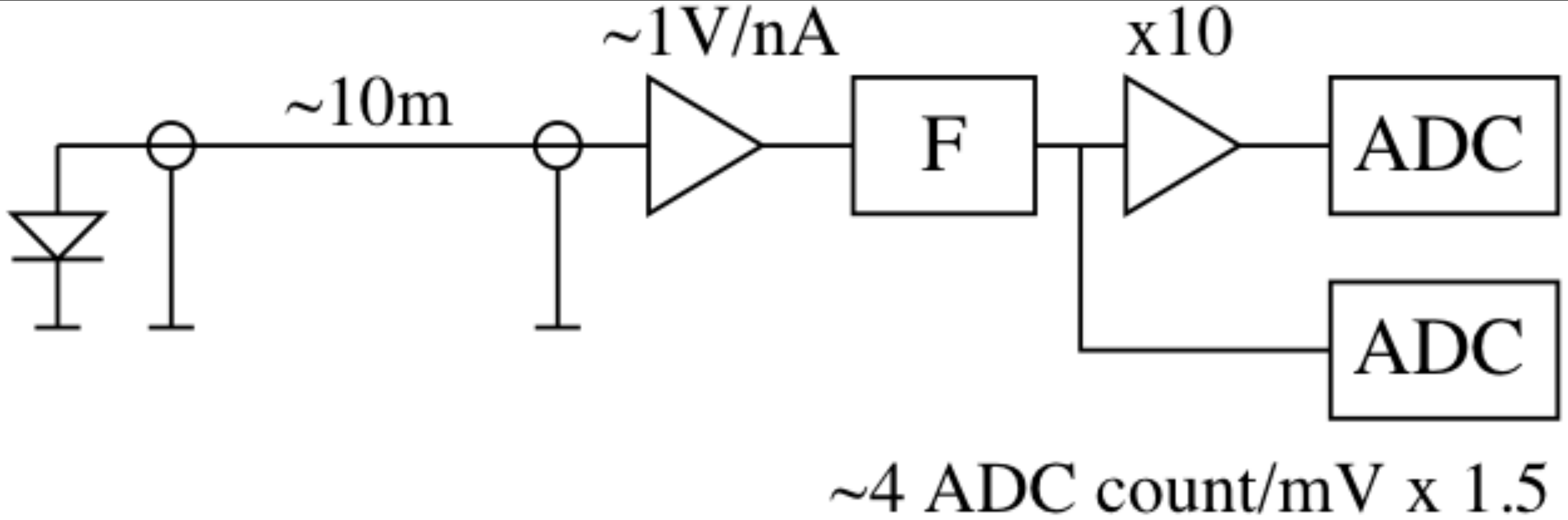
- System based on Siemens SFH 206K PIN Diodes.





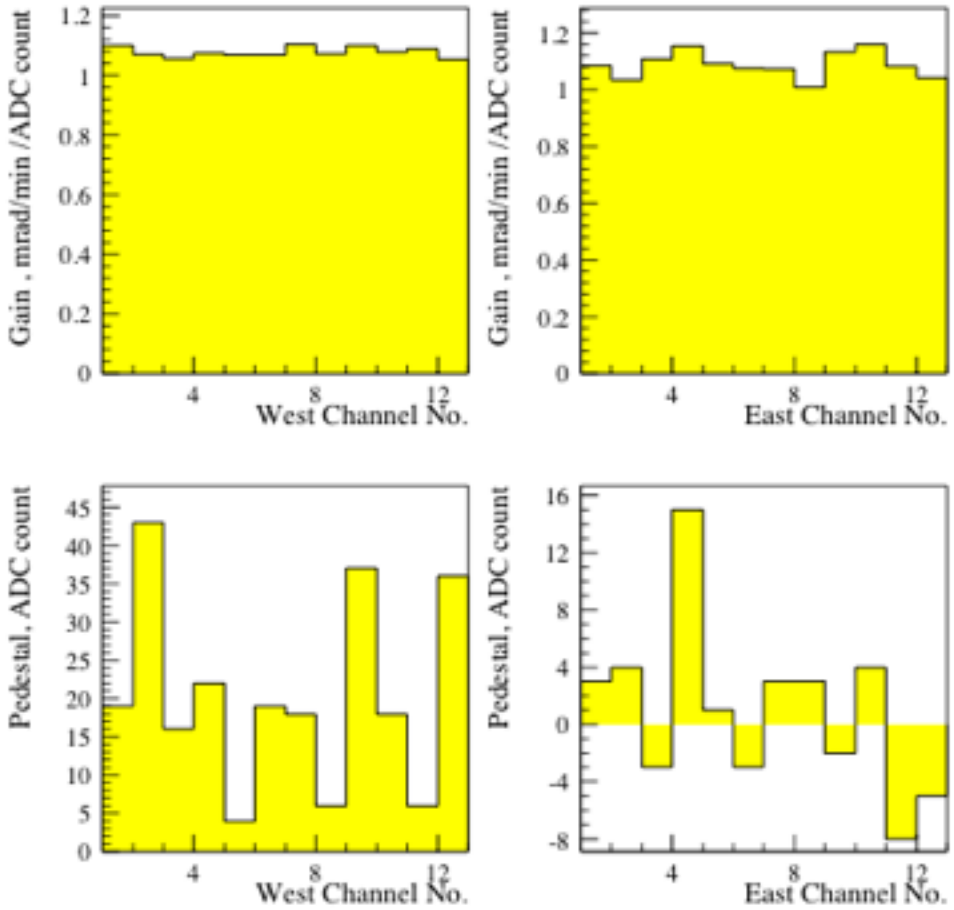


- Diodes around 2cm radius Be beampipe, +/-14cm from nominal IP (just beyond end of the first layer of silicon vertex detector + readout boards)
- Test running had all against Be pipe. Real running had all even numbered diodes behind a layer of Au paint to block synchrotron x-rays.

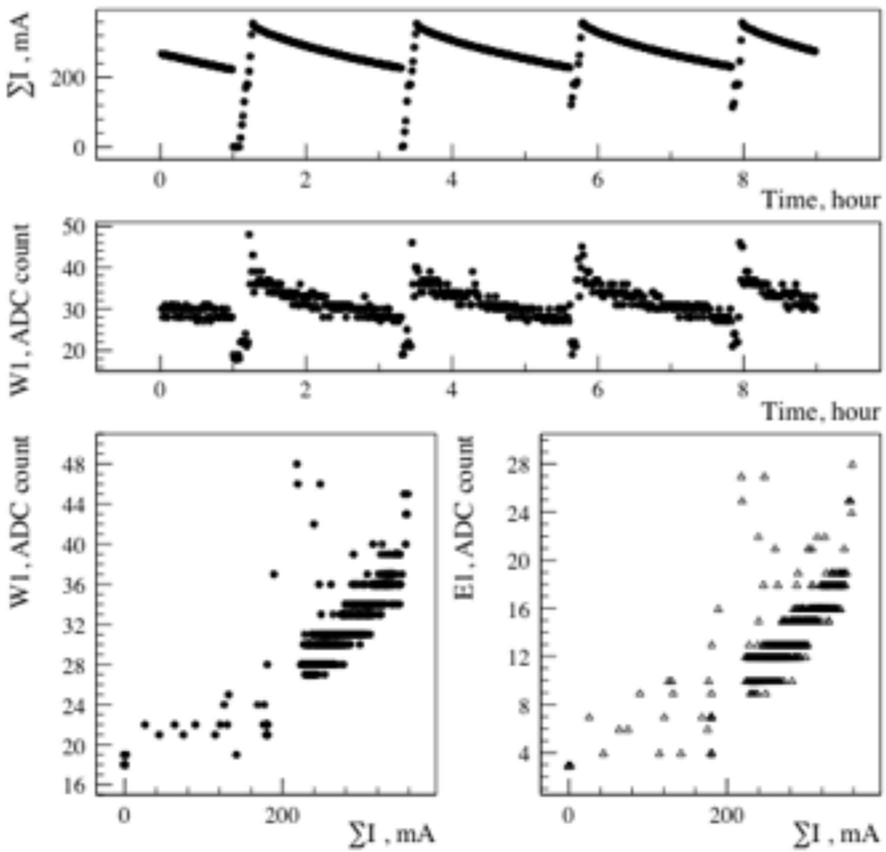


- Readout electronics were childishly simple. Passively collect ionization current and amplify with the simplest possible op-amp based amplifier.
- Analog signal split with one channel x10 and digitized in existing CESR general voltage 8-bit ADC system.
- System always active and essentially indestructible.
- Electronics were in CLEO pit. Gain adjustable without action on inaccessible sensors.

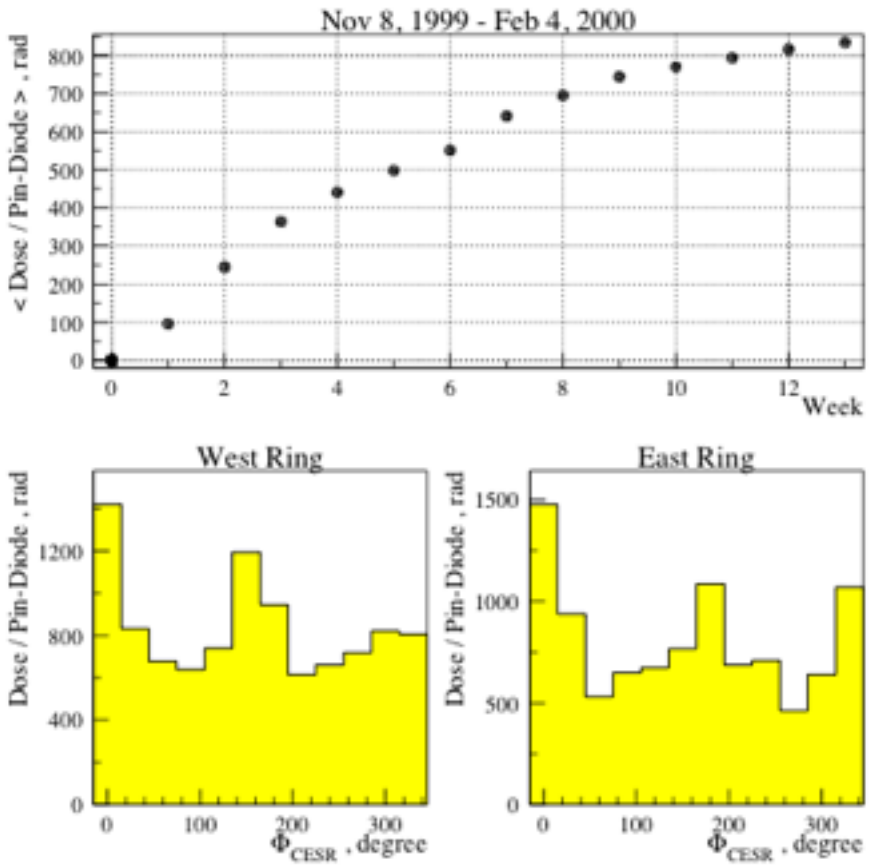
- Electronic gain and pedestal monitored with charge injection calibration circuit.
- Radiation response dead reckoned assuming minimum ionizing and using known properties of silicon and geometry of the diodes.
- Checked with x-ray data at CHESS (x-ray source at CESR). Dead reckoned response was correct to 10%.



- Performed without problem during 12-week test run.
- One headache was that diode pedestal, driven by dark current, is temperature dependent. Calibrated away. Small problem in real running as beam pipe was actively cooled.



- Running experience showed clear synchrotron fan to outside of ring, back scatter off mask on opposite side, and general phi-independent particle background as expected.
- Clear benefit of sacrificing half the diodes to directly measure both components.



Reflections

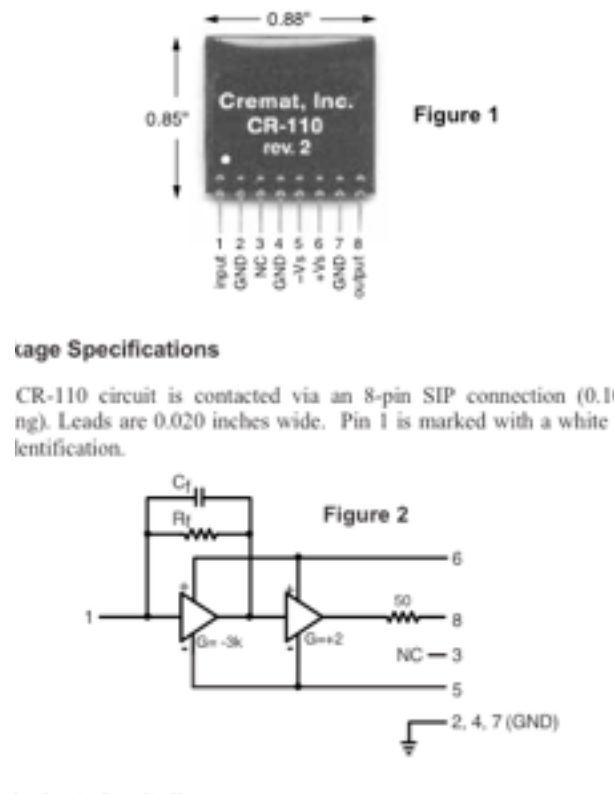
- This very inexpensive and simple system worked flawlessly for ~10 years of CLEO-III/-c.
- Never off.
- Easy to give visual/automated feedback to machine operators for background tuning.
- Easy to monitor and keep track of accumulated dose.
- Small. Can easily be positioned close to innermost detector.
- Diodes few dollars each. Cost ~5k$ (~$100/channel) dominated by electronics. Built in house at Cornell.
- Ideal radiation monitor for near-IP.

Cremat Inc. Preamps

- Cinabro noted their ads in the CERN Courier and discovered that their electronics were very much like the CLEO system.

- Simple op-amp based amplifier.

- Gain is fixed but can buy different preamp cards with different gains.

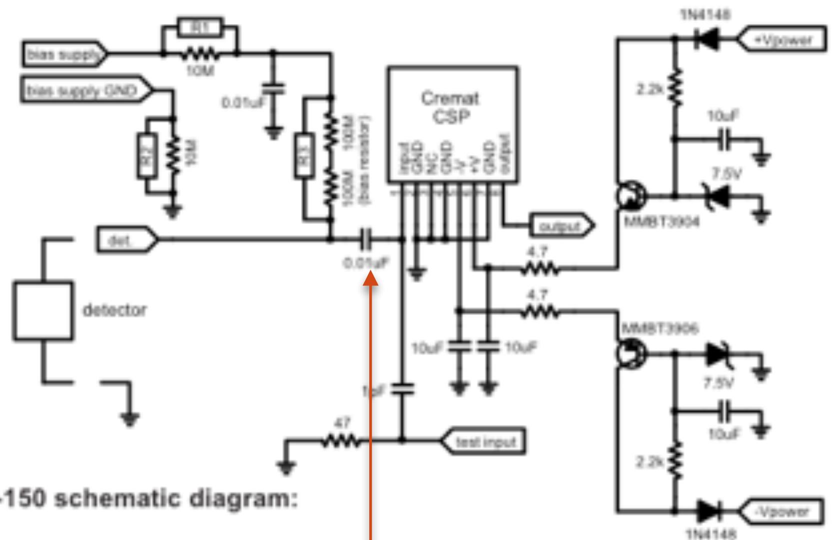


Readout Board

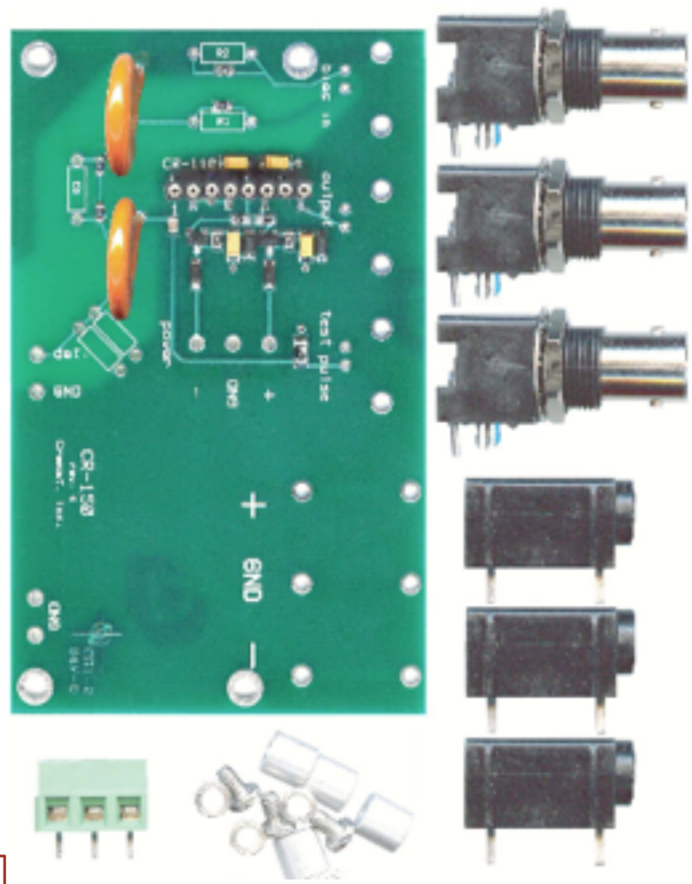
Board dimensions: 3.7 in. x 2.3 in x 0.063 in.

The CR-150 prototyping test board will aid the experimenter in using and evaluating Cremat's charge sensitive preamplifiers (CSPs). The board has an 8-pin socket for the insertion of the preamplifier, as well as power connectors, a power supply regulation circuit and other components needed to filter the detector bias.

The CR-150 board schematic is shown below. The CR-150 uses 'AC coupling' between the detector and preamplifier input.



CR-150 schematic diagram:



Short this out as it blocks DC signal

Performance

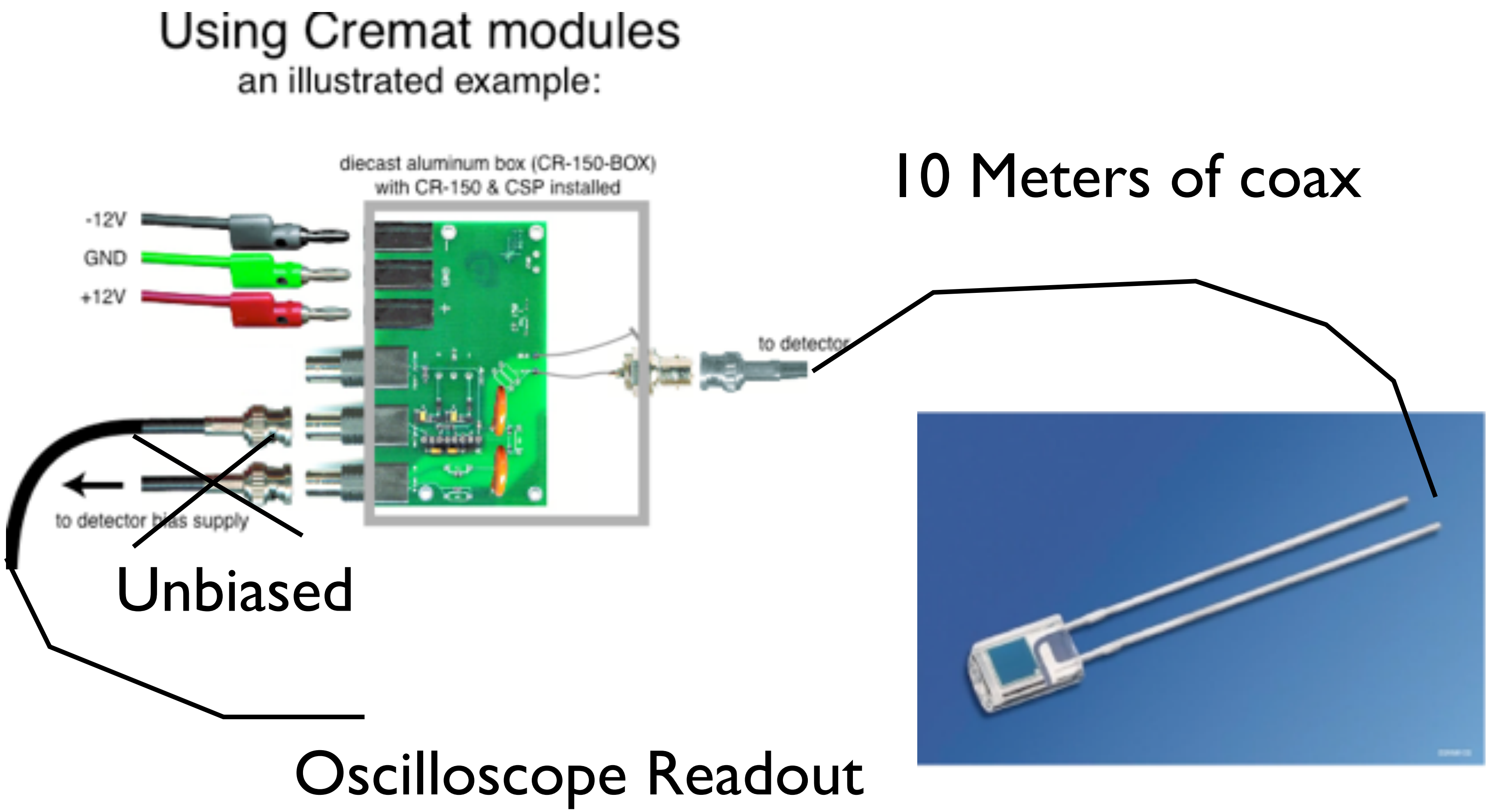
preamp model	gain (mV per picoCoulomb)	maximum detectable pulse (electrons)	noise (ENC) in electrons RMS*
CR-110	1400	10^7	200
CR-111	130	10^8	630
CR-112	13	10^9	6,800

preamp model	maximum DC input current (uA)
CR-110	0.01
CR-111	0.1
CR-112	3

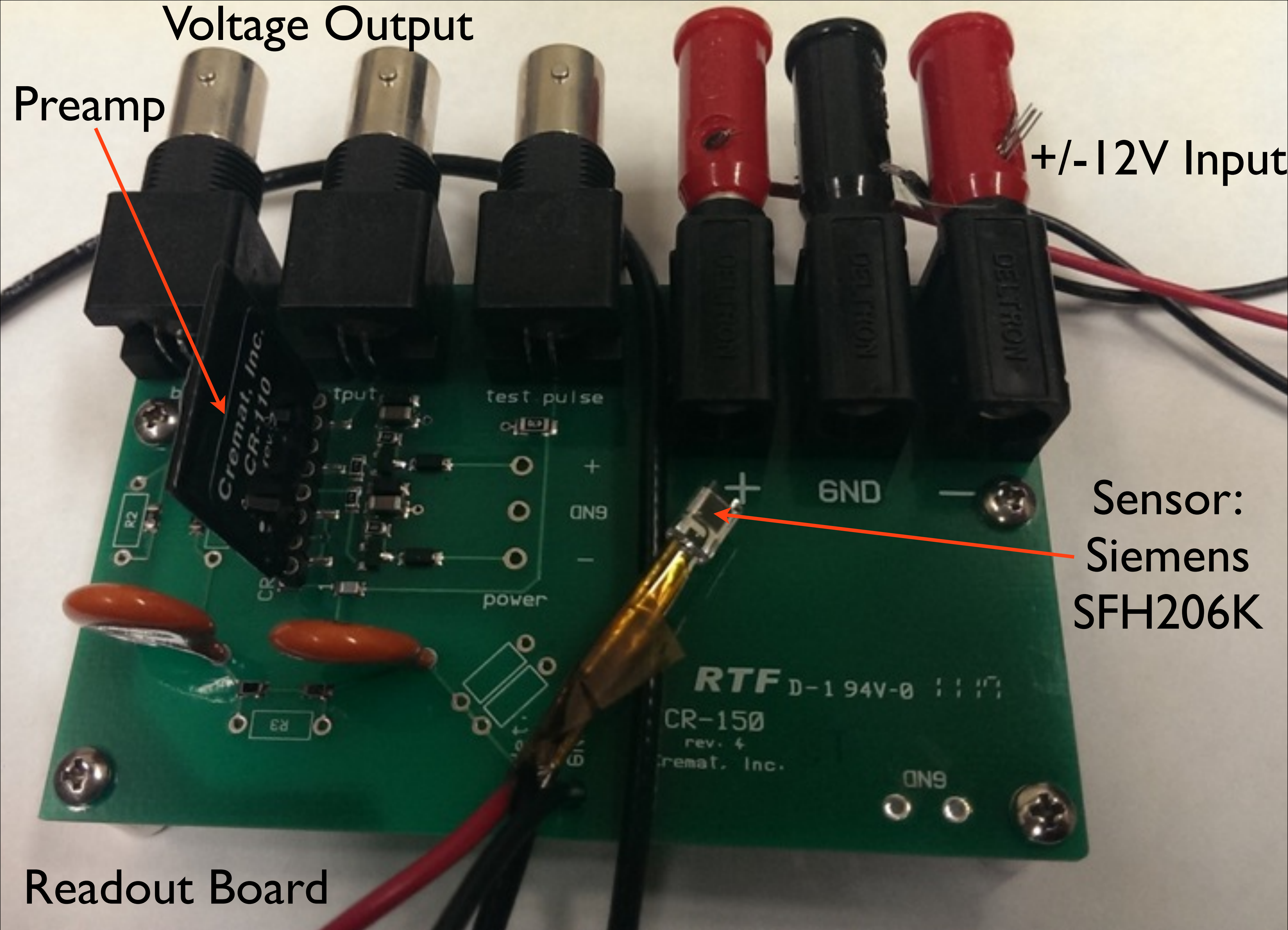
Pre-amp is $65 and board is $55. One set (CR-110) for evaluation in Detroit

Attractive as no design work necessary.

Can adjust gain by introducing a resistor between pins 1 and 8 of the preamp card. Need to test this.



Using Cremat modules
an illustrated example:
diecast aluminum box (CR-150-BOX)
with CR-150 & CSP installed
-12V
GND
+12V
to detector
to detector bias supply
10 Meters of coax
Unbiased
Oscilloscope Readout


Voltage Output
Preamp
+/-12V Input
Sensor:
Siemens
SFH206K
Readout Board
Cremat, Inc.
CR-110
test pulse
+
GND
−
power
DELTRON
RTF
CR-150
rev. 4
Cremat, Inc.

Prototype System

- Purchased at Wayne State using internal money.
- Tested with Sr-90 Beta Source
- Works as expected
- Clear signal above noise in presence of source.
- Signal disappears when source blocked by lead.
- Signal shows $1/\text{distance}^2$ dependence when source moves away from sensor.
- Gain within 30% of dead reckoned value. Not sure why gain calculation is not as good as old CLEO system.

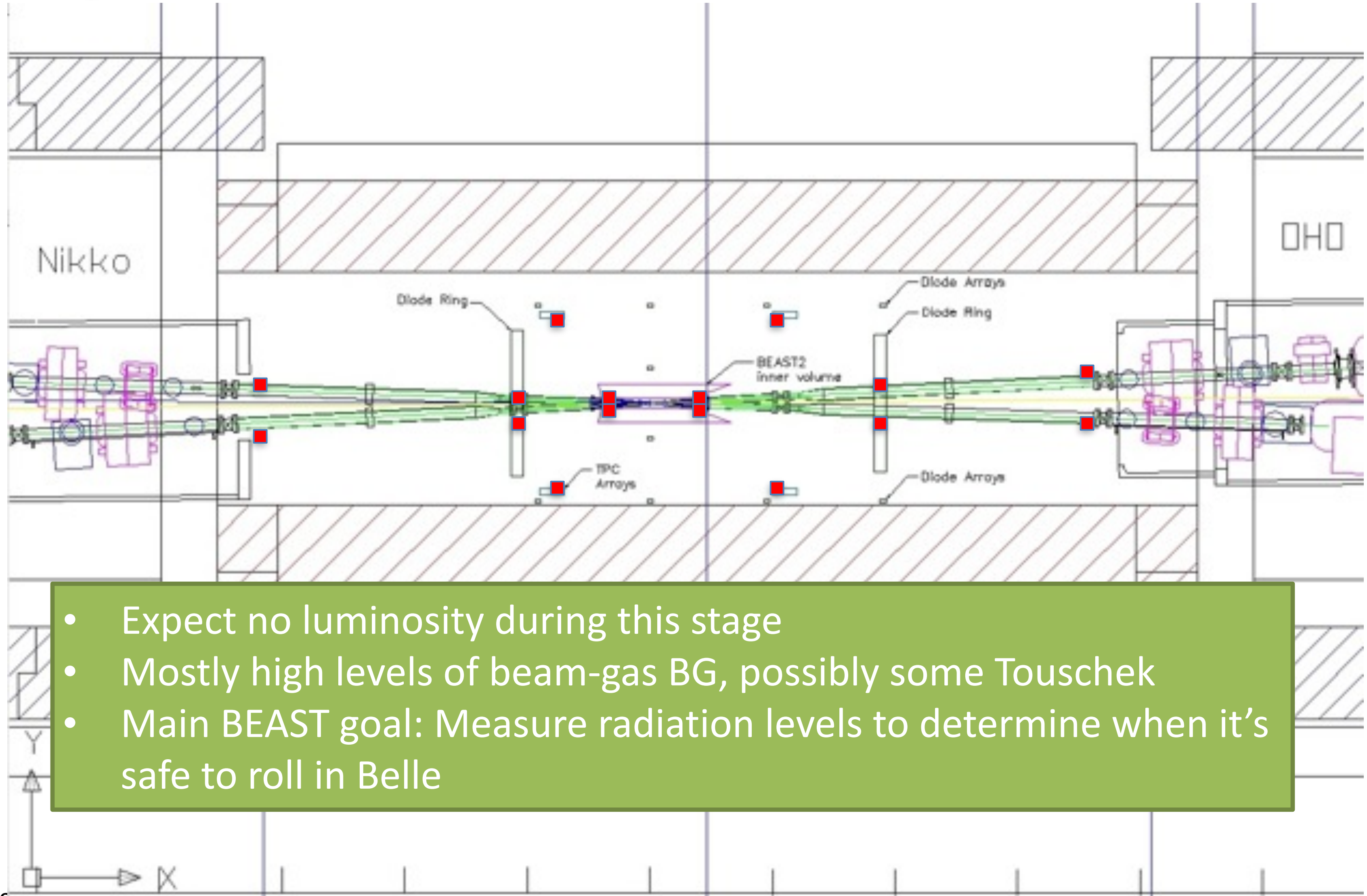
Plans for locations in BEAST II

- Want to monitor dose in IR region to decide if OK to put in more of Belle II.
- Initial shadowing of TPC's to validate their ionization dose measure.
- Then move diodes to loss locations for mask control feed back.
- Final stage at inner ring of calorimeter where dose is expected to be highest.
- Make sets of 8 (4 locations in phi x 2 diodes, one shielded and one not) at each location in z
- 8 locations in z for 8 sets of 8 = 64 channels

CAD drawing by Kanazawa-San / Marc Rosen

Commissioning Phase I

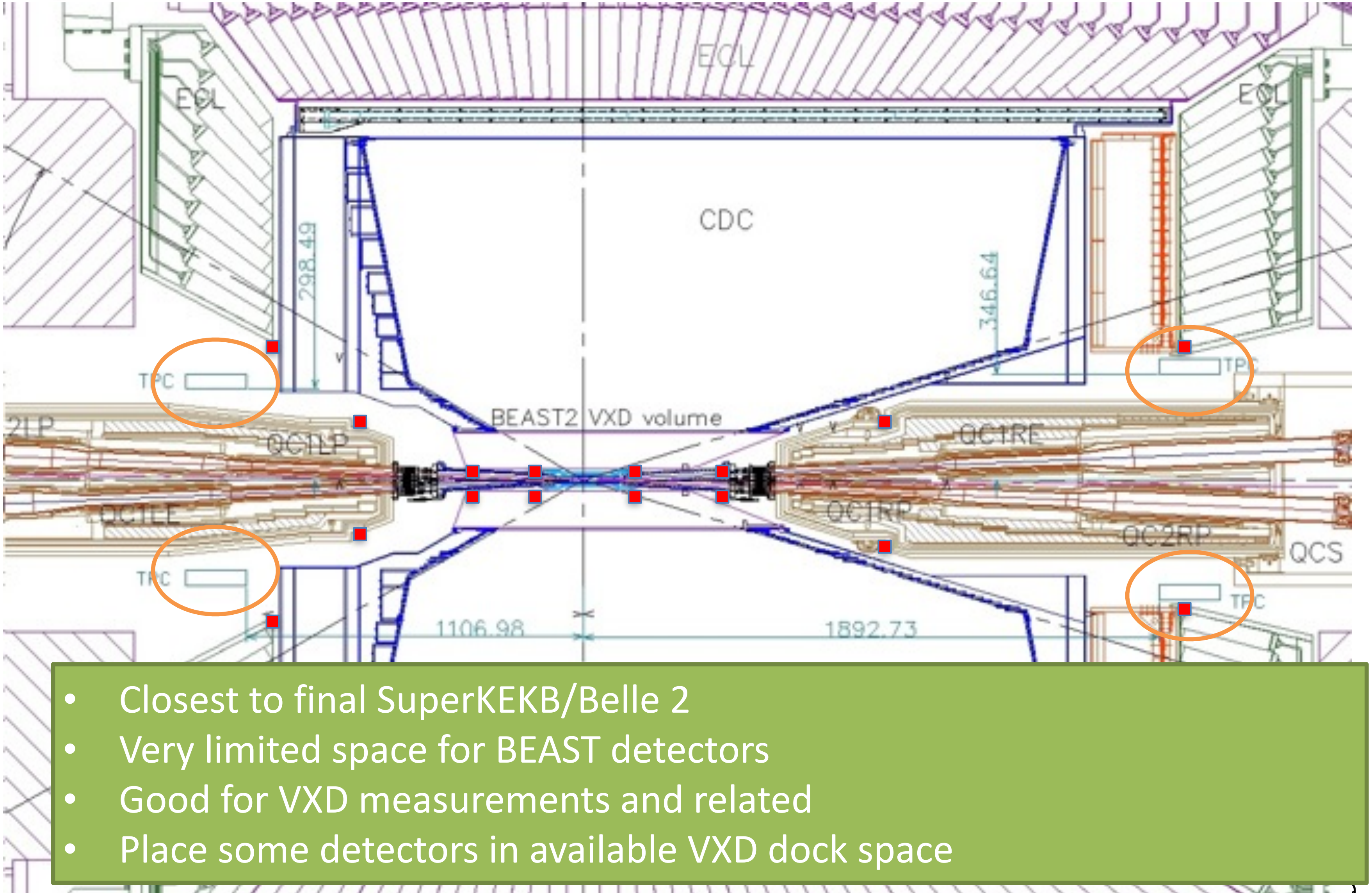
■ Proposed Radiation Diode Positions: Set of 8 around beam pipe.



- Expect no luminosity during this stage
- Mostly high levels of beam-gas BG, possibly some Touschek
- Main BEAST goal: Measure radiation levels to determine when it's safe to roll in Belle

Commissioning Phase II

■ Proposed Radiation Diode Position: Inner radius of Calorimeter Endcap, inner radius of CDC, along beam pipe



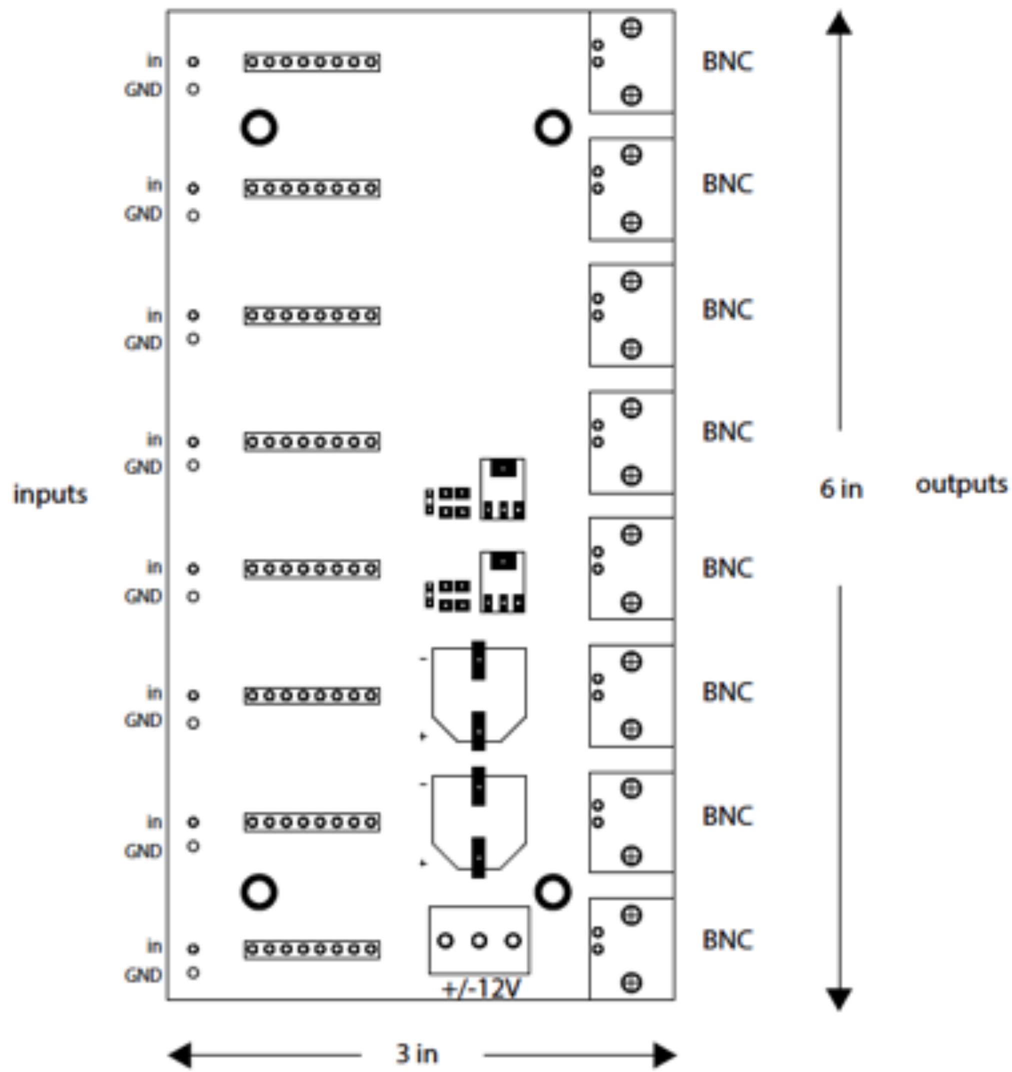
- Closest to final SuperKEKB/Belle 2
- Very limited space for BEAST detectors
- Good for VXD measurements and related
- Place some detectors in available VXD dock space

Mounting

- Diodes housed in 1x1x2cm aluminum block with drilled hole for diode window.
- Half are shielded either with lead foil or gold paint over window.
- Simply "velcroed" in place. Easy to move.
- Phase I drawing still show old idea of having a ring that equals inner radius of calorimeter end cap to mount radiation monitors.

Multichannel System

- Worked with Cremat summer of 2013 to design an 8-channel system.
- Common power input
- Common ground for power, input, and output.
- BNC connectors for output.
- Ordered 10 such boards. Delivery expected 20 Dec.



DAQ Plans: Peter Lewis (Hawaii)

- Use KEK Slow ADC System
- -10-10V input, 16 bit digitization, 1 Hz readout rate
- Logs current reading, max and min since last reading
- Nearly ideal, and easy integration into SuperKEKB system.
- Note: Cannot resolve background from a single bunch. Cremat amplifier has a decay time of ~150 μsec.
- Plan is to purchase some test systems at Hawaii.

Issues

- Temperature sensing? Have not worried enough about this, but it is needed.
- Why is that gain not exactly correct? CLEO system tested with CHESS x-rays. Some different response for minimum ionizing electrons?

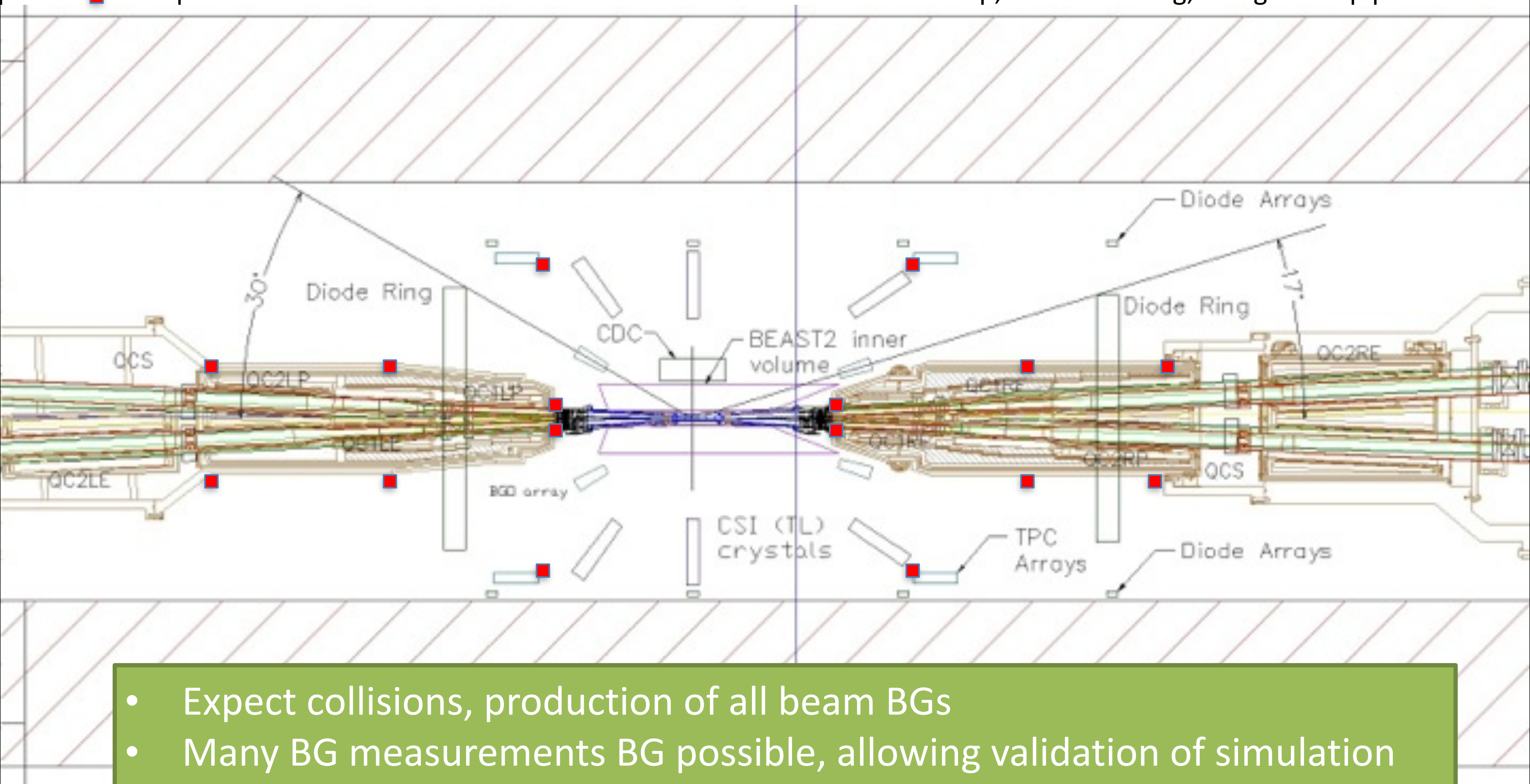
Plan and Timeline

- Ordered and gathering parts at Wayne State for 8 channels. Some have already arrived. Cremat boards not yet, but delivery promised for 20 December.
- Assemble and test 8-channel system in January 2014.
- Ship to Hawaii for assembly based on Wayne State model and tests with DAQ system - Spring 2014.
- Expand to full 80 channels (64 + 16 spares) at Hawaii.
- To KEK ready for BEAST II installation - by end of 2014.

Back Up Slides

Unlikely Commissioning Phase I.V

- Proposed Radiation Diode Position: Inner radius of Calorimeter Endcap, inner shielding, along beam pipe



- Expect collisions, production of all beam BGs
- Many BG measurements BG possible, allowing validation of simulation
- Plenty of space for BEAST subsystems
- Interesting stage for BEAST, but in scenario A we would skip this stage