Characteristics and Production of Gas Sealed, Radiation Hard, Small Ionization Chambers

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on behalf of the SIC team

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NBI2002 - CERN

Motivation

- Produced Chambers than can be used in <u>High Rate Environment</u> :

1. *Radiation Hard Materials*
2. *Small Gaps ,1 mm (avoid saturation, expect > 10^10/p/cm^2/ 8 microsec)*
3. *Strong Tolerances (reproducibility of chambers construction)*
4. *Gas sealed (Helium-Ionization Chamber) or in Vacuum (SEM-like)*
5. *Reliable Calibration…*

Preview Working plan

Design

- Glass Chamber
- Ceramic Chambers
  - Design 1 , 2 , 3 , 4

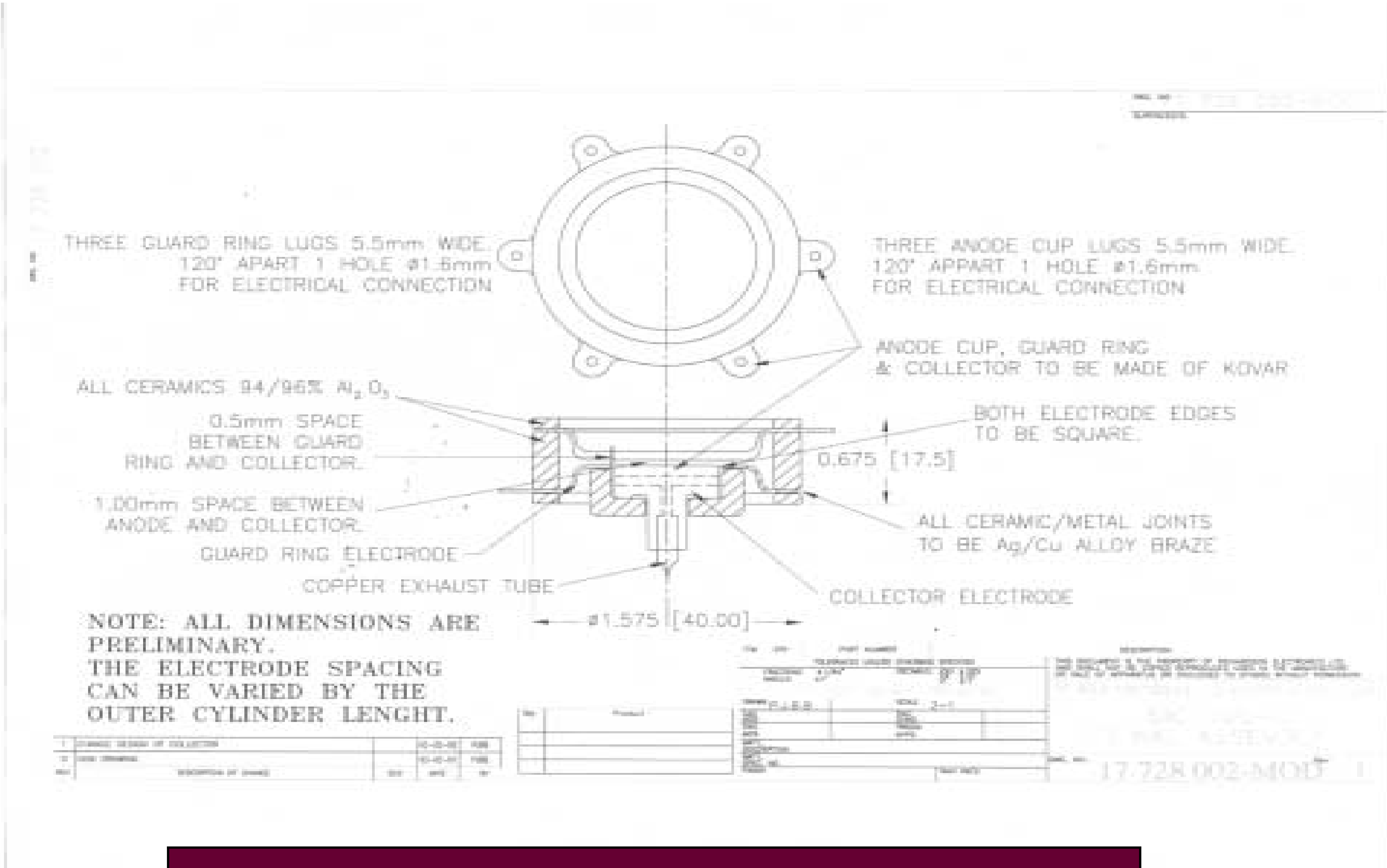
Testing

- ATF (BNL)
  - Electron Source
  - (e8 - e9)
- Radiation Calibration Facility (FNAL)
  - Photon Emission
  - 424 R/hr
- Booster (FNAL)
  - Proton Source
  - (1e11 - 1e12)

Timeline for Design Development

- Started about 2 years ago. Richardson Electronics (REL) made Glass Chambers (Inspired by V. Falaleev Design). Some detection was observed, but decided to change to ceramic because of the high tolerance requirements.
- Ceramic design changed from round edges to edges square and flat for signal collector & guard ring.
- Multiple chambers produced, and gas refilling tested. Found occasional shorts on due to metal filings inside the chamber…tooling redesign.
- Now we believe that we have final design (testing by producing several chambers….already under construction). If successful then mass production will start at the rate of 10 chambers/week.

Small Ionization Chamber (SIC)

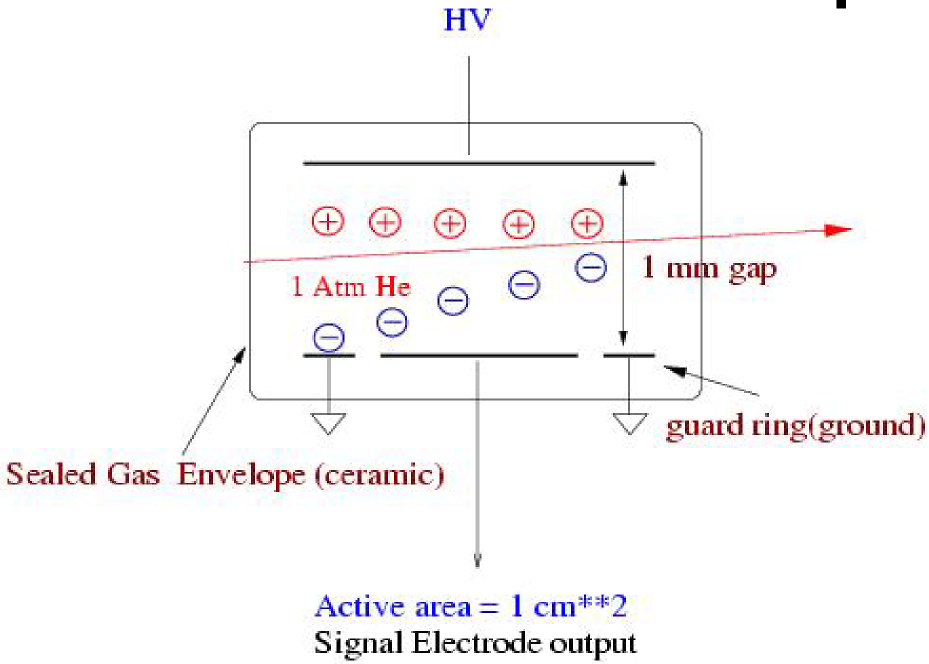


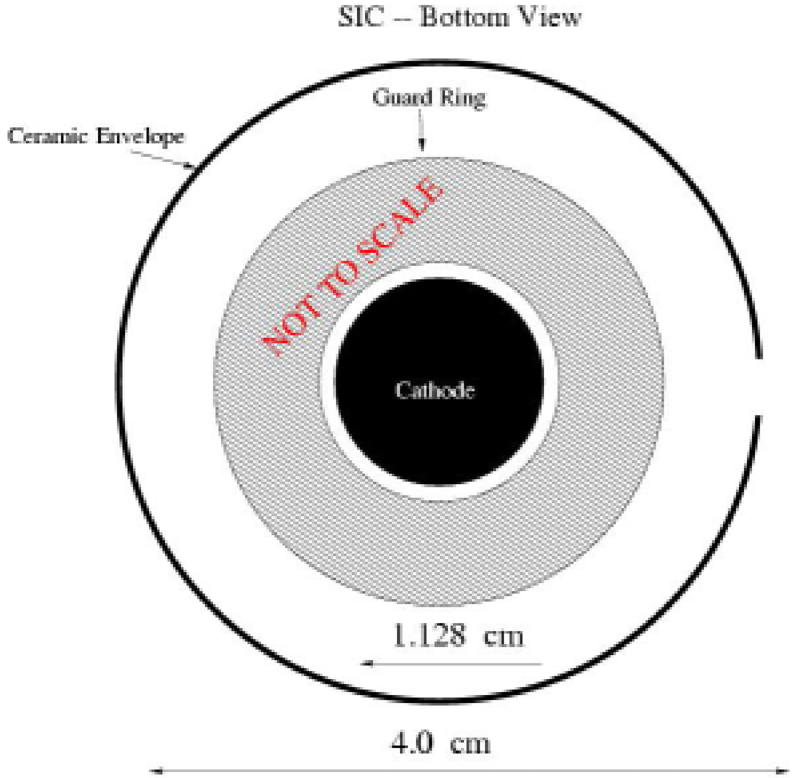
Tolerances: Gap=1mm +/- 0.001”

guard-to-collector=0.5 +/- 0.002”

Flatness 0.001”

Basic Description of Design





- Chamber filled with Gas -- Ionization SIC (< 10^11/p/cm2/s)
- Chamber in Vacuum -- Secondary Emission Monitor SEM (above 10^10 /p/cm2/s)

Basic Chamber Design

•Fixed volume, Temperature and Pressure changes do not affect calibration

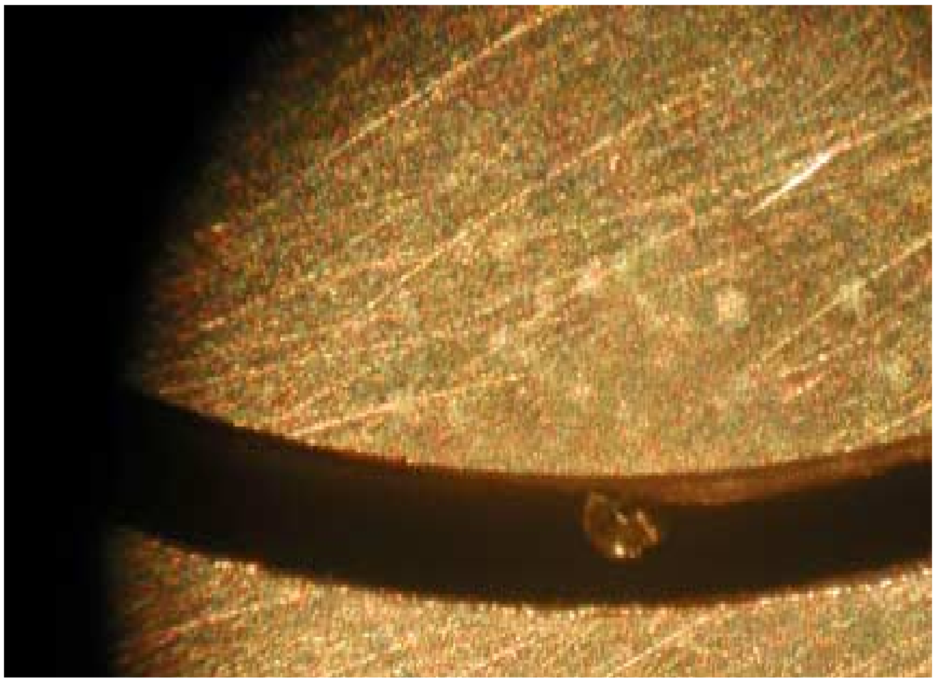
•Radiation Hard Materials (> 10^10 Rads)

– Ceramic (AL_2O_3, 94%, 96%)

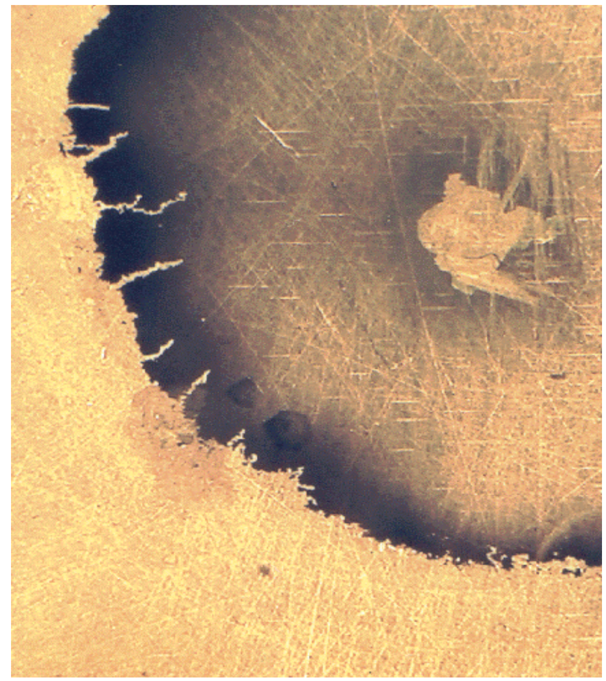
– Kovar (nickel, iron, cobalt)

New machining to avoid rough edges and trapping of filings between Guard Ring and Signal Collector

Filing trapped causing short



Magnified by 150



Can not use HV to `burn' filings without damaging surface … made 10microm hole in surface

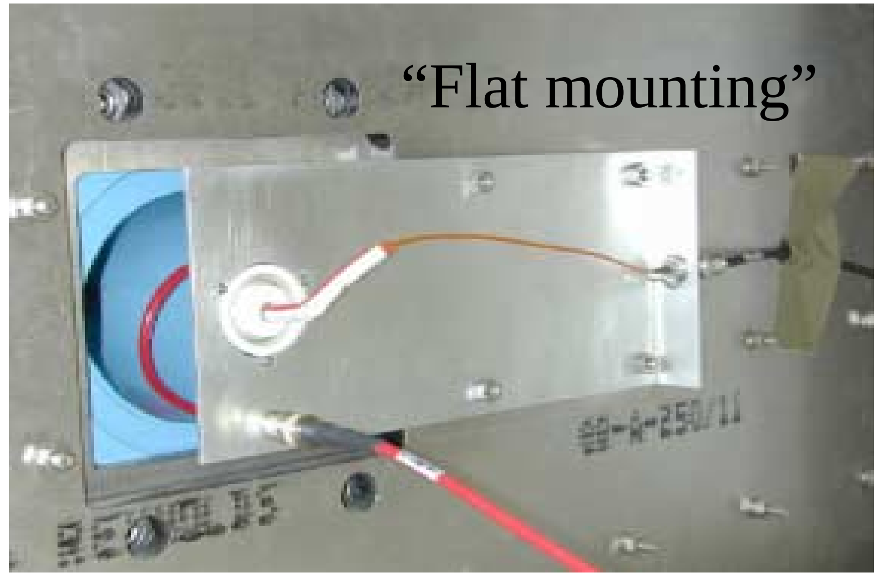
List of some of the tests & setups made

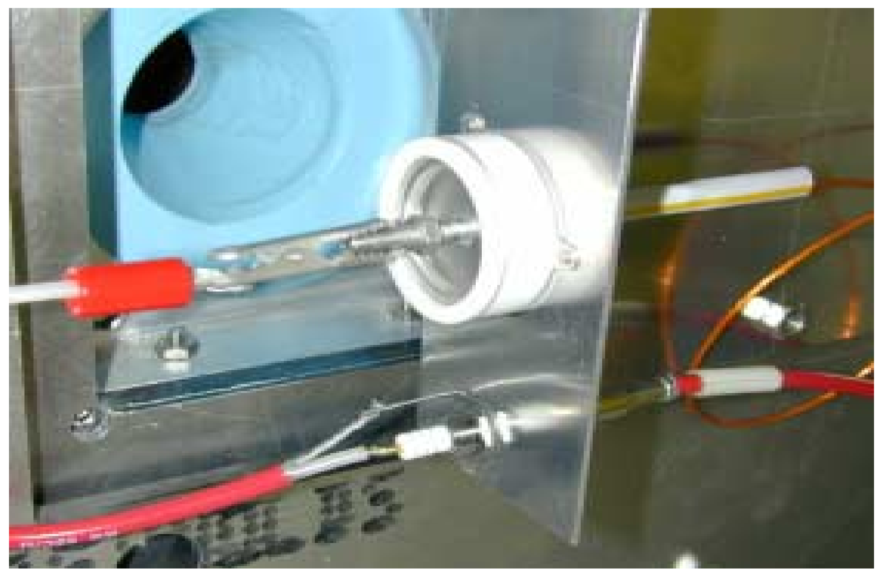
- *@RPCF*: Check Chamber quality … plateau, and knee of ionization response.
- *@RPCF & BOOSTER*: Determine operation modes, voltage, gas or no gas…
- *@BOOSTER*: Radiation hardness
- *@BOOSTER & ATF*: Saturation
- @PAB: Helium leak checks
  - … pending response to neutron (need it for MiniBoone)
  - … much more but not enough time ☺

Radiation Physics Calibration Facility

(RPCF,FNAL)

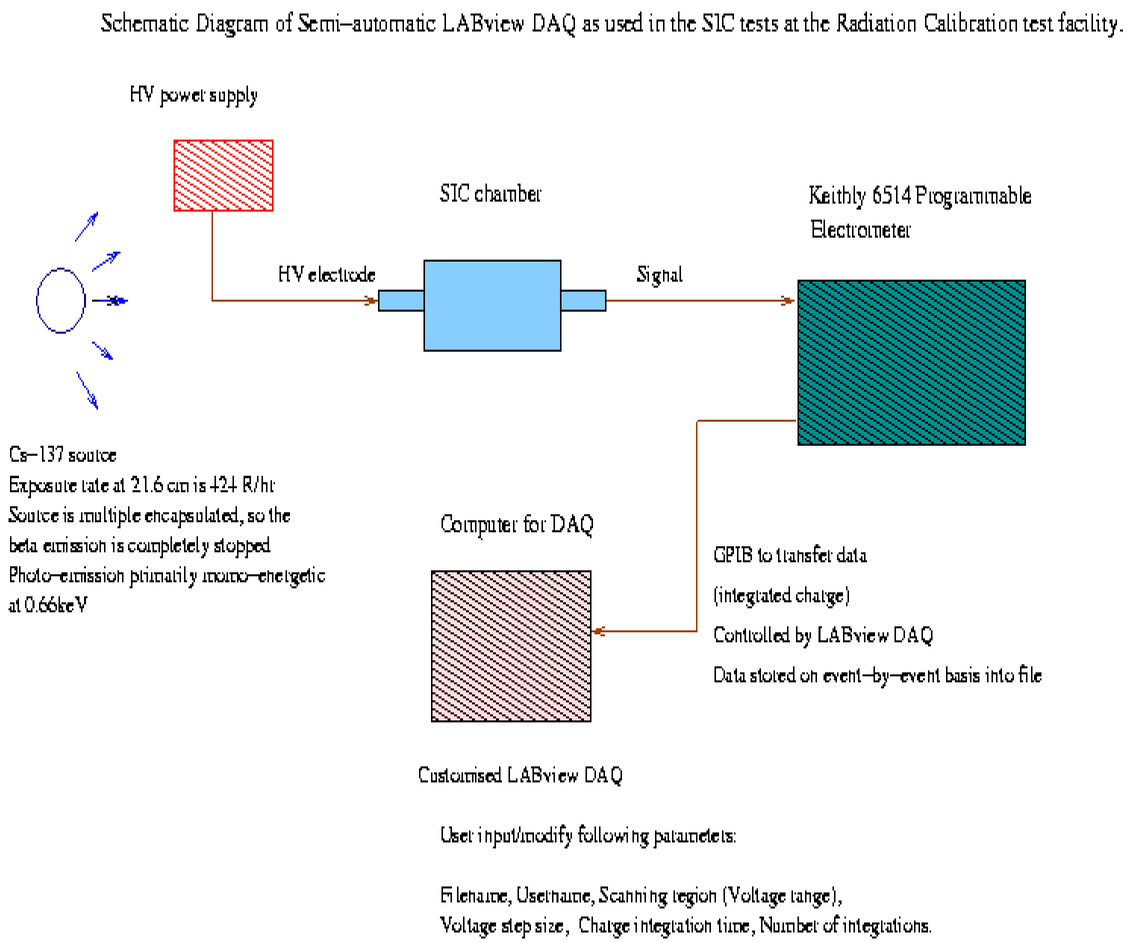
- Two new Cs^{137} sources:
- Max:1600 Rad/Hr
- The old source was
- 400 Rad/Hr



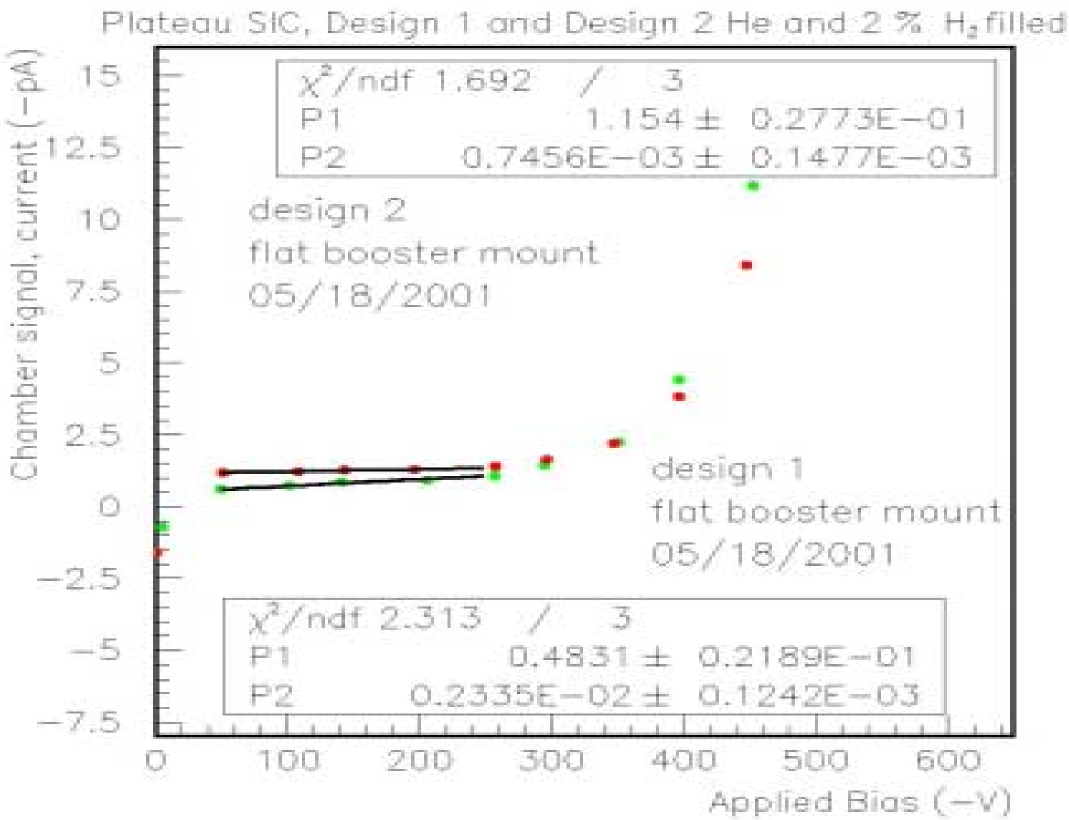


Setup to test chambers at the RPCF– pre-calibration for all SICs

- A Keithly electrometer was use during the RPCF tests:
- Sensitivity 2 nC
- Resolution of 0.1 pC
- Bias current of < 3fA
- Output of electrometer goes to a computer running LabView to a data file.
- Procedure almost automatic → Good for summer students that will check all chambers ☺



Design studies: Round Edges distorts signals such that we get a slope in plateau
➔ Flat surface between signal and guard ring selected instead



What Changed?
Design 1 vs. Design 2

The electrode edge … Curved (field lines get curved as voltage increases) ➡ Flat

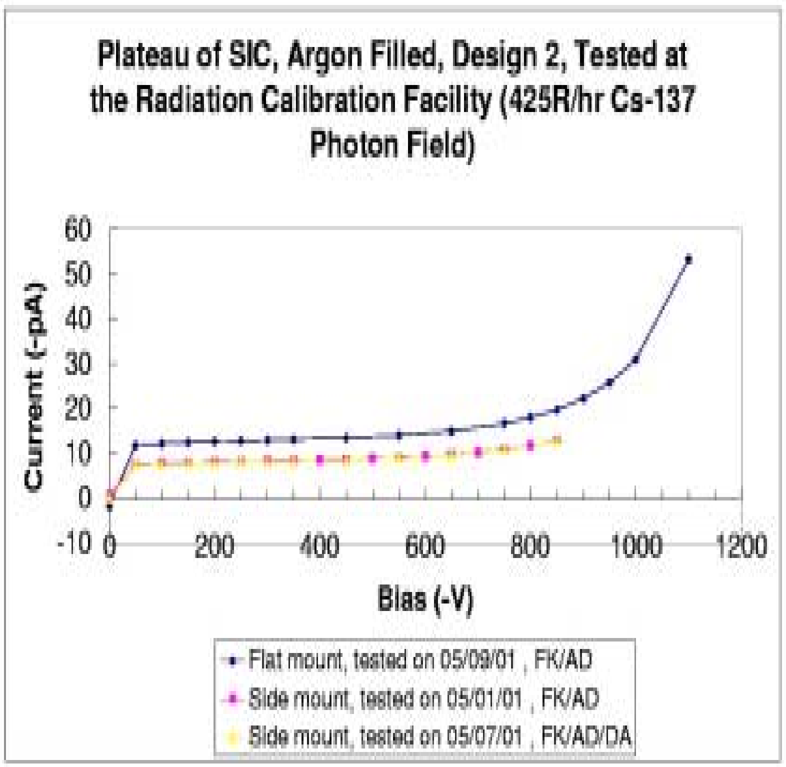
—

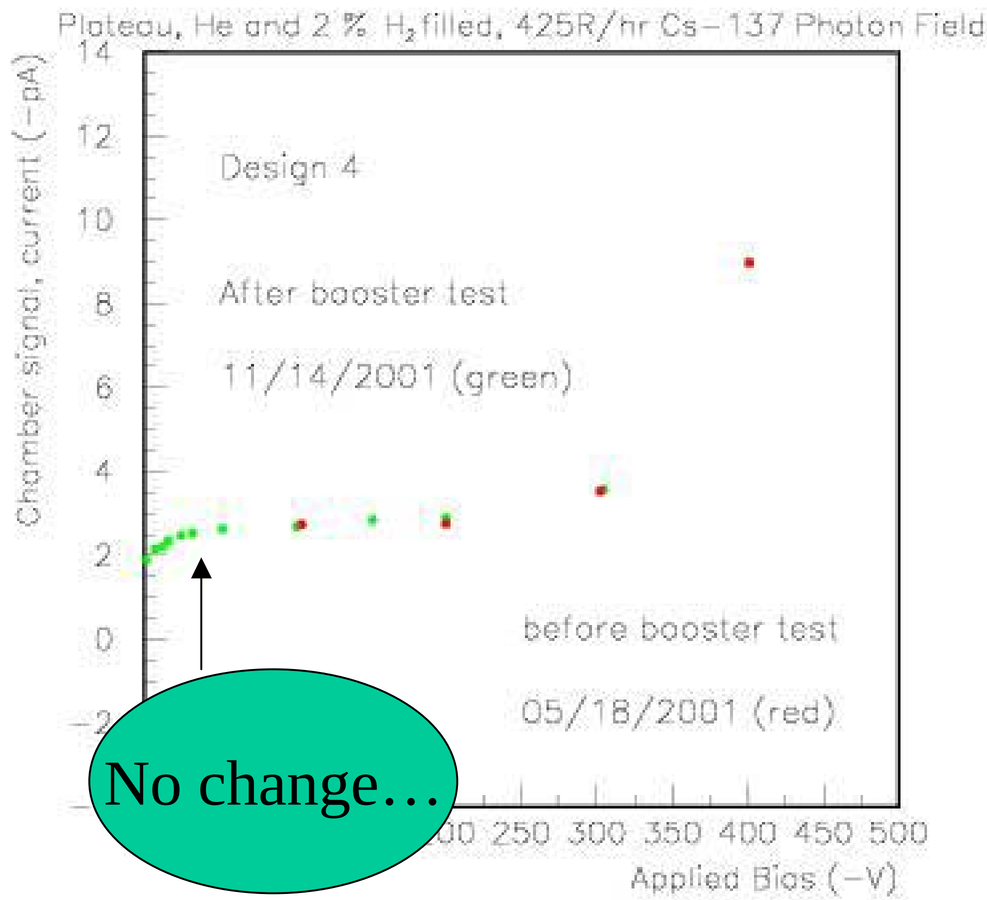
Effected slope of plateau … reduced by ~ 70 %

Chamber Characterization show no radiation damage after XX protons

Reproduce calibrations

Chamber filled with He for more than a year





No change…

Summary of RPCF Results:

• Good reproducibility

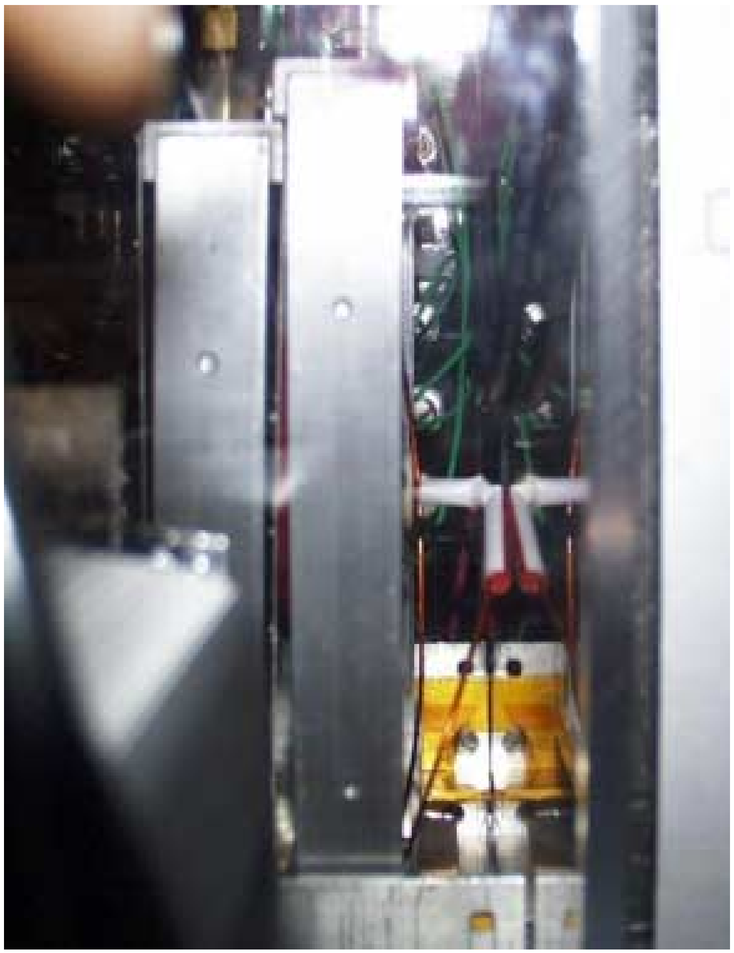
• Can measure both small and large currents.

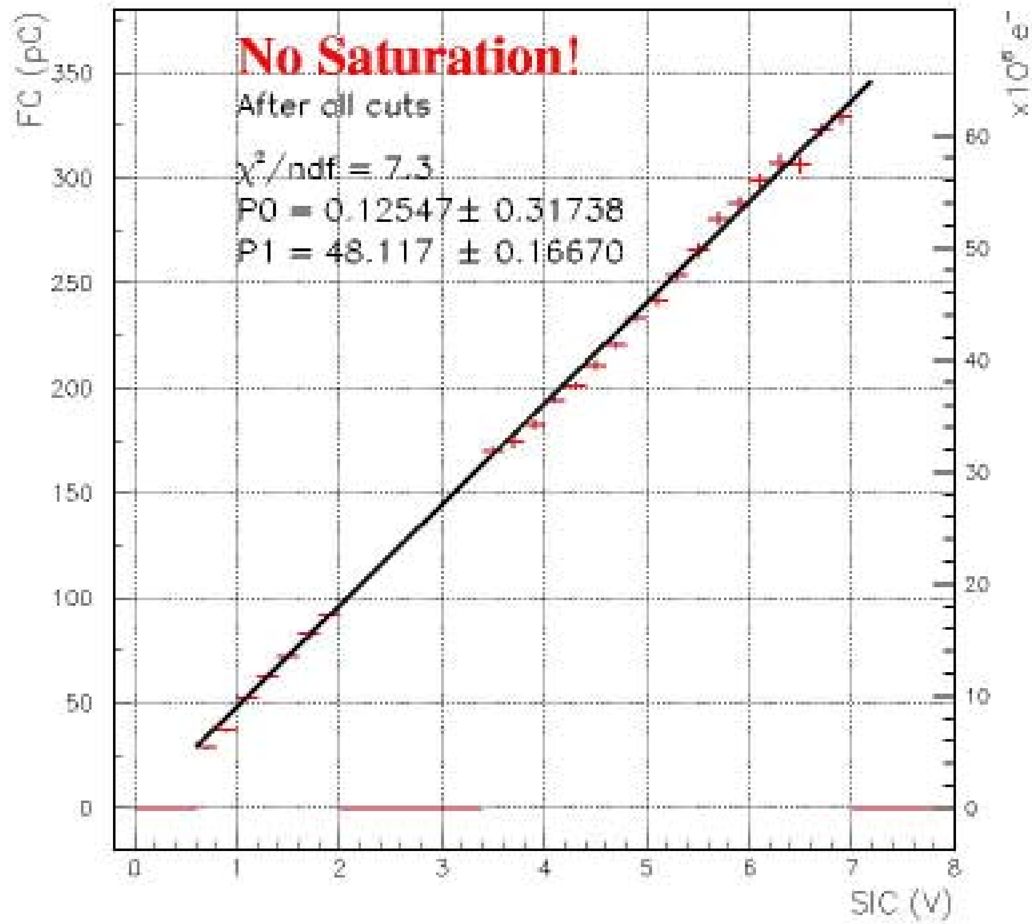
•Keithley Electrometers and Powers Supplies allows to do good measurements of knee of plateau need to test gas quality of chambers… no degradation see so far.

•LABview DAQ – user enter customized measurement parameters – automated DAQ

•Slopes good – but not quite flat… we believe we understand it.

Tests at ATF (BNL) low energy electron beam No saturation below 8*10^9/p/cm^2

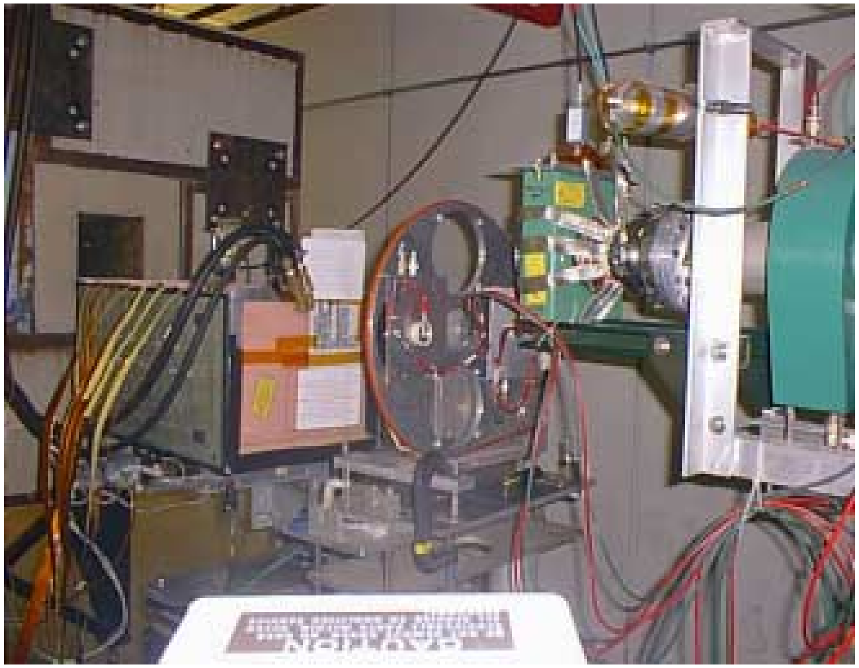


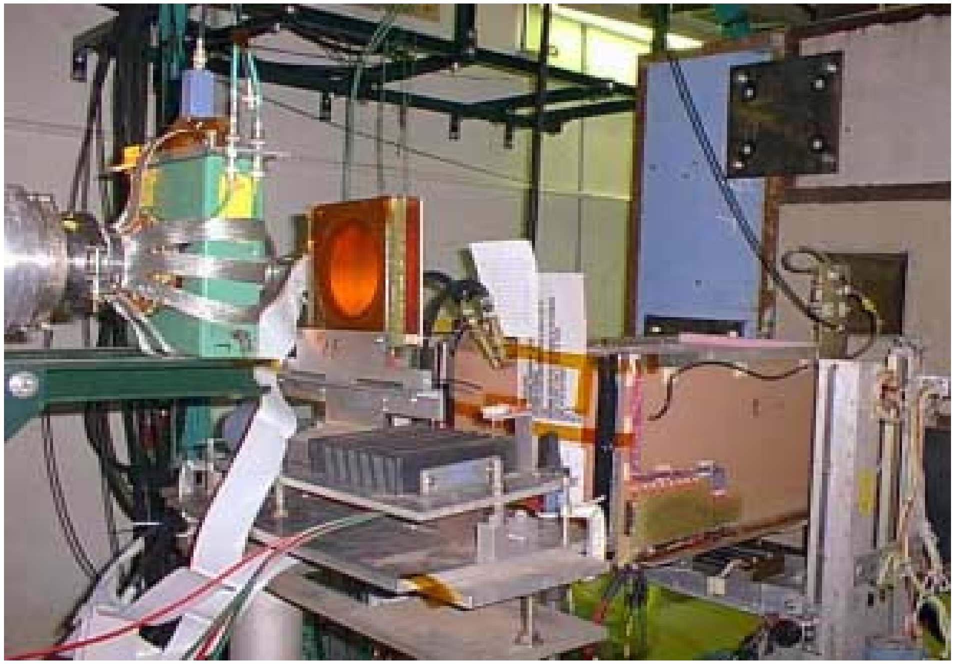


Test Setup @ Booster

SIC ONLY

1mm Chamber +SIC





Old➔ Toroid only for Flux measurement

New➔ Toroid +chamber for Flux measurement & Longitudinal movement for alignment

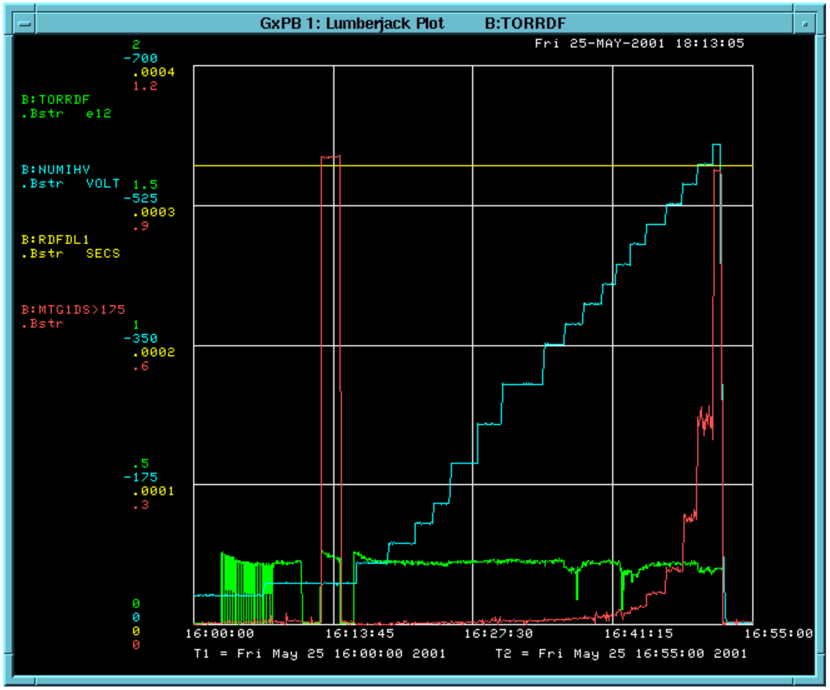
Booster (FNAL) Halo

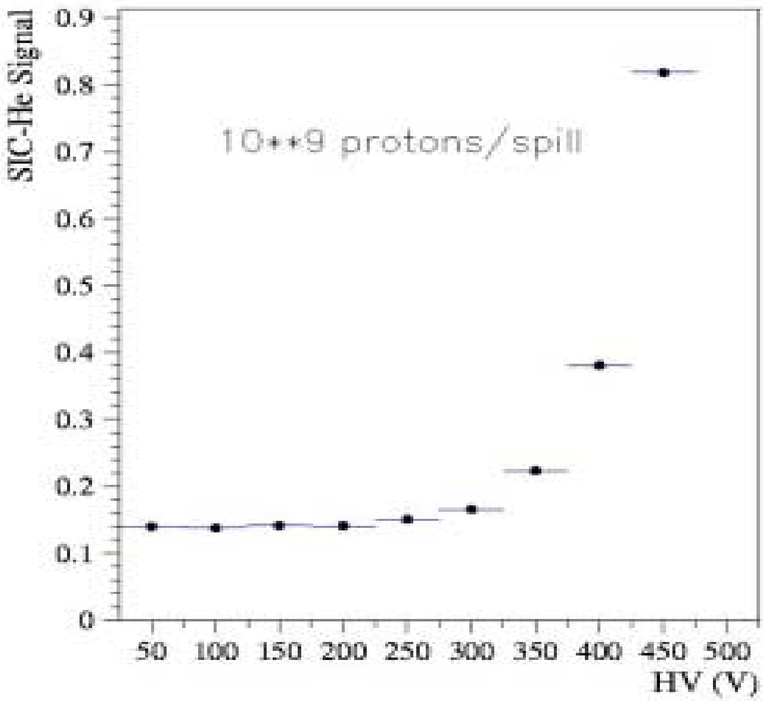
High intensity ~ 1e9 proton source

1.5 μs per spill … halo see 1/100 of total beam

ONLINE

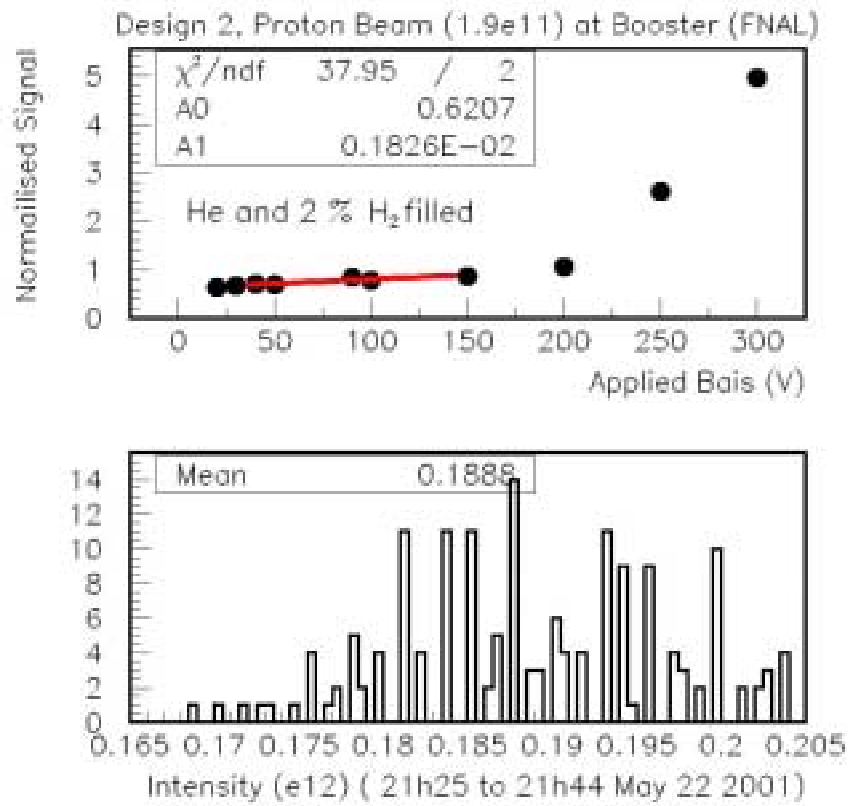
OFFLINE

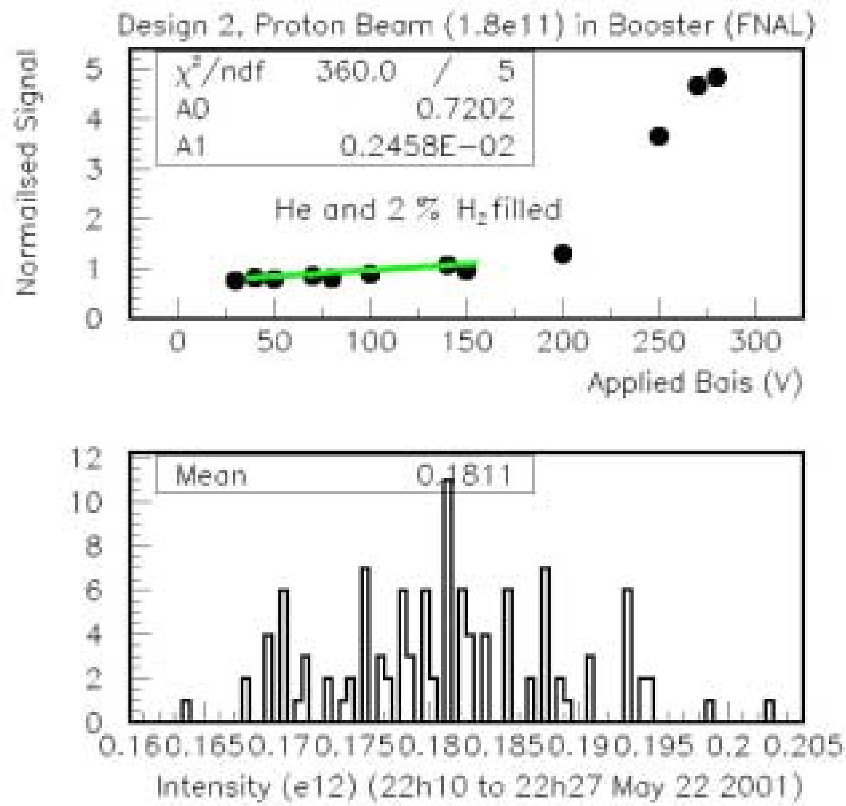




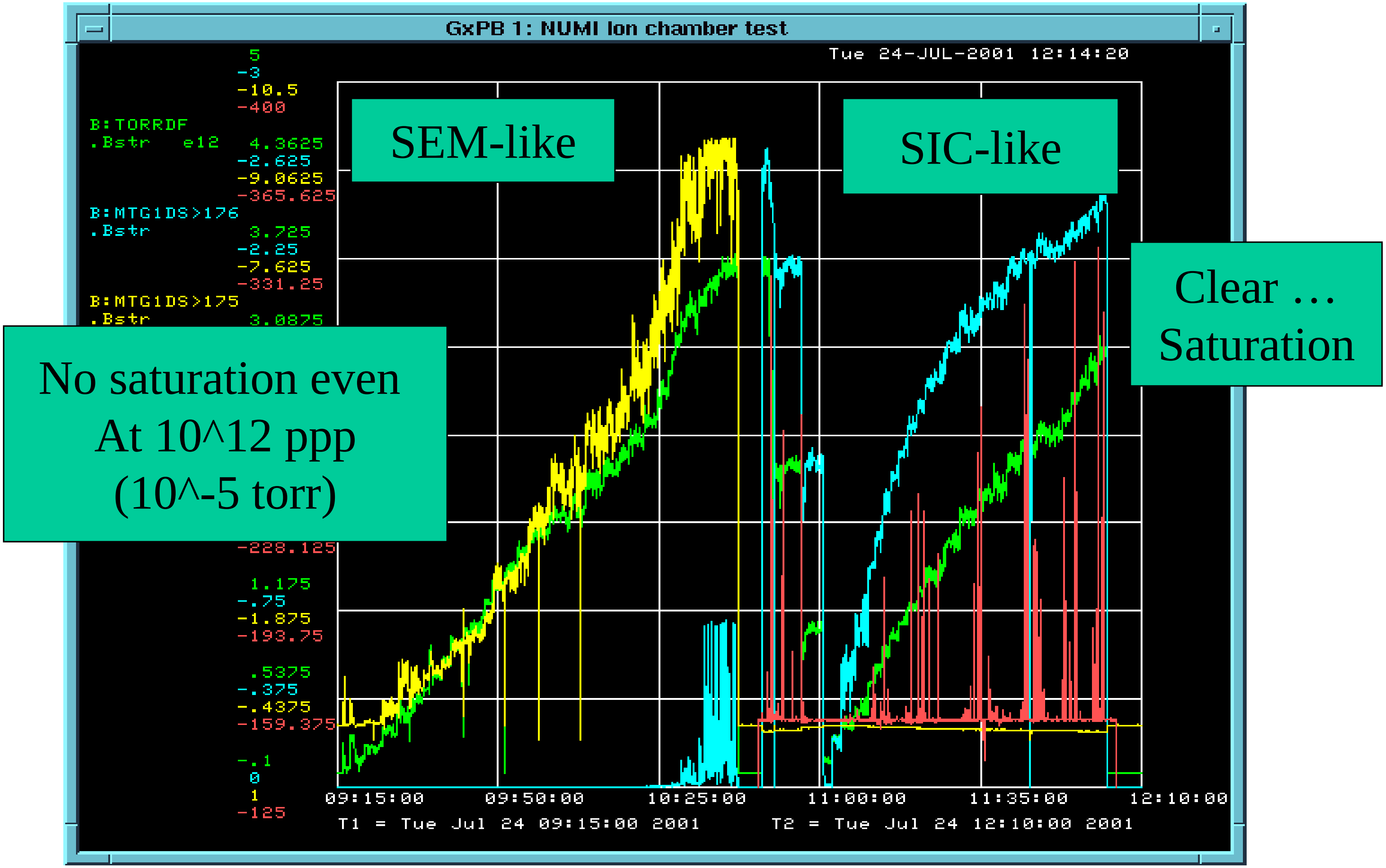
Booster (FNAL)

Plateau in the beam (1.8e11)---saturation (same effects present with design 4) shortens plateau—space charge

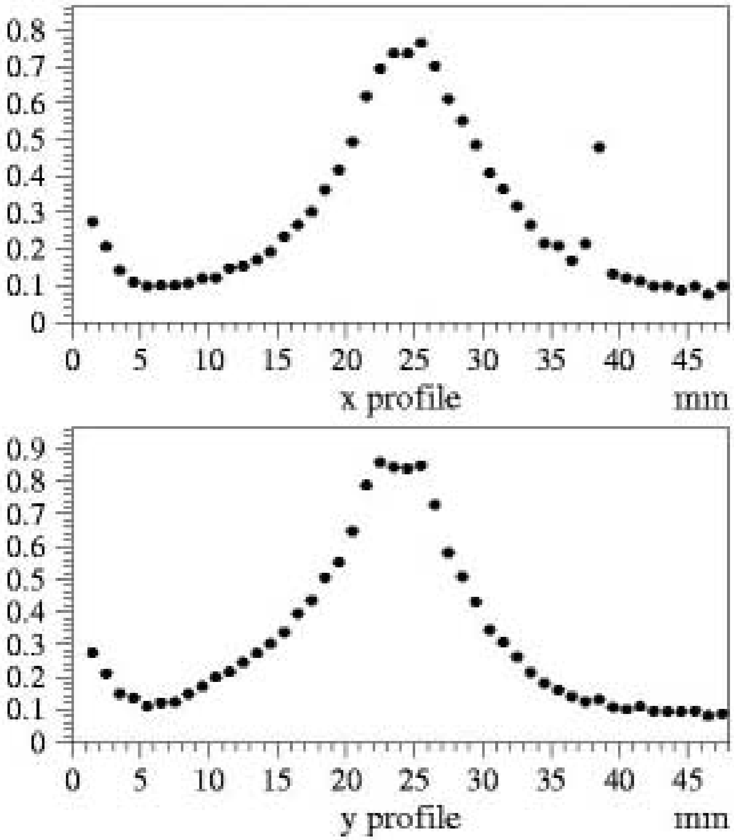




Booster (FNAL) – Intensity Scan



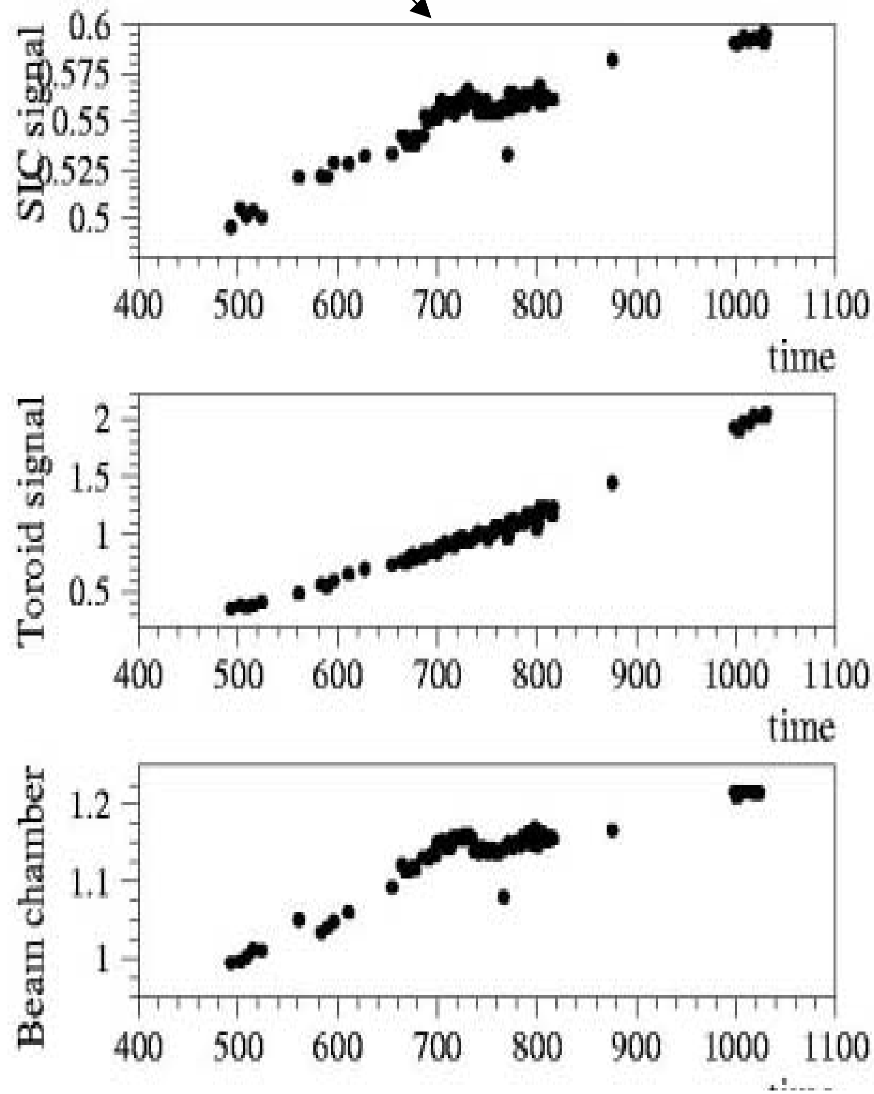
Beam Profile from
Wire chamber



Chamber see about 40%
Of the beam

Beam
Moved

Need to repeat
With vertical movement



Summary of results from Booster

Saturate above e11 in SIC-mode, but no saturation in SEM-mode.

- When making plateaus: gain observed at 200 V in the beam center, but not seen at 350 V in the "halo" like in the RPCF tests
- Convinced that the SWIC electronics can be used for both low and high currents just change capacitors
- So far no signs of radiation damage … or helium leakage
- To do… add vertical movement to get proper alignment.

Secondary Emission Monitor– SIC chamber in vacuum

- Getter - Place a strip of barium under the collector and activate it at about 1000 degree C.
- Ion Bombardment - Apply a voltage across the electrodes while pumping for reducing atmosphere of H_2.
  - Richardson used this process on vacuum tubes to 10^{-8} torr

This look like a very promising way of operating
The chambers for >10^11 ppp

Permeation Test– test run for 3-4 days … Helium is not leaking….

- The ion chamber was then put in side of a small vacuum chamber and tested using a Dupont Mass Spectrometer leak detector the total leak rate was found to less than $2X10^{-10}$ STD CC P/S.
- Then the temperature was raised slowly to 100 degree C.
- Max leak rate < $40X10^{-10}$ STD CC P/S

Conclusion

Believe to have a working design that can be operated at :

- I<10^11 ppp in SIC-mode
- I>10^10 ppp in SEM-mode

200 chambers to be build with the new tooling design.