Beam Loss Detection System

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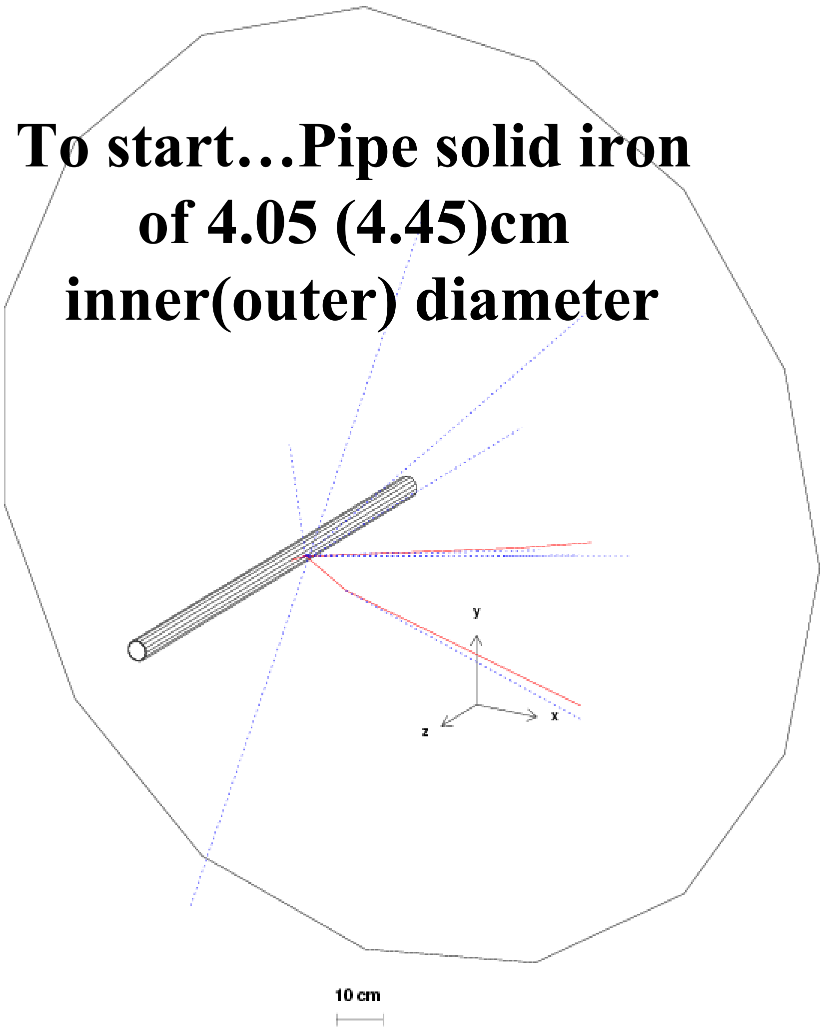
Outline

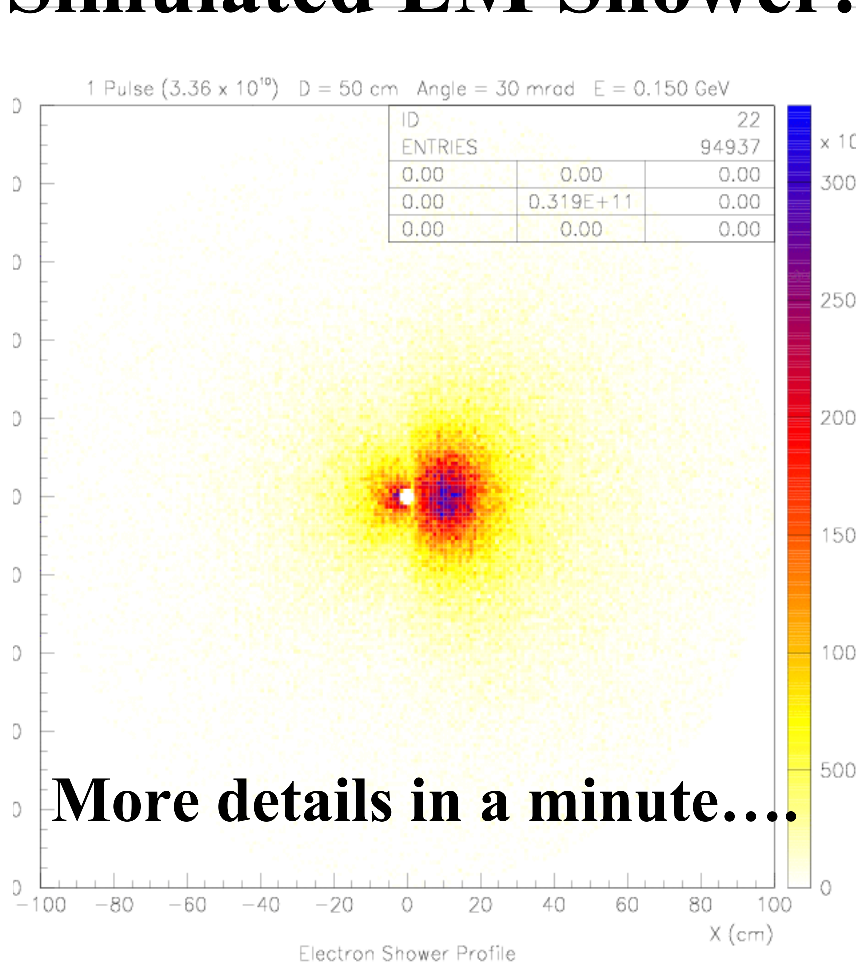
- ***On going work:***
  - **Beam loss GEANT simulations**
  - **Detector selection**
  - **Getting ready for Oct. run…**

Full GEANT Simulation of CTF3 drive beam Linac is our Ultimate goal… (Matthew Wood)

To start…Pipe solid iron of 4.05 (4.45)cm inner(outer) diameter



Simulated EM Shower:



More details in a minute….

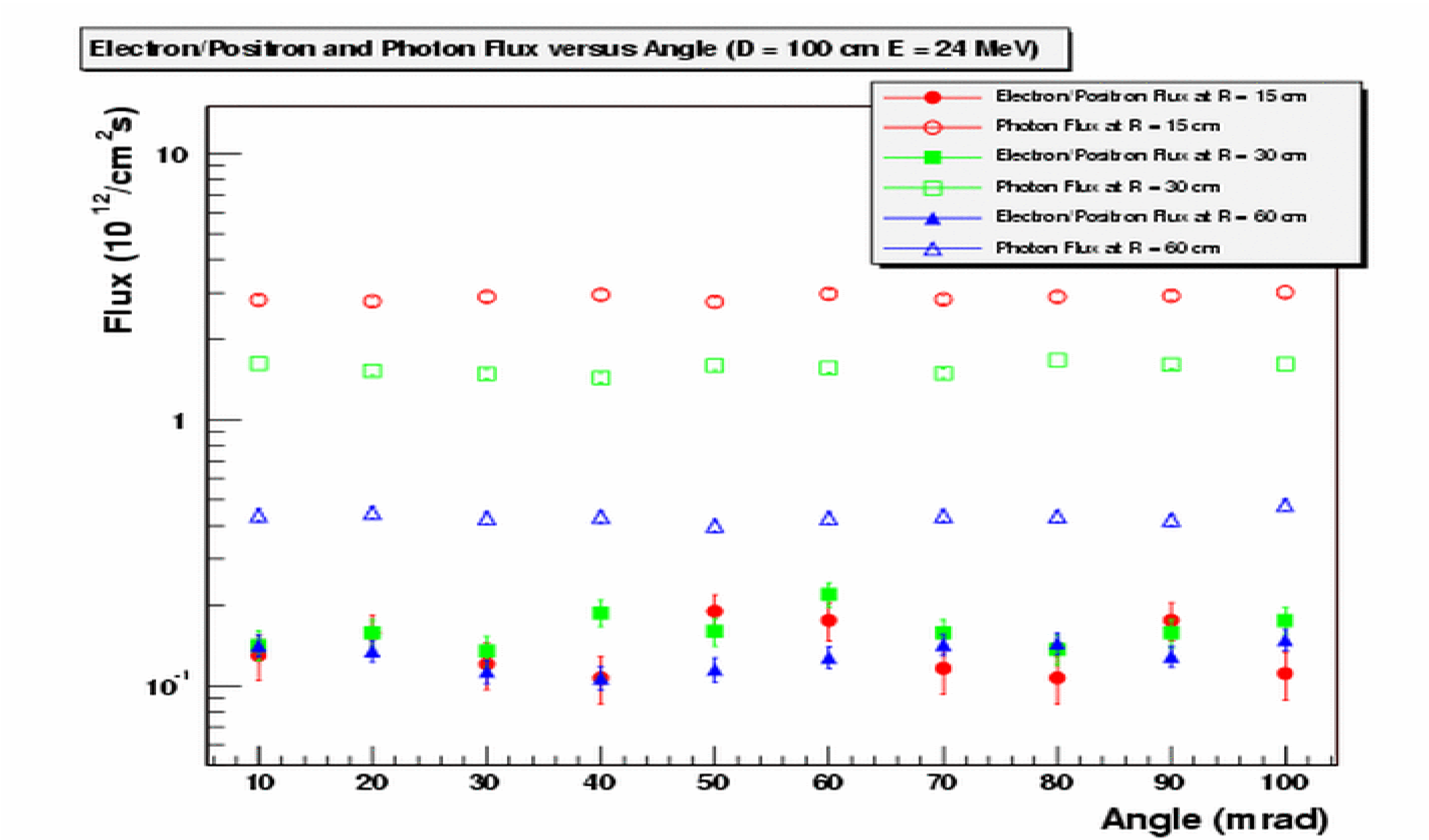
Assumptions made for studies and for normalizing results

- **Linac beam has a series of pulses with a length of 1.54μs & 3.5 Amps.**
- **Per mil loss of a single pulse → 3.36×10^{10} electrons**
- **Initial energy 24 MeV:**
  - **Simulated losses at 24, 50, and 150 MeV**
- **Single point at a fixed angle of 30 mrad**
- **Minimum energy cuts for e @100 keV**

& γ @ 1 MeV

We are in an energy range where there is only a small dependence between the flux and exit angle

(multiple scattering dominates)



Example:Distribution of particles

(e- interacted on the right side of the horizontal plane)

e-/e+

γ

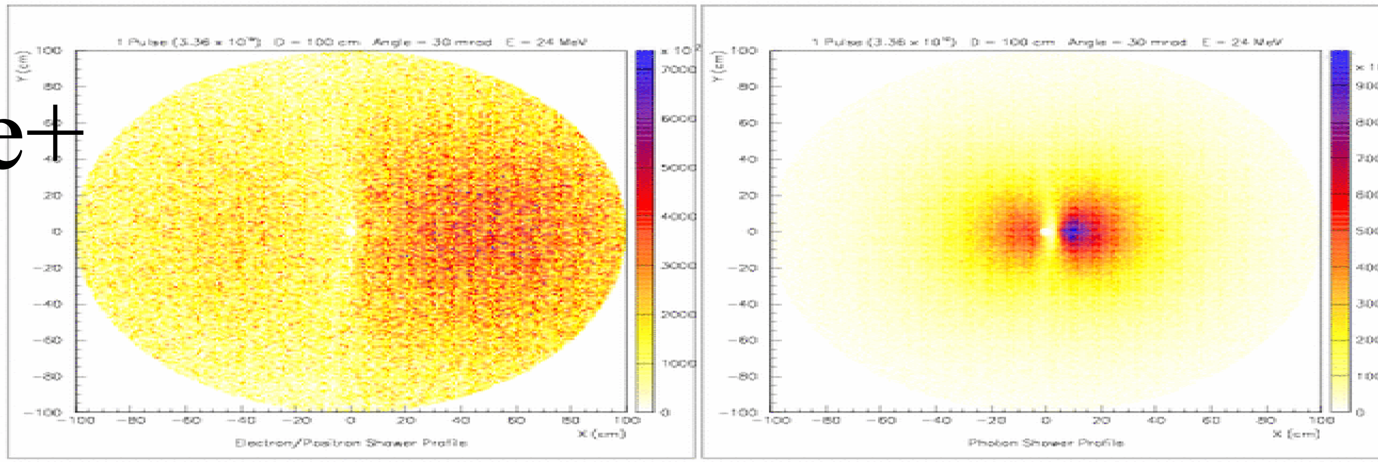


Figure 5: Shower profiles for Electrons/Positrons and Photons at a beam energy of 24 MeV.

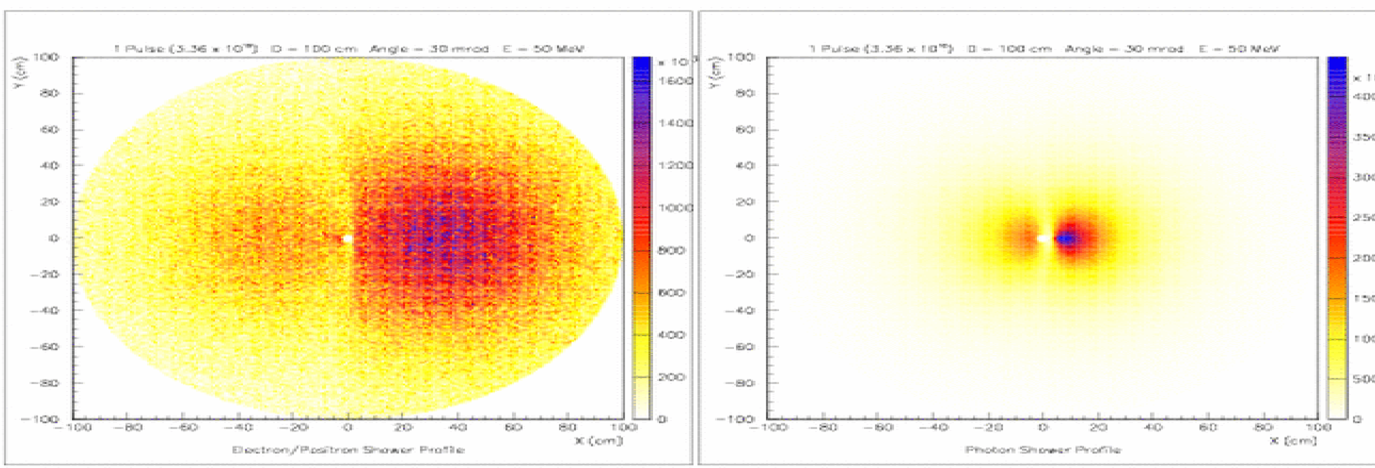
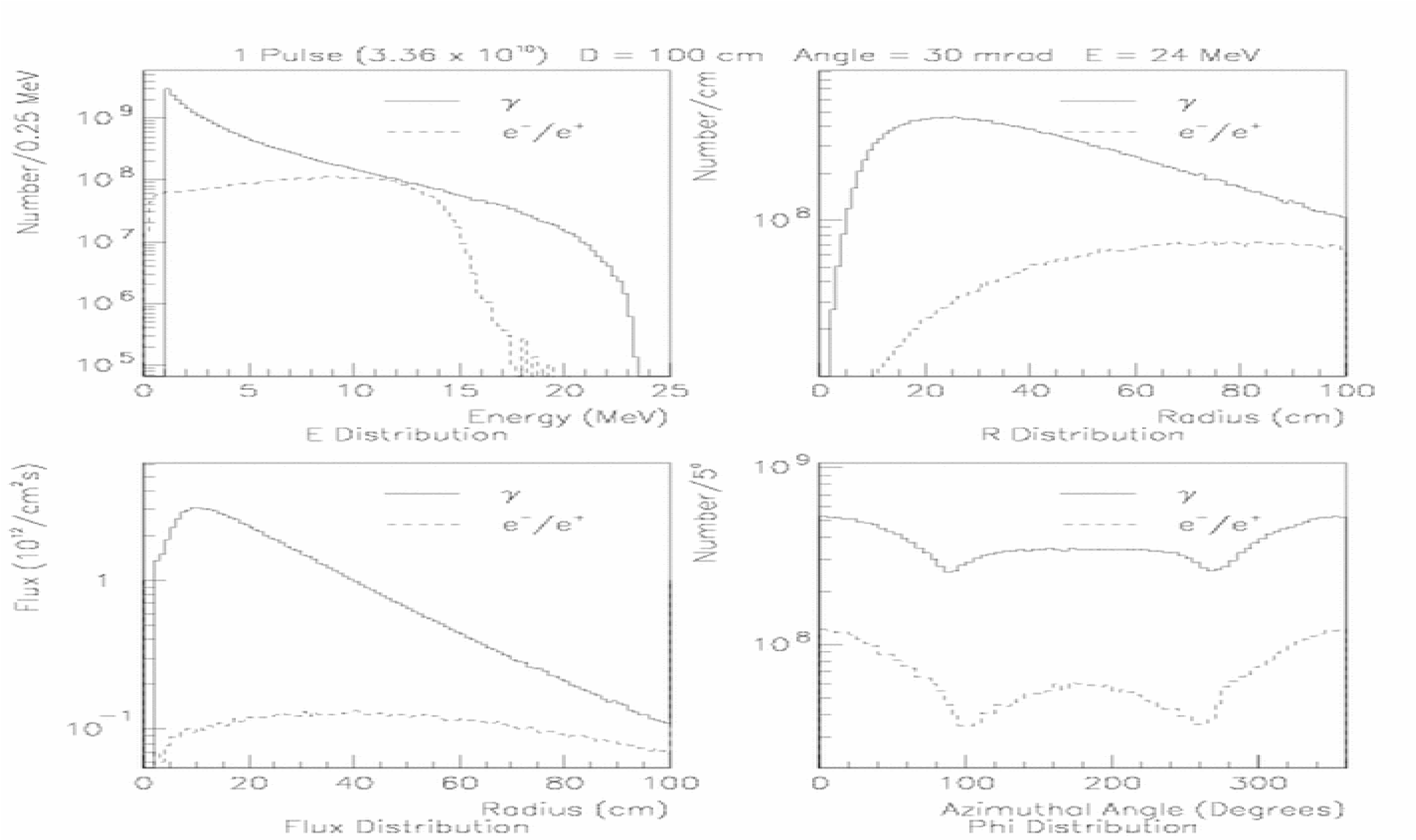
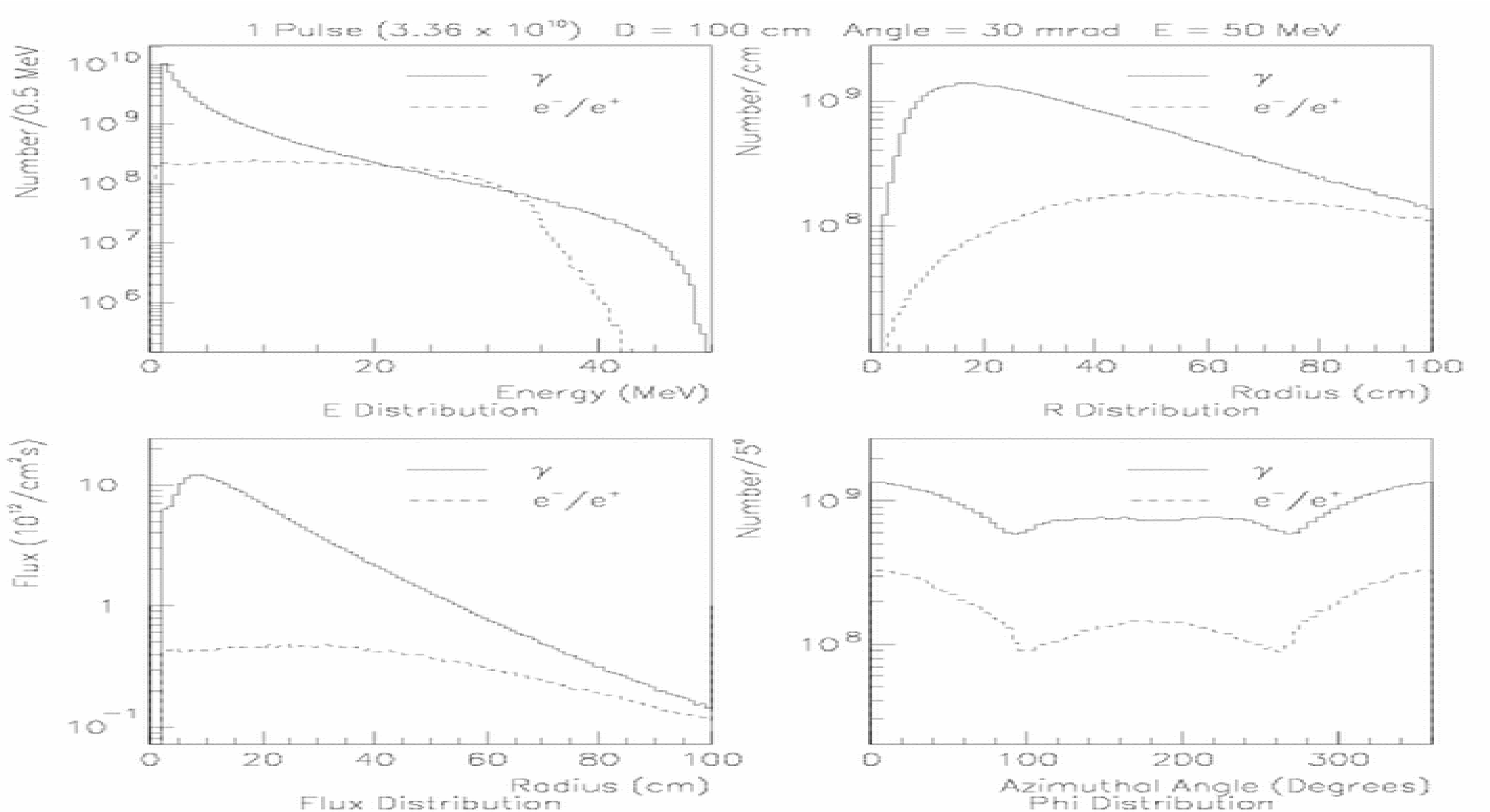


Figure 6: Shower profiles for Electrons/Positrons and Photons at a beam energy of 50 MeV.

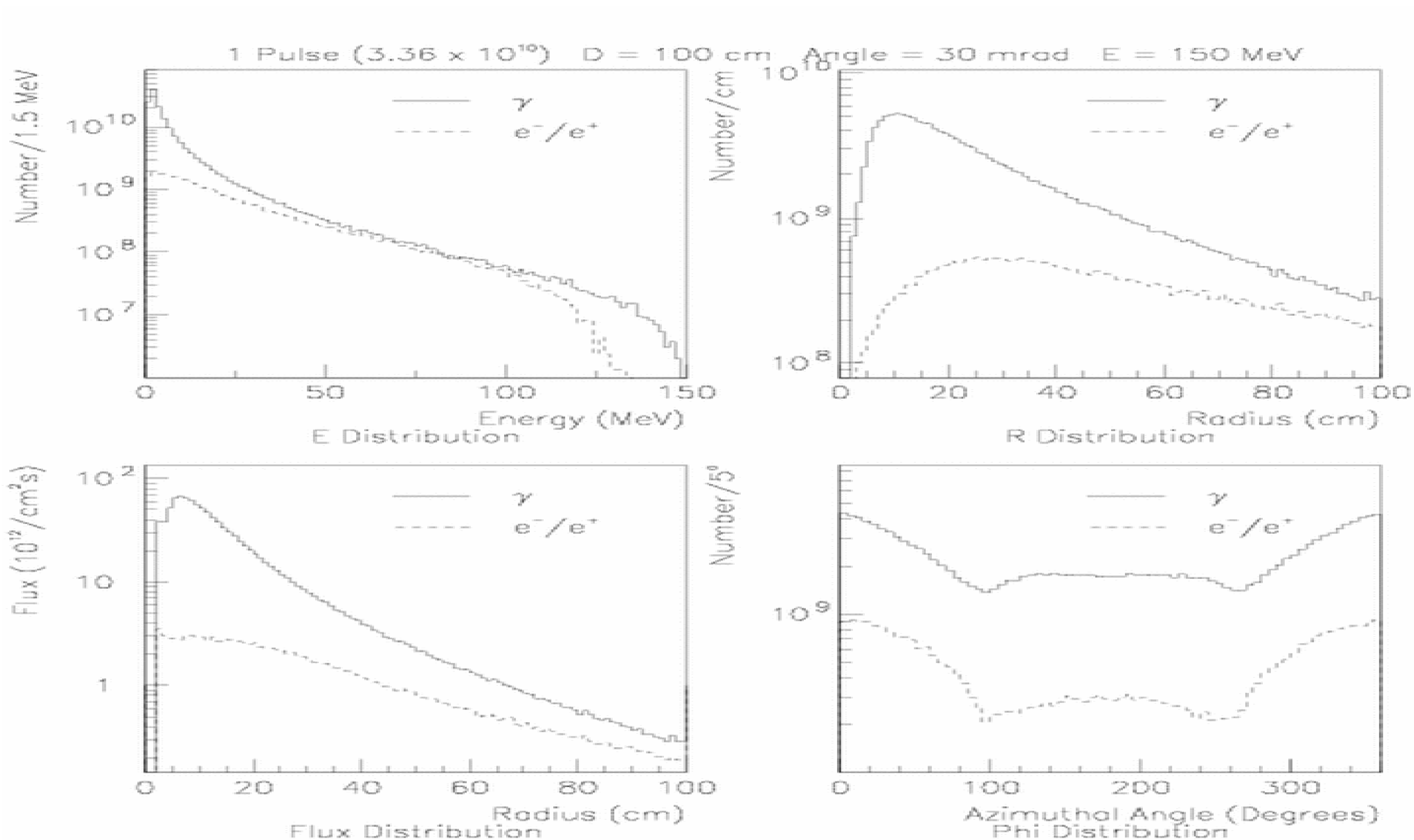
Summary of flux at 100 cm from the interaction for 24 MeV e-



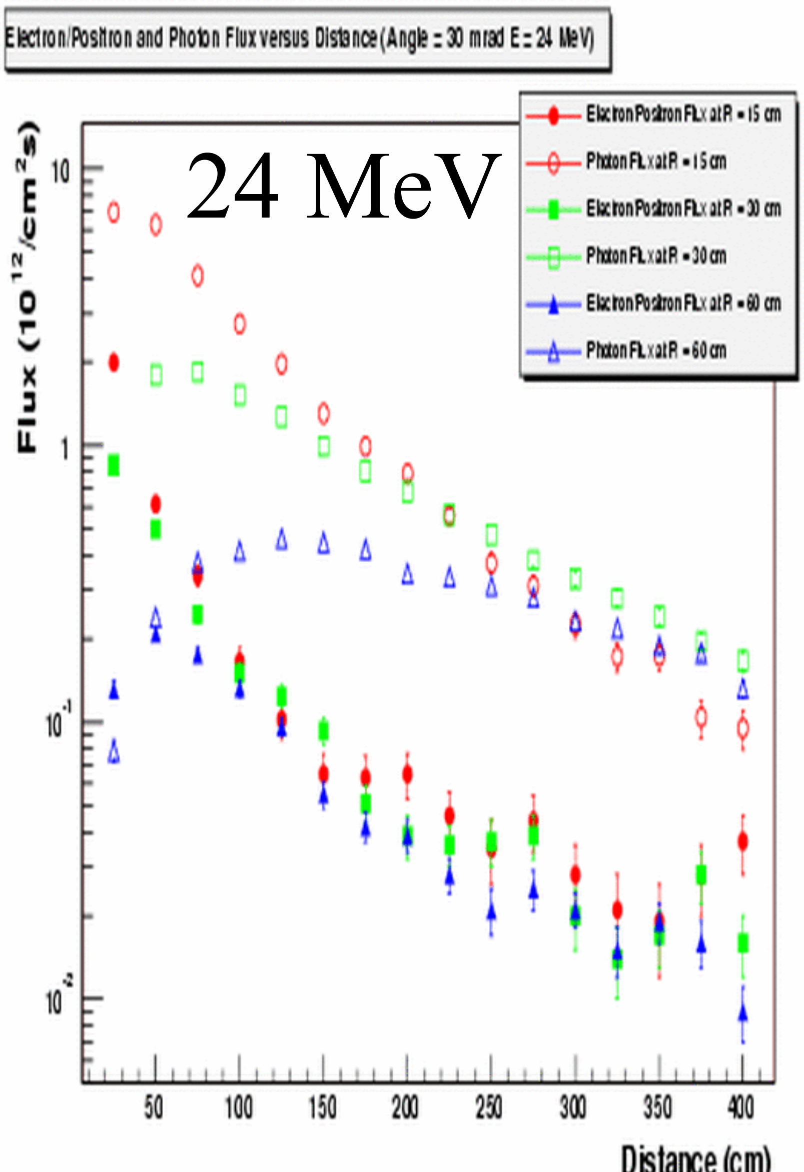
Summary of flux at 100 cm from the interaction for 50 MeV e-

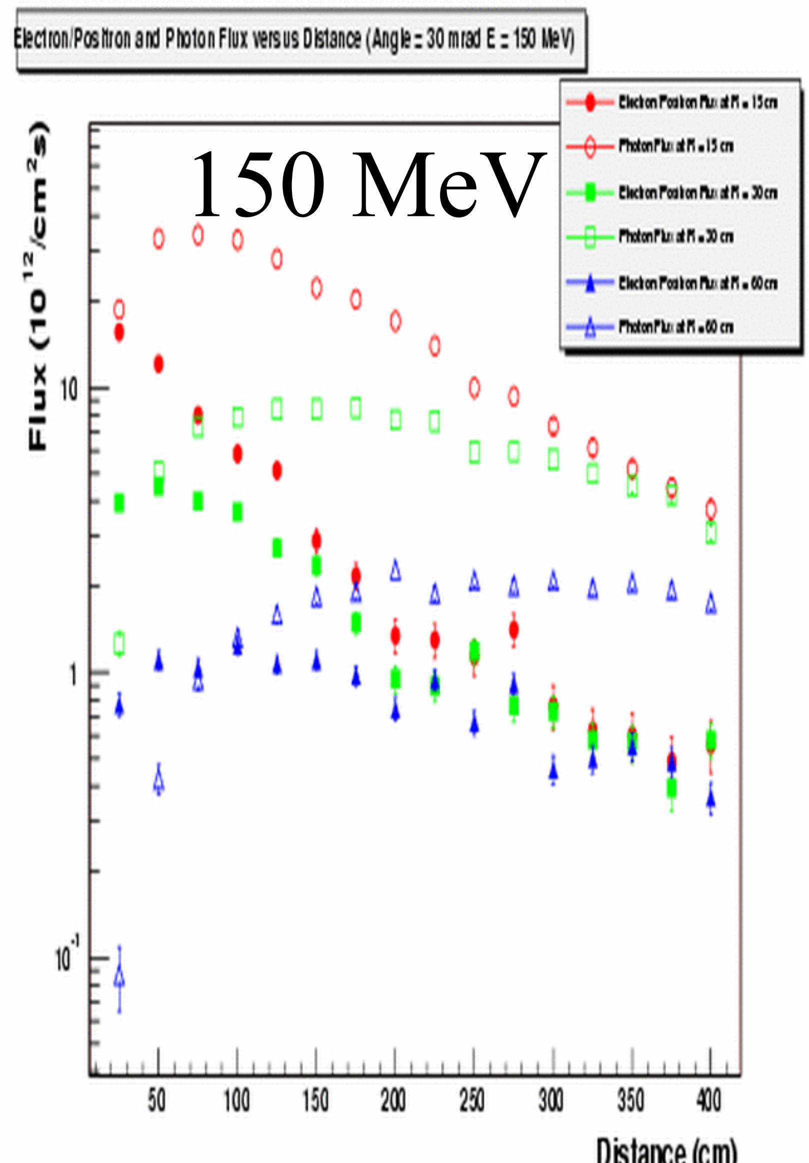


Summary of flux at 100 cm from the interaction for 150 MeV e-



Can we tell where the interaction occur?



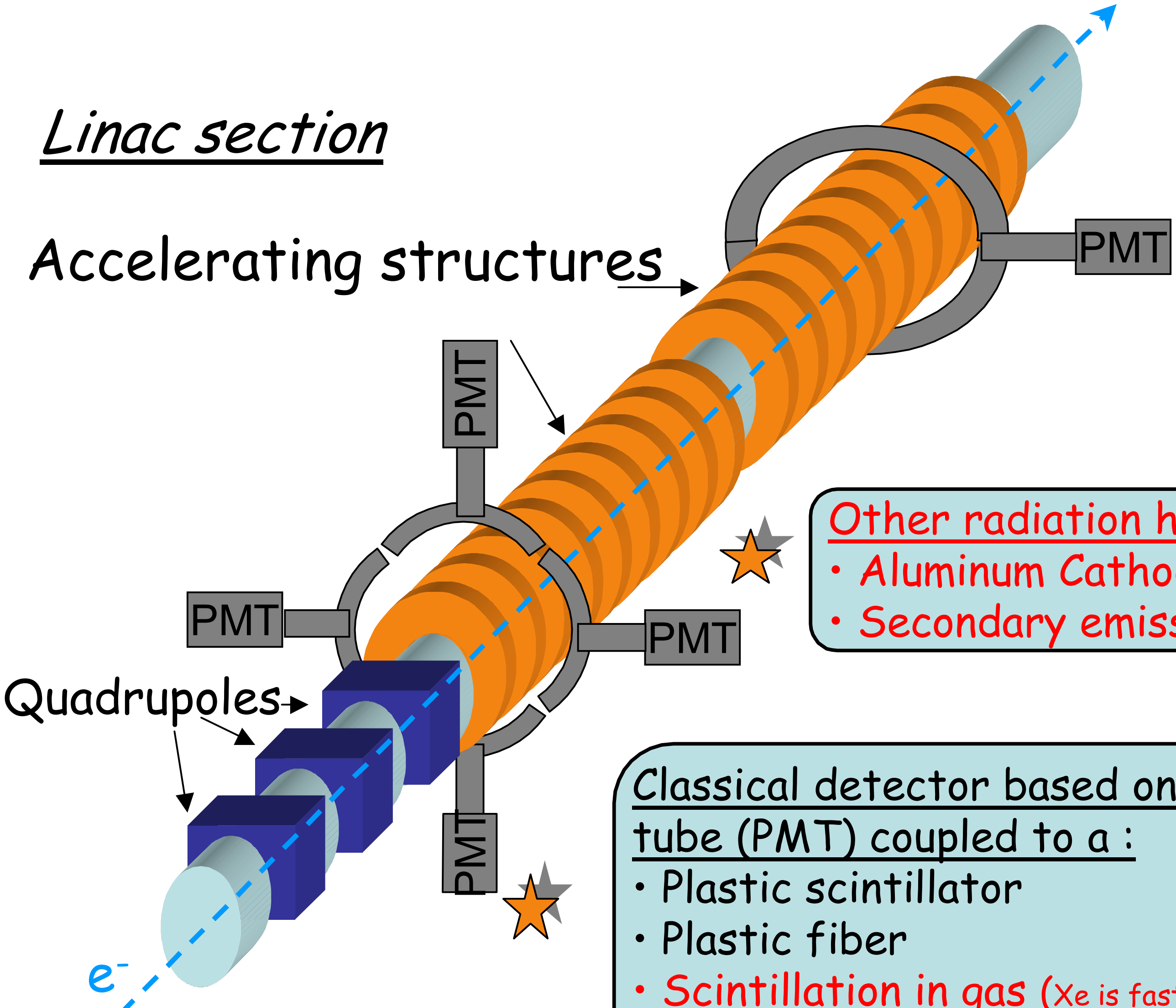


CTF3 beam loss detection system

- Initial goal : Protection of major components of the accelerator (accelerating structures, RF deflectors, collimator ,...)
  - Nanosecond time response is required for the feedback system
- From simulations, assuming 1‰ beam loss induces a large flux of electrons and photons of 10^{12} (/cm^2/s)
  - High sensitivity is not required
  - But need to be radiation hard (lifetime ?)
- From simulations, we see that induced showers are transversely position dependant
  - Possibility to localize spatially where the losses occurs(beam loss position monitor)

CTF3 beam loss detection system

Linac section



Other radiation hard detector :

- Aluminum Cathode Electron Multiplier
- Secondary emission monitor

Classical detector based on a Photo multiplier tube (PMT) coupled to a :

- Plastic scintillator
- Plastic fiber
- Scintillation in gas (Xe is fast few ns)
- Cherenkov in gas

} Longer life time 'Radiation hard'

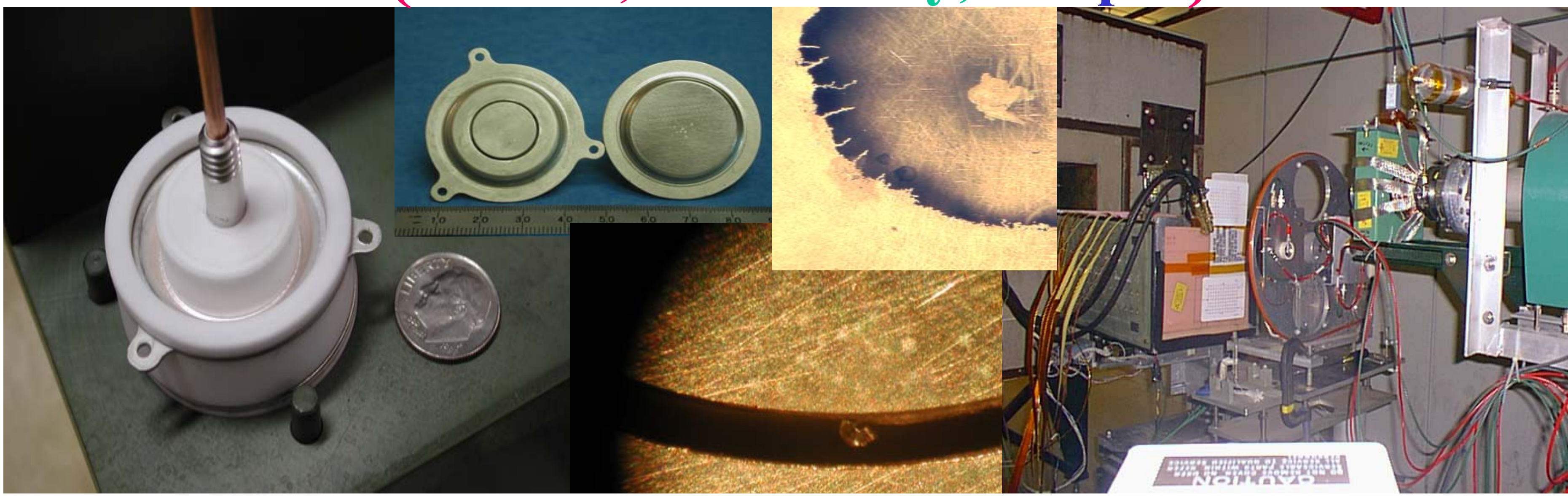
Radiation Hard Ionization Chambers / Secondary Emission Monitors

Work done in collaboration with:

- FNAL
- Richardson Electronics

NEW Radiation Hard Ionization Chambers / Secondary Emission monitors

(Velasco, Dabrowsky, Szleper)



- Invested 2 years – partnership with industry –Richardson electronics & FNAL (help with design challenges)

Richardson Electronics
Engineered Solutions

- Reproducible radiation hard, high intensity flux, excellent tolerances

- Gas sealed… or in high vacuum

Motivation & Preview Work done

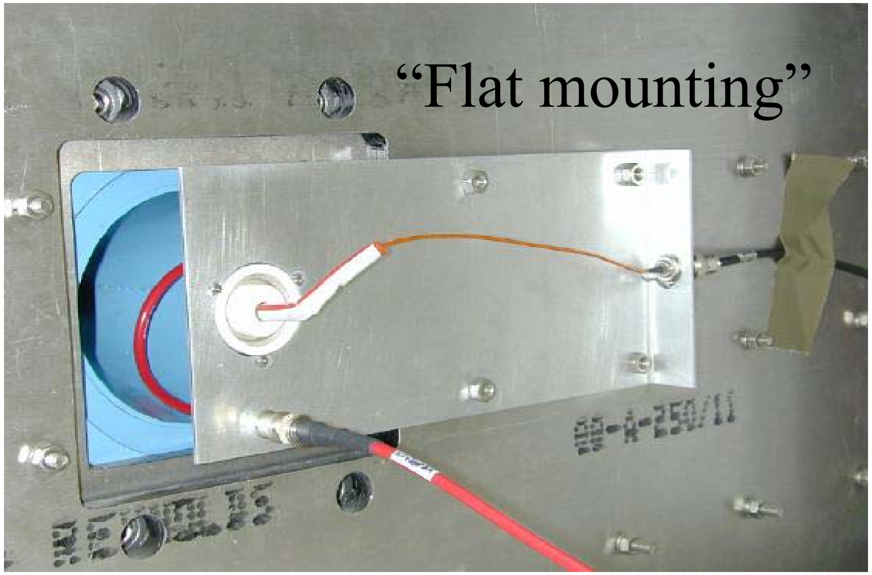
- Produced Chambers than can be used in <u>High Rate Environment</u> like those of next generation of proton drivers

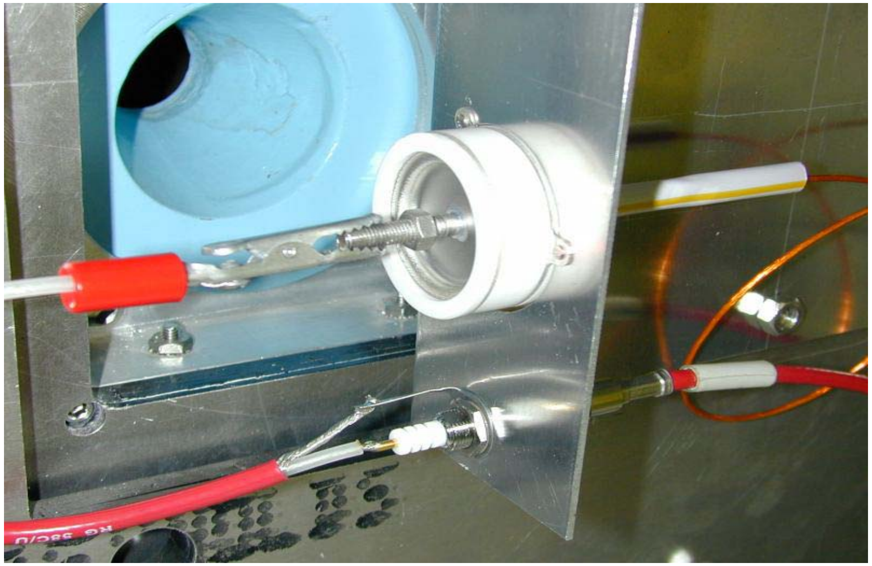
- **Design**
  - Glass Chamber
  - Ceramic Chambers
    Design 1 , 2 , 3 , 4
- **Testing**
  - ATF
    (BNL)
    Electron Source
    (e8 - e9)
  - Radiation Calibration Facility (FNAL)
    Photon Emission
    424 R/hr
  - Booster
    (FNAL)
    Proton Source
    (1e11 - 1e12)

Radiation Physics Calibration Facility

(RPCF,FNAL)

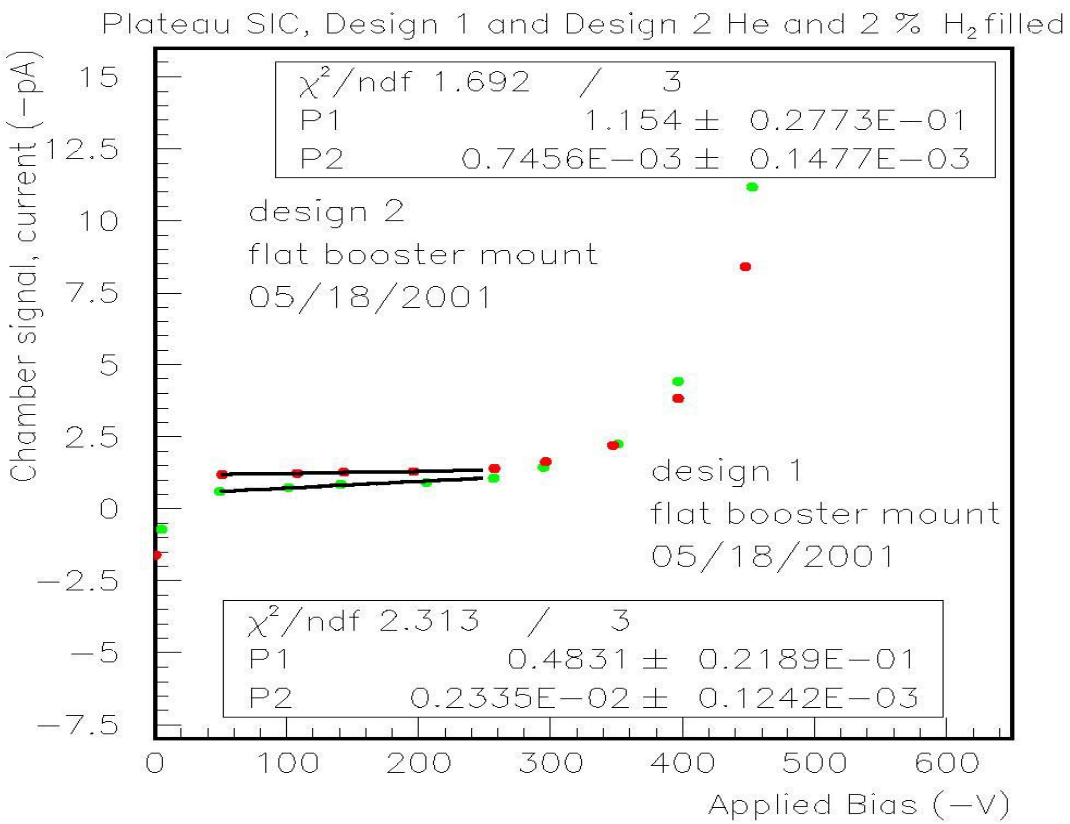
- Two new Cs^{137} sources:
- Max:1600 Rad/Hr





<u>Design studies</u>: *Round Edges distort signals such that we get a slope in plateau*

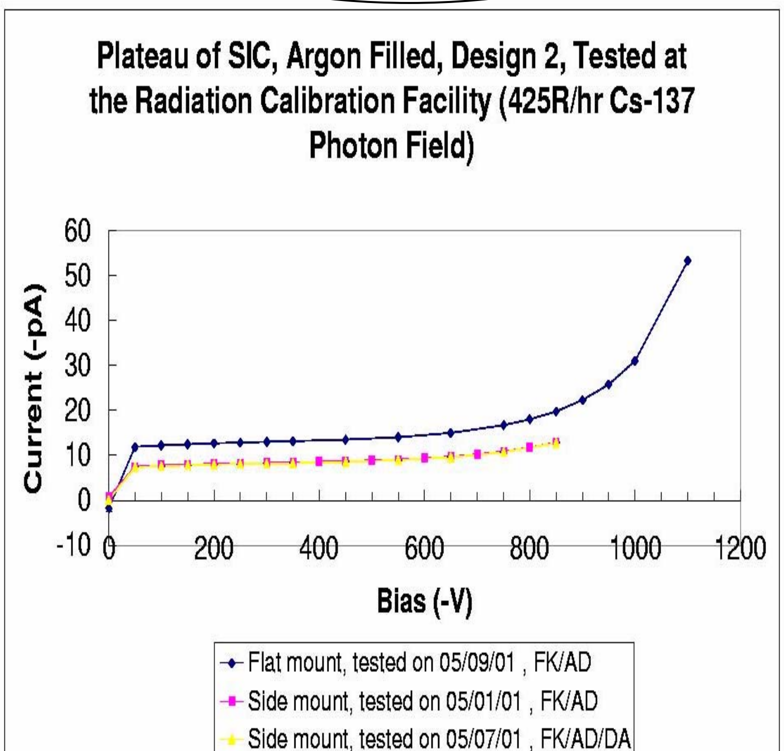
➔ Flat surface between signal and guard ring selected instead.

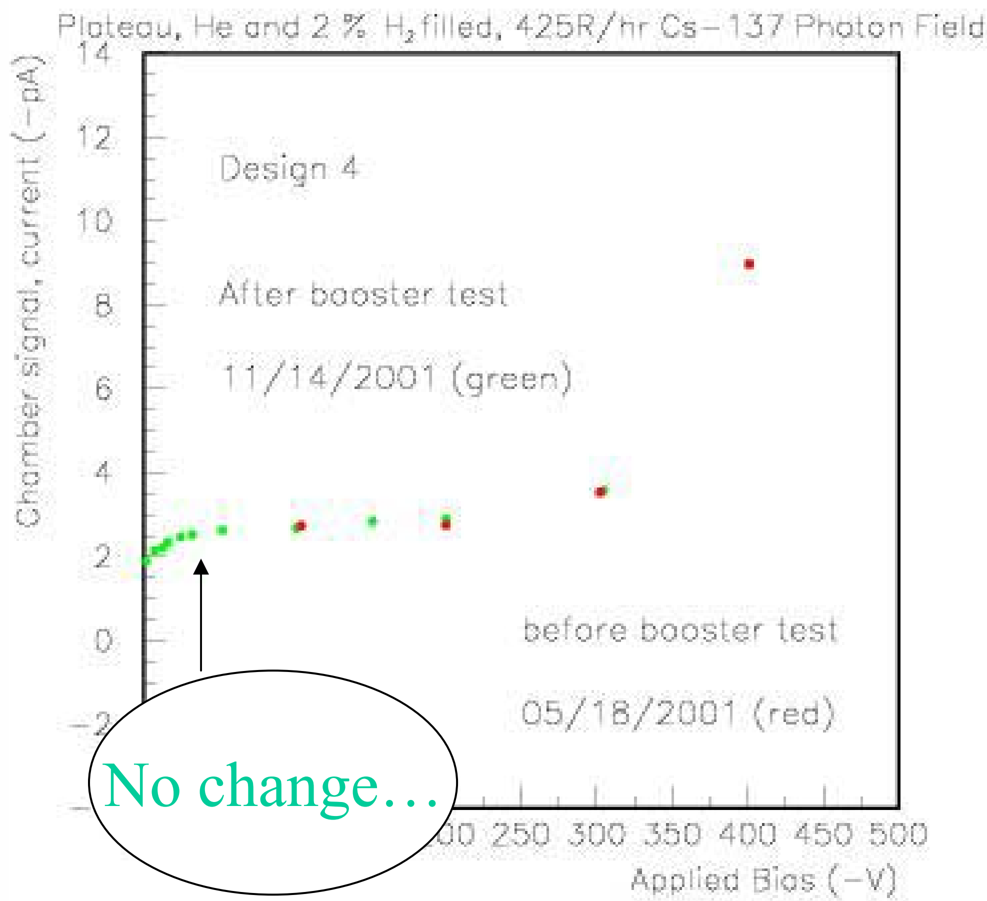


Chamber Characterization show no radiation damage after XX protons

Reproduce calibrations

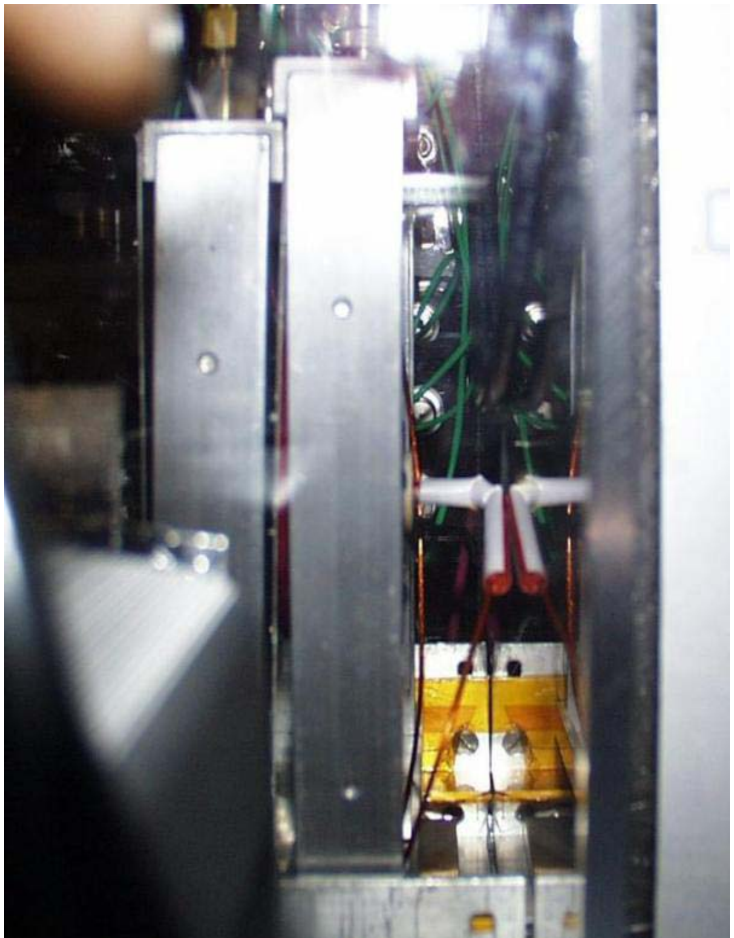
Chamber filled with
He for more than 2 year

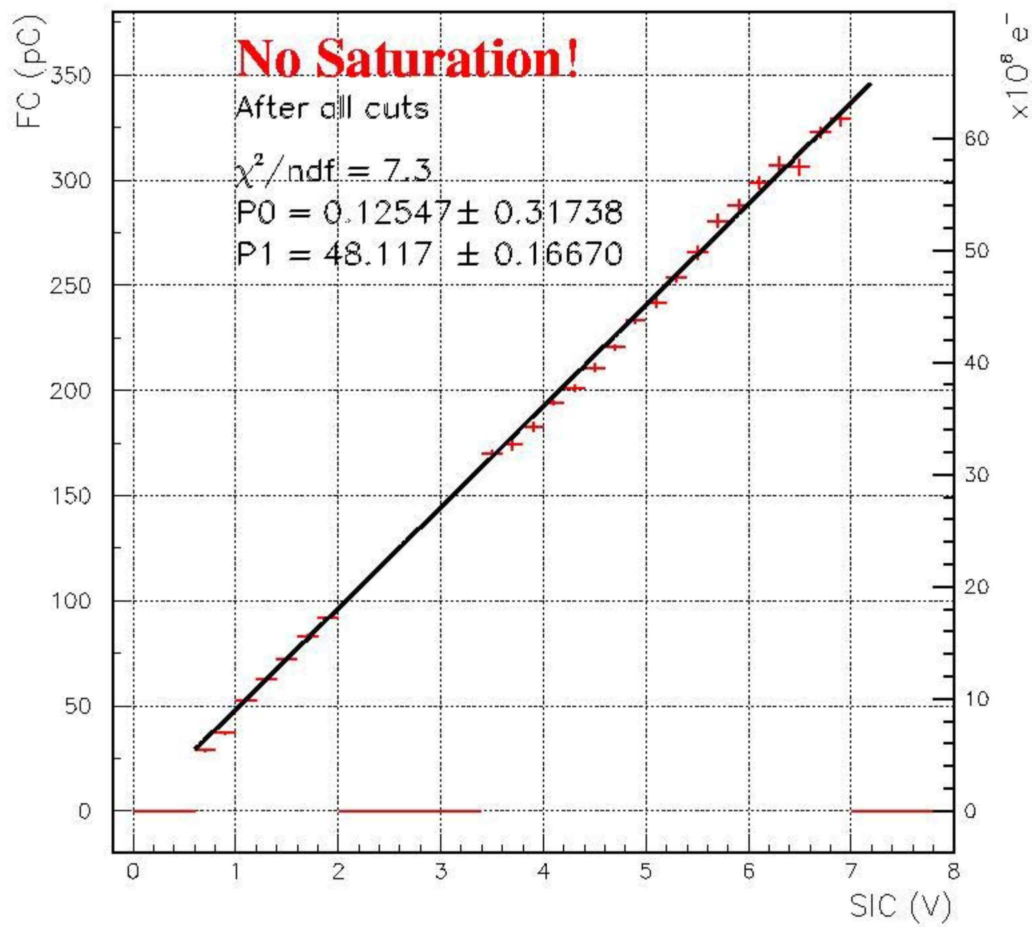




No change…

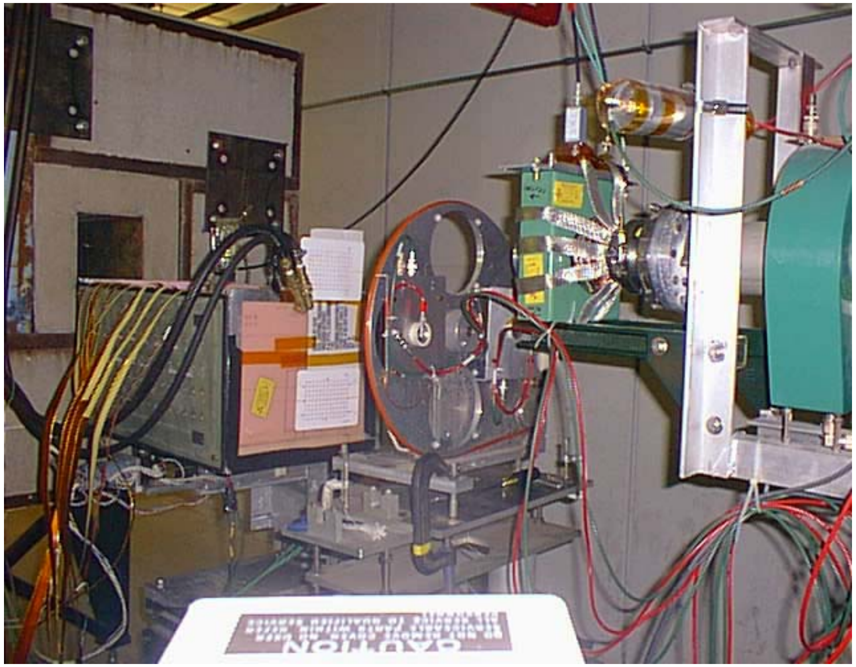
Tests at ATF (BNL) low energy electron beam No saturation below 8*10^9/p/cm^2





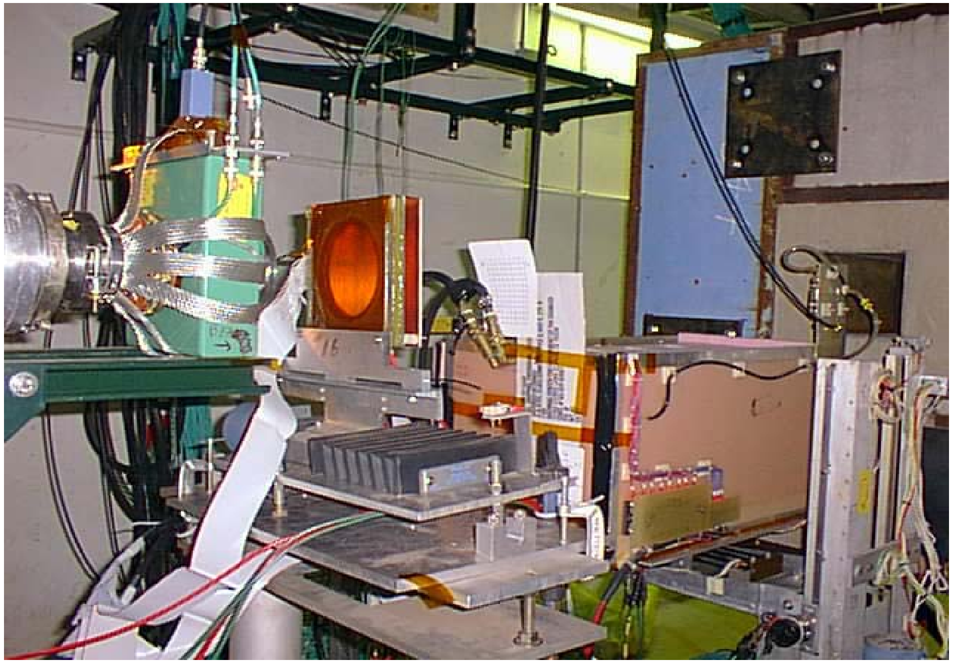
Test Setup @ Booster

SIC ONLY



Old➔ Toroid only for
Flux measurement

1mm Chamber +SIC



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

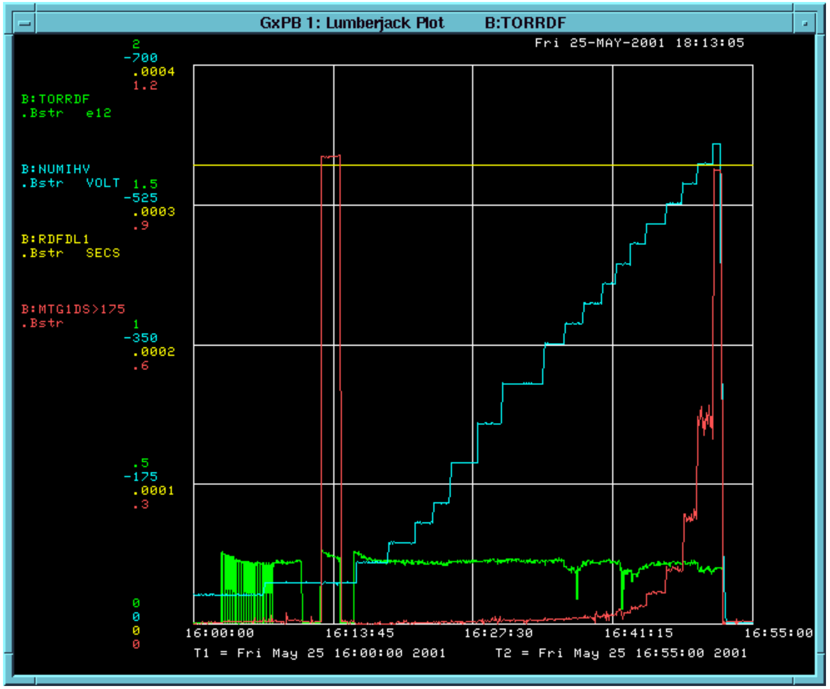
Booster (FNAL) Halo

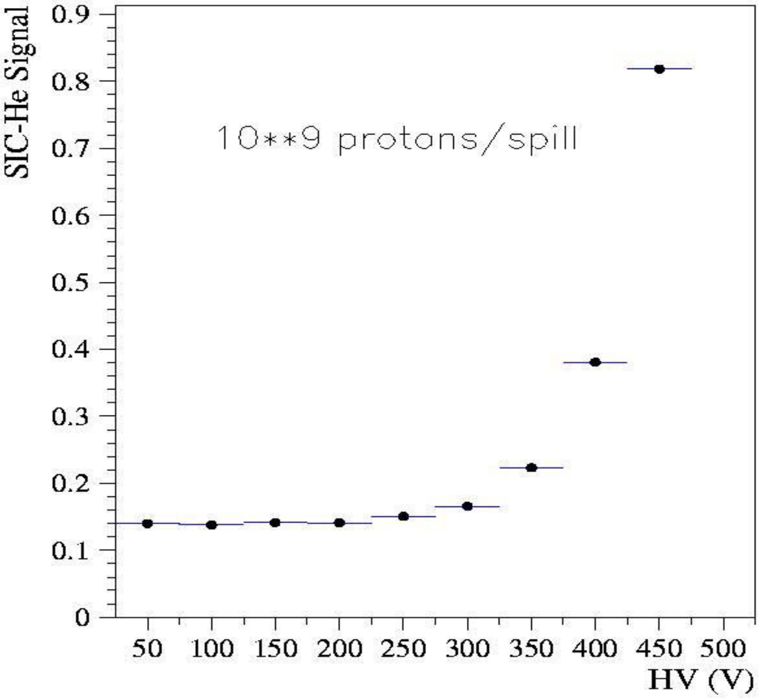
High intensity ~ 1e9 proton source

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

ONLINE

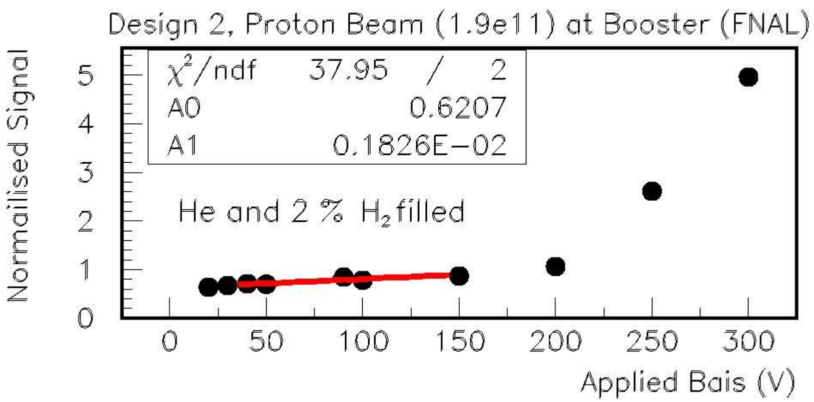
OFFLINE

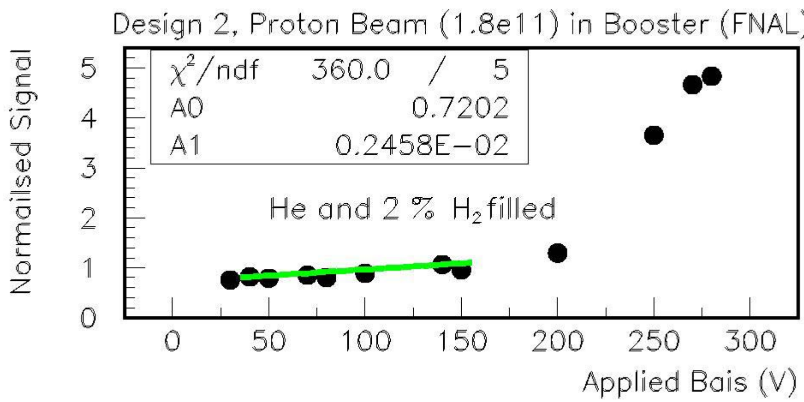


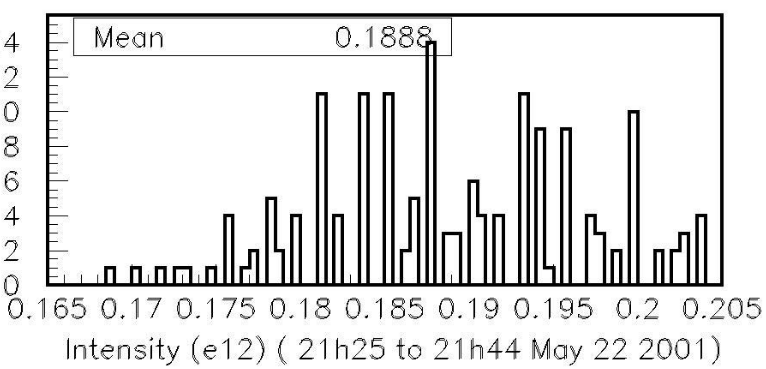


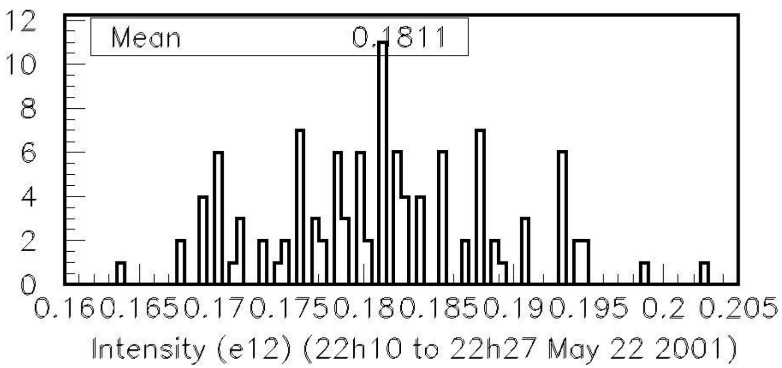
Booster (FNAL)

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

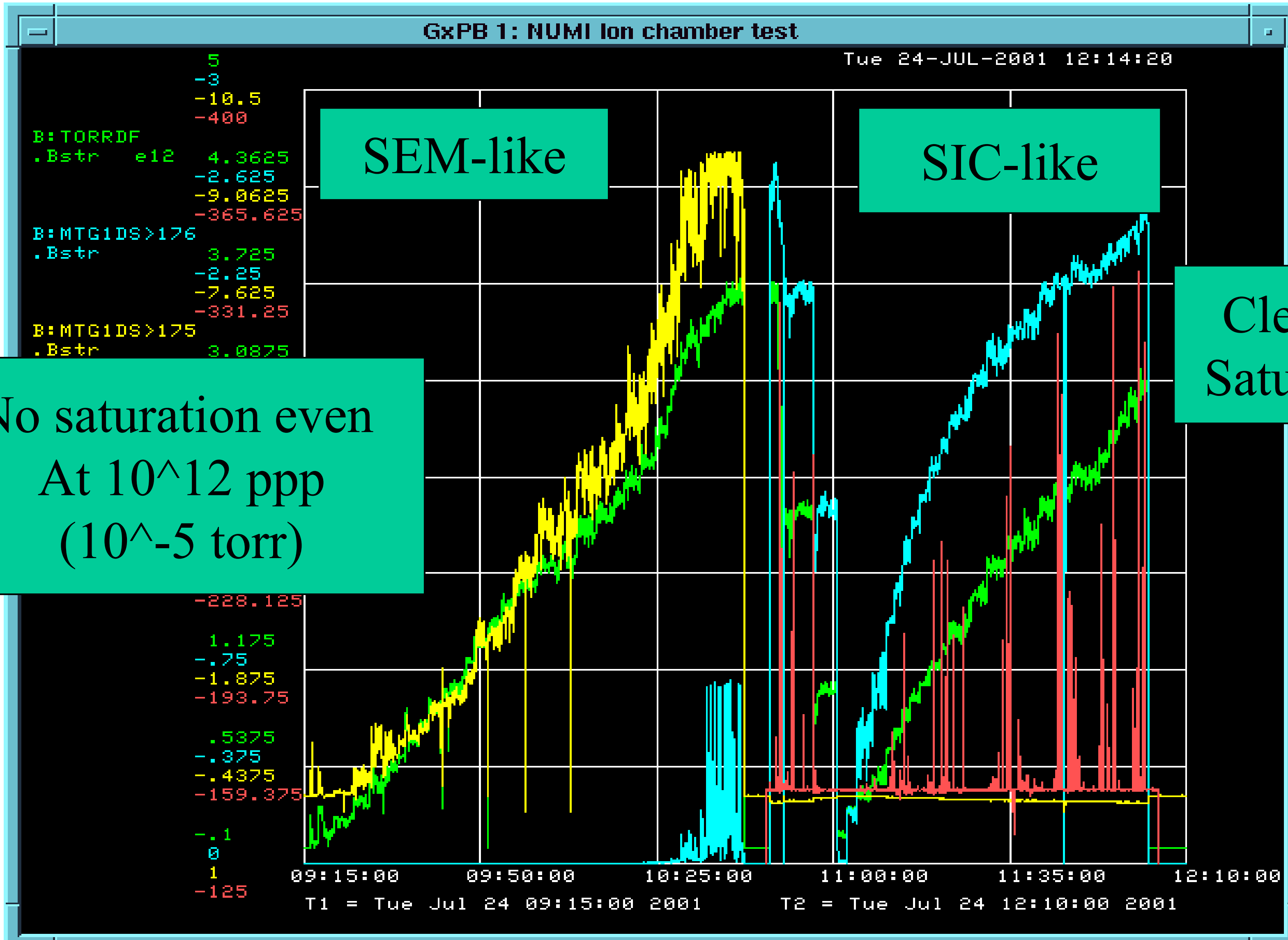








Booster (FNAL) – Intensity Scan



SEM-like

SIC-like

Clear …
Saturation

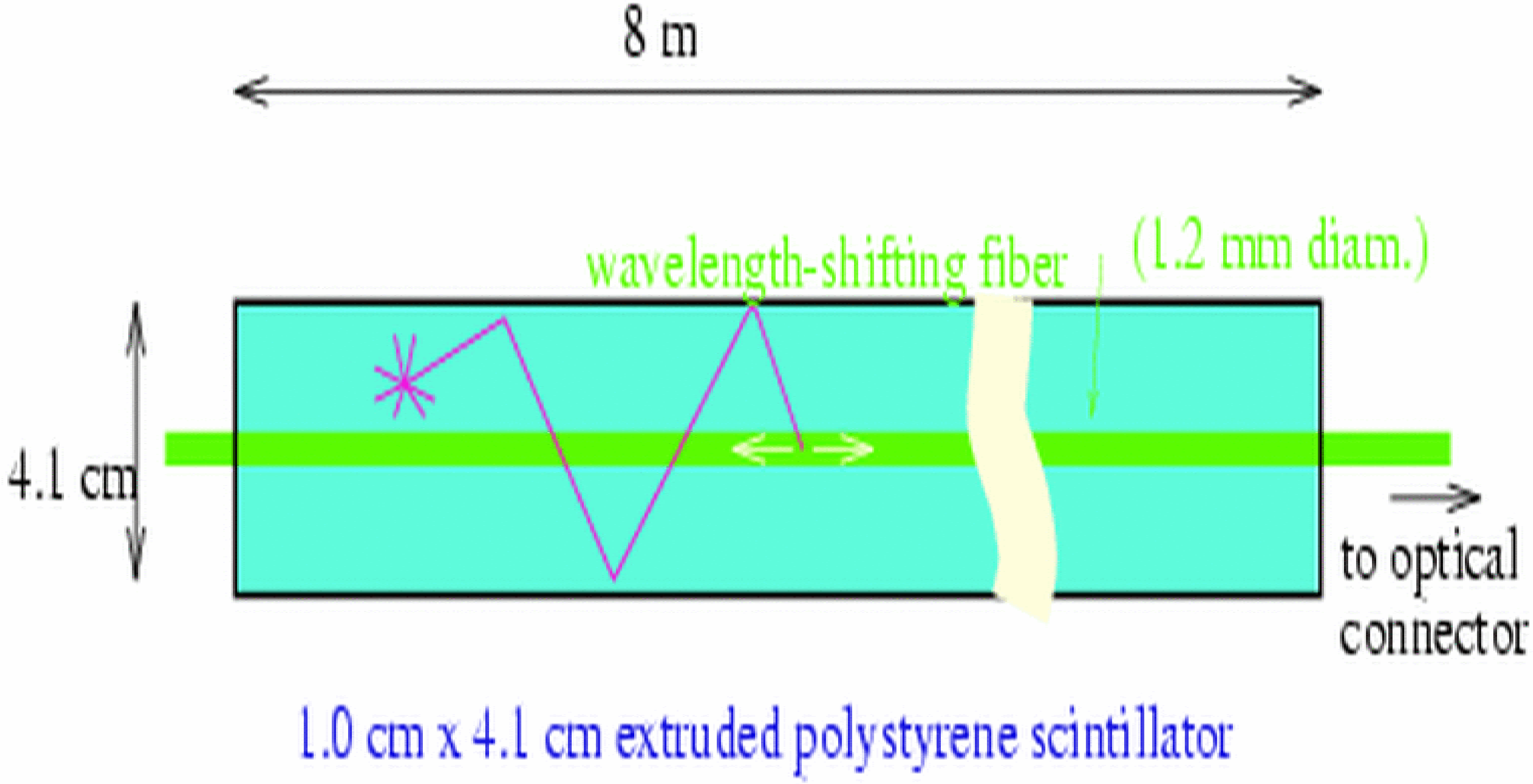
No saturation even
At 10^12 ppp
(10^-5 torr)

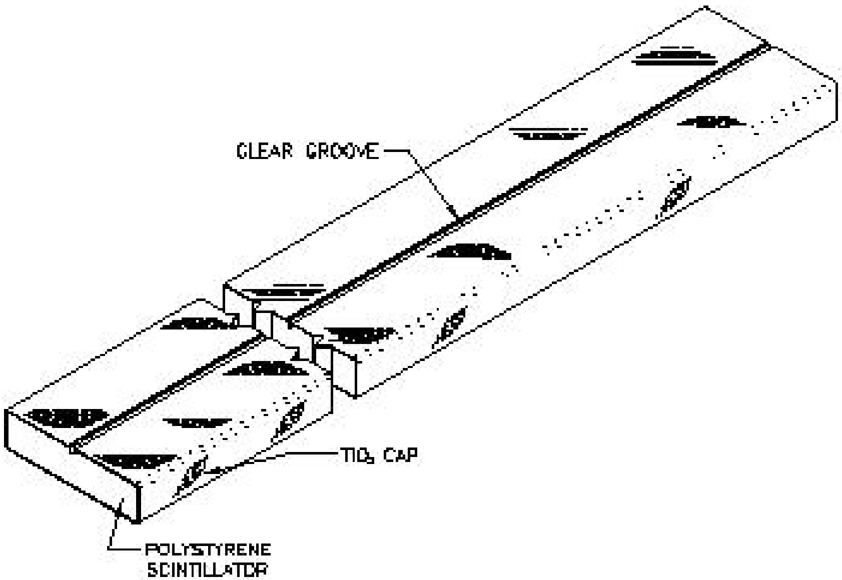
Secondary Emission Monitor– SIC chamber in vacuum

- 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 to reduce atmosphere of H_2.
  - Richardson used this process on vacuum tubes to 10^{-8} torr

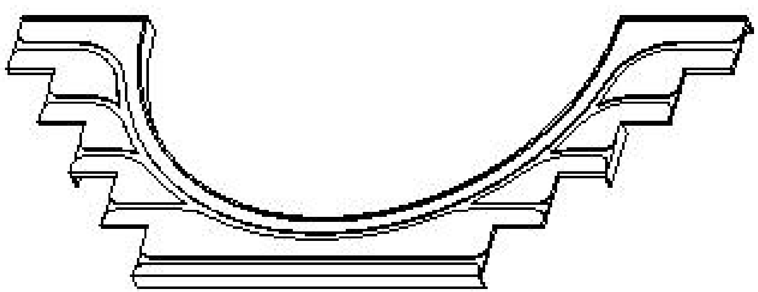
This look like a very promising way of operating
The chambers for >10^11 ppp

What do we know about scintillators and fibers…





Minos example



- We know how to machine in different shapes
- Light response as function of groove depth
- Electronics for the fiber… Hamamatsu
- Etc…

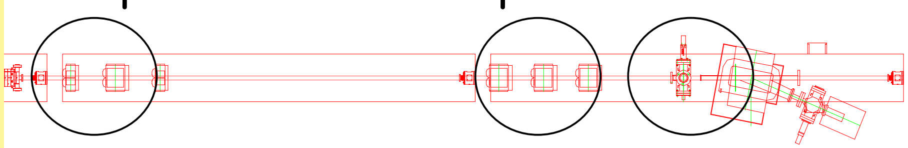
→Several options…more information by the oct. workshop

CTF3 beam loss detection system : October 2003

Benchmarking Geant simulations

' Measuring the induced showers for a controlled and measured beam loss '

Well equipped region with beam position and beam profile monitors



- Possibility to use four detectors
- Beam loss detectors can be easily moved from one location to the other

Testing different equipments

- Scintillators + PMT
- Scintillating fiber + PMT

Conclusion: Work on Beam Loss System is just starting…

- **Still not clear if:**
  - **We need total flux only, and/or (*integrated over spill*)**
  - **Spatial information (*segmentation*)**
  - **Information within the spill (*flux vs time*)**
- **It all depends on what their final use will be:**
  - **Beam Interlock**
  - **Feedback System**
  - **Beam Dynamics studies**
  - **Etc.**

➔ Time will tell… ☺