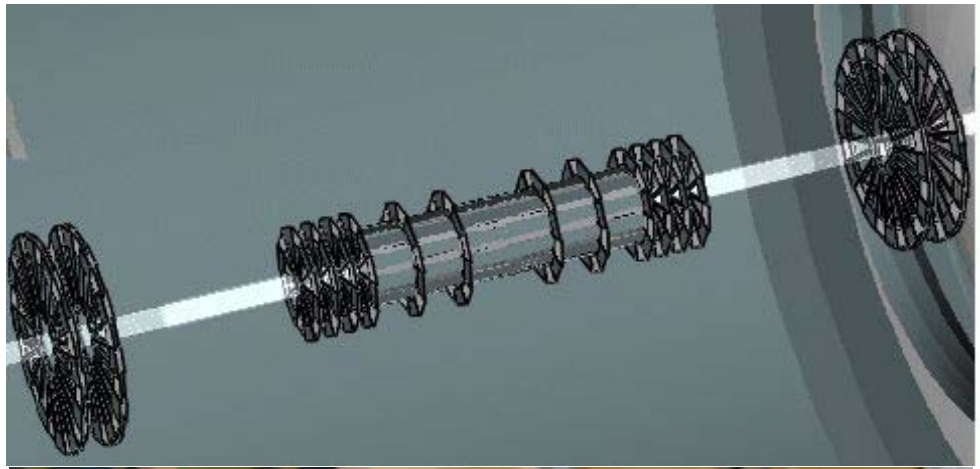
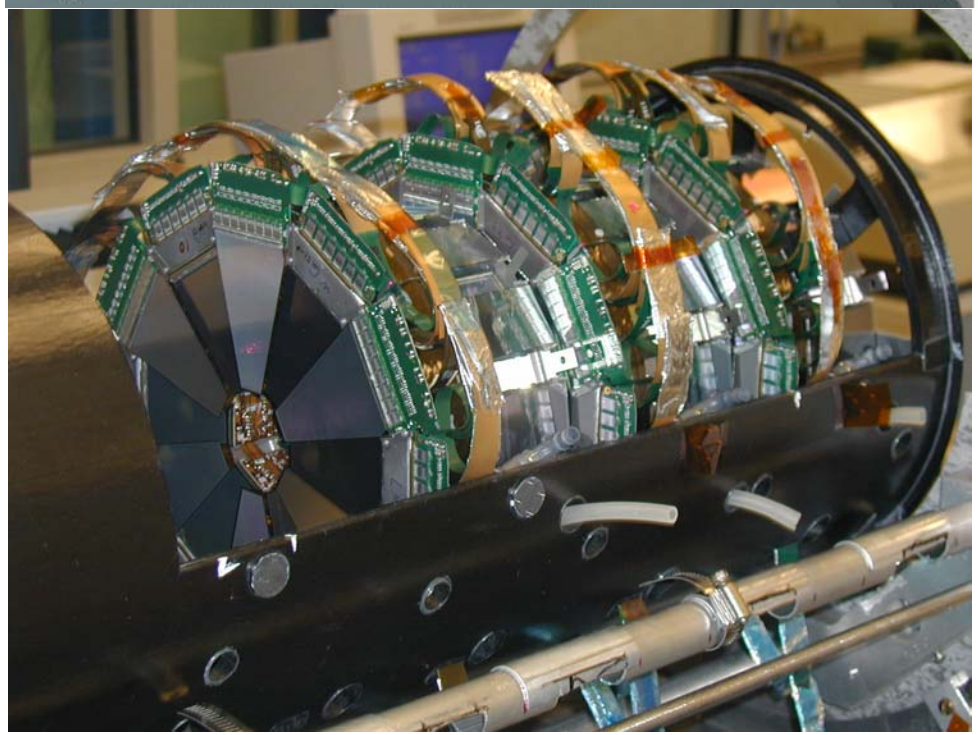
D0SMT Radiation Monitoring

Contents:

- Radiation effects in silicon and impact on RunIIb
- Dosimetry techniques
  - The BLM system
  - The finger diode system
  - TLDs and foils
  - Detector currents
- Results so far

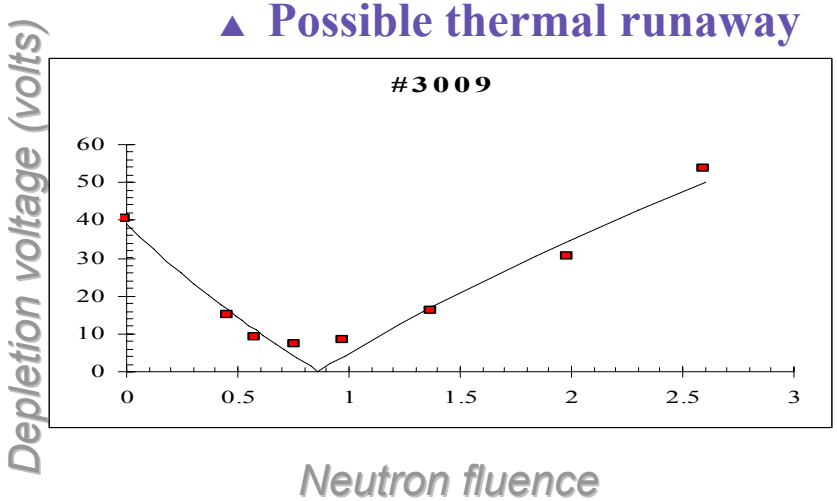


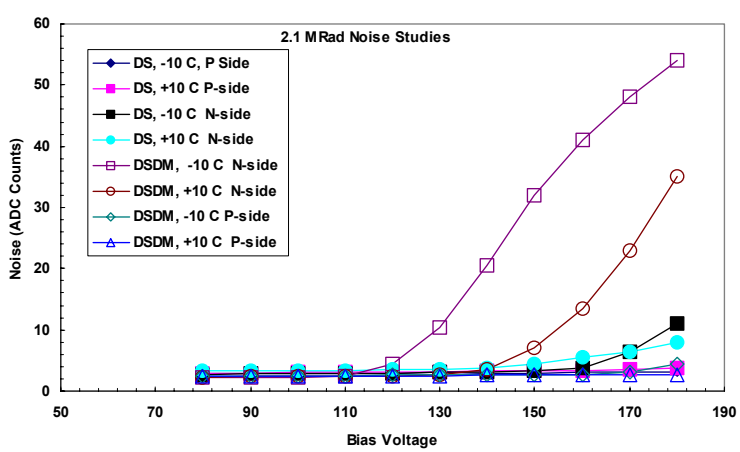


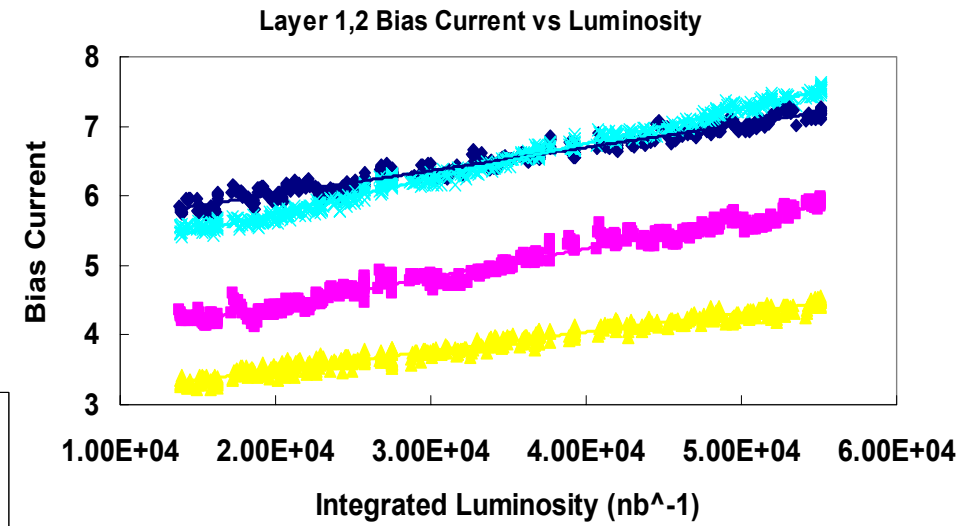
R. Lipton

Radiation effects on Silicon

- Two major effects
  - Increased leakage current
    - More noise
    - Possible thermal runaway







- Increase in Depletion voltage
  - Increases operating voltage of detectors
  - Change sensors from n to p type silicon
  - Will cause breakdown of coupling capacitors, microdischarge breakdown of p-n junction

Both depend on temperature

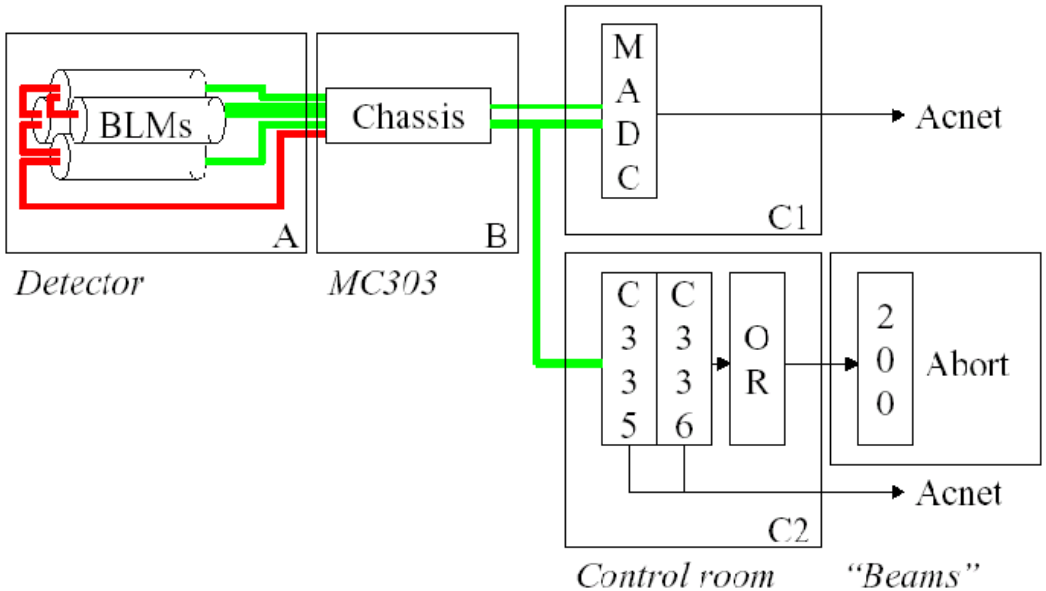
$$Neff = -N_0 e^{-c\Phi} + g_c(\Phi) + g_s \Phi e^{-t/\tau(T)} - N_y(\phi,\tau,T)$$

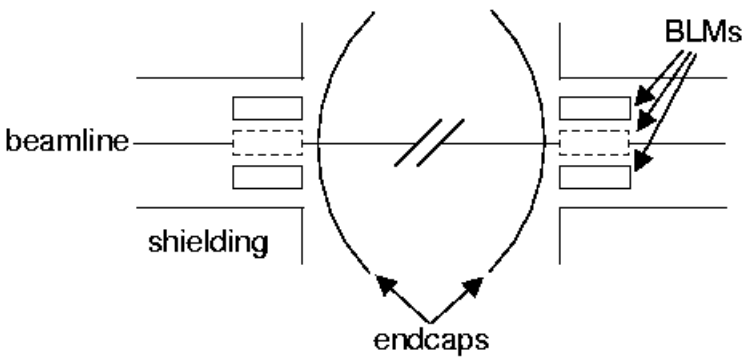
BLM System

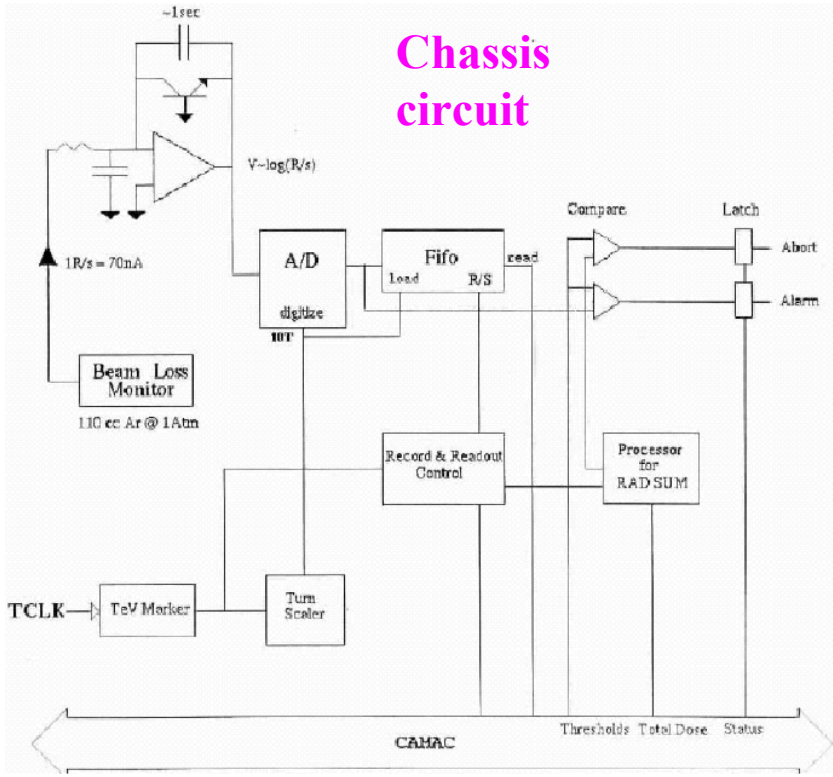
- BLM system
  - copy of run 1/current CDF system
  - Interfaced to beam abort – this is what currently dumps the beam
  - Far from silicon (downstream of calorimeter), large extrapolation to silicon dose.
  - Integral not very sensitive to small, continuous dose due to integration thresholds.
  - Logarithmic response – odd behavior and quantized jumps at low dose rates

- Technical:
  - 8 glass ion argon ion chambers (coke bottles).
  - Very simple devices – no gain – integrate total charge
  - Large dynamic range – log amp in chassis
  - Processing in 2 CAMAC modules C336/C337 – do inversion of log response, keep rolling sums and fast FIFO buffer than can be dumped if the beam is aborted to examine dose at millisecond time scale

BLM Readout


BLMs
A
Chassis
B
M
A
D
C
C1
Acnet
Detector
MC303
C
3
3
5
C
3
3
6
O
R
2
0
0
Abort
Acnet
C2
Control room
"Beams"


BLMs
beamline
shielding
endcaps


Chassis circuit
~1sec
V~log(R/s)
1R/s = 70nA
A/D
digitize
Fifo
Load
R/S
read
Compare
Latch
Abort
Alarm
Beam Loss Monitor
110 cc Ar @ 1Atm
Record & Readout Control
Processor for RAD SUM
TCLK
TeV Marker
Turn Scaler
CAMAC
Thresholds
Total Dose
Status

BLM

ACNET BLM Variables

Alarms and limits

- Rate/sec : D0BLXX
- Integrated dose: D0BRXX
- Rate/min: D0BAXX (set)
- FIFO: D0BFXX

- Locations:
- UT – Upstream top (P side) (monitored by MCR)
- UB – Upstream bottom
- UI – Upstream inner
- UO – Upstream outer

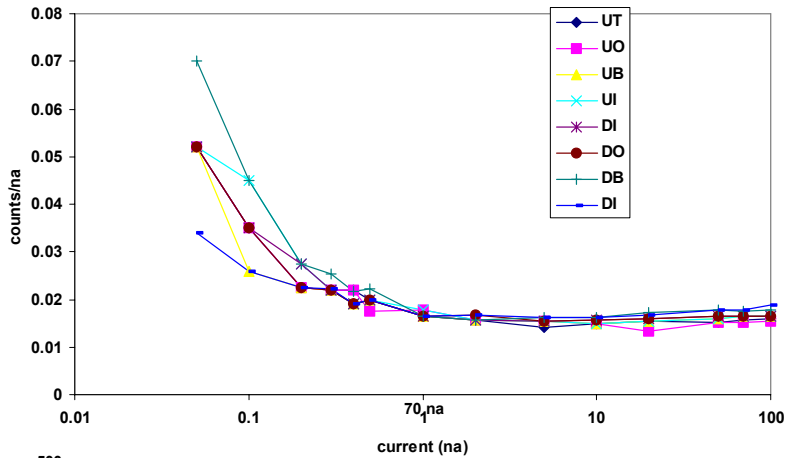
- D - downstream

Fig.3: Fall of D0 luminosity and number of particles in the Tevatron (IBEAM) together with losses recorded by BLMs on both sides of the D0 detector.

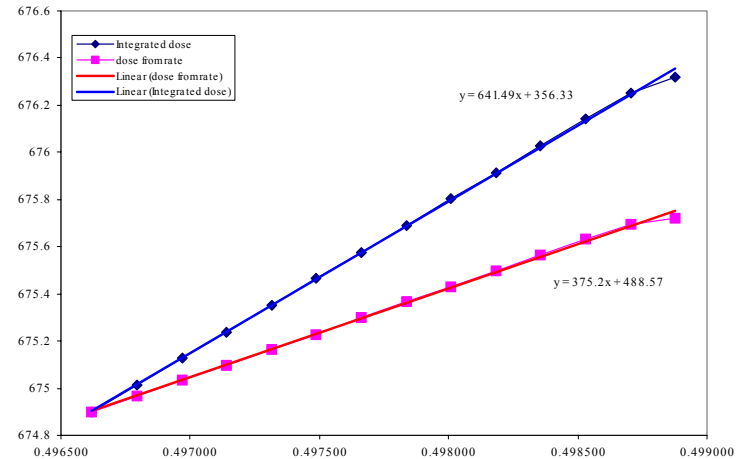
BLM Calibration

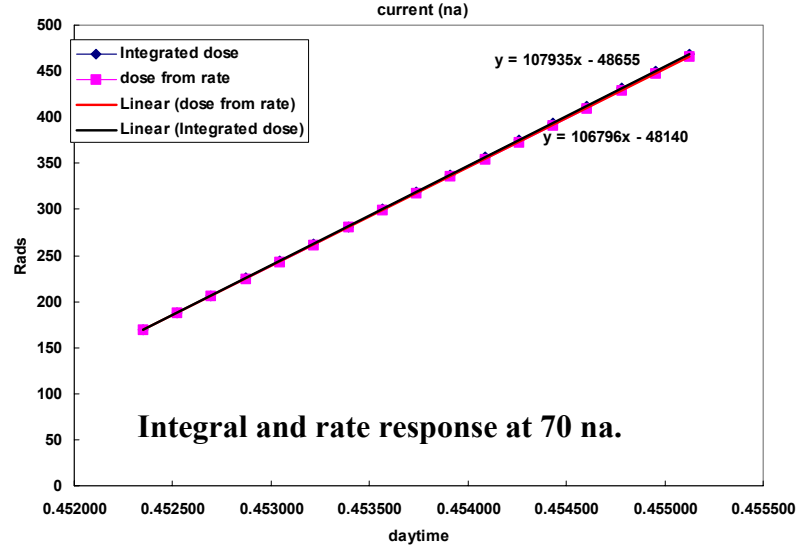
- **Our initial calibration found that the dose rate CDF was using for Run I was off by a factor of 7! Not a perfect system by any means…**

Normalized response

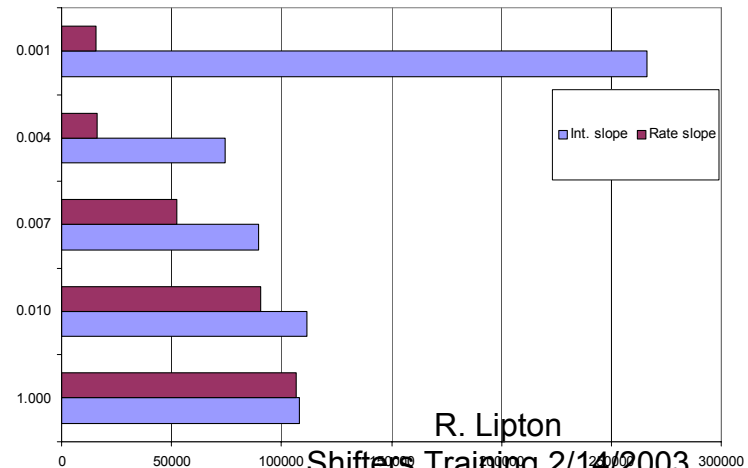


Integral and rate response at 0.5 na.





BLM integral and rate response as a function of current

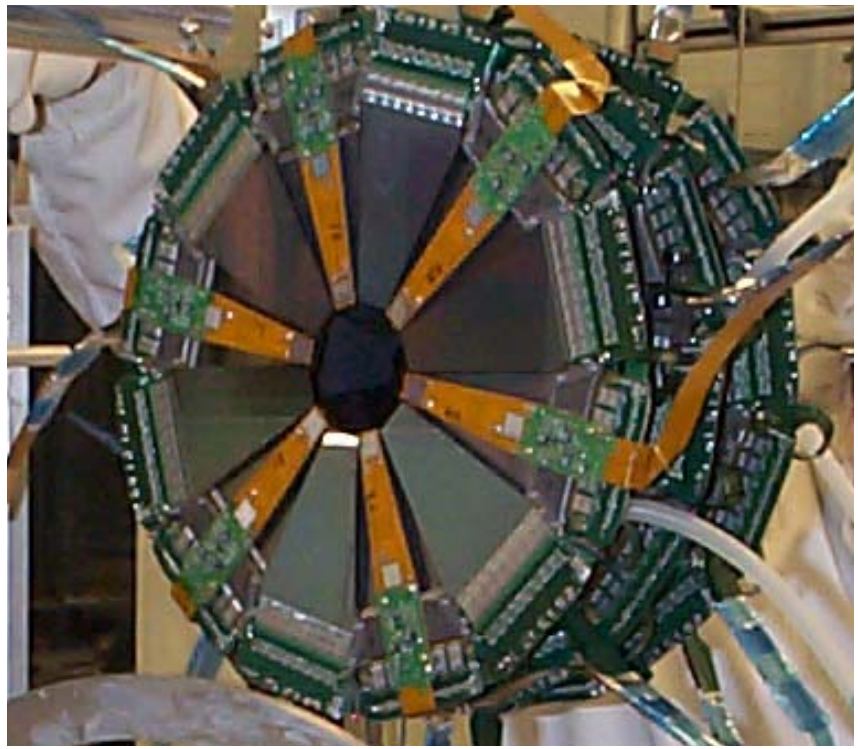


BLM Alarms and Limits

	Abort and Alarm Thresholds for D0SMT Radiation Protection System							
				nominal		Device		
Period	**Location**	**Alarm/Abort**	**Type**	**Level**	**Device**	**Setting**	**Units**	**Comments**
Shot Setup	CAMAC	Alarm	Rate	6.37 rad/sec	D0BLXX	169	counts	OR of 8 devices
	CAMAC	Abort	Rate	12.6 rad/sec	D0BTXX	188	counts	OR of 8 devices
	CAMAC	Alarm	Integral	1 Krad	D0BRUT	1000	rads	single device
	MCR	Man Abort	Integral	2 Krad	D0BRUT	-		single device
	D0	Man Abort	Integral	3 Krad	D0BRXX	-		
Store	CAMAC	Alarm	Rate	6.37 rad/sec	D0BLXX	169	counts	OR of 8 devices
	CAMAC	Abort	Rate	12.6 rad/sec	D0BTXX	188	counts	OR of 8 devices
	CAMAC	Alarm	Rate	20 rads/Min	D0BRXX			C336 sum
	CAMAC	Alarm	Integral	3 Krad	D0BRUT	1000	rads	single device
	MCR	Man Abort	Integral	4 Krad	D0BRUT	-		single device
	D0	Man Abort	Integral	5 Krad	D0BRXX	-		Notify RDCO
Studies	CAMAC	Alarm	Integral	4 Krad	D0BRUT	4000	rads	single device
	D0	Man Abort	Integral	6 Krad	D0BRXX	-		Notify RDCO
	MCR	Man Abort	Integral	5 Krad	D0BRUT	-		

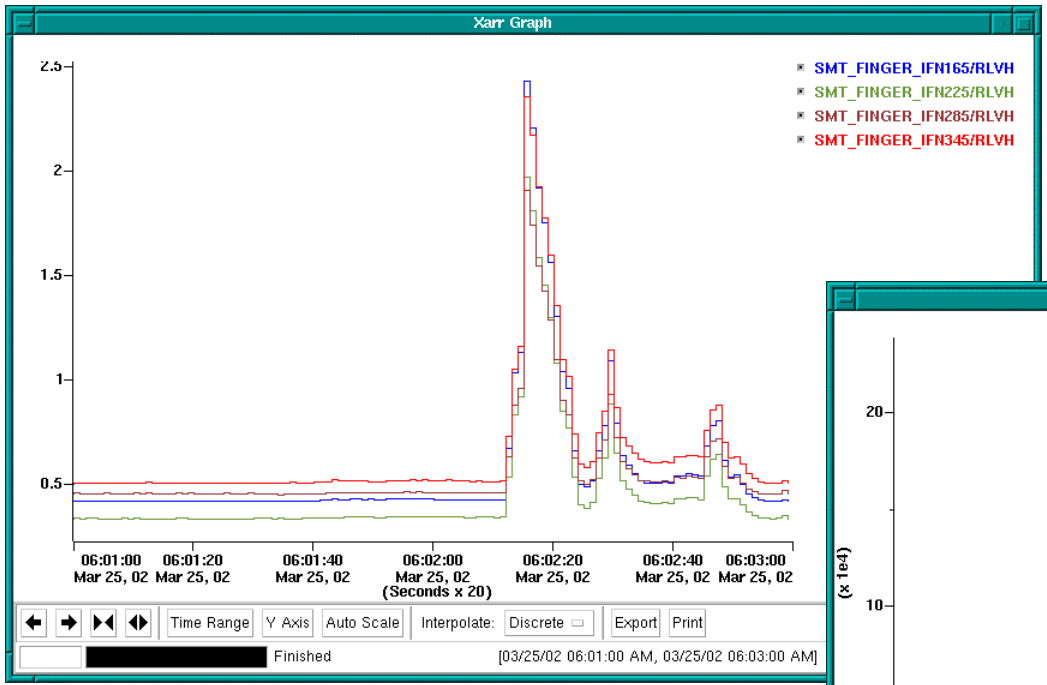
The Finger Diode System

- Detectors- 24 one cm photodiodes at 4 radii
  - Provide MIP signals
  - Three electronics paths
    - Single particle scalers (thresh ~ 2.5 MIPs)
    - High gain integration
    - Low gain integration
- Data fed to EPICS – not yet used for beam abort
- Dynamic range from mrads/sec to Krads/sec
- Original ADC system not sensitive to small losses – add scalers

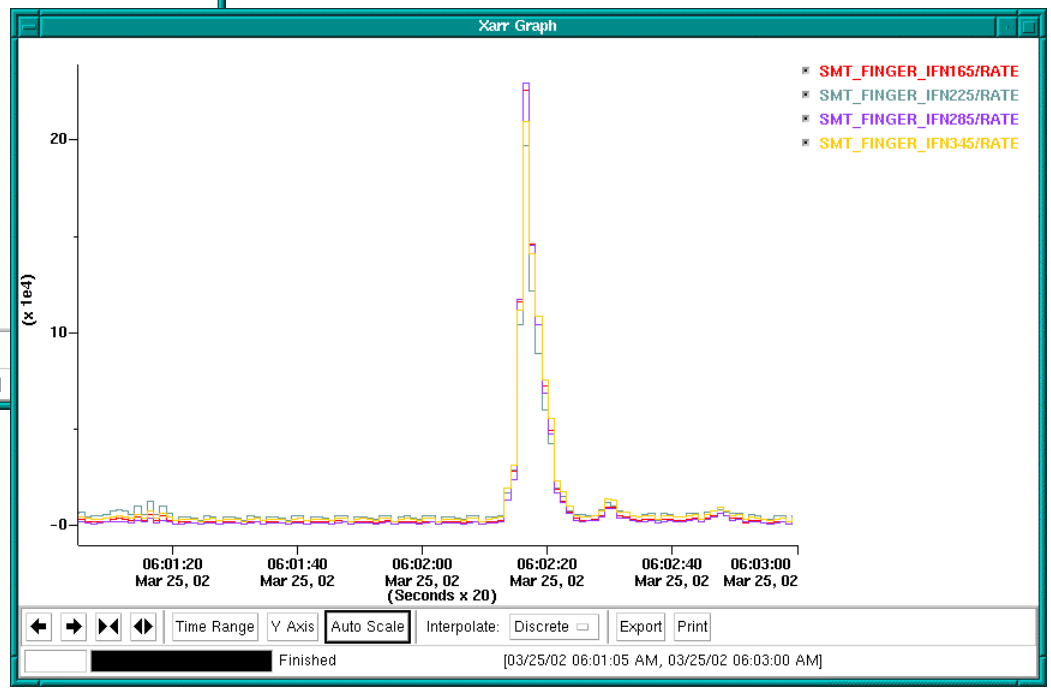


Fingers during Shot Setup

ADC Output

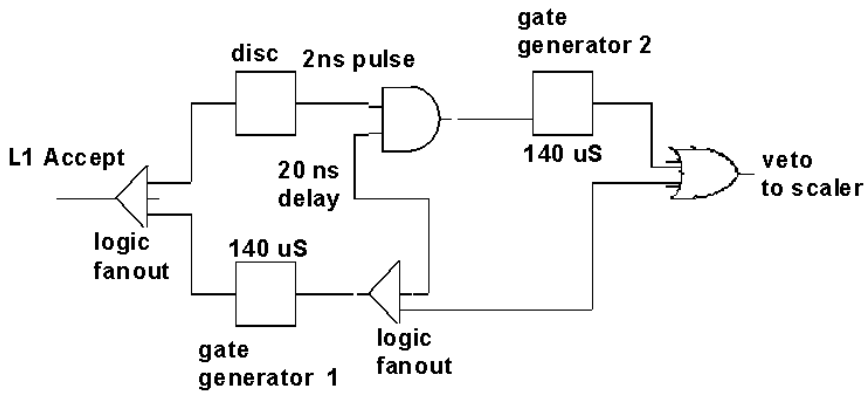


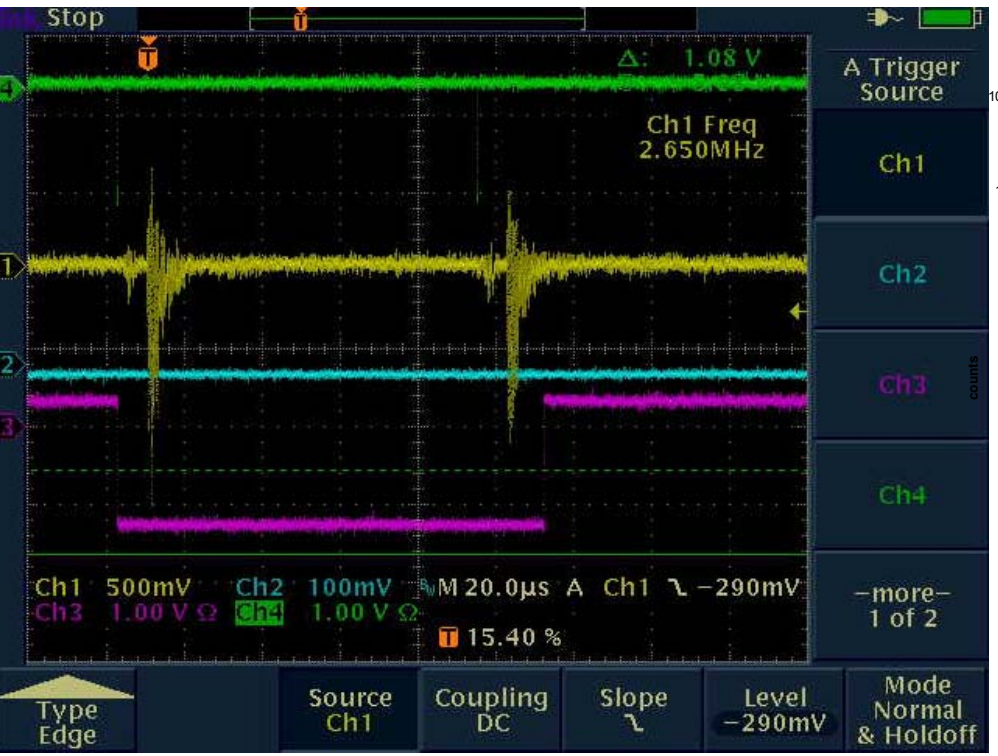
Scaler Output

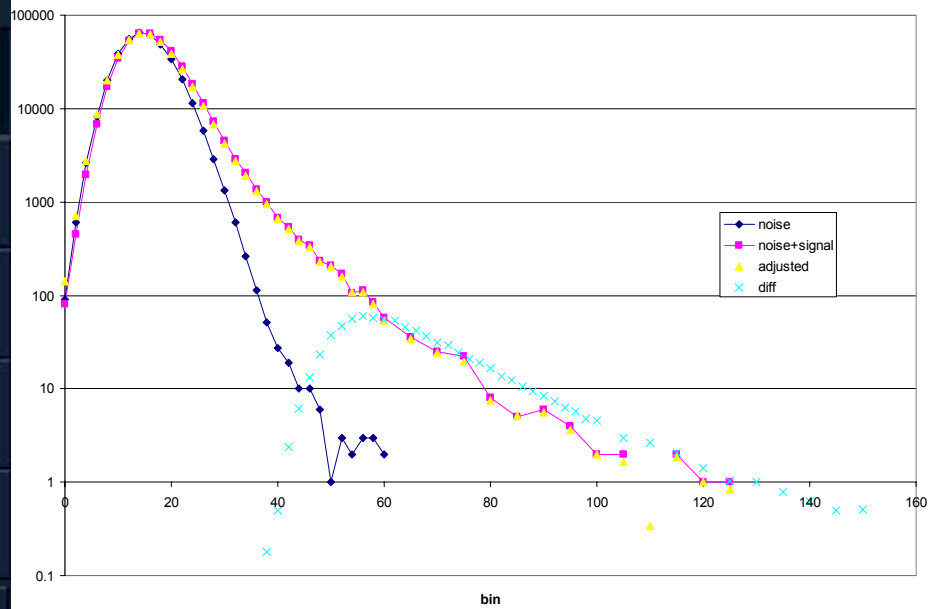


Readout

- MCH3 2 VME crates
  - ADCs and scalers + NIM logic
- Devices sensitive to noise during SMT readout
  - ADC jumps – solve in software?
  - Large scaler count rate – solved by gating







Finger Diode III

Dose rates

Temperatures

The radmon Gui

New finger GUI

File View Help

FINGER:		Rate (Rad/s)	Temp (C)	FINGER:		Rate (Rad/s)	Temp (C)
FN045	Inner	disabled	disabled	FS045	Inner	0.003 (s)	disabled
ADC	Outer	disabled		ADC	Outer	0.0 (s)	
FN105	Inner	0.004 (s)	−3.9	FS105	Inner	0.0 (s)	−4.7
ADC	Outer	0.001 (s)		ADC	Outer	0.0 (s)	
FN165	Inner	0.002 (s)	−5.0	FS165	Inner	0.019 (s)	−5.0
ADC	Outer	0.0 (s)		ADC	Outer	0.0 (s)	
FN225	Inner	0.0 (s)	−4.5	FS225	Inner	0.238 (s)	−4.6
ADC	Outer	0.0 (s)		ADC	Outer	0.0 (s)	
FN285	Inner	0.004 (s)	−4.4	FS285	Inner	0.007 (s)	−4.8
ADC	Outer	0.001 (s)		ADC	Outer	0.0 (s)	
FN345	Inner	0.0 (s)	−5.9	FS345	Inner	0.013 (s)	−6.4
ADC	Outer	0.0 (s)		ADC	Outer	0.0 (s)	
HN000	Inner	0.0 (s)	−6.2	HS000	Inner	0.0 (s)	−6.8
ADC	Outer	0.0 (s)		ADC	Outer	0.0 (s)	
HN060	Inner	−0.013 (s)	−6.4	HS060	Inner	disabled	−5.6
ADC	Outer	−0.008 (s)		ADC	Outer	disabled	
HN120	Inner	0.006 (s)	−6.0	HS120	Inner	disabled	disabled
ADC	Outer	−0.007 (s)		ADC	Outer	disabled	
HN180	Inner	0.001 (s)	−5.4	HS180	Inner	−0.244 (s)	−5.1
ADC	Outer	0.0 (s)		ADC	Outer	−0.01 (s)	
HN240	Inner	0.06 (s)	−6.2	HS240	Inner	disabled	disabled
ADC	Outer	0.001 (s)		ADC	Outer	disabled	
HN300	Inner	0.0 (s)	−7.0	HS300	Inner	disabled	−6.8
ADC	Outer	0.0 (s)		ADC	Outer	disabled	

Status: ALIVE | T crate: 44.9 (C) | BLM NHV: 1724 (V) | BLM SHV: 1990 (V)

Status: GUI intialization complete

Plot North | Plot All North | Experts | Plot All South | Plot South

Watch these

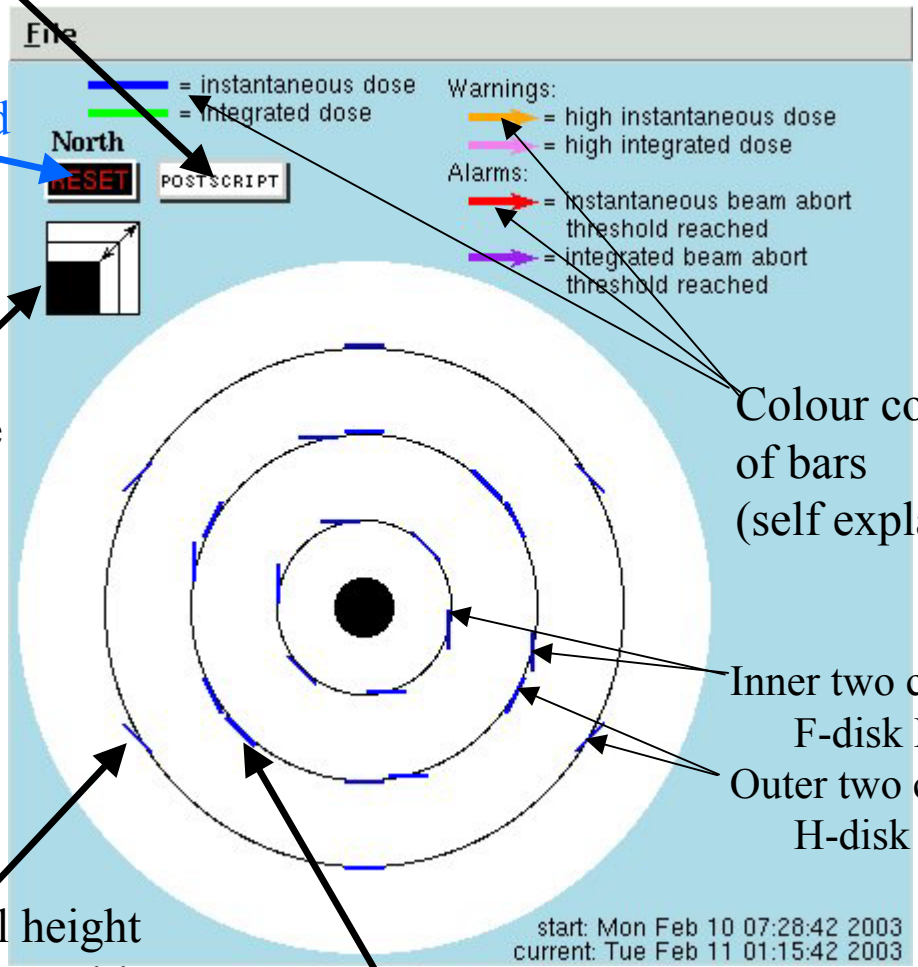
Online crate alive

HV for BLMs (1500<HV<2200)

Finger GUI

Makes ps file /projects/D0smt/radmon/RADMON_north_yyyymmdd_hhmmss.ps

Disabled



Resize

Colour coding of bars (self explanatory)

Inner two circles: F-disk Fingers;
Outer two circles: H-disk Fingers

Minimal height To show position

Outside ring positive value, inside negative (noise)
Max scale between circles is 1 Rad/s, scale linear

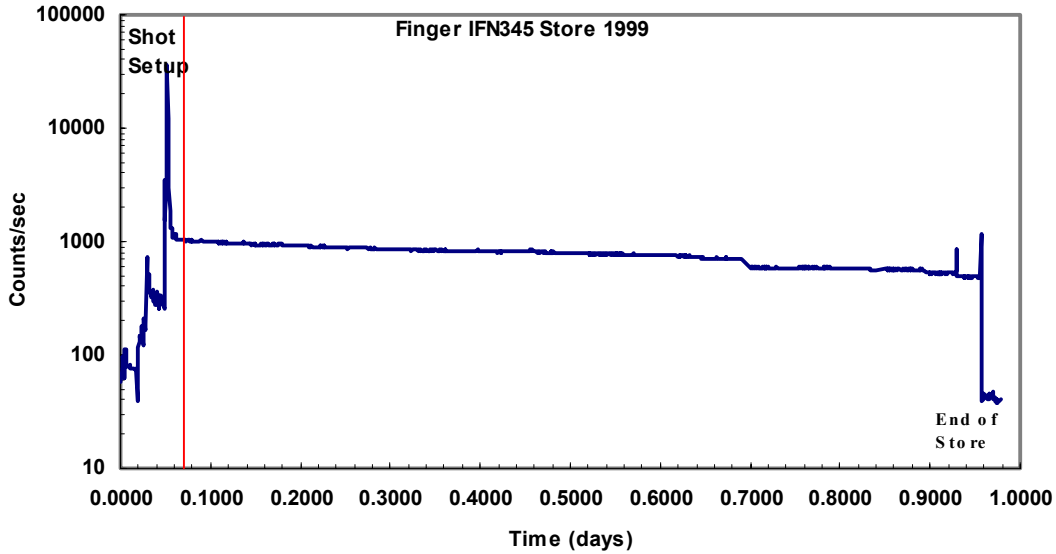
The radmon Circle plots

Wherever North is mentioned als South applies

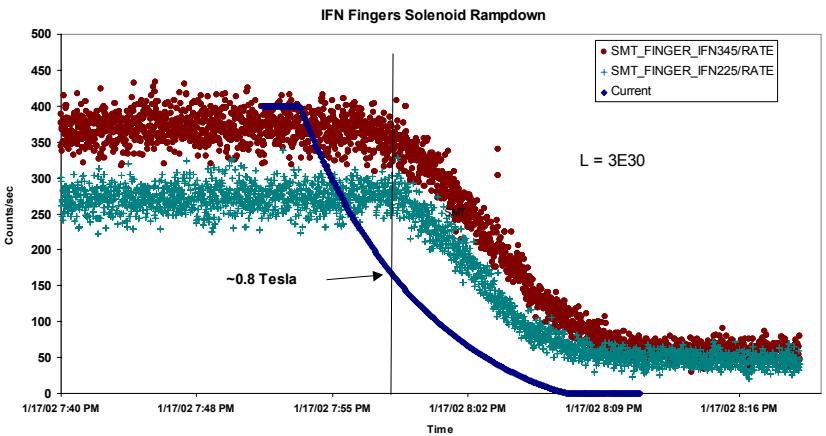
Finger Archiver

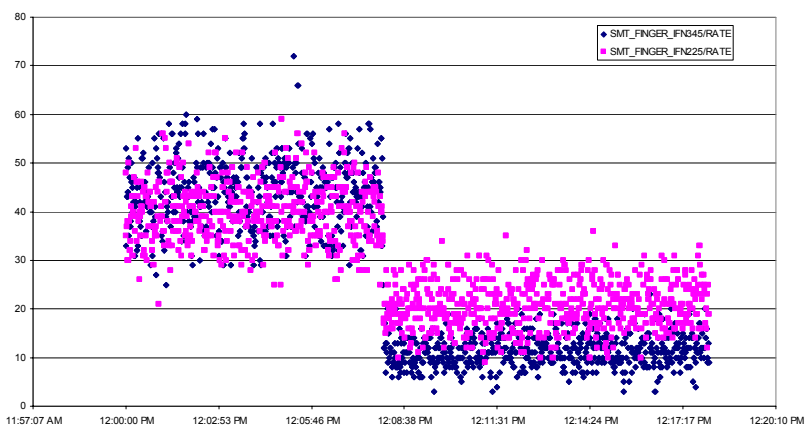
- To look at data from the SMT finger channel archiver: > cd /projects/archive/radmon/current
  > ls
  20011217-000000 archive_active.lck dir.20011217-095540 radmon_rad_low.cfg
  20011218-000000 cfg log radmon_scaler.cfg
  20011219-000000 config_file radmon_rad_high.cfg radmon_temp.cfg
  20011220-000000 core radmon_rad_int.cfg
  > setup d0online
  **** setup D0RunII t01.67.00
  > setup chan_archiver
  > Xarr.py dir.20011217-095540 & !paste name of current directory
  You then enter device names in the Xarr window, * can be used as a wild card.
  Names are: SMT_FINGER_AAANNN/XXX
- Where :
- AAA: IFN, IFS, OFN, OFS, IHN, IHS, OHN, OHS
- I: inner radius device
  O: outer radius device
  F: F Disk
  H: H Disk
  N: North
  S: South
  NNN: finger angle (12:00 = 0 degrees)
- F: 45,105,165,225,285,345
  H: 0,60,120,180,240,300
  XXX: RATE,RLVH,RLVL,INT
- RATE: scaler rate ~ 1/3 x MIP rate (working channels)
  INT : rolling sum of scaler rate.
  RLVH: Calculated dose rate from currents, high gain channel
  RLVL: Calculated dose rate from currents, low gain channel

Finger Diode II



Typical store – shot setup and normal running

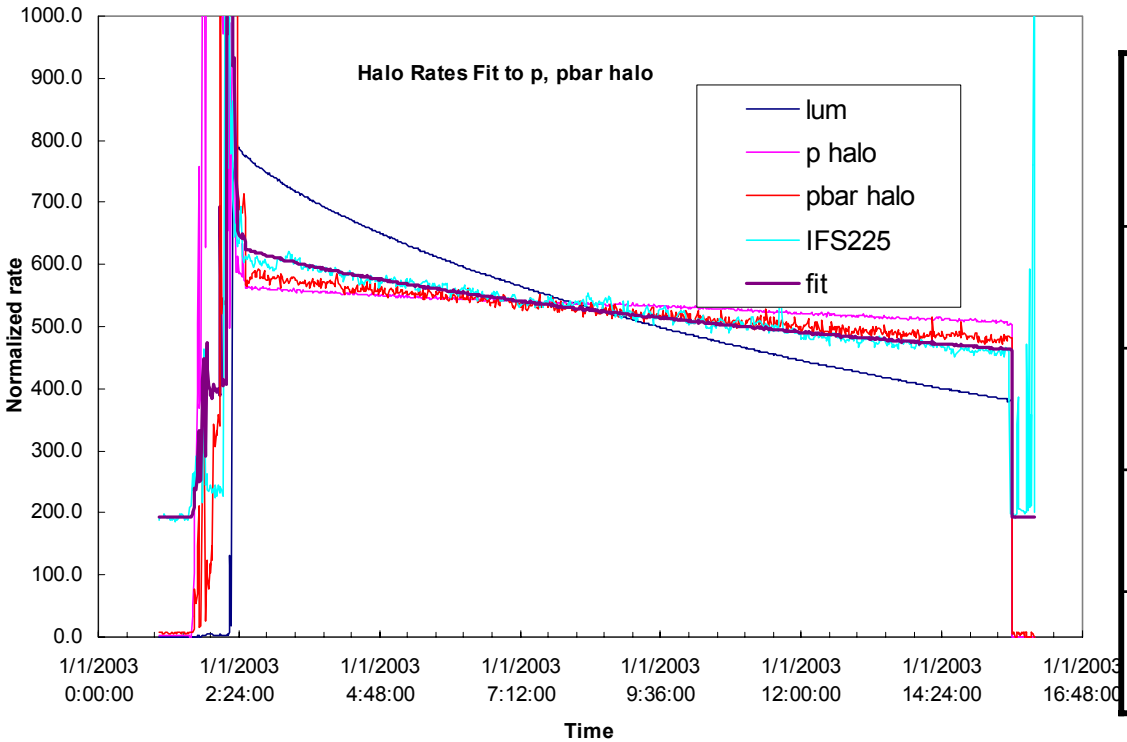




Effects of looping tracks on silicon Dose - compare with CDF at 1.5 T

Contributions of Luminosity and Halo

Technique – losses during a store have different shapes for halo and luminosity. Normalize to mid –store and fit finger rates to shapes of the luminosity and p/p halo rates. This gives us a rough idea of how losses contribute to irradiation.

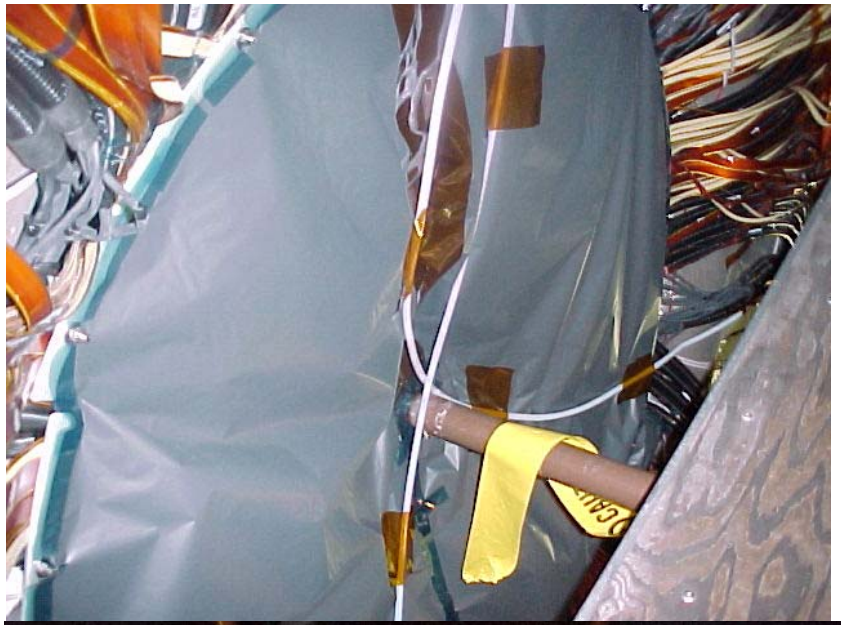


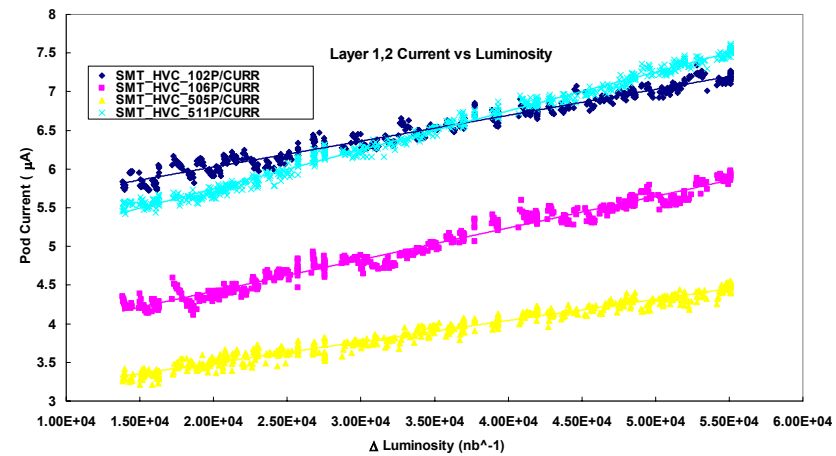
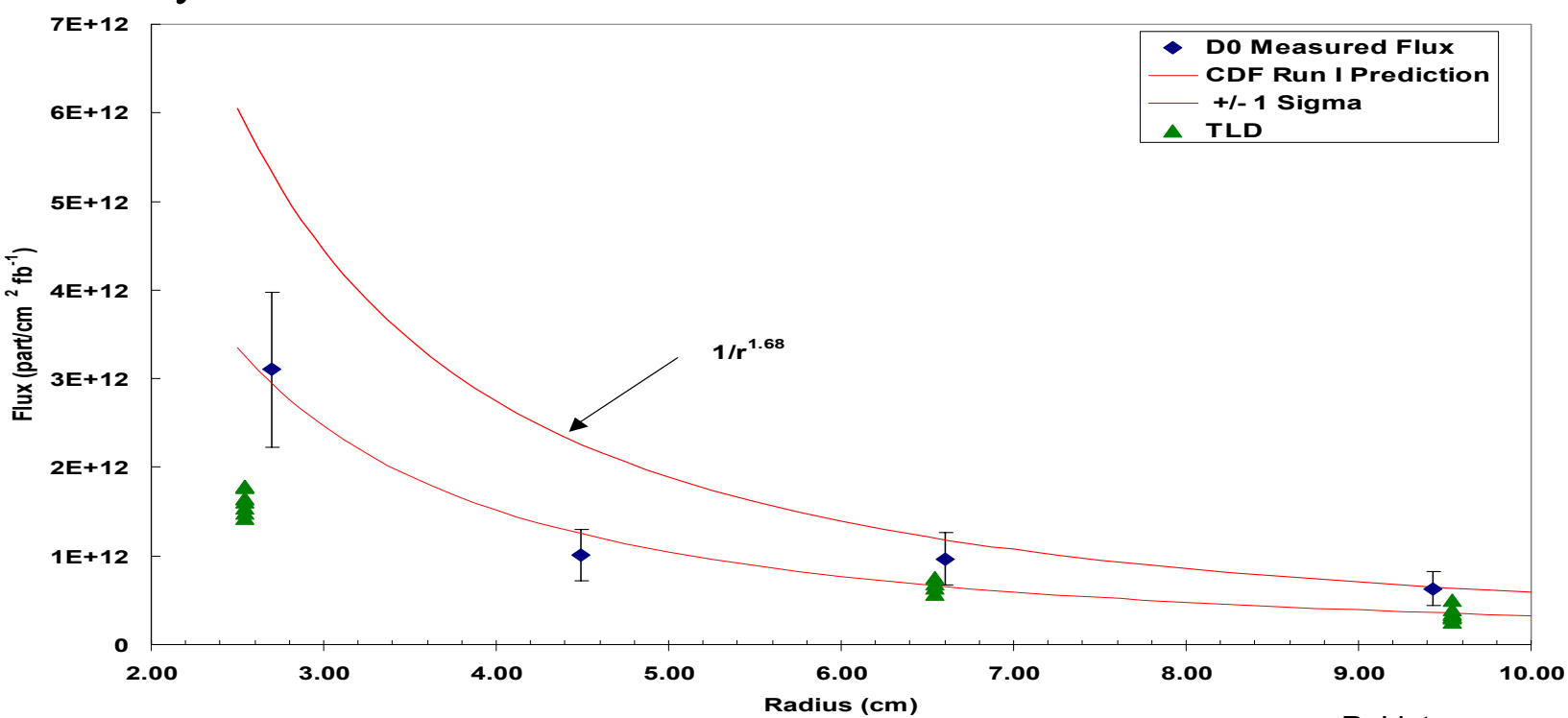
Name	Three parameter fit	Two Parameter fit
Phalo factor	0.150	0.250
Ahalo factor	0.121	
Lum Factor	0.359	0.378
Lum fraction	0.57	0.60

Rates for store 2121. Fit is to pbar, p halo and luminosity

TLDs

- TLD 600 (β, γ and neutrons)
- TLD 700 (β, γ only)
- Calibrated to few % but only linear to ~ 5-10 Krad
- Added Al foils to integrate larger doses (1 year)
- Installed removable system during shutdown



Dose estimate

- Particle flux as calculated from leakage current increase as a function of radius. Correct for temperature, area, annealing …
- Errors on the D0 points are statistical only