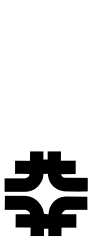
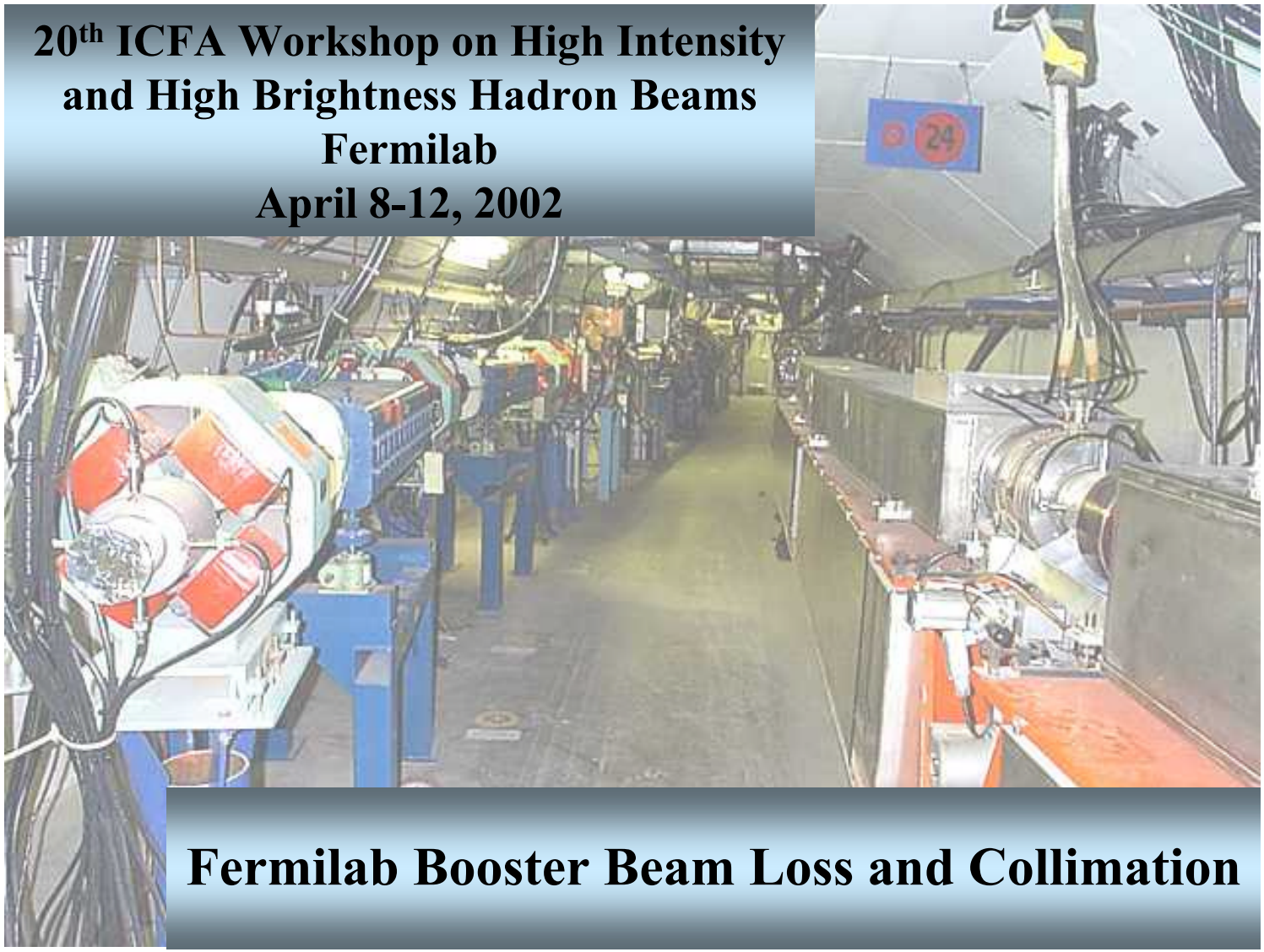


Proton Source Department

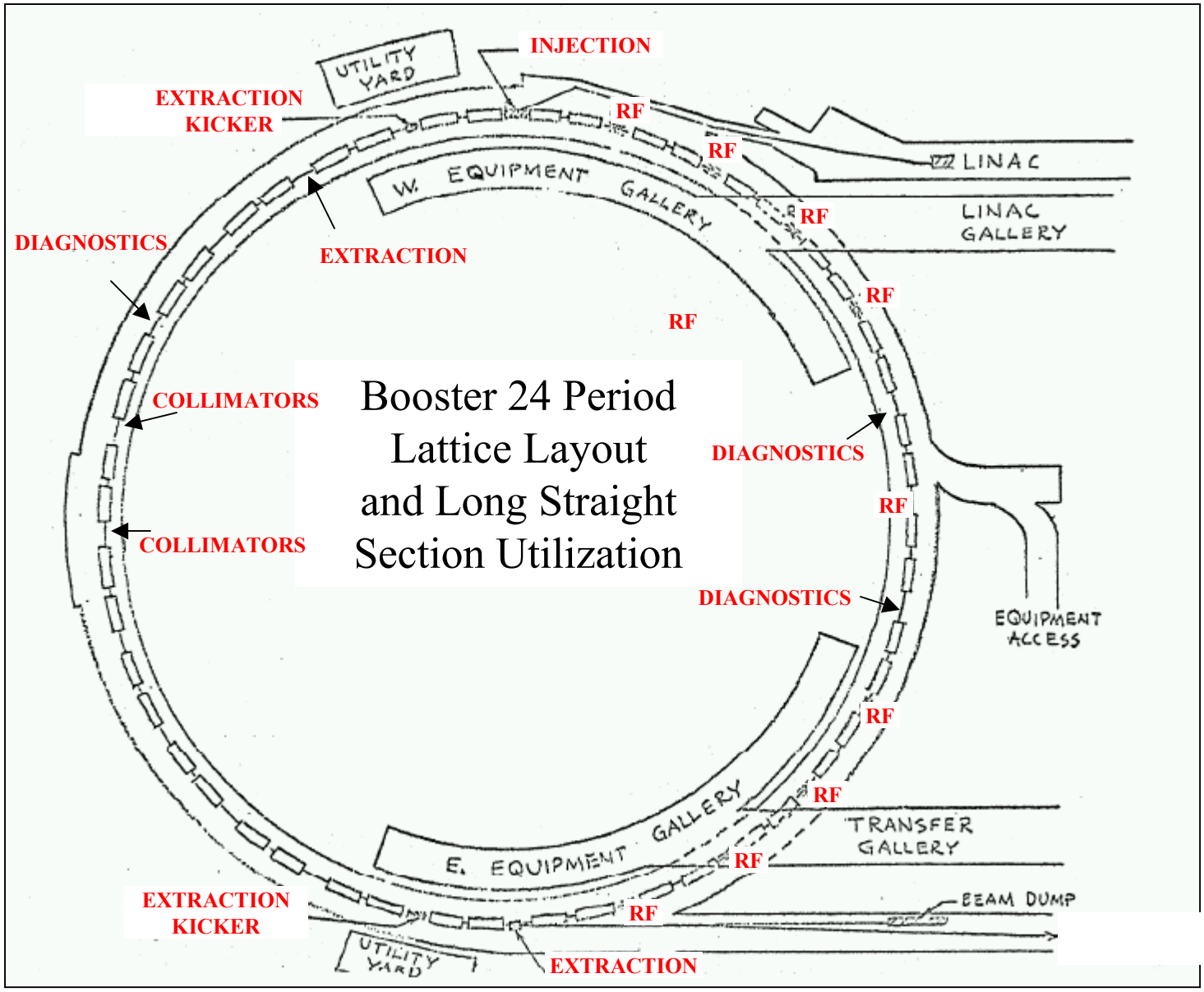
20th ICFA Workshop on High Intensity and High Brightness Hadron Beams
Fermilab
April 8-12, 2002



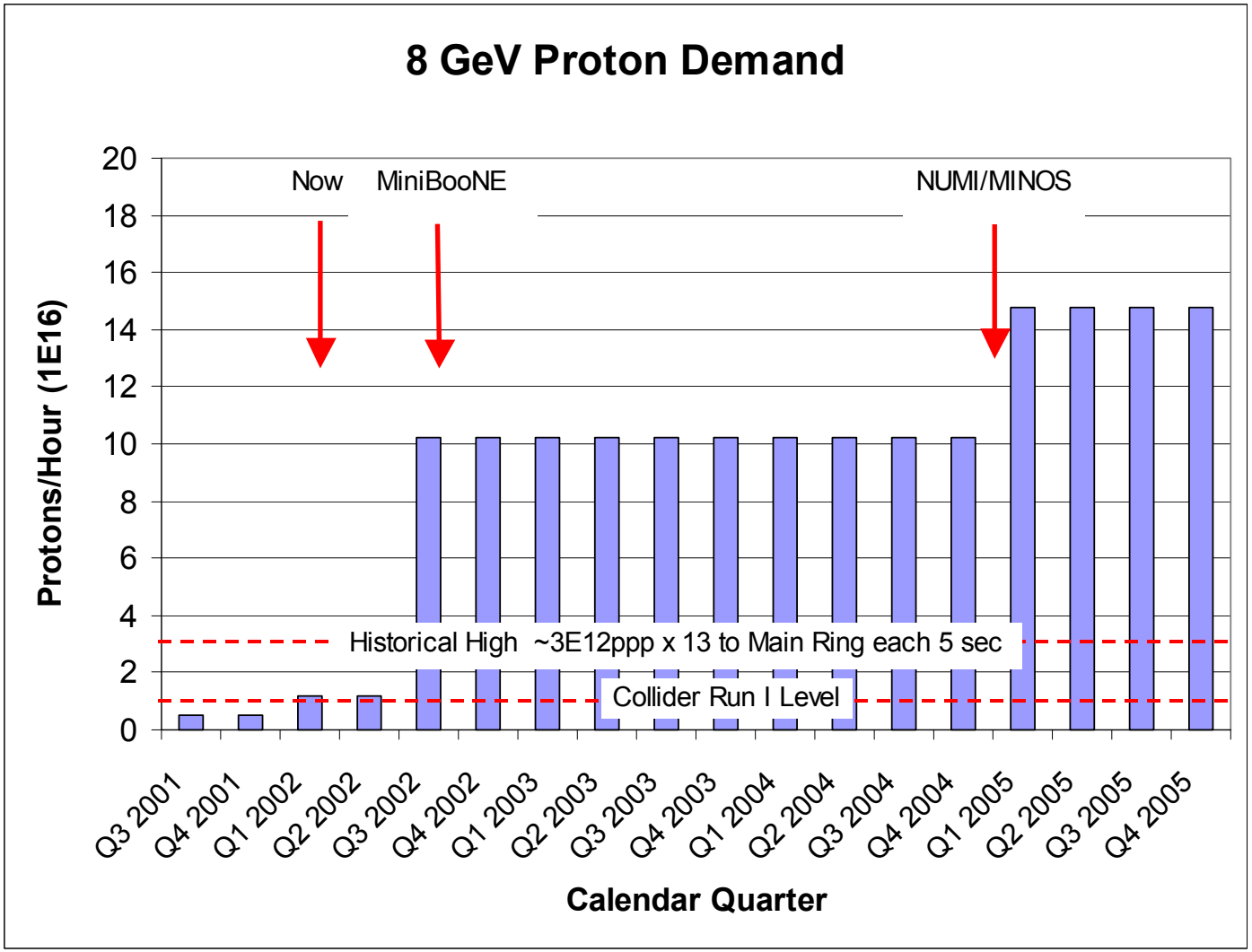
Fermilab Booster Beam Loss and Collimation

Fermilab Booster Parameters

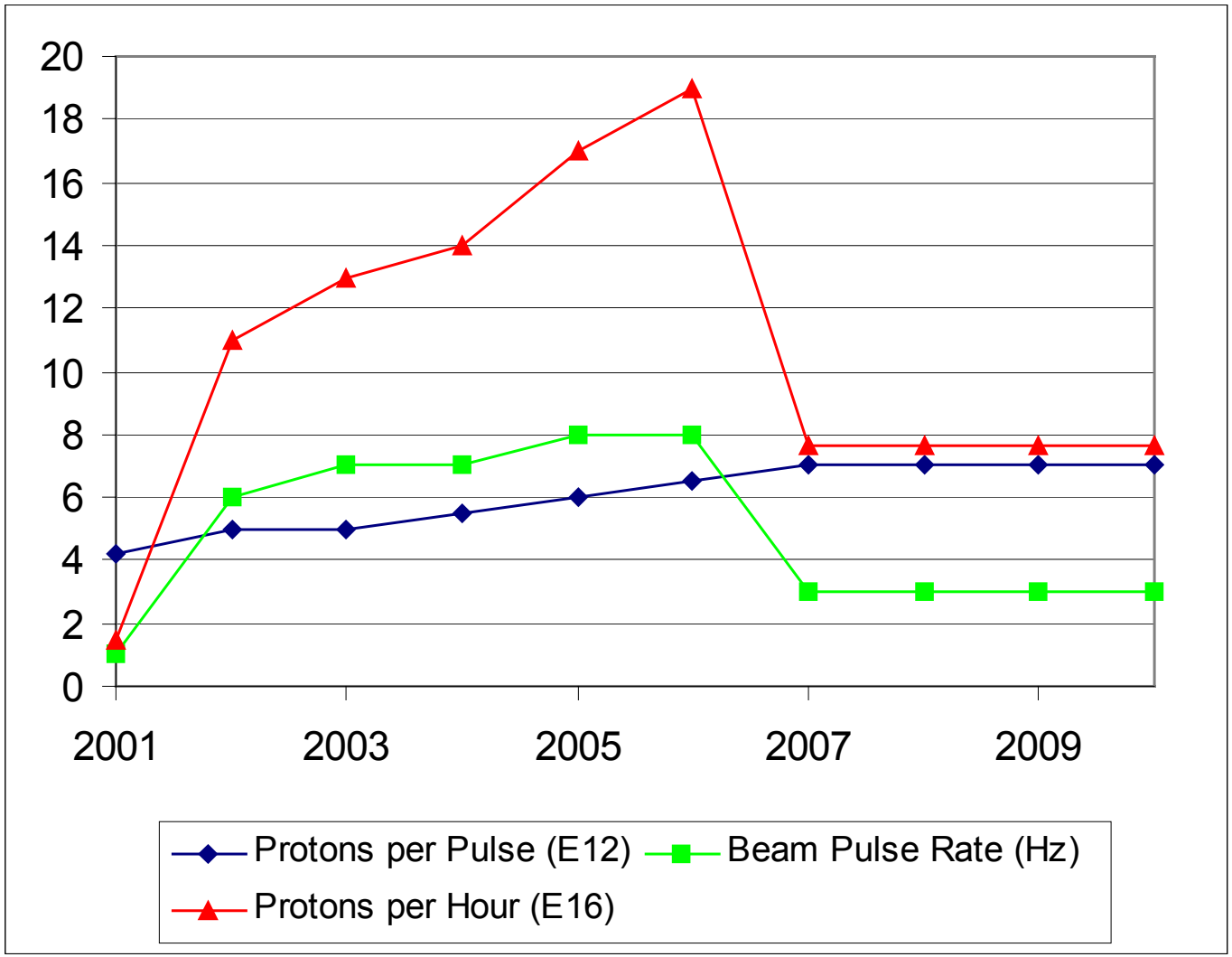
- 200 MeV -- 8 GeV proton synchrotron built ~ 1970
- Combined function magnetic lattice with $\gamma_t = 5.4$
- 75 meter average radius
- 15Hz resonant magnetic cycle
- Harmonic 84 RF system, 38 - 53 Mhz
- Adiabatic capture of injected beam by Booster RF
- Upgrade to H- charge exchange injection in 1977
- Upgrade to 400 MeV injection in 1993
- Primary extraction point relocated to Long 3 in 1997
- Inadequate passive radiation shielding for beam demand
- Power, control, and infrastructure systems and components aging


Booster 24 Period
Lattice Layout
and Long Straight
Section Utilization
INJECTION
EXTRACTION
KICKER
EXTRACTION
DIAGNOSTICS
COLLIMATORS
COLLIMATORS
DIAGNOSTICS
DIAGNOSTICS
EXTRACTION
KICKER
EXTRACTION
RF
UTILITY YARD
W. EQUIPMENT GALLERY
E. EQUIPMENT GALLERY
LINAC
LINAC GALLERY
TRANSFER GALLERY
EQUIPMENT ACCESS
BEAM DUMP
UTILITY YARD

Demand Schedule for 8 GeV Protons



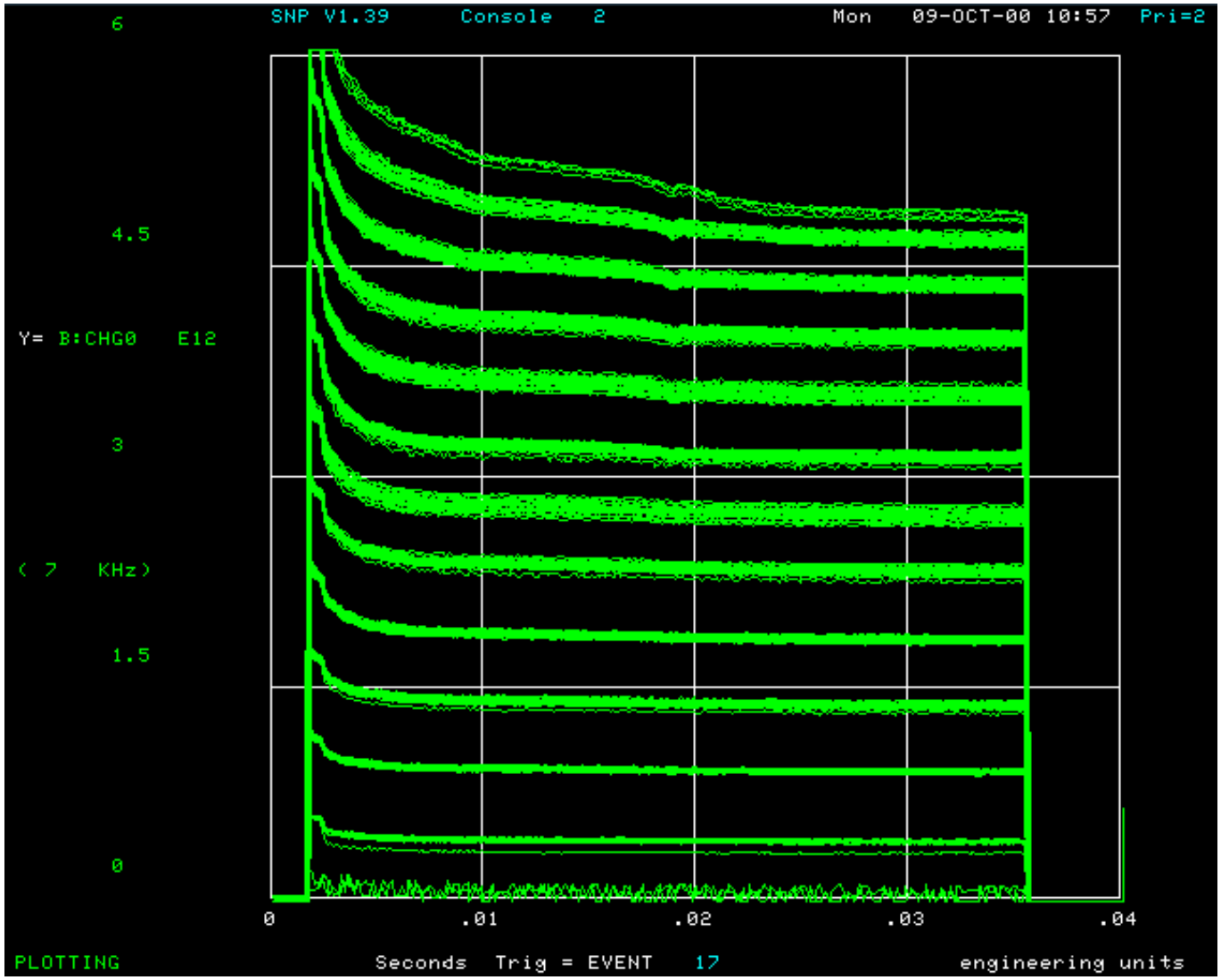
Proposed 8 GeV Proton Production by Year



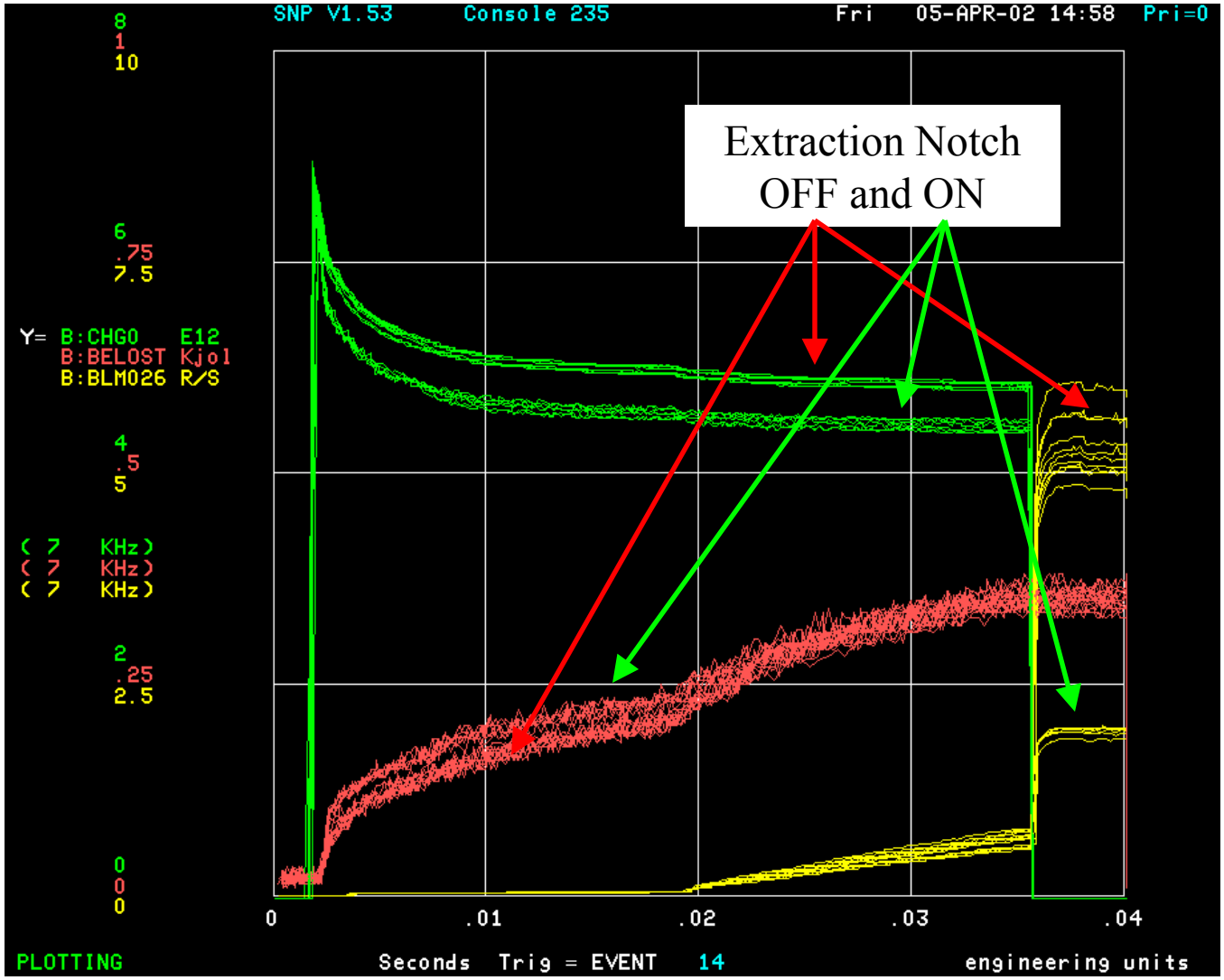
The Challenge and Actions

- To meet the increasing demand for protons from a 30 year old machine without destroying it and within the safety regulations of the Fermilab Radiation Control Manual
- Increase intensity 25% and rep rate 10x from current levels
- This is a challenge to the entire program of the Laboratory. Every proton utilized by any Fermilab HEP experiment (RunII, MiniBooNE, NUMI, SY120) for at least the next 6 years must be accelerated by the present Booster.
- Attack the causes of beam loss and resultant radiation
  - Ramp controls for dipole corrector system
  - Longitudinal and transverse? dampers
- Mitigate the effects of unavoidable beam loss and radiation
  - Collimator system
  - New BLM data acquisition/logging system (hardware & software)

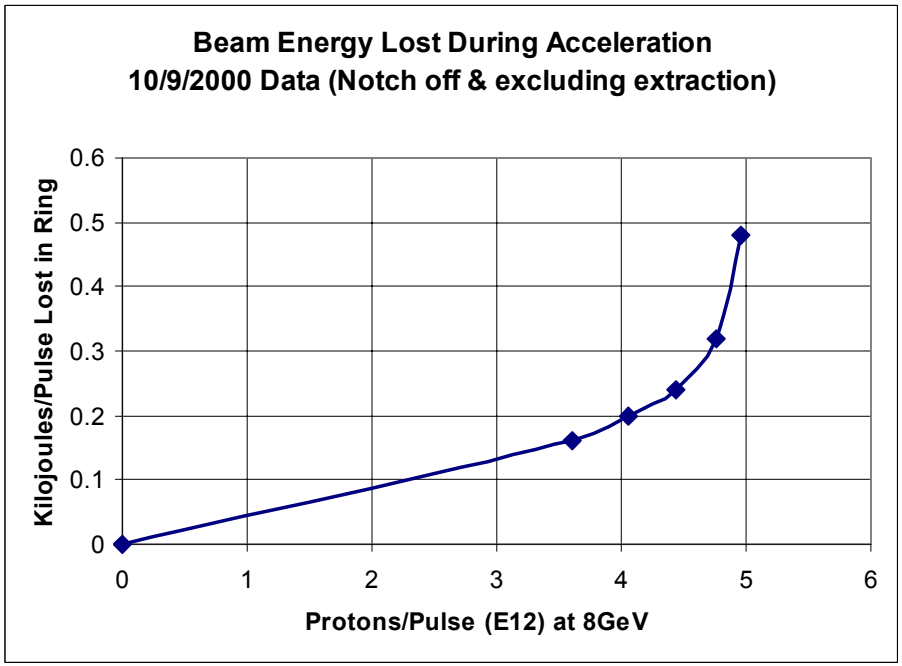
Booster Intensity Up to 12 Injected Turns

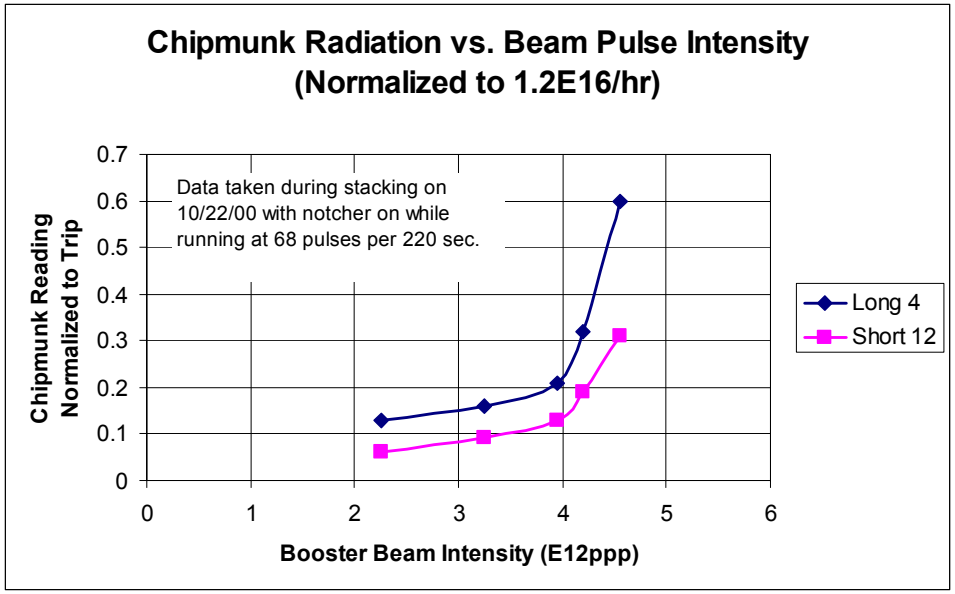


Booster Charge, Integrated Beam Energy Lost, and Extraction Region Loss Monitor

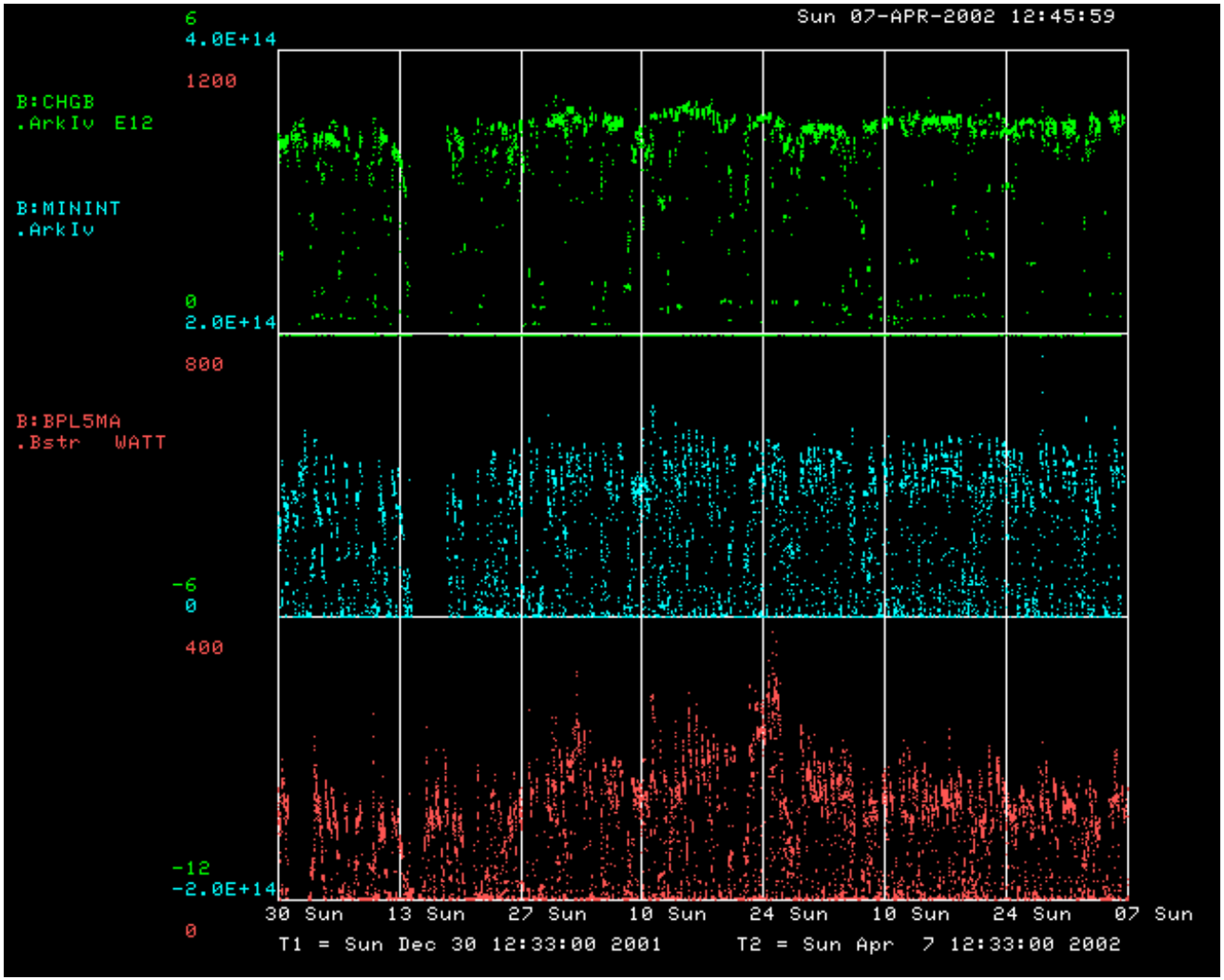


Beam Loss Intensity Sensitivity





14 Weeks of Operation in 2002



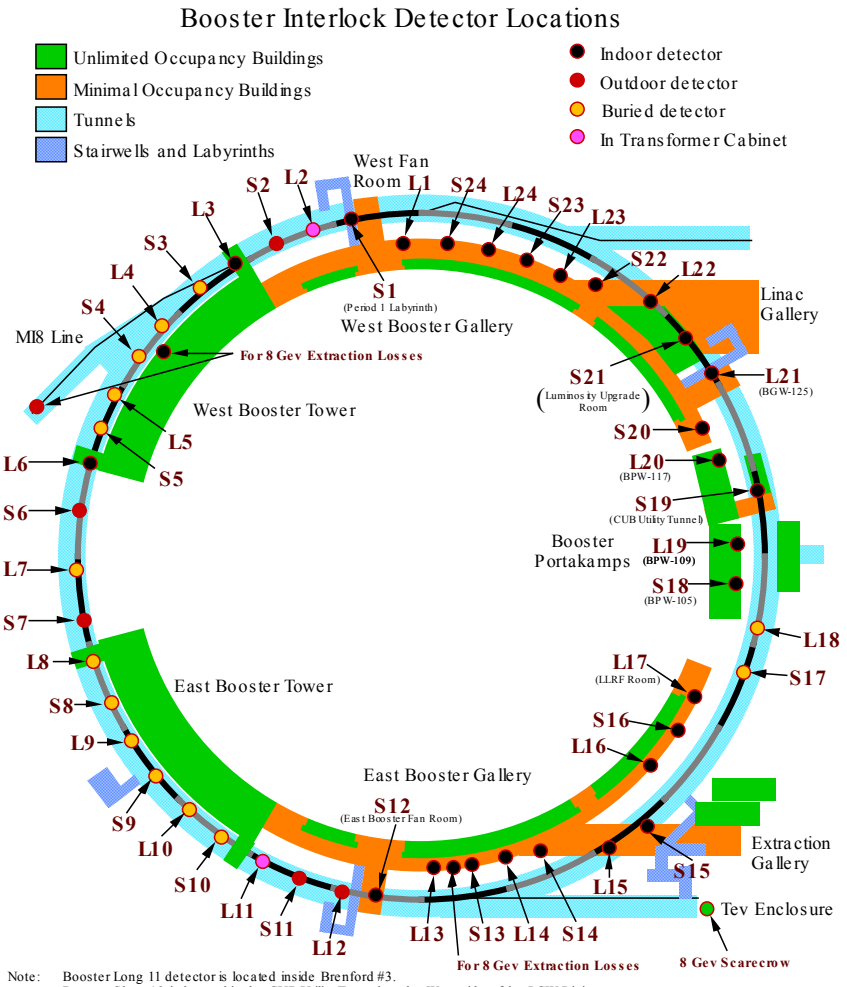
Operation to Date in 2002

SUMS FROM TUE 01-JAN-2002 TO SUN 07-APR-2002 07-APR-2002 12:40:21
99.5 % of time interval recorded
marsh.bbmyrsumdatadatav2 SUM FROM 01-JAN-2002 00:00:00 TO 07-APR-2002 12:00:00

LABEL	TOROID	SUM	HAND SUM	CORRECTION	TOTAL	<--SUM TIME--> YR LIMIT	% SUM	% HAND
NTF	L:CINT	2.20E+19	0	0	2.20E+19		100	0
LINAC	L:RF3INT	1.94E+19	0	0	1.94E+19		100	0
	B:CHG1	6.95E+18	0	0	6.95E+18		100	0
BOOSTER	B:CHGBBM	7.06E+18	0	0	7.06E+18		100	0
REV INJ-99	M:TOR105	1.24E+15	0	0	1.24E+15		100	0
8 GEV->MI	B:BBM800	6.96E+18	0	0	6.96E+18		100	0
AP0--81	M:TOR109	5.17E+18	0	0	5.17E+18	1.390E+20	100	0
TEV--42	T:IBEAMB	7.03E+14	0	0	7.03E+14		100	0
TEVABRT 47	T:ABTINT	6.39E+13	0	0	6.39E+13		100	0
TEVABRT 4b	T:ABTINT	6.72E+14	0	0	6.72E+14		100	0
	B:CHG2	7.10E+18	0	0	7.10E+18		100	0
MI8 DUMP	I:TOR833	0	0	0	0	3.500E+18	100	0
BOOST DUMP	B:BBM10	8.61E+17	0	0	8.61E+17	6.900E+19	100	0
RECYCLR-f2	R:TOR803	6.50E+15	0	0	6.50E+15		100	0
RECL DUMP	R:TOR003	3.36E+15	0	0	3.36E+15		100	0
MI ABRT	I:TOR003	1.80E+14	0	0	1.80E+14		100	0
MI CLEAN	I:TOR003	6.30E+16	0	0	6.30E+16		100	0
F PRTN--86	M:TR109L	2.38E+10	0	0	2.38E+10	1.390E+20	100	0
SY DUMP	S:SYDUMP	0	0	0	0	8.000E+16	100	0
RAD DAMAGE	B:BBMRDF	2.10E+16	0	0	2.10E+16	3.800E+18	100	0
NO THRESH	S:SYDUMP	0	0	0	0		100	0
TEV 47	C:BBMIBM	4.51E+14	0	0	4.51E+14		100	0
TEV 4B	C:BBMIBM	8.02E+14	0	0	8.02E+14		100	0
LINAC 2	L:D74INT	1.89E+19	0	0	1.89E+19		100	0
	B:BIM10	8.60E+17	0	0	8.60E+17		100	0
	B:TORRDF	2.57E+16	0	0	2.57E+16		100	0
	D:TOR910	1.38E+17	0	0	1.38E+17		100	0
TEV ABRT		6.80E+14	0	0	6.80E+14	7.00E+17		
A0 ABRT		5.17E+14	0	0	5.17E+14			

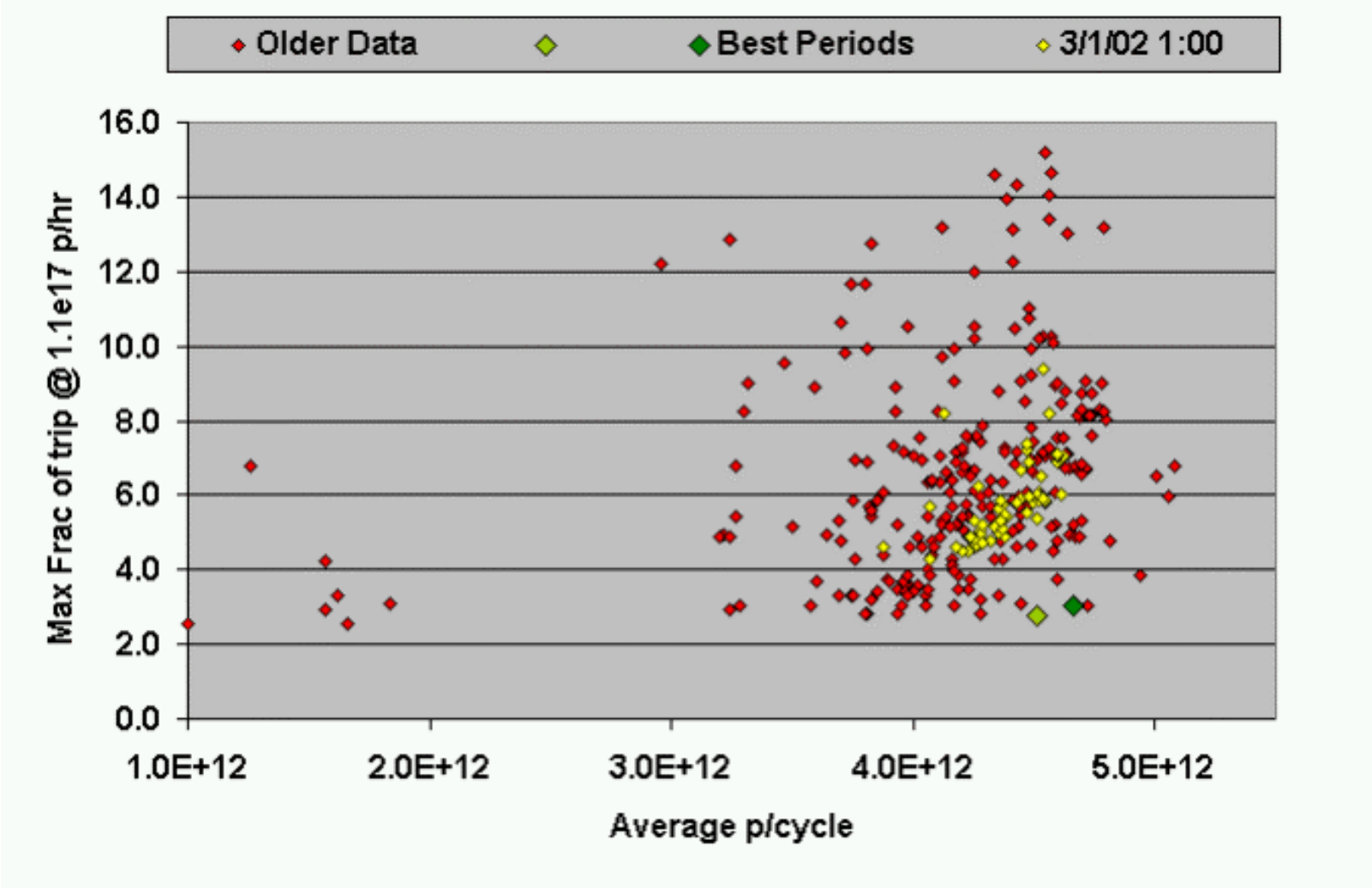
7.06E18 in 14 Weeks corresponds to average intensity of 3E15pph

Surrounded by Chipmunks

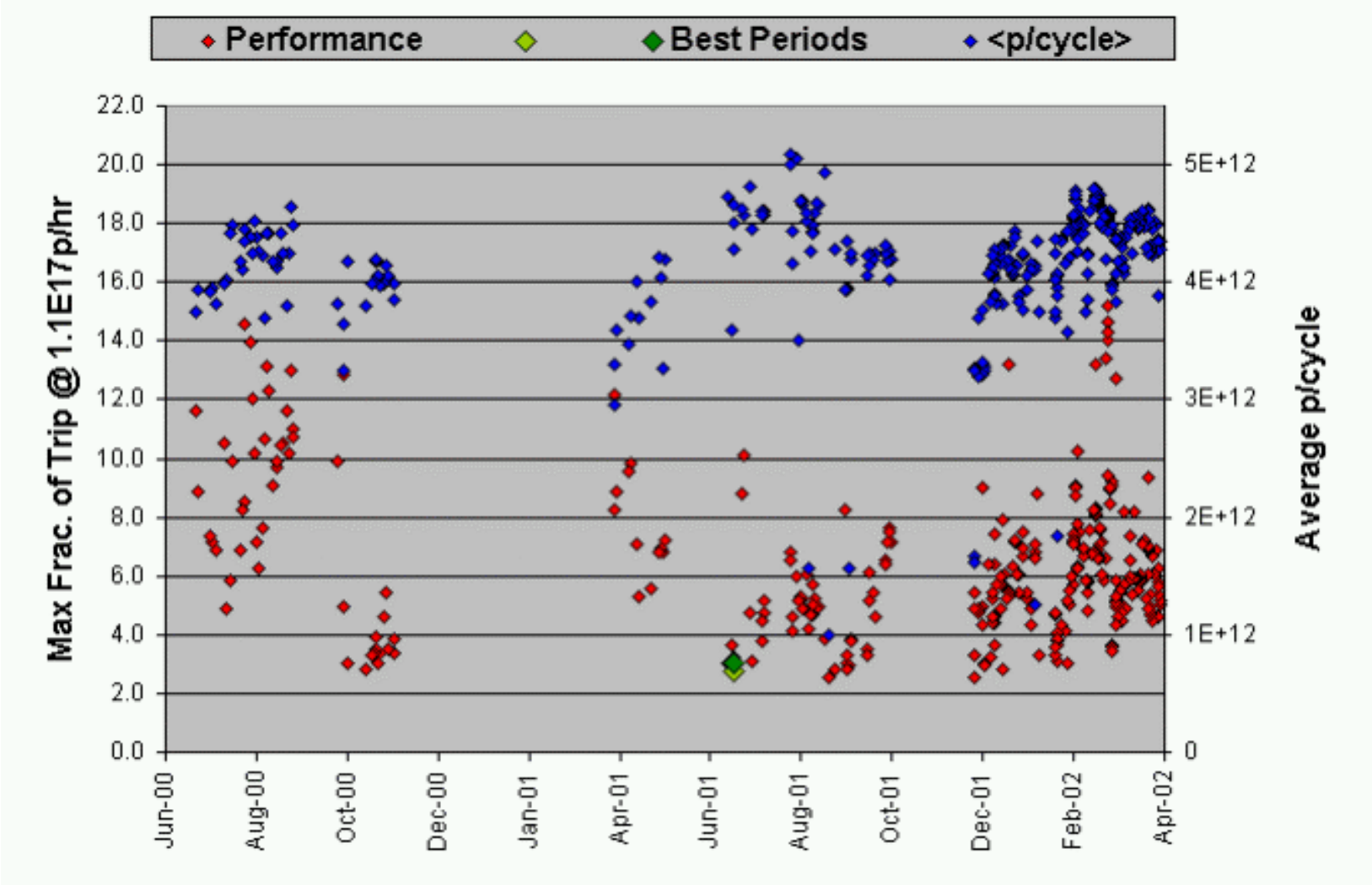


Note: Booster Long 11 detector is located inside Brenford #3.
Booster Short 19 is located in the CUB Utility Tunnel on the West side of the LCW Piping.
Booster Short 12, located in the East Booster Fan Room, requires an AC-33 key.
Booster Long 21, located in BGW-125, requires an AC-2 key.
Booster Short 21, located in the Luminosity Upgrade Room, requires an AC-2 key.
Booster Long 7 located in a manhole in the road between the Booster Towers.
Booster Long 2 detector is located in the YBW1 transformer cabinet.
The 8 Gev Line Sarecrow is located in the Tev enclosure.

Chipmunk View of Performance vs. Intensity



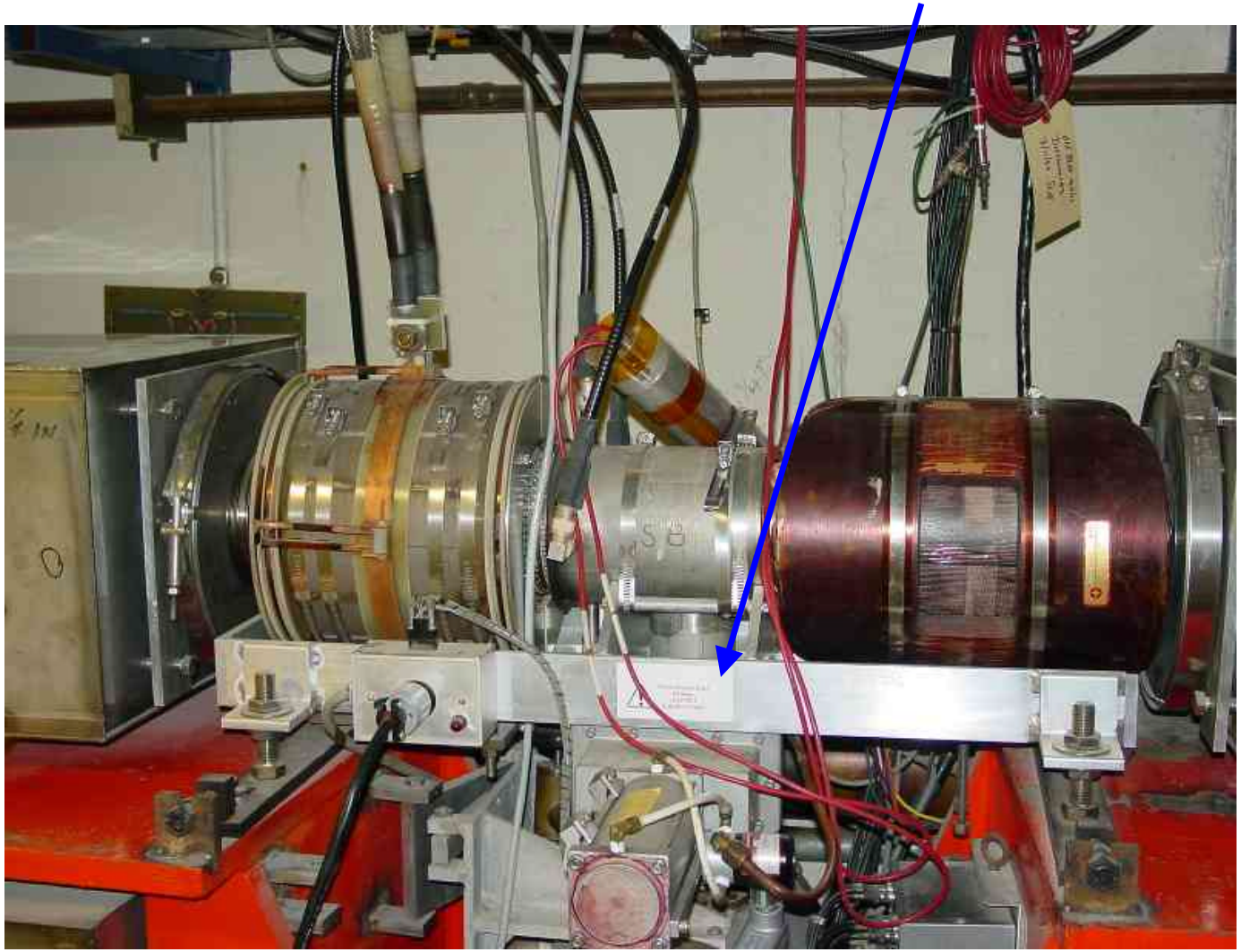
Chipmunk View of Performance vs. Time



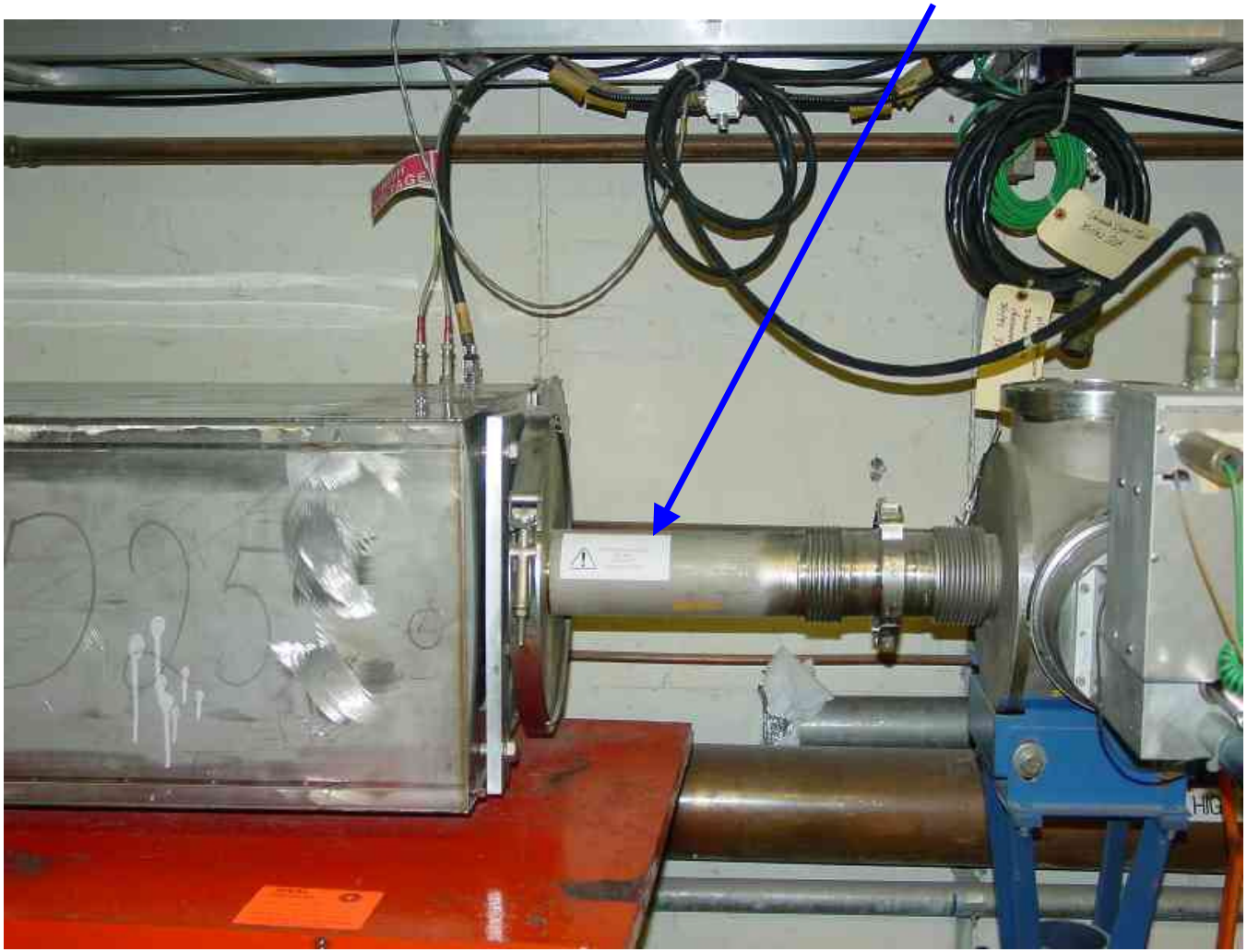
Residual Radiation Tracking Program

- Establish "fixed" measurement locations around Booster ring
  - Selected easily repeatable measurement locations
  - Some measurements at contact (some on beam pipe some not) and some at 1 foot
- Make measurements most opportunities for access
- Typically 2-8 hours after beam is shut down
  - "fuzzy" number because operation is irregular
- Provide good "baseline" prior to MiniBooNE operation

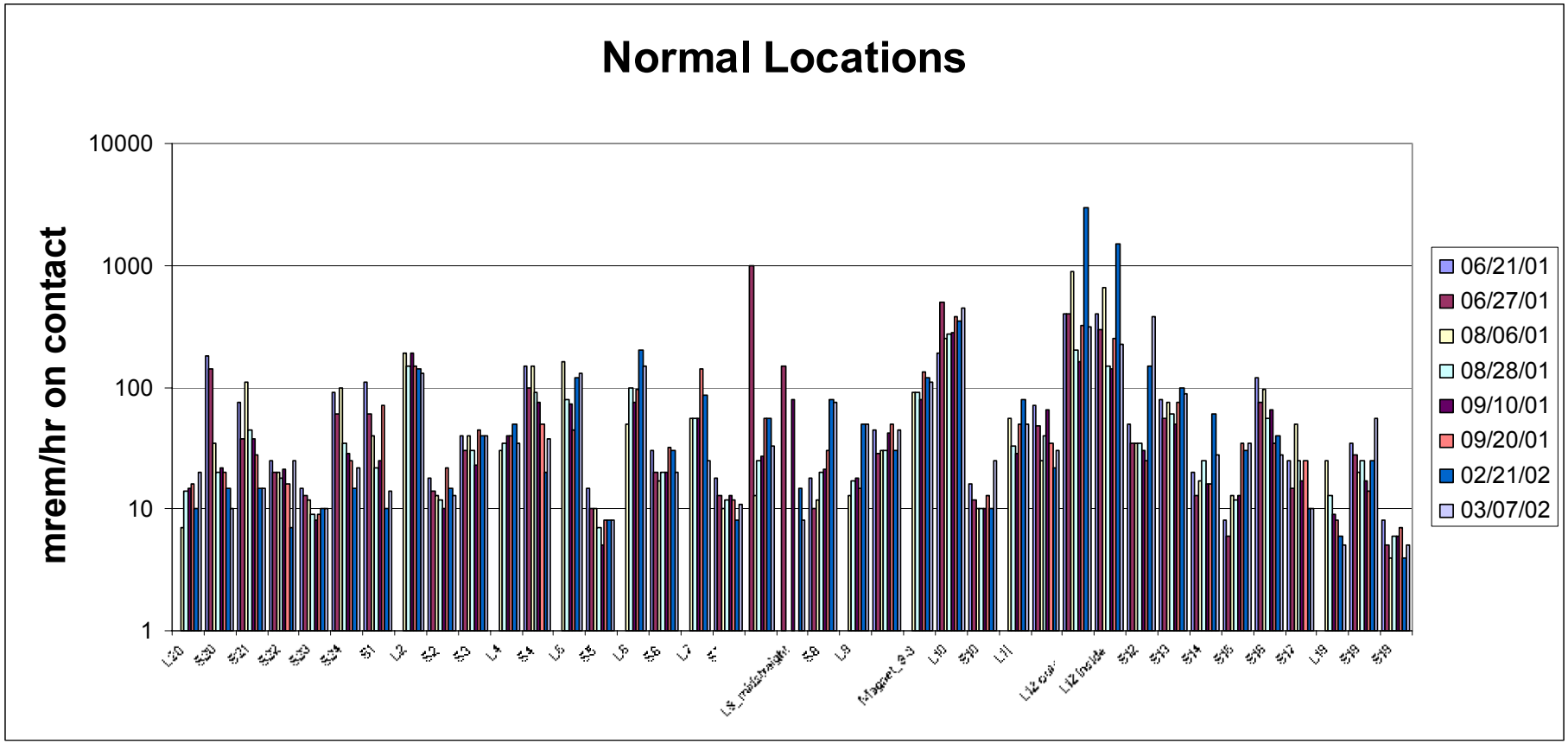
Short Straight Survey Point (@contact)



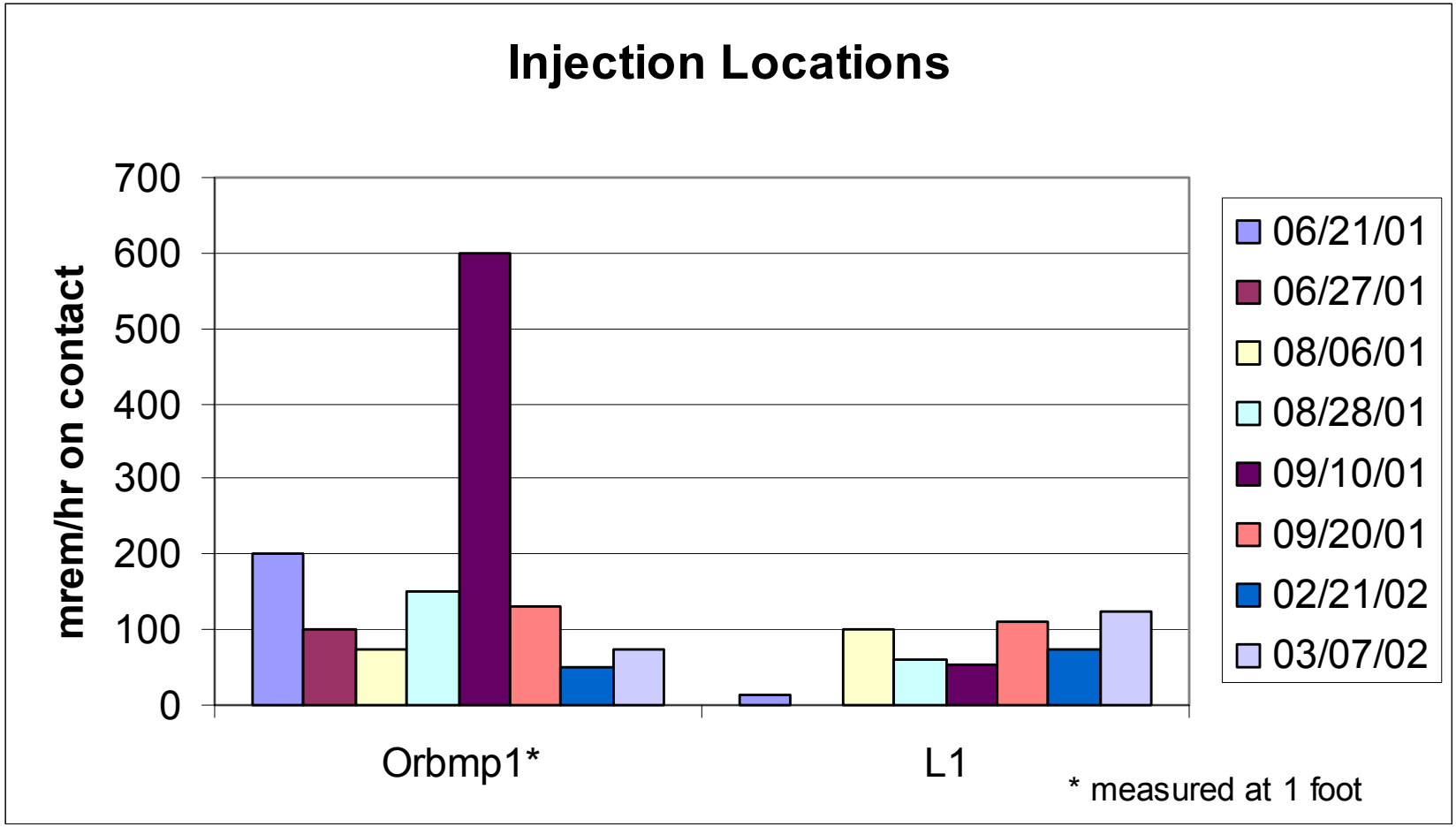
Long Straight Survey Point (@contact)



Booster Residual Radiation Data

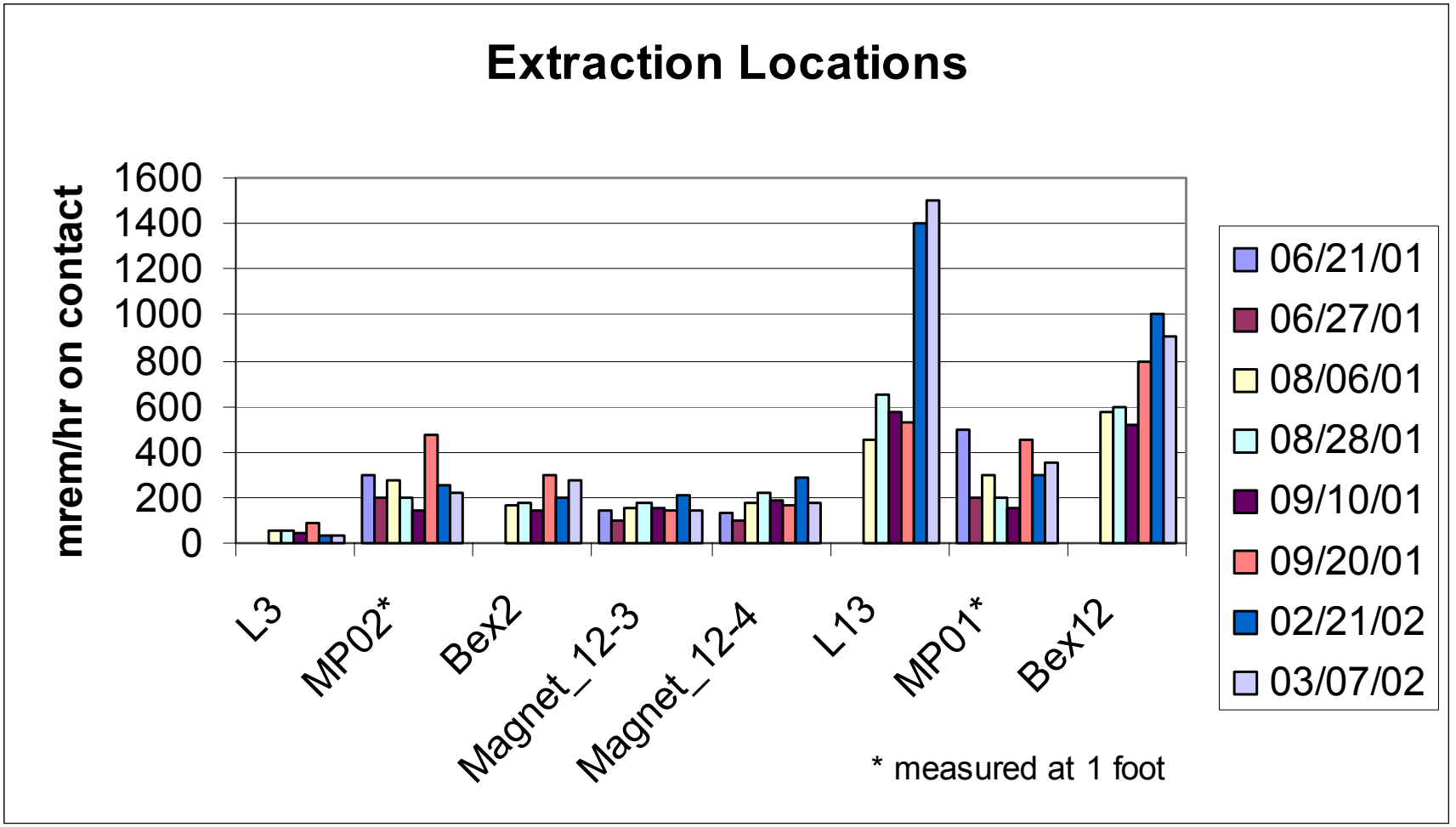


Booster Residual Radiation Data

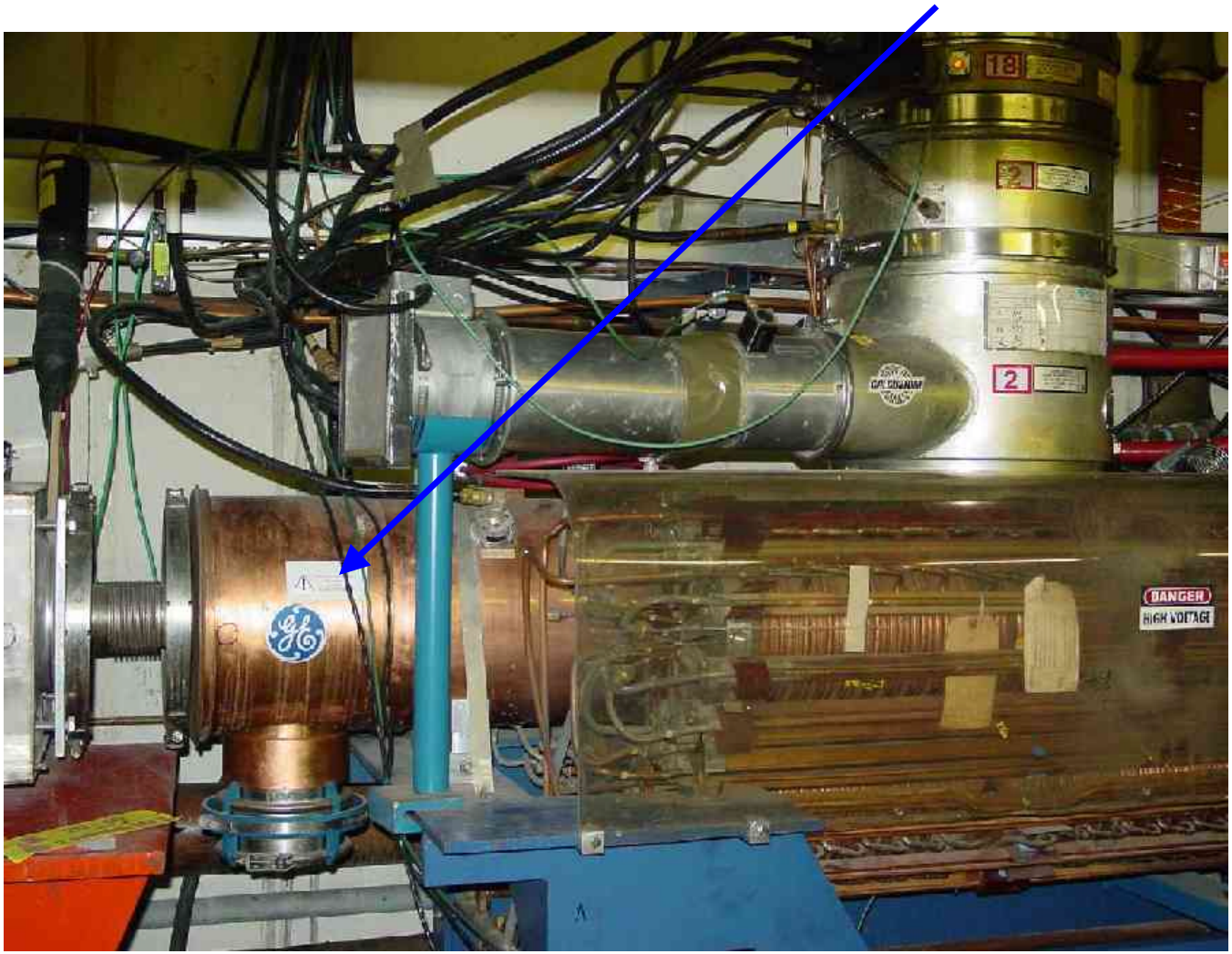


Extraction Survey Point (@ 1 foot)

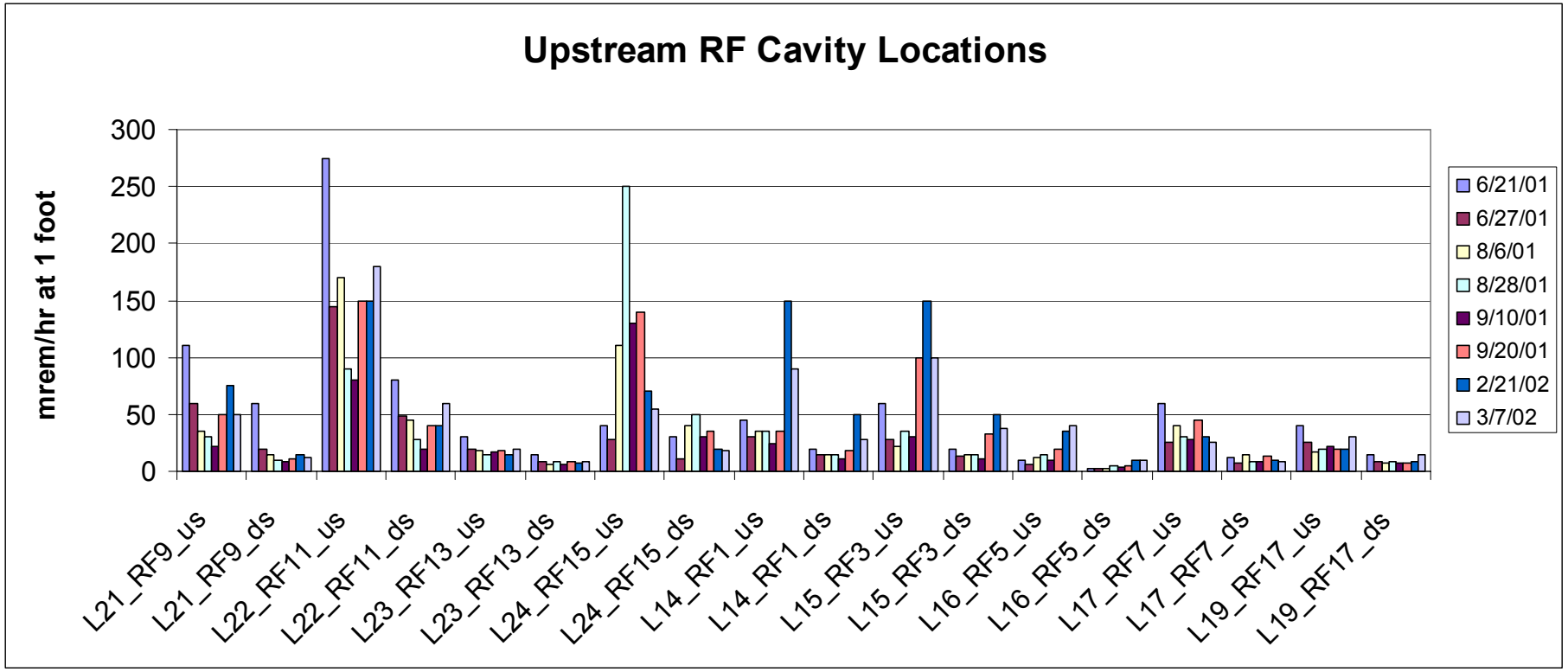
Booster Residual Radiation Data



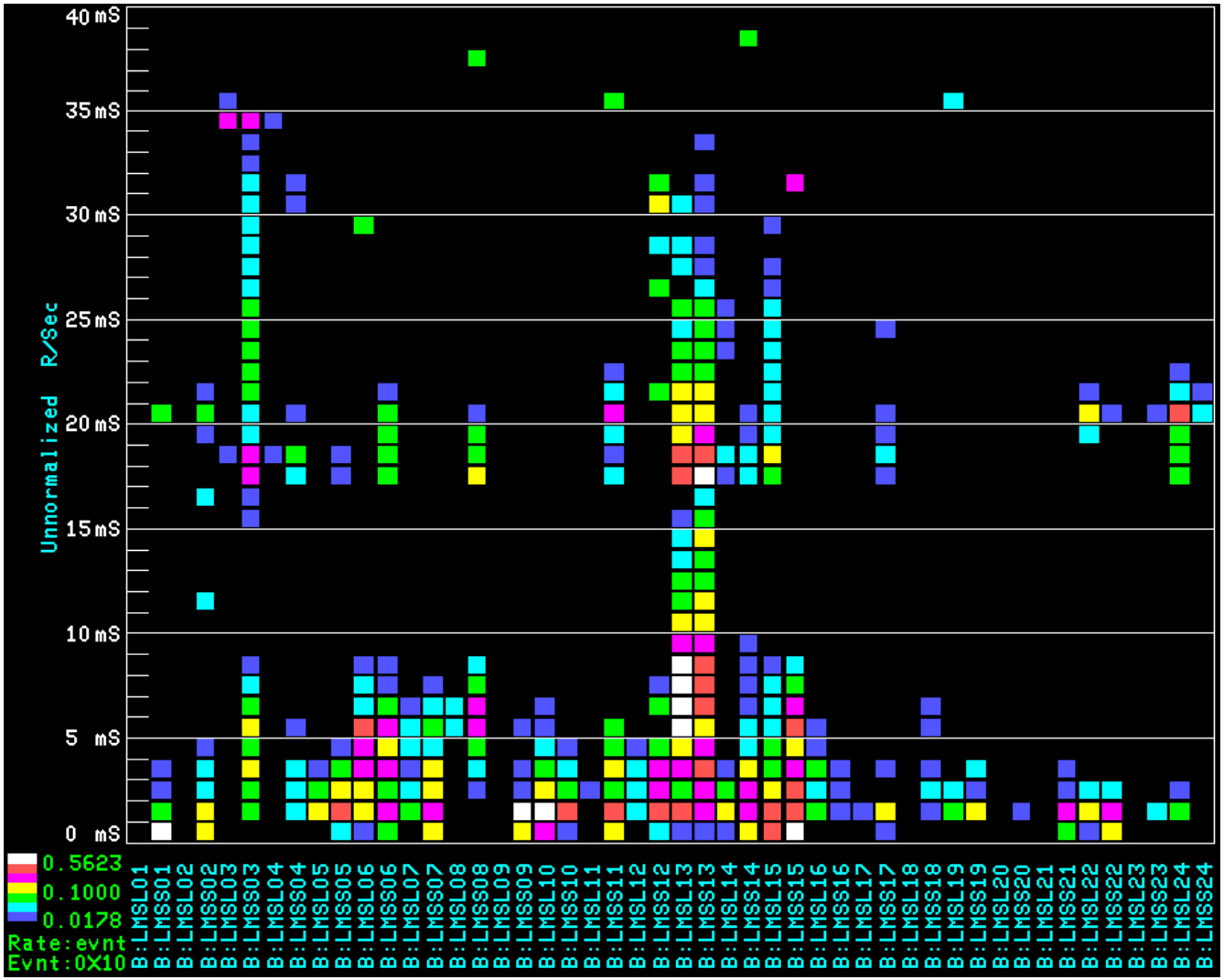
RF Cavity Survey Point (@ 1 foot)



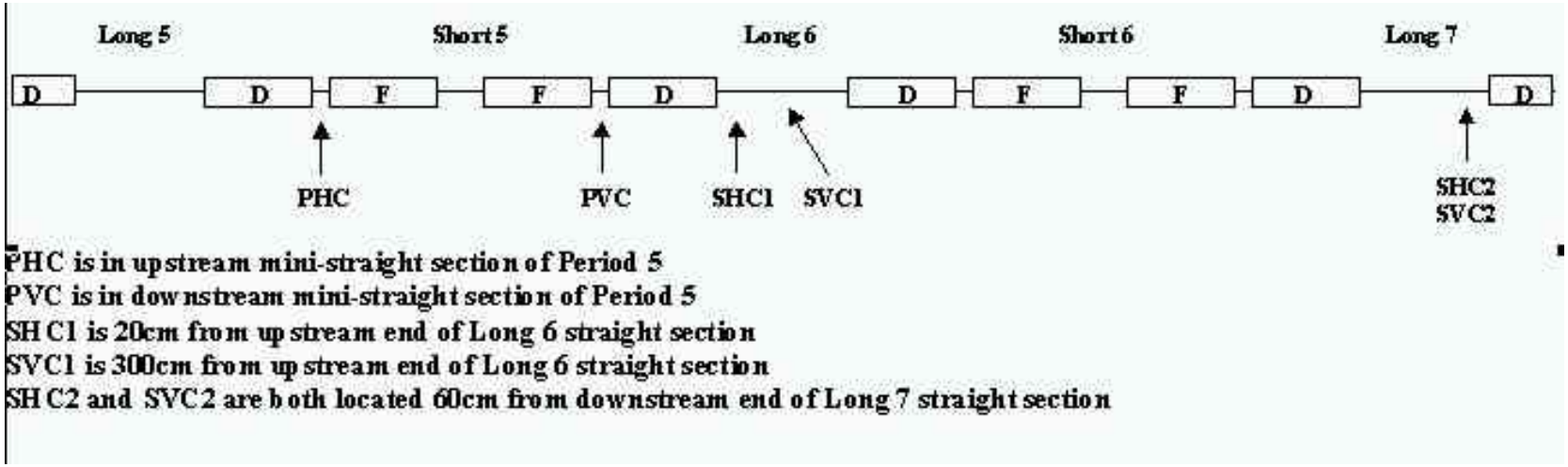
Booster Residual Radiation Data



Typical Operational Booster Beam Loss Plot

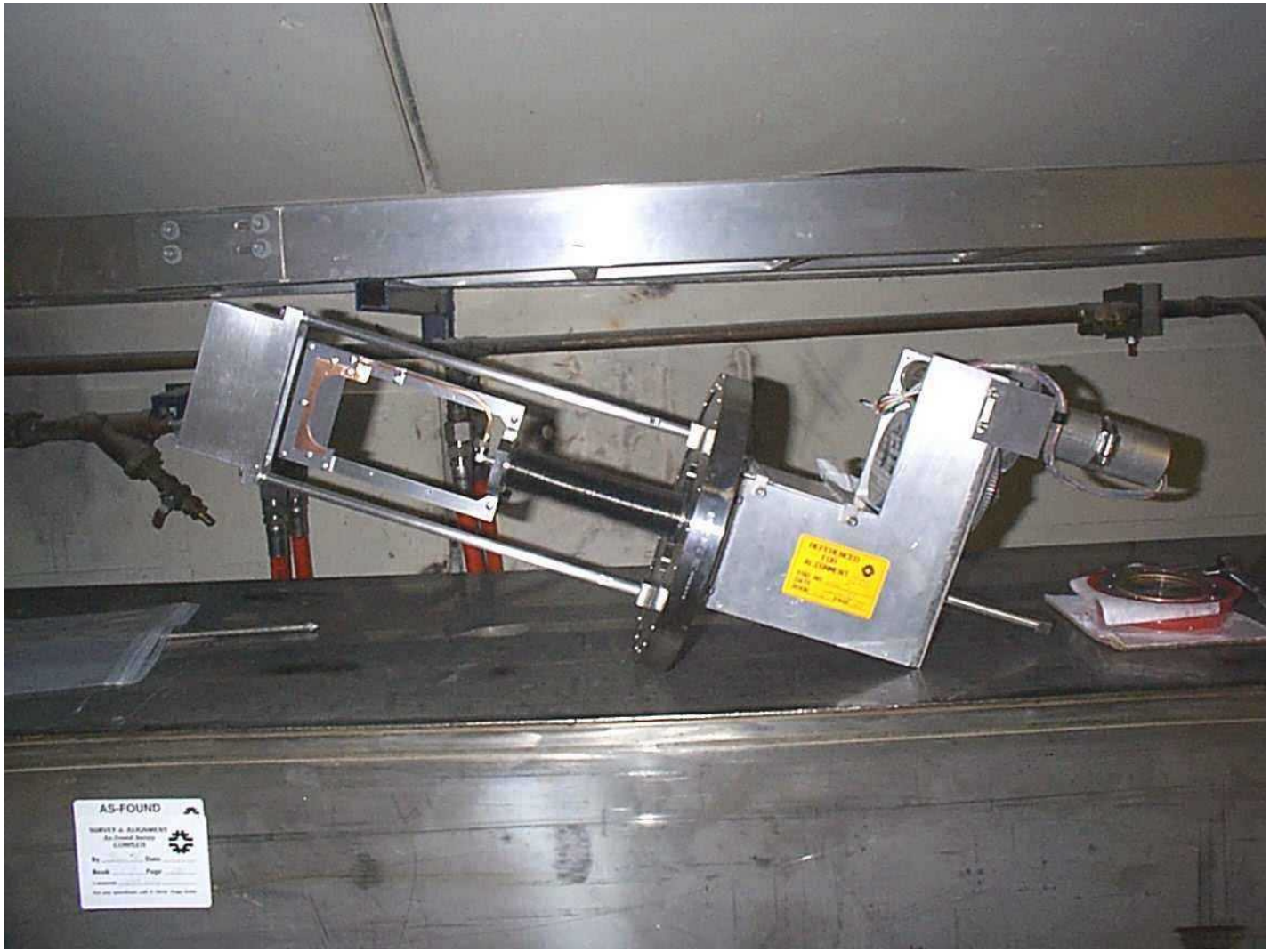


Planned Booster Collimator Layout



PHC is in upstream mini-straight section of Period 5
PVC is in downstream mini-straight section of Period 5
SHC1 is 20cm from upstream end of Long 6 straight section
SVC1 is 300cm from upstream end of Long 6 straight section
SHC2 and SVC2 are both located 60cm from downstream end of Long 7 straight section

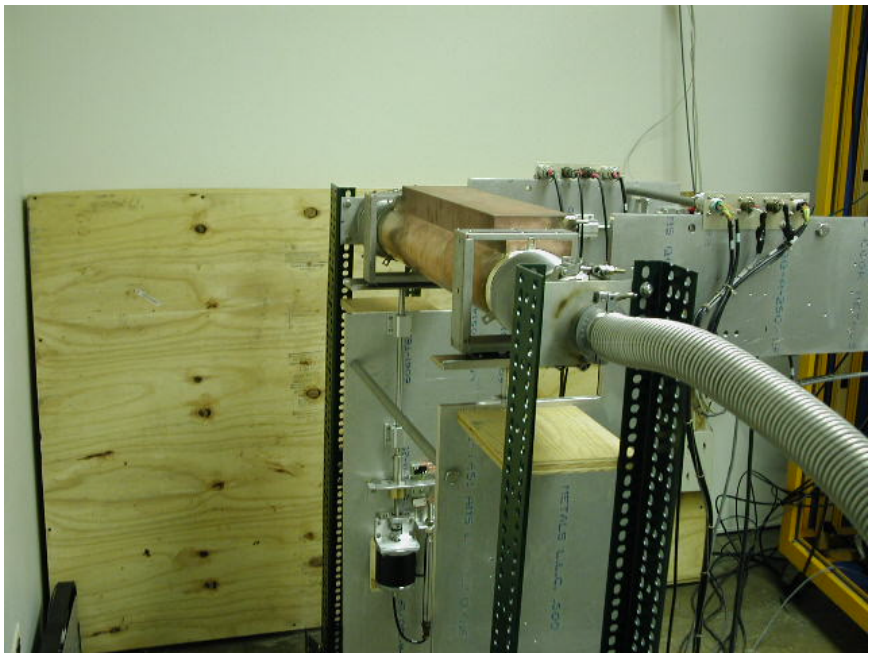
Primary Collimator

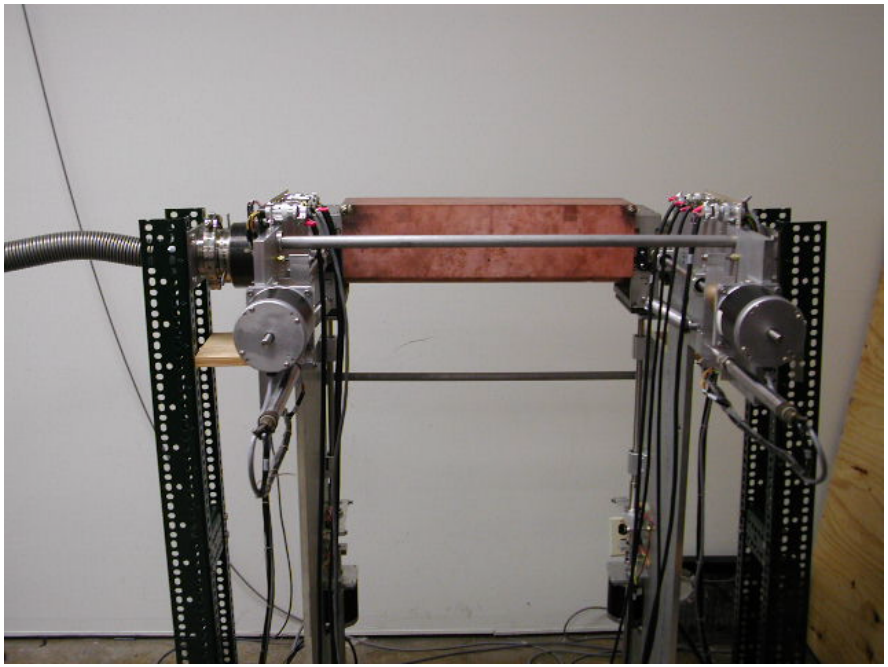


Vertical Primary Collimator Installation

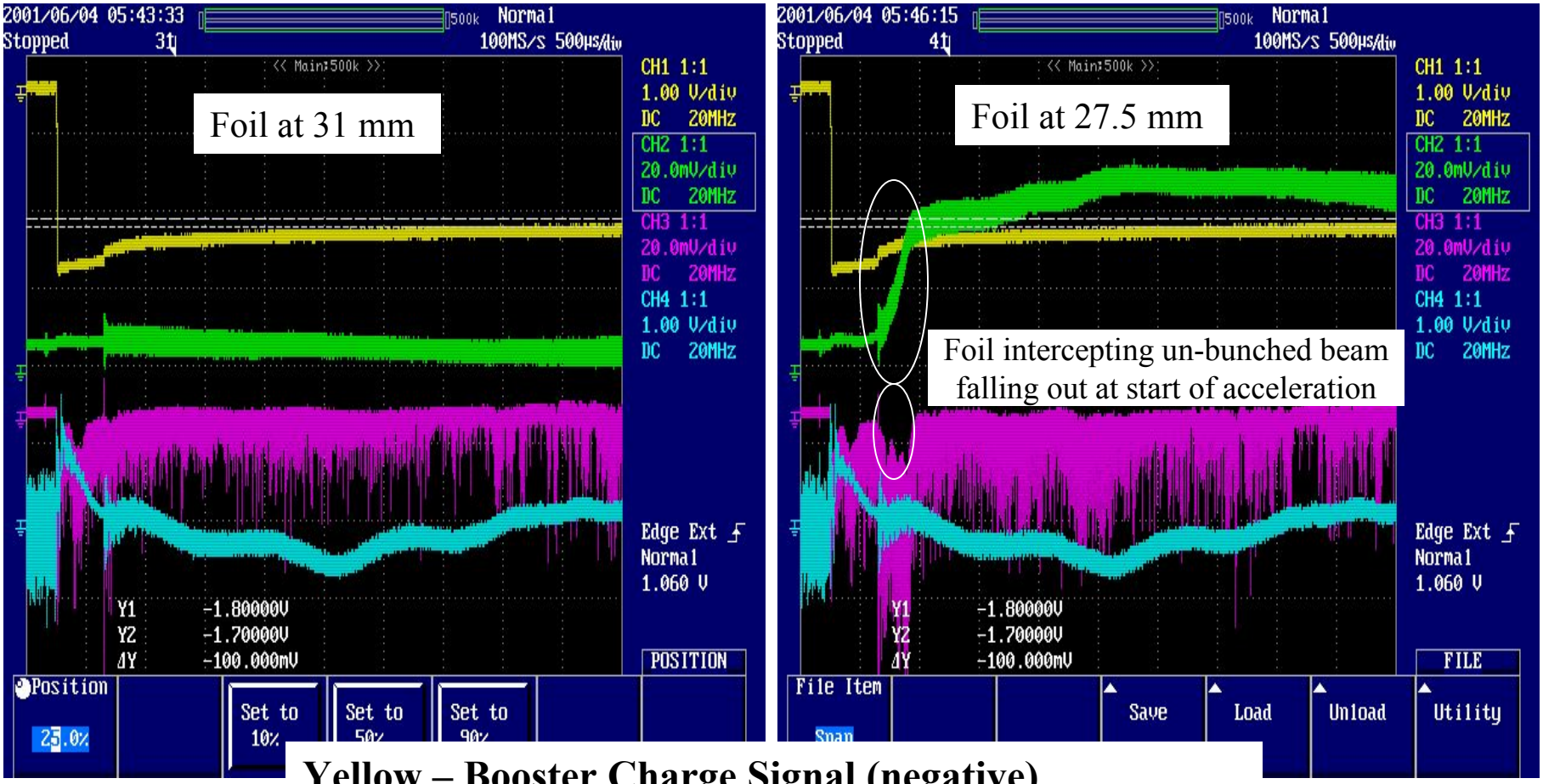
Booster Collimator Status

- Undergoing final? mechanical testing
- To be installed Thursday, April 11





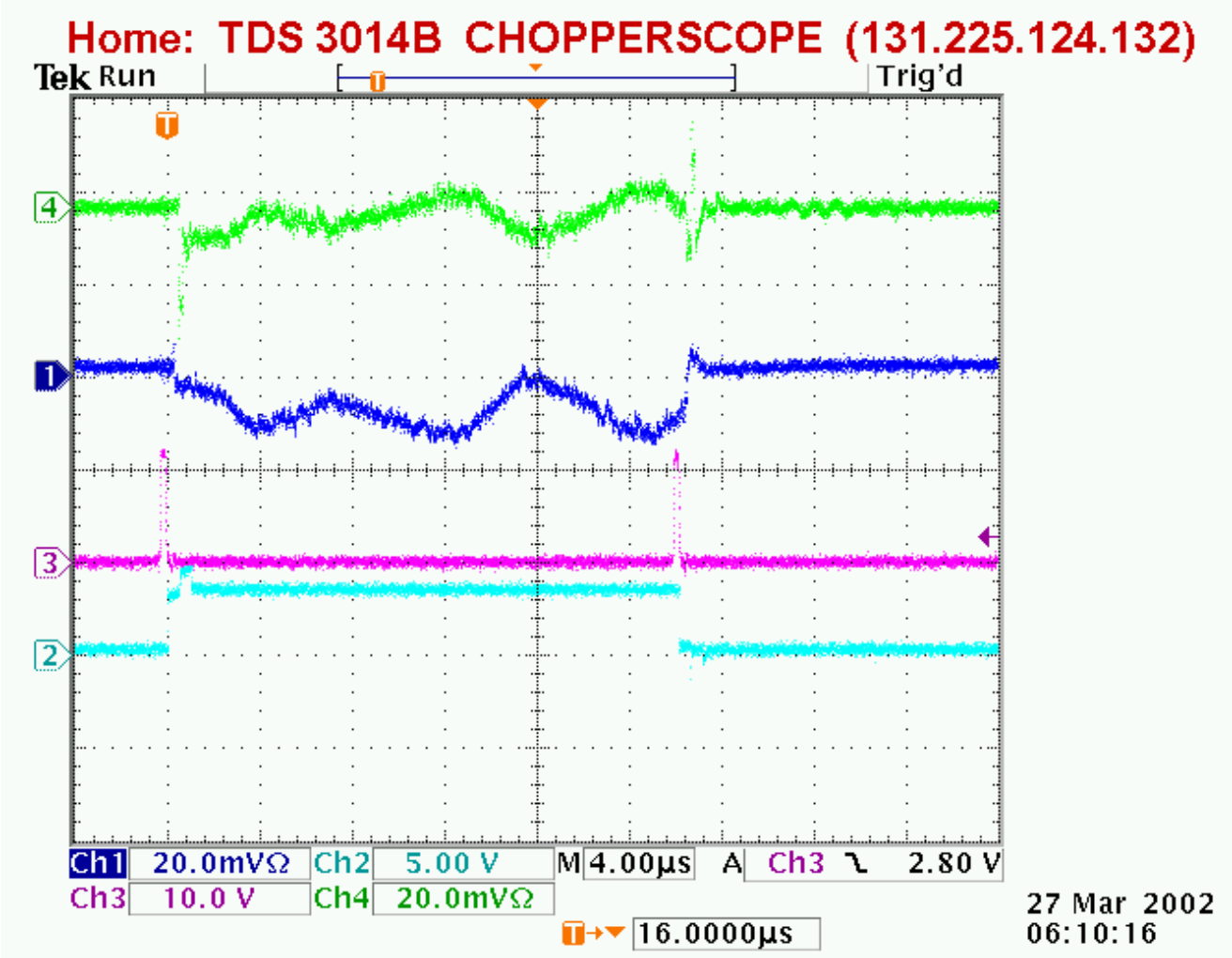
Signals from Horizontal Primary Collimator



Yellow – Booster Charge Signal (negative)
Green – Secondary Emission Signal from Isolated Foil
Pink – PhotoTube Signal at 90 degrees to Foil
Blue – Horizonal Position Signal Near Foil

Real-Time Linac Beam Energy Diagnostic

400MeV Line Time of Flight Monitor



Inductive Inserts in Booster (installed 10/01)

Conclusion

- Long way to go to achieve MiniBooNE beam rate of 5E12 at 5Hz
- Tunnel activitation will set initial beam rate limit
- Collimator operation/performance will be key
- Operational discipline and automated loss monitoring and data logging are important
- We will need to establish operational limits based on “grey” information to limit machine damage, personnel radiation exposure, and reduced machine reliability
- We will face a new era in dealing with maintenance in a high radiation environment