Beams-doc-3568 v1

Predicting Residual Radiation using Beam Loss Data – Early Results

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Main Injector/Recycler Group Meeting

Personal Note

Early operation of the Main Injector was at modest intensities and very high transmission (Think Tevatron, not the Booster or Main Ring) but in 2004, we were preparing for NuMI operation at about x10 intensity. I have been seeking since then to understand losses: mechanisms, residual radiation, monitoring.

Can we relate: protons lost to Residual Radiation, to BLM readings, to radiation safety limitations?

Can we control the loss locations?

Today's Outline

- Primary Goal – Predict Residual Radiation
- How to relate Residual Radiation to BLM's
- Some Results
- Preliminary Conclusions
- Issues with BLM data in Datalogger
- Proposed additional efforts
  - Data cleanup for BLM – faulty readings
  - How much loss is important?
  - Lost Protons vs. BLM readings
  - Exploring BLM pedestal with I129 or I130

Predicting Residual Radiation

We need to predict residual radiation so that:

- We can plan tunnel access work

  Will we need time for cool down?

  Can we predict cool down for shutdown?
- We know long term trends

  Will the current loss rate make work difficult?

Relating Residual Radiation to BLM

- Data Logs of LI(T) for losses - since 11Oct06
- Residual Radiation at Bar-Coded location since 10Oct05
- We access the tunnel after about 1 hour or more. We find that the lifetimes of interest are about 2.5 hours.
- We will store sums of LI(T) for 10 minute intervals

$$LI_j = \sum_{t=t_j}^{t_j+\tau_s} LI(t)$$

- Create half life weighted integrals

  (I is isotope, T_M is measurement time).

$$LW(I, T_M) = \sum_j LI_j \; 2^{\frac{-(T_M - T_j)}{\tau_I}}$$

Relating Residual Radiation to BLM

- Assume geometry of loss is constant:
  - Constant pattern for creating ionization in BLM
  - Constant pattern for creating residual radiation at bar-coded locations
- Measured Residual Radiation is linear in weighted BLM Sums

$$RR(T_M) = \sum_I E_I \frac{LW(I, T_M)}{\tau_I}$$

Note that we are dividing by the half life so the coefficient relates the residual radiation to the weighted loss rate . This is a linear fit so we can perform it with existing data. However, if long half life isotopes were produced well before the BLM data record, we will need to add a term to take care of it. We have a plan.

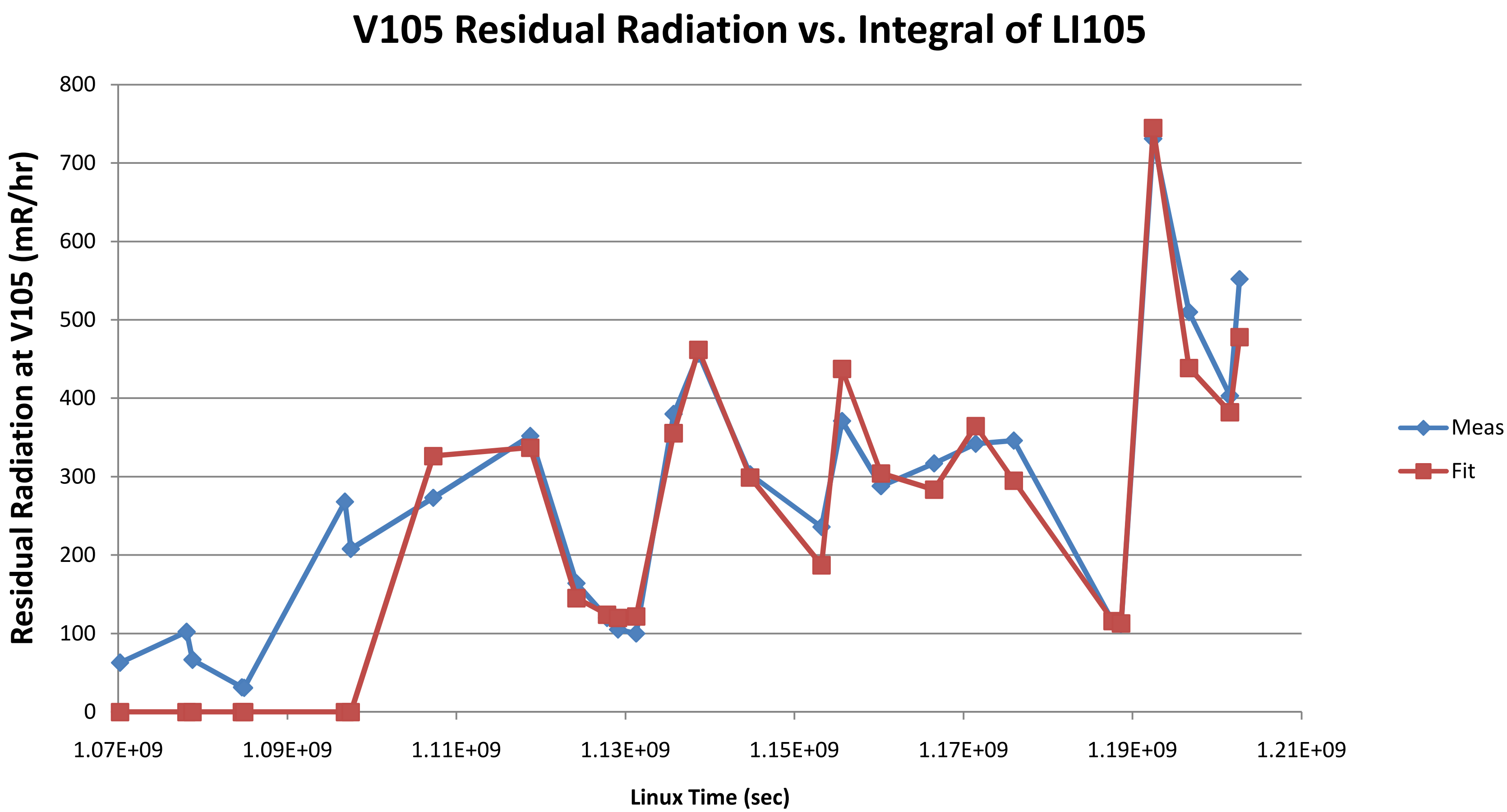
Console Application I130

Guan Wu is developing a program to implement a fitting procedure:

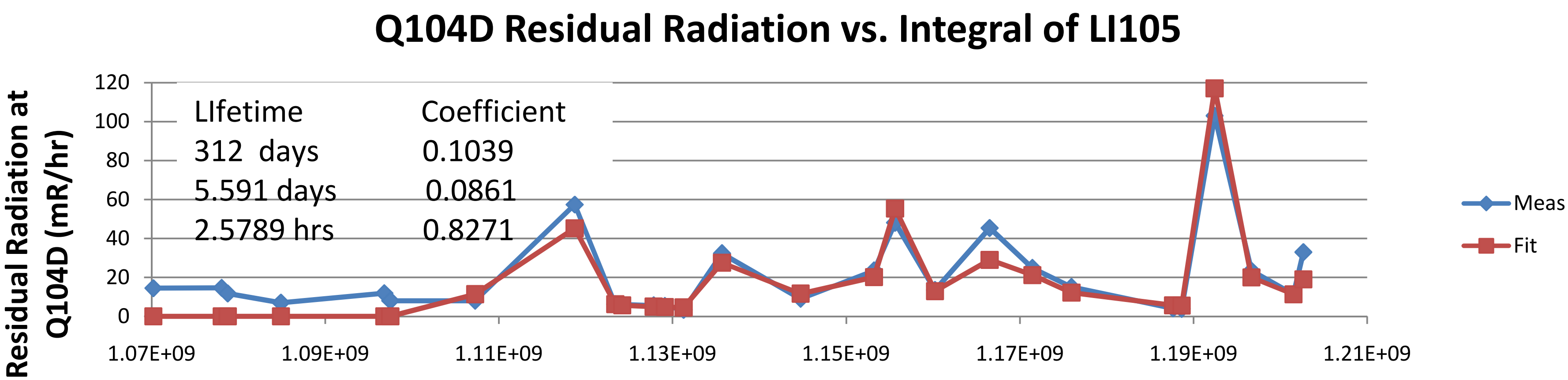
- It reads data from the data logger tables, applies some cuts (more to be developed) and sums them to a convenient set of 'Quanta' and stores the results in Sybase.
- It plots data logger or Quanta results for examination
- It provides a fit as shown above.

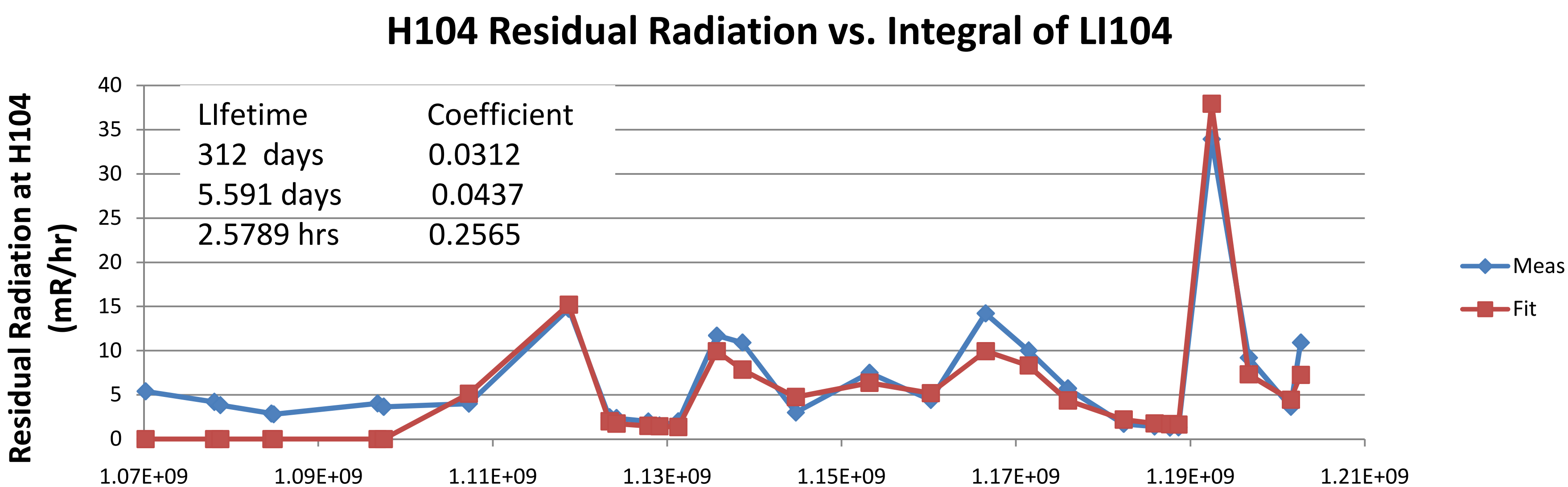
He is doing the work so I will do the talking !!

Fit Results at V105 Corrector

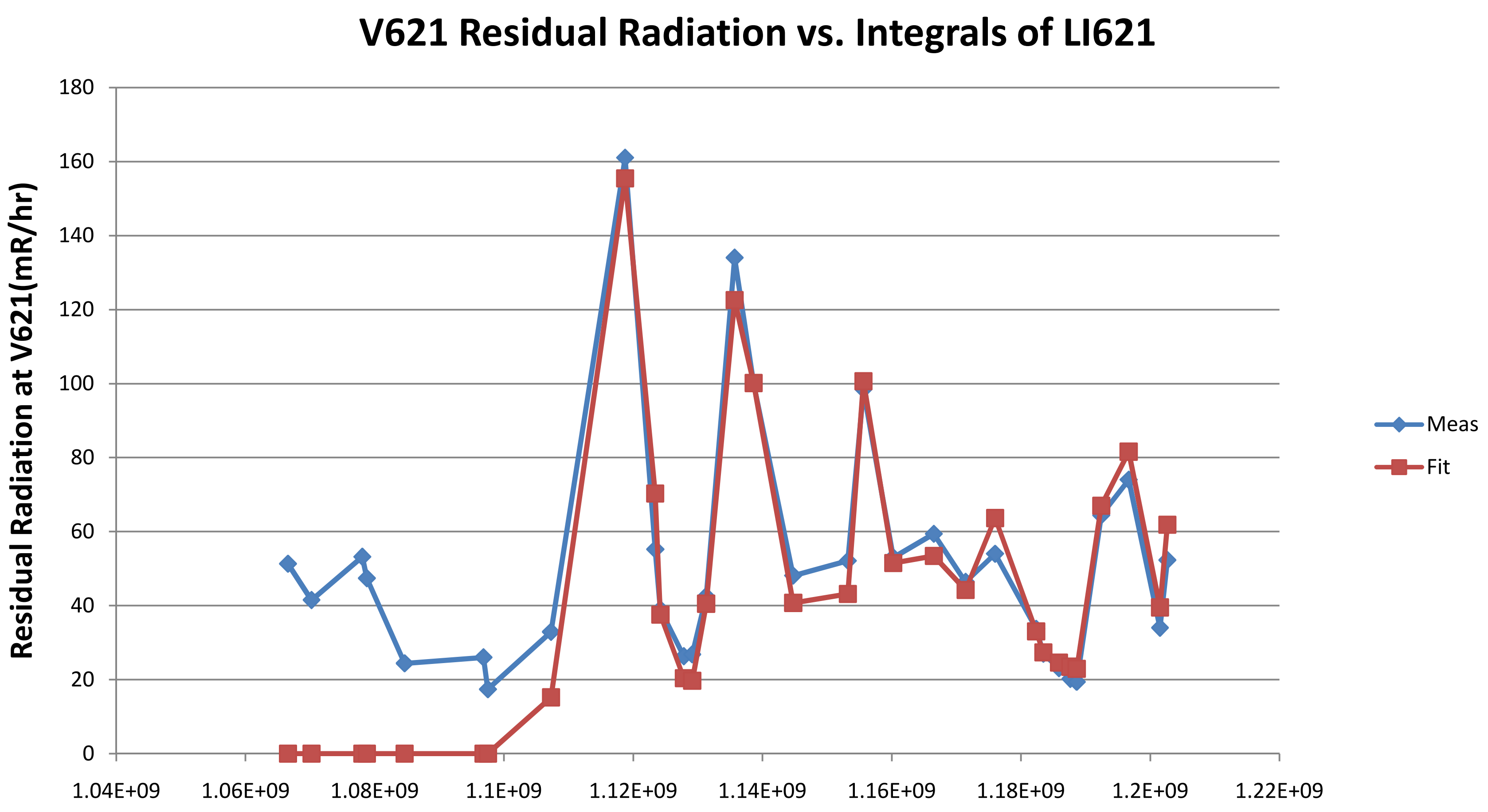


Fit Results at H104,Q104D



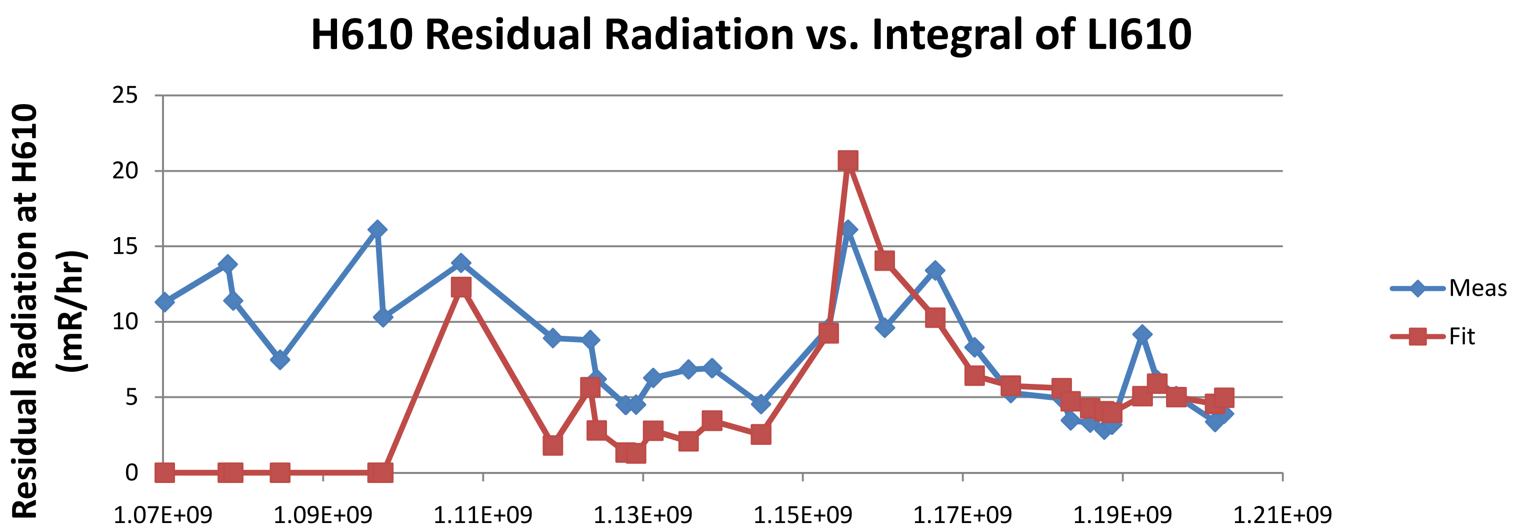


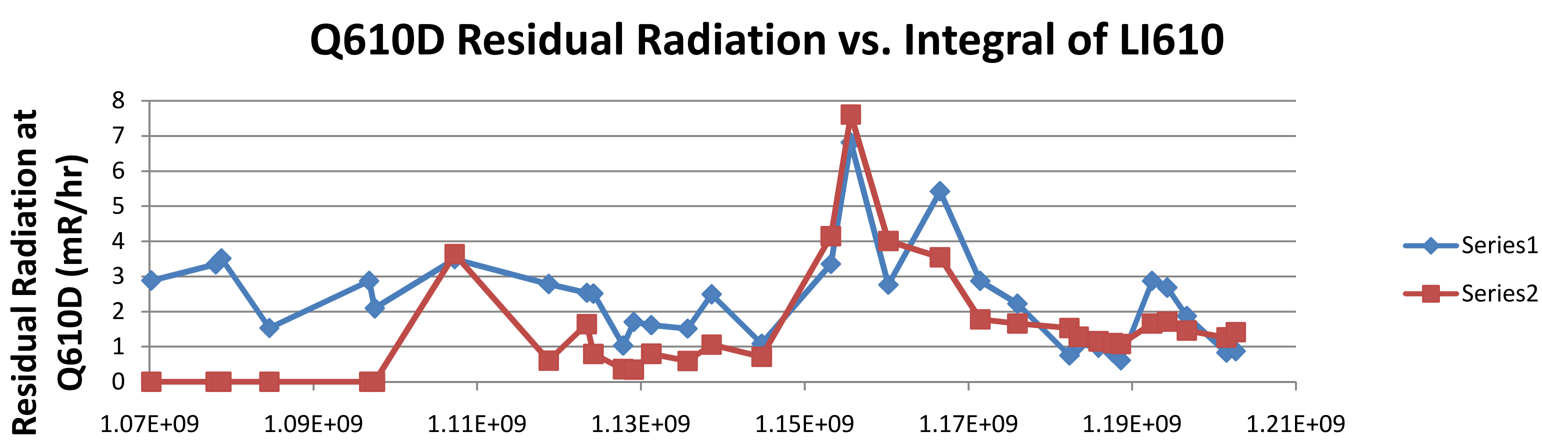
Fit Results at V621 Corrector



Results at 610

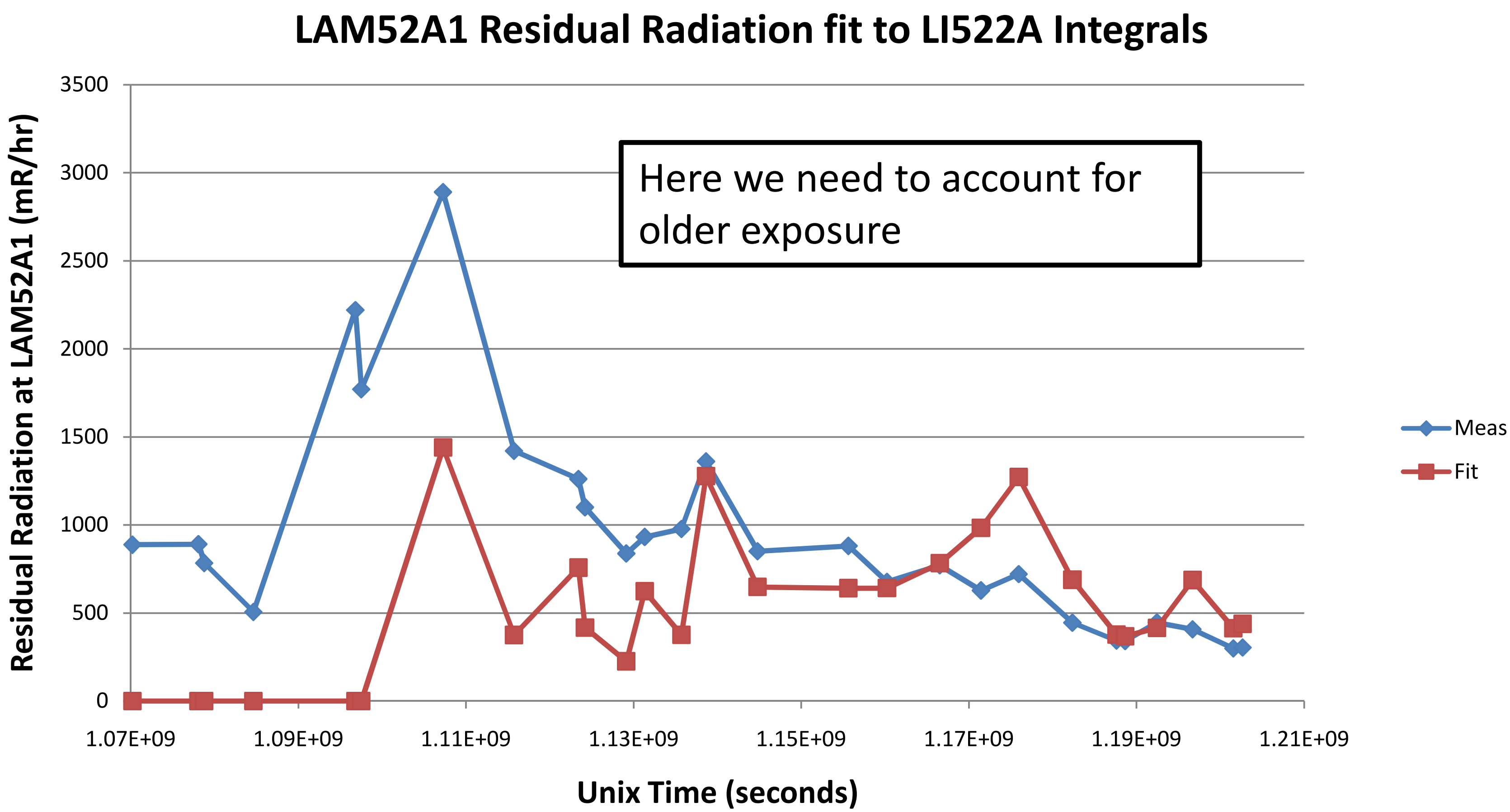
We get useful results even at low loss



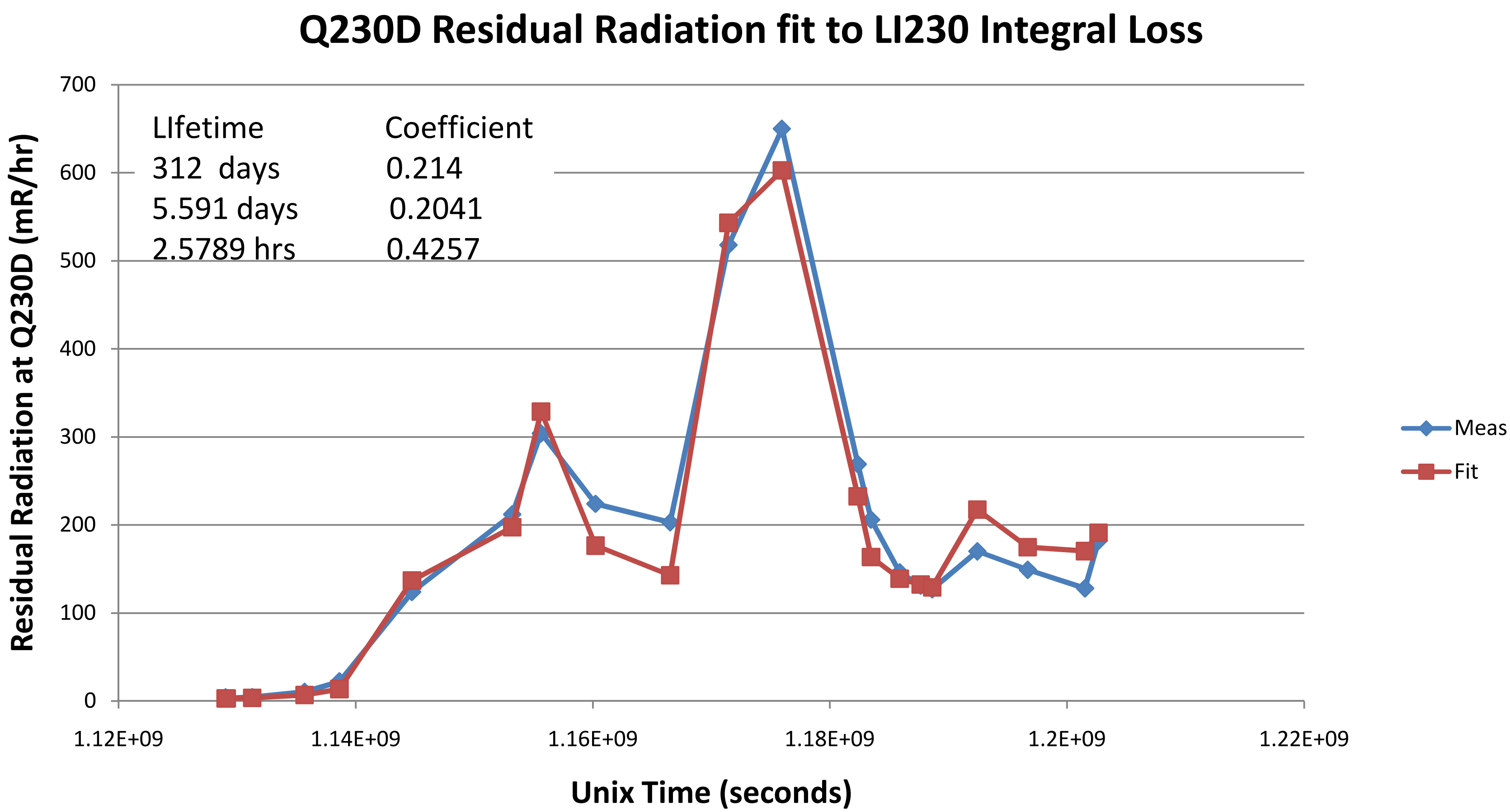


Residual Radiation Fit at LAM52A1

Previously at 3000 mR/hr now 300 mR/hr

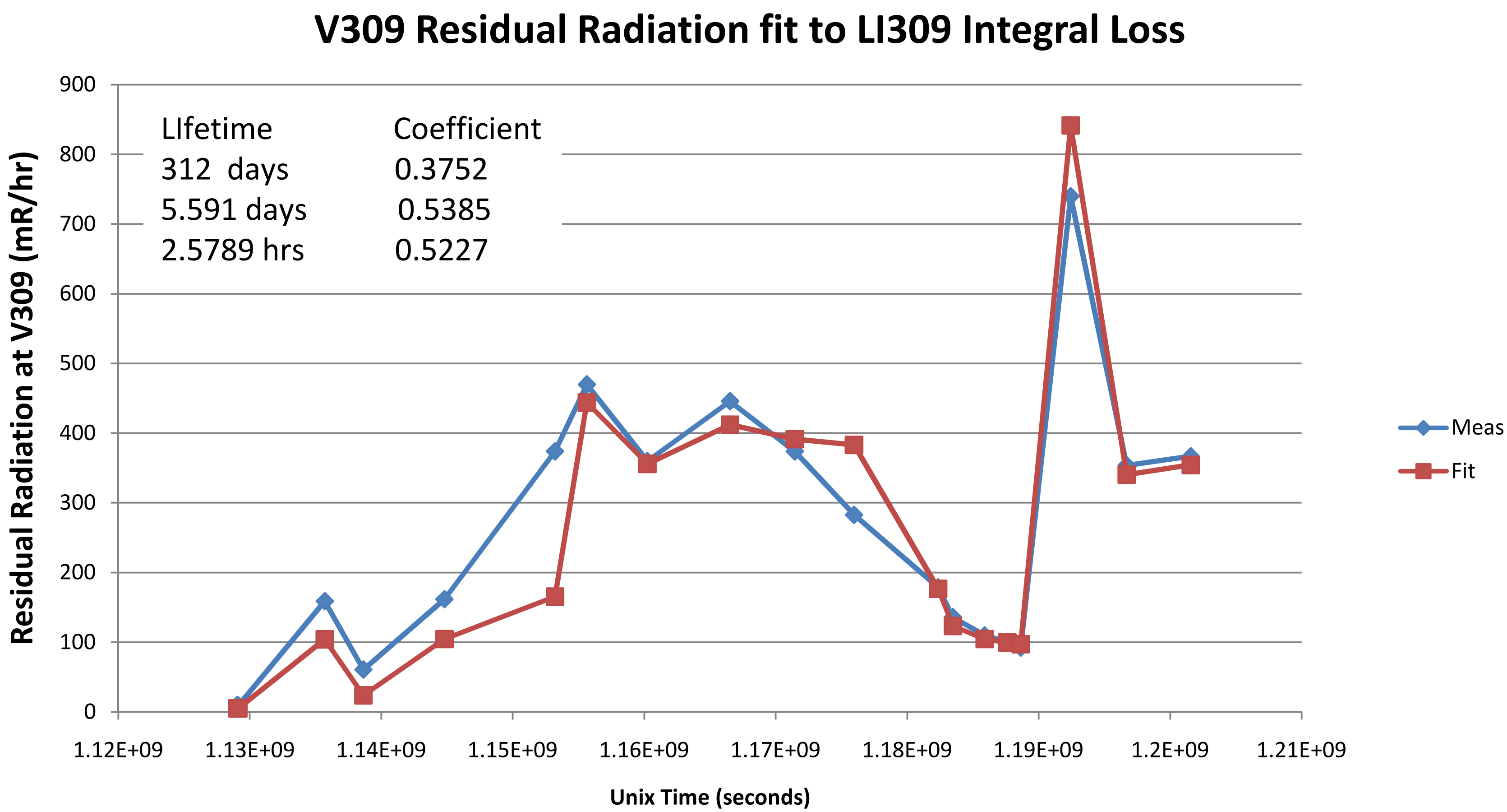


Residual Radiation at Primary Collimator – Q230D

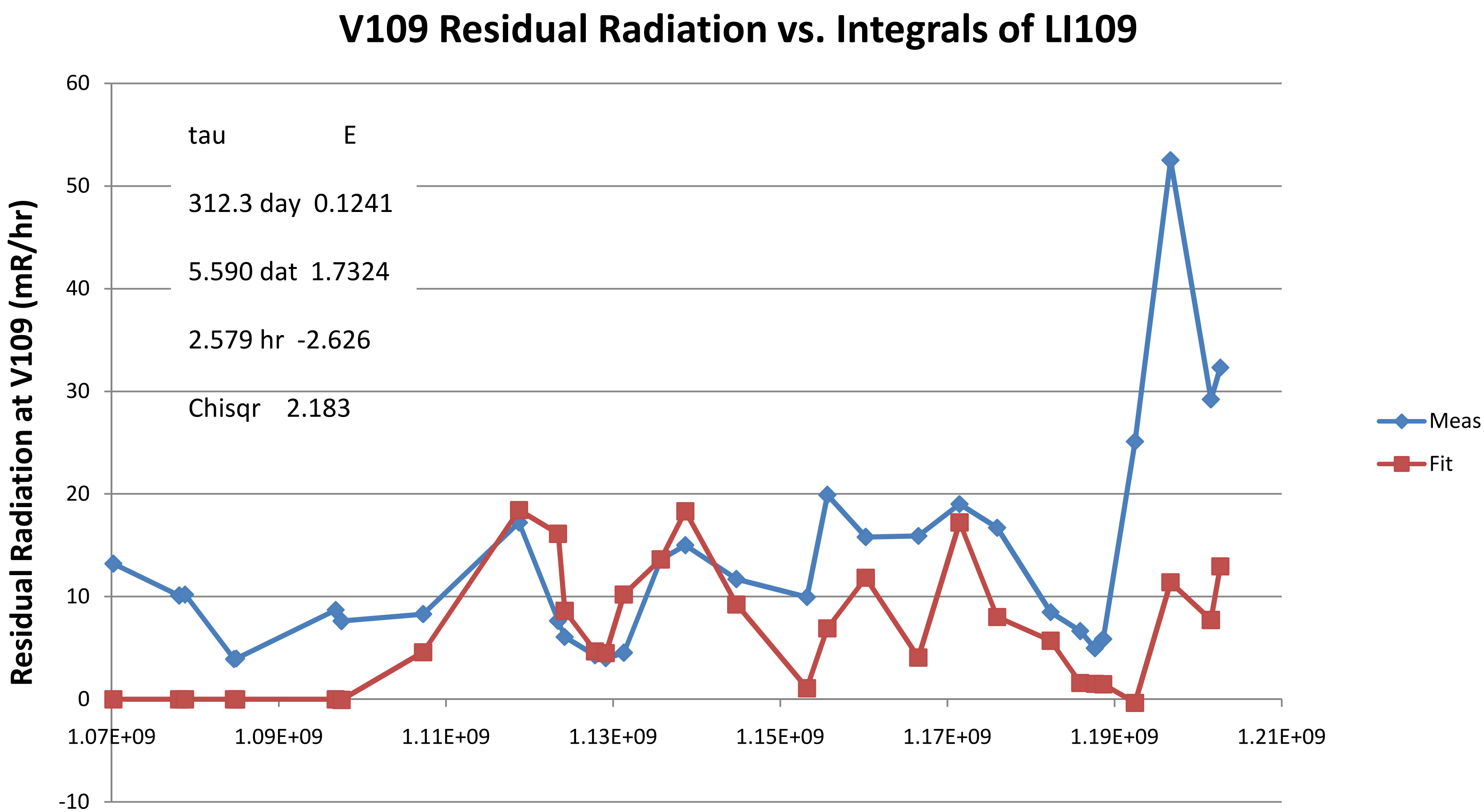


Residual Radiation at V309

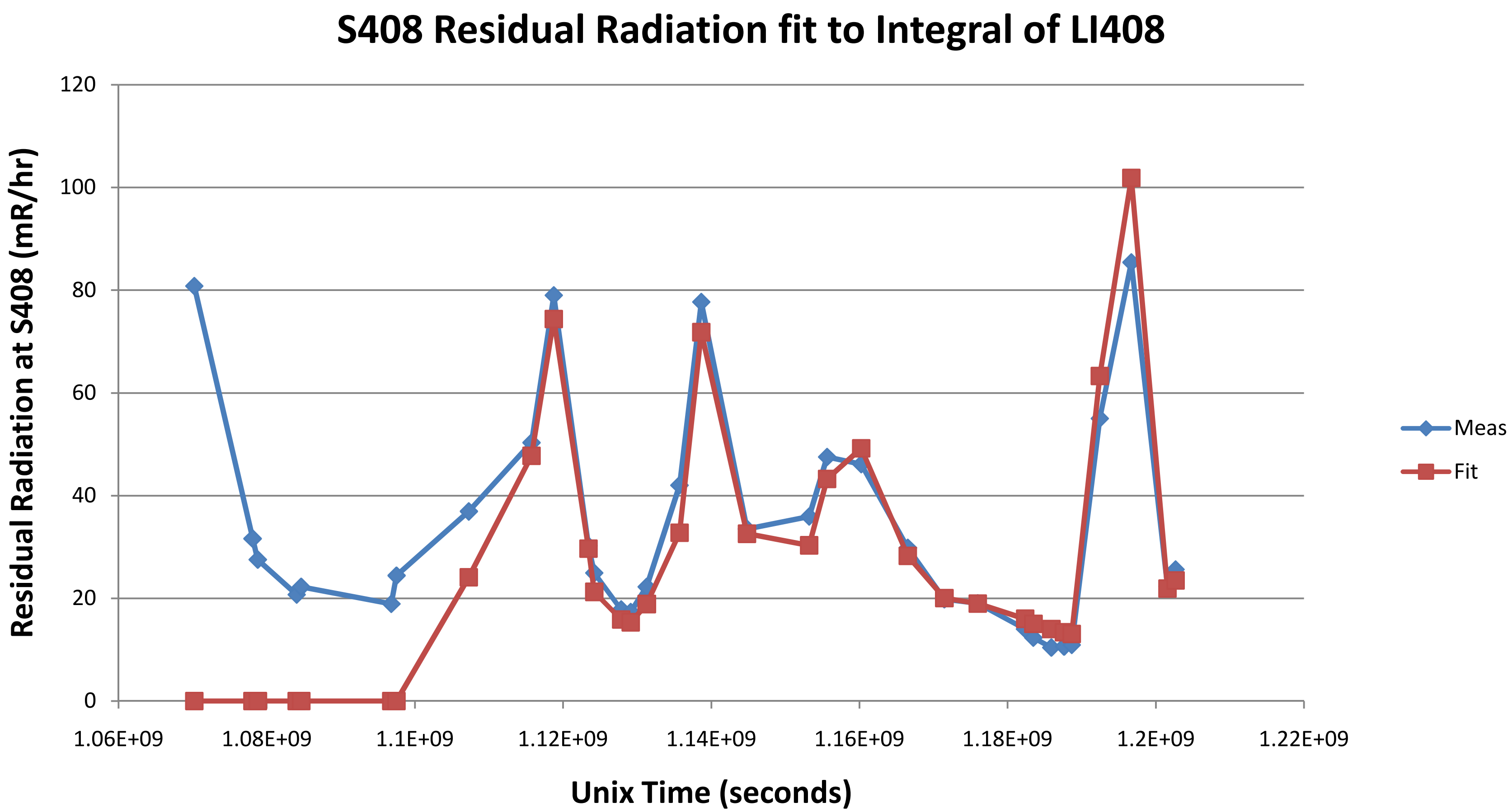
Last corrector in Collimation Region



Residual Radiation at V109
Why the poor fit to recent data?

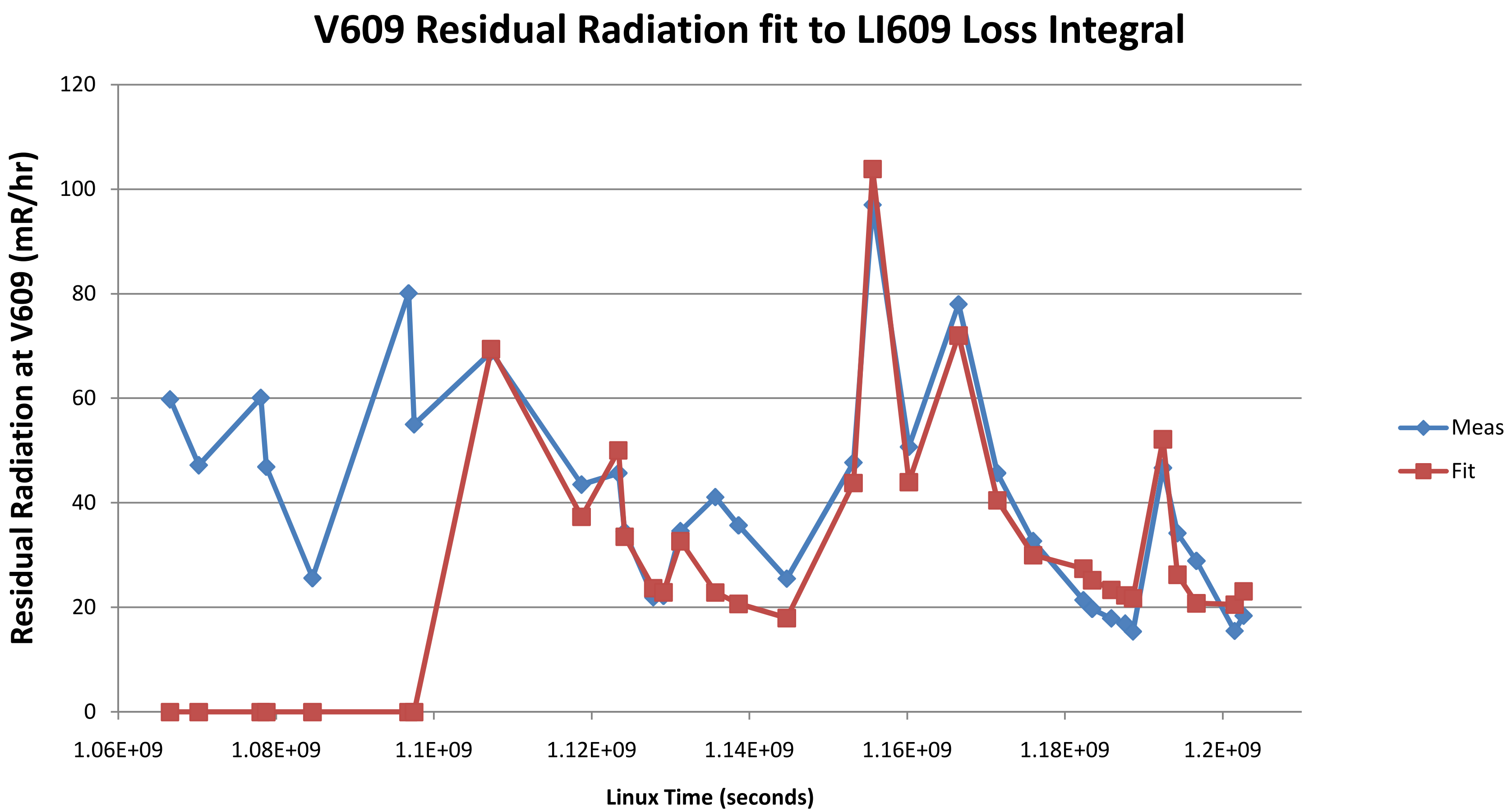


S408 Residual Radiation



Residual Radiation at V609

Note old radiation levels here



Various Fit Results using 3 Isotopes

Coefficients are 10^4 times E_I in fit.

Location	BLM	312.3 day	5.591 day	2.5789 hr	chisqr
		312.3	5.591	2.5789	
V105	LI105	1.0843	1.3421	0.9249	14.653
V621	LI621	0.373	0.3916	0.2069	3.576
V109	LI109	0.1241	1.7324	-2.626	2.183
Q230D	LI230	0.214	0.2041	0.4257	6.668
V309	LI309	0.3752	0.5385	0.5227	15.132
LAM52A1	LI522A	0.236	0.2738	-0.0172	153.681
H104	LI104	0.0312	0.0437	0.2565	0.518
Q104DS	LI104	0.1039	0.0861	0.8271	1.799
V609	LI609	3.2885	1.328	2.5358	4.733
S408	LI408	1.8541	1.1733	1.5016	3.269

Preliminary Results

- The proposed fit seems to provide a useful description of the residual radiation based on the BLM integrals.
- Coefficient of 1E+4 implies 1 mRad/sec of BLM loss yields 10 mR/hr on typical object in the tunnel
- Using three isotopes provides a useful description for present purposes. Will explore alternative options later. Software handles 5 now.
- Better review of the data logger information may produce better fits.
- Should be able to provide cool down curve prediction for shutdown planning.

Issues with BLM results in Datalogger

- We know that Main Injector Cycles without a prepare for beam will result in storing the same result again and again. If this was due to a high loss abort, the data may show high loss (fix code ready to tweak).
- Present 600 second sums have a few unphysical points. Will have to explore how to remove them. At present simply cut after reviewing data.
- The pedestal is not a zero so the integrals may have added or missing Rads. Pedestal of 2 Rad may create 10 mR/hr residual radiation.

Lost Proton Measurement

The Beam Loss Monitors have a measured calibration in Rads. This relates the ionization detected to the radiation field which produced that ionization

The loss geometry varies around the ring but fortunately the regular placement of BLM detectors (above beam height on the wall at the downstream end of each quadrupole) makes the characteristic response to lost protons somewhat regular

Using the integral around the ring, a nominal response is 0.66 Rads/1E12 Protons lost at 8 GeV. Extinction scans produce a number about half of this. May be able to calibrate this for typical loss points using aperture scans.

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