Booster Activation

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The Problem

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- Beam losses in the Booster cause activation of accelerator components which can lead to equipment failure and long down times due to the need to restrict doses to personnel.
- Since the turn on of MiniBooNE the Booster has increased its output by an order of magnitude.
  - The tunnel is hotter.
  - Equipment (particularly HV cables) failure rates has increased.
  - Personnel are accumulating higher doses
- The proton demand is not expected to go down in the foreseeable future. (Will continue to increase.)
- Is the situation getting out of hand? (I don't think so.)
- What are we doing about it?

Activation Monitoring

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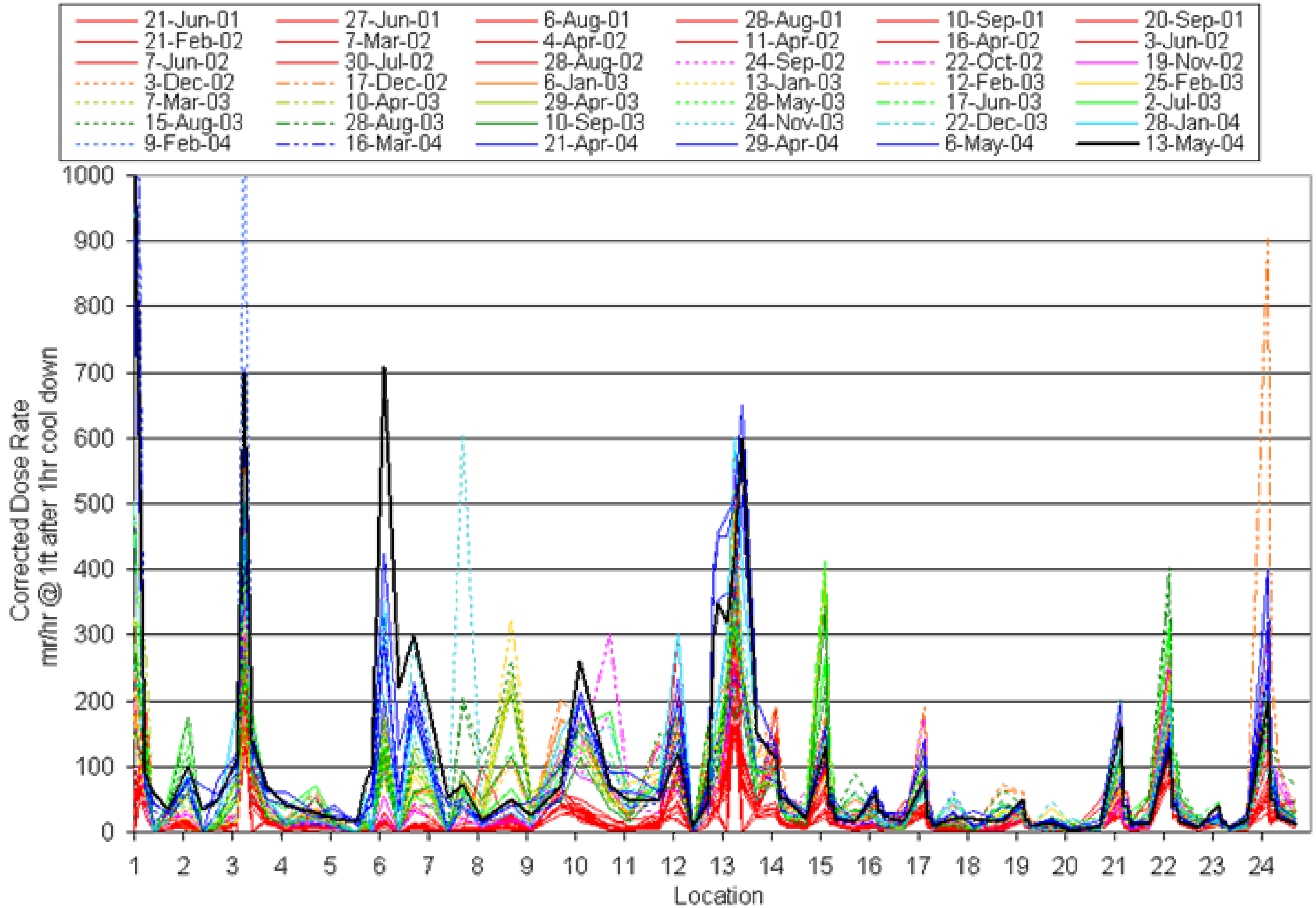
- Since June 2001 we have been performing systematic radiation measurements at many locations around the ring.
  - 1 measurement at each of the 24 short straight sections
  - 2 measurements at each of the 18 RF cavities
  - 3 measurements at the injection and extraction sections
  - 2 measurements at complicated long straight sections
  - 1 measurement at each of the 8 remaining long straights
  - Several miscellaneous "hot spots".
- This has been done during each significant shutdown period.
- Daily measurements were made during the January 2003 shutdown in order to understand cool down rates.
- Results are posted on the web :-
  (http://www-bd.fnal.gov/proton/booster/activation/)

Corrected Dose Rates at All Measurement Points



Corrected Dose Rates at RF Cavities

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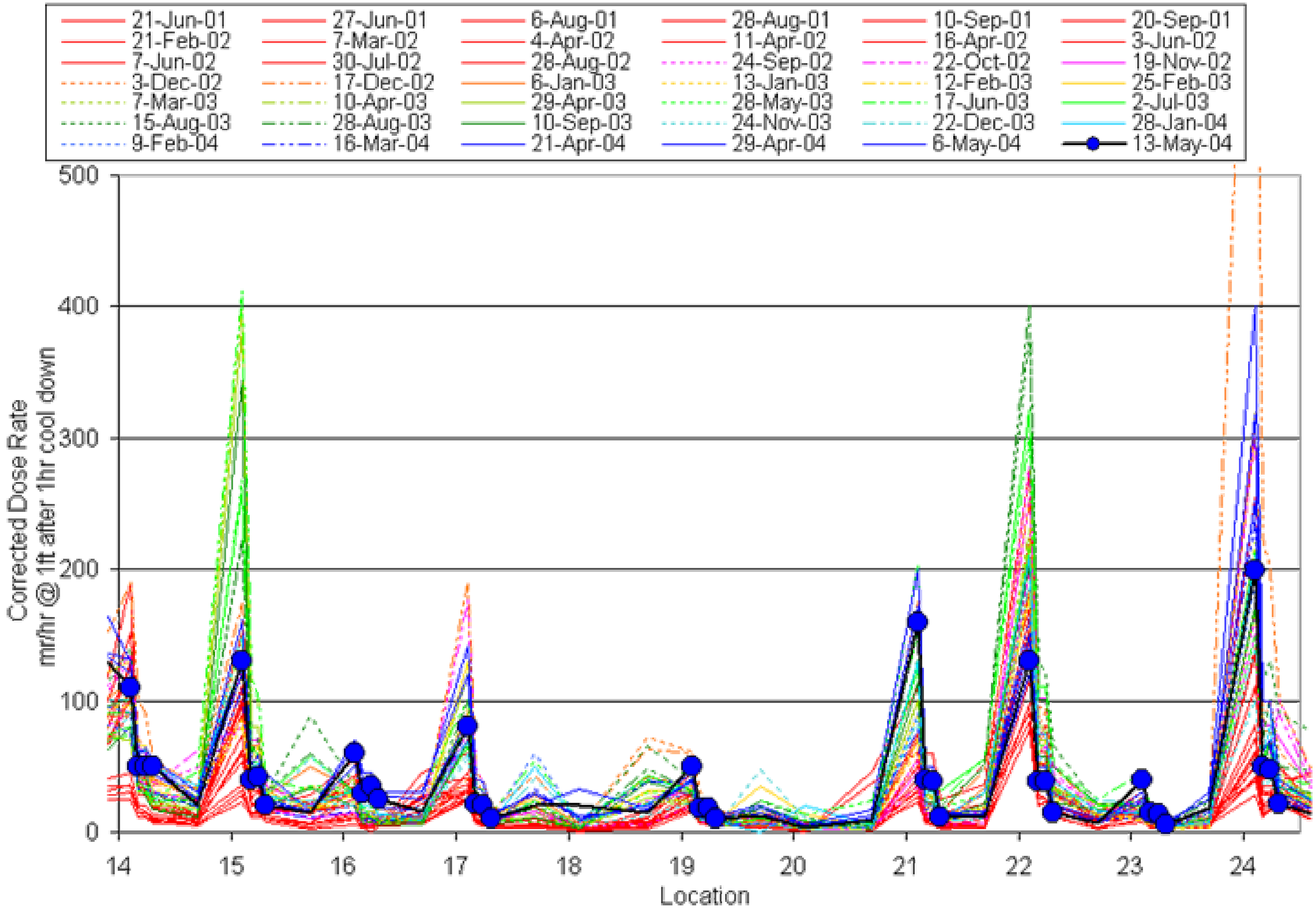

Dose Rates versus Time Shorts 1 to 12

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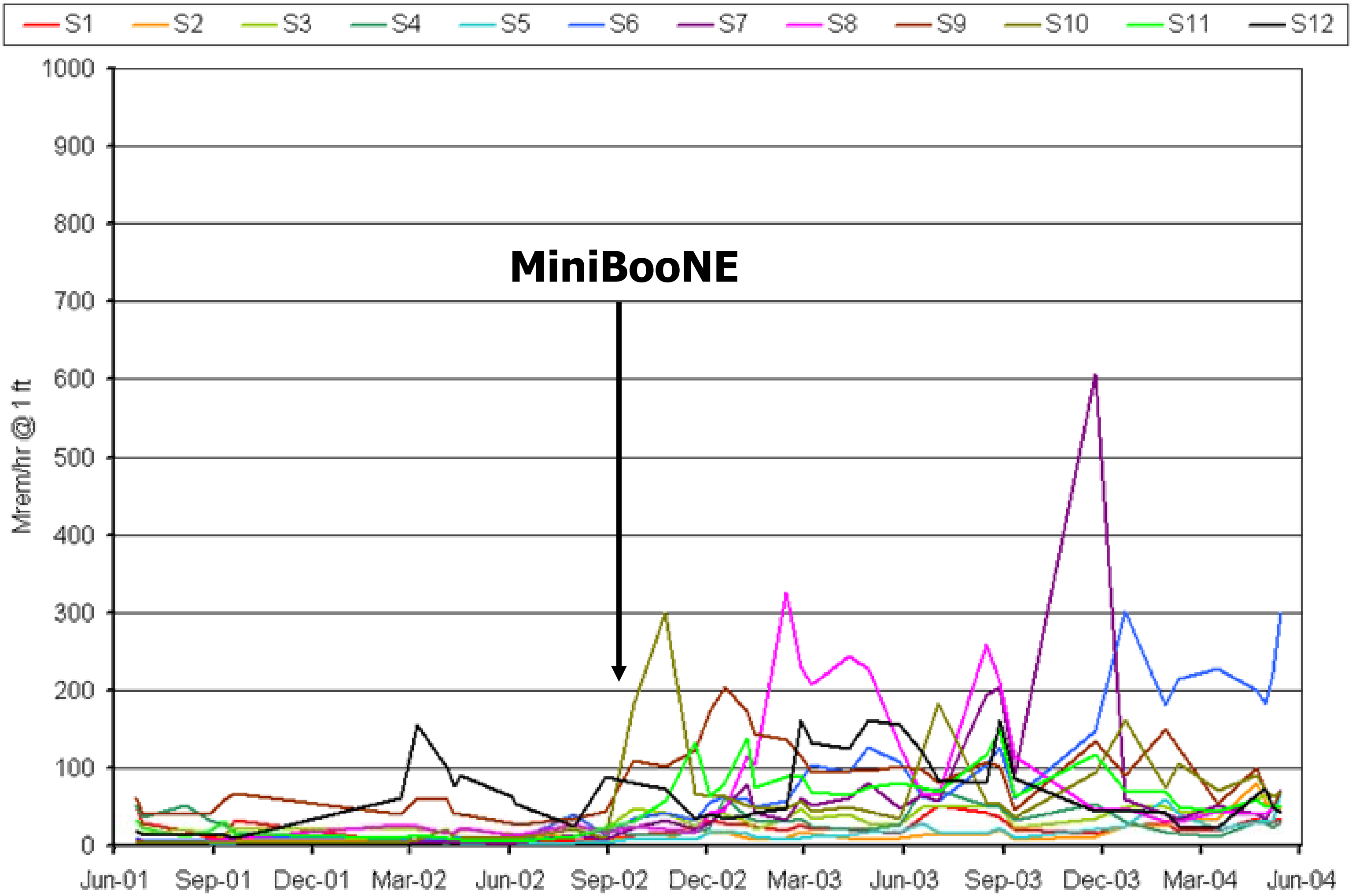

Dose Rates versus Time Shorts 13 to 24

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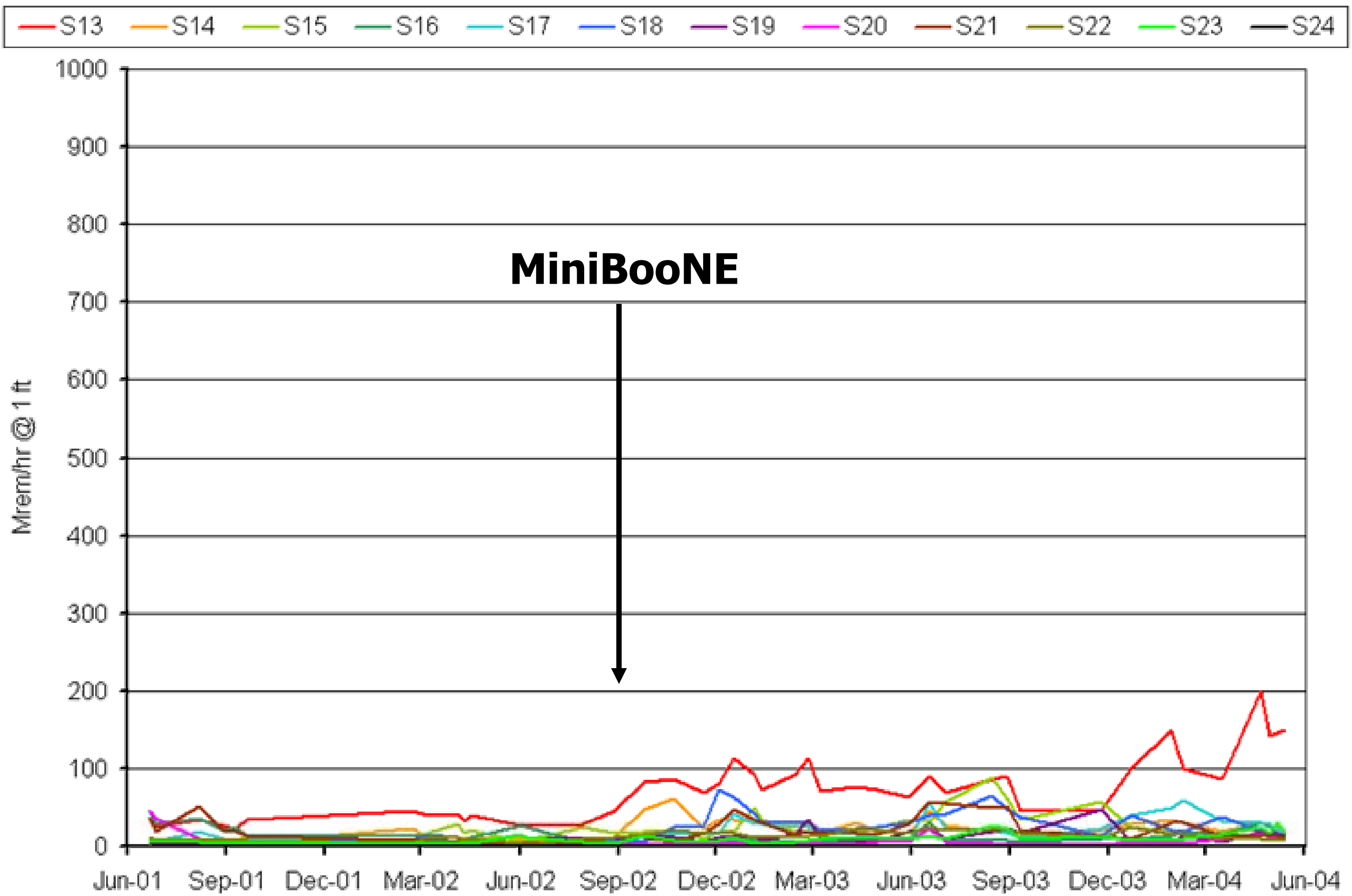
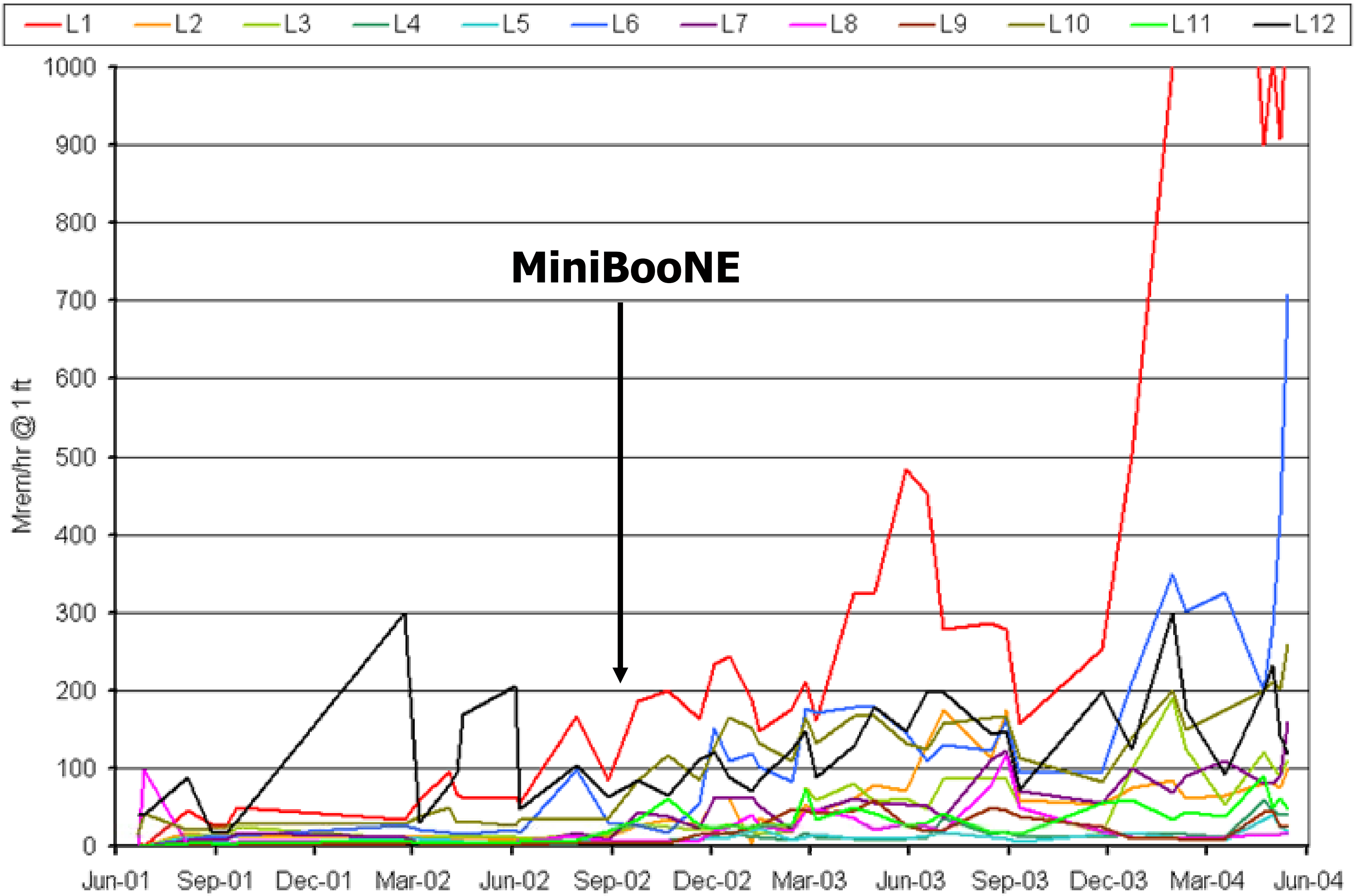


Dose Rates versus Time Longs 1 to 12



Dose Rates versus Time Longs 12 to 24

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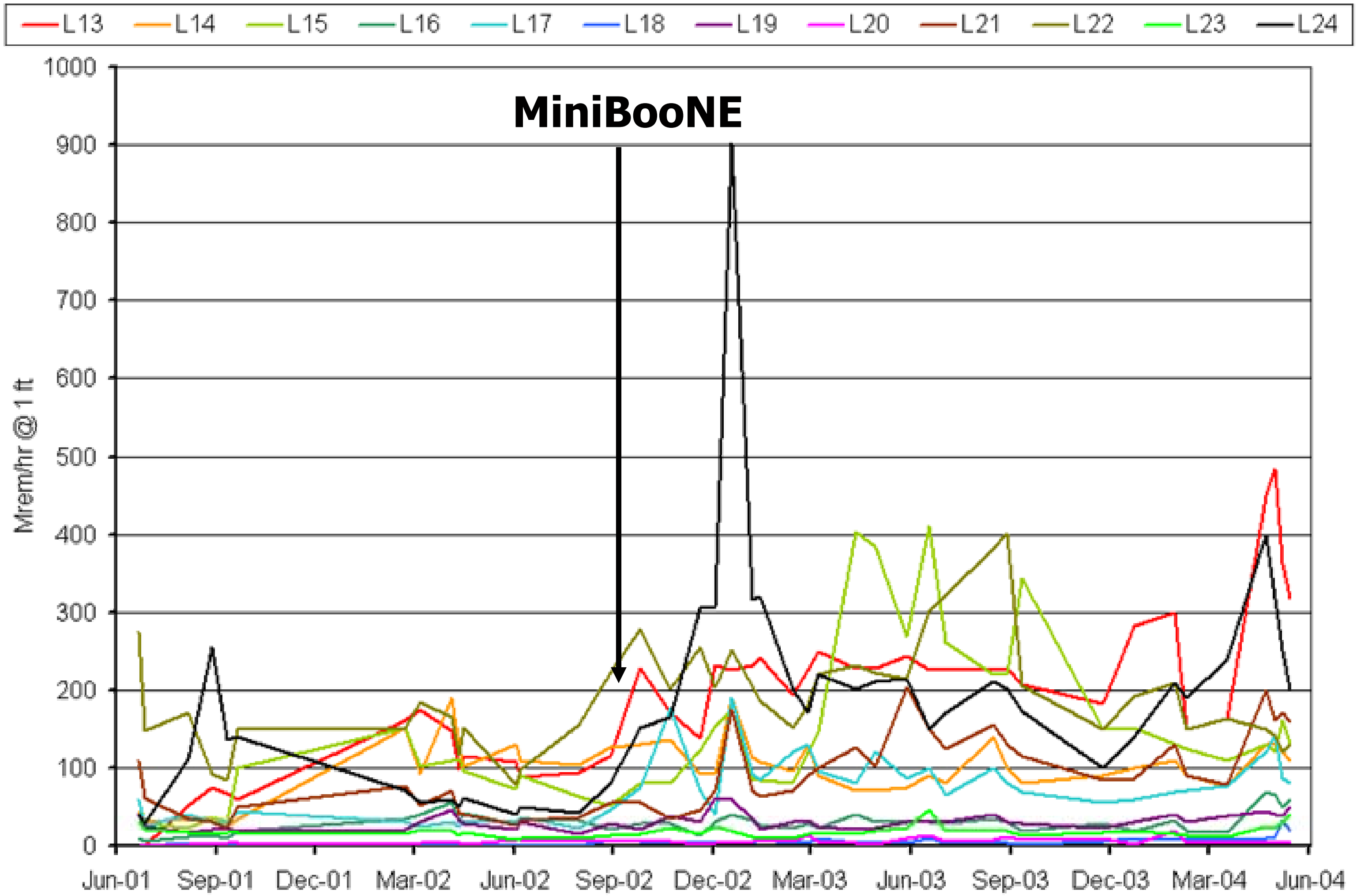

Overall Trends

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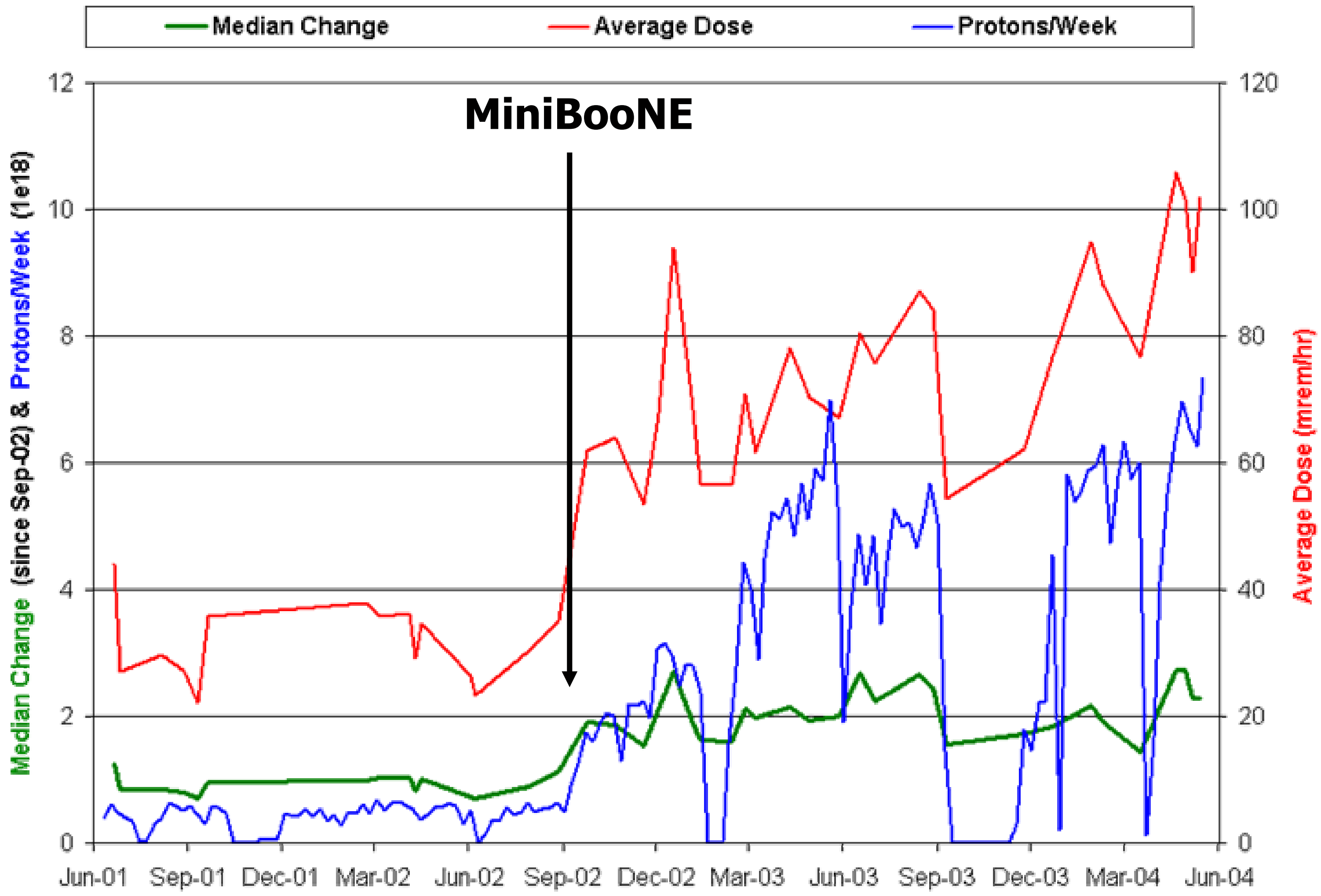
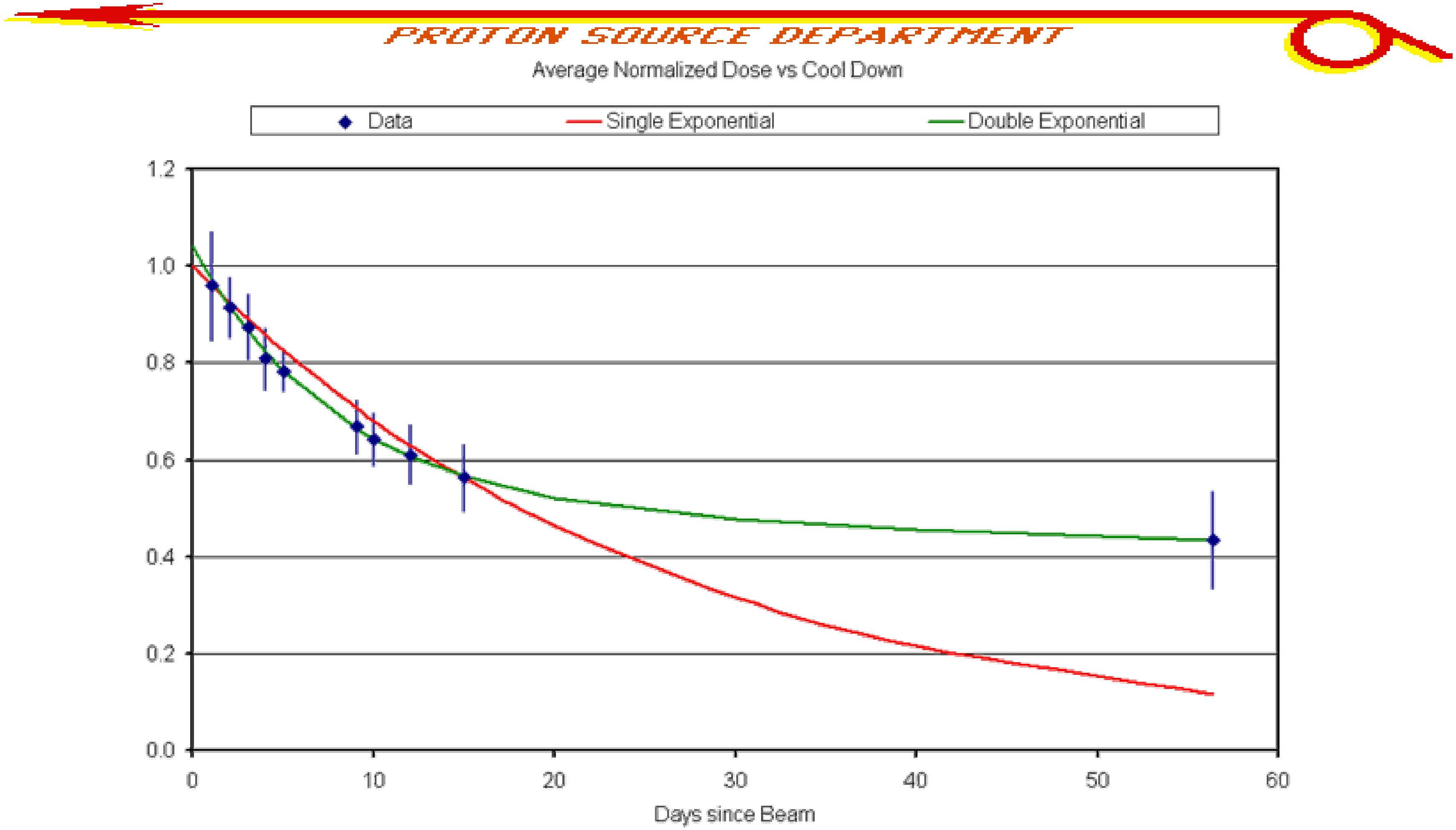


Cool Down Data



Long time scales!

If 57Co (282 days half life) is assumed for the long-lived term in the double exponential fit, then the second term requires a 5.6 days half life.

Controlling Activation – The Watt Meter

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- The “watt meter” (B:BPL5MA) measures the beam power loss averaged over the past 5 minutes.
  - Limit is currently set to 400 watts and is generally the most restrictive limit on what the Booster can deliver.
  - Initially intended to run at 450 watts which roughly corresponds to the SNS design goal of 1 watt/meter.
- A “blunt instrument”, it does not distinguish where the losses occur.
  - Not effective against losses concentrated in sensitive locations (e.g. RF cavities).
  - Is unnecessarily restrictive when losses are concentrated in “safe” locations (e.g. collimators).
- Will need to replace it (soon) in order to get full benefit from the Booster collimators.

Controlling Activation – The BLM system

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- The Booster is equipped with ~60 Beam Loss Monitors strategically located around the ring.
- Devices (B:BLxxx0) associated with each BLM return the total loss recorded by the BLM, integrated over the last ~100 sec.
- Trip points have been established for each BLM in order to separately control losses at each BLM location.
- The problem reduces to choosing appropriate trip points.
  - But not so easy!
  - The relationship between recorded losses and measured activation is complicated ...
  - $A(T) = (\Sigma_i\, x_i\, e^{-\lambda_i T})\, A_o + \Sigma_i \int k_i\, BLxxx0(t)\, e^{-\lambda_i (T-t)}\, dt$

    Sum is over produced isotopes
  - Many parameters (x_i, λ_i, k_i) need to be determined

Choosing Trip Points – The Ad Hoc approach

- Original settings were defined as twice the BLM sums observed during a "typical" stable running period in April, 2002.
  - Don't let the tunnel get any more than twice as hot as it was at the time.
  - Trip values varied enormously between BLM's
- The loss pattern quickly evolved away from the original and the operators had difficulty managing losses in areas with very low trip points
  - Raised low value trip settings in regions known to have little activation
- When MiniBooNE turned on all levels were increased by 50% as agreed to by the Division Head.
- Adjustments were then made based on observed activation levels (e.g. L24 and L15 to reduce rates at RF cavities)

The Near Future

- Would like to determine more “defensible” BLM limits
  - Take a series of closely spaced (~ 1 week) activation measurements
  - Compare measurements with BLM data and try fitting to a “two isotope model”
  - If a predictive fit can be found then adjust BLM trip levels accordingly.
  - Work in progress
- Once relationship between BLM’s and activation is established we need to decide on an acceptable activation level <u>at each location</u> and set an appropriate trip point.