Scope of Proton Driver Beam Diagnostics

- Beams
  - Ion source and RFQ beams
  - Linac beams
  - Transport line beams
  - Compressor ring beams
  - Synchrotron beams
  - Targeted beams
- Charge distribution = Signal Time and Amplitude Scale
  - Bunch length
  - Bunch frequency/spacing
  - Intensity
- Machine designers/beam physicists need to appreciate diagnostics limitations, specify beam structures and parameters to be measured and prioritize what is critical for machine commissioning and operation
- Coupling to machine design, e.g. mechanical constraints and measurements require that they be “built-in” at the time of lattice design

Customers of Beam Diagnostics

- Commissioning Physicists (diagnostic capabilities, performance at low end of dynamic range)
- Operations Crew (robust, friendly, unambiguous information)
- Feedback Systems (reliability and unamgibuous information)
  - SLC is example of tight coupling between instrumentation and control systems
- Documentation and Records Systems (Accuracy, Calibration Tracing, and Recording)
- Protection Systems (Reliability and Accuracy)
  - Machine Protection
  - Administrative Protection (assure operation within approved limits)
  - Environmental Protection (both FNAL Booster and SNS are (will be) heavily “chipmunk” interlocked)
  - Personnel Protections
- Clean reliable interface to machine protection systems, accuracy and precision more critical as beam power increases

Persistent Deficiencies of Proton Beam Diagnostics

- Ill specified BPM systems
- Permanent vs. 'ad hoc' measurements
- Cost estimation – cost is heavily design, commissioning, interpretation loaded generally foolish to focus on hardware costs alone
  - SSC EDIA less than component costs
  - Generally one of the smallest line item subsystems and probably the most overbudget
- Beam loss monitor coverage
- Accuracy of IPMs is a persistent question
- On-line betatron tune measurement
- Radiation hardness for devices in high rad areas, injection, extraction, collimators
- Communication with physics detector developers, radiation calculation experts
- Multi-turn injection diagnostics energy, position, painting, profile, loss (differentiation between injected beam and circulating beam)

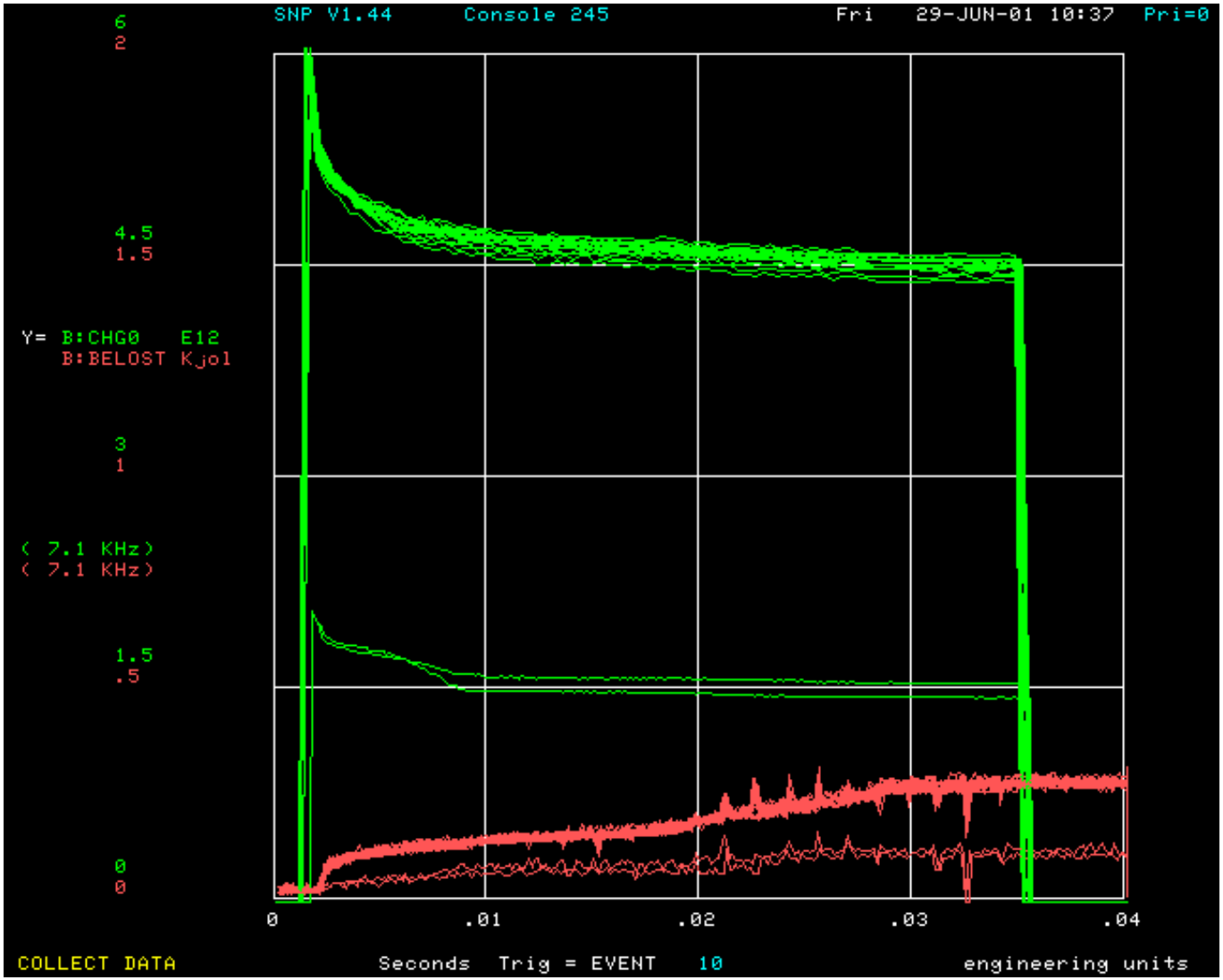
Specific Challenges of Beam Diagnostics

- Being able to make measurements at the diagnostic and predictive level as opposed to measurement of the end result
- Linac halo diagnosis
- Ring injection energy measurement for momentum painting
  - 1000 turn injection – measuring position of injected beam relative to circulating beam, is Linac/ring frequency locked, what is debunching time of Linac bunch structure, will this change during injection?, e.g. in Fermilab Booster we can shift bunch phase one full cycle in one turn with Debuncher setting?
- Turn-by turn injection efficiency measurement with BCT's
- Tunnel radiation monitoring, considering installing such a system in Fermilab Booster
- Easy to use and believable bunch length monitors (10 psec level)
- Halo detectors as protection devices

Specific Challenges of Beam Diagnostics

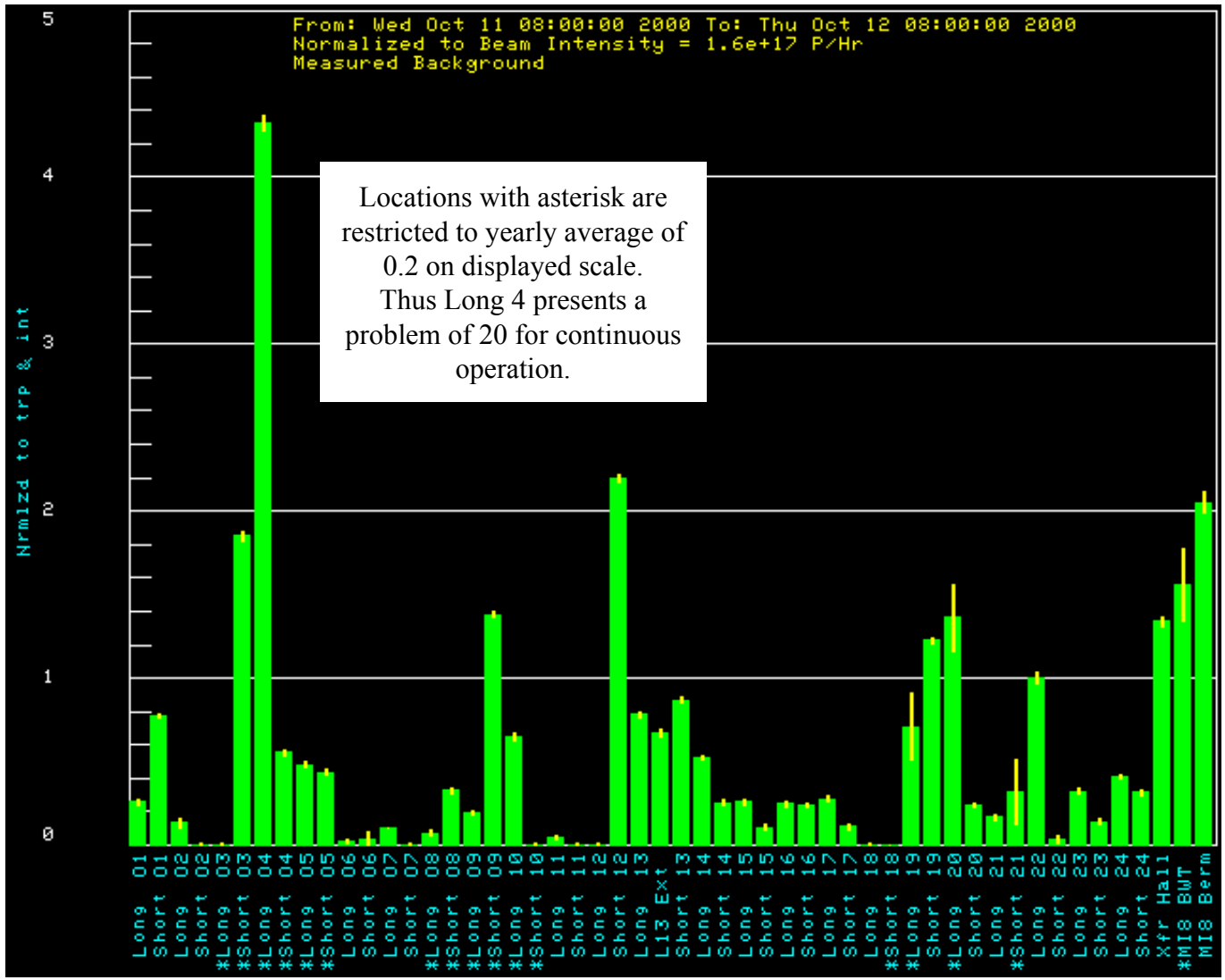
- Measurement issues in SCRF section
  - E.g. Profile measurements in SCRF sections (SCRF will become more prevalent in proton/H- linacs, Wangler talk, Frankfort Univ, and Julich.
  - Problem of intercepting devices in vicinity of high gradient SC surfaces.
- Beam in gap
- Halo at level that matters, SNS Linac performance will be halo driven
- Electrons in machine – e-p instability issues
- Stripping efficiency diagnostics
- Meaningful online energy and energy spread measurments (SNS momentum painting)
- SNS Ring with large tune adjustment range, 1 unit H, 3 units vertical
- Integrated absorbed dose
  - Optical dosimeter like used at TTF
  - On-line residual radiation monitoring system
- Large aperture diagnostics (FFAG with ~1 meter aperture, R=4.4-5.3m)

Booster Beam Intensity and Beam Energy Lost

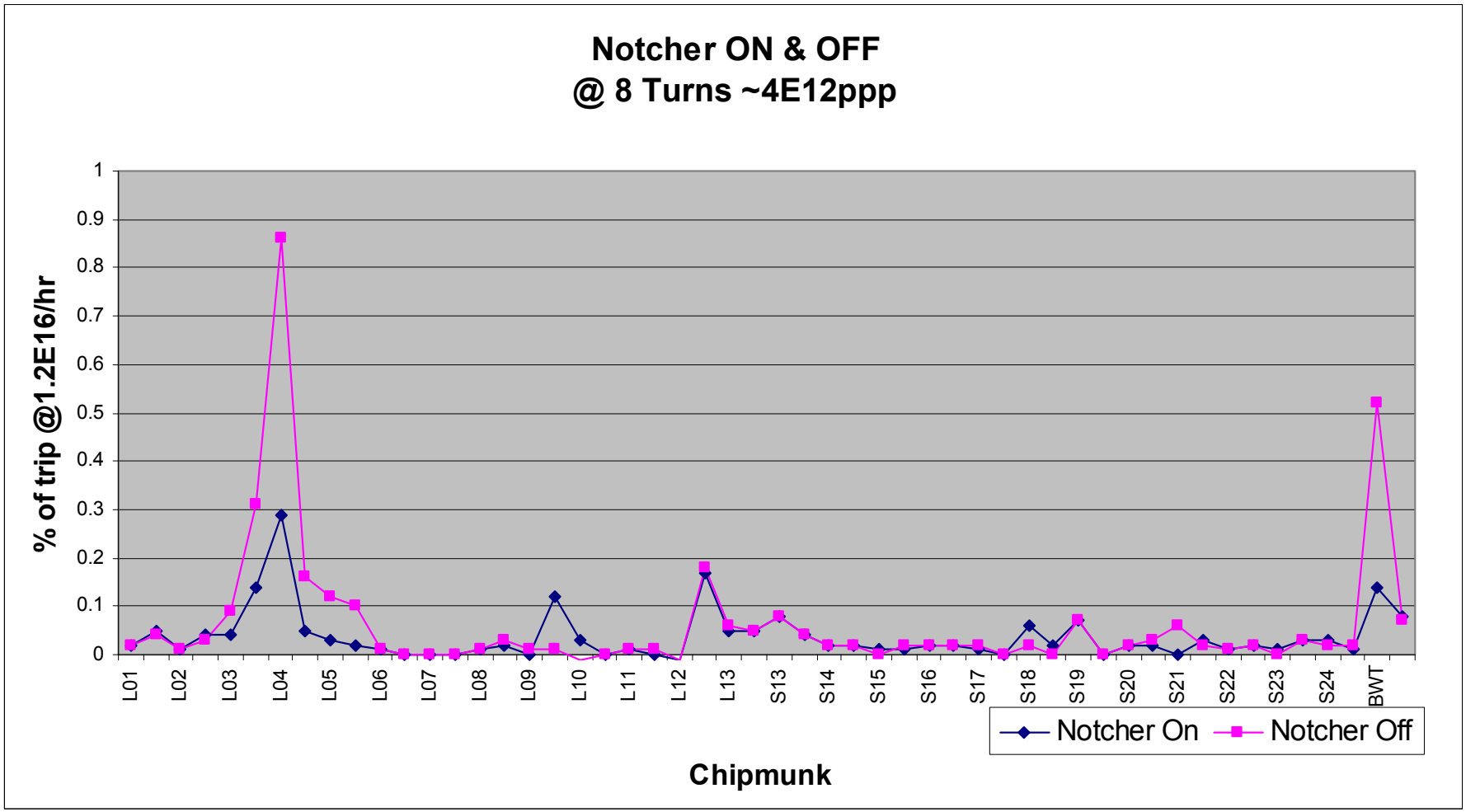


Typical Booster Interlocked Chipmunks

Normalized to Individual Trip Points and MiniBooNE + NUMI Rates



Booster Chipmunks with Notcher On & Off



R&D Suggestions

- Experimental verification of collimator designs
  - Fermilab Booster
  - SNS Ring
- Data Acqusition/Transmission/Processing
  - Fast systems
  - High data volume systems
  - Geographically distributed systems
- E.G. global orbit control at light source rings