The Main Injector Proton Intensity, Emittances & Efficiency

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Lehman Review

Proton source breakout session

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http://waldo.fnal.gov/~yang/mi/MIProton_intensity_n_emitt.pdf

Timeline of events

- Start of shut-down
  - ✓ September, 6, 2003
  - ✓ Last collider shot: 2997
- End of shut-down
  - ✓ Mid November, 2003
  - ✓ First collider shot: 3032
- RF upgrades commissioned after shut-down
  - ✓ Feed-forward compensation up the ramp.
  - ✓ Station control for turning Off 53 MHz RF drive.
- Damper on $2B cycle for collider operation.
  - ✓ Operational since December 19, 2003
  - ✓ Shot# 3106

Main Injector $2B cycle Proton Coalescing

- RF improvement
  - Implemented Feed-forward up the ramp.
  - Station control during coalescing
    - ✓ 53 MHz RF drive turned off during 2.5 MHz rotation.
- Bunch-by-bunch longitudinal damper
  - Commissioned on $2B cycle late December, 2003.
  - No more blowing up long. emittance in Booster.
  - 15 % decrease on bunch length after coalescing.
    - ✓ About 25% reduction in longitudinal emittance.
- 7-bunch coalescing
  - Coalescing efficiency is above 90%.
  - Optimized transverse emittance
    - ✓ Less # of Booster turns.
  - Coalescing not yet optimized for this smaller emittance
    - ✓ Aiming for L. emittance 2.0 ev-sec or smaller and
    - ✓ Coalescing efficiency 95% or better.

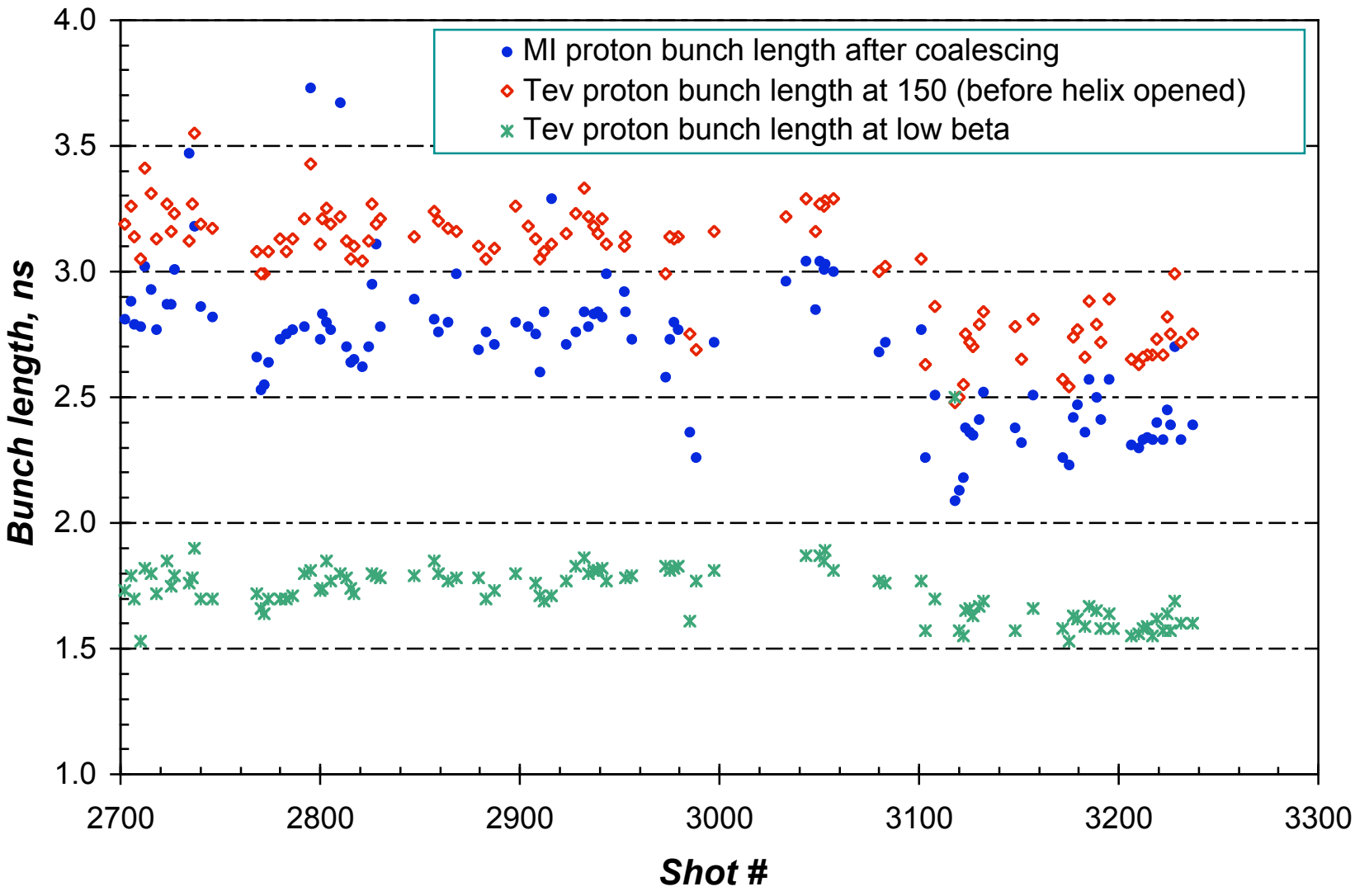
MI $2B cycle Proton Transverse Emittances

- Horizontal plane
  - 12 π-mm-mr at 8-GeV.
  - 12.5 π-mm-mr at 150 GeV, after coalescing.
  - Emittance growth is less than 1 π-mm-mr.
- Vertical plane
  - 11.5 π-mm-mr at 8-GeV.
  - 12 π-mm-mr at 150 GeV, after coalescing.
  - Emittance growth less than 1 π-mm-mr.
- Flying wire work during September shut-down
  - ✓ Photo tube changed, both horizontal and vertical plane.
  - ✓ The wire of vertical flying wire was found loose and fixed.

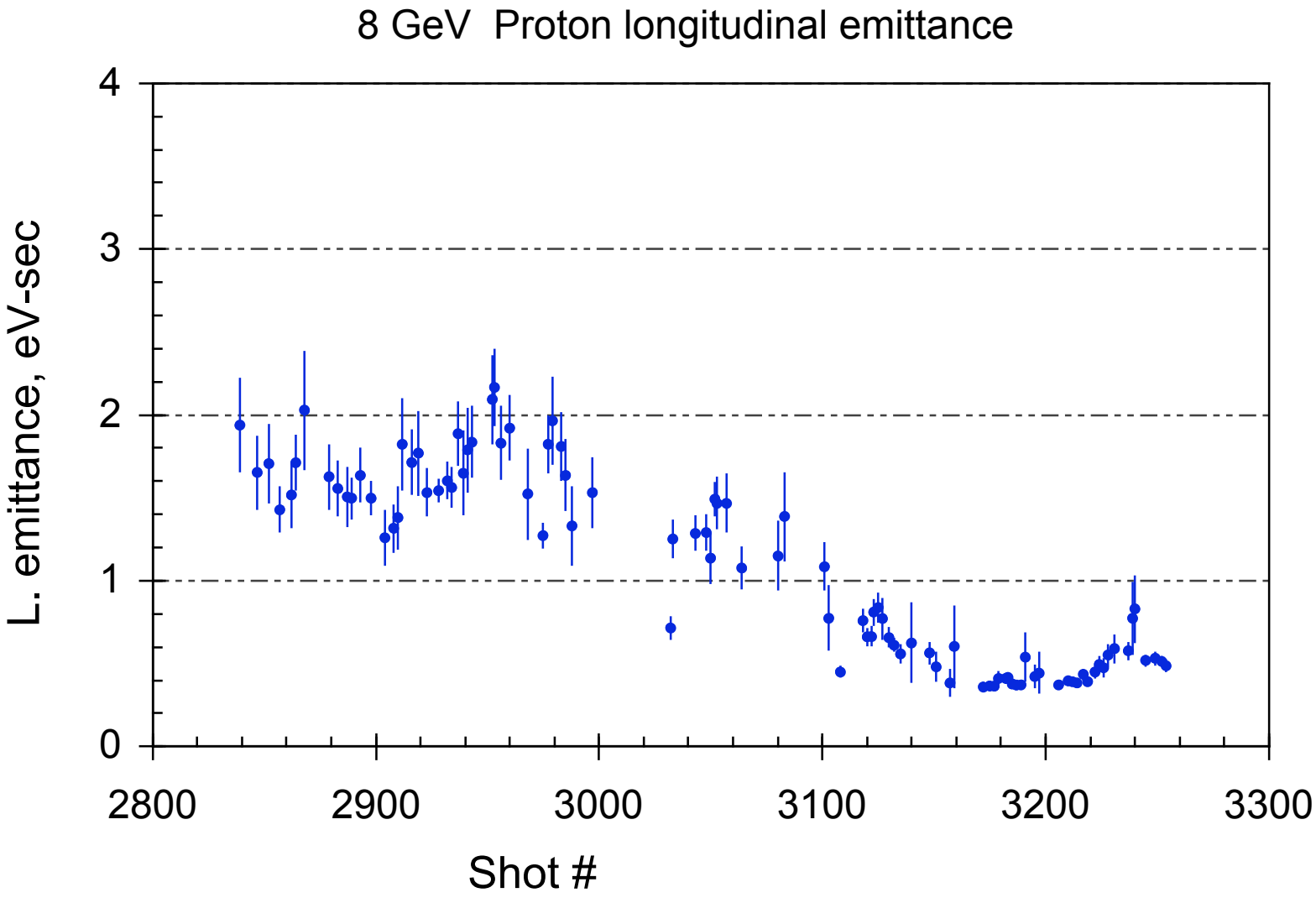
MI proton on $29 pbar stacking cycle

- Longitudinal
  - Feed-forward beam loading compensation.
  - Bunch-by-bunch longitudinal damper is being commissioned.
- Transverse emittance
  - 16.5 horizontal and 15.5 π-mm-mr vertical.
  - Less than 1 π-mm-mr growth from injection to flat-top.
- Intensity
  - 5.2 E12 average intensity delivered.
  - Tracks Booster output.

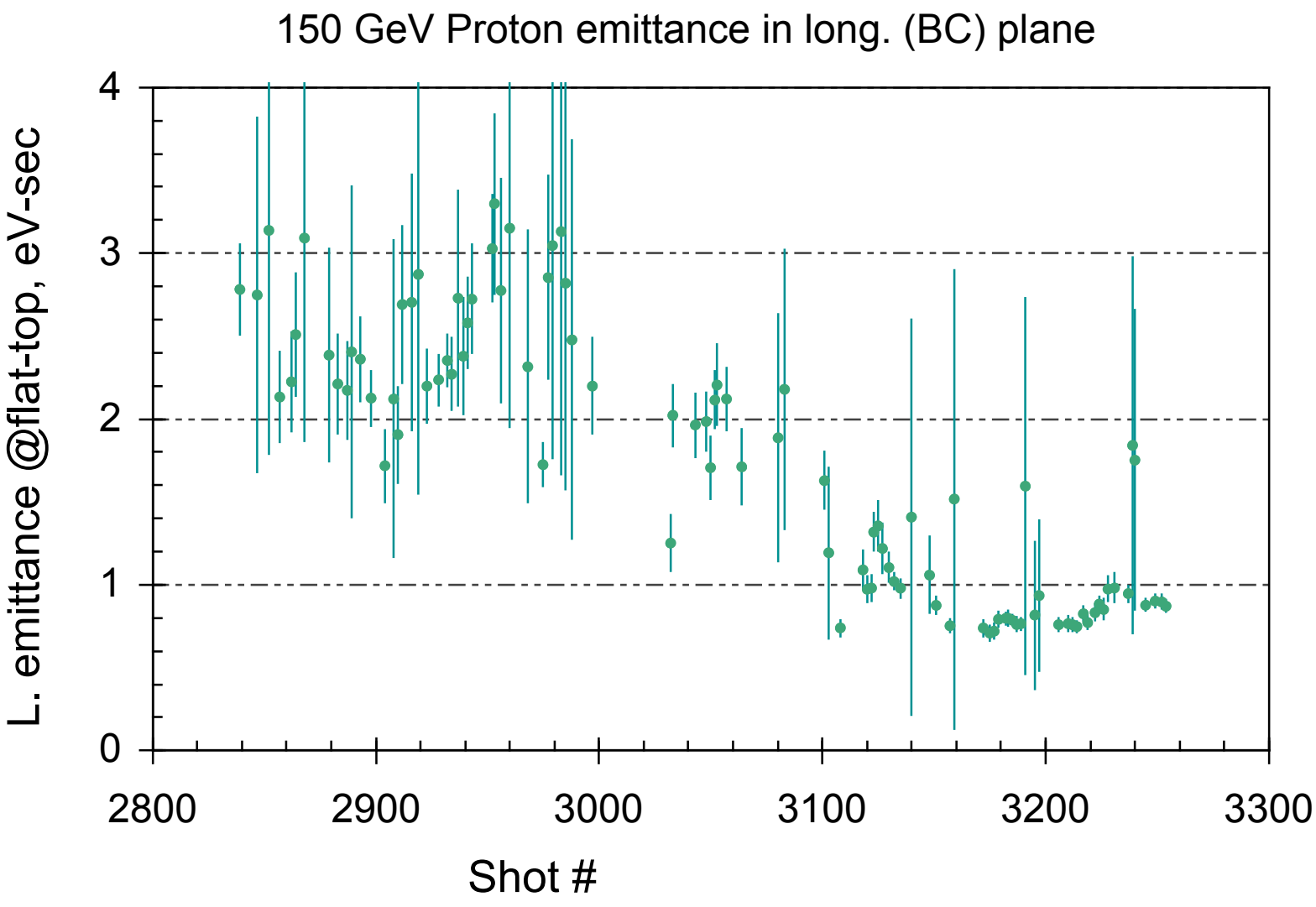
Bunch length from MI to TeV Low Beta



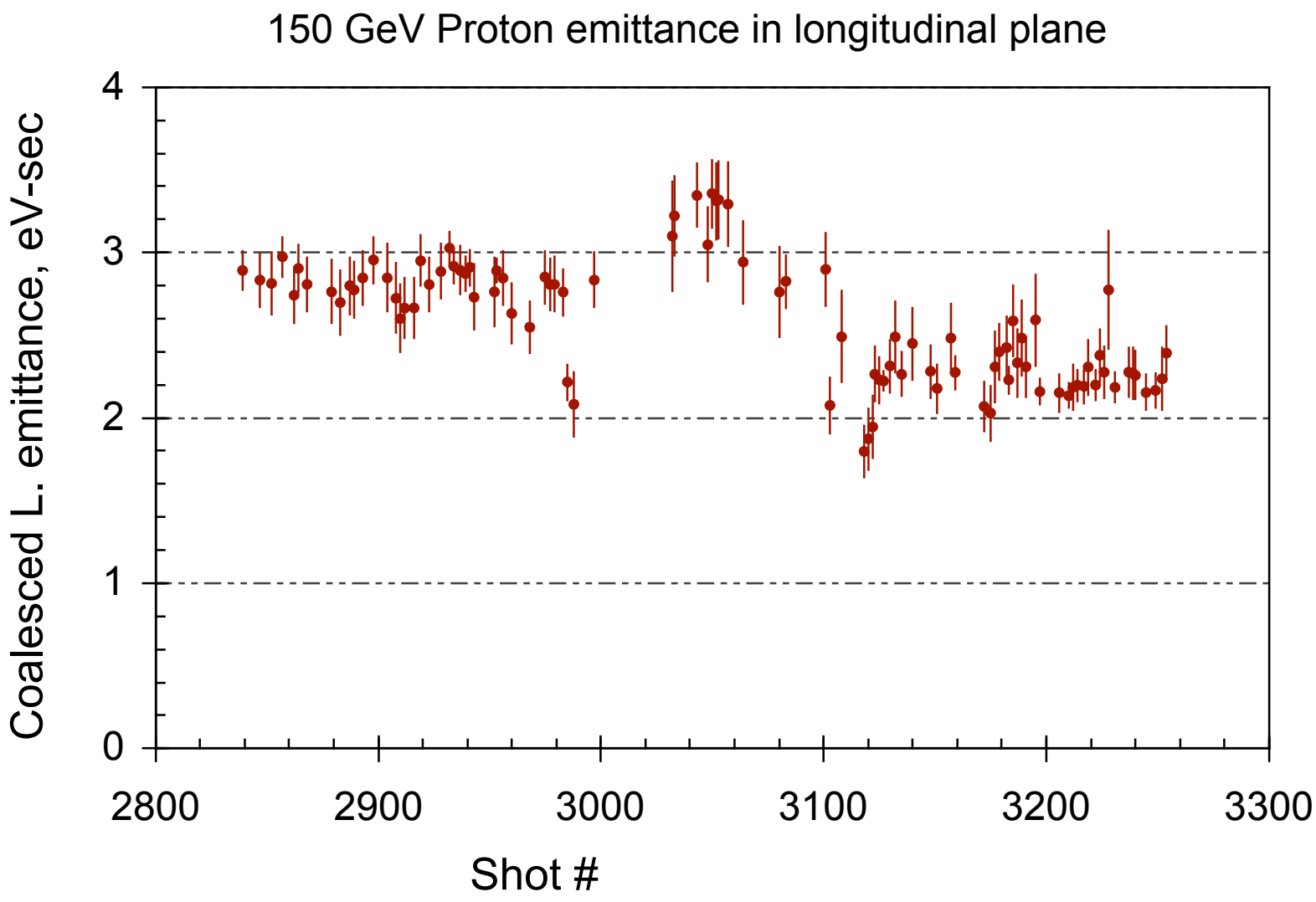
Main Injector proton long. emittance @8GeV



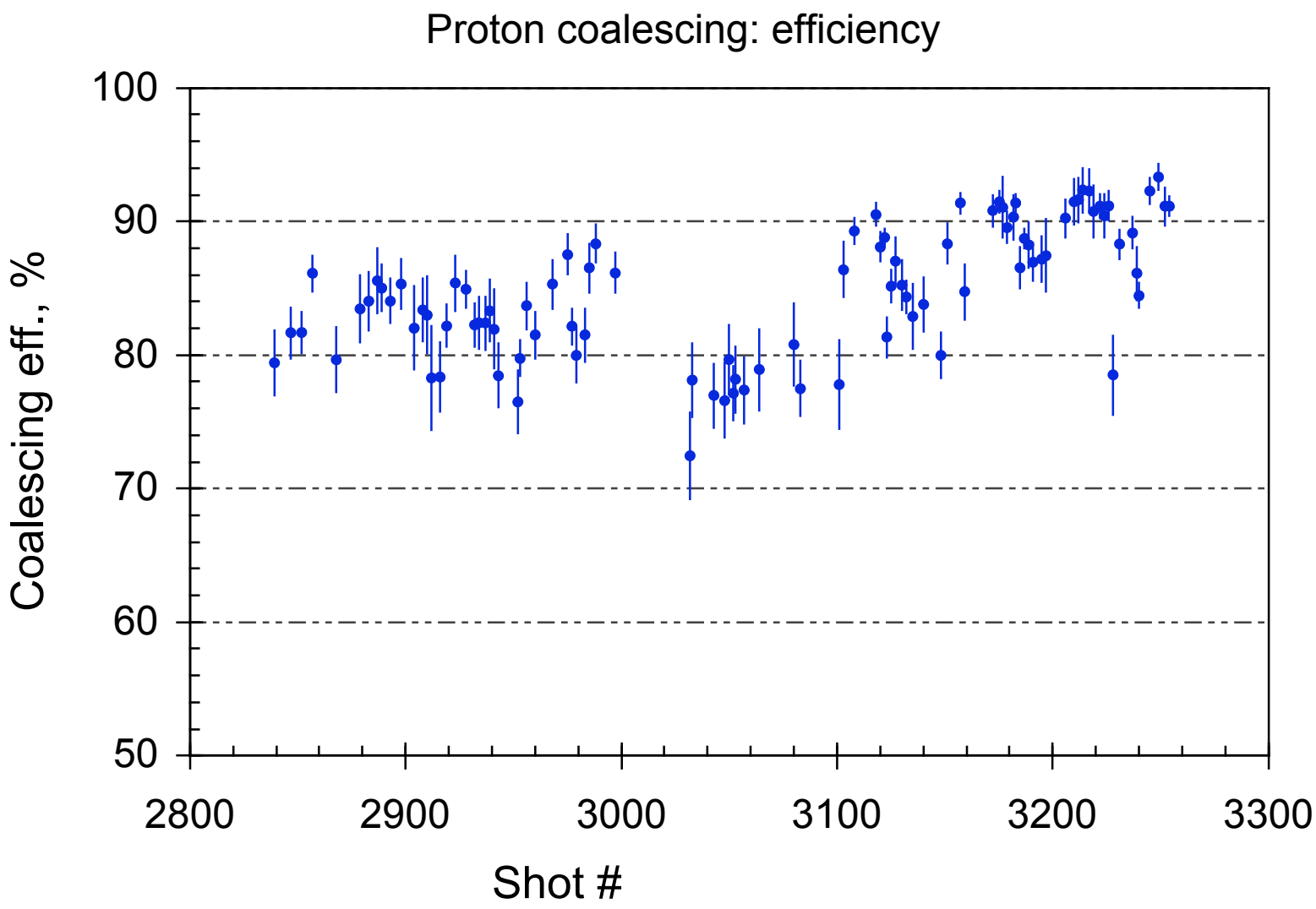
MI proton 150 GeV long. emittance, Before Coalescing



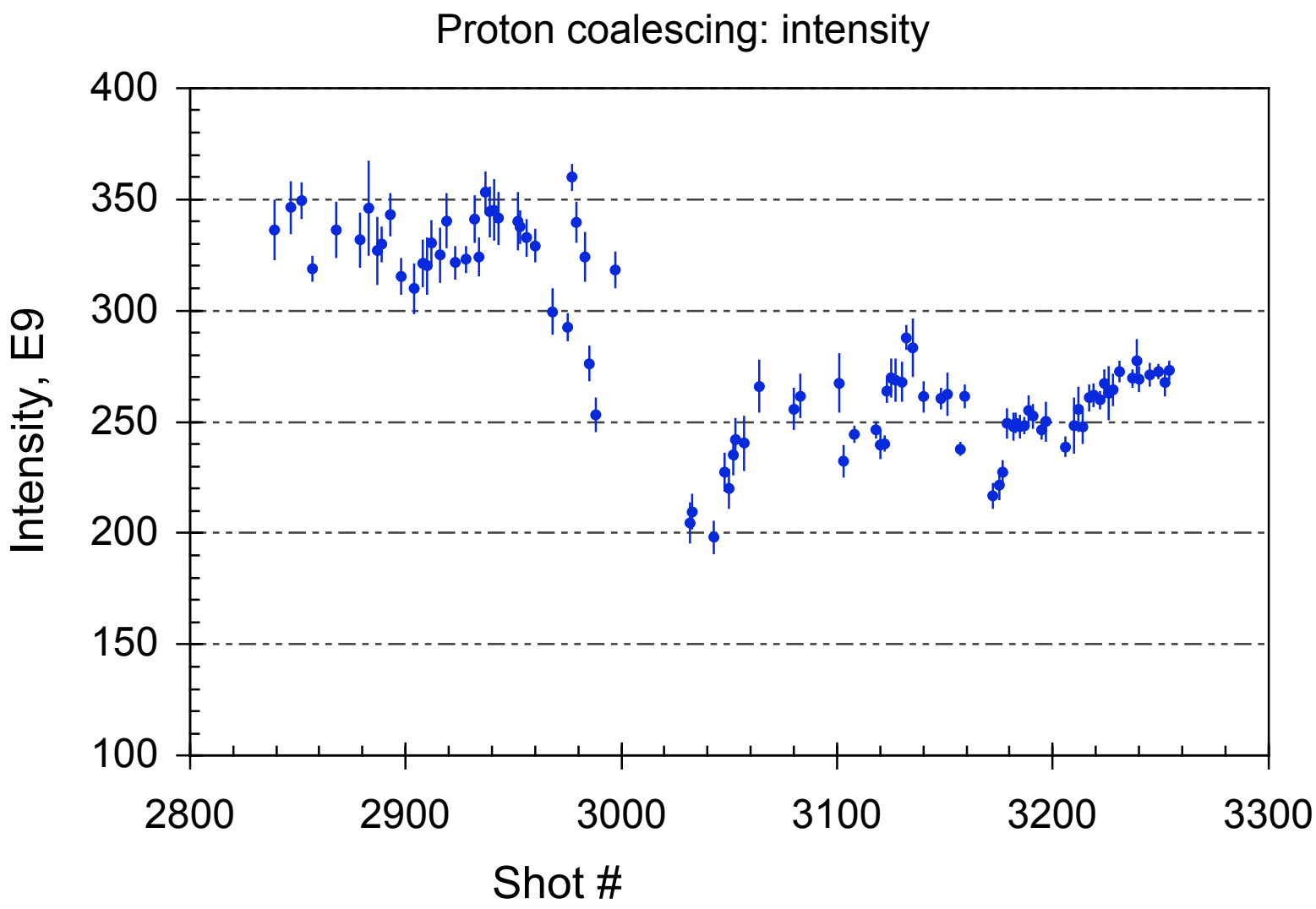
MI Proton coalesced longitudinal emittance



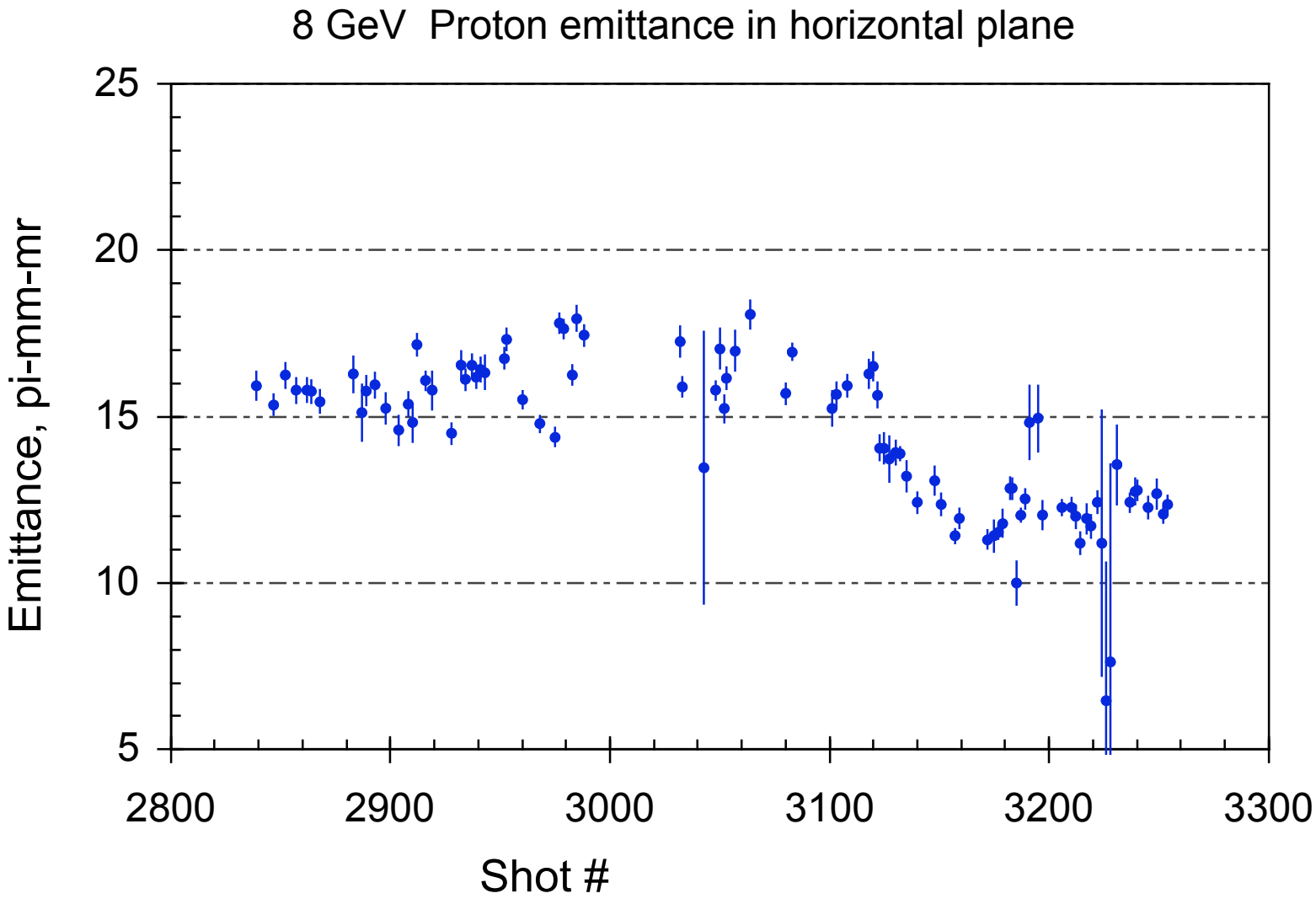
Main Injector Proton coalescing efficiency



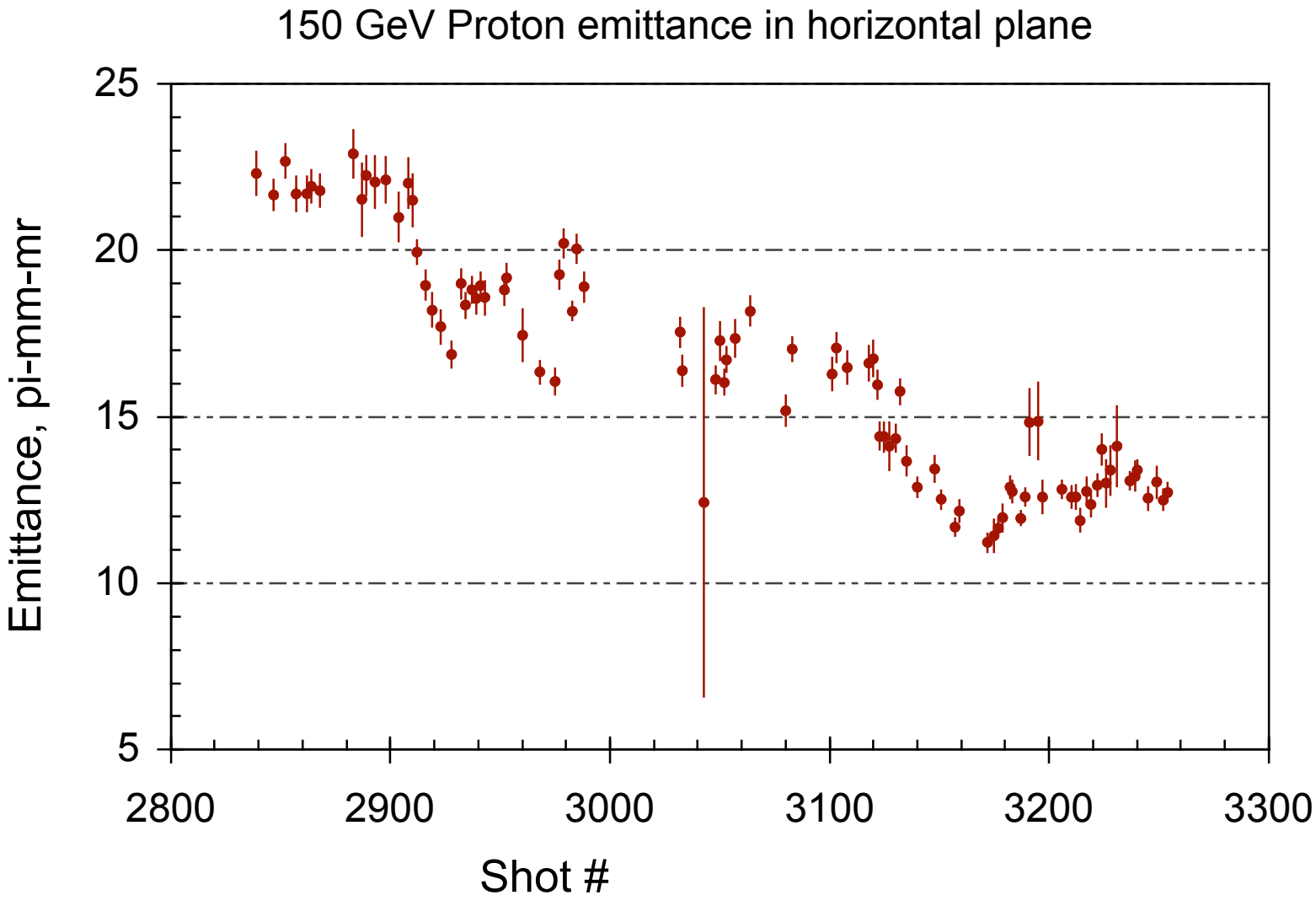
Proton intensity per bunch after coalescing



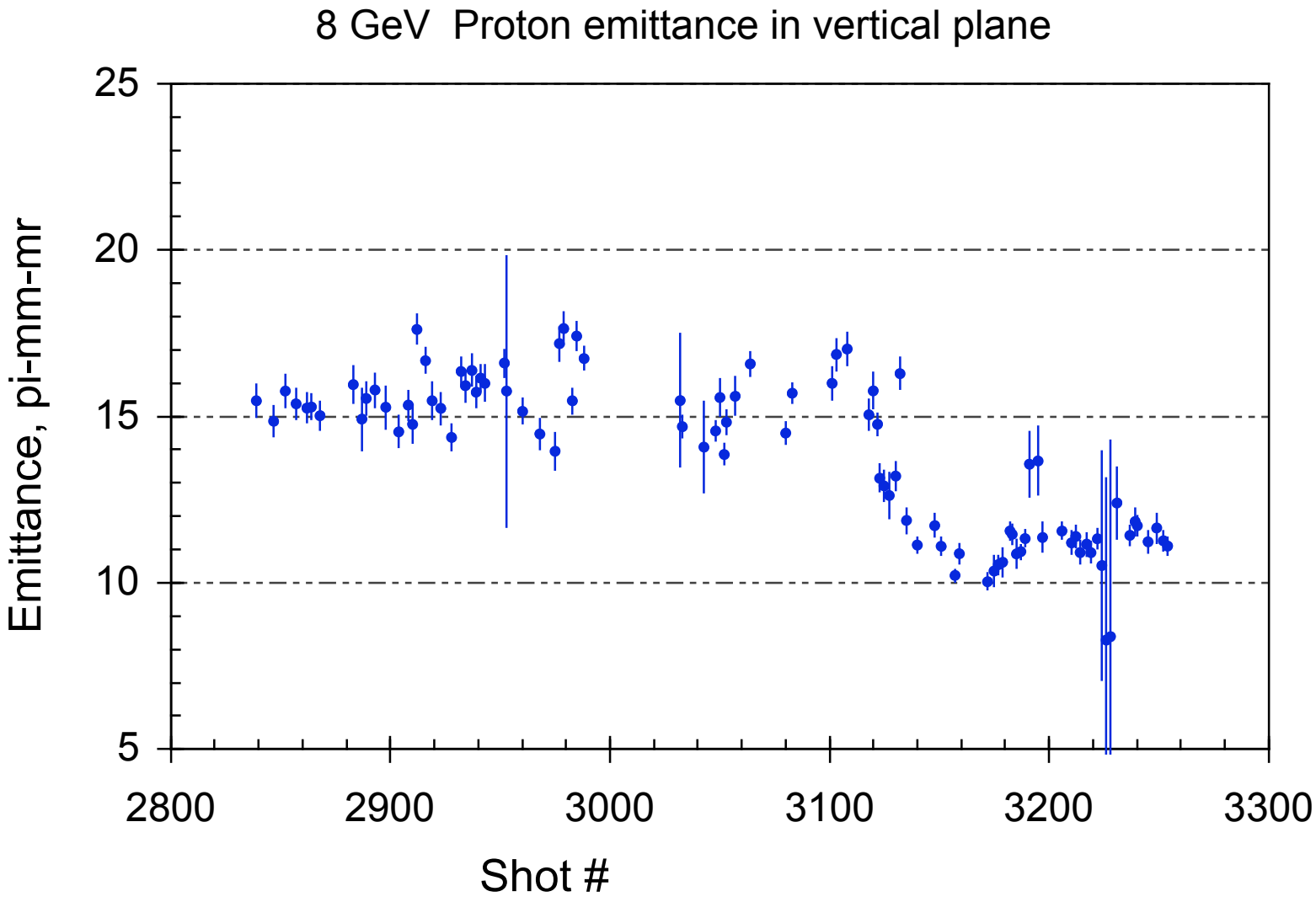
Proton horizontal emittance at 8-GeV



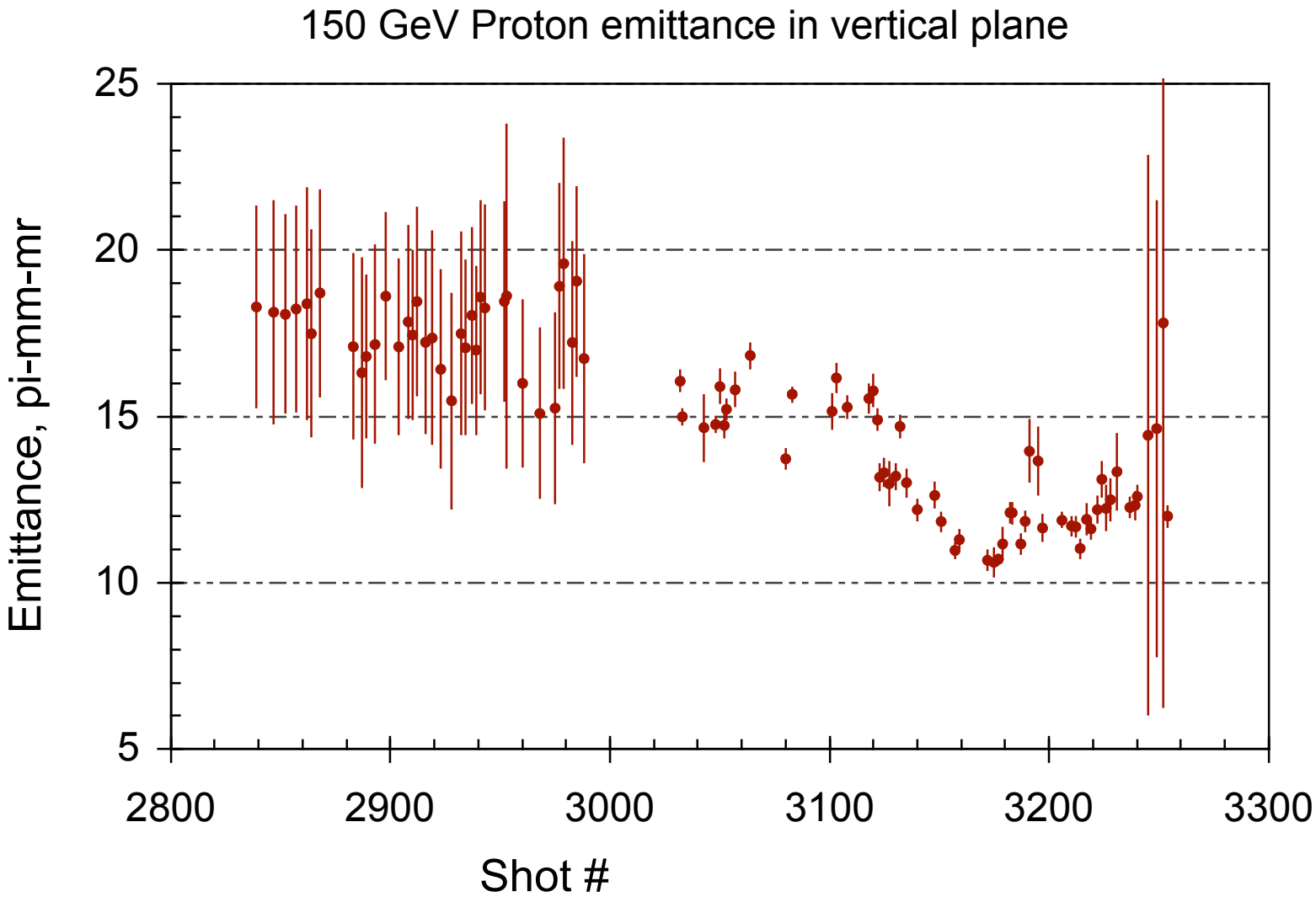
Proton horizontal emittacne at 150 GeV



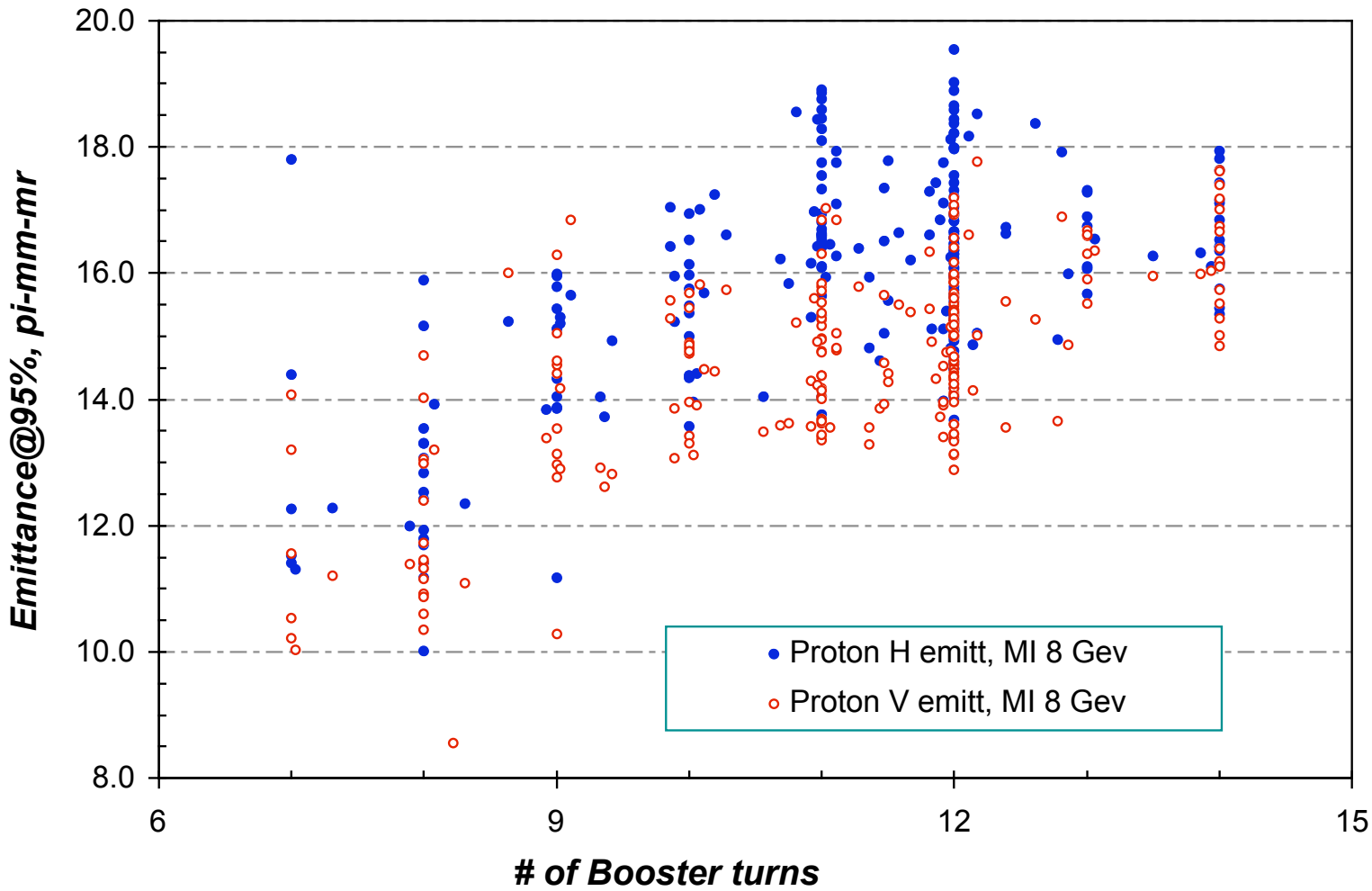
Proton vertical emittance at 8 GeV



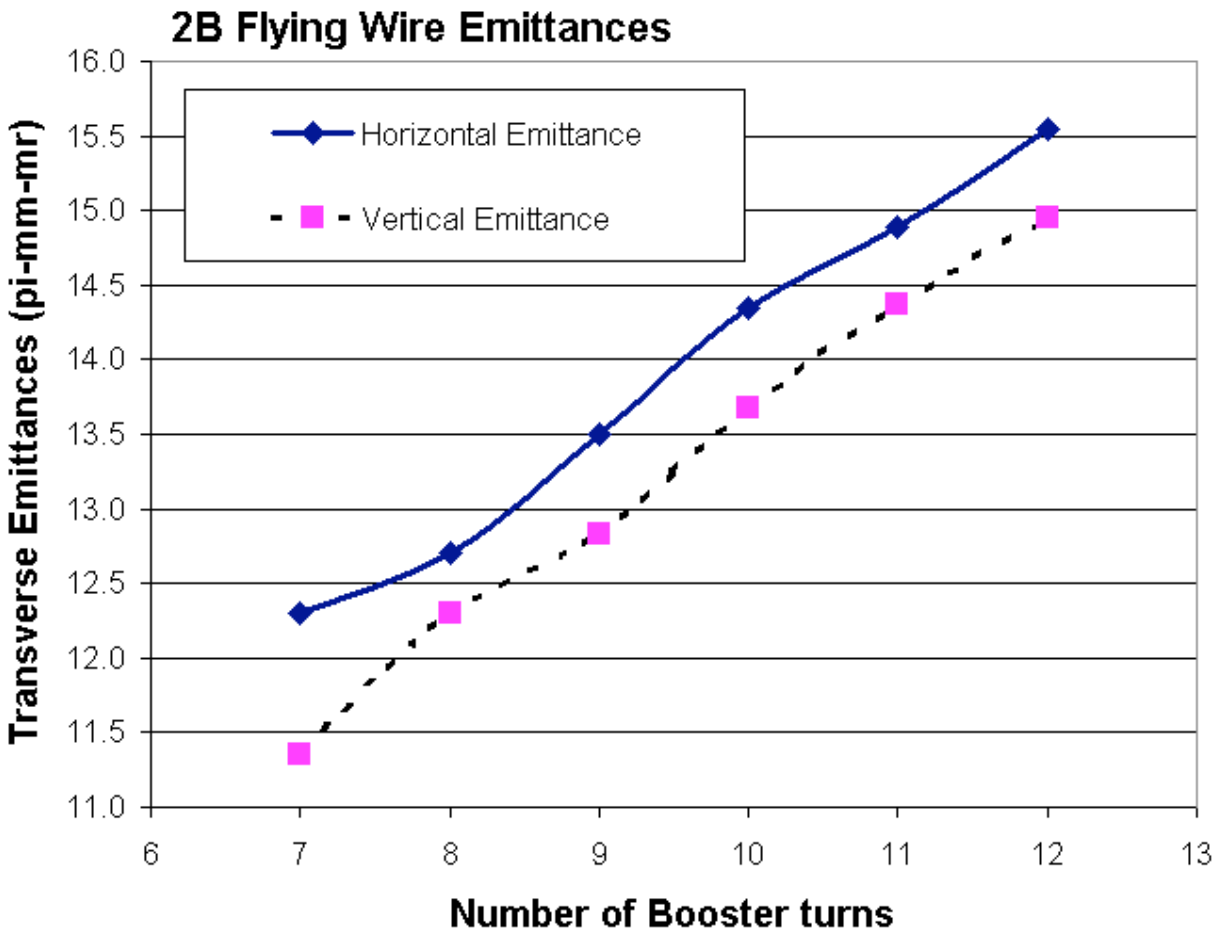
Proton vertical remittance at 150 GeV



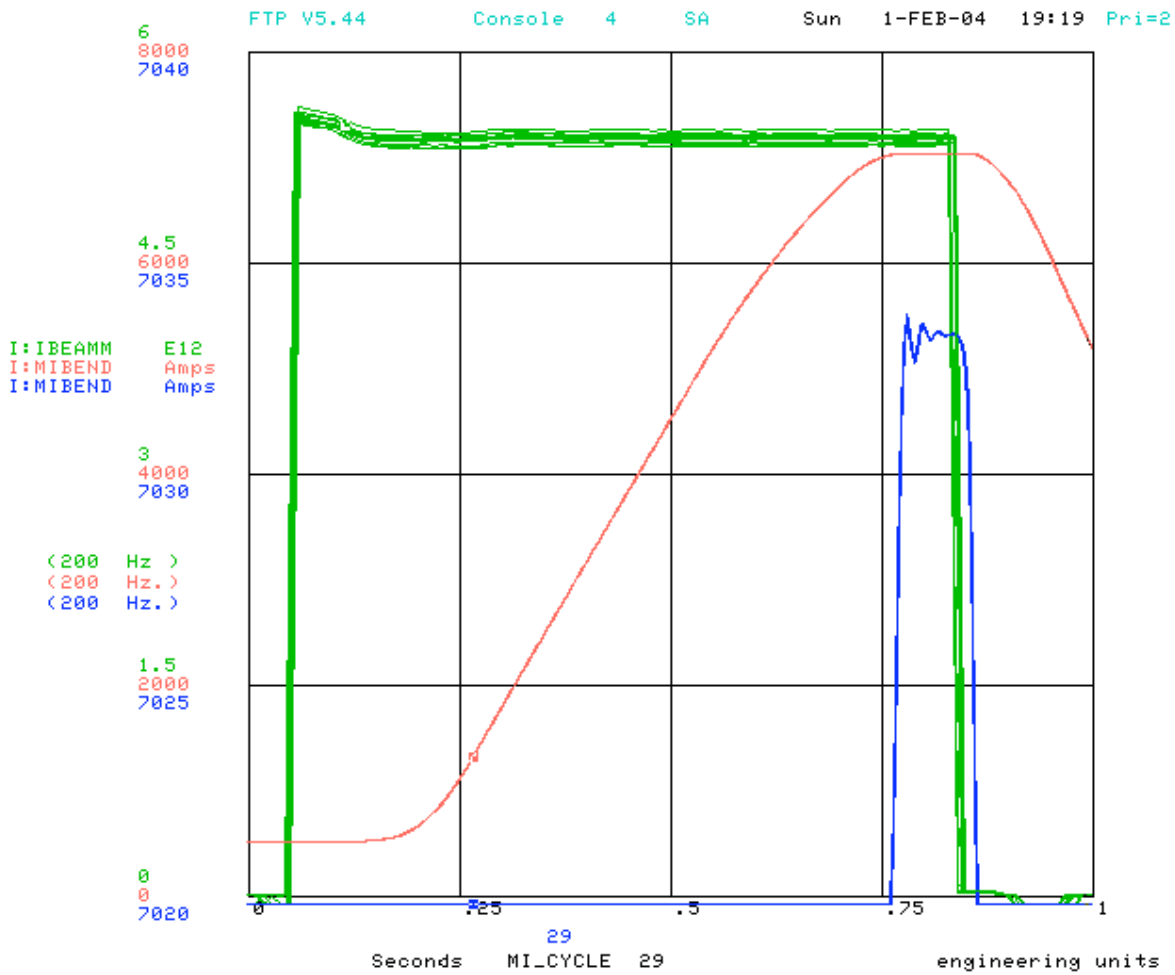
MI transverse emittance @8-GeV



MI $2B study: emittance vs # of Booster turns

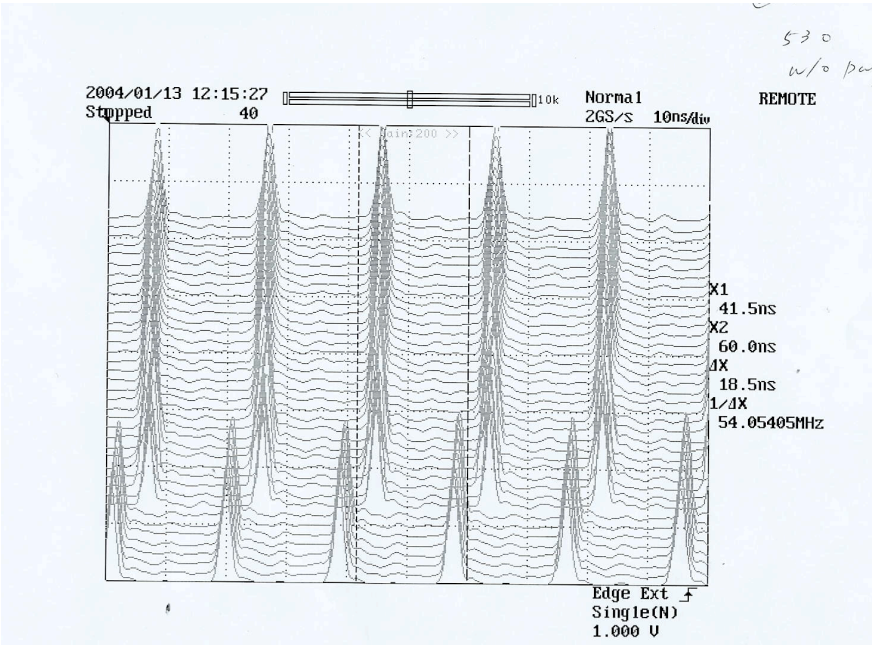


MI $29 cycle intensity fast-time-plot

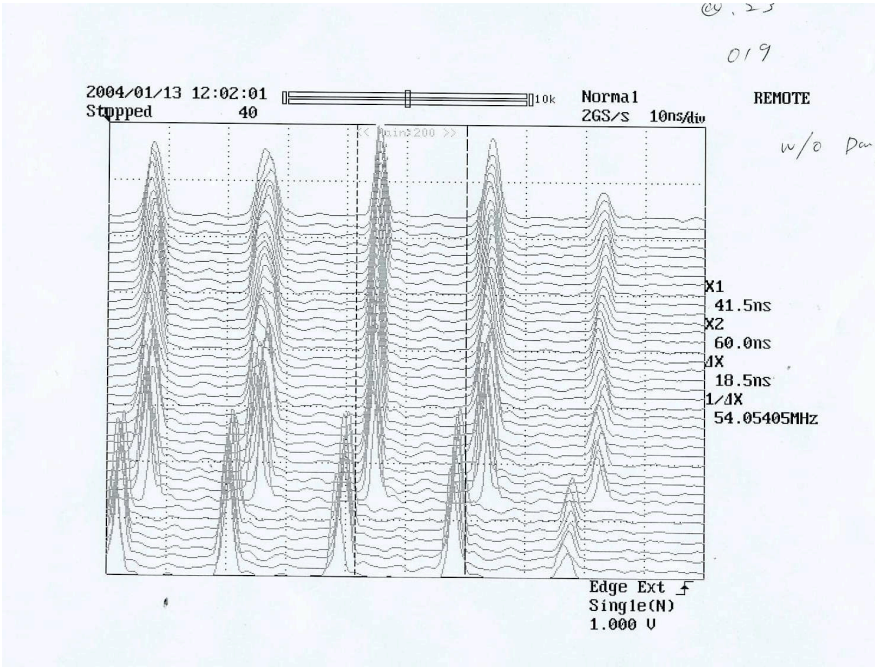


Transition crossing: Normal MI $29 stacking cycles

leading 5 bunches

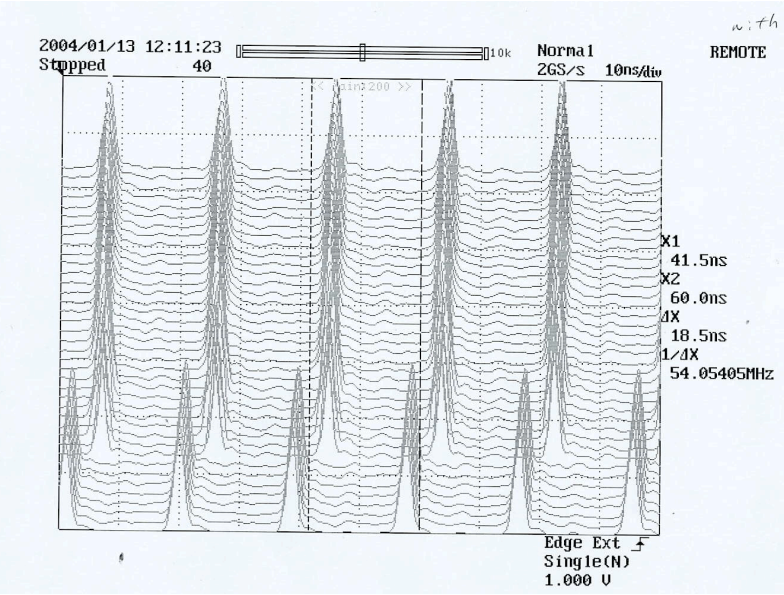


trailing 5 bunches

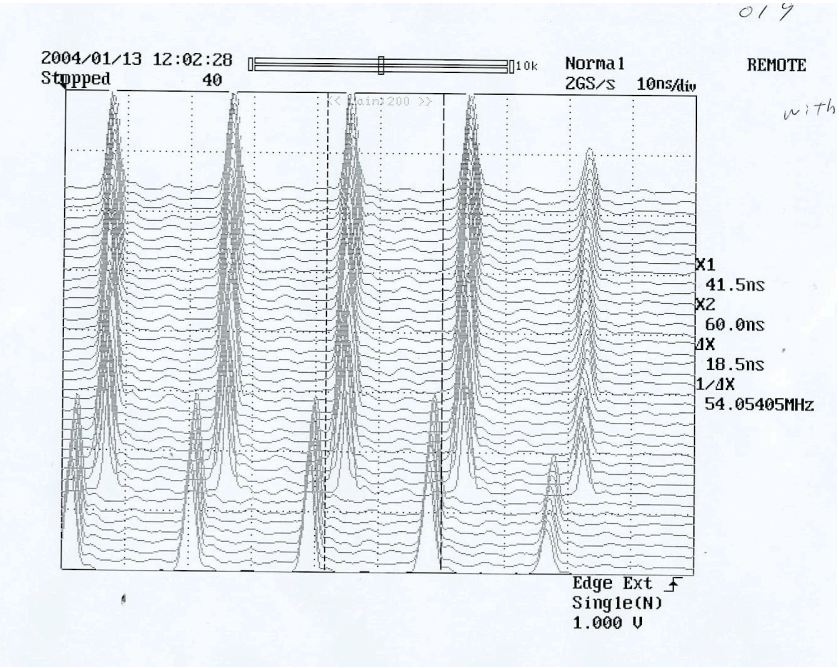


Transition crossing: MI $29 cycle with Long. damper

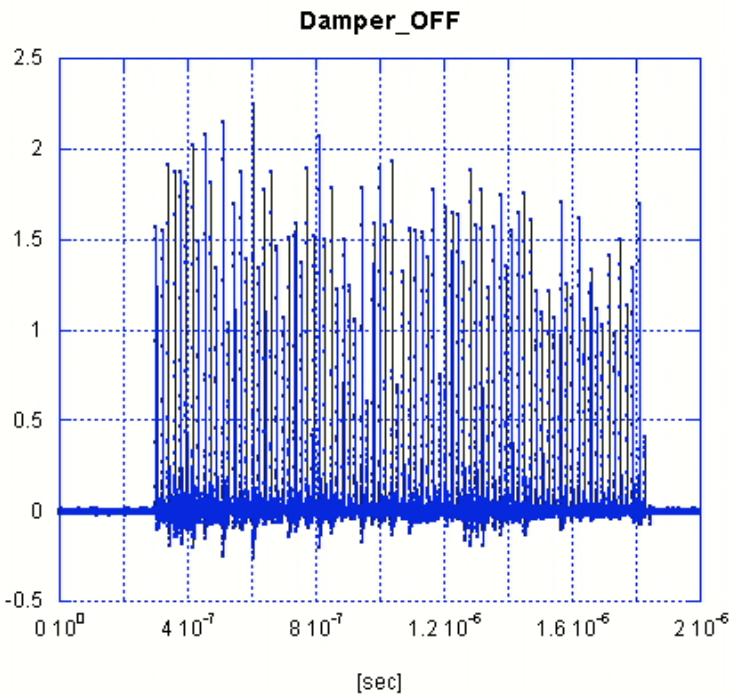
leading 5 bunches

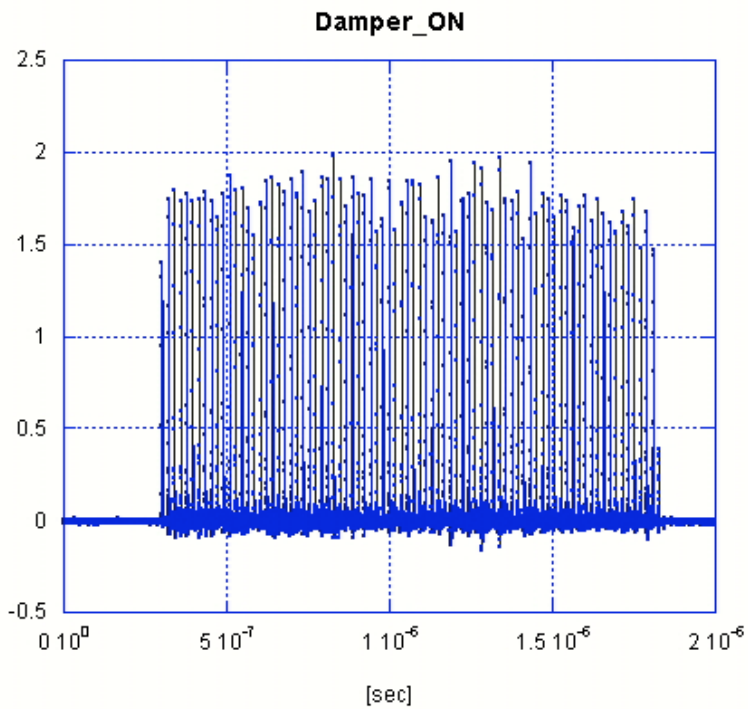


trailing 5 bunches



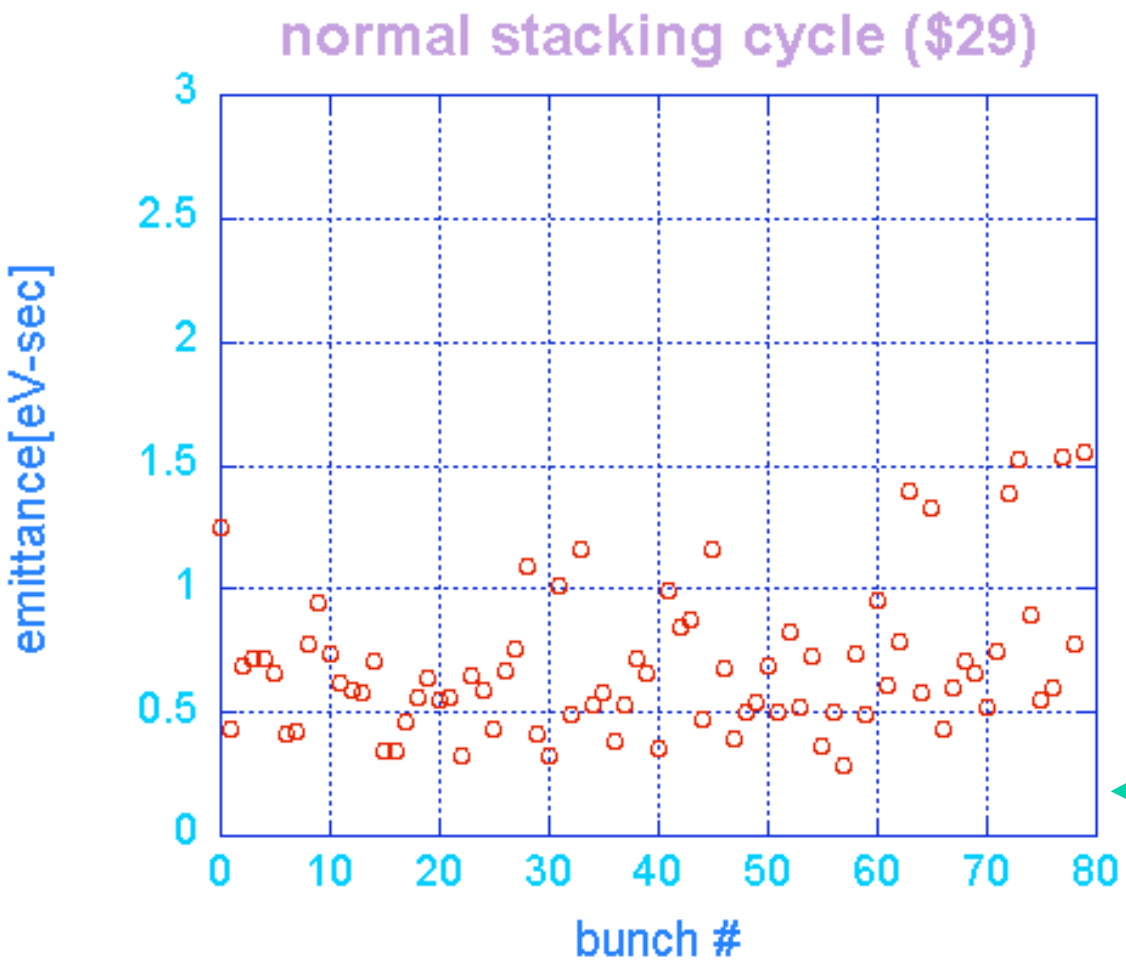
MI $29 batch intensity profile



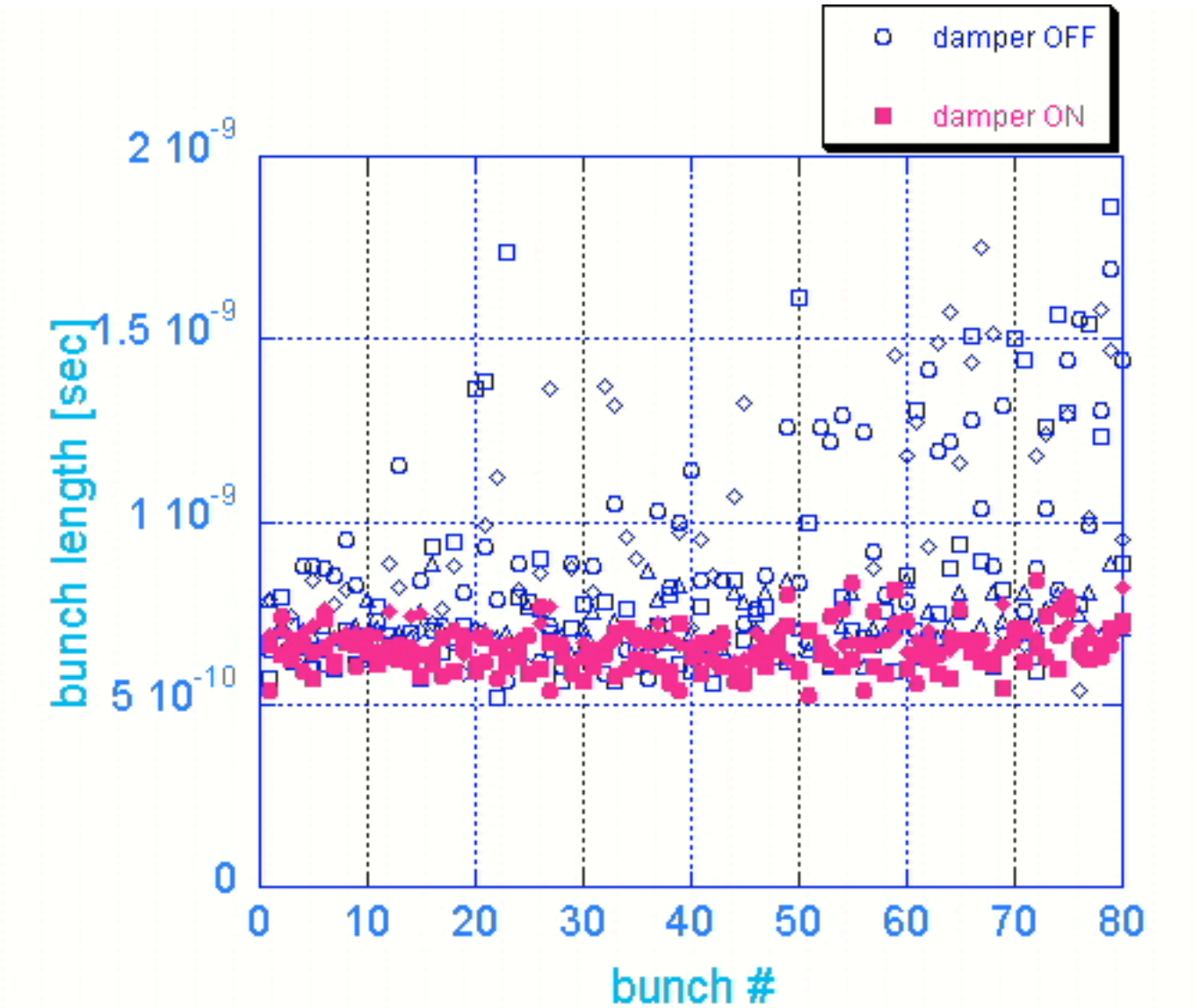


Proton long. emittance at $29 cycle flat-top

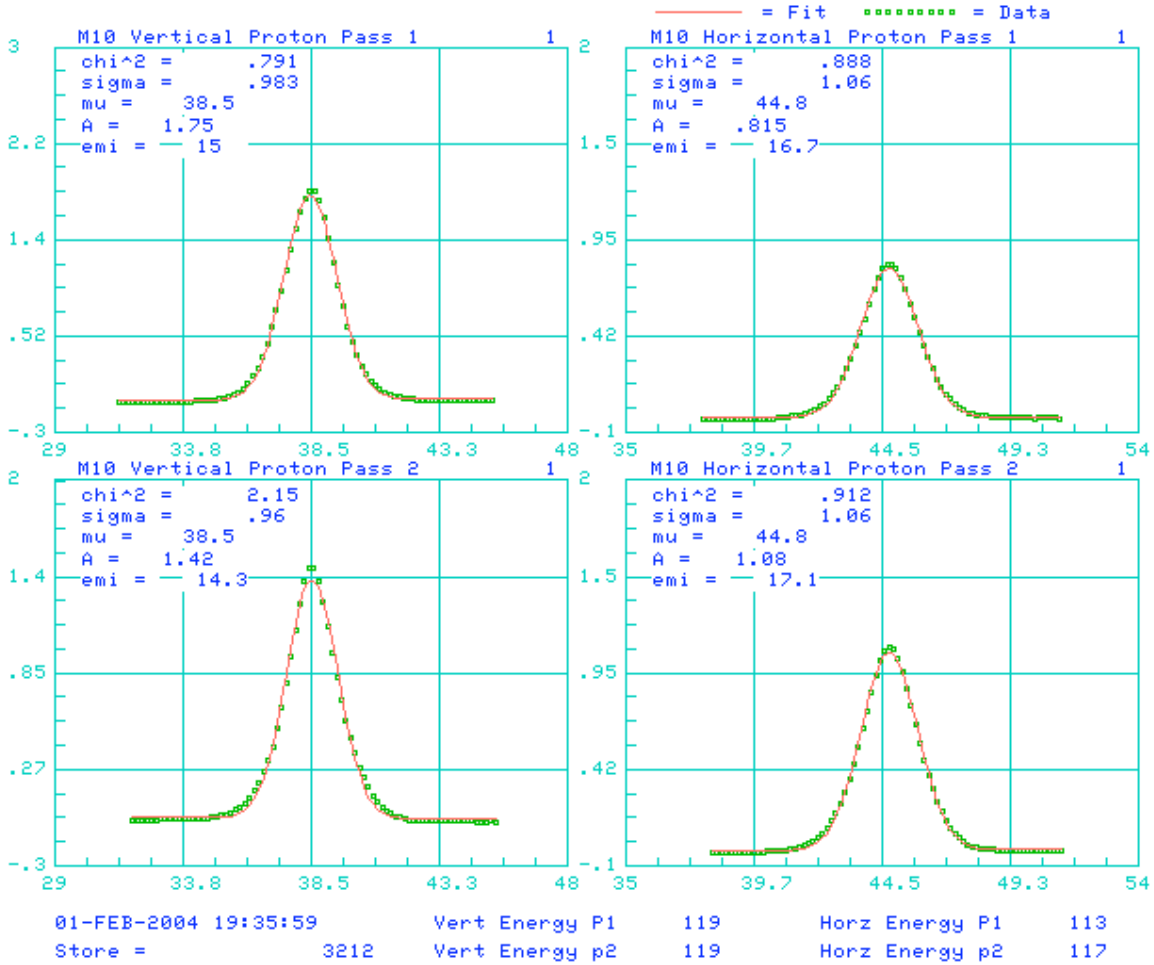
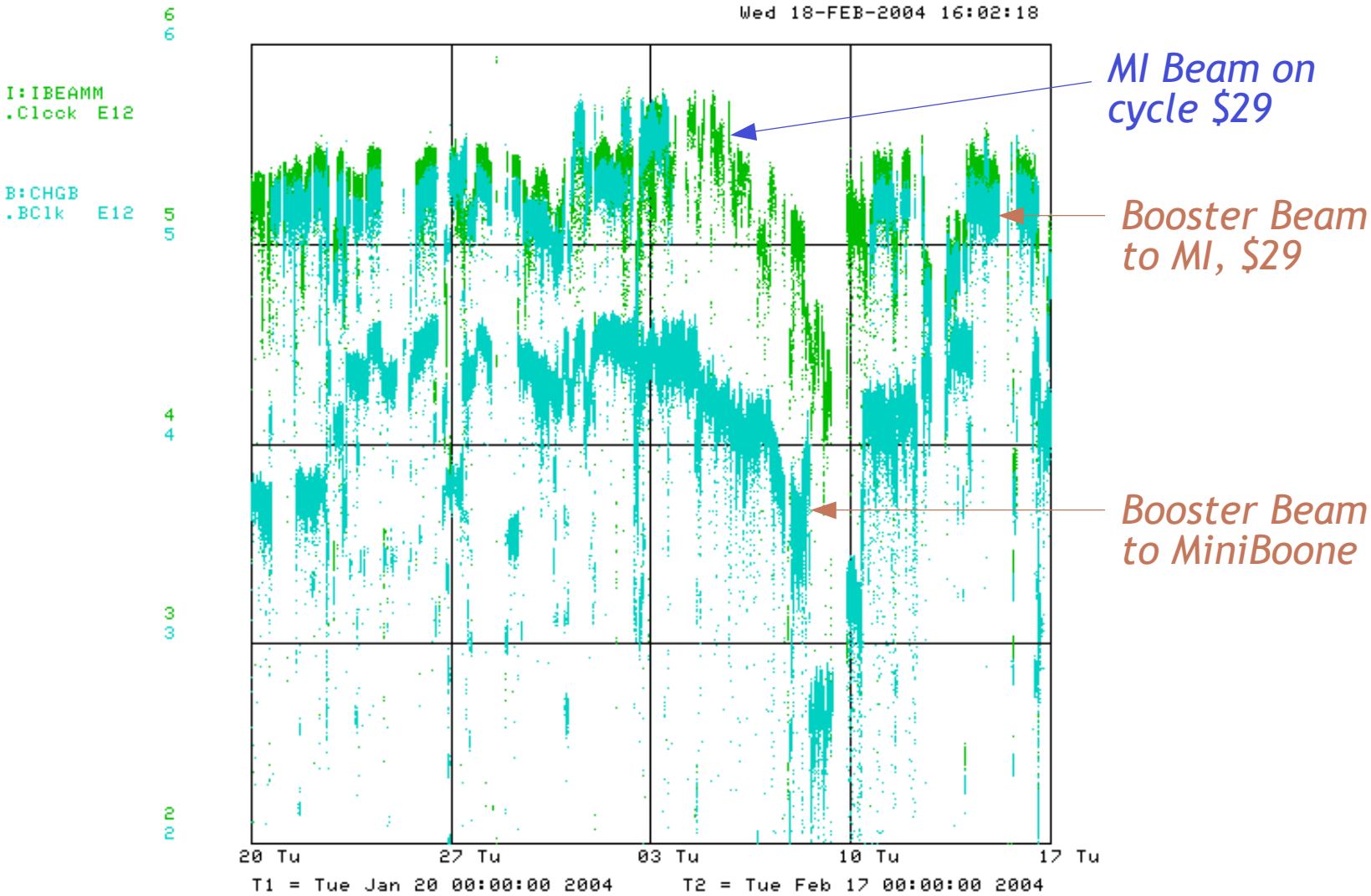
(0.15 eV-sec at injection)



Proton bunch length on $29, after bunch rotation



MI $29 cycle emittances @120 GeV



MI $29 delivered intensity, data logger