

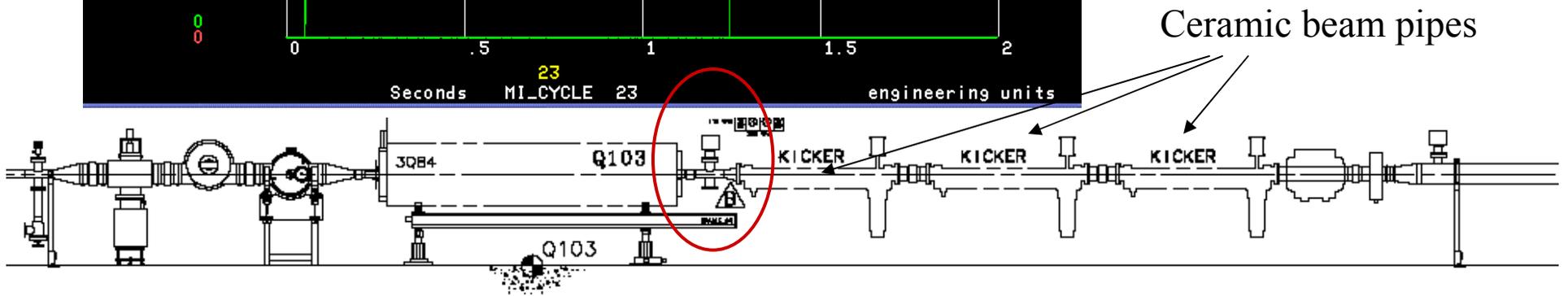
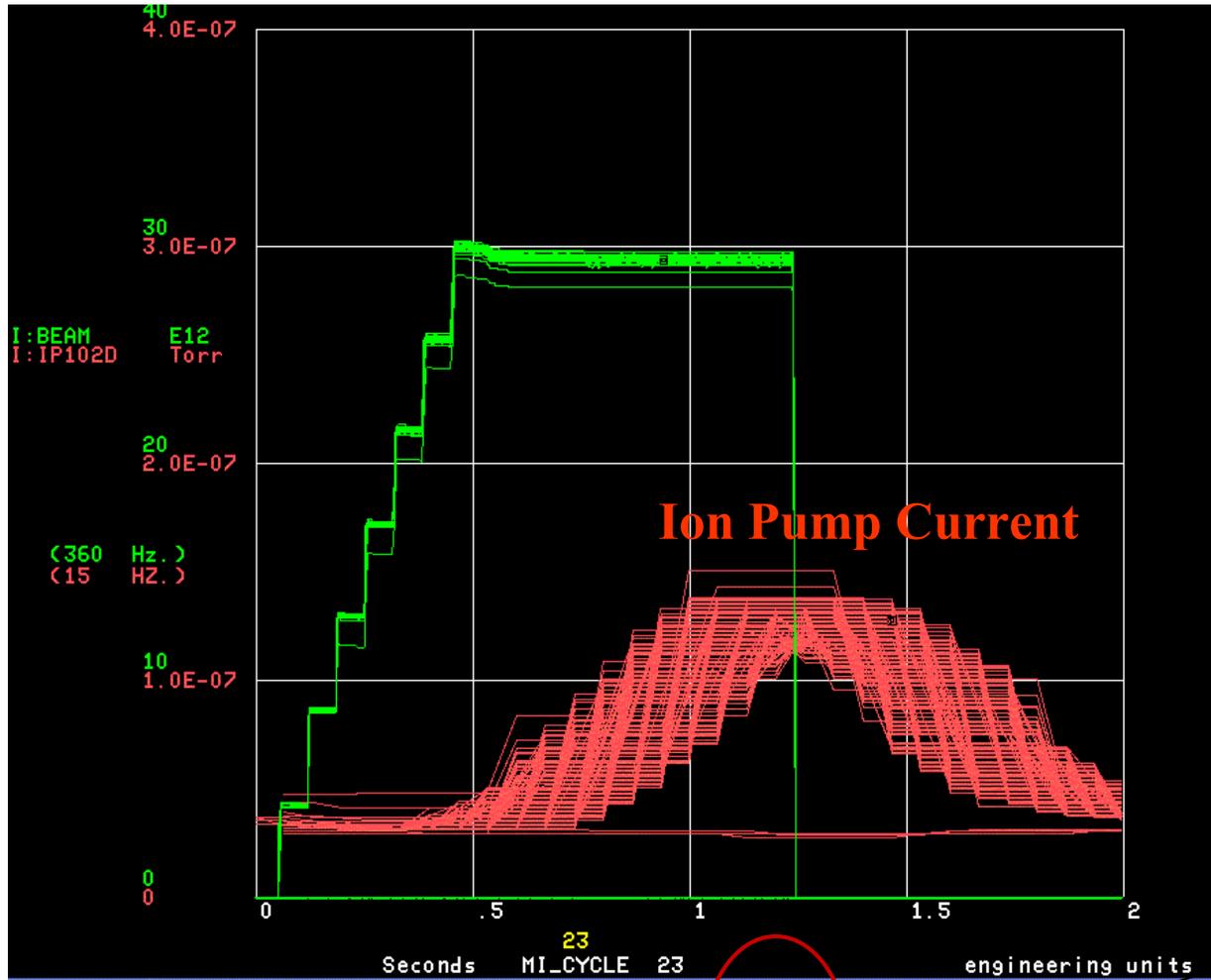
# Electron Cloud Measurements in the Fermilab Main Injector

*Robert Zwaska - Fermilab*

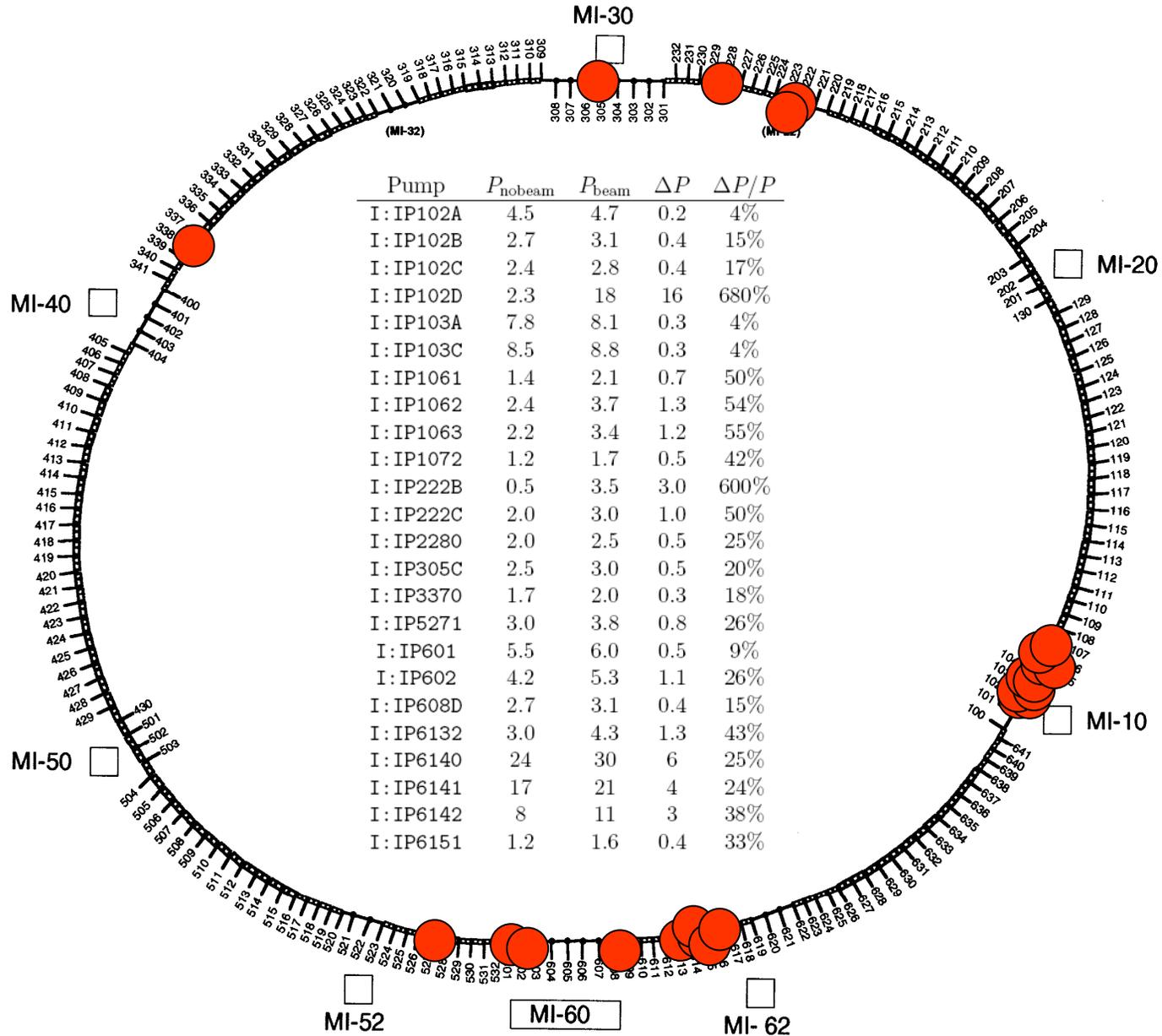
## Outline

1. Vacuum Rises in the Main Injector
2. Close look at a particular rise
3. Installation of new instrumentation
4. Beam parameters available for study

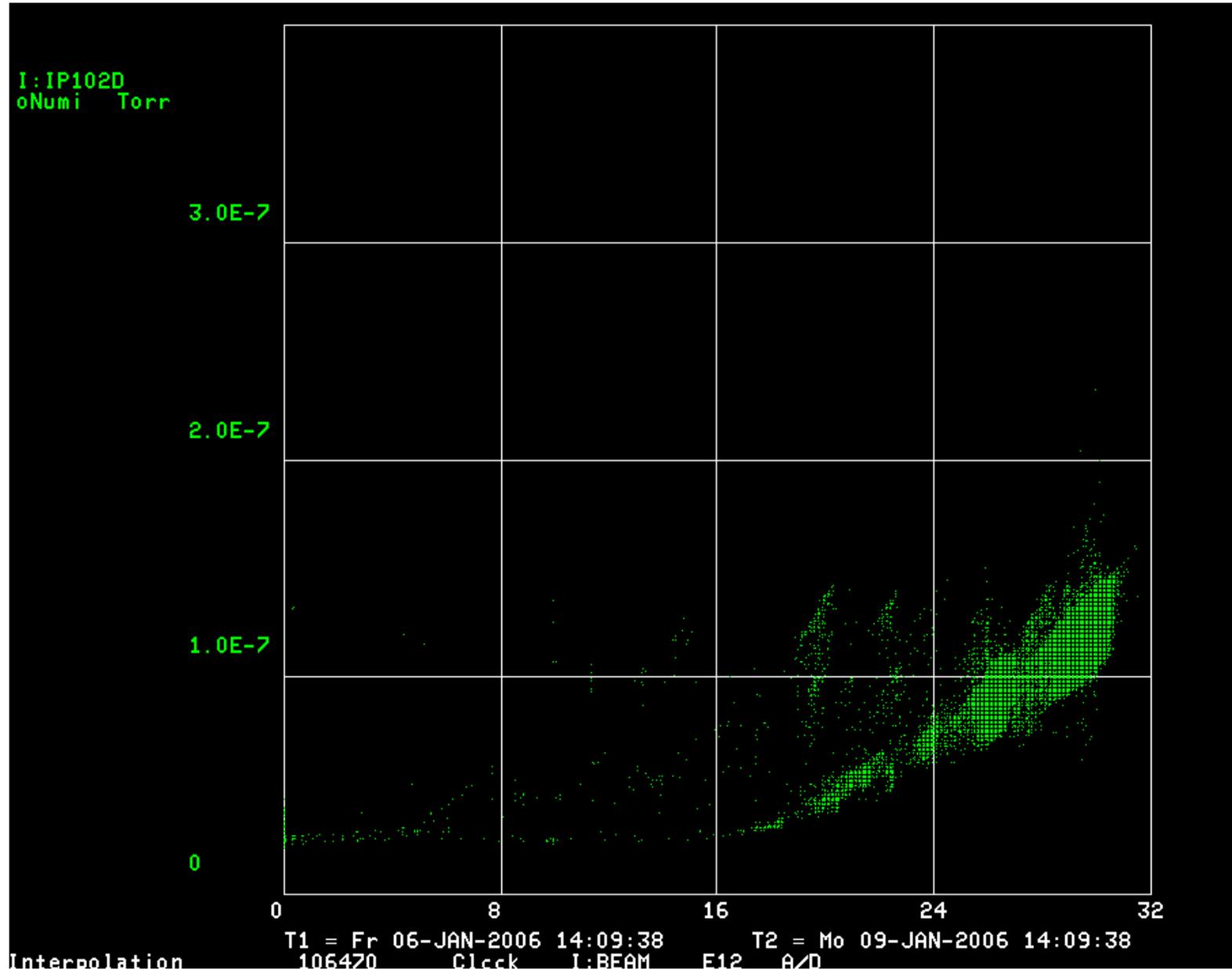
# Initial Measurements of Dynamic Pressure Rise



# Dynamic Rises Around the Ring

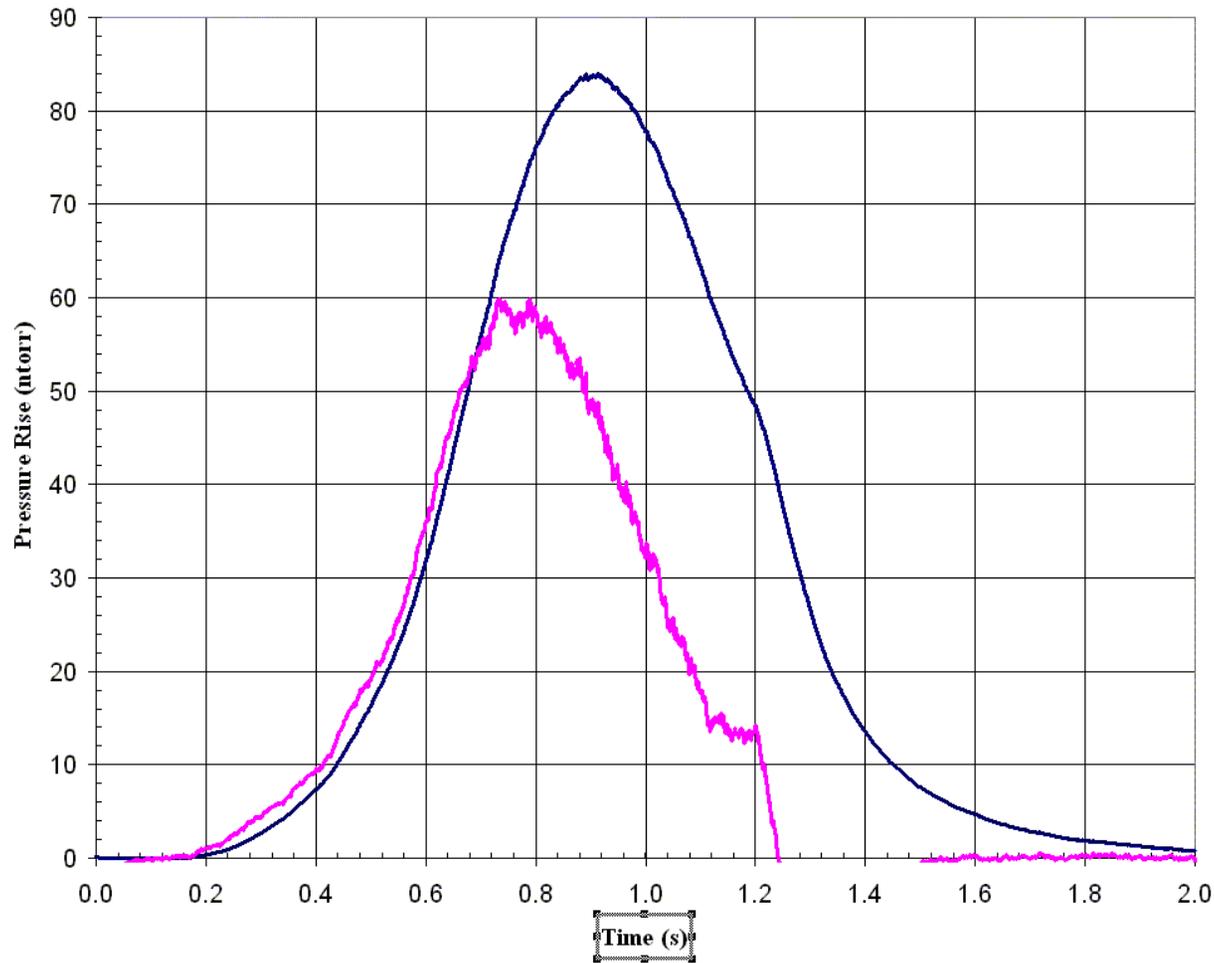


# Nonlinear Response

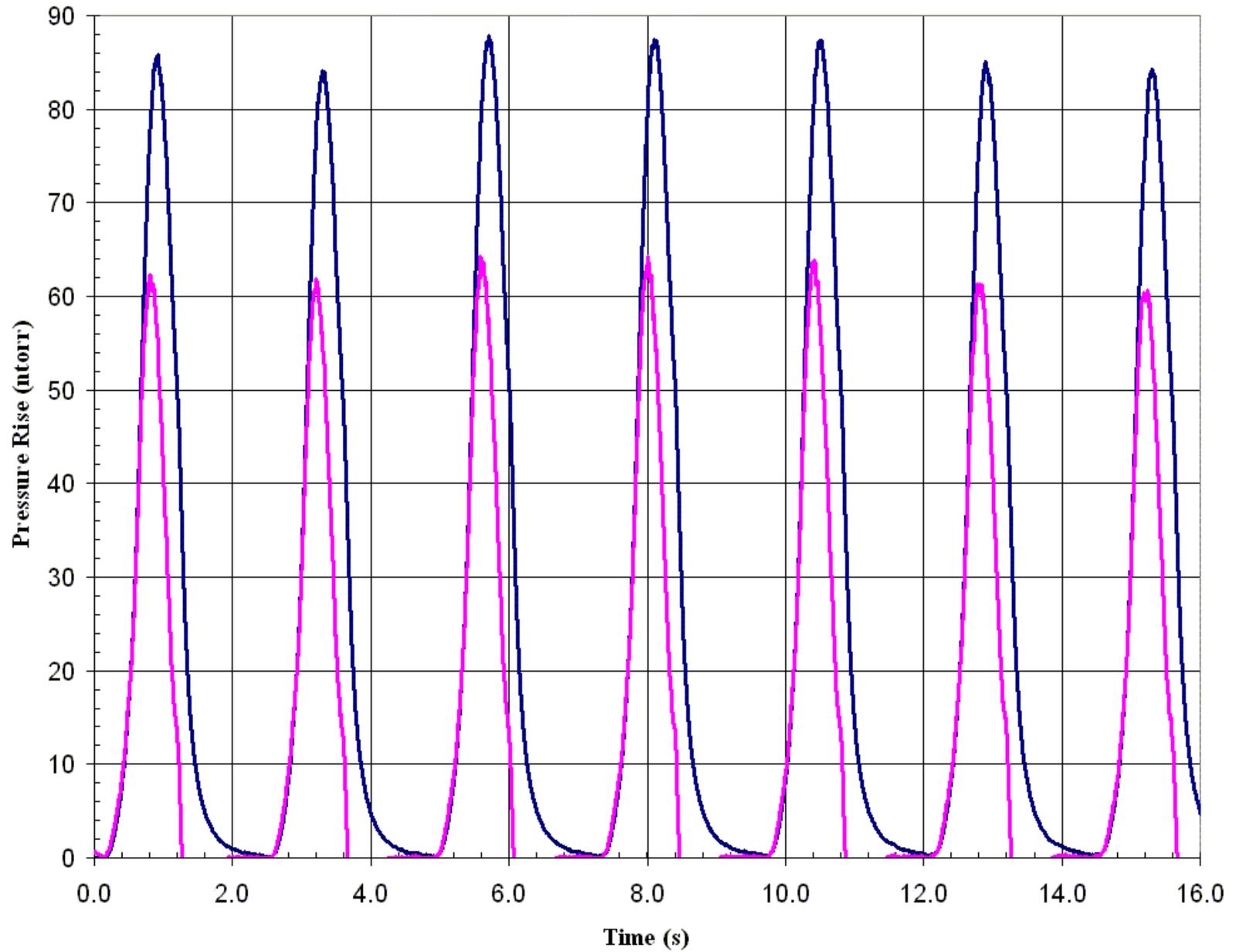


# Closer Look – 5 Hz ion pump

- Beam-coincident pressure rise is clear
- Deconvoluted impulse correlates well with cycle



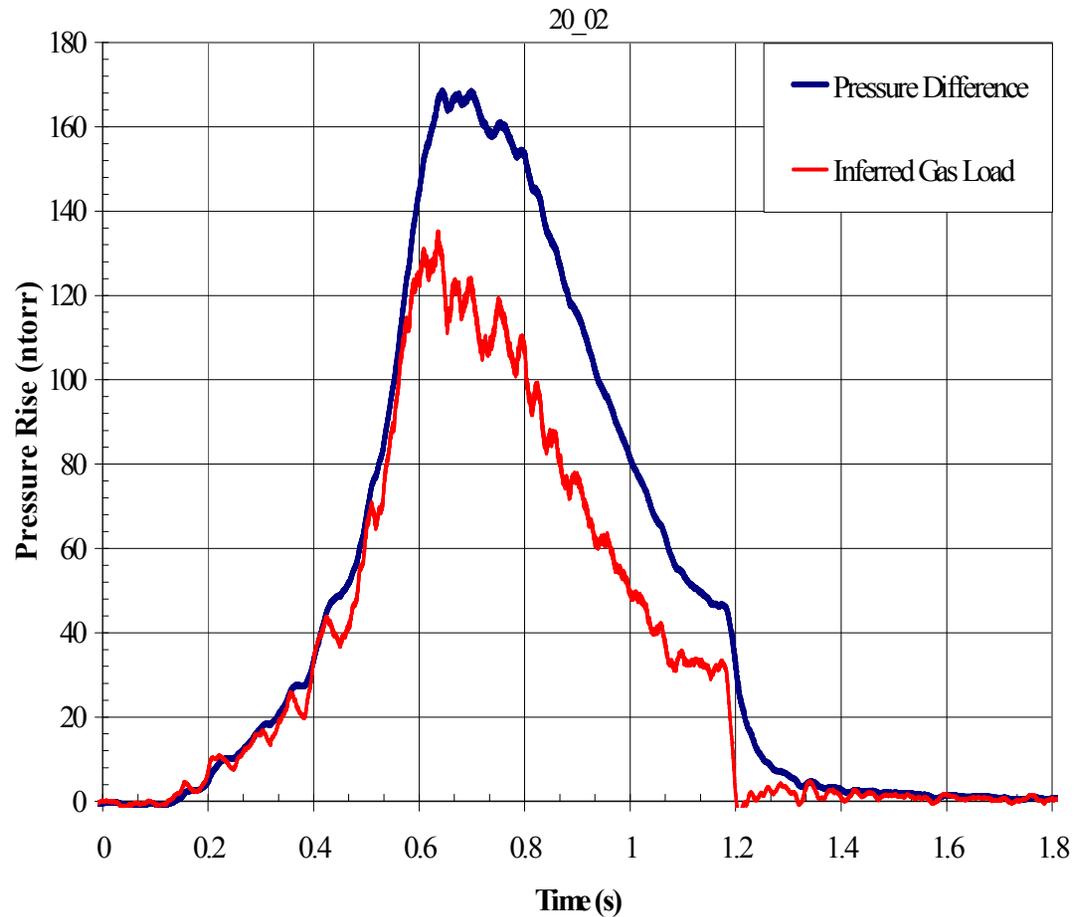
# String of Pulses



# 50 Hz Pump

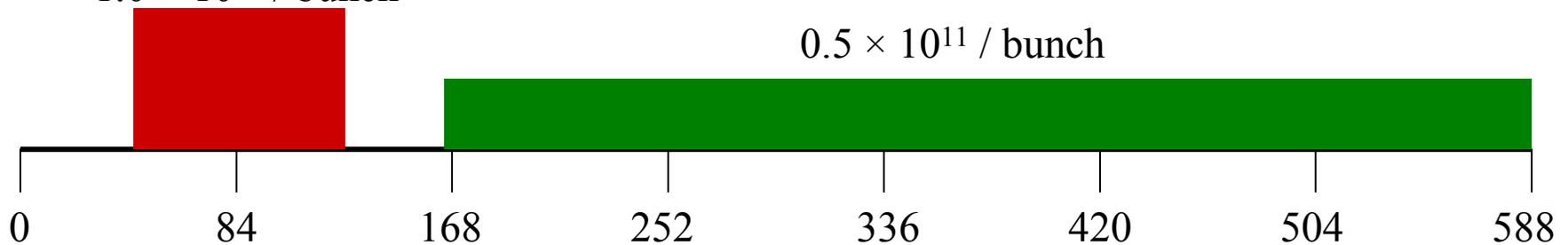
- Higher resolution reveals cycle details

- Injections
- RF capture
- Ramp
- Transition
- Flattop
- Extraction

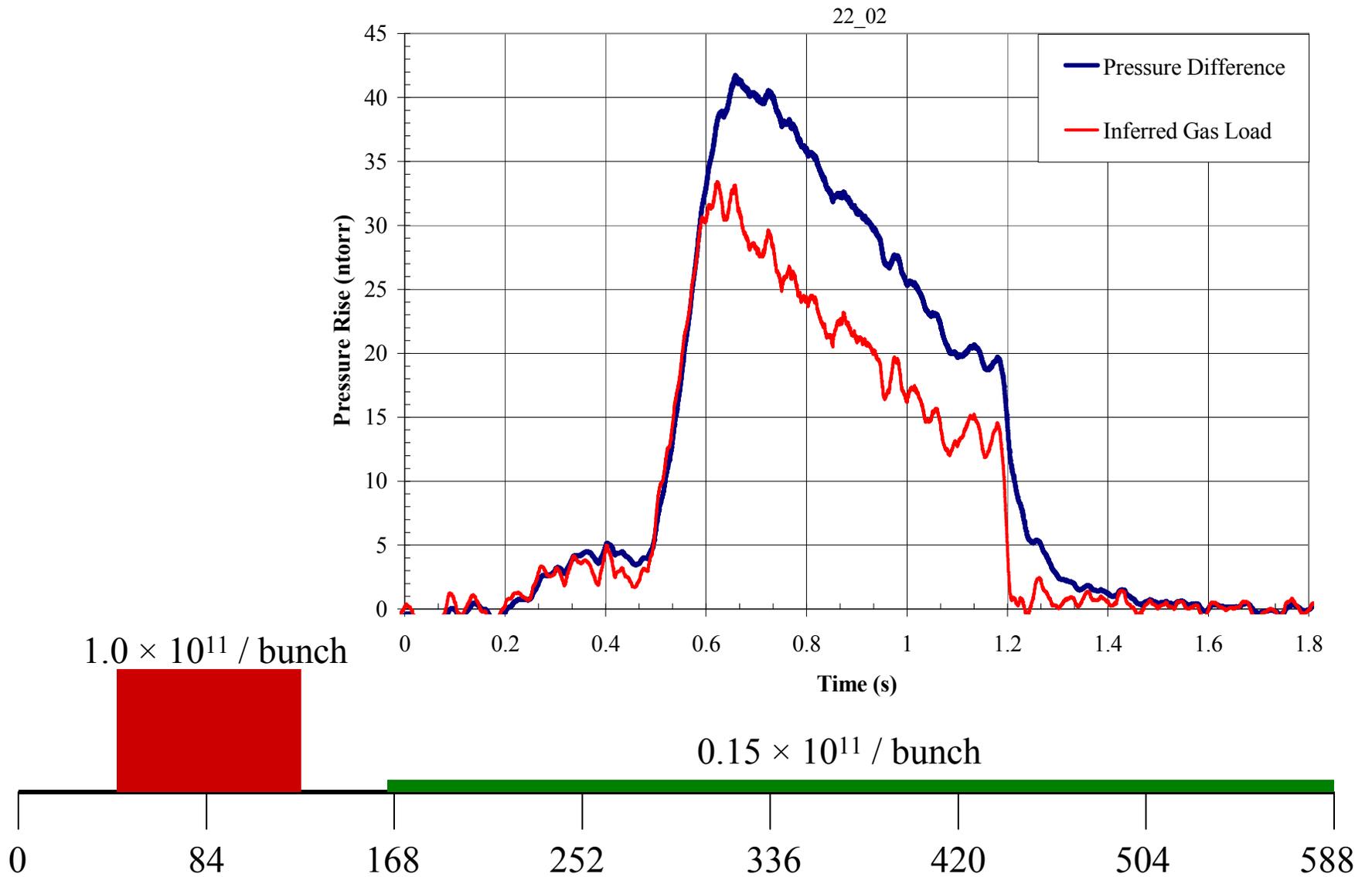


$1.0 \times 10^{11}$  / bunch

$0.5 \times 10^{11}$  / bunch

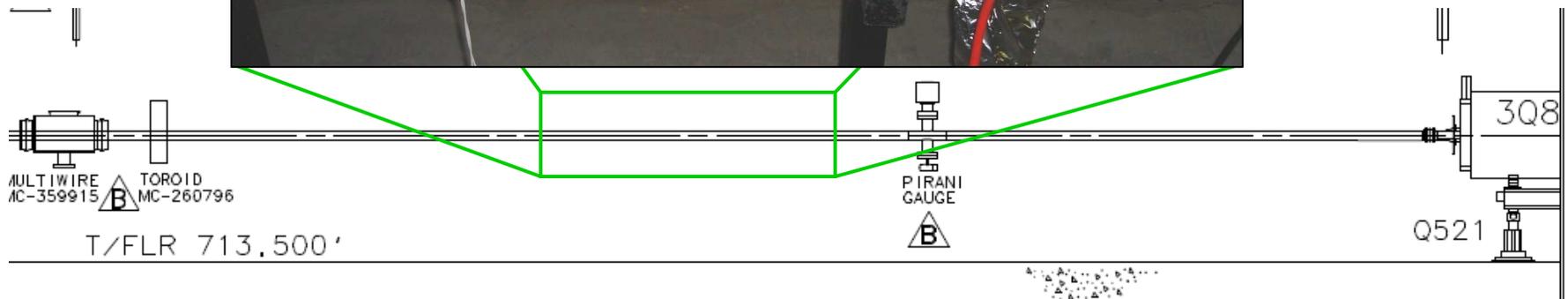


# Lower Intensity

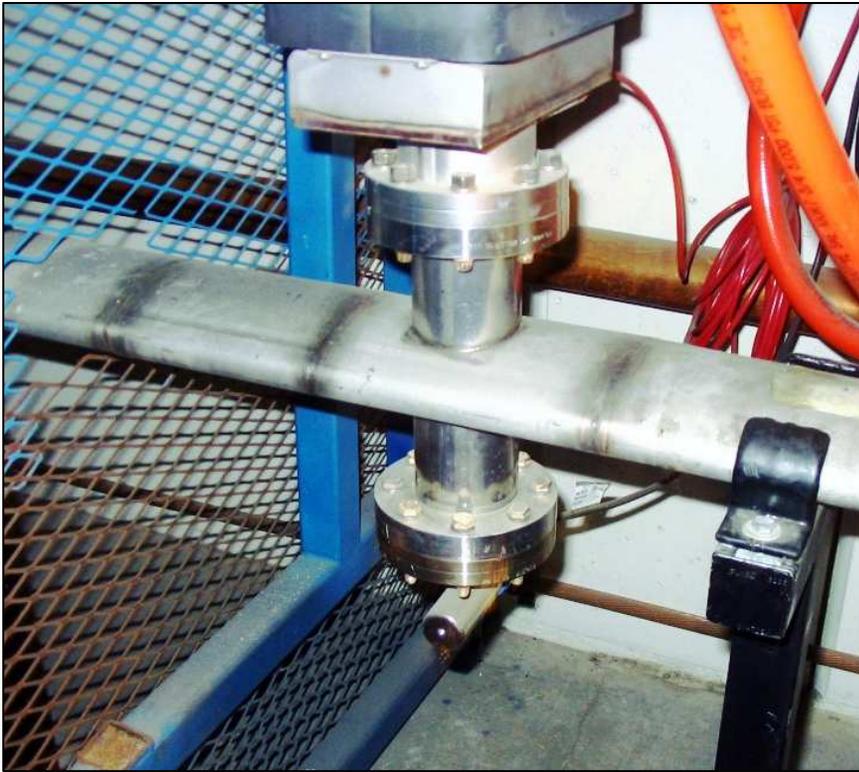


# Electron Detector

- Borrowed an electron detector from Argonne (RFA type)
  - Directly measure electron current incident on the beampipe
  - Might allow study of the electron energy distribution
    - Installed at one location
- Expect to be able to make measurements parasitically, and in dedicated studies

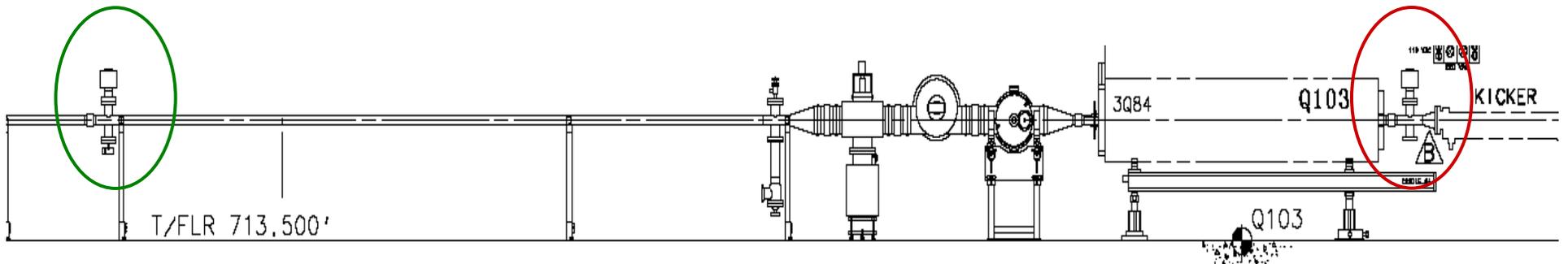


# Ion Gauge Installations



- One with electron detector
- One at highest pressure rise

– Idea is to provide a crosscheck of ion pump measurements, and perhaps get more accurate and quicker measurements



# Possible Beam Parameters

- Studies can be parasitic with normal beam operations
  - 6 & 7 batch operation @  $5-10 \times 10^{10}$  / bunch
    - Intensity modulation requires dedicated study
  - Bunch length and width change during cycle
    - The two are correlated throughout, unless dedicated cycles are used
- Intense beam pulses
  - Bunches of  $30 \times 10^{10}$  are possible, but nearest spacing is 21 buckets
- Fill patterns
  - Dedicated studies can produce less filled cycles
  - A variable gap can be placed between batches
  - A nearly full ring is possible, in principle, but presents several issues
    - Mostly an issue of machine protection

# Summary

- We believe we see electron cloud build-up in at least one location in the Main Injector
  - Area with ceramic beam pipe – not representative
  - Gas rise is correlated with cycle events
- We expect to be able to make immediate measurements of the cloud build-up when the machine returns to operation
- We plan to perform a series of studies over the next year
  - These studies need to be designed to support code benchmarking as much as possible