BROOKHAVEN NATIONAL LABORATORY

# RHIC Pressure Rise

*RHIC Retreat, June 12, 2003*

*S.Y. Zhang, for many who contributed in past year*

## Pressure Rise at Injection -

Electron cloud?

## Pressure Rise at Transition -

Halo scraping?

## Unsettled Issues -

Role of ions scraping

## Counter Measures -

Secondary electron yield

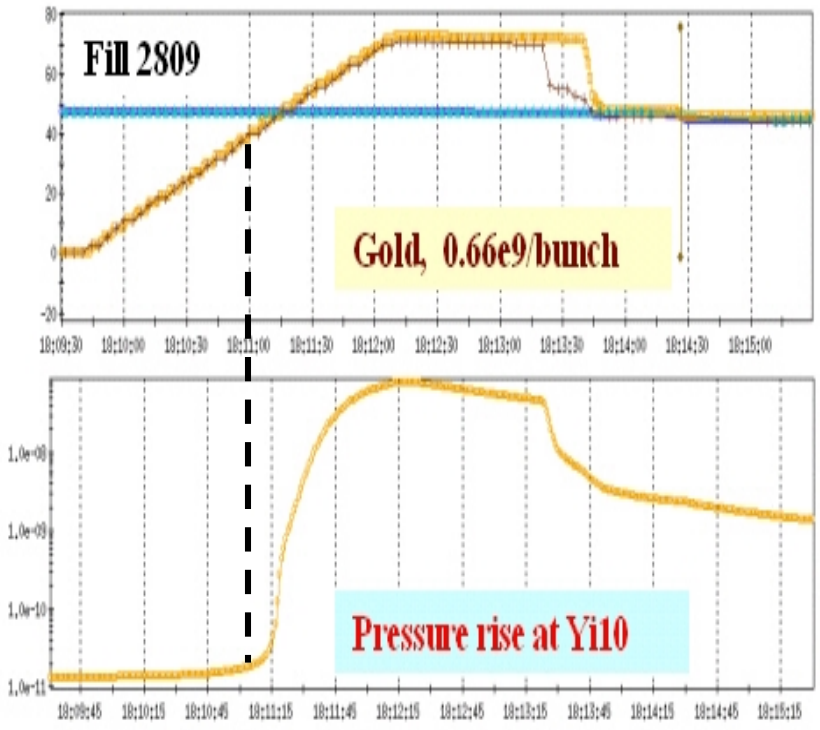
Electron and ion gas desorption rates

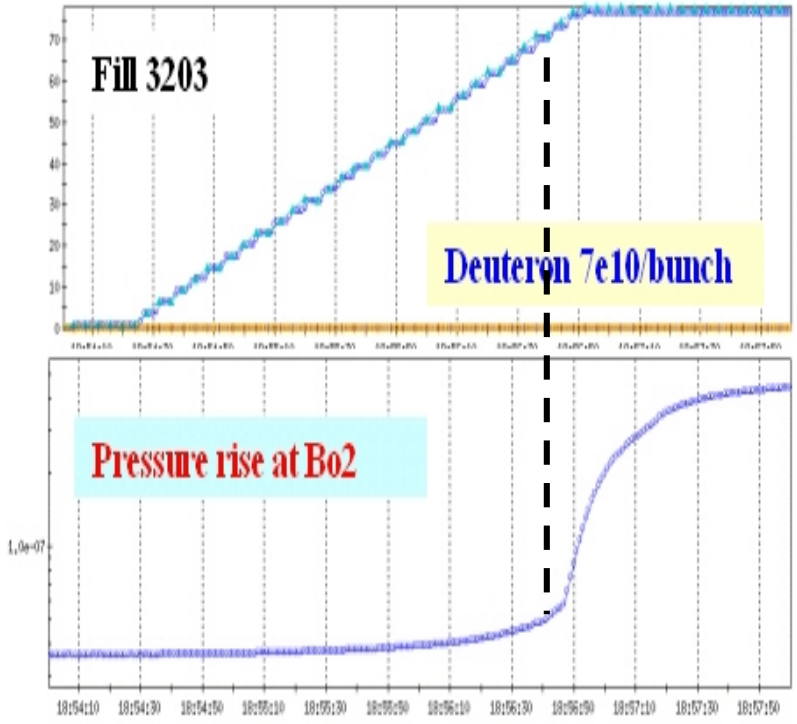
NEG coating at RHIC, test stand at Tandem?

## Workshop -

Beam induced pressure rise in rings

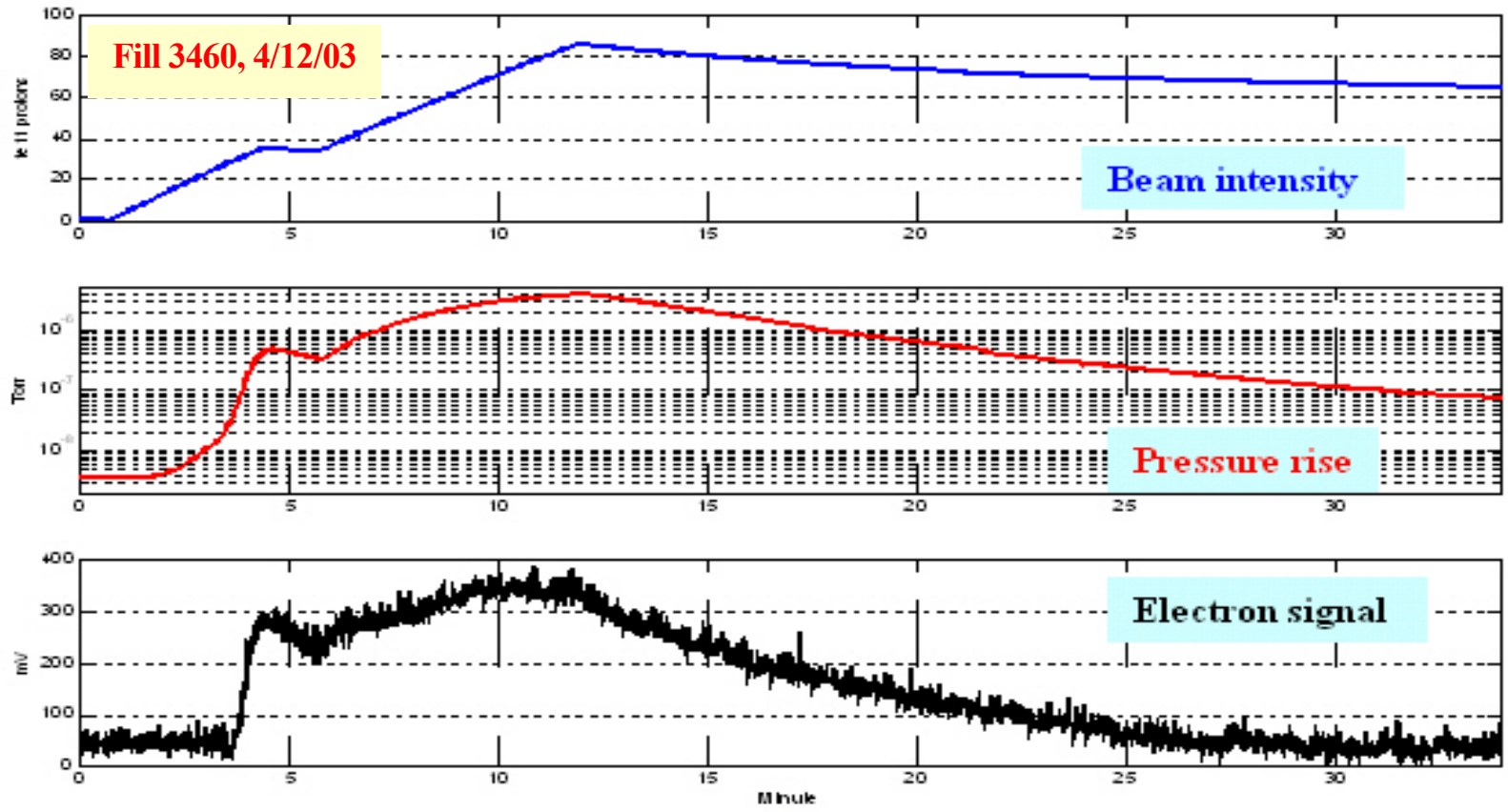
# Pressure Rise at Injection - gold, deuteron and proton beams



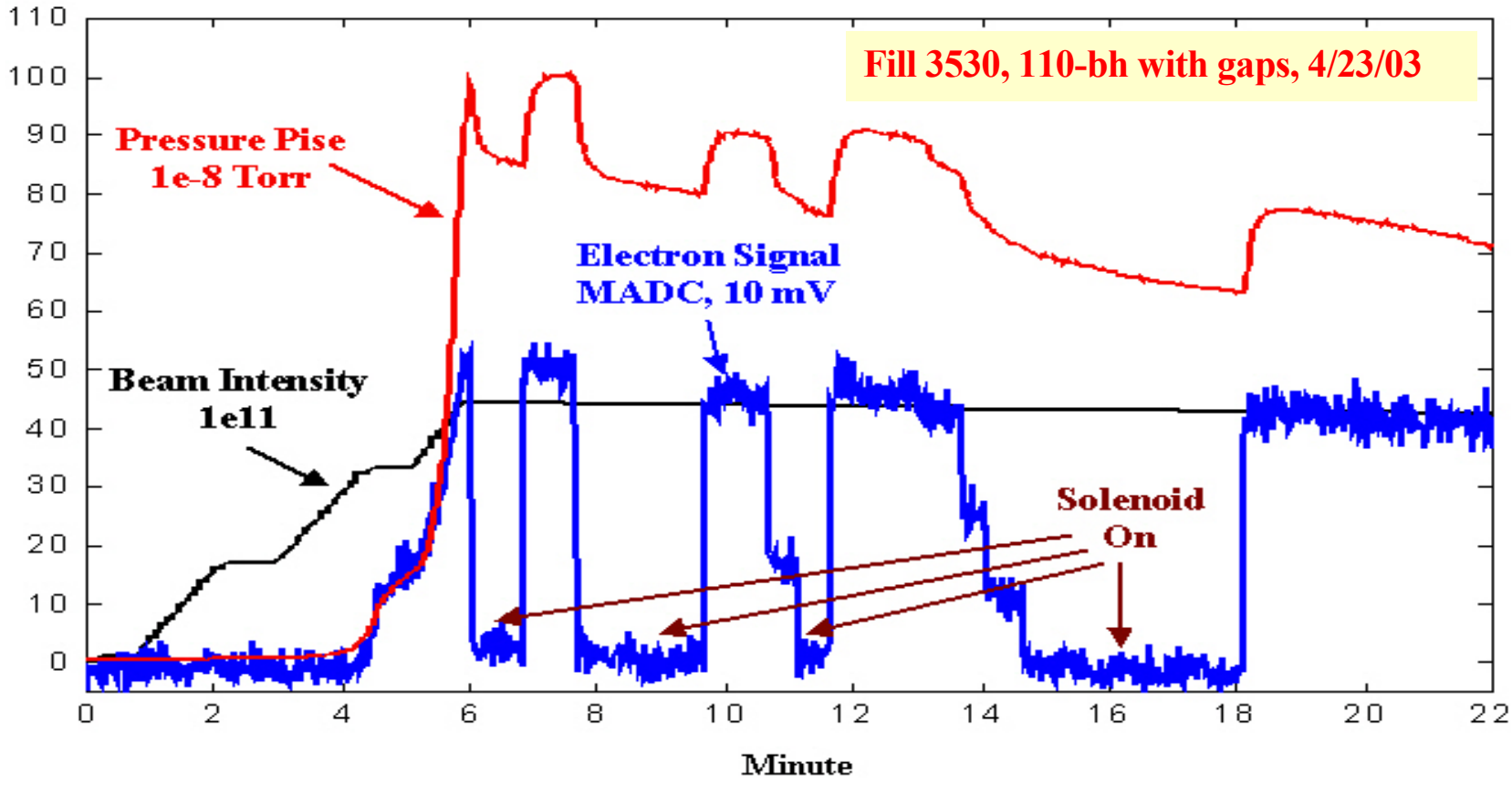

- Pressure rise at injection has been observed for gold, deuteron, and proton beams.
- Pressure rise pattern is very similar to each other.
- Above threshold, pressure started to rise, and then saturated.
- Threshold depends on bunch intensity and bunch spacing.

# Pressure Rise at Injection - Electron cloud responsible?



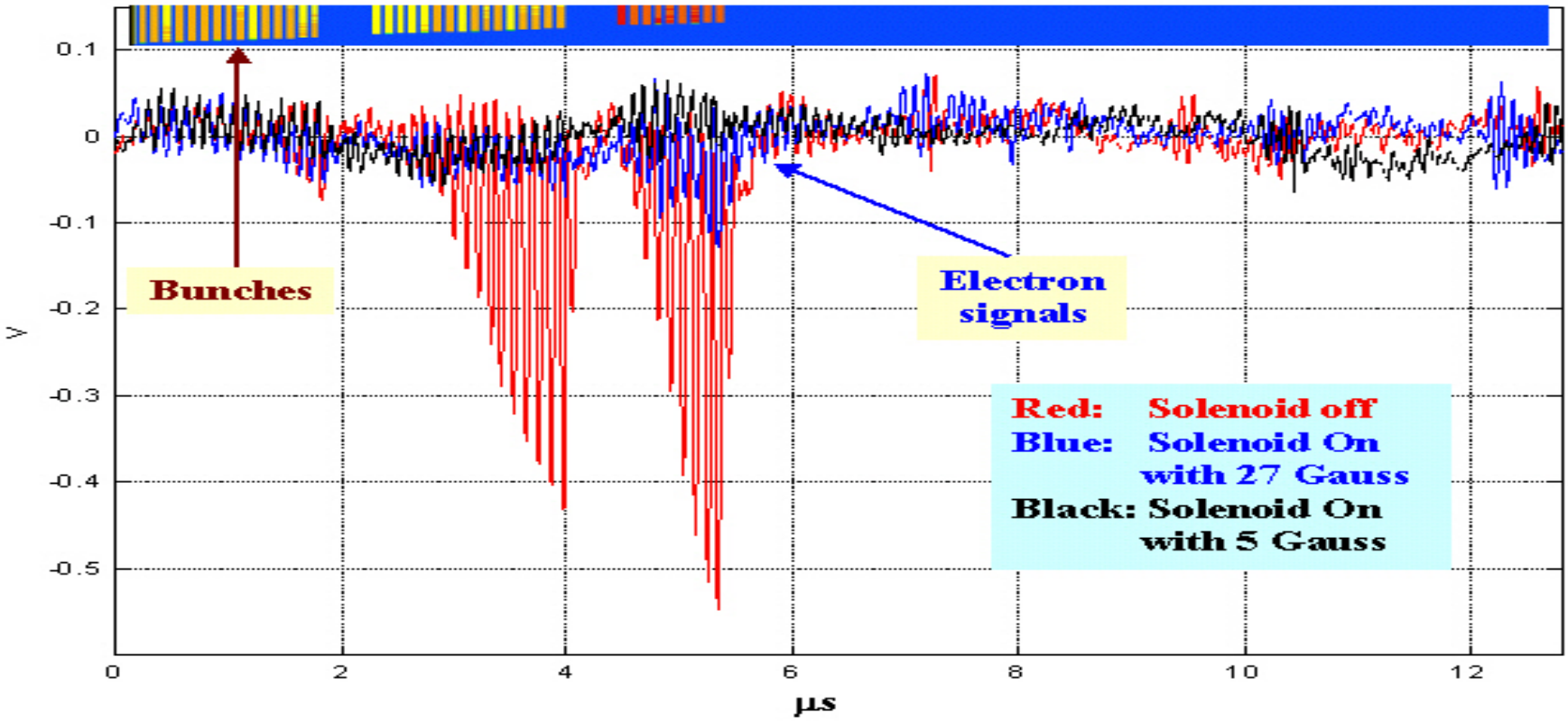

- Electron signal was always coincided with the pressure rise, for gold, deuteron, and proton beams.
- Stronger the electron signal, higher the pressure rise.

# Pressure Rise at Injection - Solenoid effect at Bo2



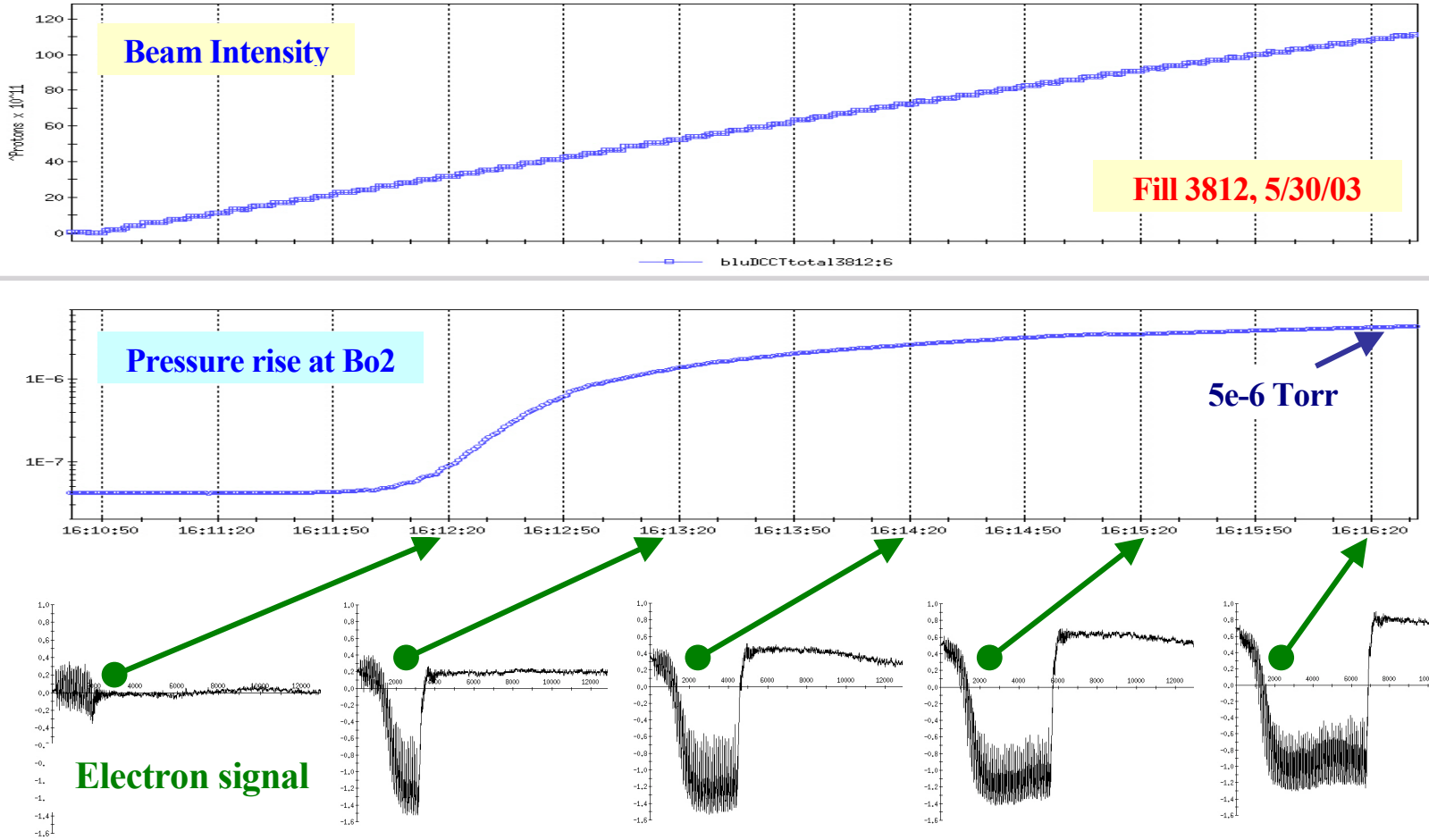

- Solenoid around the electron detector eliminated electron signal.
- Solenoid of 4 meters long partially reduced pressure rise in the 34 meters long straight section.

# Pressure Rise at Injection - Bunch gap, fast electron signal



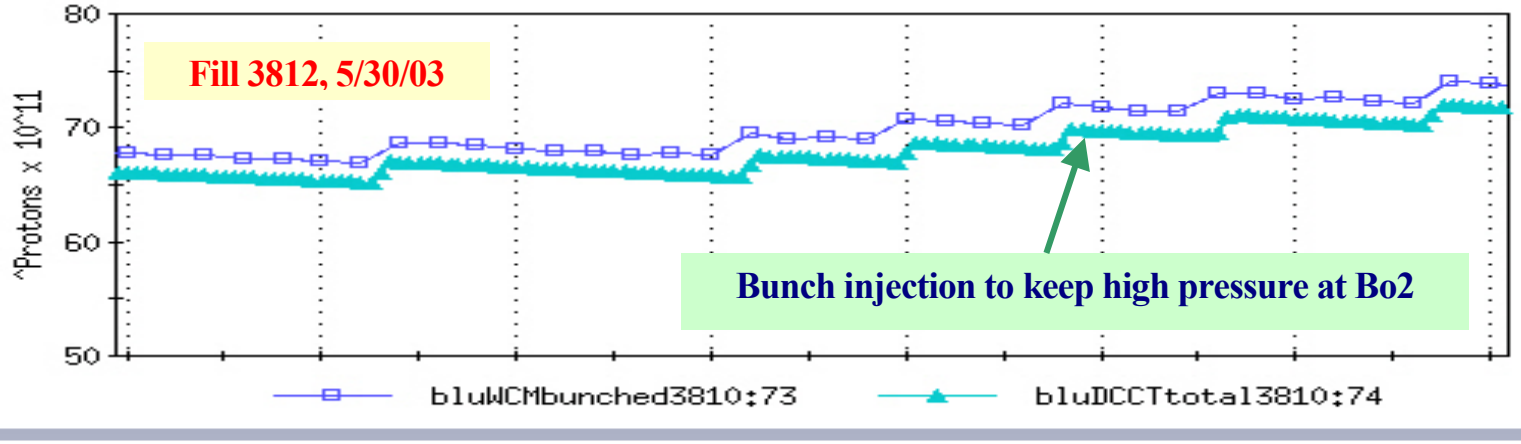

- Fast electron signal (1 ns resolution) shows that the bunch gaps reset the electron multipacting (not completely in this case).
- 5 gauss solenoid field eliminated e-signal for 1e11 bunch intensity.
- In 5/30/03 study, 67 gauss field was not enough (?) to completely eliminate e-signal for 2e11 bunch intensity.

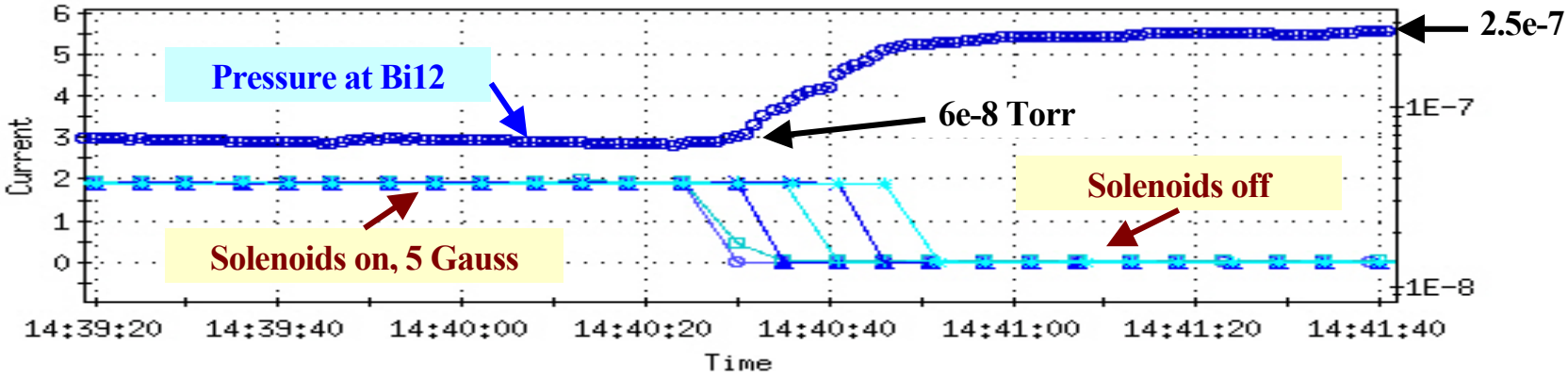
# Pressure Rise at Injection - Pressure rise and fast e-signal




- **Electron multipacting signal and pressure rise are well agreeable with each other.**

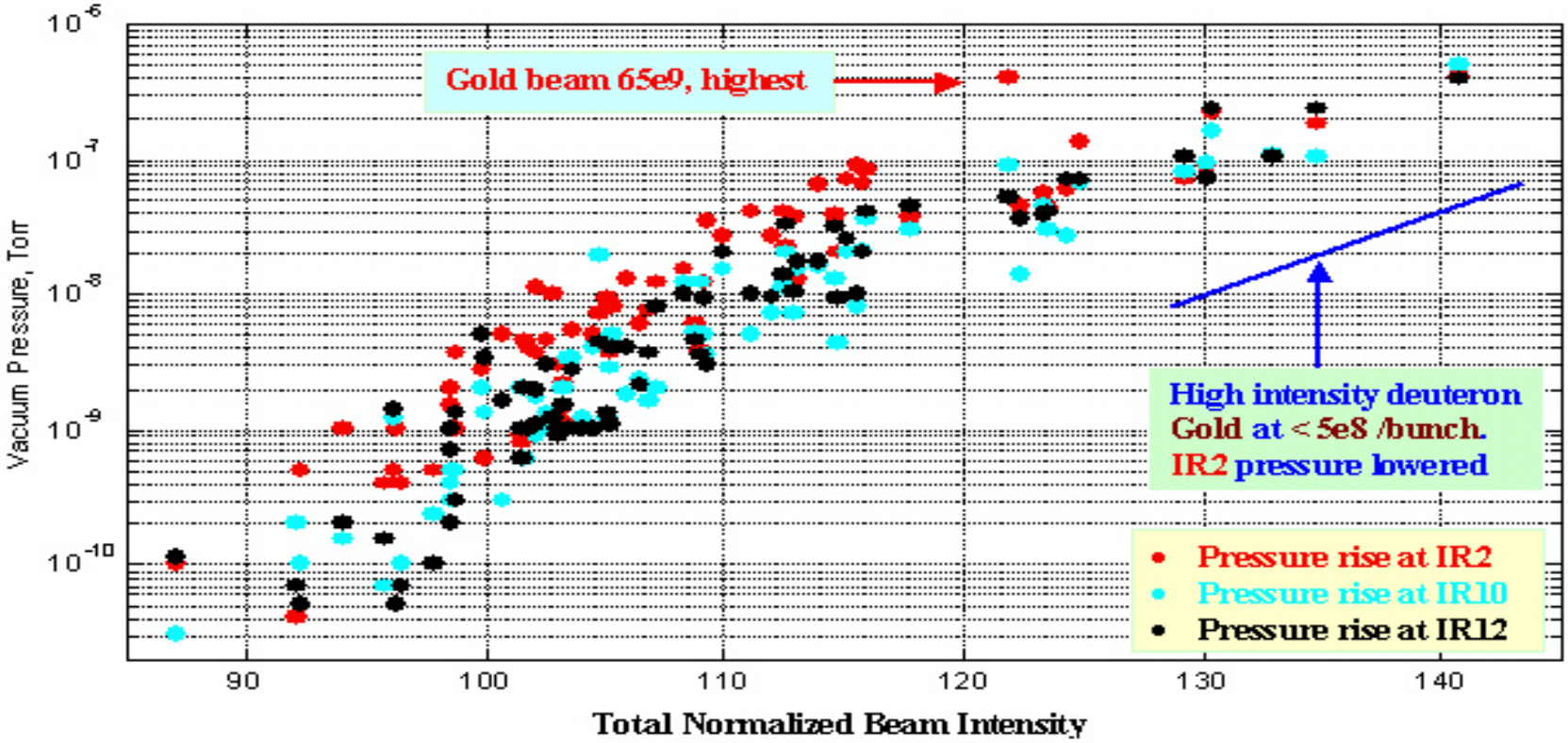
# Pressure Rise at Injection - Solenoid effect at Bi12



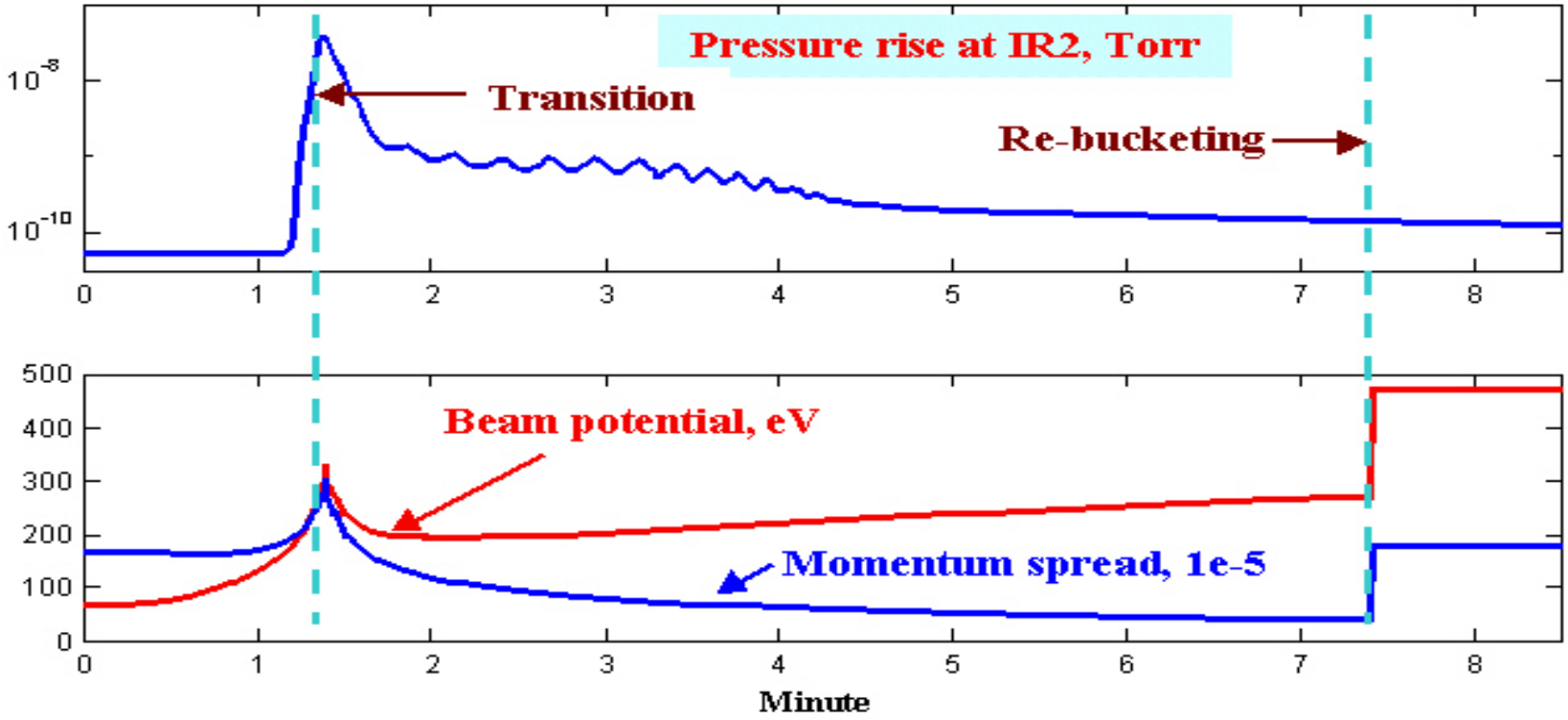

- Solenoid field of 5 gauss affected pressure rise by a factor of 4, at Bi12. Solenoid coverage is 24 meters.
- Solenoid at IR12 reduced electron signal, but not as much as that at Bo2. Need more studies.

# Pressure Rise at Transition - Total beam intensity



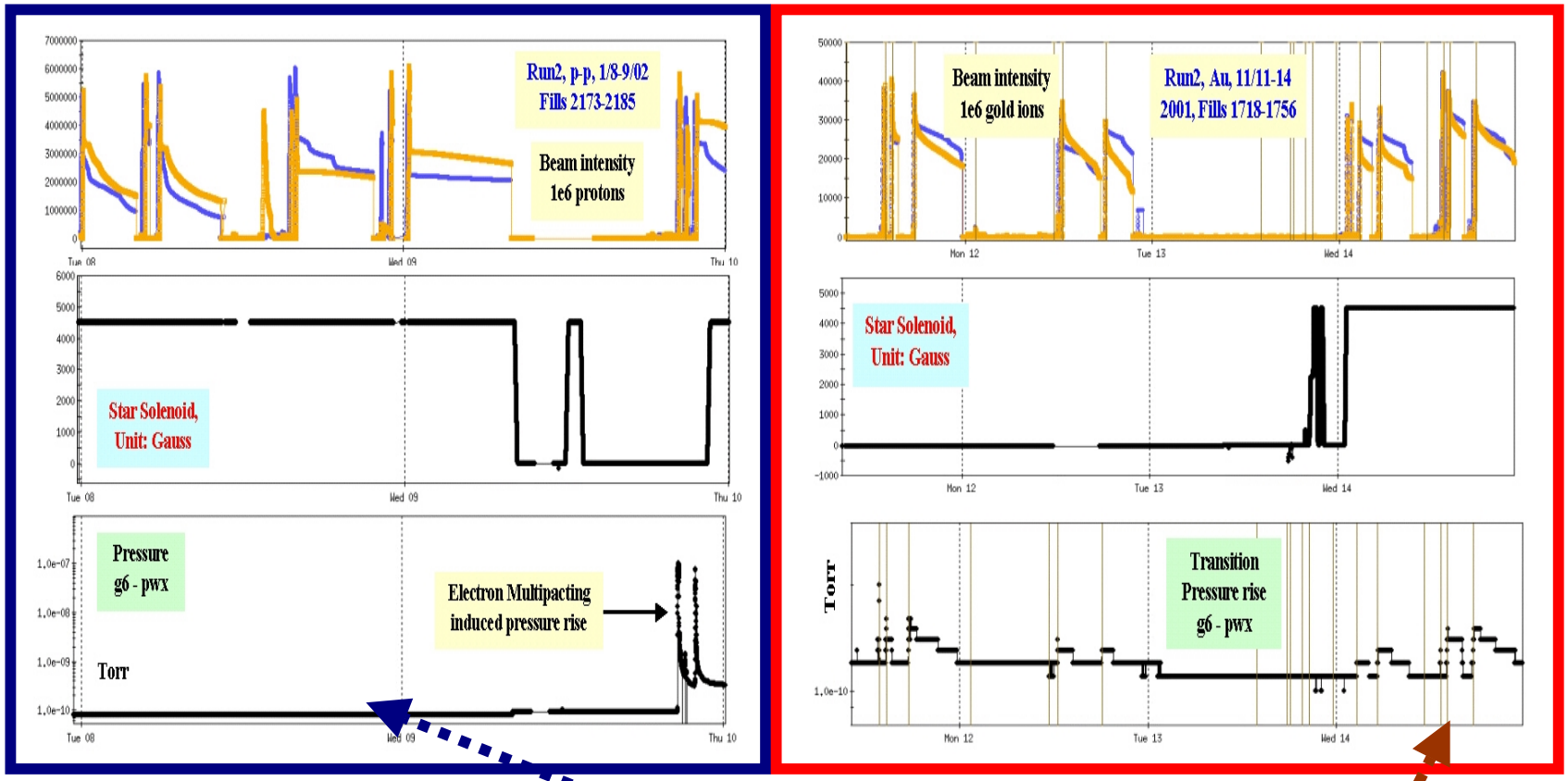

- Transition peak pressure rise at IR2, IR10, and IR12, is quasi-exponentially proportional to total beam intensity.
- Both 55- and 110-bunch included - not sensitive to bunch spacing.
- Gold and deuteron accounted same - no ions charge effect, e.g. $Z^2$.
- Pressure settled down in several hours - experiment background.

# Pressure Rise at Transition - Beam halo scraping?



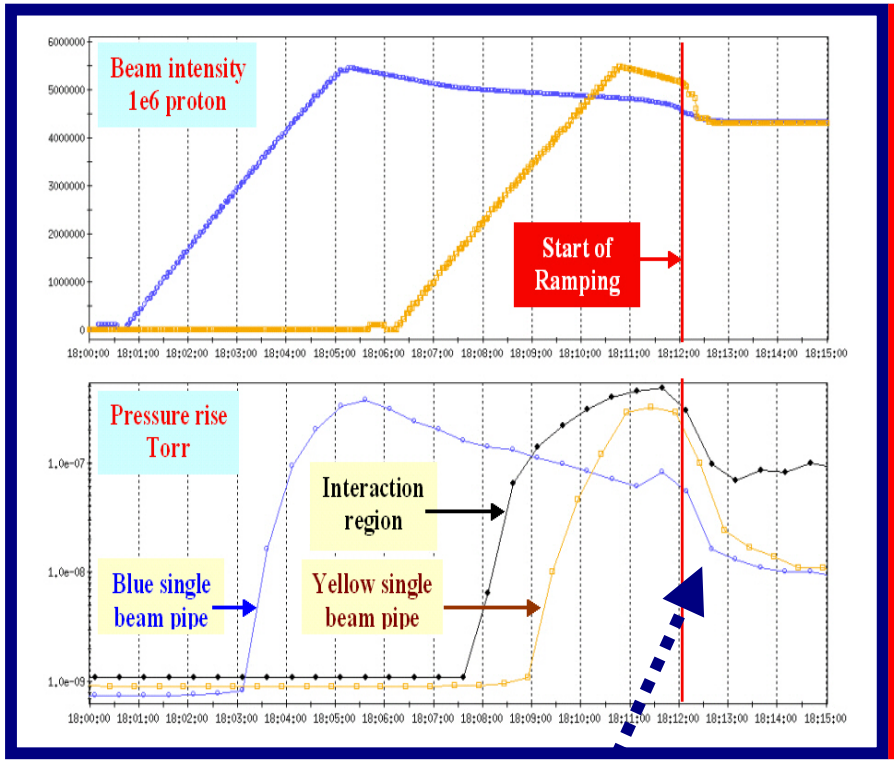

- At storage cavity re-bucketing, bunch potential is higher than at transition, but no pressure rise observed.
- Beam momentum spread is highest at transition - beam halo scraping is the main driving force for transition pressure rise?

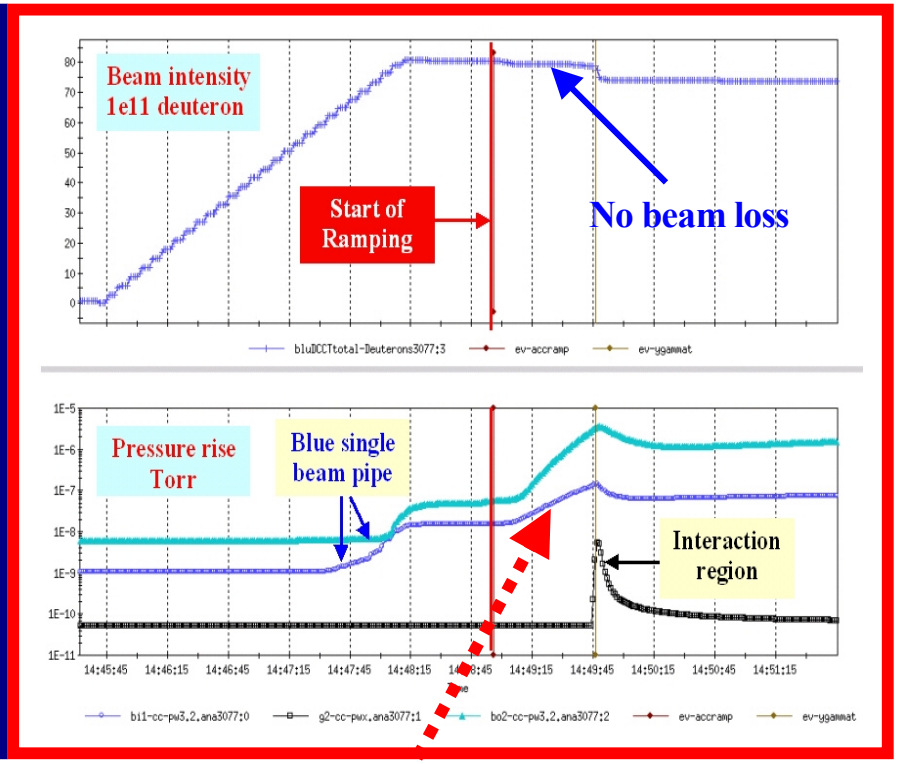
# Pressure Rise at Transition - STAR solenoid effect




- STAR solenoid field can eliminate pressure rise at injection.
- It has no effect on the transition pressure rise (brown lines stand for transition).
- Transition pressure rise of 2001 Au run was small, since total intensity was low, less than 80 unit.

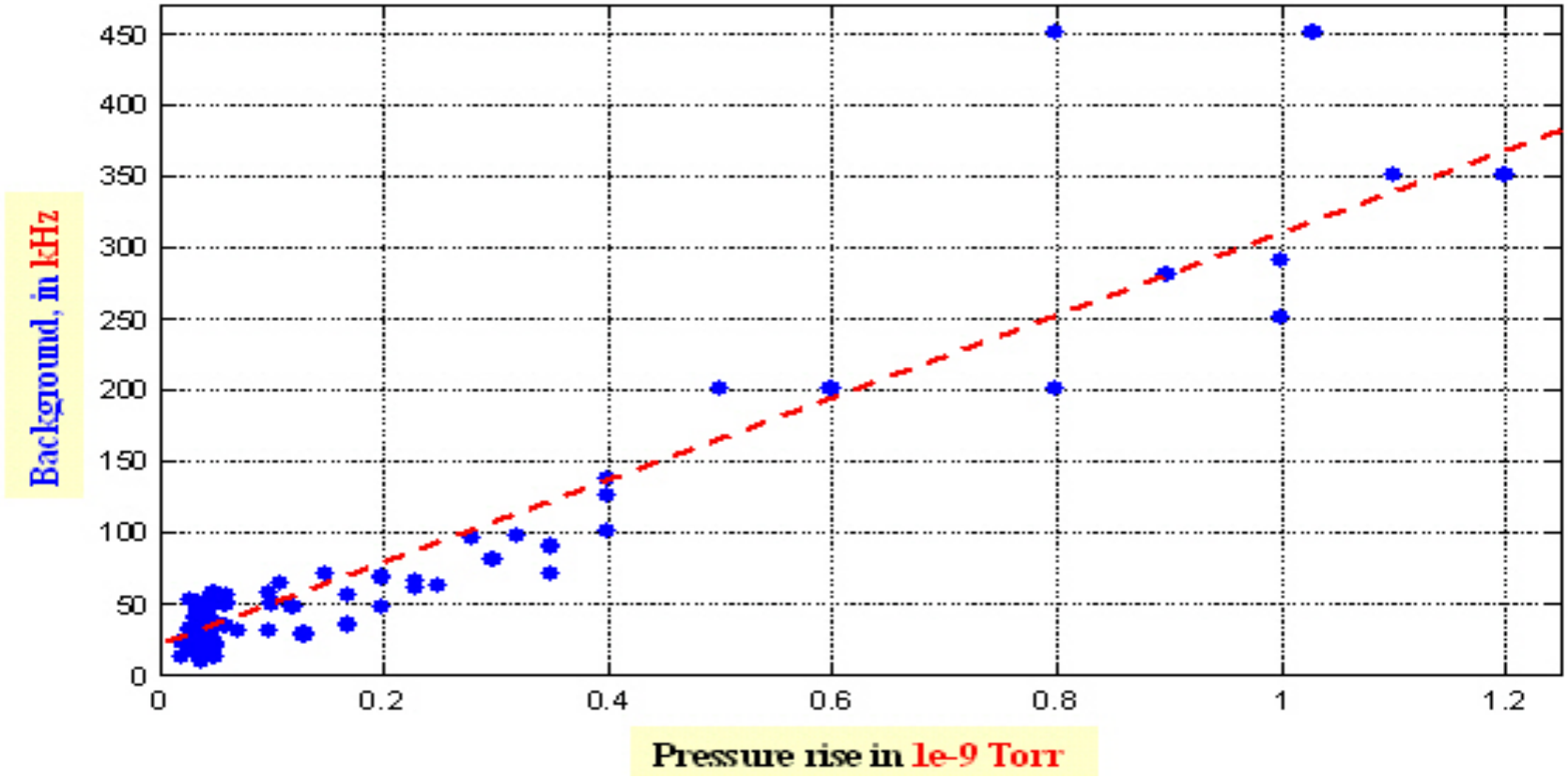
# Pressure Rise at Transition - Evidence of beam halo scraping effect?



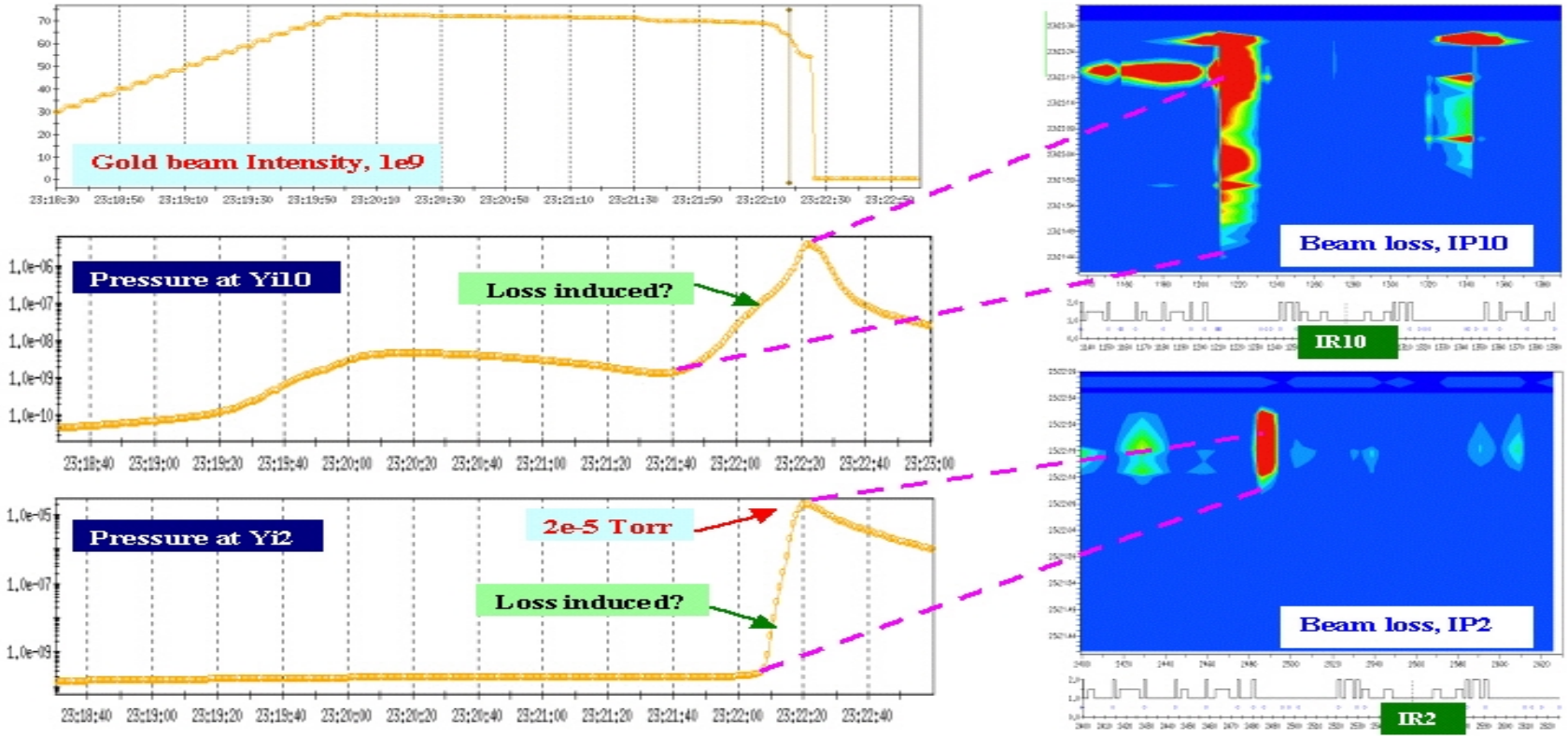

- Pressure is decreasing as proton beam starts to accelerate : smaller beam transverse size reduced halo scraping - less electron survived gap - reduced electron multipacting and pressure rise.
- Gold and deuteron beam ramp: pressure rises and peaked at transition, because momentum spread increases at the ramp?

# Pressure Rise at Transition - Pressure vs. background, PHOBOS




- Data taken at 30 minutes after transition.
- Pressure rise around transition affected PHOBOS background. For 1e-9 Torr, the background is 300 kHz.
- Higher total beam intensity - higher pressure - higher background.

# Unsettled Issues - Ion desorption




- Beam loss is irrelevant in both types of pressure rise, at injection and transition.
- Loss induced pressure rise - beam ion gas desorption rate.
- Assuming all lost beam ions were dumped at Yi2, the gold ion's gas desorption rate, at ~10 GeV/n, is 15 e6.

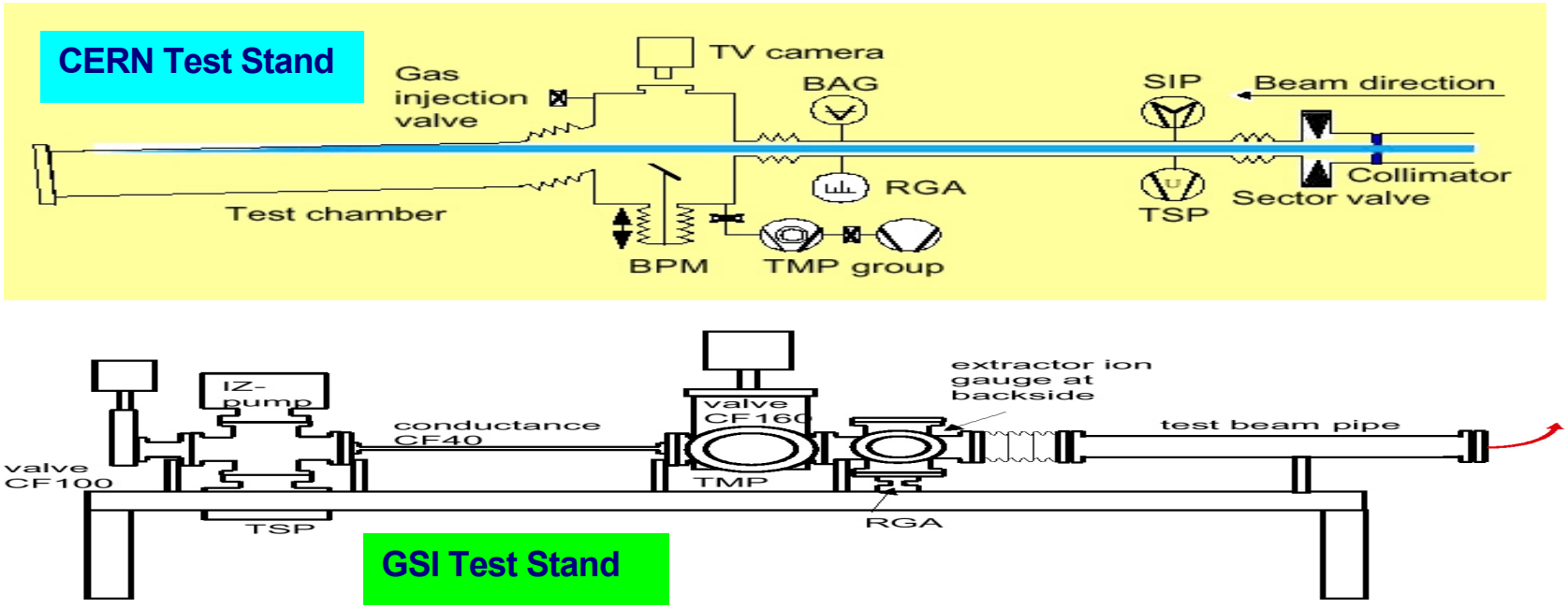
## Unsettled Issues - Understand RHIC pressure rise

- Beam ion's incident angle is critical for gas desorption rate.
- Assuming that ion's grazing angle scraping on the long straight beam chamber can create large amount of positive ions, then most of RHIC observations might be explained:
  - RHIC electron multipacting may happen at bunch spacing of 216 ns - positive ions helped secondary electron to survive gap?
  - EC intensity threshold at long straight chamber is lower than that at shorter chamber - more effective scraping at longer pipe?
  - Pressure rise unevenly distributed - beam halo conditions are different?
  - A < 1mm radial steering increased pressure rise from 5e-9 to 4e-8 Torr - halo condition changed?
  - Larger beta* (smaller beam size at triplet and straight) improved pressure rise - halo scraping improved?

## Counter Measures

- **Vacuum chamber baking** - pressure rise improved at the locations baked in last shutdown, but not eliminated.
- **Solenoid** - RHIC pressure rise takes place only in straight sections, solenoid can be used, however, it will not be effective for the transition pressure rise.
- **Beam scrubbing** - RHIC pressure rise is very unevenly distributed in the ring, a complete scrubbing of the ring is very difficult.
- **Beam injection pattern** - Useful in the future operation.
- **NEG (Non-evaporable getter) coating** - NEG coating reduces not only the secondary electron yield, but also the electron and ion gas desorption rates. Therefore, it may improve both types of pressure rise. NEG coating provides linear pumping as well, hence may improve the experiment background due to beam-gas. Aging, activation, etc. are under studying. Details - most important things!

# Counter Measures - NEG coating at RHIC, test stand at Tandem




- NEG coating test at RHIC for next run, 60 m, at Bi9, Yi10 and IP2?
  - Pressure rise at injection - reduced SEY and electron desorption rate.
  - Transition pressure rise - ion desorption measurement not sufficient.
- Use Tandem ion beams for NEG coating measurement
  - Ion desorption rate with functions of incident angle, ion species, charge state, energy, unsaturated and saturated surface, and activation, etc.
  - Sputtering type of beam scrubbing for AGS Booster?

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Workshop of

# Beam Induced Pressure Rise in Rings

**Time:**

December 9-12, 2003

**Place:**

BNL

**Scope of the Workshop:**

Main sources of beam induced pressure rise include electron stimulated gas desorption, ion desorption, and beam loss/halo scraping. Beam induced pressure rise had limited beam intensity in CERN ISR and LEAR. Currently, it is a limiting factor in RHIC, AGS Booster, and GSI SIS. It is a relevant issue at SPS, LANL PSR, and B-factories. For projects under construction and planning, such as SNS, LHC, LEIR, GSI upgrade, and heavy ion inertial fusion, it is also of concern. In this workshop, status of existing machines and various measurement results will be reported. Remedies to reduce secondary electron yield, electron and ion desorption rates, etc. will be discussed. These include beam scrubbing (both electron bombardment and ion sputtering), beam chamber coating and treatment, solenoid field, and beam bunch pattern.