

# Some Initial ECloud Measurements

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September 23, 2009

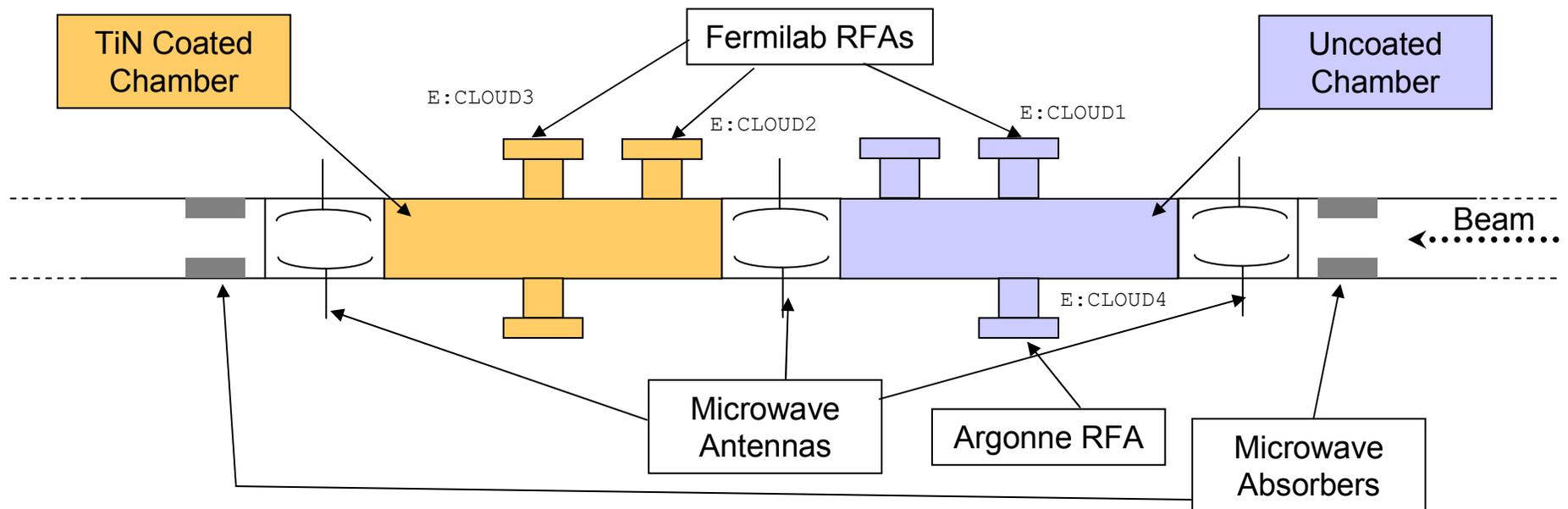
Electron Cloud Working Group Meeting

# Electron Cloud Experimental Upgrade - 2009

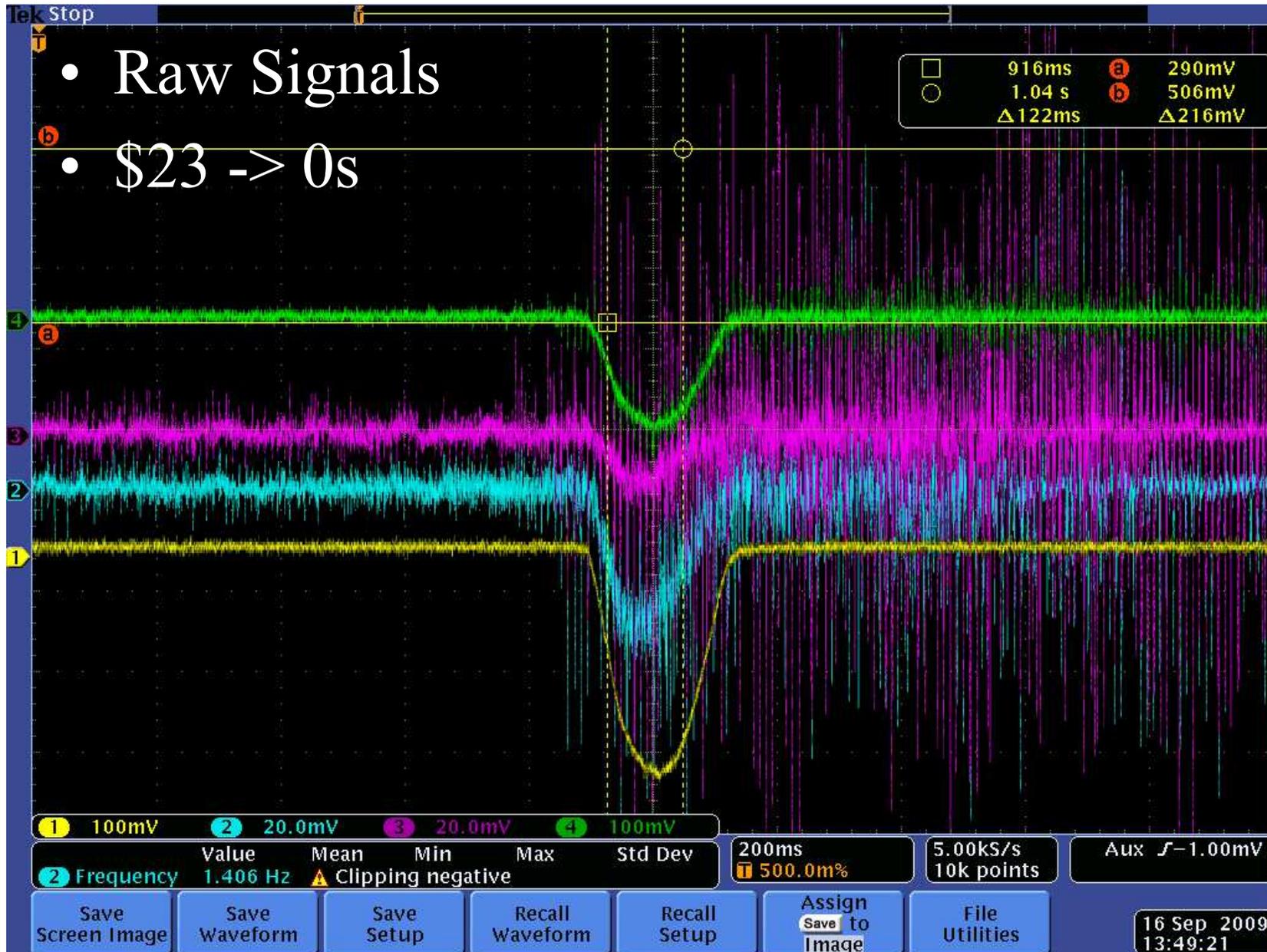
Major upgrade just finished installation, this summer 2009

- 2 New experimental Chambers
  - Identical 1 m SS sections, except that one is coated with TiN
- 4 RFAs (3 Fermilab & 1 Argonne)
- 3 microwave antennas and 2 absorbers
  - Measure ECloud density by phase delay of microwaves

- Primary Goal: validate TiN as a potential solution for Project X
- Secondary Goals:
  - Remeasure threshold and conditioning
  - Further investigate energy-dependence
  - Measure energy spectrum of electrons
  - Test new instrumentation
  - Directly compare RFA and Microwave
  - Measure spatial extinction of ECloud

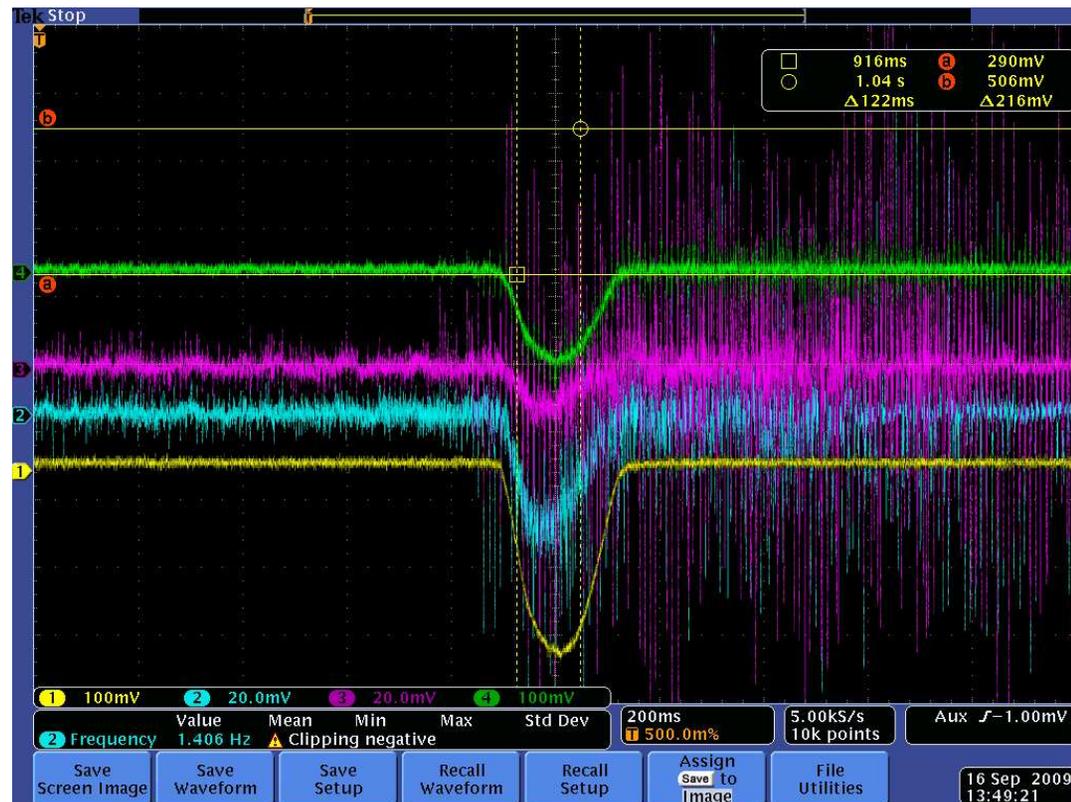


# 9/16/09: 12e12 on 6-batch



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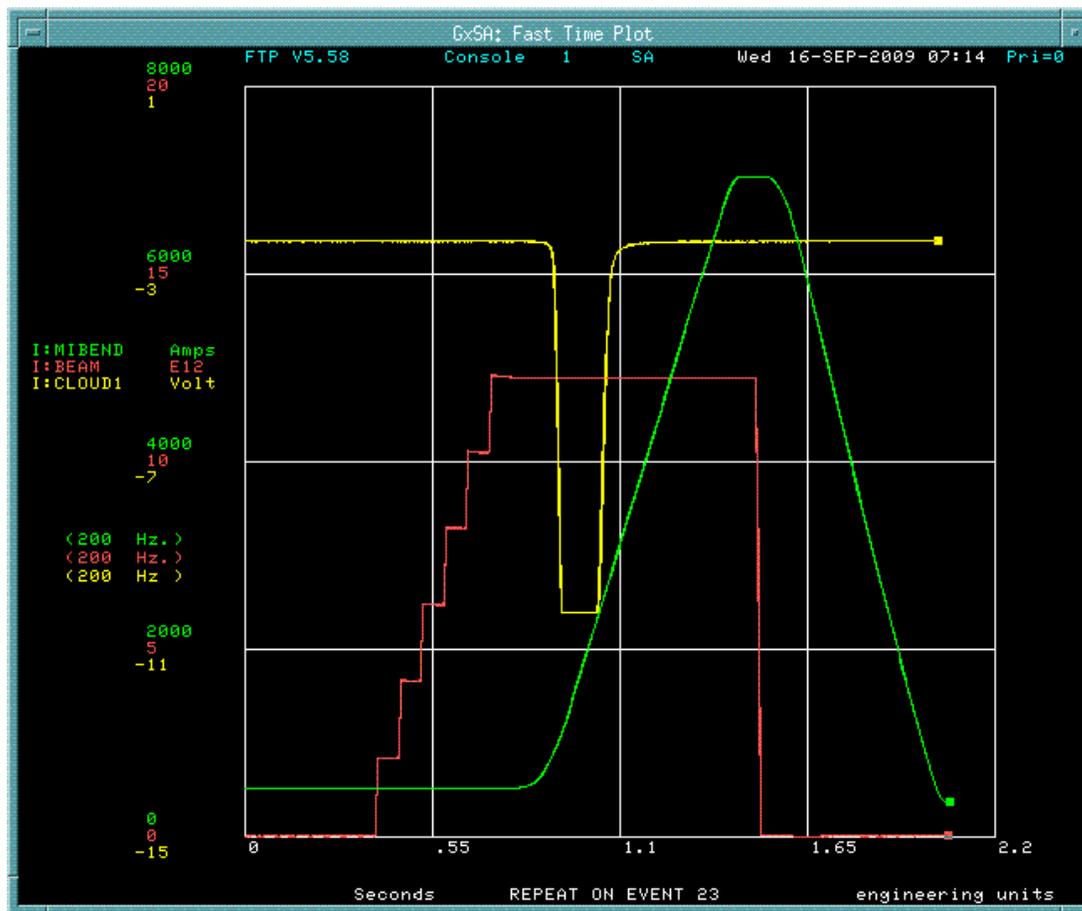
- Uncoated (FNAL): 280 nA
- Uncoated (ANL): 110 nA
- Coated (5''): 25 nA
- Coated (mid): 15 nA
- FNAL/ANL  $\approx 2.5$
- Uncoated/Coated  $\approx 18$
- Longitudinal Penetration Distance  $\approx 4$  cm (e-folding)
- Temporal dips are mostly similar, and similar to what was seen before



# Early Status (9/16)

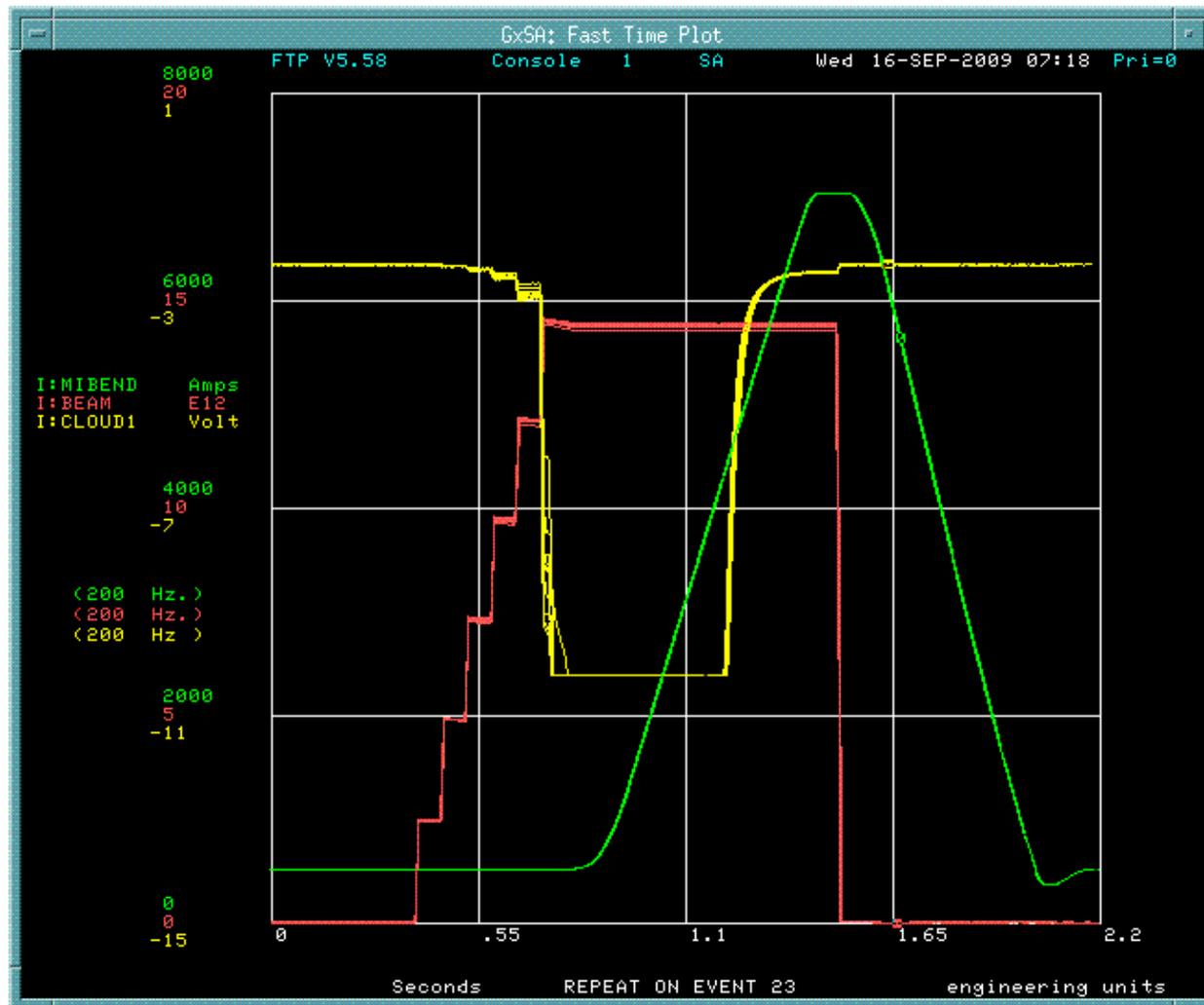
- Signal was strong with marginal intensity
  - Unconditioned beampipe surfaces
- Amplifiers were well-saturated – useful only for energy scans (which suppresses signal)
- Raw signal could be easily measured into scope
  - w/o amps ( 1 MOhm): 1 V -> 1 uA
  - w/ amps: 1 V -> 0.01 uA (nonzero offset)
- MADC channels: E:CLOUDx
  - w/o amps 1V -> 20 uA
  - w/ amps: 1 V -> 0.01 uA (nonzero offset)
  - Raw signals without amplifier need a resistor & cap to ground to suppress MADC noise
    - This causes some funny effects (filtering and build-up) – mostly small
  - We are getting help from Peter Prieto for another amplifier solution
- Signal looked roughly consistent with previous data
  - No transition dip (yet)
- See great pictures from Mike (first data, earlier in morning)

# Mike's Pics (backup)

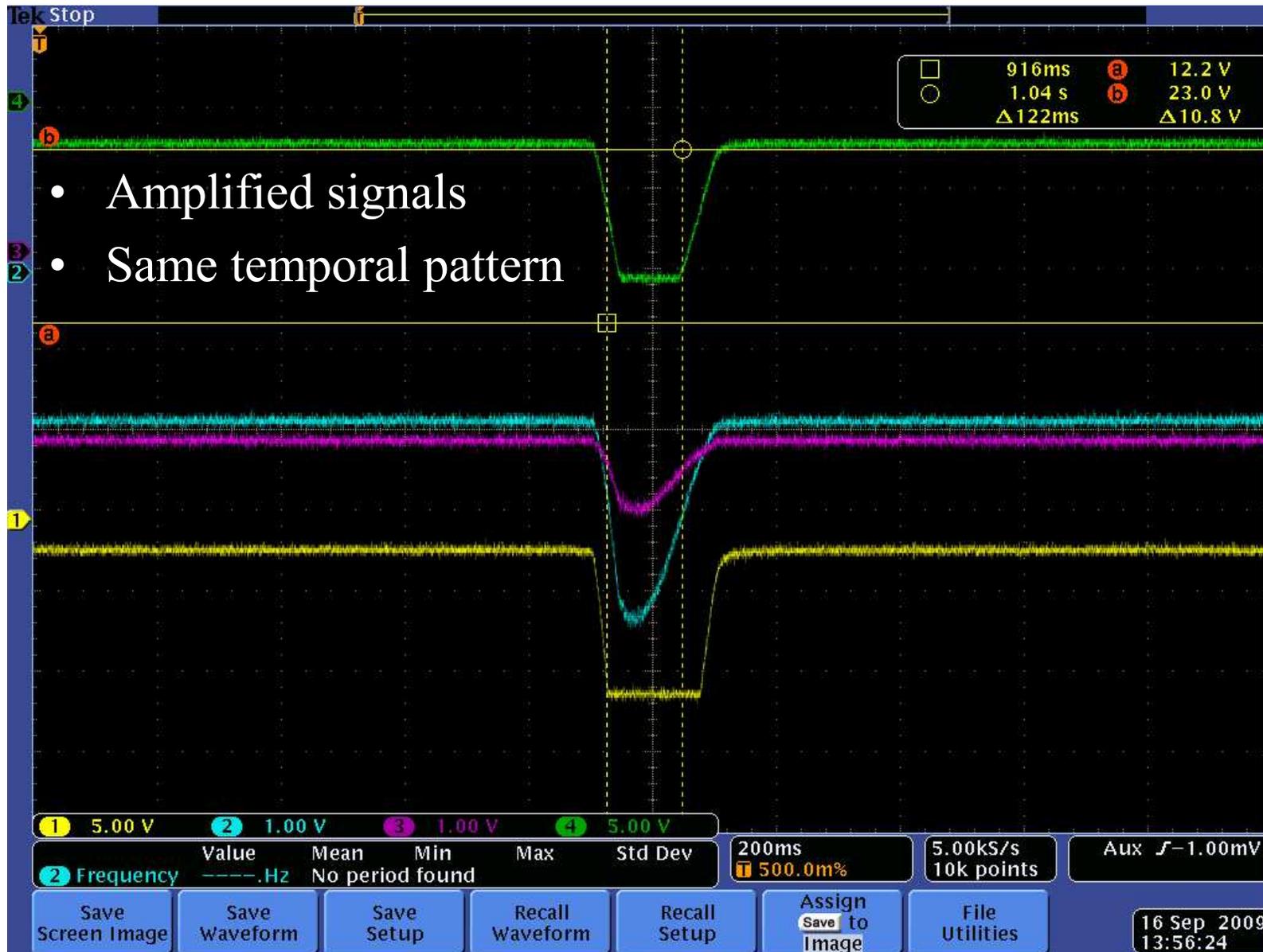


# Mike's Pics (backup)

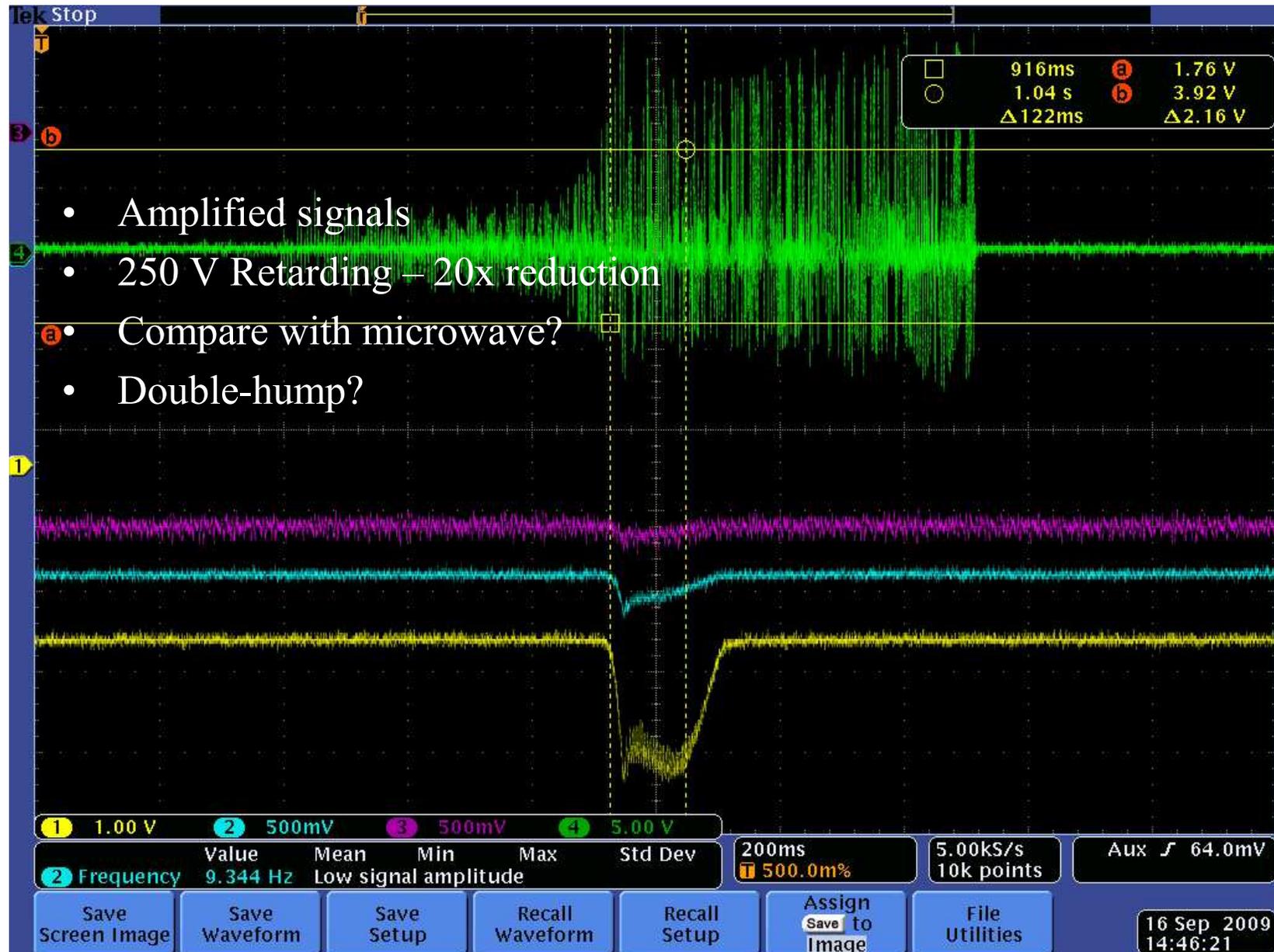
- Bump up to  $14e12$  – can see injections, extr



# 9/16/09: 12e12 on 6-batch

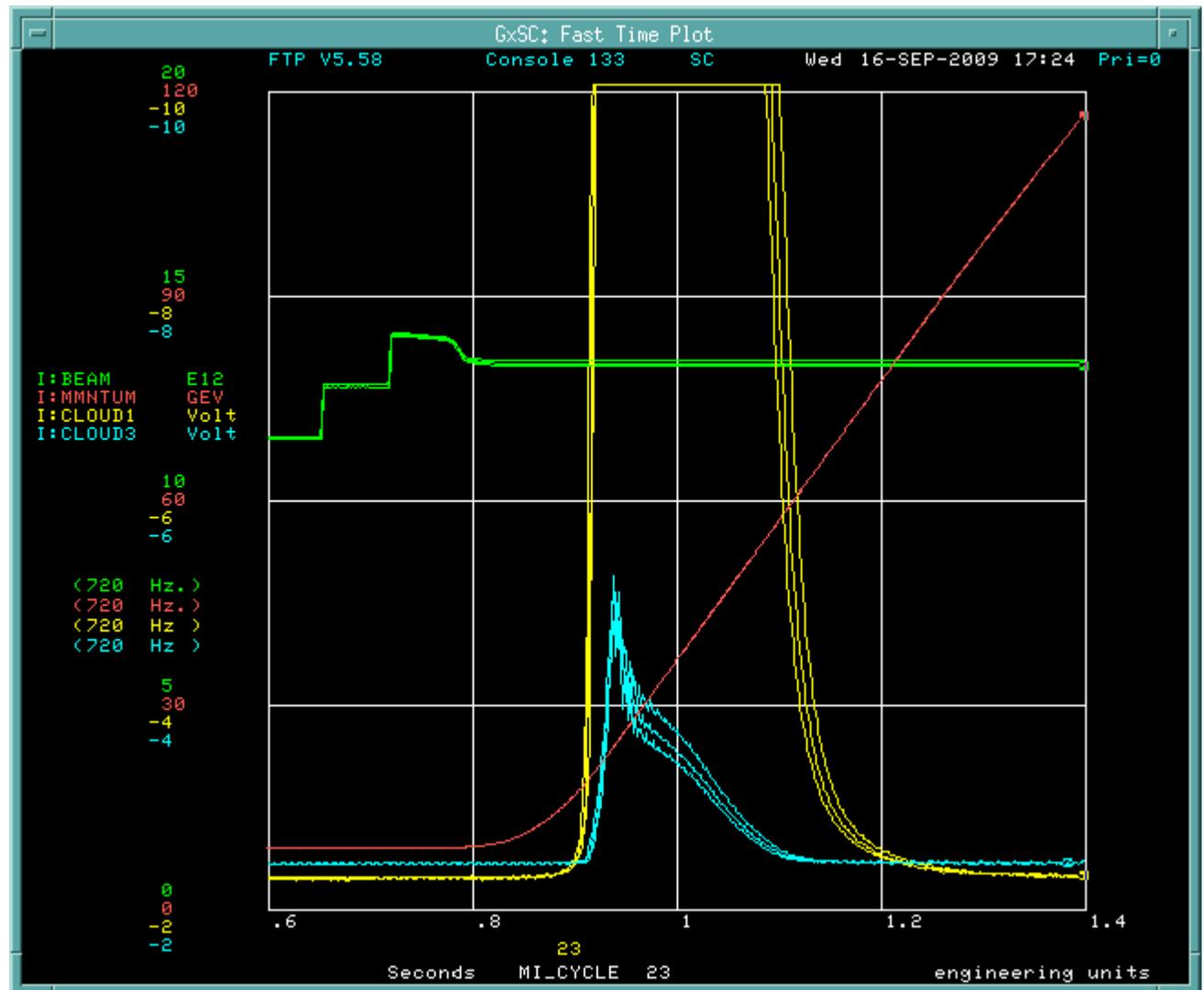


# 9/16/09: 12e12 on 6-batch



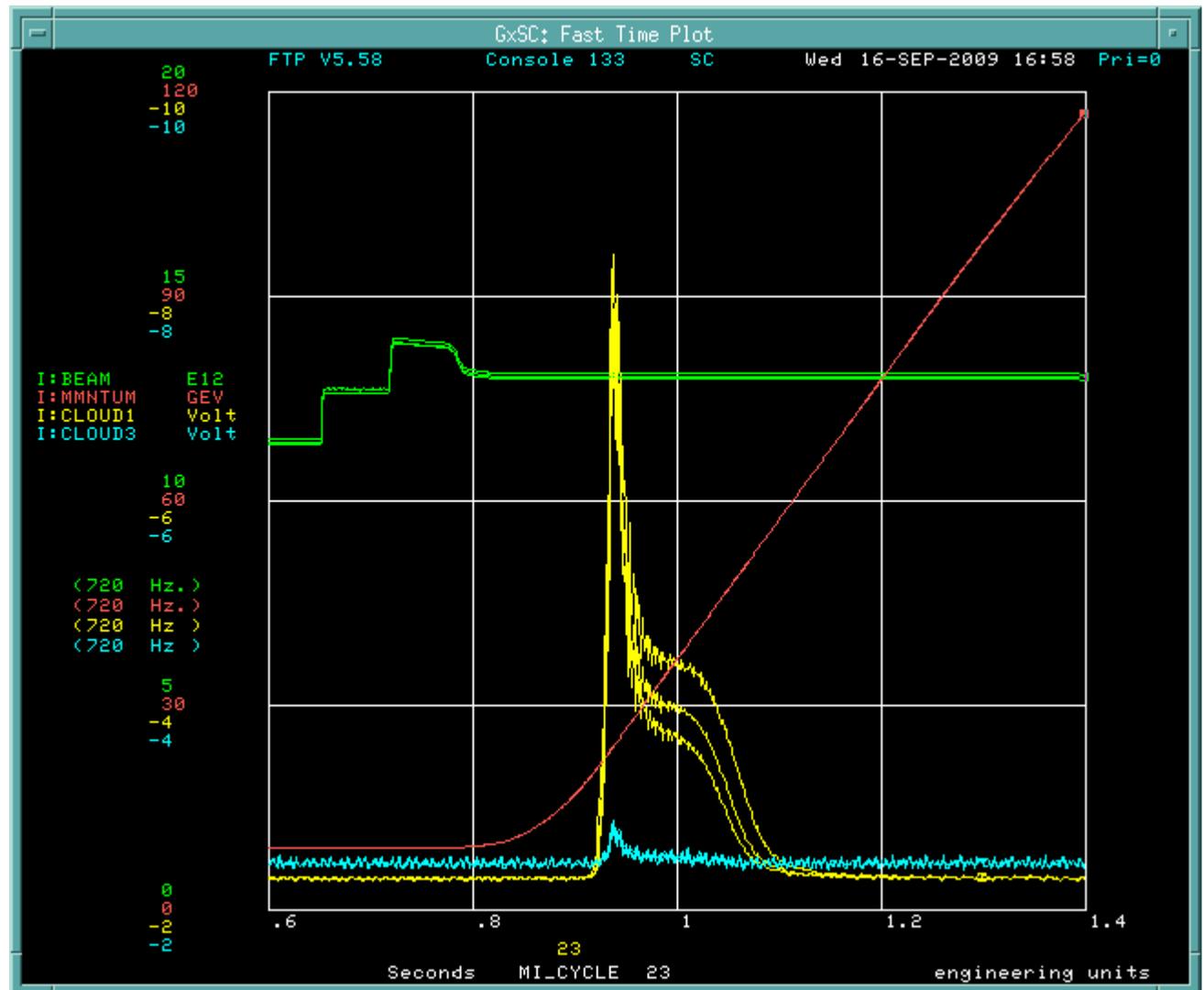
# 9/16/09: 13e12 on 11-batch

- FTP shows the saturation
- Comparing coated with uncoated



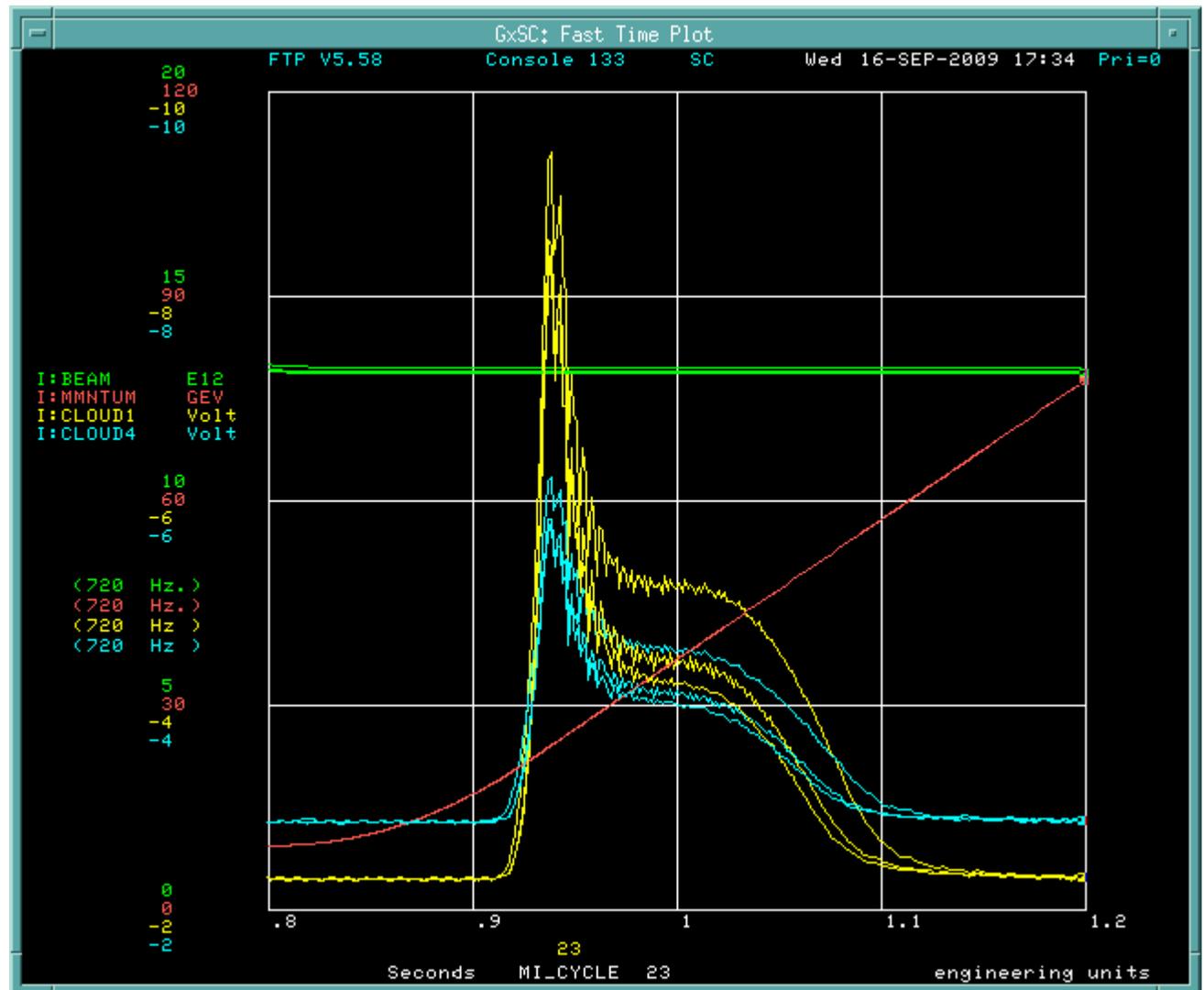
# 9/16/09: 13e12 on 11-batch

- Out of saturation at 120 V
- Coated vs uncoated



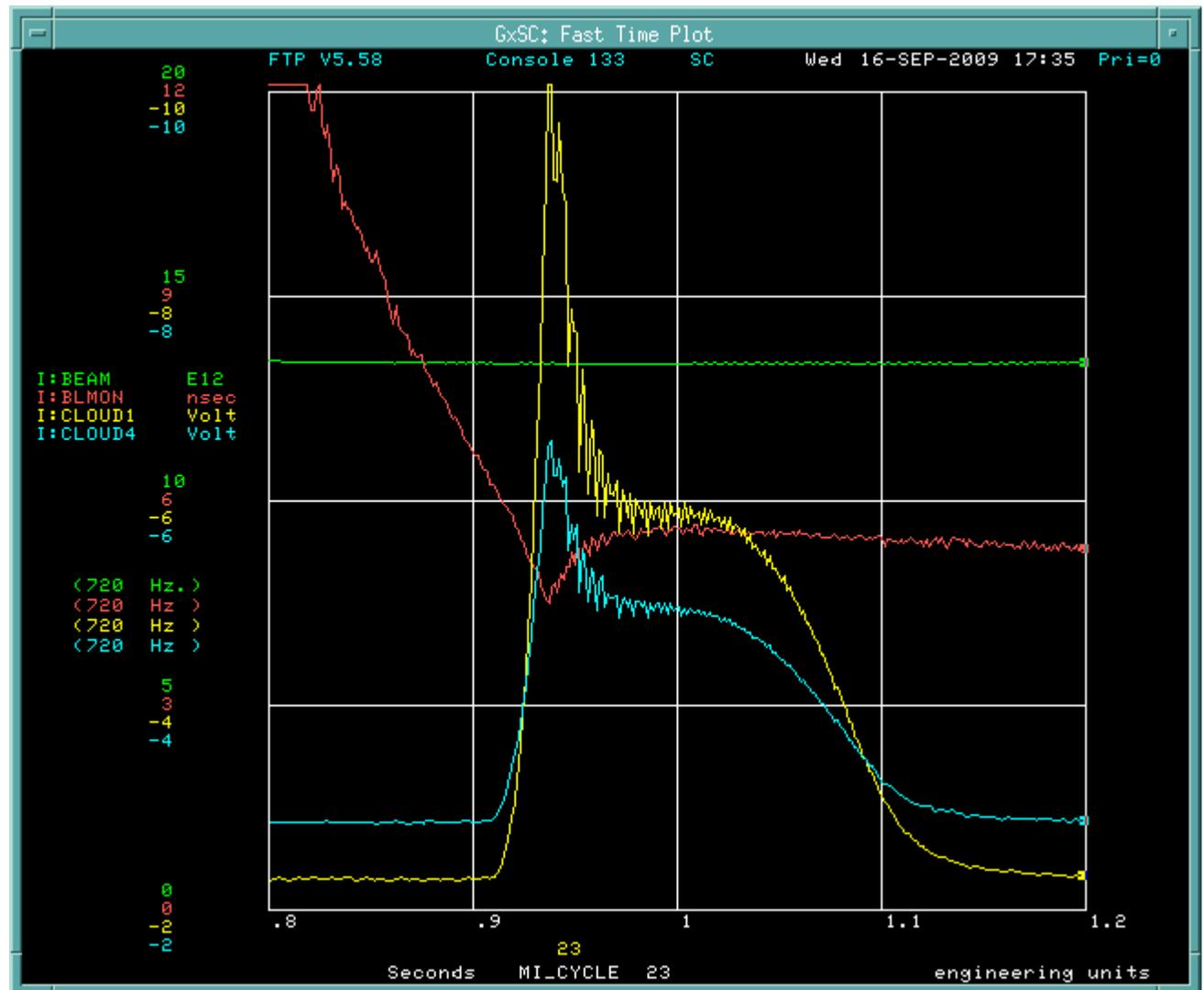
# 9/16/09: 13e12 on 11-batch

- Out of saturation at 120 V
- ANL vs FNAL



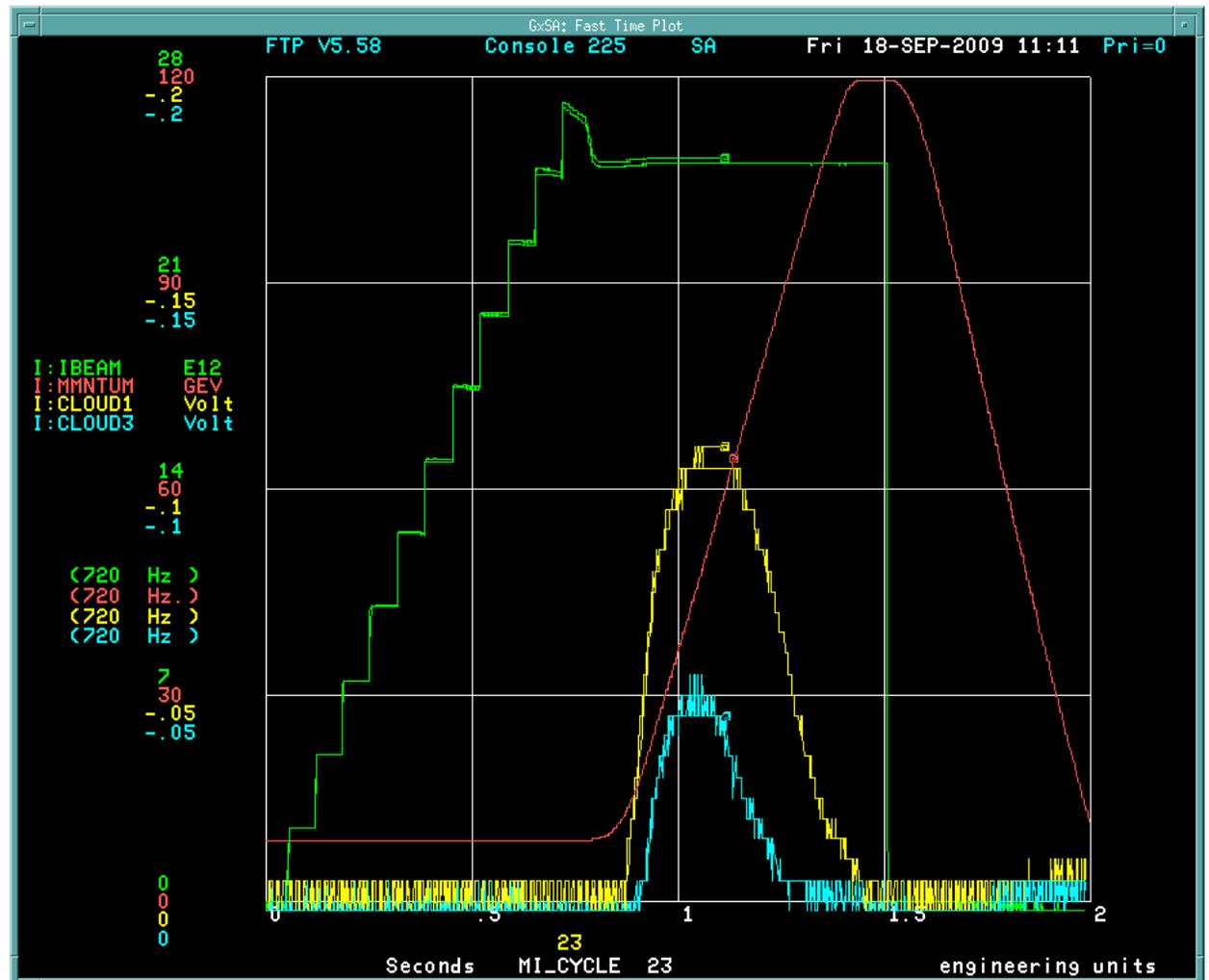
# 9/16/09: 13e12 on 11-batch

- Out of saturation at 120 V
- With BLMON



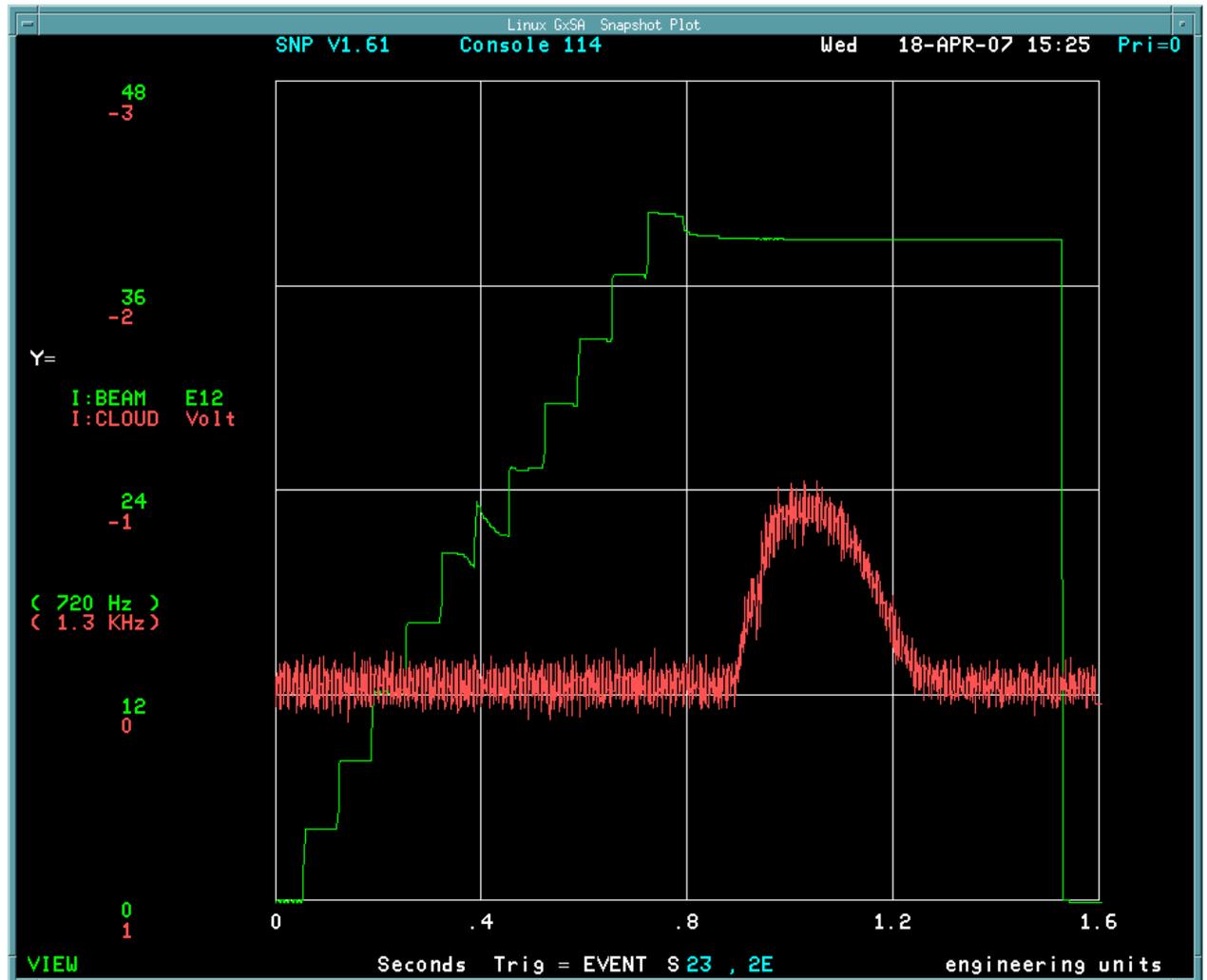
# 9/18/09: 26e12 on 11-batch

- Higher intensity pushes up the cloud
  - Raw signal on MADC is okay
- 2  $\mu\text{A}$  signal is almost as much as seen before with ANL RFA (next slide)
- Uncoated/coated has shrunk to 2.2
  - Asymmetric conditioning
  - (ECloud induced)



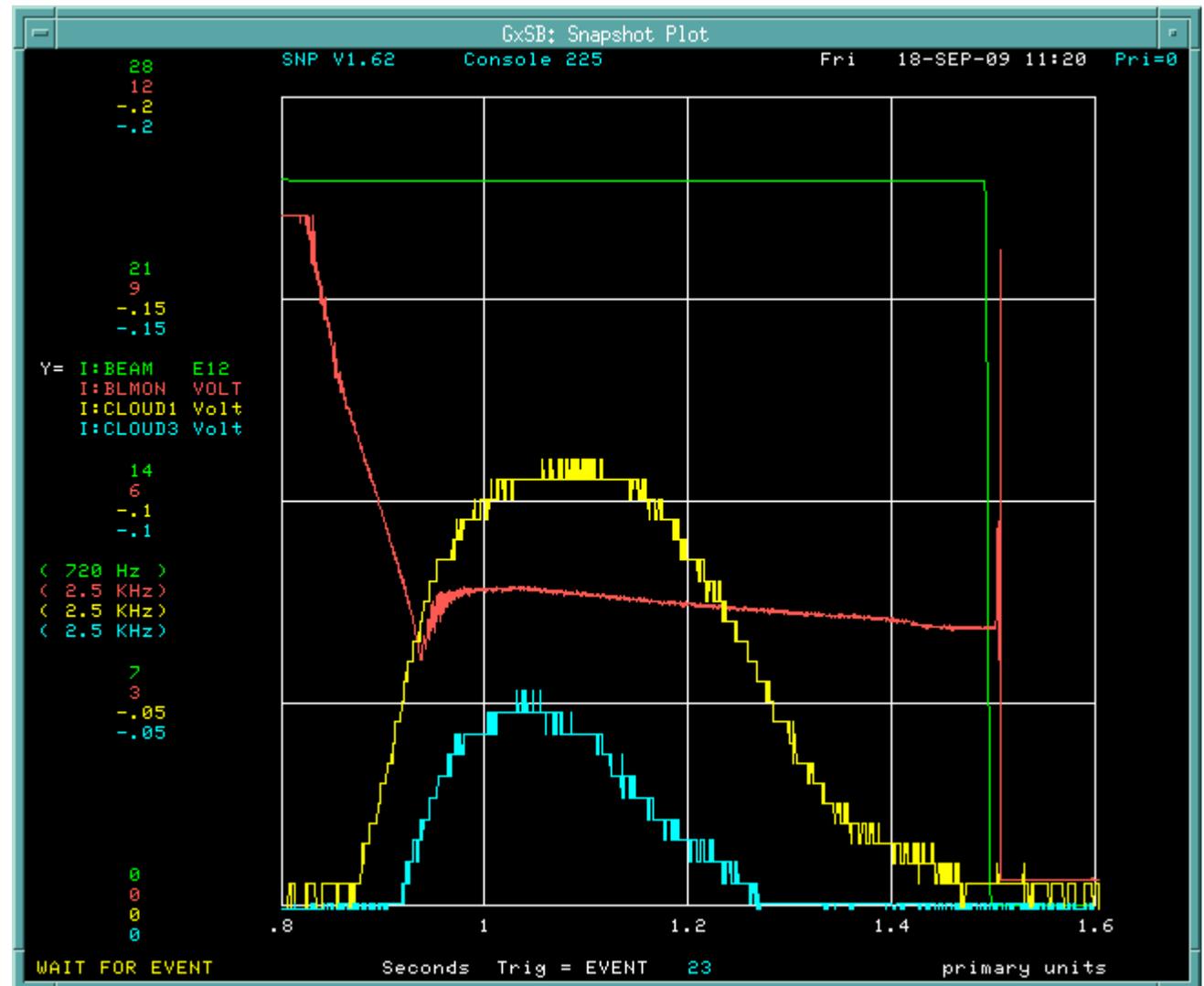
# Legacy - 4/18/07: 39e12 on 11-batch

- Argonne RFA shows 1 uA



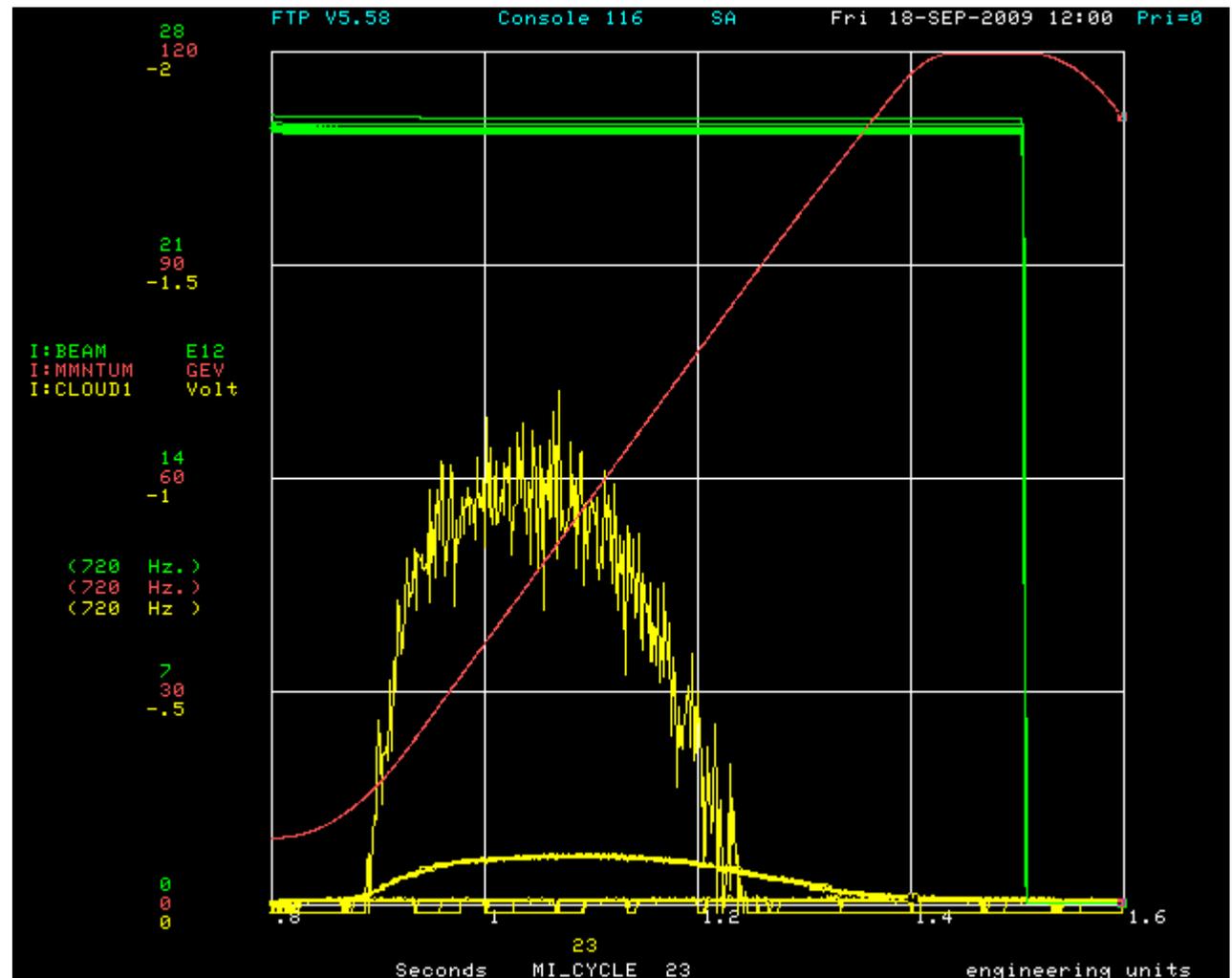
# 9/18/09: 26e12 on 11-batch

- Closer look:
- Ratio is not constant in time:
  - Moving in and out of (ecloud) saturation
  - Some may be instrumental (Capacitance on line filters signal)
  - Raw -> MADC is not ideal



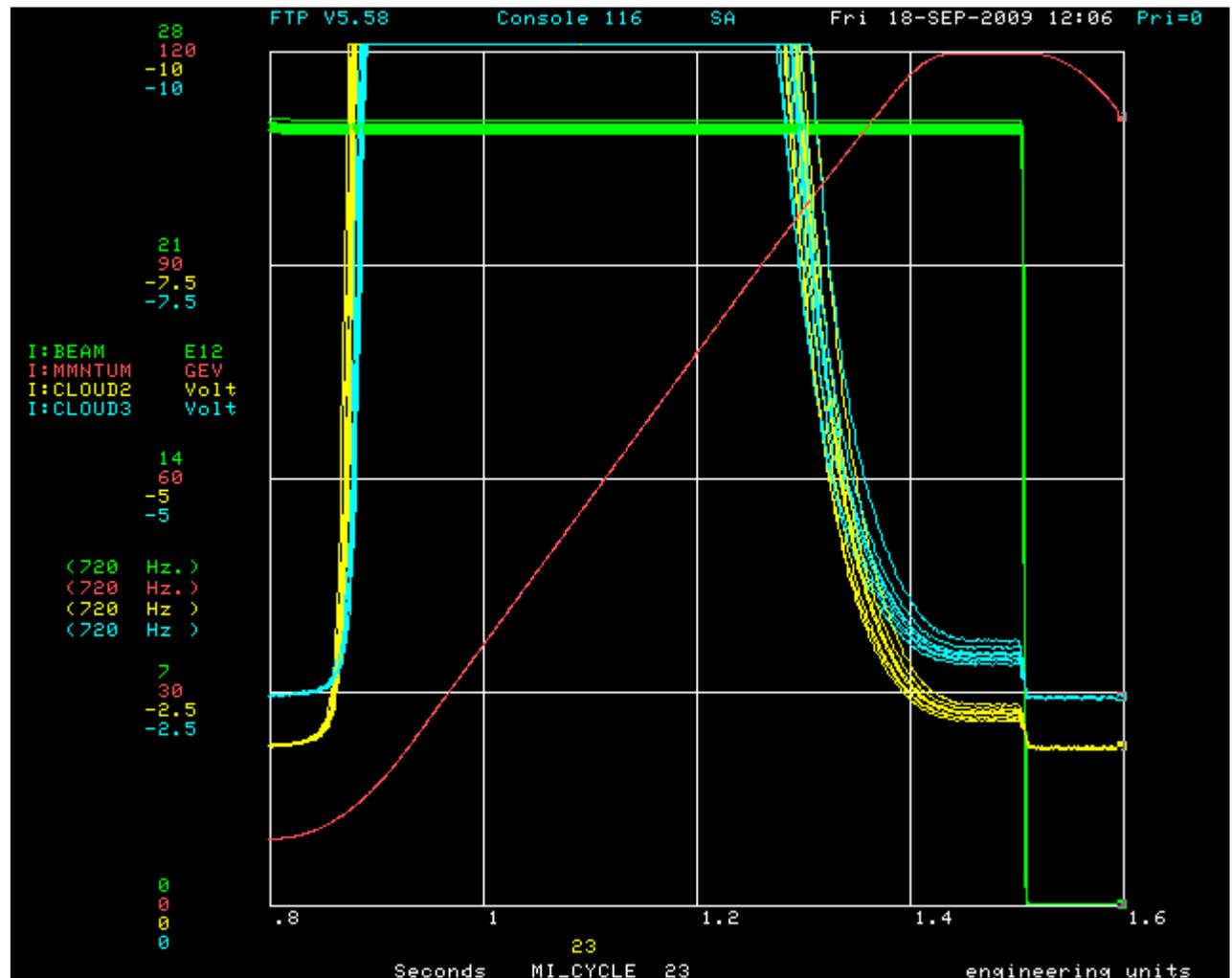
# Example of MADDC effects

- Used old amplifier (1V  $\rightarrow$  1 uA)
- Compare with raw signal
- Ratio is 10x
  - Expect 20x
- Tail is visible



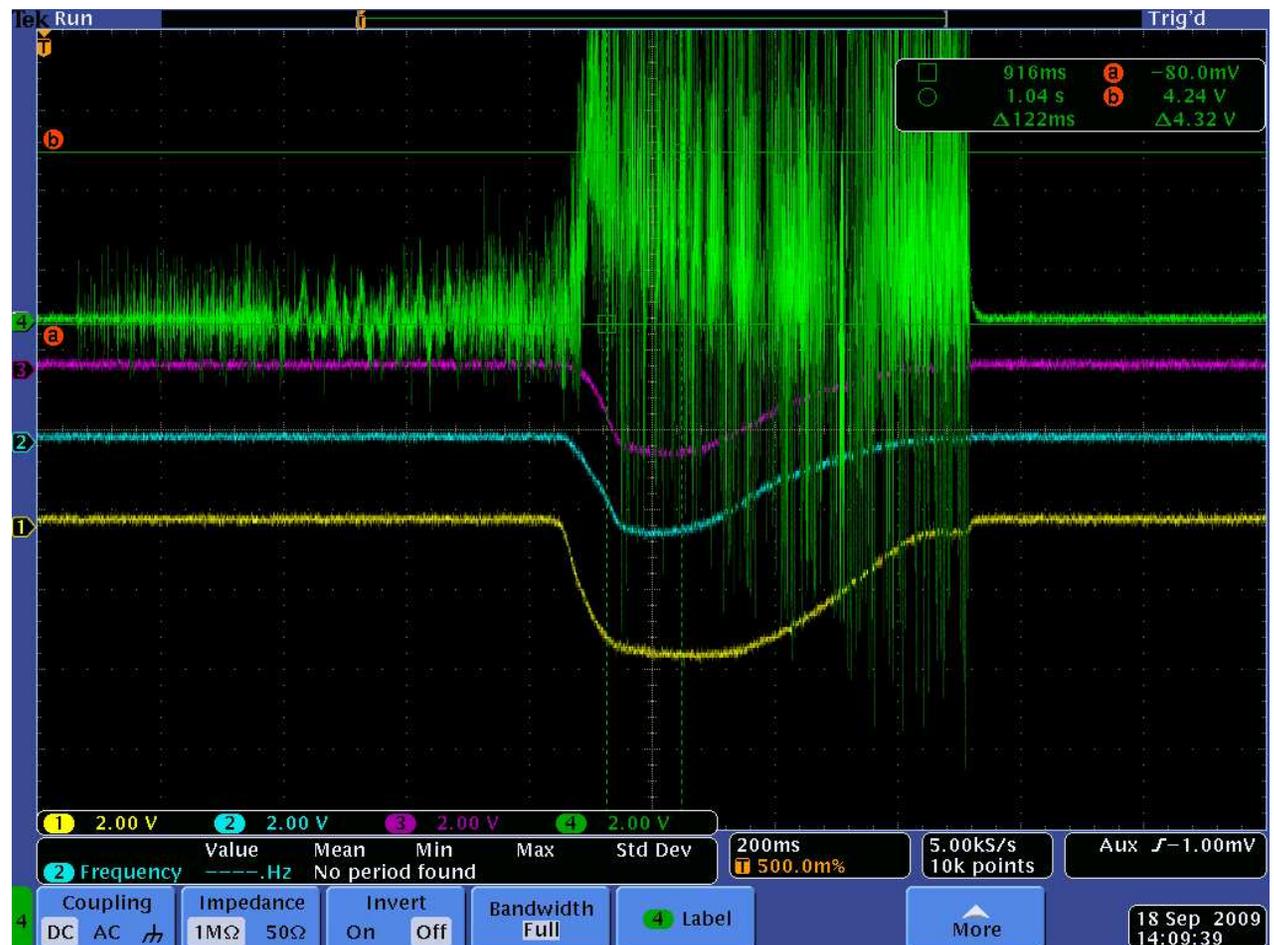
# 9/18/09: 26e12 on 11-batch

- Supersaturated signals with amplifiers
- Nothing during slipping
- Persists until extraction



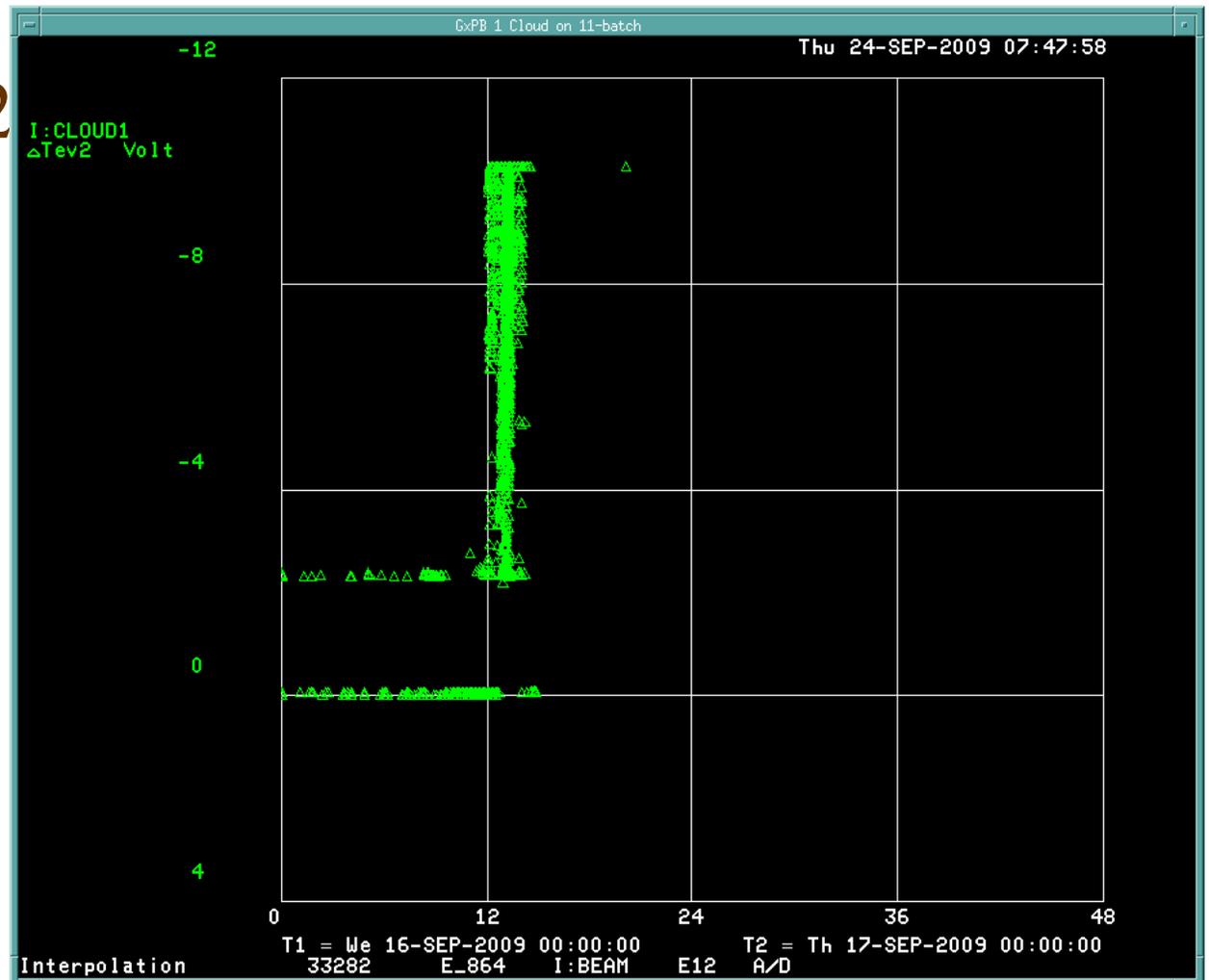
# 9/18/09: 26e12 on 11-batch

- Same, with scope (no amps)
- Time duration is much larger
- Max: 1.8  $\mu\text{A}$
- Uncoated/coated is  $\sim 2$  in peak
  - Greater in tails
- BPM shows skew?
- Energy scan from Tan



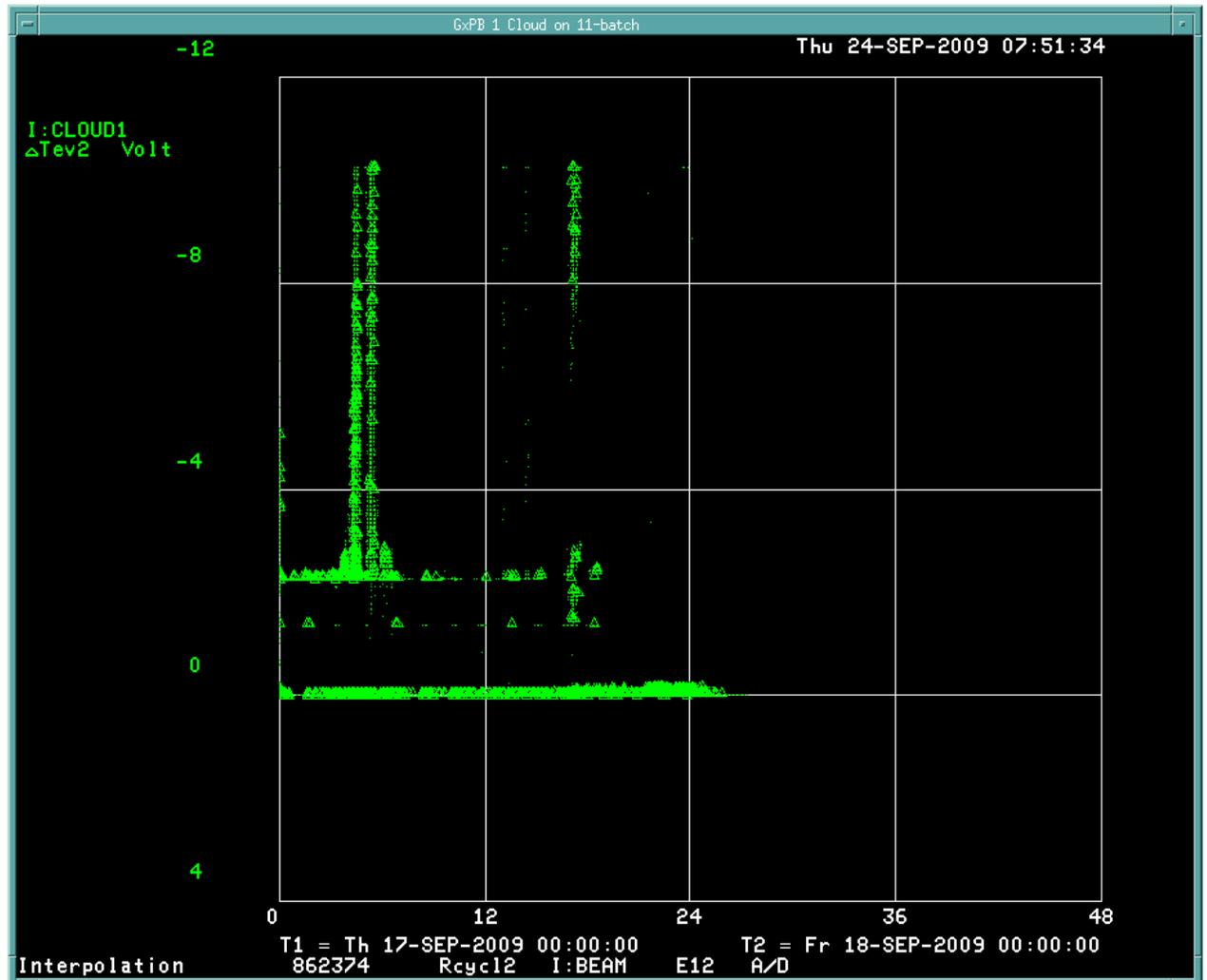
# Conditioning

- Uncoated (FNAL) 9/16
- Amps on
- Saturate  $1.3 \times 10^{12}$



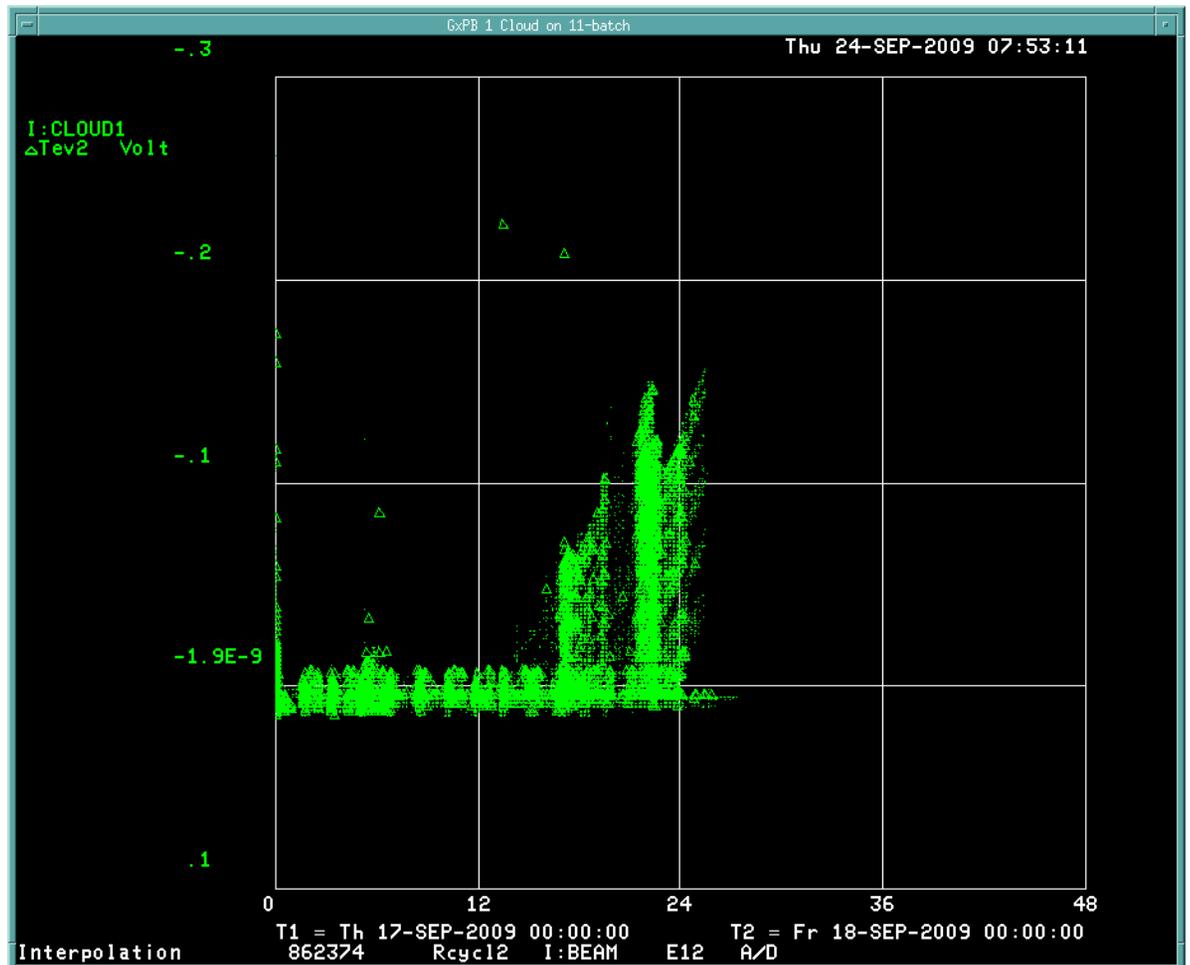
# Conditioning

- Uncoated (FNAL) 9/17
- Amps on
- Low-p saturation
  - 2-batch HI



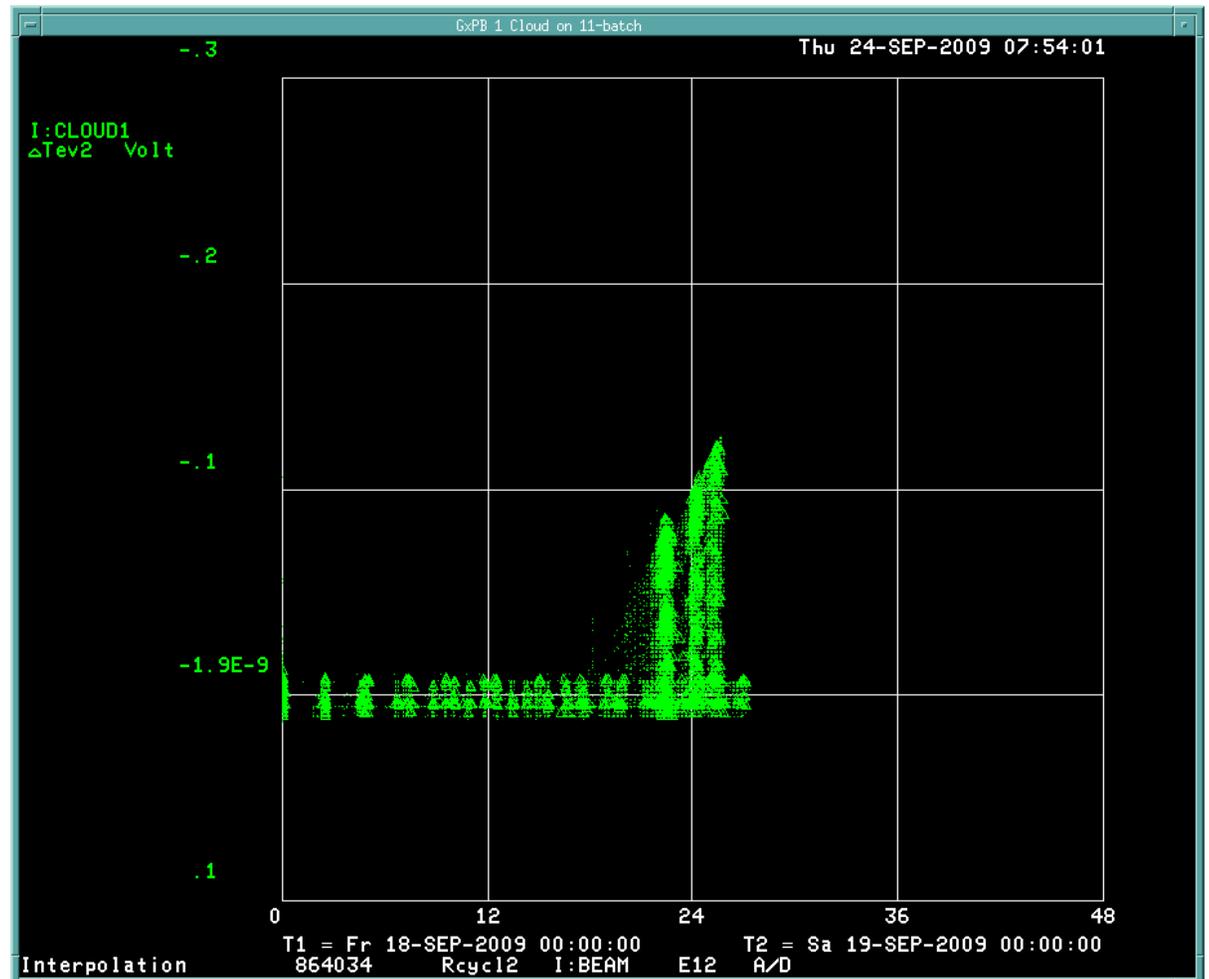
# Conditioning

- Uncoated (FNAL) 9/17
- Amps off
- Can see turn-on
- Trouble with datalogger
- Threshold @  $12e12$
- Branch on right is later in day



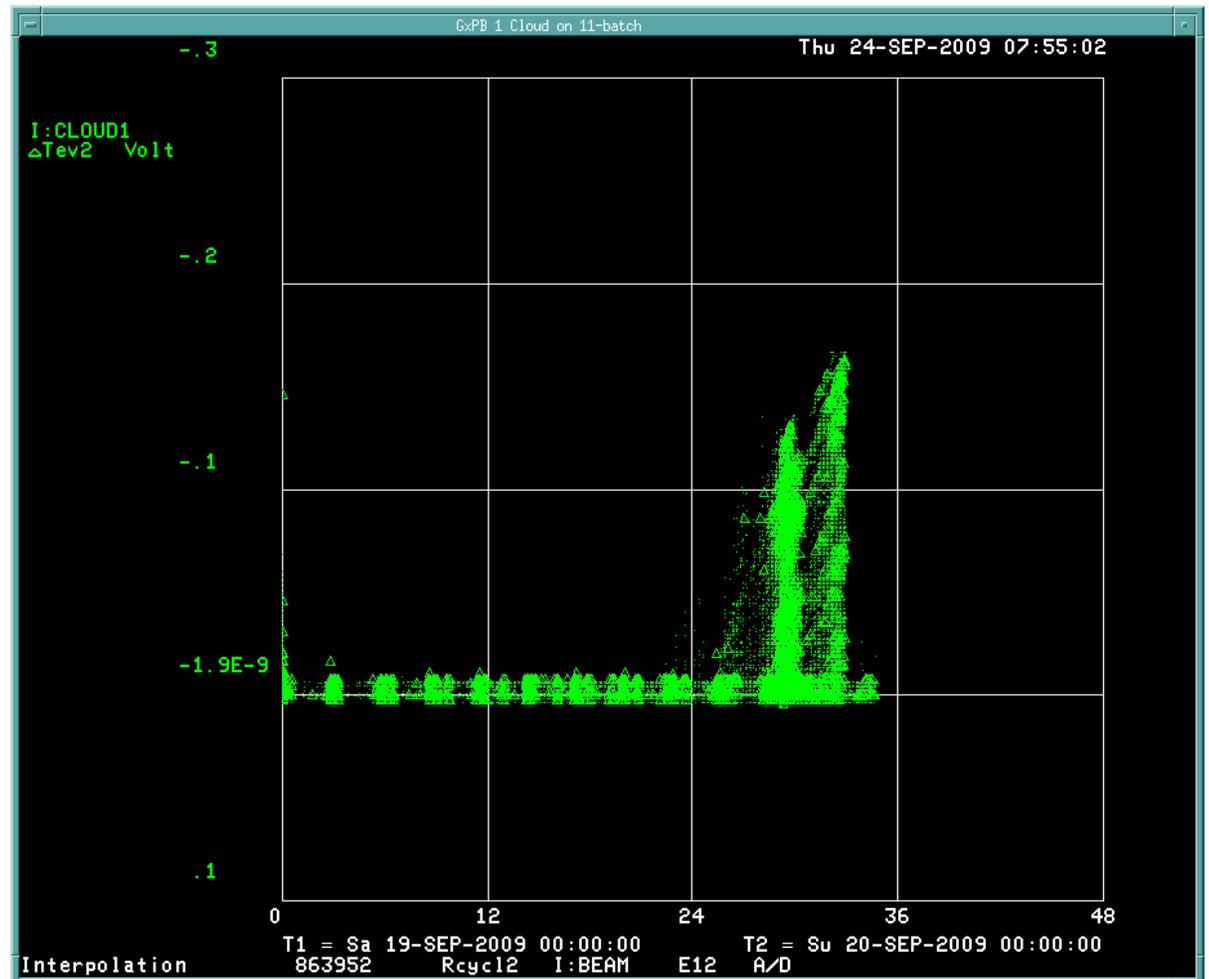
# Conditioning

- Uncoated (FNAL) 9/18
- Amps off
- Threshold @  $18e12$



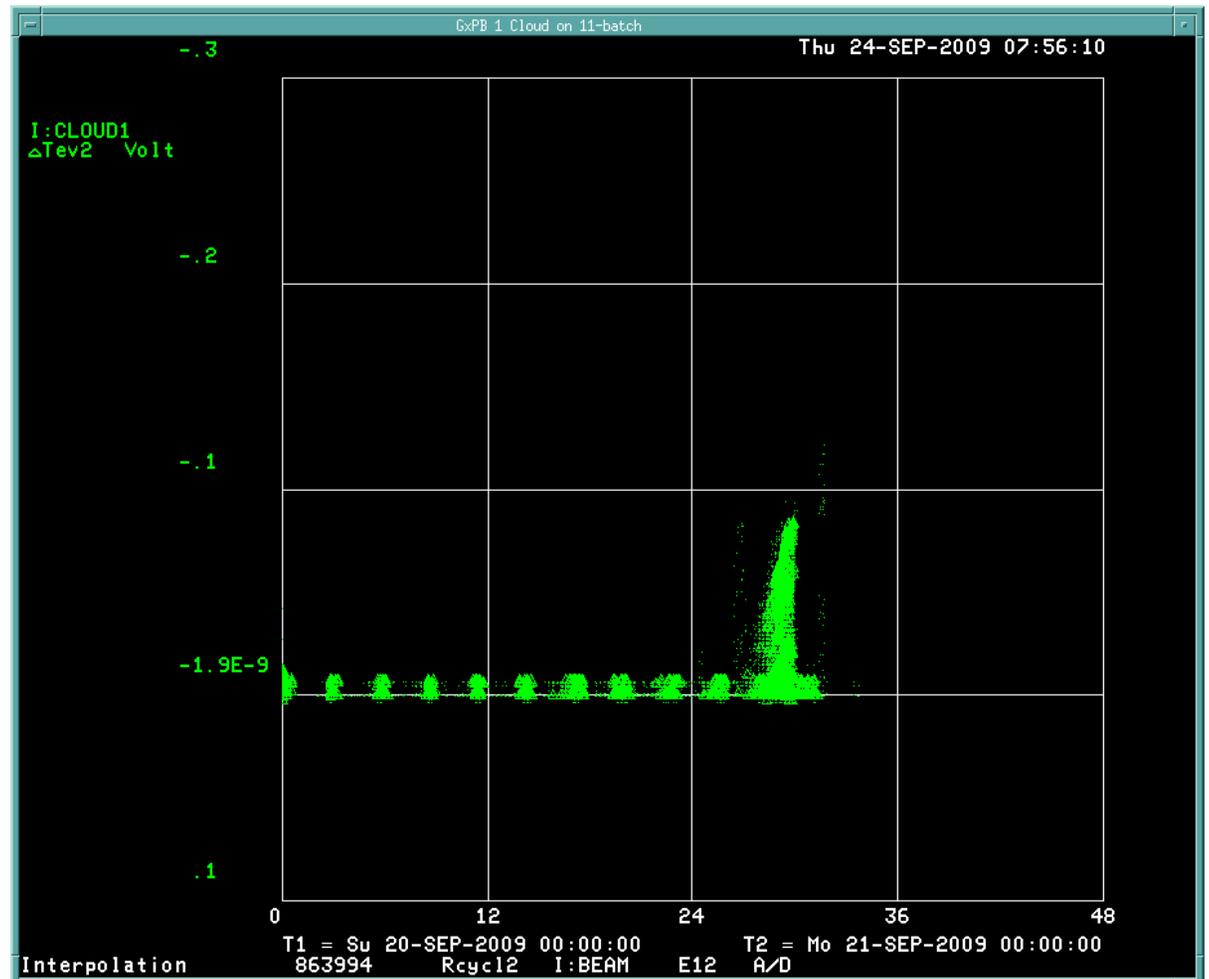
# Conditioning

- Uncoated (FNAL) 9/19
- Amps off
- Threshold @  $22e12$



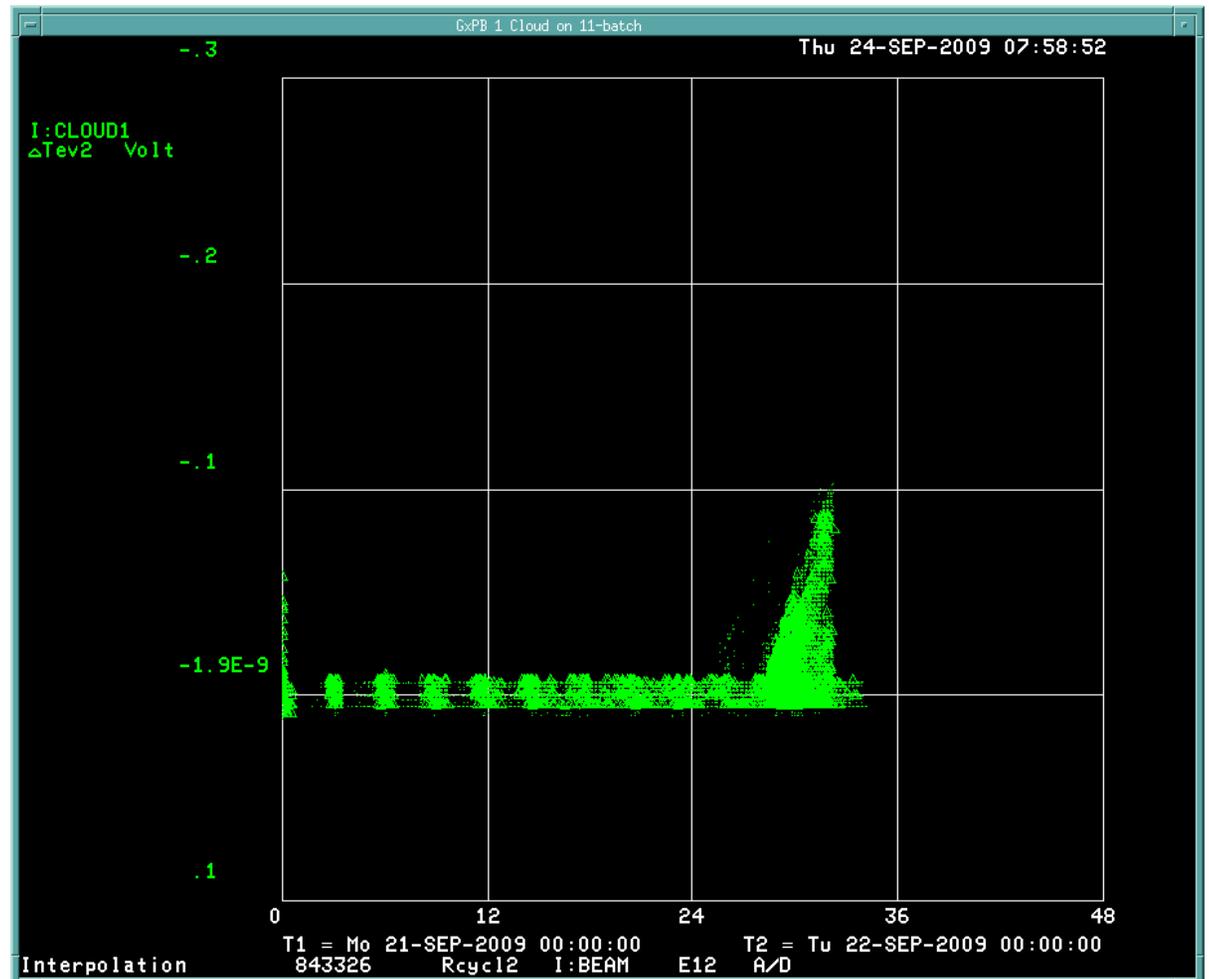
# Conditioning

- Uncoated (FNAL) 9/20
- Amps off
- Threshold @  $27e12$



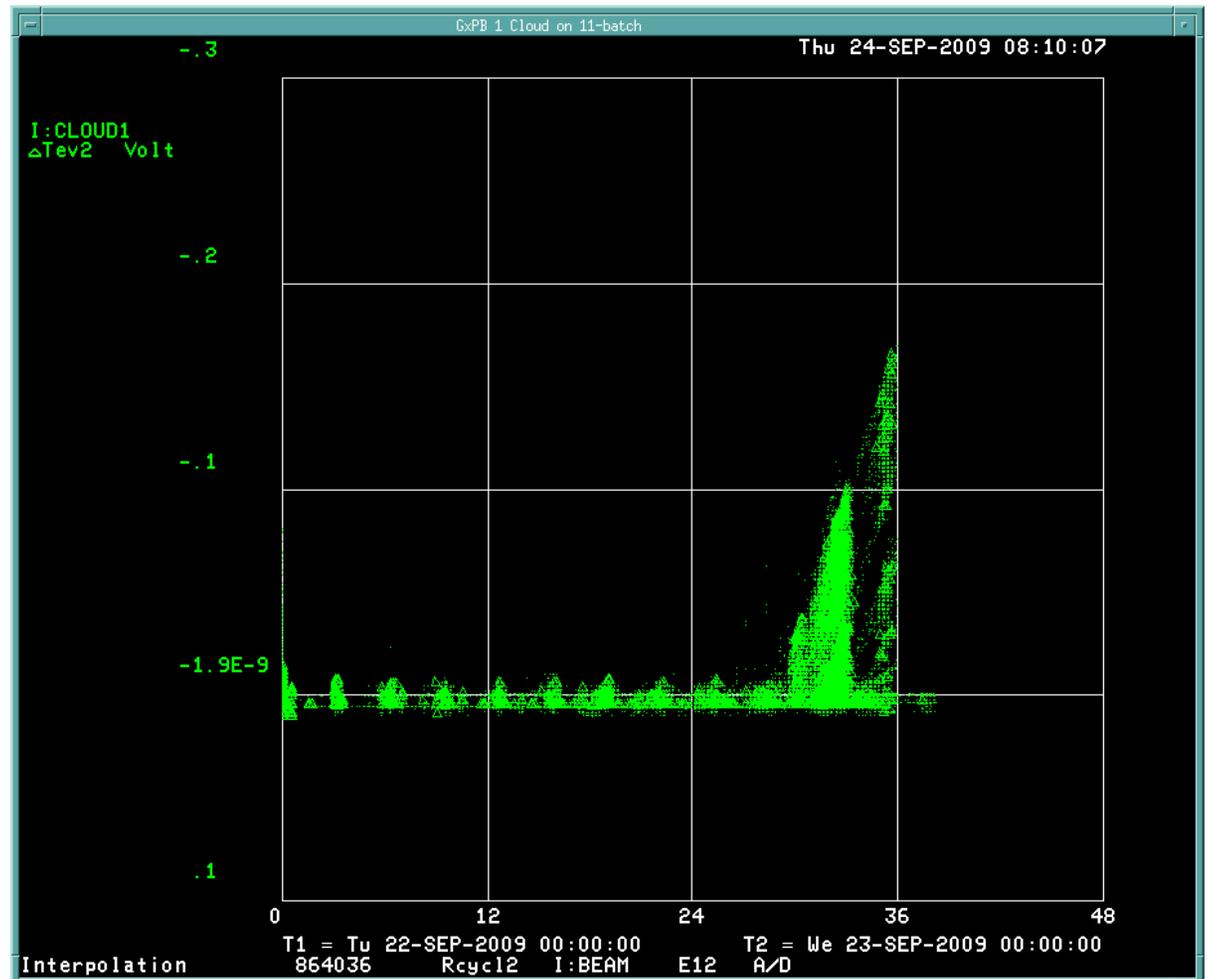
# Conditioning

- Uncoated (FNAL) 9/21
- Amps off
- Threshold @  $29e12$



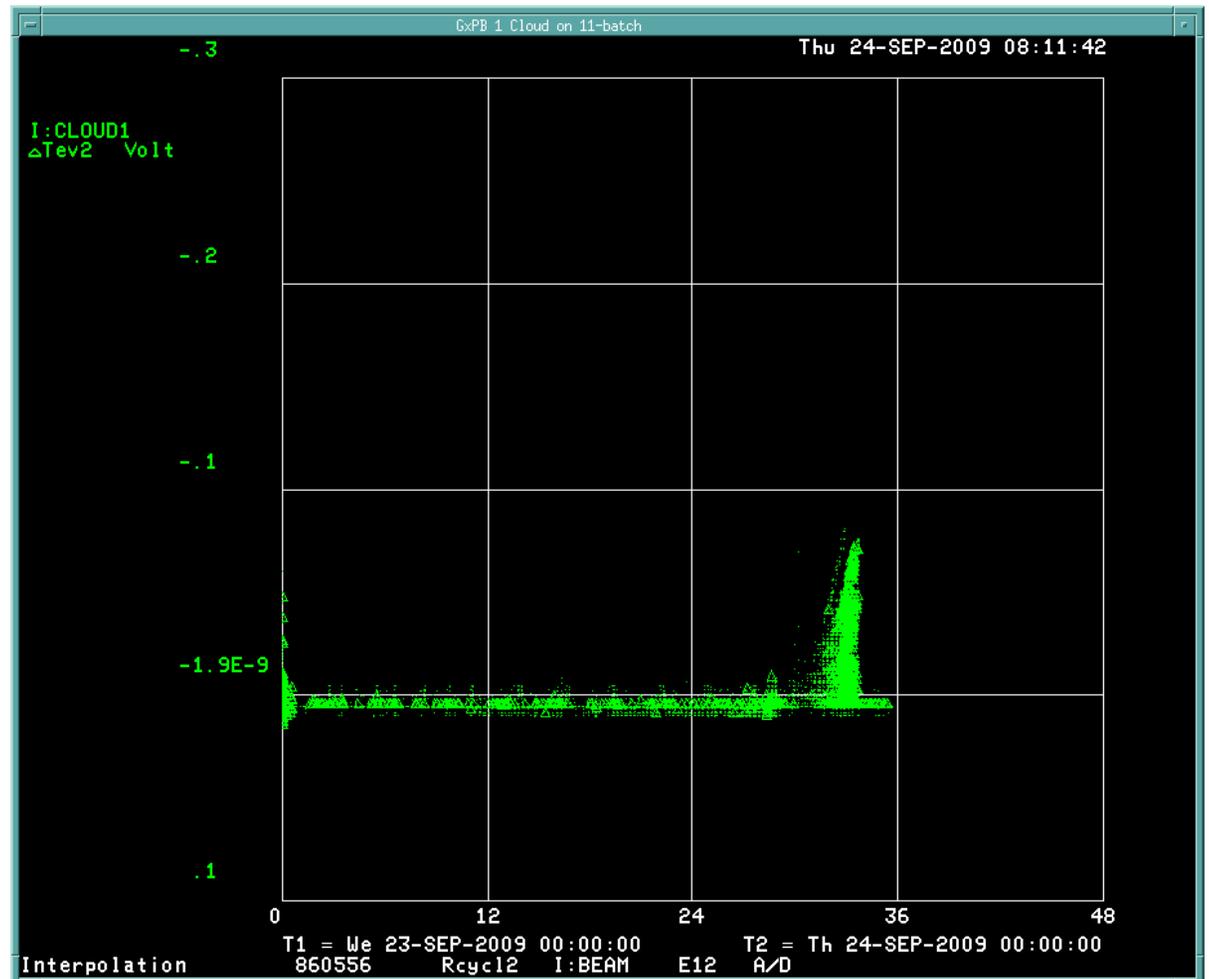
# Conditioning

- Uncoated (FNAL) 9/22
- Amps off
- Threshold @  $29e12$



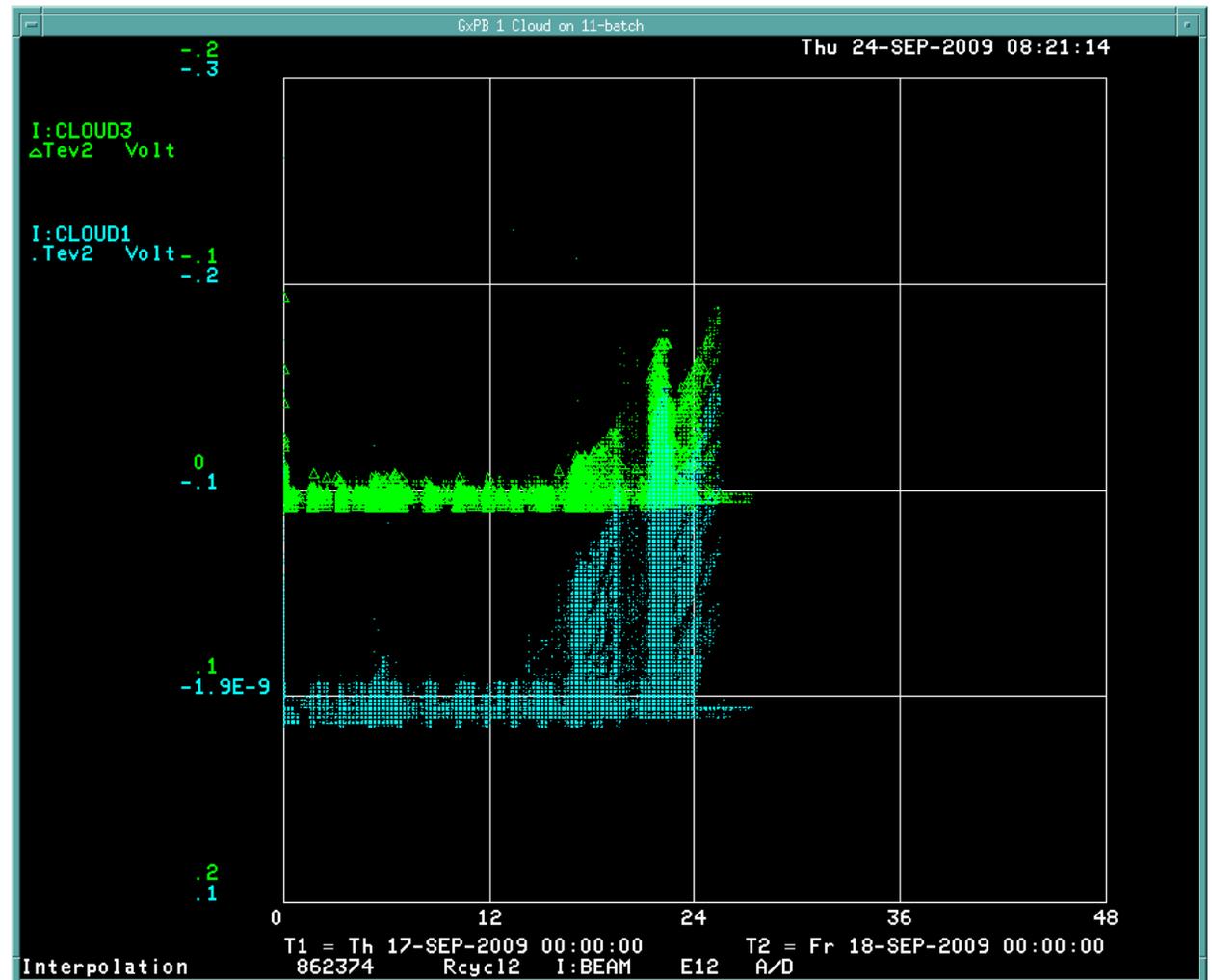
# Conditioning

- Uncoated (FNAL) 9/23
- Amps off
- Threshold @  $31e12$



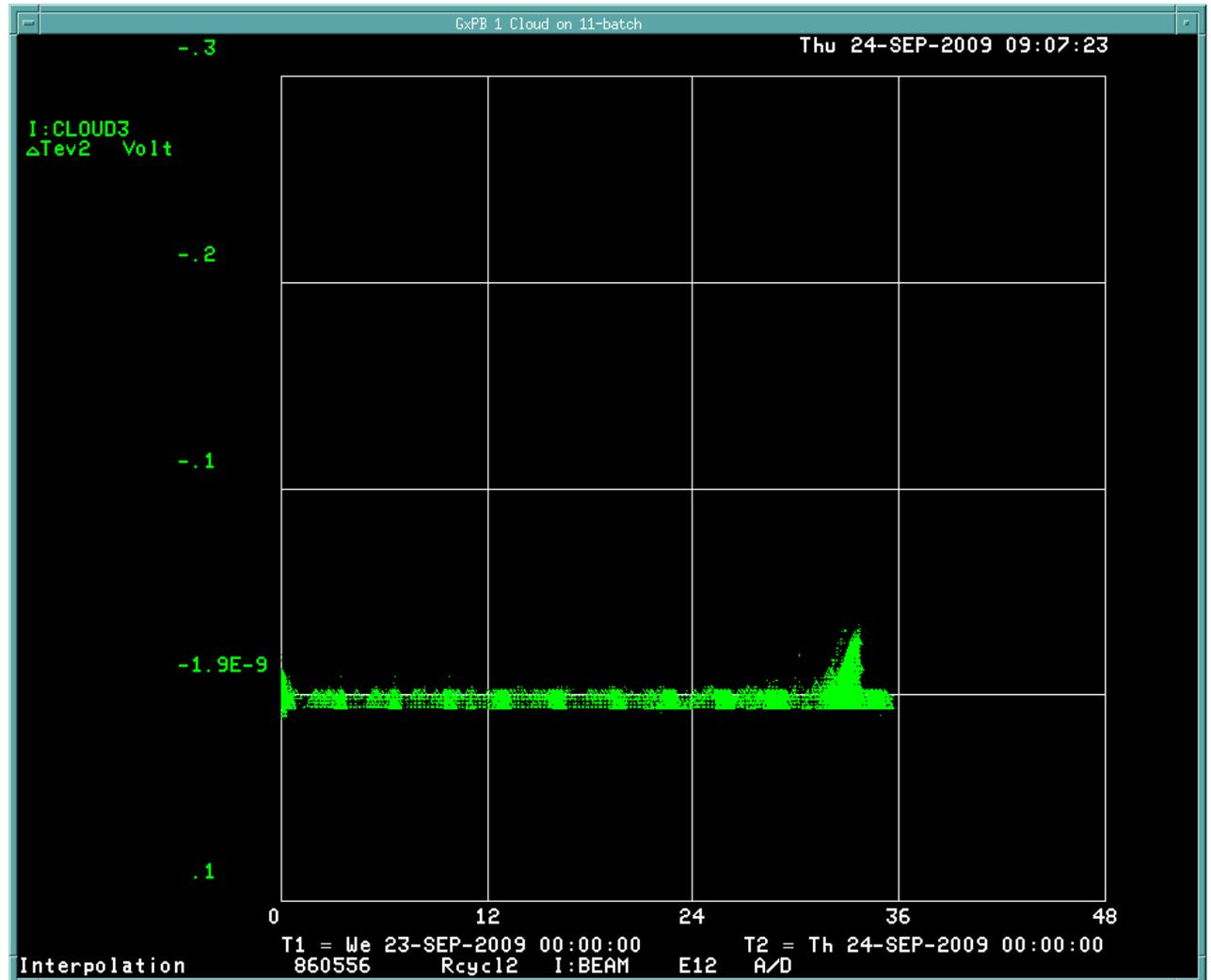
# Conditioning: Compare Coatings

- 9/17, coated (middle) and uncoated (FNAL)
- Amps off
- Coated @ 17e12
- Uncoated @ 13e12
- Uncoated turns on stronger



# Conditioning: Coated 9/23

- Coated (Middle) 9/23
- Amps off
- Threshold @  $33e12$
- Stub is slip-stacking



# Conditioning Summary

## Eyeballed thresholds

Date	Uncoated	Coated
9/16	10	13
9/17	12	15
9/18	18	19
9/19	22	26
9/20	27	28
9/21	29	30
9/22	29	30
9/23	32	32

# Conclusions (1)

- All RFAs work
- Electron Cloud started strong, is evolving rapidly
  - Catch it before it is gone
- Rough shape of cloud evolution matches what we saw before
  - Bump in center of cycle
  - Maximum after transition
  - Do not clearly see a dip at transition, except maybe at high electron energy
  - Only with extremely fresh machine do we see any Cloud during injection or slipping
    - Otherwise nothing
  - I expect shape to evolve with conditioning
- Fermilab RFA looks like Argonne RFA, except with ~ 120% more signal
  - Consistent with expectations
  - Comparing energy filter behavior in beam will be difficult
    - Probably leave for bench

# Conclusions (2)

- Coating has a clear suppression effect
  - Initial ECloud signal was 15-20x lower
  - Differential conditioning has reduced this difference to  $\sim 2x$ 
    - However, the difference was greater in the tails
  - Deconvolving these ratios into SEY will take some additional work
    - May require input from simulation
- Conditioning is proceeding rapidly
  - Expect that conditioning is caused by bombardment of electrons from the cloud
  - Thus, conditioning is faster in uncoated pipe
  - Still, ECloud has always been at least 2x smaller in coated pipe
  - Signals are getting smaller, but we have a long way to go in terms of exhausting our amplifiers' ranges
- Other talks:
  - Energy spectra – interesting behavior, have at few different intensities/conditioning
  - Microwave data – May have some correlation with RFAs
    - Question: if both detectors agree, but phenomenon doesn't agree with simulation, where do we go?