AGS Beam Intensity Upgrades

High intensity history at the AGS

Sextupole power supply upgrades

Bunch manipulation and merging

Extraction and beam transport

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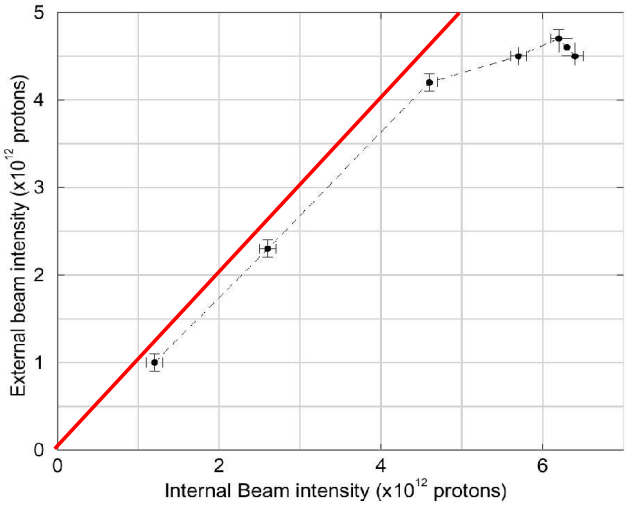
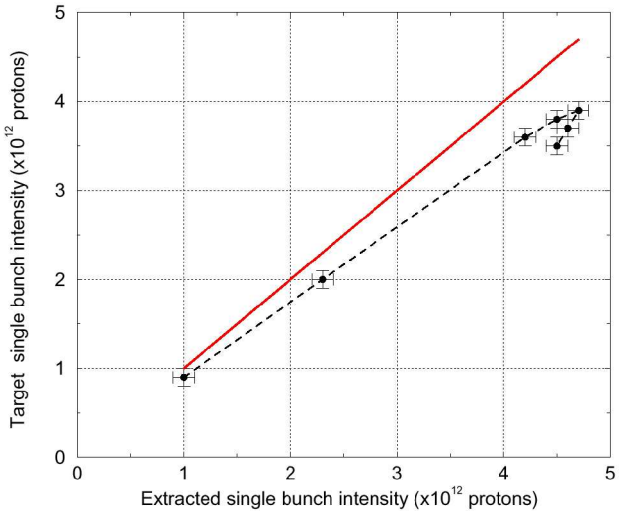
Kevin Brown
Muon collaboration meeting
May 9-15, 2002

High Intensity History at the AGS

- Single bunch extraction: 6 TP circulating in AGS, 4.5 TP in beam line, 3.7 TP at target (Goal: 16 TP)





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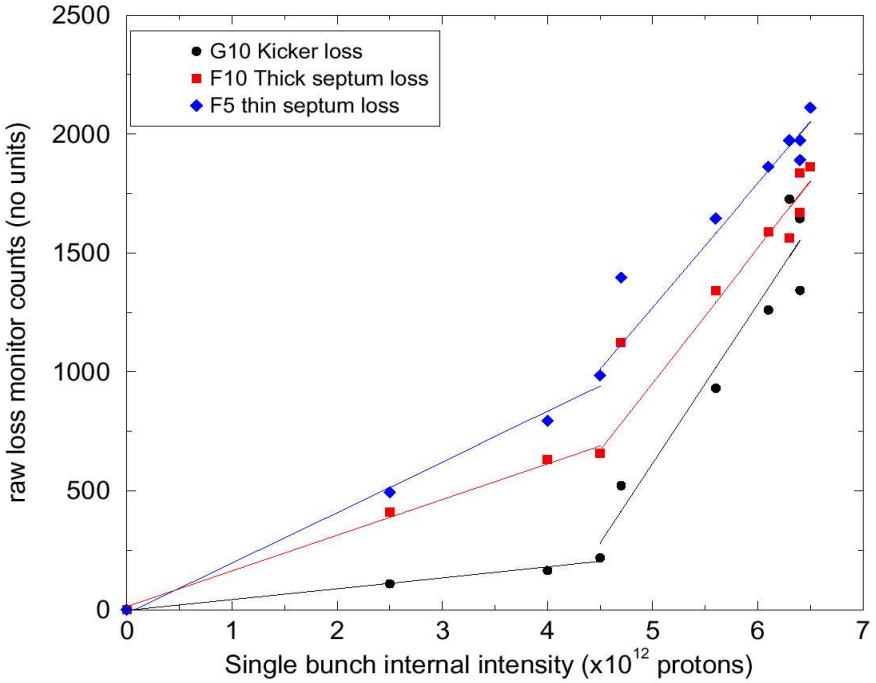
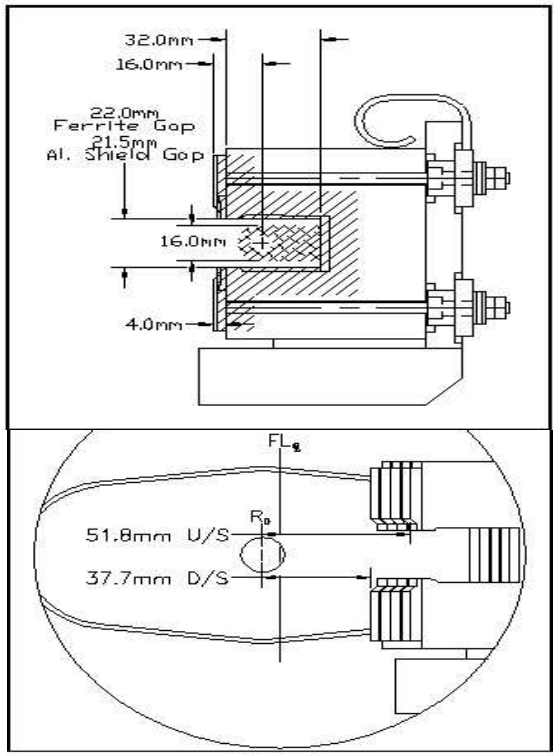
High Intensity History at the AGS

- To get low loss extraction it was necessary to run with negative vertical chromaticity. This seems to cause vertical transverse instabilities at higher intensities.



No. of Magnet Sections:	4
Length per Section:	58.4 cm
Total length:	241.3 cm
Aperture Specification:	32 mm Deep x 22 mm High
Field Strength :	1000 Gauss at 2000 Amps



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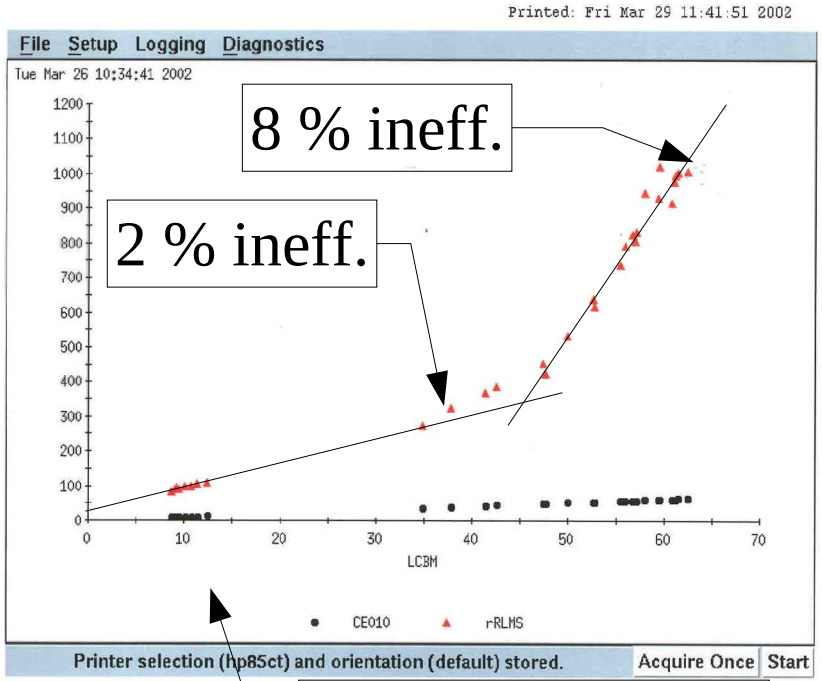
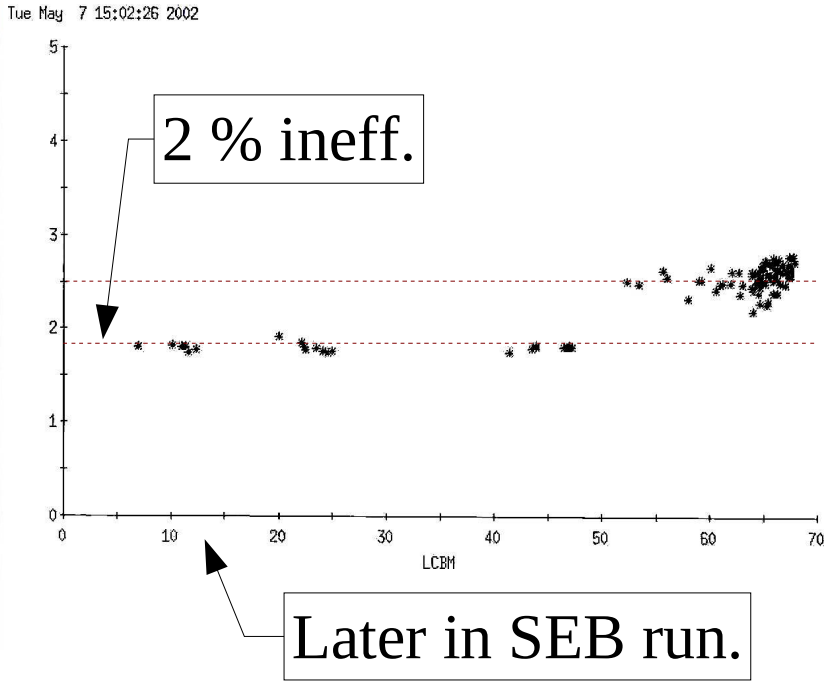
High Intensity History at the AGS

- 70 TP Slow extracted beam observations. Vertical Chromaticity is kept positive after transition.





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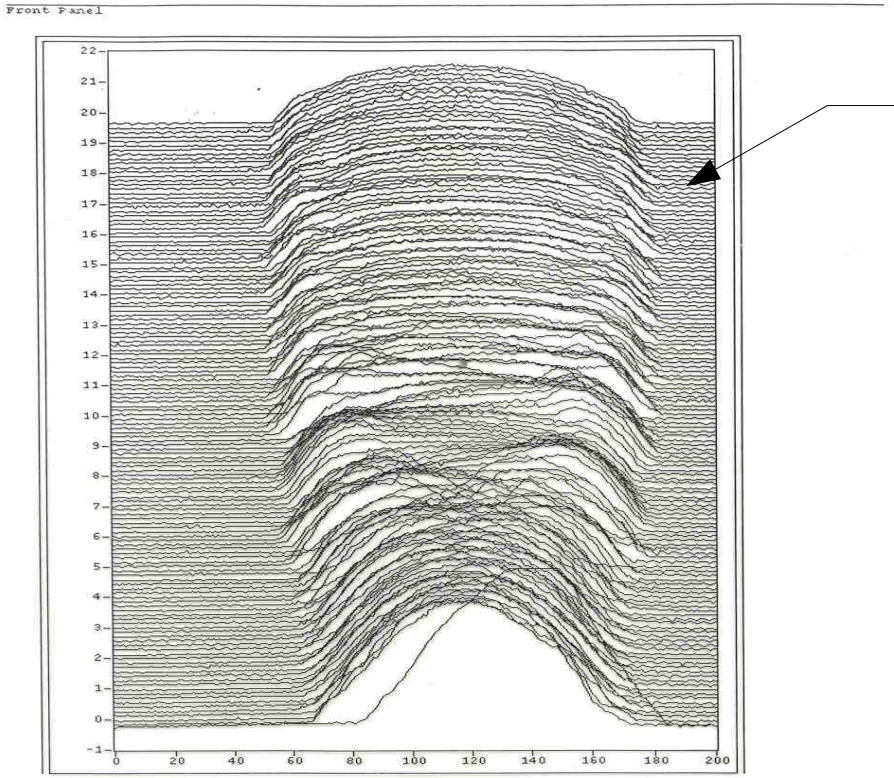
High Intensity History at the AGS

- A key parameter is peak beam current.



Bunch Dilution using VHF cavity

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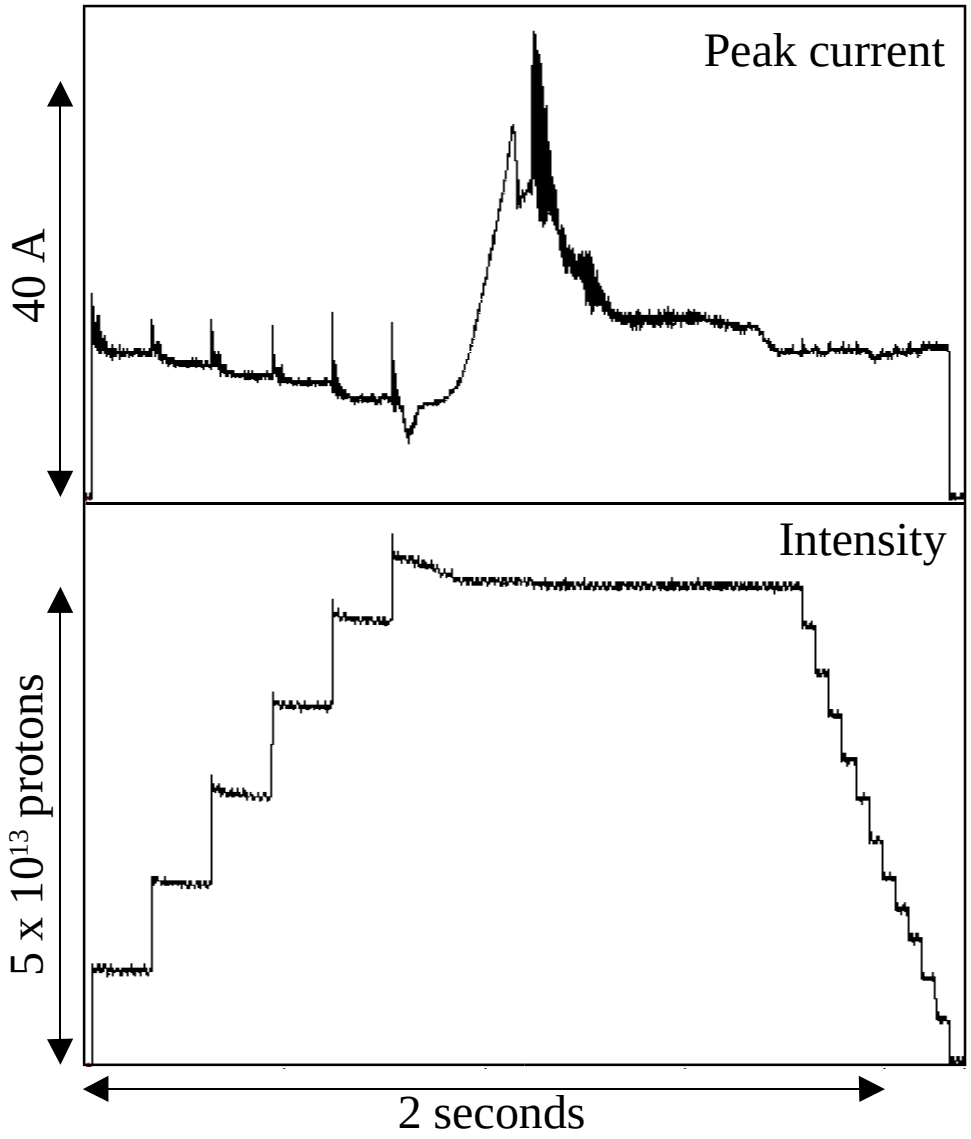
AGS performance for g-2 operation

- 6 single bunch transfers from Booster
- Peak intensity reached: 72×10^{12} ppp
- Bunch area: 3 eVs at injection
  10 eVs at extraction
- Intensity for g-2 ops: $50\text{-}60 \times 10^{12}$ ppp
- Strong space charge effects during accumulation in AGS
- 2nd order transition energy jump limits available momentum aperture.
- Chromatic mismatch at transition causes emittance dilution
- Dilution needed for beam stability



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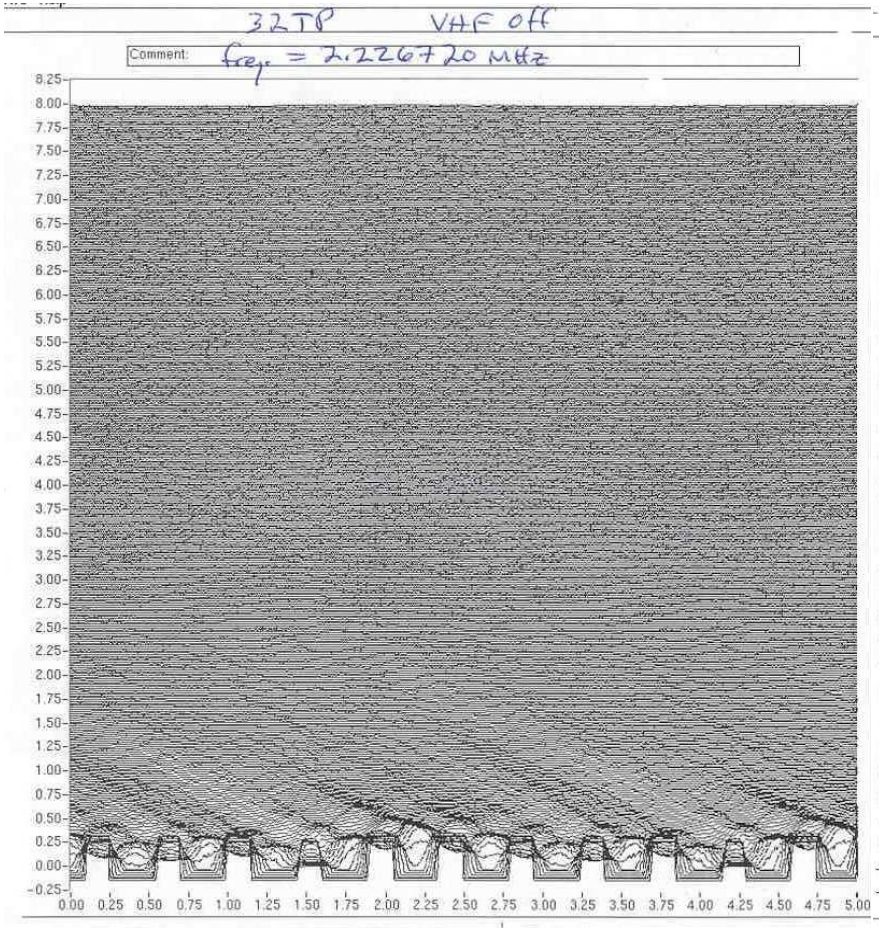
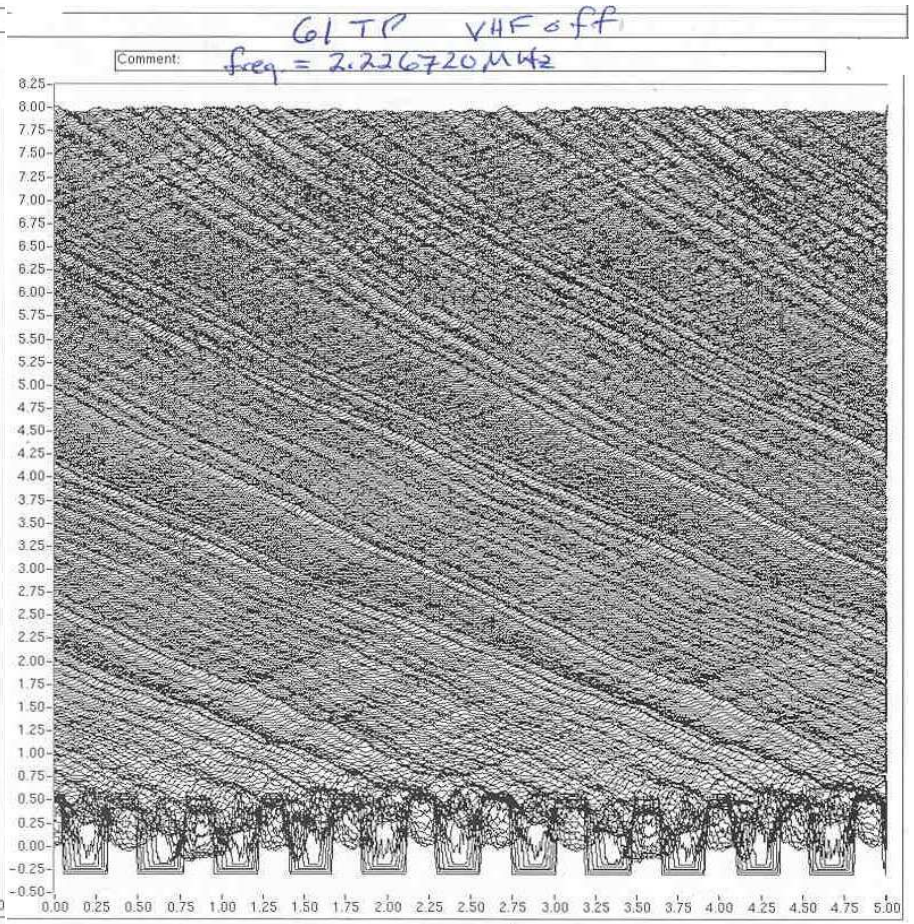
High Intensity History at the AGS





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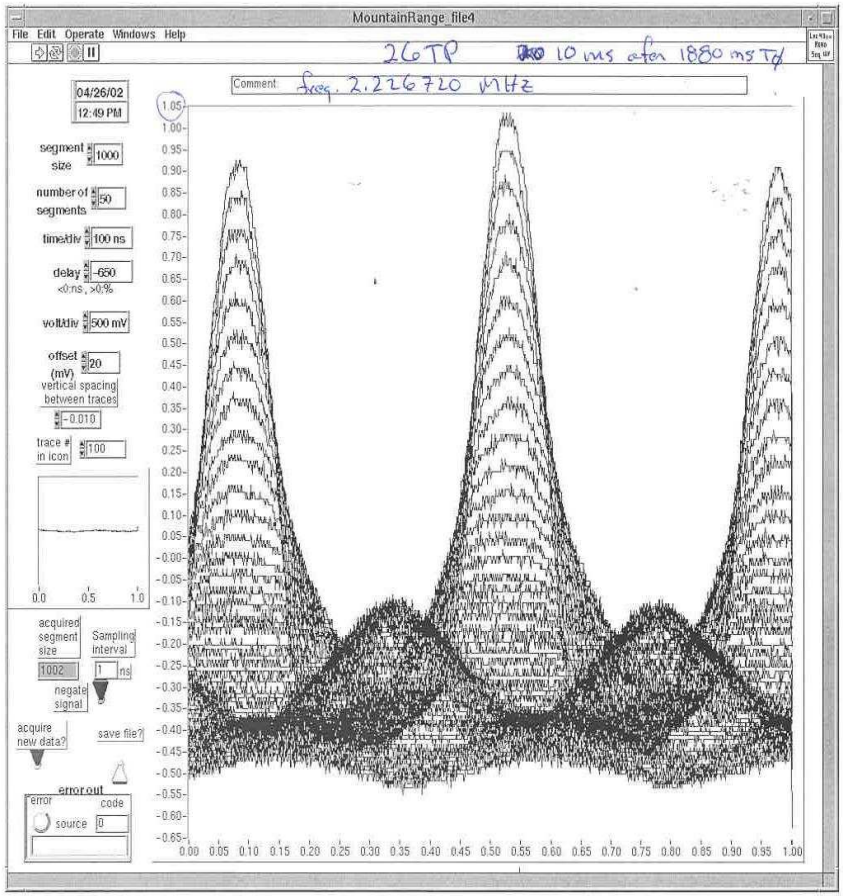
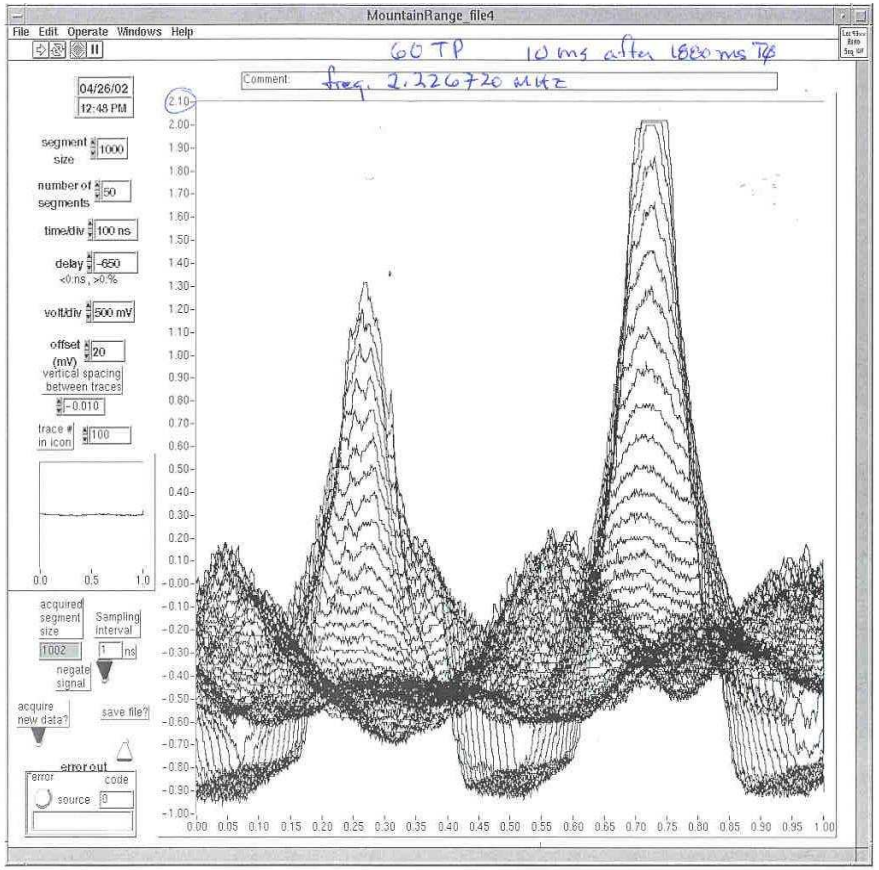
High Intensity History at the AGS





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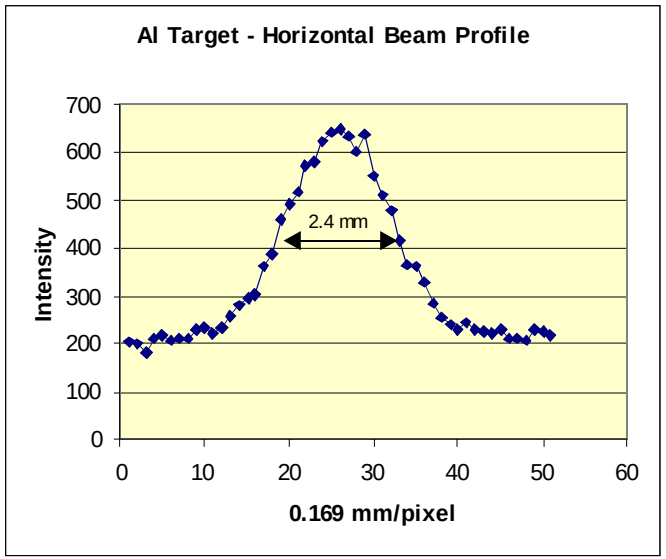
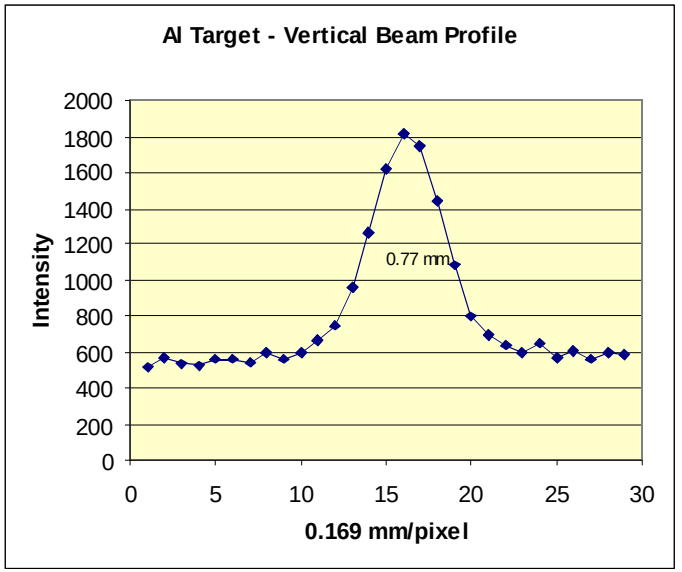
What has been achieved

- Spot size: $\sigma^2 \sim 1$ mm^2 measured by flag (Goal: 1 mm^2)
- Spot size measured by foil activation: $\sigma^2 \sim 0.4$ mm^2





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Upgrades

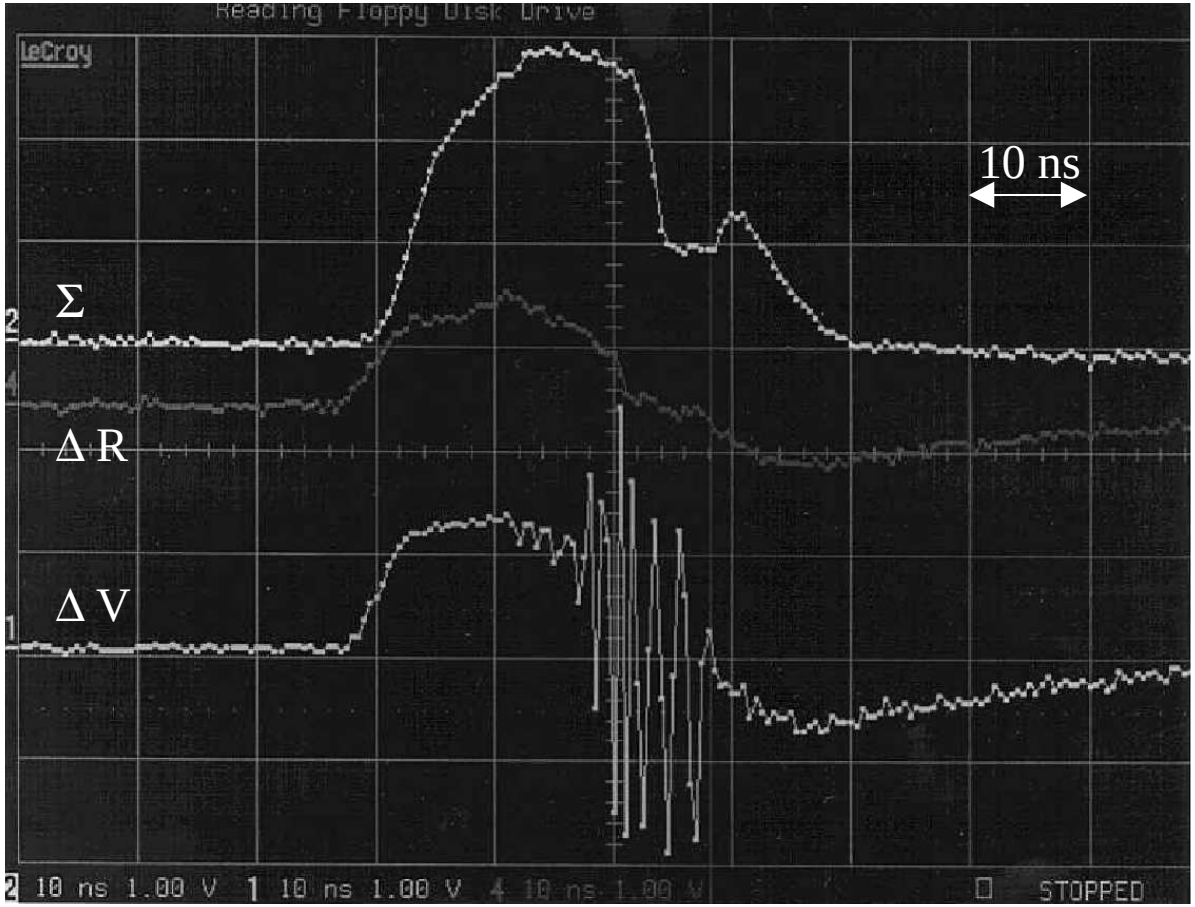
- New separate power supply for vertical sextupole (F7) to keep losses low with positive vertical chromaticity ($75k)
- New power supply to allow for positive horizontal chromaticity after transition ($150k)
  - CERN PS experience:
    with gammat jump and chromaticity jump (-1 -> +0.1) reached
    7 TP/bunch with 2.2 eVs [3.2 TP/eVs]
  - Limited by beam break-up instability (transverse microwave inst.)
  - AGS has gammat jump but large negative horizontal chromaticity (~ -2). Limited to about 1 TP/eVs after transition.
  - With new supply could get 10 TP/bunch in ~ 4 eVs ->
    bunch length at extraction ~ 50 ns (peak current: 65 A)

Beam break-up at CERN PS

7×10^{12} ppb, > 2.2 eVs

Occurs close to transition

Cured with long. blow-up



(R. Cappi, Snowmass 2001)

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AGS Modifications

HORIZONTAL SEXTUPOLE SPECIFICATION DATA SHEET

Input Voltage:	460 Vrms 3 phase, +10%, -5%, 60 Hz
DC Output Voltage:	-300 V to +300 V Continuously Adjustable
DC Output Current:	600A Continuously Adjustable
Pulse Repetition Frequency:	DC to 10 Hz
Regulation mode:	Current
Load Current Tracking:	0.01% during flat-top, 0.5% during rise/fall
Zero Current Crossover Distortion:	< 0.5%
Load Current Rise Time:	< 20 msec @ 100A
Load Current Settling Time:	< 5 msec
Output Voltage Ripple:	< 0.03%, DC to 10 kHz < 0.3%, 10 kHz to 1MHz
Electrical Load:	0.34 ohm + 40 mH

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AGS Modifications

VERTICAL F7 P. S. SPECIFICATION DATA SHEET

Input Voltage:	460 Vrms 3 phase, +10%, -5%, 60 Hz
DC Output Voltage:	-40 V to +40 V Continuously Adjustable
DC Output Current:	-500A to +500A Continuously Adjustable
Pulse Repetition Frequency:	DC to 10 Hz
Regulation mode:	Current
Load Current Tracking:	+/- 0.01% during flat-top, 0.5% during rise/fall
Load Current Rise Time:	< 20 msec @250A
Load Current Settling Time:	< 5 msec
Output Voltage Ripple:	< 0.1%, DC to 10 kHz < 1%, 10 kHz to 1 MHz
Electrical Load:	0.02 ohm + 3 mH

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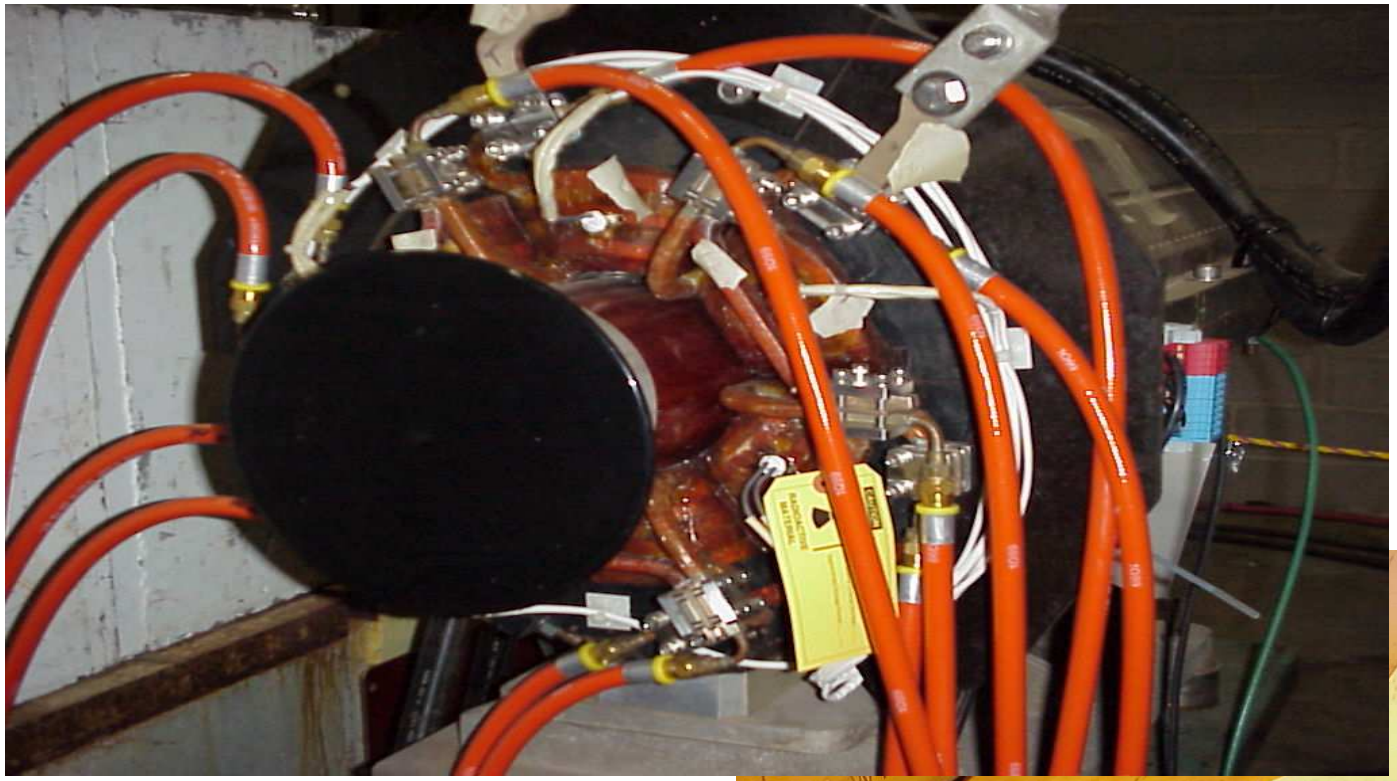
AGS Modifications

New Coils for AGS Sextupoles: tested to 600 amp dc



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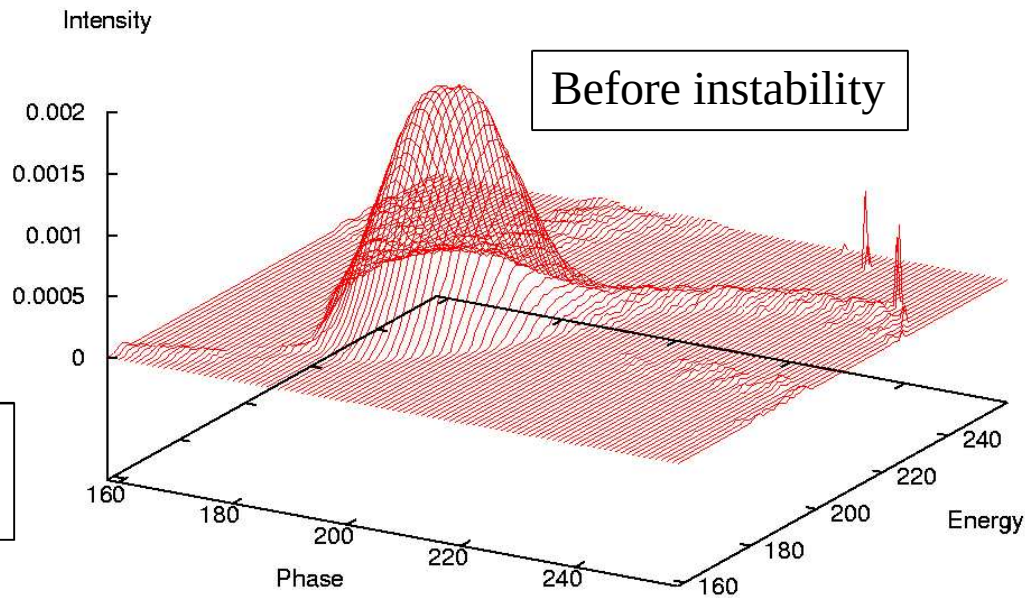
Fast transverse instability at RHIC

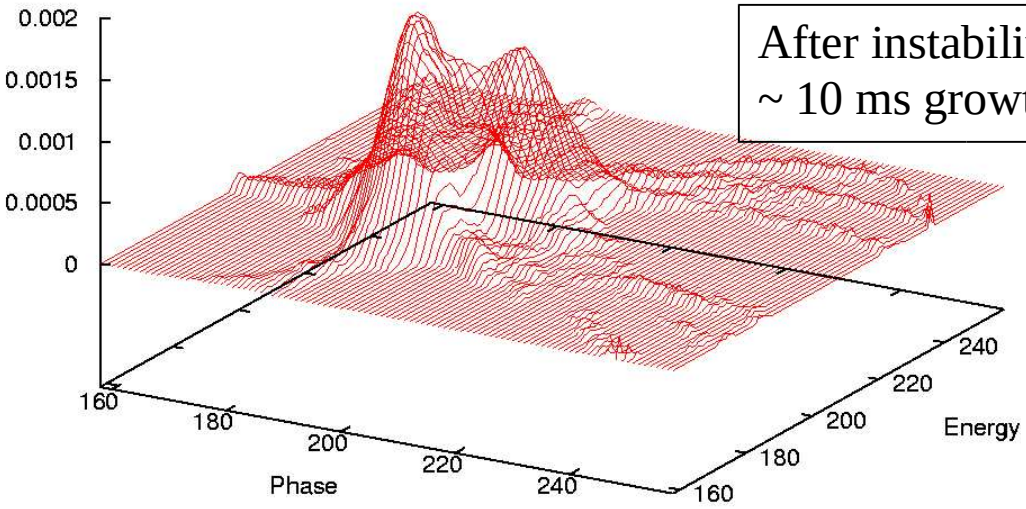
Occurs close to transition when chromaticity crosses zero

Cures: beam-beam tune spread, octupoles

Tomographic reconstruction of 2D bunch density



Before instability



After instability with ~ 10 ms growth rate

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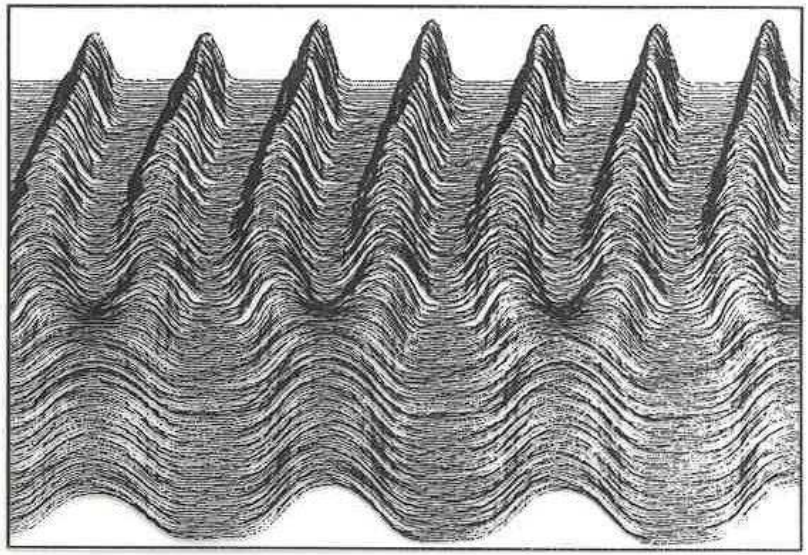
Rf bunch merging

- Increased intensity per bunch by accelerating 2 bunches and then merge before extraction.
- Accelerate two adjacent bunches with h = 12 and then coalesce to h = 6. With the lower ramp rate of the Westinghouse motor-generator extra cavities are available for operation with two harmonic numbers
- Could reach 2 x 7 TP in the final bunch
- Need ~ 3 shifts for a dedicated study (preferred)
- Need ~ 6 shifts for a parasitic study (3 shifts to set-up ppm)

Rf bunch merging

g-2 Experiment limited by production target to 7×10^{12} protons/bunch.

Six Bunches were Split into 12 by Adiabatic Ramping of h=6 and h=12 RF Voltage



Splitting of 9×10^{12} bunches

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Beam Transport to A3 Target

- Third Current transformer added in middle of transport line
- Modifying Flag/Camera setup to get higher quality images.
  - Investigate flag materials/properties
  - Disable automatic gain and blacklevel
  - cross-calibration from foil activation ?
- Reviewing beam optics for possibly smaller beam spots. In particular, making the last quadrupole horizontal focusing.

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