

Recycling pbars in the Main Injector- Issues

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Contents

- What is the role of the MI during pbar Recycling (Introduction and History) ← Beam parameters, Issues, etc.,
- Findings from beam experiments with protons (1999-2000)
- Other ways of recycling pbars in MI and transfer to the Recycler
- Summary

MI parameters

Recycler Tech. Design Report

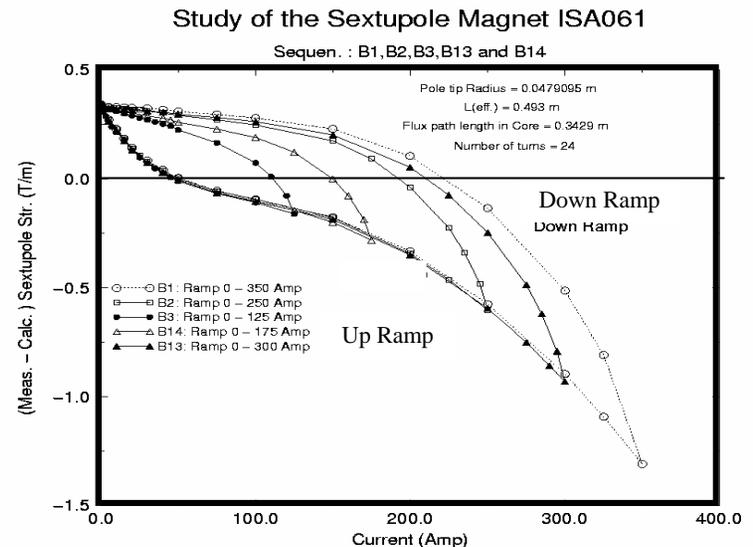
Parameter	MI Flattop	MI 25 GeV
Beam Kinetic Energy (GeV)	150	25
RF Voltage (MV)	0.4	1.2
RF Frequency (MHz)	53	53
Momentum Compaction Factor	0.0021	0.0008
RF Bucket Half Length (nsec)	9.4	9.4
RF Bucket Half Height (MeV)	178	206
Invariant RF Bucket Area (eV-sec)	4.2	4.9
Synchrotron Frequency (Hz)	65	168
Invariant 95% Longitudinal Emittance (eV-sec)	4	4
Matched RMS Bunch Length (nsec)	2.7	2.5
Matched RMS Energy Spread (MeV)	80	85
Fractional RMS Momentum Spread (%)	0.053	0.33
Ratio of Emittance to Bucket Area	0.93	0.81

Beam Dynamics Issues

- Transverse Beam Dynamics:
 - Hysteresis in Main dipole magnets and orbit correctors
 - Quadrupole Magnets (Tunes)
 - Sextupole magnets (Chrom.)

Tedious but “carefully” done Job (2000)

- ⇒ We developed a new corrector control program for the down ramp.
- ⇒ Tune Calibration table
- ⇒ Chromaticity for down Ramp

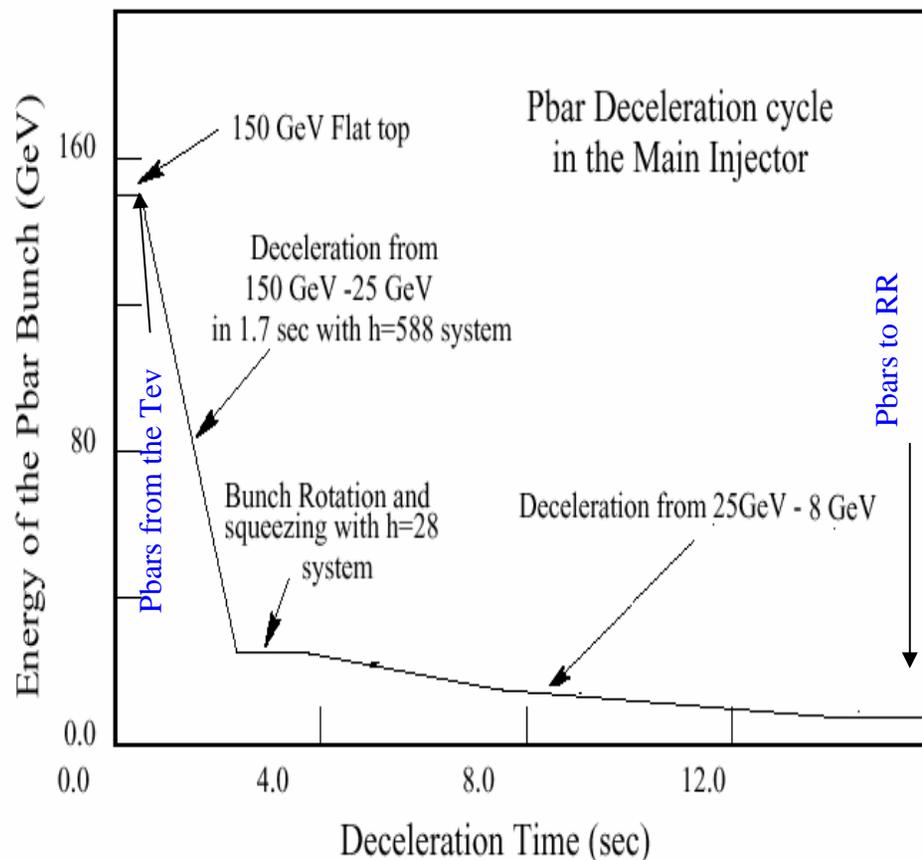


- Longitudinal Beam Dynamics:
 - Bunches from the Tevatron are typically 3-4 eVs in 53 MHz rf buckets. But the MI admittance at transition is only 0.7 eVs (for 53 MHz bunches). Hence, we must do some rf manipulations above transition energy to go below transition energy.

Deceleration Schemes in MI

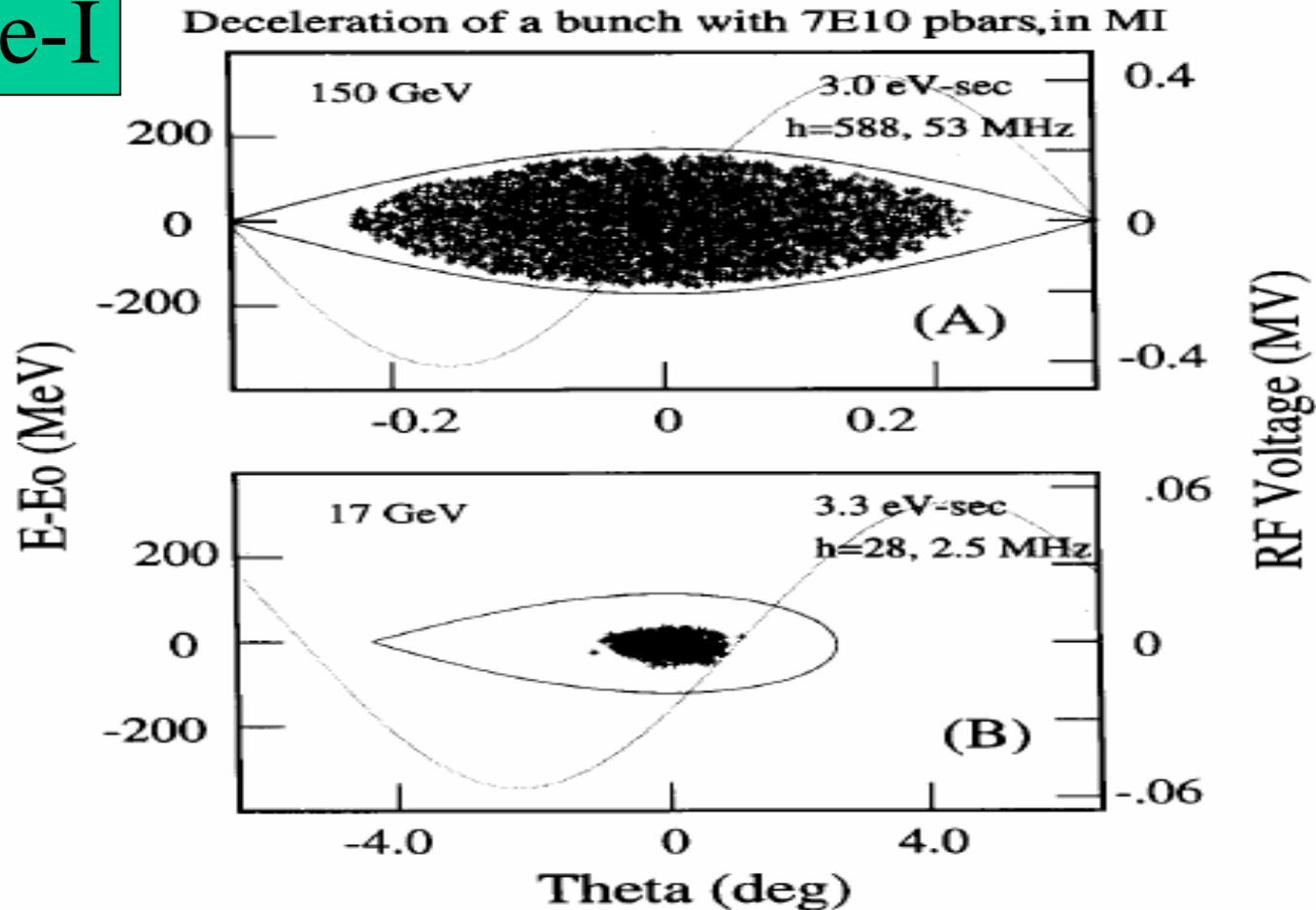
- **Scheme-I (Fermilab-TM-1991)**
 - Decelerate pbars from 150 GeV to 25 GeV using 53 MHz rf system
 - Decelerate from 25 GeV to 8 GeV using 2.5 MHz rf system (to eliminate the transition loss and emittance growth of big bunches).
 - MI 2.5 MHz to RR 2.5 MHz transfer

Simulations – MI Note 271,
PAC1997 p 1590



Longitudinal Beam Dynamics Simulations

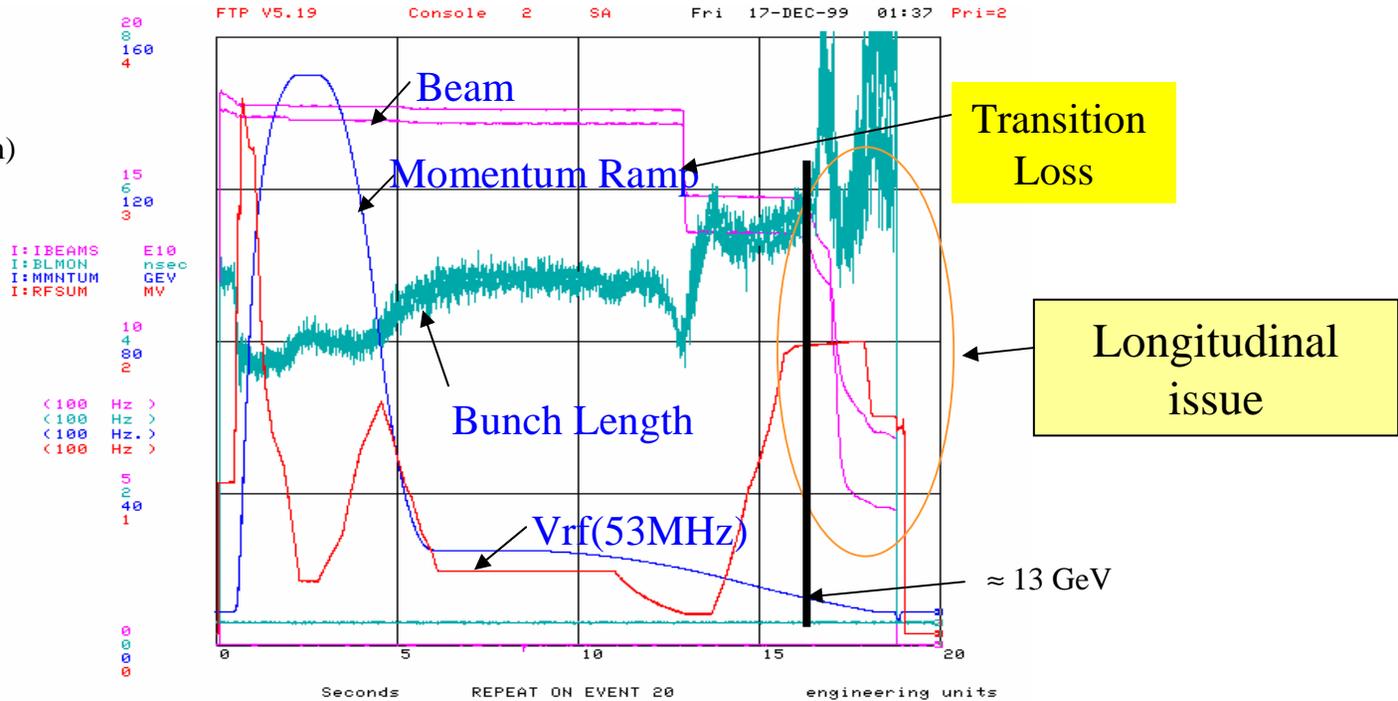
Scheme-I



30% emittance growth with
100% deceleration efficiency

Proton Deceleration in the MI from 150 GeV to 8 GeV

Scheme I
(with 53 MHz RF system)



Emittance Measurements

	Energy (GeV)	BL (nsec)	LE (eV-sec)	Transverse Emittance(π -mi-mr)	
				H	V
Flat-top	150	4	0.4	7	6
Back-porch	25	5	0.4	7	7
RR Injection Energy	8	7	> 0.8	8	8

Run-II Meeting

Chandra Bhat

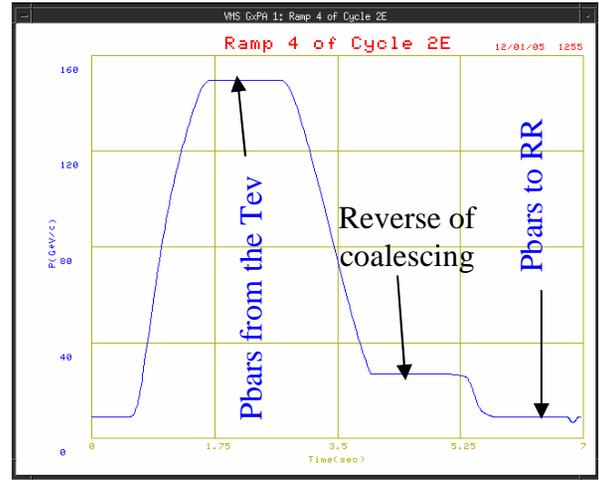
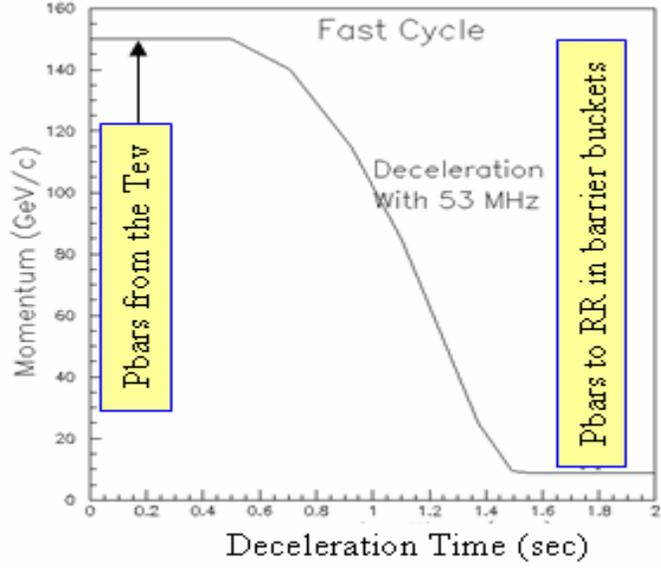
Dec. 1, 2005

Other ways of recycling pbars in the MI

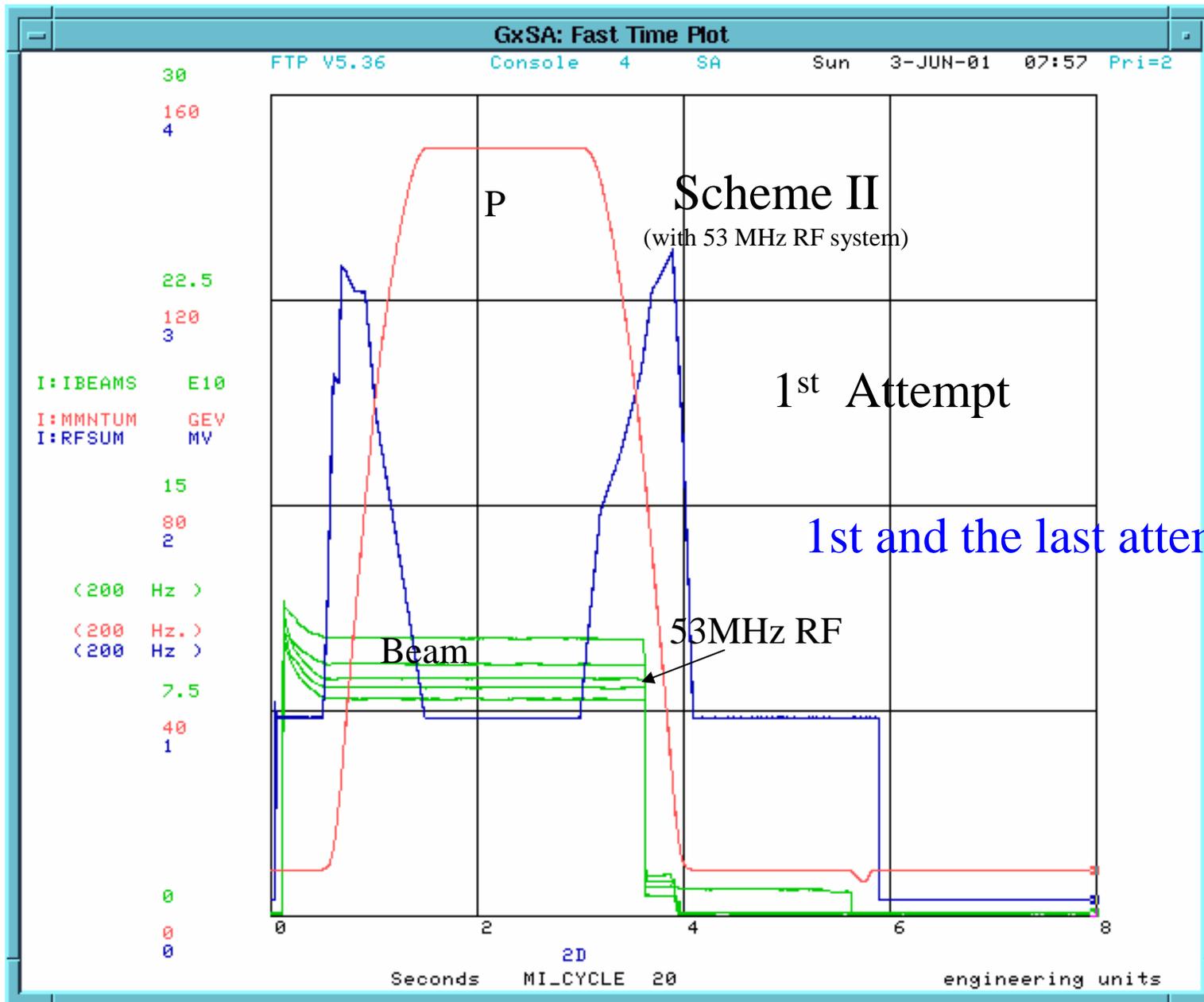
- **Scheme-II (PAC1997, p 1590)**
 - Reverse of coalescing at 150 GeV and Decelerate pbars using 53 MHz rf system from to 8GeV
 - Coalesce at 8 GeV in 2.5 MHz rf system and create 2.5 MHz bunches for RR injection

- **Scheme III**
 - Up to 8 GeV same as above
 - At 8 GeV De-bunch adiabatically beam in MI rectangular barrier buckets and make barrier-bucket to RR-barrier bucket beam transfer.

- **Scheme IV**
 - Decelerate from 150 GeV to 27 GeV and Reverse of coalescing at 27 GeV. Decelerate to 8 GeV with 53 MHz system.
 - At 8 GeV De-bunch adiabatically beam in MI rectangular barrier buckets and make barrier-bucket to RR-barrier bucket beam transfer.



Most promising method



Summary

- We have demonstrated deceleration of beam in the MI from 150 to 8 GeV in the MI on “a slow ramp” with 53 MHz rf
 - Beam Transmission:
 - 100% efficiency from 150 to transition energy
 - 85% efficiency beyond transition energy
 - Emittance
 - No observed transverse emittance growths
 - No LE growth from 150-25 GeV. But seen LE growths during 25-8 GeV deceleration.
- Can be done better!**
- Issues
 - Transverse Dynamics (Tedious, but had partial success)
 - Hysteresis in Main dipole magnets and orbit correctors
 - Tunes and chromaticity corrections
 - Longitudinal Dynamics
 - Expect $\approx 30\%$ of LE growths (same as that for pbars during acceleration)
 - Needs lots of Machine time (???)

