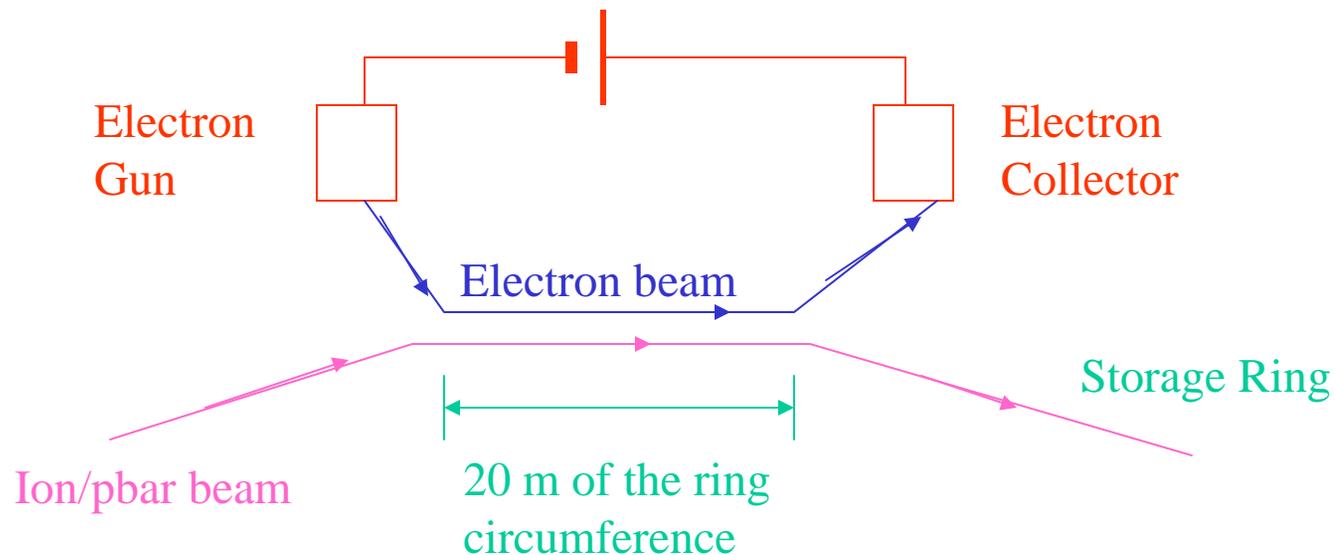

Electron Cooling Status

Sergei Nagaitsev

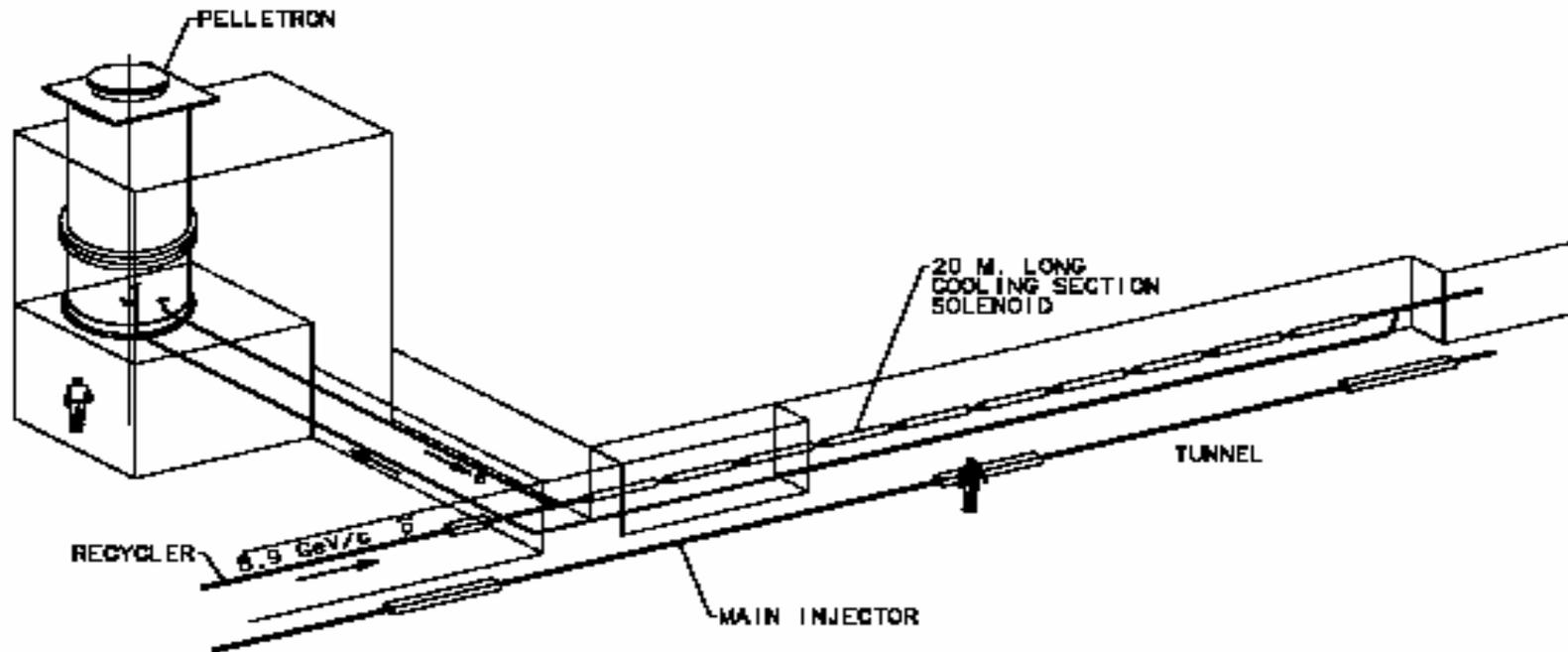
April 4, 2005

Principles of Electron Cooling

- A stored pbar beam is overlapped with a nearly monochromatic and parallel electron beam in a straight section of the storage ring
- The velocity of the electrons is made equal to the average velocity of the ions.



Schematic Layout of the Fermilab Electron Cooling



ECOOOL status -- summary

- The electron cooling R&D program was finished on May 31, 2004 (as scheduled). The electron cooling system was moved and installed at a new building (MI-31). After a month of troubleshooting the commissioning has begun on Mar 1, 2005.

Ecool Installation AIP Project Summary

- MI-31 Building Construction AIP
 - Construction of Building (1/03 - 5/04)
 - Total Project Cost - \$3.8M
 - Project Completed - On Schedule, Within Budget, No Lost Work Time Injuries (>20,000 man-hours)

- Electron Cooling Installation AIP
 - Dates of Disassembly/Move/Installation (6/04 - 2/05)
 - Total Project Cost - \$3.4M
 - Project Completed - On Schedule, Within Budget, No Lost Work Time Injuries (>20,0000 man-hours)

- Project Mgt. Team for Both AIP's
 - Jerry Leibfritz & Jeff Sims

Electron Cooling Installation Schedule/Highlights

- 5/04 - MI31 Building Construction Complete
- 5/04 - R&D Operations at Wide Band Complete
- 6/04 - Disassembly/Move of Pelletron Begins
- 8/04 - 13-Week Lab Wide Shutdown Begins (Pelletron Assembly Suspended)
- 11/04 - Lab Wide Shutdown Complete (Pelletron Assembly Resumes)
- 2/05 - Pelletron/E-Cool Installation Complete
- 3/05 - Commissioning Began

Pelletron Disassembly/Move



- Pelletron at Wide Band Lab Before Disassembly (5/04)
 - 1.5 Months to Disassemble



- Lower Half of Pelletron Being Transported to MI31
 - All Components Transported 3-Miles Across the Laboratory

Lab Wide Shutdown



- **Before and After Pictures of E-Cool Section of MI Tunnel**
 - 13-Week Shutdown
 - Modified MI Utilities, Removed Recycler Section, Installed all Beam Lines
 - Lab-Wide Effort

Cooling section solenoid

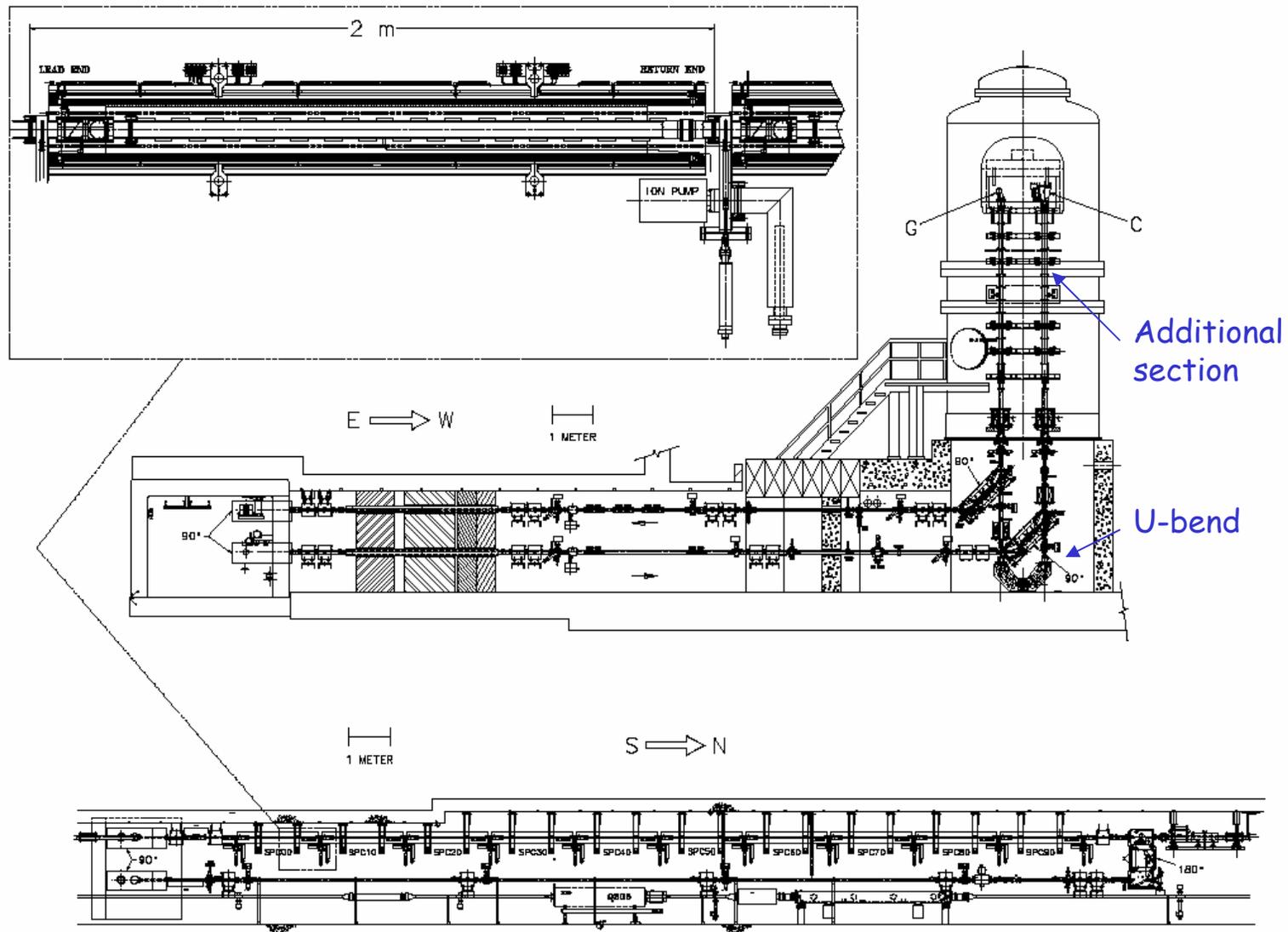


Installation at MI31 Building



- Pictures of MI31 Service Building Before and After Installation of Pelletron

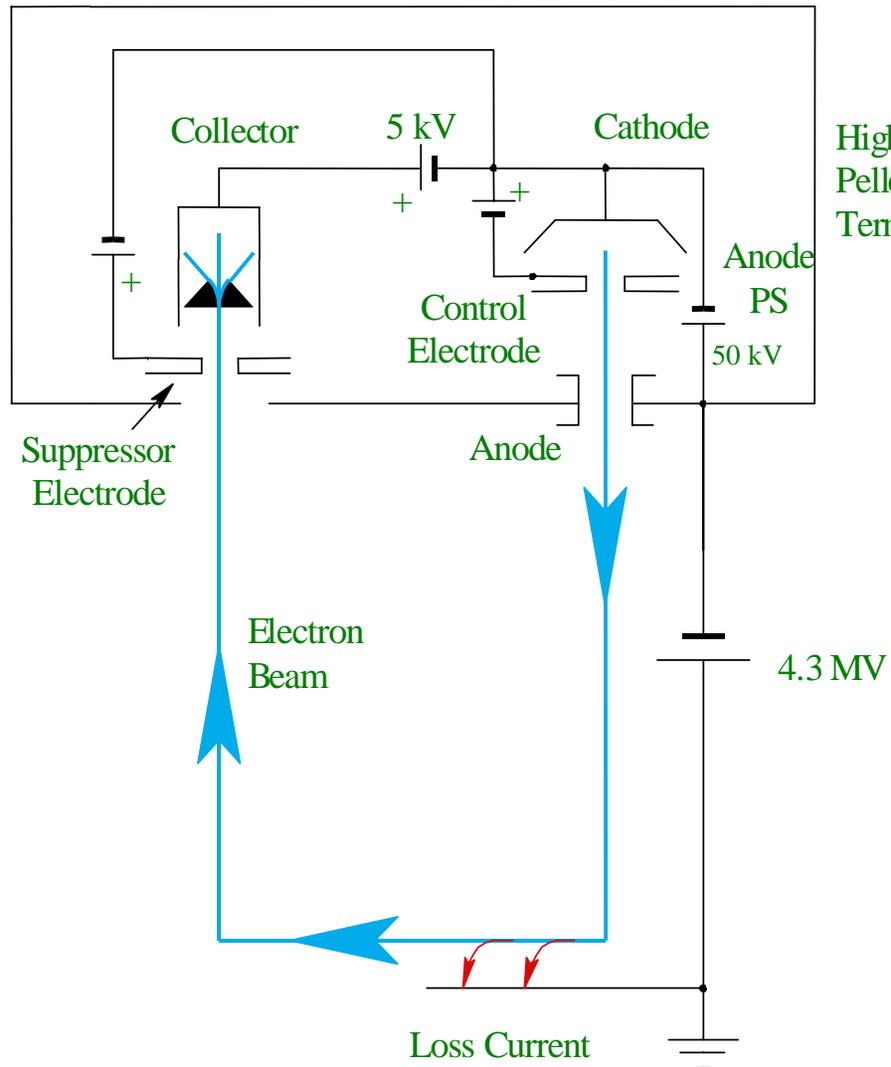
Electron cooling setup at MI-30



Electron beam parameters

- Electron kinetic energy 4.34 MeV
- Absolute precision of energy $\leq 0.3 \%$
- Energy ripple $\leq 10^{-4}$
- Beam current 0.5 A DC
- Duty factor (averaged over 8 h) 95 %
- Electron angles in the cooling section (averaged over time, beam cross section, and cooling section length), rms ≤ 0.2 mrad

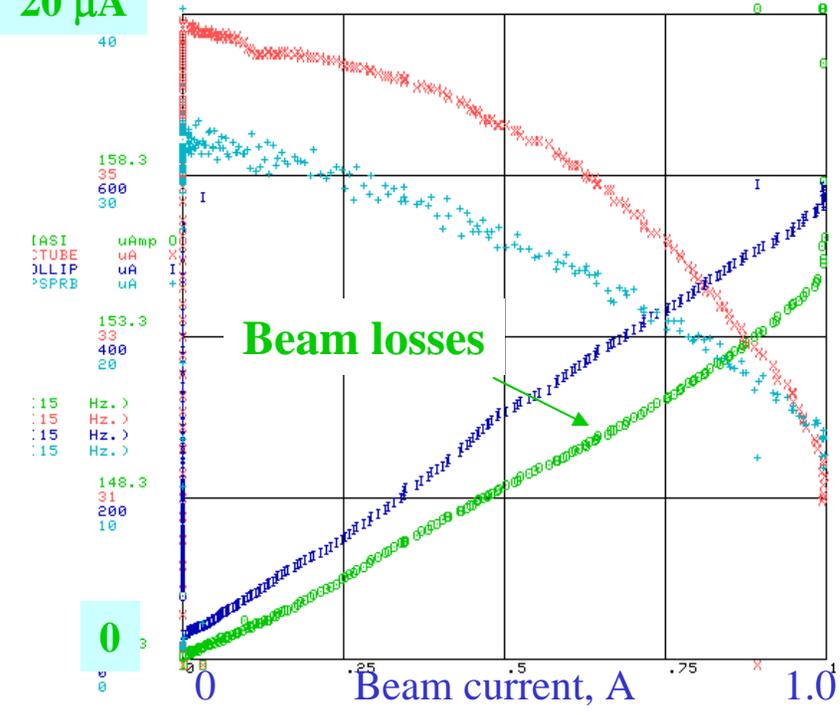
Simplified electrical schematic of the electron beam recirculation system.



For $I = 0.5 \text{ A}$, $\Delta I_{\text{loss}} = 5 \mu\text{A}$:

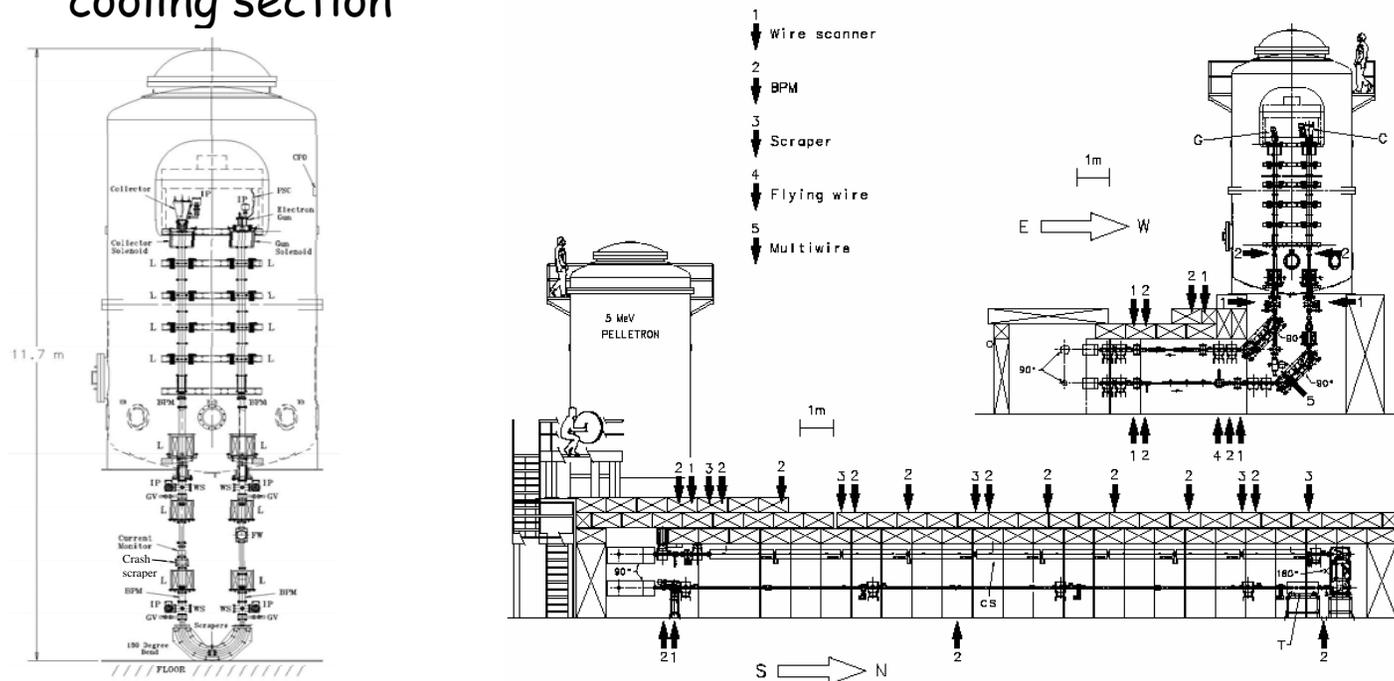
- Beam power 2.15 MW
- Current loss power 21.5 W
- Power dissipated in collector 2.5 kW

20 μA



The R&D program at WideBand

- 20-Mar-01- First time HV on both tubes
- 28-Dec-01 - 0.6 A in the short beam line
- 18-Nov-02 - $I_{max}=1.7$ A; beginning of a shutdown
- 17-Jul-03 - DC beam recirculated through the full-scale line
- 30-Dec-03- 0.5 A DC beam
- 29-May-04- 0.1 A beam with required beam properties in the cooling section



Milestones

	Plan	Actual
▪ Commissioning begins	02/01/05	03/01/05
▪ U-bend commissioned	03/14/05	
▪ Full beamline commissioned	04/04/05	
▪ A 0.5 A DC beam	07/08/05	
▪ Cooling of antiprotons	09/08/05	

Electron cooling commissioning -- summary

- Finished the R&D program on schedule (May 04)
- Prepared and reviewed a commissioning plan (Aug 04)
- Continued detailed modeling of optics, procedures, IBS and cooling rates with the emphasis on commissioning.
- Commissioning high-lights:
 - Pelletron conditioned to 5 MV. Operate at 4.3 MV
 - Worked only with pulsed beam. A 0.5-A beam passed thru U-bend to collector with no losses.
 - Pulsed beam passed thru the cooling section.
 - Can co-exist with pbar-beam operations