Luminosity Leveling & 132 nsec Operation

132 nsec Study Group
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Run II Luminosity Goals

- The luminosity goal for Run IIa is 2 fb^{-1}
  - » Peak luminosity up to $2x10^{32}$ $cm^{-2}sec^{-1}$
  - » Switch to 103 bunches at $1x10^{32}$ $cm^{-2}sec^{-1}$
  - » Length of Run IIa is about 2 years
- The luminosity goal for Run IIa+Run IIb is 15 fb^{-1}
  - » Increase antiproton intensity by 2-3
  - » Peak luminosity up to $5x10^{32}$ $cm^{-2}sec^{-1}$
  - » 103 bunch operation
  - » Length of Run IIb is about 4 years

Operating Modes

The Number of Interactions per Crossing

- Normal 36×36 operation up to 5×10^{31} cm $^{-2}$ sec^{-1} luminosity
- Use of "luminosity leveling" at (perhaps) 1×10^{32} cm $^{-2}$ sec^{-1}. The β^* is increased to limit the luminosity to a maximum value.
- Use 132 nsec bunch spacing 140×103* at higher luminosities

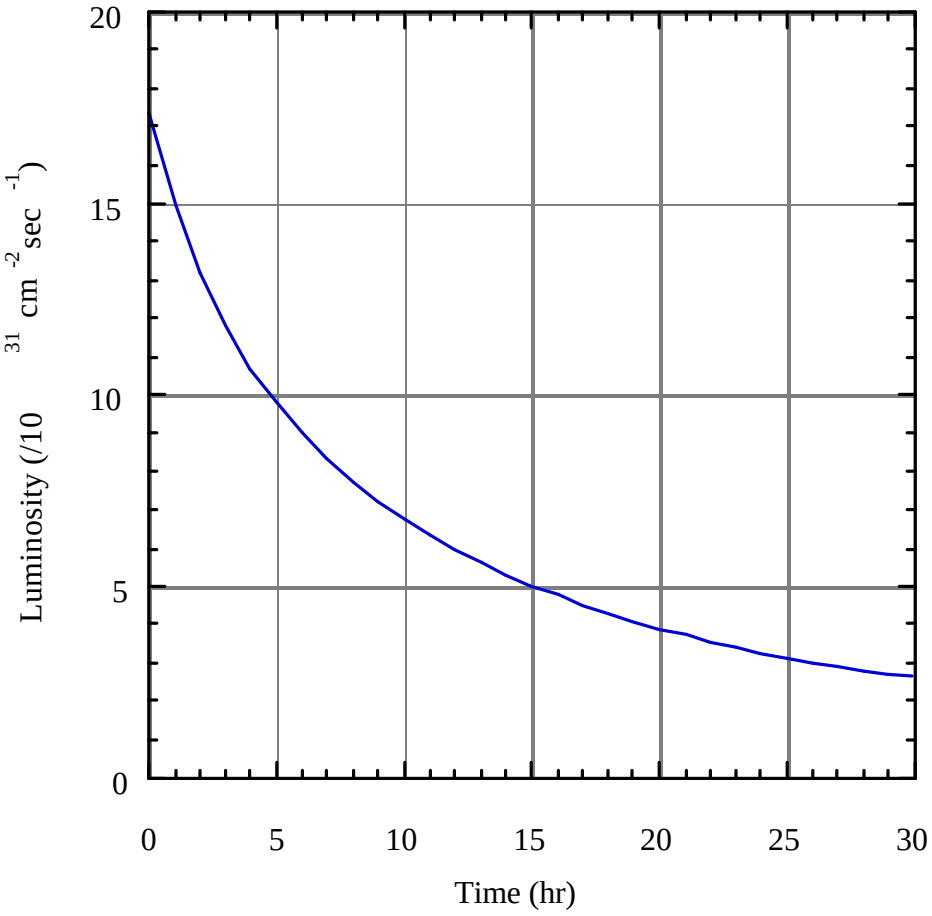
* 103 is the current best guess for the number of antiproton bunches. Older slides say 121. It will probably change again, but it is expected to be "about" 100.

Run II Parameters

RUN	Ib (1993-95) (6x6)	Run IIa (36x36)	Run IIa (140x103)	Run IIb (140x103)	
Protons/bunch	2.3×10^{11}	2.7×10^{11}	2.7×10^{11}	2.7×10^{11}	
Antiprotons/bunch *	5.5×10^{10}	3.0×10^{10}	4.0×10^{10}	1.0×10^{11}	
Total Antiprotons	3.3×10^{11}	1.1×10^{12}	4.2×10^{12}	1.1×10^{13}	
Pbar Production Rate	6.0×10^{10}	1.0×10^{11}	2.1×10^{11}	5.2×10^{11}	hr^{-1}
Proton emittance	23π	20π	20π	20π	mm-mrad
Antiproton emittance	13π	15π	15π	15π	mm-mrad
β^*	35	35	35	35	cm
Energy	900	1000	1000	1000	GeV
Antiproton Bunches	6	36	103	103	
Bunch length (rms)	0.60	0.37	0.37	0.37	m
Crossing Angle	0	0	136	136	µrad
Typical Luminosity	0.16×10^{31}	0.86×10^{32}	2.1×10^{32}	5.2×10^{32}	$cm^{-2}sec^{-1}$
Integrated Luminosity †	3.2	17.3	42	105	pb^{-1}/week
Bunch Spacing	~3500	396	132	132	nsec
Interactions/crossing	2.5	2.3	1.9	4.8	

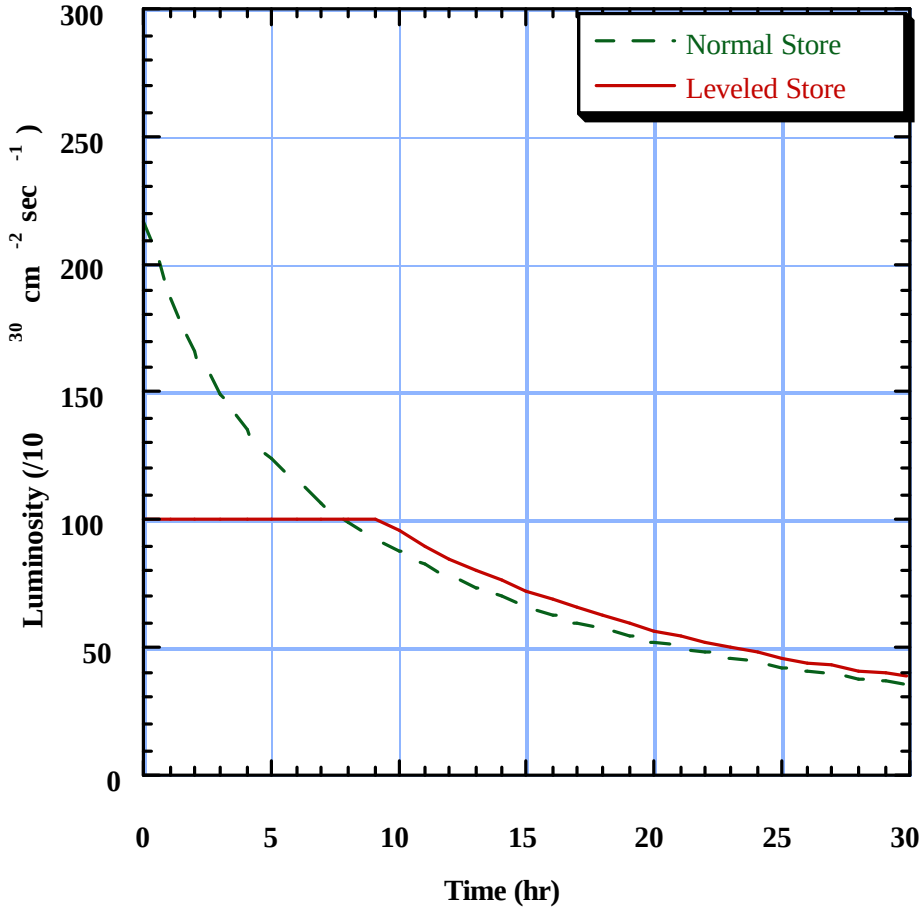
†The typical luminosity at the beginning of a store has traditionally translated to integrated luminosity with a 33% duty factor. Operation with antiproton recycling may be somewhat different.

Evolution of a Typical Store



Luminosity Leveled Store

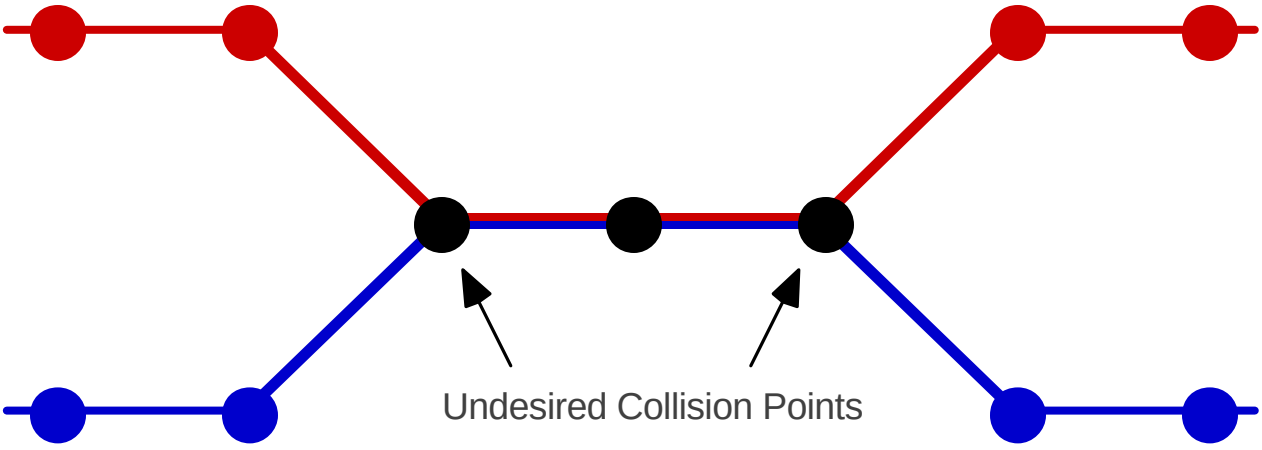
One can limit the peak luminosity in a store by dynamically modifying the β*. Most of the integrated luminosity is retained.



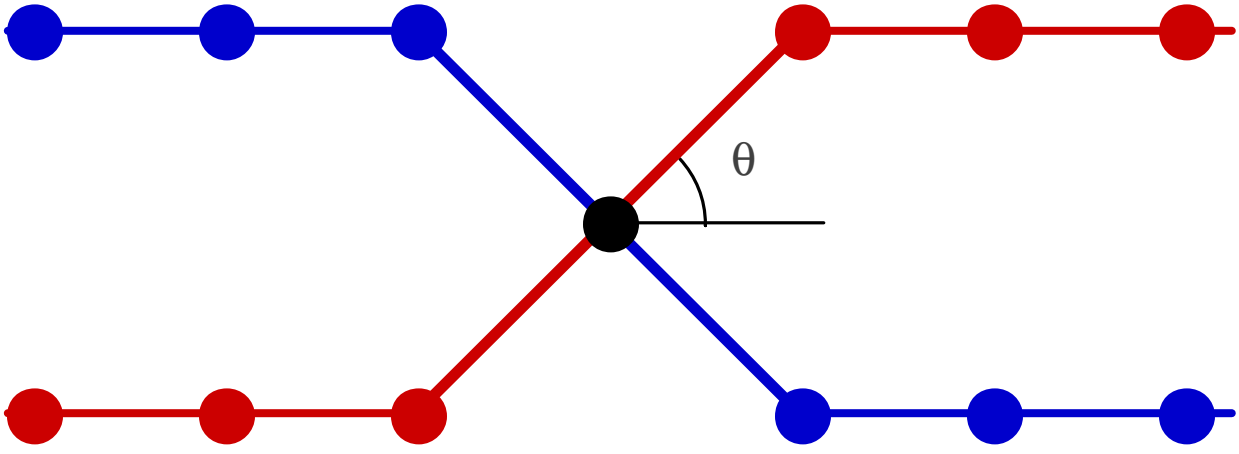
7 rf bucket Bunch Spacing & Crossing Angles

- A crossing angle is required for 132 nsec spacing but is not required for 396 nsec.
- We are still working on determining the best crossing angle geometry. The “Run II Handbook” contains a strawman proposal
  - » There is a luminosity penalty for introducing the crossing angle - about a factor of 2 in initial luminosity compared to zero crossing angle with the same bunch parameters
  - » There are uncertainties in the dynamics of the beam-beam interaction with this mode of operation

The Need for a Crossing Angle

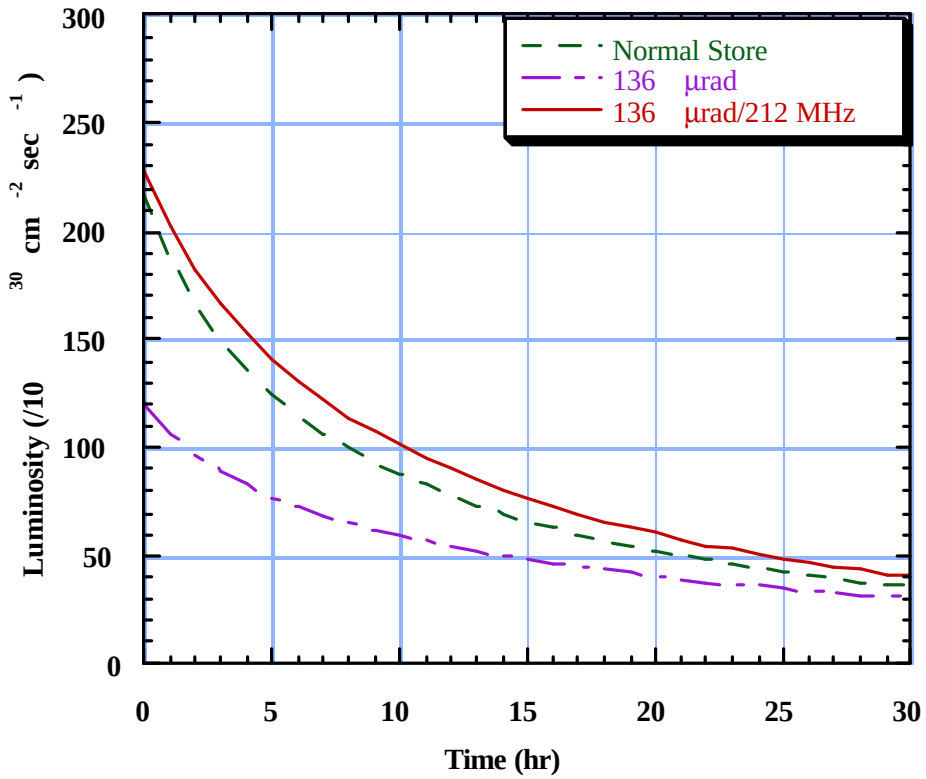


With a 7 rf bucket spacing a crossing angle is required



Luminosity Penalty for a Crossing Angle

- There is a significant luminosity penalty for colliding the beams at an angle
- Higher rf voltages reduce the bunch length and can eliminate the penalty

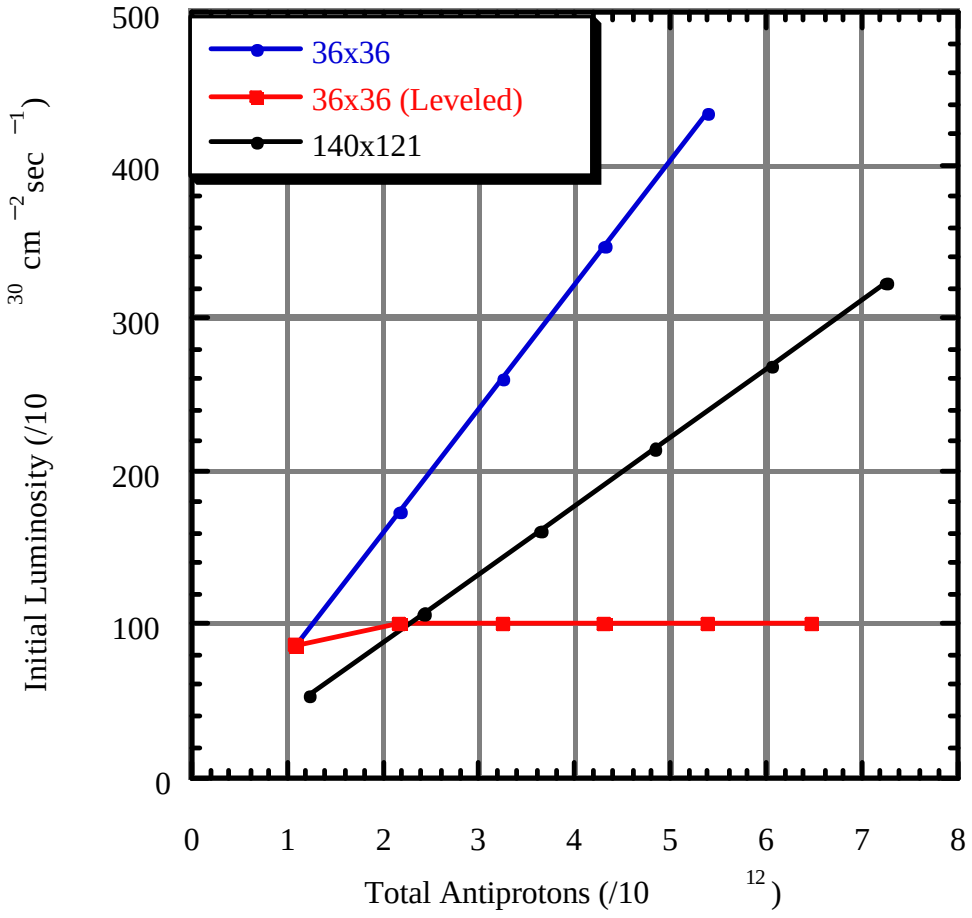


Integrated Luminosity Comparisons

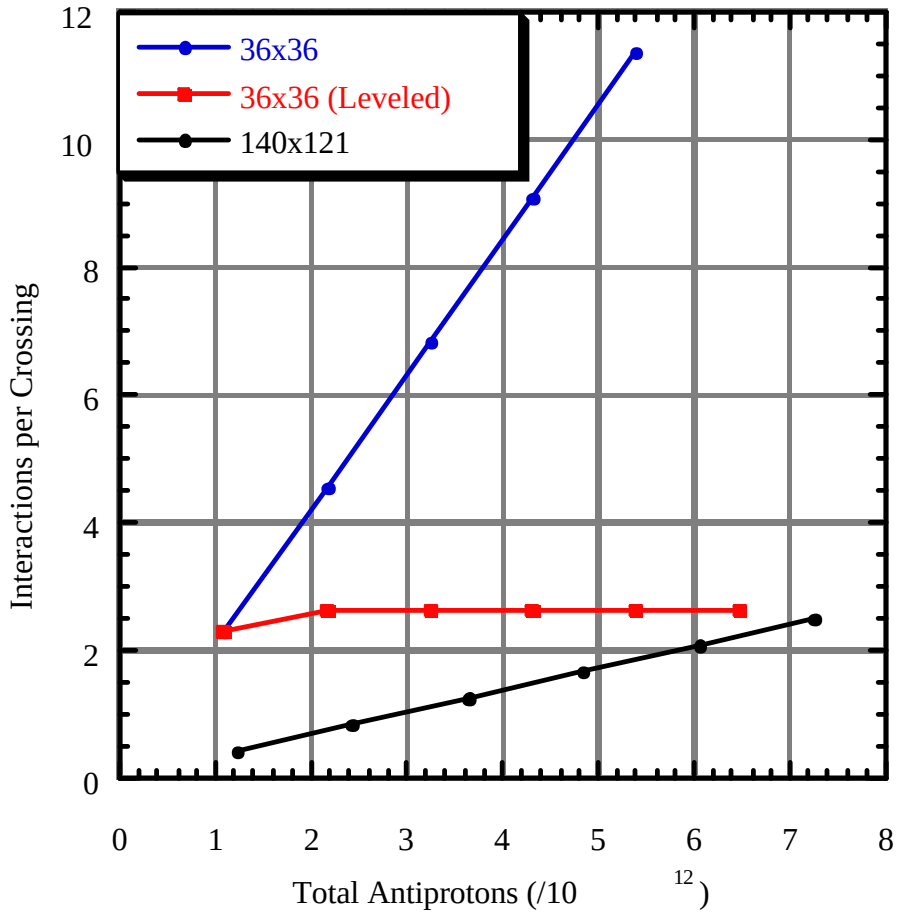
Calculations are made under the following assumptions

- A stacking rate of 20×10^{10} hr^{-1}
- High antiproton intensities are obtained by long stores and long stacking times
- Emittance growth and loss of particles cause the luminosity to decrease during the course of a store
- Recylcing efficiency is reduced by larger emittances
- Inefficiencies in cooling large antiproton stacks and transferring them to the Tevatron are not included but are much higher than historical values

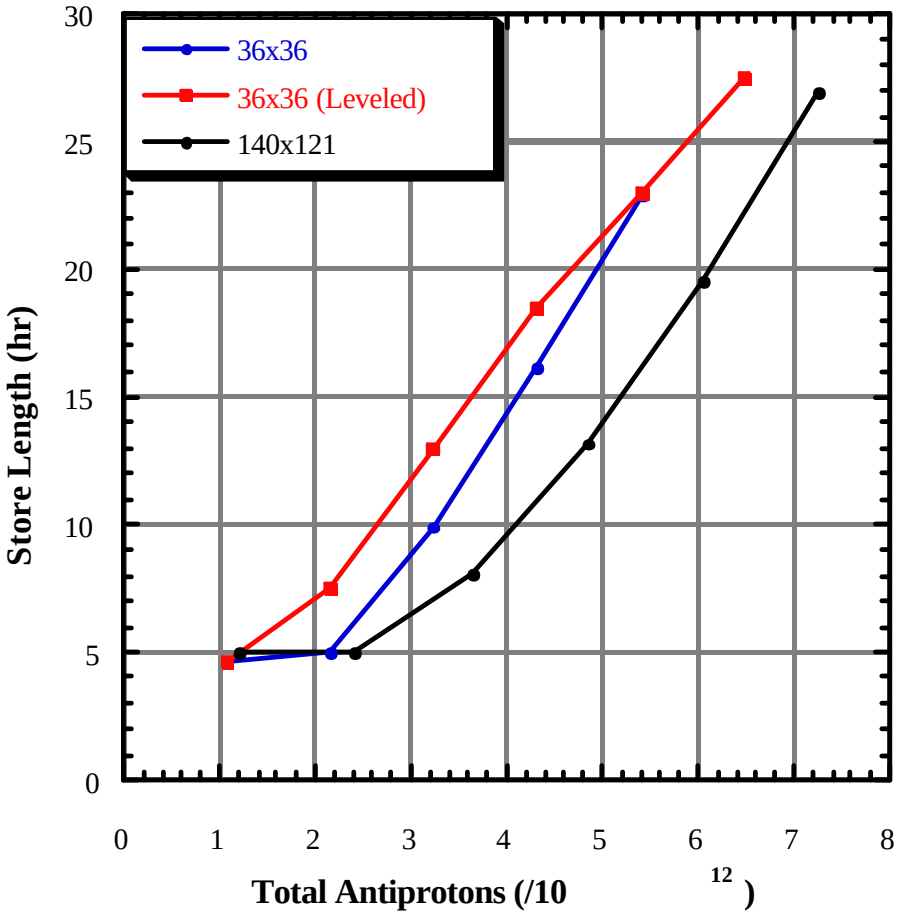
Luminosity versus Antiproton Intensity



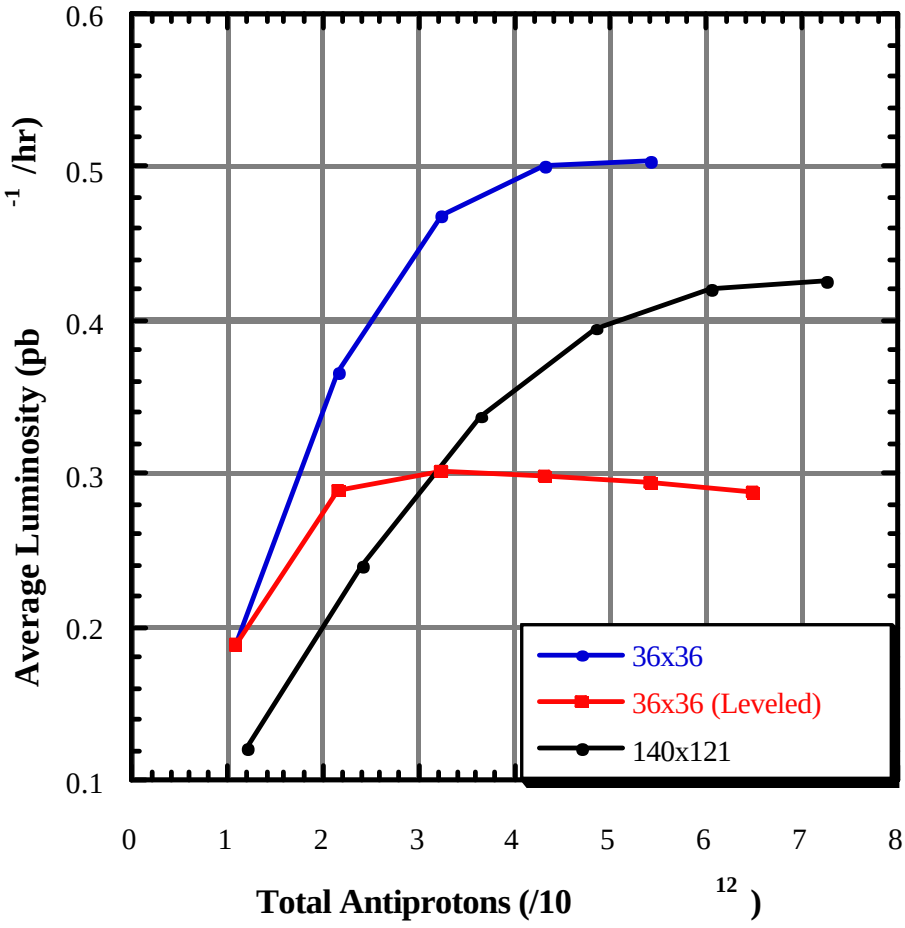
Interactions per Crossing vrs Antiproton Intensity



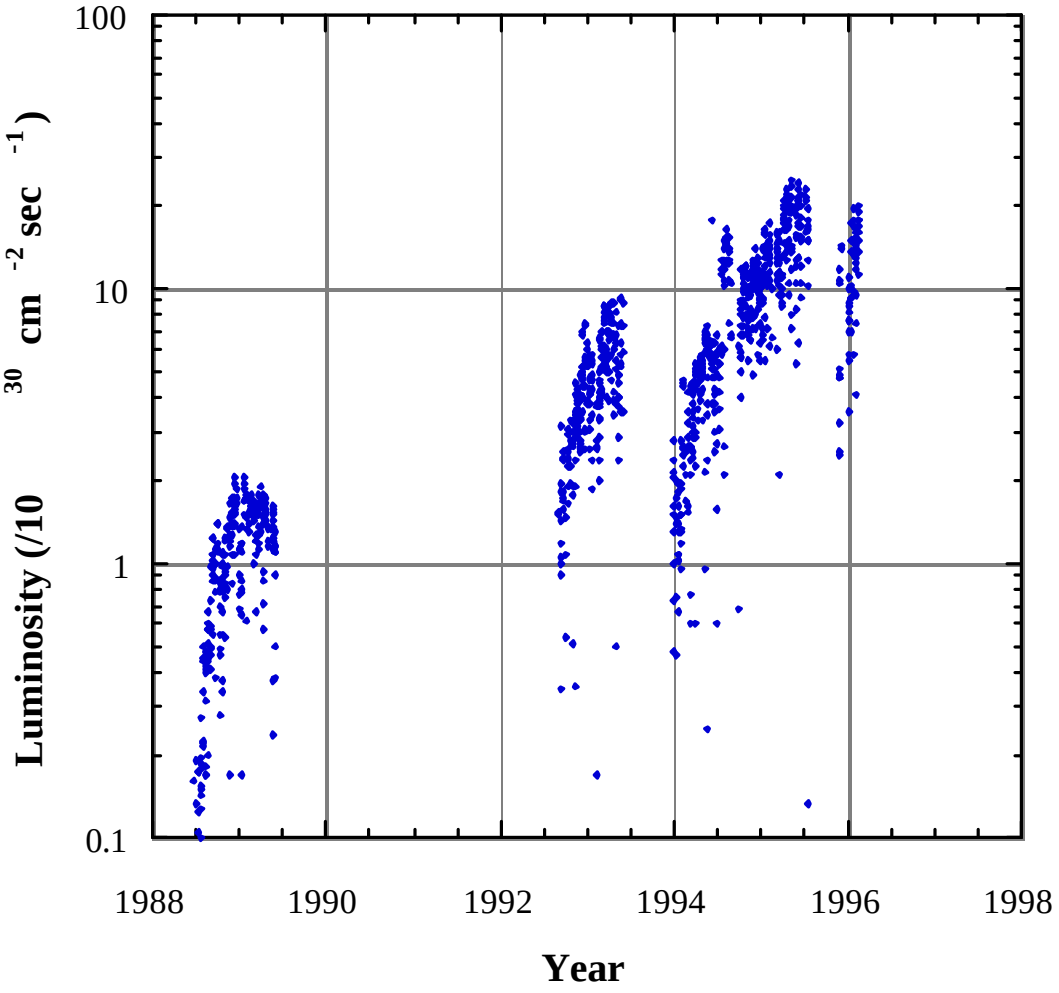
Store Length versus Antiproton Intensity



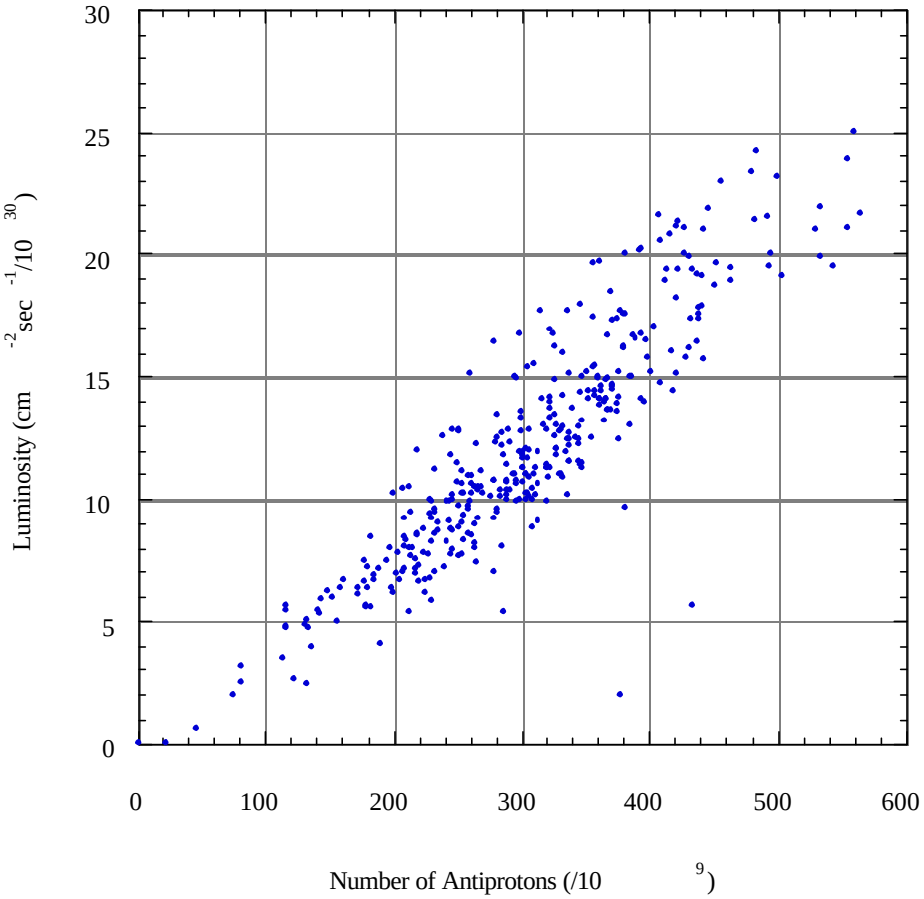
Average Integrated Luminosity



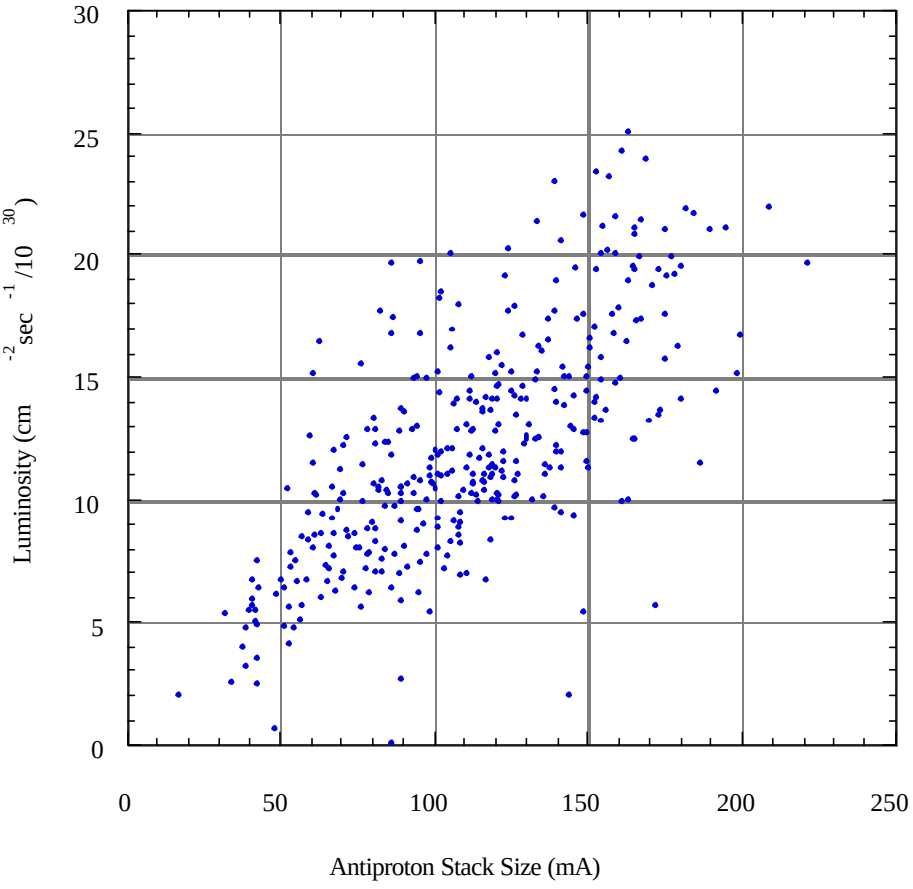
Tevatron Collider Luminosity



Luminosity versus Antiproton Intensity



Luminosity versus Antiproton Stack Size



Model Parameters

- Shot setup time=1 hr
- Stacking rate = 10^{10} antiprotons/hr
- Acceleration efficiency = 90%
- Mean time between store loss = 72 hr
- Recycling Efficiency ranges from 70$\rightarrow$90% (assume all beam with ε_H>35π mm-mrad, ε_V>35π mm-mrad, or ε_L>3.5 eV-sec)