Progress with Hollow Electron Beam Collimation

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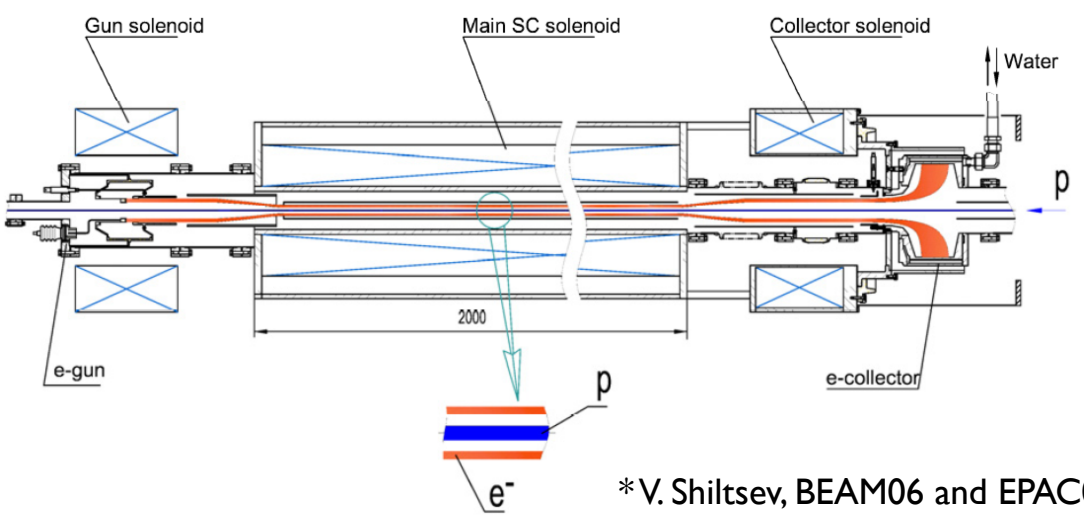
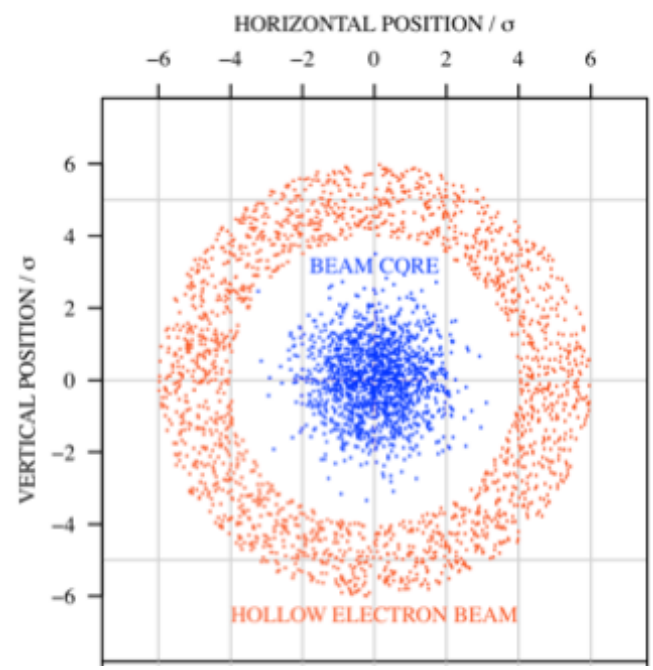
The Concept*

- Use magnetically confined hollow electron beams as scrapers for high energy circulating hadron beams to remove halo particles leaving the core unperturbed
  - Motivation: Presently, no viable collimation solution for LHC beams at full intensity below 5 sigma.

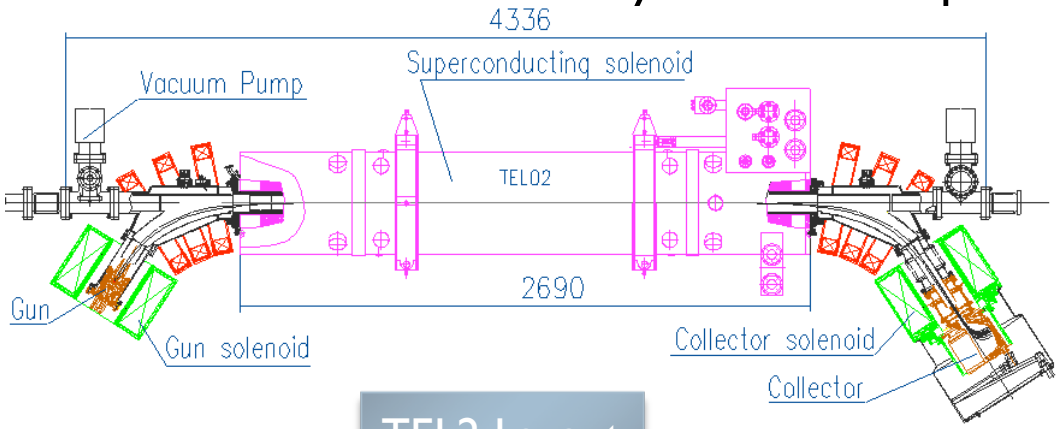




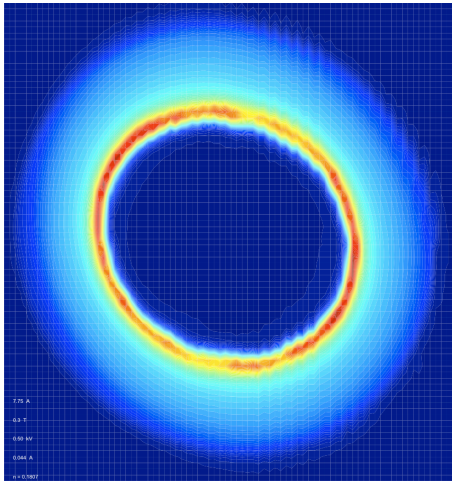
*V. Shiltsev, BEAM06 and EPAC08

Proof-of-principle Experiment at Tevatron

- Uses the existing Tevatron Electron Lens no. 2
  - A hollow e- gun was installed in TEL2 in August of 2010
- Questions to answer:
  - Is TEL setup with e- bends acceptable?
  - Demonstrate collimation without affecting beam core
    - Effect of imperfections
    - Collimation efficiency for different pulsing



TEL2 Layout



Measured e- beam profile

Staged Approach to Studies

- TEL2 e- beam can be pulsed to act on a single circulating Tevatron bunch, thus producing minimal excitation and losses. Hence the experiments can be staged:

1. Experiments with one bunch
   - Evaluate HEBC effect on bunch intensity and luminosity life time
   - e not gated – can not evaluate effect on loss
   - erns

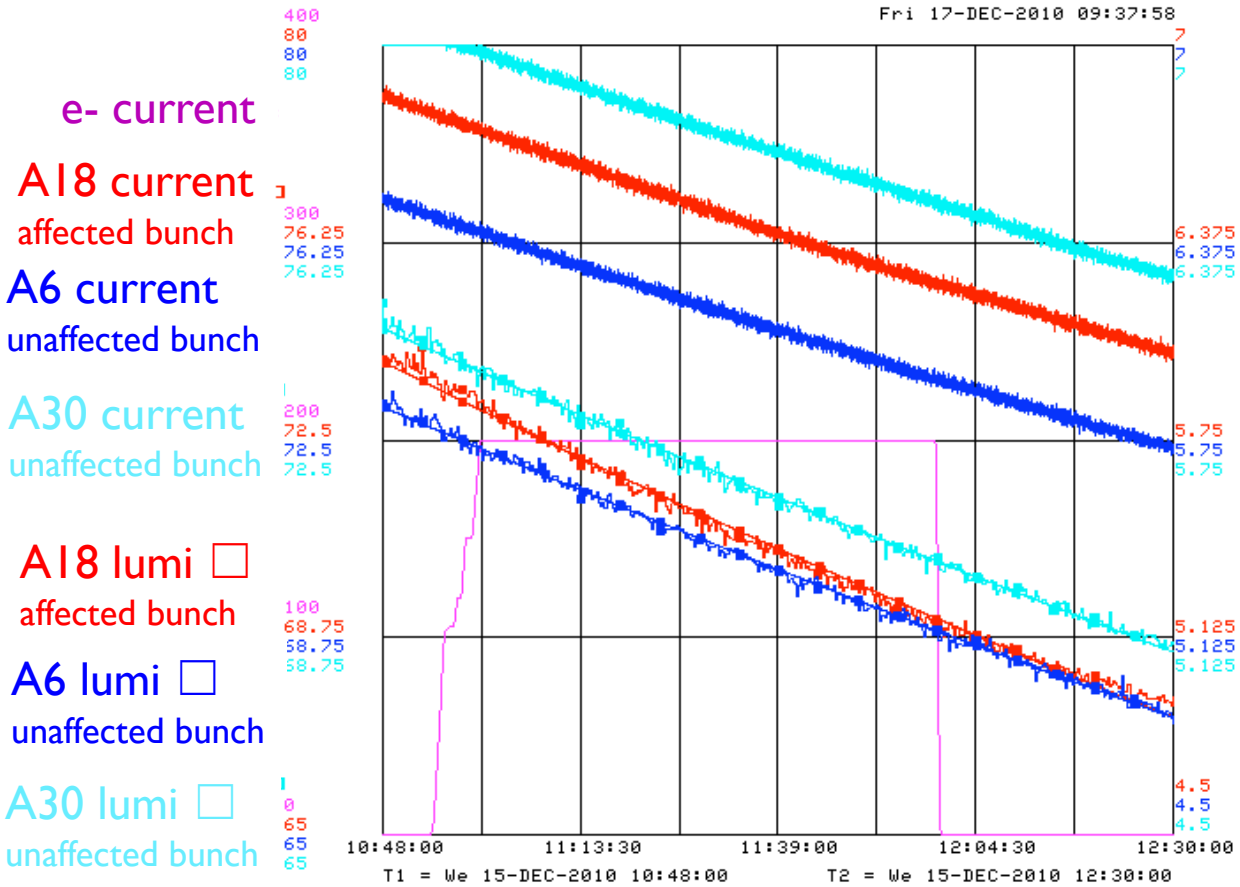
Currently here (as of Jan-21-2011)

2. Experiments with a train of 12 bunches
   - Multibunch effects (orbit, bunch-to-bunch betatron tune and coupling)
3. Experiments with e- beam in DC mode
   - Study ring-wide loss patterns
4. Collimator scans - destructive

Parasitic during HEP stores

Stage Ia. HEBC (r=7σ) on a single antiproton bunch A18, pulsed 1/6 turns

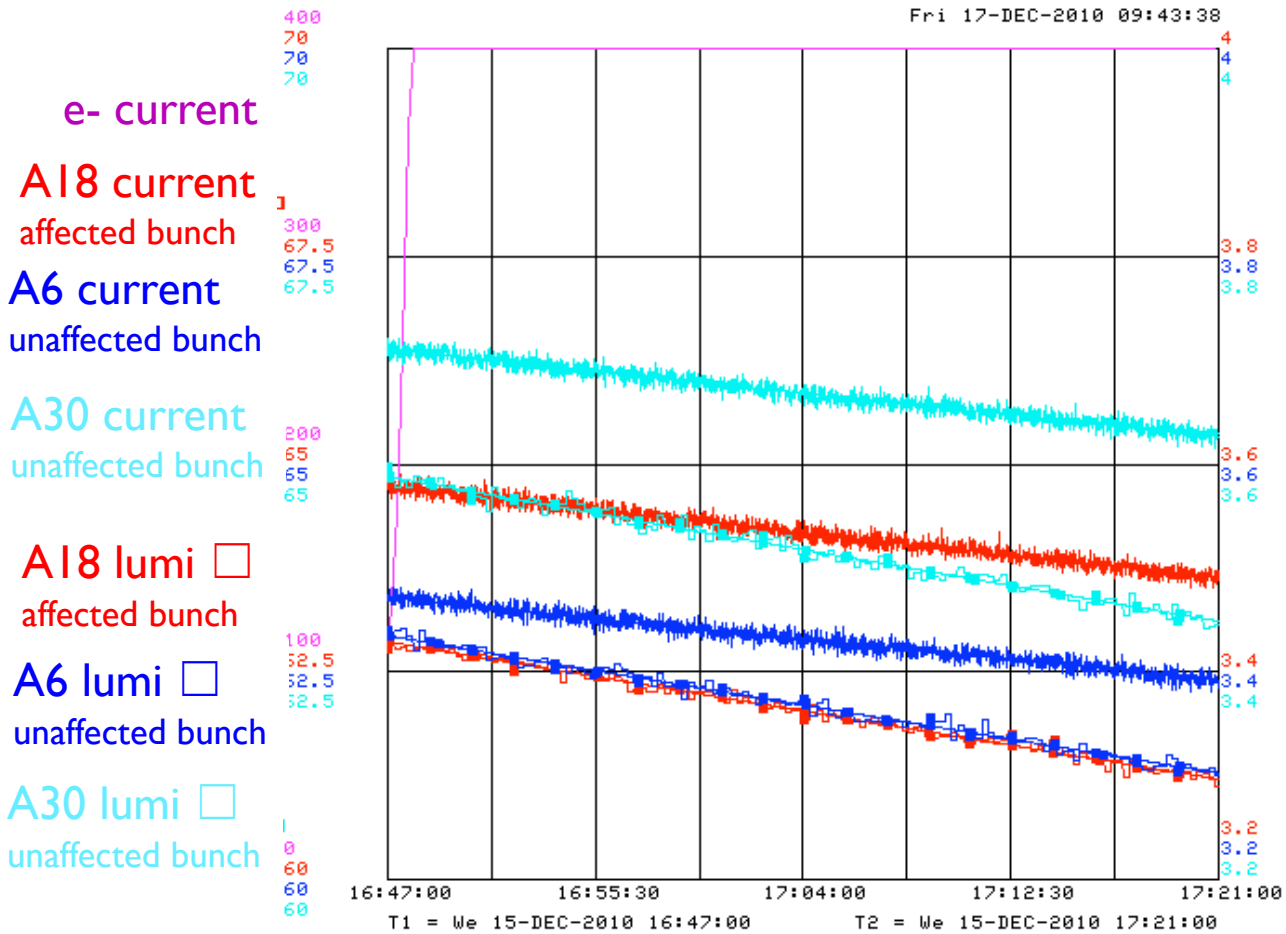
Luminosity lifetime of A18 degraded by ~10%, no effect on bunch intensity lifetime



Conclusion: resonant pulsing mode (1/6 turns) affects the beam core
the effect depends on betatron tune and coupling

Stage Ib. HEBC (r=5σ) on a single antiproton bunch A18, pulsed every turn

No effect on A18 luminosity lifetime, bunch intensity lifetime ~10% lower.



Conclusion: non-resonant excitation may provide collimation

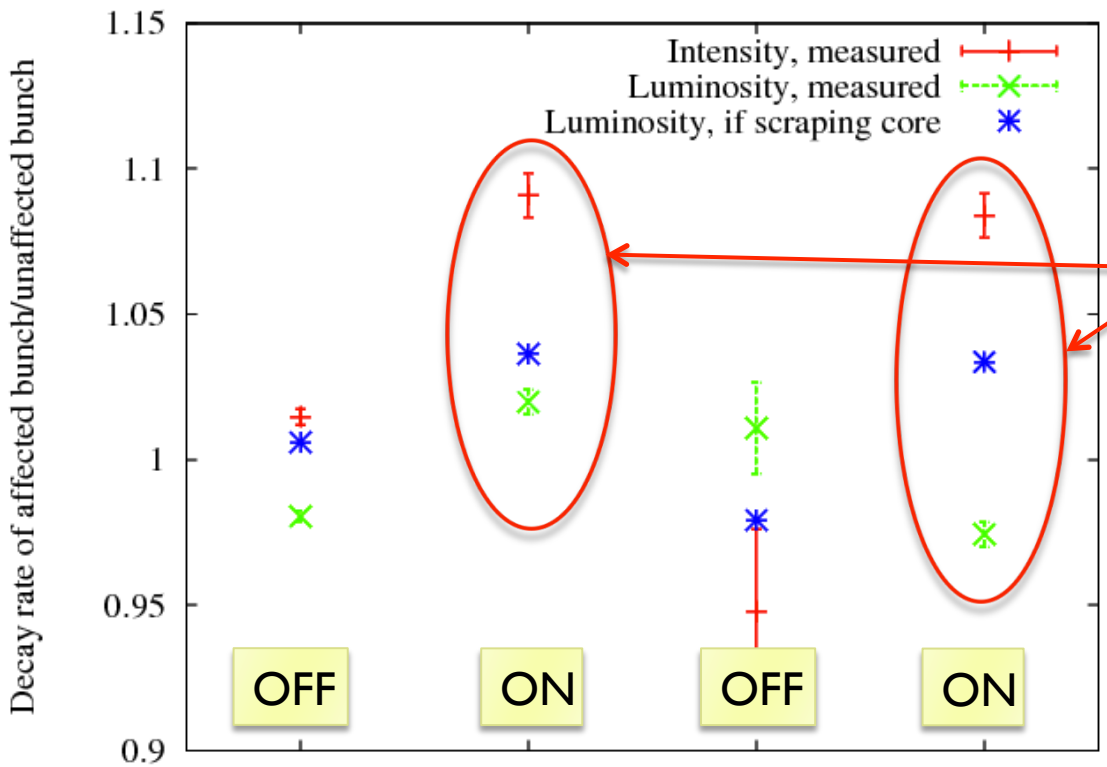
Stage Ic. HEBC (r=5σ), A18 pulsed every turn. Evaluation of life times.

$$\frac{\dot{L}}{L} = \frac{\dot{N}_a}{N_a} + \frac{\dot{N}_p}{N_p} + \ldots$$

thus if the luminosity lifetime is changed due to the degradation of the antiproton core life time

$$\frac{\delta\tau_L}{\delta\tau_a} = \frac{\tau_L}{\tau_a}$$

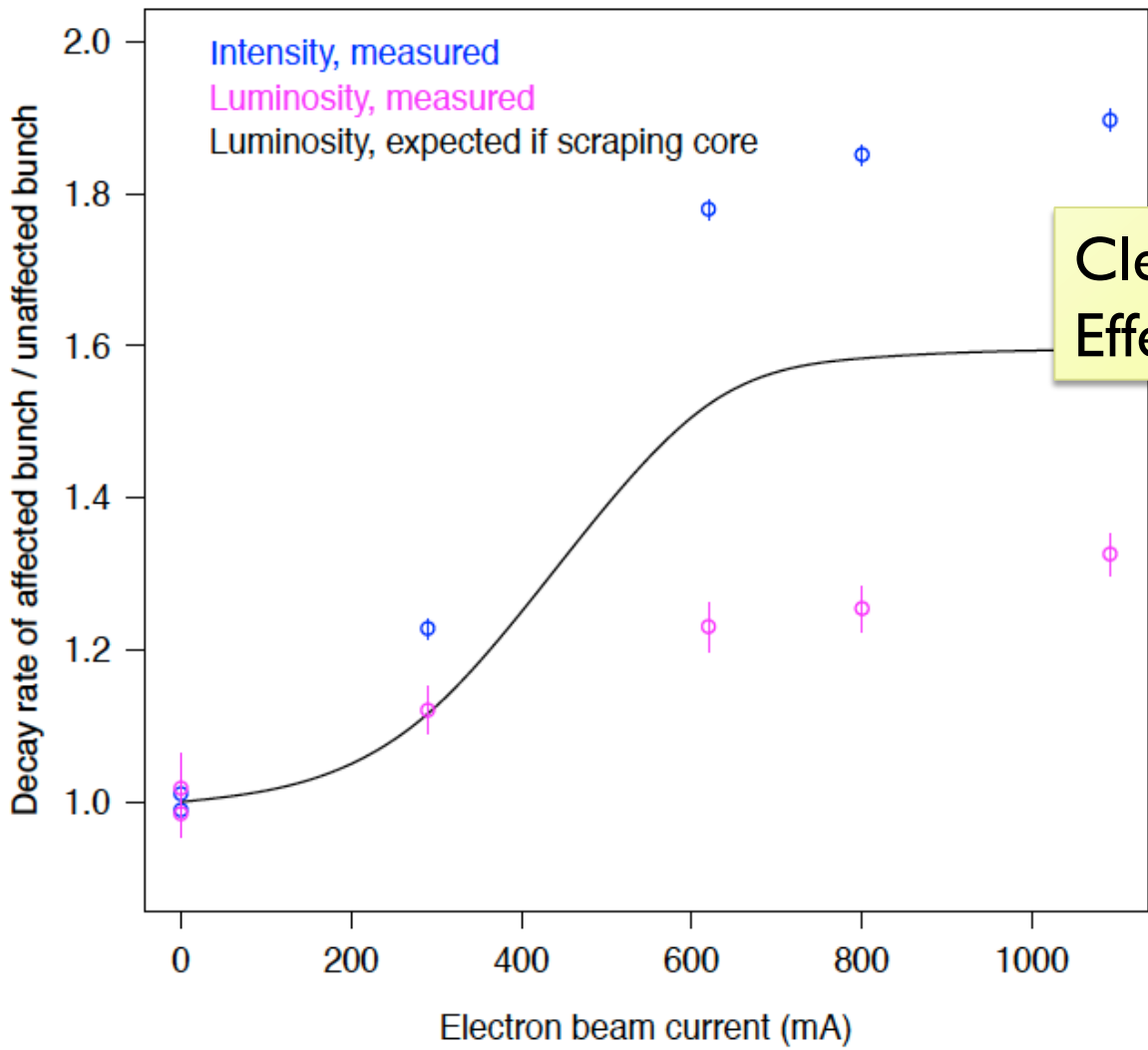
For τ_L=14 h, τ_a=35 h, 10% drop in antiproton life time should result in 4% luminosity life time change



Scraping halo ! Effect is well reproducible

Each point is based on 30-45 min observation

Stage Id. HEBC (r=4σ) on A18 pulsed every turn. Evaluation of life times vs. e- current



Clear collimation at 4σ!
Effect on core is small

Each point is based on 20 min observation

Summary

- Experiments at Tevatron with HEBC acting on a single antiproton bunch provide conclusive demonstration of collimation of the beam halo at 4σ. The effect is significant and reproducible.
- Performance of HEBC is stable over long period of time and at high luminosity
- Effect of HEBC on the beam core is small
- Experiments with bunch trains are in progress, aiming at the measurement of collimation efficiency
- Present 0.6" e- gun does not allow studies of HEBC with proton beam. Design and fabrication of 1" hollow gun are in progress.