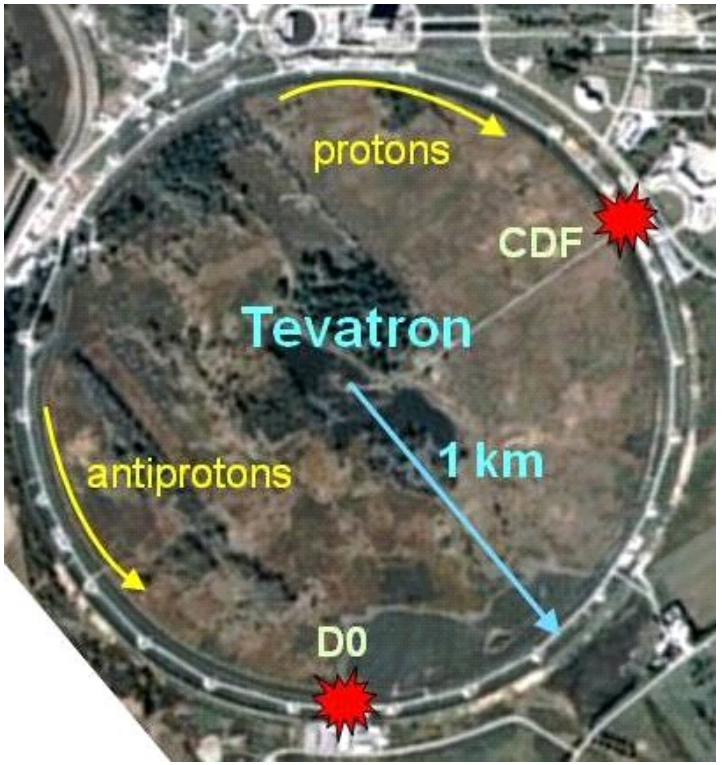
# FNAL Interest in Tevatron Accelerator Studies




Ron Moore

*Fermilab – AD / Tevatron Dept. Head*

# Fermilab Interest in Tevatron Accelerator Studies

- FNAL staff participating with T-980 & LARP, etc.
  - e.g., a number of folks actively participating in collimator studies, BBC
- Own interest and benefit
  - Pursuing/completing Collider Run 2 studies
  - Applications to possible future programs
- Electron cooling folks also expressed some interest
  - Could use dedicated period prior to Recycler revamping for protons
  - Collider studies require them to remain operational during that time anyway
- See workshop presentation slides for more information on some topics

# ½ Integer Tevatron Working Point

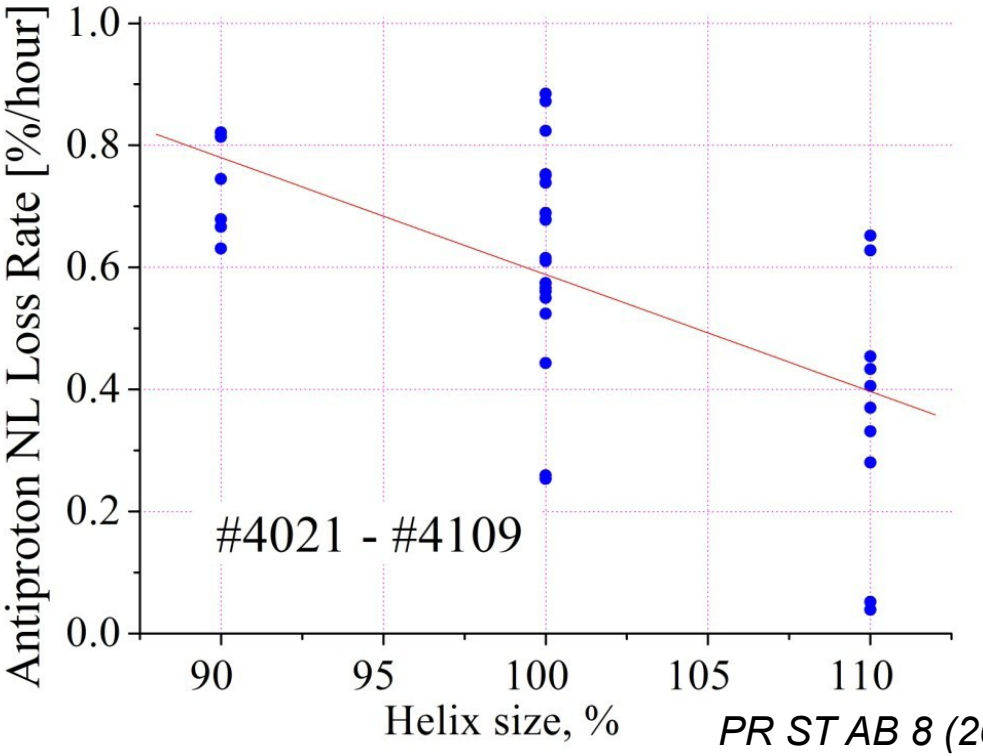
- Considered several years ago for operation, too much time to implement
  - Collider run has been essentially year-to-year since that time
  - Some preparatory work already done
  - Larger tune space would allow >30% higher proton intensity
  - Also part of a plan for Run 2 extension

- Work list *(A. Valishev)*
  - Develop beta-beating correction scheme for Injection, Squeeze and
  - Collision lattices (reconnect Q39 circuits?)
  - Develop helix modifications (if necessary)
  - Develop feeddown configurations for all sequences
  - Tune-up injection, ramp and squeeze near ½ - estimate 2 weeks
  - Run colliding-beam stores 36x36 for high peak luminosity or 1x1 to demonstrate high beam-beam parameter ~0.03
  - ~1 month total for implementation and colliding beam stores

# Lifetime vs Helix Size (Beam Separation)

- Repeat measurements done 5 years ago *(R. Moore, V. Shiltsev)*
  - Now have additional separators, smaller β*
  - Quantify losses/lifetime versus beam separation (enlarge/reduce helix)
  - Few colliding beam stores and/or 1 shift dedicated store

*Non-luminous pbar loss vs helix size*




*PR ST AB 8 (2005) 101001*

# Phase Averaging

- Confirm worse lifetime with smaller $\sigma_z/\beta^*$ *(V.Shiltsev)*
  - Compare collisions at flattop (1.5 m β*) to normal conditions (28 cm β*)
  - 1x1 to eliminate long-range interaction effects
  - ½ – 1 shift: 2 colliding beam stores

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**Bunch-length effects in the beam-beam interaction**

S. Krishnagopal and R. Siemann
*Newman Laboratory of Nuclear Studies, Cornell University, Ithaca, New York, 14853*
(Received 25 September 1989)

The Hamiltonian analysis of the beam-beam interaction is extended, for round beams, by including its finite longitudinal extent. For small synchrotron amplitudes resonance strengths are derived that are smaller than those obtained in the impulse approximation. This is a consequence of averaging over the betatron phase during the collision. Results of simulations that reproduce this feature are also presented. More complete simulations, relevant to storage-ring colliders, argue for bunch lengths comparable to the value of the amplitude function ($\beta$) at the interaction point.

# Miscellaneous Collider

- Wide tune scans during collisions *(Zhang, Shiltsev)*
  - Help benchmark simulations
  - Even try without head-on collisions
  - 1 shift over a couple of stores, better if dedicated

- Lifetime vs Phase Advance between CDF & D0 IPs *(Yu. Alexahin)*
  - Based on lattice measurements, already close to optimum
  - Compare lifetimes vs phase advance
  - Colliding beams, maybe just 1x1 store(s)?
  - ½ shift to change optics, tune-up; try collisions; restore

- Coherent beam-beam effect
  - Excite single bunch, measure response in other bunches
  - Compare observation of pi, sigma, continuum to simulations
  - 1-2 shifts over several colliding beam stores; dedicated probably better

# Miscellaneous

- Luminosity leveling *(dynamic β* squeeze, bunch length control via RF voltage)*
  - Interest from CERN
  - Considered in past for Tevatron, but experiments always able to cope
  - Should be relatively straightforward to attempt the RF voltage change idea

- AC dipole measurements
  - CERN interested in measuring beam-beam resonances
  - M. Bai described dynamic aperture measurements in RHIC
    - Repeat for Tevatron for documentation, future application
    - 1 shift proton-only @ 150 & 980 GeV

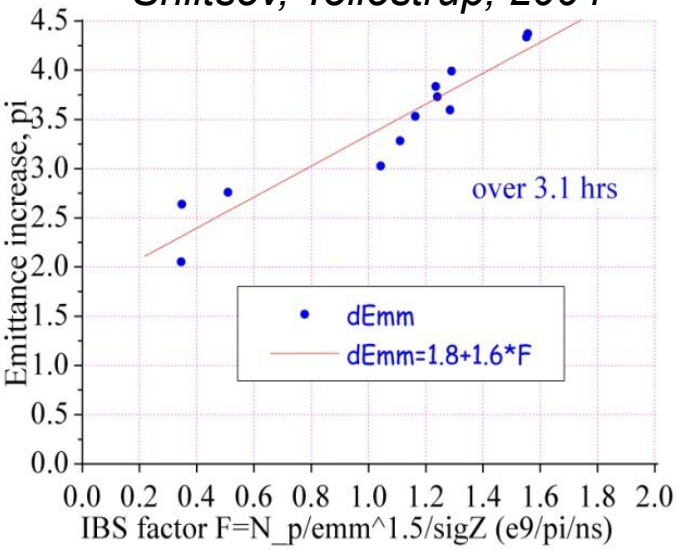
- Tevatron as Stretcher Ring for Slow Spill *(M. Syphers)*
  - Considered for post-collider 120/150 GeV slow-spill fixed-target operation
  - Ultimate scheme requires reverting low-β sections and reinstalling extraction
  - Just for testing purposes:
    - Investigate b2 drift effects and drifts @ 120 GeV
    - Try pushing proton intensities (lower impedances and dampers)

# Miscellaneous

- Instability studies
  - Operation with zero chromaticity – need higher power damper?
  - Longitudinal instabilities – a long-term annoyance
    - What is the actual source? Why recent pbar instabilities?
    - Dedicated time for more freedom to play with RF system
    - Several ½ shift blocks proton-only and colliding beams

- Lifetime measurements for IBS / vacuum / noise
  - Refine data input for various machine models *(Lebedev, Valishev)*
  - Measure lifetime & emittance for various bunch intensities, sizes
  - Two 4-8 hour proton-only stores @ 150 and 980 GeV

*Shiltsev, Tollestrup, 2004*



# Miscellany Proton-Only

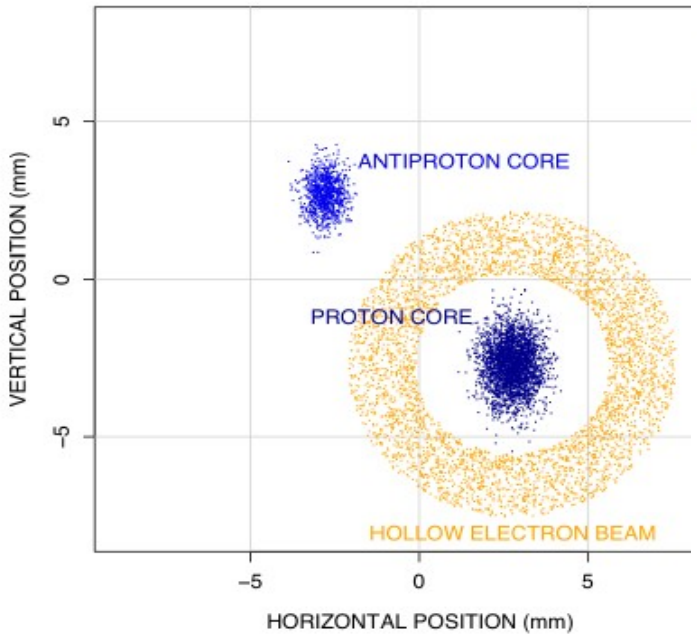
- Electron Cloud *(X. Zhang)*
  - Simulations and studies in conjunction with Main Injector studies
  - Have observed vacuum activity and emittance growth consistent with e-cloud
    - Uncoalesced (pilot) proton bunch trains (30 bunches in 53 MHz buckets)
  - Could add instrumentation, clearing electrode fairly easily
  - Don't need/want to duplicate efforts elsewhere

- Generation of Flat Bunches *(C. Bhat)*
  - Interest from CERN for large Piwinski angle
  - Need to install a 2nd or 3rd harmonic cavity
    - 106 MHz cavity in Main Injector currently used for coalescing protons, pbars
    - 159 MHz cavity is available
    - Where/how to install? Difficult in short time for Tevatron.
  - Could do in Main Injector alone, just not use for collisions?

# Hollow e-beam Collimation

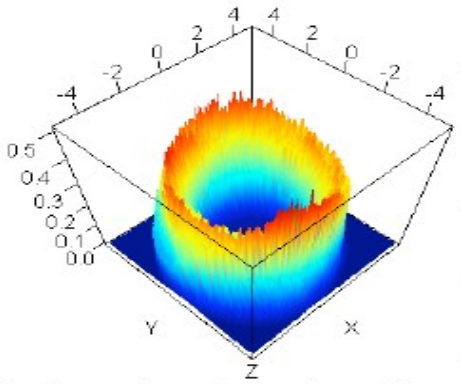
- Now installing hollow beam gun in TEL-2
- Verify alignment procedures, effect on core beam and halo
- Request end-of-store studies throughout Run 2
- Dedicated running also useful (guess: 5  8-hour shifts)

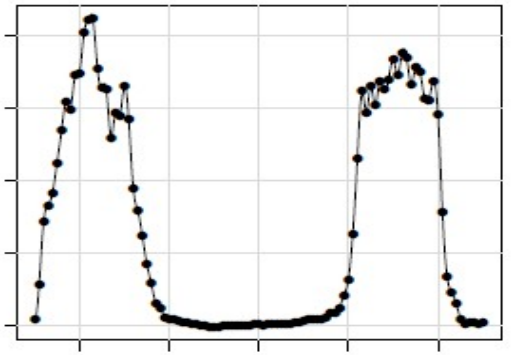
*G. Stancari*

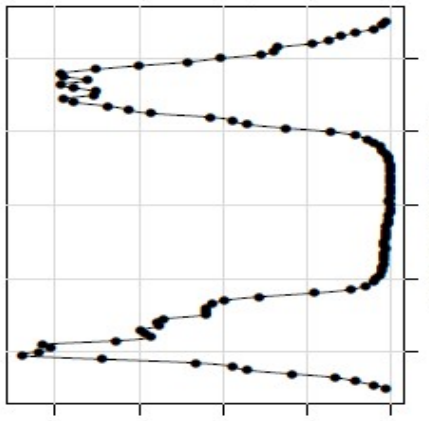


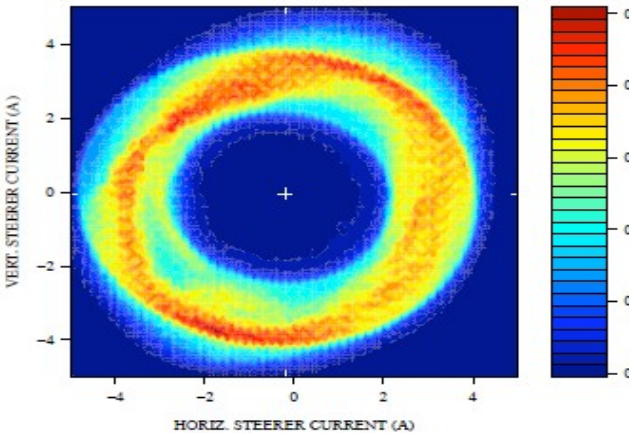

**HOLLOW GUN**
October 26, 2009

Vacuum: 2x10$^{-8}$ mbar
Filament: 66 W (7.75 A)
Cathode voltage: -9.0 kV
HV PS current: 1.43 mA
Pulse width: 6 us
Rep. period: 80 ms
Peak current: 2.5 A
Solenoids: 3-3-3 kG

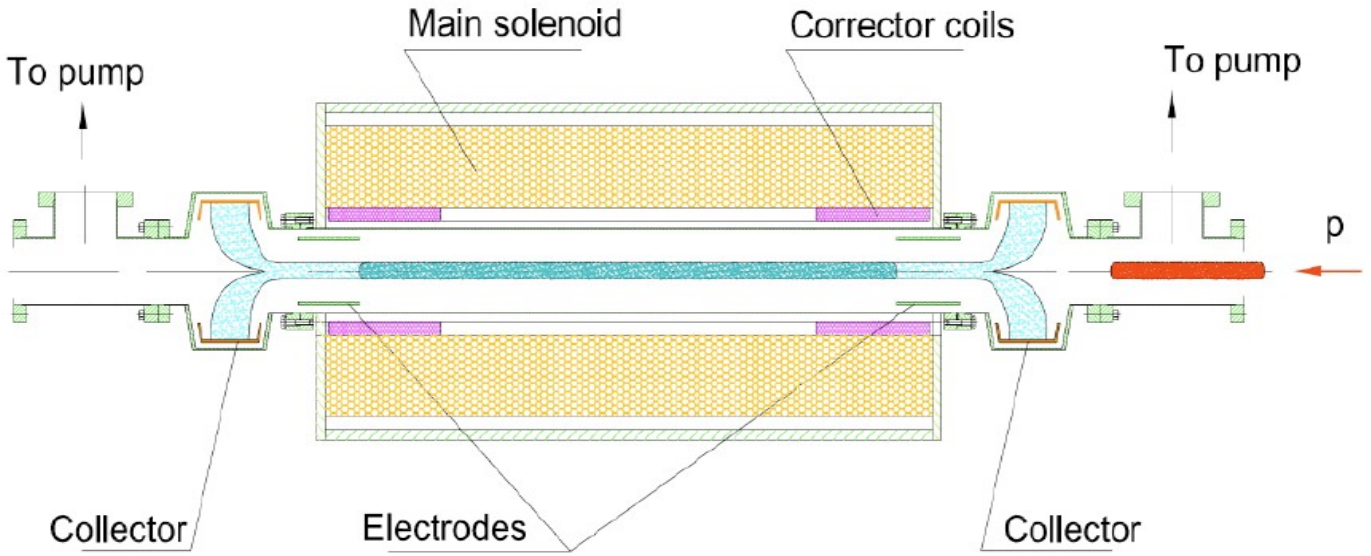






- Use existing TEL to trap e from beam-ionized gas *(G. Stancari)*
  - Have attempted preliminary experiments
  - Proton-only stores during Run 2 and dedicated run (guess: 4  8-hour shifts)
  - Find stable electrode configuration
  - Detect charge accumulation
  - Measure tune shifts vs beam intensity, electrode voltage, gas pressure
  - Extend to 8 GeV for Main Injector or Recycler for intensity frontier?




*Shiltsev, PAC07*

# Instrumentation

- OTR turn-by-turn profile differences
  - Left over from commissioning several years ago
  - ½ shift: repeated proton injection, extraction after few turns

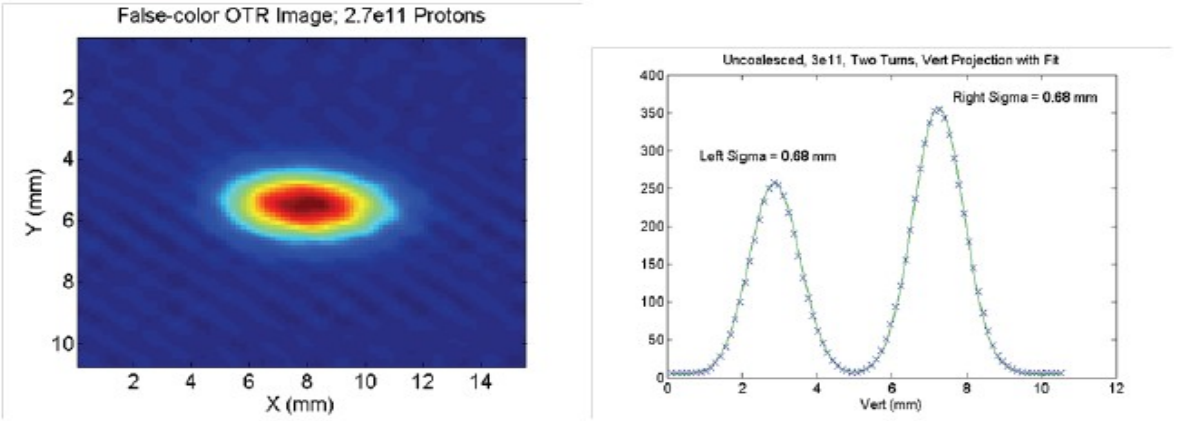



**Figure 20.** a) (left) Transverse 2D bunch profile as measured by the OTR b) (right) Vertical profiles of a single proton bunch from the OTR on two consecutive turns. The second turn profile is offset from the first, and the images are summed together by the slow camera. Note that over the two first turns, the OTR does not show evidence of the quadrupole oscillations seen in the IPM. However, from the IPM data only a 5% effect is expected between these two turns.

- Try to detect ODR using (modified?) sync-light or OTR systems
  - Up to 1 shift with protons @ 150 or 980 GeV + hardware prep time
- Test electron beam profile scanner
  - ½ shift with protons @ 150 GeV
  - Need to build and install? Could be time-constrained.

# Summary

- Fermilab has strong interest in a Tevatron accelerator studies program
  - Own staff participating in studies for benefit of CERN, LARP, BNL
  - Wrap-up of Collider Run 2 studies
  - Experiments and measurements could benefit possible future programs
  - General accelerator science

- Variety of studies under various beam conditions
  - Some during Run 2, some better for dedicated run

- Other FNAL groups (electron cooling) also interested in dedicated studies
  - Can envision expanding participation of dedicated period for injector chain

# Tevatron Devices and Instrumentation

- Flying wires
- Sync-light monitor
- BPMs, BLMs (both can do turn-by-turn)
- AC Dipole
- 21 MHz and 1.7 GHz Schottky systems
- Ionization Profile Monitor
- Intensity pickups (DCCT, Resistive Wall Monitor)
- SBD (Sampled Bunch Display) for intensity, bunch lengths
- FBI (Fast Bunch Integrator) for intensities
- Tune and chromaticity trackers
- Couple of stripline pickups (used for dampers, noise sources)