

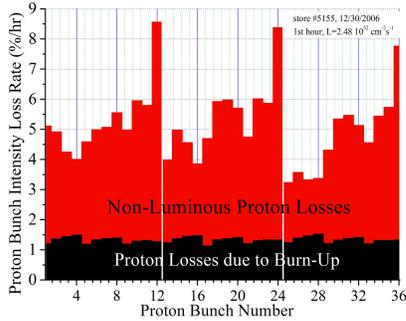
# Demonstration of beam-beam compensation with electron lenses in the Tevatron



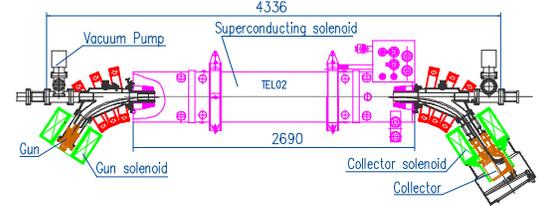
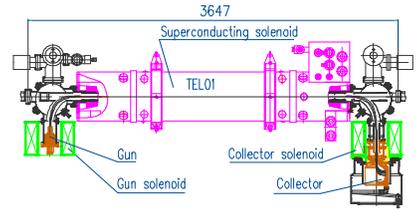
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## Introduction

The beam-beam effects have been the dominating sources of beam loss and lifetime limitations in the Tevatron in Collider Run II (2001 - present). Electron lenses were originally proposed as compensators of electromagnetic long-range and head-on beam-beam interactions of proton and antiproton beams. In our recent experiments, electron lenses were applied to high intensity proton beam at 980 GeV.

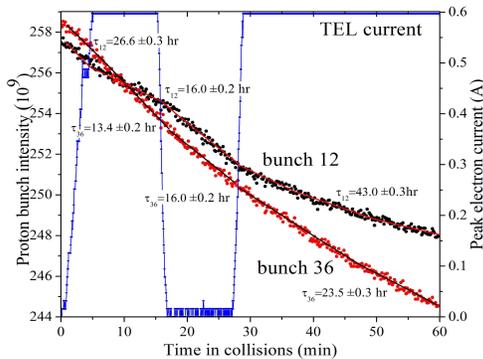


In the TEL a low energy electron beam is guided onto the Tevatron orbit by a longitudinal magnetic field. After interacting with high energy protons or antiprotons electrons are extracted and dumped into the collector. The TEL can operate in dc or pulsed mode. The latter allows introducing tune shifts on a bunch-by-bunch basis. TEL1 is designed for horizontal beam-beam compensation. TEL2 works in vertical plane. It was quickly realized that TELs are capable of removing unwanted particles from the beam abort gaps. So one of the TELs is still routinely used for abort gap cleaning.

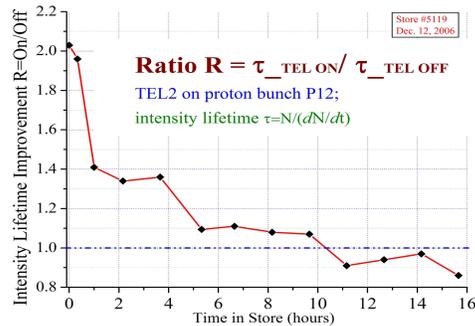


## TEL2 BBCompensation results

### Reduction of proton losses



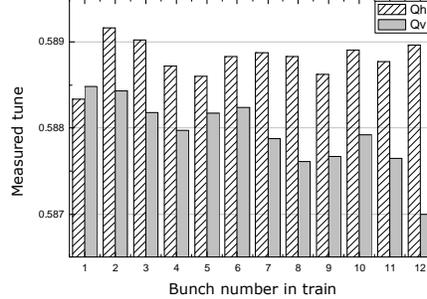
### Improvement of proton lifetime



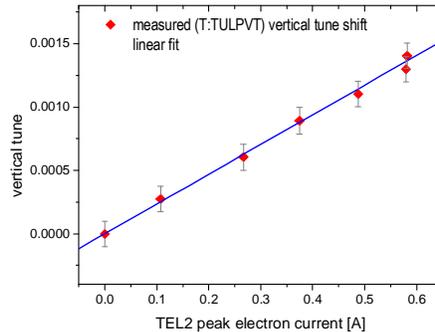
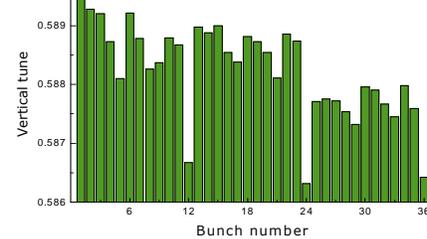
- ✓ Lifetime improvement up to 100% for last bunches in the train
- ✓ Reliable operation using solid state Marx generator (radiation shielding installed)

## Bunch-by-bunch tune measurements

### 1.7 GHz Schottky data, end of store

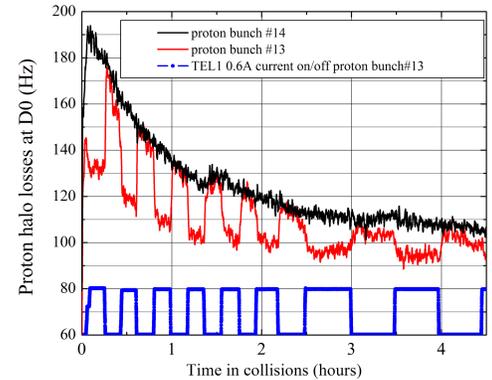


### DTM data, beginning of store

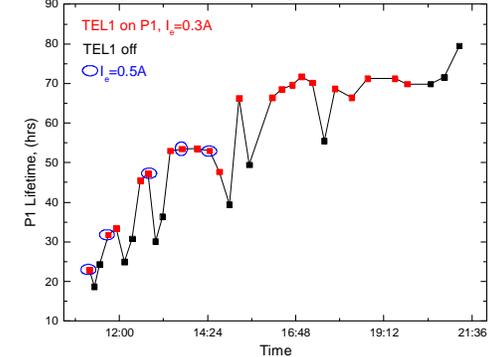


## TEL1 BBCompensation results

### Reduction of proton loss rate



### Improvement of proton lifetime



- ✓ Lifetime improvement up to 60% for the first bunches in the train
- ✓ Reliable operation using RF tube based modulator

## Summary & plans

- ✓ Both Tevatron Electron Lenses are operational and are used for BBCompensation experiments
- ✓ Both TELs have been shown to generate the expected tune shift and to improve proton lifetime significantly
- ✓ Two novel HV pulsers and a new type of electron gun are under development to further boost the TEL capabilities
- ✓ Electron Lenses are being considered for installation in RHIC and LHC

## Acknowledgements

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