

# Performance Analysis of Multi-Turn Extraction from the PS to the SPS

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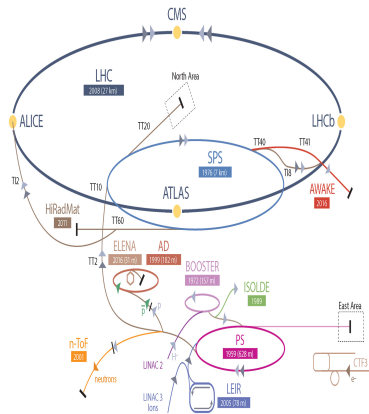


# Presentation Overview

- 1 Introduction
  - Overview of PS to SPS Extraction
  - Multi-Turn Extraction (MTE)
- 2 Performance Analysis
  - Figures of Merit
  - MTE Vs. CT
  - Improvement Over Time
- 3 Future Work

# Overview of PS to SPS Extraction

CERN's Accelerator Complex



▶ p (proton)  
 ▶ ion  
 ▶ neutrons  
 ▶  $\bar{p}$  (antiproton)  
 ▶ electron  
 ↔ proton/antiproton conversion

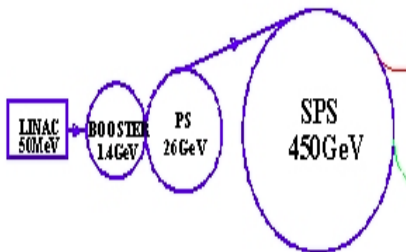
## Continuous Transfer (1970's – 2015)

- Beam sliced in horizontal plane with an electrostatic septum.
- After each turn, beam rotates by  $90^\circ$  in phase space.
- Full extraction takes five turns.

## Drawbacks

- High radiation levels in PS
- Inconsistent phase space shape

# Overview of PS to SPS Extraction



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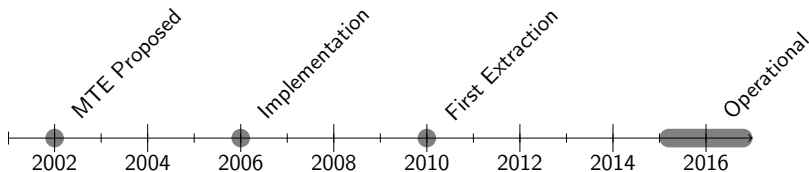
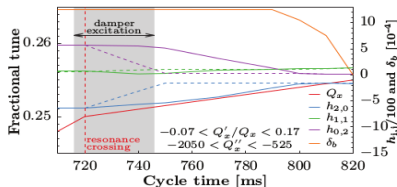
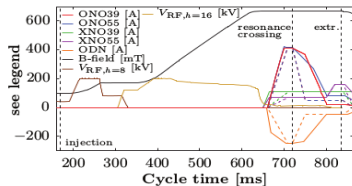
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# Multi-Turn Extraction (MTE)

## Jargon

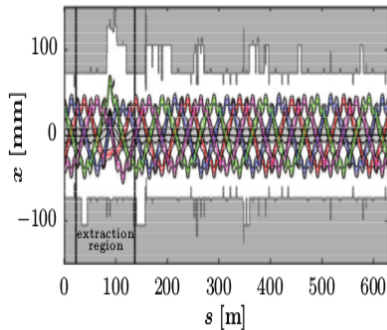
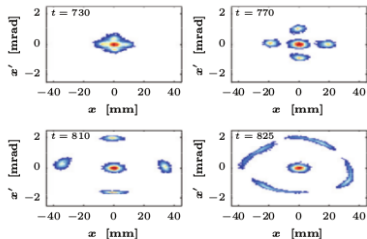
By adiabatically crossing resonance excited by sextupoles and octupoles, particles are trapped in stable islands of low-order 1D resonances of horizontal phase space.



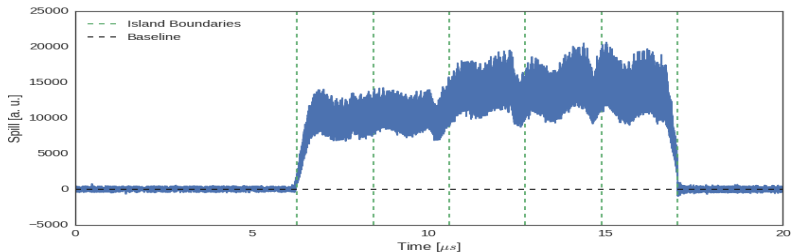
# Multi-Turn Extraction (MTE)

## Simplified

Beam is split into core and four islands in horizontal phase space.



# Figures of Merit

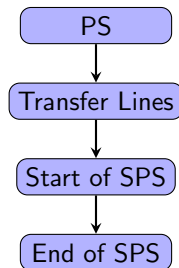


## DC Efficiency

$$\eta_{DC} = \frac{1}{T} \frac{\left[ \int_0^T I(t) dt \right]^2}{\int_0^T I^2(t) dt}$$

Variability of intensity

## Transmission Efficiencies

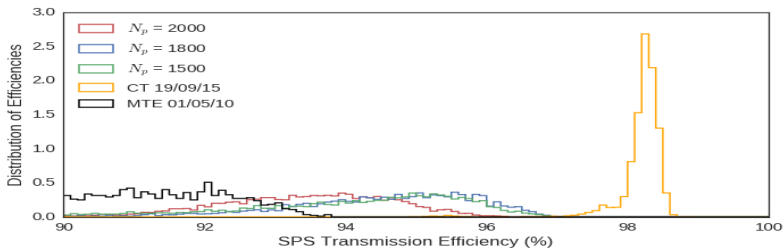
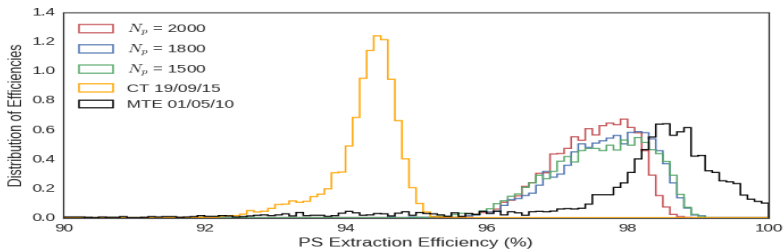


## MTE Efficiency

$$\eta_{MTE} = \frac{\langle I_{islands} \rangle}{I_{total}}$$

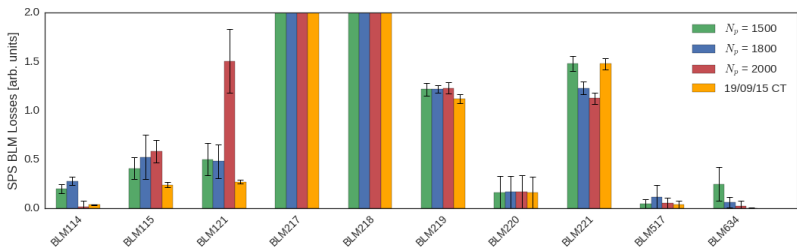
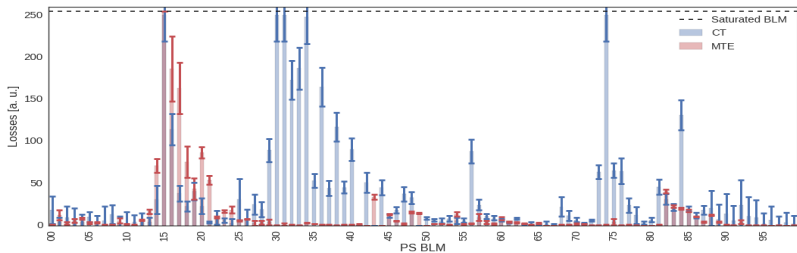
Beam intensity in  
*outer islands*

# MTE Vs. CT

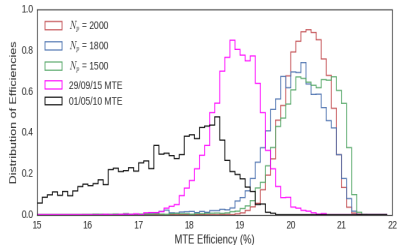
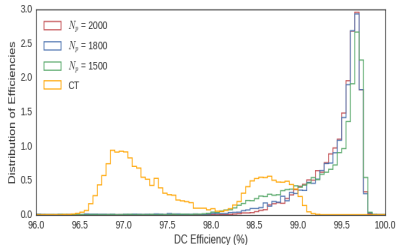
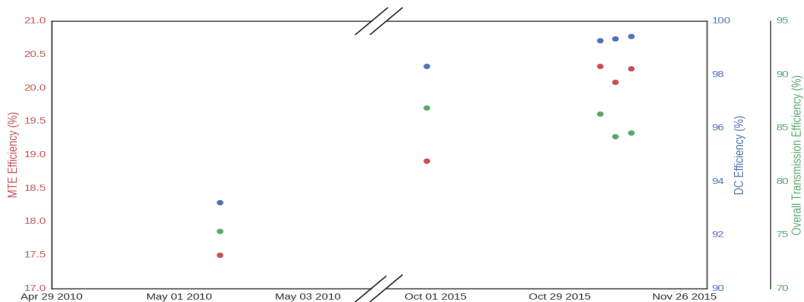




# MTE Vs. CT

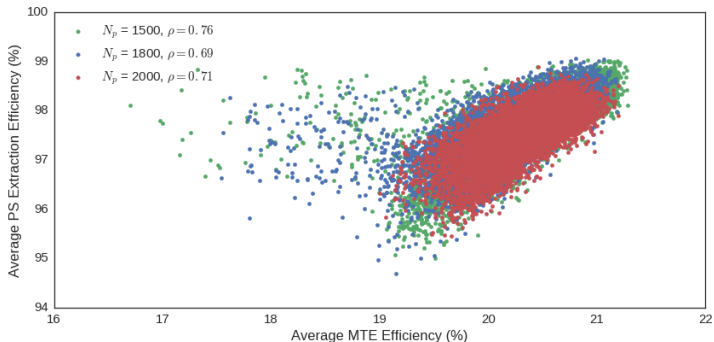


# Improvement Over Time



# Future Work

- Investigate correlations between PS and SPS



- Full results will be available in a paper later this summer
- Extend analysis to 2016 data

# Thank you!

- Dr. Massimo Giovannozzi, CERN
- Dr. Guido Sterbini, CERN
- Dr. Adam Sarty, Saint Mary's University



## Questions?

## Sources

- Borburgh, J. et. al., *First implementation of transversely split proton beams in the CERN Proton Synchrotron for the fixed-target physics programme.*, EPL Journal.
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