

Halo Measurement

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Outline



- Motivation and Specification
- Tools to AVOID halo
- Tools to DIAGNOSE halo
- Digression to Islands
- Conclusions

Motivation and Specification



- Motivation

- Halo (and beam-beam) Workshop at BNL (actually, Montauk) in May 03 (the week after PAC). Working groups are

- Beam Dynamics
 - Diagnostics
 - Collimation
 - Beam-beam

- Halo control essential to minimize activation

- Specification – 10^{-4} ?

Tools to AVOID Halo formation



Fedotov - Mechanisms of HALO production in Hadron Machines

Linacs:

1. mismatch
2. space charge coupling
3. residual gas
4. magnet errors,...

High-intensity rings:

5. painting
6. mismatch
7. space-charge induced resonances
8. machines resonances
9. collective instabilities
10. e-cloud effects
11. error-related halo
12. beam in gap
13. SNS banana beam (extr kicker impedance)
14. transverse-longitudinal coupling (short bunches)
15. effects of synhrotron motion (short bunches)
16. IBS, instabilities, beam-beam,... (high energy)

Tools to DIAGNOSE Halo



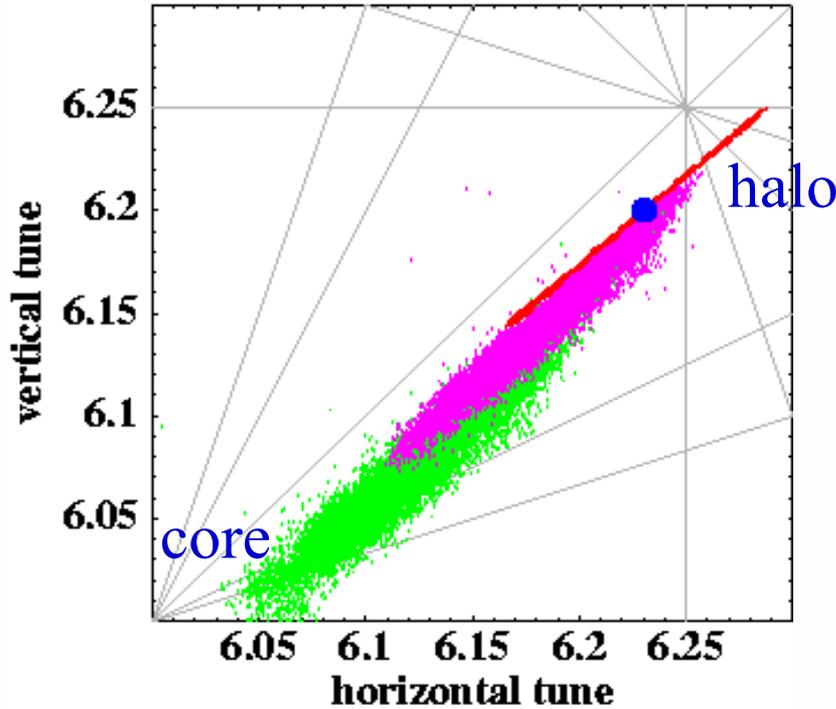
- scrapers
- IPM
- laser wire (for H-minus machines only)
- carbon wire
- non-linear bpms
- Tune-based measurements
 - amplitude detuning, schottky measurements, PLL measurements, island exploration,...

Digression to Islands

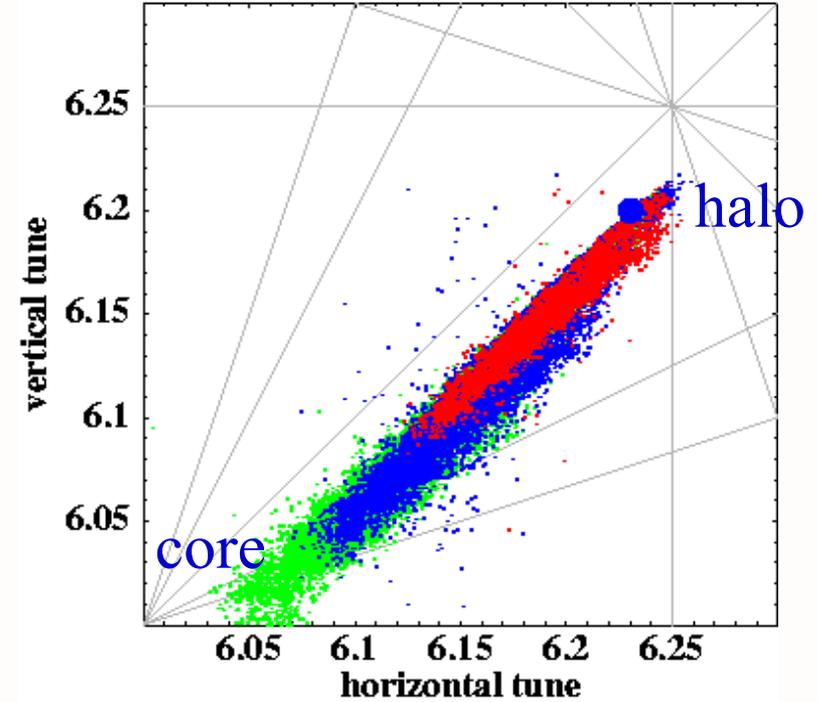


- Island tune is precise – narrowband measurement
- Amplitude is large – power goes as square
- Experience – PLL locks on islands in RHIC
- Schottky Power spectral density ~
$$QN_x^2 q^2 f k^2 g_{SC} / n \eta dp / p$$
- Relevant here $S/N \sim N^2 x^2 / \delta f$
 - Inside separatrix $N \sim 10^{14}$, $x \sim 1 \text{ cm}$, $\delta f \sim 100 \text{ KHz}$
 - In island $N \sim 10^9$, $x \sim 10 \text{ cm}$, $\delta f \sim 10 \text{ Hz}$
- Down 40dB, island $N \sim 10^9$
- Doesn't look easy, beam studies in RHIC?

Tune Footprints - blue dot is coherent tune



Footprints for 3 intensities
(0.1 , 1 , and 2×10^{14}) at cycle end



Footprints after 263, 526,
and 1060 turns, 10^{14} beam

Conclusions



- Halo control is crucial for low-loss high-intensity operation
- Halo control implies Halo measurement
- Halo measurement is fun
- Tools can be approximately grouped into
 - Tools to AVOID halo
 - Tools to DIAGNOSE halo
- Montauk workshop