Ion Beam Energy Qualification in the Synchrotron

Tools for risk reduction

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Outline

Baseline qualification

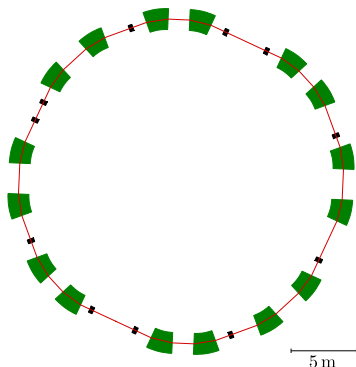Precise qualification
    Circumference measurement
    Revolution frequency measurement

"Energy budget"

Summary

Synchrotron as spectrometer

A baseline energy qualification method

5 m

$$E_{kin} = \sqrt{(B\rho qc)^2 + m^2 c^4} - mc^2$$

Limitations

- Limited B precision
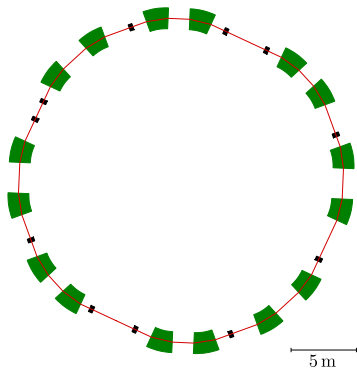- ρ not really constant

Additional: Particle type

By two measurements at different B values[a]

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[a]Requires different values for $\frac{q}{m}$

Time-of-flight measurement

An improvement on top of the baseline

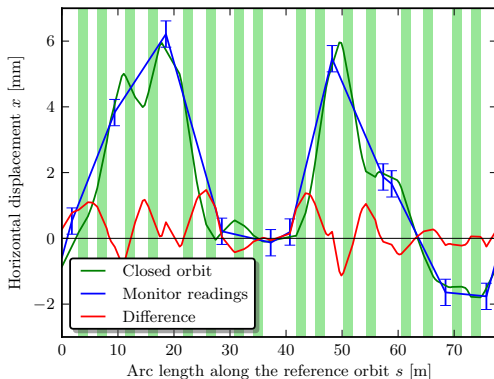$$E_{\text{kin}} = \sqrt{\frac{(mvc)^2}{1 - v^2/c^2} + m^2 c^4} - mc^2$$

$$v = \frac{C}{t} = Cf$$

Measurements

▶ Closed orbit circumference

▶ Revolution frequency

Circumference measurement

Multiple possible tracks

Performance

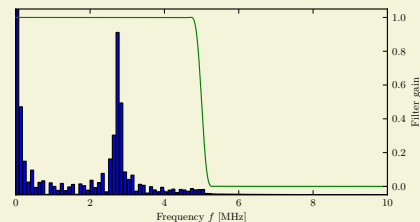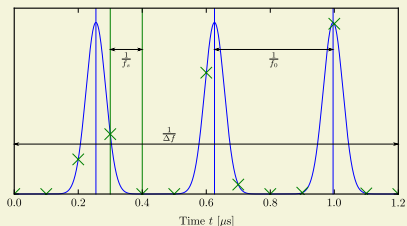$\sigma_C \approx 0.6\,\text{mm}$

Assumption
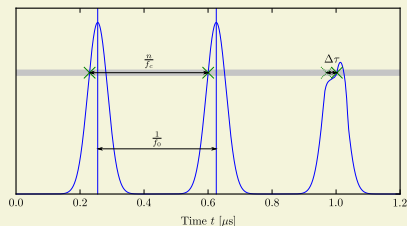
BPM precision
$\pm 0.4\,\text{mm}$

Revolution frequency measurement

Two comparable approaches

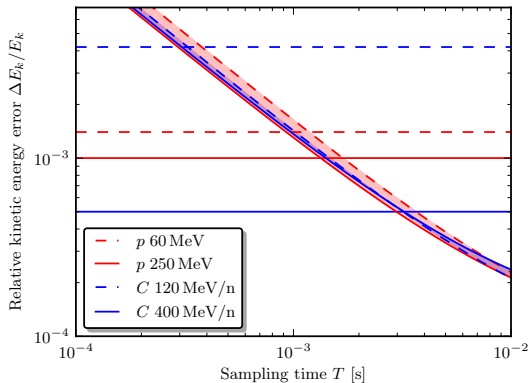## Fourier transform

RF counter

Limitation

► Integration time /
  measurement duration

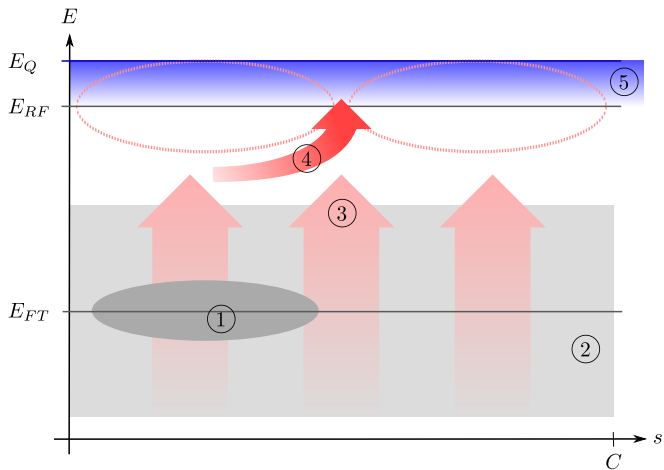# Measurement duration

Fourier transform

$$\Delta f \propto \frac{1}{T}$$

RF counter

$$\Delta f \propto \sqrt{\frac{1}{T}}$$

"Energy budget"

How the extraction changes the energy

Summary

Dipole field

- Very simple implementation
- Limited precision[a]
- Baseline

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[a]Still covers at least 95% of all incorrect energies

Time of flight

- Relatively simple implementation
- Very precise
- Not instantaneous

Limitation

- Qualification is not verification ("energy budget")