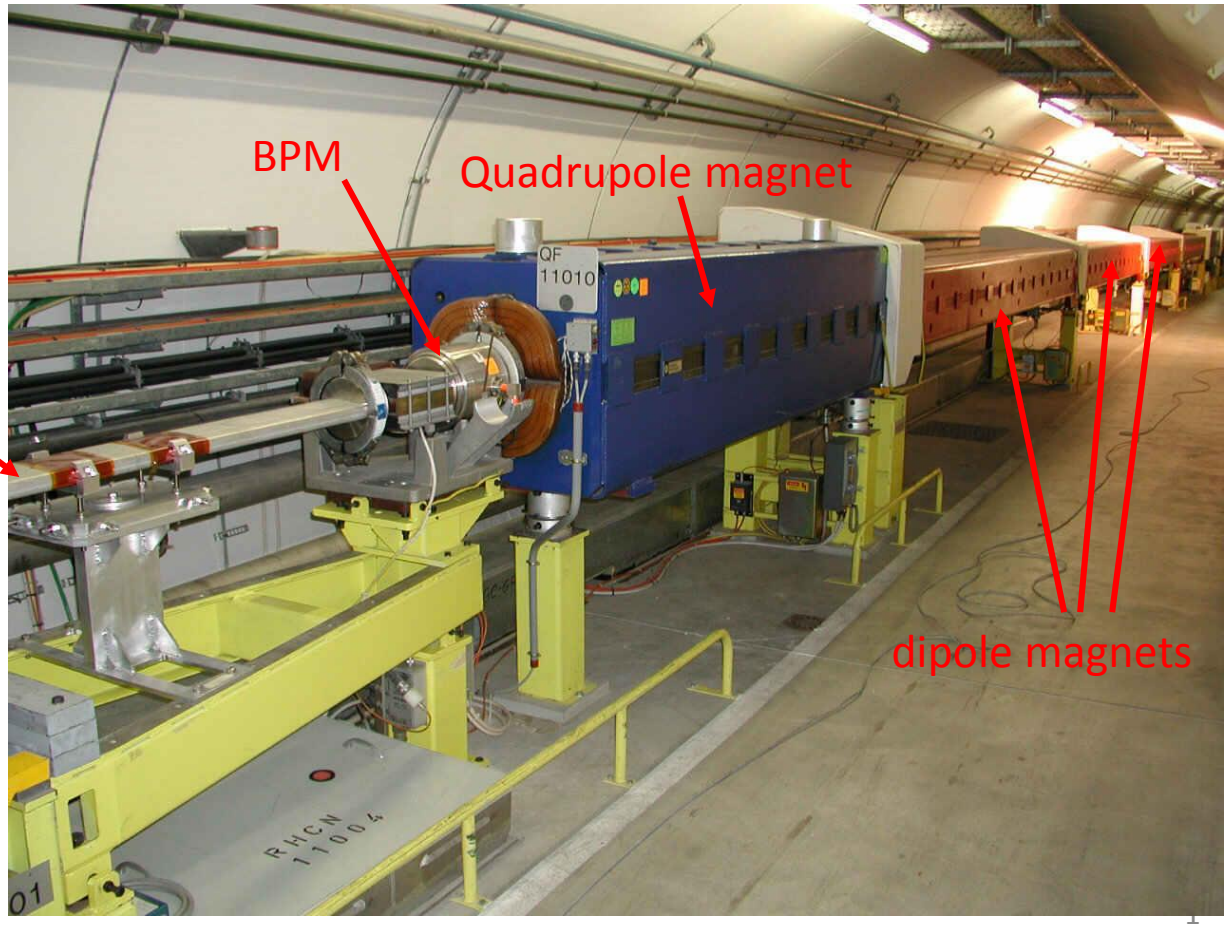
Wakefields and impedances:
Surrounding of the beam in an accelerator

- Accelerated particles travel inside a vacuum chamber, grouped into bunches.
- Various accelerator elements are needed for various purposes:

  → The shape and the material around the beam changes along the machine

Example
of the SPS tunnel



Wakefields and impedances:

Surrounding of the beam in an accelerator

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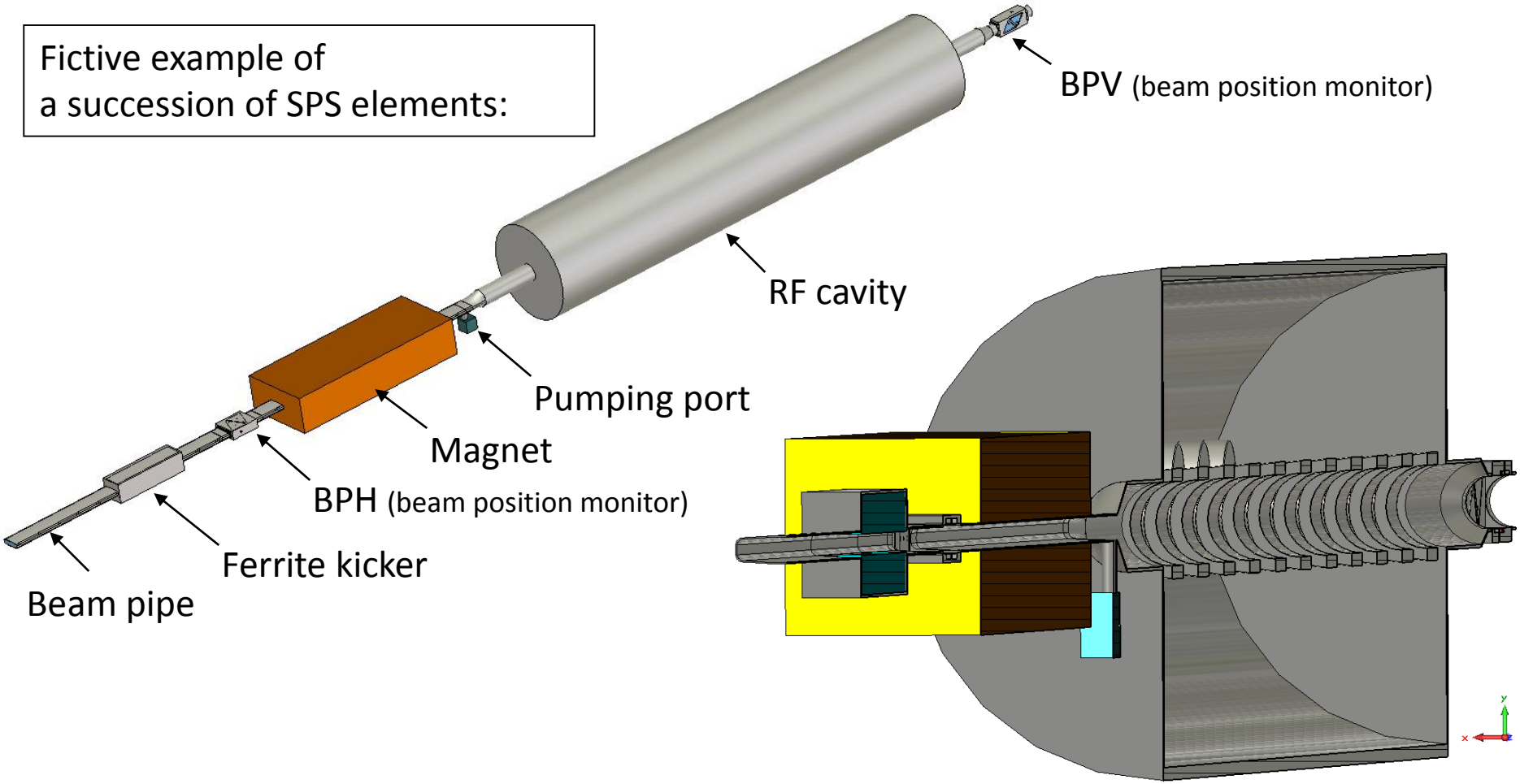
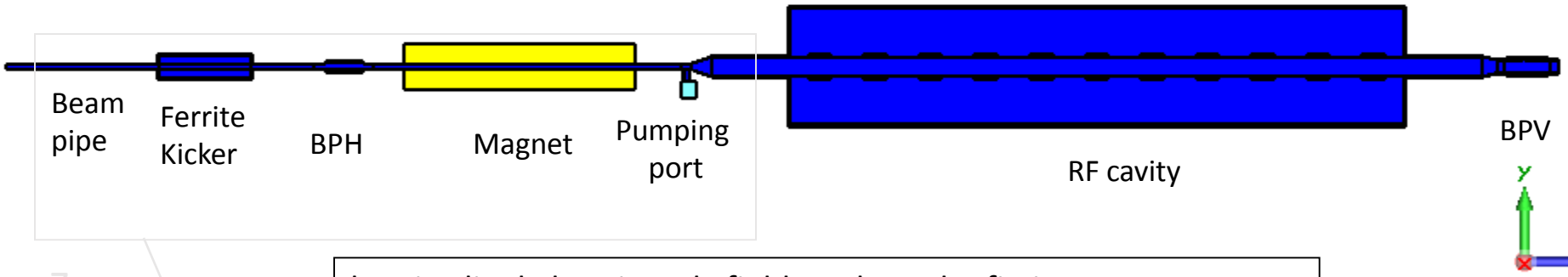
Fictive example of
a succession of SPS elements:



Wakefields and impedance :

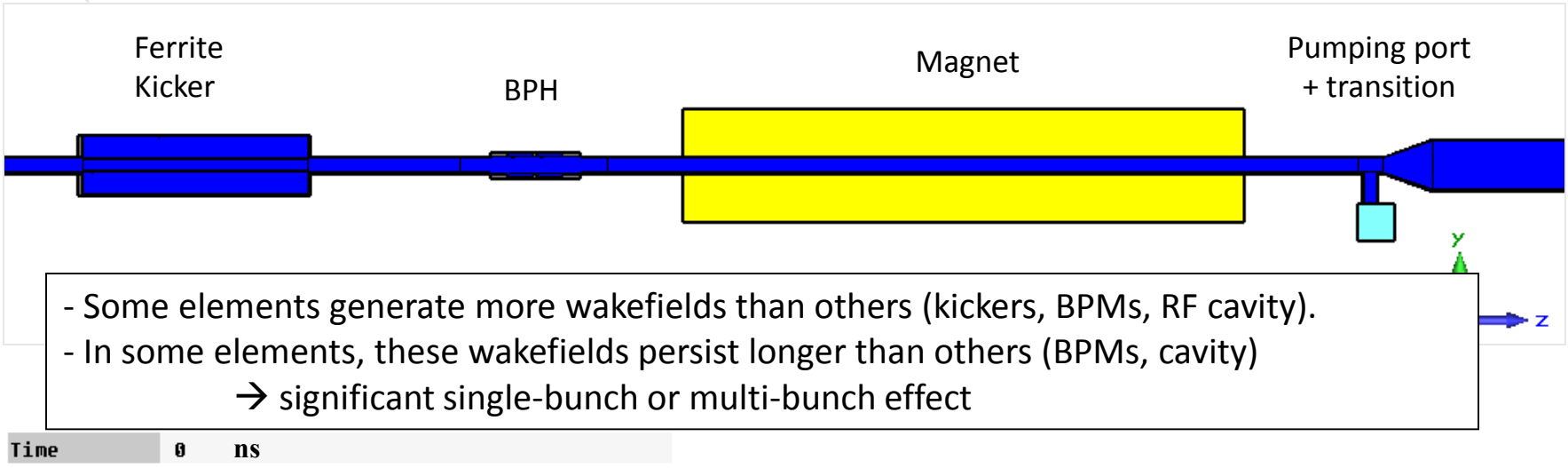
Example of wakefields in a sequence of elements

3D EM simulation of the interaction of a charged particle bunch with this sequence of elements



Zoom

longitudinal electric wakefield Ez along the fictive sequence



- Some elements generate more wakefields than others (kickers, BPMs, RF cavity).
- In some elements, these wakefields persist longer than others (BPMs, cavity)
  → significant single-bunch or multi-bunch effect

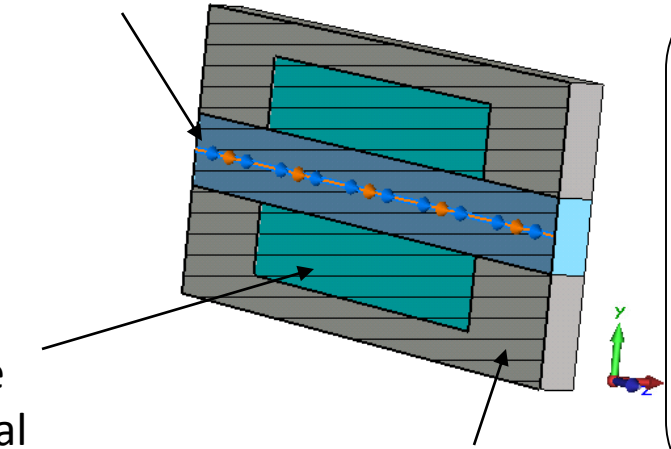
Wake fields are generated by the interaction of a bunch with:

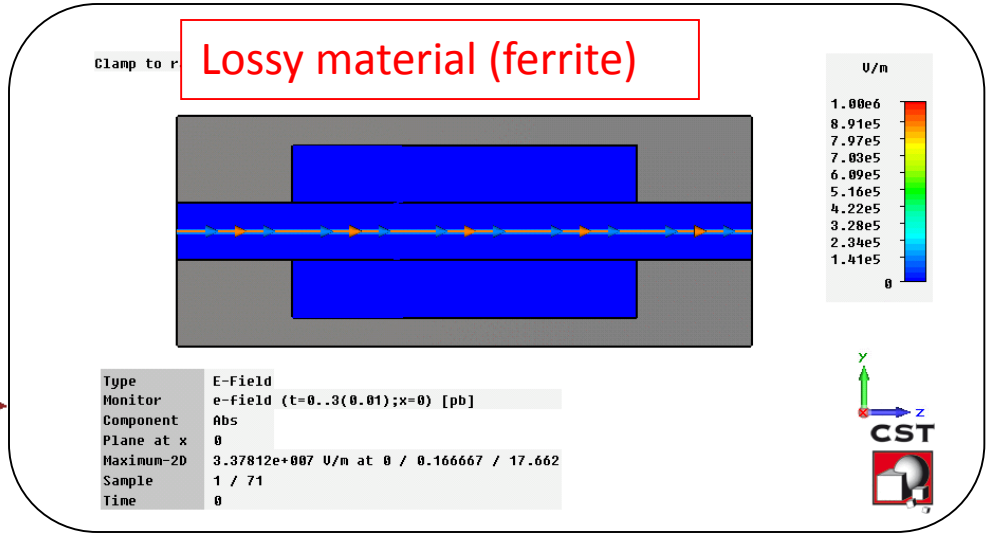
- perfectly conducting smooth beam pipes (***indirect space charge***) → beam pipe
- abrupt changes of the surrounding of the beam (***geometrical***) → BPMs, cavities
- materials with large electric of magnetic losses (***resistive wall***) → ferrite kicker

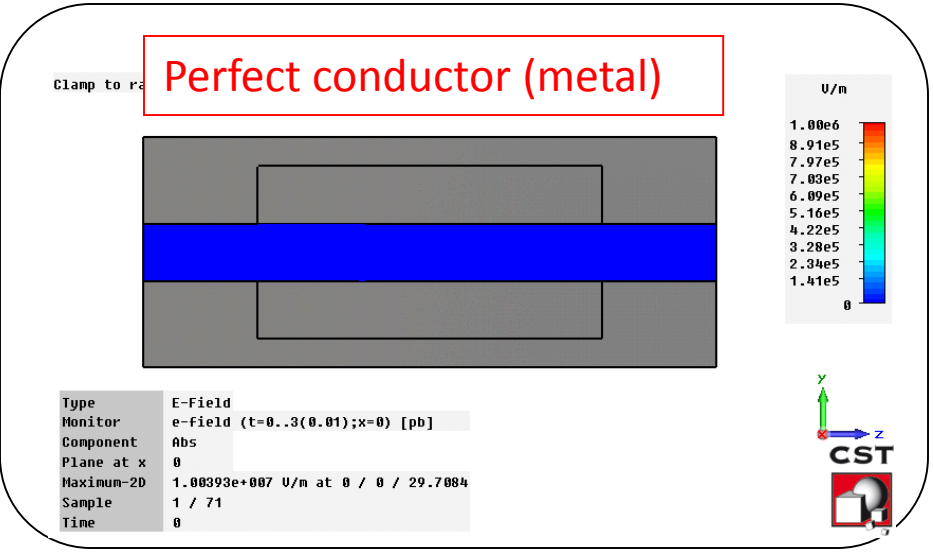
Wakefields and impedances:

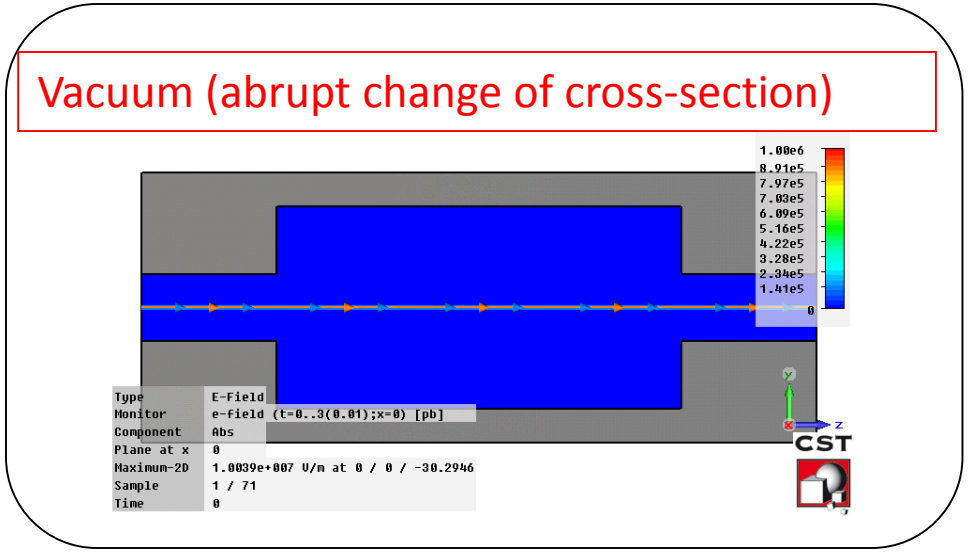
Examples of wakefields for different types of structures

Simulated beam of charged particles





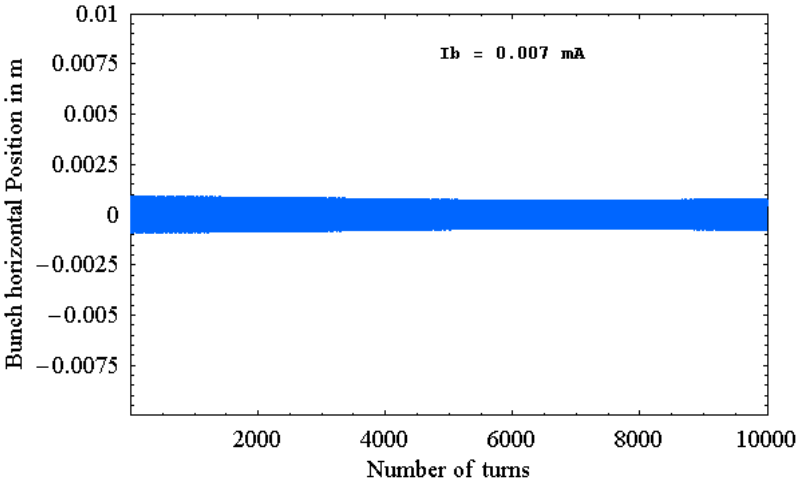




The material and the shape surrounding the beam strongly affects the EM fields

SPS with high currents: What do HEADTAIL simulations predict?

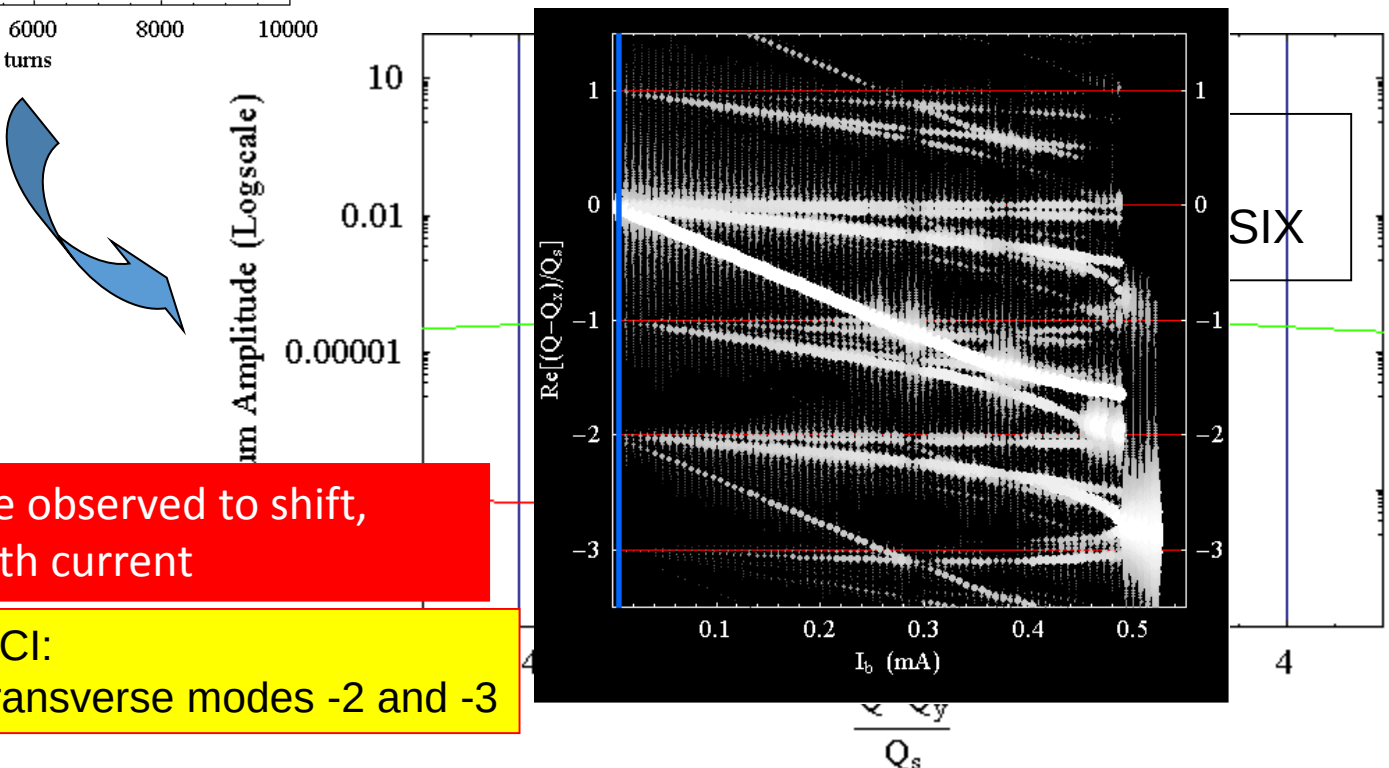
HEADTAIL simulated coherent
bunch transverse position at a BPM location



HEADTAIL simulation parameters:
- Broadband impedance
- Round beam pipe
- No space charge, no spread, no chromaticity
- Linear longitudinal restoring force

FFT
or
SUSSIX

HEADTAIL Simulated mode spectrum



→ Transverse modes are observed to shift, couple and decouple with current

HEADTAIL predicts a TMCI:
large coupling between transverse modes -2 and -3