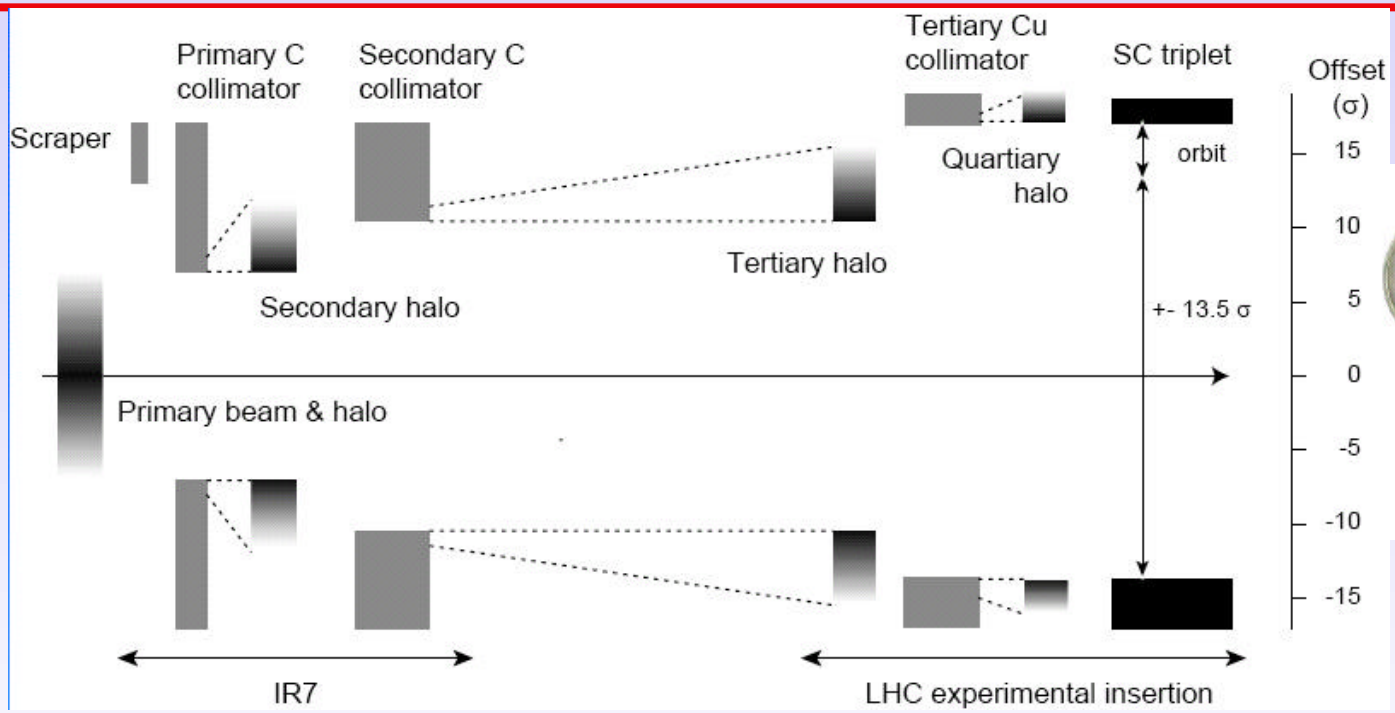
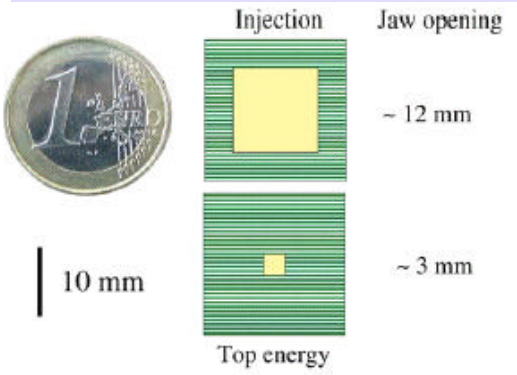
(One of the) LHC challenges

- Energy
  - 7 Tev = 7 * Tevatron
  - 27km = 4 * Tevatron
  - 8.3 T field = 2 * Tevatron
- Luminosity
  - 10^{34} = 300 * Tevatron (an issue but primarily a detector one !)
- Beam Power (a function of energy and luminosity)
  - 350 MJ = 200 * Tevatron (!!!)
    - Vacuum effects
    - Allowable beam losses - machine protection - operability - experimental backgrounds

LHC - machine protection





350 MJ of circulating beam energy: magnets will quench with mJ of deposited energy (11 orders of magnitude)

Problems involve limiting initial beam loss to 1 part in 10^5 with complex beam dynamics, alignment(absolute, relative, and dynamic) of many (~60) elements at fractions of a sigma, collimator damage, collimator impedance, amplifies the impact of any beam instability

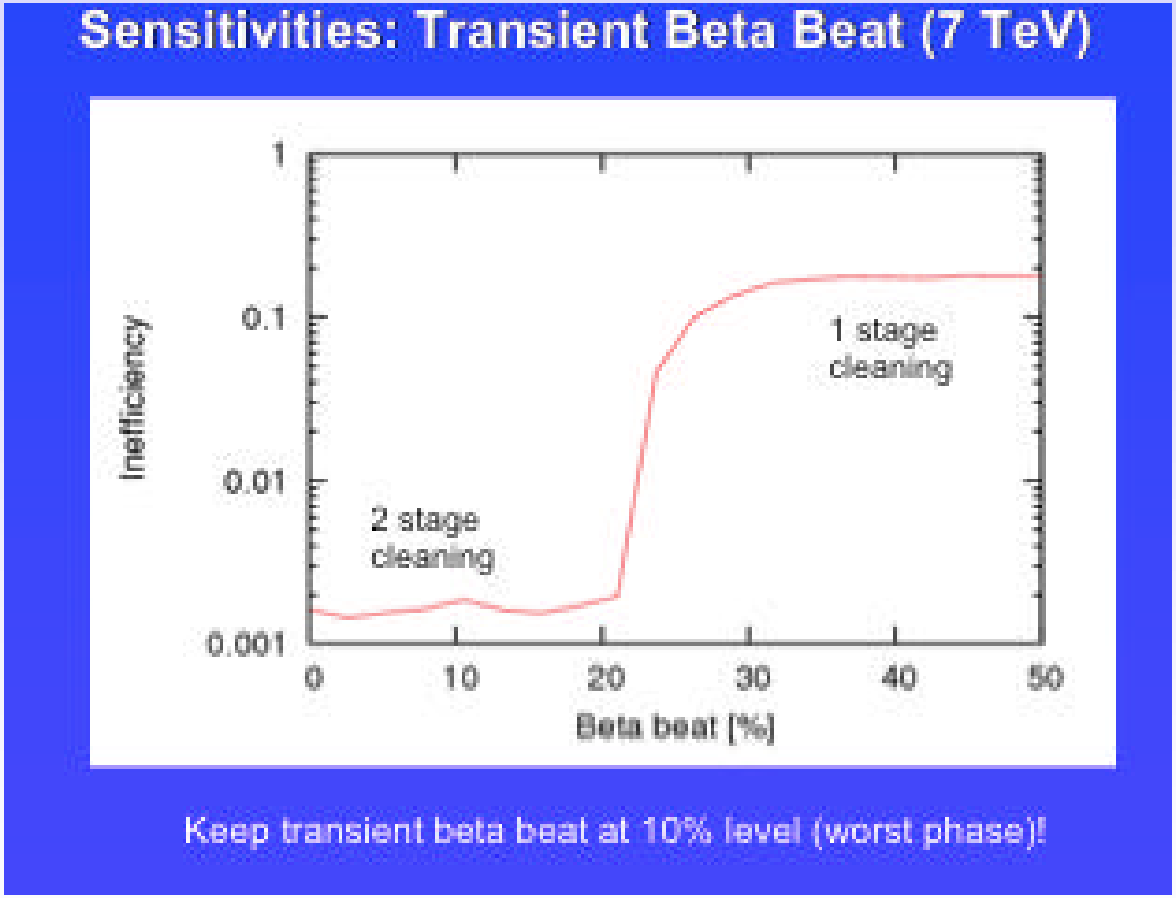
To date most machines operate with beam loss at the % level. What causes beam loss ?

Causes of beam losses

There is no reliable simulation of slow (millions of turns) beam loss mechanisms. There are some general rules of thumb which can be crudely approximated as “clean living”:

- Correct the optics
- Place the closed orbit in the right place and inject the beam on top of it.
- Maintain the closed orbit during dynamic effects (snapback, acceleration, squeeze)
- Place the tune in the right place and hold it constant
- Maintain chromatic tune spread small
- Maintain beam stability

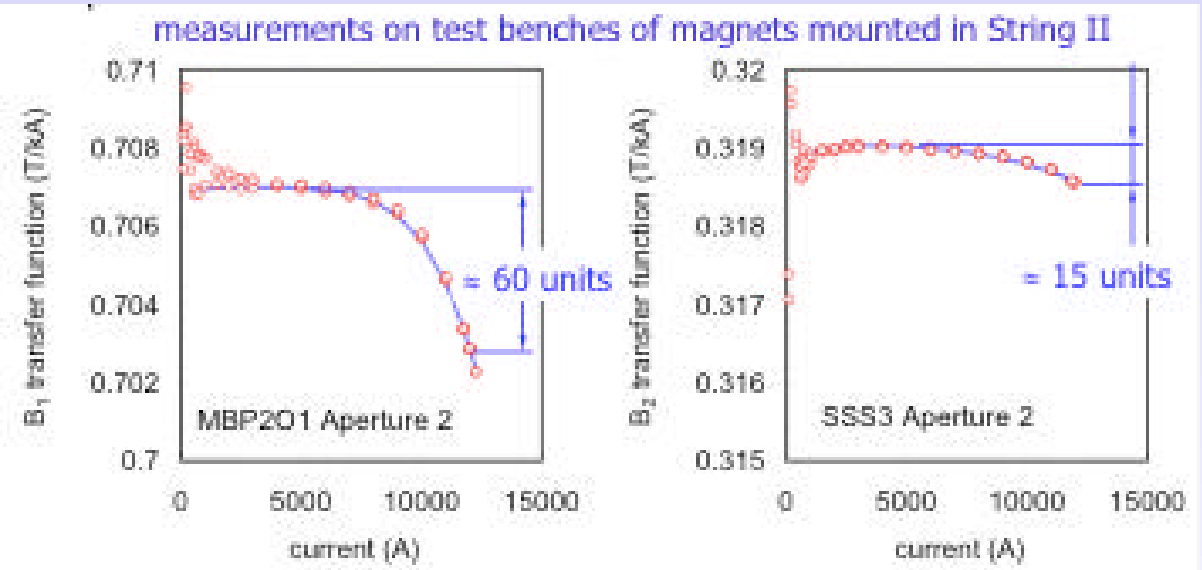
Collimation of beam losses



Collimation requires correct optics. How do we ensure these optics ?

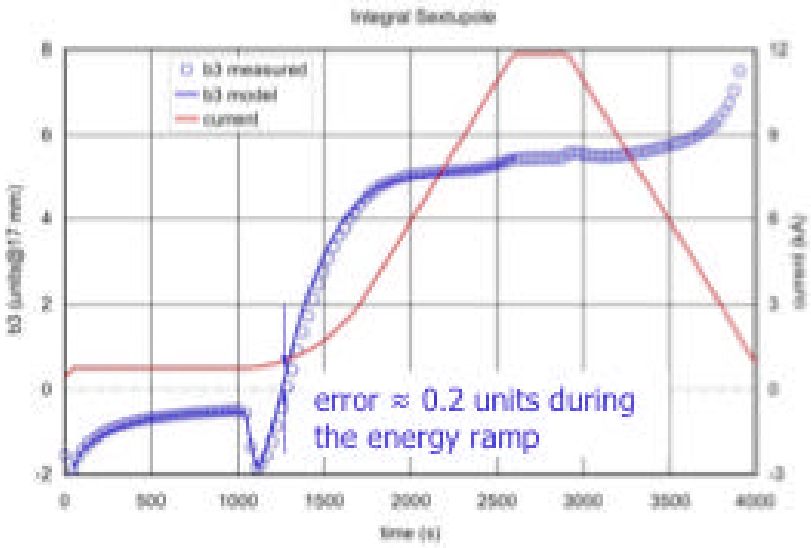
Diagnostics and instrumentation.

Dynamic effects

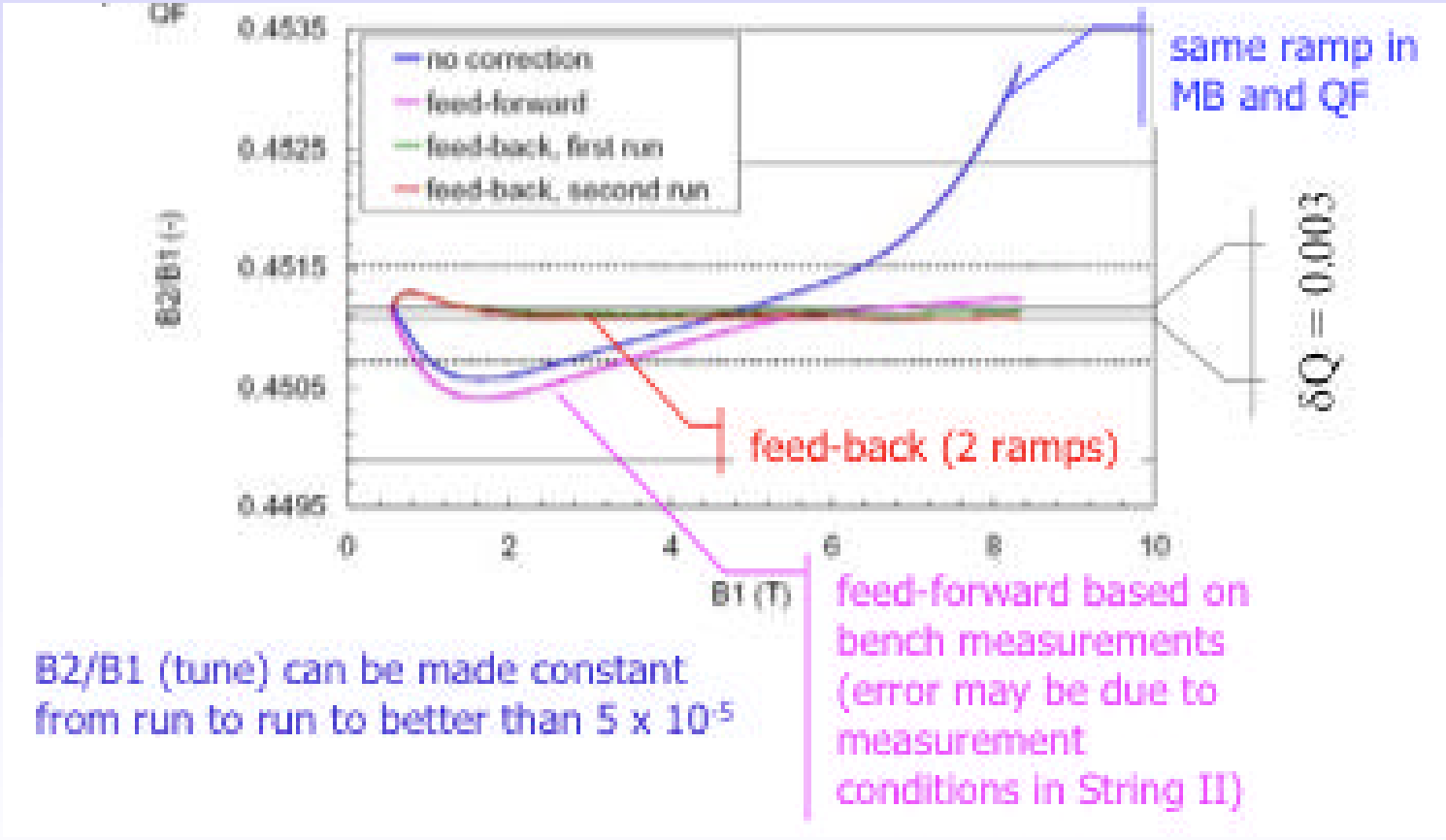


The saturation at high field is significantly different and must be compensated: feed-forward !

- Big ring, many magnets -> significant sensitivity

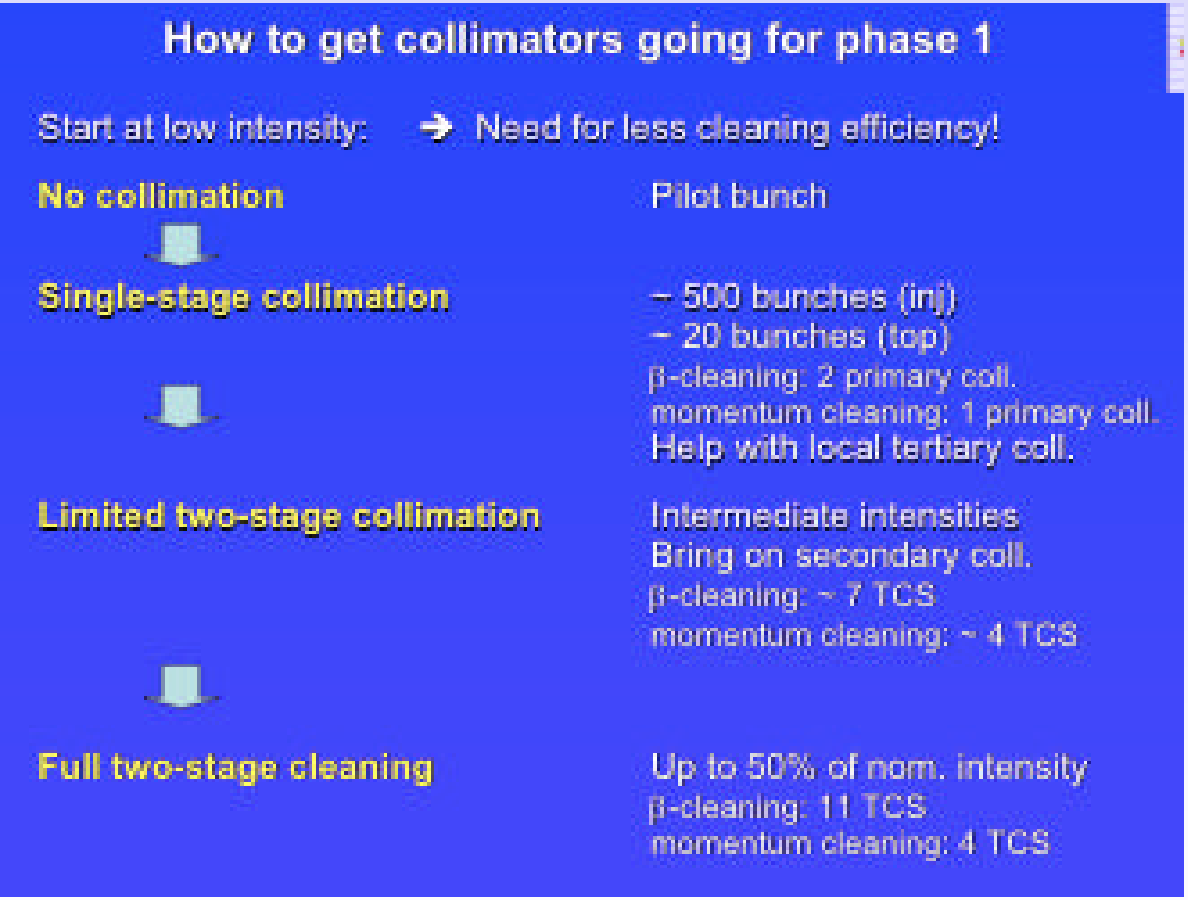


Popular myths - feed-forward will take care of everything



- Too many random effects to get the necessary precision for design luminosity

Operational Issues



Large dynamic range ~ 10e5: single bunch to full turn

Bunch by bunch discrimination

The machine protection system will be “twitchy” - diagnostics and instrumentation systems will need post mortem capabilities