

(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 !)

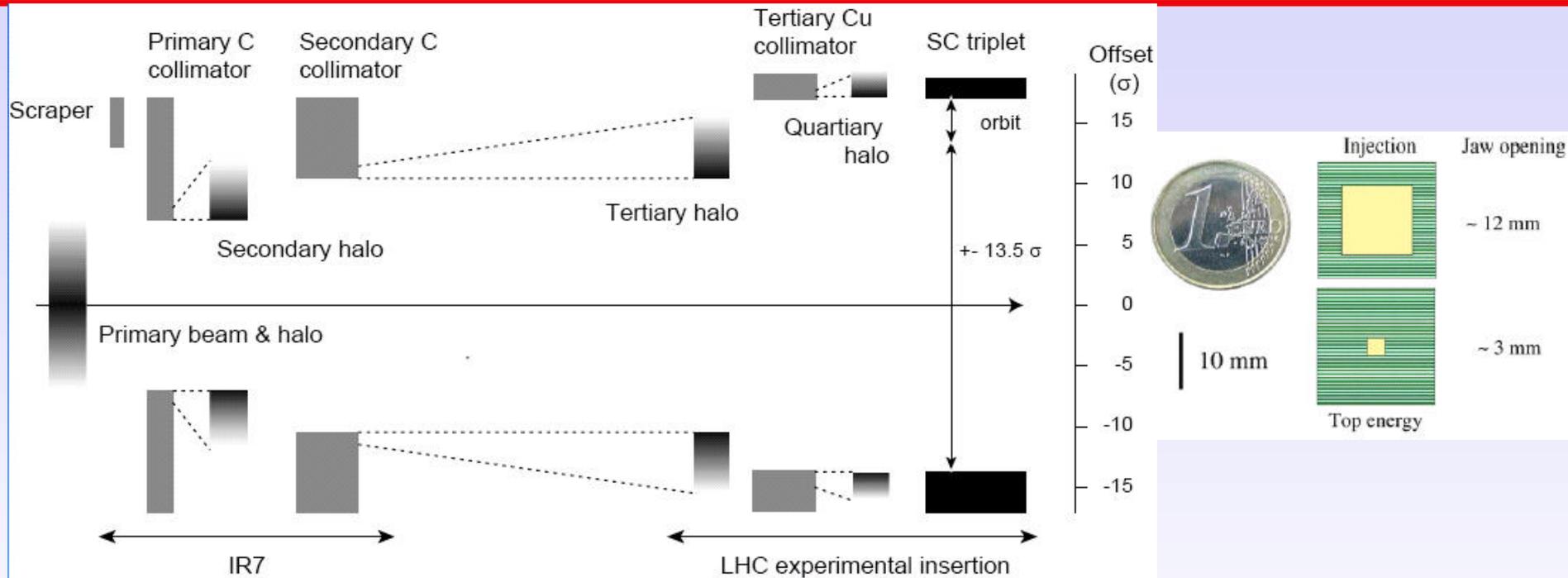
Beam Power (a function of energy and luminosity)

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)

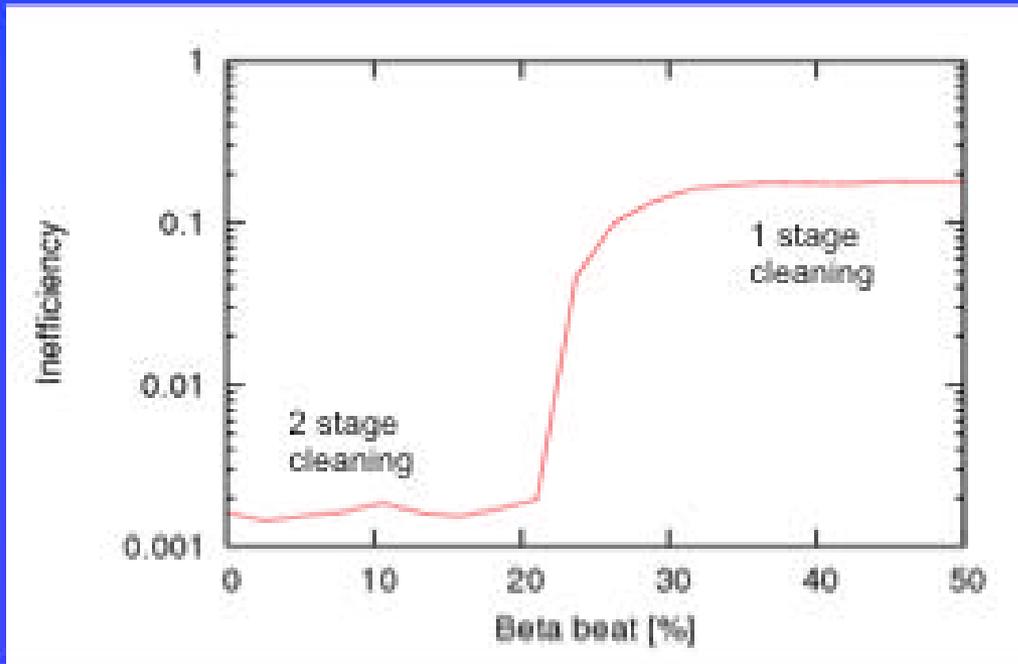
Place the tune in the right place and hold it constant

Maintain chromatic tune spread small

Maintain beam stability

Collimation of beam losses

Sensitivities: Transient Beta Beat (7 TeV)

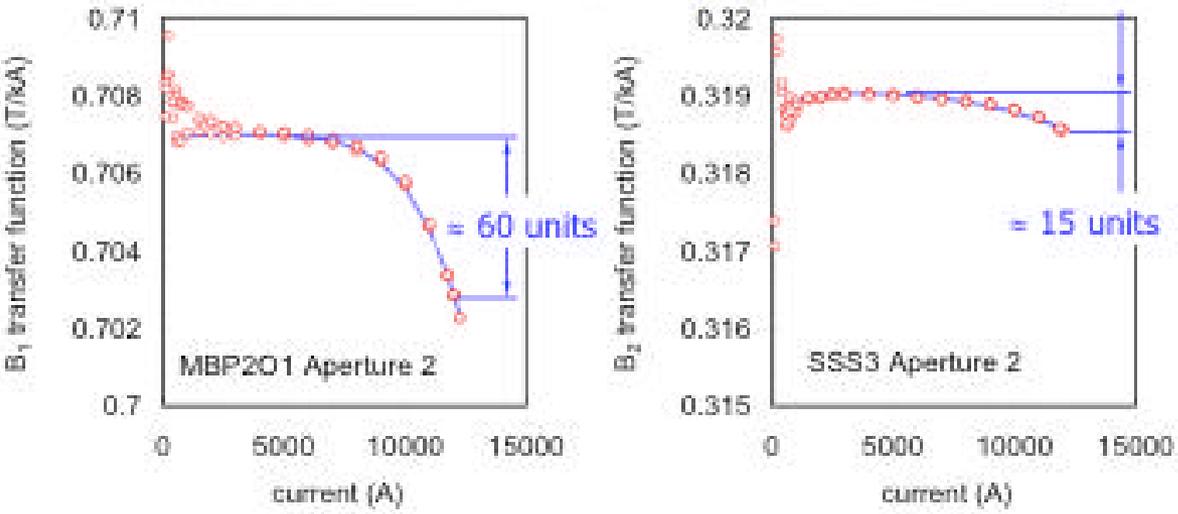


Keep transient beta beat at 10% level (worst phase)!

Collimation requires correct optics. How do we ensure these optics ?
Diagnostics and instrumentation.

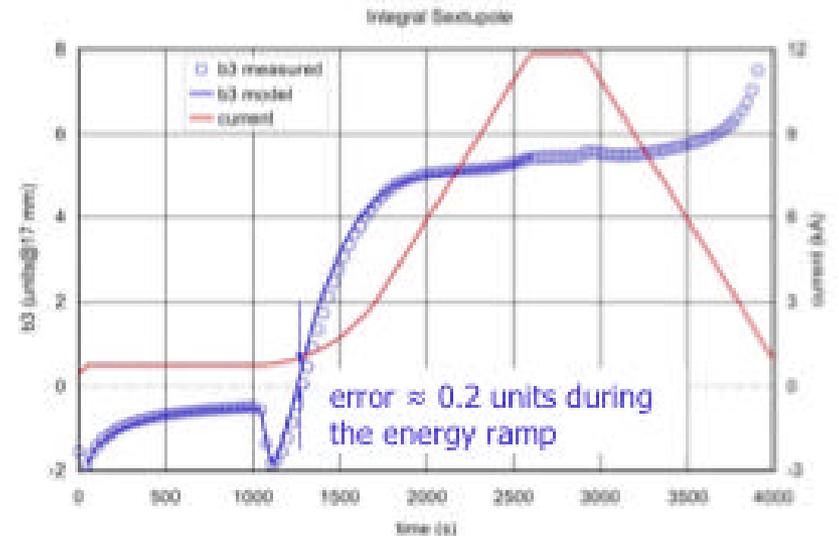
Dynamic effects

measurements on test benches of magnets mounted in String II

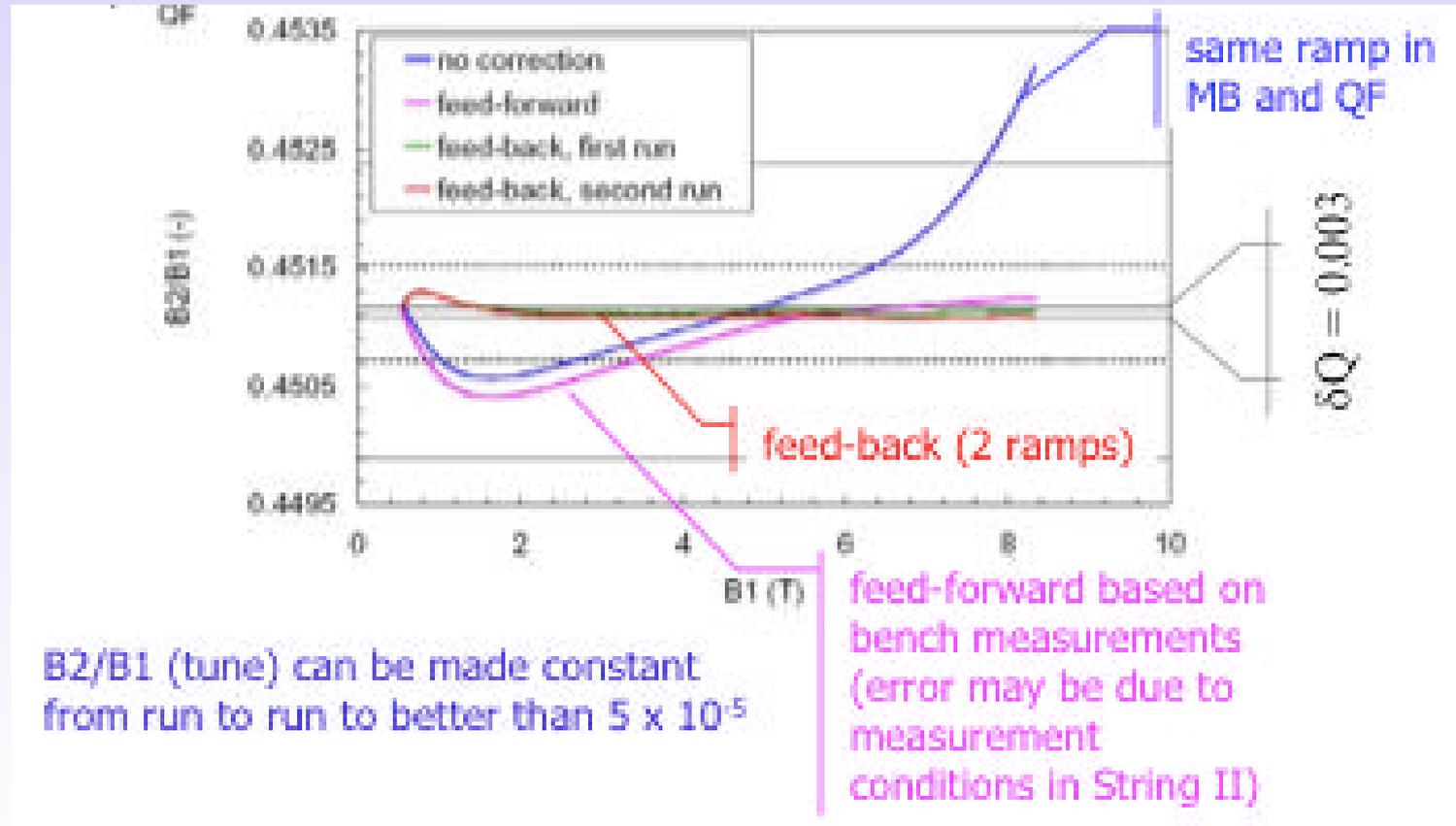


The saturation at high field is significantly different and must be compensated: feed-forward !

- 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

How to get collimators going for phase 1

Start at low intensity: → Need for less cleaning efficiency!

No collimation



Single-stage collimation



Limited two-stage collimation



Full two-stage cleaning

Pilot bunch

– 500 bunches (inj)
– 20 bunches (top)
β-cleaning: 2 primary coll.
momentum cleaning: 1 primary coll.
Help with local tertiary coll.

Intermediate intensities
Bring on secondary coll.
β-cleaning: ~ 7 TCS
momentum cleaning: ~ 4 TCS

Up to 50% of nom. intensity
β-cleaning: 11 TCS
momentum cleaning: 4 TCS

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