PS losses during CT extraction, a history about 30 year long...

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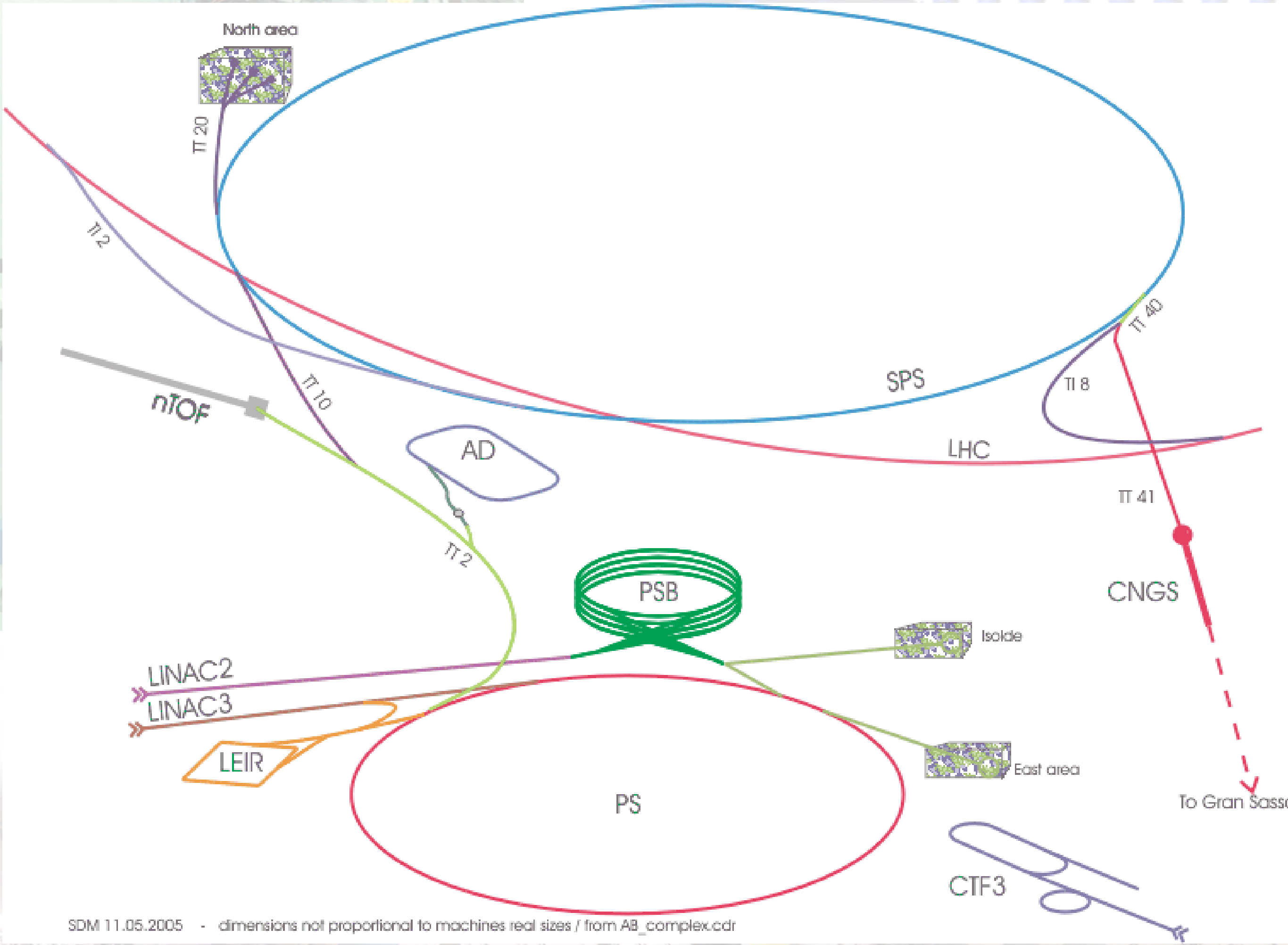
PS to SPS transfer: CT extraction



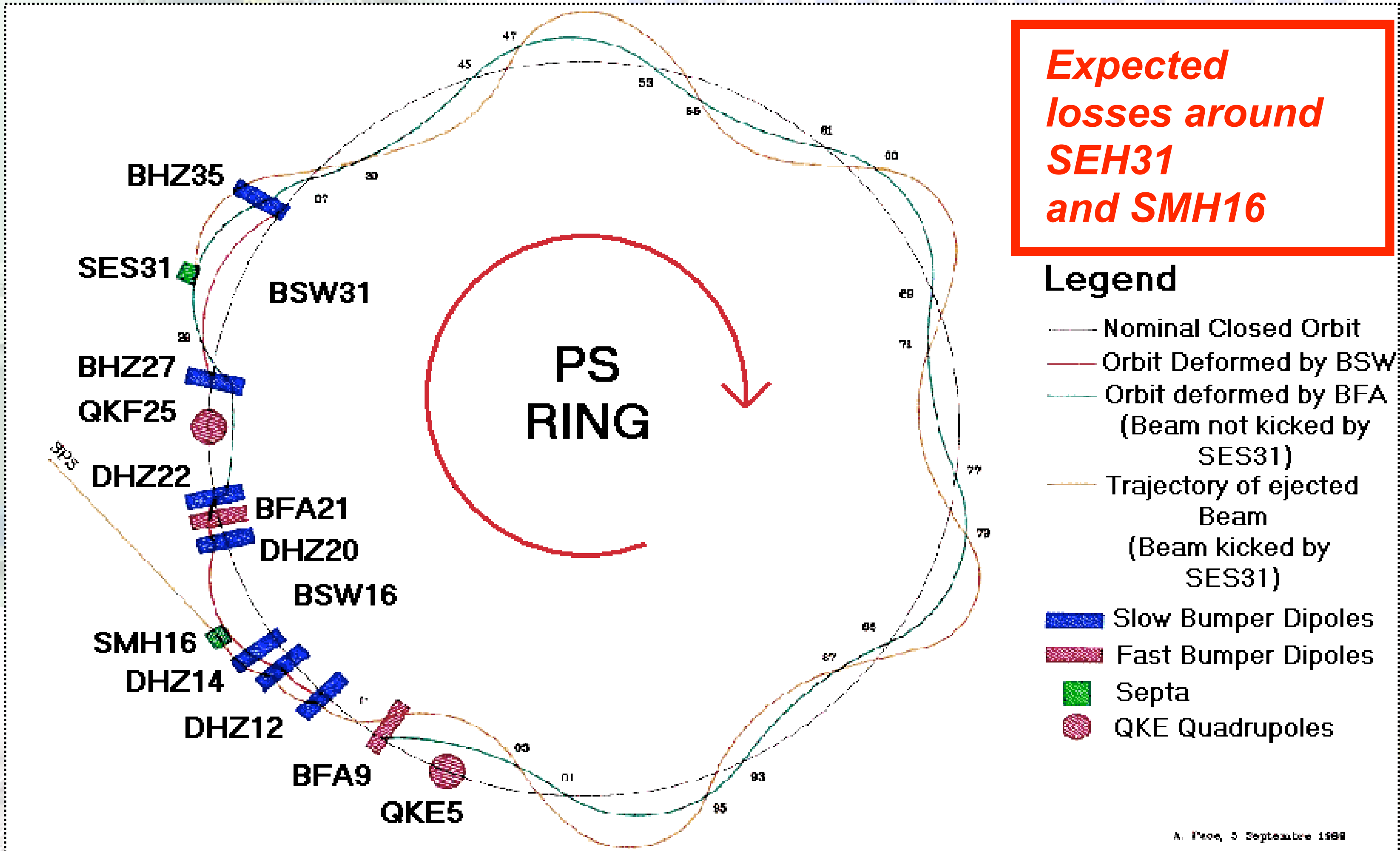
PS:
100 combined function magnets
FDDF lattice
100 Straight Sections (SS)
Radius: 100 m

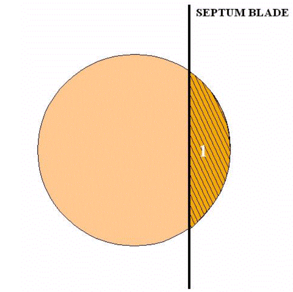
Large aperture: H about 15 cm
V about 7.5 cm

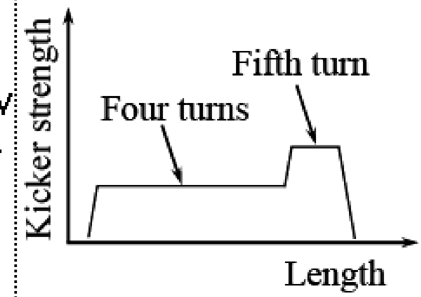
CT extraction: Continuous Transfer extraction to eject from the PS to the SPS in 5 turns.
Introduced first in 1978, before for 10 GeV/c extraction, today for 14 GeV/c. The most lossy extraction in the PS.

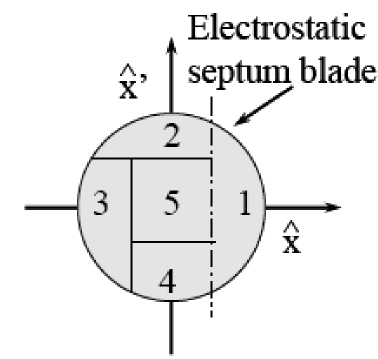
Element used during CT extraction

Expected losses around SEH31 and SMH16









Bump31 (BSW31) to send the beam near the septum 31, about 2 m long

BFA9-BFA21 fast kickers (5 turns) to send the beam above the septum 31

Septum31 (SEH31) to slice the beam during the 5 turns

QKE16(5-25) to increase the beta and reduce the dispersion to zero at the SEH31

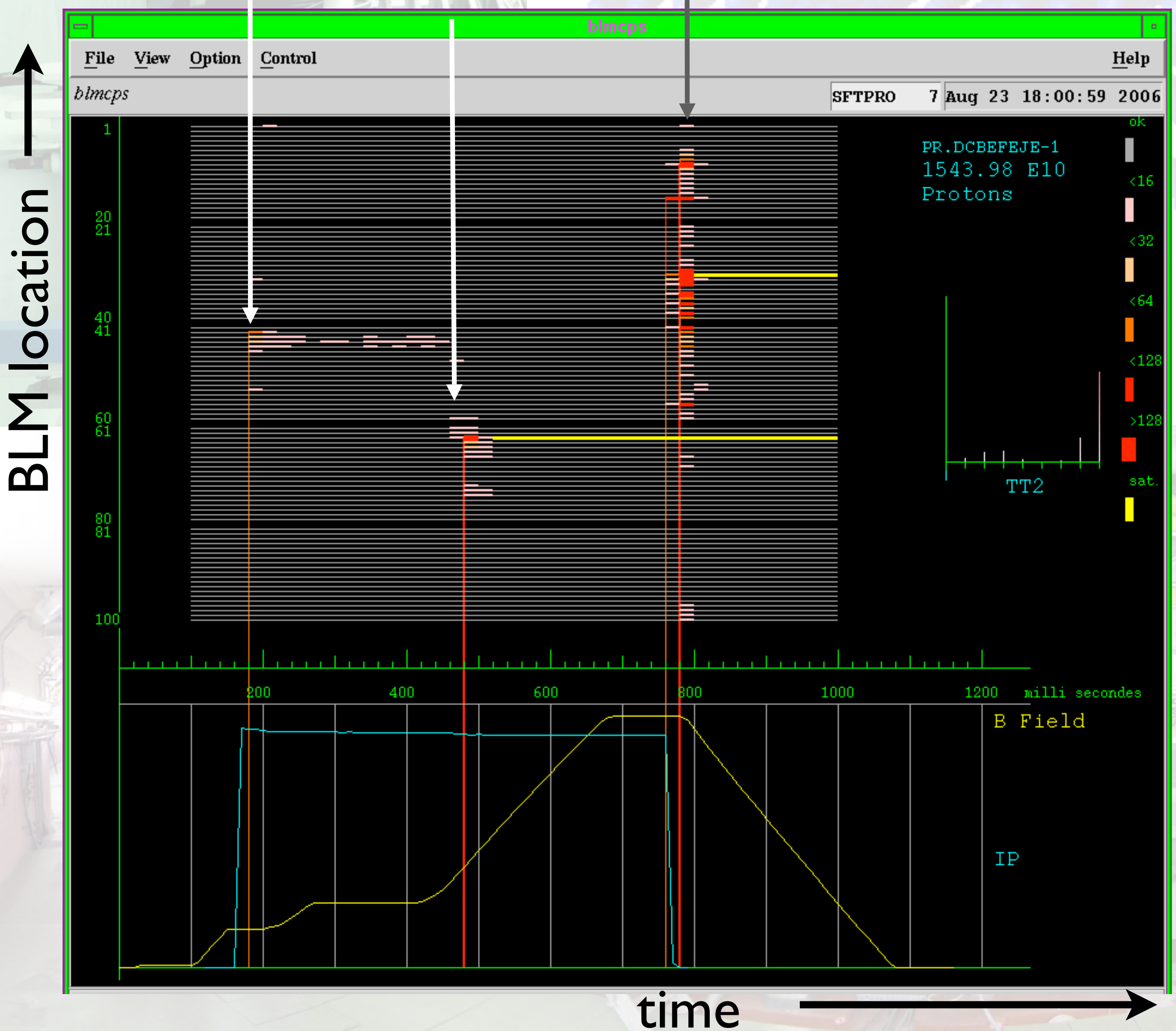
Bump16 (BSW16) to send the beam to SPS

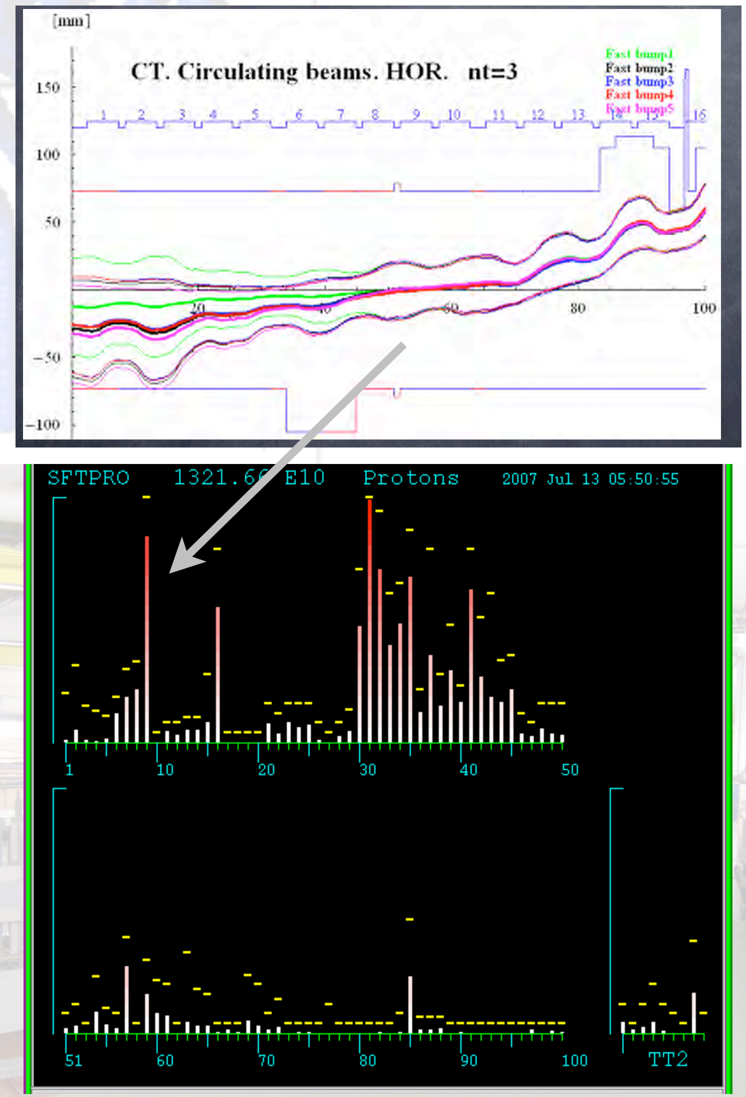
Septum16 (SMH16) extraction septum

Aims of the study: large losses in non expected SS

a) Understand losses during CT extraction

b) Develop and test simulation tools for losses evaluation and collimation design for synchrotrons at low energy (Ex. PS2)

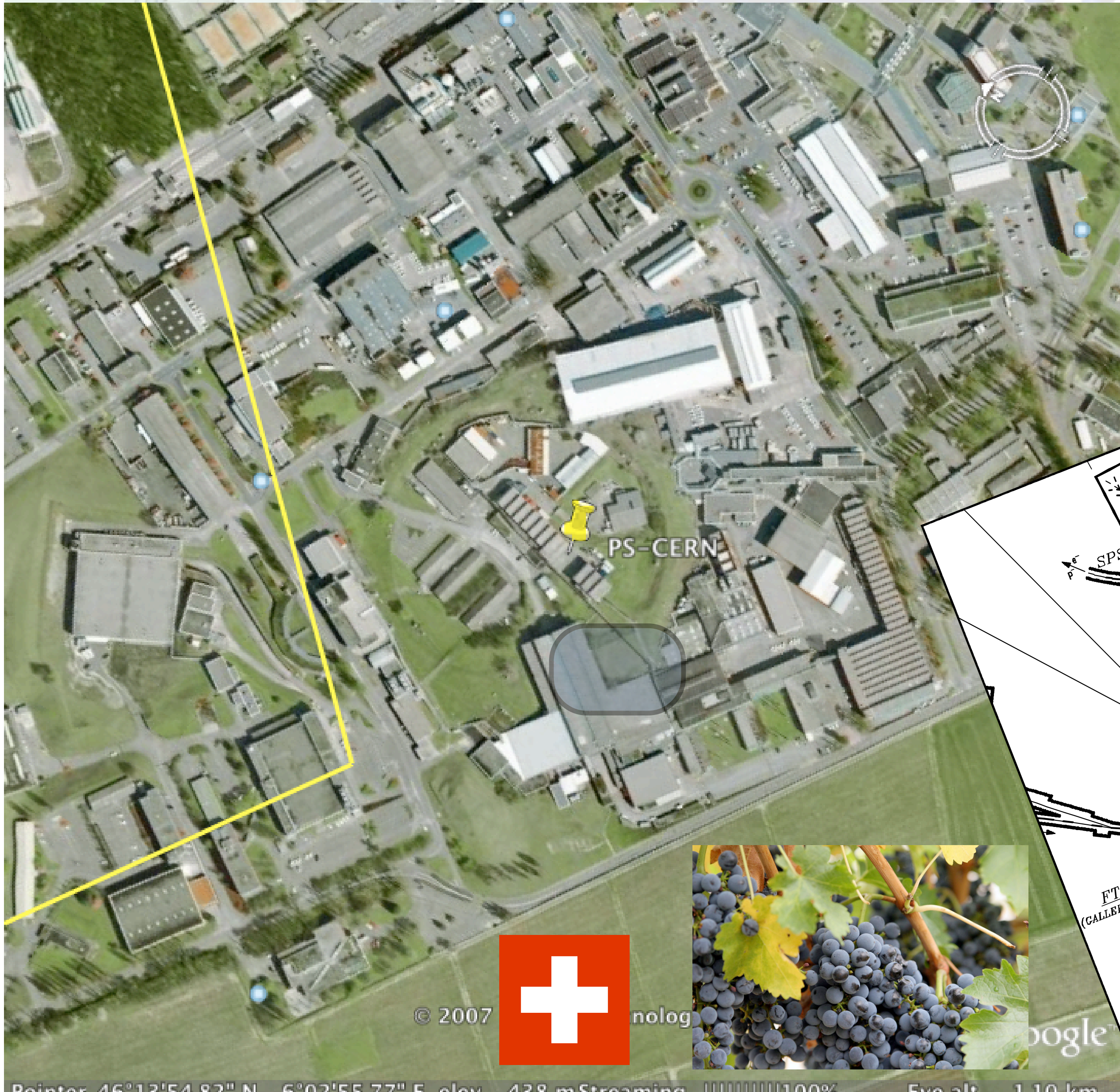


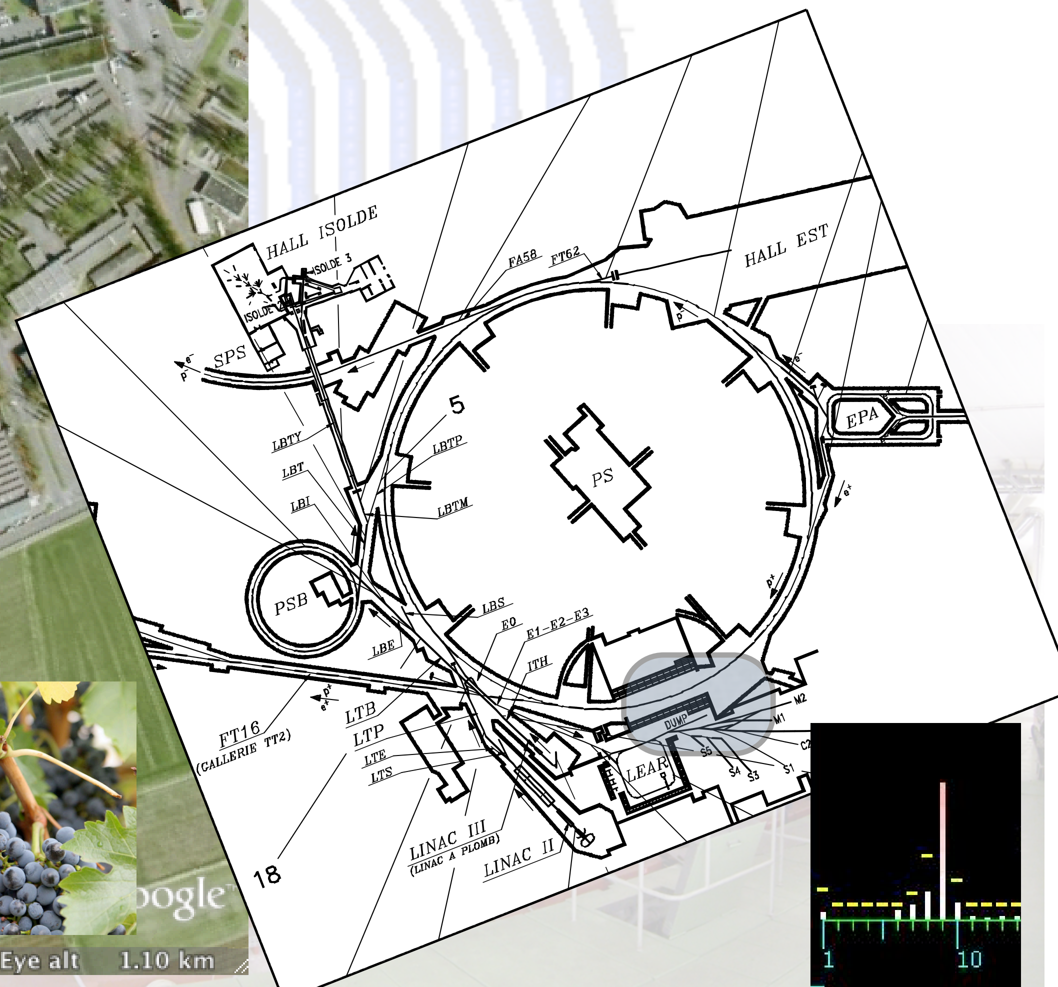


… and save the Suisse wine from irradiation

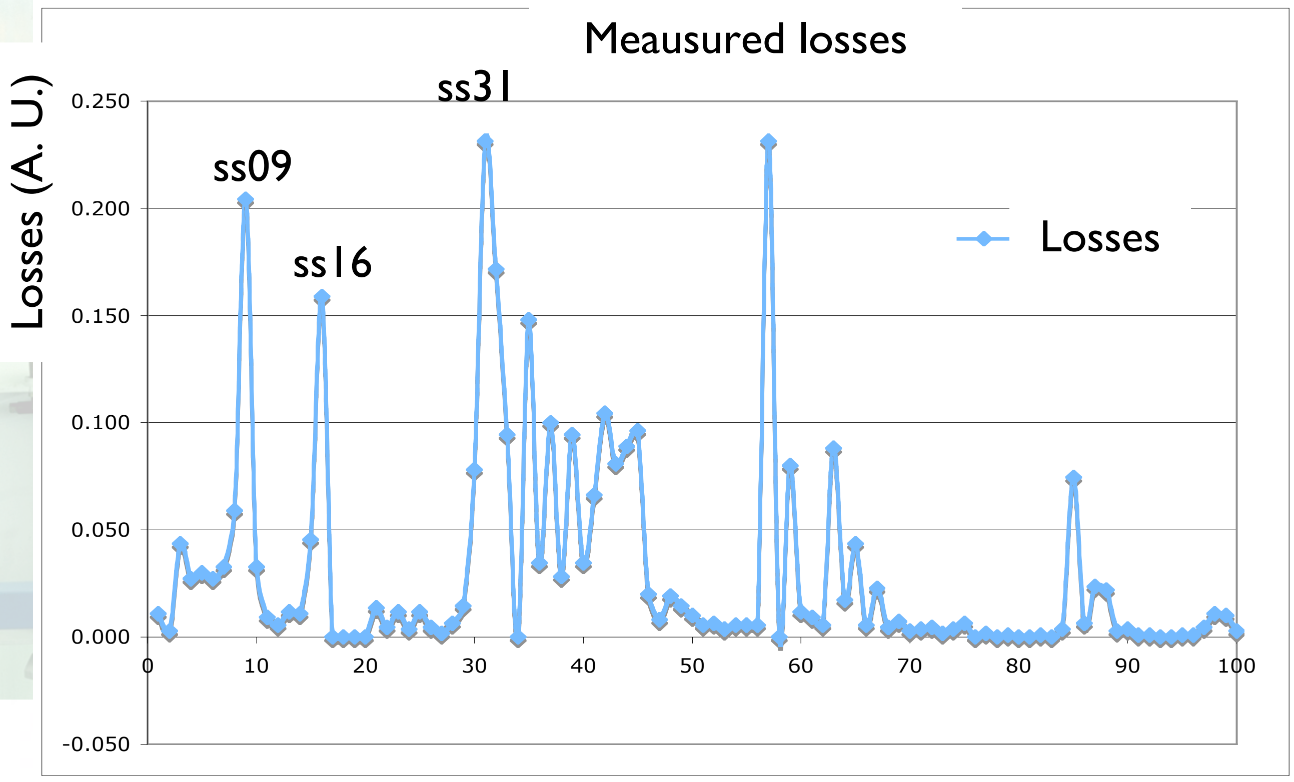
PS extraction main source to dose at the CERN site limits

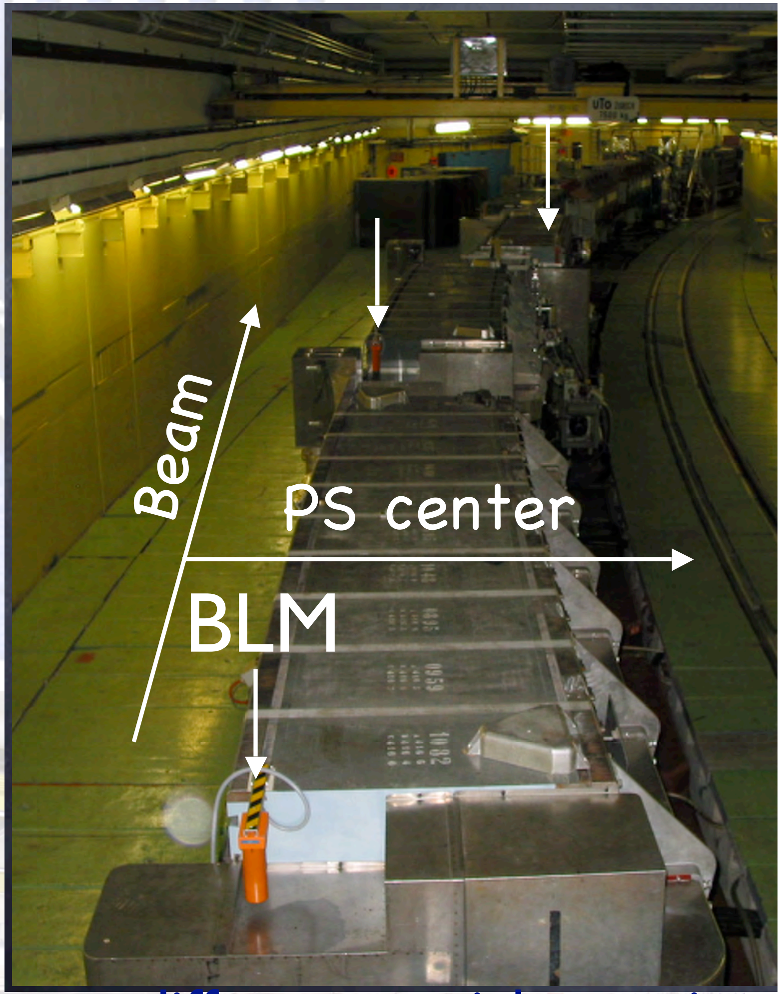
Tunnel built at ground level, not enough shielding in some locations





Observed loss pattern

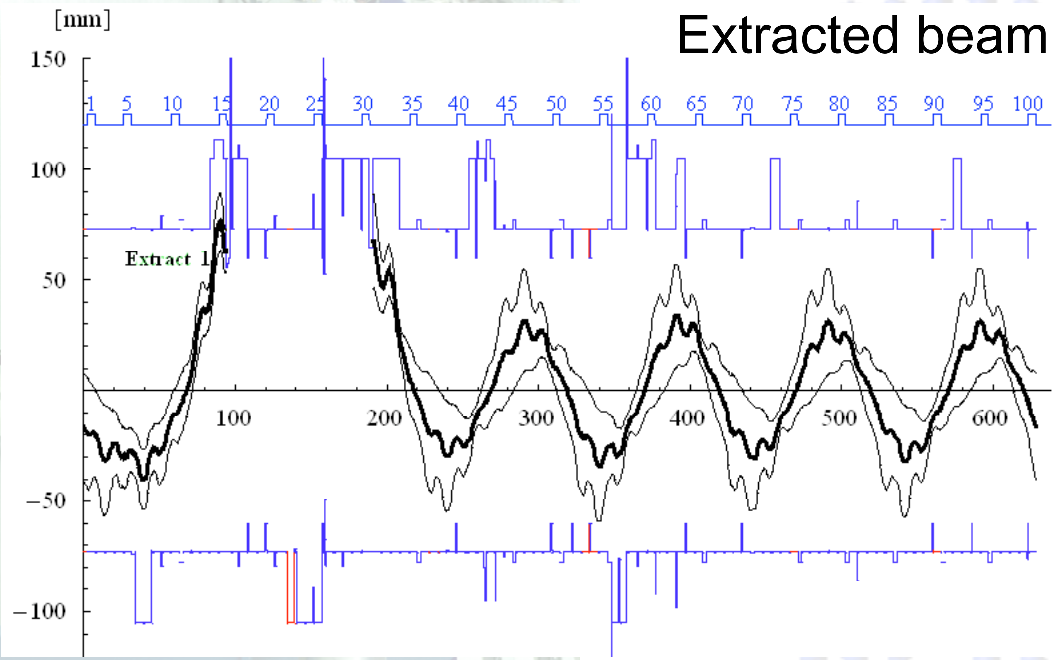




a) BLMs located at each main dipole, 100 BLMs
b) Not all the BLM have same installation location
c) Not possible to evaluate the ratio of losses between different straight section wrt the ratio of the BLM signals

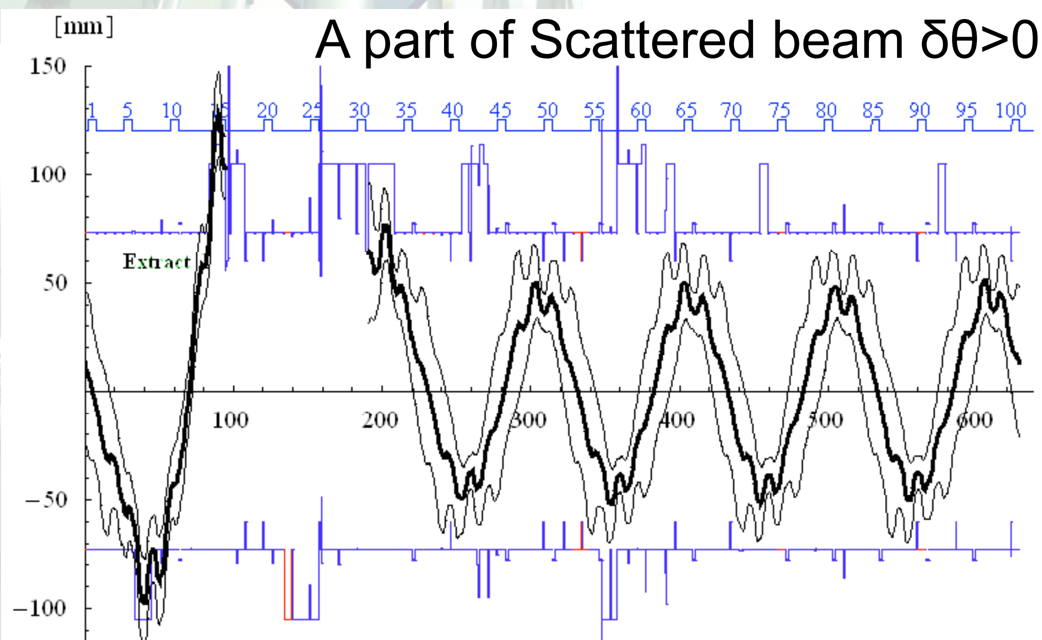
Hp: Pattern identified as produced by particles interacting the septum located in SS31

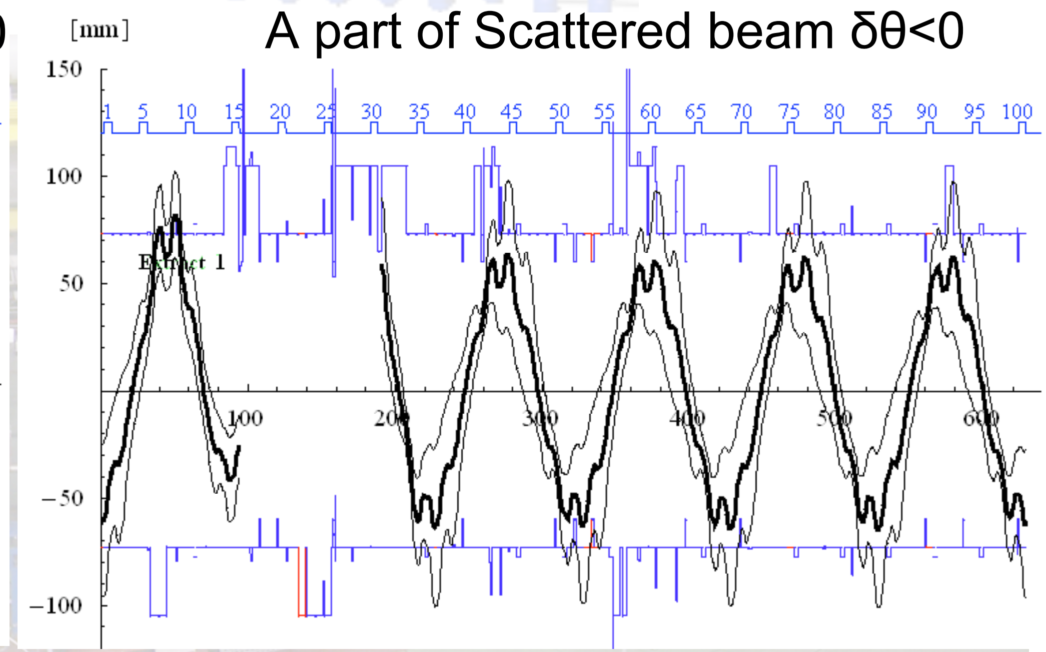
CT extraction losses in non expected sections



Mechanism generating the loss: particles interacting with the ~ 200 µm thick Mb septum blade are then defocused by the quadrupole in SS5.

Tool needed to simulate particle interaction with the septum blande and precise tracking on 5 turns for particles with large momentum deviation and large angle





Simulation strategy

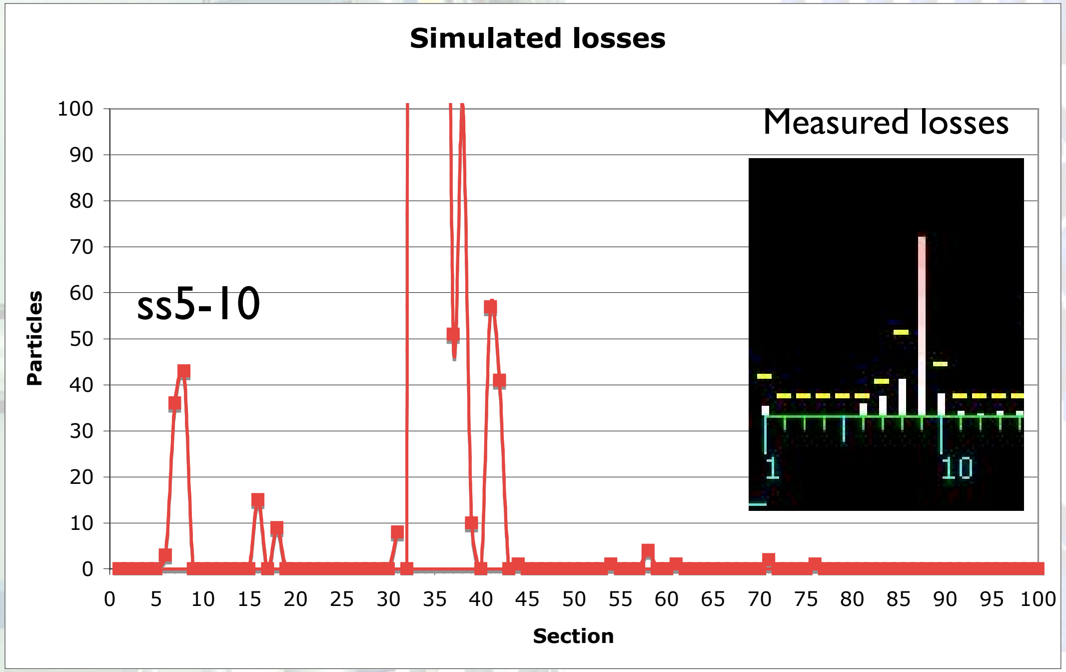
a) Fast approach:

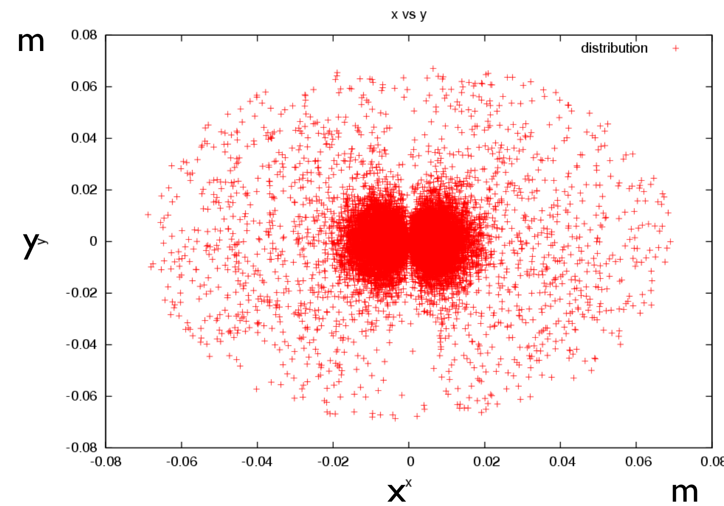
- Use MADX tracking taking an external particle distribution
- MARS (Monte Carlo) as external particle generator

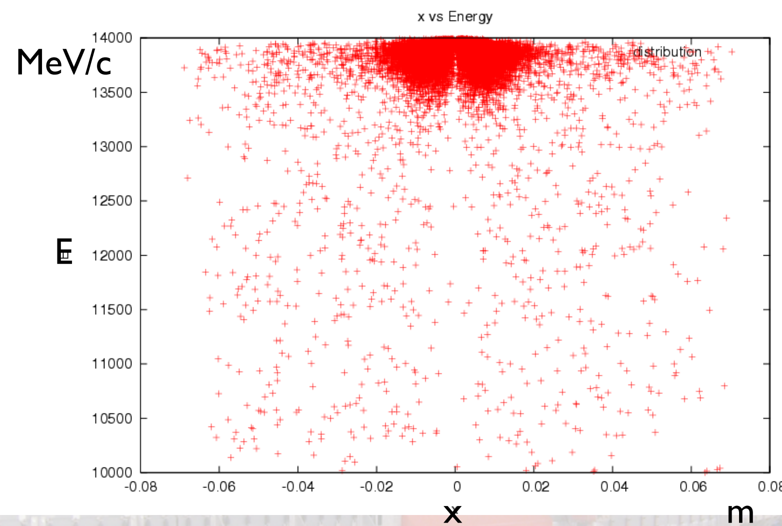
b) More refined approach, LHC style:

- adapt LHC-like collimation study tools for loss pattern evaluation
  - SIXTRACK + K2 + eternal program for aperture mode
  - Procedure: A bunch of particles is tracked through a thin lens lattice (generated by MADX), undergo scattering processes in the collimator (K2) and, finally loss locations are determined by means of an external program and the aperture model. Thin lens model: High order terms of edge effects are not symplectic in thin lens. Thin multipoles were included and tune and chromaticity matching were performed.
  - K2: Scattering processes revised for low energies.

Simulation: Simplified approach



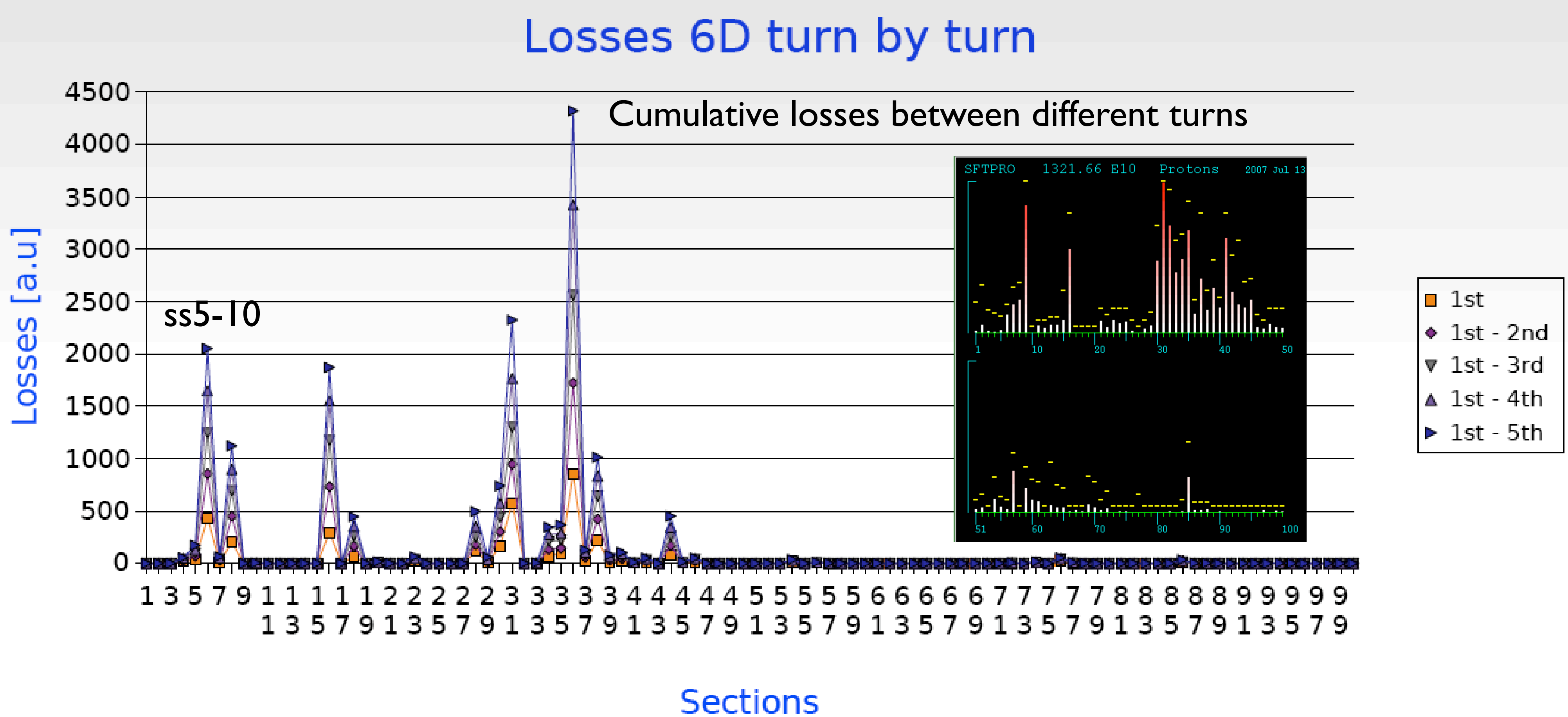




Simulation implemented to understand if the loss pattern observed can be produced by secondary or scattered particles. Only slow bumps.

Simulation includes:
a) particle interaction on the septum blade (MARS)
b) tracking with nominal optics with a crude aperture model (MAD8)
c) Main limitations: too low statistics, no multi-passage effects included

“LHC style” approach: Sixtrack + K2



a) Different optics for each turn: different fast bumps

b) Septum element implemented both for material as for kick, multi-turn re-interaction taken into account

c) Detailed aperture model

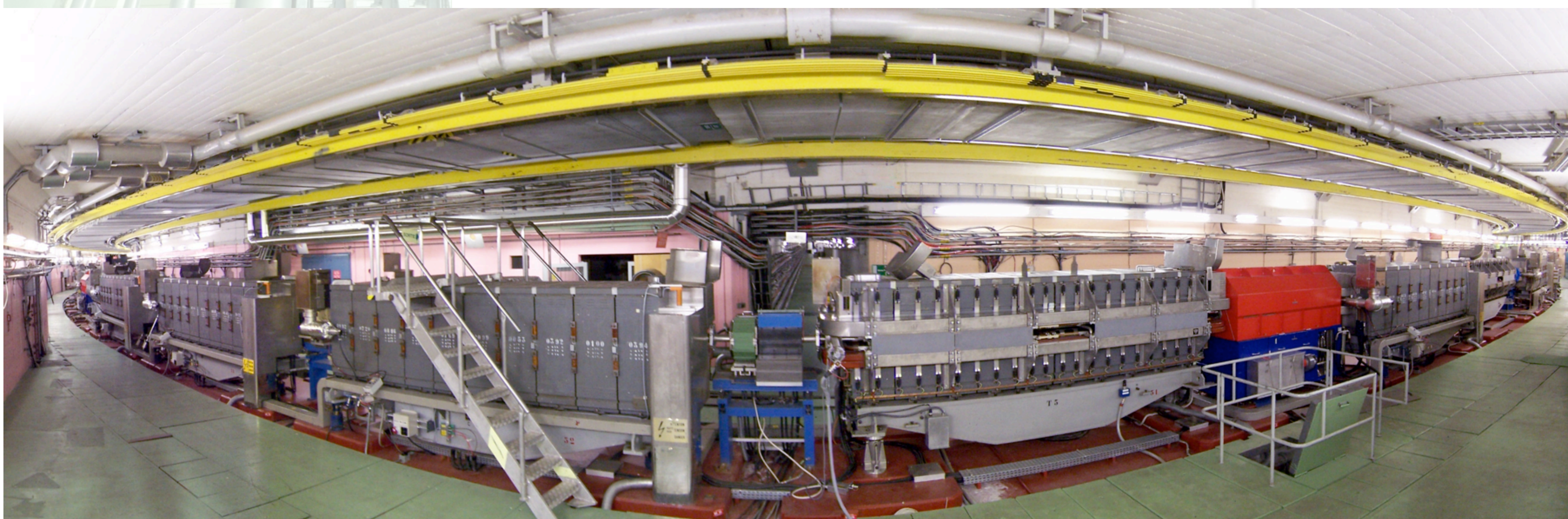
d) Not included: 1) other septa, 2) large dp/p particles > 1%

BLMs location

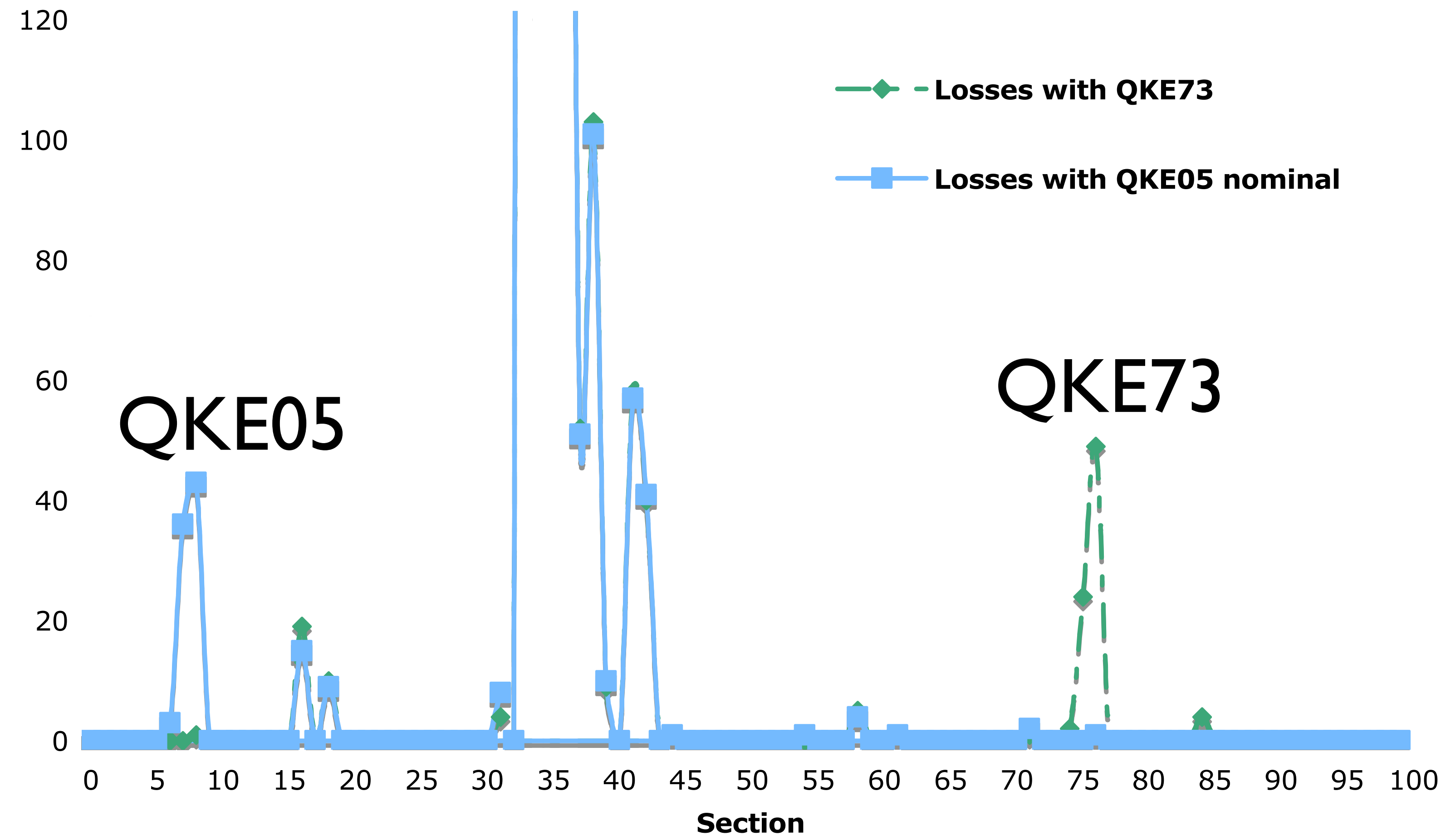
BLMs are installed on top of the magnet at the end of the SS:

a loss in the magnet n will be seen by the BLM n+1.

Simulated losses in SS n can be seen by BLM n+1.
(Shower not included)



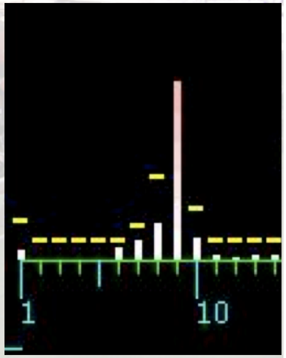
“Cleaning” by moving the QKE05 in SS73, simplified case



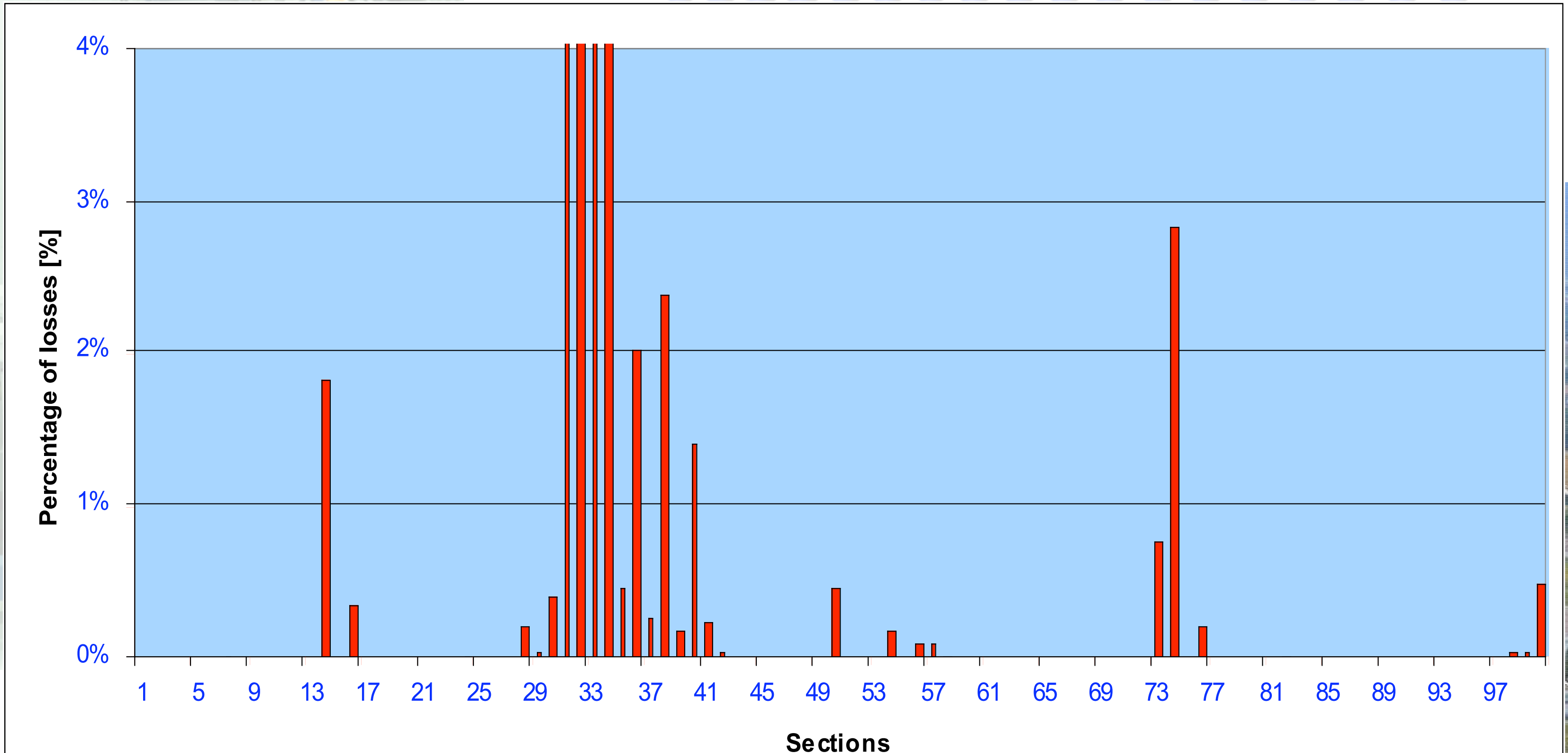
Losses simulated only with slow bumps plus the QKE effect

Simulated losses move with the position of the QKE

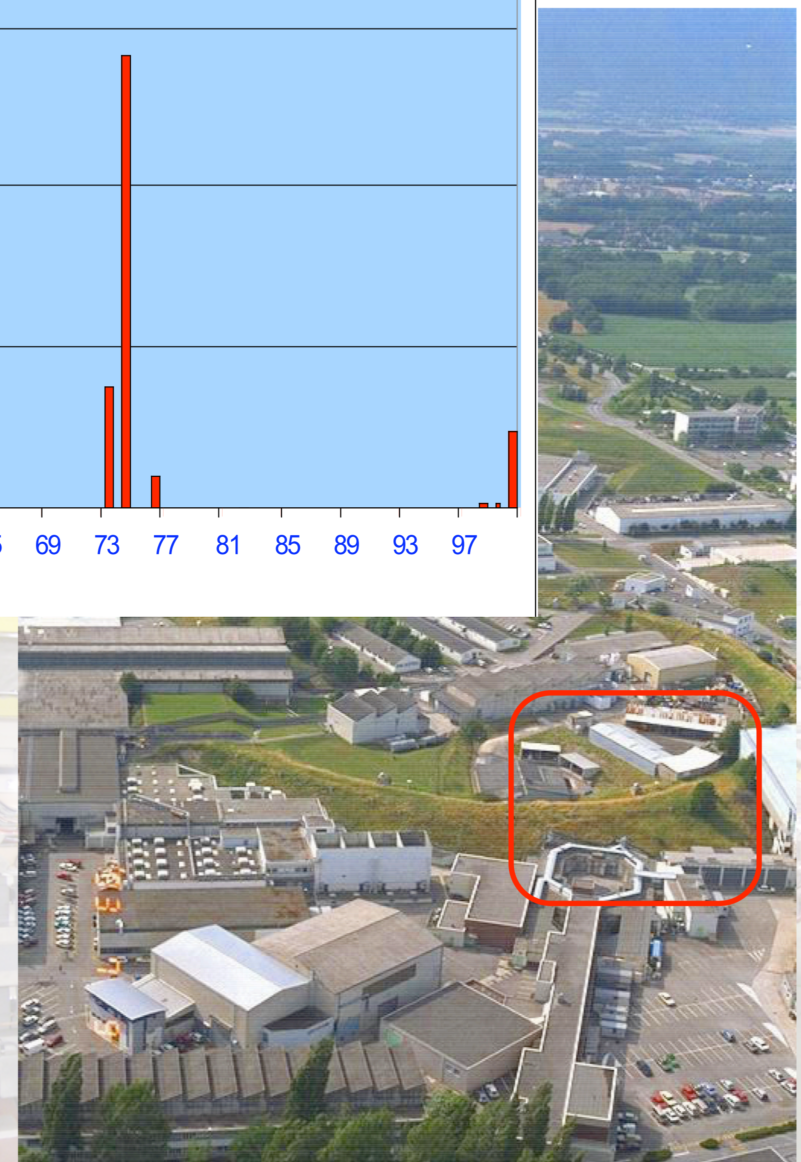
We can save the grapes and *irradiate inside the CERN site since the losses cannot be avoided due to matter interaction*



Moving the losses around with Sixtrack

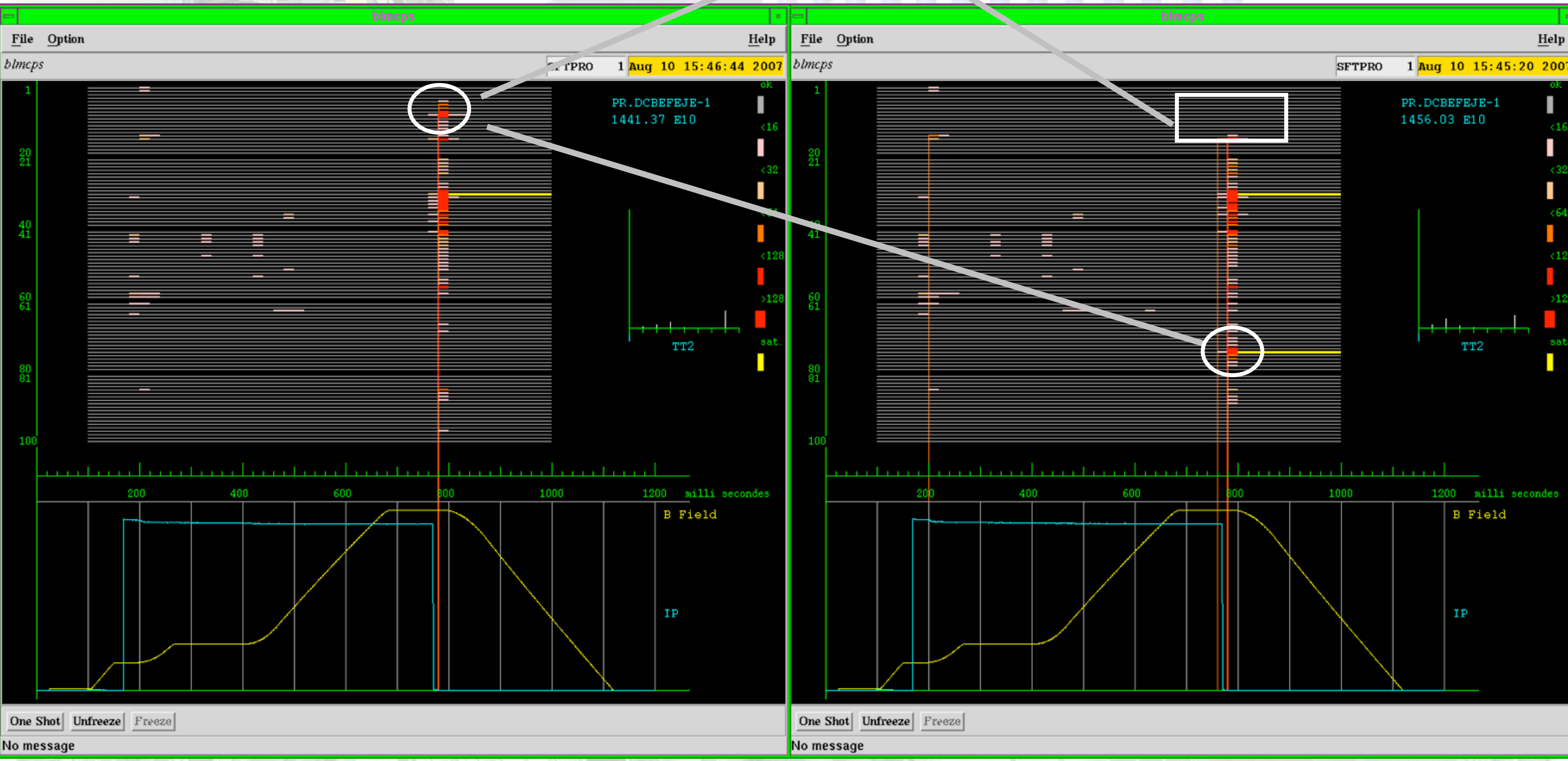


Simulations are consistent: moving the quadrupole in SS05 should set losses to zero in that zone and move them entirely in SS73-77



Current losses situation - Aug. 07

CT extraction losses



Experimental proof:
Losses moving with the quadrupole

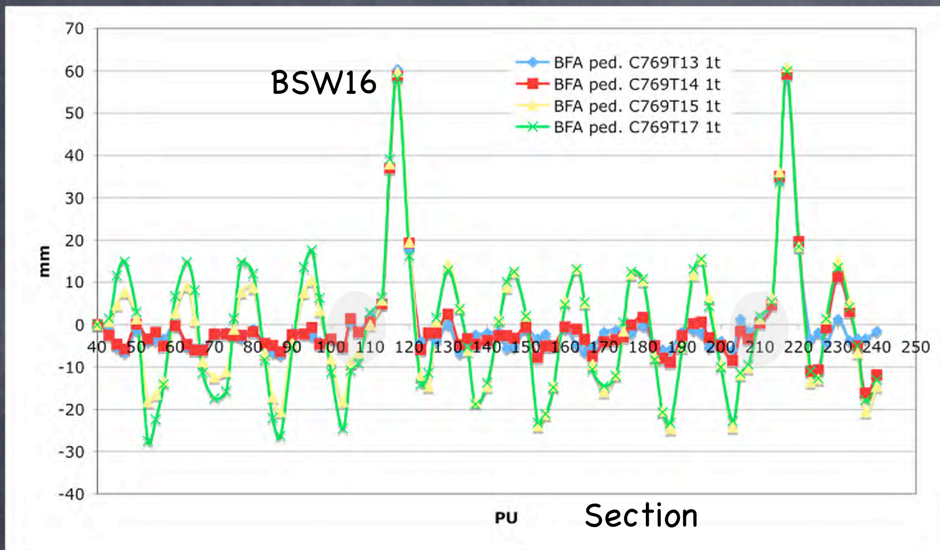
Conclusions

- Losses during CT extraction are generated by the interaction with the electrostatic septum used to slice the beam in 5 turns.
- Losses cannot be avoided but only displaced
- Simulations and experiments confirm the mechanism of losses and the loss pattern observed
- New simulation tools developed using Sixtrack+K2 adapted to low energy synchrotron plus the proper aperture model shows to be suitable for the study of the mentioned losses

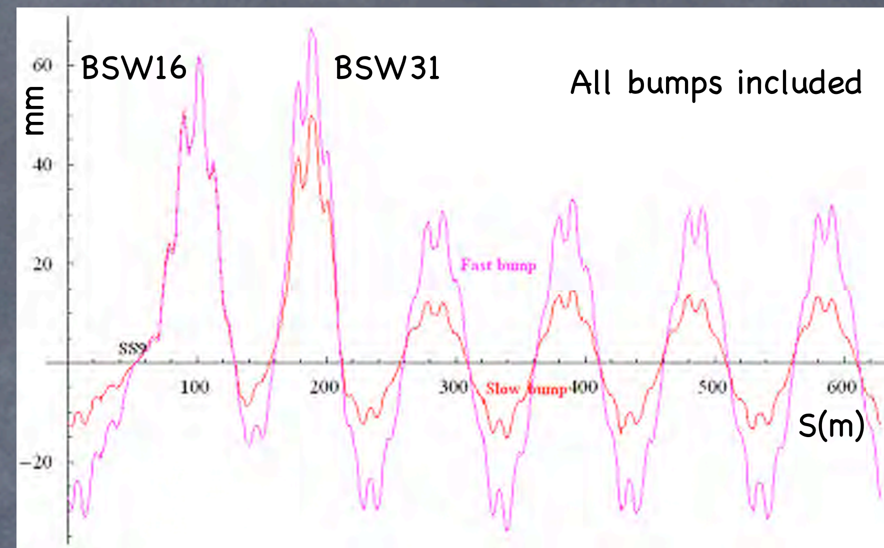
- spares...

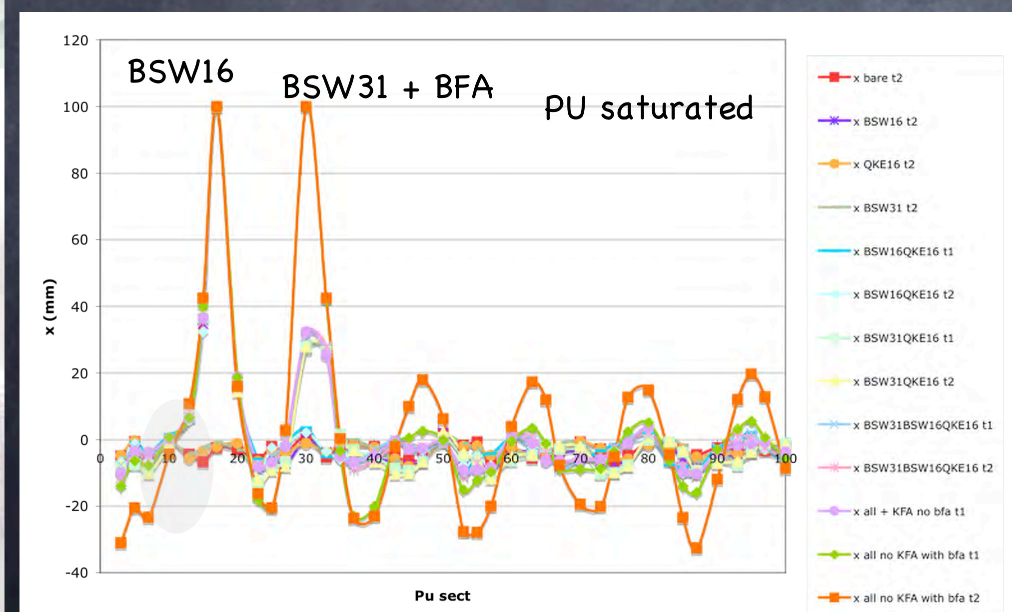
The losses is coming from an unwanted orbit distortion ?

Measured: only BSW16 and BFA pedestal

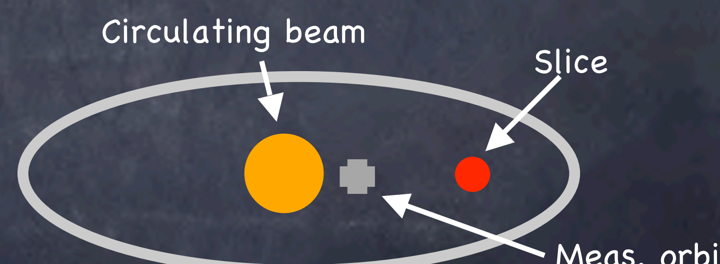


Th. Orbit (O. Berrig)

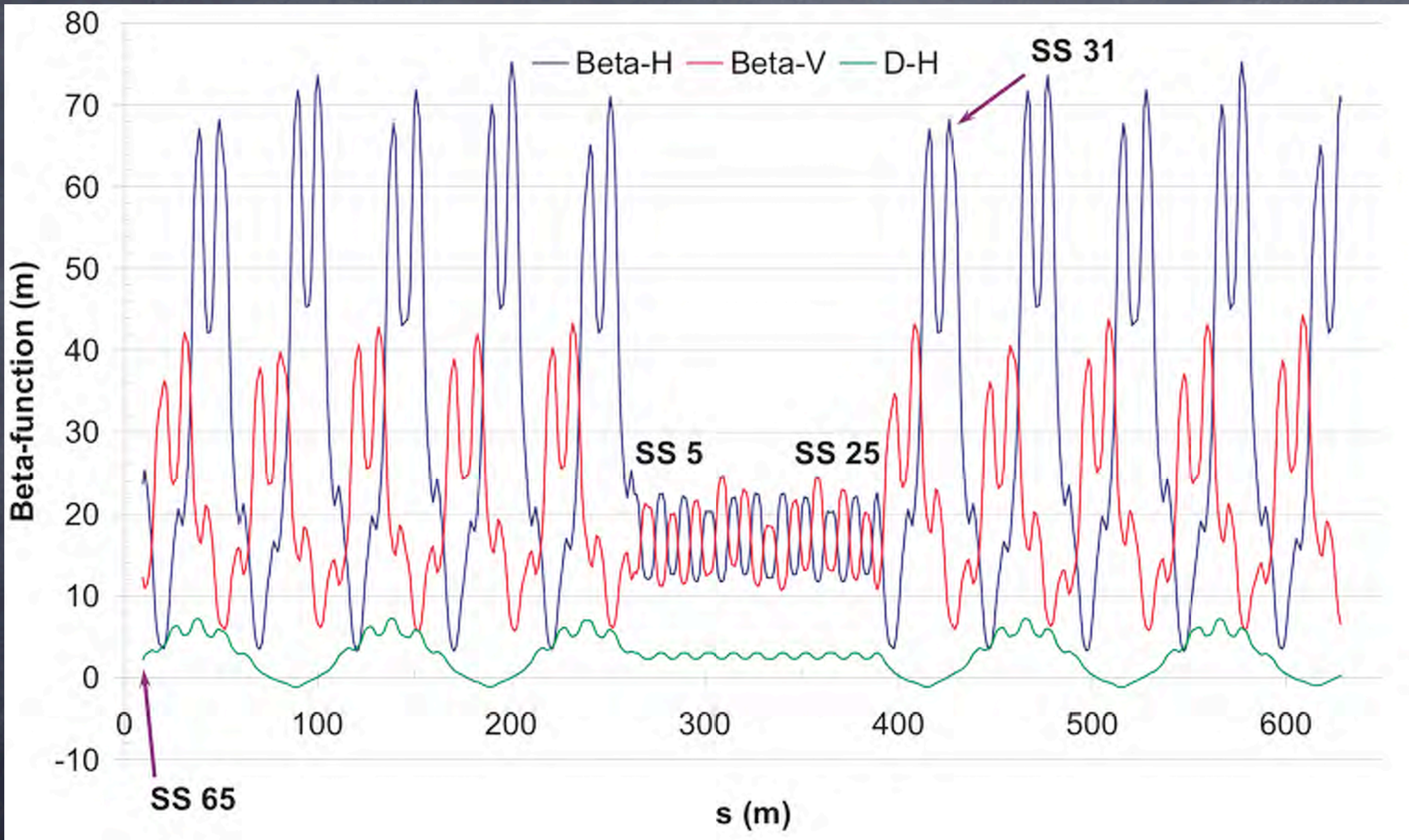




Answer: <u>no evident discrepancy with expected trajectory found. Only concern (from O. Berrig): orbit measurements might be affected by the beam slicing.</u>

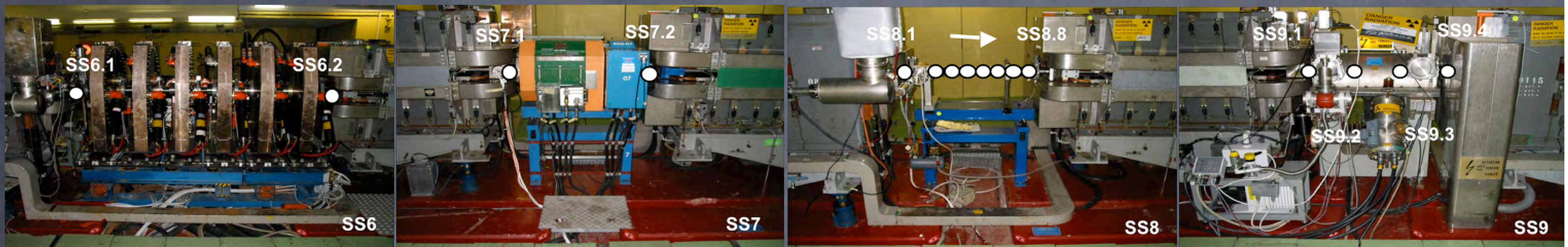


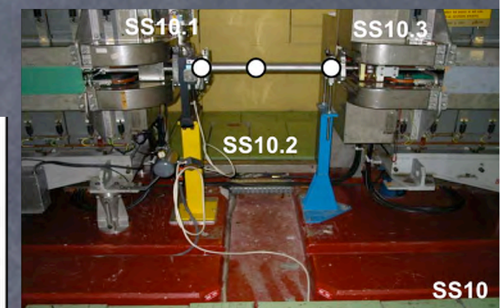
CT theoretical optics



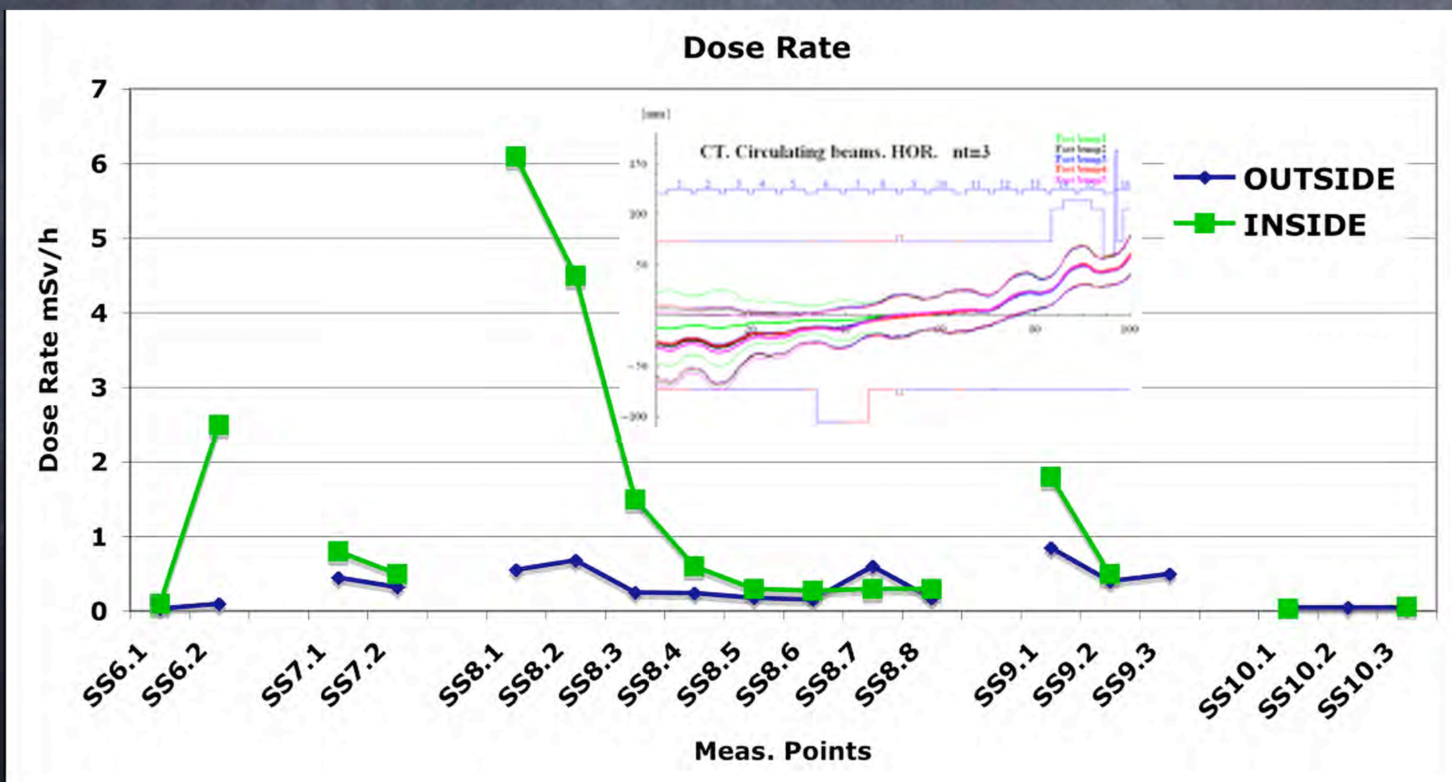
From MTE Design report

The losses in SS9 follow the nominal CT orbit?





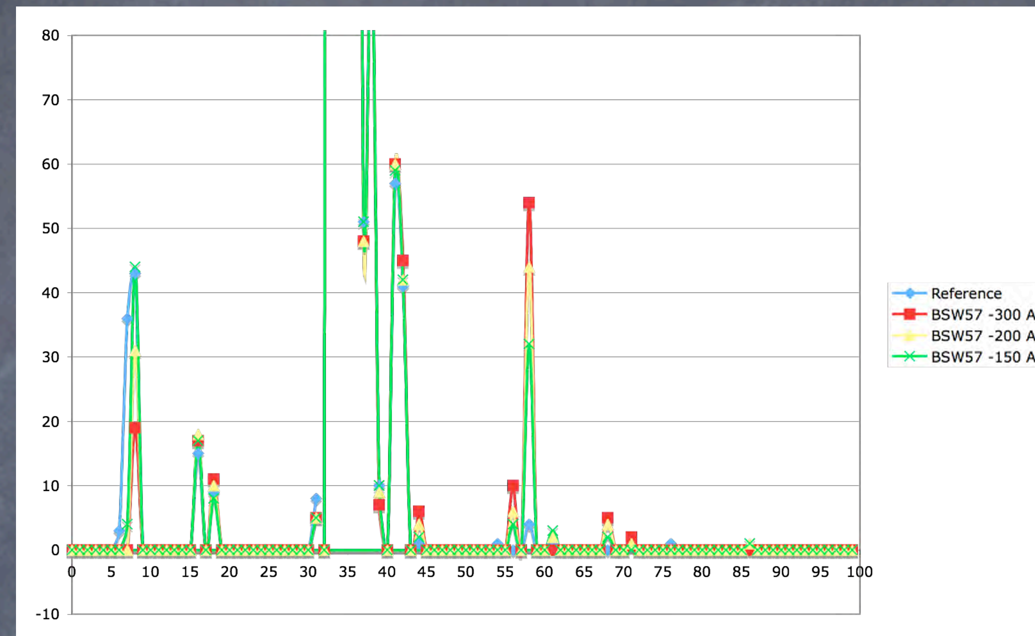
Dose on contact measurements done by I. Floret

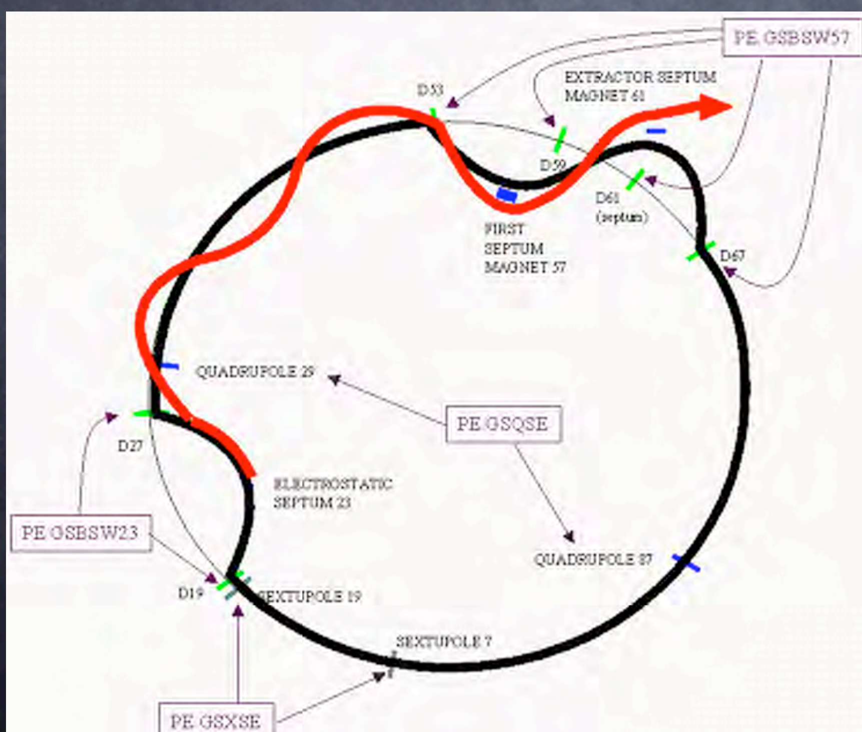


Answer: Dose on contact larger on the element side facing the center of the ring as expected from nominal orbit

BSW57 scan: attempt to clean the beam

Simulation shows that BSW57 can be used to displace the losses from SS09 to SS57





BSW57 current scan on SFTPRO, $4.5e10^{12}$

Losses of BLM09 and BLM57 from OASIS before the BFA triggering. Losses generated, as in the simulation, only during the slow bumps.

Warning: losses quoted are the integral of the OASIS signals, it would be more precise to quote the absolute difference but signals were too noisy