Particle-Tracking and the Analysis of Quench Tests in the LHC

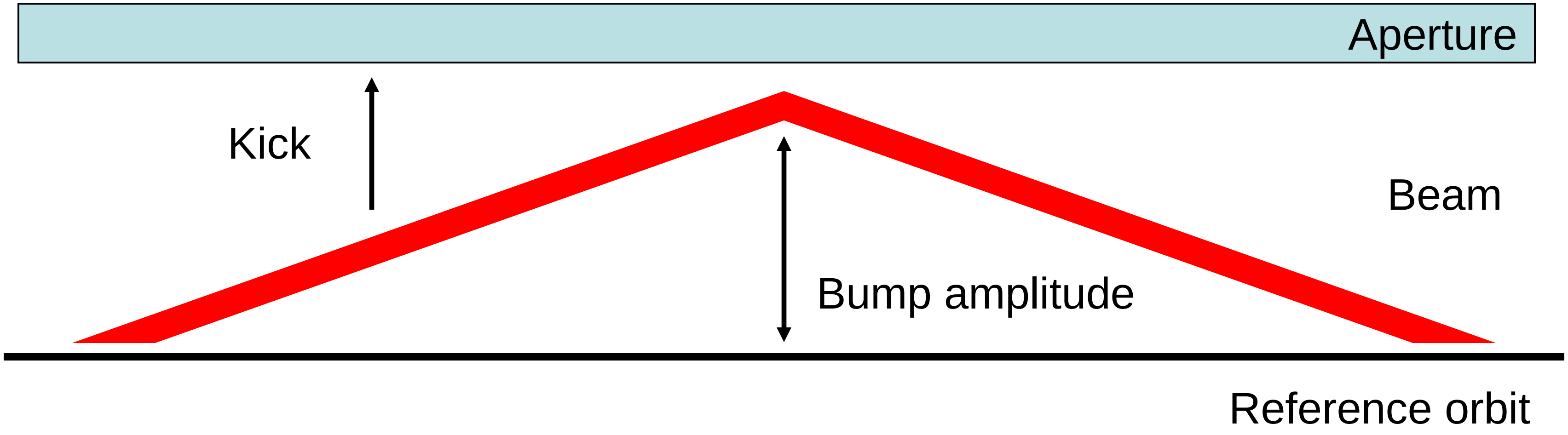
V. Chetvertkova
CERN
Technology Department-
Machine Protection and Electrical Integrity-
Performance Evaluation

Contents

- Introduction
- Parameters influencing the spatial loss distribution
- Particle-tracking (MADX) results
- FLUKA results vs. Experiment
- Conclusions

Introduction

- Orbital bump quench test

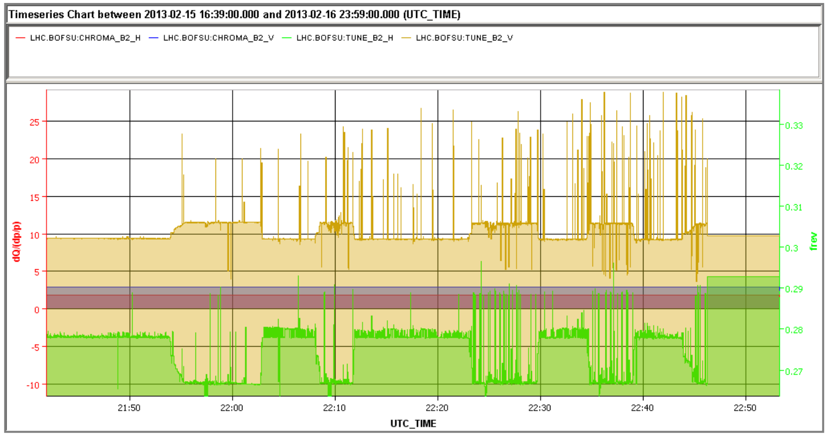


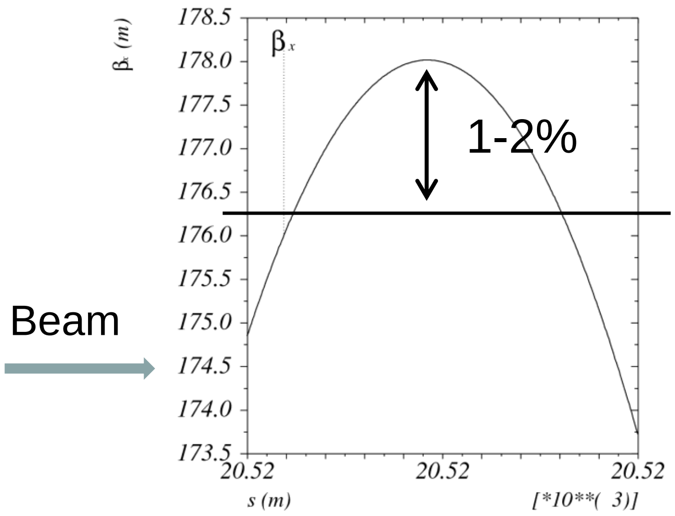
Kick

- Coherent excitation
- Incoherent excitation (random kicks)

Parameters, influencing the spatial loss distribution

- Tune
- Beam profile
  - Beam emittance
  - Tail population
- β-function in the MQ.12L6
- Bump amplitude
- Diffusion rate (kick strength)
- Aperture restrictions
  - Surface roughness
  - Misalignments

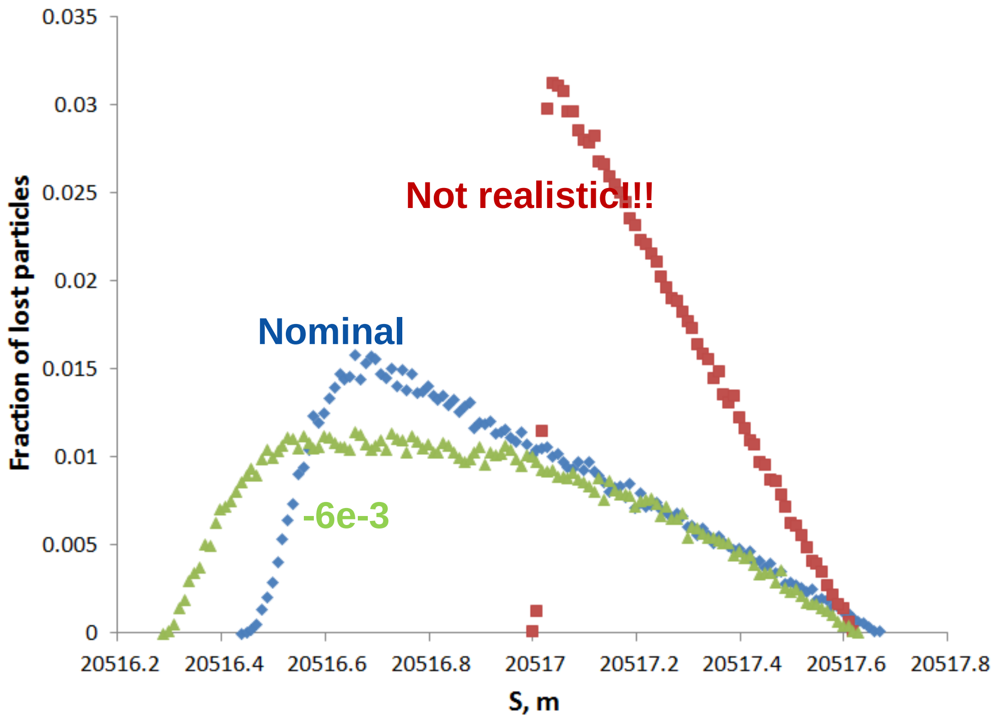




β-function along the magnet

Particle-tracking (MADX) results

Dependence on the tune



Nominal tune spread < 1e-3

Beam size:

ε_x = 5.195e-7

ε_y = 1.409e-5

Bump amplitude:

4.3σ_{nom}

Tune:

Q_x = 64.28 → (3CB) Q_x = 64.274

Q_x = 64.28 → (matching) Q_x = 64.268

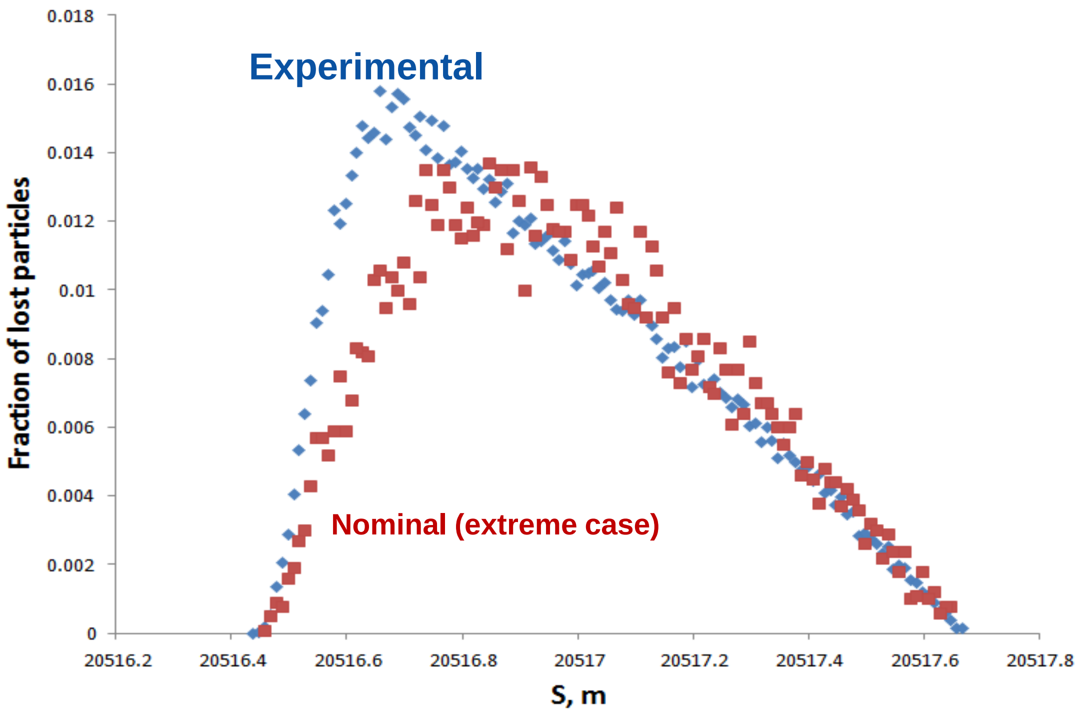
Q_x = 64.(3) → (3CB) Q_x = 64.3330

3CBm – correcting tune after bump

Conclusion:
Tune variation influences longitudinal loss distribution, however the **maximum for realistic cases varies ~ 20%**

Particle-tracking (MADX) results

Dependence on the beam size



Beam size:

$\varepsilon_y = 1.409e\text{-}5$

$\varepsilon_{n,x} = 5.19e\text{-}7$

$\varepsilon_{nom,x} = 3.5e\text{-}6$

Bump amplitude:

$4.3\sigma_{nom}$

Tune:

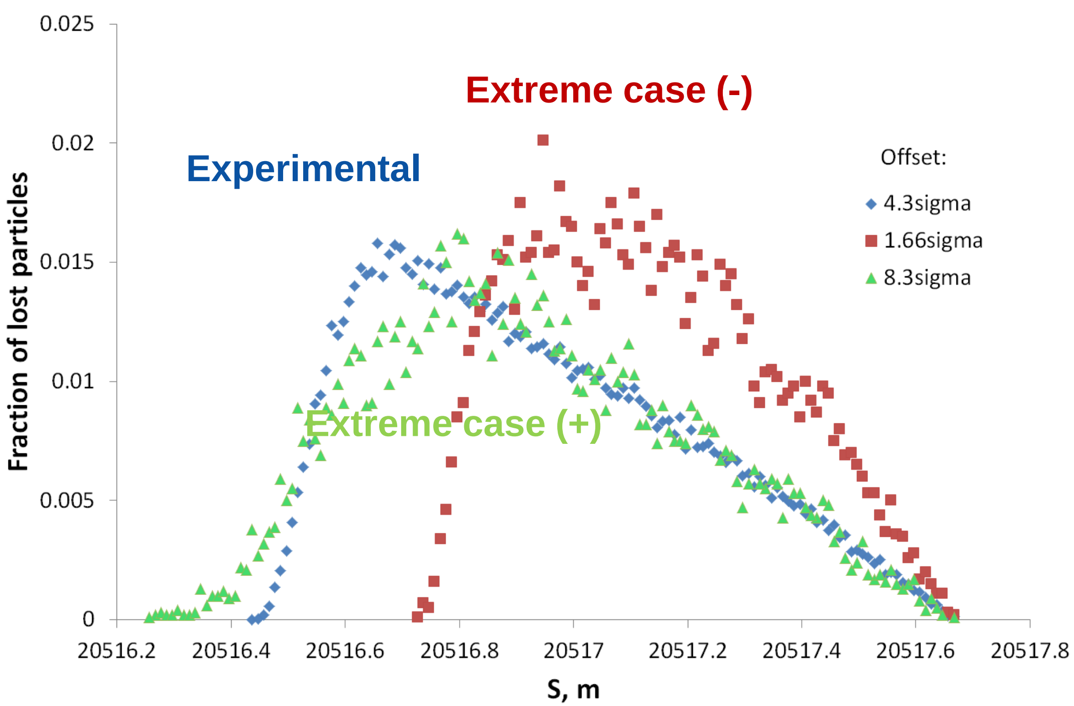
$Q_x = 64.28$

$Q_y = 59.31$

Conclusion:
Influence of beam size on longitudinal loss distribution **is small**.

Particle-tracking (MADX) results

Dependence on the bump amplitude



Beam size:

ε_x= 5.195e-7

ε_y= 1.409e-5

Bump amplitude:

$4.3\sigma_{nom}$

$1.66\sigma_{nom}$

$8.3\sigma_{nom}$

Tune:

Q_x = 64.28

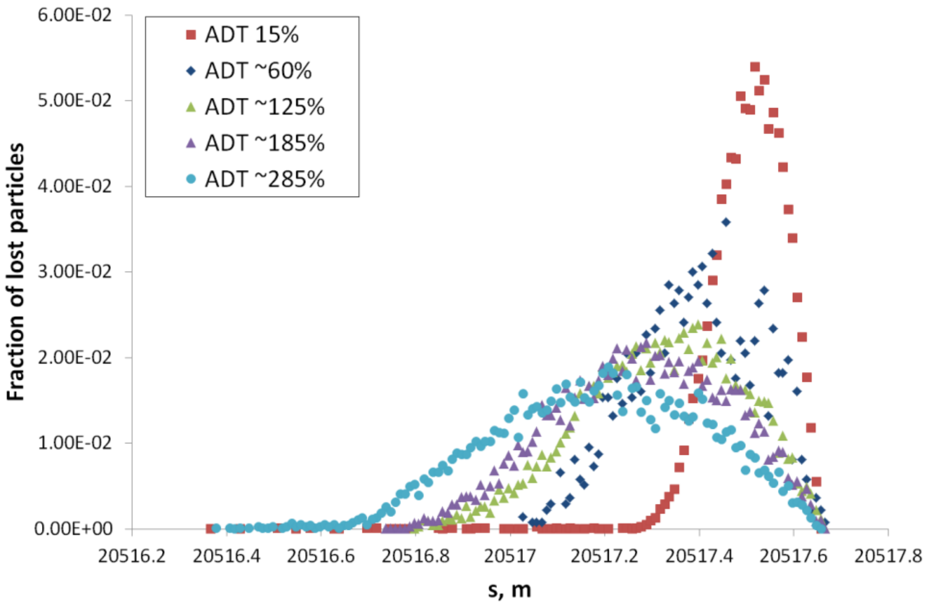
Q_y = 59.31

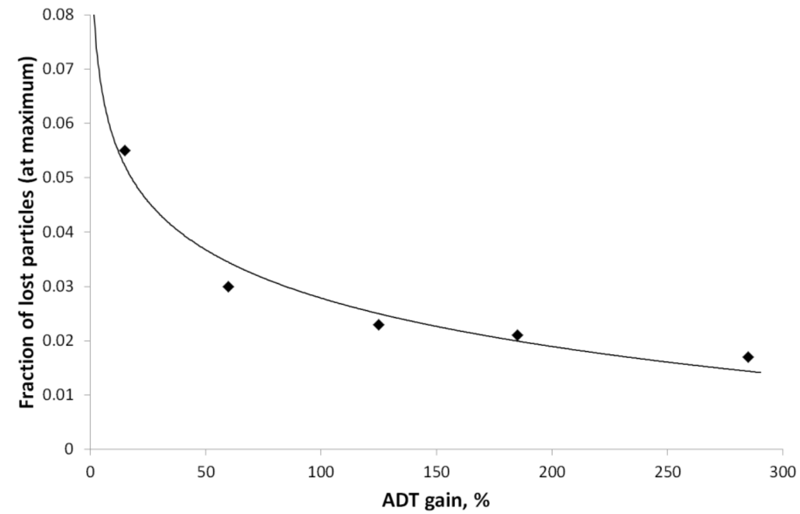
Conclusion:

Size of orbital bump has only **small influence** on maximum of lost-particles distribution

Particle-tracking (MADX) results

Dependence on diffusion rate



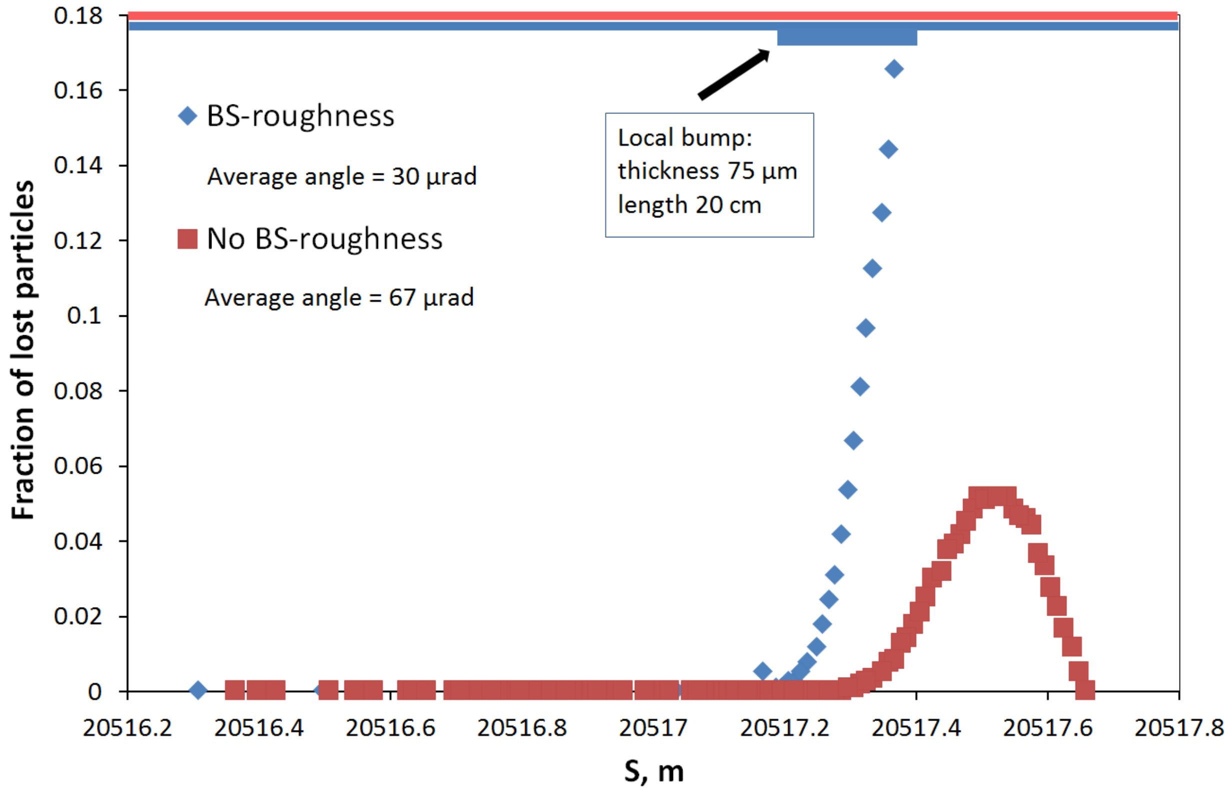


Conclusion:

Decrease of **diffusion rate** leads to **compressing** of longitudinal distribution

Particle-tracking (MADX) results

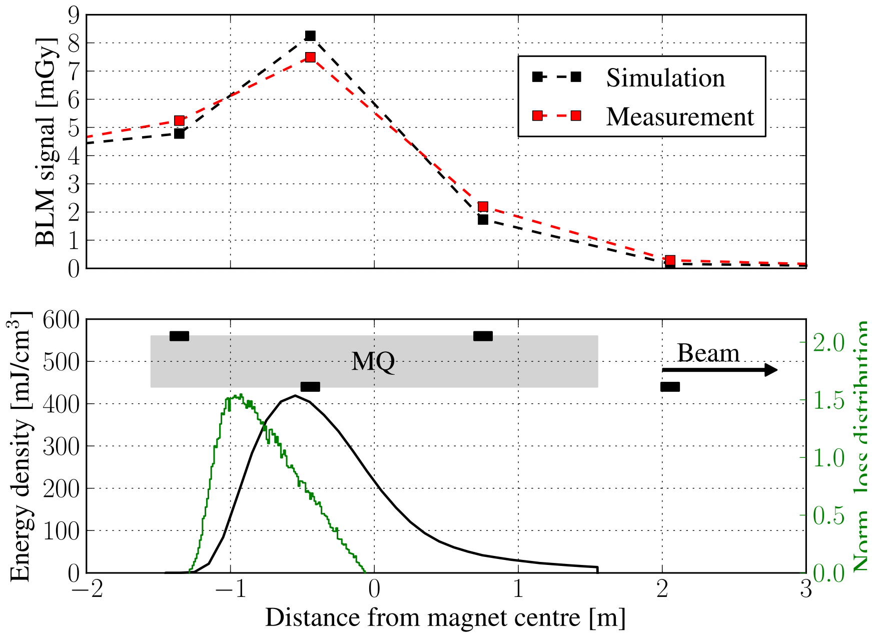
Dependence on aperture limitations



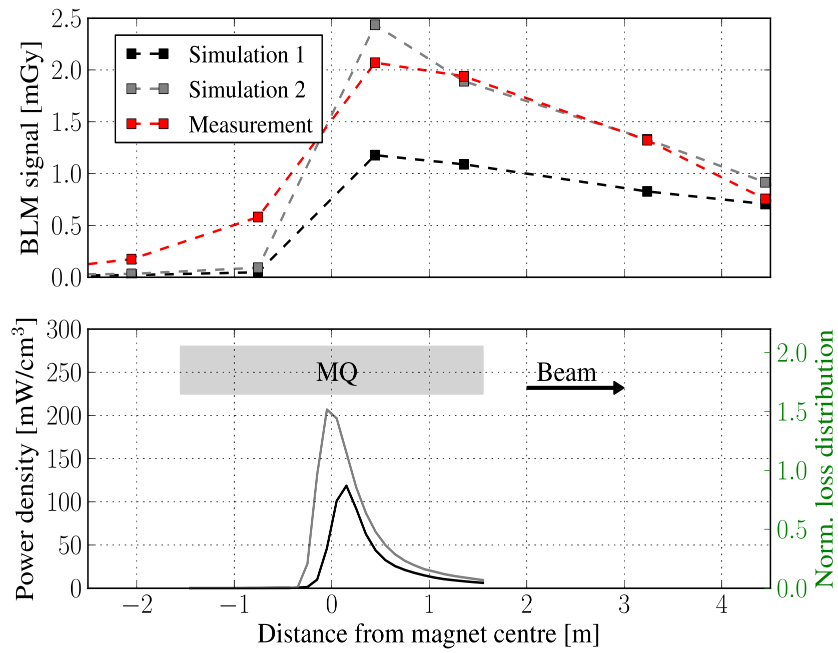
Presence of the aperture limitation of 75 µm shifts the longitudinal distribution and therefore changes the average impact angle.

FLUKA results vs. Experiment

- FLUKA results in comparison to BLM signals (courtesy N. Shetty)



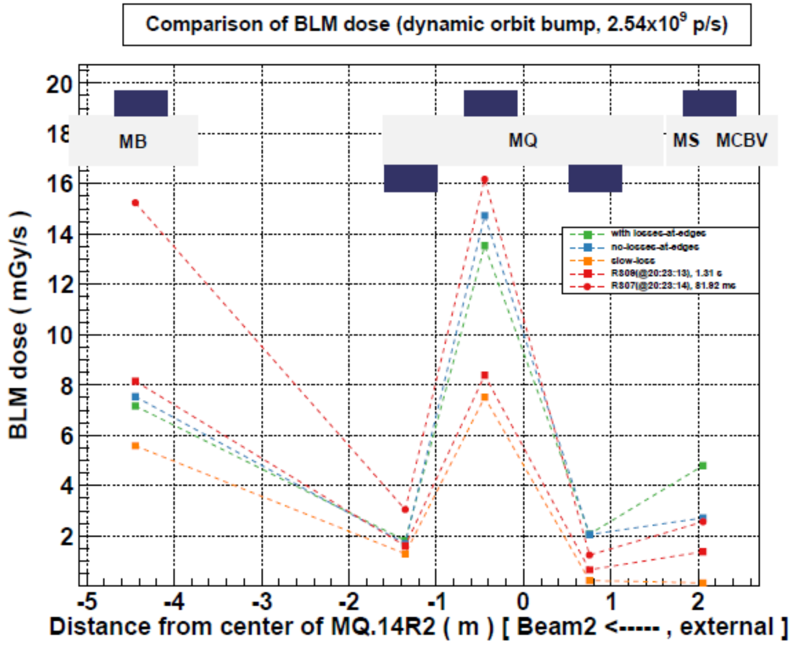
Fast losses



Slow losses

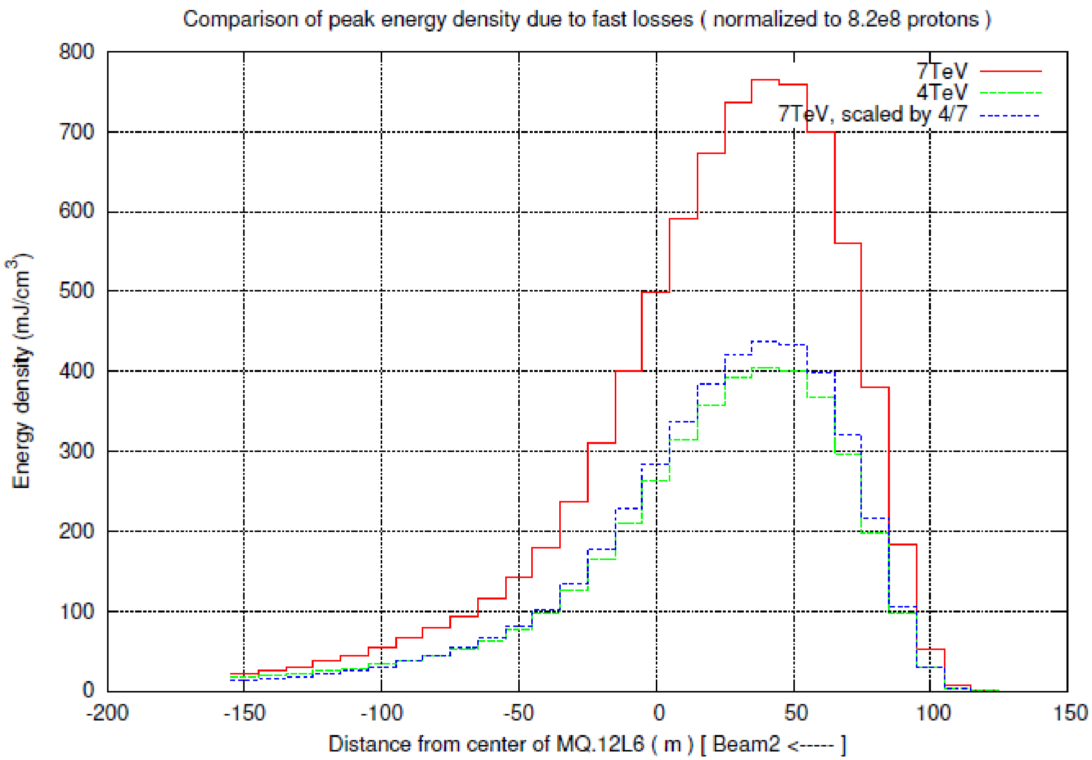
FLUKA results vs. Experiment

- FLUKA results in comparison to BLM signals (courtesy N. Shetty)



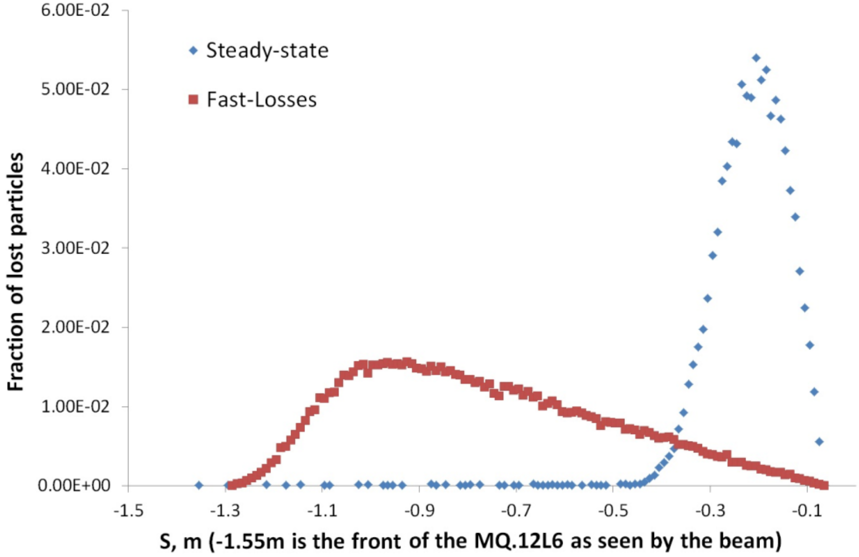
Tuning the input parameters of tracking simulations allows achieving realistic spatial loss distribution

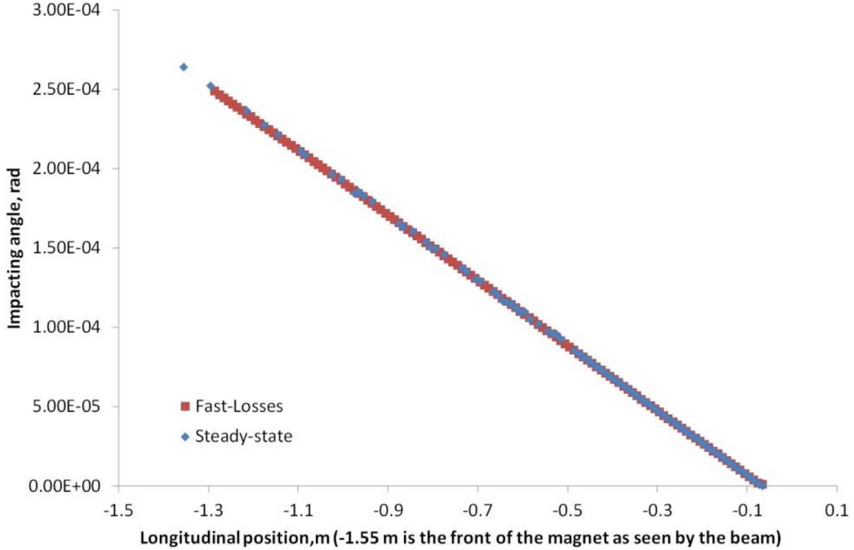
Expectations for LHC Run 2



If the optics stays the same, the increase of the beam energy will influence the value of the energy deposition maximum

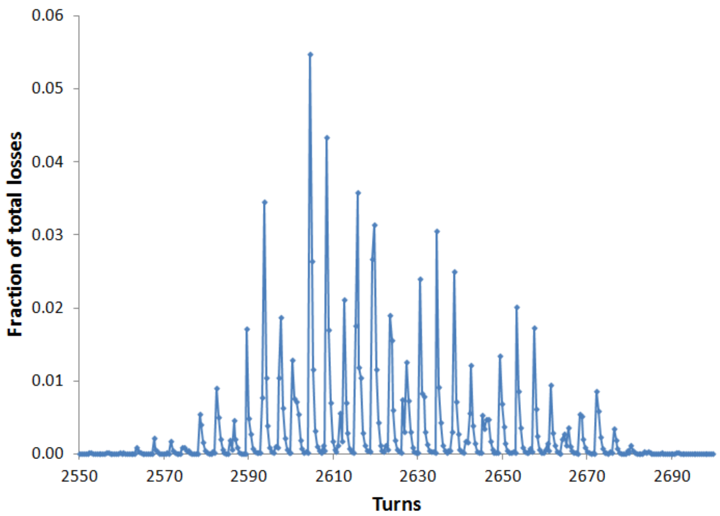
Conclusions



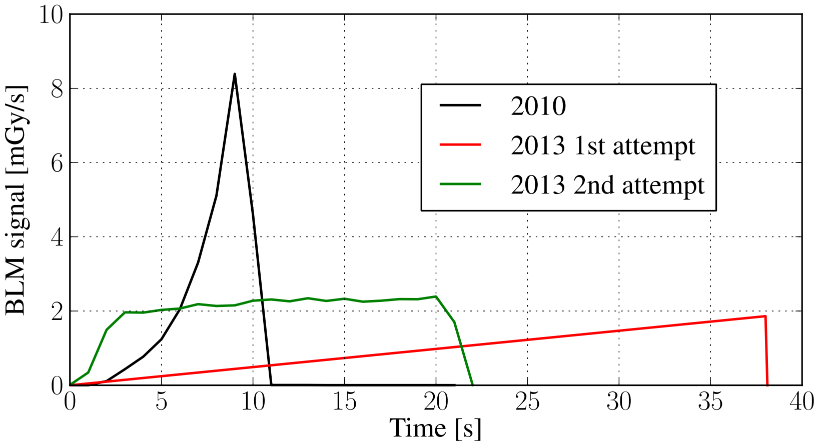


- Spatial loss distribution varies significantly depending on the parameters of the excitation
- Results of the particle-shower simulations depend both on the spatial and angular loss distributions

Time structure



Fast losses



Slow losses