Particle Tracking for Orbit-Bump Quench Tests at LHC

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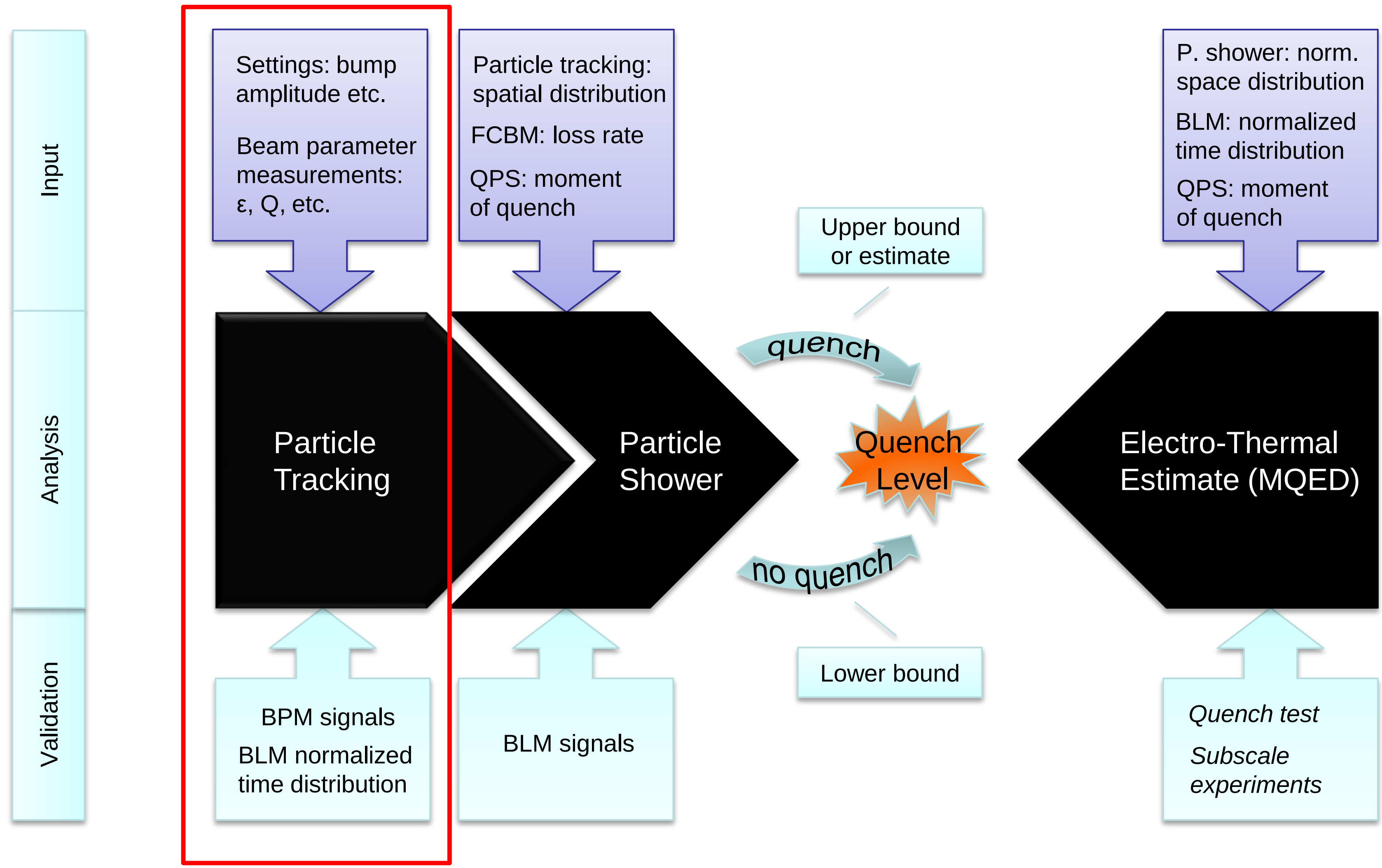
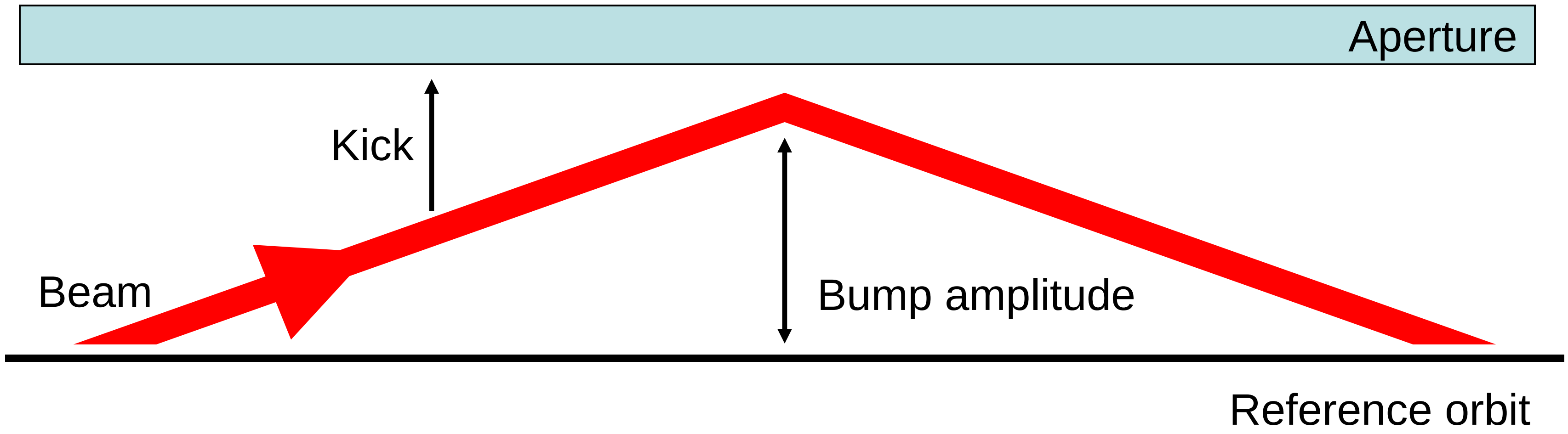
Quench Test Analysis

What is the energy deposition in the coil at the moment of quench?



Orbit bump quench test



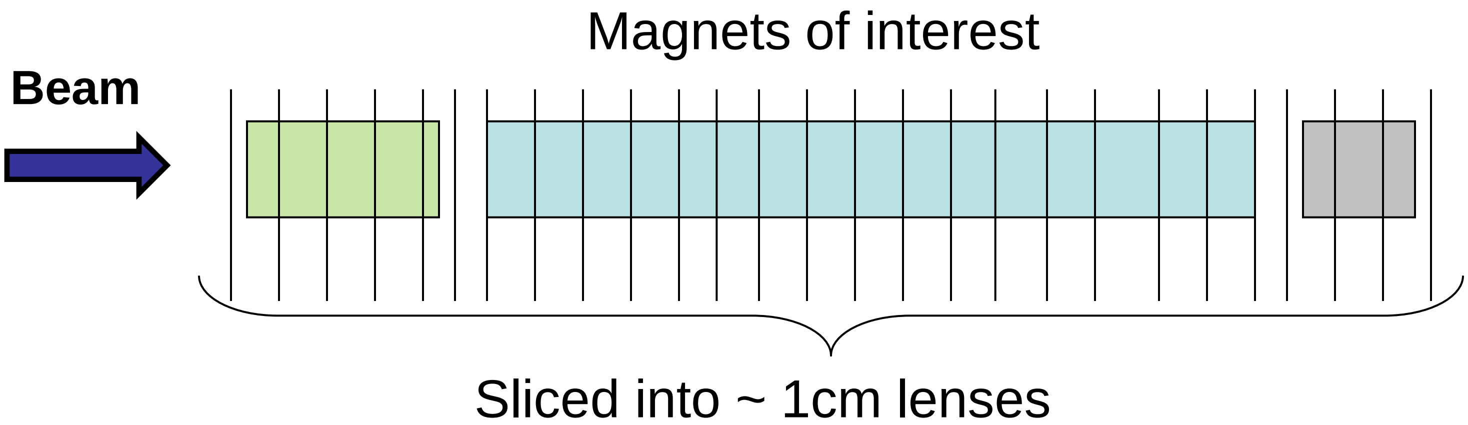
How to lose the beam:

- Increasing the bump amplitude (Dynamic bump test)
- Exciting the beam
  - Non-coherent excitation (Steady-state orbit bump)
  - Coherent excitation (Millisecond timescale test)

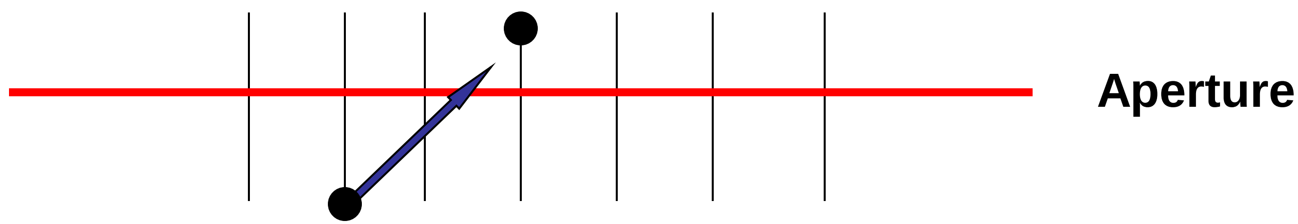
Methodology

- MADX, thin-lens tracking:

  1 cm resolution for further FLUKA simulations

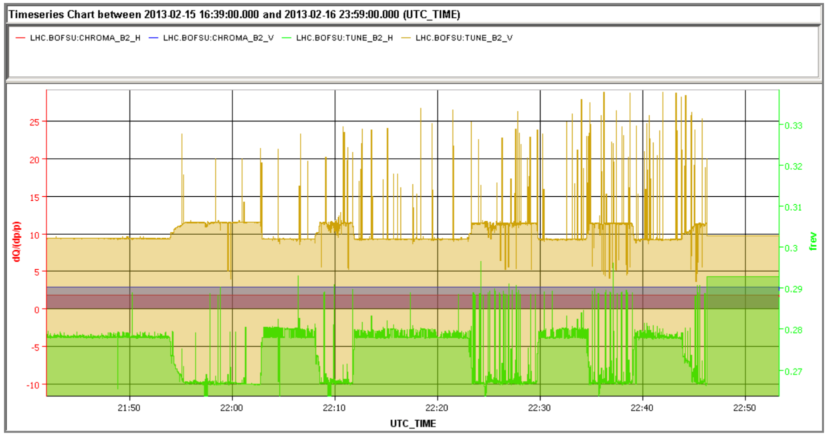


- Aperture: black absorber (no scattered projectiles)



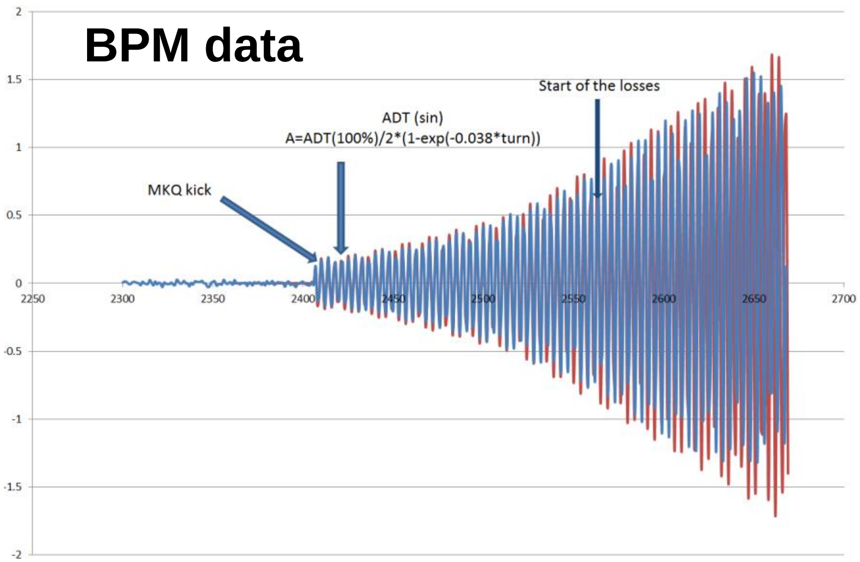
Input parameters / Validation

– Beam parameters
  - Energy
  - Profile
  - Tune, Chromaticity



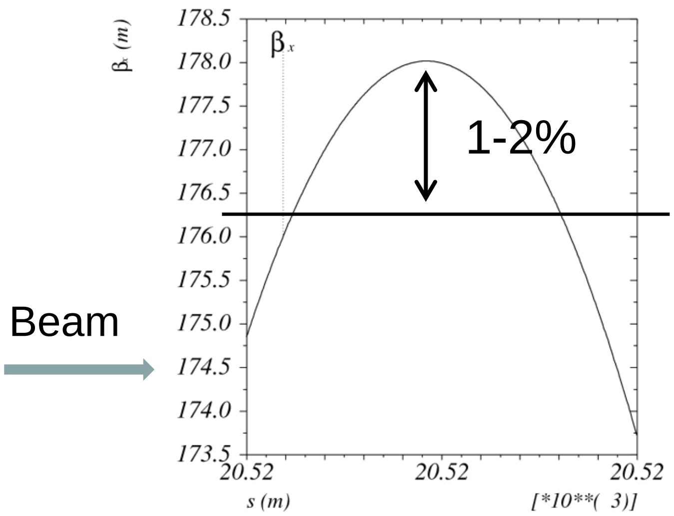
– Orbit bump amplitude

– Transverse kick
  - MKQ kick strength
  - ADT kick strength



Other parameters influencing loss distribution

– Beam profile:
  - Tail population
– β-function in the magnet
  - β beat is <10%
– Aperture restrictions
  - Surface roughness
  - Misalignments

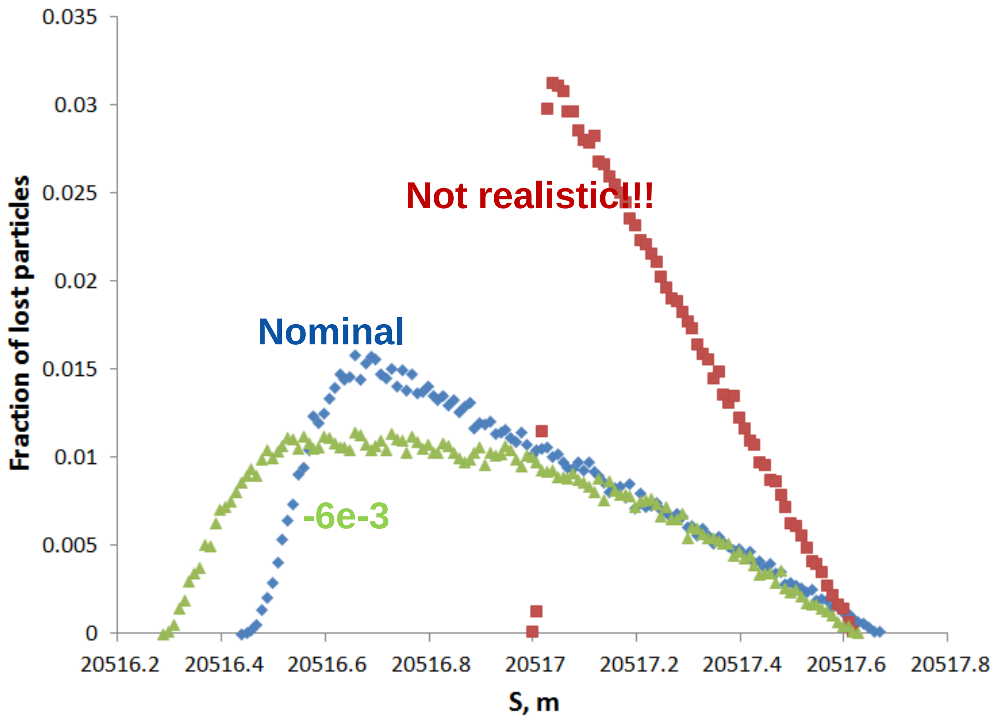


β-function along the magnet

Aperture restriction:
Height: 30 μm
Length: 10 ÷ 30 cm

Millisecond timescale test

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:

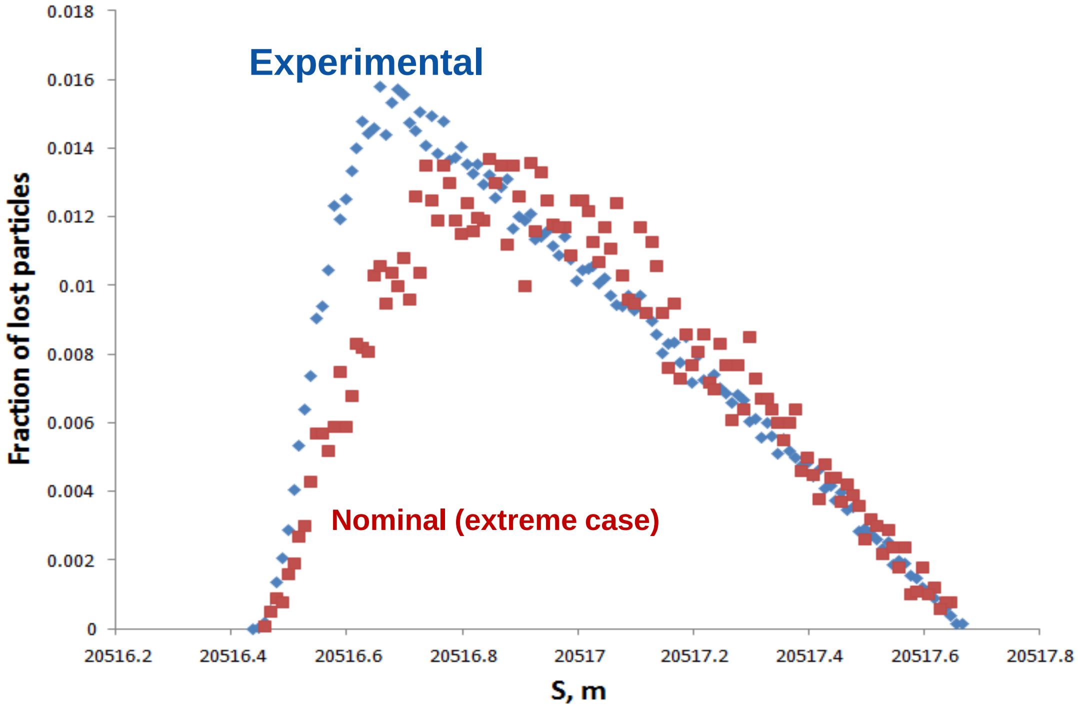
Q_x = 64.28	→ 3CB	Q_x = 64.274
Q_x = 64.28	→ matching	Q_x = 64.268
Q_x = 64.(3)	→ 3CB	Q_x = 64.3330

Matching – correcting tune after establishing bump

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

Millisecond timescale test

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:

$Q_x = 64.28$

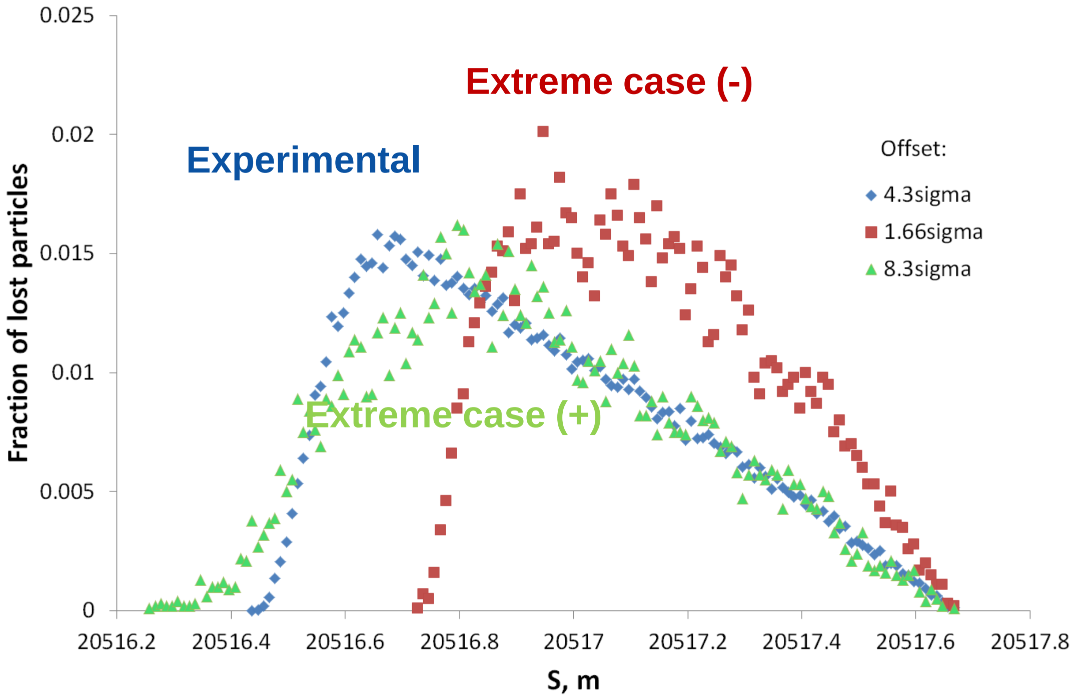
$Q_y = 59.31$

Conclusion:

Influence of beam size on longitudinal loss distribution **is small** in case of **fast losses**

Millisecond timescale test

Dependence on the bump amplitude



Beam size:

ε_x= 5.195e-7

ε_y= 1.409e-5

Bump amplitude:

4.3σ_{nom}

1.66σ_{nom}

8.3σ_{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 in case of **fast losses**

Dynamic orbit bump

Beam size:

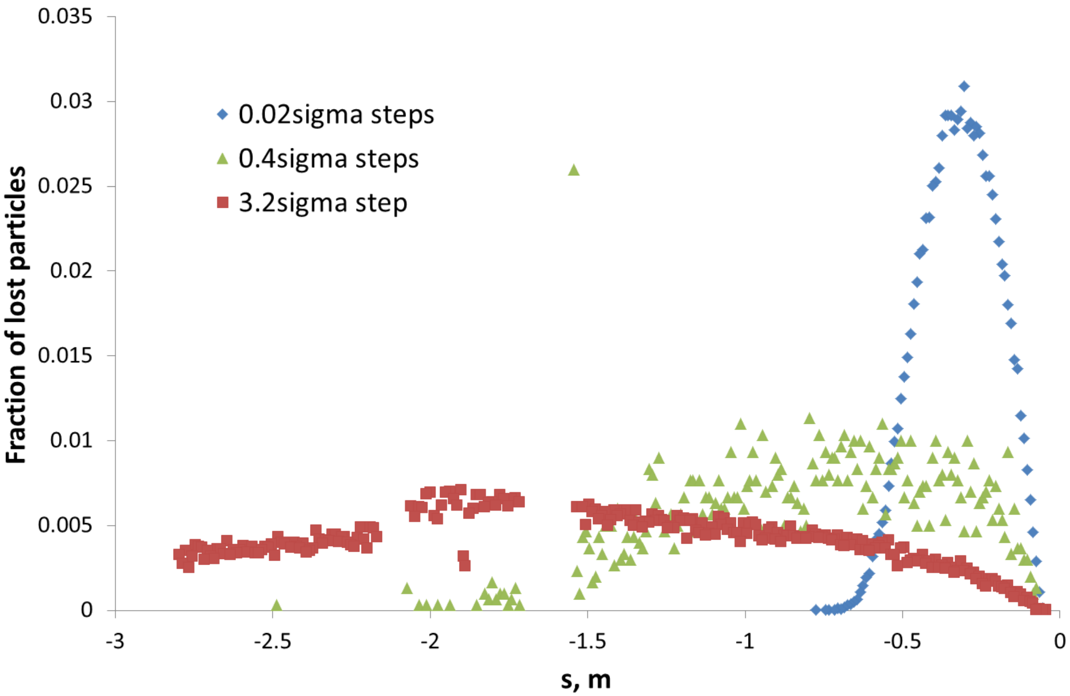
ε_x= 6.1e-6

ε_y= 7.1e-6

Initial bump amplitude:

$3.5\sigma_{nom}$

Step: every 50 turns



Conclusion:
Slow increase of the orbital bump leads to the **compression** of the lost-particle distribution in case of **slow losses**

Steady-state orbit bump

Dependence on diffusion rate

Beam size:

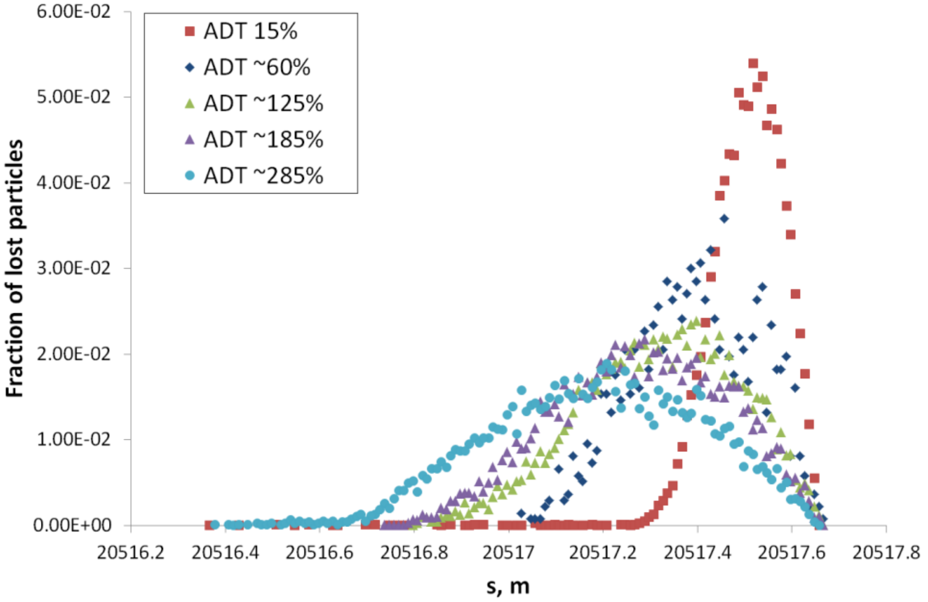
ε_x= 1.9e-6

ε_y= 1.4e-5

Bump amplitude:

2.5σ_{nom}

ADT gain, %	Kick strength, sigma
15	1.15E-05
60	4.60E-05
125	9.58E-05
185	1.42E-04
285	2.18E-04

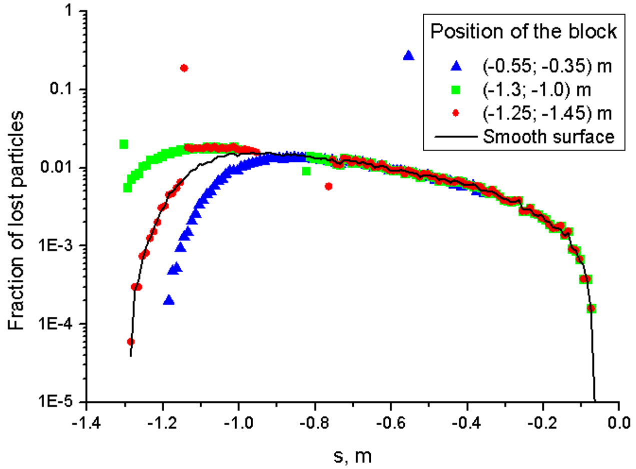


Conclusion:

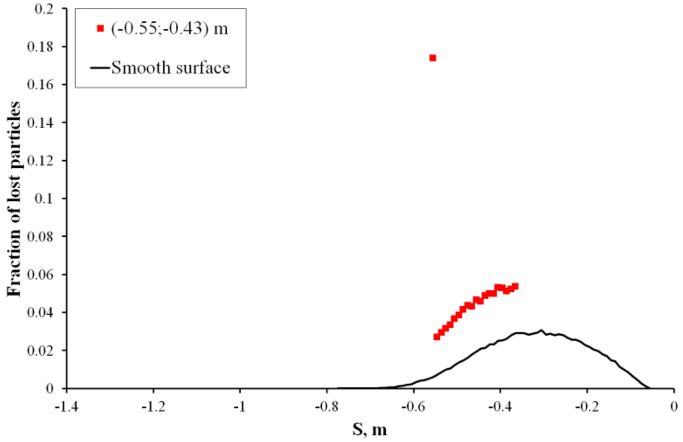
Decrease of **diffusion rate** leads to **compression** of longitudinal distribution

Aperture limitations

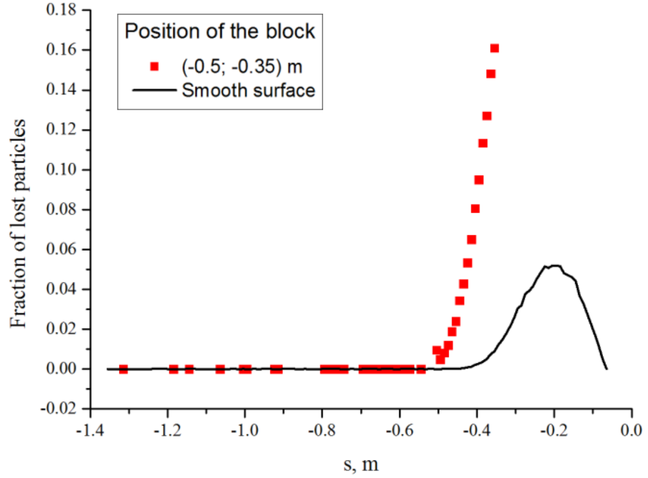
Millisecond timescale test



Dynamic orbit bump



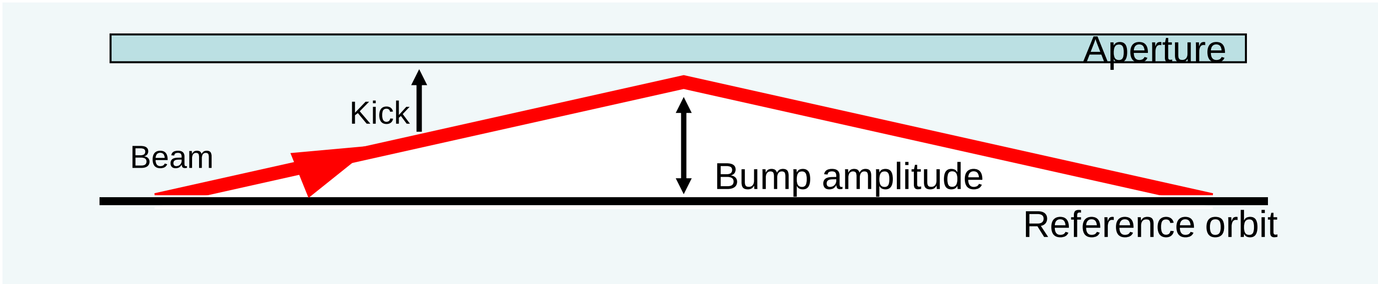
Steady state orbit bump test

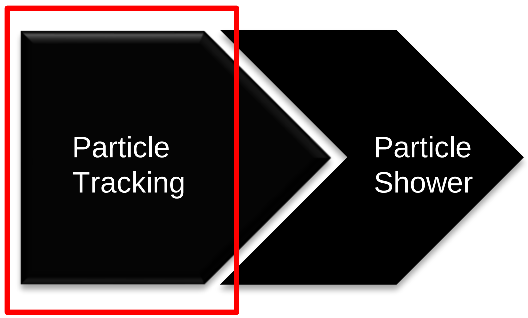


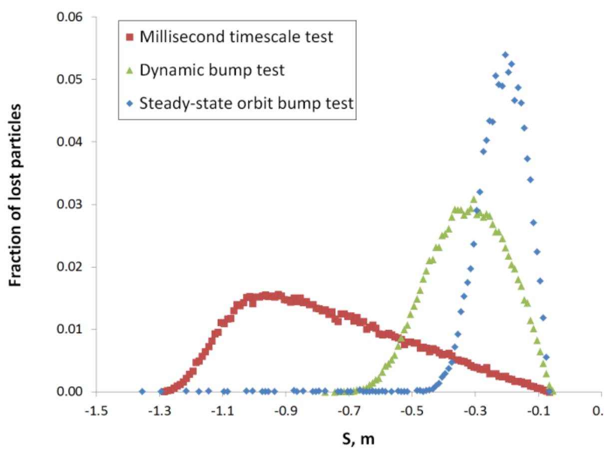
Conclusion:

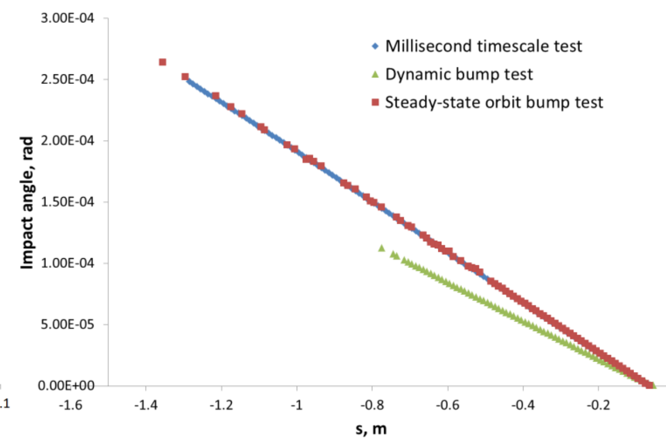
Presence of the aperture limitation of 30 μm shifts the longitudinal distribution and therefore changes the average impact angle.

Summary



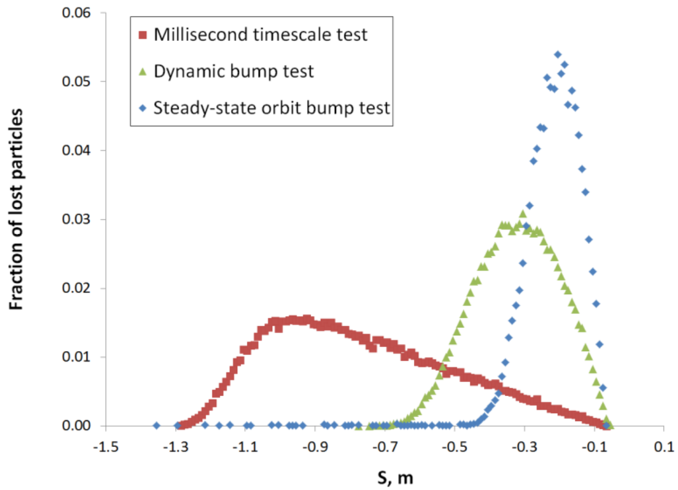


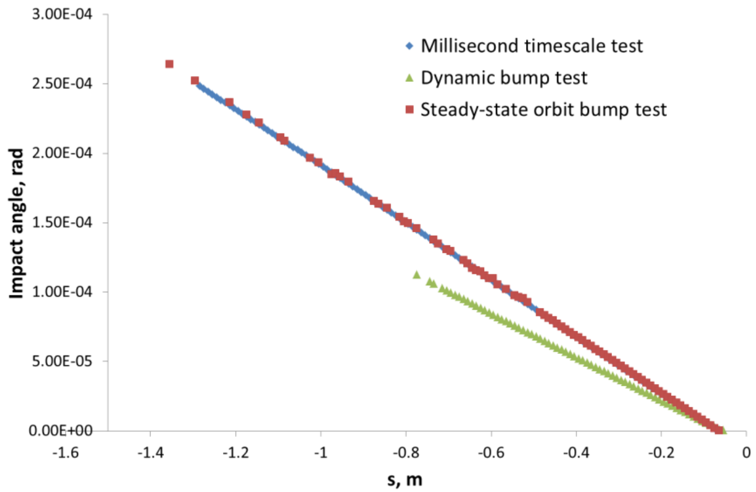




- Spatial loss distribution was calculated for orbit bump quench tests.
- Integrated over time this distribution was provided for further particle-shower simulations.

Conclusions

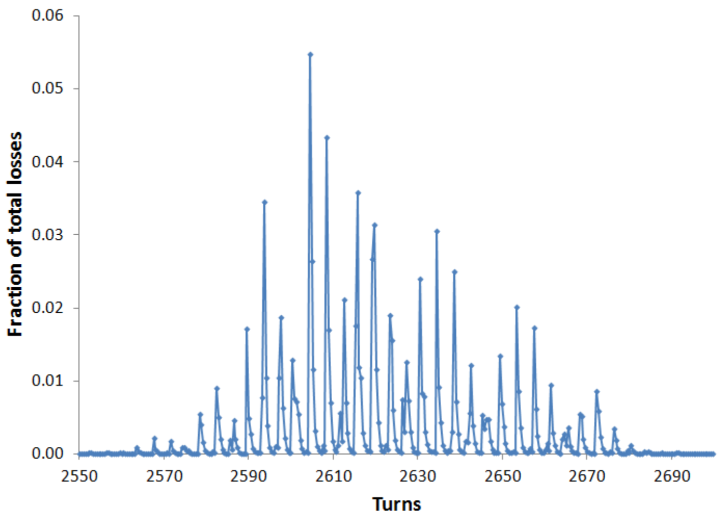


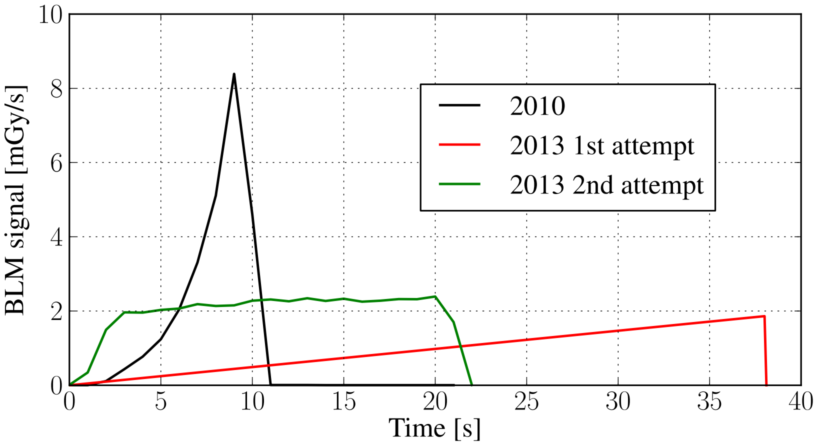


- Spatial loss distribution varies depending on the scenario.
- Impact angle does not depend on the scenario, but only on the integral magnetic field seen by the particles.
- Weighted average angle changes with the spatial distribution.
- Results of the FLUKA simulations depend both on the spatial and angular loss distributions (see talks of A. Lechner and B. Auchmann).

Time structure

Experimental BLM signal





Fast losses

Slow losses