SUMMARY FROM WG4 (BEAM DYNAMICS)

Coordinated by A. Lombardi (CERN)

1) Summary
2) Future activities

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Participants to the WG

-CERN/BE/ABP : end-to-end multiparticle tracking; layout definition/validation; WG coordination.

-CERN/TE/ABT : extraction areas; transfer lines ; collimation

-CERN/AB/RF : HOM calculations.

-ESS-S : end-to-end multiparticle tracking; layout definition/validation

- CEA Saclay : consulting on beam dynamics, provide tracking code

-future TAC (Turkey) with exchange of students

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Topics :

1) Layout definition/validation, including connection from LINAC4, extraction at 1.4 GeV and 2.5 GeV, transfer lines – ok

2) Definition of tolerances (quads alignment and field quality, RF phase and amplitude) – ok

3) Definition of correction and monitoring system (steerers, diagnostics) –ok

4) HOM effects – ongoing

5) Other issues (sextupole stripping)– ongoing

6) Collimation – on hold

7) Impact of cavity performance: lower than nominal field (19MV/m low-beta 25MV/m high beta) , modules switched off….- on hold

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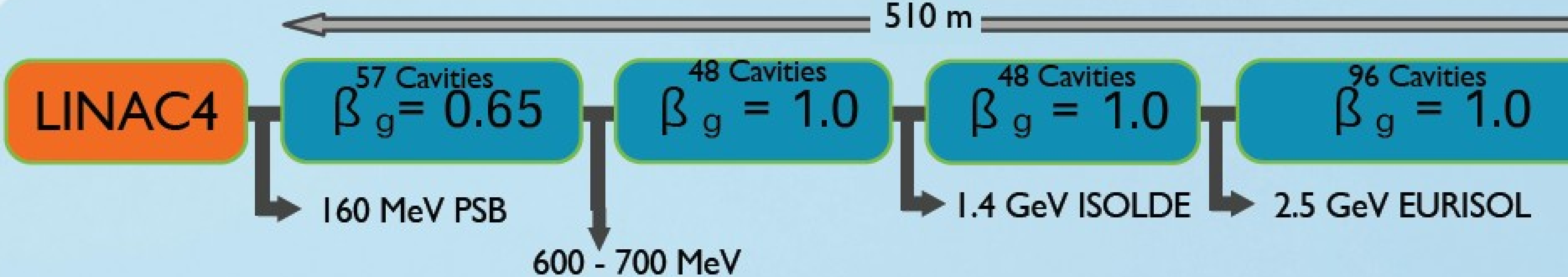
Achievement since last meeting :

1) solidified a mixed structure layout including
transition at 1.4 GeV and 2.5 GeV,
compatible with cryo segmentation and
linac4 beam
minimises the magnetic stripping losses

2) Discovered problems!

-sextupole component in the steerer can severely impact the emittance
-intra beam stripping losses
-we cannot discard lightly the HOM coupler based on SNS
-our transition energy and geometrical betas are not optimum to
minimise the HOM effects

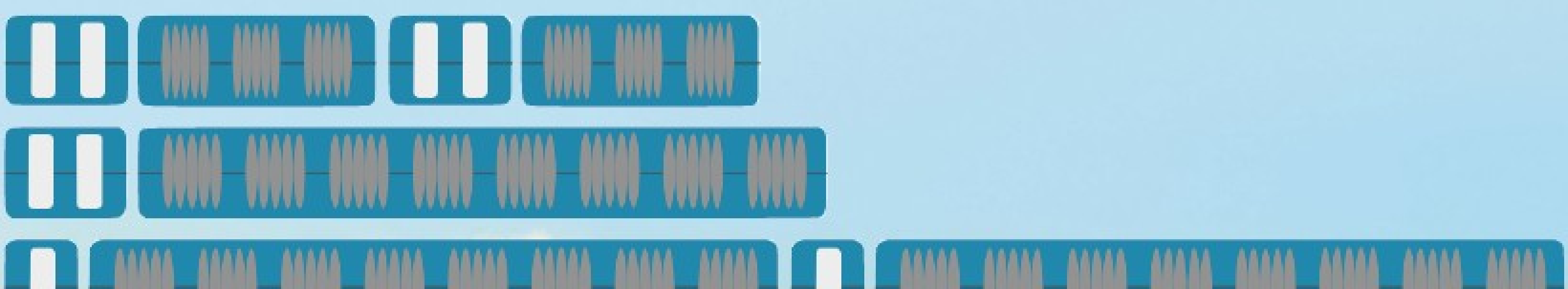
SPL



1 x Lp drift space for lossless extraction at 1.4 GeV

1.5 x Lp drift space for lossless extraction at 2.5 GeV

Room temperature quadrupoles



The mixed structure

- Attempt to combine
    - cryo segmentation flexibility
    - Reduce the probability of stripping in the quads

- Using the fact that
    - the H- stripping probability is higher at higher energies
    - Focusing period can be made longer at higher energies

sextupole

- Combining quadrupole and dipole has the result of generating a sextupole component
- Measure the sextupole component in terms of the main field at a reference radius.
- 1unit = 10-4

Effect of Sextupole

10 units

A sextupole component proportional to 0.1% of the stee
B field is added to the simulations to see the effect on
beam:

Reference radius: 97.5% of Aperture radius = 48.75 mm

$G_6 = 0.1\% \times B_{steerer} / R_{ref}^2 = 0.003$

Effect of the sextupole:

$\Delta\epsilon_x = 360\%$ $\Delta\epsilon_y = 222\%$

$Hx = 18.5$ $Hy = 10.5$

Losses: 1.938%

Comments :

All the steerers are turned o
and at the maximum value

Very Small Sextupole

1 unit

For the case where we decrease the component to 0.01
Steerer field (0.003 T/m²):

$\Delta\epsilon_x$ [%]= 9.52

$\Delta\epsilon_y$ [%]= 11.1

$\Delta\epsilon_x$ [%]= 9.3 Nominal

$\Delta\epsilon_y$ [%]= 10.1 Nominal

Hx = 0.82

Hy = 0.88

Examples :

LHC main quadrupole : 1.0 uni
(random) at ro=17mm (60% ap

LINAC4 PMQs : 30 units at ro=

LINAC4 EMQ with steerer : 5 u
(idea was abandoned) at ro=75

No Losses

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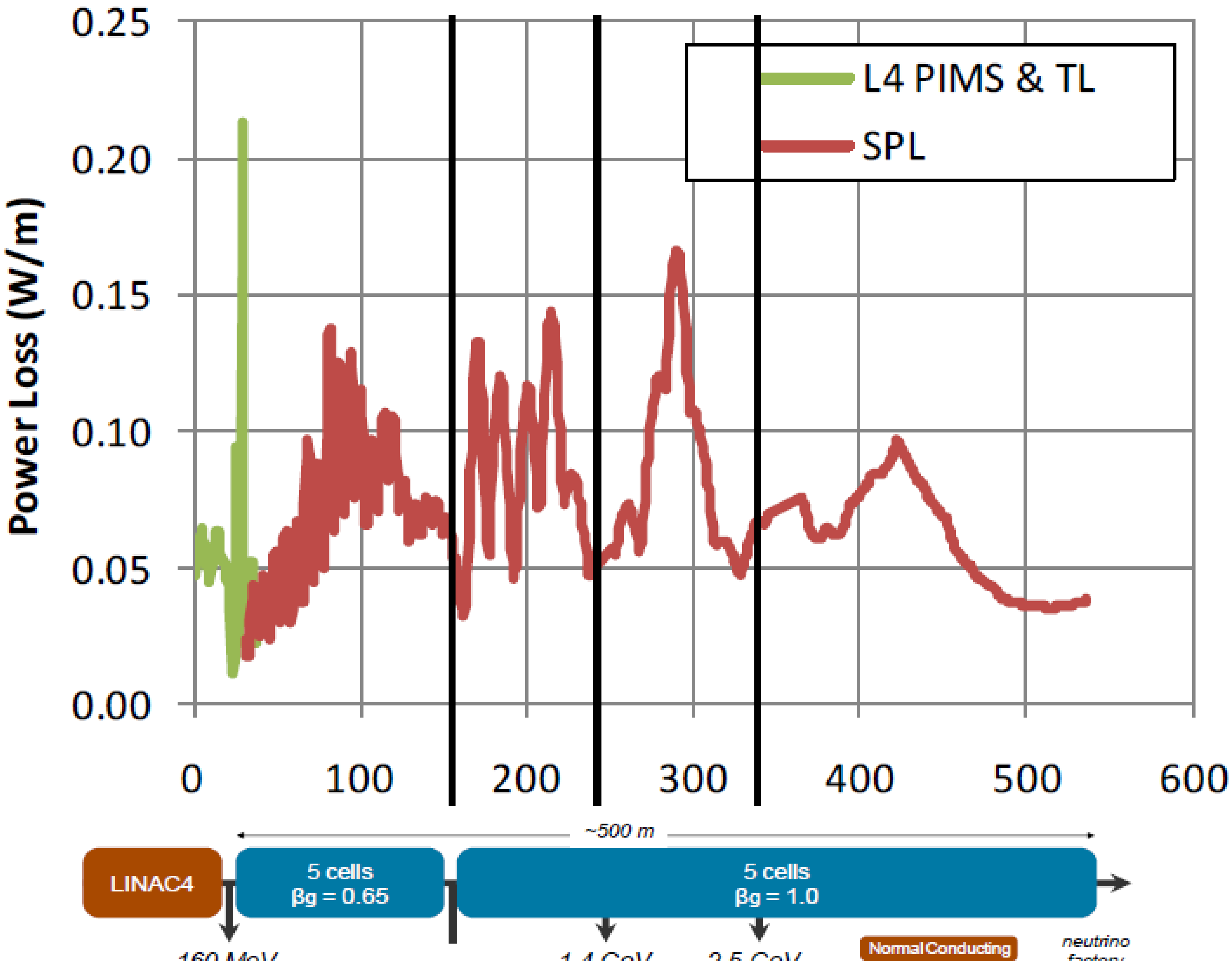
Intra Beam Stripping

- Not considered so far in all the loss pattern calculations.
- Cross section was measured by M. Chanel et al, in LEAR in 1987.
- Might be the explanation for some unexplained high energy losses in SNS, might be the explanation of the difference between empirically optimised settings and theoretical settings.
- Depends on the beam volume, and on the relative velocity of the partcles.

Power Loss (High Current)

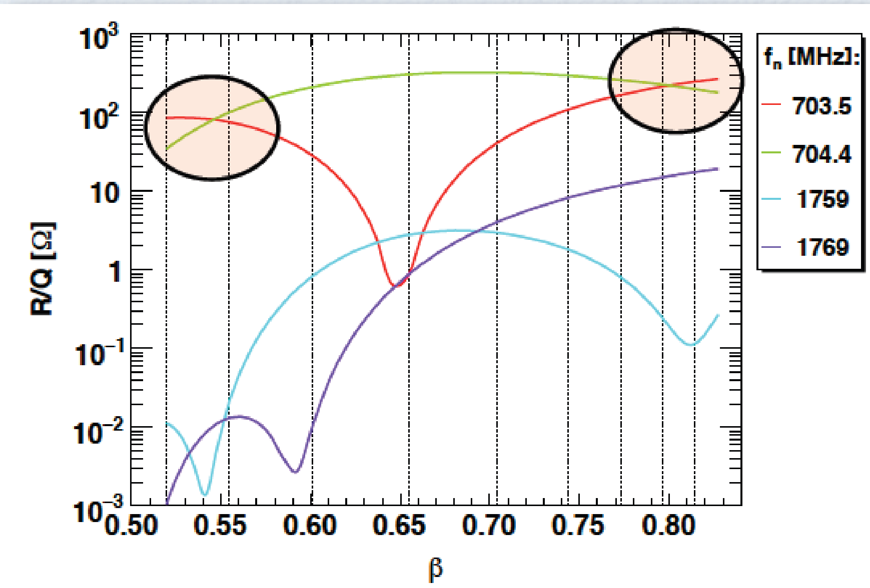


SPL vs SNS

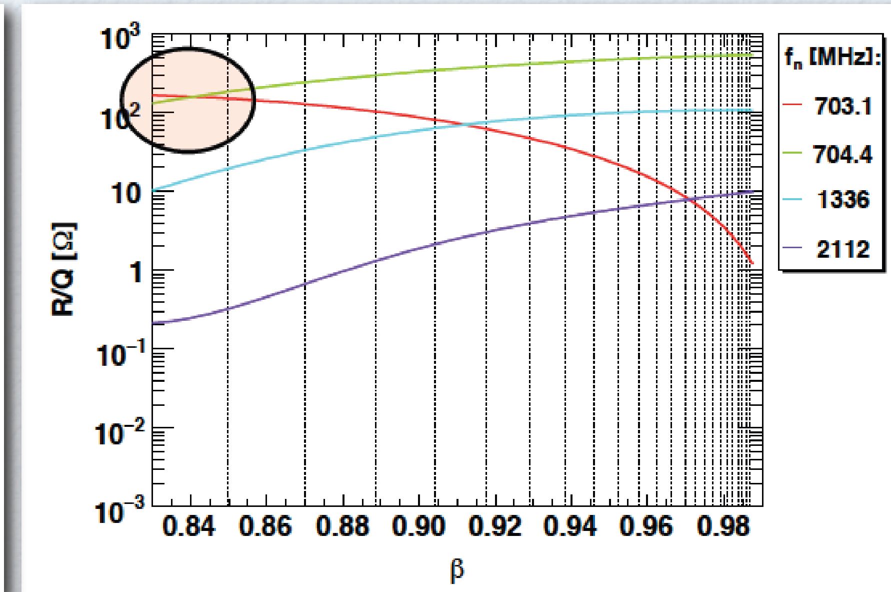
	SPL	SNS
Cavities	~250	81
$\text{Max}\left(\frac{R/Q(\beta)_{\text{HOM}}}{R/Q(\beta)_{\text{acc}}}\right)$	6% and 20%	2% and 7%
$\text{Max}\left(\frac{R/Q(\beta)_{\text{PB}}}{R/Q(\beta)_{\text{acc}}}\right)$	83% and 31%	46% and 27%
Chopping	high frequent	low frequent
HOM frequency statistics	not available	available (no HOM at machine line)

R/Q vs beta for SPL baseline

$\beta_g = 0.65$



$\beta_g = 1.0$



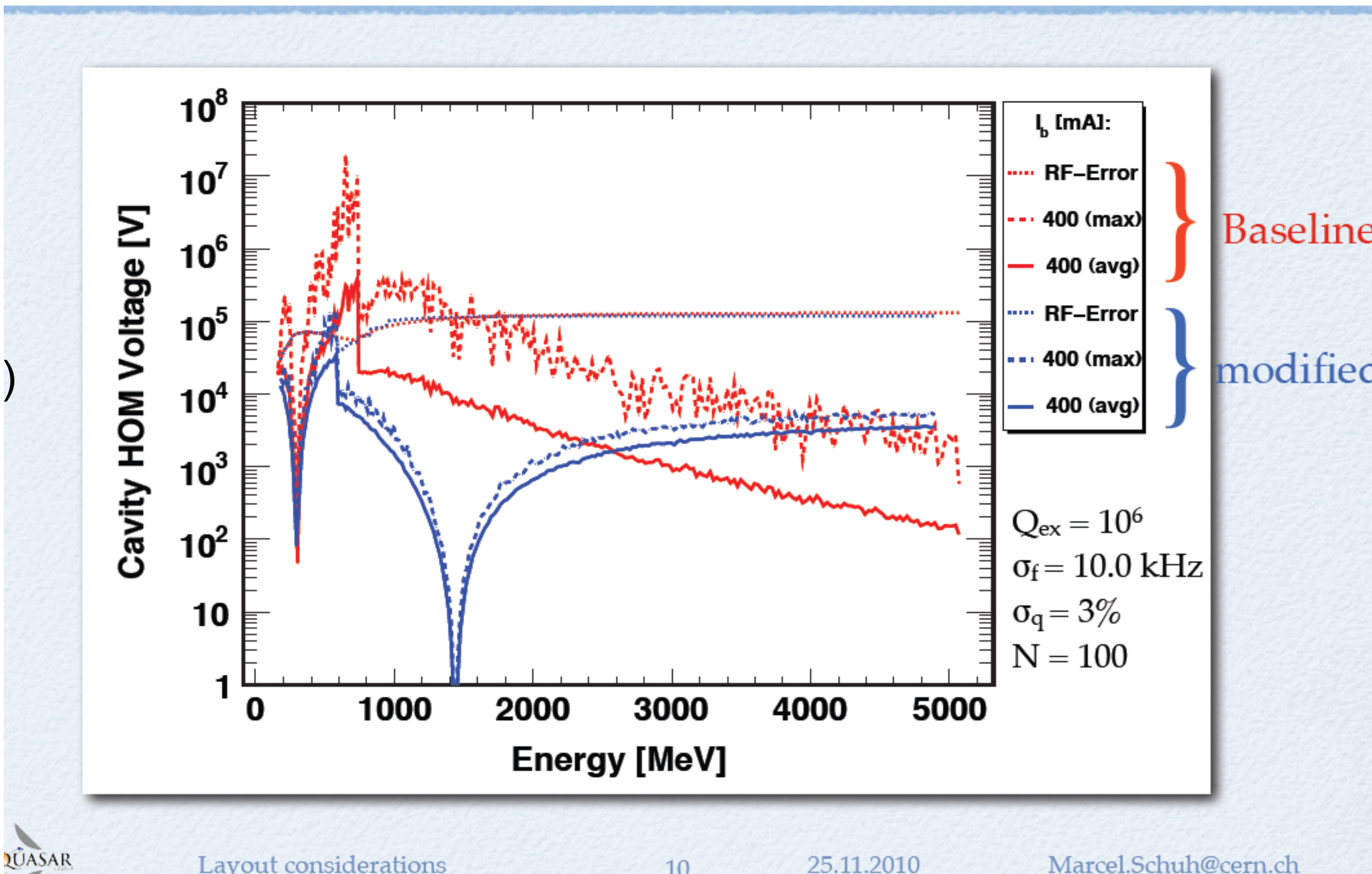
704.4	f_{acc} [MHz]	704.4
5	cells	5
54 (6)	cavities (per module)*	196 (8)

* old CDR2 layout

HOM voltage

Modified =
180 MeV (vs 160)
injection energy

Beta=0.92 (vs 1)



Future activities

Left from previous collaboration meeting :

2) Definition of a collimation system - more critical for HPSPL

3) Impact of cavity performance

4) Considering the idea of BPM for envelope information

5) Tracking in field map to verify cross-talk transverse long

Acquired at this meeting :

6) Check how much the assumption used for calculating the HOM induced voltage at 160 MeV and for the beta=1 cavity are realistic and applicable to the SPL case.

7) Verify if the intra beam tripping losses for the high current case are acceptable.