Summary WG4 (BEAM DYNAMICS)

A. Lombardi (CERN)

"we are not too badly off but we have still a lot of work to do"

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 :

-Soltan Institute : collimation

-STFC/ Cockroft institute : collimation

-TRIUMF : HOM calculations , WG coordination.

Session 1 (with WG2)
Today 16:30

HOM

Scope : revisit workshop conclusions, further simulations recommended at the workshop.

Session 2
Tomorrow 9:00

Doublet vs. FODO

Scope : discuss pros and cons of alternative focusing system, possibly select one.

Session 3 (Partly with WG3)
Tomorrow 10:30

Alignment and correction

Scope : converge on an alignment tolerance, input to further sensitivity studies and correction scheme

Session 4
Tomorrow 16:30

Transfer lines /collimation

Scope : from linac4, to ps2 , beam quality from linac4 …..

HOM

16:30->*17:30* 1st combined session WG2 & WG4 (30-7-018 (TE auditorium))

16:30	Brief report on the HOM workshop (20') (Slides)	Alessandra Lombardi (*CERN*)
16:50	On the baseline HOM damping scheme for SPL Beta = 1 cavities (20') (Slides)	Hans-Walter Glock (*Institut für Allgemeine Elektrotechnik Universität Rostock*)
17:10	Higher order modes in the SPL, transverse and longitudinal effects (20') (Slides)	Marcel Schuh (*CERN*)

Agreed parameters for further simulations at June workshop

Beam Intensity	40 mA
Intensity pulse-to-pulse jitter	1-3%
r/Q	Take nominal and keep into account the effect of beam velocity
Frequency spread	1-2 MHz

- Other effects to be included as drivers of HOM are:
- Variable chopping pattern and partially deflected bunches
- Transverse alignment errors

Conclusions of the June Wokshop

- It was agreed that new simulations of the SPL case with the parameters shown in Table 2 should be performed before taking any conclusion on the need of HOM dampers. Heat dissipation because of HOMs shall also be evaluated.
- The possibility to use a design similar to SNS, with the inter-cavity connections (bellows) providing sufficient HOM damping, shall be studied carefully. Should this not be sufficient in view of the results of the next simulations, a careful design (or possibly a test) of a sound technical solution for a damper shall be studied. Steps in this direction were presented during the discussion on “dampers technical solutions”.
- It was also agreed that, because of the variety of potential future uses of the SPL, the superconducting cavities should be equipped with ports to allow both HOM monitoring as well as the possibility of adding dampers at a later stage. The design of these ports shall be part of the overall cavity design handled by the cavity working group.

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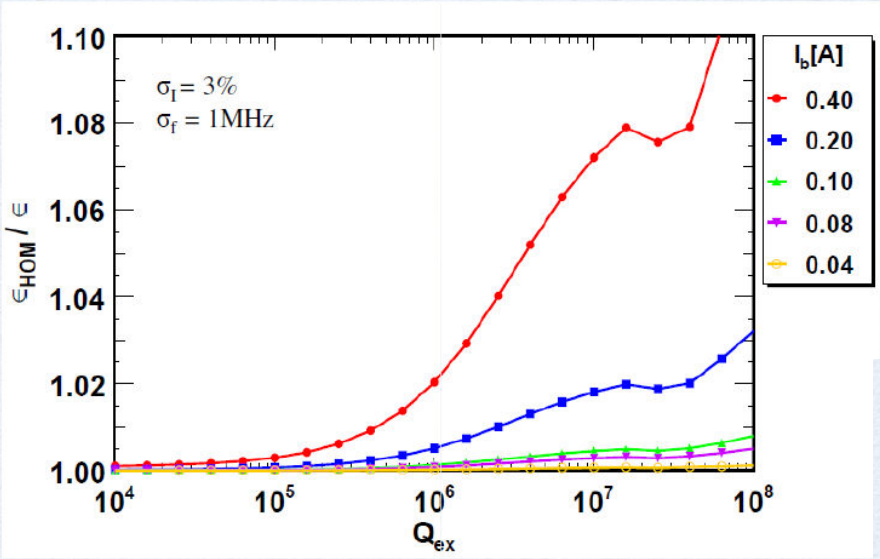
M Schuh – CERN/BE/RF

Basic beam settings used in all simulations:

Parameter	Mean	Variance	Simulation
Bunch period [ns]	$1/f_b \approx 3$	0.00315	long
Pulse length [ms]	1.0	0	both
Period length [ms]	20	0	both
Beam current [mA]	40...400	3%	both
W_{Input} [MeV]	160	0.078	long
Tr. position [mm]	0	0.3	trans
Tr. momentum [mrad]	0	0.3	trans

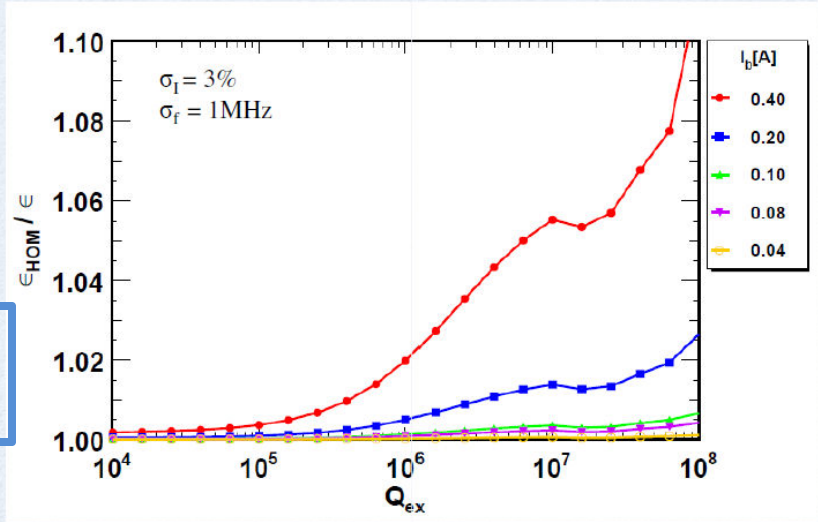
Longitudinal Bunch Center Emittance Growth Rate



Section Parameter	Longitudinal		Transversal	
	Medium β	High β	Medium β	High β
f_{HOM} [MHz]	1783±1	1330±1	1015±1	915±1
R/Q(β) [Ω*] (avg)	12	114	60	48

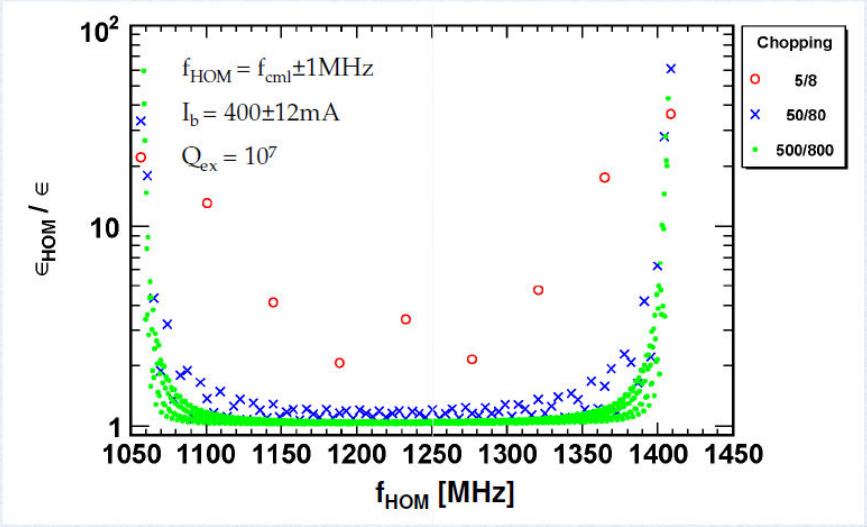
* linac def.

Transversal Bunch Center Emittance Growth Rate

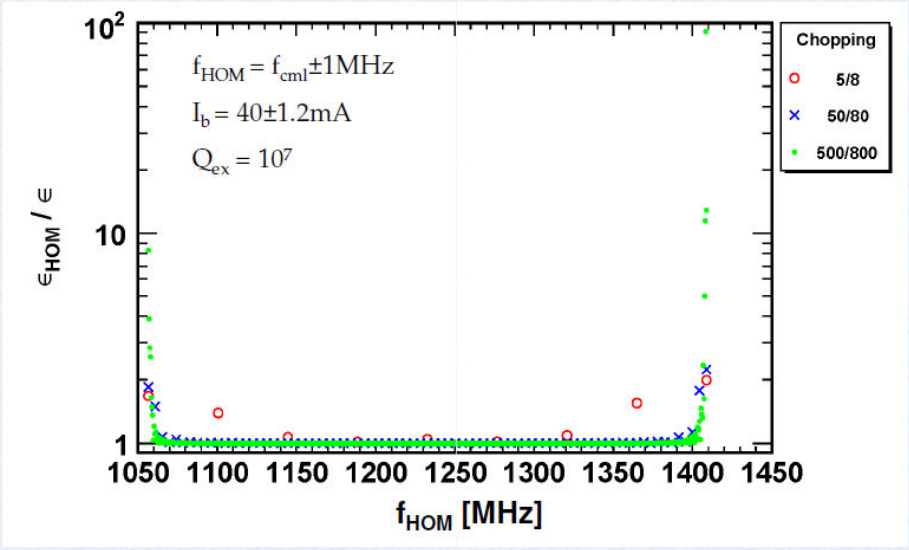


Need to push current up a factor 10 to see a 10% effect .

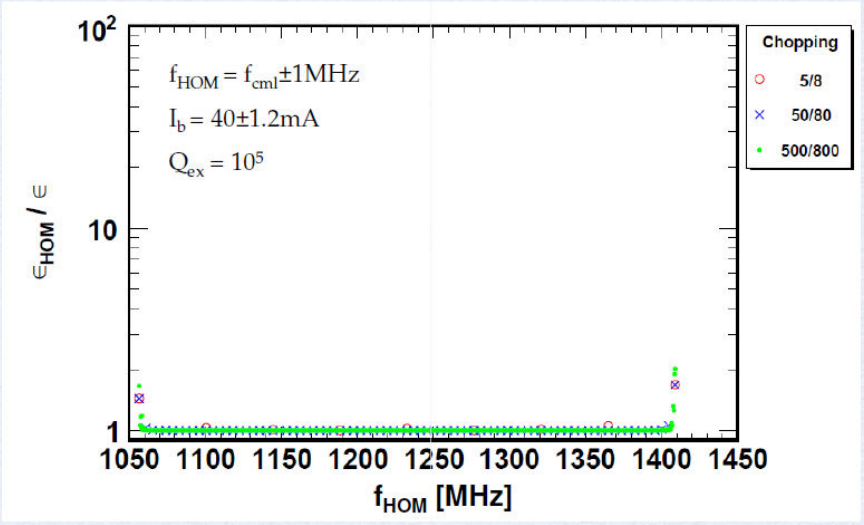
Longitudinal Bunch Center Emittance Growth Rate



Longitudinal Bunch Center Emittance Growth Rate



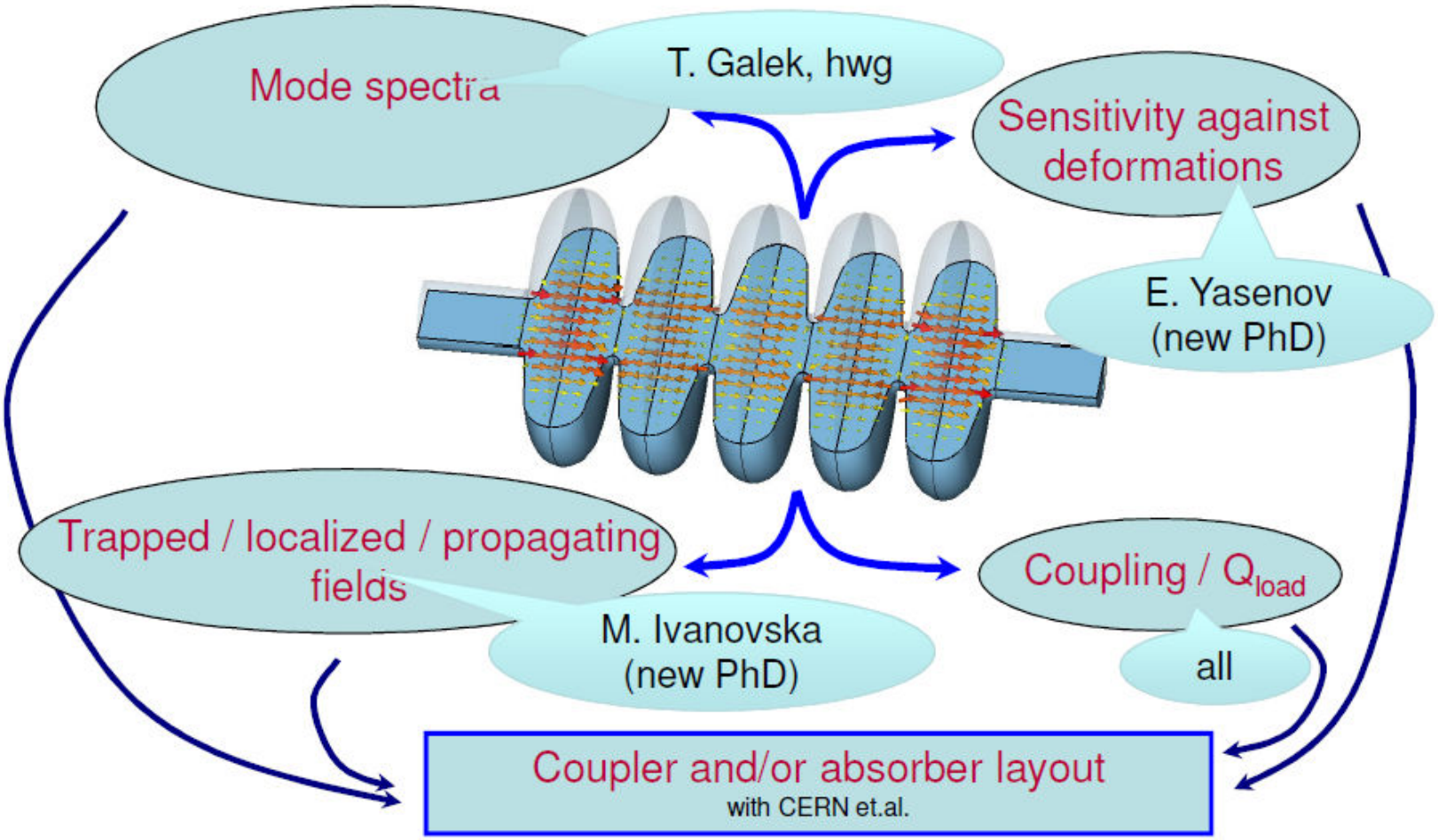
Longitudinal Bunch Center Emittance Growth Rate



To be sure that with any chopping pattern beam dynamics will not be perturbed we need

$Q<10^5$

Like an outlook



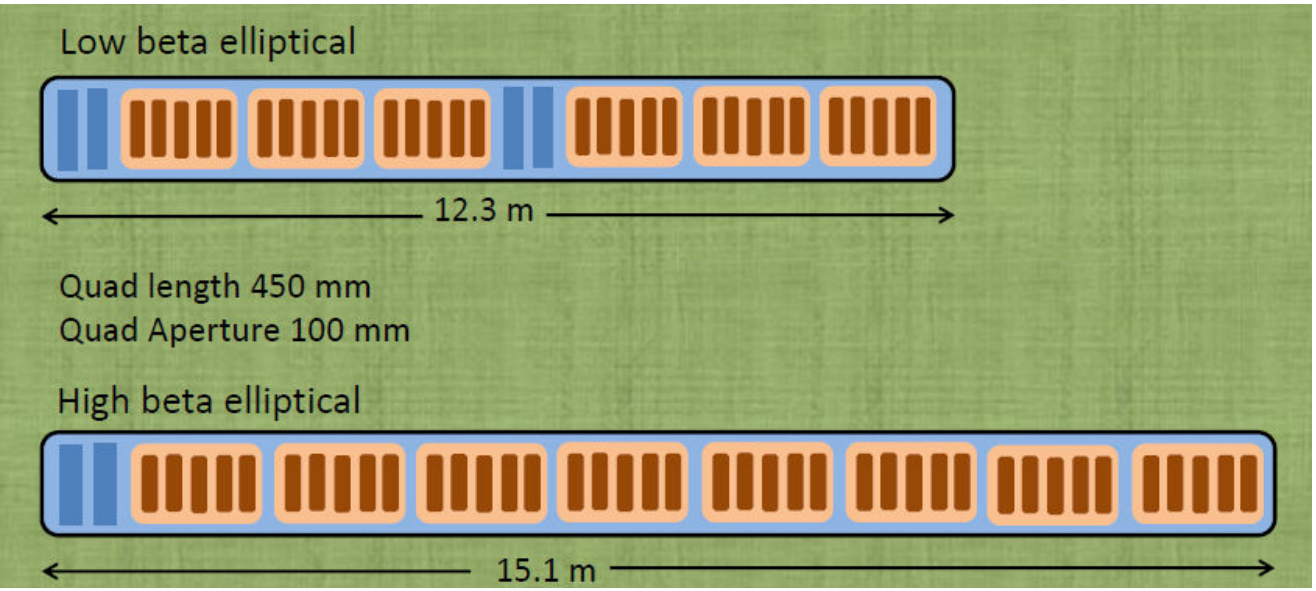
European Spallation Source
Scandinavia

CERN sLHC

Doublet vs. FODO structure: beam dynamics and layout

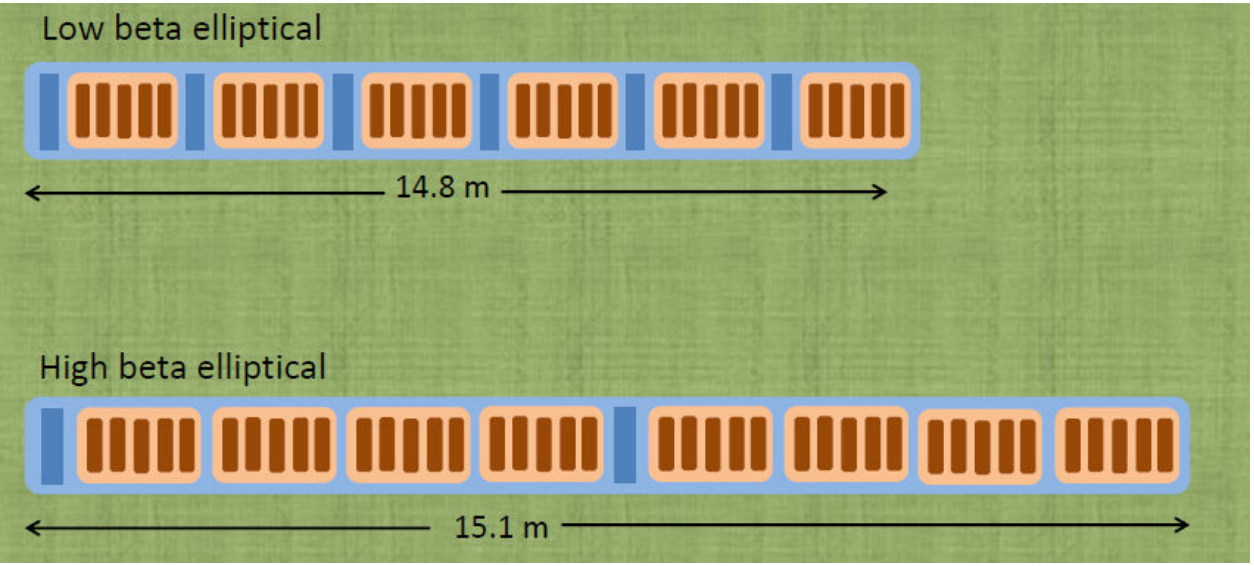
Mohammad ESHRAQI

3rd SPL Collaboration meeting CERN 12-11-2009



Building blocks for

Doublet



Building blocks for

FODO

Compare Doublet vs FODO on

1) structure
2) beam dynamics
3) sensitivity to alignment
4) impact on cryo layout

Structure : only difference is that the gradient of the quadrupoles is lower in FODO

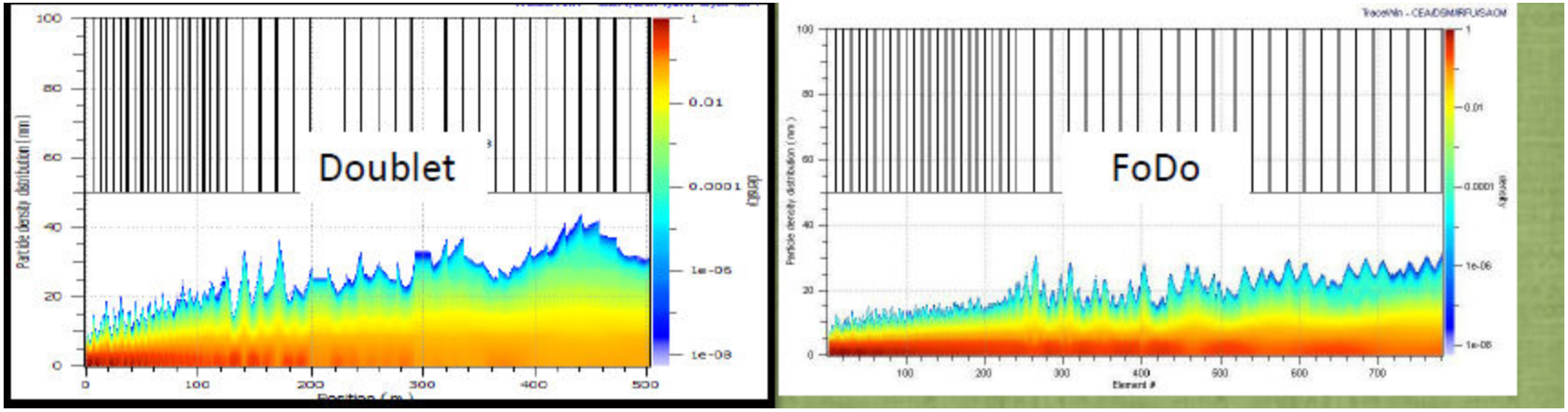
	L (m)	E (MeV)	Periods	Cav/period	Total Cav/ Quad (PS)
Doublets	501	786 / 4989	20 / 23	3 / 8	244 / 86+4^{warm} (54)
FoDo	510	710 / 5020	24 / 24	2 / 8	240 / 96 + 4^{warm}(59)

Beam dynamics : no real difference

Doublet	x	y	z
Initial ε	0.328	0.334	0.468
Final ε	0.369	0.365	0.486
Δε%	12.5	9.4	3.8

FoDo	x	y	z
Initial ε	0.328	0.334	0.468
Final ε	0.359	0.356	0.546
Δε%	9.5	6.5	16.6

Sensitivity to alignment : slightly better for FODO



Impact on cryo-layout : FODO is not compatible with warm magnets

Decision : wait decision on cryo-segmentation before excluding one of the solution.

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10:30->*11:30* 3rd combined session WG3 & WG4 (30-7-018 (TE auditorium))

10:30	Sensitivity study on the SPL : definition of alignemnet tolerances, diagnostics and correction systems (20') (slides)	Piero Posocco (*CERN*)
10:50	A non invasive technique for transverse beam envelope matching and its consequence on the cryomodule layout (20') (slides)	Romuald Duperrier
11:10	Survey and alignment techniques for SPL (20') (Slides)	Dominique Missiaen (*CERN*)

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	STEP I	STEP II	STEP III
50k particles from RFQ to PIMS, 500 runs each error configuration, TraceWin (CEA)			
SPL design	FD and FODO	common	FD and FODO
Input beam misalignment	none	±0.2mm ±0.2mrad	±0.2mm ±0.2mrad
Magnet errors:			
Gradient	±0.5%	±0.5%	±0.5%
Displacement	±0.1mm ±0.2mm ±0.3mm ±0.5mm	±0.1mm	±0.1mm ±0.2mm ±0.3mm
Discovered tolerances:			
	±0.1mm for PIMS ±0.2mm for SPL	±0.1mm ±0.1mrad residual beam mis.	±0.2mm for SPL

P. A. Posocco - "Sensitivity studies on the SPL" 11/12/2009

D.Missaien :
The alignment tolerances (0.3 mm) are not too challenging

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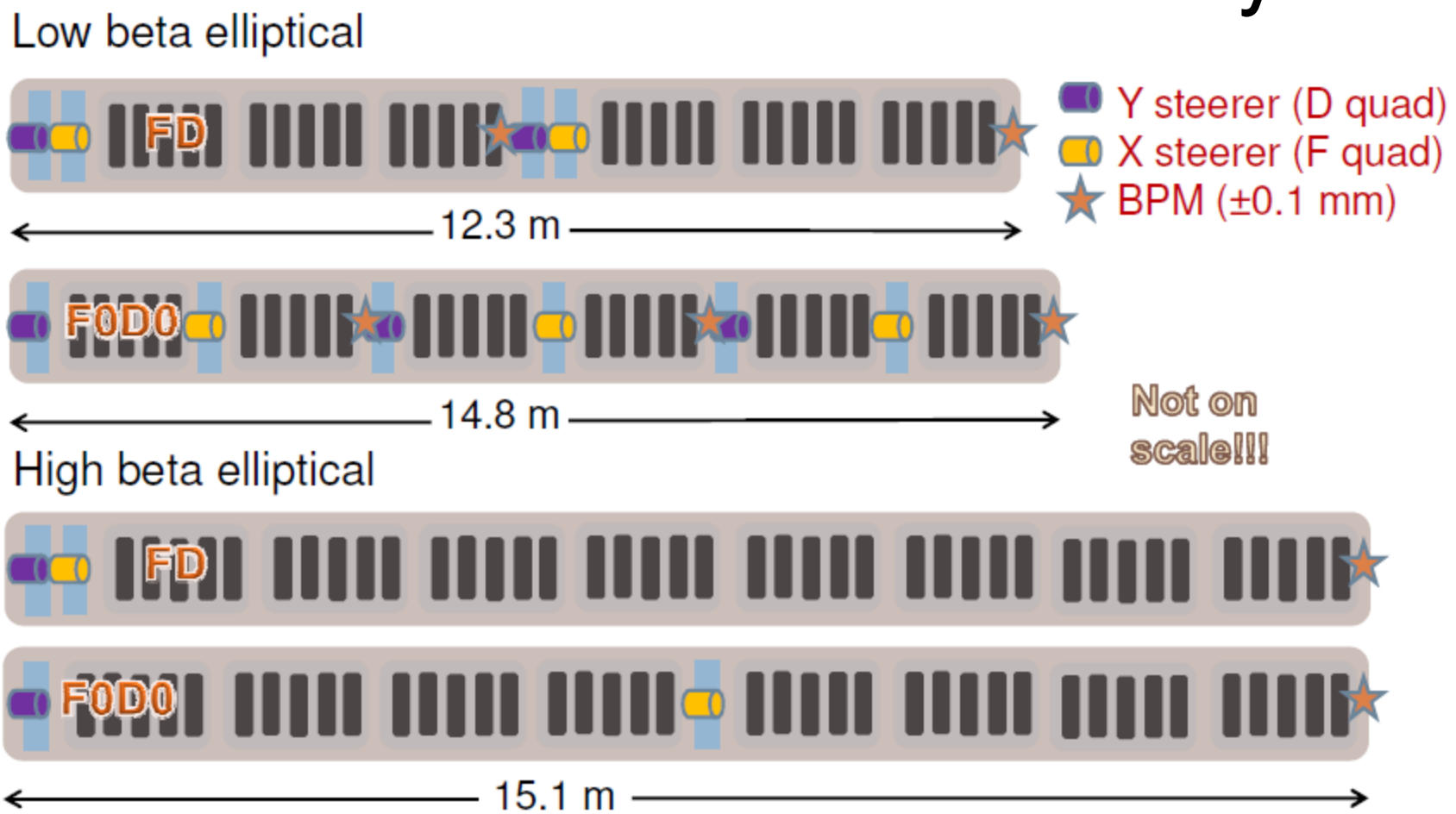
Correction system



P. A. Posocco - "Sensitivity studies on the SPL" 11/12/2009

- 1 steerer for each quad (strength less than 0.02 Tm)
- 1 BPM after 2 quads (just before the following quad)

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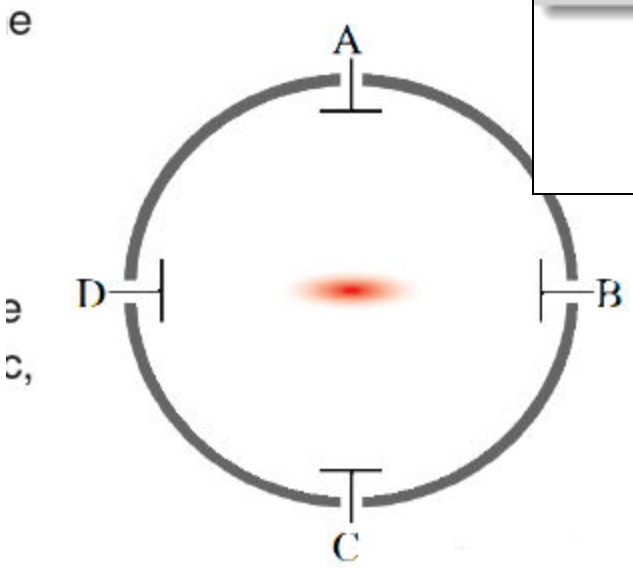
A non invasive technique for transverse beam envelop matching and its consequence on the cryomodule layout

Romuald Duperrier - Didier Uriot



CONCLUSIONS :

1) The quadrupolar signal in a Beam Pick up can be used to derive information about the beam envelope matching.
2) Proof of principle placing the BPM inside a quadrupole on a test linac gives results comparable to having a standard profile meausrements.
3) Details for SPL still to be worked out (position outside the quadrupole, reduction of acceptance)

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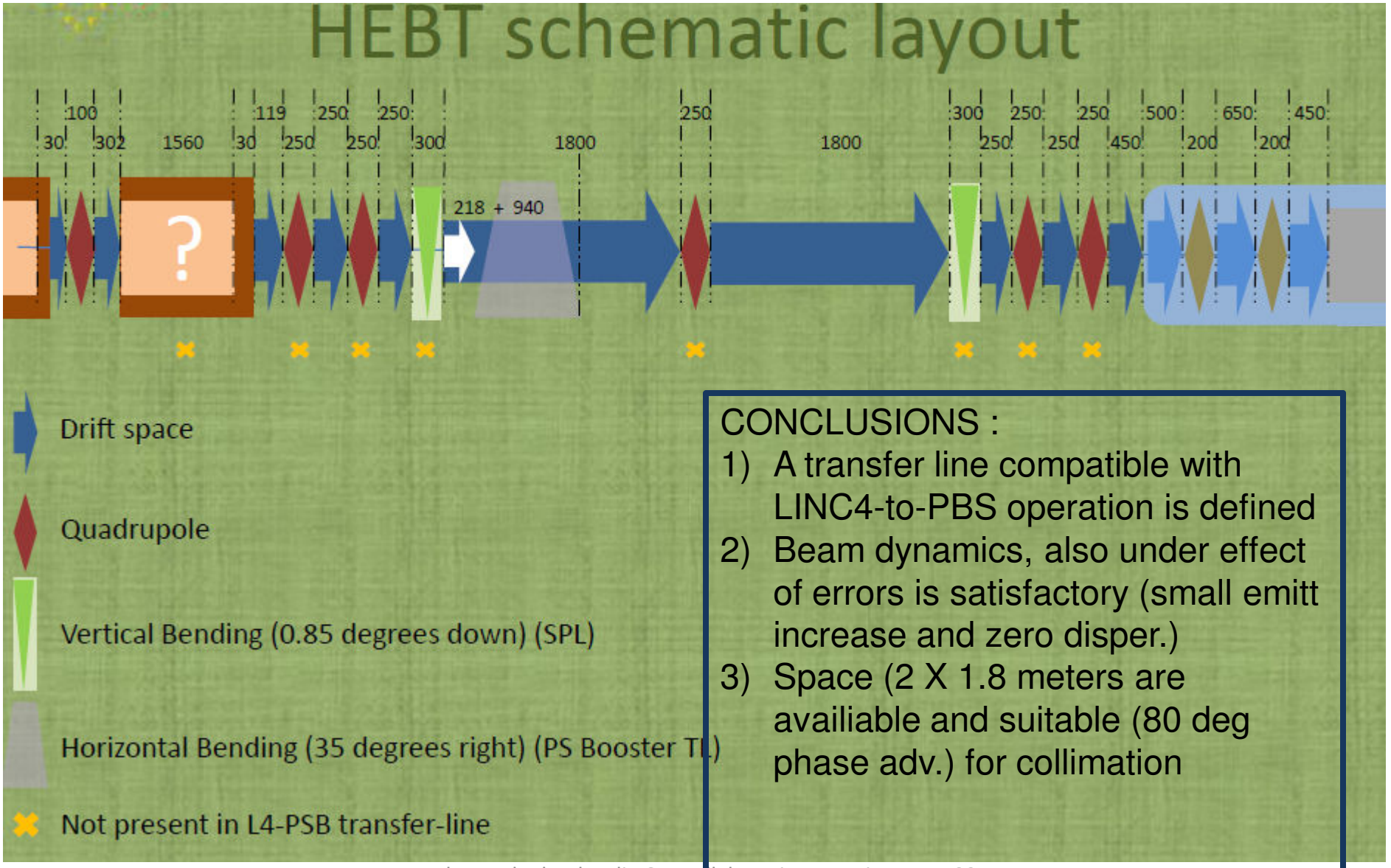
16:30->*18:00* 4th session WG4 (30-6-041)

16:30	From Linac4 to SPL (20') (slides)	Mohammad Eshraqi (*CERN*)
16:50	Collimation in the SPL transfer line & integration of waveguide ducts (20')	Marcin Staszczak (*Soltan Institute*)
17:10	Collimator design : plans at STFC (20') (Slides)	Luis Fernandez (*STFC*)
17:30	SPL to PS2 transfer line and PS2 injection requirements (20') (slides)	Bartmann Wolfgang (*CERN*)

Drawing linac4 transfer line

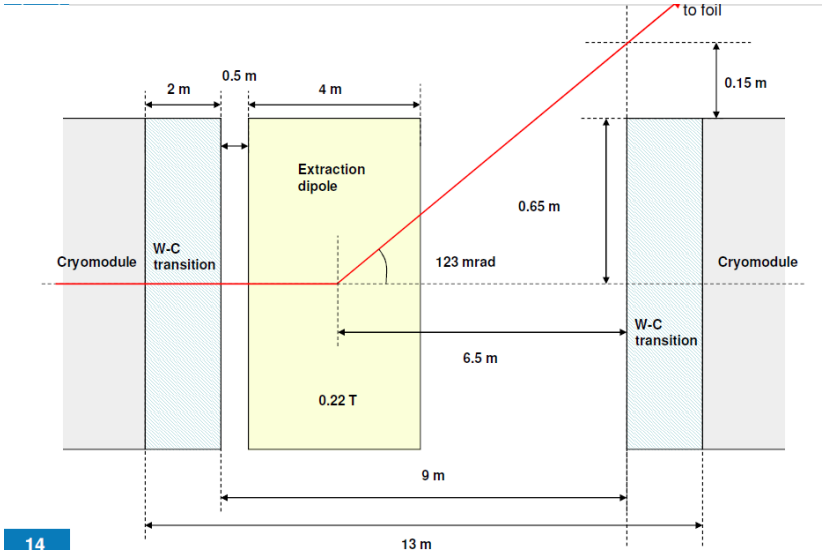
LINAC4 to SPL (160 MeV)



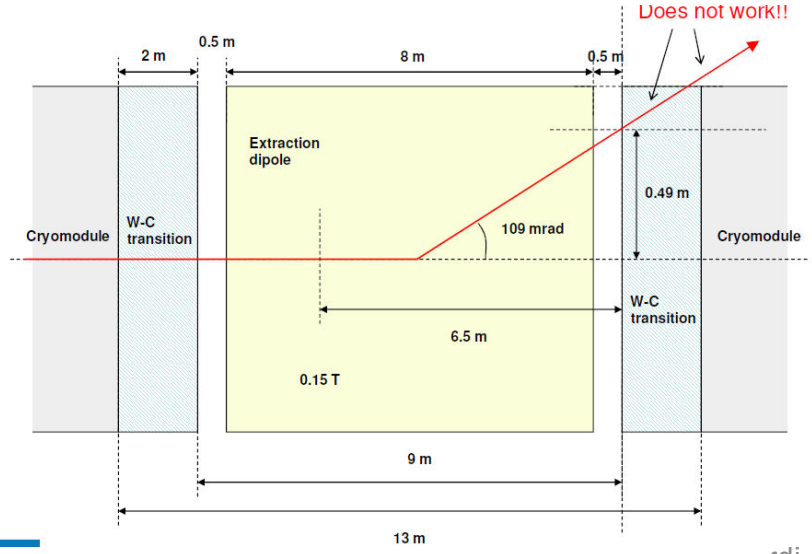
CONCLUSIONS :

1) A transfer line compatible with LINC4-to-PBS operation is defined
2) Beam dynamics, also under effect of errors is satisfactory (small emitt increase and zero disper.)
3) Space (2 X 1.8 meters are availiable and suitable (80 deg phase adv.) for collimation

Extraction (1.5 and 2.5 GeV)



0.29 T maximum bending field (0.1 W/m)

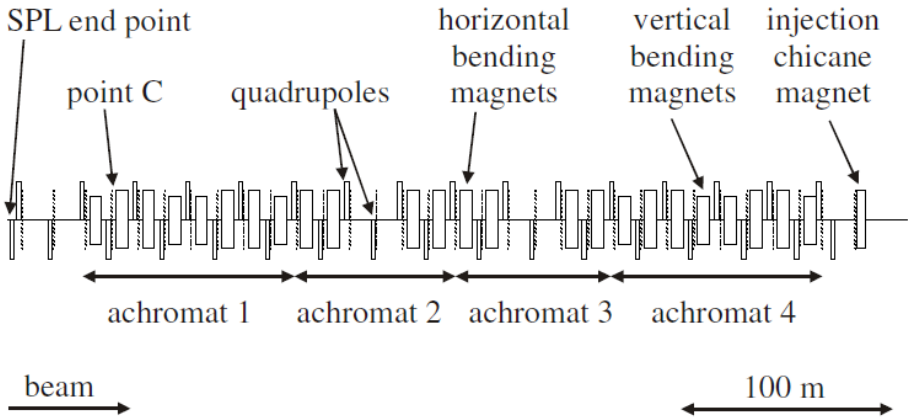


0.15 T maximum bending field (0.1 W/m)

CONCLUSIONS :

1) At 1.5 GeV a solution fits, just skipping a cryomodule, no perturbation to periodicity of the lattice
2) At 2.5 GeV we need to make more space (order 4-5 meters) and evaluate impact on dynamics.
3) NB : WE HAVEN"T INTEGRATED THE DIAGNOSTICS YET

SPL to PS2 (5 GeV)



- first part compatible with HP-SPL, second part only compatible with LP-SPL @ 4 GeV
- second part can be compatible with LP-SPL @ 5 GeV if 7.2 m (instead of 5.75 m) long dipoles are used
- large slope of 8.1%

CONCLUSIONS :

1) A transfer line layout has been established.
2) Need to optimise transport with space charge and multiparticle simulations.
3) Need to integrate RF to match the energy spread requirement and jitter at PS2 (tbd)
4) Stripping : foil vs laser still to be studied in details
5) Back-burner : effect and mitigation of blackbody radiation.

COLLIMATION :

•Exploratory work going on at STFC and Soltan Institute

•NEED COORDINATION :

•Beam dynamics : beam halo and establish how much we want to collimate
• Collimation optics : aperture and position
•Collimation design : choice of material…..
•RP consideration : shielding yes/no; how distant from a magnet …..

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Objective of this meeting :

1) Discuss and select (or define what is needed to select) a focusing scheme/layout. [ok]

2) Validate alignment tolerances and correction system. [ok]

3) Define a path to finalize diagnostics requirement. [partly]

4) Solidify the collaboration with external institutes. [……..…]

5) Define dates and topics of the next-year workshop(s) [ok]
   - Collimation .

THANK YOU ALL for the interesting discussion and useful input

Topics :

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

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

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

4) HOM effects

5) Compatibility with e-

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

Priorities!

1) Study which have a strong impact on civil engineering :
    1) Transition LINAC4-SPL (determine the position of the first cryo)
    2) Layout including extraction areas

2) Study which have a impact cryo design :
    1) Alternative focusing systems
    2) Position of corrective elements
    3) Position of cold diagnostics
    4) Position of the warm diagnostics
    5) Alignment studies
    6) HOM dampers

3) The rest :
    1) Collimation Loss control
    2) Beam dynamics fine tuning
    3) H- stripping in the transfer lines