Search for optimal IR solutions for the LHC Luminosity Upgrade:

Questions to the Experimentalists

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Introduction

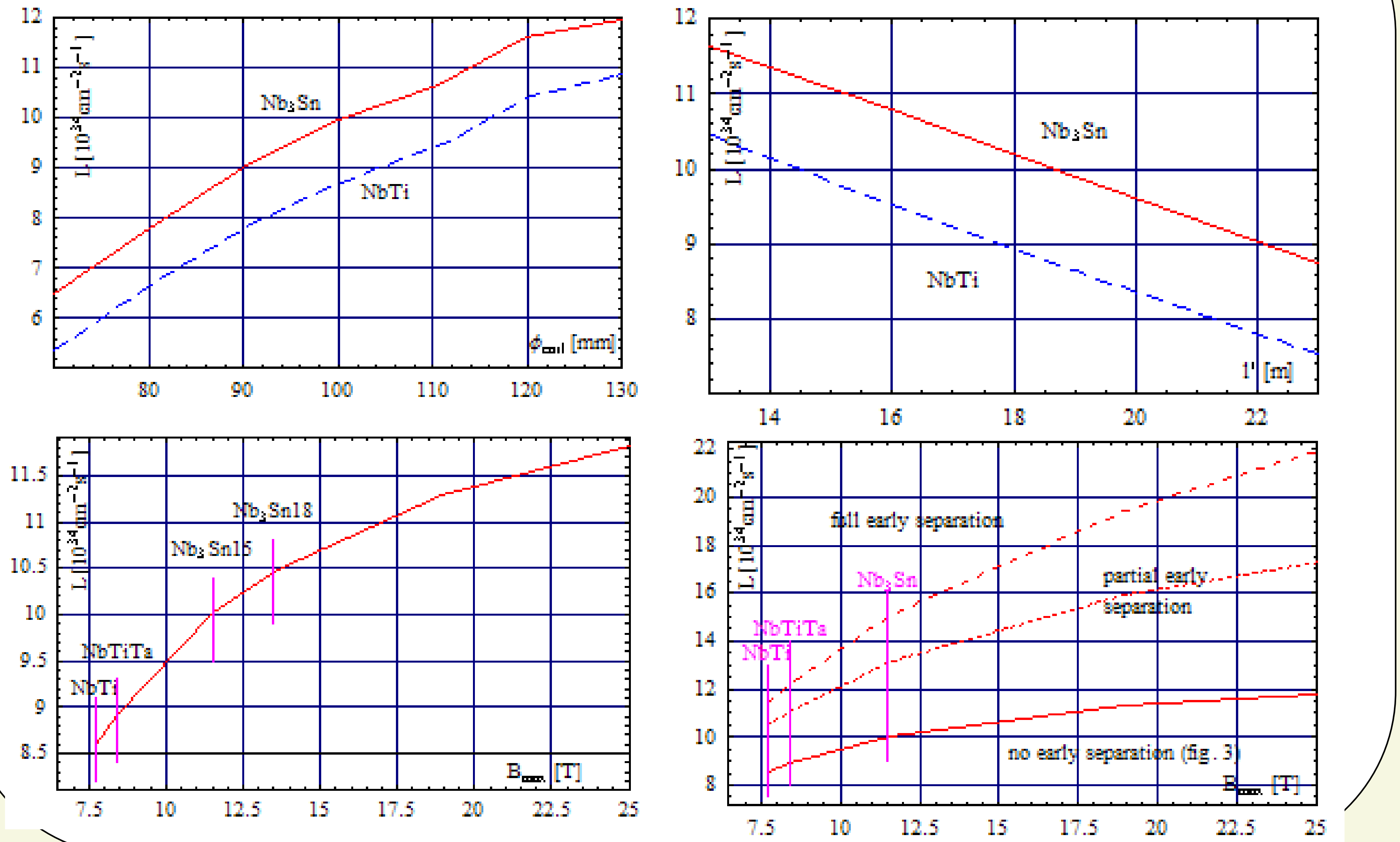
- A **parametric insertion model** has been developed for Arcidosso 2005 to investigate the performance of **Quadrupole-first insertions**. It solves in a **simplified** but **self-consistent** way the problems of layout, optics, aberrations, beam-beam, quadrupole technology and gives hints on energy deposition.
- It was used in Arcidosso mostly to evaluate the proposed upgrade solutions and identified issues, such as the requirement to decrease l*,…
- For EPAC 2006, it was used to explore *more systematically* the parameter space. There are potentially **interesting new solutions**. **Before doing *more accurate studies*, some feedback is needed.**

Parameters & Optimization strategy

- **Optimization goal:** *peak luminosity*
- **Assumptions on the upgraded beam:**
  - Up to 1.7 10^{11} p per bunch (+ 50%)
  - Up to 5616 bunches (× 2)
  - Down to 3.7 cm bunch length (× 0.5)
- **Parameters:** l*, {♐quad, Bmax, lquad}
- **Constraints:**
  - ***Head-on and LR Beam-beam limits*** respected
  - ***Linear*** chromaticity correctable by the lattice sextupoles
  - Sensitivity to harmonics ***not too far from nominal***
  - ***10*** ♦ betatron aperture in the triplet
  - ***25% field margin*** in the super-conducting coils.
- **Options:** early separation, nominal bunch length, reduced beam current.

A Glance at the parametric dependences

Defaults: no early sep., l=19m, ⌀coil=100mm, Nb3Sn15T, heat deposition not included*



Potentially interesting solutions

1. High peak luminosity

Full beam current upgrade and “practical” early separation.

	Q’ corrected			
l^*	β^*	x_{coil}	L_{PES}	L_{NES}
[m]	[m]	[mm]	$[10^{34}\ cm^{-2}s^{-1}]$	
13	**0.087**	**126**	**20.5**	12.2
19	0.124	130	17.3	11.4
23	0.15	131	15.3	10.7

Questions: This is two times the bunch luminosity proposed in the feasibility study:

- Can this high luminosity be handled by upgraded detectors?
- What is the dependence of the integration complexity versus l*?
- Is it worth pursuing (small l*, large quads,…)?

Potentially interesting solutions

2. Conservative upgrade parameters

Use nominal bunch number and length; assume *practical early separation*.

*l** [m]	*β** [cm]	*Np* [10^{11}p]	*L*	*L* [10^{34} $cm^{-2}s^{-1}$]
13	8.7	1.7	7.5	→**13.7** (FES or ♦ $_s$/2) →***3.1*** (NES)
		1.15	3.6	→ 6.2 (FES or ♦ $_s$/2)
16	10.7	1.7	7.5	→11 to **12**. (FES or ♦ $_s$/2)
		1.15	3.6	→ 5.4 (FES or ♦ $_s$/2)
19	13	1.7	7.3	→9.7 to **10.5** (FES or ♦ $_s$/2)
		1.15	3.5	→ 4.9 (FES or ♦ $_s$/2)

Aperture 120 mm

βmax 16500 m

Question: For the nominal bunch length and practical early separation, the performance is rather constant with l*. However the potential for further upgrades increases significantly with a reduced l*.

- What is more important: a higher potential for Lumi or the l*?

Potentially interesting solutions

2. 50 ns bunch spacing

Almost Full early separation becomes possible and compensates the loss due to the reduced number of bunches:

For l*=13m, the luminosity prospect is 6.8 instead of 7.5 for ultimate bunch current. This loss can be compensated by increasing by 10 mm the quad aperture. If the bunch length is further reduced by a factor of 2, a luminosity of 10 is reached.

Question:

- ***Any interest in this direction?***

Conclusions

- It seems at first possible to increase significantly the luminosity above the feasibility report assumptions.

- Solutions with a much reduced risk on machine performance (and hence on overall integrated luminosity) appear to exist.

(These two points will be discussed in Valencia from the machine point of view).

In both cases, magnetic elements have to be introduced deep into the detectors. Is it feasible? If yes, is the overall expected gain worth this added complexity?