Early separation scheme for the LHC upgrade

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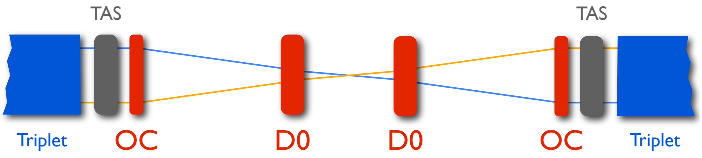
CARE-HHH Scenarios for the LHC upgrade and FAIR

Thanks to J.-P. Koutchouk and F. Zimmermann.

Outline

1. Early separation scheme
   - Introduction on the ESS
   - The integrated fields
   - A proposal at 6.8 m
2. A D0 at 14 m?
   - The 7 σ case...
   - The 5 σ case...
3. Conclusion

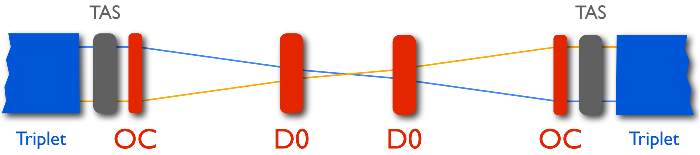
An introduction. . .



The D0 scheme is a possible player in the Phase II Luminosity Scenario. It consists of two dipoles per each side of each experiment: the D0 and the OC. There are several ways for the upgrade: all are a different combination of the same ingredients

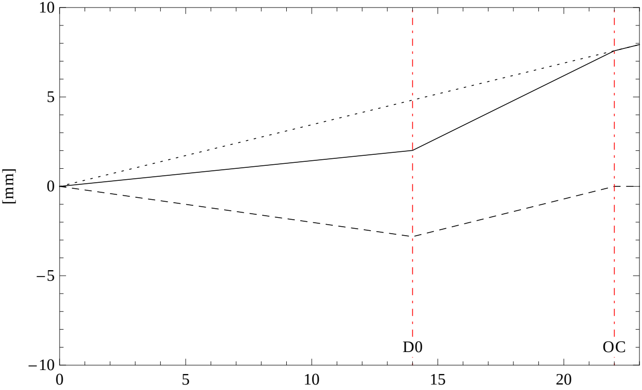
- more beam current
- lower β^*
- reduction of the θ_c at the IP

An introduction. . .



- But the reduction of the for θ_c for boosting the luminosity enters in competition with the BB effect.
- D0, Crab cavities and Wire compensation are the three HW proposals to solve this problem. The possible dynamic change of θ_c (luminosity leveling) can be taken into account.

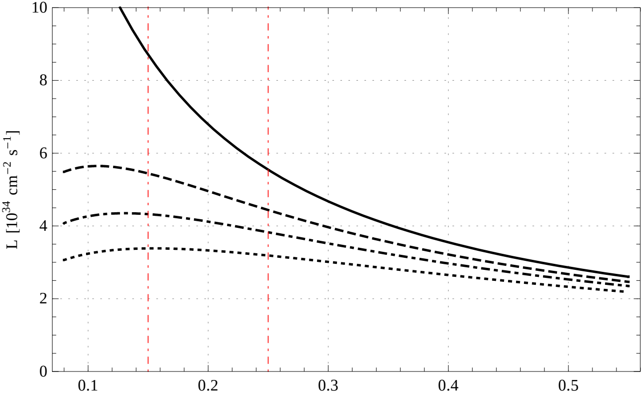
Inner and outer separation



Distance from the IP [m], β^{*}=0.15 m, IS = 5 σ, OS = 12 σ

Beam trajectory (—) = 12 σ external bump (--) − 7 σ internal bump (···)

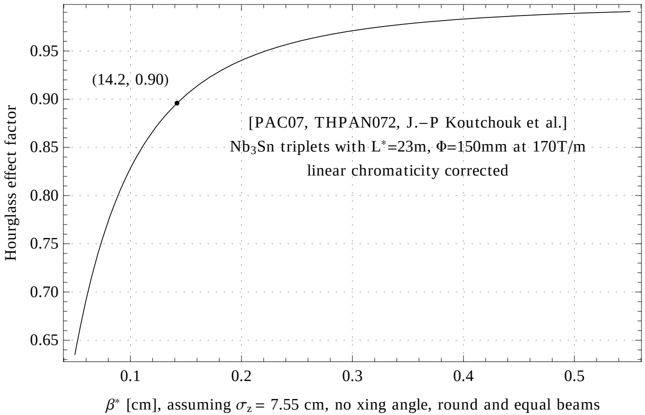
The ESS has to come with a reduced β^* but. . .



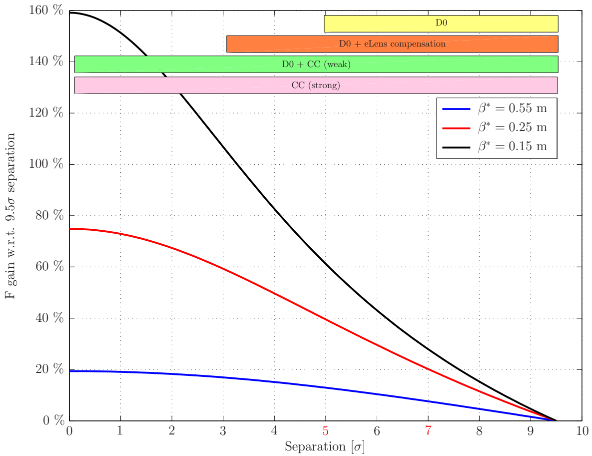
β^* [m], $\theta_c \rightarrow 0\ \sigma$ (—), 5 σ (--), 7 σ (·--·) and 9.5 σ (···)

N=1.7 10^{11}, n=2808, σ_z=7.55cm

The hourglass effect. . .



How much do we gain?

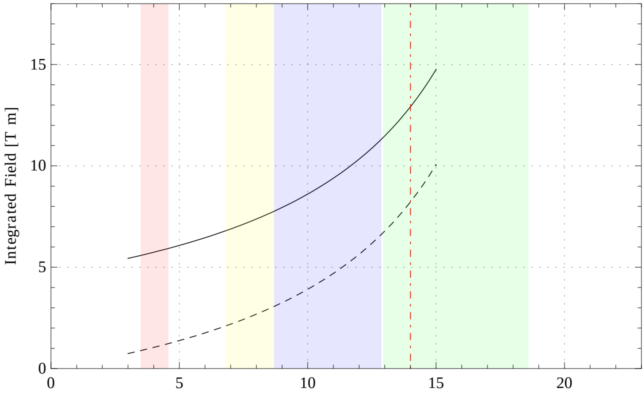


The players for the integrated fields....

It depends on...

- the D0 position
- the OC position: let us assume 22 m
- the β^*: let us assume 0.15 m
- the inner beams separation (between the IP and the D0): let us assume 5 σ
- the outer beams separation (between the OC and the triplet): let us assume 12 σ.

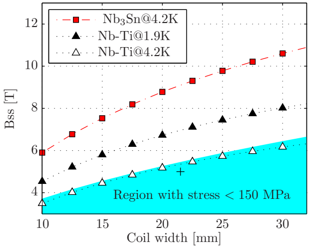
The integrated fields....

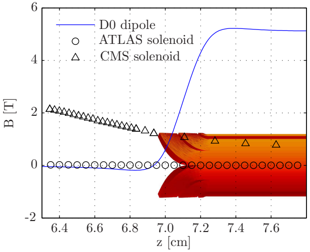


D0 distance from the IP [m]: D0 (—), OC(--)

OC at 22m, $\beta^* = 0.15$ m, IS = 5 σ, OS = 12 σ

HW for 6.8m slot proposed: Nb-Ti @1.9K



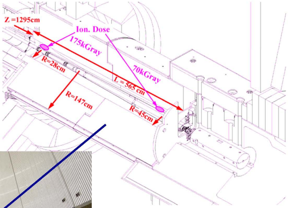


- 30 cm aperture magnet, ironless magnet, Nb-Ti coils at 1.9 K can deliver the required 7 Tm in a 2 m long cryostat.
- The total heat load of 74 W.
- The Lorentz force on the coils due to the detectors solenoid is an issue in CMS.

A possible position in ATLAS: a slot at 13 m!

Only place which make sense

Forward Shielding Region (JF) …. which need to be redesigned for SLHC in any case



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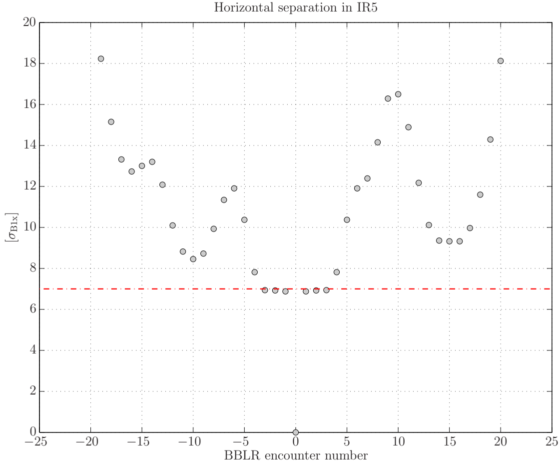
Courtesy of M. Nessi ("LHC Crab Cavity Validation", 21st August 2008)

Shaping a proposal. . .

Let us assume

- to put the D0 at 14 m from the IP
- to put the OC at 22 m from the IP
- to have a mean separation in the triplet of 12σ
- to level L starting with a separation at the D0 of 16σ
- to have $\beta^* = 0.15$ m

With 7σ we gain the 30% on the F factor



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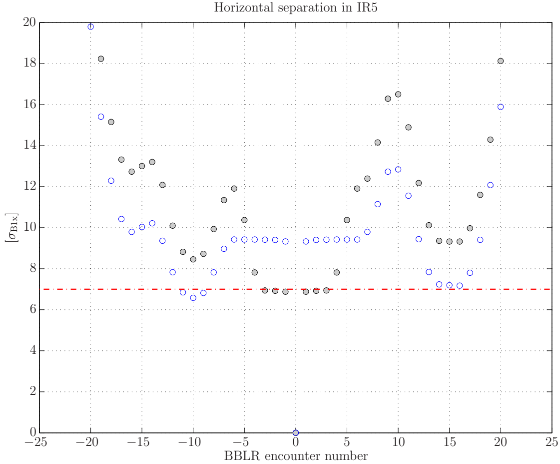
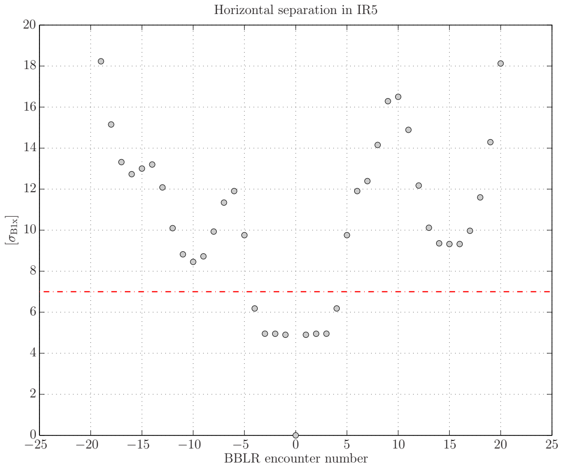


With 7σ we gain the 30% on the F factor

But. . .

- Separation pattern similar to the nominal
- We need a bigger separation in the triplets 12σ
- The field request for D0 and OC is almost doubled w.r.t the position st 6-9 m!
- A complete study on the heat load has to be done.

With 5σ we gain the 60% on the F factor, but...



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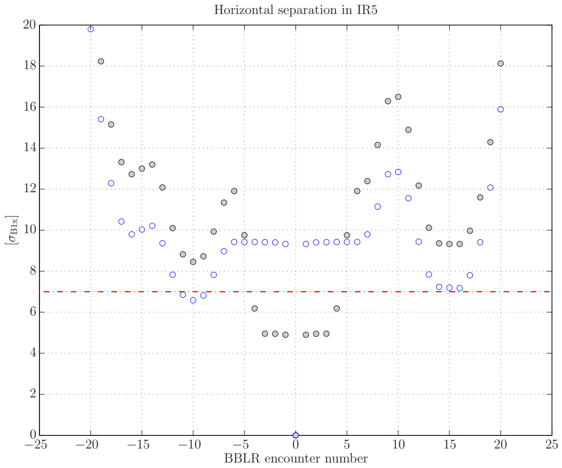
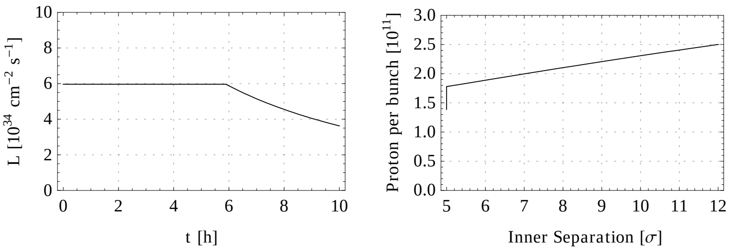


With 5σ we gain the 60% on the F factor, but...

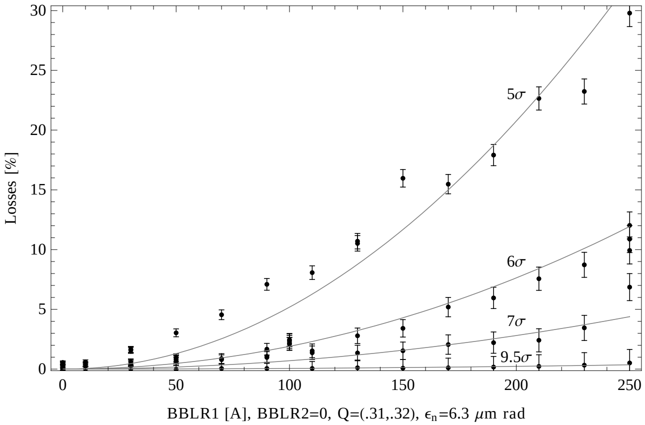
But...

In this case we have to study by tracking if the 6 encounters at 5σ per IP can be tolerated or not.
It is worth noting that if we consider the leveling only at the end of the run the 5σ separation will occur.

e.g. $\beta = 0.15$m, $N = 2.5\ 10^{11}$, n_b=2808, leveling from 12 to 5 σ, max total HO tune shift 7 10^{-3}



SPS results (measured on 2s flattop)



Thanks to JPK, FZ, E. Metral, R. Calaga, E. Laface, R. Tomás, B. Salvant, G. Burtin, U. Dorda and J.-J. Gras.

Conclusions

- D0 at 14m has a significant impact on the required integrated field (13 Tm + 8 Tm) and BB effect
- The energy heat load can be a major problem
- A D0 with 7σ separation at $\beta = 0.15$ m provides a gain of 30% on the F factor with an impact similar to the nominal LHC scheme but we need 12σ separation in the triplet
- The 5σ solution can present seriuos BB problems (SPS results not encouraging): W. Herr and D. Kaltchev are working in that direction with a complete 6D tracking.

Thank you.... . .

- LUMI05, Possible quadrupole-first options with $\beta \leq 0.25$ m, J.-P. Koutchouk: the concept.
- EPAC06, WEPCH094, J.-P. Koutchouk and al.: D0 at 2 m and 9.5 m from the IP.
- CARE06, D0 and its integrability, G. Sterbini: results of meeting organized by E. Tsesmelis.
- PAC07, THPAN072, J.-P. Koutchouk and al.: global optics solution.
- CARE07,D0 design and beam-beam effect, G.Sterbini: D0 at 3.5 m from the IP.
- PAC08, WEPD025, G. Sterbini and al.: D0 at 6.8 m.
- PAC08, WEPP013, J.-P. Koutchouk and al.: Luminosity leveling.