MDI Status and Plans

Michele Modena and Lau Gatignon
on behalf of the MDI working group

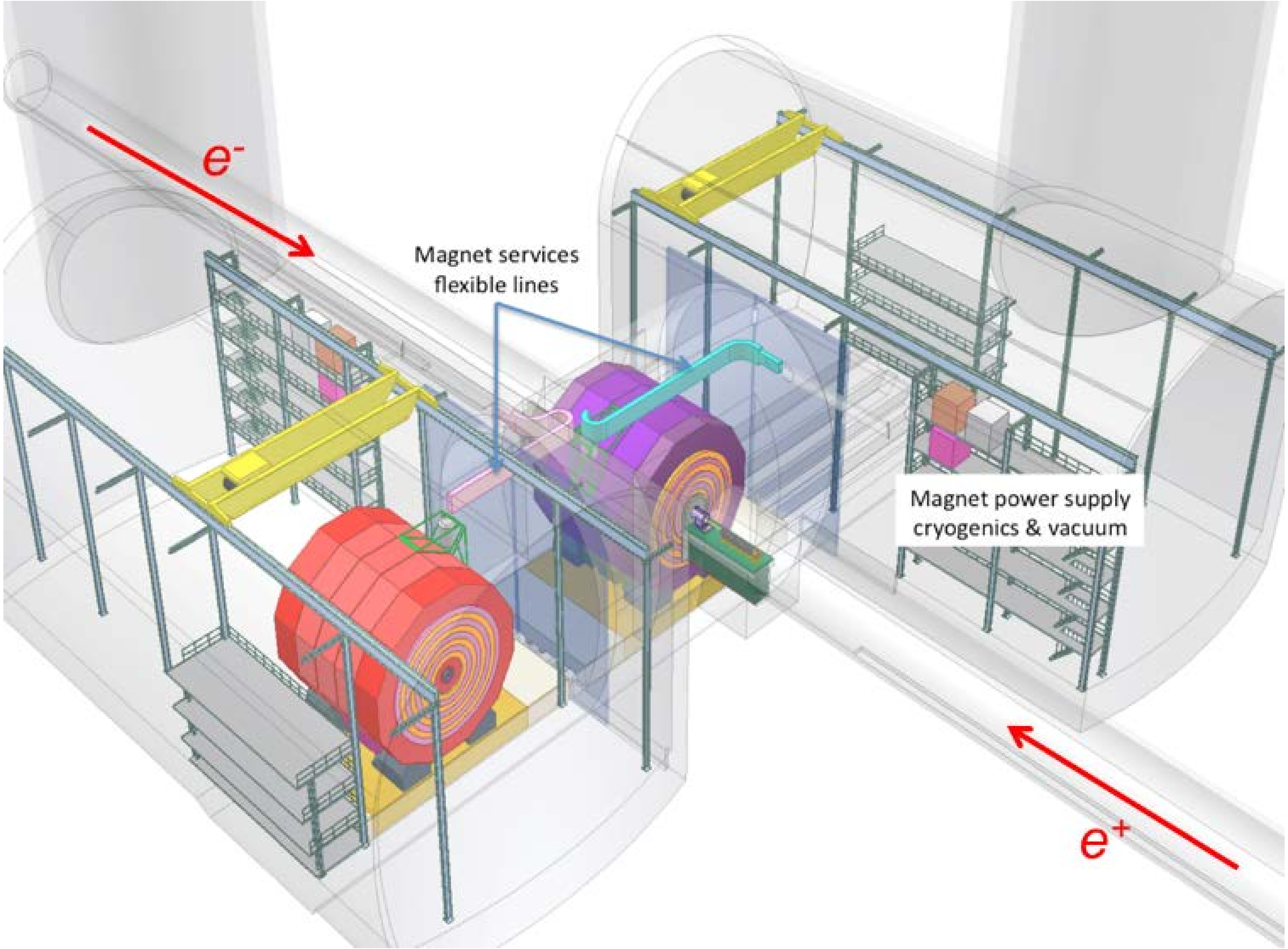
Outline

- MDI (recall of CDR and previous status)
- Studies done and ongoing
  1. Studies for longer L*: impact on the various systems
  2. IP feedback
  3. Muon scrapers study
- Conclusion and future plans

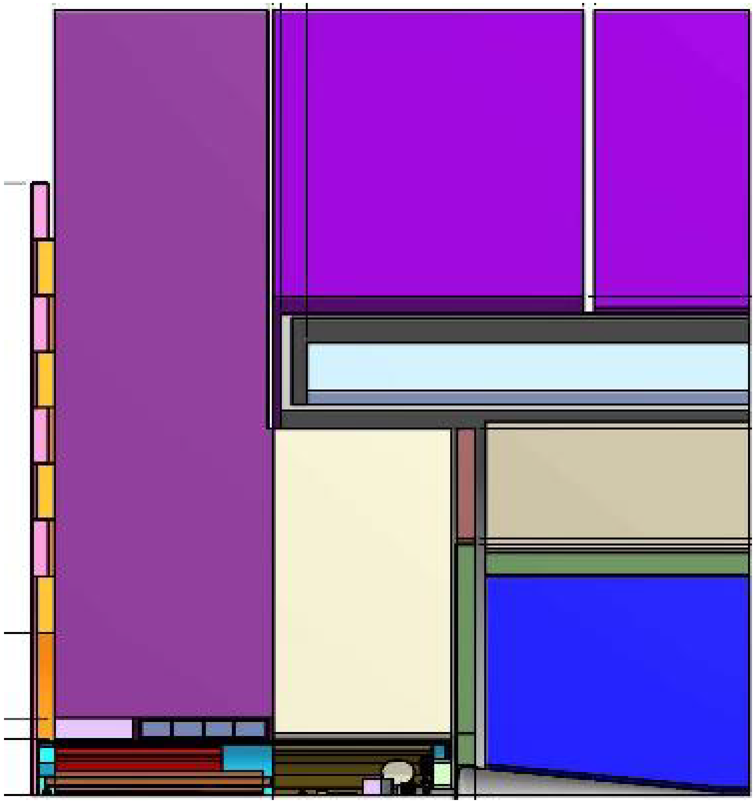
What is MDI

- The Machine Detector Interface must ensure optimum luminosity for the experiment(s) with minimal backgrounds. It includes the integration of all systems and infrastructure.
- The baseline for the CDR was based on a concept with two detectors operating in push-pull mode and with the final focus quadrupoles QD0 as close as possible to the interaction point ($L^* = 3.5$ m, i.e. INSIDE the detectors).
- The MDI design and studies include the studies for the QD0 design as well as its stabilisation and pre-alignment, but also IP feedback, BeamCal and Lumical integration, vacuum layout, cavern layout, post-collision line systems etc.

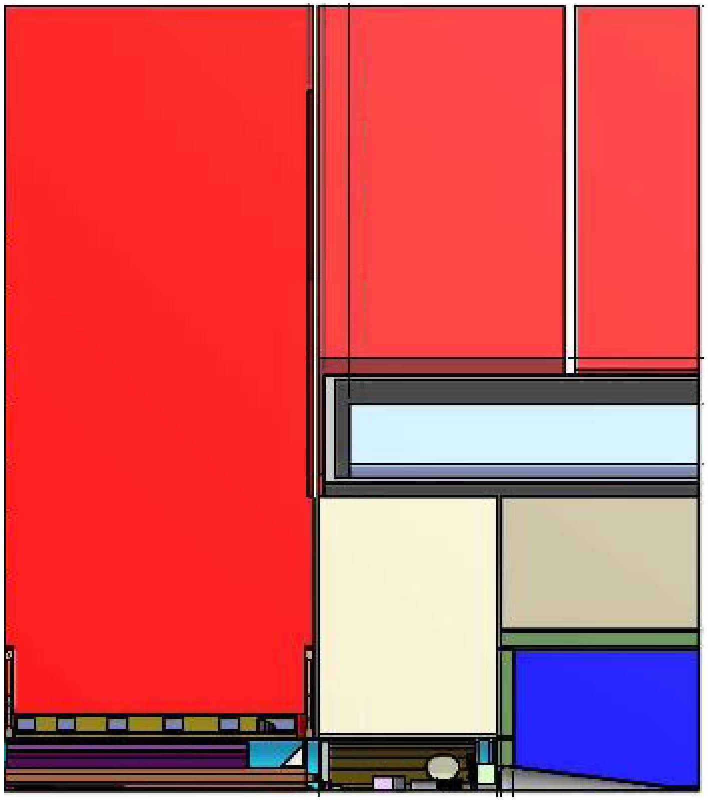
The CDR MDI concept:



CDR Detectors Concepts

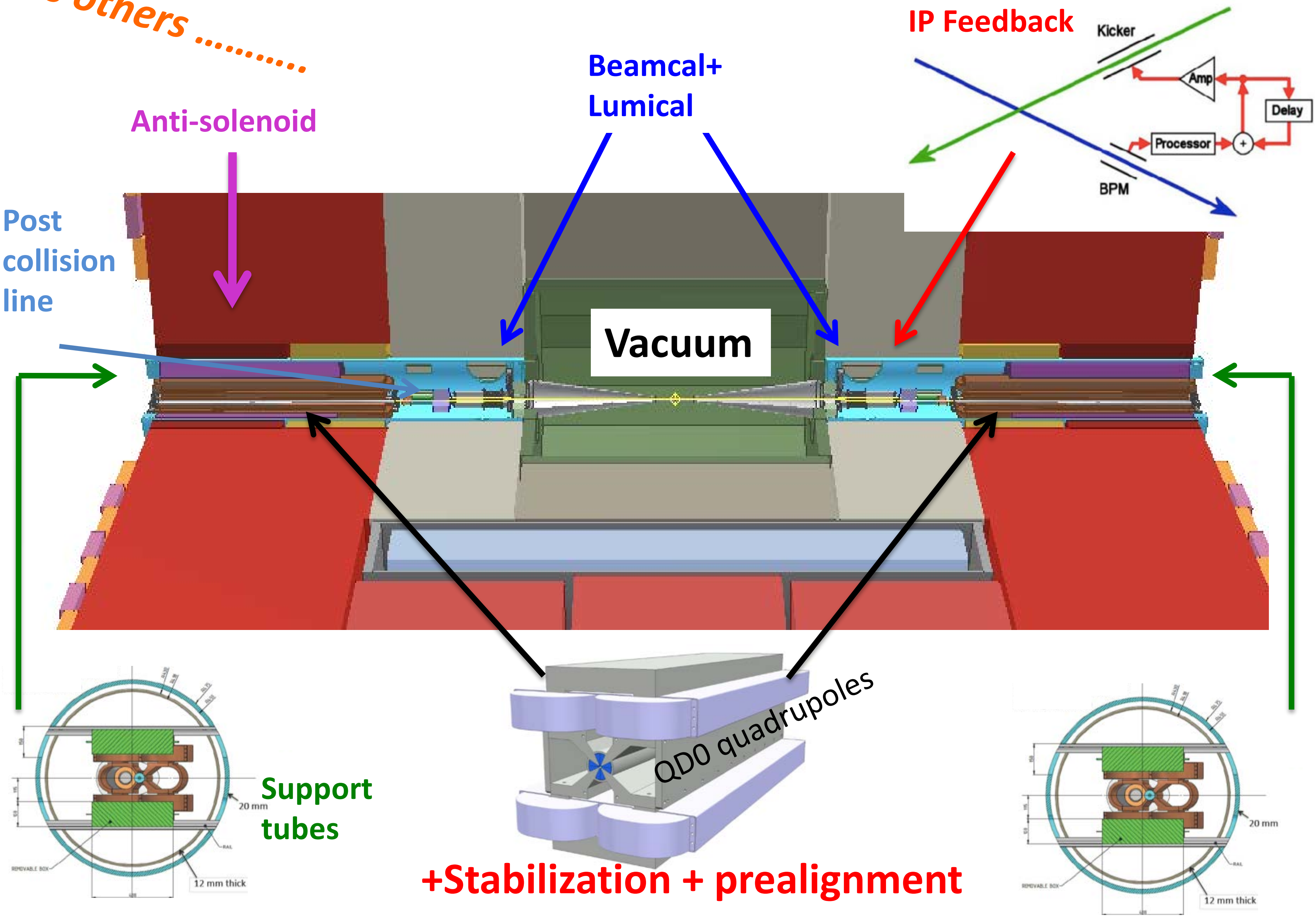


SiD: 5 Tesla field; L* = 4.4 m



ILD: 4 Tesla field; L* = 3.5 m

MACHINE DETECTOR INTERFACE for L*= 3.5 m



Plus others ………

Anti-solenoid

Beamcal+ Lumical

IP Feedback

Post collision line

Vacuum

Support tubes

QD0 quadrupoles

+Stabilization + prealignment

1. Studies for longer L*:

Some justifications for the CDR choice (L=3.5 m)*

The choice of short L* was justified by:

- this option would provide the maximum (peak) luminosity
- this layout is the most challenging: if you have a plausible solution for short L*, the longer L* should be easier for the stabilisation, radiation, impact of detector solenoid B-field, etc.
- at the time the pre-alignment tolerance for longer L* was considered unrealistic (2 μm for L*=8 m, 10 μm for L*= 3.5m), but since then significant progress has been made in the BDS optics.

1. Studies for longer L*:

PROS & CONS

Pros:

- *Maximize detecting volume* *(forward acceptance)*
- *Less complex integration* *(QD0, stabilization system integration, alignment concept, vacuum systems, etc.)*
- *No need of an antisolenoid* *(at least for QD0 operation)*

Cons:

- *Lower peak luminosity*

(see F. Plassard presentation)

- *Impact on Beam Delivery System (BDS)*

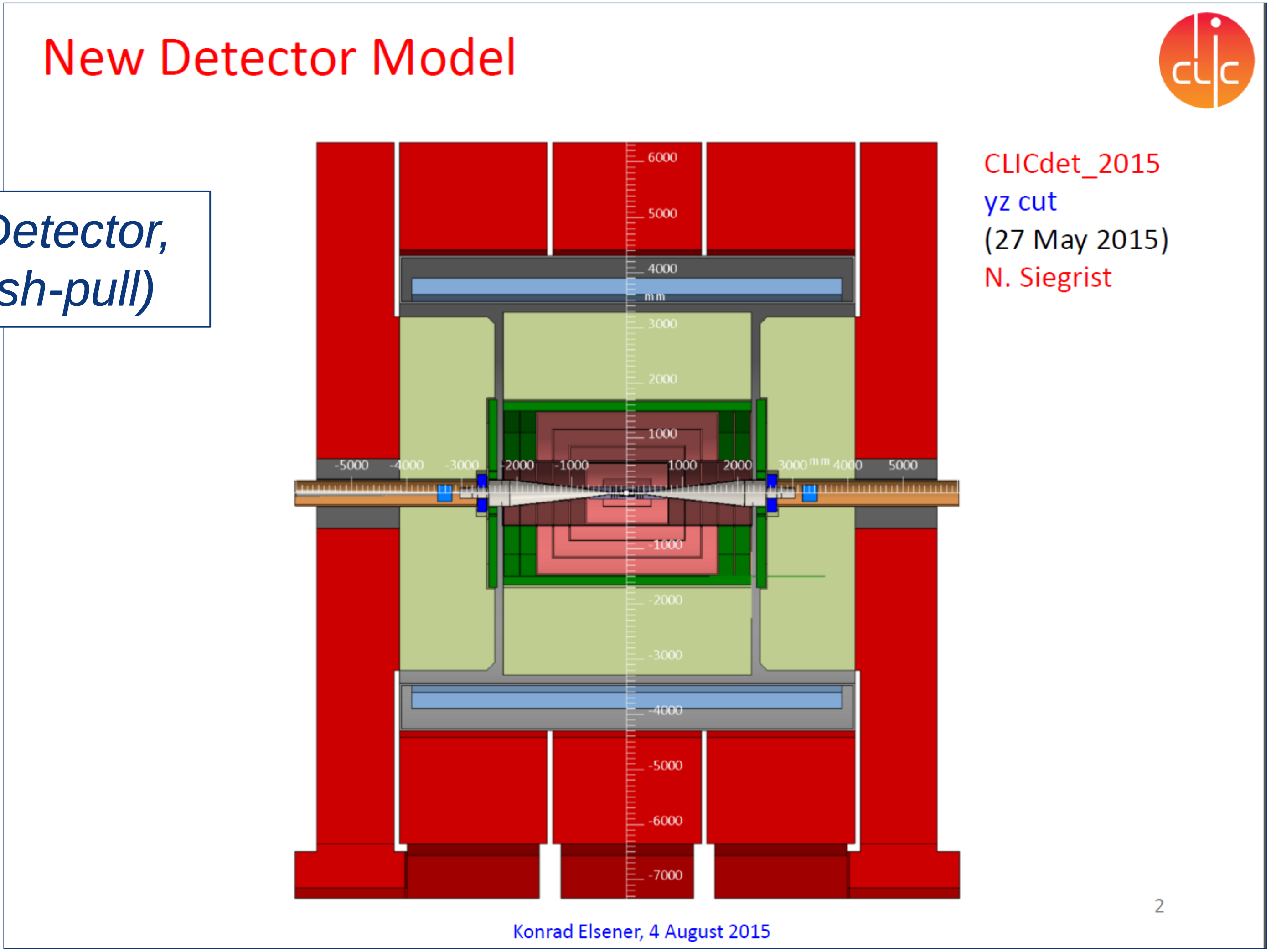
(see F. Plassard presentation)

- Alignment requirements are tighter (more precise evaluations are on-going)

1. Studies for longer L*:

Detector new conceptual design

ONE Detector,
(no push-pull)



New Detector Model

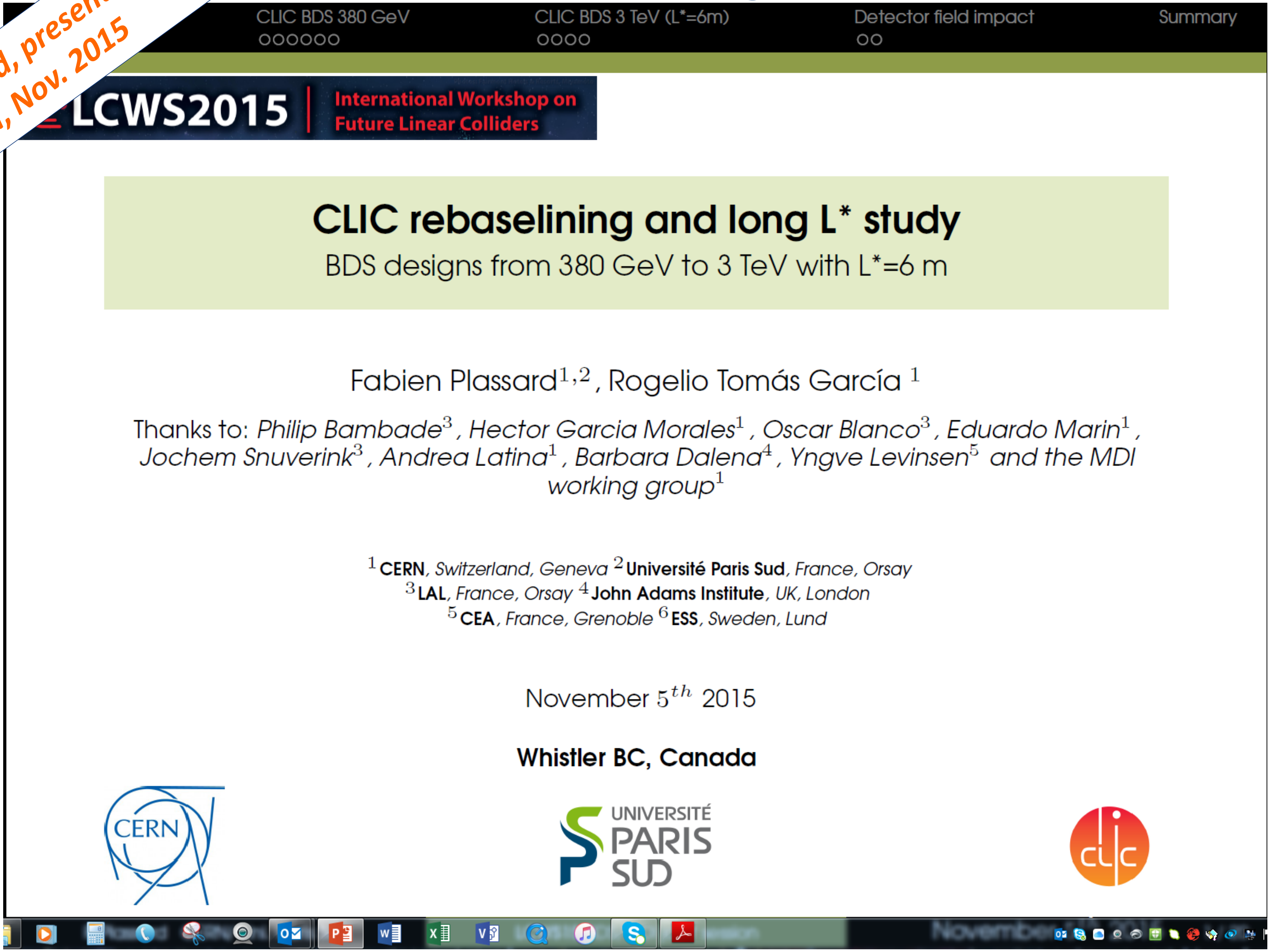
CLICdet_2015
yz cut
(27 May 2015)
N. Siegrist

2

Konrad Elsener, 4 August 2015

1. Studies for longer L*:

Slides from F. Plassard, presentation at LCWS15, Canada, Nov. 2015



CLIC rebaselining and long L* study

BDS designs from 380 GeV to 3 TeV with L*=6 m

Fabien Plassard[1,2], Rogelio Tomás García [1]

Thanks to: *Philip Bambade*[3], *Hector Garcia Morales*[1], *Oscar Blanco*[3], *Eduardo Marin*[1], *Jochem Snuverink*[3], *Andrea Latina*[1], *Barbara Dalena*[4], *Yngve Levinsen*[5] *and the MDI working group*[1]

[1] **CERN**, *Switzerland, Geneva* [2] **Université Paris Sud**, *France, Orsay*
[3] **LAL**, *France, Orsay* [4] **John Adams Institute**, *UK, London*
[5] **CEA**, *France, Grenoble* [6] **ESS**, *Sweden, Lund*

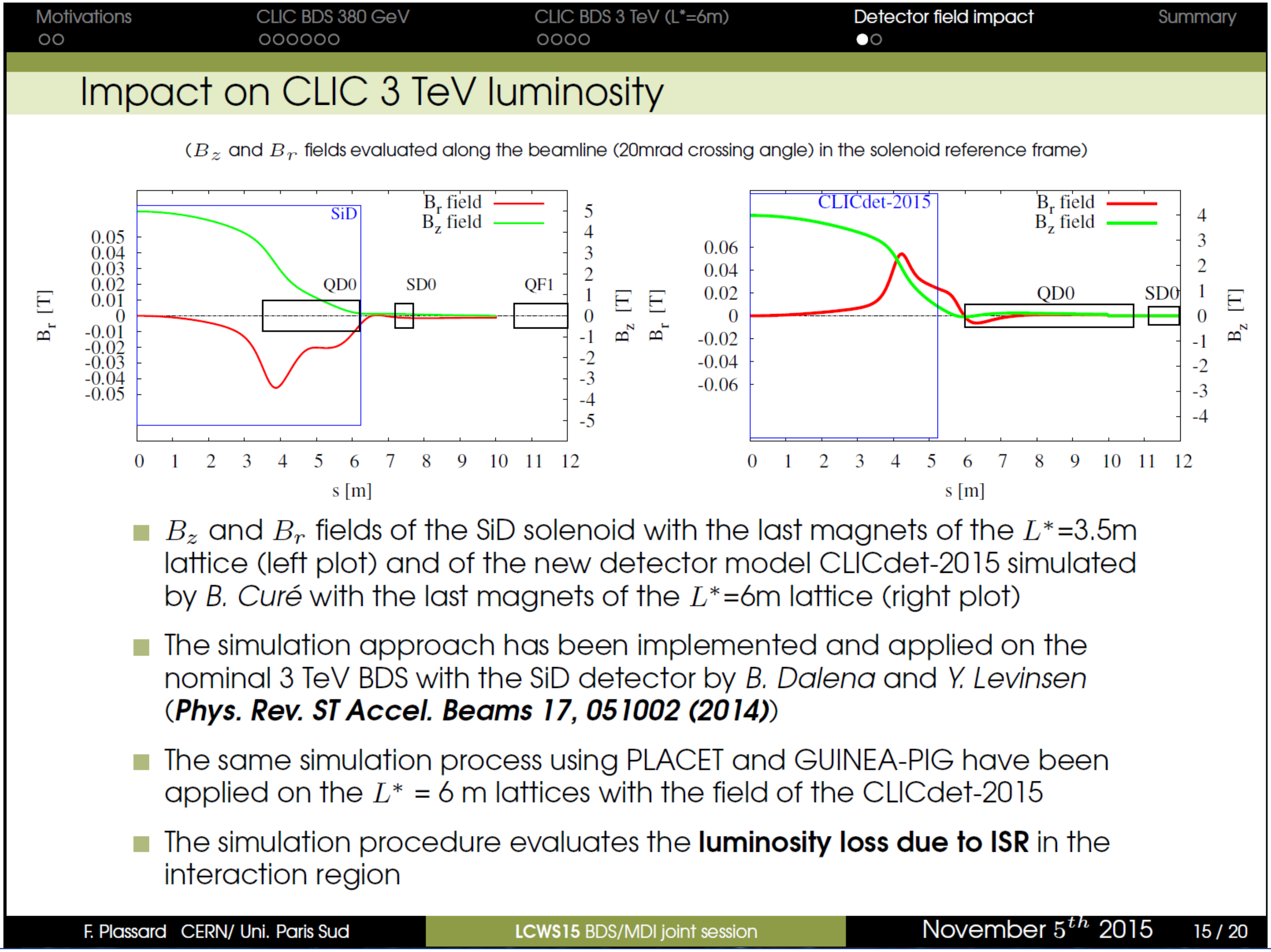
November 5th 2015

Whistler BC, Canada

Please refer to F. Plassard presentation:"Rebaselining and longer L for CLIC and ATF2"*
AT THIS WORKSHOP, Accelerator Parallel Sessions, Tuesday 19 at 14h20

1. Studies for longer L*:

BDS Implication



Motivations | CLIC BDS 380 GeV | CLIC BDS 3 TeV (L*=6m) | Detector field impact | Summary

Impact on CLIC 3 TeV luminosity

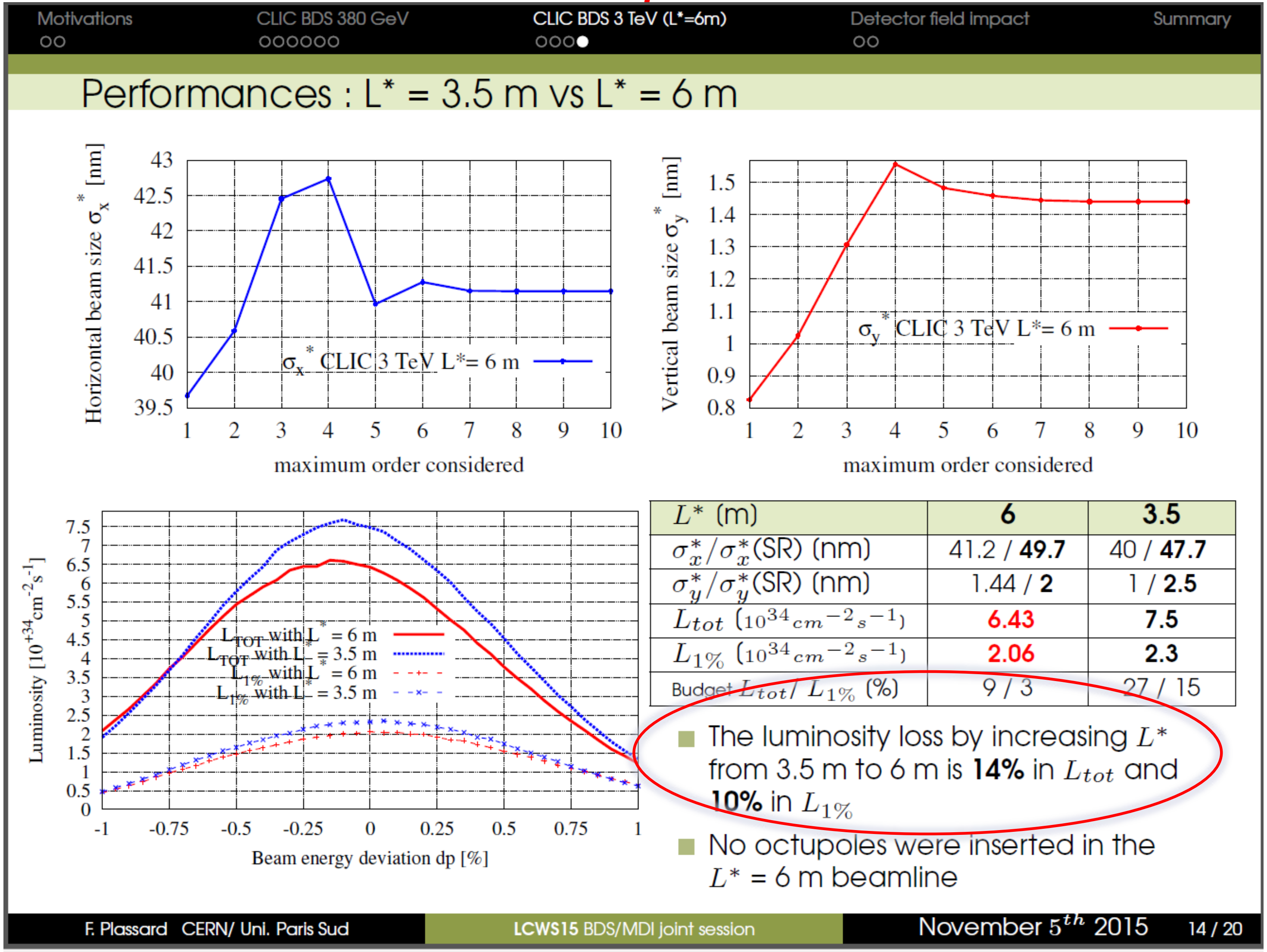
(B_z and B_r fields evaluated along the beamline (20mrad crossing angle) in the solenoid reference frame)

- B_z and B_r fields of the SiD solenoid with the last magnets of the $L*$=3.5m lattice (left plot) and of the new detector model CLICdet-2015 simulated by *B. Curé* with the last magnets of the $L*$=6m lattice (right plot)
- The simulation approach has been implemented and applied on the nominal 3 TeV BDS with the SiD detector by *B. Dalena* and *Y. Levinsen* (***Phys. Rev. ST Accel. Beams 17, 051002 (2014)***)
- The same simulation process using PLACET and GUINEA-PIG have been applied on the $L*$ = 6 m lattices with the field of the CLICdet-2015
- The simulation procedure evaluates the **luminosity loss due to ISR** in the interaction region

F. Plassard CERN/ Uni. Paris Sud | **LCWS15** BDS/MDI joint session | November 5^{th} 2015 | 15 / 20

1. Studies for longer L*:

BDS Implication



Performances : L* = 3.5 m vs L* = 6 m

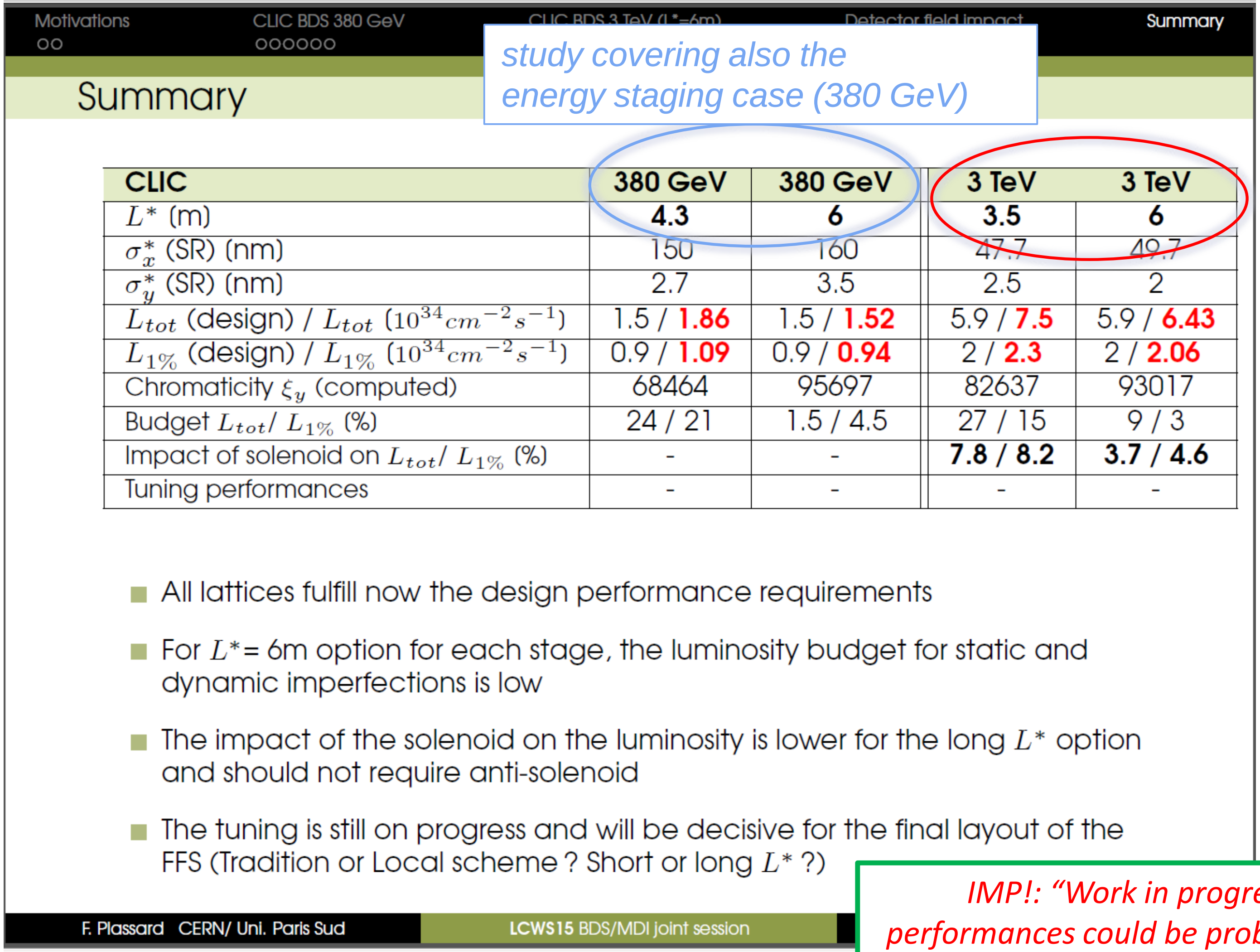
L^* (m)	**6**	**3.5**
σ_x^*/σ_x^*(SR) (nm)	41.2 / **49.7**	40 / **47.7**
σ_y^*/σ_y^*(SR) (nm)	1.44 / **2**	1 / **2.5**
L_{tot} ($10^{34}cm^{-2}s^{-1}$)	6.43	7.5
$L_{1\%}$ ($10^{34}cm^{-2}s^{-1}$)	2.06	2.3
Budget $L_{tot}/\ L_{1\%}$ (%)	9 / 3	27 / 15

- The luminosity loss by increasing L^* from 3.5 m to 6 m is **14%** in L_{tot} and **10%** in $L_{1\%}$
- No octupoles were inserted in the L^* = 6 m beamline

F. Plassard CERN/ Uni. Paris Sud — **LCWS15** BDS/MDI joint session — November 5^{th} 2015 — 14 / 20

1. Studies for longer L*:

BDS Implication



study covering also the energy staging case (380 GeV)

Motivations CLIC BDS 380 GeV CLIC BDS 3 TeV (L*=6m) Detector field impact **Summary**

Summary

CLIC	**380 GeV**	**380 GeV**	**3 TeV**	**3 TeV**
L^* (m)	**4.3**	**6**	**3.5**	**6**
σ_x^* (SR) (nm)	150	160	47.7	49.7
σ_y^* (SR) (nm)	2.7	3.5	2.5	2
L_{tot} (design) / L_{tot} $(10^{34}cm^{-2}s^{-1})$	1.5 / **1.86**	1.5 / **1.52**	5.9 / **7.5**	5.9 / **6.43**
$L_{1\%}$ (design) / $L_{1\%}$ $(10^{34}cm^{-2}s^{-1})$	0.9 / **1.09**	0.9 / **0.94**	2 / **2.3**	2 / **2.06**
Chromaticity ξ_y (computed)	68464	95697	82637	93017
Budget L_{tot}/ $L_{1\%}$ (%)	24 / 21	1.5 / 4.5	27 / 15	9 / 3
Impact of solenoid on L_{tot}/ $L_{1\%}$ (%)	-	-	**7.8 / 8.2**	**3.7 / 4.6**
Tuning performances	-	-	-	-

- All lattices fulfill now the design performance requirements
- For L^*= 6m option for each stage, the luminosity budget for static and dynamic imperfections is low
- The impact of the solenoid on the luminosity is lower for the long L^* option and should not require anti-solenoid
- The tuning is still on progress and will be decisive for the final layout of the FFS (Tradition or Local scheme ? Short or long L^* ?)

F. Plassard CERN/ Uni. Paris Sud **LCWS15** BDS/MDI joint session

IMP!: "Work in progress"; performances could be probably even improved but FEEDBACKS and MOTIVATIONS from Detector Community are NEEDED!

1. Studies for longer L*:

Magnet system implication

- The QD0 requirement for E= 3TeV / L*= 3.5 m are:

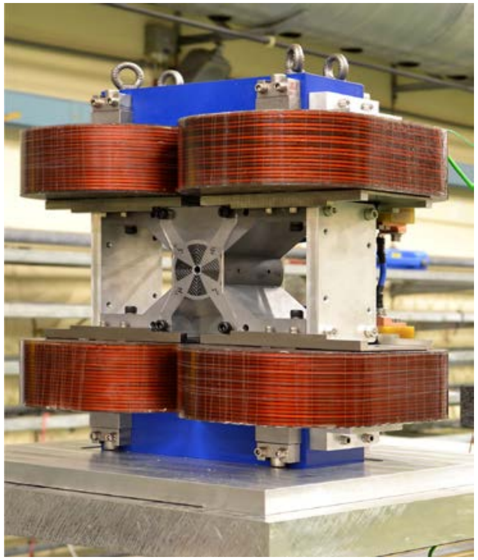
Gradient: **575 T/m**; Aperture Ø: **8.25 mm**, Length: **2.73 m**, tunability: **20%**

- The *(preliminary)* requirements for E=3TeV / L*=6 m are:

Gradient: **197 T/m**; Aperture Ø: **10 mm**, Length: **4.7 m** *(eventually split in 2-3 elements)*

The QD0 parameters for L=6 m are evidently more relaxed. Furthermore, the magnet would be positioned OUTSIDE the detector.*

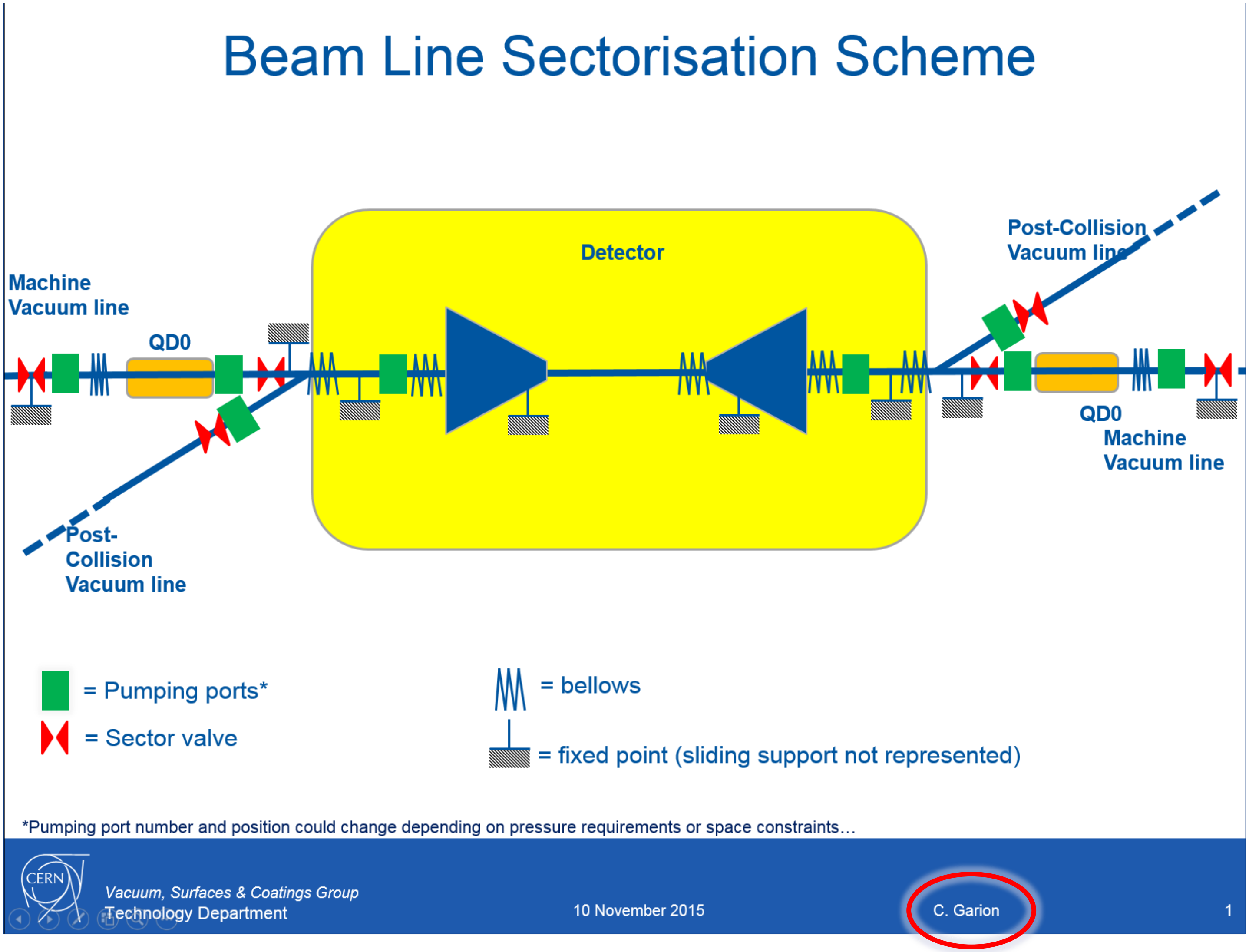
The hybrid design developed for the L=3.5 m case is a possible but maybe not necessary solution. To be reminded that the magnet still need to be nanometer stabilized and has to be compatible with the passage of the post-collision line (chamber at ~ 60 mm in transverse direction of QD0 axis)*



Hybrid QD0 prototype developed with the L=3.5 m main parameters*

1. Studies for longer L*:

Vacuum system implication



Beam Line Sectorisation Scheme

🟩 = Pumping ports*

⧓ = Sector valve

= bellows

⊥ = fixed point (sliding support not represented)

*Pumping port number and position could change depending on pressure requirements or space constraints…

Vacuum, Surfaces & Coatings Group
Technology Department

10 November 2015

C. Garion

1

1. Studies for longer L*:

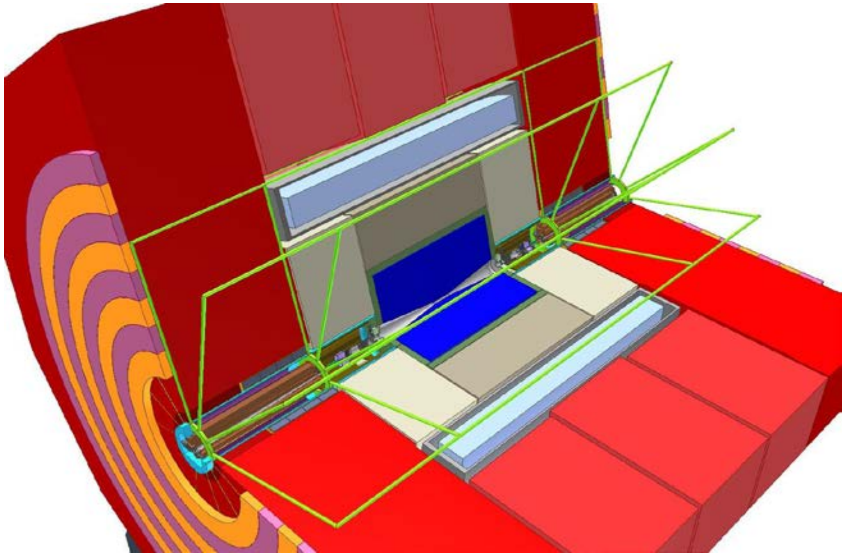
Alignment system implication

- Tolerances will be tighter: for CDR requirements were evaluated at 10μm for L* = 3.5 m .

For L*=6 m will be ~6-8 μm (?) → *study ongoing by beam dynamic team.*

- The system would be simpler (no needs of the “ZERODUR” spokes system as for L*=3.5 m

(ZERODUR® has a thermal expansion coefficient of 0±0.007×10^{-6}/K in the range 0°to 50°C)



- Needs of “survey mini-galleries” bypassing the cavern ?

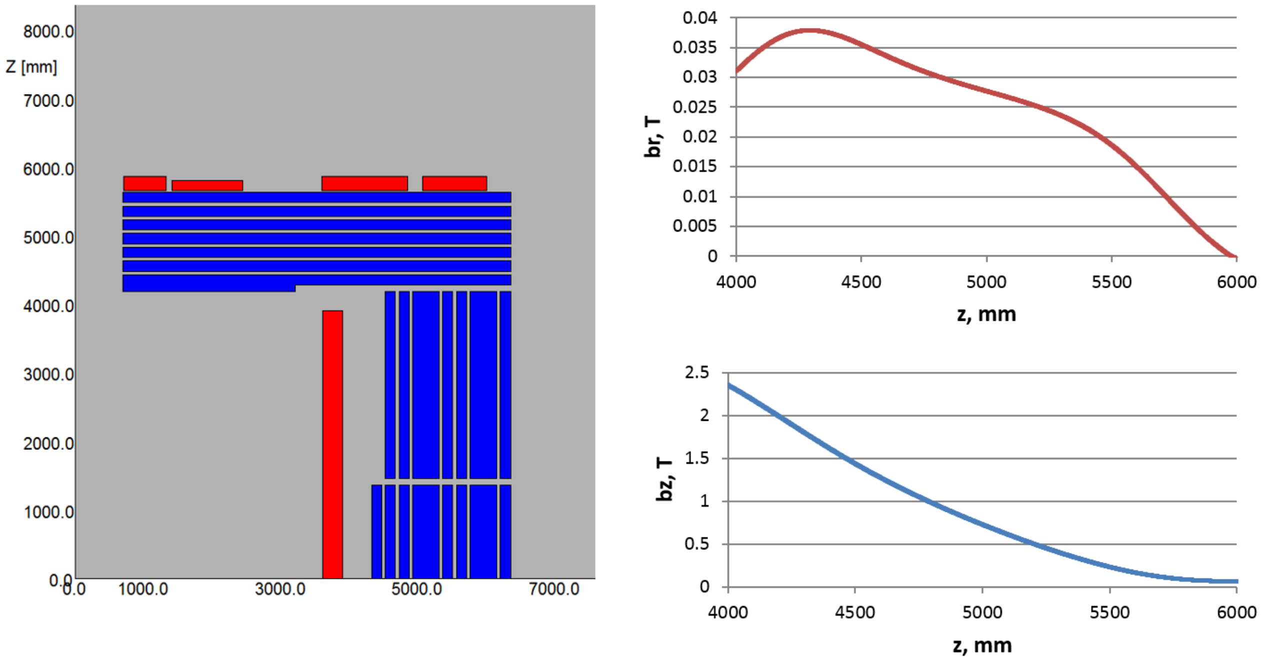
1. Studies for longer L*:

Antisolenoid system implication

Field distribution along the beam line in the yoke end cap region

(inclined by 0.01 rad with respect to the detector axis)

Target: br < 0.04 T

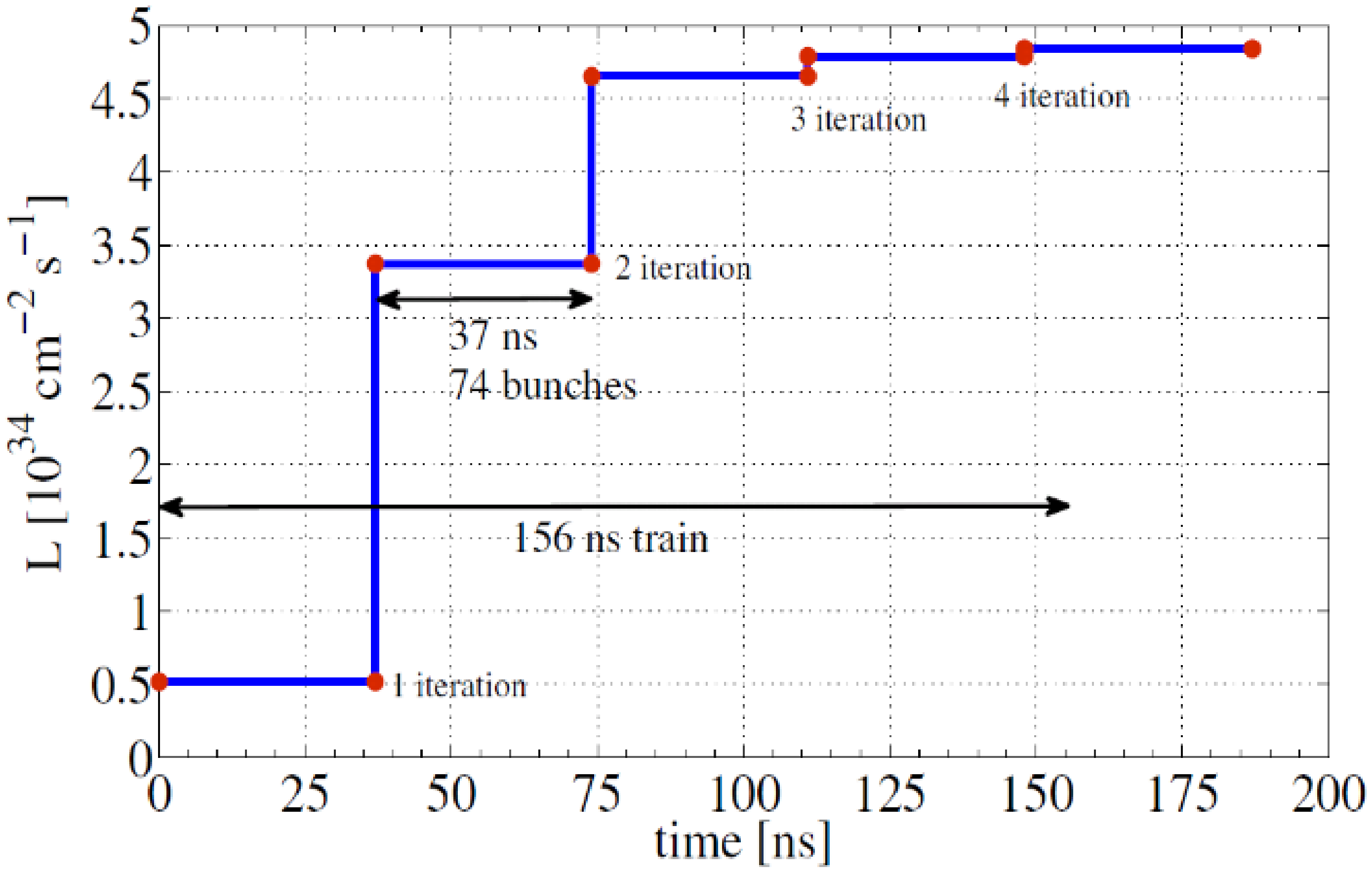


(A. Aloev)

2. IP Feedback study

CLIC IP FB Performance (CDR)

Single random seed of GM C, CDR implementation



(Ph. Burrows, Resta-Lopez)

Ph.Burrows

2. IP Feedback study

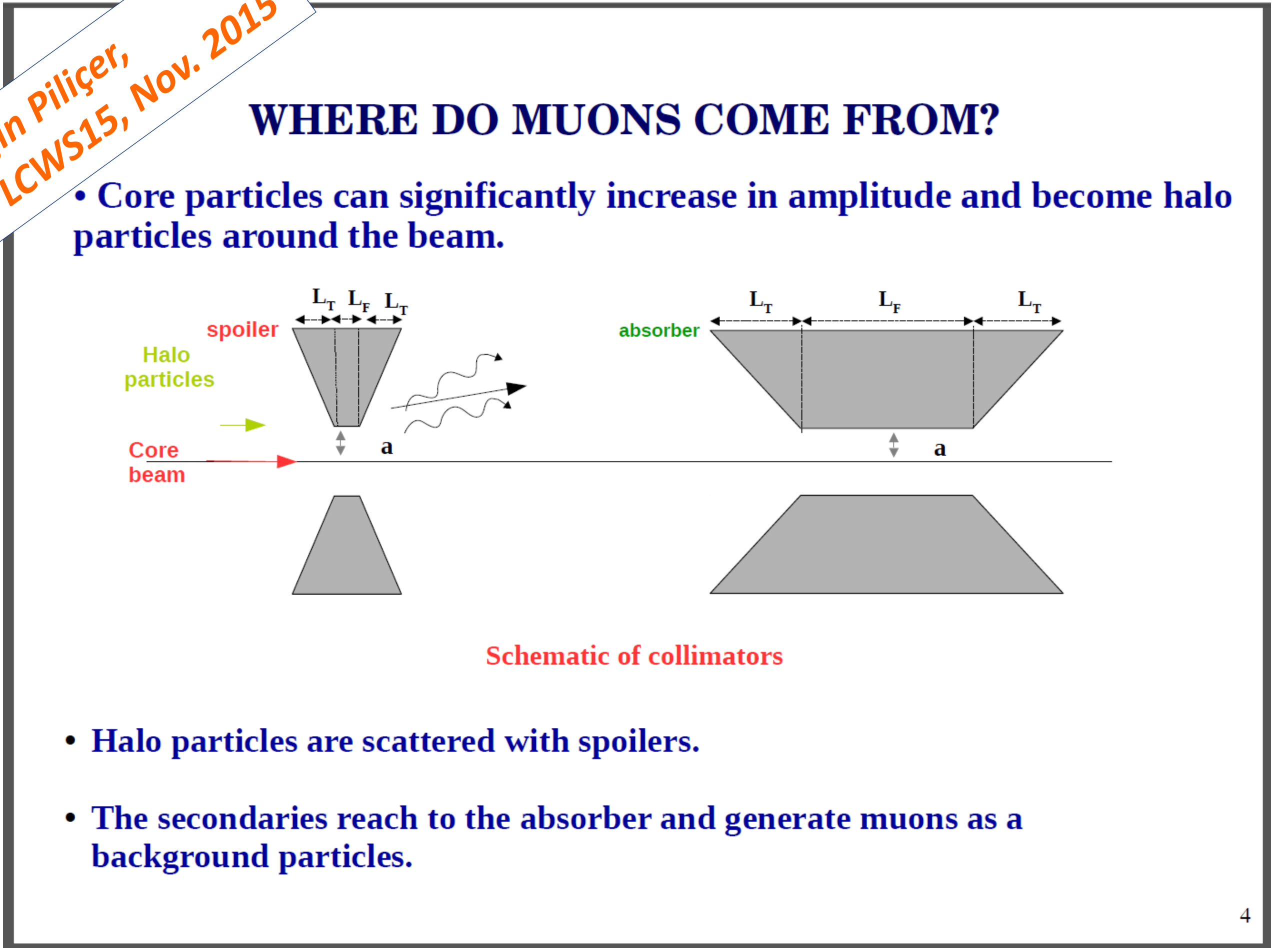
*IP FB with long L**

- Current CDR geometry:
  time of flight IP → BPM → kicker → IP ~ 24 ns
- Demonstrated FONT3 electronics latency = 13ns
- Estimated IPFB latency = 37ns
- In principle, change of L* need not affect IPFB position and latency, but needs to be engineered carefully, considering other beam line components

3. Muons scrapers studies:

Status and perspectives

Slides from F. Belgin Piliçer, presentation at LCWS15, Nov. 2015



WHERE DO MUONS COME FROM?

- **Core particles can significantly increase in amplitude and become halo particles around the beam.**

Schematic of collimators

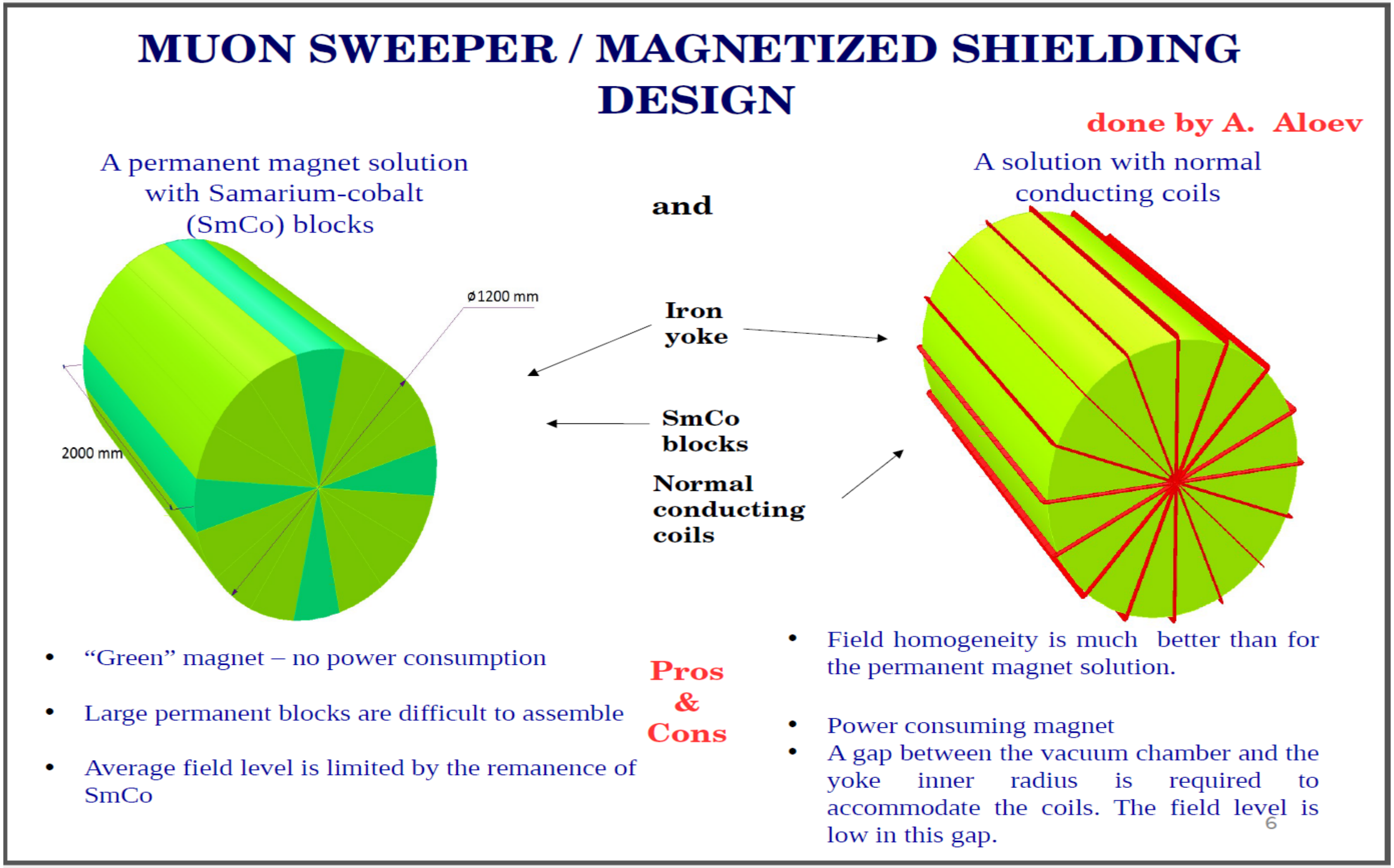
- **Halo particles are scattered with spoilers.**
- **The secondaries reach to the absorber and generate muons as a background particles.**

Please refer to A. Aloev presentation: “Magnetized muon absorbers”

AT THIS WORKSHOP, Accelerator Parallel Sessions, Tuesday 19 at 15h40

3. Muons scrapers studies:

Status and perspectives



MUON SWEEPER / MAGNETIZED SHIELDING DESIGN

done by A. Aloev

A permanent magnet solution with Samarium-cobalt (SmCo) blocks

and

A solution with normal conducting coils

Iron yoke

SmCo blocks

Normal conducting coils

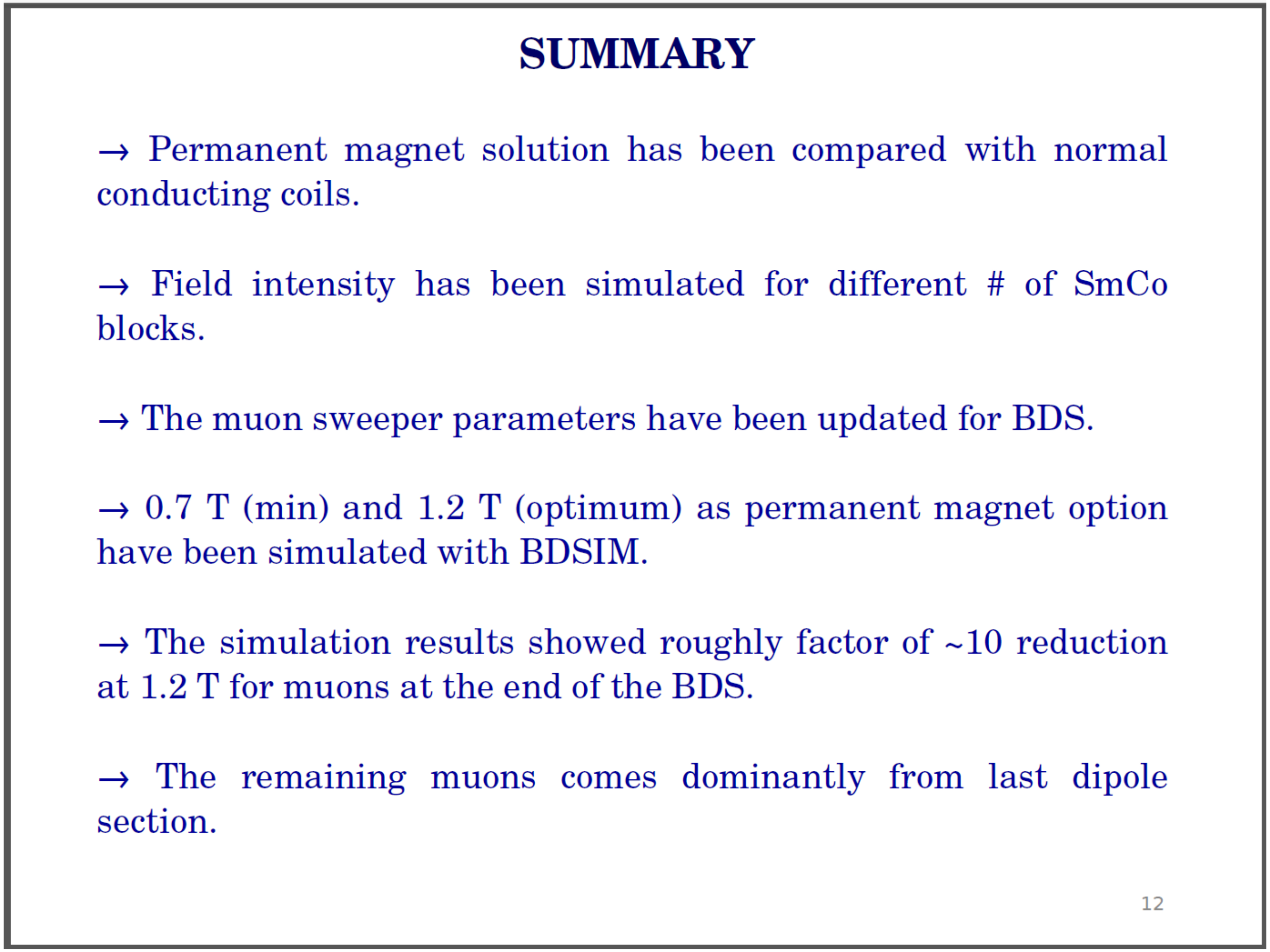
Pros & Cons

- "Green" magnet – no power consumption
- Large permanent blocks are difficult to assemble
- Average field level is limited by the remanence of SmCo

- Field homogeneity is much better than for the permanent magnet solution.
- Power consuming magnet
- A gap between the vacuum chamber and the yoke inner radius is required to accommodate the coils. The field level is low in this gap.

3. Muons scrapers studies:

Status and perspectives



SUMMARY

→ Permanent magnet solution has been compared with normal conducting coils.

→ Field intensity has been simulated for different # of SmCo blocks.

→ The muon sweeper parameters have been updated for BDS.

→ 0.7 T (min) and 1.2 T (optimum) as permanent magnet option have been simulated with BDSIM.

→ The simulation results showed roughly factor of ~10 reduction at 1.2 T for muons at the end of the BDS.

→ The remaining muons comes dominantly from last dipole section.

12

4. Conclusion and Future Plans:

- *COMPLETION of BDS OPTIMIZATION and PERFORMANCES evaluation:* work on-going with the beam dynamic team. We need operative requirements for stabilization and pre-alignment tolerances.
- *MAGNET STUDY:* The required gradient for QD0 in L*=6 m permit to envisage different solutions, driving aspects link with the following points:
  - *QD0 STABILIZATION:* one of the most critical aspect of the new layout. QD0 will be longer (4.7 m) but can be split in 2-3 elements (each length ~ 1.5 m; → always try to minimize the QD0 mass; → correlation/matching of the 2-3 stabilizing systems)
  - *REQUIREMENTS FOR QD0 PRE-ALIGNMENT:* the requirements are tighter respect to L*=3.5 m, but QD0 is outside of the detector → a new approach must be study (survey mini-galleries?)
- *FEEDBACK and INPUT* from the Detector Community are needed in order to advance with the study and for eventual improvement of final performances

The MDI working group

A.Hervé, A.Aloev, A.Vorozhtsov, A.Gaddi, A.Jeremie, A.Latina, A.Sailer, B.Dalena, B.Pilicer, B.Cure, L.Brunetti, C.Garion, C.Collette, C.Perry, D.Schulte, D.Tommasini, D.Mergelkuhl, E.Bravin, F.Plassard, F.Duarte-Ramos, F.Butin, F.Zimmermann, G.Christian, G.Bobbink, H.Mainaud-Durand, H.Burkhardt, H.Gerwig, J.Resta-Lopez, J.Axensalva, J.Vollaire, J.Snuverink, J.Osborne, K.Elsener, K.Artoos, L.Gatignon (chair), L.Linssen, M.Battaglia, M.Gastal, M.Guinchard, M.Modena, P.Burrows, R.Tomas, R. Bodenstein, S.Mallows, S. Stapnes, T.Lefevre, Th.Otto, H.van der Graaf, V.Ziemann, Y.Levinsen, Y.Kim

Thanks for your attention