MDI Status and Plans

Lau Gatignon / EN-EA
On behalf of the MDI working group

Outline

- Quick reminder: what is MDI
- Changes to detector model
- Changes to MDI
  - Luminosity and tuning
  - Stabilisation
  - Some other implications
- Plans

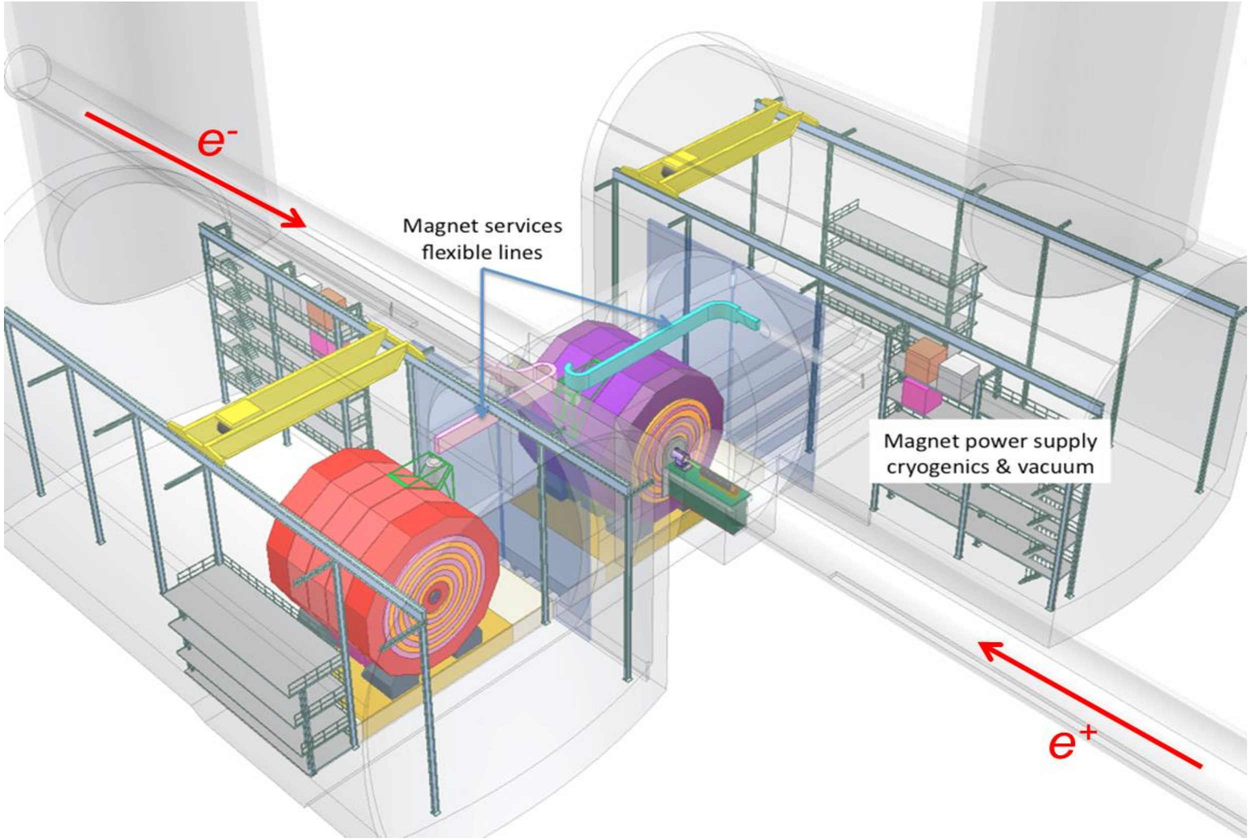
What was MDI at the time of the CDR?

- The Machine Detector Interface must ensure **optimum luminosity** for the experiment(s) with minimal backgrounds and includes the **local environment and infrastructure**. It integrates the post-collision line.

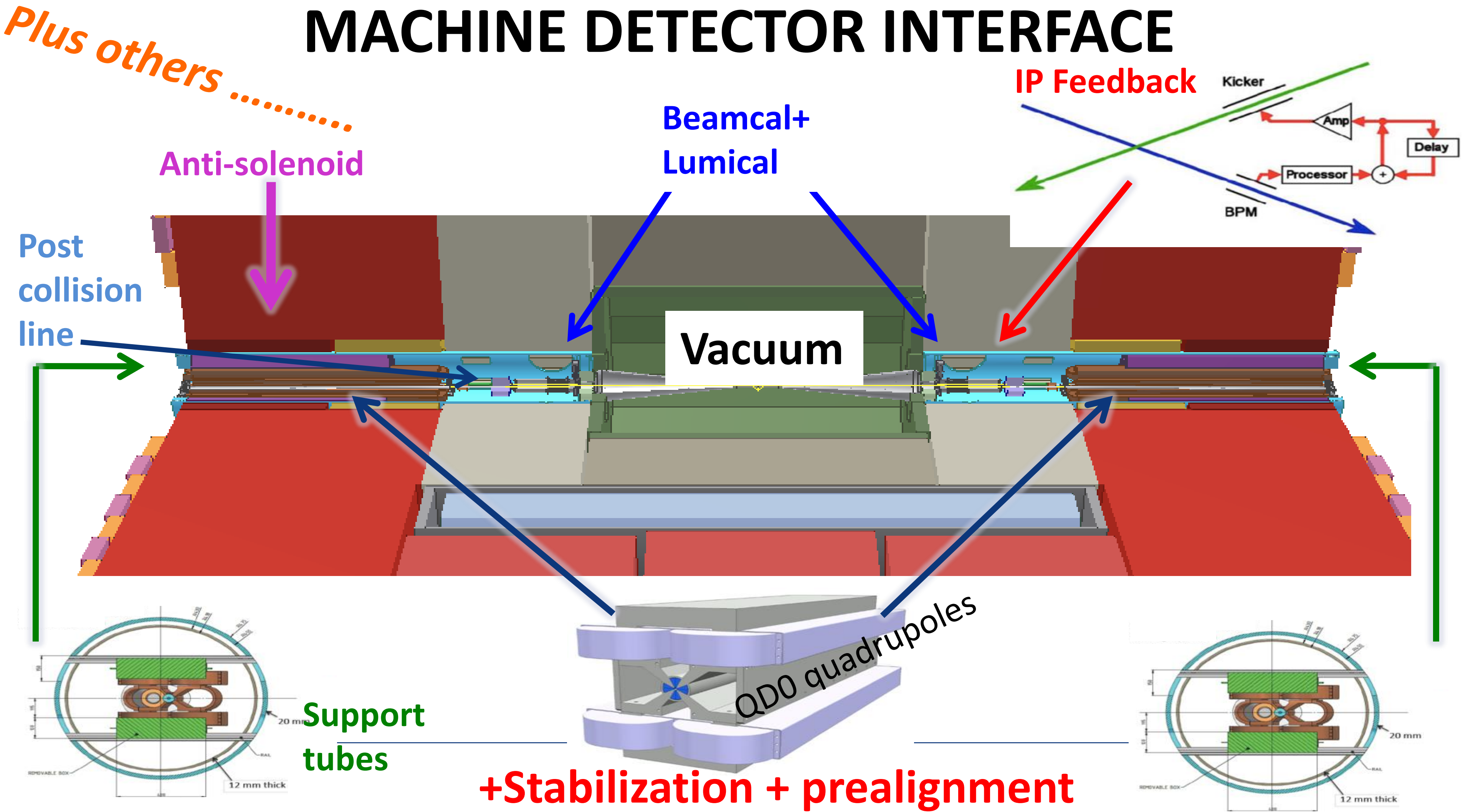
- The baseline for the CDR was based on a concept with two detectors operating in push-pull mode and with the final focus quadrupoles QD0 as close as possible to the interaction point (L* = 3.5 m), i.e. in the detectors.

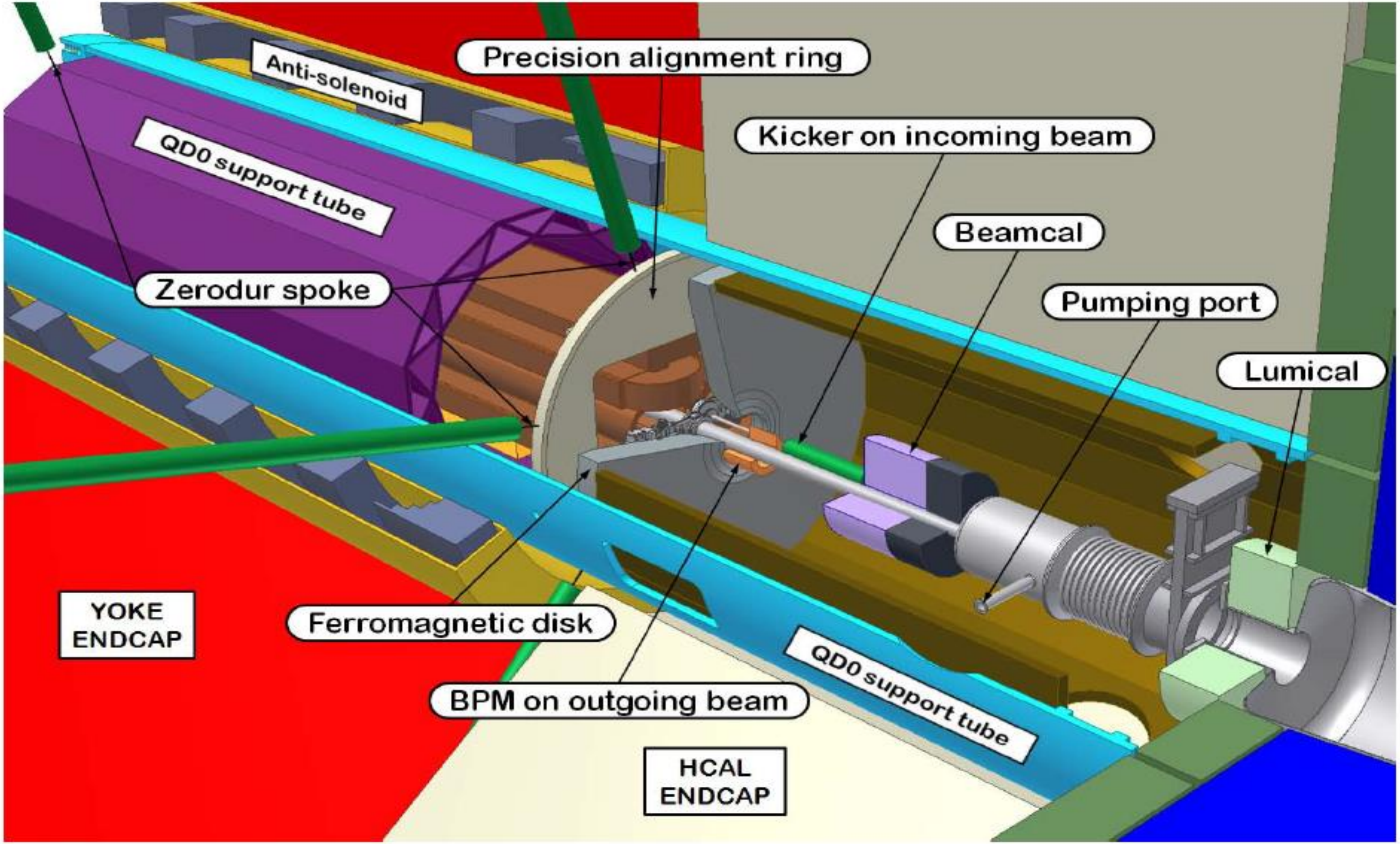
- The MDI design included concepts for the QD0 design as well as its **stabilisation** and pre-alignment, but also IP feedback, BeamCal and Lumical integration, **vacuum layout**, **cavern layout**, and so forth.

The CDR concept:



MACHINE DETECTOR INTERFACE




Precision alignment ring
Anti-solenoid
Kicker on incoming beam
QD0 support tube
Beamcal
Zerodur spoke
Pumping port
Lumical
YOKE
ENDCAP
Ferromagnetic disk
BPM on outgoing beam
QD0 support tube
HCAL
ENDCAP

Announced changes to the detector model

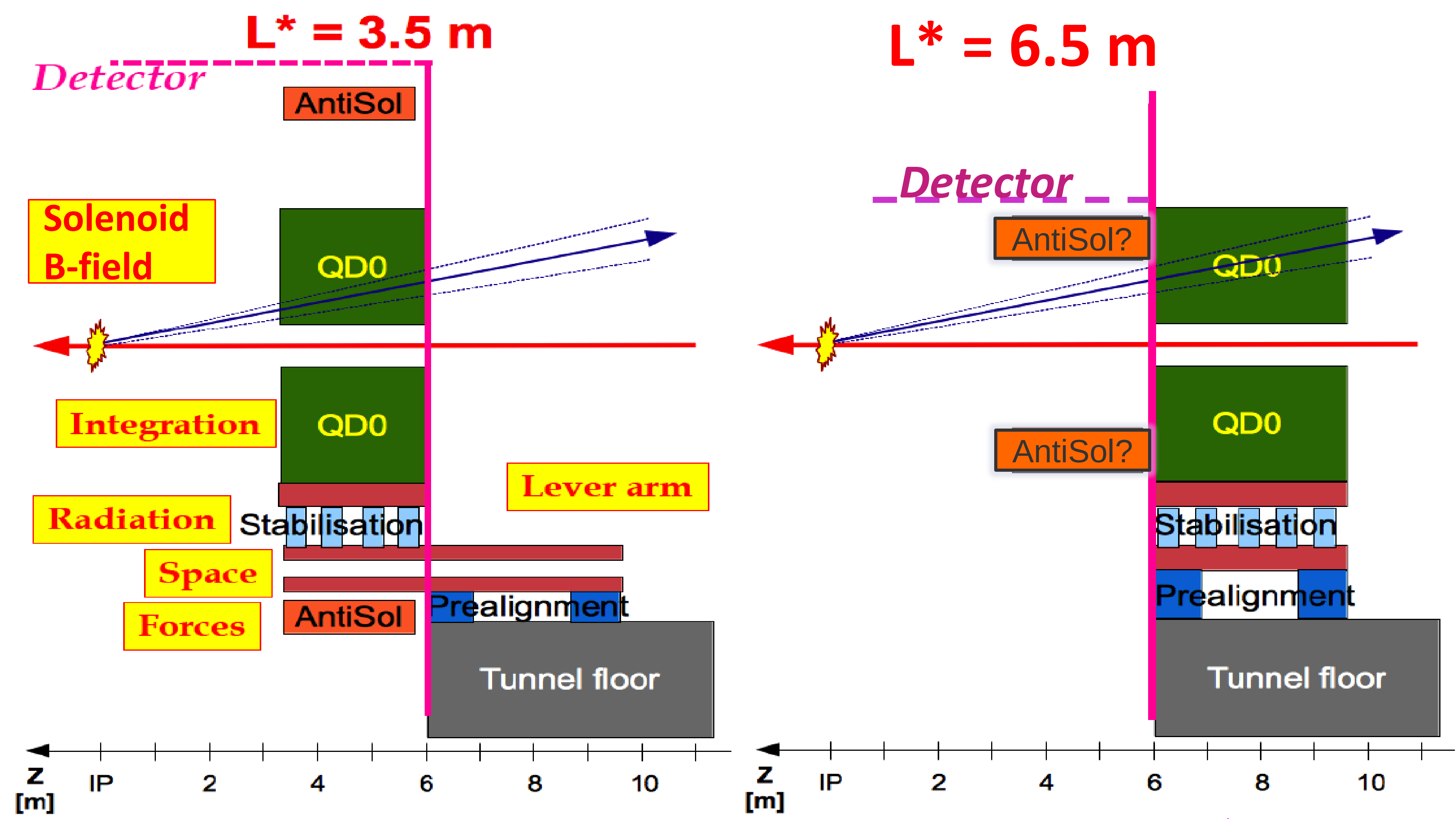
- The detector team has decided to concentrate for the time being on a **single** detector with all-silicon tracking.

No more push-pull

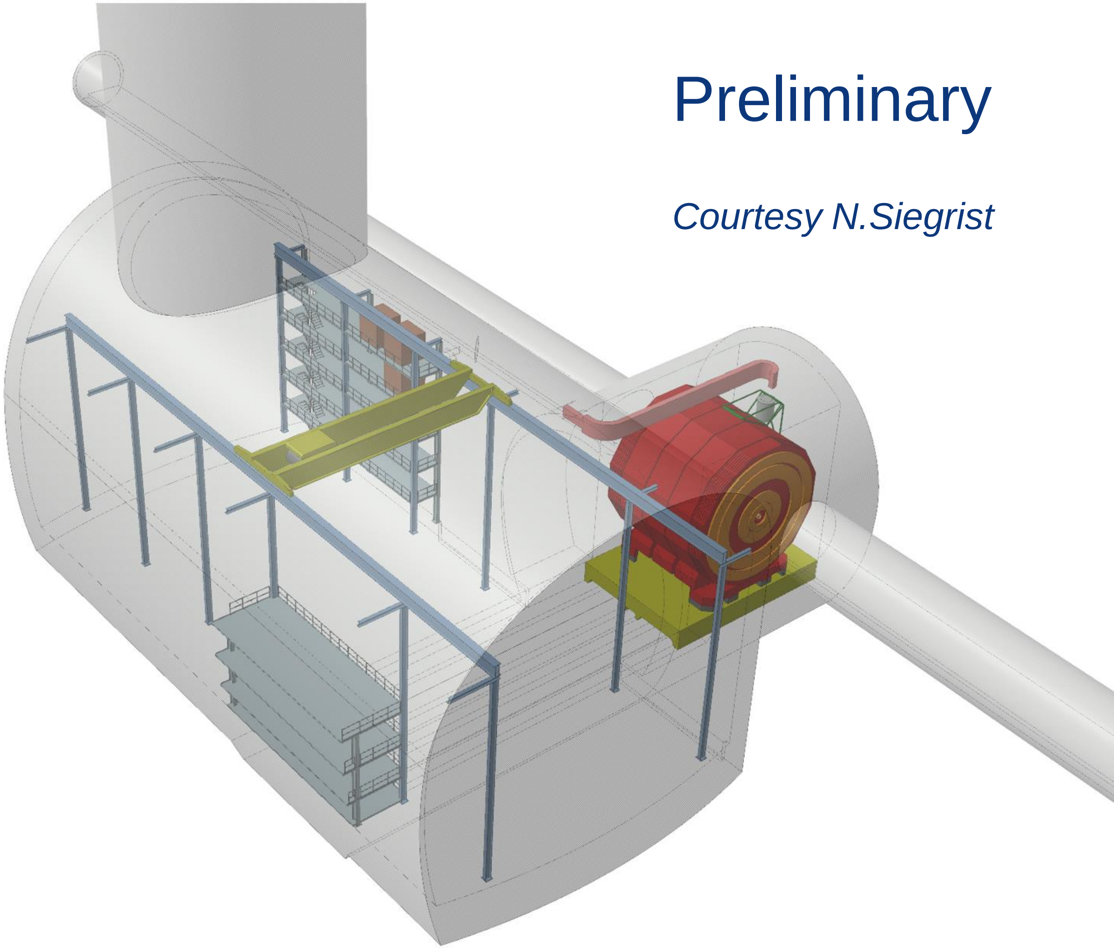
- A number of **parameters have been** frozen to allow consistent studies on detector optimisation and performance.

- For the forward region design they concentrate now on the long L* solution with **QD0 in the tunnel**, i.e. outside the detector.
  The exact value of L* has been defined as 6 m.

This has major implications for MDI


L* = 3.5 m
Detector
AntiSol
Solenoid
B-field
QD0
QD0
Integration
Lever arm
Radiation
Stabilisation
Space
Forces
AntiSol
Prealignment
Tunnel floor
Z
[m]
IP
2
4
6
8
10
L* = 6.5 m
Detector
AntiSol?
QD0
QD0
AntiSol?
Stabilisation
Prealignment
Tunnel floor
Z
[m]
IP
2
4
6
8
10

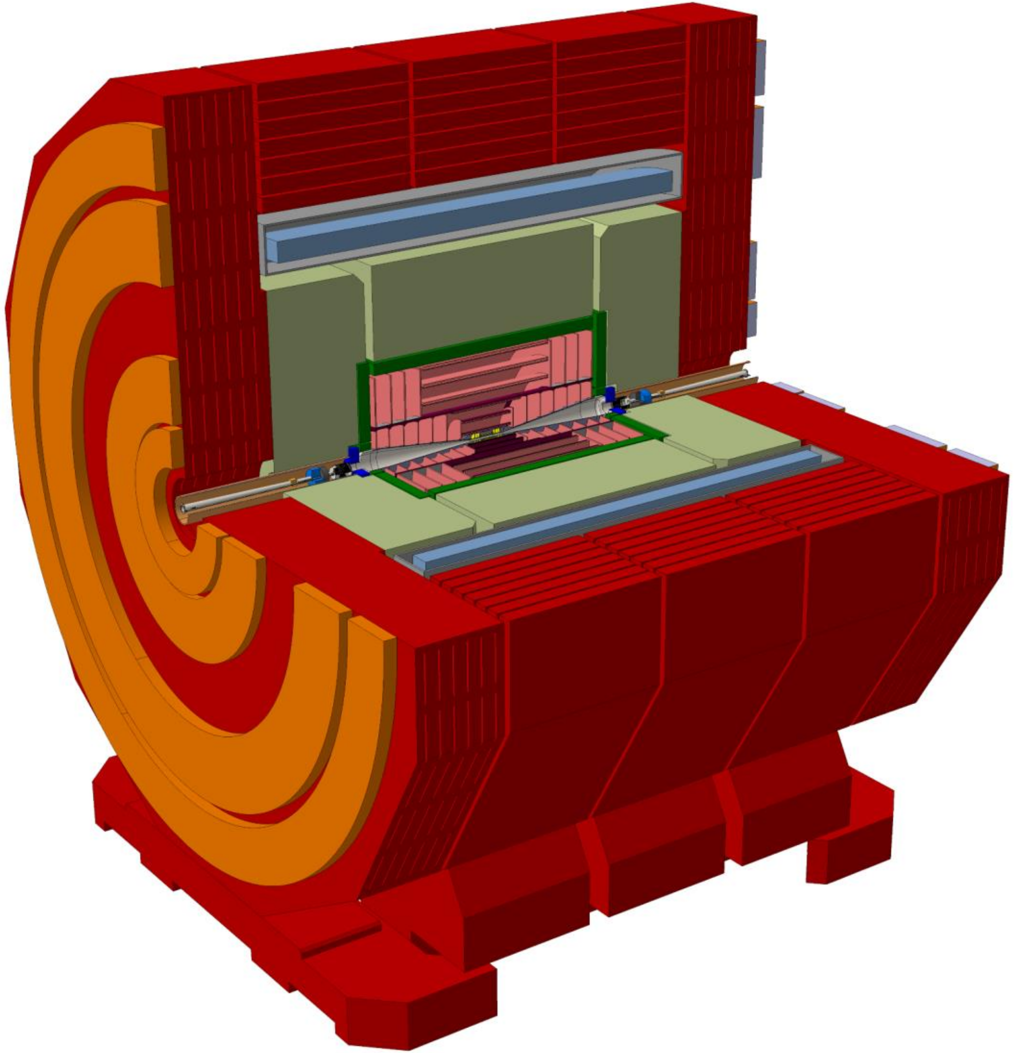
Cavern layout

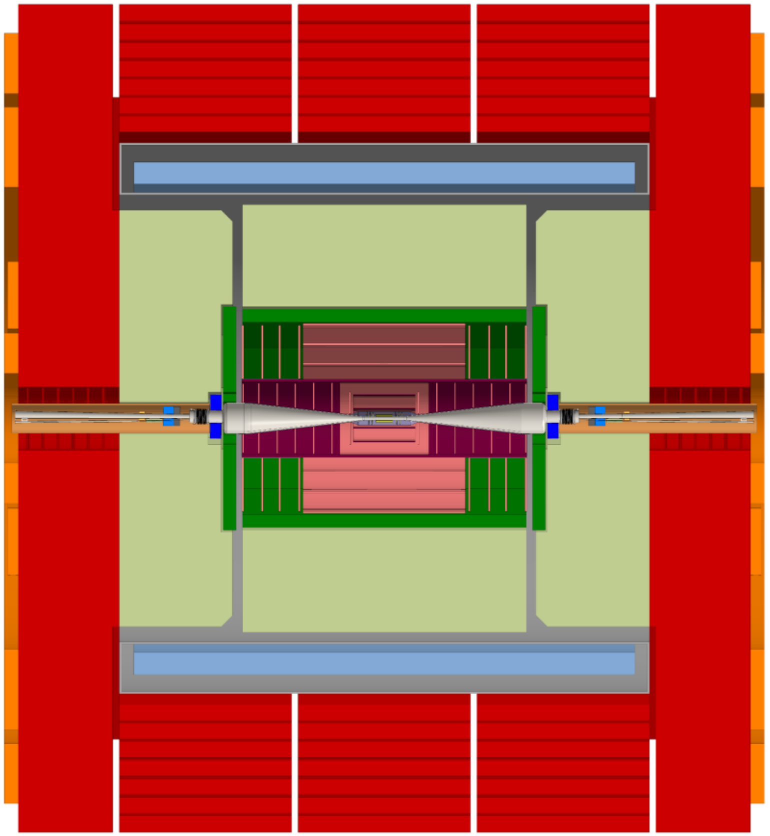


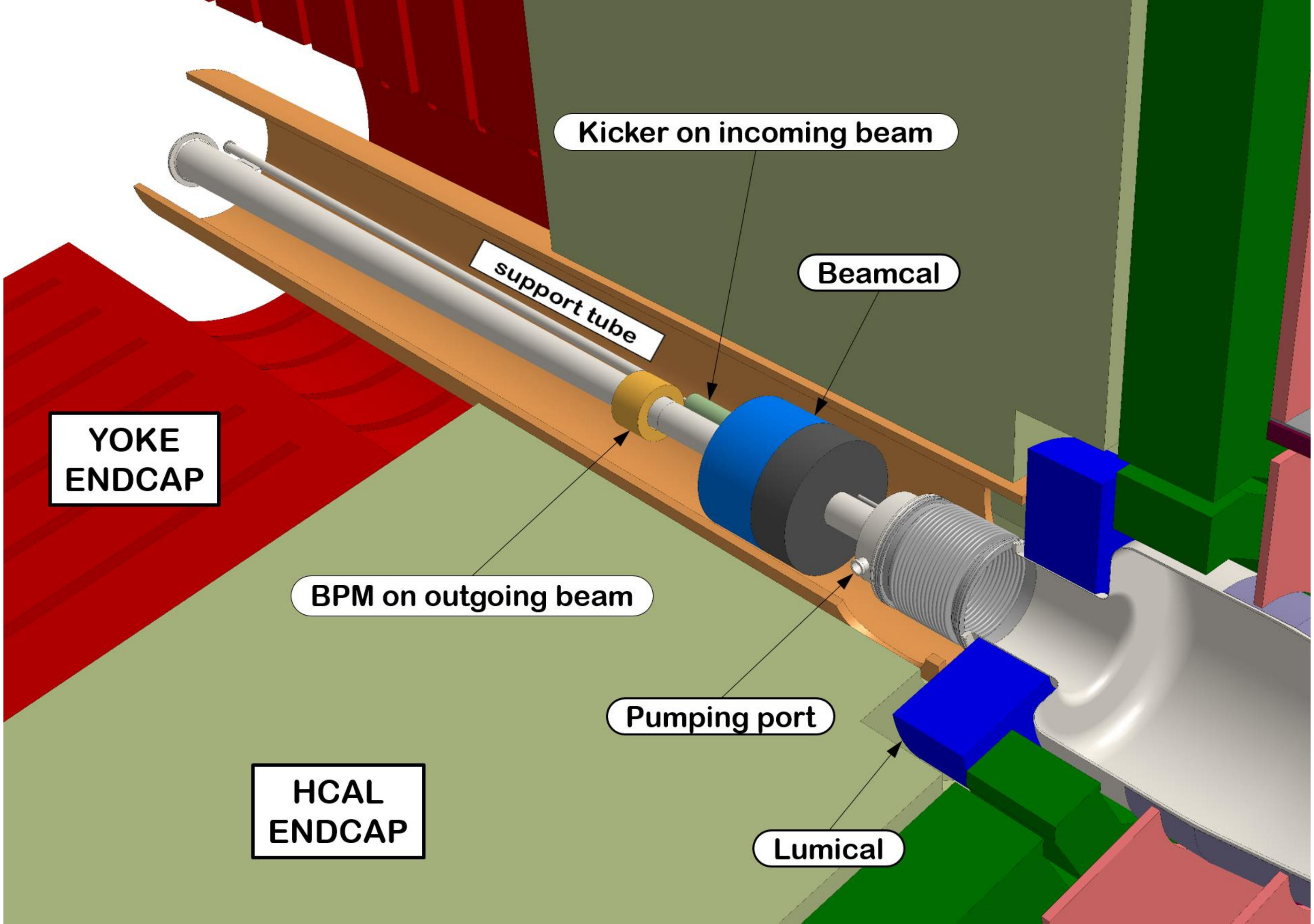
Preliminary

Courtesy N.Siegrist

- Proposal by EP/LCD
- Detector opening not on IP
- Mechanical and civil engineering stability to be verified

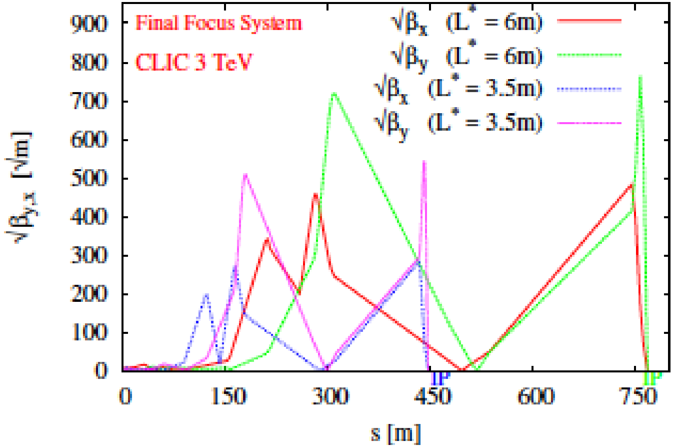


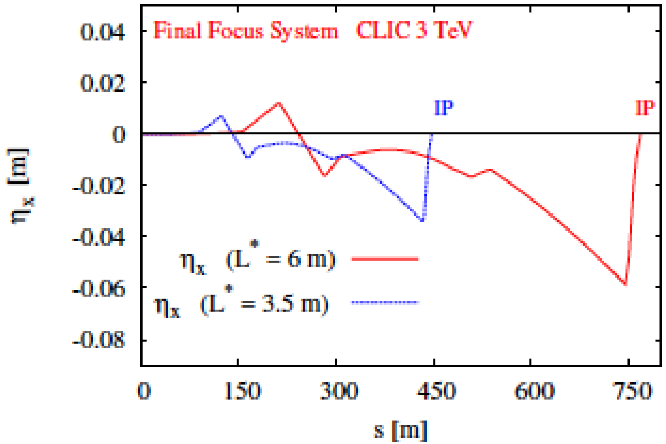



Kicker on incoming beam
Beamcal
support tube
YOKE ENDCAP
BPM on outgoing beam
Pumping port
HCAL ENDCAP
Lumical

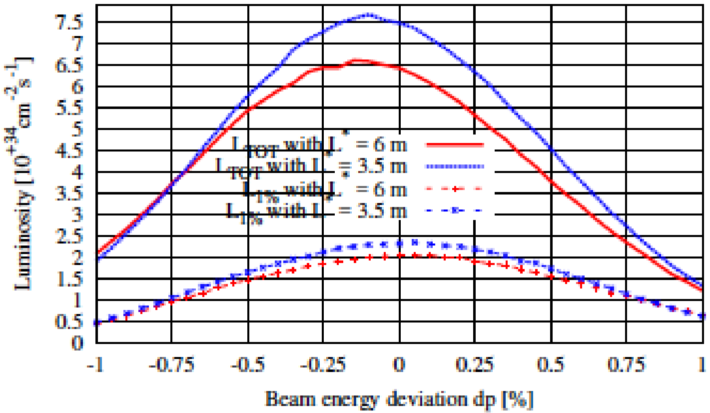
Parameters and performances with L^* = 6 m

Fabien Plassard / BE-ABP





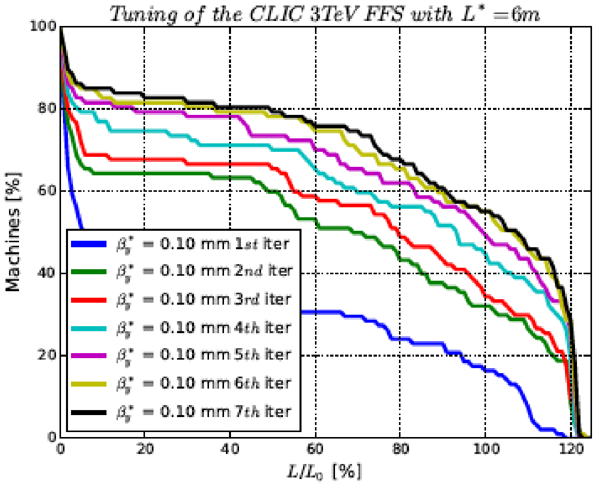
CLIC energy	3TeV	3TeV
L^* (m)	**3.5**	**6**
FFS length (m)	**450**	**770**
$\gamma\epsilon_x / \gamma\epsilon_y$ (nm)	660 / 20	660 / 20
β^*_x / β^*_y (mm)	7 / **0.068**	7 / **0.10**
σ^*_x ($\sigma^*_{x,design}$) (nm)	**47.7** (40)	**49.7** (40)
σ^*_y ($\sigma^*_{y,design}$) (nm)	**1.8** (1)	**2** (1)
L_{tot} ($L_{tot,\ design}$) ($10^{34}cm^{-2}s^{-1}$)	**7.5** (5.9)	**6.44** (5.9)
$L_{1\%}$ ($L_{1\%,\ design}$) ($10^{34}cm^{-2}s^{-1}$)	**2.3** (2)	**2.06** (2)
Chrom. ξ_y (L^*/β^*_y)	51500	60000

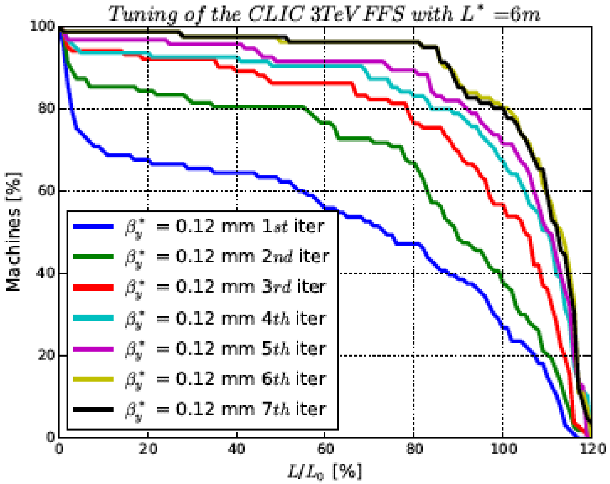


β_y^* changes for tuning performance

Fabien Plassard / BE-ABP

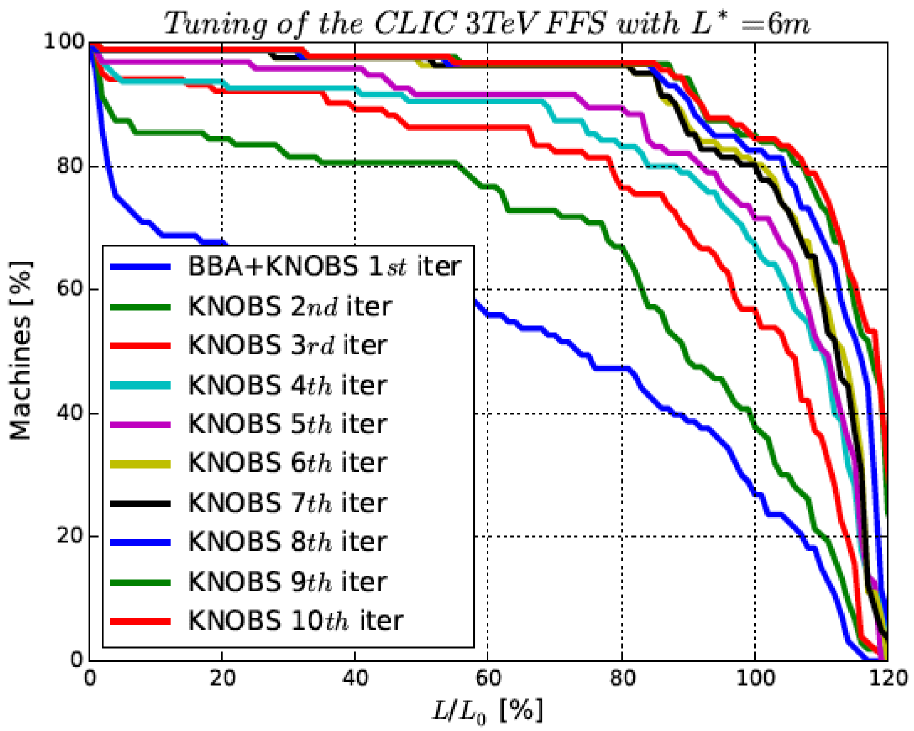
CLIC energy	3TeV	3TeV
L^* [m]	6	6
FFS length [m]	770	770
$\gamma\epsilon_x / \gamma\epsilon_y$ [nm]	660 / 20	660 / 20
β_x^* / β_y^* [mm]	7 / 0.10	7 / 0.12
σ_x^* ($\sigma_{x,design}^*$) [nm]	49.7 (40)	49.4 (40)
σ_y^* ($\sigma_{y,design}^*$) [nm]	2 (1)	1.9 (1)
L_{tot} ($L_{tot,\ design}$) [$10^{34}cm^{-2}s^{-1}$]	6.44 (5.9)	6.4 (5.9)
$L_{1\%}$ ($L_{1\%,\ design}$) [$10^{34}cm^{-2}s^{-1}$]	2.06 (2)	2.1 (2)
Chrom. ξ_y (L^*/β_y^*)	60000	50000





Status of Tuning: $L^* = 6$ m

- 10^{th} iteration: Nominal FFS length have 93% of machines that reach $0.9.L_0$
- 10^{th} iteration: Nominal FFS length have 85% of machines that reach L_0
- 10^{th} iteration: Nominal FFS length have 77% of machines that reach $1.1.L_0$
- **Luminosity measurements ≈ 4000**



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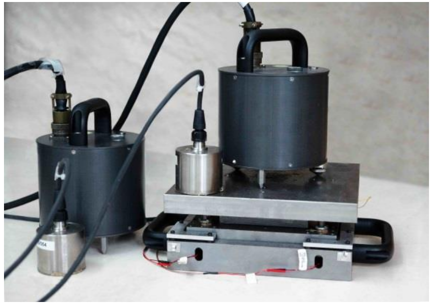
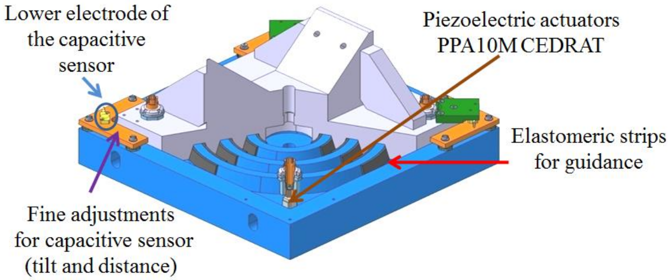
Stabilisation

❑ *LAPP CNRS[1] & SYMME[2] : B. Aimard[1], G. Balik[1], J.P. Baud[1], L. Brunetti[1], B. Caron[2], A. Jeremie[1]*

Before 2016 : CLIC faisability demonstration at reduced scale dedicated to the QD0 magnet final focus

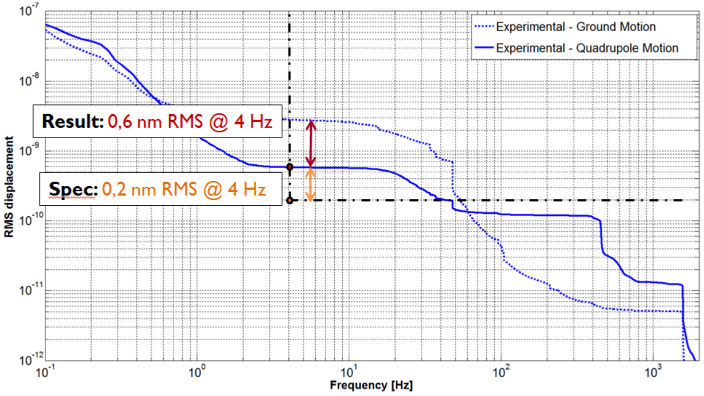


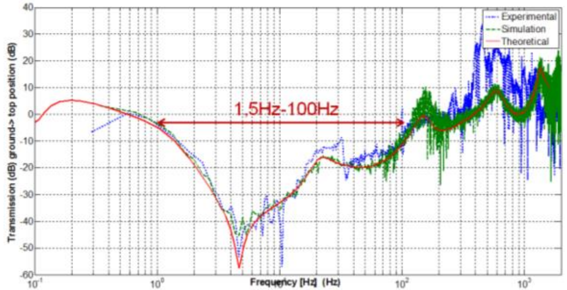
- *Developed active foot with commercial sensors (geophones and accelerometers)*
- *2 sensors used in feedforward and 2 sensors used in feedback*



- *Sensors dedicated to measurement but not to control*
- *Two technologies needed for the selected bandwidth (geophones for low frequencies and accelerometers for high frequencies)*
  - ➢ *complexity of the control*
- *Limitation of the internal instrumental noise*

▪ ***Obtained results :*** ***0,6 nm RMS@4Hz*** *(vs 0,2 nm RMS@Hz specification of CLIC)*





- *Balik et al, "Active control of a subnanometer isolator", JIMMSS, 2013.*
- *R. Le Breton et al, Nanometer scale active ground motion isolator, Sensors and Actuators A: Physical, 2013.*

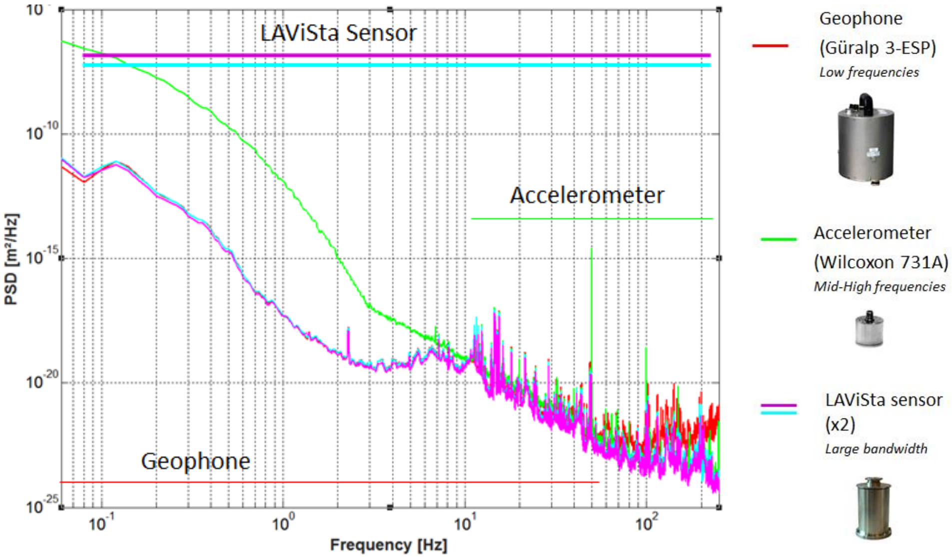
➢ ***Main limitation : SENSORS (Experimental and theoretical demonstration).***

Before 2016 : Development of a vibration sensor

- Promising results (similar to the best commercial sensors)
- French patent (FR 13 59336)
- **Dedicated to control**

Prototypes developed since 2011

▪ Comparison with industrial sensors at CERN (ISR – January 2015):



- The mechanical system of the sensor is used by P. Novotny (PhD PACMAN) to evaluate the most efficient sensitive sensor which could be integrated inside the sensor (capacitive sensor, interferometer, optical encoder…)

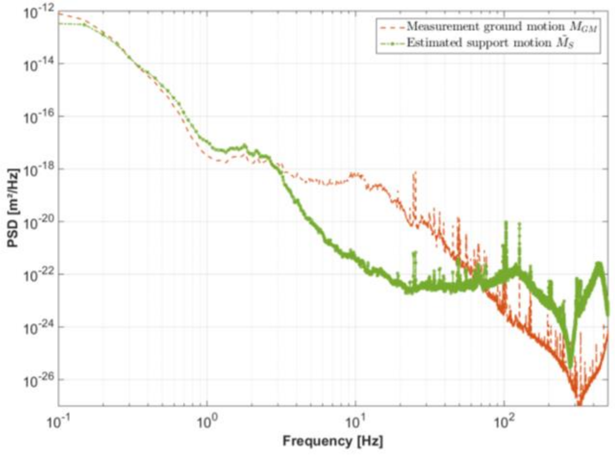
2016 : CLIC Demonstration of feasability at reduced scale

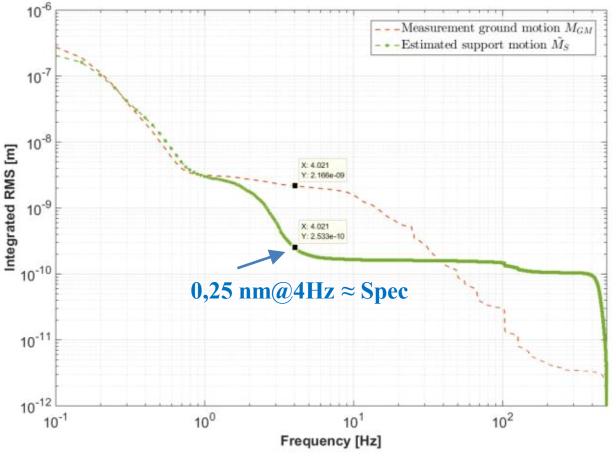
- CLIC specification (displacement of the QD0 final focus) : 0,20 nm RMS@4Hz
- Previous results with LAPP active foot + 4 commercial sensors : 0,60 nm RMS@4Hz
- Developpement of the vibration sensors at LAPP dedicated to control

➤ **Results of control (autumn 2016) with LAPP active foot + 1 LAPP vibrations sensor : 0,25 nm RMS@4Hz**

- *Only 1 sensor in feedback -> control less complex and more efficient*
- *Published in December 2016, in collaboration with SYMME (approbation in progress)*

- LAPP active foot + LAPP sensors (one on ground used to monitor ground motion and 1 on top used in feedback) -



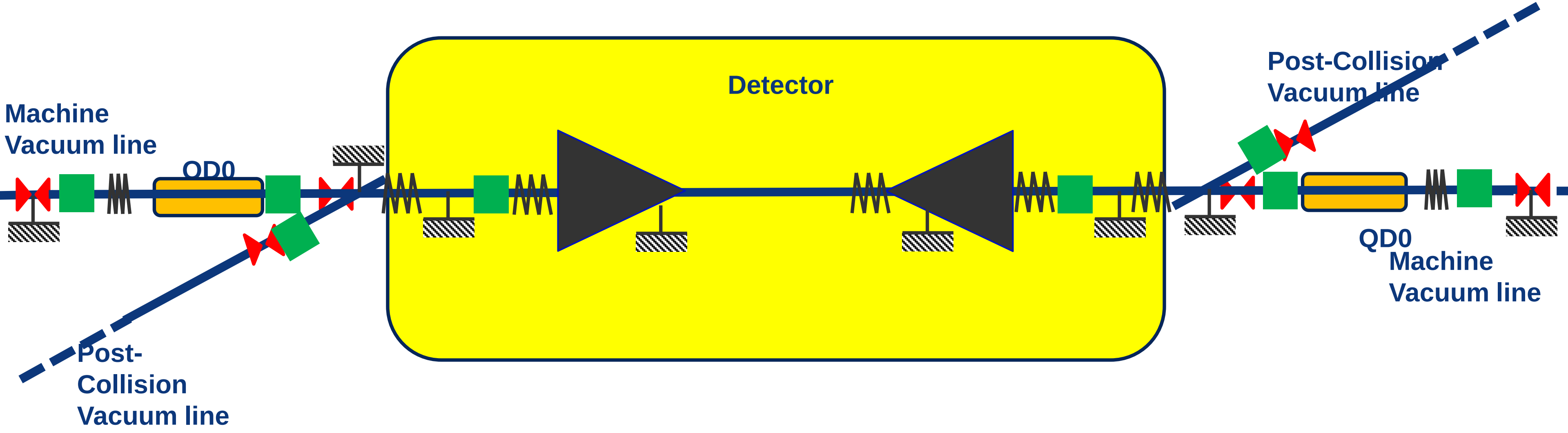


*- Displacement **without control** / **with control** at LAPP -*

Already an application in CMS, but need also passive insulation in CMS detector environment

C.Garion

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…

Summary and Outlook

- A new detector model with L* = 6 m is being evaluated
- The optics for L* = 6 m leads to < 15% luminosity loss and the tuning is approaching the nominal level
- The QD0 stabilitisation tests reached 0.25 nm RMS at 4 Hz
- Now ready to also study more detailed MDI integration aspects
- The impact of the new layout on the physics performance must be established, to decide whether a new baseline can be proposed

The MDI working group

A.Aloev, K.Artoos, J.Axensalva, M.Battaglia, G.Bobbink, E.Bravin, L.Brunetti, H.Burkhardt, Ph.Burrows, F.Butin, G.Christian, Chr.Collette, B.Dalena, F.Duarte Ramos, K.Elsener, A.Gaddi, C.Garion, M.Gastal, L.Gatignon, H.Gerwig, H.van der Graaf, M.Guinchard, A.Hervé, A.Jérémie, Y.Kim, A.Latina, T.Lefèvre, Y.Levinsen, L.Linssen, H.Mainaud Durand, S.Mallows, D.Mergelkuhl, M.Modena, J.Osborne, Th.Otto, C.Perry, B.Piliçer, J.Resta Lopez, A.Sailer, D.Schuilte, J.Snuverink, R.Tomàs, D.Tommasini, J.Vollaire, A.Vorozhtsev, V.Ziemann, F.Zimmermann

CERN

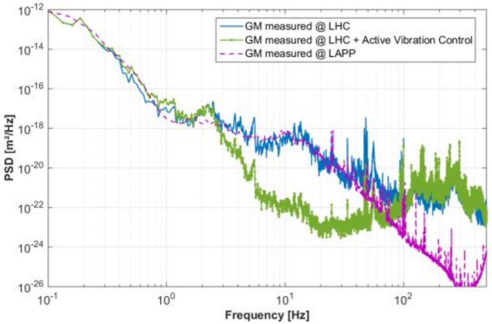
YEARS / ANS CERN

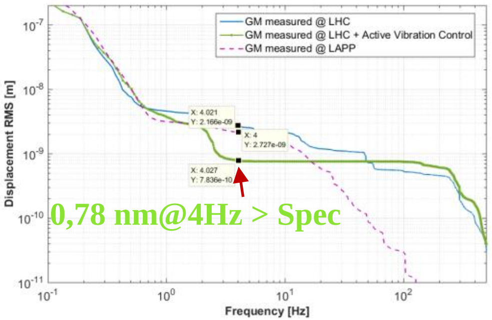
EN

ENGINEERING DEPARTMENT

Beginning of 2017 : Collider application

- Simulation of the system (foot + sensors) with disturbances equal to the CMS detector motion

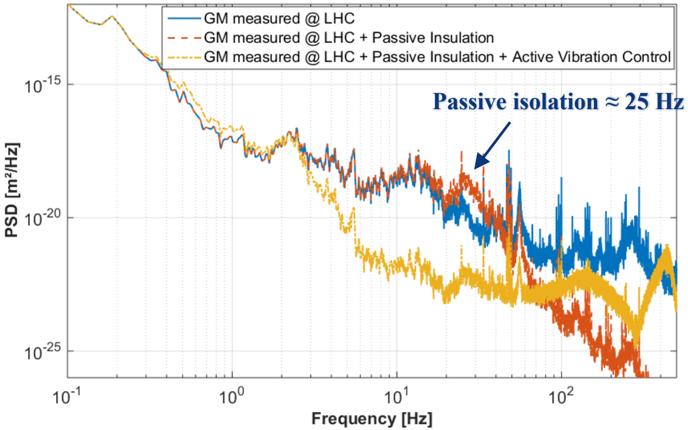


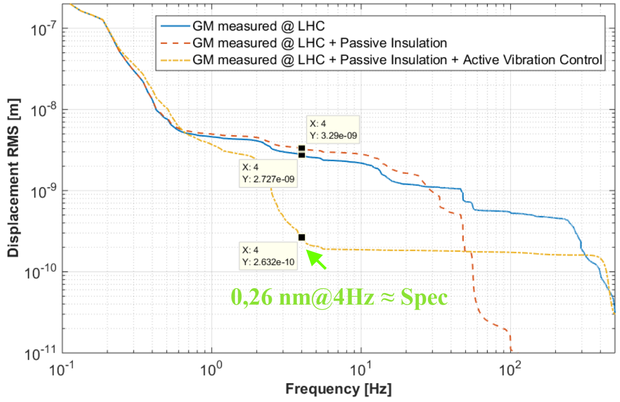


- *Disturbances don't reveal the same distribution (more cultural noise).*
- *Control is not efficient enough in this case (above 100 Hz)*

➢ Necessity to have a passive insulation under the concrete or under the last elements

Poster @ IPAC17





- *A passive insulation at about 25 Hz is common to the standard industrial solutions*

QD0 in the tunnel or not

- QD0 in the detector takes away a significant fraction of the **acceptance in the forward region**. **Although with recent HTS magnet technology it may be possible to reduce the loss.**
- Due to the presence of a **strong magnetic fiel**d, **higher radiation** and **lack of space and access** inside the detector some critical components may require more or longer interventions, leading to loss of integrated luminosity.
- For the **chosen L* value** the **BDS optics must be re-optimised** (impact on QD0 parameters, required pre-alignment precision, etc).
- In case QD0 moves to the tunnel, the question is legitimate whether the **anti-solenoid** and/or **IP feedback** are still required inside the detector and how their implementation must be revised.

Some justifications for the CDR choice

The choice of short L* was justified by the fact that

- 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, B-field, etc)
- at the time the pre-alignment tolerance was considered unrealistic (2 µm for L*=8 m, 10 µm for L* = 3.5.m).
  Since then significant progress has been made in the BDS optics.