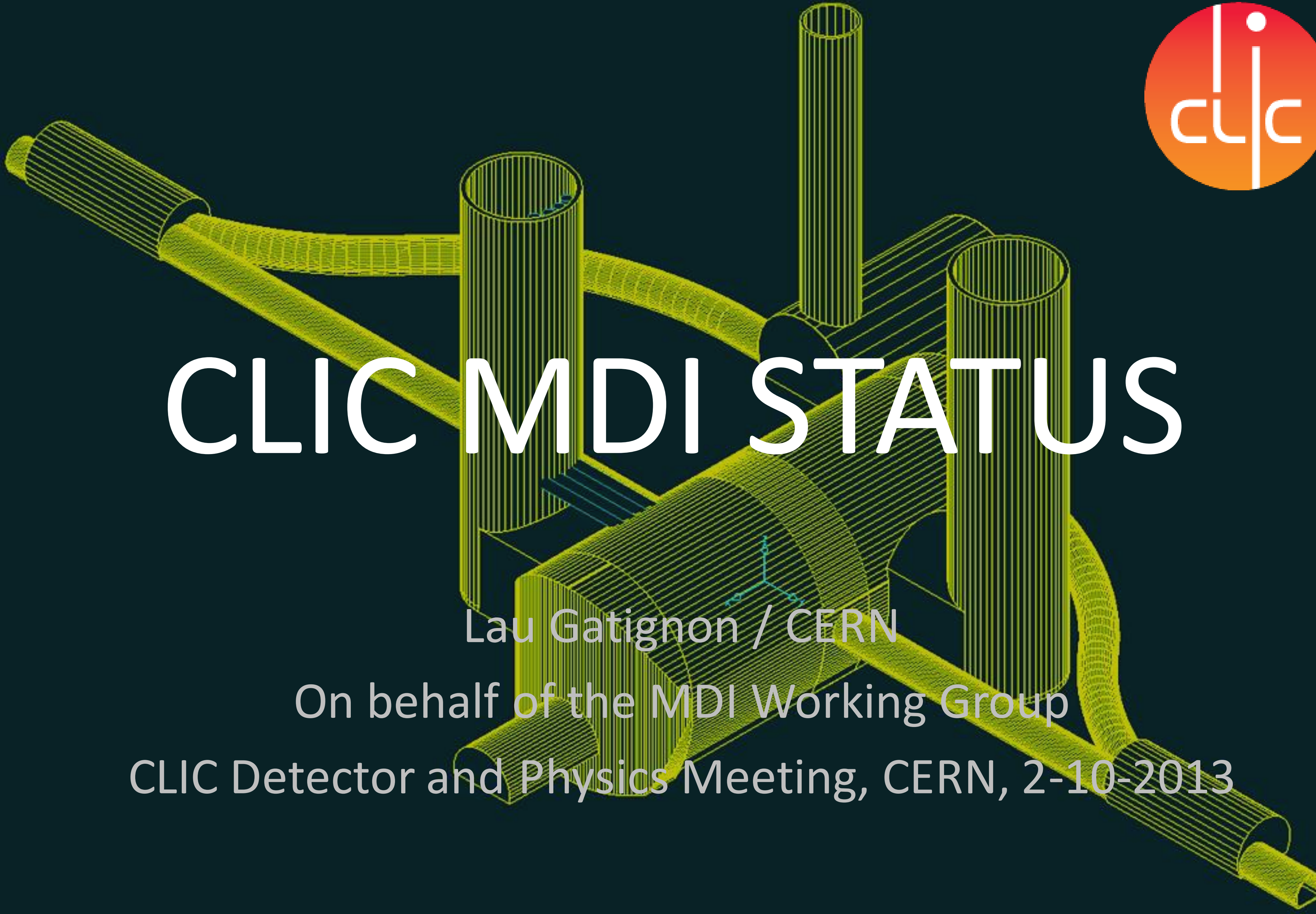


CLIC MDI STATUS

Lau Gatignon / CERN

On behalf of the MDI Working Group

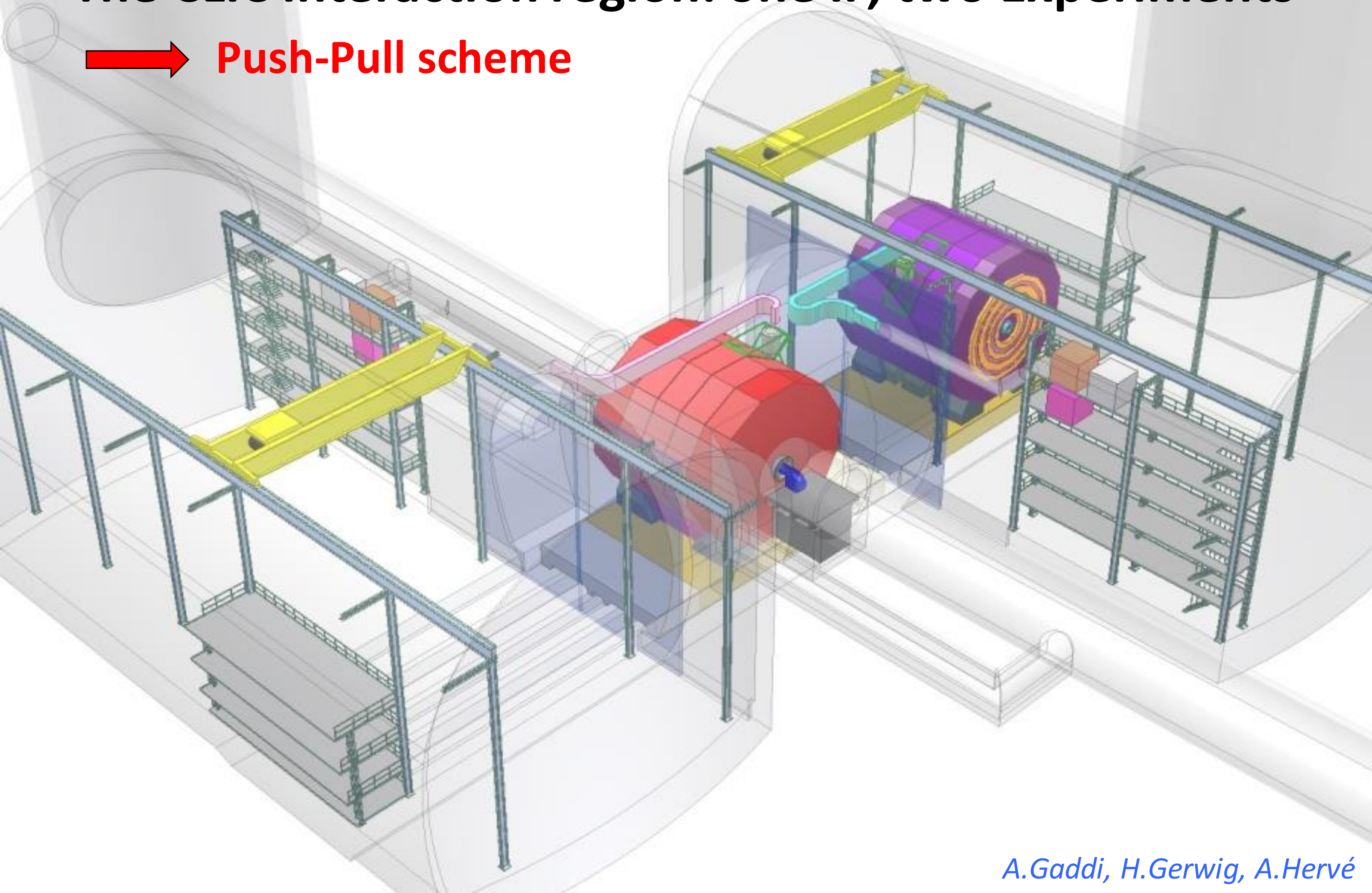
CLIC Detector and Physics Meeting, CERN, 2-10-2013

OUTLINE

- Introduction
- QD0 prototype measurements
- QD0 pre-alignment
- QD0 stabilisation
- IP feedback
- Anti-solenoid compensation
- Post-collision line (back to MDI since 2012)
- Coming soon…

The CLIC interaction region: one IP, two Experiments

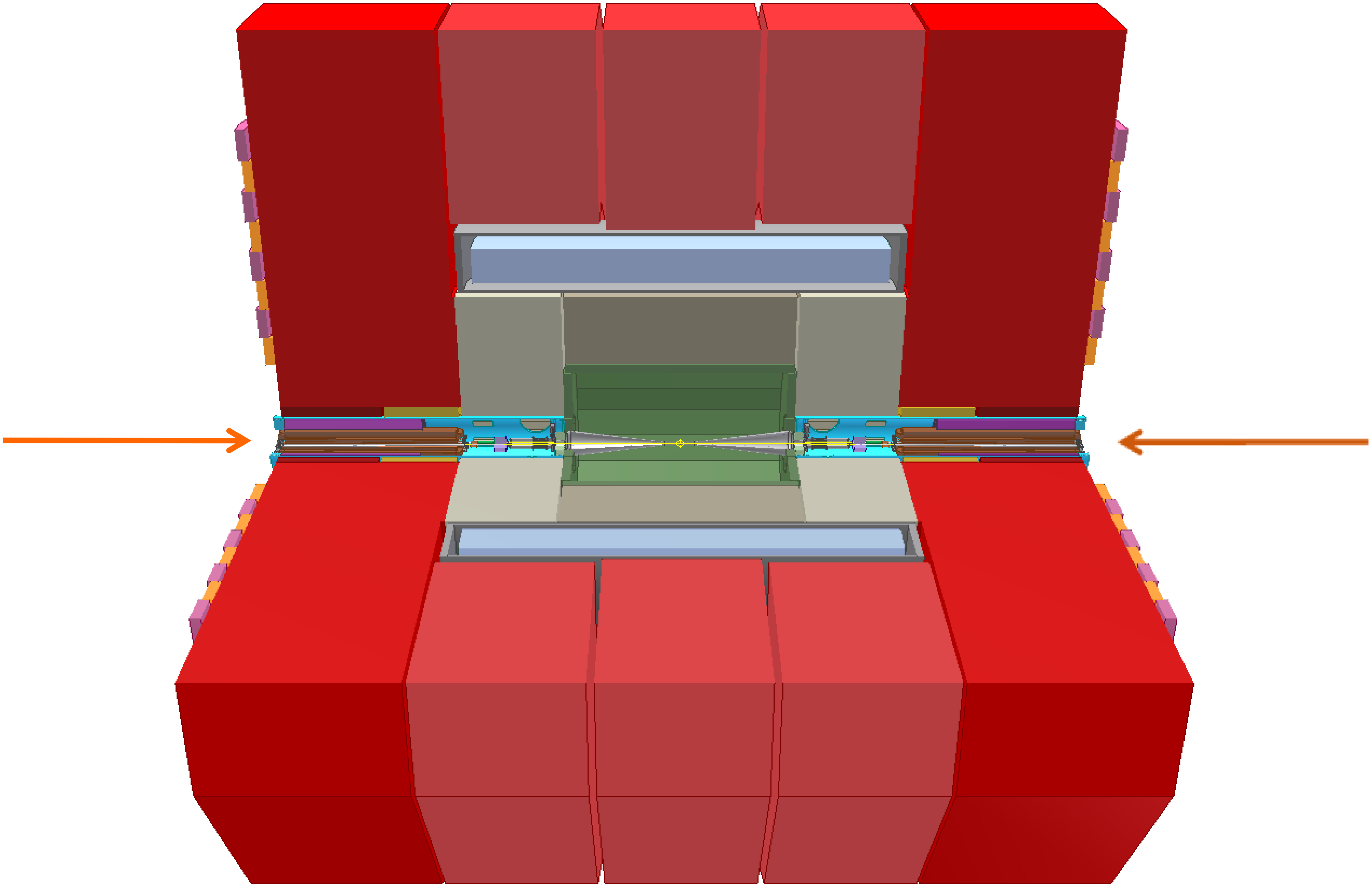
→ **Push-Pull scheme**



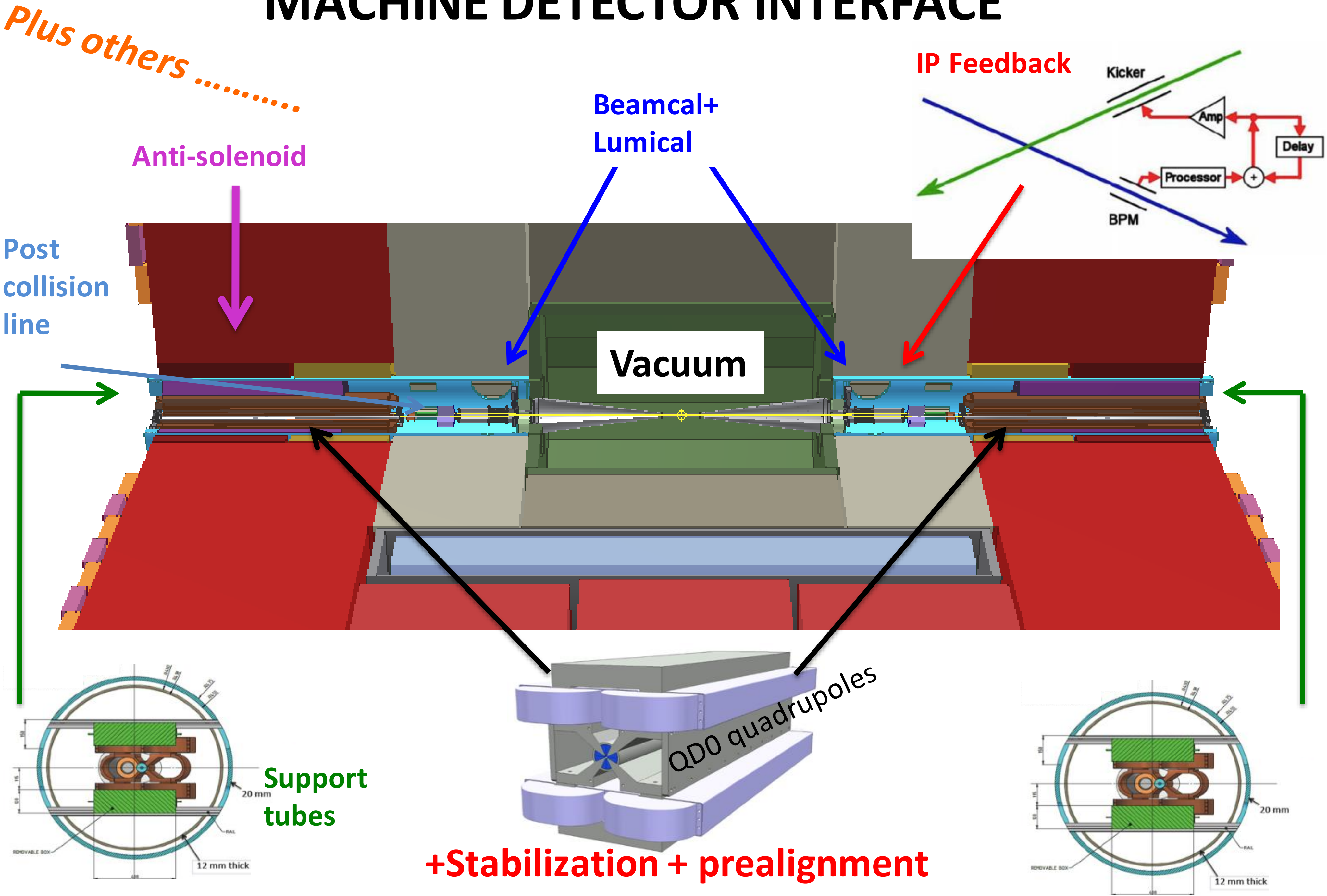
A.Gaddi, H.Gerwig, A.Hervé

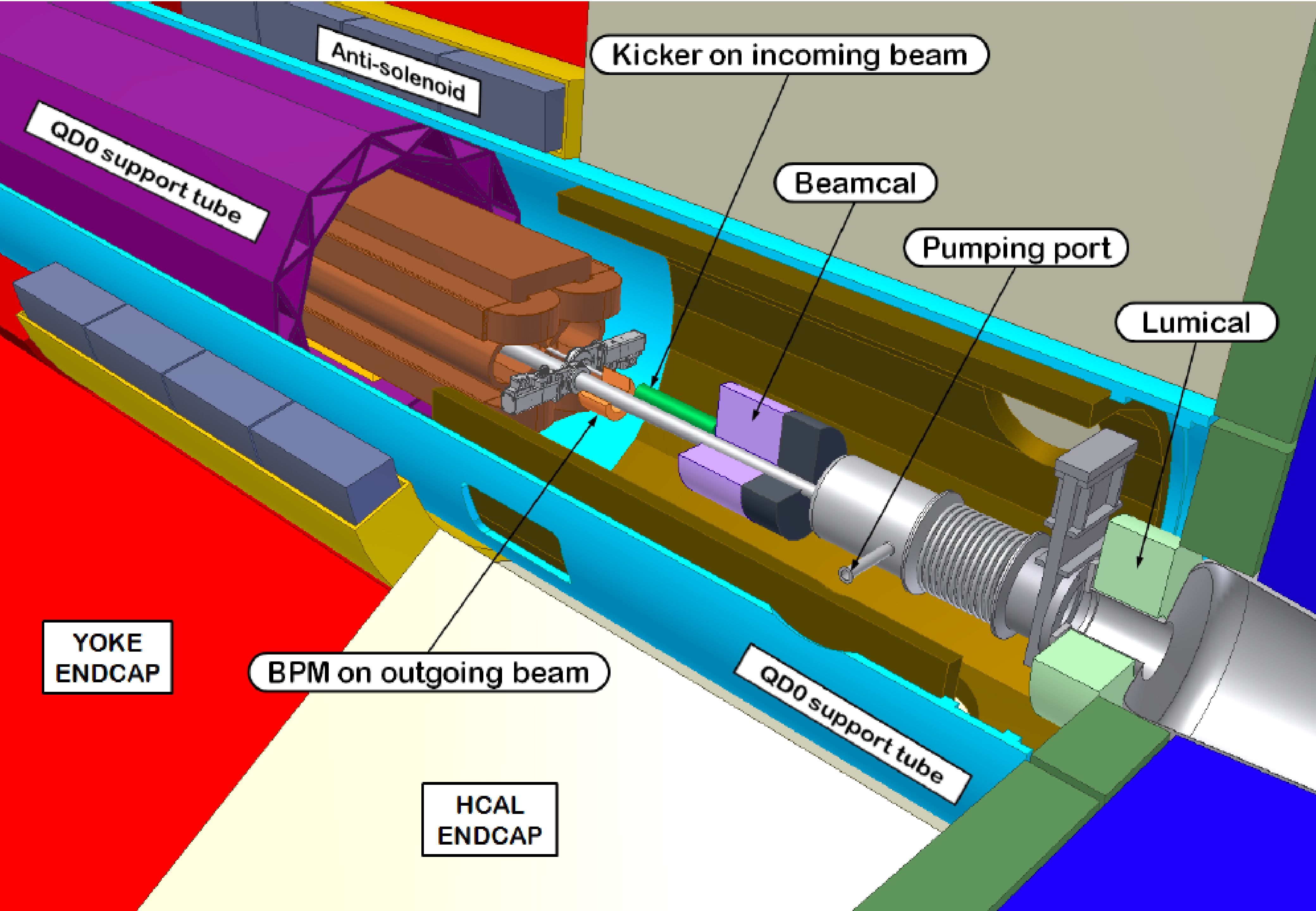
e.g.: CLIC_SID DETECTOR

N.Siegrist, H.Gerwig



MACHINE DETECTOR INTERFACE




Kicker on incoming beam
Anti-solenoid
QD0 support tube
Beamcal
Pumping port
Lumical
YOKE
ENDCAP
BPM on outgoing beam
QD0 support tube
HCAL
ENDCAP

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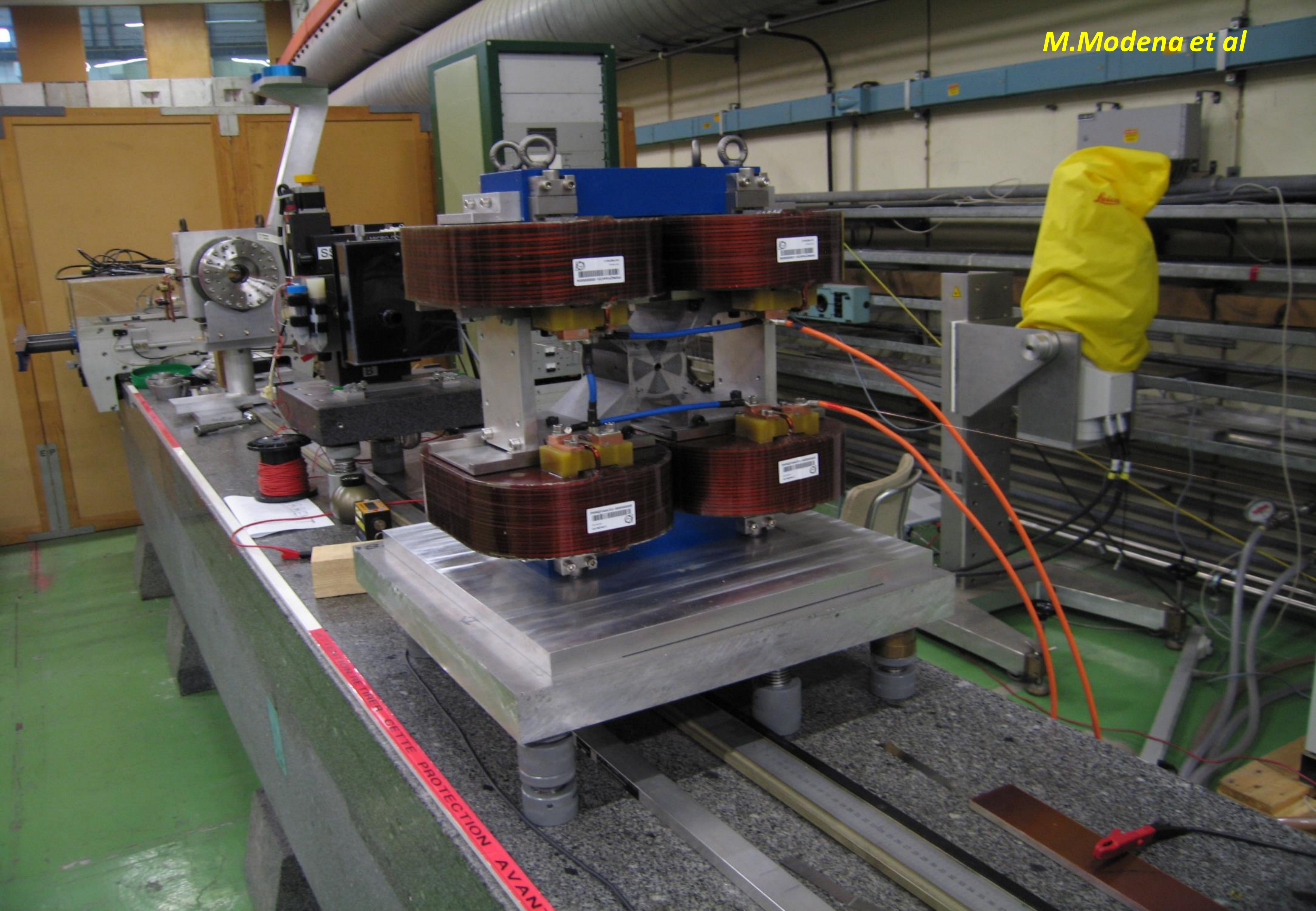
QD0 study & design requirements

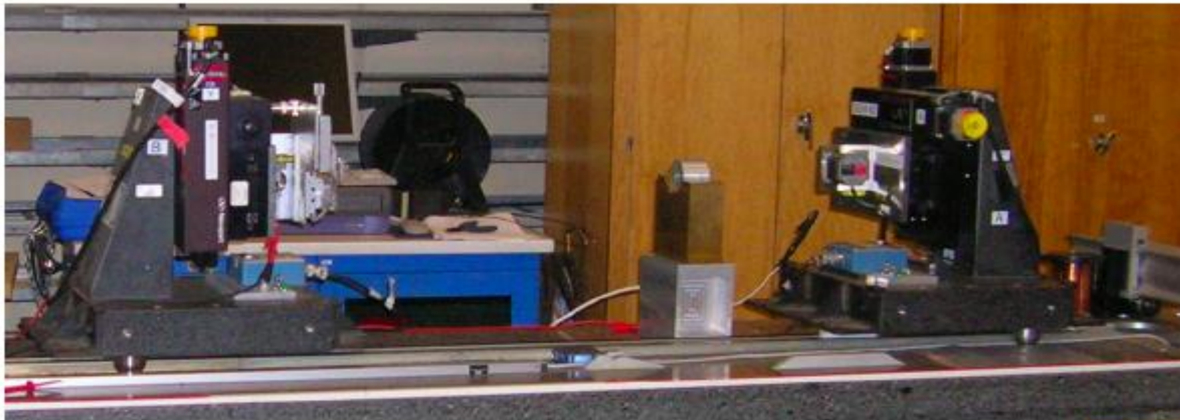
QD0 Baseline Parameter	*Value*
Nominal target for field gradient	575 T/m
Magnetic length	2.73 m
Magnet aperture (required for beam)	7.6 mm
Magnet bore diameter	8.25 mm* ** Including a 0.30 mm vacuum chamber thickness*
Good field region (GFR) radius	1 mm
Integrated field gradient error inside GFR	< 0.1%
Gradient adjustment	+0 to -20%

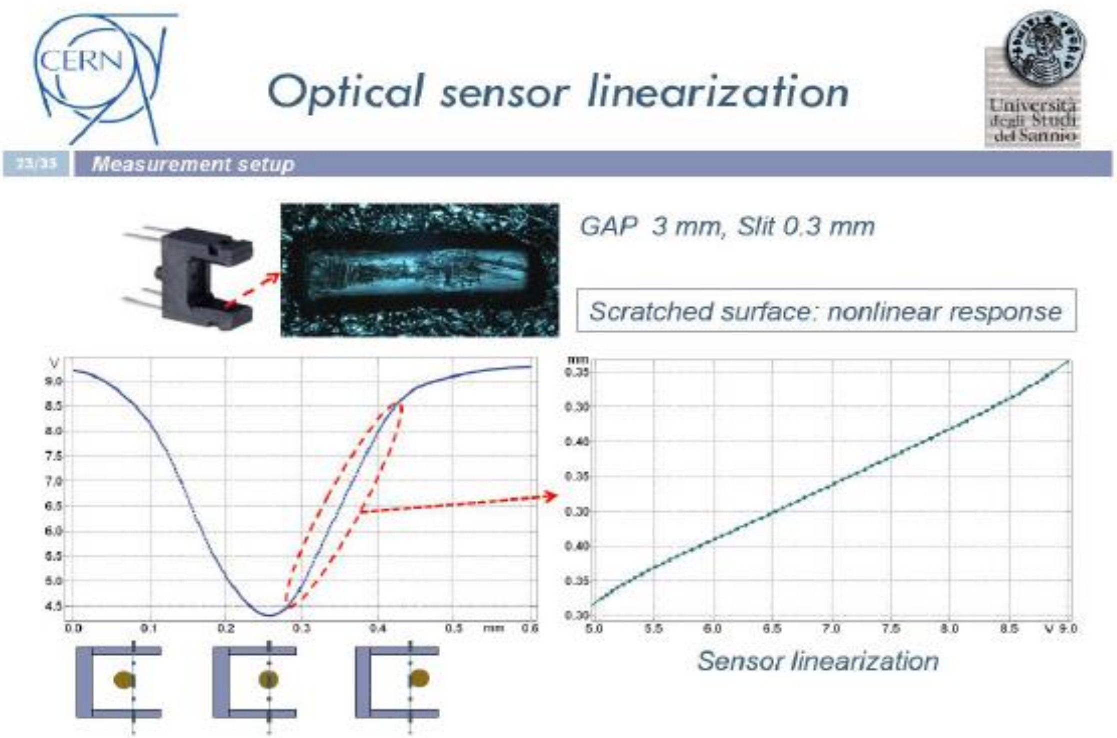
Magnet design boundary conditions:

- *As much as possible **compact design** (to be compatible with an L* of 3.5 m, so minimizing the solid angle subtracted to the experiment Detector)*
- *Compatible with **magnet active stabilization** (i.e. minimize magnet weight and vibration sources, ex. coil water cooling)*
- *Presence of the **post-collision line beam vacuum chamber** (in its closer position at 35 mm from beam axis)*


M.Modena et al

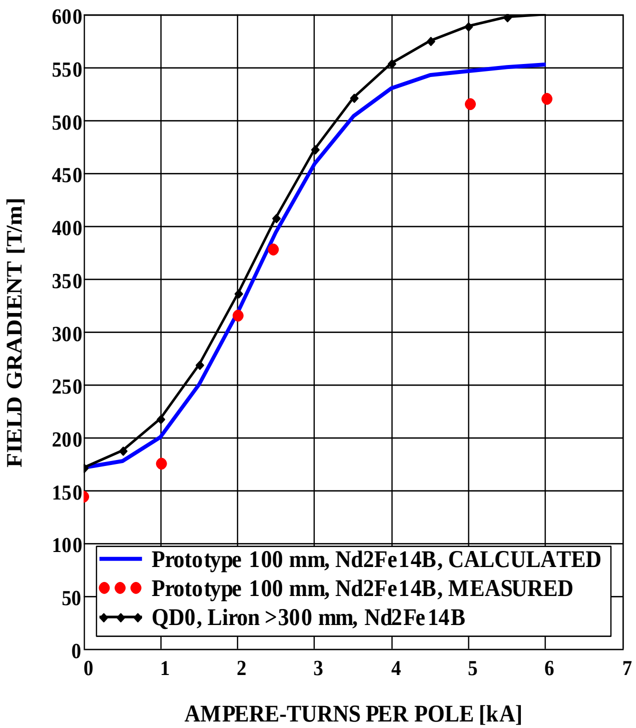
The “Single Stretched Wire” and “Rotated Vibrating Wire” MM System

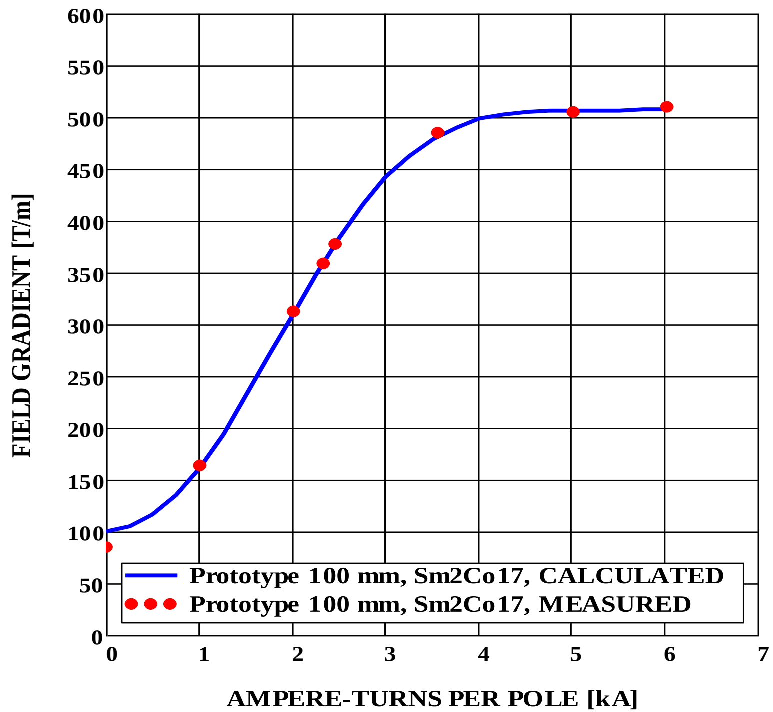




***Two** campaign of measurements were done in 2012 with QD0 prototype in two different configuration:*
*- in January 2012: the magnet equipped with the **$Nd_2Fe_{14}B$** blocks was measured with the Vibrating wire system*
*- in August 2012: the same type of measurement was done for the configuration with **Sm_2Co_{17}** blocks.*

Here below are shown the measurements of the MEASURED Gradient (red dots) (extrapolated from the INTEGRATED GRADIENT effectively measured), together with the COMPUTED Gradient (blue curves).





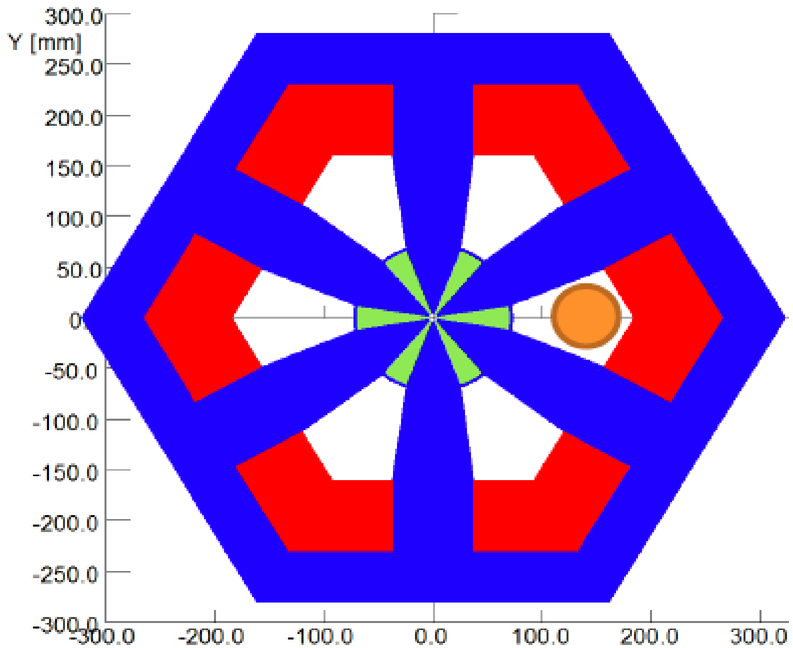
The measured Gradient in the configuration with Sm_2Co_{17} blocks it is in very good agreement with the FEA computation. This is not the case for the $Nd_2Fe_{14}B$ blocks were a difference of ~ - 6% is visible. This could have 2 possible explanation but the 1^{st} was then excluded by a 2^{nd} FEA cross-check:

-The Permendur saturate at lower level than expected. → The magnetization curve extracted from the Test Report of the raw material provided by the Supplier was utilized for the FEA computation that confirm that the problem is not coming by the Permendur quality.

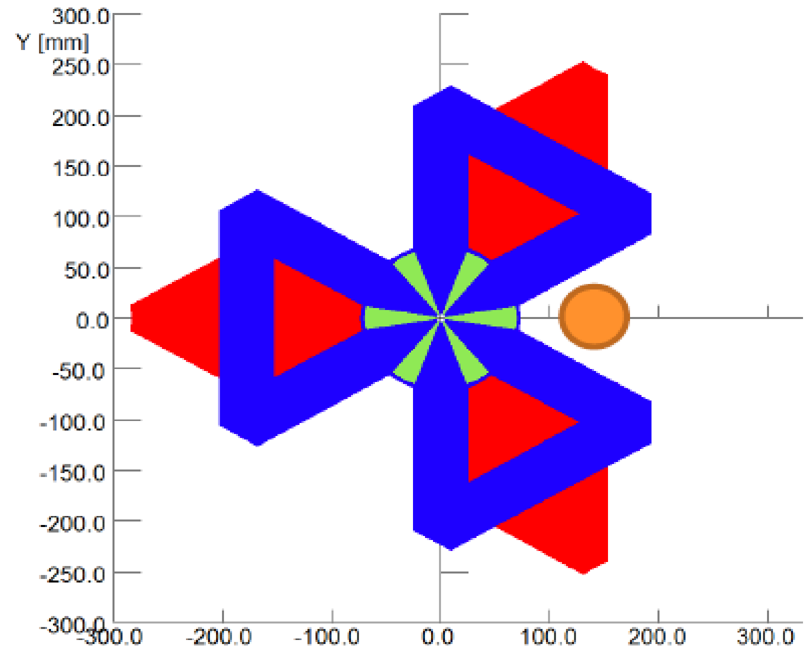
-The quality (magnetization module and/or direction) of the $Nd_2Fe_{14}B$ PM blocks is not the expected one → we should get more indication of this possibility when the PM blocks measuring device (by Helmholtz coils) will be delivery to the MM Section.

2. Preliminary considerations for CLIC SD0 sextupole design:

"Closed yoke" version:



"Open yoke" version:



Coils
1010 steel yoke
Permanent magnet blocks (NdFeB)
Post-collision line

Main parameters:

Aperture (radius):	4.3 mm
Max. Achievable Sextupole gradient:	220 000 T/m^2
Magnetic length	250 mm
Amperturns NI	5300 Amps

A. Aloev, M. Modena at: "29th MDI meeting": 14th December 2012

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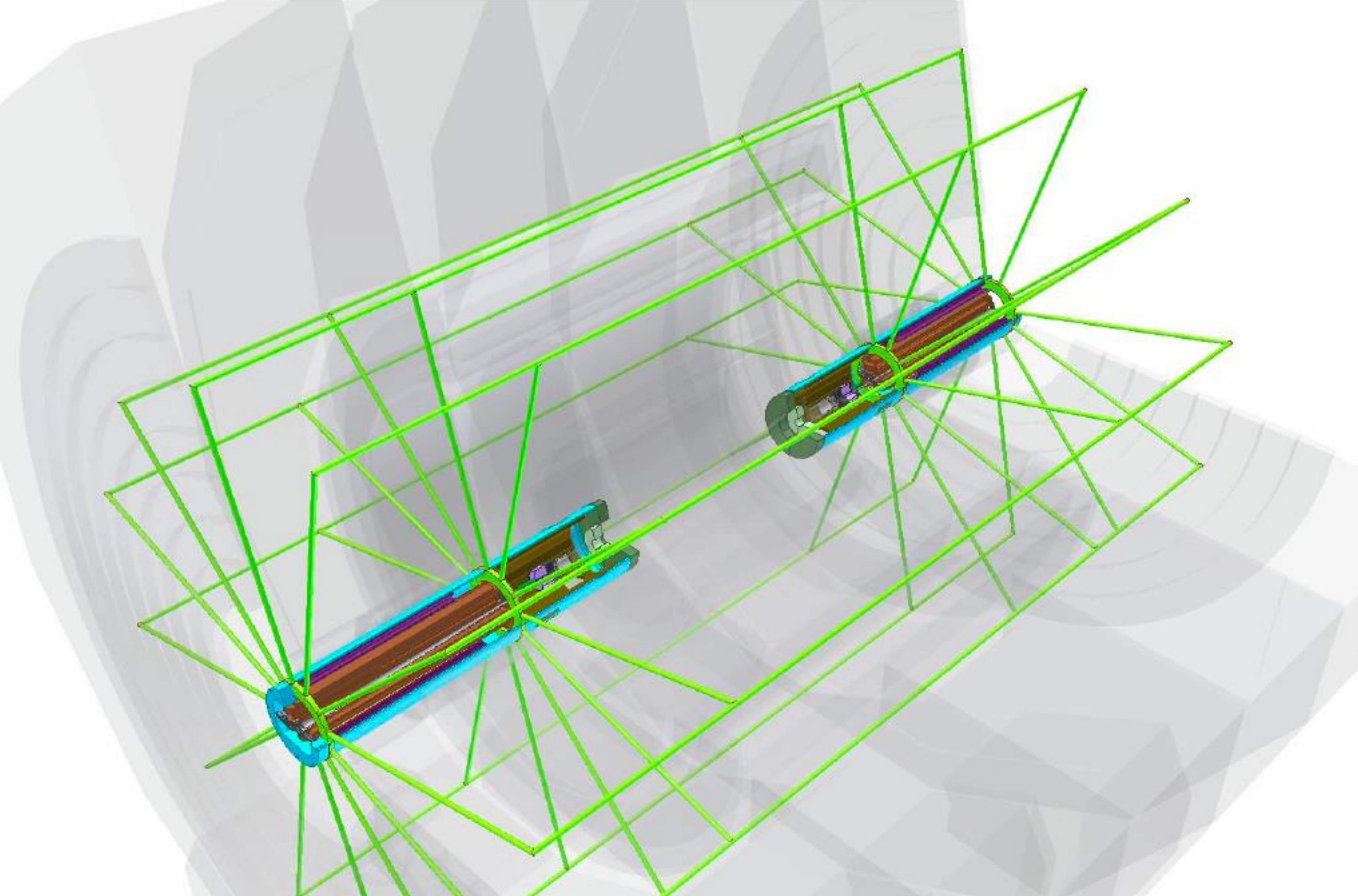
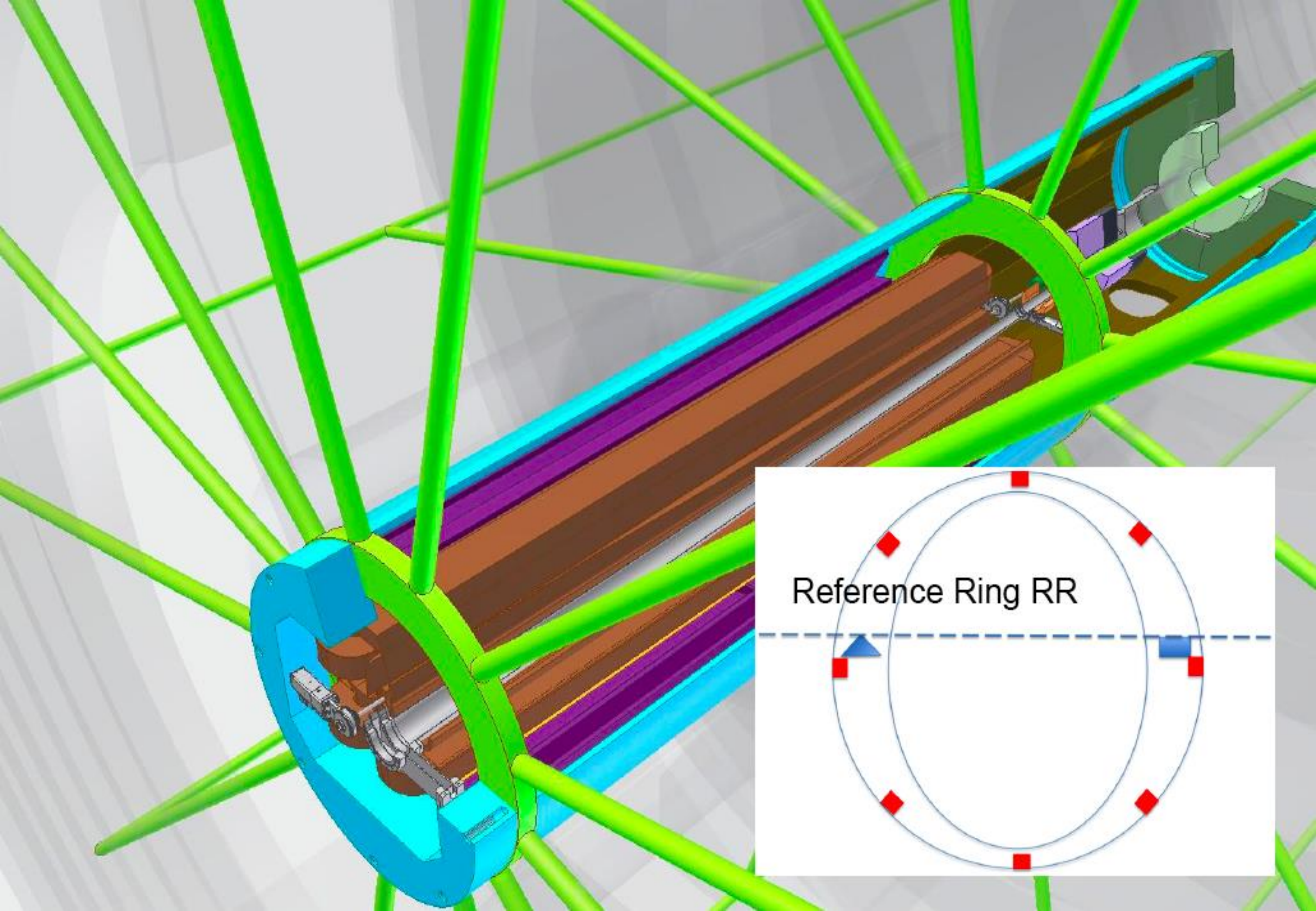
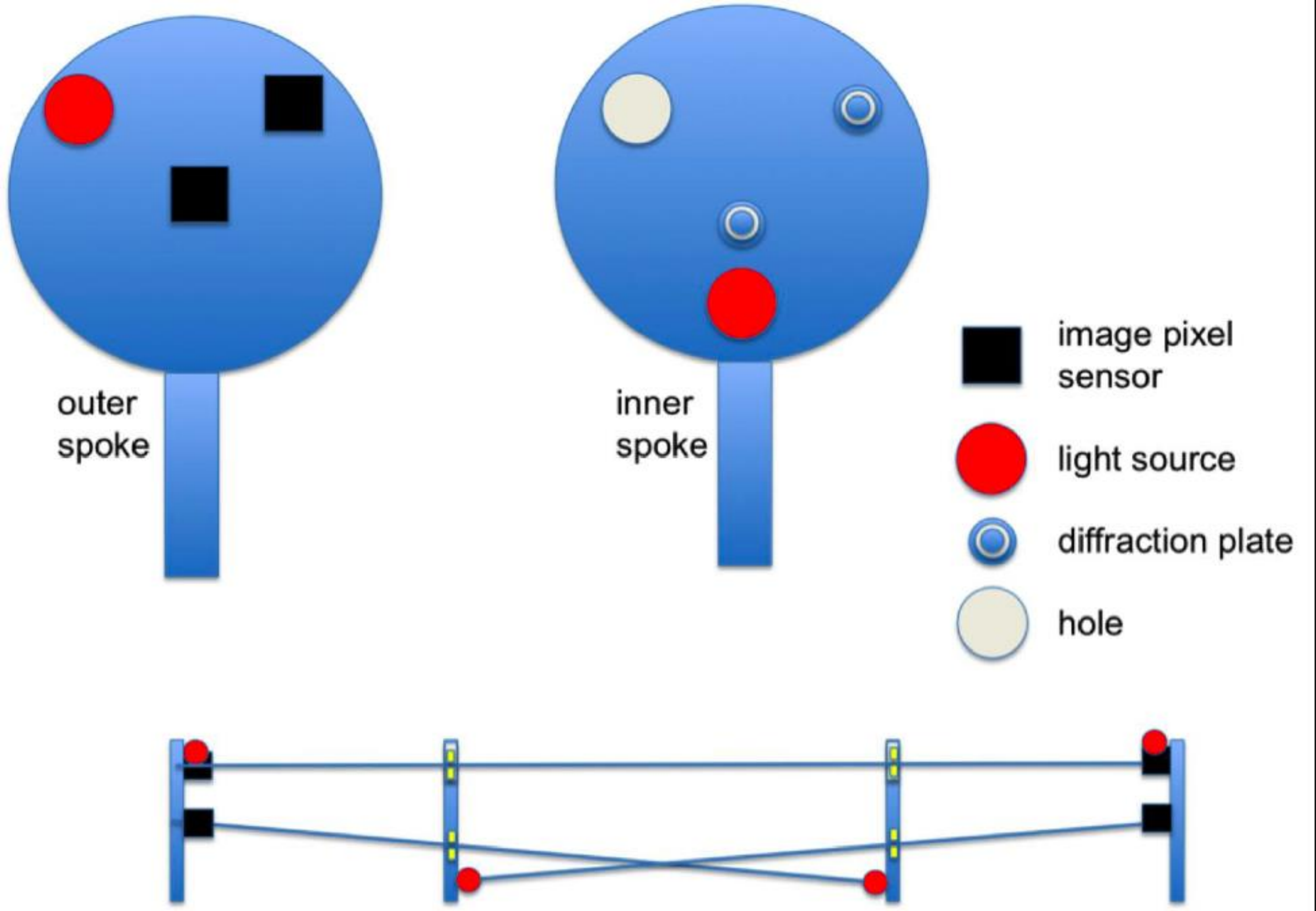
Harry van der Graaf / NIKHEF




Reference Ring RR


outer
spoke
inner
spoke
image pixel
sensor
light source
diffraction plate
hole

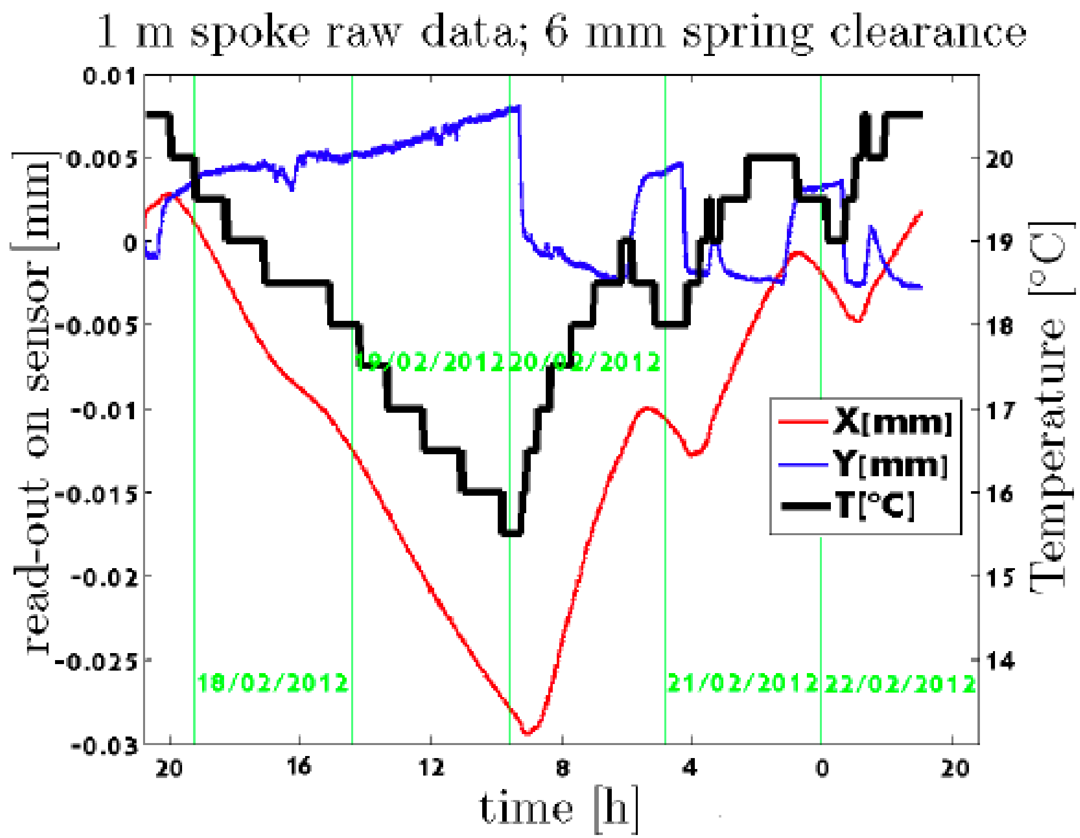
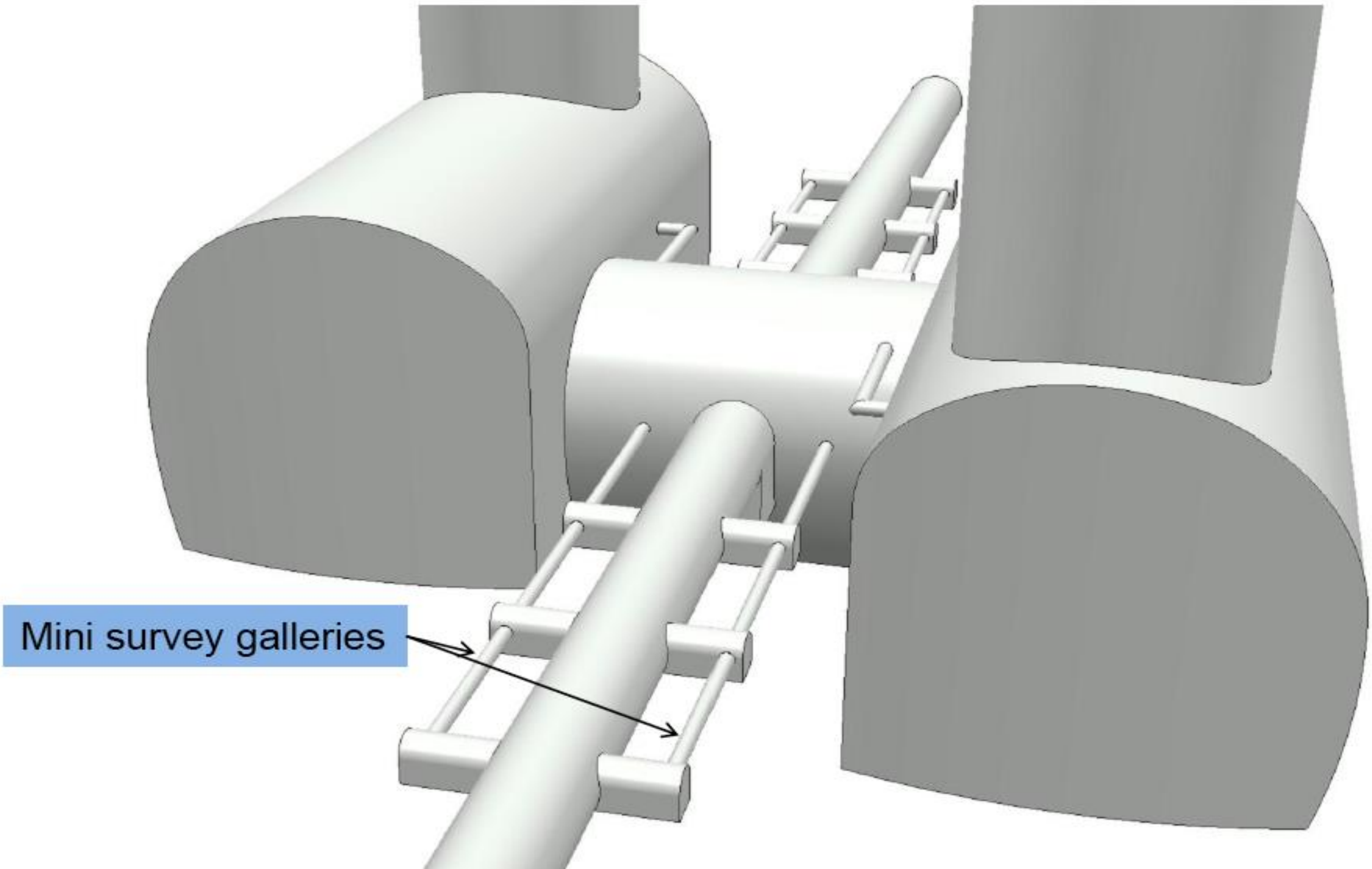


Figure 7.10: 4 day Rasnik measurement of the expansion of granite table and temperature. The x coordinate is in the length direction of the 1 m Zerodur spoke

MDI area - proposed survey channels



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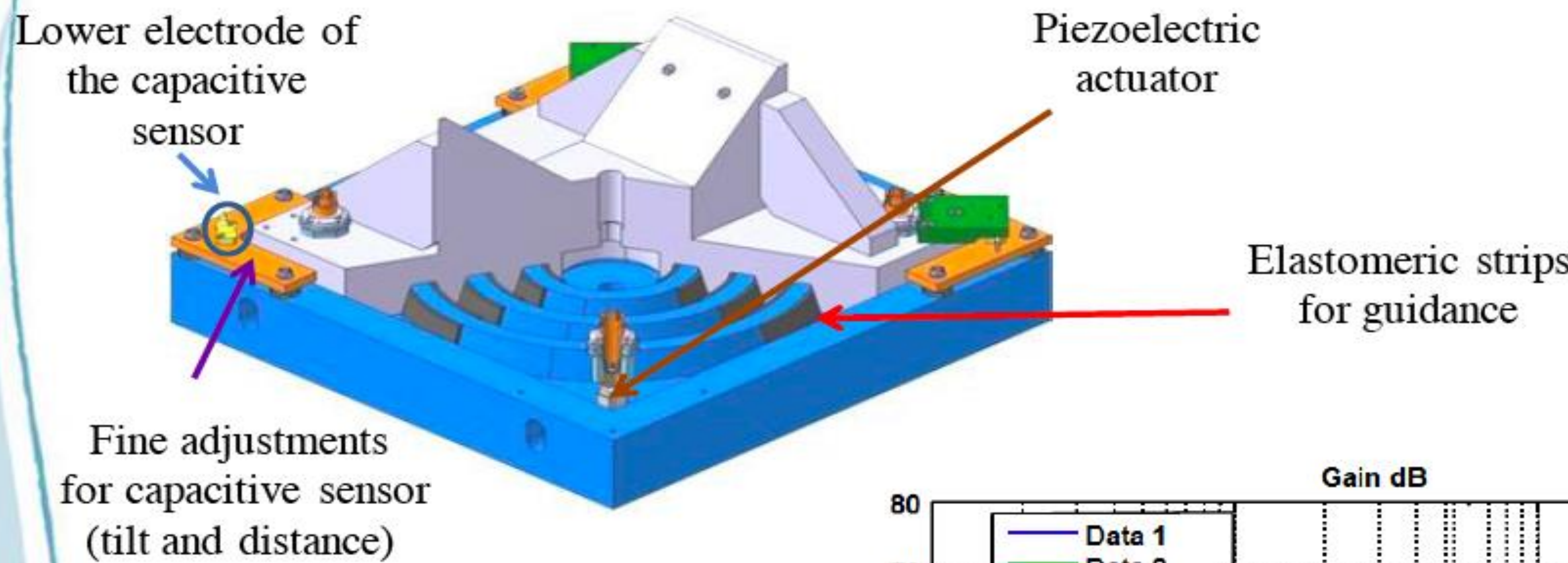
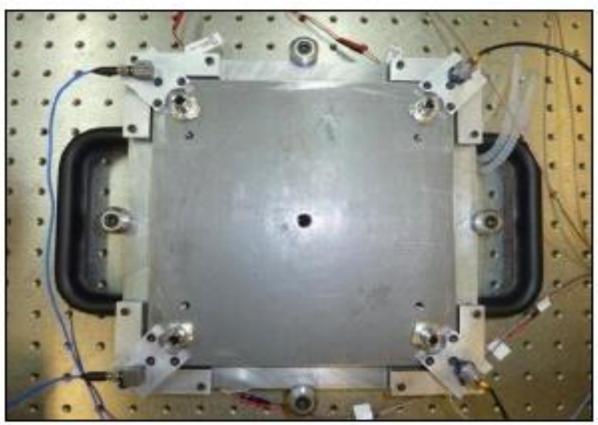
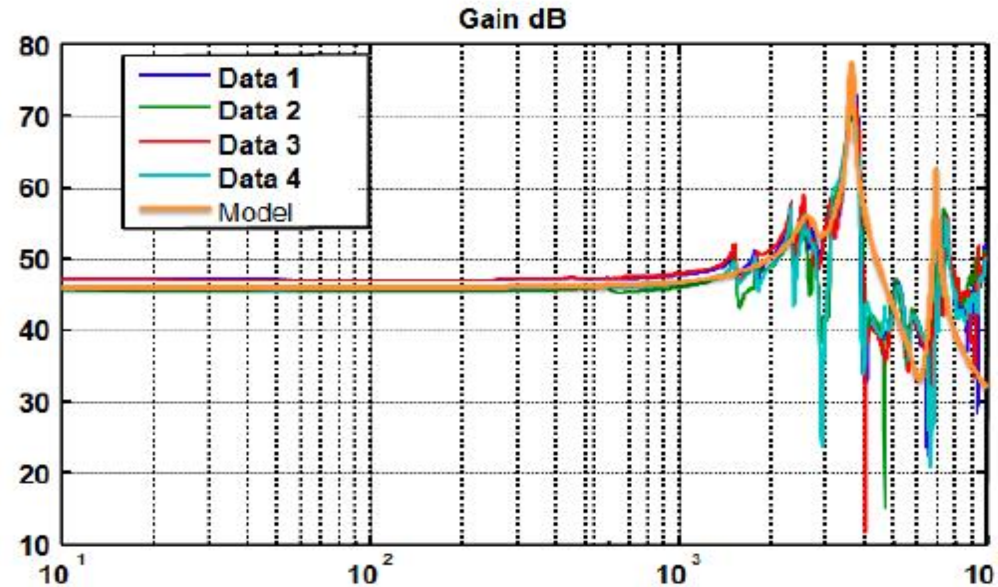
A.Jeremie et al

-Active foot:







L.Brunetti

Mechanical active stabilisation – experimental setup

- *Control architecture :*

Matlab and dSPACE ControlDesk
For monitoring and analysis

- *Used sensors :*

- Geophones : GURALP CMG-6T
- Accelerometers : WILCOXON 731A

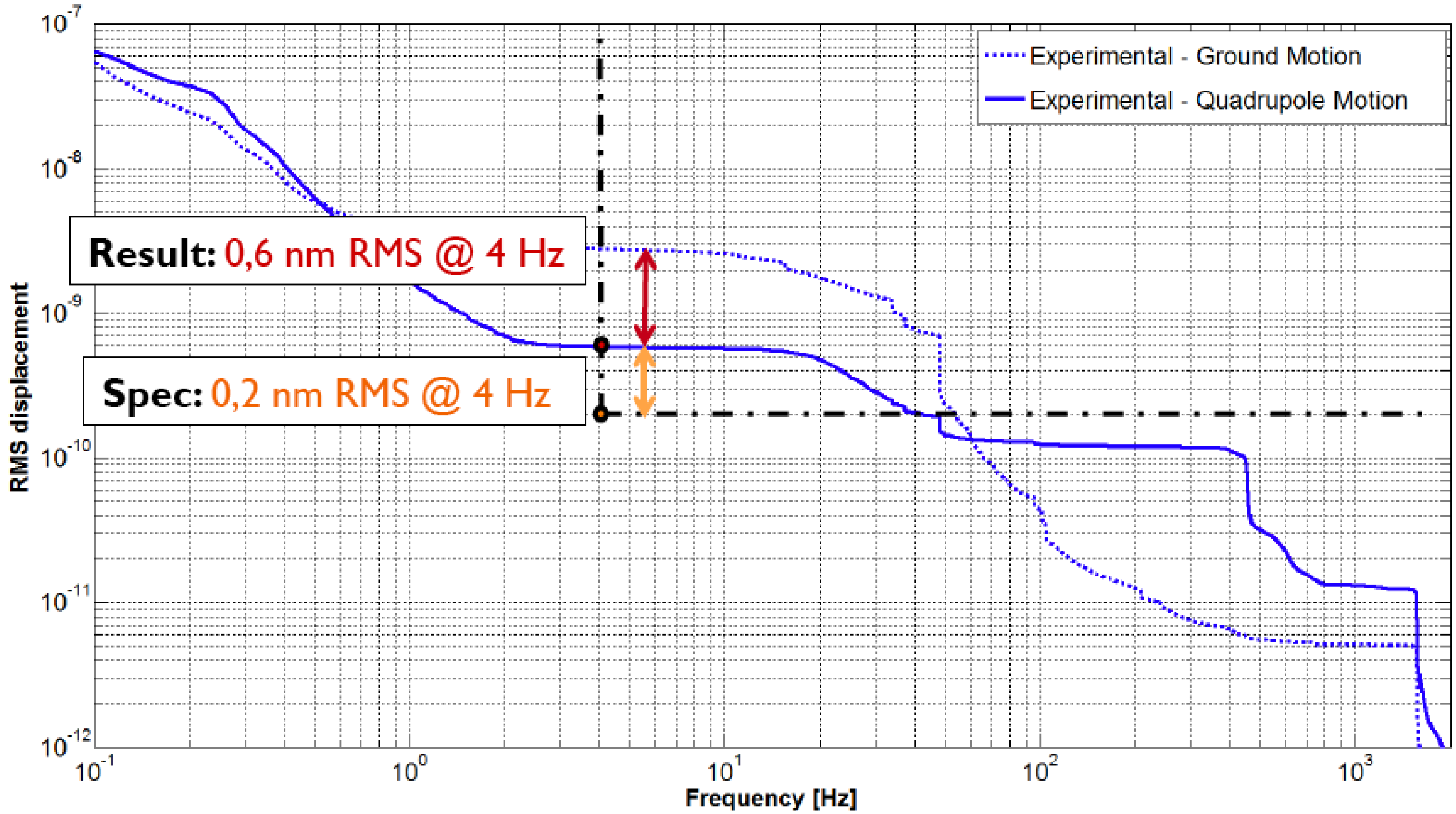
Amplifiers, filters input/output board for signal conditioning

dSPACE
Real time hardware for
Rapid Control Prototyping

✓ **All is taken into account in simulation (noise, ADC, DAC…).**

Mechanical active stabilisation – Results

- *Simulation and experimental results (RMS) :*



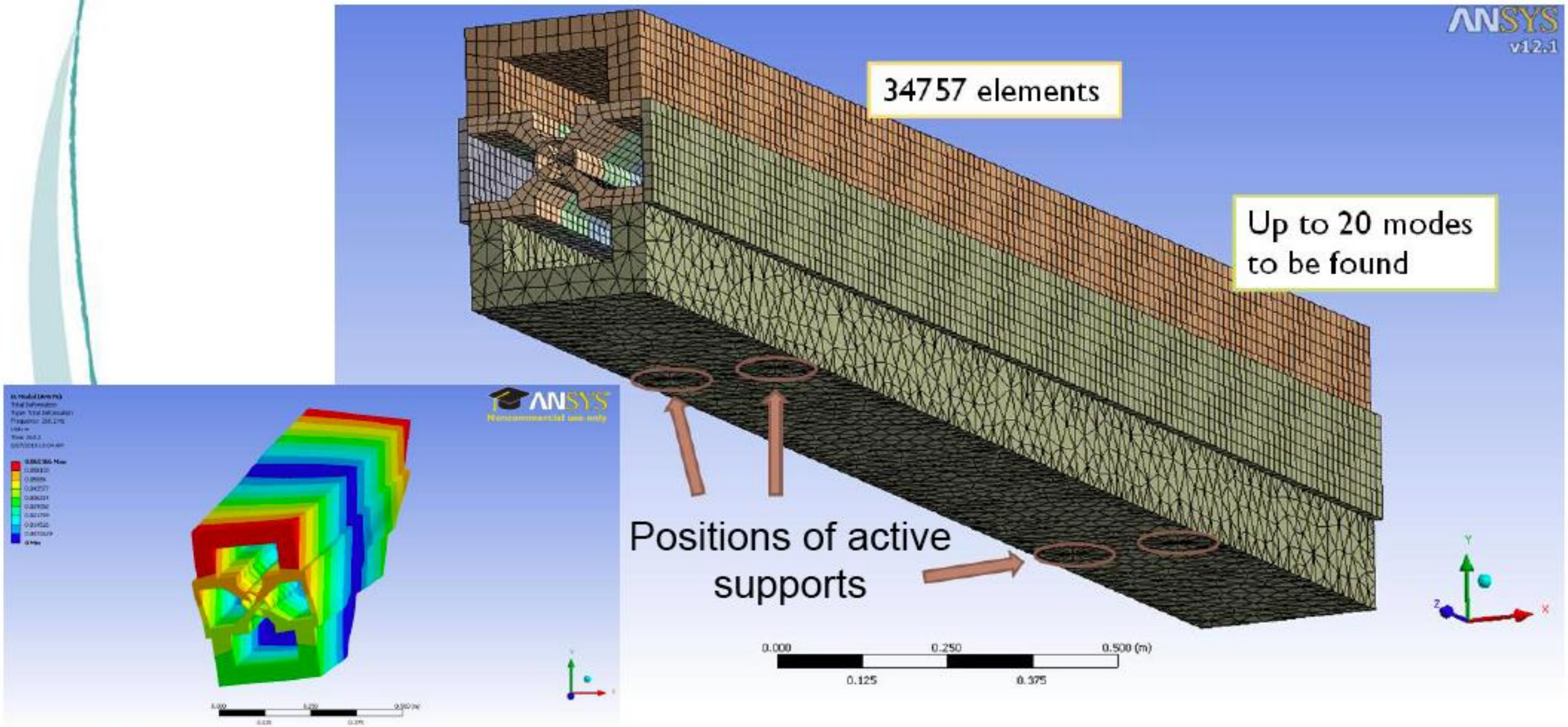
➢ **Publication in progress (accepted) : Balik et al, "Active control of a subnanometer isolator", JIMMSS.**

Limited by sensor noise – working on better sensors

B.Carron

New development

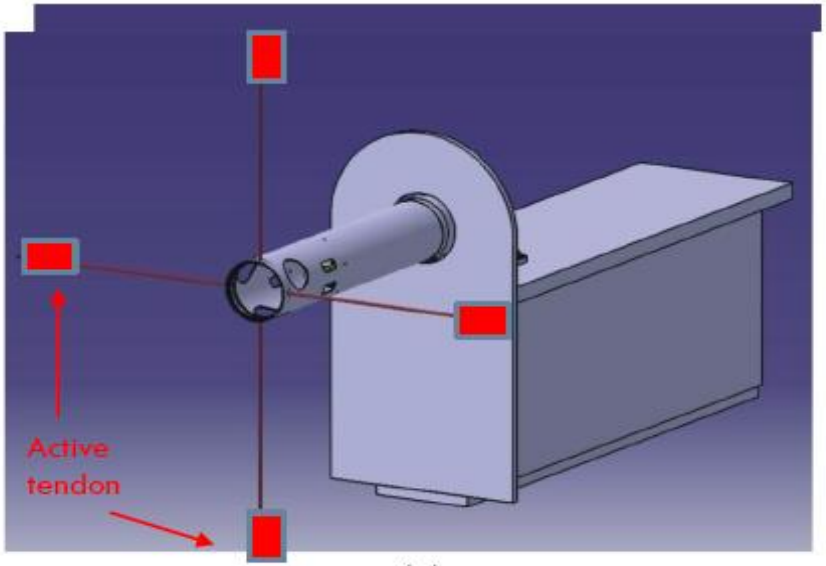
Dummy QD0 magnet stabilization



- QD0 Model Ansys-> Matlab ->simulink
- Multi-support simulation -> demonstrator

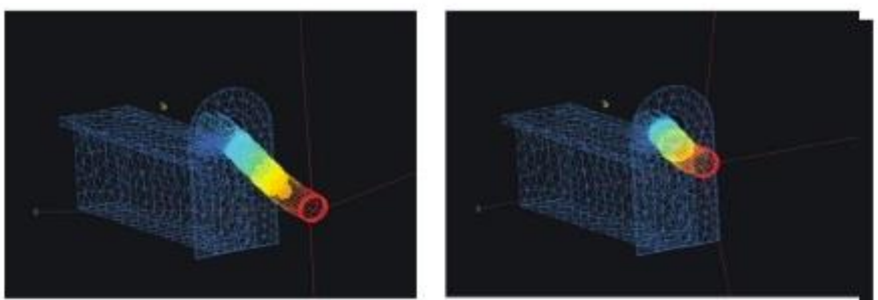
Christophe Collette started study of alternative approach: stiffening with cables

Finite element model (Full scale)



(a)

$$\begin{cases} k_{cable} = 6.7\ 10^7\ N/m \\ L_{cable} = 3.32\ m \\ d_{cable} = 39.64\ mm \\ E_{cable} = 180\ Gpa \end{cases}$$



mode 1 52.78 Hz

mode 2 54.15 Hz

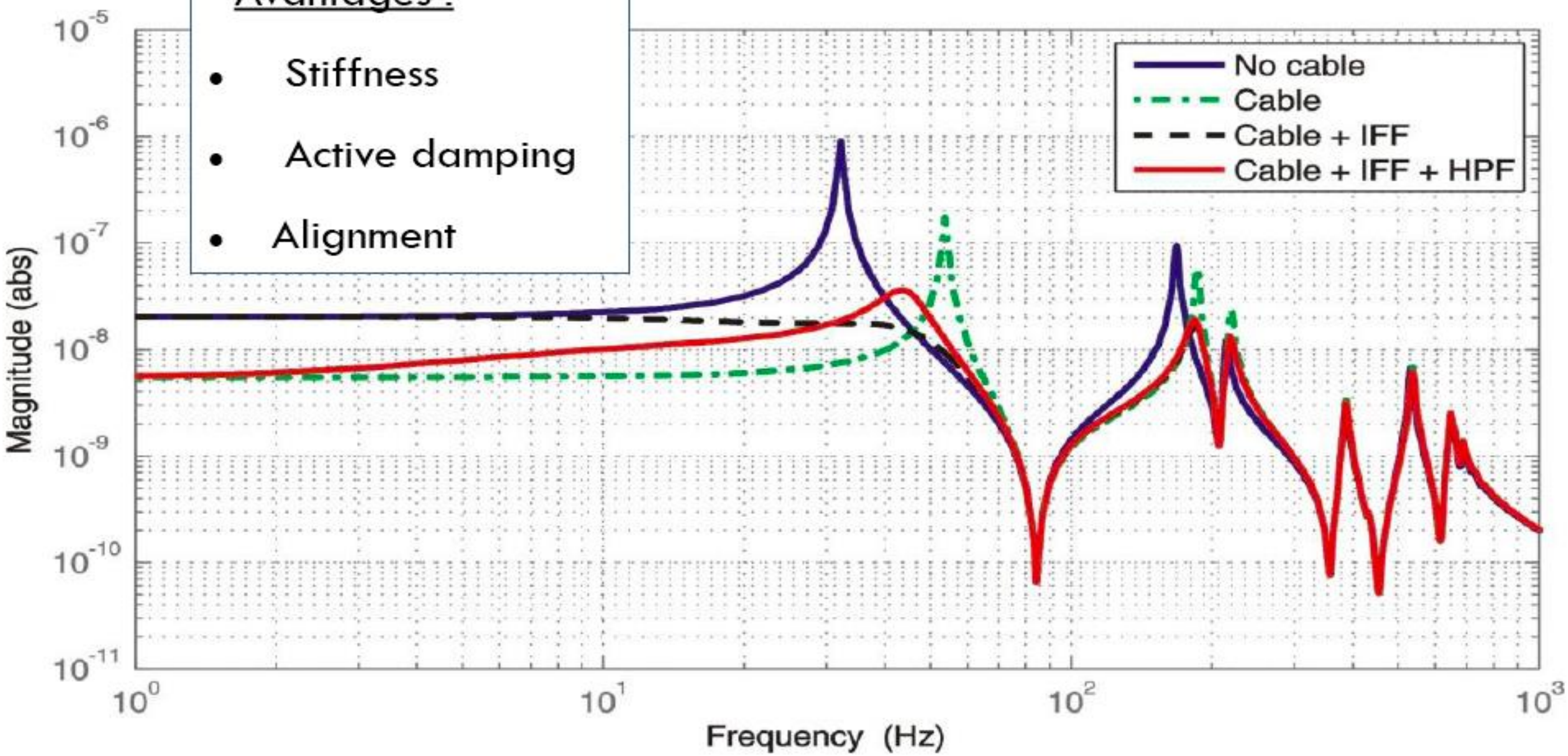
Resonances frequencies multiplied by 2

Q: Where to fix the cables?

Numerical results

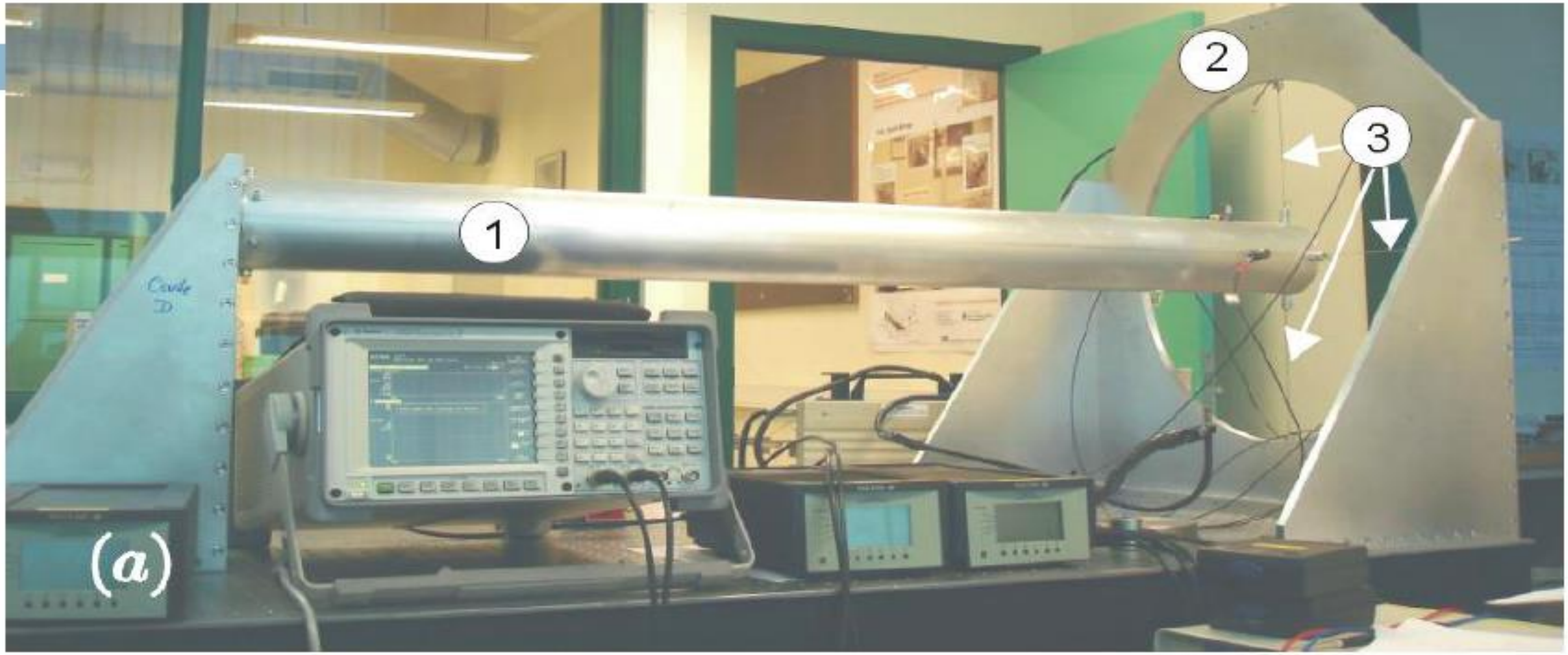
Avantages :

- Stiffness
- Active damping
- Alignment

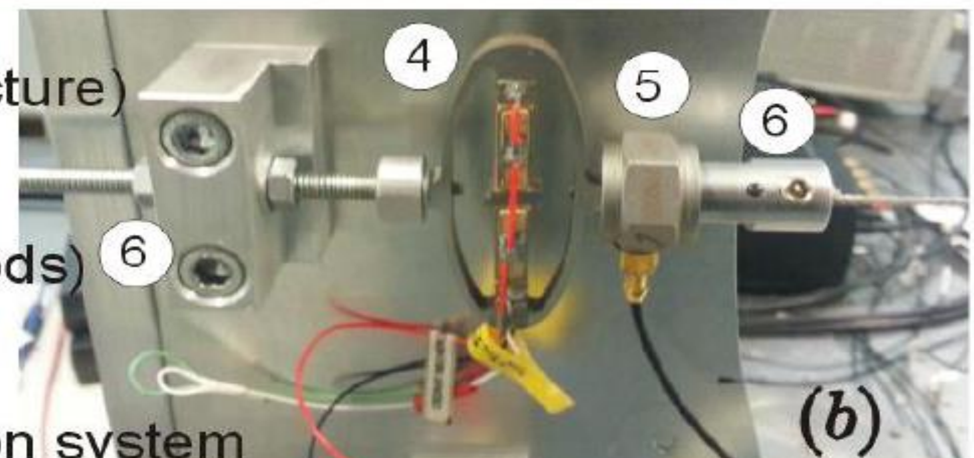


Small-scale mock-up in Brussels:

Experimental set-up



1. Cantilevered tube (corresp. to flexible structure)
2. Rigid frame
3. Carbon cables (corresp. to carbon tie rods)
4. Piezoelectric actuator
5. Force sensor
6. Dedicated fixation/tension system



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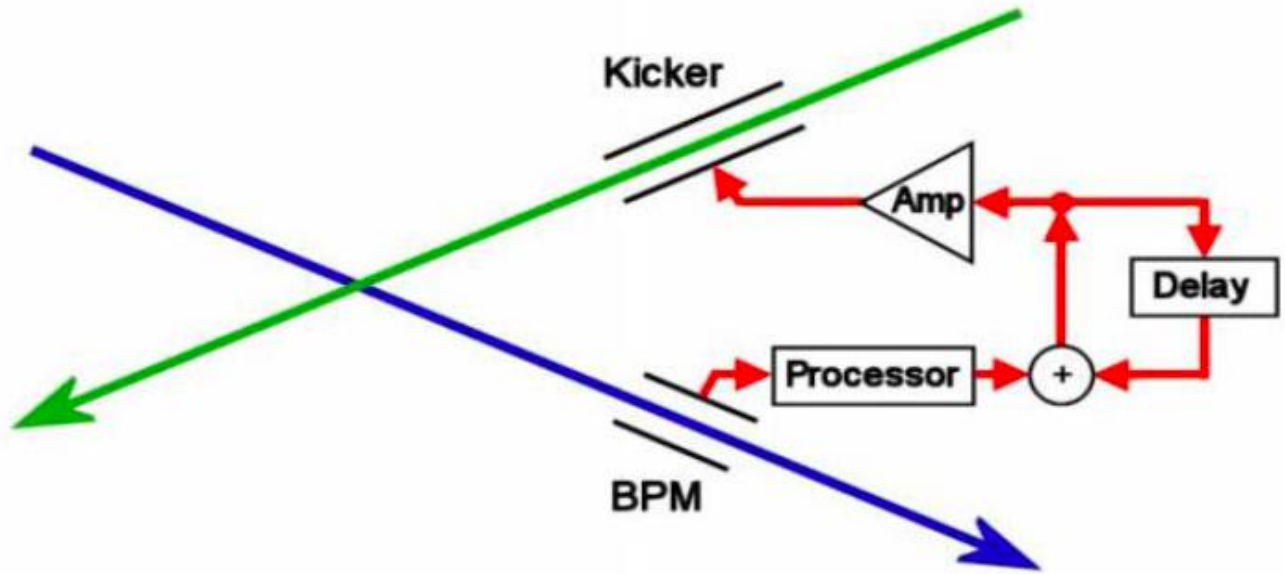
LC intra-train feedback system - concept

- Last line of defence against relative beam misalignment
- Measure vertical position of outgoing beam and hence beam-beam kick angle
- Use fast amplifier and kicker to correct vertical position of beam incoming to IR



FONT – Feedback On Nanosecond Timescales

IP FB Design Status: CLIC

Conceptual design developed and documented in CLIC CDR (2011)

NB primary method for control of beam collision overlap is via vibration isolation of the FF magnets, and dynamic correction of residual component motions

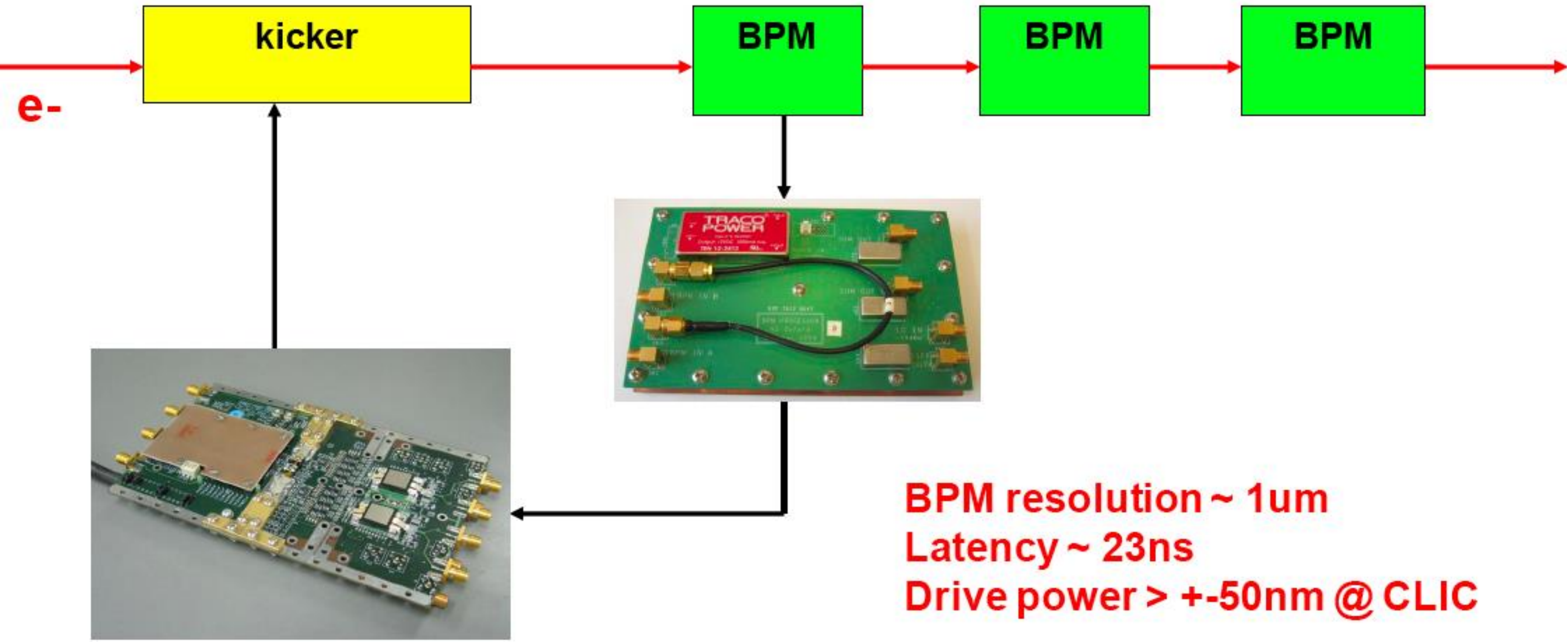
IP position feedback:

allows IP beam position correction of +- 50 nm of vertical beam motion,

and possibility to correct within bunchtrain duration

More realistic engineering design can be developed in next project phase

CLIC prototype: FONT3 at KEK/ATF



BPM resolution ~ 1um
Latency ~ 23ns
Drive power > +-50nm @ CLIC

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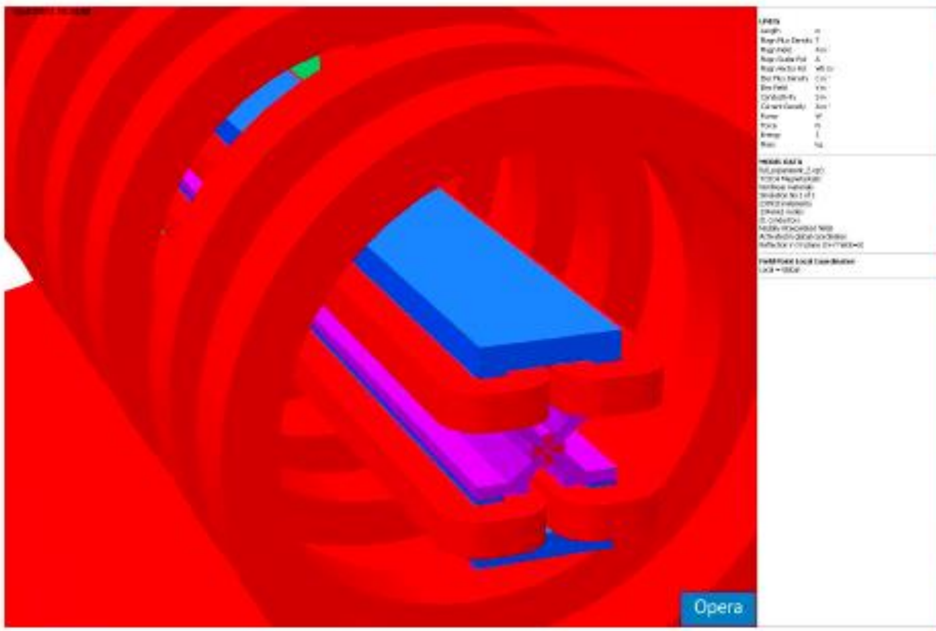
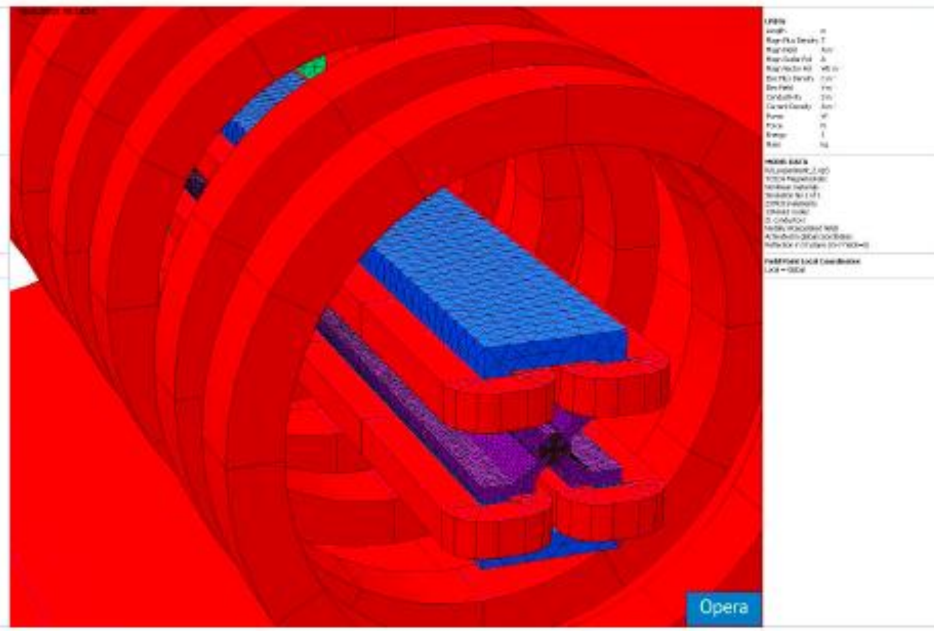
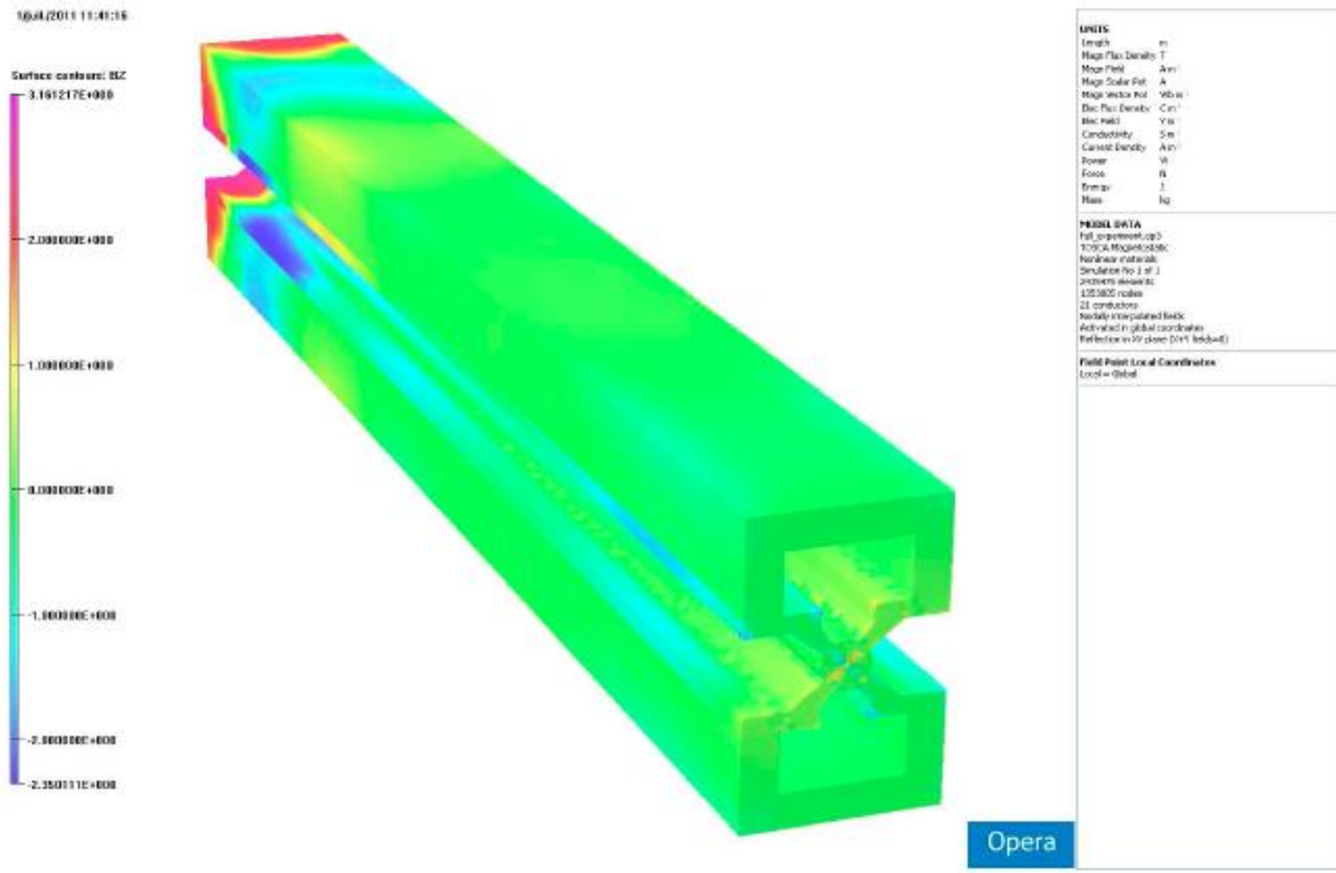
The 3D model, a zoom in the QD0 region





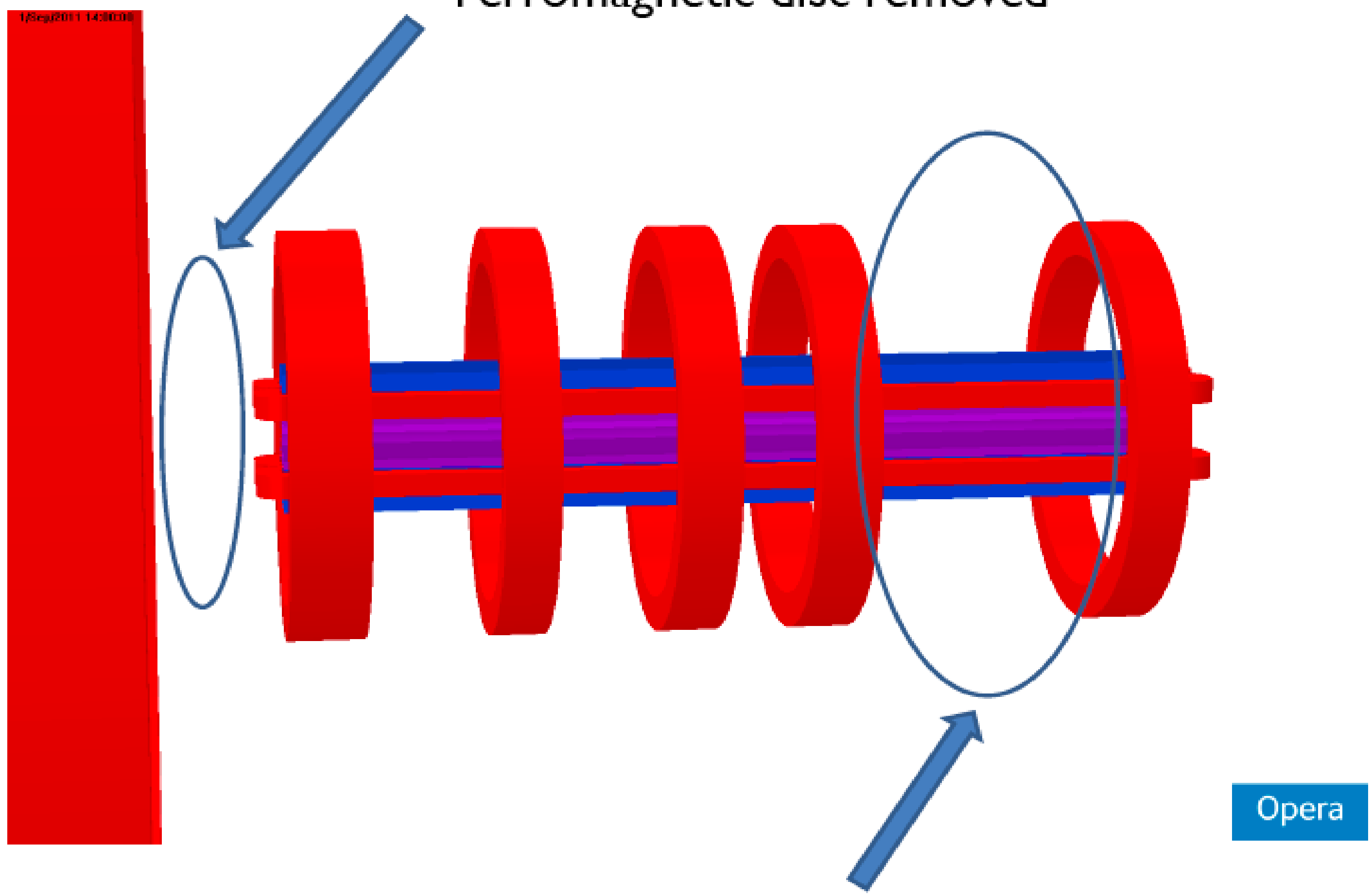
Residual field (BZ) inside QD0



Excellent performance of anti-solenoid,
still some issues at the QD0 extremity

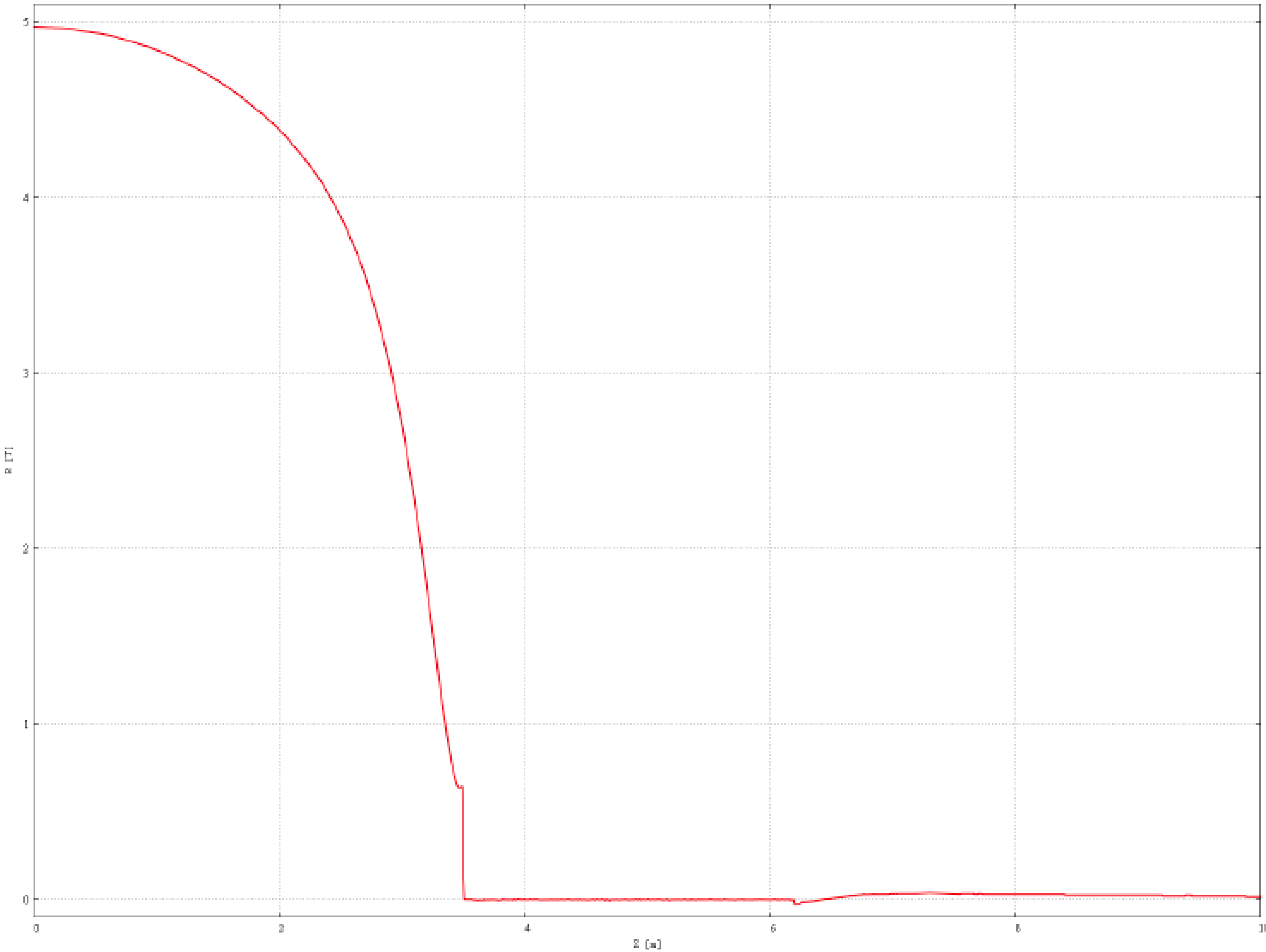
Main improvements

Ferromagnetic disc removed



One coil removed (now 5 coils in total)

Field maps – BZ



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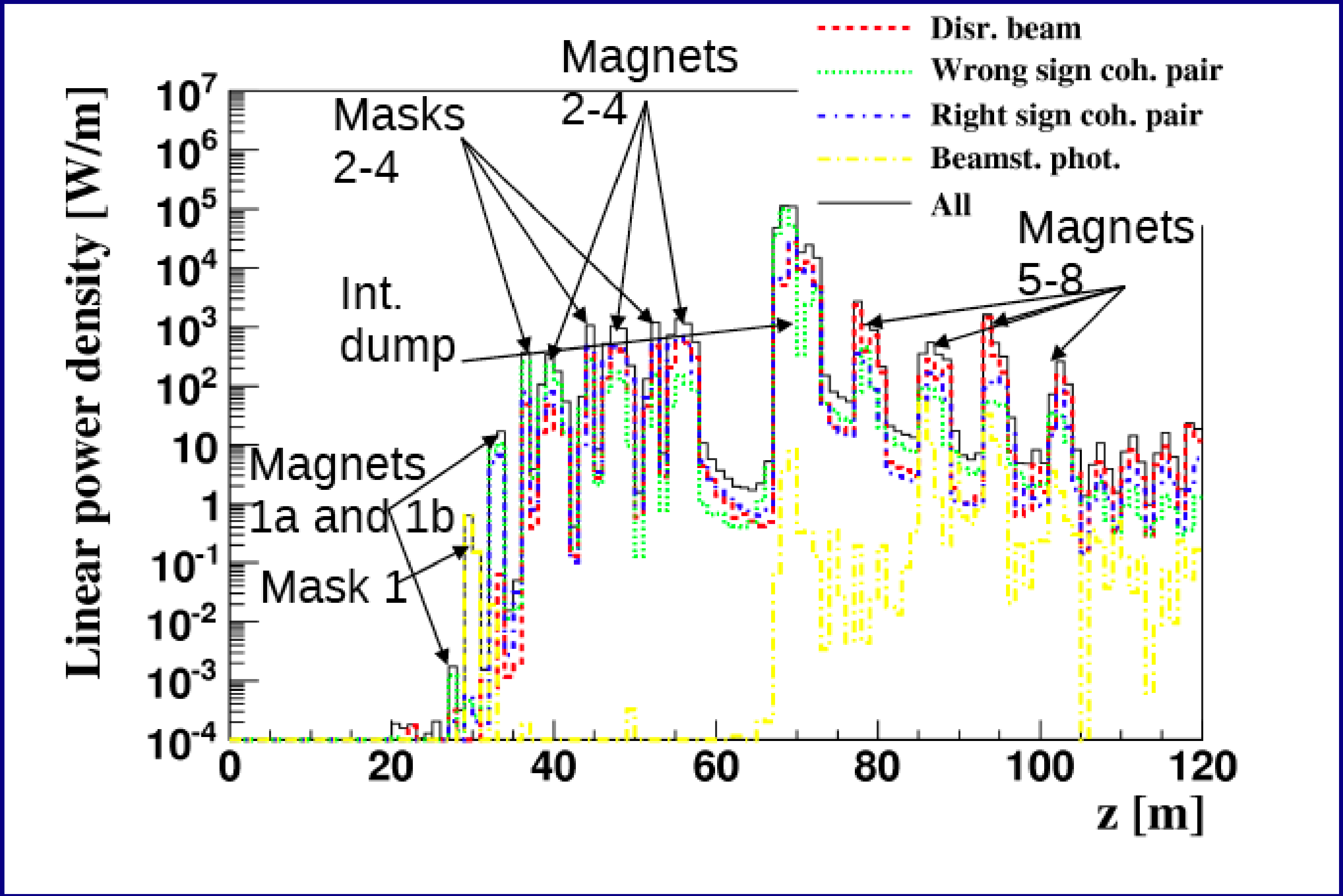
Energy deposition in beamline components



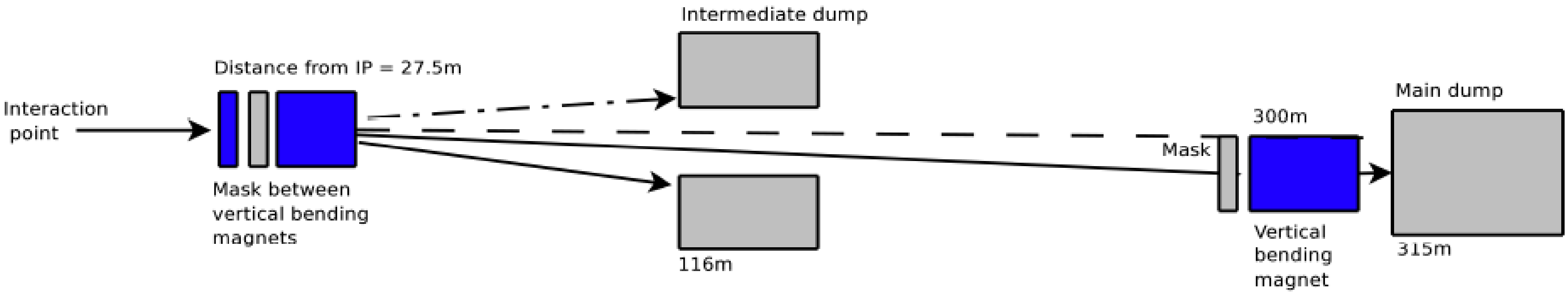
- **IPAC 11, TUPC023**
- As much energy lost in magnets as in masks
- For energy loss in ***coils*** of magnets 5-8, wrong sign coherents dominate.

Magnet lifetime

- **[TUPC028 IPAC 2011]**, V1 is the original post-collision line, V2 is the changed version with iron masks and 2m longer intermediate dump.

Component	Rate of E. dep. In coils [W] – v1	Rate of E. dep. In coils [W] – v2	Volume of coils [cm3]	Mass of coils [kg]	Lifetime [year] – v1	Lifetime [year] – v2
1a + 1b	0.37	4.57	327152	2931.28	2525.47	203.18
2	250.78	39.57	503936	4515.27	5.71	36.16
3	1338.49	216.88	579120	5188.92	1.23	7.58
4	1739.05	256.71	755904	6772.9	1.23	8.36
5	229.63	102.16	921600	8257.54	11.4	25.61
6	207.84	133.28	921600	8257.54	12.59	19.63
7	137.01	79.03	921600	8257.54	19.1	33.11
8	15.37	11.28	921600	8257.54	170.26	232.02

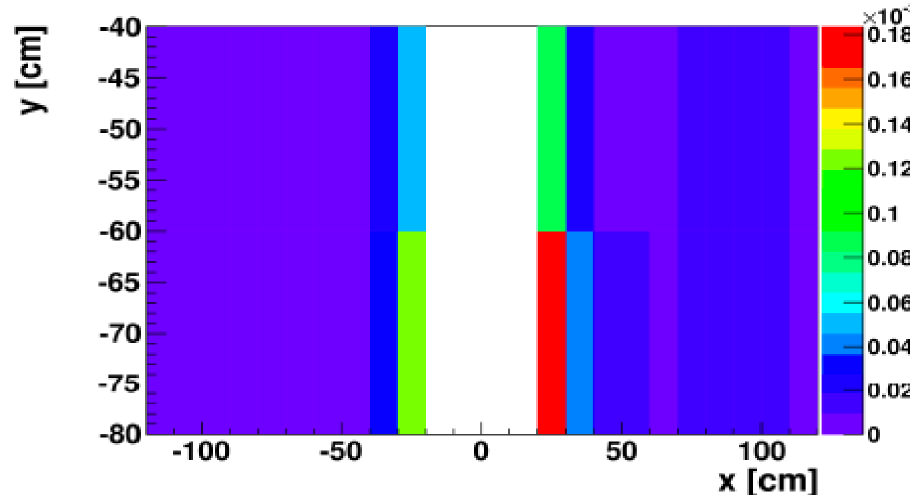
New layout

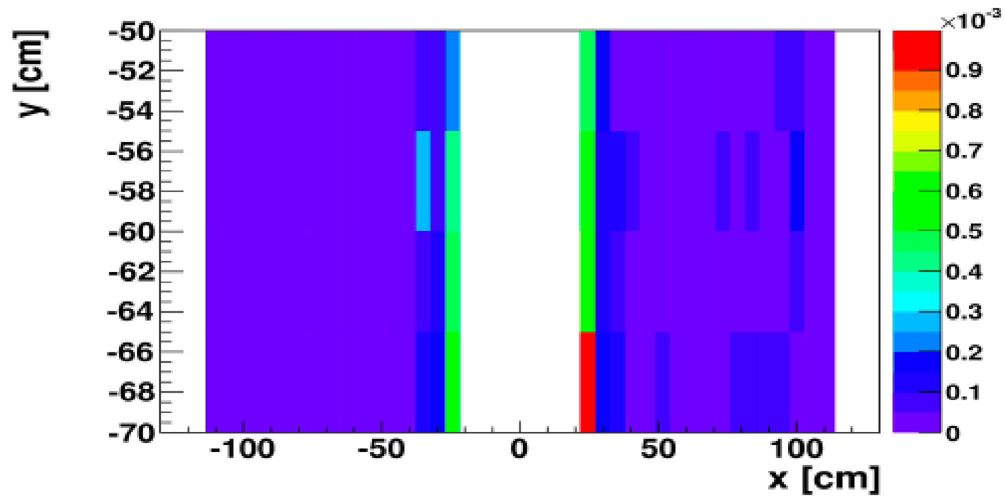


- Fewer magnets
- Downstream magnet further from intermediate dump
  - Less radiation damage
- Mask in front of last bending magnet coils

Magnet lifetime study - new PCL

- New results
    - *Right:* energy dep. In magnet coil insulation material [W/cm²]
  - *Top right:* 1 litre voxels, magnet lifetime is 68000 +/- 7000
  - *Bottom right:* 125 cm³ voxels lifetime 900 +/- 100 years





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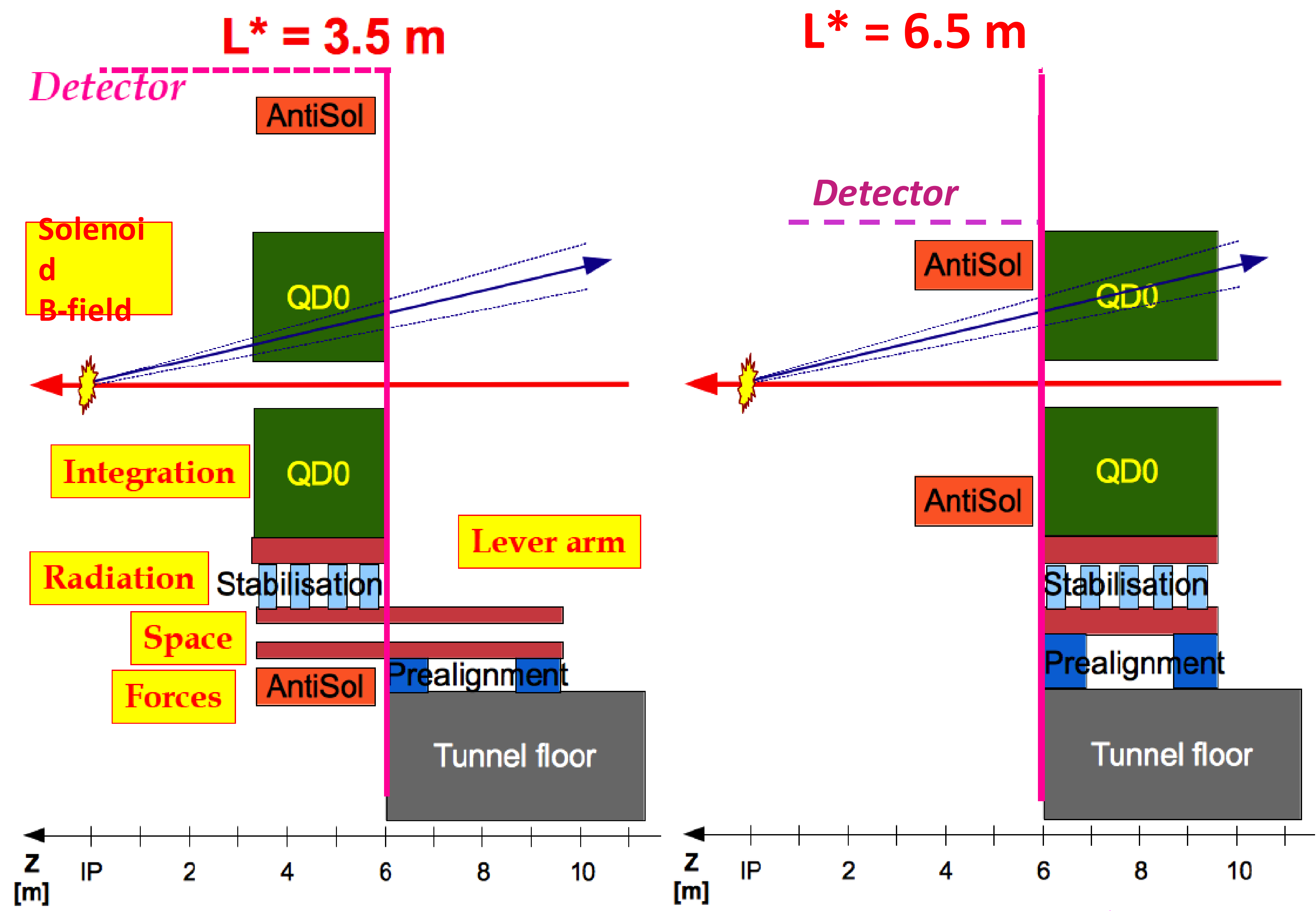
L* = 3.5 m
Detector
AntiSol
Solenoid B-field
QD0
QD0
Integration
Lever arm
Radiation
Stabilisation
Space
AntiSol
Prealignment
Forces
Tunnel floor
Z [m]
IP
2
4
6
8
10
L* = 6.5 m
Detector
AntiSol
QD0
AntiSol
QD0
Stabilisation
Prealignment
Tunnel floor
Z [m]
IP
2
4
6
8
10

So the questions are

- How much luminosity does one loose (on paper)?
- How much acceptance can one gain (on paper)?
- How serious is the luminosity loss with respect to the difficulties to keep it stable inside the detector environment, i.e. are there effective luminosity losses due to such issues for the short L* ?
- What is the net balance between luminosity and acceptance in terms of the physics reach?

This will soon be addressed

RECENT IDEAS

Following discussions in the Hamburg LC2013 workshop, stronger collaboration between the BDS and MDI groups for CLIC and ILC is encouraged.

Recently a first phone meeting took place to initiate this. Most of the projects concern BDS rather than MDI. The MDI is rather different for CLIC.

However, there is an interest to study a possible use of the **CLIC QD0 hybrid technology** for the ILC case. Discussions are starting to organise this study, starting asap.

MDI members and contributors

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Guillermo Zamudio Ascensio, Jerome Axensalva, Antonio Bartalesi,Marco Battaglia,
Gerjan Bobbink, Enrico Bravin, Laurent Brunetti, Helmut Burkhardt, Phil Burrows,
Francois Butin, Christophe Collette, Barbara Dalena, Fernando Duarte Ramos,
Lawrence Deacon, Konrad Elsener, Arnaud Ferrari, Andrea Gaddi, Mark A. Gallilee,
Martin Gastal, Lau Gatignon, Hubert Gerwig, Christian Glenn, Harry van der Graaf,
Christian Grefe, Edda Gschwendtner, Michel Guinchard, Alain Hervé,
Andréa Jérémie, Michel Jonker, YoungIm Kim, Andrea Latina, Thibaut Lefèvre,
Yngve Levinsen, Lucie Linssen, Helène Mainaud Durand, Sophie Mallows,
Dirk Mergelkuhl, Michele Modena, John Osborne, Thomas Otto, Colin Perry,
Javier Resta Lopez, Giovanni Rumolo, André Philippe Sailer, Hermann Schmickler,
Daniel Schulte, Jochem Snuverink, Markus Sylte, Rogelio Tomàs Garcia,
Davide Tommasini, Raymond Veness, Joachim Vollaire, Alexey Vorozhtsov,
Volker Ziemann, Franck Zimmermann