Warm magnet projects

Michele Modena, TE-MSC

Outline:

- Quick overview on studies and procurements done up to now

- Activities and procurements on-going

- Future activities

Overview of activities and procurements done in the past years:

- CLIC Magnet Catalogue:
  - 5 CLIC Notes released, evaluating (1st dimensioning & cost) the magnet system for CLIC 3TeV layout.

- *CLIC Magnet Catalogue:*

(Ref: CLIC Notes: 863-864-865-873-984)

1) **CLIC Drive Beam complex** (turnaround, delay line, combiners rings, TL, etc.) :
12096 magnets in total; divided in **14** types with population from **32** to **1872** units.

2) **CLIC Main Beams Transport** :
2291 magnets in total; divided in **17** types with population from **1** to **250** units.

3) **CLIC Damping Rings** :
4076 magnets in total; divided in **11** types with population from **76** to **1004** units.

4) CLIC Post-Collision line :
18 magnets in total; divided in **5** types with population from **2** to **8** units.

5) **CLIC Beam Delivery System** :
400 magnets in total; divided in **70** types with population from **1** to **96** units.

Treated independently:

- CLIC **DBQ** (EM or PM design): (**41848** magnets)
- CLIC **MBQ**: (**4274** magnets) and **steering correctors**
- MDI Magnets: (**QD0** and **SD0**)
- **SC wigglers** of DR (next presentation)

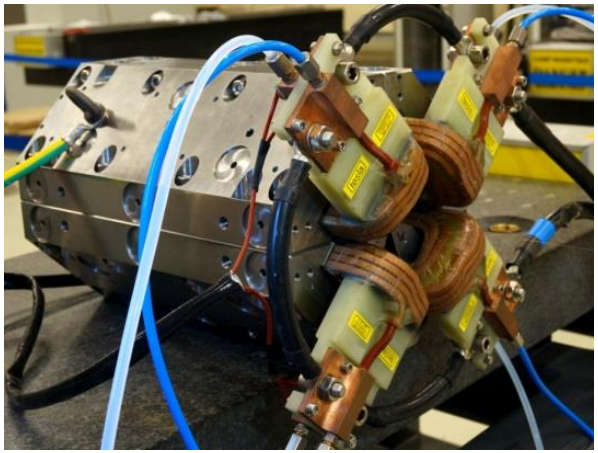
Overview of activities and procurements done in the past years:

- CLIC Magnet Catalogue:
  - 5 CLIC Notes released, analysing (1st dimensioning & cost) the magnet system for CLIC 3TeV layout. ***(Ref: CLIC Notes: 863-864-865-873-984)***

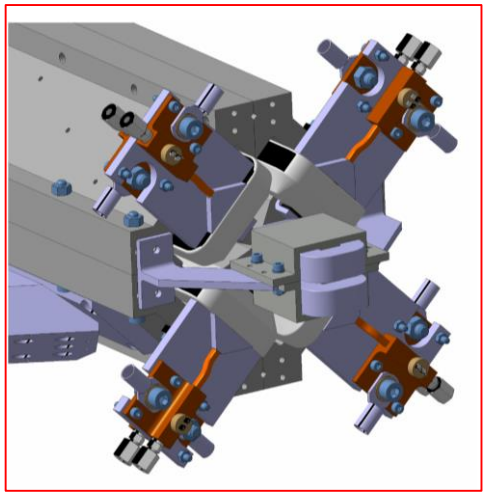
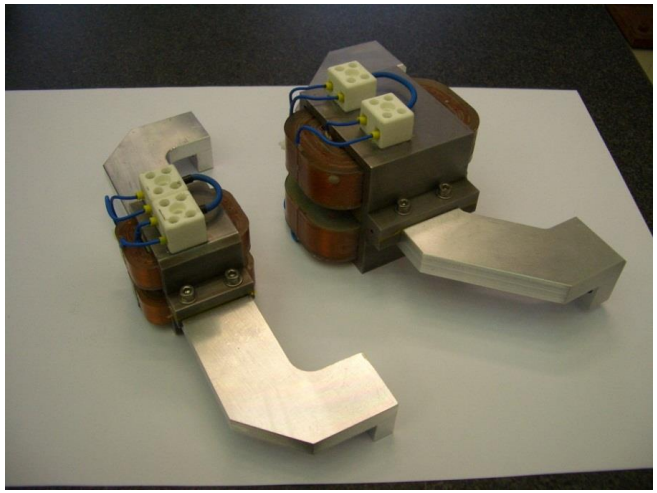
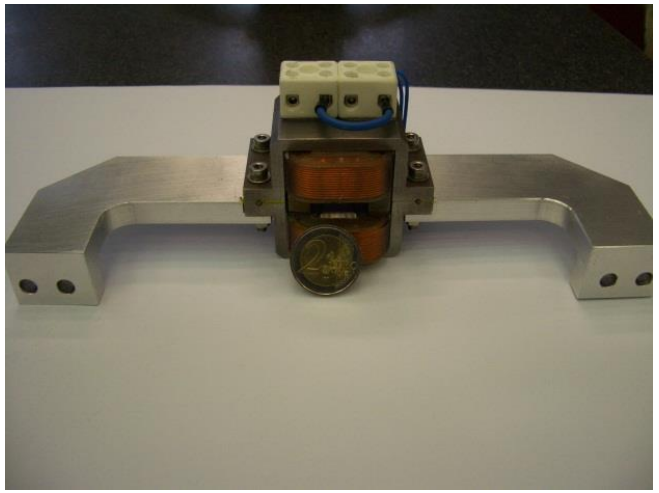
- Main Beam Magnet prototypes procurement and studies:
  - 3 MBQ Type1 and 1 MBQ Type4
  - 2 Steering correctors (for Type1 and Type4)
  - Study on ultra-precise quadrants assembly.

- *Main Beam Magnet procurement and studies*

MBQ: 4142 magnets (308 TYPE1, 1276 TYPE2, 964 TYPE3, 1594 TYPE4):

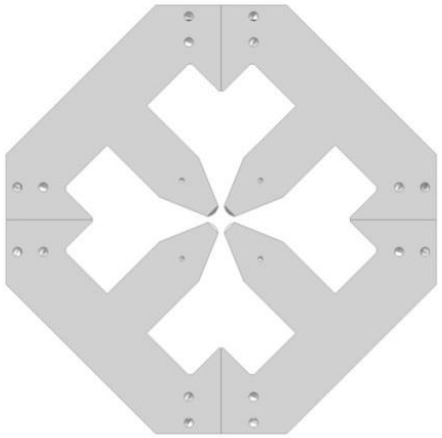




MBQ: Steering dipole correctors:

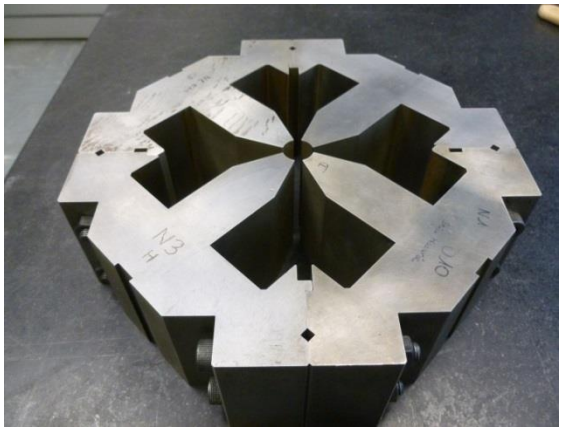




- *Main Beam Magnet procurement and studies*

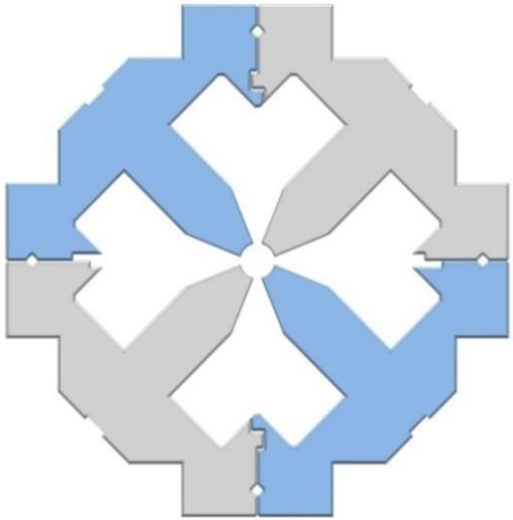
Studies to determine the best quadrants assembly cinematic were done with “smart” test pieces *(see Ref.)*

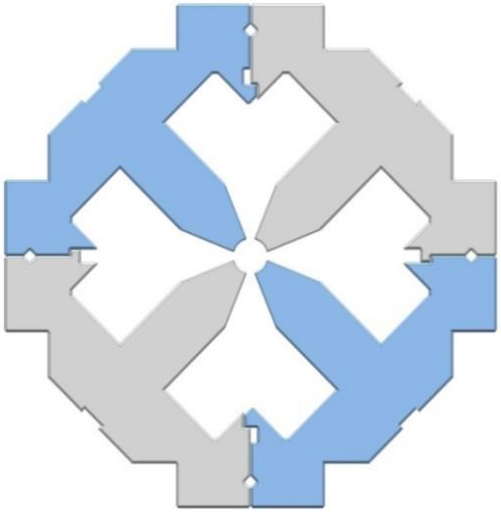


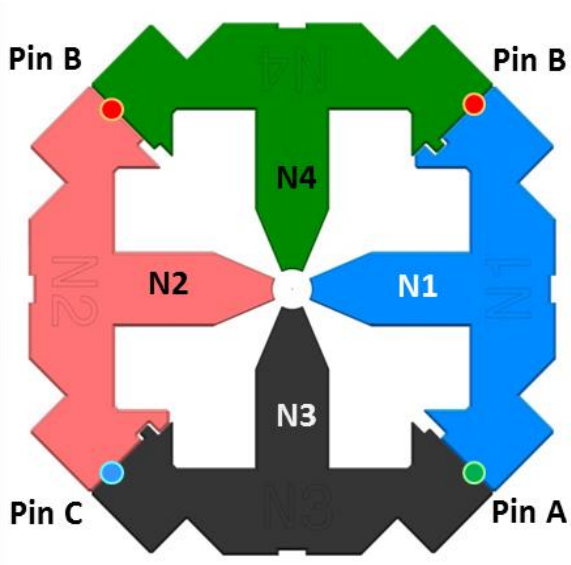
“Ad hoc” pieces (produced by EDM), permit to study different assembly methods.



Best cilindricity achieved ~13 µm (in comparison to ~74 µm also utilized for the real prototype assembly)







(Ref: IEEE Transactions on Applied Superconductivity, Vol. 24, No. 3, June 2014, 9001304)

Overview of activities and procurements done in the past years:

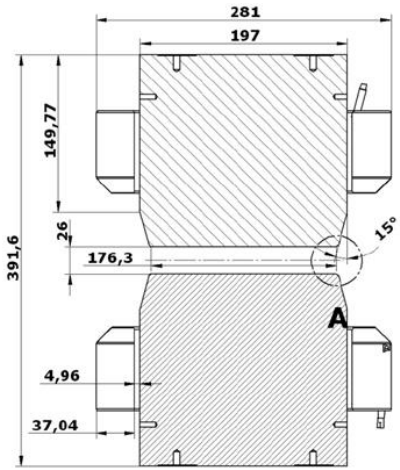
- CLIC Magnet Catalogue:
  - 5 CLIC Notes released, analysing (1st dimensioning & cost) the magnet system for CLIC 3TeV layout.

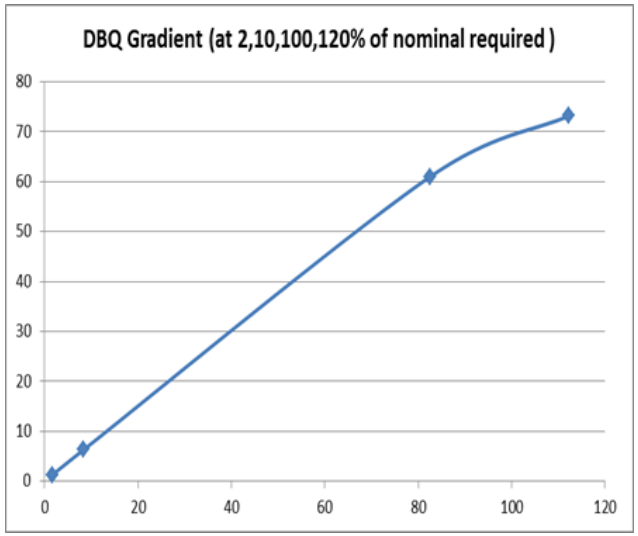
- Main Beam Magnet prototypes procurement and studies:
  - 3 MBQ Type1 and 1 MBQ Type4
  - 2 Steering correctors (for Type1 and Type4)
  - Study on ultra-precise quadrants assembly.

- Drive Beam Magnet procurement:
  - 8 DBQ (electromagnetic version)
  - 2 DBQ (permanent magnet version, Daresbury design and procurement).

- *Drive Beam Magnet procurement and studies*

8 EM DBQ prototypes

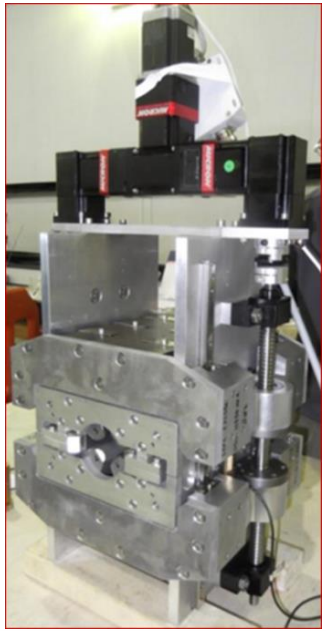


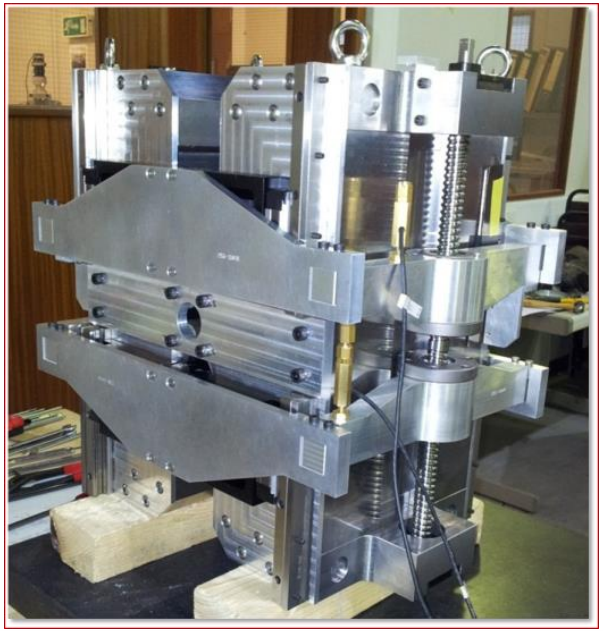


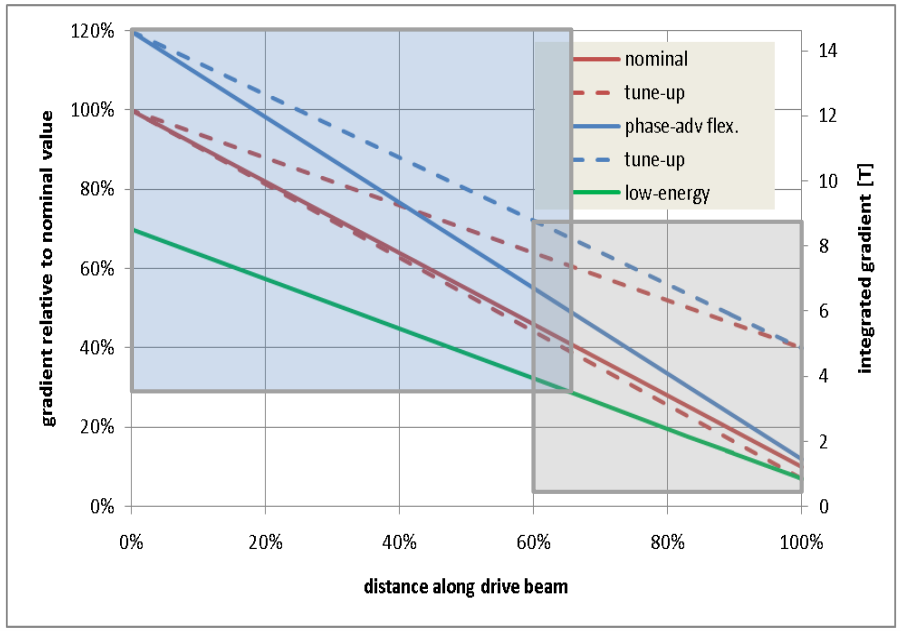
ZEPTO *(Zero-Power Tunable Optics)* Quad1 and Quad2 *(Daresbury Lab procurement)*

Ref: CLIC Note 940)

2 PM DBQ prototypes







Overview of activities and procurements done in the past years:

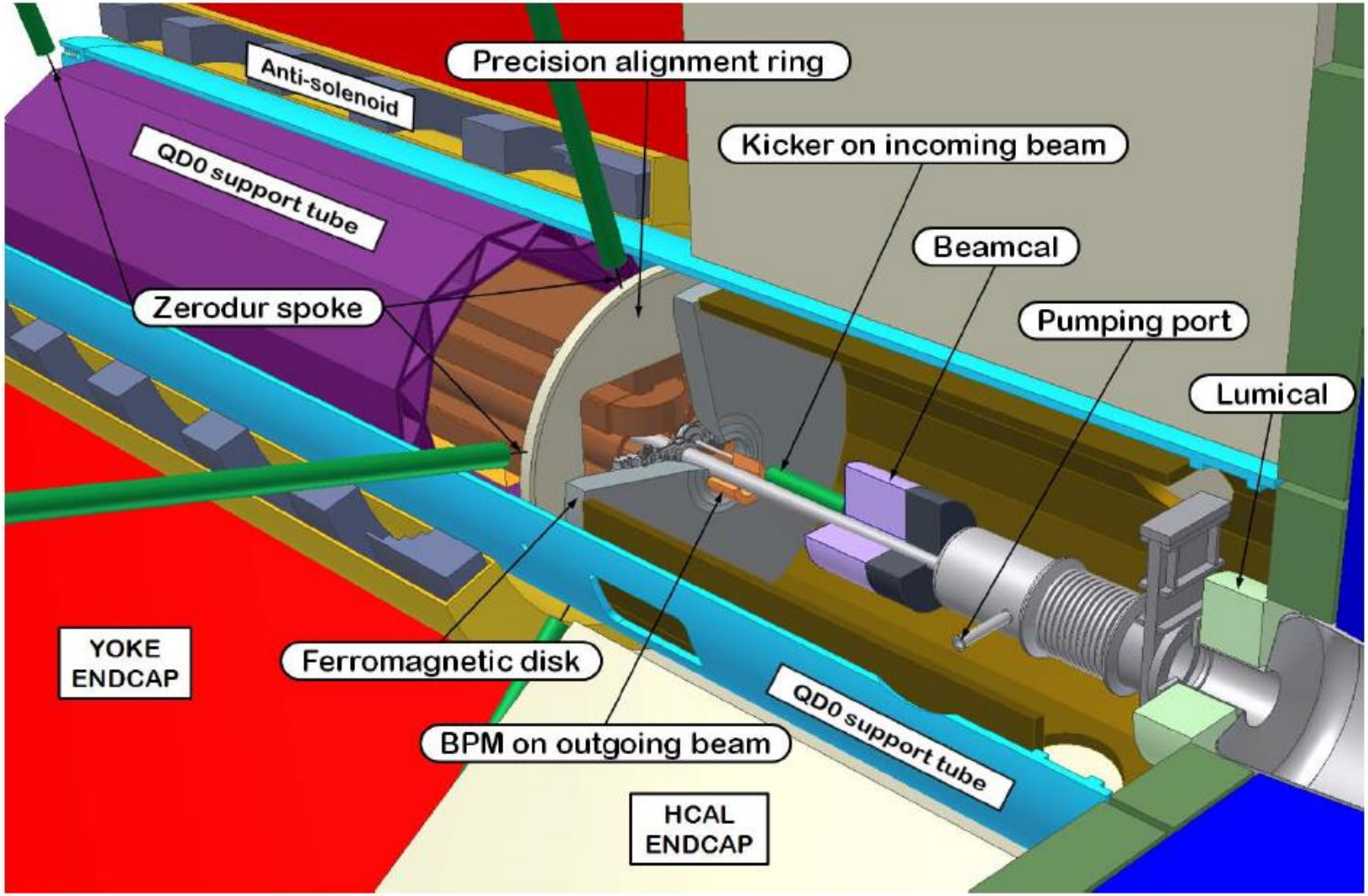
- CLIC Magnet Catalogue:
  - 5 CLIC Notes released, analysing (1st dimensioning & cost) the magnet system for CLIC 3TeV layout.

- Main Beam Magnet prototypes procurement and studies:
  - 3 MBQ Type1 and 1MBQ Type4
  - 2 Steering correctors (for Type1 and Type4)
  - Study on ultra-precise quadrants assembly.

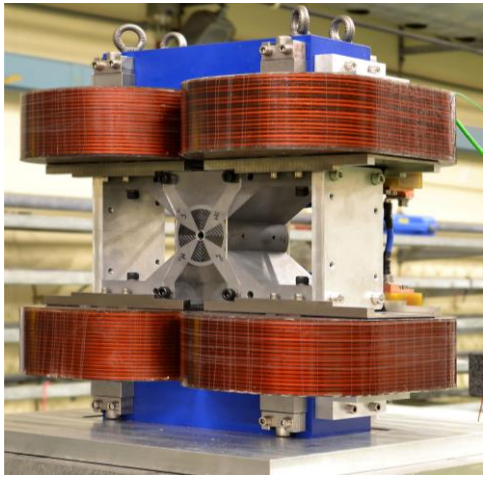
- Drive Beam Magnet procurement:
  - 8 DBQ (electromagnetic version)
  - 2 DBQ (permanent magnet version, Daresbury design and procurement).

- MDI/BDS procurement and studies:
  - QD0 hybrid magnet
  - Study for the SiD antisolenoid system.

CLIC 3 TeV, L = 3.5 m Machine Detector Interface (MDI) simplified layout:*

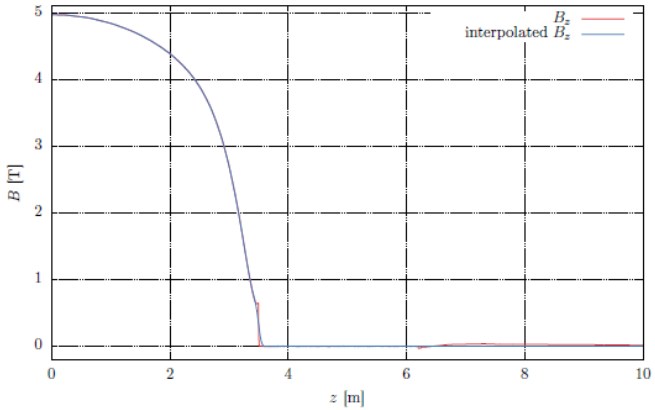


MDI/BDS procurement and studies:

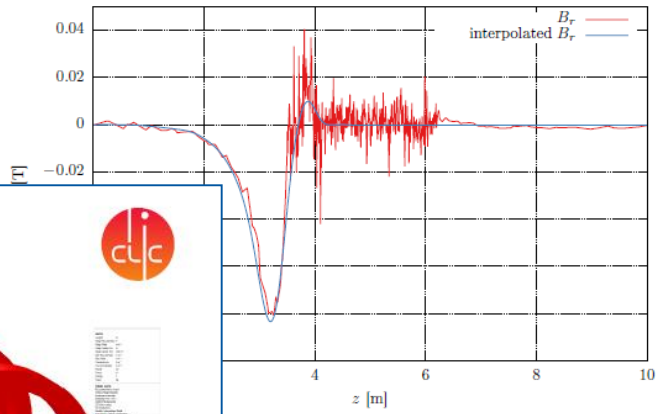


QD0 hybrid magnet prototype:

TE Technology Department



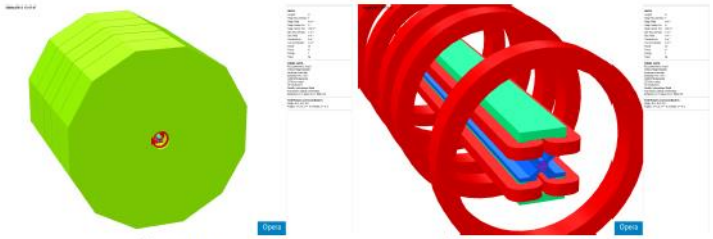
(a) Axial magnetic field from the IP to 10 m away.



al magnetic field from the IP to 10 m away.

terpolated field on the beam line, second Opera3D™ des

TE Technology Department



(a) Detector. (b) QD0 and anti-solenoid.

Figure 16: An overview of the Opera3D™ model.

TE Technology Department

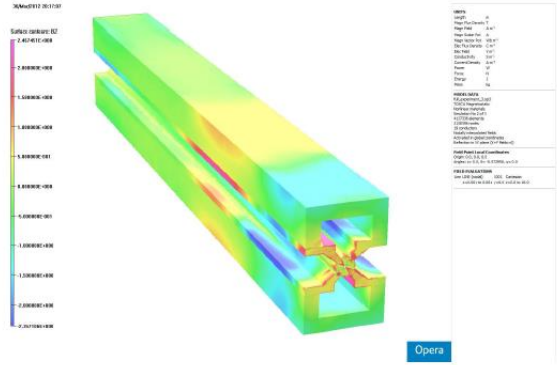


Figure 21: The axial field attracted by QD0, second Opera3D™ anti-solenoid design.

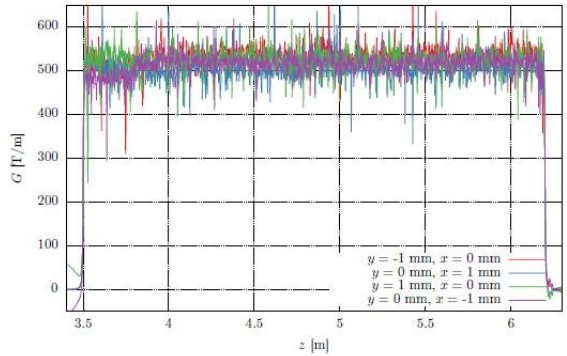


Figure 22: QD0 gradient, second Opera3D™ design.

28

(Ref: CLIC Note 944)

Overview of activities and procurements done in the past years:

- CLIC Magnet Catalogue:
  - 5 CLIC Notes released, analysing (1st dimensioning & cost) the magnet system for CLIC 3TeV layout.

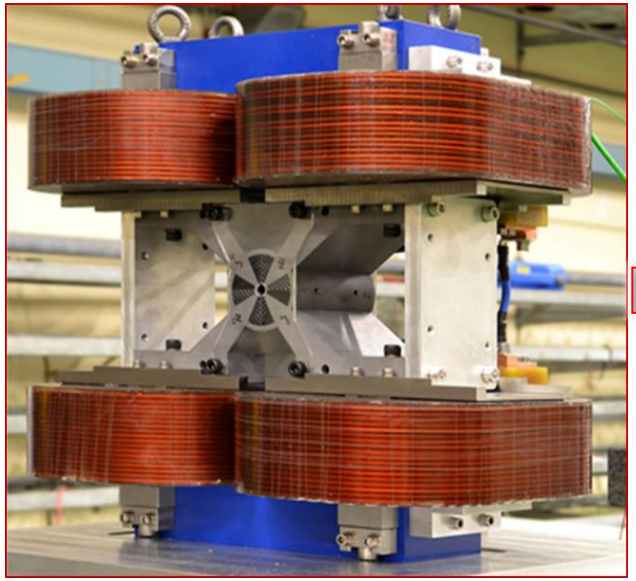
- Main Beam Magnet prototypes procurement and study:
  - 3 MBQ Type1 and 1MBQ Type4
  - 2 Steering correctors (for Type1 and Type4)
  - Study on ultra-precise quadrants assembly

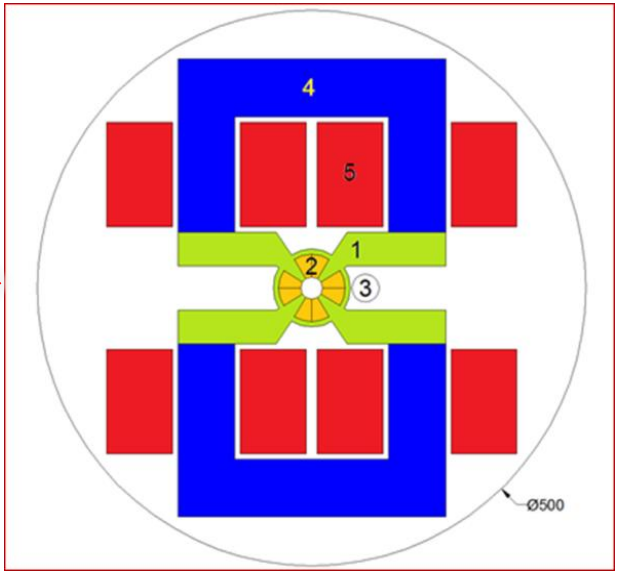
- Drive Beam Magnet procurement:
  - 8 DBQ (electromagnetic version)
  - 2 DBQ (permanent magnet version, Daresbury design and procurement).

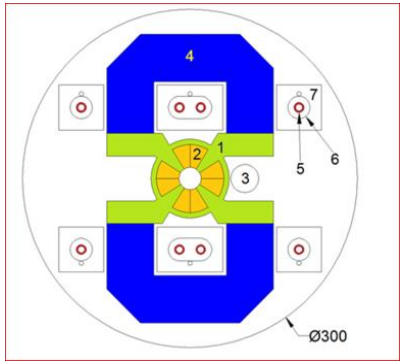
- MDI/BDS procurement and studies:
  - QD0 hybrid magnet
  - Study for the SiD antisolenoid system

- Other:
  - Study for a superferric and hybrid QD0 for ILC (or CLIC).

Possible QD0 design evolution, a super-ferric version:







ILC parameters:

Gradient	127 T/m
Aperture radius	10 mm
Ampere-turns	5 kA

(Ref: Proceedings of IPAC2014, Dresden, Germany (TUPME006)

Outline:

- Quick overview on studies and procurements done up to now

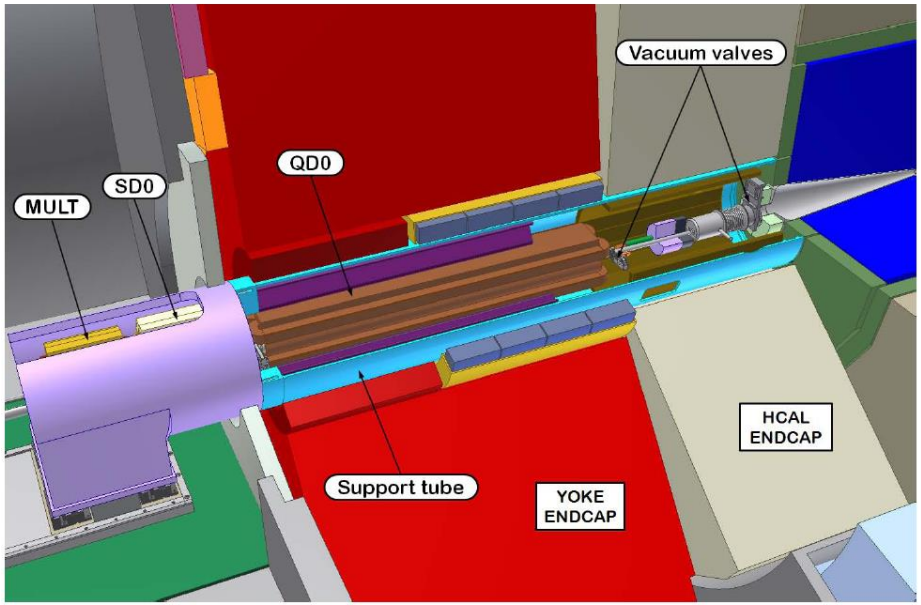
- Activities and procurements on-going

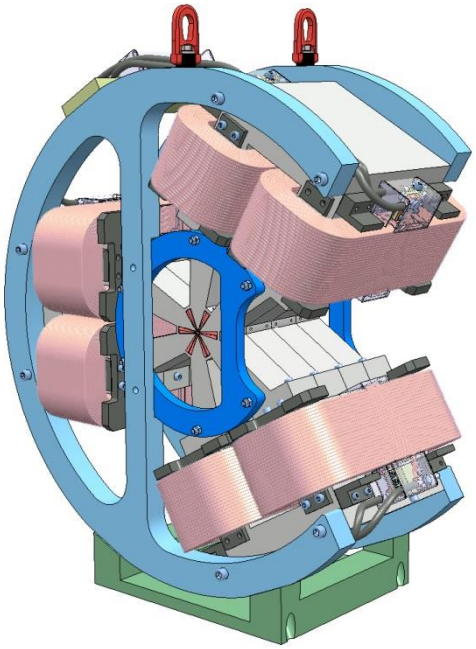
- Future activities

Activities and procurements on-going

- MDI/BDS procurement and studies:
  - SD0 hybrid magnet prototype

SD0 hybrid magnet prototype:



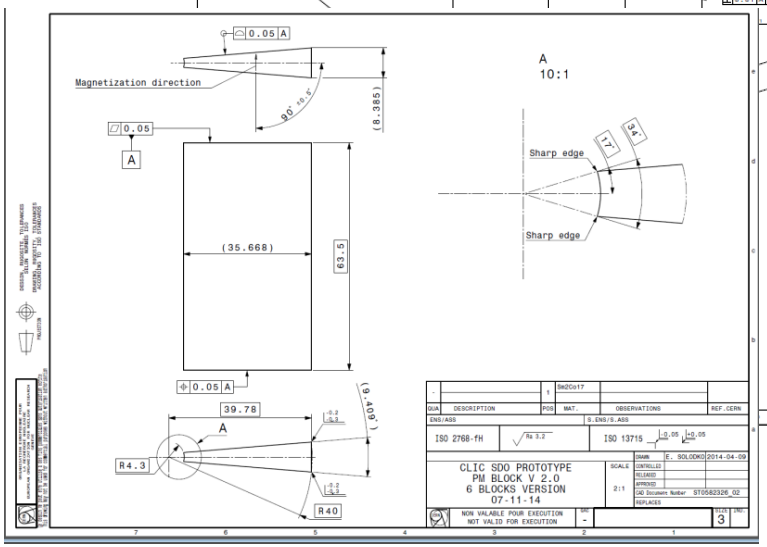


Key aspects:

- Manufacturing (precision) of each Permendur sector, PM block, etc.
- Sorting of PM blocks
- Assembly of the sectors (magnetic forces between blocks, fragility of PM blocks,…)
- Magnetic Measurements (an ad-hoc coils will be developed by a PACMAN PhD student).
- Fiducialisation and alignment

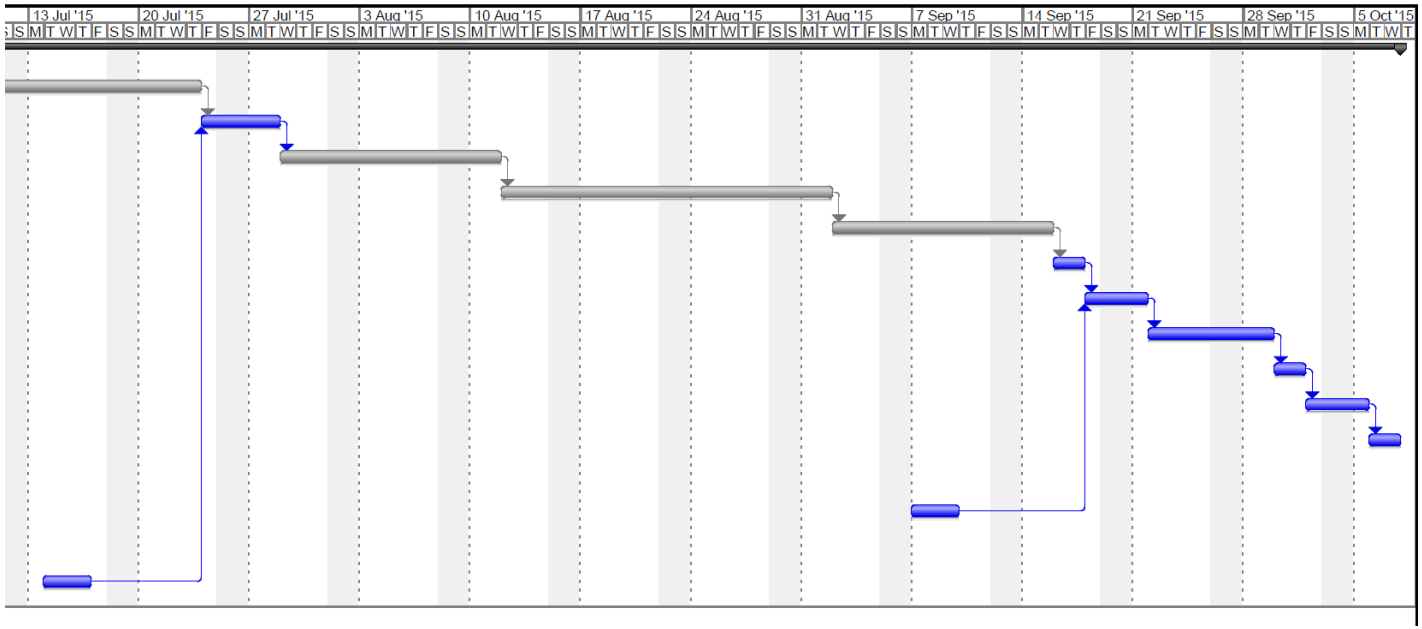
Parameter	Value
Inner radius	4.3 mm
Nom. Sext. Gradient	219403 T/m^2
Magn. Length	0.248 m

SD0 hybrid magnet prototype:



Order for central components placed in March 2015 with VDL (NL)

ID	Task Name
1	**ST0582332 02 (CLIC Center Part)**
2	Material
3	CNC-Milling
4	Annealing
5	Wire EDM
6	Grinding
7	CNC-Milling
8	3D-Measuring
9	Wire EDM
10	3D-Measuring
11	Assemble
12	Transport
13	
14	Programming 3D-Measuring
15	
16	Programming CNC-Milling



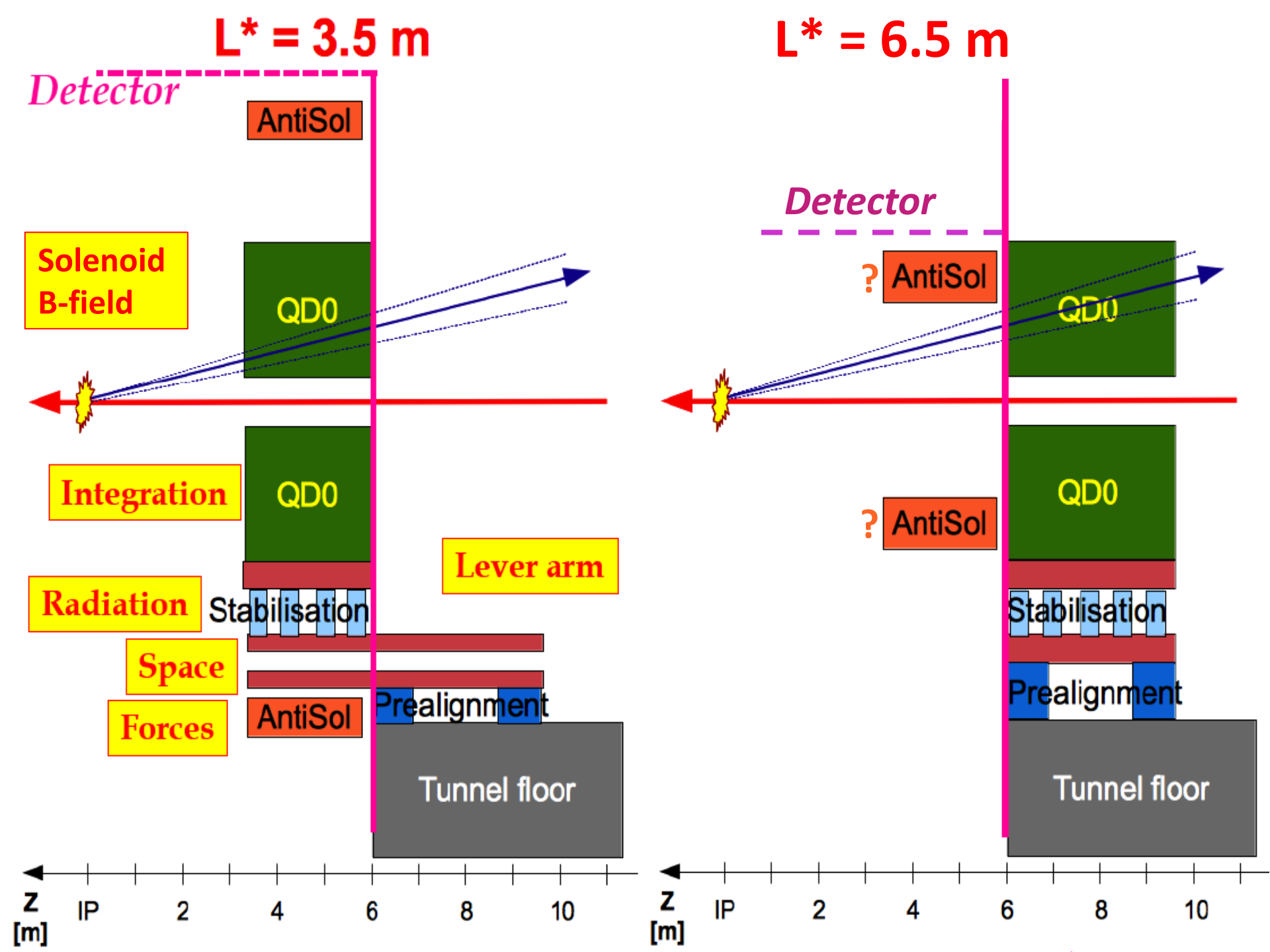
Activities and procurements on-going

- MDI/BDS procurement and studies:
  - SD0 hybrid magnet prototype
  - Study for the SiD antisolenoid system for L* 6 m case

Progress with long L*

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

CERN | YEARS/ANS CERN | EN ENGINEERING DEPARTMENT

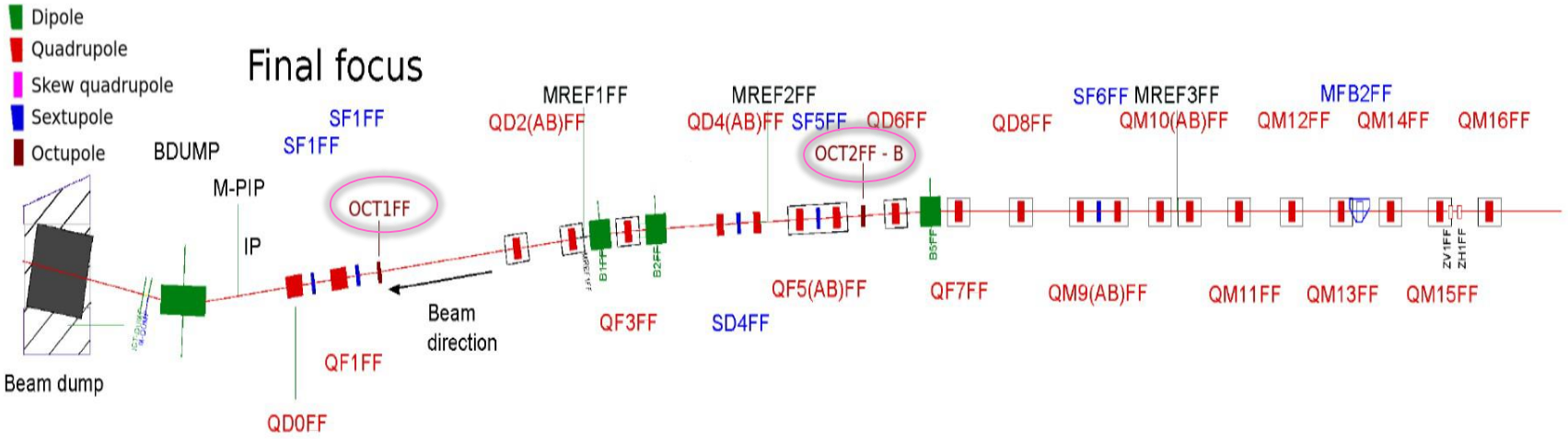

L* = 3.5 m
Detector
AntiSol
Solenoid
B-field
QD0
Integration
QD0
Lever arm
Radiation
Stabilisation
Space
Forces
AntiSol
Prealignment
Tunnel floor
Z
[m]
IP
2
4
6
8
10
L* = 6.5 m
Detector
?
AntiSol
QD0
?
AntiSol
QD0
Stabilisation
Prealignment
Tunnel floor
Z
[m]
IP
2
4
6
8
10

What are the new parameters?

- Need to **fix L***
- What are the **QD0 parameters**?
- Which impact on luminosity and bandwidth?
- Can we simplify the construction and other issues?

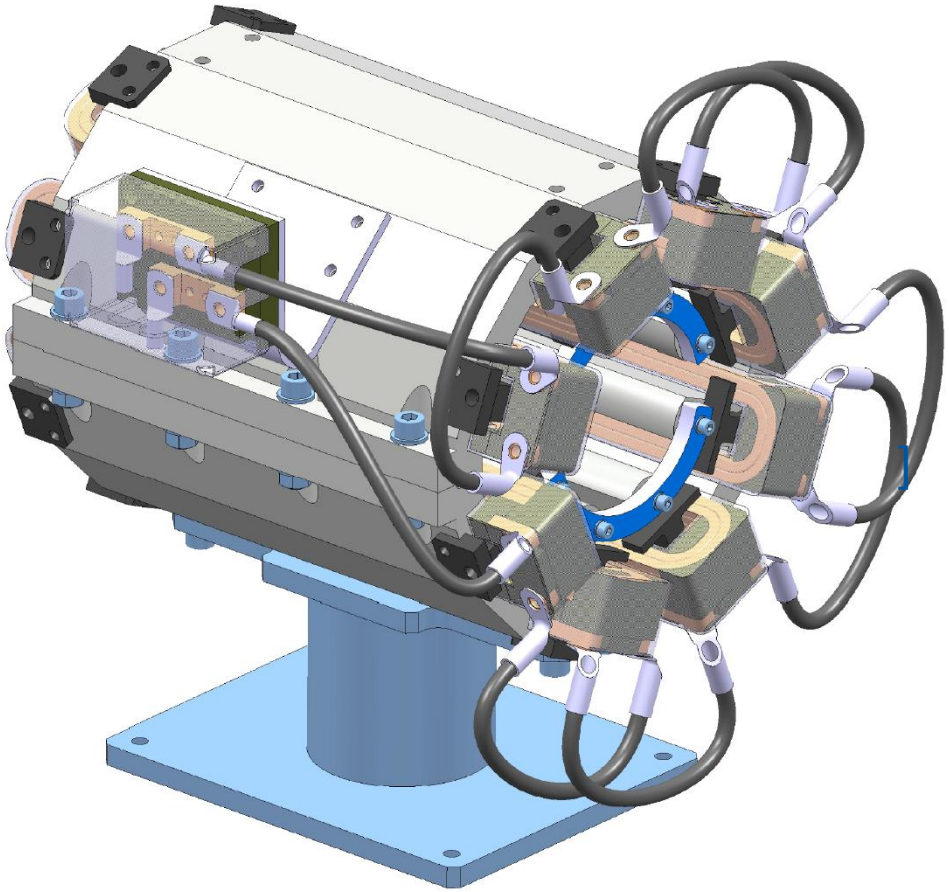
Activities and procurements on-going

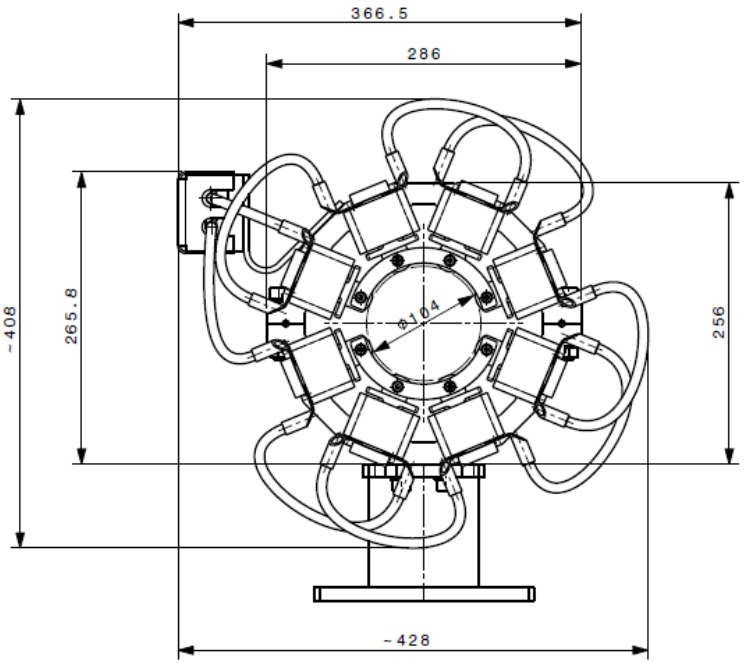
- MDI/BDS procurement and studies:
  - SD0 hybrid magnet prototype
  - Study for the SiD antisolenoid system for L* 6 m case
- Other:
  - Design and procurement of 2 octupole magnets for ATF – KEK (J)

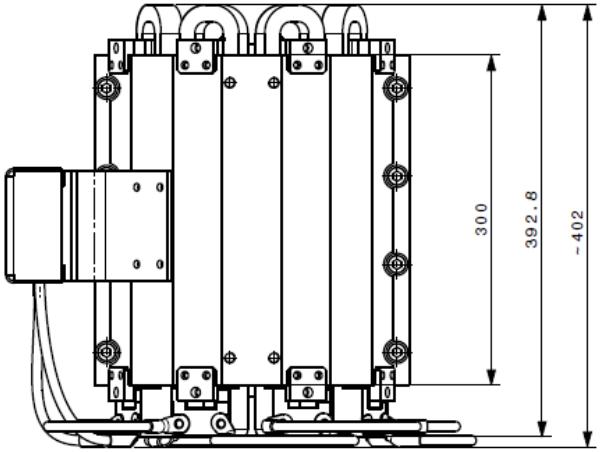


- *OCT1 (S=708 T/m^3) will be place on an micrometric stage for final tuning*
- *OCT2 (S=6820 T/m^3) will be fix (so needing a very precise alignment).*
- *The supports will be responsibility of KEK colleagues.*
- *Fiducialization and alignment shared responsibility (under discussion)*

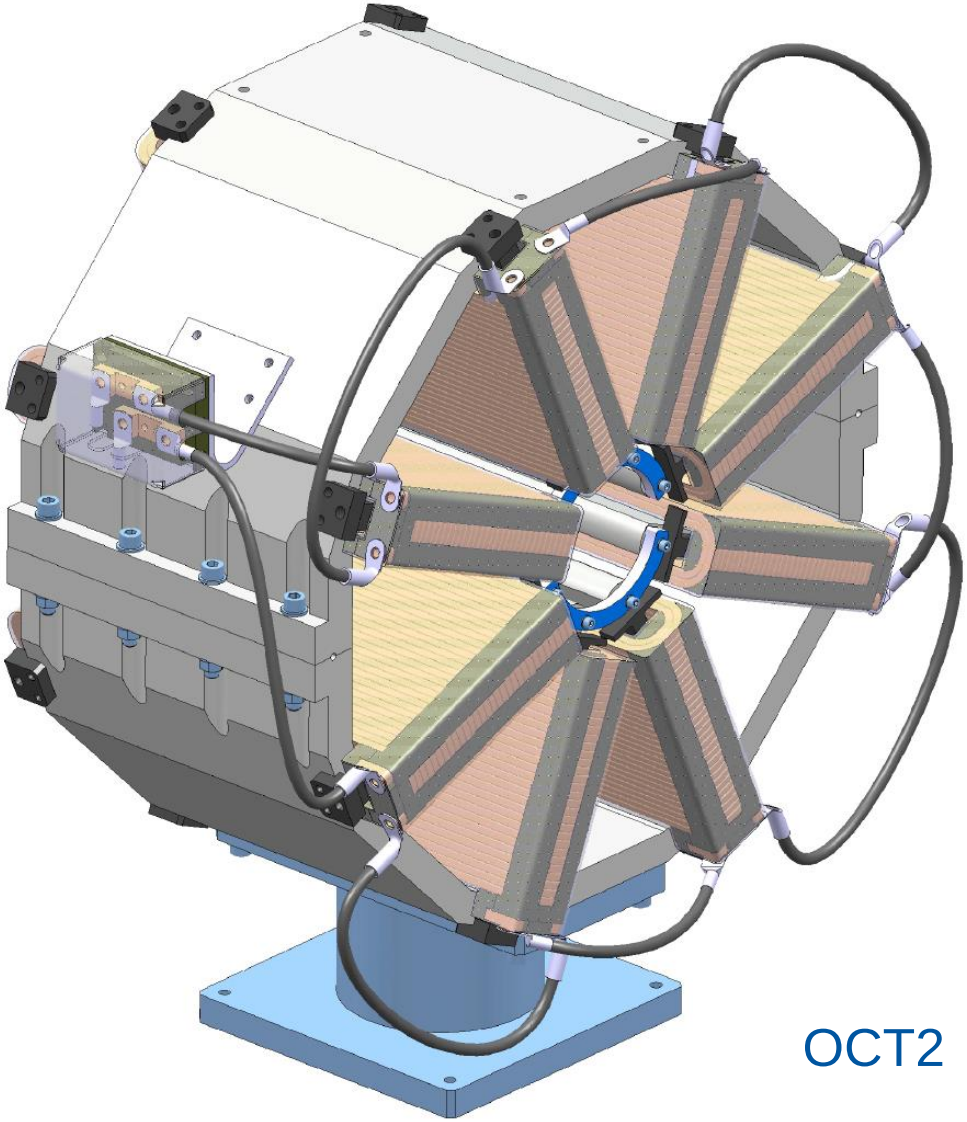
(Ref: "Towards Ultra-Low beta* in ATF2" by M.Patecki (CERN, Geneva) et al. presented at IPAC'15, May 2015,Richmond, Virginia, USA)



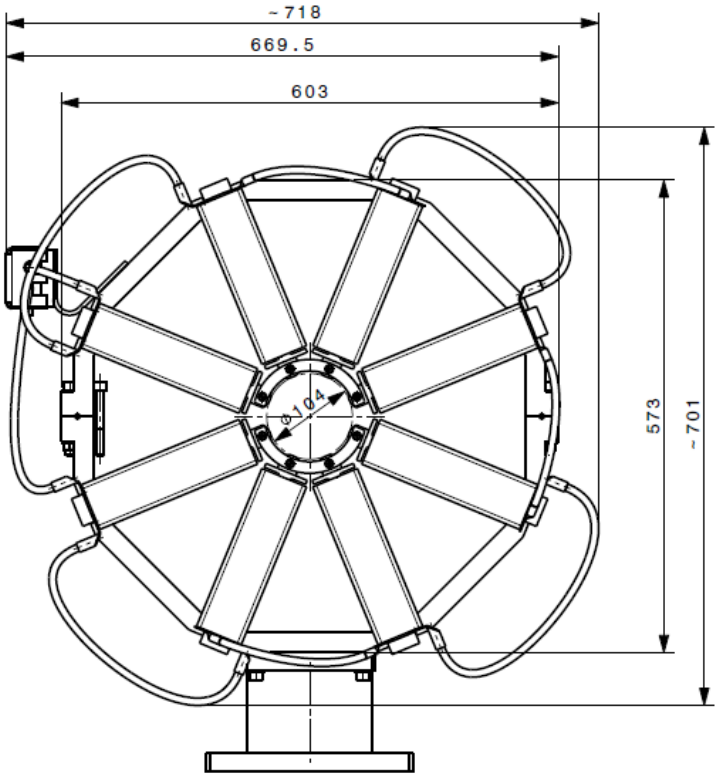


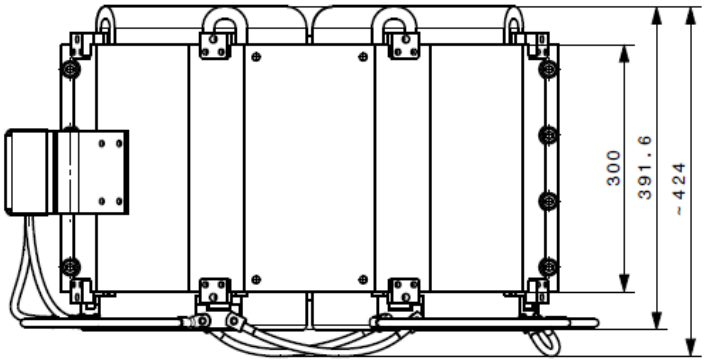


OCT1



OCT2





Prototype coils *(courtesy of SEF- Toulouse)*

Outline:

- Overview of activities and procurements done in the past years

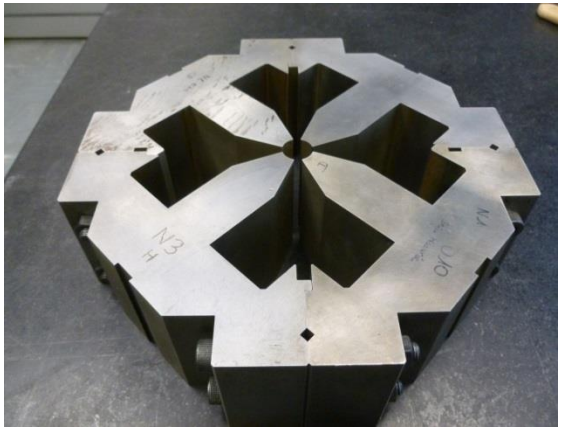
- Activities and procurements on-going

- Future activities

Future activities

- Main Beam Magnet procurement and study:
  - Assembly and measurements of NEW quadrant design for MBQ Type1

- Main Beam Magnet procurement and study:
  - Assembly and measurements of NEW quadrant design for MBQ Type1



- Modified quadrants just arrived
- Measurements at Metrology Lab
- Assembly tests
- Magnetic measurements ← → Metrology measurements

Future activities

- Main Beam Magnet procurement and study:
  - Assembly and measurements of NEW quadrant design for MBQ Type1
- CLIC Transfer lines:
  - Studies and prototype for PM based solution *(collaboration with Daresbury Lab)*

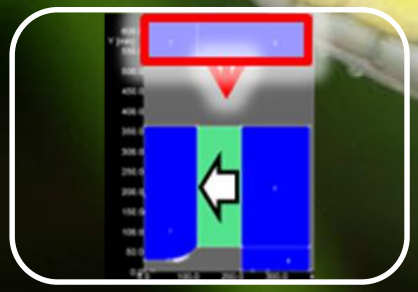
- Collaboration with ASTeC - Accelerator Science and Technology Centre - Daresbury Lab ***(J.Clarke, N.Collomb, B.Shepperd)***

- Worked on the PM DBQ (with the procurement of the 2 prototypes shown before)

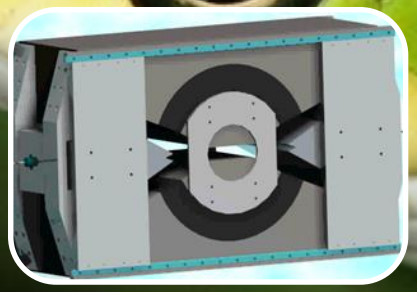
- Working now on PM based design for TL dipoles (Main Beam Ring To Main Linac (MB RTML) and Drive Beam Turn Around Loop (DB TAL) dipoles)

Review of options

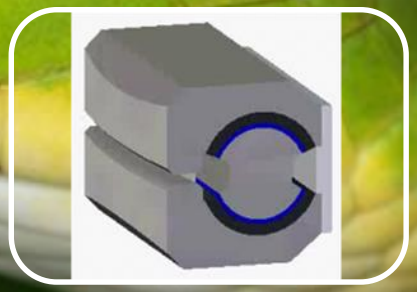
- Model numbers replaced by code names
  - Named after species of snake (arbitrary choice!)
- All these models have **0.8-1.6T** tuning range **in 2D**



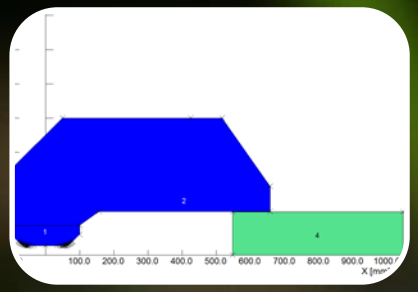
Adder



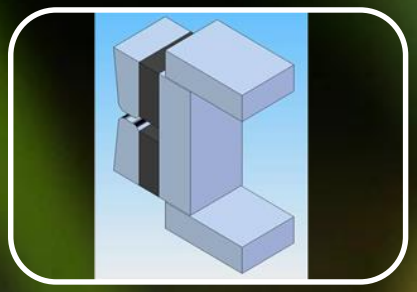
Boa



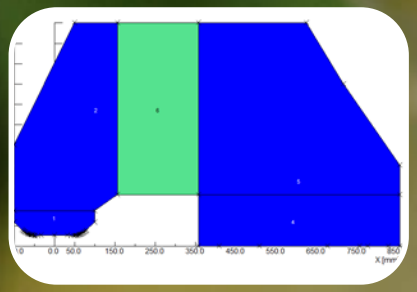
Cobra



Python

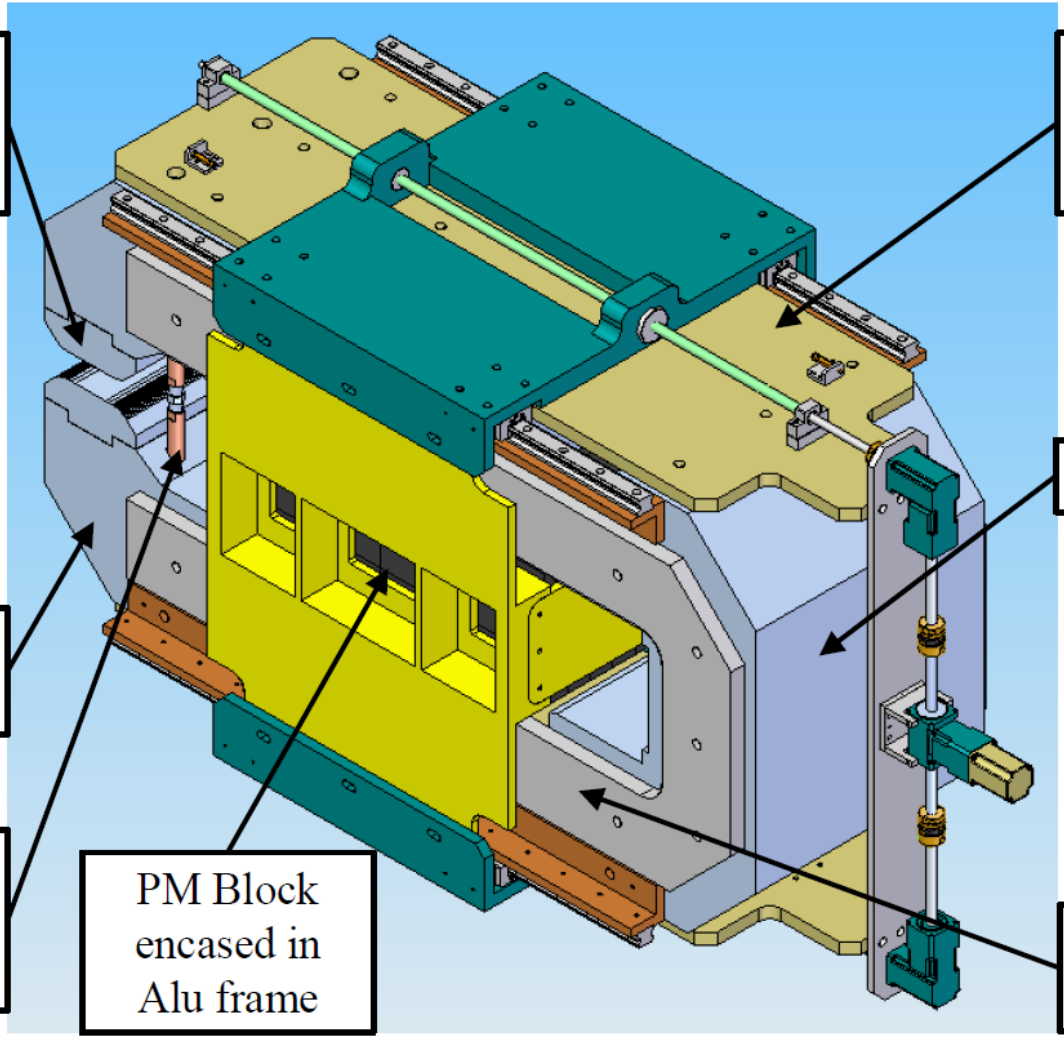


Sidewinder



Viper

Python Design proposal option two



Future activities

- Main Beam Magnet procurement and study:
  - Assembly and measurements of NEW quadrant design for MBQ Type1
- CLIC Transfer lines:
  - Studies and prototype for PM based solution *(collaboration with Darebury Lab)*
- Low emittance rings studies:
  - Design and prototype procurement for variable gradient dipole *(inside the new collaboration with CIEMAT)*

- Low emittance rings studies:

COLLABORATION AGREEMENT FOR A SPECIFIC PROJECT AT CERN ("K-CONTRACT") BETWEEN: THE EUROPEAN ORGANIZATION FOR NUCLEAR RESEARCH ("CERN"), AND: CENTRO DE INVESTIGACIONES ENERGÉTICAS, MEDIOAMBIENTALES Y TECNOLÓGICAS ("CIEMAT")	
WP2	The aim is the development of a dipole magnet with longitudinally variable field for CLIC damping rings. CERN will provide the technical specifications. CIEMAT will take care of the magnetic and mechanical design, the fabrication of the parts and the assembly. CIEMAT will also take care of the magnetic measurements.

Thank you for the attention