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Task 7.3: VAriable Dipole for the Elettra Ring (VADER)

3rd I.FAST Annual Meeting - 18/04/24

Y. Papaphilippou for the **Task 7.3 collaborators**

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VAriable Dipole for the Elettra Ring - VADER

- **Task 7.3** within I.FAST **WP7**: High Brightness Accelerators for Light Sources
- Partners and collaborators:

Y. Papaphilippou
(A. Poyet)

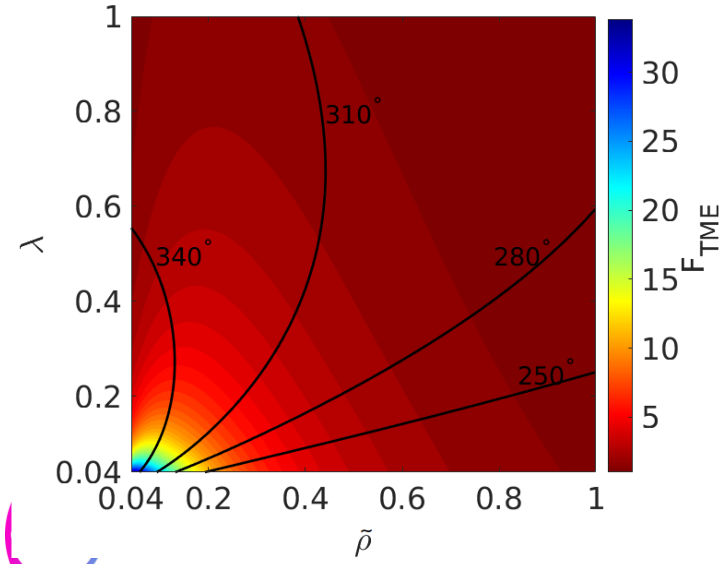
M. Dominguez
F. Toral

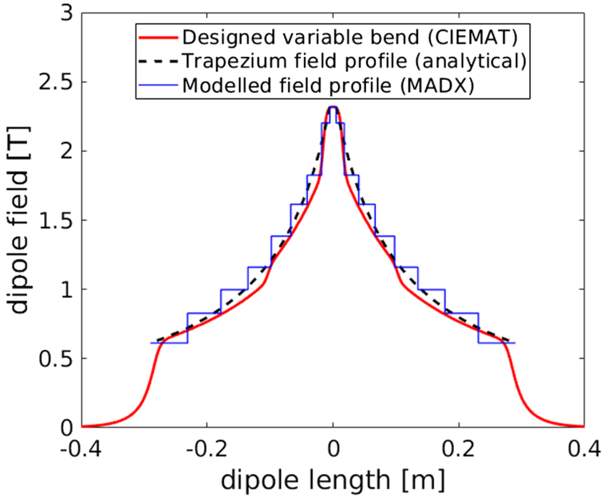
E. Karantzoulis
D. Castronovo

R. Geometrante

VADER objectives

- **Fabricate** an innovative dipole magnet prototype with longitudinal varying dipole field, including a transverse gradient for the ELETTRA upgrade
- Permanent magnet **concept** with trapezoidal bending radius, **2.3 T** peak field and ~**10 T/m** gradient, already established (CERN/CIEMAT)
- Proved the **horizontal emittance reduction** to ultra-low levels of i.e. **~60 pm @ 2.86 GeV**, for the CLIC DR (M. A. Domínguez Martinez et al., [IEEE Trans. Appl. Supercond. 28, 1, 2018]; S. Papadopoulou et al, [PRAB 22, 091601, 2019])
- First **demonstrator constructed/qualified** by CIEMAT





VADER objectives

- Keep the same **S6BA-E** lattice for Elettra and replace the LG dipoles by VADER ones.
  - Implement a **trapezoidal profile in bending radius**
  - Observe a **clear emittance reduction**

- Some **constraints**:
  - Same **geometrical layout**
  - Same **total bending angle** for each dipole
  - Same **dipole length**

- But also some freedoms:
  - We set the dipole **peak field at 2.3 T** (as for the CLIC magnet) instead of the current 1.8 T

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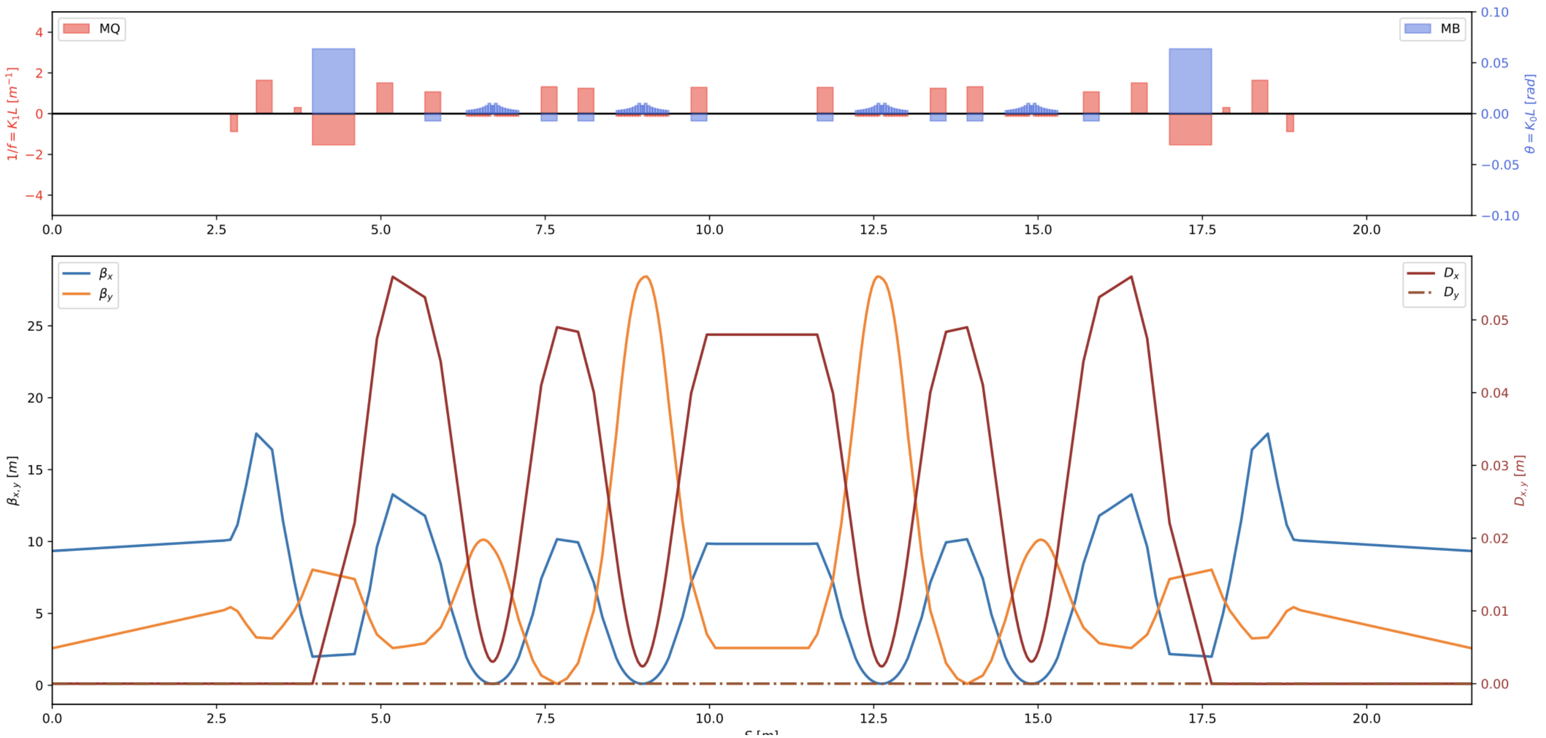
Lattice and optics design

A. Poyet

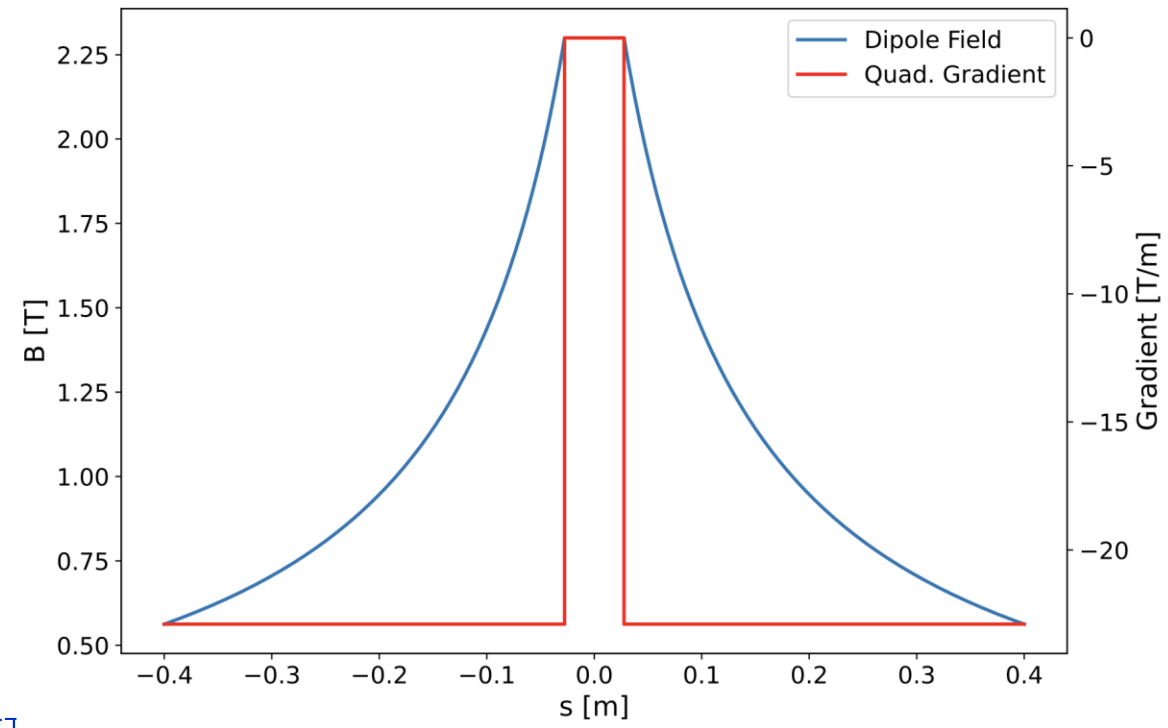


- Optics constraints at the ID are **matched**
- **Horizontal emittance reduction from 212 to 100 pm (more than factor of 2!)**
  - ✓ Non-linear optimization: **already good on-momentum DA**
- **Tunes: 34.706 / 22.852**
- **Chromaticities: -157/-125**

Profile Design and Magnet Specifications

- **Similar parameters as CLIC DR but…**
  - **Higher transverse gradient (> factor of 2)**
  - **Higher magnetic gap (~40%)**
  - **Longer magnet (~40%)**

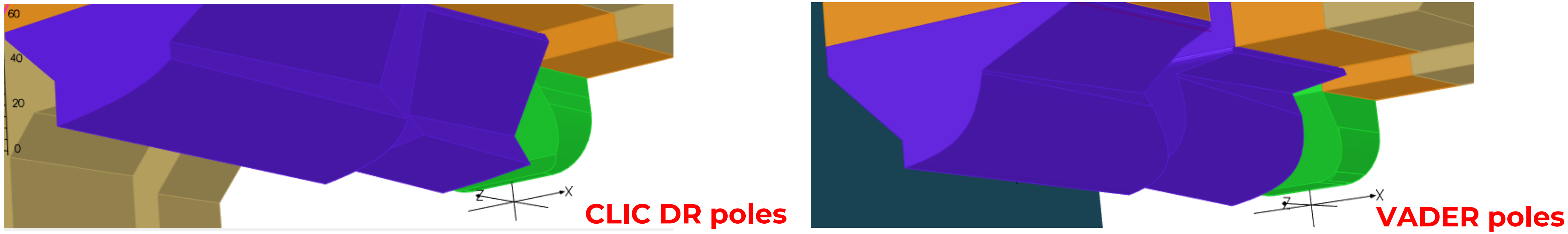
Specifications	CLIC DR	VADER
Magnet Gap (mm)	**13**	**18**
Max Field (T)	2.3	2.3
Transverse G (T/m)	**11**	**23**
Field Quality (Units 1E-4)	≈ 1	≈ 1
Magnet Length (cm)	**56**	**80**



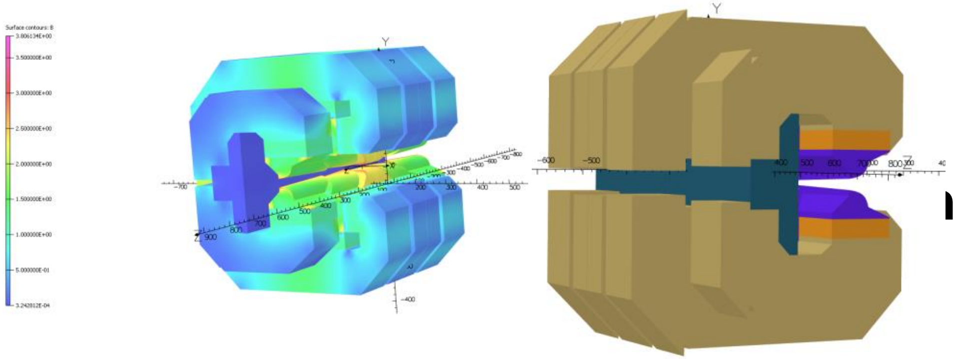
Magnetic Design @ CIEMAT

M. Dominguez,
F. Toral

- No changes in philosophy, **major changes** in **poles** (90% of the design time)



- All **NdFeB permanent magnet blocks**, including low-field modules
- **Permanent magnet volume increased around 40%** reaching demanded field peak of **2.3 T** with **magnet gap** of **18mm** (17+1mm)
- **New field trimming design** implemented
  - **Yoke** completely **split** in two parts supported by an **aluminium block**
  - Sliding parts achieve **higher/better** than CLIC DR prototype



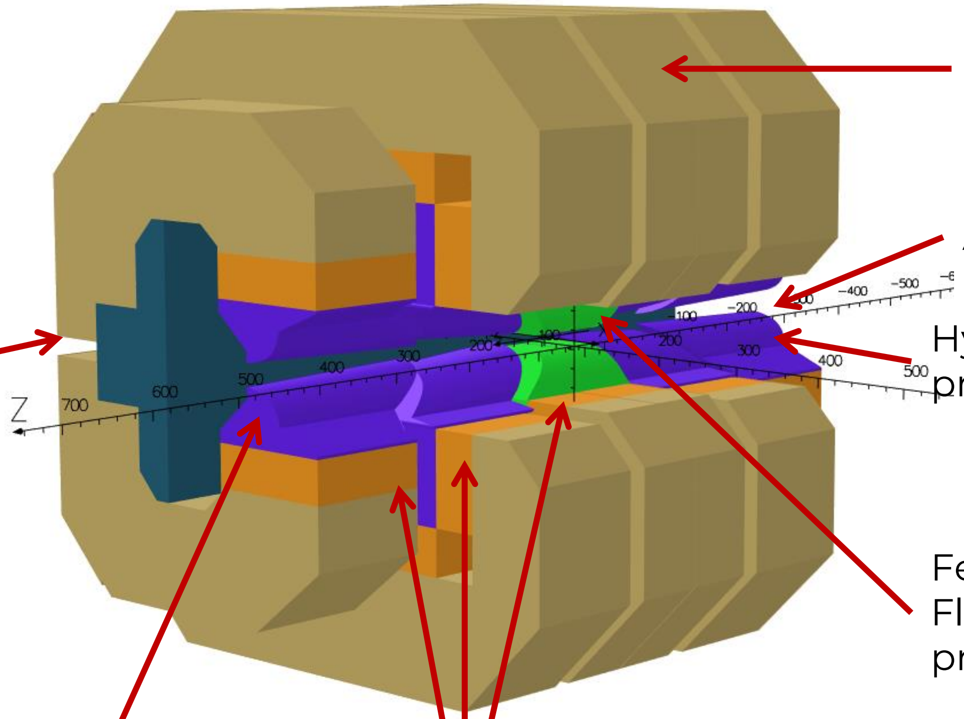
Magnetic Design @ CIEMAT

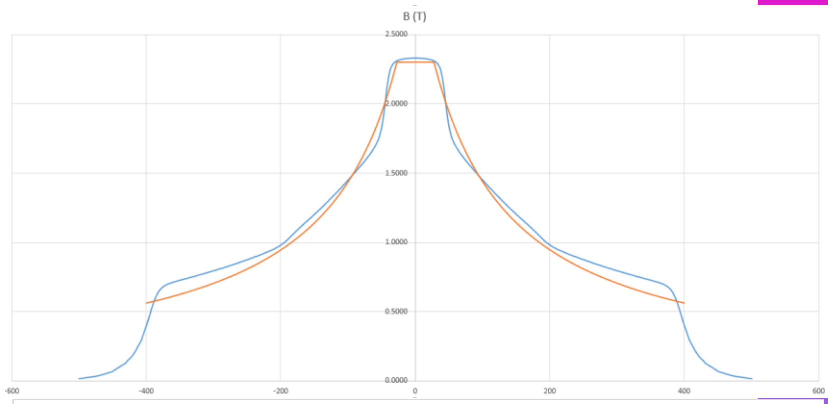
M. Dominguez,
F. Toral

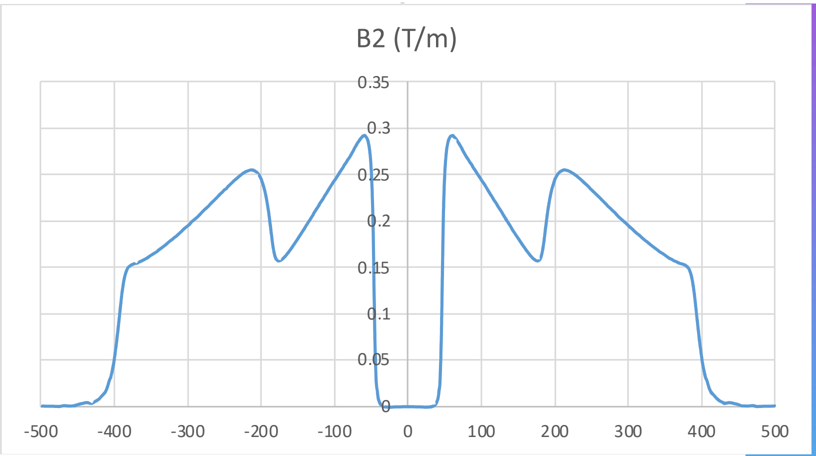
Combined Function
Longitudinal gradient with trapezoidal shape (2.3 T Peak)
Transverse gradient 23 T/m

Dimensions:
0.65 x 0.68 x 0.80 m

Weight: 1.5 T

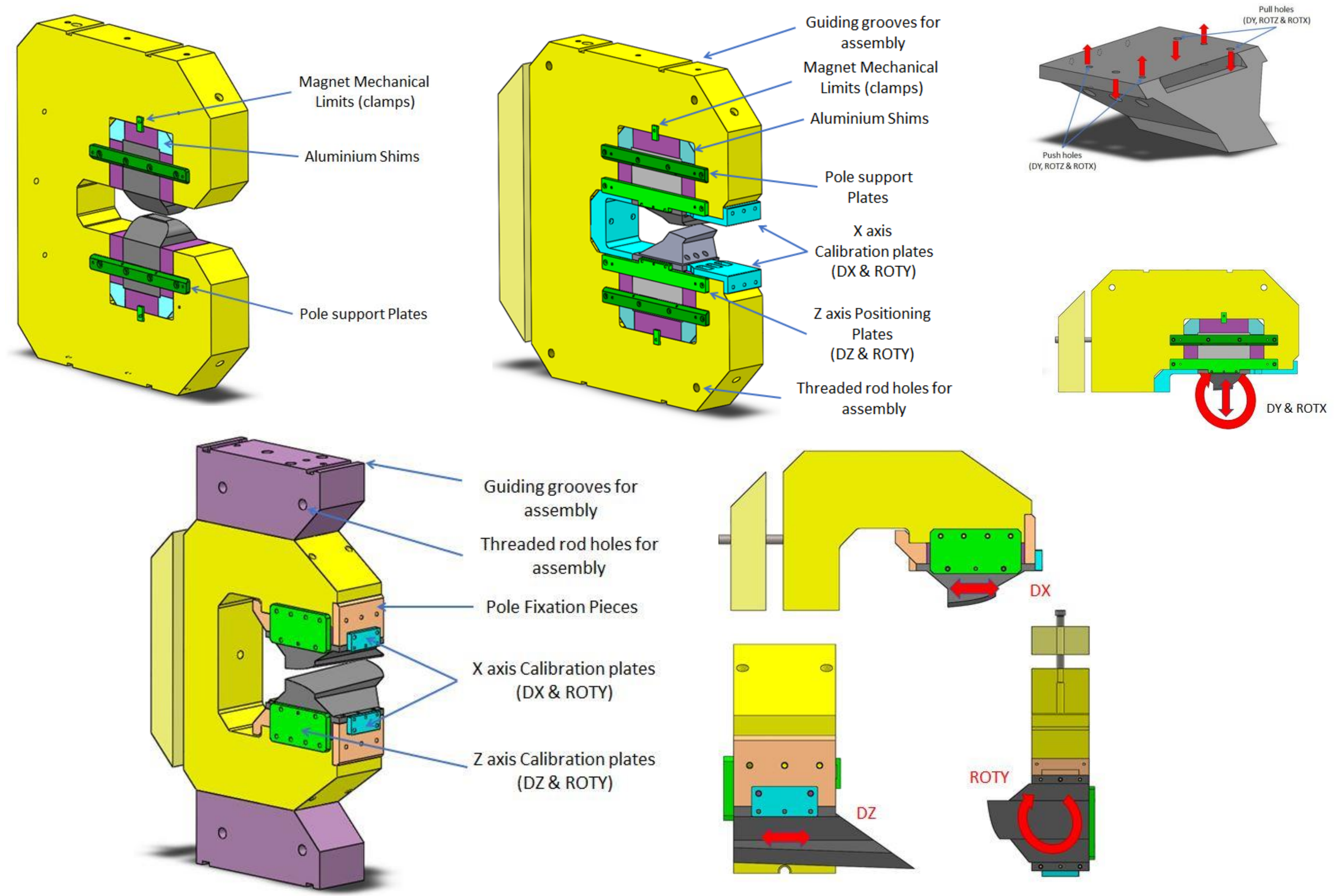






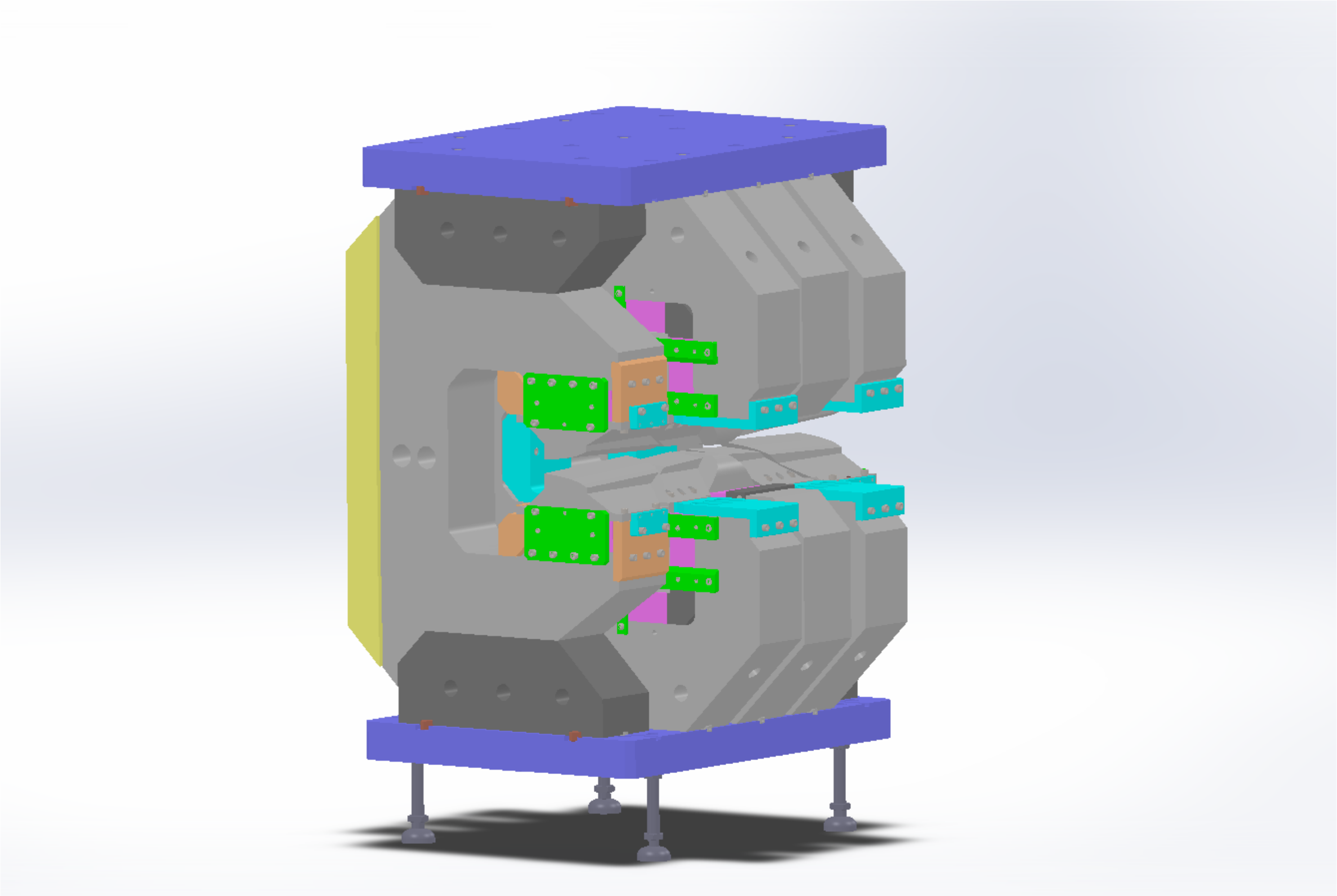
- **Longitudinal gradient** profile **achieved**
- **Integrated transverse gradient exceeds specs**
- **Field quality** looks reasonable (final iteration)

Mechanical Design @ CIEMAT



Mechanical Design @ CIEMAT

- **Magnet progressing towards its fabrication**



VADER timeline

	Deliverable description	Month
1	Magnet Specifications based on optics calculations for ELETTRA	12
2	Magnetic and mechanical design (including fabrication drawings)	24
3	Fabrication of the prototype	42
4	Acceptance tests	48

Milestone **MS 26** (rows 1–2)

Deliverable **D7.3** (row 3)

Milestone **MS 27** (row 4)

- **Optics work including magnet specifications completed** (CERN/Elettra) **since end of 2022** (**8 months delay**, delay in hiring fellow)
- **Magnetic and mechanical design** from CIEMAT **in final stage** with input from KYMA for fabrication, to be **ready** by **April 2024 (11 month delay)**
- **Fabrication** of the prototype by KYMA start on **May 2024** ready for acceptance tests by **beginning of 2025 (3 months delay)**
- Acceptance tests may be delayed **beyond M48**

Instead of a conclusion…

- **SAC feedback** on 2nd IFAST annual meeting (2023)
  - Permanent magnets as **key technologies** to reduce **energy consumption**
  - **Excellent idea** of dipole at center and gradient at longitudinal ends
  - **Small adjustability** may be required in the practical applications,
  - **Suggestions**:
    - Encourage to achieve the **progress in time**
      - Struggled from beginning of project with **delays on hiring** and available **personnel resources**
      - Accumulated a **few months delay**
    - Suggest to study/investigate the **field adjustability** in long term operation
      - **New field trimming design** implemented for small **field adjustments**
- **Next steps**
  - Transmission of final drawings and **fabrication** of the **prototype**
  - Implementation of **realistic field profile** and in Elletra optics model and **final non-linear optimization**, including **field errors**

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Thank you for your attention!

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