HEPS-ALBA virtual workshop

ALBAII magnet design and production

13th July 2026

Maisui Ning on behalf of IDMAFE section

Outline

- ALBA upgrade plans
- Magnets for ALBA II

Introduction to ALBA

ALBA is a **3rd generation Synchrotron Light source** in **operation for users since 2012** in Cerdanyola del Vallès, close to **Barcelona**.

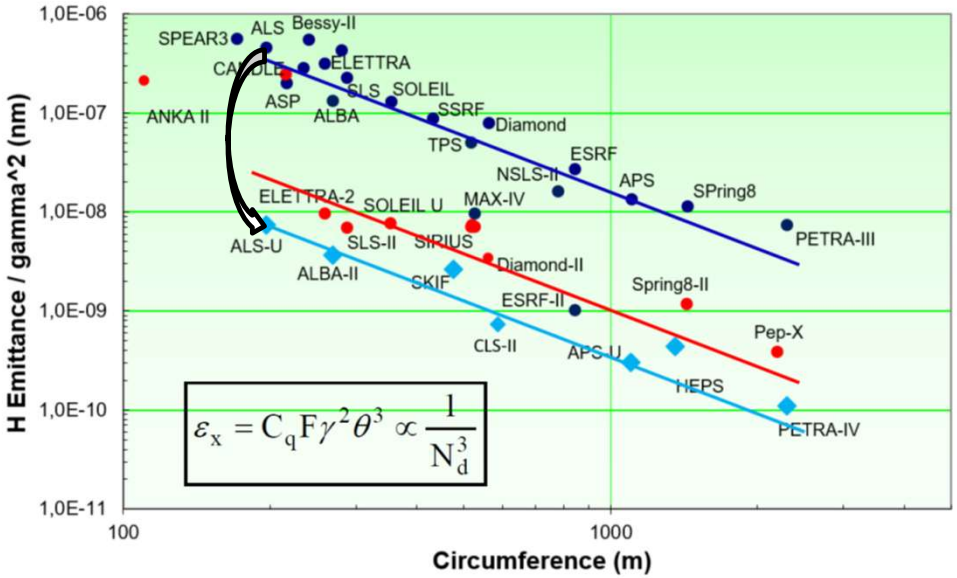
Aerial view of ALBA site

Synchrotron light sources in Europe

Inside Main Building

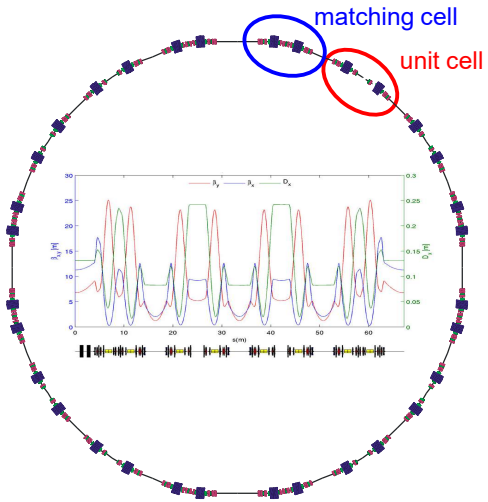
Upgrade plans

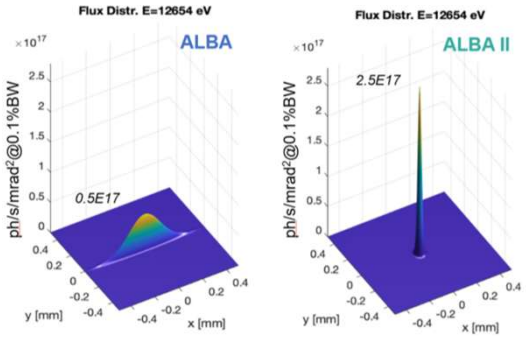
Following the worldwide wave of **upgrade plans for 3rd generation facilities**, aimed to **decrease the beam emittance** and to **became diffraction limited** at higher photon energies, **ALBA** started thinking in its own upgrade in **2018**.



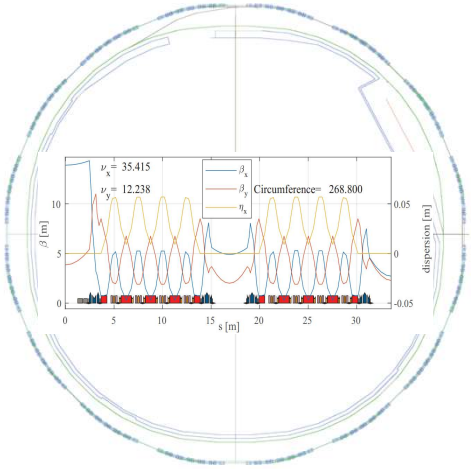
Reproduced from: R. Bartolini "Overview of ongoing 4th generation light source projects worldwide", 7th DLSR Workshop (2021)

Upgrade plans





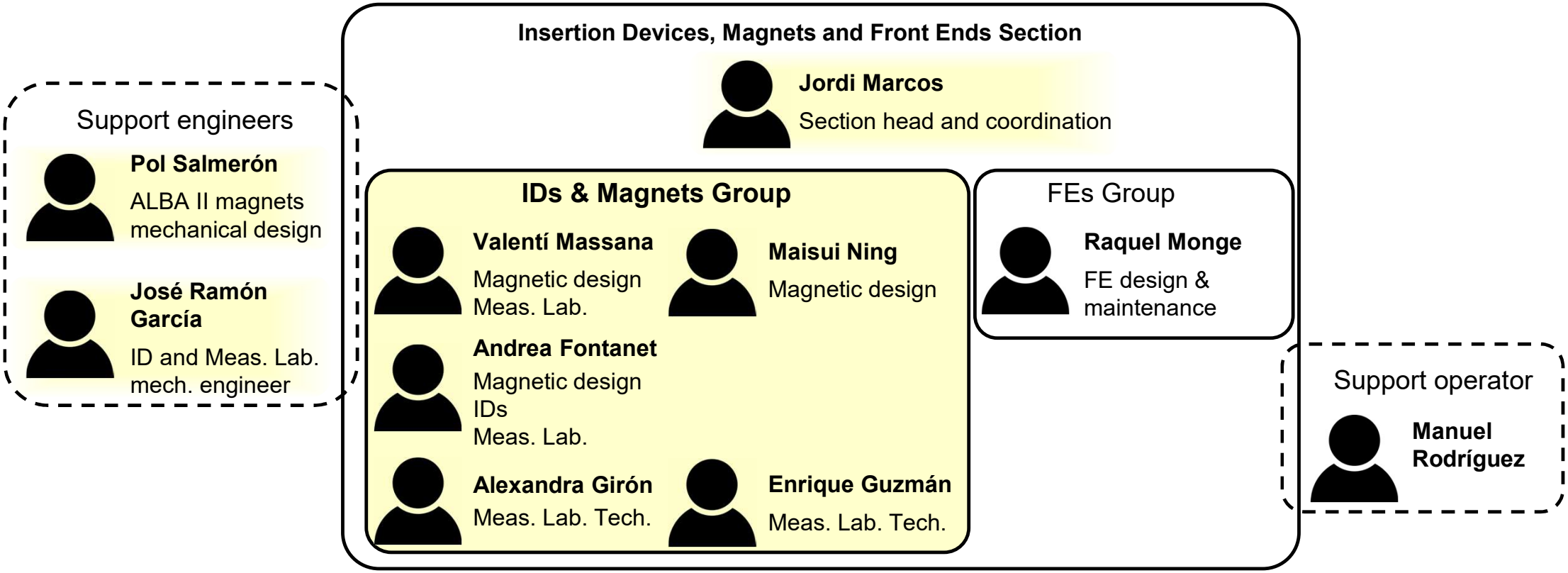
	ALBA		ALBA II
Energy	**3 GeV**		**3 GeV**
Circumference	268.8 m		268.8
Symmetry	4-fold		4-fold
Lattice	8×2-DBA cells		16×5BA cells
Emittance	**4.5 nm·rad**	÷20	**~200 pm·rad**
Nº of cells	8+8		16
# of straights	4 / 12 /8		4 / 4 / 8 (16)
Straight length	7.8 / 4.0 / 2.3m		4.7 / 4.4 / 3.5 m
Nº of cells	264	×3	720



M. Carlà et al. “Status of lattice studies for ALBA II”, **IPAC26, WEP5034**

Magnets for ALBA II

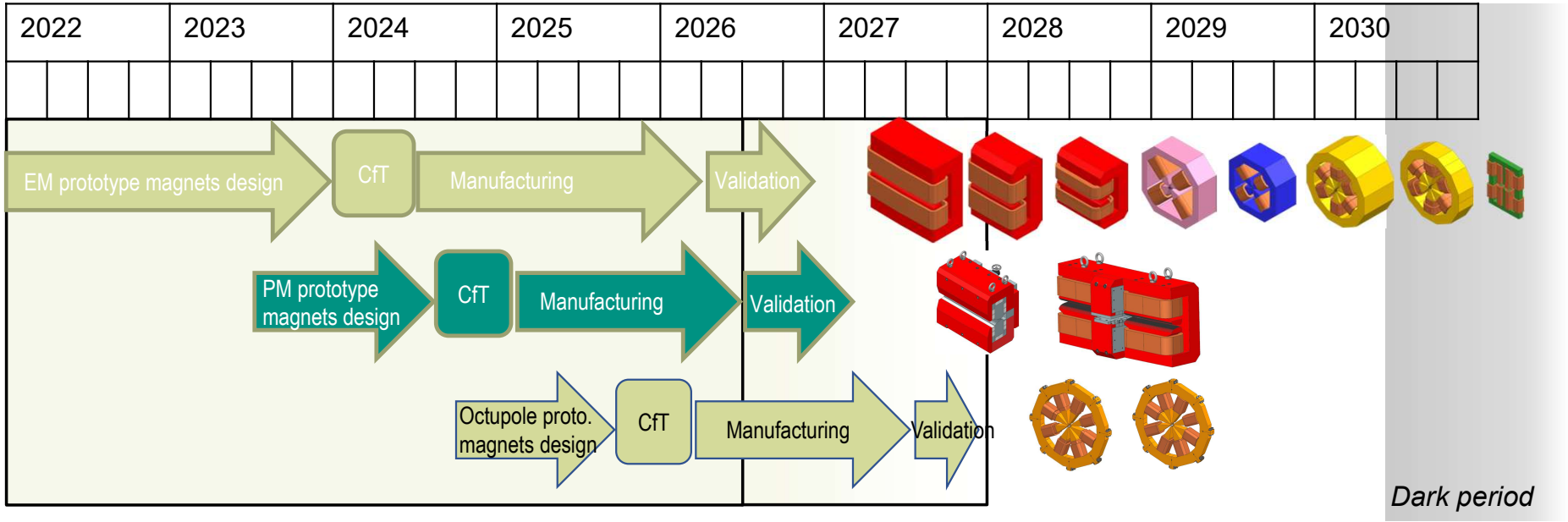
The **IDMAFE section** has been enlarged (from 3 up to **7 people**), and we also have the dedicated support of people from other sections.



Magnets for ALBA II

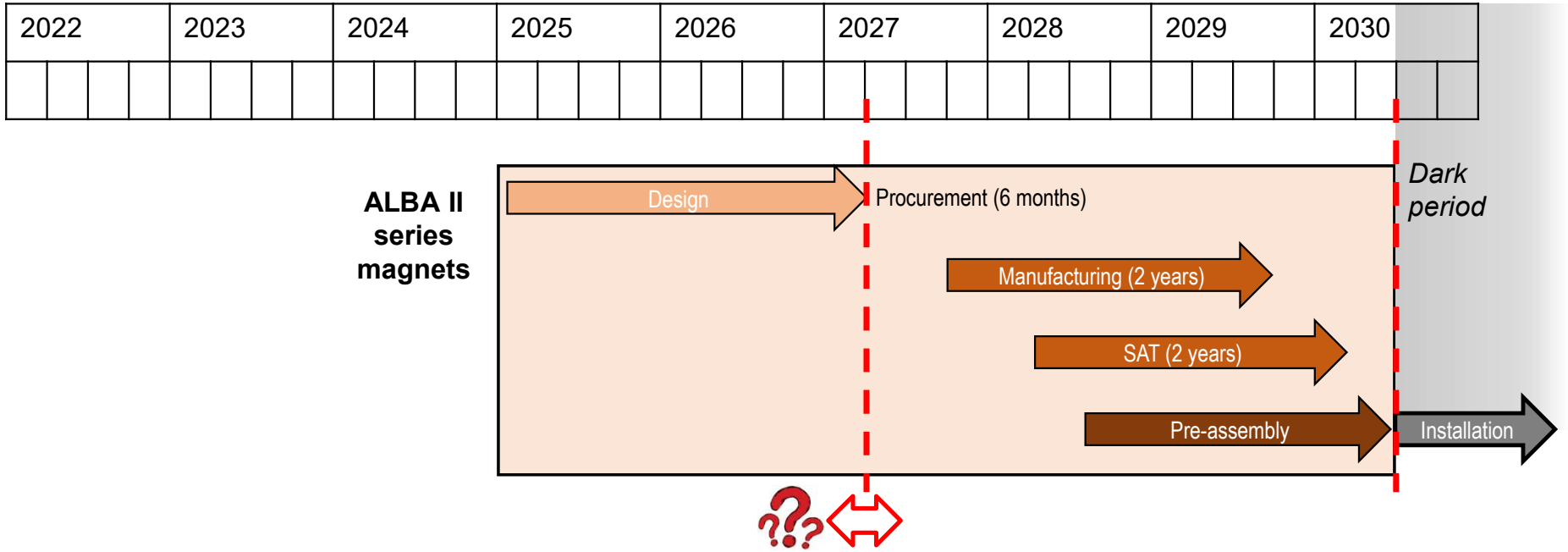
The design/procurement of magnets for ALBA II is being done through a **prototyping phase** (within ALBA01 project), which will be followed by the **series production phase**.

ALBA II magnets prototyping



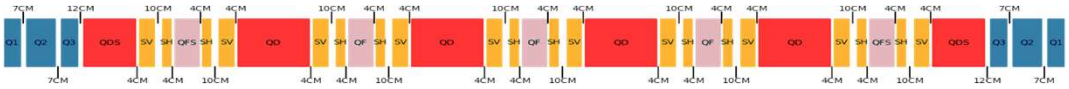
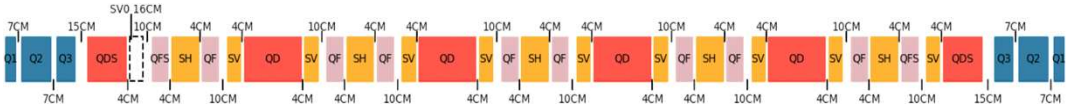
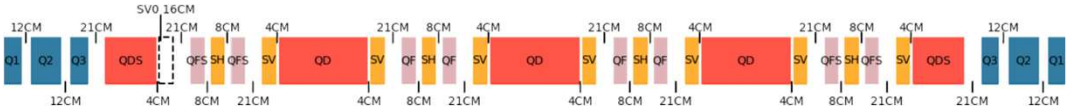
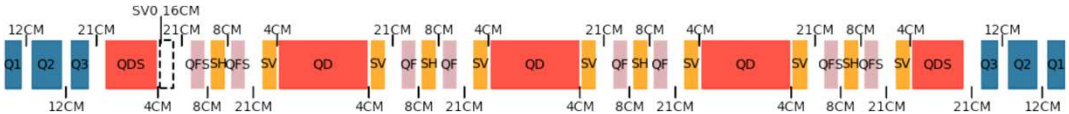
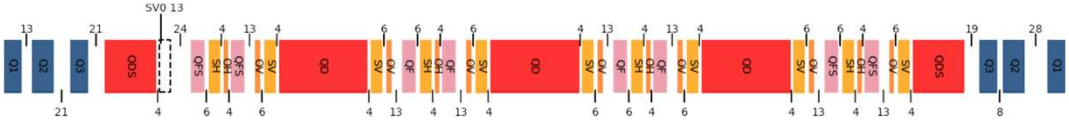
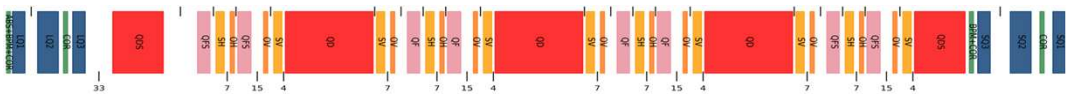
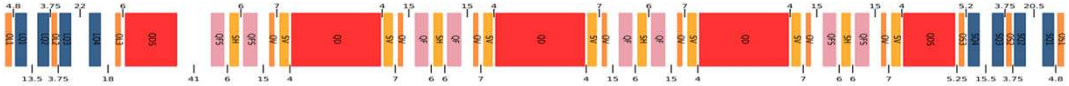
Magnets for ALBA II

The design/procurement of magnets for ALBA II is being done through a **prototyping phase** (within ALBA01 project), which will be followed by the **series production phase**.



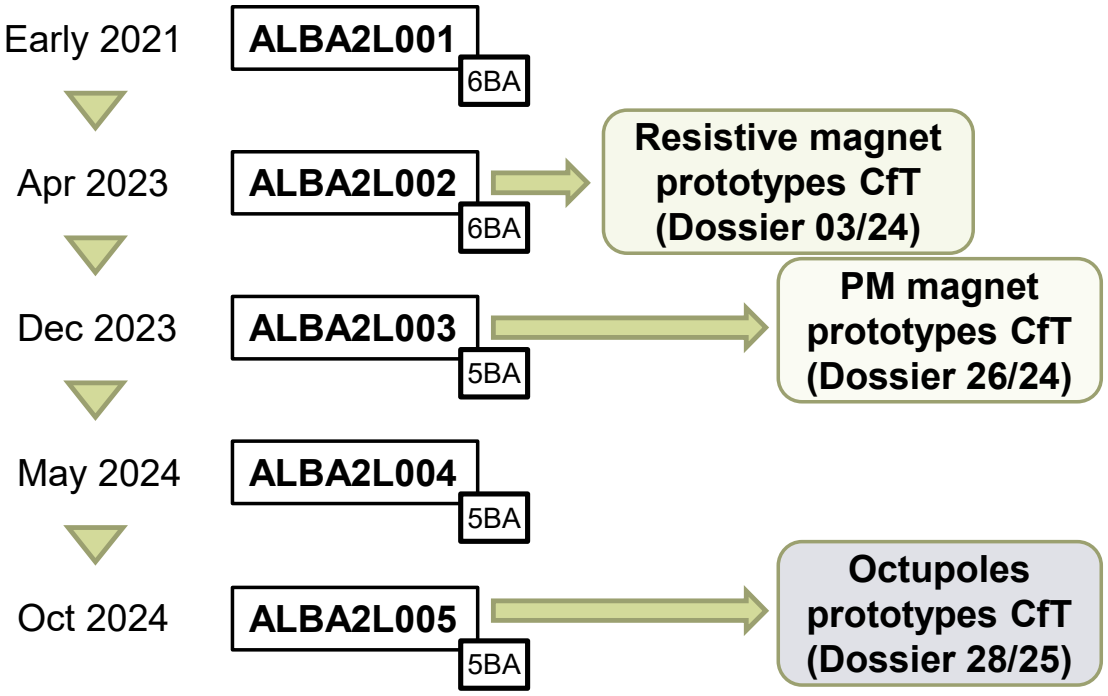
Magnets for ALBA II

The **lattice** that we have to design the magnets for has been **evolving continuously** since **2021**.

Early 2021	**ALBA2L001**		First released **6BA lattice** (published IPAC21).
Apr 2023	**ALBA2L002**		Modification **6BA** to improve injection and correction of chromaticity (published IPAC23)
Dec 2023	**ALBA2L003**		Lattice relaxed to **5BA** to get more space and flexibility
May 2024	**ALBA2L004**		Modification of **5BA** lattice to improve tune shift with amplitude (published IPAC24)
Oct 2024	**ALBA2L005**		Introduction of **octupoles** into **5BA** lattice to help improving DA (published IPAC25)
Oct 2025	**ALBA2L006**		Modification of **injection** and minor readjustments (published IPAC26)
Apr 2026	**ALBA2L007**		**Redistribution** of **octupoles (final lattice?)**

Magnets for ALBA II

Given that the **prototyping project has its own timing** (all items shall be received by **mid 2026**), prototype magnets have been **designed according to the lattice version available at each moment**.



Even if the **prototypes will be different from the magnets for the final lattice**, we are confident that the **lessons learnt from them will be useful for the design of the final series magnets**.

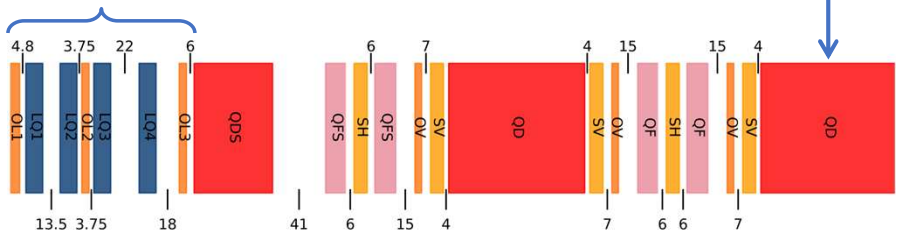
Magnets for ALBA II

As per today, ALBA II lattice is based in **16 (almost) identical 5BA cells**, with **10 magnet types**, for a total of **720 individual magnets** (currently 264 magnets at ALBA SR).

Function	Types	# per cell	total	Leff [mm]	B [T]	G=B' [T/m]	S=½B'' [T/m²]	O=⅙B''' [T/m³]
Bending	QD	3	48	1050	1.04	-13.0		
	QDS	2	32	605	1.06	-12.5		
Reverse Bend	QF	4	64	160	-0.51	+64.8		
	QFS	4	64	160	-0.48	+69.4		
Quadrupole	Q1…Q4	8	128	130		≤100		
Sextupole	SH	4	64	100			≤5000	
	SV	7	112	100			≤5000	
Octupole	O1	2	32	72				≤2.1e5
	O2-O3	4	64	55				≤2.1e5
	OV	7	112	50				≤1.3e5
TOTAL		45	**720**					

Precise distribution of quads & octupoles at the entrance/exit depend on the cell type

center of the cell



Distances between effective lengths in [cm]

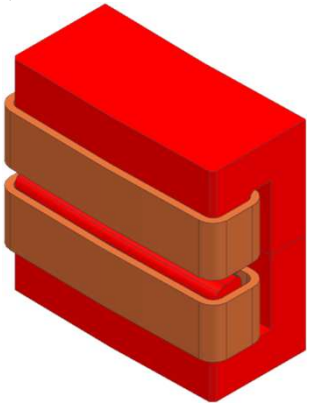
Magnets for ALBA II

Main dipoles (**QD** and **QDS**) have transversal gradient, with a moderate gradient-to-field ratio. They have been implemented as **2-pole conventional C-shape magnets**, with a **vertical opening** of **20mm**.

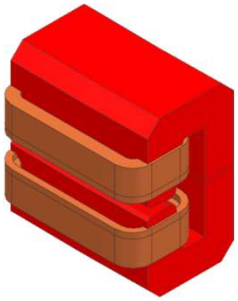
In the case of **QDS**, where field tuning is not mandatory, **a pure PM version has been designed**.

In the case of **QD**, an alternative **"Superbend" version** with a central high-field pole (**3.2T, 10.2mm pole gap**) powered with NdFeB blocks has been developed for dipole BLs requiring **higher critical energies**.

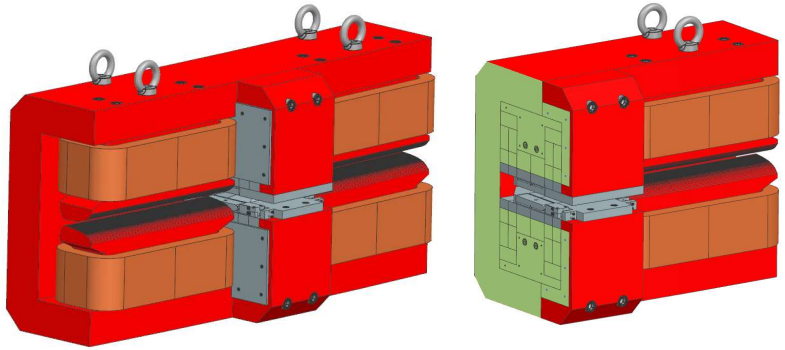
QD resistive version



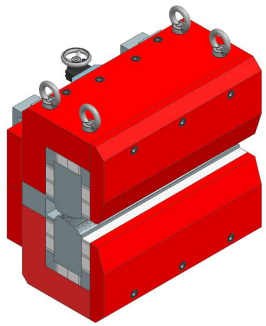
QDS resistive version (embedded coils)



QD "superbend" version (hybrid resistive+PM)



QDS PM version



Magnets for ALBA II

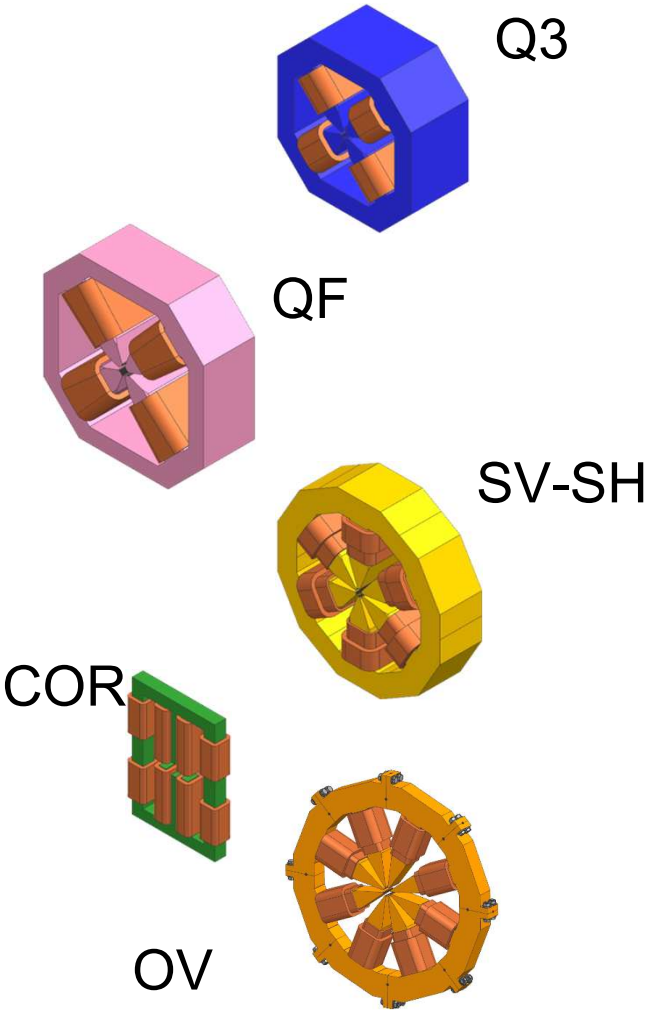
Pure quadrupoles at the end of each cell (**Q1-Q2-Q3-Q4**) have a common transversal geometry and an **aperture diameter** of **20mm**, allowing them to reach up to **100T/m** with an **efficiency >90%**.

Reverse bends (**QF-QFS**) require a high gradient **(~70T/m**) and a moderate field **(~0.5T**), and hence they have been implemented as **horizontally displaced quadrupoles** (**7-8mm**). Due to this, a larger **aperture diameter** of **~29-30mm** is required.

Sextupoles (**SH-SV**) shall reach **5000T/m²** and they shall include correctors for H/V position and skew quadrupole. An **aperture diameter** of **23mm** has been used.

Fast correctors (**COR**) integrate a **horizontal and vertical steerer** on the **same yoke**, with a **6-pole design** similar to the one developed for ESRF-EBS (not used in A2L007 lattice).

Octupoles (**O1-O2-O3-OV**) have an **aperture diameter** of **24mm**. The usage of air or water cooled coils has not been decided yet, and it is currently being prototyped.



Magnets for ALBA II

We want to prototype **all magnet types** in order to test/compare:

- **Different magnet technologies**: EM vs PM, conventional vs embedded coils…
- **Magnetic performance** of the developed designs: field/gradient levels, linearity/efficiency, multipolar content, magnetic axis stability with current, cross-talk between main component and correctors for sextupoles…
- **Mechanical accuracy** issues: pole machining precision, repeatability upon dismounting/remounting, tolerances coil manufacturing, compactness of the engineering design (power/water distribution systems)…
- **Mechanical integration** aspects: mounting mechanism on girders, vacuum chamber assembly…
- **Cross-talk effects between adjacent magnets**.

Characterization is being carried out at **Magnetic Measurements laboratory** at **ALBA**.

Magnets for ALBA II

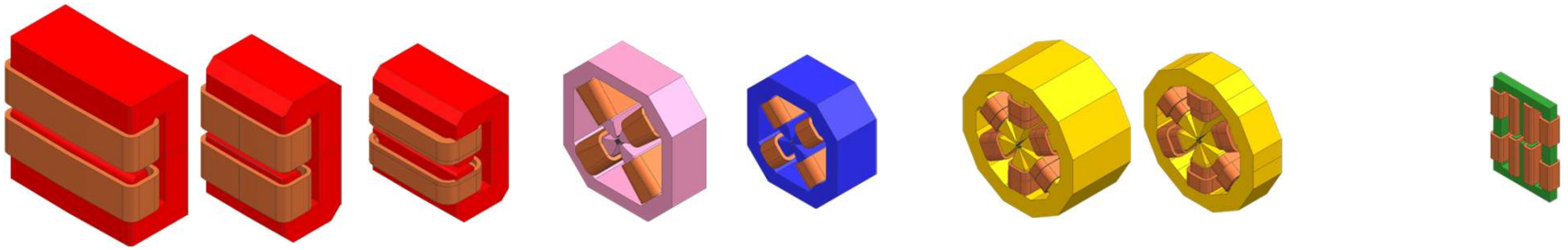
The **CfT for resistive prototypes (Dossier 03/24)** included **8 magnets** divided into **4 lots.**

Bending magnets	
Lot 1	QD
	QDS conventional
	QDS embedded

"quadrupoles"	
Lot 2	Q3
	QF/QFS

Sextupoles	
Lot 3	SH
	SV

Correctors	
Lot 4	CORR



CfT was published on **14 Feb'24**

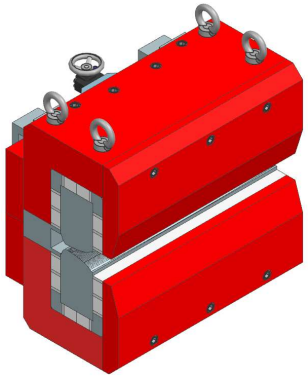
All the lots were awarded to one single company **(ANTEC S.L.U.**), and the contract signed on **18 Jun'24**.

All prototypes (except sextupoles) have already been delivered.

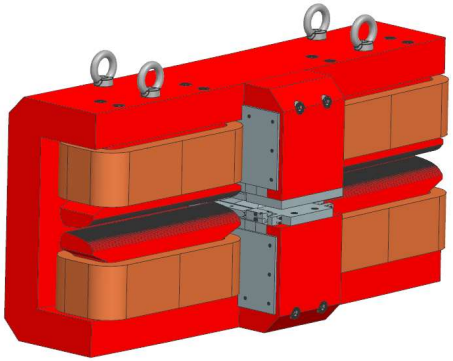
Magnets for ALBA II

The **CfT for PM prototypes (Dossier 26/24)** included **2 magnets** divided into **2 lots.**

Bending magnets	
Lot 1	QDS-PM



Bending magnets	
Lot 2	QD-Superbend



CfT was published on **30 Sep'24.**

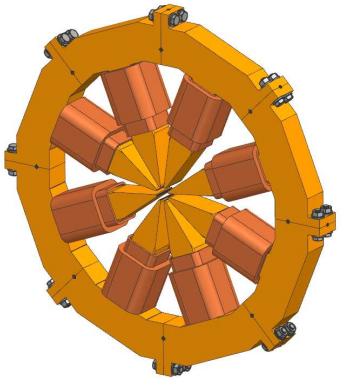
The 2 lots were awarded to one single company **(Danfysik A/S**), and the contract signed on **03 Feb'25**.

One prototype has already been FAT delivered., and the other one will be completed soon.

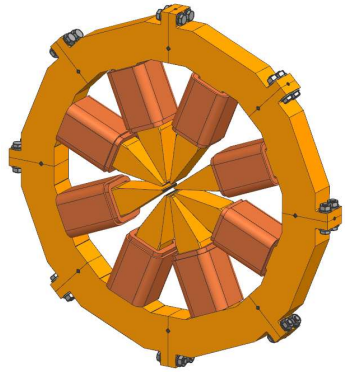
Magnets for ALBA II

The **CfT for octupole prototypes (Dossier 28/26)** includes **2 magnets** in **1 single lots.**

Octupole magnets	
Lot 1	Octupole water cooled
	Octupole air cooled



Water cooled OCT



Air cooled OCT

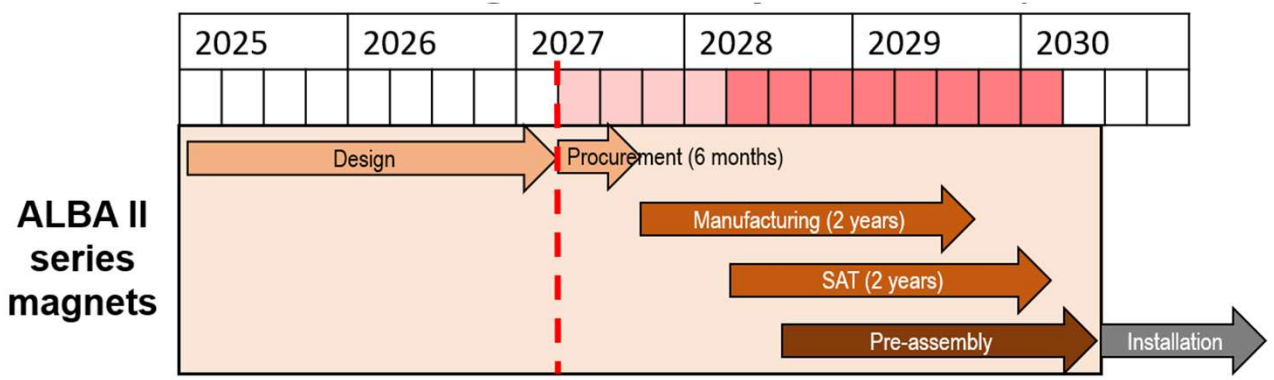
The CfT was published on **17 Oct'25**.

Contract was awarded to **Sigmaphi** and signed on **18 Mar'26**.

Delivery of prototypes is expected in **mid Jun'27**.

Magnets for ALBA II

The **calendar** for the **magnet series production** phase is still tentative.



We need **720(+14) magnets** to be produced:

Solid or Iminated yoke magnets

- 48(+1) resistive dipoles
- 32(+1) PM based dipoles
- 128(+2) large aperture quadrupoles
- 128(+2) small aperture quadrupoles

Laminated yoke magnets

- 176(+2) sextupoles
- 208(+6) octupoles

Magnets for ALBA II

As for the strategy for the characterization for series magnets, it is still under development.

We will explore the **possibility of outsourcing at least a part of the characterization to manufacturing companies**, but taking into account the experience from other labs **our "Plan A" assumes that the characterization will be carried out in-house**.

We will have to characterize:

80 curves magnets (QD and QDS) → **Hall probe** bench (×1)

640 straight magnets (multipolar magnets of all sorts) → **Stretched Wire (SW)** bench (×2)

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Series characterization strategy

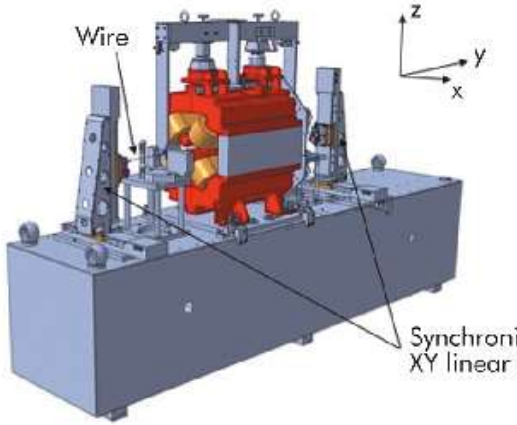
For the **Hall probe measurements** we will use the **existing system** (**x1**) at our Magnetic Measurements Lab. Assuming 180 working days per year, we will have at least **4 days to characterize each dipolar magnet**.

In the case of **Stretched Wire (SW) measurements**, assuming **1 day/magnet** and 180 working days per year, we **will need at least two** (**x2**) **systems** in order to complete the task (**640 magnets**) within 2 years.

We have already received one system at ALBA by the **end of 2025**.

The second system will be procured later on (it will not be needed until end of 2027).

Conventional Hall probe bench (ALBA)



ESRF Stretched Wire bench