

DYNAMICAL MODELLING VALIDATION AND CONTROL DEVELOPMENT FOR THE NEW HIGH-DYNAMIC DOUBLE-CRYSTAL MONOCHROMATOR (HD-DCM-Lite) FOR SIRIUS/LNLS

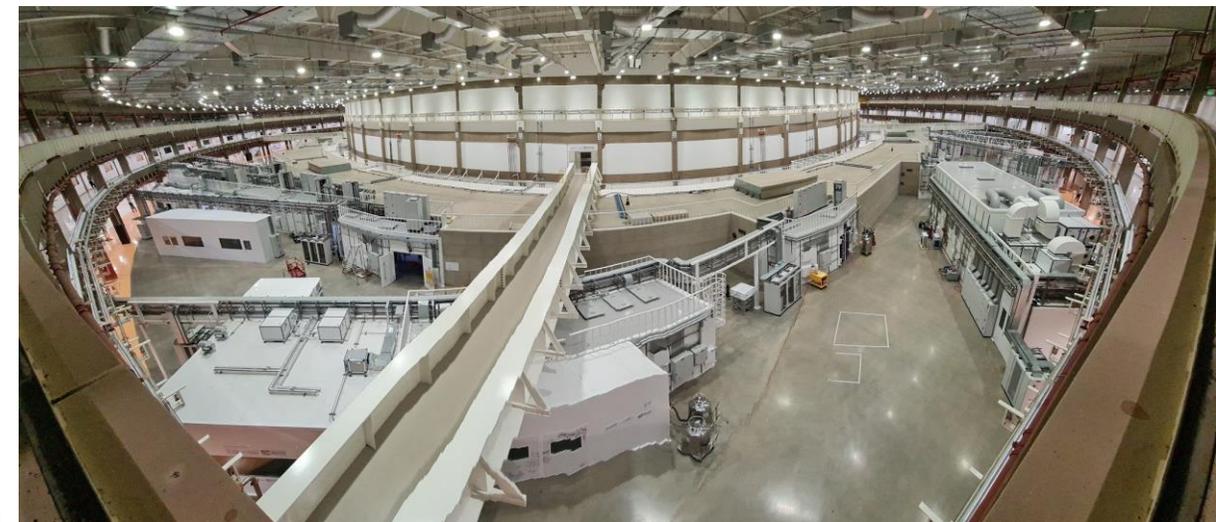
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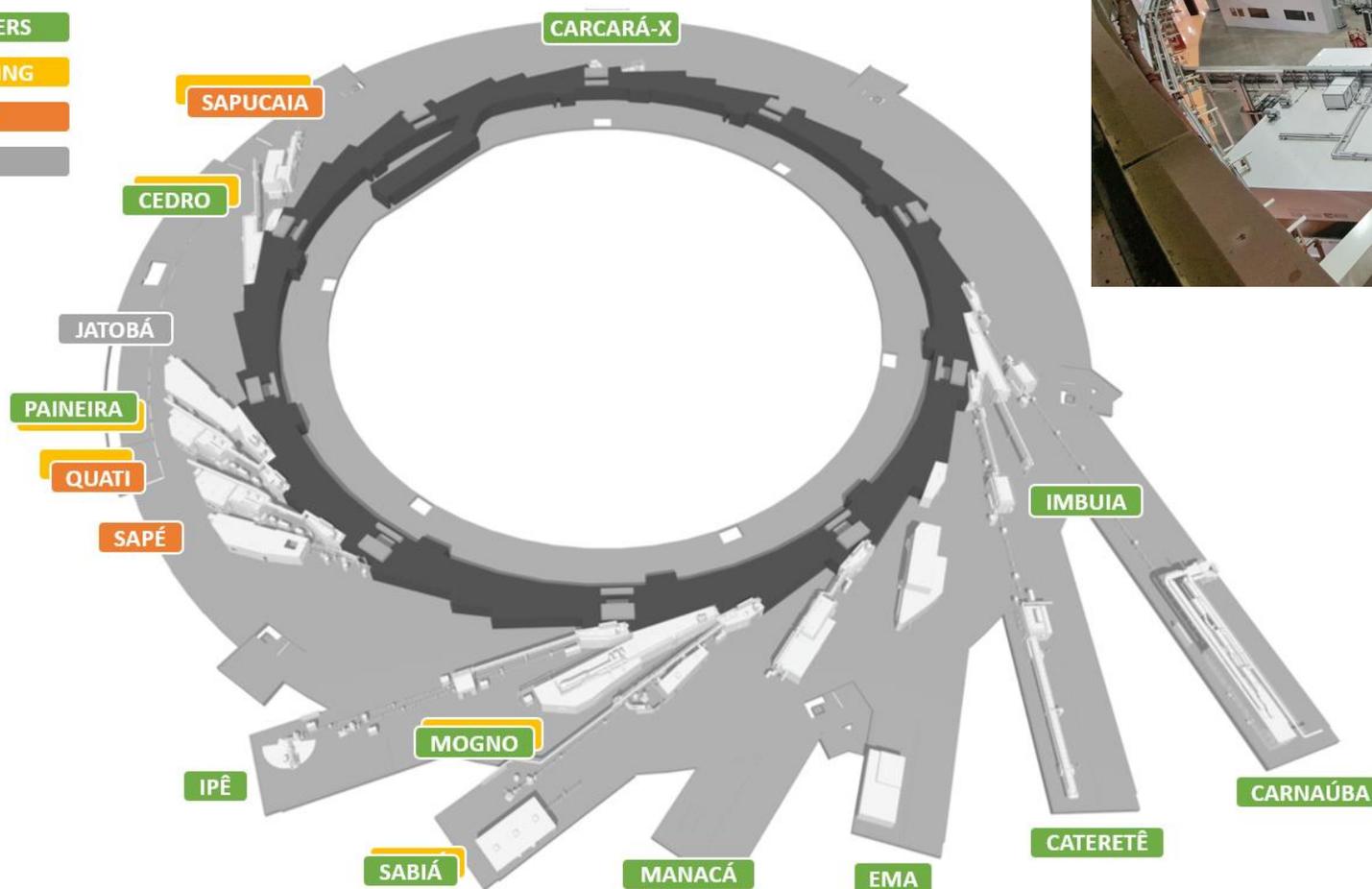
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Sirius Status – Phase 1

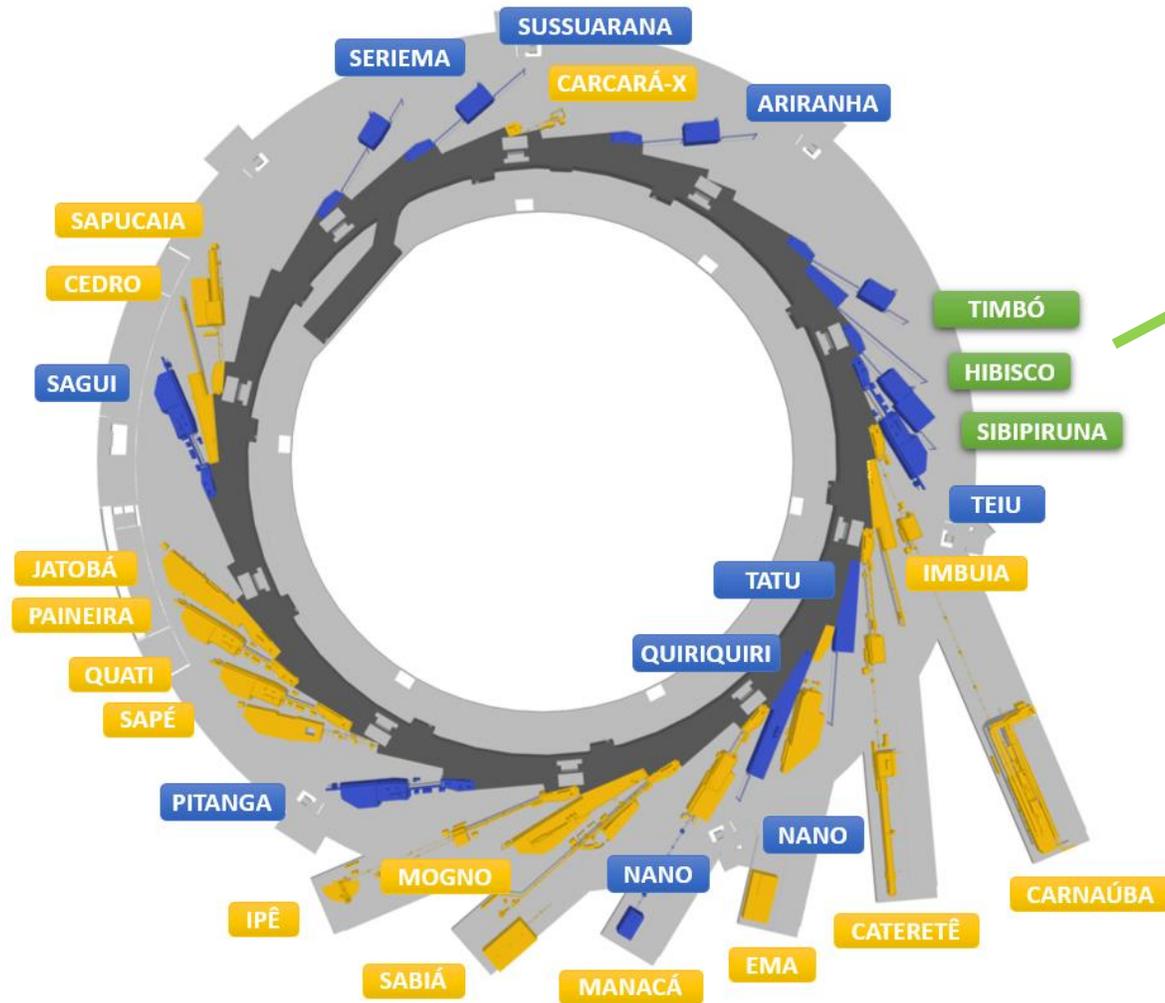


- EXTERNAL USERS
- COMMISSIONING
- ASSEMBLY
- DESIGN



Sirius Status

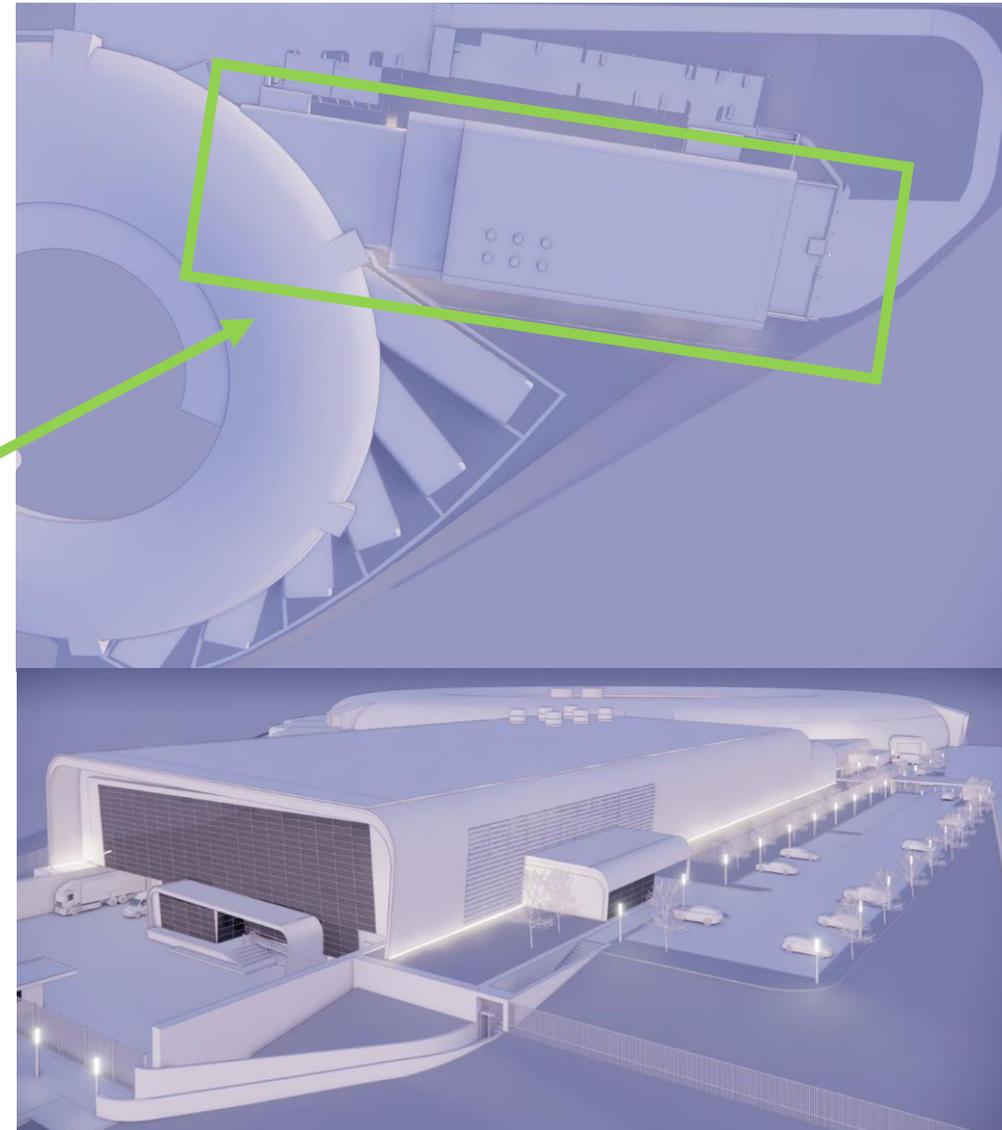
- PHASE I
- PHASE II
- ORION



Orion (NB4)

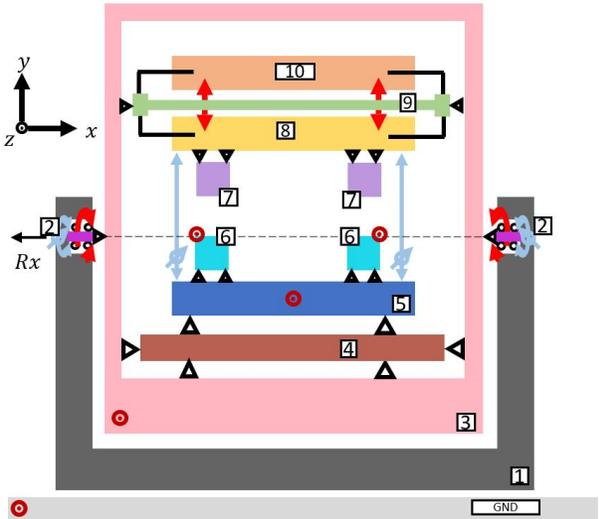
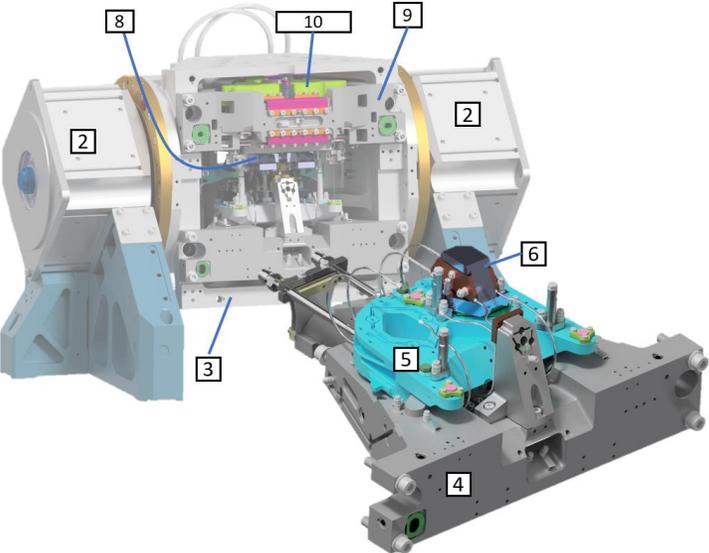


CNPq

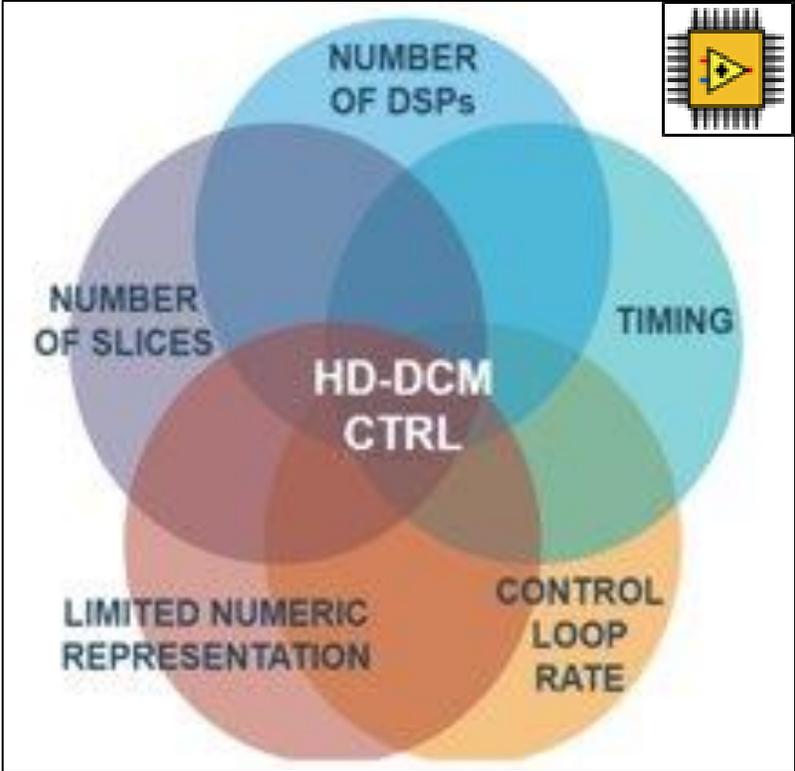
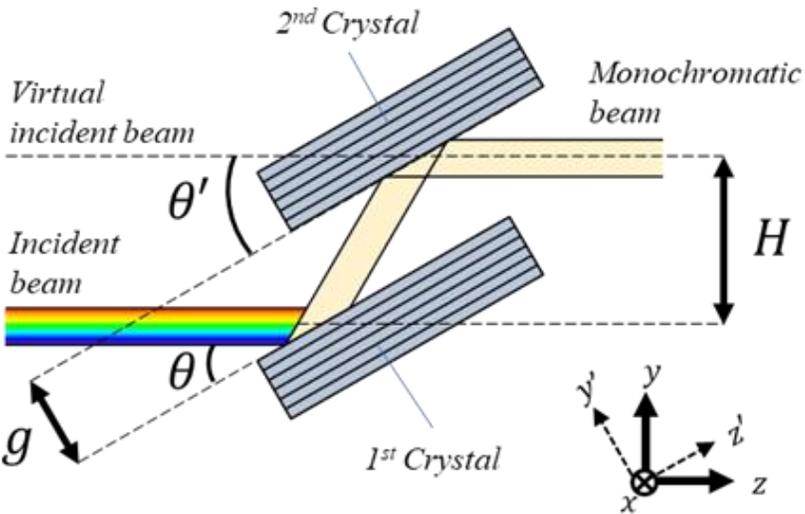


Introduction

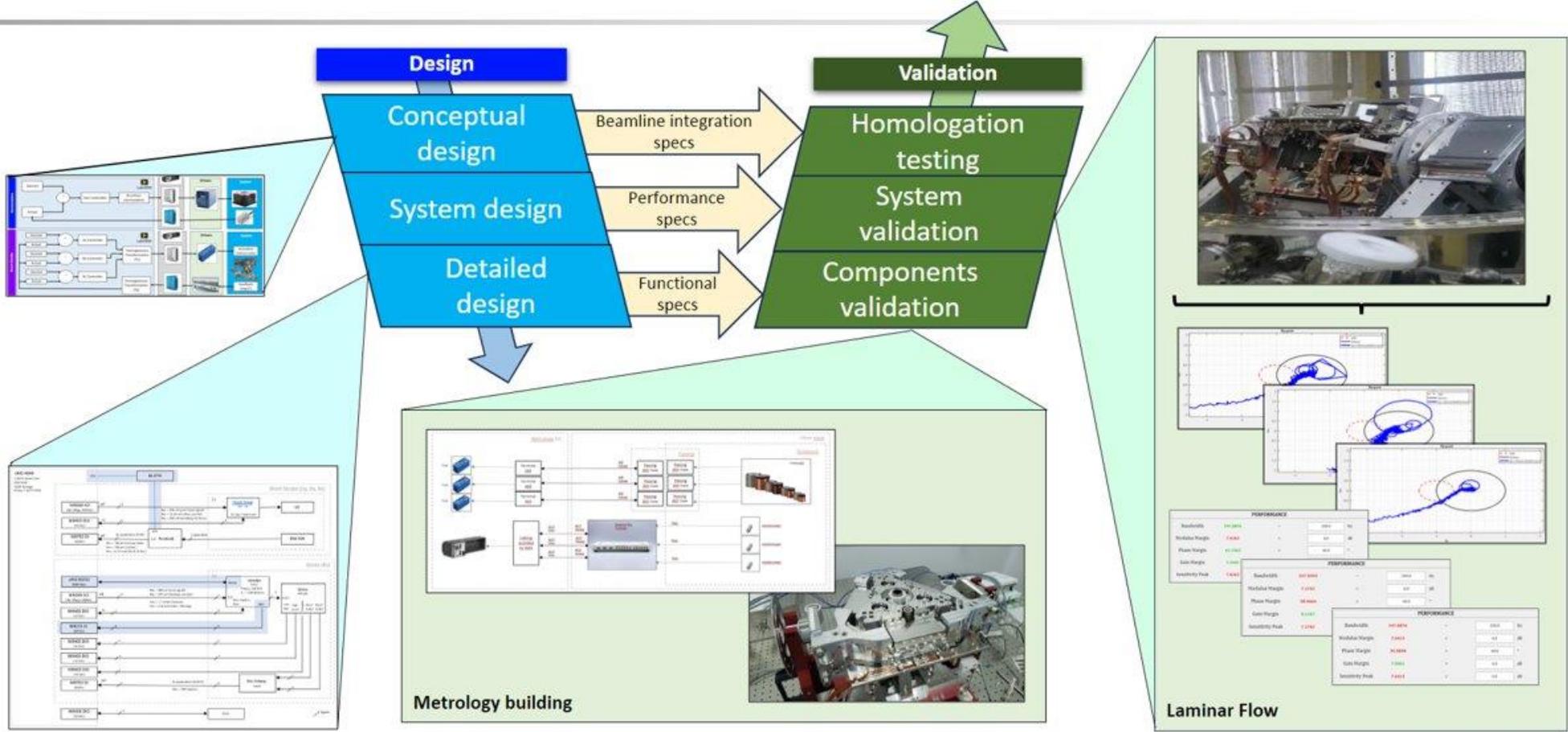
- HD-DCM-Lite.



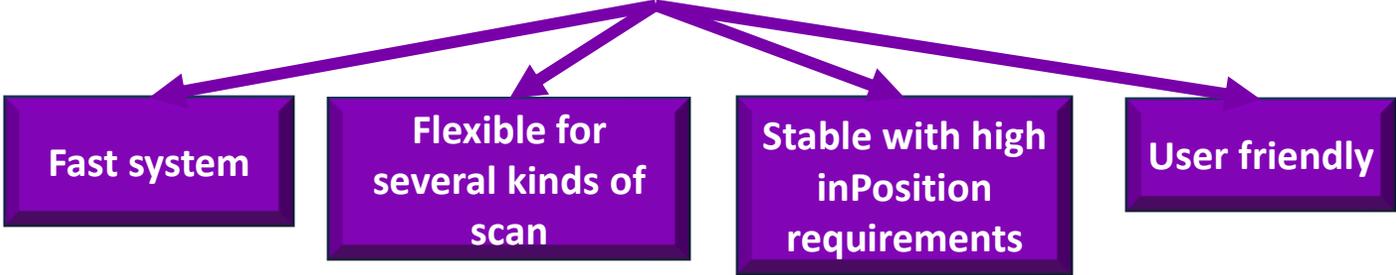
- 0. GND
- 1. GRA
- 2. ROT
- 3. GOF
- 4. AF1
- 5. MF1
- 6. CR1
- 7. CR2
- 8. SHS
- 9. AF2
- 10. BMS
- ▲ Fixed sup.
- ⊕ Bearing
- └ Leafspring
- ◊ Actuation
- ⚡ Metrology
- ⊙ Disturbances



Systems Engineering applied in a Monochromator

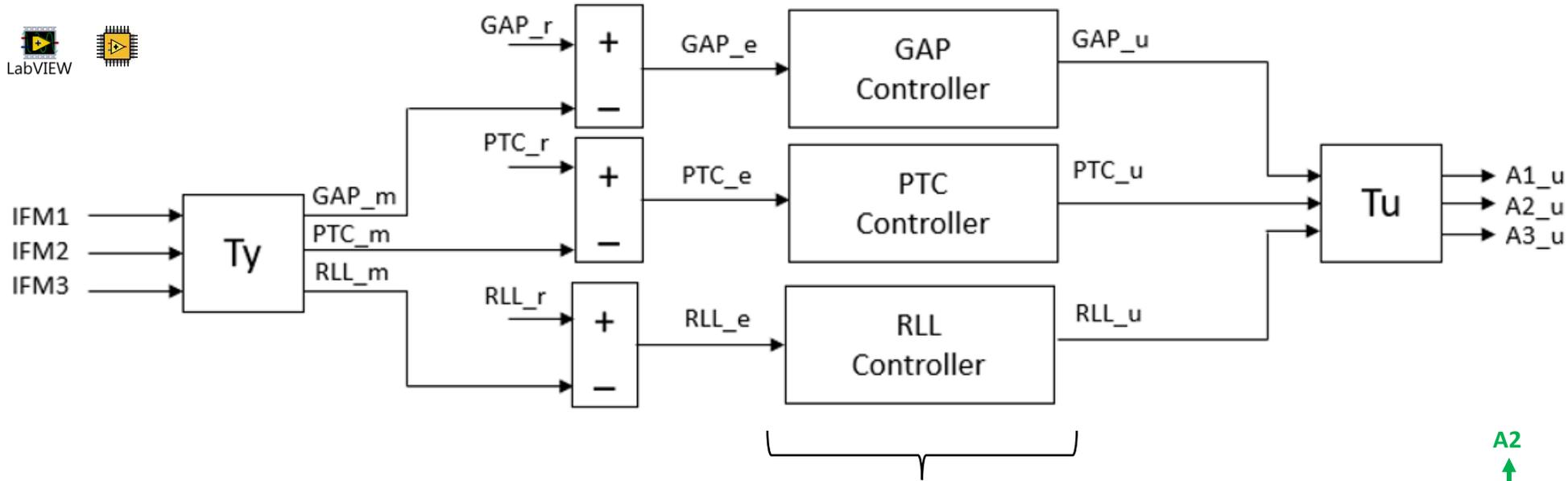


Targets



General System Architecture – Short-Stroke

The general architecture for Short-Stroke is as follow:



Homogeneous Transforms

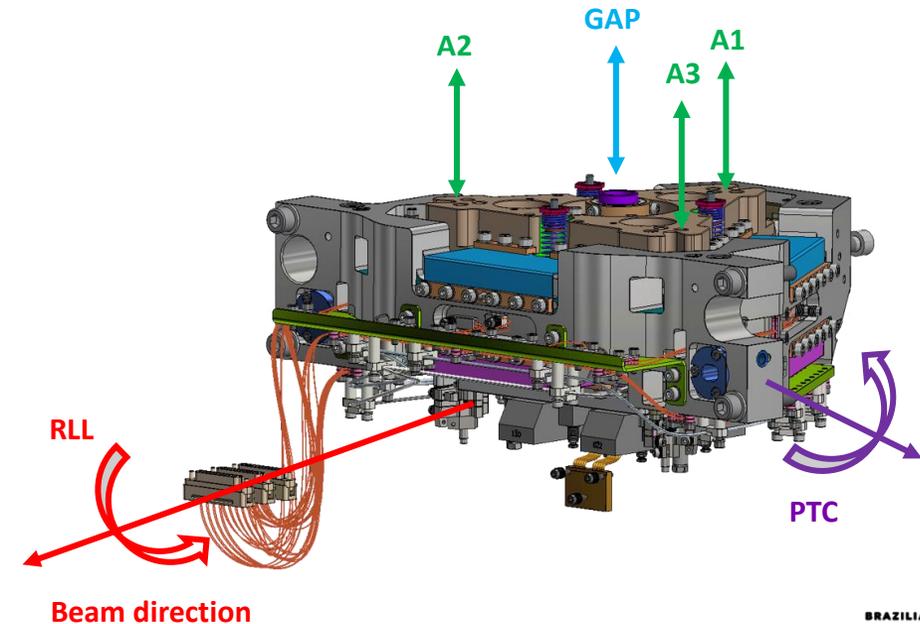
$$\begin{bmatrix} \text{GAP}_m \\ \text{PTC}_m \\ \text{RLL}_m \end{bmatrix} = \frac{1}{3r_{\text{sens}}} \begin{bmatrix} r_{\text{sens}} & r_{\text{sens}} & r_{\text{sens}} \\ 2 & -1 & -1 \\ 0 & \sqrt{3} & -\sqrt{3} \end{bmatrix} \begin{bmatrix} \text{IFM1} \\ \text{IFM2} \\ \text{IFM3} \end{bmatrix}$$

$$\begin{bmatrix} \text{A1}_u \\ \text{A2}_u \\ \text{A3}_u \end{bmatrix} = \frac{1}{3r_{\text{act}}} \begin{bmatrix} r_{\text{act}} & 2 & 0 \\ r_{\text{act}} & -1 & \sqrt{3} \\ r_{\text{act}} & -1 & -\sqrt{3} \end{bmatrix} \begin{bmatrix} \text{GAP}_u \\ \text{PTC}_u \\ \text{RLL}_u \end{bmatrix}$$

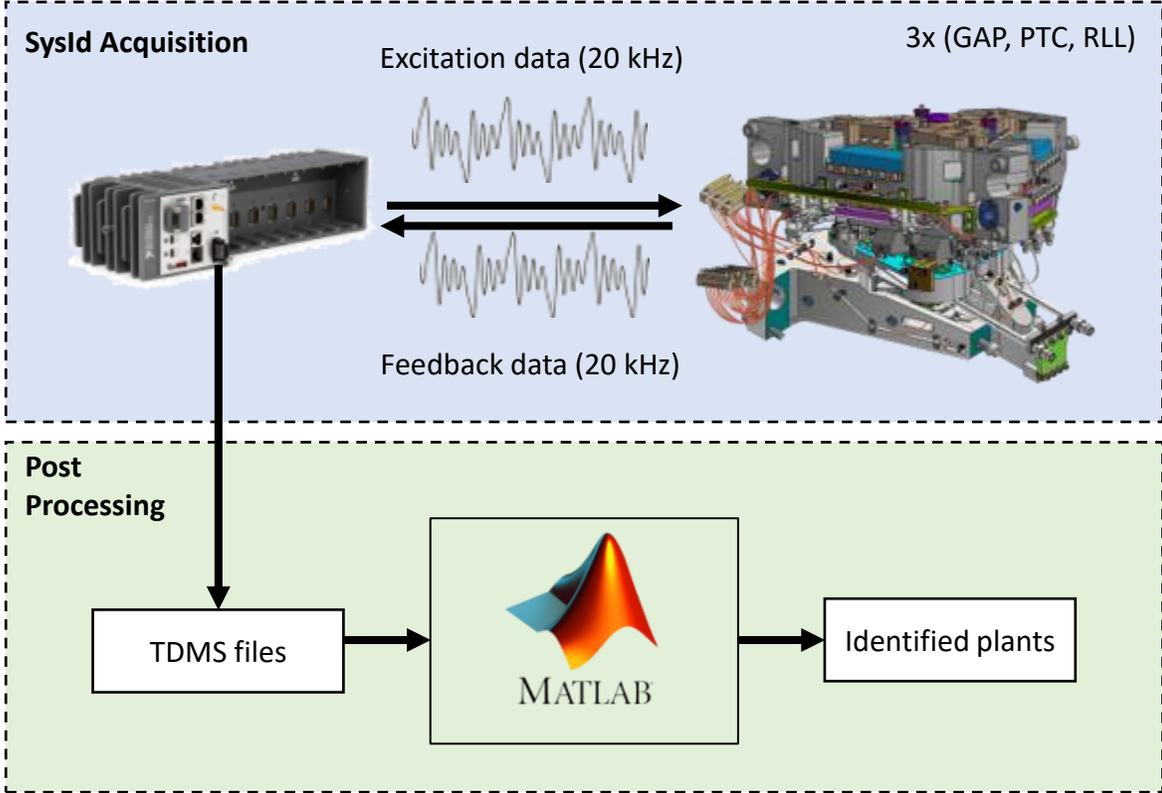
In which $r_{\text{sens}} = r_{\text{act}} = 0.1 \text{ m}$

Each degree of freedom has its own controller

This schematic will only be effective if the system has a low crosstalk (will be shown in the next few slides)



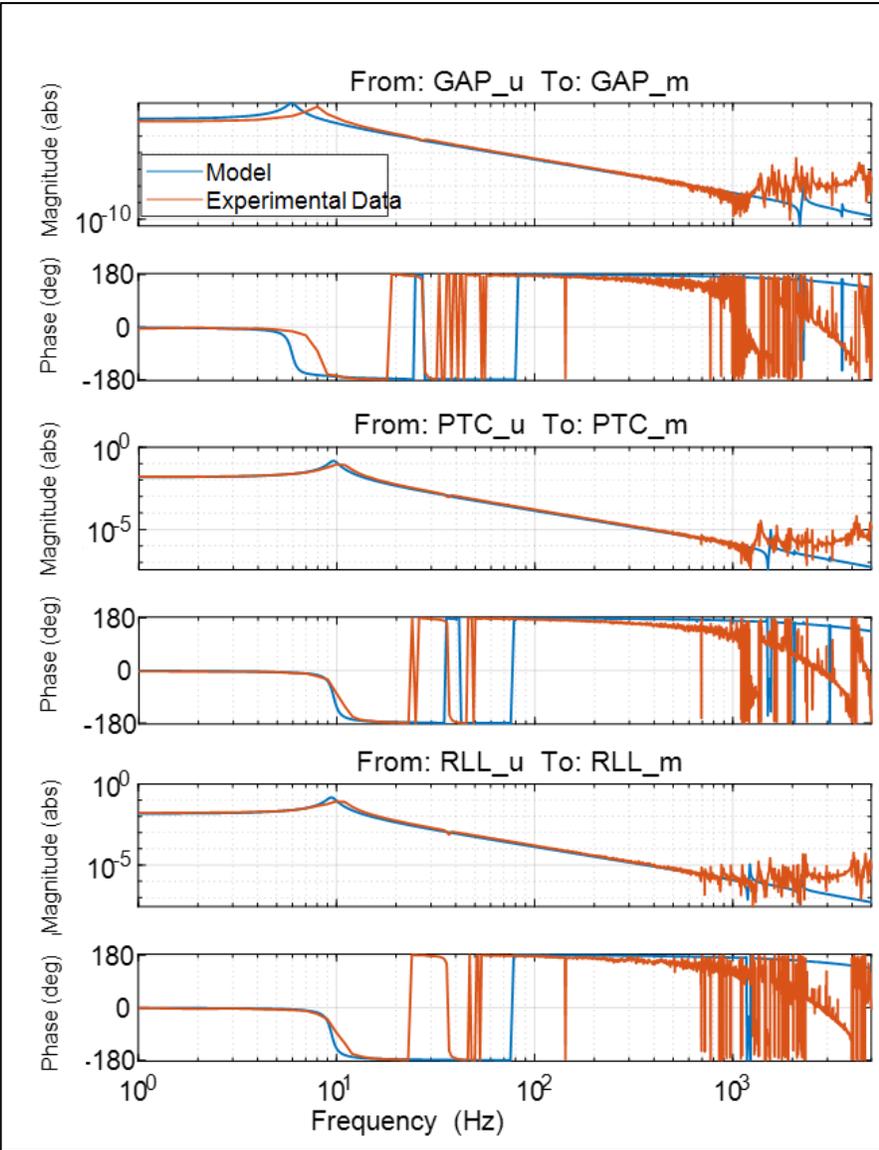
System Identification



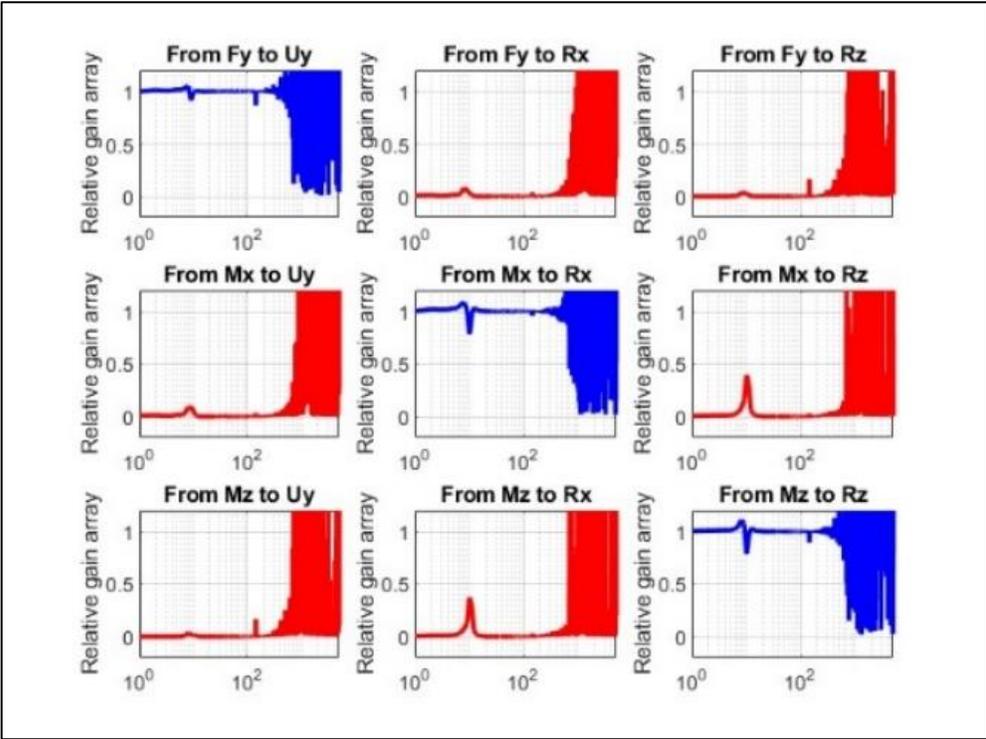
Multi sine setup
(Schroeder phase)

	From	To	Fmin	Fdelta	Fmax	Mod
Multi sine setup (Schroeder phase)	GAP_u	GAP_m	1 Hz	1 Hz	10 kHz	0.5 N
	PTC_u	PTC_m	1 Hz	1 Hz	10 kHz	0.025 Nm
	RLL_u	RLL_m	1 Hz	1 Hz	10 kHz	0.015 Nm

System identification



Crosstalk



Experimental plant matched the designed model.



Crosstalk shows the degrees of freedom are uncoupled, so the SISO approach can be Applied (control each degree separately)



Controller Design- Short-Stroke

Proportional gain

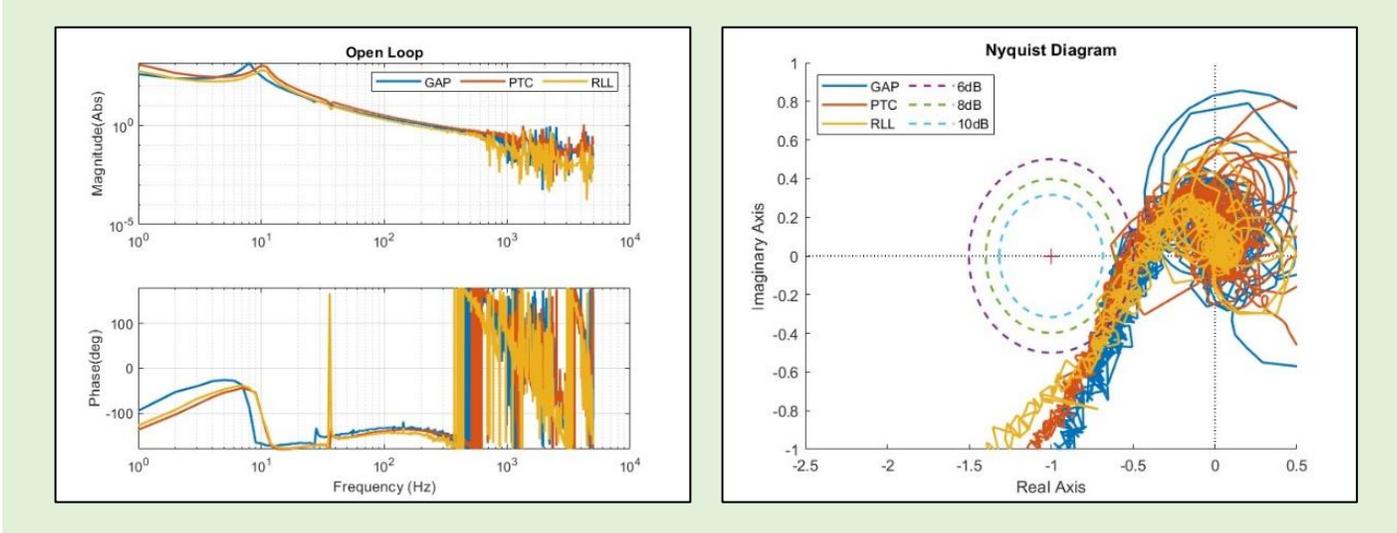
Lead-lag

Integrators

2nd Order Low-pass filter

Notches

Frequency domain charts: STABILITY



Bandwidth and margins: ROBUSTNESS

Performance parameter	Target	GAP (reached)	PTC (reached)	RLL (reached)
Bandwidth	200 Hz	226 Hz	287 Hz	173 Hz
Modulus margin	< 10 dB	8.80 dB	8.97 dB	8.78 dB
Phase margin	> 30°	35.96°	31.73°	34.02°
Gain margin	> 6 dB	4.53 dB	4.10 dB	5.82 dB

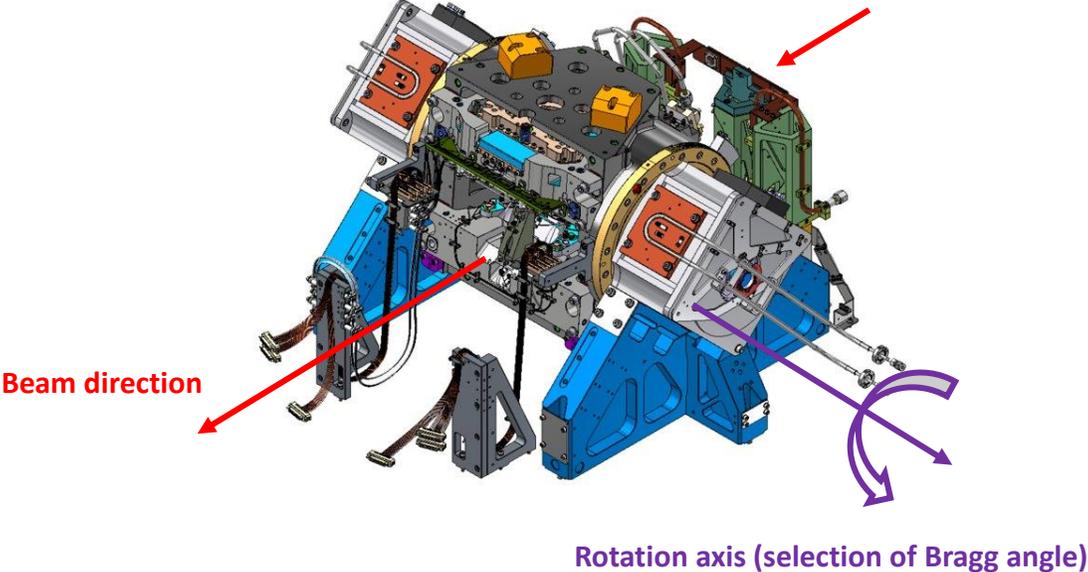
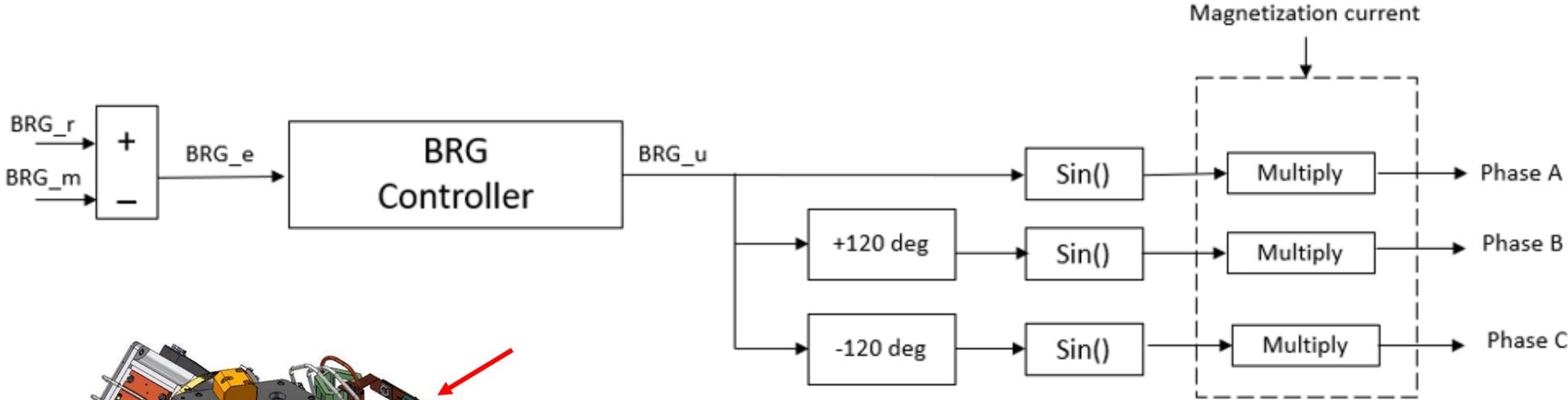
InPosition stability:

- GAP: < 1nm (RMS)
- PTC: < 6nrad (RMS).
- RLL: < 7nrad (RMS).

General System Architecture – Rotary Stages

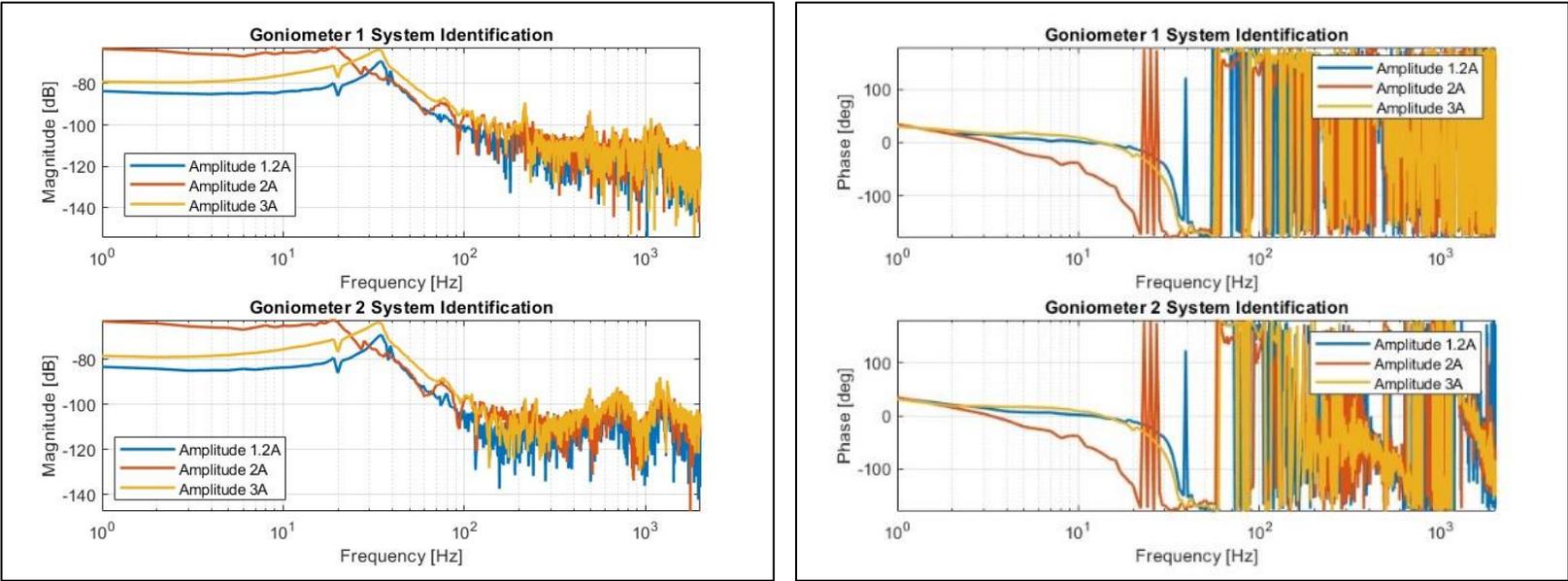


The general architecture for goniometers (rotary stages), by the moment actuation strategy, is as follow : (diagram for a single goniometer)



- Extra goniometer brings:
- Faster scanning possibilities
- Improvements on sync with other equipment

Identified plant after exciting a single goniometer:



Then the controller can be designed in the same way of ShS, with a lower bandwidth target (~30 Hz)

Applied blocks

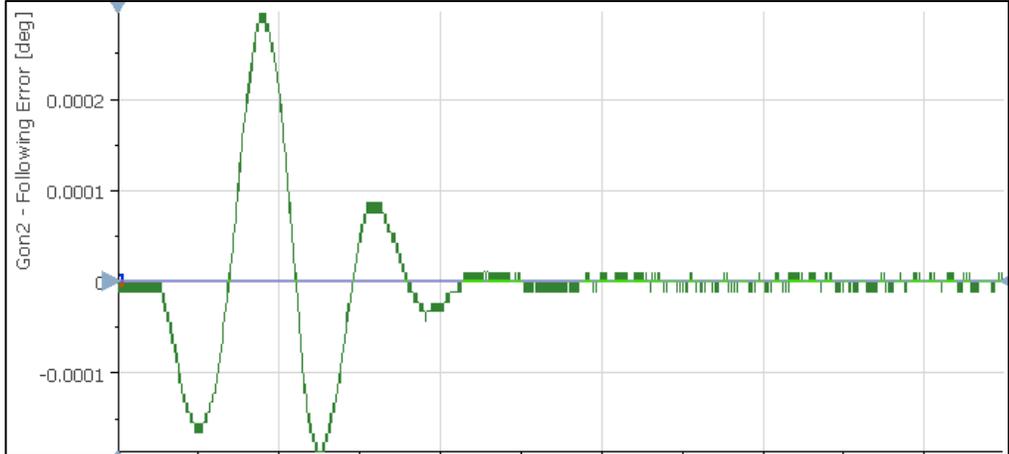
Proportional gain	Lead-lag	Integrators	2nd Order Low-pass filter	Notches
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Features in closed-loop - Rotary Stages

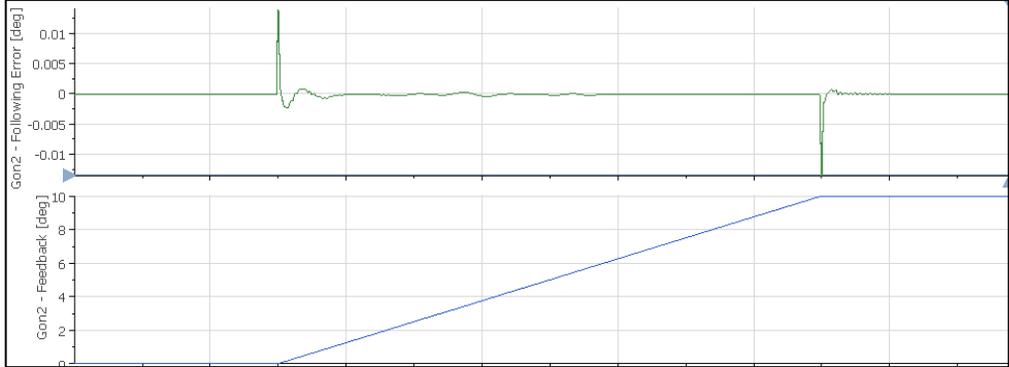


The following features were applied for goniometers:

Phasing (magnetization current grows in closed-loop mode)



Movement at 2.5 degrees per second



Quick and intuitive application for the offline commissioning



THANK YOU

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