- Journées Lisa France 2026 -

Testing Lisa with the Beam Simulator

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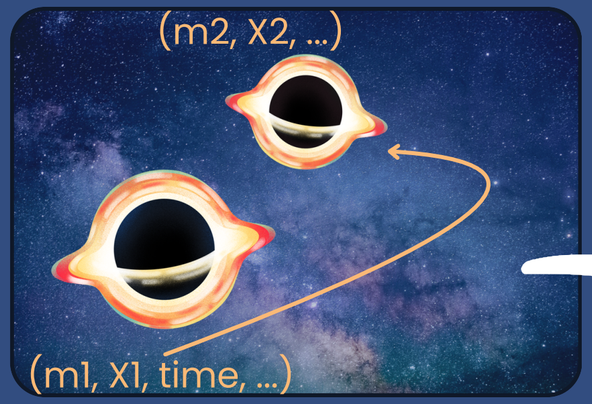
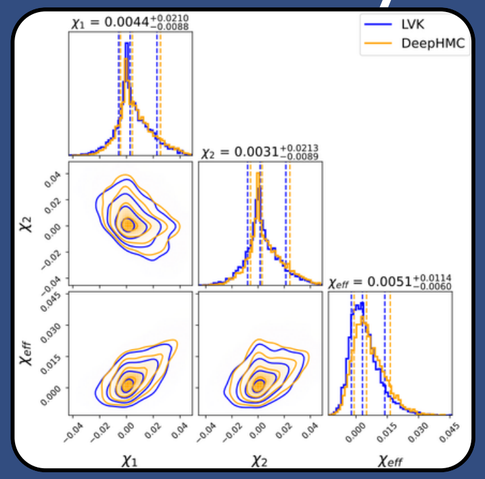
LISA goal



- Source **catalogue**
- **Astrophysics** & **cosmology** applied on the catalogue

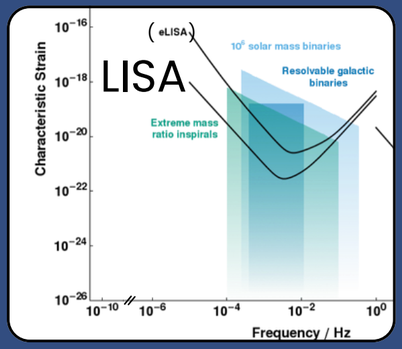
Data analysis



- Event **detection**
- **Parameter estimation**

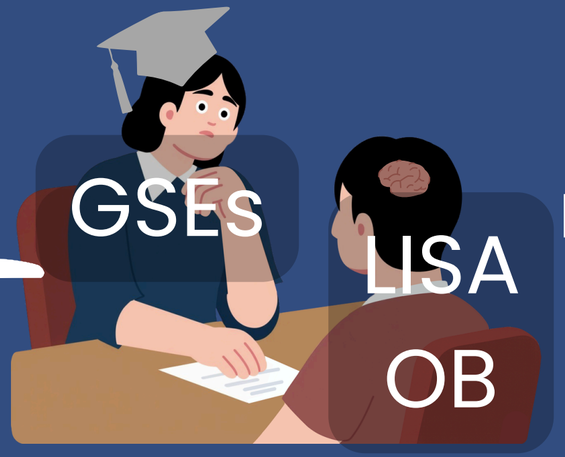
Instrumentation

(& launching & constellation orbiting & etc.)



- Instrument must reach **performances** that allow detection
- Instrument **characterization**

GSE (Ground Support Equipment) must reach performances allowing for LISA performances assessment



BSIM + Test Mass Simulator + Laser + ... = GSEs

The Beams SIMulator (BSIM) is an Optical Ground Support Equipment, one of the solutions to test the Lisa Optical Bench (OB)

- The IDS test setup (~ GSEs + OB)
- What is the BSIM ?
- How does the BSIM work ?
- What happened last year ?

  Focus on:
  - BPAM
  - RxPCS
  - Masks

IDS test setup

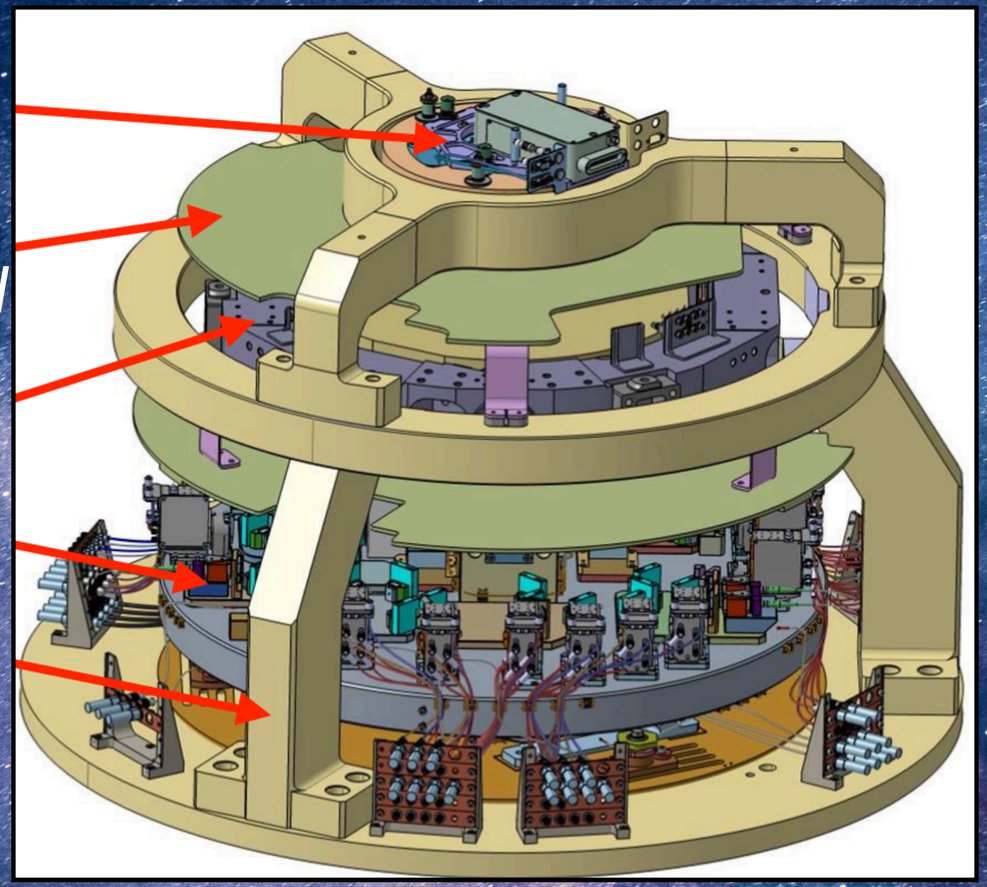
Test Mass Simulator

Thermal & straylight shield

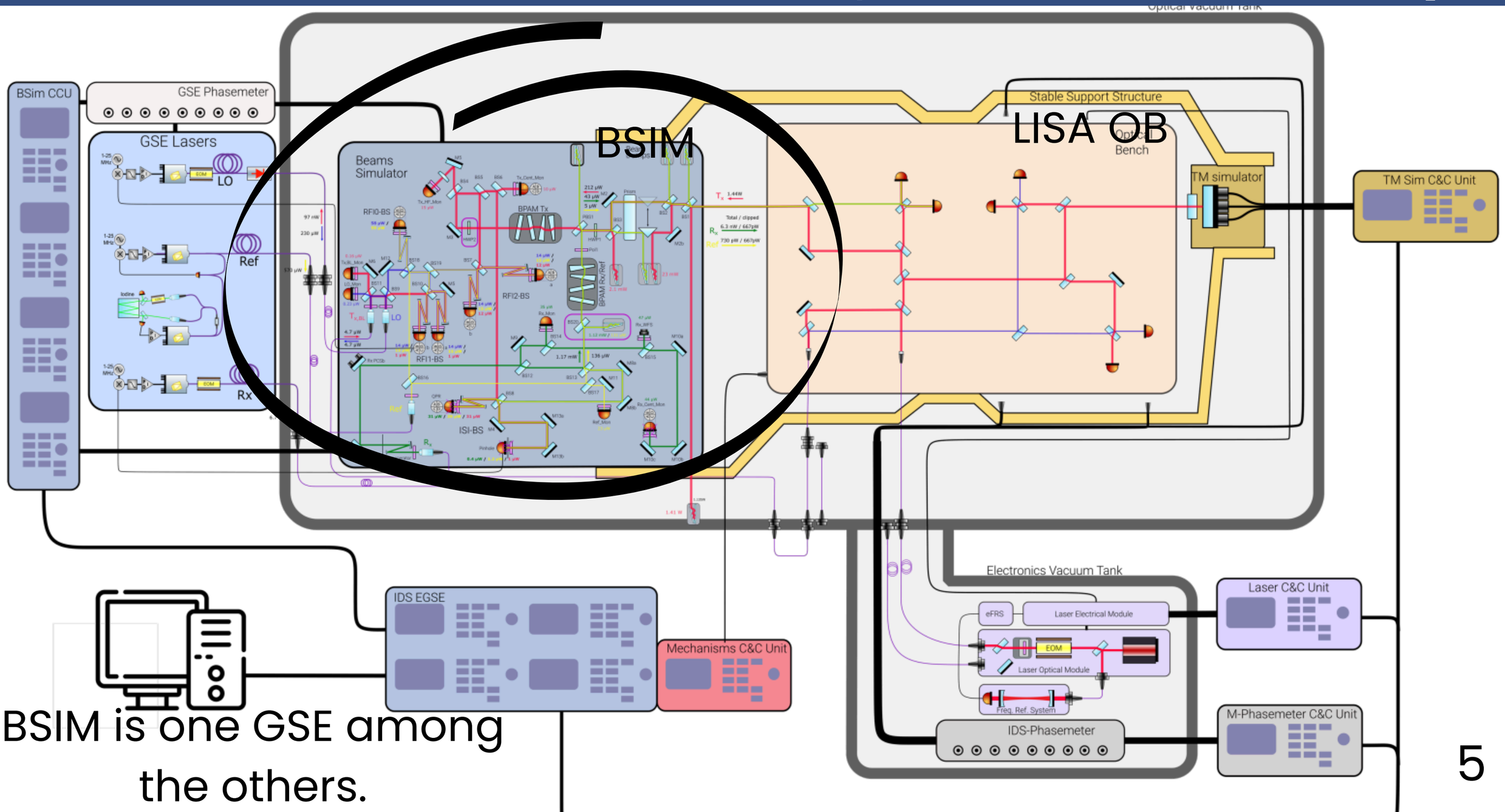
Optical bench

Beams Simulator

Stable Structure

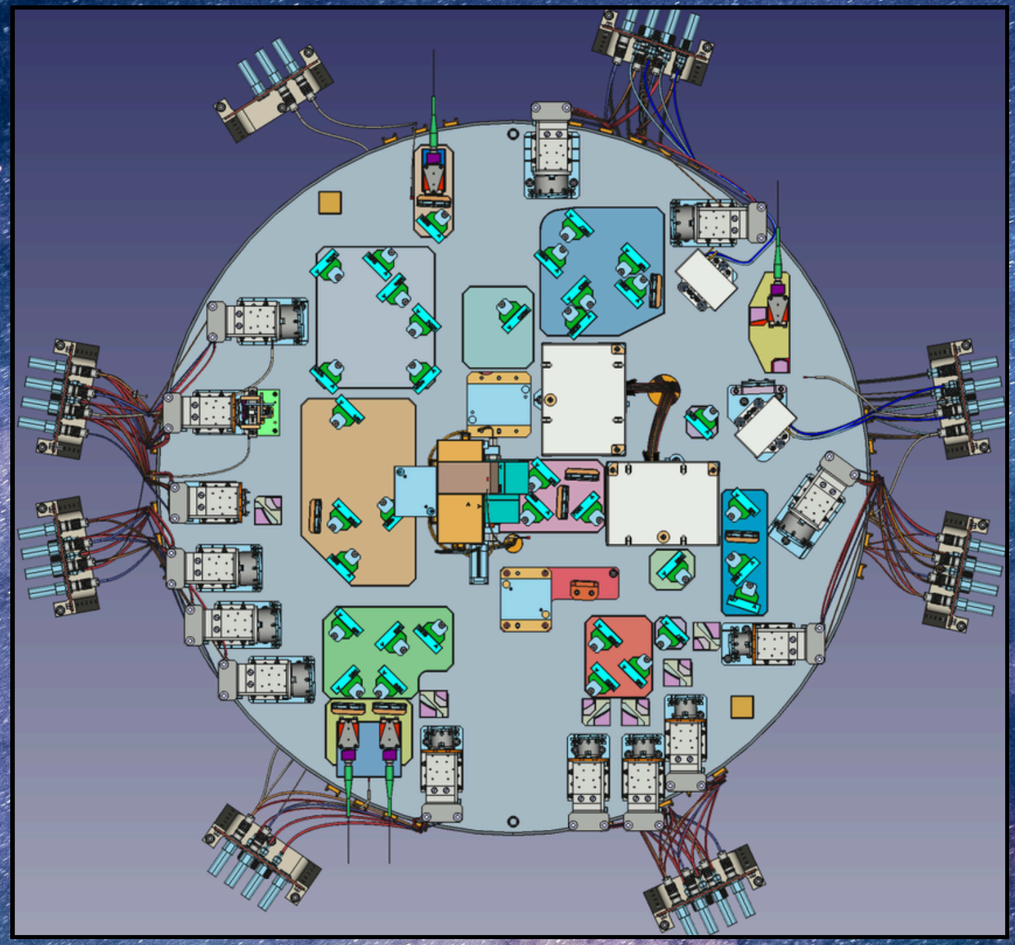


Interferometric Dectection Subsystem (IDS) **test setup**



BSIM is one GSE among the others.

BSIM

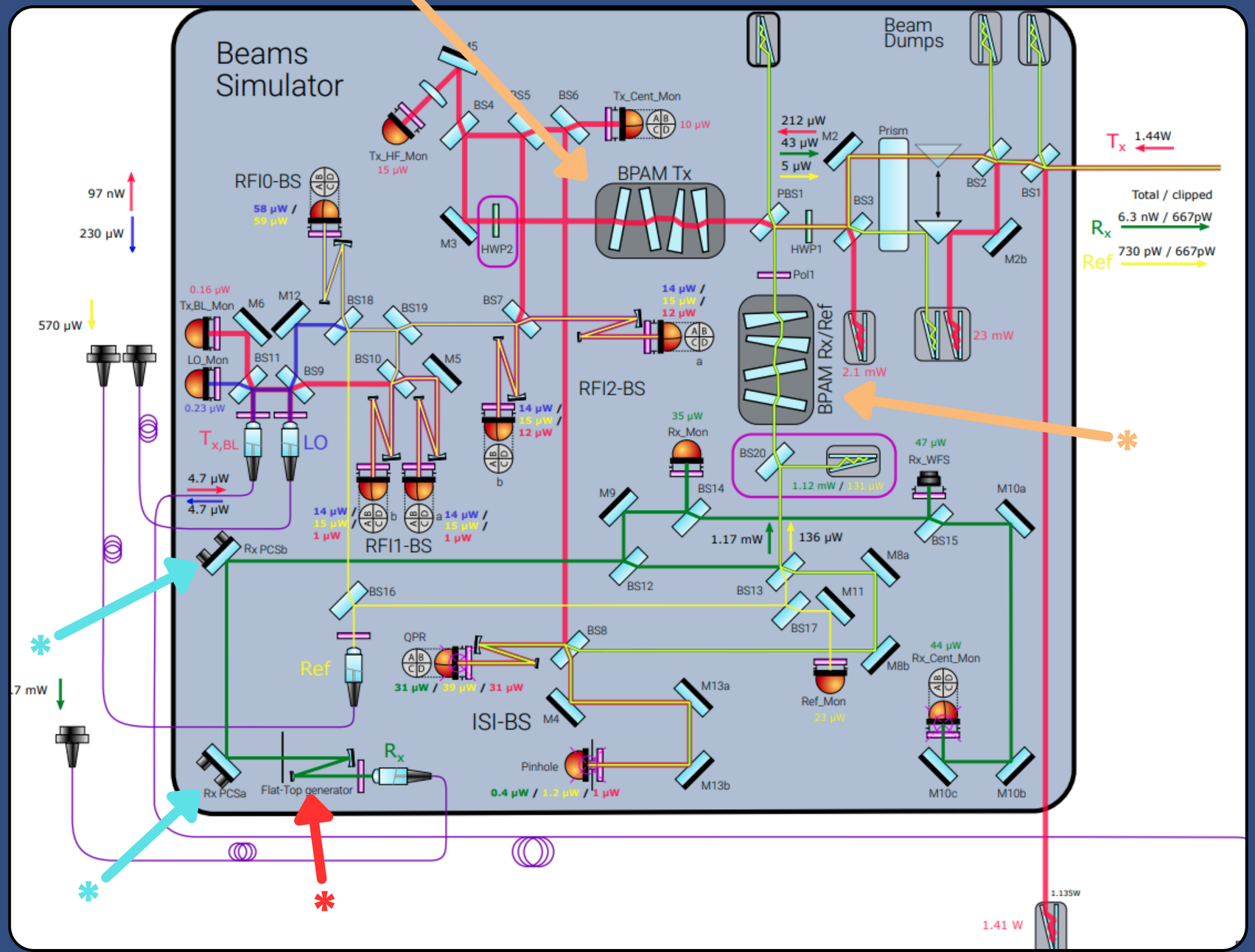


What is the BSIM ?

ZIFO example: zerodur slab with optical contacted components

- 775 mm diameter disk zerodur bench
- Contacted optical components

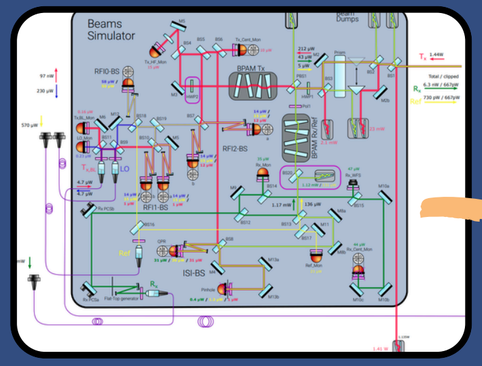
How does the BSIM work ?



Main function:
Simulate the optical interfaces of one Lisa OB

Functions in BSIM are ensured by subsystems (**RxPCS***, **BPAM***, **Flat-top generator***, etc.)

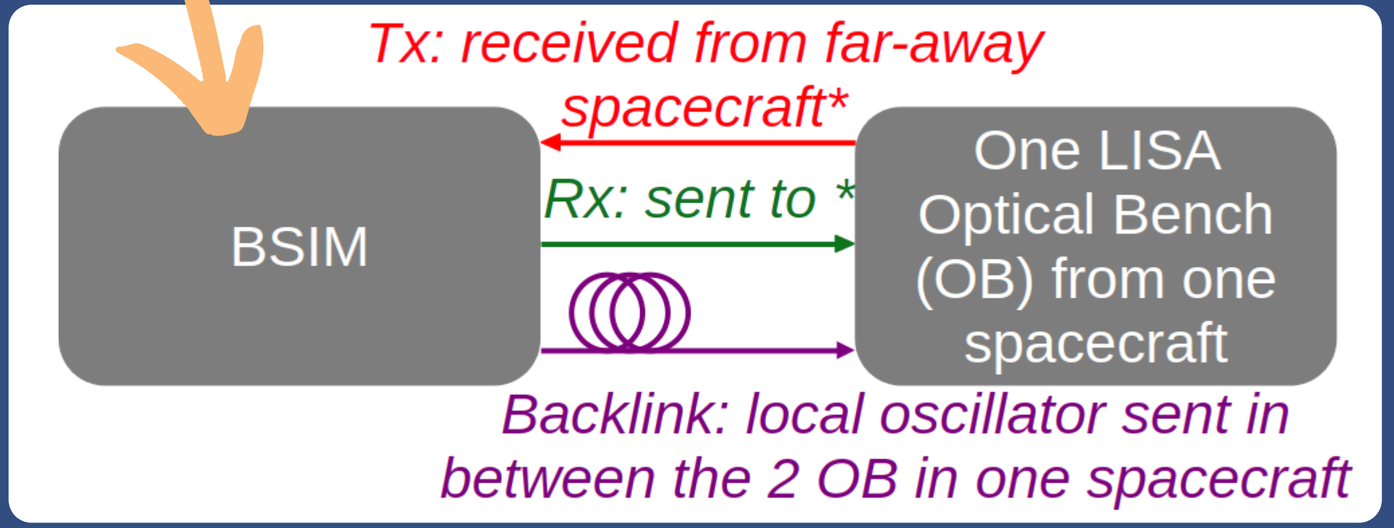
How does the BSIM work ?



Main function:
Simulate the optical interfaces of one Lisa OB

Main test objectives:

- TTL Rx measurement
- OB/BSIM stability measurement
- Scientific interferometer performances
- Functionnal/performance validation

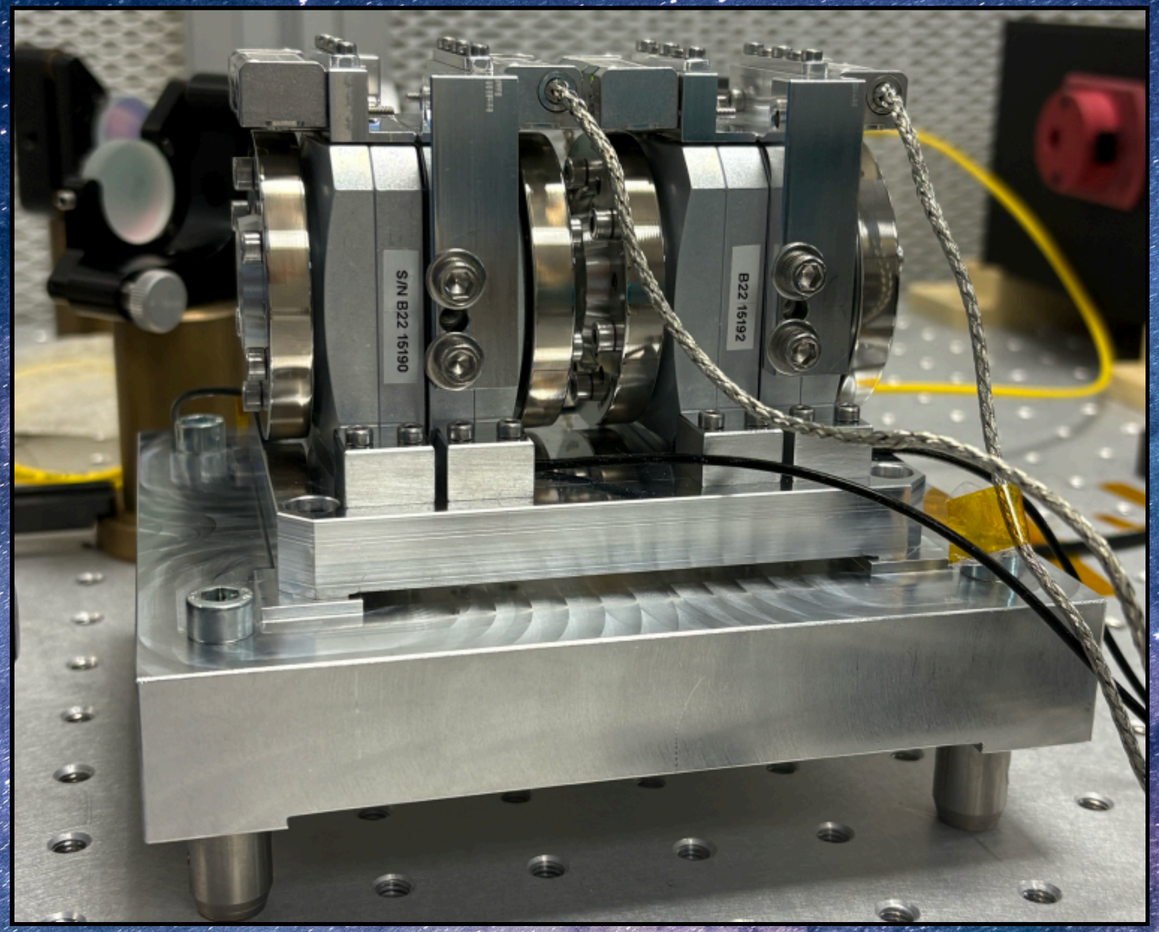


What happened last year in BSIM team ?

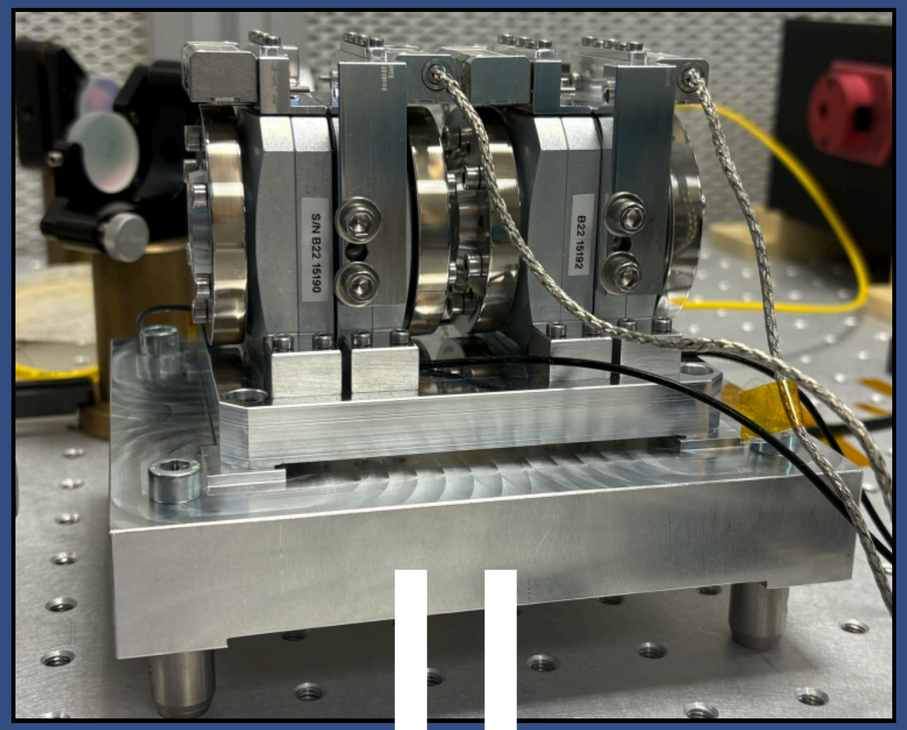
Focus on 3 main subsystems (3 APC Customer Furnished Items)

- BPAM: performance characterization
- RxPCS: feedback loop
- Masks: simulation & production

BPAM



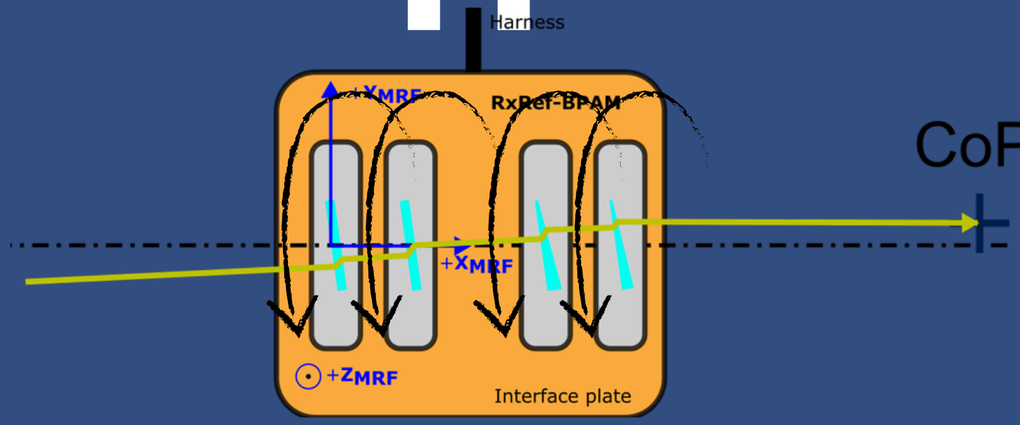
What is the BPAM ?
Beam Pointing Alignement Mechanism



BPAM main function

Align OB and BSIM at um (alignment) and urad (pointing) precision (after mechanical alignement).

Pointing, alignment and optical path have to be very stable



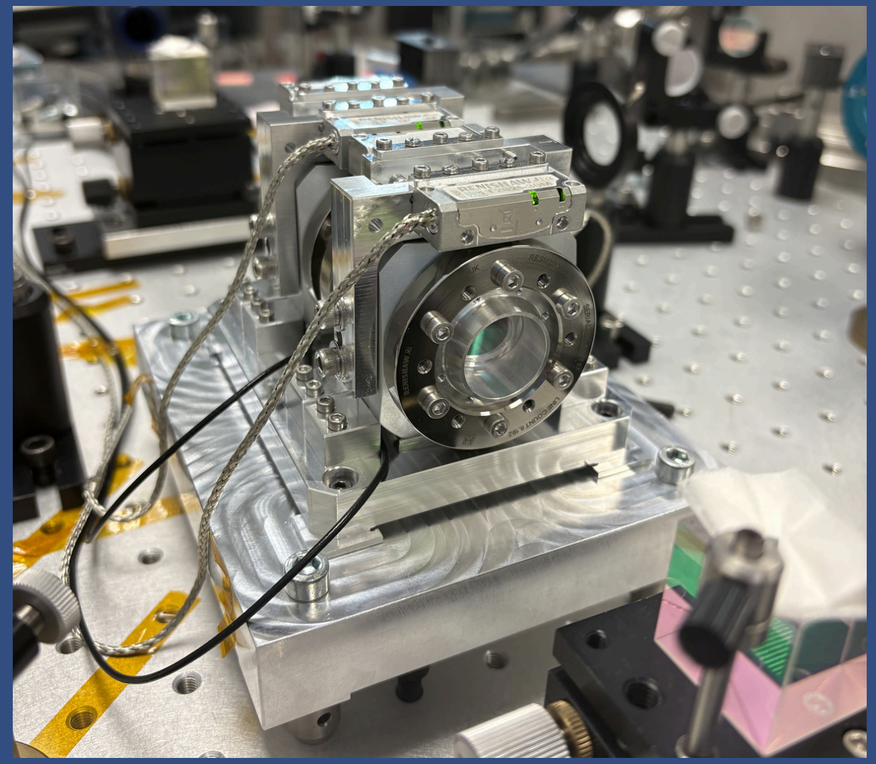
=

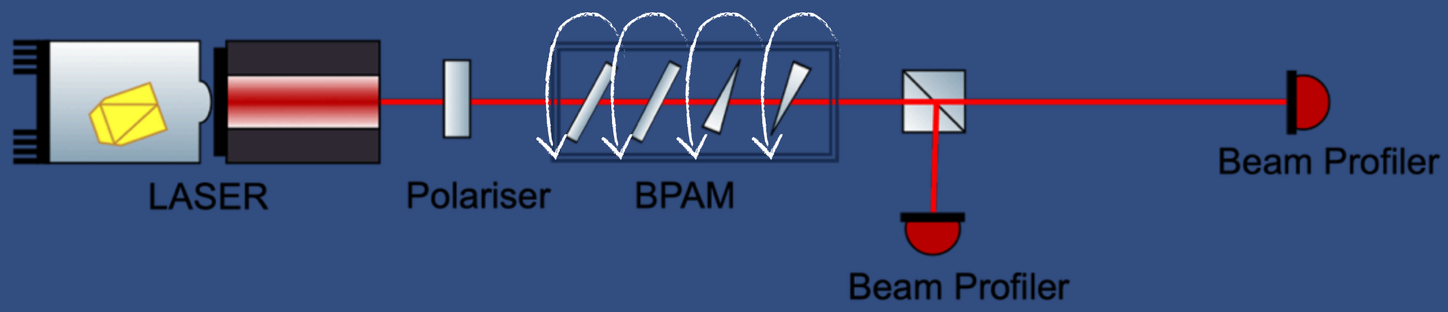
2 rotating parallel face blades
+ 2 rotating non parallel face prisms

BPAM main prototyping activities

Validate BPAM specifications

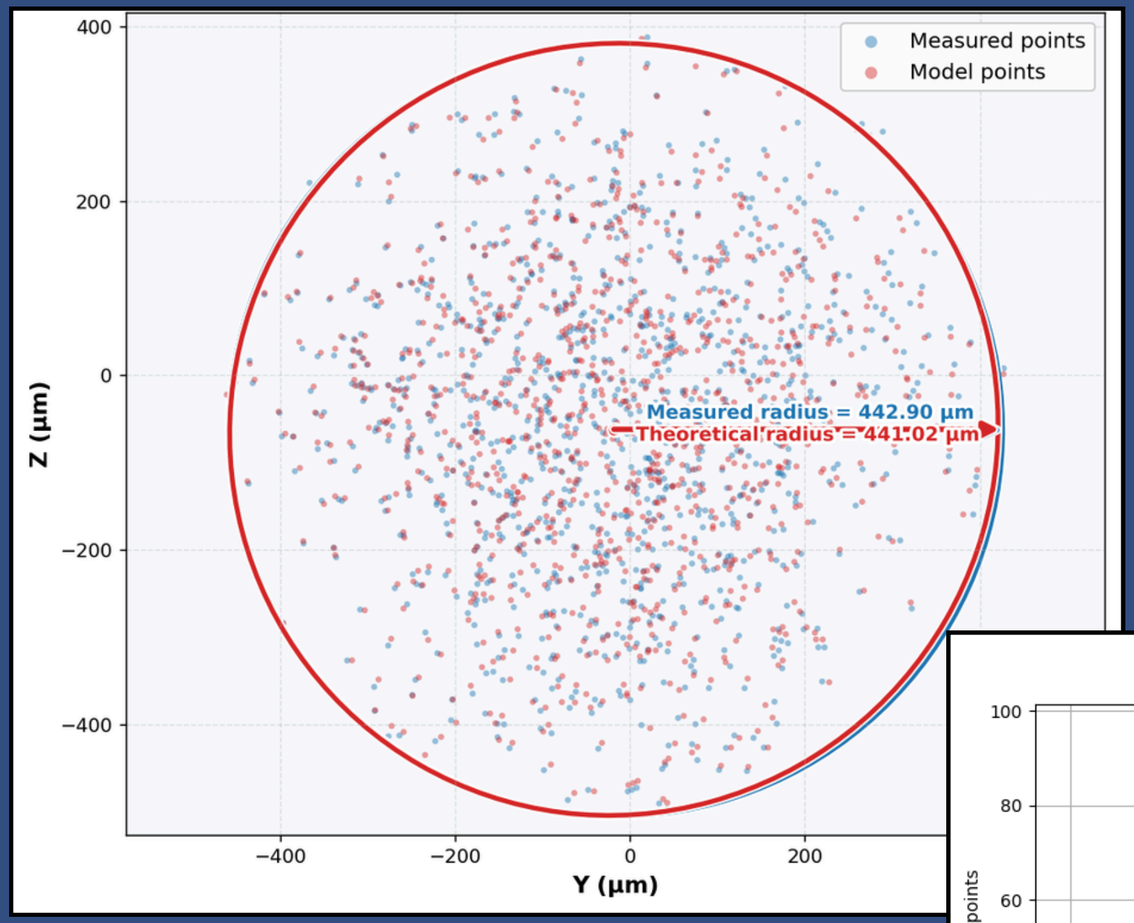
→ Focus on um & urad precision: rotating all 4 prisms and explore the space of positions (allignement) and angles (pointing).



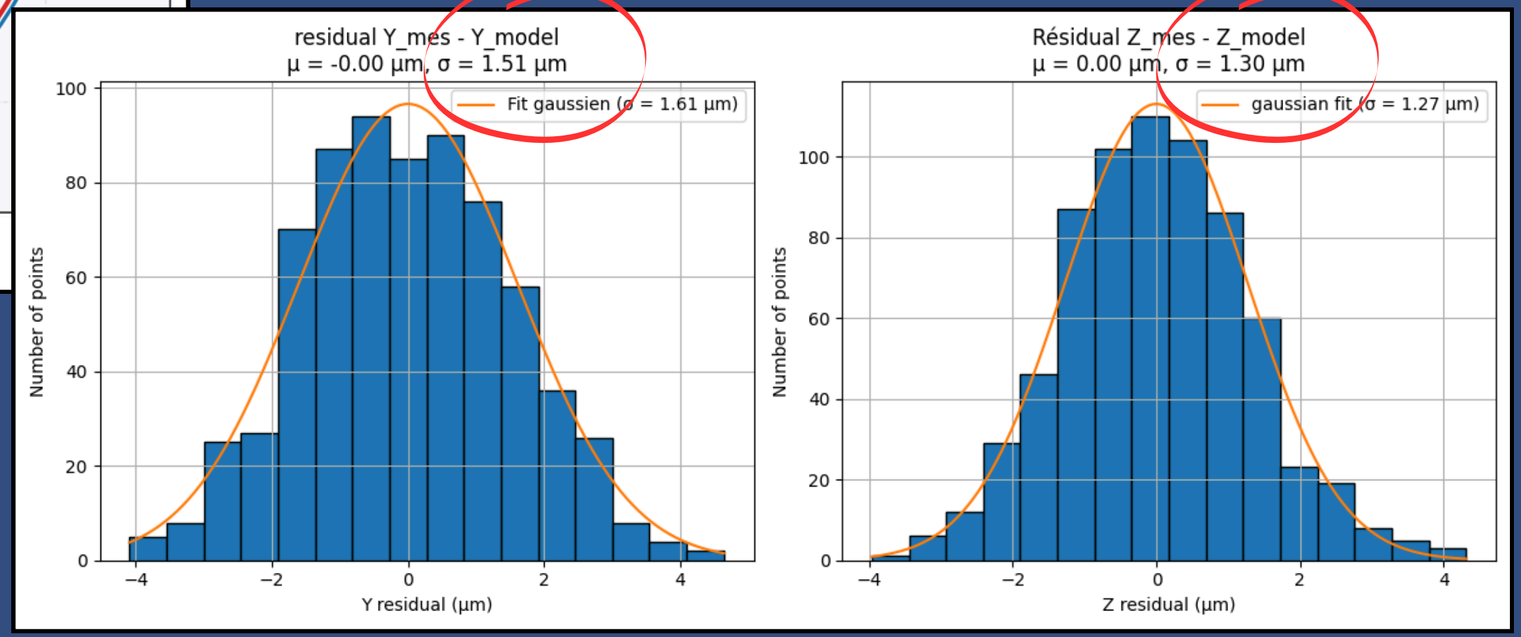


Comparing measurement and simulation ....

BPAM allignement results



Statistics on residuals
(theory - measurement
for each point)



RxPCS

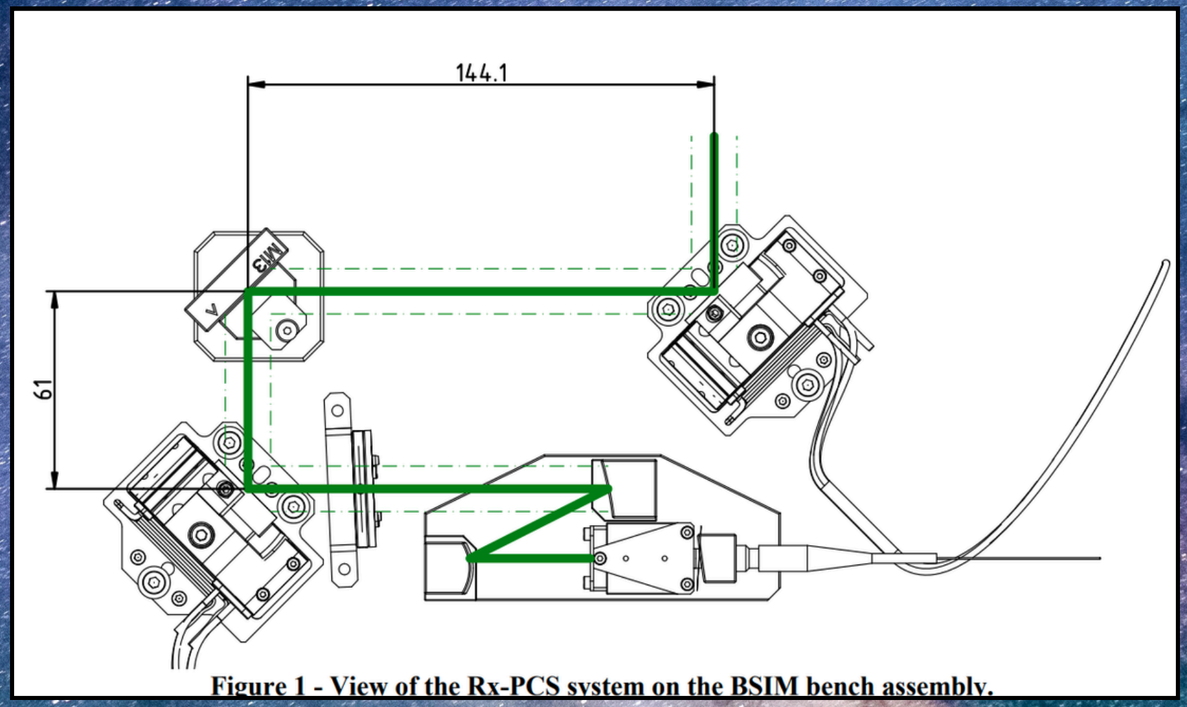


Figure 1 - View of the Rx-PCS system on the BSIM bench assembly.

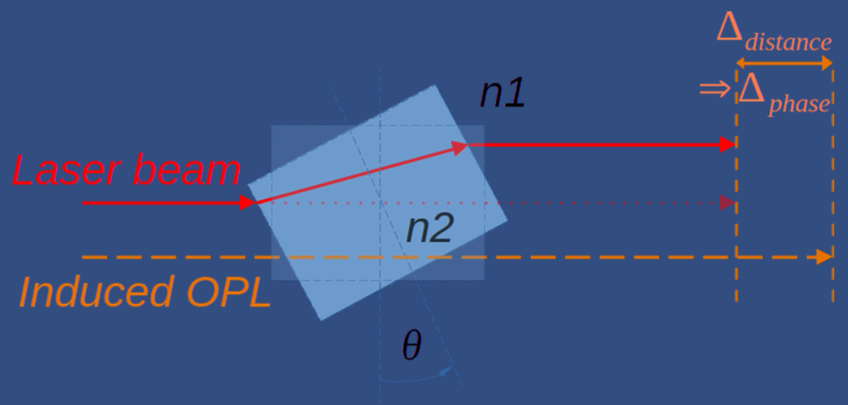
What are the RxPCS ?
Rx (Beam) Pointing Control System

Main function

Evaluate OB residual
Tilt-To-Length (TTL)

→ OK but what is TTL ?

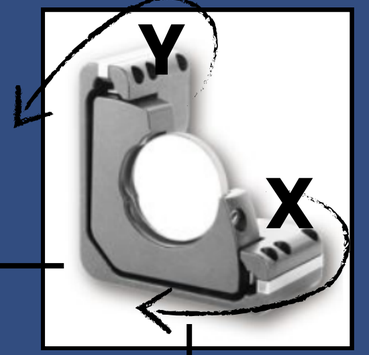
Coupling between optical path length and mechanical rotation, example:

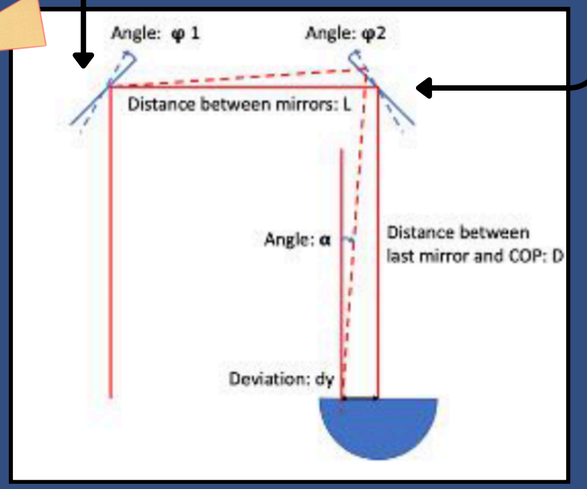


To allow pointing the center of a photodetector and choose the angle

Hardware

A pair of 2-axis actuated mirors to control allignement and pointing

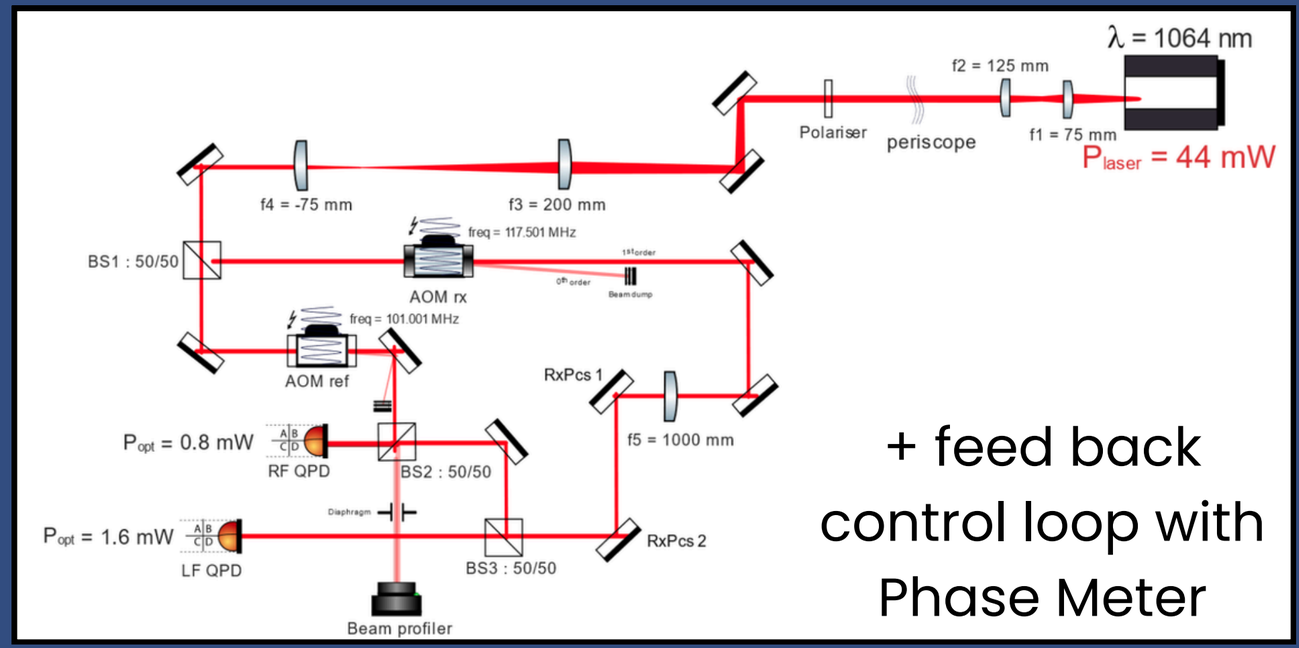




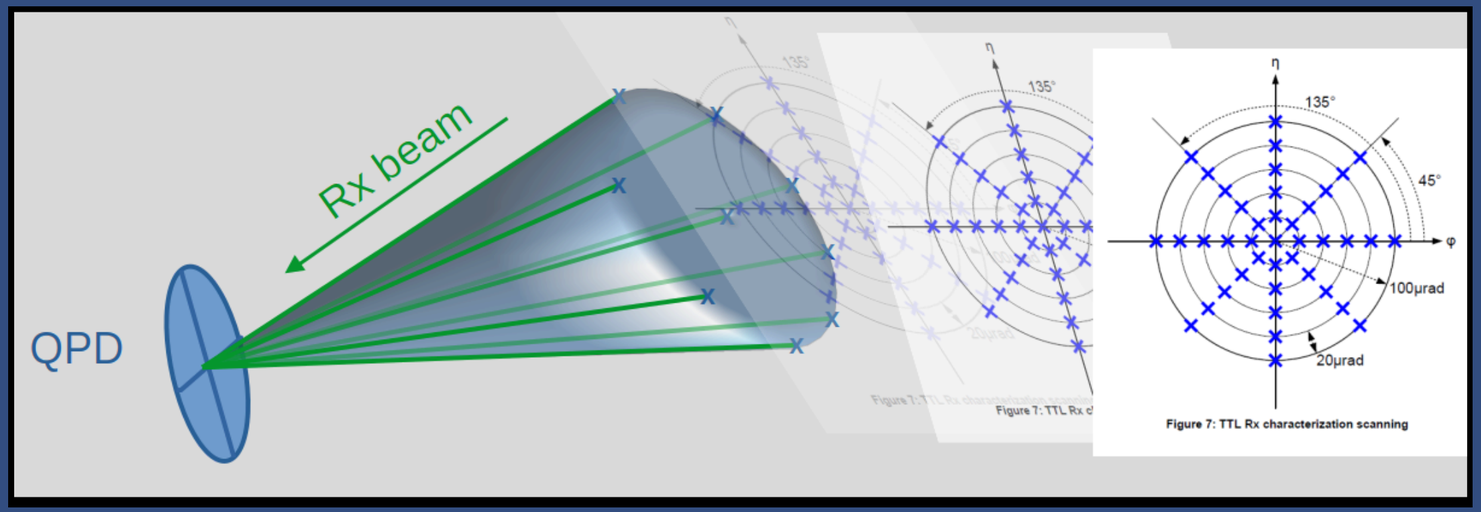
RxPCS main prototyping activities

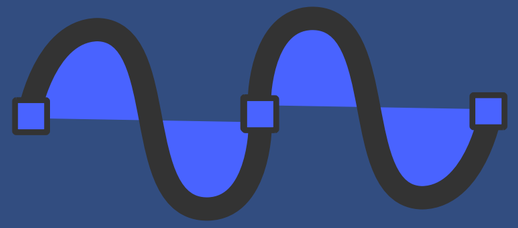
Goal of the experiment

Pointing center of Quadrant PhotoDetector (QPD) with sinusoid input angle

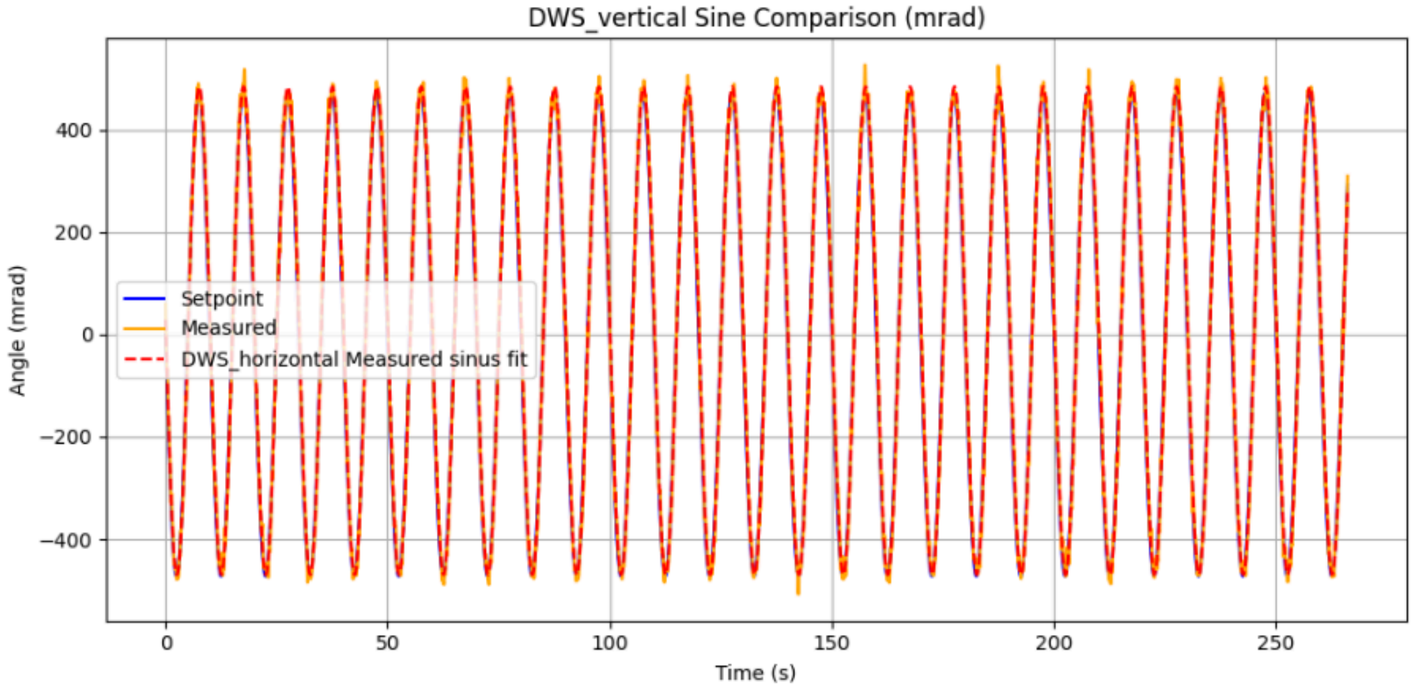


+ feed back control loop with Phase Meter





RxPCS control feedback loop results



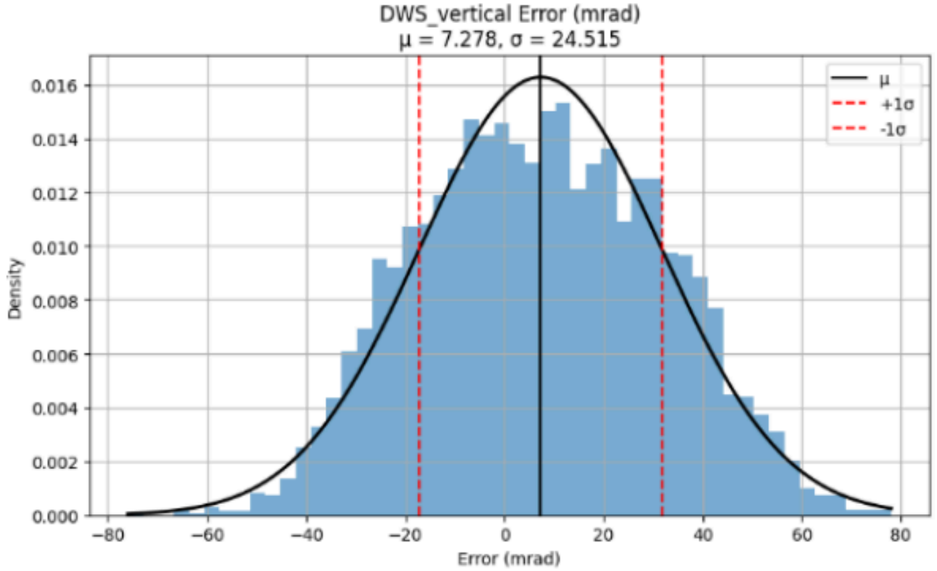
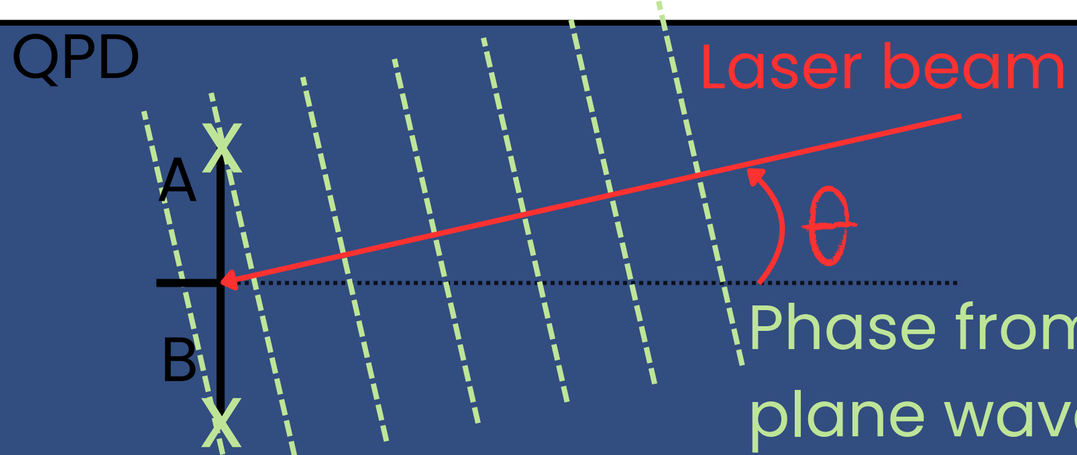
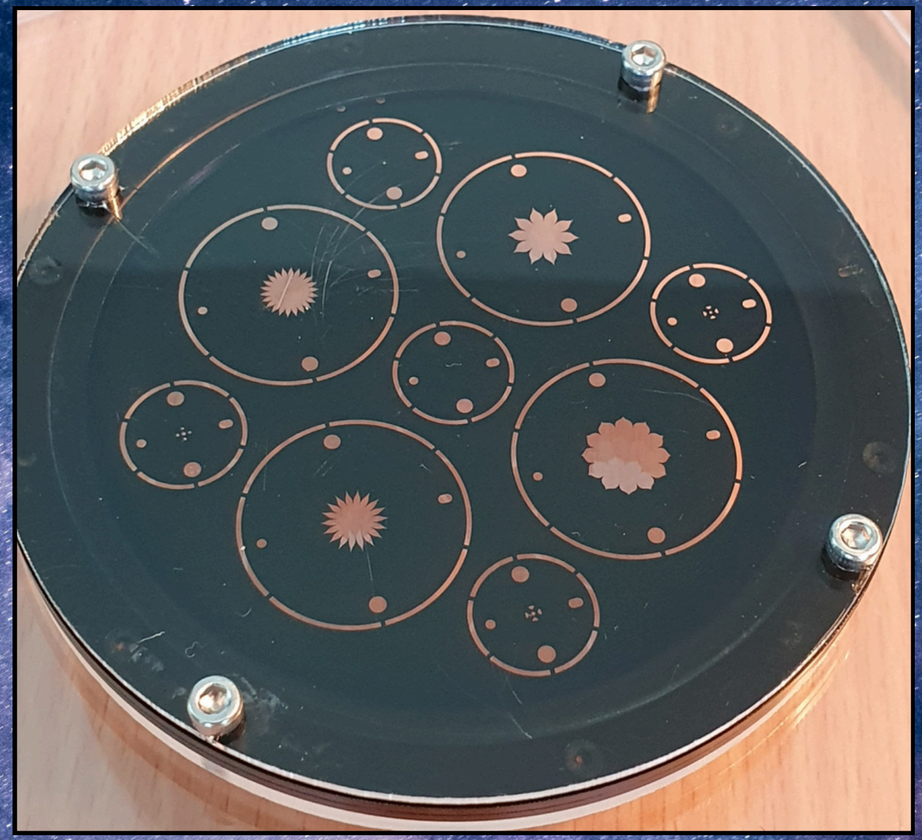


Figure 20: Sinusoidal command with closed control loop



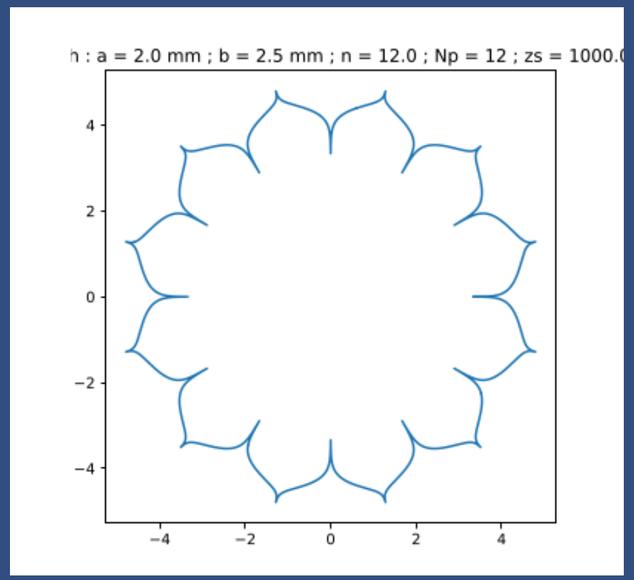
θ is proportional to phase difference between A & B

Masks



Masks descriptions

Apodization

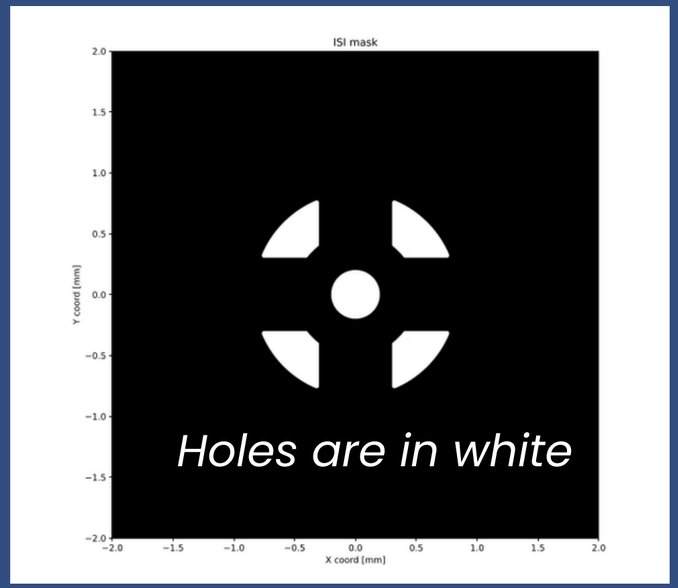


Main goal
Create a flat top by truncating gaussian beam without creating diffraction.

Shape comes from star occulter and is driven by specifications after 1 m propagation:

- Intensity must be uniform & above a threshold in a defined radius (flat-top)
- Phase must be erratic outisde of this radius (no interferences outside RIO)
- etc.

Centering



Main goal
Create reference CoP for Ref beam = pinhole

- 4 holes on the sides to center mask on a QPD.
- Then only the hole in the center will be used on a classic PD.

Mask manufacturing

Prototypes:

Laser cut in metal (10-20 um)

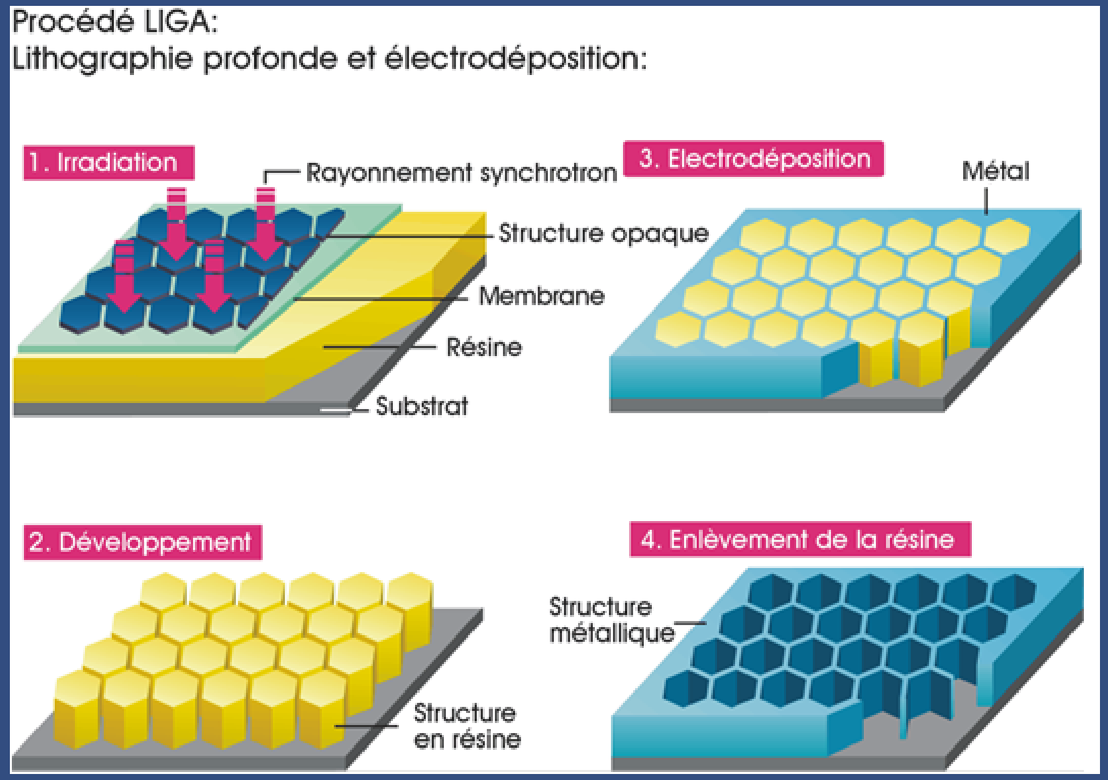
Final version:

Growing a thin Nickel plate at Soleil (< 1 um)

Both masks (apodization and centering) require high precision manufacturing, at a few µm level :

- Petal details and uniformity for the apodization mask
- Accurate shape and relative positions of the holes for the centering mask.

In addition, the masks shall be AR coated to minimize straylight.



https://www.synchrotron-soleil.fr/fr/solutions-pour-les-entreprises/autres-prestations-specifiques/microfabrication-avec-le-rayonnement

Thank you !

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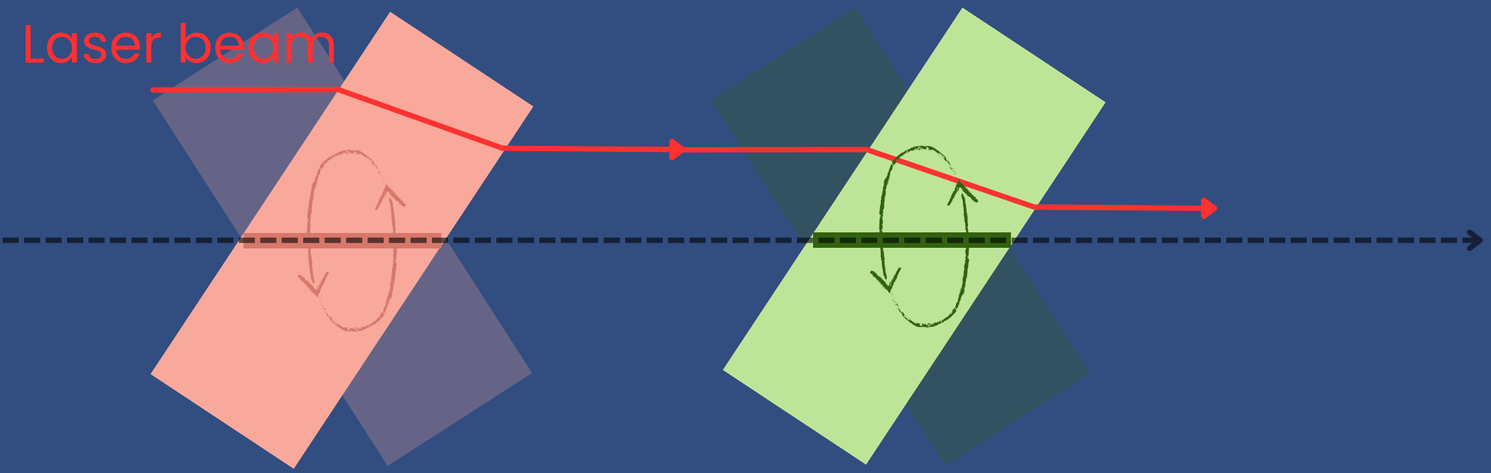
1st year phd student

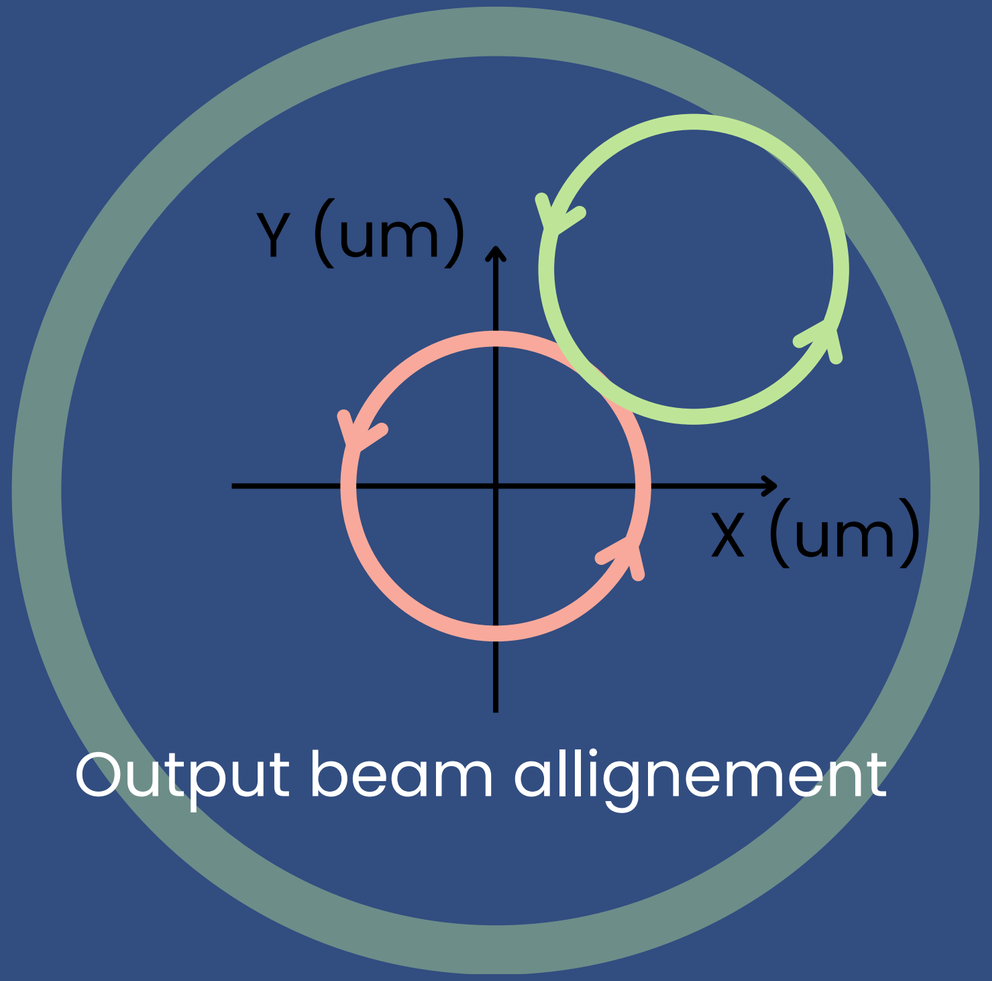
Annex 1 – BPAM functionning

BPAM



First parallel face blade rotates

Second parallel face blade rotates

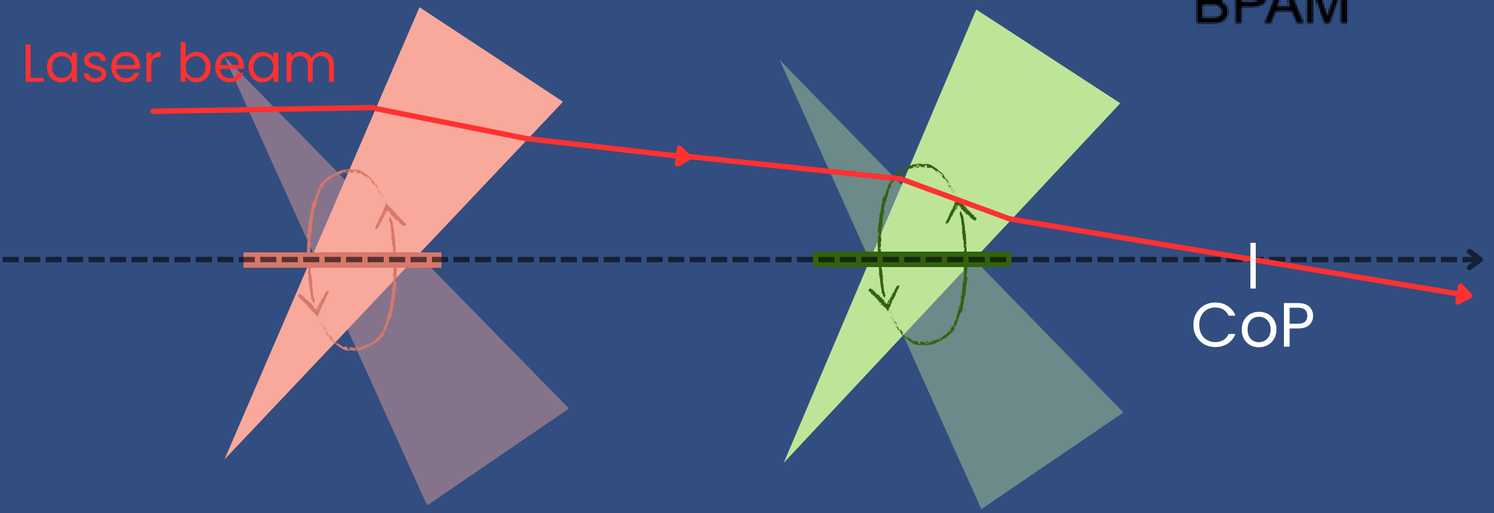


Output beam allignement

100% allignement
0% pointing

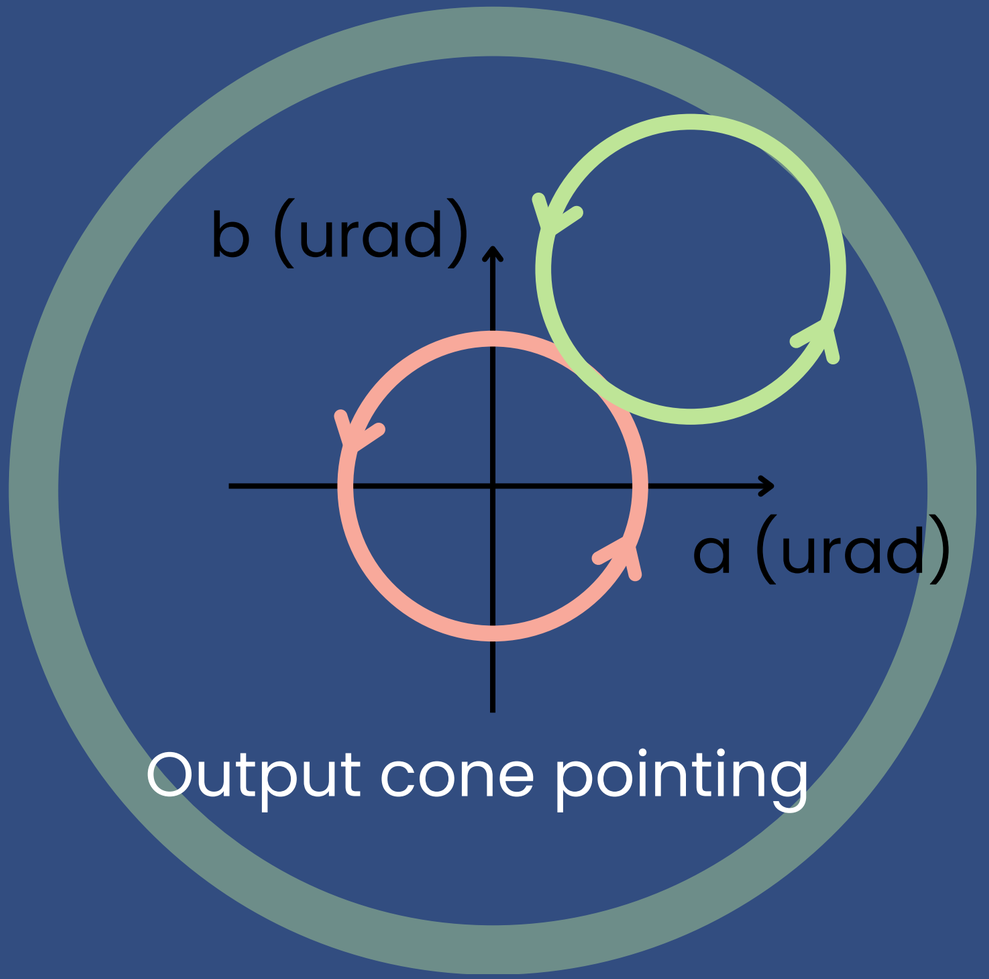
Annex 1 – BPAM functionning

BPAM



First prism rotates

Second prism rotates



Both allignement & pointing.
Except if you observe on CoP (Center of Phase = Pivot point) where it is 100% pointing.

Annex 2 - angle cone pointing for RxPCS