

Conception de l'isolement mécanique du VOPO

LIGO MIT Lab: Matichard, Fabrice

ISAE-Supaero: Michon, Guilhem
Rivallant, Samuel

PFE ISAE-SUPAERO / ETSEIB-UPC

Fernandez Galiana, Alvaro

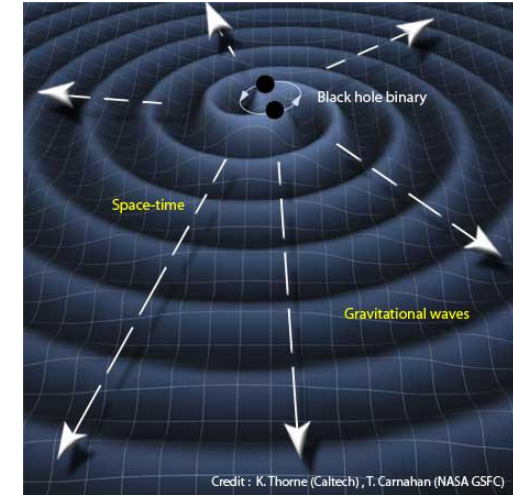
23.11.15

PLAN

- **INTRODUCTION aLIGO**
- CONCEPTION DE LA SUSPENSION
- ANALYSE DE CONTACT
- OPTIMISATION DE LA TABLE OPTIQUE
- CONCLUSIONS

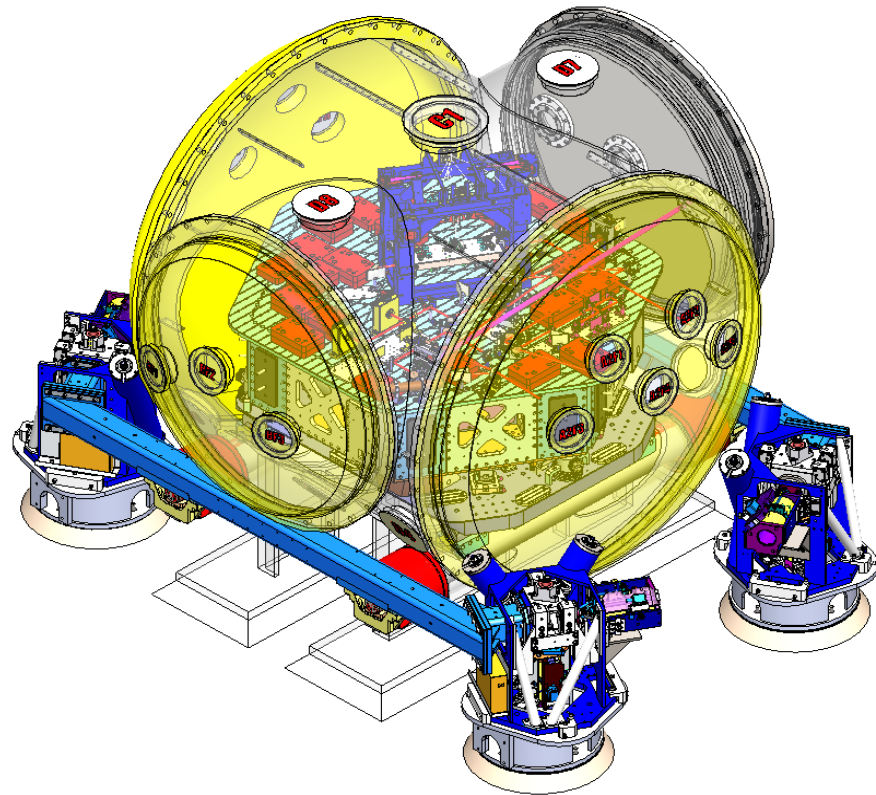
INTRODUCTION aLIGO

- Projet LIGO
 - Laser Interferometer Gravitational-Wave Observatory
 - 2 interféromètres de 4km de longueur de bras

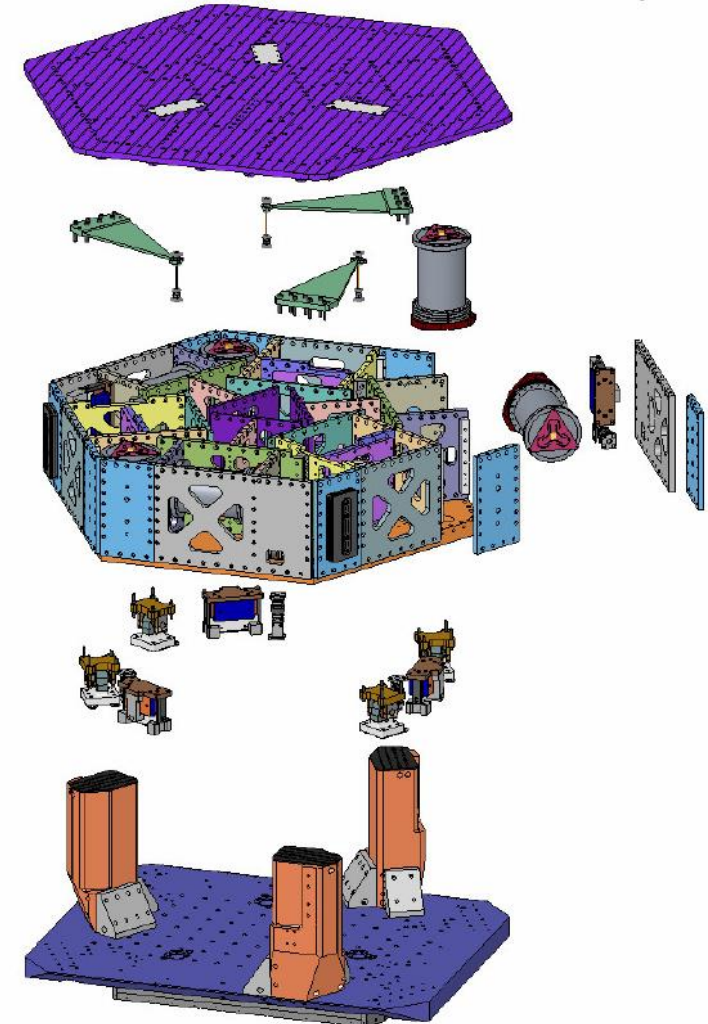


aLIGO INTRODUCTION

- ISOLEMENT SISMIQUE A aLIGO



Chambres sous vide (gauche) et modèle CAD d'une des suspensions (droite)

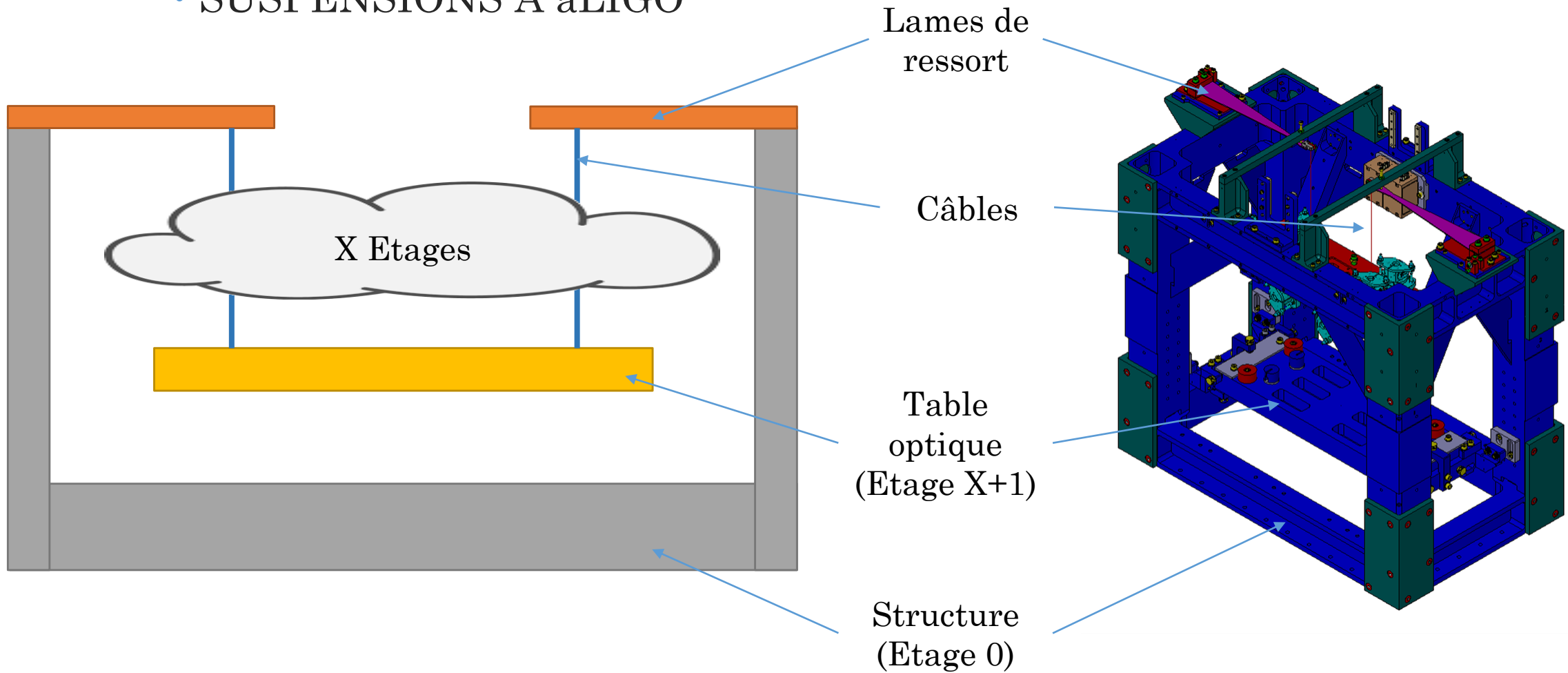


PLAN

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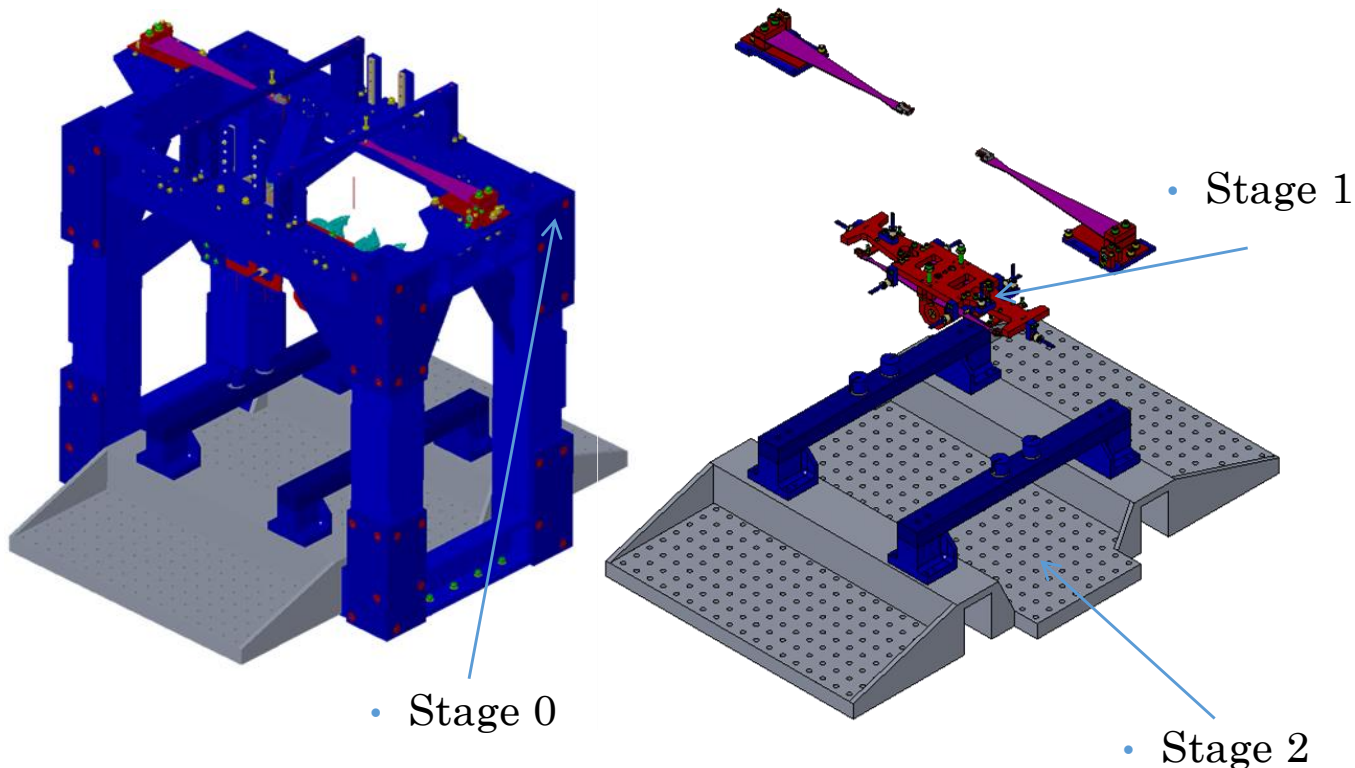
CONCEPTION DE LA SUSPENSION

- SUSPENSIONS A aLIGO



CONCEPTION DE LA SUSPENSION

- PREMIERS CONCEPTS



- Réutilisation d'une suspension existante
 - Suspension à 2 étages

- Simple conception (Suspension existante)

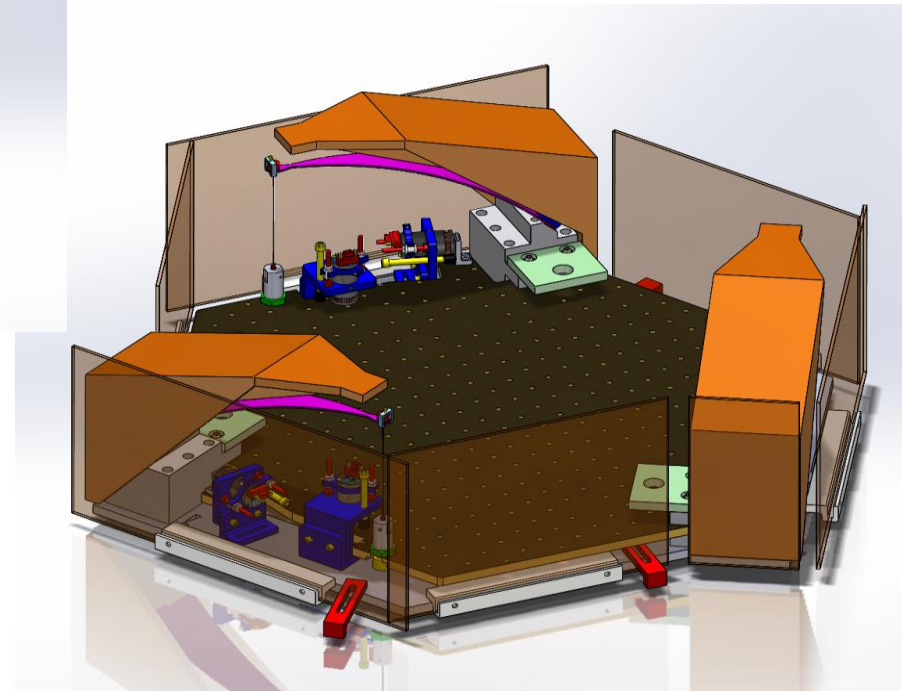
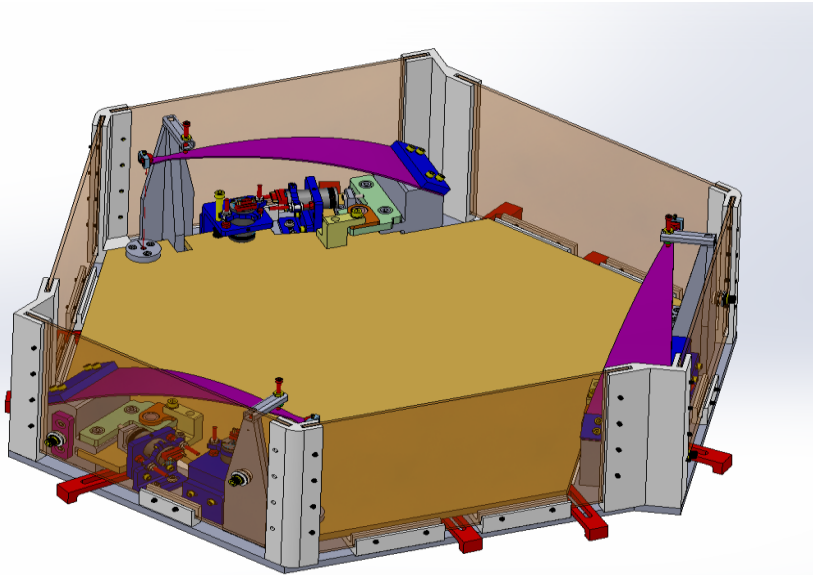
- Possibilité d'utiliser structure libre

- Suspension surdimensionnée

- Besoin de table optique plus grande

CONCEPTION DE LA SUSPENSION

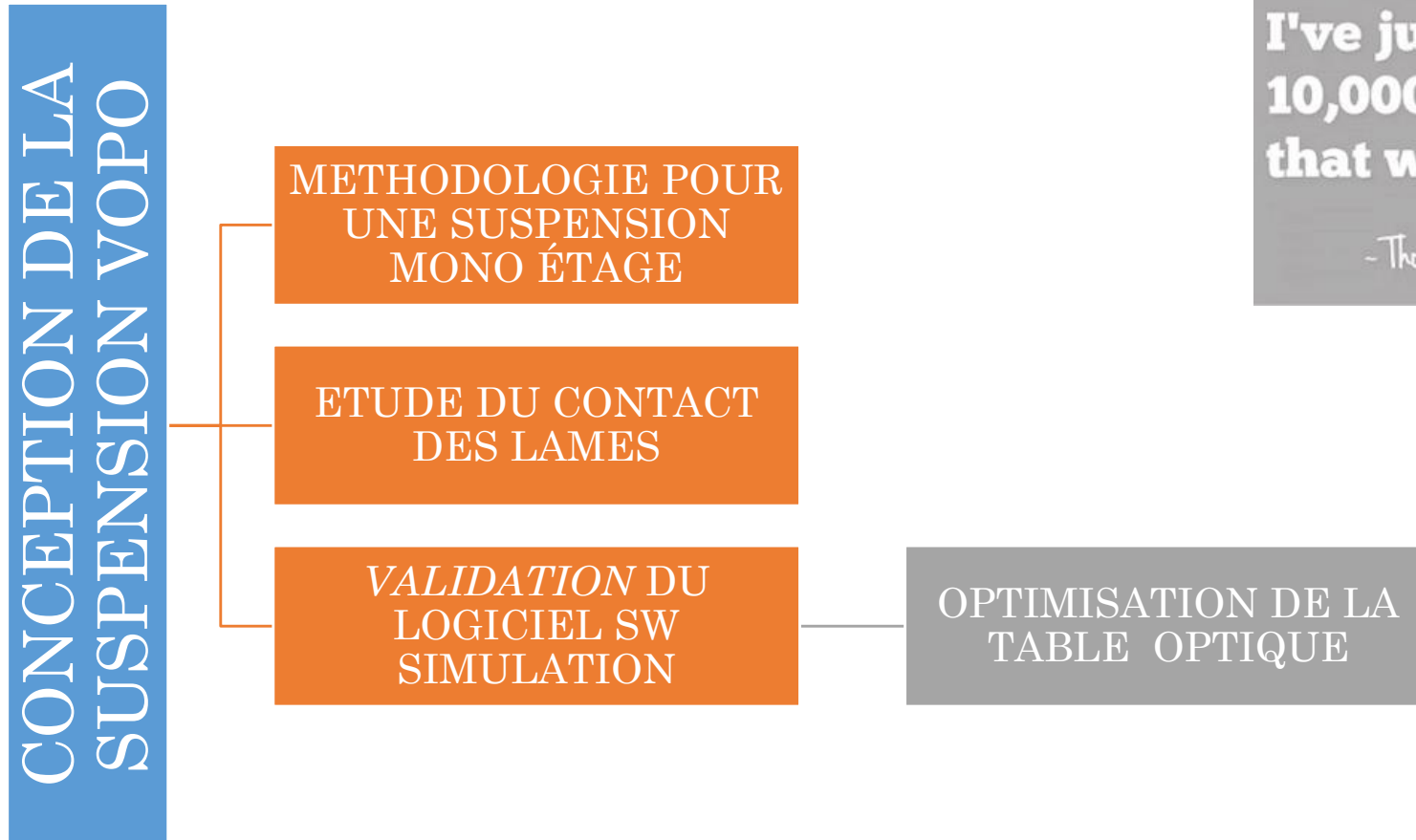
- PREMIERS CONCEPTS



- Premières conceptions de la suspension mono étage pour VOPO
- Structure élancé -> amélioration basse fréquence
- Suppression des soudures
- Possibilité d'adapter les dimensions aux besoins particuliers

CONCEPTION DE LA SUSPENSION

- PREMIERS CONCEPTS



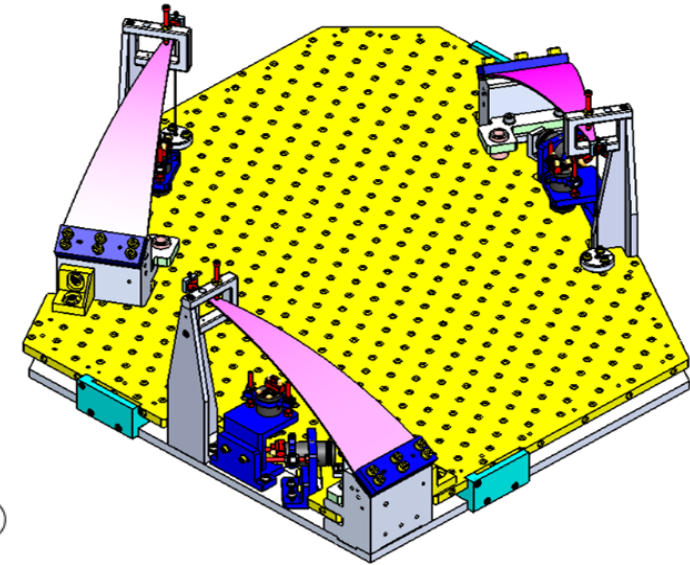
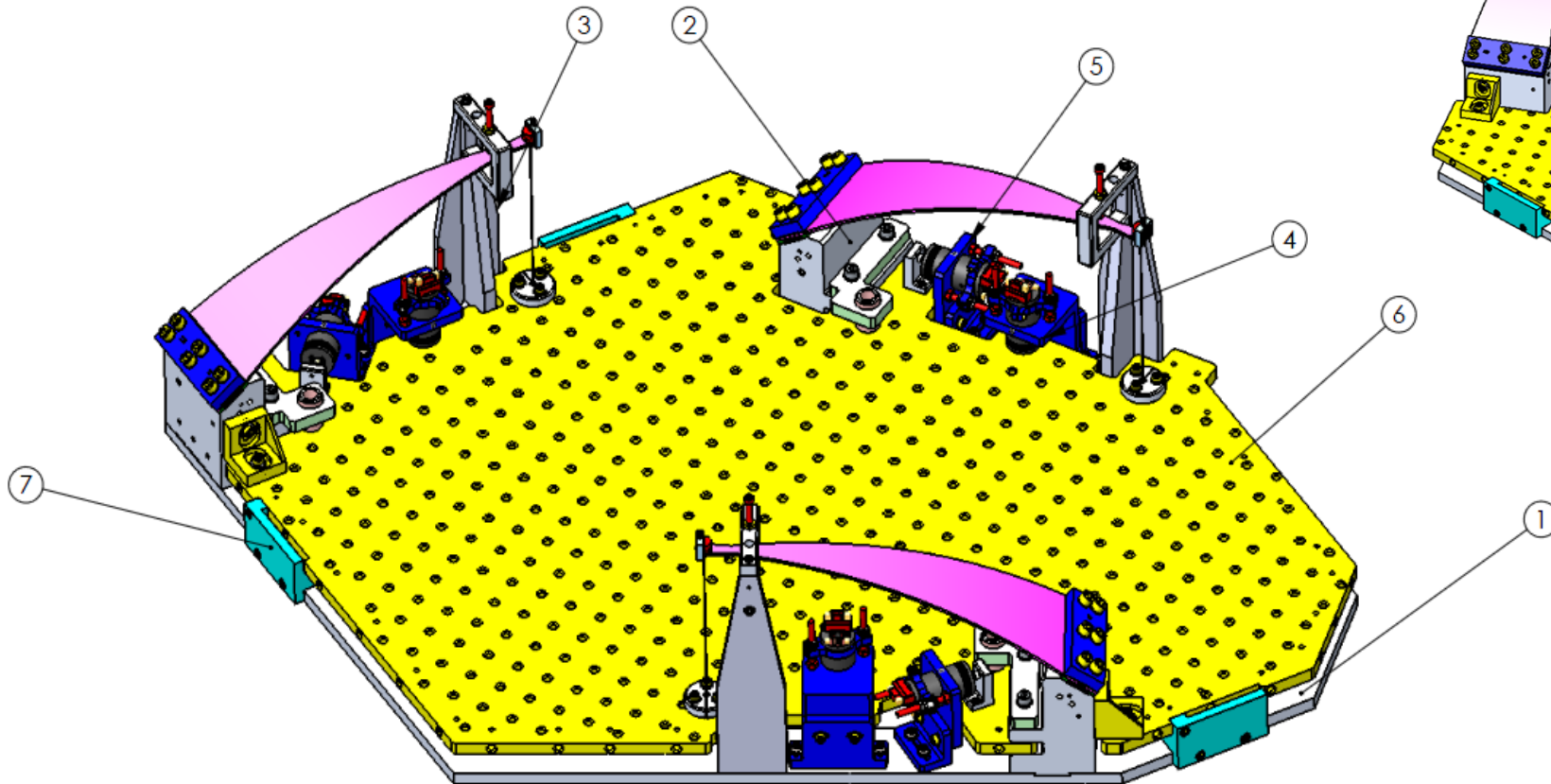
**I have not failed,
I've just found
10,000 ways
that won't work.**

- Thomas Alva Edison



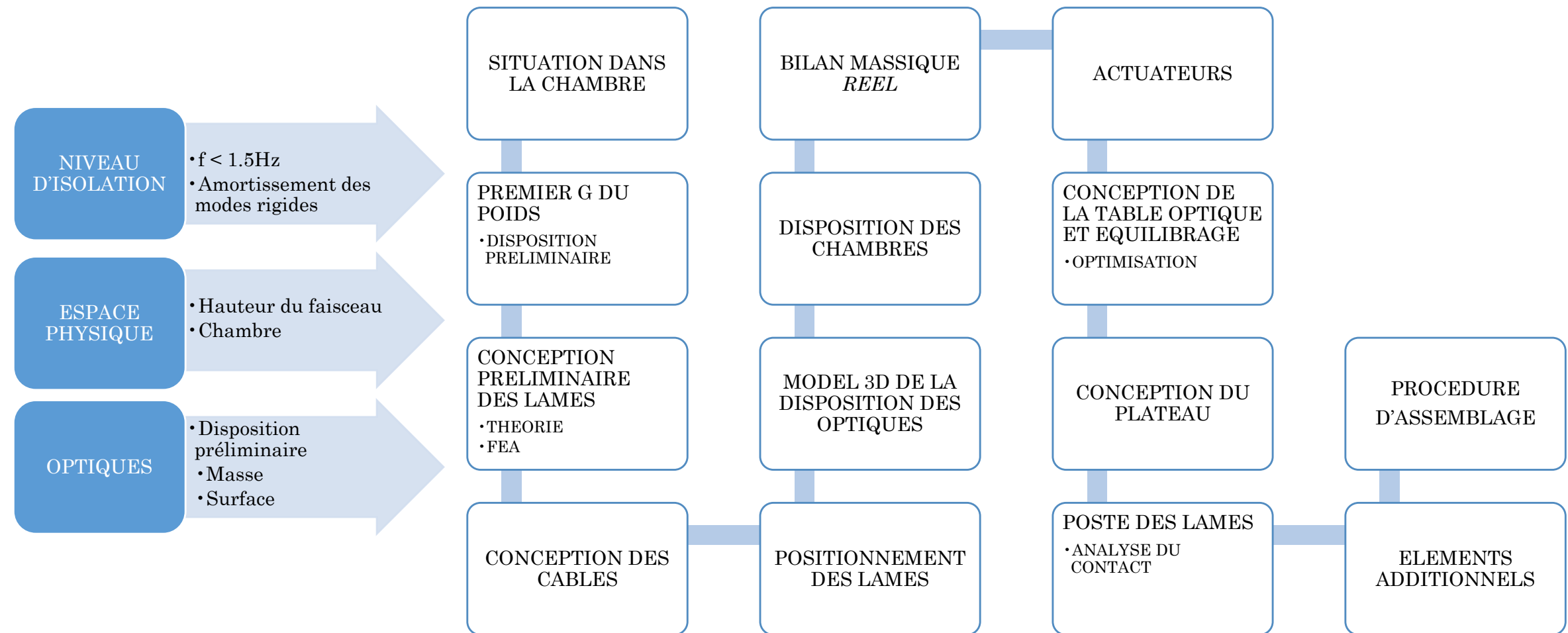
CONCEPTION DE LA SUSPENSION

- APERÇU DE LA SUSPENSION DU VOPO



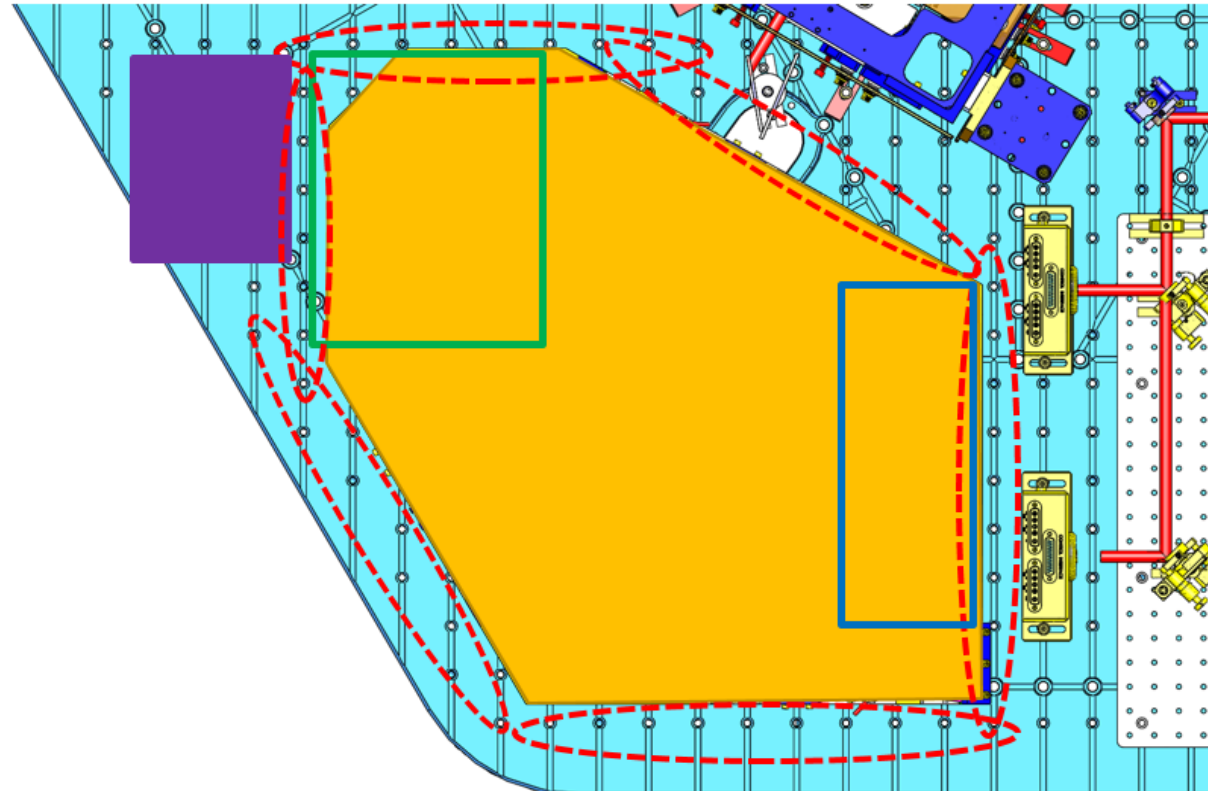
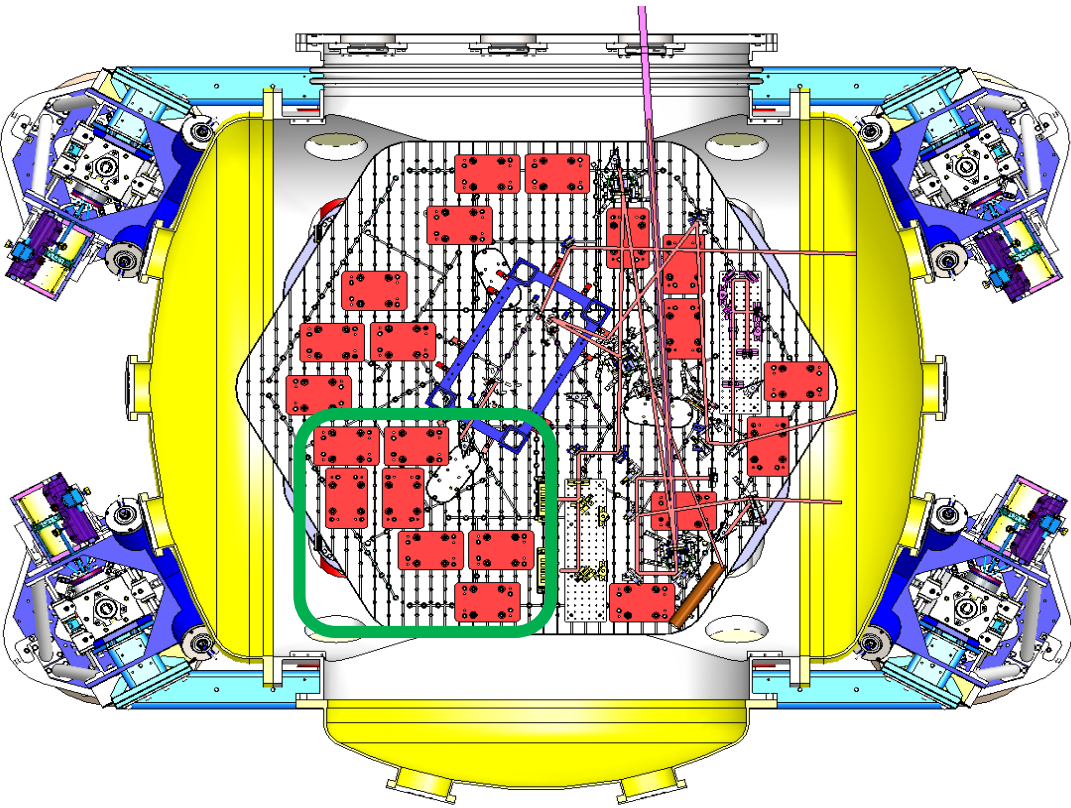
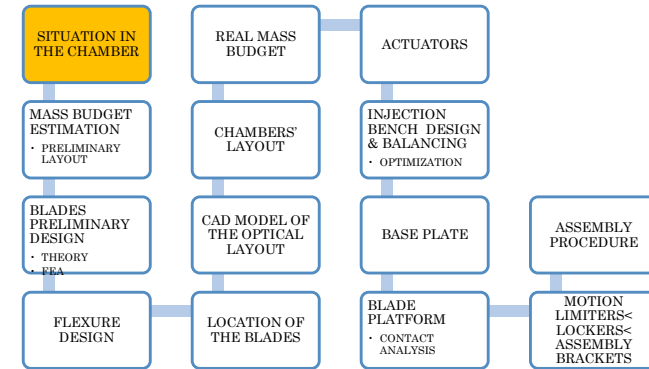
CONCEPTION DE LA SUSPENSION

• METHODOLOGIE SUSPENSION MONO ÉTAGE



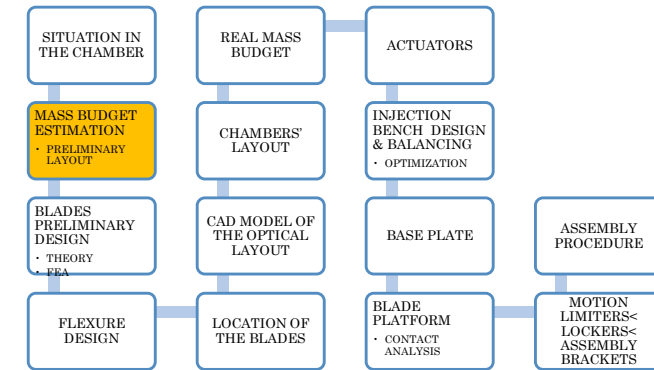
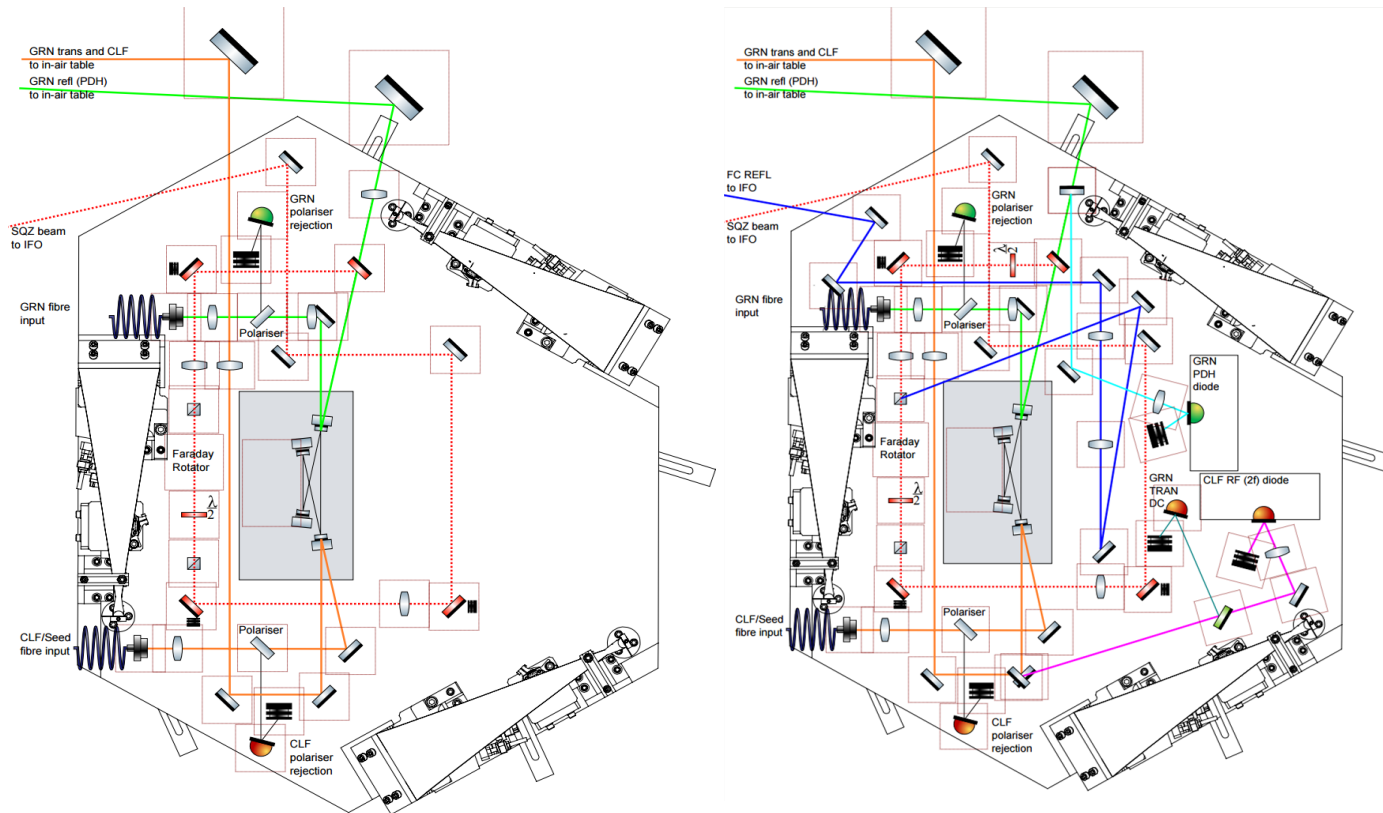
CONCEPTION

- SITUATION DANS LA CHAMBRE



CONCEPTION

• PREMIER G DU POIDS



- Optiques: 12 kg
- Table: 18 kg
- Contrepoids: 6kg



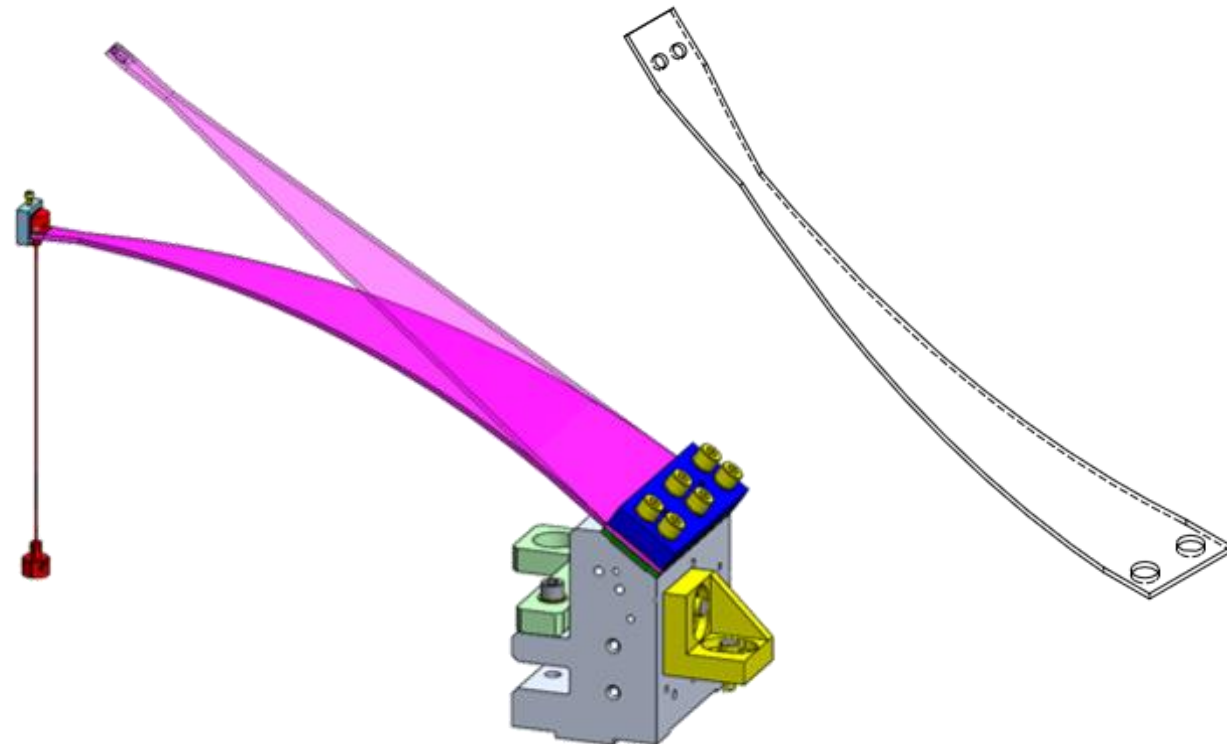
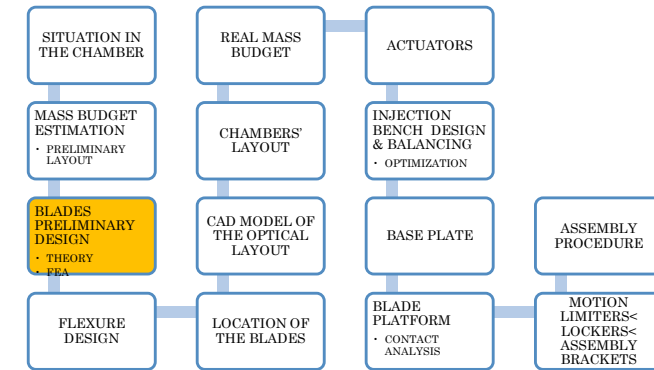
MASSE SUSPENDUE: 36 kg

DISPOSITION PRELIMINAIRE POUR O₂ (gauche) and O₃ (droite)

CONCEPTION

- CONCEPTION PRELIMINAIRE DES LAMES

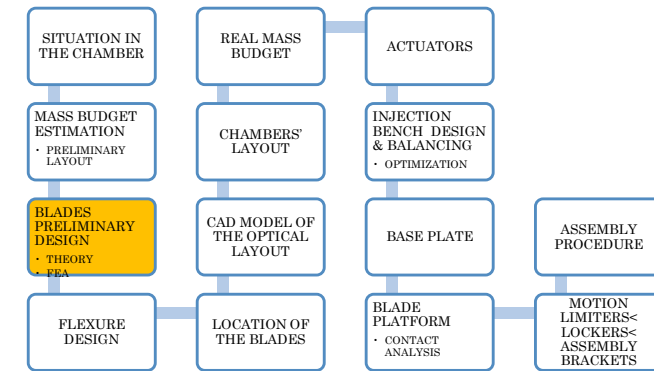
- Contraintes:
- Niveau de contrainte: $\geq 33.3\%$ ($FoS \geq 3$)
- Première fréquence: $f \approx 1.5$ Hz



- Matériel: 440C SSTL
- Fabriquée plate

CONCEPTION

- CONCEPTION PRELIMINAIRE DES LAMES

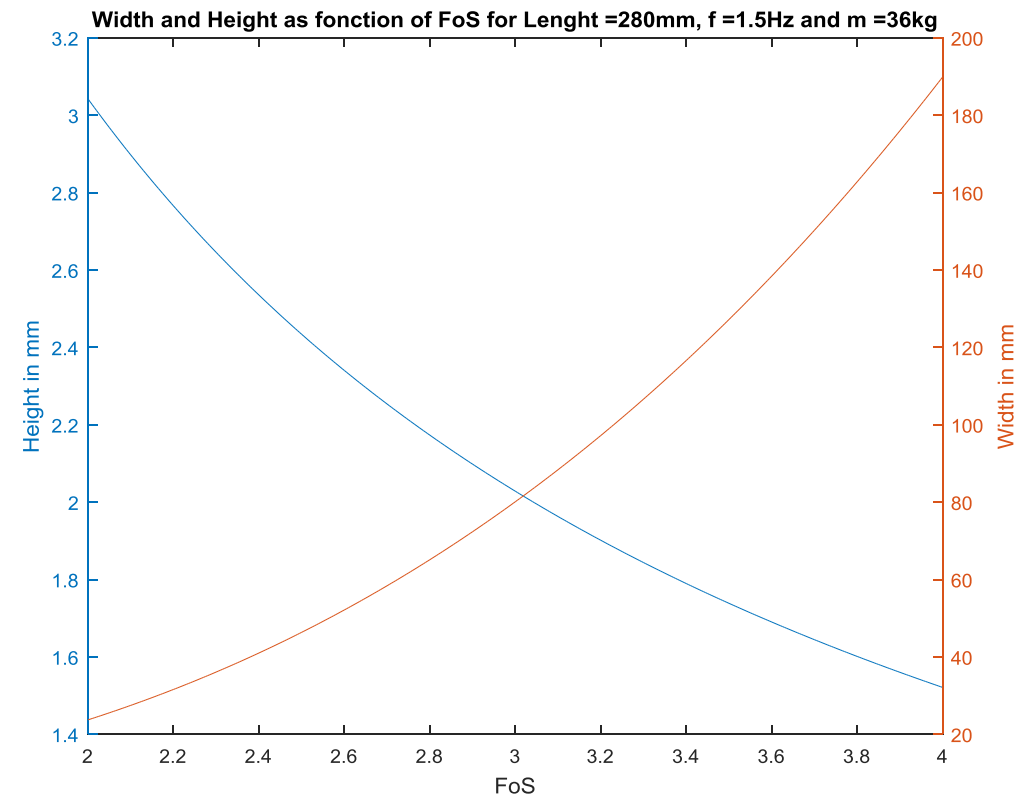


- Paramètres de la conception:

- Largeur de la lame: a
- Longueur de la lame: l
- Epaisseur de la lame: h

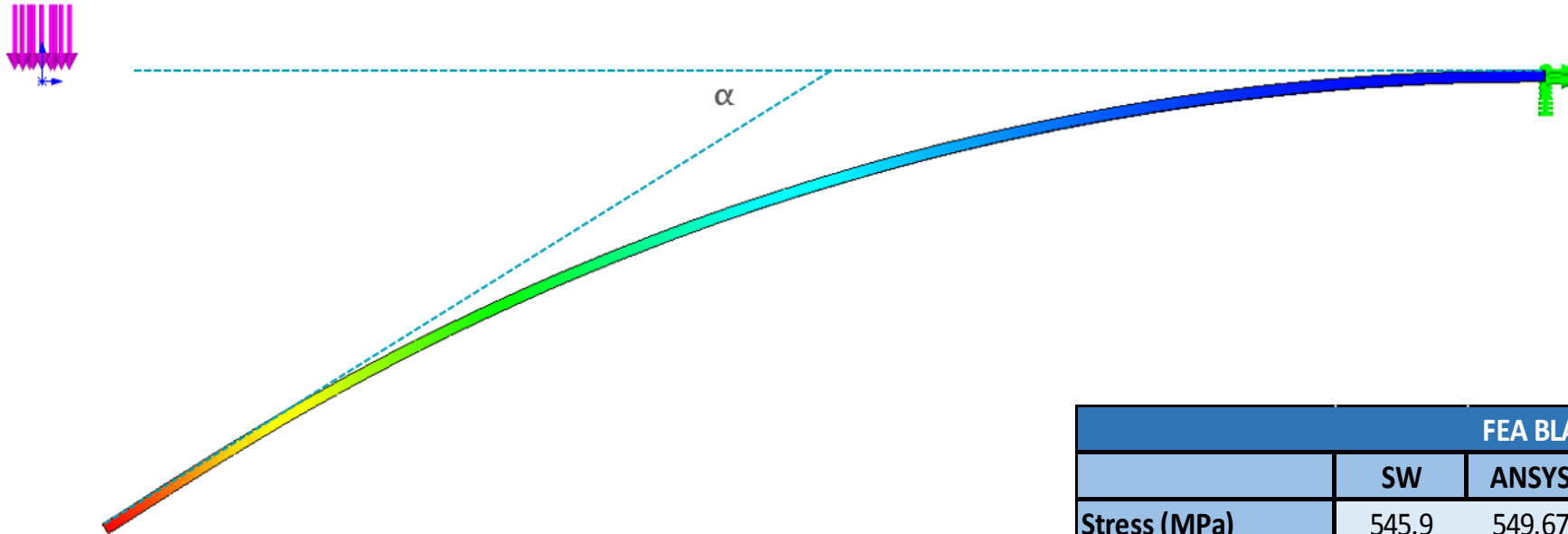
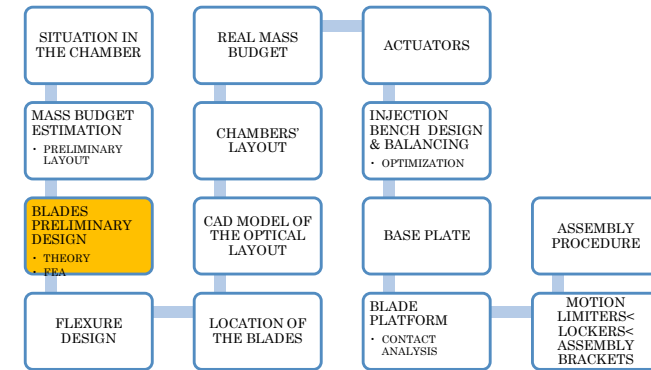
- Equations Bernoulli (pour lames triangulaires):

- $K_{ZZ} = \frac{Eah^3}{4l^3}$
- $f = \frac{1}{2\pi} \sqrt{\frac{K_{ZZ}}{m}} = 1.5 \text{ Hz}$
- $\sigma_{max} = \frac{6Pl}{ah^2}$



CONCEPTION

- CONCEPTION PRELIMINAIRE DES LAMES
 - Analyse par éléments finis



FEA BLADE					
	SW	ANSYS	Difference %	THEORY	Error
Stress (MPa)	545.9	549.67	0.686	527.60	4.016
Displacement (mm)	85.87	85.21	0.775		
FoS	3.30	3.27		3.41	

CONCEPTION

• CONCEPTION DES CABLES

- $f < 1.5 \text{ Hz}$
- $FoS \geq 33.3\%$ ($FoS \geq 3$)

- Paramètres:
 - $l = 130\text{mm}$
 - $d = 0.61 \text{ mm}$

• CONTRAINTE

$$Section = \frac{\pi D^2}{4}$$

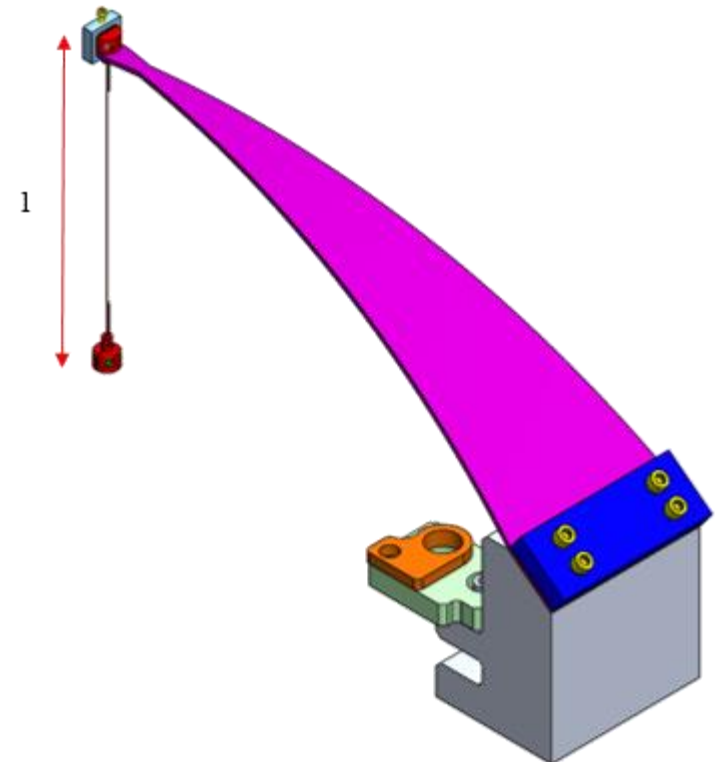
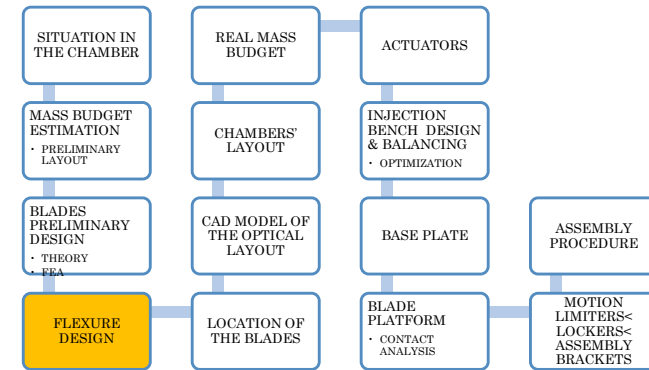
$$\tau_{max} = \frac{P\delta}{Section l_z}$$

$$\sigma_{norm} = \frac{P}{Section}$$

$$\sigma_{eq} = \sqrt{\sigma_{norm}^2 + \sigma_{bend}^2 + 3\tau_{max}^2}$$

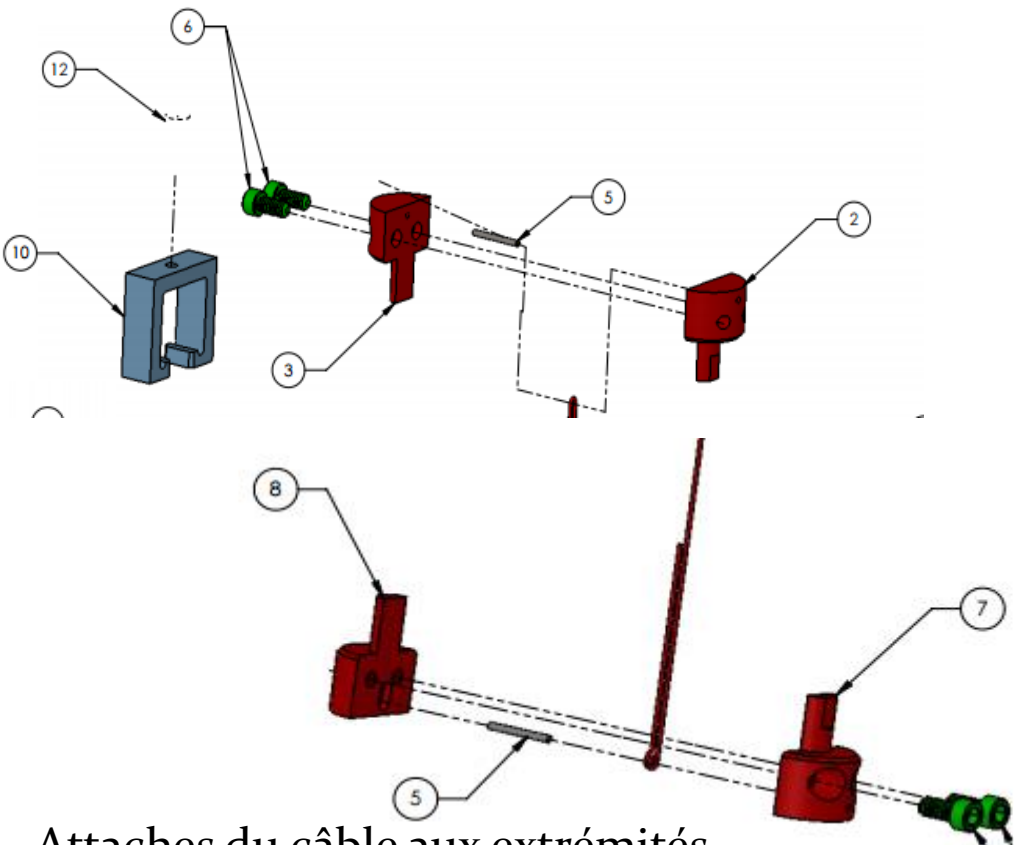
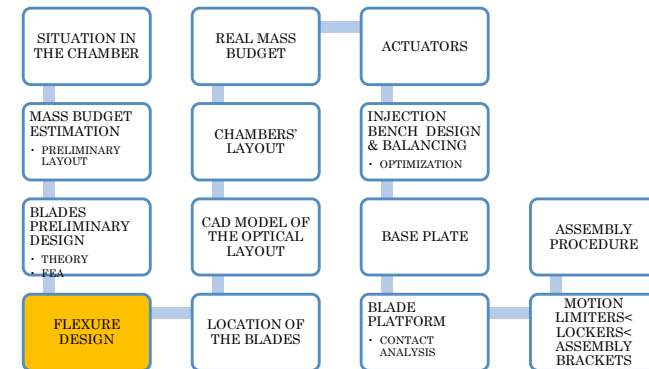
$$\sigma_{bend max} = \frac{P ZMP \frac{D}{2} \delta}{I l_z}$$

$$FoS = \frac{\sigma_Y}{\sigma_{eq}}$$

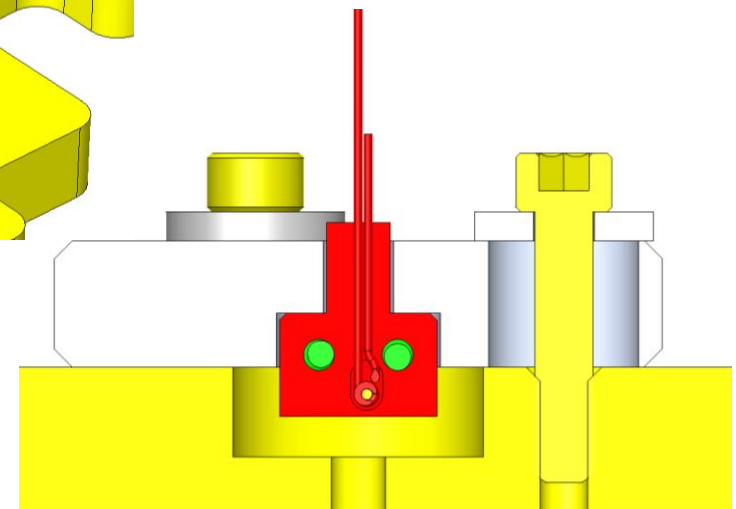
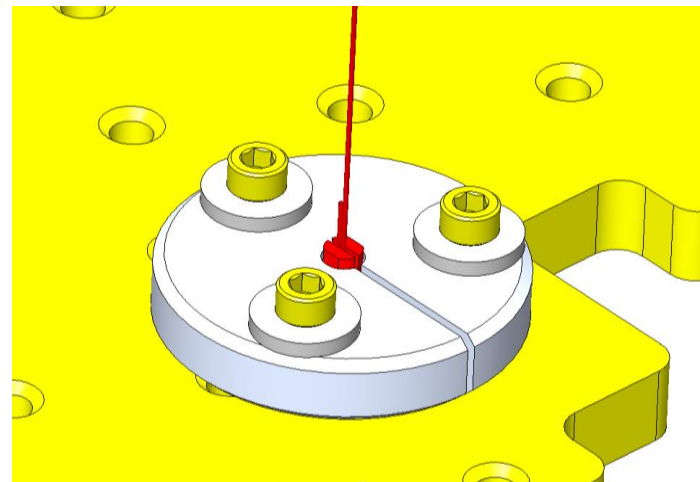


CONCEPTION

• CONCEPTION DES CABLES



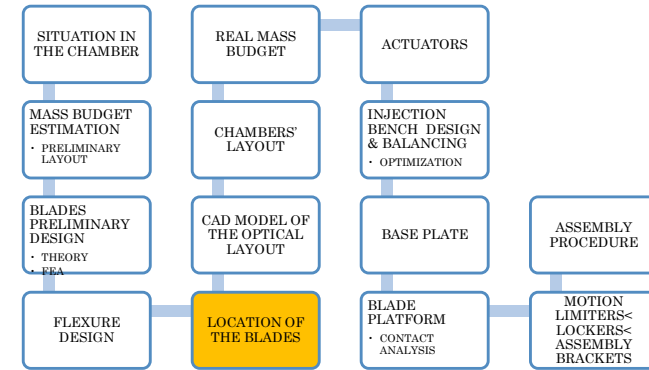
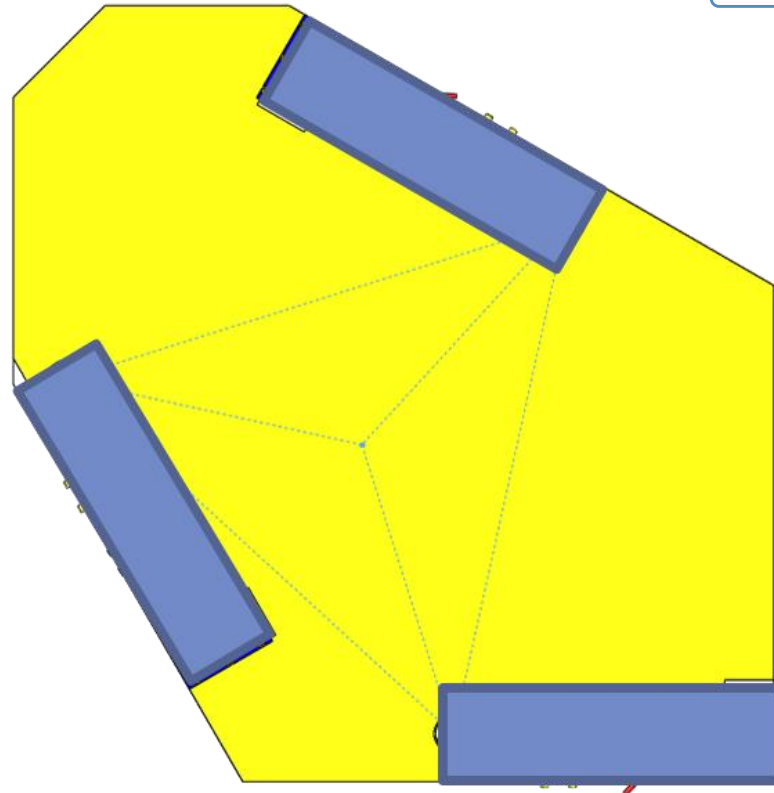
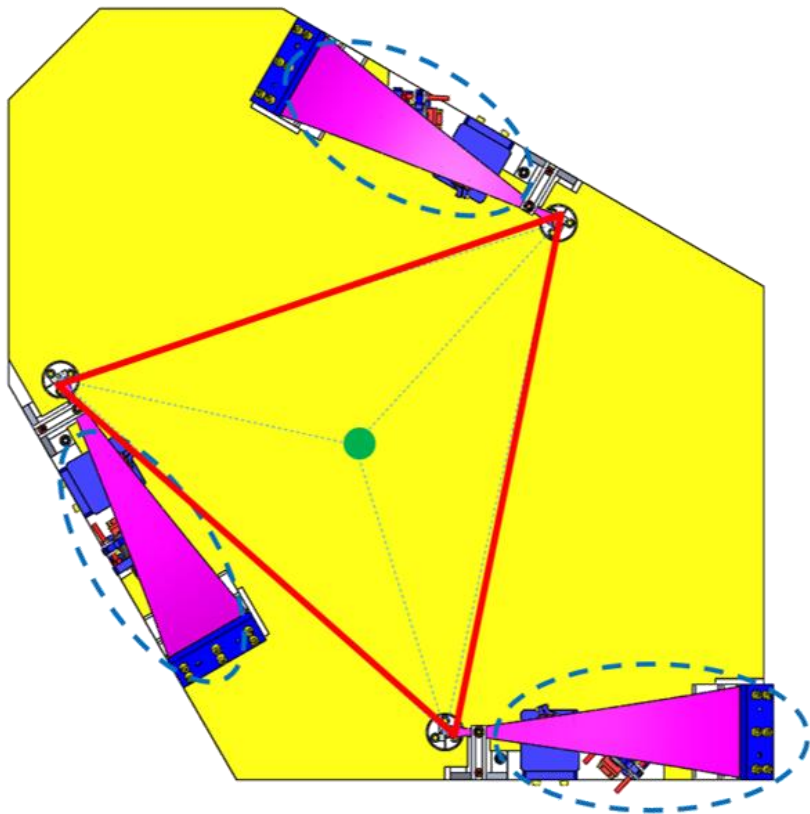
Attaches du câble aux extrémités



Attaches du câble 'a la table

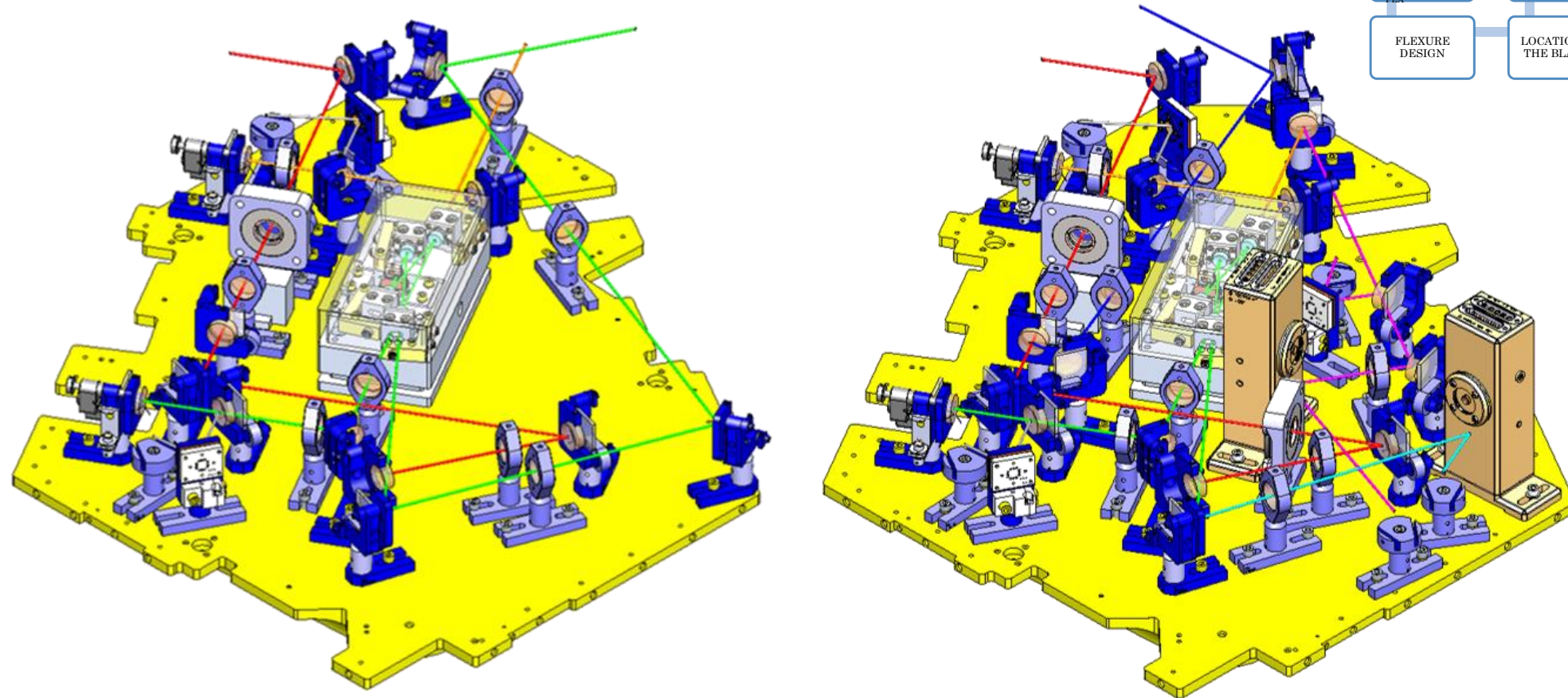
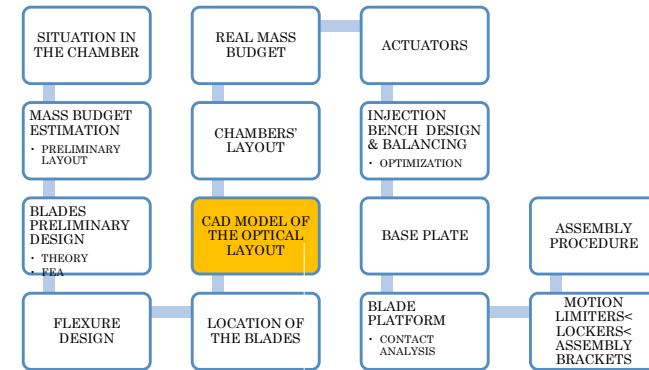
CONCEPTION

- POSITIONNEMENT DES LAMES



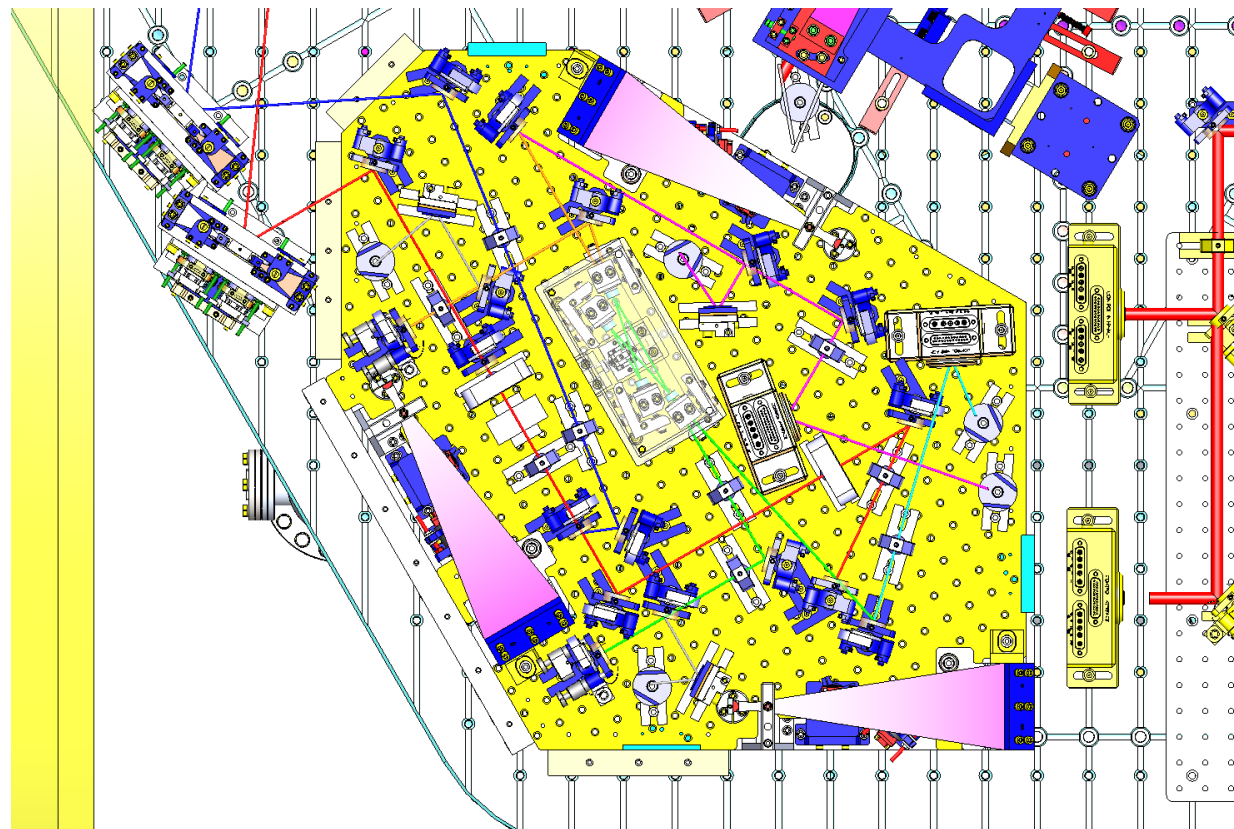
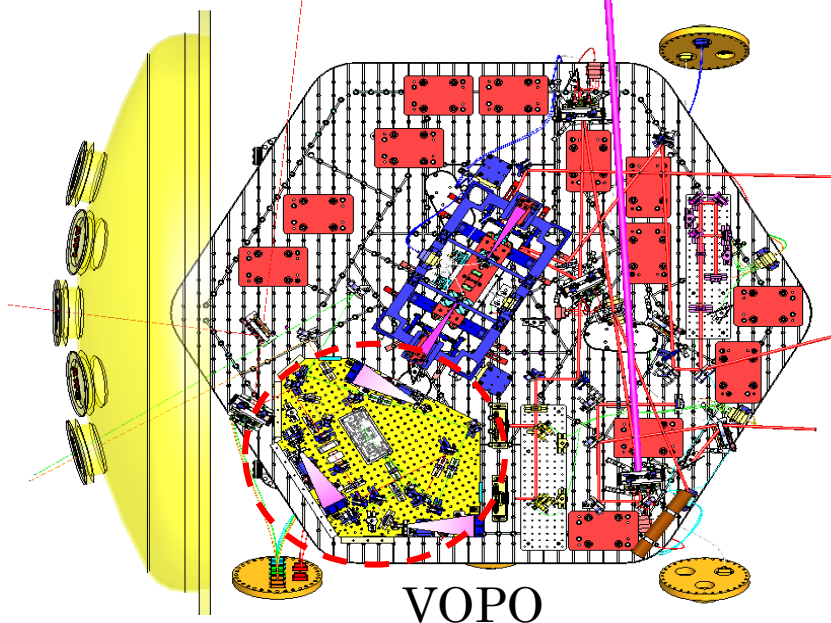
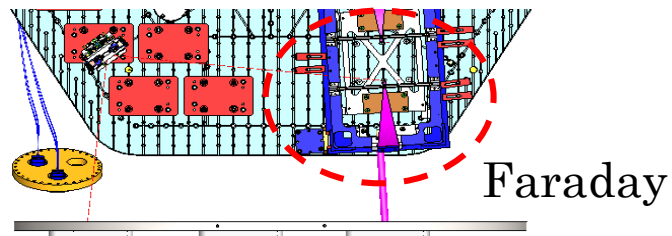
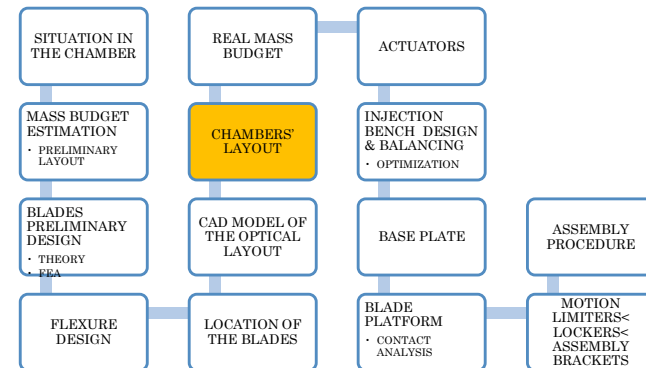
CONCEPTION

- MODEL 3D DE LA DISPOSITION DES OPTIQUES



CONCEPTION

• DISPOSITION DES CHAMBRES

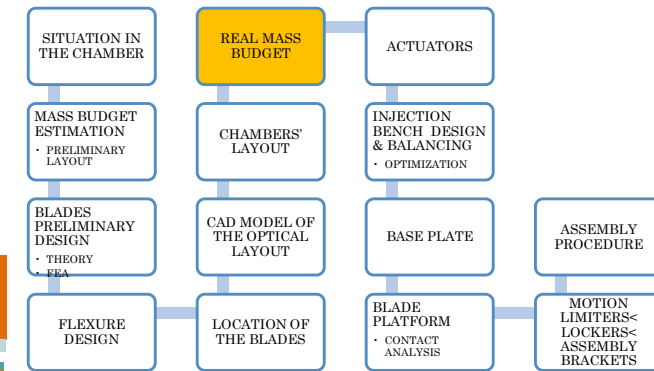


CONCEPTION

- BILAN MASSIQUE *REEL*

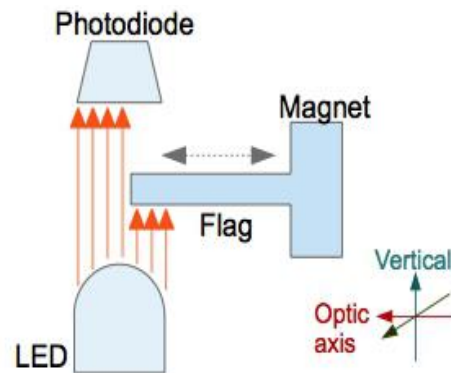
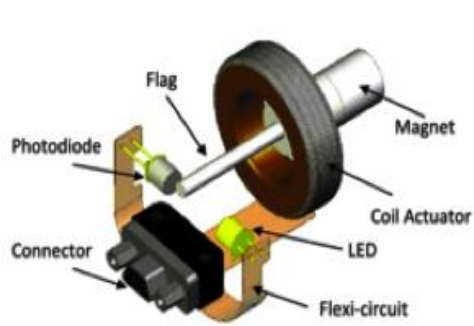
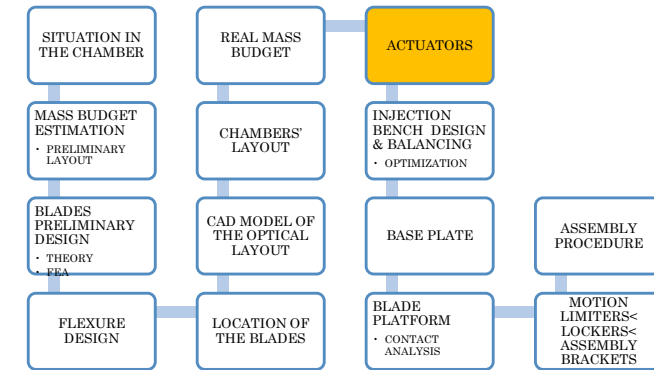
MASS BUDGET

ELEMENT TYPE	Name	Description	Unit Weight (g)	Quantity O ₃	Total mass O ₃ (g)	Quantity O ₂	Total mass O ₂ (g)	Mass Checked?
OPTICS	MIRROR	With Beam Dump	205.87	4	823.48	2	411.74	YES
OPTICS	MIRROR	With Beam Dump 2	207.55	4	830.20	1	207.55	YES
OPTICS	MIRROR	Without Beam Dump	192.90	4	771.60	6	1157.40	YES
OPTICS	MIRROR II	1in Lens Mount	121.38	0	0.00	0	0.00	YES
OPTICS	MIRROR III	Lens Sigle Base	97.07	0	0.00	0	0.00	YES
OPTICS	LENS	Desc 2	121.38	9	1092.38	8	971.00	YES
OPTICS	BEAM DUMP	Without One Black Glass	156.83	5	784.15	2	313.66	YES
OPTICS	QPD	QPD	142.98	3	428.94	2	285.96	YES
OPTICS	POLARIZER	Polarizer (Mirror Mount)	203.05	4	812.19	4	812.19	YES
OPTICS	WAVE PLATE	Wave Plate	299.69	2	599.38	1	299.69	YES
OPTICS	RFPD in Vacuum	4" RFPD	270.41	2	540.82	0	0.00	YES
OPTICS	FIBER IN	Mirror Mount	252.01	2	504.02	2	504.02	YES
OPTICS	FARADAY ROTATOR	Aluminum Base	170.43	1	170.43	1	170.43	YES
OPTICS	VOPO CAVITY	D1500296	3289.00	1	3289.00	1	3289.00	YES
SUSPENSION	INJECTION BENCH	Injection Bench	18000.00	1	18000.00	1	18000	NO
SUSPENSION	LIMITERS & CLAMPS	Magnet, motion limiter...	0.00	1	0.00	1	0	NO
MASS	BALANCE MASS 1	Lateral	1857.36	0	0.00	0	0.00	NO
MASS	BALANCE MASS 2	Lateral Removable	1391.65	0	0.00	0	0.00	NO
MASS	BALANCE MASS 3	On Bench	2631.72	0	0.00	0	0.00	NO
MASS	SCREWS	On Bench	174.88	0	0.00	0	0.00	NO
OPTICS					10.647 kg		8.423 kg	
SUSPENSION					18.000 kg		18.000 kg	
MASS					0.000 kg		0.000 kg	
TOTAL WEIGHT					28.647 kg		26.423 kg	
Mass to 36 kg					7.35 kg		9.58 kg	

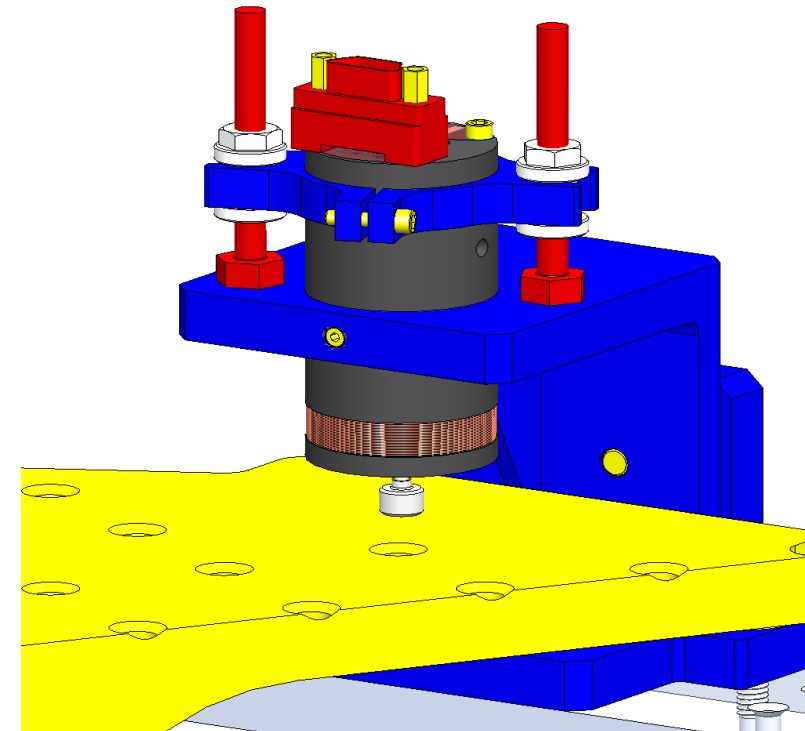


CONCEPTION

• ACTUATEURS



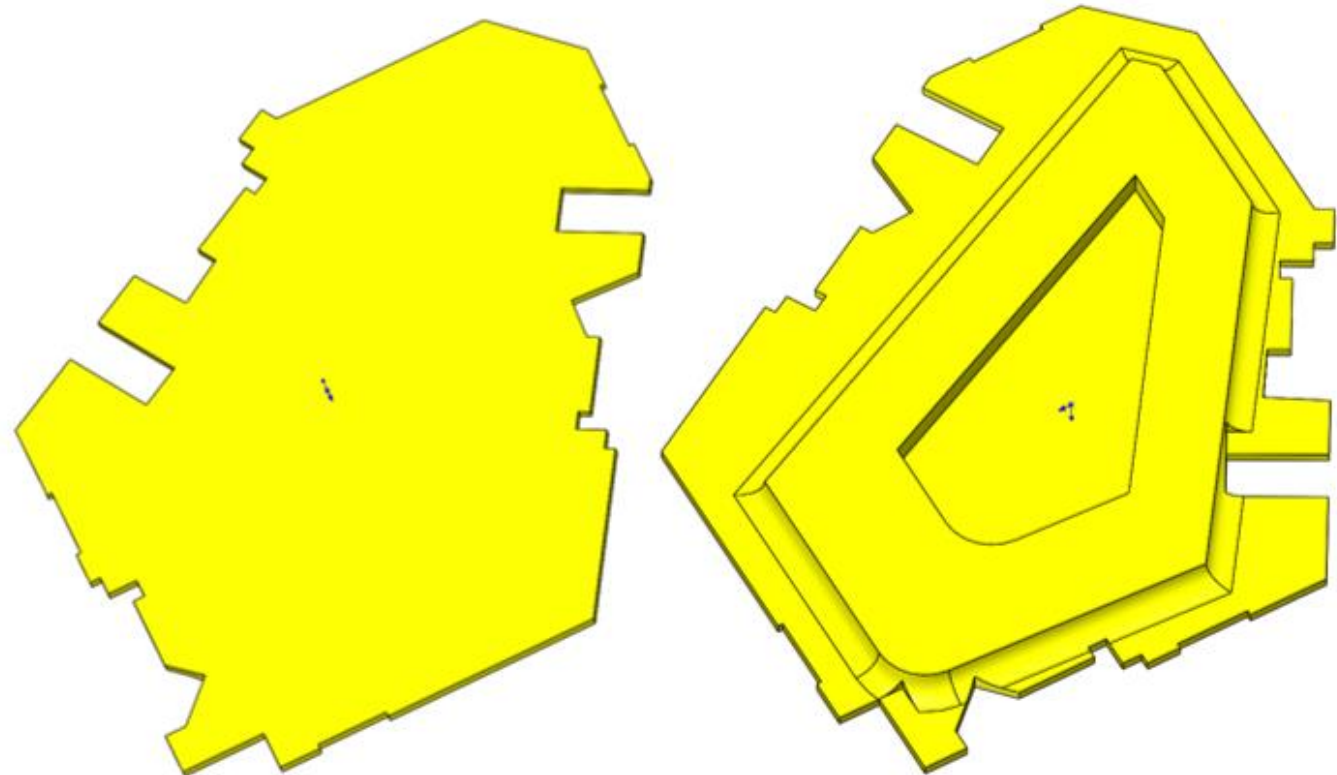
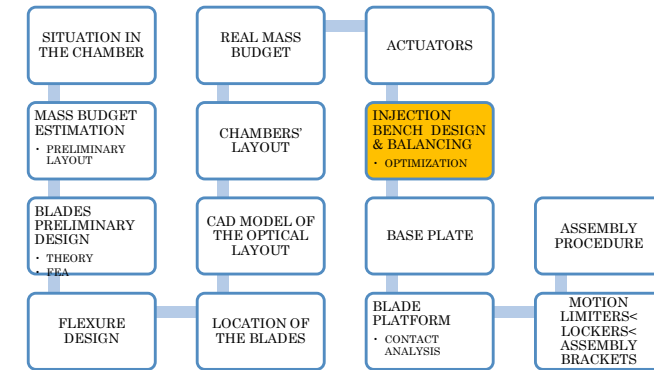
Actuateur magnétique avec système de détection optique



CONCEPTION

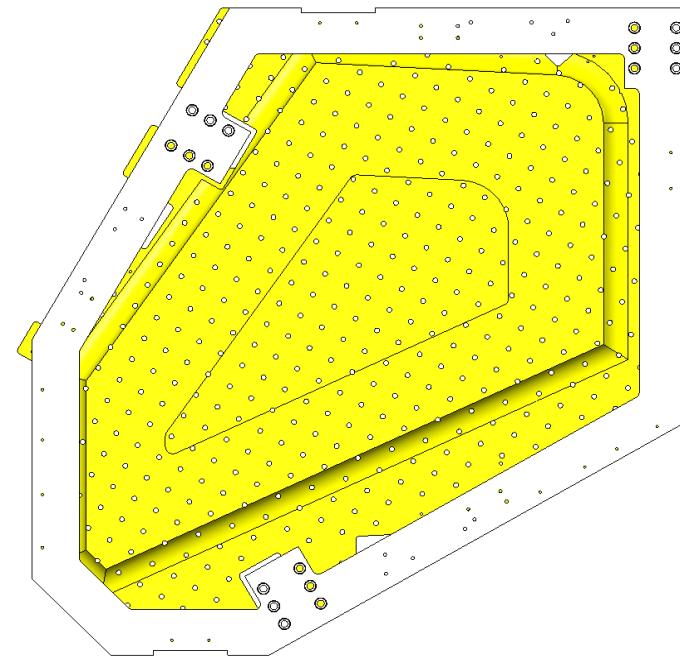
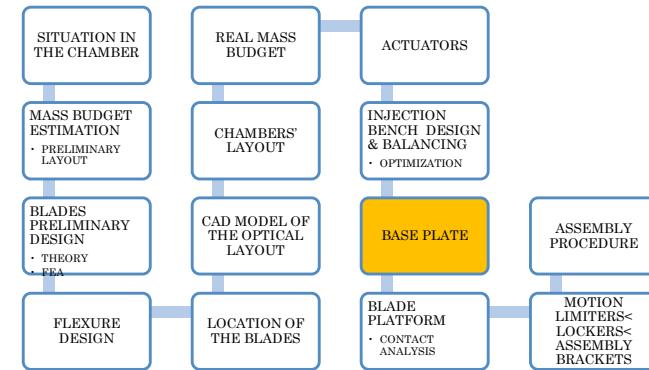
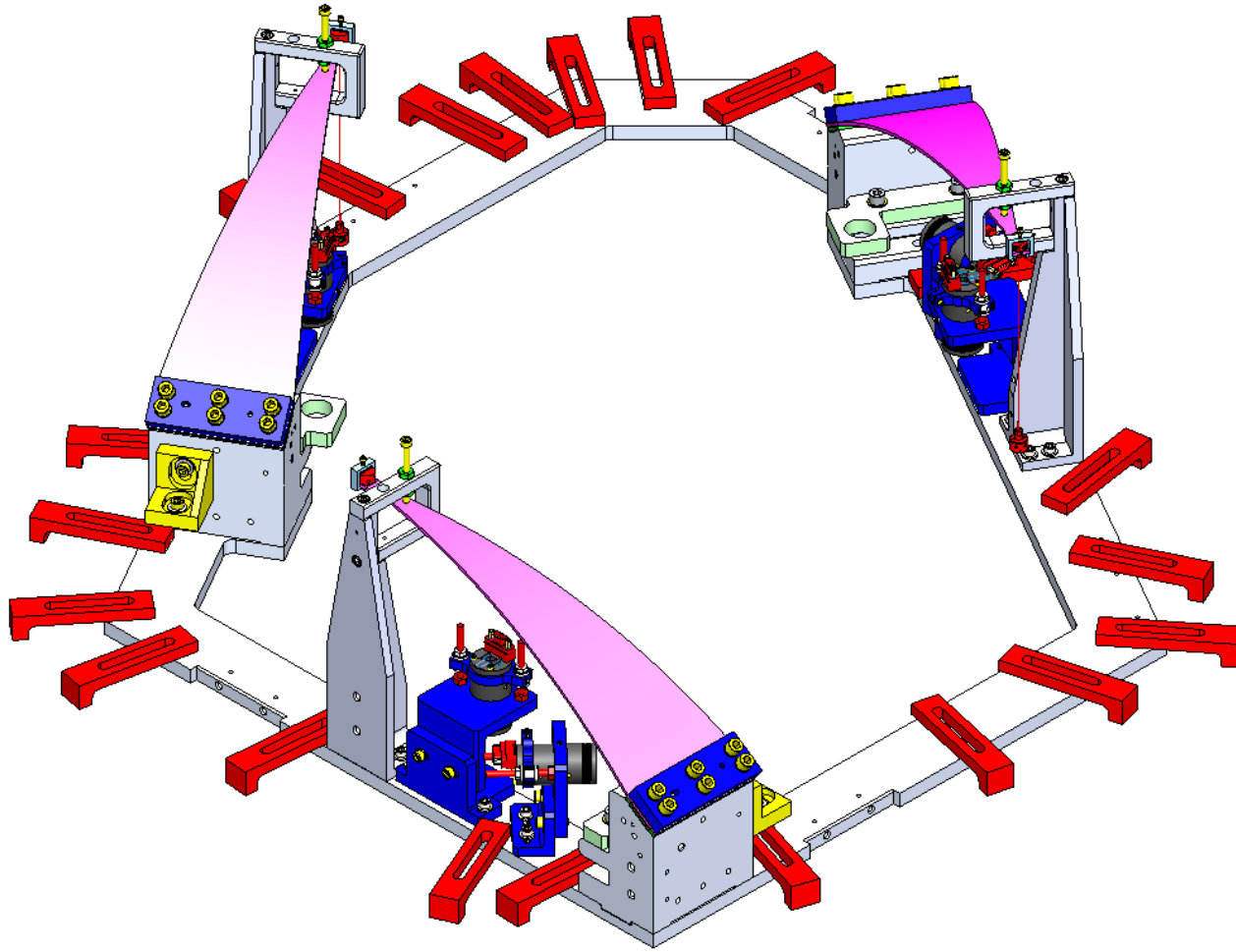
• CONCEPTION DE LA TABLE OPTIQUE ET EQUILIBRAGE

- Fréquence résonance élevée
- Centre de gravite



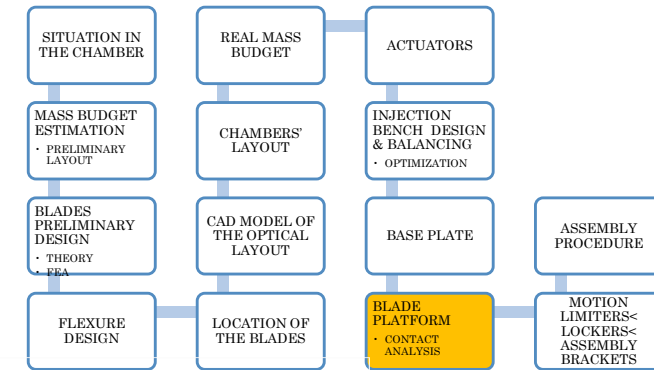
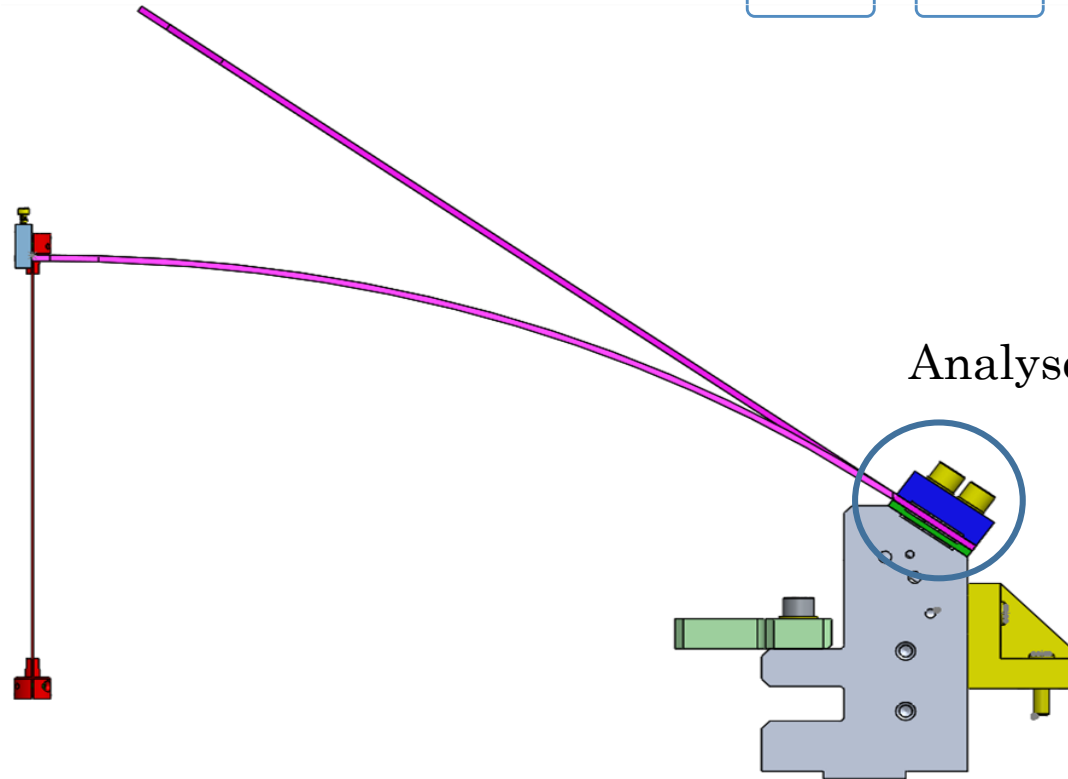
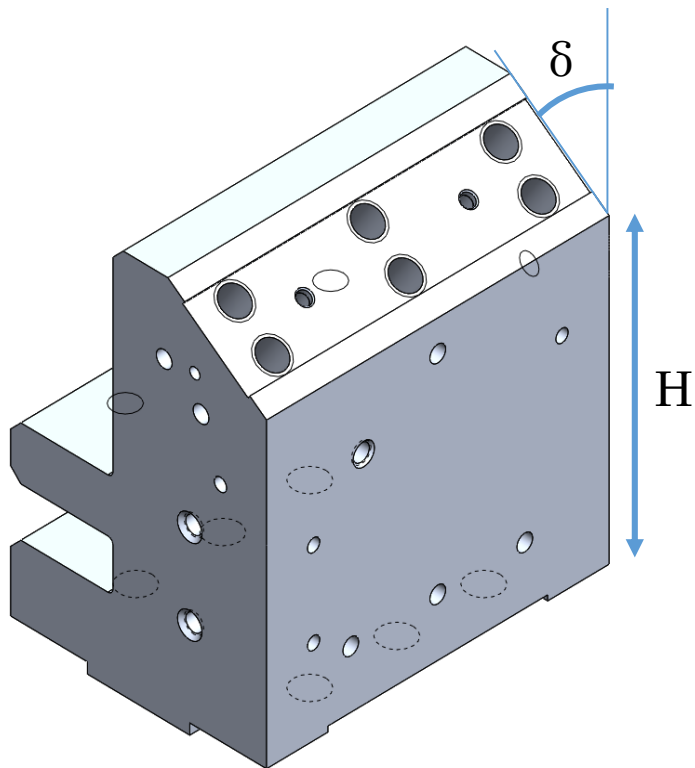
VOPO SUSPENSION D.

• CONCEPTION DU PLATEAU



CONCEPTION

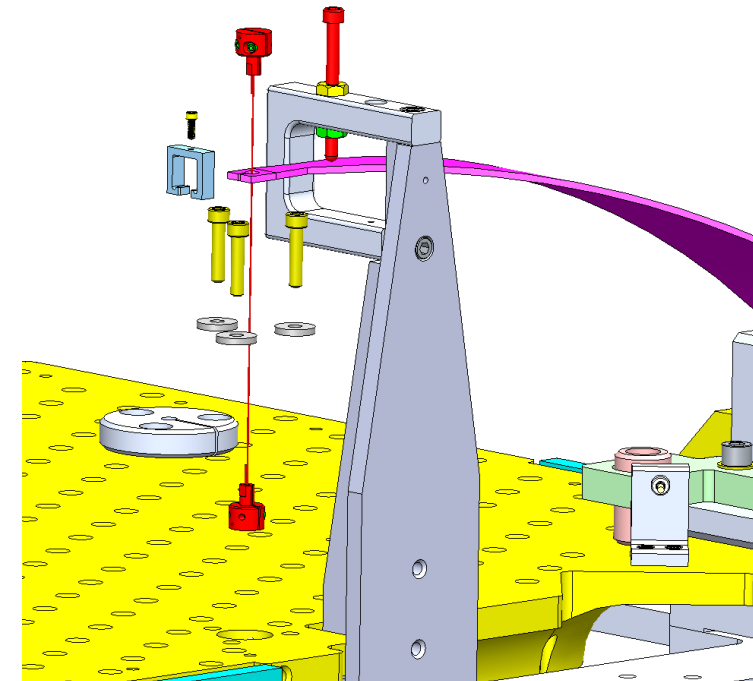
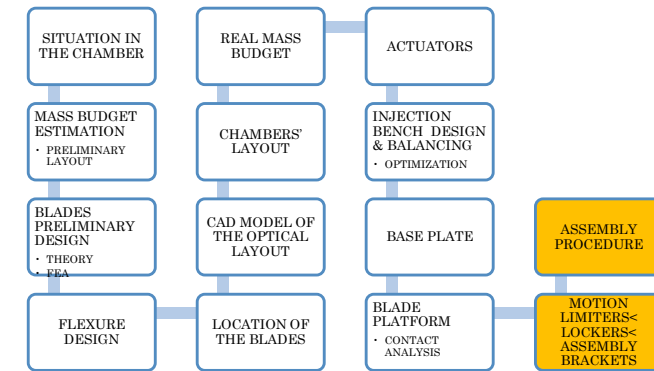
• POSTE DES LAMES



CONCEPTION

- ELEMENTS ADDITIONNELS
 - SYSTÈME DE VERROUILLAGE
 - SYSTÈME DE BUTEE
 - ELEMENTS DE TRANSPORT

- PROCEDURE D'ASSEMBLAGE

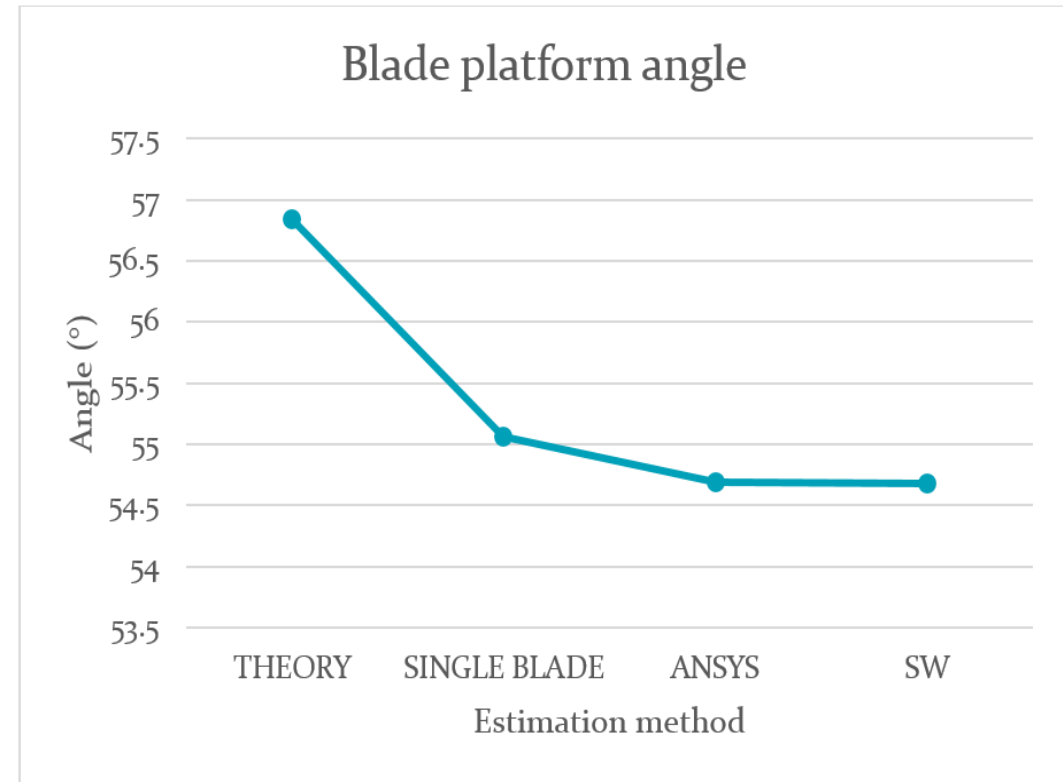
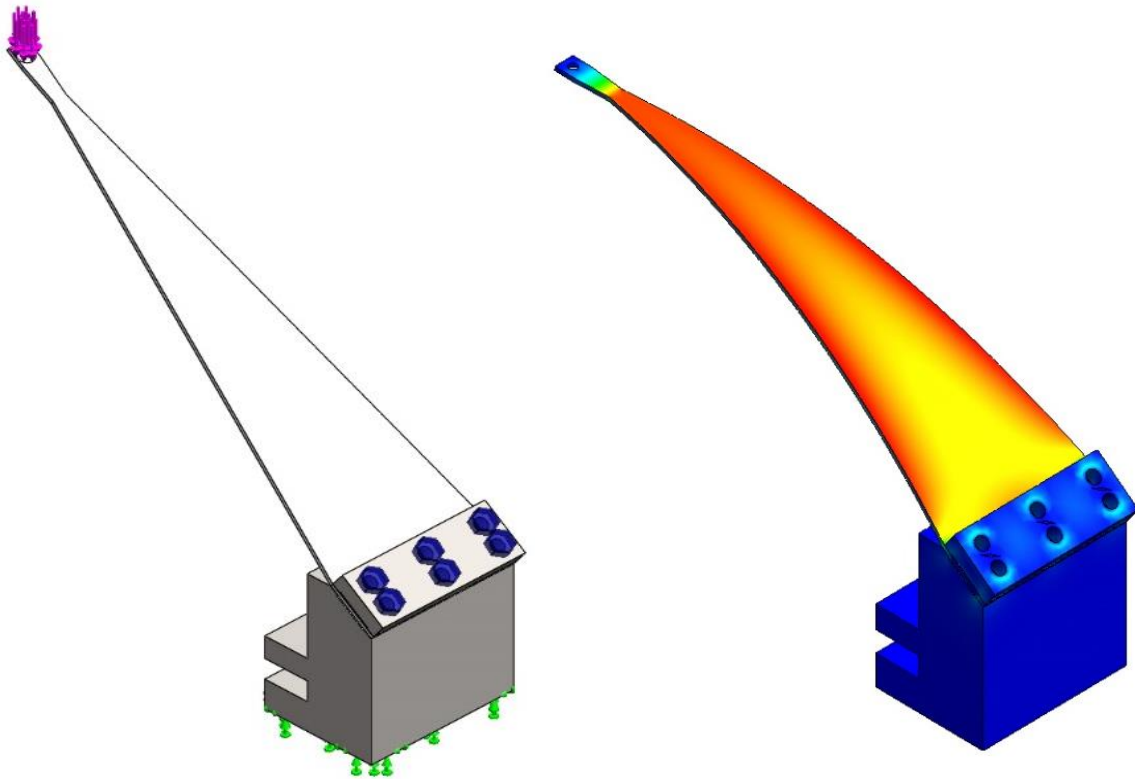


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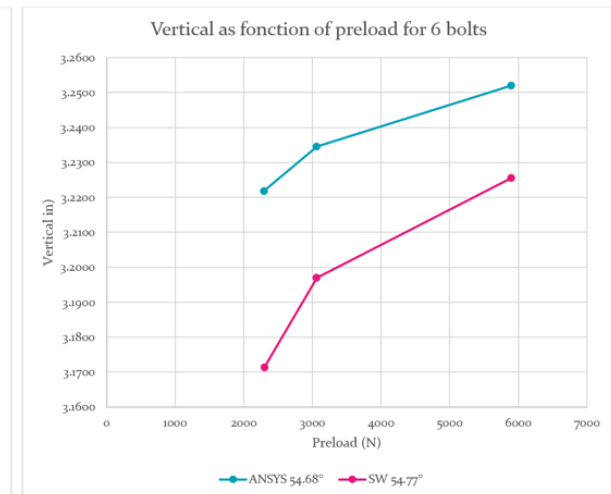
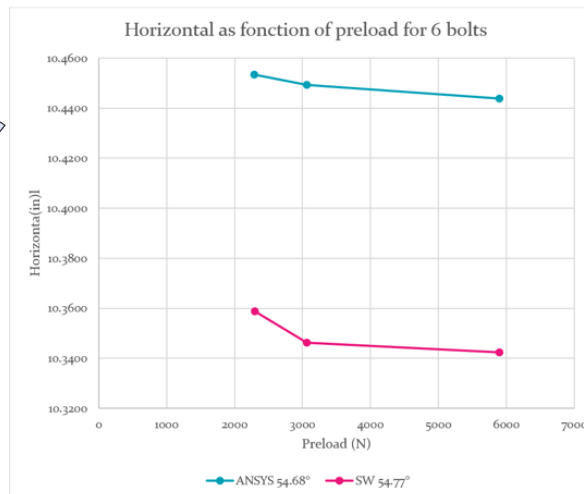
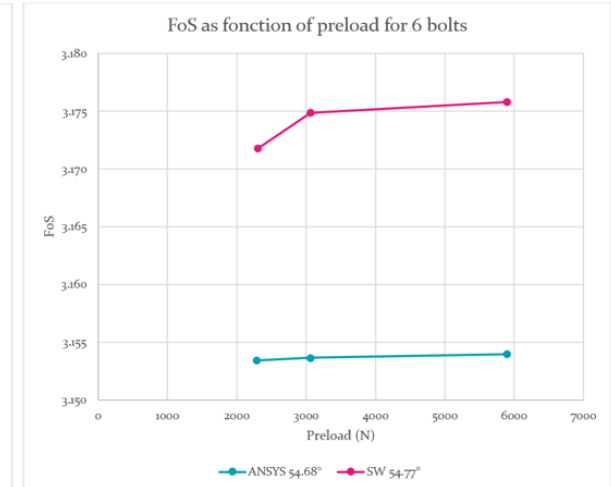
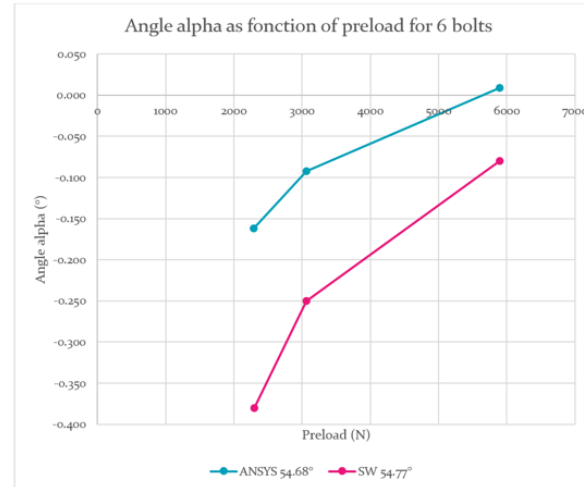
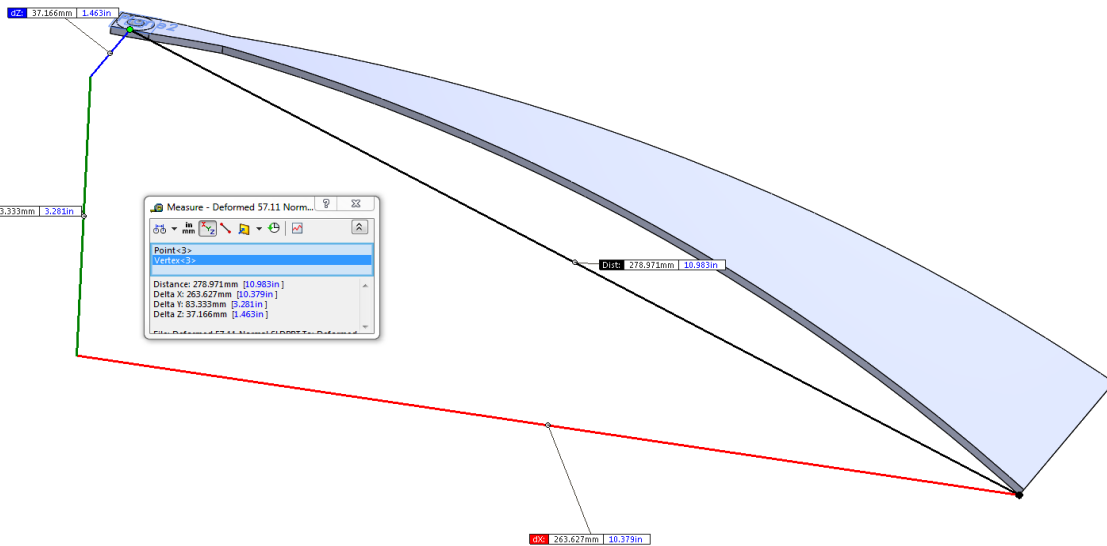
ANALYSE DU CONTACT

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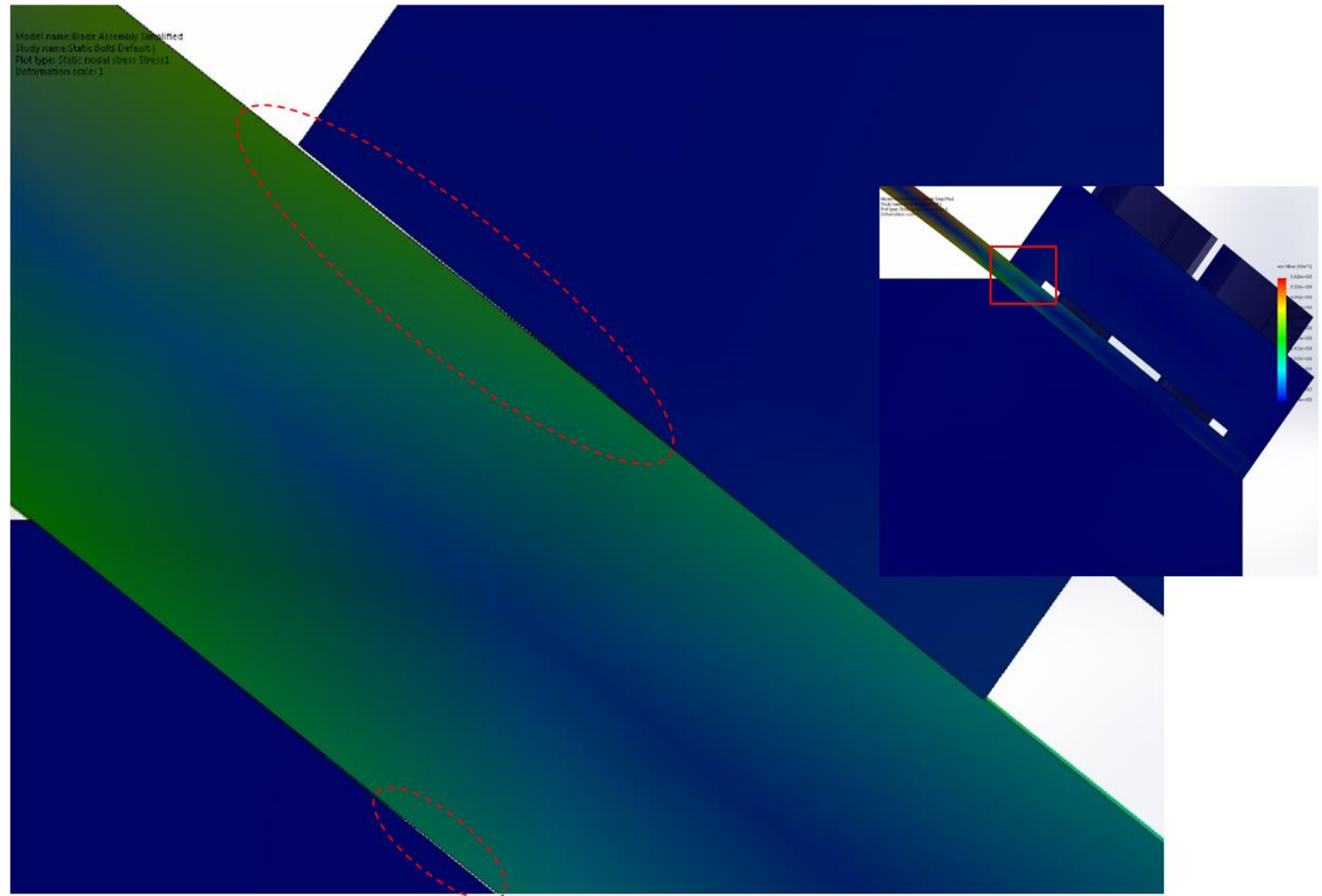
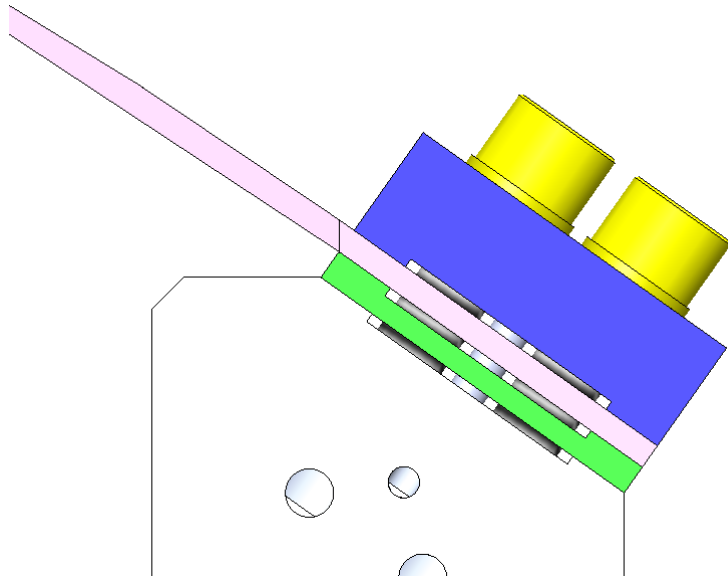
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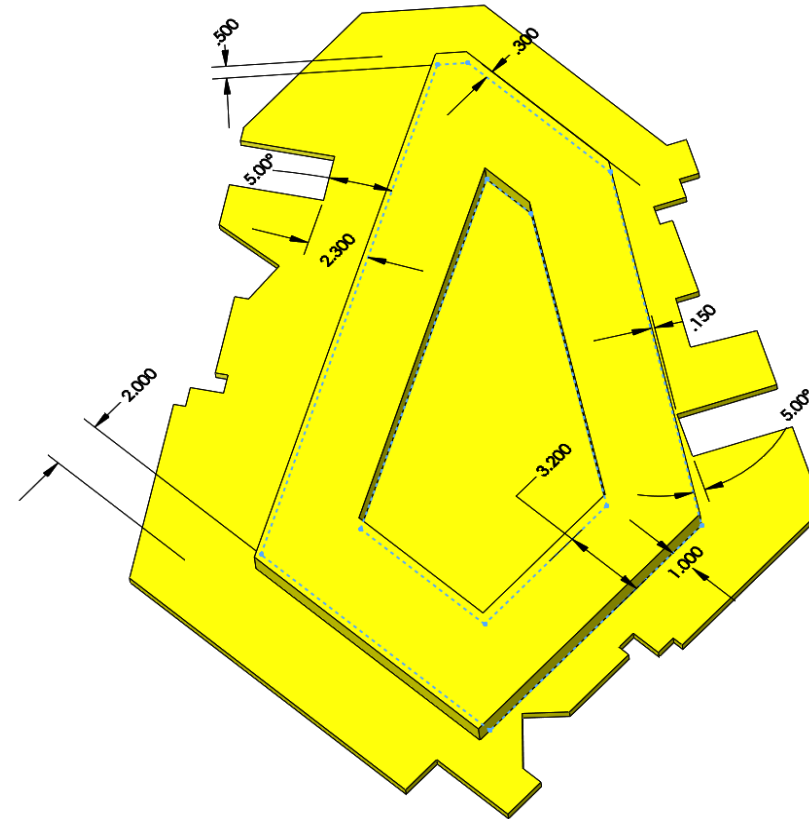
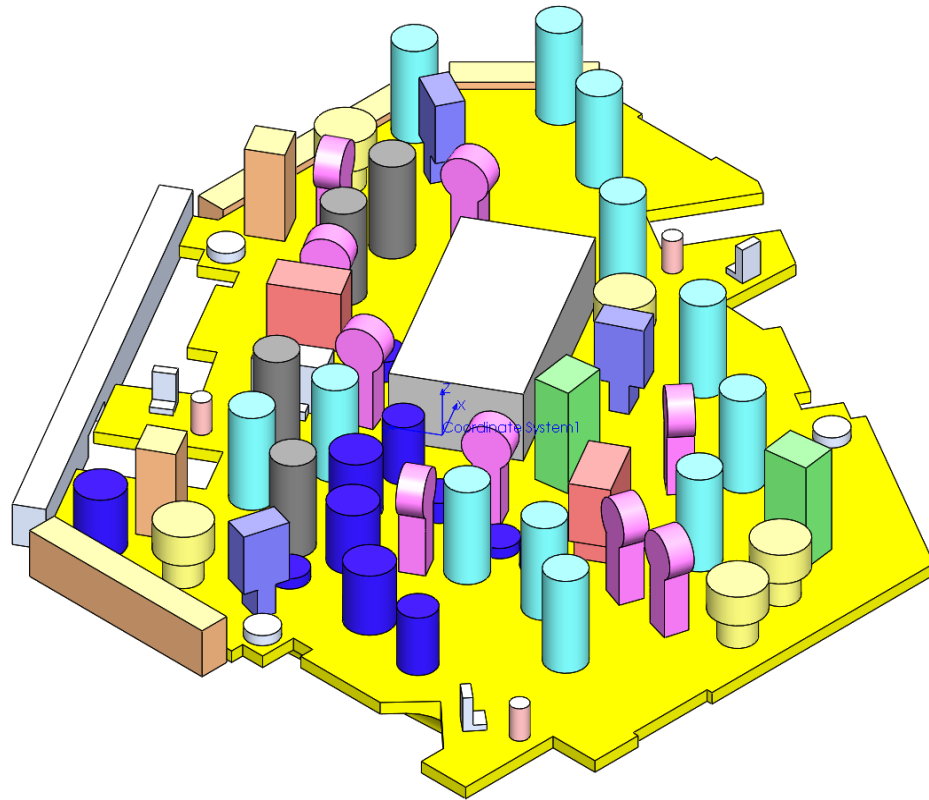


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OPTIMISATION DE LA TABLE OPTIQUE

- OPTIMISATION DE LA TABLE OPTIQUE



OPTIMISATION DE LA TABLE OPTIQUE

• OPTIMISATION DE LA TABLE OPTIQUE

Design Study Setup

Design Variables

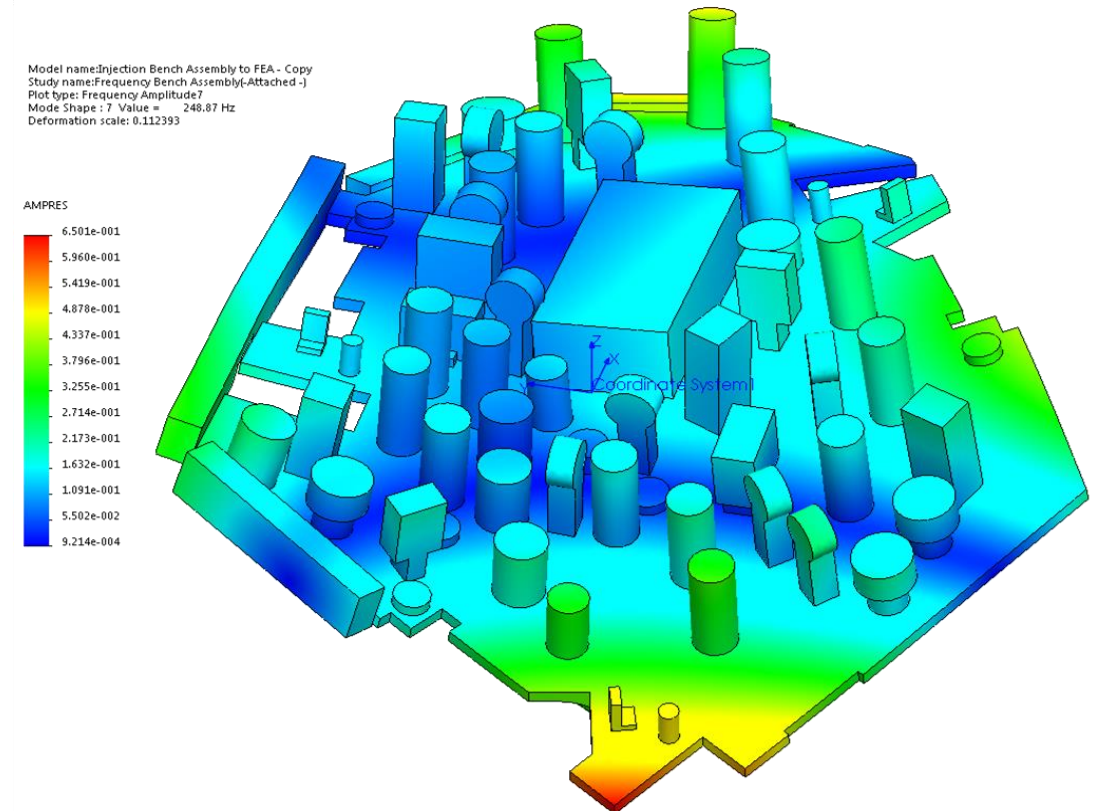
Name	Type	Value	Units
A	Range with Step	Min:1 Max:3 Step:1	in
B	Range with Step	Min:1 Max:3 Step:1	in
C	Range with Step	Min:0.5 Max:2.5 Step:1	in
D	Range with Step	Min:0.5 Max:2.5 Step:1	in
G	Range with Step	Min:0.5 Max:2.5 Step:1	in
I	Range with Step	Min:0.5 Max:2.5 Step:1	in
W	Range with Step	Min:2.4 Max:4.8 Step:0.8	in

Constraints

Sensor name	Condition	Bounds	Units	Study name
Mass	Is lower than	Max:18	kg	-

Goals

Name	Goal	Properties	Weight	Study name
Frequency	Maximize	Frequency 7	10	Frequency Injection Assembly



PLAN

- INTRODUCTION aLIGO
- CONCEPTION DE LA SUSPENSION
- ANALYSE DU CONTACT
- OPTIMISATION DE LA TABLE OPTIQUE
- **CONCLUSIONS**

CONCLUSIONS

- CONTRIBUTIONS DE CE PROJET
 - Système d'isolation pour l'instrument VOPO
 - Méthodologie pour des suspensions mono étage
 - Étude du contact des lames
 - Méthodologie d'optimisation des tables optiques

CONCLUSIONS

- TÂCHES A RÉALISER:
 - Contrôle des modes rigides
 - Test des performances
 - Assemblage complet



MERCI DE VOTRE ATTENTION

