

Sapphire news

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SAPIENZA
UNIVERSITÀ DI ROMA



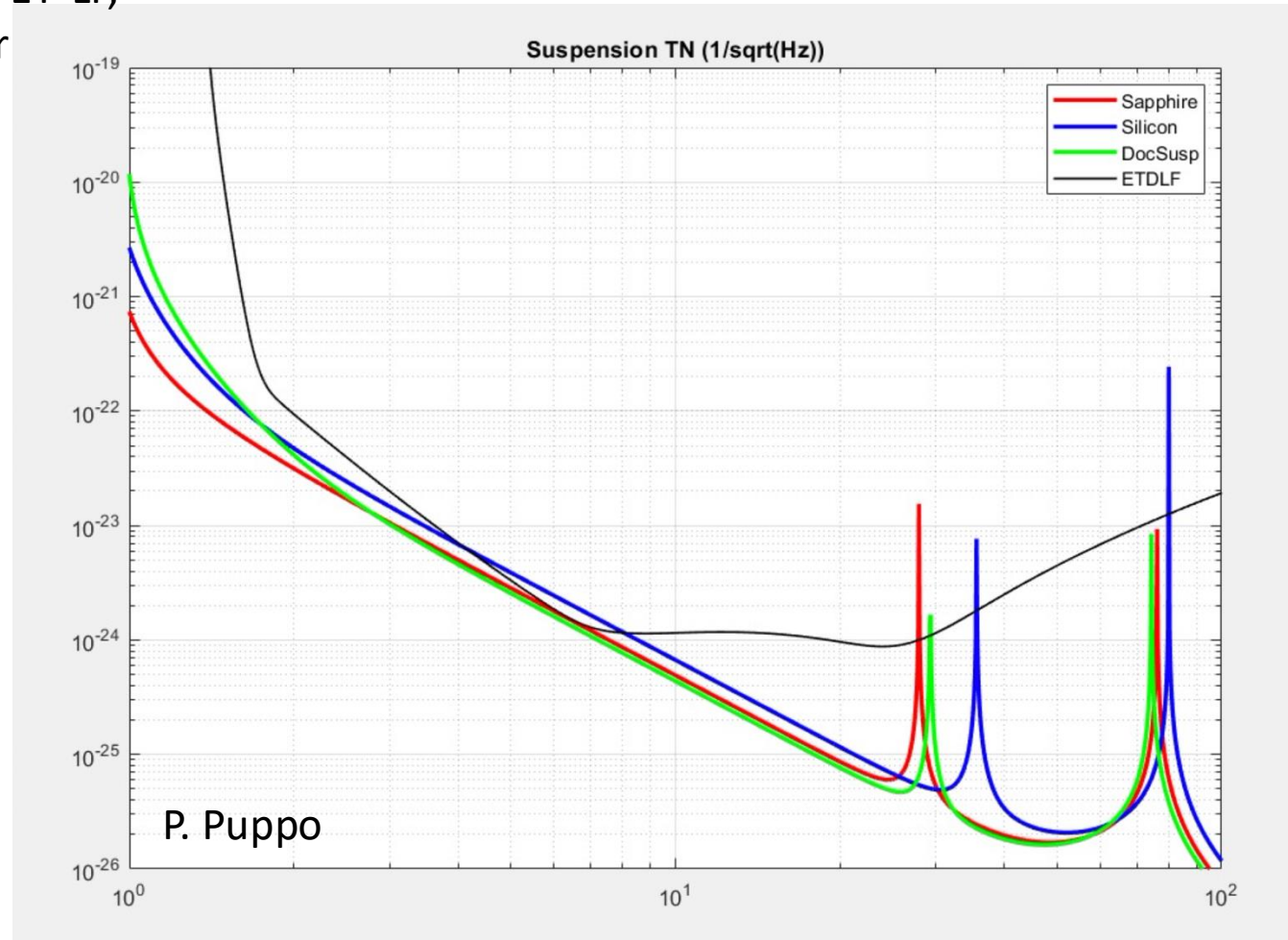
ET-0673A-24

PAYLOAD SEED SCHEME PARAMETERS DEFINED (Nov-2024)

X. Koroveshi et al. PHYSICAL REVIEW D 108 (2023)

Now tuned and shared into the suspension document for ET-LF,

- large range of adjustment is foreseen in the parameter Breakdown Structure (PBS)
- this STN budget does not consider ribbons, (also considered in the PBS)



Notice that the marionette is suspended through sapphire

Bending strength summary

Lot No	2223151	2223152	2223153
Up	CMP	CMP	CMP
Bottom	CMP	Dia	CMP
Side1	CMP	Dia	Dia
Side2	CMP	Dia	Dia
Chamfer	CMP	Dia	Dia

Measured values were really scattered. The highest value was 2605 MPa and the lowest was 1091 MPa.

Tendency depending on surface quality cannot be concluded. All results showed over 1000 MPa of breaking strength although Shinkosha initially told us some degradation of strength by Diamond polishing.

***Shinkosha catalog value: 910 MPa.**

a nice material concerning strength

Condition	Breaking strength [Mpa]
Alumina1	296
Alumina2	364
Alumina3	333
Alumina4	280
Alumina5	312
Lot 51-1	2248
Lot 51-2	2298
Lot 51-3	1091
Lot 51-4	1388
Lot 51-5	1631
Lot 52-1	1957
Lot 52-2	1828
Lot 52-3	2453
Lot 52-5	1270
Lot 53-1	2264
Lot 53-2	1632
Lot 53-3	1670
Lot 53-4	2605
Lot 53-5	1931

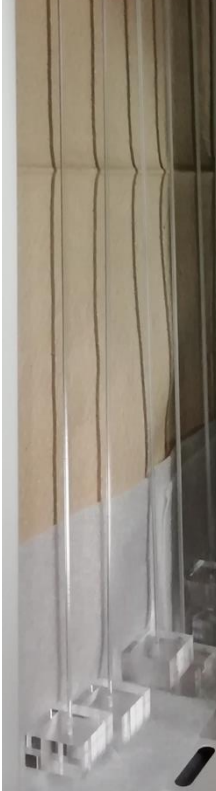
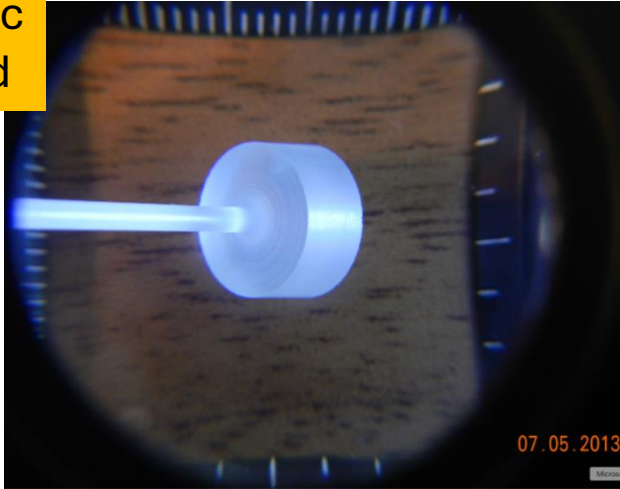
HEADS

glued

Q expected relatively low

monolithic
machined

Q expected relatively low



2024

Close to be able
to welded

- to an anchor
- to a ear

(both equipped
with a
protrusion)

2013

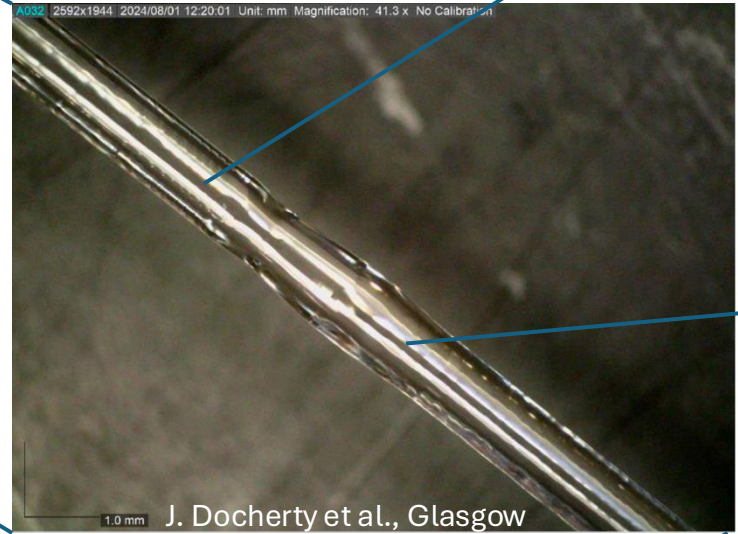
2014

3rd Annual meeting Warsaw 15/11/2024

RELEVANCE OF MOST RECENT R&D AT A GLANCE

Strength OK
(better than Si)

Quality factor ~OK
Relevant
parameters
identified



2024

Thermal
conductivity
OK

Crystallography

The diagram illustrates crystallography with two unit cells labeled 'Upper stack unit cell' and 'Lower stack unit cell'. It also shows a vertical 'c-axis' and 'Upper stack piece' with 'Random rotation around c-axis' indicated by a curved arrow.

- Analysed crystal orientations using x-ray diffraction
- Found two c-axis orientations at joint region
- Weld region found to be $\leq 200 \mu\text{m}$, promising for thermal noise level

a very remarkable investigation !

1. Growing Al_2O_3 crystal suspension is an actual technology
2. Welding is a reality using the CO_2 crystal growth machine is an actual technology

OTHER SITES !



OSAG (Optiques en Saphir pour l'Astronomie Gravitationnelle) project with IDEX Lyon.



Production of long Al_2O_3 suitable for ET-LF achieved (1 m)
BUT AT THE MOMENT CRITICALLY AFFECTED BY PERSON_POWER LACK !!!

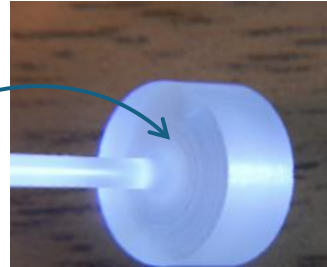
3rd Annual meeting Warsaw 15/11/2024



320 mm diameter achieved goal 450 mm

OPEN ISSUES

1. Detaching/fixing suspension units ?

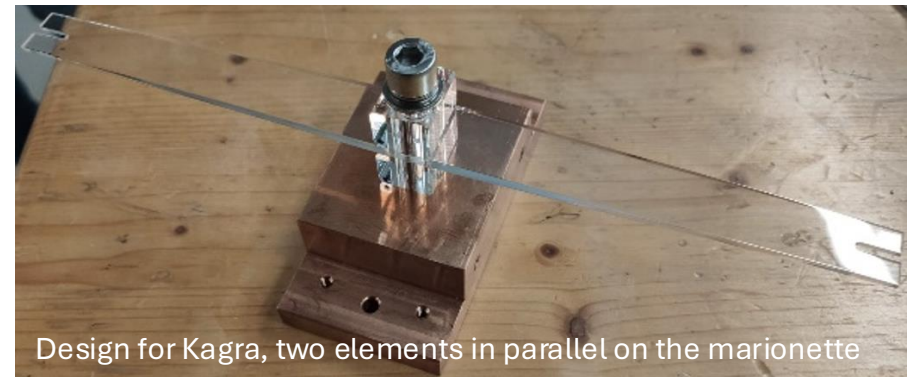


2. Contacting to ears anchors in case

3. Equal lengths among units: equalization seems non-trivial (this is why KAGRA used Sumiceram glue)

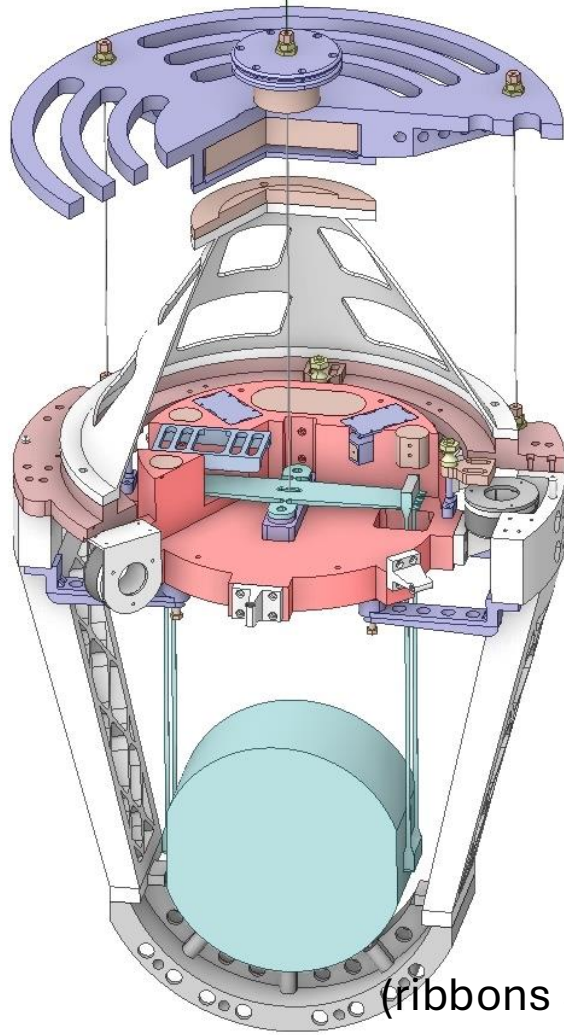
4. Possible need of blades on the marionette ?

- So far, up to $Q \sim 1.5e5$ the losses seem dominated by the material purity more than on surface treatment and shape
- A single piece clamped clamped at the center to minimize recoil losses ? Excellent but not so easy to build it with as a 450-500 mm piece, tapered (R&D/production ongoing)

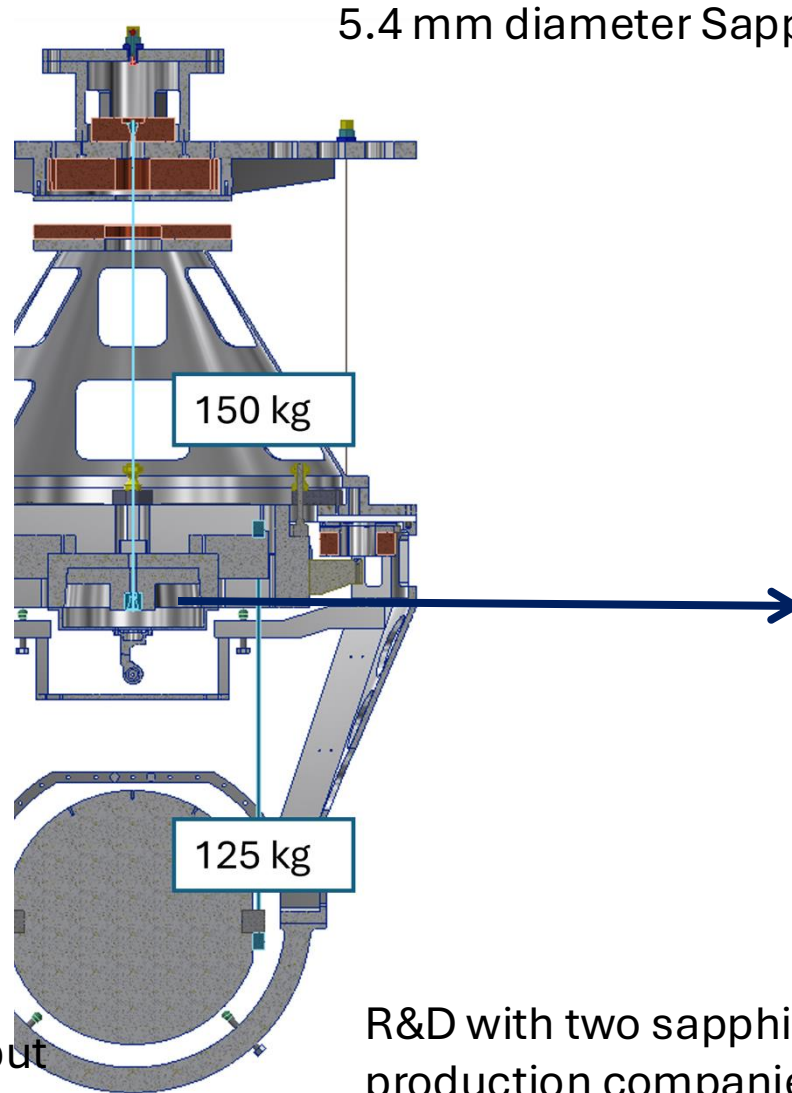


Design for Kagra, two elements in parallel on the marionette

WORKS ON ARC-ETCRYO payload prototype



(ribs so far, but cylindrical rods can be adapted)

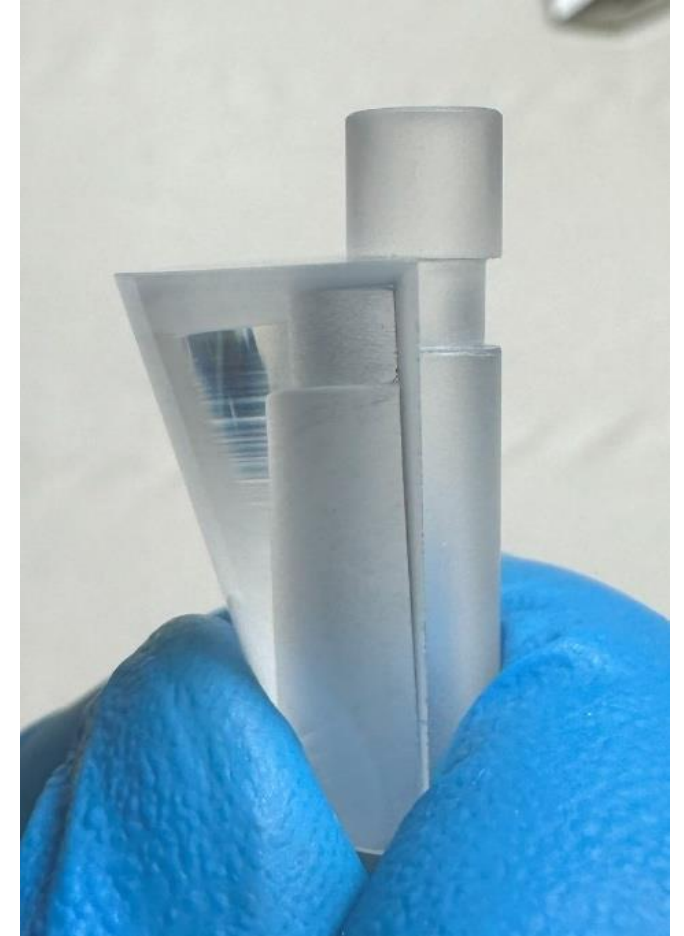


5.4 mm diameter Sapphire suspension needed

150 kg

125 kg

R&D with two sapphire production companies (IMPEX and Kyocera)



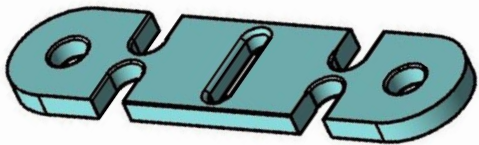
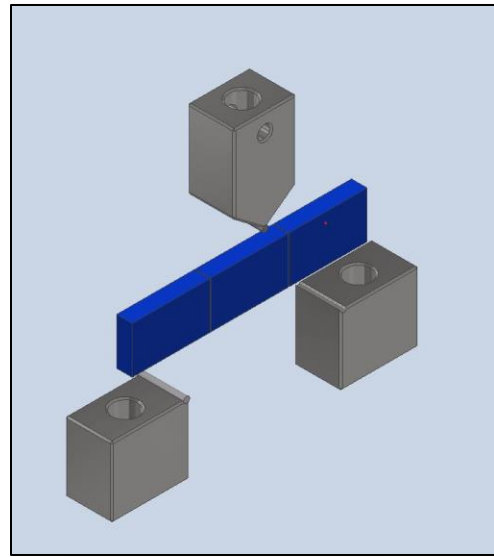
WORKS ON ARC-ETCRYO:

practical solution for a flexible payload prototype waiting for welding: ribbons/marionette/HCB

STEP 0: strength tests, obligatory step for studying the mirror suspensions

Status:

- full mechanical design compliant with mechanics and cryogenics done
- samples partially delivered: small blocks, short ribbons with flat heads, short rods for the marionette



STEP 1

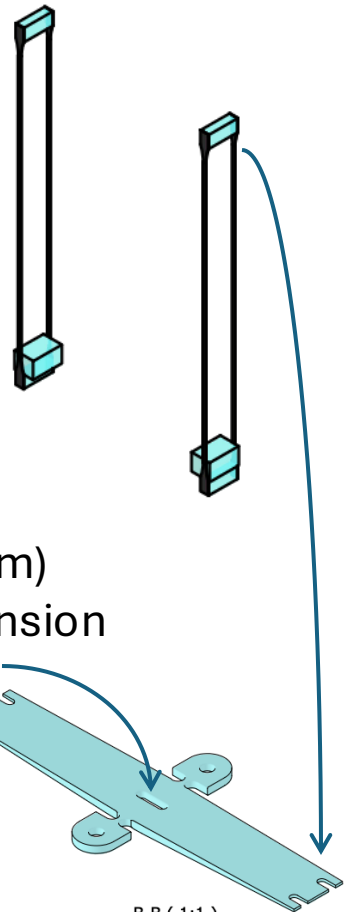
- Ears on Flats (encapsulated on Al dummy mirror 125 kg)
- Anchors (glued or HCB on rods or ribbons)

Structure of Central part of the blade

STEP 2

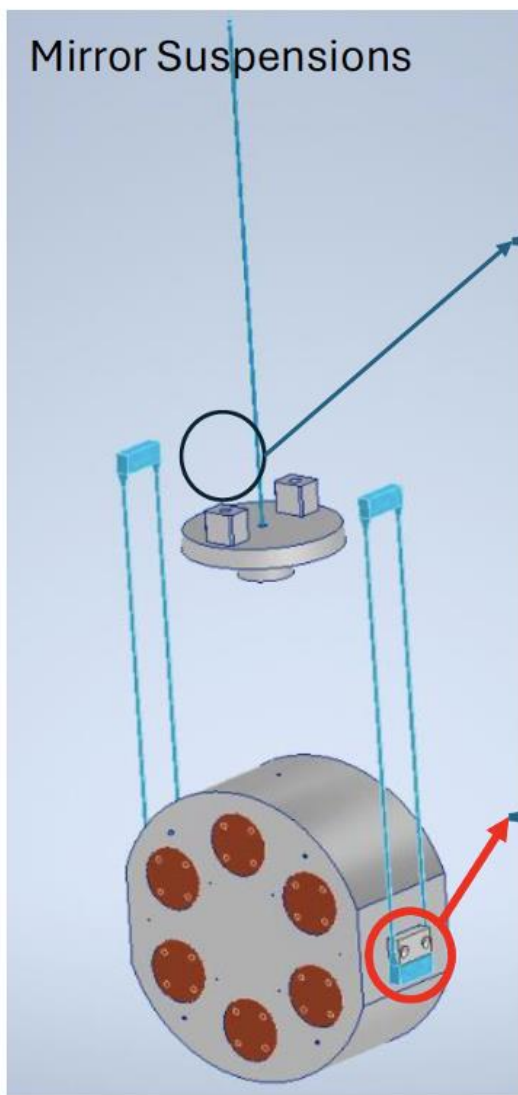
Development of long rods/ribbons

Development of large blade (500 mm) with central suspension wire passthrough

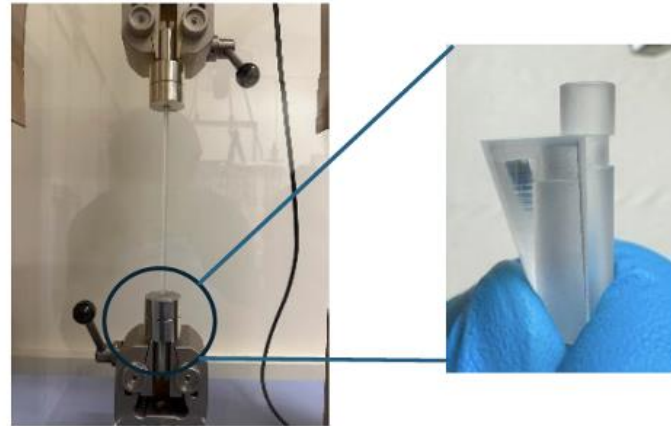


B-B (1:1)

ARC

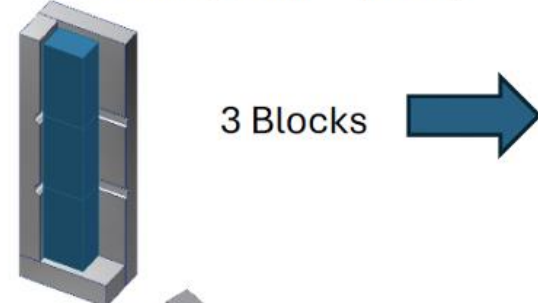


Testing new mechanical lock for the marionette

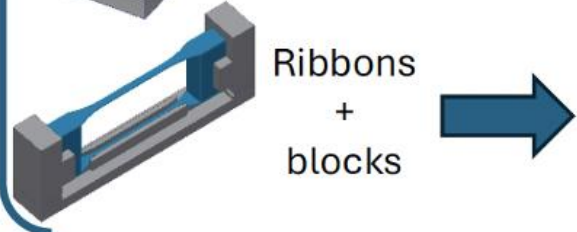


We are also considering the use of glues such as Sumiceram or Stycast.

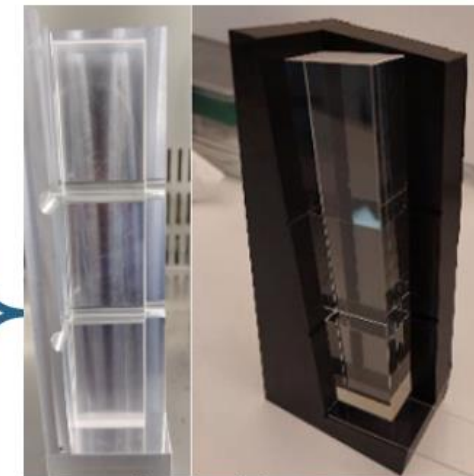
1. Bonding Phase (HCB) 2. Testing Phase



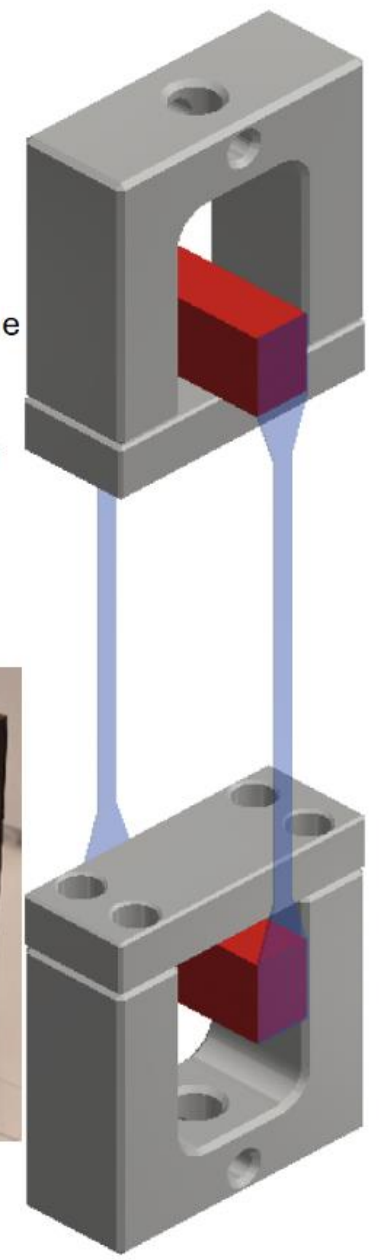
3 Blocks



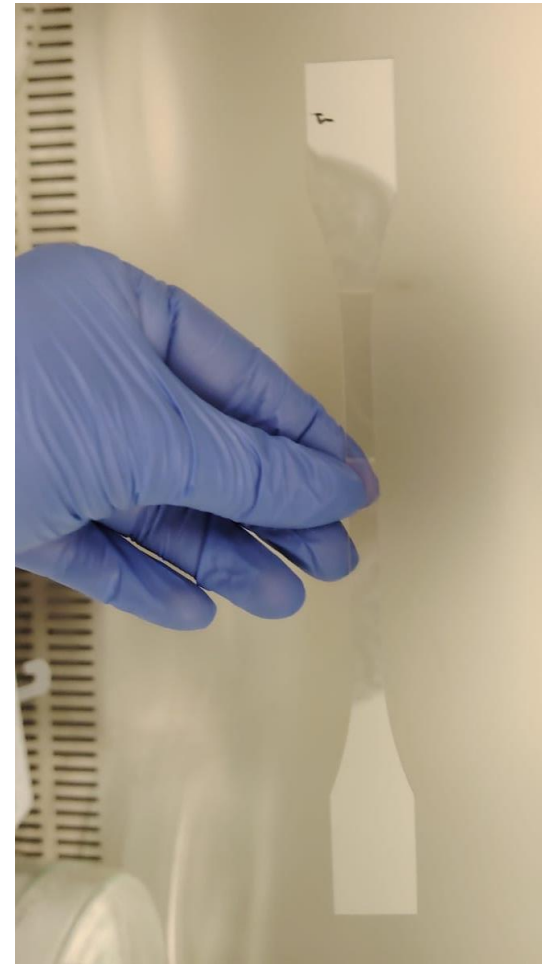
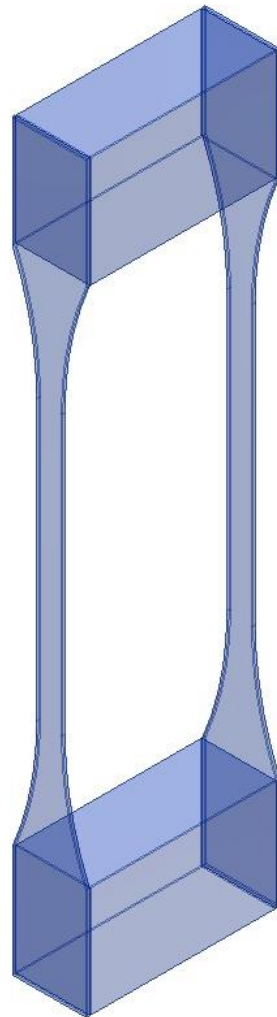
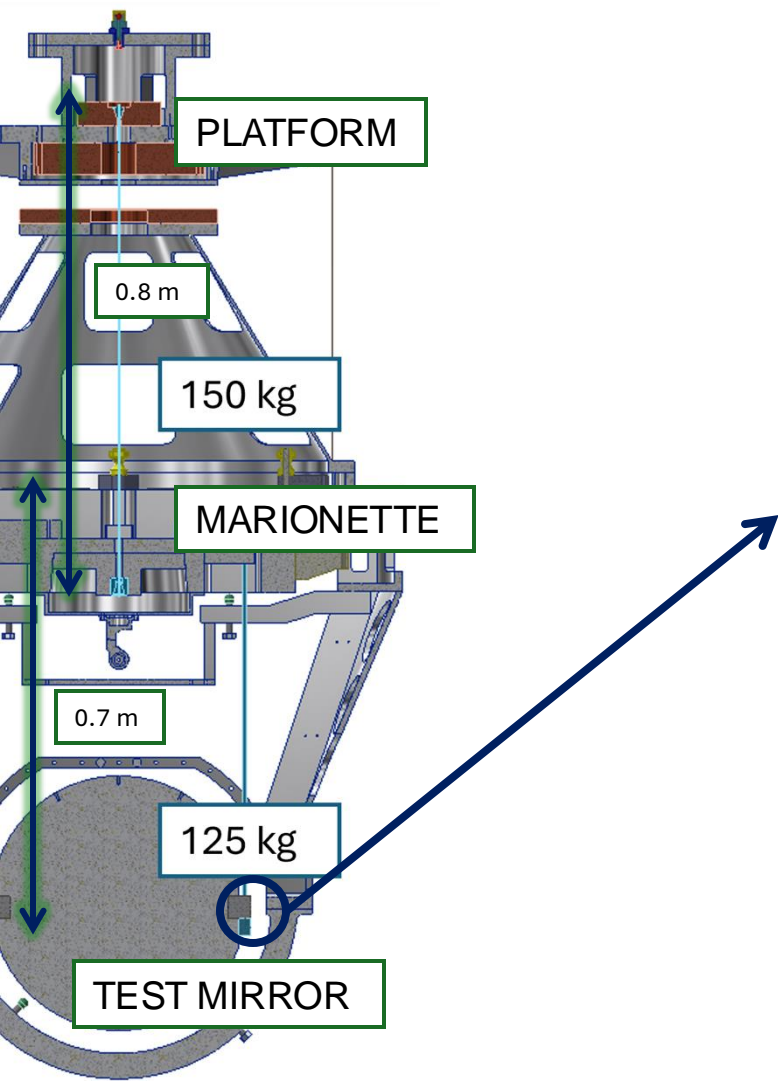
Ribbons + blocks



Finally doable in Rome (Glasgow collab)

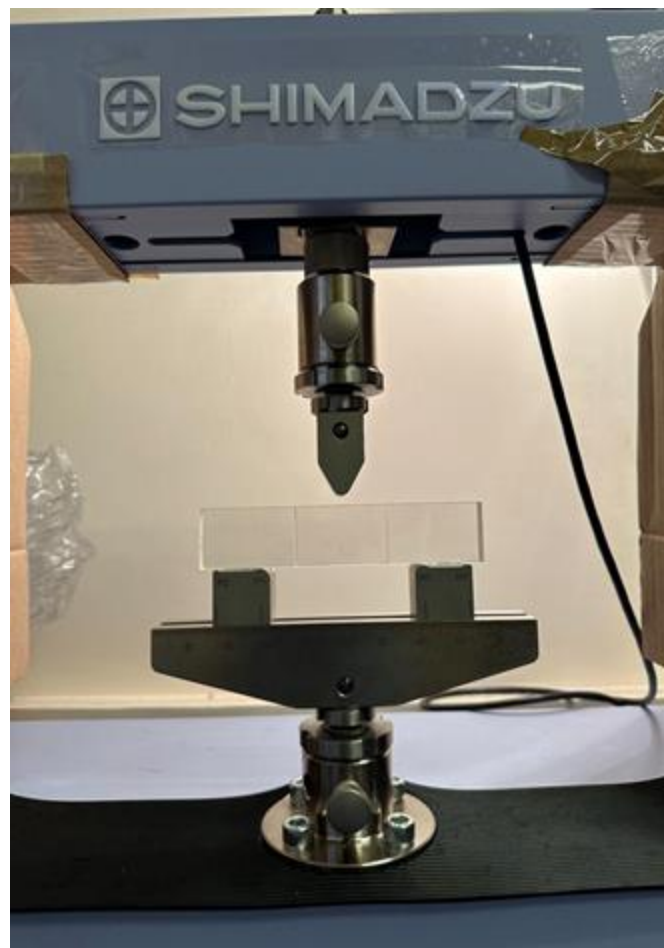


Sapphire Ribbons Mirror Suspension Pair



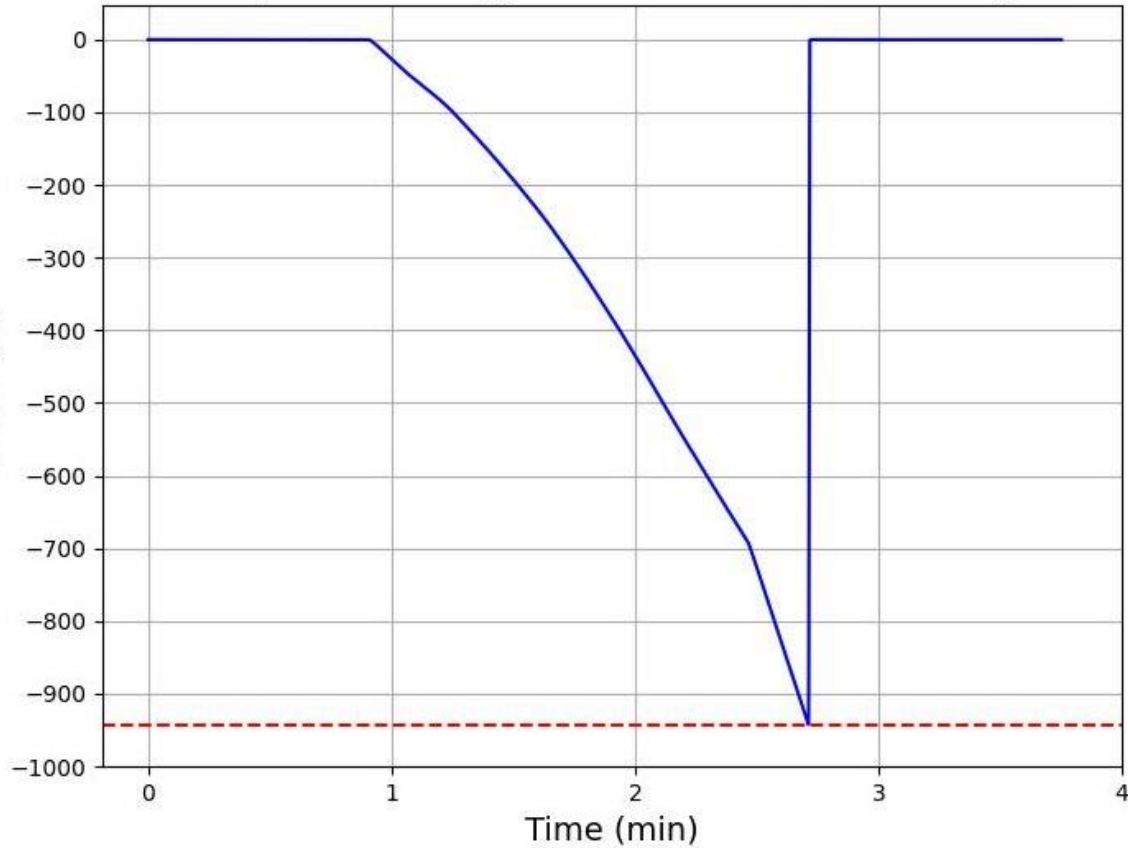
Test campaign to test shear strength (meant for ribbon HCBs)

B.

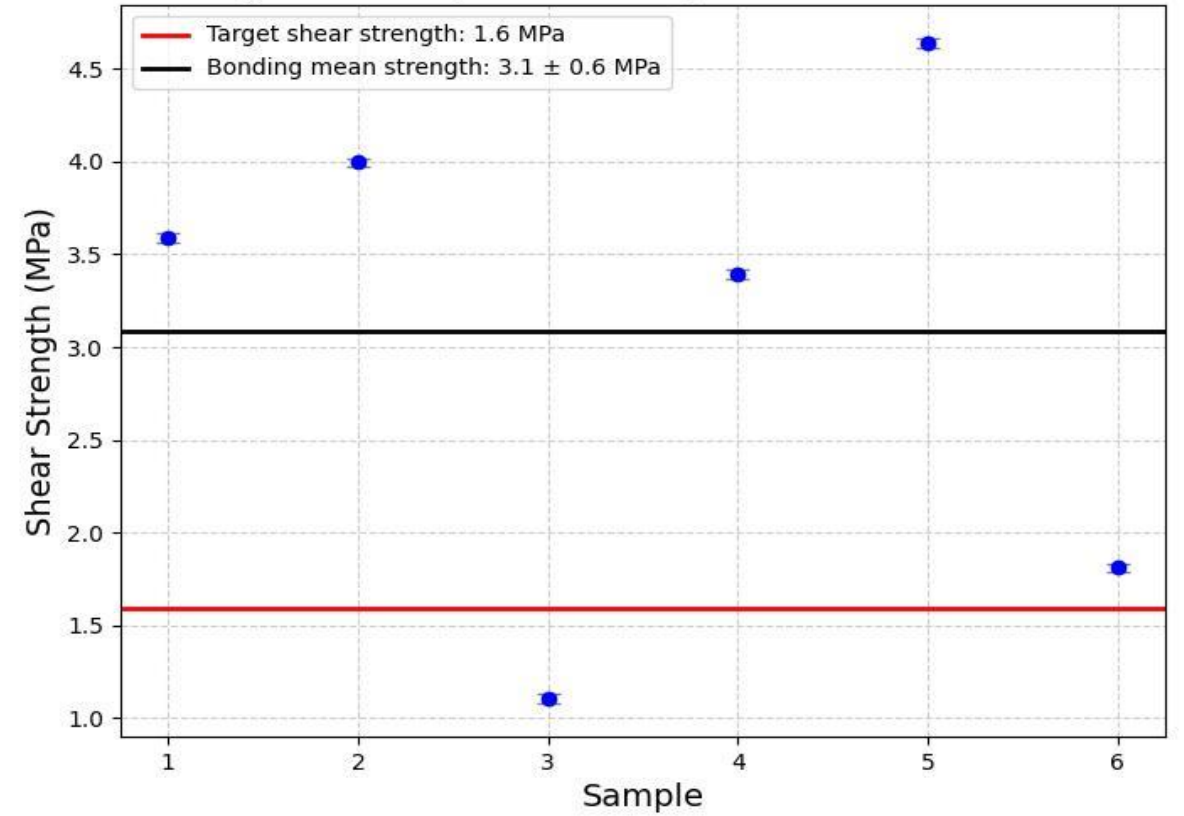


HCB shear strength measurements

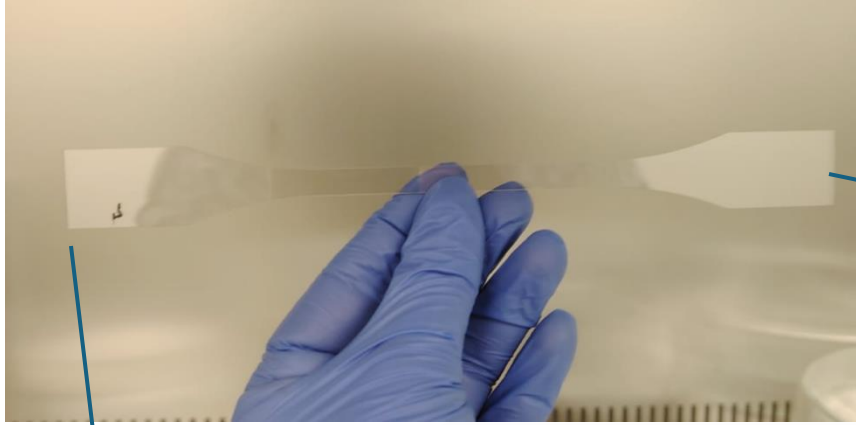
Example of Stress application trend on a bonded sample



Shear Strength of bonds produced using Sodium Silicate solution at 293 K



WORKS ON ARC-ETCRYO: FUTURE



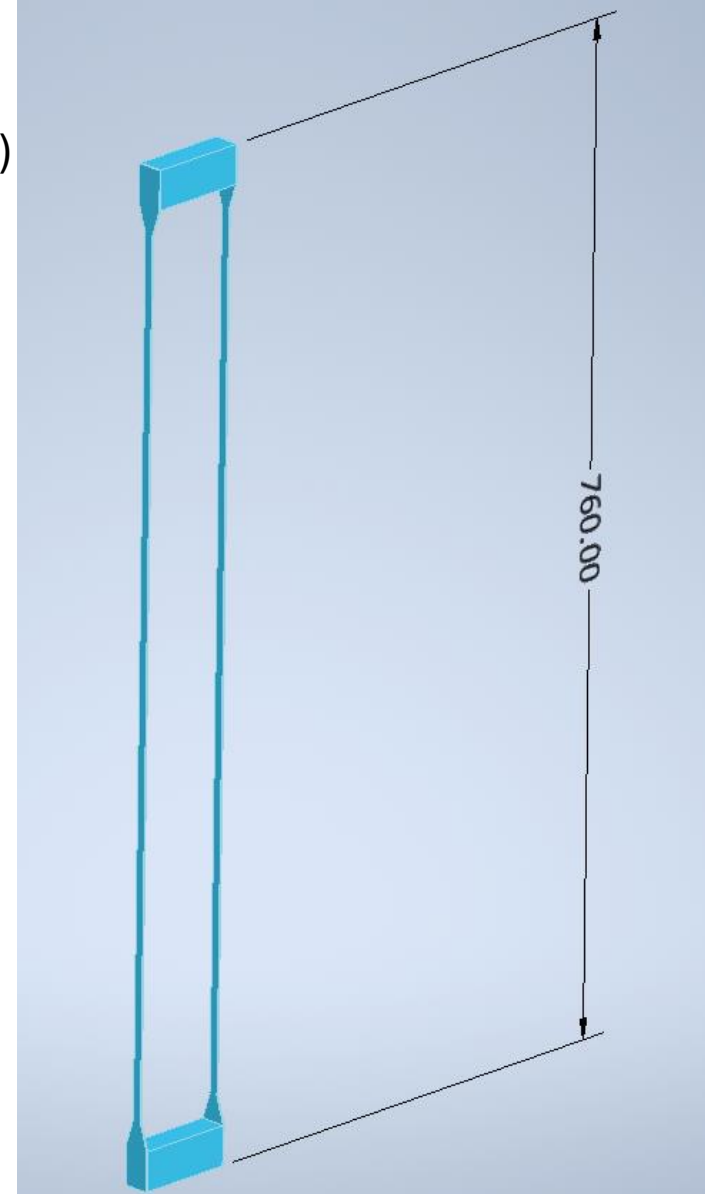
after strength and Q measurements on short suspension units
(both monolithic (Kyocera) and HCB (IMPEX))

760 mm
VERY LONG PRODUCTION TIME

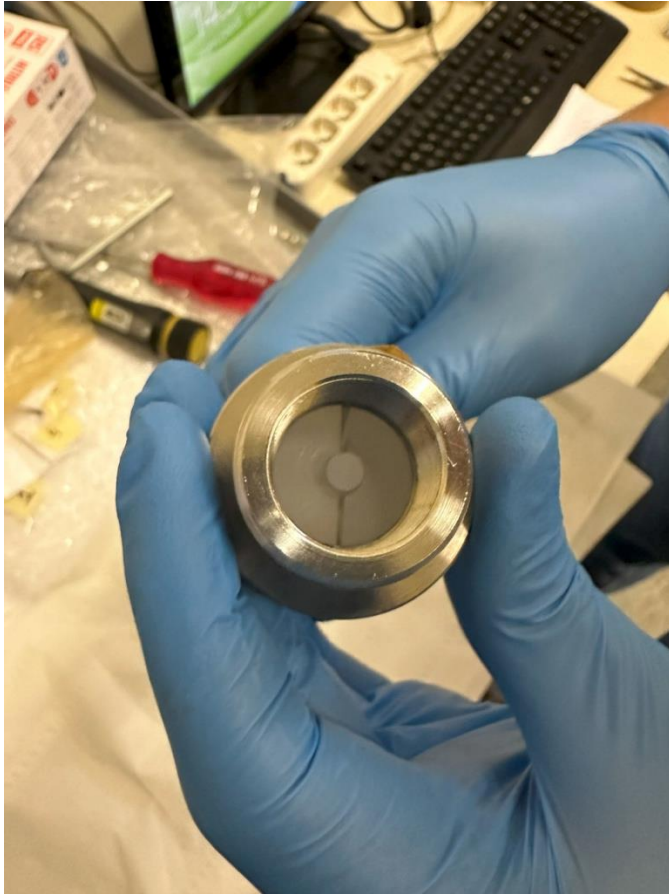
The assembly of the two units on the two sides of the marionette will be revolutionary different

So far no blade is under production due to

- the too long schedule
- need to assess the robustness of the central part



Experimental set-up to test tensile strength for Al₂O₃ marionette



A non-trivial (and expensive) task, several samples purchased

- Involvement of IMPEX to provide a hybrid metal-Sapphire brazed nail head for the marionette as back-up solution
- Welding would strongly help just here