Cryogenics sub-Group (CRY) Report

#PABの資料に追加

21. Jun. 2016

Cryogenics Subgroup Chief, KEK

Takayuki TOMARU

Major Milestones of CRY toward bKAGRA-1

- 2016. 5 - 7 X-end and Y-end cryostats assembly
- 2016. 8 - 10 Cool-down test of X-end and Y-end cryostats
- 2016. 12 End of fabrication of 4-cryogenic pendulums
- 2017. 2 - 3 Assembly of sapphire parts onto two End Mirrors (ETMs)
- 2017. 4 - 8 Cryogenic test of ETMs
- 2017. 8 Assembly of sapphire parts onto two Input Mirrors (ITMs)
- 2017. 9 - 10 ETMs installation into cryogenic payload (pendulum)
- 2017. 10 – 11 Cryo-Payload installation into the Y-end cryostat
- 2017. 12 –
  2018. 1 Cryo-Payload installation into the X-end cryostat
- 2018. 1. Short test of Michelson by Cryo-Payloads at room temperature
- 2018. 2 - 3 Cool down of the X-end and Y-end Cryo-Payloads.
- 2018. 3 bKAGRA-1 run

We don’t have sufficient time to do full test and improvement of cryo-payloads and cryostats.
These can be imperfect version…

But

We absolutely keep

- 2018. 1 Completion of Two ETM cryo-payloads installation
- 2018. 3 Ready of Cryo-Michelson

schedule

Answers to PAB 2015 Recommendation

Recommendation 8:

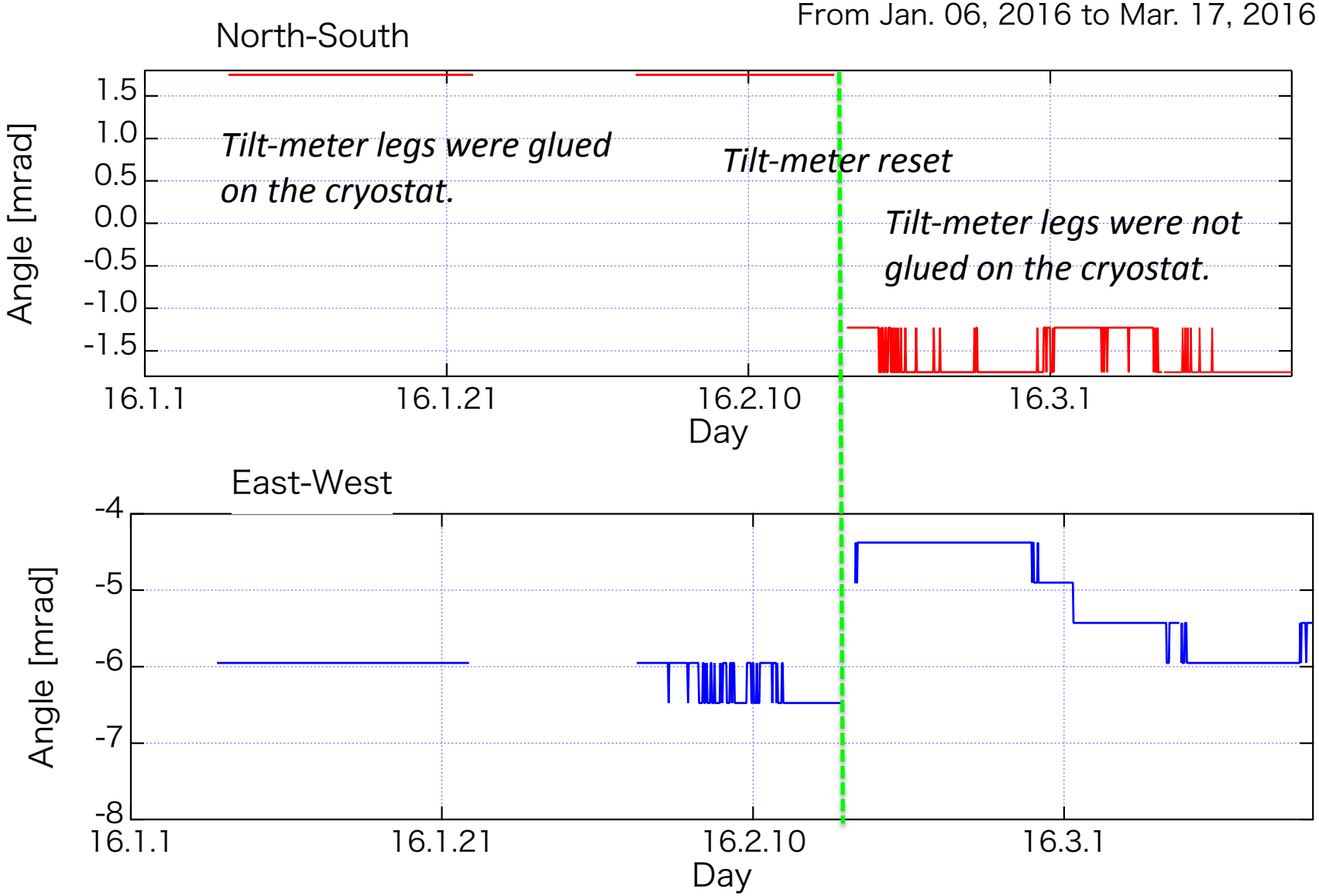
It is critically important to understand the movement/tilting of the floor especially at the upper payload base location, and to find a reliable solution.
Systematic continuous monitoring of this is recommended and, in parallel, monitoring of environmental data to find correlations and to find a systematic solution.

Answer:

We put a plumb bob on the Y-end through the vertical hole from the second floor to the roof of the clean booth, and started to monitor a change of installed positions. Also we put a digital inclination sensor on the cryostat at the X-front. Those monitors have worked since September 2015. A sensitivity of monitors are 0.01 deg (nearly equals to 0.2 mrad). Although we had a less groundwater in this early spring, no significant movement of position was observed until May 2016.
Positioning error of cryostat and of vertical shaft of type-A vibration isolator seem to be within an adjustable range of their designed structure.
The cross-duct with 900 mm in diameter will connect between the vertical shaft and the top of the cryostat at both X and Y ends in middle of July 2016. At that time, we will measure a relative disagreement of positions and correct them.

Tilt Measurement of Y-front Cryostat

From Jan. 06, 2016 to Mar. 17, 2016



Major Milestones of CRY toward bKAGRA-1

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- 2018. 2 - 3 Cool down of the X-end and Y-end Cryo-Payloads.
- 2018. 3 bKAGRA-1 run

新たなPABのコメント：X, YのETMを一辺にアッセンブリ・試験せず、まずはETMYの片方だけ先に組立・アッセンブリするような順序すると、トラブルがあったときに対処しやすくないか？

→ 原理的には可能。

Updated Major Milestones of CRY toward bKAGRA-1

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- 2016. 8 - 10 Cool-down test of X-end and Y-end cryostats
- 2016. 12 End of fabrication of 4-cryogenic pendulums
- 2017. 2 - 3 Assembly of sapphire parts onto two End Mirrors (ETMs)
- 2017. 4 - 6 Cryogenic test of ETMY
- 2017. 7 ETMY installation into cryogenic payload (pendulum)
- 2017. 8 Assembly of sapphire parts onto two Input Mirrors (ITMs)
- 2017. 8 – 9 Cryo-Payload installation into the Y-end cryostat
- 2017. 10 – 11 Cryogenic test of ETMX
- 2017. 12 ETMX installation into cryogenic payload (pendulum)
- 2017. 12 –
  2018. 1 Cryo-Payload installation into the X-end cryostat
- 2018. 1. Short test of Michelson by Cryo-Payloads at room temperature
- 2018. 2 - 3 Cool down of the X-end and Y-end Cryo-Payloads.
- 2018. 3 bKAGRA-1 run

Details of
Cryogenics sub-Group Report

KAGRA Cryogenics subGroup

Takayuki TOMARU
Chief
KEK, Assoc. Prof.

Nobuhiro KIMUR
Cryostat sub-chief
KEK, Assoc. Prof.

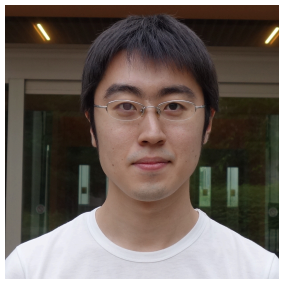
ICRR, Assist. Prof.

KEK, Prof.

ahul KUMAR
mulation, Payload
KEK, PD

CRY team has good international collaboration among Japan, Taiwan and Italy

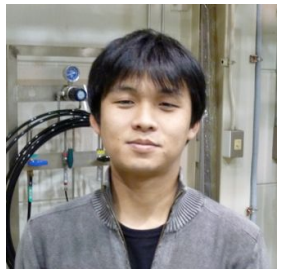
Kieran CRAIG
Cryogenic Payload
ICRR, PD



USHIHBA
Cryogenic Payload
U-Tokyo, PD

Yuki Inoue
Cryogenic Payload
AS, PD

Helios VOCCA
HCB, Perugia U,
Assist. Prof.



Suguru TAKADA
Cryogenics
NIFS, Assist. Prof.

Hiroki TANAKA
Cryo-Payload, Q
ICRR, D1

Takahiro MIYAMOTO
Cryo-Payload
ICRR, D1

S. TERASHIMA
Machining
KEK, Technical Staff

Y. Namai
CAD, KEK
Technical Staff

A. Ueda
CAD, KEK
Technical Staff

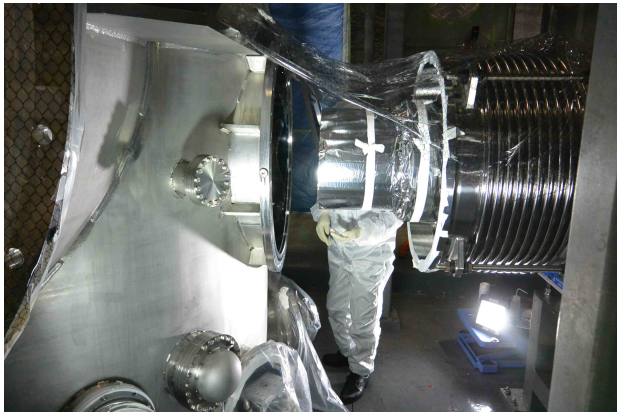
A. HAGIWARA
CAD
KEK, Technical Staff

Status of the end room cryostats construction

- X&Y-end room cryostat from components including connecting cryo-cooler units and the duct shields are now under assembling, and will be completed at the beginning of this July.
- X-end cryostat have almost completed except connection of vertical duct between the cryostat and vacuum chamber for VIS. This work will be started after assemblage the end cryostats.
- Vacuum test with leak hunting will be started after all of the construction work.
- Performance test of the cryostat shall be finish until end of this Oct.

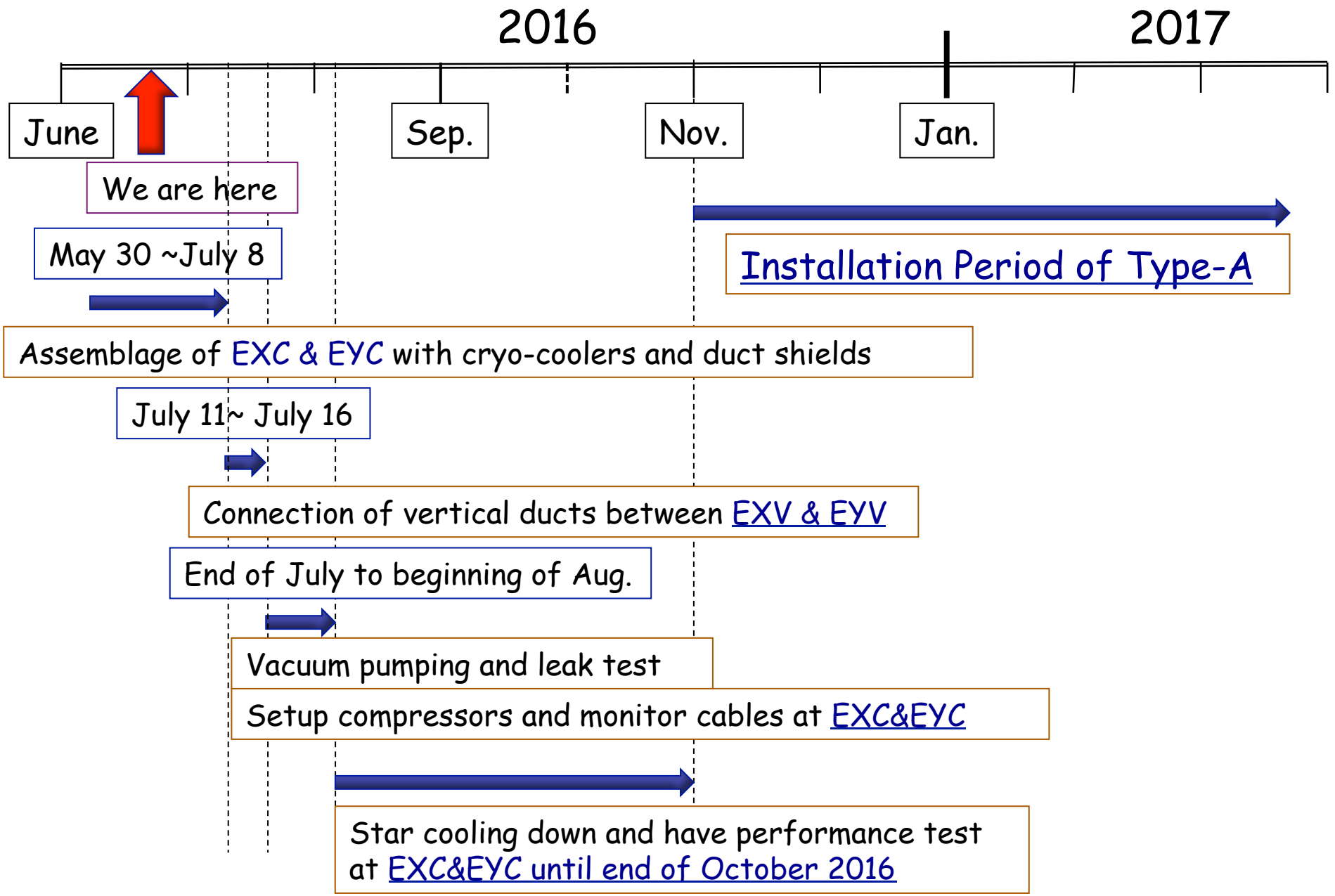
Duct shield transportation

Duct shield installation



Duct shield connection

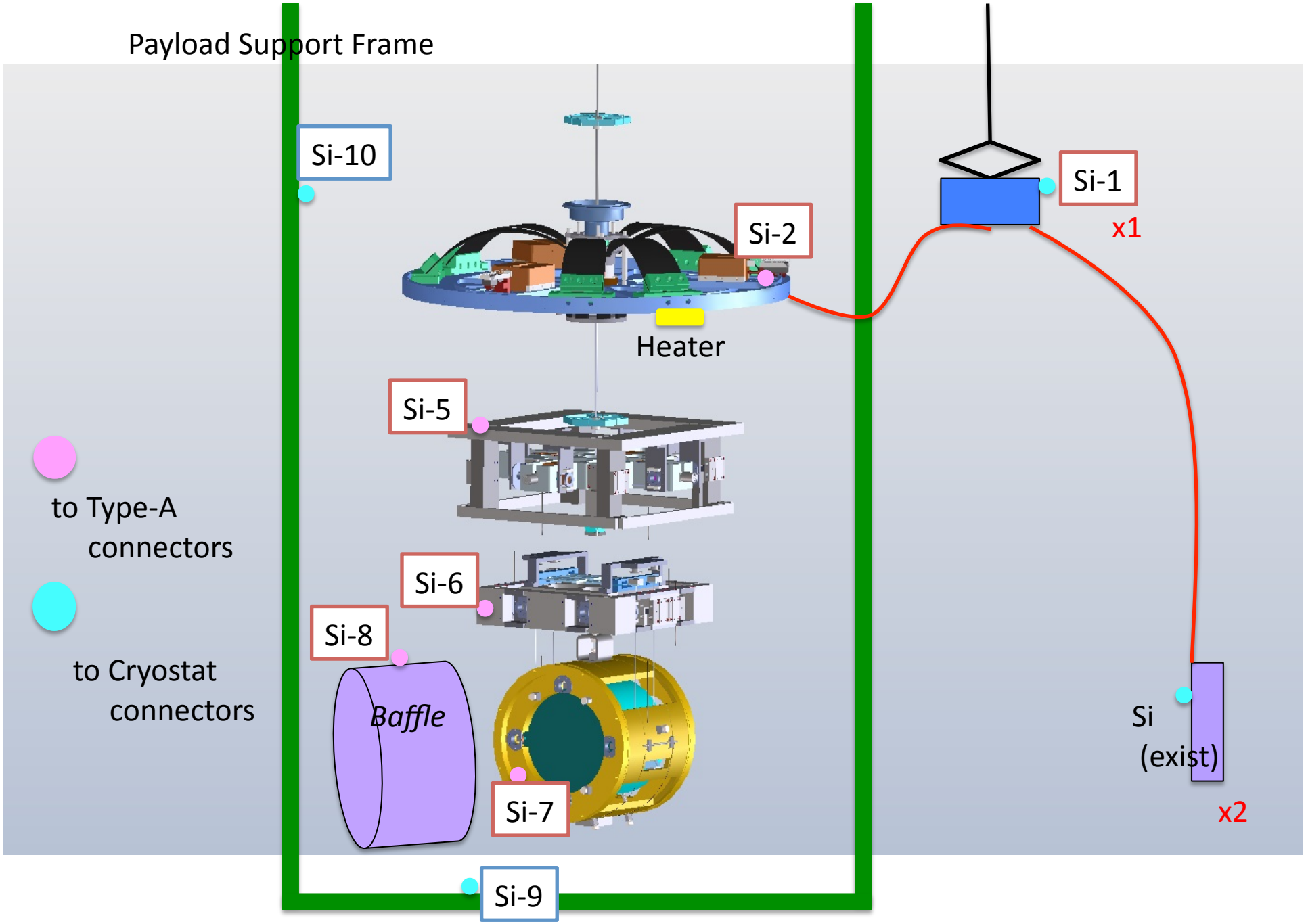
Performance Test Plans for KAGRA EXC & EYC

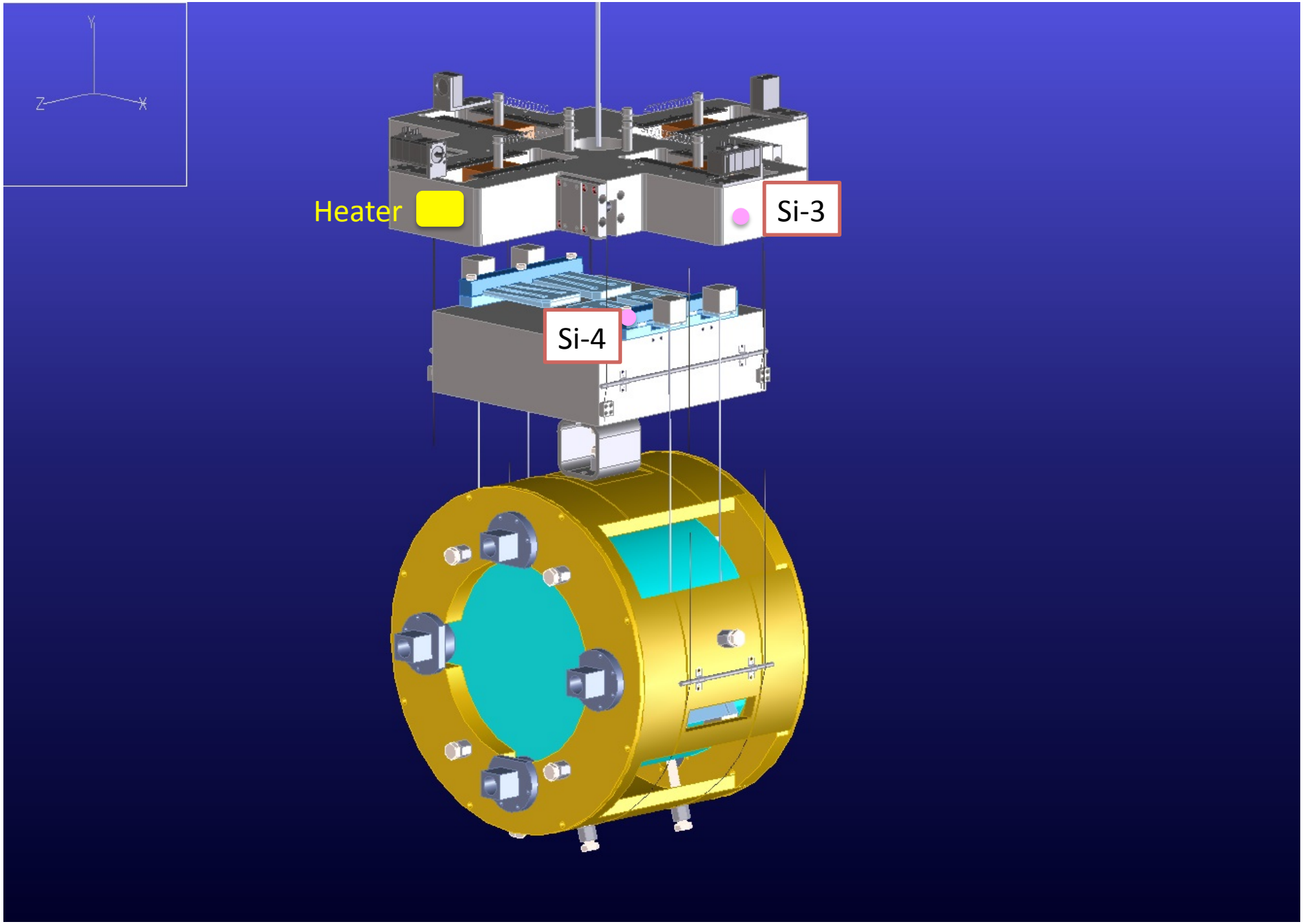


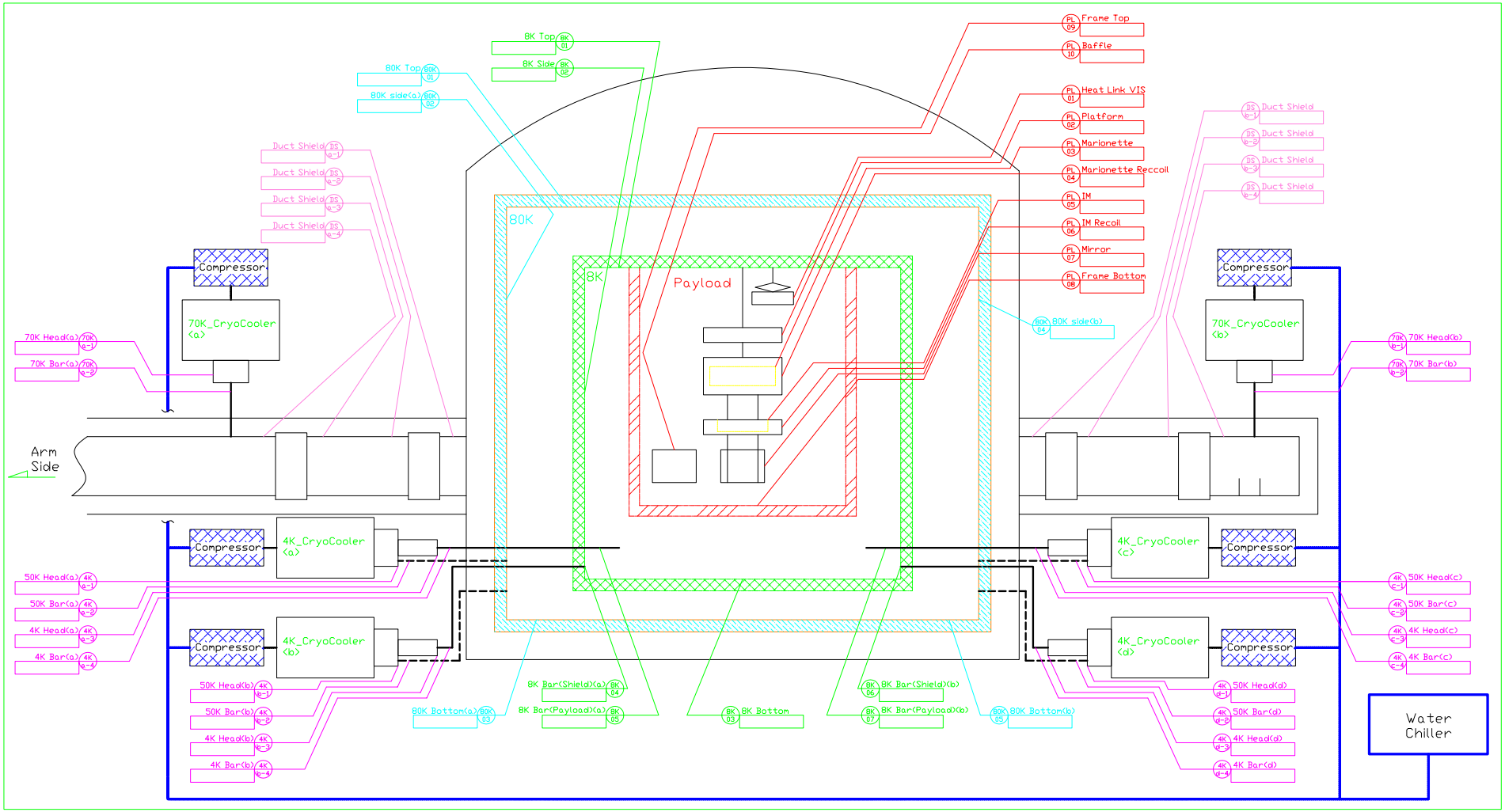
Slow DAQ

← 8月から冷却試験を始めるので喫緊の課題

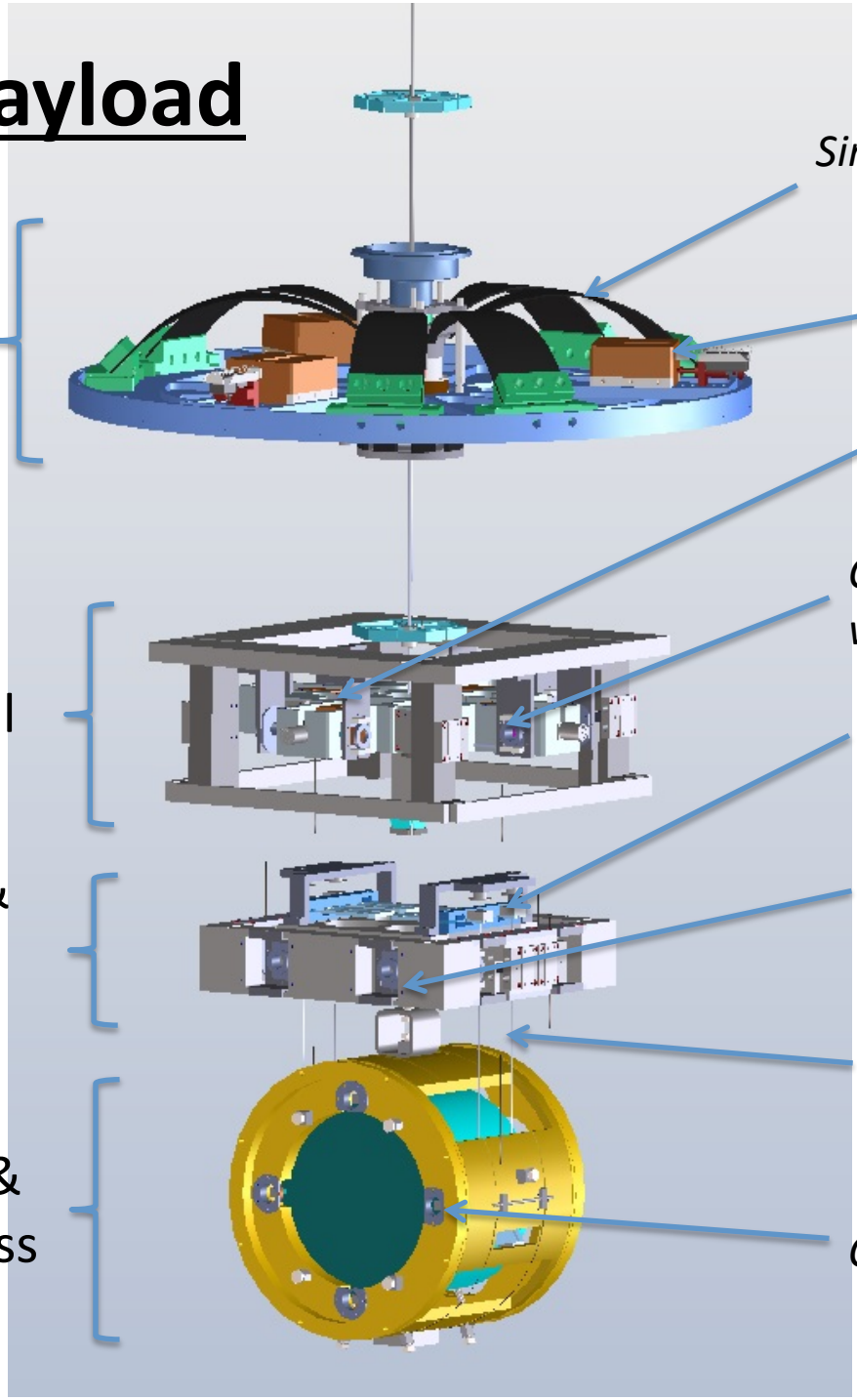
- ダイナミックレンジの問題から、温度計のDAQには温度モニター CryoCon 18iを用いる事とした。これは8chの温度計を読むことが出来、LAN接続でCAに接続出来る。EPICSソフトも搭載できる。14台調達済み。残り14台を今年度調達。
- 温度計はかなりたくさんあり、これを全て読むのではコスト的に厳しい。温度計のモニターは最低限に絞り、CryoCon 7台/Cryostatで済むように配線設計済み。
- それ以外の、コンプレッサー、冷却水循環器、真空ポンプ、ゲートバルブ、真空ゲージは、麻生さんのSlow DAQに接続する。
- KAGRA全体にわたりInter-Lockの議論がなされていない。安全対策として必須と考える。
- DAQしたこれらのSlow DAQ dataは、DetCharのHasKAL上でGUI的なモニターができるように準備中。


Payload Support Frame
Si-10
Si-2
Si-1
x1
Heater
Si-5
Si-6
Si-8
Baffle
Si-7
Si-9
to Type-A connectors
to Cryostat connectors
Si (exist)
x2


Y
Z
X
Heater
Si-3
Si-4


8K Top
8K Side
80K Top
80K side(a)
Duct Shield
Duct Shield
Duct Shield
Duct Shield
Frame Top
Baffle
Heat Link VIS
Platform
Marionette
Marionette Reccoil
IM
IM Recoil
Mirror
Frame Bottom
80K
8K
Payload
80K side(b)
Compressor
70K_CryoCooler <a>
70K Head(a)
70K Bar(a)
Arm Side
Compressor
4K_CryoCooler <a>
Compressor
4K_CryoCooler <b>
50K Head(a)
50K Bar(a)
4K Head(a)
4K Bar(a)
50K Head(b)
50K Bar(b)
4K Head(b)
4K Bar(b)
80K Bottom(a)
8K Bar(Shield)(a)
8K Bar(Payload)(a)
8K Bottom
8K Bar(Shield)(b)
8K Bar(Payload)(b)
80K Bottom(b)
Compressor
70K_CryoCooler <b>
70K Head(b)
70K Bar(b)
Compressor
4K_CryoCooler <c>
Compressor
4K_CryoCooler <d>
50K Head(c)
50K Bar(c)
4K Head(c)
4K Bar(c)
50K Head(d)
50K Bar(d)
4K Head(d)
4K Bar(d)
Water Chiller

Cryogenic Payload



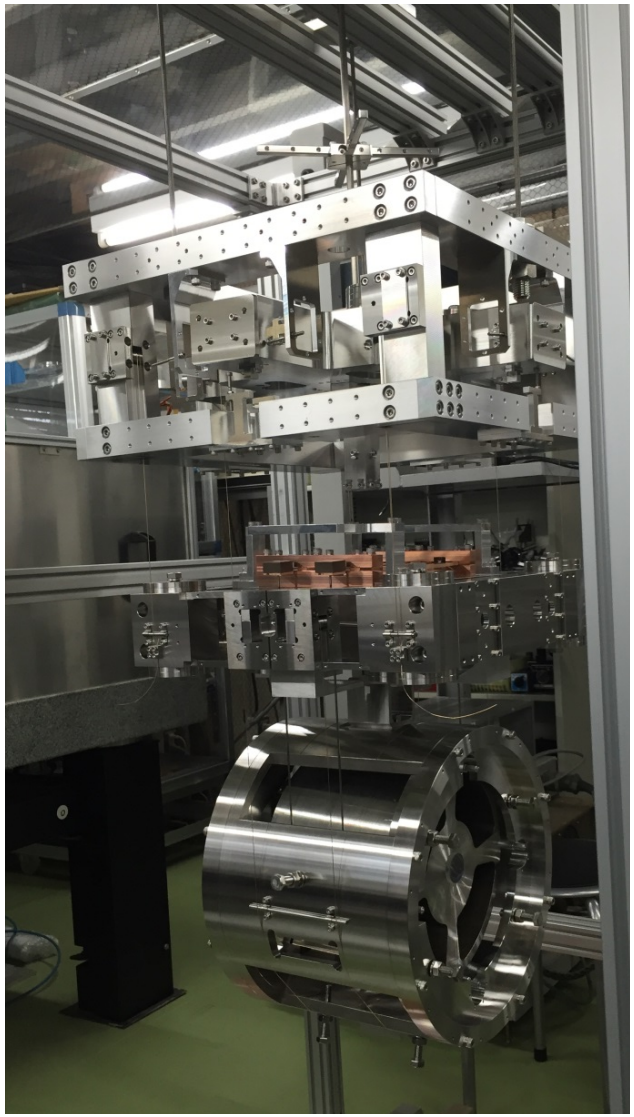
Platform

Marionette & Marionette Recoil Mass

Intermediate Mass & Intermediate Recoil Mass

Sapphire Mirror & Mirror Recoil Mass

Cryogenic Payload No.1 assembly test



Fabrication of 1st cryogenic Payload has been done.

- Platform is still under designing.
  Paylaod-1 is suspended from a frame now.
- Sapphire suspension is still under preparation.
  A dummy mirror with same weight as sapphire is suspended.
  CuBe blade-springs and stainless steel rods are also used instead of sapphire.

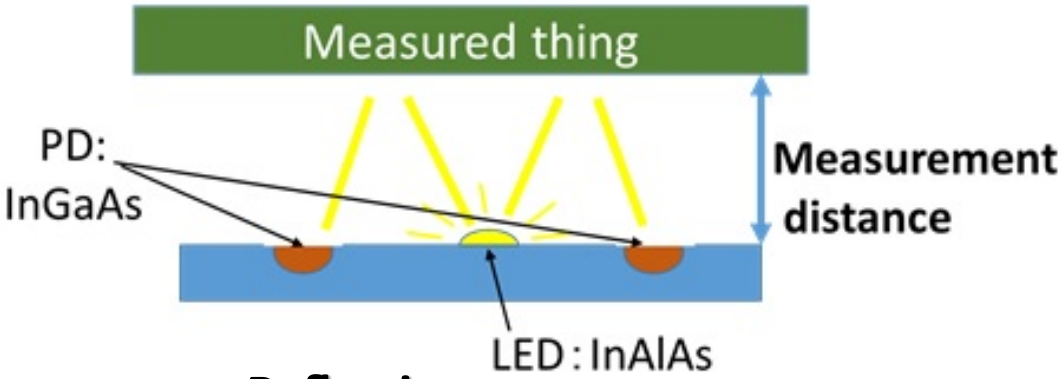
We just checked principle issues of payload and assembly procedure in this hanging test.
And we got some minor advises from VIS folks from their experiences.

These will be reflected to remaining 3 payload fabrication in this year.

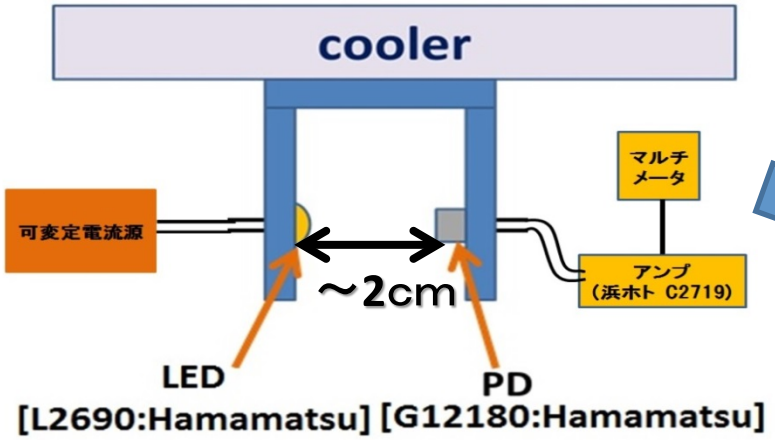
- あまり知られていませんが、これまでにも、何度もVISのみなさんから
  アドバイスを頂いており、それらを設計に反映させてきている。
- Payload No.1の仮組後のIntegration meeting時、VISのみなさんから
  いくつかのマイナーなアドバイスを頂いた。これらは追加工可能であり、
  反映させる。また、残りのNo.2-3の製作にも反映させる。
- Marionette, Marionette recoil, Intermediate Recoilに採用されている
  調整可能なワイヤーのクランプメカニズムには、VIS -> 大丈夫だろう、
  Glasgow -> 変えた方が良い　と賛否両論ある。
- 現在はフレーム（earthquake stop）とインストールジグ・設備の設計を
  行っている。

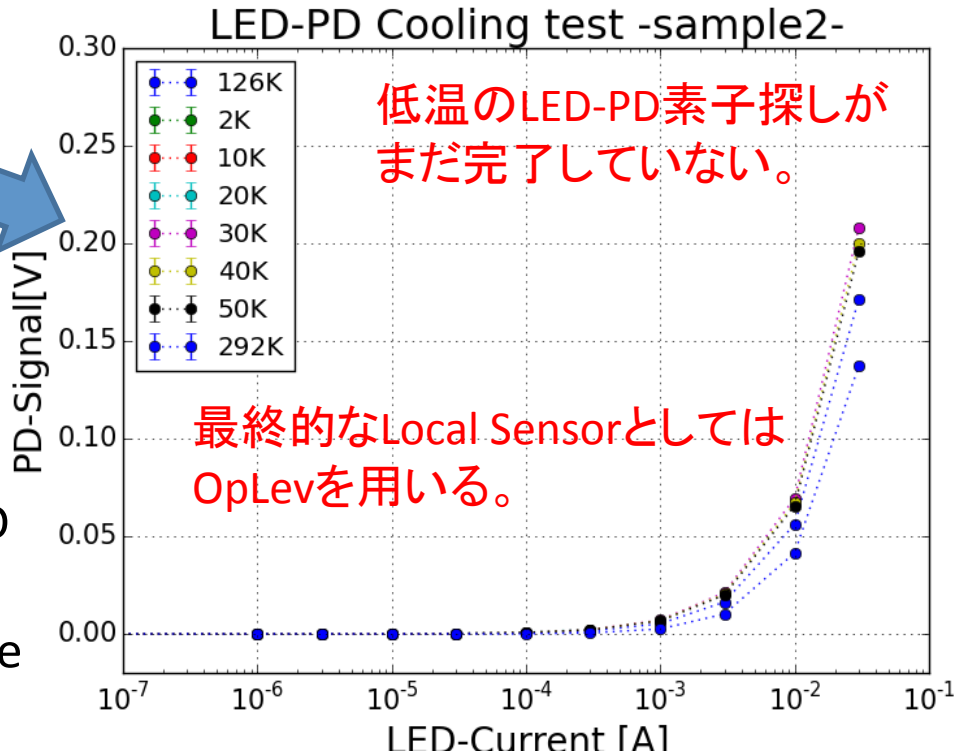
Local Displacement Sensor

We use reflection type photo-sensors in cryogenic payload, because dynamic range of this type of sensor is larger than OSEM.

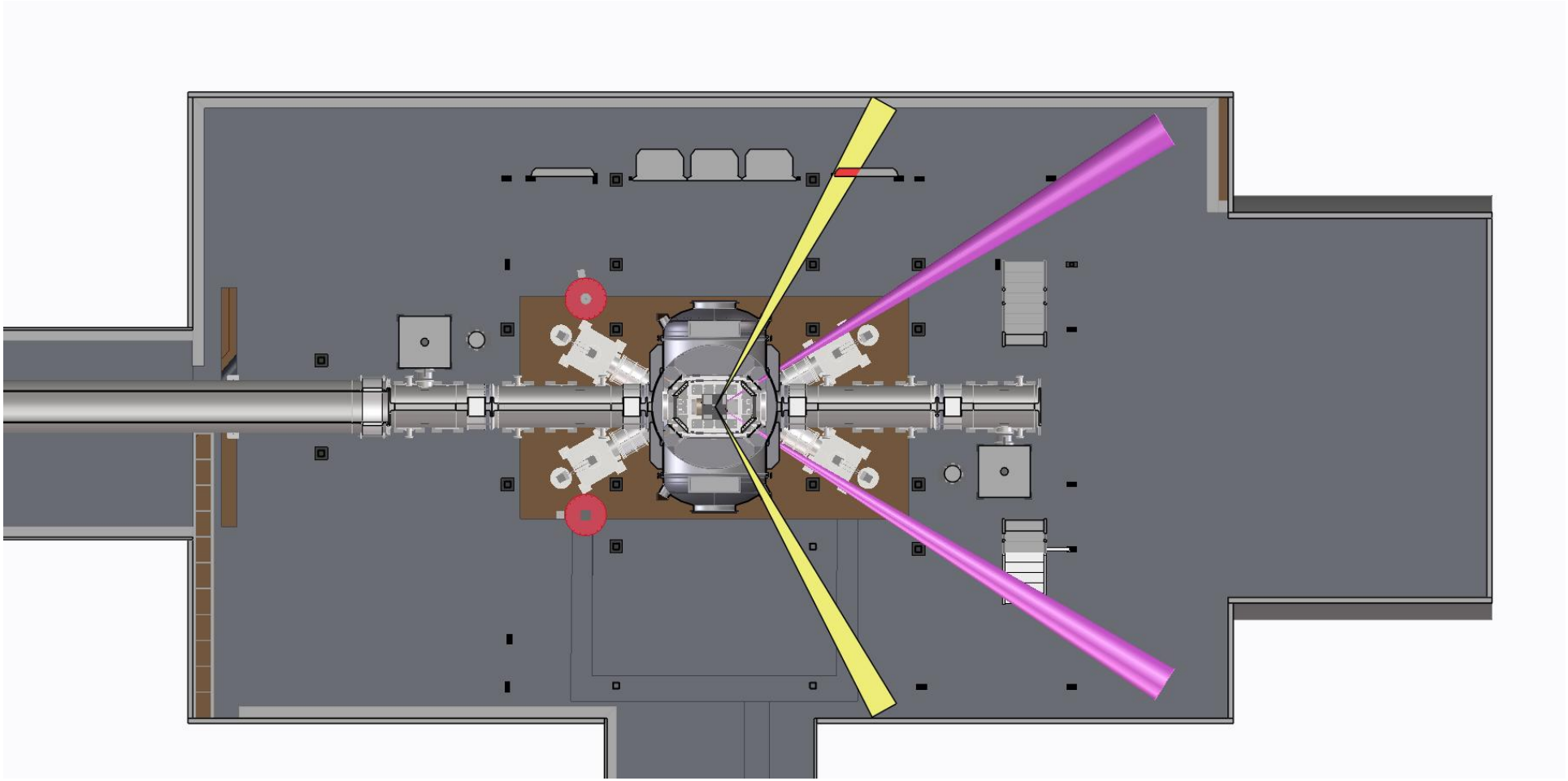


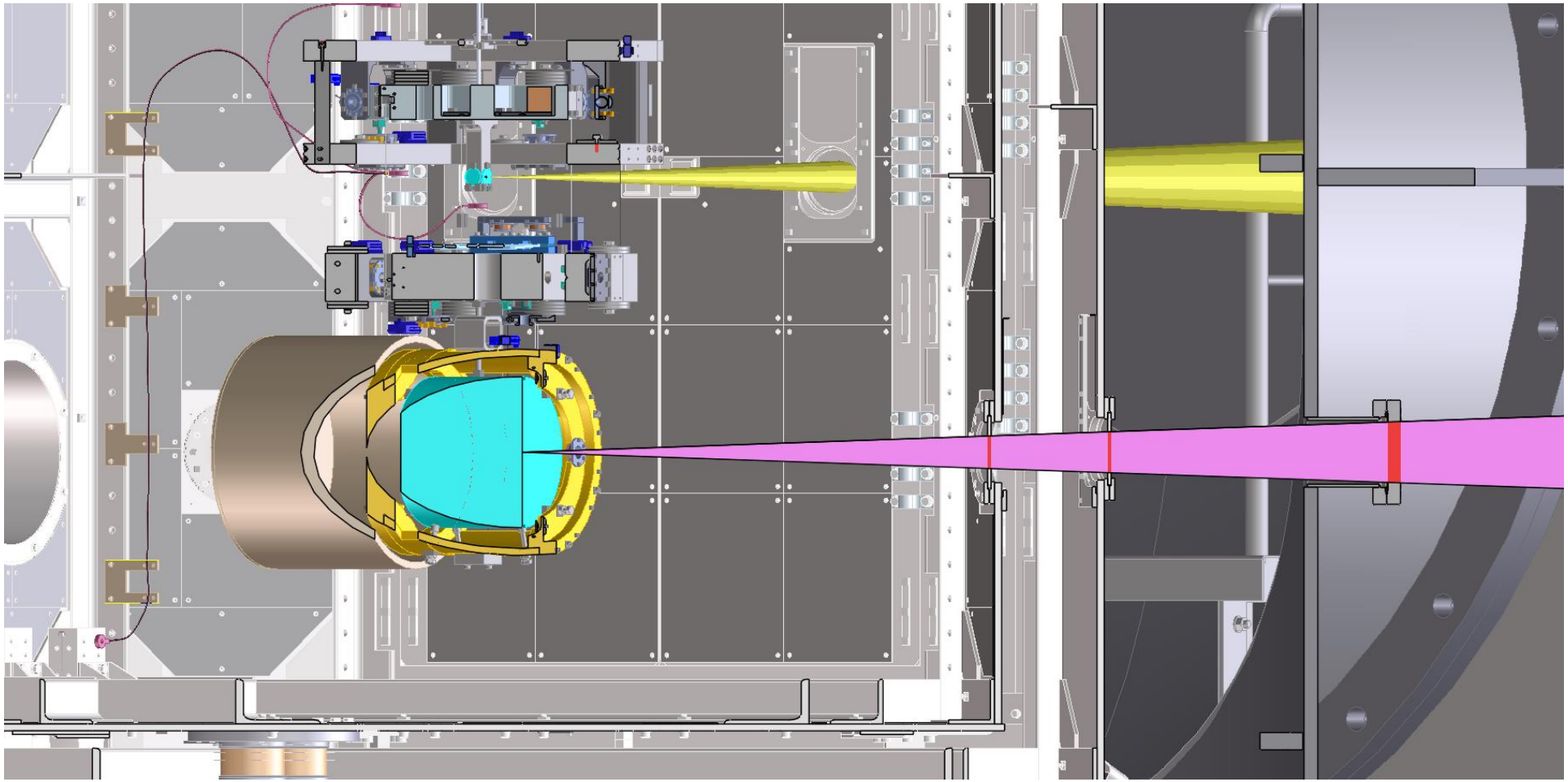
Reflection sensor





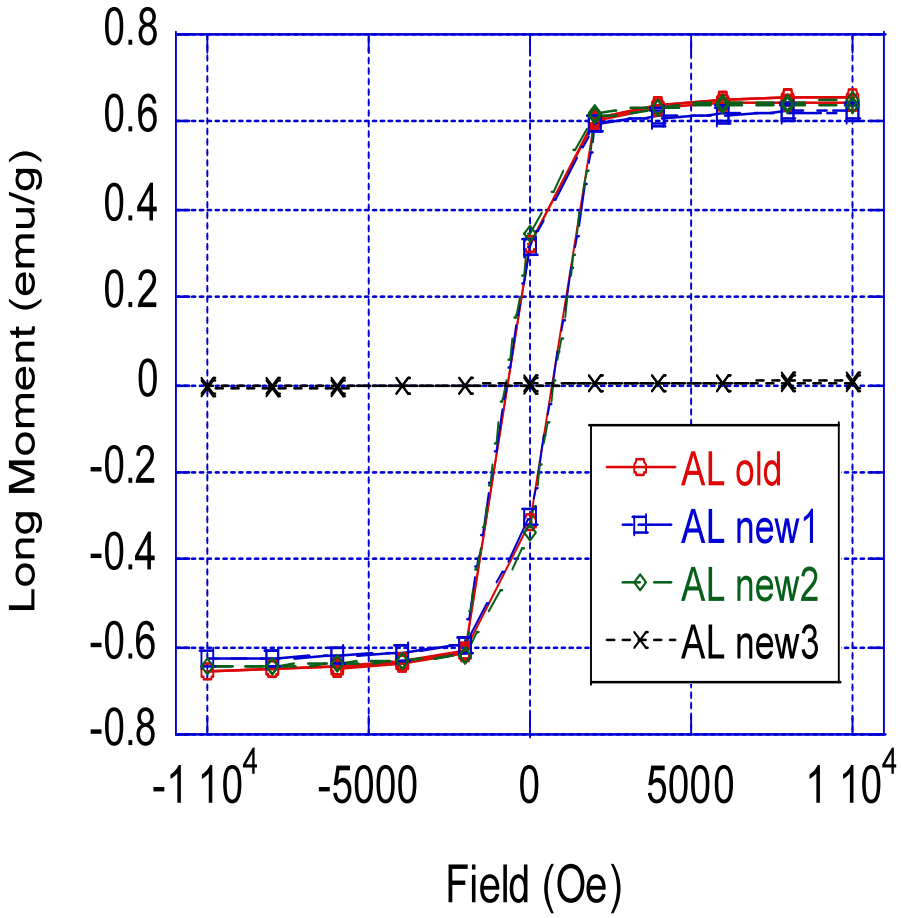
We found a combination of PD and LED worked in low temperature.
Statistical check of PD-LED performance is under performing.



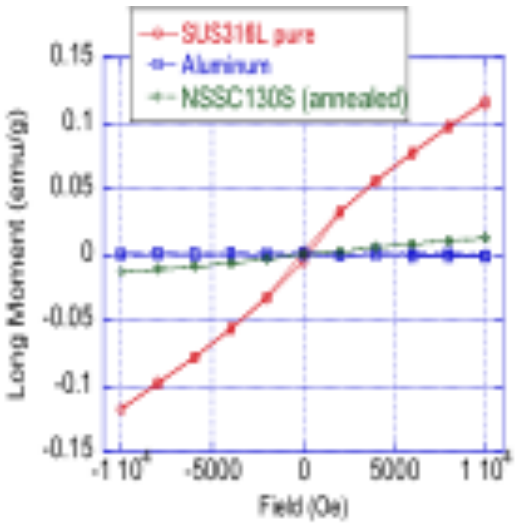


Magnetization of Black coating

Measurement results of magnetization of black coating by SQUID.



This is a black coating based on Phosphor-Nickel.
Amorphous Nickel have no magnetization.
We have tried to develop low magnetization black coating.



Comparison btw annealed Stainless steel & Aluminum at 5 K

Development Brand new “SOLBLACK” coating on Aluminum at 5 K

高純度アルミ撚り線

- CLIOの時の技術は一旦失われた。
- CLIOと同じ5N純度のアルミ撚り線製作が出来るメーカー開拓から
  やり直し、なんとかCLIOと同じレベルの5Nアルミ撚り線は製作
  出来る見込みが立った。
- 6N純度も思考錯誤したが、素線引きは成功、撚り線は失敗。
  撚り線製作は無理そうなので、束ねる技術を試している。
- どうしても6Nの束ねができなければ、手作業で素線を張る手法で
  ヒートリンクを作るつもり。これはコストはかかるがなんとかなりそう。

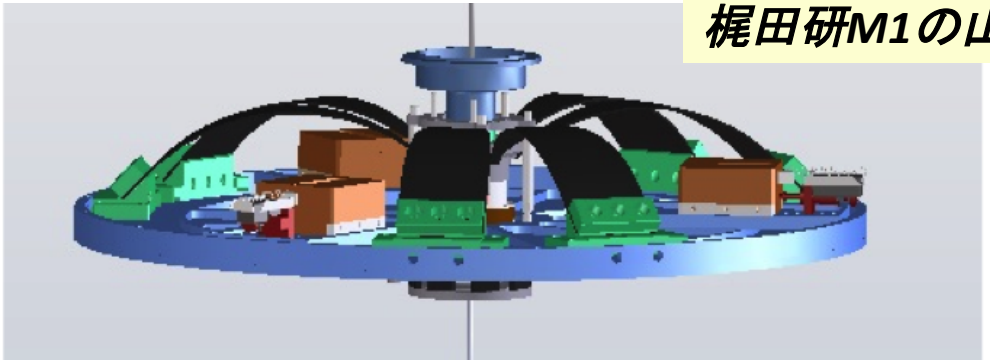
Digital system in KEK

- A digital control system used in NAOJ to test Type-B vibration attenuation system was moved to KEK to built Cryo-Payload control model.

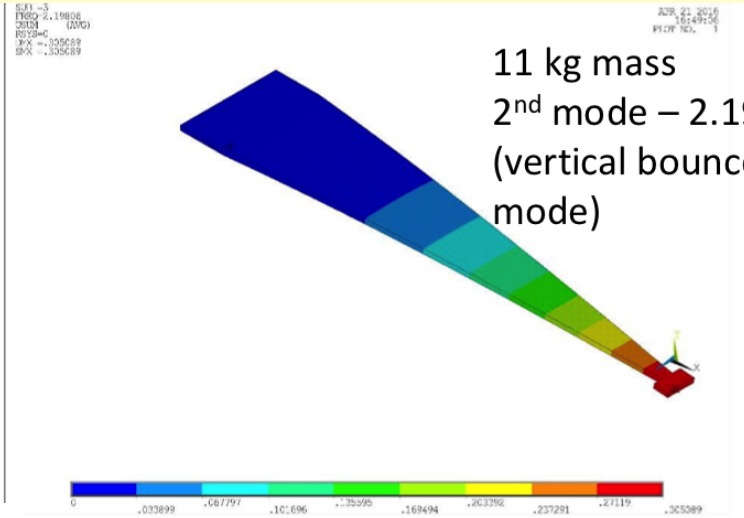
回路系のところは検討が遅れている。

Study of Material Properties at Cryogenic Temperature

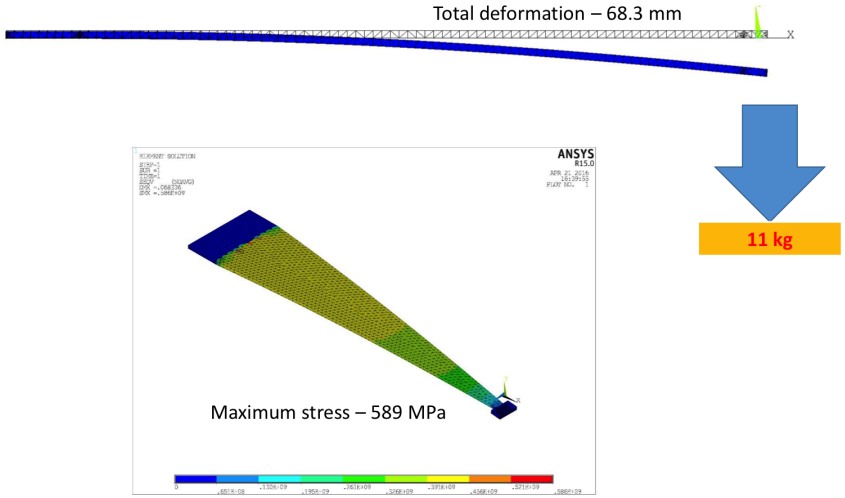
梶田研M1の山田君がRahulと一緒にやることとなった。

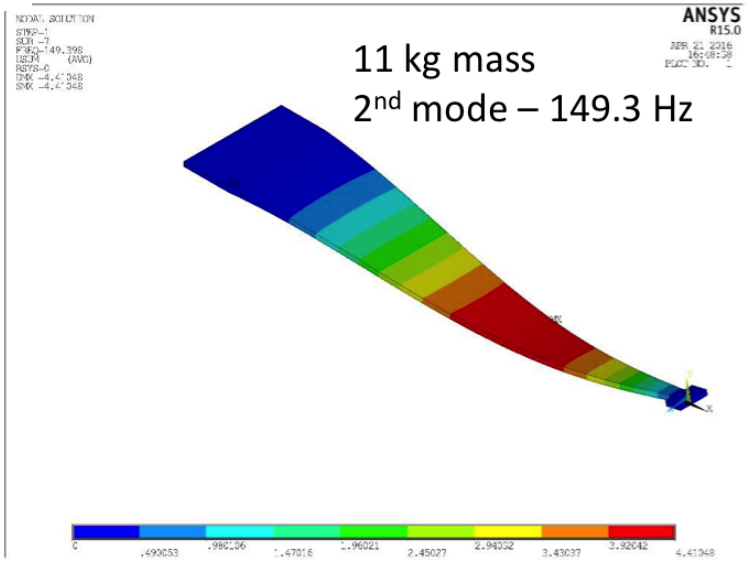


BeCu blade-springs are used in the platform.
We plan to use simple blade-spring.



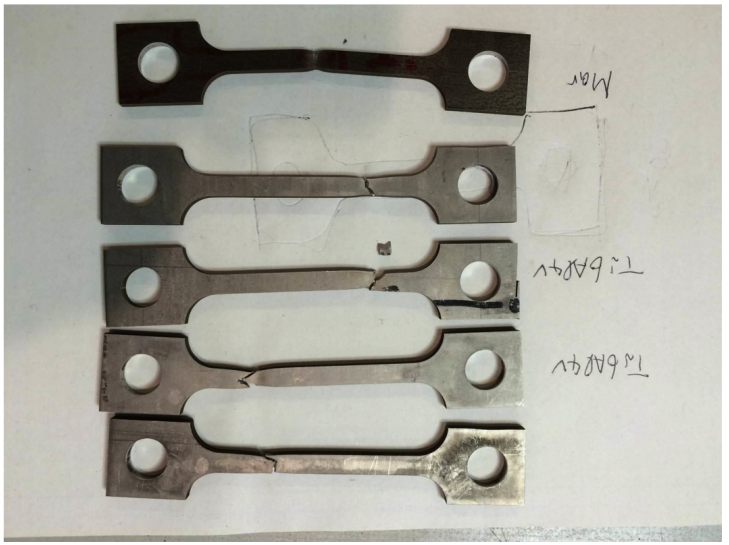
ANSYS simulation for blade-spring at room temperature

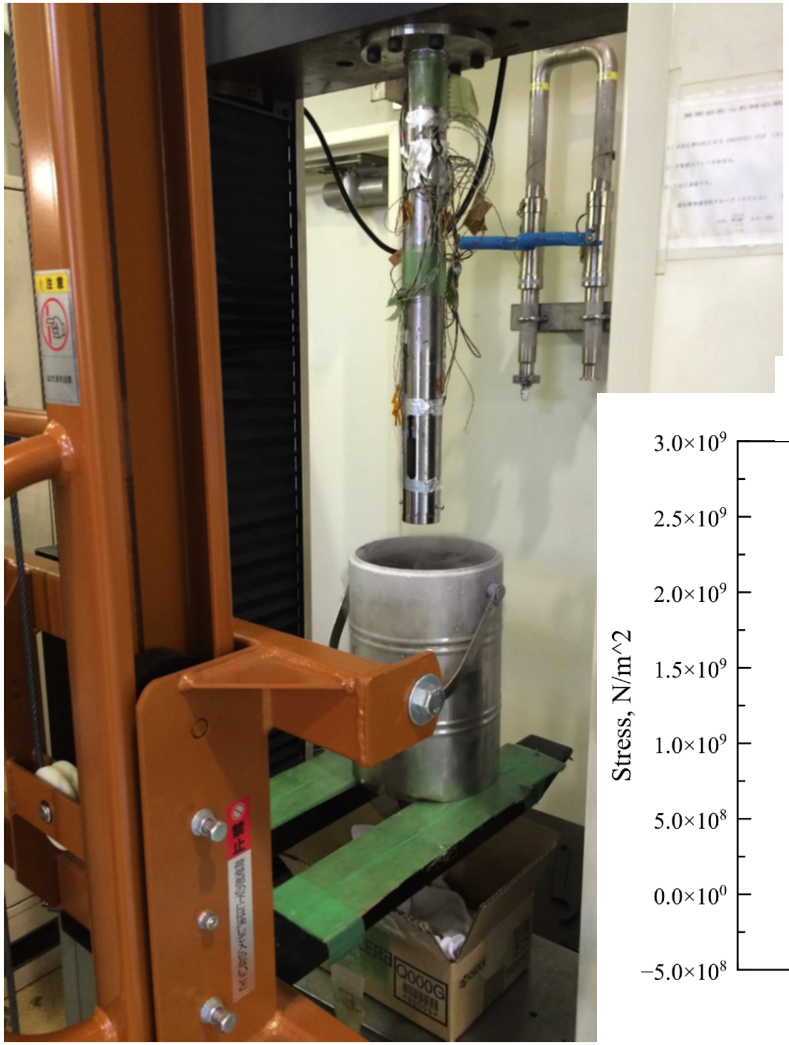




Measurement of Young's modulus at cryogenic temperature is under performing in KEK

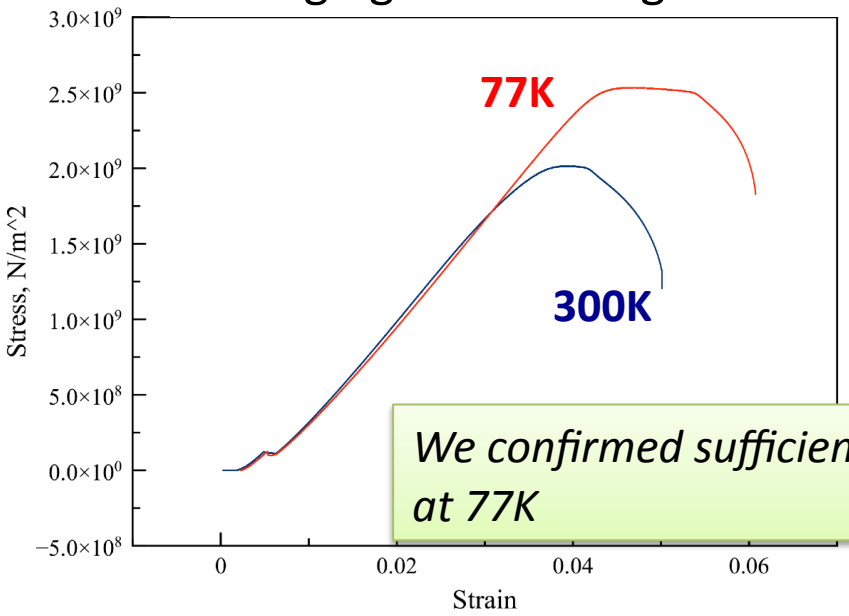
Strength Test of wire/blade materials at cryogenic temperature





BeCu strength is also under doing.

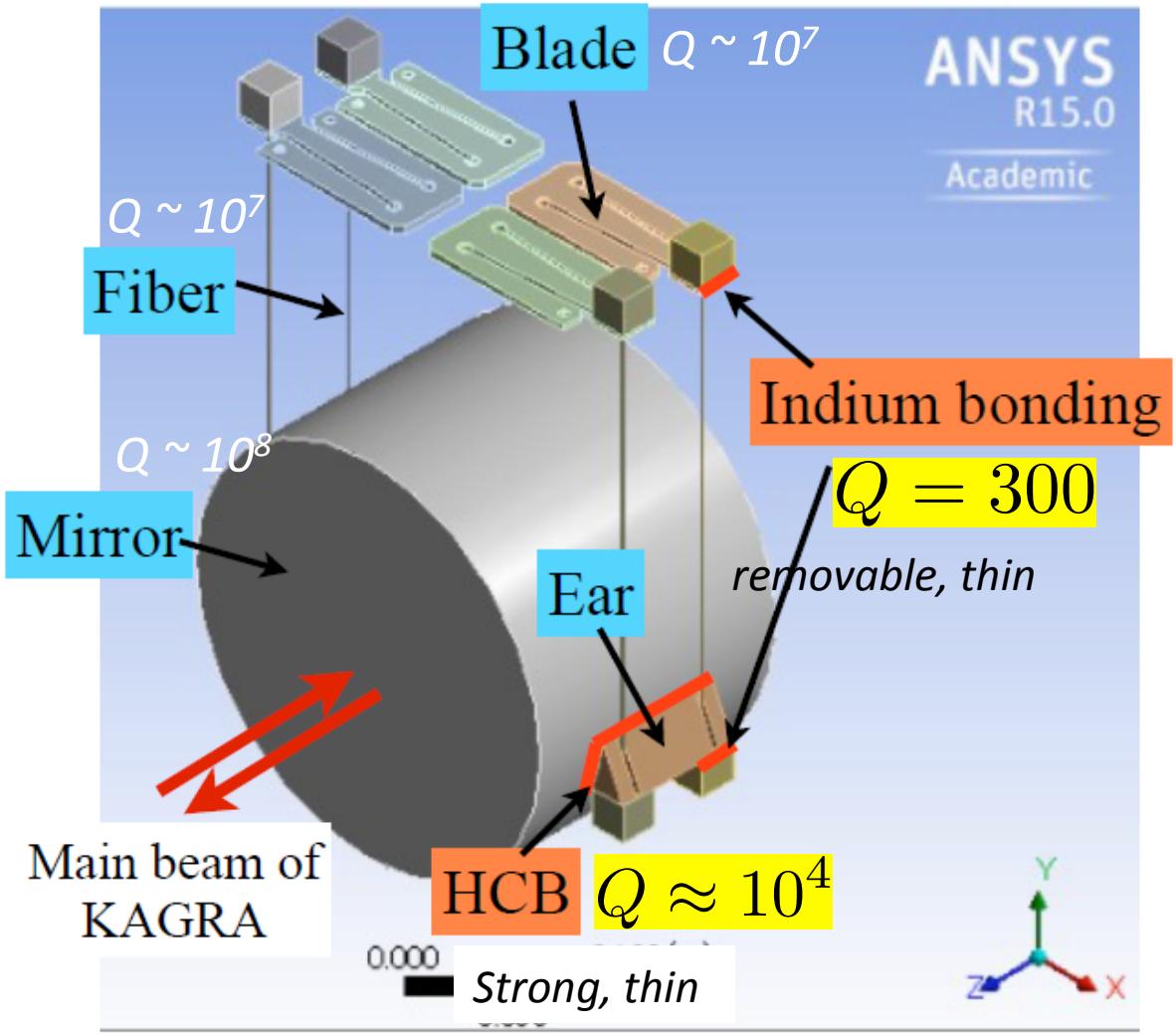
Maraging Steel Strength Test Result



Temp.	Ultimate strength	Breaking stress
300 K	2.0 GPa	1.32 GPa
77 K	2.5 GPa	1.84 GPa

We confirmed sufficient strength at 77K

Hydro-Catalysis Bonding (HCB) and Indium Bonding on Sapphire



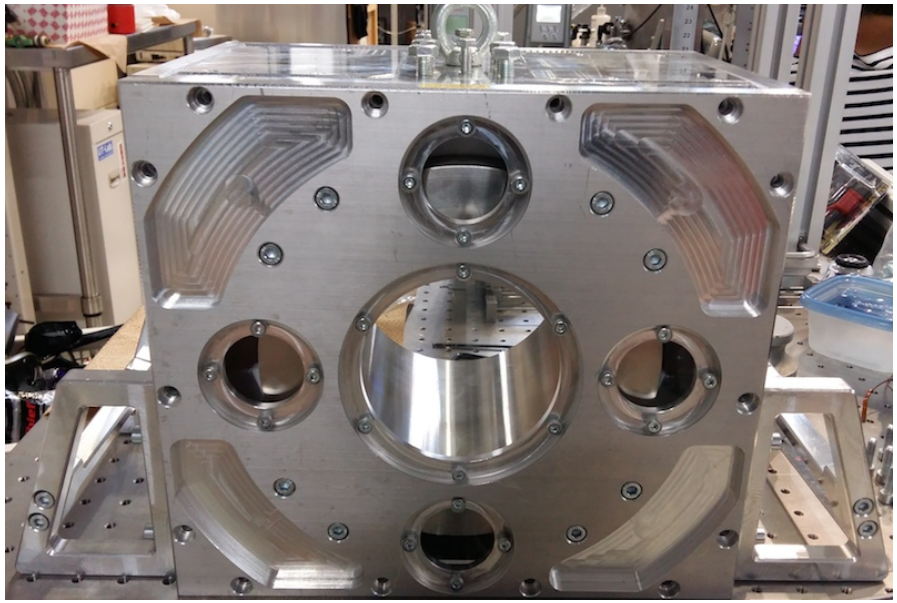
Semi-monolithic sapphire suspension must be realized to be sufficiently small thermal noises.

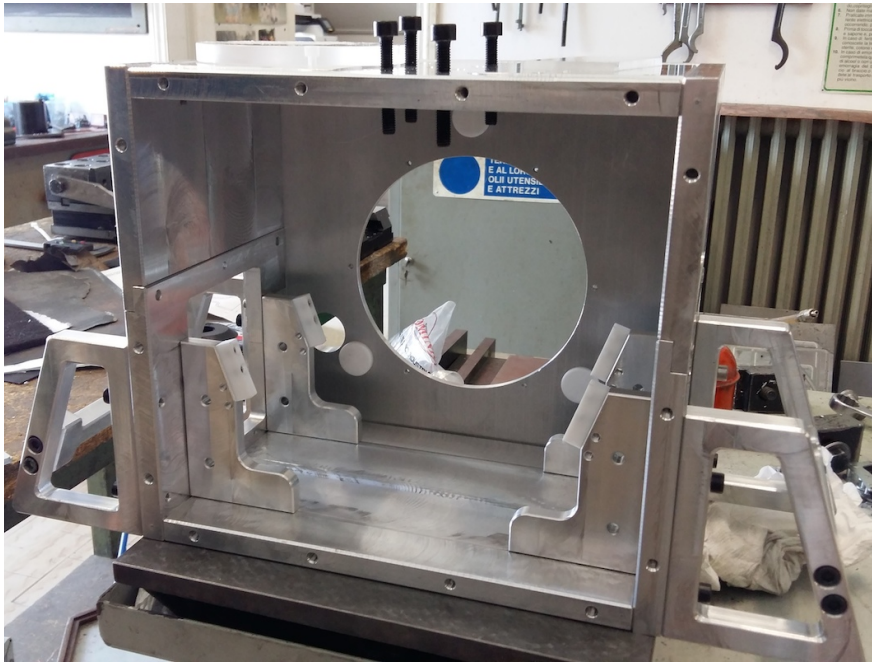
HCB and Indium bonding on sapphire satisfies requirements of mechanical Q.

Practical way to do these bonding is under testing.

HCB Bonding Jigs

- The jigs for ear positioning during HCB bonding are incorporated into a box, which may also be used for transport and to support the mirror during suspension
- This is same way as aVIRGO.
- Perugia Univ. fabricated this KAGRA box and it is in our hand now.

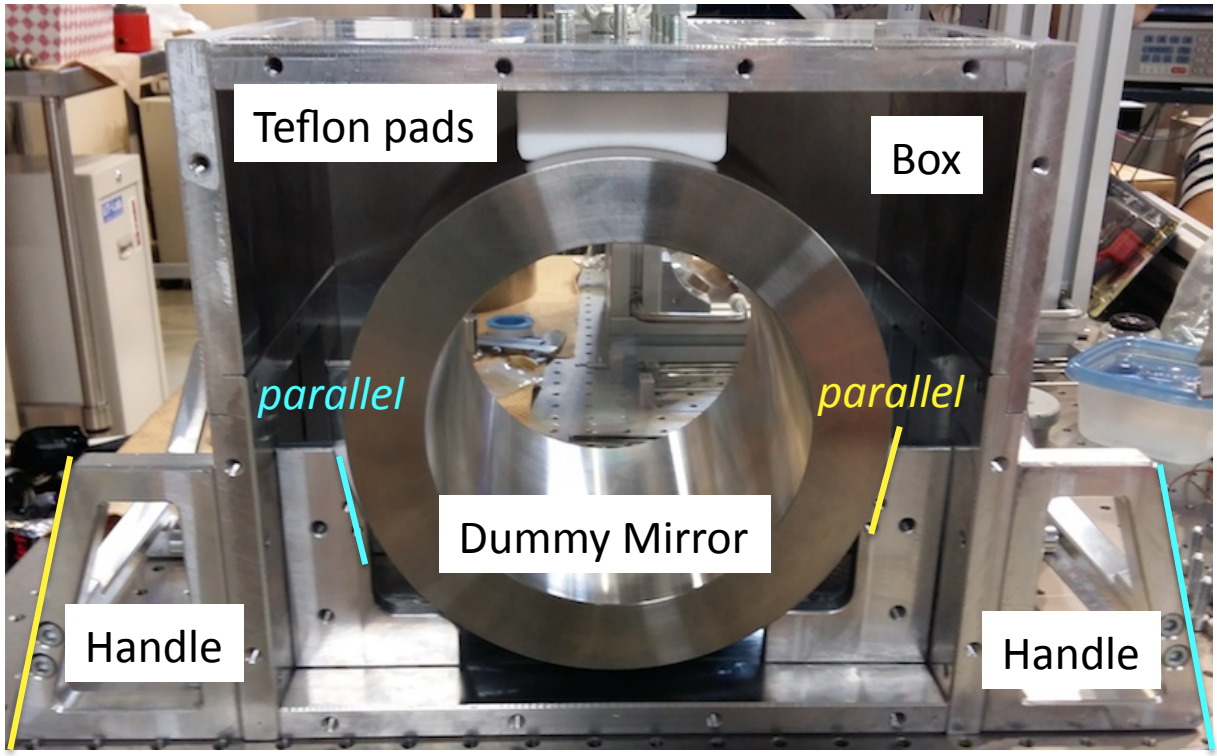


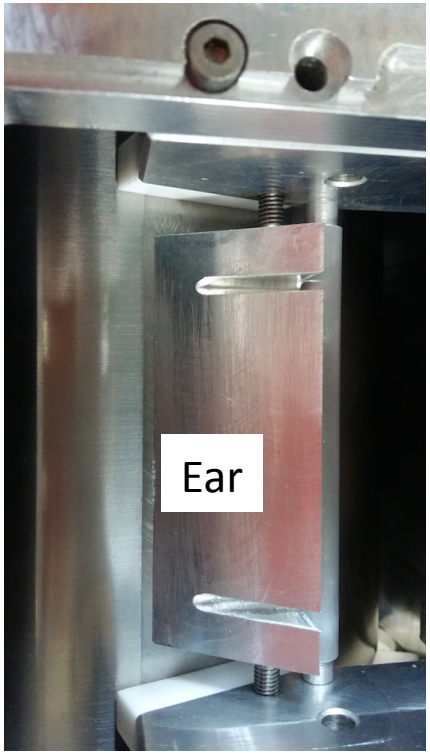


HCB / Mirror Transportation Box for KAGRA

HCB Bonding Jig

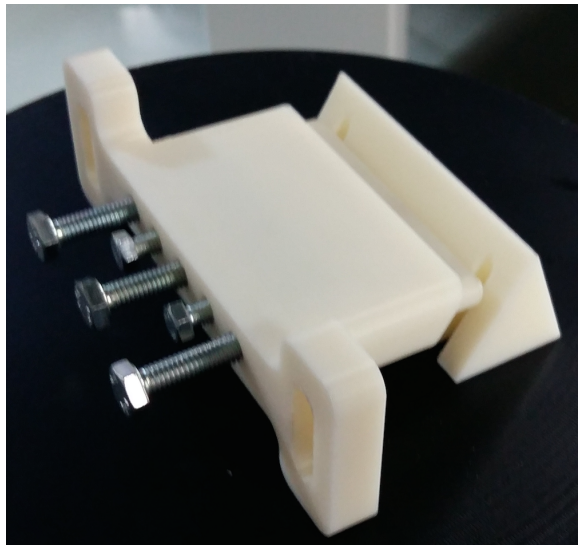
- Mirror is pressed on all sides by teflon
- The box is rotated to rest on the handles during bonding
- Handles parallel to mirror flats
- Ear fixed in all degrees of freedom during bonding
- Glasgow style HCB (silicate bonding) will be applied.



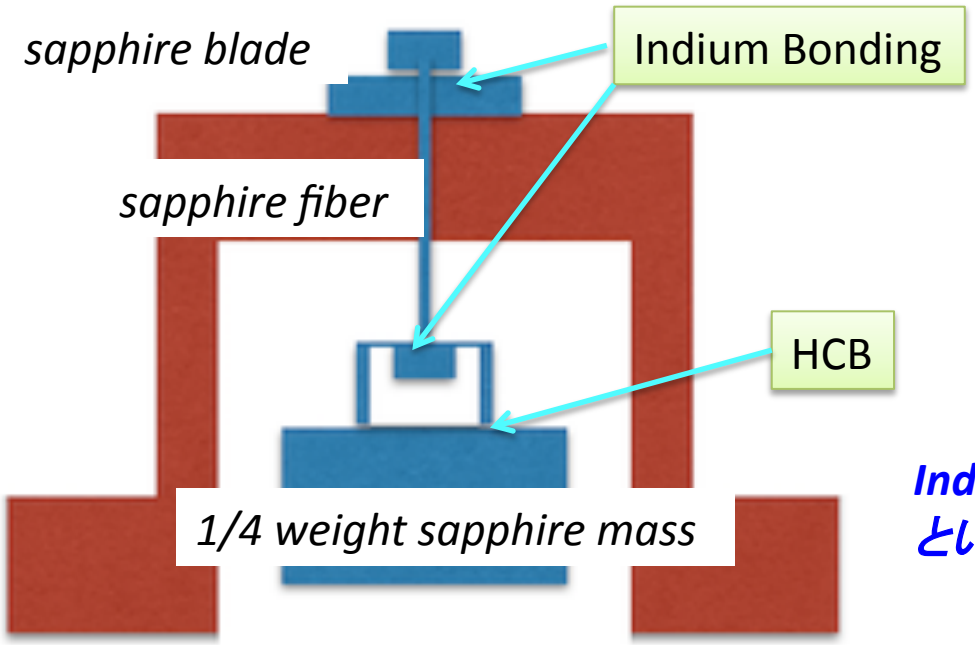


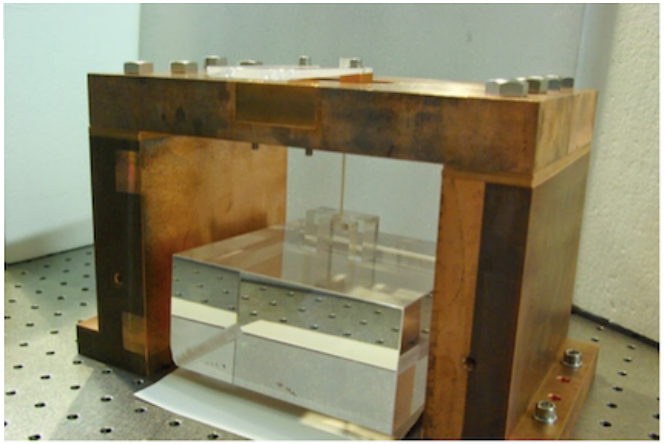
HCB jig testing

- Currently testing with stainless steel mass and ears
- Ear positioning and reproducibility will be verified using 3D measurement system
- After verification, sapphire dummy mass and sapphire ears will be used



Demonstration by one fiber prototype





Indium Bondingの熱抵抗は小さそうだという結果が一応出た。

- Technical feasibility was demonstrated.
- Thermal resistance and mechanical Q are under measurement
- Installation jig of fibers is under designing.

Schedule for Sapphire Suspension Development

- 2016. 7 - 8 HCB on prototype sapphire mirror
- 2016. 9 Indium bonding on prototype sapphire
- 2016. 10 Cool down test
- 2016. 11 – 12 Q measurement
- 2017. 2 HCB on ETMs
- 2017. 3 Indium bonding on ETMs
- 2017. 4 - 8 Cryogenic test of ETMs
- 2017. 8 Assembly of sapphire parts onto ITMs
- 2017. 9 - 10 ETMs installation into cryogenic payload

aVIRGOで新たなファイバー破断が発生。今月Heliosは来られないかもしれない。

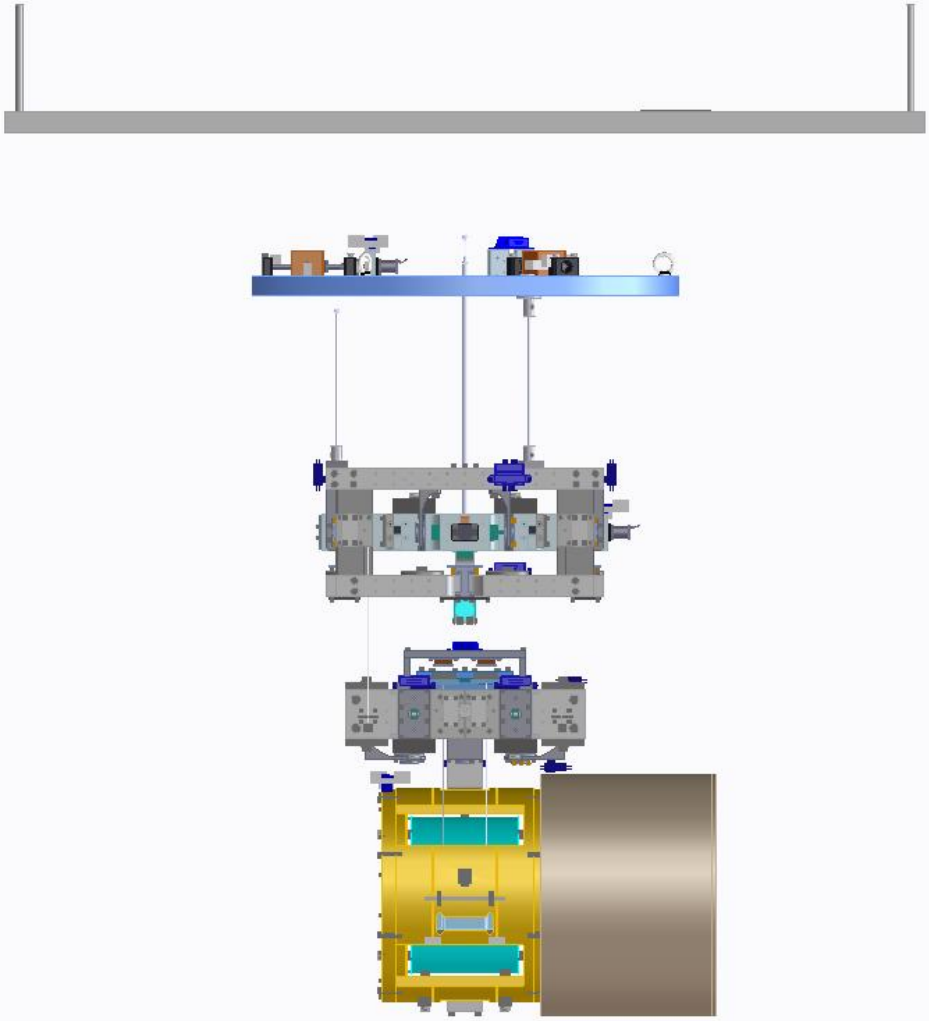
MIR subgroupとの議論のまとめ

- Perugiaで製作したミラーボックスをCRYが用いる事で了解。
- ミラーをミラーボックスに入れるタイミングは、
  コーティング終了 -> Caltechで評価 -> 日本到着
  となって日本で行う。このため、ミラーをボックス内に移し換える
  ジグが必要。VIRGOでは写真のようなものを使っている。
  このようなものを作ろうかと思案中。
- CRYで予定するミラー周りの作業
  では、ISO Class 3が要求される。
  MIRでは特別な要望は無いとのことで、
  Class 3で了承。

HCBは、プロトタイプに関してはNAOJ ATCの
クリーンブースを借りる予定で、本番のミラー
では、富山大にClass 3のクリーンブースを設置して使用することを議論中。

ISO class 3でよい？他に富山大クリーンブースの利用希望は？

Baffleのインストール



その他の議論

- クライオスタットサイドの大フランジの開閉は、非常に難しいことがわかった。
  また、ダストだけでなく湿度管理も必要。あまり簡単に考えないで欲しい。
  素人には無理。やる際にはこの作業をよく理解している業者さんを雇って欲しい。
- 各サブグループ間のインターフェースを調整する作業は絶対に必要。
  これは、各サブグループに任せるのではなく、責任を持って統括する人が絶対に必要。善処を求む。
- CRYとVISばかりレビューを要求されるが、他のサブシステムもちゃんと議論の俎上に上ってくれ。
- 梅雨で縁切りおよびアンカーホールから僅かに湧水が発生している。
  このままでは高いクリーン度が得られるとはとても信じられない。どうする？
- 測量は従事者と手法を明確にした方が良い。
- ACコンセント、ケーブルラック等基本電気設備が整っていない。
  X, Y-endについては有志が集まって機器配置・配線を議論。X-endはラックを設置。Y-endは来週。中央も要議論。

その他の議論　2

バイオリンモード等ピークノイズに
ついてのデータ解析グループからの要求

↓

DASとCRYで議論を始めた

↓

端山さんのプレゼン