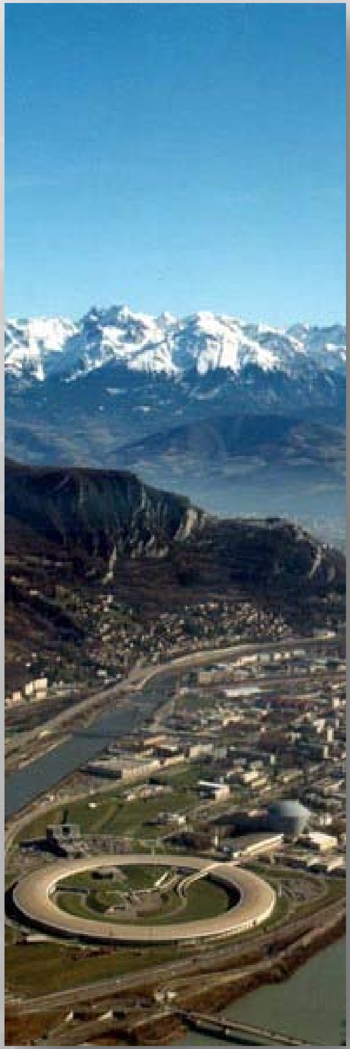
ESRF DCM Workshop
13th & 14th May 2014

Industrial Suppliers - An Engineering Overview

ESRF

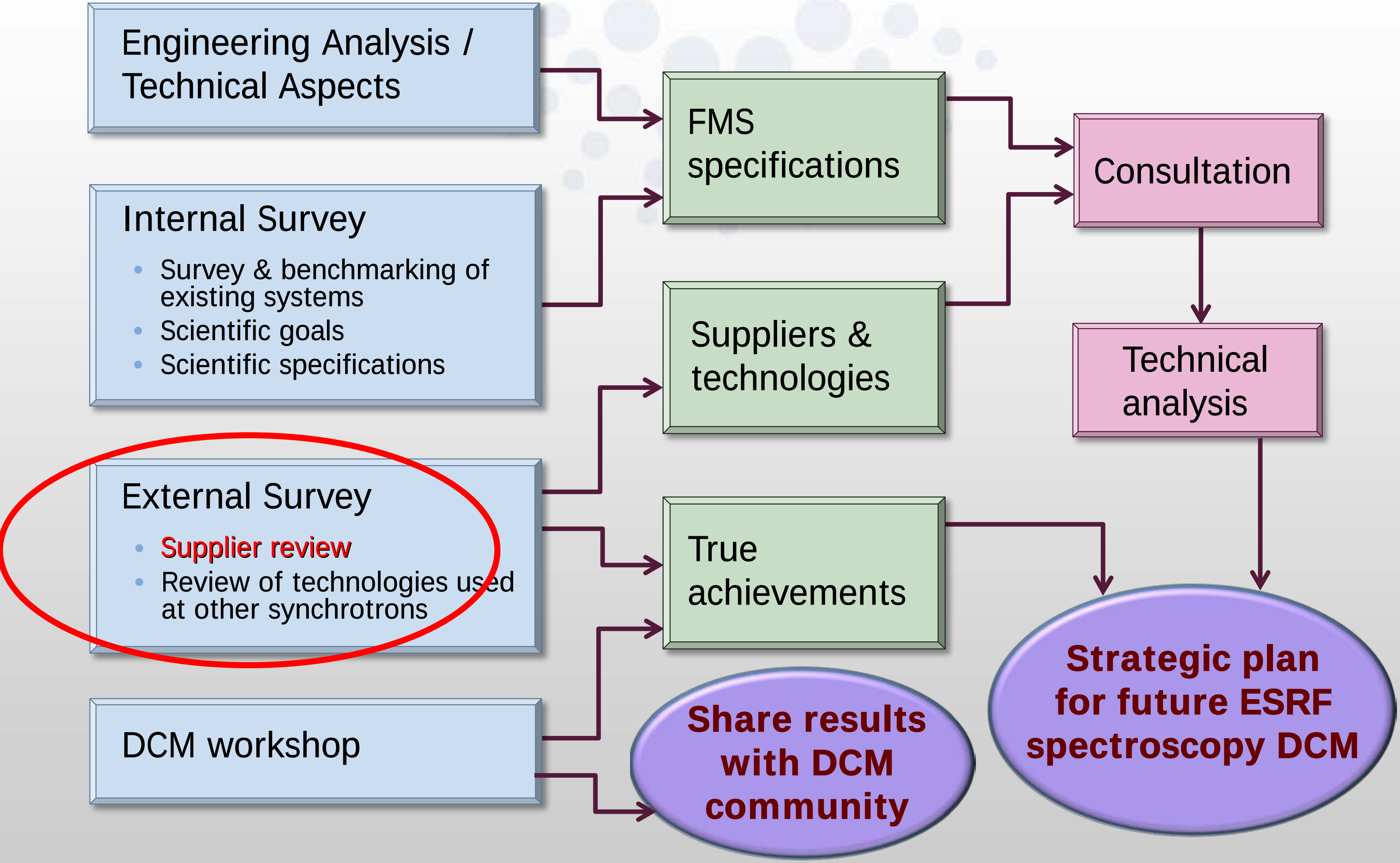
FMS Working Group

Industrial Suppliers – Engineering Overview



- DCM Working Group tasks & goals
- Task #2 – Supplier review
- Identified / shortlisted industrial suppliers
- Supplier survey – concept
- Survey results
  - Chassis structure
  - Mechanical support & vessel
  - Bearing & crystal parallelism
  - Load distribution
  - Thermal load management
- Identified critical points
- Conclusion

Industrial Suppliers - Engineering Overview



Working Group task #2 – Supplier Review
Sub - tasks

- Establish a list of possible suppliers
- Request documentation
- Shortlist suppliers mastering required technologies
- Request specific information (survey)
- Visit suppliers for technical discussions
- Define recommended supplier & strategy

Identified Industrial Suppliers – Shortlist

After contacts with known suppliers and synchrotron community users

Company	Origin	Details
Kohzu	Japan	• Strong past experience in novel designs (cam) • Good service record over 20 years at ESRF
Toyama	Japan	• Strong recent involvement with SPring-8 • Close collaboration with users for development
FMB - Oxford	United Kingdom	• Number of monos supplied worldwide • Experience with LN_2 systems
IDT	United Kingdom	• Young, expanding company • Good reputation in state of the art design (air bearing)
Bruker	Germany	• Impressive in house resources • Radically different design principles
Cinel	Italy	• Complete in house production expertise • Flexibility, open to collaboration

Survey Document - “Open” type questions

- Understanding of critical points
- Strategy towards development

Category	Information requested
Chassis structure	*Type, floor interface, mechanics interface…*
Bragg angle drive	*Motor, bearings, range, speed…*
Crystal parallelism during scan	*1° and full range angular errors, distortion…*
Vacuum	*Feedthrough, base pressure, RGA….*
Encoder on Bragg angle	*Mounting details, air side or vacuum…*
Pre alignment	*Techniques used, vacuum forces…*
Fixed exit technique	*Displacements & guide type…*
Mechanical load distribution	*Cantilever on Bragg bearing…*
Vibration & thermal stability	*Performance, FEA, analysis…*
Thermal load management	*Cooling system, Compton, deformation…*
Strong points w.r.t. market	*Supplier assets…*

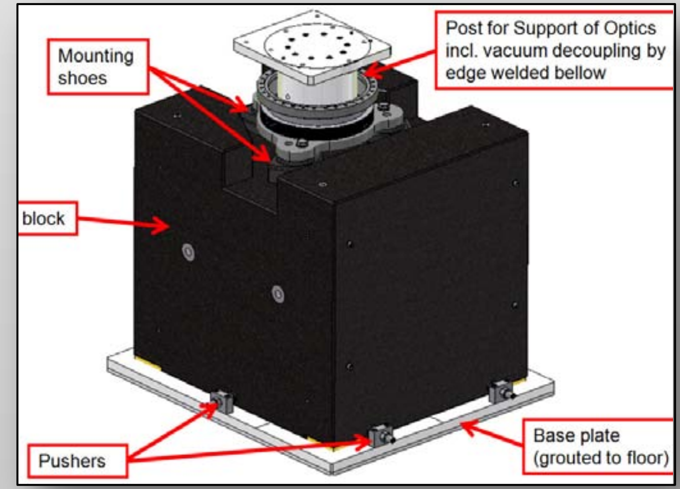
Chassis Structure

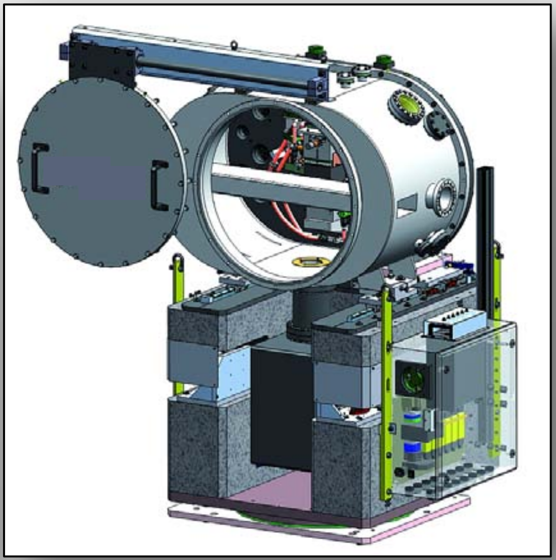
Supplier specificities:

- Welded steel structure & adjustable feet, or granite option
- Height adjustment is a source of instability – direct grouting to floor
- Natural granite & wedge adjusters, plus Sorbothane$_{TM}$ pads
- Lockable wedge type feet
- grouted synthetic granite & 3 DoF jacks

Comments:

- Manual adjustment in all directions considered essential
- Adjustable feet not recommended
- High stiffness, thin layer, large area grouting highly recommended

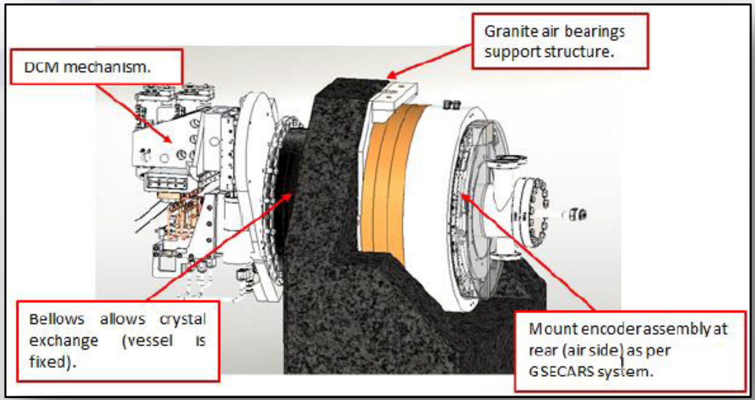




Mechanics Support & Vacuum Vessel

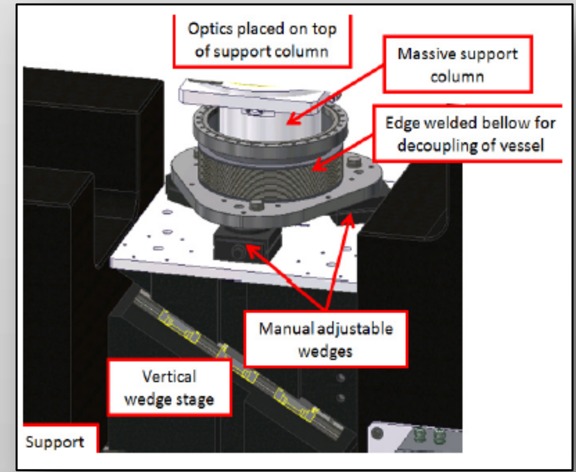
Supplier specificities:

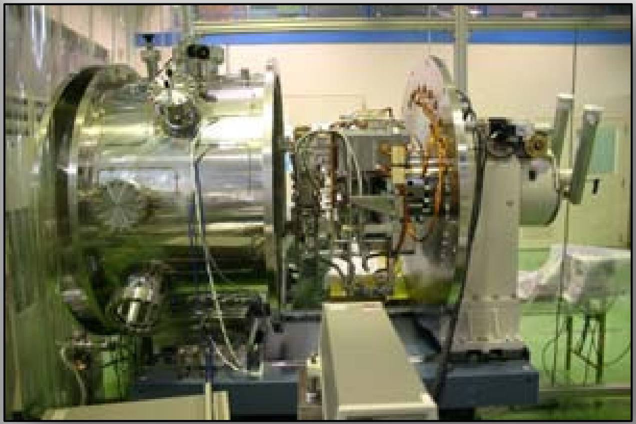
- All in vacuum solution, ex vac wedge adjusters and bellows. No rotary feedthrough.
- Lubrication & wear under vacuum? Vac compatible encoder?
- Large bellows between vessel and mechanics support
- Vessel & mechanics on same TY (requires entrance & exit bellows)
- *Cinel:* Only supplier not using Ferrofluidic seal



Comments:

- Fixed vessel preferable
- Decoupled mechanics
- Vacuum forces should not effect alignment
- Crystal change should not move vessel
- ESRF happy with Ferrofluidic seals

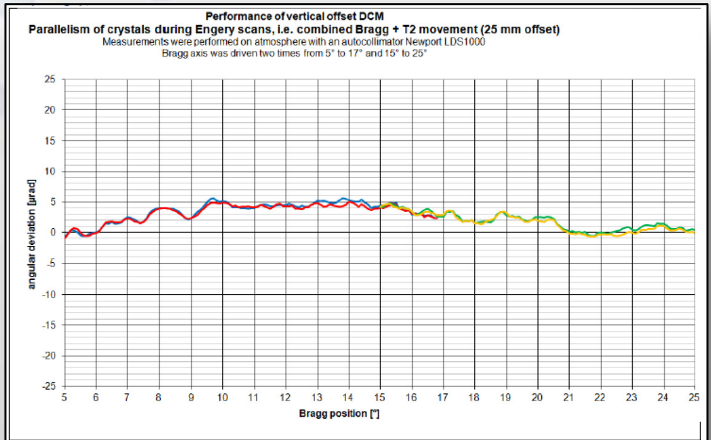




Bragg Bearing & Crystal Parallelism

Supplier specificities:

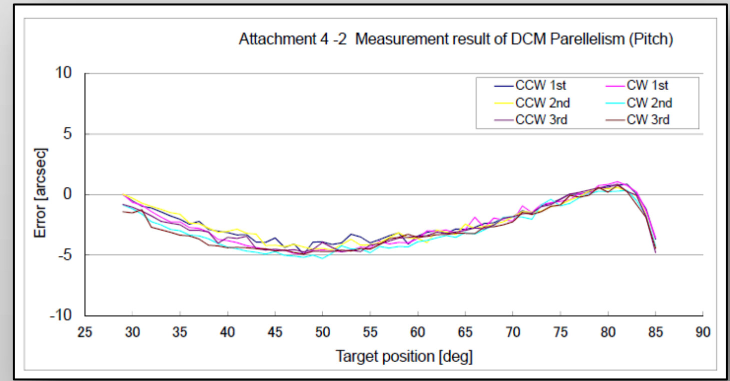
- In vac bearings & drive based on commercially available UHV compatible goniometer tables
- Classic ball bearing and worm wheel
- Scanning speeds up to 5°/sec possible with direct drive & air bearing
- Direct drive offers over 1°/sec



1) Parallelism between 1st and 2nd crystal during E-Movement (combined Bragg and T2)

Comments:

- Crystal parallelism over 1° <0.1µrad requires development
- Possible long term issues of wear on bearings & drive
- Air bearing & direct drive for high scan speeds
- Bearing stiffness / lever arm
- Cantilever loads

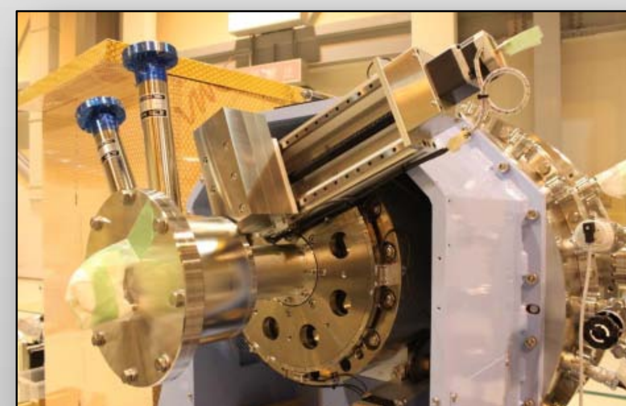


Load Distribution

Supplier specificities:

- 2nd crystal assembly is kept light & compact (= stiff) with minimal displacements (= long crystal)
- Cam & long translation system. If range >30°, gap & longitudinal translations
- Custom ex vac counterweight on linear translation for constant centre of mass
- Large differences for max load on Bragg bearing

Load on Bragg axis (kg)
250
110
<100
50
80
Up to 300



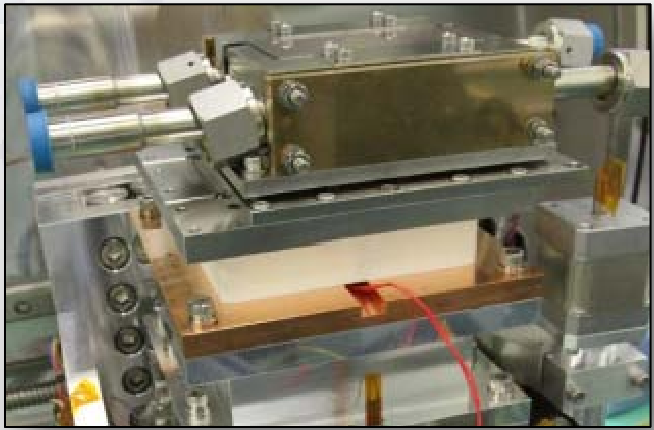
Comments:

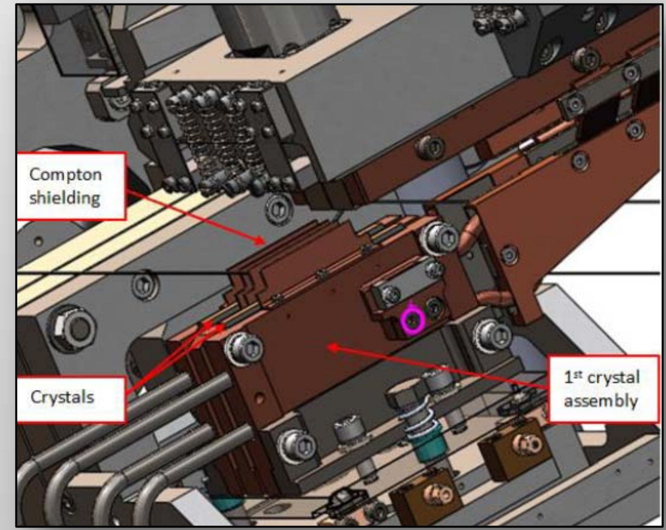
- Only gap translation for fixed exit
- 2nd crystal : 150 – 200mm long
- Deformation at extreme positions
- Large angular range 3 - 81°
- High energy = long 2nd crystal
- Low energy = long gap translation

Thermal Load Management

Supplier specificities:

- Thermally insulated crystal mounts, thermalised mechanics & cryo radiation shields.
- Quality of cryo cooler
- Cryo cooler included in package?
- Useof thermalisation & heater elements – for or against?
- Most suppluers propose insulator & heater element between 1st crystal mount & mechanics – control?





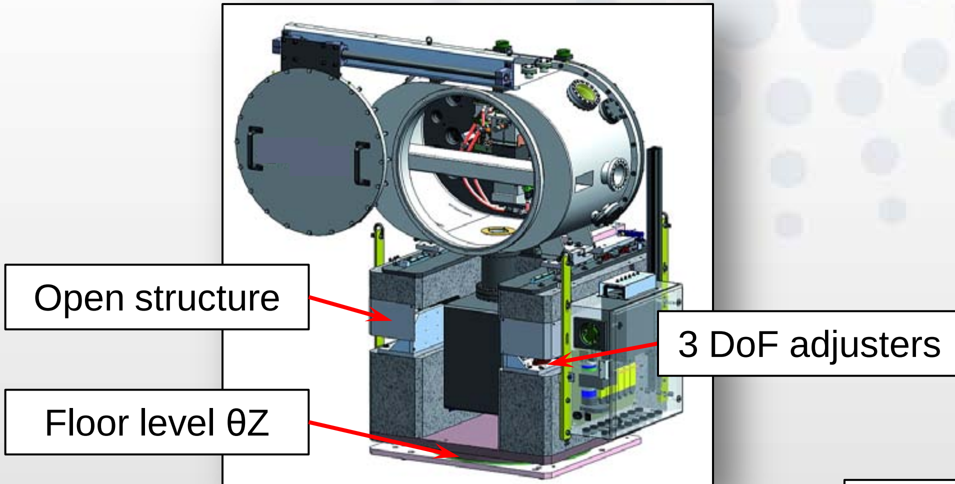
Comments:

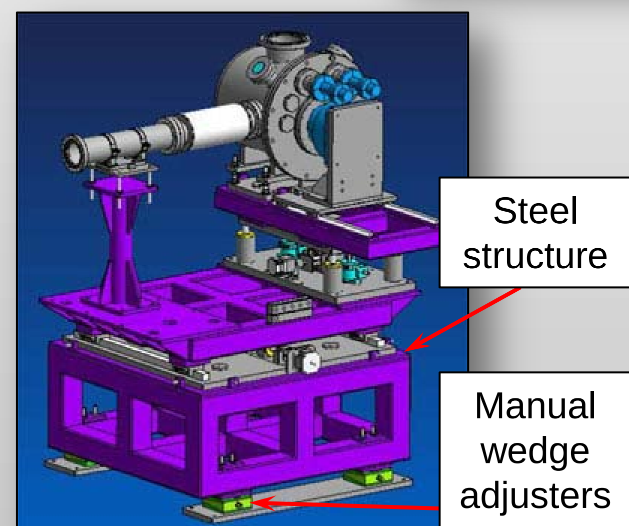
- Heater thermal transfer function
- Mechanical stability of thermal insulator
- Smooth walled cryo tubes
- Thermal radiation shielding
- Compton scattering: (up to 20% of total power) – shielding mandatory
- 2nd crystal cooling critical for minimal ΔT

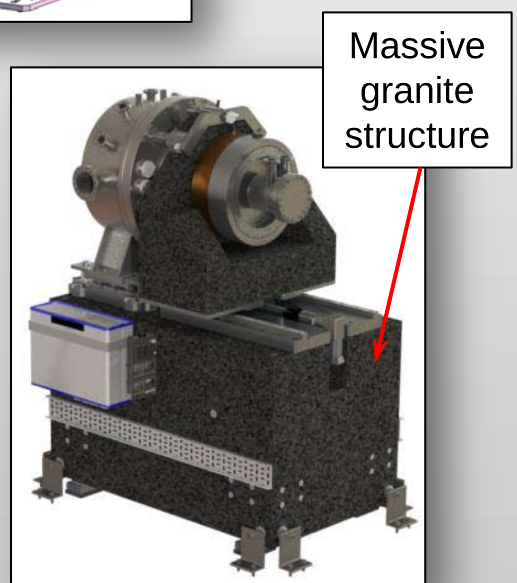
Other

- Only one supplier uses a dedicated encoder shaft to eliminate error due to shaft “wind up”. Also only supplier proposing absolute encoder
- Two suppliers clearly demonstrate comprehensive in house mechanical & thermal FEA, metrology & testing
- One supplier indicates impressive vibration performance figures: 85 Hz on 1st crystal
- Vibration analysis generally performed during customer acceptance tests

Identified Critical Points - Chassis Vibration Transmission

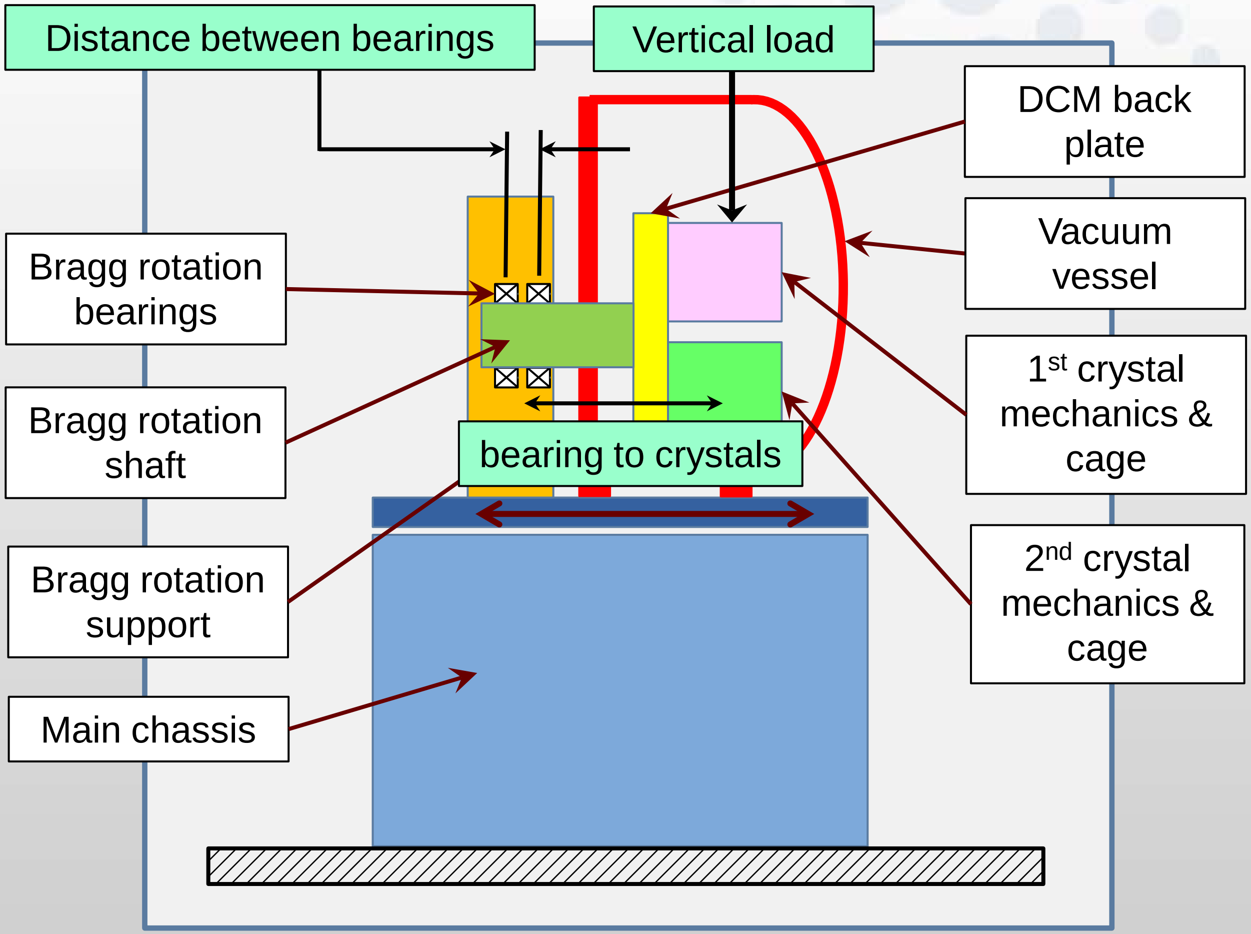






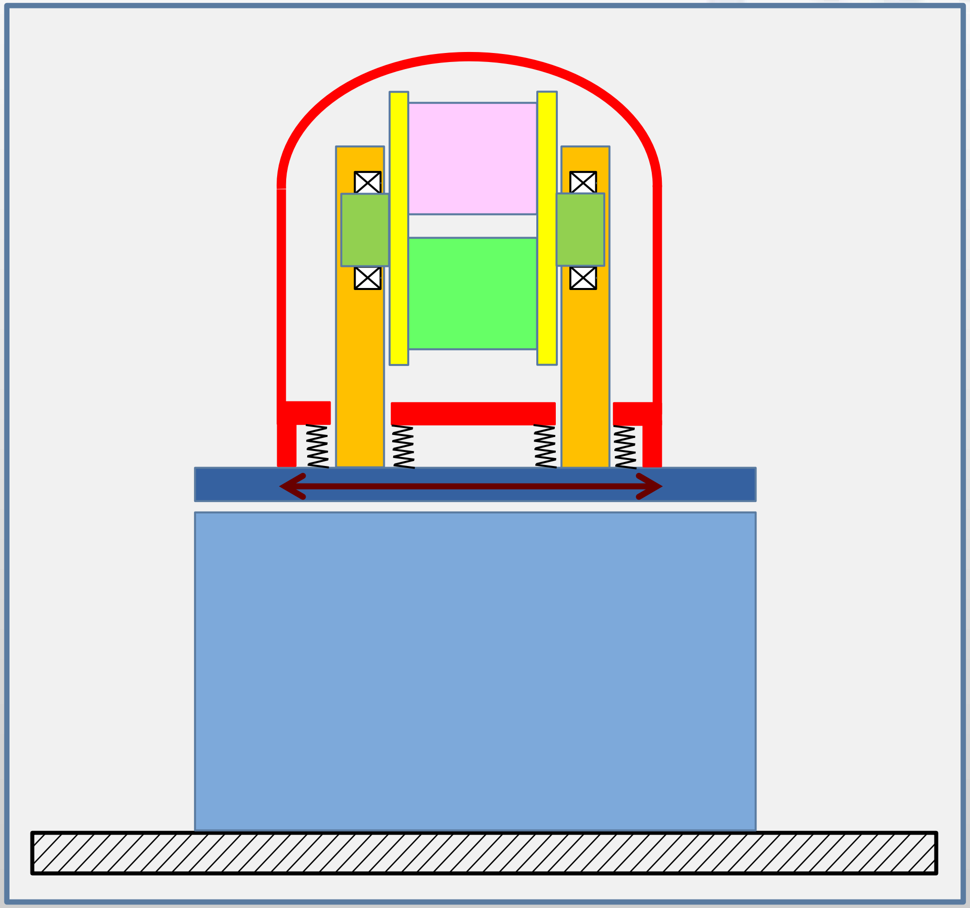
- Welded steel structures mechanical & thermal stability compared to natural or synthetic granite
- Natural granite = stable & cheap
- Synthetic granite = awkward shapes, pump access
- Interface to floor
- Grout stiffness / thickness
- Adjustable feet
- Remote ex vacuum displacements (unlockable)
- Low level movements
- Open structures

Identified Critical Points - Mechanical Stability



- Cantilever vertical load up to 250 kg!
- Deflection during large angular movements?
- Vibrations?
- Vacuum forces on Bragg rotation support bracket
- Vacuum forces on rear of vessel?

Alternative solution?



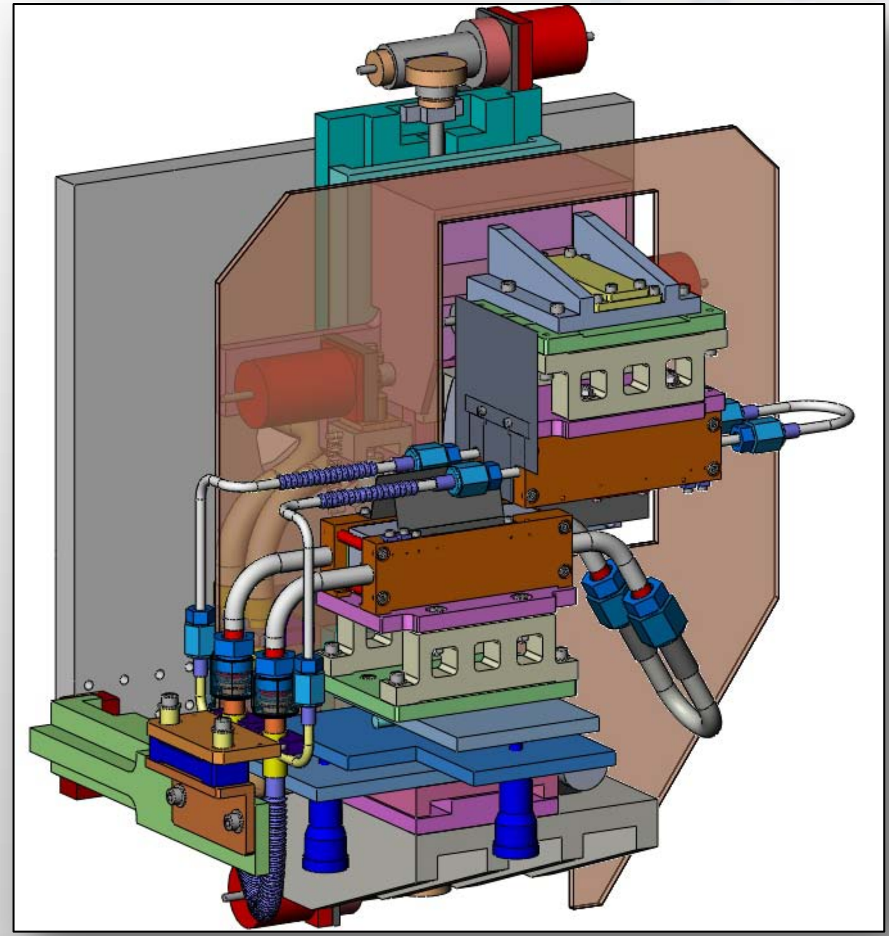
Advantages:

- More compact design
- No cantilever load
- Much stiffer
- Less sensitive to vibrations
- No influence of vacuum forces
- Thermally symmetrical

Disadvantages:

- In vacuum bearings (& motor?)
- Lubrication & lifetime issues
- In vacuum encoder
- Radiation damage issues
- Crystal access
- Crystal cooling
- No one has done this!

ID20 Pre - Monochromator



Refurbished ID16 Kohzu pre-mono

- LN_2 cooling
- Energy range 4 – 20 KeV
- Bragg angle 5 – 30^o
- 1st crystal fixed but no longer centered on axis of main rotation
- Beam moves on 1st crystal with energy
- 2nd crystal small (10mm) motorised vertical translation, and fine pitch & roll correction

Courtesy Kieth Martel - ESRF

Conclusion

- Difficult to conclude before direct discussions with each possible supplier
- All shortlisted suppliers are reputed & show excellent qualities, but all have drawbacks / limitations
- ESRF will favour a generic design from a single supplier if at all possible
- No “off the shelf” solution exists - future ESRF DCM will require developments in several fields
- Development will require considerable material resources
- Significant on site tests & metrology will be required (ESRF facilities)
- Close collaboration or co-development with supplier is therefore mandatory
- The possibility of partial in house development or collaboration with other facilities should be evaluated

Acknowledgements

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Thank you for your attention