



Engineering Challenges on the I14 Nanoprobe Beamline

Andy Peach
Diamond Light Source

Structure of talk

I14 Overview

- Outline of the beamline layout
- Key goals & challenges
- Highlight a few key points
 - Building
 - Primary optics



Structure of talk

I14 Overview

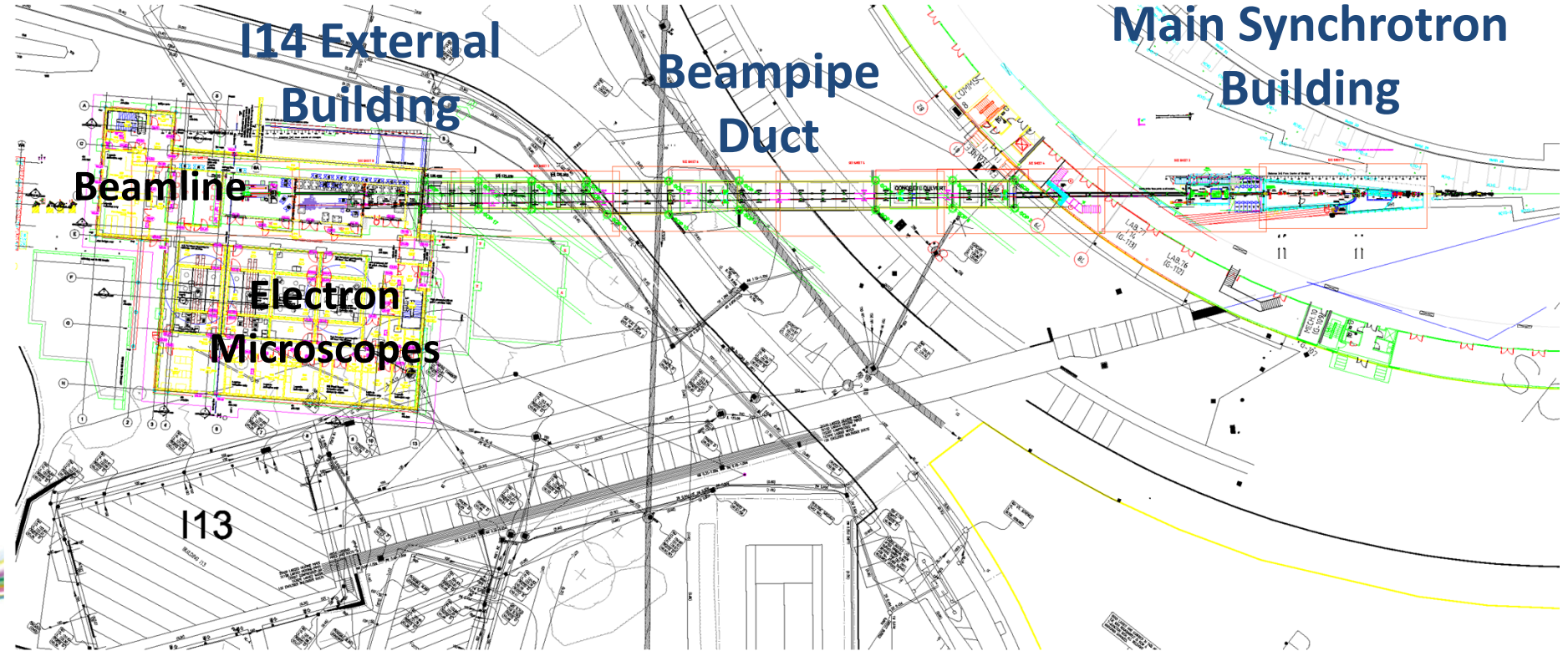
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 - Building
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I14 Endstation in more detail

- Nano KB/sample station
- Detector table

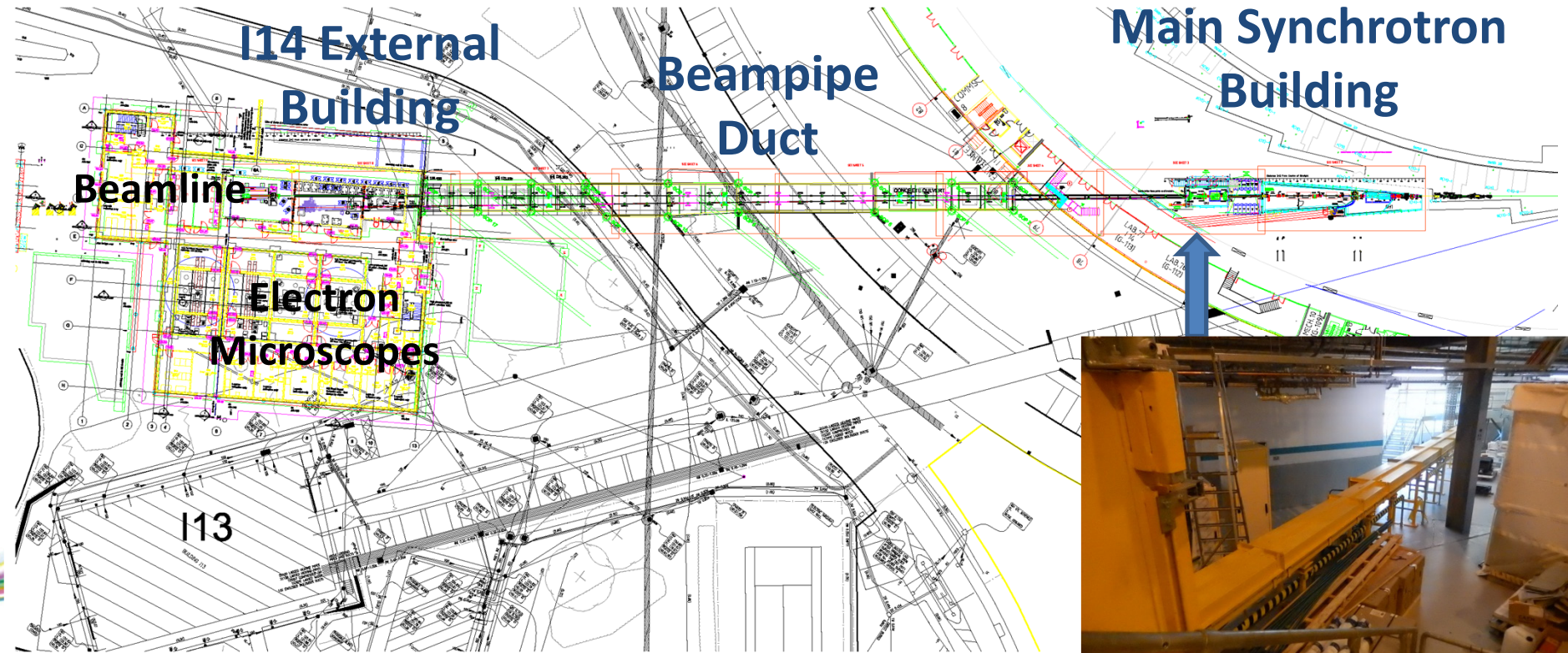
I14 Site Layout

- 186m long for demagnification & coherence
- 2 Branches – Nanoprobe & Mesoprobe



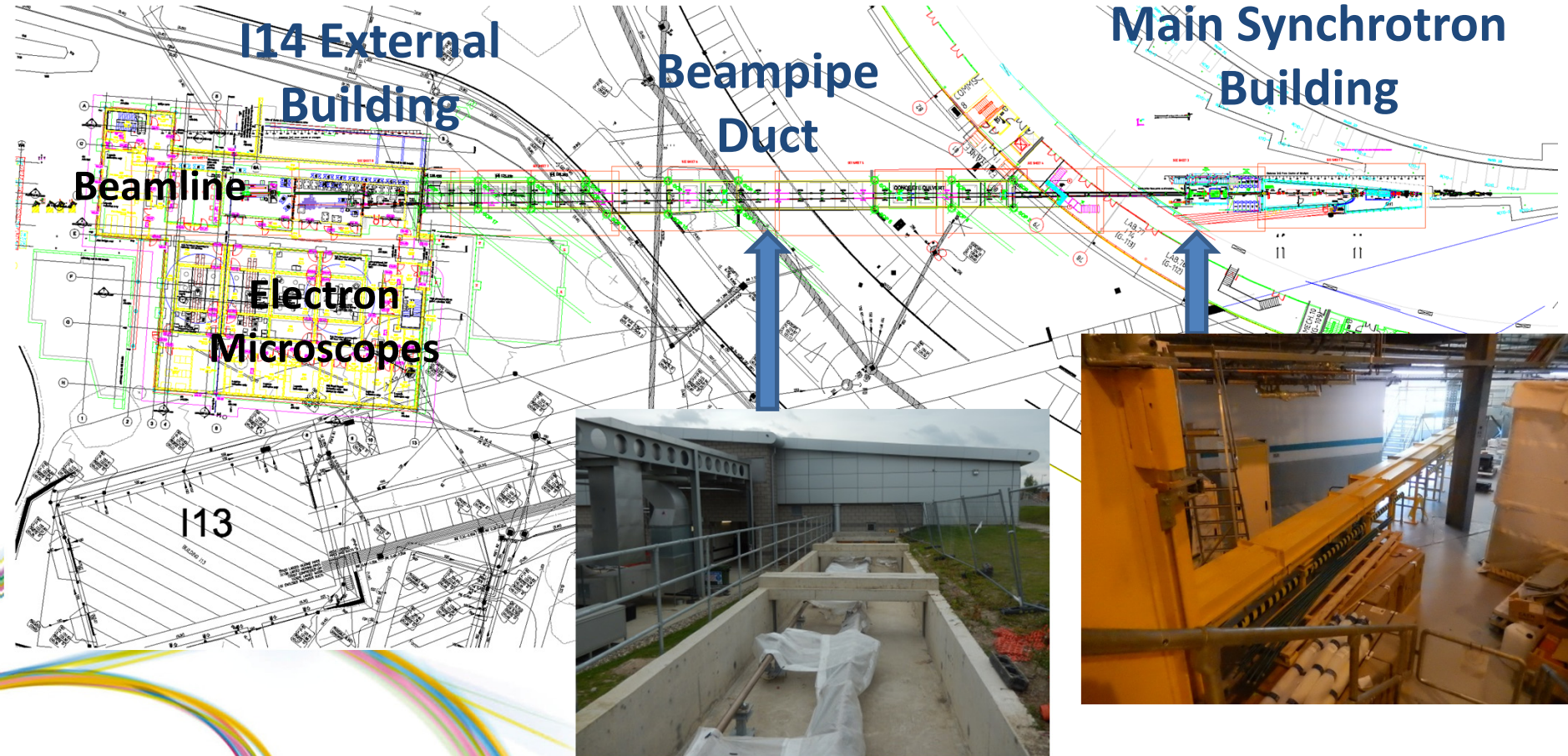
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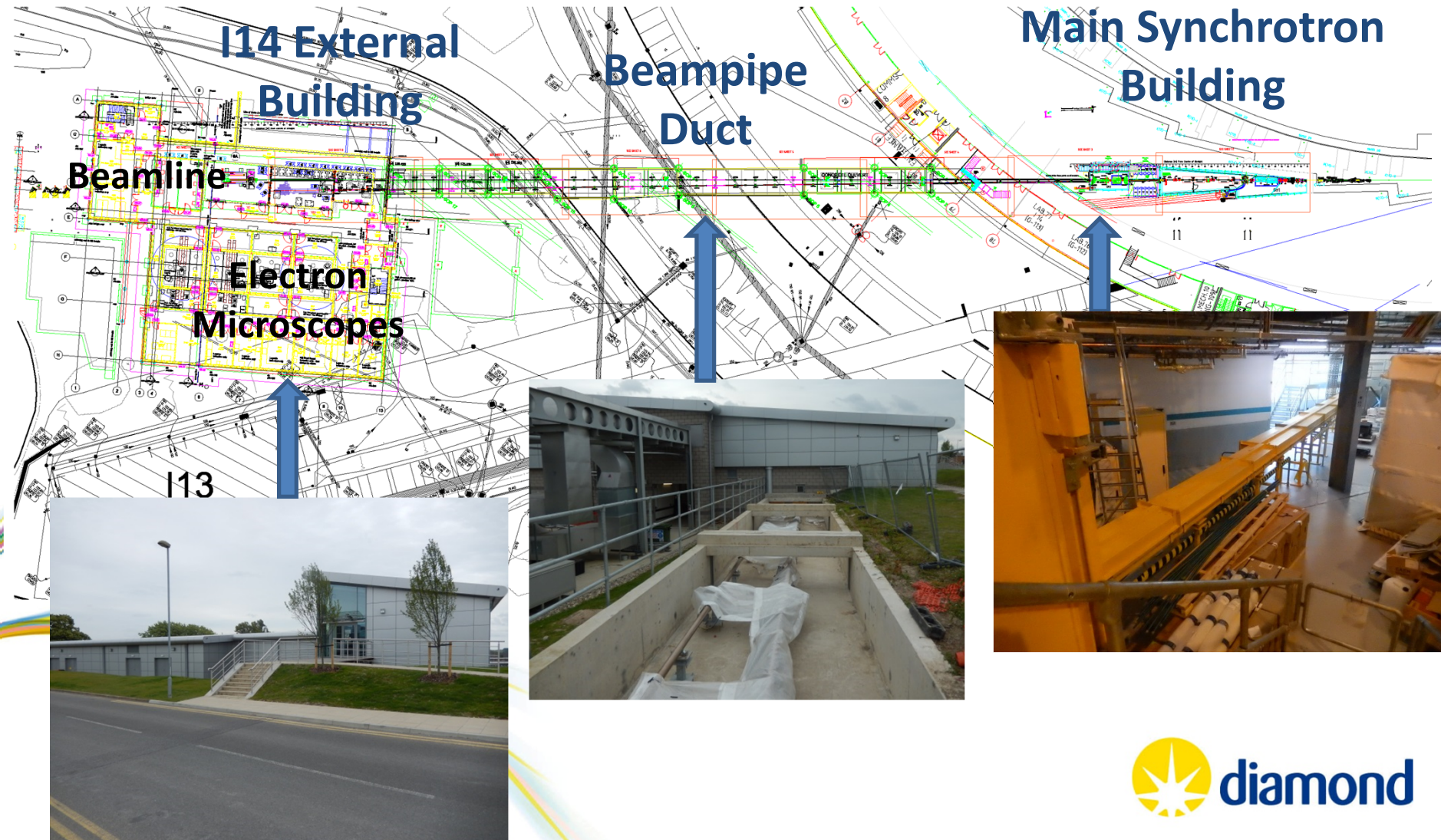
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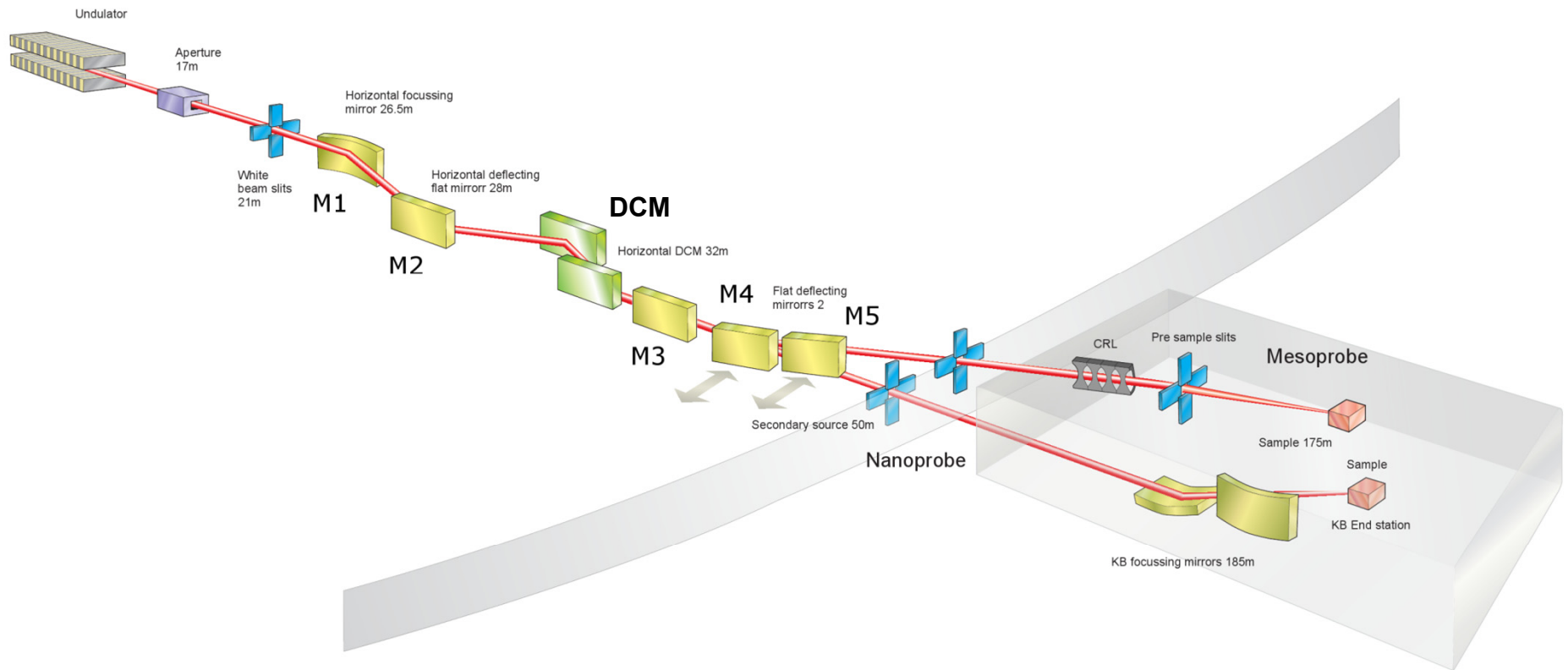
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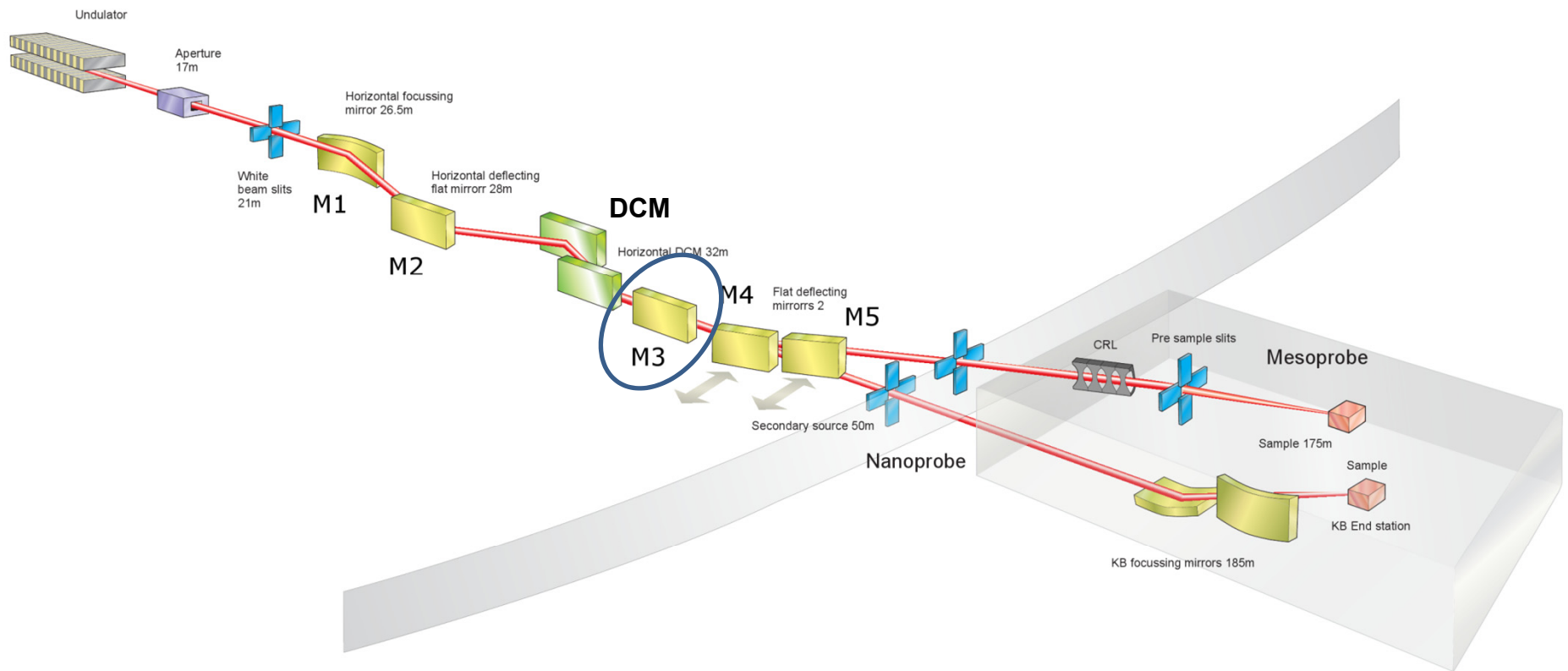
I14 Beamline Layout

- All primary optics side bounce for best vertical beam stability



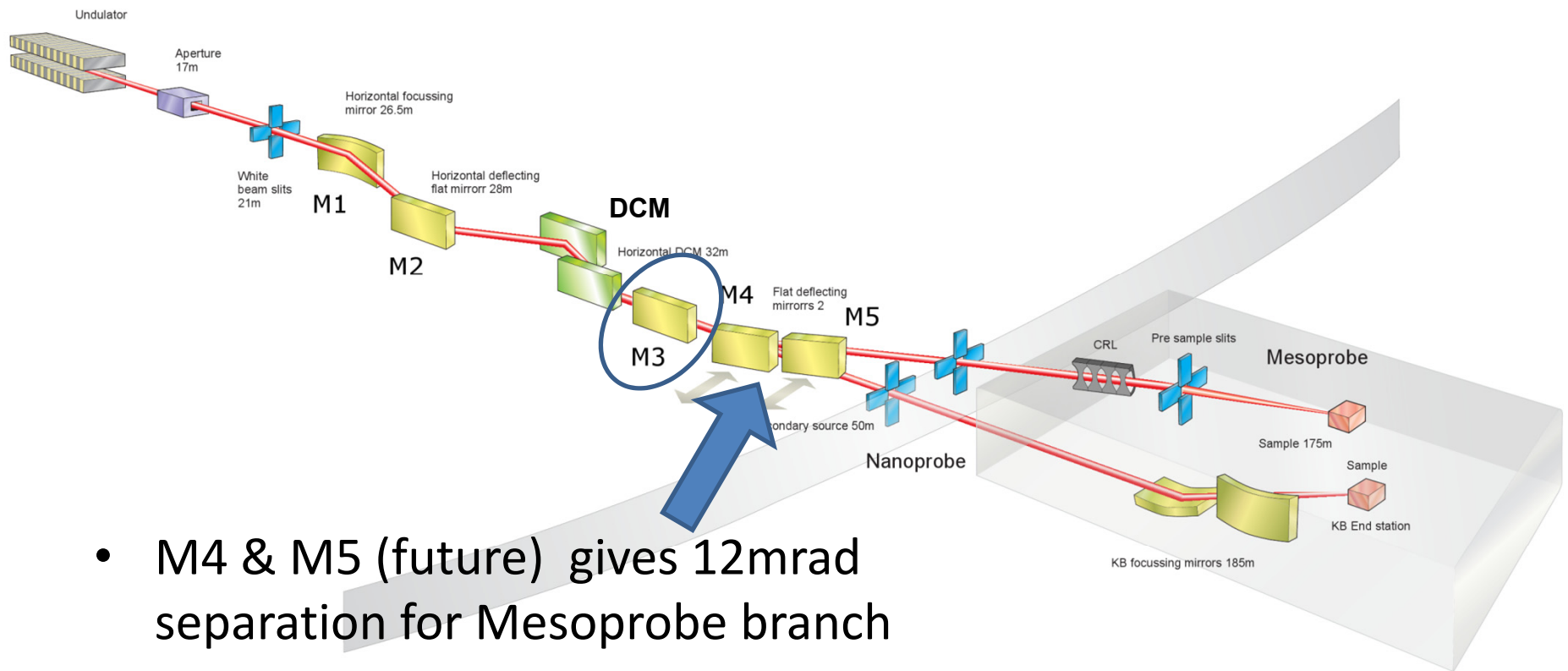
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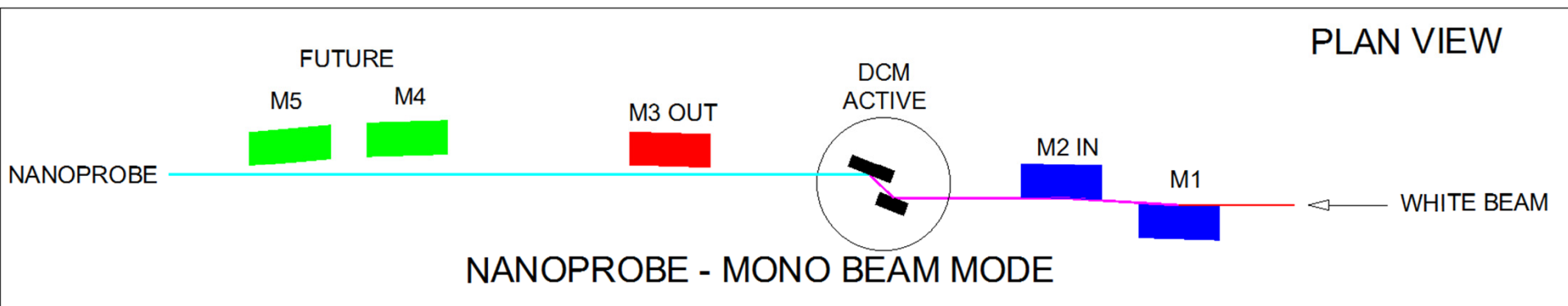
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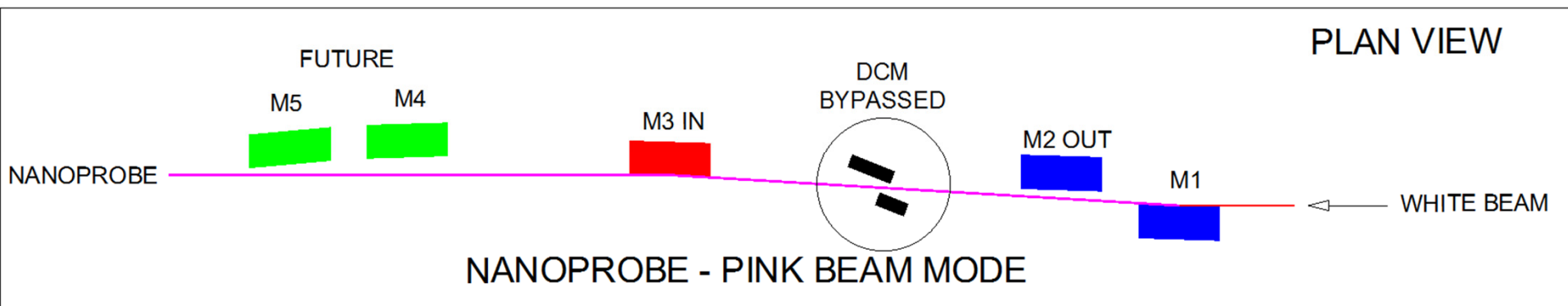


- M4 & M5 (future) gives 12mrad separation for Mesoprobe branch

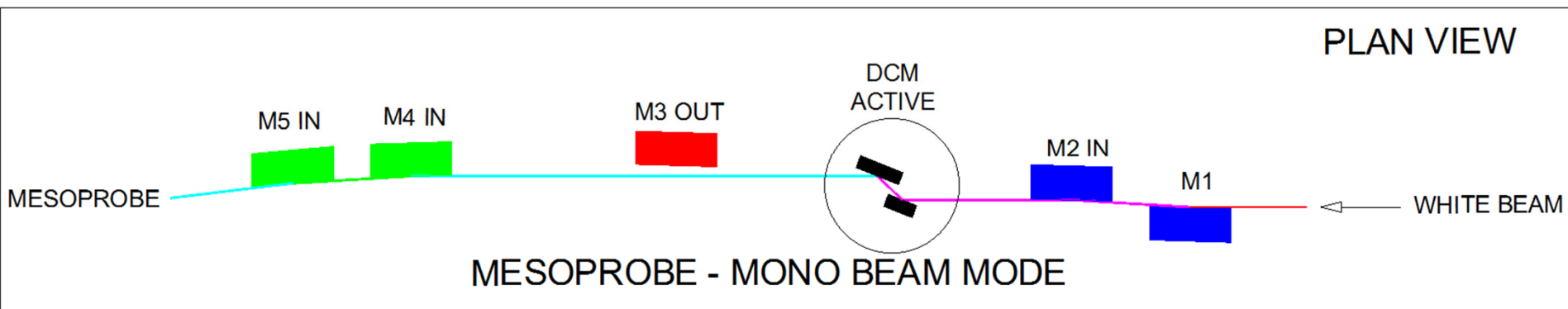
Mono & Pink Beams to Both Branches



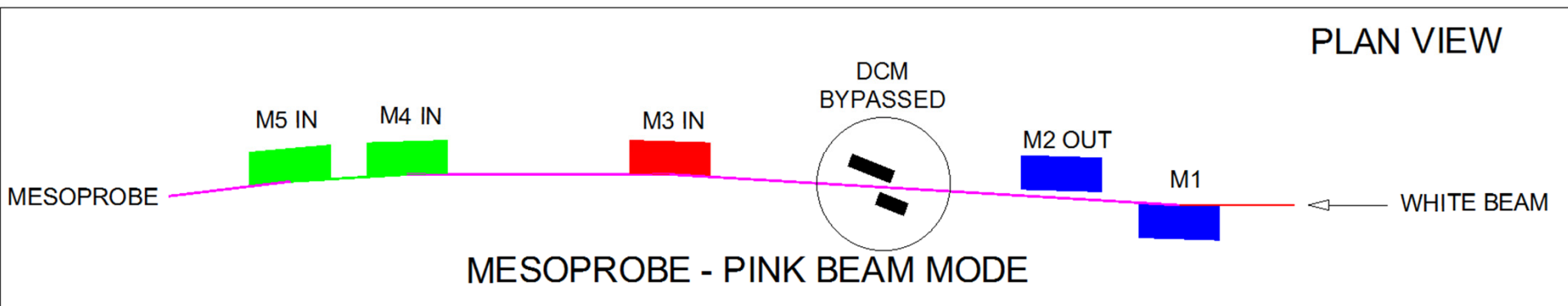
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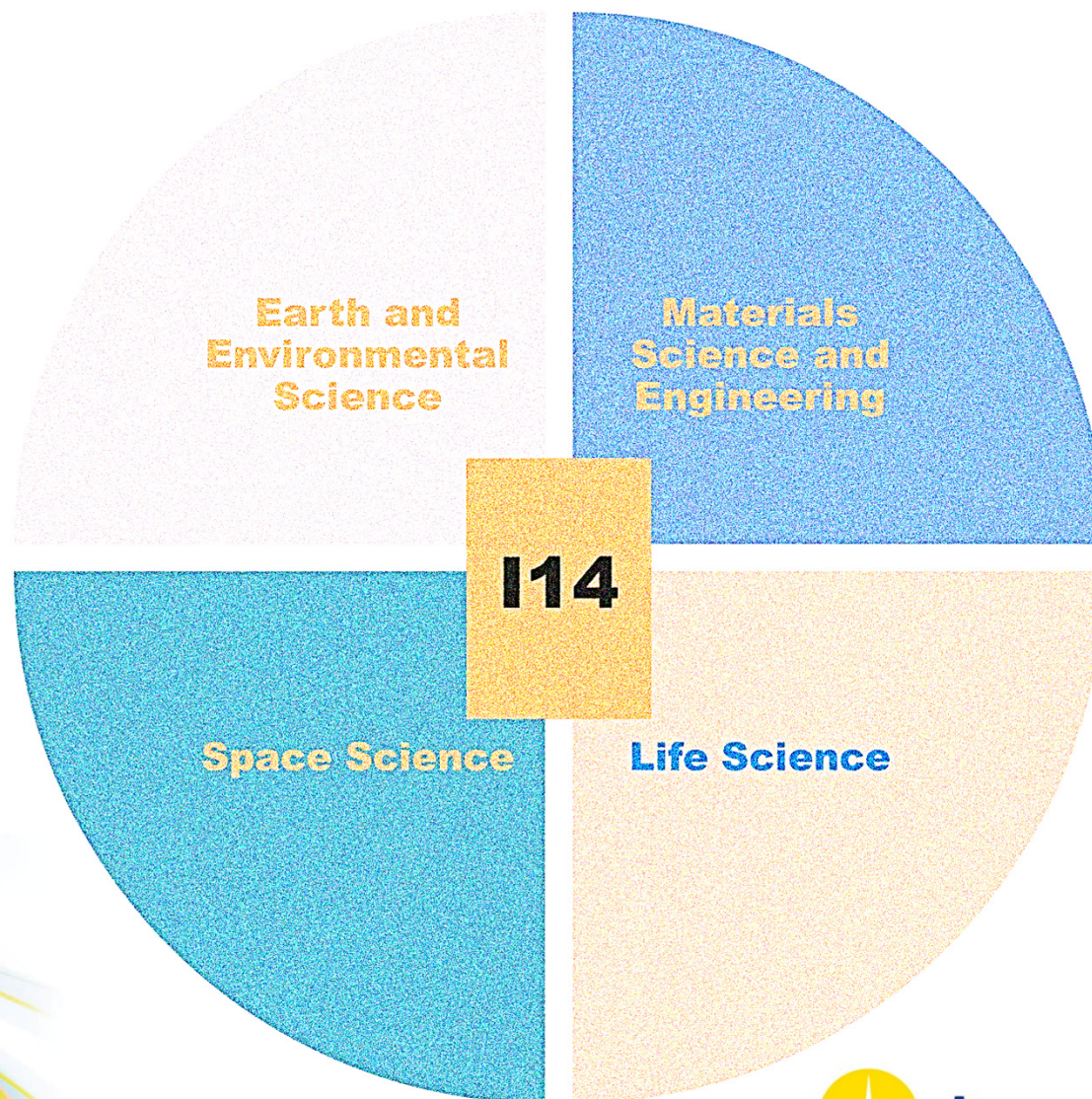
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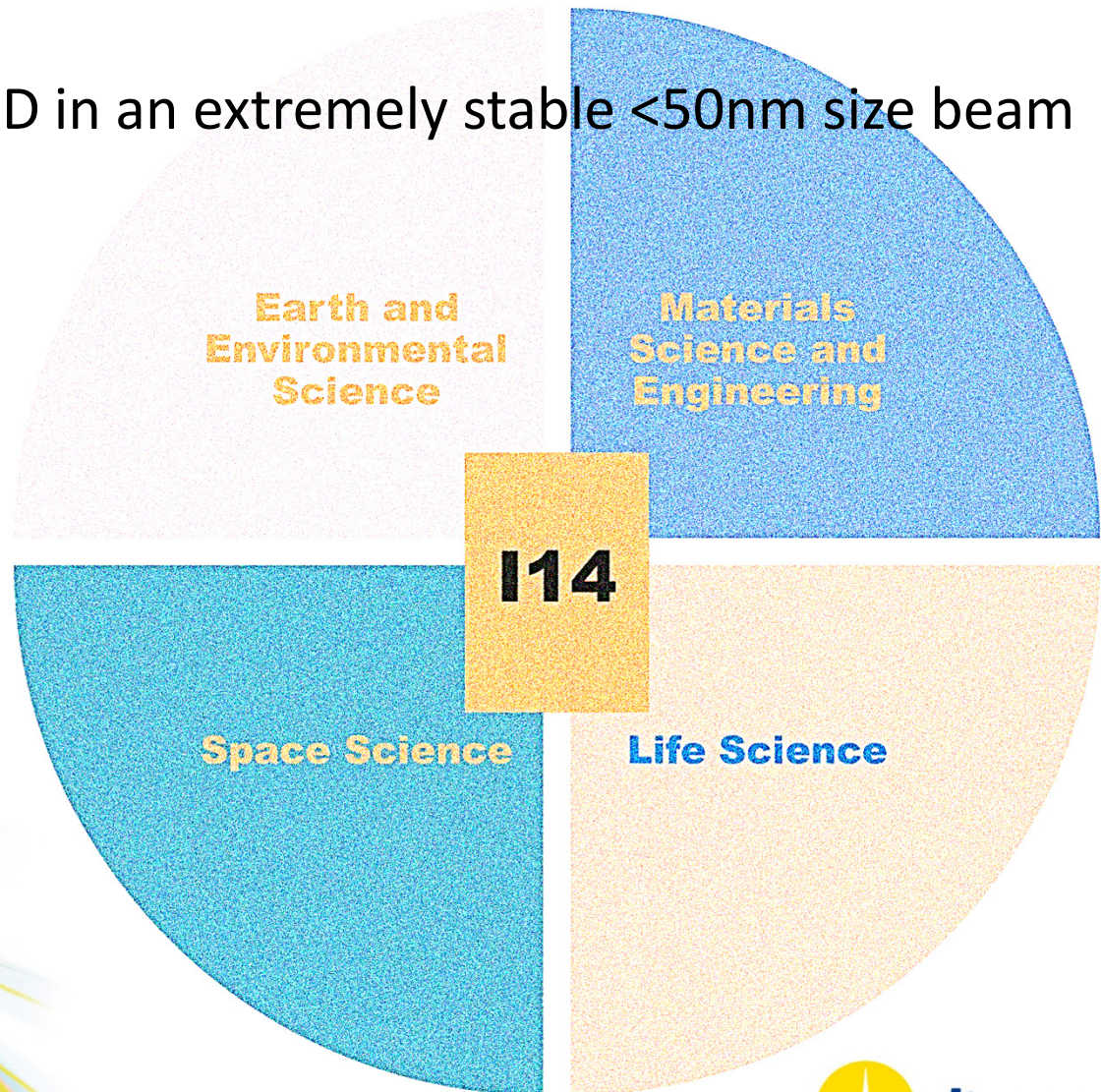


Key Goals of the I14 Nanoprobe



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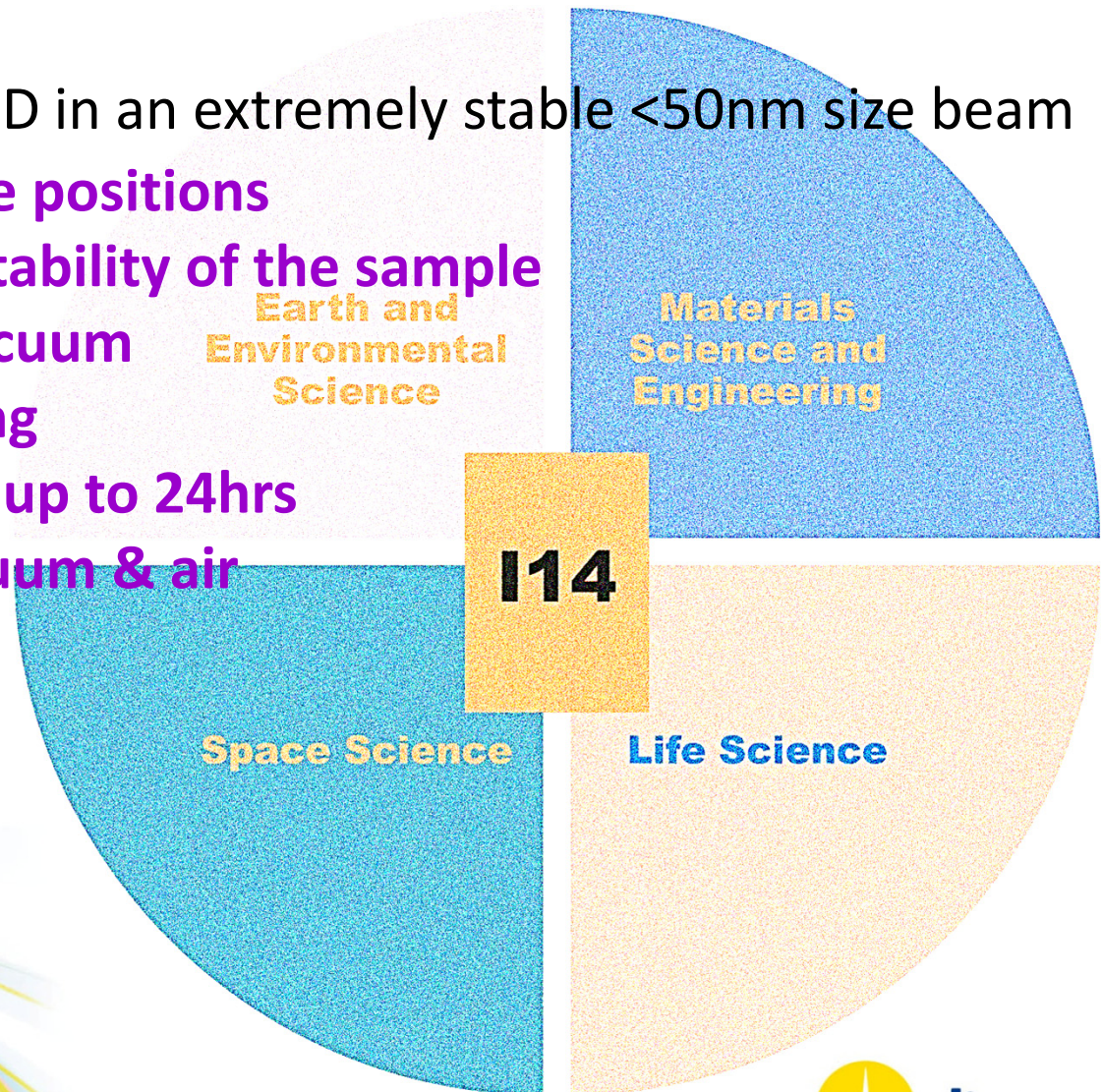
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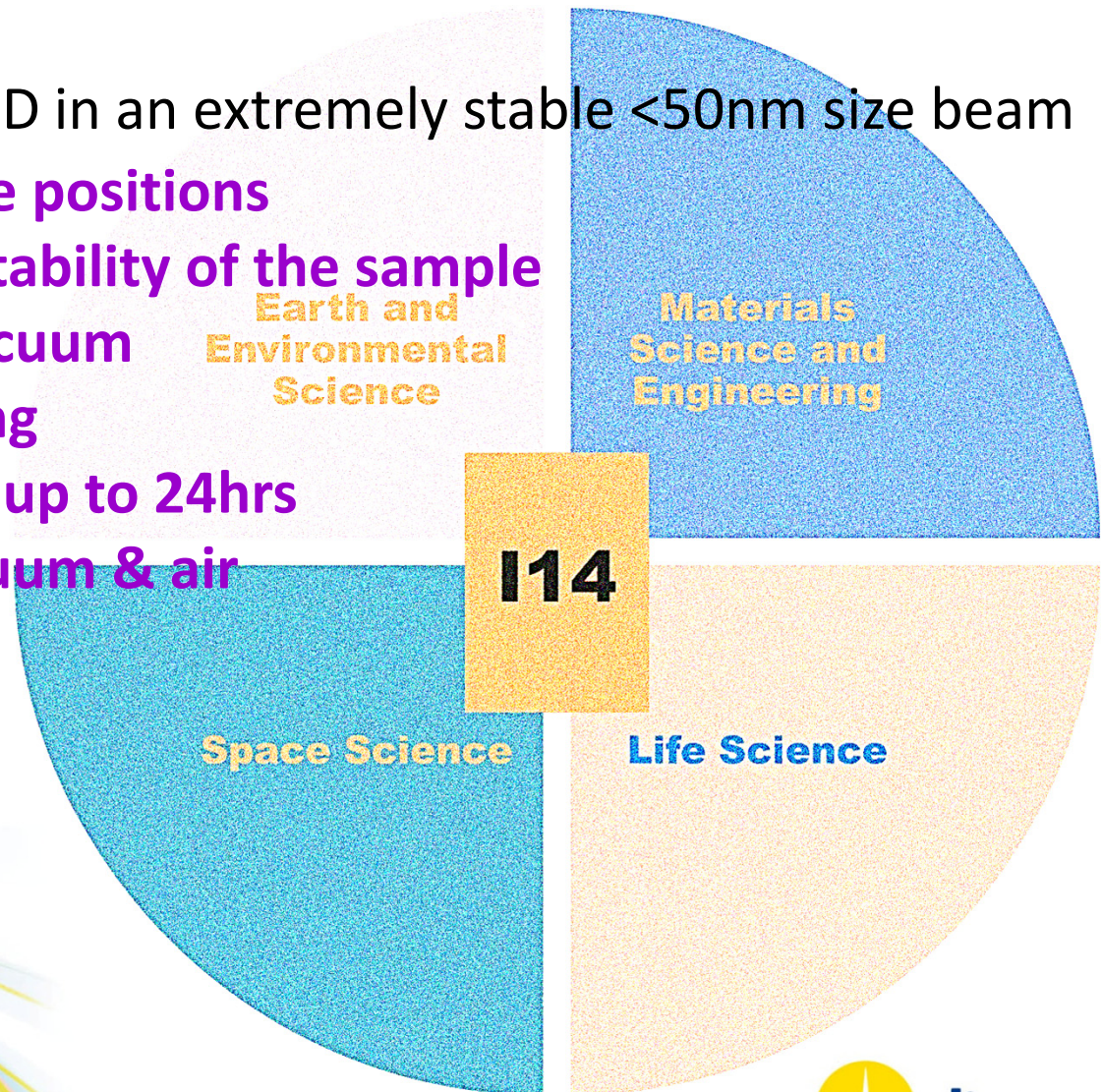
- ✓ Different sample positions
- ✓ Maintain 3nm stability of the sample
- ✓ Atmosphere/vacuum
- ✓ Cryogenic cooling
- ✓ Long duration – up to 24hrs
- ✓ Detectors – vacuum & air



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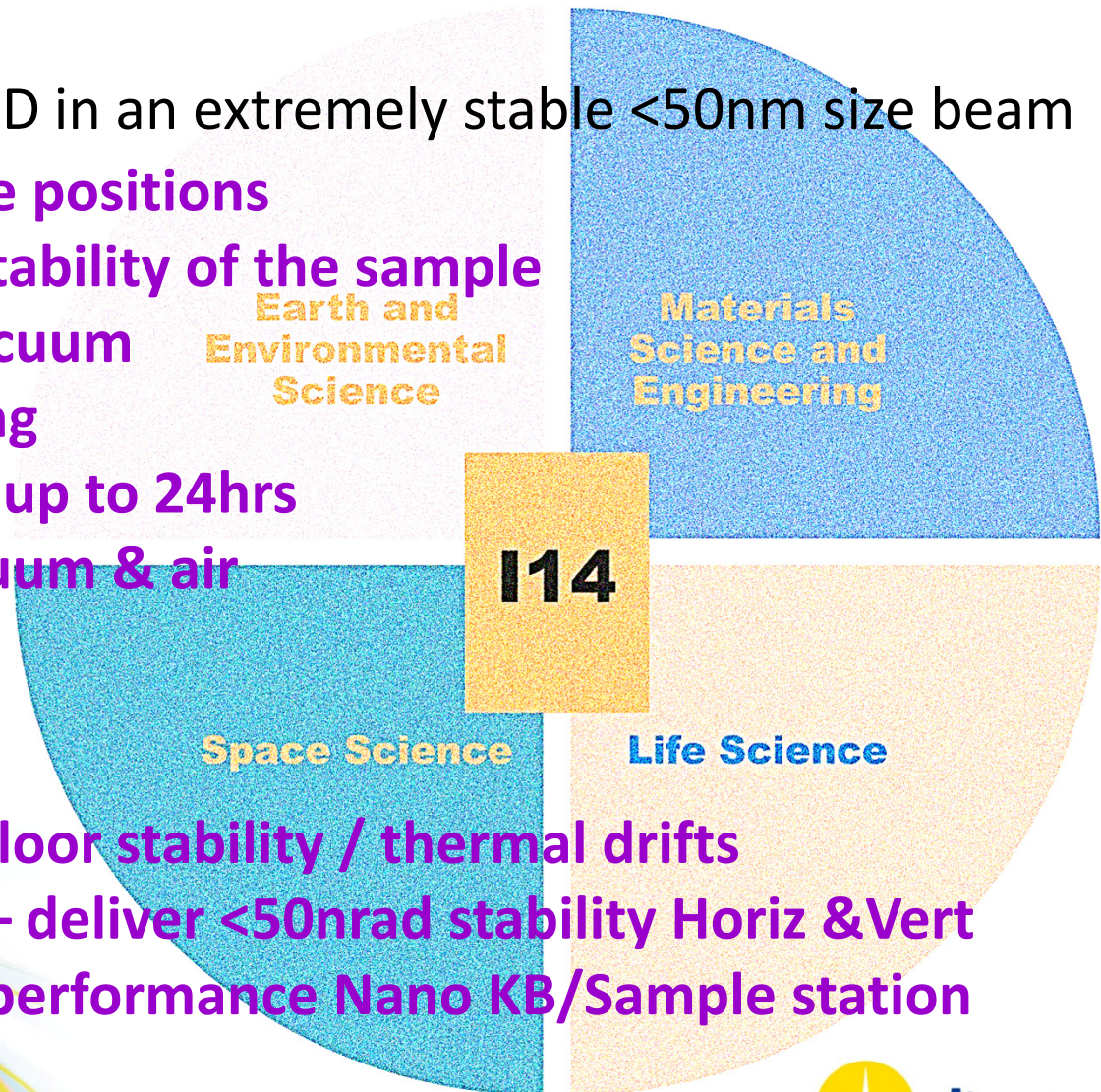


Primary Challenges

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Primary Challenges

- ✓ Environment – floor stability / thermal drifts
- ✓ Primary Optics – deliver <50nm stability Horiz & Vert
- ✓ Develop a high performance Nano KB/Sample station

Environment – External Building

- Concrete hutches – high thermal mass
- Floors – 0.8m thick concrete on 14m piles
- Floors isolated from walls (separate foundation)
- Radiant panels not forced air conditioning



Concrete hutches
under construction
- Jan 2015

Environment – Radiant Panels



- Passive cooling (idea from EM labs)
- Low air pressure fluctuations
- Removes short term thermal oscillations
- Fitted to walls and ceilings
- Vestibule entrance to hutch

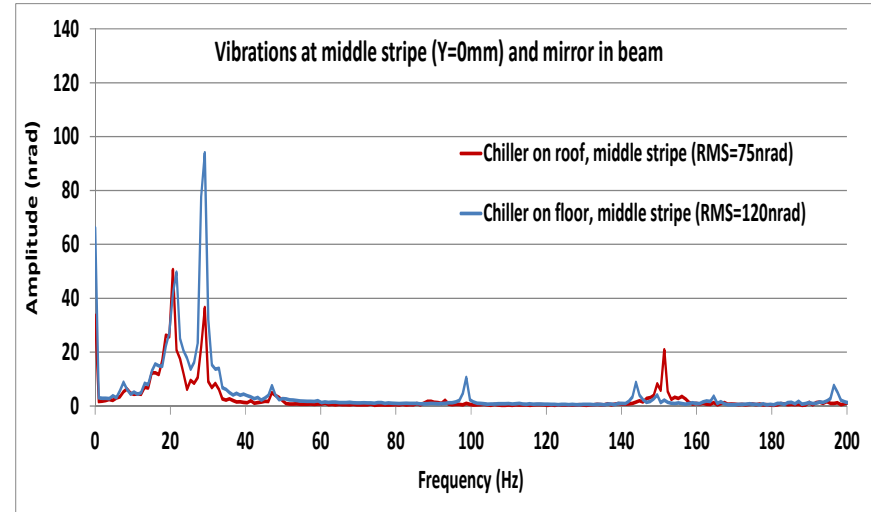


Cooling Capacity:
3-4KW per room.

Primary Optics

Mirrors

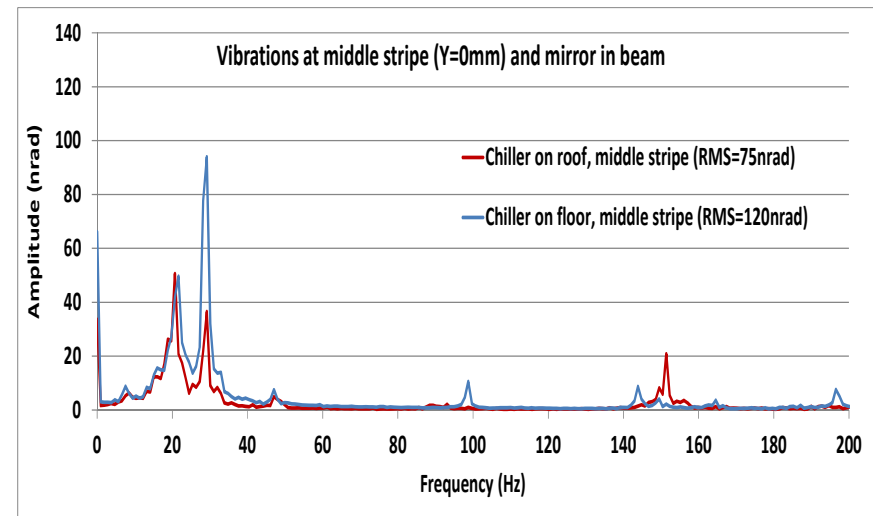
- Metrology - autocollimator & cap sensor tests
- Some issues with vibration & repeatability – cooling related
- Modified cooling + gravity feed cooling
- Stability now 75 nrad RMS (horiz) with cap sensors



Primary Optics

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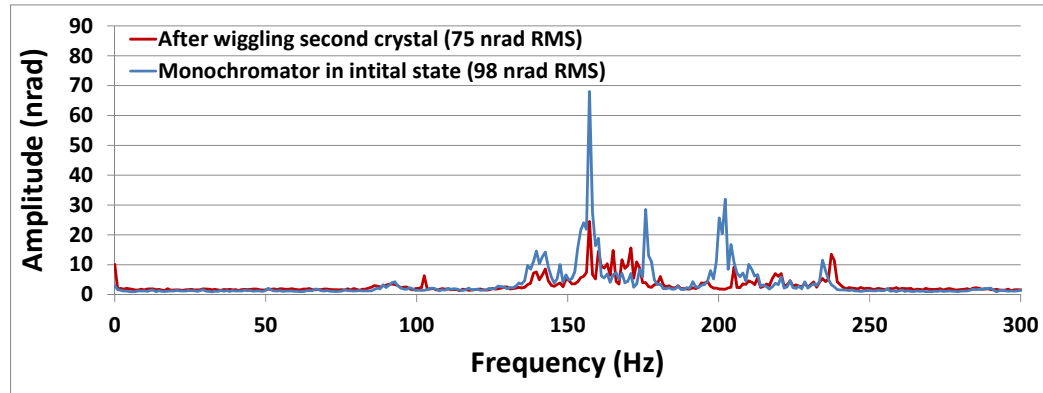
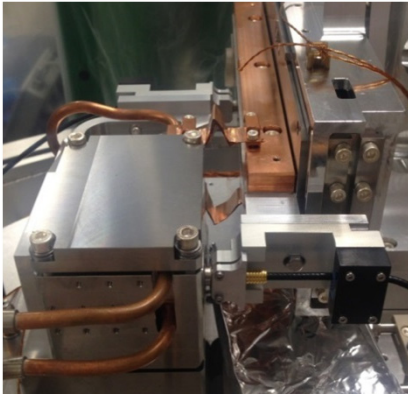
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- 20HZ resonance – stiffness improvements possible (future)



Primary Optics

DCM

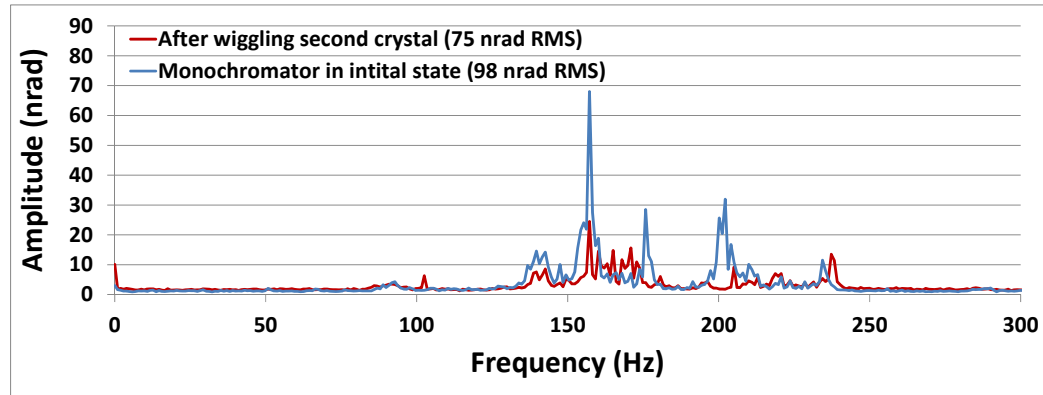
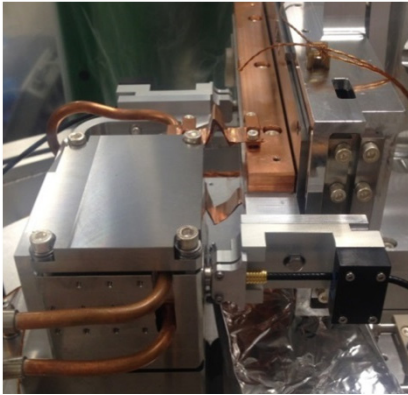
- No vibration peaks <150Hz, 75nrad RMS (cap sensors)



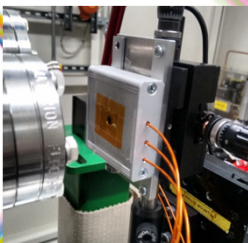
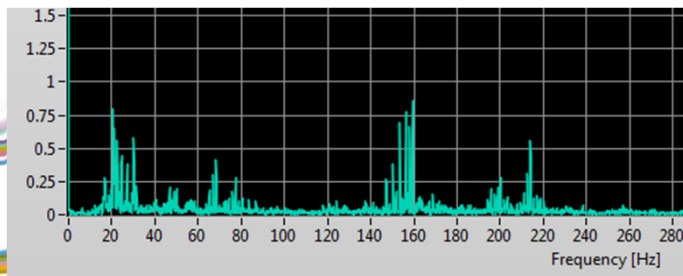
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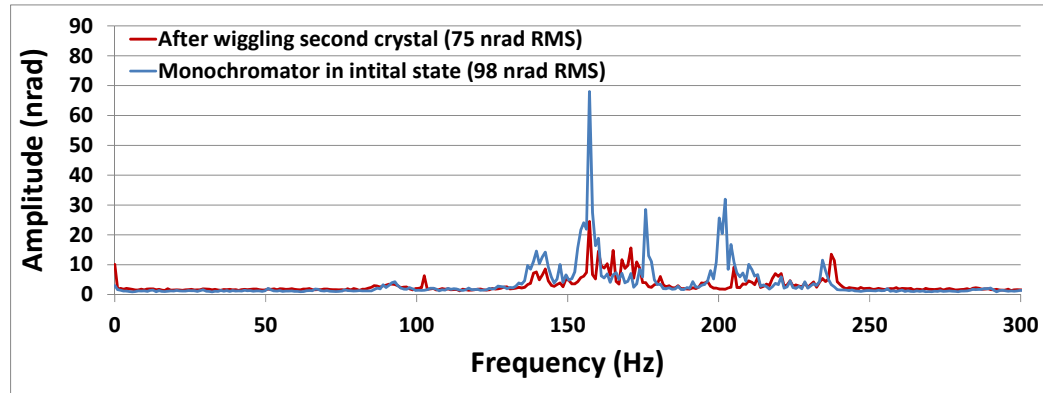
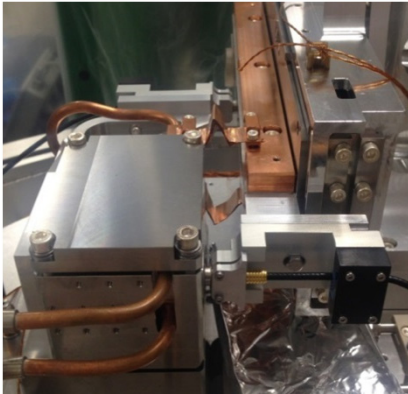
Initial beam measurements in OH2 with Cividex diamond BPM



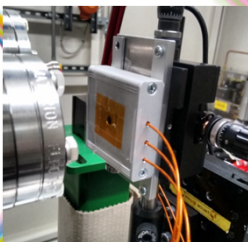
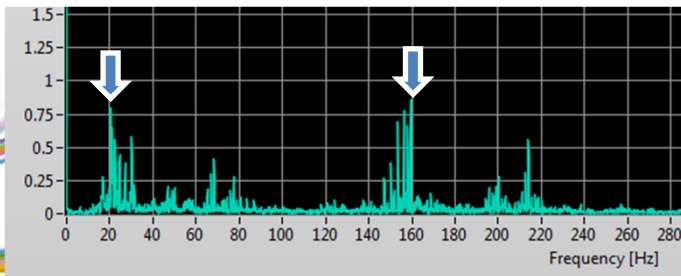
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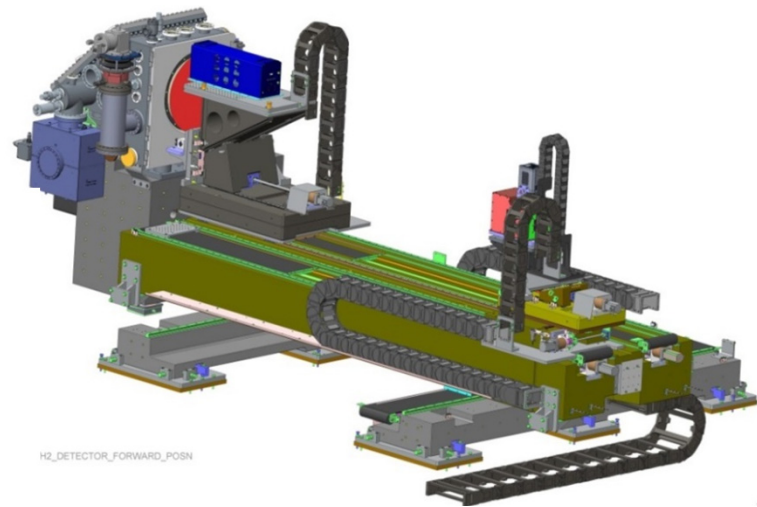
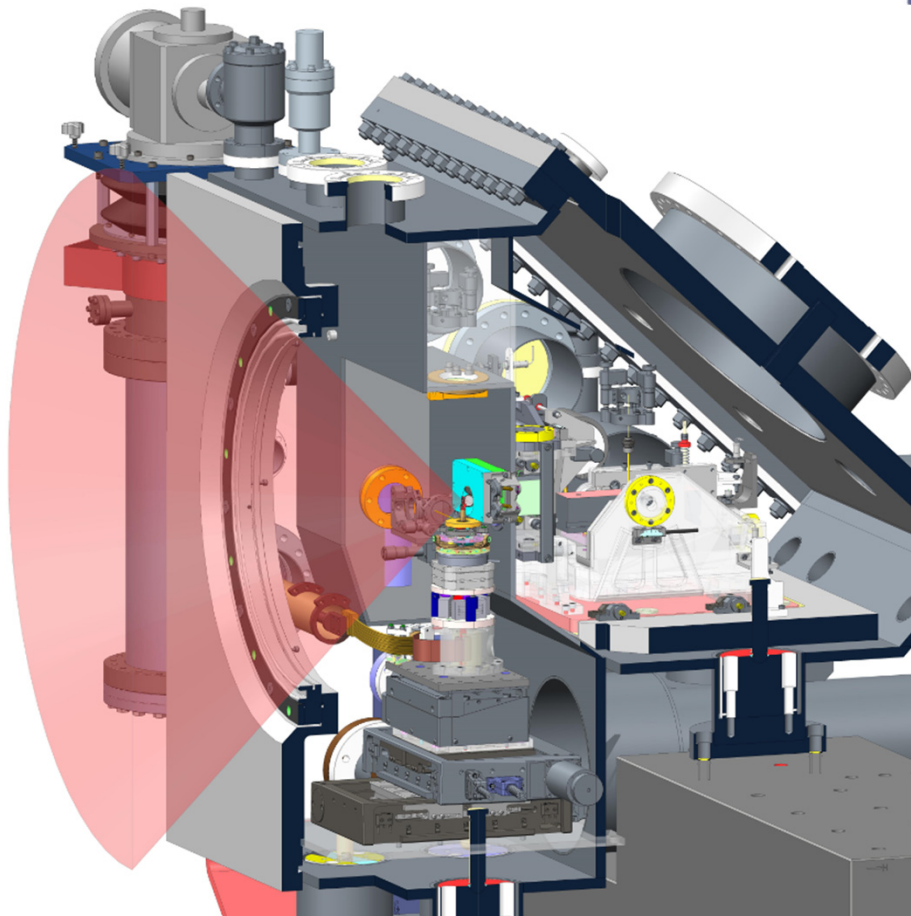


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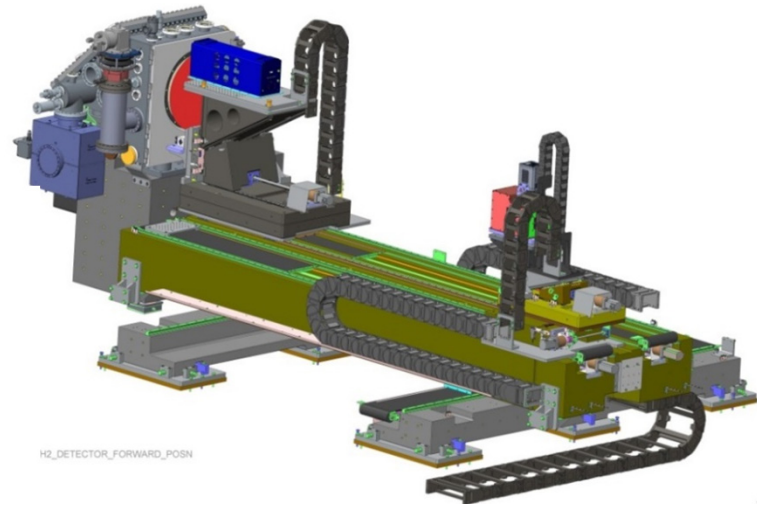
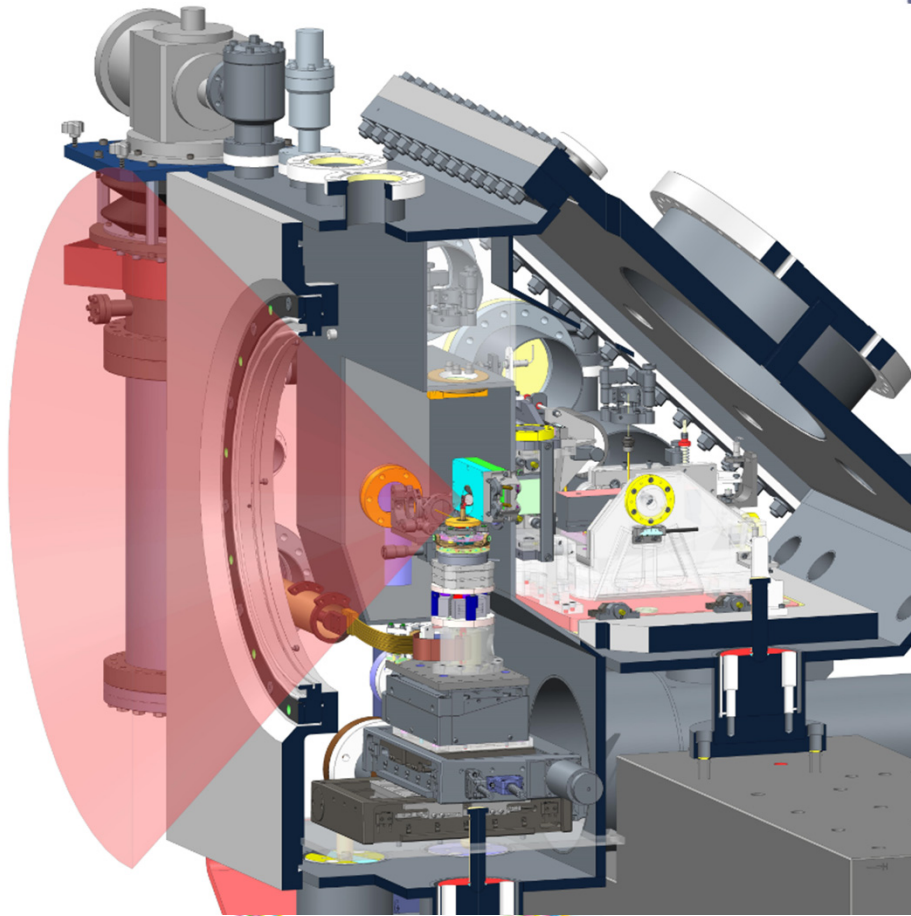


- Mirrors/DCM frequencies clearly seen
- Cap sensors good for frequency
- Cap sensors conservative on amplitude (set up)
- Reality with beam both systems total instability more like 40-50nrad (horiz), negligible vertical vibration

KB/Sample Station - Major Design Areas



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H2_DETECTOR_FORWARD_POSN

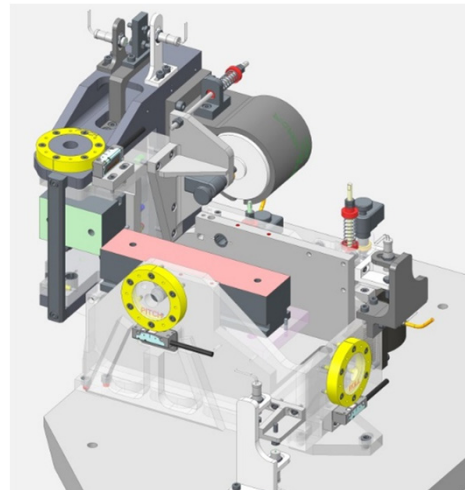
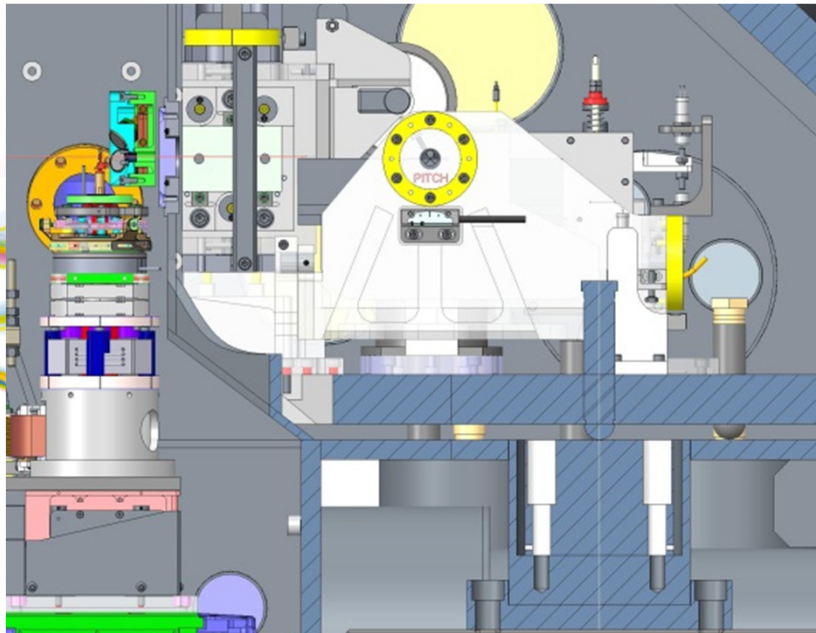
- KB mirror mechanism
- Sample environment
- Cooling
- Sample mounts & transfer
- Interferometry
- Vessel / support
- Sample viewing camera
- Detectors

KB Mirror Mechanism

- Coarse/piezo fine pitch & roll <50nrad resolution
- Axes directly encoded, 35nrad resolution – may improve on
- Optics slope errors <50nrad, 0.2nm figure error verified by DLS

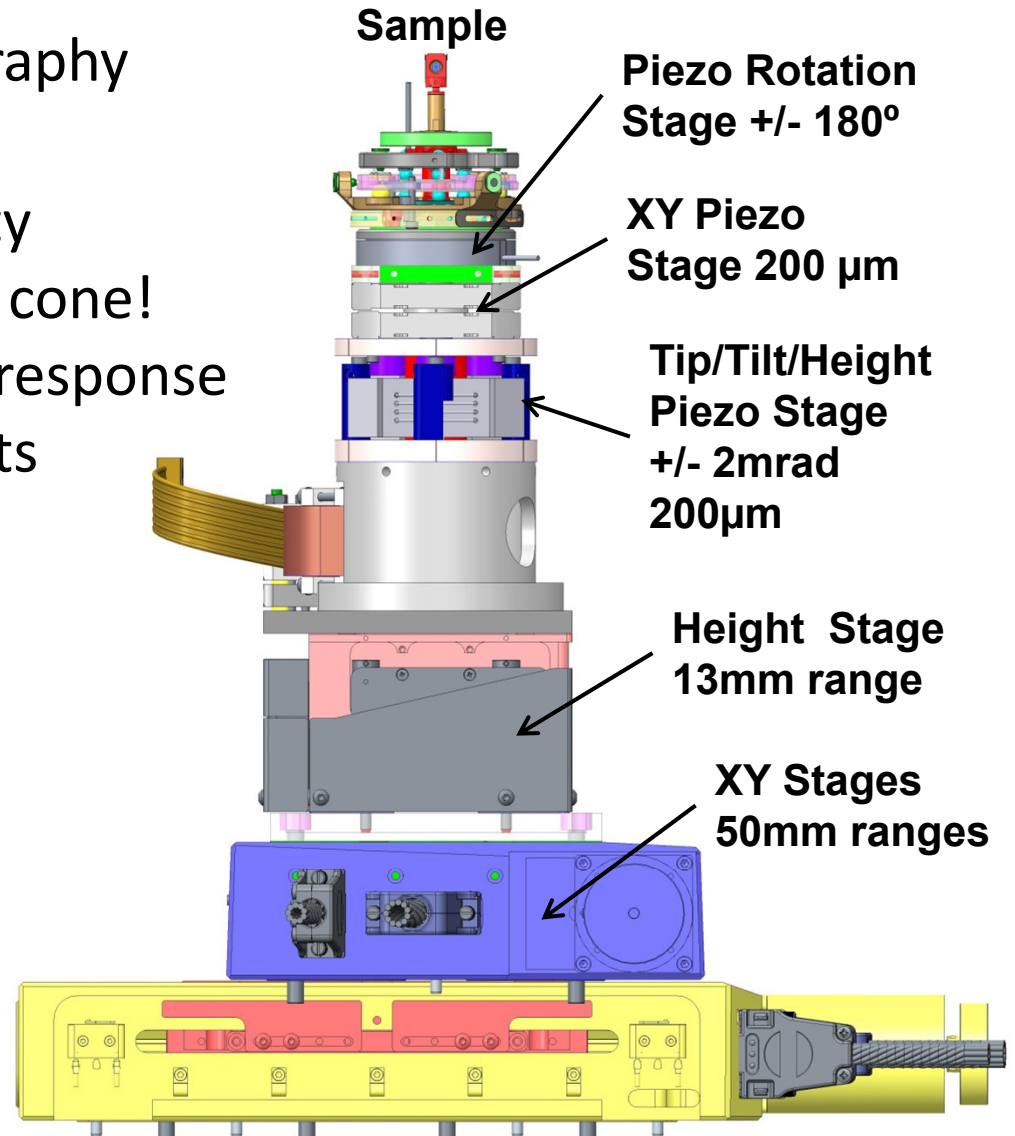
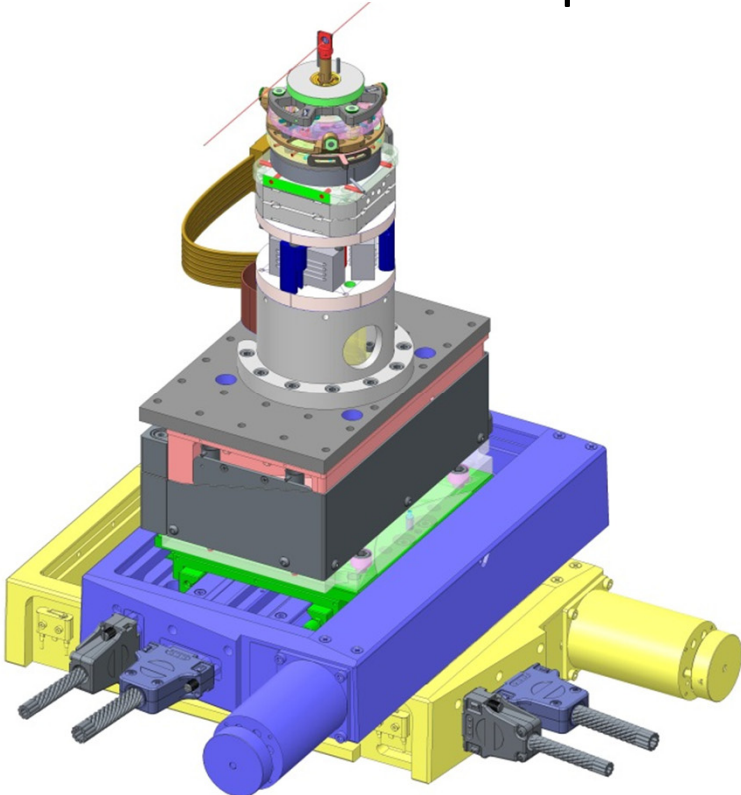
Challenges

- Space constraints dominated support
- Maintain KB's at UHV – complex vessel
- Mechanism built & tested – unable to establish any issues...



Sample Stages

- 2D Scanning, 3D tomography
- ## Challenges
- Flexibility & 3nm stability
 - Space constraints – the cone!
 - Minimise mass – piezo response
 - Different sample mounts

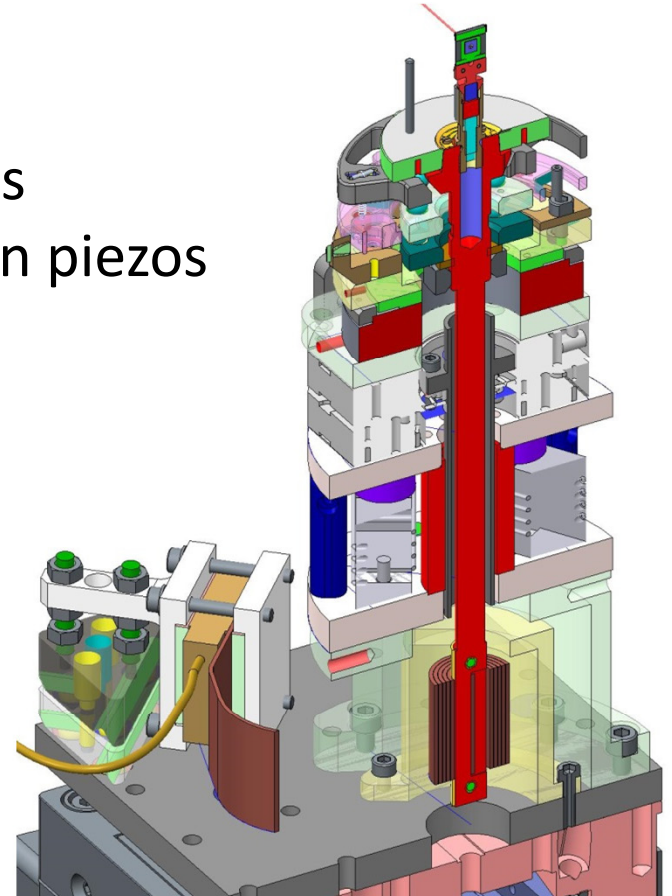


Cooling the Sample

- Max sample temp $\sim 100\text{K}$ with beam
- 0.01mW over a $0.1\mu\text{m} \times 0.1\mu\text{m}$ – high power density
- FEA showed LN2 not enough – He pulse tube cooler

Challenges

- Getting cooling through centre of stages
- Soft needed link for rotation – strains on piezos
- Minimise cold leakage

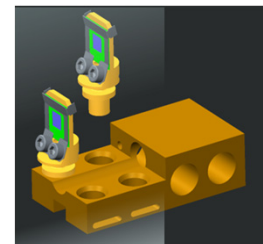
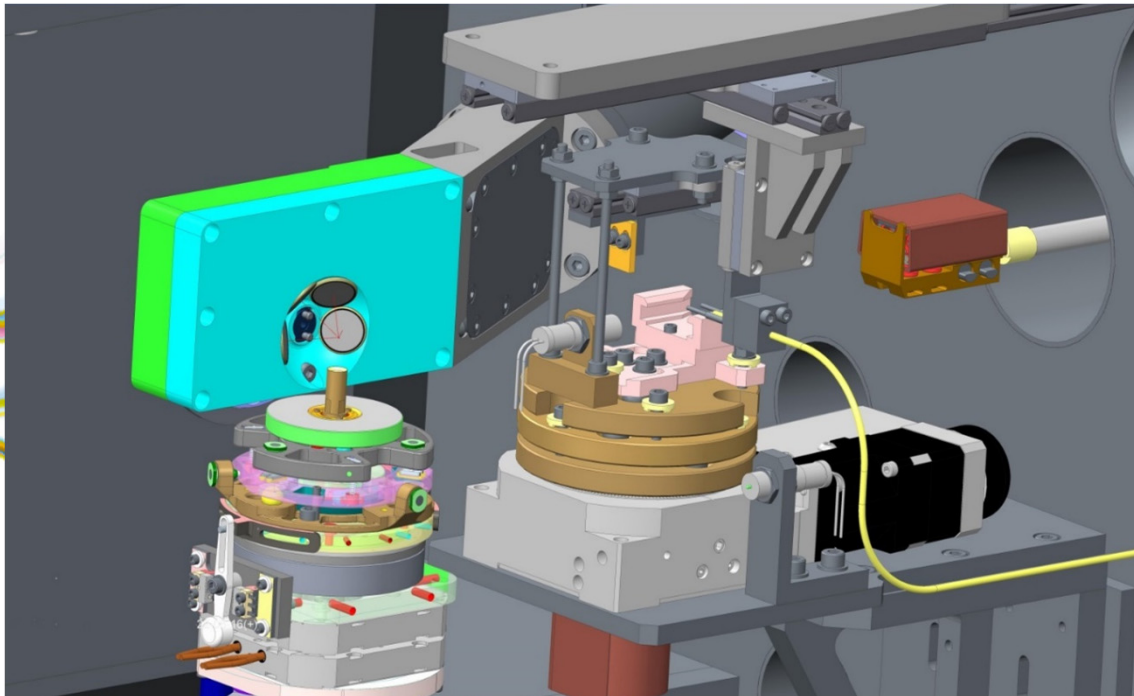


Sample Mounts & Transfer

- Adaption of Leica transfer arm system

Challenges

- 4 samples loaded at once
- Minimise thermal gain during transfer
- In vacuum remote handling
- Reliability – endoscope for image recognition?

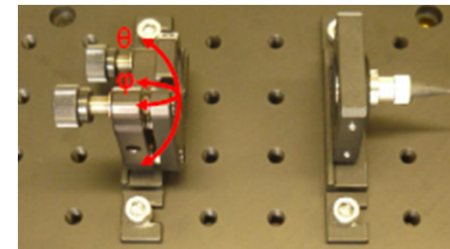
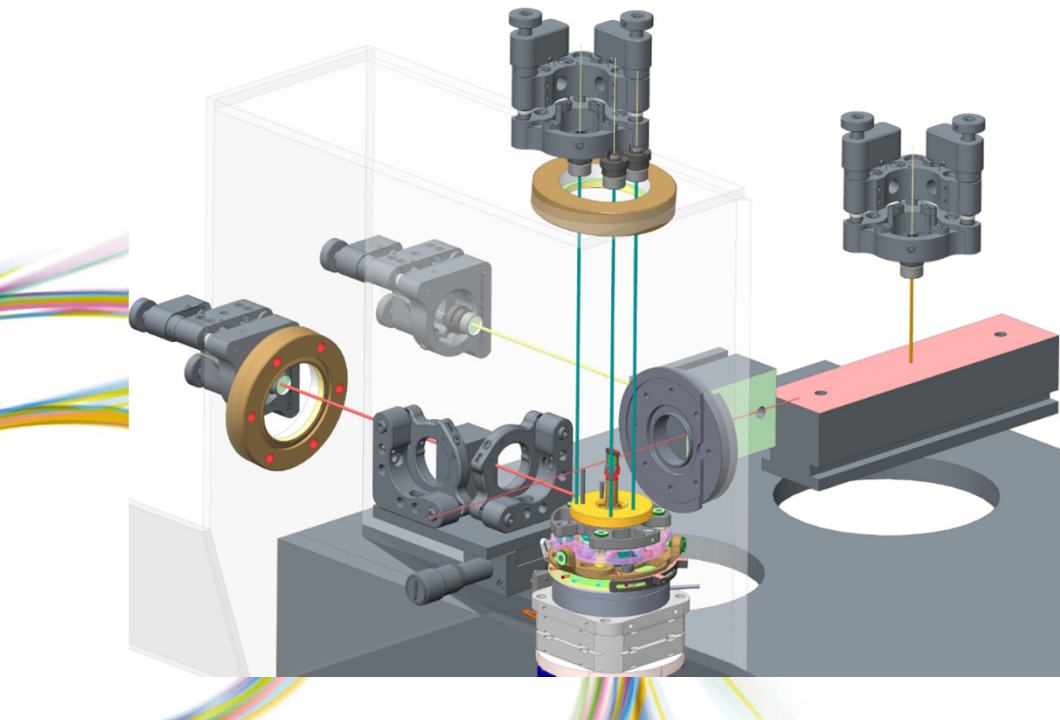


Interferometry

- Interferometry on sample posn & KB's for active feedback
- Highly polished mirror disk near sample (cryo temp)

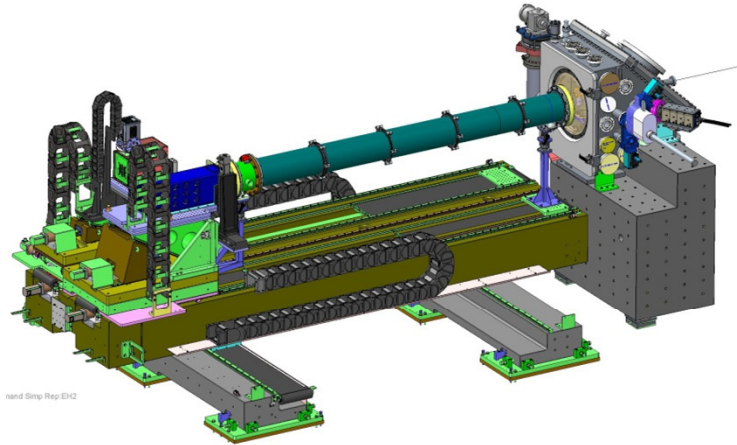
Challenge

- Stability of interferometer support – common reference (KB side)
- Getting view thro' vessel to sample side
- Tracking stage – and remote adjustments – motorised mounts



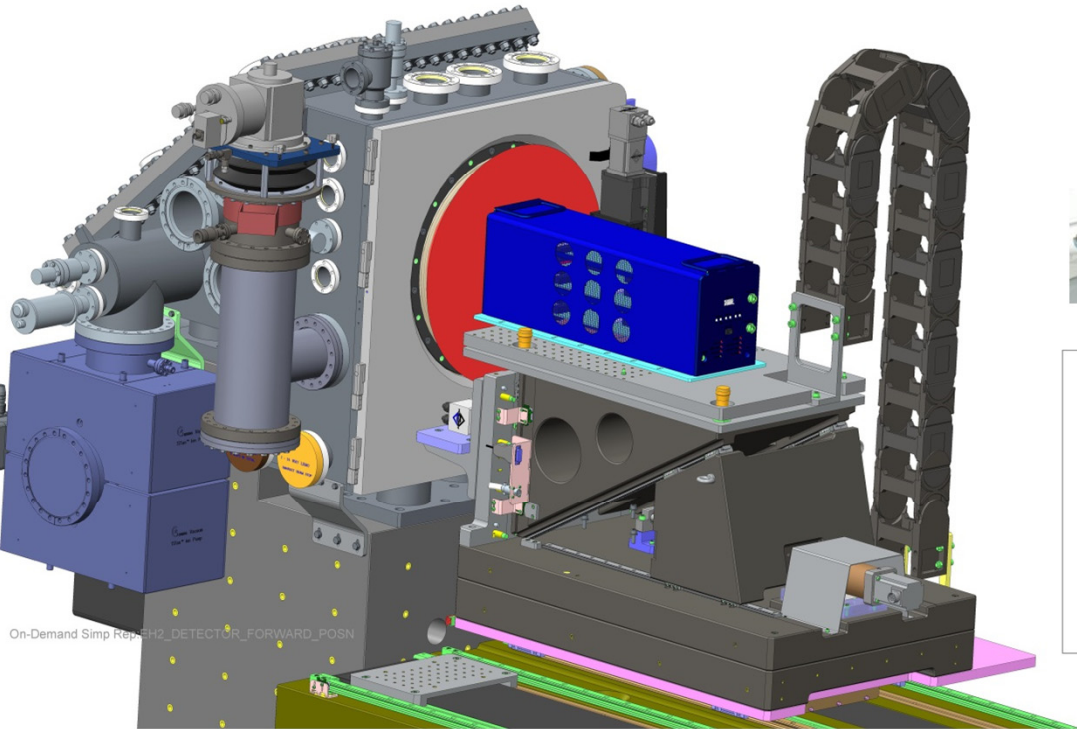
Attocubes
& mirrors

External Detectors Table

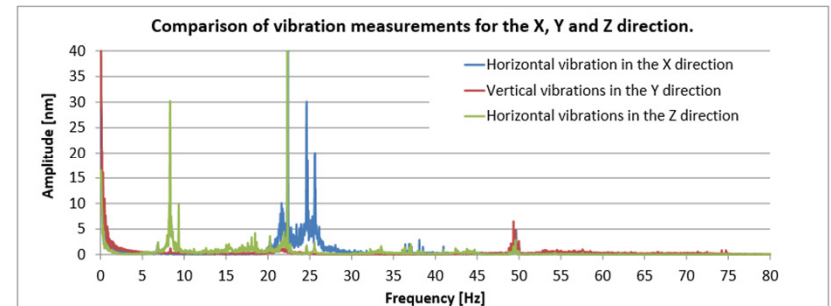
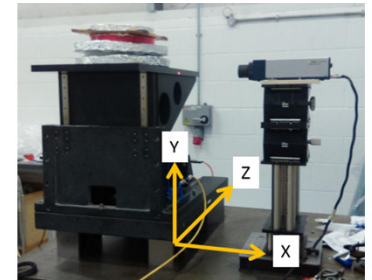


- Detector 0.25-3m from sample
- High as poss table height requested
- Originally designed for Pilatus 2M
- “Aggressive” super wedge - 200mm lift
- 45 sec swap time between detectors

Hand Simp Rep CH2

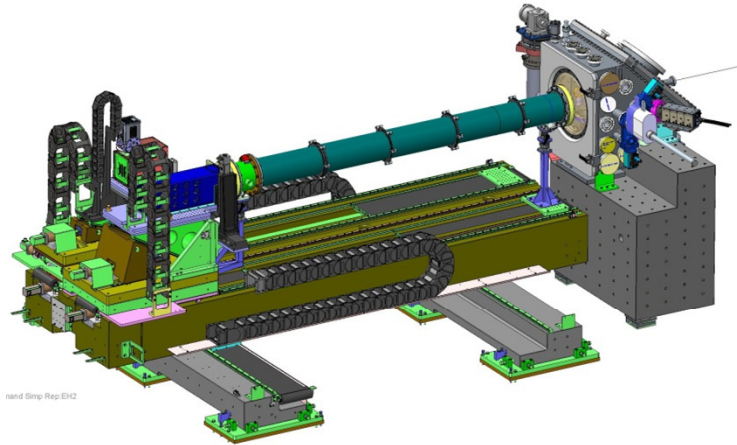


On-Demand Simp Rep EH2_DETECTOR_FORWARD_POSN

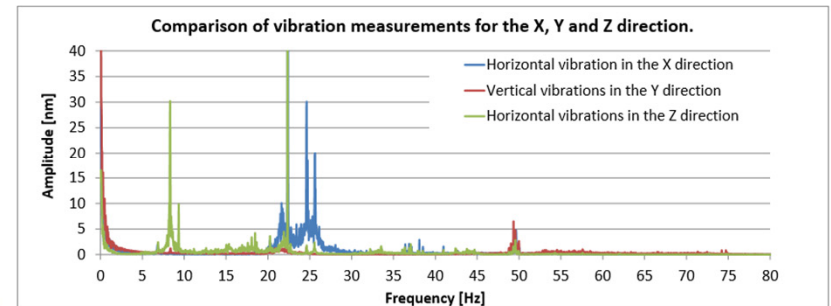
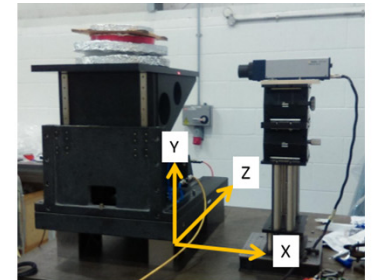
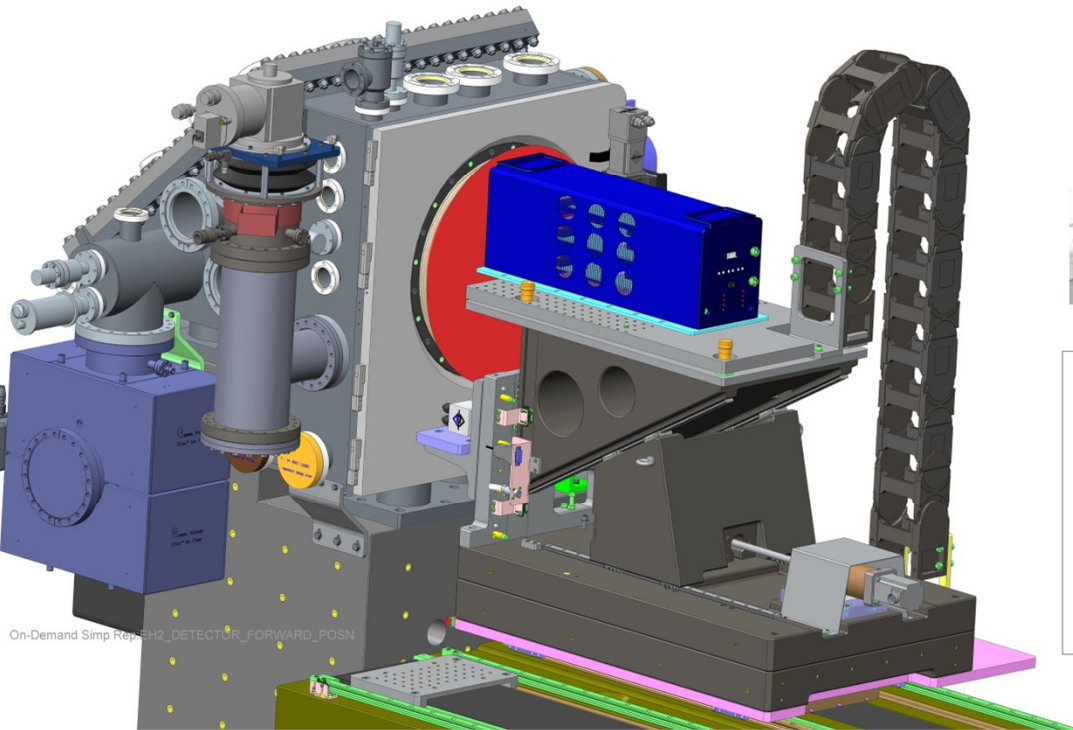


X.X+0.1
X.XX+0.01
X.XXX+0.001
ANG.+0.5

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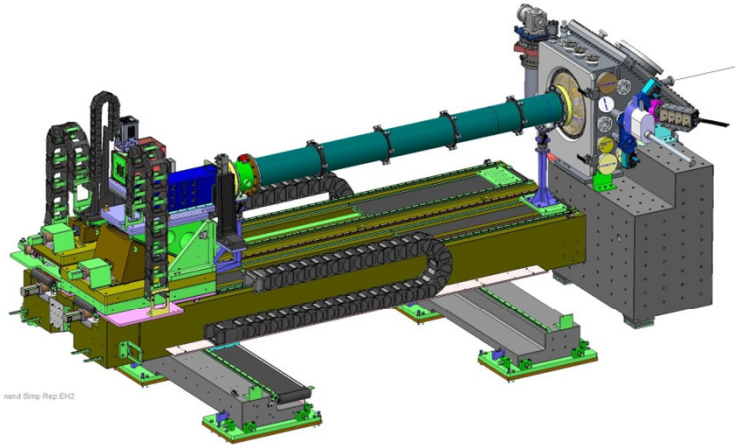


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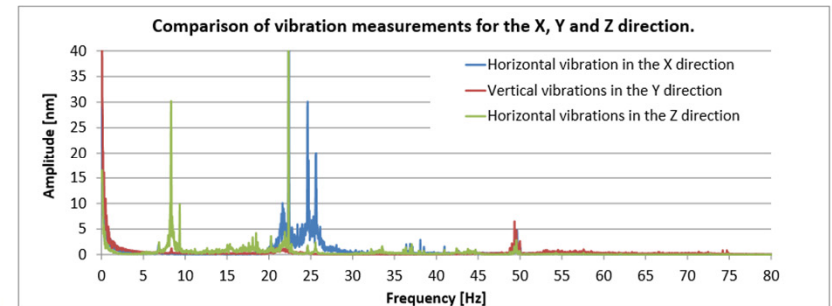
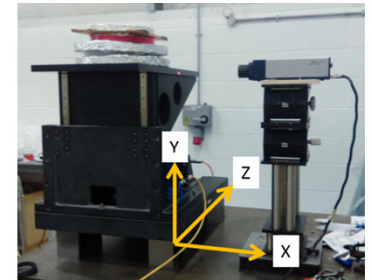
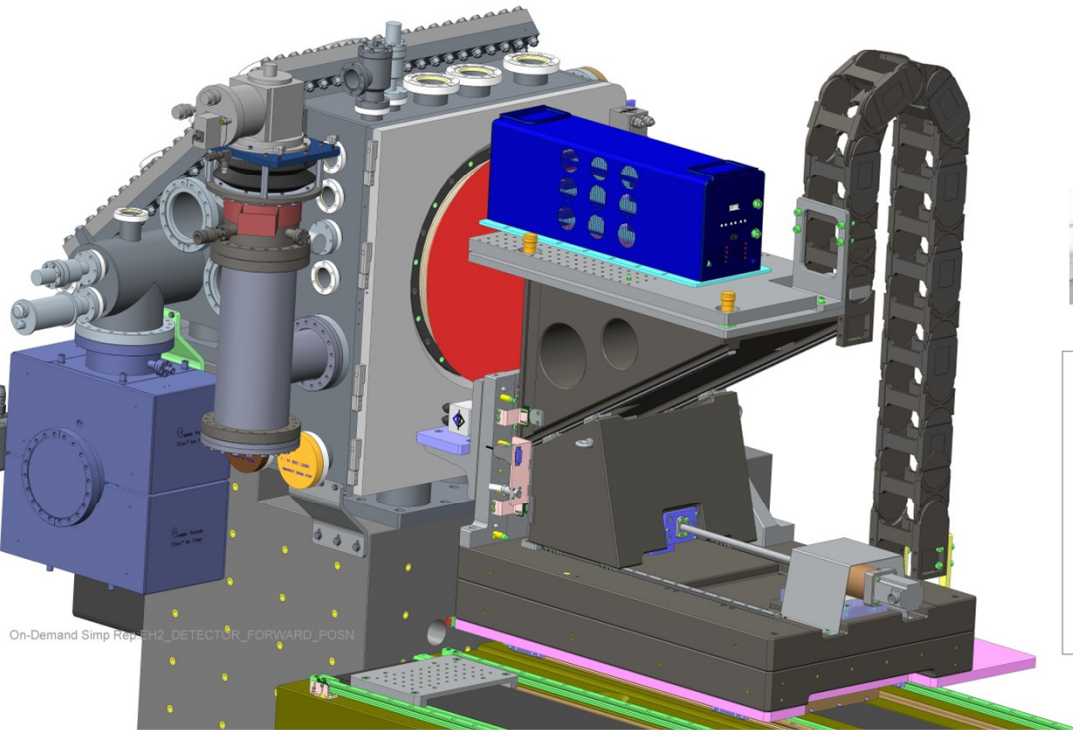


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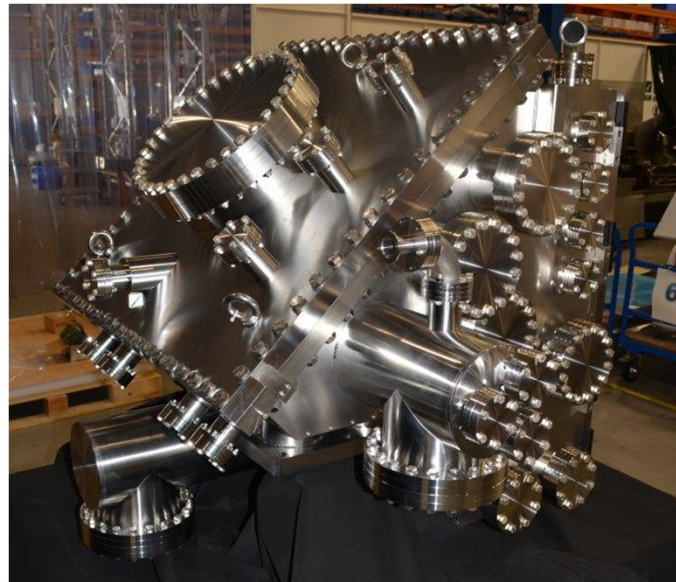
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Summary

- Beam achieved at external building last week
- Beam stability looks within spec
- Much work to do to refine, build & test KB/Sample system
- Critical that sample station reliability is proved
- Air bearing slide base to swap setups - future upgrade
- First users Spring 2017



Thank You For Your Attention !

Thanks to:

Paul Quinn, Julia Parker, Fernando Cacho-Nerrin, Kevin Collins, Ljubo Zaja, Mark Hooper, Dave Mahoney, Rob Pocock, Guy Wilkin, Adrian Marsh, Lee Hudson

