IWAA 2012 - Fermilab
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HIE ISOLDE

ALIGNMENT AND MONITORING SYSTEM TECHNICAL DESIGN AND PROJECT STATUS

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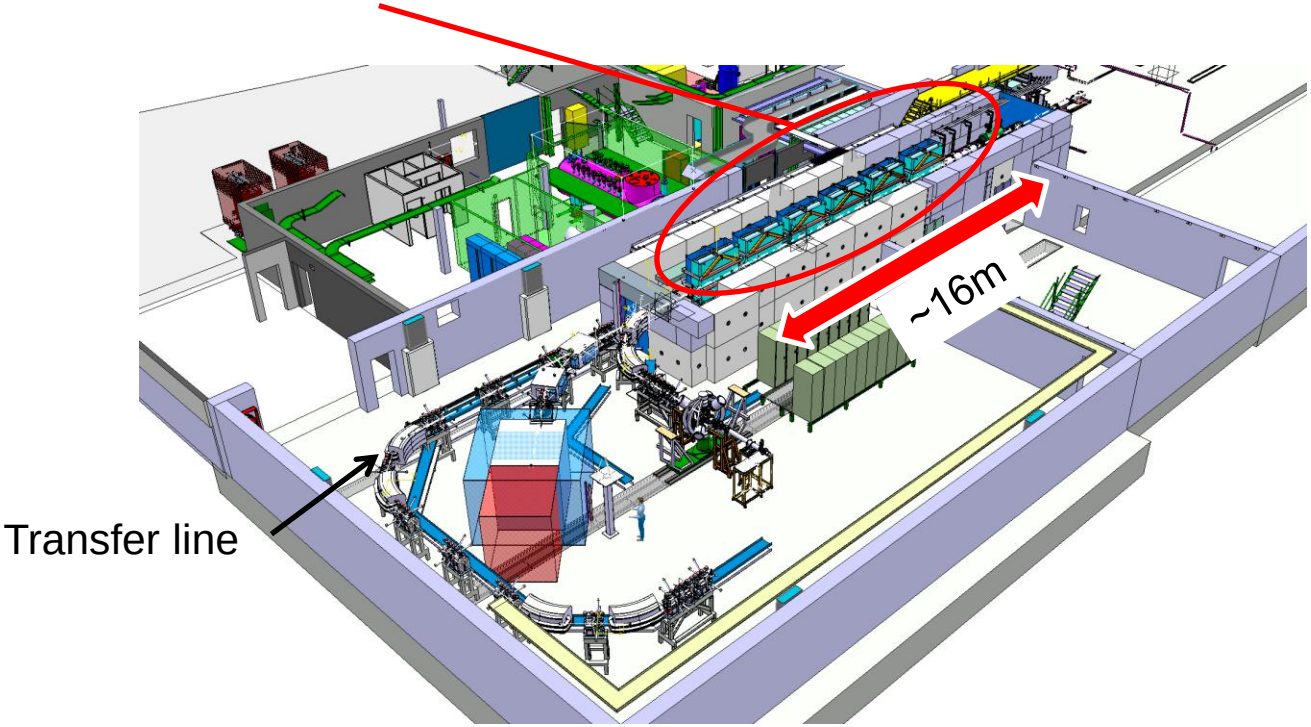
- Introduction
- Alignment Specifications
- BCAMs
- Viewports
- Targets
- Mechanical supporting and adjustment system
- Schedule
- Conclusions

HIE-ISOLDE

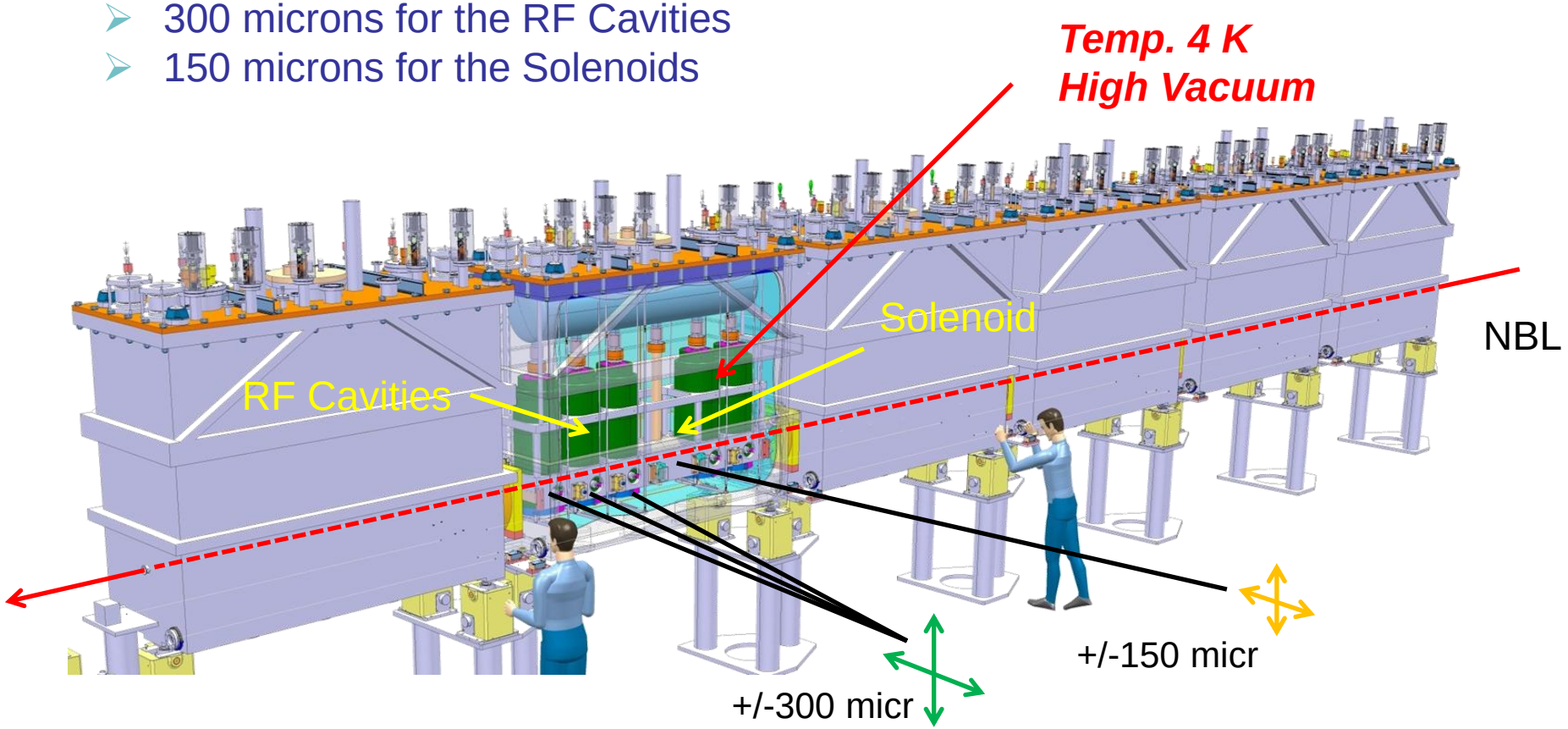
HIE-ISOLDE SUPERCONDUCTING LINAC



- High Intensity and Energy (HIE)-ISOLDE ➔ Important upgrades of REX-ISOLDE
- Goal: Increase the energy and the quality of post-accelerated Ion Beams

Linac and Alignment Specifications

- Alignment and monitoring of the Cavities and Solenoids in the Cryomodules
- Alignment w.r.to a common nominal beam line along the Linac
- Permanent system
- Precision demanded along radial and height axis at 1 sigma level :
  - 300 microns for the RF Cavities
  - 150 microns for the Solenoids



Alignment System

CONCEPT

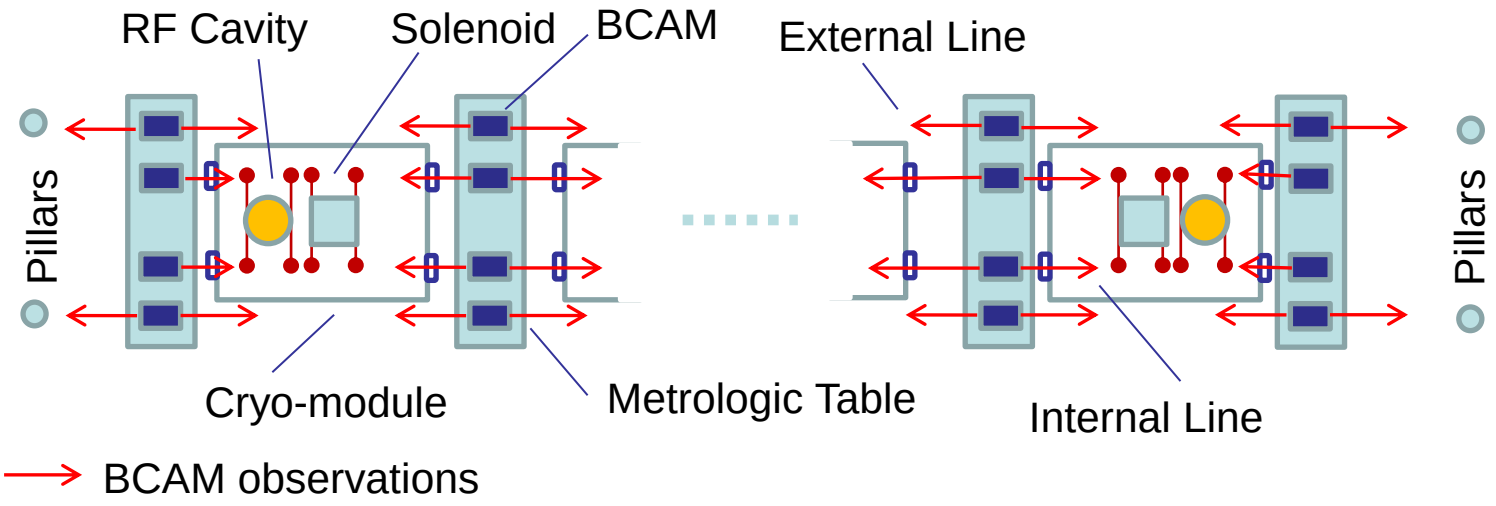
- Creation of a closed geometrical network continuously measured
- Observation and position reconstruction of Cavities and Solenoid in this Network

SYSTEM

- RF cavities and solenoid equipped with targets
- Interface Atmosphere / High Vacuum → Precise viewp*orts*
- BCAM cameras fixed to inter-module metrological tables

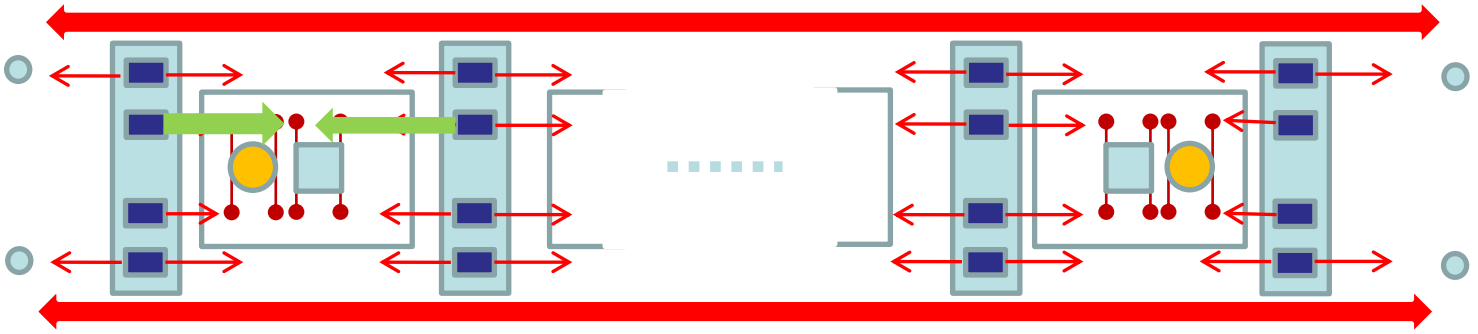
External Lines => Position and orientation of metrological tables and BCAMs

Internal Lines => Position of the targets inside the tank



Alignment System

Top view

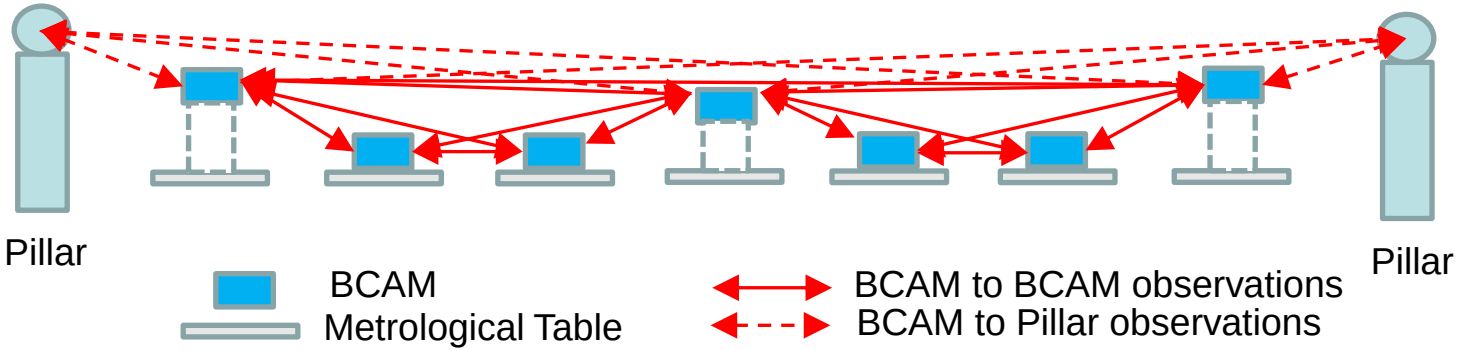


Overlapping zone of BCAM obs. on external lines

Double sided targets observations on internal lines

=> Redundancy

Side view
Ext. line
Overlapping

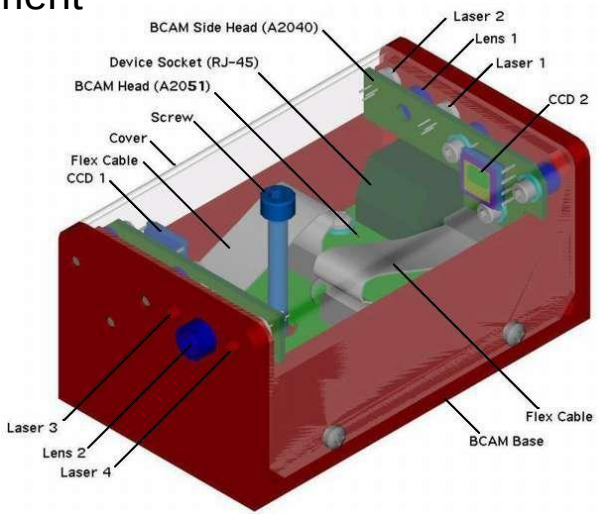


BCAMs

Developed on 1999 by Brandeis University for ATLAS Muon alignment

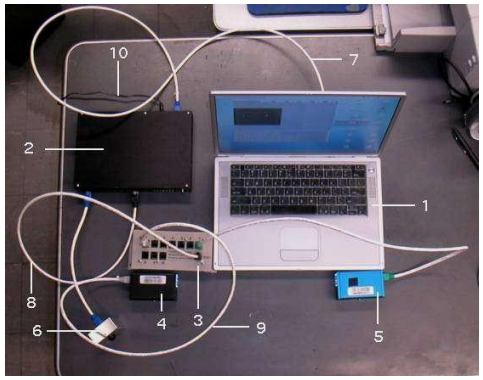
OSI (Open Source Instruments) http://alignment.hep.brandeis.edu/ http://www.opensourceinstruments.com/

Original BCAM:→ HBCAM



Camera focal length: 72 mm → 50 mm
Sensor: 336 x 243 pixels 10 microns → 659p × 494p, 7.4 microns
Field of view: 40 mrad x 30 mrad → ~ 100 x 70 mrad
Sources: Laser Diodes 650 nm
+ Additional synchronized illumination system

Mounting: "Plug-in" isostatic system under the BCAM body



Double sided model → Chain of BCAMs

Resolution: 5 micro radians constructor (OSI)
Accuracy of 50 micro radians to absolute

Cable length BCAM/Driver > 60 m

Delivered calibrated (focal length, position diodes, geometric relationship with plate support)

HBCAM – Some news

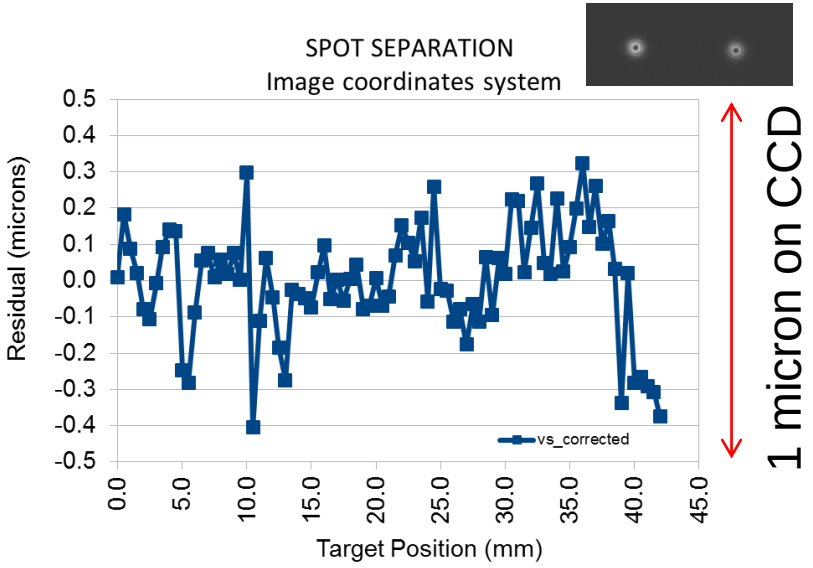
HBCAM - LAST NEWS FROM OSI - BRANDEIS

First tests results:

→ No cyclic error
→ Resolution spot position of 0.1 um on CCD
→ Spot separation over a CCD scan: rms 0.15 um

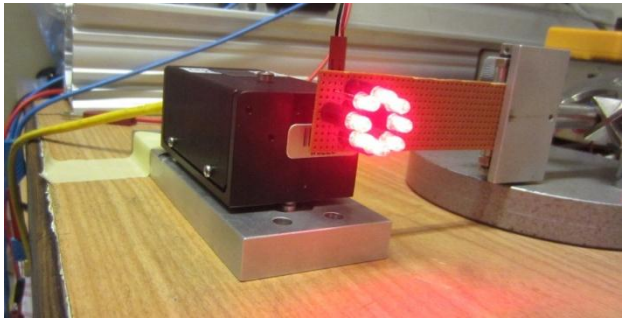
Test conditions
- No cover on HBCAM Box
- Ambient light on

Many thanks to Kevan Hashemi and Jim Bensinger

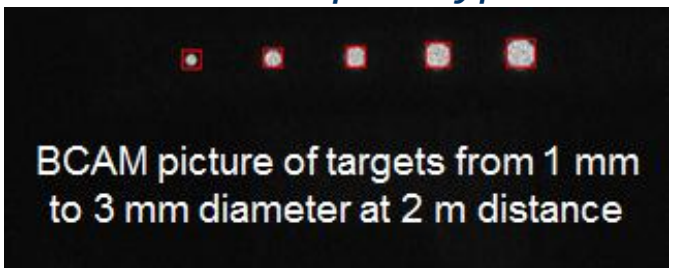


HBCAM – Some news
Illumination of Retro Reflective Targets

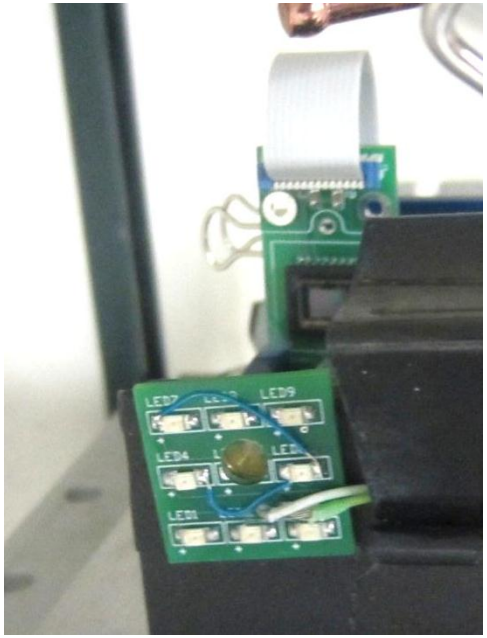
HBCAM integrated illumination system for retro-reflective targets observations



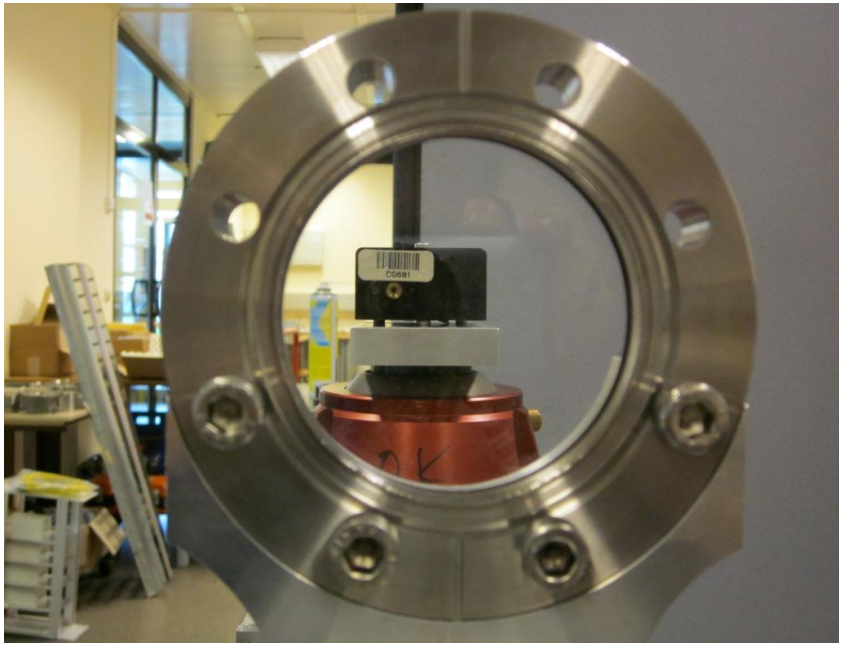
1st illumination prototype



- 1st Prototype
  - Validation of the components / intensity …
- 2nd Prototype - Brandeis
  - Remotely controlled by HBCAM Driver
  - No extra power supply needed
  - Synchronized with the HBCAM

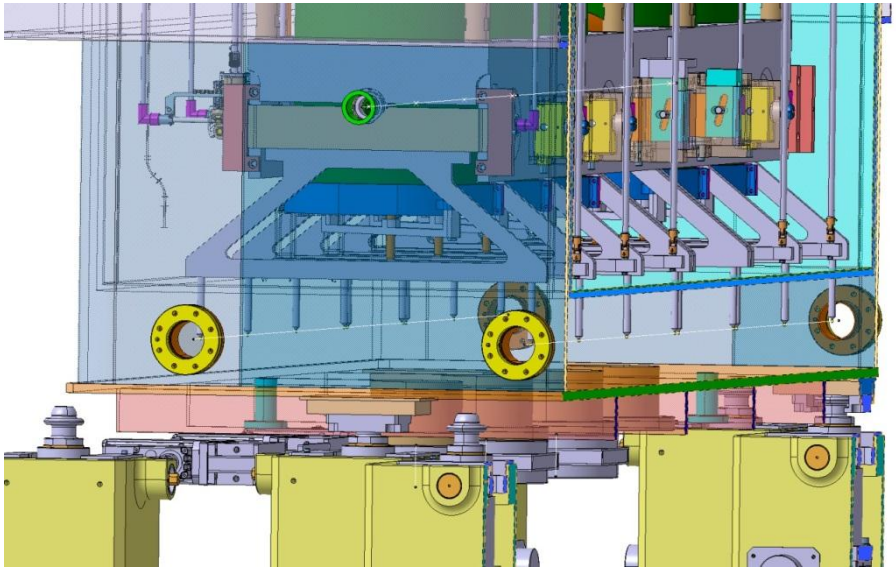


Viewports



Atmosphere / Vacuum interface

- Parallel plates window
- Viewports at CM ends (off the shelf)



Study of viewport effects on BCAM observations

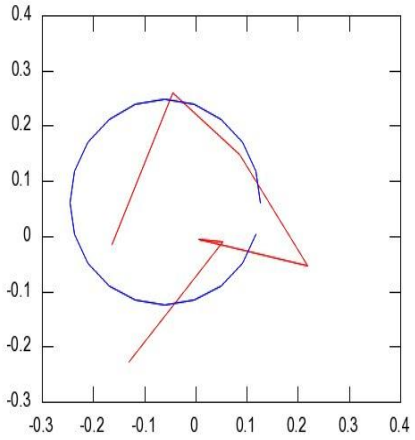
- Viewport 6.55 mm thick
- 3 opt. quality classes tested

Viewport Study
Wedge Angle

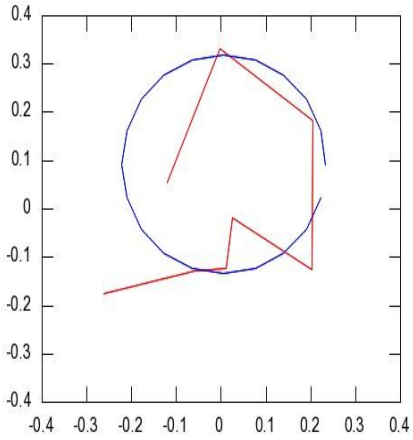
Wedge angle and wedge angle effect evaluation

Principle: Measure a fix point through the window → Rotation of the window around the main axis → Observation of the point image coordinate change → Calculation of the wedge angle

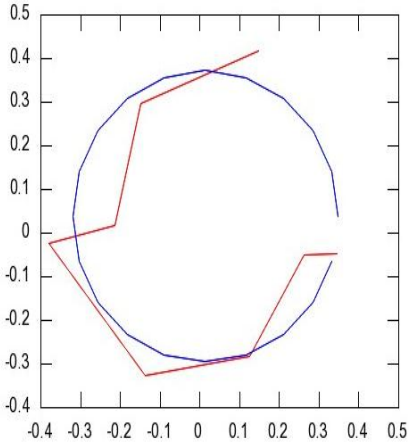
Window A,1 (micr)



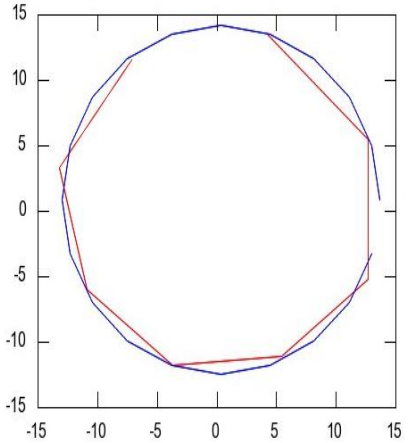
Window A,2 (micr)



Window B (micr)



Window C (micr)



Window	Given wedge angle (microrad) from window's technical data	Wedge angle observed (microrad)	Influence on target at 1m (micr)	Influence on target at 2m (micr)
A	25	5	2.5	5
B	50	10	5	10
C	500	300	150	300

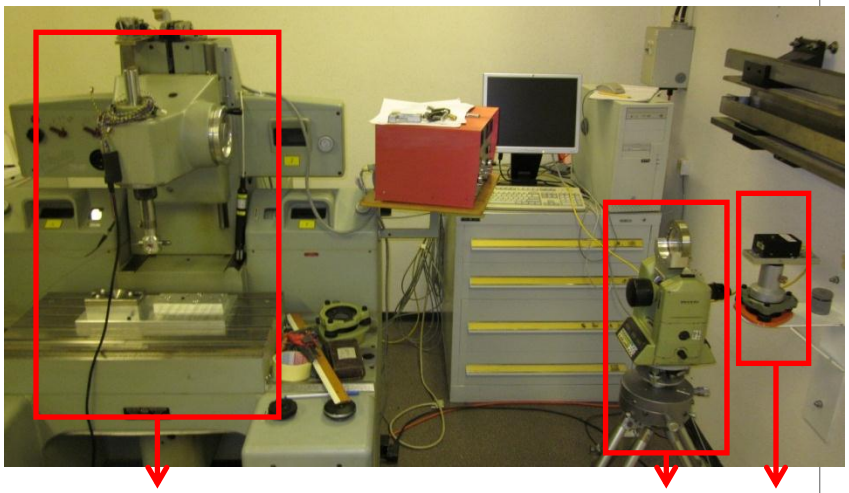
Tests: Nicolas Gauthé

In red: measurements on the CCD
In blue: best fit circle

10 microrad wedge angle acceptable
Viewports better than manufacturer data

Viewport Study
Parallel Plate Effect

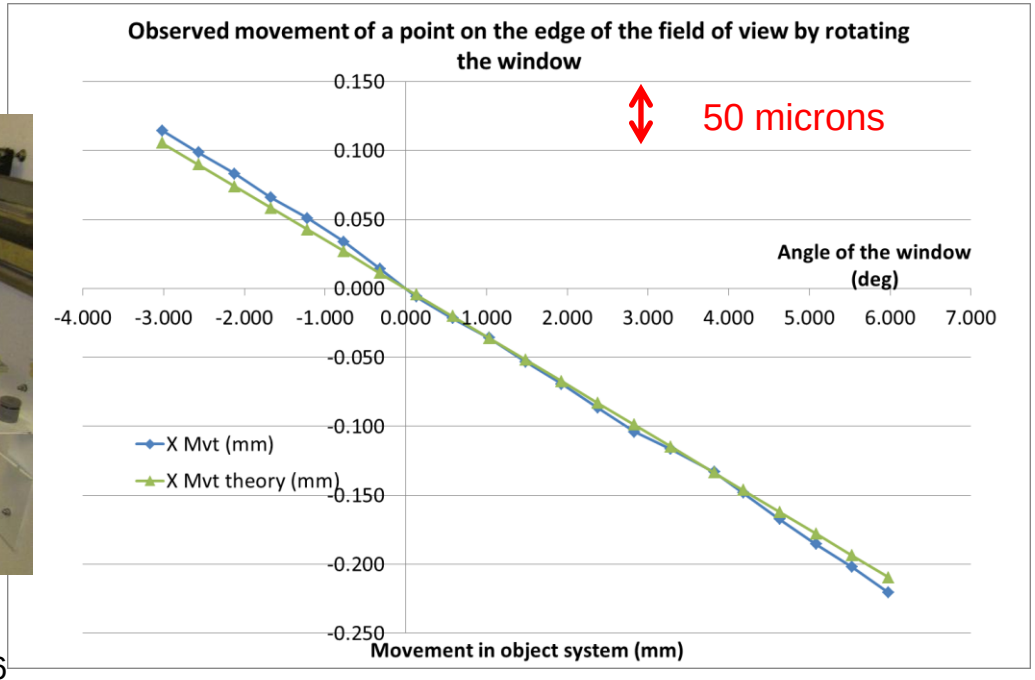
Parallel plate effect on image at different incident angles



Optical fiber attached to a Coordinate-measuring machine controlled with an interferometer

Window mounted on a theodolite (rotation) and a translating holder

BCAM W0226

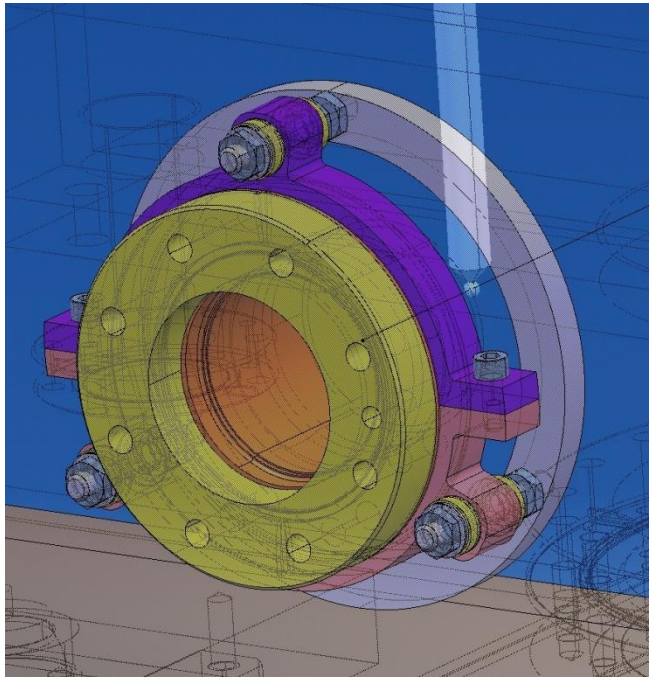


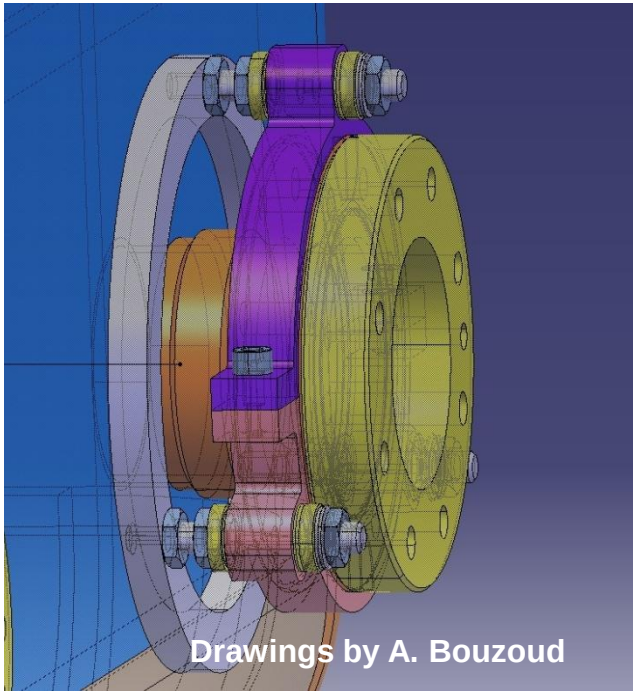
Difference Theory/observed:
Average: 0 micr
Standard deviation: 6 micr

BCAM to Target distance: 1.3 m

- Incident angle change of 1gon (0.9deg) → 37 microns radial object “displacement”
- Match the theory by a few microns → Easy observation correction by software
- Adjustment of the Window within less than 1 degree → Ease the correction

Viewport Study
Viewport Adjustment System





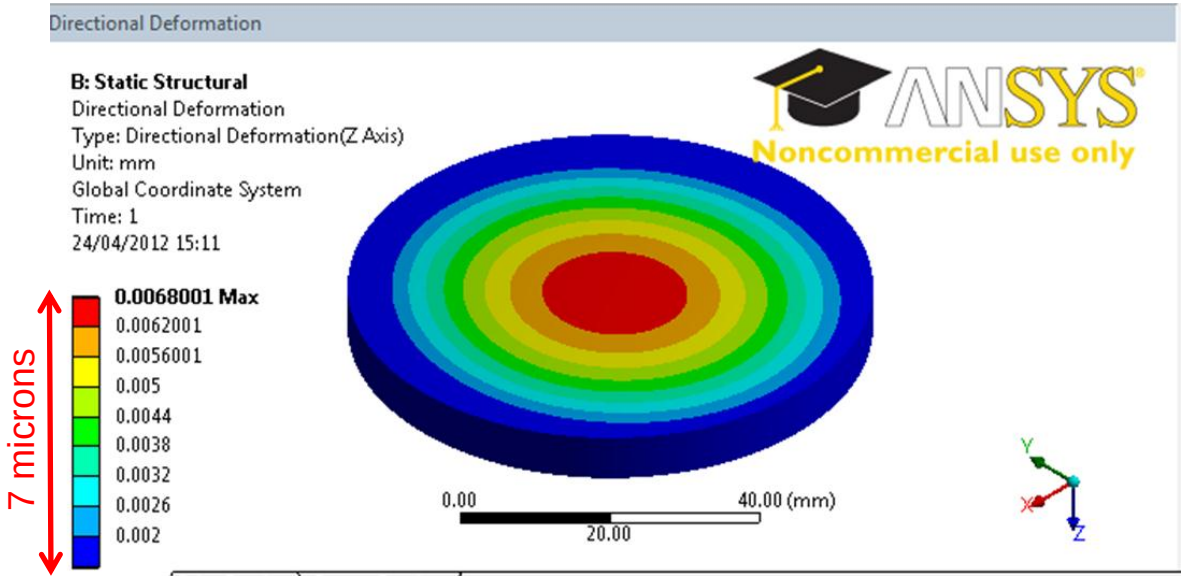
Preliminary design for a viewport alignment system

- Adjustment of the viewports within less than one degree
  - Viewport adjustment system
  - Collimator (under development) or Standard Survey methods

Viewport Study
Vacuum Deformation

Viewport: 6.55mm thick

- Less than 7 microns deformation at the center
- Less than 0.015 degree of angular deviation



Y.Leclercq – CERN

Deformation measurements at Liberec University (CZ):

- Results match the calculated deformations by a few microns
- Same deformation on both side → Parallelism kept

The Targets
Overview

Constraints → HIGH VACUUM - CRYO CONDITIONS - SIZE

Studied Target Types

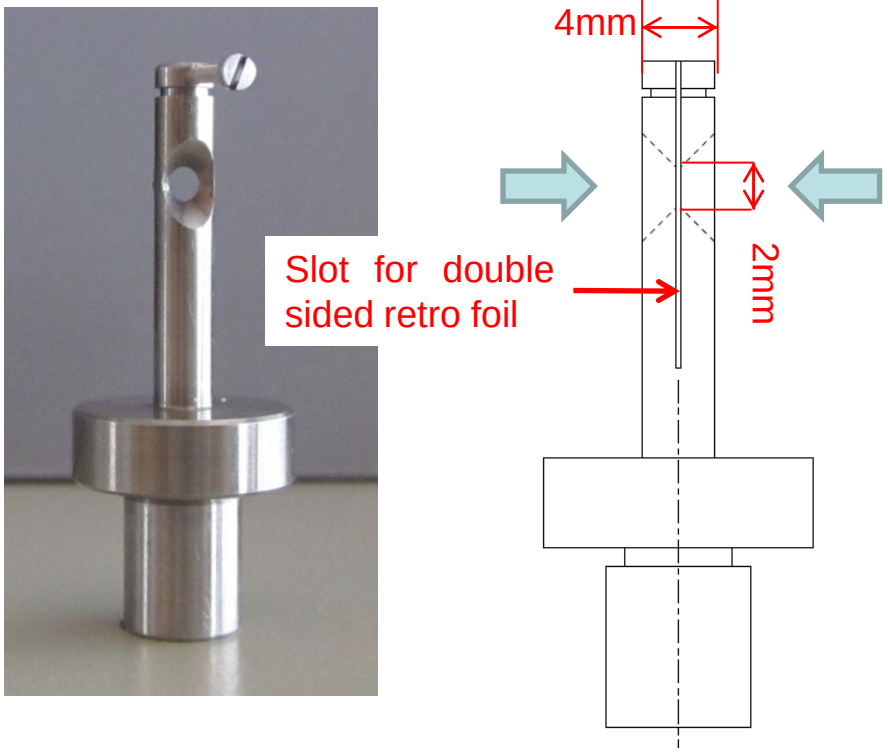
- **Silica Silica optical fiber end**
  - \- feed-through needed, one-sided target
  - \+ easy light level control, OK with cold and vacuum (tested)
- **Silica Silica optical fiber ended by a ceramic ball**
  - \- feed-through needed, connection fiber/ball
  - \+ visible from all positions, good diffuser
- **Retro-reflective targets**
  - \- illumination needed, all targets in one shot
  - \+ double-sided, passive target, no feed-through

  More tests in cold and vacuum ongoing

Double Sided Targets

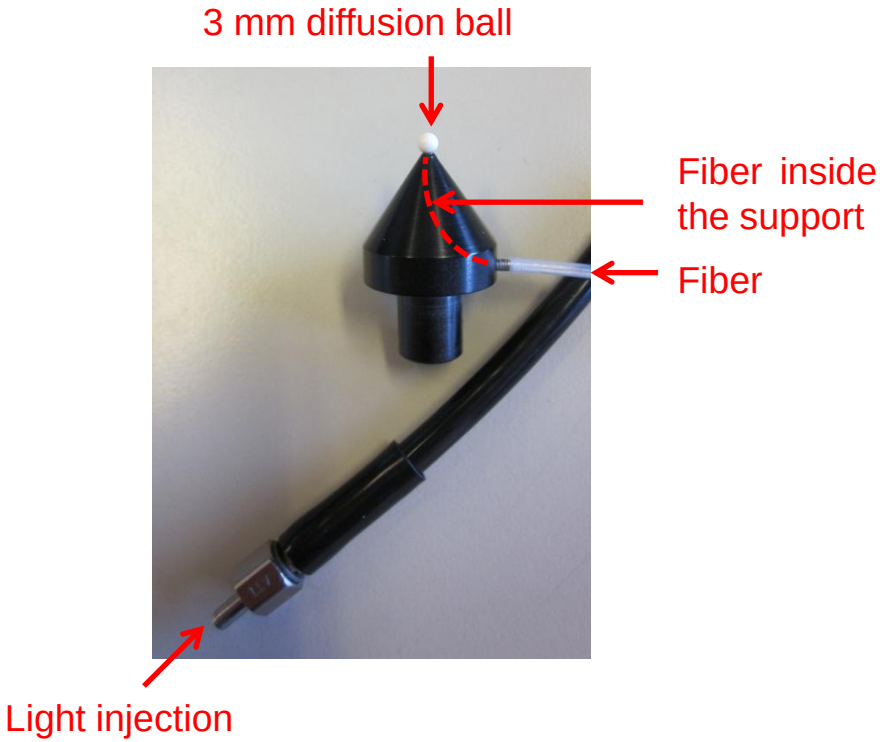
Two types of “double sided” targets considered

Retro-reflective bi-directional target



Double sided retro-reflective target
Prototype tests on-going

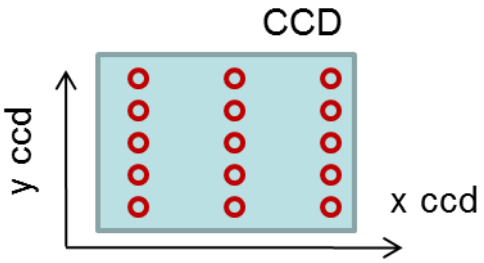
Laser illuminated ceramic balls



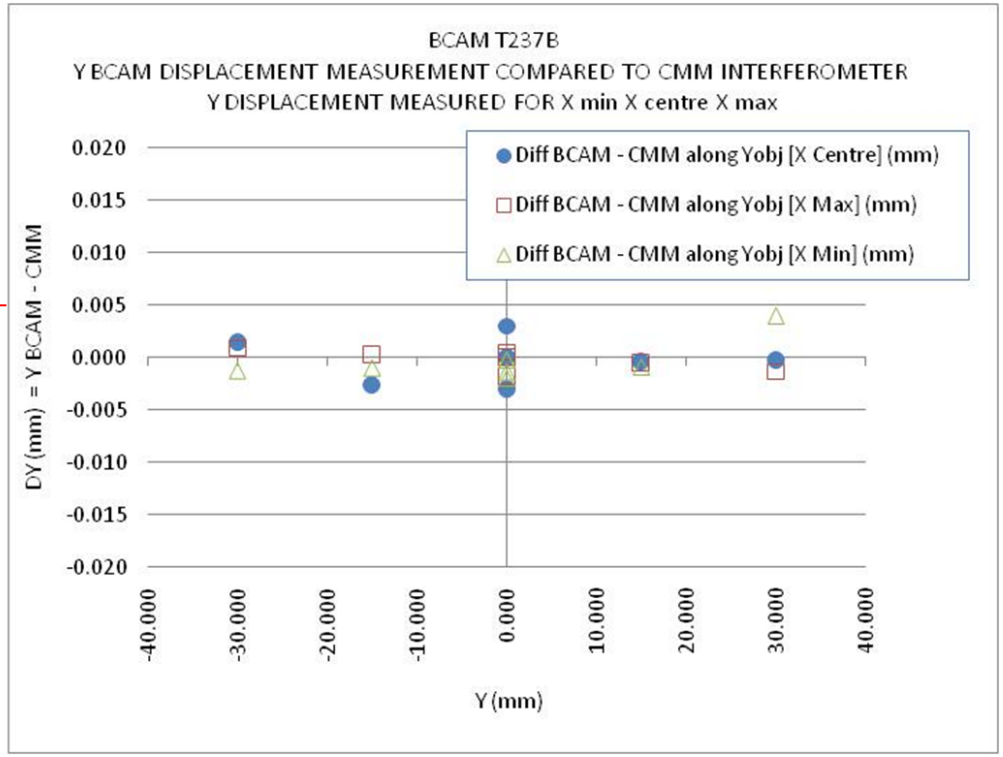
Test prototype for an illuminated ceramic ball synchronized to the acquisition system

Target Movement Reconstruction

BCAM measurements on Optical Fiber End – Ref CMM measurements



5 microns in object space



Large part of the CCD surface covered

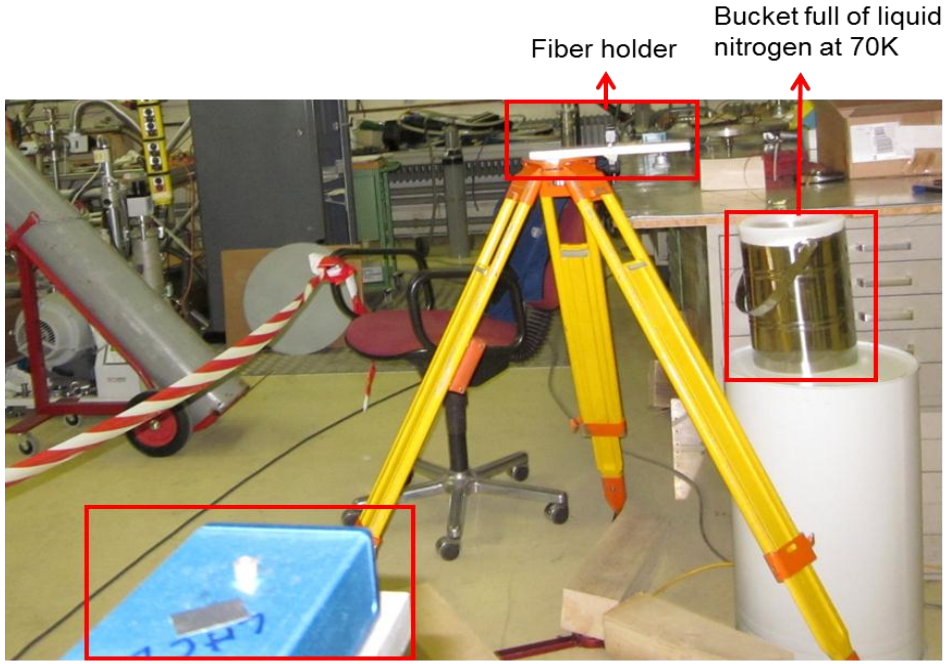
Target at 1.415 m from the BCAM lens

⇒ [BCAM to Optical Fiber End] compared to CMM → Better than 5 microns

⇒ Comparison of different types of targets → Differences at 7 microns level

Target Study
Cryogenic Conditions

Targets and fiber tests in cold conditions – Liquid nitrogen at 70K



BCAM. Distance 2.25m

Test carried out in the Cryolab with Mario Herrmann (TE/VSC)

- Tested: fibers, retro-reflective ball, retro-reflective targets and ceramic diffusion balls
- All of them resist to 70K cold conditions
- No visible crack on the fibers (Microscope)
- Light transmission in the fiber still OK

Inside the Cryomodules: Common beam and insulation vacuum

Outgassing tests of:

- Ceramic balls (Al2O3 and ZrO2)
- Silica/Silica optical fibers
- Photogr. retro-reflective ball on anodized support
- Macor plate

Test performed by
Mario Herrmann
(TE/VSC)

ALL TESTED TARGET CAN BE USED

Retro-reflective tape: under test

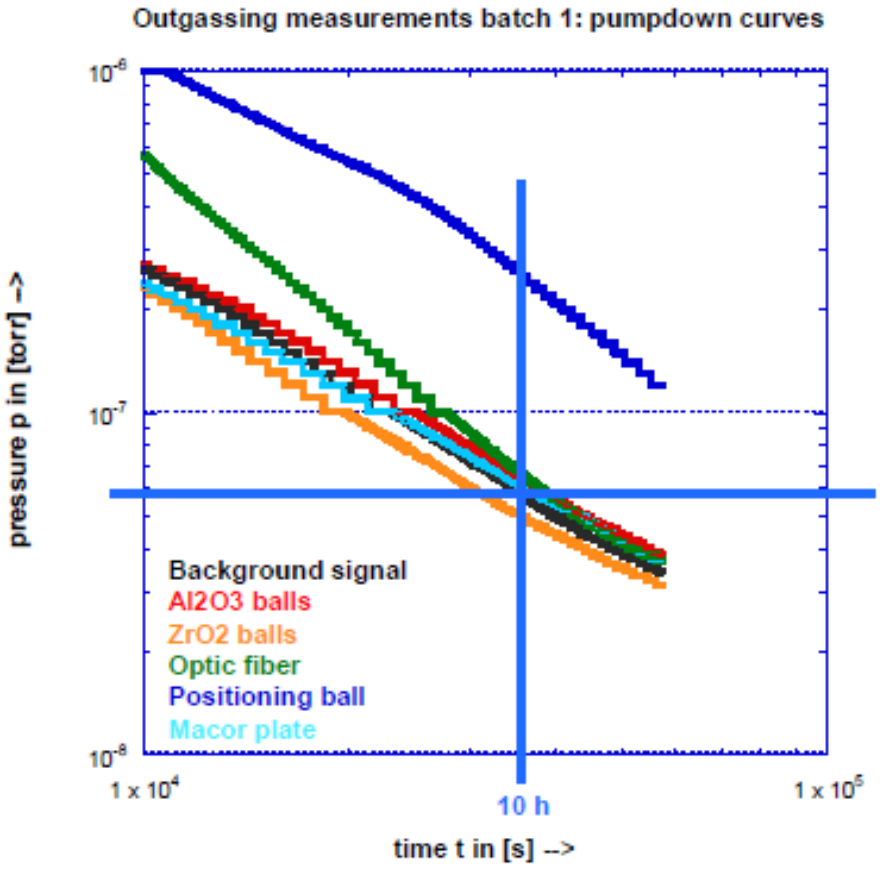
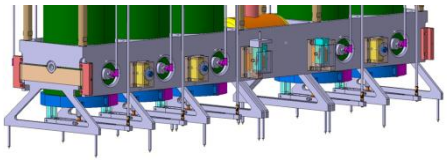
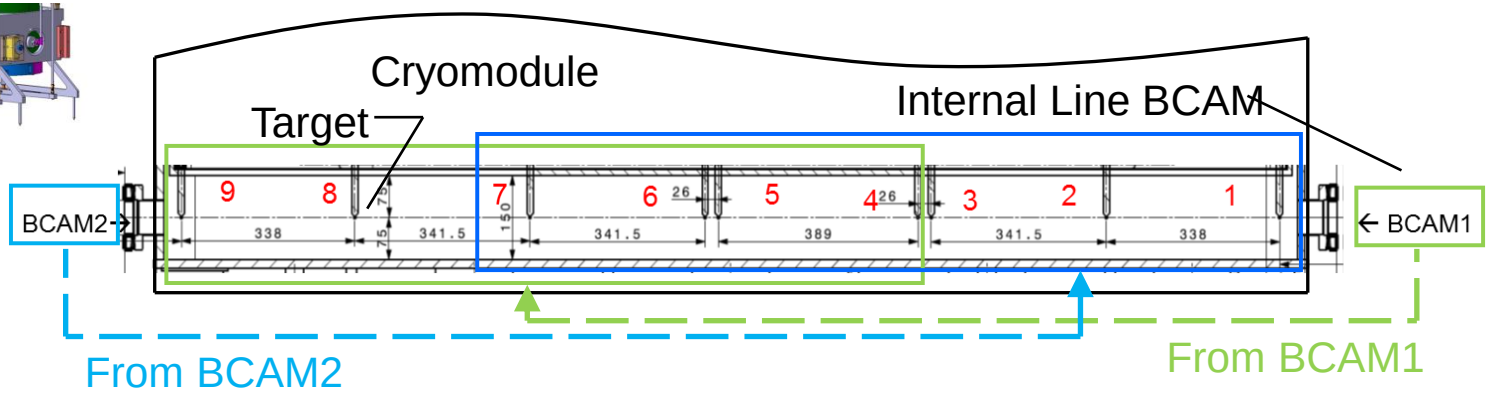


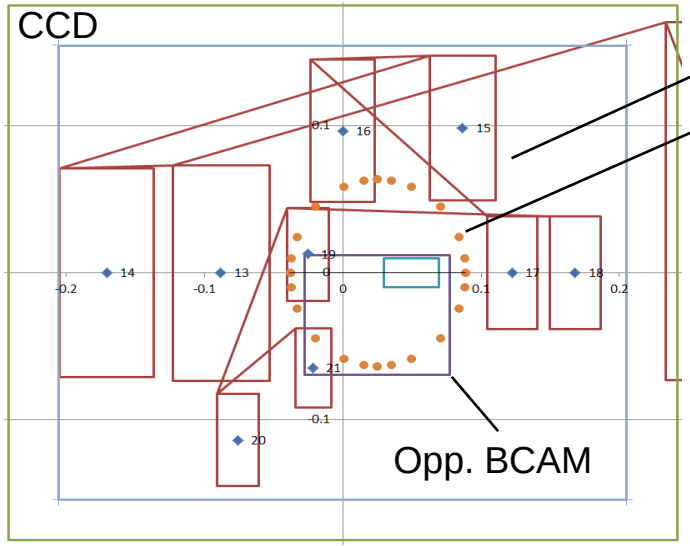
Figure 2: Pumpdown curve detail 10 h

Integration
Target Distribution

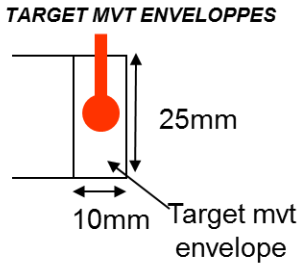


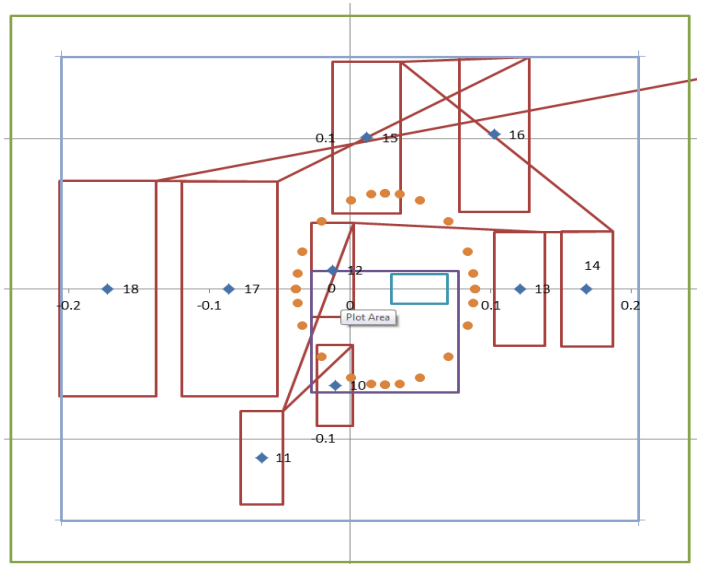
Drawing A. Bouzoud





BCAM2 Simulation

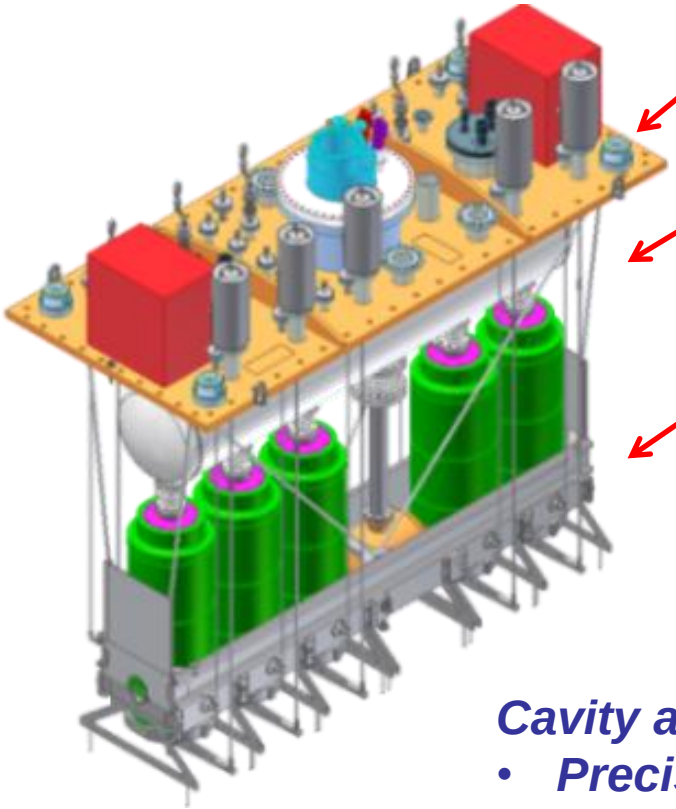




BCAM1 Simulation

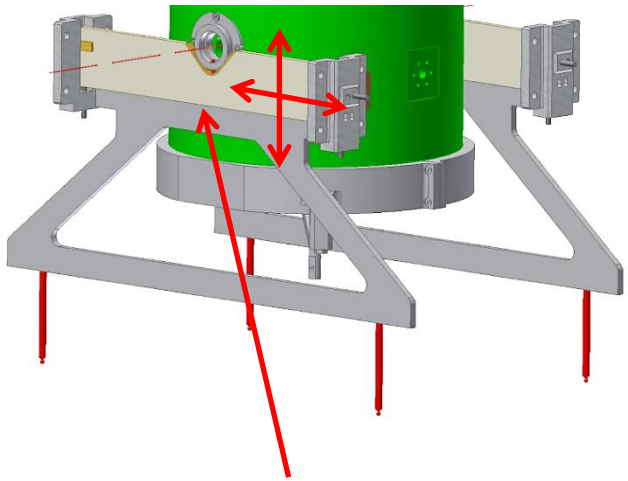
Supporting and Adjustment

Cryomodule assembly in ISO Class 5 clean room



Survey sockets → Assembly / CM pre-alignment

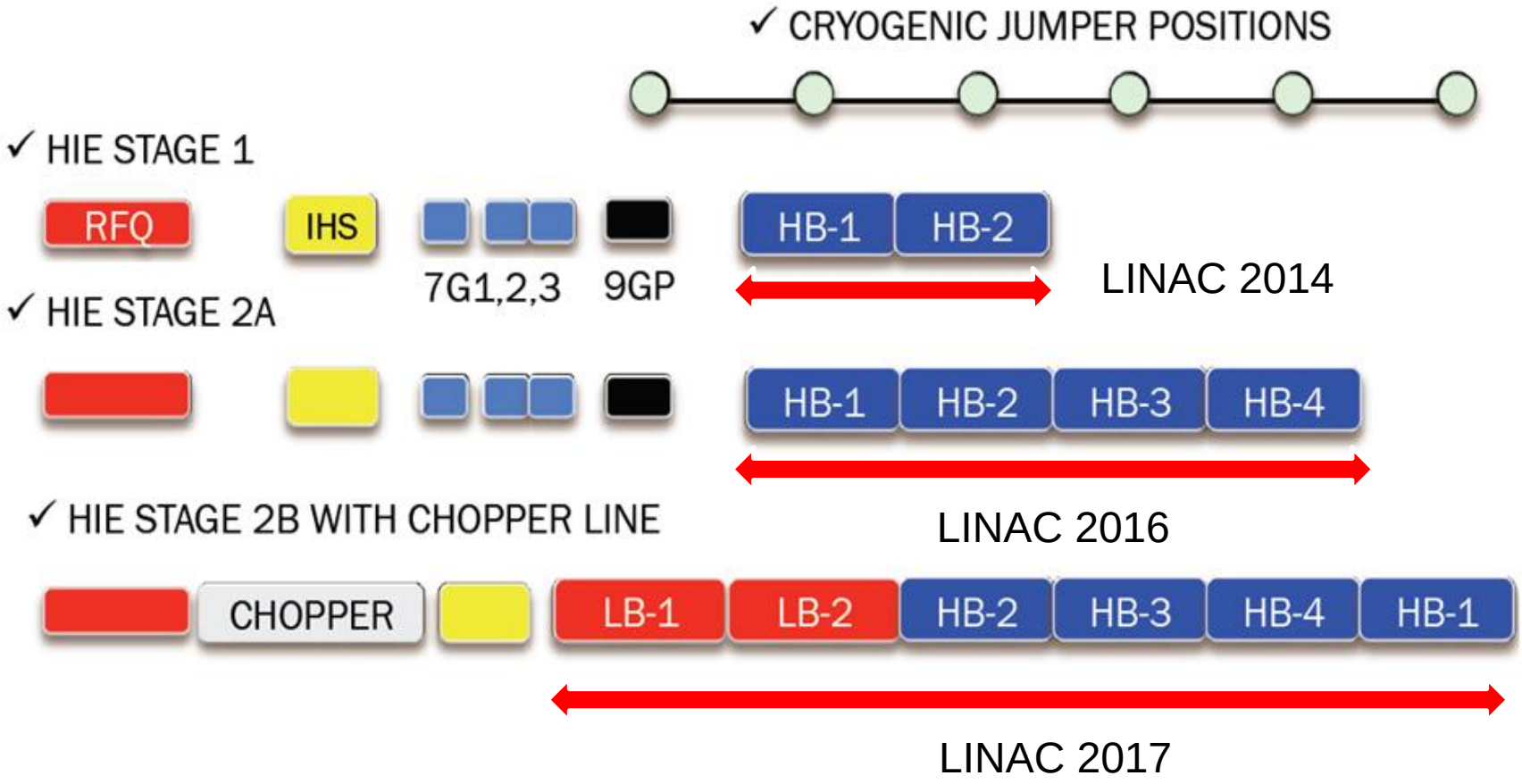
Tie-rods → Frame suspension and adjustment



Cavity and solenoid isostatic support: Sphere – V-shape

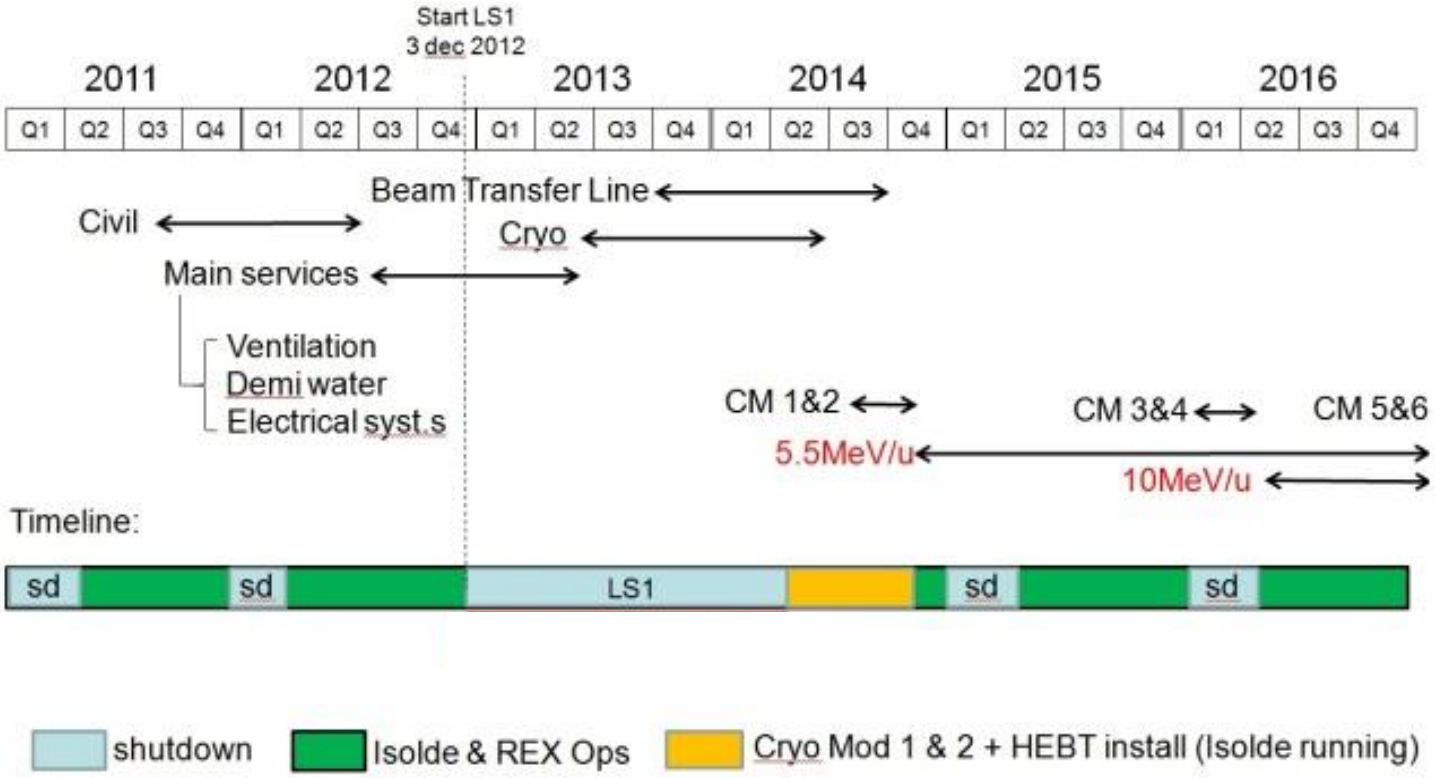
- ***Precise adjustment***
- ***Solenoid adjustment allowed in operational conditions***
- ***Used as Target support***

Project Staging



Modular Alignment System → Adapted to staging of the project

Project Planning



Minimum disturbances to the Experiments presently running

Conclusions

ALIGNMENT SYSTEM MAINLY BASED ON WELL KNOWN ELEMENTS

BCAMs

- Proved and used devices
- HBCAM development → Very promising results

VIEWPORTS

- Fit well to the theory → Easy BCAM observation corrections
- Be careful in the choice of the viewport → High optical quality needed

TARGETS

- All alternatives seem to work well (Fibers – Ceramic balls – Retro targets)
- Retro targets looks promising → Passive targets
- Target support ~ Std Survey → Easy control when CM open (Clean room…)

SOFTWARE:

- Development well advanced
- Simulation of metrol. table position reconstruction → ~20 microns at 1 sigma level
- Validation tests on going → Promising results

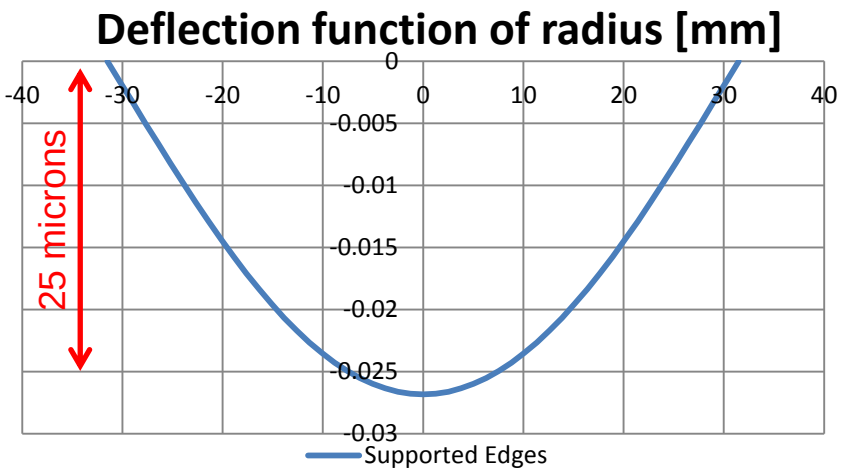
GOAL: BE READY FOR THE VACUUM AND CRYOGENIC TESTS OF 1st CRYOMODULE

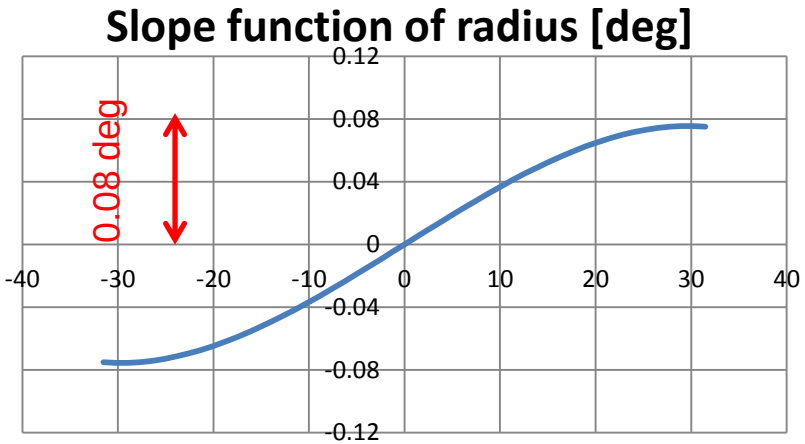
Thank you

Viewport Study
Vacuum Deformation

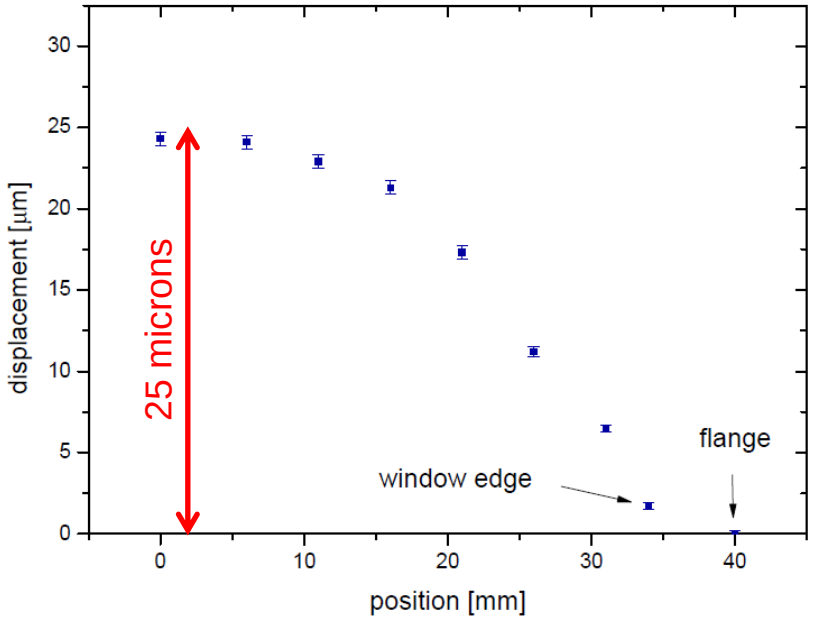
Viewport: 3.55mm thick

Simulation





Experimental results by Liberec University
Many thanks to Miroslav SULC

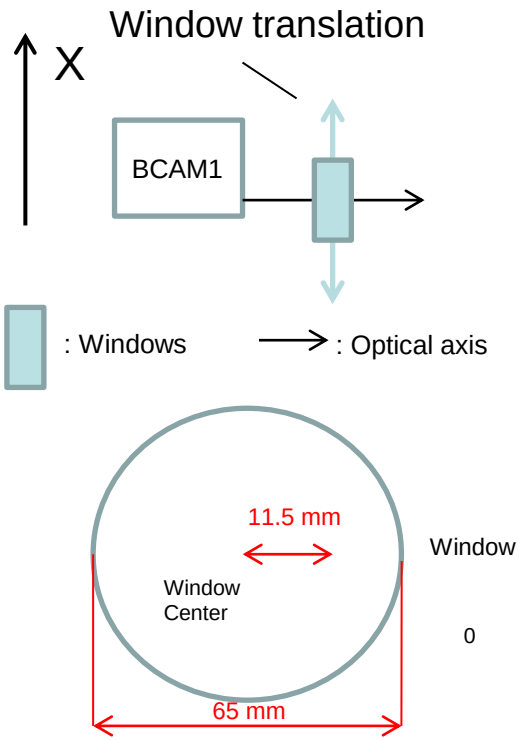


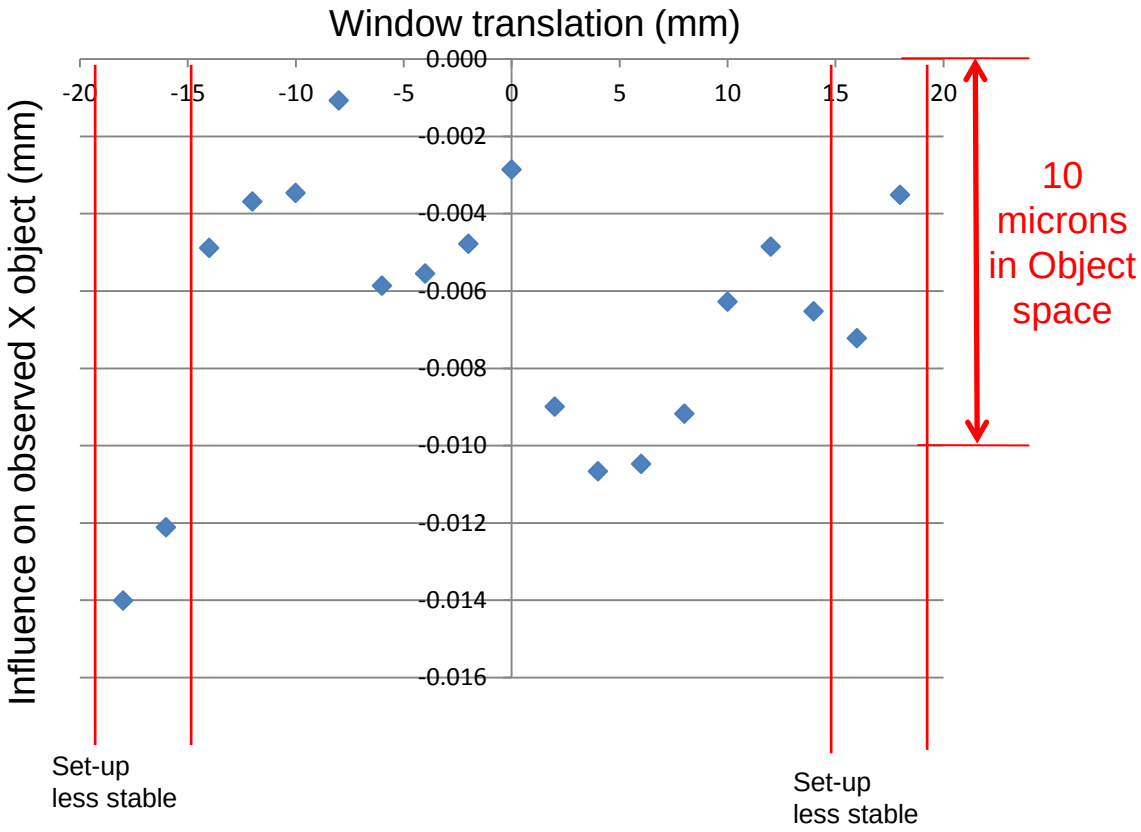
- Viewport of 3.55mm thick
  - → 25 micr (±0.4) in the center
  - → 0.08 deg angular deviation
- Results match the theory by a few microns
- Same deformation on both side
  - → Parallelism kept

Viewport Study
Window Uniformity

Effect of a lateral translation of the B viewport in front of the BCAM

Measurement of a fix point through a window translated in front of the BCAM

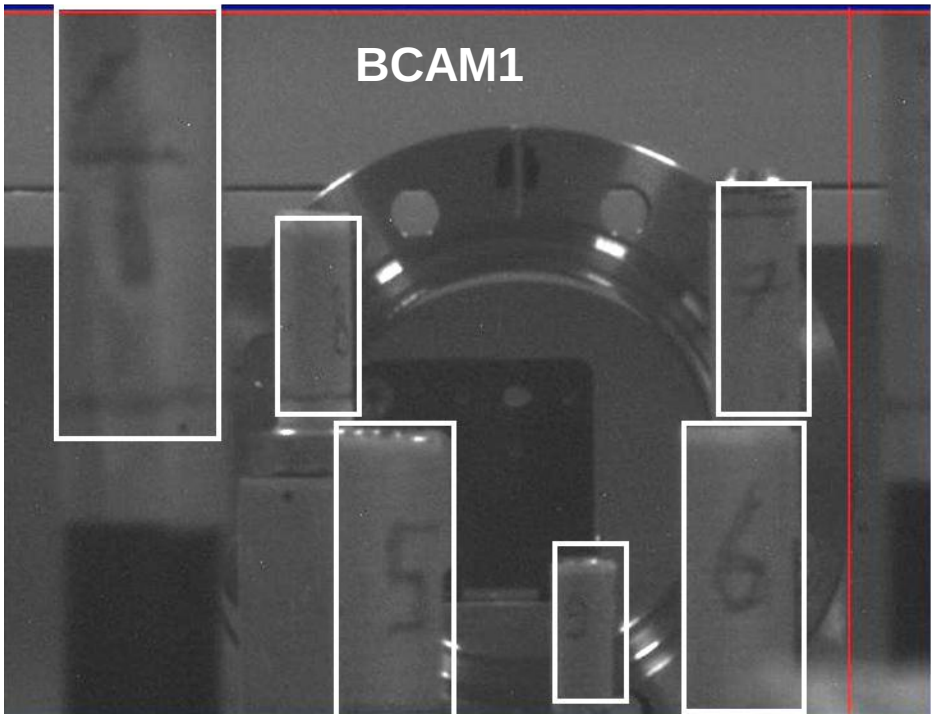


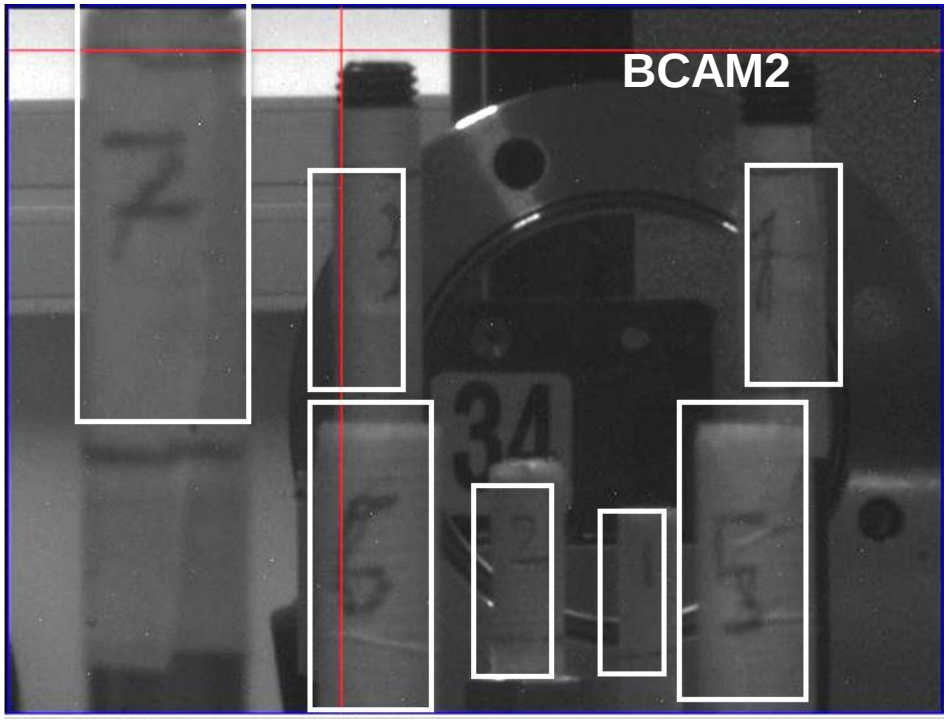


No visible influence / In the instrumental precision (about ±7micr at this distance)

Integration
Target Distribution

Validation of calculated target distribution - Apr 2012 - Setup for a 8 targets design





In White: the expected position according to simulations.

Done with prototype W0226
Field of view 70x50 mrad

No standard length and position for target support

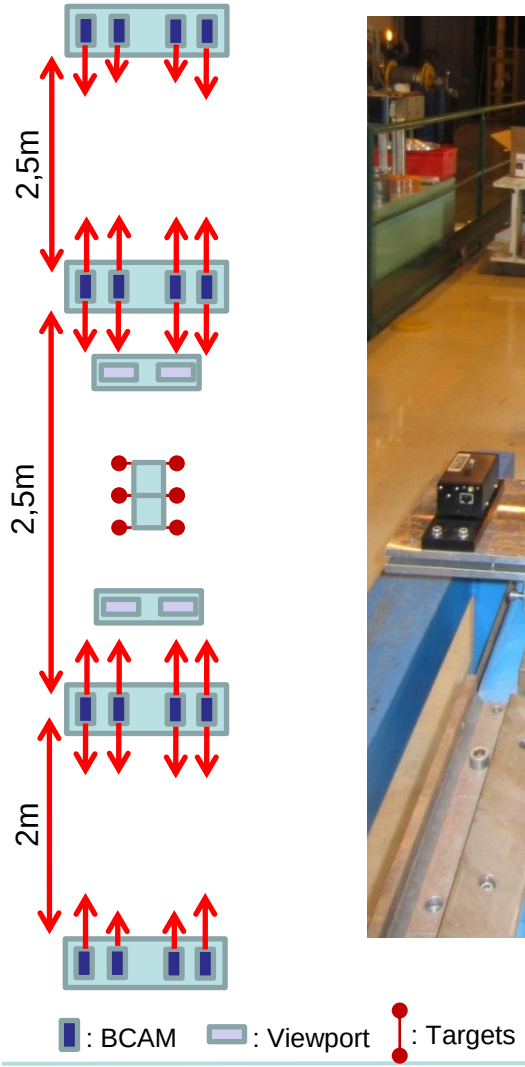
Decrease of BCAM focal length to 50 mm → approx. 30% more field of view

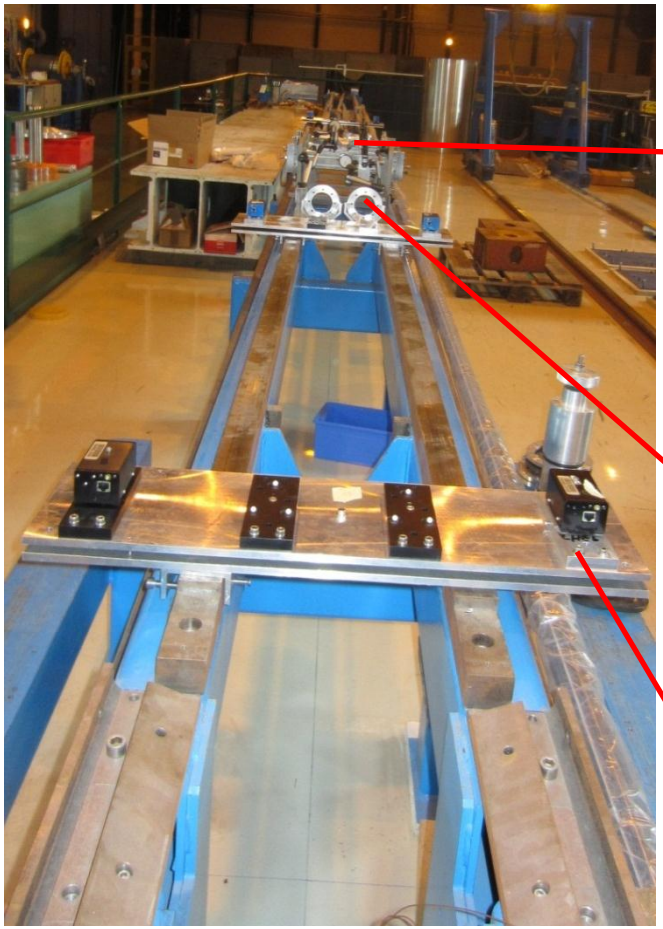
To be refreshed with the new supporting design (more plates)

Large Scale Test Bench

Tests with standard BCAMs lent by OSI

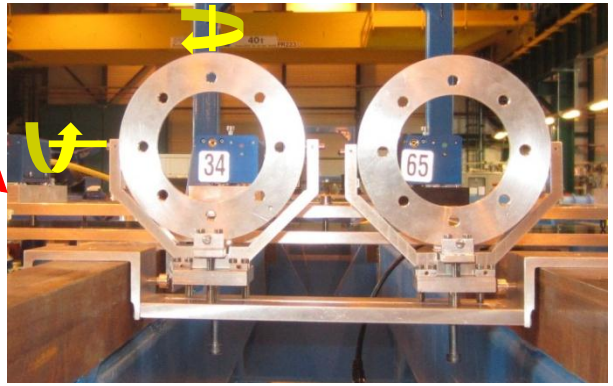
Under construction



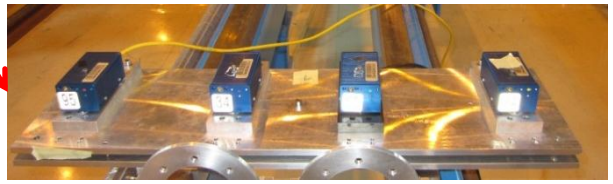


Complete set-up in SMI2
Almost 1:1

Cavity support mockup



Adjustable viewport table



Adjustable BCAM table