Description of ALBA BL29 scattering setup

1. Overall view of the scattering endstation

The endstation is referred to as MaReS, from Magnetic Resonant Scattering, but also Spanish word for "seas". The scattering endstation is a UHV reflectometer conceived for potential UHV experiments with sample transfer via a load-lock, and includes a magnet that can be either used or removed down when not in use to free the reflectivity and scattering constraints set by it. Sample and detector rotations are on top, with the detector circle carrying the sample one. There is an additional rotation circle for the magnet, on the bottom side.

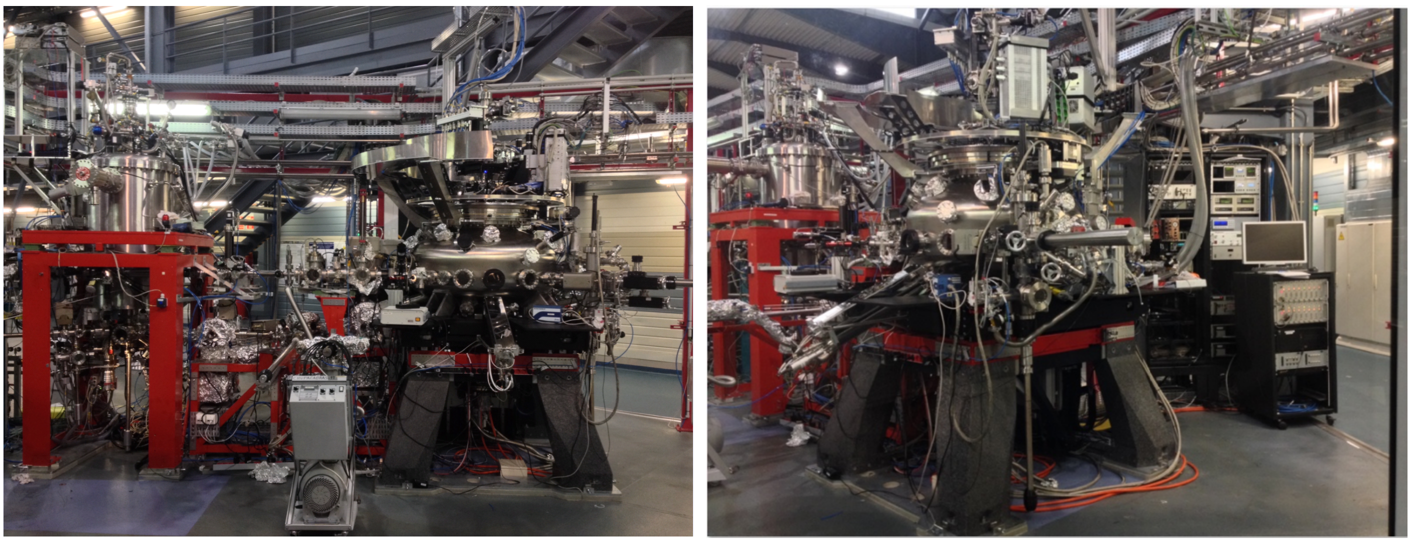


Fig.1. (left) XMCD endstation and scattering endstation; (right) closer view at scattering endstation, showing the load lock and transfer arm.

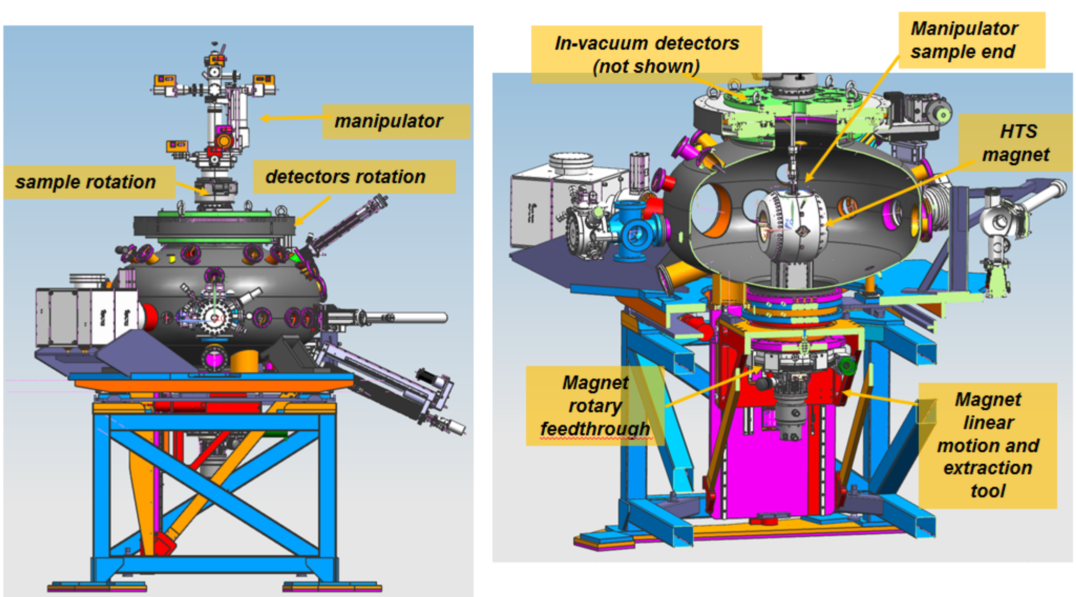


Fig2. CAD drawings illustrating aspects of the conceptual design and arrangements. Some details were not final, like the support.

2. Sample holders for reflection and transmission experiments

Sample holders are shown below. It is a solid block (manipulator as well), so transmission studies are still possible but are done using an L-shape mount, as apparent from the figure below. There is also sample holder adapter for STM plates.

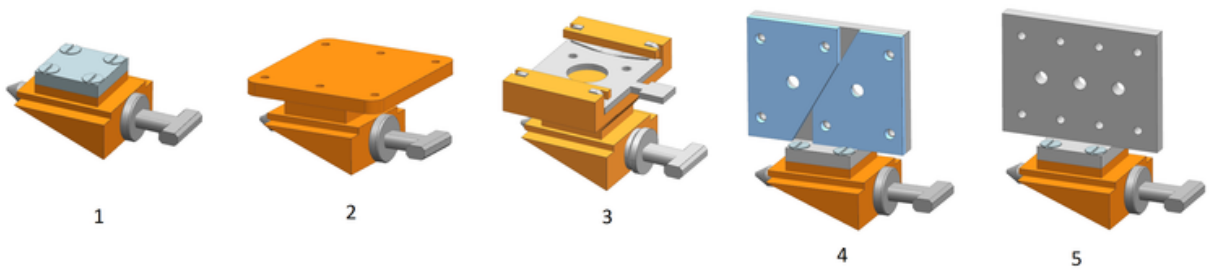


Fig.4. Range of sample holders available, for reflection studies (1-3) and transmission studies.

Actual photos of sample holders with samples are shown below.

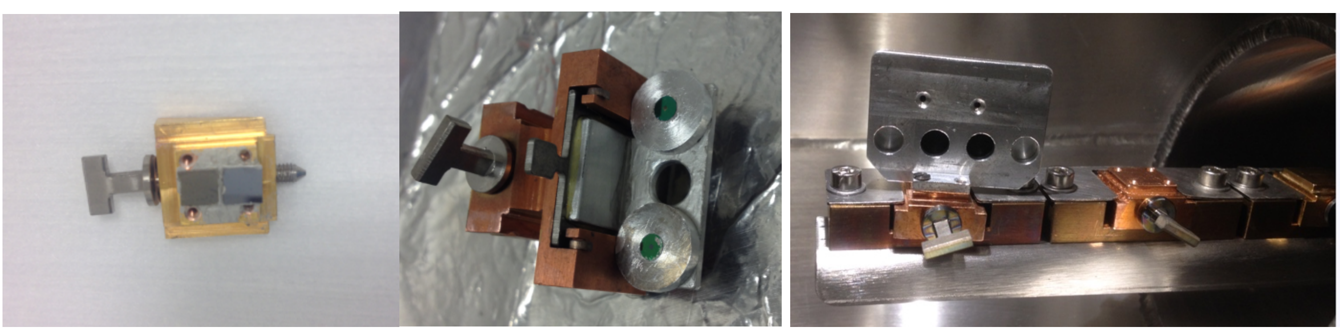


Fig.5. (left) Sample holder for reflection geometry, which has a base of about 1cm x 1cm. It is a copper block with gold coating, and samples are typically mounted with silver paint. (middle) a peculiar early transmission mounting is shown using a STM platen adapter. (right) Simpler transmission mounts. Plates with different holes are available and could be eventually custom made, whose purpose is to screen as much as possible parasitic light.

3. Sample manipulator

The sample manipulator is a C6 multiaxes cryomanipulator from VacGen (VG-Scienta) with custom modifications by ALBA and VacGen. Has X,Y,Z, tilt and azimuth. It has also a polar motion that is not used (it is disabled), as the manipulator sits on a more precise rotation circle.

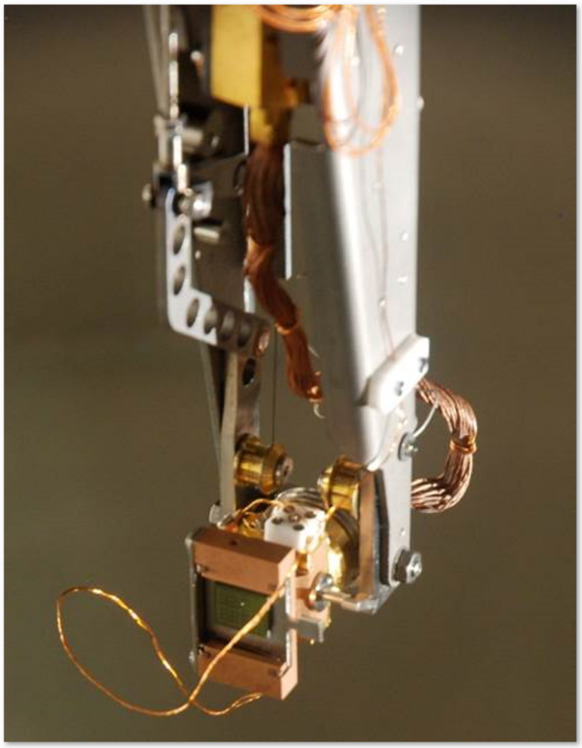


Figure 6. Photo of end of cryomanipulator with an STM adapter sample holder. On the STM plate a YAG crystal was mounted and shows a relatively well focused beam (bright spot). Somehow the wires of the temperature sensor were not well wrapped to the back at the time of this old image, which now is properly arranged. (long wires are needed due to the large azimuthal rotation capability)

Here is a datasheet of VG Scienta C6 manipulator (taken from their brochure). Consider a realistic sample temperature range of 18K up to 400K. The polar rotation is disabled and some motions ranges are slightly limited with software limits. Tilt rotation has significant crosstalk on Z, slightly on Y. (A pseudo tilt with Z,Y correction is planned but not yet implemented.)

The manipulator heater is a ceramic resistive heater that produces significant light. It has been significantly screened, but some weak background light occurs at high power settings of the heater.

Cryoax 6 Specification

Cryogenic data:

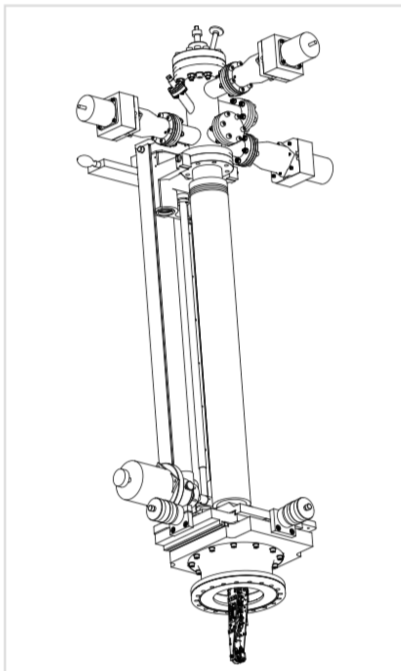
- Operation temperature from <16 K - 400 K
- Stable temperature during movement

Angular movement (Motorised only)

- *Θ_1 Polar rotation*
  Total: 320° (+95° -225°)
  Resolution: <0.1°
  Repeatability: ±0.1°
- *Θ_2 Azimuth rotation*
  Total: ±190°
  Resolution: <0.1°
  Repeatability: ±0.1°
- *Θ_3 Tilt rotation*
  Total: 15° (+5° -10°)
  Resolution: <0.1°
  Repeatability: ±0.1°

Translation

- *x/y movement*
  Total: 50 mm
  Resolution: 0.5 μm (motorised)
  10 μm (manual)
- *z movement*
  Total: 600 mm
  Resolution 0.5 μm (motorised)
  10 μm (manual)

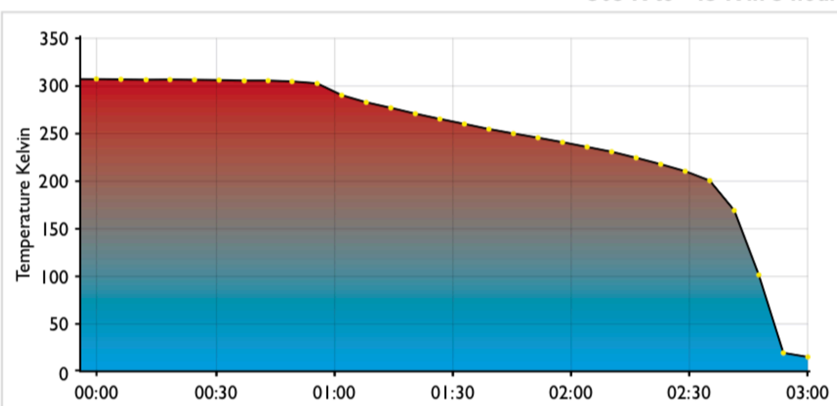


Cryoax 6 illustrated with the highly stable Omniax manipulator. Can be configured with full motorisation.

Figure 7. C6 manipulator datasheet.

The manipulator at ALBA was custom modified to enhanced stability, but still this datasheet is representative of main characteristics.

Cryoax 6 cool down chart
305 K to <15 K in 3 hours



Data recorded under unit test conditions at VG Scienta Ltd research and development lab. Test stopped at 180 minutes to conserve LHe. LHe consumption rate 3.0 l/h.

4. Magnet

The endstation is equipped with a 2T cryogen free magnet mounted from the bottom on an independent rotation circle. It is also mounted on a linear motion allowing to bring it down when not in use, or for sample transfer.

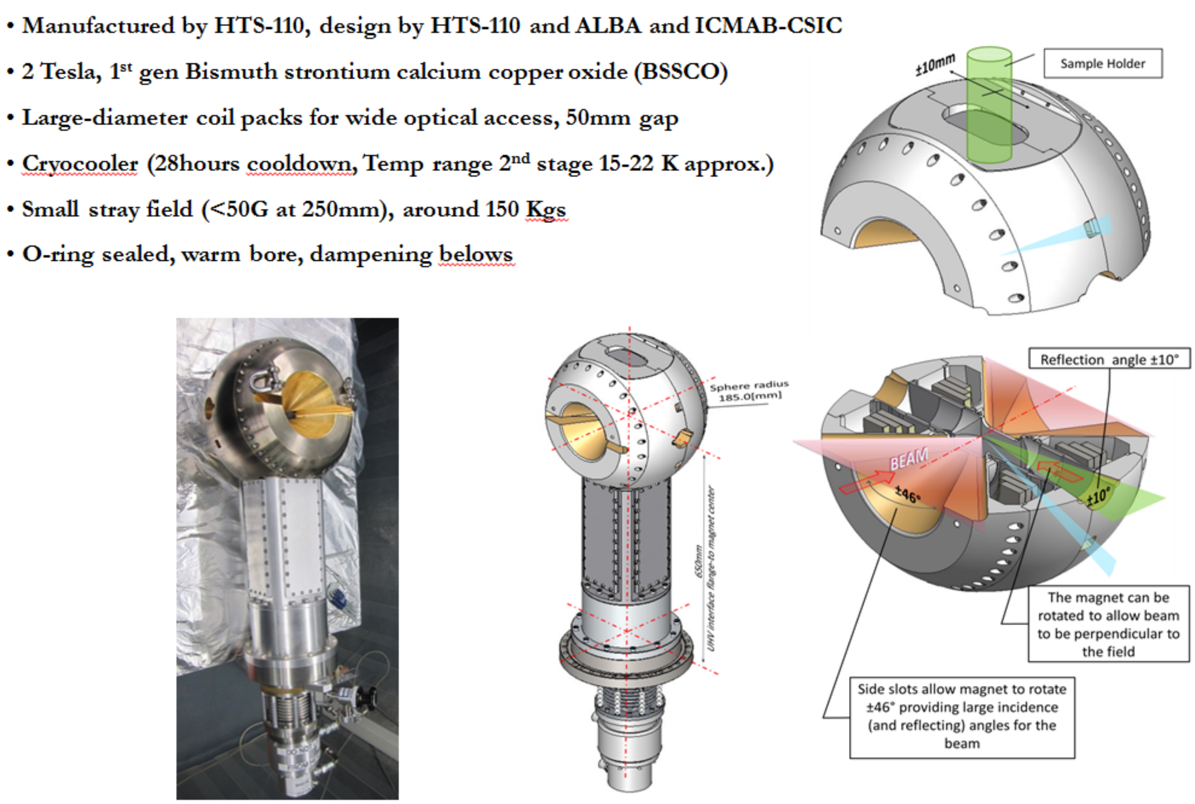


Figure 8. Photo and cad concept of the magnet

5. Manipulator and magnet geometrical constraints

The manipulator has been customized to be as narrow as possible (very narrow at about 38 or 39mm, considering it is a multi-axis system). Still the fit within the magnet gap space is tight, but ok. However, it is not possible to rotate the manipulator inside the magnet, as the manipulator end is deeper than the gap due to the copper braid, but also to the designed shape of the manipulator to keep the sample leveled on the manipulator center flange axis.

As a result, for reflection the geometry is magnetic field along sample surface, and for transmission, magnetic field perpendicular. The orientation of the magnetic field to the beam can be changed, by rotating the magnet and manipulator circles.

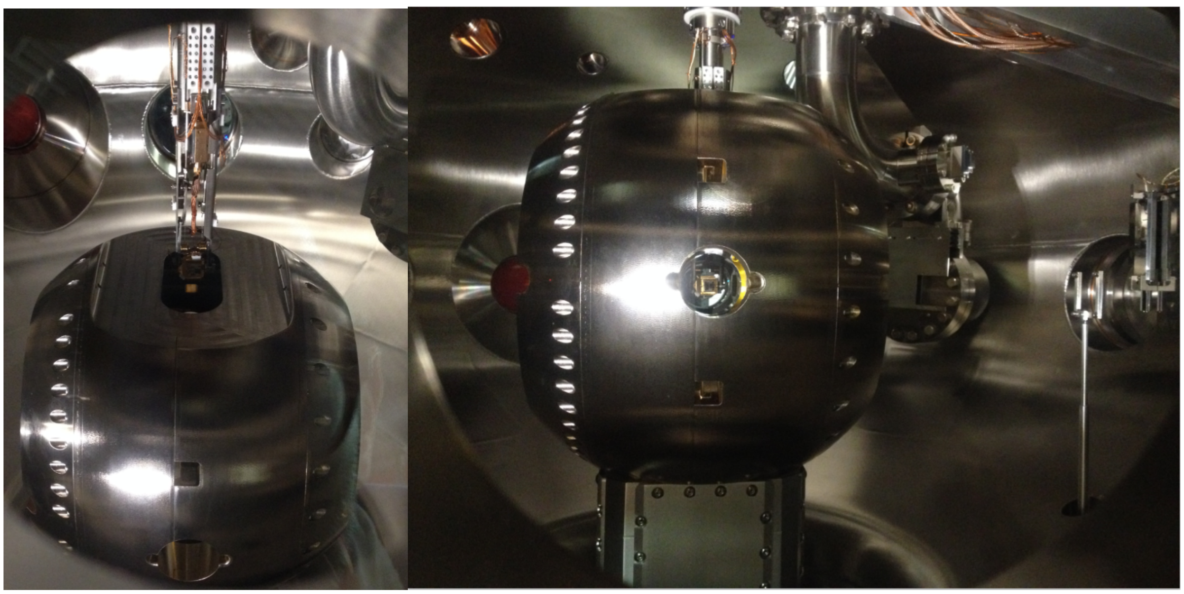


Figure 9. Illustration of the magnet and manipulator geometry. Sample holder with sample for reflection.

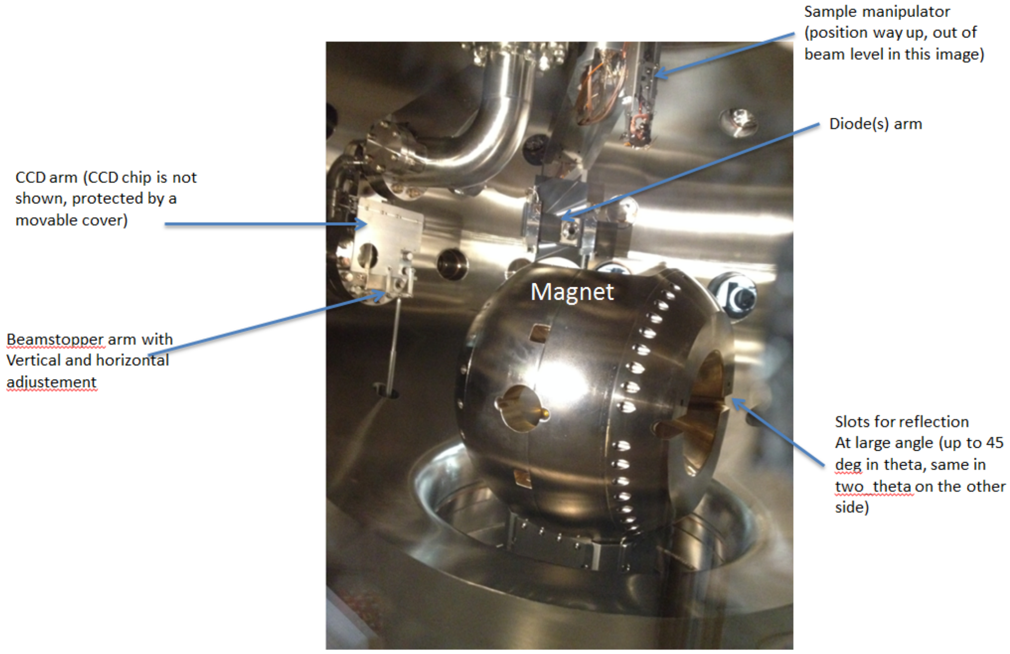


Figure 10. Illustration of CCD and diode(s) arms, and space inside the chamber.

6. Diode arm

The arm contains several diodes, such a Si diode (IRD) or a GaAsP diode (Hamamatsu), and adjustable detector slits.

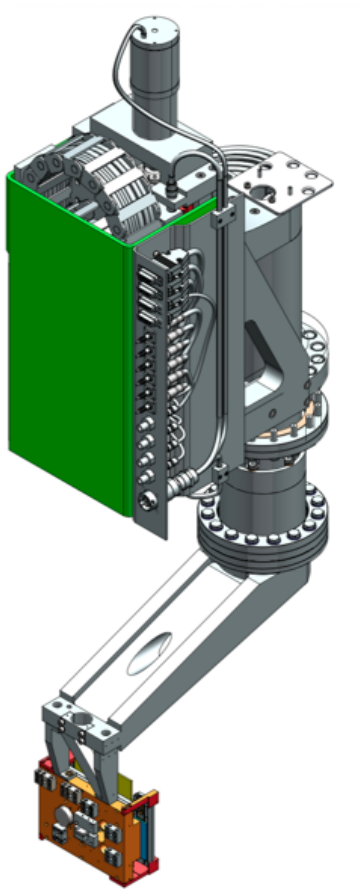
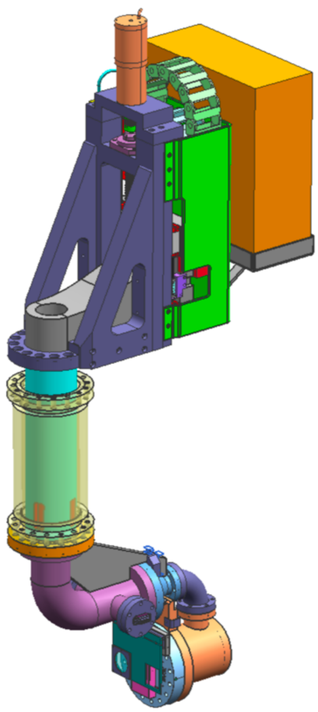


Figure 11. Illustration of “diode arm”.

7. CCD arm

1.1. Arm

The CCD detector arm carries a direct, soft x-ray CCD that is rotated with the detector circle and can also be translated some distance up and down in the chamber.



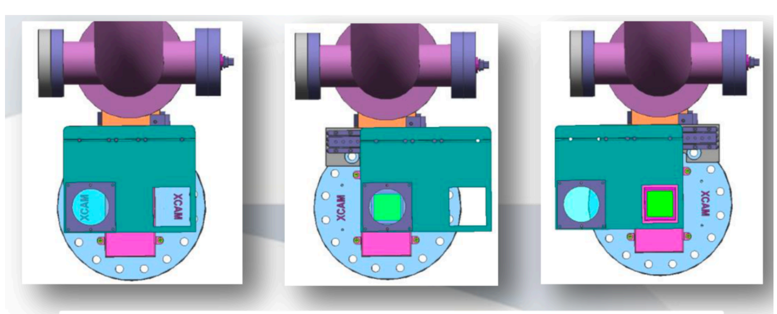
The CCD was a custom specification by ALBA and has been designed by XCAM Ltd. It is like a flange CCD in wich only the sensor and cooling block are in the vacuum-side, a reduced proximity electronics is on the flange air-side, and a main electronics is within 1-2 meters. The CCD chip is the 4240 by e2V manufacturer, which is about 2k x 2k sensor with 27mm x 27 mm area and 13.5 micron pixel size. The chip is a back-thinned, un-coated CCD. The chip is peltier cooled down to -35 ºC (can be pushed to -40ºC).

- The CCD will intercept direct beam at a nominal two-theta angle of 169 deg. (but I kind of remember seen the direct beam to get cut at about 167 deg.).

- The CCD chip is at a nominal distance of 402mm from the center of the chamber.

Fig.12. CCD arm

The CCD has a cover for protection, that is moved with a piezo slide from SmartAct. In this cover, a beamstopper piece is mounted. A second beamstopper and/or phosphor screen were planned and might be mounted in the future.



Function of screen: Shutter, Phosphor screen, CCD Camera

Fig.13. CCD piezo-slide actuated cover (the design concept illustrated here was enlarged to include a 4th position for a beamstop, to enable speckle studies in specular geometry).

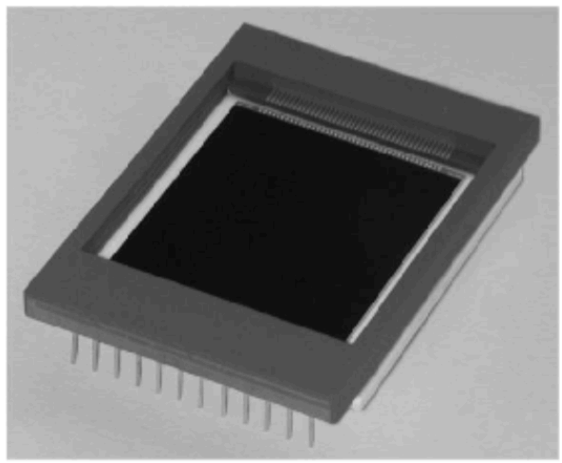
e2V

e2v technologies

CCD42-40 Ceramic AIMO Back Illuminated Compact Package High Performance CCD Sensor

FEATURES

- 2048 by 2048 pixel format
- 13.5 µm square pixels
- Image area 27.6 x 27.6 mm
- Back Illuminated format for high quantum efficiency
- Full-frame operation
- Symmetrical anti-static gate protection
- Very low noise output amplifiers
- Dual responsivity output amplifiers
- Gated dump drain on output register
- 100% active area
- New compact footprint package
- Advanced inverted mode operation (AIMO)



APPLICATIONS

- Scientific Imaging
- Microscopy
- Medical Imaging

INTRODUCTION

This version of the CCD42 family of CCD sensors has full-frame architecture. Back illumination technology, in combination with extremely low noise amplifiers, makes the device well suited to the most demanding applications requiring a high dynamic range. To improve the sensitivity further, the CCD is manufactured without anti-blooming structures.

There are two low noise amplifiers in the readout register, one at each end. Charge can be made to transfer through either or both amplifiers by making the appropriate RØ connections. The readout register has a gate controlled dump drain to allow fast dumping of unwanted data.

The register is designed to accommodate four image pixels of charge and a summing well is provided capable of holding six image pixels of charge. The output amplifier has a feature to enable the responsivity to be reduced, allowing the reading of such large charge packets.

The advanced inverted mode operation (AIMO) gives a 100-times reduction in dark current with minimal full-well reduction and is suitable for use at Peltier temperatures.

Other variants of the CCD42-40 available are front illuminated format and non-inverted mode. In common with all e2v technologies CCD Sensors, the front illuminated CCD42-40 can be supplied with a fibre-optic window or taper, or with a phosphor coating.

Designers are advised to consult e2v technologies should they be considering using CCD sensors in abnormal environments or if they require customised packaging.

TYPICAL PERFORMANCE

(Low noise mode)

Maximum readout frequency	3	MHz
Output amplifier responsivity	4.5	µV/e⁻
Peak signal	100	ke⁻/pixel
Dynamic range (at 20 kHz)	33 333:1	
Spectral range	200 - 1060	nm
Readout noise (at 20 kHz)	3	e⁻ rms

GENERAL DATA

Format

Image area	27.6 x 27.6	mm
Active pixels (H)	2048	
(V)	2048 + 4	
Pixel size	13.5 x 13.5	µm
Number of output amplifiers	2	
number of underscan (serial) pixels	50	
Fill factor	100	%

Package

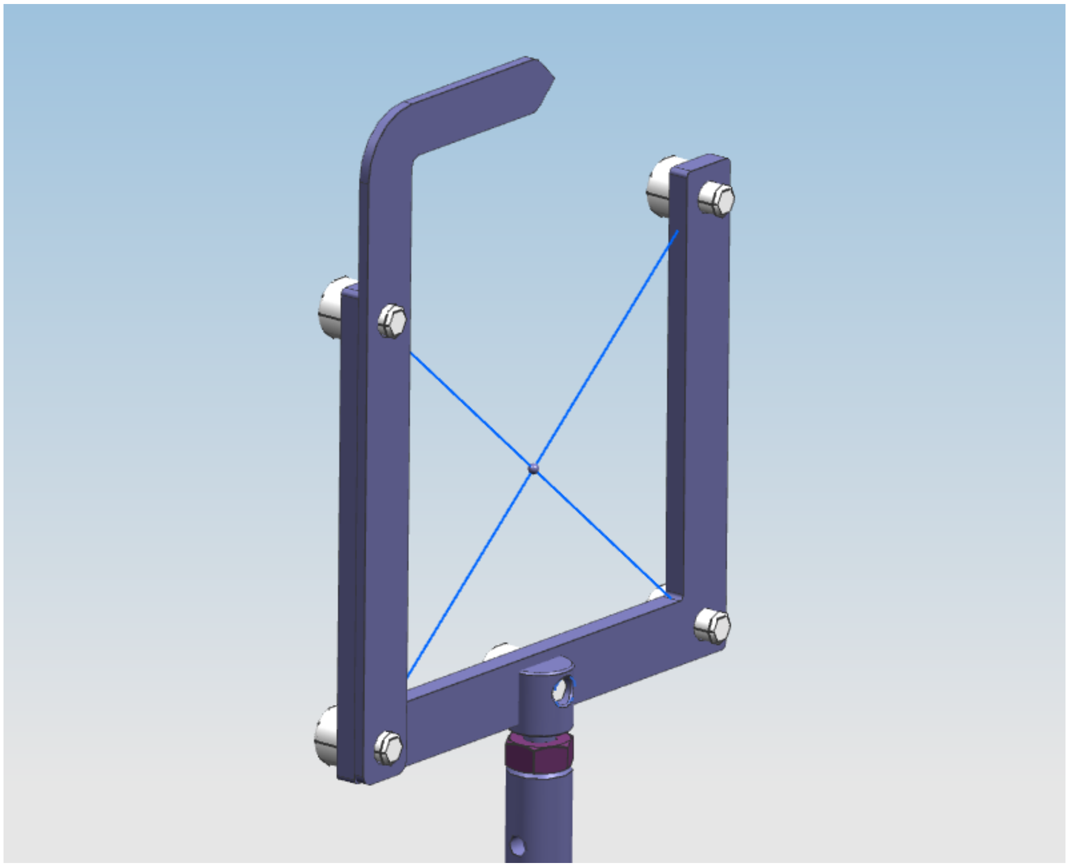
Package size	37.0 x 51.7	mm
Number of pins	24	
Inter-pin spacing	2.54	mm
Inter-row spacing across sensor	45.72	mm
Window material	removable glass	
Package type	ceramic DIL array	

Fig.13. CCD chip datasheet (e2V technologies)

2. Beamstops

2.1. Fixed "dual" beamstop

This beamstop does not rotate, but it has a linear motion and tilt that works as a XZ stage for its positioning. A wide stopper is for GISAXS, the smaller "ball-like" is for coherence.



2.2. CCD beamstop

Another beamstop has been mounted on the CCD, which can be used to blocked strong specular beams. For now it is a 4mm or so wide horizontal bar. Its design might be refined at some point.