Image stabilisation system of the Photospheric and Helioseismic Imager

The Photospheric and Helioseismic Imager (PHI) on board of the ESA mission Solar Orbiter, to be launched in 2017, will provide measurements with high polarimetric accuracy of the photospheric solar magnetic field at high solar latitudes (orbital inclination up to 25°; 36°@extended mission).

The needed pointing precision requires an image stabilisation system (ISS) to compensate for spacecraft jitter. The image stabilisation system works as a correlation tracker (CT) with a high-speed camera and a fast steerable tip-tilt (TT) mirror.

Requirements

➤ Residual error: 0.1 arcsec rms during 10sec (S/C jitter 1 arcsec rms)
➤ Image scale 0.8arcsec/pixel
➤ Bandwidth: >30 Hz
➤ Frame rate: >300 Hz
➤ Power consumption TT controller and CT camera: 3.4W
➤ Total mass ISS (CT camera + TT drive incl. M2): 600g
➤ Operational temperature range: -30°C to +80°C

Overview scheme of the ISS optics and control
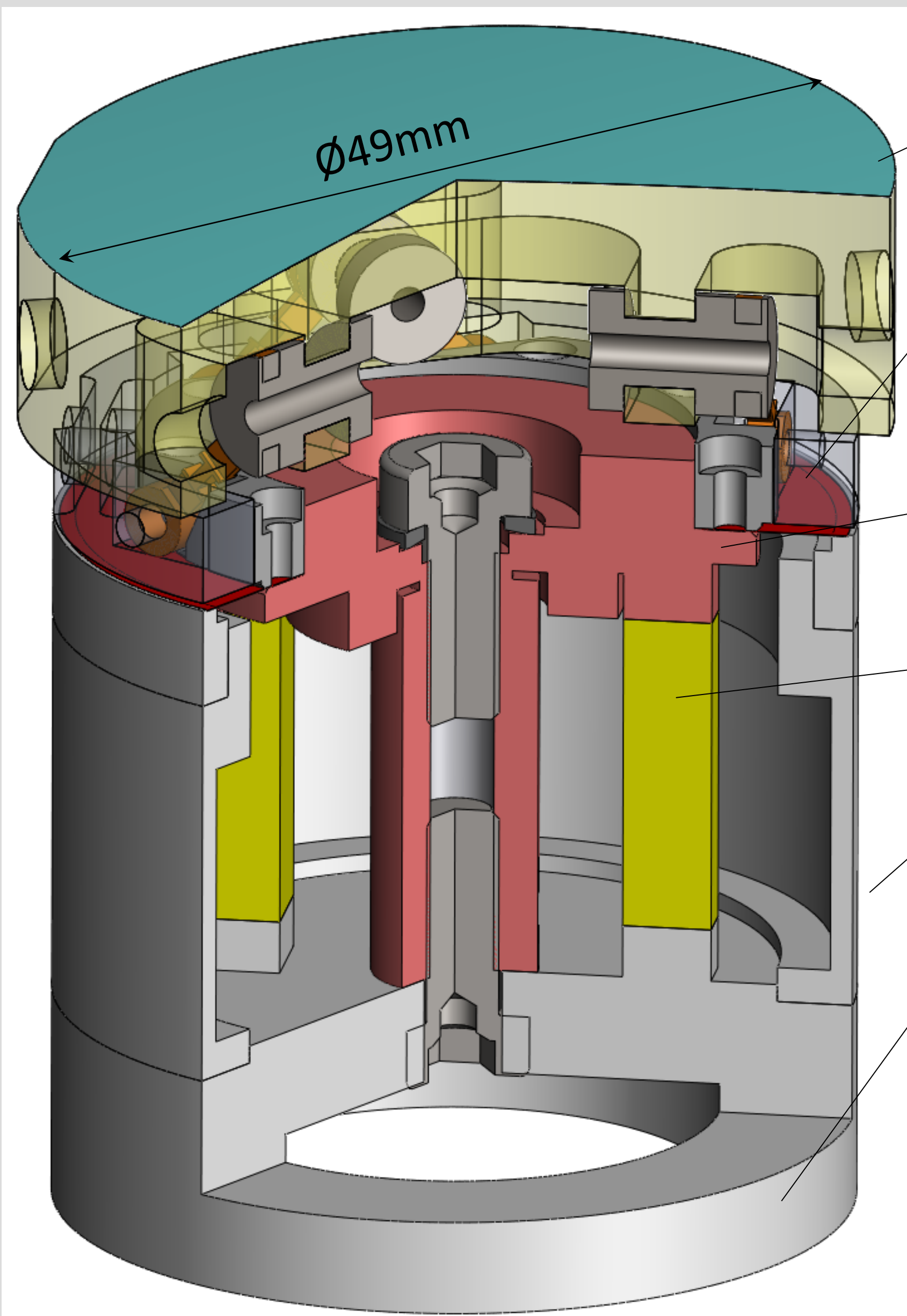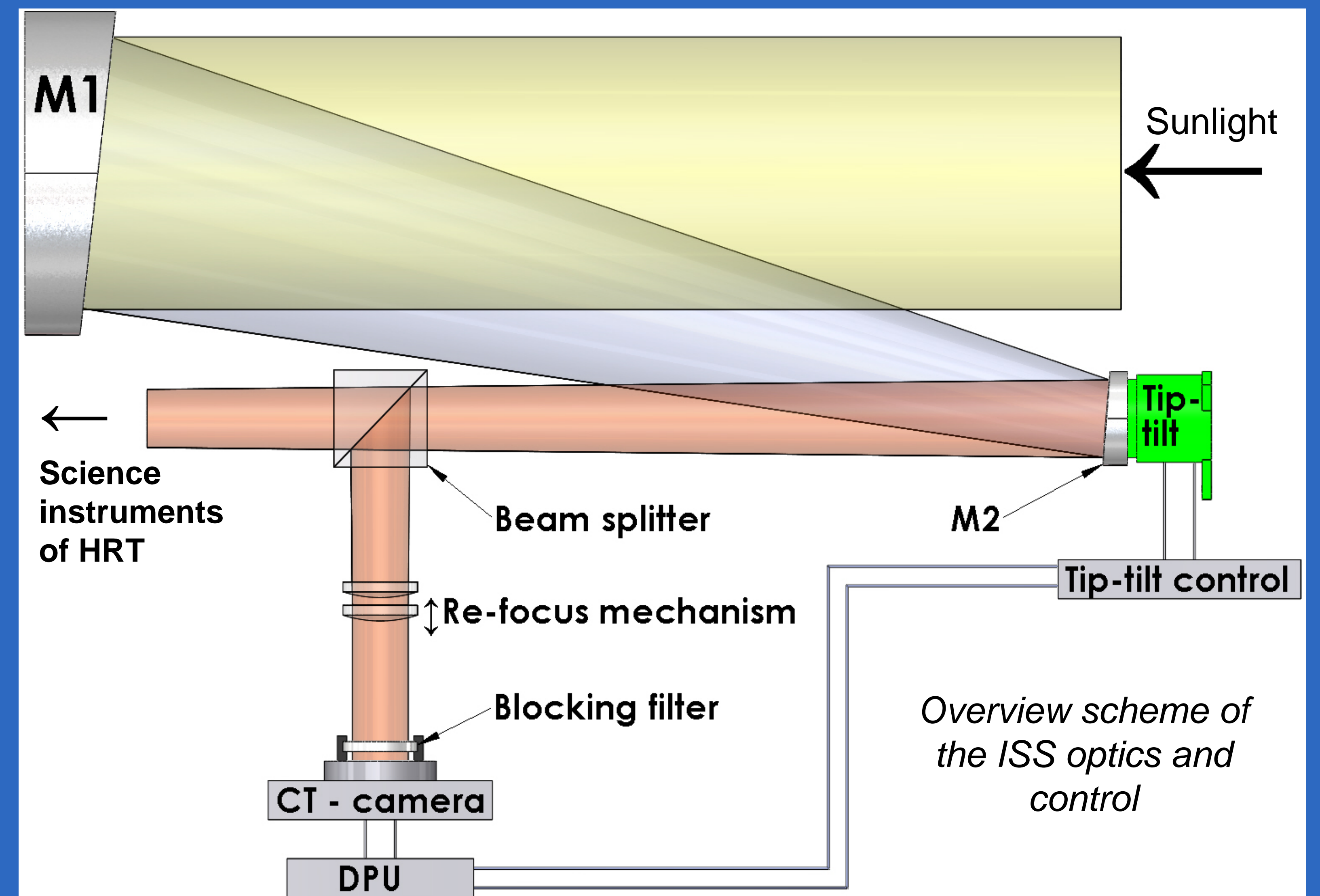
Schematic drawing of the M2 tip-tilt drive assembly

TT drive assembly specifications

Mass without Mirror & harness	160g
Number of Axis	2
Voltage difference for max. tilt	47V
Total tilt range (@47V)	535 µrad
Resolution	< 0,2 µrad
Total capacity (one axis)	3µF / axis
Operational temp. range	-30° C - +80° C
Non-op. temp. range	-40° C - +100° C
Eigenfrequency	1.3kHz (with mirror)

TT drive bread board with dummy mirror
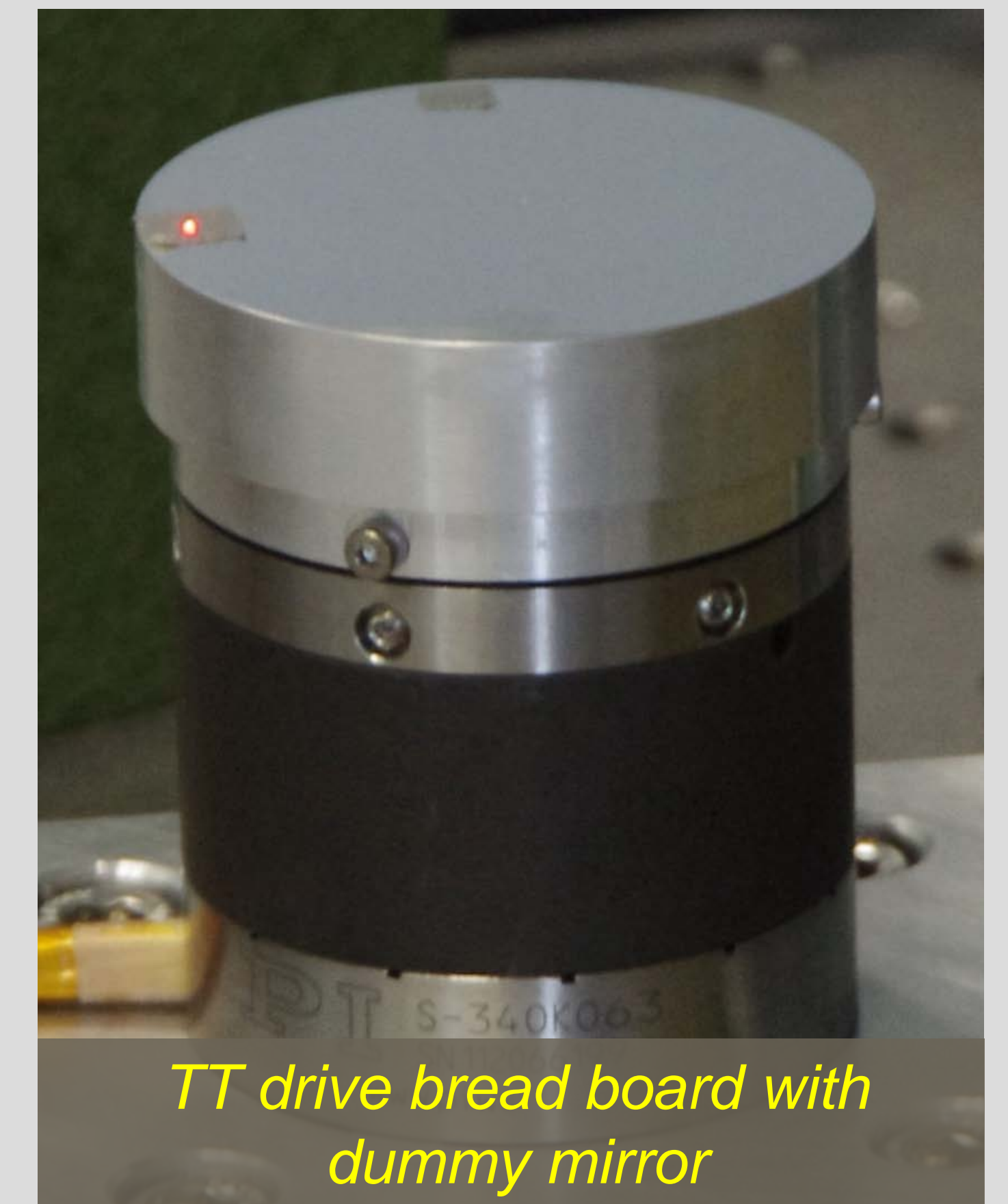
The piezo drive is an optimized device of the series S-340 manufactured by P.I. The low voltage PICMA piezo stacks with a few hundred layers are encapsulated to be insensitive against vacuum and environmental impact. Each pair of piezo stack is working in a bridge configuration to allow for negative and positive angles of the mirror movements.
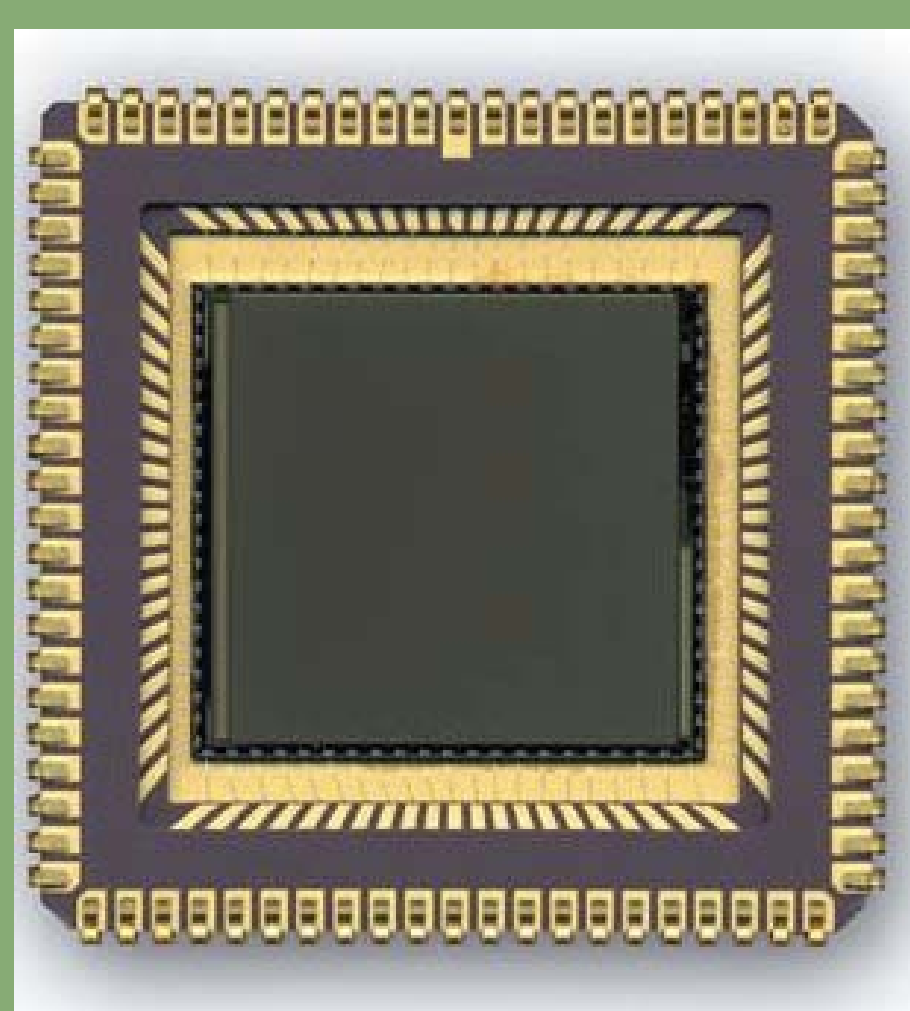
The housing is made of Titanium to achieve a stiff and light weighted structure. The drive is mounted to the front plate of the PHI instrument with an isostatic mounting.
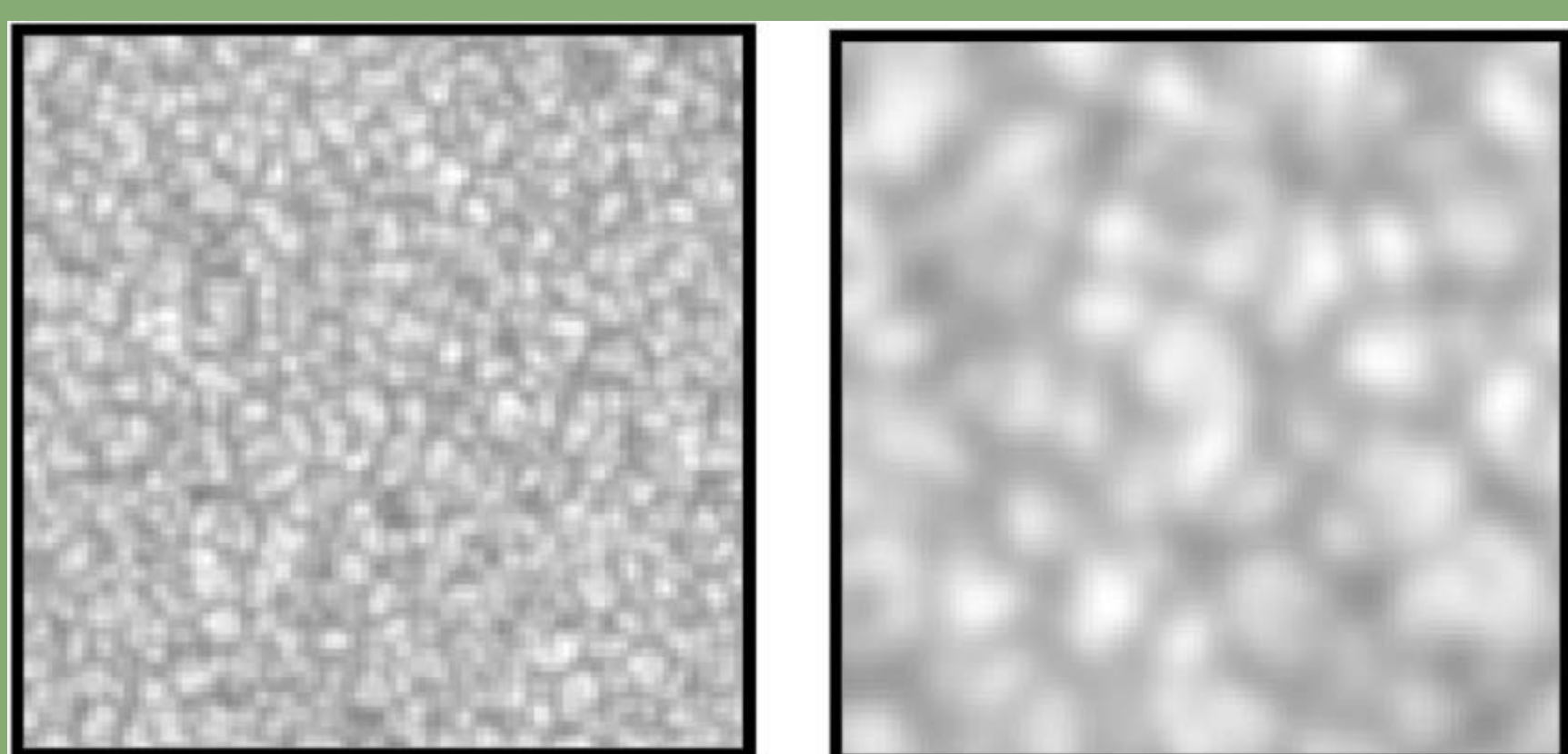
0.9 AU   0.29 AU

A simulated CT images (100 x 100 pixel) as seen from different distances of the Sun with the angular resolution of the 140 mm HRT (not a science image!)

The CT sensor Star1000 with 1024 x 1024 pixels and a 15µm x 15µm pitch

The CT camera (CTC) is a high speed camera and observes an area of solar granulation within the field of view (FOV) of the high resolution telescope (HRT).

2% of the incident light from the telescope reaches the camera where a band pass filter restricts the transmitted wavelength to 617nm± 5nm. The CTC will allow integration times between 0.125ms and 3ms, frame rates up to 600 fps and a FOV from 64x64 to 128x128 pixel.

The ISS control firmware runs in one of the two FPGAs of the PHI control unit (DPU). It compares the position of the real time image with a reference image. The reference image must be updated about each 60 seconds due to the temporal change of the solar granulation pattern. The displacements of the images are calculated by an absolute differences algorithm with sub pixel resolution in a field of 7x7 pixels. The detected shifts are converted to a tilt angle and the corresponding signal is sent to the fast tip-tilt mirror M2 in closed loop.

The CTC sensor is thermally connected to the hot plate interface (<50°C) and the CT camera control FPGA to the housing of the camera (<65°)

Detailed results of already performed tests are given on poster 18 (T. Maue: Ground Testing of the PHI Image Stabilisation System (ISS) for Solar Orbiter)
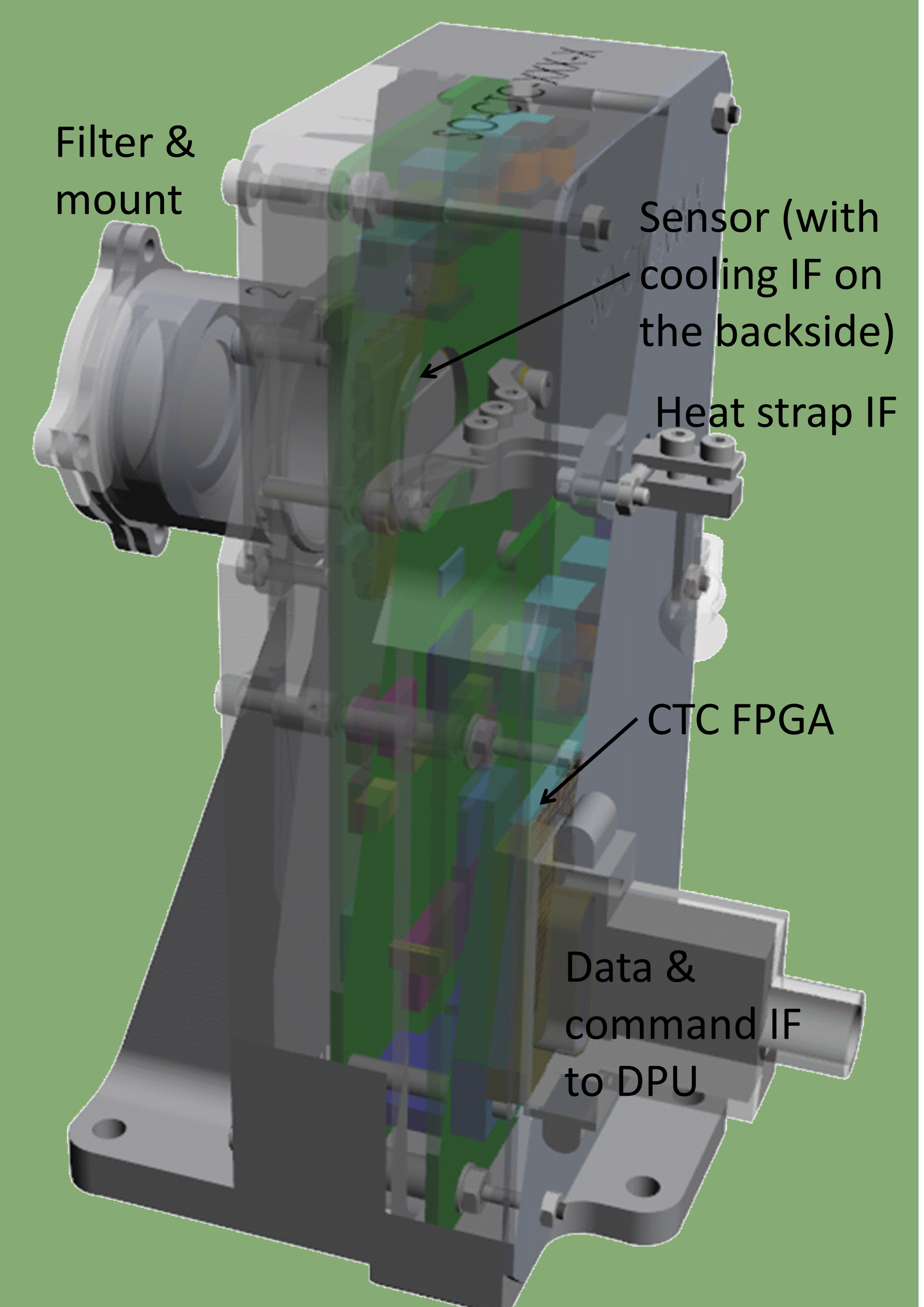
CT Camera assembly

R. Volkmer*[a], T. Berkefeld[a], J. Baumgartner [a], J. Bosch[b], A. Casas[b], M. Carmona[b], J. M. Gomez[b], F. Heidecke[a], T. Maue[a], E. Nakai[a], D. Roma[b], W. Schmidt[a], T. Scheiffelen[a], D. Soltau[a]

[a] Kiepenheuer-Institut für Sonnenphysik, Schöneckstrasse 6, 79104 Freiburg, Germany;
[b]Dept. d'Electrónica, Facultat de Física,Universitat de Barcelona, C/Marti i Franques 1, 08028 Barcelona, Spain

*volkmer@kis.uni-freiburg.de; phone 49 761 595210-32; fax 49 595210-31; www.kis.uni-freiburg.de