SLED HOSTING AT LSO - TECHNICAL ISSUES

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1/ INTRODUCTION

In this document the technical issues, related to the SLED instrument testing and hosting at the LSO. This summary is based on currently available information on the SLED instrument original design and our experience gained by operation of instruments at the LSO.

We also list things the LSO and the AISAS can offer for the SLED operation at the LSO. Finally, some preparation issues, related to the SLED testing/hosting at LSO, are proposed for the SLED consortium and the LSO/AISAS separately.

All issues mentioned in this document are still open for discussion with an exception of some technical limitations given by the ZEISS coronagraph/mount and the LSO dome.

The main message of the document is that in our opinion the original SLED design has to be reevaluated in order to attach and operate the SLED instrument at the LSO coronagraph. One possible alternative idea, how to modify the original design to meet the technical limitations given by the ZEISS coronagraph/mount and the LSO dome, is described below. Of course, we expect that the SLD consortium with its professional opticians will come with much better design ideas. We would welcome such alternative design ideas a lot.

We hope that the SLED consortium together with the AISAS/LSO group will find the right ways how to overcome this main obstacle as well as several other minor ones. We expect that finally the SLED hosting at the LSO ZEISS coronagraph will become reality providing the observational data for the scientific research we all are dreaming about. Although at the moment the SLED operated at the LSO coronagraph seems to be really a challenge!

2/ Technical parameters and limitations of the LSO ZEISS coronagraph/mount/dome

a) coronagraph:
   - ZEISS 200/3000/4000 coronagraph
   - spectral range: 500 - 1100 nm
   - FoV: radial extension 1.0 - 1.8 R_sun
   - final image scale: ~52 arc secs/mm
   - objective lens focal length dependent on wavelength

- coronagraph focusing by motion of the objective lens only
- a movable diffuser in front of the primary objective lens
- a diffraction limited secondary optics
- a fixed final focal plane position for installation of a post-focus instrument
- an off-axis installation of the post-focus instrument (adjustable at the coronagraph)
- a free positioning of the SLED FoV in positional angle (PA) rotating the coronagraph rare interface with the SLED around the optical axis of the coronagraph
- distance between the coronagraph rare interface and the re-imaging objective last optical surface = 20 mm (Fig.1)
- free distance between coronagraph re-imaging objective last optical surface and final focal plane of the coronagraph = 400 mm (Fig.1)
- coronagraph optics drawing: Fig.2
- articles and technical information (including the coronagraph optics ZEMAX file): LSO_ZEISS_coronagraph.zip file

b) mount:

- ZEISS equatorial mounting type VII S
- an electrically insulated power line for electrical power supply of post-focus instrument
- free distance between coronagraph re-imaging objective last optical surface and the dome floor = 1130 mm (Fig.1)
- free distance between the coronagraph rare interface and the dome floor = 1150 mm (Fig.1)
- free distance between the coronagraph final focal plane position and the dome floor = 730 mm (Fig.1)
- minimum distance between the optical axis of the coronagraph and the mount pillar = 500 mm (Fig.1)
- technical information: pages 5-7 of the PDF file in LSO_ZEISS_mount.zip file

c) dome:

- coronagraphs with their post-focus instruments has to be positioned vertically in the dome for maintenance actions of the post-focus instrument, coronagraph, mount, and dome and in cases of an extremely bad weather
- all possible alpha/delta positions of the coronagraphs with the post-focus instruments have sufficient space for their free motion, i.e. all distances to any other mount and dome parts are longer than the distances for the vertical position of the coronagraph
- operating temperature lower limit: -20 degrees Celsius
- dome air temperature during observations may vary from -20 to +20 degrees during the year
- air pressure at the LSO altitude is only at about ¾ of the nominal air pressure at the see level

3/ Modifications of the SLED original design

The technical issues listed below come from the technical limitations described in Sect.2 and our experience gained by operation of instruments at the LSO.

The items a/ - l/ are related already to the testing period and the items m/ - r/ only to the hosting period.

a) a very strong preference of the SLED installation at the rare position of the coronagraph around the final focal plane of the coronagraph along the optical axis of the coronagraph. (See picture of the SCD instrument currently attached to the reare position at the left coronagraph – Fig.3, left panel). This strong requirement is due to operation of the LSO instrumentation in the dome during observations and also due to inevitable maintenance of the LSO dome. An alternative SLED location along the coronagraph not in the rare position but in position towards the coronagraph's objective with the reverted light beam is very problematic due to momentum balance problems, auxiliary parts of the coronagraph in these areas (Fig.4), and the LSO dome maintenance.

b) usage of the coronagraph rare position interface for attaching the SLED to the coronagraph (Fig.3, right panels).

c) preparation of a new mechanical/optical interface for the SLED instrument attachment to the coronagraph rare interface.

d) a reconsideration the SLED optics for feeding the instrument with the coronagraph final beam of f=4000 mm, i.e. without any additional re-imaging optics. If this is not possible, addition of a translating optics into the SLED design is inevitable.

e) note that due to the coronagraph objective lens focal length dependence on wavelength the SLED instrument could not obser 2 different wavelengths simultaneously (and refocusing of the coronagraph is needed to change one line for another one)

f) the SLED instrument box will shifted will for ~20 mm radially from the optical axis of the coronagraph by the ZEISS coronagraph slide mechanism (Fig.5) to allow free selection of any PA for the FoV and a proper illumination of the SLED.

g) minimization of the SLED instrument weight (if possible well below already mentioned 50 kg)

h) minimization of the SLED instrument dimensions to - cross-section radius of MAX 50 cm and distance from the end of the coronagraph rare interface to the back side of the SLED box of MAX 1150 mm - to meet the rare position limitations for the vertically positioned coronagraph. (Please, note, that this MAX distance of 1150 mm has to be lowered depending on the actual cross-section dimensions of the SLED box to allow movement of the coronagraph and instrument from the vertical to any other position.)

i) an almost complete balance of the SLED momentum around the optical axis of the coronagraph (not the SLED entrance optical axis which will be in fact shifted for the optical axis of the coronagraph for ~20 mm).

j) bear in mind that the coronagraph final focal plane is located 730 mm above the dome floor and 400 mm below the bottom side of the coronagraph rare interface

k) hereby we propose an alternative idea with suggestions how to squeeze the SLED length and to balance its momentum as the original SLED design with the instrument box dimensions 1.0*0.7*0.3 m exceed the allowed values considerably:

1) keep the core part of the instrument optics the same as its is proposed in the original design (parts L1-M1-L2-M2-L3-L4-G)! These optical parts would need just volume of dimensions at about 65*60*30 cm (length*width_1*width_2).

2) move the other optical parts (light entrance W, image slicer M4-SSM-SMM-M5, output to camera M6-L5-M7-L6-C) and light beams to them out of the instrument core part volume to volume side by side with the core part. Use couples of mirrors to incline the beams perpendicularly out of the instrument core part and to invert the light beams back paralleling them along the core part in direction toward location of M1 and G creating an additional side part volume of the instrument. This side part could occupy volume of dimensions at about 65*60*40cm (length*width_1*width_2).

3) adjustment of the SLED entrance position W with the final focal plane position of the coronagraph in the side part volume of the instrument

4) a balance of the SLED momentum relatively to the optical axis of the coronagraph preferably by an intrinsic counterweight of core part and side part of the SLED instrument themselves

5) in our opinion the total dimensions of the SLED box, consisting of the core and side part, could be just at about 65*60*70 cm (length*width_1*width_2). Such dimensions do not cause any mechanical conflict with the coronagraph parts, the mount, and the dome floor at any location of the coronagraph with the attached SLED instrument including the most demanding vertical position.

6) Of course, a professional optician definitely can come with much more clever design ideas. We would welcome your alternative design concepts for the SLED at the LSO.

l) to add to the SLED box or its interface a focusing ability to match the output coronagraph beam in its final focal plane (as the coronagraph with the its rare interface does not offer any focusing possibility).

m) to add to the SLED box also a motorized/computer controlled pre-filter mechanism with pre-filters needed for 2 coronal and 2 prominence spectral line and with a metal sheet for DARK exposures in addition

n) to add to the SLED instrument a heating system to maintain temperature inside the SLED box at the operation temperature of the narrow-band pre-filters while the ambient air temperature is expected within the range from -20 to +20 degrees

o) to add to the SLED box an outer insulation minimizing heat transport from inside the SLED box to ambient air

p) to add to the SLED a heating/cooling system for the camera which has to be operated/stored within the above mentioned temperature range of the ambient air keeping in mind also the operation temperature of the narrow-band pre-filters

q) AISAS could offer for the SLED instrument a better camera (ANDOR Neo) with the same chip as the ANDOR Zyla 5.5 chip but cooled down to -30 degrees and so beating the Zyla with much lower data noise (sigma of ~1 electron). Unfortunately, at the moment, this camera needs a repair of electronics. Nevertheless, the SLED could be adapted for an alternative use of these two cameras - ANDOR Zyla 5.5 and ANDOR Neo - in case the camera repair will be managed.

r) to equip the ANDOR Zyla camera with the fiber optics based data transfer from the camera body to the computer in the server room and the fiber optics based command delivery from the computer to the SLED instrument

4/ LSO/AISAS suggestions and offers for the SLED operation at the LSO

All items b/ - k/ will be provided only for the hosting period.

a) the LSO left coronagraph with its rare interface will be provided for the SLED instrument testing and hosting

b) AISAS ANDOR Neo camera (after a repair) for alternation of the ANDOR Zyla 5.5 camera
c) motorized and computer controlled operation of the coronagraph diffuser in front of the objective lens (for flat-field exposures), a mechanism for focusing the coronagraph objective lens for wavelength range between 500 and 1100 nm, and rotation of the SLED box in PA
d) incorporation of the SLED instrument operation (camera, pre-filters) to the AISAS SCMP/LabVIEW computer code for operation of the coronagraph parts (diffuser, focusing of coronagraph, and rotation of the SLED)
e) a photoelectric pointing system of the coronagraph operated completely independently from the SLED operation
f) a rack computer in the server room for operation of the SLED instrument using the AISAS SCMP/LabVIEW code and for temporary data storage during measurements
g) data archive for the SLED data within the LSO data archive
h) computing power for performing the regular SLED data reduction pipeline (linux, IDL)
i) an IDL license for the SLED data reduction pipeline
j) year-round operation of the LSO
k) free accommodation of the SLED consortium members at the LSO during they visits/stays (according to the limited LSO building space only up to 3 persons in single sleeping rooms at the same time)

5/ Preparations for the SLED testing/hosting at LSO - the SLED consortium

Actions proposed for the SLED consortium in order to realize the SLED testing/hosting at the LSO are listed below. The items a/ - c/ are related to the testing period and the items d/ - e/ only to the hosting period.

a) adaptations of the SLED original design
b) preparation of the SLED mechanical interface
c) functional tests of the SLED in a lab and/or Bialkow Observatory

d) adaptations of the SLED resulting from the testing period
e) data reduction software pipeline - IDL based

6/ Preparations for the SLED testing/hosting at LSO - the LSO/AISAS

Actions offered by the LSO/AISAS to realize the SLED testing/hosting at the LSO are listed below. The items a/ - c/ are related to the testing period and the items d/ - j/ only to the hosting period.

a) the ZEISS coronagraph rare interface drawings provided to the SLED consortium
b) manual operation of the diffuser, focusing of the objective lens, rotation of the post-focus instrument at the left coronagraph at the LSO
c) the left LSO coronagraph free for the SLED testing

d) adaptations of the left coronagraph resulting from the SLED testing period
e) incorporation of the SLED instrument operation (camera, pre-filters) to the AISAS SCMP/LabVIEW computer code for operation of the coronagraph
f) the photoelectric pointing system of the coronagraph operated completely independently from the SLED operation
g) the rack computer in the server room for operation of the SLED instrument using the AISAS SCMP/LabVIEW code and for temporary data storage during measurements
h) the data archive for the SLED data within the LSO data archive
i) computing power for performing the regular SLED data reduction pipeline
j) an IDL license for the SLED data reduction pipeline

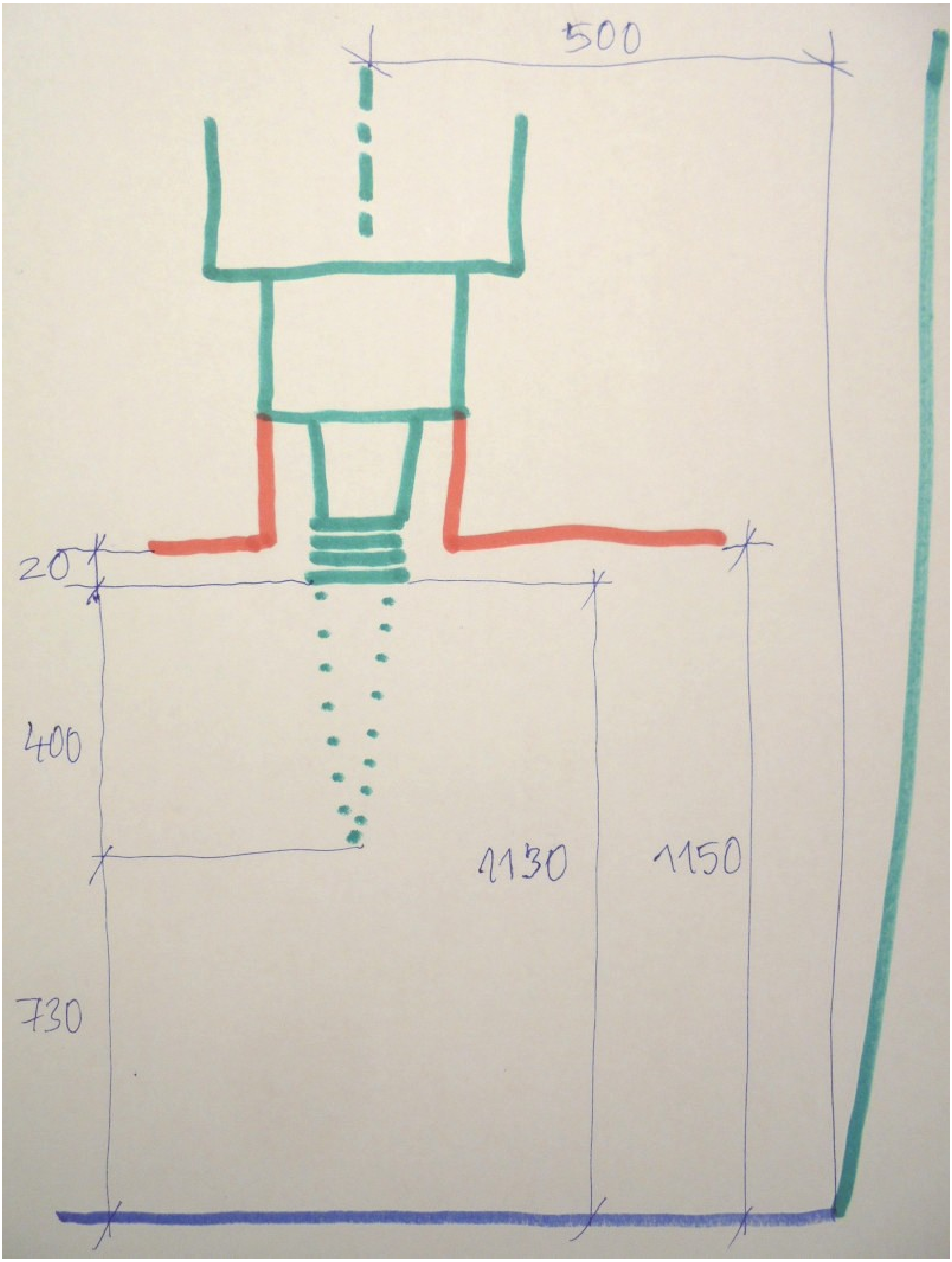

Fig.1: A drawing of the rare part of the coronagraph and the mount pillar with the critical dimensions. Green: coronagraph rare part with slide mechanism, holder of the 4-lens re-imaging objective, 4-lens re-imaging objective itself, the output converging beam with the final focal plane, and the edge of the mount pillar (at the right side). Red: the coronagraph rare interface. Blue: the dome floor.

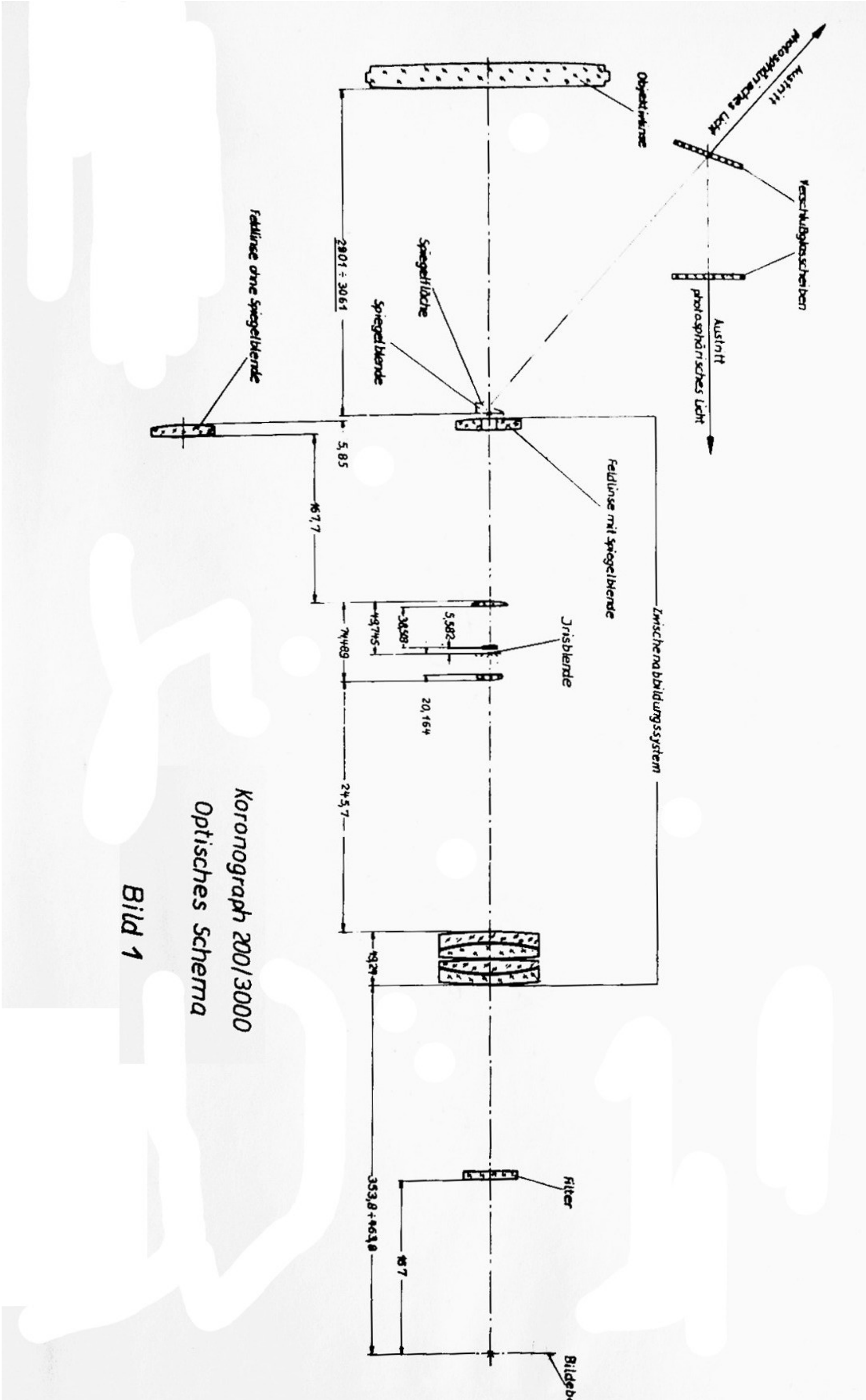

Fig.2: The original ZEISS drawing of the ZEISS 200/3000/4000 coronagraph optics.

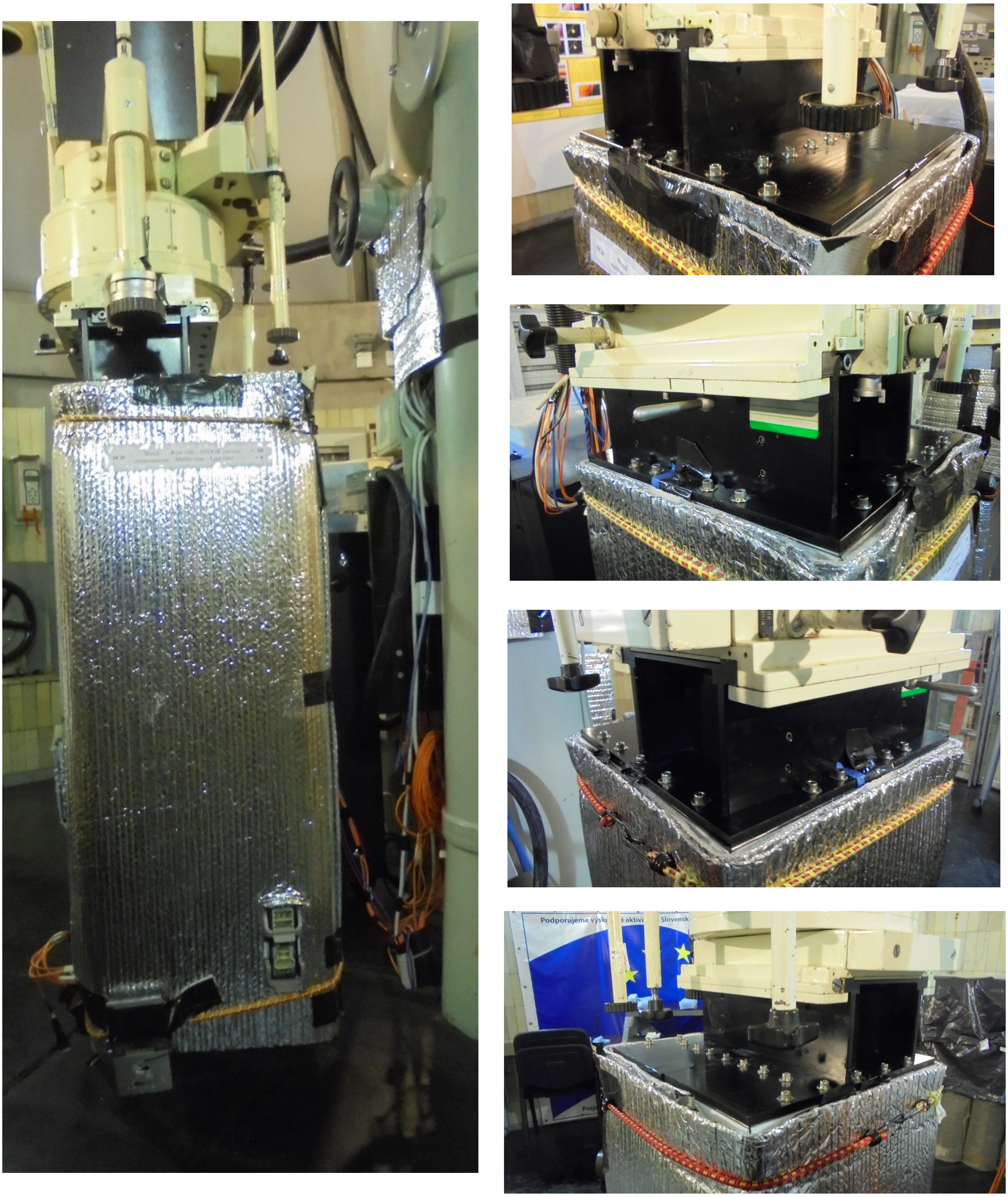

Fig.3: Right: The rare part of the left coronagraph with the SCD instrument box (in silver insulation plastic material) attached to it using the coronagraph rare interface (black metal). Left: views of the coronagraph rare interface from 4 sides.

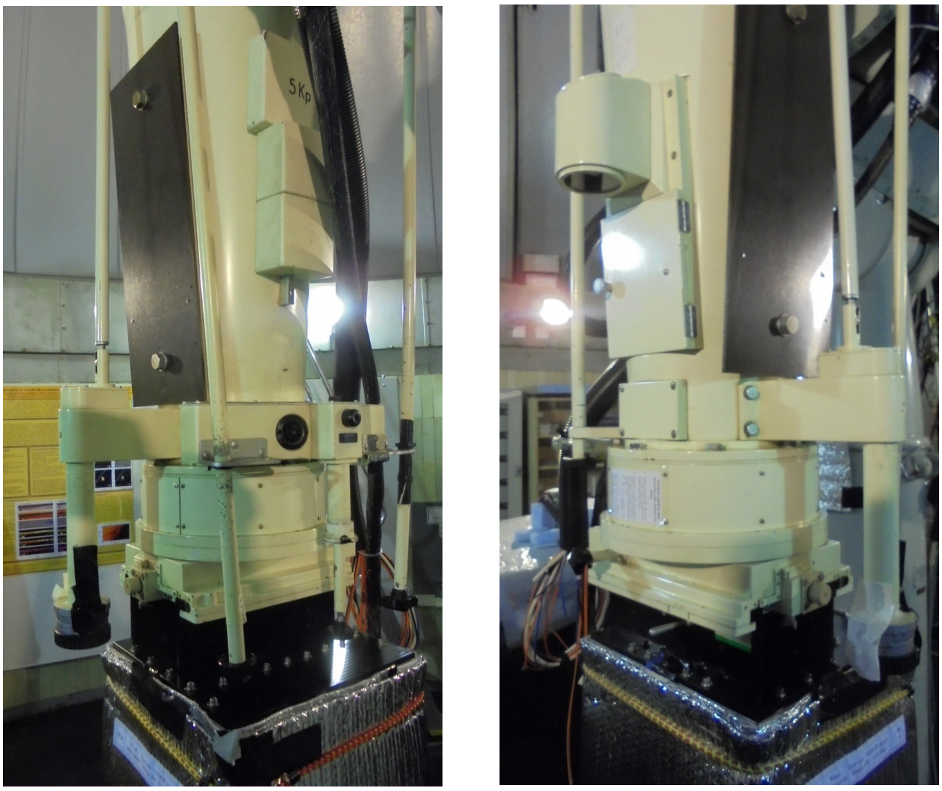

Fig.4: The auxiliary coronagraph parts located in the areas around the rare part of it.

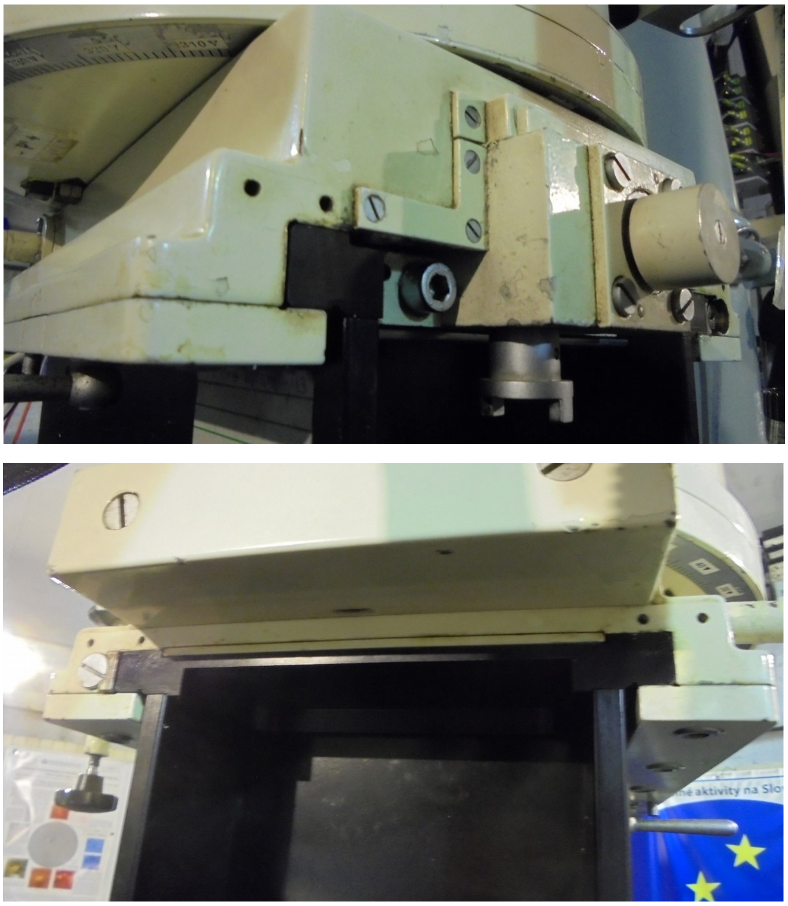

Fig.5: The coronagraph sliding mechanism for radial shift of the post-focus instrument relatively to the optical axis of the coronagraph.