

CISS

Circular Slit Spectrometer

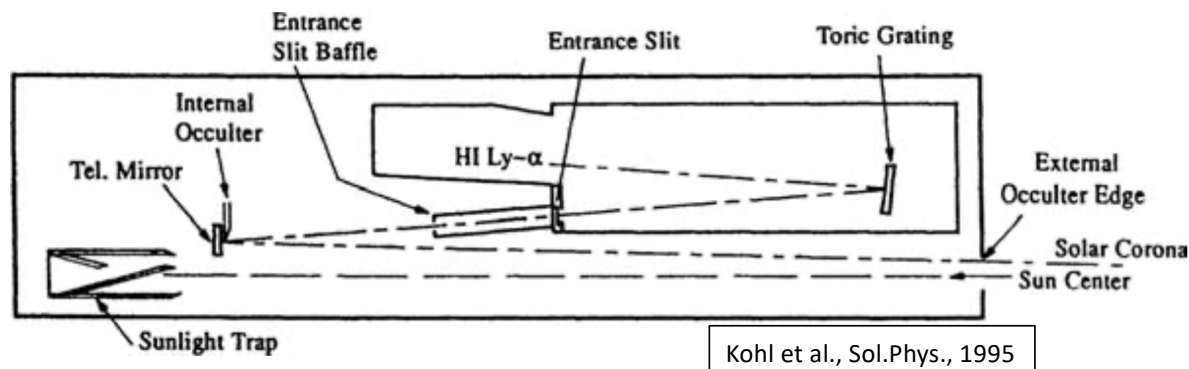
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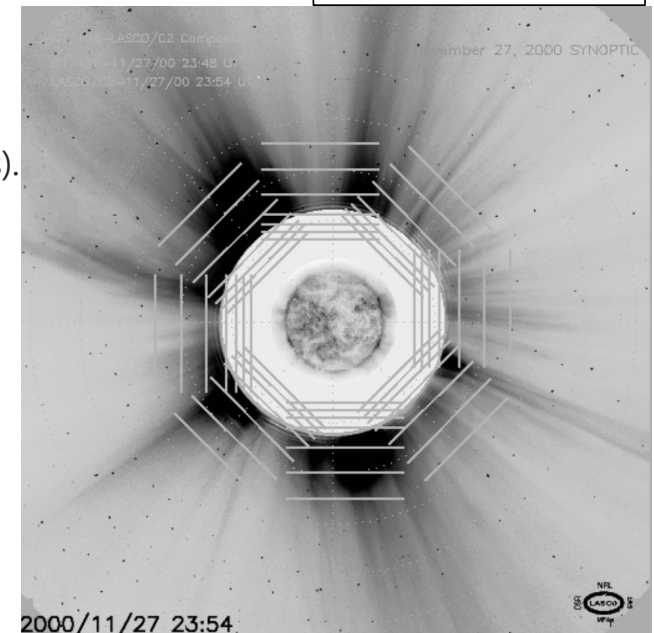
State of the art

- The temperature of the solar corona is above 1 MK. Its spectrum is characterized by several emission lines, many of which in the UV/EUV parts of the spectrum.
- To investigate the physics and the composition of the coronal plasma, spectroscopic investigations are mandatory.
- The only coronagraph spectrometer that has observed the extended solar corona (from 1.5 to 5 Rsun) is SOHO/UVCS (1995-2005): great results but limited spatial and temporal resolution due to the design.
- UVCS provided fundamental breakthroughs in the physics of solar corona, implementing solar wind diagnostics (sources and on acceleration) and allowing to infer physical parameters (electron density, elemental abundances and velocity distributions of many ions).
- Linear slit: mirror tilts and full instrument rolls to patch the entire corona.



Kohl et al., Sol.Phys., 1995

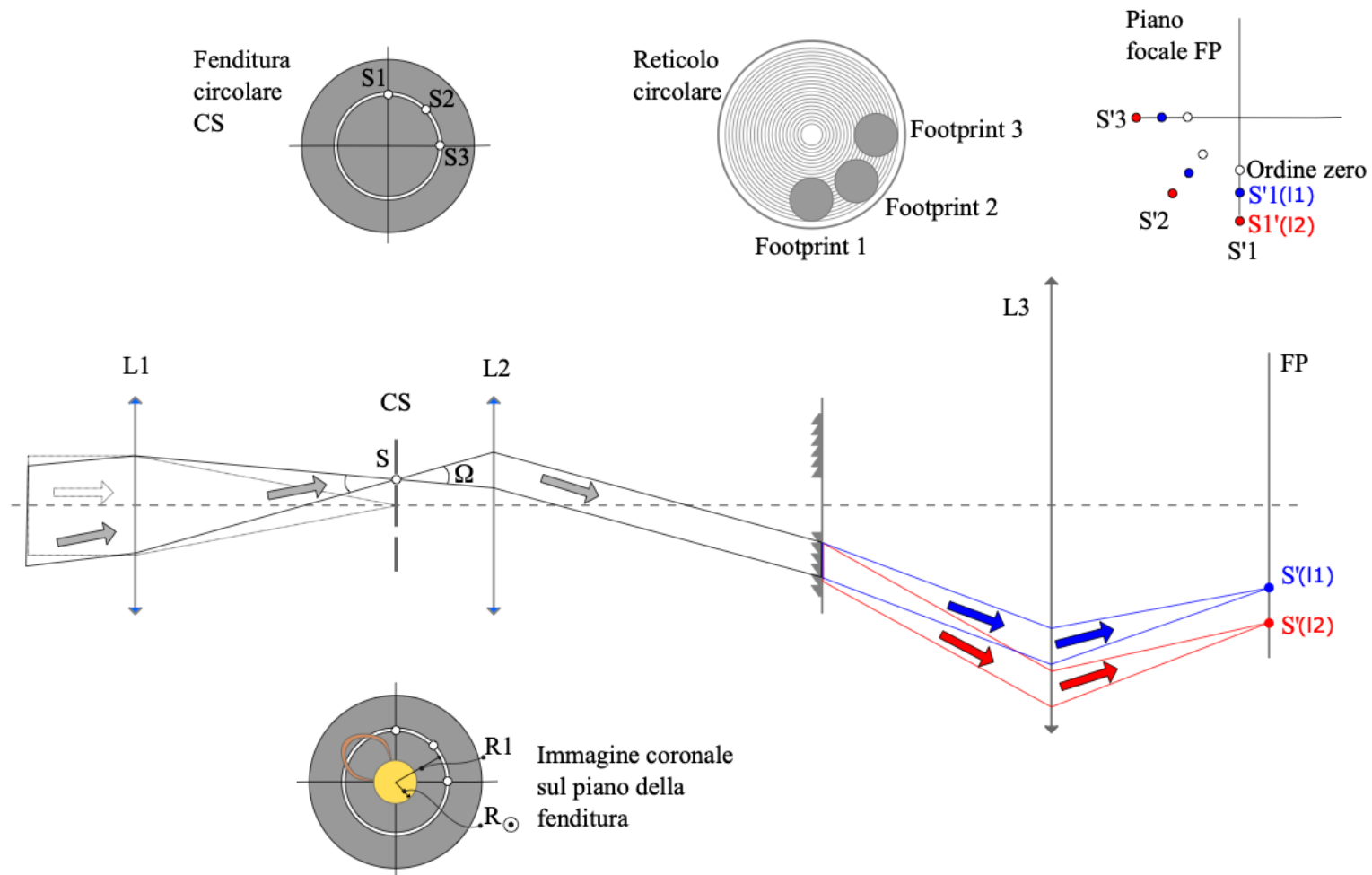
Mancuso et al., A&A, 2014



CISS: Circular Slit Spectrometer

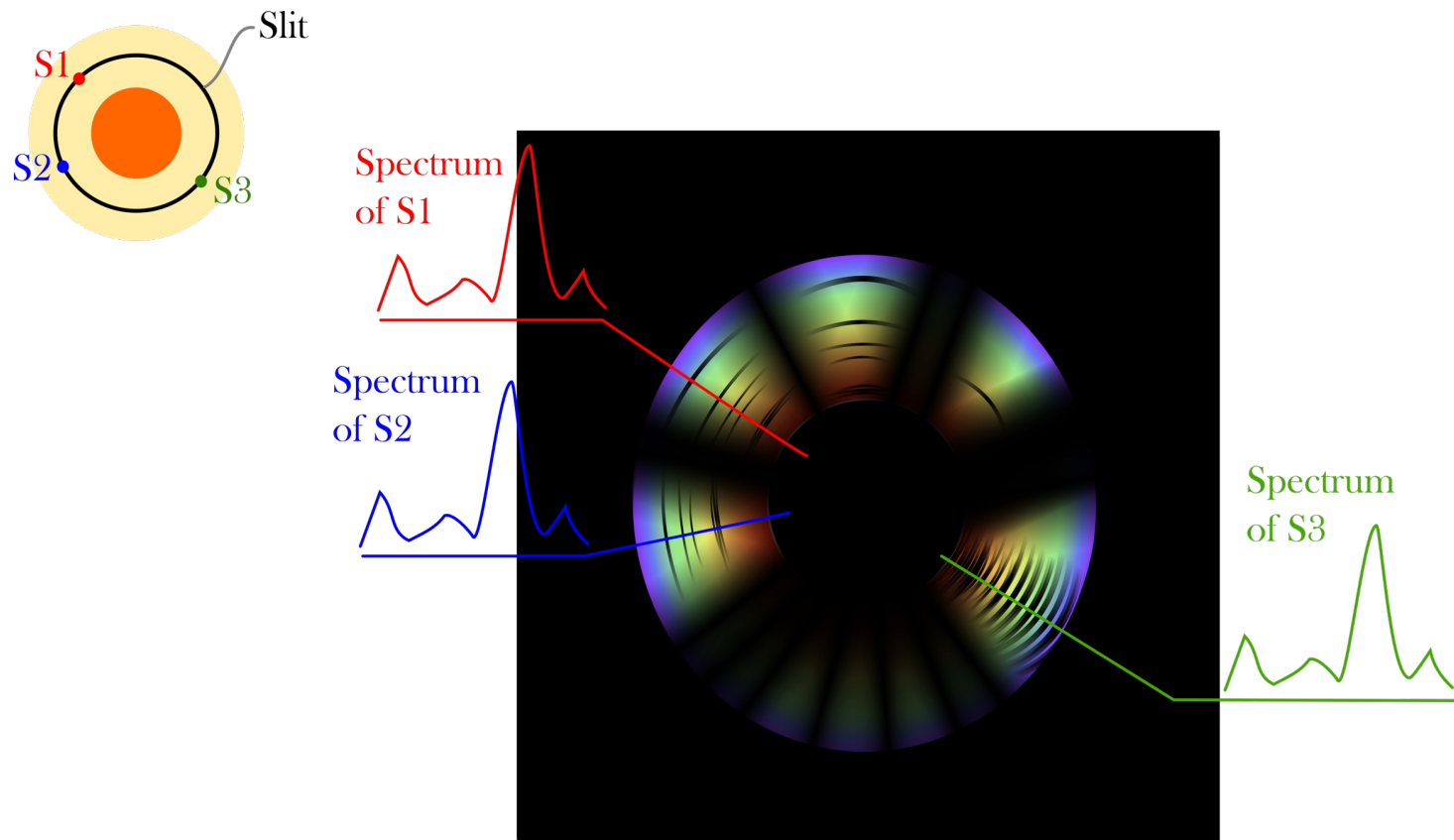
- With UVCS a spectrum of the whole extended corona at full resolution could take up to ~1 day.
- Not Compatible with the spectral investigation of coronal dynamic features.
- In order to perform the investigation by following the dynamical evolution of the solar corona, it is mandatory to reduce the acquisition time by at least 1 order of magnitude.
- A circular slit could eliminate the most demanding of the UVCS degrees of freedom, i.e. the roll. A complete coronal spectrum could be obtained at a fixed heliocentric height.
- By varying the slit radius, different heliocentric heights can be explored.
- CISS: Circular Slit Spectrometer, proposed within the INAF call for fundamental astrophysics 2023, has the required characteristics.
- The CISS paradigm is new, it is something that simply does not exist and shall be proven. Our goal is to design and manufacture a laboratory breadboard of a circular slit spectrometer in the VL, with the ambition of extending its functionality to the UV in the near future.

CISS principle 1/2



CISS principle 2/2

For each source element on the slit we obtain a radial spectrum on the focal plane

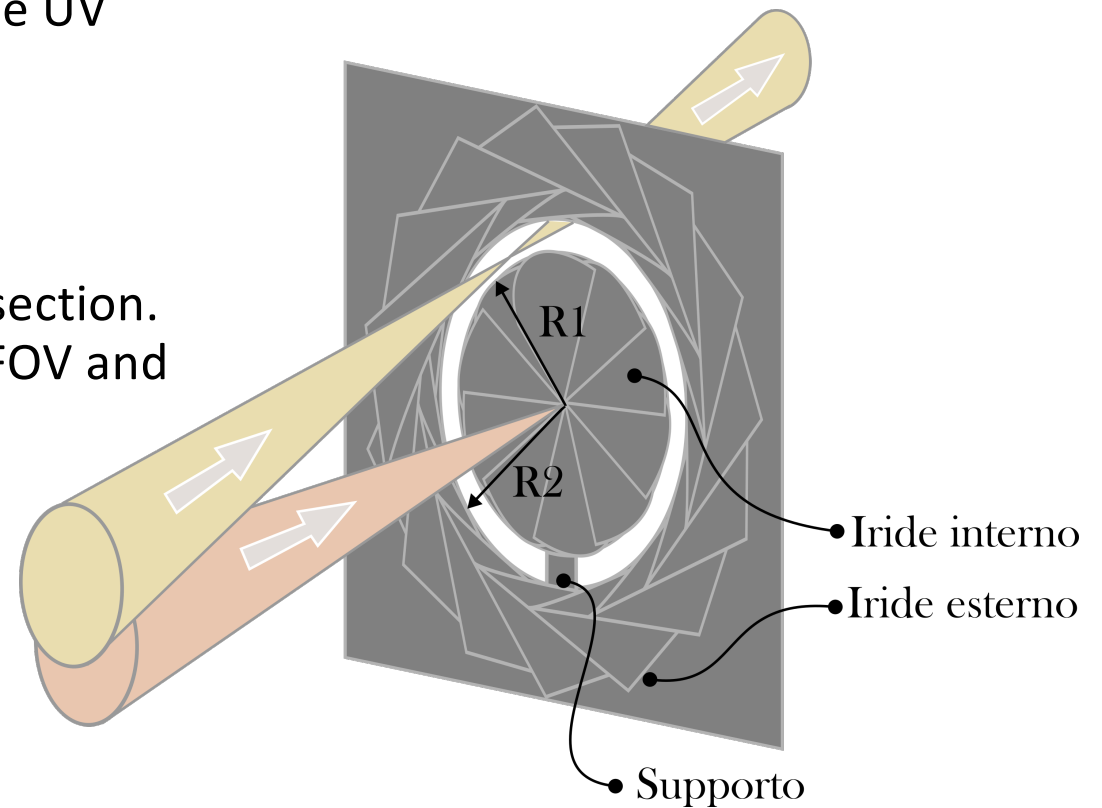


Circular grating and Circular slit

- Circular grating
 - Inprentus Inc. has been contacted to probe the feasibility: the grating can be manufactured.
 - Criticality: the working principle of CISS is based on the local approximation of grating linearity. The larger the grating (at fixed resolution), the better the approximation and the higher the cost.
 - Goal: find the best trade off between grating dimension and cost. A possible work-around is to manufacture a breadboard grating made by just a circular sector, which would contain the costs and allow to prove the principle.
- Circular slit with variable radius
 - Mechanical: two mechanism working similarly to optical irises.
 - Optical: actuated micro-mirrors (MEMS, microelectromechanical systems).

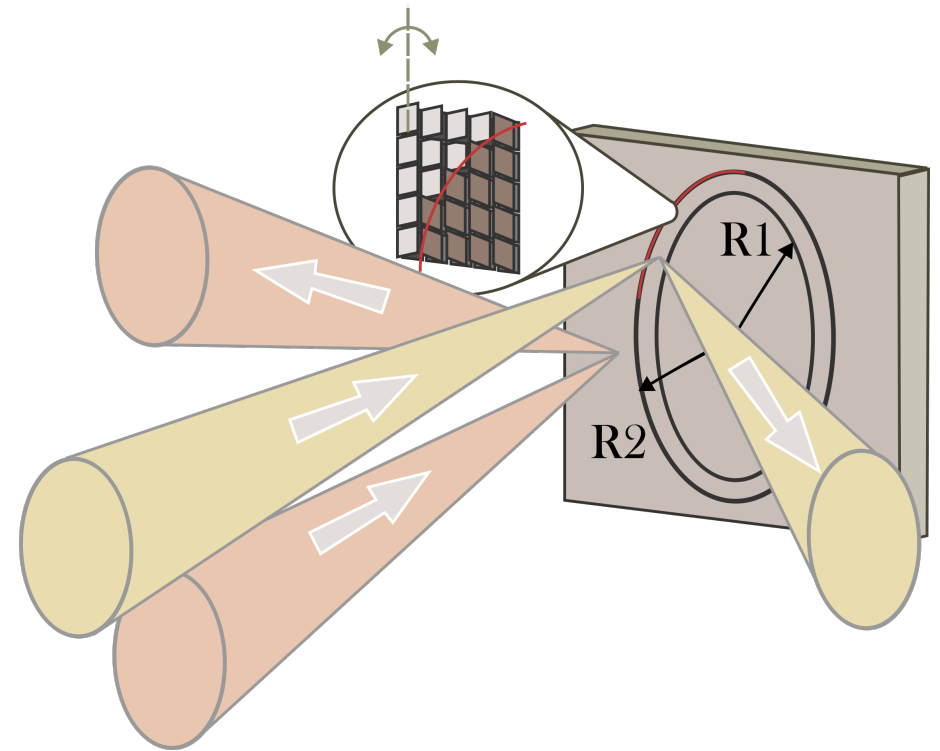
Circular slit, mechanical version

- Pros: it can directly be extended to the UV
- Cons:
 - Co-planarity not easy to achieve
 - Need for supporting the internal section. A pylon would vignette part of the FOV and produce stray light.



Circular slit, optical version: MEMS

- Pros: can provide unprecedented flexibility
(like, for example, select portions of the circle to explore delimited areas of the solar corona and increase the resolution)
- Cons:
 - Need for accurate coating calibration.
 - Coating development needed for extending its application to the UV.



Activity

- 1st year:
 - Prototype optical design, optics purchase
 - Grating design and development
 - Slit design and development
- 2nd year:
 - Prototype sub-system characterization in laboratory (CNR-IFN Padova)
 - Prototype integration and calibration (INAF-OPSys – Torino)

Conclusion

- A proper investigation on the physics of the solar corona cannot be performed without spectroscopy.
- The unique coronagraph spectrometer that has observed the extended solar corona is SOHO/UVCS (1995-2005): great results but poor spatial and temporal resolution due to the design.
- An evolution can be obtained by introducing the new concept of circular slit, which allows to perform spectroscopy of the whole corona at a fixed heliocentric height. By varying the slit radius, different heights can be explored.
- The CISS (Circular Slit Spectrometer) project aims at designing and manufacturing a prototype of spectrometer with a variable diameter circular slit and a circular grating. For the time being it will be designed for the VL, but the long-term goal is to explore the UV.
- A circular slit with variable diameter can be obtained either with a double optical iris or by using MEMS.
- The prototype will be assembled and tested in the CNR-IFN and INAF-OPSys laboratories.
- Thought for solar physics but applicable to all investigations with suitable symmetry.