Cleanliness and Calibration stability of UV instruments on SOHO

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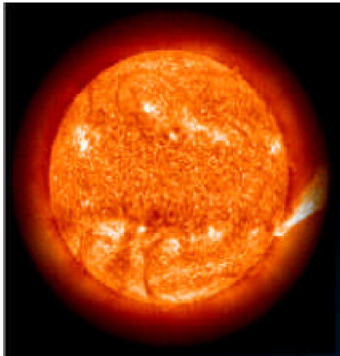

Outline of the talk

- Conclusions
- Cleanliness efforts for SOHO UV instruments
- Calibration stability of SOHO UV instruments: some results
- Relevance for future solar missions

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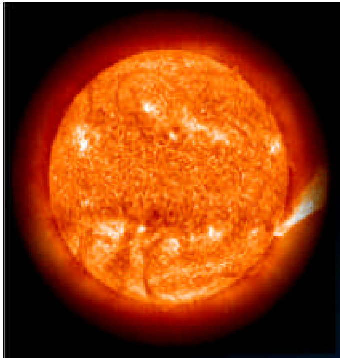

Conclusions

- SOHO UV instruments have been very stable due to the successful cleanliness program.

but

- SOHO UV detectors have been remarkably unstable.

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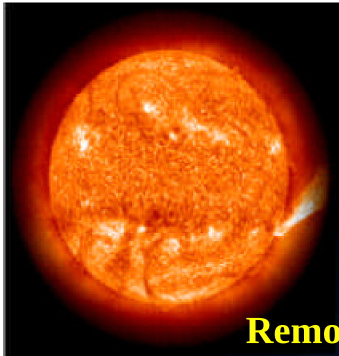


Instruments on SOHO

Remote sensing Instrumentation:

- CDS (Coronal Diagnostics Spectrometer)
- EIT (Extreme ultraviolet Imaging Telescope)
- SUMER (Solar Ultraviolet Measurements of
- SWAN (Solar Wind Anisotropies)
- UVCS (Ultraviolet Coronagraph Spectromete
- LASCO (Large Angle and Spectrometric Coronagraph)

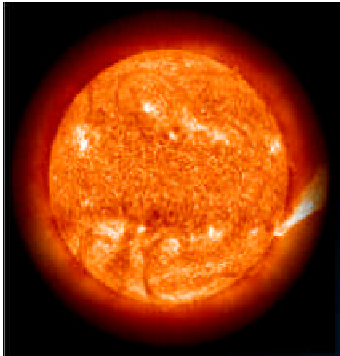
Ultraviolet remote sensing telescopes and spectrographs:
CDS
EIT
SUMER
UVCS

Helioseismology Instrumentation:

- MDI/SOI (Michelson Doppler Imager/Solar Oscillations Investigation)
- GOLF (Global Oscillations at Low Frequencies)
- VIRGO (Variability of Solar Irradiance and Gravity Oscillations)

In-situ instrumentation:

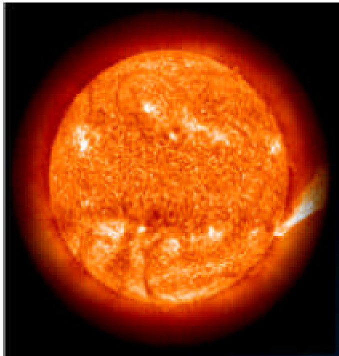
- CELIAS (Charge, Element, and Isotope Analysis System)
- COSTEP (Comprehensive Suprathermal and Energetic Particle Analyzer)
- ERNE (Energetic and Relativistic Nuclei and Electron experiment)



Stability of calibration: concerns

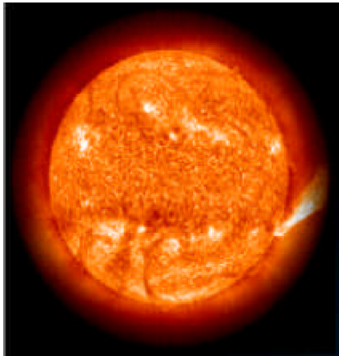
- Molecular contamination
  - From outgassing organic materials
  - From ground facilities and test environment
- Polymerisation of organic contaminants by solar UV (especially on mirrors of solar instruments)

  ➔ Degradation of responsivity
- Laboratory and space experiments have quantitatively measured the UV-degradation.



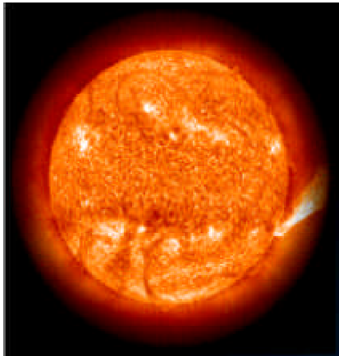
Calibration degradation: preventive measures (1)

- Establishment of SOHO Cleanliness Review Board and SOHO Intercalibration Working Group
- SOHO Cleanliness Control Plan
- Instrument Cleanliness Control Plans



Calibration degradation: preventive measures (2)

- Most important preventive measures:
  - Determine your contamination sensitivity
  - Design your instrument for cleanliness: Design features, material selection
  - Avoid contamination during ground handling



Cleanliness design rules (derived for SUMER)

- Clean metal optical housing (no organic composite material)
- Avoid organic material inside optical housing (to minimise potential outgassing)
- Aperture door to close/open the optical compartment (to reduce ingress from outside)
- Solar wind deflector plates (with HV applied to deflect solar wind away from the telescope mirror)
- Use of ultra-high vacuum components/materials inside optical housing (high-T materials)
- Keep electronic components outside optical housing (to keep organic materials outside)
- Large venting ports for all subsections of the optical housing (for efficient venting)
- Purging of optical compartments at all times (to overpressurise and clean away offgassing species)
- Keep primary mirror at highest temperature by solar illumination (to reduce deposition on sensitive surfaces)
- Dry lubrication on MoS_2 basis for all mechanisms (inorganic lubrication, no outgassing)
- Use flexural metal pivots instead of bearings where possible (no lubrication needed)

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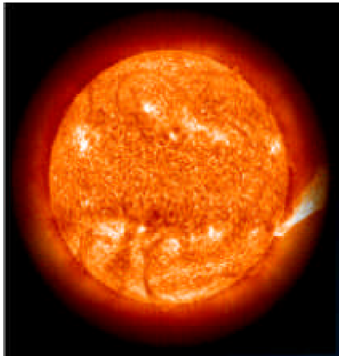

Calibration stability, In-flight calibration

Laboratory calibration by secondary source standards traceable to a primary standard.

In-flight calibration tracking by observing a constant source:

- the “quiet Sun”
- celestial standards (stars)
- calibration lamps (not for SOHO)
- Calibration updates by rocket “underflight”

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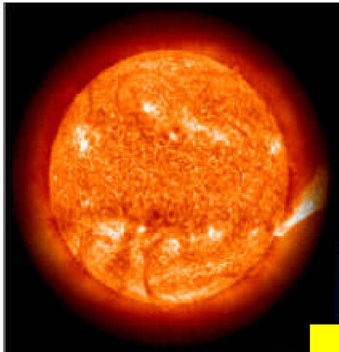
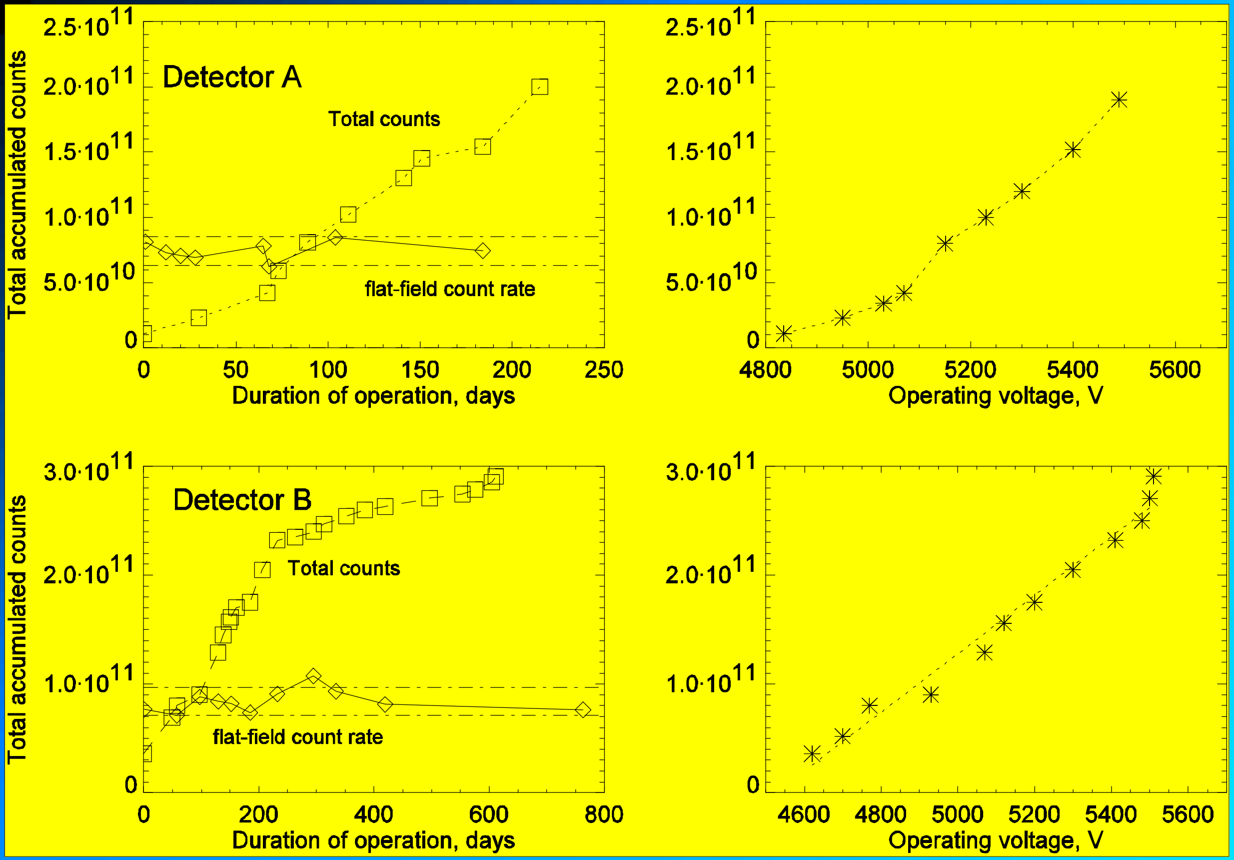


Calibration stability of SOHO instruments (example: SUMER)



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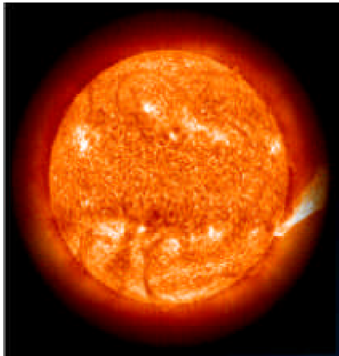
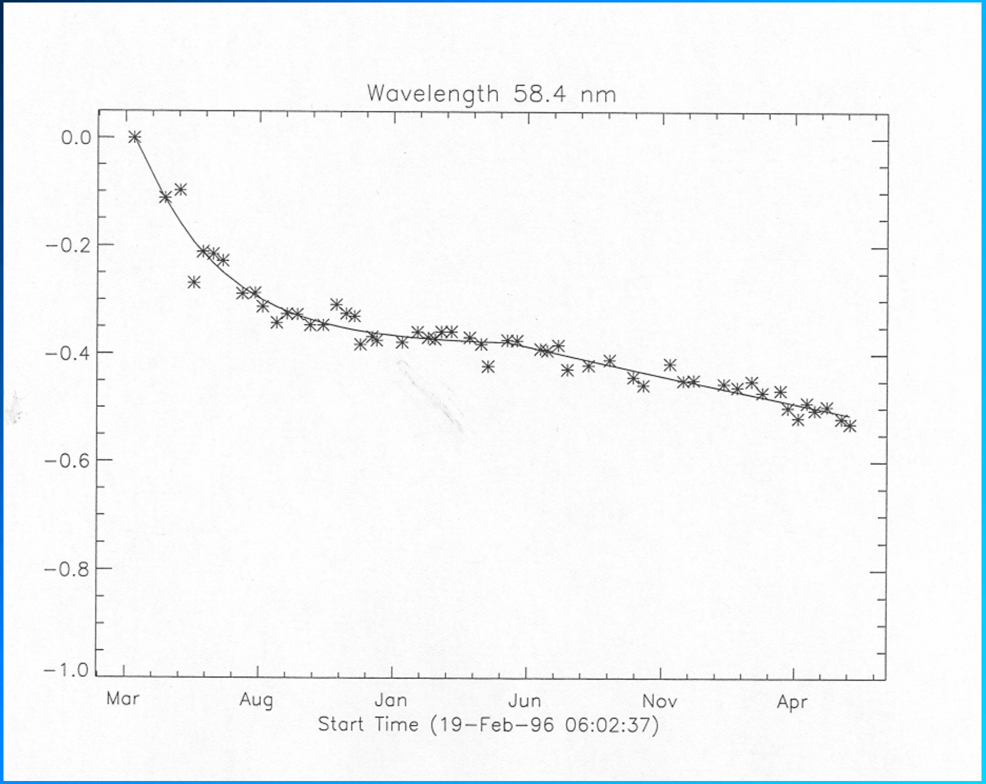


CDS burn-in of NIS detector at 58.4 nm



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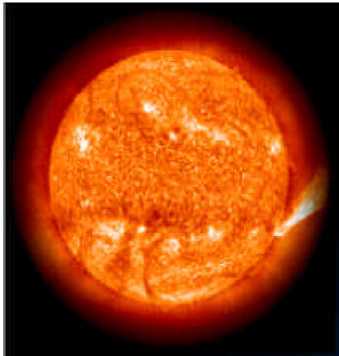

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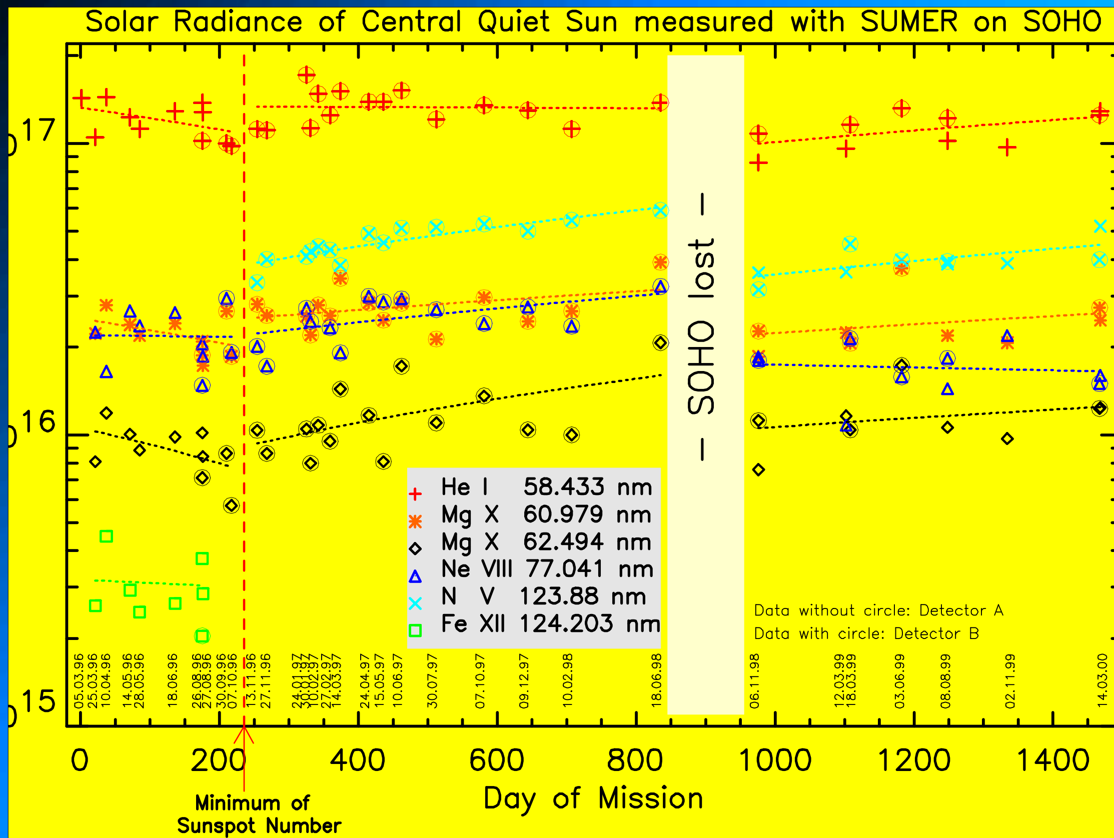

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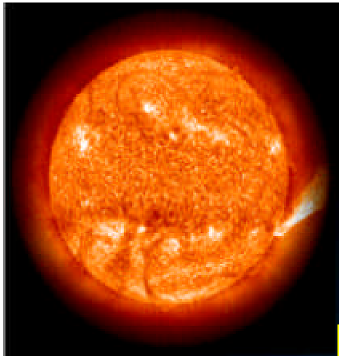

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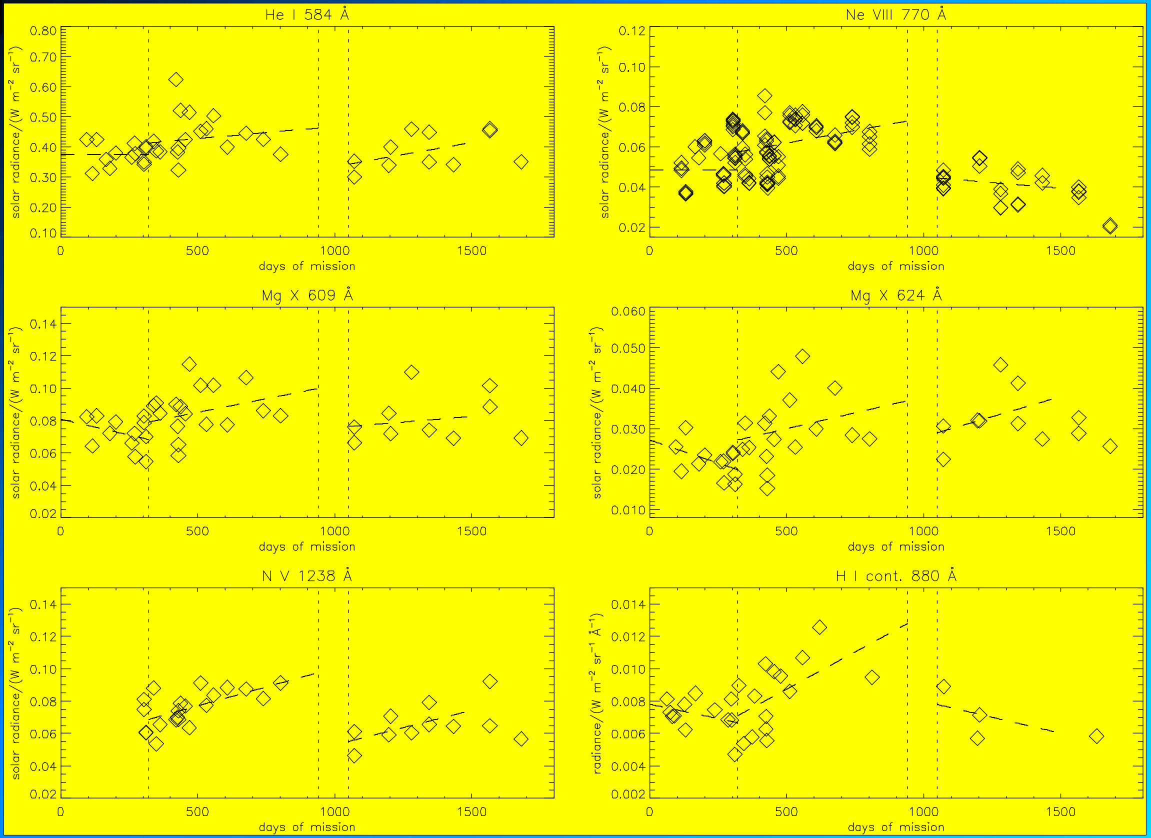

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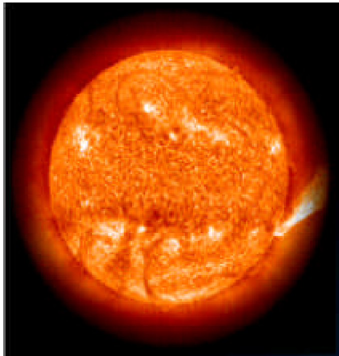
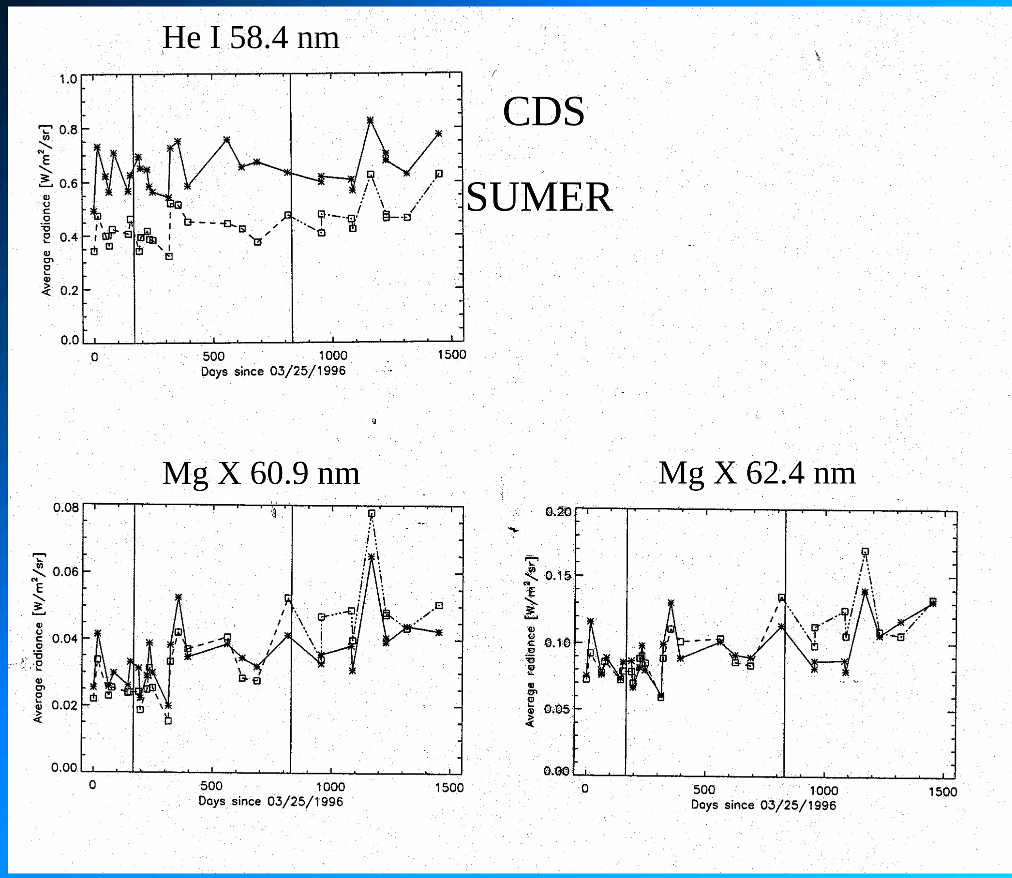


Intercalibration of SUMER and CDS



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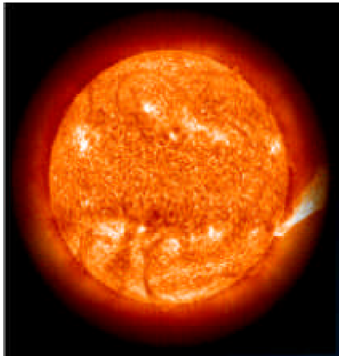
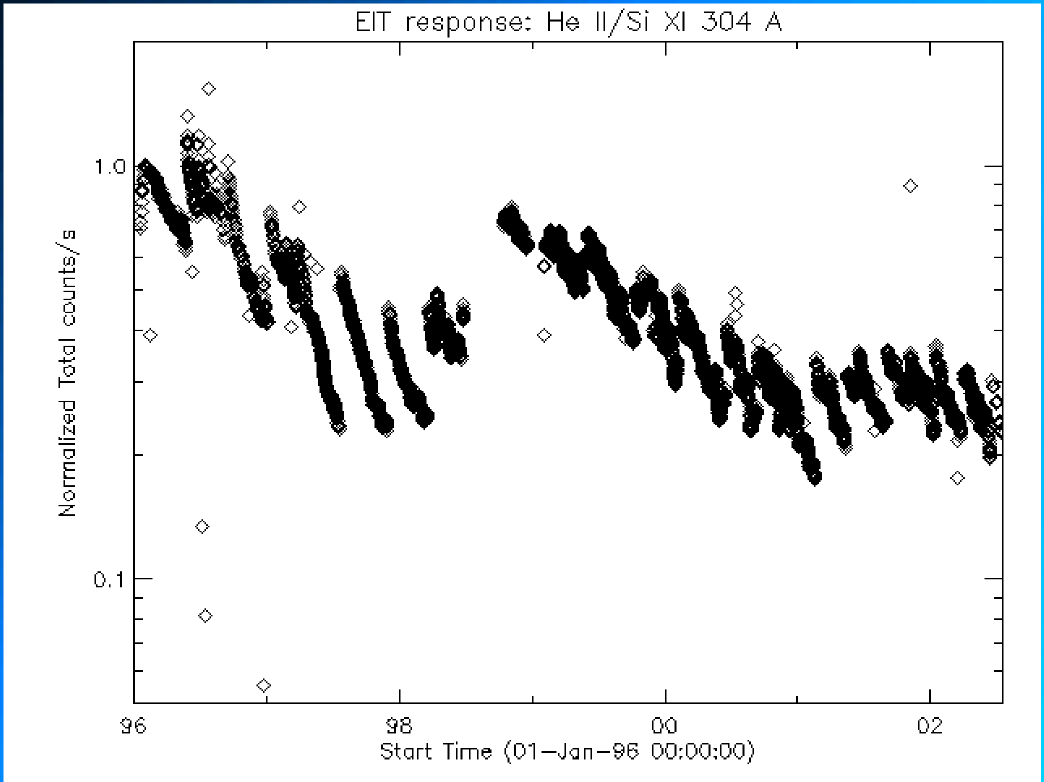


Example EIT: 304Å response vs. time



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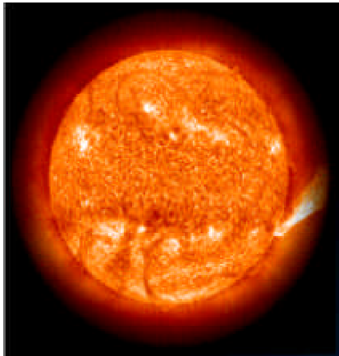


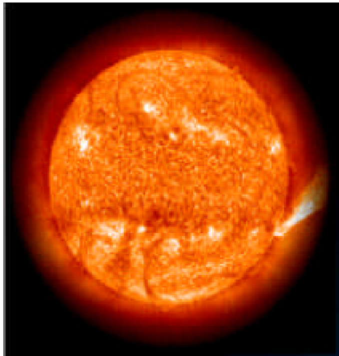
Relevance for future solar missions

- SOHO has extremely stable orbit:
  - Always Sun pointing
  - No eclipses
  - No (almost) changes to the orbit

  ⇒Thermal stability

- Future missions might not have such stable conditions (e.g. SDO, Solar Orbiter)

  ⇒Redistribution of contaminants, temperature sensitivity



Lessons learned from SOHO

- Calibration tracking throughout a mission is very difficult. Thus, recalibration, Intercalibration among instruments and calibration underflights are necessary
- The cleanliness efforts have been necessary and were not excessive
- Cleanliness design (at spacecraft and instrument level) greatly reduces contamination

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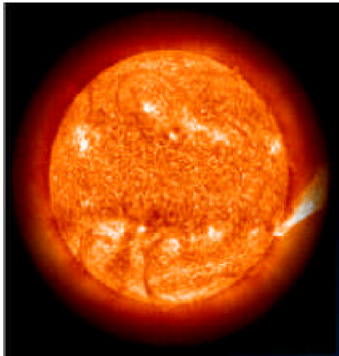

Literature

- For further information read the book:

  “The Radiometric Calibration of SOHO“,
  ISSI Scientific Report SR-002, in press, 2002,
  (eds. A. Pauluhn, M.C.E. Huber, and R. v. Steiger)