Degradation Free Spectrometers for Solar Physics NASA-36.263 (Judge)

USC Space Sciences Center

Dr. D. Judge, PI

Dr. L. Didkovsky, Co-I

Dr. S. Wieman, Co-I

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Degradation of EUV and Soft X-Ray Instruments

All existing short wavelength instruments currently in space develop a time-dependent (and instrument dependent) rate of degradation of their optics, including reflective surfaces of telescope mirrors, reflection diffraction gratings, and thin-film filters. The degradation is produced by a contamination layer (typically by a hydro-carbon) which changes the reflection or transmission of the instrument's optics.

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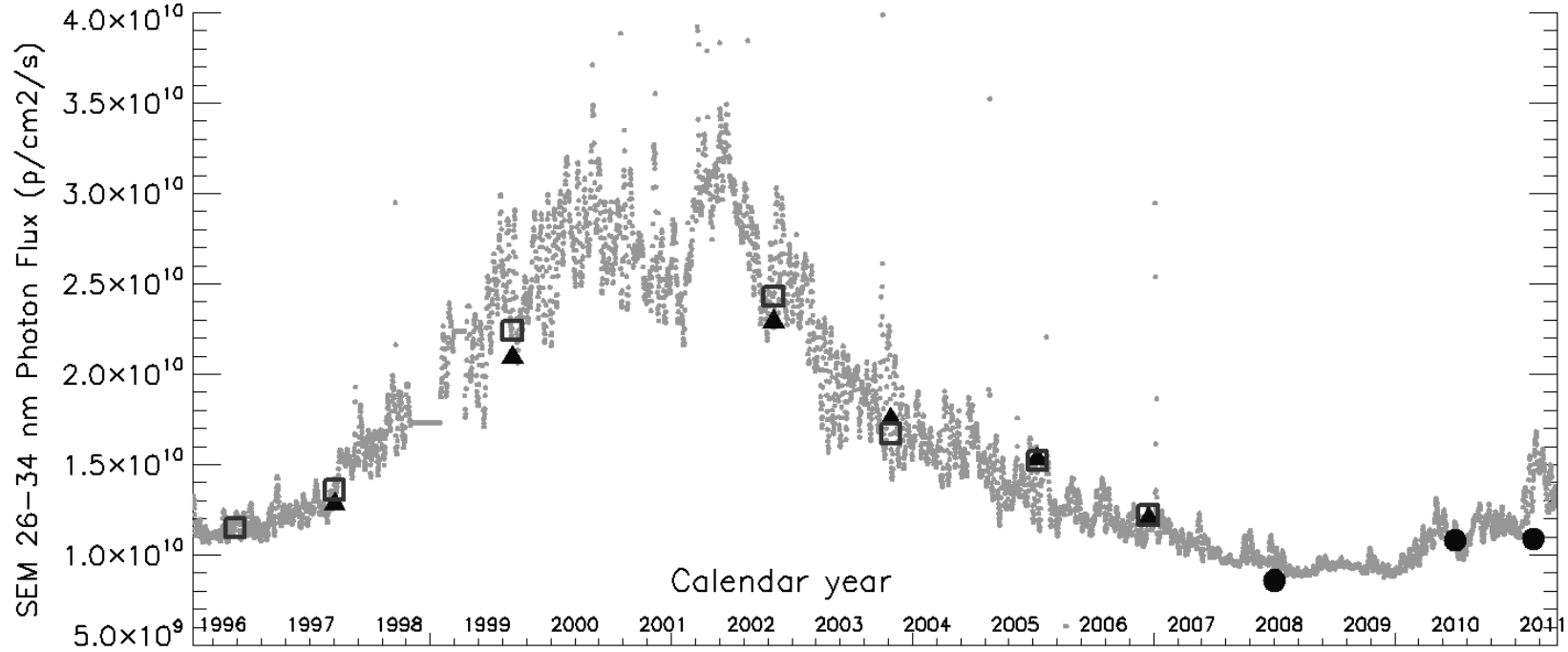
How Degradation Rate Affects EUV and Soft X-Ray Measurements

Degradation rate is wavelength dependent and in some spectral regions may decrease the efficiency of the instrument by 200% or more. The rate is hard to measure in space. Sounding rocket flights with copies (clones) of flight instruments are required to provide the measurements of the degradation rate (see next slide).

An Example of SOHO/CELIAS/SEM Flight and Underflight Data

Judge, Ogawa, McMullin. Solar Phys. 177, (1998), Didkovsky, Judge, Wieman, ASP Conf. Ser.428, (2010)



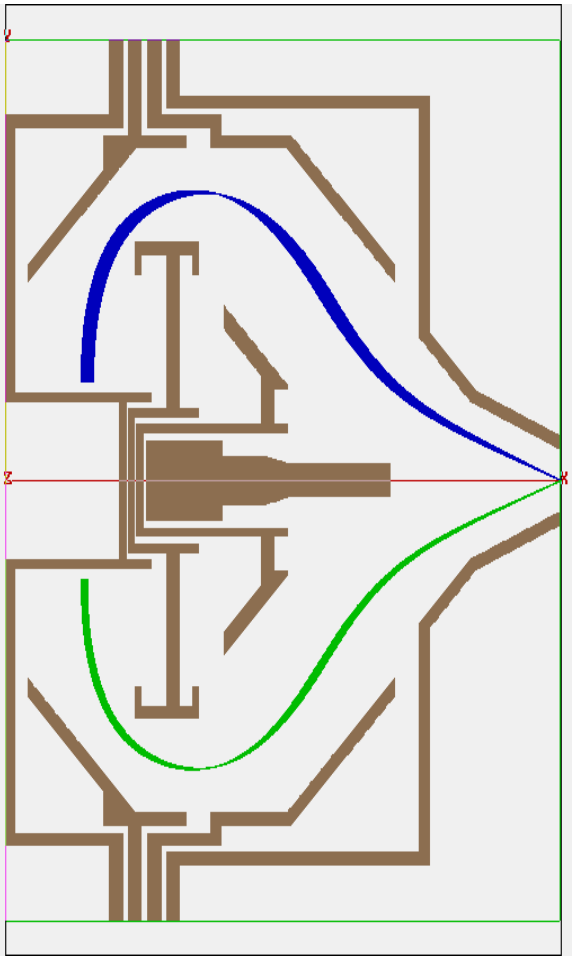
SOHO/CELIAS/SEM daily average 26-34nm irradiance measurements (gray dots - expressed in photon flux units) are nearly continuous, with the exception of the SOHO mission interruption that took place around day 1000, over the entire SOHO mission. Black triangles and squares represent sounding rocket calibration measurements using the SEM clone instrument and RGIC respectively. SDO/EVE/ESP data are filled circles.

NASA 36.263 Science and Technical Goals

- First flight of two new degradation-free EUV instruments: an advanced Optics-Free Spectrometer (OFS) and a Dual-Grating Spectrometer (DGS). These two instruments have no optical surfaces or thin-film filters to degrade. Detectors use digital pulse counting (Amptek) design and are practically insensitive to any change of the pulse height (electronics gain).
- To validate new degradation-free EUV instruments that can significantly improve long-term accuracy of absolute solar irradiance measurements and thus permit a more critical analysis of solar physics models.
- In addition to the OFS and DGS on 36.263 we will fly a SOHO/SEM clone and a Rare Gas Ionization Cell (RGIC) instruments for absolute integrated solar flux calibration.
- Inter-calibration with other space EUV data, such as SOHO/SEM, TIMED/SEE, and SDO/EVE

New OFS For 36.263

Didkovsky, Judge, Wieman. SPIE 6689, 2007



- **No Degradable Optics and Filters**
- **Completely blind to the visible light**
- **Adjustable wavelength range of interest**
- **7-electrode focusing** (the design previously flown by USC used two electrodes) to provide better focusing, which in turn provides stronger signal and better spectral resolution. Blue and green beams of photo-electrons from the ionized target gas are shown on the left. Brown areas represent cross-sections through the axi-symmetric electrodes.
- **Compact and scalable design;**
- **Modeled Spectral Resolution 0.1 nm or better**

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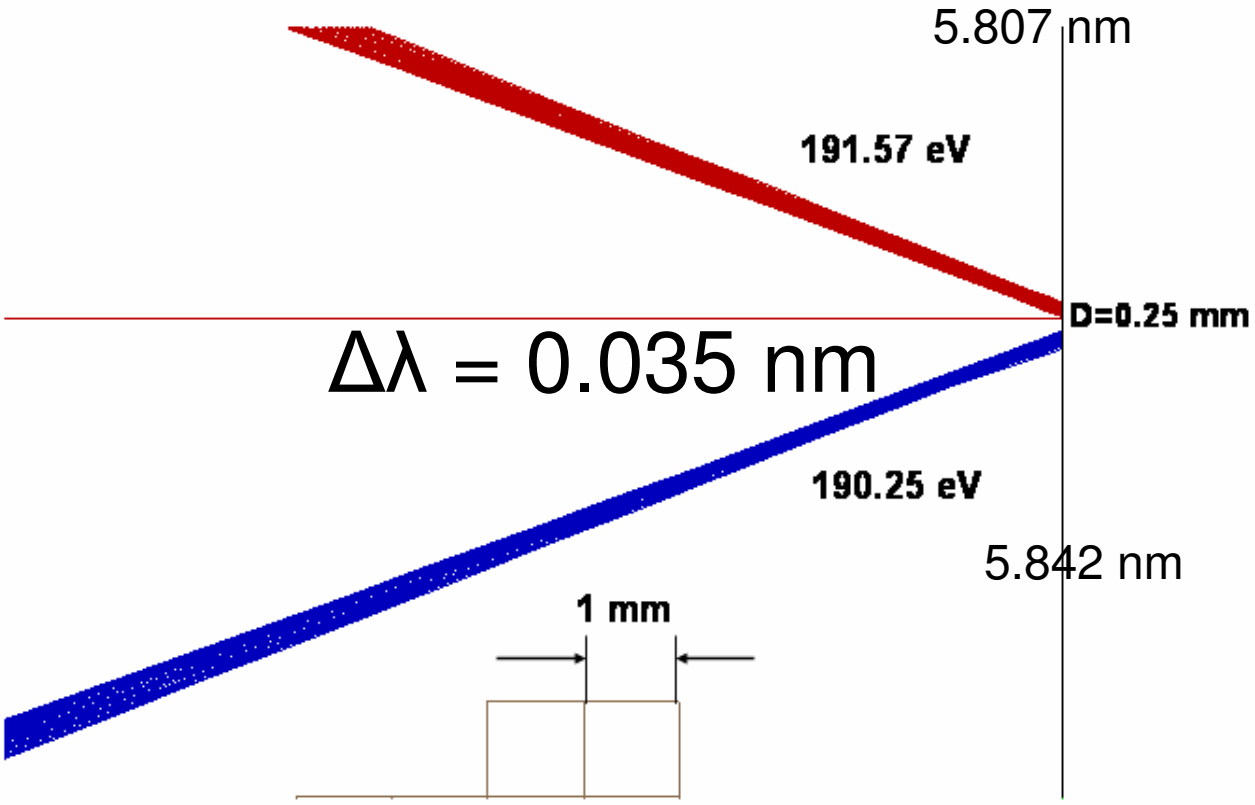
OFS Modeled Spectral Resolution



Example of exit slit approach trajectories are shown for electrons that enter the focusing system with two slightly different initial energies: 190.25 eV (blue paths) and 191.57 eV (red paths). A detector with an entrance aperture of 0.5 mm will allow spectral resolution of 0.035 nm

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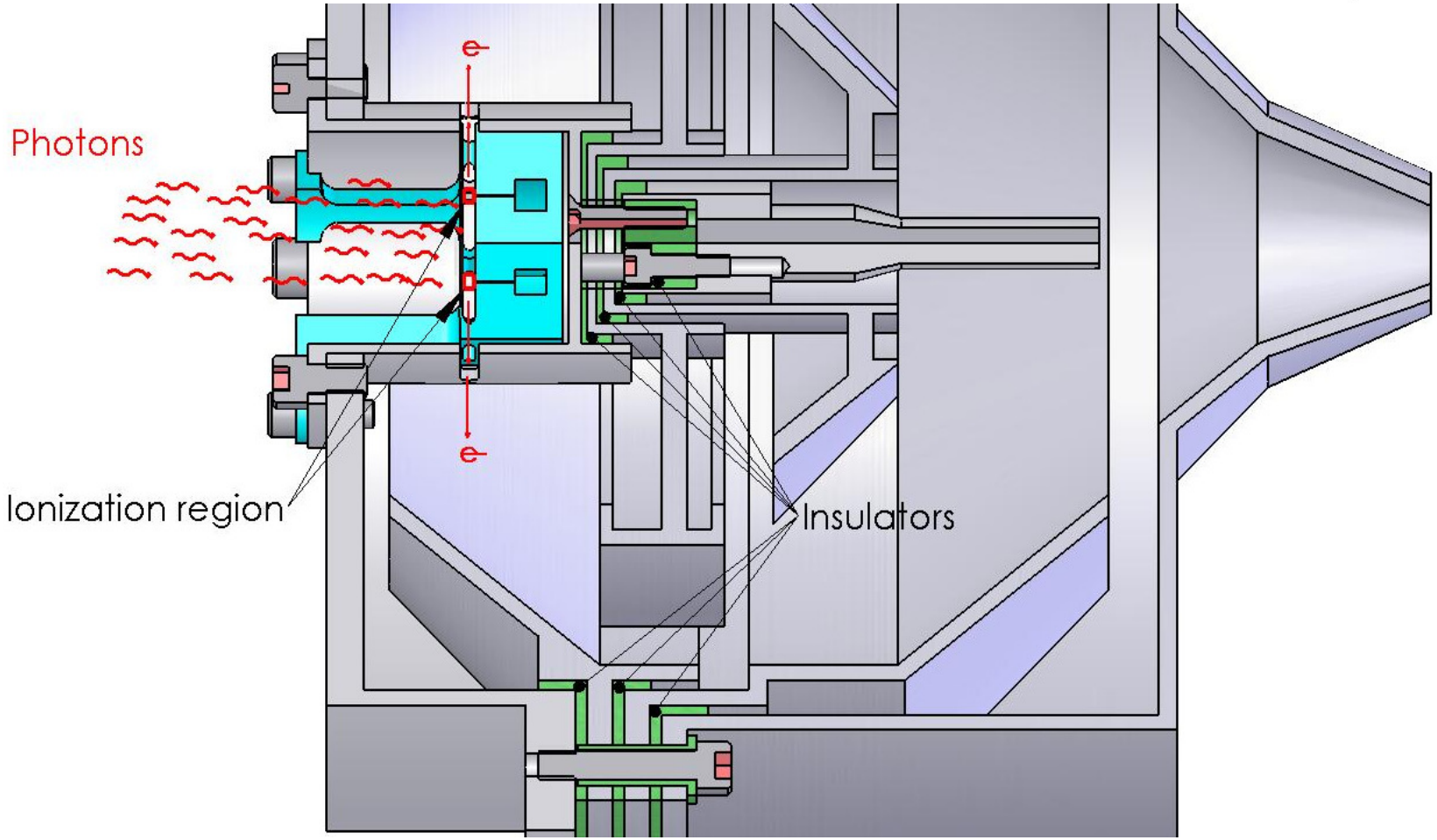
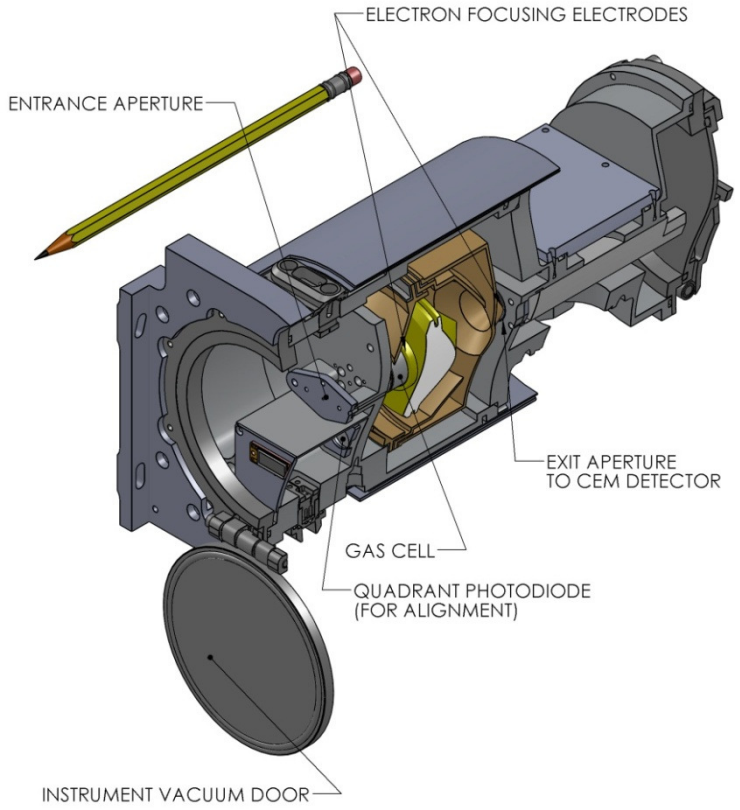
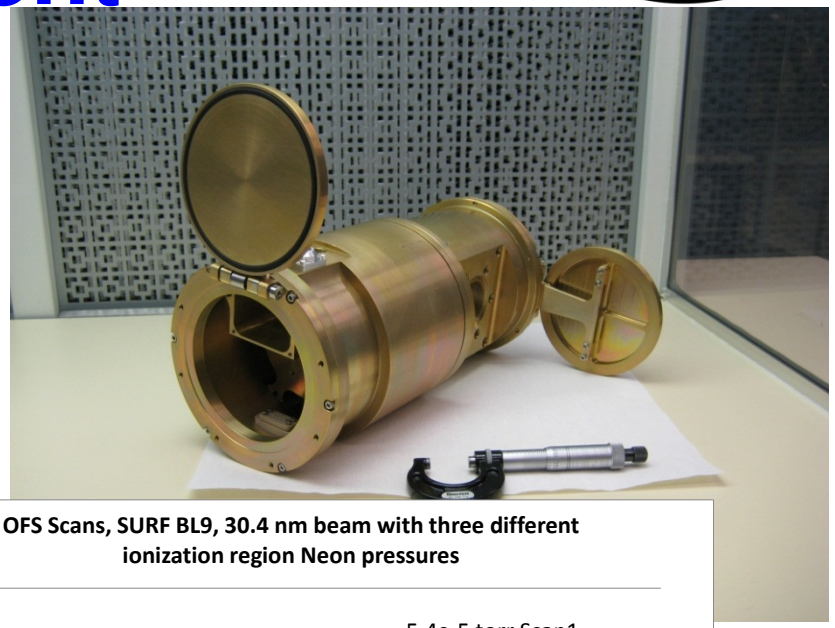
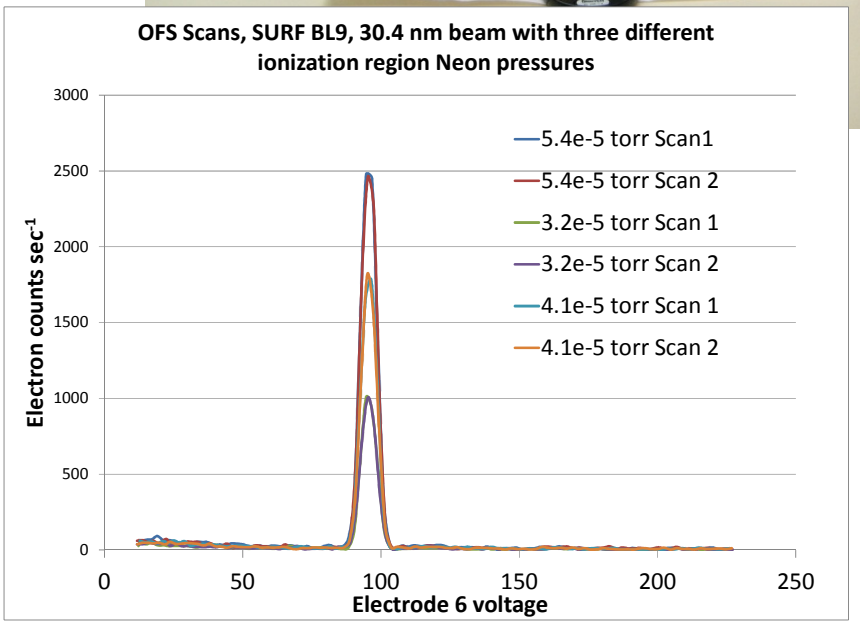
OFS Ionization Area



OFS: From a Solid Works Model to a Rocket Instrument



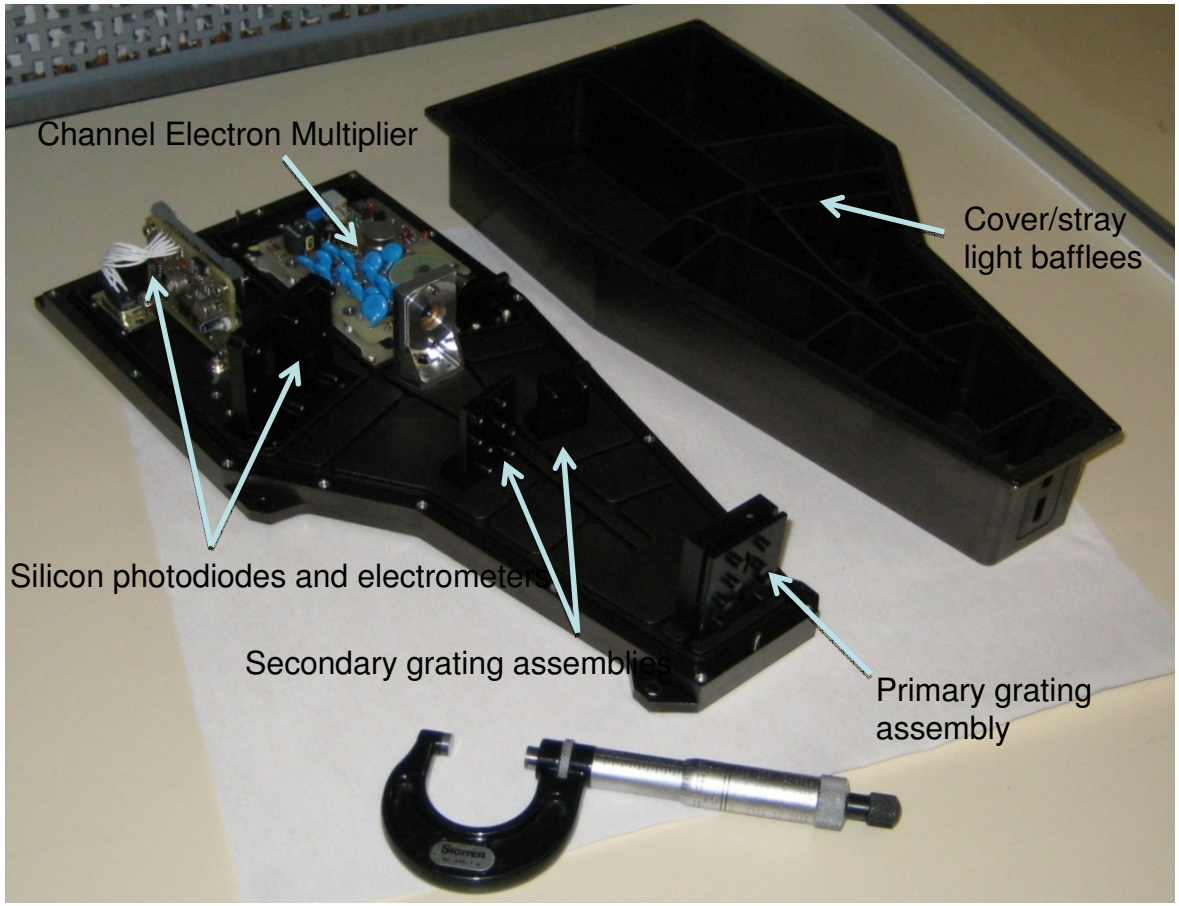




OFS measurements of monochromatic (30.4 nm) photons from NIST BL9 (June 2012) using three different gas cell pressures

Dual-Grating Spectrometer (DGS)

Wieman, Didkovsky, Judge, Jones. "SPIE 6689-23, San Diego (2007)



- Optical layout provides excellent rejection of out of band "white" light, thus allowing the isolation of specific EUV bands **without the use of thin film filters**
- Flight demonstration model Includes two first order channels covering 4 nm bands centered on the Helium 30.4 nm line and one 8 nm band centered on Lyman-alpha.
- Uses stable silicon photodiode and channel electron multiplier detectors

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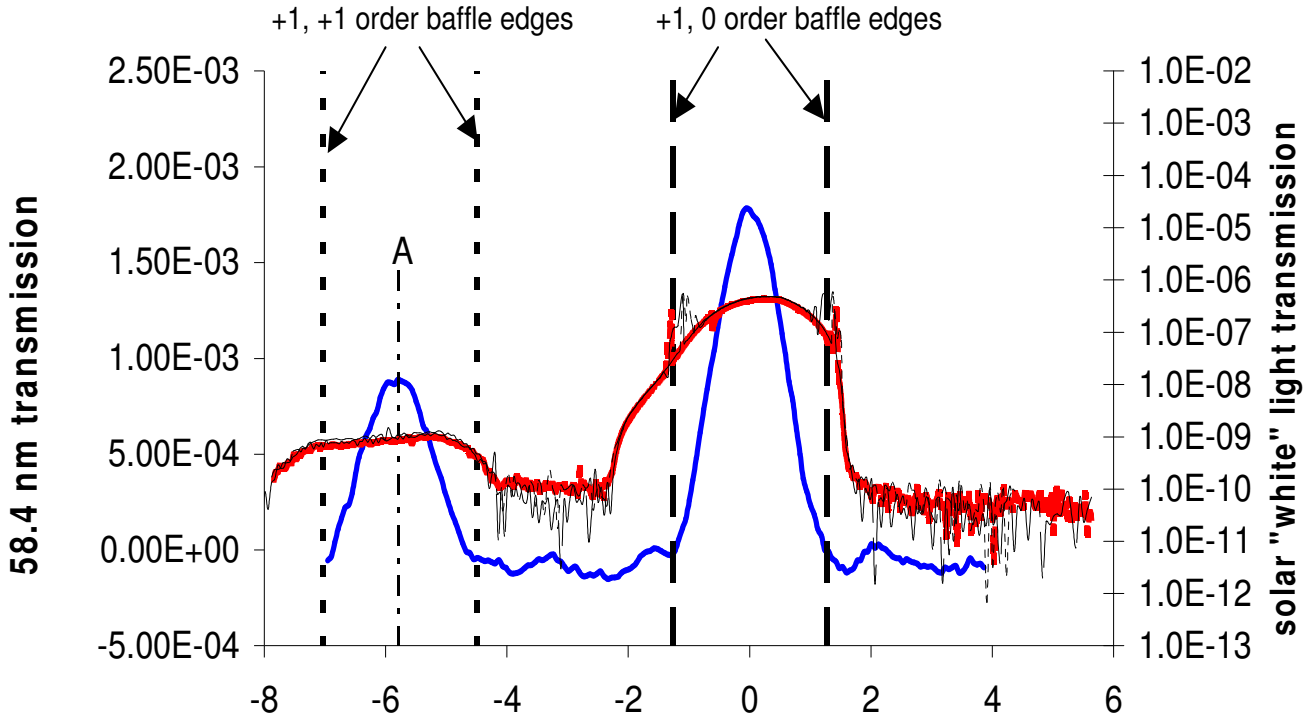
Dual-Grating Spectrometer (DGS)



Measurements of photon transmission as a function of position on the DGS detector plane for 58.4nm EUV photons (blue line) and visible “white” light (red line)

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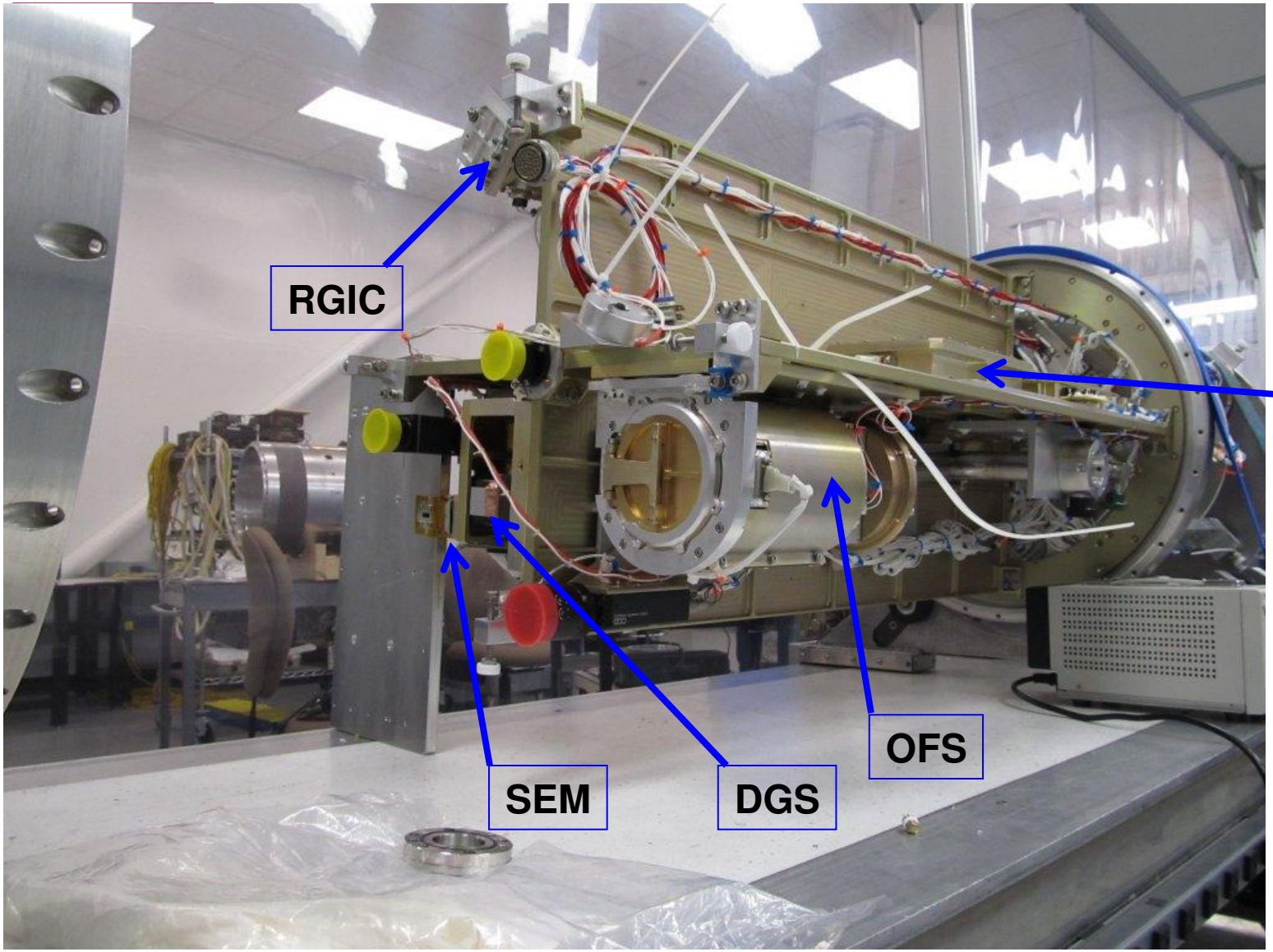
Partial Interior Assembly of 36.263 (Judge) Payload at WSMR



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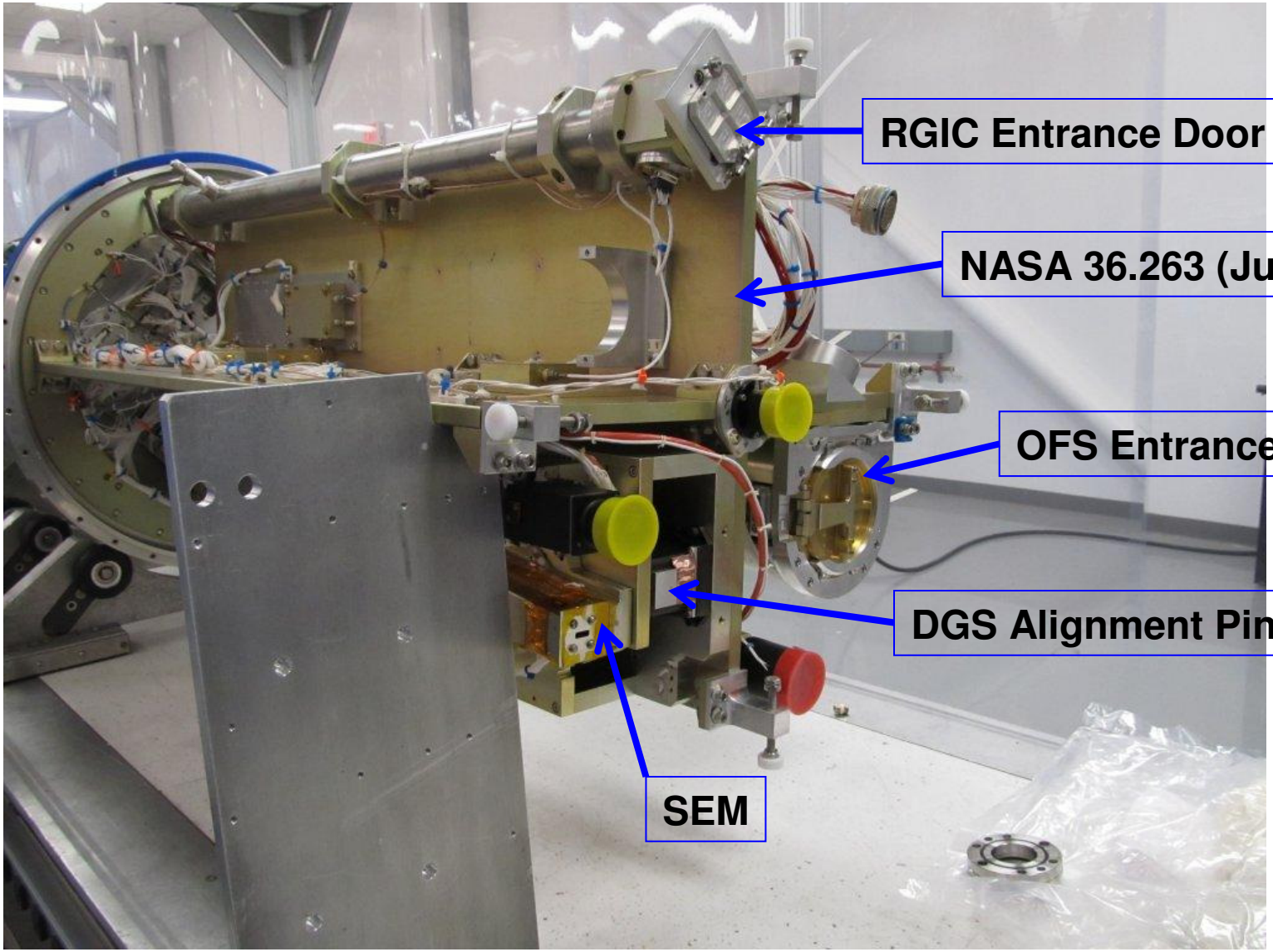

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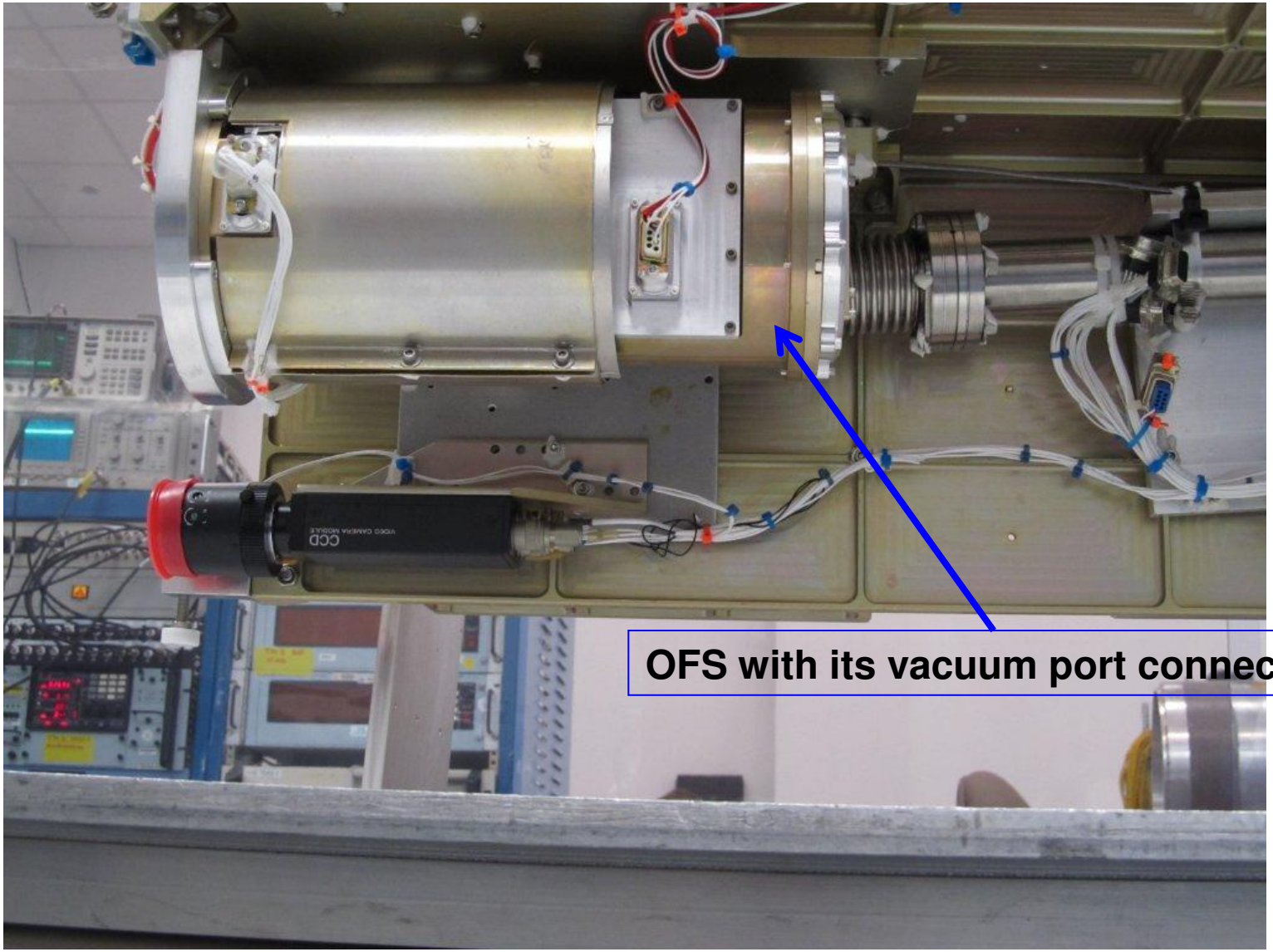

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NASA 36.263 (Judge) is Ready for Launch!