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Wavelength Calibration of the Full-Sun Ultraviolet Rocket SpecTrometer (FURST)

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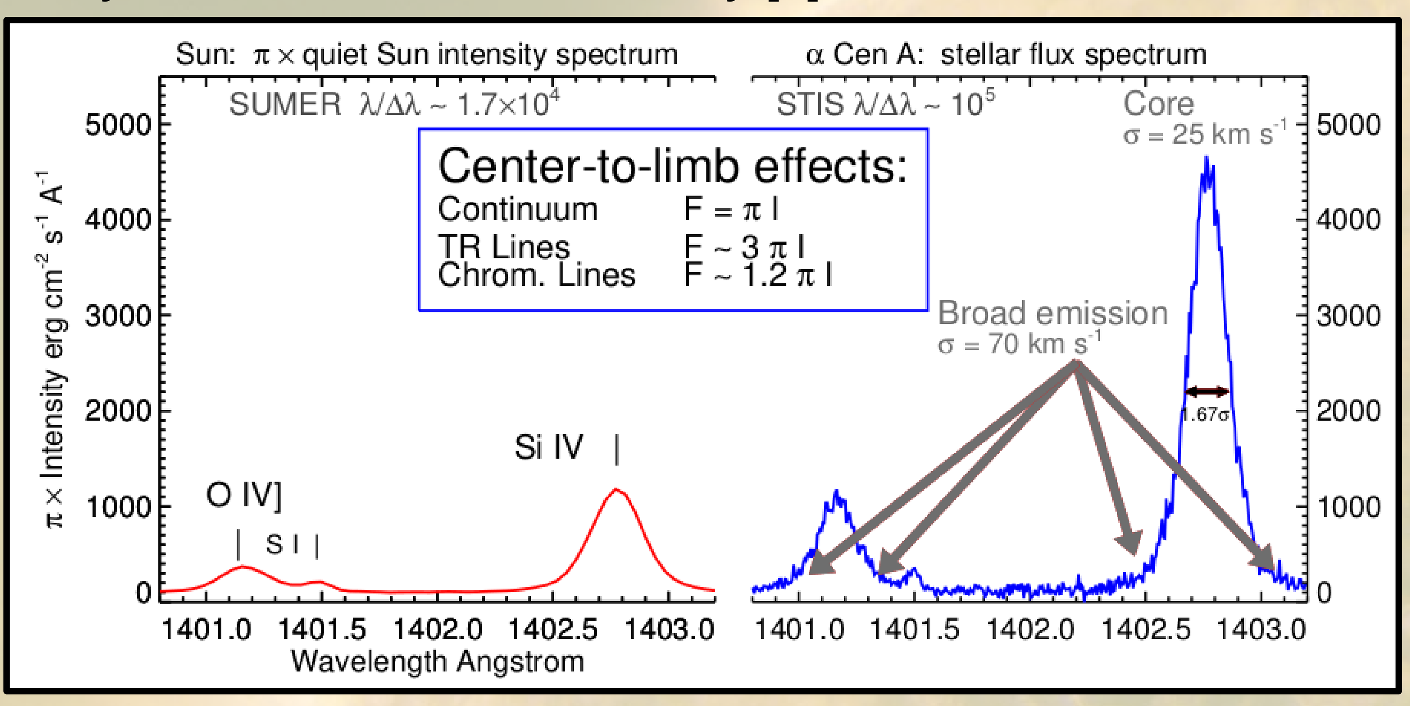
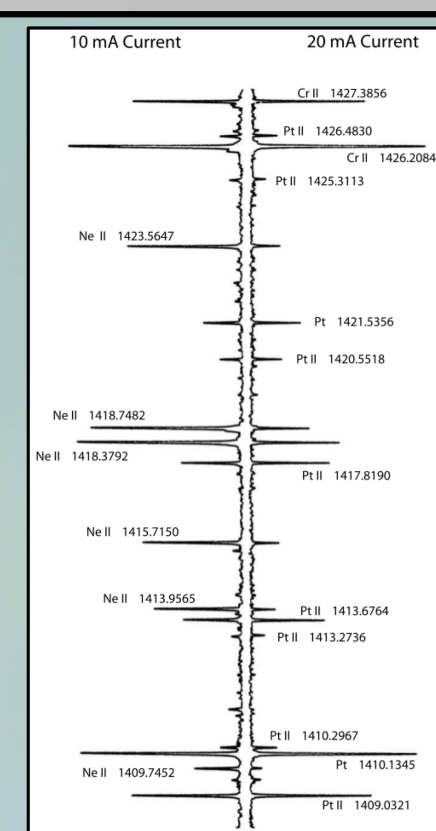
The Motivation

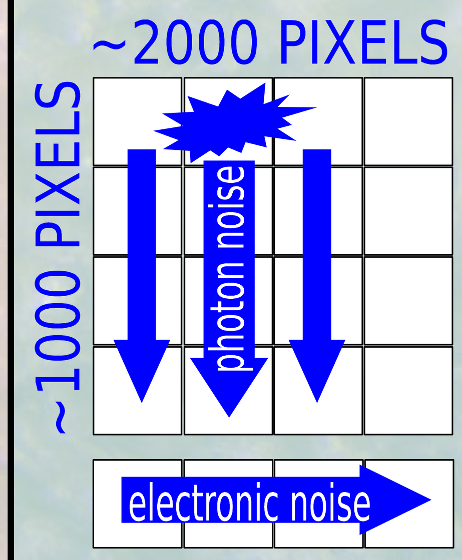
- Sounding Rockets are test-beds for new technology
  - CLASP [1], MaGIXS (2020), **MOSES-II**, **ESIS**, etc [2-7]
- FURST will launch in August 2021
  - Aim: Highest resolution **full-disk** FUV spectra to-date (**comparable with Hubble data**)
- Very limited data exists currently [8]:

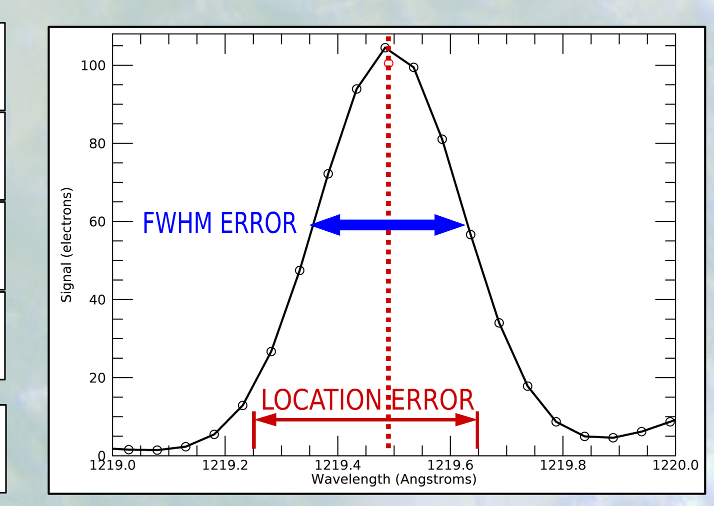


The Simulation

- Diagnostic signal from a **Pt/Cr-Ne hollow cathode lamp** [9]
  - The same type on HST
  - Used 10 mA current signal (left)
- We simulate an incident signal with approximations for:
  - photon noise (**Poisson error**)
  - CCD electronic **readout noise** (DNs)
  - Statistical error (**Monte-Carlo** method)



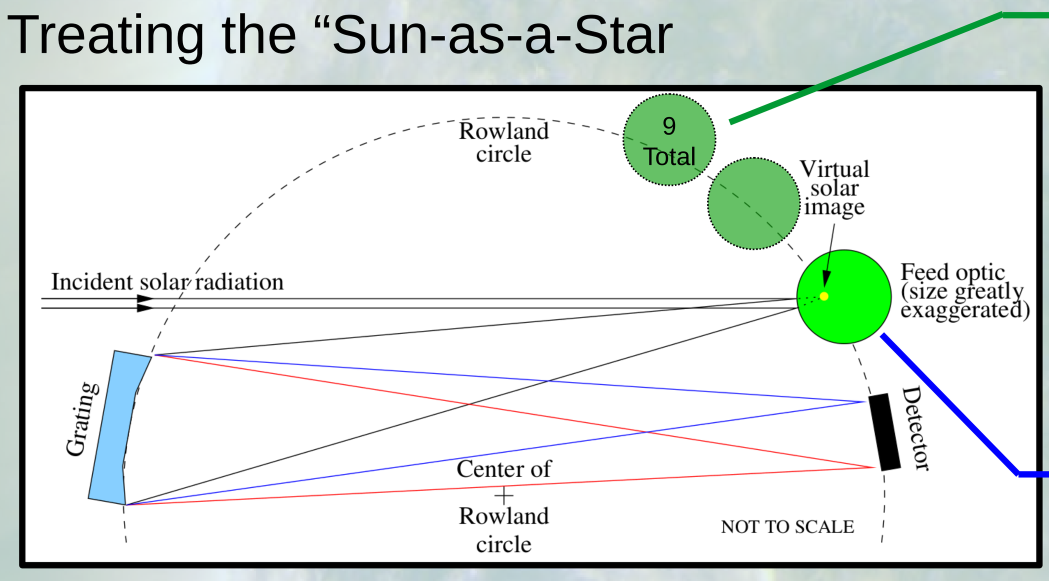




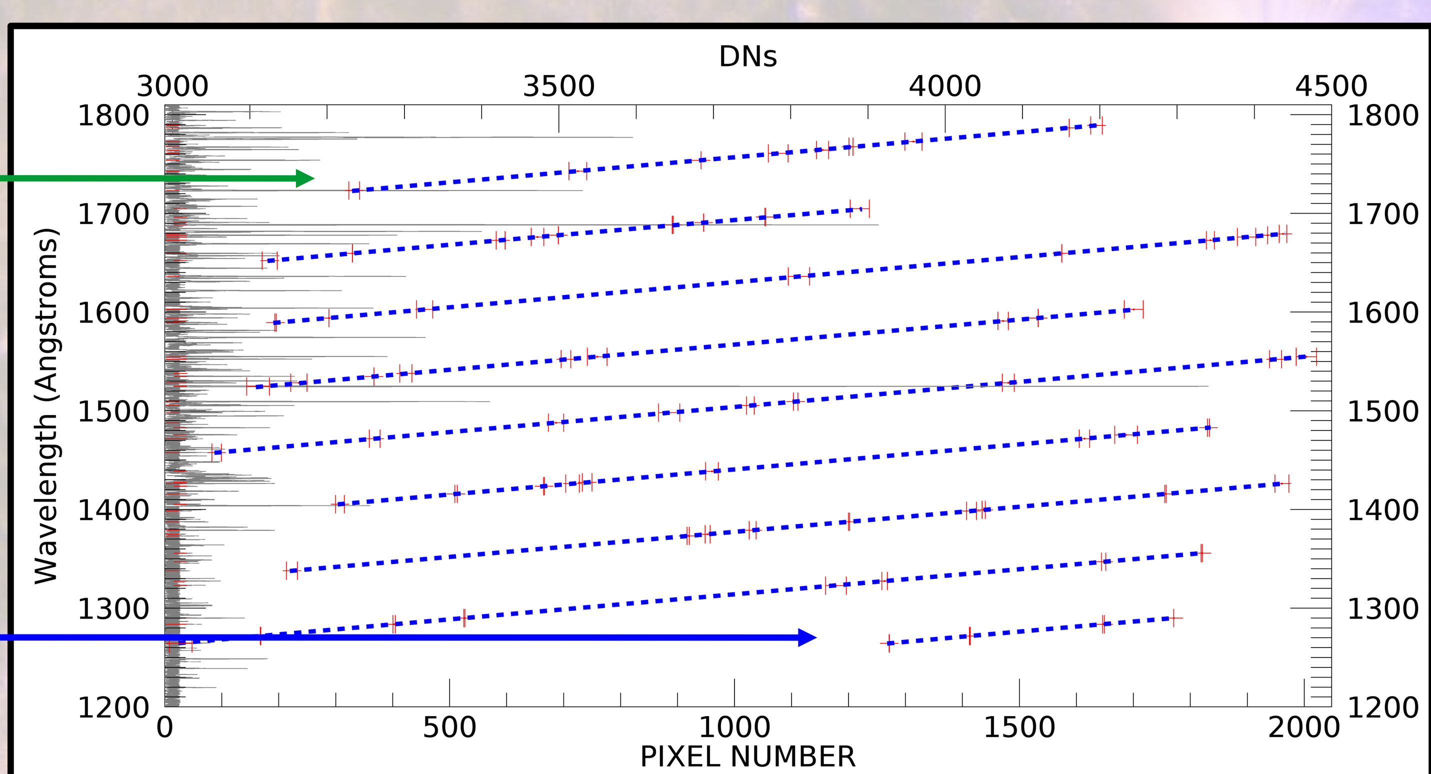
- Used to determine the error budget
- Allows us to resolve the relative motion of **Low Temperature Plasma**

The Instrument

- Treating the "Sun-as-a-Star



- Uses an optical cylinder [10]
- Adapted from the ESIS detector
- Resolution goals:
  - ***R* = λ/Δλ > 10,000**
  - Range: 1120- 2000 Å
  - SDO EVE has a maximum ***R* = 1,000** [11]
- Solves many problems in solar spectroscopy:
  - Large solid angle and extreme intensity
  - **Most detectors saturate at Lyα**
    - **121 nm**



The Results

- Signal and error are mapped as a function of pixel number
- Diagnostic lines with error-bars are highlighted in red

$$\lambda = \lambda_0 + A \cdot x + B \cdot x^2$$

- Nonlinear **Orthogonal Distance Regression** (ODR) employed using an **IDL/Python** bridge
- Assuming linearity, parameter A gives:

Resolution (per pixel) $R = \lambda/\Delta\lambda = c/\Delta v$ → Δλ (Å) $10^{-3} \pm 10^{-7}$ → Δv (km/s) $10^{-1} \pm 10^{-5}$ → ~3 km/s resolution goal is possible!

The Collimator

- Our current Collimator needs upgrading
  - Higher **radiometric requirements**
  - Larger rocket-skin
- Used for **calibration and alignment**
  - Essentially a Newtonian telescope
  - **Calibration at MSFC and NIST**

The Future

Simulation Results → Calibration Requirements

Improve accuracy of
- **photon noise**
- **electronic error**
- **Diagnostic lines (NIST)**

Add more sources
Nonlinear model

- Absolute Radiometric
- Absolute Wavelength
- Relative Wavelength

Acknowledgments

References: [1] Ishikawa et al., 2017; [2] Kobayashi et al., 2013; [3] Kobayashi et al., 2014; [4] Kano et al., 2012; [5] Shimizu et al., 2008; [6] Tsuneta et al., 2008; [7] Kosugi et al., 2007; [8] Peter, 1999; [9] Sansonetti et al., 2004; [10] Kankelborg et al., 2017; [11] Woods et al., 2010

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