Solar-C Spectrometer (SCS) Science

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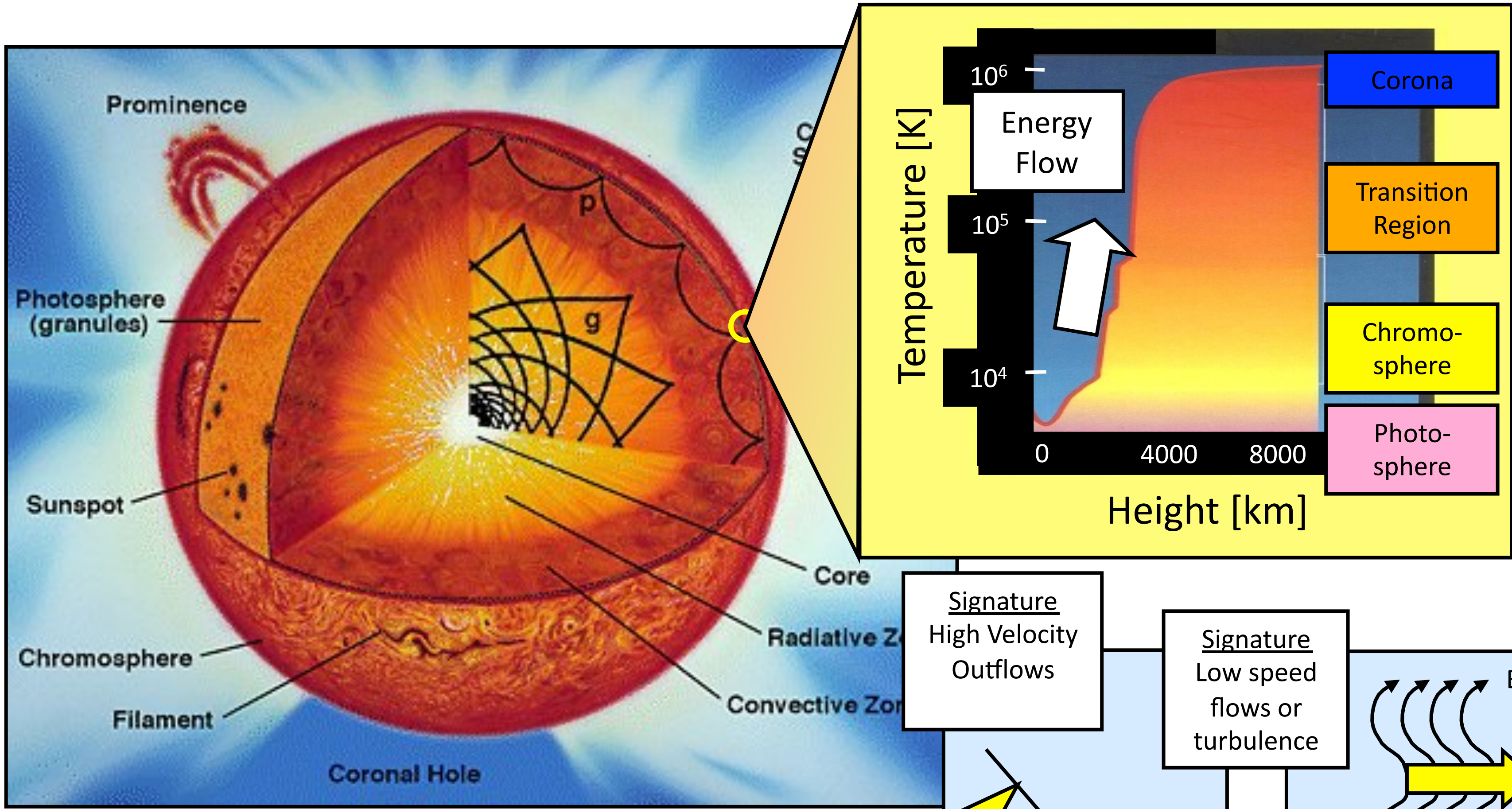
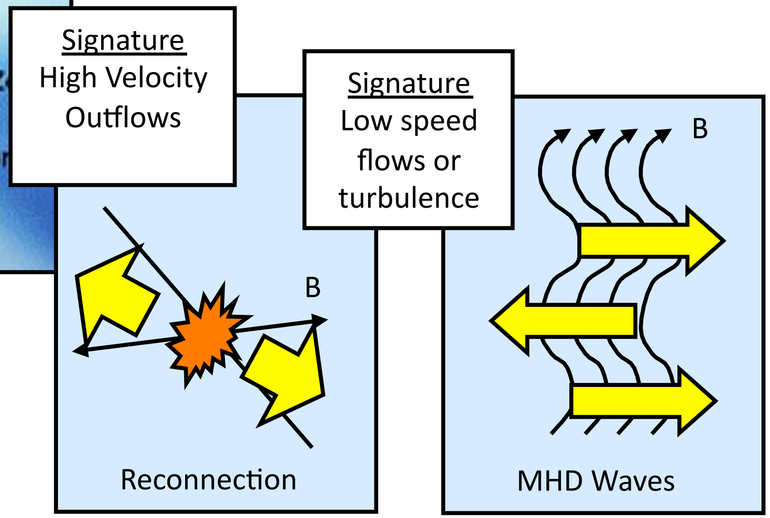
Code 670

Solar Activity Driven by Convection

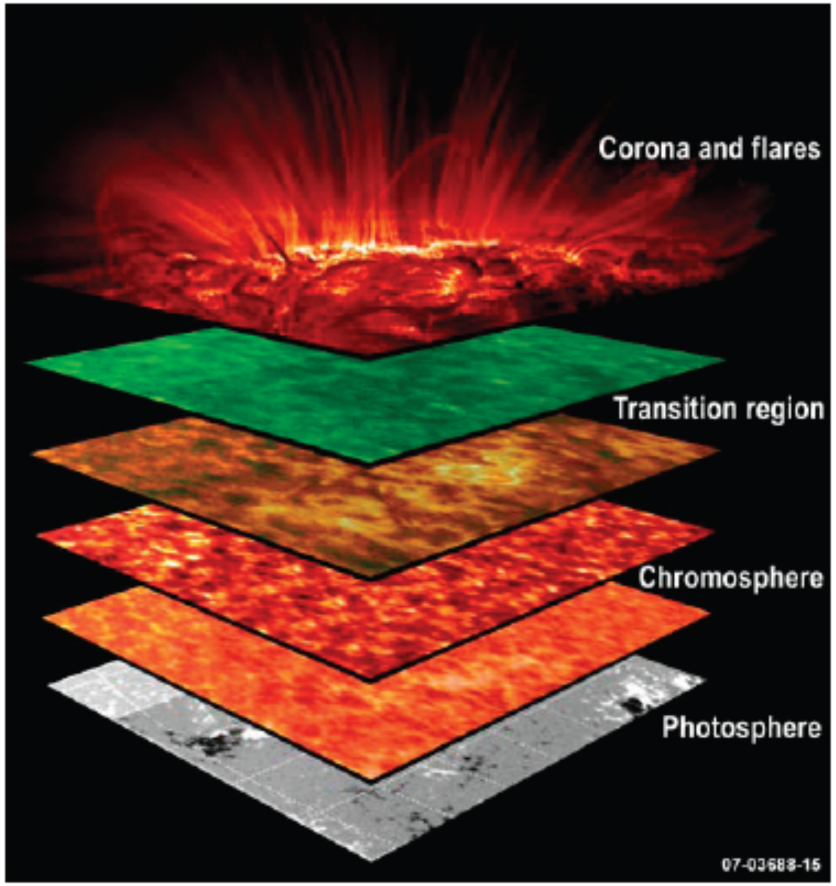




Convection and magnetic field combine to cause coronal activity.

The Challenge

- Large temperature gradient
  - T= 10^3 to 10^7 K
- Large density gradient
- Rapid time evolution
  - Higher spatial resolution requires better temporal resolution

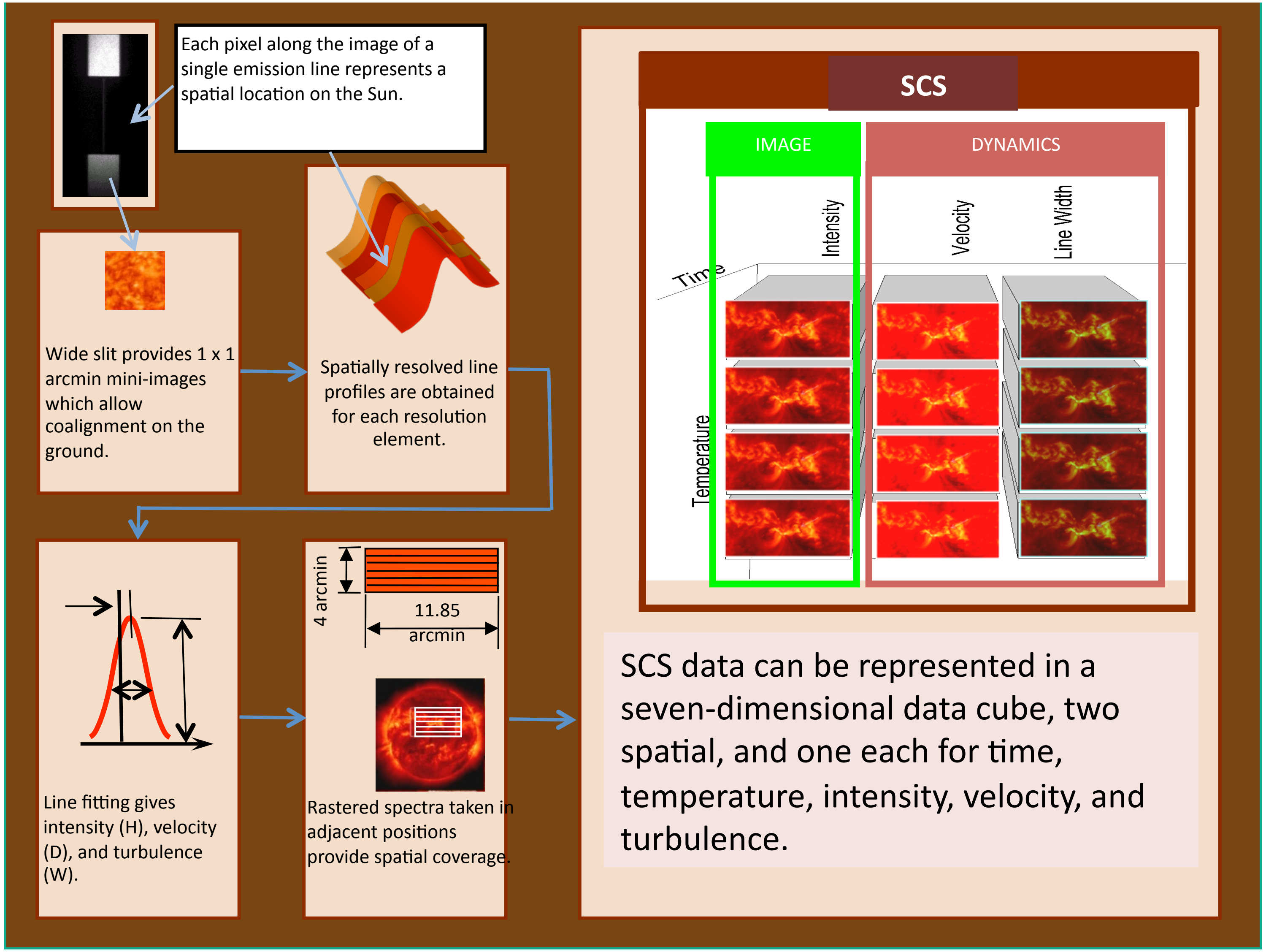


Issues Limiting Science

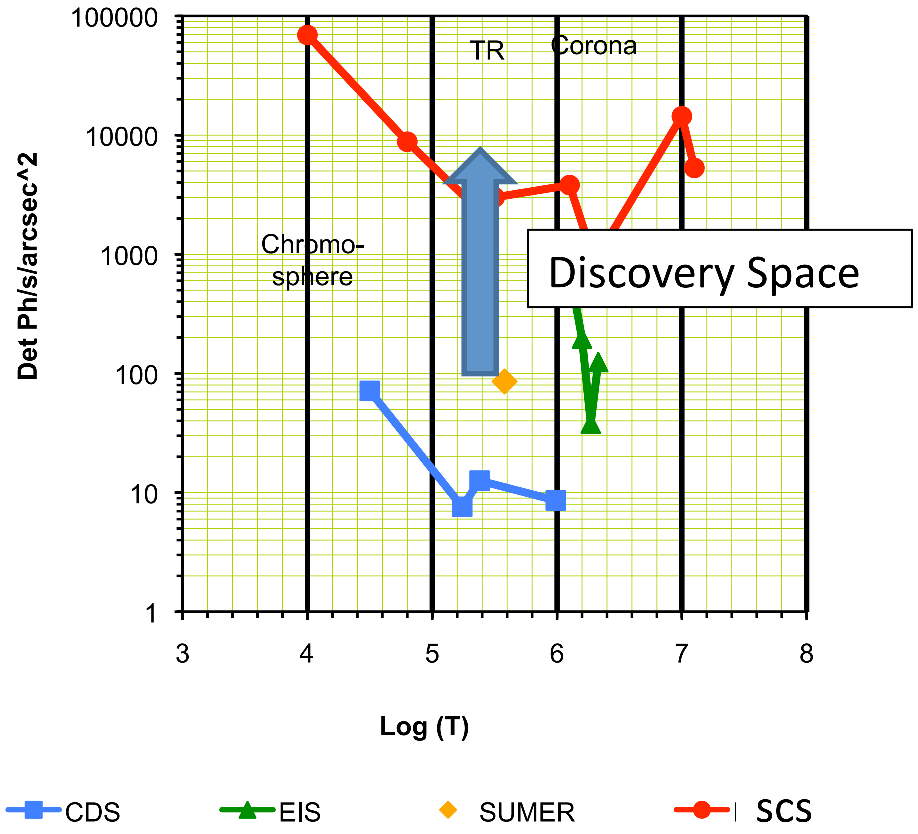
- SOHO (EIT, LASCO), TRACE, and Hinode have provided dramatic images of solar events. CDS, SUMER, and EIS have provided spectra. But energy flow remains a puzzle, Why?
  - Existing spectrometers have insuffici... narrow simultaneous tempe...
  - Multilayer imagers ... ansition region and higher tem... distinguish plasma flow fr... olution unambiguously
  - ... xtrapolation from photospheric ... ements least accurate in most interesting regions (energy storage) of the corona

<u>A Missing Piece:</u> Spectra optimized for dynamics with broad temperature coverage, high time resolution

New Discovery from Rapid Raster Times

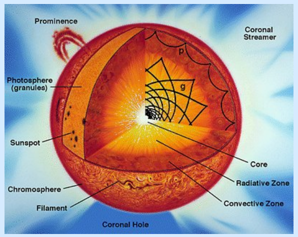


Spectrograph Optimization for Dynamics



- **Large A_{eff}**
- **Fast readout electronics system**
- **Broad simultaneous spectral coverage**
- **Bright spectral lines that span appropriate temperature range**

Science to Link Photosphere to Corona



Convection

Science Objectives

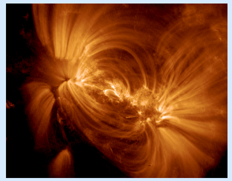
How are coronal loops heated? – Role of reconnection, waves in energy transfer process

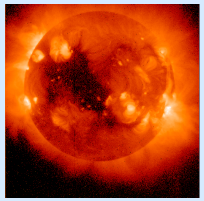
How and where is the solar wind accelerated? – Definitive test of ion cyclotron heating

What initiates coronal mass ejections? – Observe CME buildup, initiation, and relaxation, precursors

What are the sources of UV irradiance variations? – Discover the physics responsible for UV irradiance variations from spatially resolved observations


CMEs and Transients


Heating

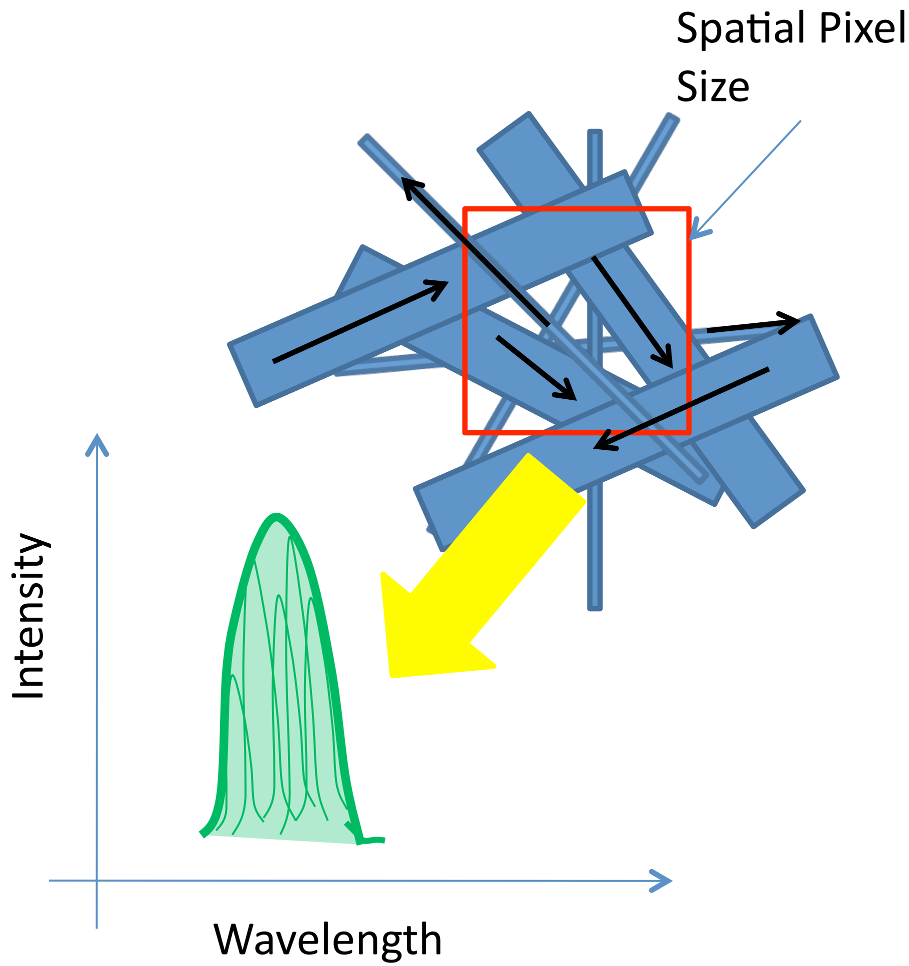

Solar Wind

Coronal Heating

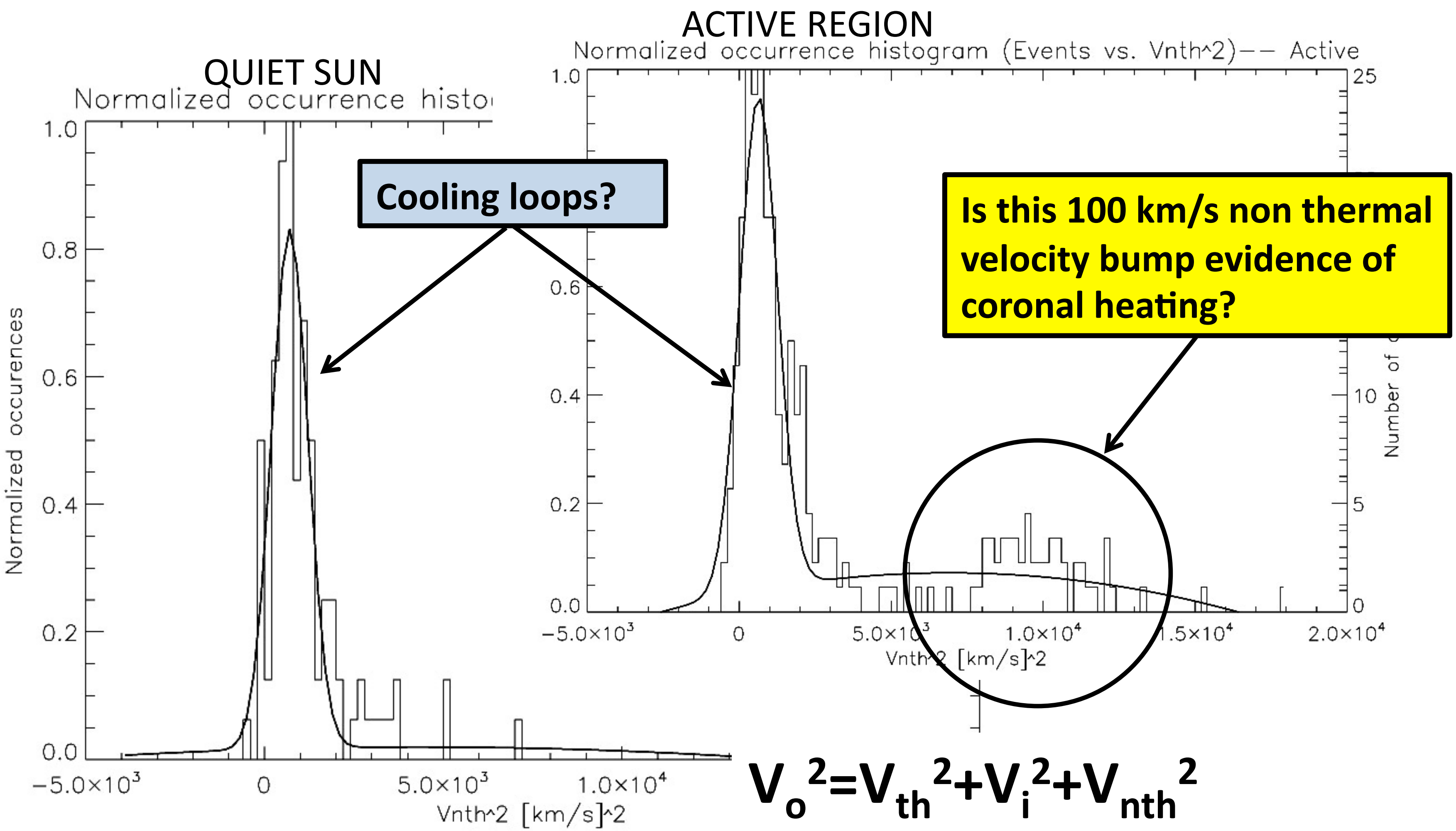
- Reconnection flows should be easily seen
  - Fraction of the Alfven speed
- Must choose the proper temperature range
  - Likely 10^7 K
- Possibly low emission measure initially

Dynamic Resolution is Not Limited by Spatial Pixel Size

- Velocity information for all structures in the resolution element is contained in the line profile
- Structures with sufficient emission measure are observed whether they are resolved or not
- Not true for density and temperature diagnostics



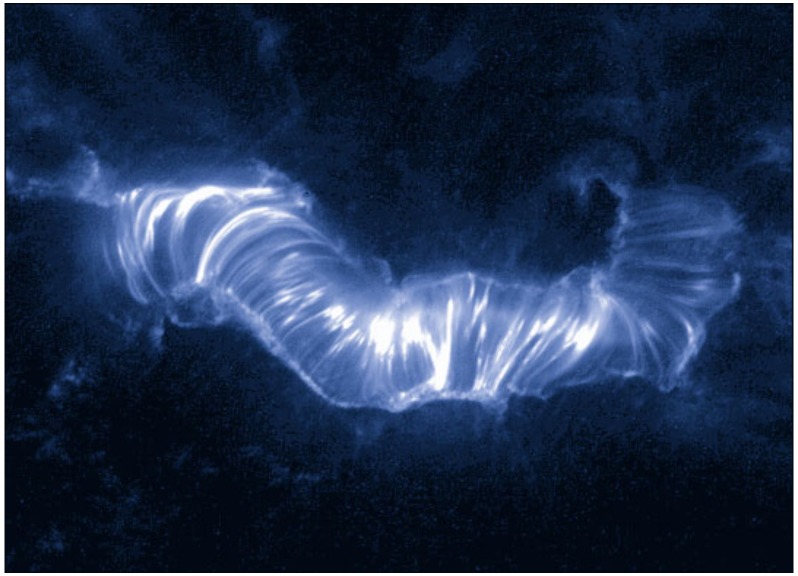
Coronal Heating



$$V_o^2 = V_{th}^2 + V_i^2 + V_{nth}^2$$

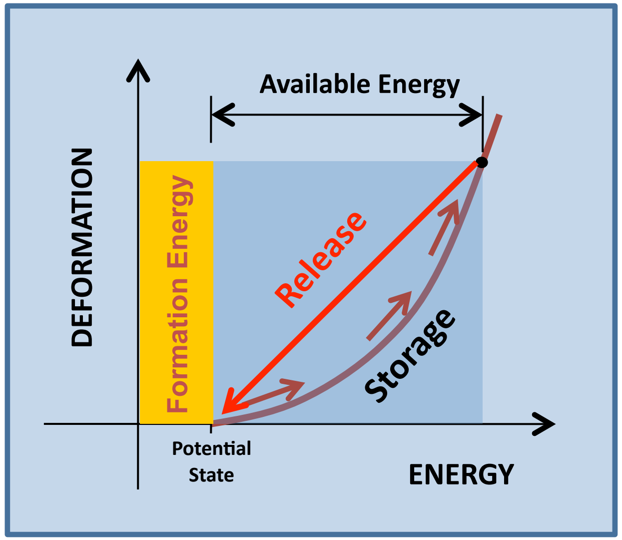
CMEs, Flares, and Transients
What leads up to energy release?

- Key questions:
  - Where and how is the energy stored?
  - How is it released?
- Theories point to magnetic field evolution



What Happens before the EUV, and X-ray emission is seen?

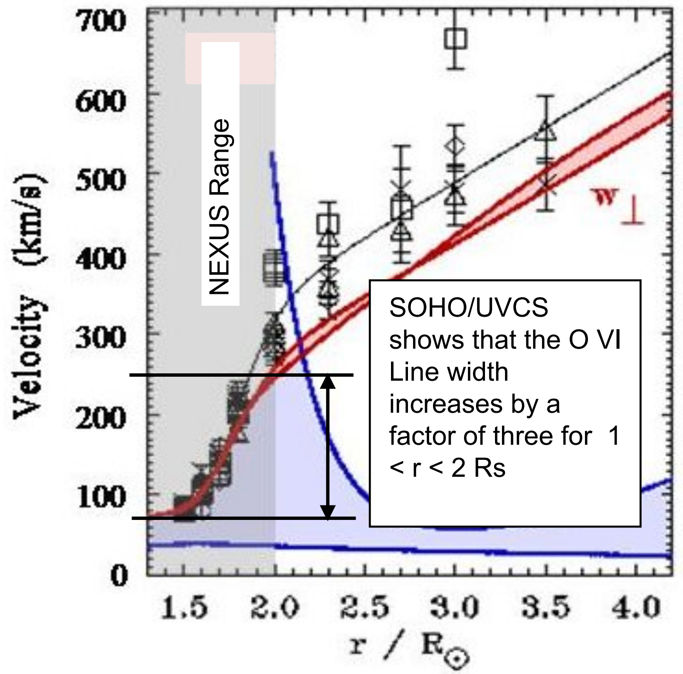
- Techniques to extrapolate from the photosphere are least effective in non-potential regions, which is where energy is stored
- Magnetic field evolution will generate multi-temperature slow flows in the storage region as the configuration readjusts



- Observation of these flows during the build up and relaxation period in a broad range of temperatures will provide observational basis for coronal field models
- Open question: Dynamic precursors of eruptive events?

Solar Wind Acceleration

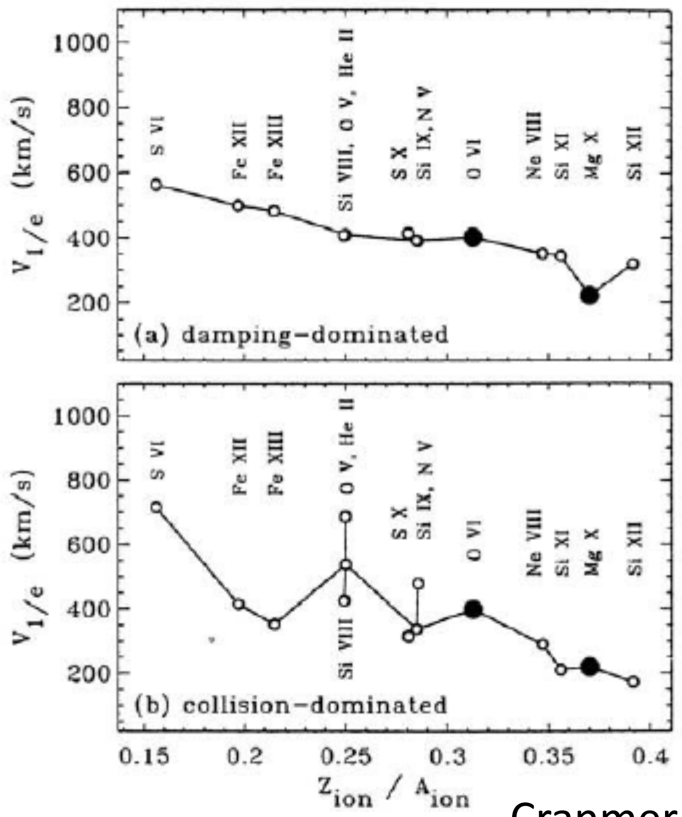
- Unexpectedly broad O VI line width in coronal holes attributed to ion-cyclotron wave heating by Kohl et al
- Stimulated a large number of theory papers
- Alternate view by Solanki et al explains line widths as due to a coronal hole geometric effect
- SCS can resolve this issue



Kohl, et al

Solar Wind Acceleration

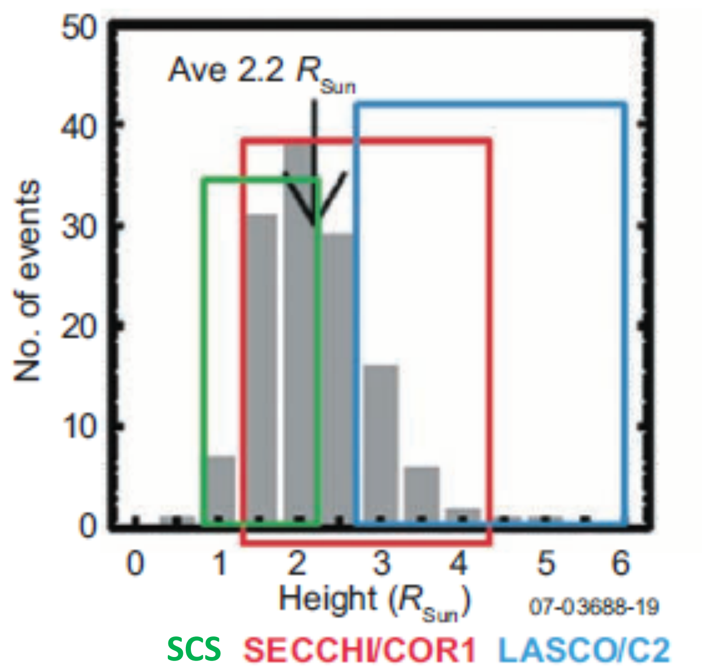
- All ions interact with the same wave spectrum
- Observation of multiple ions will provide definitive test of ion-cyclotron wave predictions
- Improved sensitivity of SCS is key to this observation



Cranmer, et al

Shocks/Energetic Particles

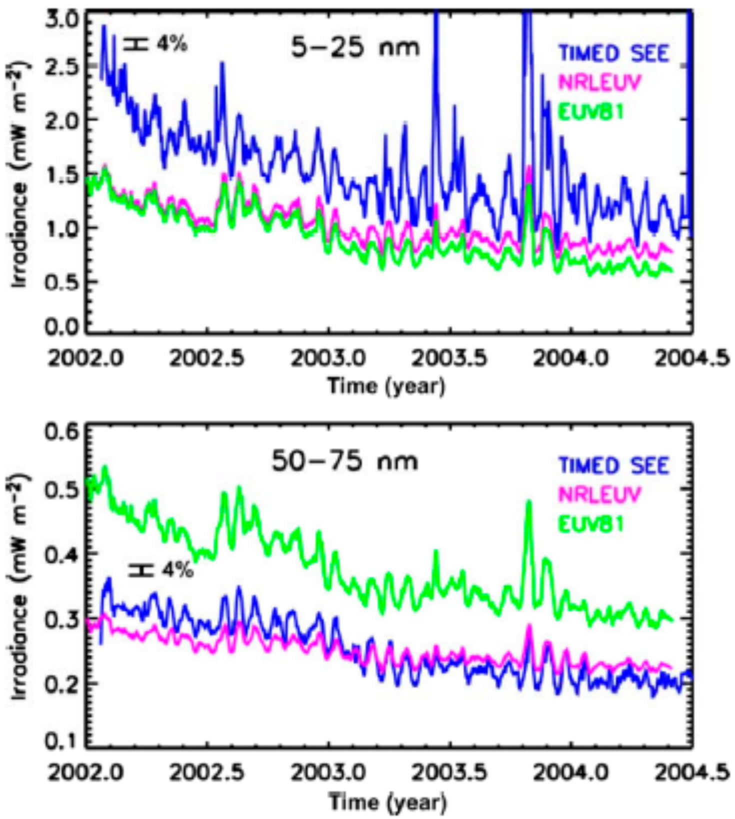
- Type II radio events are generated by coronal shocks
- Most are below 3 Rsun
- Shocks passing through FOV visible as narrow high temperature events



Gopalswamy

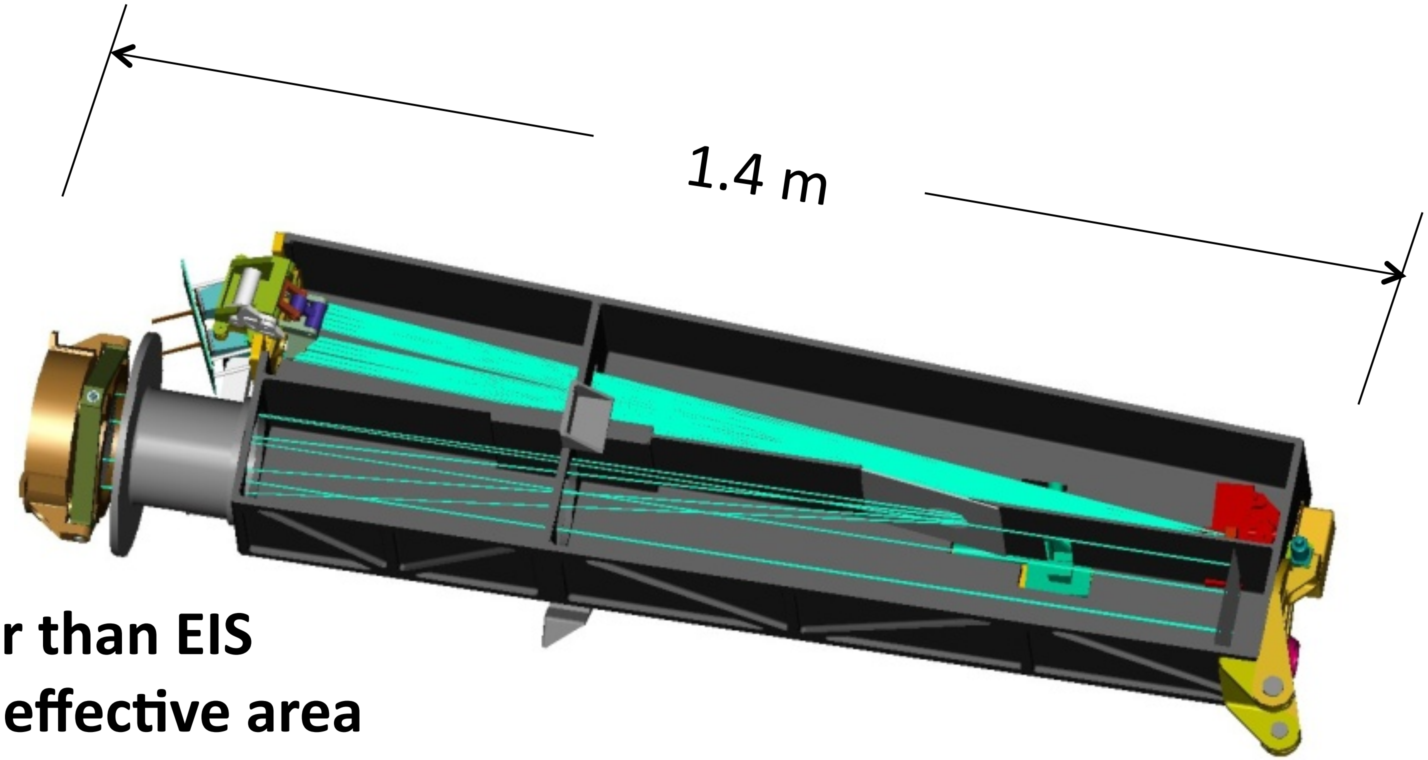
Improved Irradiance Models

- Spectral data contributes to improved irradiance models
  - NRLEUV (Warren)
  - FISM (Chamberlain)
  - SRPM(Fontenla)
- Necessary for Earth Science
  - Possible tie in to global warming



H. Warren & T. Woods

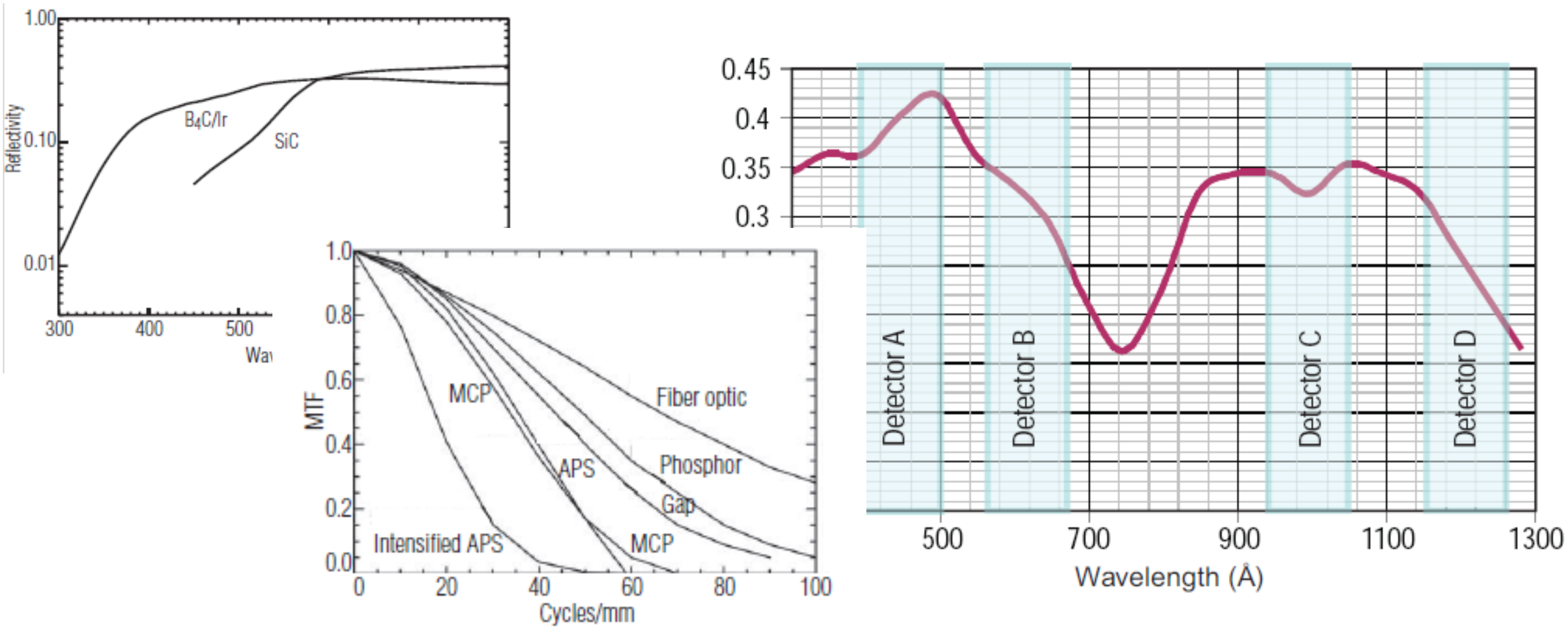
Spectrograph Development Since EIS



- **Smaller than EIS**
- **Larger effective area**
- **Higher temporal and spatial resolution**
- **Can be scaled up, or down to fit mission requirements**
- **Can satisfy broad wavelength range instantaneously, and extremely broad range with simple change of ruling density**

Broad Wavelength Range

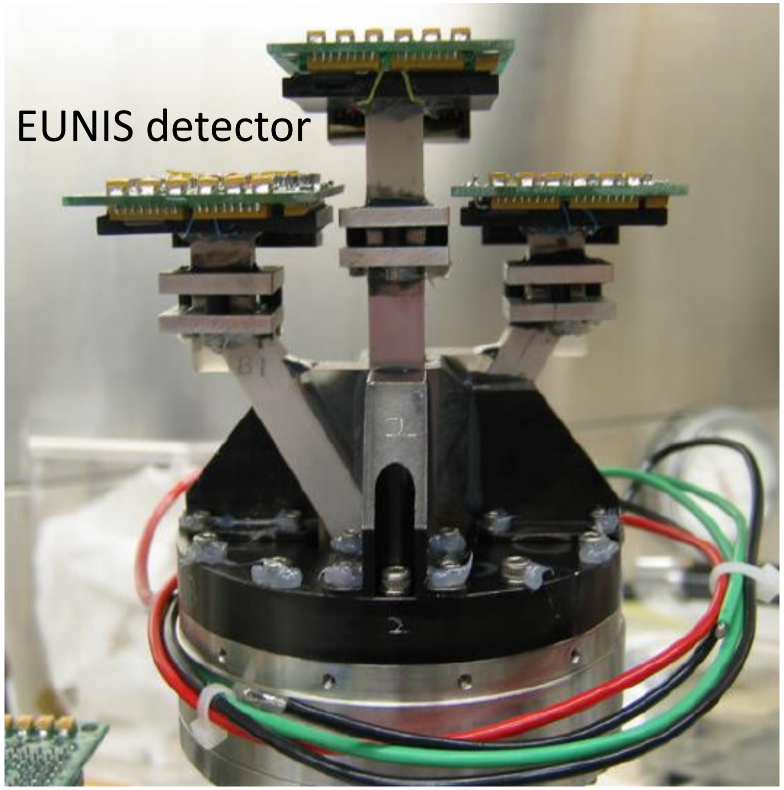
Optimized optical coating and Detector Design

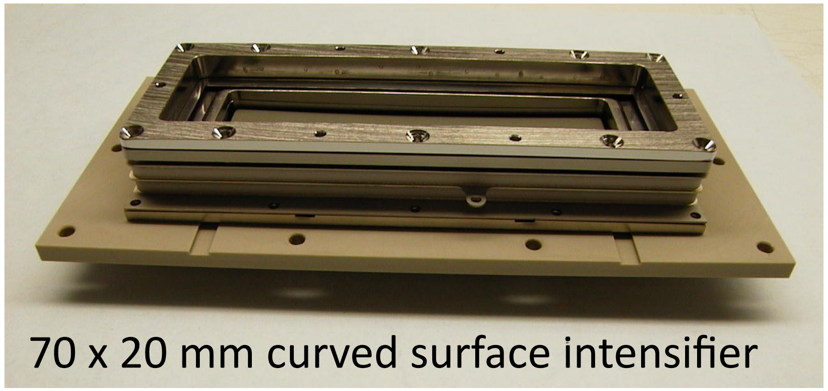


- Solar blind – stray light design simple, saves mass
- ~5 x Better sensitivity than backside
  - CCD = 0.8 x 0.3 x 0.3 = 0.07 - ICCD >0.35
- Equivalent or better resolution to backside CCD

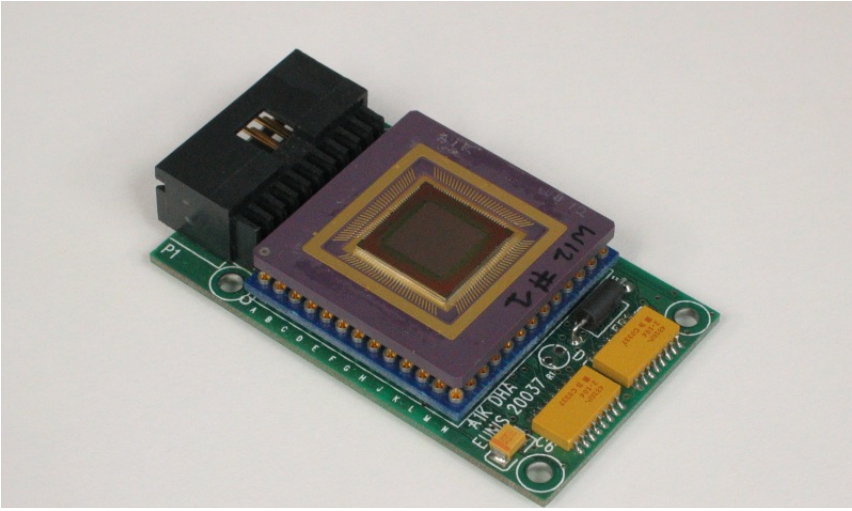
Intensifier Technology

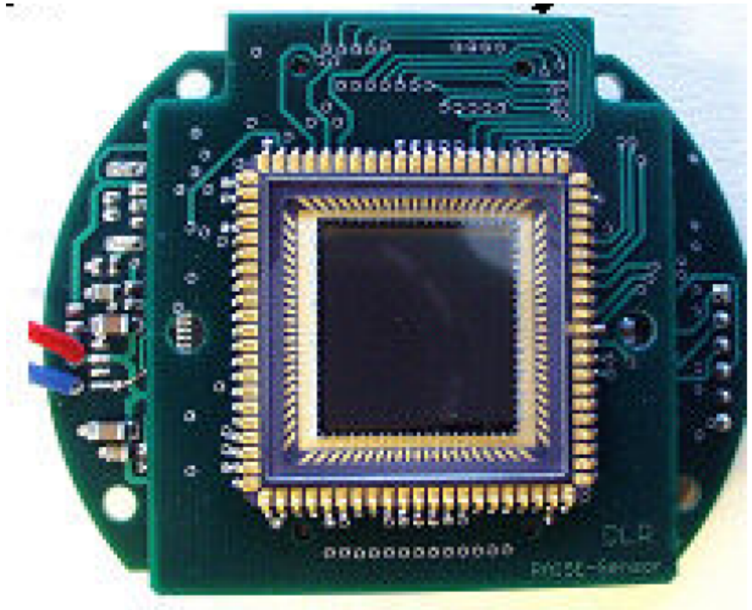
- Solar blind
- High Resolution
- Existing sensors can be tiled to fill the desired focal plane
- Active areas of 20 x 70 mm demonstrated
- Magnification and/or tiling available to optimize sensor configuration





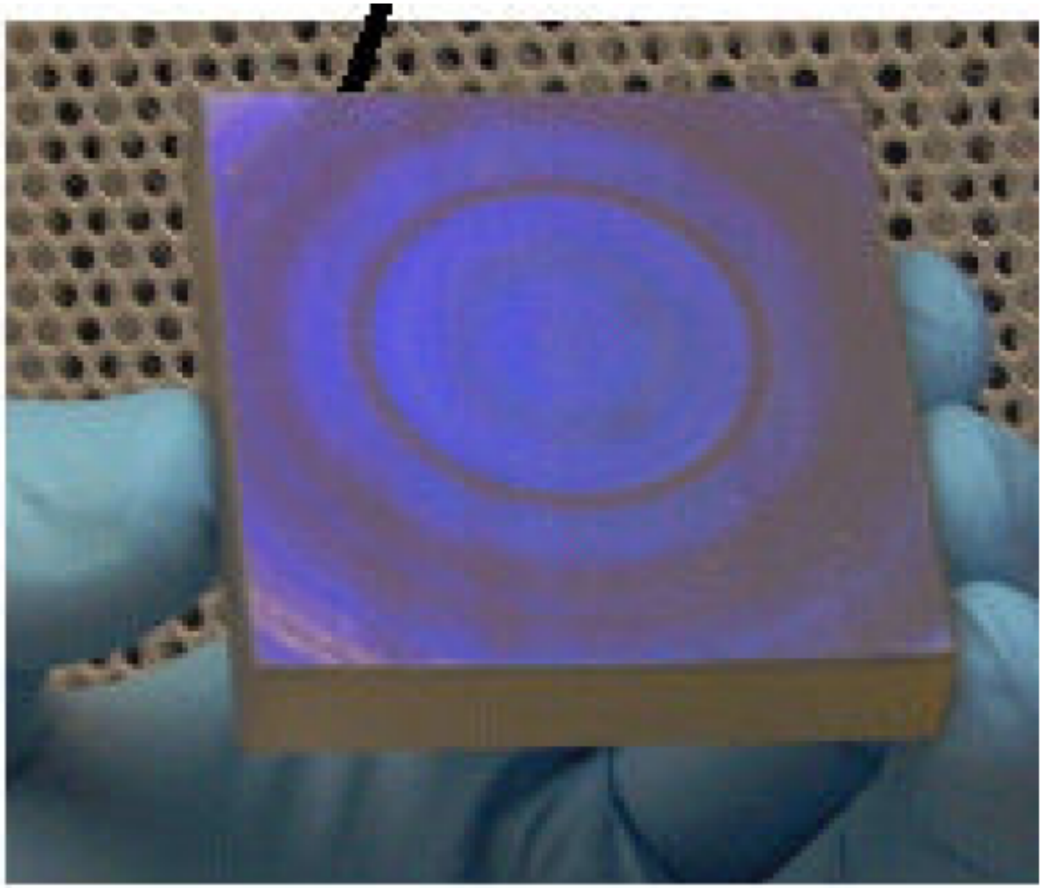
APS (CMOS) Detector Technology





- Rapid readout
- Simplified electronics
- Increased read noise not significant for bright lines (photon noise limited)
- **<u>Flown twice on EUNIS</u>**
- Planned for RAISE, Proba-2

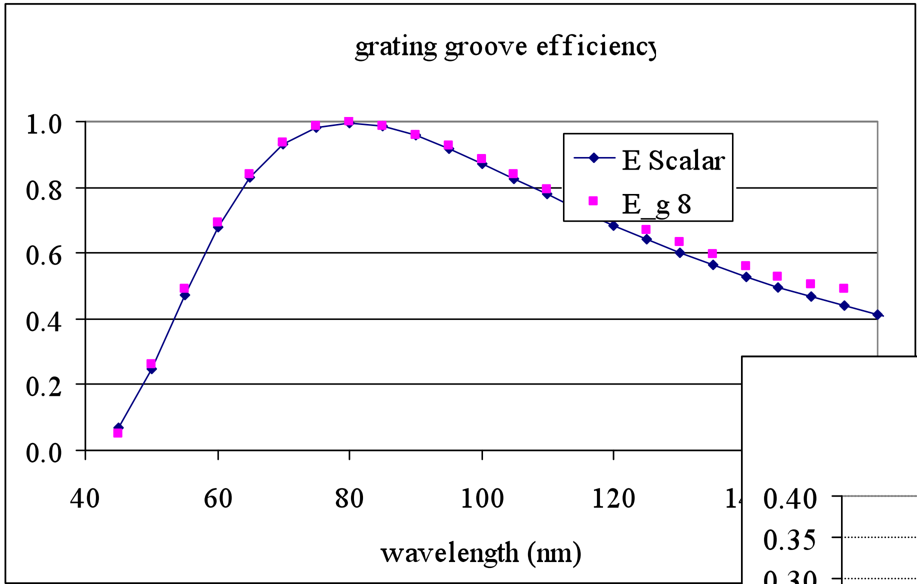
TVLS Grating Available

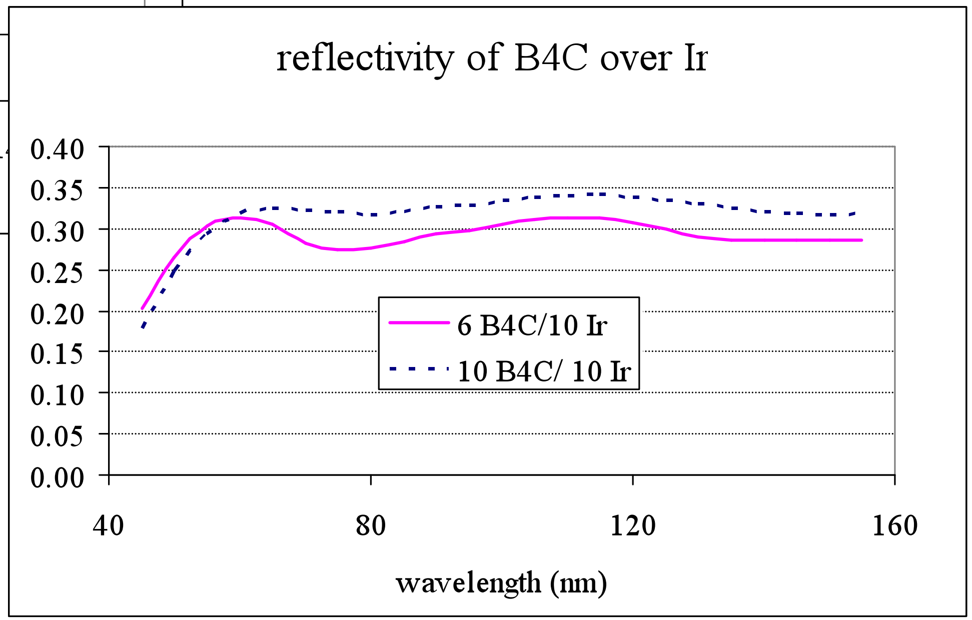


RAISE TVLS Grating (Hassler)

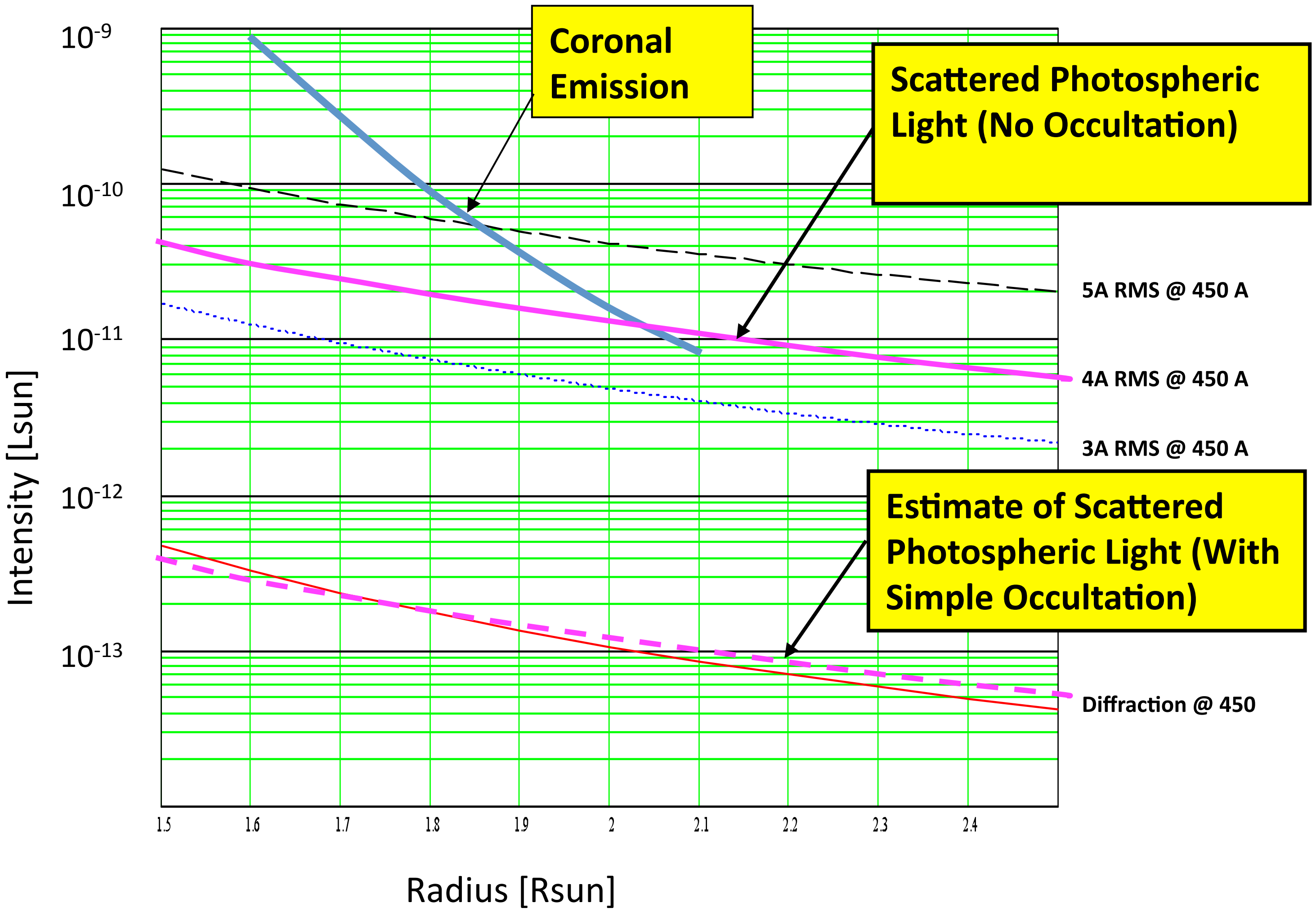
- TVLS grating allows spectrograph magnification
- Lab demo complete, several versions fabricated (Zeiss, Bach, J-Y)
- Planned flights on SUMI, RAISE, VERIS (?), and EUNIS

High Efficiency Gratings and Coatings Are Available





Scattered Light Model Results

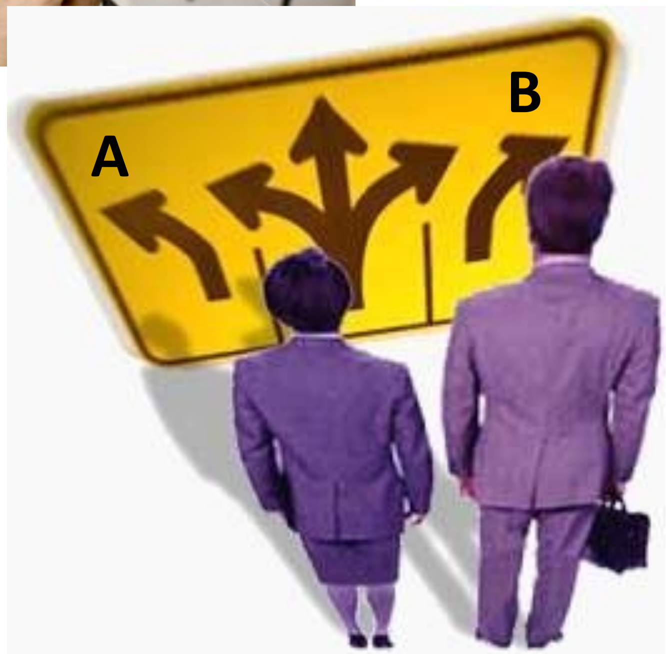


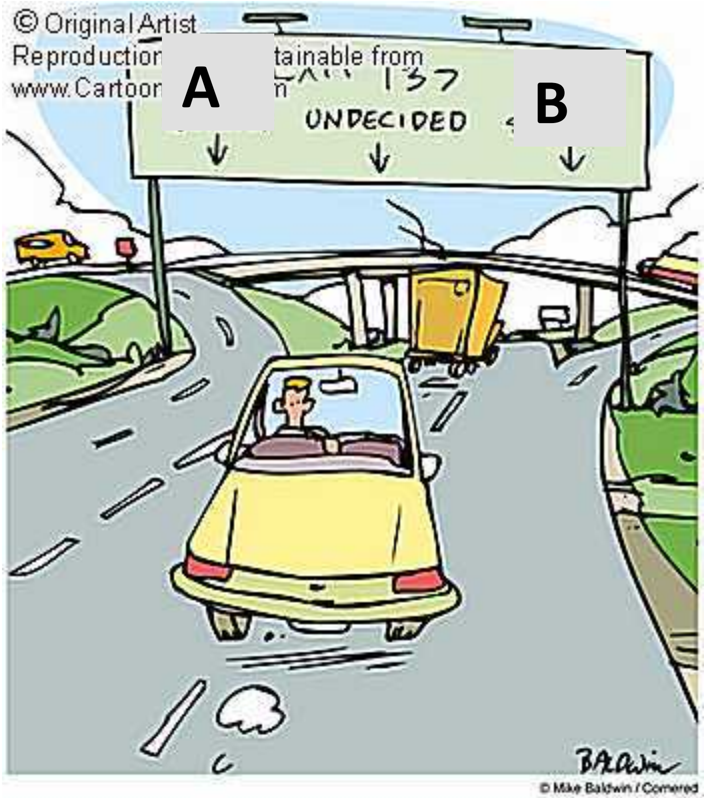
Science Impact

- Improved knowledge of magnetic energy storage.
- Dynamic precursors of transient events?
- Carry on new critical test of ion–cyclotron heating theory in coronal holes.
- Observe pre-shock conditions and shock structure to test theories of particle acceleration.
- Discriminate between theories of wave and impulsive coronal loop heating mechanisms.
- Discover physics of extreme ultraviolet spatial irradiance variations, important as geospace input.


A or B ….???
iStockphoto

In the End…


A
B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