

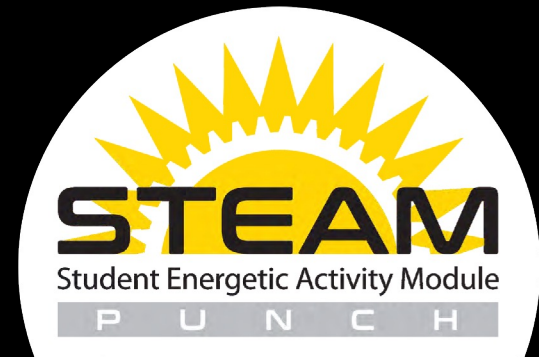
Polarimeter to Unify the Corona and Heliosphere

Student Thermal Energetic Activity Module STEAM

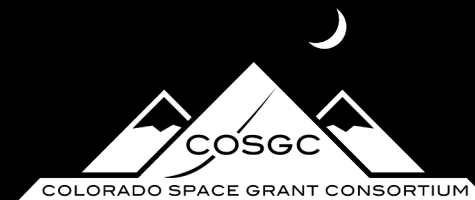


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STEAM Science
July 7th, 2023





Introduction

Science Objectives

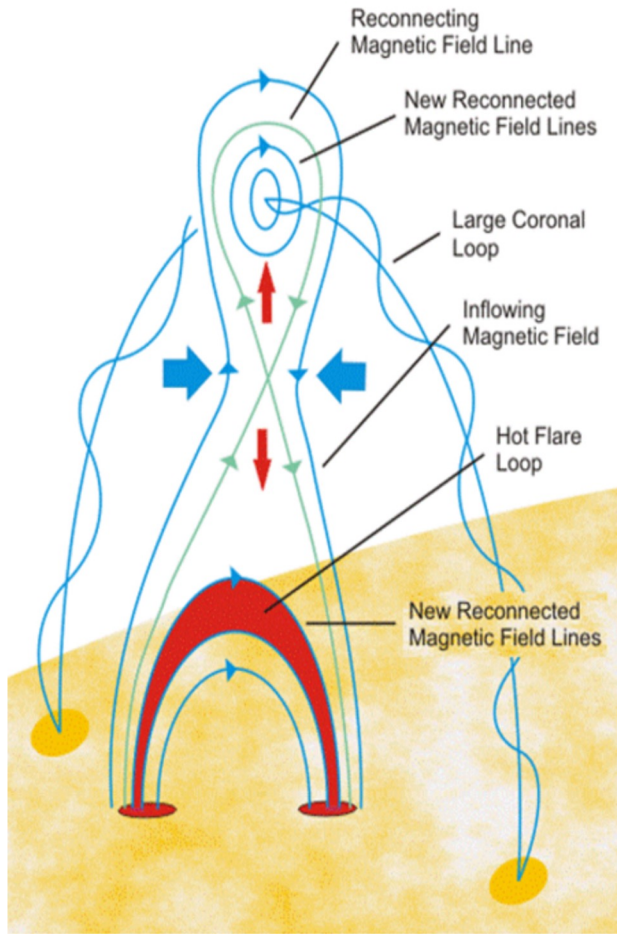
Explore the enhancement of low First Ionization Potential (FIP) elements in the solar corona.

Explore how solar coronal plasmas are heated in flares and quiescent active regions.

Support PUNCH science in understanding the source regions of solar wind and coronal mass ejections.



Magnetic Reconnection & Plasma Heating



Oppositely oriented field lines cancel



Field lines rearrange themselves into a lower energy state



Releases an explosion of energy



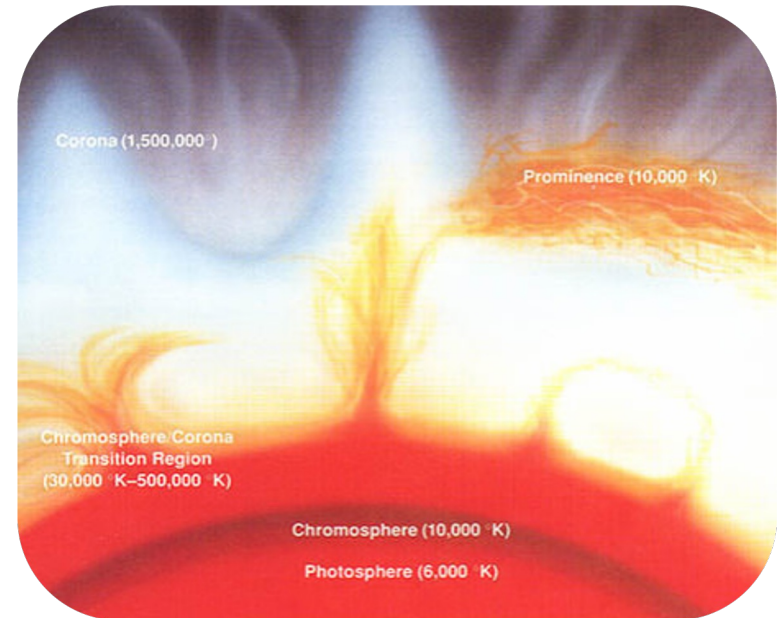
Releases heat and energy into the corona



Low-FIP Elements in the Corona

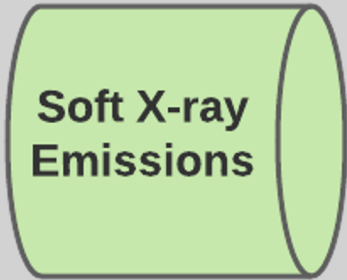
Low FIP (< 10 eV) elemental abundances point to origin of plasma

- Prominent above thermal continuum
- Abundances enhanced by a factor of ~ 4 in corona over chromospheric values
- Abundances allow STEAM to infer origin of plasma for flares and active regions (AR)





Why X-rays

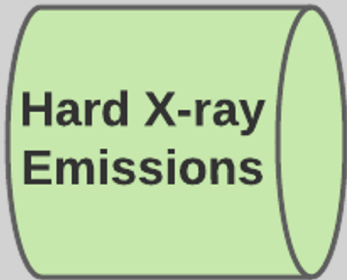


Soft X-ray Emissions

Provide most direct signatures for hot plasmas

Highly sensitive to hot temps & fluctuations

Not sensitive to cool temps



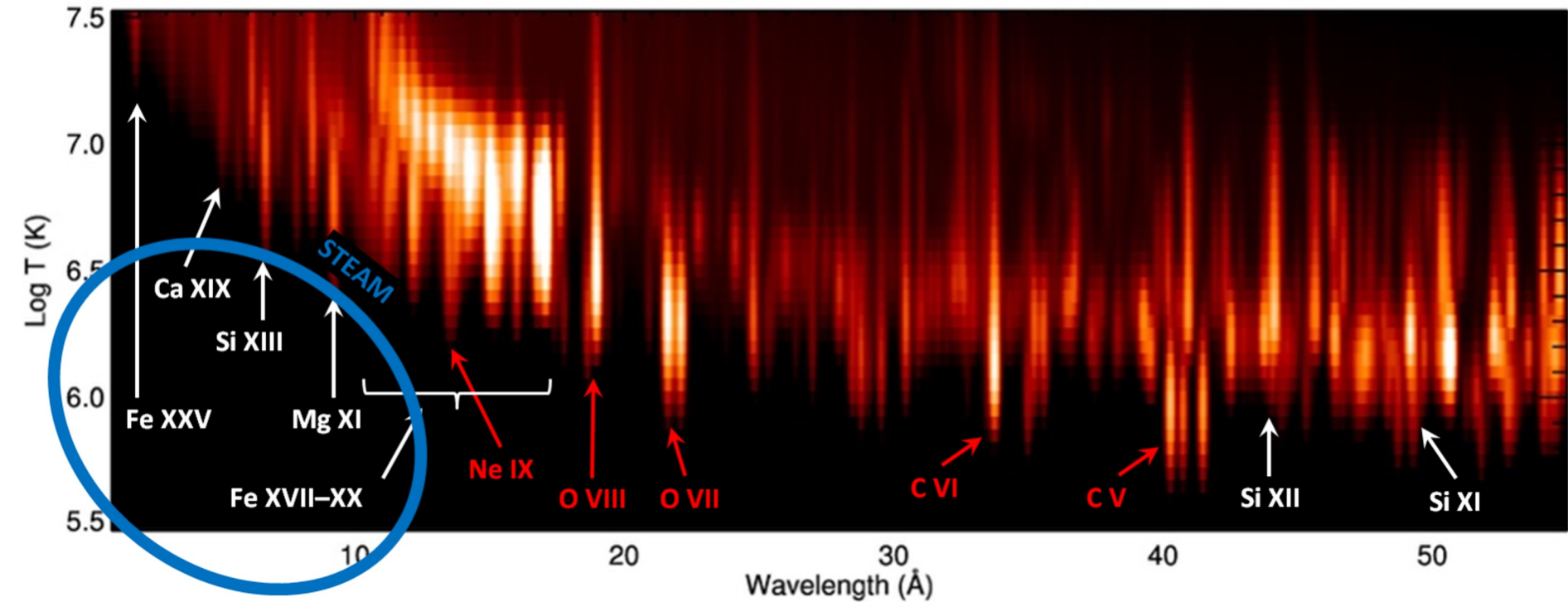
Hard X-ray Emissions

Provides a more complete look at plasma evolution

Covers higher energy events >10 keV

Extends thermal continuum

Comprehensive coverage of thermal plasma temperature and composition

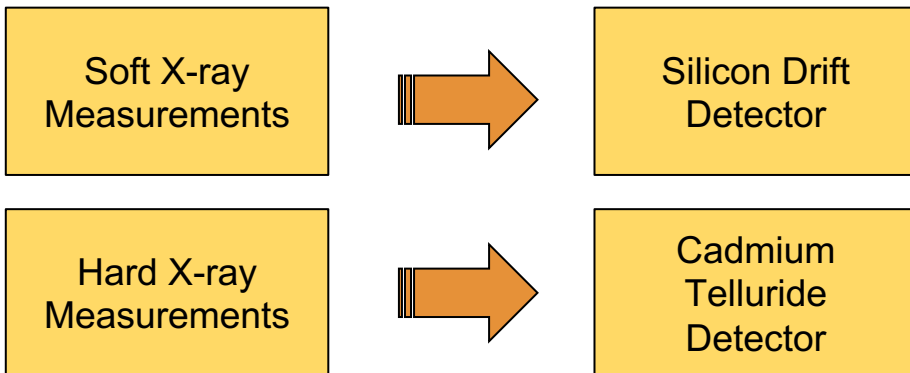


STEAM will be able to observe low FIP spectral lines with a greater resolution



What is STEAM?

Slide updated



Expected Performance

SXR

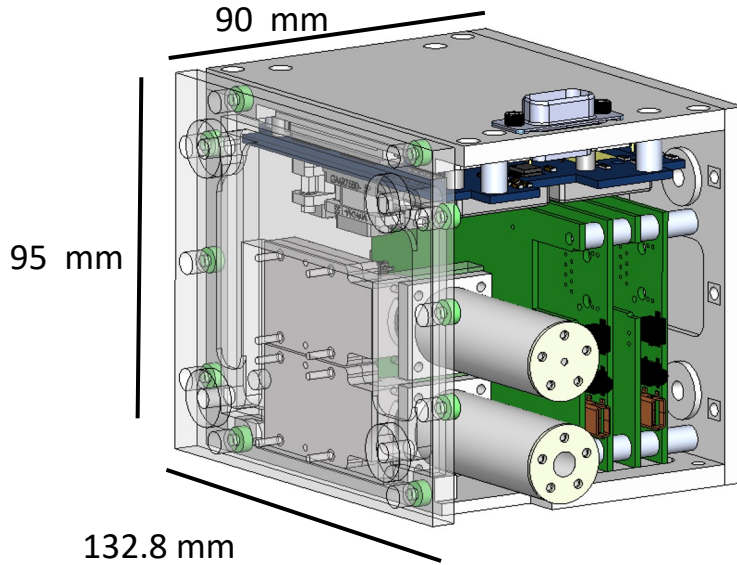
HXR

| Expected Performance | SXR | HXR |
|----------------------|--------------|--------------|
| Energy Range | 1 to 7 keV | 7 to 20 keV |
| Resolution | < 0.3 keV | < 1 keV |
| Field of View | 5.25° to 10° | 5.25° to 10° |
| Aperture Size | 300 μm | 2700 μm |
| Filter | PI, 5.5 μm | Al, 50 μm |

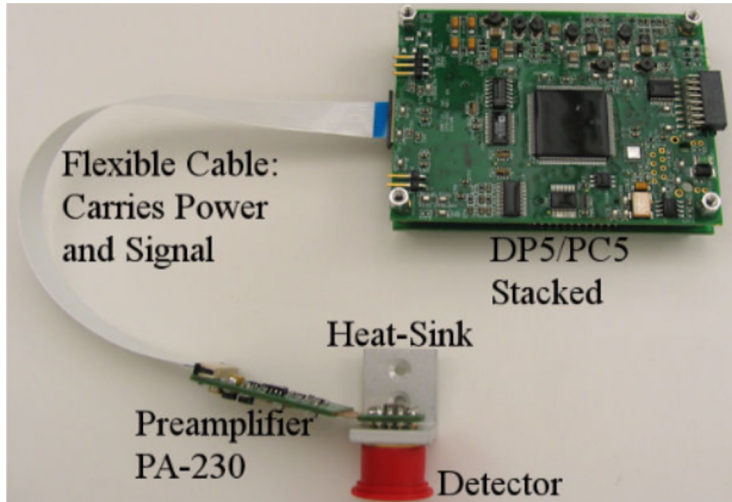




Current Model & Hardware



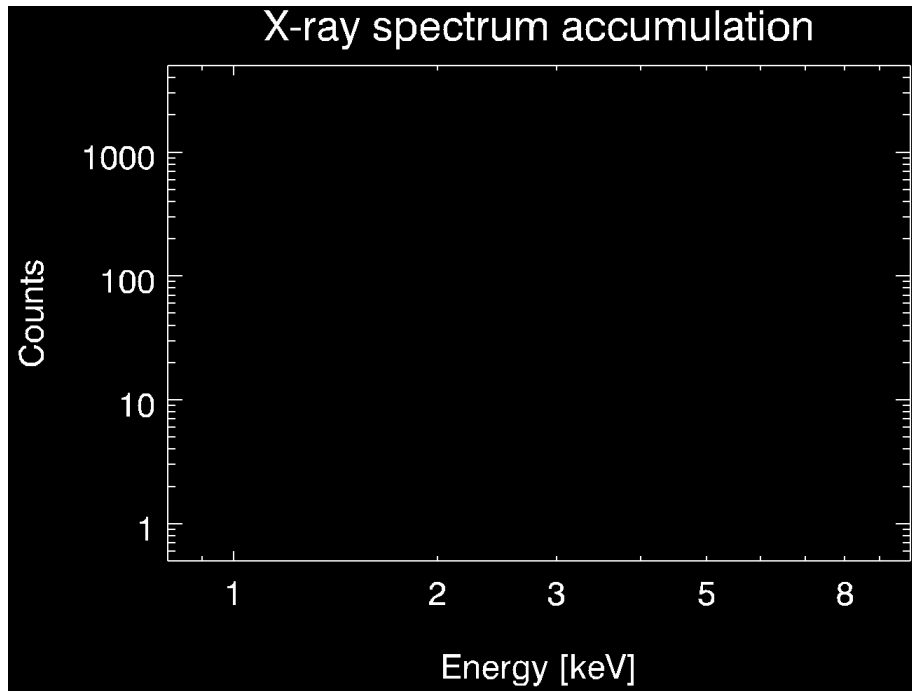
A rendering of the STEAM instrument and its dimensions



Detector head and electronics are about the size of a pack of cards.



Integrating Photon Counts Over Time

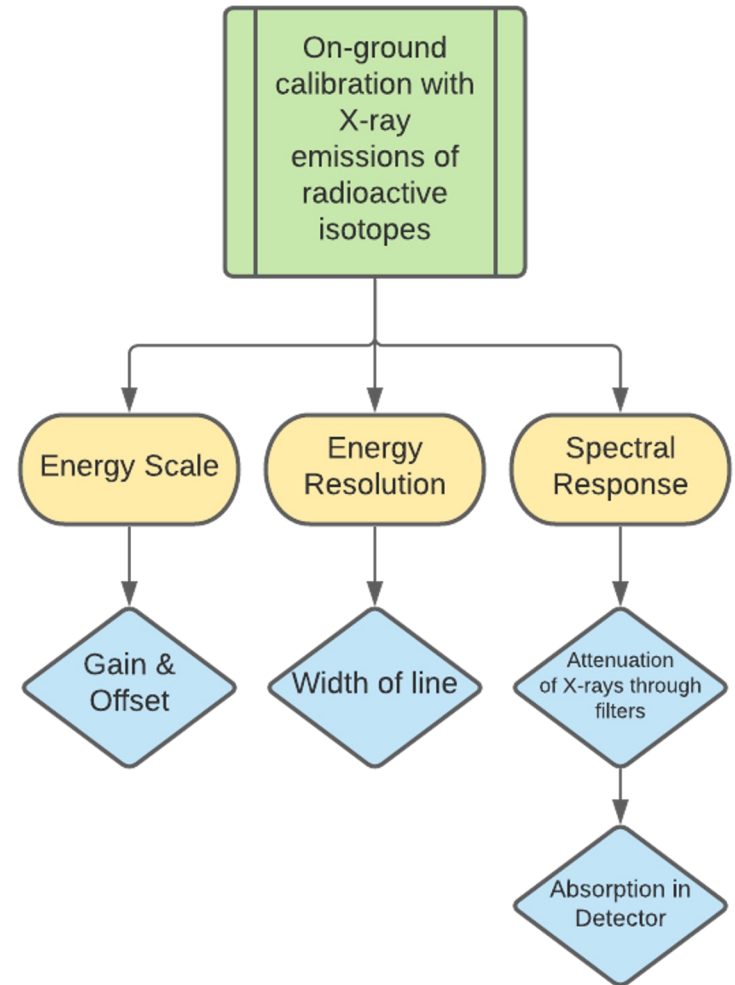
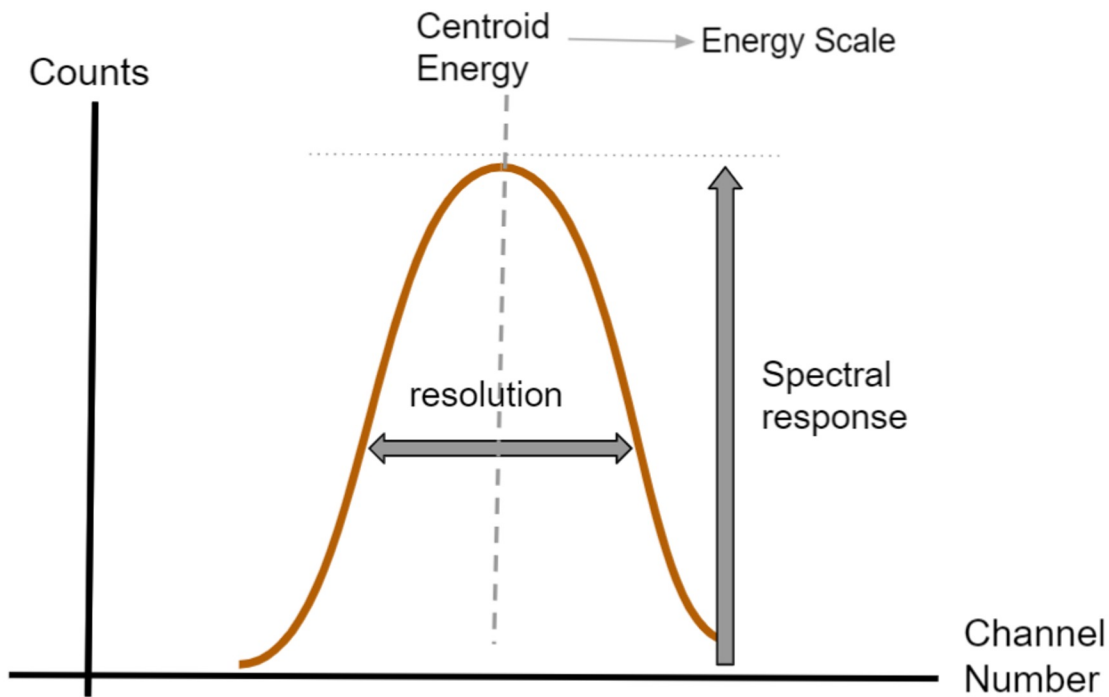


The individual histograms from 10-second integrations (red) can be summed to create a spectrum (white).



Spectrometer Calibration

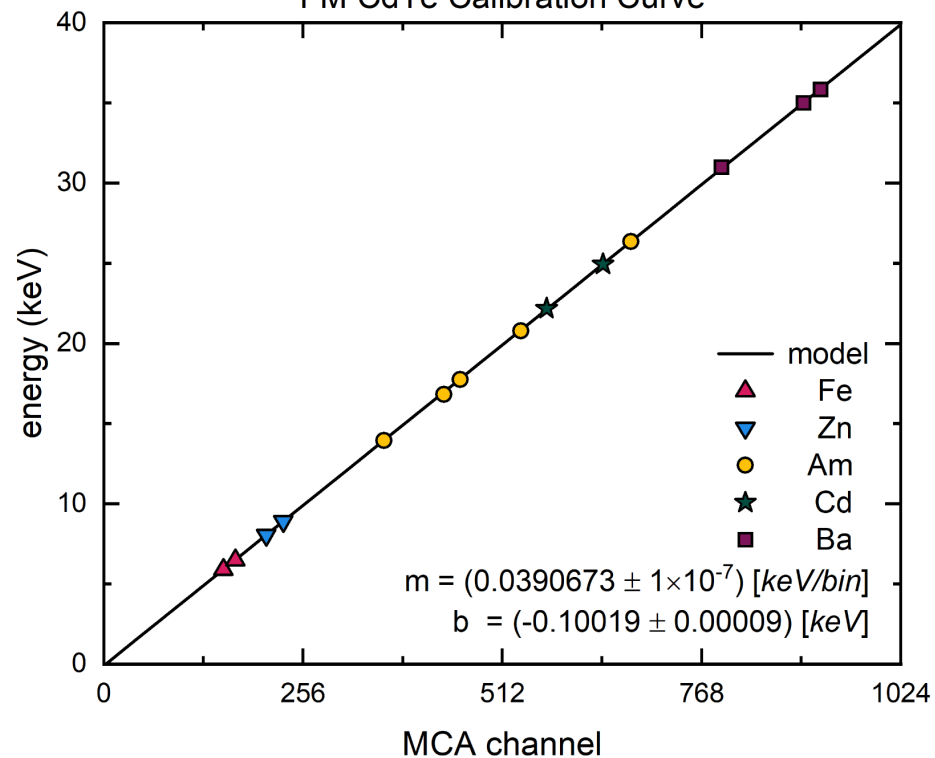
Below is a schematic of an emission line we would use to calibrate the energy scale of our detectors



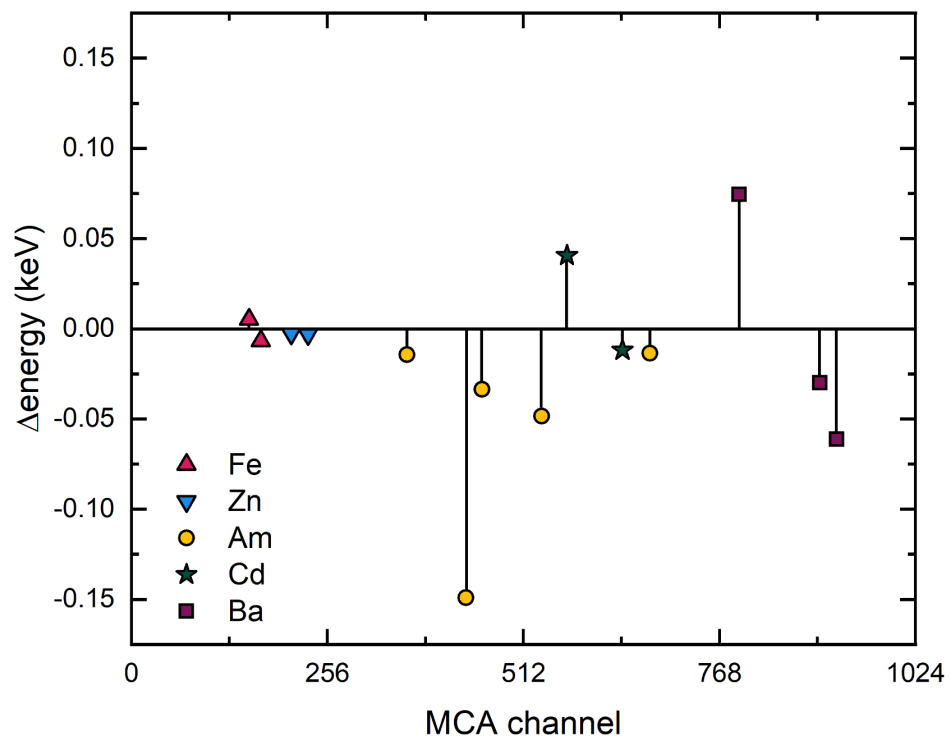


Calibration Data

FM CdTe Calibration Curve



FM CdTe Calibration Curve Residuals



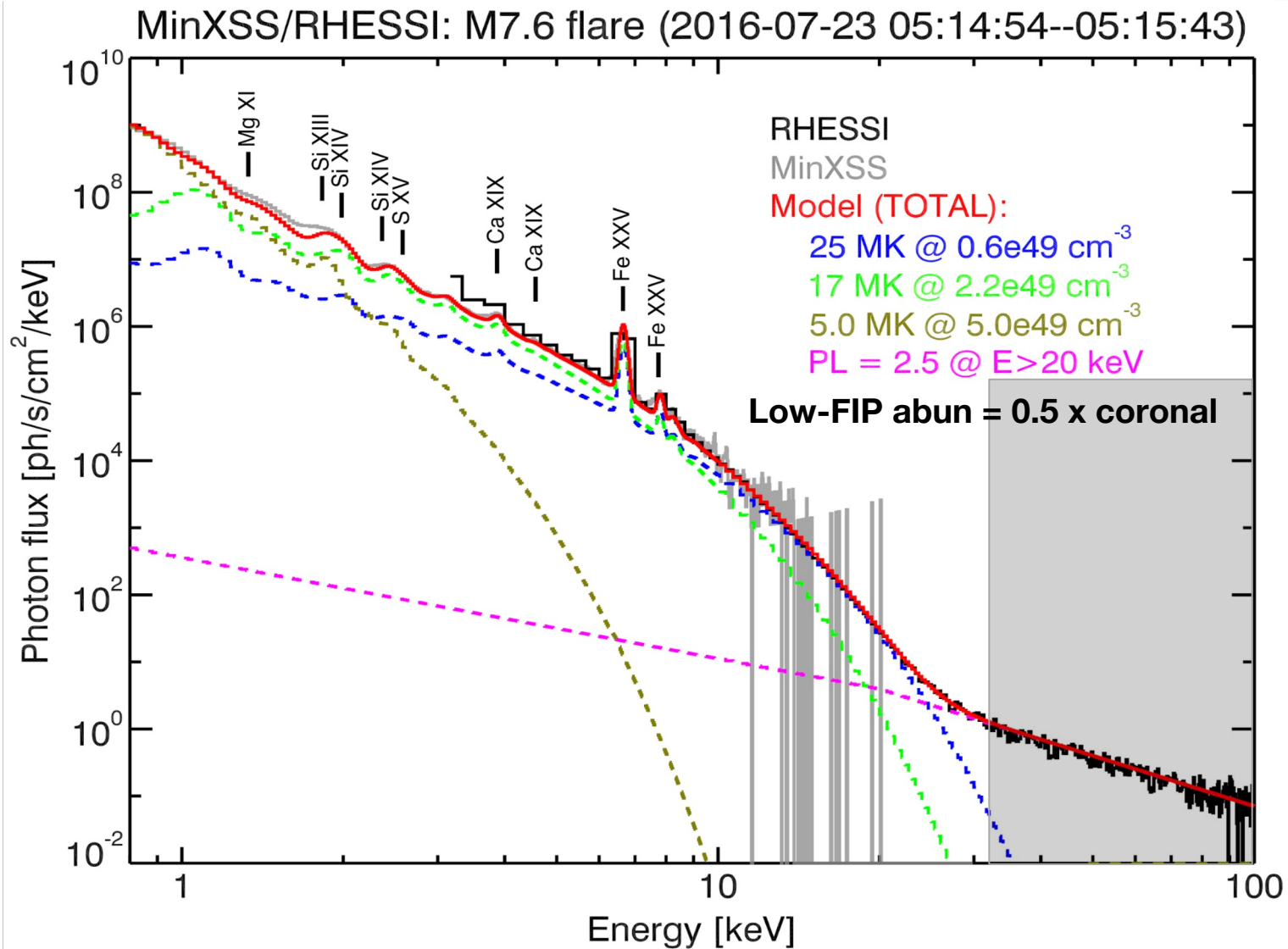


Achieving Science Goals

| Observables | Applying the Physics | Modeling |
|--|---|---|
| <p data-bbox="343 629 653 701">X-ray photons from source</p> <p data-bbox="336 1001 660 1033">↓</p> <p data-bbox="336 1001 660 1033">Respective energies</p> | <p data-bbox="832 401 1190 472">Define continuum and spectral line emissions</p> <p data-bbox="1000 511 1020 686">↓</p> <p data-bbox="846 696 1176 768">Fit temperatures and abundances</p> <p data-bbox="857 919 1164 1076">SXR (bound-bound radiation) Majority of line emissions</p> <p data-bbox="846 1143 1176 1300">HXR (free-free and free-bound radiation) Helps to constrain continuum shape</p> | <p data-bbox="1367 401 1682 472">Continuum shape & line intensities</p> <p data-bbox="1516 491 1535 625">↓</p> <p data-bbox="1367 654 1676 686">Forward Modeling</p> <p data-bbox="1516 719 1535 825">↓</p> <p data-bbox="1360 839 1688 953">Use Bremsstrahlung and atomic emission databases</p> <p data-bbox="1516 972 1535 1106">↓</p> <p data-bbox="1290 1129 1760 1200">Chi-squared minimization to derive physical parameters</p> |

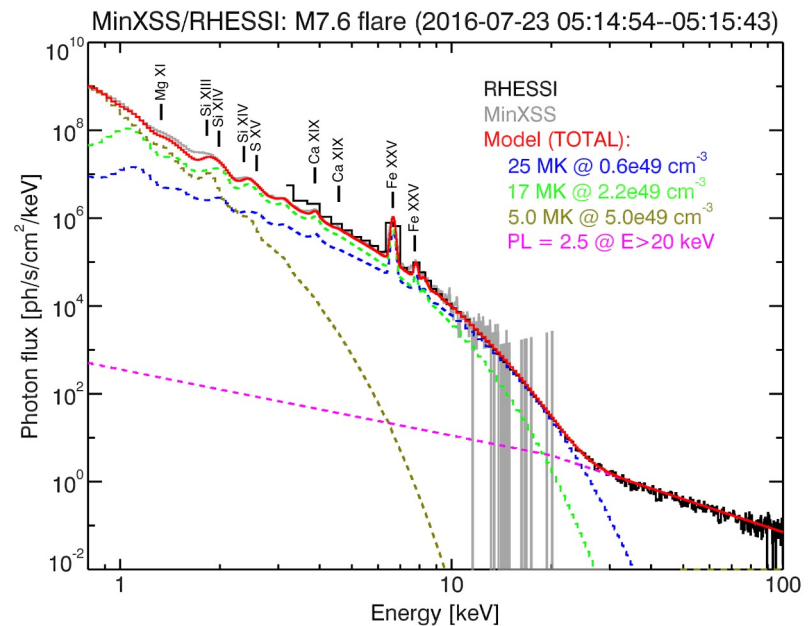
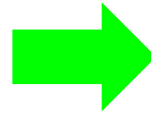
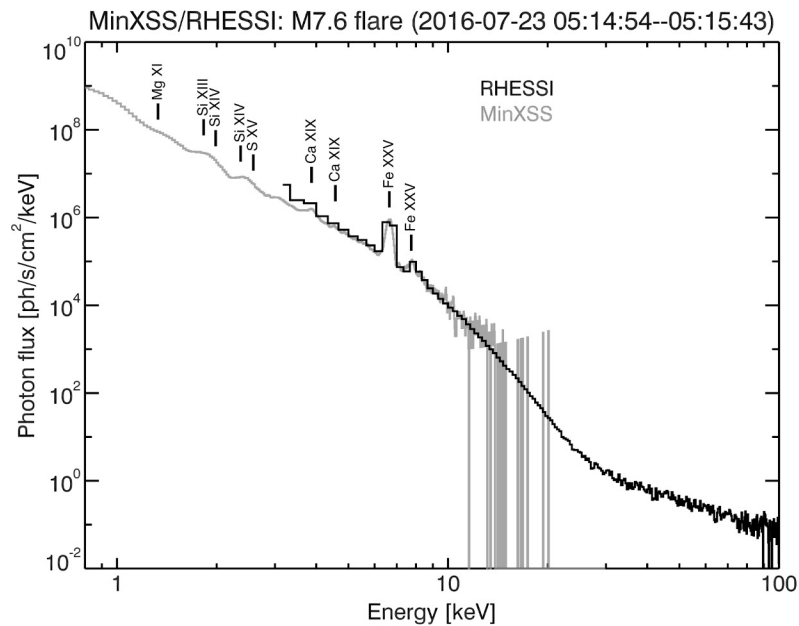
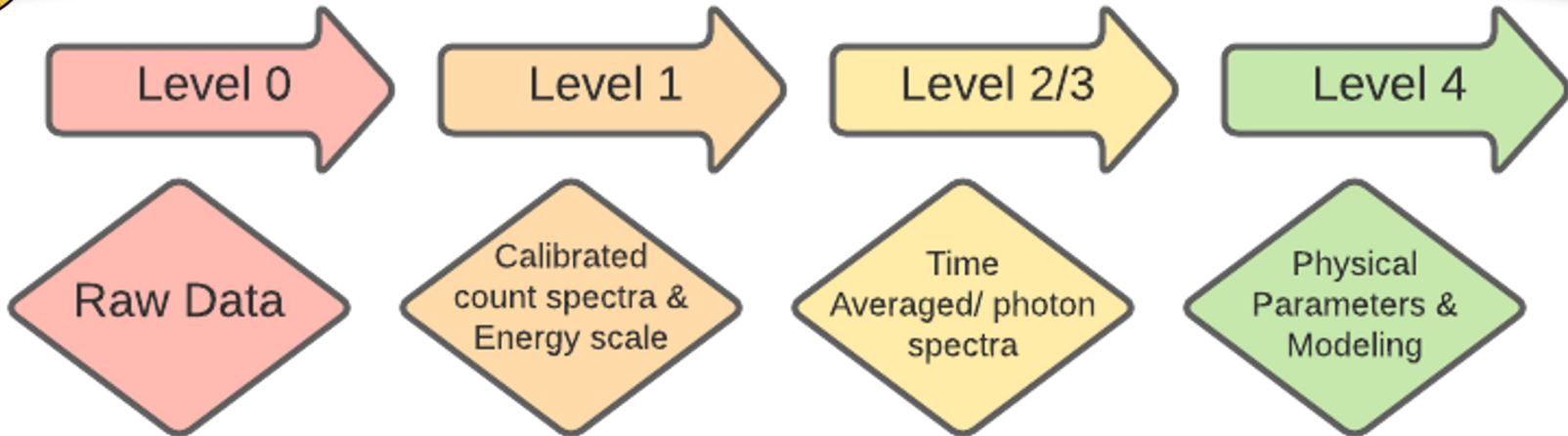


Expected Data & Analysis/Modeling



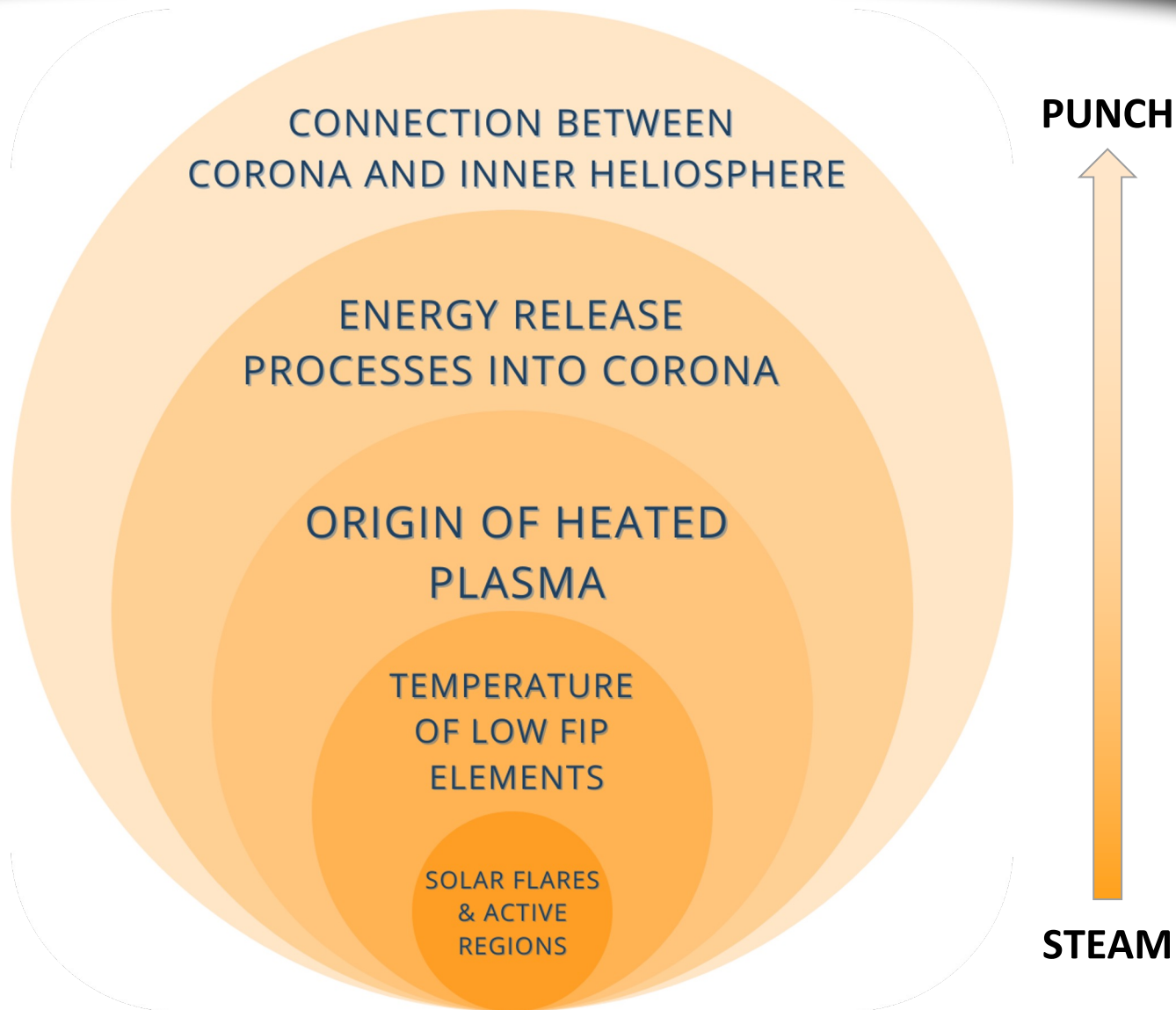


Tentative Data Pipeline





Connections to PUNCH





Current Work and Future Outlook

Current Work:

Finish assembly of Flight Model (FM)

FM Environmental tests

Analysis of FM spectrometer data for calibration between tests

Future Outlook:

Finish FM environmental tests

Complete final comprehensive testing

Delivery in August!