Polarimeter to Unify the Corona and Heliosphere

Student Thermal Energetic Activity Module (STEAM)

Gabriela Galarraga
Sarah Bordiuk
Samantha Honan
Owen Ahlers

Alvin Angeles
Anne O'Connor
Cassidy Bliss

Amir Caspi
Victor Andersen
Craig DeForest

STEAM
Student Energetic Activity Module
PUNCH

STEAM Science
August 10th, 2021

SwRI

COSGC
COLORADO SPACE GRANT CONSORTIUM

NASA

Introduction

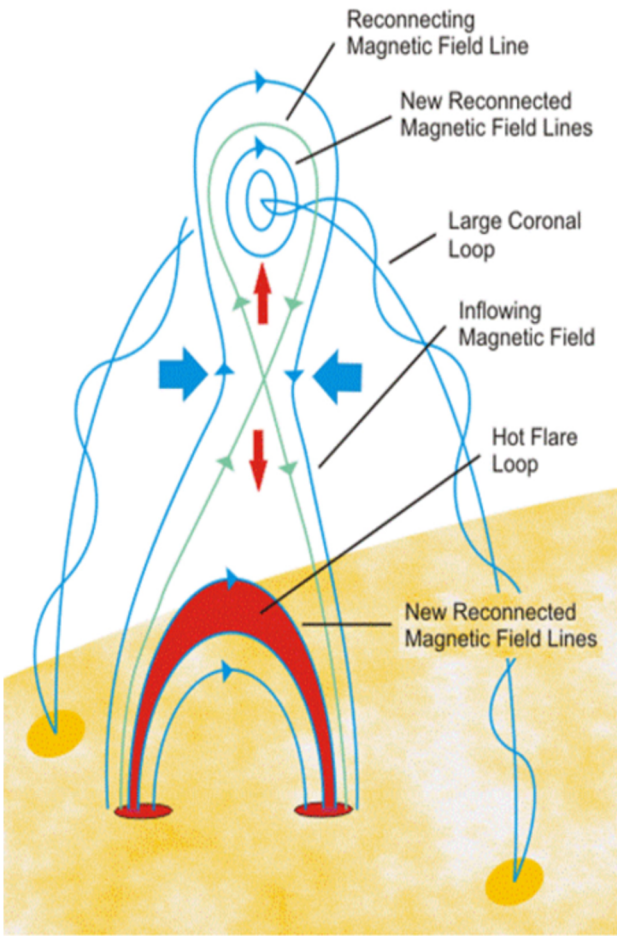
Science Objectives

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

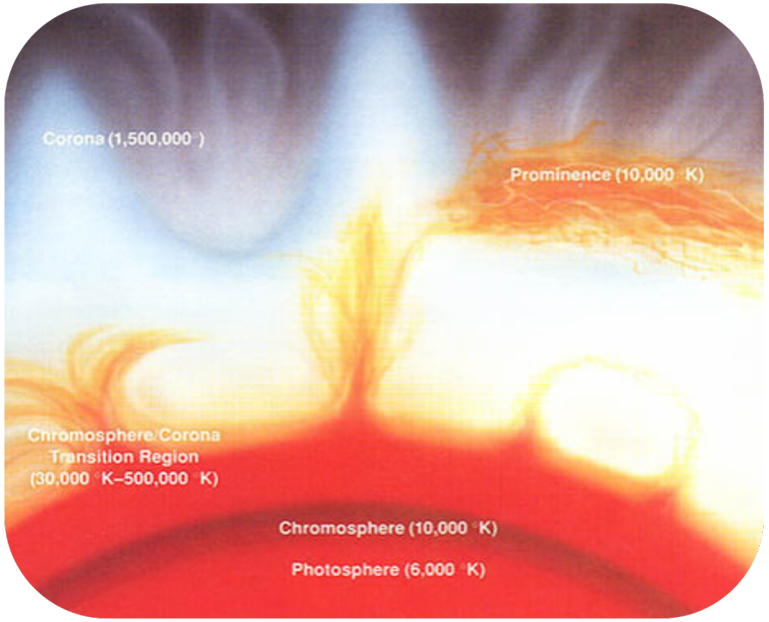
↓

Releases heat and energy into the corona

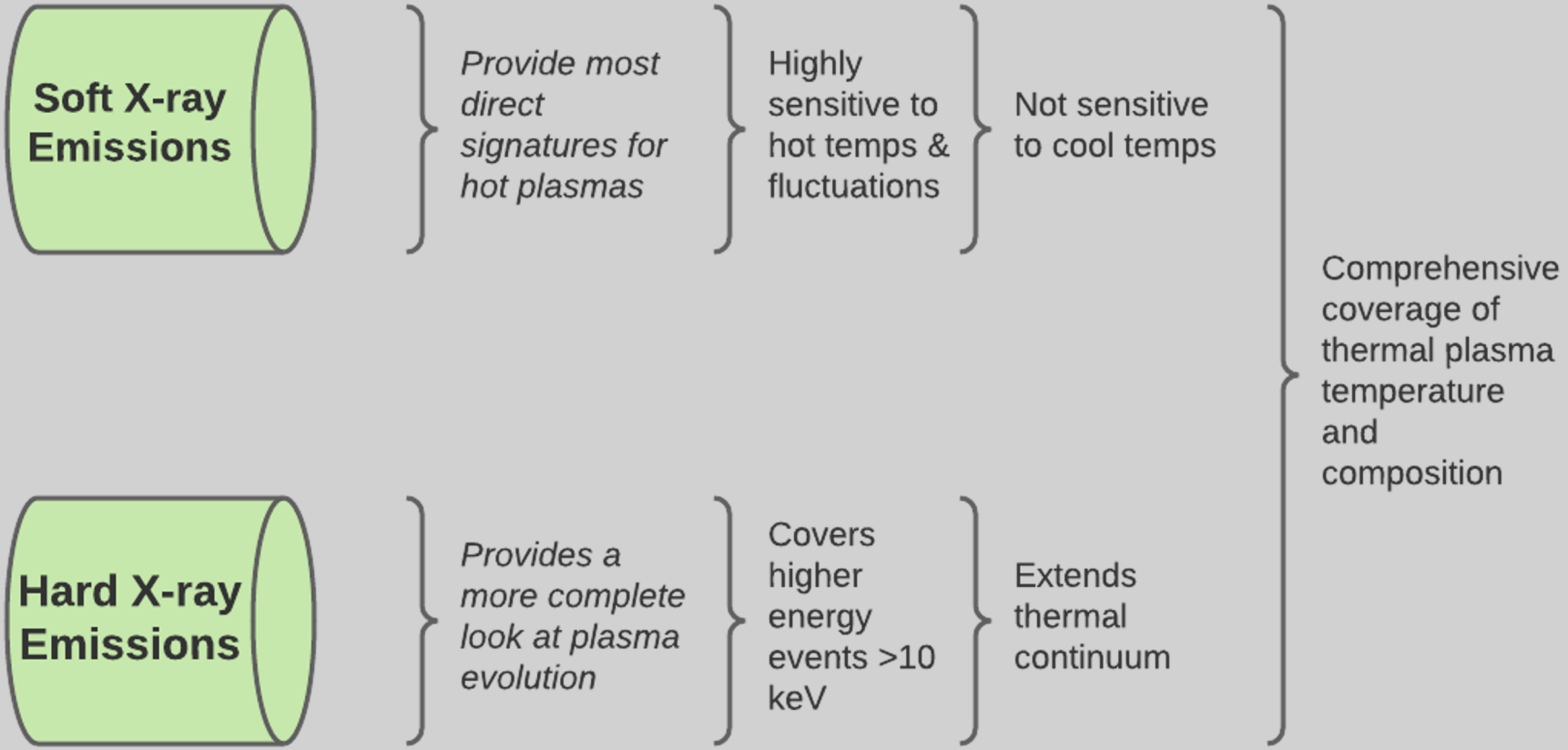
Low FIP Elements in Corona

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

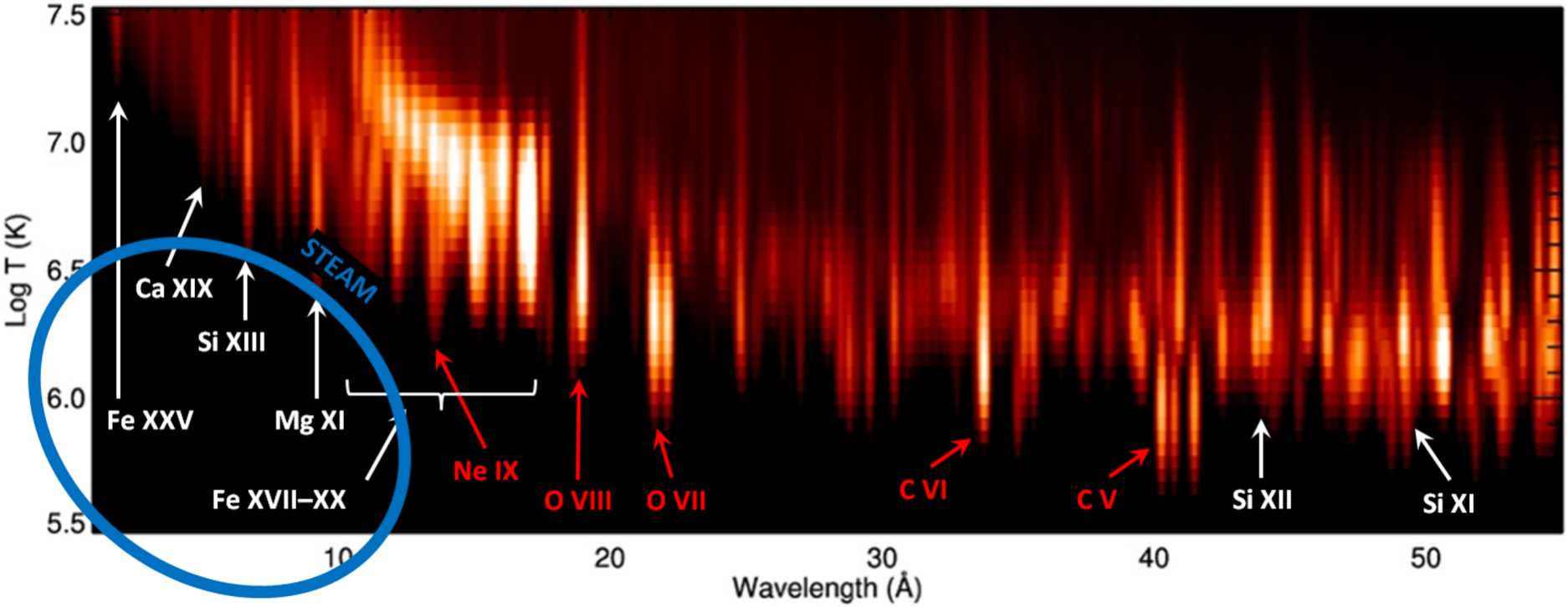
- Prominent above thermal continuum
- Abundances enhanced by a factor of ~4 in corona over chromospheric values
- Abundances allow STEAM to infer origin of plasma for flares and active regions (AR)



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

Why X-rays?

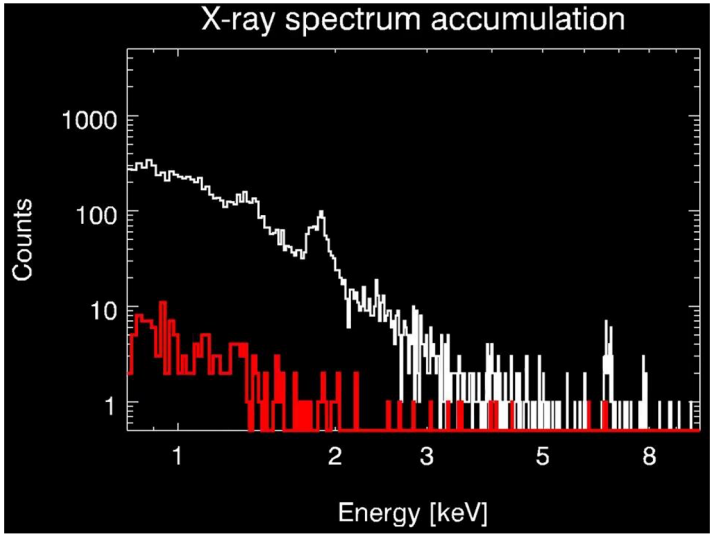


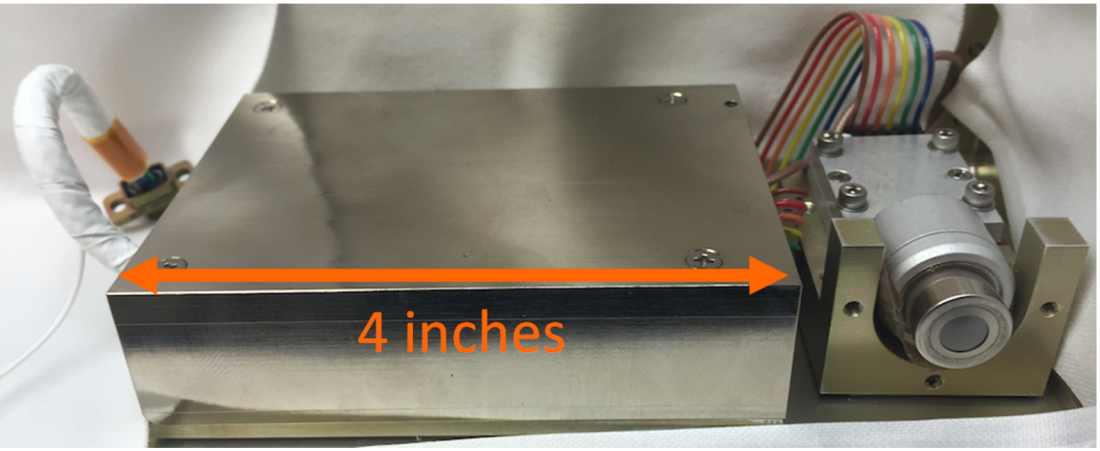
- STEAM will observe similar low-FIP spectral lines as MinXSS-1 but with greater resolution, energy coverage, and temporal coverage

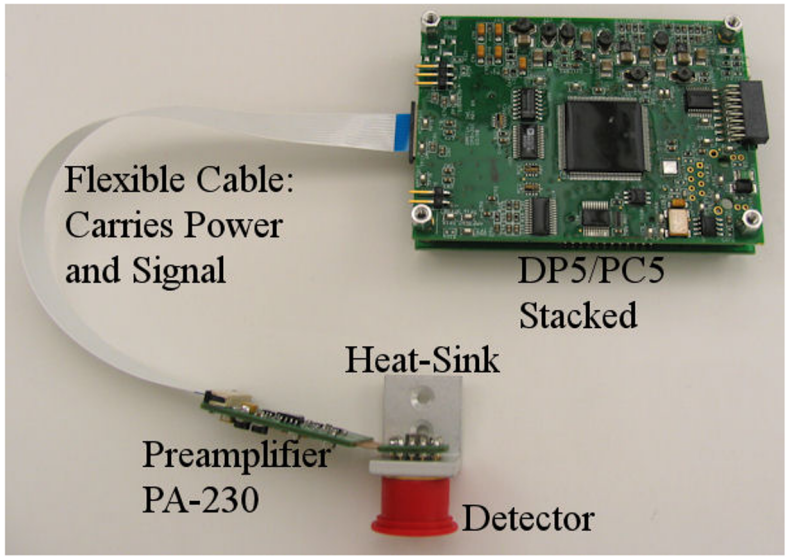
How are we going to measure X-rays?

- Detector will measure individual incident photons and their energies
- Photons are assigned into appropriate bins based on their energies.
- Each integration period provides a histogram spectrum of detected photons

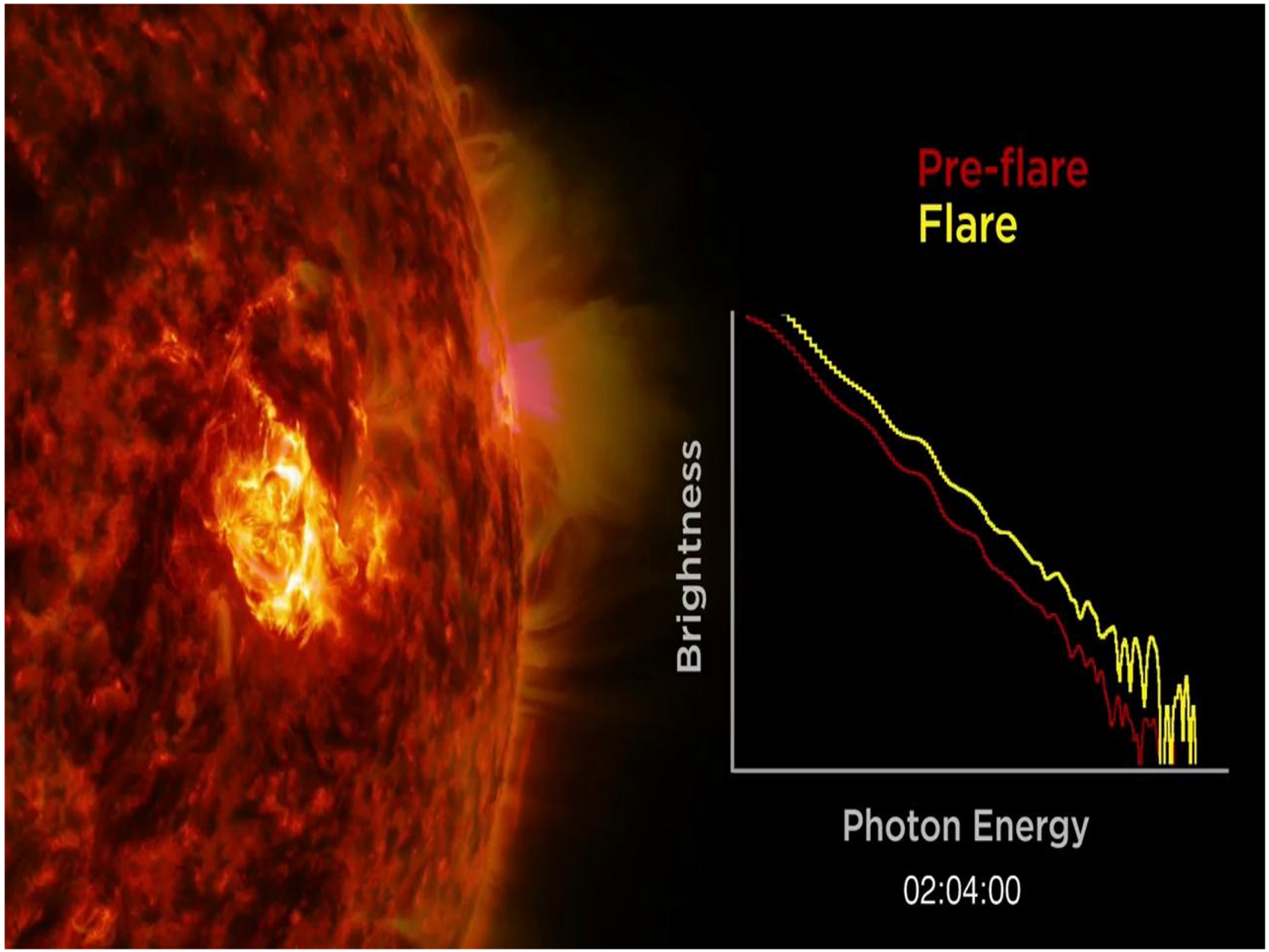
  → Can be summed to improve statistics







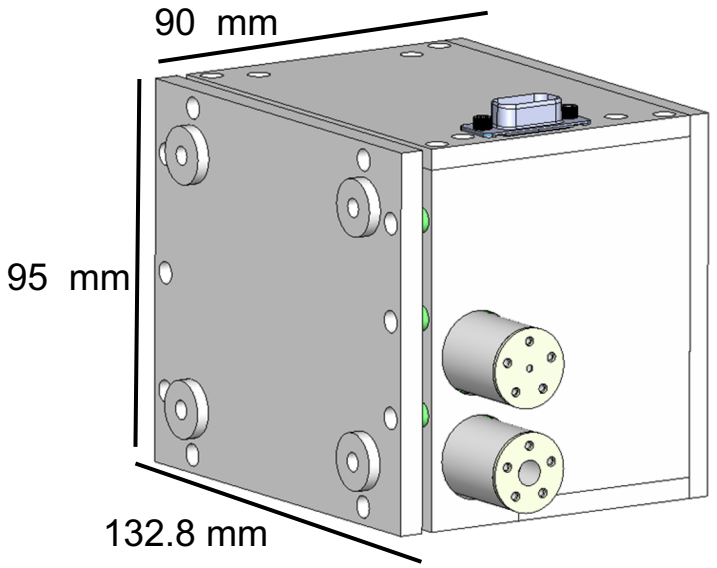
Flare observed by MinXSS



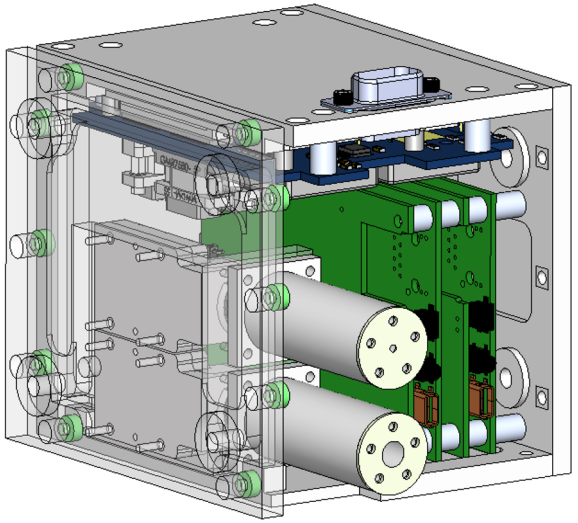
What is STEAM?

Soft X-ray Measurements	Silicon Drift Detector
Hard X-ray Measurements	Cadmium Telluride Detector

CAD model of STEAM instrument and its dimensions

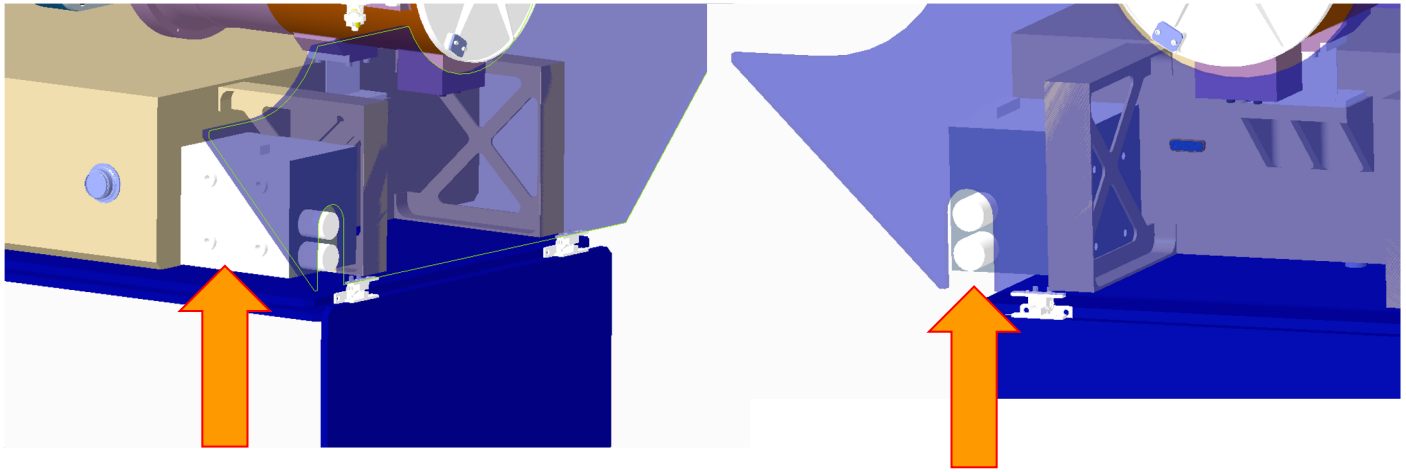


	SXR	HXR
Energy Range	1 to 7 keV	7 to 20 keV
Resolution	< 0.3 keV	< 1 keV
Field of View	5.25° to 10°	5.25° to 10°

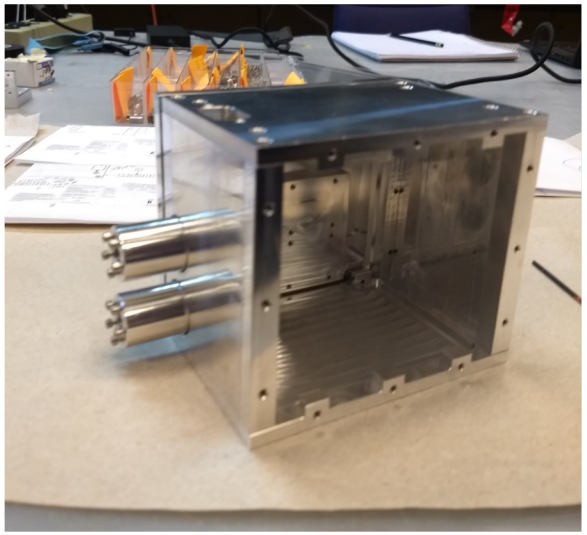


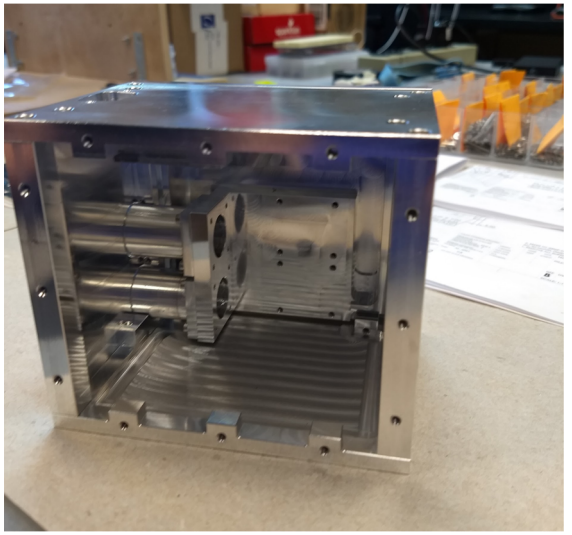
What is STEAM?

STEAM as it would fit in the PUNCH NFI satellite



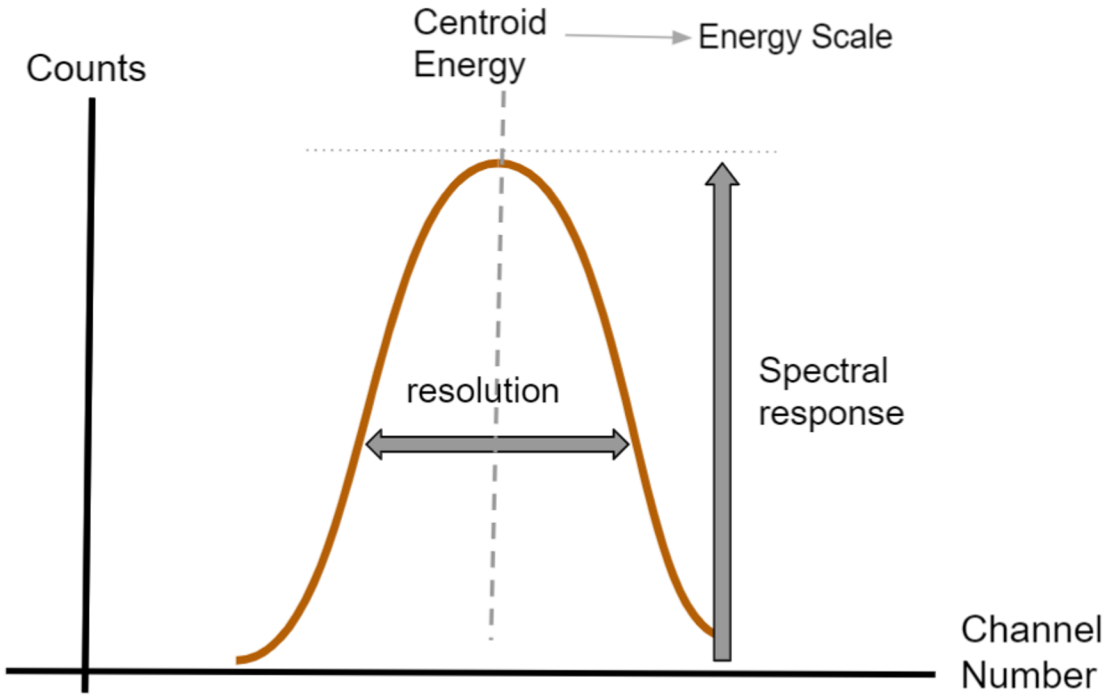
Prototype build of STEAM

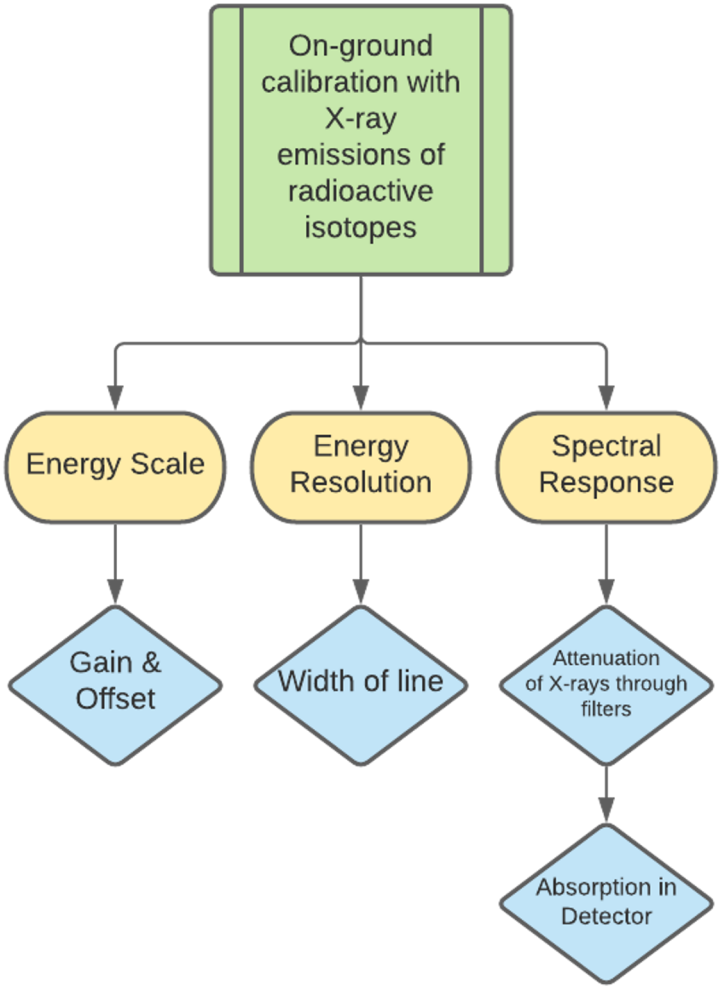




Spectrometer Calibration

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

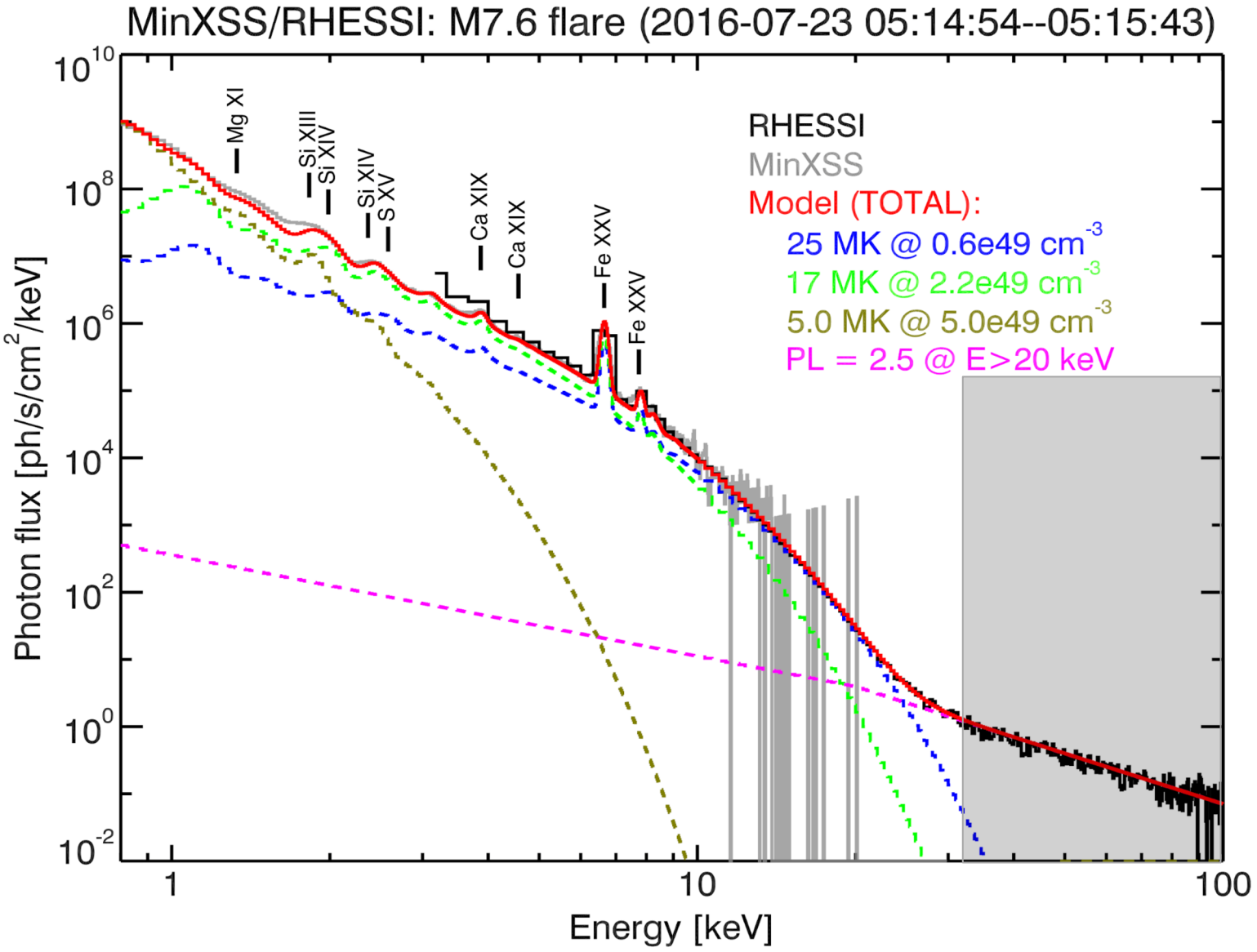




Achieving Science Goals

Observables	Applying the Physics	Modeling
	Define continuum and spectral line emissions	Continuum shape & line intensities
	↓	↓
X-ray photons from source	Fit temperatures and abundances	**Forward Modeling**
↓		↓
		Use Bremsstrahlung and atomic emission databases
	SXR (bound-bound radiation) Majority of line emissions	↓
Respective energies		**Chi-squared minimization** to derive physical parameters
	HXR (free-free and free-bound radiation) Helps to constrain continuum shape	

Expected Data & Analysis/Modeling



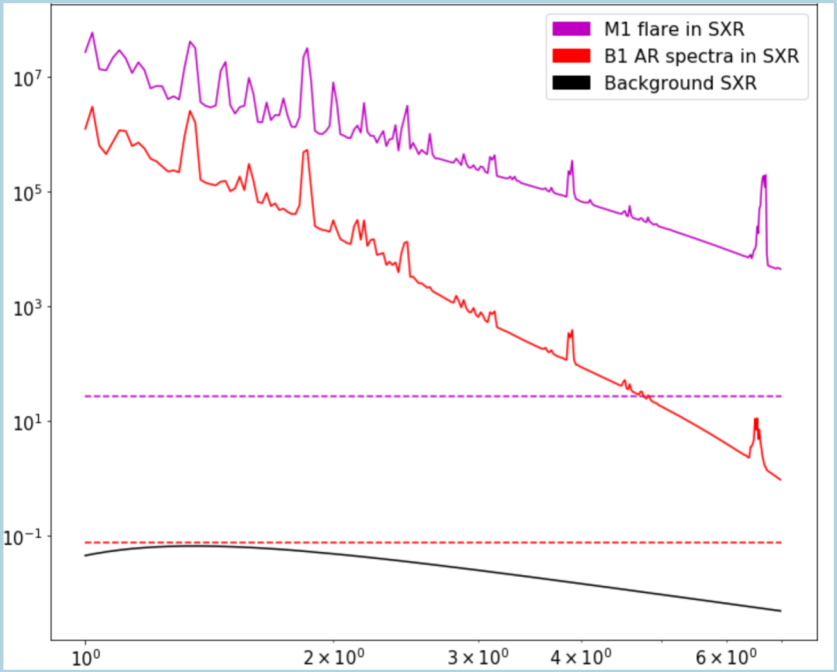
Addressing Cosmic X-ray Background

Soft X-Ray

- CXB is not a significant source of uncertainty
- CXB < 1% Solar Flux

FOV= 10 degrees

SXR: M1 flare, B1 Active Region, & Background



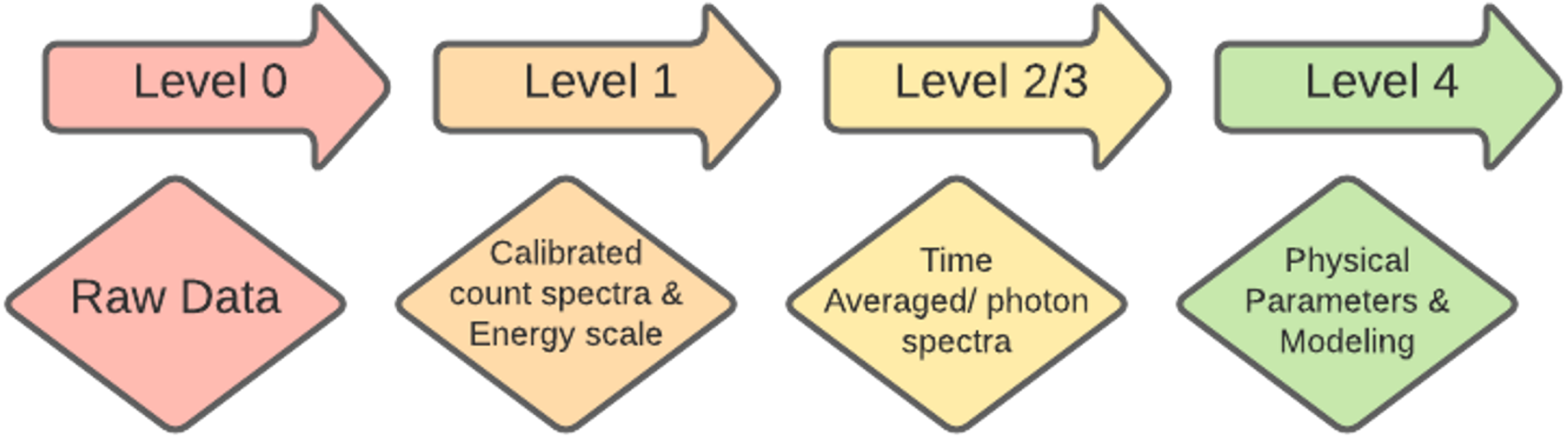
Counts/s/cm^2/KeV

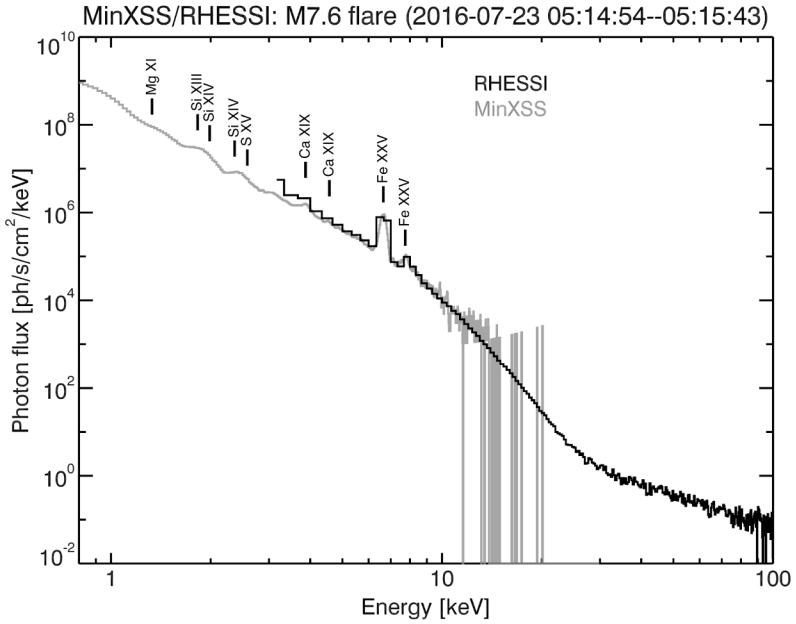
Hard X-Ray

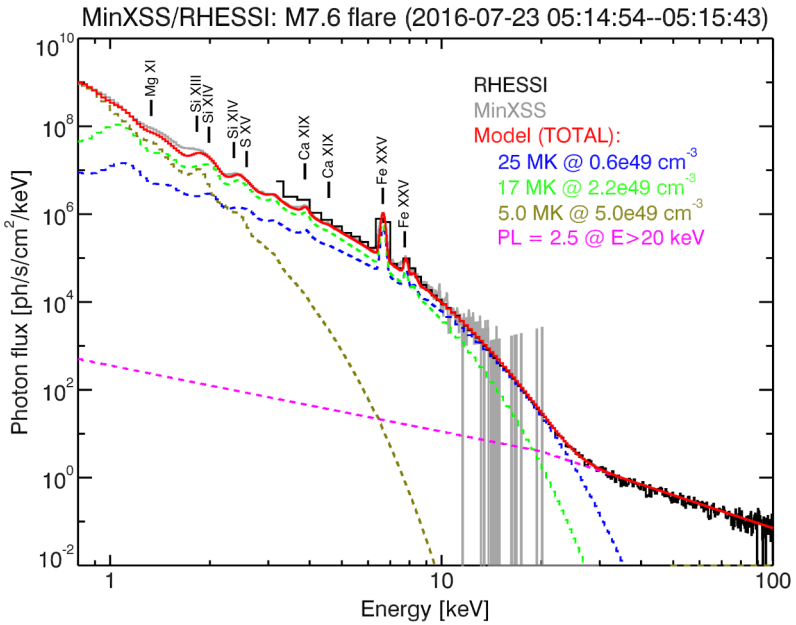
- Flares produce significant counts
- HXR active region counts are insignificant

HXR: M1 flare, B1 Active Region, & Background

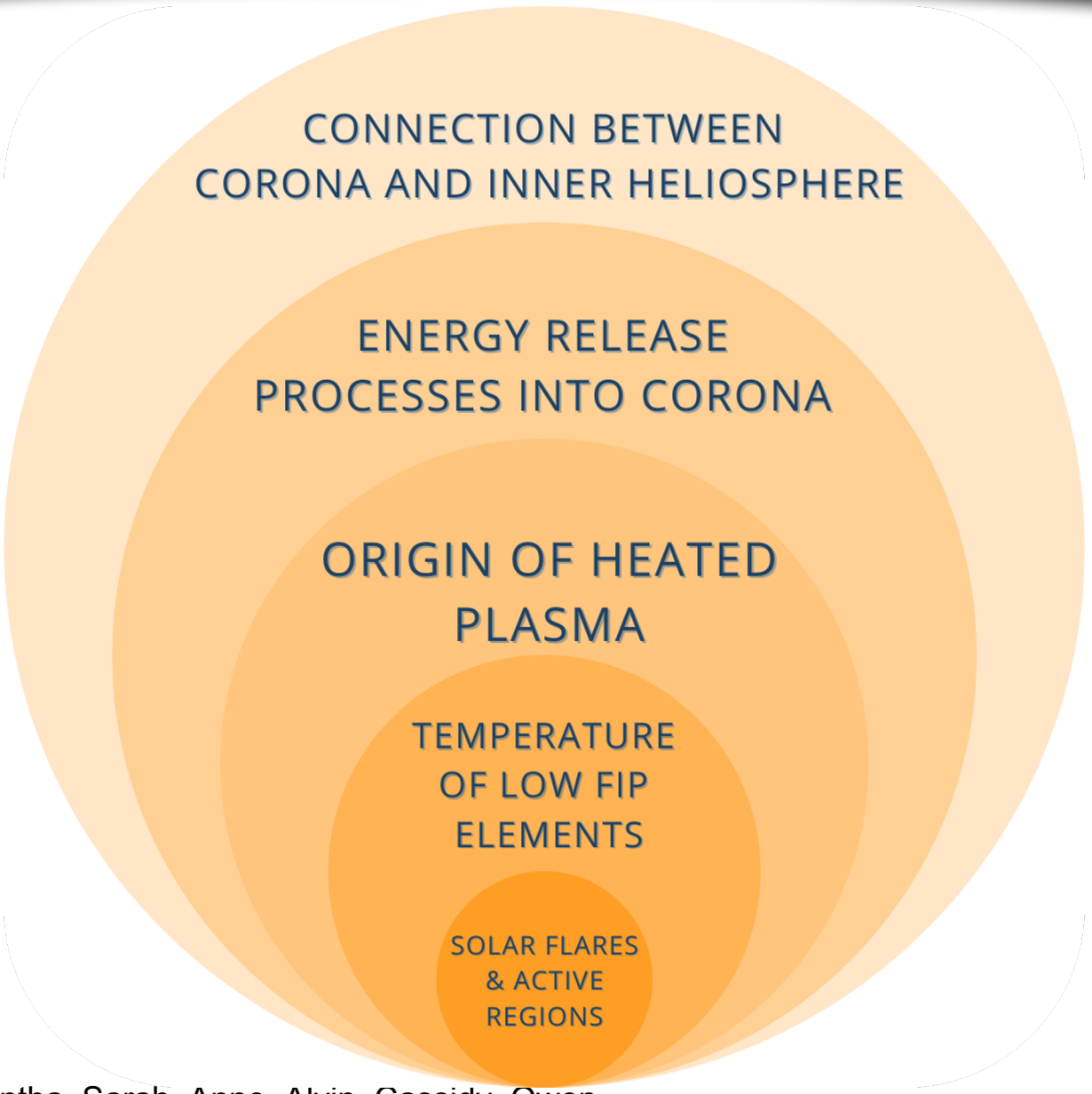
Tentative Data Pipeline







Connections to PUNCH



Current Work and Future Outlook

Current Work:

We are currently in Phase C of development

- PDR (Preliminary Design Review) passed!

Spectrometer testing and calibration using radioactive isotopes

- working towards obtaining Fe 55, Am 241, Ba 133, Zn65, & Cd109

Future Outlook:

- Create Engineering Model (EM)
- Instrument Critical Design Review ~ October 2021