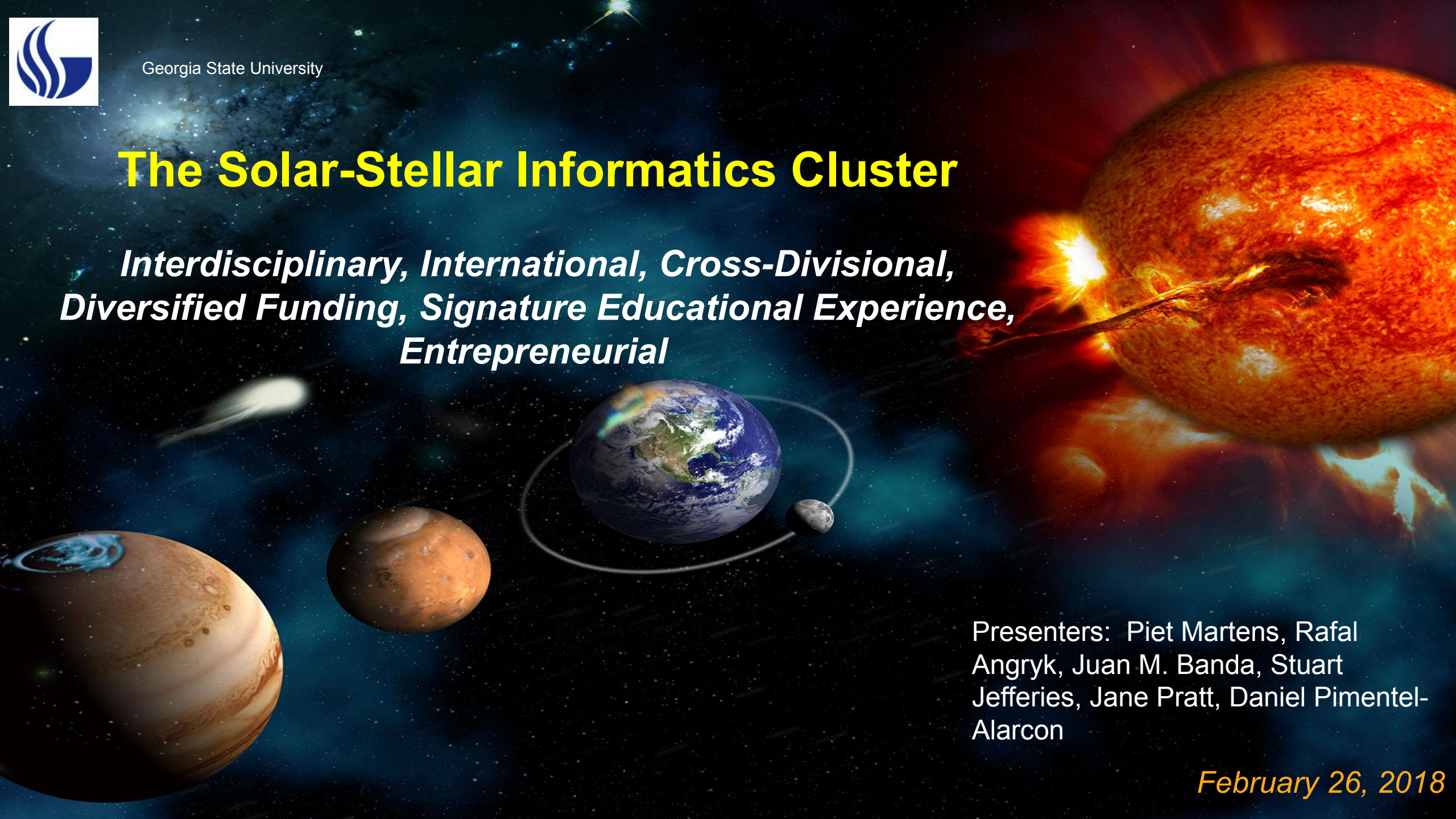


Georgia State University

The Solar-Stellar Informatics Cluster

Interdisciplinary, International, Cross-Divisional, Diversified Funding, Signature Educational Experience, Entrepreneurial

Presenters: Piet Martens, Rafal Angryk, Juan M. Banda, Stuart Jefferies, Jane Pratt, Daniel Pimentel-Alarcon

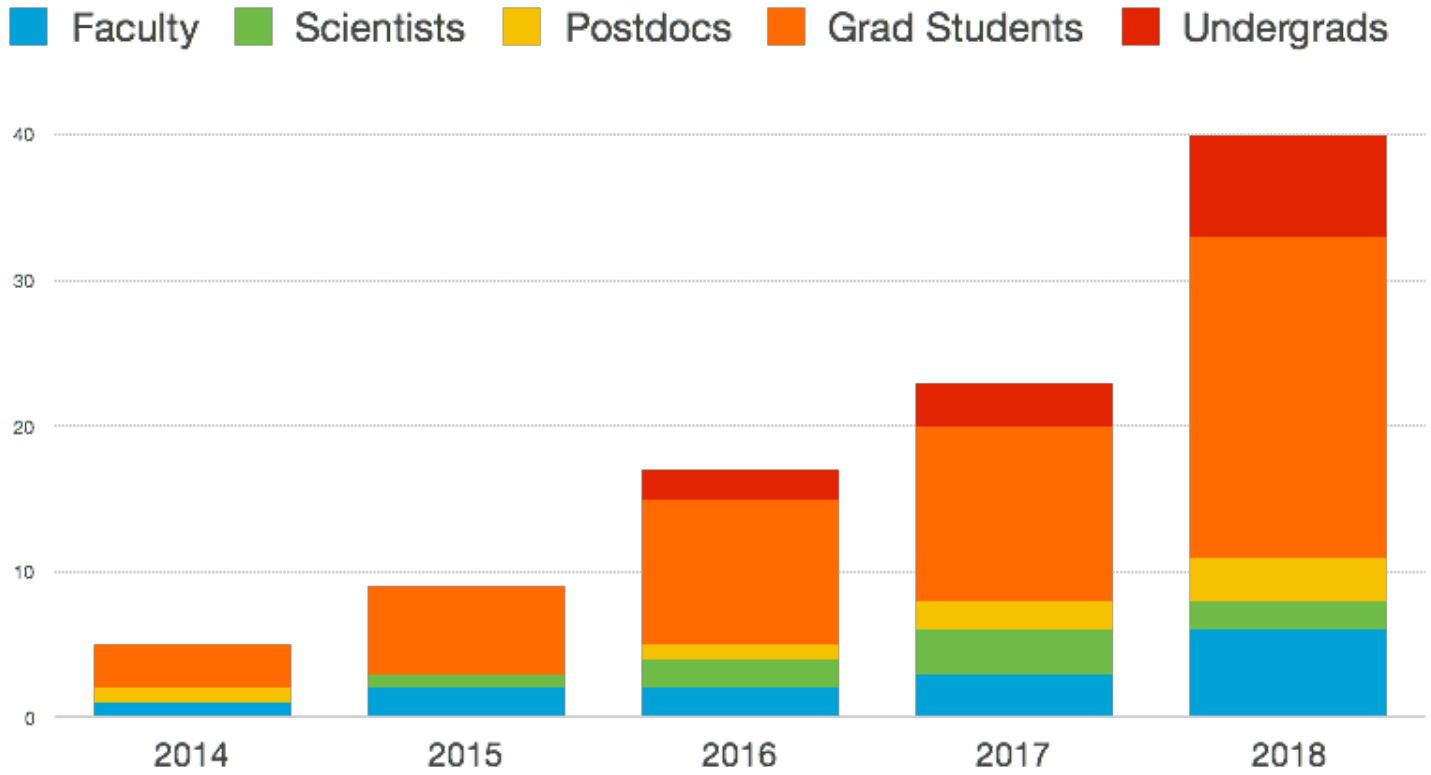
February 26, 2018

Outline

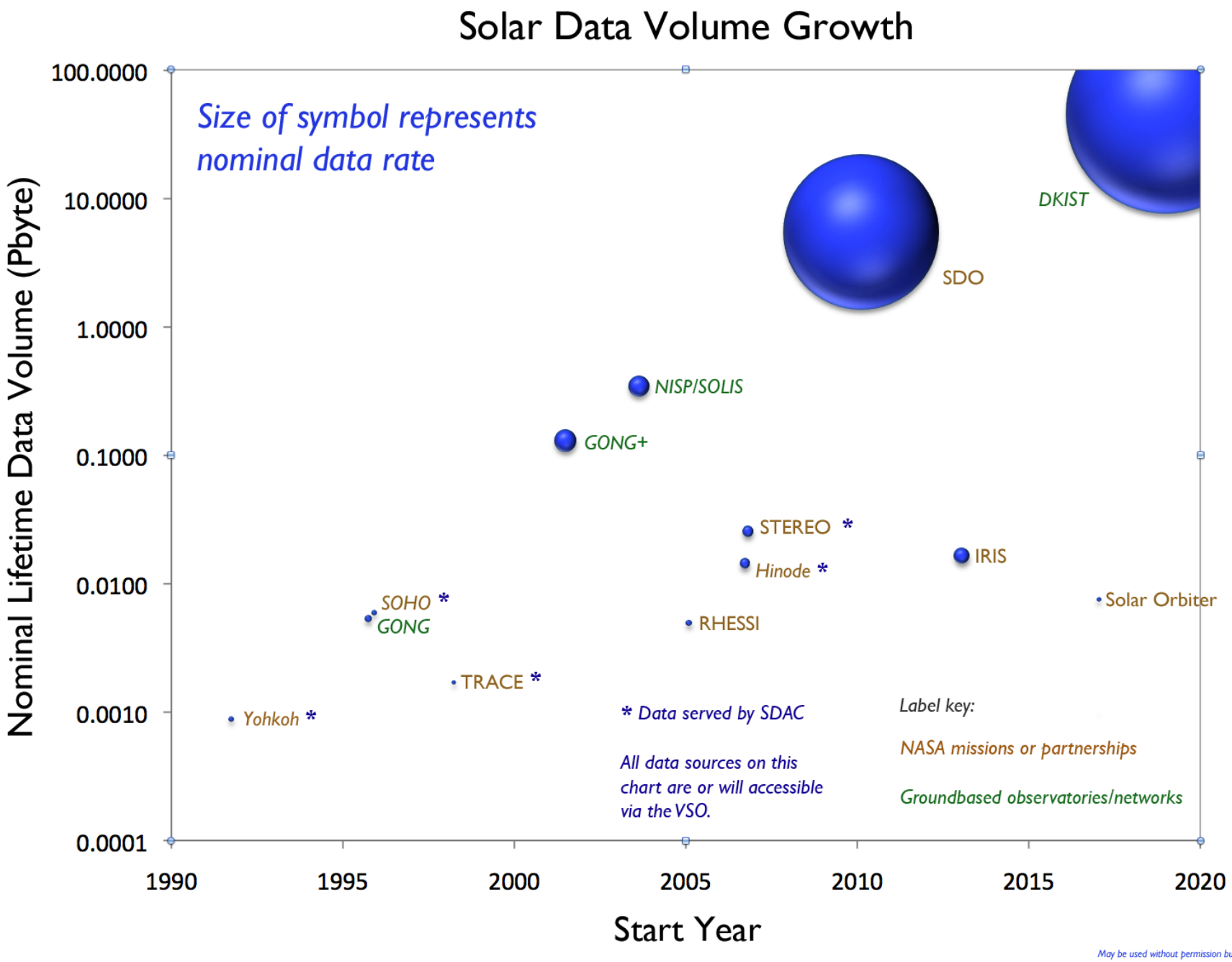
1. Introduce Group
2. Science Motivation
3. Science Objectives
4. Educational Program
6. Individual Science Highlights
7. Public Relations and Outreach
8. SWOT Analysis: Strengths, Weaknesses, Opportunities, and Threats, including funding
9. Compliance with University Objectives

Basics: Please feel free to interrupt and question. The presentation is designed to be < 40 minutes for that purpose

Solar-Stellar Informatics Cluster – 38 Group Members



700% growth in just 4 years!

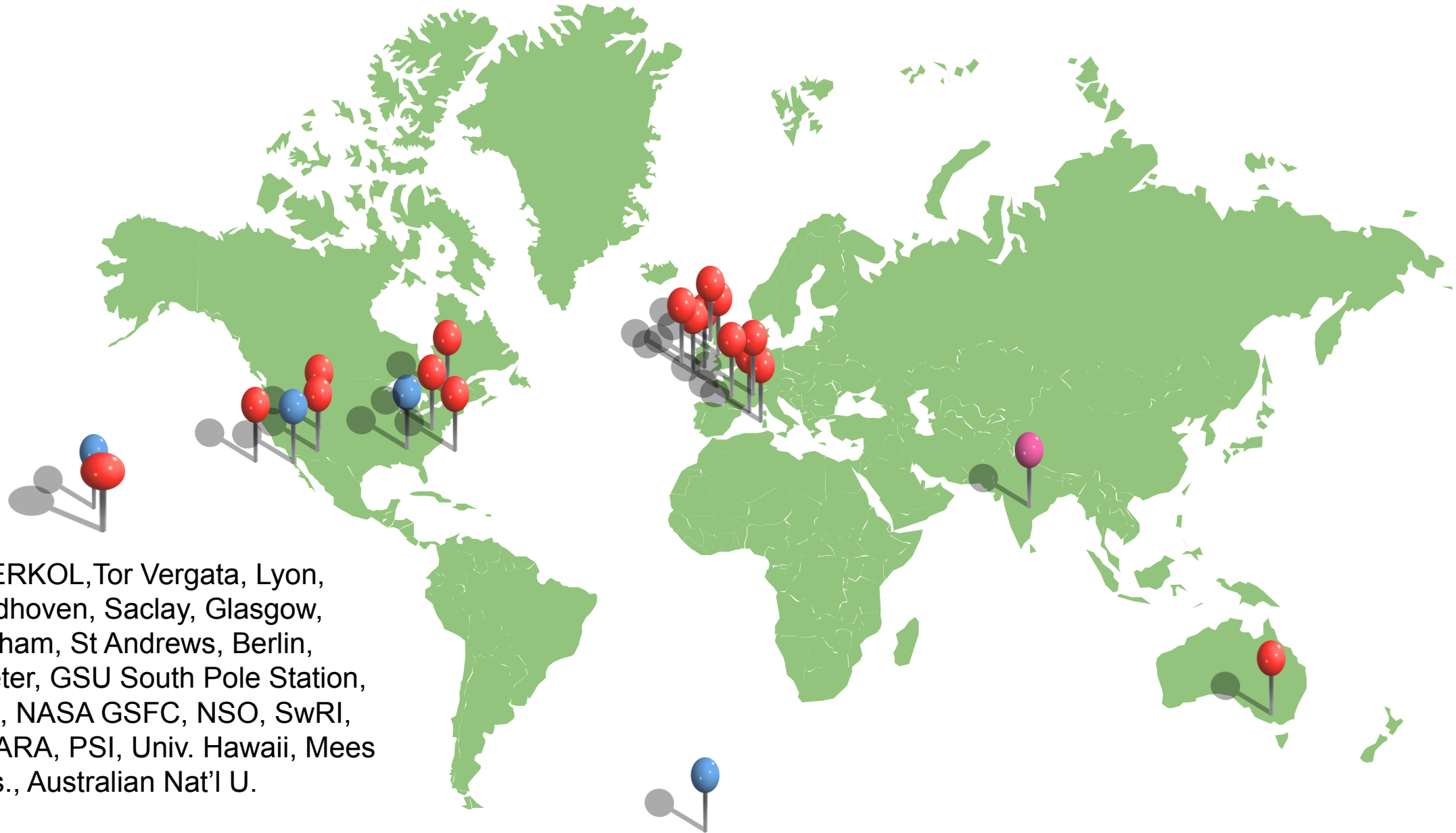


Why does this matter?

- "*A solar superstorm, similar to the 1859 Carrington event, could cripple the entire US power grid for months and lead to economic damage of $1-2 trillion dollars*" (Space Studies Board of the National Research Council, 2008)

- Confirmed in independent study by Lloyd's of London

Solar-stellar Informatics Active Collaborations



IISERKOL,Tor Vergata, Lyon, Eindhoven, Saclay, Glasgow, Durham, St Andrews, Berlin, Exeter, GSU South Pole Station, CfA, NASA GSFC, NSO, SwRI, CHARA, PSI, Univ. Hawaii, Mees Obs., Australian Nat'l U.

A Core Cluster Research Objective

Solar Event Prediction: Develop benchmark datasets, apply cutting edge machine learning techniques to forecast hazardous solar events

Solar Cycle Prediction: Data-driven MHD forecasts. Combine with CHARA and Lowell observations of Sun-like stars to and improve our physical understanding of the dynamo

Content Based Image Recognition (CBIR): Develop novel feature recognition, and feature tracking algorithms for solar and spin-off applications

Short term: Solar flare prediction

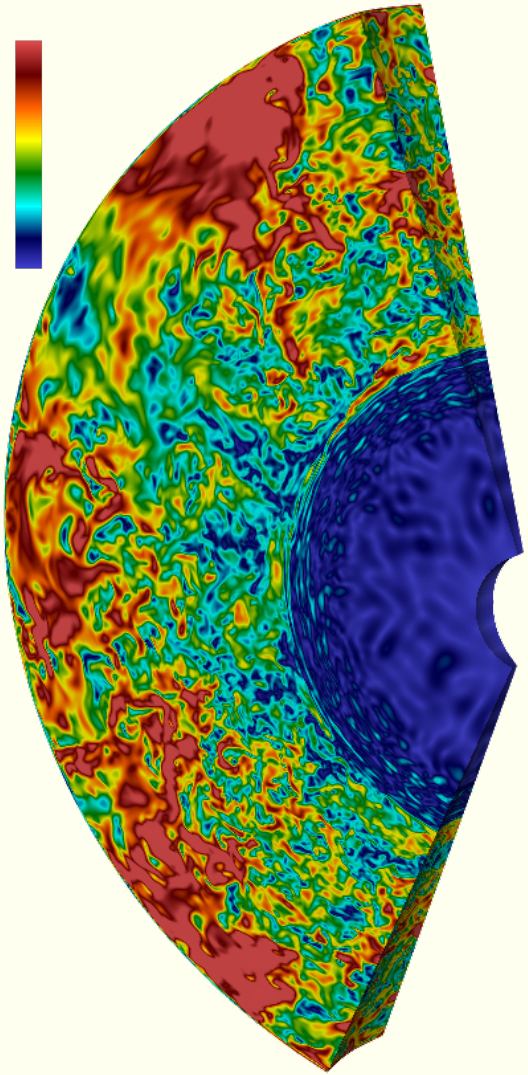
Longer term: Explore stellar data-sets, e.g. TESS & PLATO, branch out into medical and biological research

A Signature Educational Experience

Graduate Students in our group, both in Astronomy and Computer Science:

- **Students and faculty take part in a common weekly interdisciplinary meeting. Thesis advising from both disciplines.**
- **Cross-disciplinary courses, data mining for astronomy students, solar and stellar physics for CS students.**
- **Internships and exchanges abroad and nationally: NASA Heliophysics and Space Weather summer school, La Serena school for data science, internships with Google, Apple, long-term student visit to Kolkata, JPL, CIOS, AFRL.**
- **Dual PhD program with Tor Vergata (Rome): strategic recruitment.**
- **The icing on the cake! The Astromundus initiative. Exchanges of students between 10 European and two US universities to gain local expertise. GSU brings in: Big Data, Machine Learning, HPC, Instrumentation.**

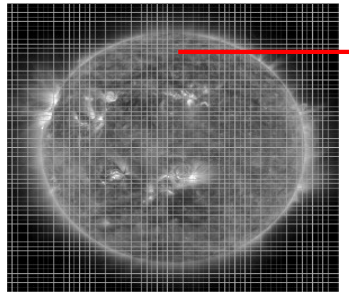
Theory/Computation of Stellar Interiors, J. Pratt



Velocity magnitude in a pre-main sequence star. 3D grid $1312 \times 1024 \times 64$.

- MUltidimensional Stellar Implicit Code (MUSIC) interfaced & realistic to Lyon and MESA 1D stellar evolution codes.
- Next generation of stellar evolution models motivated by CFD, improvement over simple phenomenologies and fitted parameters.
- Research Highlights: new approach and new models for convective overshooting and penetration, consequences for lithium depletion: [1] Pratt, Baraffe, et al. (2017) A&A. [2] Baraffe, Pratt, et. al. (2017). ApJ Lett.
- High Performance Computing: purchase of seed for a HPC cluster with start-up funds, need for continuing investment and support.

Solar event classification: from classical methods to deep neural networks



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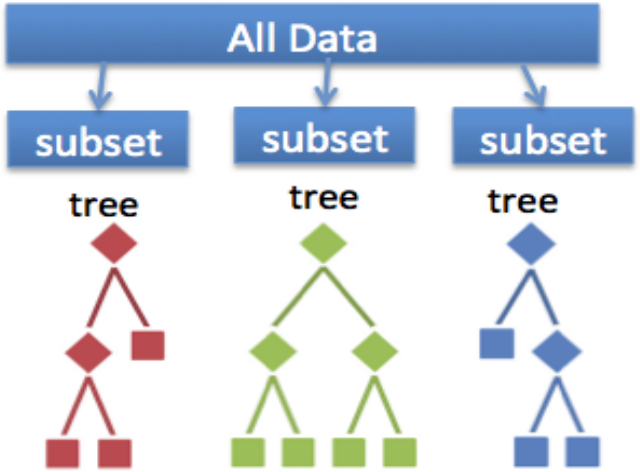
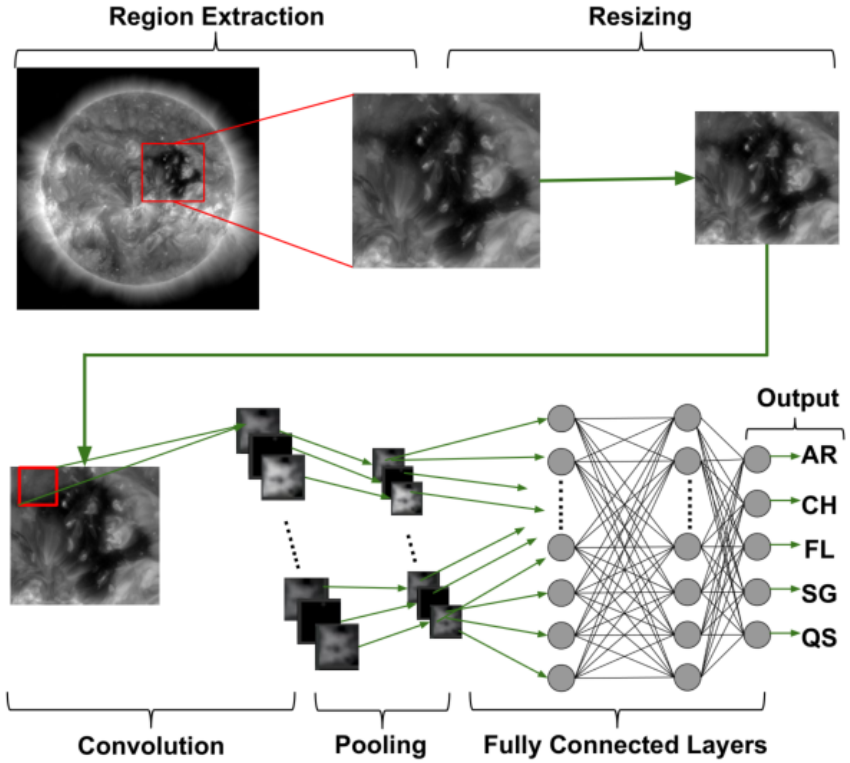
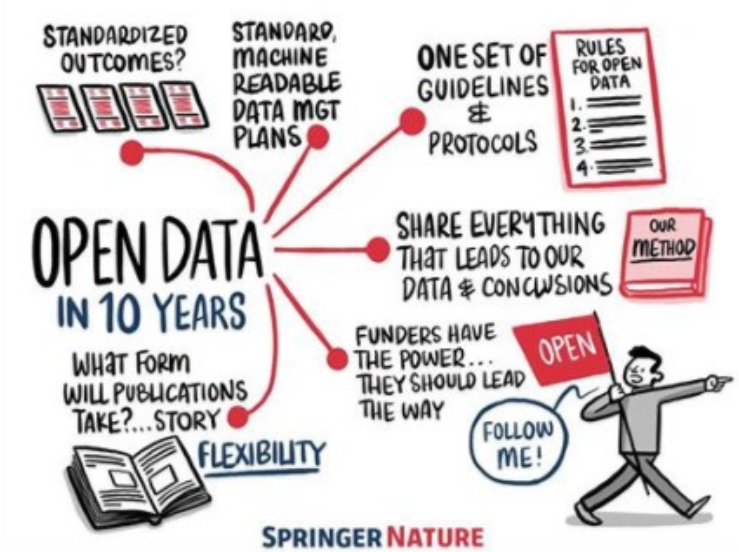
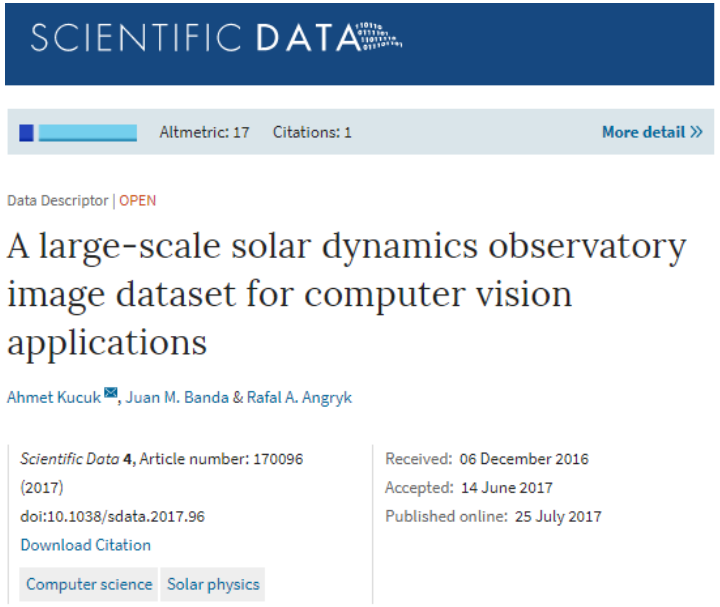
Mean	0.2695
Standard Deviation	0.5751
3rd Moment (skewness)	0.3652
4th Moment (kurtosis)	0.1112
Uniformity	0.9984
Relative Smoothness (RS)	0.2154
Fractal Dimension	0.0014
Tamura Directionality	0.1512
Tamura Contrast	0.1412

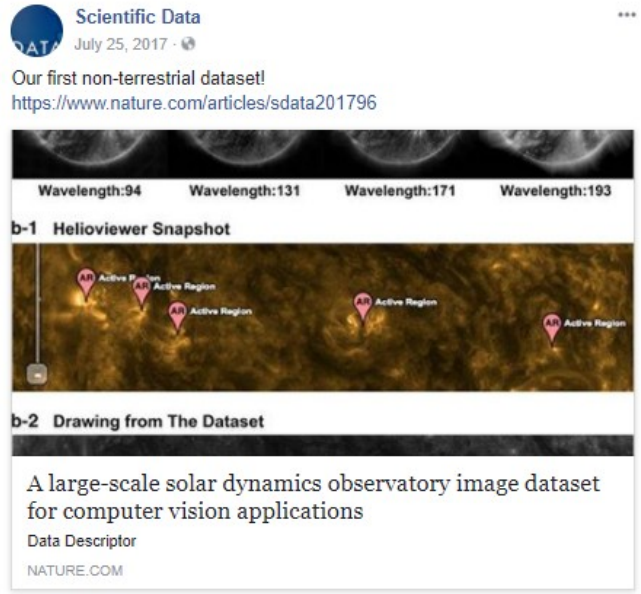




Data availability for non-Solar scientists







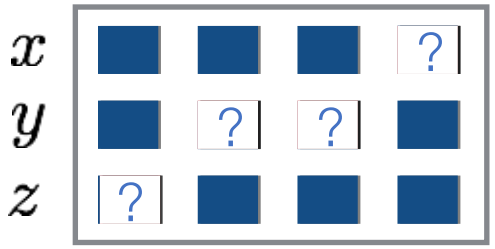
Data from: January 1, 2012, and December 31, 2014

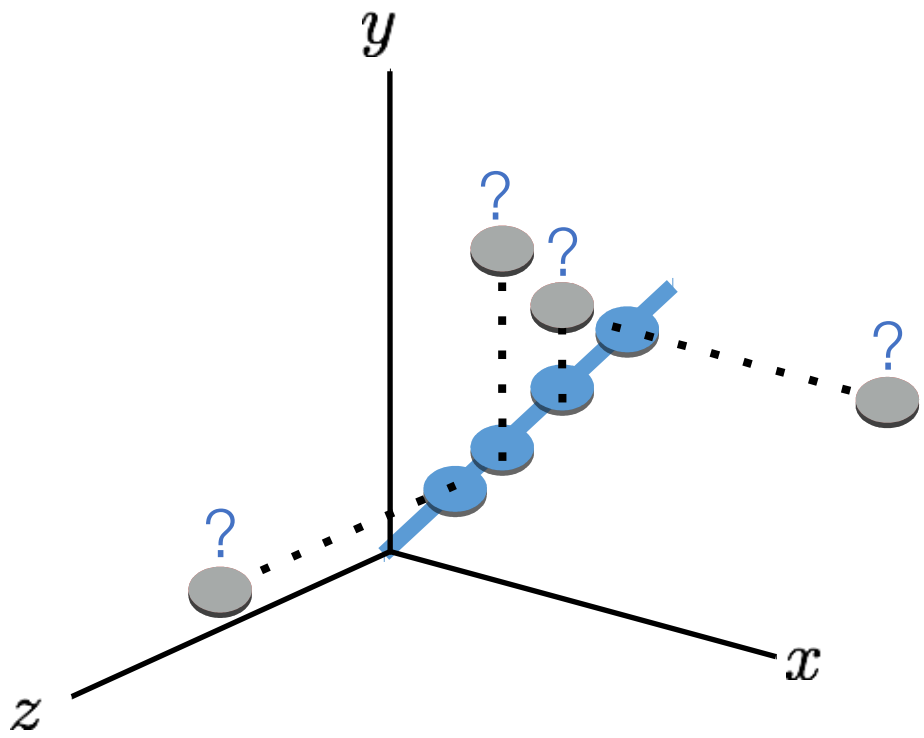
Long-term goals and perspective:

- Move to data-driven multi-modal modeling
- Incorporate both Computer Science and Solar Physics knowledge in to the data processing and understanding process
- From data silos into inter-connected, machine readable and directly referenceable data points

Georgia State University

Daniel Pimentel-Alarcón
(CS: Machine Learning)





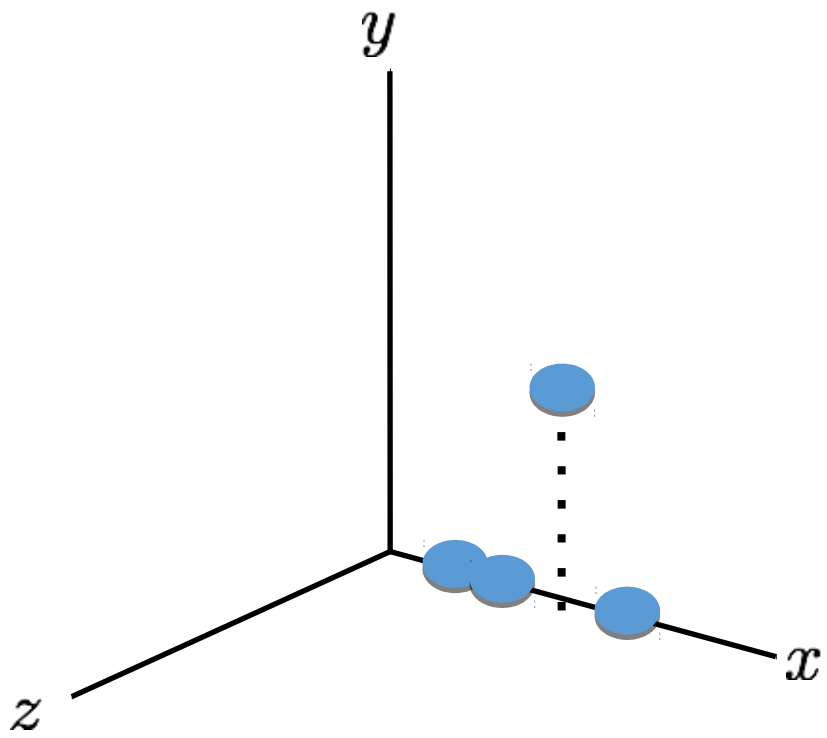
Learning from *challenging* data

Corrupted **Incomplete** **Sparse**

Georgia State University

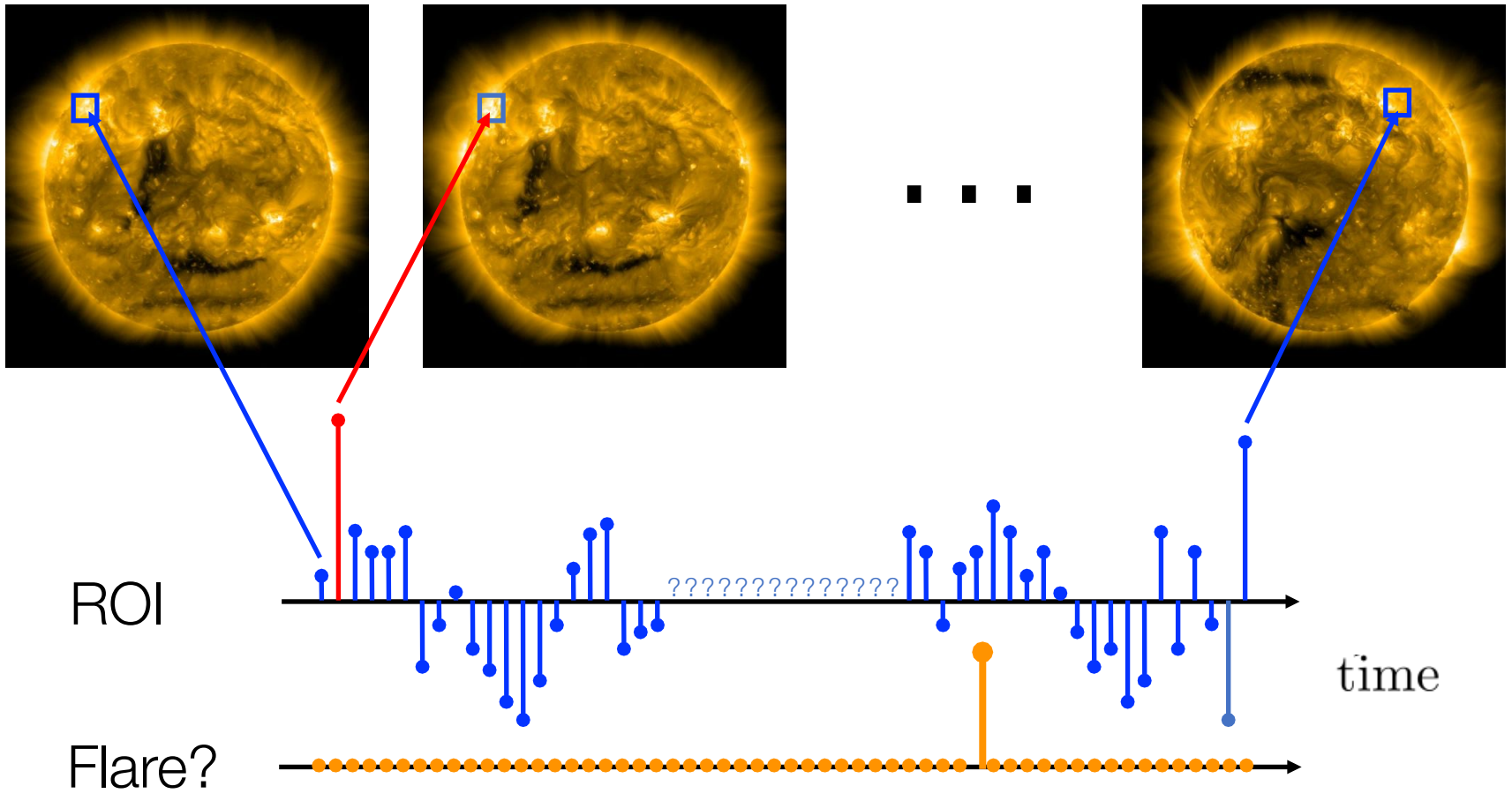
Daniel Pimentel-Alarcón
(CS: Machine Learning)

x	0	0	1	0
y	0	0	0	0
z	0	0	0	0



Learning from *challenging* data

Corrupted **Incomplete** **Sparse**



Learning from *challenging* data

Corrupted **Incomplete** **Sparse**

Big Data at GSU

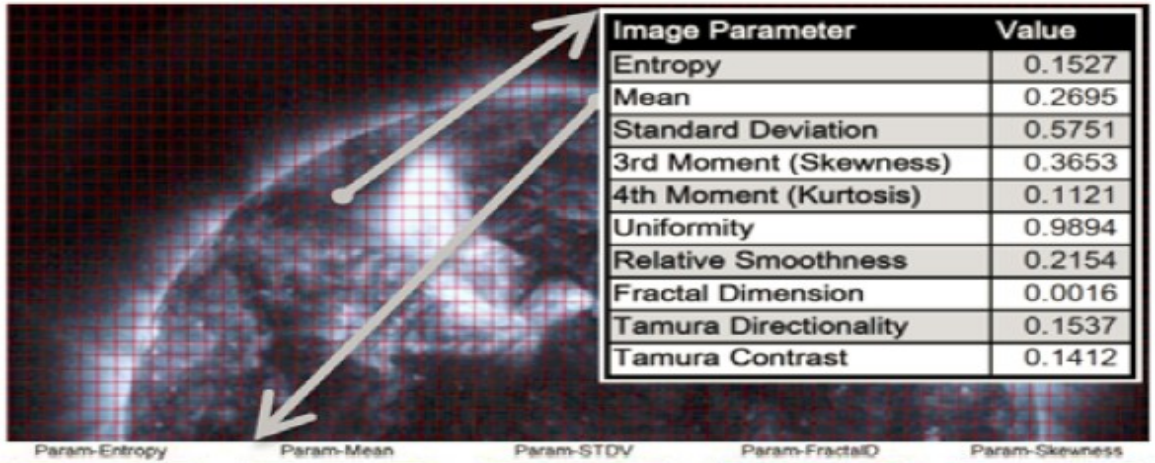


Image Parameter	Value
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Mean	0.2695
Standard Deviation	0.5751
3rd Moment (Skewness)	0.3653
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Uniformity	0.9894
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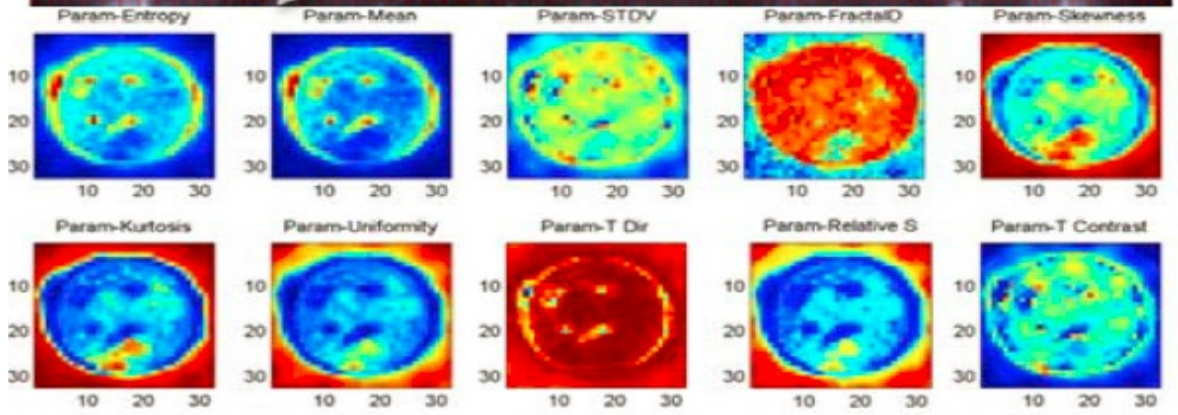
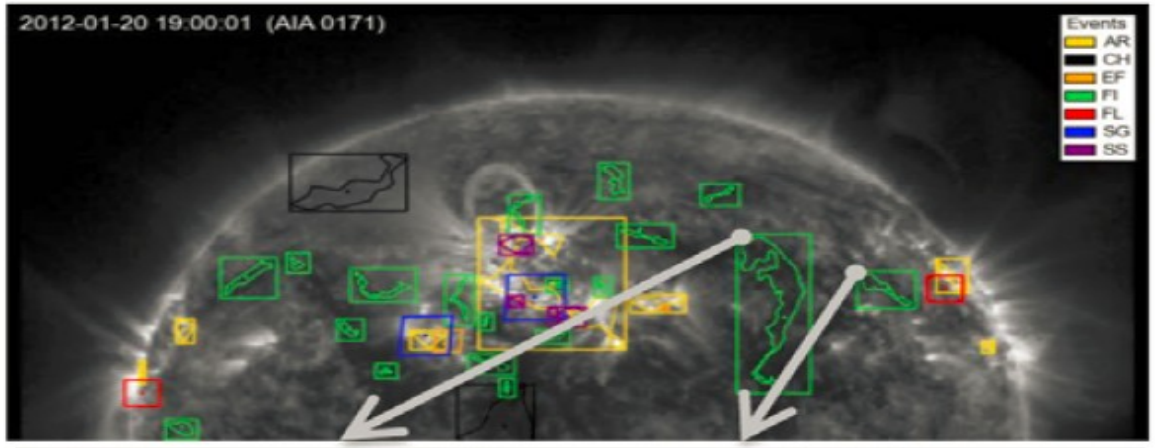


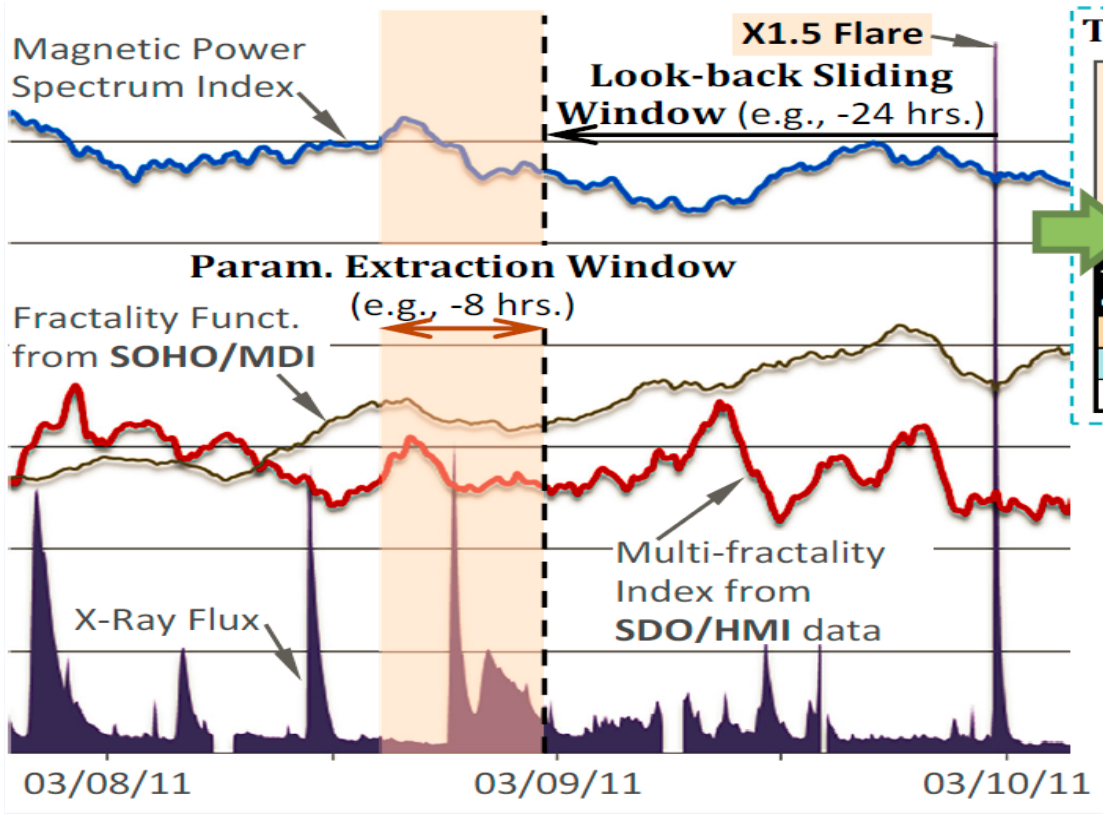
A. Grid Data/Feature Parameters (GSU)



Attribute	Filament 1	Filament 2
FI_Length	9.18E+09	4.16E+09
FI_Tilt	14.11	66.88
FI_BarbsTot	3.00	2.00
FI_BarbsR	1.00	1.00
FI_BarbsL	2.00	0.00
FI_Chirality	0.00	-1.00
FI_BarbsStartC1	-675.38,-677.38,-631.49	-595.57,-601.56
FI_BarbsEndC1	-688.35,-672.39,-630.49	-573.62,-594.57
Event_StartTime	2014-03-04T19:58:11	2014-03-04T19:58:11

B. Events Metadata (HEK)

Parameters Extraction & Exhaustive Analyses (**NEVER** done before)



Time Series Data Decomposition (trans. into **Tabulated Data**):

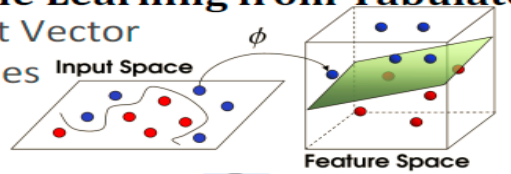
Data from **AR flaring in 24 hrs.**:

Data from **AR non-flaring in 24 hrs.**:

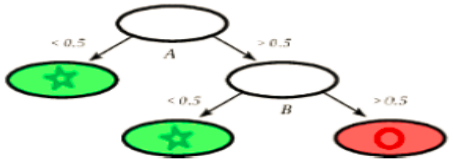
Total Uns. Current Helicity	Tot. Magnitude of Lorentz Force	Unsigned Vertical Current	Avg. Fractality	Flare History	...	Class Label
3.59E-04	4.11E-01	1.06E+01	9.73E-01	Yes	...	Flaring AR
9.67E-01	5.60E-03	3.17E+01	1.58E+00	No	...	Non-flaring AR
...	...	...	...	...	...	...

Machine Learning from Tabulated Data:

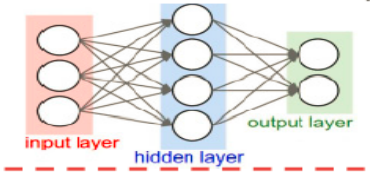
Support Vector Machines



Decision Trees



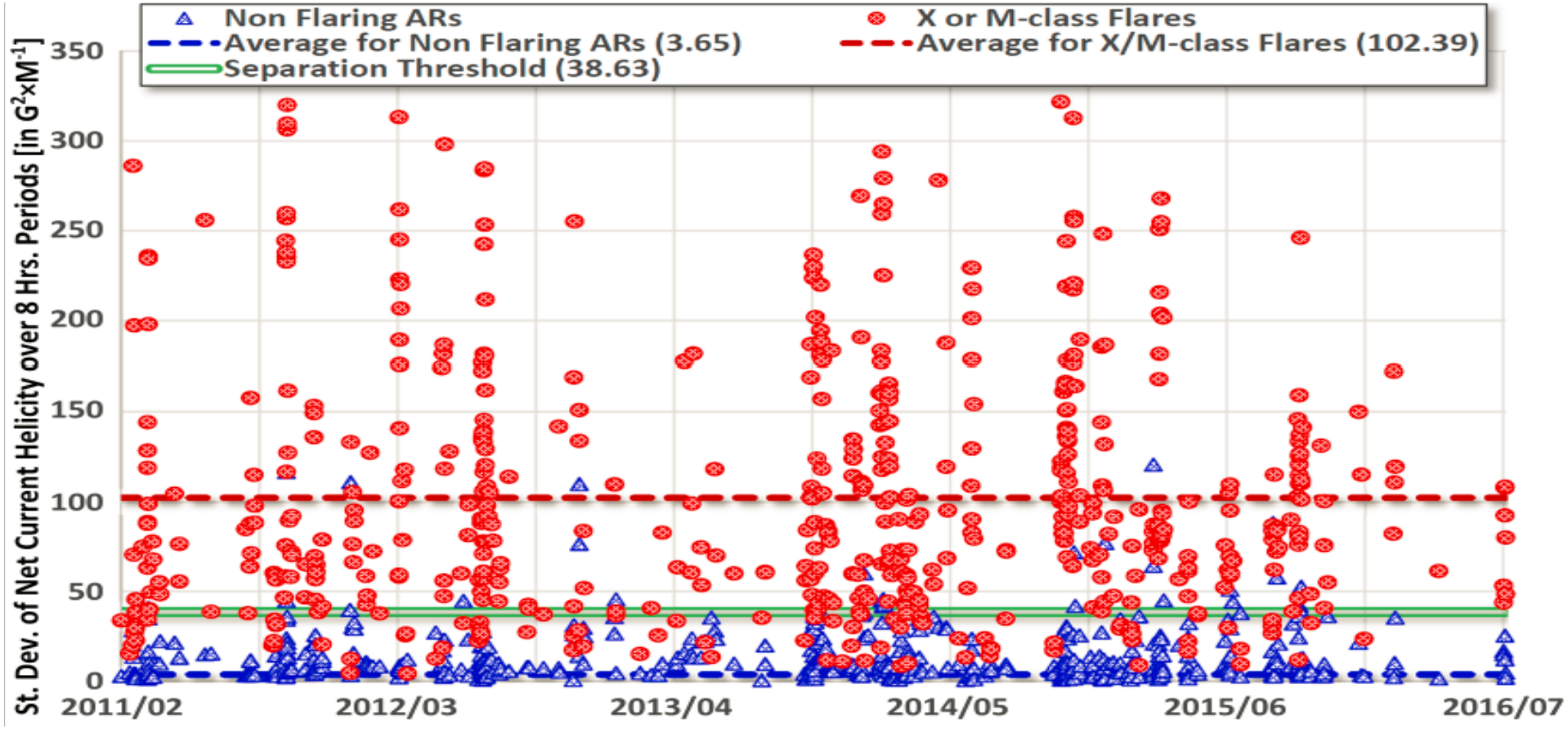
Artificial Neural Networks



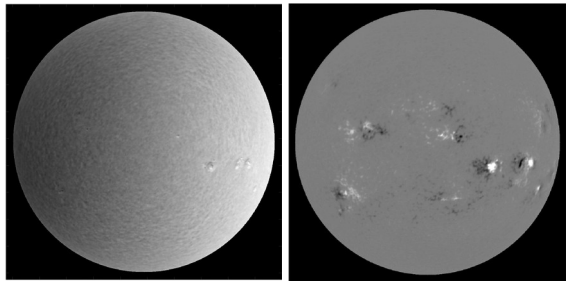
and many others...

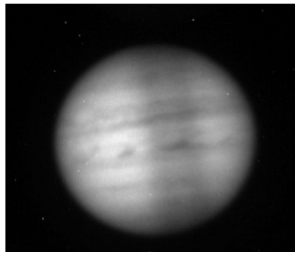
We focus on human-friendly decision making ☺

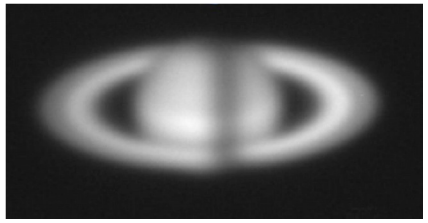
Standard Deviation of Active Region Net Current Helicity measured over 8 hours period prior for **580** X- or M-class Solar Flares (red) from **02/2011 to 07/2016** compared to non-flaring Active Regions (blue). Green line represents threshold recommended by our decision tree to separate flaring and non-flaring ARs

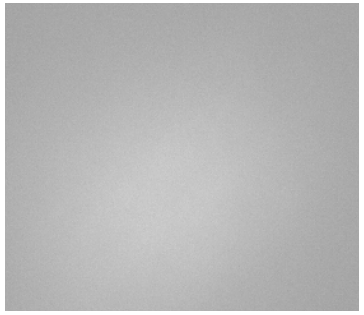


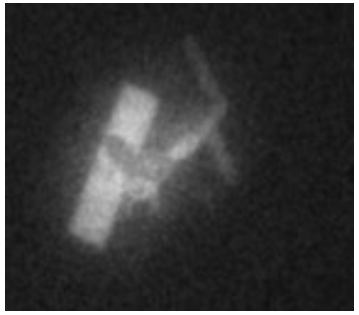
We seismically probe the solar system, develop techniques for high-resolution imaging, and build instruments.

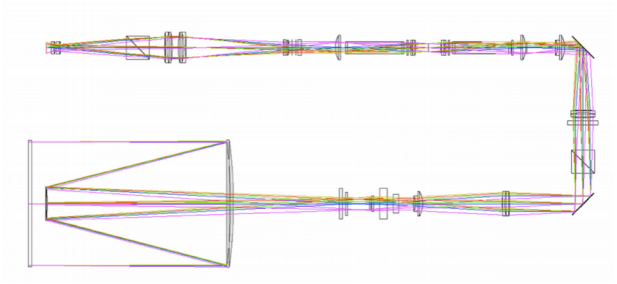


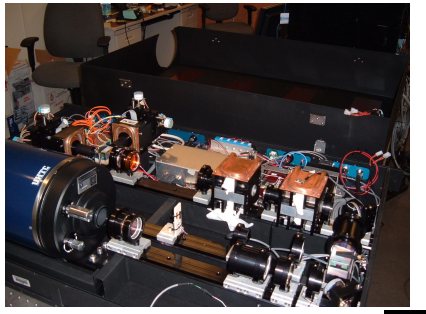












Queen Mary University of London

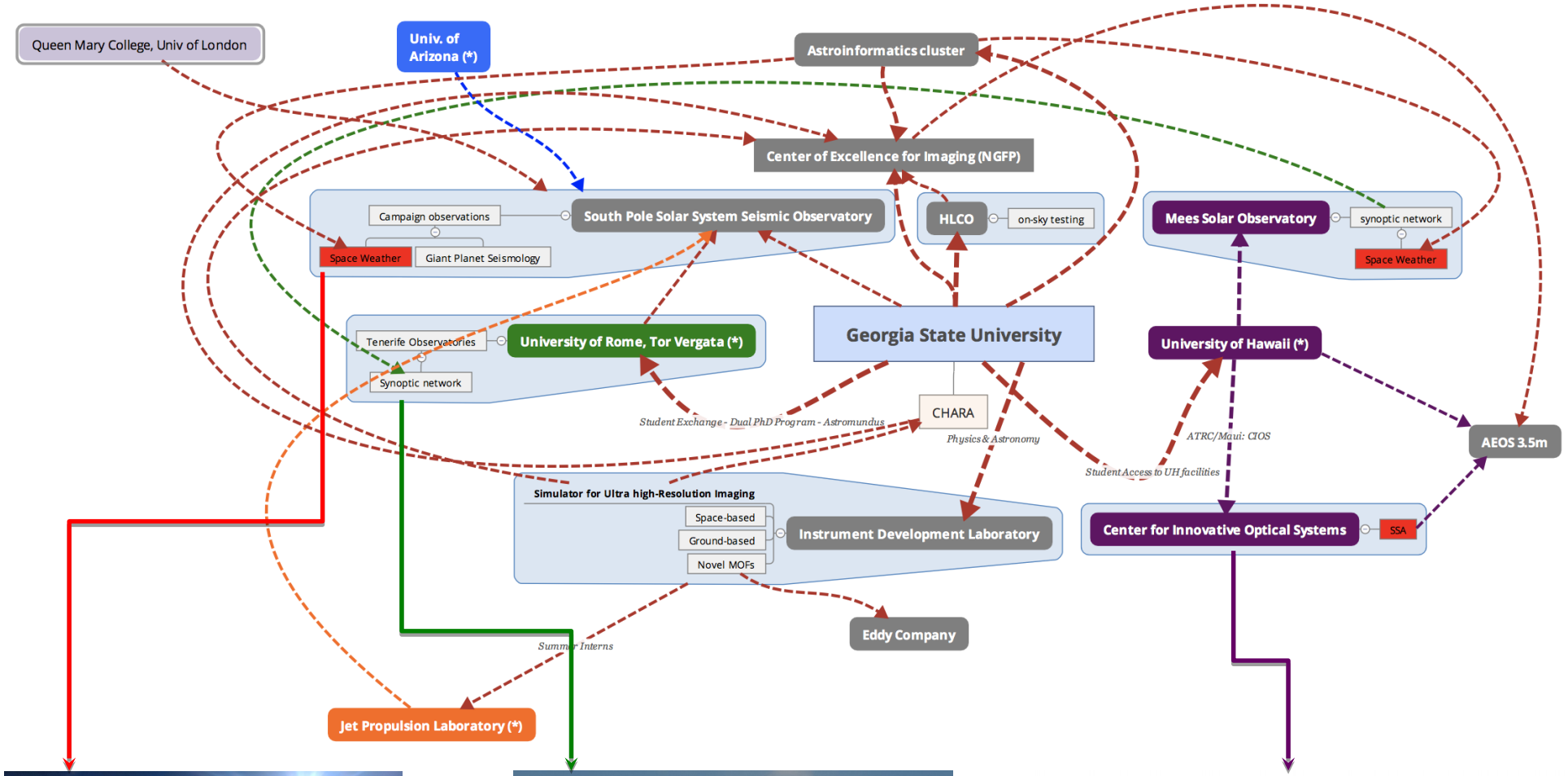
Università di Roma Tor Vergata

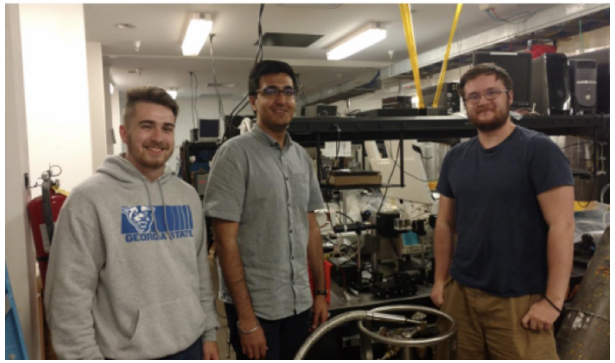
JPL

Institute for Astronomy University of Hawai'i

EDDY

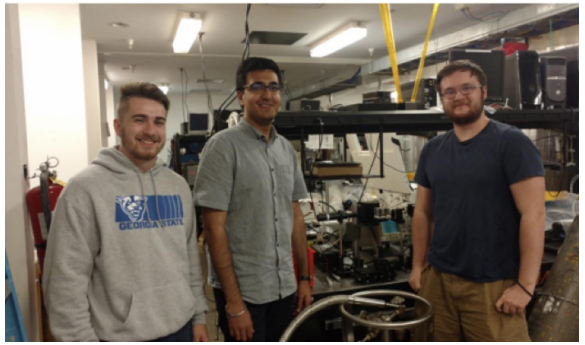
Strategic Plan 2018-2025



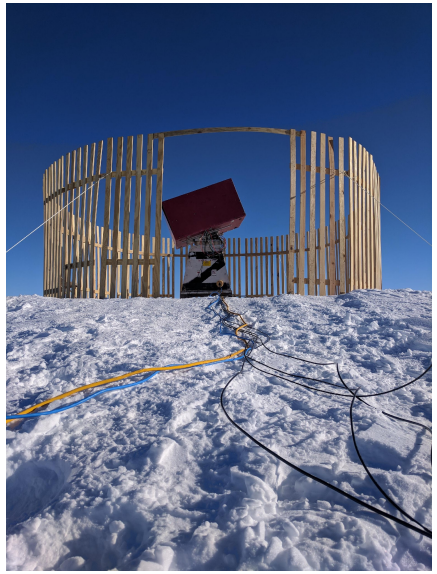


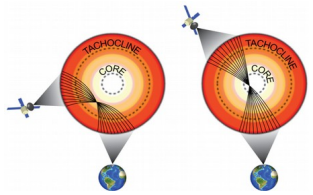
Laboratories and Observatories

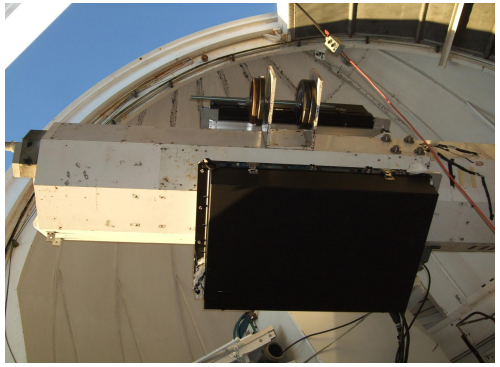
- **Laboratories**
  - GSU's Natural Sciences Building
    - Funding – DURIP award ($300K), GSU ($250K)
    - Transfer of equipment from UH (~$1M value)
  - Optics Laboratory at UH's Advanced Technology Research Center
    - MOU in place for GSU staff and students



- **Observatories**
  - Hard Labor Creek Observatory
    - On-sky validation of instrumentation
    - Demonstrators for students
  - South Pole Solar Observatory
  - Mees Solar Observatory
    - Part of MOU with UH
  - AEOS 3.5m (Maui)
    - Part of MOU with UH
  - Targeting instrument deployment on
    - High-altitude balloons
    - CubeSats
    - Satellites







Public Relations and Outreach

GSU has a very energetic and pro-active PR department. They have strongly highlighted:

1) *Jefferies' GSU South Pole Observatory*
2) *White House Visit Angryk & Martens*
3) *Data Benchmark Release Banda (GSU)*

Public outreach, apart from the standard lectures and classroom visits:

4) *August 2017 Eclipse*
5) *Teaching for the Dalai Lama*

Georgia State University

Georgia State is a community of faculty members who engage in pioneering research and creative achievement, and successfully involve students in these activities.

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Two Georgia State Scientists Invited to White House to Discuss Preparedness for Space Weather Events

Posted On October 29, 2015

Categories Colleges & Schools, Discovery Tags Astronomy, CHARA, Computer Science, Piet Martens, Rafal Angryk, space weather, Technology, White House

WASHINGTON, D.C.—Two Georgia State University scientists were among experts invited by The