Secondary scientific objectives for SODISM

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Introduction

- SODISM primarily designed for geometric and radiometric *metrology* at the solar *limb*
  - Most *telemetry, shutter operations, calibration analysis* devoted to primary objectives:
    - limb metrology
    - disc & limb helioseismology

- Yet, SODISM is a general purpose solar NUV-VIS telescope producing
  - Synoptic still images (20 per day in all channels)
  - image sequences displaying --*or not*-- solar events (a few special campaigns)

- Hence, *secondary objectives* (non limb, non oscillatory), of 2 types:
  - Investigations of individual features
    - together with non-SODISM instruments
  - Statistical investigations
    - Spatial dependencies: center-to-limb, latitudinal, North-South…
    - Temporal dependencies: Schwabe activity cycle, intermittency, other cycles…

+ Some *non-strictly-solar* targets of opportunity arise
  - Occultations by the Earth atmosphere during the “eclipse season” (winter)
  - Venus transit in *June 2012* + (Mercury transit in May 2016 and Nov. 2019…)
  - Solar eclipses by the Moon (2-3 per year)
  - Stellar observations

Original SODISM science fields

Solar limb metrology (Sci.field.1)	• Radial profile of the limb • Angular profile of the solar disc (asphericity and higher moments) • Temporal evolution of the above
Helioseismology (Sci.fld.2)	• Helio-seismic diameter • Solar intensity oscillations, and especially g-modes
Solar spectral irradiance (Sci.fld.3)	• Contribution to the reconstruction of the SSI (solar spectral irradiance)
Other solar physics studies (Sci.fld.4)	• Surface motions and their evolution • Study of magnetic activity features • YOUR IDEAS HERE! (Serendipity)
Solar-terrestrial relationships & aeronomy (Sci.fld.5)	• Space Weather • Studies of the Earth atmosphere via occultations, albedo studies, etc. • Contribution to understanding the Sun-Earth connection and climate

Secondary objectives enabled by SODISM data
discussed in this talk

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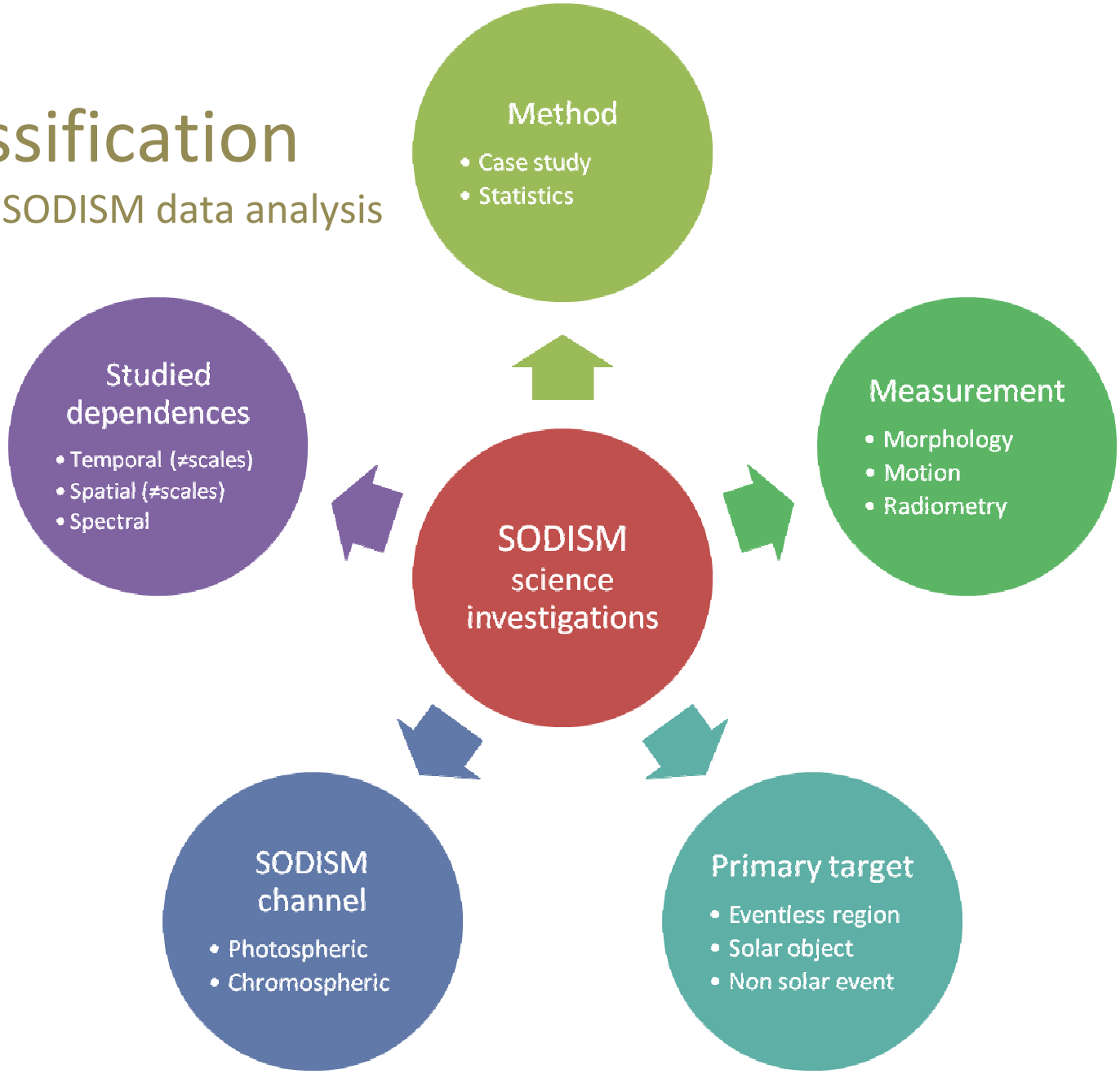
The astrophysical content of *secondary* SODISM observations

1. Content of *still* images
   a. The "featureless" non-magnetized photosphere
      - Its center-to-limb variation, latitudinal dependence, evolution, etc.
   b. Photospheric objects
      - Sunspots, faculae
   c. Chromospheric objects
      - Chromospheric network, plages

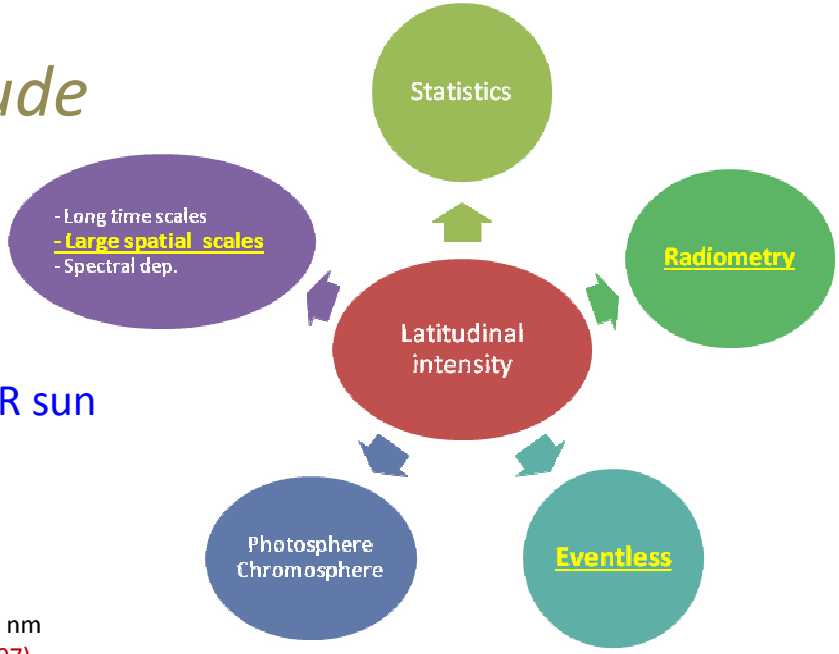
2. Content of image *sequences*
   a. Eventless
      - Torsional oscillations, meridional circulation, supergranular pattern
   b. Eventful
      - Solar: White-light flares, Moreton waves, eruption signatures, etc.
      - Non solar: eclipses by the moon, Earth occultations

A meek classification

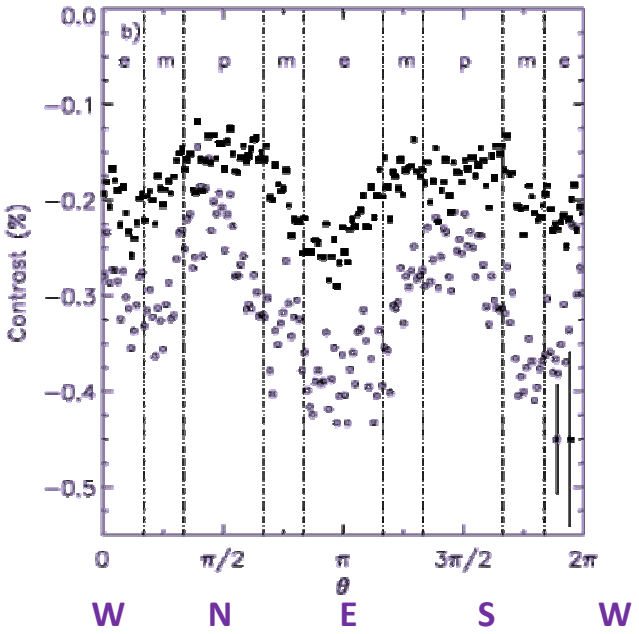
The 5 dimensions of SODISM data analysis



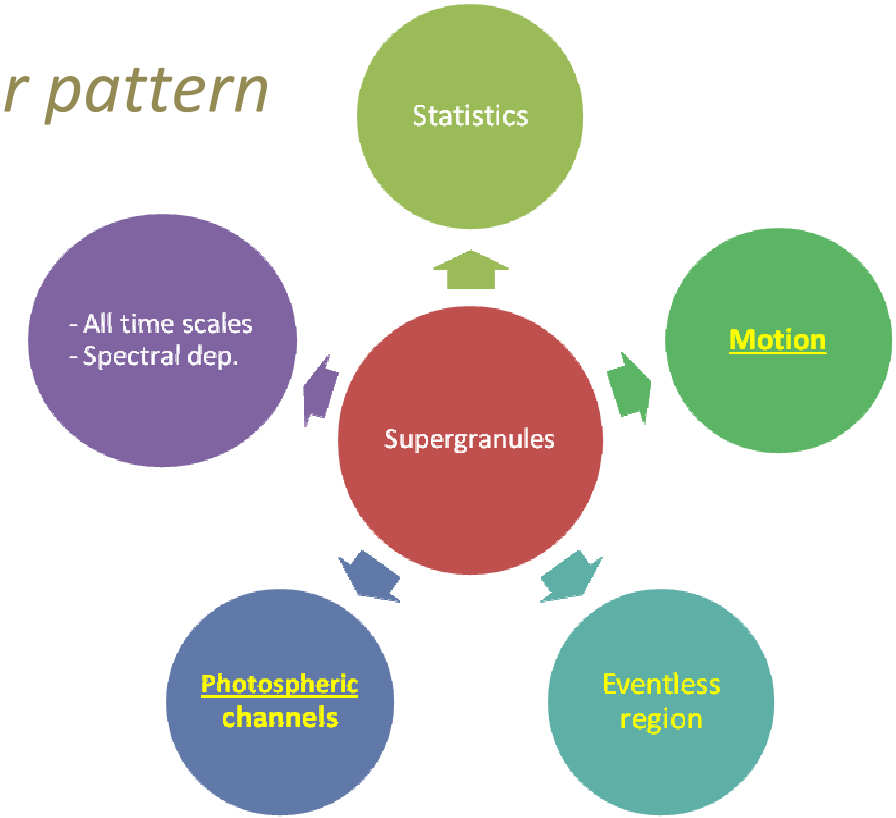
Intensity as a function of *latitude*
GI suggestions #1



- Radiative North-South asymmetry of the NUV-NIR sun
  - Livingston and Sheeley, ApJ (2008)
    - How uniform can a solar-like stellar disk be?
      - ➔ Exoplanets research
    - Is magnetism the sole source of irradiance variation?
    - North-South asymmetry
      - In continuum and Fraunhofer lines from 313.4 nm to 4 688 nm
      - Non magnetic photosphere (solar minimum conditions, 2007)
      - 0.05% in the IR
      - 1% in the violet and UV
      - 15% in photospheric and chromospheric line cores
      - Faculae = *probable* source for the measured asymmetries
- Latitudinal variation of the photospheric intensity
  - Rast, Ortiz, and Meisner, ApJ (2008)
    - Baroclinicity expected for models to match differential rotation
      - Poles and equator regions few K warmer than mid-latitudes
    - Contrasts in the red [▪] and in the blue [◦] ➔
      - Non magnetic photosphere (outside faculae)
      - inside $0.3 < \mu < 0.45$
    - Contradicted by Livingston, Galayda, Milkey (2011)
- NB: benefit of eclipses

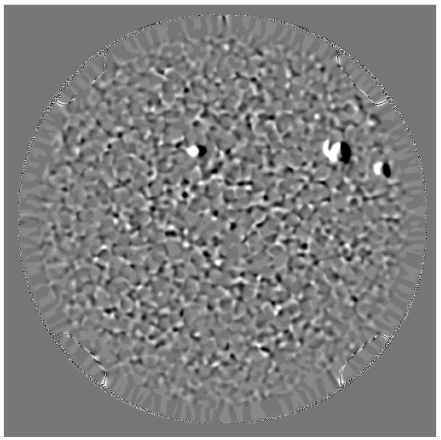


Evolution of the *supergranular pattern*
GI suggestions #2



- Meunier, Roudier, Rieutord, AA (2008) "Supergranules over the solar cycle"
- Williams, Pesnell, Sol. Phys. (2011) "Comparisons of supergranules characteristics during the Solar Minima of cycles 22-23 and 23-24"

- Supergranules observed by T. Roudier with SODISM
  - 535nm, 3min cadence
  - LCT technique
  - Cf. J.-M. Malherbe's talk

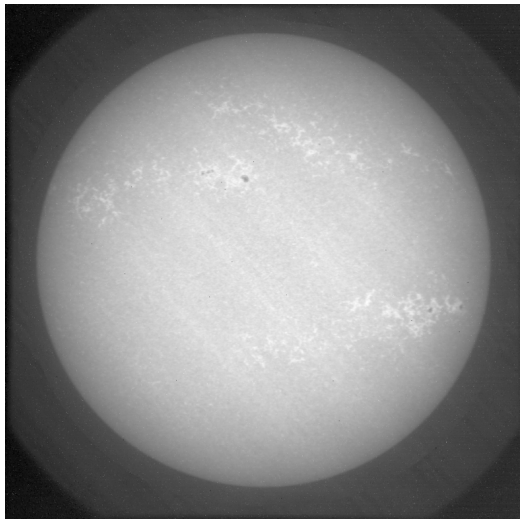


SODISM 535nm divergence field
T. Roudier, April 2012

Chromospheric investigations
GI suggestions #3

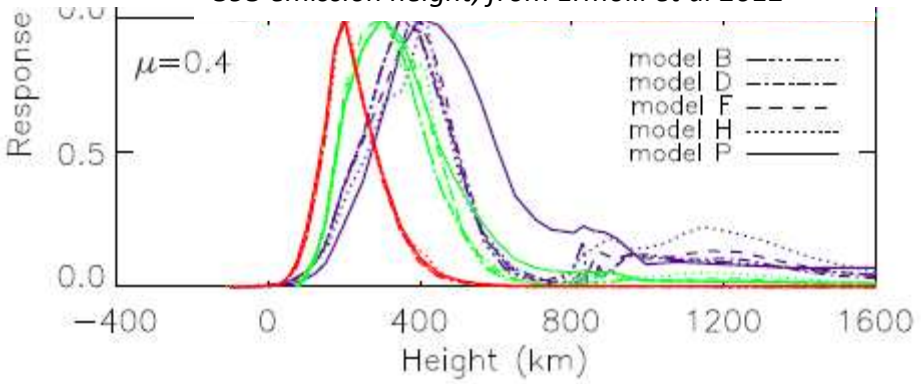
- 215 nm
  - Uniqueness of such imaging observations
    - "terra incognita"
  - 1 lossless image per day
  - Synergies with PREMOS

SODISM 215nm
➔
2011-04-01



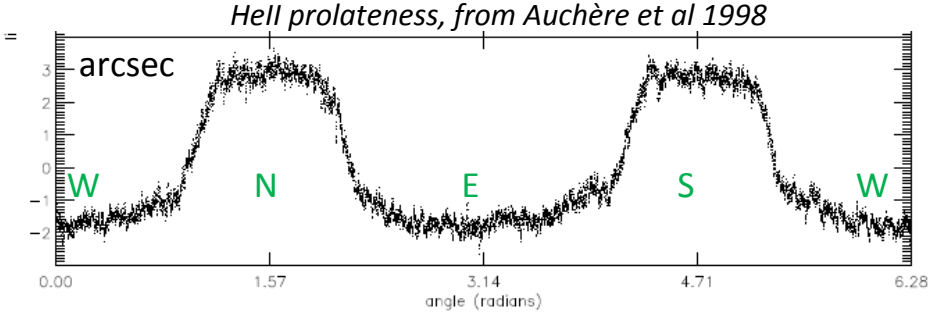
- 393 nm
  - 11 (lossy) images per day!
  - Modeling Ca II K emission (<500km?) ➔
  - Proxy (tbc) for the *horizontal* magnetic field away from disc center

393 emission height, from Ermolli et al 2012



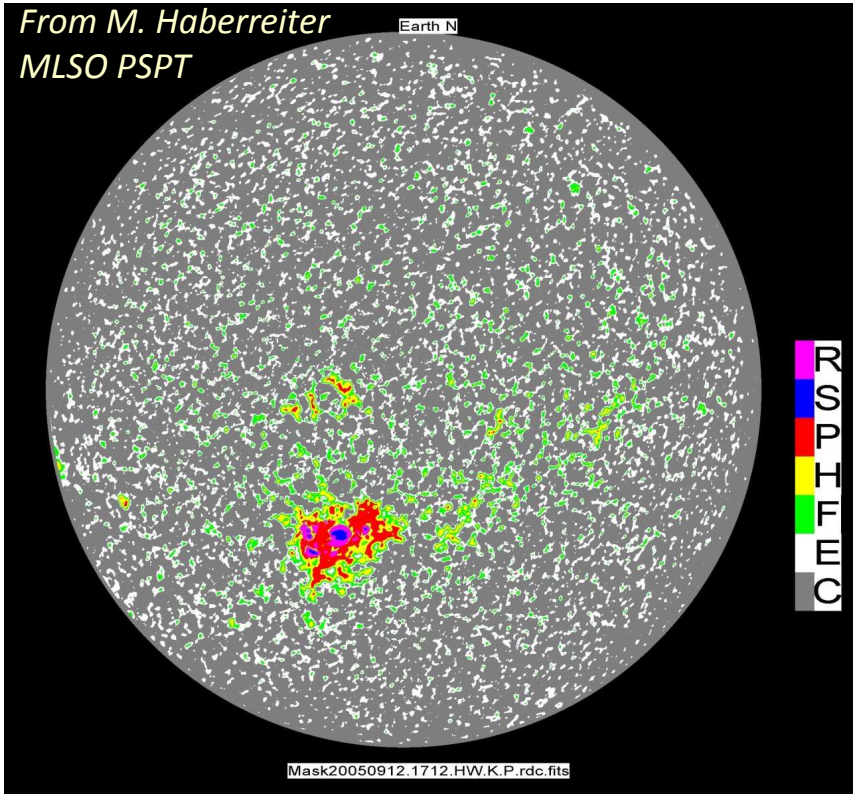
- Auchère et al, A&A 1998, "The prolate solar chromosphere"
  - ΔD ~ 2 arcsec in H-alpha
  - ΔD ~ 10 arcsec in He II ➔
  - ΔD ~ 10 mas in the photospheric continuum
  - Dynamical vs. magnetic pressure interplay
  - ΔD at 215nm and 393nm ??
  - Cycle evolution?

HeII prolateness, from Auchère et al 1998



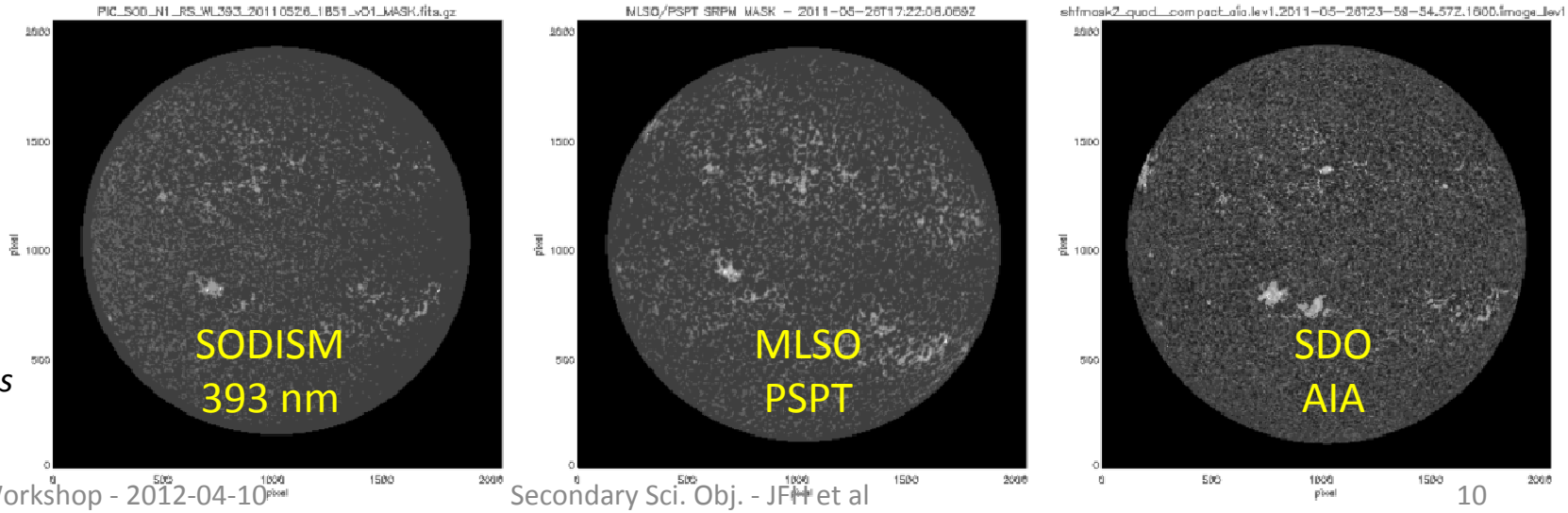
SSI reconstruction
GI suggestions #4

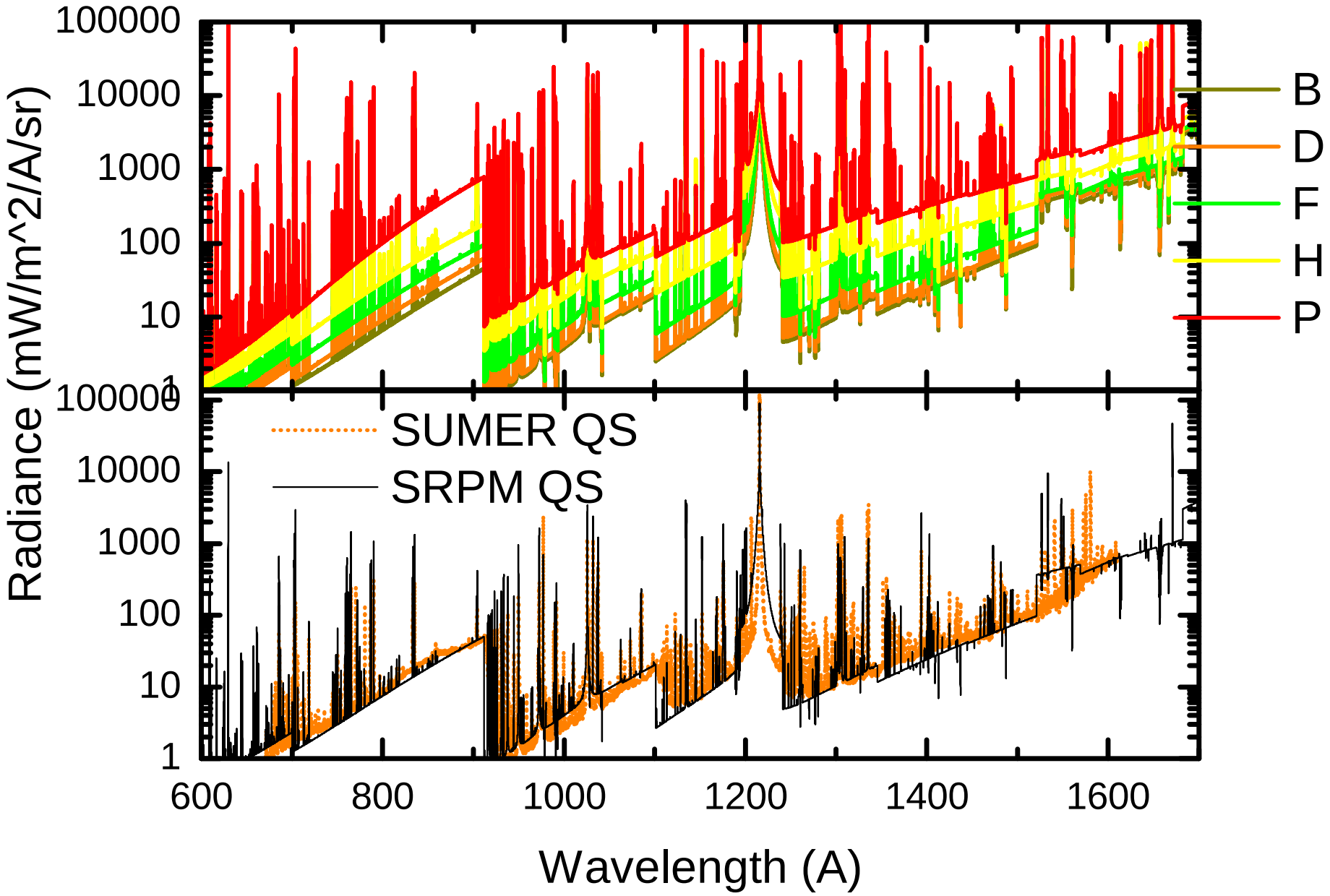
Sunspot Penumbra
Sunspot Umbra
Faculae
Plage
Active network
Quiet network
Intergranular Cells



- Segmentation based on intensity in 1 channel
  - use several, segment on morphology!
- Assign atmosphere (and spectrum) to segmented region
  - SRPM: Fontenla et al
  - SolMod3D: Haberreiter et al (COSI & SRPM heritage)

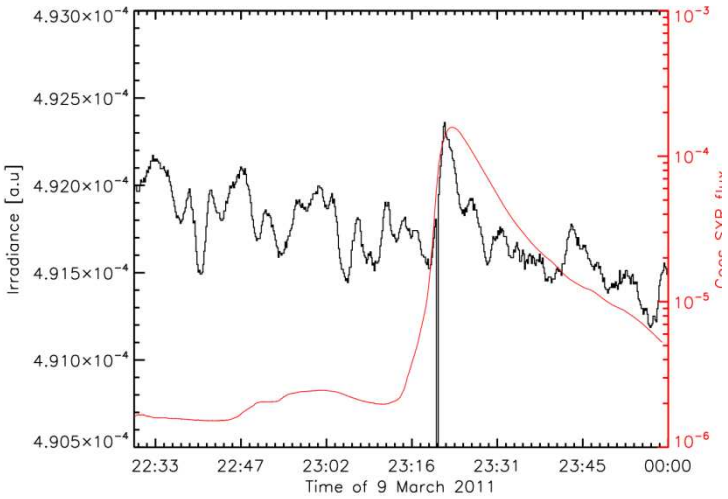
From E. Quémerais



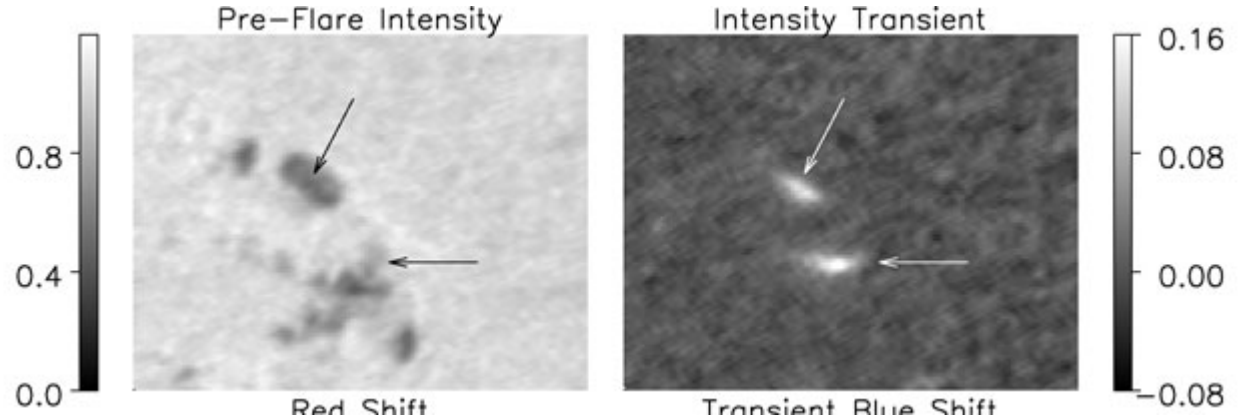


Fontenla, Curdt, Haberreiter et al., 2009, ApJ 707, 482-502

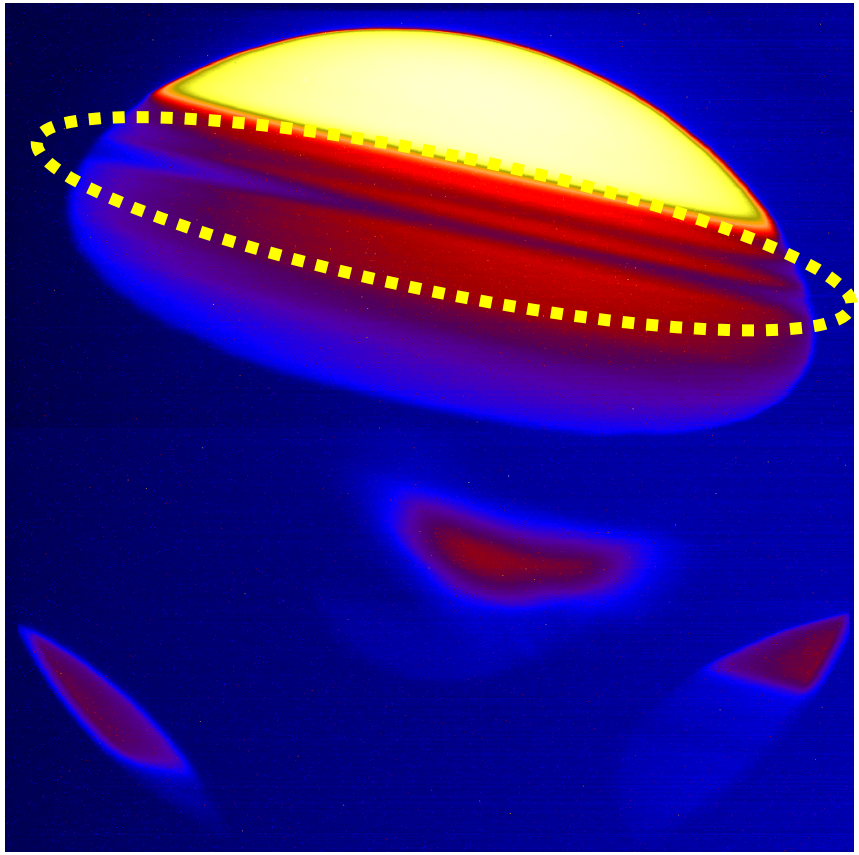
White Light Flares
GI suggestions #5

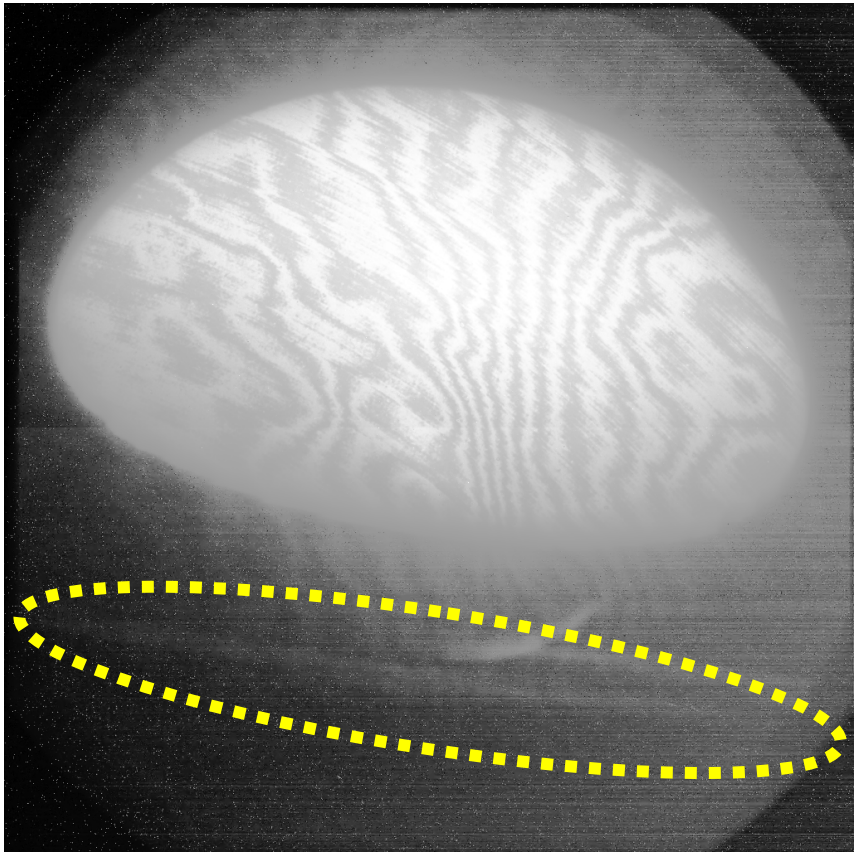


- Eruption, as seen by PREMOS 210 nm ➔
  - SODISM could observe such events
- Veselovsky and Koutchmy (2009)
  Scientific requirements for future spatially resolved white-light and broad-band high-cadence observations of the Sun
- Martínez Oliveros et al (2011)
  Imaging Spectroscopy of a White-Light Solar Flare
  Eruption seen by SDO - HMI
  ➔

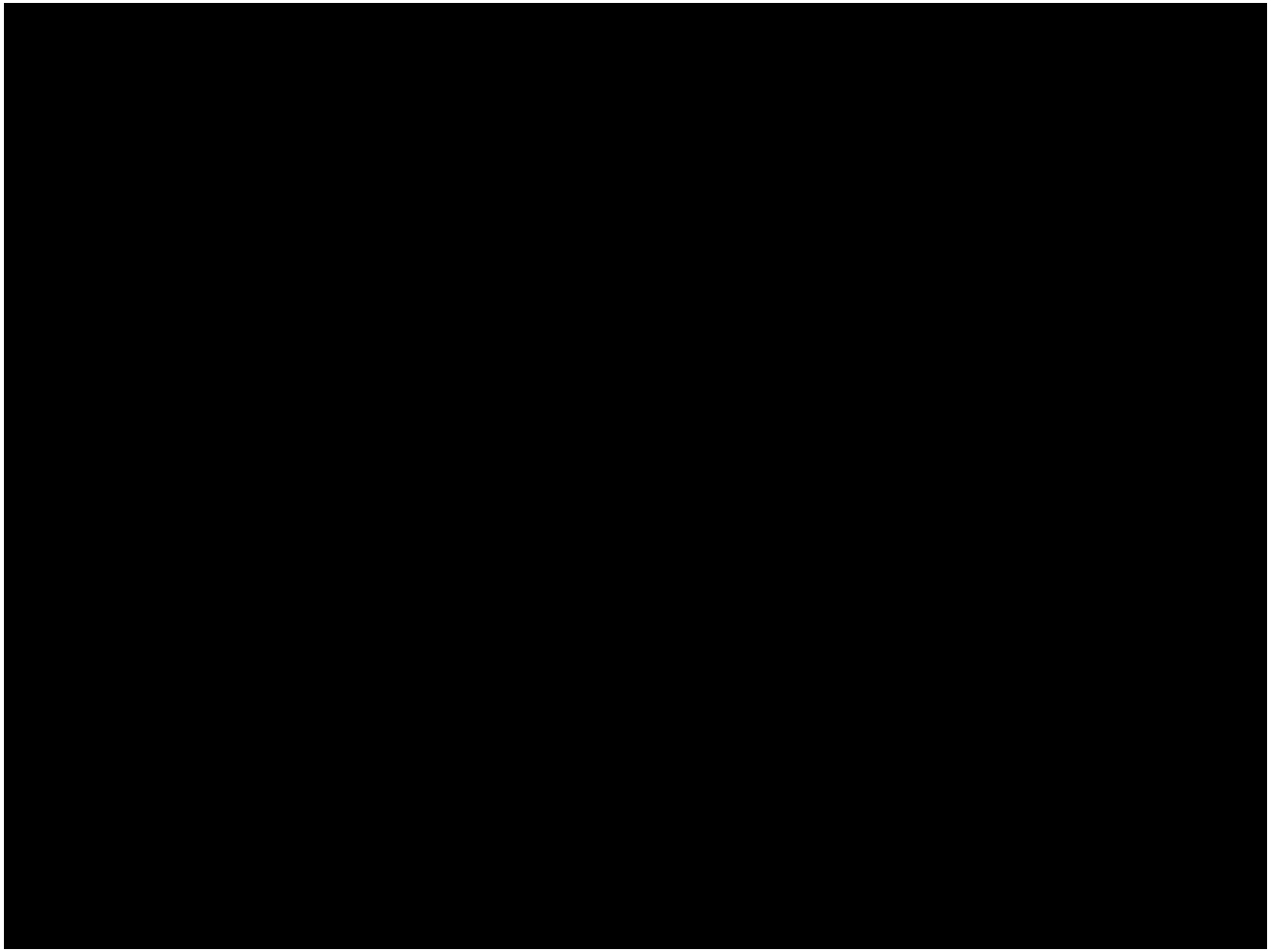


Observation of the Sun occulted by the Earth atmosphere
GI suggestions #6

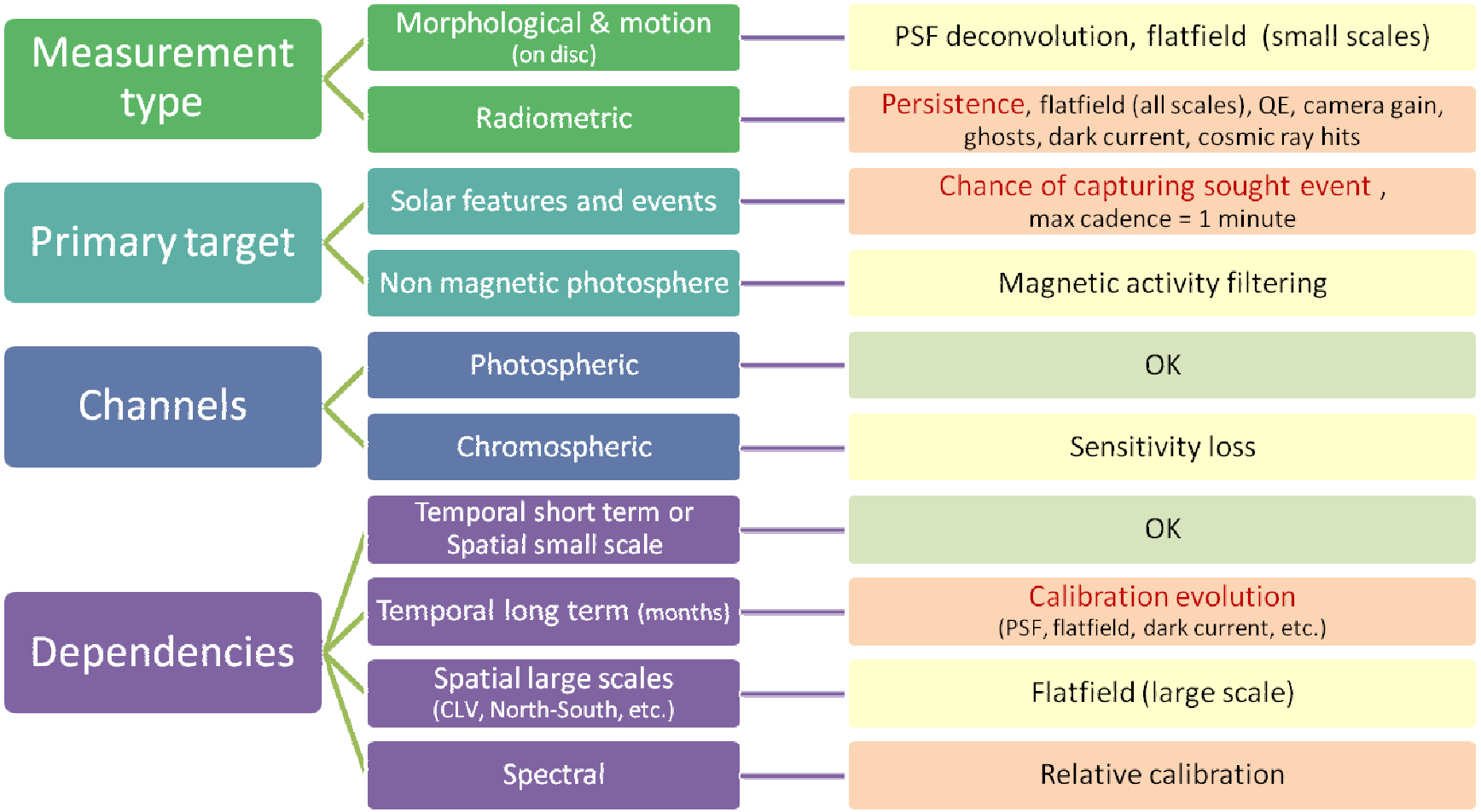




GI suggestions #7: Venus transit of June 2012



Classification of expected hurdles



Color code:

Not so bad, promising, or better than feared

Difficult

SODISM aptitudes and frailties

- Weaknesses
  - Unknown PSF
  - Unexplained persistence
  - Quasi all full disc images compressed lossily, what's more at x16 rate
  - Few sequences of full frame images, none yet acquired at the max cadence of 1 minute
  - Sparse exploration of the space of image acquisition parameters
    - E.g. fixed exposure time
  - Ghost and scattered light
    - Difficult off-limb observations
- Plusses
  - 24h/7d operations
  - Potentially frequent Z-axis rotation → large scale flatfield precision (if full frames)
  - Uniqueness of the 215 nm channel
  - Plurality and narrowness of the passbands
  - Stability of the telescope body
  - Relatively frequent solar eclipse observations
  - Earth occulted observations in winter
  - No technical impossibility for NRT (near real time) data delivery, but presently unavailable

Expected collaborations

- PREMOS filter radiometers
- Solar full-disc imaging monitors
  - PSPT, SOLIS, and other ground-based telescopes
  - SDO-HMI, SDO-AIA
- SOVAP and PREMOS TSI radiometers
- Others (SORCE - SIM, PROBA2 - LYRA, etc.)

- Join internationally coordinated observations

- Guest investigators!