Interpreting SECCHI White Light Images: FOV Sensitivity & Stereo Viewing

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Outline

1. Motivation:
   - What can we learn from stereo white light images?
   - How will we interpret stereo views of optical thin features?
2. Method: New IDL code for computing Thomson scattering along rays
3. Results:
   - High sensitivity regions of FOVS of CORs and HIs
   - Synthetic stereo view of a simple CME model

What can we learn from Stereo white light images?

Stereo: simultaneous views from two SC - large and small angles

- CME Velocity, Acceleration & Deceleration

  Can determine velocity vs. time when bright leading edge seen from both SC (true stereoscopy)--angular range unknown

  How does solar wind speed effect deceleration? How does CME interact with solar wind structures (CIRS, etc.)?

- CME Structure and Evolution

  Quantitative 3D reconstruction & quantitative stereoscopy for small angles if same "features" visible in both images

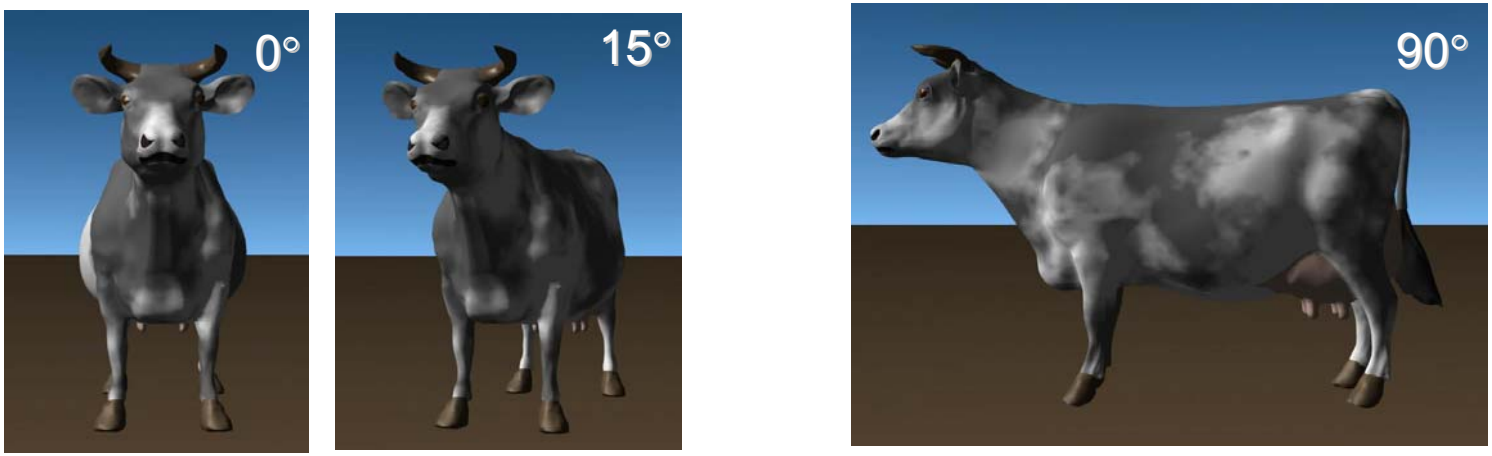
  3D information from two view points (all angles) -- Very useful for comparison with results from modeling

  Clues about structure from 3D viewing of CME expansion

  What is the spread in latitude of CMEs? (large angles)

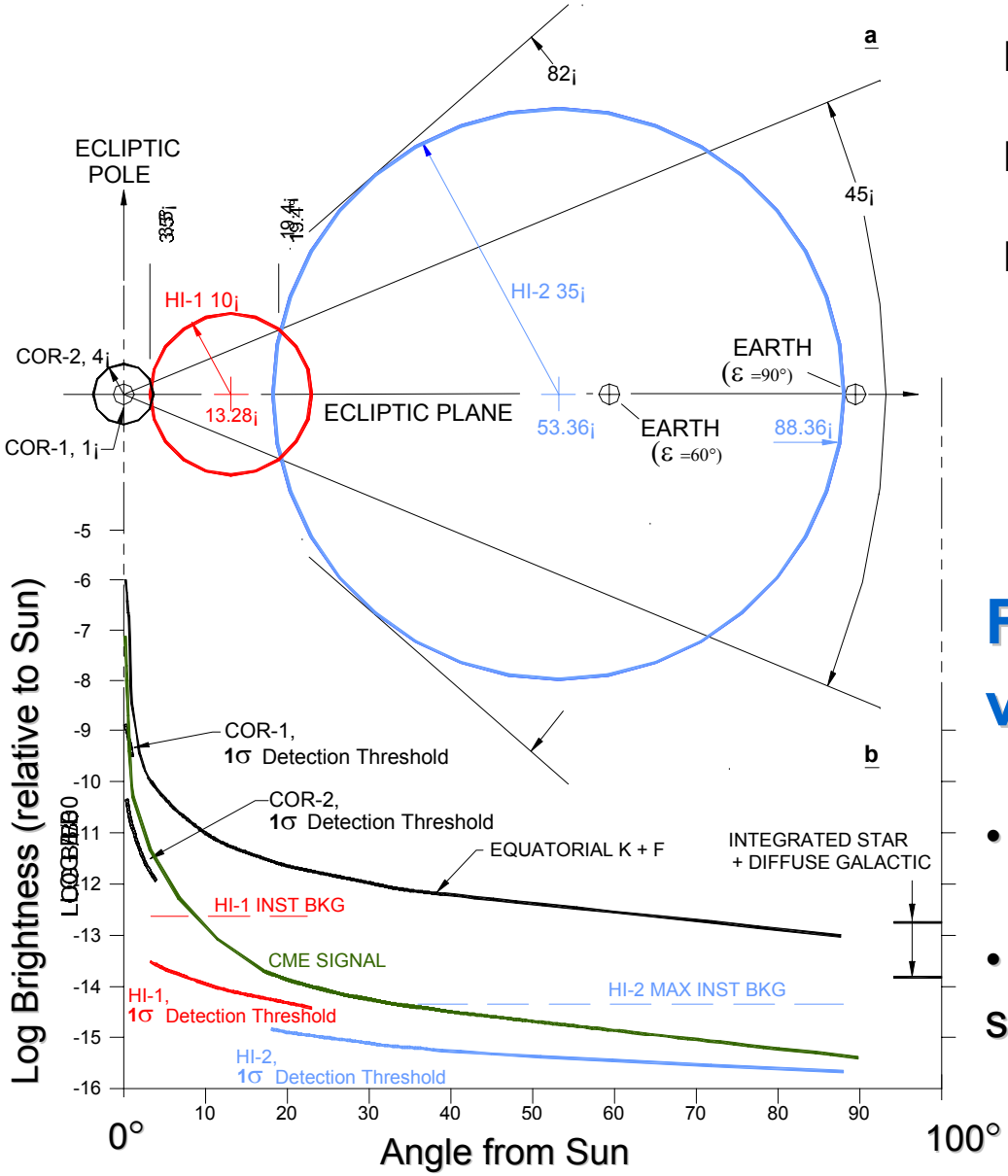
Problems for White Light Stereo Observations

- For 3D viewing (goggles, etc.) and quantitative stereoscopy, must see same "features" in both views
  - Depends heavily on viewing geometry: stereo angle and overlap of Fields-Of-View (FOV) and sensitivity of FOV
- For interpretation of small and large angle stereo views & tomography
  - Great uncertainty because of line-of sight effects in an optically thin medium
  - For HI-2 LOS is on AU scale!
- Need practice with simulated white lights data sets for planning
  - Need models and their synthetic images



Imagine if the cow were optically thin!

FOV and Geometric Considerations



EUVI, COR-1 & 2 Sun-pointed

HI-1 points 13°; fov ±10 °

HI-2 points 53°; fov ±35°

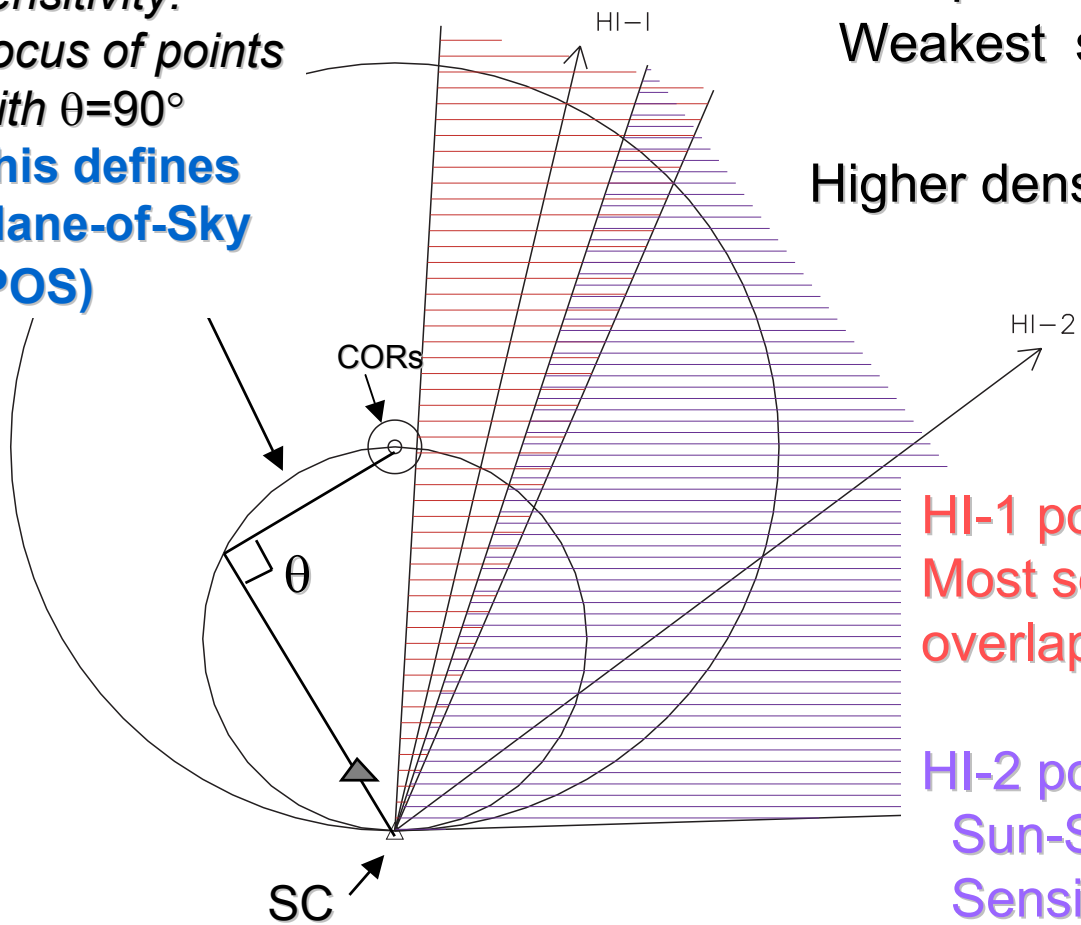
CORs +HIs designed to follow CME from Sun to Earth & SC

For stereo analysis and viewing

- FOV from each SC must overlap
- Signal from **overlap** region must be significant along integrated LOS

COR and HI Scattering Angle Considerations

Best WL sensitivity: Locus of points with θ=90°
This defines Plane-of-Sky (POS)



Optimum scattering angle θ=90°
- Gentle fall off with θ for B
- Sharper fall off with θ for pB
- Weakest signal for Sun-SC line

Higher densities closer to Sun

HI-1 points 13±10°
Most sensitive off solar limb to overlap with HI-2

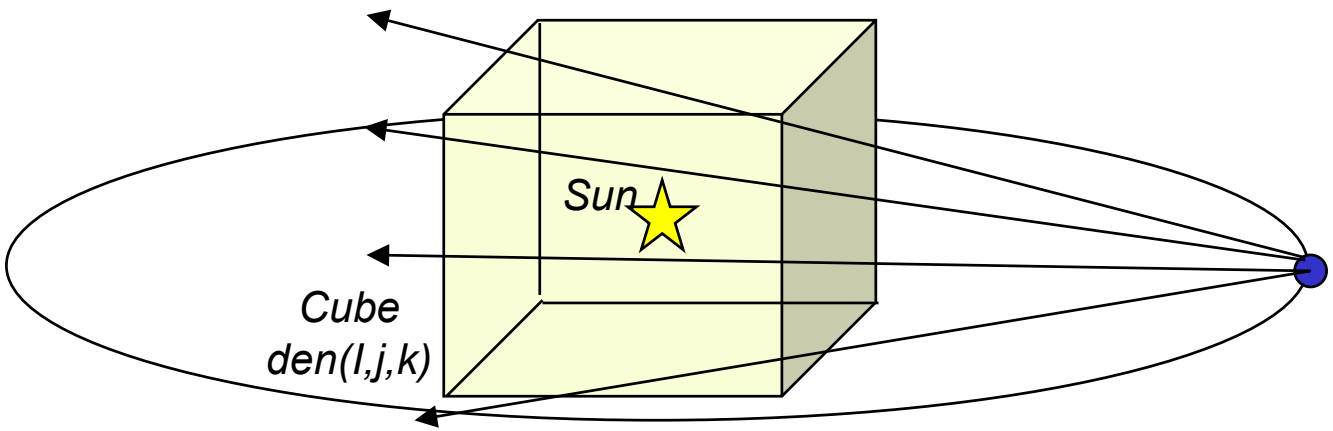
HI-2 points 53±35°
- Sun-SC line not in HI-2 FOV
- Sensitive over entire FOV

Code for Sensitivity Study and Synthetic Images

Computes Thomson scattering along camera rays

- Uses NRL IDL procedure for single electron scattering
- User defines density in a 3D cube: *den(i,j,k)*
- Camera/SC confined to ecliptic *(x-y)* plane
- User specifies CCD size (j by k pixels), FOV & boresight angle
- Units in R_{sun}, Sun at *(0,0,0)* & Earth at *x=215, y=0*

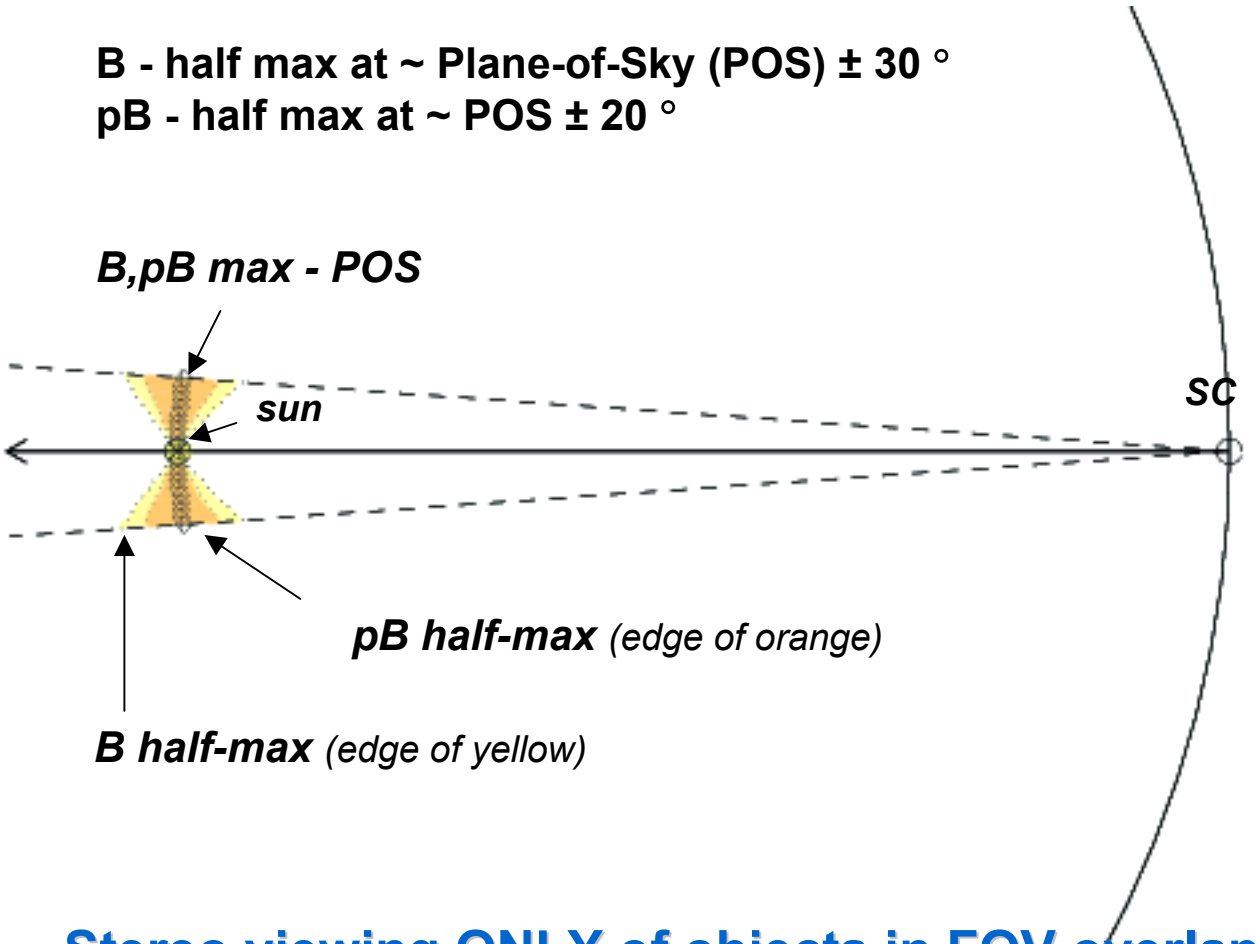
Can plot total and polarized brightness along ray or sum to create synthetic stereo coronagraph images



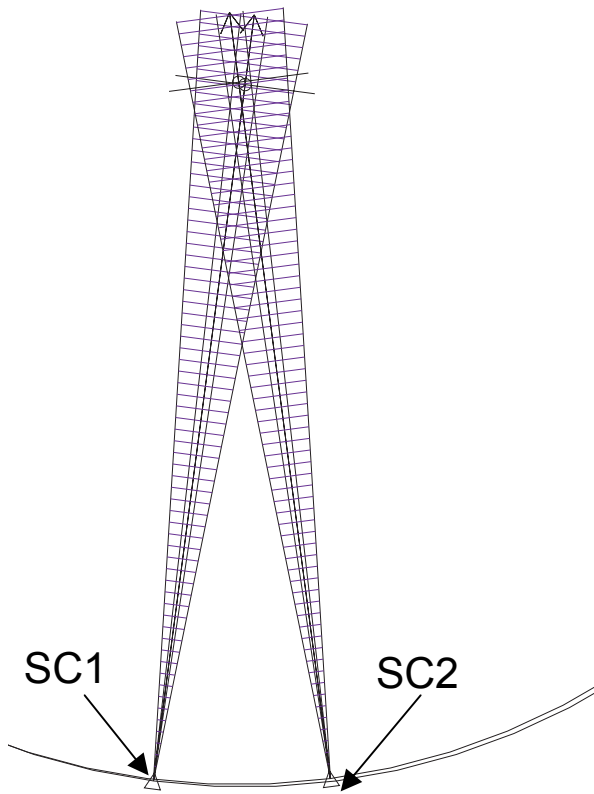
COR 1&2 FOV Considerations

Brightness B & Polarization Brightness pB computed for $n(r) = n_0/r^2$

B - half max at ~ Plane-of-Sky (POS) ± 30 °
pB - half max at ~ POS ± 20 °



Configuration for SC Separation α=15°



Stereo viewing ONLY of objects in FOV overlap of SC1&2

COR stereo overlap includes region of max B and pB for wide range of SC separation/stereo angles α ~ 0° - 45°

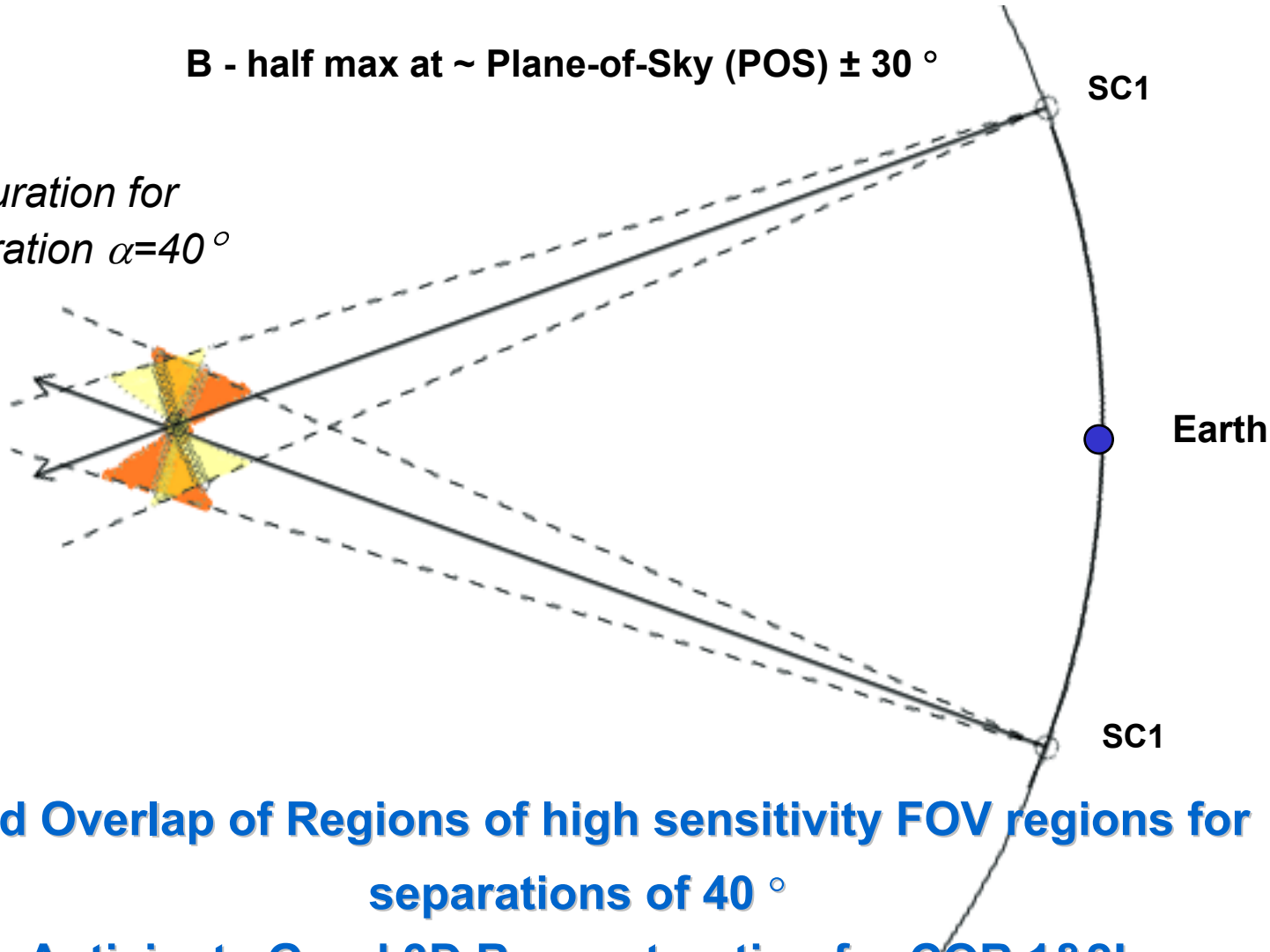
Anticipate Good 3D Reconstruction for COR 1&2!

COR2 Overlap for SC Separation of 40°

Brightness B computed for $n(r) = n_0/r^2$

B - half max at ~ Plane-of-Sky (POS) ± 30 °

Configuration for SC Separation α=40 °



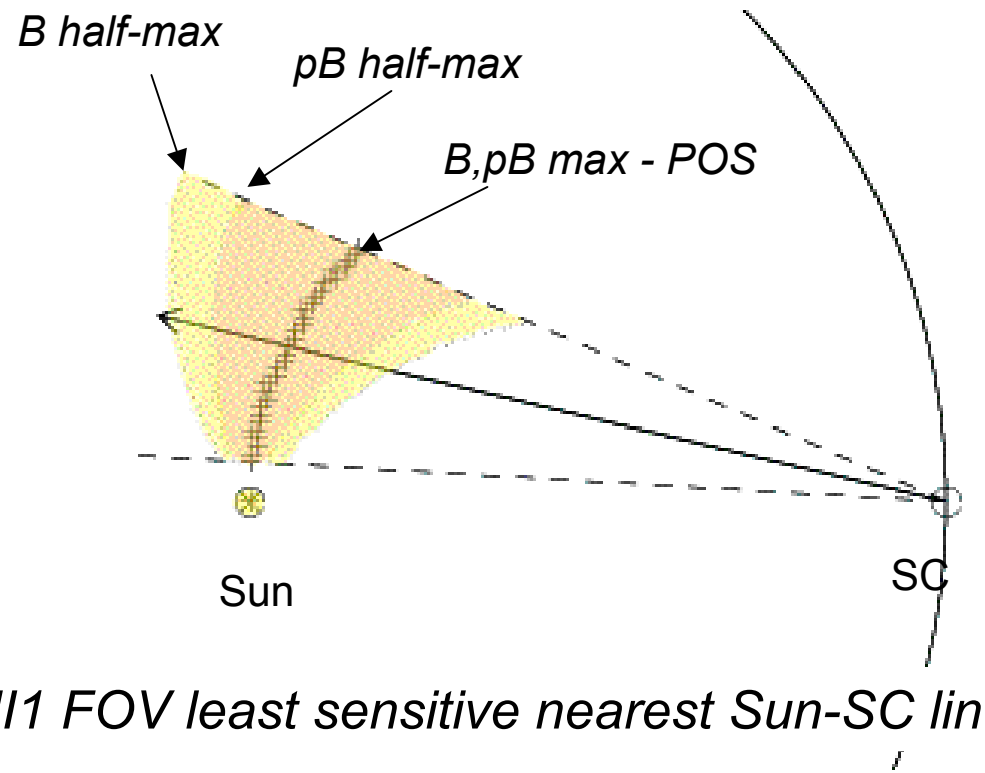
Good Overlap of Regions of high sensitivity FOV regions for separations of 40 °

Anticipate Good 3D Reconstruction for COR 1&2!

HI 1 FOV Sensitivity

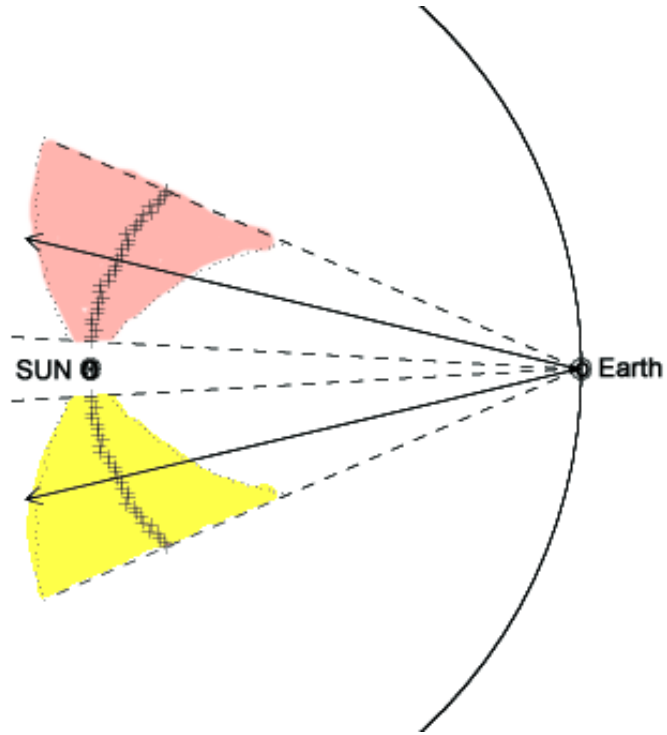
Brightness B & Polarization Brightness pB computed for $n(r) = n_0/r^2$

HI-1 points 13° from Sun
FOV: 13±10°



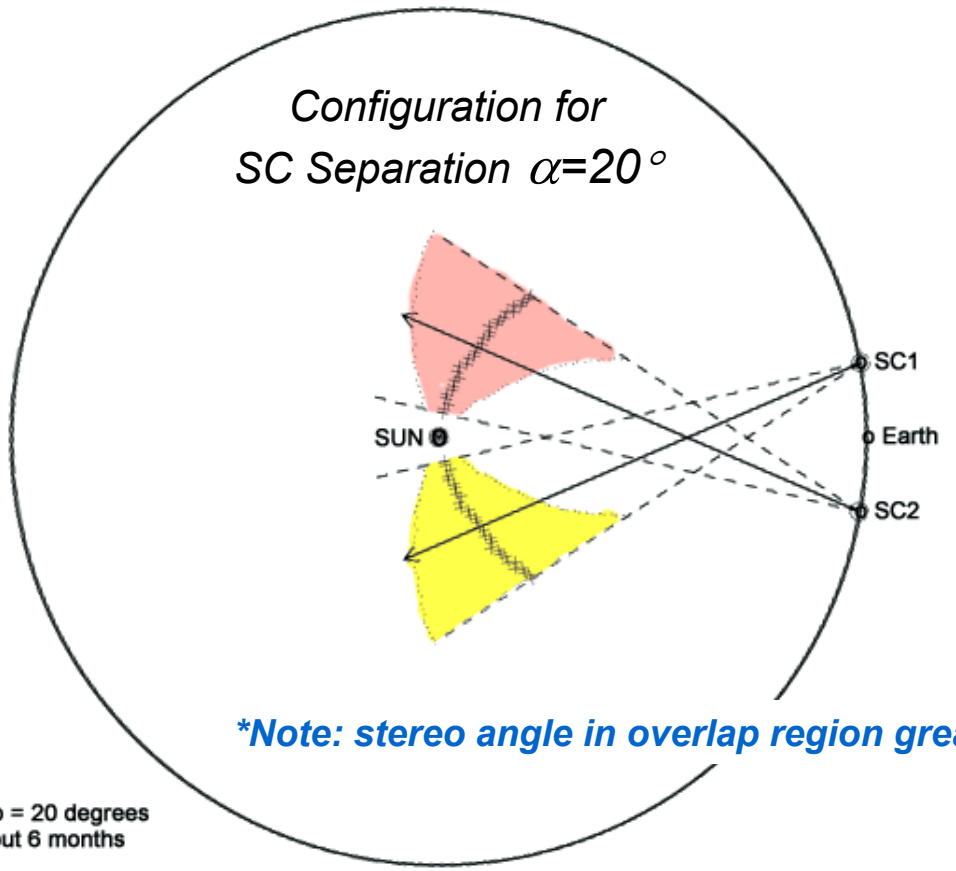
HI1 FOV least sensitive nearest Sun-SC line

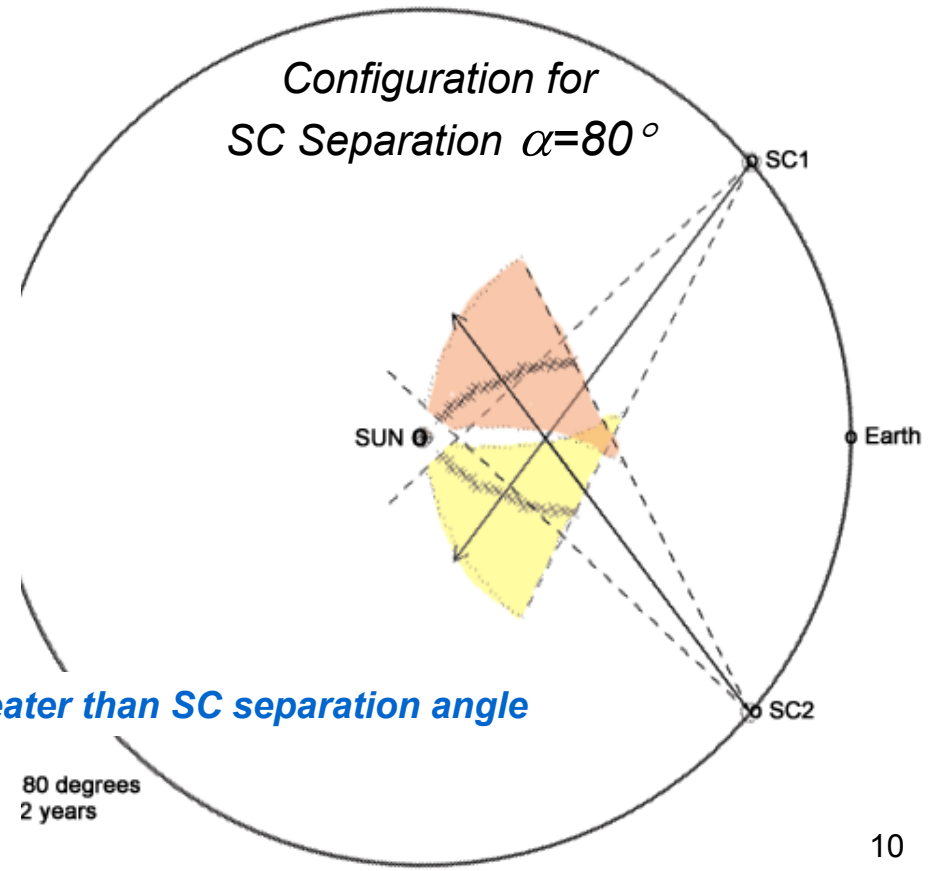
Configuration for
SC Separation α=0°



HI 1 FOV Overlaps for SC Separations of 20° and 80°

- *Overlap of FOVs of SC1&2 centered on Sun-Earth line**
  - Would be good for Earth-directed CMEs
- *Little sensitivity in region of overlap - far from POS*
- *Will 3D reconstruction be possible?*
  - Must eliminate large background signal





***Note: stereo angle in overlap region greater than SC separation angle**

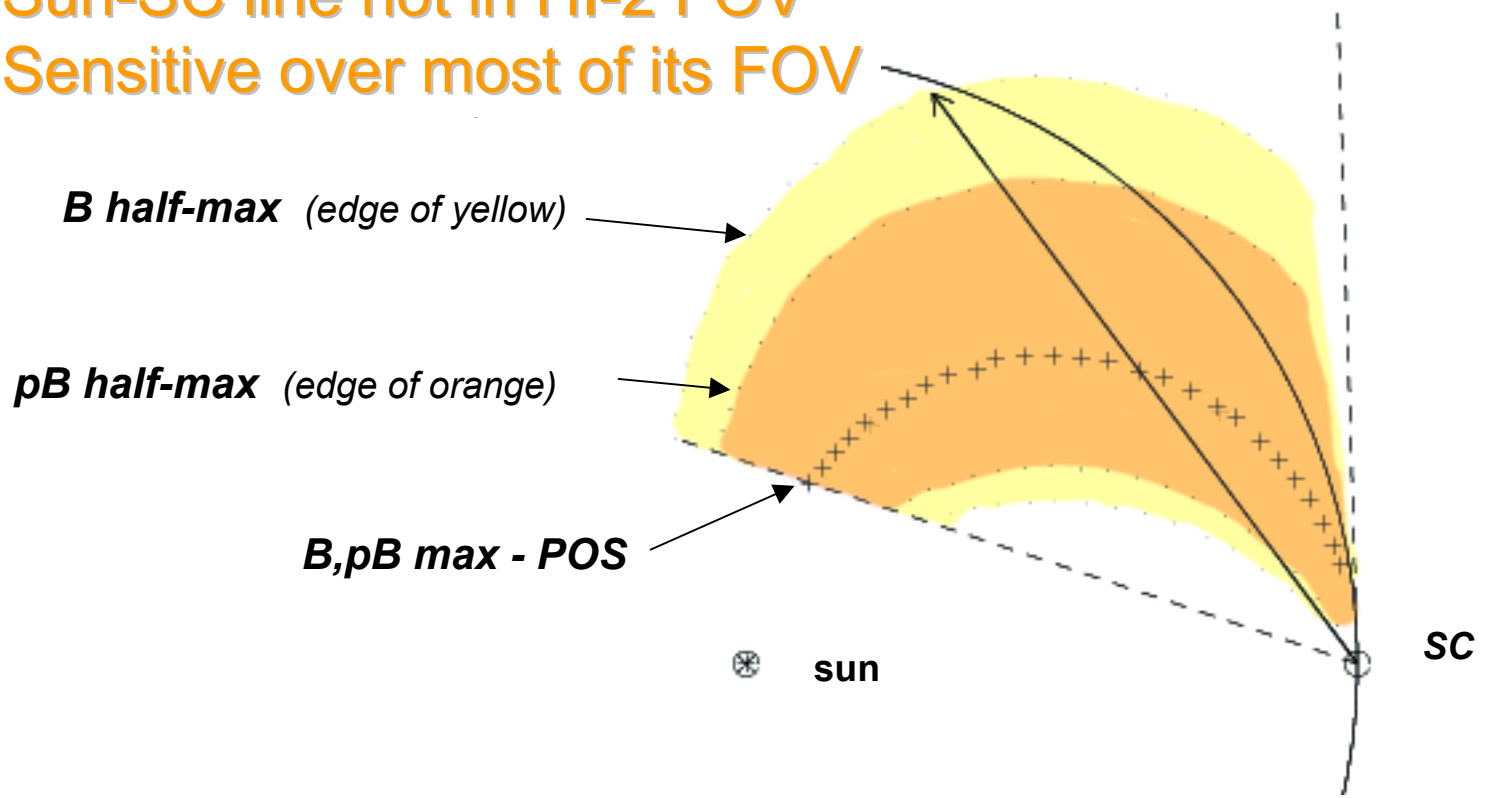
HI 2 FOV Sensitivity

Brightness B & Polarization Brightness pB computed for $n(r) = n_0/r^2$

HI-2 points 53±35°

Sun-SC line not in HI-2 FOV

Sensitive over most of its FOV

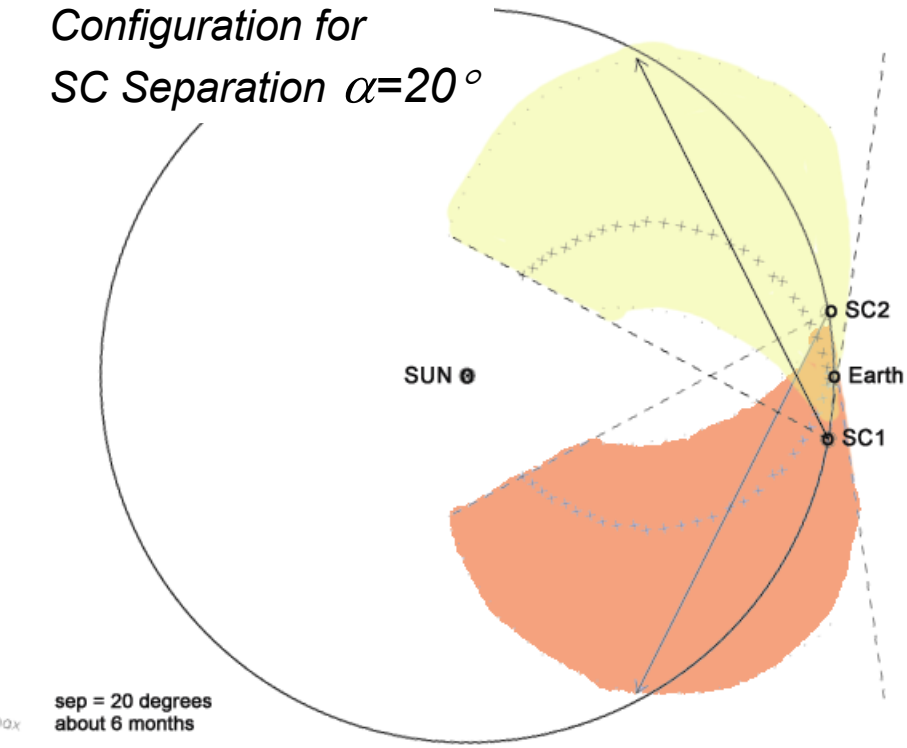


~10^2 variation in maximum brightness across HI2 70° FOV

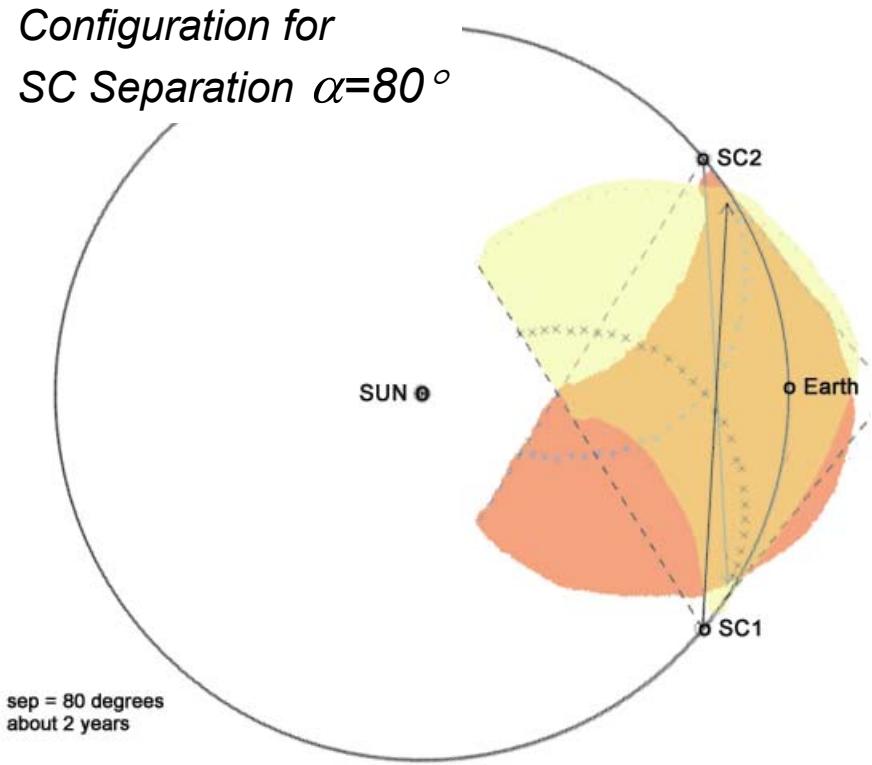
HI2 FOV Overlaps for SC Separations of 20° and 80°

- *Overlap of FOVs of SC1&2 include region of highest sensitivity*
  - Overlap also includes Earth and Sun-Earth line near Earth!
  - Stereo viewing angle in overlap region much greater than SC separation
- *Interesting prospects for stereoscopy & 3D Reconstruction early in mission*
  - *Needs more study*

Configuration for SC Separation α=20°



Configuration for SC Separation α=80°



Note: stereo viewing angle in overlap regions easily reaches ~180°

Use Code to Create Synthetic White Light Images

Need images computed from models for various angles

Useful for for observation planning

Necessary for interpretation of observations

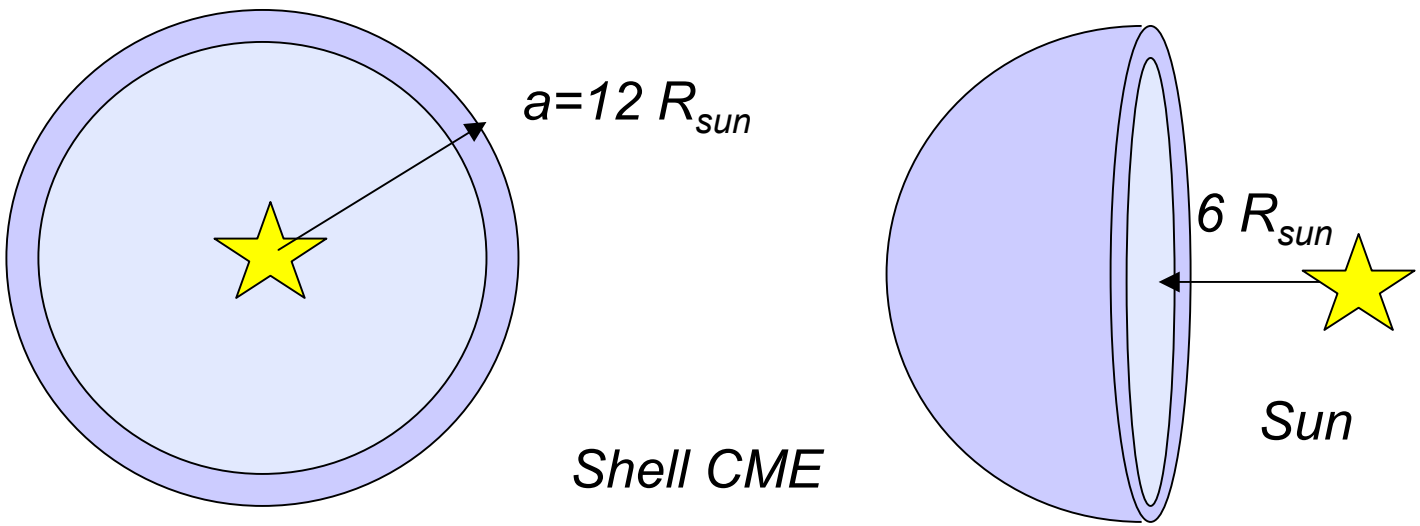
Test Case

Background $n(r) = n_0/r^2$

CME is hemispherical shell of radius $a=12\ R_{sun}$ *& thickness* $da/a=0.1$

Offset $6\ R_{sun}$ *from Sun*

Shell filled with uniform density $= 2\ n_0/\ a^3$

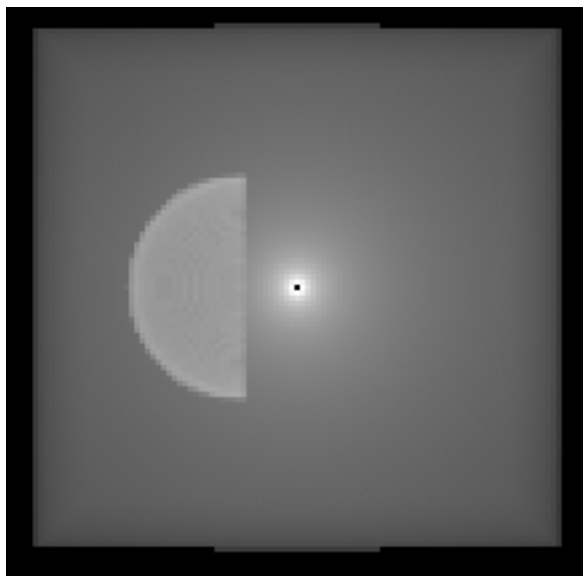


Use Code to Create Synthetic White Light Images

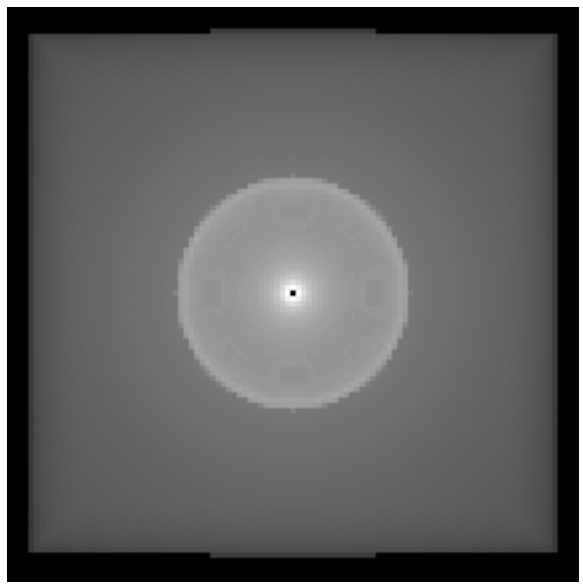
Image by integration of brightness along camera rays
CCD is 201 by 201

Test Case: *Background* $n(r) = n_0/r^2$ *with hemispherical shell CME*

Two views with 90° separation



CME moving at right angles to SC1



CME approaching SC2

Future Plans

Synthetic observations needed for SECCHI planning & analysis

- Use models to watch CME cross COR&HI FOVs
  - Create stereo pairs for various SC separations
  - Use results to help develop reconstruction techniques
- Start with simple models for CME
- Later, use MHD code results for CME propagation
  - Collaboration with Umich group (Gombosi et al.)
- Important science very early in mission
  - Need to be ready at launch