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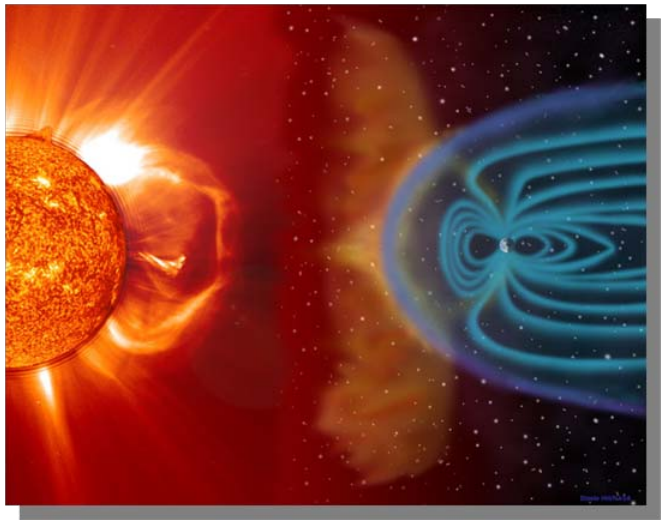
3D Reconstruction of STEREO-observed CME Events

Antunes, Cook, Newmark & Yahil



- Morphology: What is the intrinsic 3D shape of a CME, and why?

- Kinematics: How fast do they move, accel decelerate, what are the effects of the IPM and solar wind?

- Origins: CMEs are magnetic structures, so understanding them gives us insight into the solar magnetic field and how CMEs are created.

- Predictability-- Can we predict the creation, arrival time, point of arrival, mass, magnetic energy, and estimated damage potential of a given CME?

SECCHI

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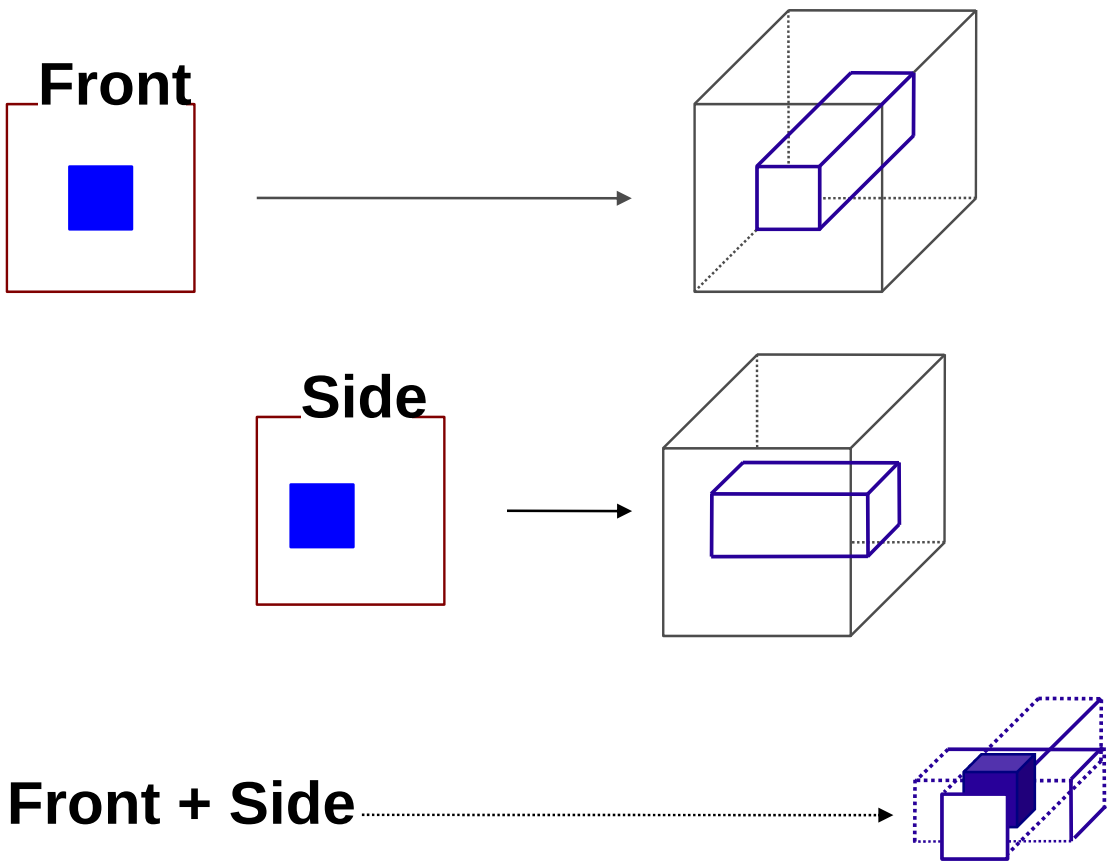
Our Approach

Inverse Reconstruction



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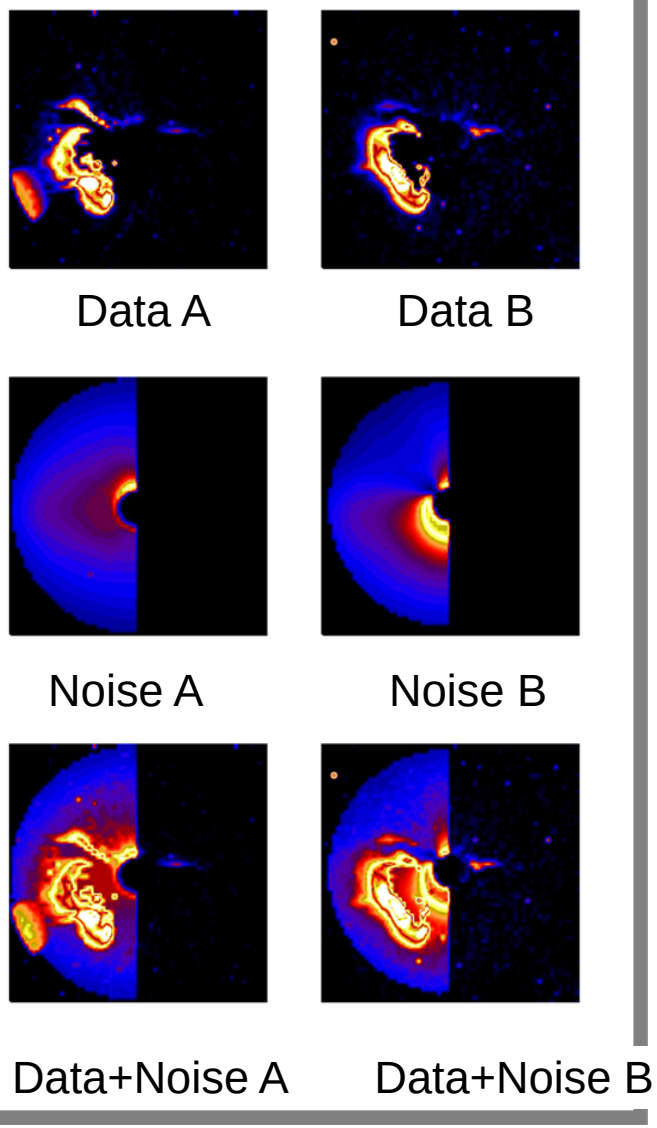
Our Approach

PIXON (Puetter & Yahil)

- Alternative to maximum entropy methods
- Elements are spatially extended, overlapping 'Pixons'
- Uses kernel-based smoothing across Pixons
- Map key is minimum complexity: a solution using fewer underlying Pixon map elements is presumed to be superior
- Produces minimum number of elements required to fit the solution as allowed by the noise. e.g. Pixon would consider the bottom pair to be roughly as good a final goal as the top pair.



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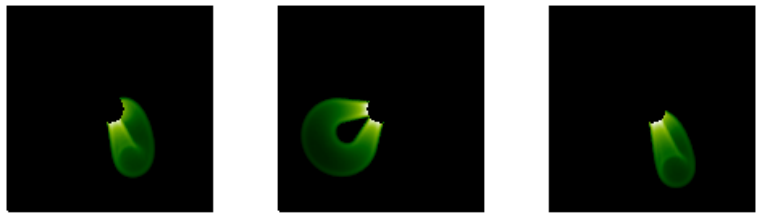
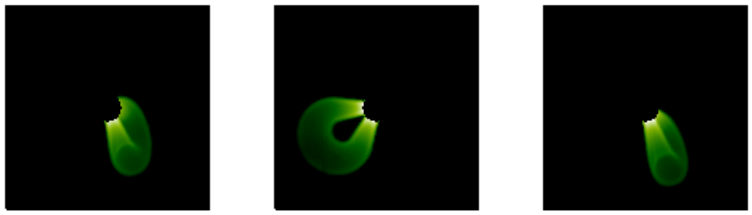
Sim Satellites: X-Y-Z & Ecliptic

Data In == Recon Out

'best case' 3-axis input data

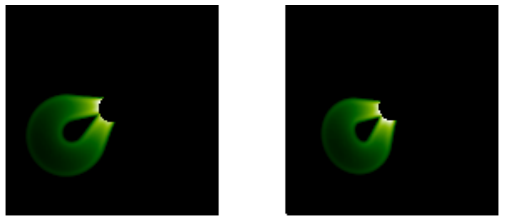


Data at 0°, 90°, and from top

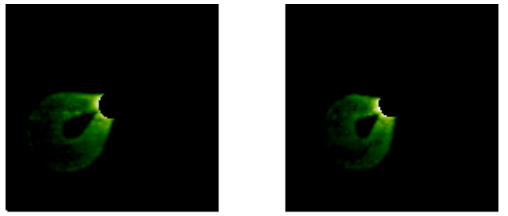


Recon at 0°, 90°, and from top

Two at 44° (B: 76°, A: 120°)



View at 0° 44°



Recon at 0° 44°

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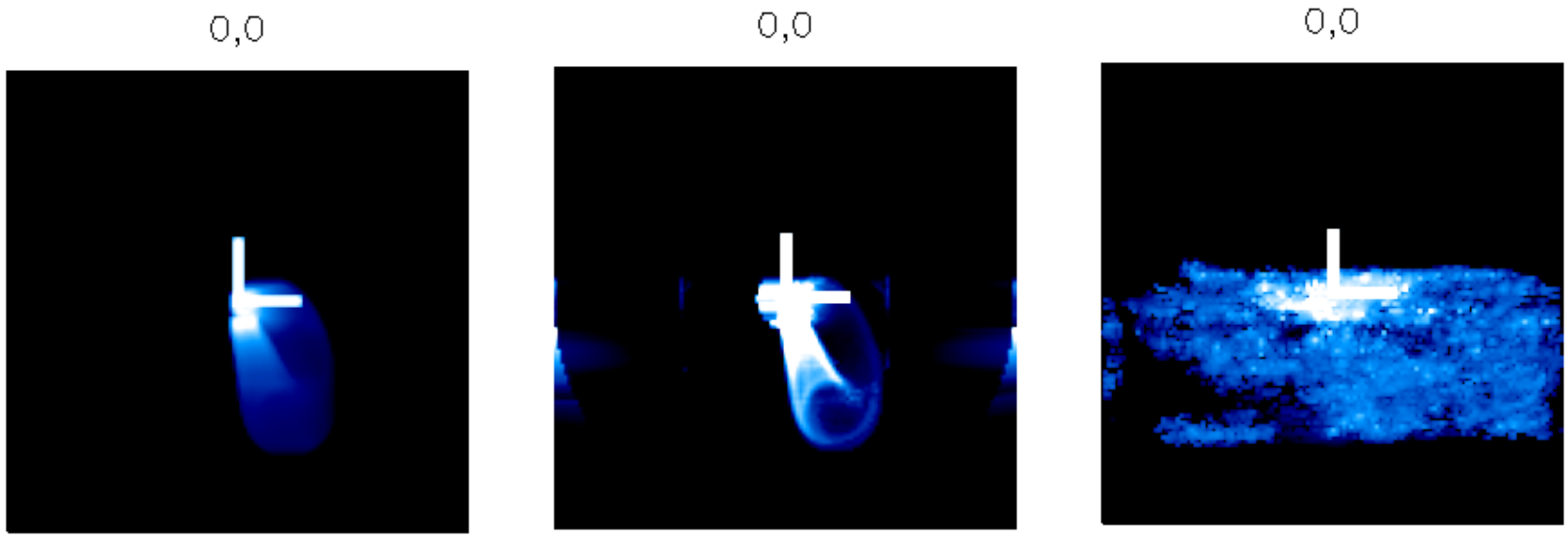
Sim Satellites: 3-axis vs Ecliptic 90° & 44°

Flyby



3-axis 'best' case separation

Ecliptic 2-view case

Only 44°

3-axis and ecliptic flybys comparing XYZ result (left) with 'just 2 satellites' ecliptic result (middle) and 'just 2 at narrow separation' (right)

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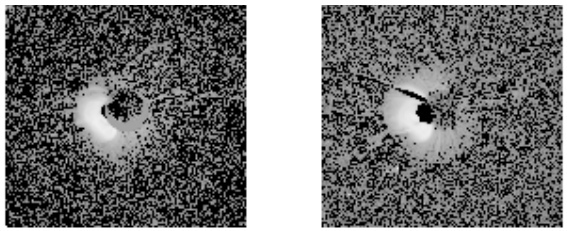
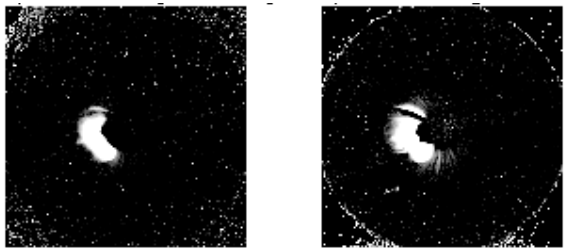
Dec 31st, 2007 CME

Reality is Messy and Evolving

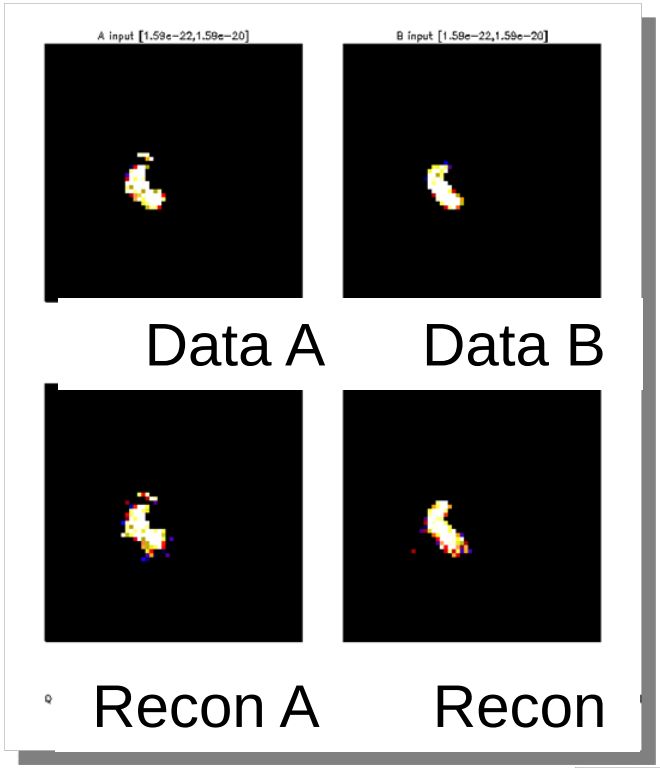
Running Difference



View at 0° 44°



View at 0° 44°



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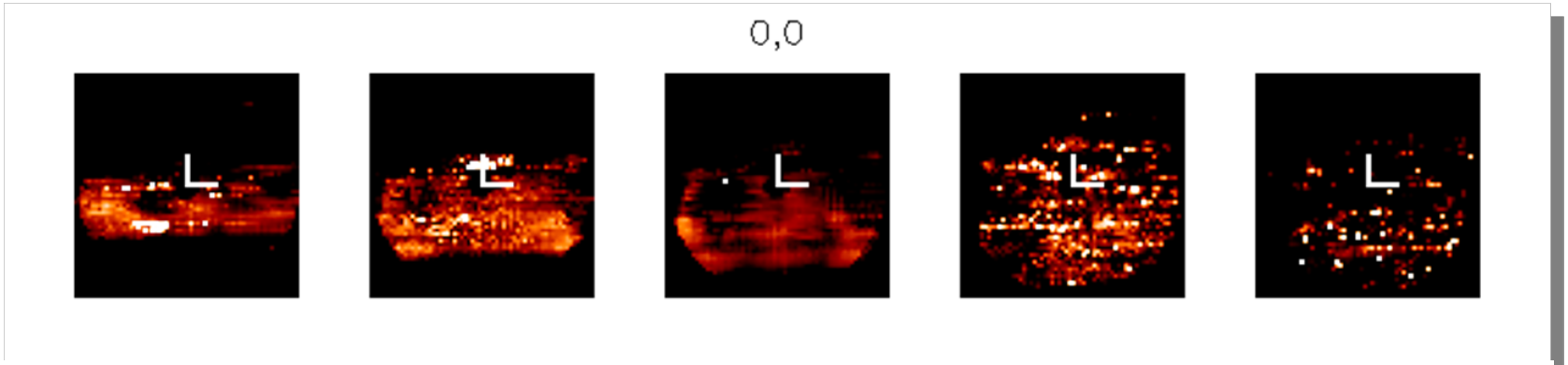
CME over time

(unconstrained, uncorrelated solutions)



(running difference reconstruction)

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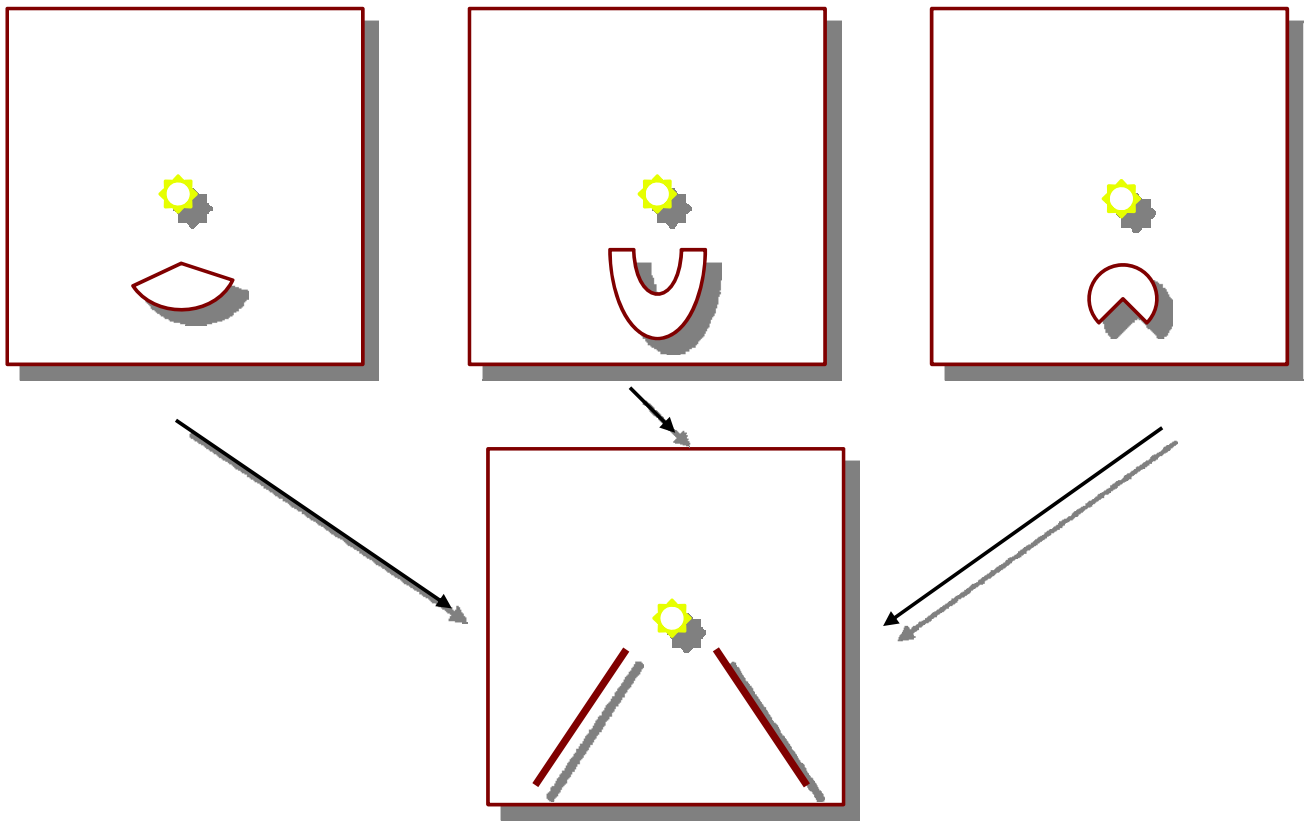
Dec 31st, 2007 CME

Constraining the Solution Space



STEREO Inverse Reconstruction

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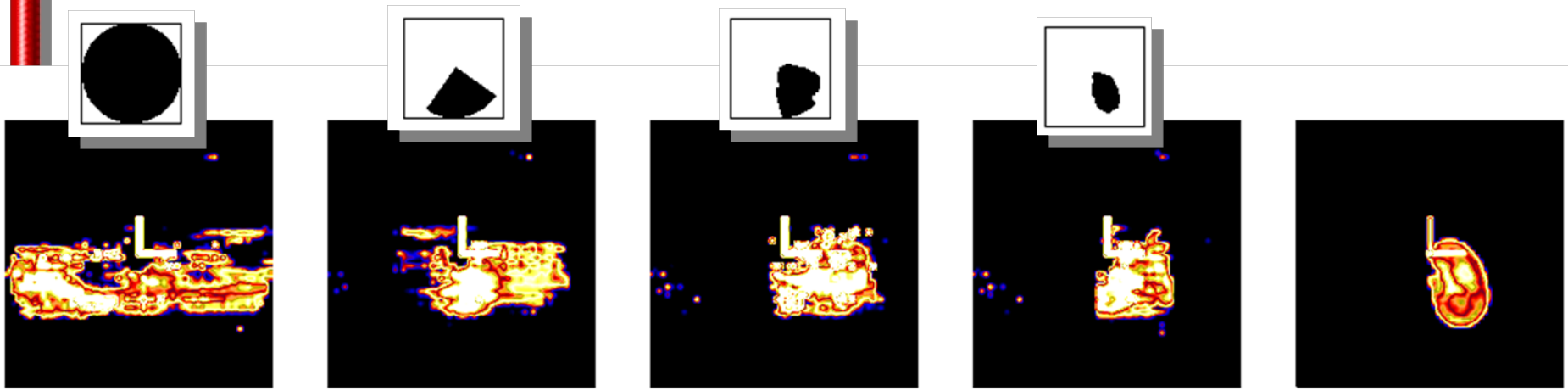
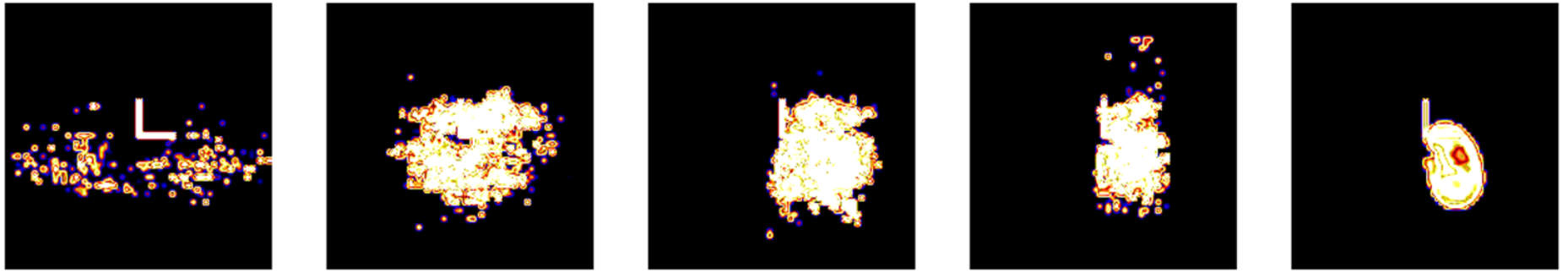
Dec 31st, 2007, 2:22





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Conclusions

- Inverse methods can help distinguish between current theoretical models, at different solar distances.
- Inverse methods can model asymmetrical features (which pure forward models cannot).
- Inverse reconstruction can separate components. e.g. for Dec 31, separate the streamer from the above and lower CME portions
- Solution is probability space map for CM
- Computational issues: fast, but resolution-limited and require high S/N

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Conclusions

Collaboration is Key

1) Study Kinematics-- CM vs time, expansion/compression, trace back/fwd
2) Apply model-based masks
3) Separate components
4) Overlay Forward Models (Thernisien et al)
5) Compare with other geometric methods (de Koning)
6) Compare with centroid location (Vourlidas et al)
7) Add the '3rd Eye' of LASCO (Cook)
8) Let others use our tools
9) Wait for a >90° CME
10) Don't like it? Use our framework and tools to try your own!