Evolution of magnetic clouds from the Sun (5–20 R⊙) to 1AU

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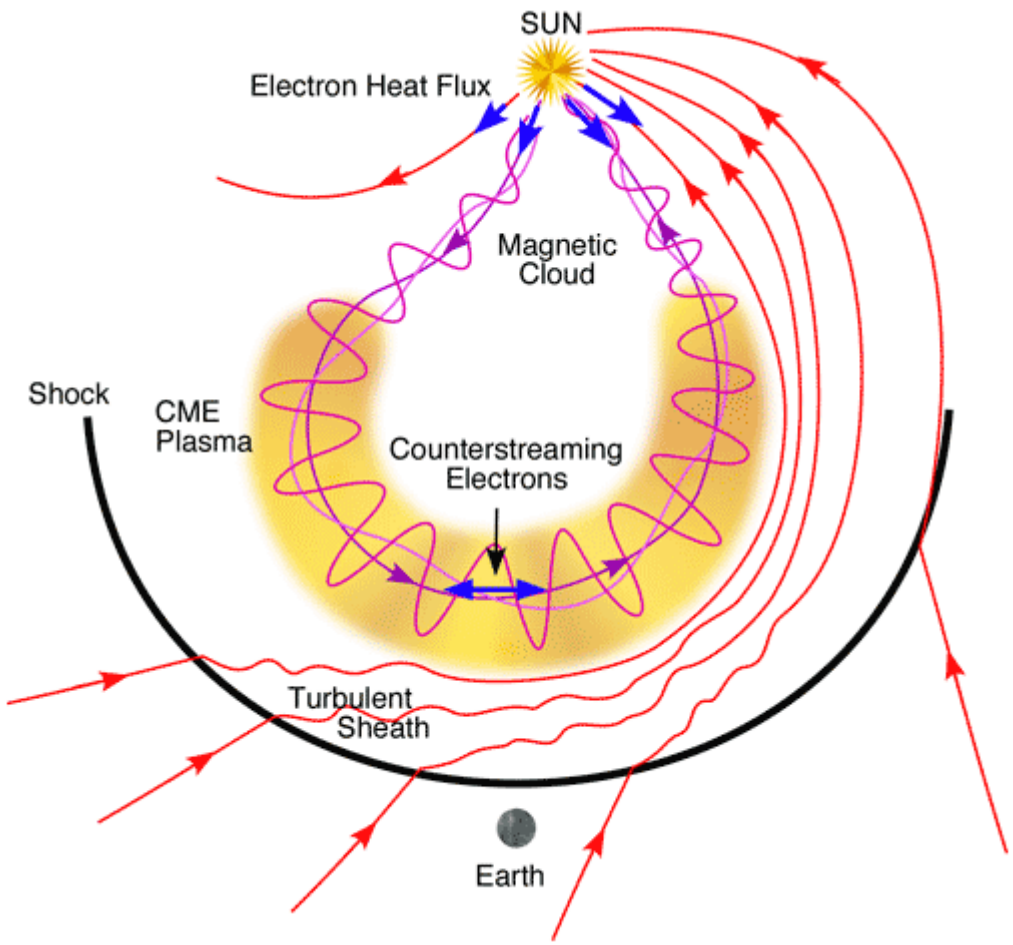
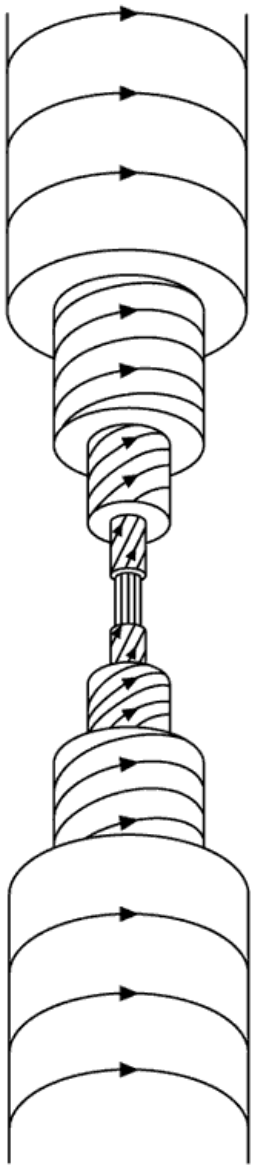
Magnetic clouds

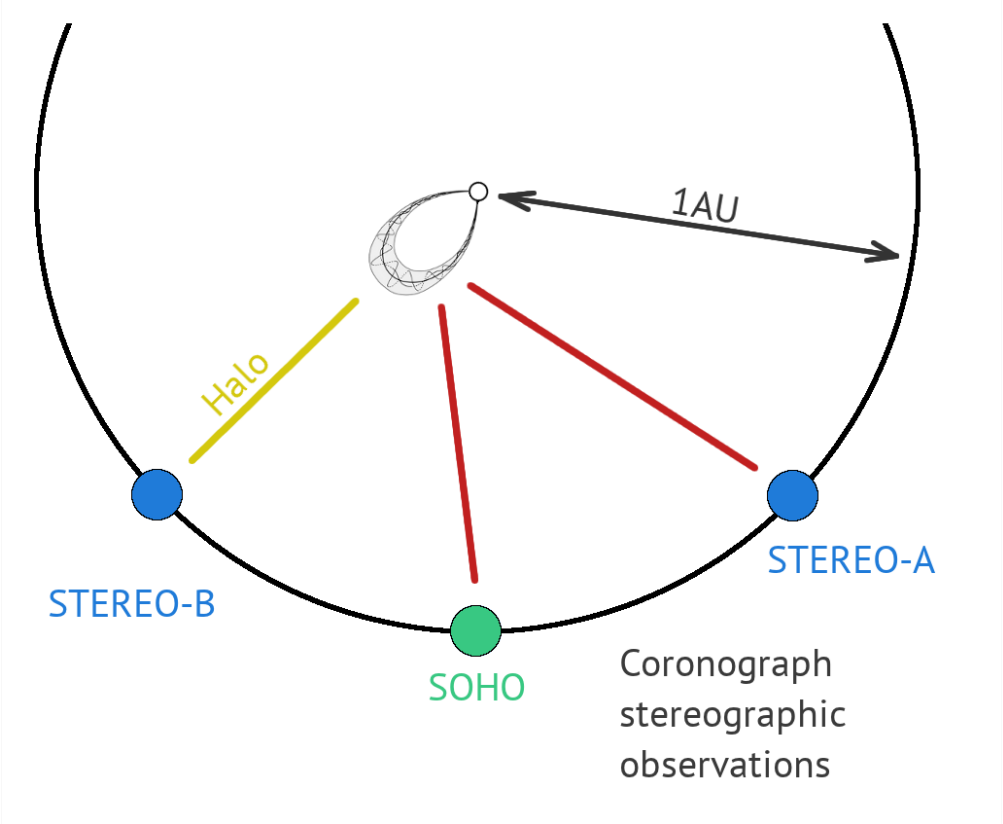




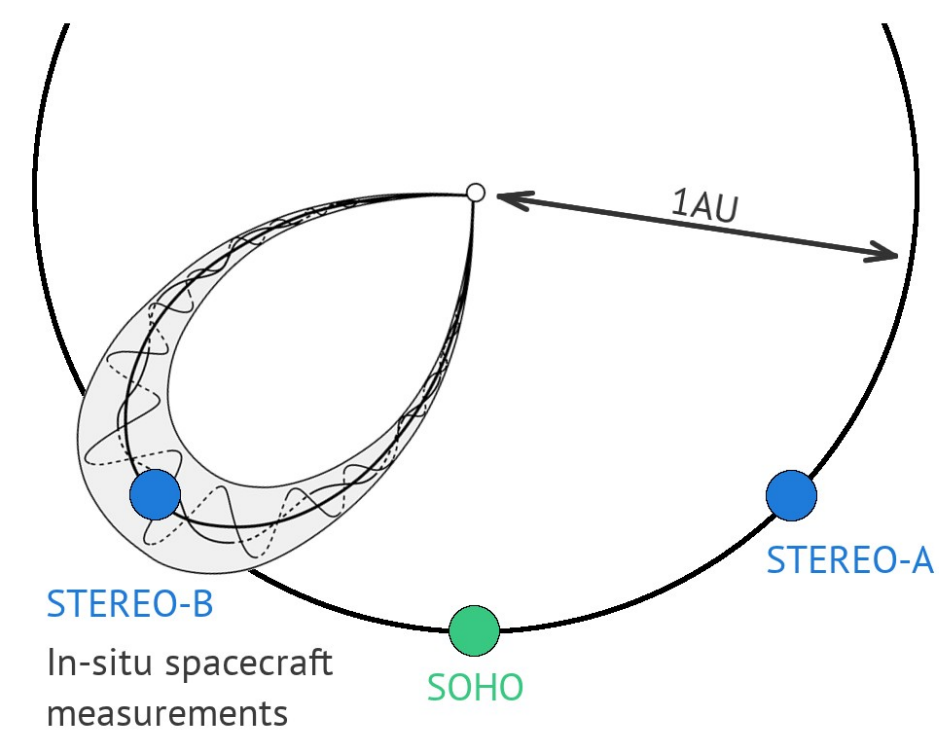
Evolution of MC

Two spatial&temporal observational points for the same MC

5 – 20 R⊙

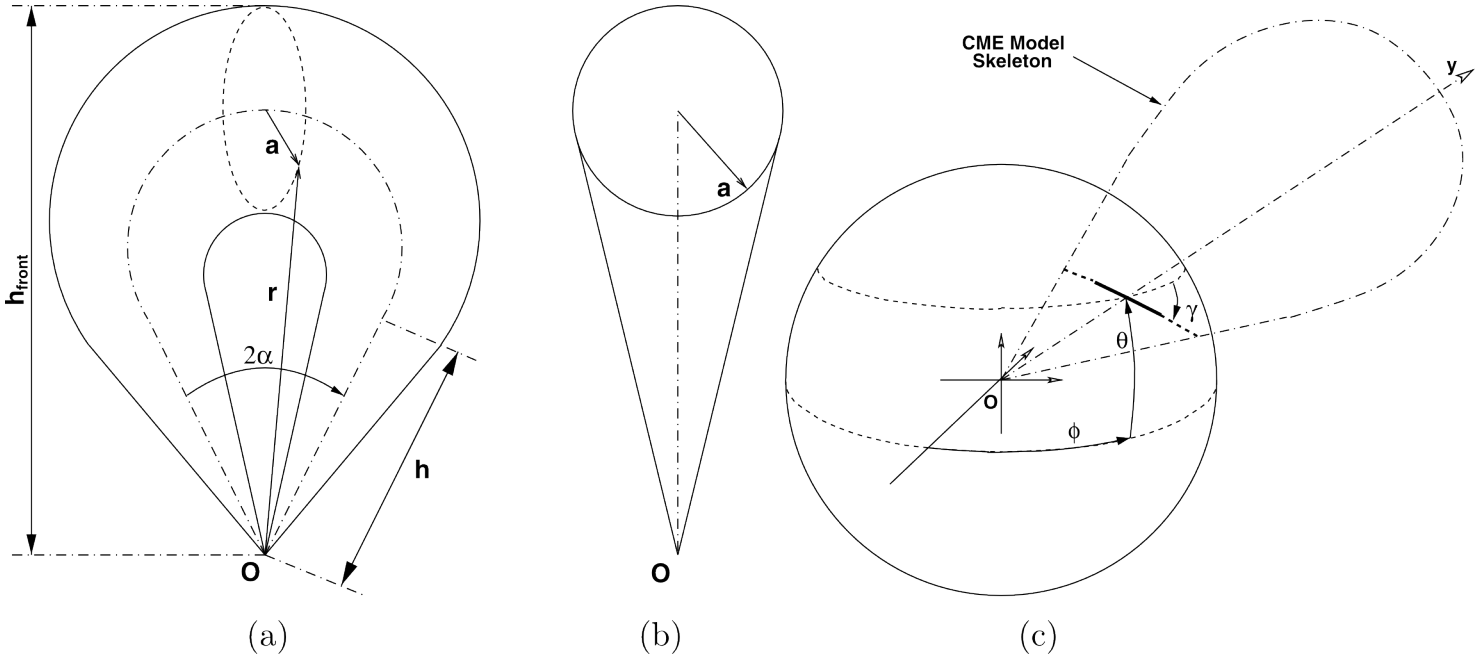


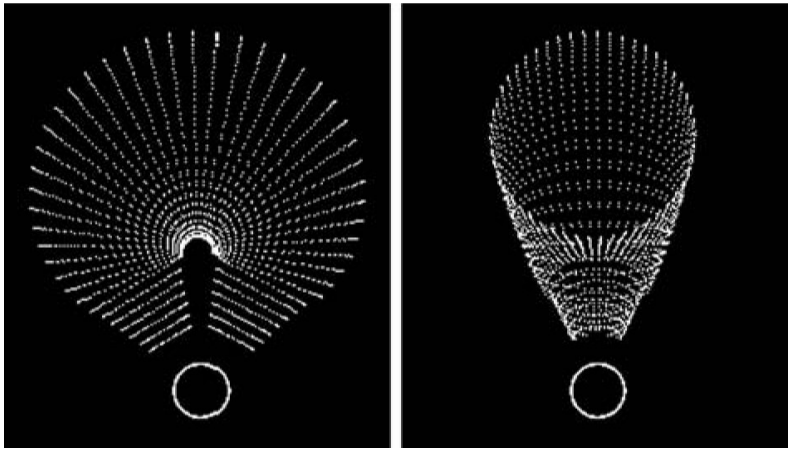
1AU



Forward model

Hollow croissant shape



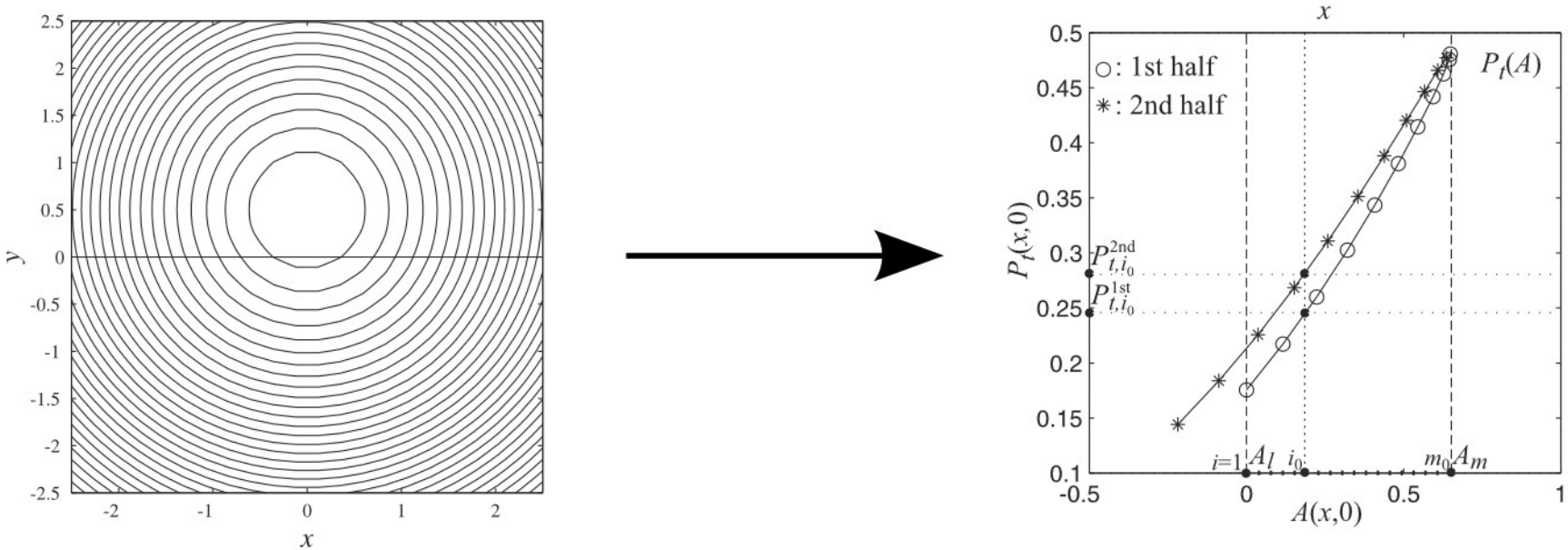


Thernisien et al. (2009)

Grad-Shafranov reconstruction

- Magnetohydrostatic equilibrium
- 2½ structure
- Time stationarity in deHoffmann-Teller frame
- Grad-Shafranov equation $\frac{\partial^2 A}{\partial x^2}+\frac{\partial^2 A}{\partial y^2}=-\mu_0\frac{d}{dA}\left(p+\frac{B_z^2}{2\mu_0}\right)$

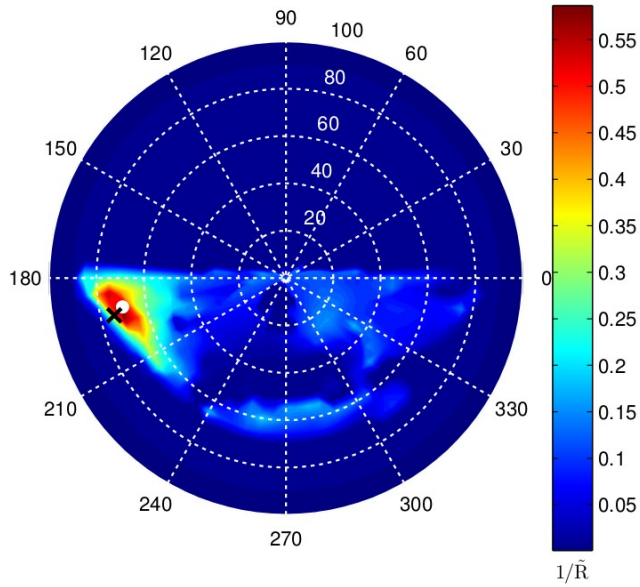
The idea behind invariant axis search algorithm



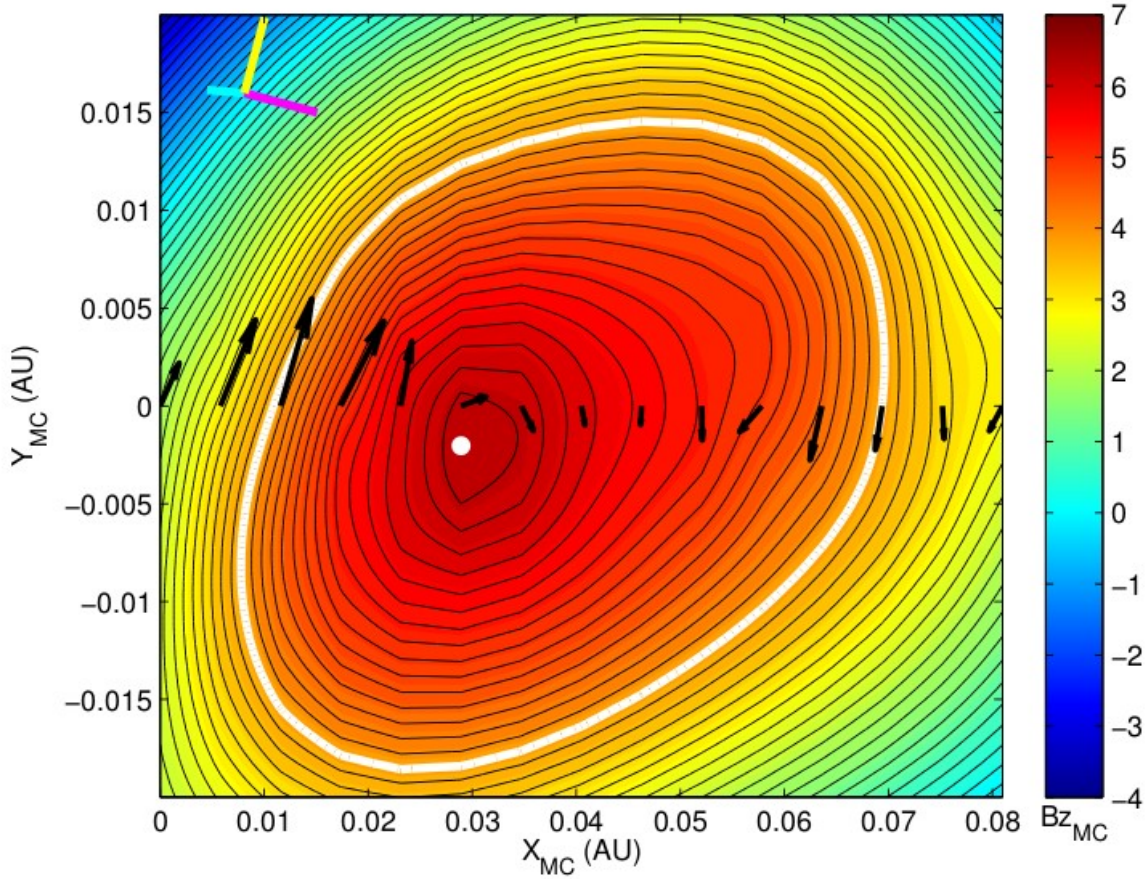
Hu, Sonnerup (2002)

Grad-Shafranov reconstruction

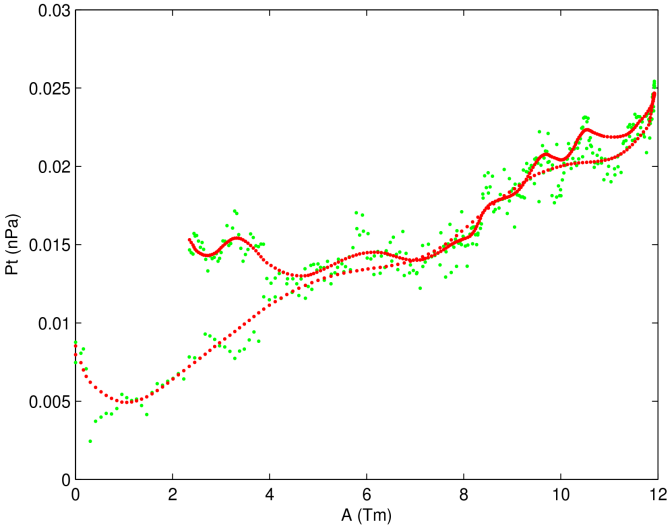
Optimized residual map



Magnetic field map



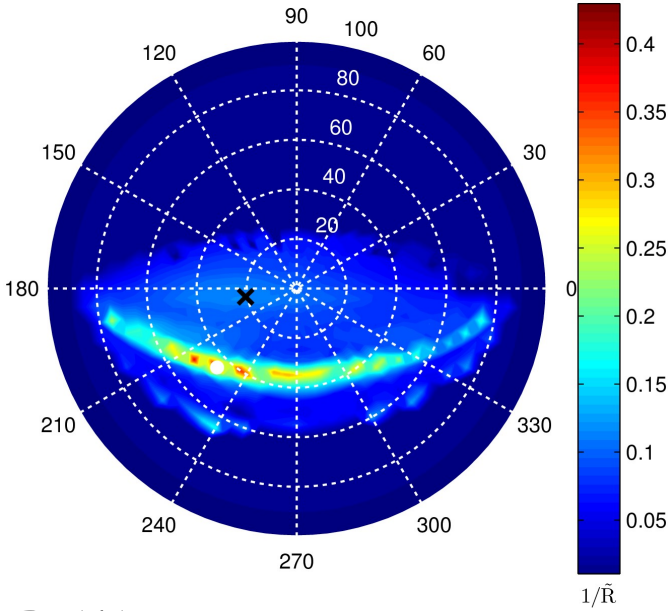
Pt(A)



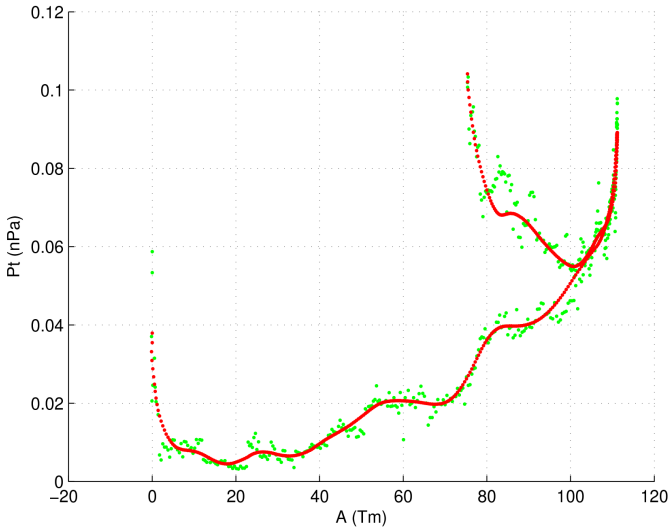
Isavnin et al. (2011)

Why GSR?

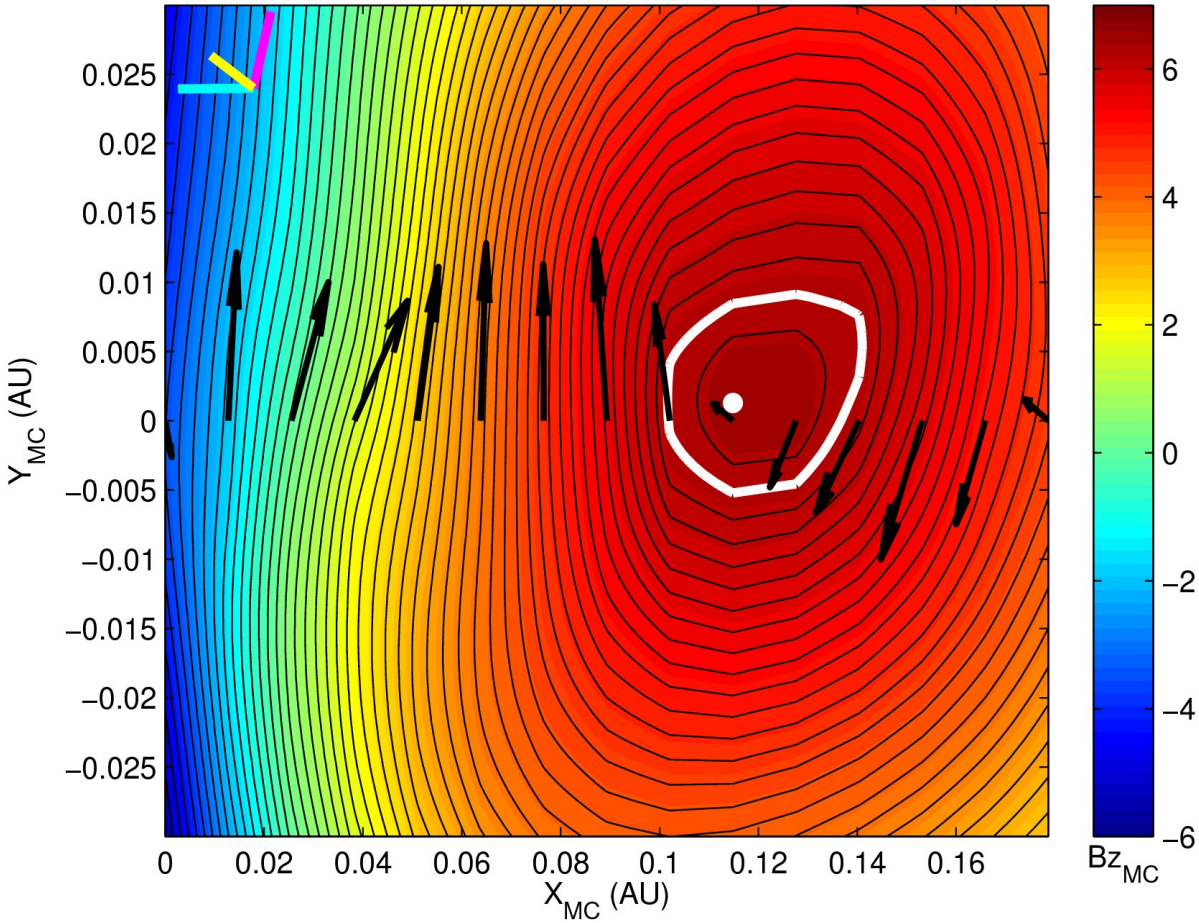
Optimized residual map



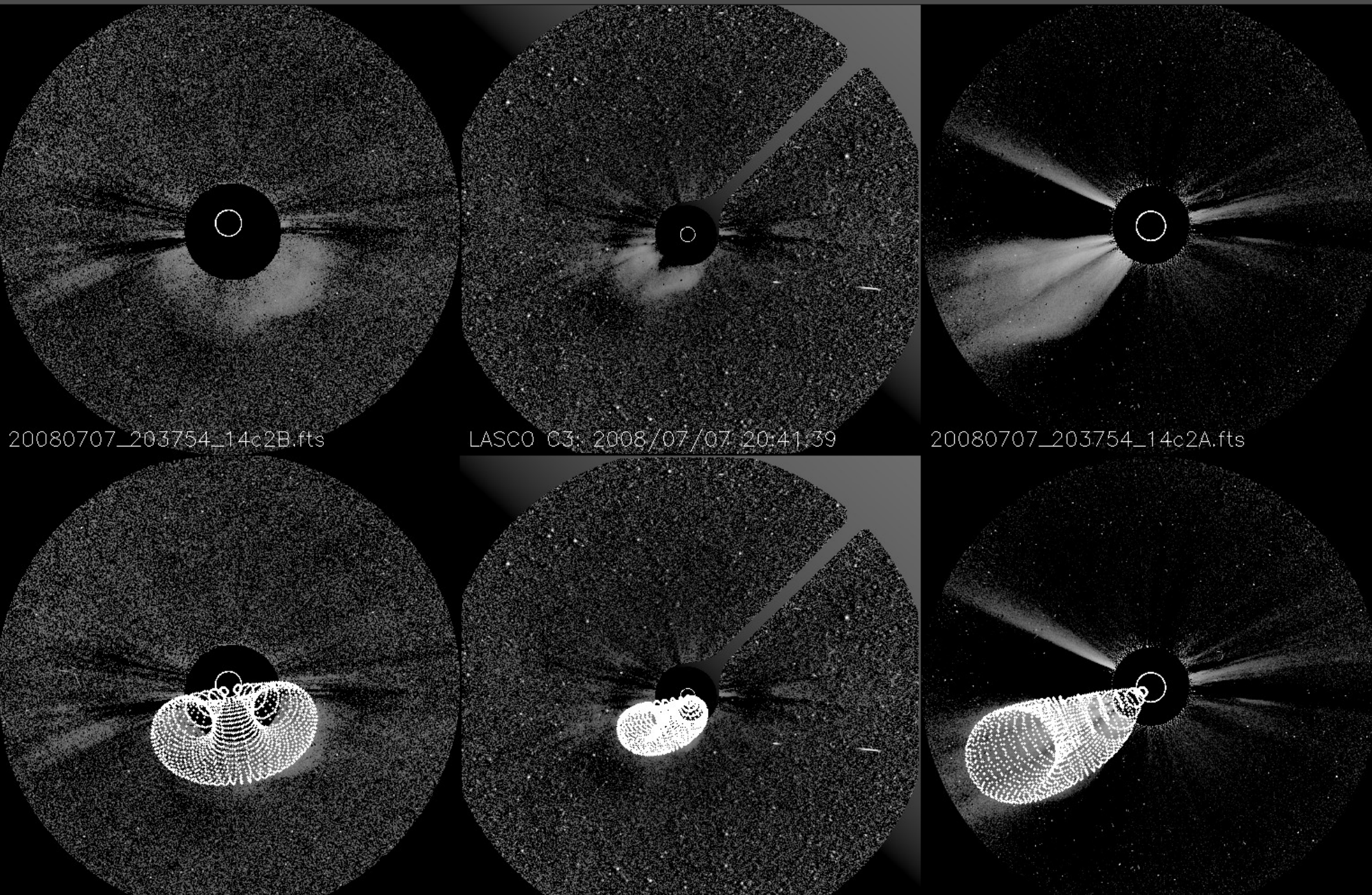
Pt(A)



Magnetic field map

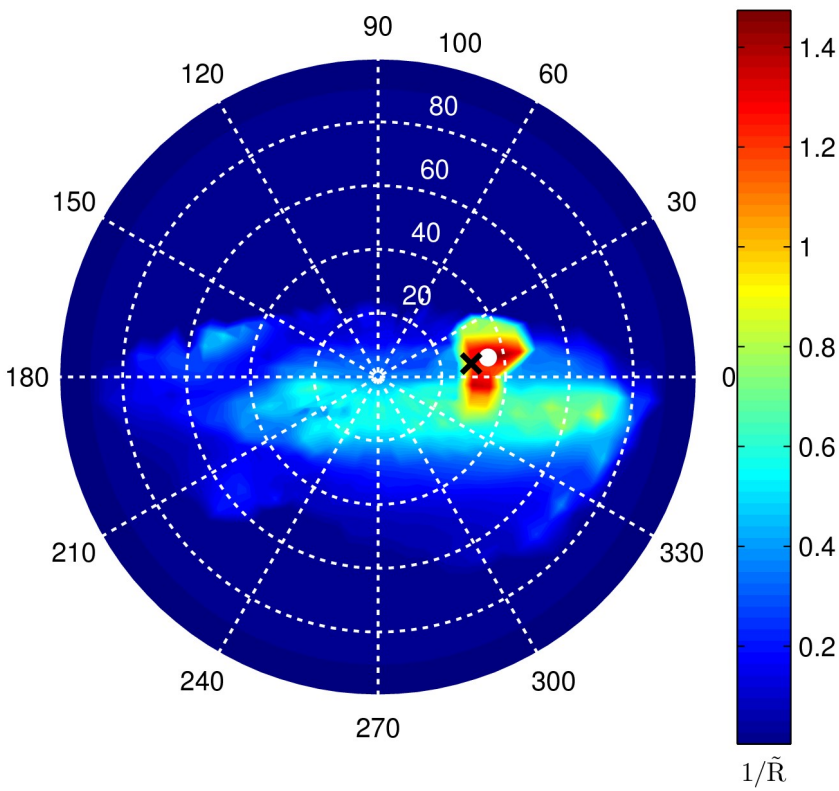


Example. 2008-07-07

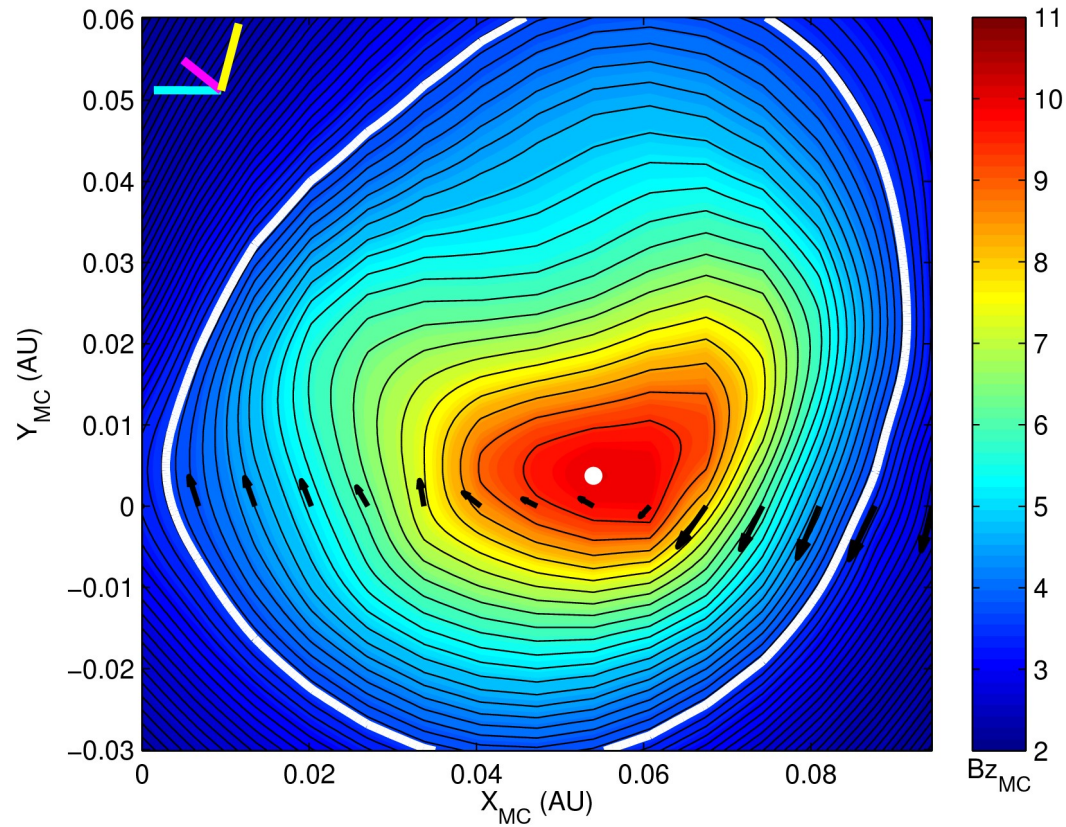


Example. 2008-07-07

Optimized residual map

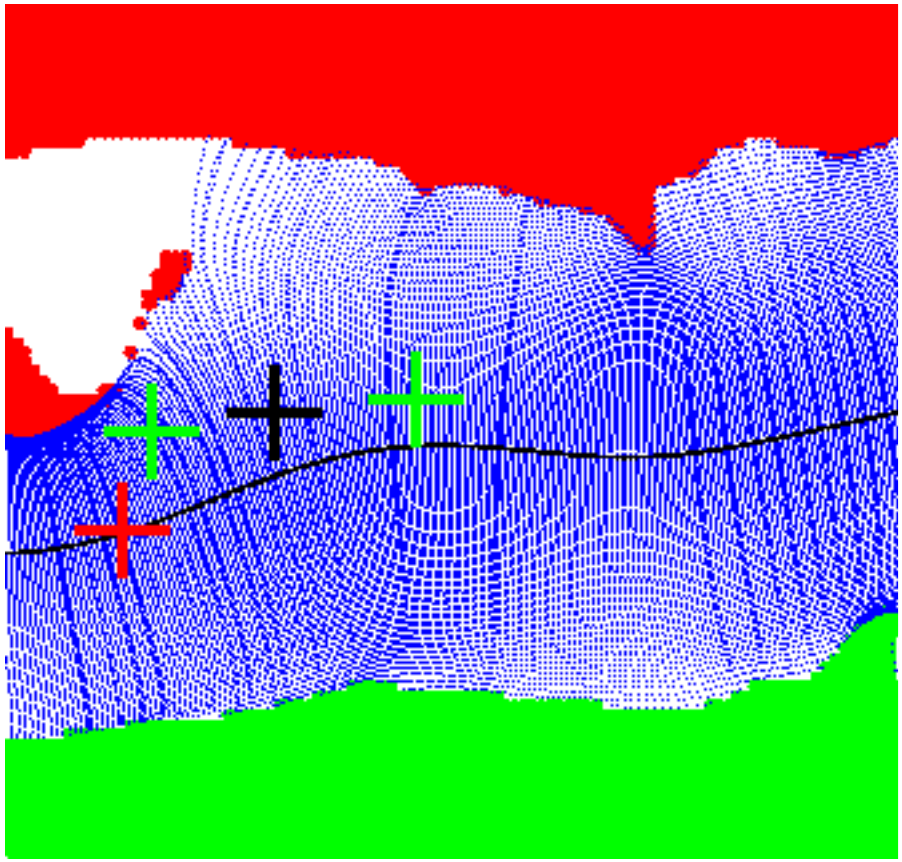


Magnetic field map

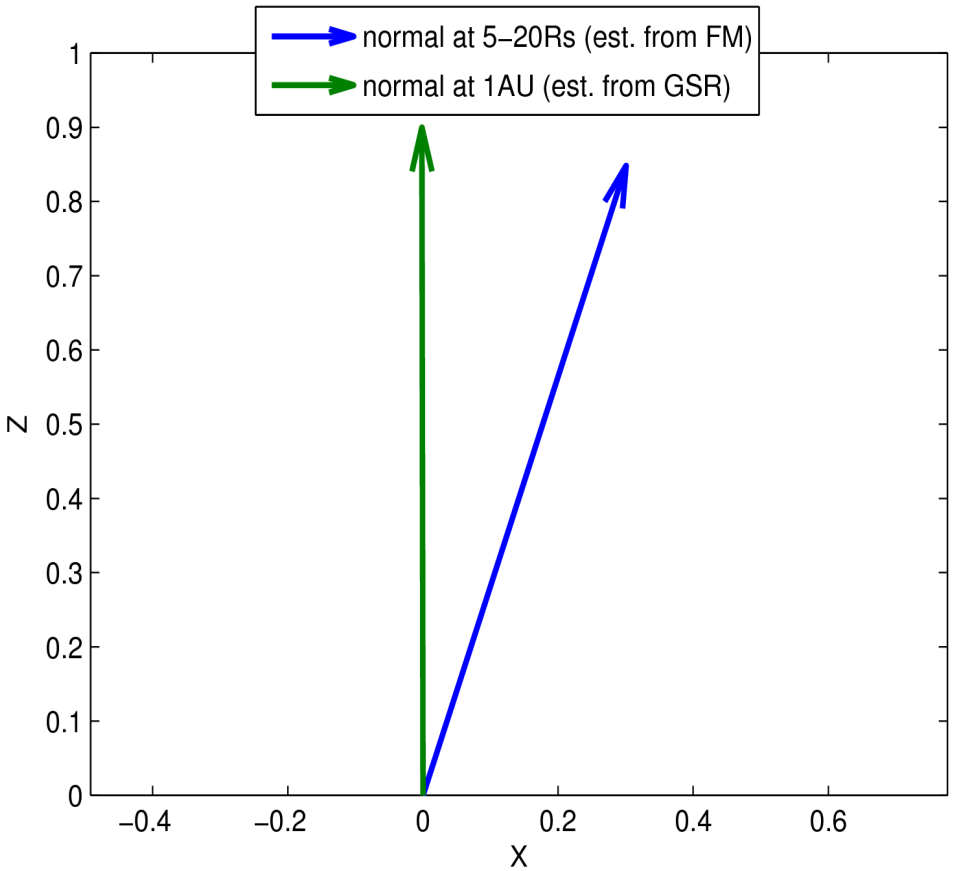


Example. 2008-07-07

Synoptic coronal hole plot (GONG)

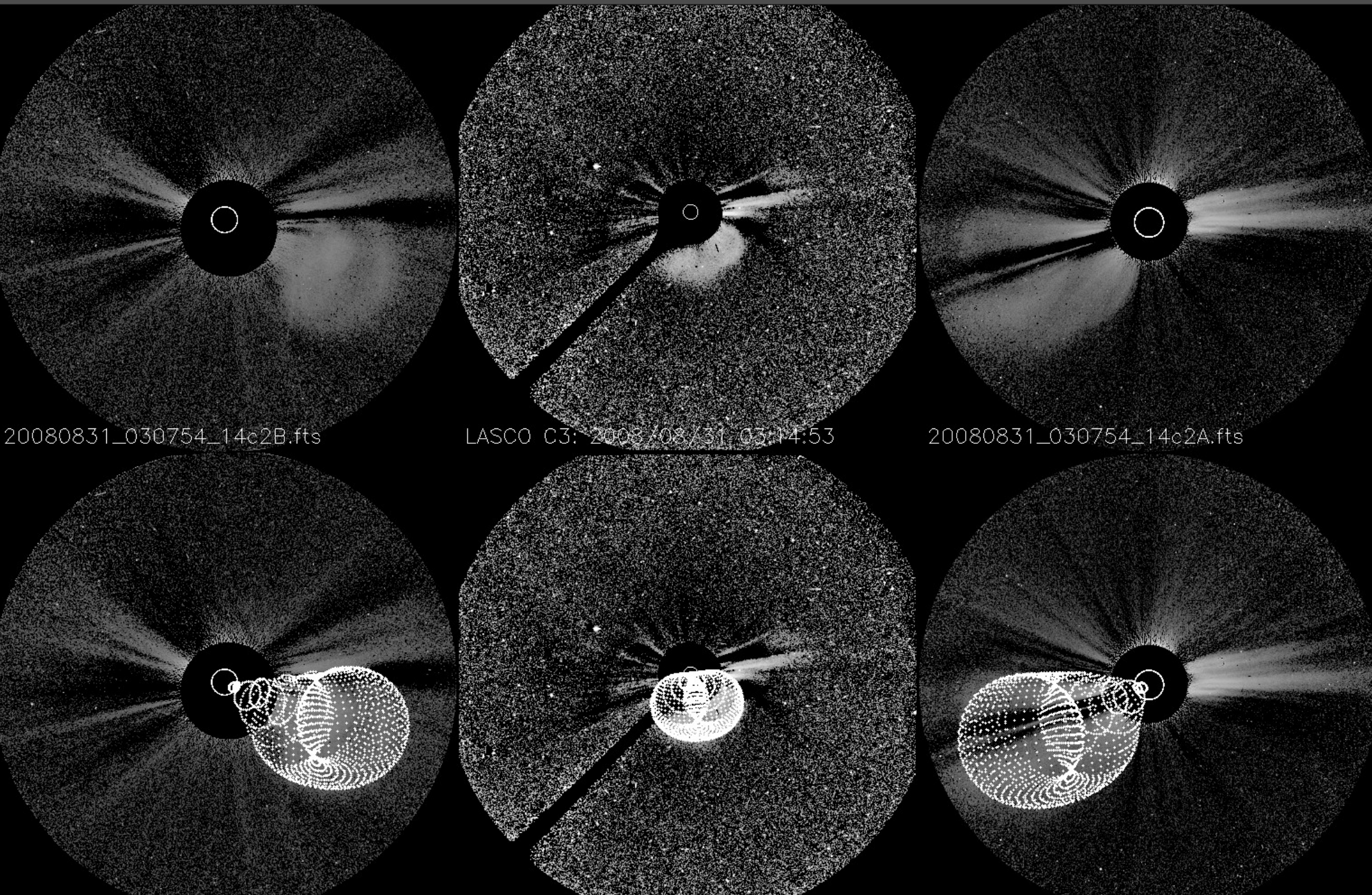


Normals to MC by FM and GSR



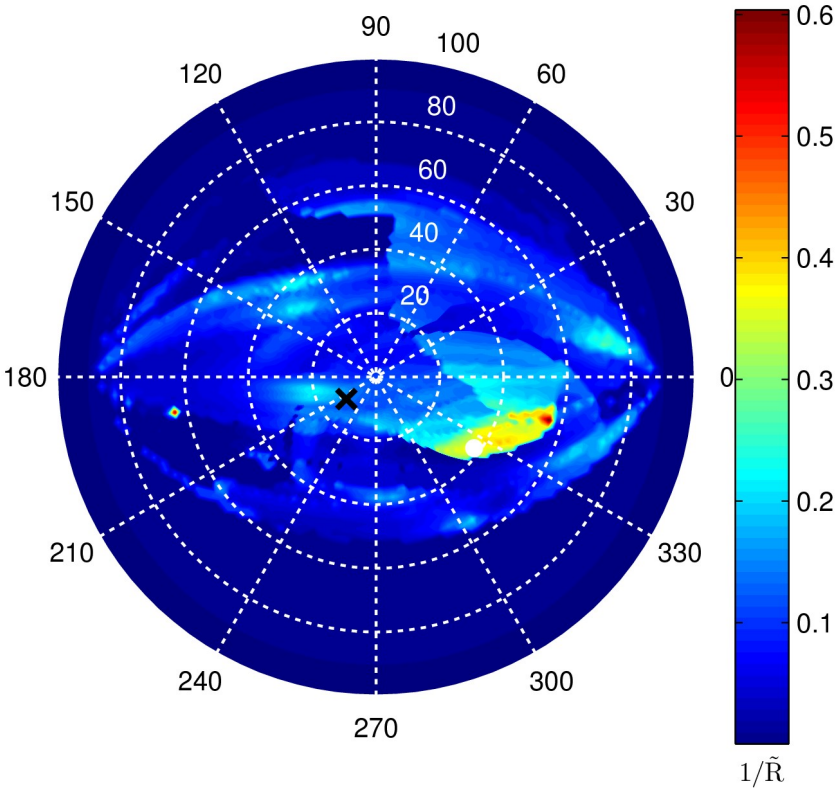
Deflection by $\Delta = 19.6\,°$ towards equatorial plane

Example. 2008-08-31

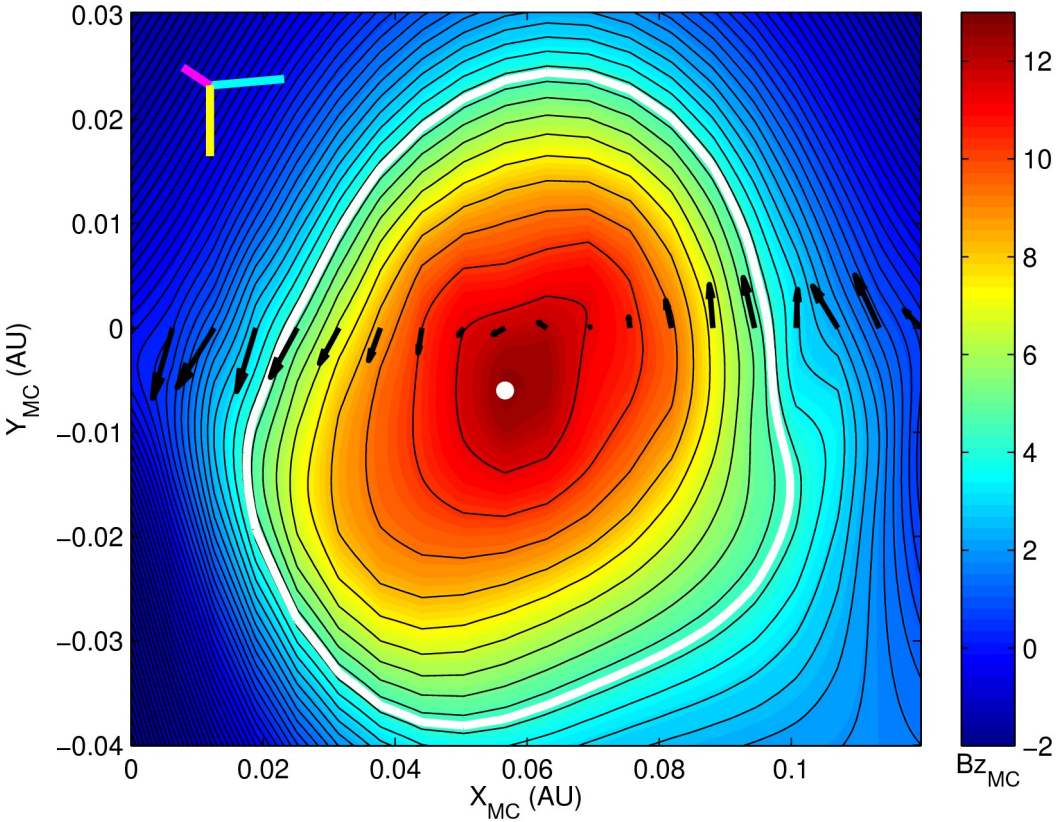


Example. 2008-08-31

Optimized residual map



Magnetic field map



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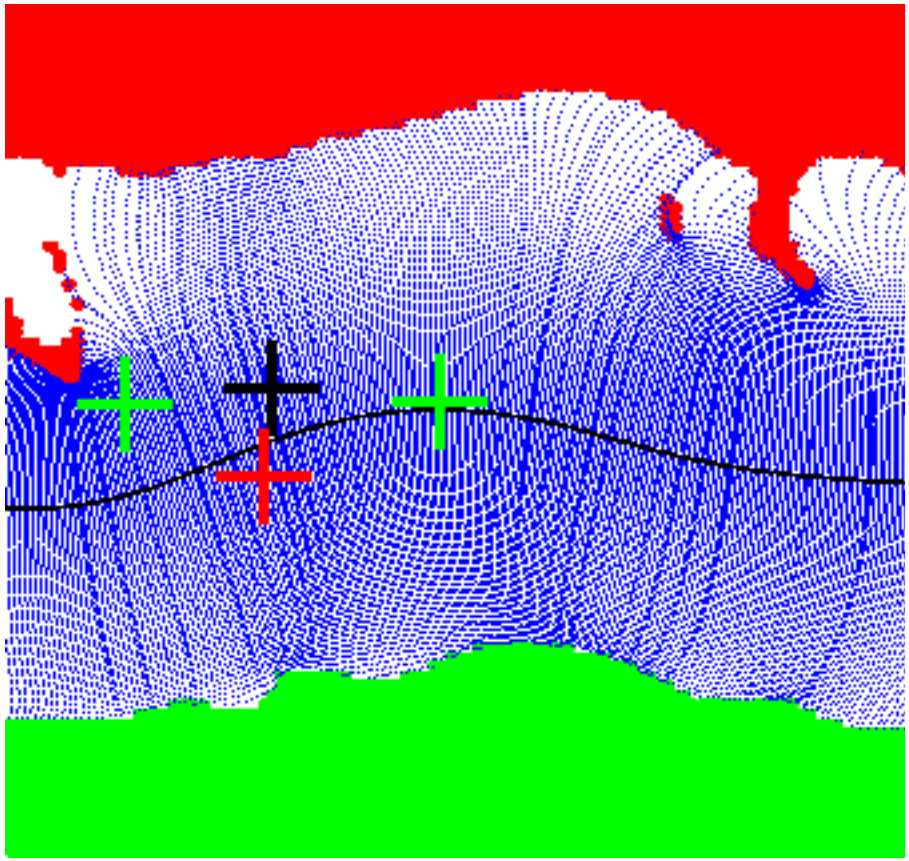
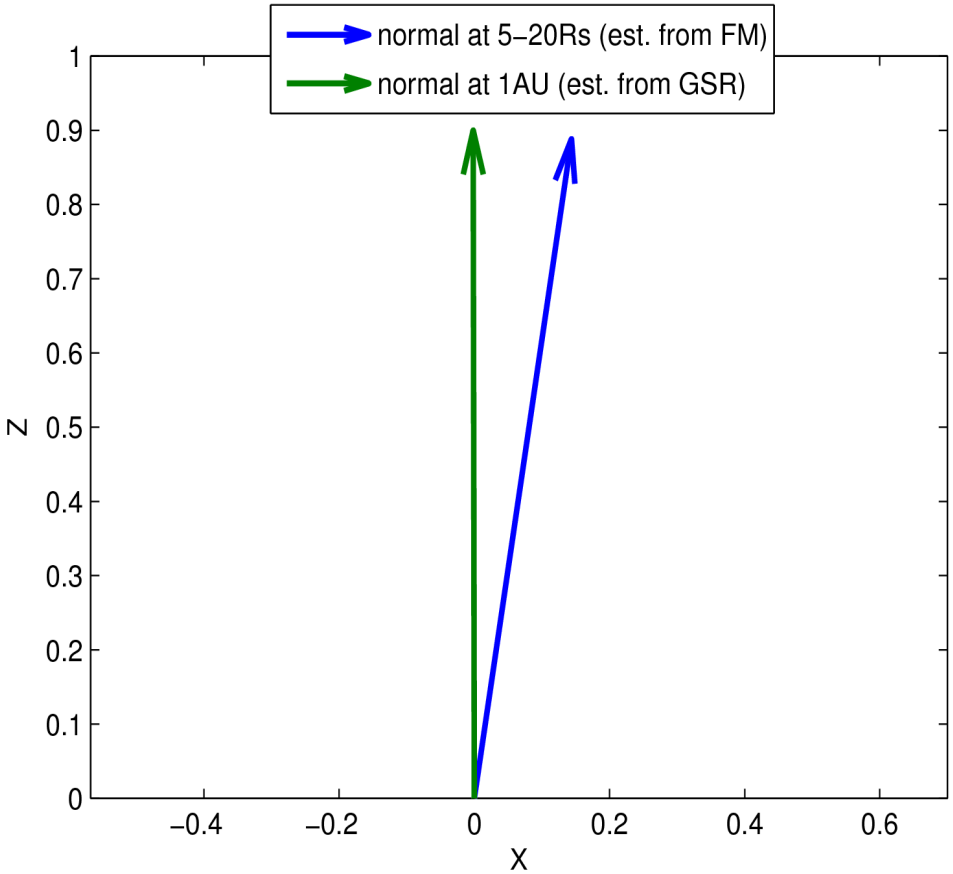
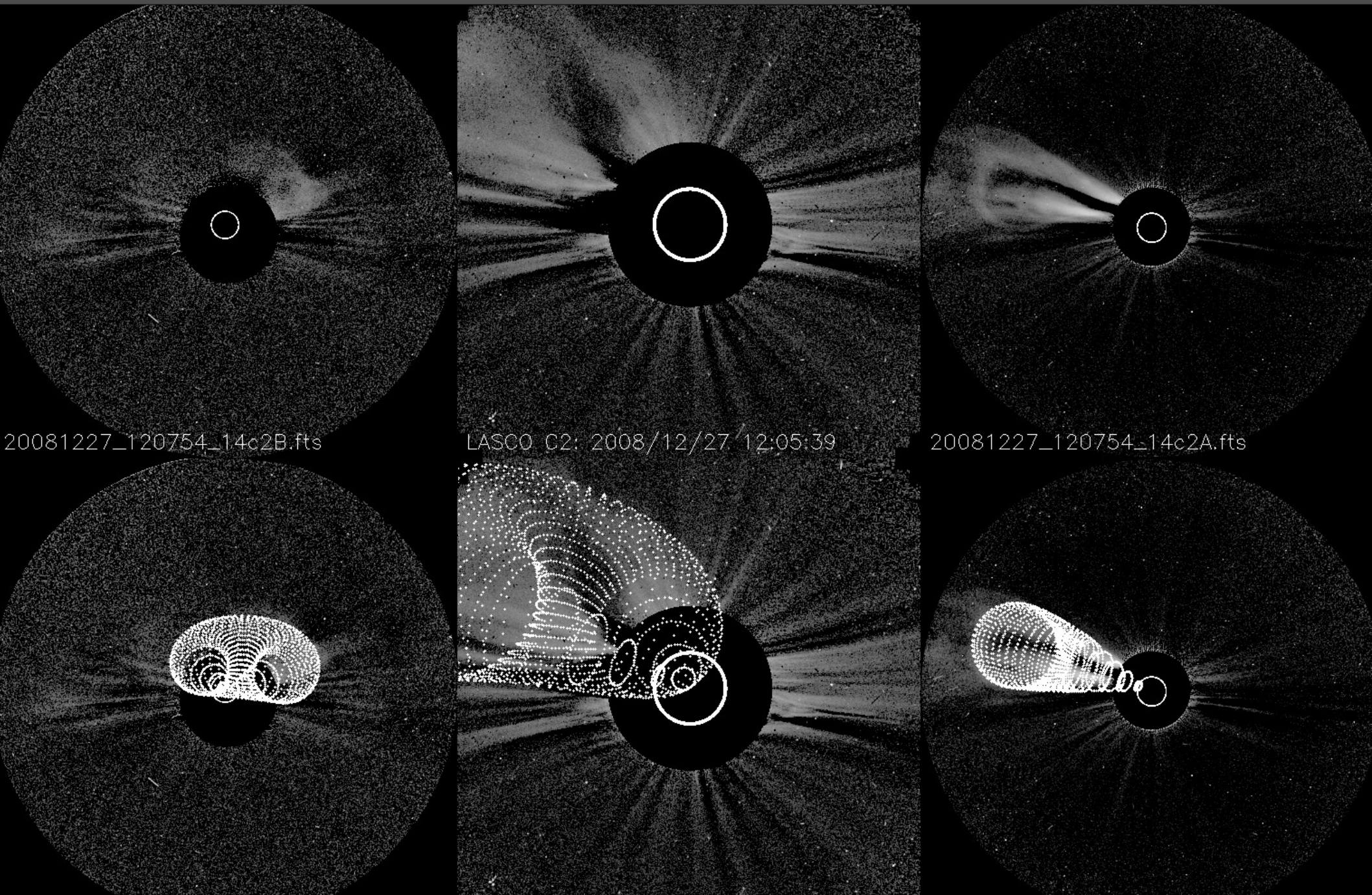


Normals to MC by FM and GSR



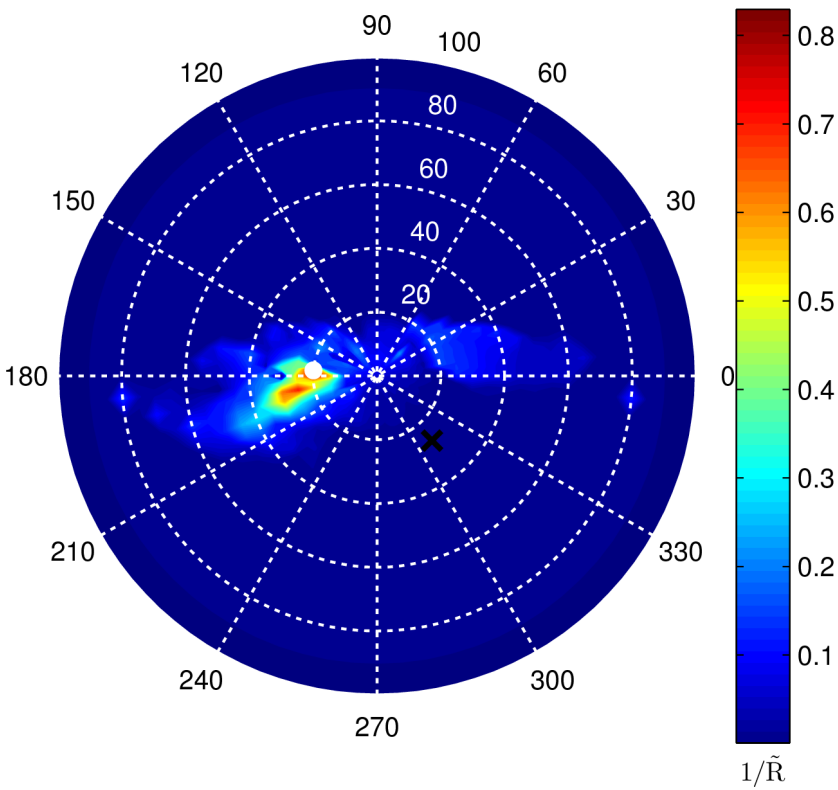
Deflection by $\Delta = 9.3°$ towards equatorial plane

Example. 2008-12-27

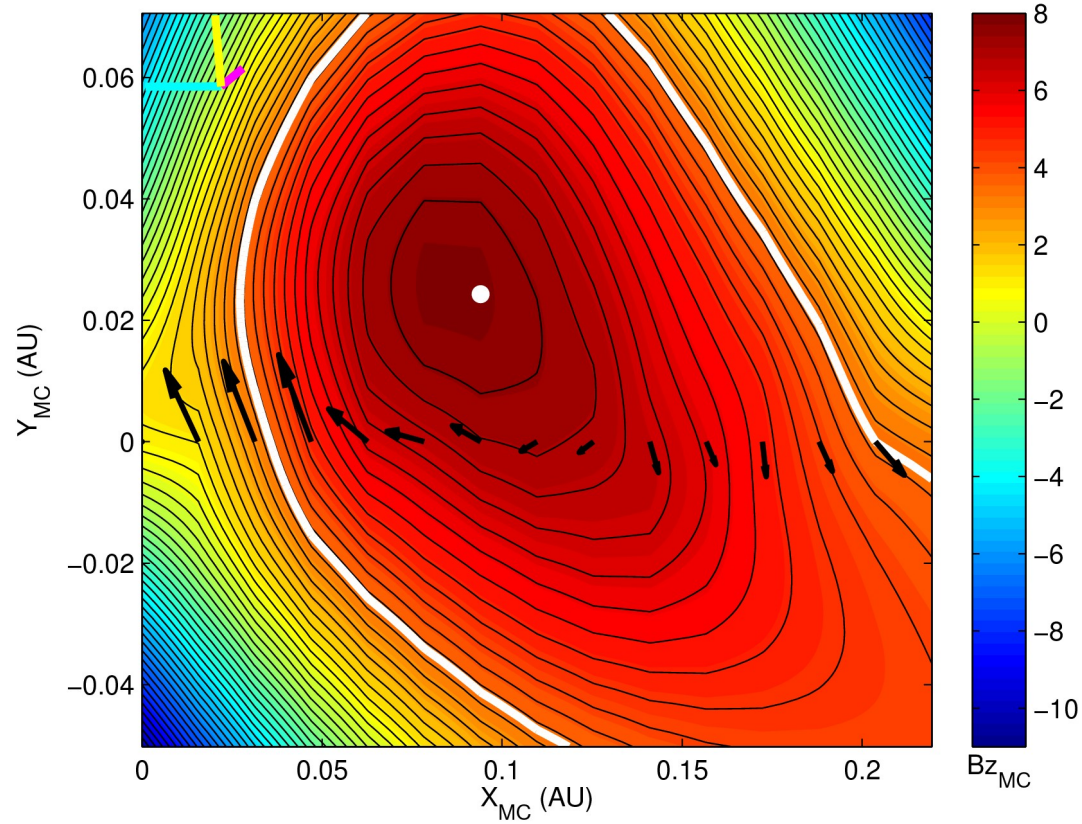


Example. 2008-12-27

Optimized residual map

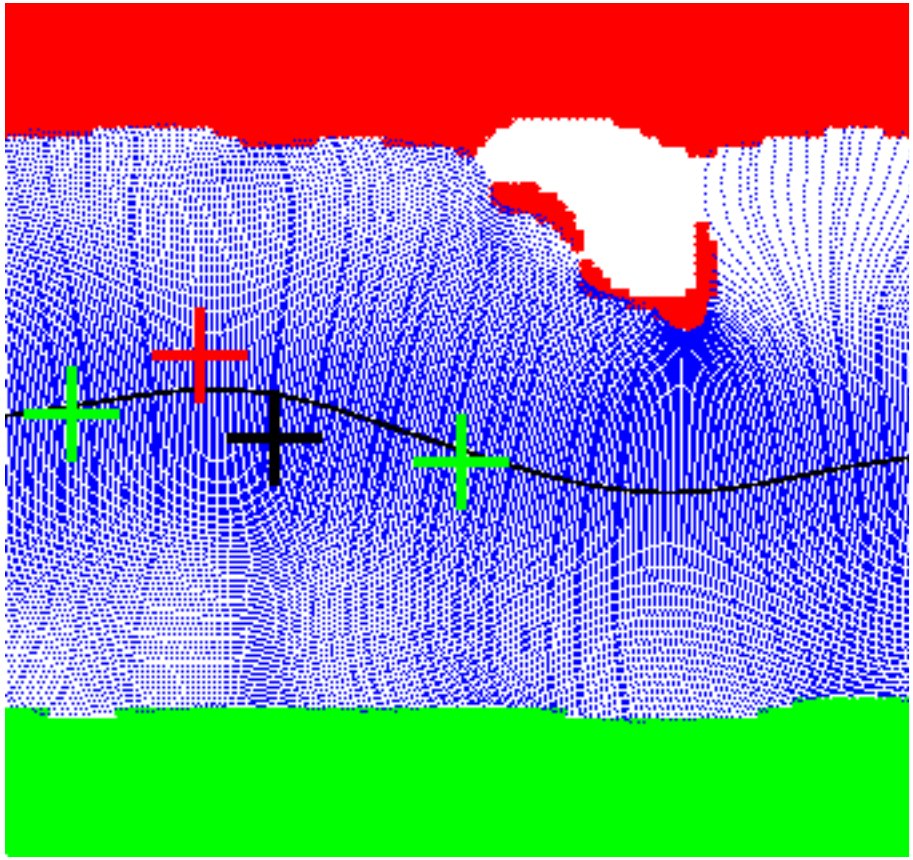


Magnetic field map

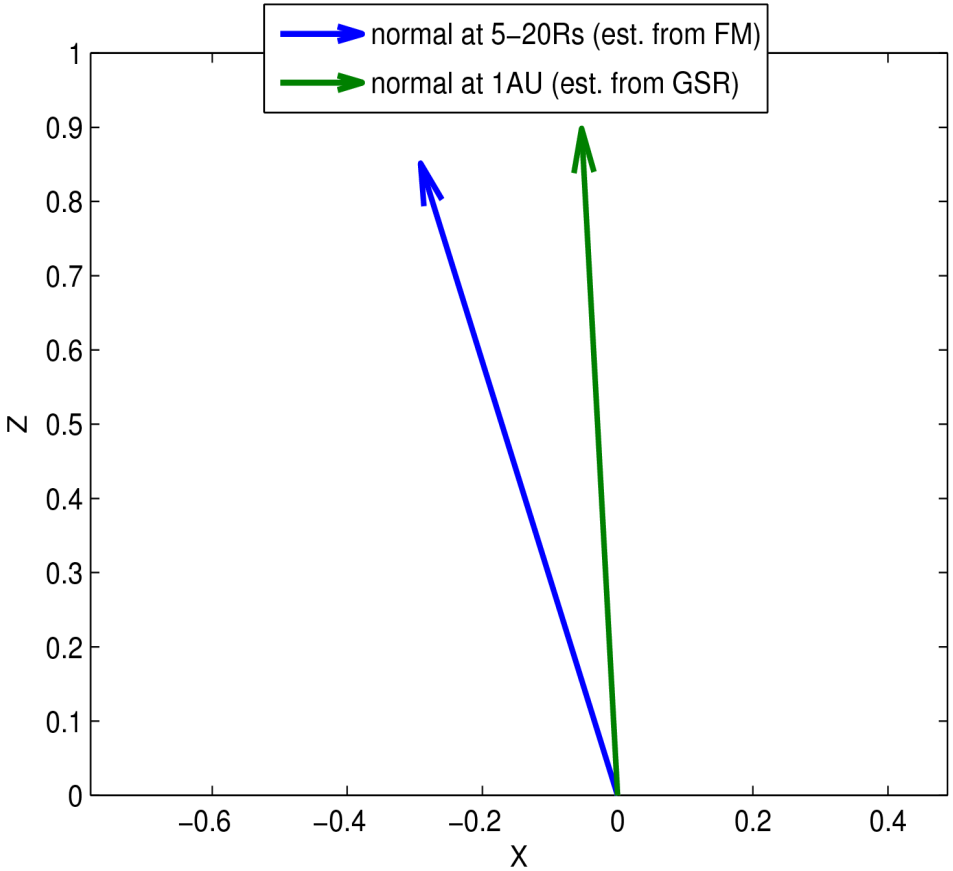


Example. 2008-12-27

Synoptic coronal hole plot (GONG)



Normals to MC by FM and GSR



Deflection by $\Delta = 15.5°$ towards equatorial plane

Results

- It is possible to get geometrical parameters of the magnetic cloud for two different spatial&temporal points and thus study its evolution
- Slow magnetic clouds tend to deflect towards solar equatorial plane during the decay of the solar cycle
- The deflection has kinematic nature – higher speed solar wind from coronal holes