Maser polarization simulation in the circumstellar envelope of an evolving star

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โครงการ **ThaisCube** ครั้งที่ 1 ระหว่างวันที่ 6-9 กันยายน 2565

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Introduction: Radio astronomy

- M51
- MHz to GHz
- Cold Gas (~100 K)

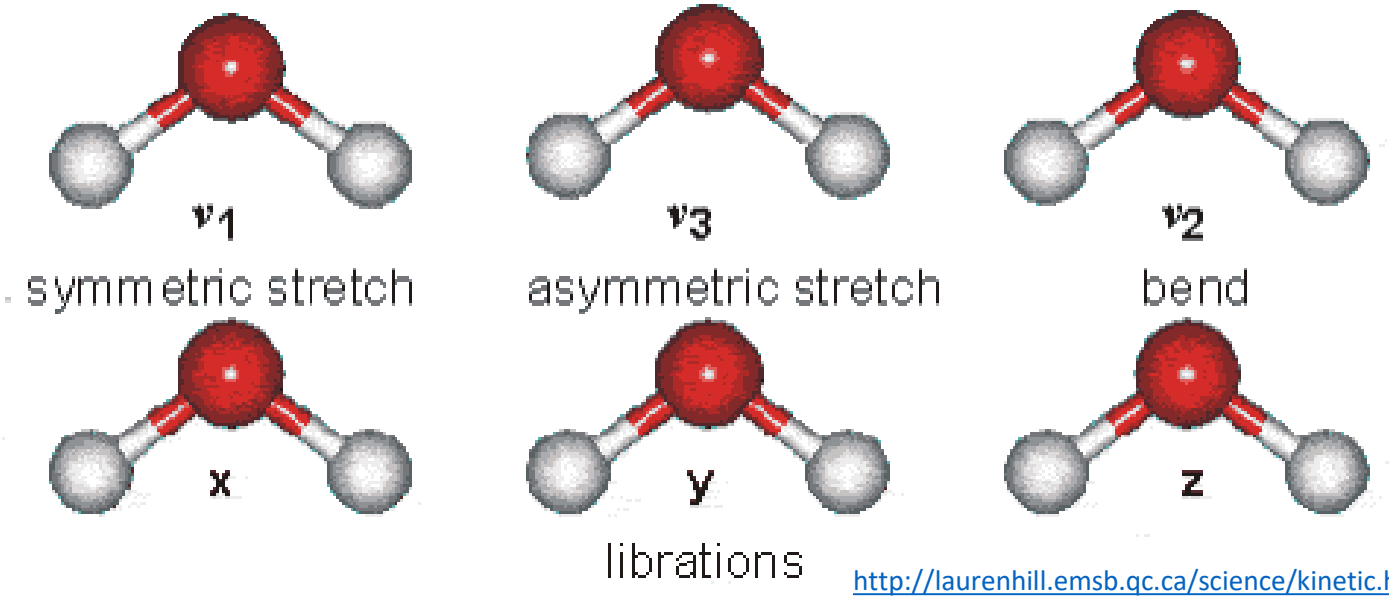
- Geometry
- Kinematic

http://earthriseinstitute.org/topic13.html

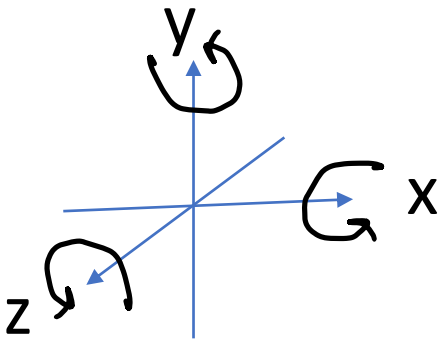
Introduction: MASER

- Microwave Amplification by Stimulated Emission of Radiation
- Vibrational state
- Rotational state
- H2O, OH, CH3OH etc.

- Molecular cloud
  - Star-forming regions
  - Bubble-gas
- Extra-galactic
  - AGNs

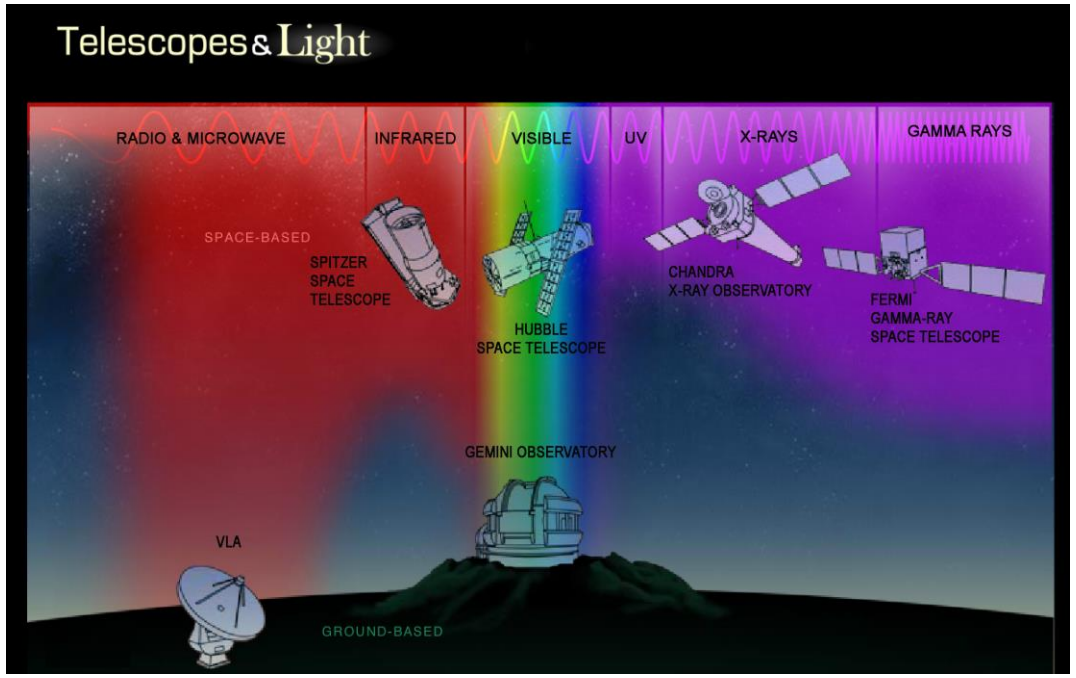


http://laurenhill.emsb.qc.ca/science/kinetic.html

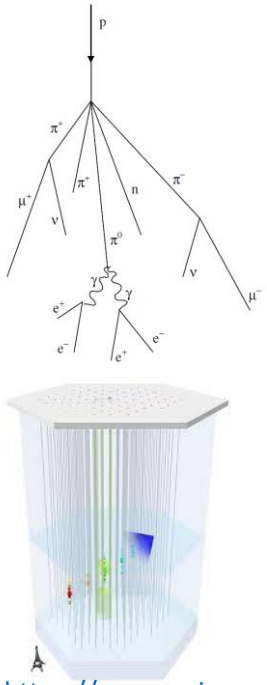


Introduction: Observatory

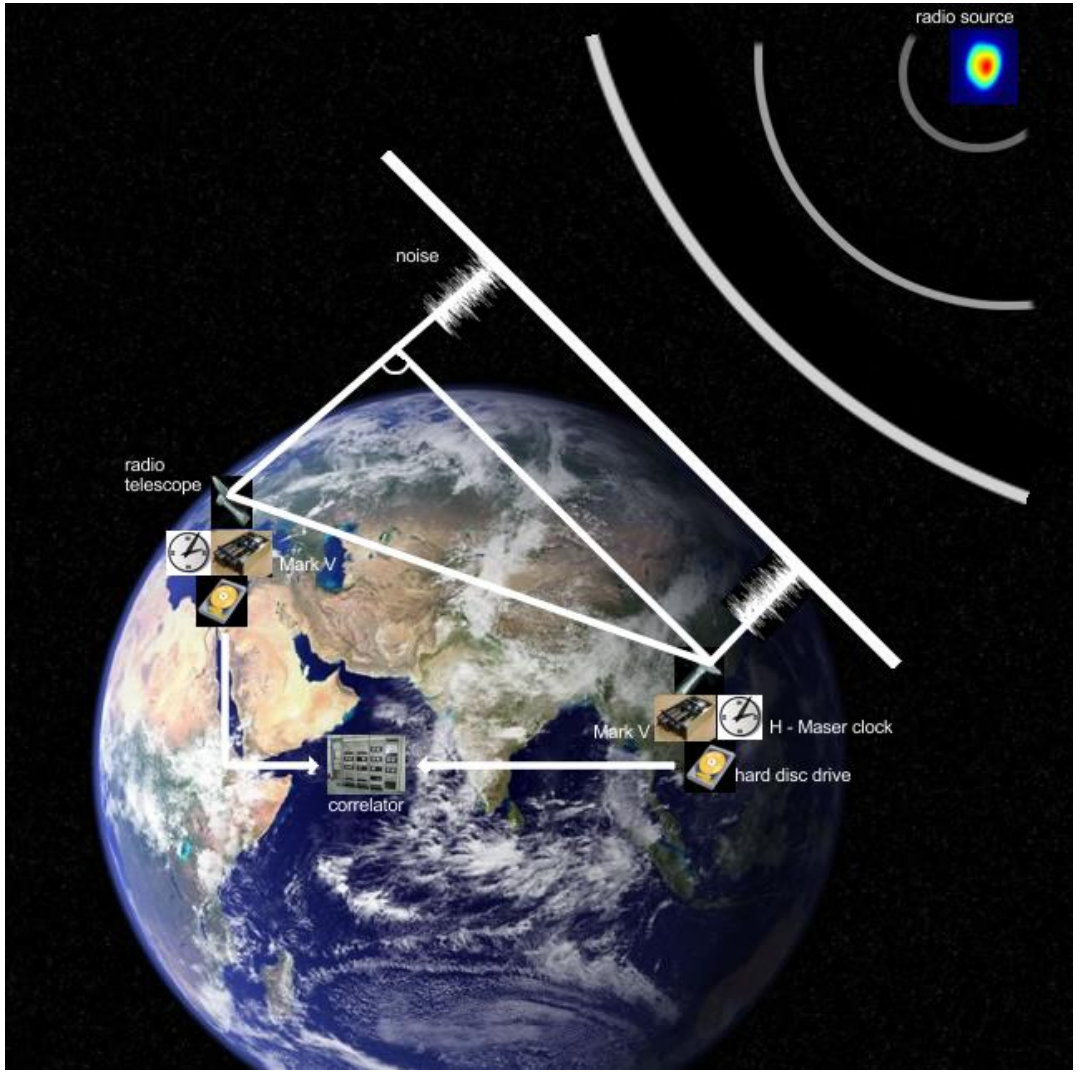
- Ground detector
- Very Long Baseline Interferometry (VBLI)
  - Earth rotation
  - High-resolution ($\theta \approx \lambda/D$)



https://chandra.harvard.edu/resources/flash/telescopes_light.html



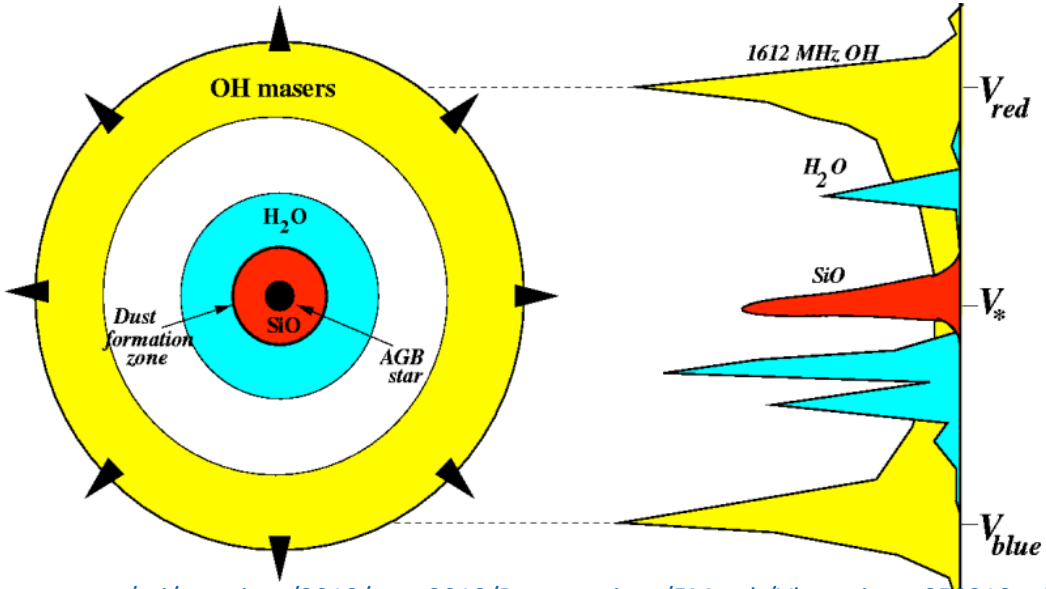
https://www.uni-mainz.de/presse/16860_ENG_HTML.php



https://www.gfz-potsdam.de/en/section/space-geodetic-techniques/topics/geodetic-and-astrometric-vlbi/

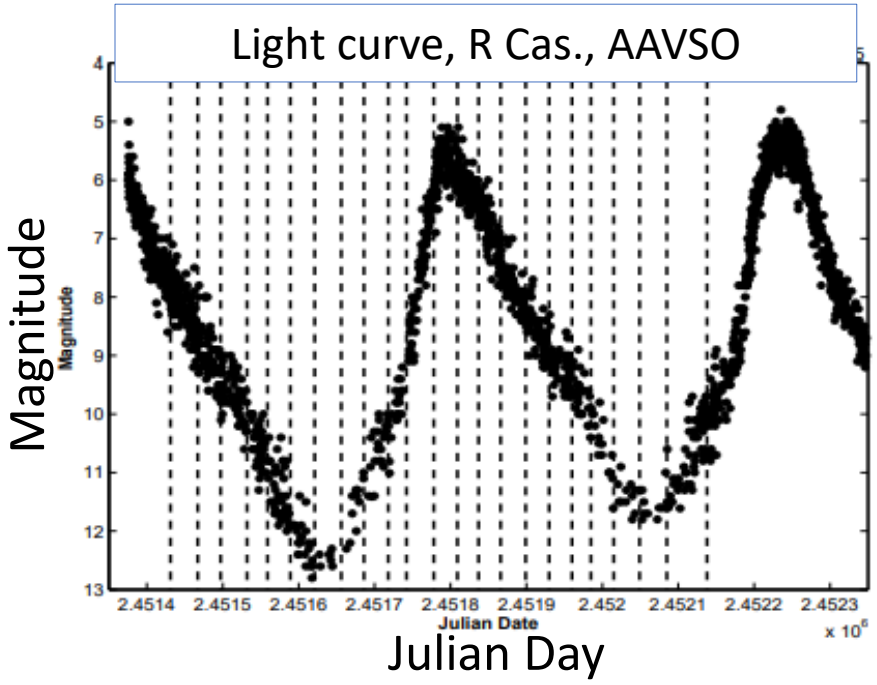
Motivation: AGB star & CSE

- AGB: Asymptotic Giant Branch
- Late stage of stellar evolution
- Variable star
- Circumstellar envelope (CSE)
- 43 GHz SiO maser (v=1, j=1-0)

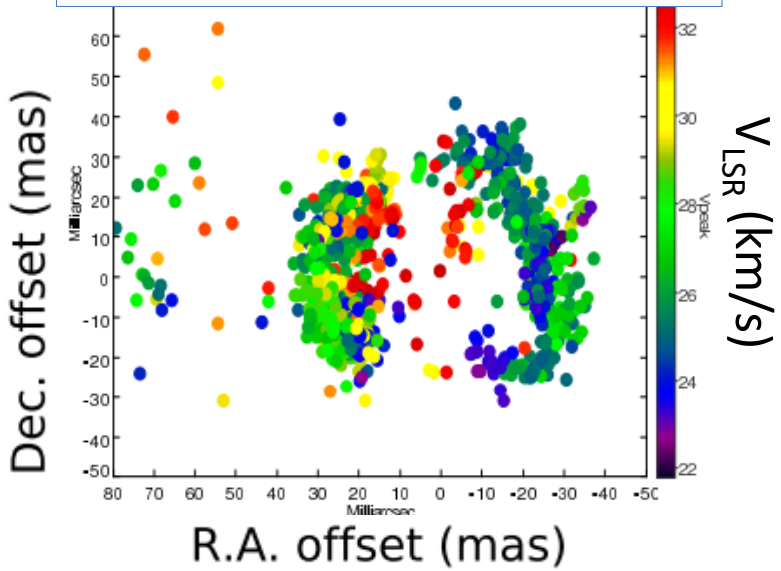


https://www.eso.org/sci/meetings/2010/stars2010/Presentations/5March/Vlemmings_050310.pdf

Light curve, R Cas., AAVSO



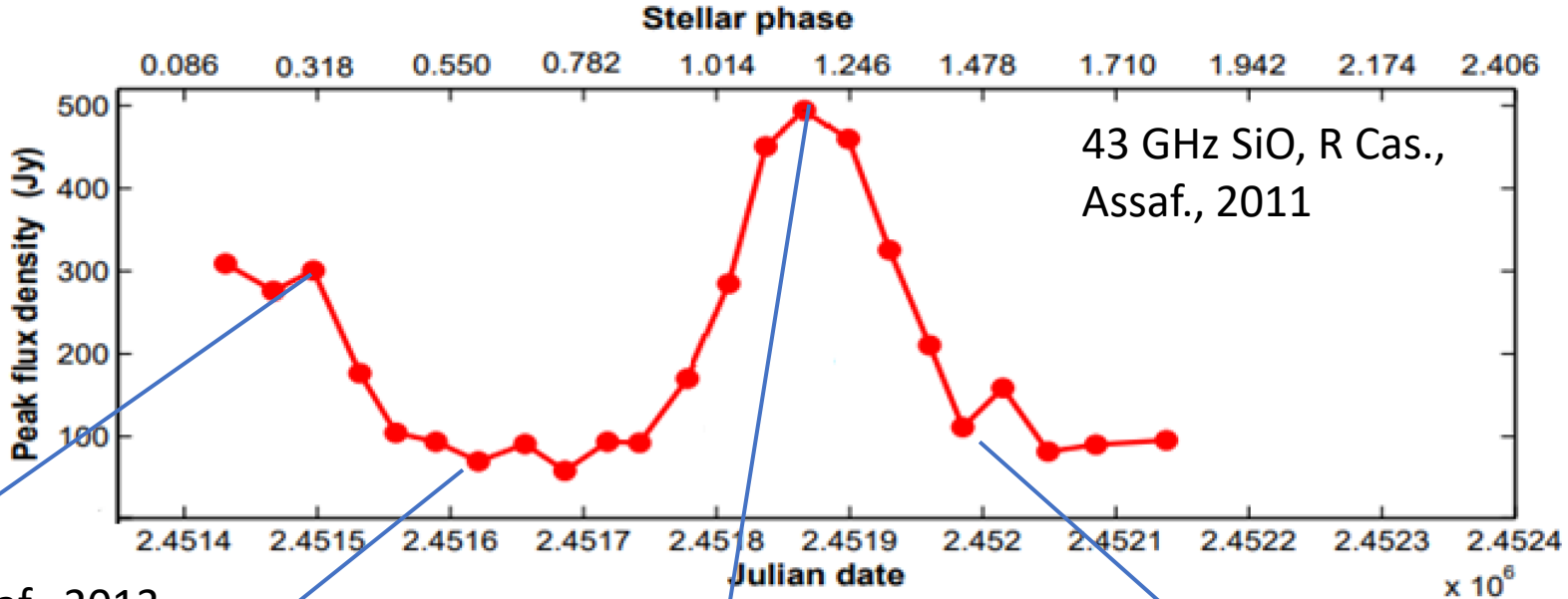
43 GHz SiO, R Cas., Assaf 2011



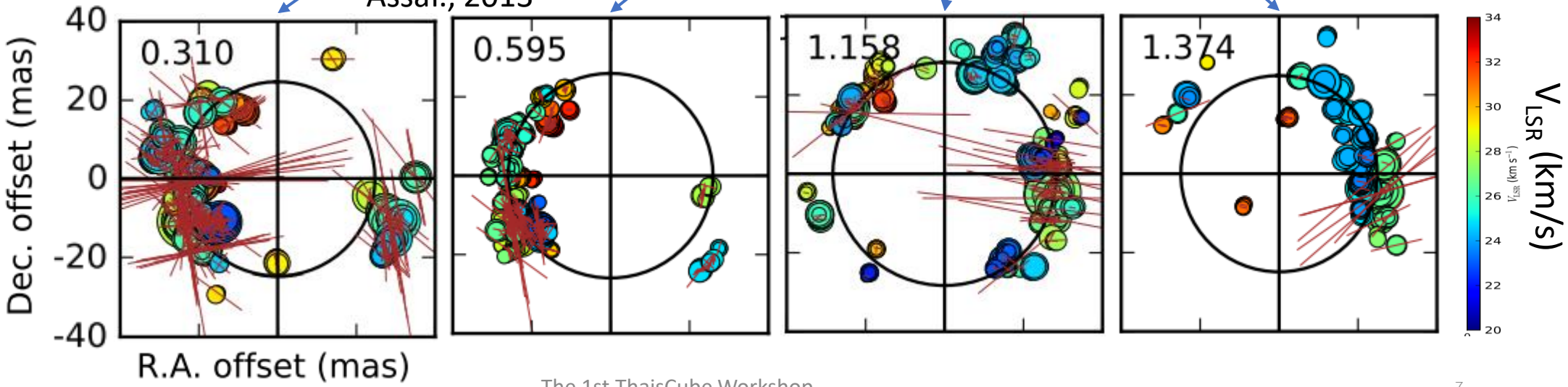
Motivation: Circumstellar envelope variability

- Flux variability
- Maser fluctuation
- Polarization fluctuation

➢ Study the polarization variability by using maser polarization-3D code (M. D. Gray and S. Etoka)



Assaf., 2013



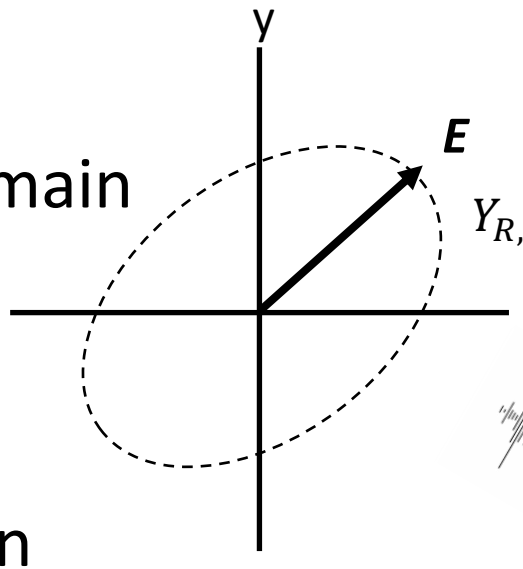
Methods: Pol3D code

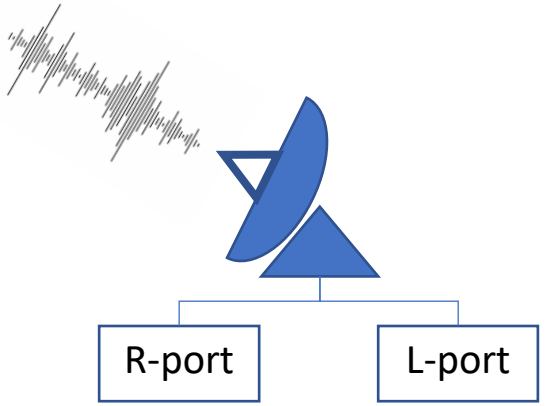
- Set-up the energy transition for domain
- Generate the background radiation
- Amplified the radiation with domain
- Convert to Stokes parameters
  - For compare with the observation

$$E_{0,R} = \frac{1}{\sqrt{2}}(E_{0,x} + iE_{0,y}) = R$$

$$E_{0,L} = \frac{1}{\sqrt{2}}(E_{0,x} - iE_{0,y}) = L$$

$$Y_{R,L}(z,t) = \omega t - kz + \phi_{R,L}(z,t)$$





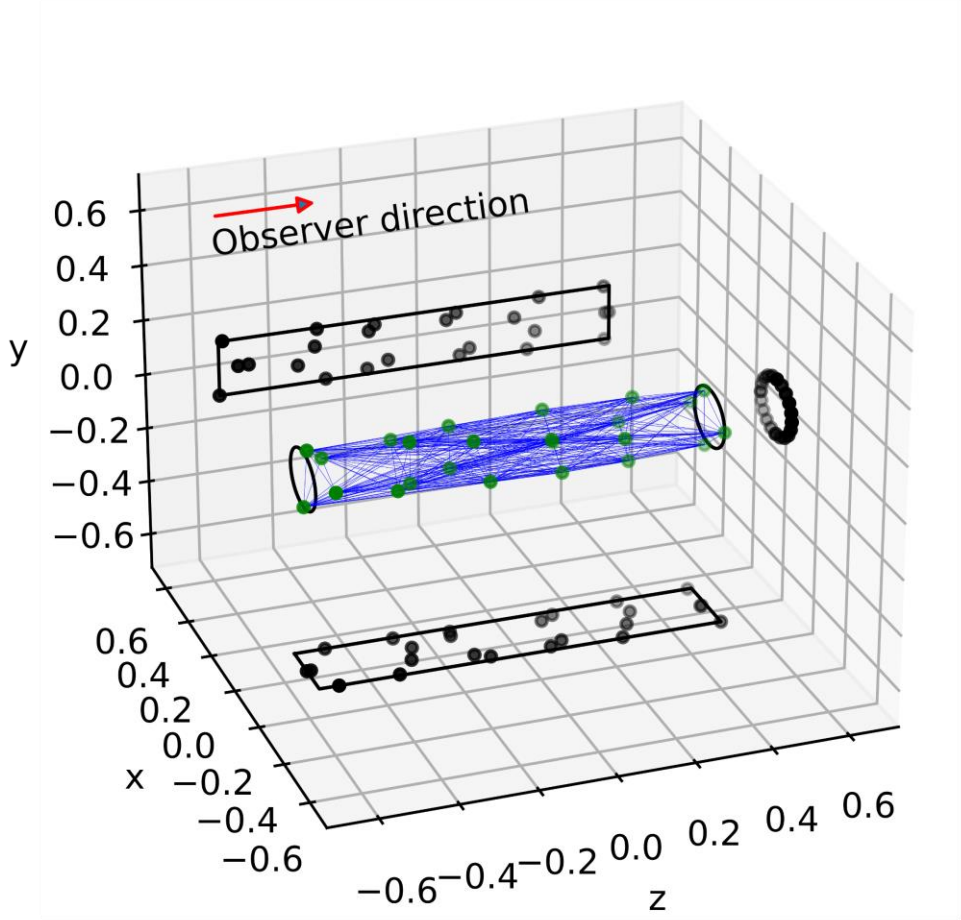
Stokes parameters

$$I = R^2 + L^2 \qquad Q = 2RL\cos\Delta\phi$$

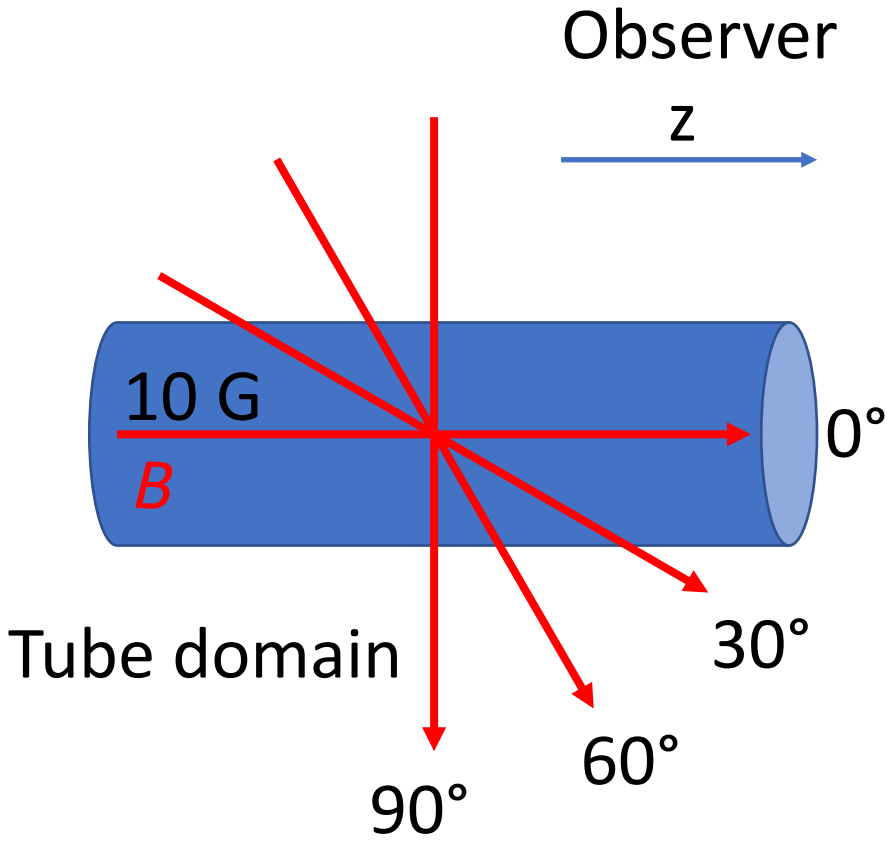
$$V = R^2 - L^2 \qquad U = 2RL\sin\Delta\phi$$

$$\Delta\phi = |Y_R - Y_L|$$

Methods: Domain setting (single cloud)



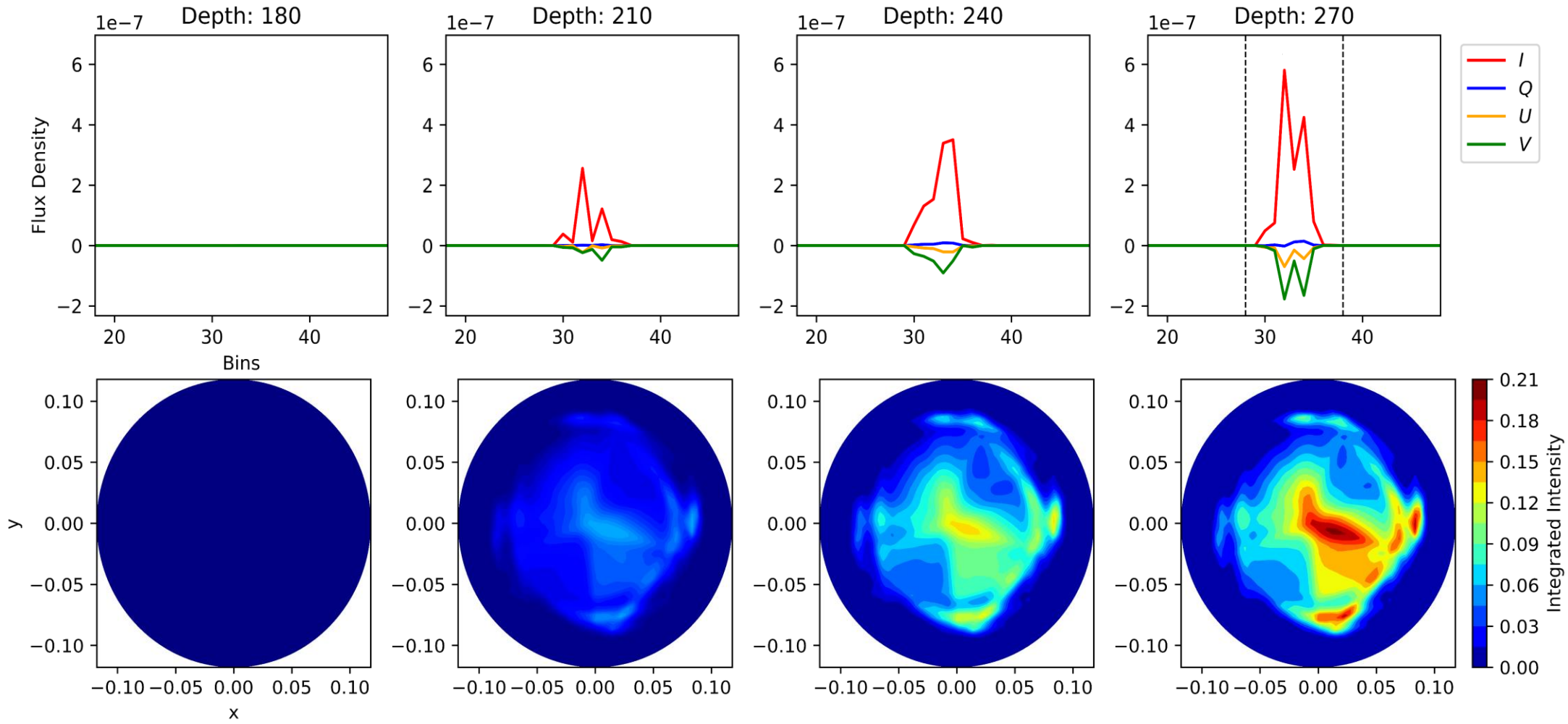
- Nodes



- Magnetic filed direction

Results: Spectra evolution

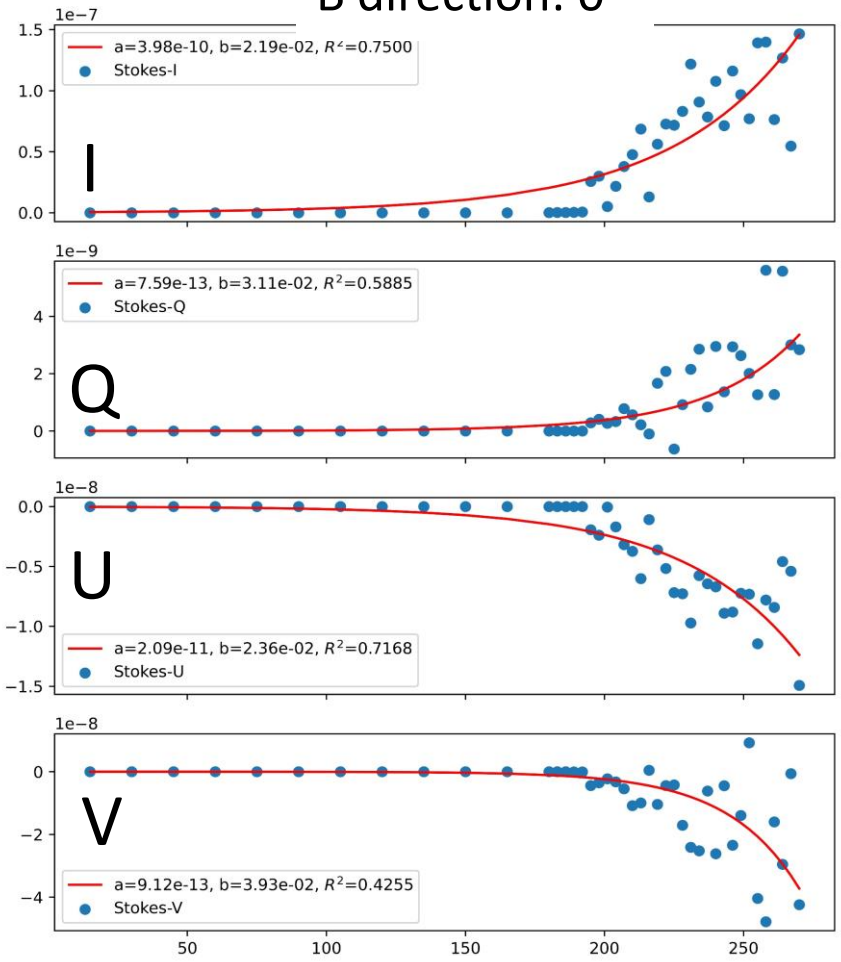
- B is parallel with observer (0 deg)



Results: Different magnetic direction

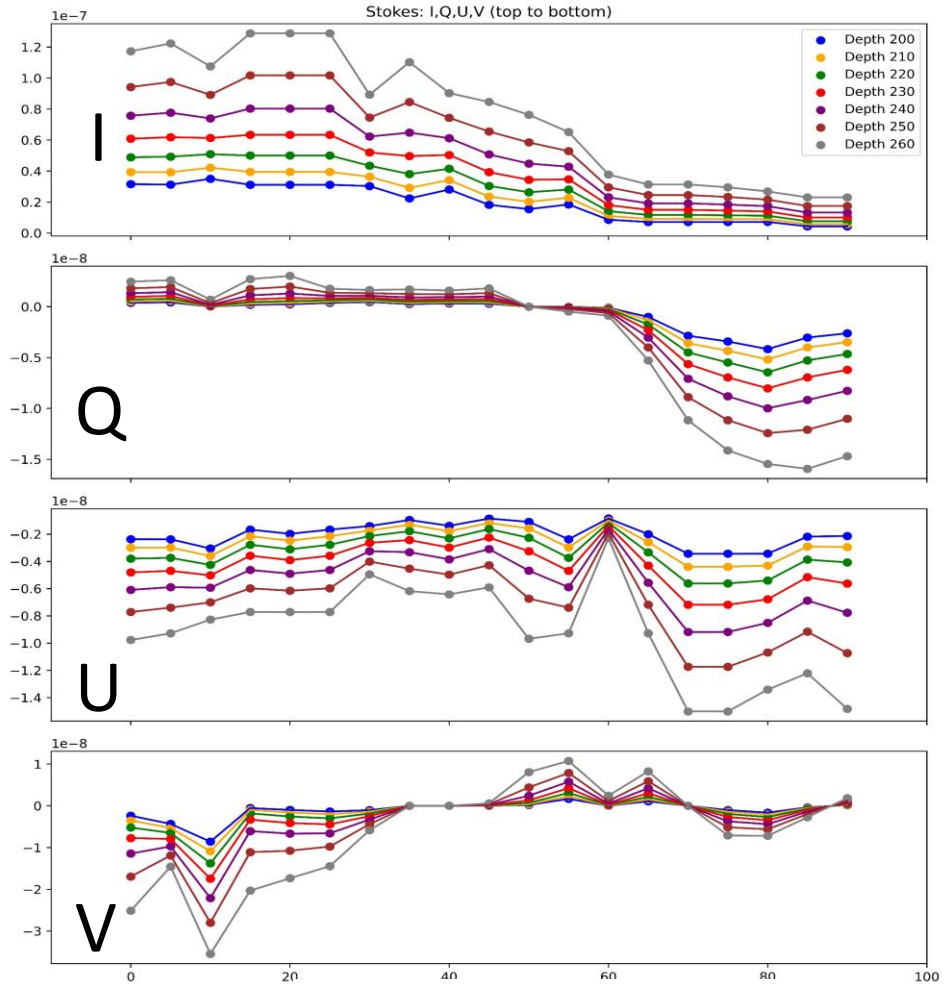
- Stokes-evolution

B direction: 0°



Depth

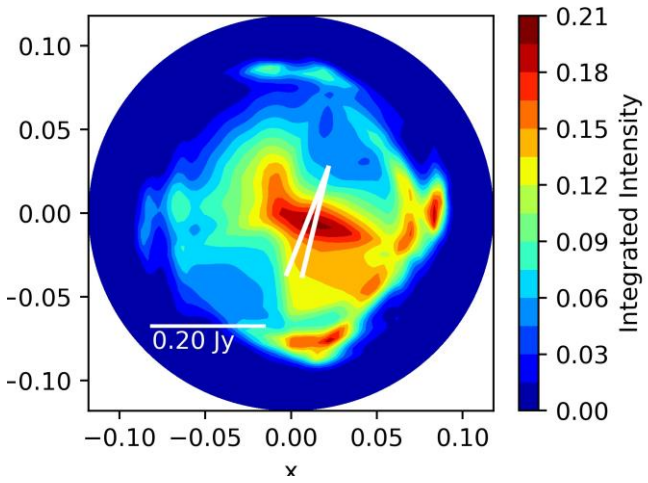
- Results in different direction



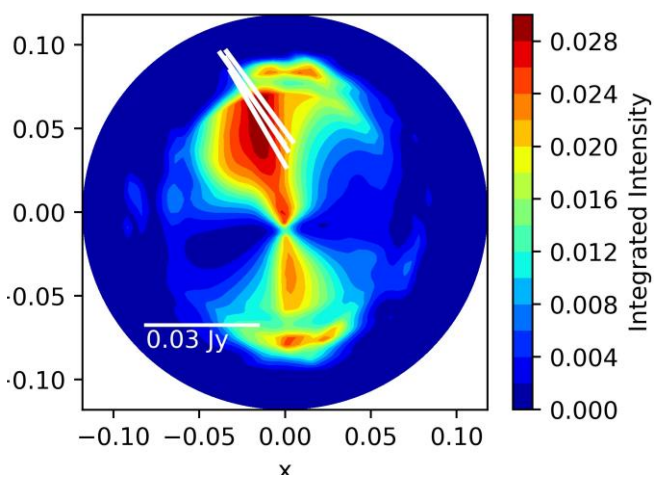
B direction: 0 ° - 90 °

Conclusion

B direction: 0°



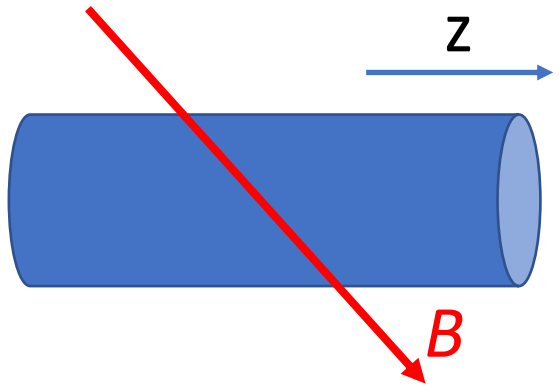
B direction: 90°



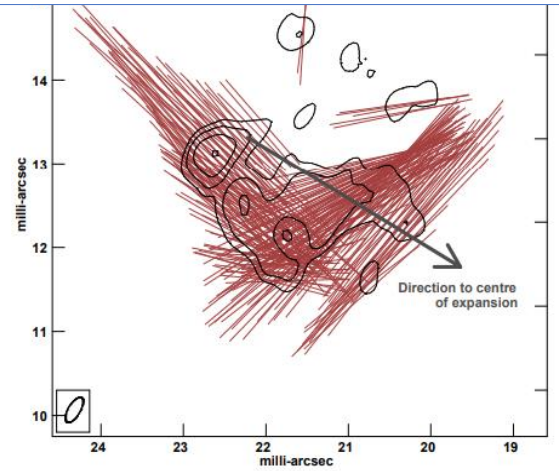
$$\mathrm{PA} = 0.5 \arctan \frac{U}{Q}$$

- Pol. angle was affected by B direction

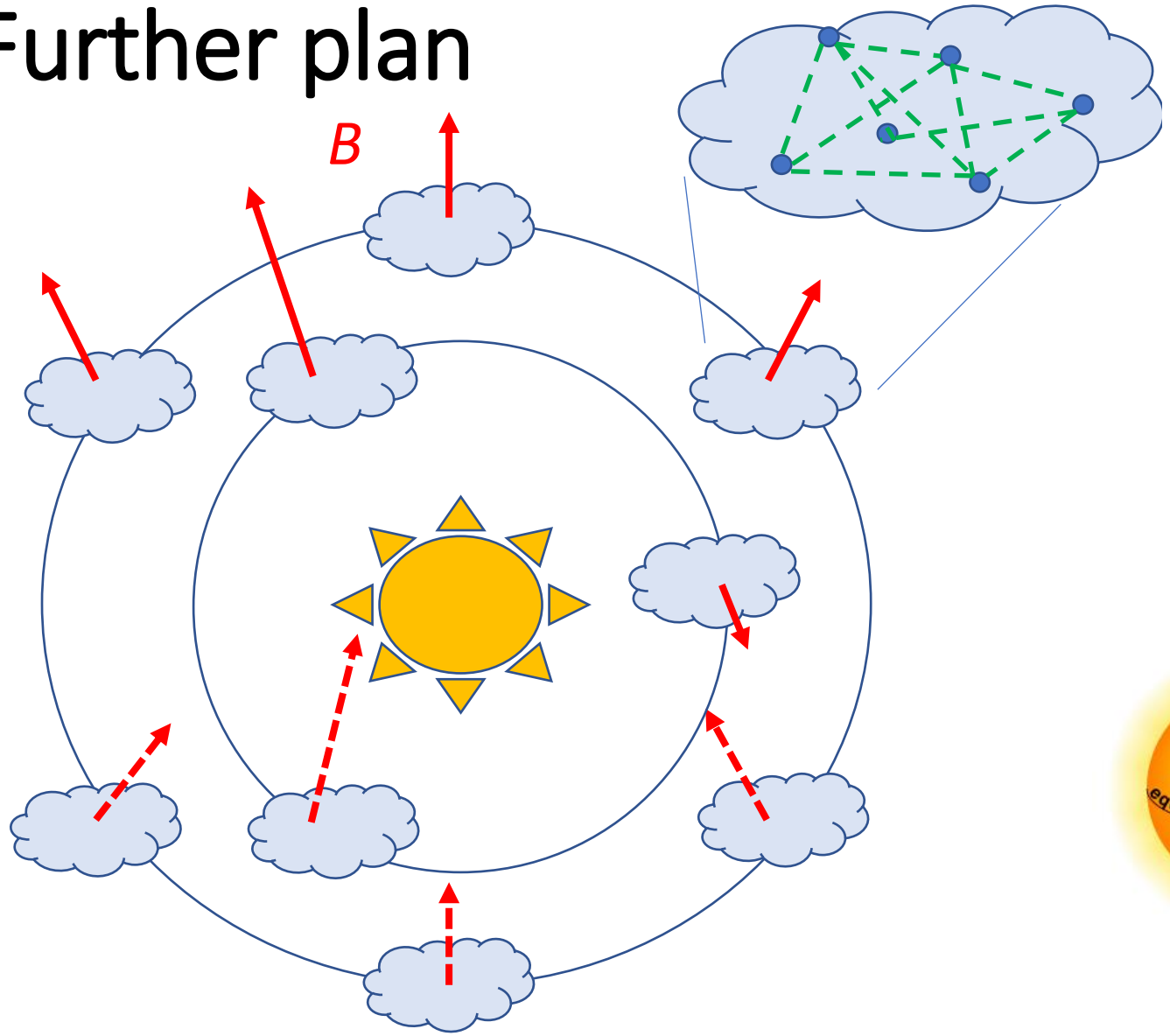
- Pol. angle flip at B ~ 45-50 deg.



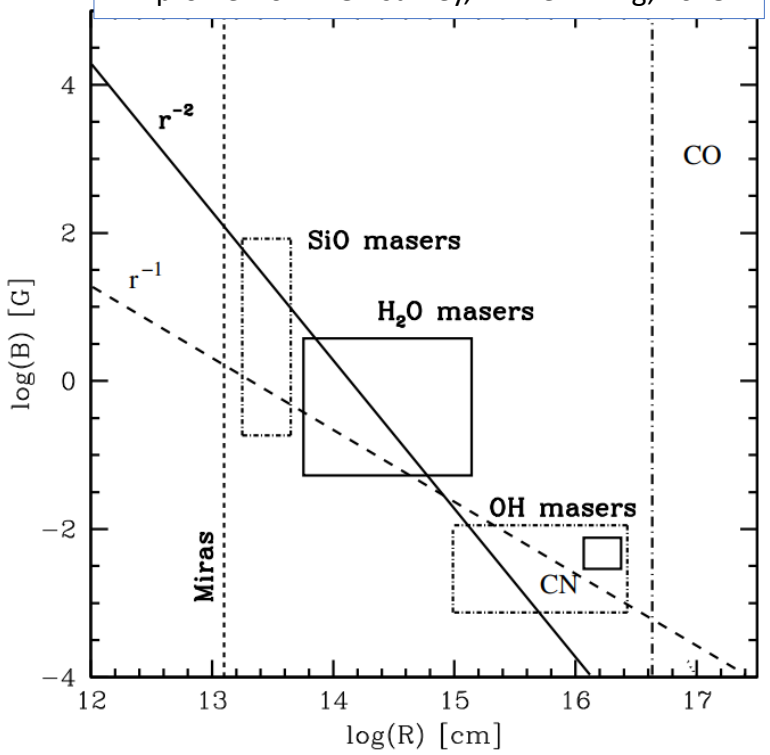
90 deg. flip, R Cas., Assaf 2011

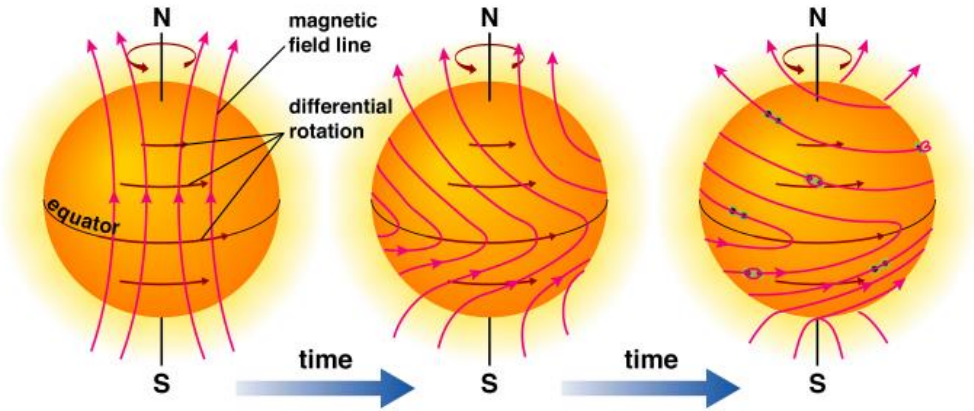


Further plan



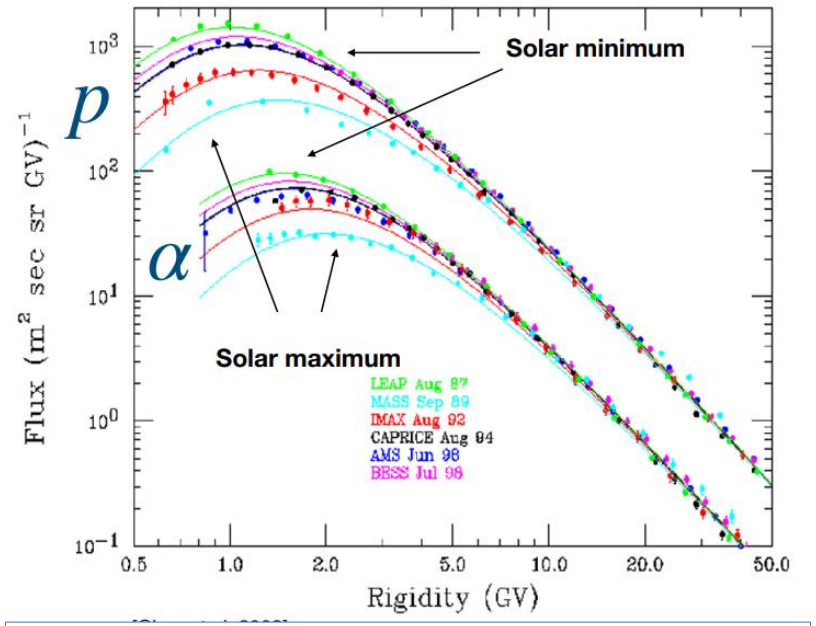
B profile from AGB survey, W Vlemming, 2018





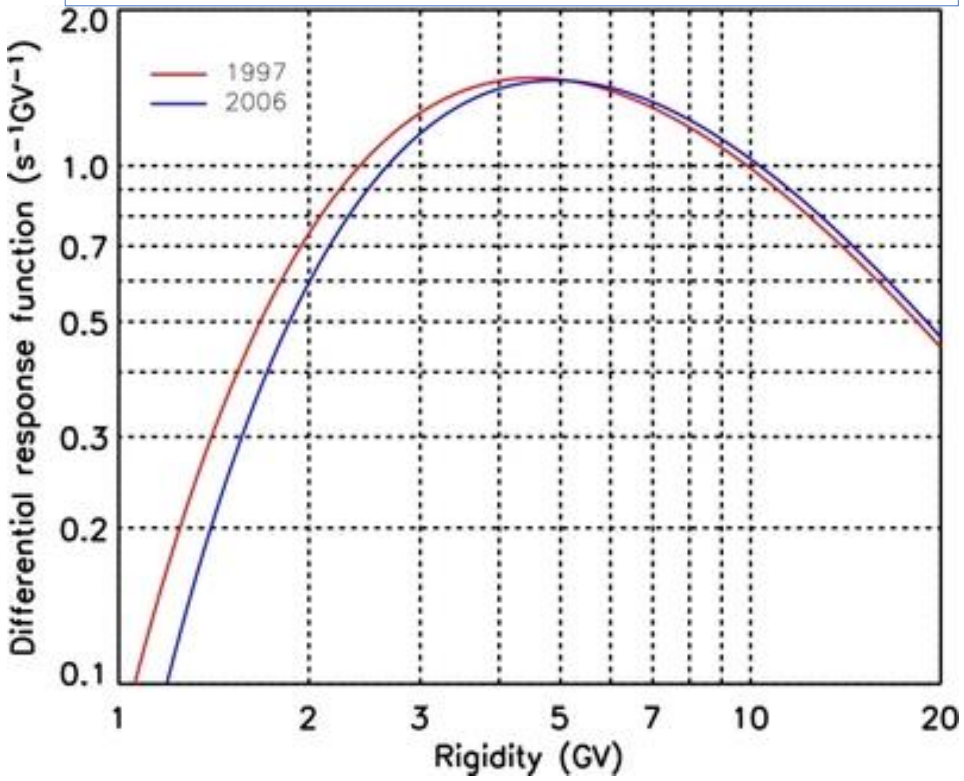
Connect with Cosmic Ray Group

- Crossover of Dif. Res. Fn. during solar magnetic polarity
- Low rigidity change



From: P' Nok (Chanoknan Banglieng)

From Aj. Fhon (W Nuntiyakul et. al. 2014)

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