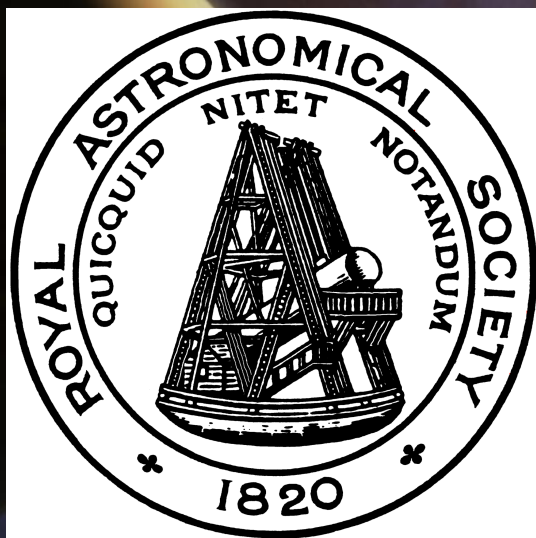


An Improved Stellar Age-Activity Relationship for Ages beyond a Gigayear

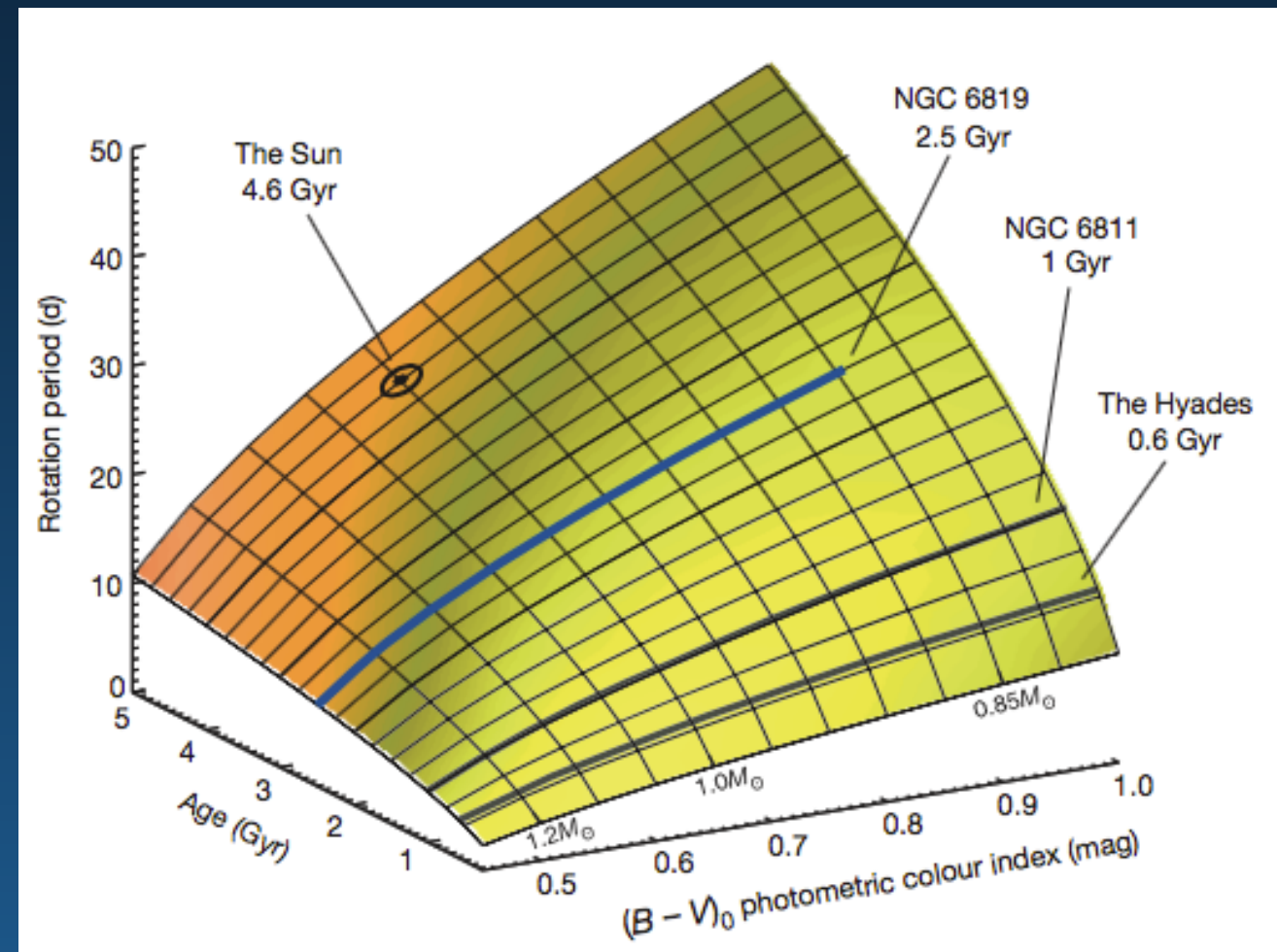
Rachel Booth
and
Katja Poppenhaeger



Background Image: NASA

Age Relationships

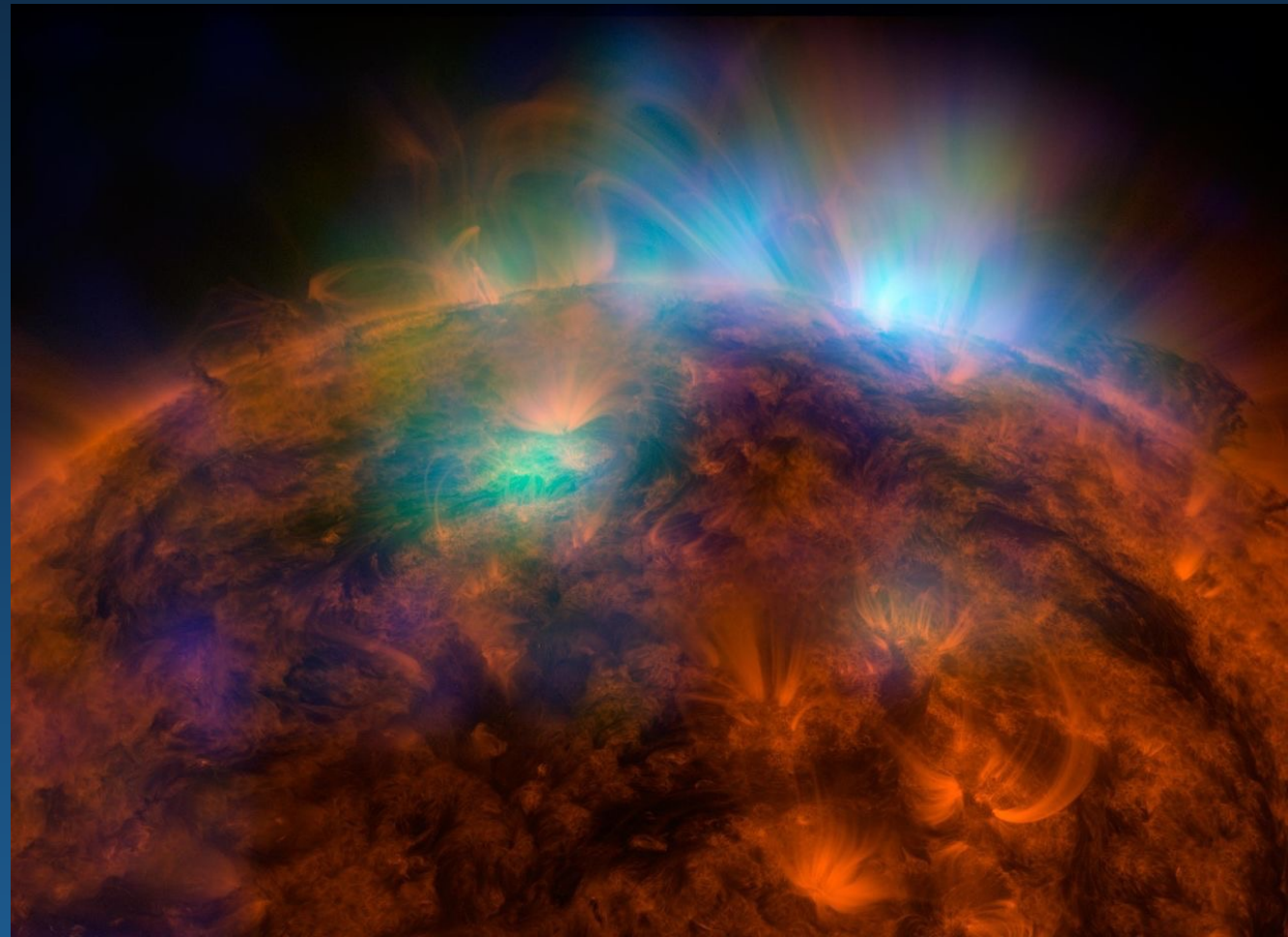
- Two types:
 - Gyrochronology
 - Magnetic Activity
- Magnetic Braking causes the change in rotation
- This has an effect on the Stellar Dynamo



Meibom et al., 2015

Age Relationships

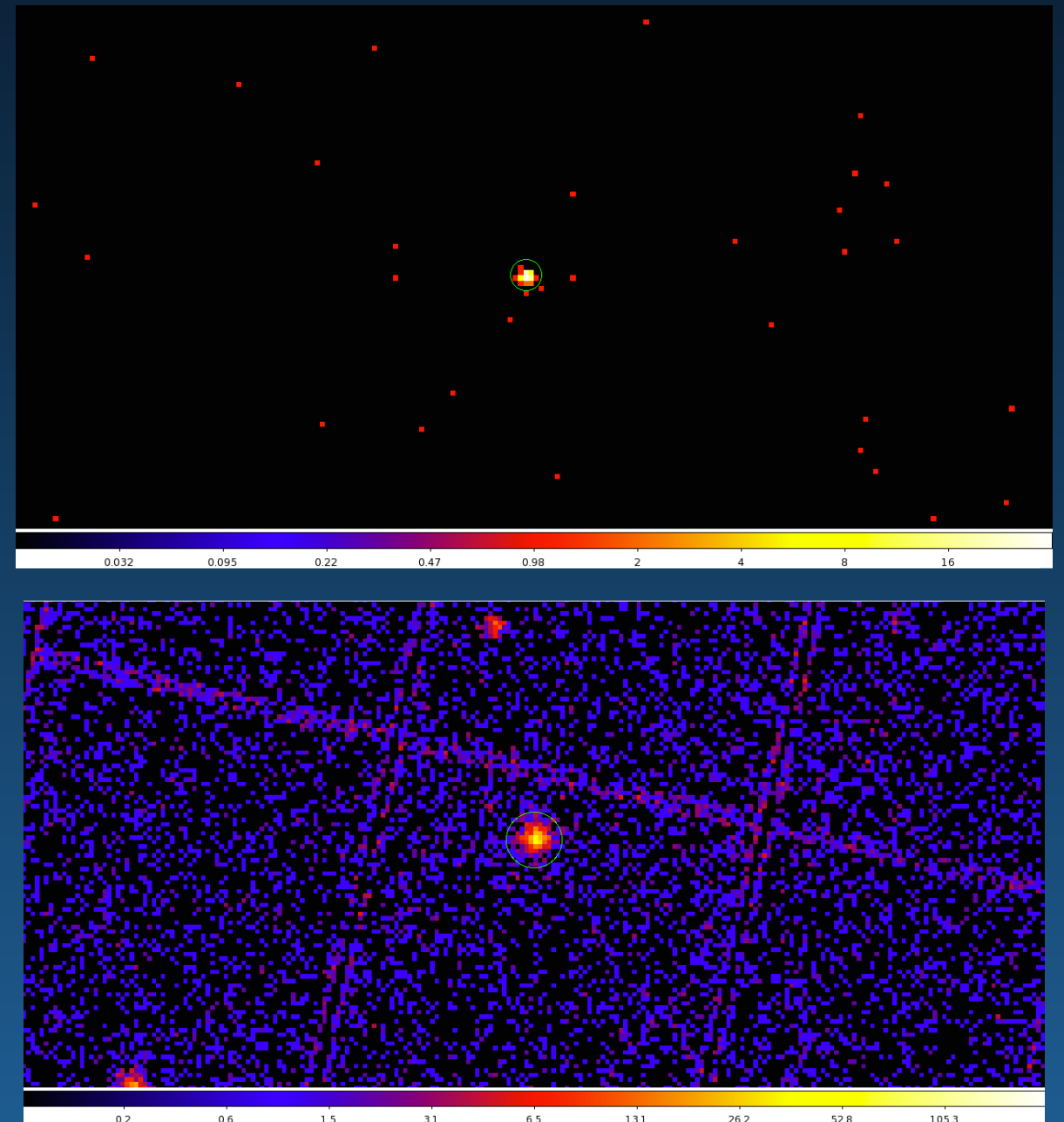
- Require calibrator stars
- Asteroseismology - Ages of field stars
- Main methods of studying Magnetic Activity:
 - Calcium II H and K
 - X-ray Luminosity
- Study Activity-Age Relationship beyond a gigayear



NASA/JPL-Caltech/GSFC

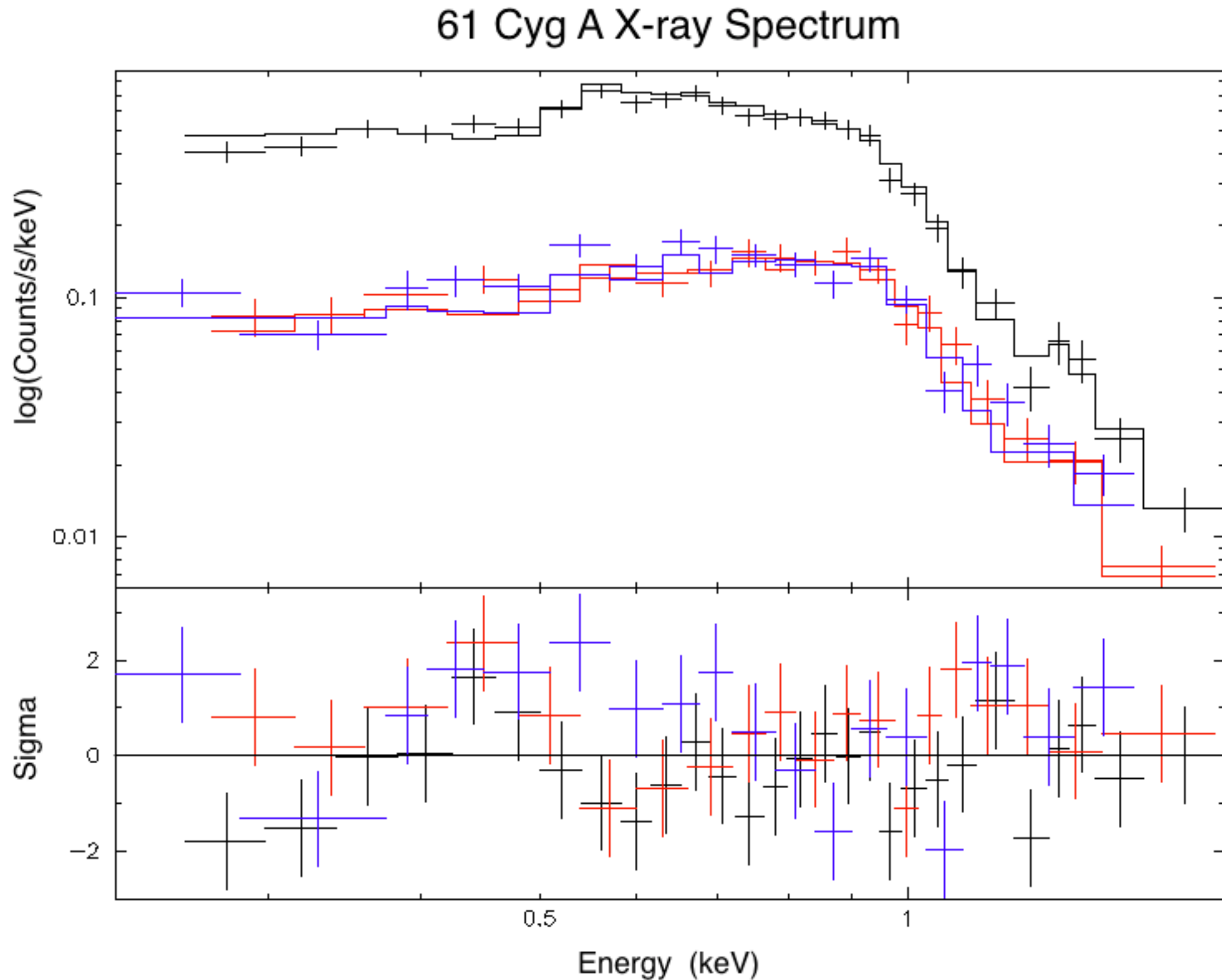
Observations

- List of target stars
 - Asteroseismology Studies
 - Aguirre et al. (2015), Chaplin et al. (2014)
 - Systems with well known ages
 - Star - White Dwarf Binaries
- Searched archive of XMM-Newton and Chandra X-ray Telescopes
- Some dedicated observations from PI Poppenhaeger



*Examples of X-Ray Observations.
Top: Chandra Bottom: XMM-Newton*

Spectral Modelling



Previous Studies of Age and Activity

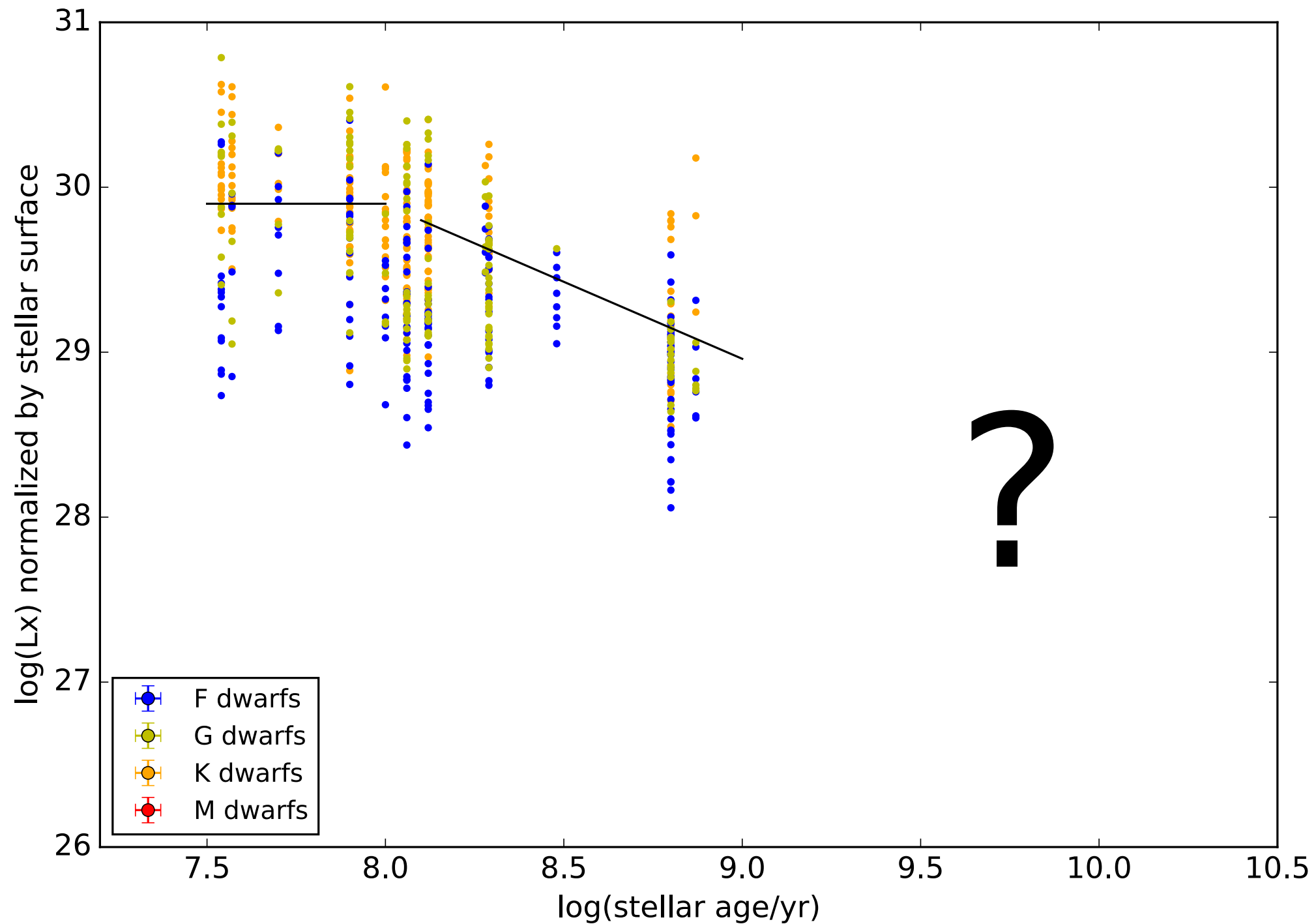
- Stelzer & Neuhäuser (2001)
 - Sample of T Tauri Stars
- Preibisch et al. (2005)
 - Sample of Pre Main Sequence Stars
- Jackson et al. (2012)
 - Sample of Clusters

Previous Studies of Age and Activity

- Stelzer & Neuhäuser (2001)
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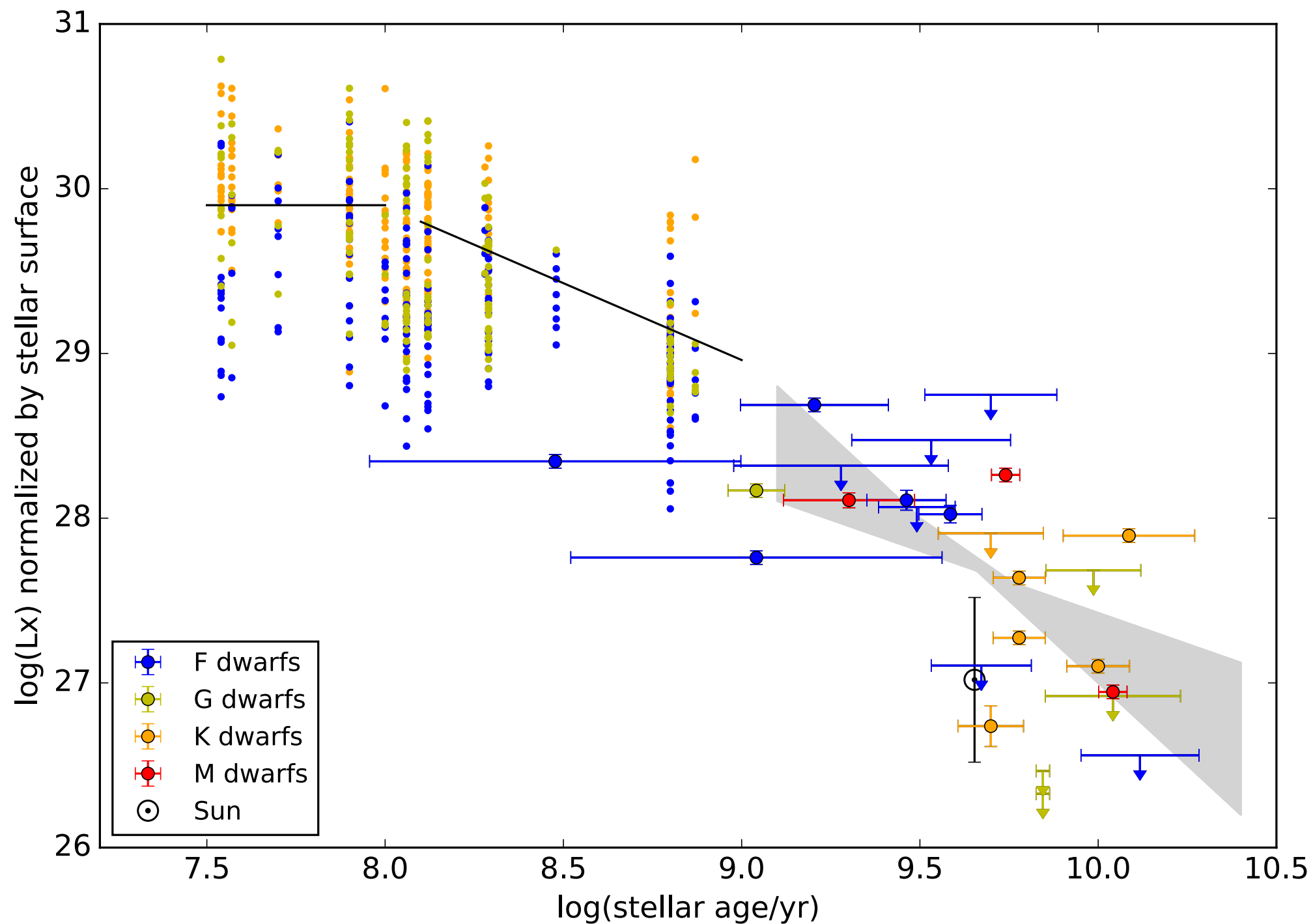
Lack of
calibrators older
than a gigayear

Previous Studies of Age and Activity



Data taken from Jackson et al., 2012

Preliminary Results



Cluster data taken from Jackson et al., 2012

Theoretical Relationship

$$v_{rot} \propto t^{\alpha}$$

$$\alpha = -0.5$$

Skumanich, 1972

$$L_x \propto v_{rot}^{\beta}$$

$$\beta = 2$$

Pizzolato et al., 2003

Theoretical Relationship

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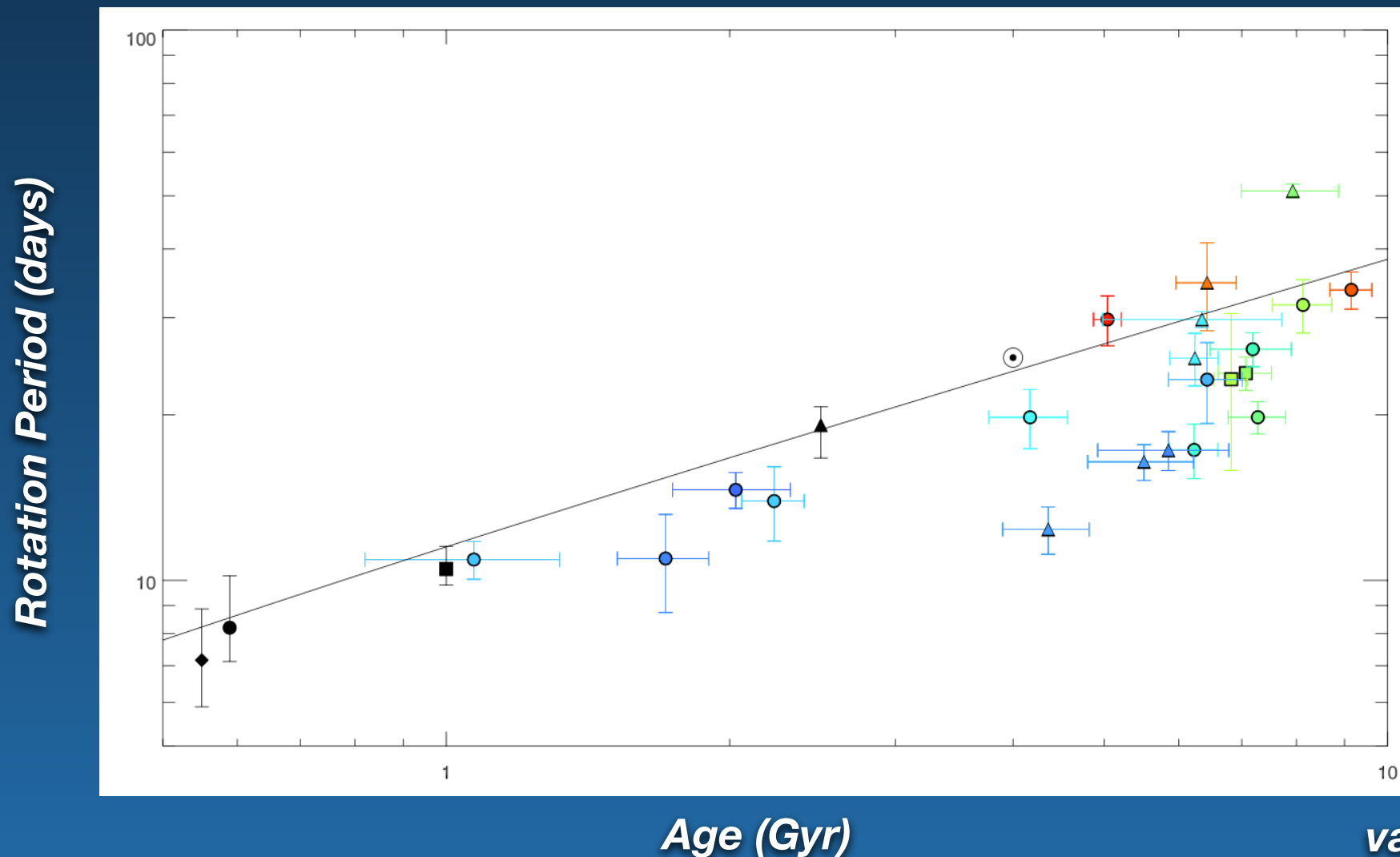
$$L_x \propto t^{\alpha\beta} \text{ where } \alpha\beta = -1$$

Possible Explanations

- Rotational Spin down is more rapid

$$v_{rot} \propto t^{\alpha}$$

- Recent evidence for weakened magnetic braking (van Saders et al. 2016)
- Theoretical Work (Garraffo et al. 2015, Vidotto et al. 2016)

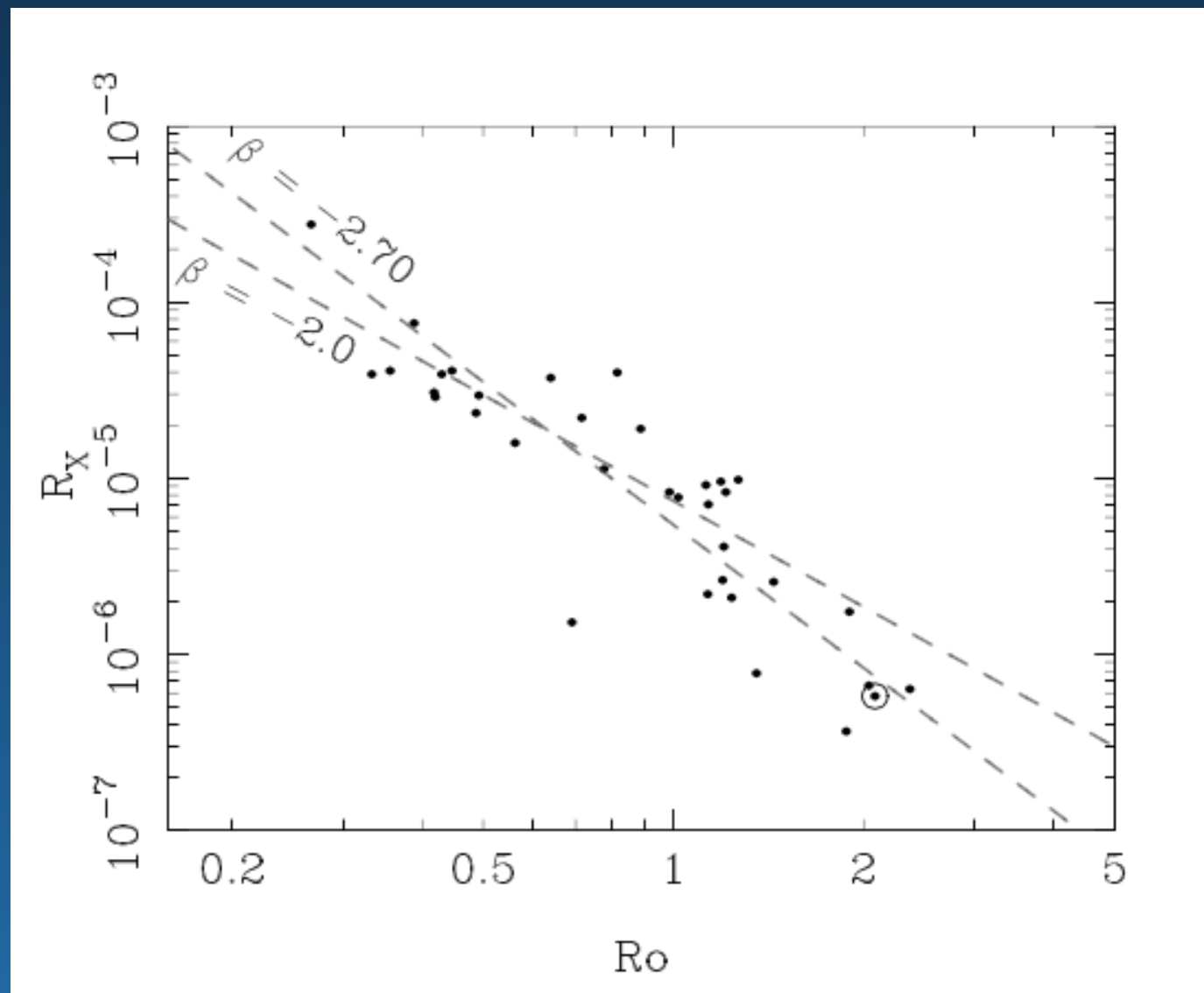


Possible Explanations

- Activity-Rotation relationship changes

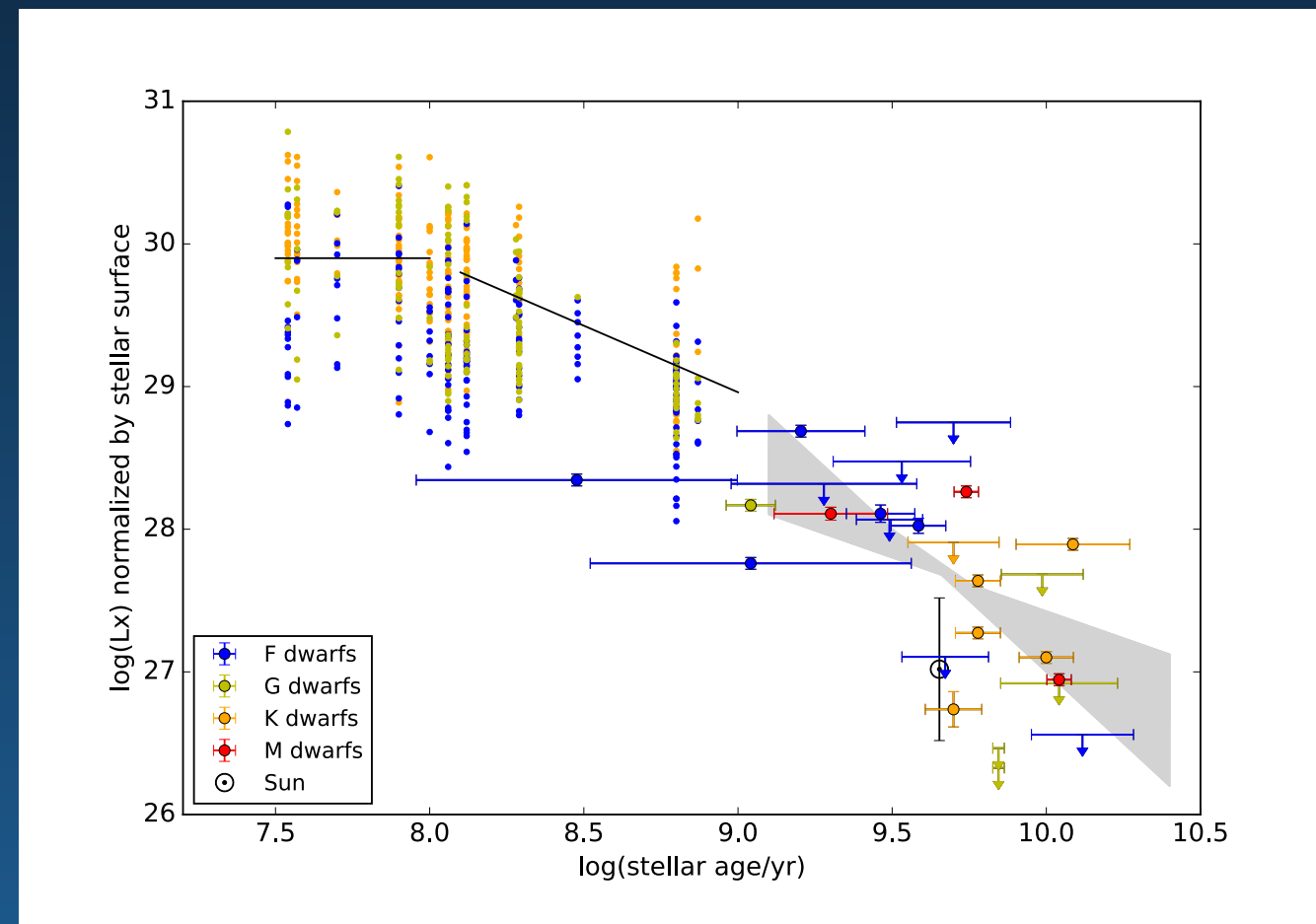
$$L_x \propto v_{rot}^{\beta}$$

- Some evidence for steepening activity-rotation relationship
- More research is needed to confirm



Conclusions

- Investigation of the Activity-Age relationship beyond a gigayear
- Data suggests a steeper relationship than previously found
- This could be caused by:
 - More rapid Rotational spin-down
 - Or a change in the Activity-Rotation relationship

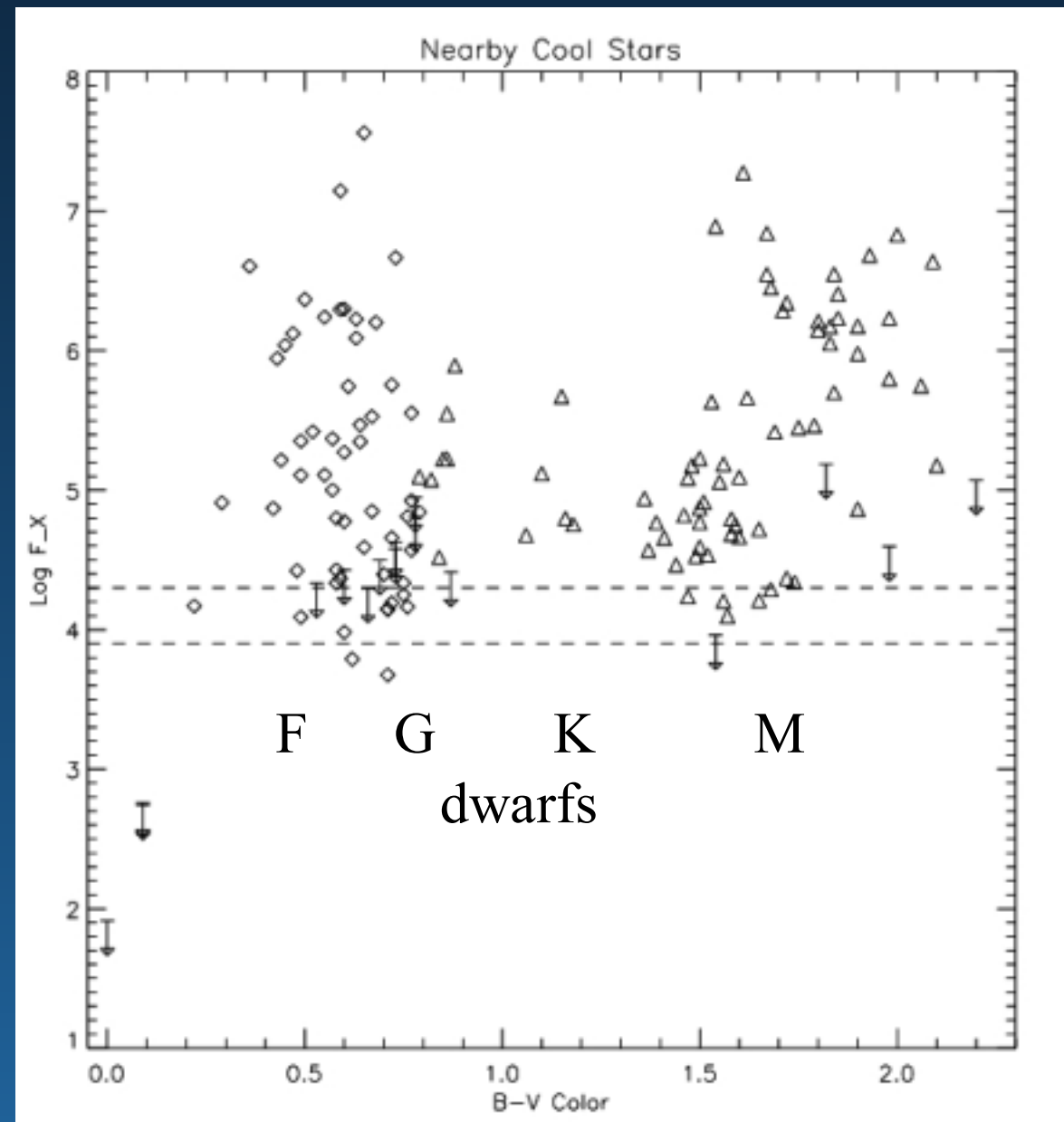


Cluster data taken from Jackson et al., 2012

Lx / Stellar Surface

- Similar spread for cool stars of different mass

Lx / Stellar surface



B-V

Schmitt (1997)