

The discovery of a nearby 1700 km/s hyper-velocity star ejected from the Galactic Centre

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with Douglas Boubert, Ting Li
and
S5 collaboration

ArXiv:1907.11725 Koposov+2019

also

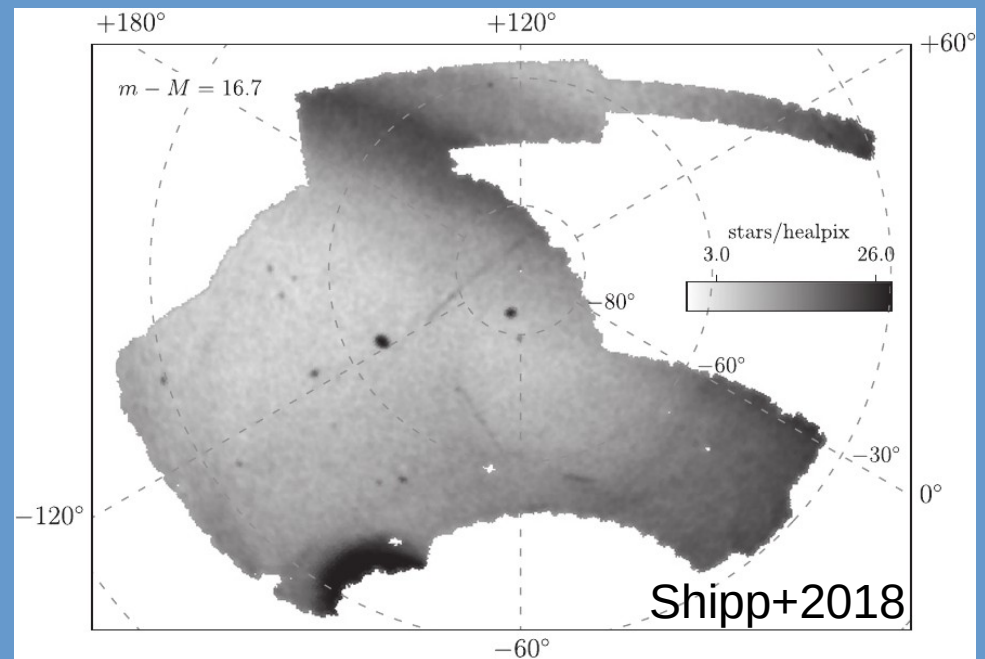
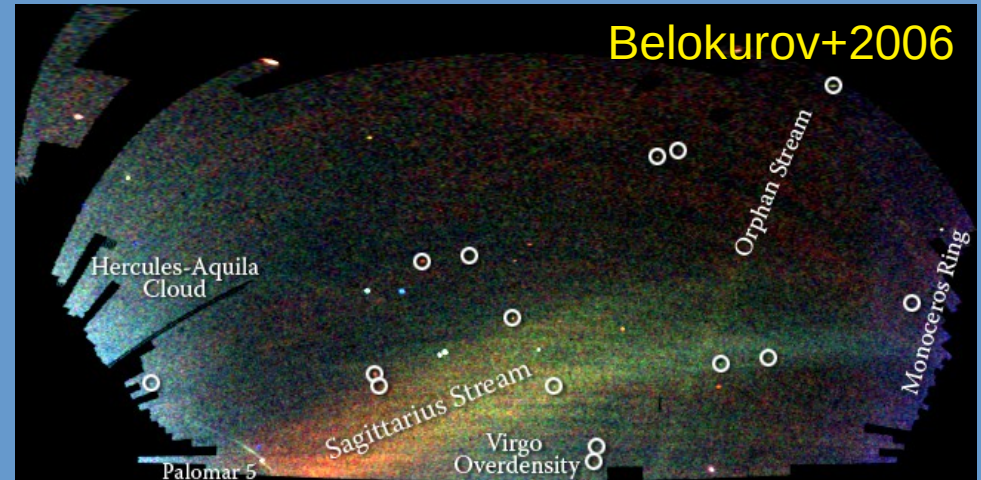
Arxiv:1907.09481 Li, Koposov+2019

Outline

- S5 project
- HVS search
- Properties of S5-HVS1
- Origin of S5-HVS1

S5 project motivation

- Stellar stream follow-up
- Measure gravitational potential, stream perturbations
- Use Gaia selected targets



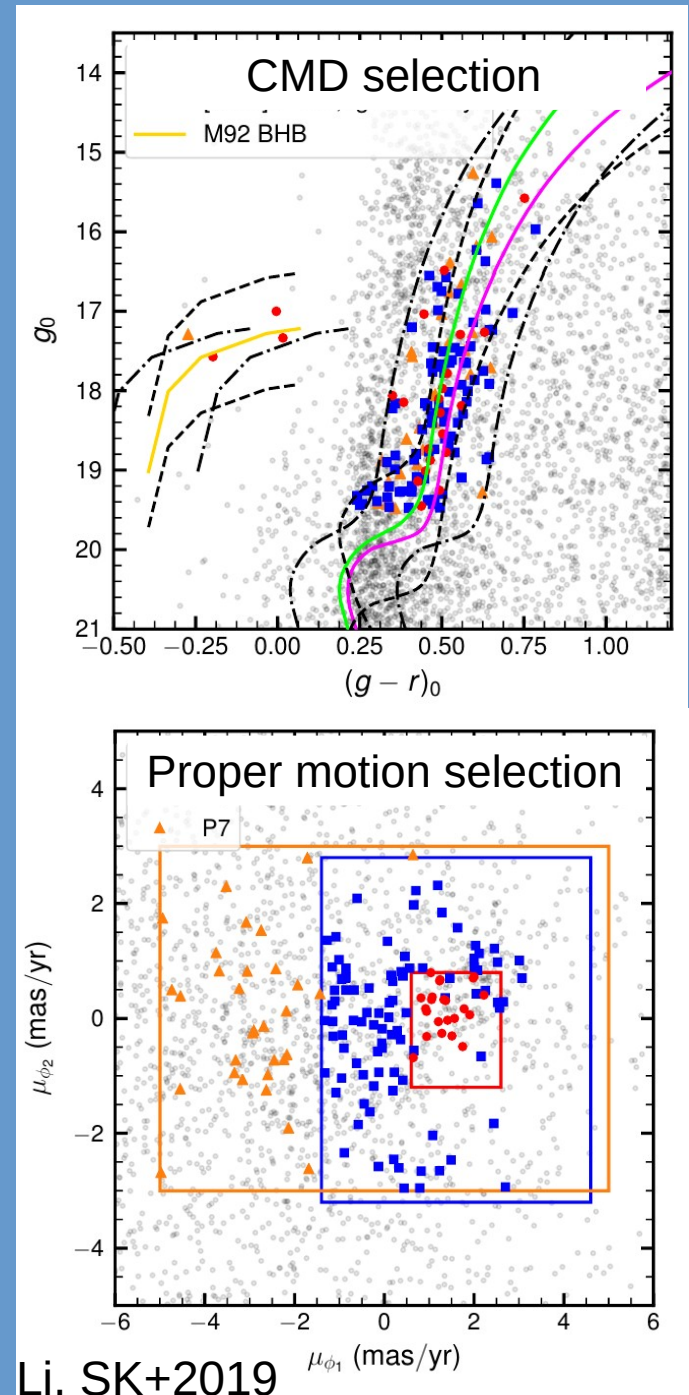
S5 project



- USA/Australia/UK
- S5 leadership: **Ting Li**, Dan Zucker, Geraint Lewis, Kyler Kuhn
- Key members: Joss Bland-Hawthorne, Denis Erkal, Alex Ji, Sergey Kopolov, Yao-Yuan Mao, Jeremy Mould, Andrew Pace, Nora Shipp, Jeffrey Simpson
- Other members: Sahar Allam, Eduardo Balbinot, Keith Bechtol, Vasily Belokurov, Andrew Casey, Lara Cullinane, Gary Da Costa, Gayandhi De Silva, Alex Drlica-Wagner, Marla Geha, Dougal Mackey, Sarah Martell, Andrew Pace, Sanjib Sharma, Josh Simon, Douglas Tucker, Kathy Vivas, Zhen Wan, Risa Wechsler, Brian Yanny
- Web-site <https://s5collab.github.io>

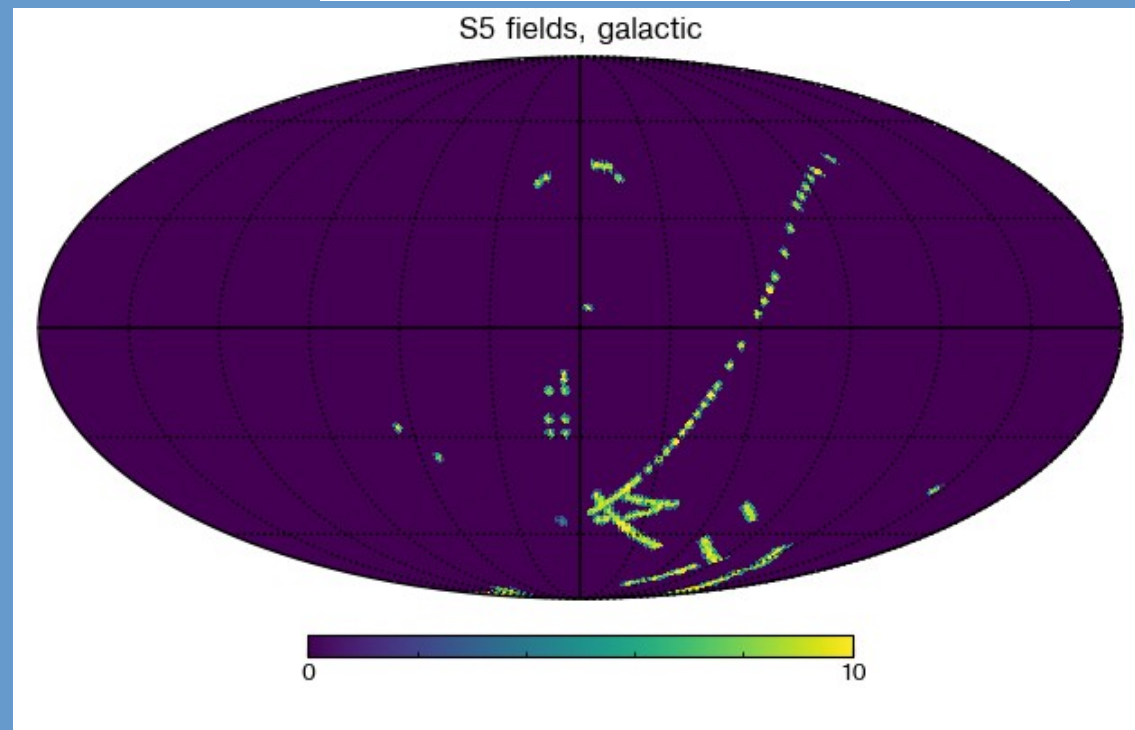
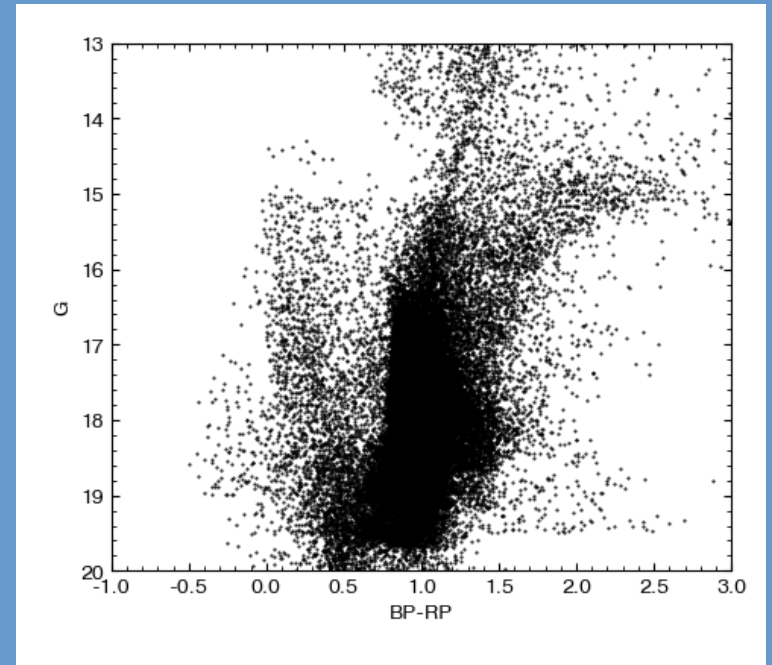
S5 observations

- AAT, AAOmega 2dF; 400 fibers, 2 degrees FoV
- 25 nights, 2 hour exposures
- Main selection: Isochrone + Gaia proper motions
- **Significant number of spare fibers**
- Targeted **all blue objects**, low-z galaxies, white dwarfs, RR Lyrae, Extremely metal-poor stars (from Skymapper)



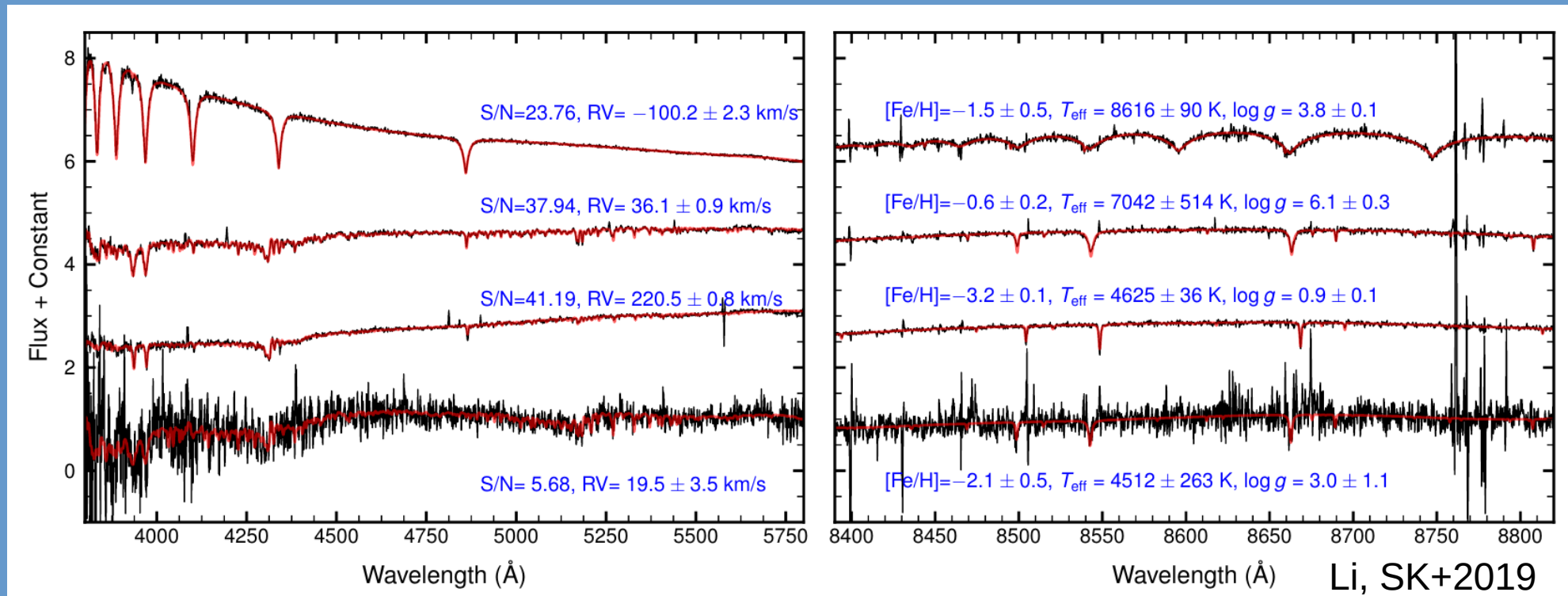
S5 statistics

- 43000 unique spectra
- ~ 200 square degrees
- Mainly Southern sky
- ~ 2000 blue stellar targets (BHB/BS/WD)



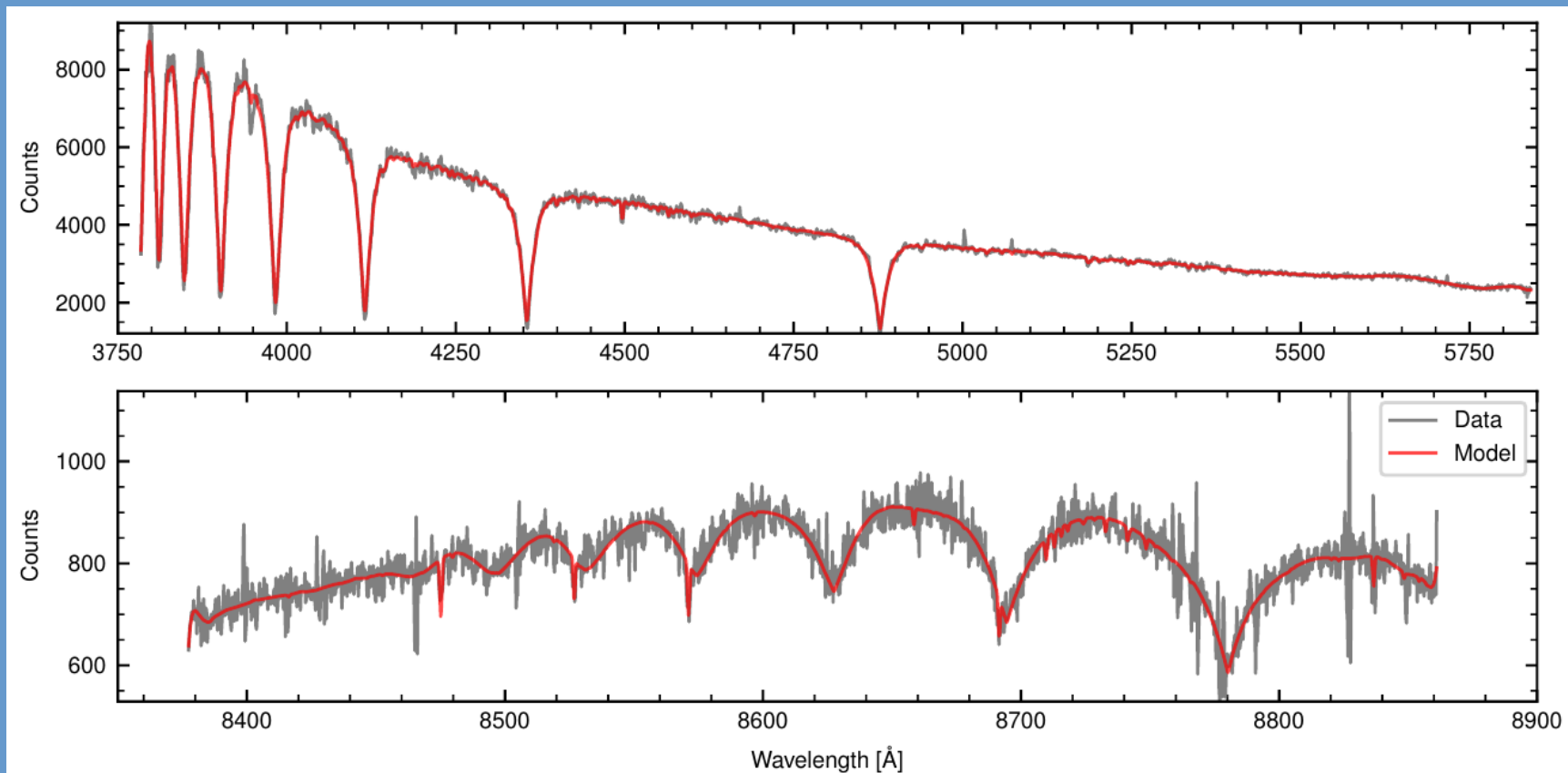
Spectra

- NIR+optical 1700D/580V; spectral resolution $R=10000/1300$
- Stellar atmospheric model fits RVSpecFit code (Koposov 2019) <https://github.com/segasai/rvspecfit>
- RV systematic floor ~ 0.5 km/s



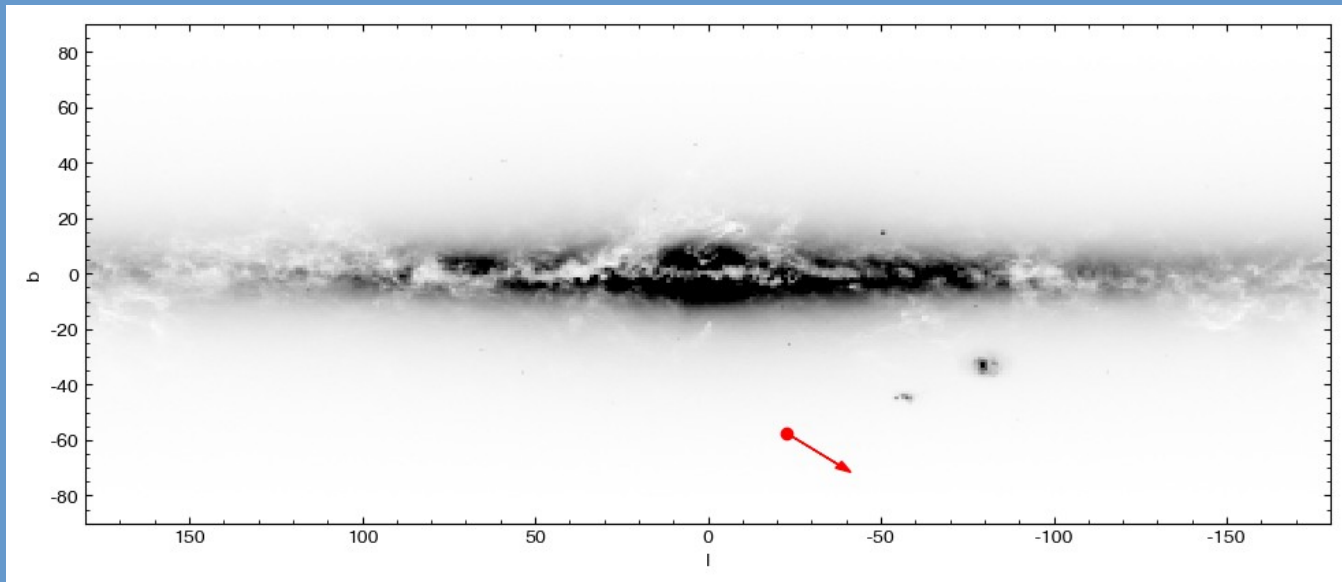
S5-HVS1

- $RV \sim 1020$ km/s
- A-type spectrum, $\log g = 4.3$, $T_{\text{eff}} = 9600$ K, $[\text{Fe}/\text{H}] \sim 0.4$
- No RV variability (over ~ 9 months)



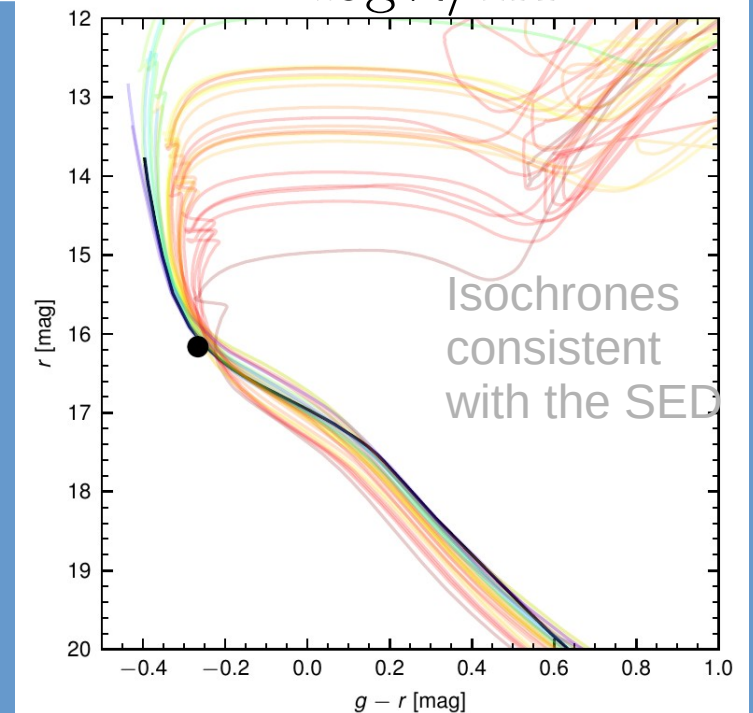
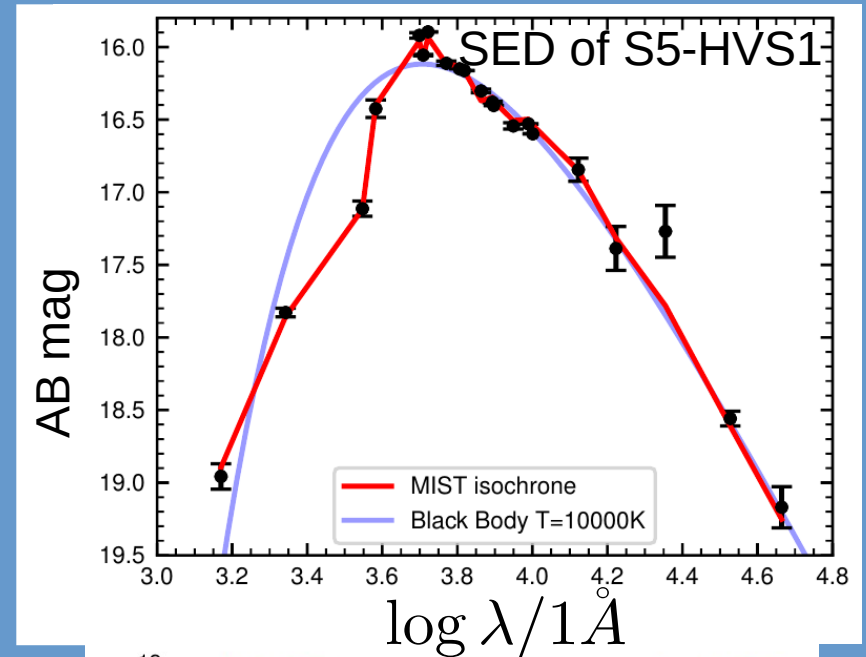
Gaia measurements for S5-HVS1

- Gaia $G = 16$
- $G_{BP} - G_{RP} = 0$
- $(\mu_{\alpha}, \mu_{\delta}) = (35.3, 0.58) \pm 0.1$ mas/yr
- $\pi = -0.04 \pm 0.09$ mas



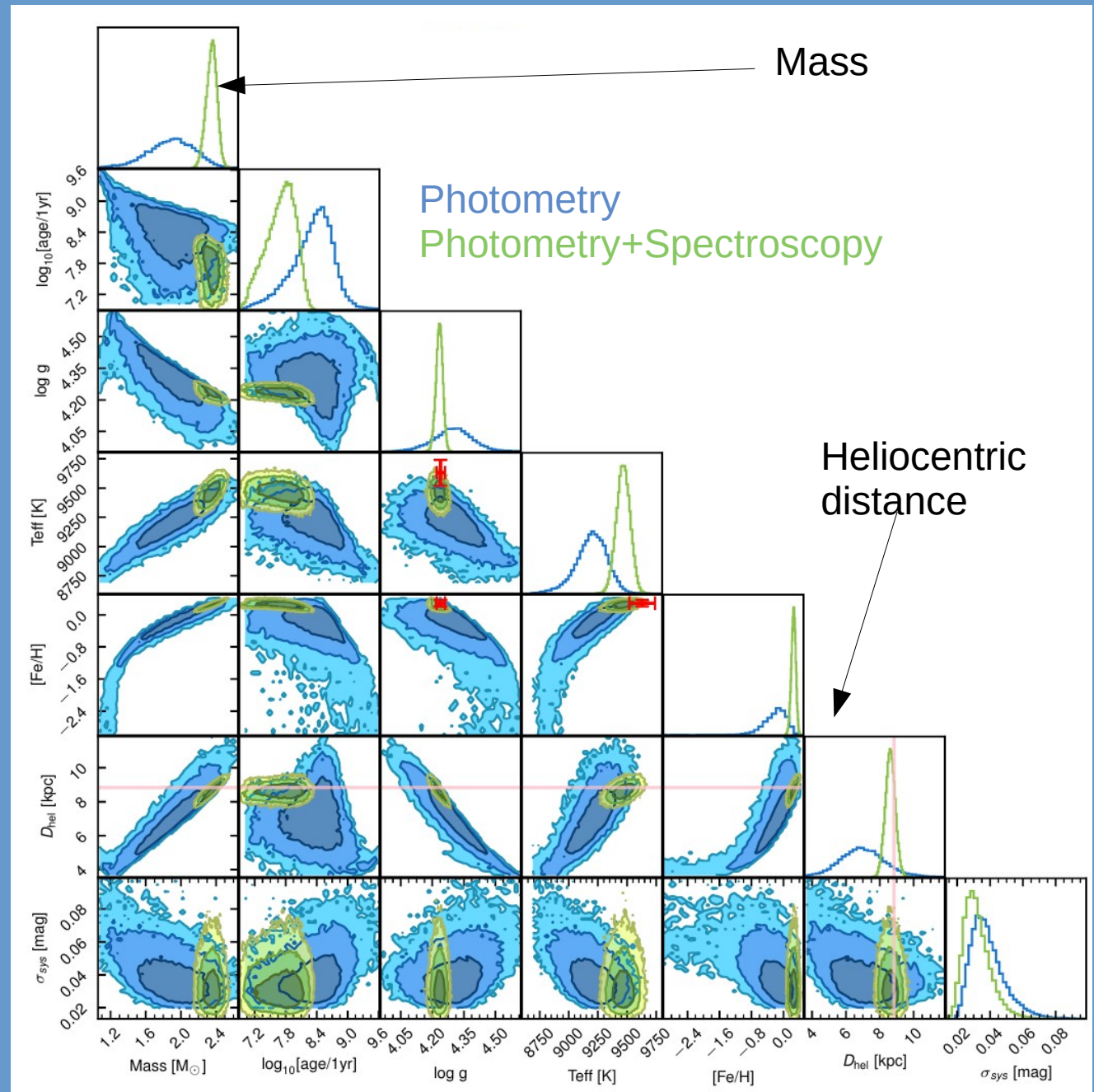
Photometry

- Gaia G = 16
- Detected from GALEX to WISE
- No evidence of photometric variability
- MIST isochrone fit



Photometry + Spectroscopy

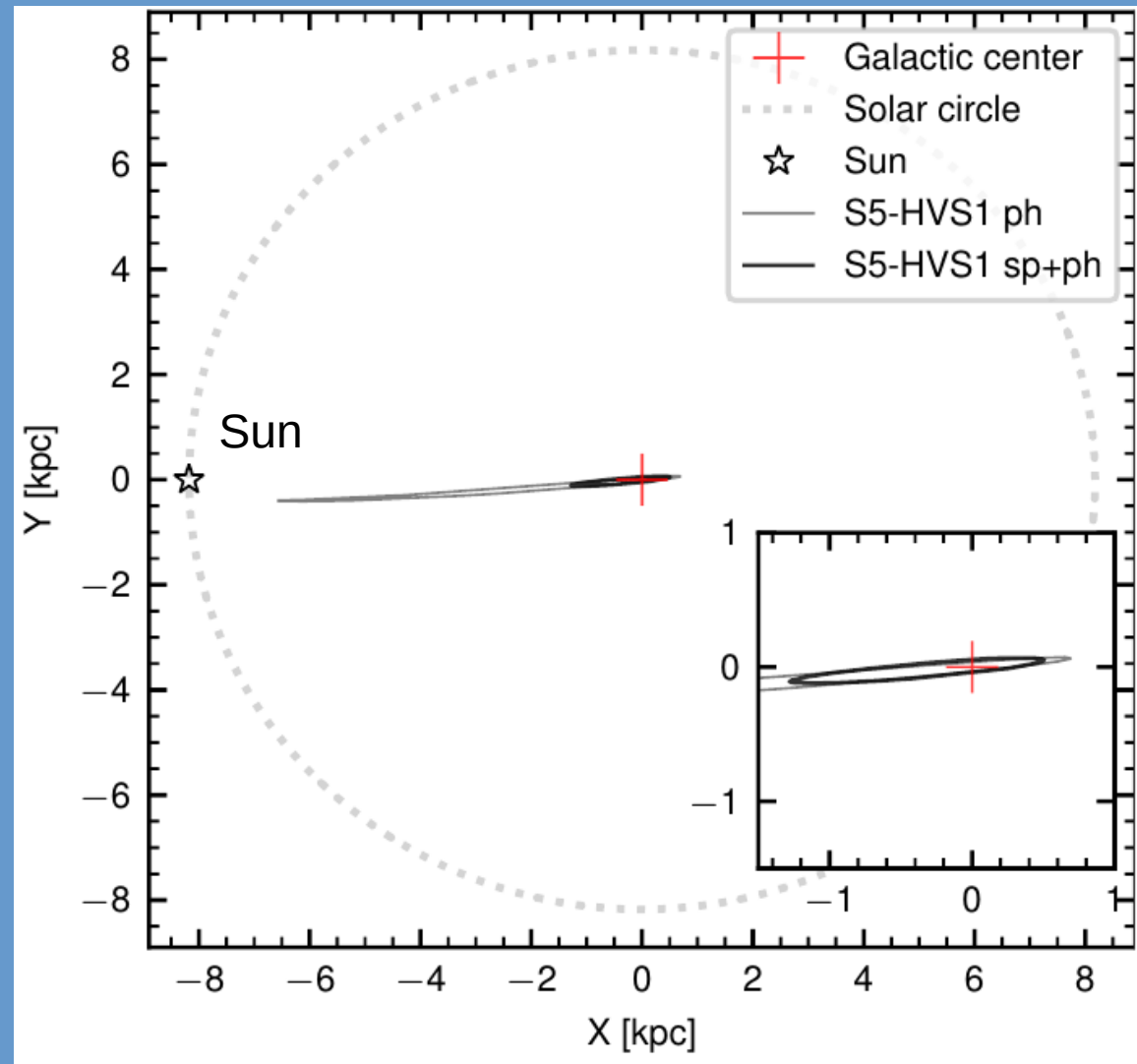
- Distance ~ 8.5 kpc
- High $\log g$
- High metallicity $[\text{Fe}/\text{H}] > 0$
- Mass $\sim 2.35 M_{\odot}$



Origin of S5-HVS1

- The 90% confidence region is an 1500 x 50 pc ellipse centred on the GC
- The association with the GC is highly significant

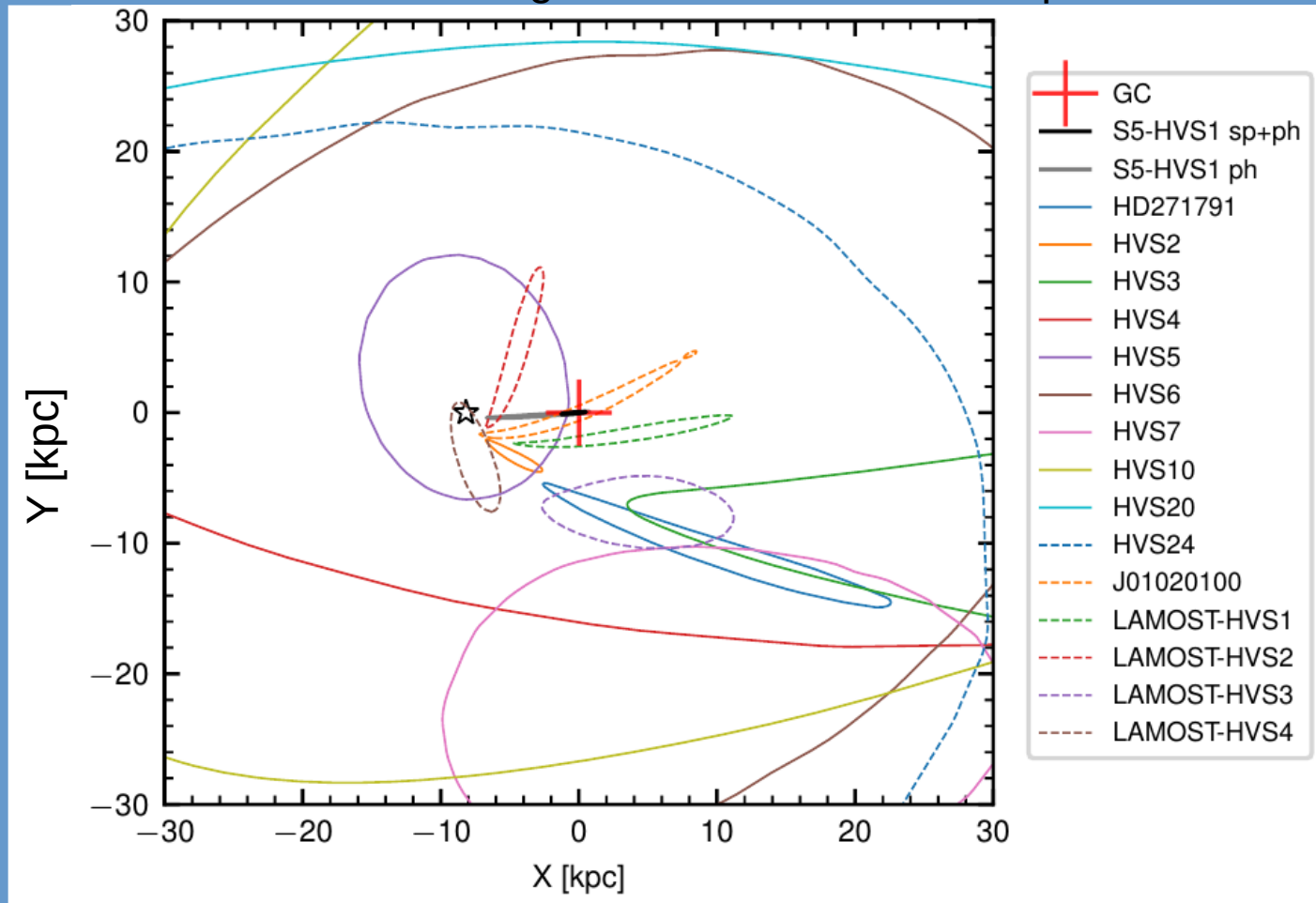
$$BF = \frac{P(D|GC)}{P(D|disk)} \gtrsim 300$$



S5-HVS1 vs other HVS

- The most confident association with the GC

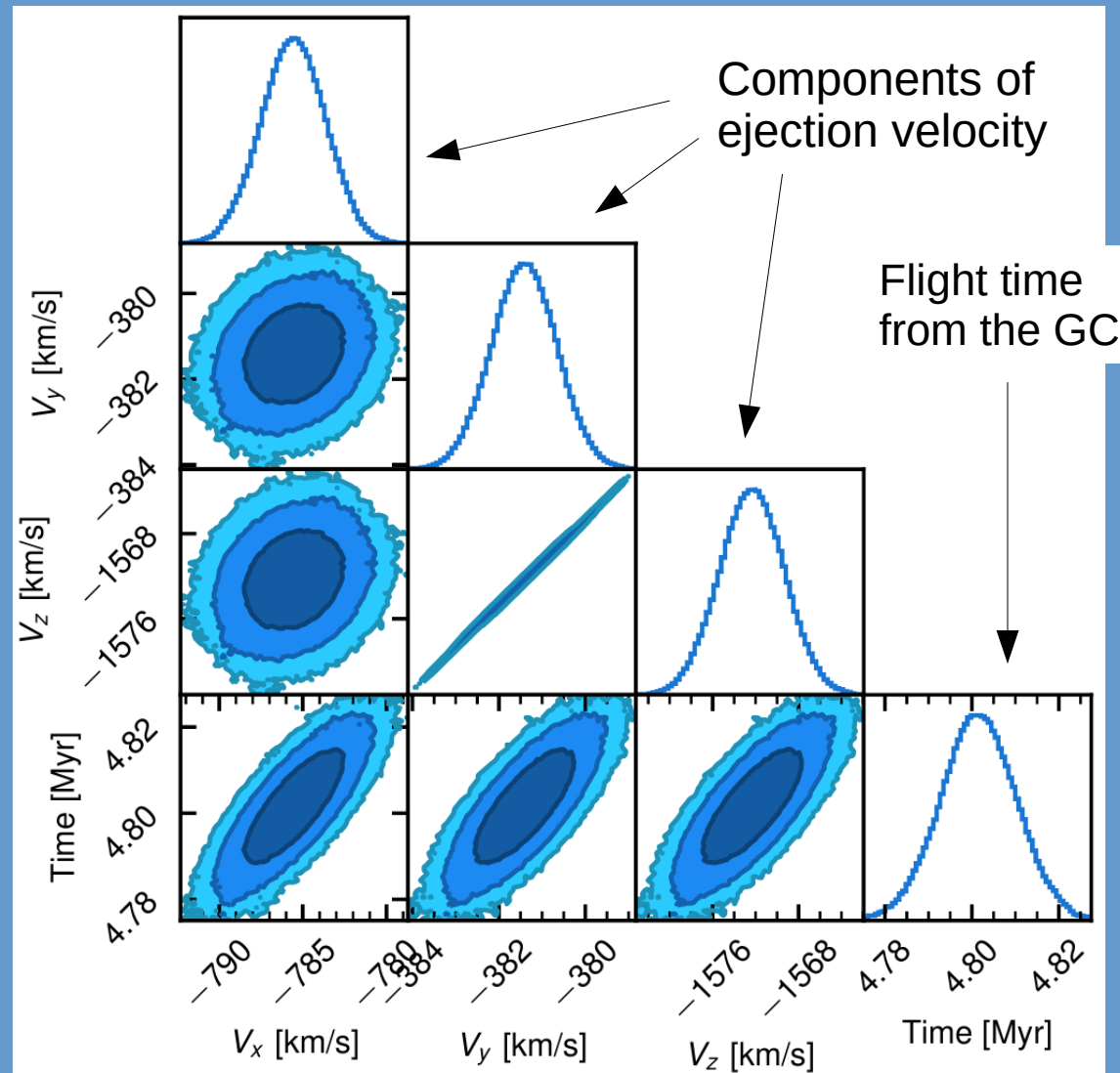
Constraints on the origin in the disk for the sample of HVS



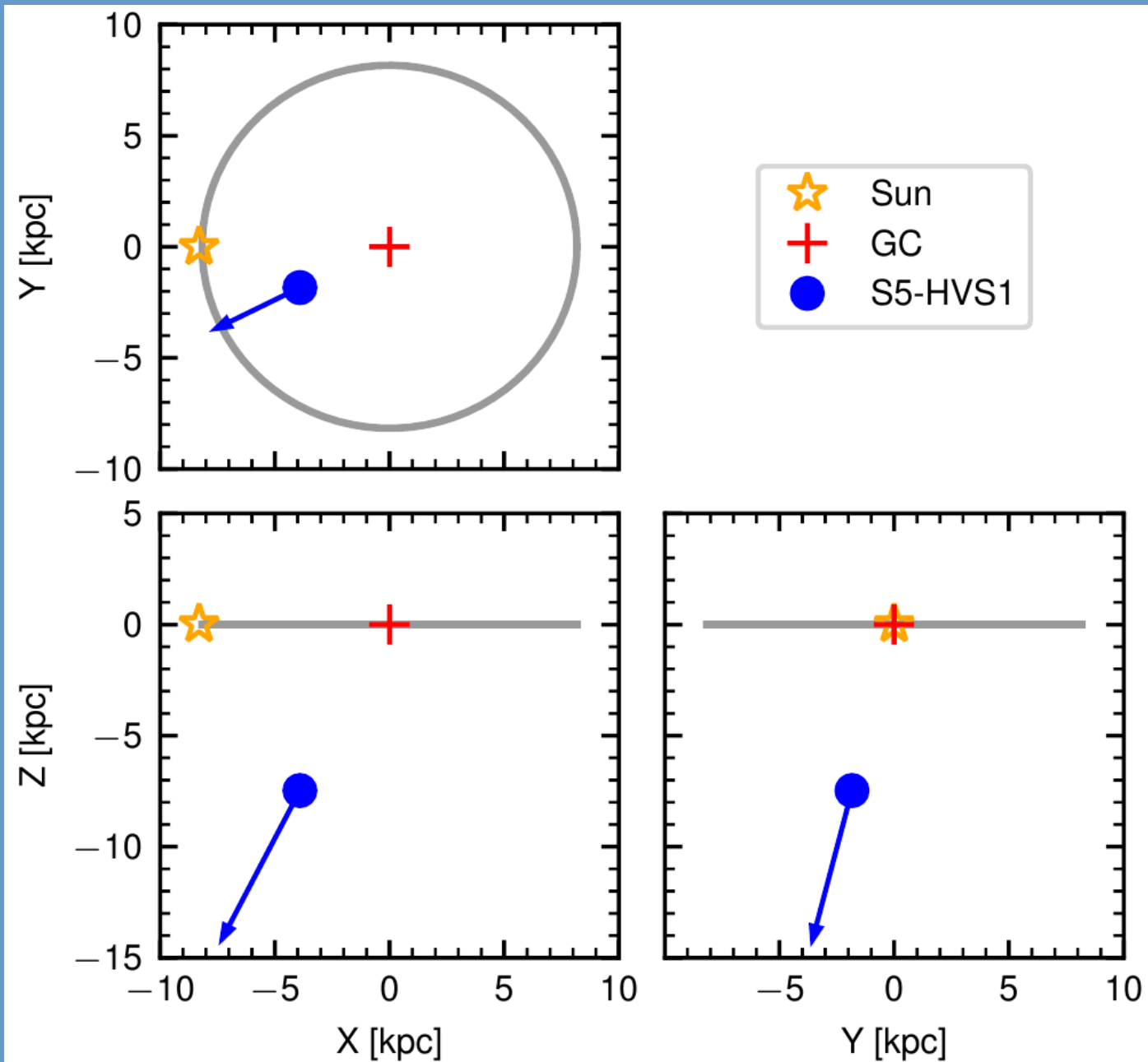
Stars from
Boubert+2018,
Massey+2018,
Li+2018

Ejection parameters

- Ejection velocity ~ 1800 km/s (vs ~ 1750 km/s current velocity)
- Flight time ~ 4.8 Myr
- SMBH potential ignored.

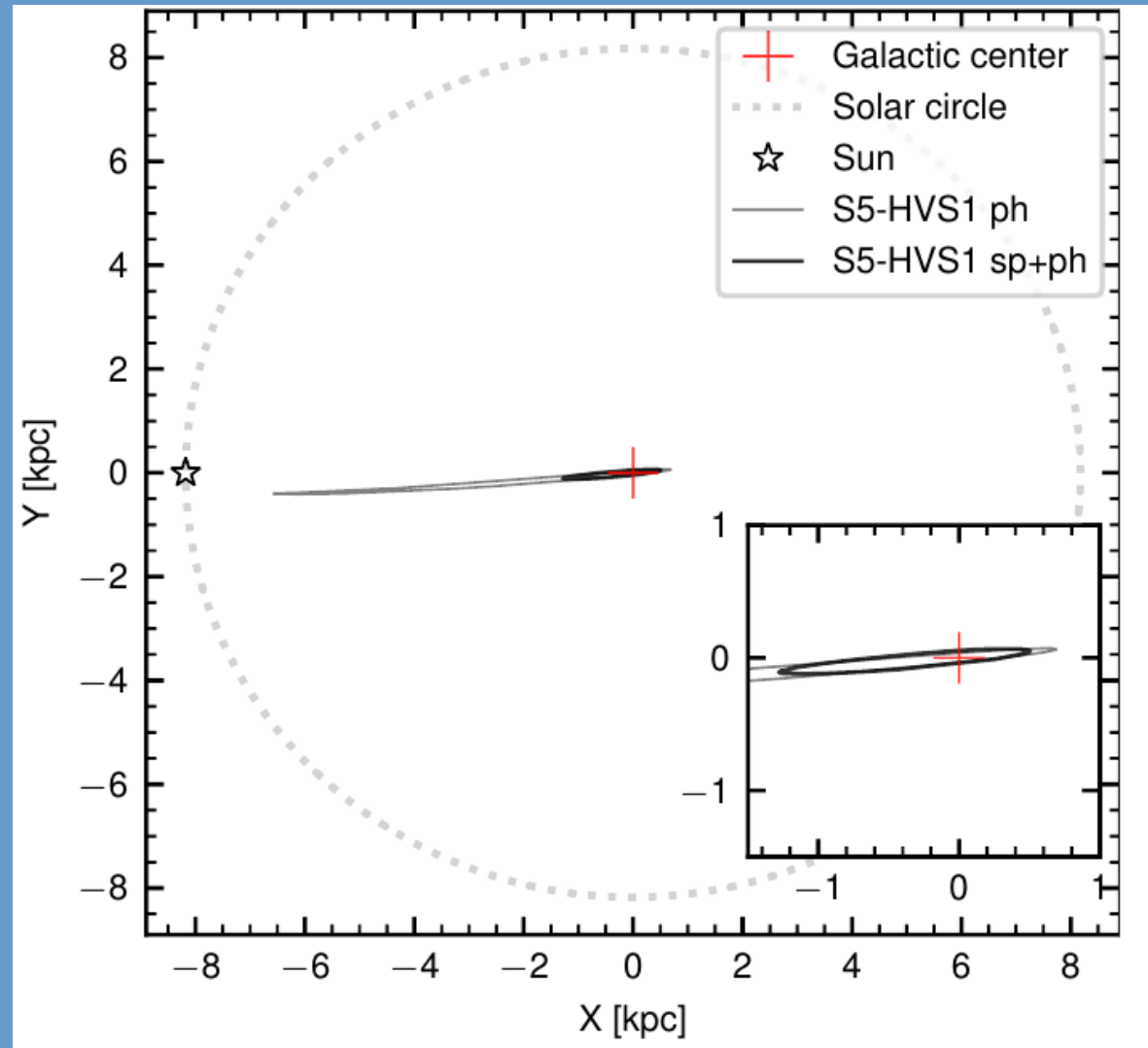


3-D geometry



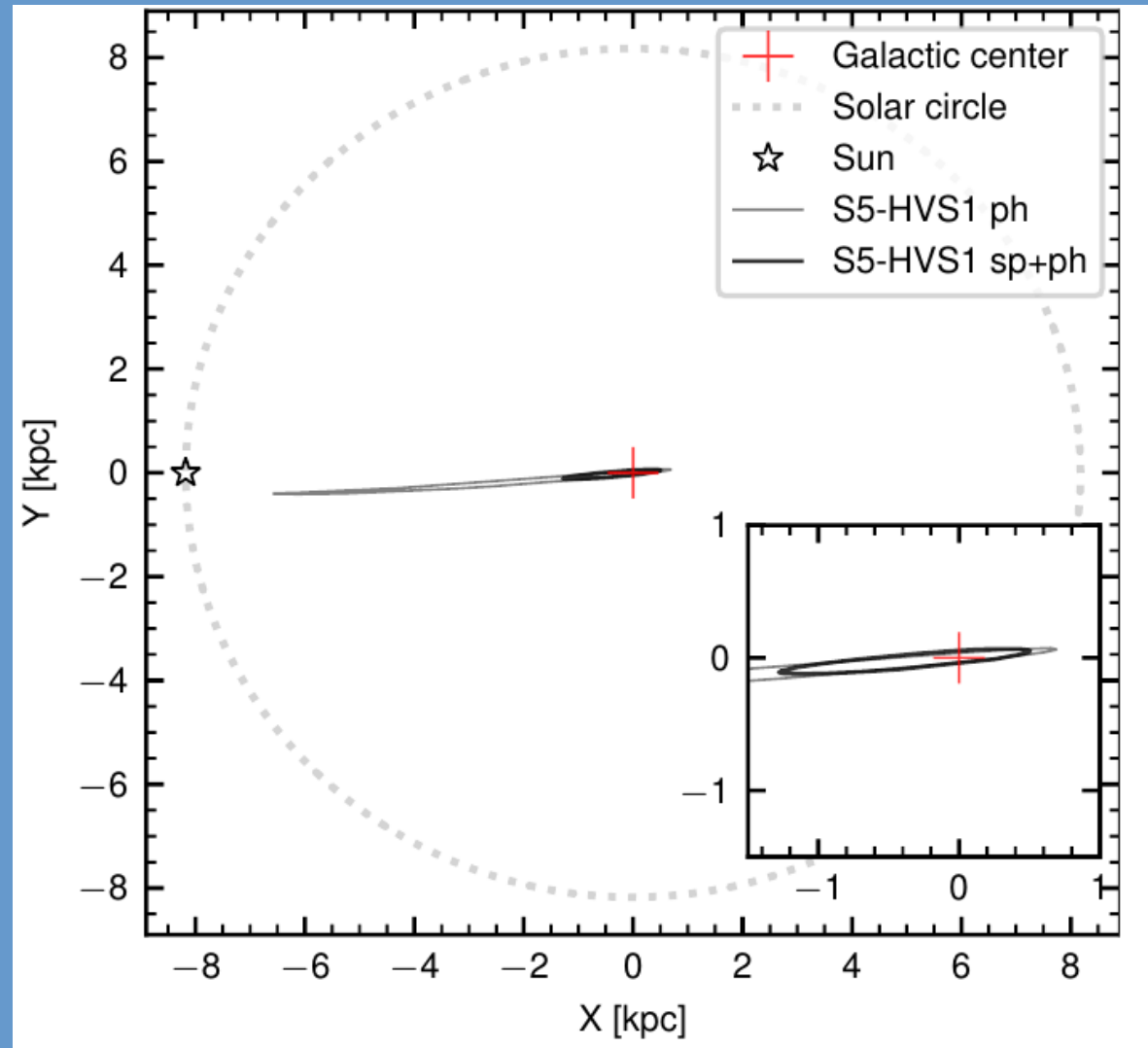
Constraining the potential

- Gnedin+2005
- Deceleration by only ~ 50 km/s
- The changes of the potential lead to $\lesssim 20$ pc shifts of the contour of origin.



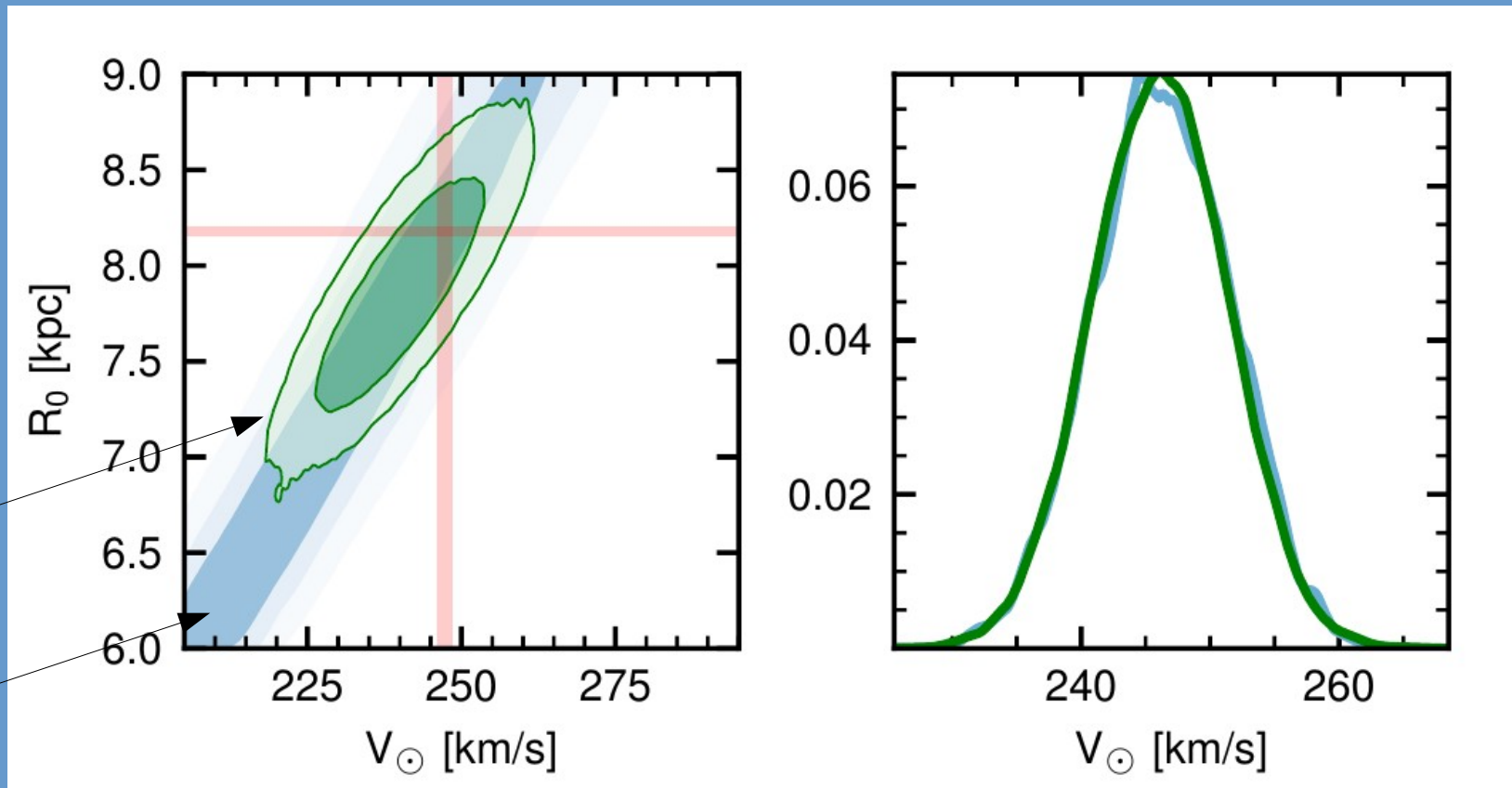
Constraining the Sun's location & speed

- Hattori+2018
- Assumption of the GC origin constrains Sun's speed and Sun-GC distance.
- V_x , V_y , V_z constraining power very different
- Only two parameters could be constrained



Constraining the Sun's location & speed

- Y-component of Solar motion and R_0
- With the Gravity prior on R_0 $V_y=246\pm 5\text{km/s}$

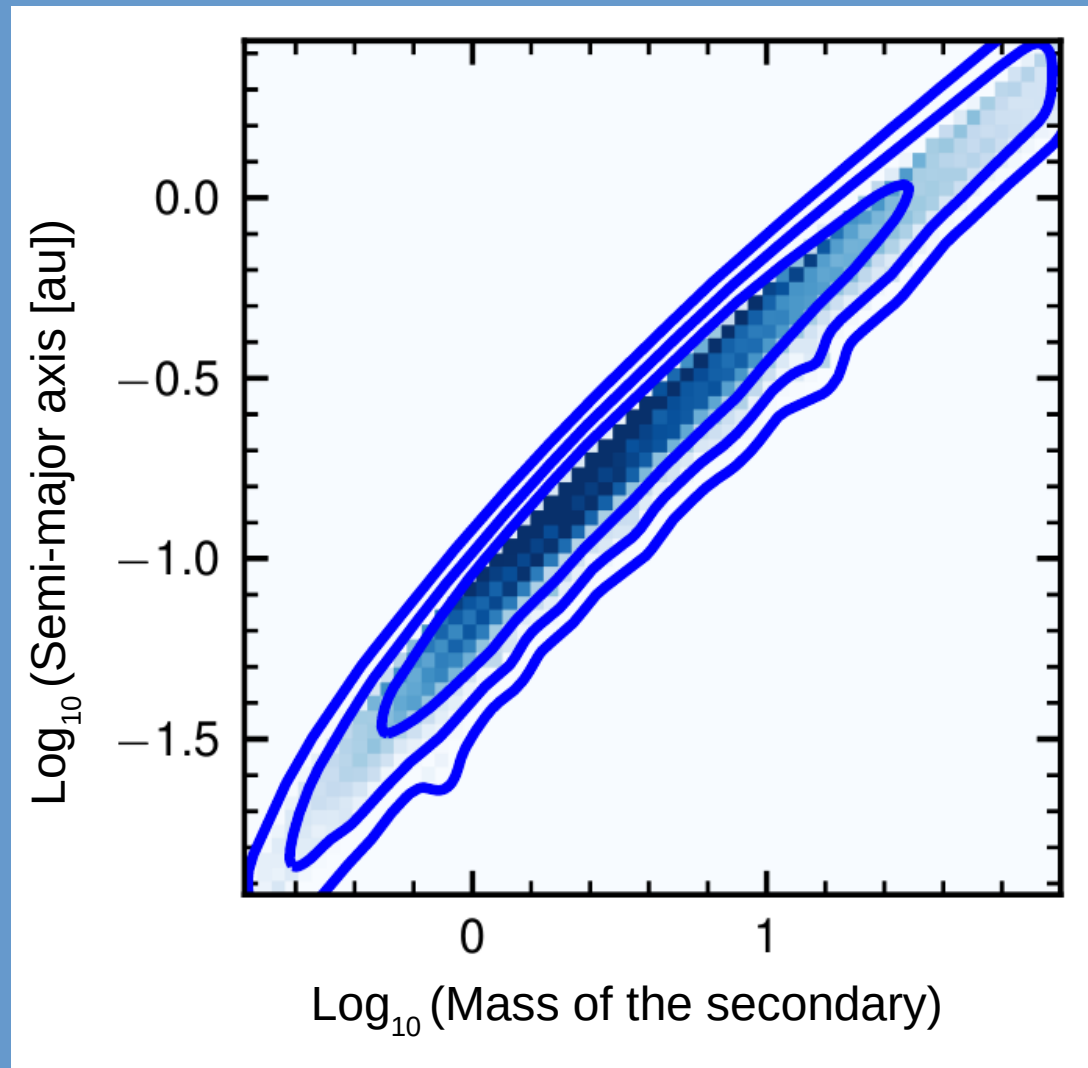


Spectro-
Photometric
distances

Photometric
distance
constraint

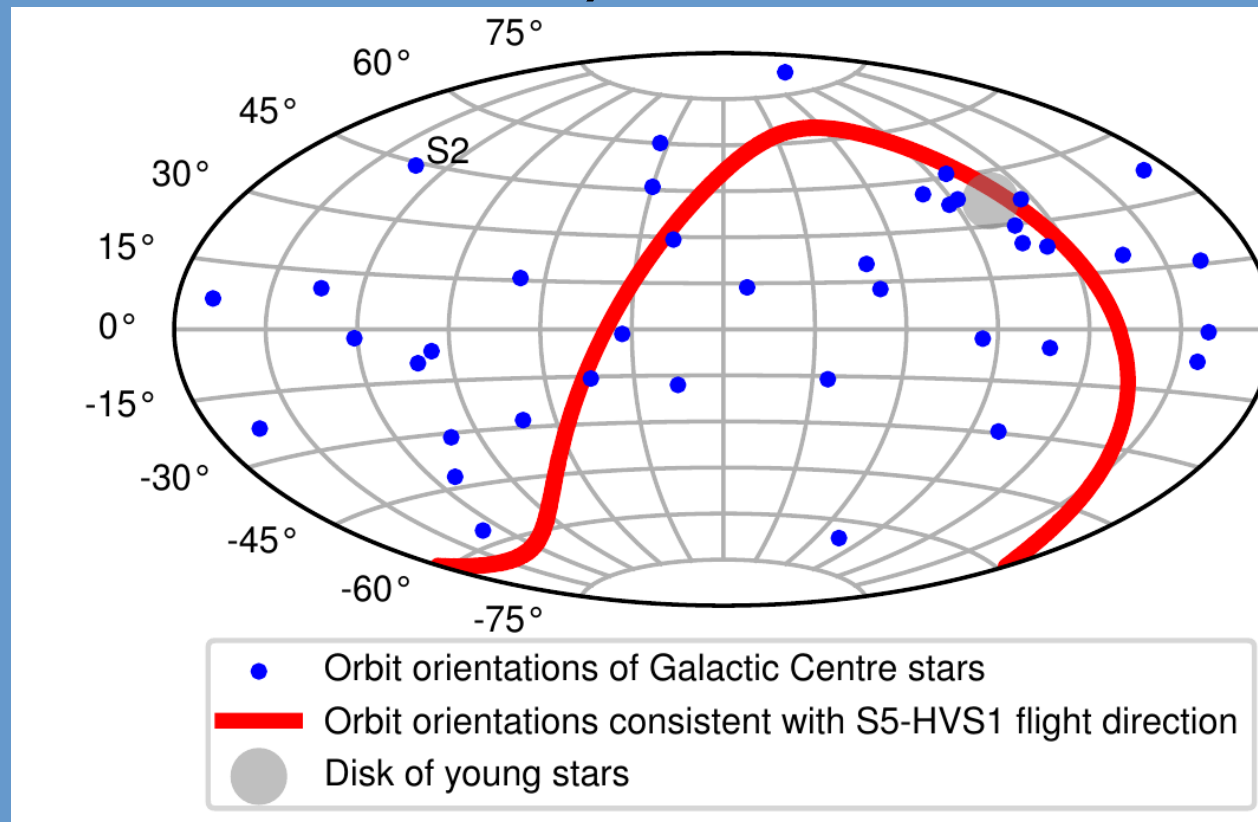
Hills mechanism; parameters of the binary

- Using Bromley+2006 we can infer
- Semi-major axis: 0.03-1 au
- Mass of the secondary 1-15 M_{\odot}



S-stars and S5-HVS1

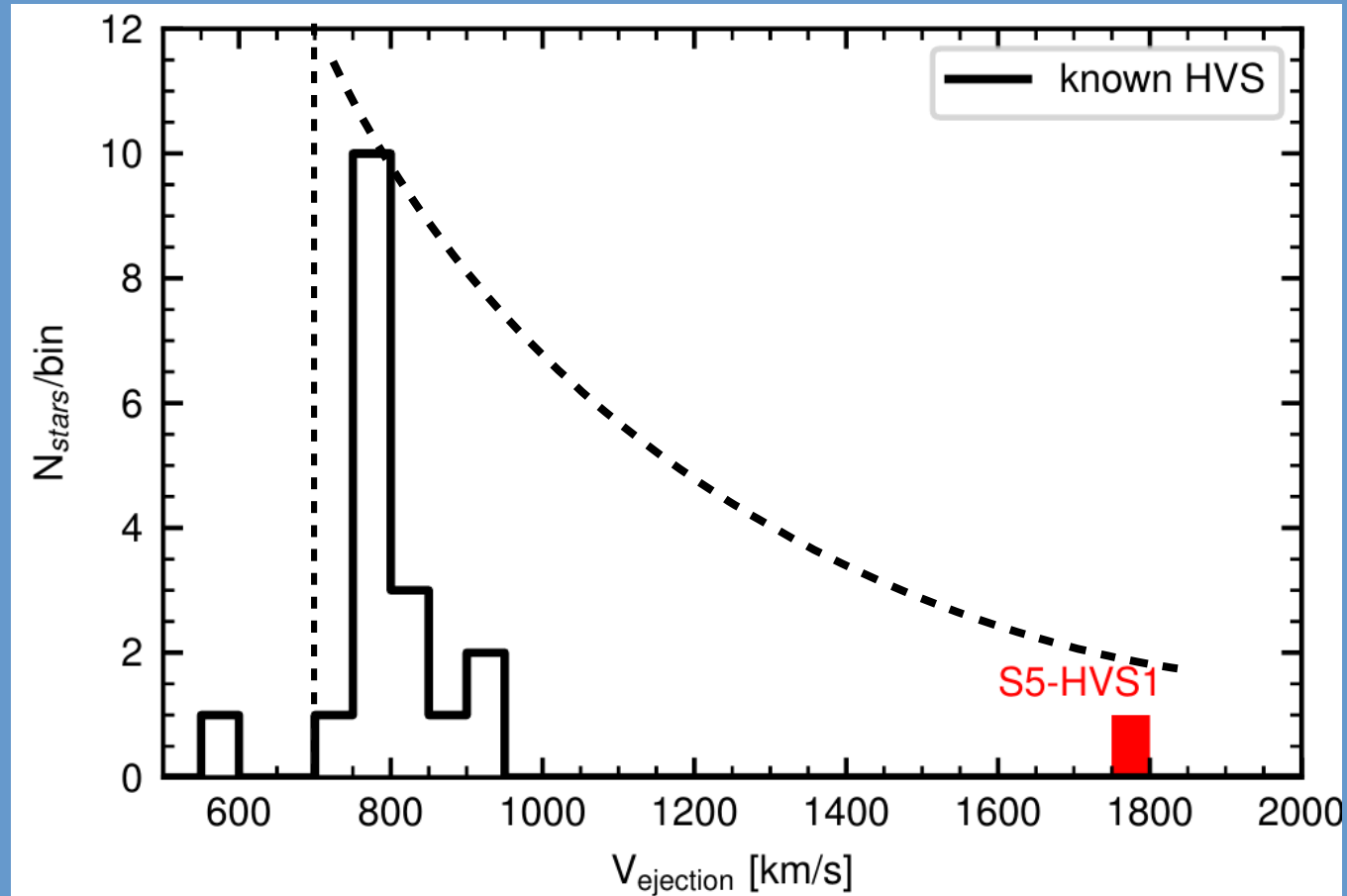
- The orbit of S5-HVS1 lies within the plane of young stars around the GC (clock-wise disk: Levin+2003; Paumard+2006; Bartko+2009)



S-stars orbits
from
Gillessen+2017

Comparing to other HVS

- The ejection velocity \sim twice the velocity of other stars
- Assuming the spectrum is a power-law P -value $\sim 1\%$
- Different mechanism ?
- A single event ?



Conclusions

- S5-HVS1 the best case for the Hills ejection by SgrA*
- S5-HVS1, we can study abundances near the GC
- Is S5-HVS1 different ?
- Is there connection to the disk of S-stars ?
- Was there an event 5 Myr ago ? Should we search hard for slower HVS near the GC ?
- Should we search for HVS in the plane clockwise disk ?

I am happy to talk/open for collaborations.