

Lecture 23: Anomalies in Galactic Motion

GAIA ASTRUM'S GAIA SATELLITE - BUILT TO MAP THE MILKY WAY

 50 EUROPEAN COMPANIES

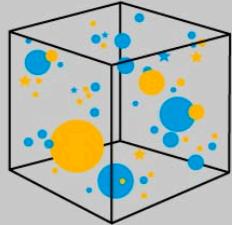
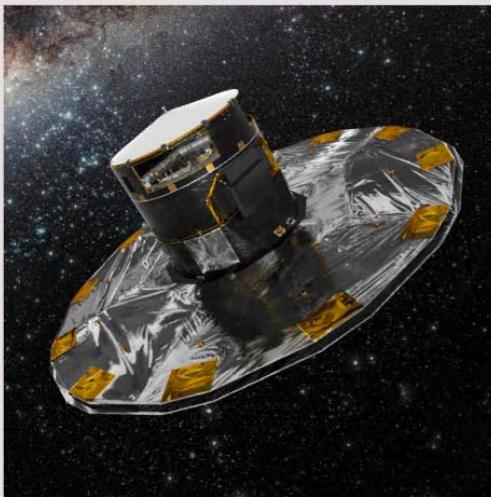
 400 ENGINEERS

 15 PROJECT INVOLVING 15 EUROPEAN SPACE AGENCY MEMBER COUNTRIES

 3 YEARS OF TESTING AND INTEGRATION

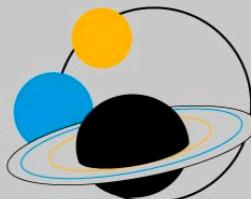
 Dec 13 LAUNCH SCHEDULED FOR DECEMBER 2013

 5 5 YEARS NOMINAL LIFE IN ORBIT



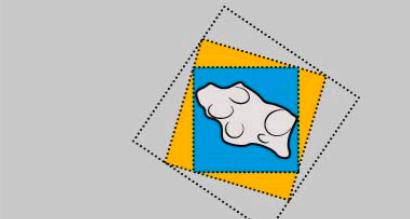
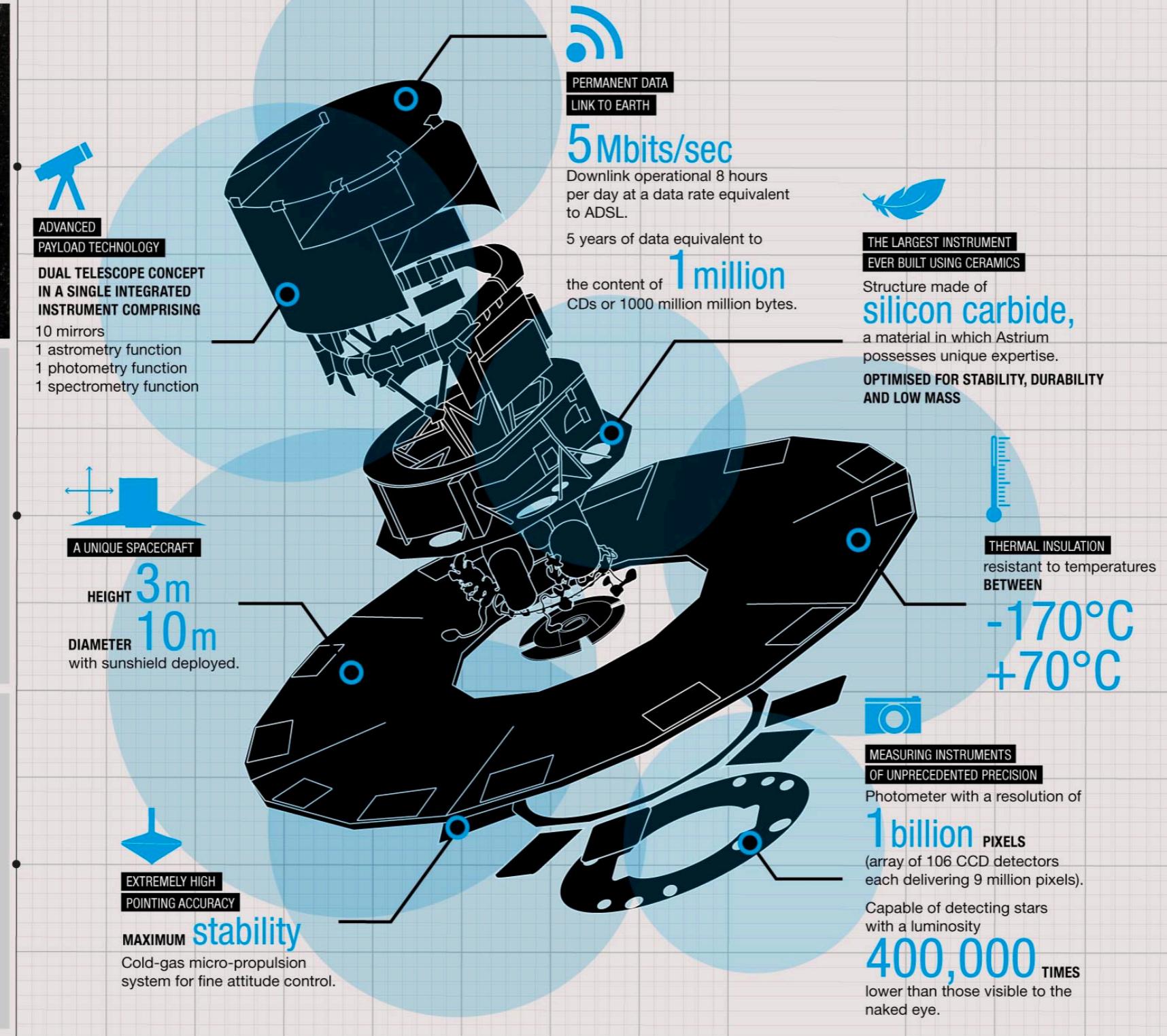
3D IMAGES OF A BILLION STARS

Each star will be detected and measured 70 times during the mission.
Gaia will determine their position, velocity, distance from Earth, colour and luminosity.



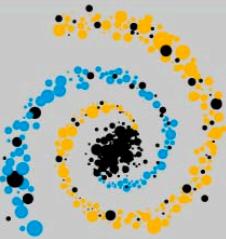
DISCOVERY OF 2,000 NEW PLANETS

Their detection will enable us to improve our knowledge of the mechanisms at work in planetary systems.



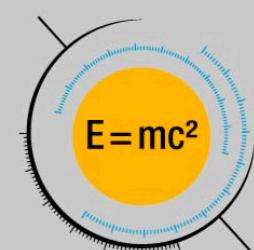
DETECTION AND STUDY OF 200,000 NEW ASTEROIDS

Gaia will log their position and calculate their speed.
A first opportunity to study asteroids in the regions closest to the Sun, normally invisible to telescopes on Earth.



THREE-DIMENSIONAL MAP OF OUR GALAXY, THE MILKY WAY

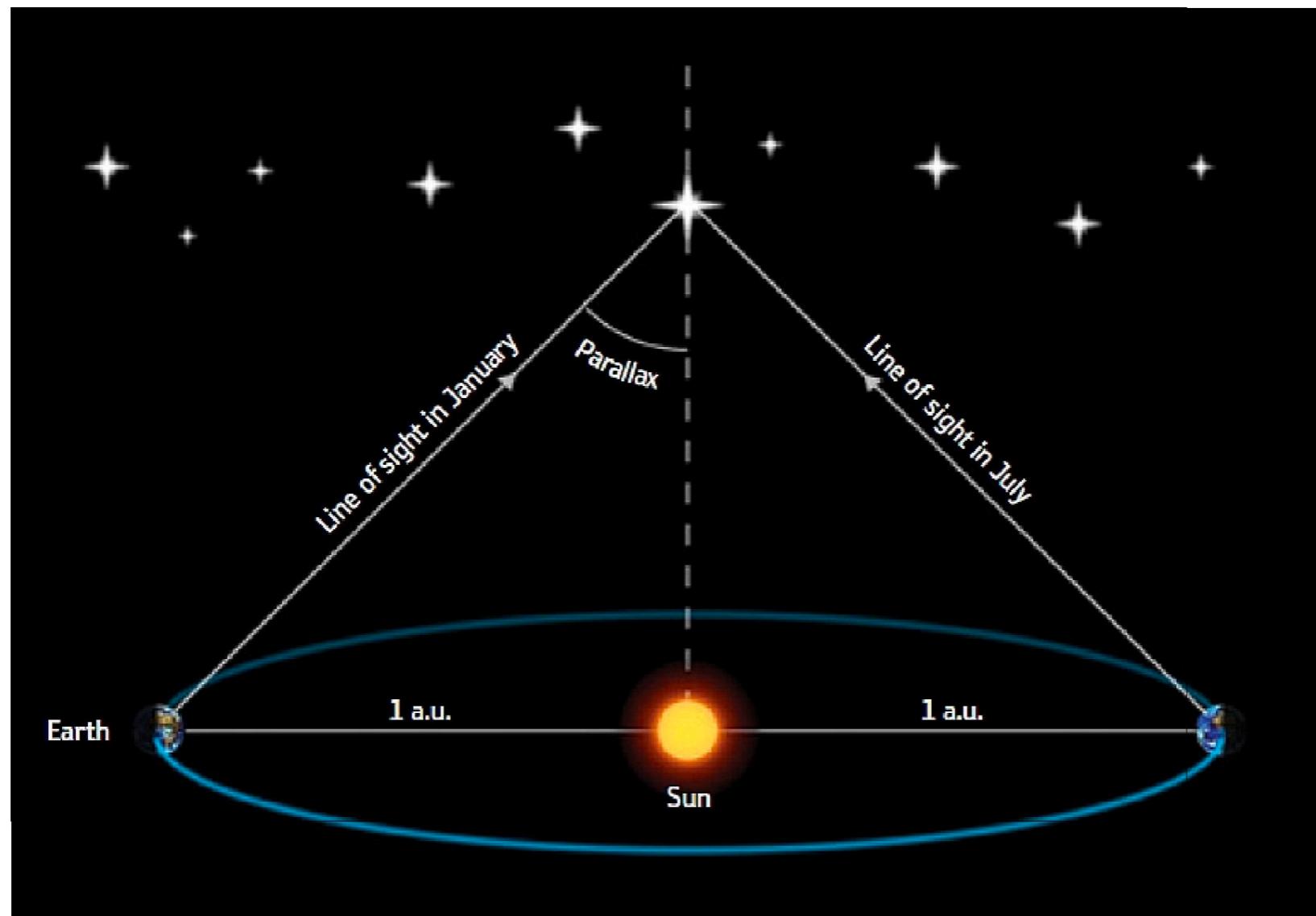
An astronomical census that will provide answers to questions about the formation and evolution of our galaxy.



NEW TESTS OF THE THEORY OF RELATIVITY

Gaia Satellite

- Gaia's main mode of measure is the Parallax



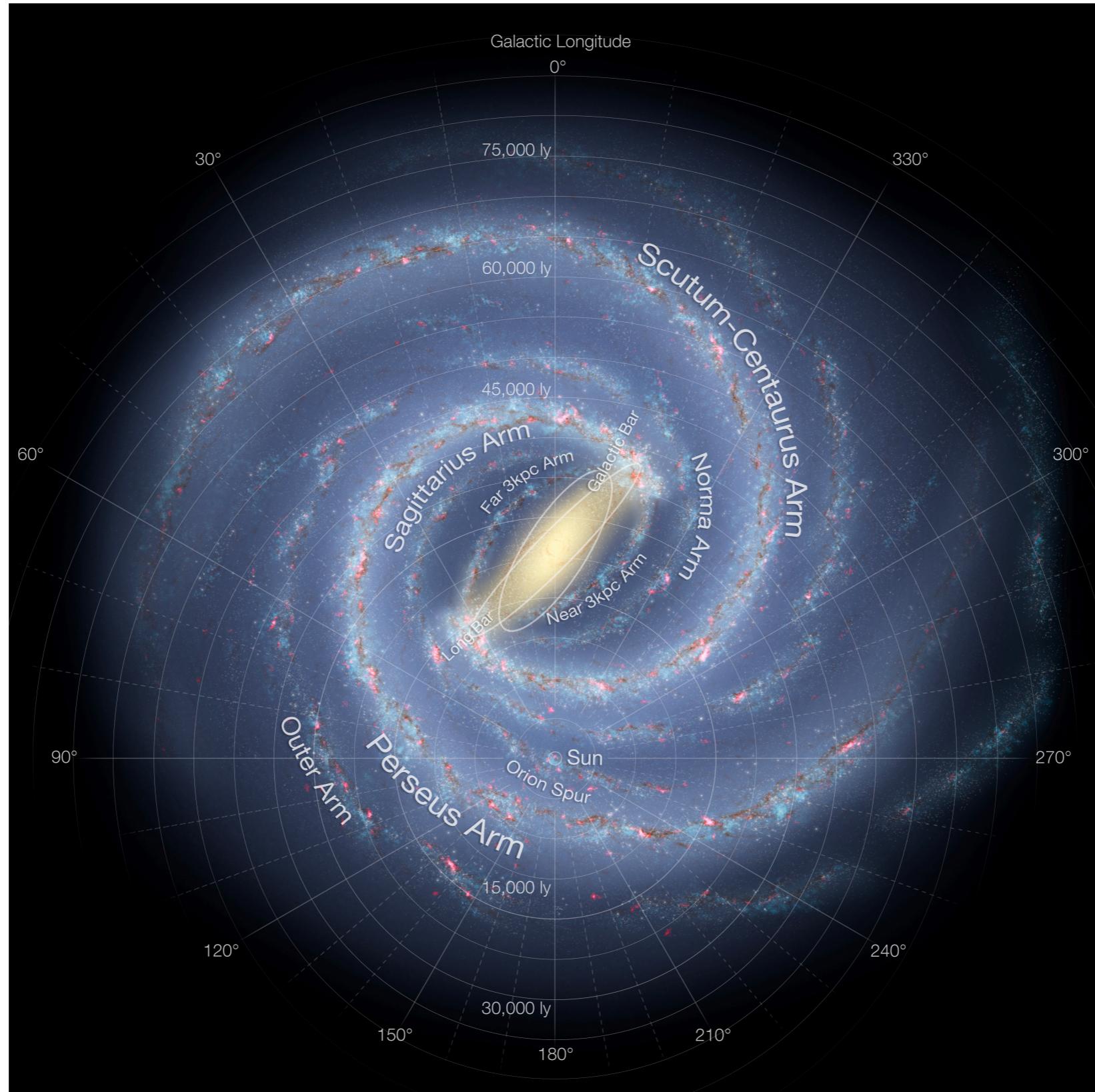
- This translates to a distance away from us
 - Many measurements yields a velocity vector

Full Gaia Stats

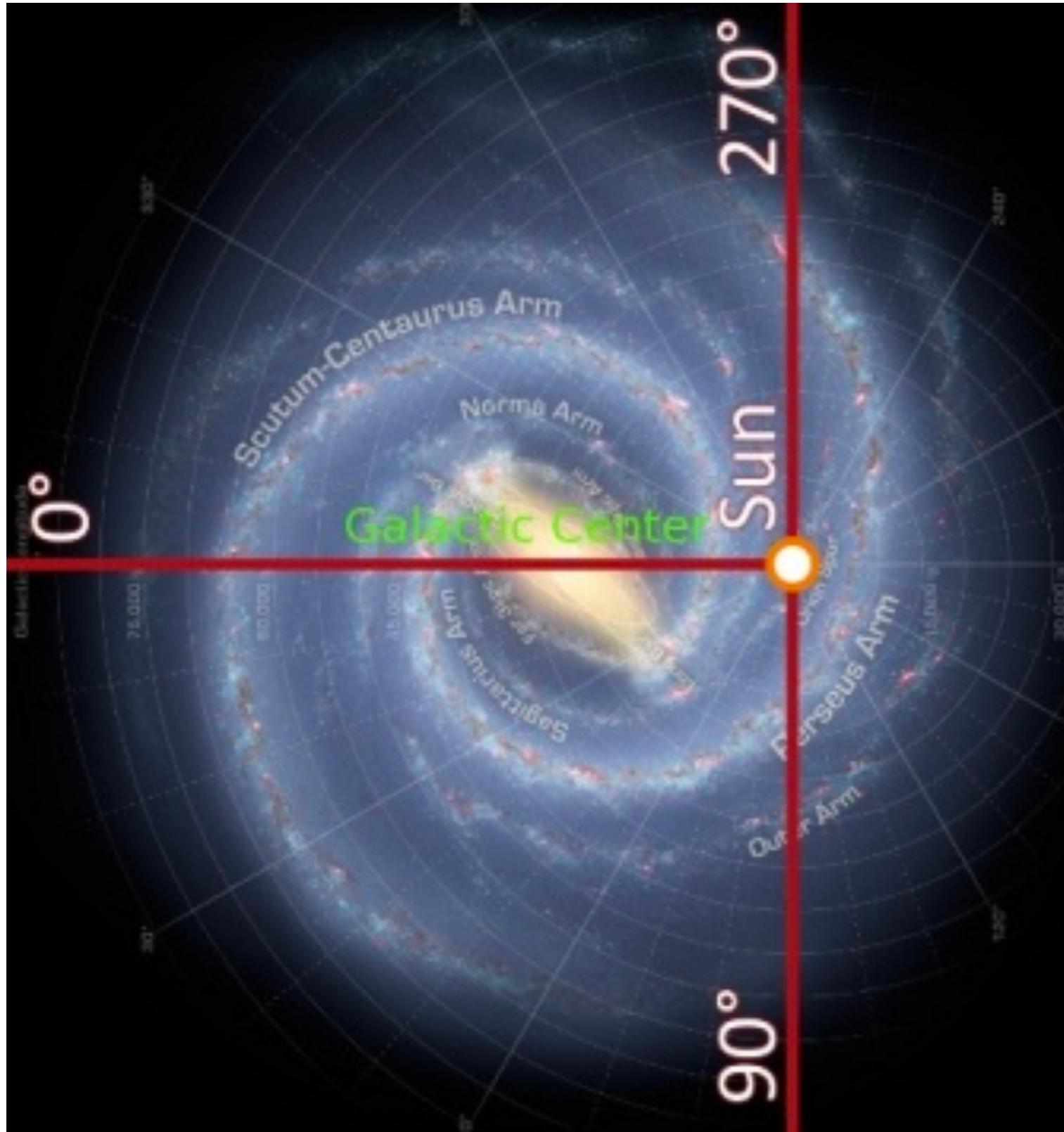
- Gaia has been running for the past 10 years

| | # sources in Gaia DR3 |
|--|----------------------------|
| Total number of sources | 1,811,709,771 |
| | Gaia Early Data Release 3 |
| Number of sources with full astrometry | 1,467,744,818 |
| Number of 5-parameter sources | 585,416,709 |
| Number of 6-parameter sources | 882,328,109 |
| Number of 2-parameter sources | 343,964,953 |
| Gaia-CRF sources | 1,614,173 |
| Sources with mean G magnitude | 1,806,254,432 |
| Sources with mean G_{BP} -band photometry | 1,542,033,472 |
| Sources with mean G_{RP} -band photometry | 1,554,997,939 |
| | New in Gaia Data Release 3 |
| Sources with radial velocities | 33,812,183 |
| Sources with mean G_{RVS} -band magnitudes | 32,232,187 |
| Sources with rotational velocities | 3,524,677 |
| Mean BP/RP spectra | 219,197,643 |
| Mean RVS spectra | 999,645 |

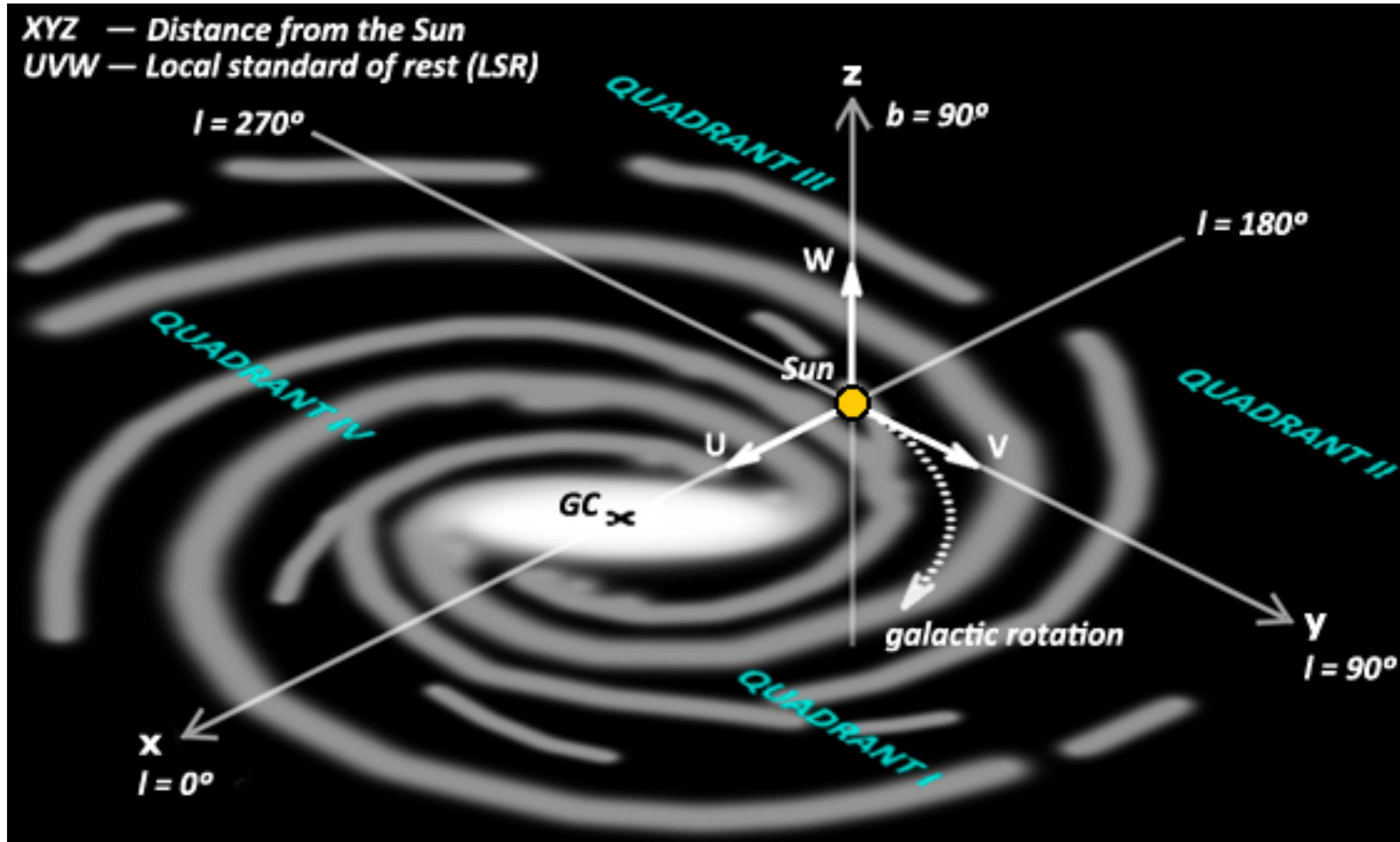
Star Observations



Galactic Coordinates

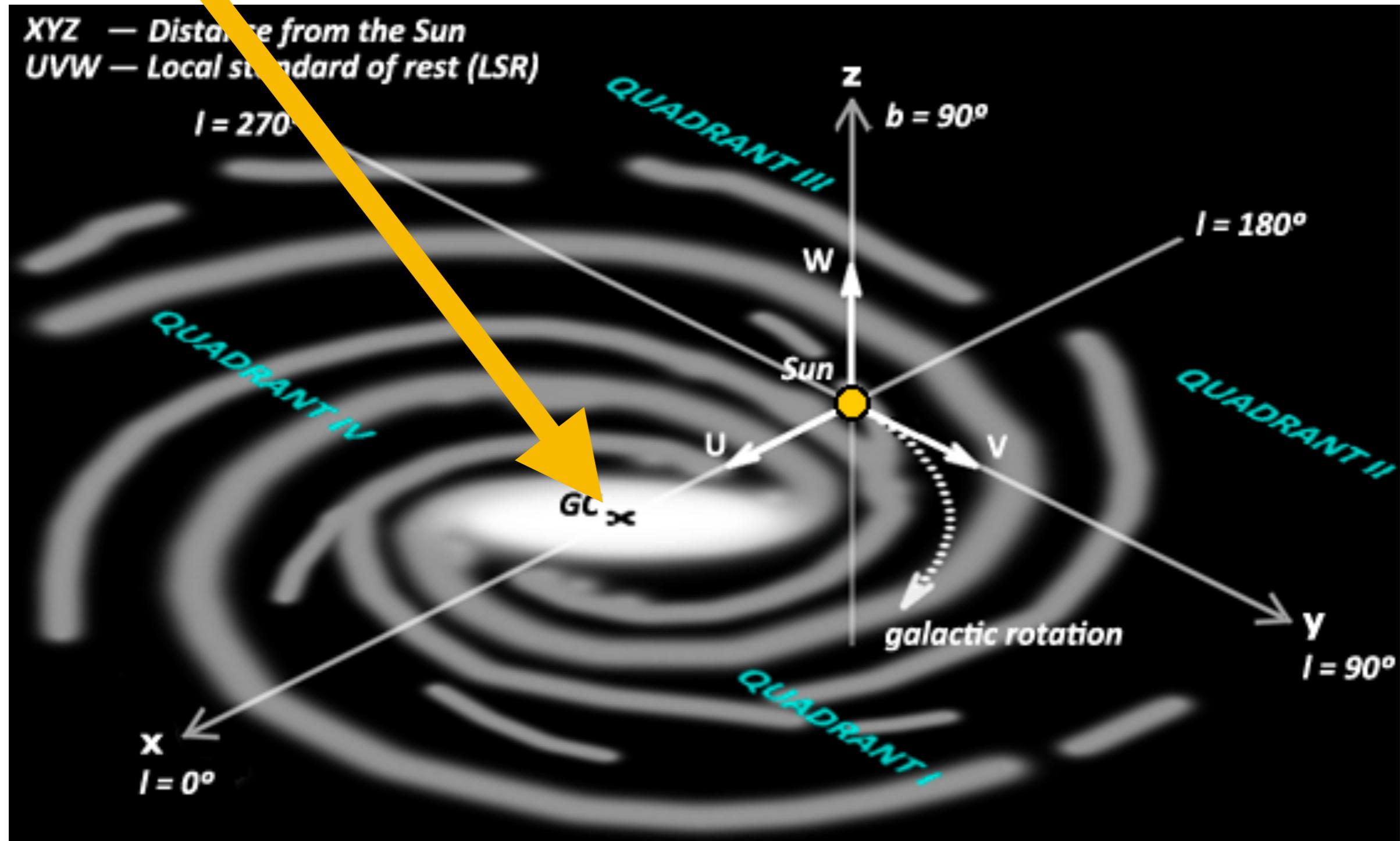


Galactic Coordinates

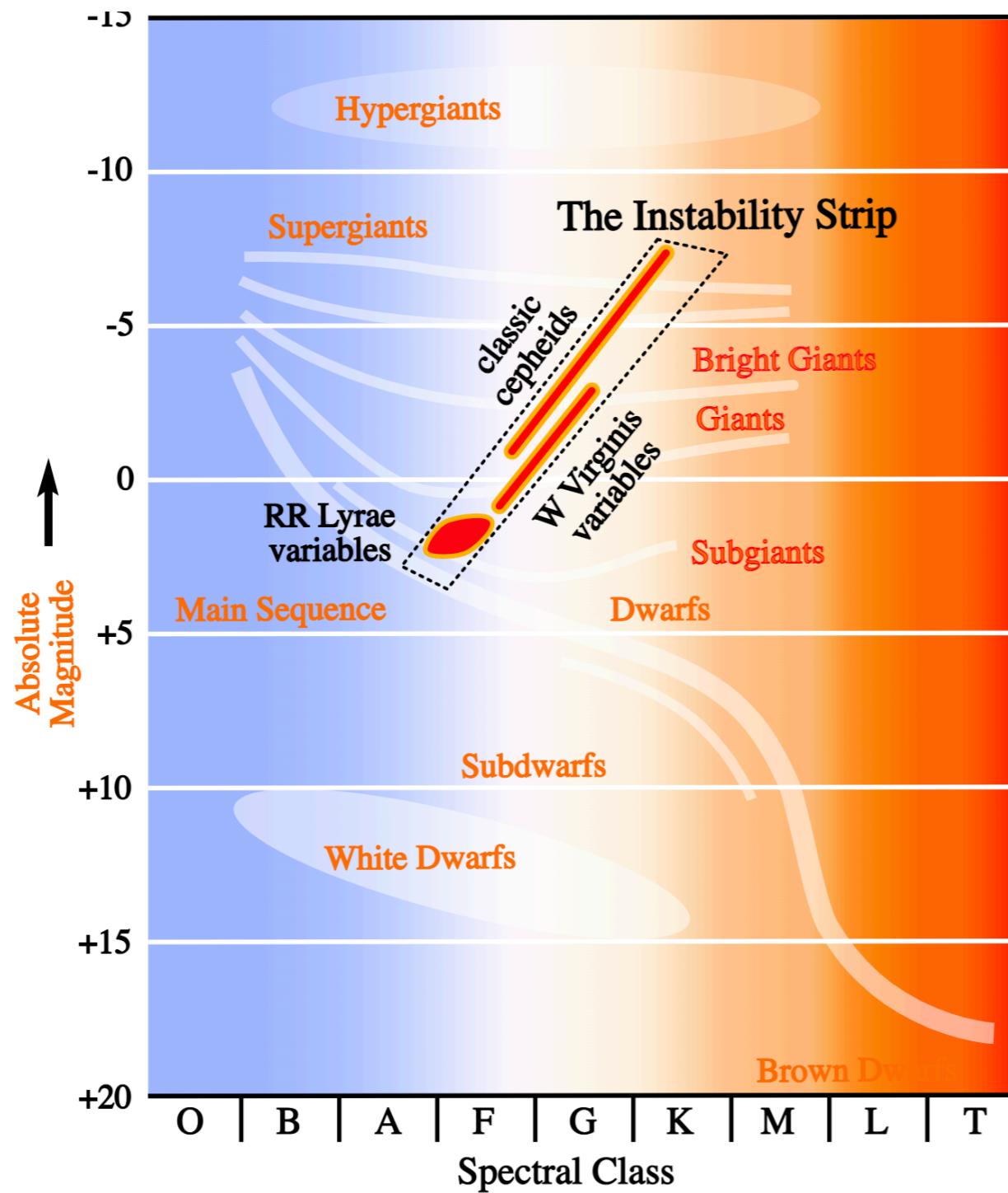


Galactic Coordinates

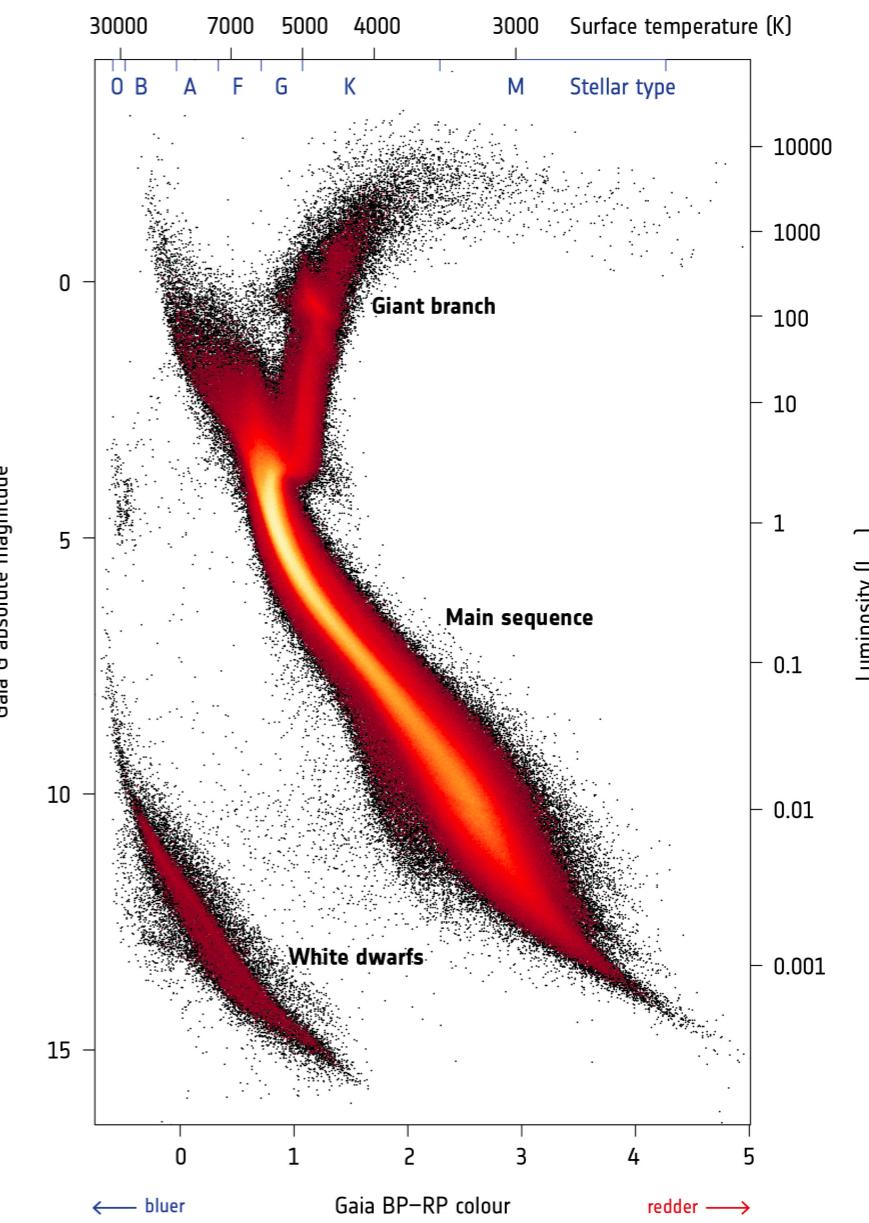
Transform so x, y, z are the same, but center is there



Star Evolution



→ GAIA'S HERTZSPRUNG-RUSSELL DIAGRAM



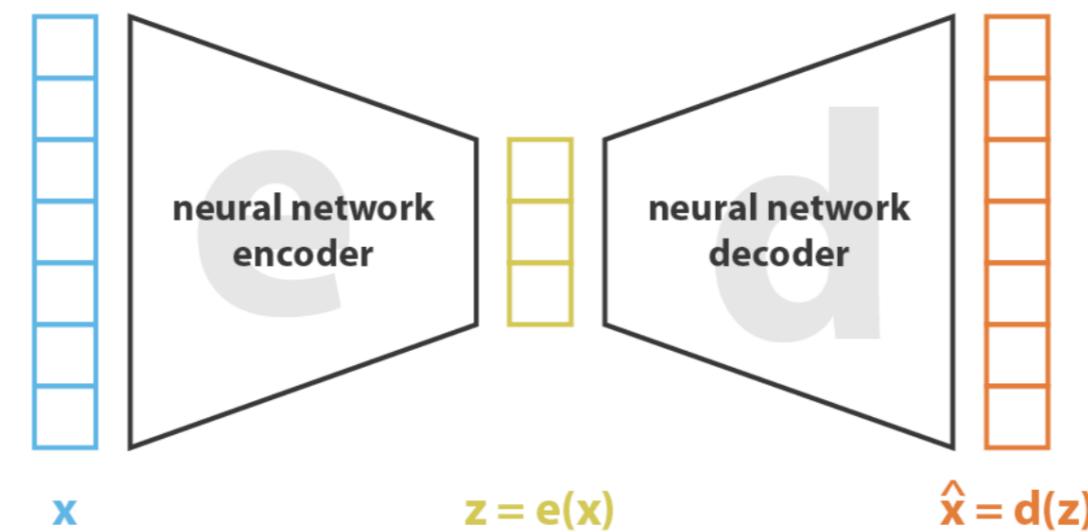
- Hertzspring Russell diagram devotes fate of star

Auto Encoder

- Regular autoencoder

Component 1:

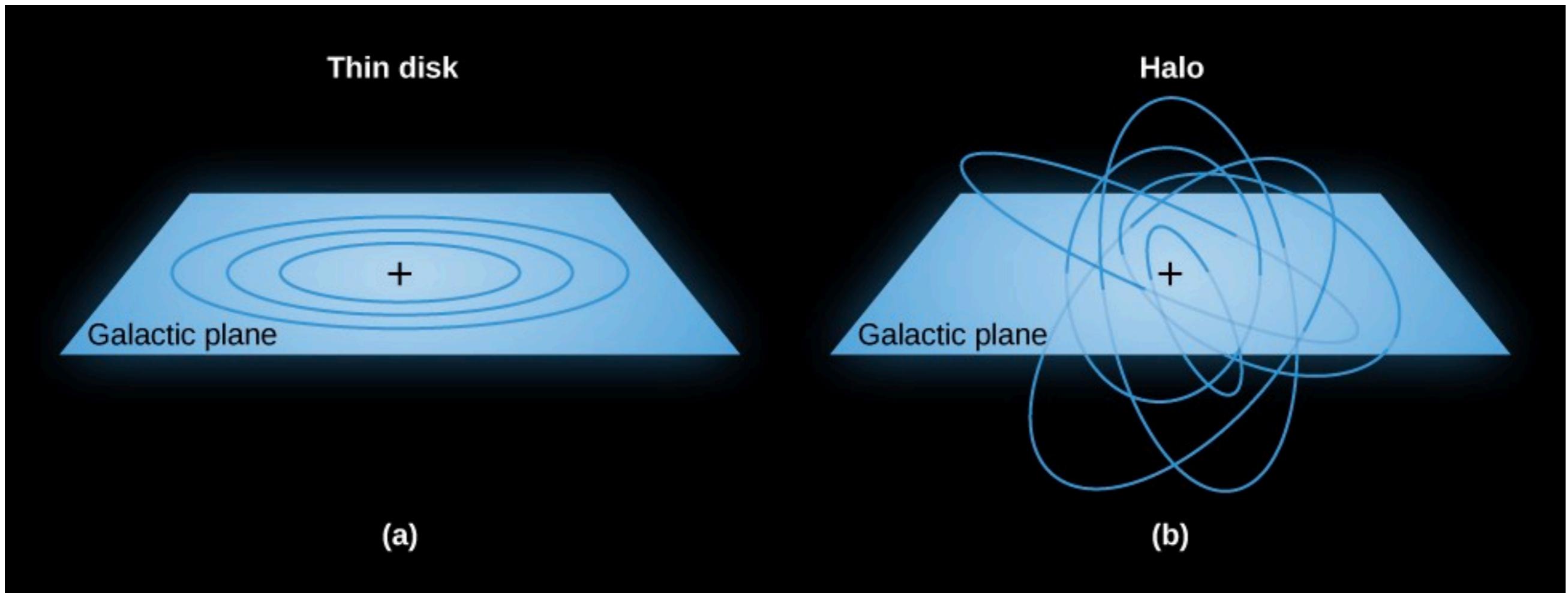
Encoder network performs “dimensionality reduction”*. High dimensional data is sent to a “latent space” of reduced dimension. The latent space is formed from (potentially) nonlinear combinations of input values.



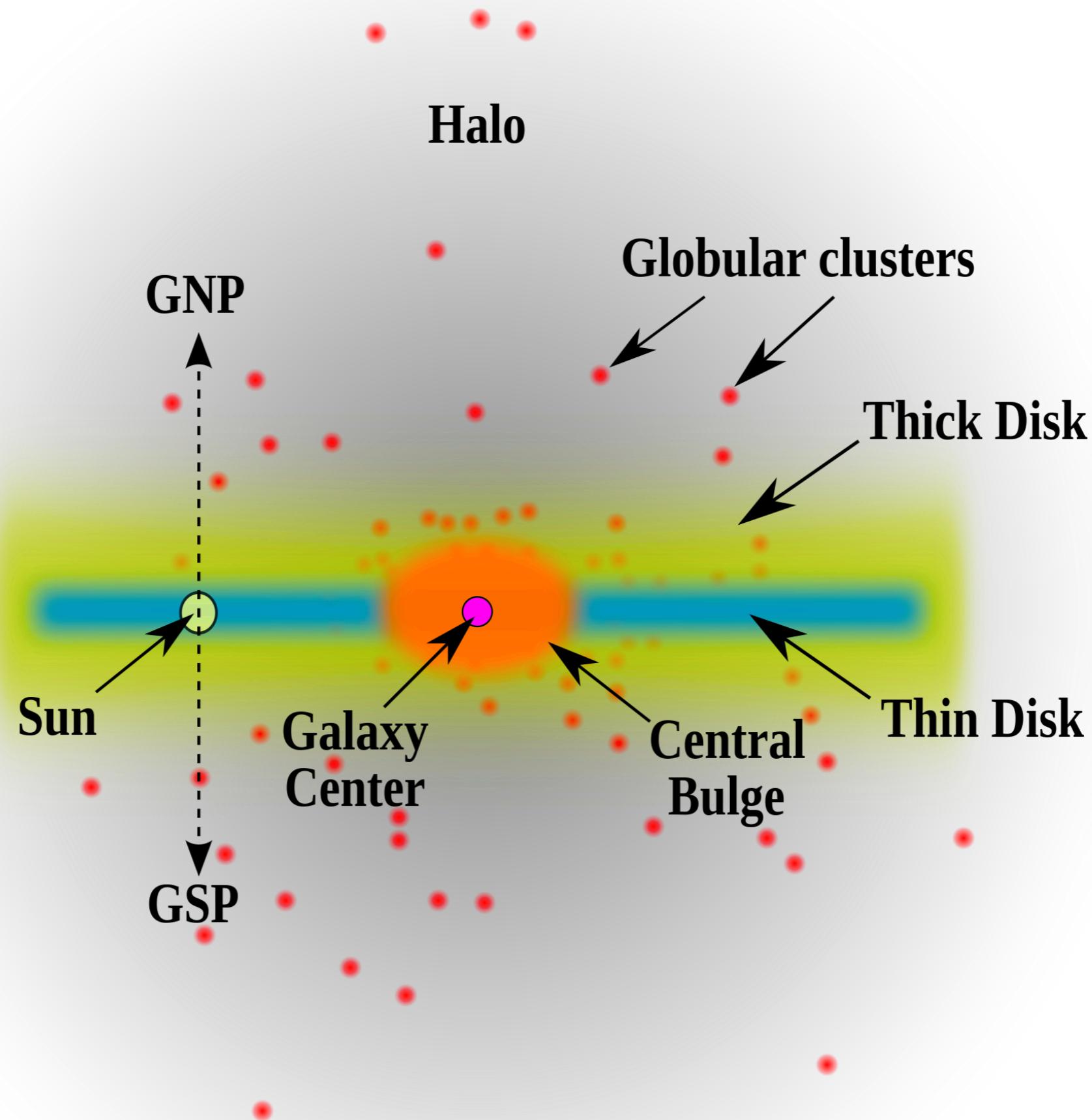
$$\text{loss} = \|\mathbf{x} - \hat{\mathbf{x}}\|^2 = \|\mathbf{x} - \mathbf{d}(\mathbf{z})\|^2 = \|\mathbf{x} - \mathbf{d}(\mathbf{e}(\mathbf{x}))\|^2$$

Training aims to minimize “reconstruction” loss, which is the difference between the initial and reconstructed data

Star Observations

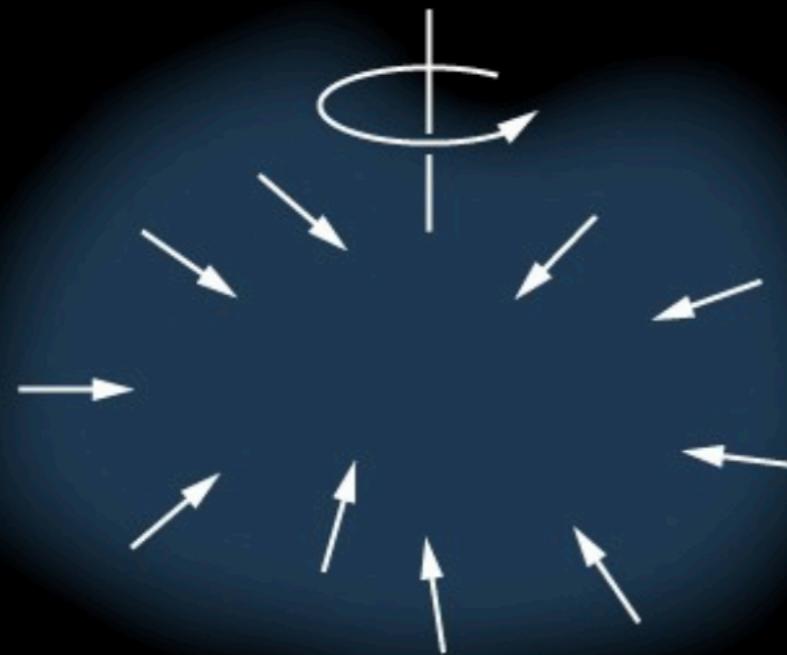


Star Observations

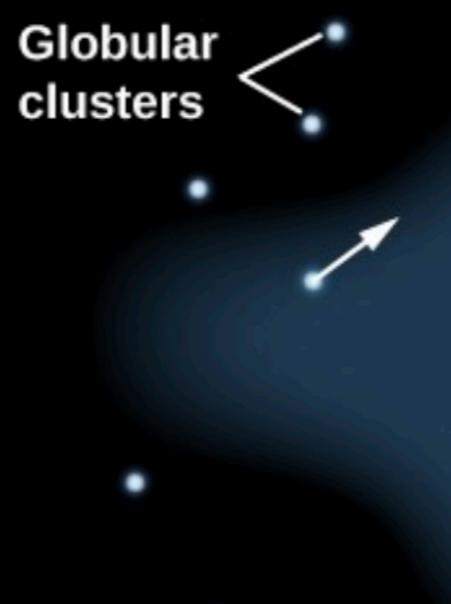


Star Observations¹³

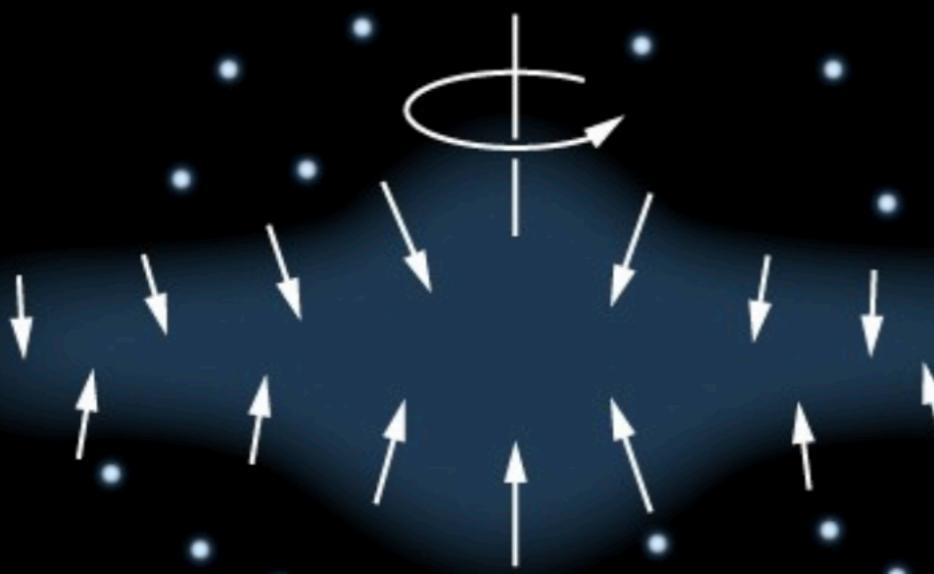
1



2



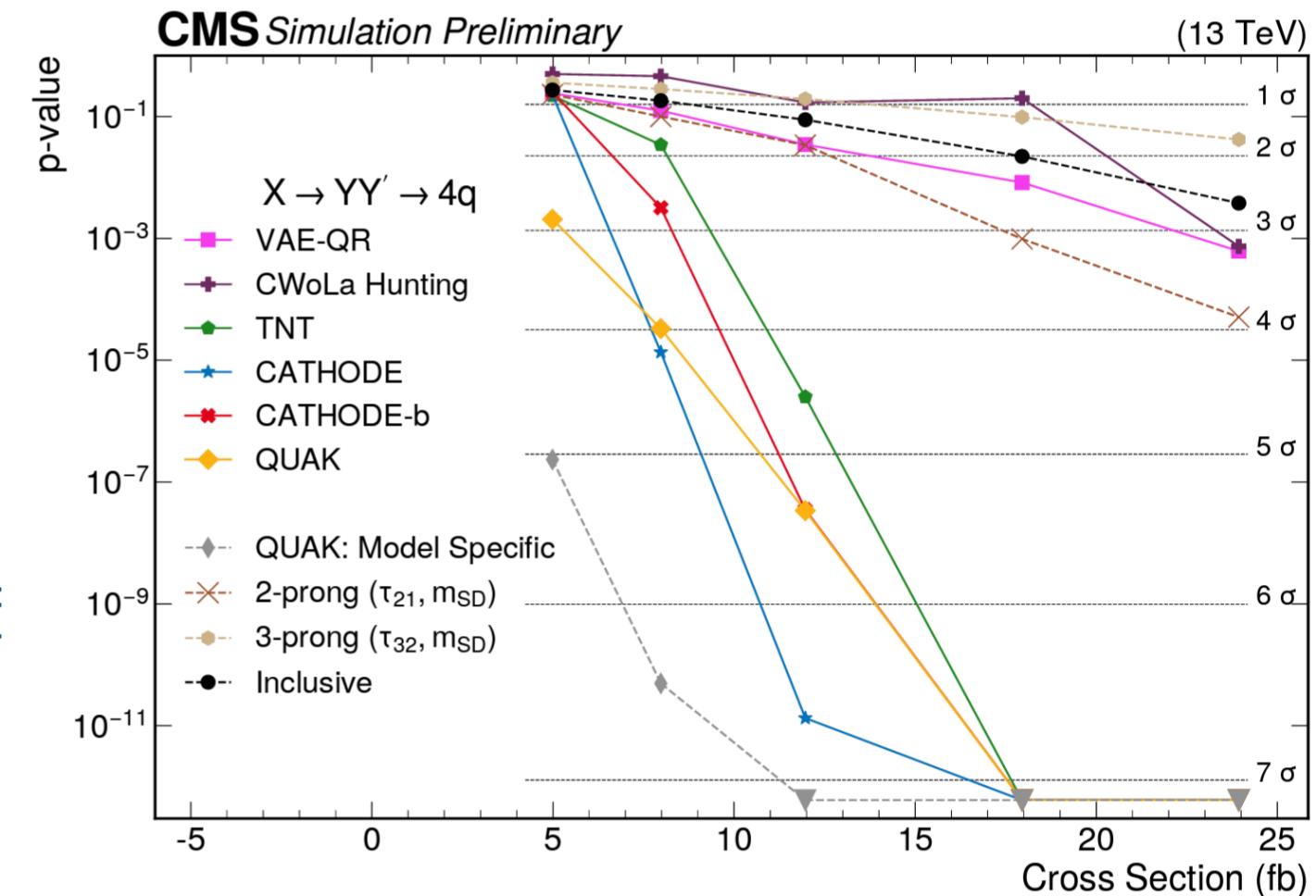
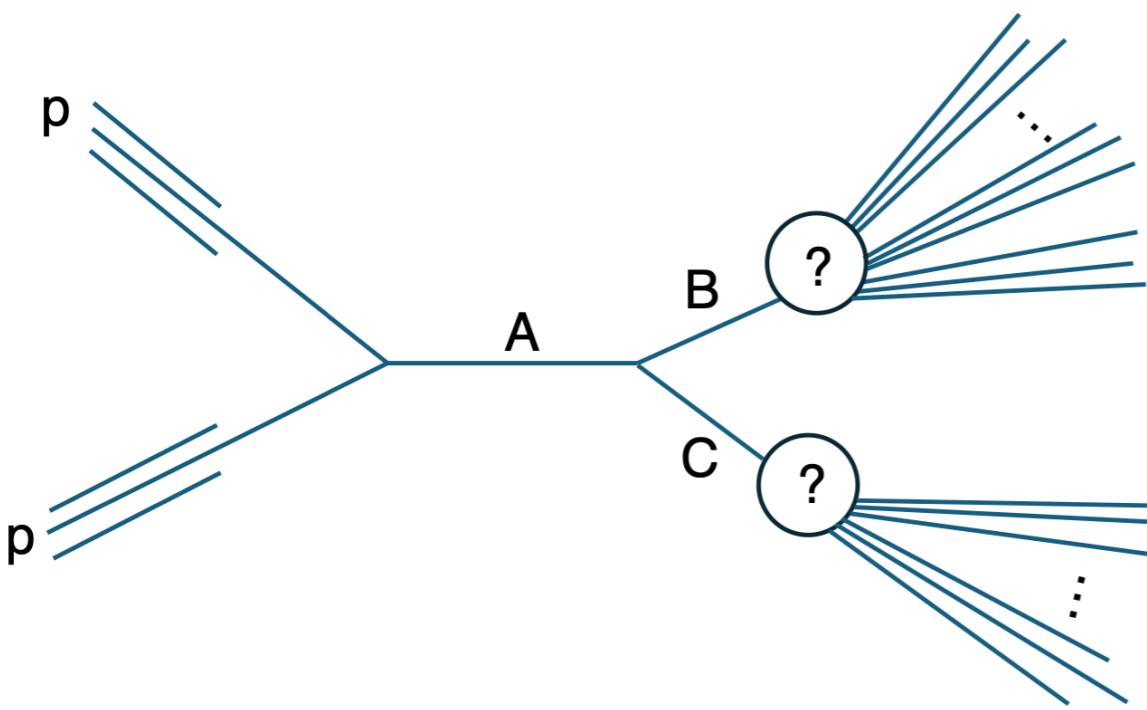
3



4



Anomaly Detection at LHC



Recently performed a similar search for anomalous collisions @LHC
Alas, we saw nothing :(

<https://cms.cern/index.php/news/can-ai-find-new-particles-its-own>

GNN Flow

