Ciências ULisboa Faculdade de Ciências da Universidade de Lisboa

centra center for astrophysics and gravitation

Vector field reconstruction using Integrated Nested Laplace Approximations: unraveling stellar cluster kinematics

I&D: Centra/SIM

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Advisors:
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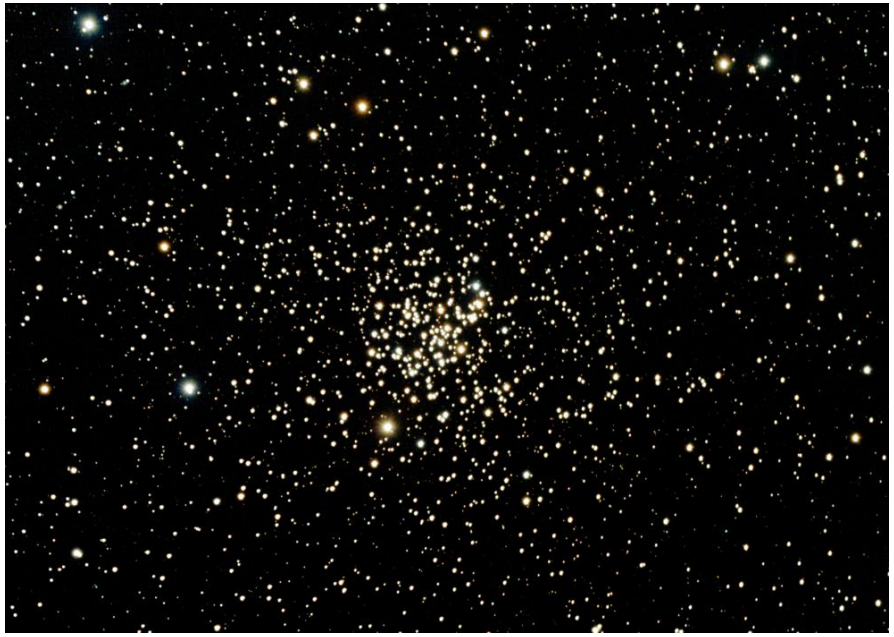
Open Clusters

- Gravitational collapse and fragmentation of a **same** molecular cloud
- **Similar** age and physical properties
- May share a **binding** gravitational **field**
- In the galactic disk
- Associated with younger stars
- Suffer **dissolution** and other disruptions



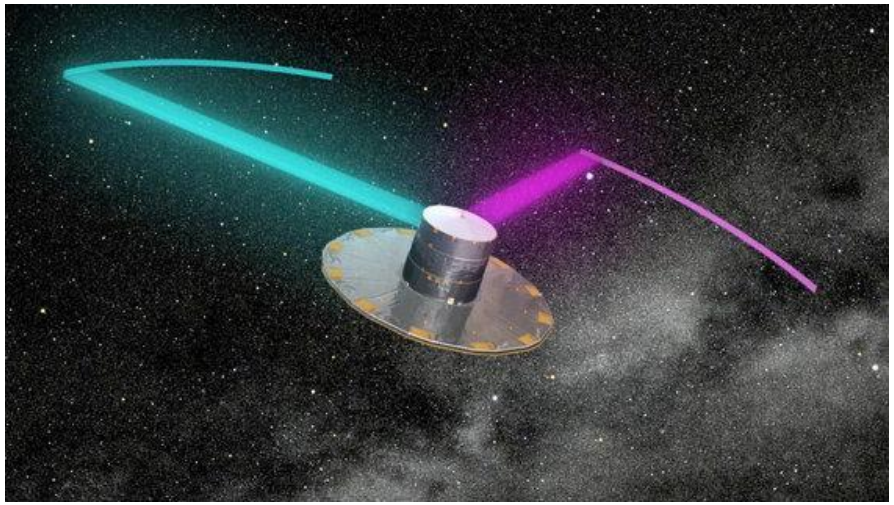
NGC 2682 (M67) – A Milky Way open cluster
http://cs.astronomy.com/asy/m/starclusters/464451.aspx

INLA

- **Bayesian inference** approximation of a field from dataset
- Using the **Laplace approximation**, INLA searches for parameters for a Gaussian approximation to the posterior distribution, that we assume **Gaussian**
- Consideration of spatial correlation: **Matérn correlation** function
- **Faster** than MCMC methods

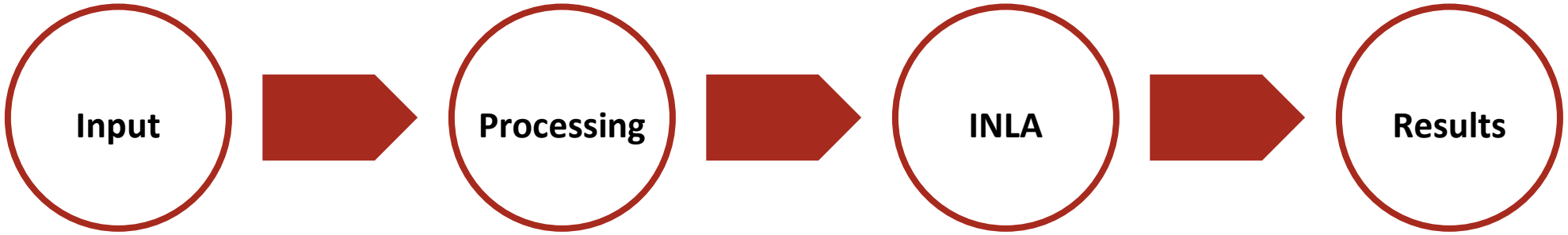
Data

- Gaia
  - Understand the **formation** and **evolution** of our galaxy
  - Positions, parallaxes, proper motions, radial velocity and color information
  - Most **precise**, **accurate** and **complete** astrometric catalog
- UPMASK
  - Derive open cluster **membership**
- Processed data
  - R.A., Dec., proper motions, uncertainties and membership probability



Gaia satellite
ESA/Gaia/DPAC

My method



- Coordinates
- Proper motions
- Membership
- Uncertainties
- Etc...

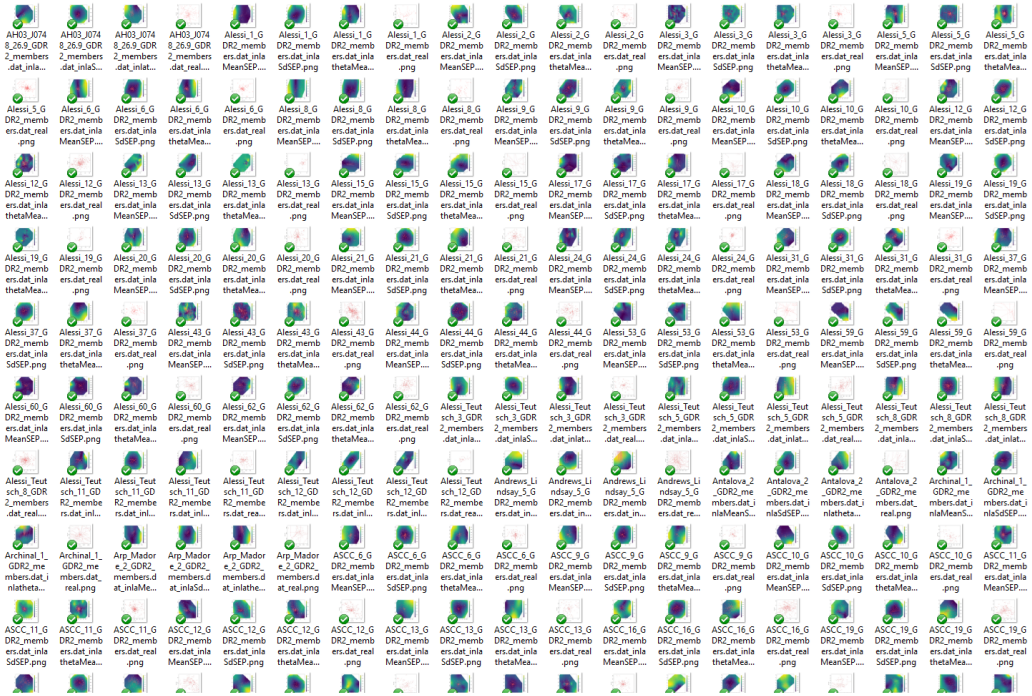
- Membership truncation
- Internal kinematics
- Perspective correction

- Mesh
- SPDE
- Matérn
- Weight factor

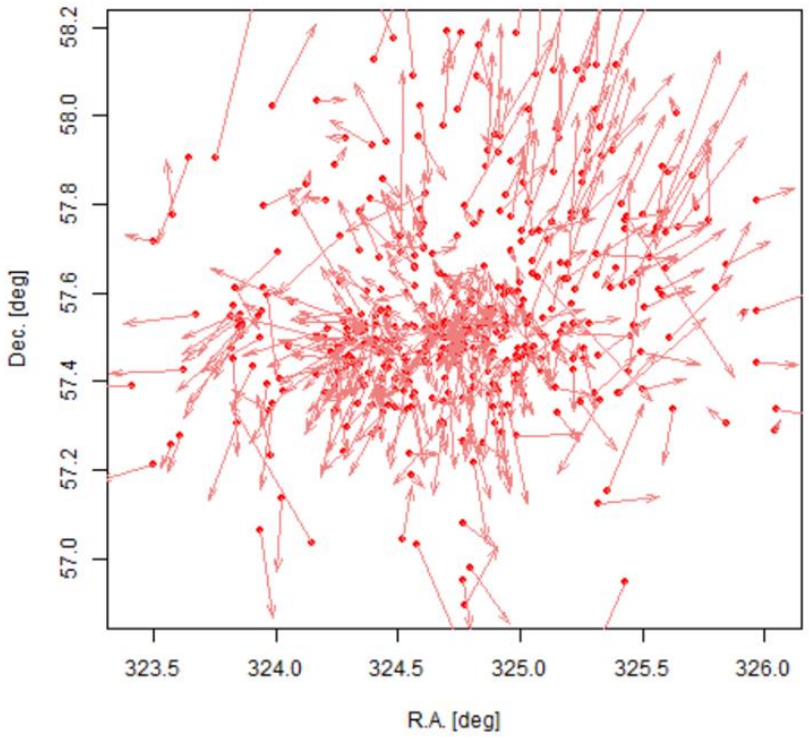
- Proper motion reconstructions
- Radial velocity reconstructions
- Velocity curves

Overview

- **1237 clusters** were processed
- We looked for **spatial patterns**: **rotation**, **expansion** and **contraction**
- Highly **uncertain** fields were **discarded**
- Gaia **errors** were taken into account
- Stars with **higher membership** probability and **smaller errors** count more in the analysis

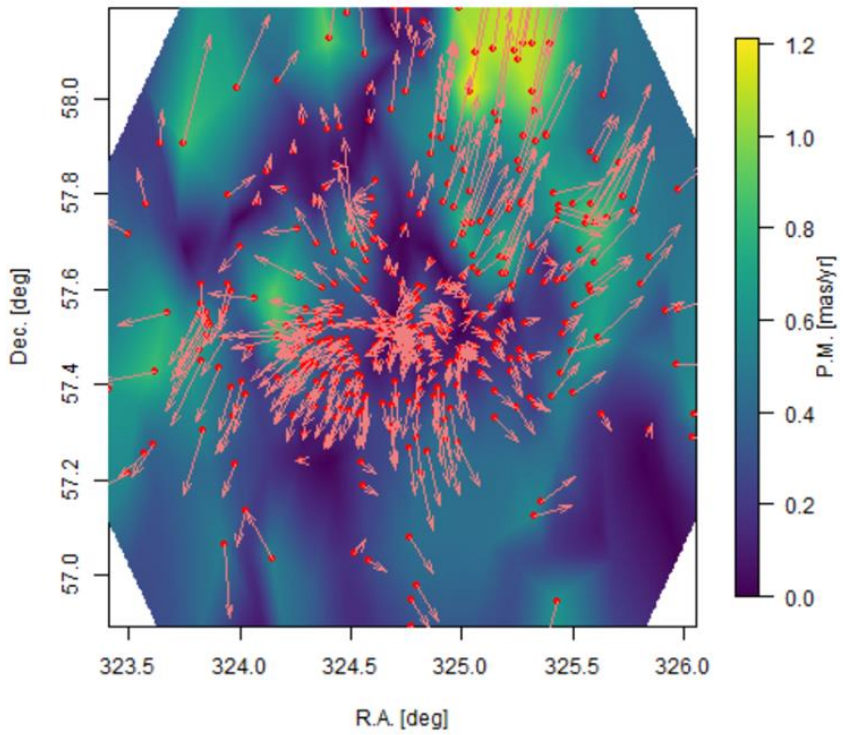


Interesting cases 1

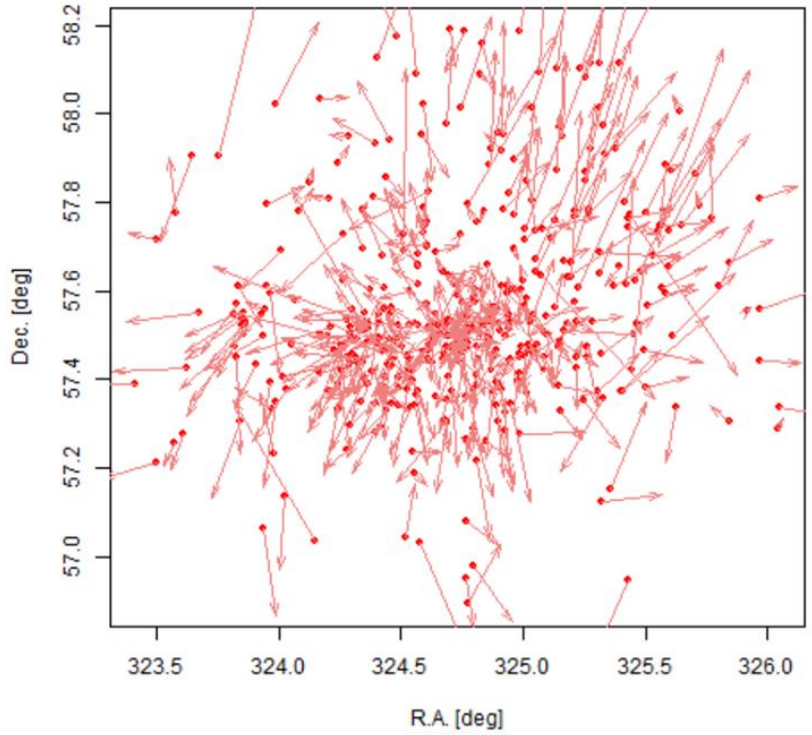


IC 1396, real data

Interesting cases 1



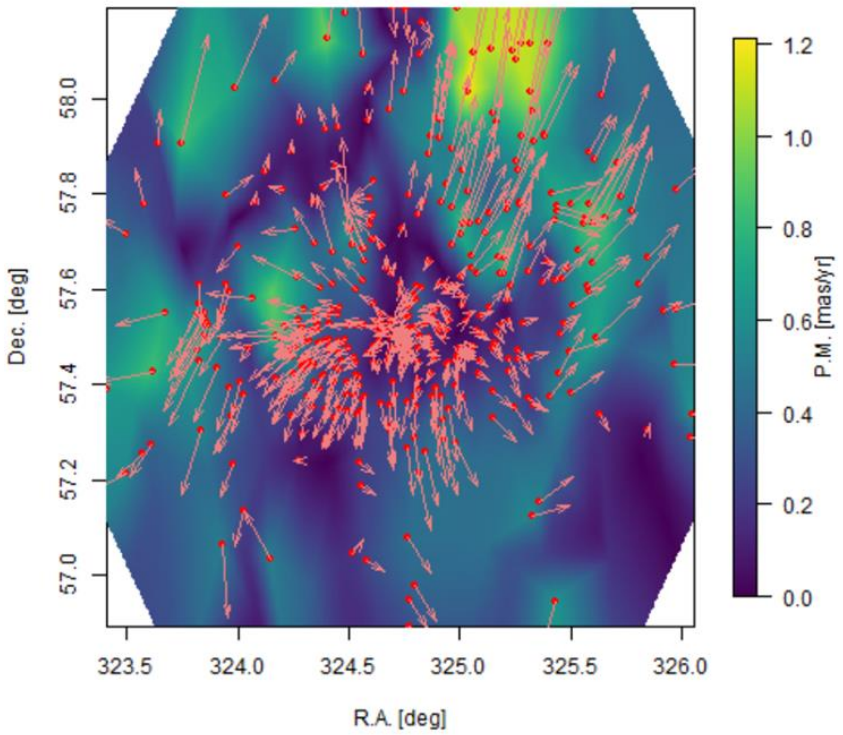
IC 1396, inferred data



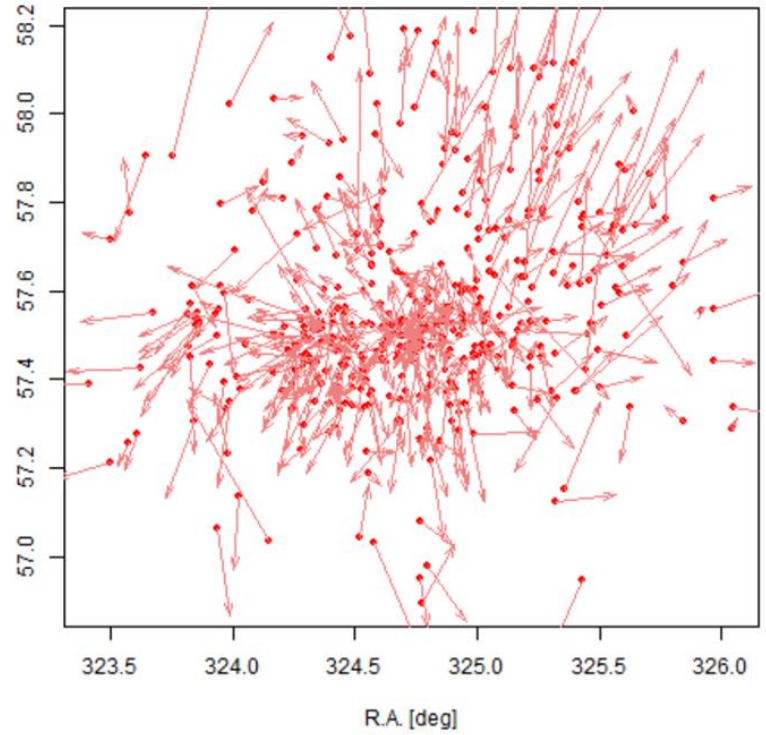
IC 1396, real data

Interesting cases 1

Spatial patterns **stand out** with more clarity!



IC 1396, inferred data

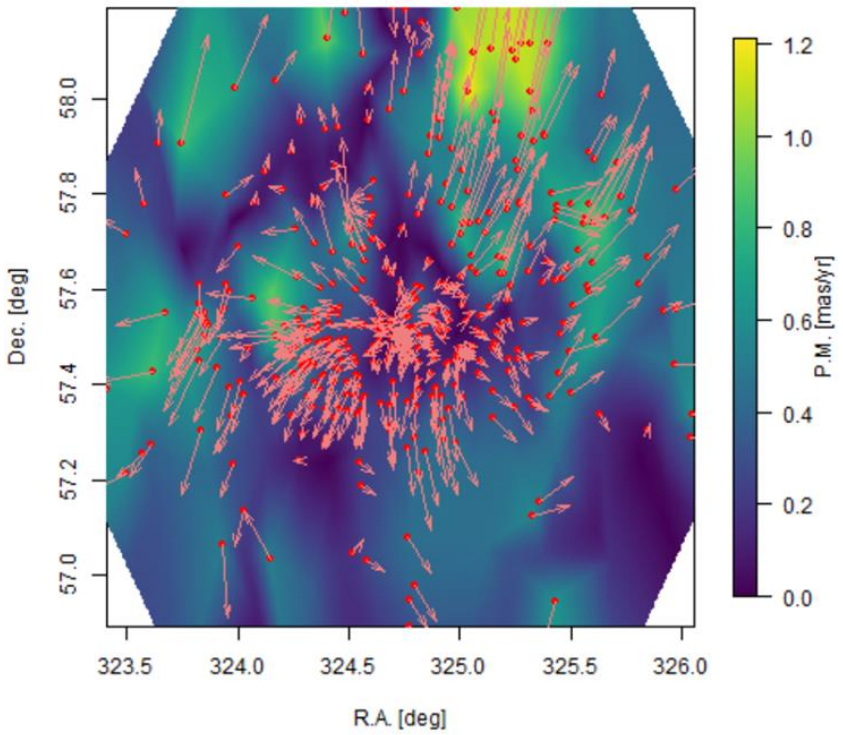


IC 1396, real data

Interesting cases 1

Spatial patterns **stand out** with more clarity!

Seems to follow the study by Garmire et al.,2012



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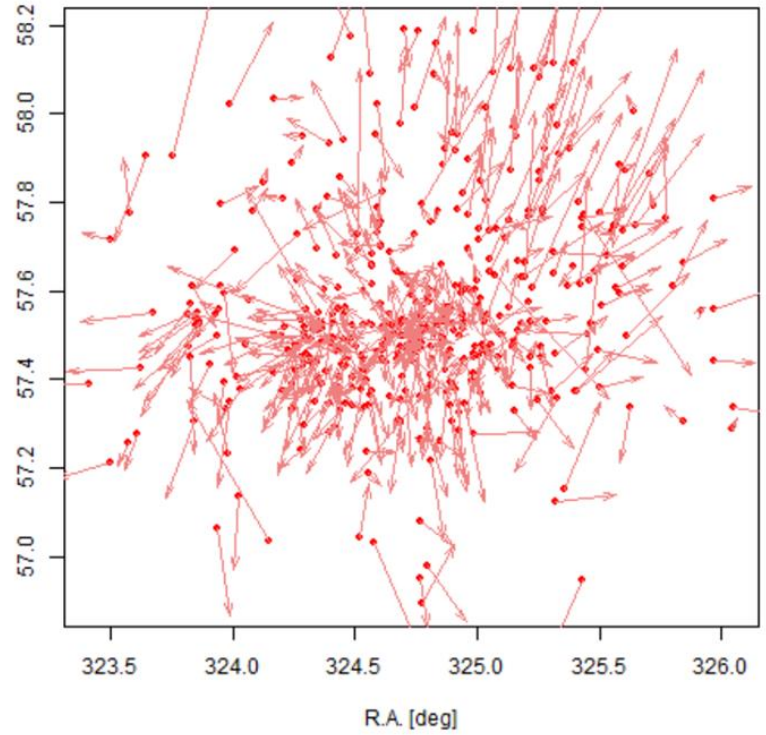
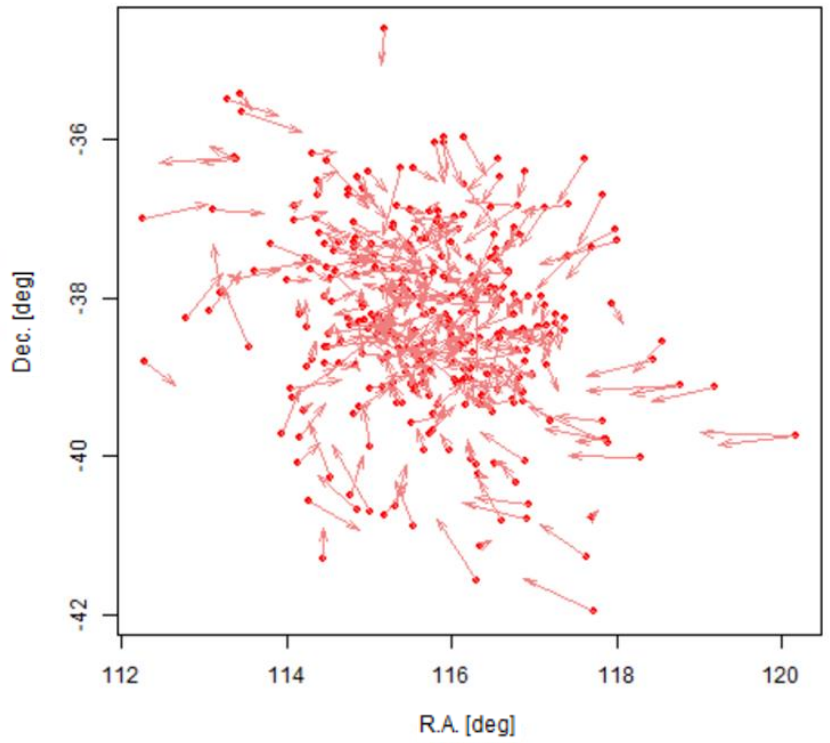


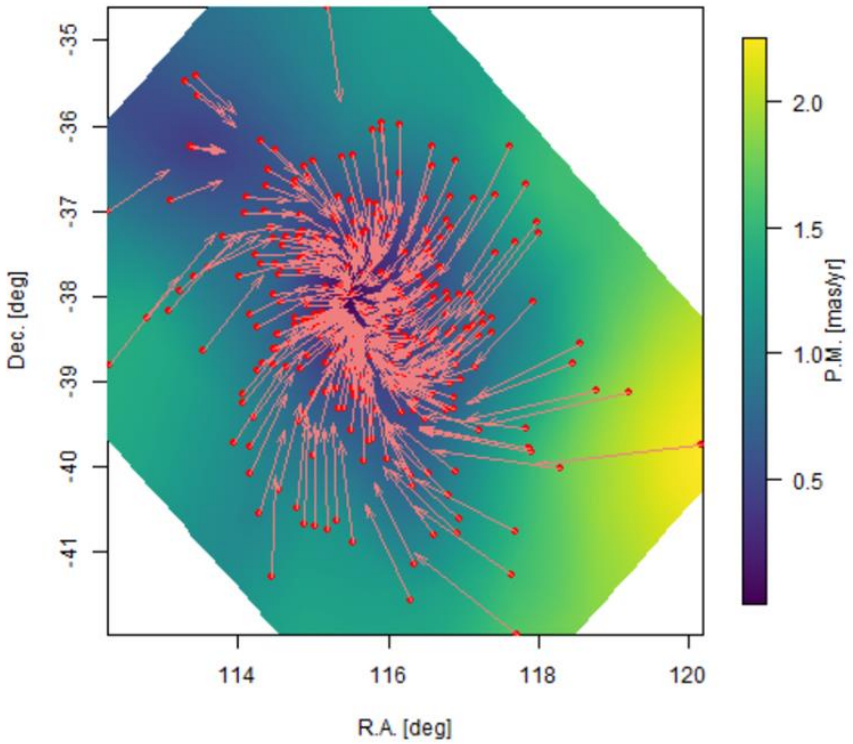
IC 1396, real data

Interesting cases 2

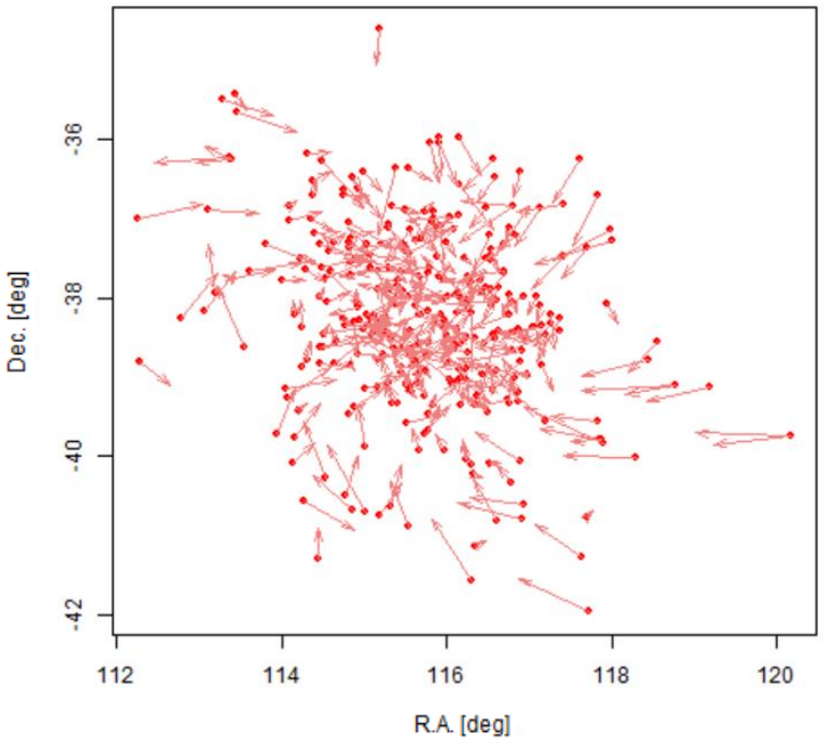


NGC 2451A, real data

Interesting cases 2



NGC 2451A, inferred data



NGC 2451A, real data

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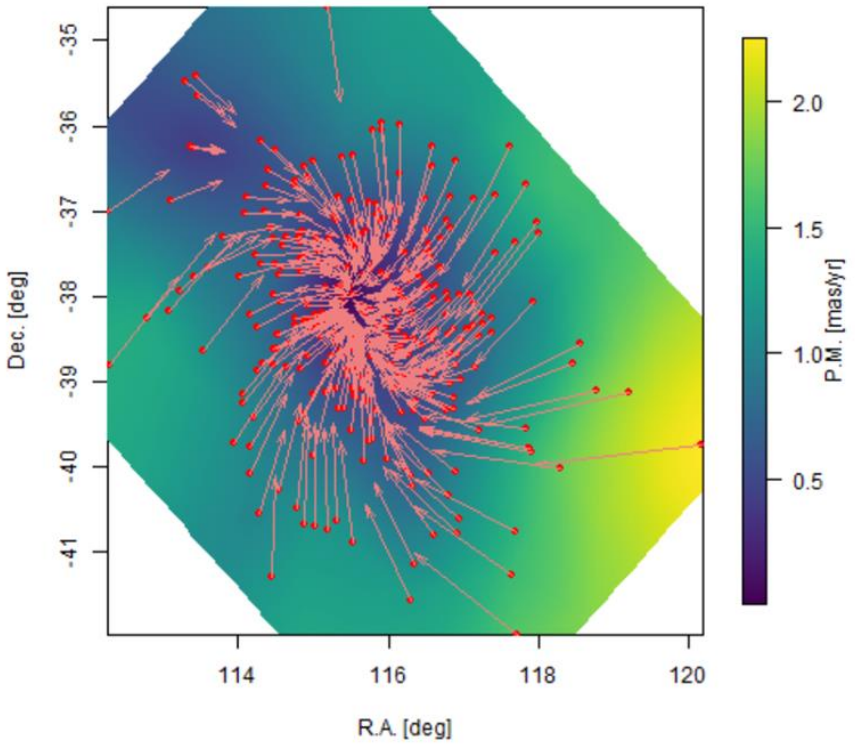
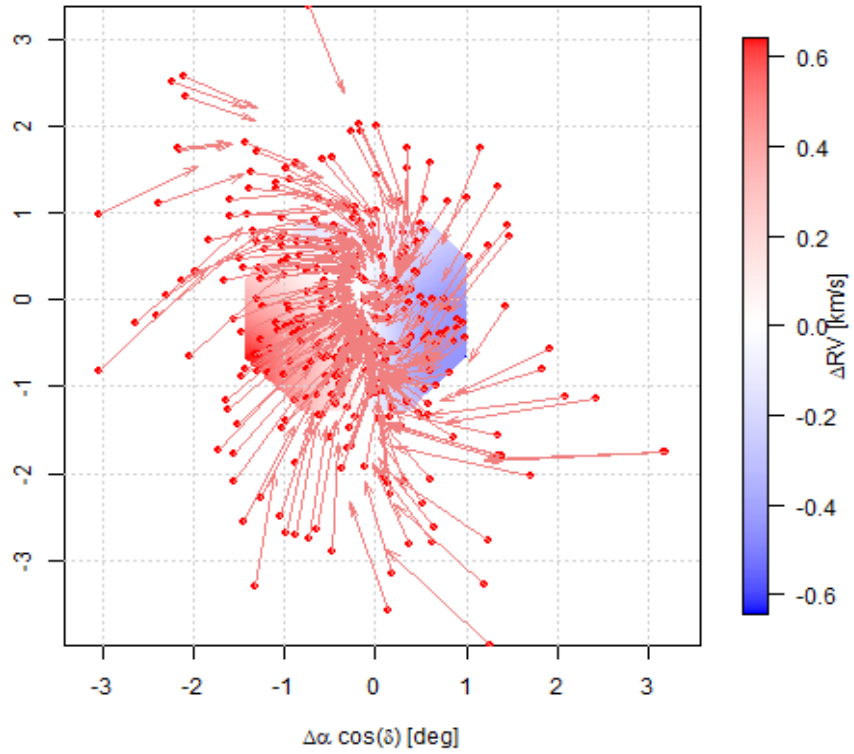
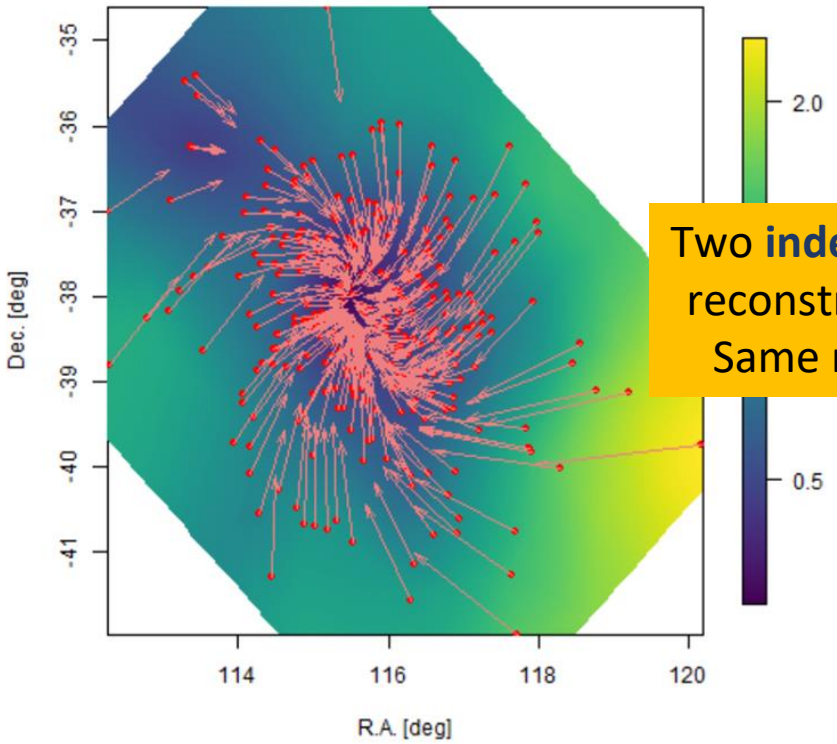


NGC 2451A, inferred data

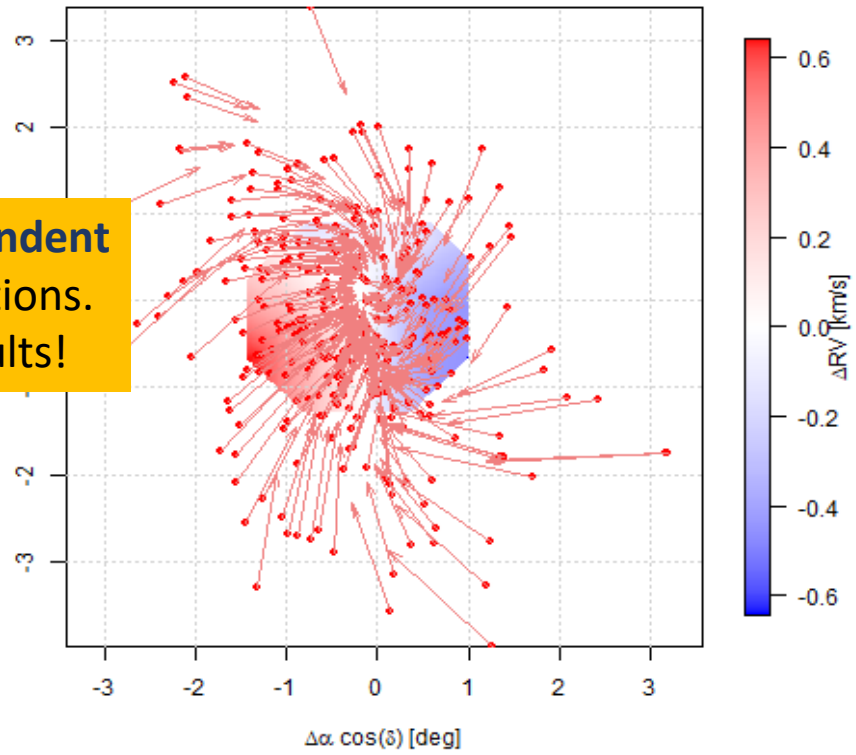


NGC 2451A, inferred RV

Interesting cases 2



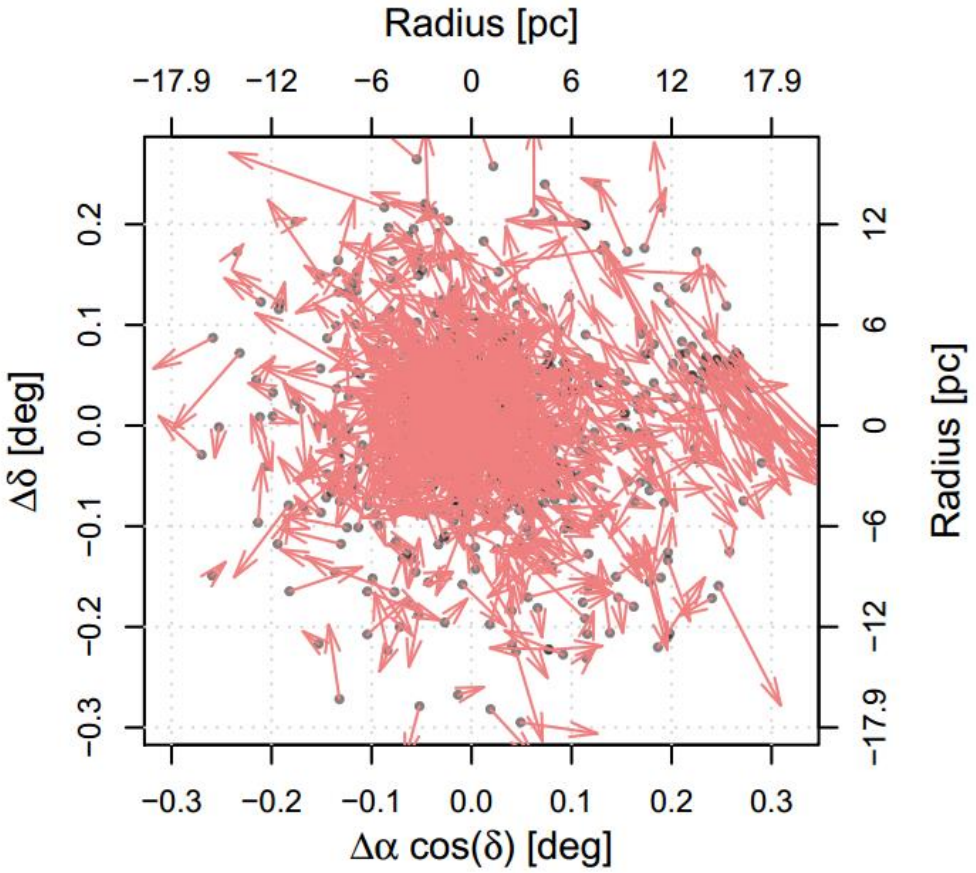
Two **independent** reconstructions. Same results!

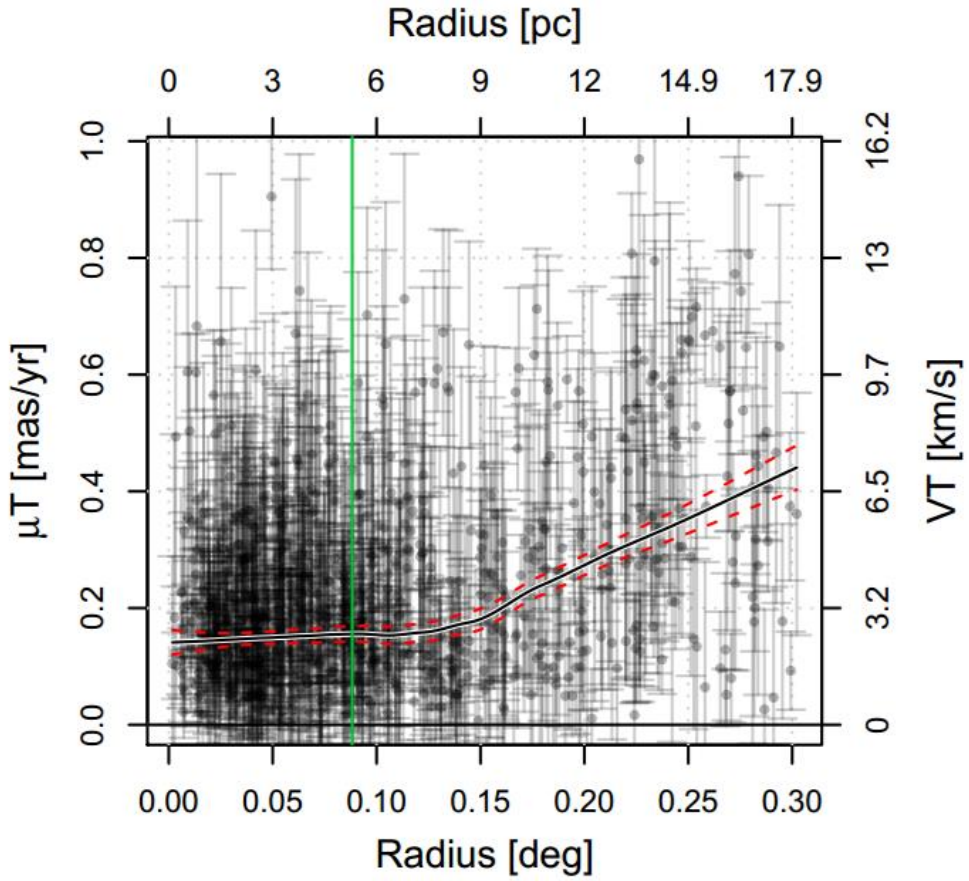


NGC 2451A, inferred data

NGC 2451A, inferred Gaia P.M. and Gaia-ESO RV

Interesting cases 3

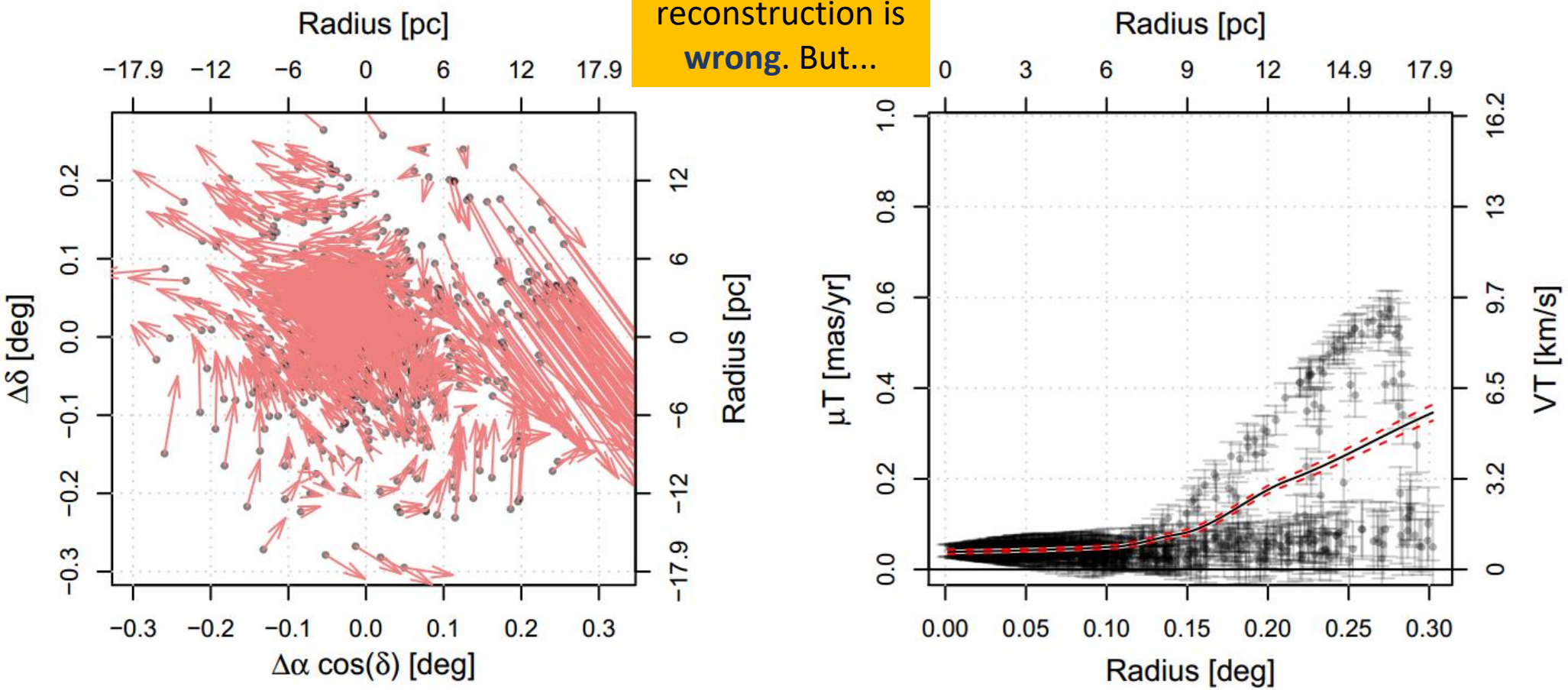




NGC 2194, real data

Interesting cases 3

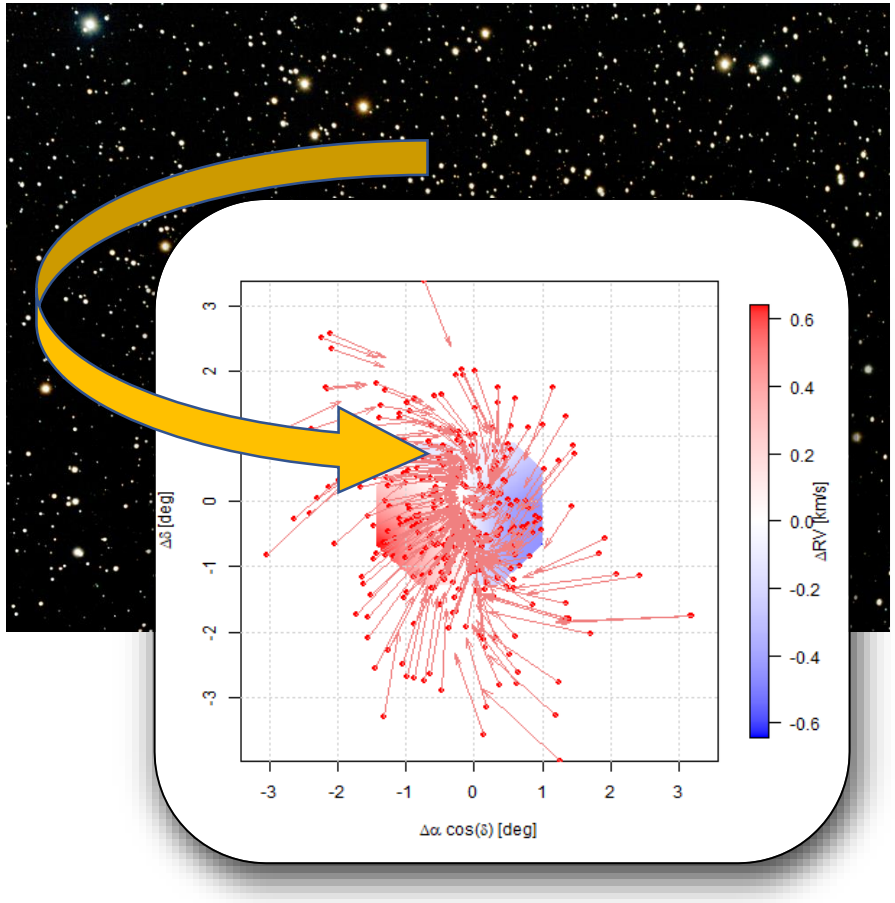
The reconstruction is **wrong**. But...



NGC 2194, inferred data

Conclusion

- The pipeline I created is a **viable option**
- **Reveals additional information** in the clusters' dynamics
- We detected objects that reveal **statistically significant** and interesting patterns in their internal proper motion fields



NGC 2451A
Proper motions vector field and RV reconstruction