StreamSim tutorial

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DESC project

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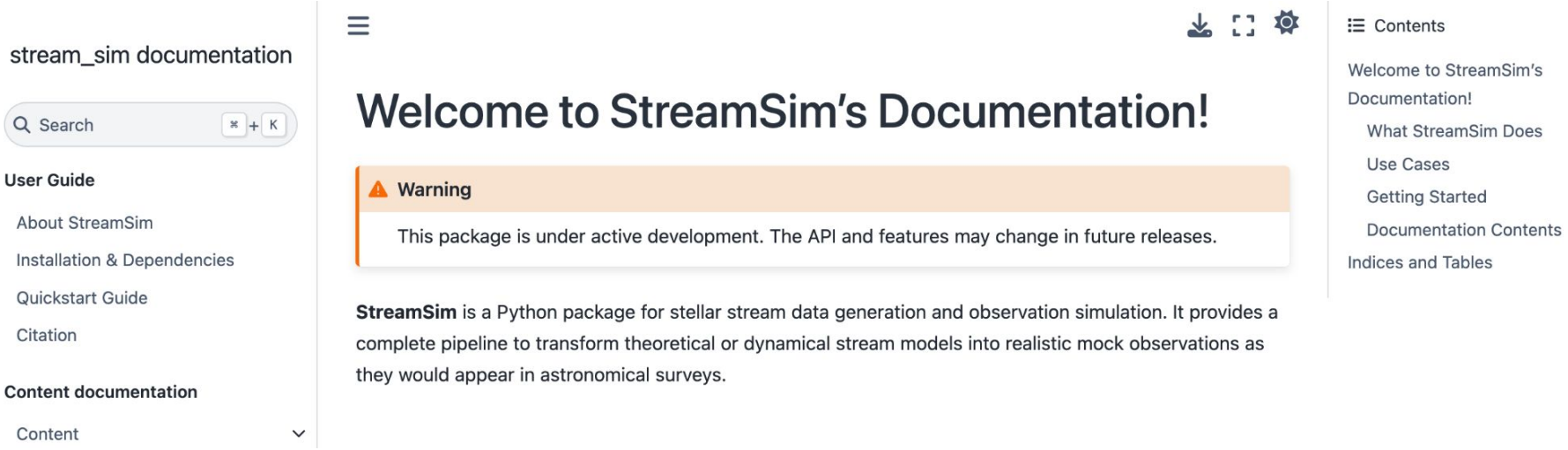
Introduction

Introduction: what is StreamSim?

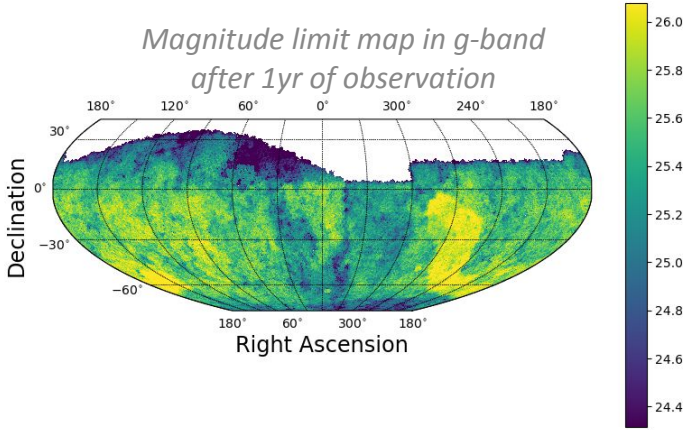
StreamSim:

- **Public** package available on GitHub
- Currently under active **development**
- Designed for **easy** use (hopefully!)
- **Documentation** and **tutorials** available



Introduction: why do we need StreamSim?

Dynamical simulations = idealized situation



- Observation **impacted** by survey's **systematics**
- **Not all** the star members are **observed**

StreamSim goals:

- **Bridge** dynamical **simulation** and **observation** in photometric surveys
- **Not** intended to generate **dynamic models** or N-body simulations

Dynamical simulations → StreamSim → Observed data

Mimic LSST observation (completeness, magnitudes and errors according to depth maps)

StreamSim functionalities

Generating mocks: parametric sampler

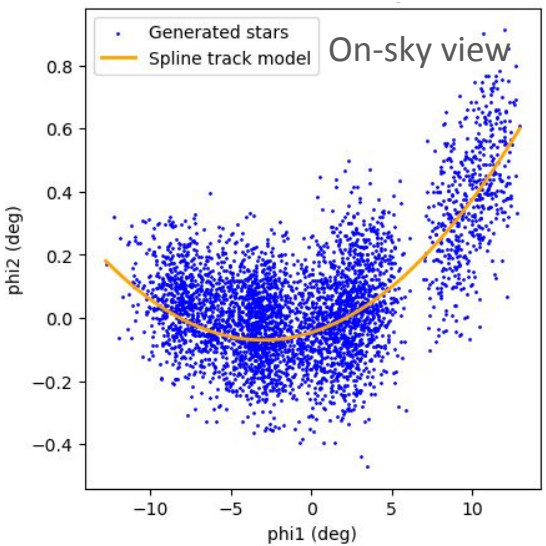
Parametric models (e.g splines) defining:

- Track
- Density profile
- Distance modulus

Sample N_stars

Or your **dynamical simulations**

Stars coordinates (phi1, phi2, distance modulus)



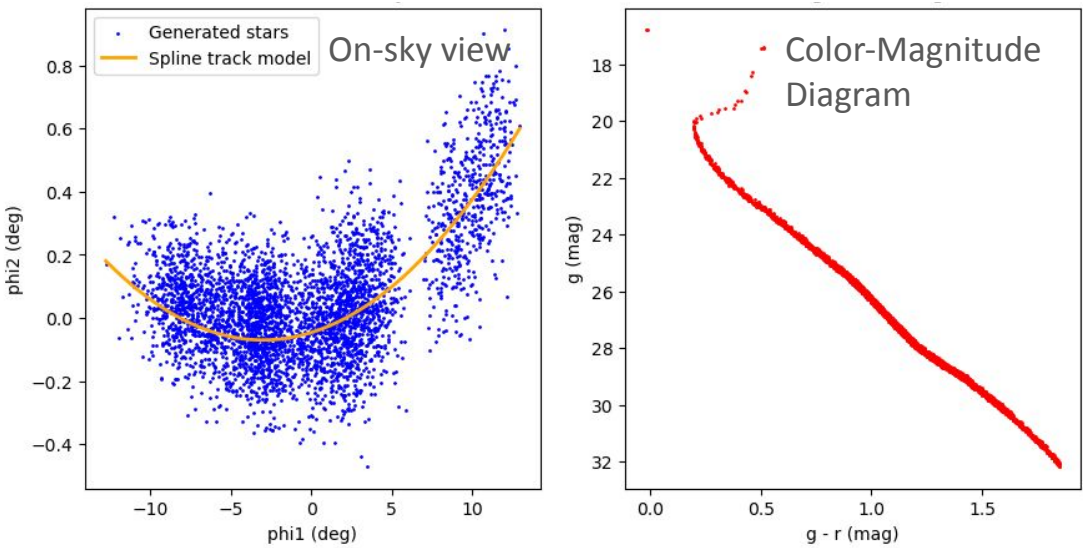
Example: realization from Phoenix stream spline

Generating mocks: magnitudes

Parametric models (e.g splines) defining:

- Track
- Density profile
- Distance modulus

Sample N_stars



Example: realization from Phoenix stream spline

Or your **dynamical simulations**

Stars coordinates (phi1, phi2, distance modulus)

Choose stars population **Age + metallicity**

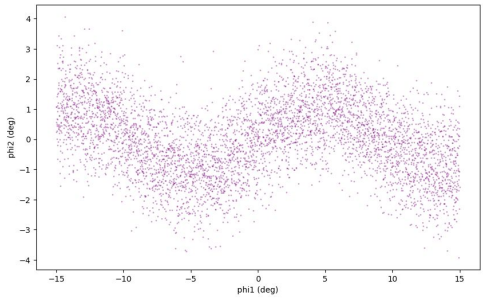
Define Isochrone (using Ugali package)

= **Distribution of a star population** in a Colour-Magnitude Diagram

Sample true apparent magnitudes in chosen **photometric bands**

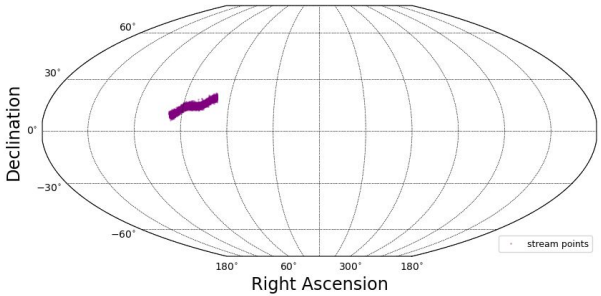
Generating mocks: coordinates conversion

Stream generated in analysis coordinates **(phi1, phi2)**



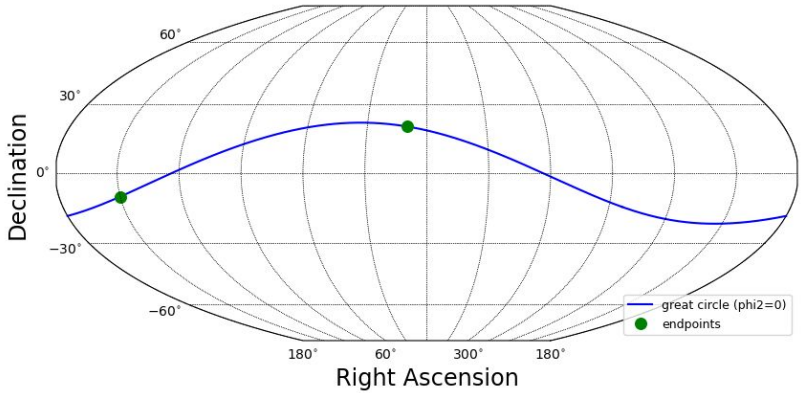
Conversion = rotation of basis

Stream observed in **(ra,dec)**



- choose 2 **endpoints** (anywhere in the sky or in a selected mask)
- They define a **great circle** (phi2 = 0)

Note: optional if (ra, dec) already in your data



Conversion to observed data-like: pipeline

(ra, dec), apparent magnitudes

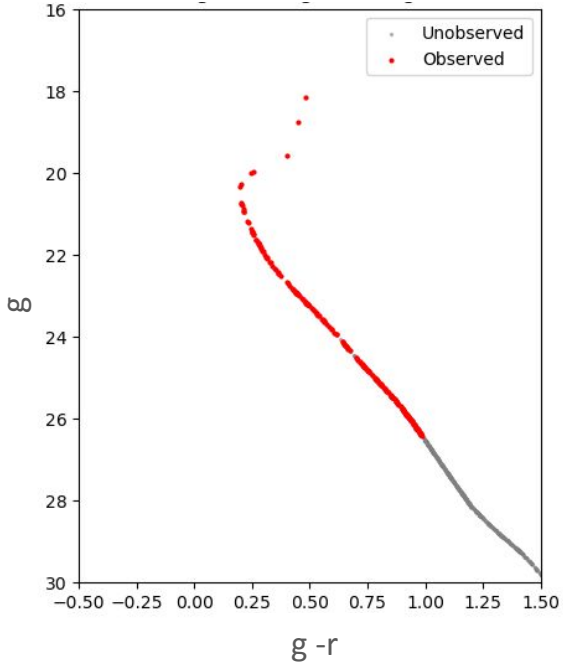
↓

Injection pipeline

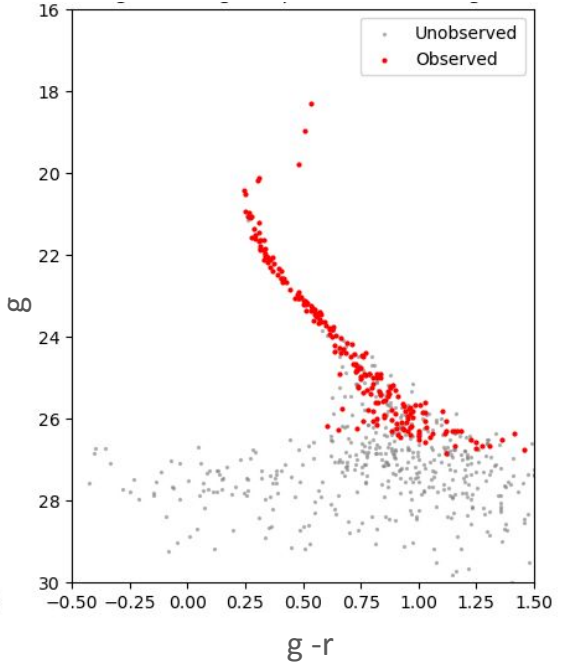
↓

Observed magnitudes + errors, detection + classification boolean

CMD with **true** magnitudes



CMD with **observed** magnitudes



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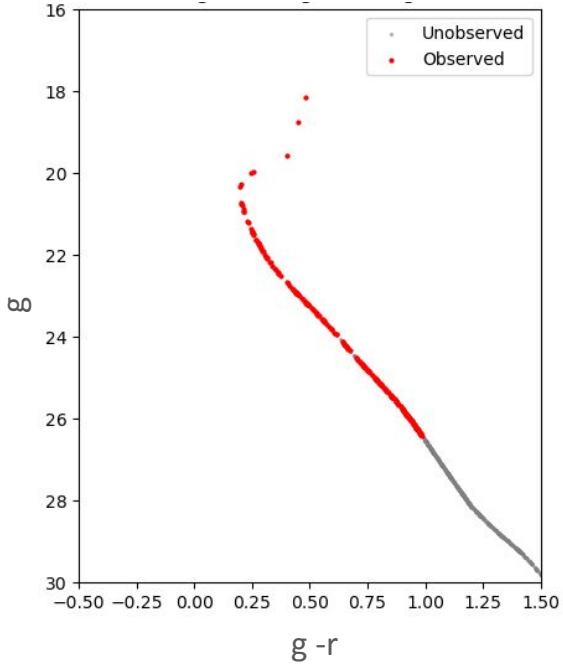
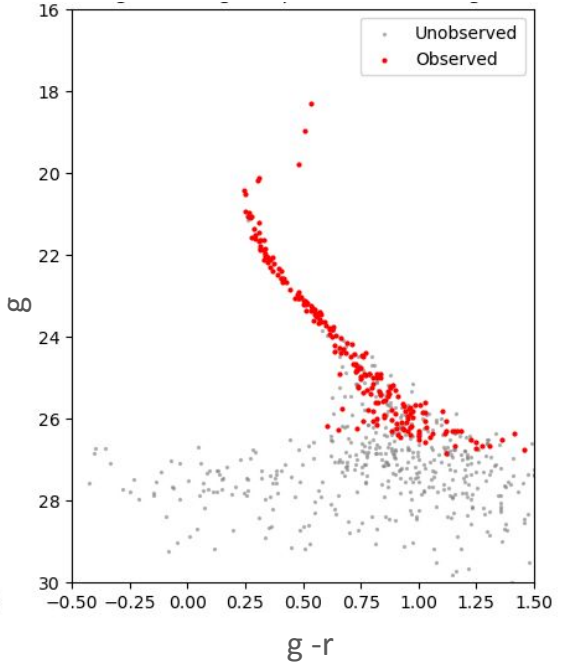
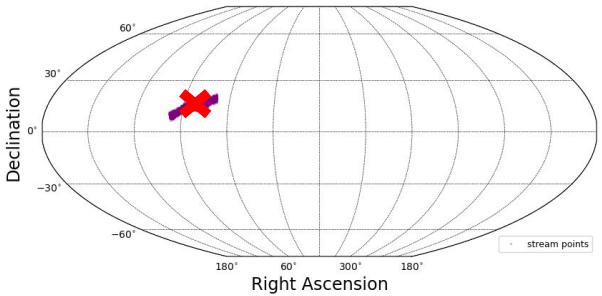


CMD with **observed** magnitudes

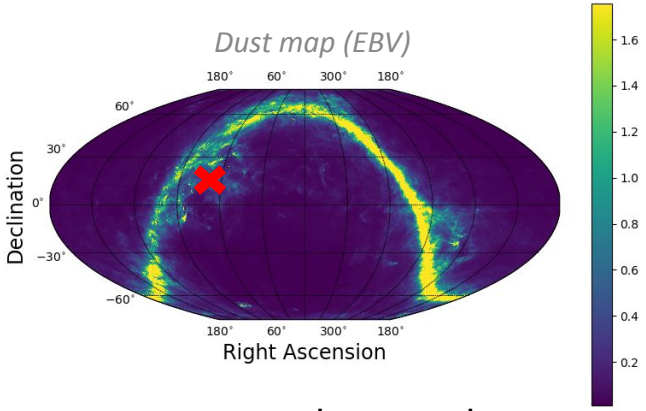


Conversion to observed data-like: dust extinction

For each stars of the stream
(ra, dec, magnitude)



Estimate **dust** extinction at (ra, dec)

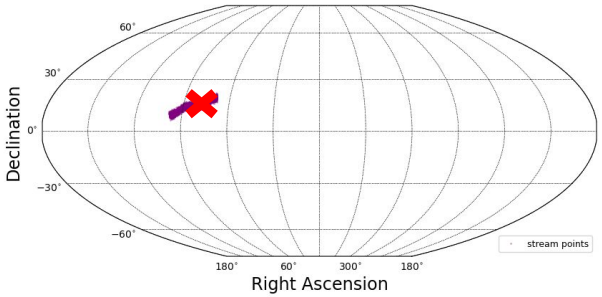


mag_apparent = mag_true + ebv × coeff

Apparent magnitude

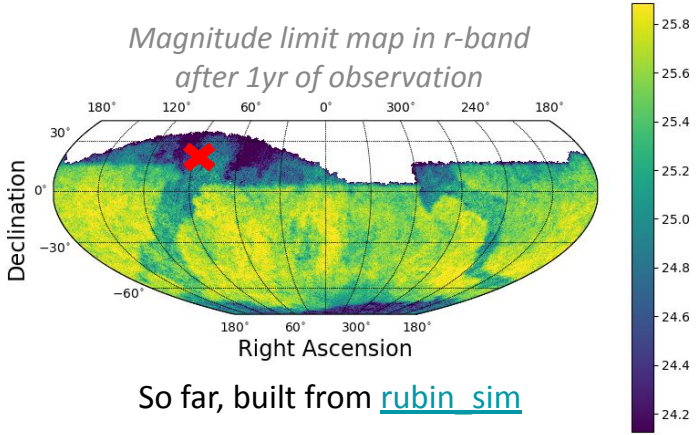
Conversion to observed data-like: magnitude limits

For each stars of the stream
(ra, dec, magnitude)



Estimate **magnitude limit** at (ra, dec)
in every bands

Magnitude limit map in r-band
after 1yr of observation

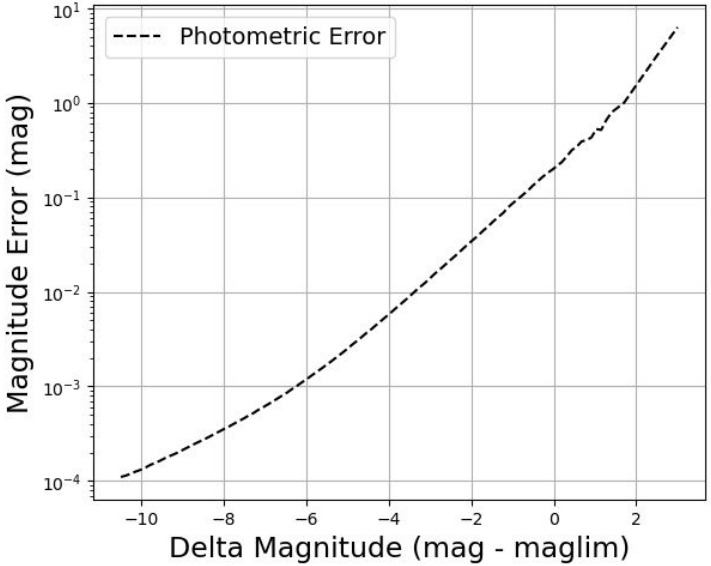


So far, built from [rubin_sim]

Delta magnitude = apparent magnitude - magnitude limit

Conversion to observed data-like: magnitude and errors

Delta magnitude → **Assign photometric errors** → **Sample observed magnitudes** (gaussian in flux)

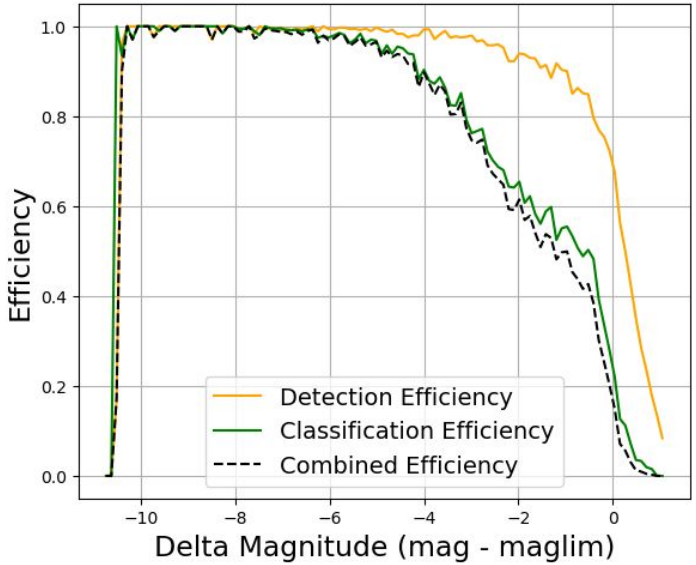


Estimated using DC2 catalog in r band (Kabelo Tsiane et al.)

Conversion to observed data-like: detection and classification

Delta magnitude

Estimated completeness



Estimated using DC2 catalog in r band (Kabelo Tsiane et al.)

Star observed if

$$Unif(0,1) < Completeness(\text{Apparent mag r})$$

\+ cut on SNR in g band

Conversion to observed data-like: summarize

Quantities estimated by StreamSim:

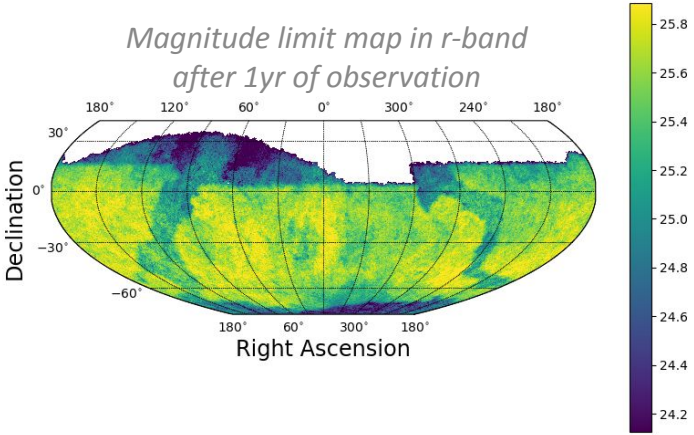
- **Coordinates** (phi1, phi2, ra, dec)
- Distance modulus
- Apparent **magnitudes**

- **Observed magnitudes**
- Photometric **errors**
- **Detection + classification** flag

Conversion to observed data-like: limits

Approximations:

- **Not** a true **synthetic source injection**
- Survey **systematics compressed** into magnitude-limit maps
- Assumes selection functions and errors shift with the magnitude limit



Advantages:

- **Low** computational **cost** → easily applied to batch of simulations
- Mimics survey selection and properties

How to use StreamSim

How to use StreamSim: resources

Documentation: available here
Including API, installation, quick start

Tutorials: available here
Notebook for the generation and injection parts

Discussions

Discussions

Future possible development:

- Add **others surveys** and **releases**: DES, DP2…
- Implement isochrone sampling in **more** than **2 bands** g and r
- Implement **velocities** sampling and the corresponding survey degradation
- Others issues (cf GitHub)

Discussions

Future possible development:

- Add **others surveys** and **releases**: DES, DP2…
- Implement isochrone sampling in **more** than **2 bands** g and r
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Thanks for your attention

Questions? Comments?

Any specific requirements you would like to see implemented in StreamSim?

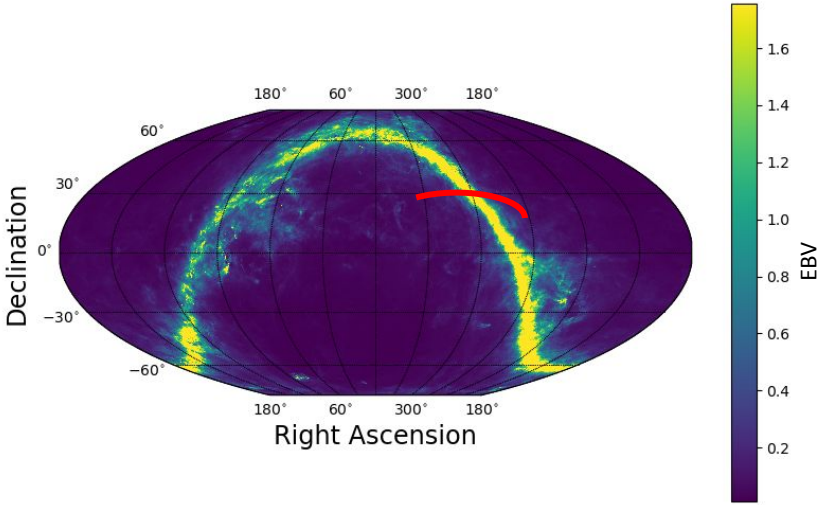
Appendix

Location injection

So far, stream were injected randomly inside the footprint → can be **crossed by dust** →

Inconvenient:

- Our pipeline will measure fluctuations that are **not due to LSST systematics** but to astrophysics
- **Not realistic**: people won't study density fluctuations of a stream crossing the galactic plane



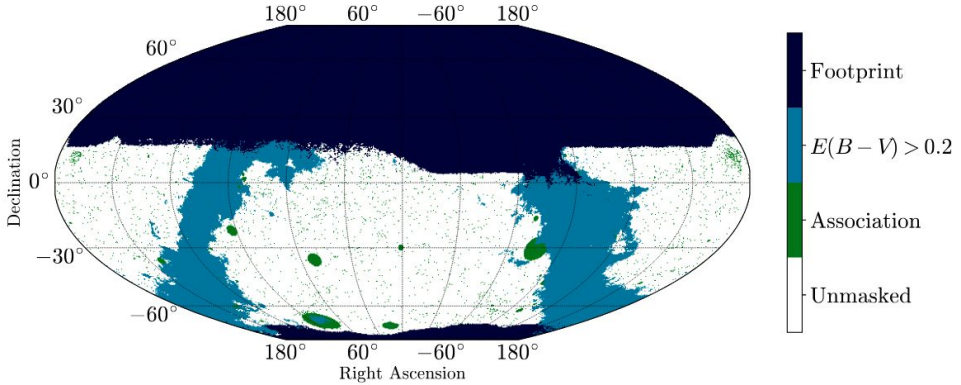


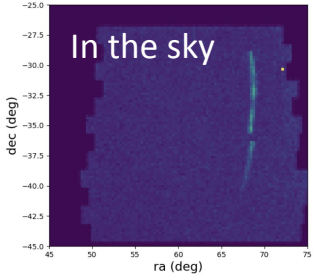
Fig 7. Kabelo Tsiane's paper

restrict the injection to the area outside dust?

IV. Annexes

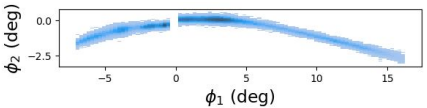
Stream rotation

- **Conversion** to preferred coordinates (ϕ1,ϕ2) to **facilitate analysis** in (ra,dec) using the Gala package



Rotation

In the analysis



(**ra, dec**) coordinates

Select **two points** in (ra,dec) that belong to the stream

It defines the **great circle** (ϕ2=0)

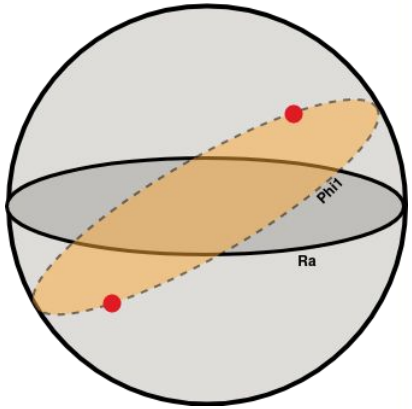
Rotation between spherical frames to **(ϕ1,ϕ2)**

(ϕ1,ϕ2) coordinates

Select **two points** in (ra,dec) that would belong to the stream (currently done **randomly** in the footprint)

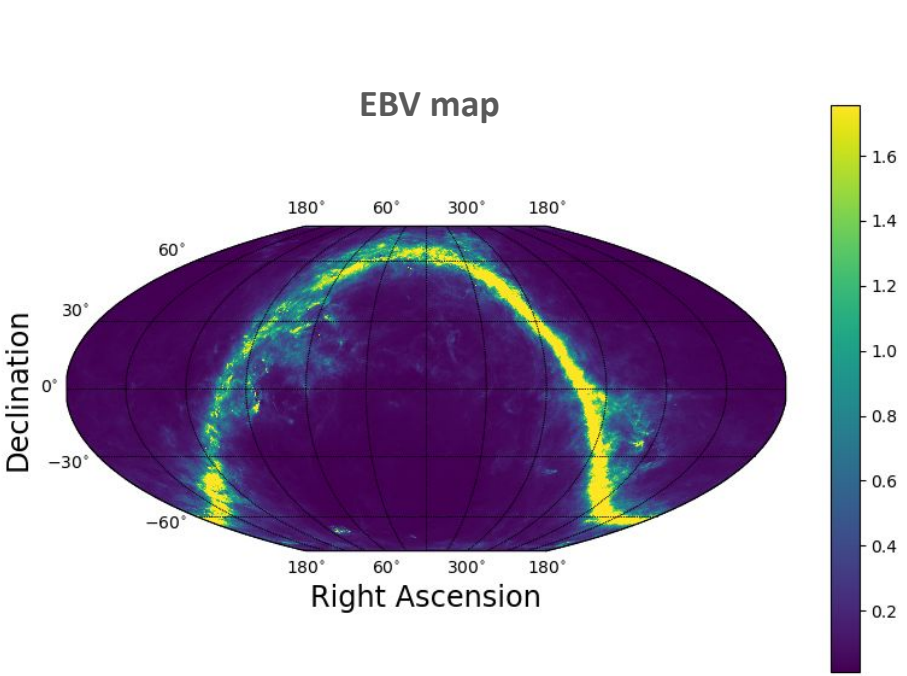
It defines the **great circle** (ϕ2=0)

Rotation between spherical frames to (**ra,dec**)



Appendix: Dust extinction estimation

Use EBV maps to obtain magnitude extinction in g and r band



x 2.273

x 3.237