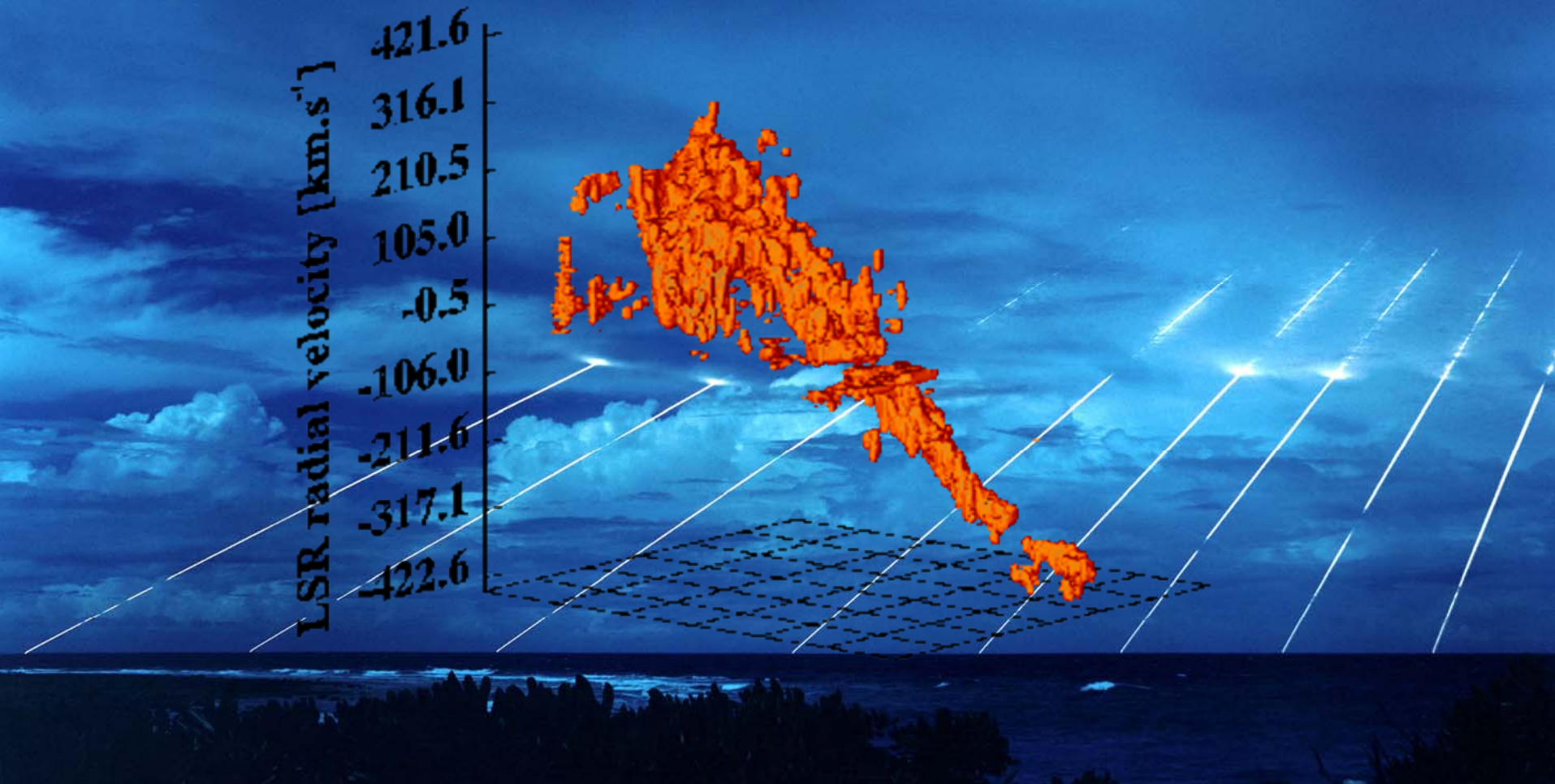
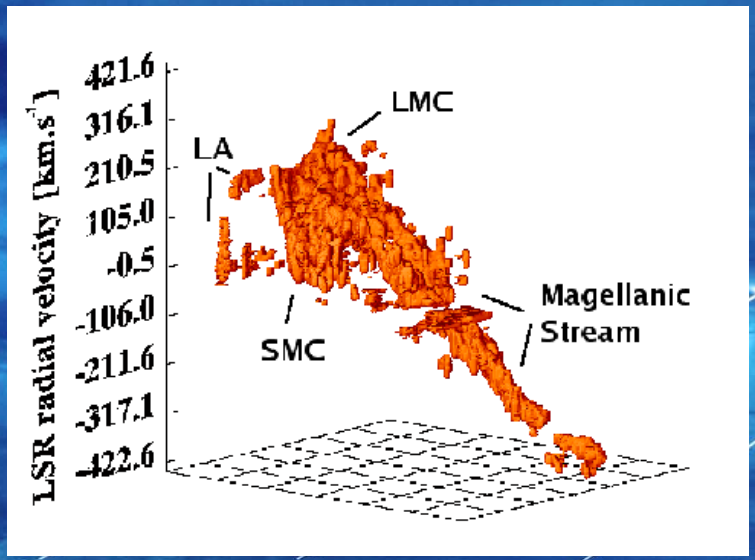
Magellanic Clouds in interaction
evolutionary search for good models

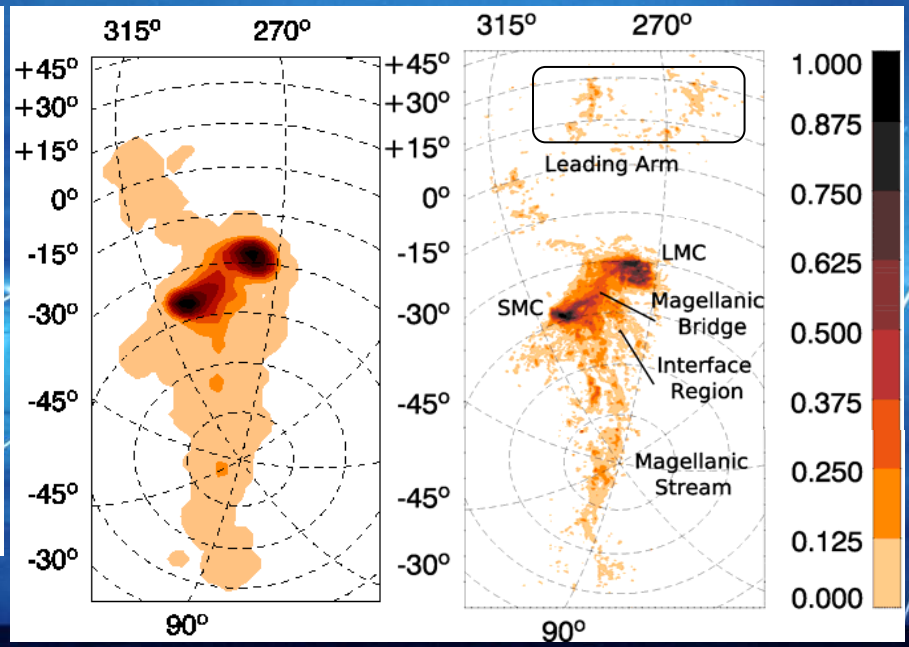
Adam Růžička[1], Jan Palouš[1], Christian Theis[2]
[1]Astronomical Institute, Prague; [2]Institut für Astronomie, Wien



Idea

- investigate the LMC-SMC-Milky Way (MW) interaction by modeling the distribution of HI related to the Magellanic System (Brüns et al. 2005)





To be more specific...

- set up a parameter and initial condition space of the interaction following the available observations of the Magellanic Clouds
- use genetic algorithms (GA) and a fast restricted N-body model to...
- ...perform a detailed and complete search of the entire parameter space to study
  - influence of the parameters on the interaction
  - proper motion of the Clouds

Motivation

- approx. 20 models of the Magellanic System carried out
- either no or insufficient answers exist to the following questions

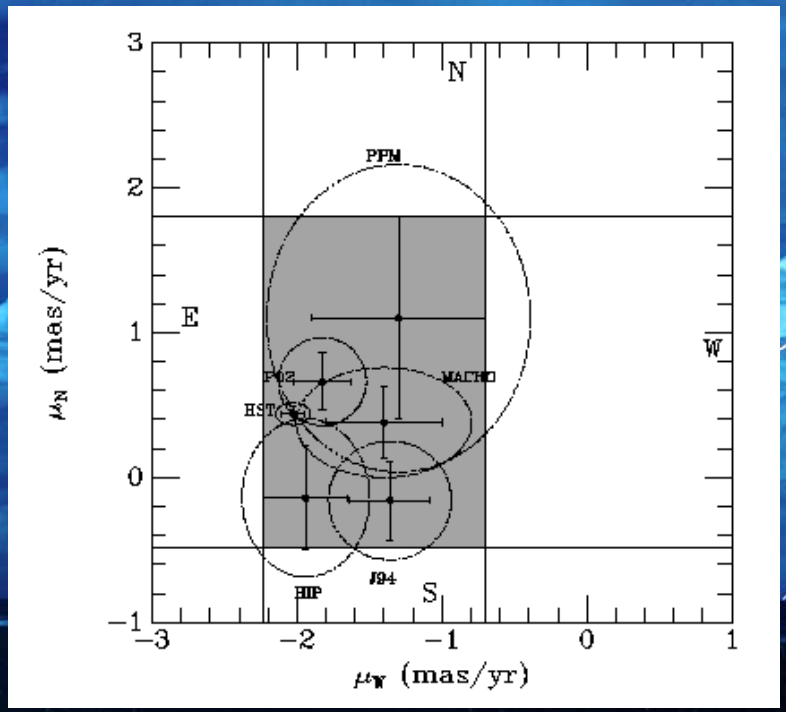
  - Are the interaction scenarios introduced so far unique?
  - How much does the HI distribution tell about the LMC/SMC motion?
  - Is a long term LMC-SMC gravitational binding necessary?
  - Is the SMC the only source of matter for the large-scale structures?
  - Why is there no stellar content in the Magellanic Stream?

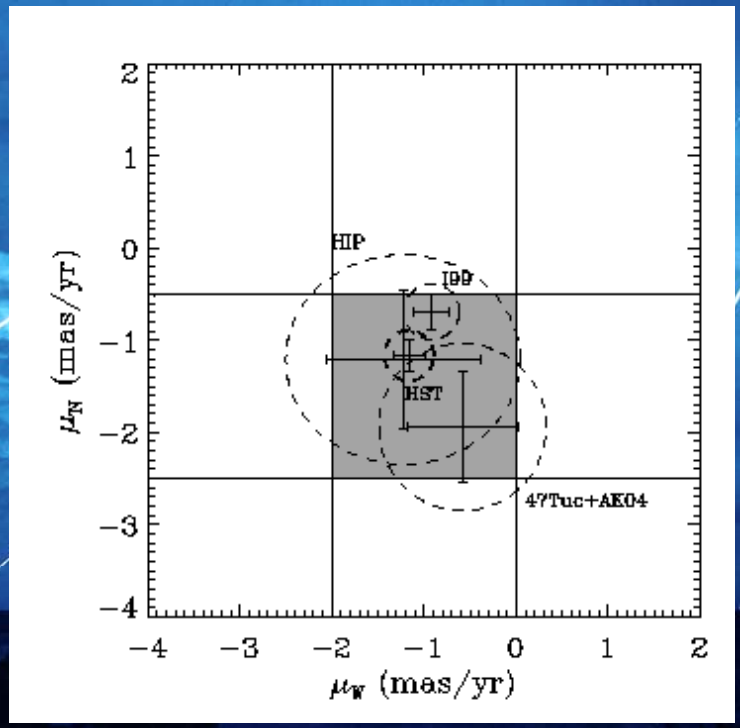
Parameter space

- interaction is determined by approx. 20 parameters including
  - total LMC and SMC masses + parameters of mass distribution
  - structure of the LMC and SMC particle setup
  - distribution of dark matter in the MW halo
  - initial conditions of LMC and SMC motion
    - no assumptions on the LMC/SMC motion
    - but just trust observations…

Proper motion

- different methods and different values in
  - Jones et al. 1994 (J94), Kroupa et al. 1994 (PPM), Kroupa&Bastian 1997 (HIP)
  - Kallivayalil et al. 2006A, Kallivayalil et al. 2006B





Numerical model

- 3D restricted N-body model of the LMC-SMC-MW interaction including
  - Newtonian law of gravity
  - flattened axisymmetric logarithmic MW potential

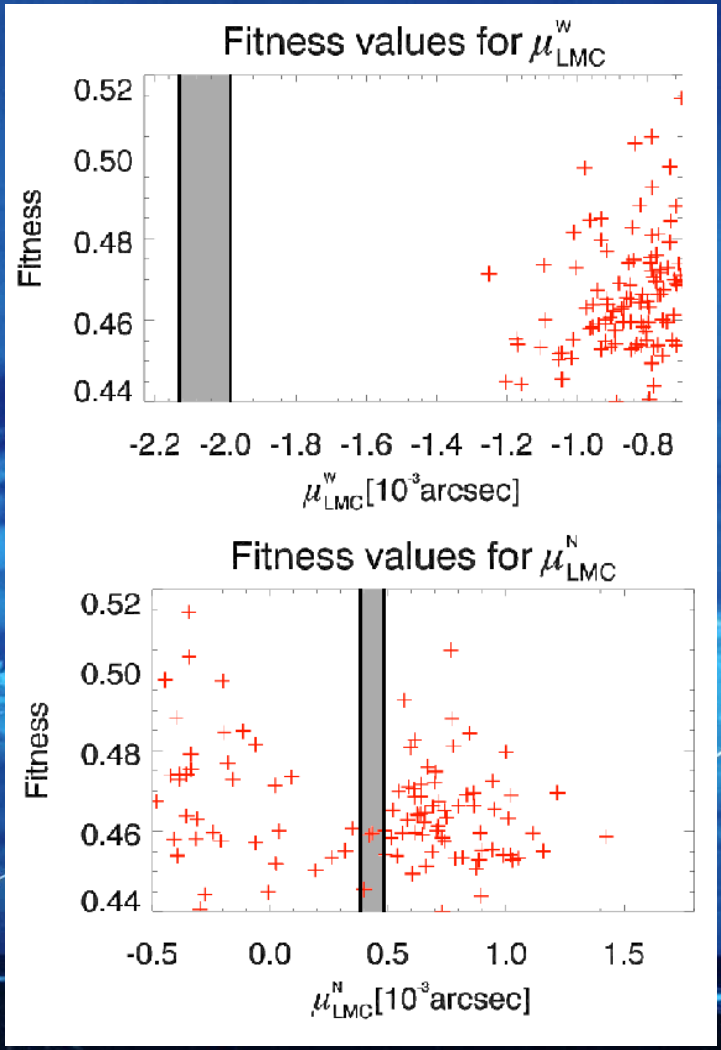
$$\Phi(R,z) = \frac{1}{2} V_D^2 \ln\left(R^2 + d^2 + \frac{z^2}{q^2} \right) + const.$$

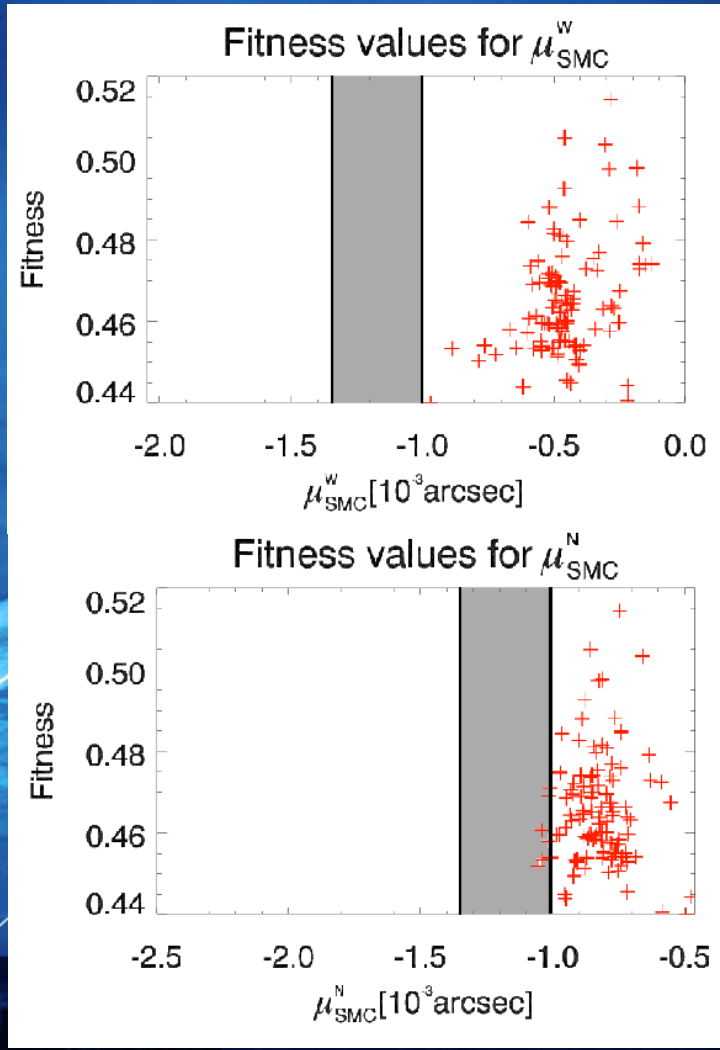
  - spherical potential of both LMC, SMC
  - Dynamical friction in the MW halo (Binney 1977)
  - run from T = -4Gyr
  - no gas but just a tidal model

Genetic algorithm search

- measure of a model quality is a func. in a 20-D space and we call it fitness func. (0 < FF < 1)
- 110 GA runs performed to map the FF
- the fits always of FF > 0.4, i.e. …
- …every fit contained major HI structures
  - trailing stream (Magellanic Stream)
  - leading tail (Leading Arm)
- in total only $\approx 10^6$ parameter combinations had to be tested to search the entire 20-dimensional parameter space
- simple testing of every parameter on even a very sparse grid of 10 nodes/dim. would mean probing $\approx 10^{20}$ parameter combinations…

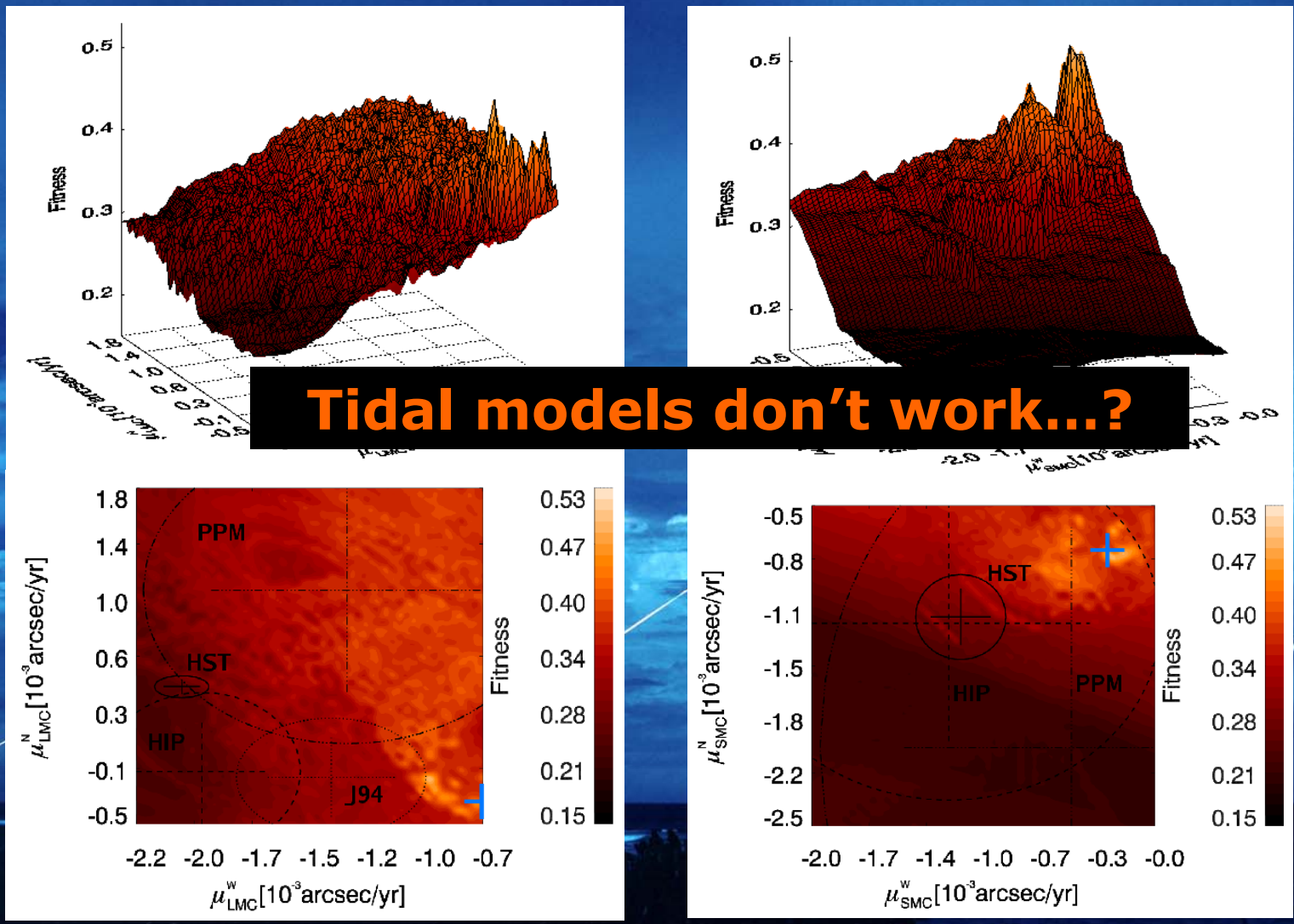
It's all about proper motion...





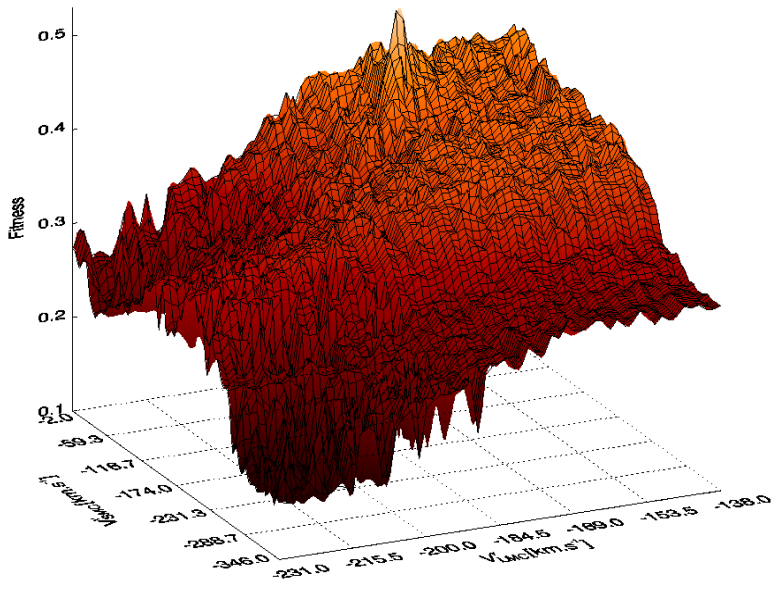
It's all about proper motion...

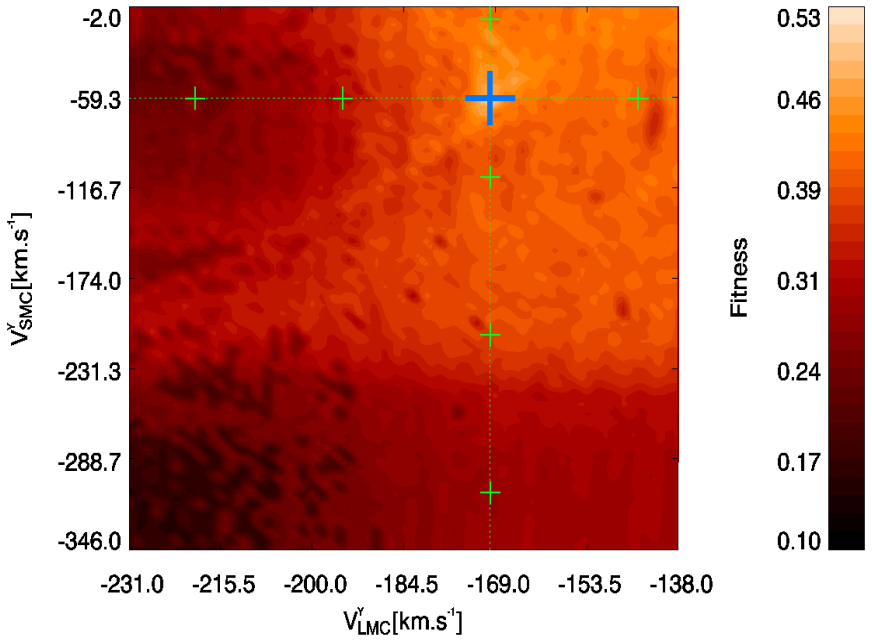
- select a high-quality model (FF ≈ 0.5) and look around



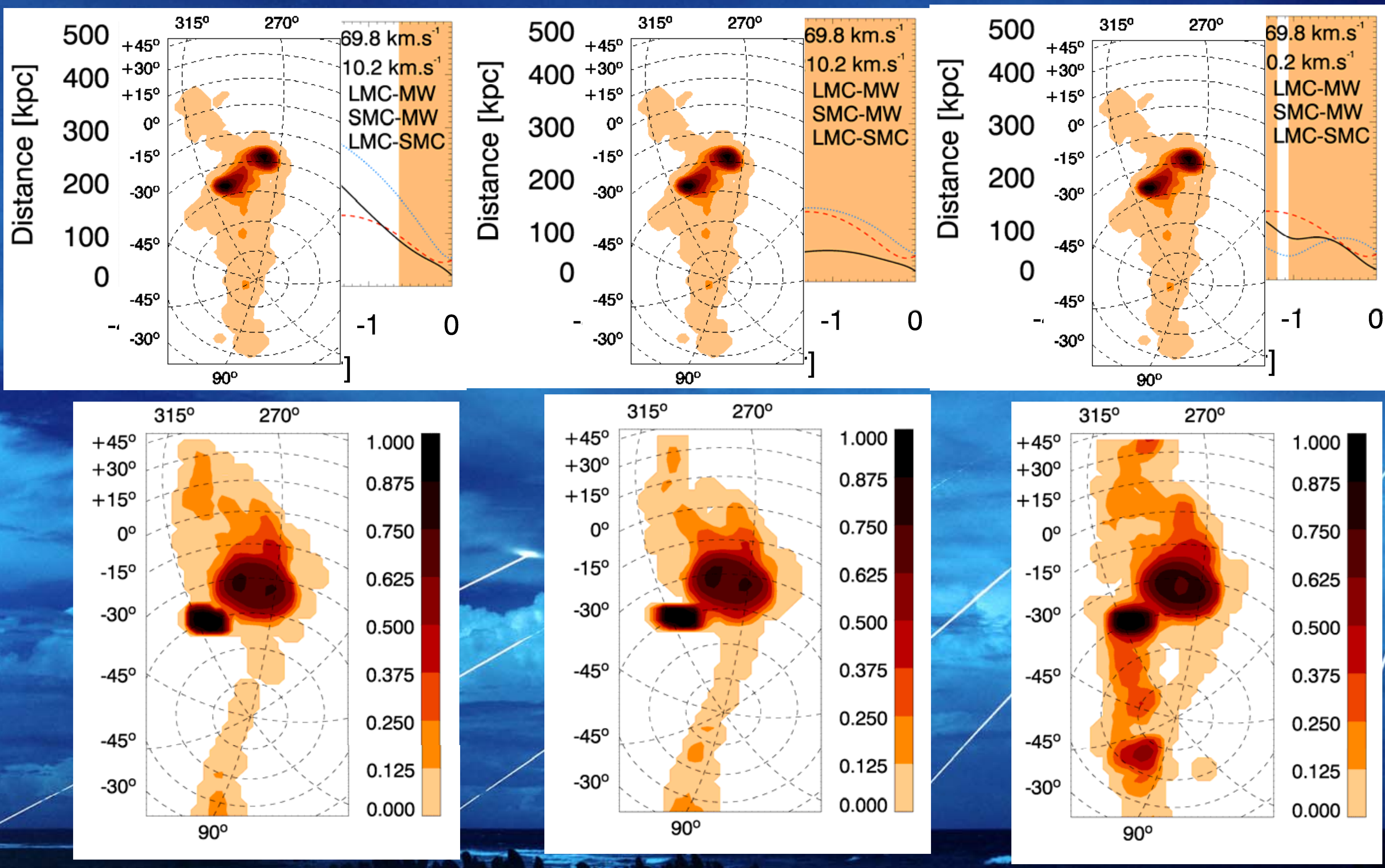
PM versus reproduction of HI

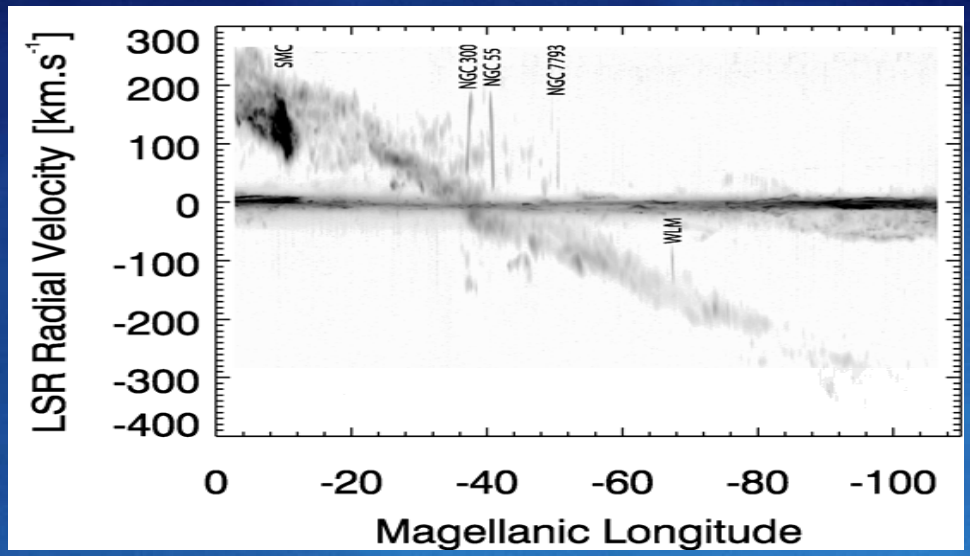
- V^{y}_{LMC} - V^{y}_{SMC} FF landscape for a good GA fit



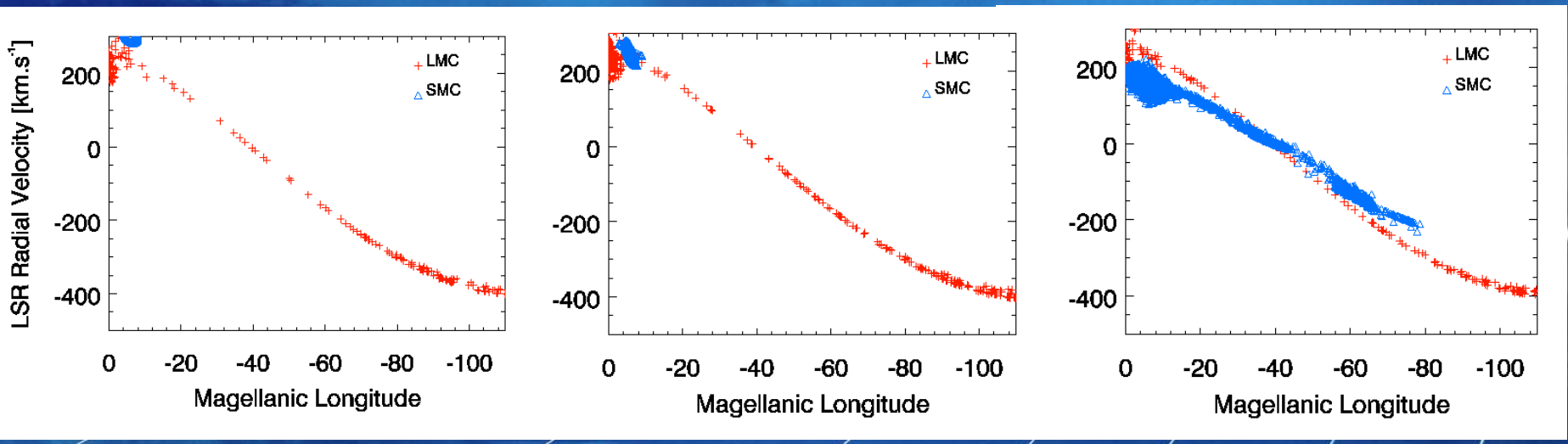


Why is the LMC/SMC velocity so critical?





Brüns et al. 2005



Conclusions

- no model
  - insuffi
  - simplif
- distributi
  LMC/SMC
- tidal mod
- …or the H

BUT

- the Cloud
  sense
- other phy
- specific parameter combinations might allow for great models surrounded by rubbish, so…
- …exclude some parameters and make life easier for the searching algorithms

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PM…

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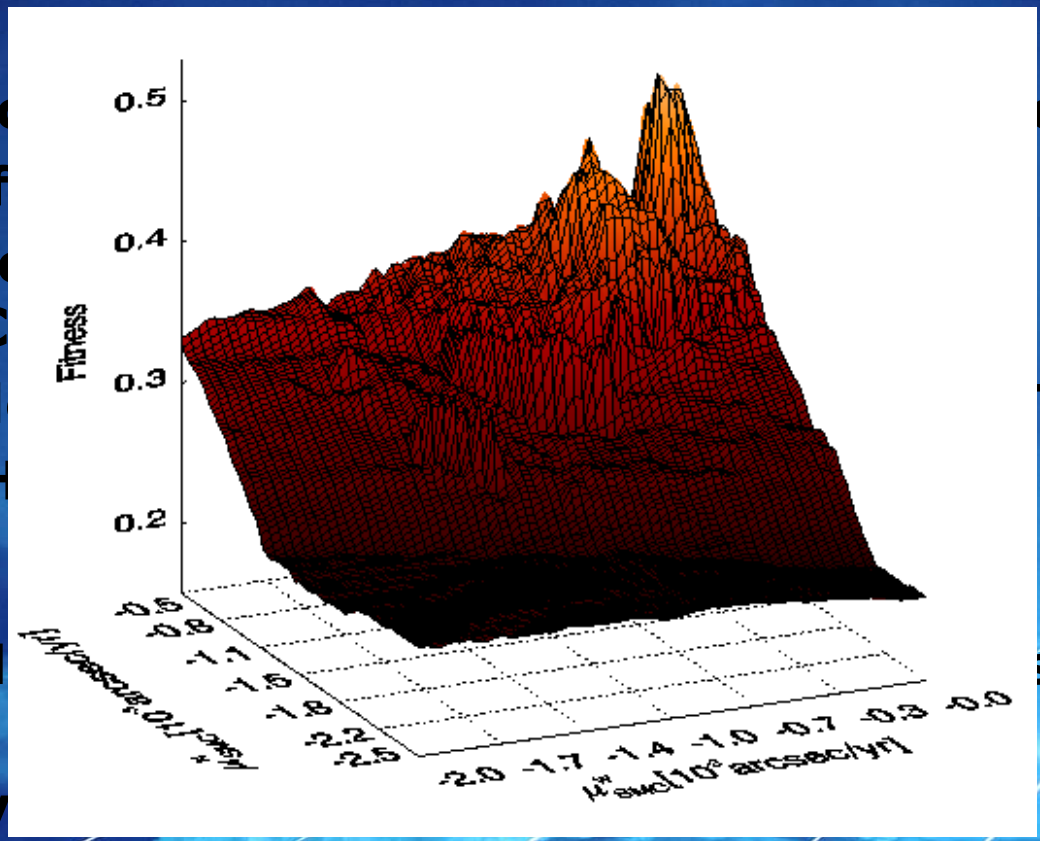

- Magellanic Stream was created for non-spherical MW halos
- q≠ 1.0
  - prevent the system from close (∆R < 10 kpc) LMC-SMC encounters
  - HI redistribution started and continued by MW-LMC/MW-SMC tidal stripping
  - offer a natural explanation of the missing star problem
- tidal models don't seem to work for the HST PM…