Searching for systematic biases in redshift-independent distance indicators

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Cosmic Flows, Large-Scale structure & Visualisation
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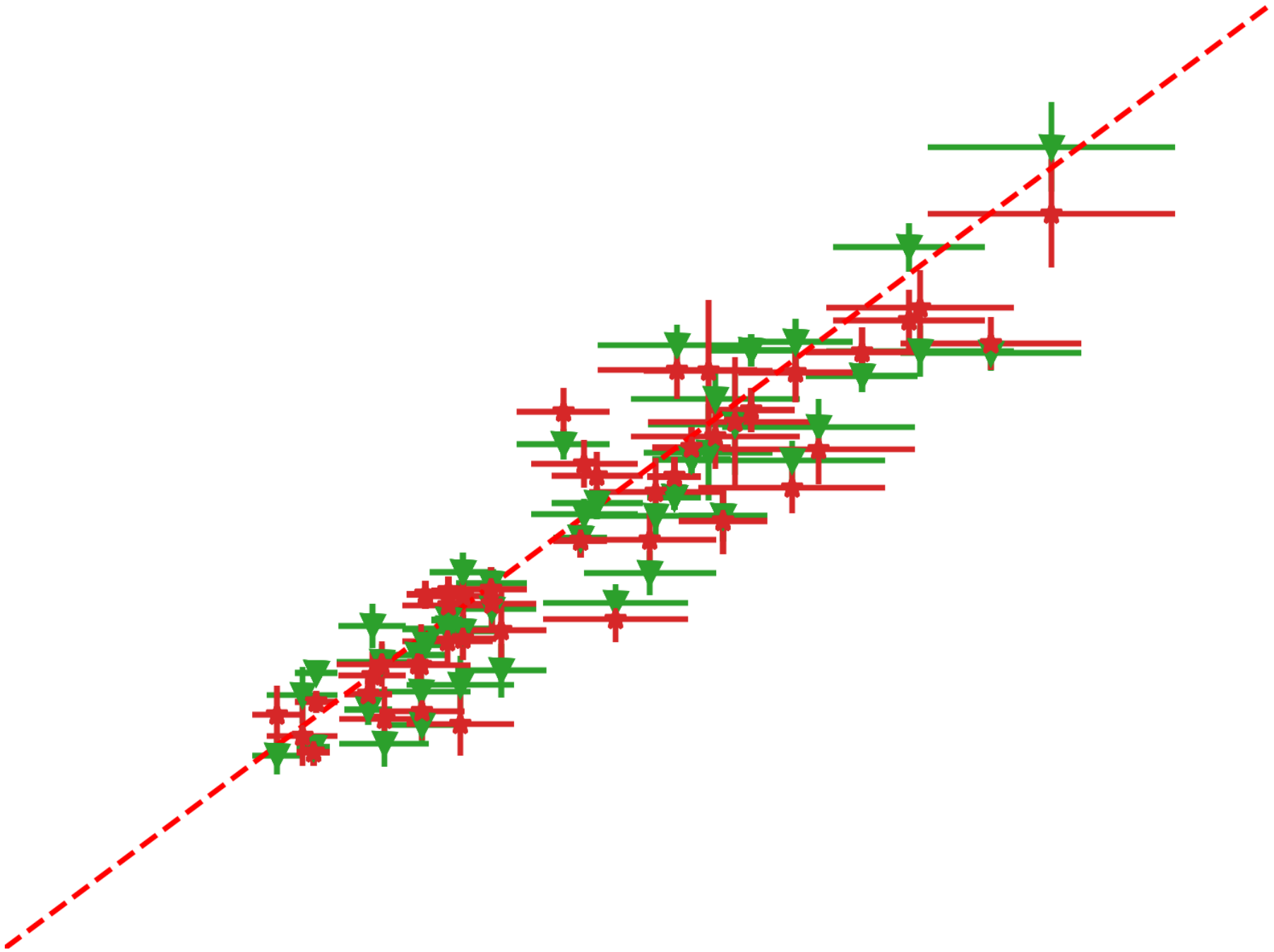


Collaborators

Christoph Saulder

Ian Steer (NED)

Owain Snaith (Paris Observatory)

Changbom Park (KIAS)

Yongmin Yoon (KIAS)

Comparing distance indicators

- Two most important methods for large samples of redshift-independent distances:
  - Fundamental plane of early-type galaxies
  - Tully-Fisher relation of late-type galaxies

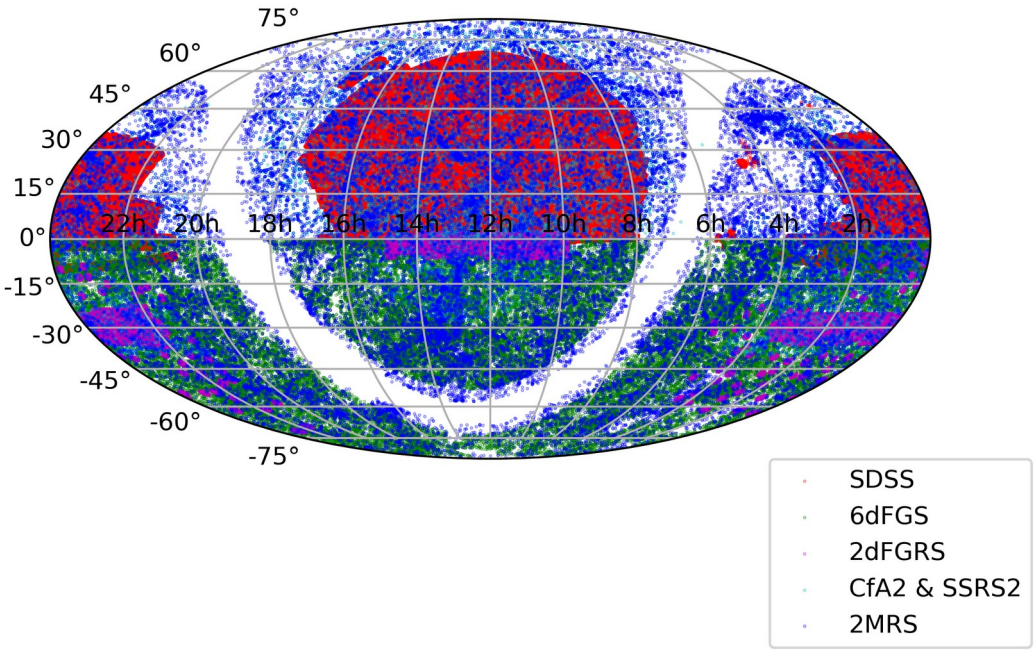
- Targeting two mutually exclusive* samples

*(with exceptions)

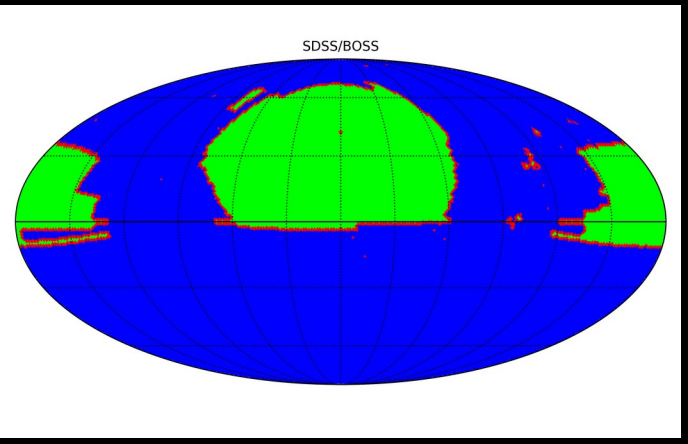
- Solid group and cluster catalogues provide a possibility for comparisons of the two methods.

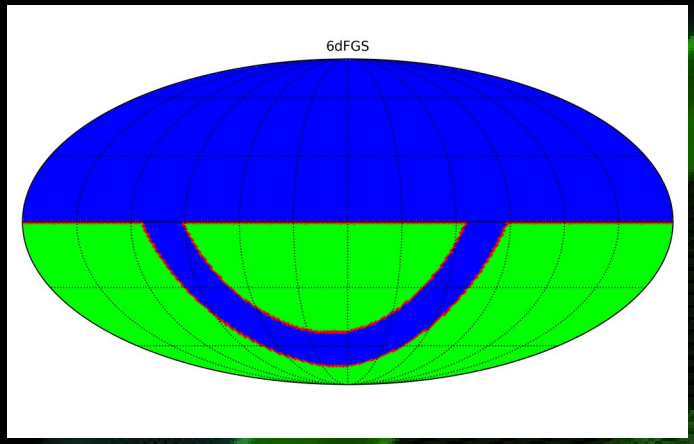
Our all-sky group catalogue

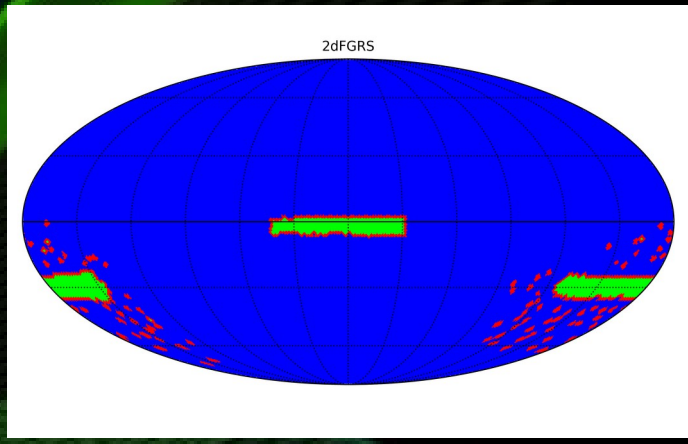
- Up a redshift of 0.5
- Combination of data for various large area redshift surveys:
  - SDSS DR16 (all subsamples)
  - 6dFGS
  - 2dFGRS
  - 2MRS
  - CfA2 and SSRS2
- 1 780 796 galaxies
- Saulder+ in prep.

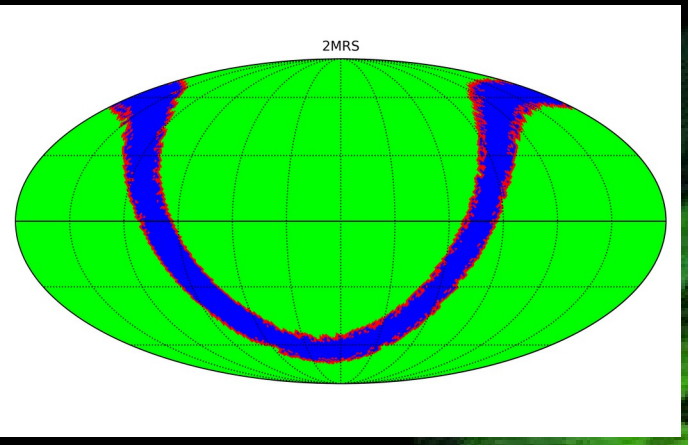


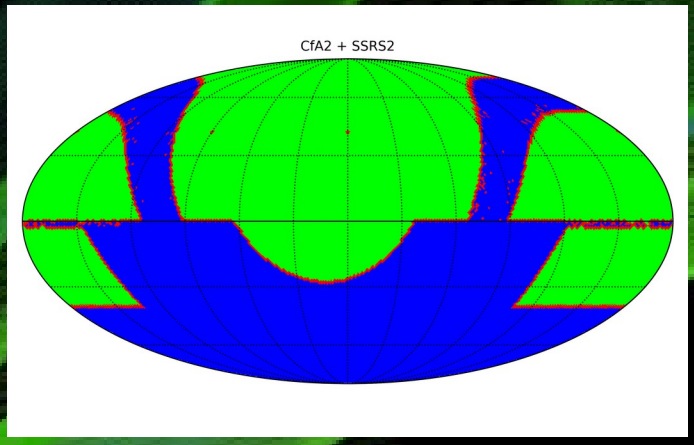
- Consistent methods for all areas, different linking lenghts depending on the catalogues present at each sky area
- FoF and MAGGIE group finder (Duarte+ 2014)
  → remove interlopers

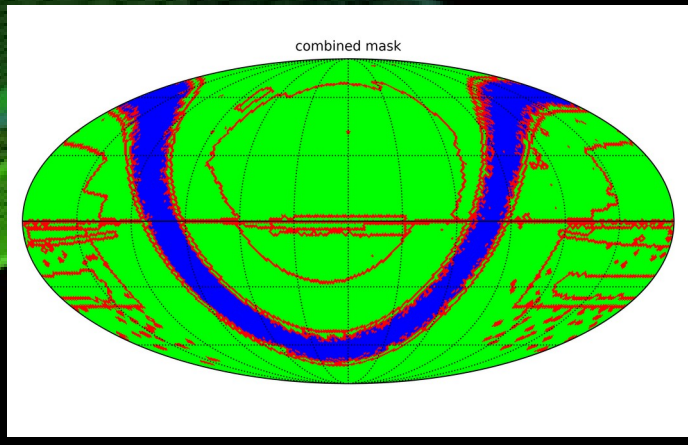












Fundamental plane data

- Our own calibrations based on SDSS DR16
  - including main galaxy sample, LRG, BOSS low-z, ...
- ~320 000 early-type galaxies (Saulder+ 2019)
- Identified using:
  - Red sequence
  - Profile likelihoods (De Vaucouleurs > exponential)
  - Quality controll (reliable redshifts, S/N, …)
  - Velocity dispersion > 100 km/s
  - Removing edge-on galaxies
- Well-defined calibration sample of ~210 000 ETG within SDSS DR7 (main+LRG)

Distance from the fundamental plane

- Providing both, traditional fundamental plane

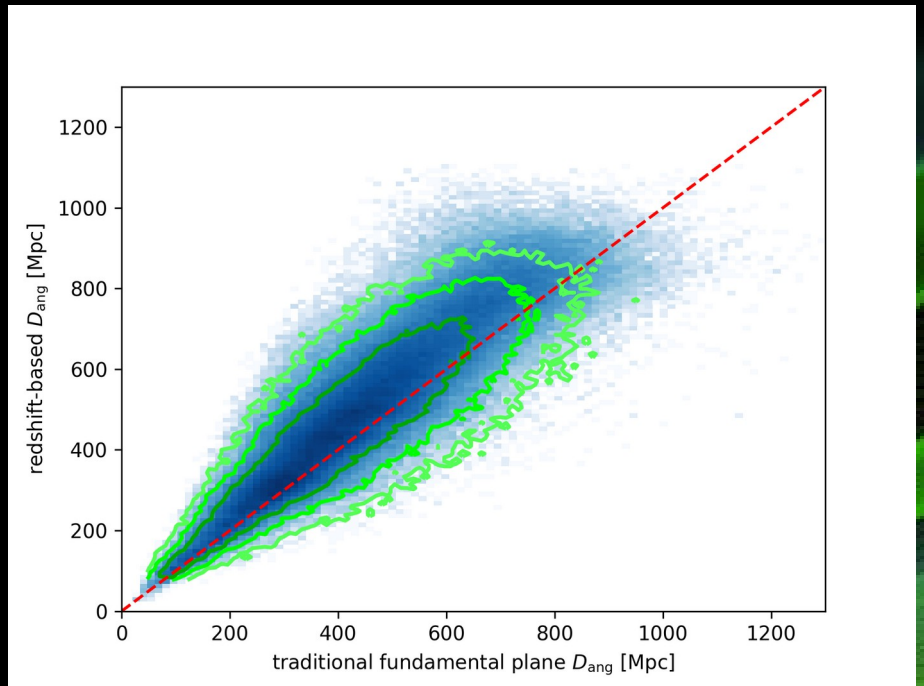
$$\log_{10}(R_e) = a \cdot \log_{10}(\sigma_0) + b \cdot \mu_e + c$$

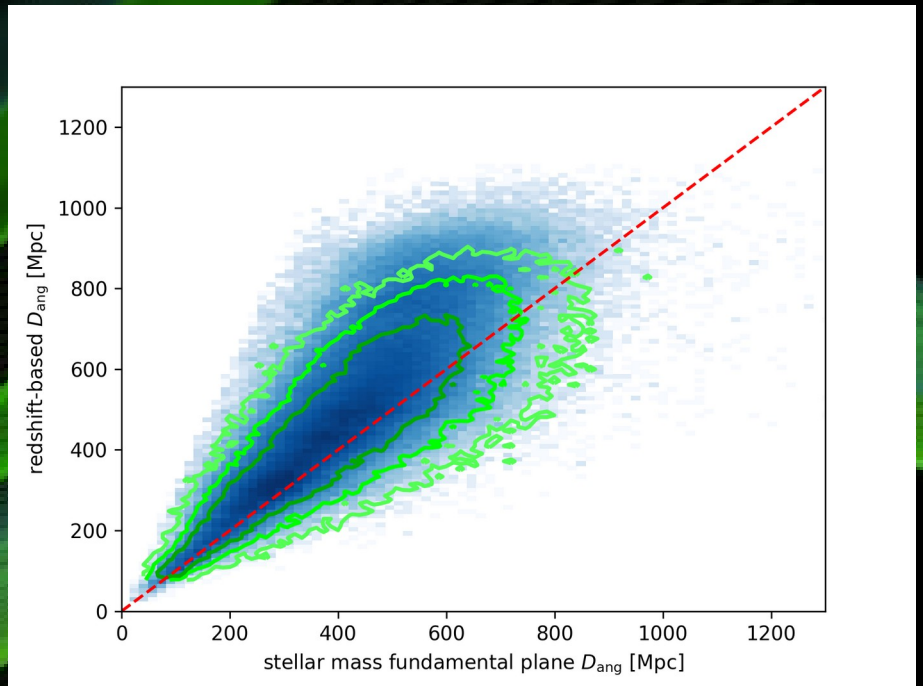
- and stellar mass fundamental plane (Hyde&Bernardi 2009) distances

$$\log_{10}(R_e) = a_* \cdot \log_{10}(\sigma_0) + b_* \cdot \log_{10}(\Sigma_*) + c_*$$

$$\log_{10}(\Sigma_*) = \log_{10}(\Upsilon_*) - 0.4 \cdot \mu_e$$

- Scatter ~18% to ~20% in distance measurement





Comparing different FP calibrations

- In addition to our SDSS data
- Other SDSS based calibrations (Hyde&Bernardi 2009)
- 6dFGS FP calibrations (Springob+ 2012 & Magoulas+ 2012 … later improvements)
- problem: limited overlap

- In the future: DESI fundamental plane calibrations (with A. Kim and D. Parkinson)

Tully-Fisher relation data

- Combined catalogue from various sources provided by my collaborator at NED
- Currently: error weighted combined sample
- Problem: different authors, methods, and calibrations
- In the future: planing to focus on the largest well-defined subsamples using the same calibrations (e.g. 2MTF)

Mock catalogues from simulations

- To model selection effects affecting the different samples (early-type and late-type galaxies)
- Initially planned: HorizonRun 4 (Kim+ 2014) and MultiVerse Simulation Set (but delayed SAM-catalogues)
- Currently: Millennium Simulation re-run (Guo+13)
- In the future: hydrodyanamical simulations … IllustrisTNG, EAGLE, (HorizonRun 5)

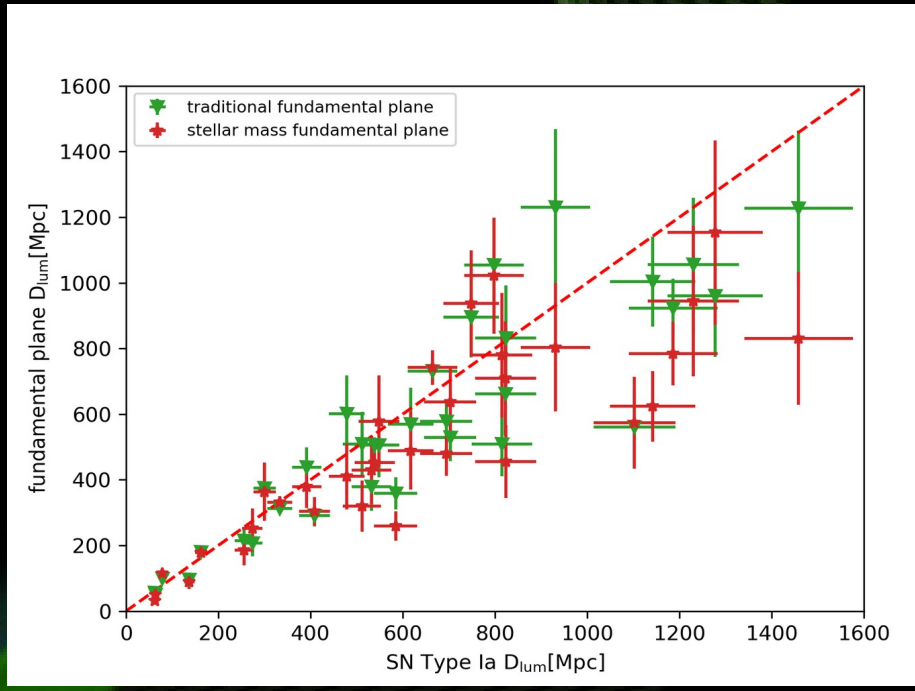
What to look for?

- Ranges for agreement or disagreement of distance measurments from different methods
- Limits of „reliable” distance measurments (useful for peculiar motions) with specific methods
- Catalogues, classifications, … are imperfect, but which ones are affecting our distance measurments the most?
- Impact of galaxy evolution and life time in clusters on the distance measurments
- Probing a large redshift regime with many galaxies: potential clues for the H_0 tension

Other distance indicators

- Supernovae type Ia
  - Betoule+ (2014) …

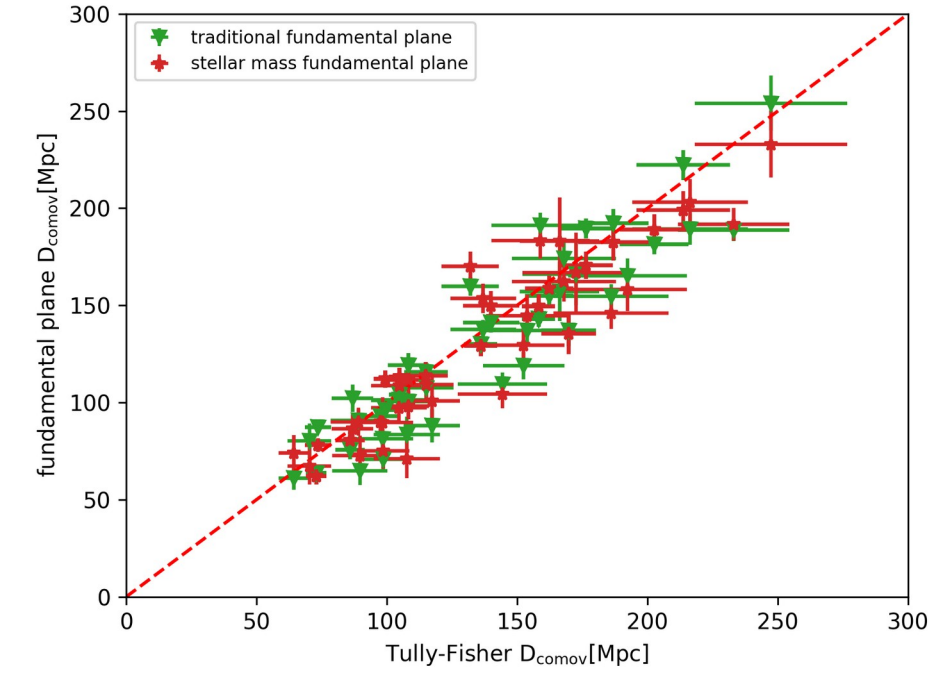
    public sample of supernovae with an uncertainty of ~8%

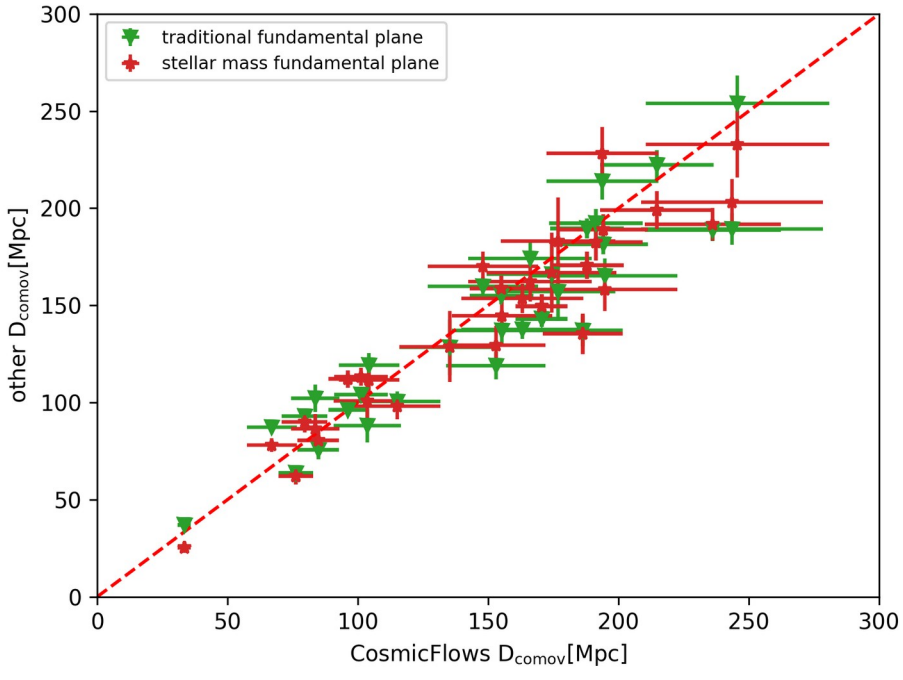


- S_K-relation (Weiner+ 2006), adapted as a distance indicator (K band magnitudes instead of M_*) … follow up on Barat+ 2019 → more direct comparisons
- CosmicFlows provides additional distance indicators:
  - surface brightness fluctuations
  - tip of the red giant branch

First results

- Preliminary comparision of fundamental plane distances to Tully-Fisher relation distances and CosmicFlows-3 distances (removed FP distances)
- Stellar mass FP despite slightly larger intrinsic scatter agrees better with other distance indicators



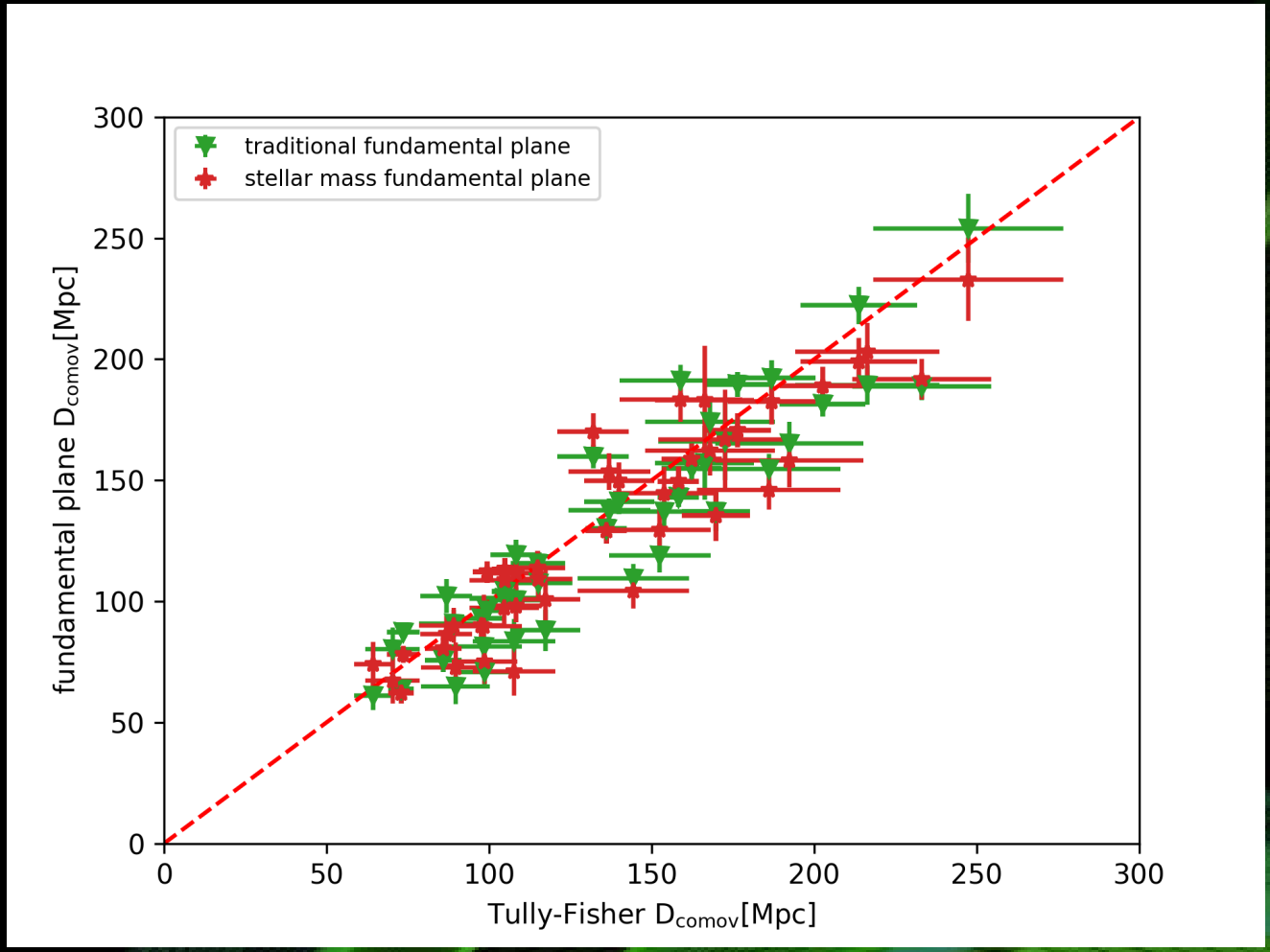


Future challenges

- Focus on clusters: bias of only studying galaxies in a high density environment
- Remaining imperfections of the group catalogue
- Including other distance indicators into the comparison
- Galaxy evolution
- Correcting for hidden technical issues (fibres, plates, …)

- What comes along in the way …

ANY QUESTIONS?



currently looking for a post-doc position or

additional opportinuties to submit my grant proposal

CV: https://tinyurl.com/CV-saulder