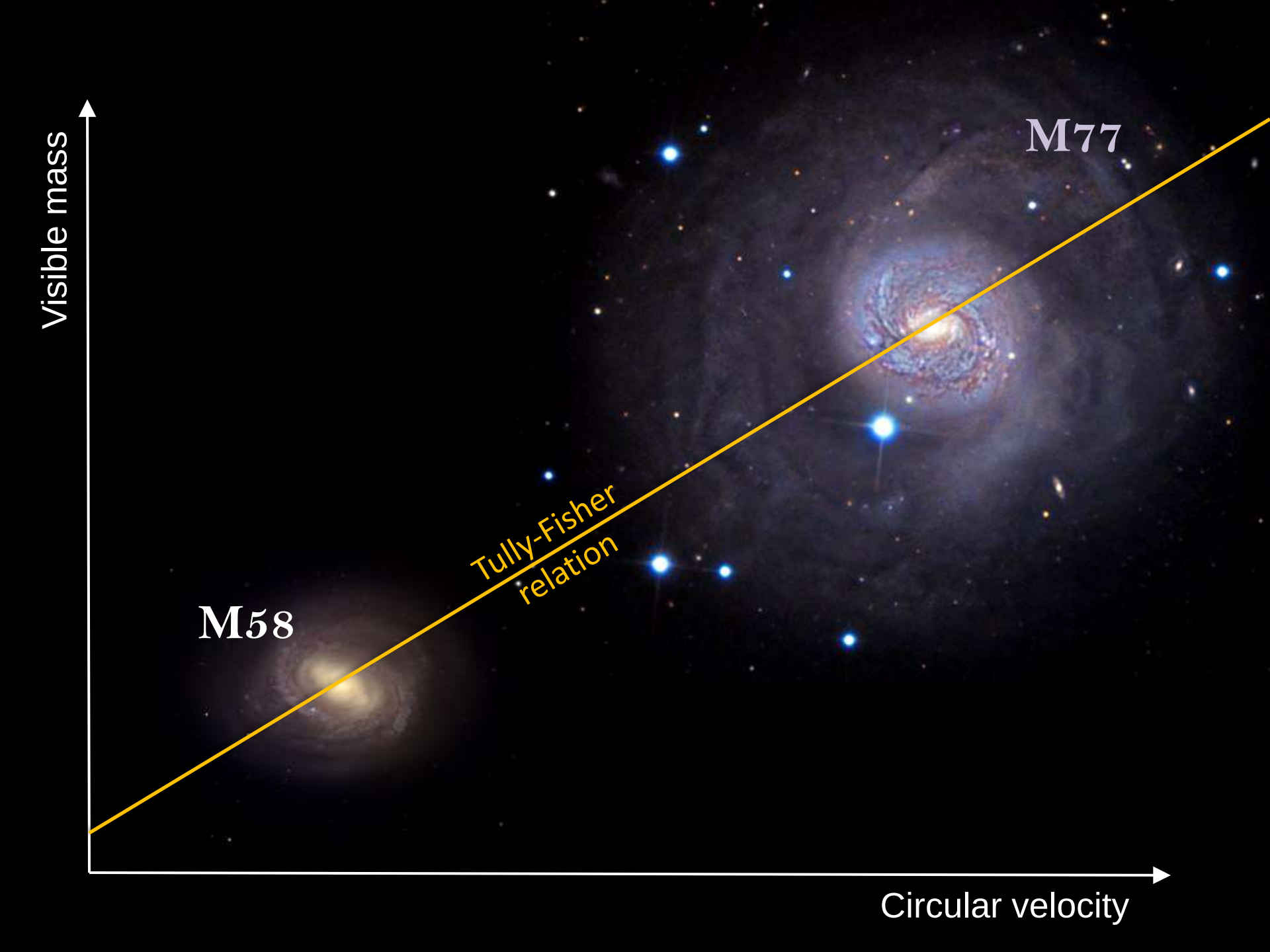
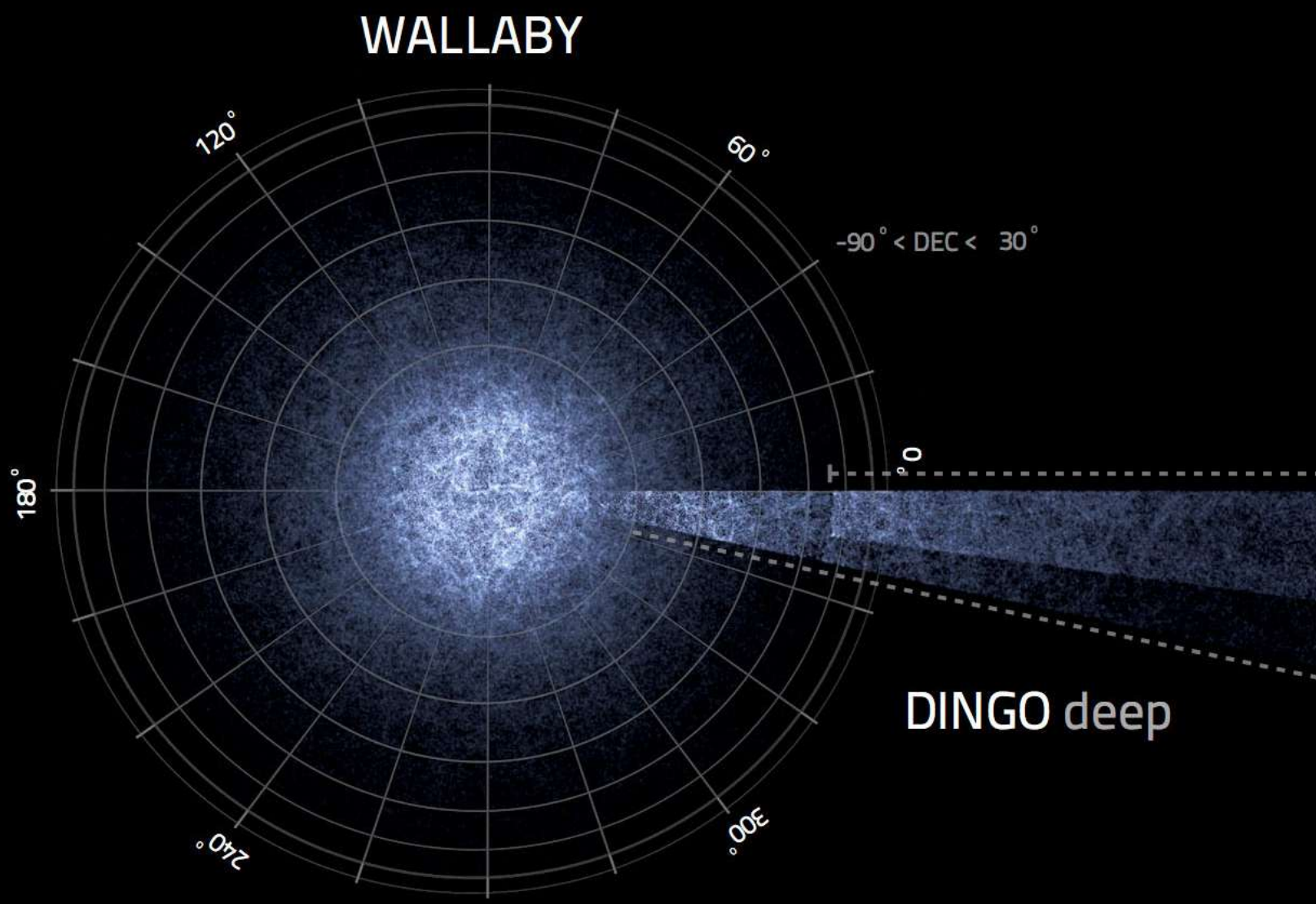
International Centre for Radio Astronomy Research

Changing the Game: Tully-Fisher Relations Without Galaxy Inclinations

Danail Obreschkow & Martin Meyer
20 June 2013

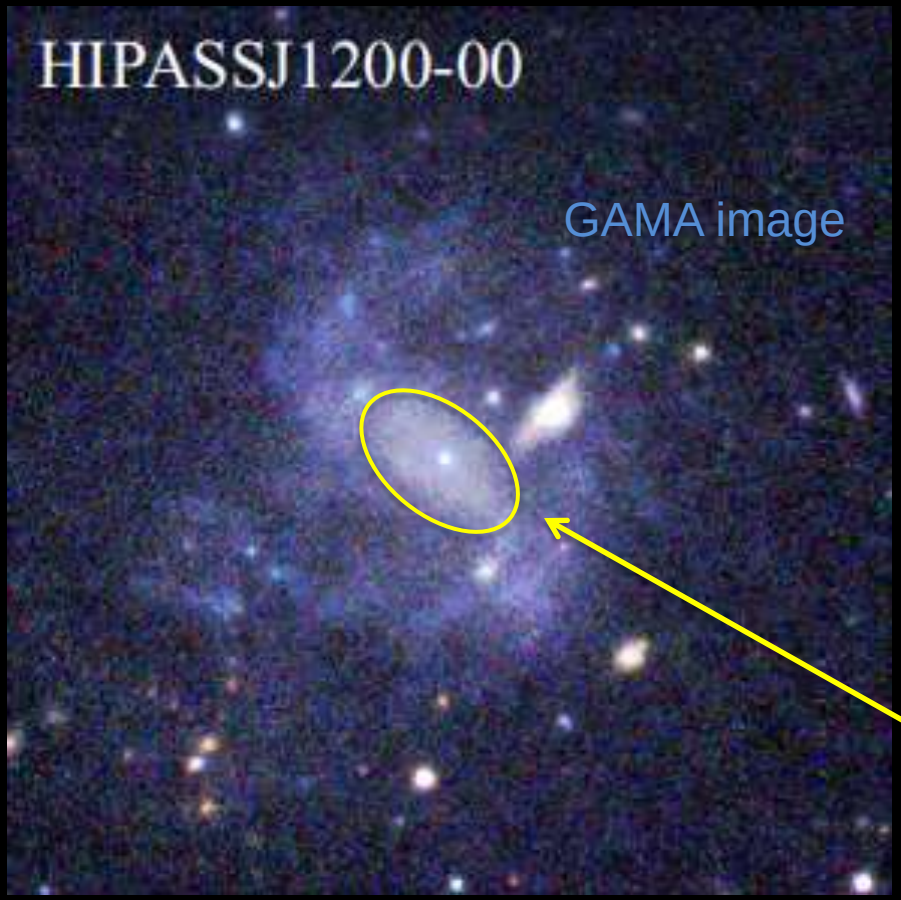

Visible mass
M77
Tully-Fisher relation
M58
Circular velocity

Problem: optical inclinations may be unavailable



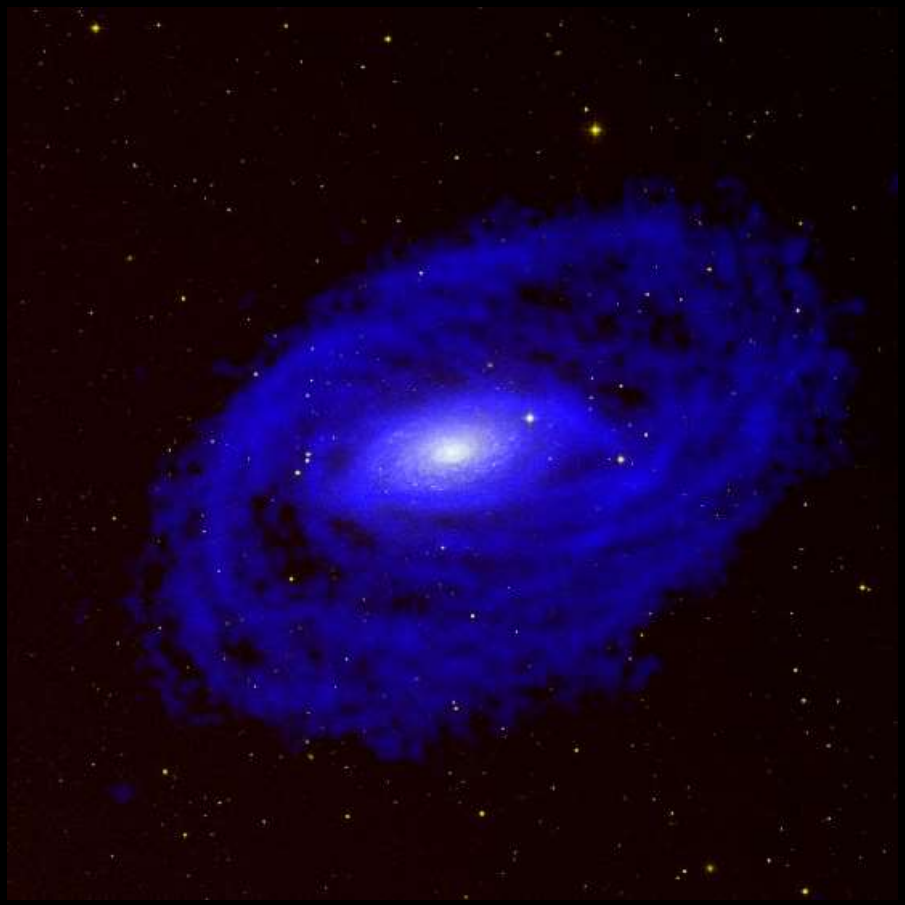
Duffy et al., (2012) & ICRAR visualization

Problem: inclination measurement errors



Obreschkow et al., ApJ 766 (2013)

Problem: Misalignment



NGC5055 visible (SDSS) and 21cm (WSRT), Wijnholds 2010

Centaurus A

PRECISE TULLY-FISHER RELATIONS WITHOUT GALAXY INCLINATIONS

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ABSTRACT

Power-law relations between mass tracers and rotational velocities of disk galaxies, referred to as Tully-Fisher relations (TFRs), offer a wealth of applications in galaxy evolution and cosmology. However, measurements of rotational velocities require galaxy inclinations, which are difficult to measure and often uncertain, thus limiting the range of TFR studies. This work introduces a maximum likelihood estimation (MLE) of the TFR in galaxy samples without or limited information on inclinations. The robustness and accuracy of this method is quantified using both virtual and real galaxy samples. Surprisingly, the inclination-free MLE approach is so reliable that in many circumstances it seems advisable not to use inclinations at all in estimating a TFR. The inclination-free MLE also opens up interesting possibilities for TFR studies with future blind H I surveys by the SKA and its parthfinders.

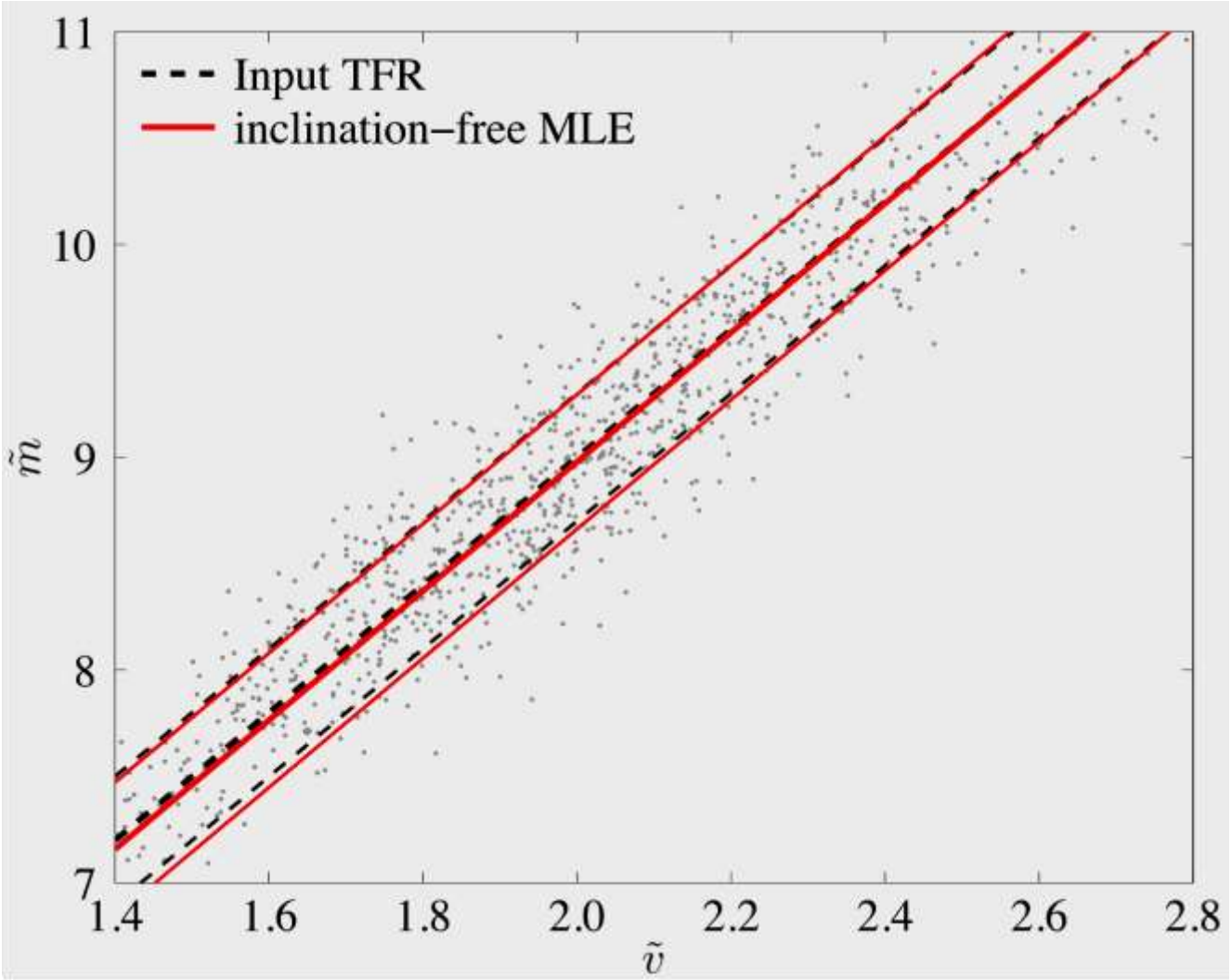
Basic concept

$$\tilde{m} = \alpha + \beta\tilde{v}\ (\pm\sigma) \qquad \mathbf{T} \equiv (\alpha, \beta, \sigma)$$

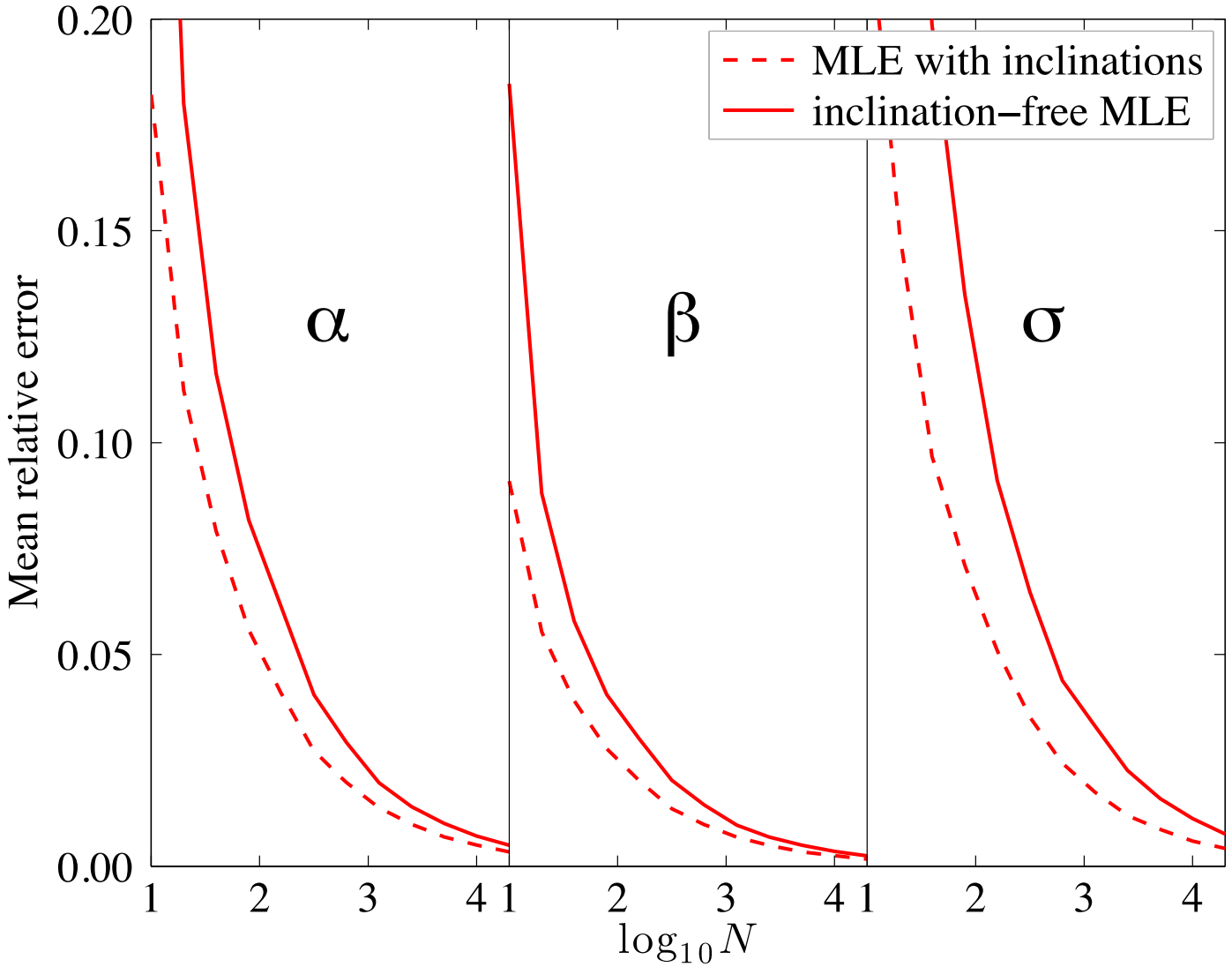
$$\rho(\tilde{v}|\tilde{m}, \mathbf{T}) = \frac{\beta}{\sqrt{2\pi}\sigma} \exp\left[- \frac{(\tilde{m}-\alpha-\beta\tilde{v})^2}{2\sigma^2} \right]$$

$$\ln \mathcal{L}(\mathbf{T}) = \sum_{k=1}^{N} g_k \ln \rho_k(\tilde{m}_k, \tilde{w}_k|\mathbf{T})$$

Mock example

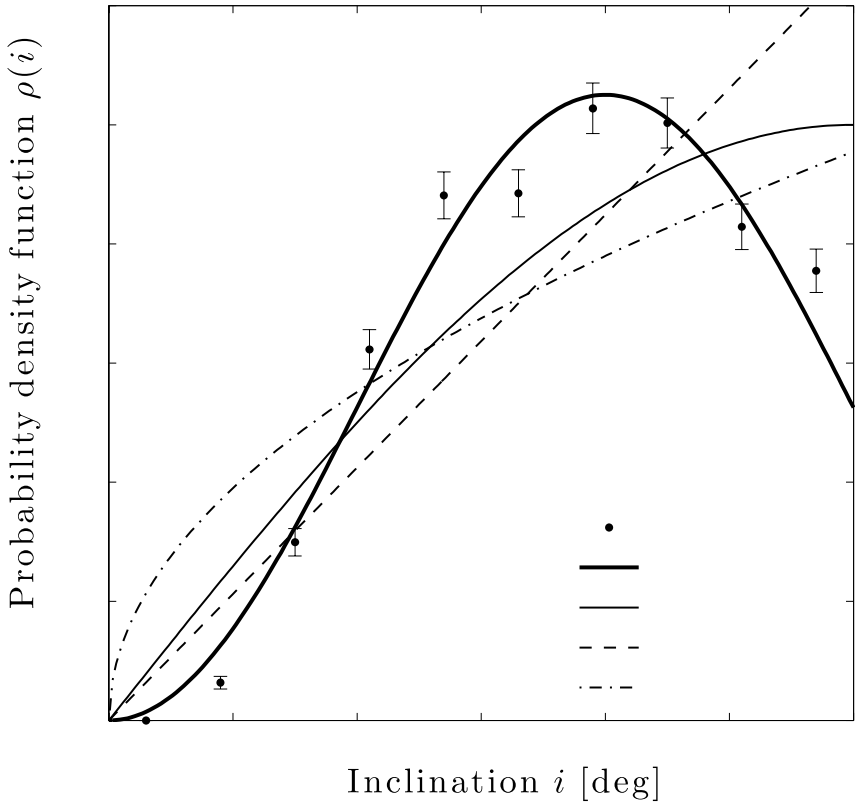


Convergence

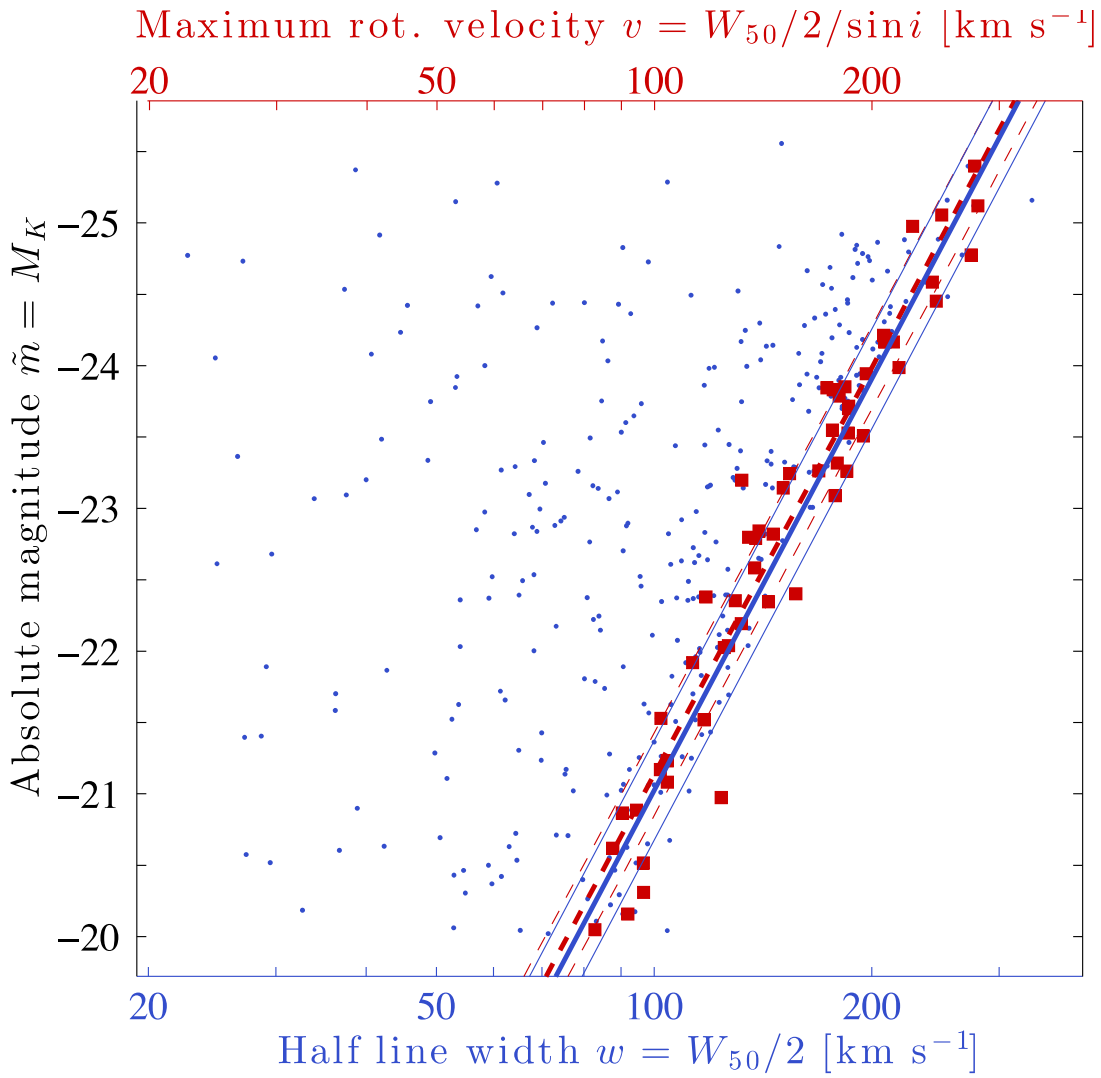


Features

- Robust against measurement uncertainties of mass and line width
- Robust against uncertainties in the inclination prior
- Robust against selection effects
- Better not to use inclinations than inclinations wrong by 10deg



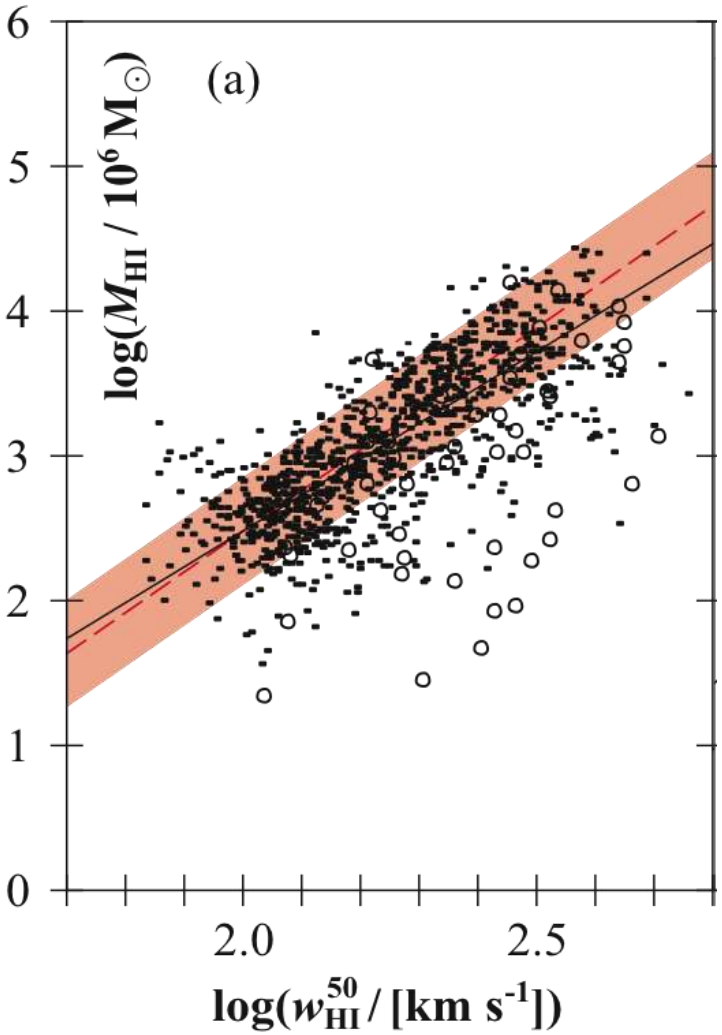
K-band TFR from Meyer et al. 2008



Change the game:
HI-only Tully-Fisher

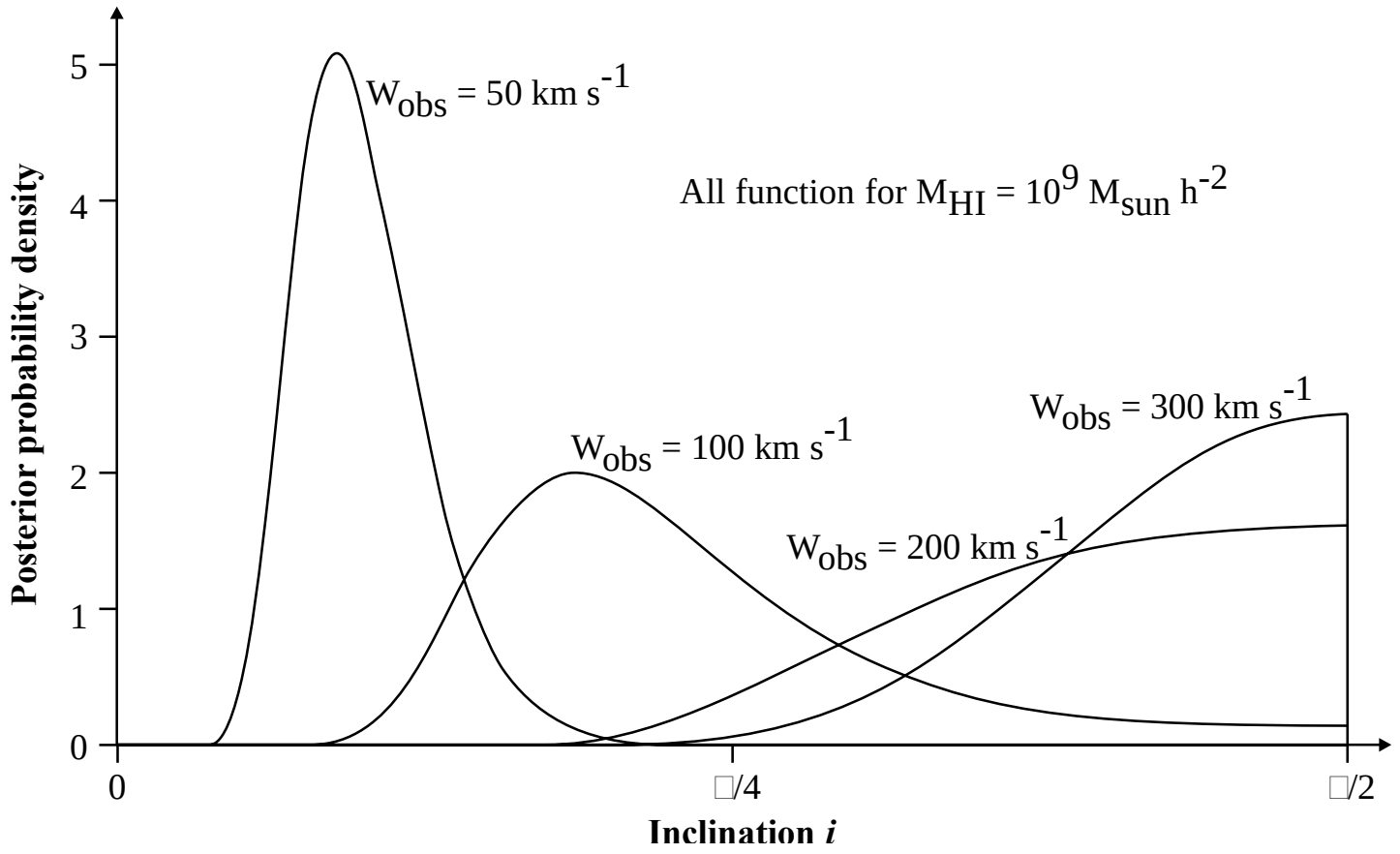
Matt Bershady & Marc Verheijen lead the LADUMA tiger team
”How can we interpret HI velocity profiles of unresolved sources?"

HI Tully-Fisher relation



Obreschkow et al., ApJ 698 (2009)

Posterior inclinations



Tully-Fisher dipole