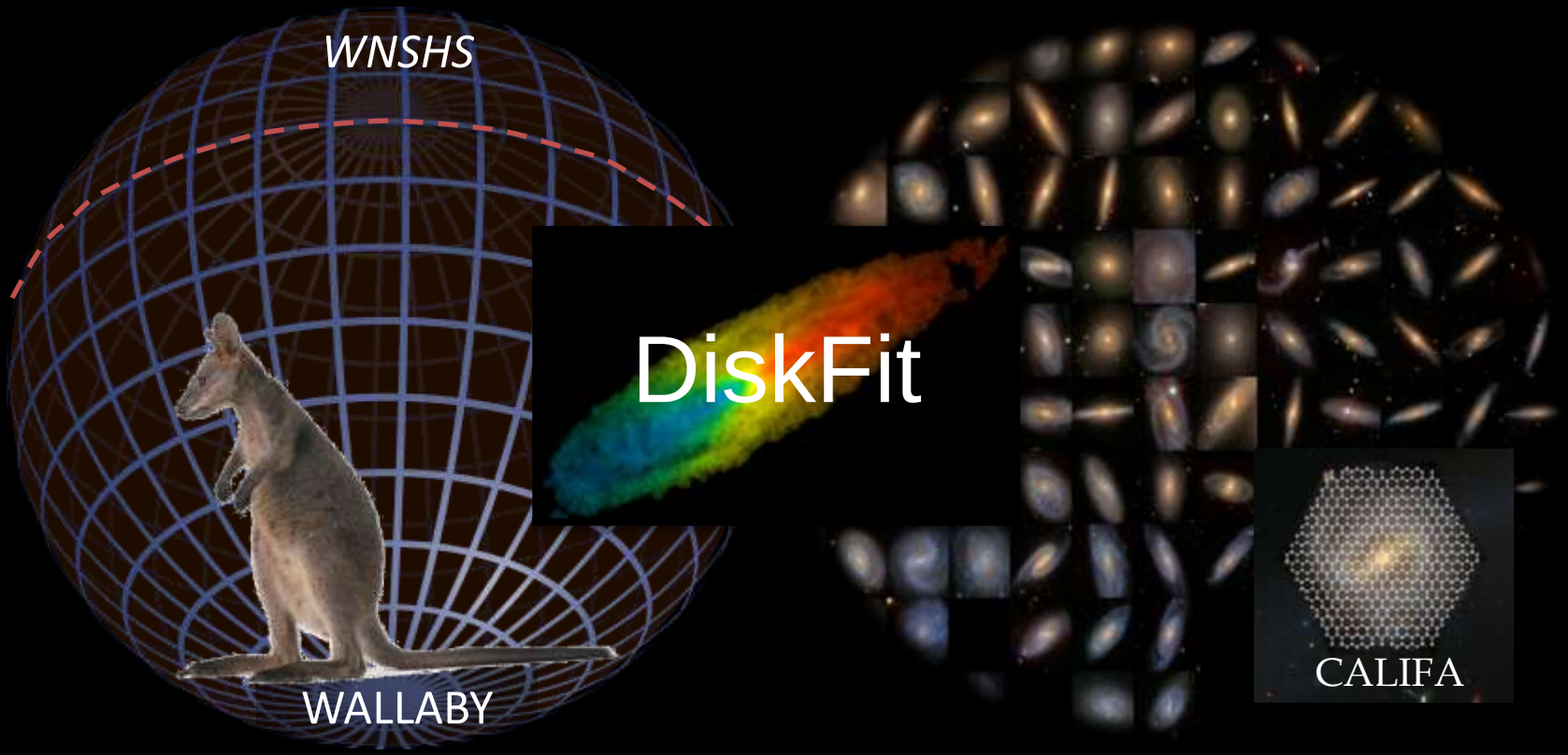
DiskFit: A Model-Based Approach to Measuring Disk Galaxy Structure



Kristine Spekkens

Royal Military College of Canada

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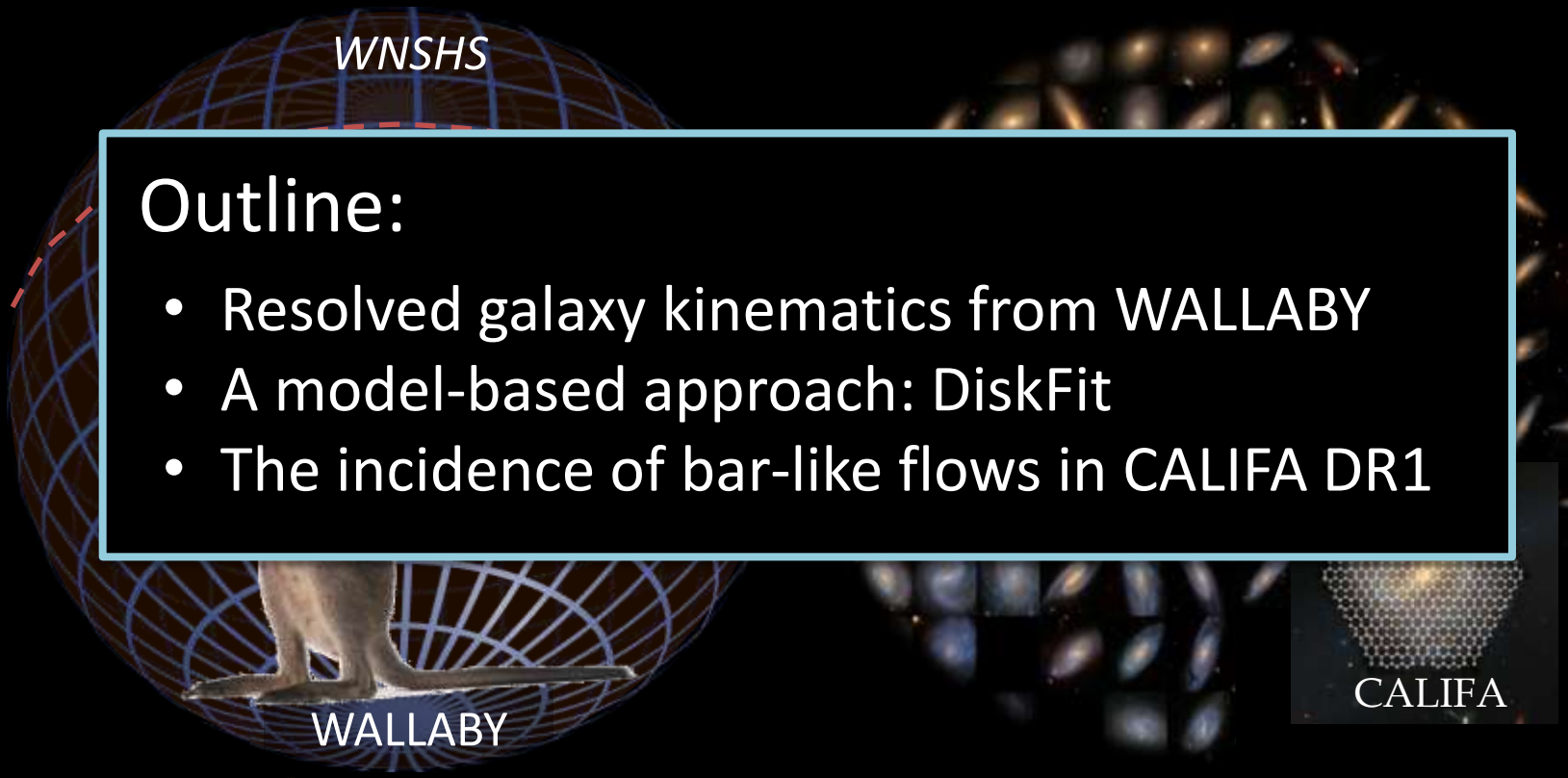


Outline:

- Resolved galaxy kinematics from WALLABY
- A model-based approach: DiskFit
- The incidence of bar-like flows in CALIFA DR1

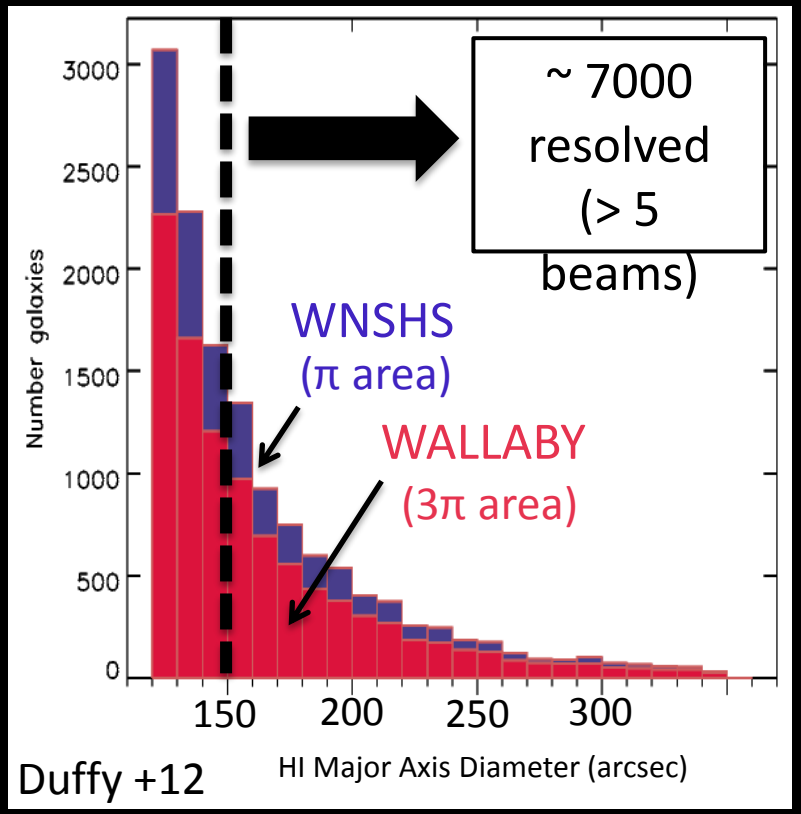
Kristine Spekkens

Royal Military College of Canada

Resolved galaxies in WALLABY

WALLABY + WNSHS:

M_{HI} ~ 4e4D^2 Mo
30”, 5km/s resolution
~ 600,000 galaxies



WALLABY+WNSHS: ~7000 resolved HI detections

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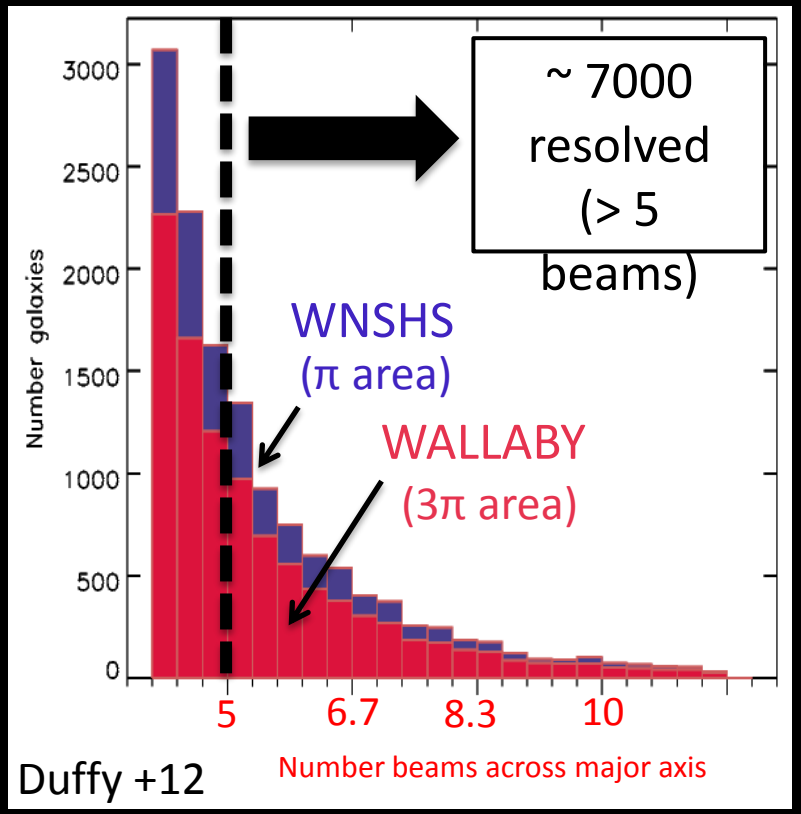

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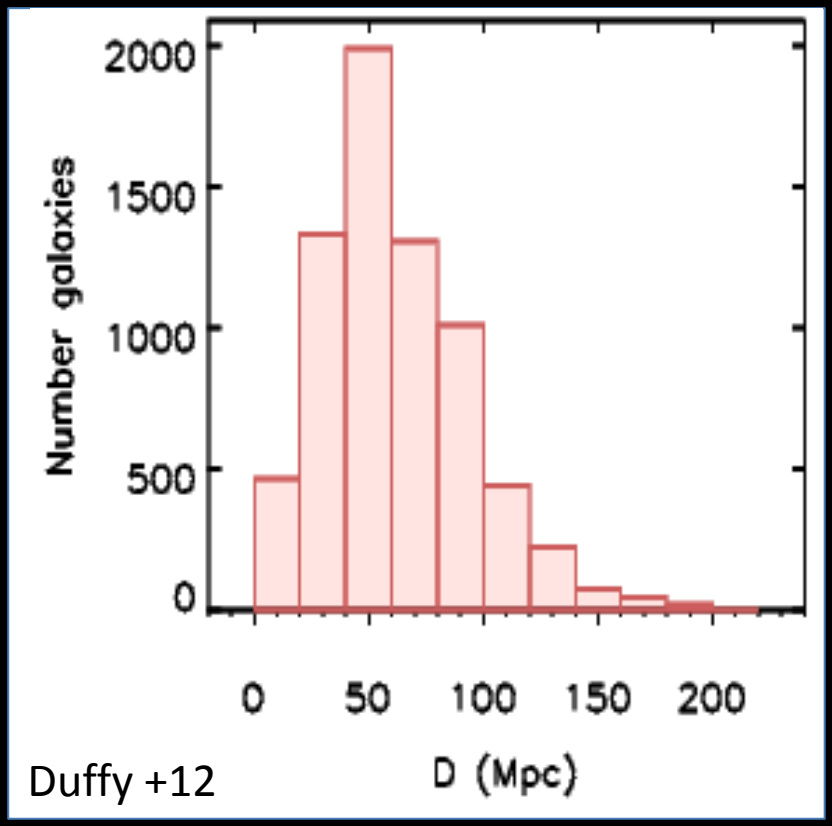

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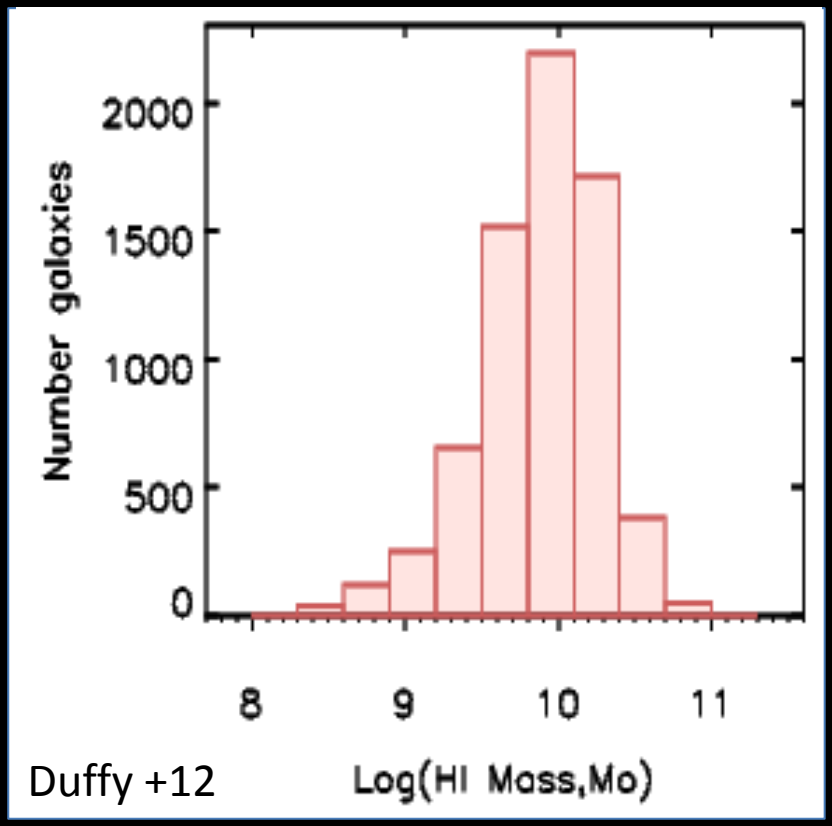

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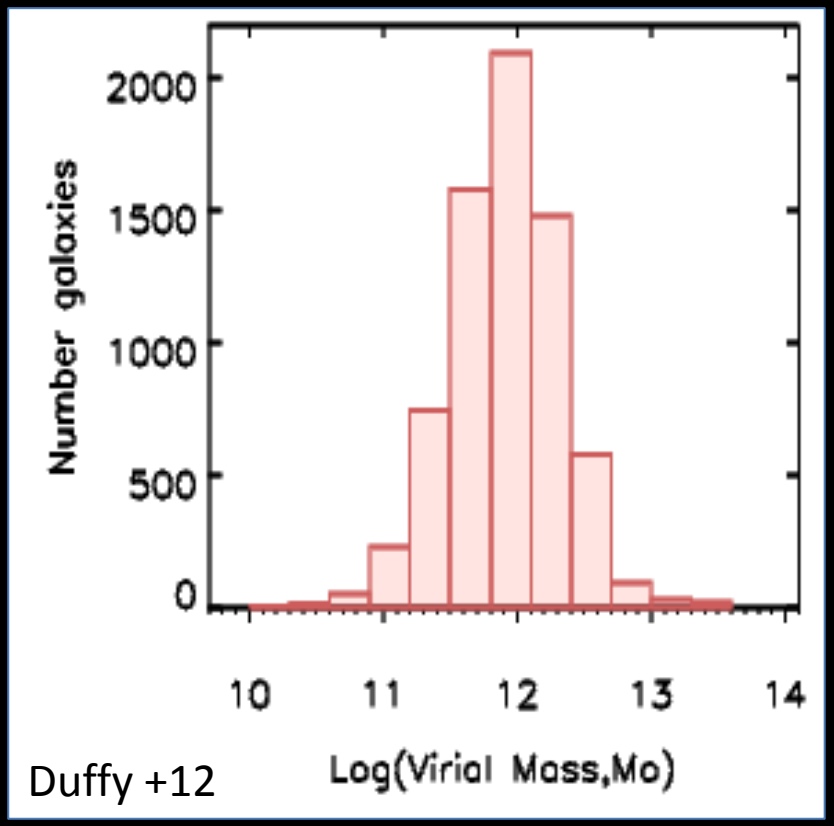

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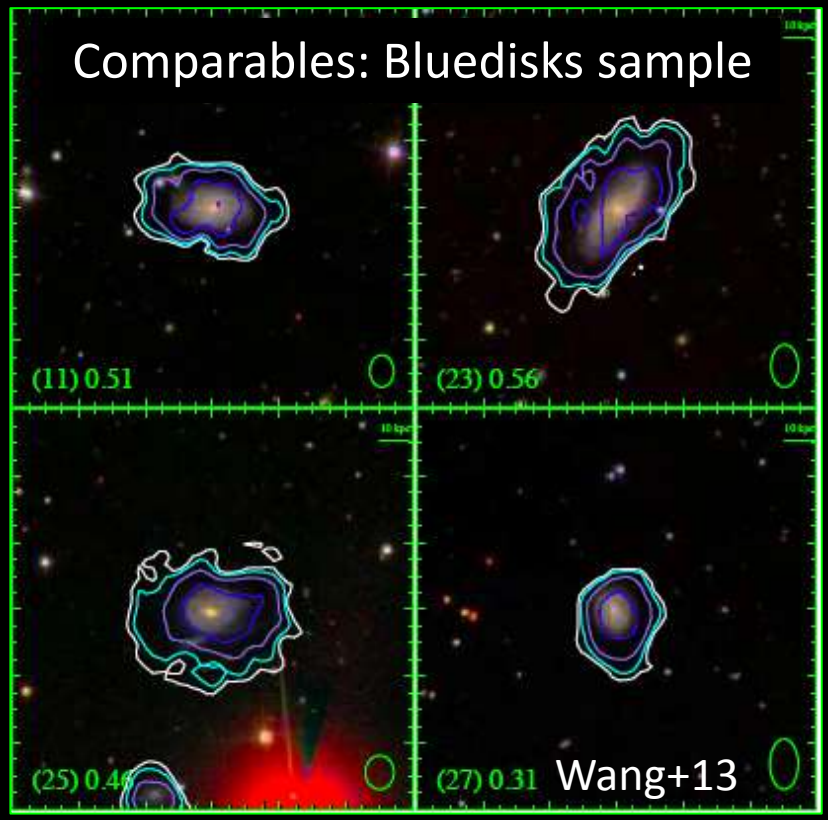

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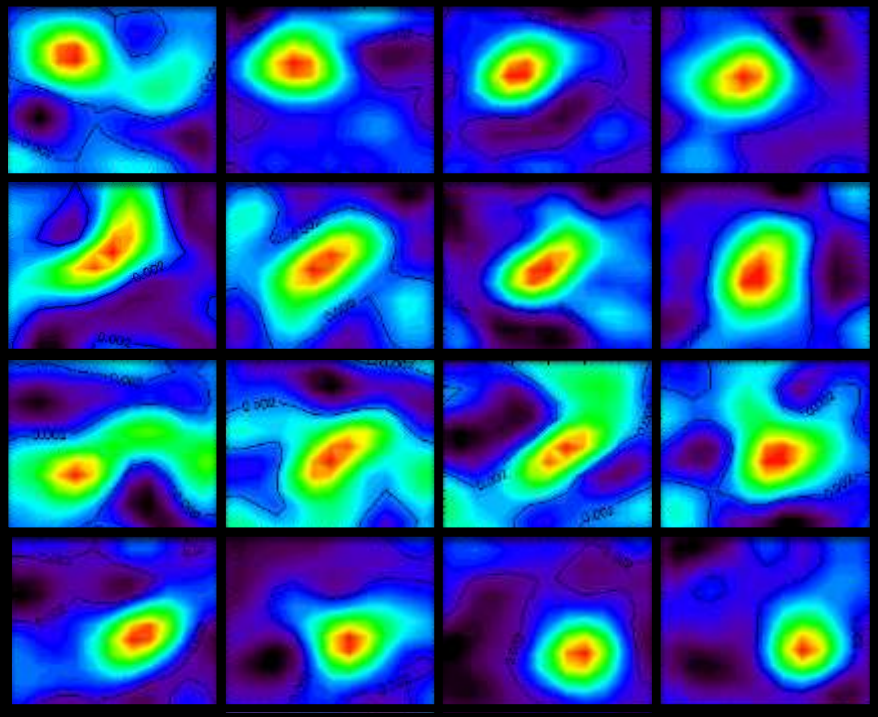
Resolved galaxies in WALLABY

Typical channel maps



Elson 2012

WALLABY+WNSHS: ~7000 resolved HI detections

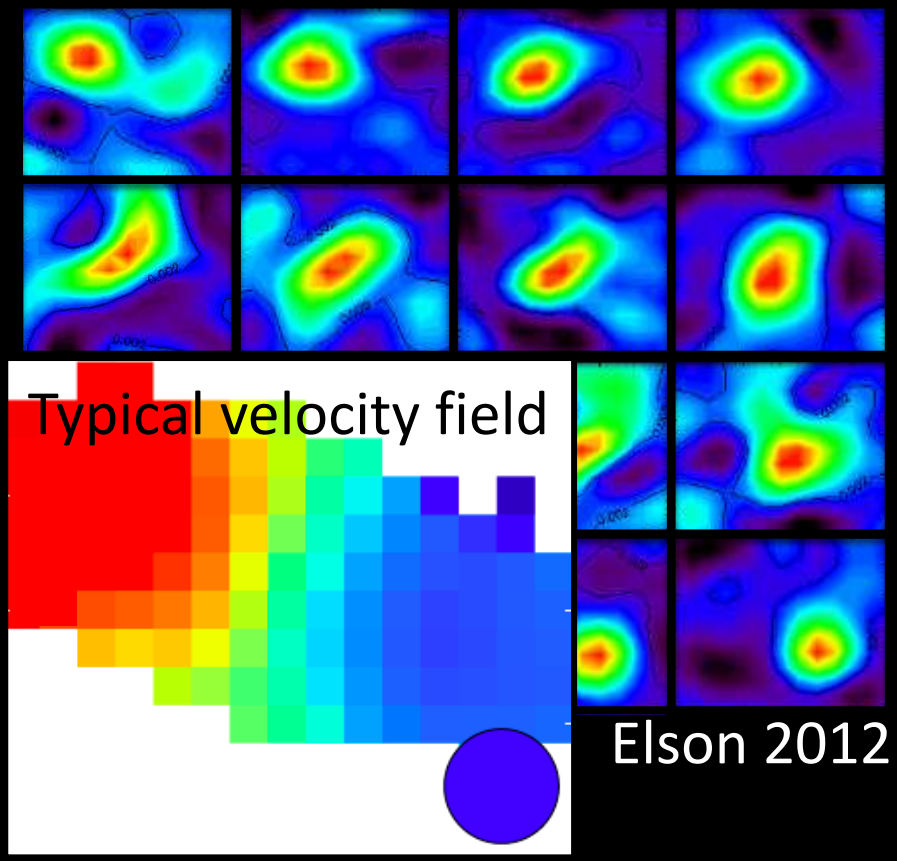
Resolved galaxies in WALLABY

Science:

What is the physical structure and mass distribution of resolved WALLABY detections?

How do they compare to cosmological predictions?

Typical channel maps



Elson 2012

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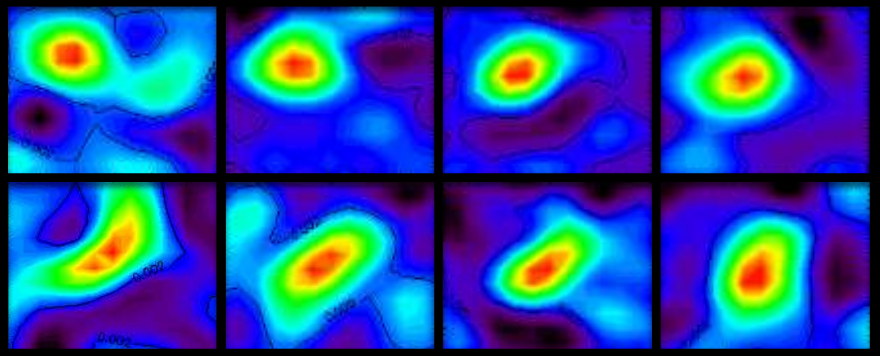
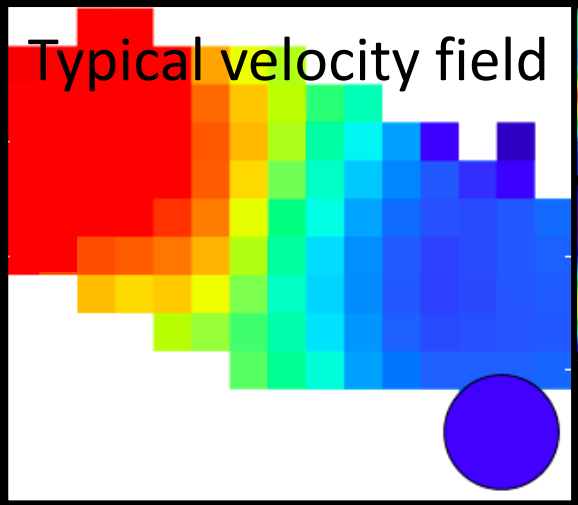
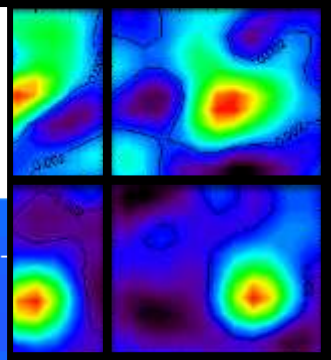




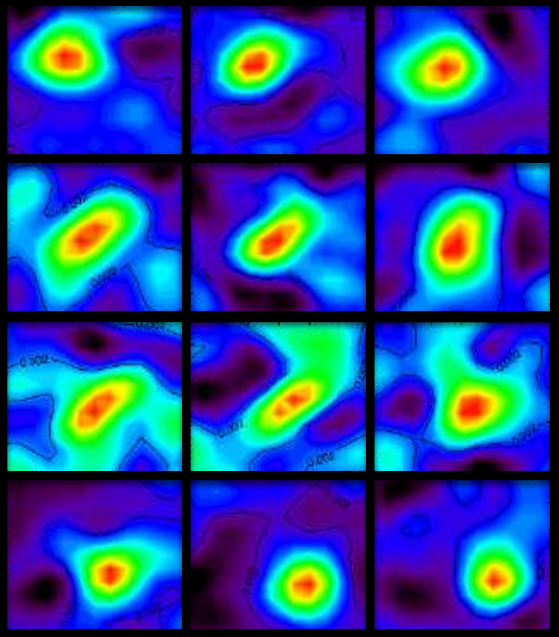


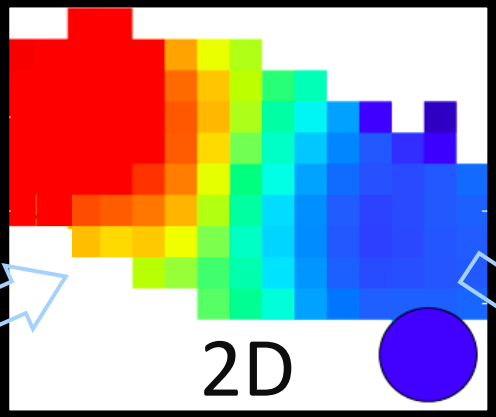
Elson 2012

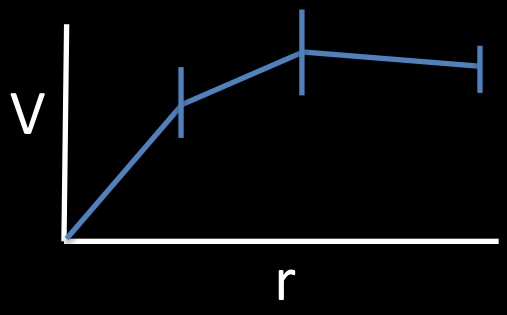
~7000 well-resolved HI disks

Towards a WALLABY Kinematics Pipeline

Well-resolved,
intermediate-incl disks







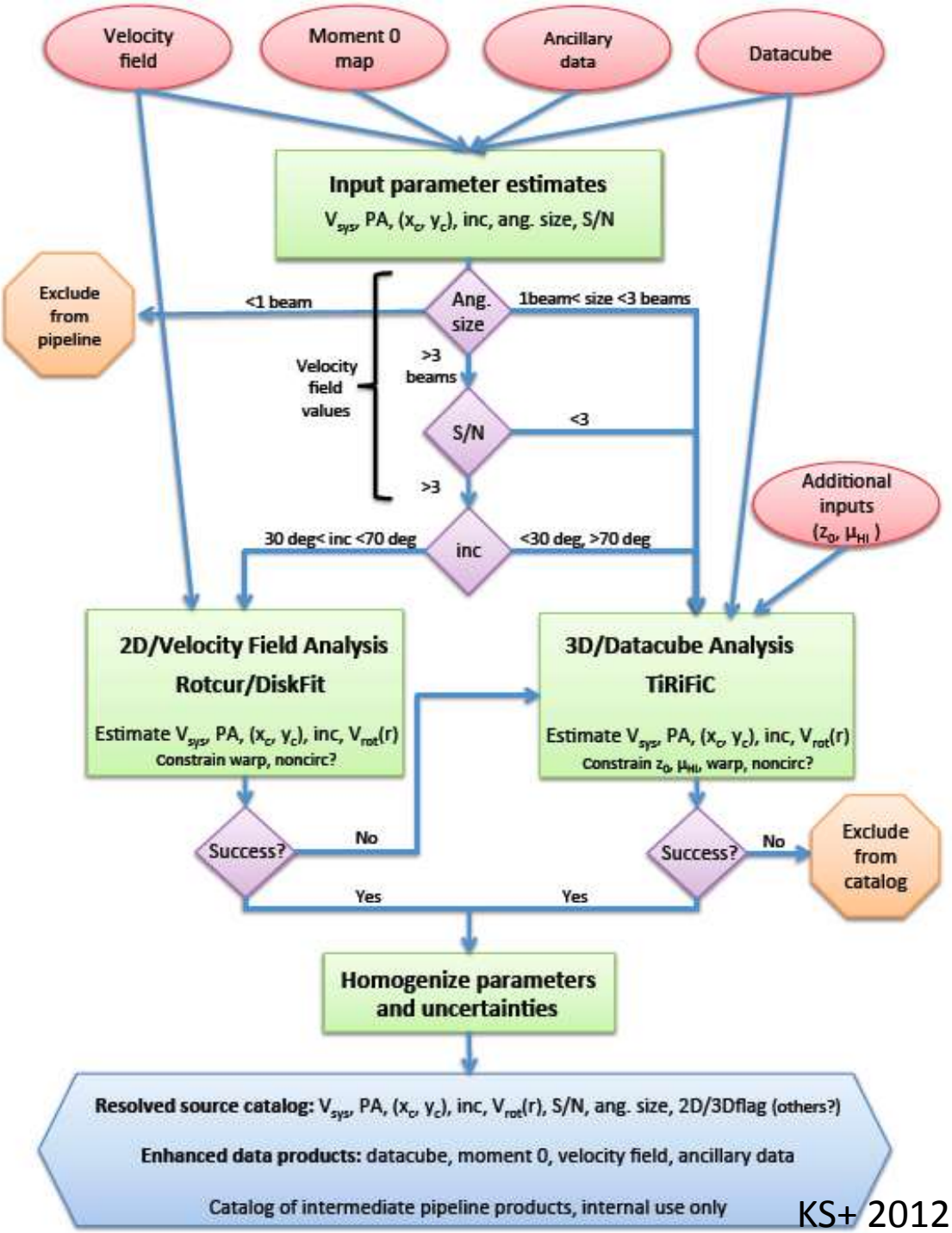
PIPELINE ➔

i, PA, Vsys
xc, yc

3D

Poorly resolved,
edge-on, disturbed disks

Conceptual Pipeline



KS+ 2012

Wallaby kinematics:

E. de Blok, E. Elson, G. Jozsa, P. Kamphuis, B. Koribalski, S.-H. Oh, K. Spekkens, L. Staveley-Smith

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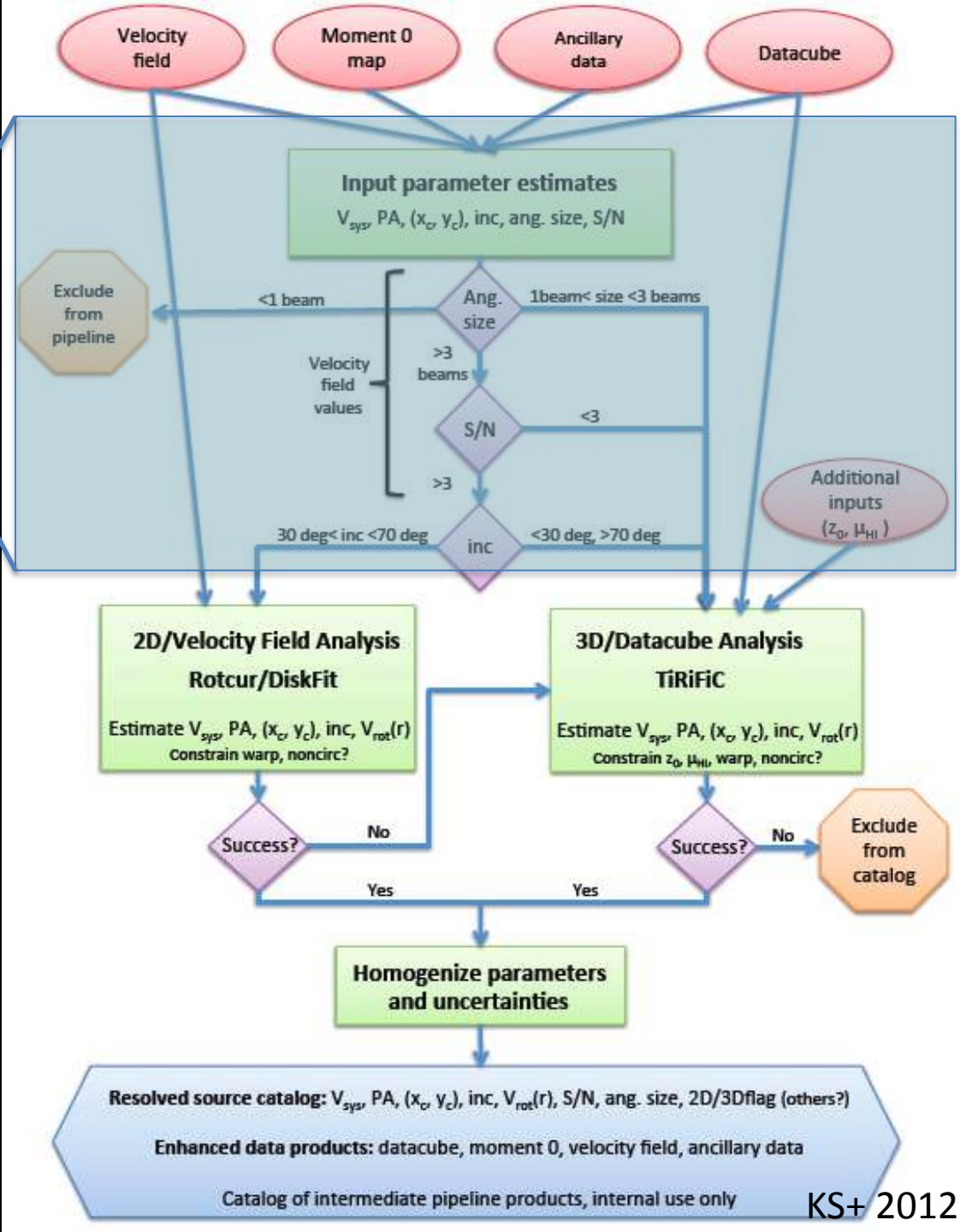

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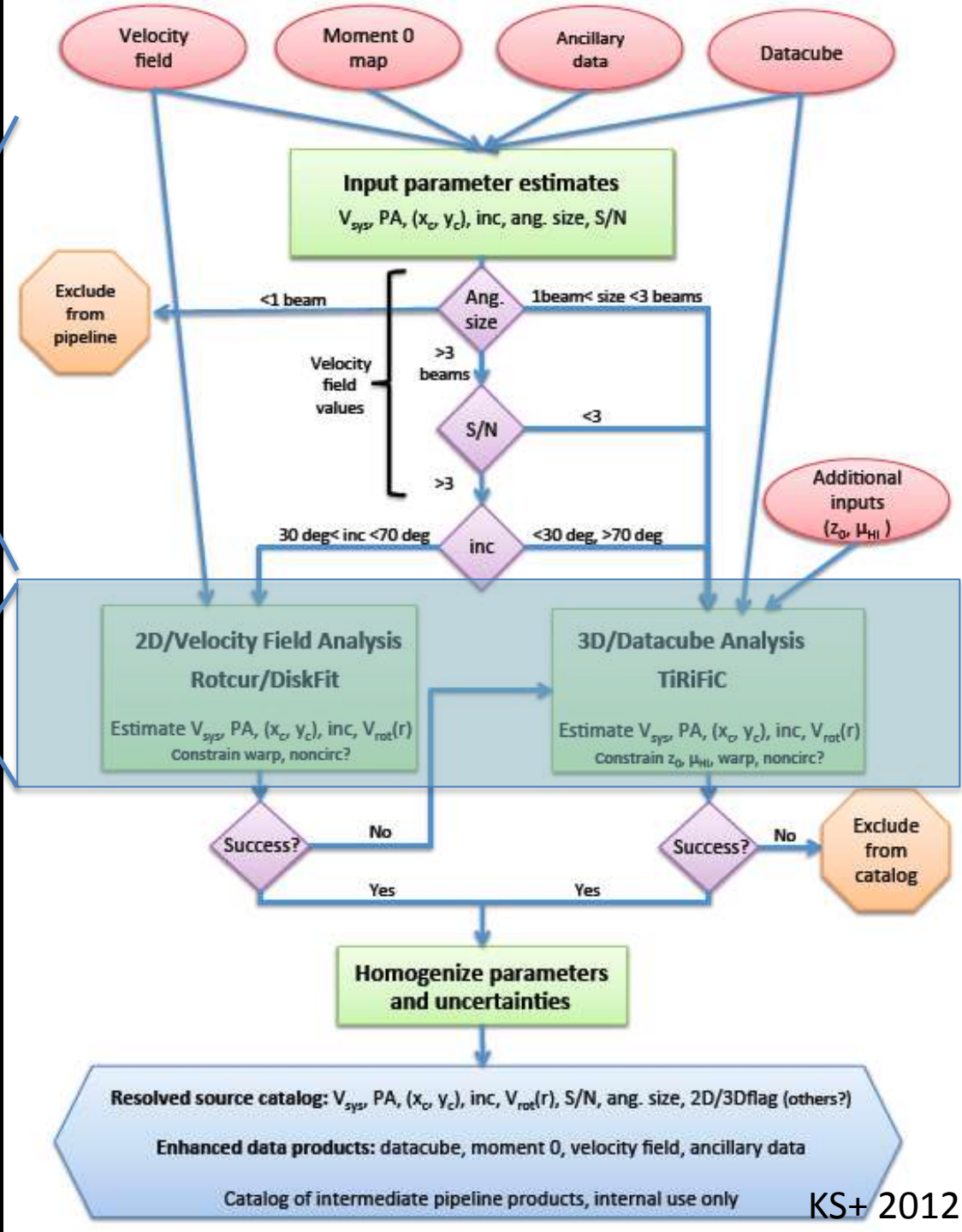

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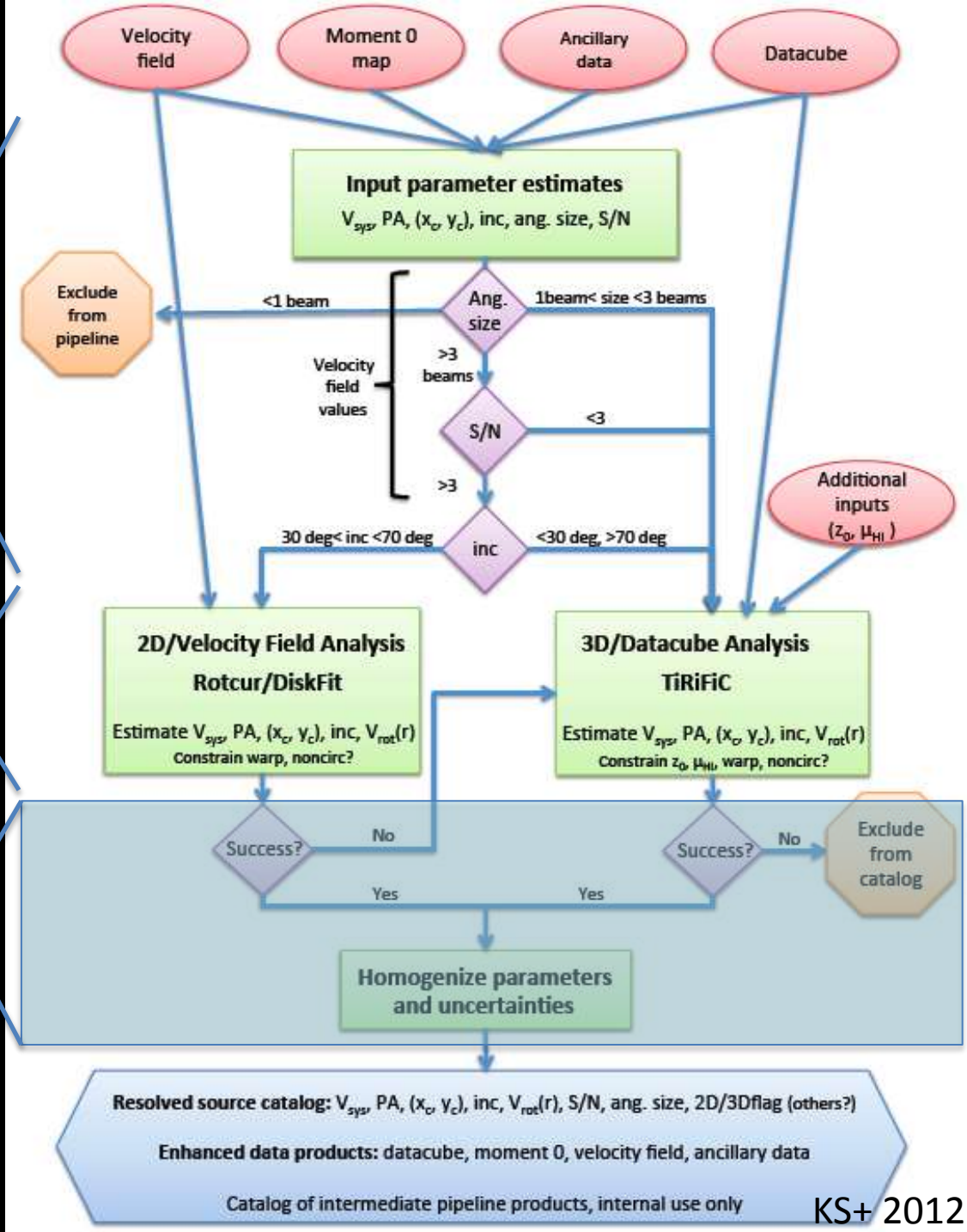

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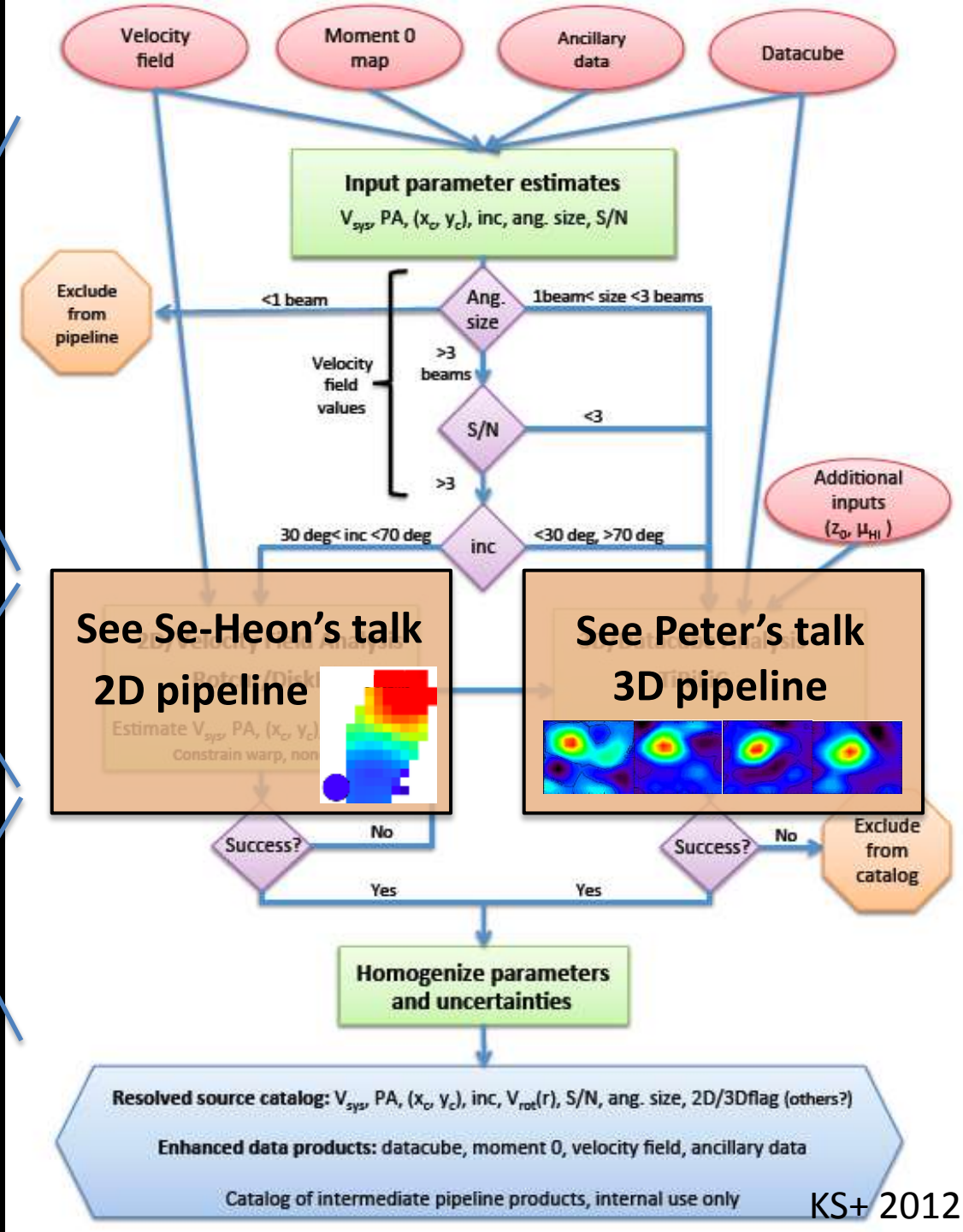

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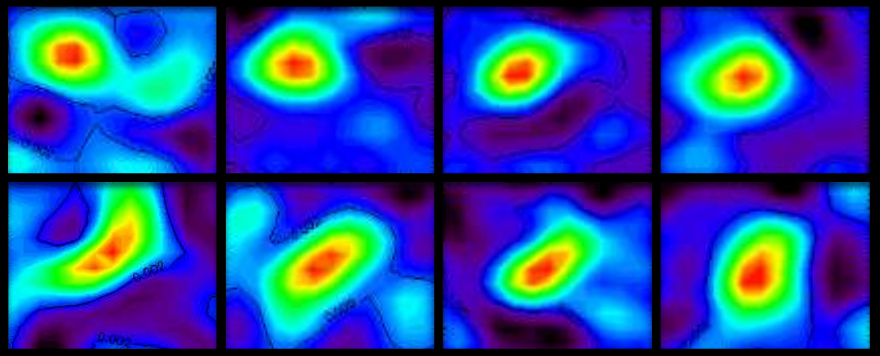
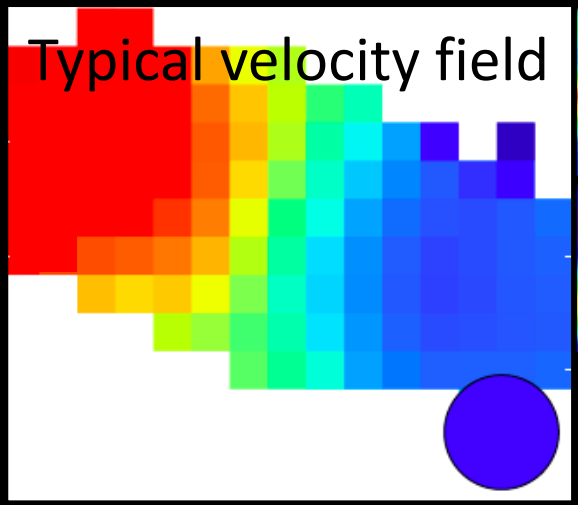
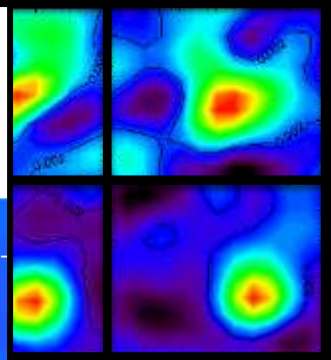






Elson 2012

~7000 well-resolved HI disks

Kinematics from Tilted Rings

Kinemetry

Rotcur

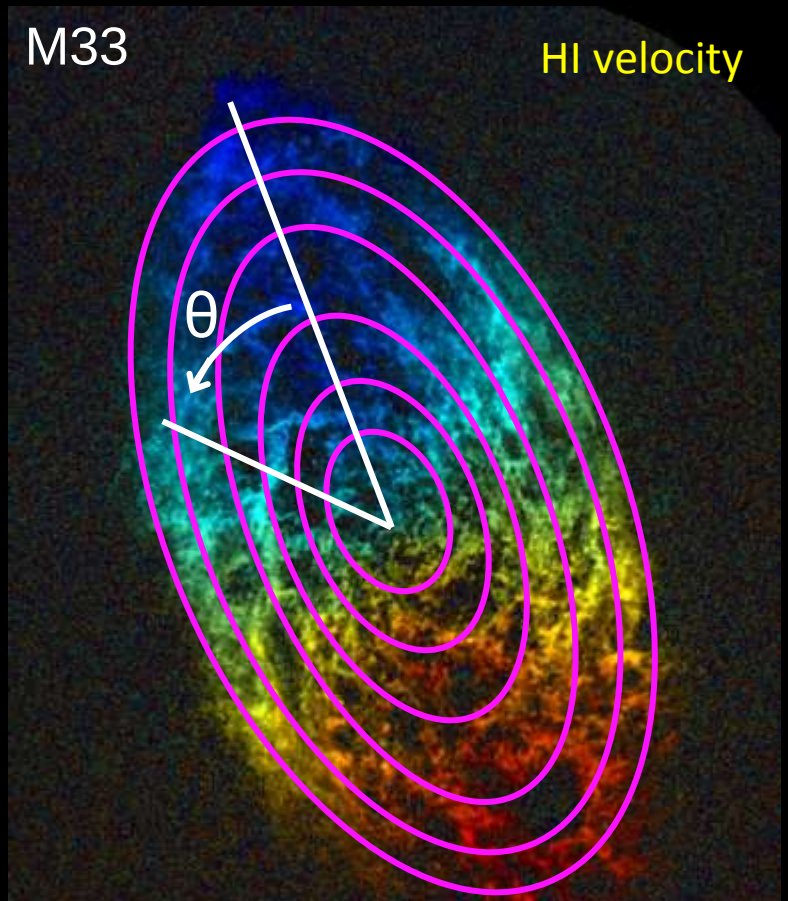
Problems:

Models under-constrained

- User intervention guides fit
- Uncertainties hard to estimate

Sky-plane coefficients indirectly related to disk-plane features

- c1 ≠ Vrot if higher order terms aren't small
- Weak, coherent features missed



"Tilted Rings":

$$\frac{V - V_{sys}}{\sin i} = \Sigma(c_m \cos[m\theta] + s_m \sin[m\theta])$$

NRAO/AUI

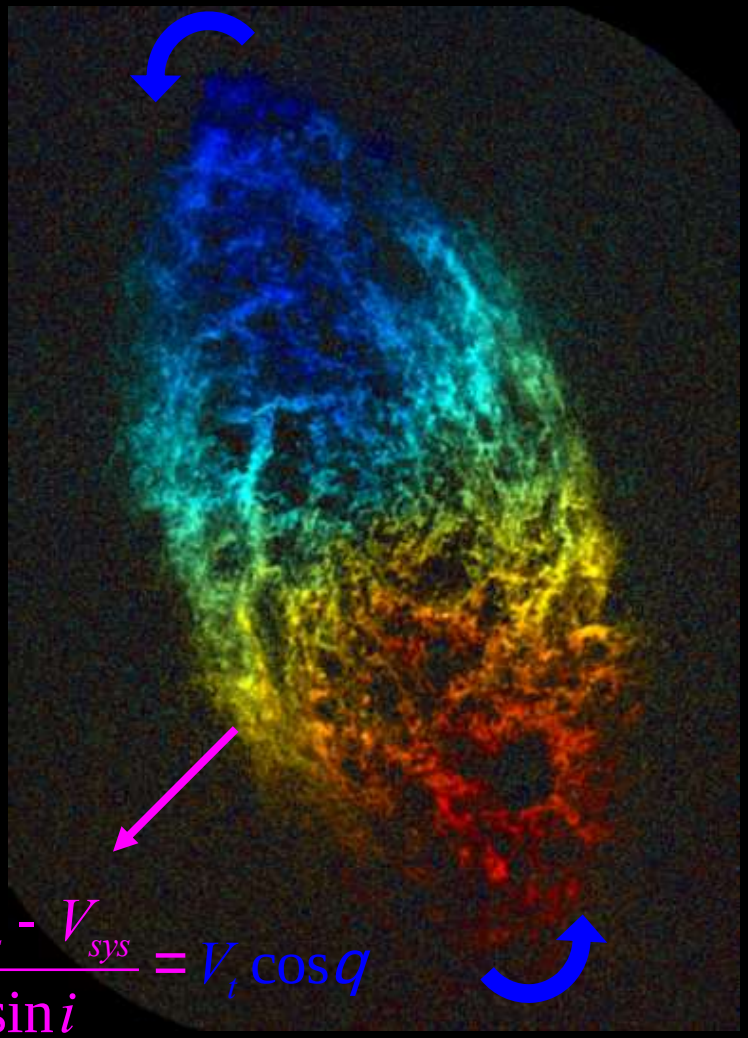
DiskFit: A Model-Based Approach to Measuring Disk Galaxy Structure

- Fits non-parametric components to either velocity fields or images
- User chooses from physically motivated disk-plane models: parameters simultaneously minimized
- Bootstrap resampling of best fitting models: statistically robust uncertainties

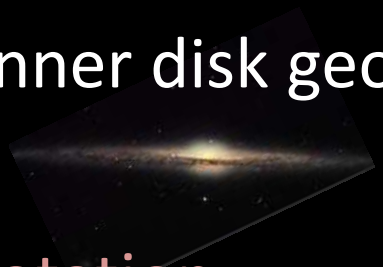
(KS, J. Sellwood)

http://www.physics.rutgers.edu/~spekkens/diskfit/

DiskFit Models

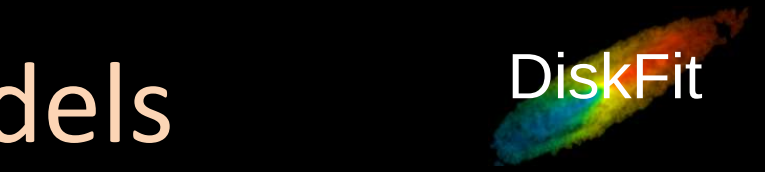


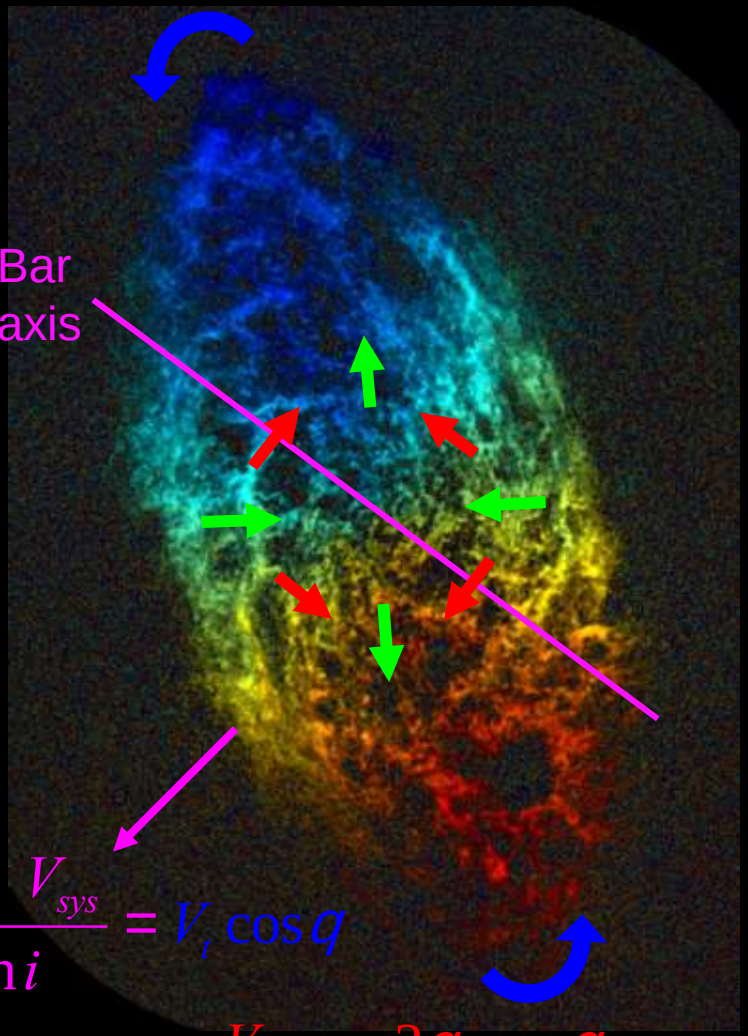
Flat inner disk geometry and:



1. Rotation

DiskFit Models





$$\frac{V_{obs} - V_{sys}}{\sin i} = V_t \cos q$$

$$- V_{2,t} \cos 2q_b \cos q$$

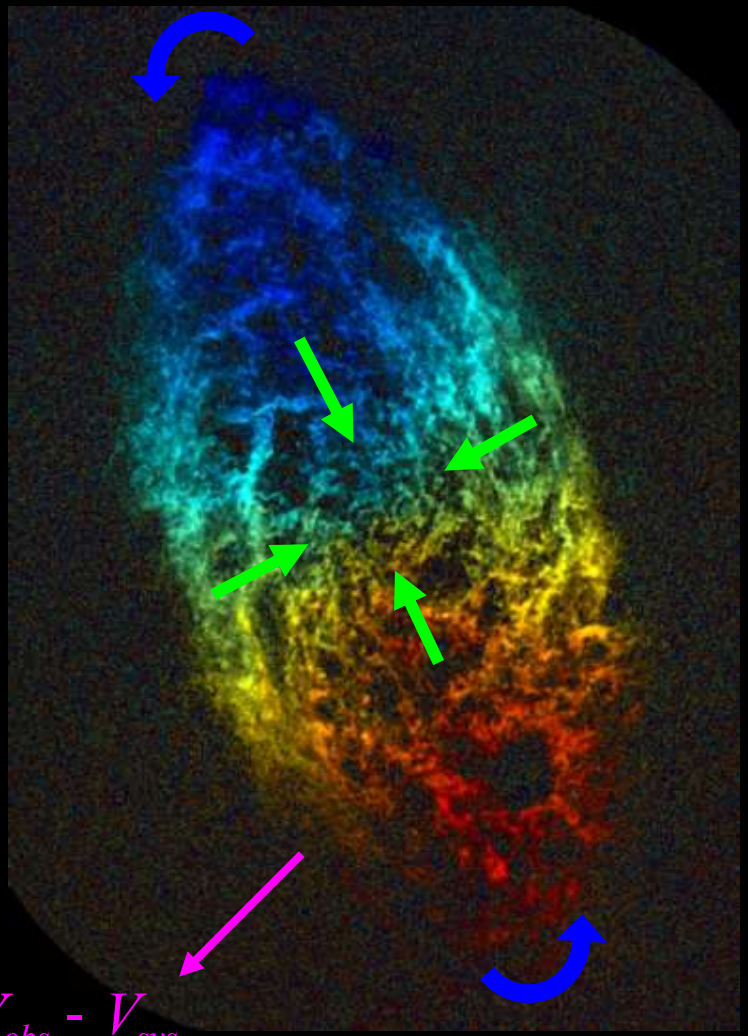
$$- V_{2,r} \sin 2q_b \sin q$$

Flat inner disk geometry and:

1. Rotation

2. Rotation + bar-like flow

DiskFit Models

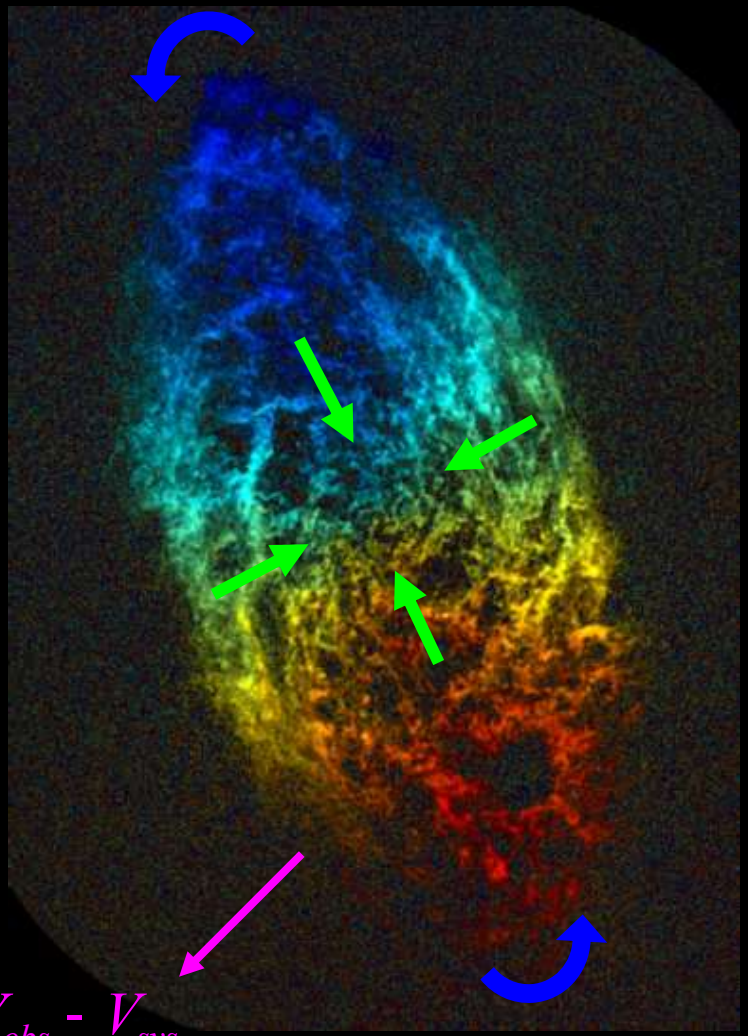


$$\frac{V_{obs} - V_{sys}}{\sin i} = V_t \cos q - V_r \sin q$$

Flat inner disk geometry and:

1. Rotation
2. Rotation + bar-like flow
3. Rotation + radial flow

DiskFit Models



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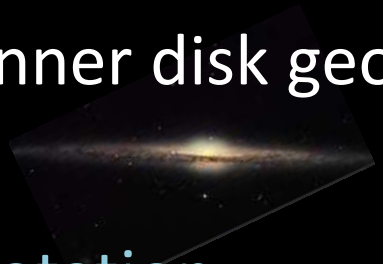
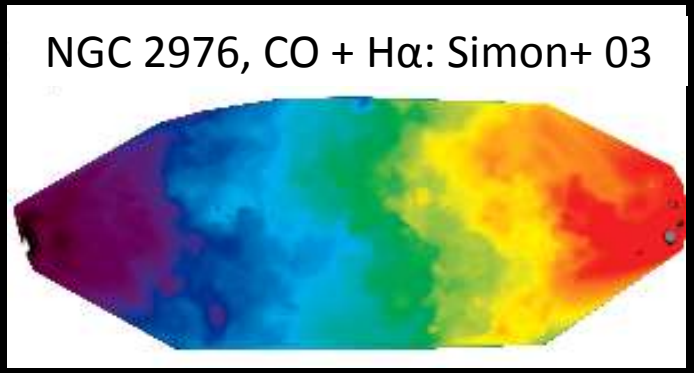
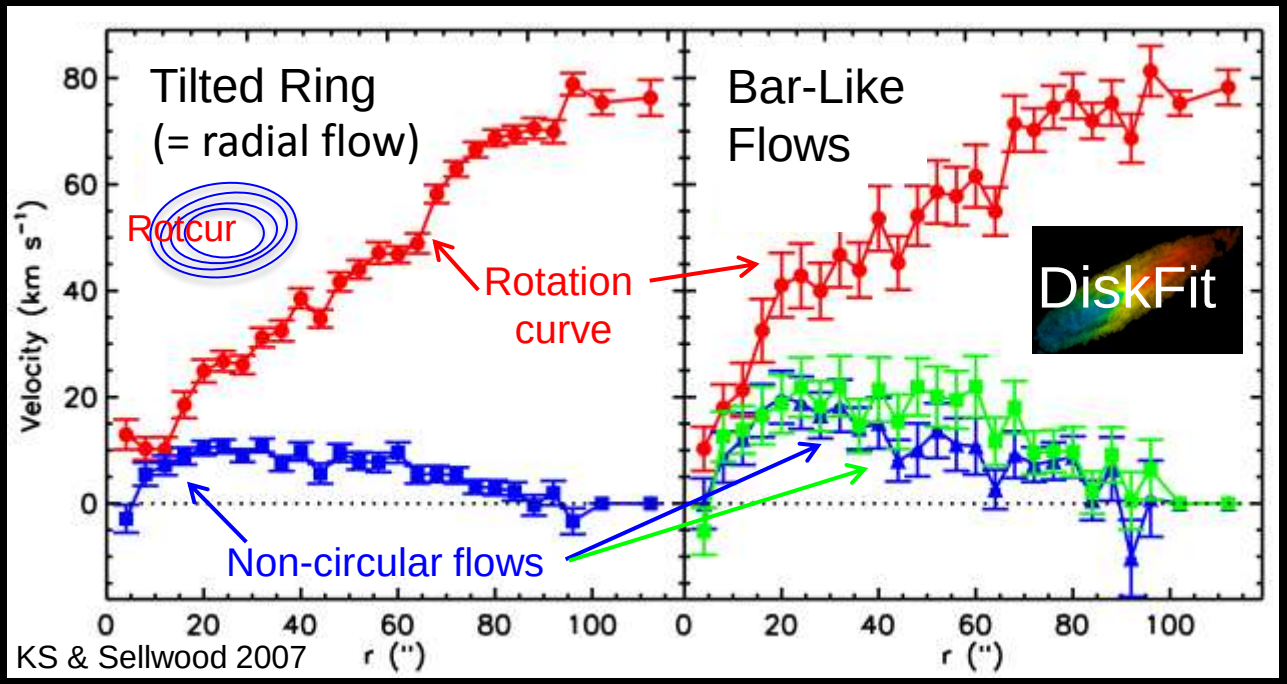


1. Rotation
2. Rotation + bar-like flow
3. Rotation + radial flow
4. Rotation + lopsided flow
5. Rotation + outer warp

The Physical Model Matters: NGC 2976

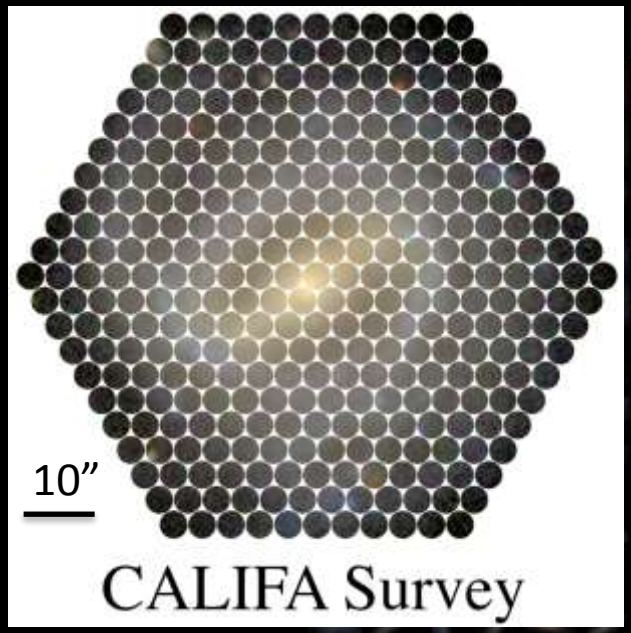




Same fit quality, different rotation curve

DiskFit and Large Samples: CALIFA

Incidence of bar-like flows in CALIFA DR1?

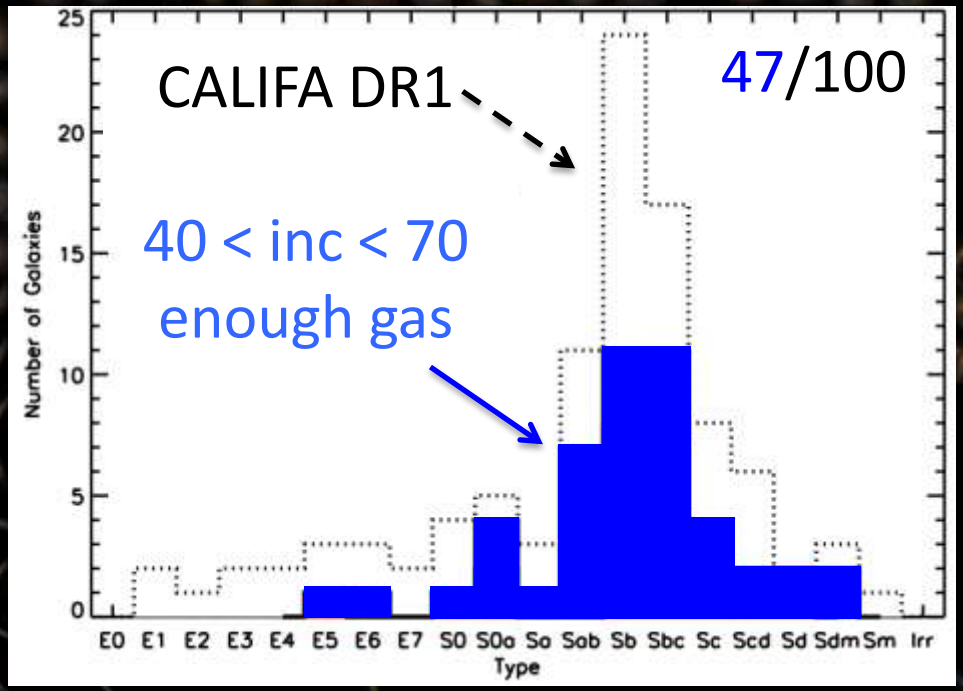


600 D + z-selected galaxies

Vels: PPAK V500 (R ~ 850)
V1200 (R ~ 1650)

Phot: SDSS

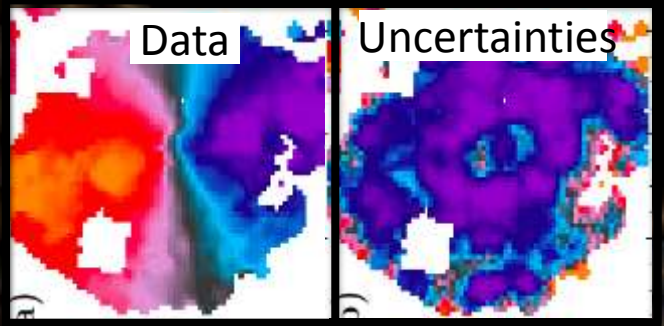
L. Holmes, MSc 2013: model Hα kinematics in DR1



Automating DiskFit

1. Pipeline-fit rotation and bar-like flow models + uncertainties (IDL, Perl, DiskFit)

2. Determine optimal model:



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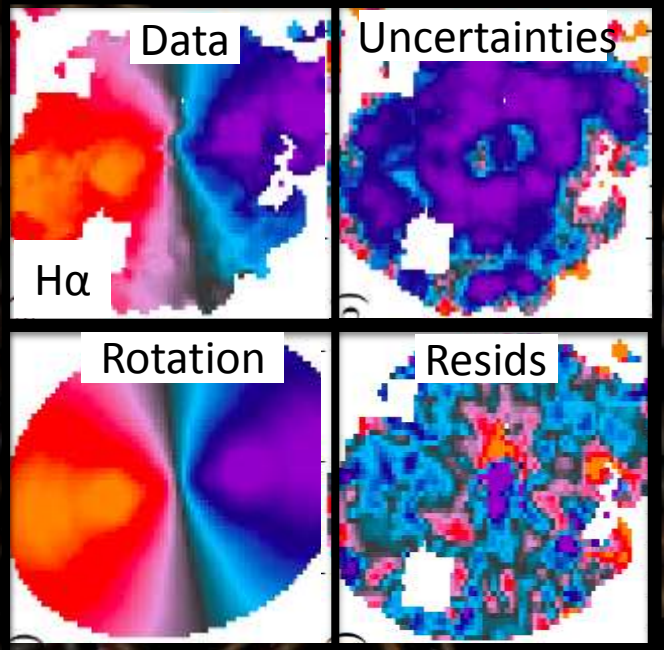

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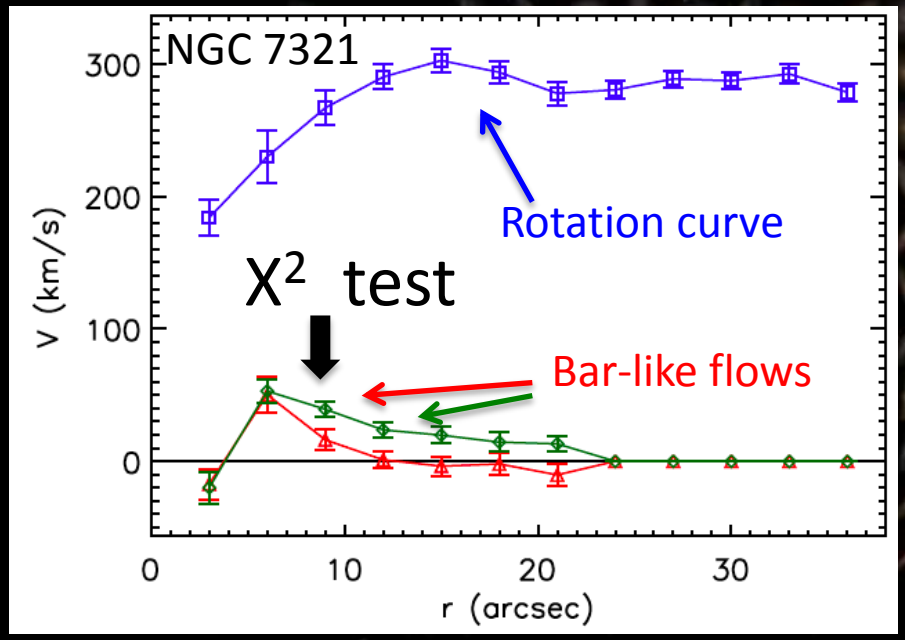
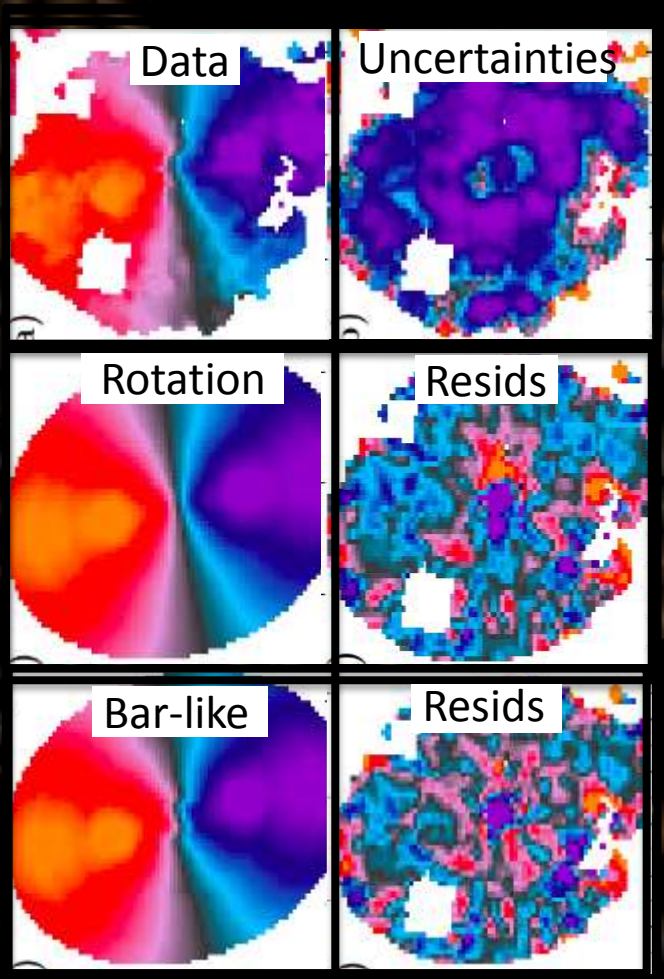
Bar-like model:





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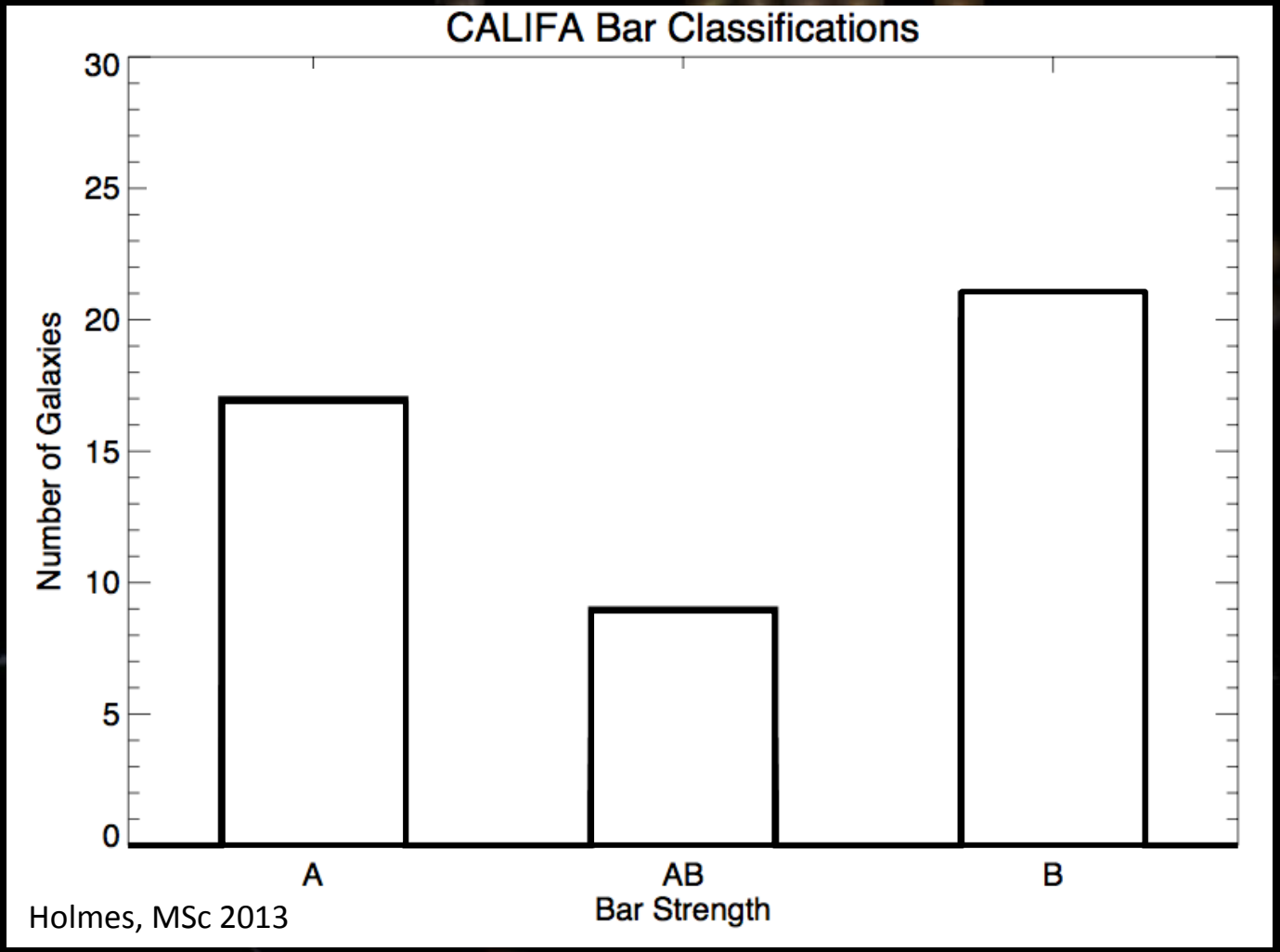

Holmes, MSc 2013

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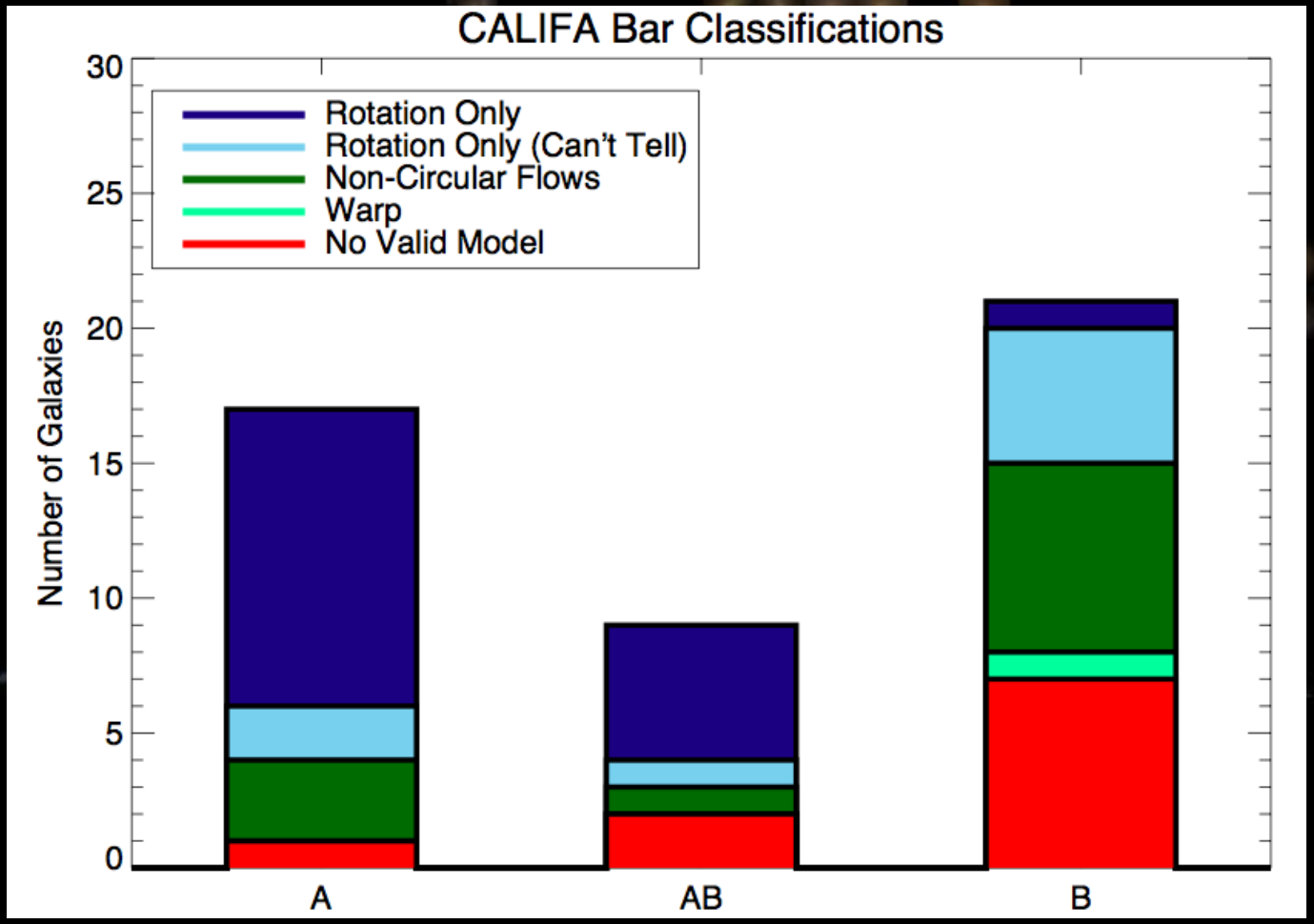


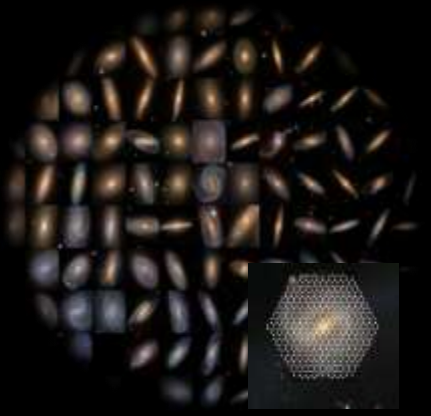
~20% of the time, photometric classification belies different kinematics

Conclusions

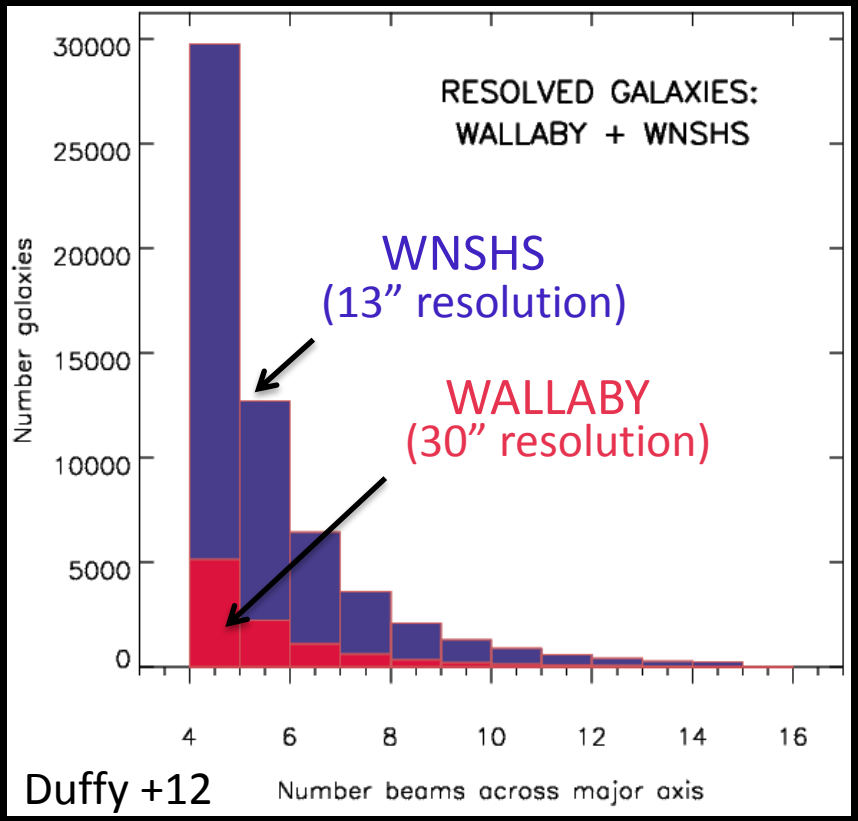
- WALLABY/WNSHS will resolve ~7000 HI galaxies: kinematics pipeline development underway

- DiskFit fits non-parametric models to kinematics or photometry – overcomes many problems with tilted rings

- CALIFA DR1: photometric bar classification belies different Hα kinematics ~20% of the time



Soon: widefield SKA pathfinder surveys

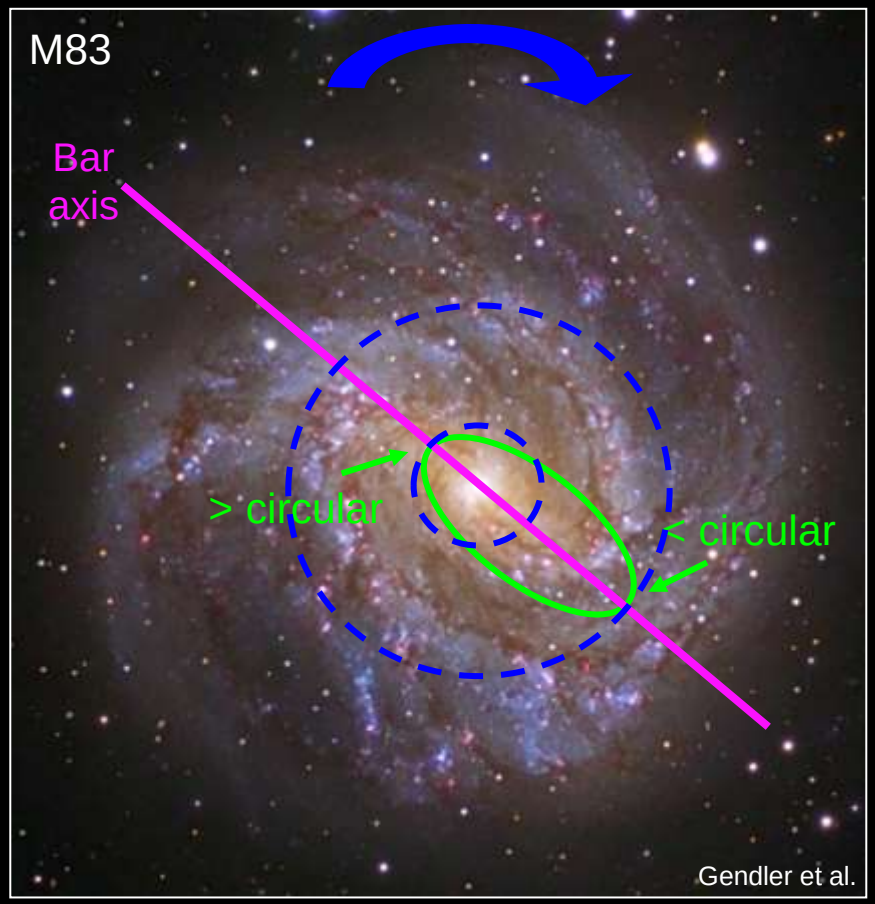


SKA pathfinders enable probe mass distributions for ~10,000 galaxies, enabling statistical comparisons to cosmological predictions

http://www.atnf.csiro.au/research/WALLABY/
http://www.astron.nl/~jozsa/wnshs/

Weak Bars Matter

- Example: missed bars bias rotation curves:



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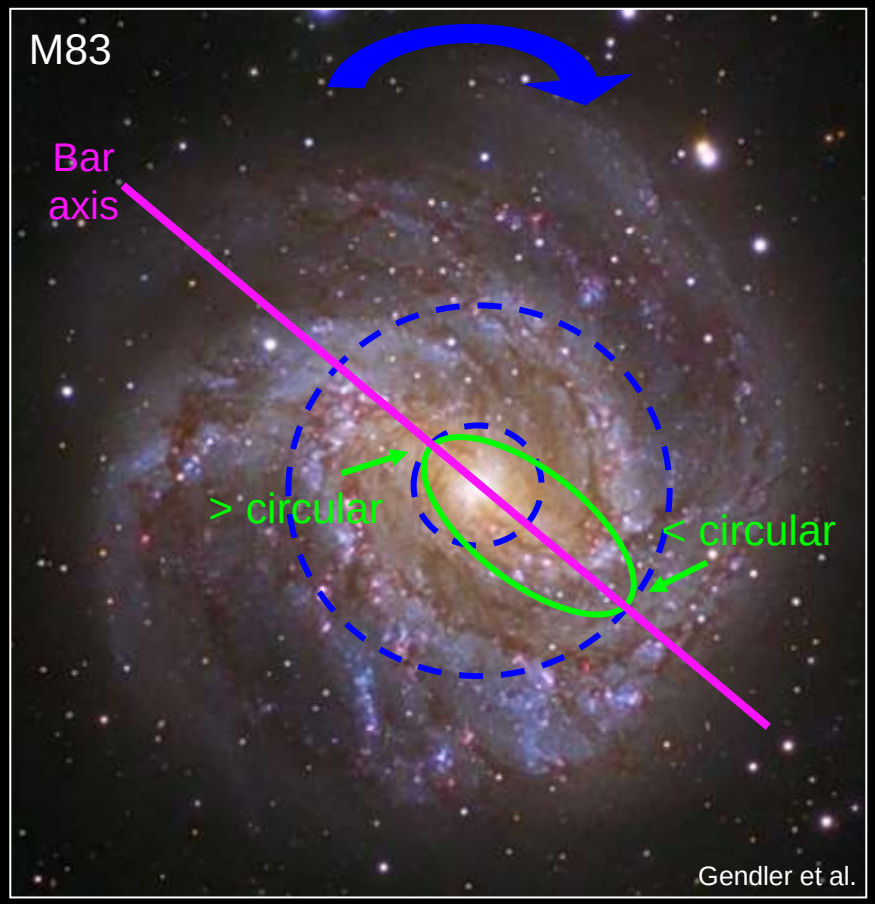
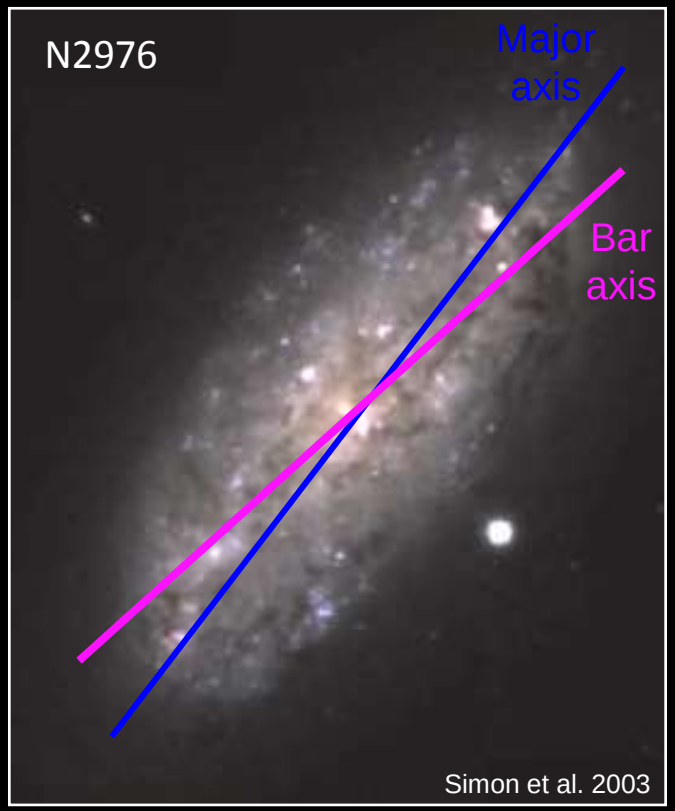
- Example: missed bars bias rotation curves:

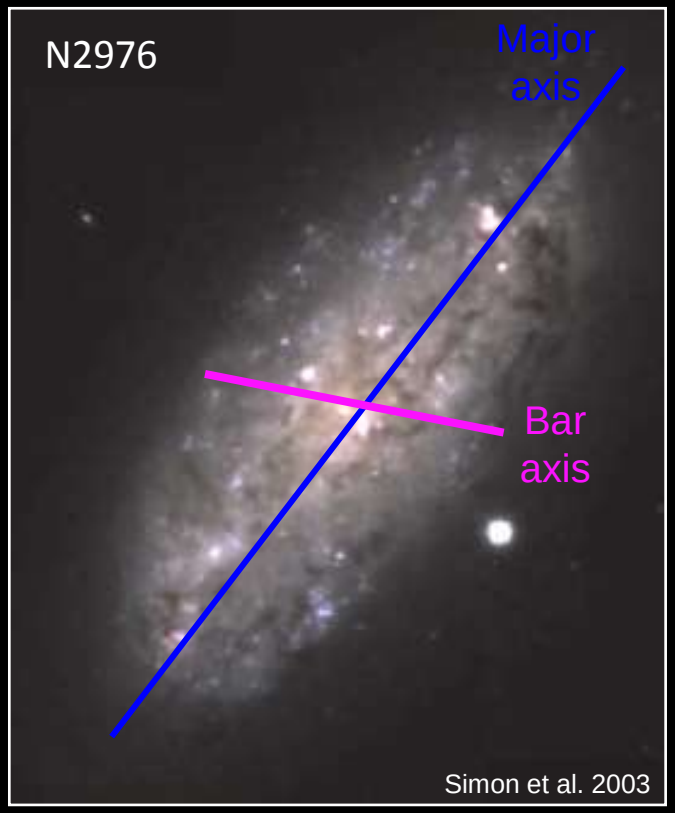




Weak Bars Matter

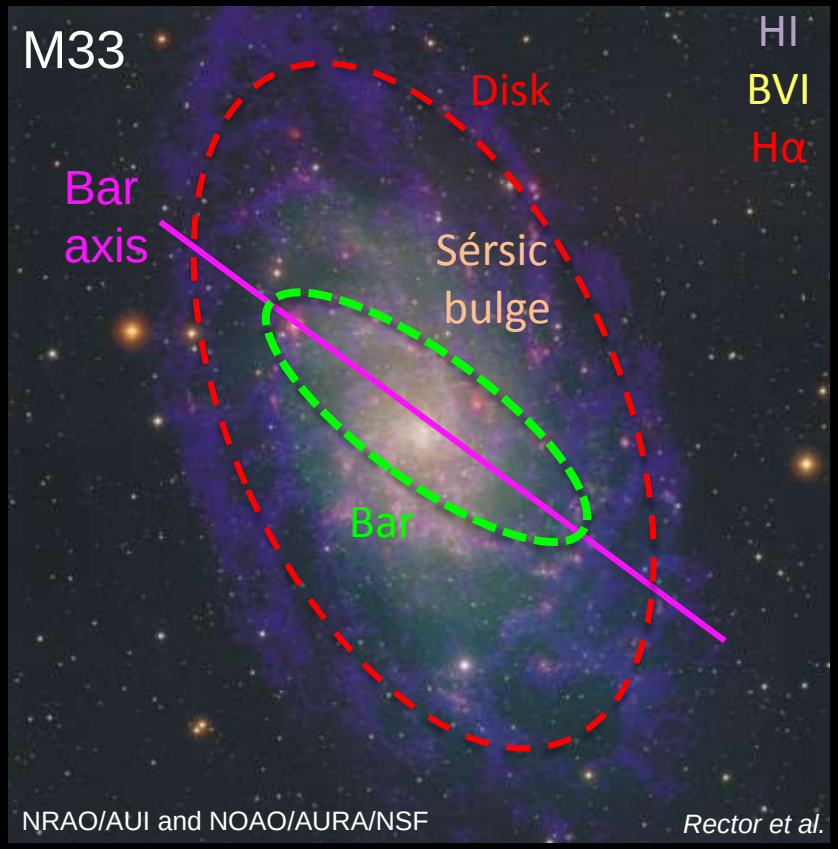
- Example: missed bars bias rotation curves:

If bar near…		then RC biased
Major axis	➔	LOW
Minor axis	➔	HIGH



Weak bars impact structure inferred from kinematics, photometry

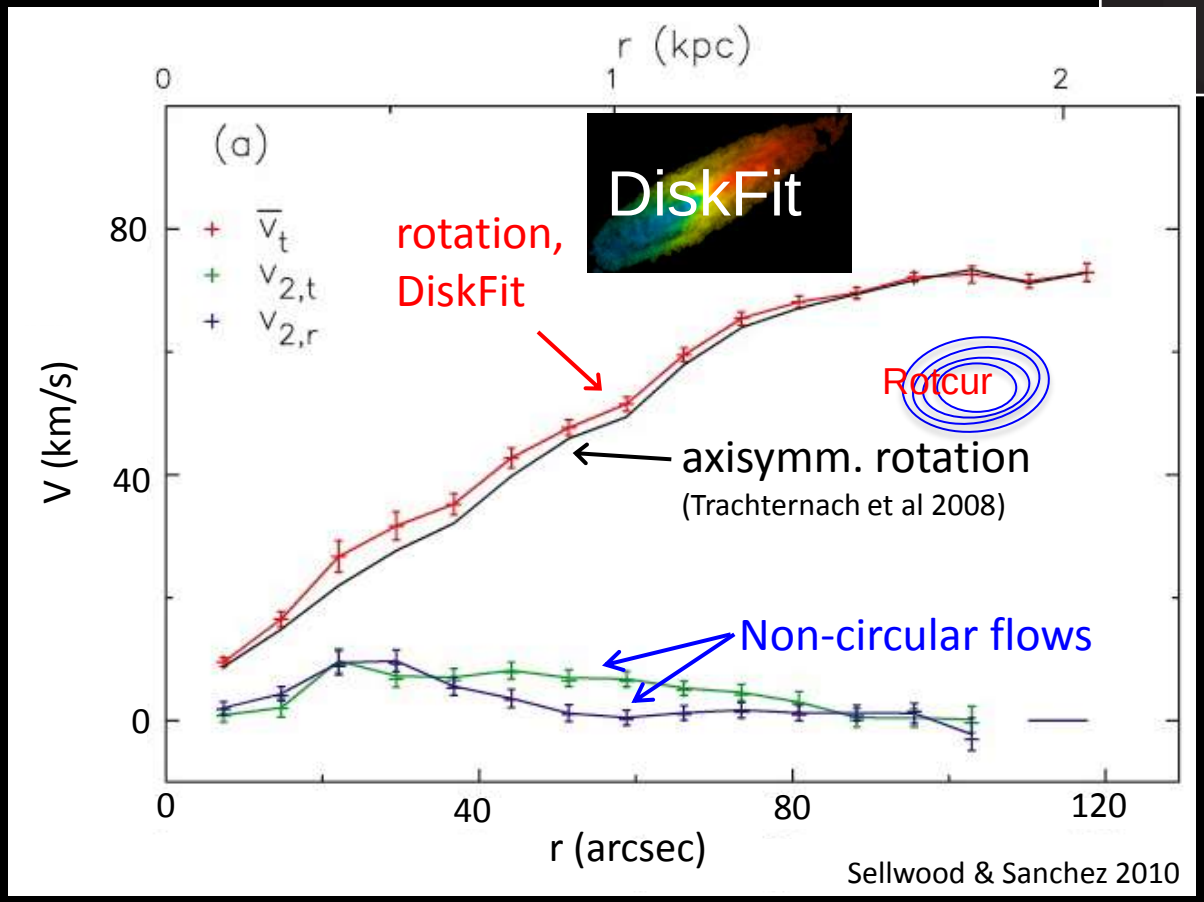
Finding Bars with DiskFit



- Uses all data at once
  - Simultaneous minimization across all parameters
- Fits large and small distortions
  - More accurate rotation curve
- Can boostrap-resample best fitting model
  - Statistically robust uncertainties

Ideal for galaxies with both photometry and kinematics

Example: Non-Circular Flows in NGC 2976



Fit quality is the same: underlying physical model is different