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Stars & Star formation 26/03

Connecting star cluster formation and HI dynamics with *HST* and *MeerKAT*

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BACKGROUND : Interacting galaxies

Definition:

- Galaxy interactions = close encounters/mergers that distort morphology (Hernández-Toledo et al. 2005; Giri et al. 2023)
- Redistribute matter & angular momentum → tidal tails, bridges

Relevance:

- Trigger elevated star formation rates → intense starbursts (Scudder et al. 2012; Moreno et al. 2021)
- Often produce LIRGs/ULIRGs with concentrated IR emission (Sanders & Mirabel 1996; Scoville 1999)

The Antennae Galaxies

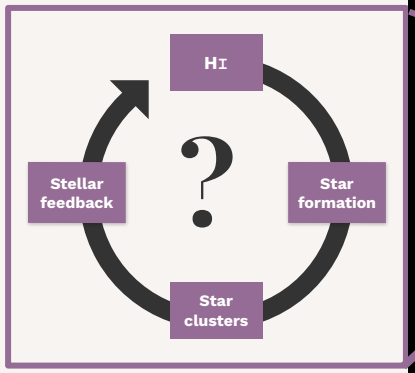
©: Robert Gendler

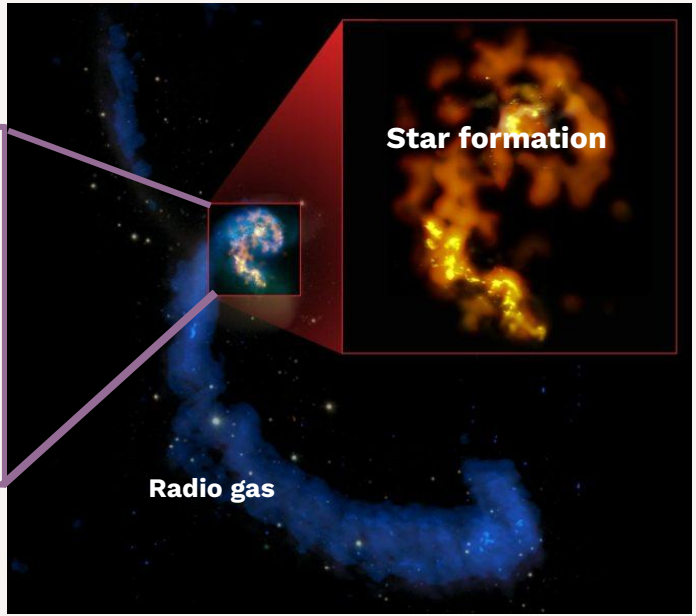
Interactions **reshape gas** → sets environment for cluster formation

BACKGROUND : The feedback loop

Definition:

- Compressed HI fosters star cluster formation (Maybhate et al. 2007)
- Young massive star clusters (YMCs): Tracers of recent star formation (Randriamanakoto 2013, 2019 , 2026)
- Feedback: radiation, winds, supernovae (Matzner & Jumper 2015; Adamo 2020b)





The Antennae Galaxies

Relevance:

- Produces HI cavities, shells, turbulence (Maybhate 2007; Weisz 2009; Gim 2021)
- Efficiency in interacting galaxies still unclear (Grisdale 2017)
- Feedback–HI coupling remains poorly constrained

Leads to the **central question**: How do clusters shape HI structure in disturbed systems?

THE PROJECT : Why and how?

Key knowledge Gaps & Motivation :

- Current models disagree on how feedback interacts with HI
- Studies show inconsistent feedback behaviour
- **Lack of spatially resolved studies linking YMCs + HI structure**
- Combination of HST and MeerKAT data

AIM :

Characterise the connection between star formation tracers and the gas dynamics of their host systems.

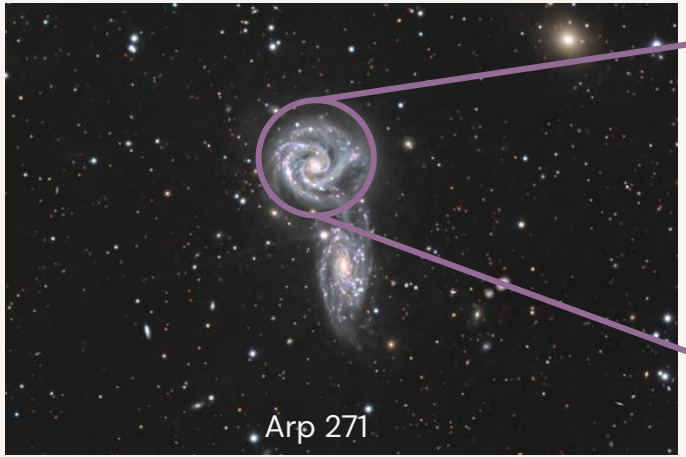
OBJECTIVES :

➔ **Compile a robust photometric catalogue of YMCs** using multi-band HST

➔ Map the HI distribution and kinematics from MeerKAT/MeerChoirs data

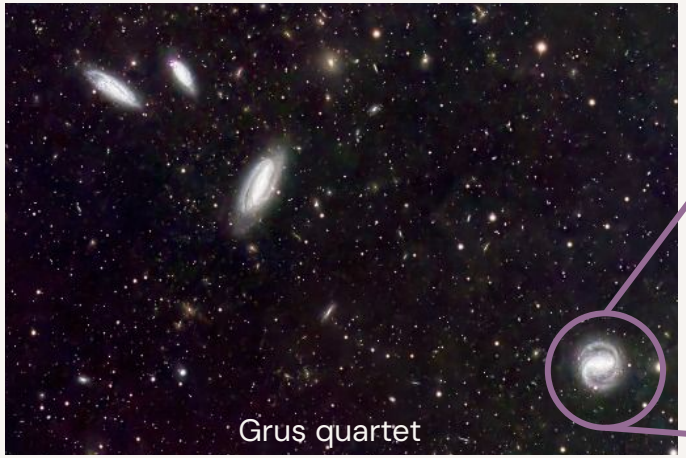
➔ Cross correlate cluster populations with HI features to assess feedback signatures

THE TARGETS : NGC 5427 and NGC 7552



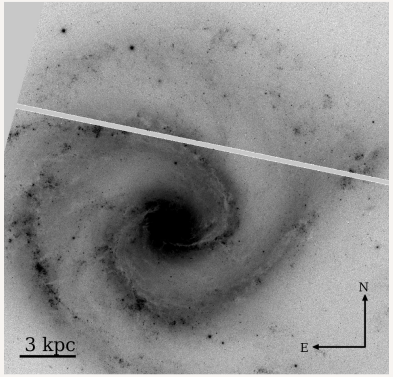
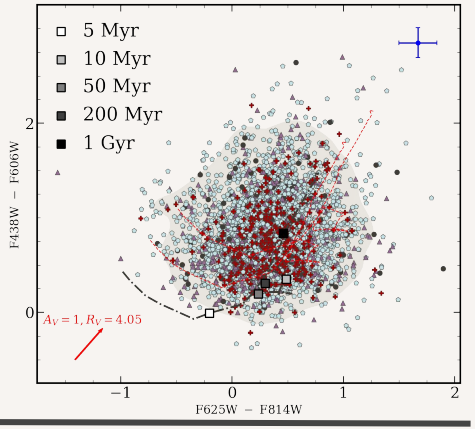
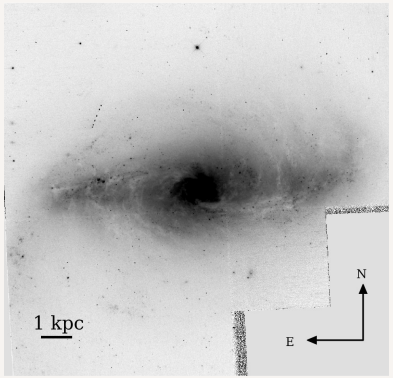
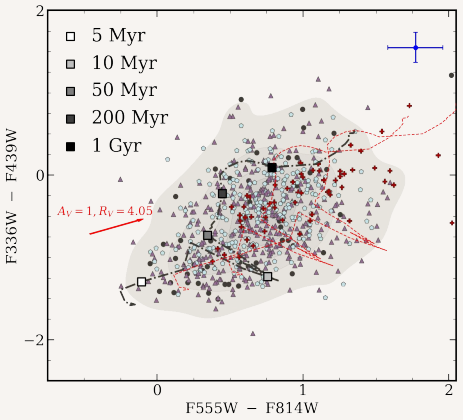
System: Arp 271 (HiPASS J1403-06)[1]
Luminosity distance : ~ 43 Mpc
Physical scale : ~197 pc/arcsec
Classification : Sbc(s)
Star formation rate : 9 $M_\odot$/yr (Misiriotis et al. 2004)
Past studies : Fuentes-Carrera et al. 2004, Dopita et al. 2014

Choirs groups (Sweet et al., 2013) with MeerKAT data & ≥ 4 HST filter images



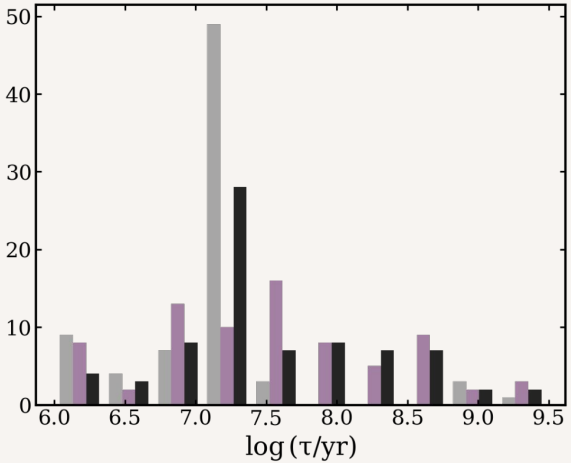
System: Grus quartet (HiPASS J2318-42a)[1]
Luminosity distance : ~ 20 Mpc
Physical scale : ~94 pc/arcsec
Classification : (R')SB(s)ab[2]
Star formation rate : 3.7 $M_\odot$/yr (Brandl et al. 2012)
Past studies : Pan et al. 2013, West et al. 2023

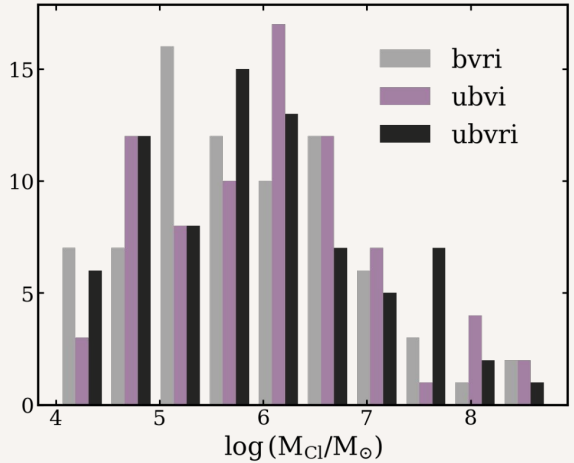
HST ANALYSIS : Optical data

Target :	HST observations :	Source catalogue :	CCD* :
 NGC 5427 (f814w)	WFC3 **f438w, f606w, f625w** and **f814w** Pixel scale : 0.04″/pix PSF : ~3 pix (0.12″ → 24 pc)	Detection on combined f438w, f606w and f814w Aperture radius: 1.5 pix (0.06 ″ → ~12 pc) Nb SC candidates: ■ bvr : 4719 ■ bvi : 4183 ■ bvri : 3986	
 NGC 7552 (f814w)	WFPC2 **f336w, f439w, f555w, f606w,** f658n and **f814w** Pixel scale : 0.1″/pix PSF : ~3 pix (0.3″ → ~28 pc)	Detection on combined f439w, f555w and f814w Aperture radius: 1.5 pix (0.15 ″→ ~14 pc) Nb SC candidates: ■ bvri : 91 ■ ubvi : 711 ■ ubvri : 76 ■ ubvrhαi : 40	

***yggdrasil** SSP models overplotted on top, metallicity Z = 0.02 (Zackirson+11)

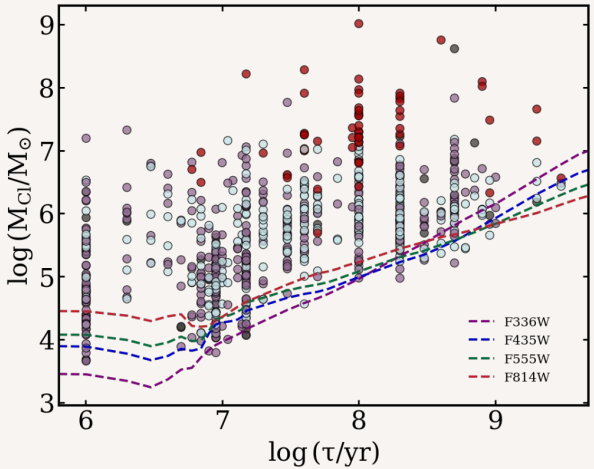
YMCs in NGC 7552 : Catalogues

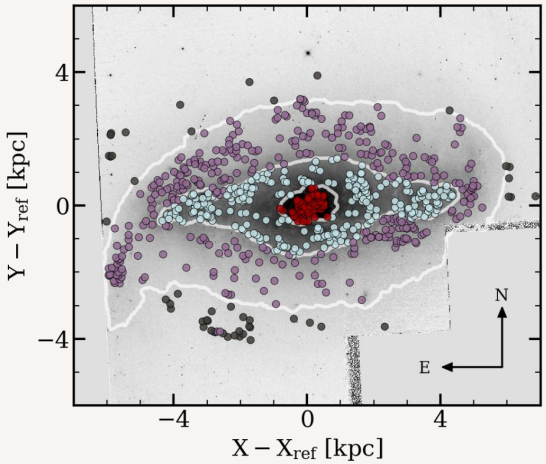


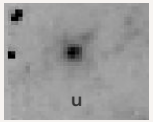


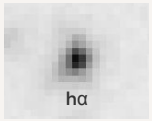
Sub-pop	bvri (%)	ubvi (%)	ubvri (%)
1 - 10 Myr	30	33	15
10 - 100 Myr	64	33	52
100 - 280 Myr	0	20	17
> **280** Myr	4	13	14

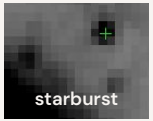
Percentage per Sub-population with respect to the catalogue







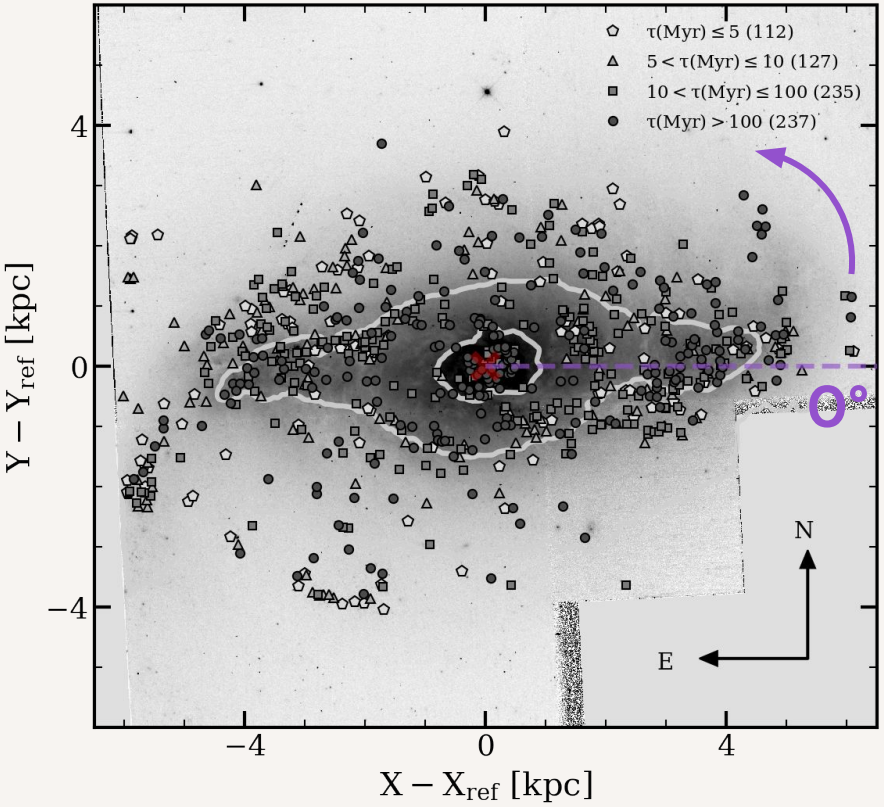


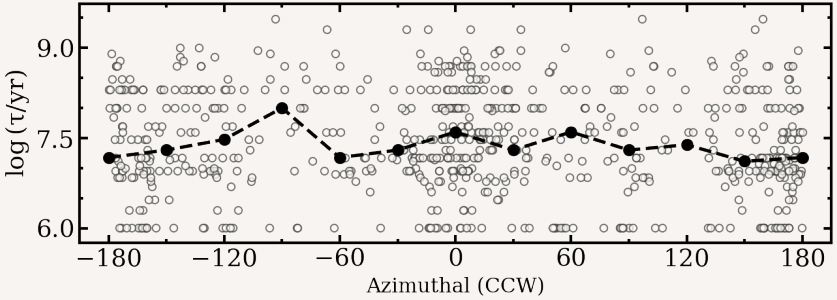


Age (Myr)	Mass log($M_{cl}/M_{\odot}$)	Cat.
15 15 15	4.77 4.55 4.55	bvri ubvi ubvri
15 9 15	5.16 4.69 4.92	bvri ubvi ubvri
15 200 200	7.26 7.82 7.66	bvri ubvi ubvri

YMCs in NGC 7552 : Age distribution

ubvi- Catalogue

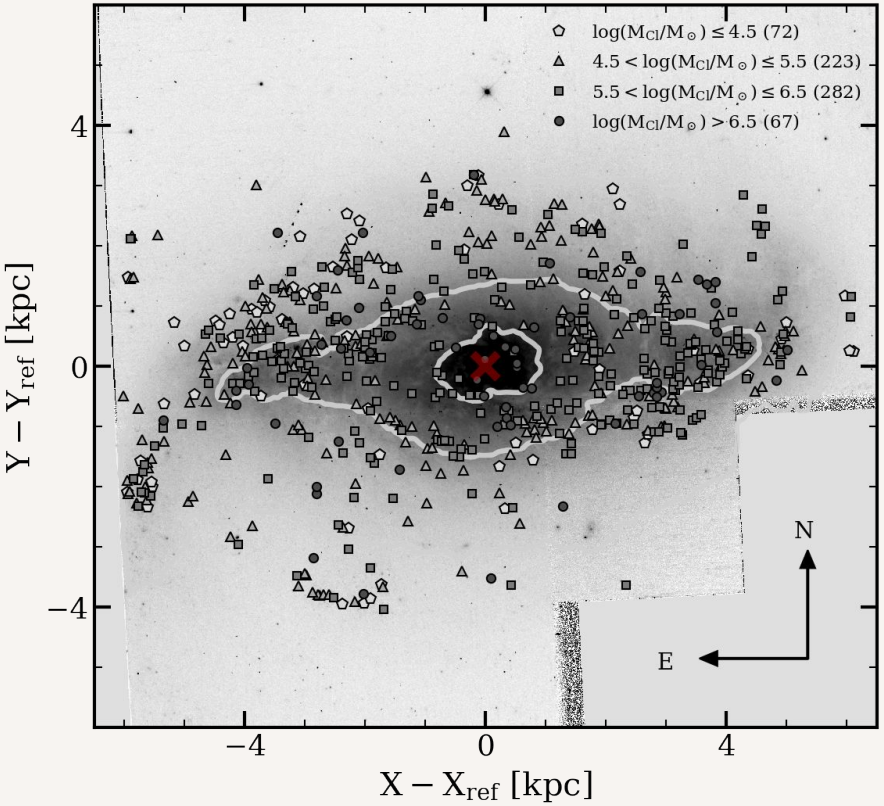


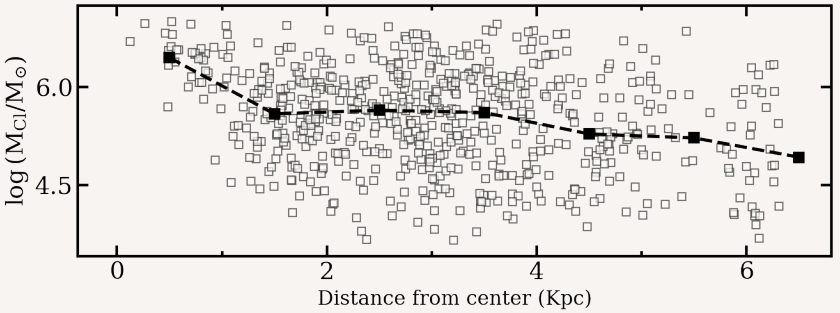


- Age range : ~ **1 Myr** to **3 Gyr**
- Generally young : > 60 % younger than 100 Myr
- >80 % of clusters are younger than 280 Myr (group crossing time, Džudžar+21)
- Bump between -120 and -60°
- "**Popcorn**" Star Formation model : * **No clear azimuthal age gradient** (Elmegreen 1994; Böker et al. 2008)
- Interaction-triggered SF is also a possibility

YMCs in NGC 7552 : Masse distribution

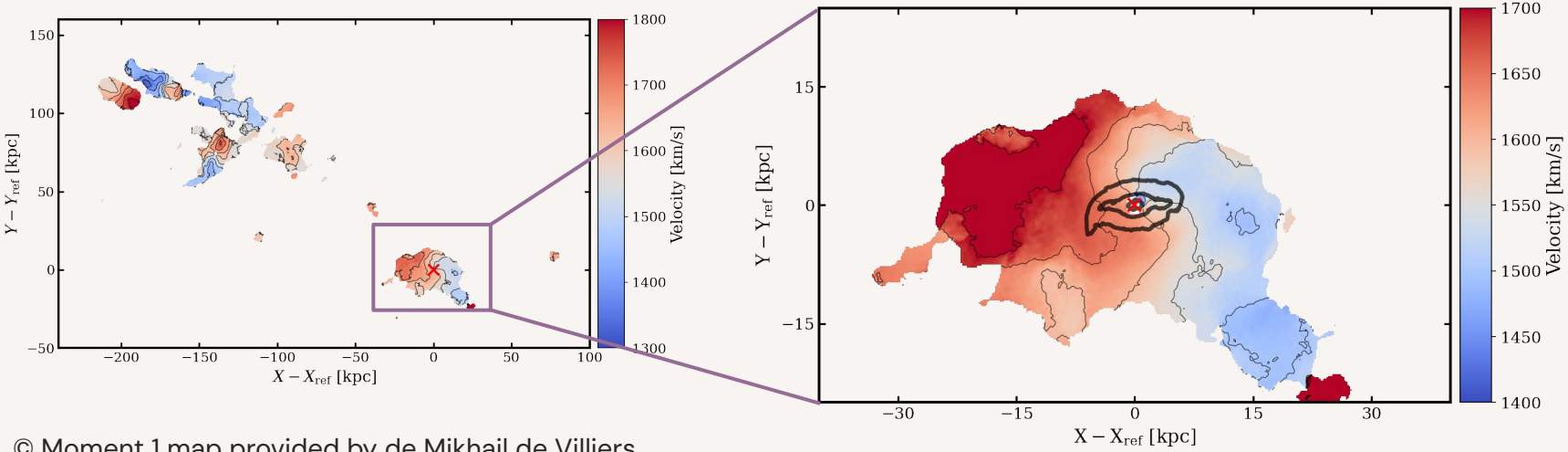
ubvi- Catalogue





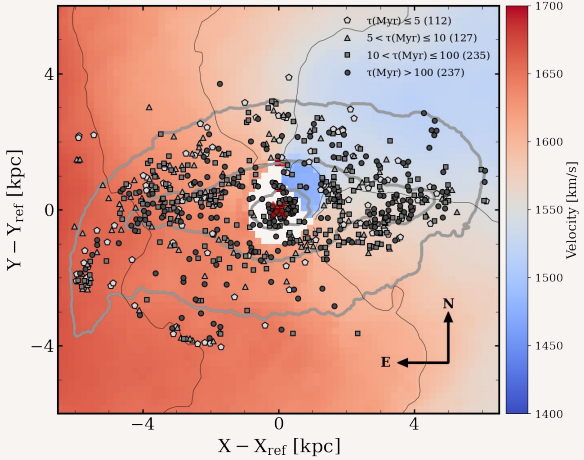
- Mass range >= 10^4
- Possible **mass overestimation** due to blending and/or age-extinction degeneracy
- Most massive clusters are located within the nuclear starburst region.
- Decrease in cluster mass with increasing distance from the nucleus.
- Trend mirrors other starburst systems (e.g., Arp 299 Randriamankoto et. al 2019, Arp 147 Randriamanakoto, Rakototafika et. al submitted).

HI DYNAMICS : The MeerKAT View



© Moment 1 map provided by de Mikhail de Villiers.

- Deep MeerKAT HI data part of the MeerChoirs survey.
- Data Processing and HI analysis: de Villiers et al in prep
- Synthesized Beam: ~ 15.7″ x 14.1″
- Interesting kinematics with clear warps in the disk and a possible tidal tail
- correlation between the YMC age spatial distribution and the HI velocity map?



SUMMARY & WAY FORWARD

Summary of the project :

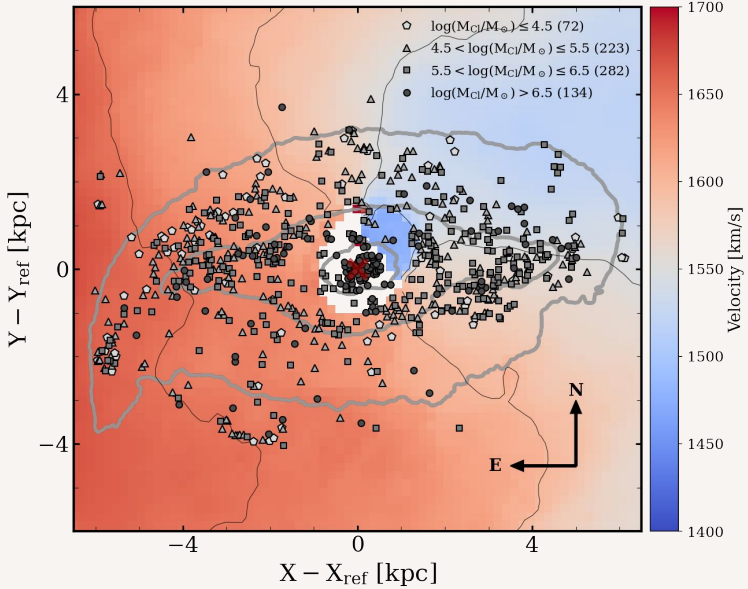
- Connecting star formation tracers and the gas dynamics of their host systems.
- Extensive YMC Catalogue: Identified thousands of star cluster candidates in NGC 7552 and NGC 5427
- Age median of NGC 7552's YMCs : **~ 20 Myr**
- Mass median of NGC 7552's YMCs : **~ 10^6 $M_\odot$**

Key Takeaways :

- U-band is essential for accurate age-dating and breaking the age-extinction degeneracy.
- Evidence for "Popcorn" formation in NGC 7552

Way forward :

- Finalise Photometric catalogue for both targets
- Comprehensive analyses including CFE, CMFs on global and sub-galactic scales
- HI Kinematics: Directly mapping cluster properties against HI data



THANK YOU

Do you have any questions?

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