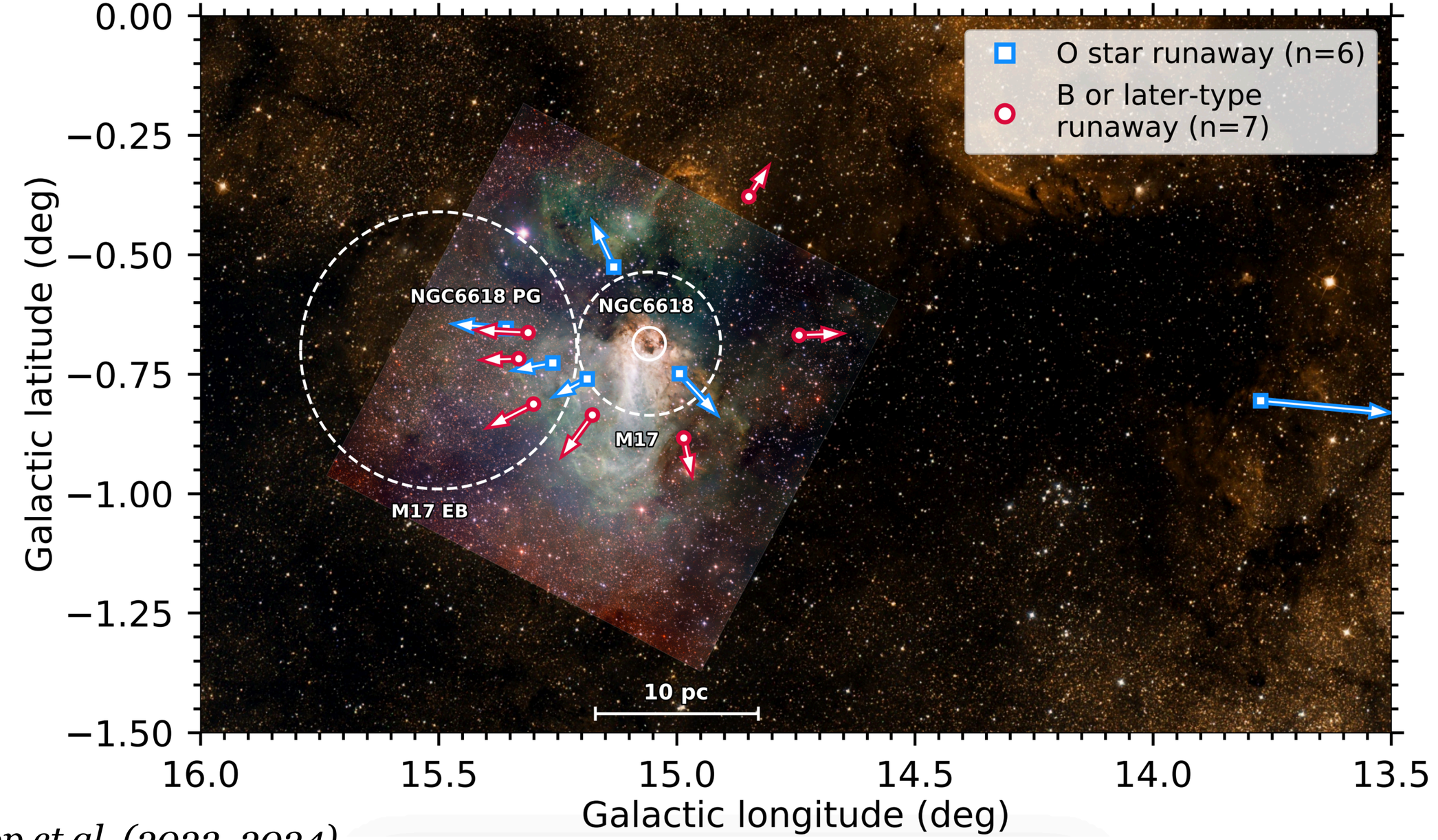
Unveiling runaway massive star bow shocks with current and future radio observatories

Jakob van den Eijnden
Warwick Prize Fellow - University of Warwick

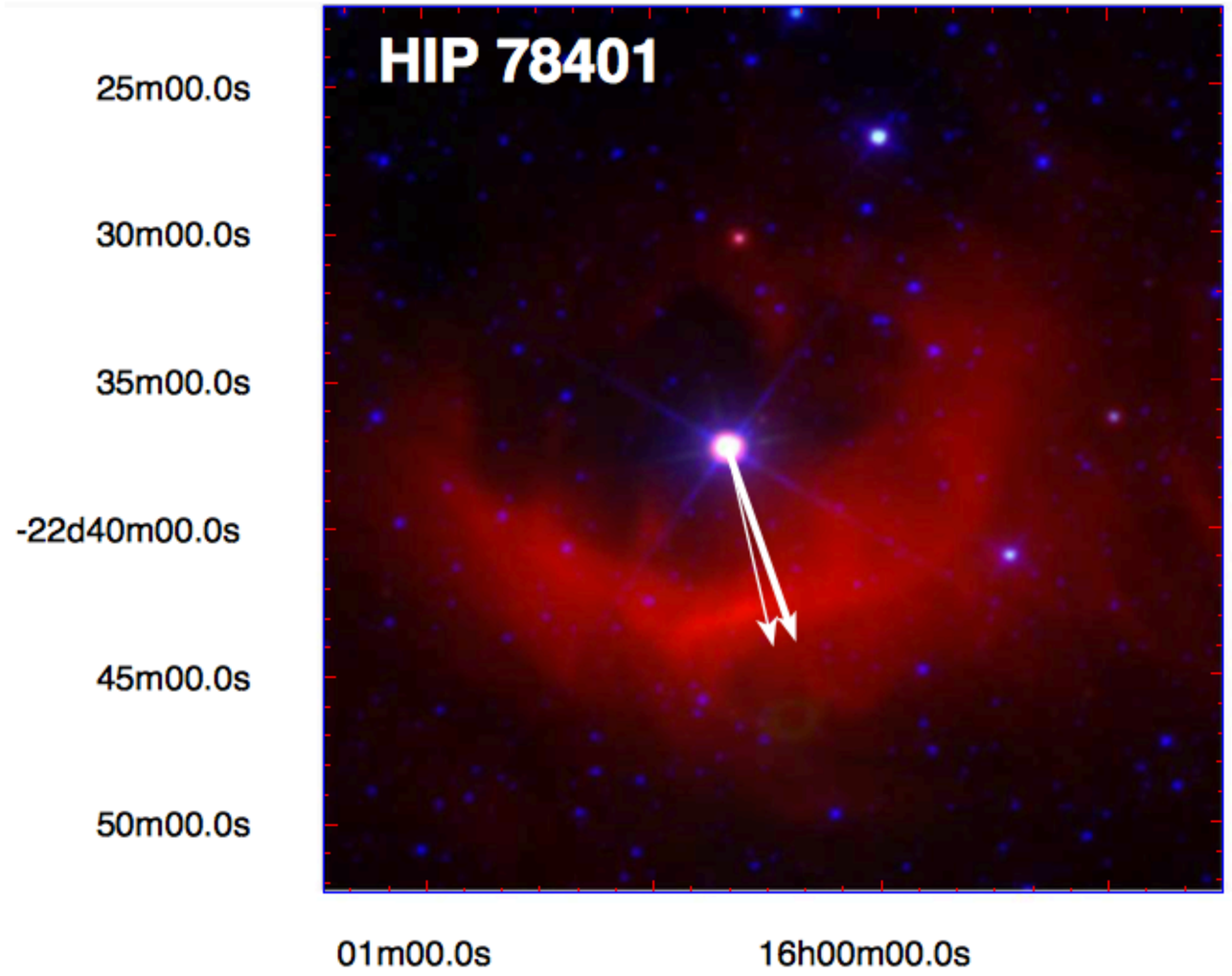
SKA pre-cursors have revolutionised radio bow shock studies and pave the way for new radio / ɣ-ray synergies

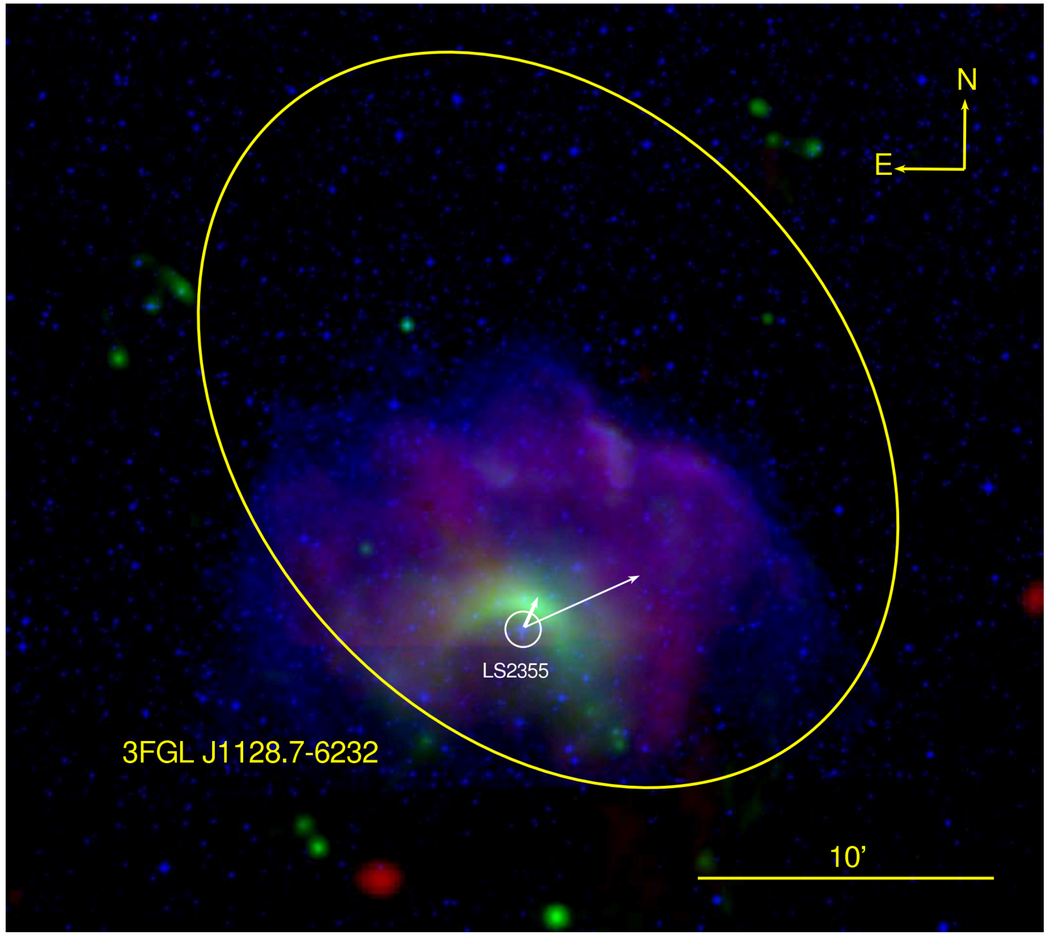
THE GLOBAL VIEW



Stoop et al. (2023, 2024)

THE LOCAL VIEW

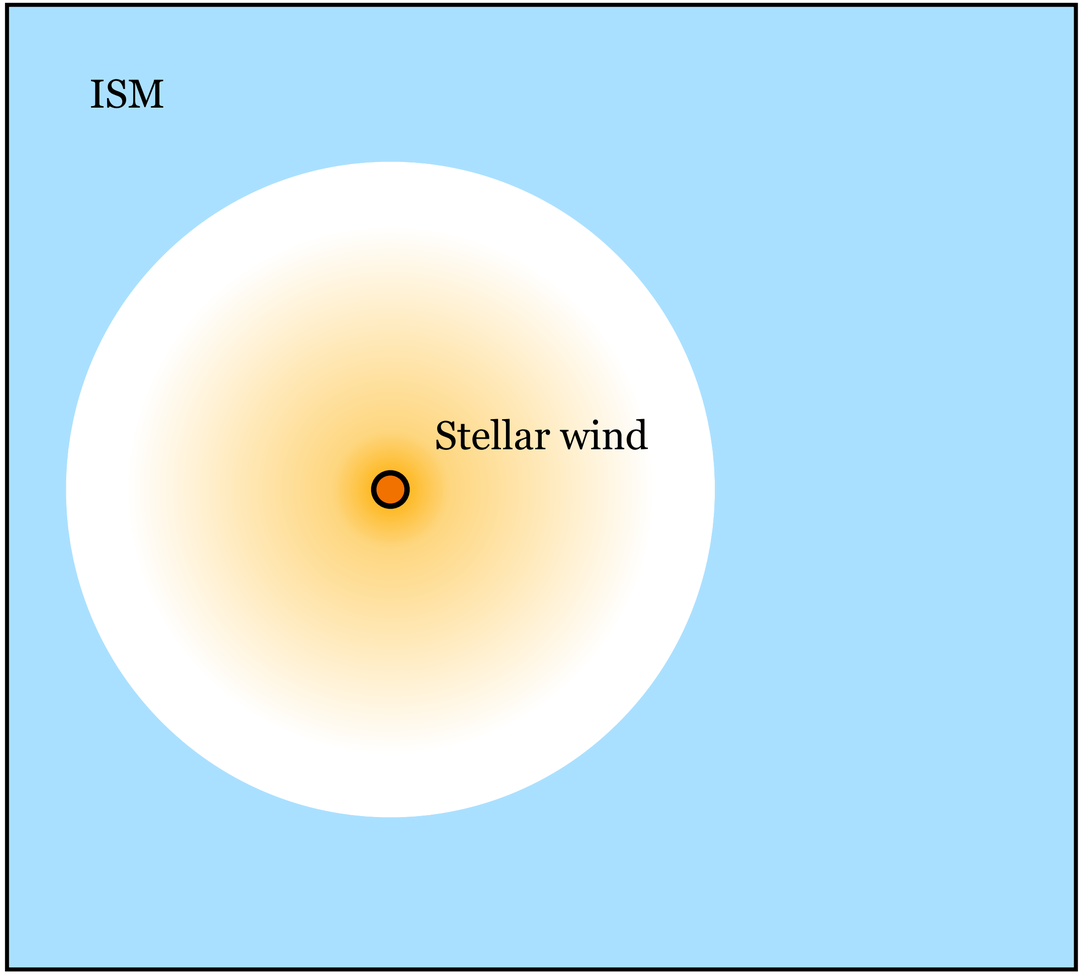




Left: Peri et al (2015) - Right: Sanchez-Ayaso et al. (2018)

BOW SHOCK FORMATION

Stationary massive stars



$$E_{\rm wind} = \dot{M} v_\infty^2 \tau / 2 \approx 10^{50} - 10^{51}\ {\rm erg}$$

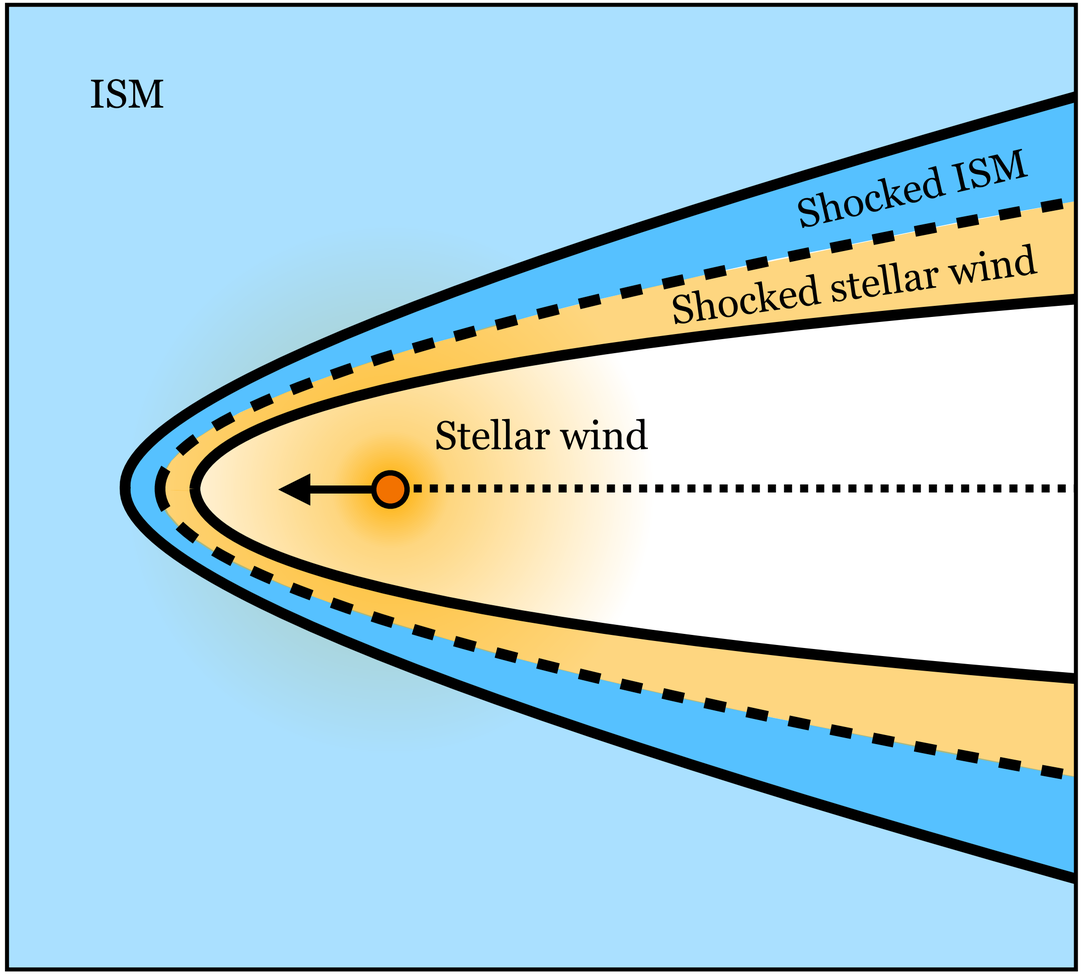
$\sim$ 1000 km/s

$10^{-5} \sim 10^{-6}\ M_\odot/{\rm yr}$

$1 \sim 10$ Myr

BOW SHOCK FORMATION

Supersonic massive stars



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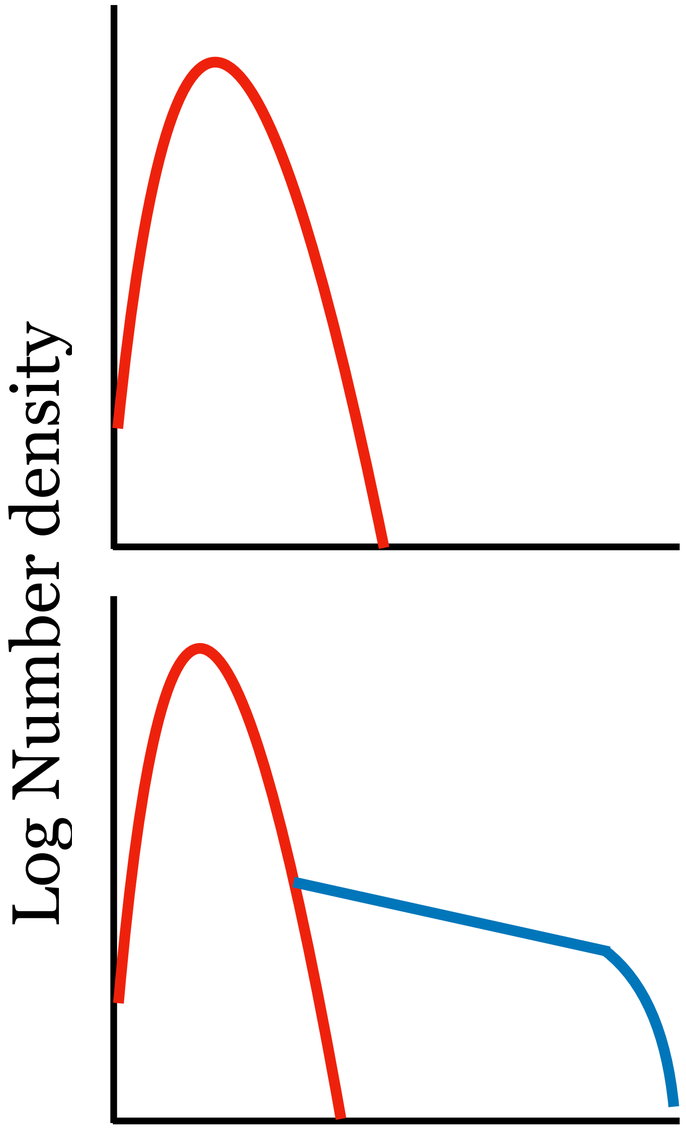
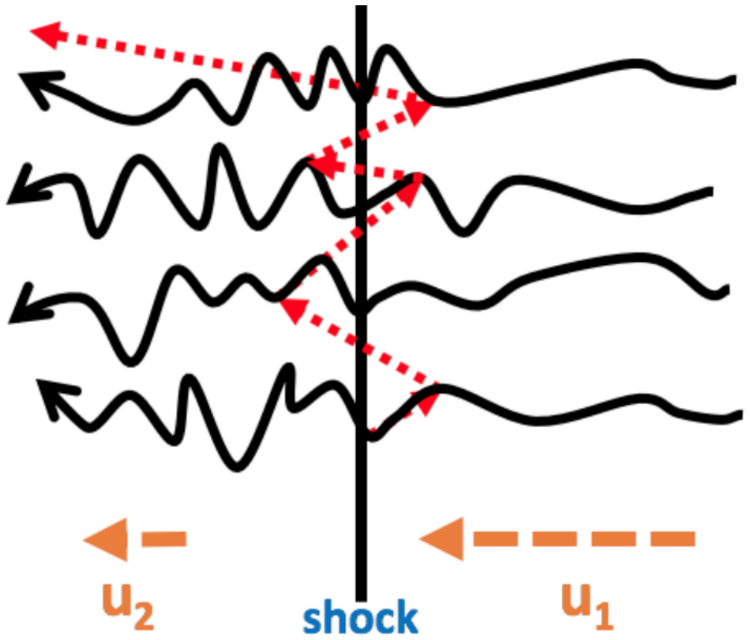
PARTICLE ACCELERATION AT BOW SHOCKS



Energy gain

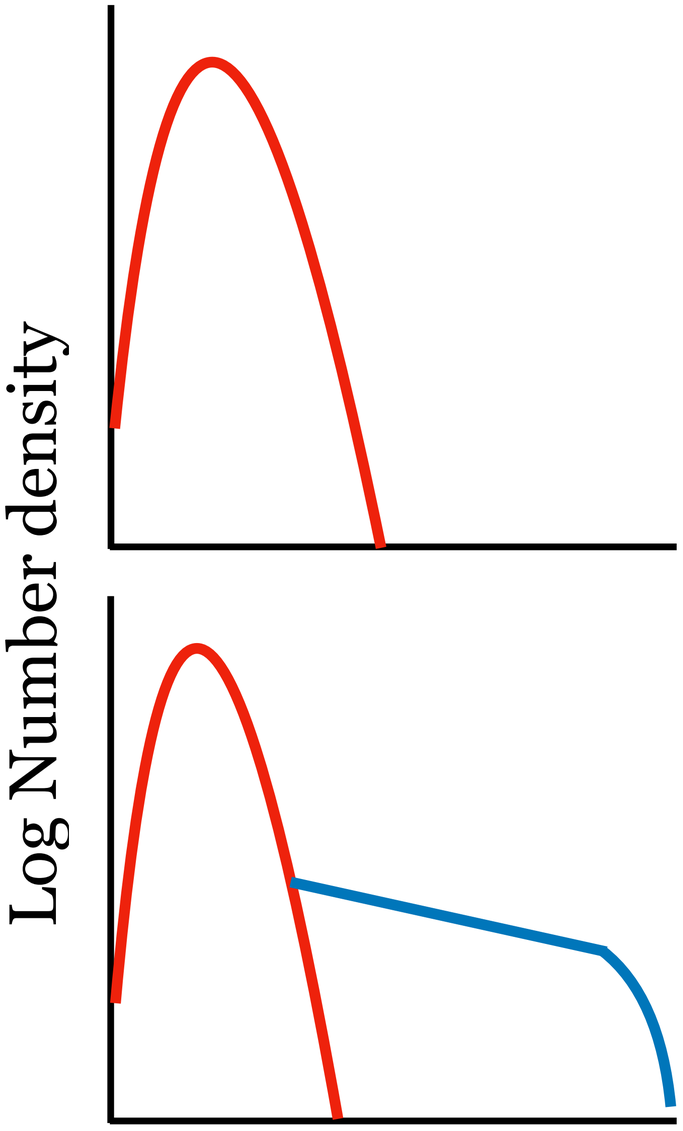
Diffusive Shock Acceleration



η_{acc} , B_{shock}

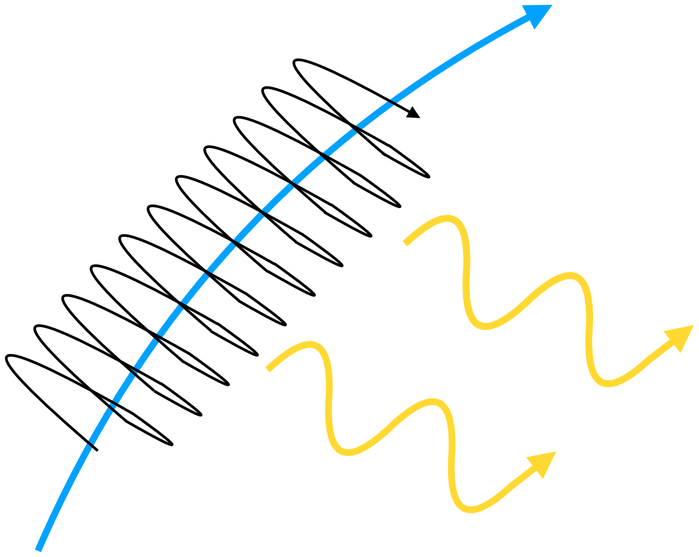
Schematic: *Matthews et al. (2022)*

PARTICLE ACCELERATION AT BOW SHOCKS



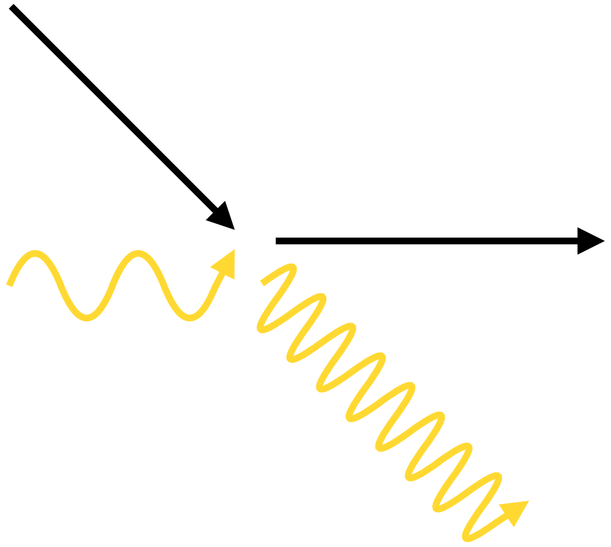
Energy loss

Synchrotron emission



typically low frequencies

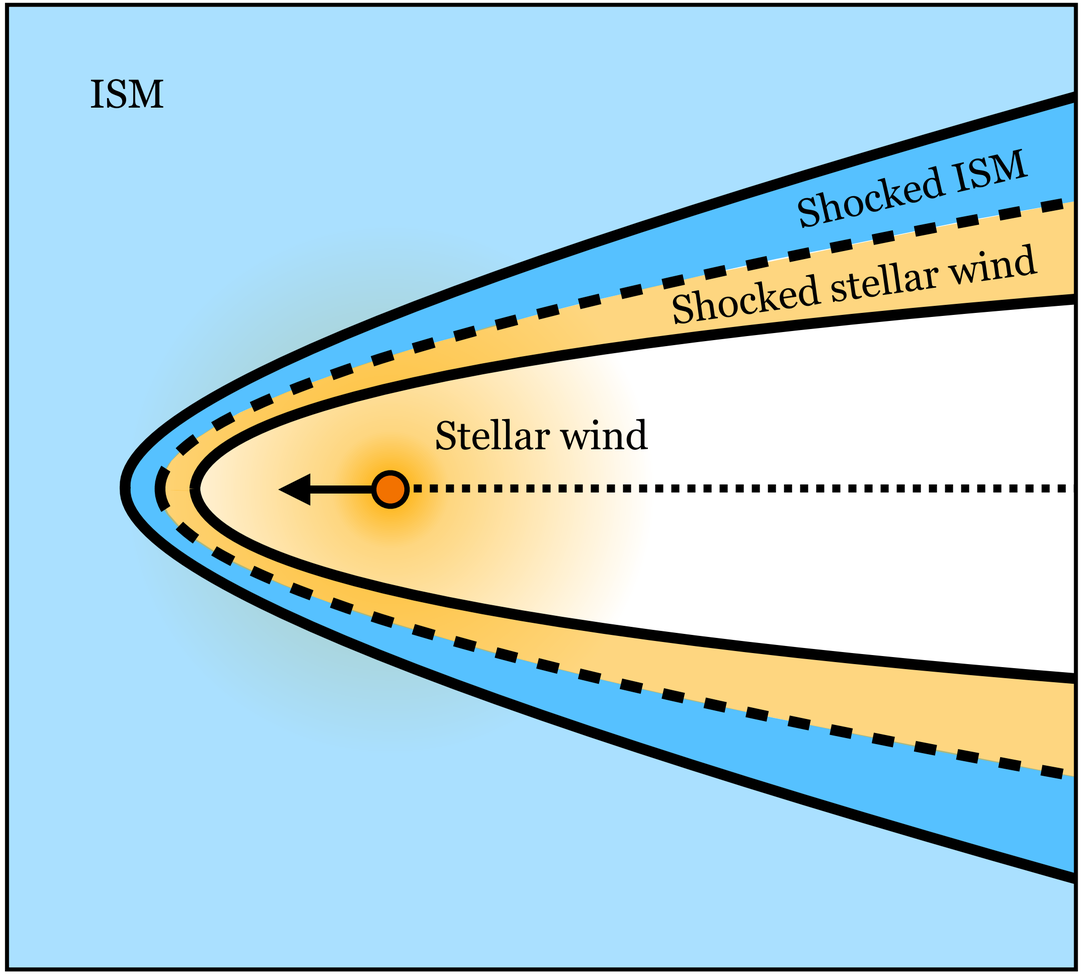
Inverse Compton scattering



X-rays/ɣ-rays

THE CHALLENGE OF DETECTING NON-THERMAL EMISSION

Supersonic massive stars



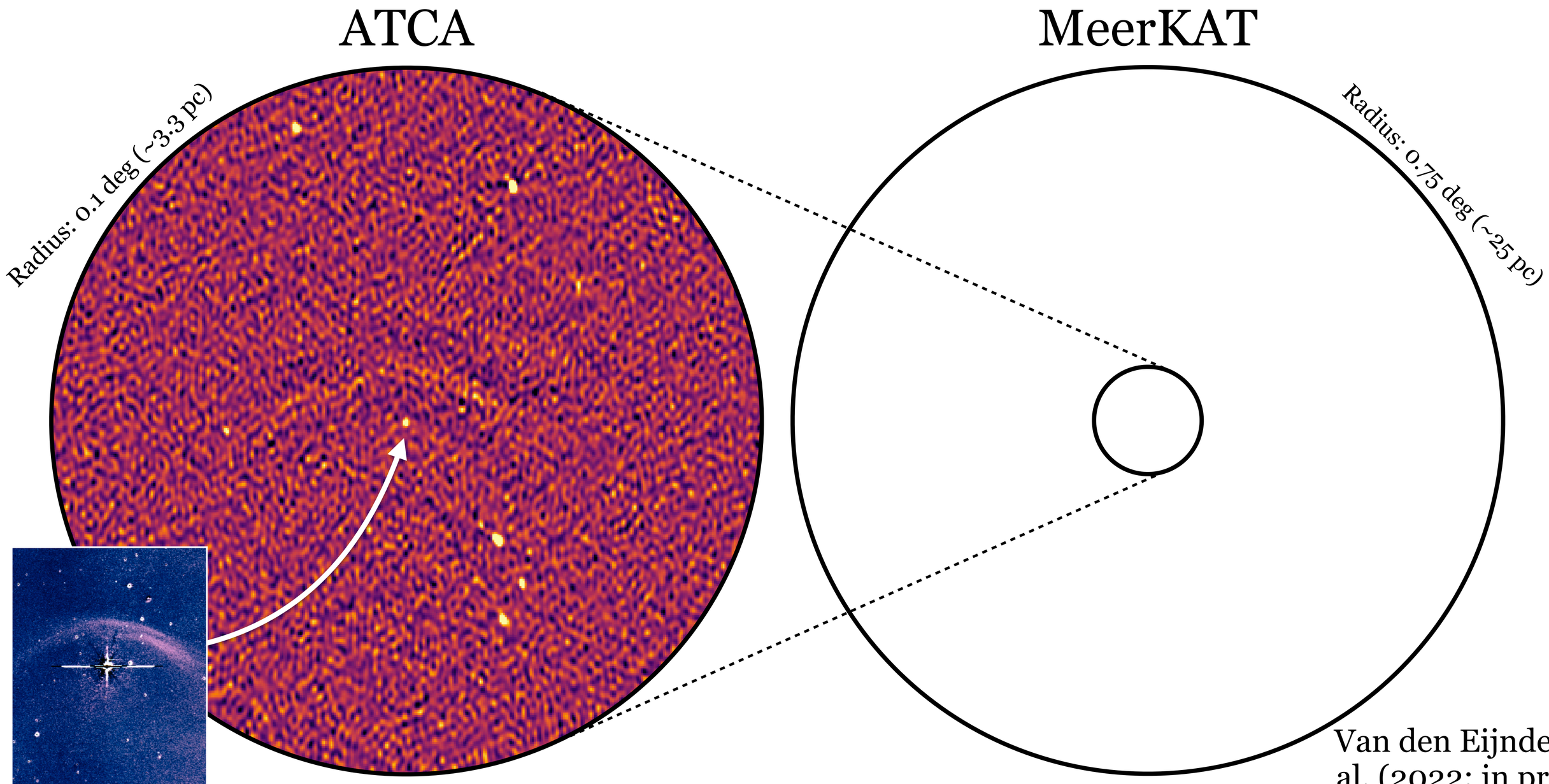
<u>Thermal emission:</u>
700 IR counterparts:
Shocked/heated dust

Optical line emission

<u>Non-thermal emission</u>
before MeerKAT/ASKAP

1 radio counterpart (Benaglia et al. (2010)
2 candidate ɣ-ray counterparts

THE CHALLENGE OF DETECTING NON-THERMAL EMISSION



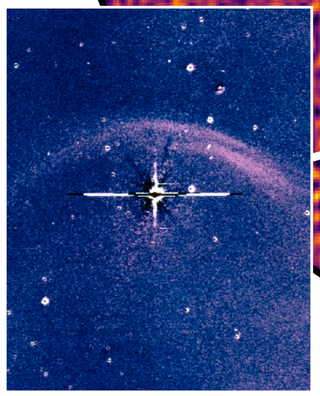
THE CHALLENGE OF DETECTING NON-THERMAL EMISSION

ATCA

MeerKAT

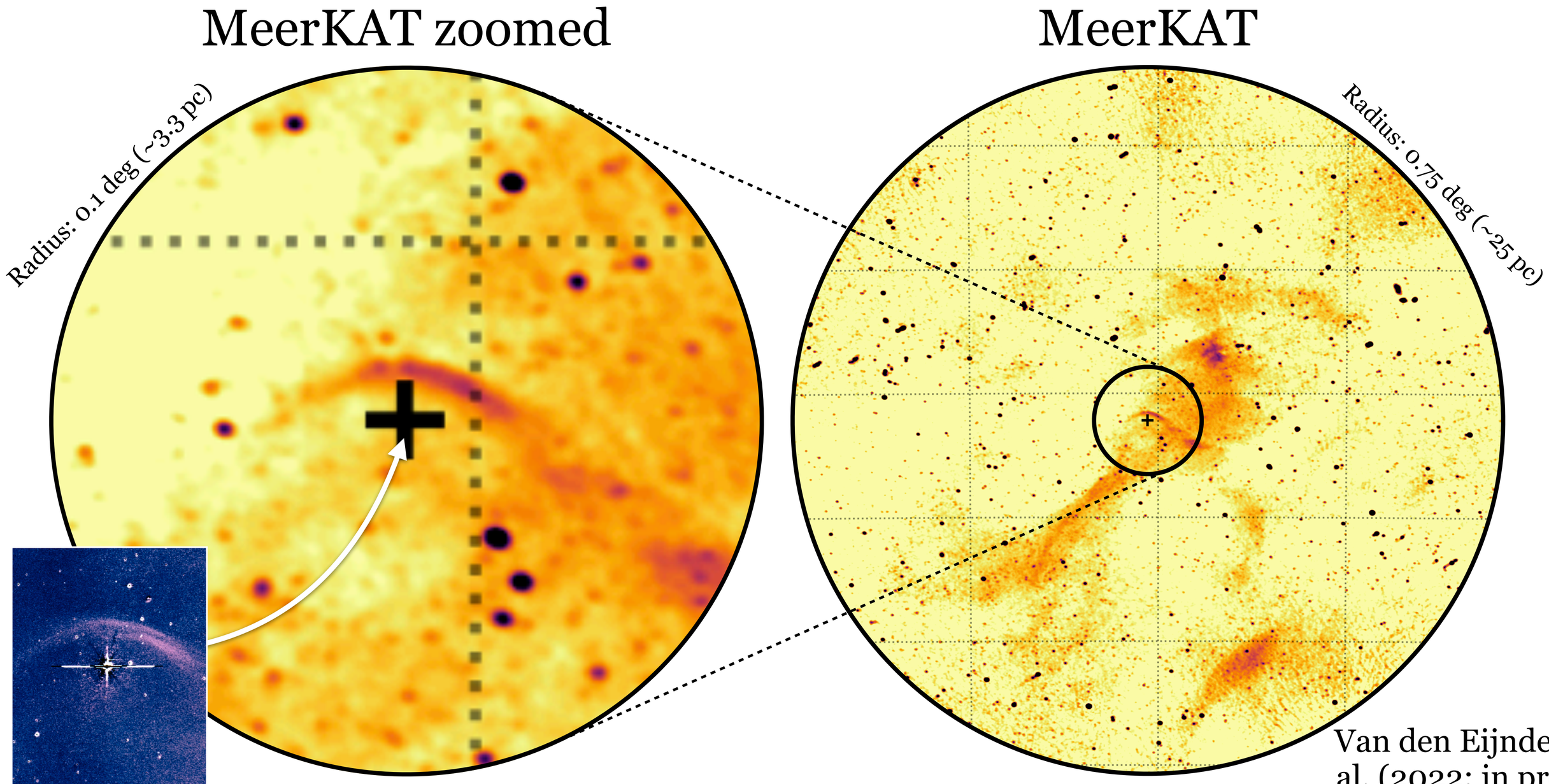
Radius: 0.1 deg (~3.3 pc)

Radius: 0.75 deg (~25 pc)



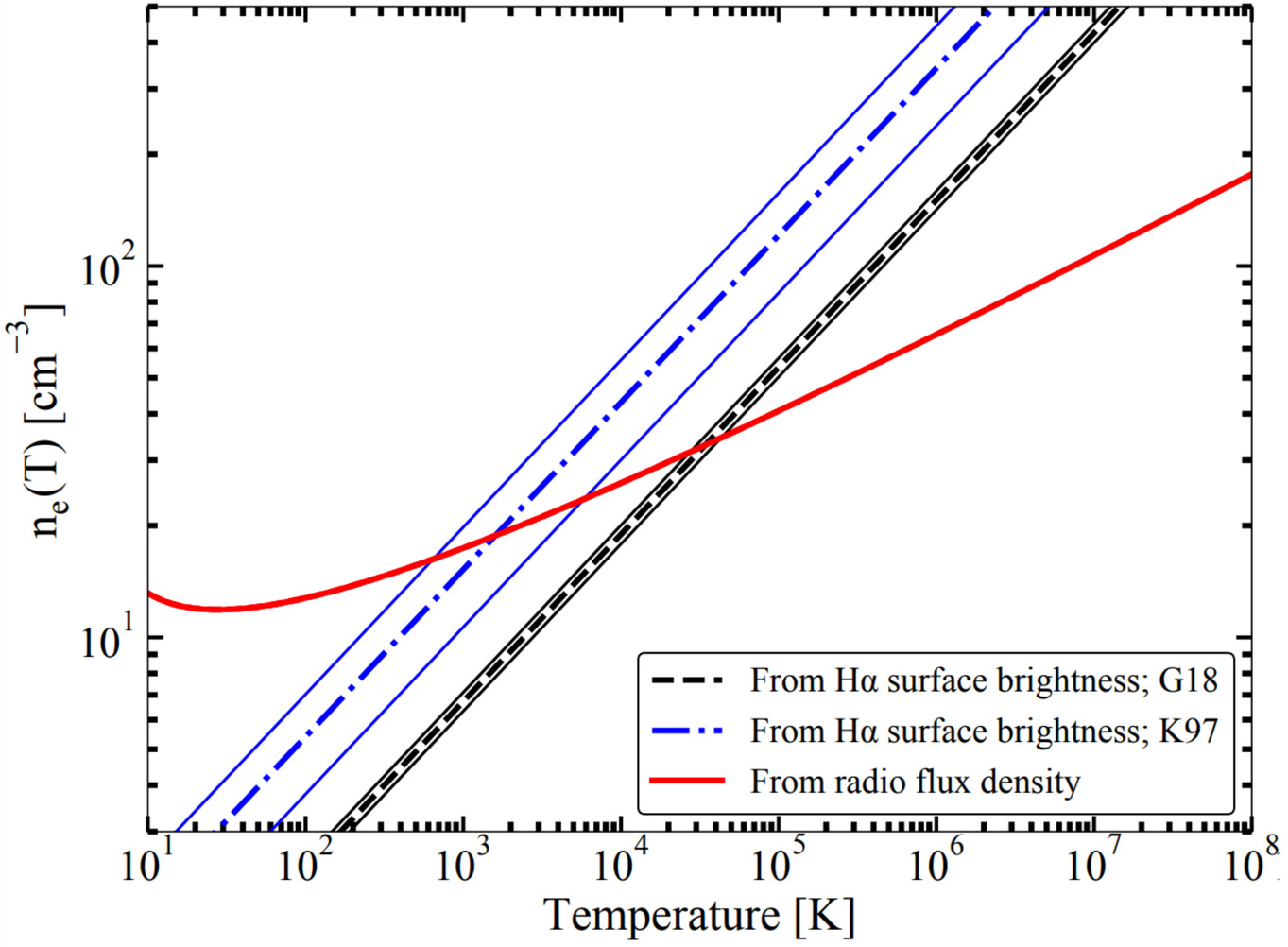
Van den Eijnden et al. (2022; in prep.)

THE CHALLENGE OF DETECTING NON-THERMAL EMISSION



INFERENCES FROM VELA X-1

Thermal scenario



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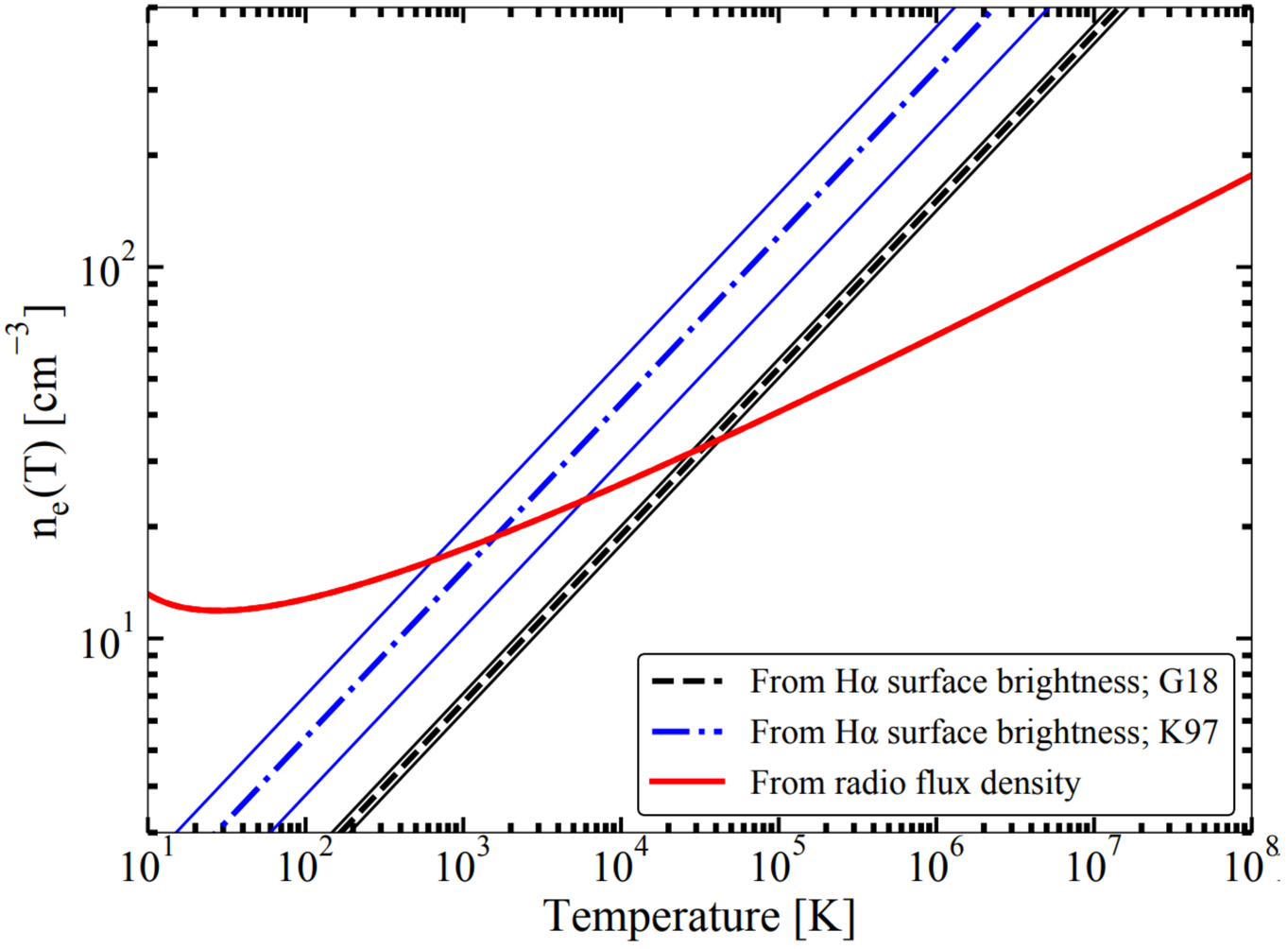
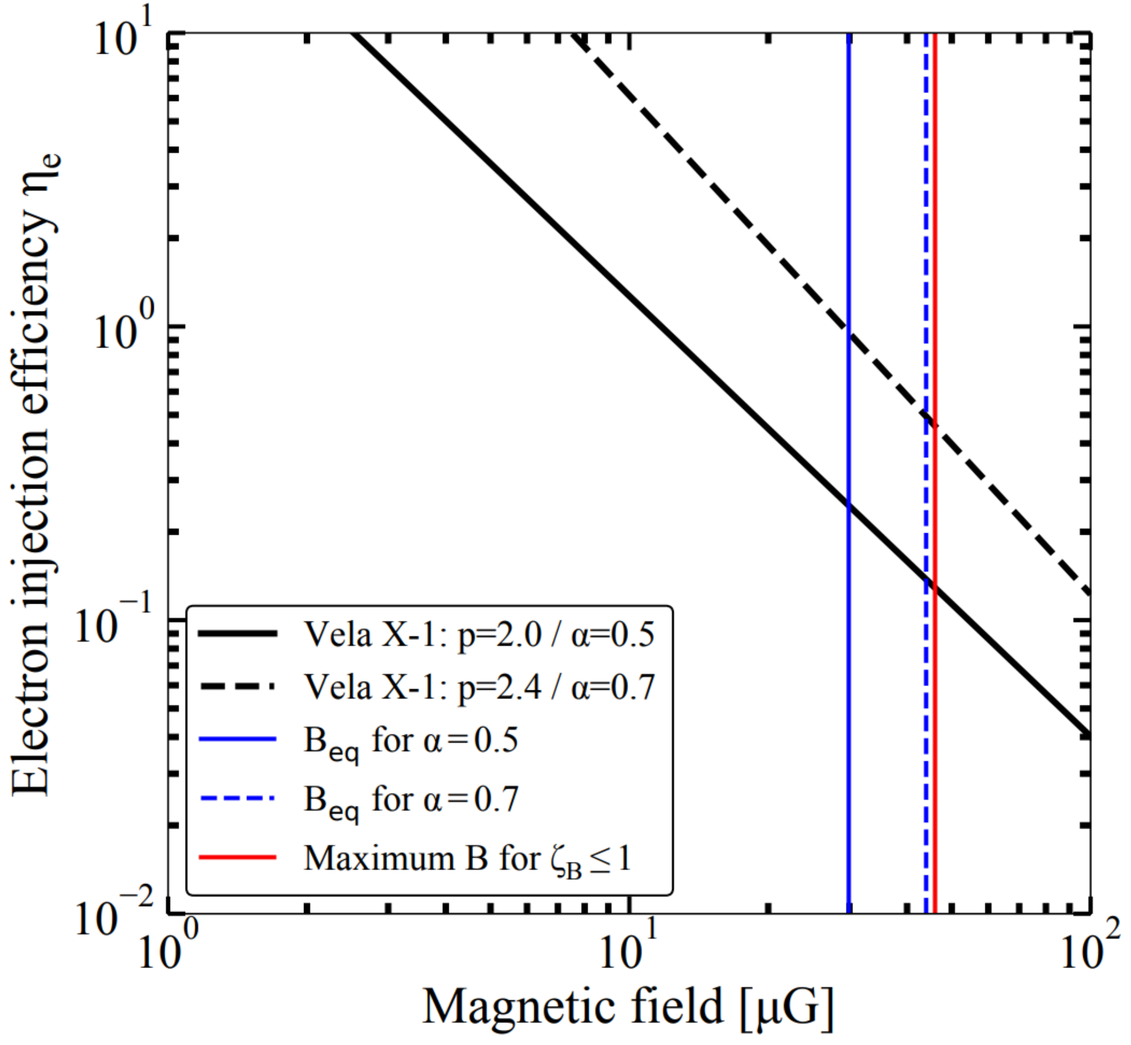
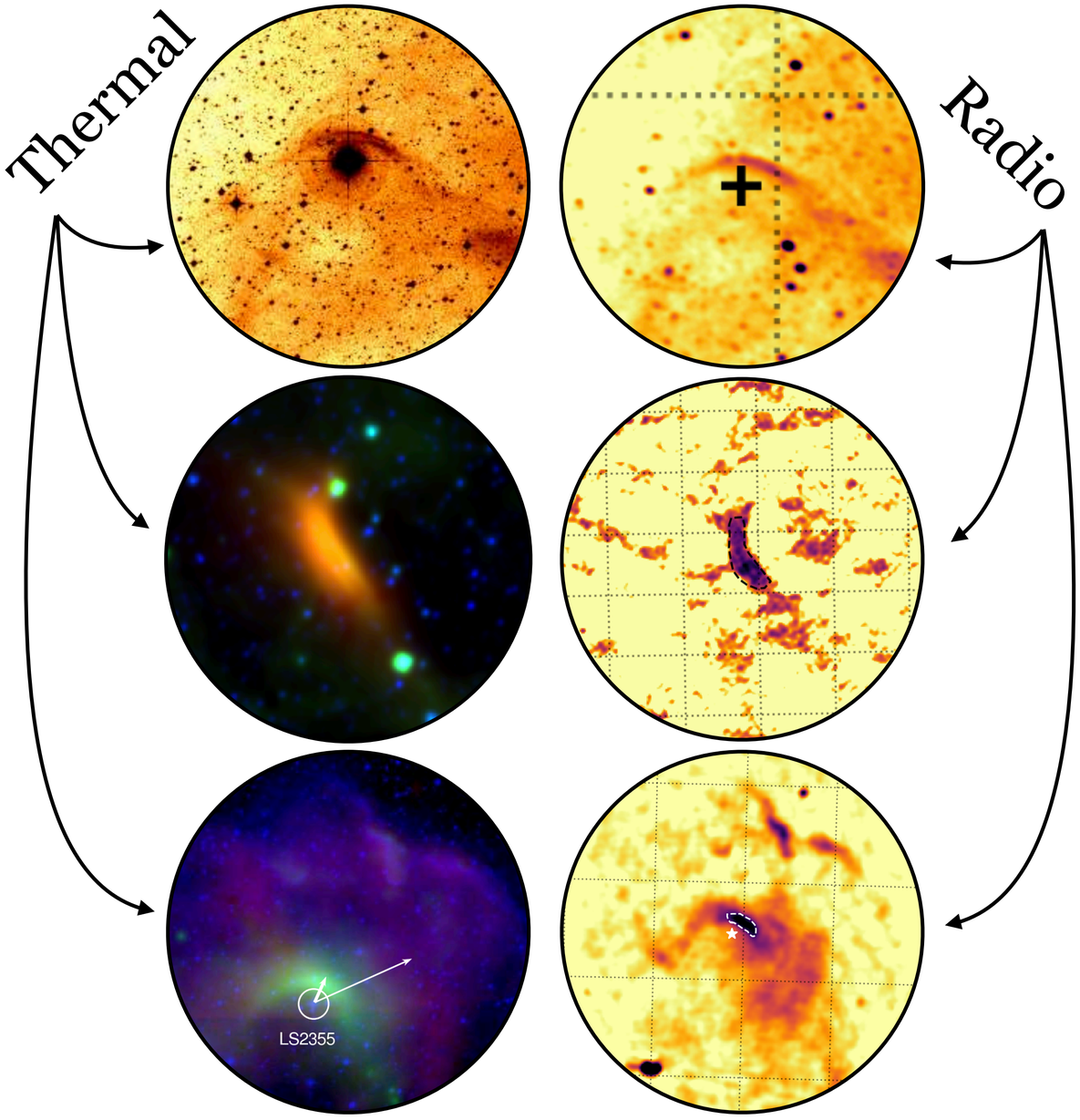


Non-thermal scenario



BUILDING A RADIO SAMPLE: ASKAP (survey)



Van den Eijnden et al. (2022b; submitted)

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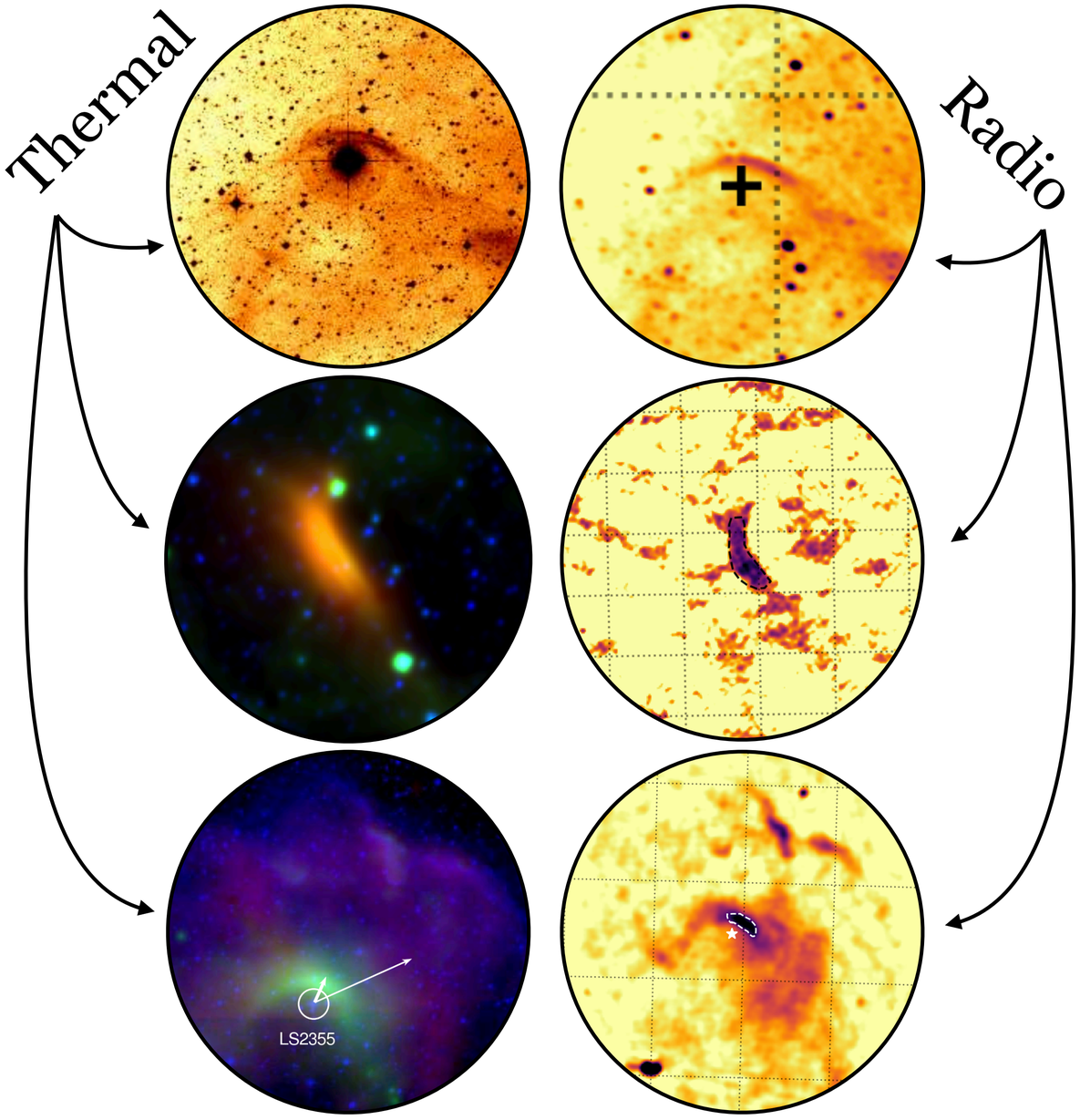
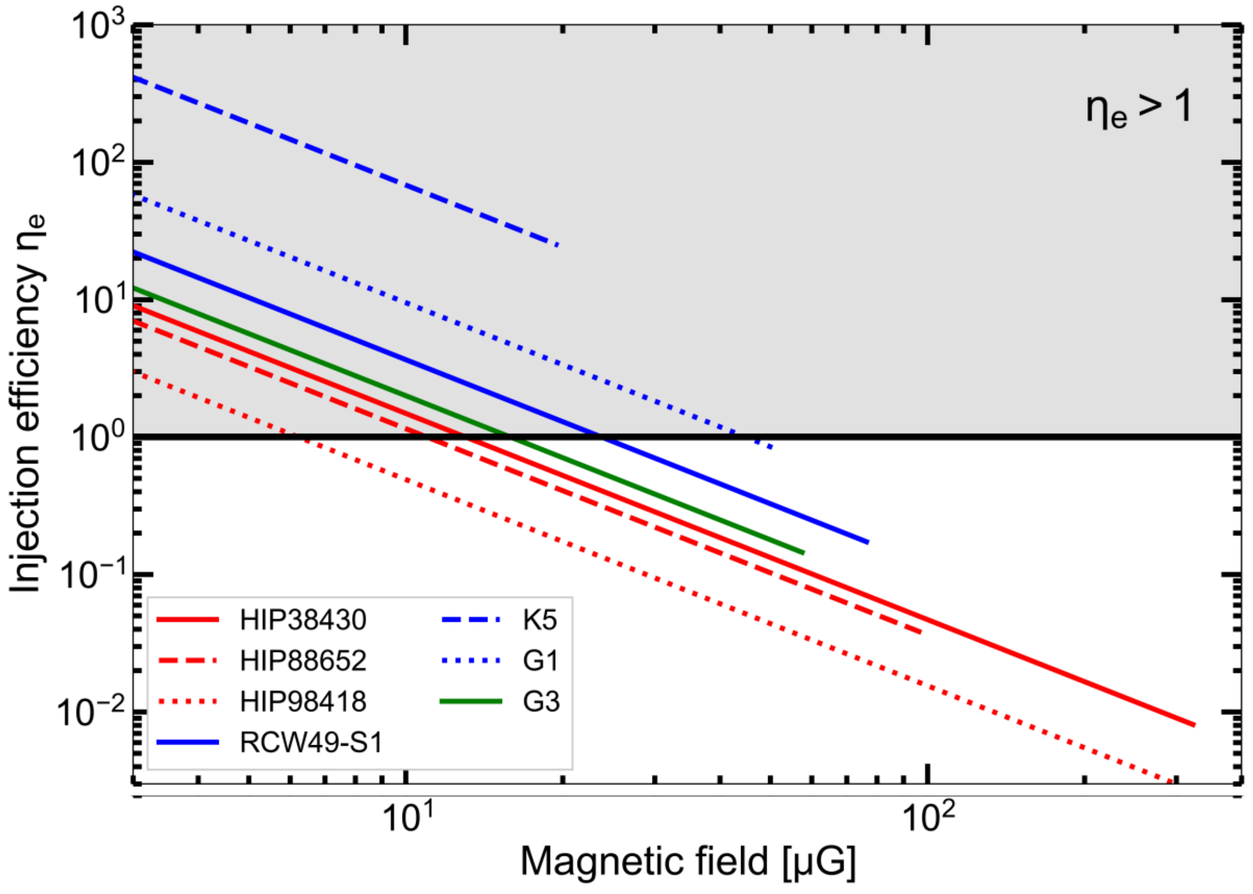
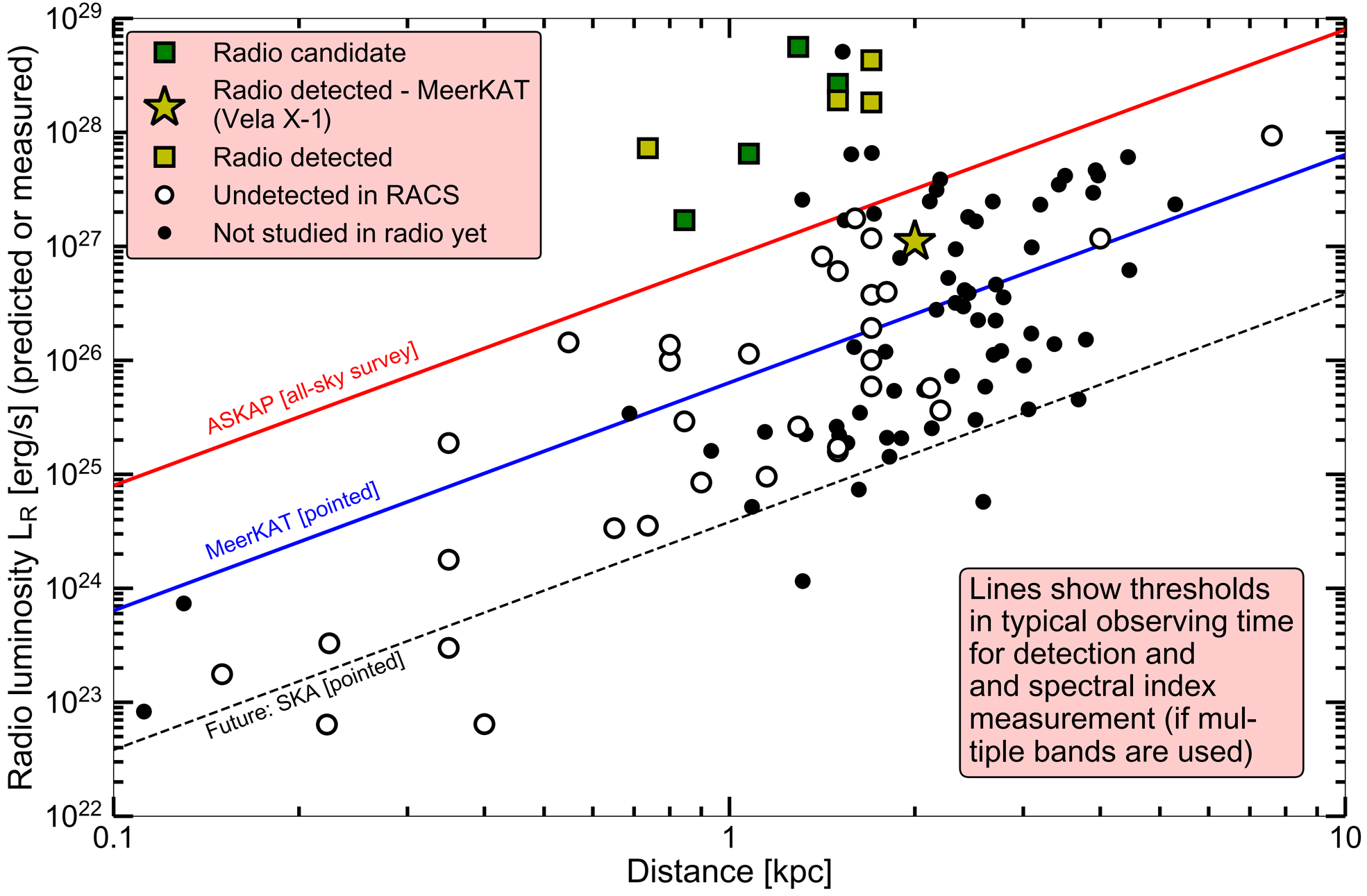




Van den Eijnden et al. (2022b; submitted)

RETRACTED SLIDE: IN PREP RESULTS/ANALYSIS

DETECTABILITY ON THE PATH TO SKA



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Questions?