MIGHTEE: Discovery of a triple-double radio galaxy

Full paper!

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Supervisors: Prof. Russ Taylor (UCT, IDIA and UWC), Dr. Zara Randriamanakoto (SAAO) and Dr. Dharam Lal (NCRA)

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UNIVERSITY OF CAPE TOWN
IYUNIVESITHI YASEKAPA • UNIVERSITEIT VAN KAAPSTAD

KANTY ASTRONOMY Research Group

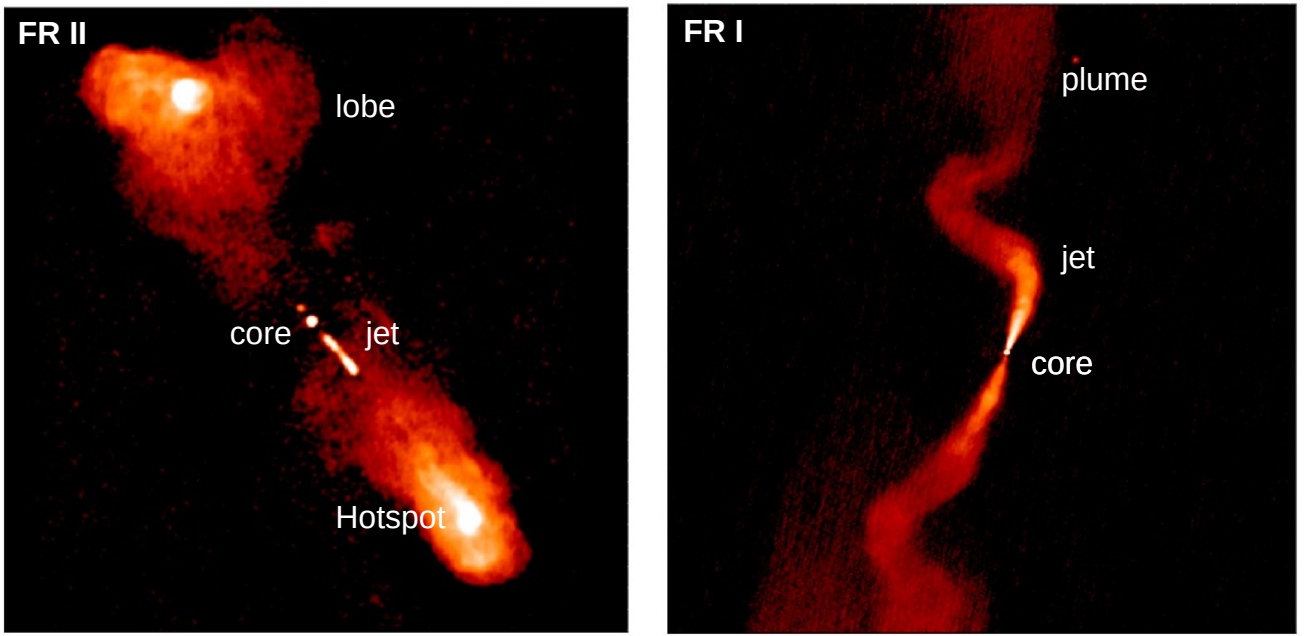
NRF National Research Foundation | SAAO South African Astronomical Observatory

2026 AfAS Conference | 22nd-27th March 2026

| tombo@saao.ac.za

Background
Life Cycle of radio galaxies (RGs)

Active Radio galaxies (Hardcastle+20)



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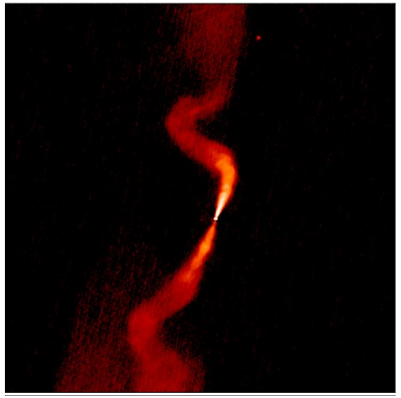

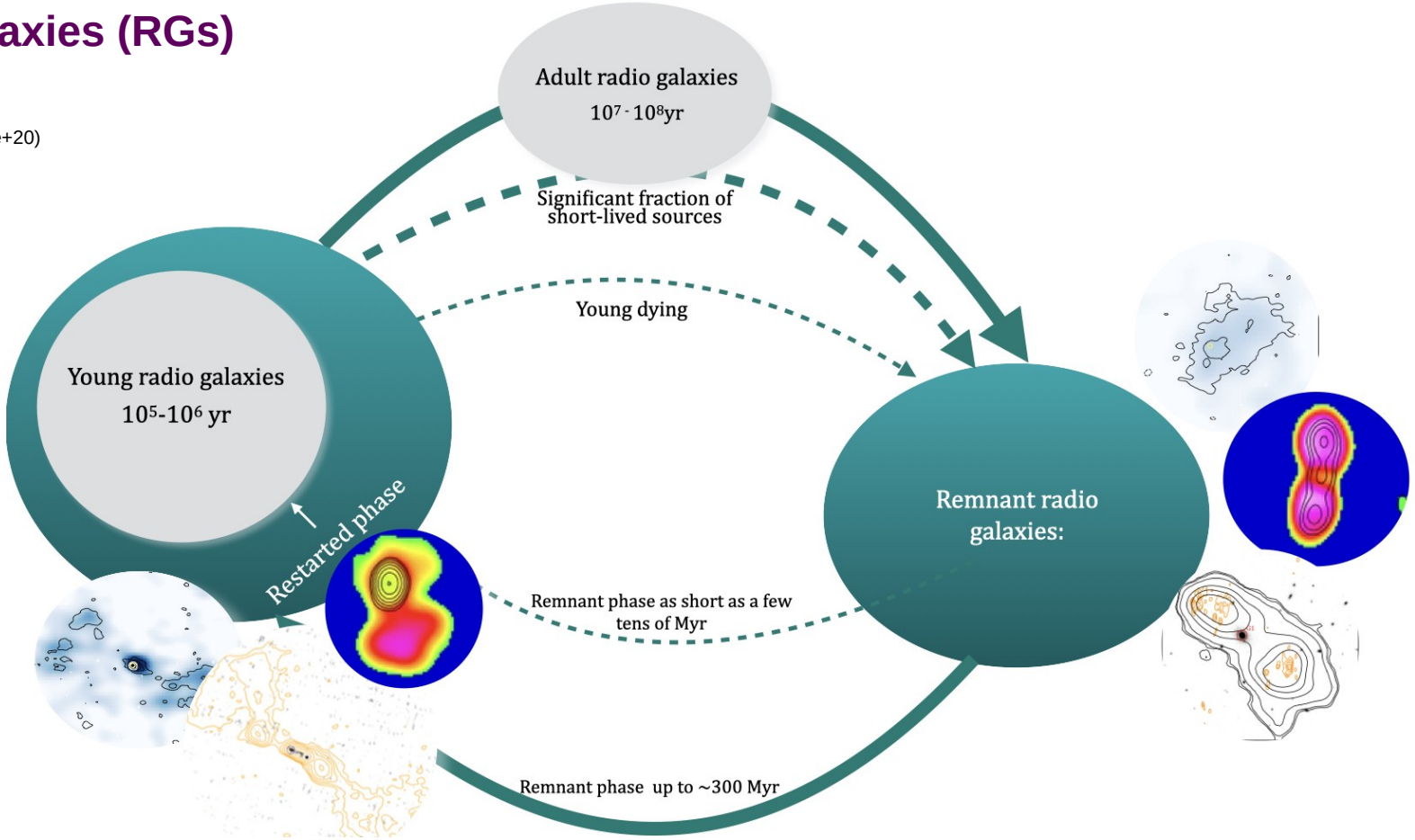

Morganti, 24

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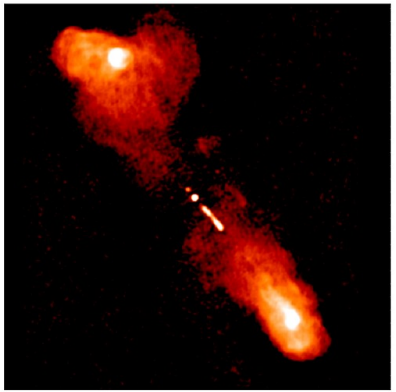
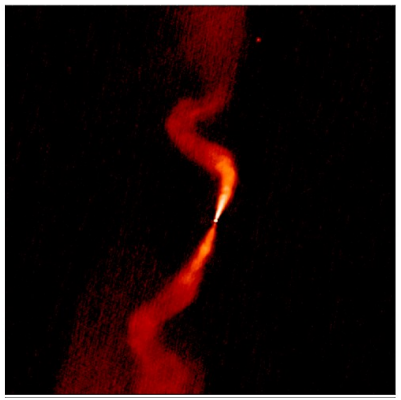
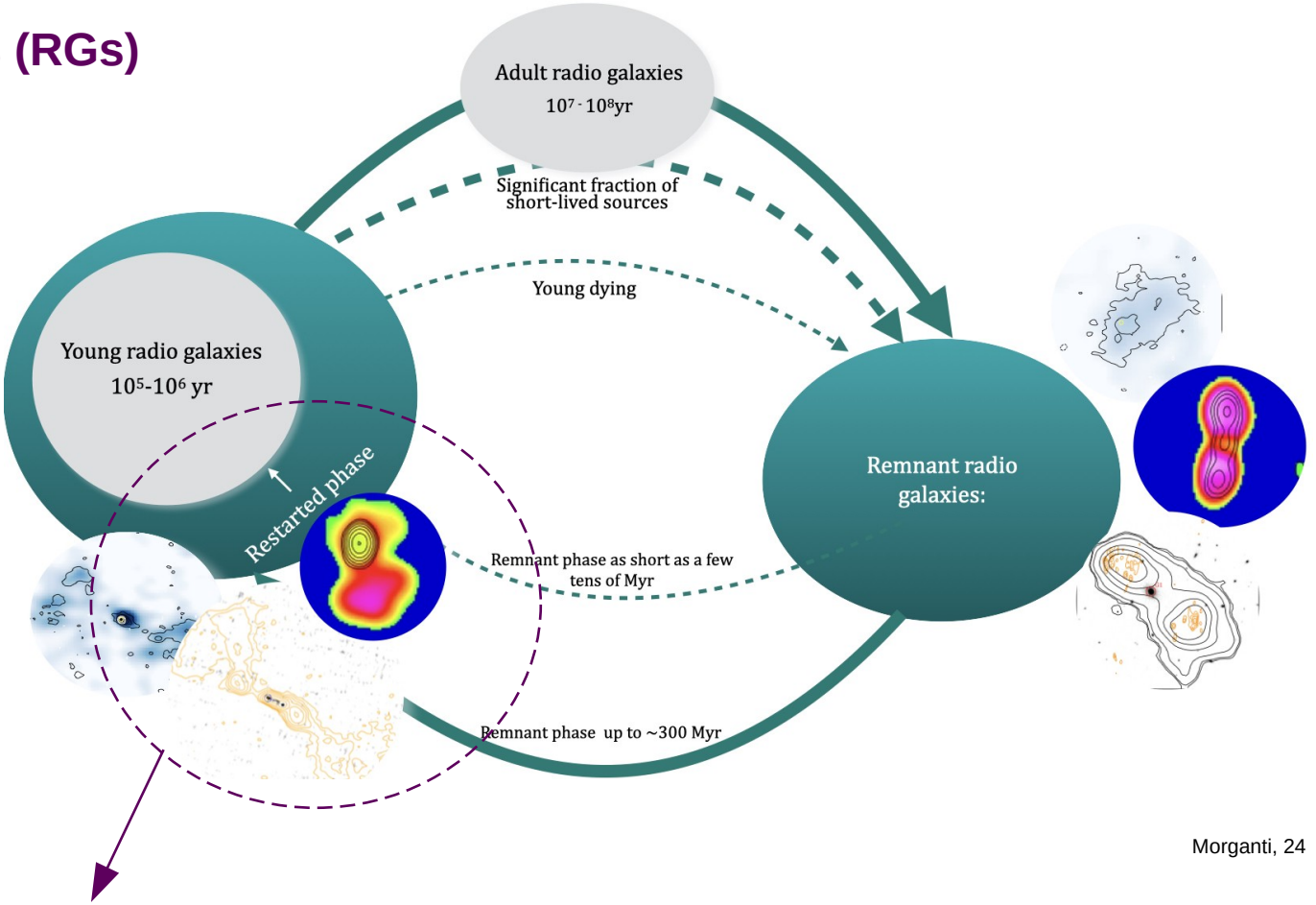






Morganti, 24

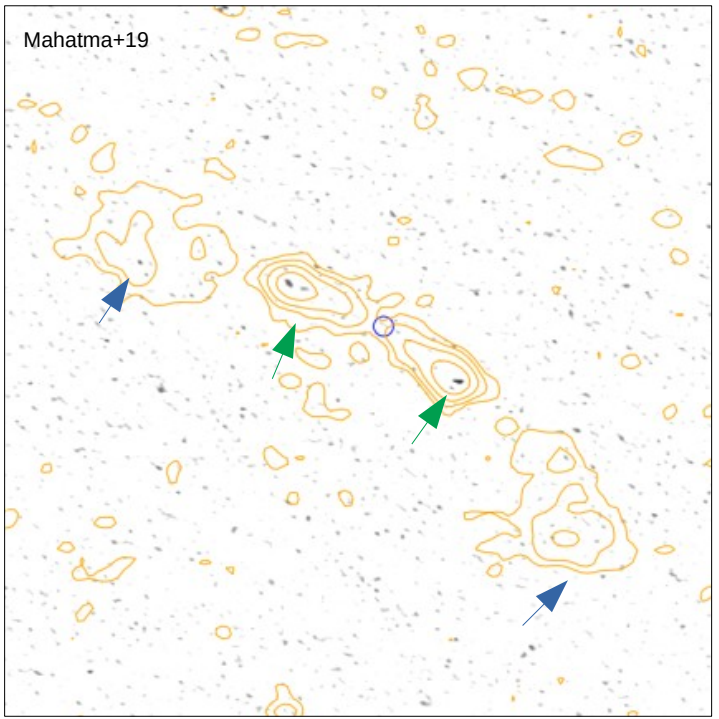
→ To better understand the duty cycle of RGs → → Quantify AGN feedback
→ Constrain galaxy evolution

Background

Double-double RGs & Triple-double RGs (TDRGs; e.g. Brocksopp+07)

Morphology:

Double-Double RGs



- Double inner lobes
- Double outer lobes
- one pair → one active episode
  → **two episodes of activity**

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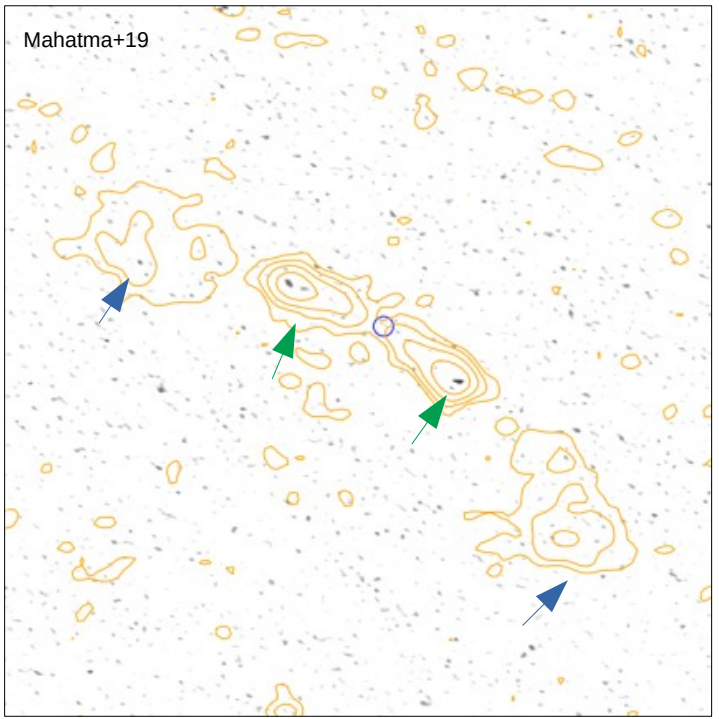

- Double inner lobes
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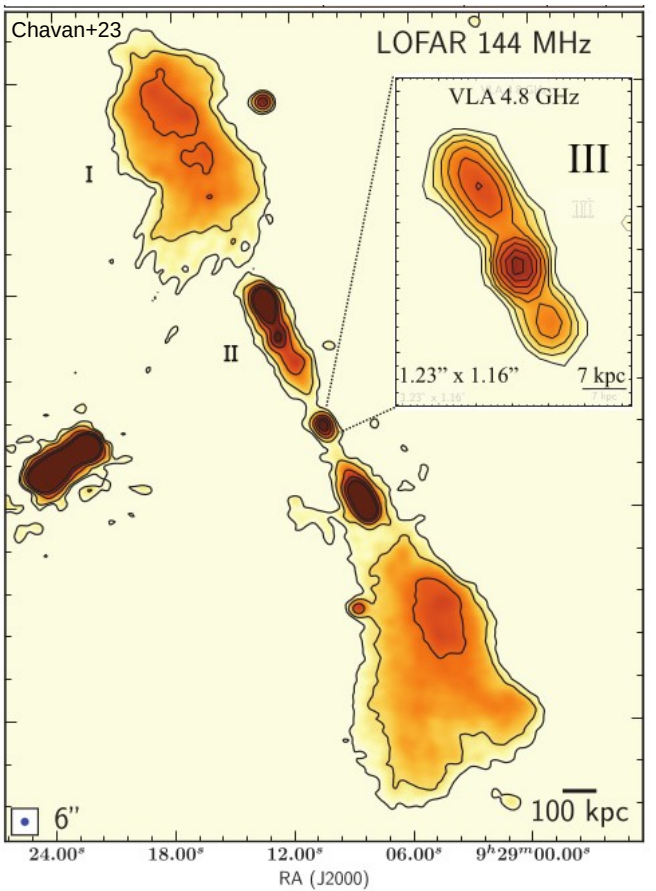
- Double inner lobes
- Double middle lobes
- Double outer lobes
- one pair → one active episode
→ **three episodes of activity**



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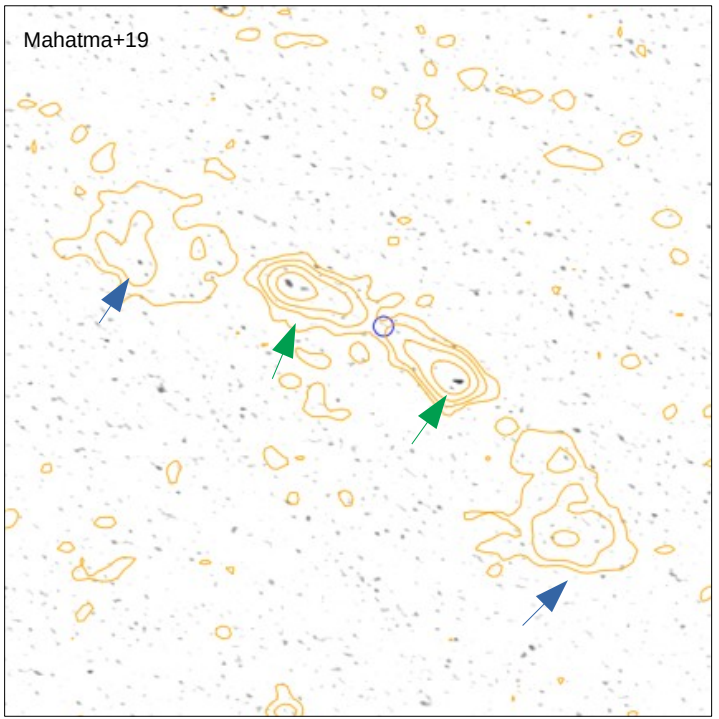

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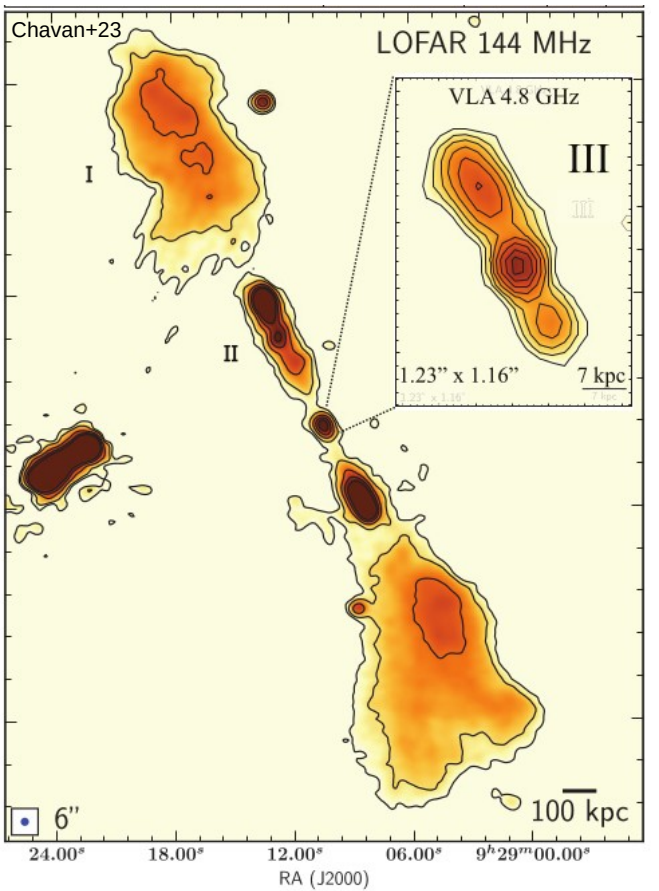
TDRGs:
- extremely rare
- only 6 reported in literature
- **7th discovered in MIGHTEE**



Data

MeerKAT International GHz Tiered Extragalactic Exploration (MIGHTEE, Hale+24**):**

- A **MeerKAT** large-scale survey project
- Data release 1 (DR1): **XMM-LSS (14.4 sq. deg)**
- **4 times** larger than the Early Science field (ES)

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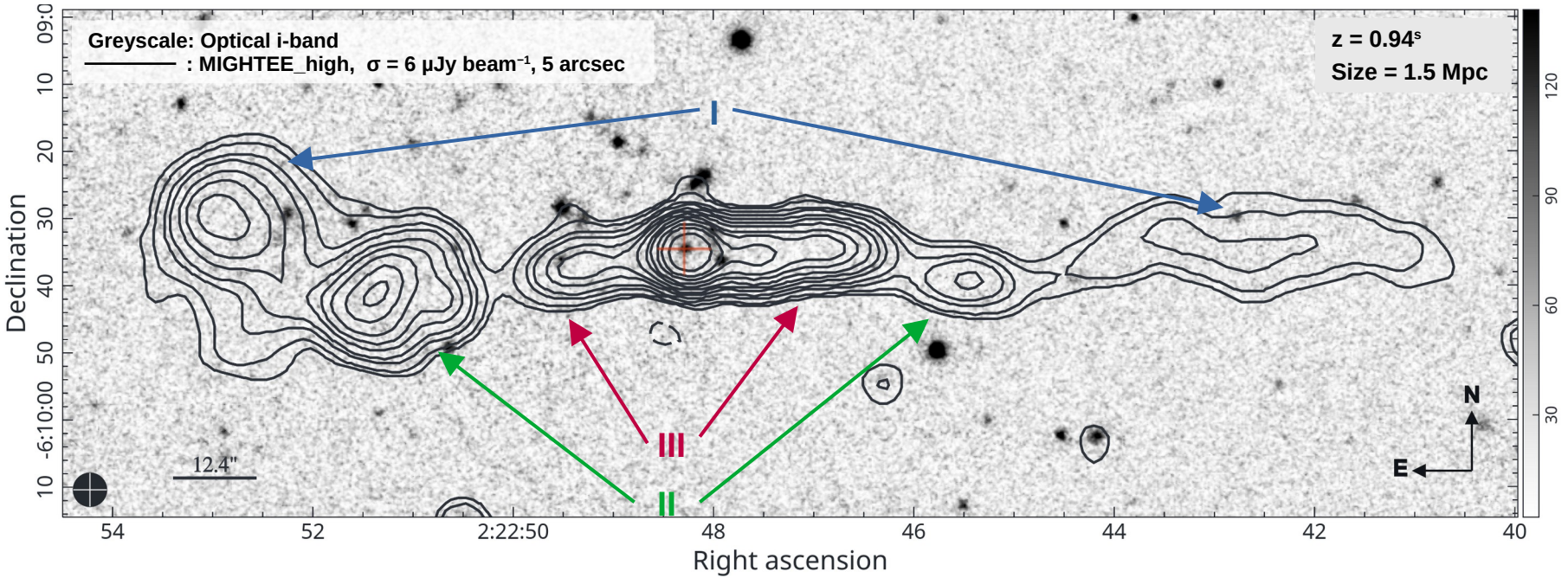
Main data				
Observation	Frequency [MHz]	Resolution [arcsec]	Sensitivity [μJy/beam]	Ref
MIGHTEE-DR1	1211	5	~ 6	Hale+25
MIGHTEE sub-BAND	967	14×11.6	~ 28	Luchsinger et al. (in prep)
MIGHTEE sub-BAND	1221	14×11.6	~ 24	Luchsinger et al. (in prep)
MIGHTEE sub-BAND	1537	14×11.6	~ 16	Luchsinger et al. (in prep)
Archival data				
LOFAR	144	7.5 × 8.5	280	Hale+19
GMRT Legacy	325	10 × 8	150	Singh+14
VLASS	3000	2.5	145	Lacy+20

Triple-double candidate: J022248−060934 (e.g. Brocksopp+07) – Optical host & radio morphology



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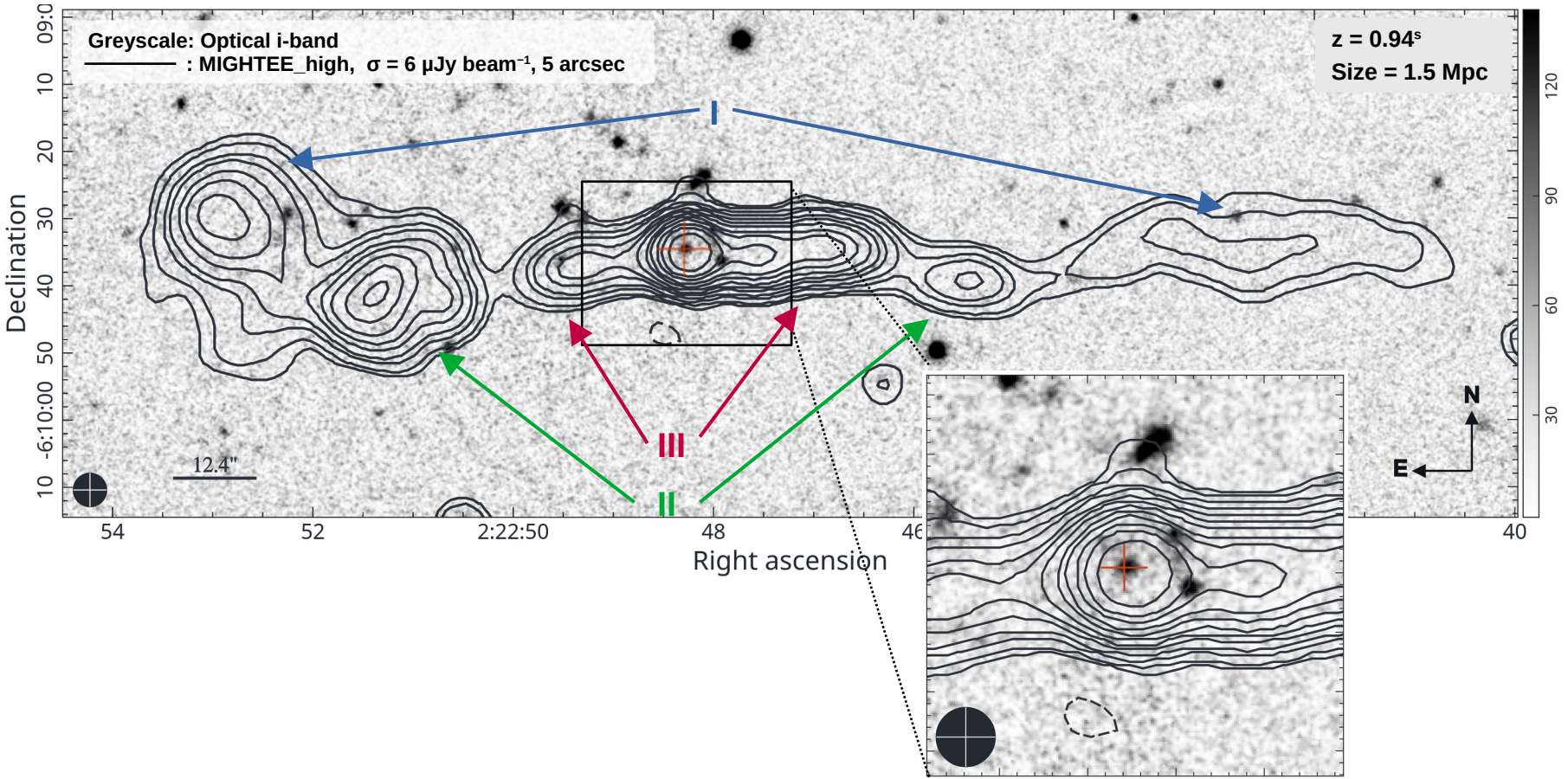

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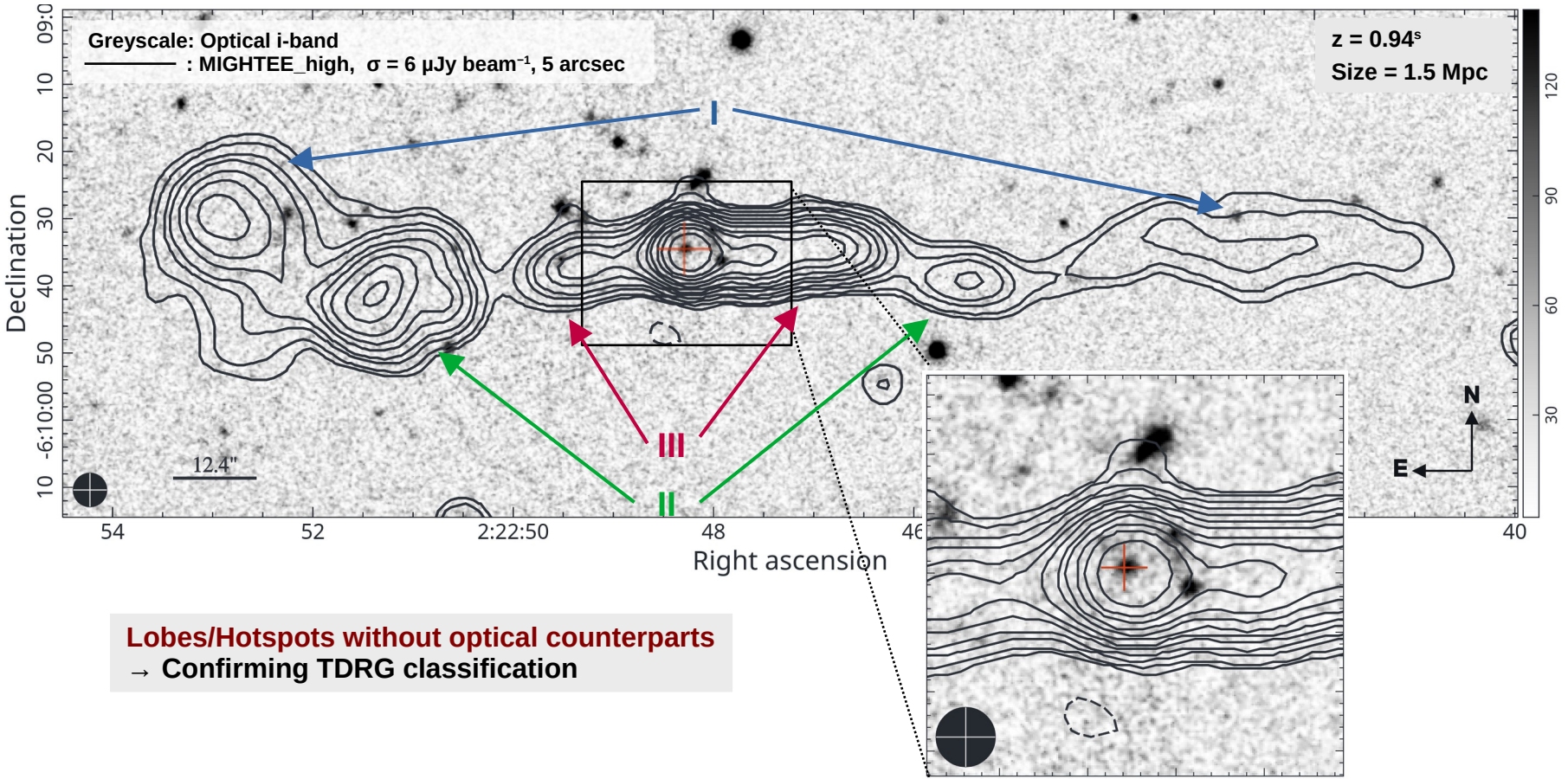

Lobes/Hotspots without optical counterparts
→ Confirming TDRG classification

- 3 pairs of radio emission peaks → **3 pairs of lobe/hotspots** → **3 episodes of activity**

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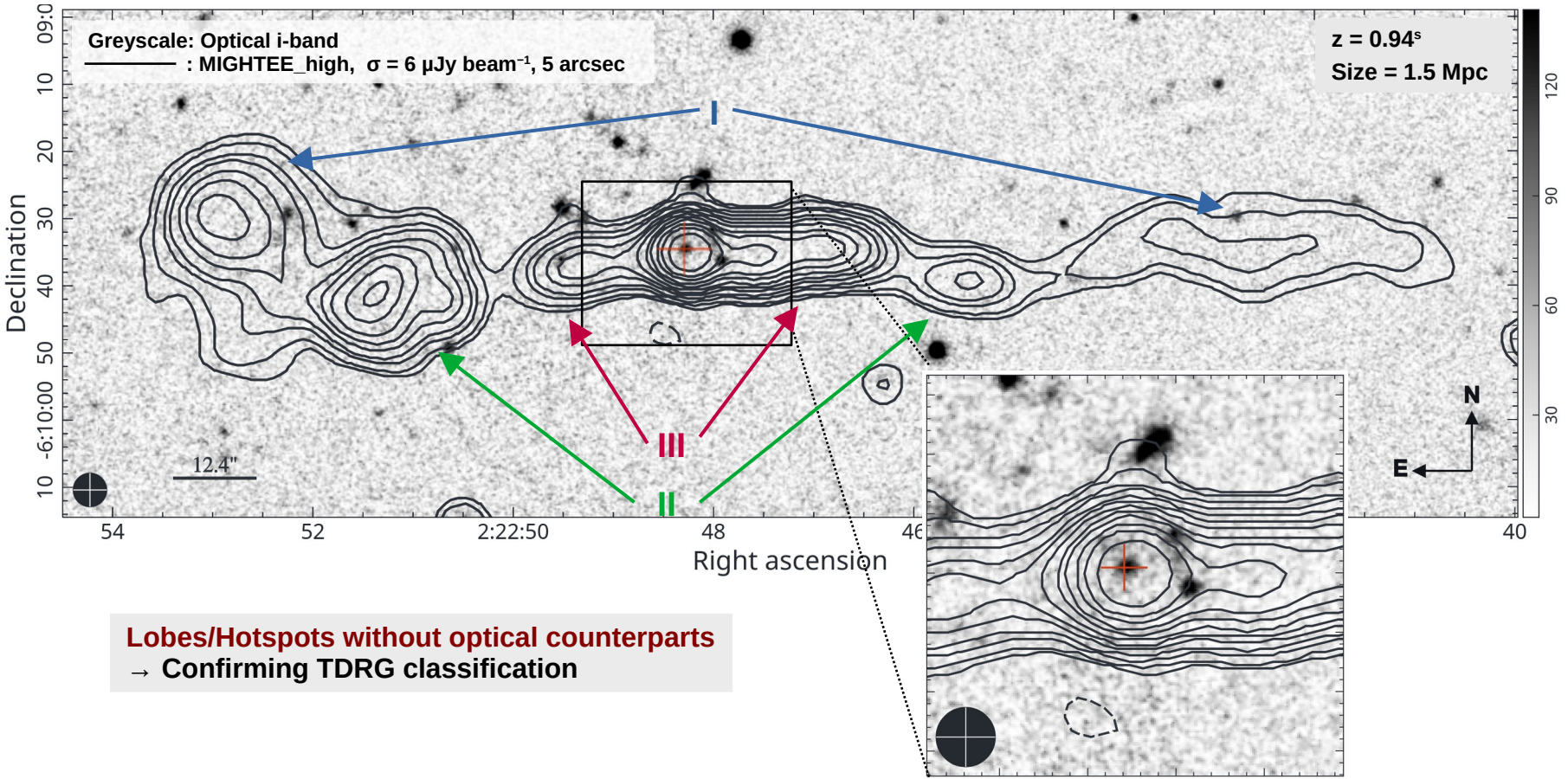
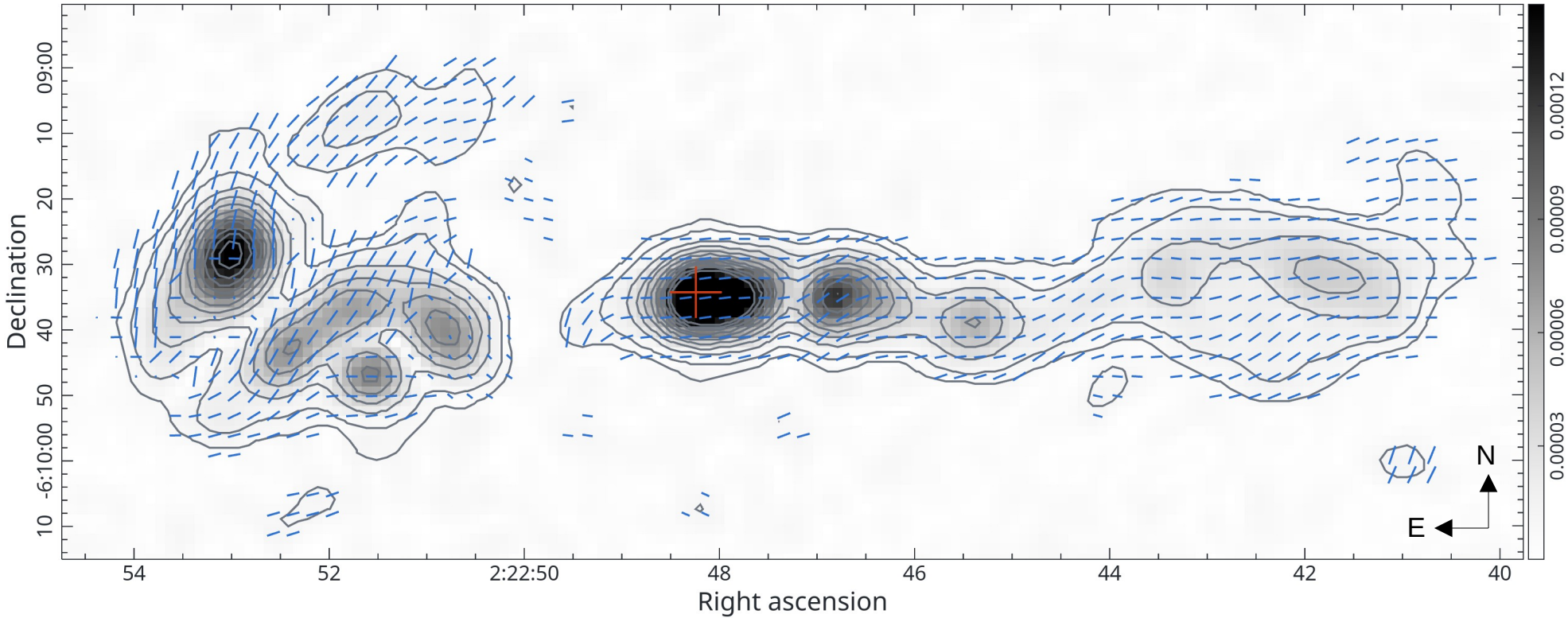


Lobes/Hotspots without optical counterparts
→ Confirming TDRG classification

- 3 pairs of radio emission peaks → **3 pairs of lobe/hotspots** → **3 episodes of activity**
- edge-brightened structure → **FR II classification**
- bending in eastern lobes → **non-uniform host environment**

Triple-double candidate: J022248−060934 (e.g. Brocksopp+07) – Polarised intensity map



- Background: polarised intensity
- Contours: polarised intensity
- Vectors: B field polarisation angle

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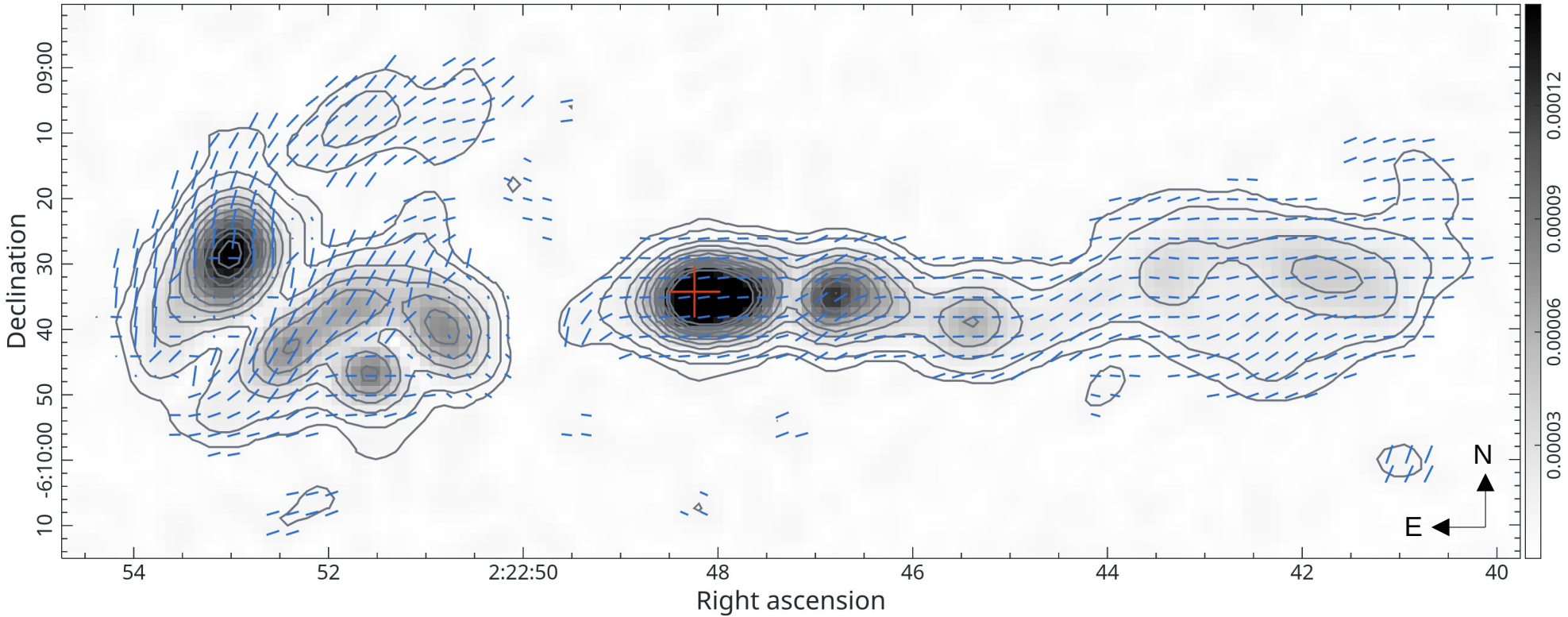

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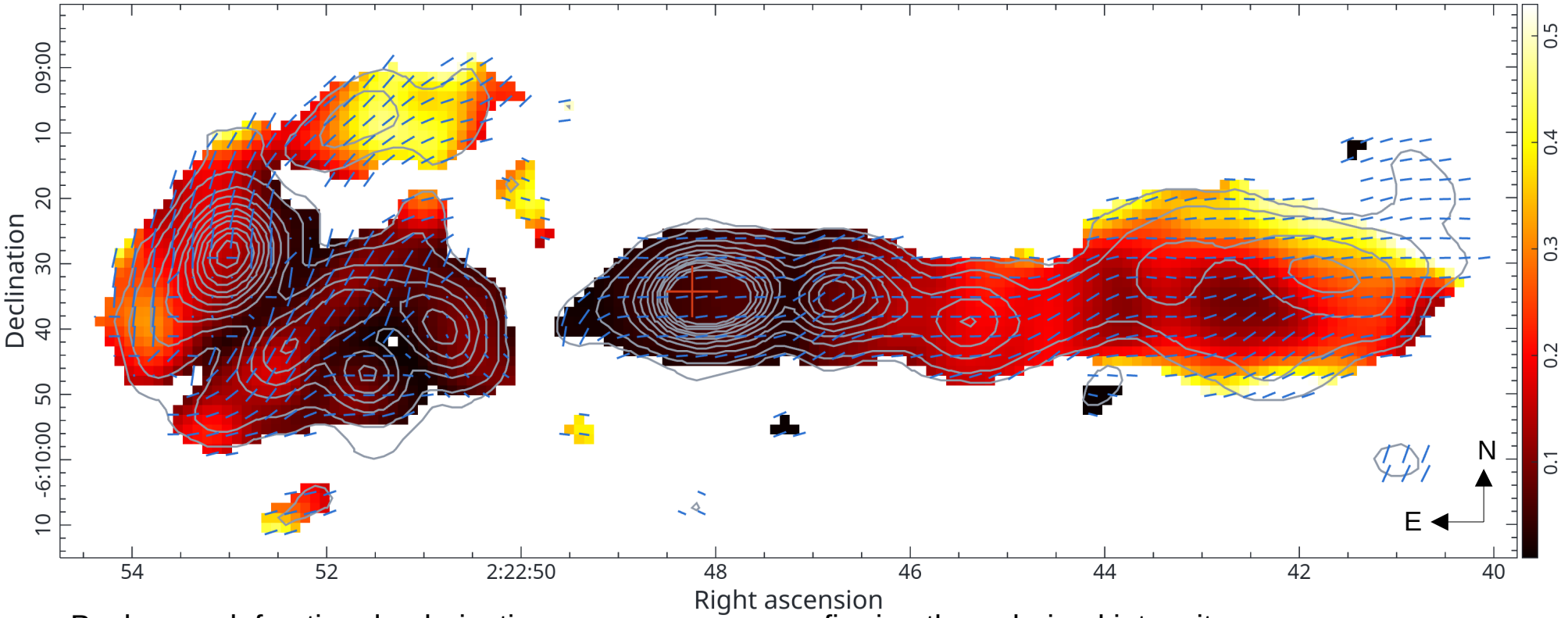
→

- core: B oriented along the jet axis
- western lobes: fainter + more ordered B field
- Eastern lobes: more polarised + mixed oriented B field

Triple-double candidate: J022248−060934 (e.g. Brocksopp+07) – Fractional polarisation map

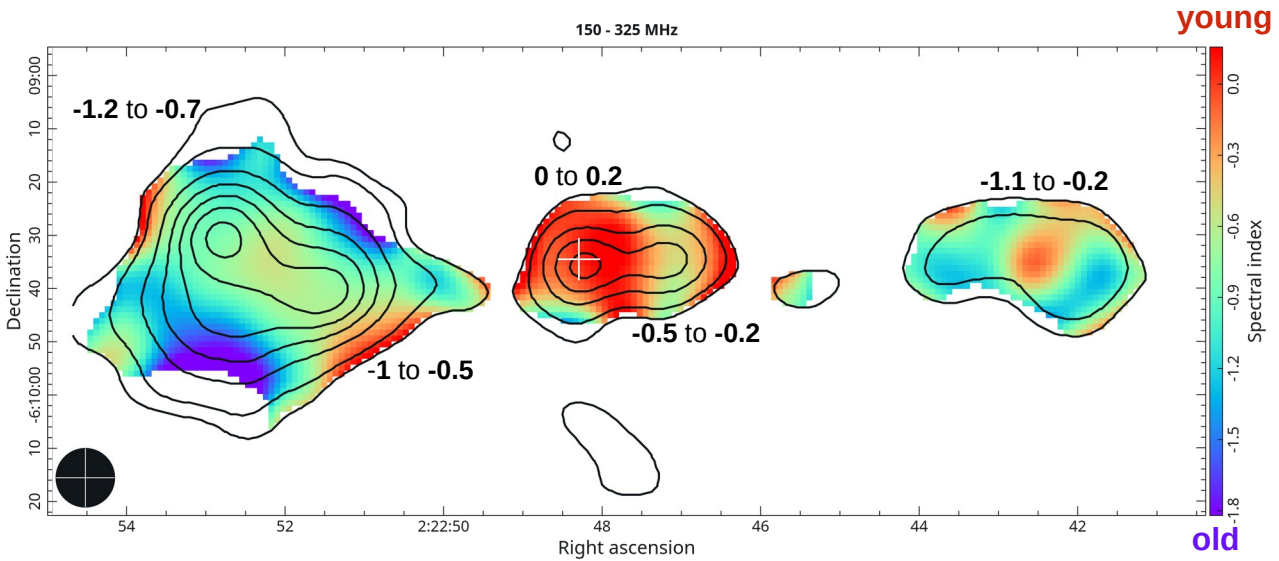


- Background: fractional polarisation
- Contours: polarised intensity
- Vectors: B field polarisation angle

→

- confirming the polarised intensity map
- **Eastern lobes: presence of turbulence or shock compression of the field**

Triple-double candidate: J022248−060934 (e.g. Brocksopp+07) – Spectral index map ($S_\nu \propto \nu^\alpha$)



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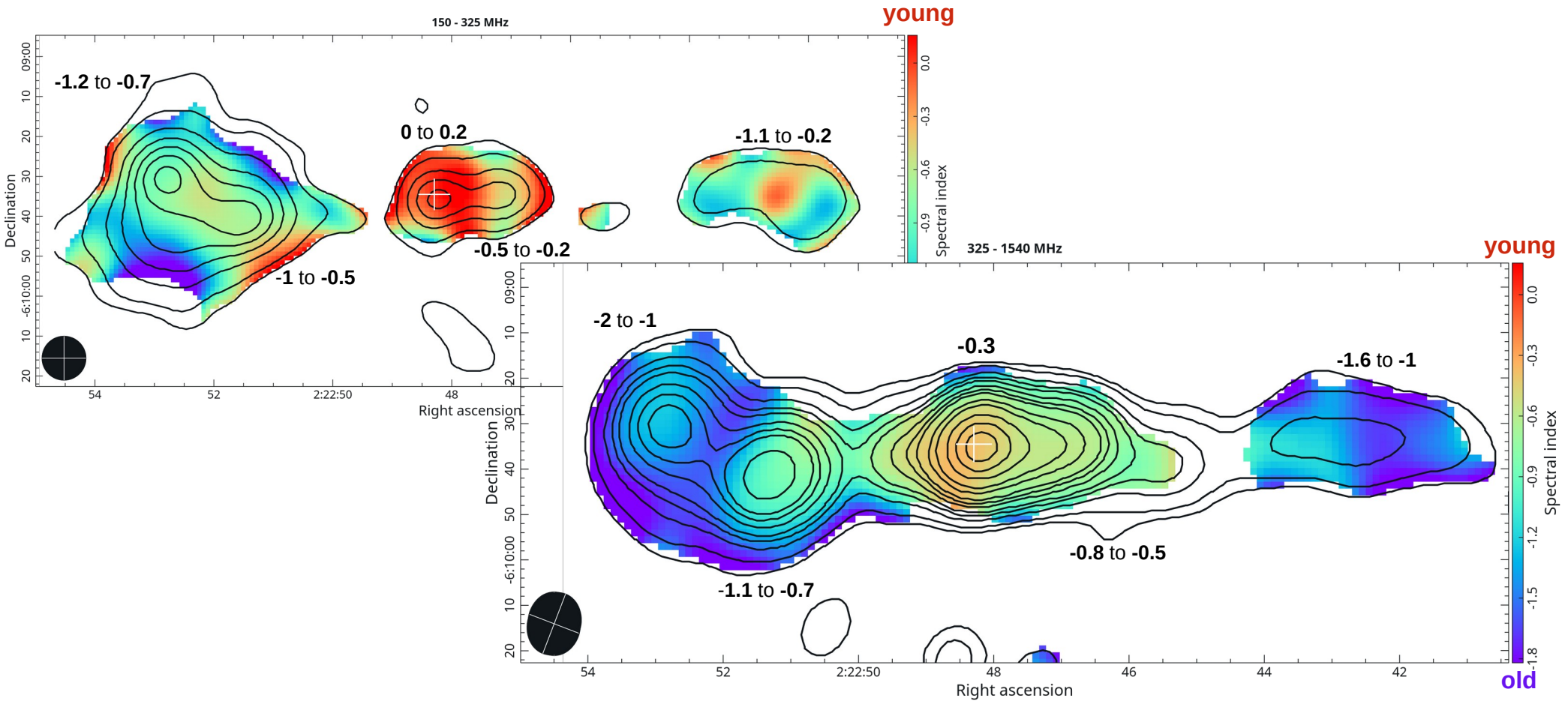

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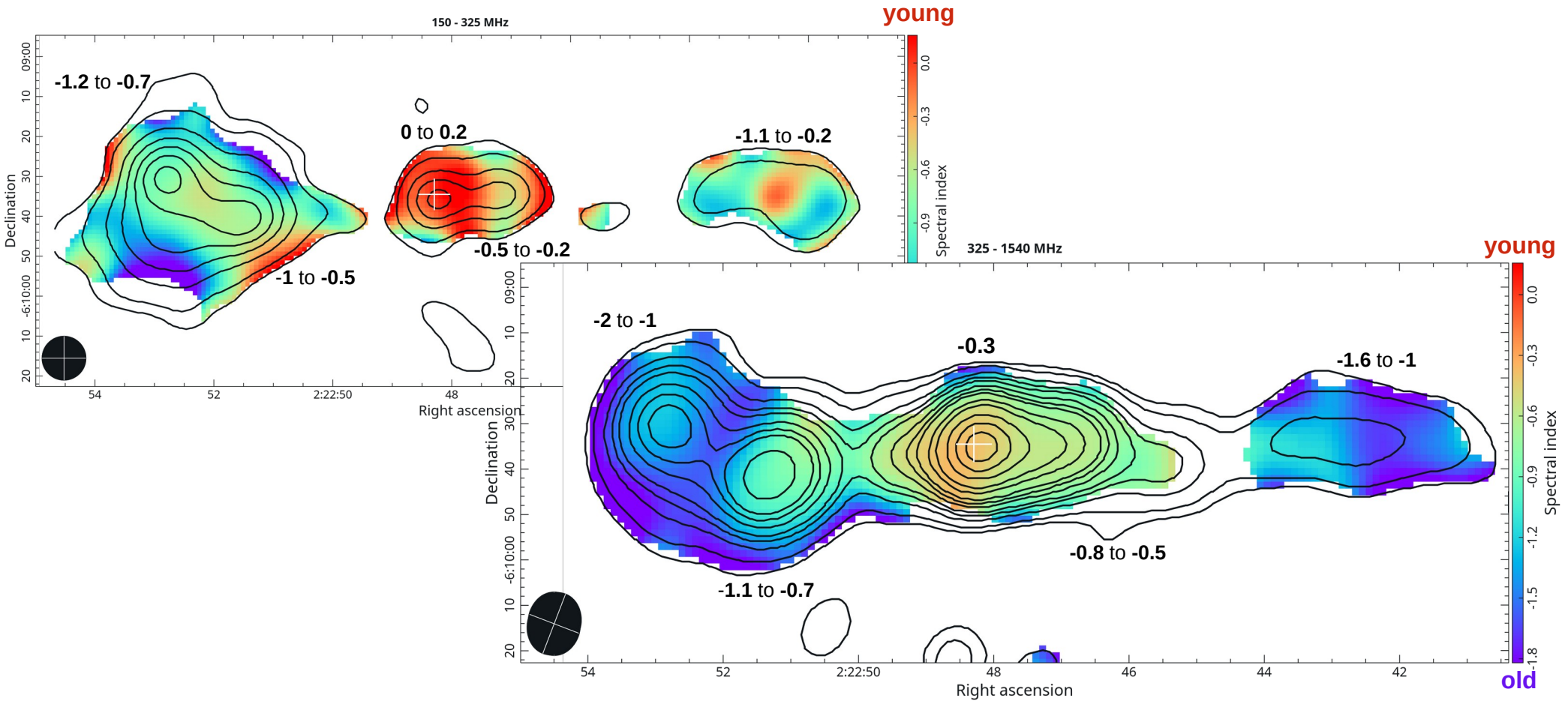

Core: **Inverted spectrum → Peak spectrum**

Lobes: **steep and curved** (higher from the outer to inner lobes)

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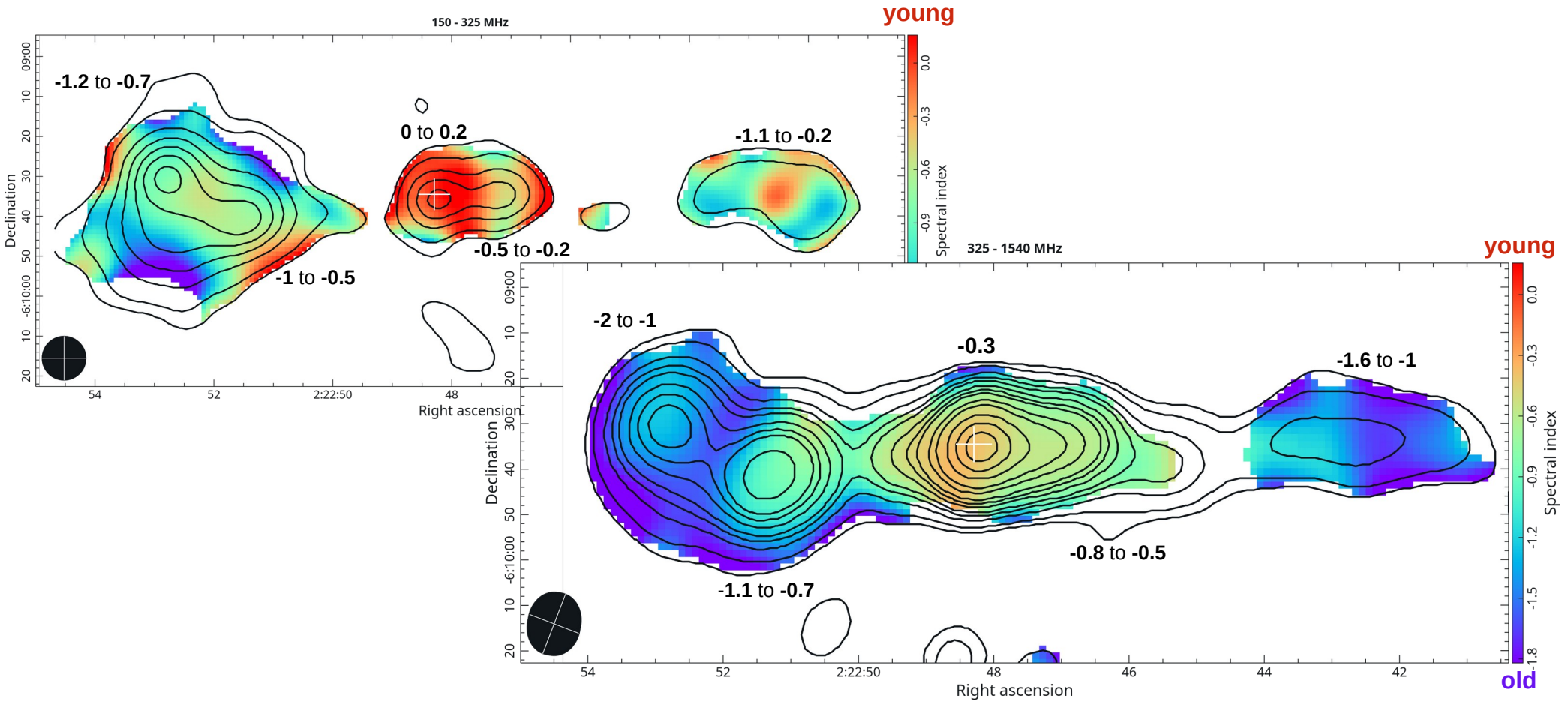
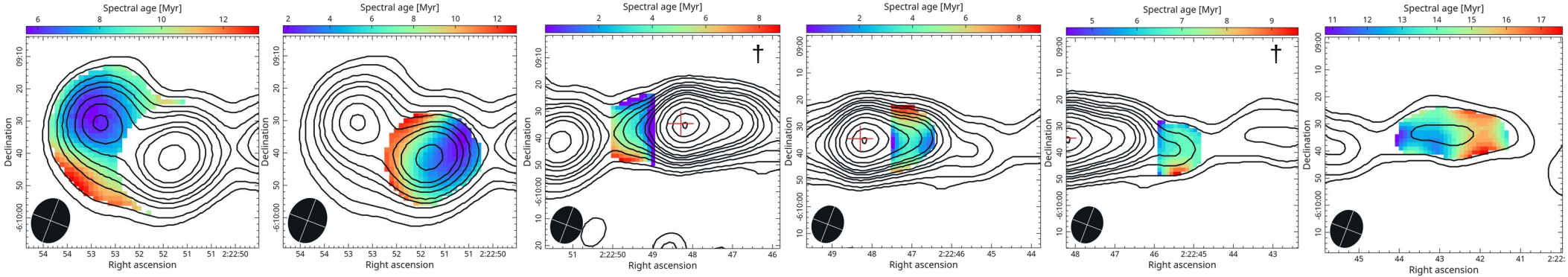


Core: **Inverted spectrum → Peak spectrum**
Lobes: **steep and curved** (higher from the outer to inner lobes)

Younger core & **Older lobes**
Evidence of a restarting activity

Triple-double candidate: J022248−060934 (e.g. Brocksopp+07) – Spectral age

Model used: JP model (Jaffe &Perola 1973) using BRATS (Harwood et al. 2013, 2015)



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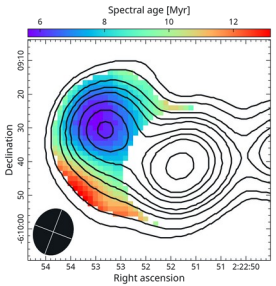

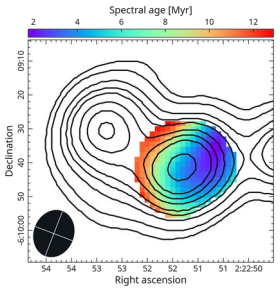

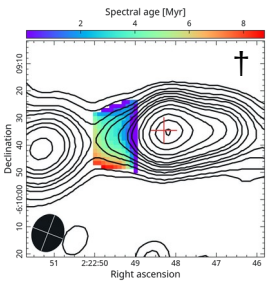

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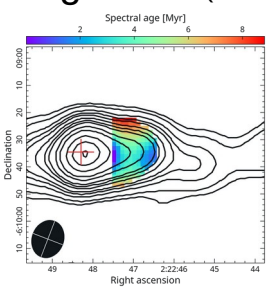
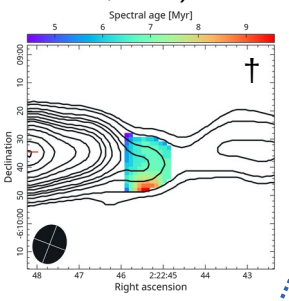
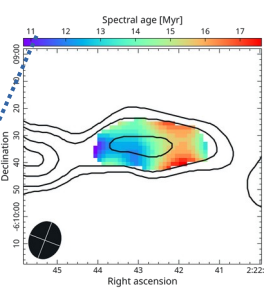
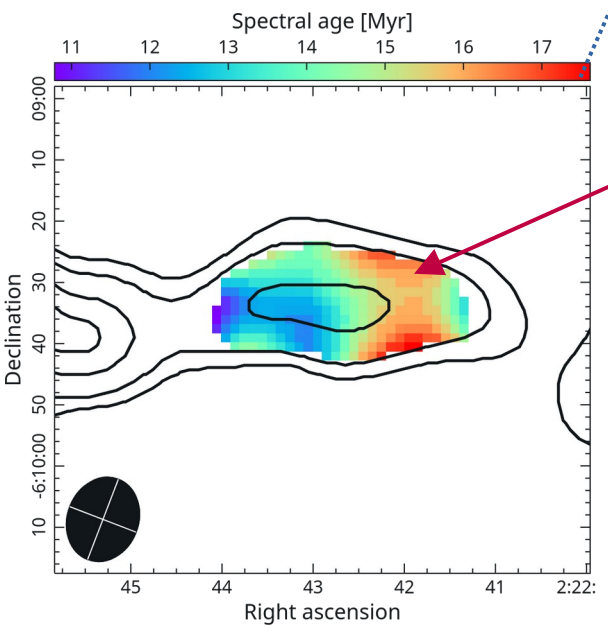






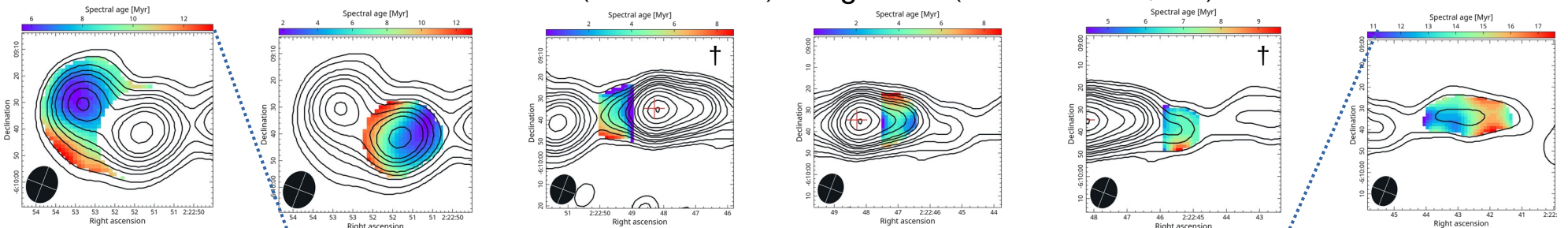


Source total age:
$T_{tot} = T_{max} = 16$ Myr

Western outer lobe

Triple-double candidate: J022248−060934 (e.g. Brocksopp+07) – Spectral age

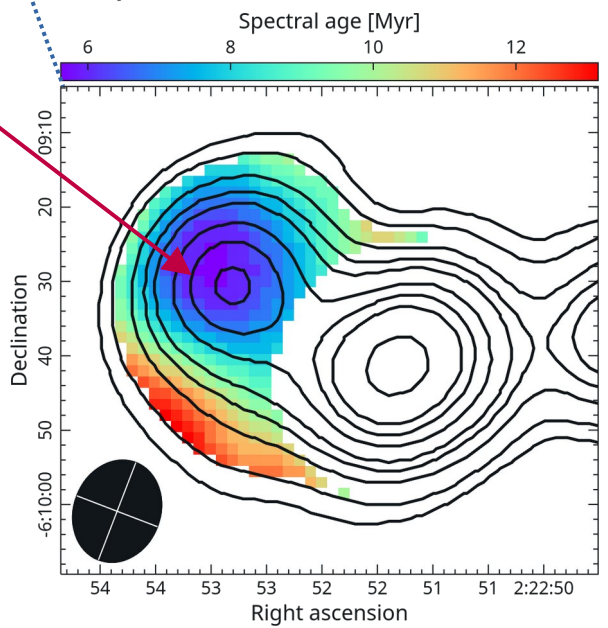
Model used: JP model (Jaffe &Perola 1973) using BRATS (Harwood et al. 2013, 2015)



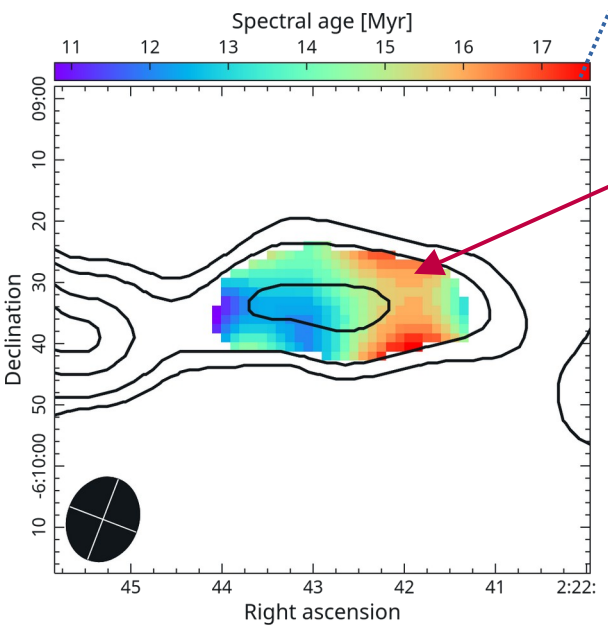
First active phase

$T_{on,1} = T_{tot} - T_{hotspot}$

$T_{on,1}$ = 10 Myr



Eastern outer lobe



Western outer lobe

Source total age:

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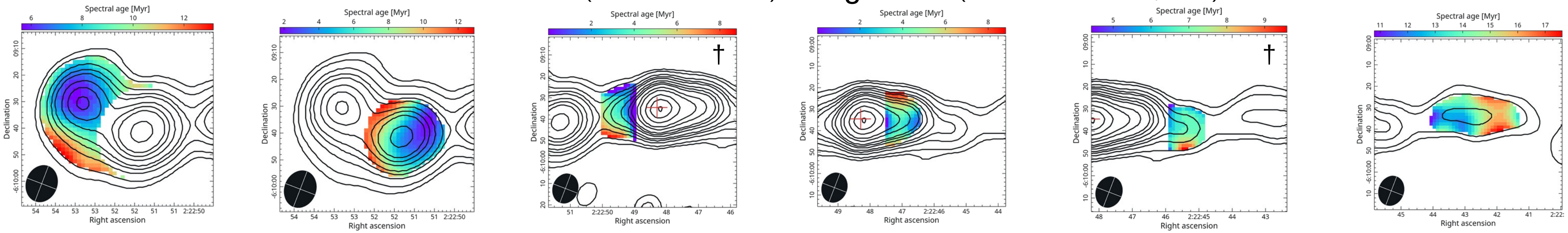

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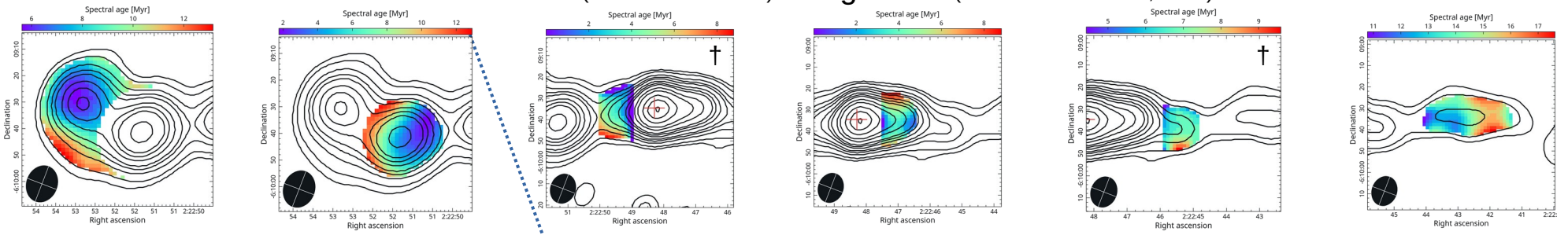

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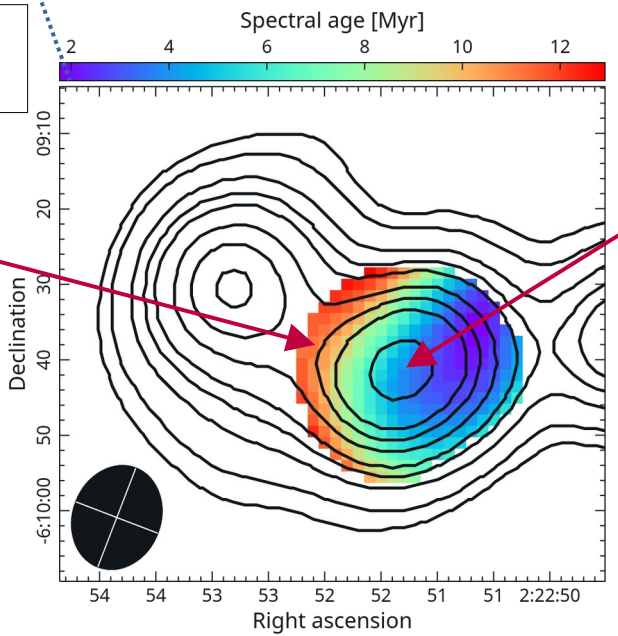

T_{max} = 12 Myr

$T_{hotspot}$ = 5 Myr

Second active phase

$T_{on,2} = T_{tot} - T_{hotspot}$

$T_{on,\,2}$ = 7 Myr

Eastern middle lobe

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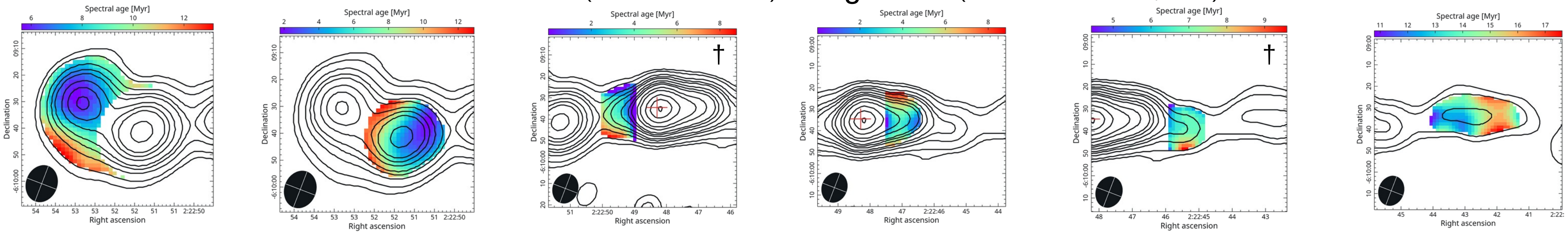

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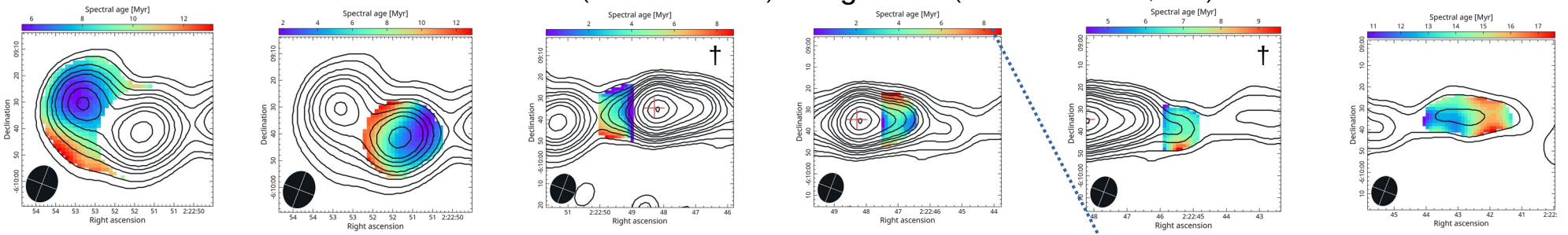
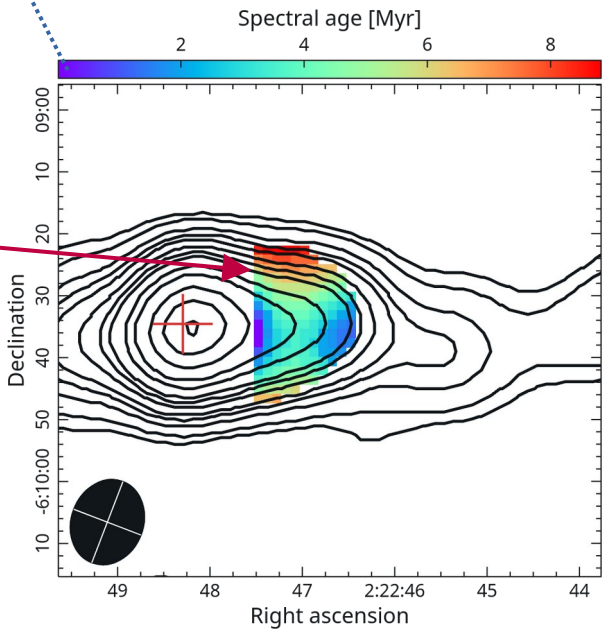


Source total age: T_{tot} = 16 Myr	First active phase $T_{on,1}$ = 10 Myr	Second active phase $T_{on,2}$ = 7 Myr

Ongoing activity
$T_{on,3} = T_{max}$
$T_{on,3}$ = 8 Myr



Western inner lobe

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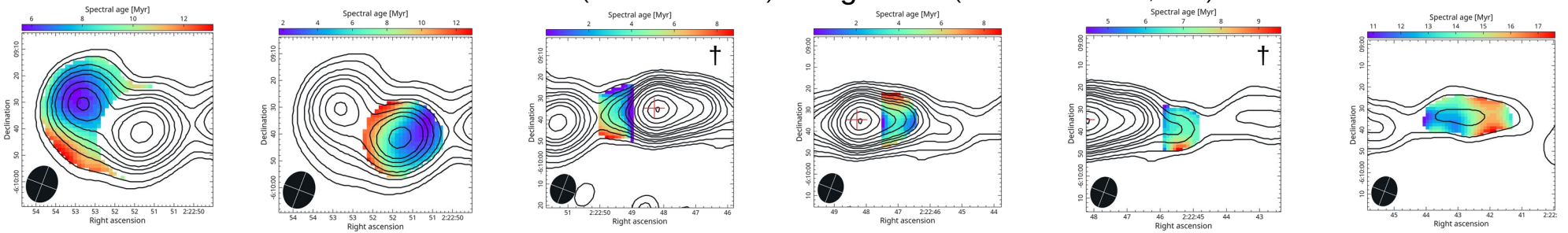

Source total age:
T_{tot} = 16 Myr

First active phase
$T_{on,1}$ =10 Myr

Second active phase
$T_{on,\,2}$ = 7 Myr

Ongoing activity
$T_{on,\,3}$ = 8 Myr

- T_{max} measured → lower limit → multiple nuclear activity erases the particles from backflow

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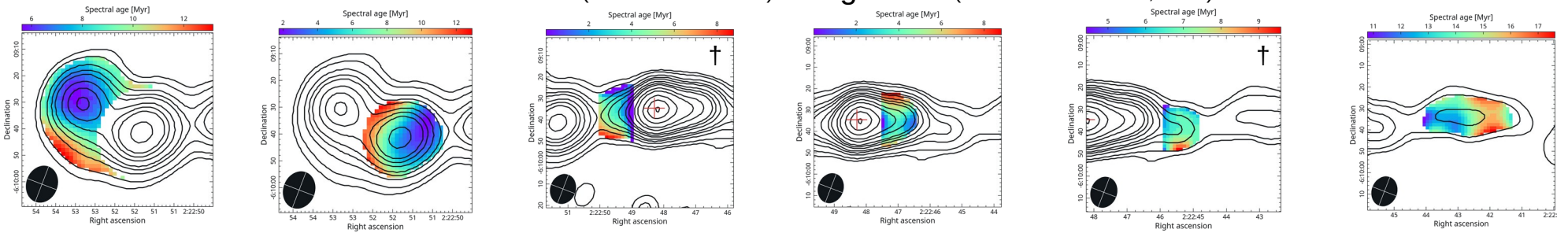

Source total age: T_{tot} = 16 Myr	First active phase $T_{on,1}$ =10 Myr	Second active phase $T_{on,2}$ = 7 Myr	Ongoing activity $T_{on,3}$ = 8 Myr

- T_{max} measured → lower limit → multiple nuclear activity erases the particles from backflow

Quiescent period: T_{off} Upper limit = youngest age(previous outer lobe) – ~~oldest~~ youngest age(following middle lobe).
Upper limit **$T_{off,1}$ = ~ 1 Myr**

Duty cycle (first order)**:** $t_{on}/(t_{on} + t_{off})$ → **90%** (first active phase)

† : modelled without LOFAR and GMRT

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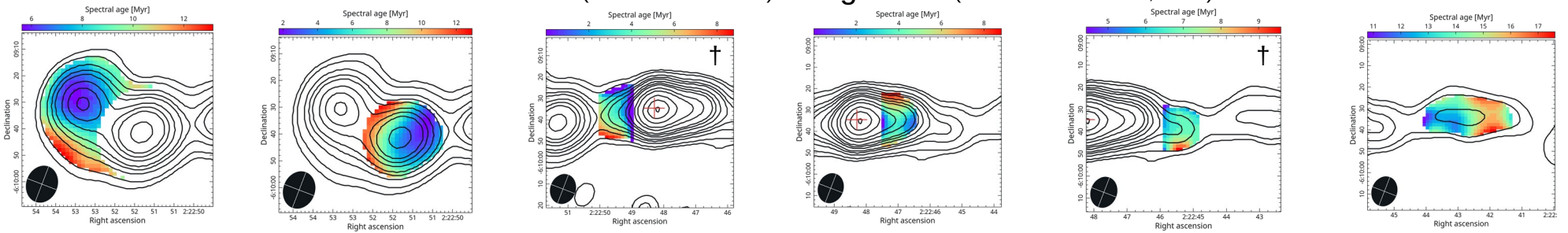

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→ - Rapid duty cycle
- The new activity restarts before the previous lobe/hotspots fading

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Triple-double candidate (e.g. Brocksopp+07) – Comparison with other TDRGs

Ref	z	Size [kpc]			R_l			$P \times 10^{24}$ [W Hz^{-1}]			Host	Kinematic Age [Myr]		
		(I)	(II)	(III)	(I)	(II)	(III)	(I)	(II)	(III)	environment	(I)	(II)	(III)
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)
(a)	0.36	2541	732	37	0.63	0.66	0.81	335	168.6	11.2	–	415	24	0.60
(b)	0.14	1433	322	55	0.46	0.98	1.14	51	9.4	1.1	BCG	233	11	1
(c)	0.14	814	235	95	1.0	1.6	2.0	4.8†	0.54†	0.35†	Group	130	7.6	1.5
(d)	0.28	1349	572	118	0.87	0.93	1.44	18.4	11.7	1.6	BCG	220	19	2
(e)	0.11	1100	–	–	–	–	–	–	–	–	BCG	–	–	–
(f)	0.94	1587	866	461	0.48	1.44	0.73	4.6‡	6.1 ‡	10.0 ‡	field	258	28	8

(a): Brocksopp et al. (2007), (b): Hota et al. (2011), (c): Singh et al. (2016), (d): Chavan et al. (2023), (e): Dabhade et al. (2025) and **(f) this work)**

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- All the known TDRGs are **GRGs** (from 0.8 to 2.5 Mpc)
- Have features closer to an **FRII or intermediate FRII/FRI** and with asymmetry
- Pair of lobes radio power decrease inwards except for J022248−060934 → hosted by field galaxy?
- α: steep/ultra-steep outer lobes + gradual flattening towards the core → consistent with our spectral age
- Similar kinematic ages if the sources have similar size → inconsistent with spectral ages

Conclusion

Summary:

More details!

- **Focus of the work:** Report the discovery and properties of the 7th TDRG
- **Main data:** MIGHTEE-DR1 and MIGHTEE sub-band images
- **Results:**

→ Asymmetries between the eastern and western lobes

→ Spectral evidence of multiple nuclear activities

→ TDRGs might not be the product of long quiescent periods but a quick duty cycle

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Thank you! Questions?

IDIA Inter-University Institute for Data Intensive Astronomy

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NRF National Research Foundation | SAAO South African Astronomical Observatory