Radio surveys of the extra galactic sky

Huub Rottgering
Leiden

Greetings from George

To learn...

rde radiobron Virgo A eveneens de jet (zie de figu-
meen heeft een aantal bijzondere eigenschappen.
van het zichtbare licht als van de radiostraling blijkt
nisme niet thermisch is; de uitstulping bestaat niet
nchrotron-bron. Enige tijd later vond men een der-
ok in de optische tegenhanger van 3C 273 (meer
11). Omdat jarenlang verder geen enkele jet meer
ouwde men beide bronnen als vreemde uitzonde-

le in de zeventiger jaren. Lange, dunne radiostruc-
n of bij de centrale bron van een radiostelsel, wer-
n honderdduizenden lichtjaren verder in de uitge-
t is niet onredelijk om te veronderstellen dat ze iets
het transport van de energie vanuit het centrale
diolobben. In enkele stelsels met radiojets hebben
ook optische tegenhangers gevonden. M 87 en
plaren van een kennelijk vrij algemeen verschijn-
tober 1980) ruim twintig.
zich manifesteren als kop/staart-stelsels, kunnen
. Alles wijst erop dat een dergelijke jet een funda-
n radiostelsels. In figuur 16 zien we een voorbeeld
15. Ook 3C 449 in figuur 9 is een goed voorbeeld
ron met jets.

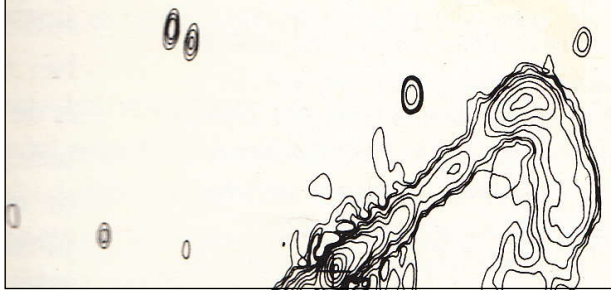
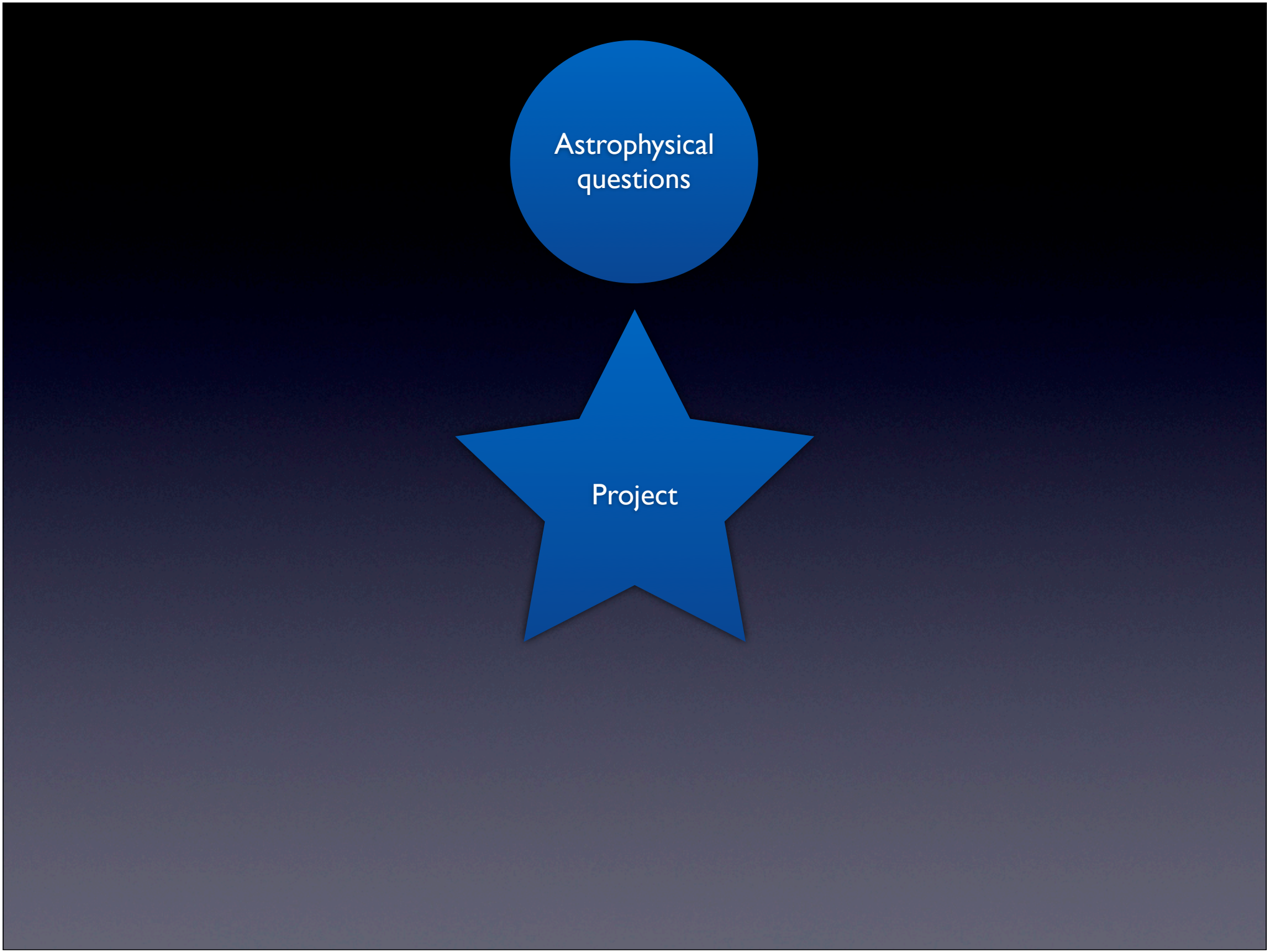


Fig. 17 Dr. A. G. de Bruyn was de gast-astronoom in deze televisieles

Astronomen neigen ertoe
voorkomend fenomeen zi
maar deze niet zien, is mis
de beperkende factor. In
in het zichtbaar licht.
Een aantal radiostelsels v
radiostraling die tot het s
ben afgebogen structuren
radiojets gevonden, hoew
gen.
De oorzaak van de radiost
die om de magnetische v
structuur en de verdeling
ten. Via polarisatiemeting
veld bepalen. Op zichzelf
bijzonders. Magnetische v
snelle elektronen eveneen
beurtenissen, zoals supern
veelheid en de plaats waa
hoeveelheden energie di
leiden tot vragen als: waa
en op welke wijze wordt
het complex? En hoe kan
grijpen? Over een schaal
structuur aanwezig. Deze
niet zó lang, want ook d
Het onderzoek van radios
kunde . . . Voortvarend o
gen van enig inzicht in de
cursus kunnen wij daarva

10.3. Naar een verkl


Project


Astrophysical questions
Project

Astrophysical questions

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- What is they made off?
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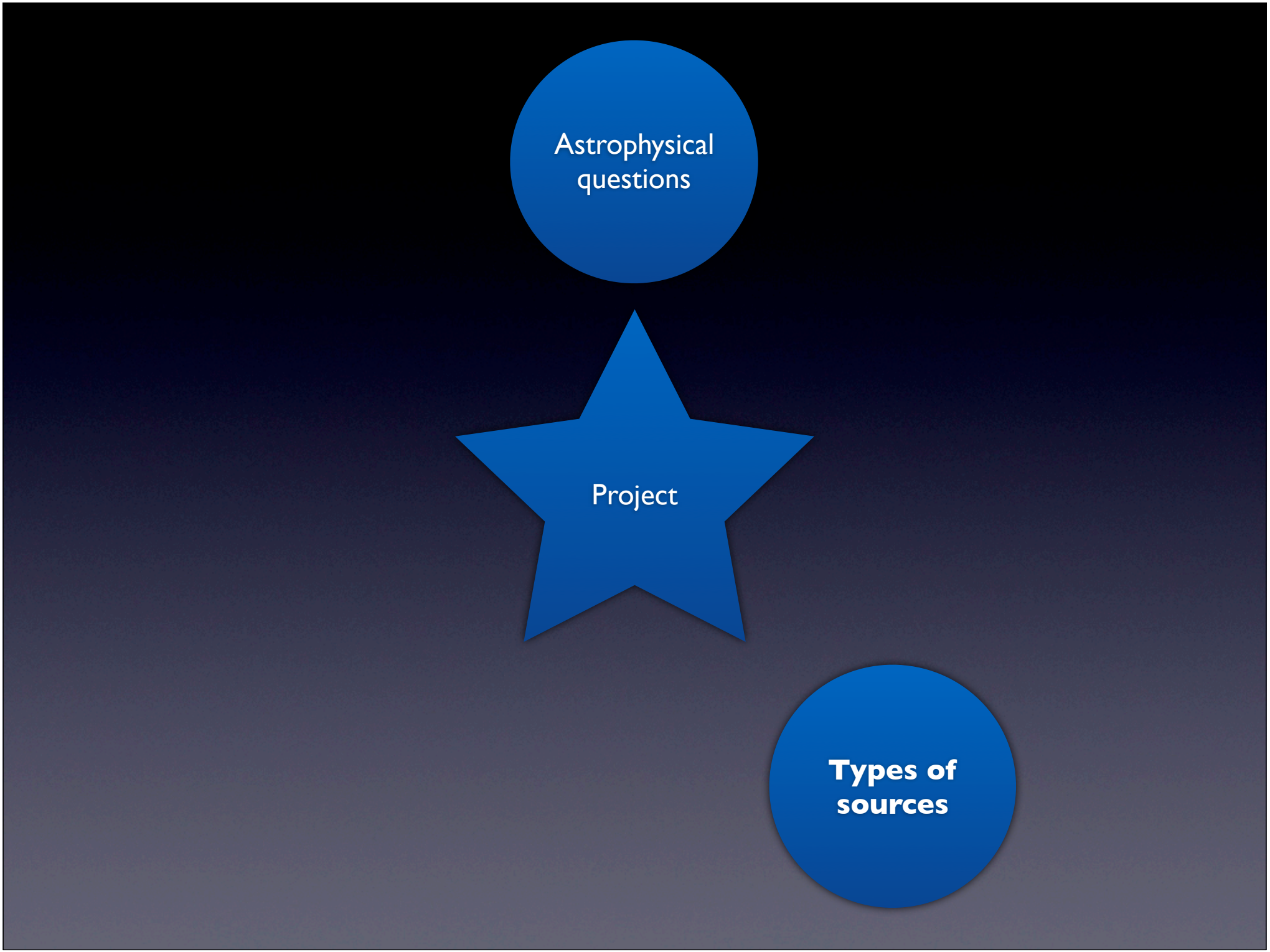
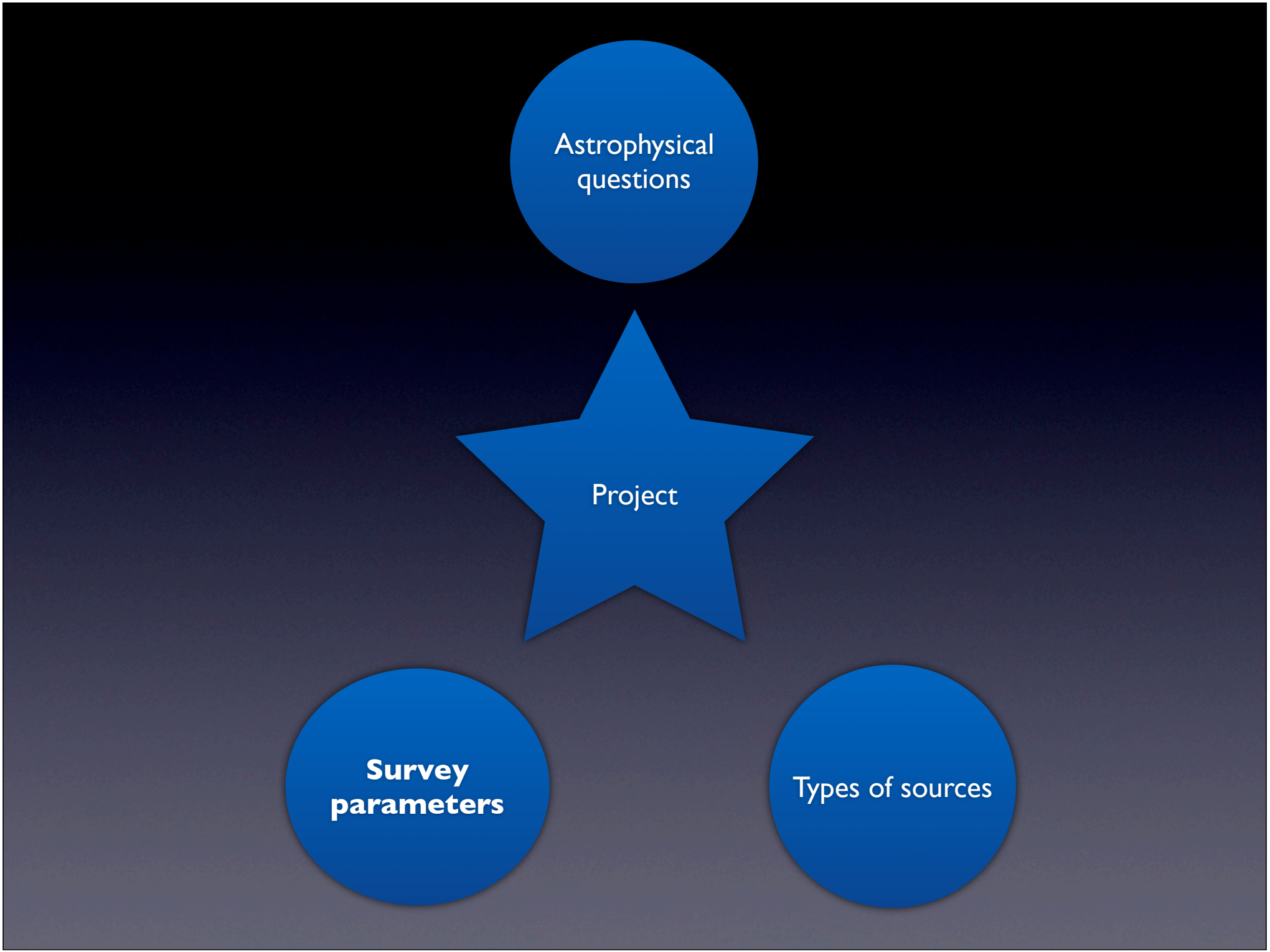

Astrophysical questions
Project
Types of sources

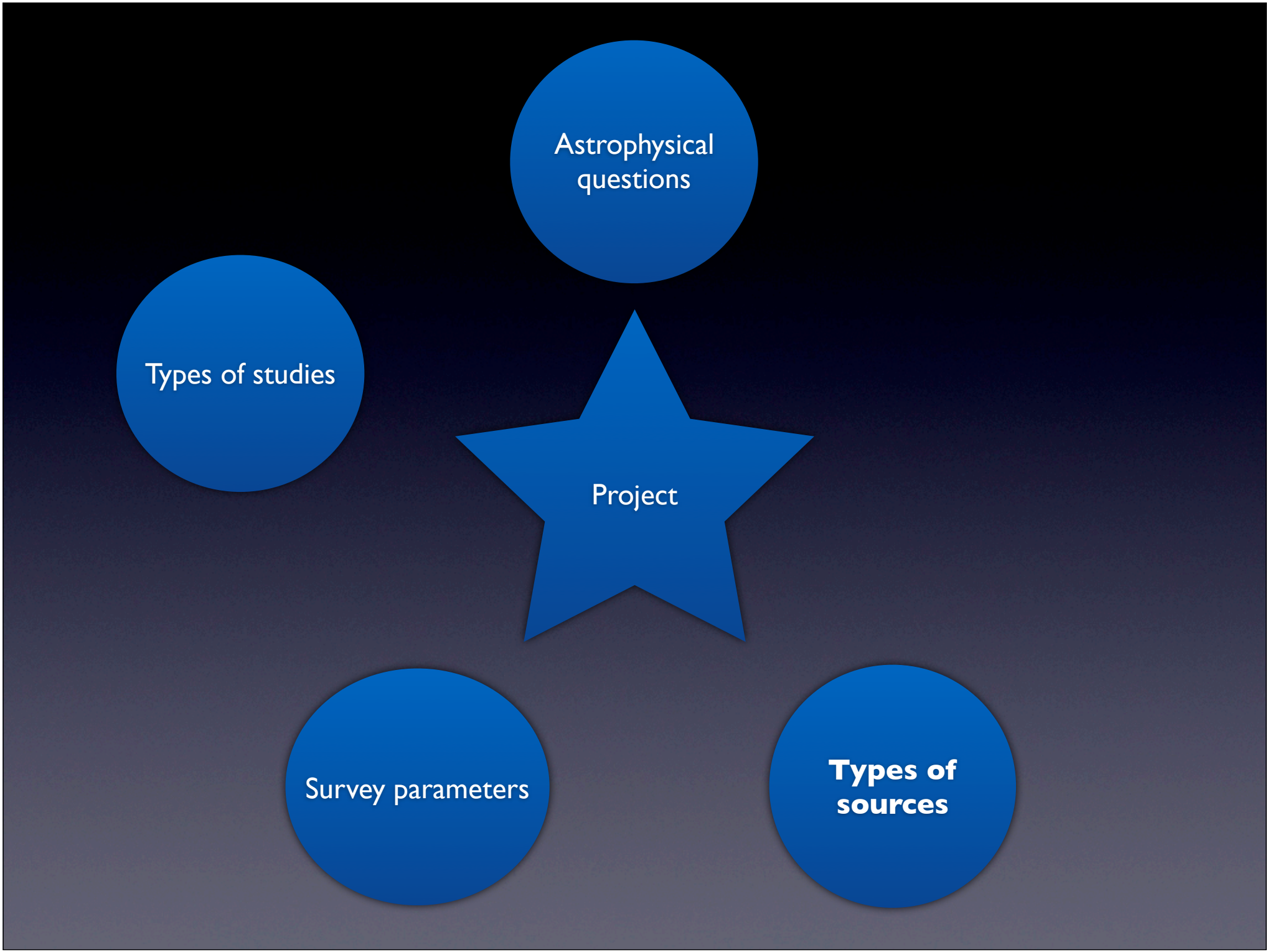
Types of sources

- Clusters halos and relics, accretion shocks
- AGN
  - radio loud AGN: FRI/FRII/Wide and narrow angle tails, double-doubles, CSS, GPS
  - radio quiet AGN: QSOs
- Starbursts
- Galaxies


Astrophysical questions
Project
Survey parameters
Types of sources

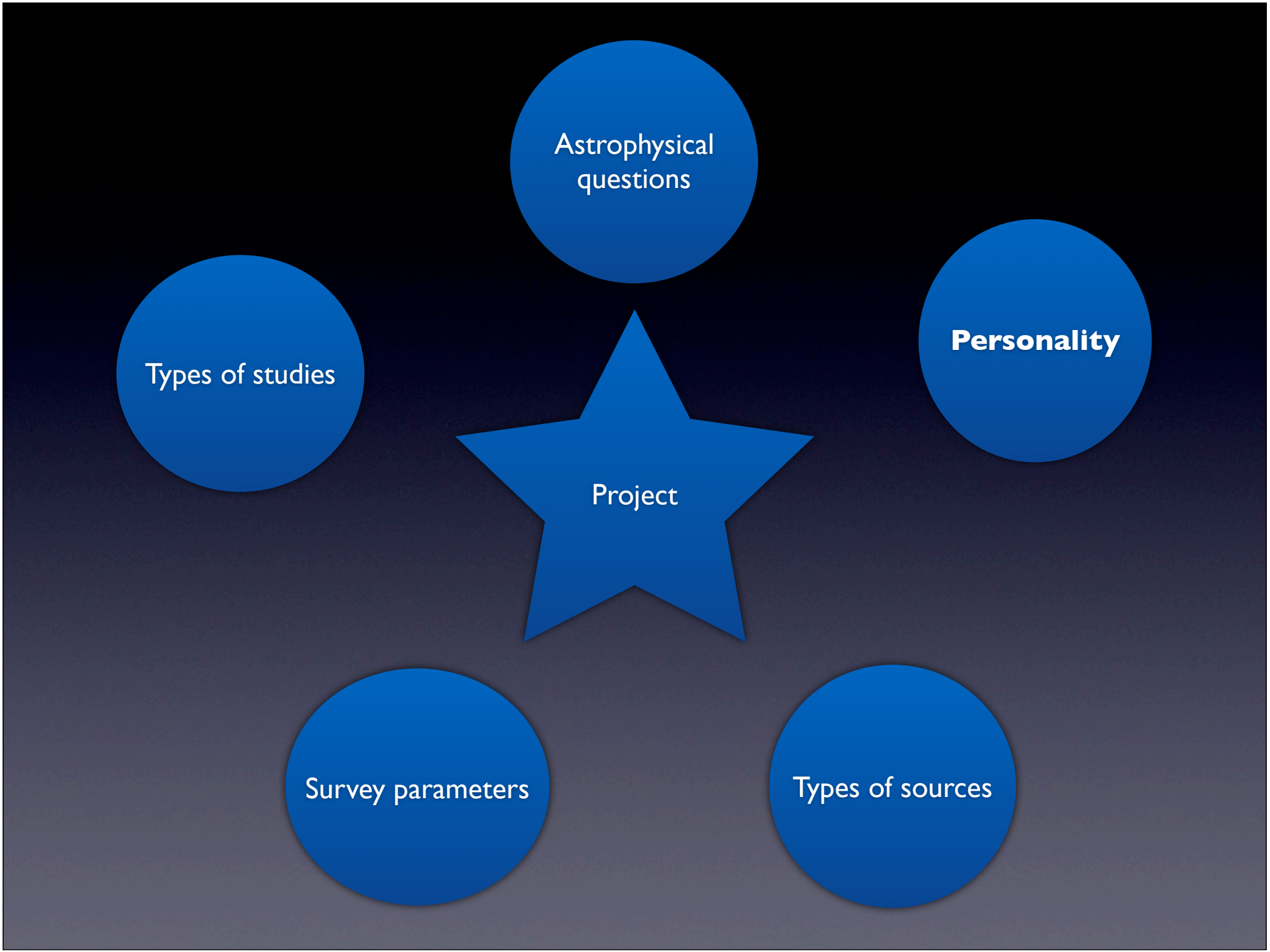
Survey parameters

- Frequency
- Depth
- Area
- Resolution


Astrophysical questions
Types of studies
Project
Survey parameters
Types of sources

Types of studies

- Radio selection
  - Outliers
    - Spectrally
    - Morphology
  - Statistical samples
- Identification work

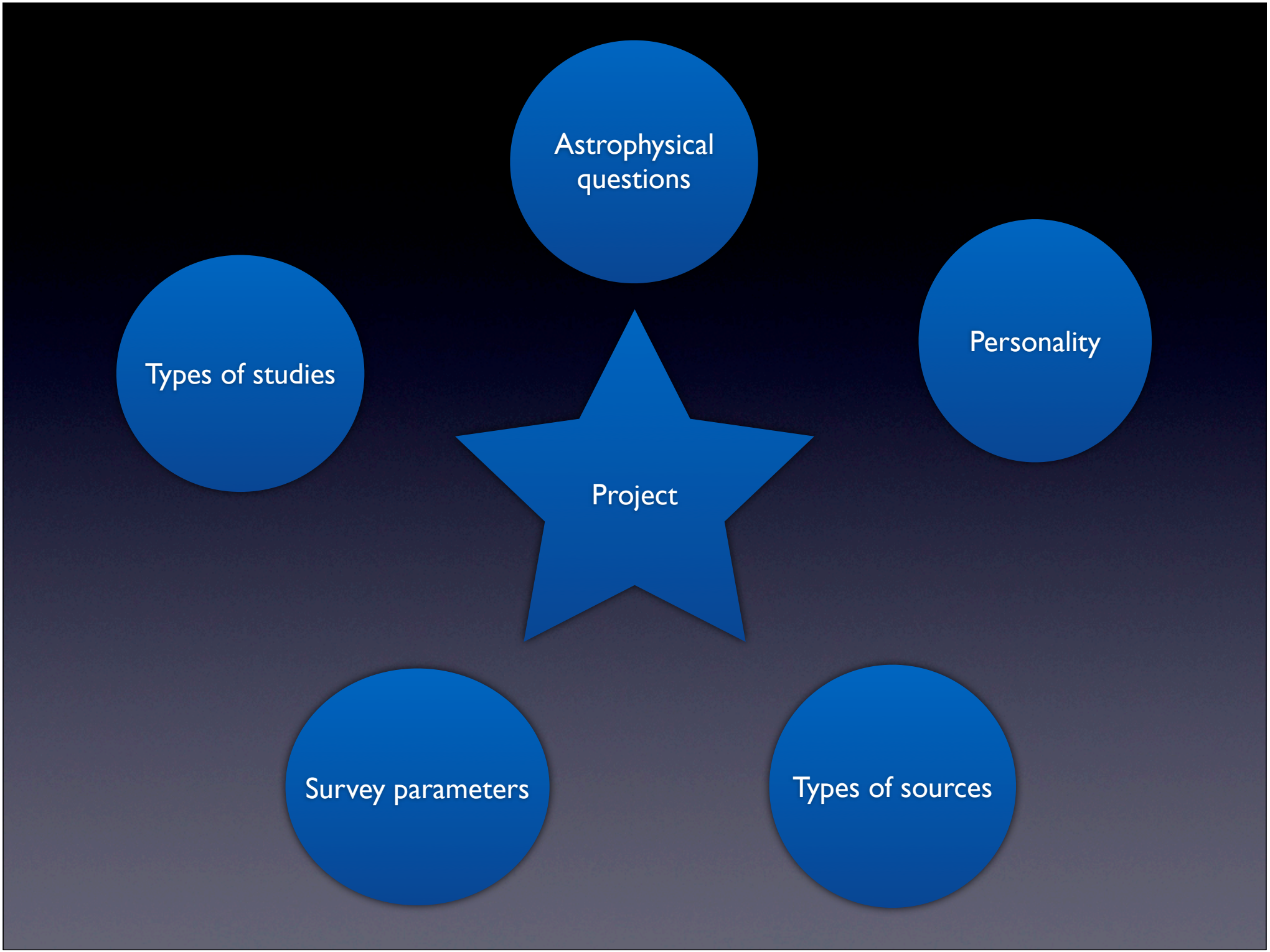

Astrophysical questions
Types of studies
Personality
Project
Survey parameters
Types of sources

Personality

- Team player versus soloist?
- Topic hopper or a true expert?
- Bold or conservative?
- Short time scorer or solid scientist?
- Into the details or with overview?
- In need for money or rich?
- Shy or aggressive?
- Traveler or home sick type
- Young or old

Important archetypes

- Instumentalist
  - build, understand, use and advocate your instrument. If your instrument can't observe it, it it probably not interesting.
- High-z hunter
  - topic hopper, bold, short time scorer, aggressive, traveler, young
- Complete sample type:
  - soloist, a true expert, conservative, solid scientist, details, rich, shy, home sick type, old
- Getting physical parameter type:
  - soloist. true expert, conservative, solid scientist, into the details, home sick type
- Scenario builders:
  - soloist, topic hopper, bold, short time scorer, with overview, in need for money, aggressive, traveler


Astrophysical questions
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How to pick a project?

- Realize who you are
- Understand your survey
- Discover or pick a class of objects that you like
- Formulate a realistic astrophysical question
- Pick a way to study it
- Define a project

Types of study

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Types of sources

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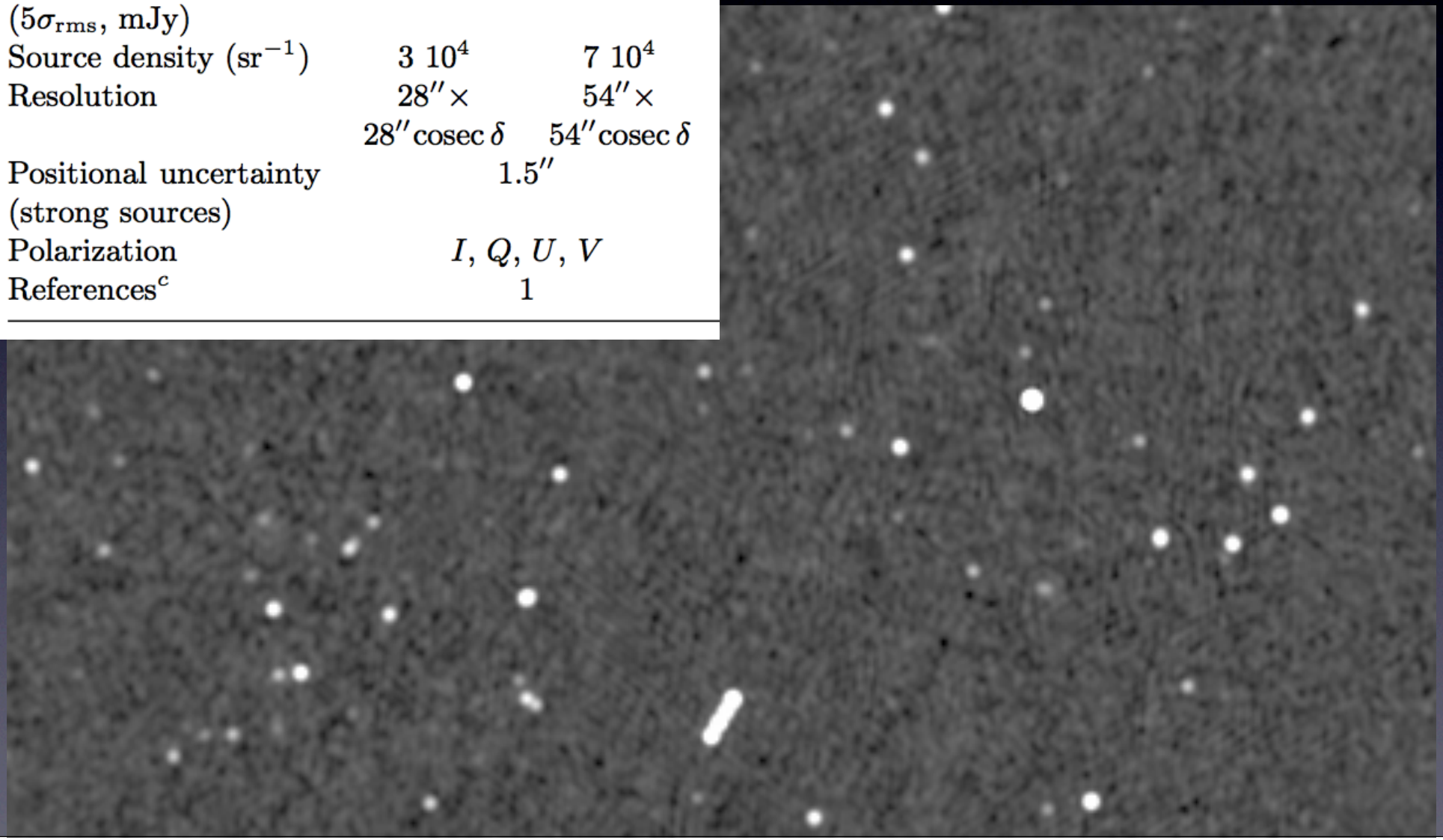
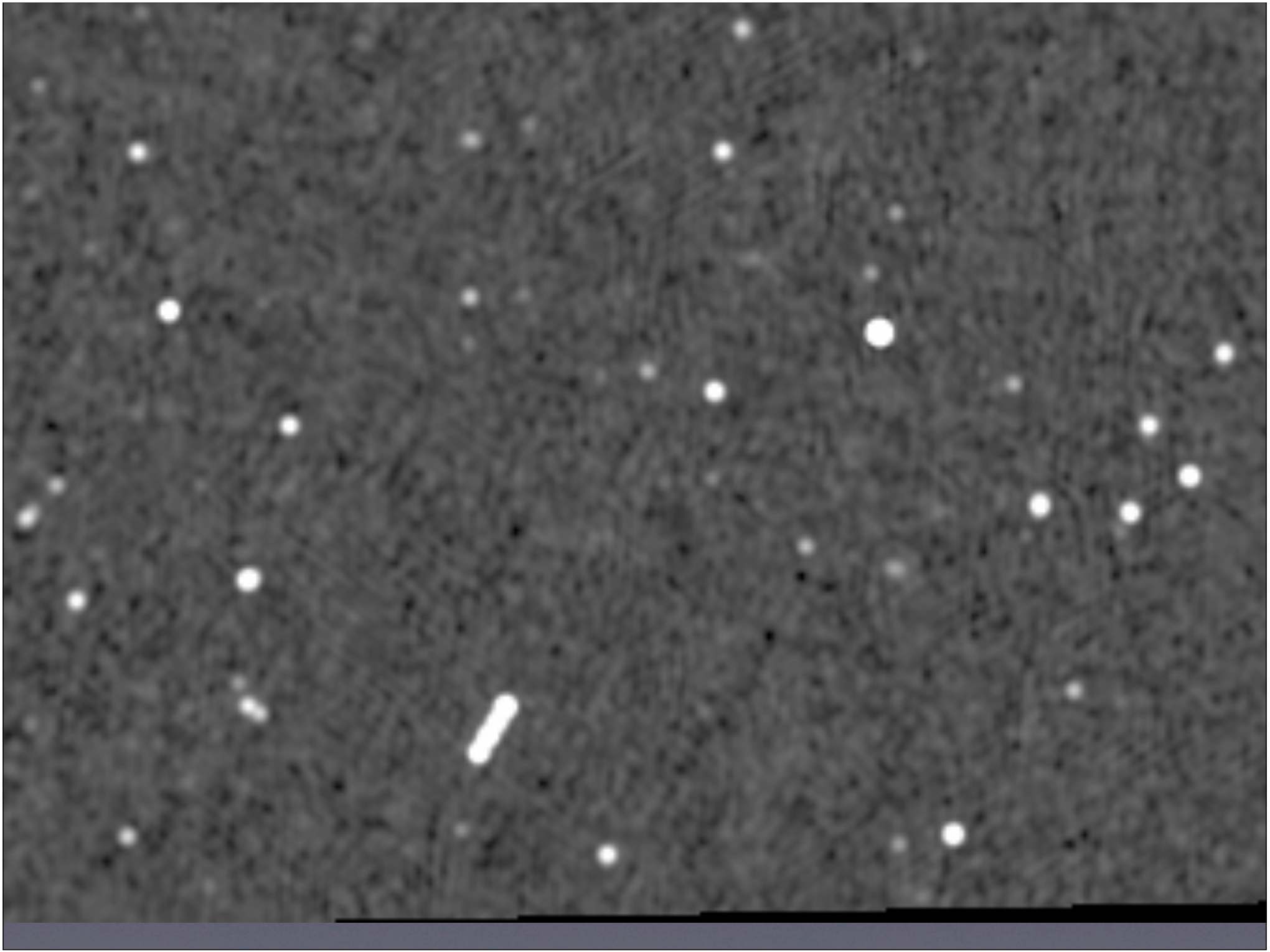
Astrophysical questions

Let’s do it all

Wenss survey (Ger's most cited paper)

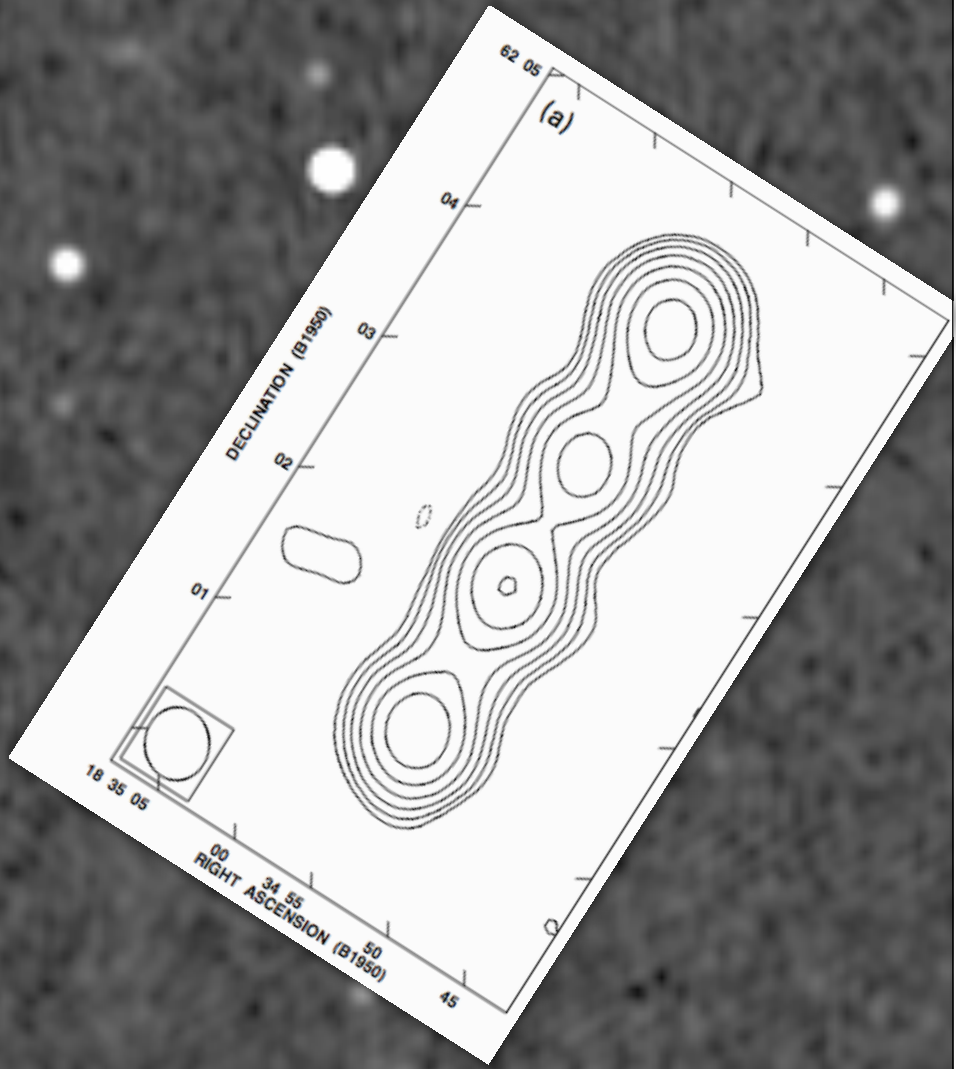
	WENSS	
Frequency (MHz)	609	325
Sky coverage	$\delta > 30°$	
	$\mid b \mid > 20°^b$	
Sky Area (sr)	0.7	3.1
Lim. Flux density ($5\sigma_{\rm rms}$, mJy)	18	15
Source density ($\rm sr^{-1}$)	$3\ 10^4$	$7\ 10^4$
Resolution	$28'' \times 28'' \,{\rm cosec}\,\delta$	$54'' \times 54'' \,{\rm cosec}\,\delta$
Positional uncertainty (strong sources)	$1.5''$	
Polarization	I, Q, U, V	
References[c]	1	

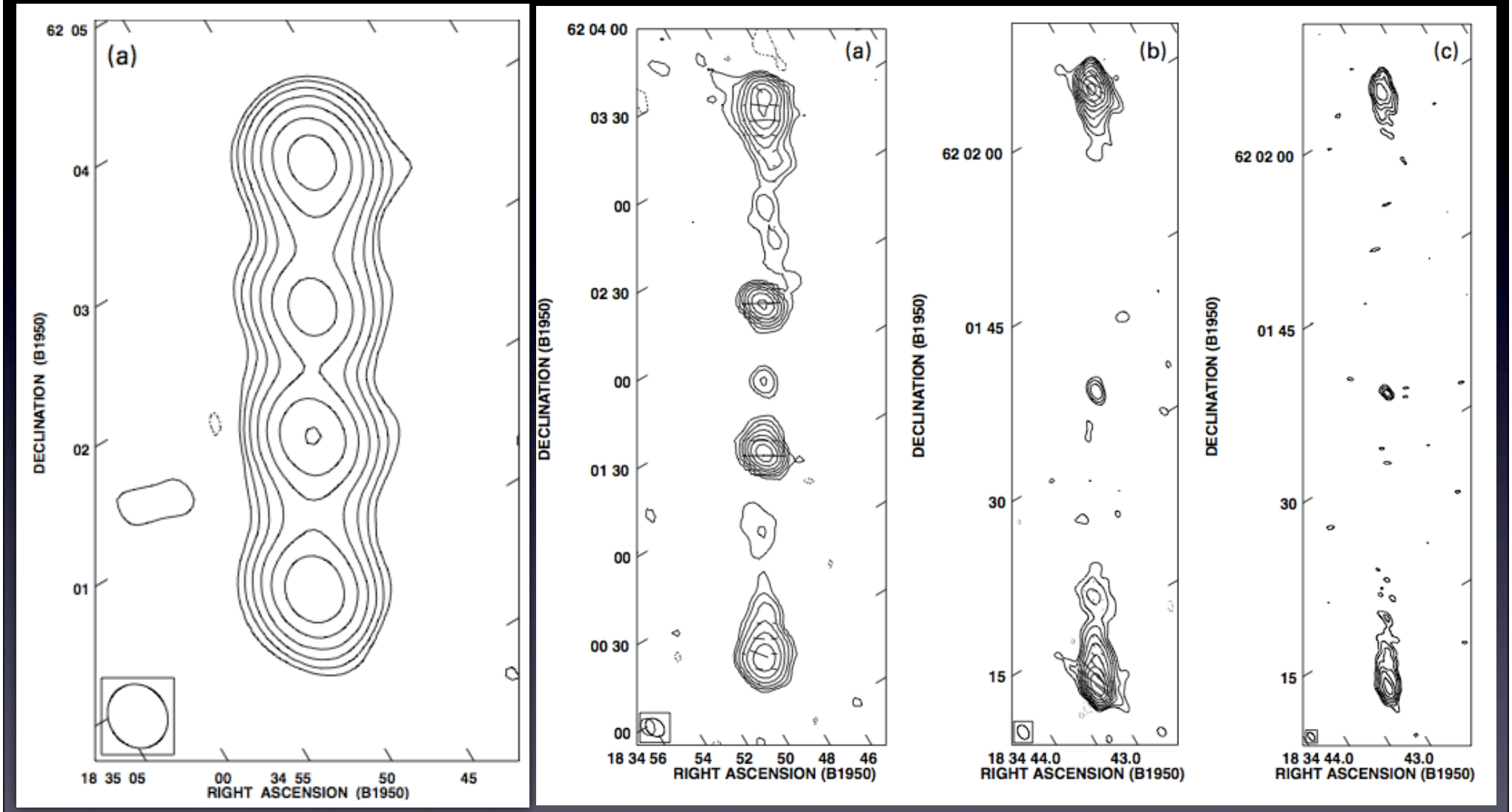




Radio galaxies with a ‘double-double’ morphology – III. The case of B 1834+620

Arno P. Schoenmakers,[1,2,3]★† A. G. de Bruyn,[3,4] H. J. A. Röttgering[2] and H. van der Laan[1]



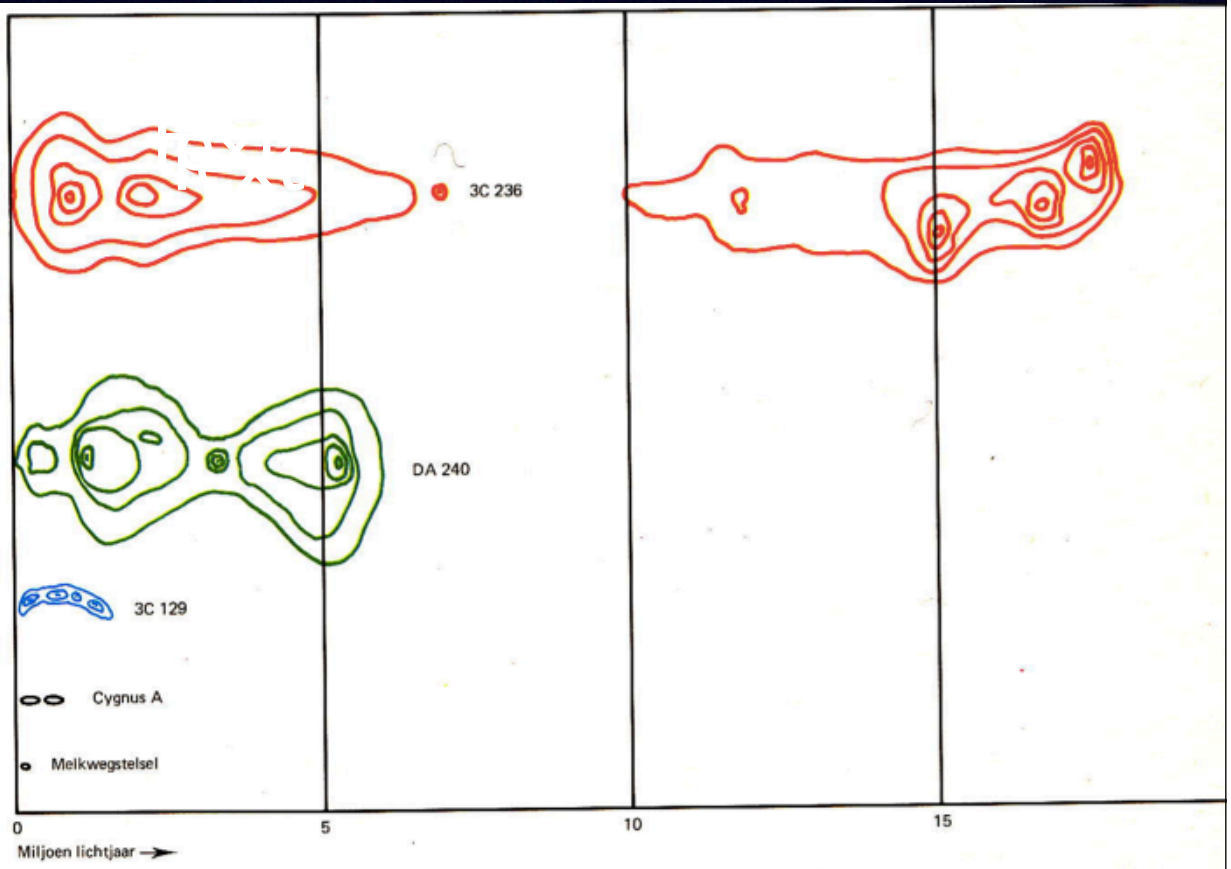


30”@610 MHz, 7”@8.4 GHz, 1.5”@1.4 GHz, 0.8@5 GHz

- 80': radio galaxies:
  - interesting but separate phenomon
  - models shaky (storm-ram theory in moderne sterrenkunde)

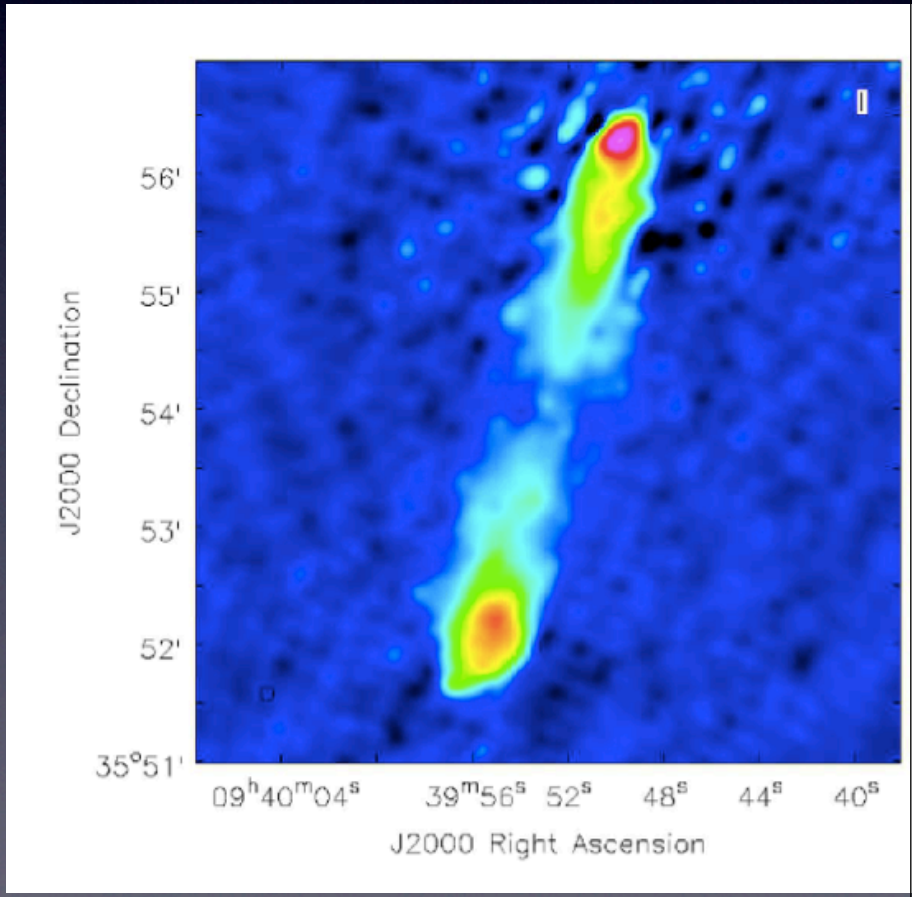
Moderne Sterrenkunde

Fig. 6 Ter vergelijking zijn hier vier radiostelsels getekend op dezelfde schaal, tezamen met het Melkwegstelsel. De doorsnede van het Melkwegstelsel – 100 000 lichtjaar – is geheel verwaarloosbaar ten opzichte van de afmetingen van de radiostelsels. De schaal staat aangegeven in miljoenen lichtjaren. 3C 129 is een zogenaamd kop/staart-stelsel



- 80': radio galaxies:
  - interesting but separate phenomon
  - models shaky (storm-ram theory in moderne sterrenkunde)
- 00': Feedback
- LOFAR: energetics and duties cycles
  - 3C223 at 137 MHz

(Jeremy Harwood)



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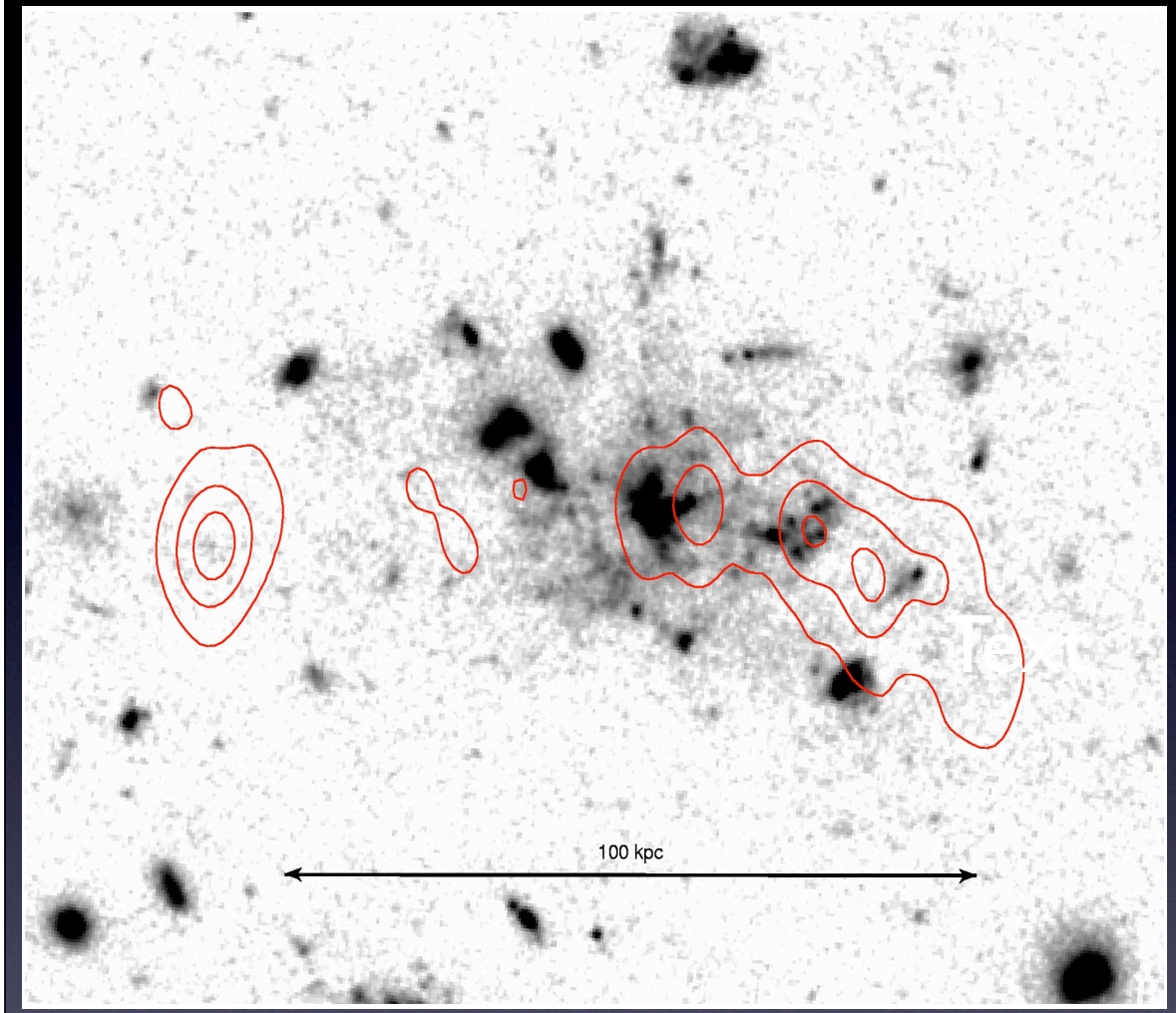
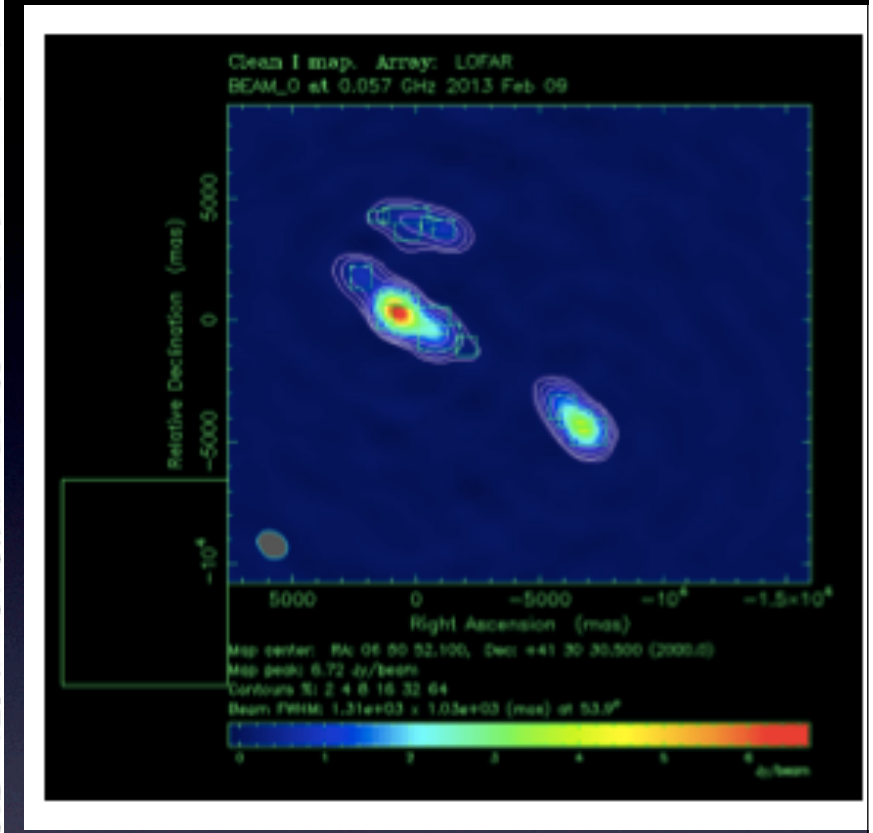
- 80': no observed galaxy evolution, radio galaxies were used as standard candles.
- Ultra-steep spectrum sources (alpha < -1.3) to hunt for z>2 radio galaxies using WENSS/NVSS
  - 343 USS sources out of 143000 WENSS/NVSS
  - lots of id and spectrocopy work
  - ~100 z>2;1 with z>5.
- 90',00':
  - HzRGs: forming brightest cluster galaxies
  - located in proto-clusters





1138-262 at z=2.1

Preliminary!!
Deller and Morabito
4C41.17 @z=3.8
1 arc@58 MHz

- 2013:
  - Herschel + Spitzer observations: BH growth order of magnitude larger then galaxy

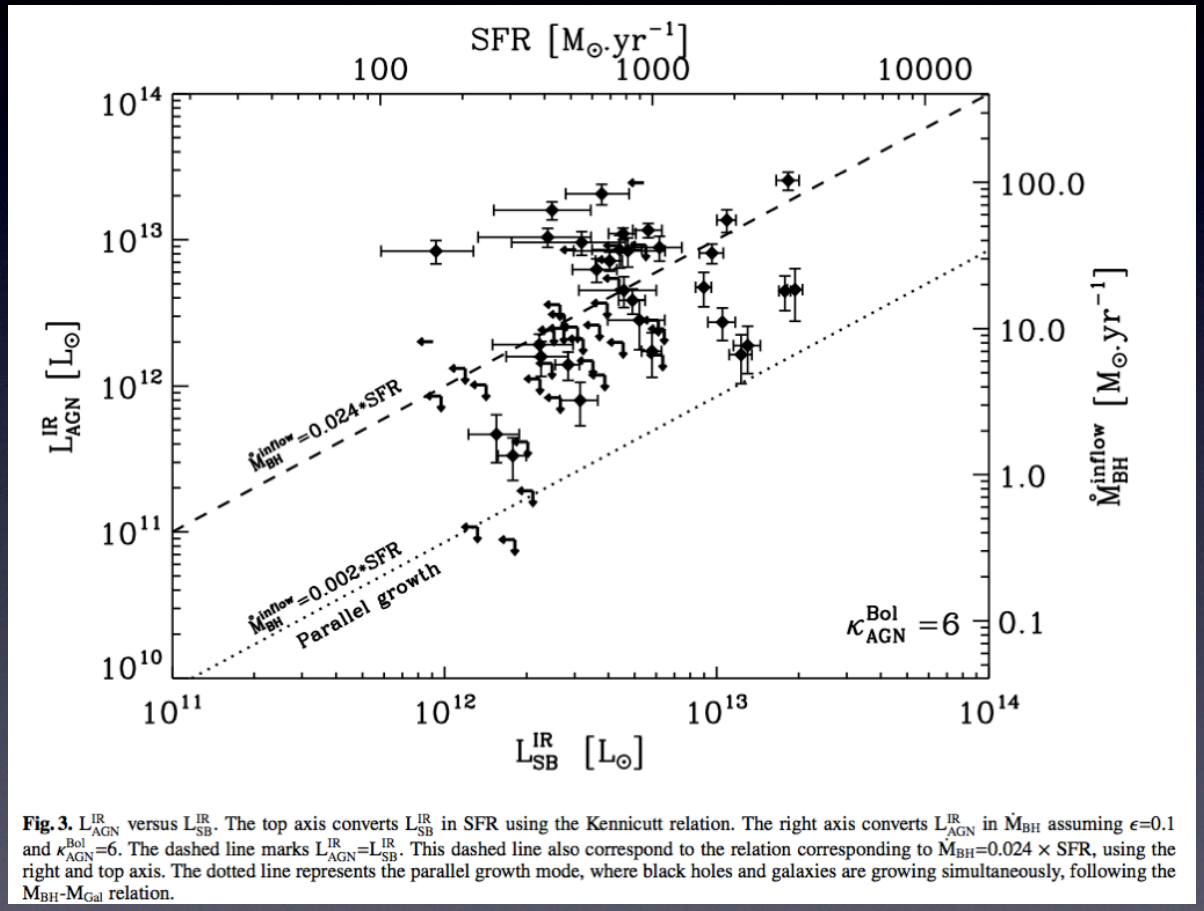
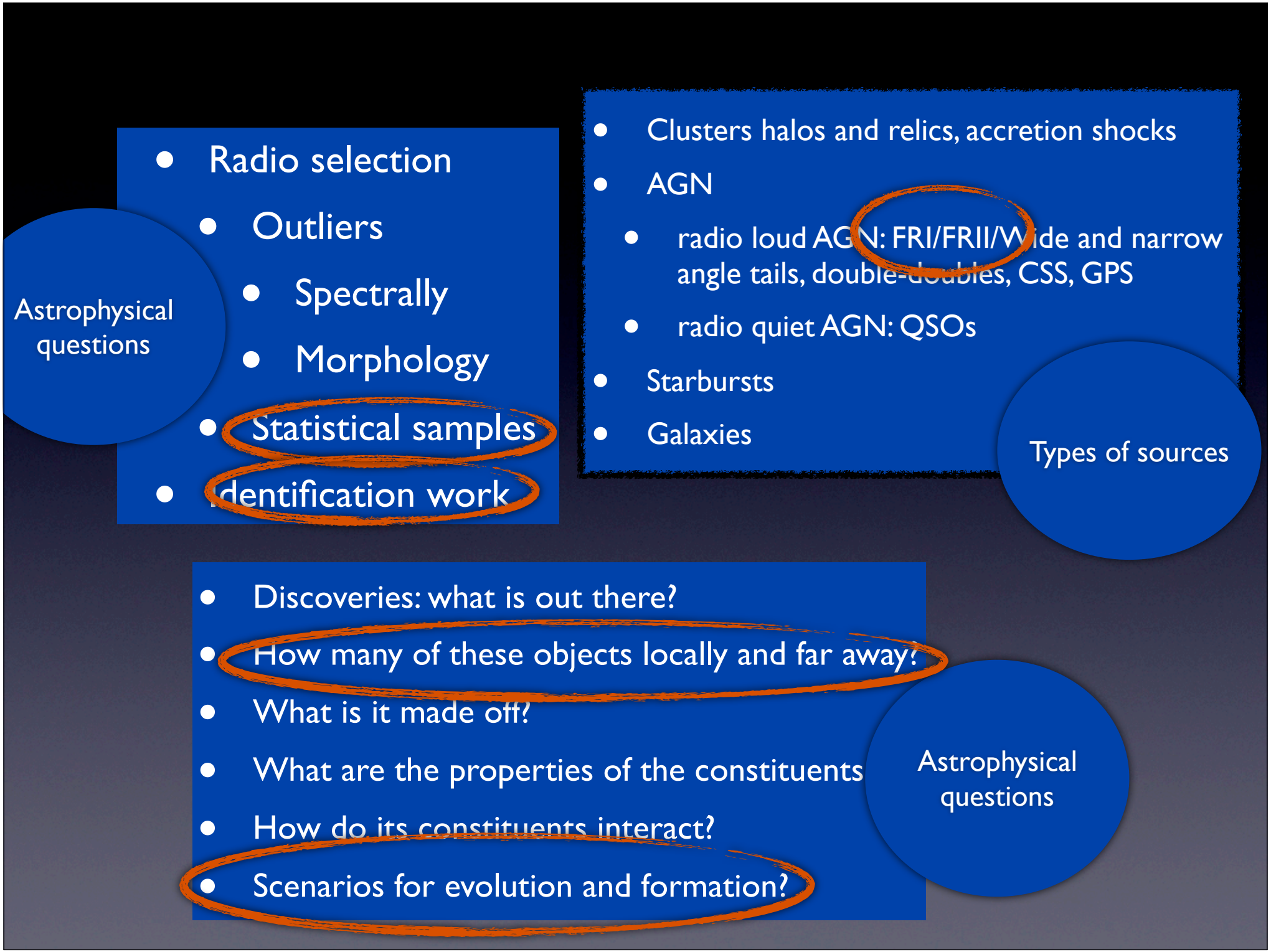


Fig. 3. L^{IR}_{AGN} versus L^{IR}_{SB}. The top axis converts L^{IR}_{SB} in SFR using the Kennicutt relation. The right axis converts L^{IR}_{AGN} in $\dot{M}_{BH}$ assuming ϵ=0.1 and κ^{Bol}_{AGN}=6. The dashed line marks L^{IR}_{AGN}=L^{IR}_{SB}. This dashed line also correspond to the relation corresponding to $\dot{M}_{BH}$=0.024 × SFR, using the right and top axis. The dotted line represents the parallel growth mode, where black holes and galaxies are growing simultaneously, following the M_{BH}-M_{Gal} relation.

Drouart et al. 2013

- LOFAR: break the z=5 barrier, HzRGs at epoch of reionisation?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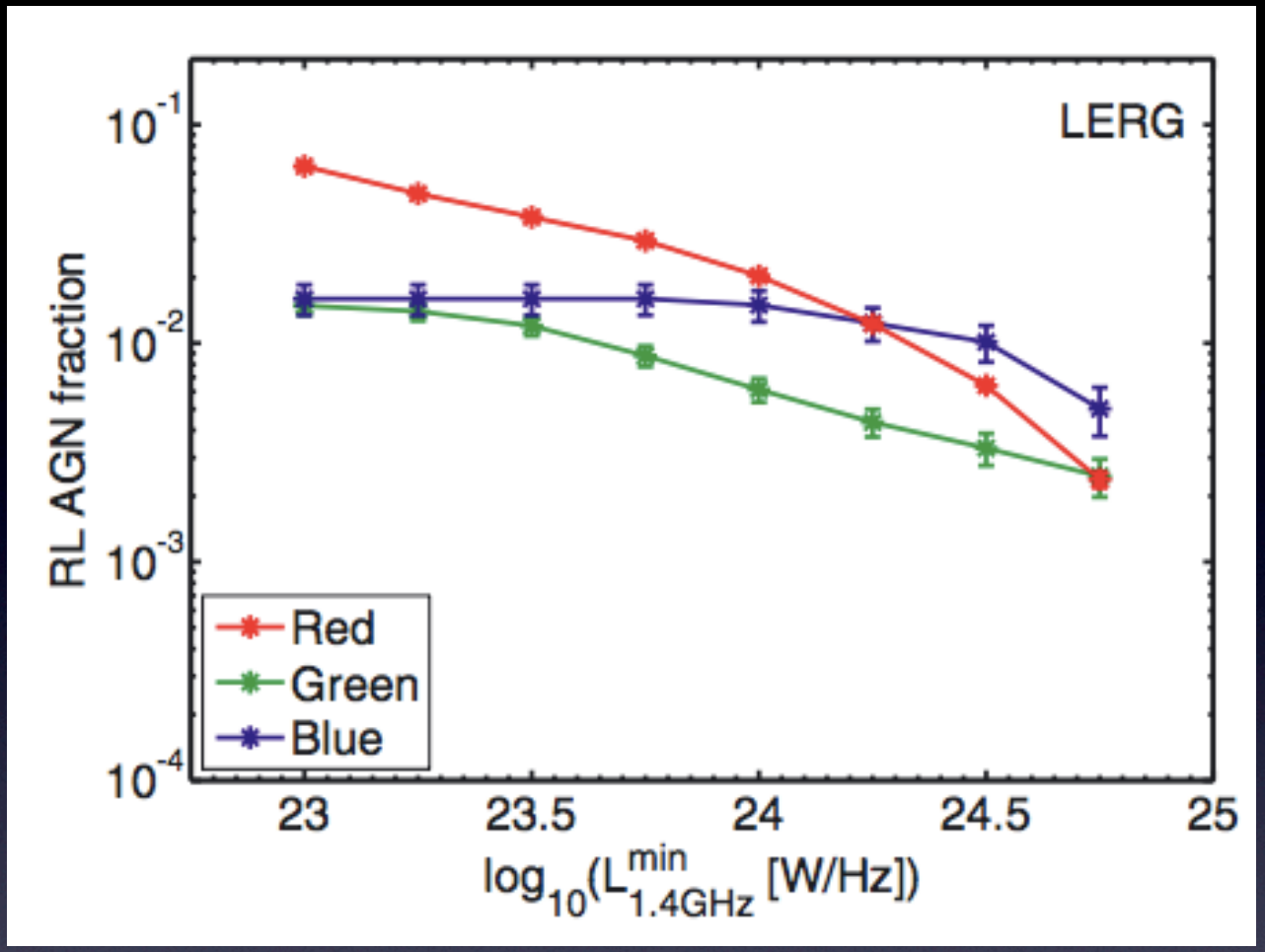
- Cold mode, also named: *quasar mode, radiative mode, fast accretor, high-excitation, strong-lined*
- Hot mode, also named: *radio mode, radiative inefficient, slow accretor, low-excitation, weak-lined*

- Question: how does AGN feedback work/how is it related to the modes?
- Study: Fraction of galaxies that are radio loud as a function
  - mass, starformation rate, ionisation state, starformation rate, colour
  - *optical galaxy type, FRI/FRII/compact types, environment, redshift*
- *Very large statistical studies: WENSS/NVSS+SLOAN*



Radio galaxies are hosted by red galaxies

Blue galaxies are more often radio loud compared to red ones in the range $10^{11}\ M_\odot \leq M_* \leq 10^{11.5}\ M_\odot$, and $P_{1.4GHz} > 10^{24.5}$

Janssen, HR, Best, Brinchmann, 2013

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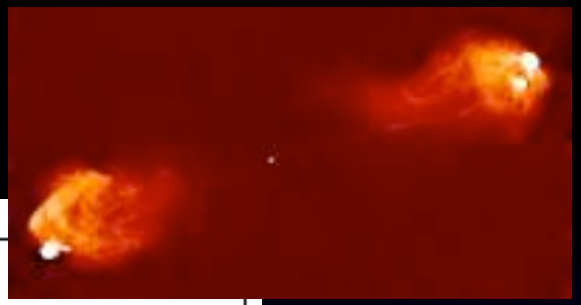
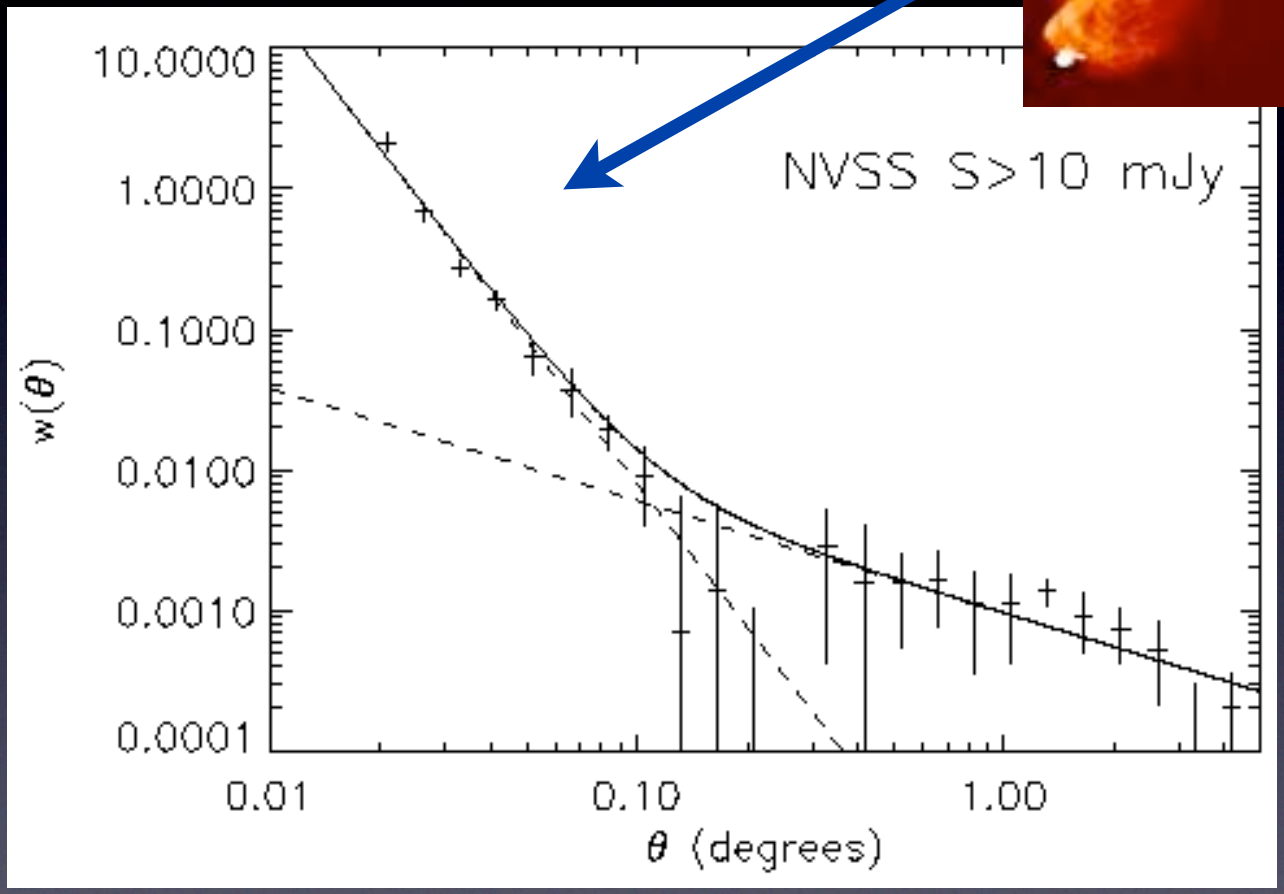
Source power spectrum: fluctuation of sources counts on various scales

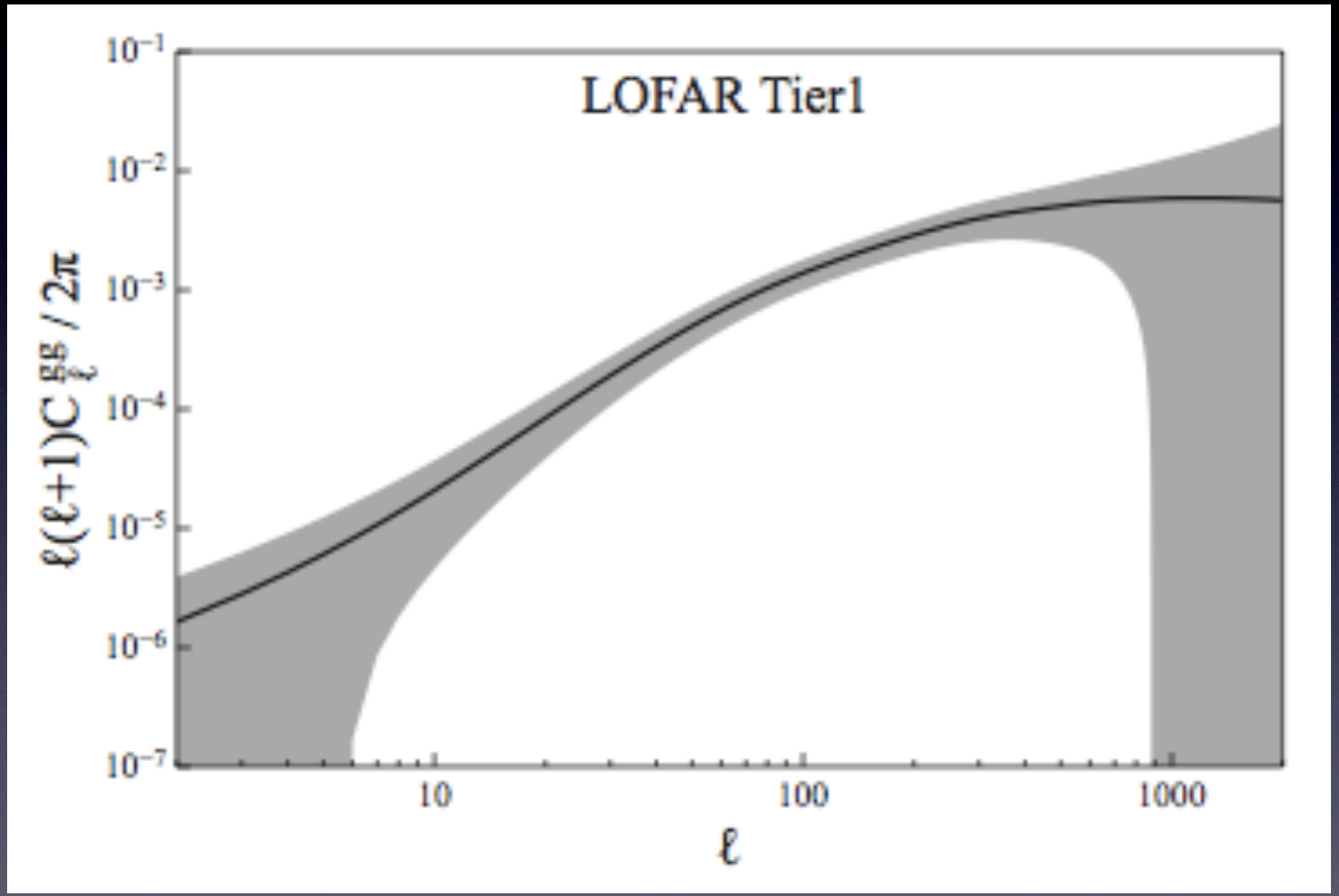




Different systematics: indeed
Overzier, HR, etal. 2003

Source power spectrum:

probing non-gaussianity/constraining cosmo parameters



Raccanelli et al. 2011

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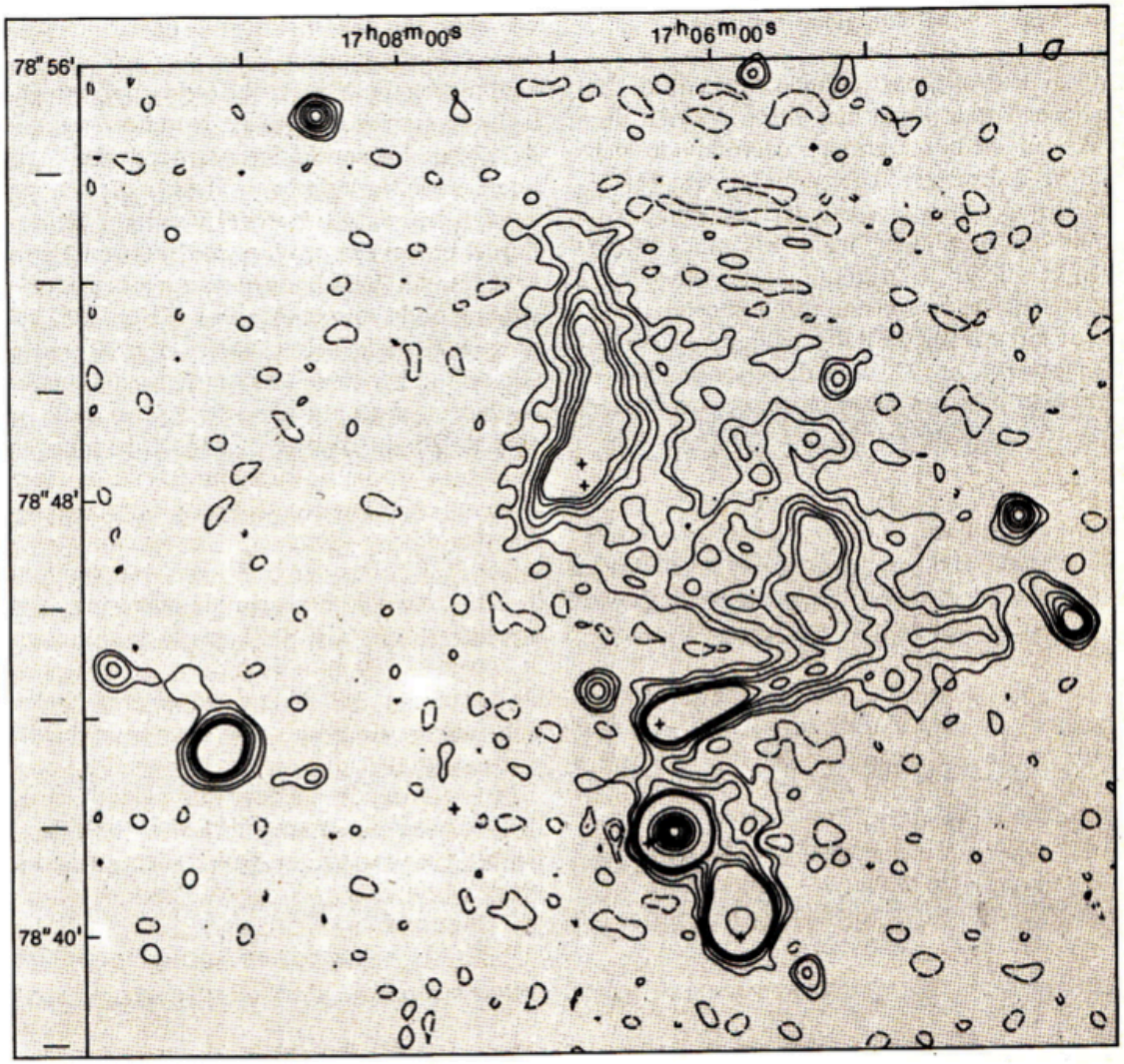
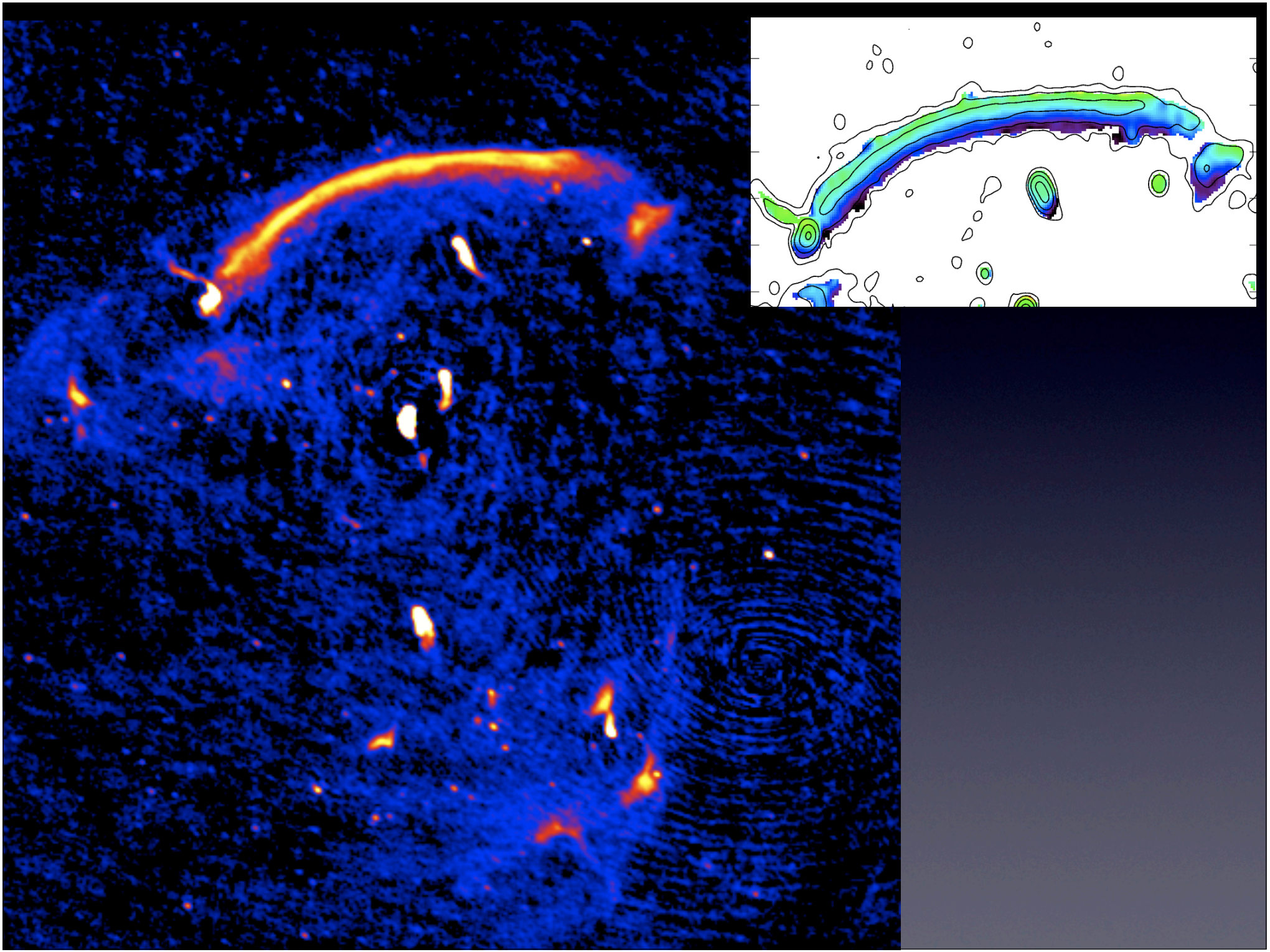
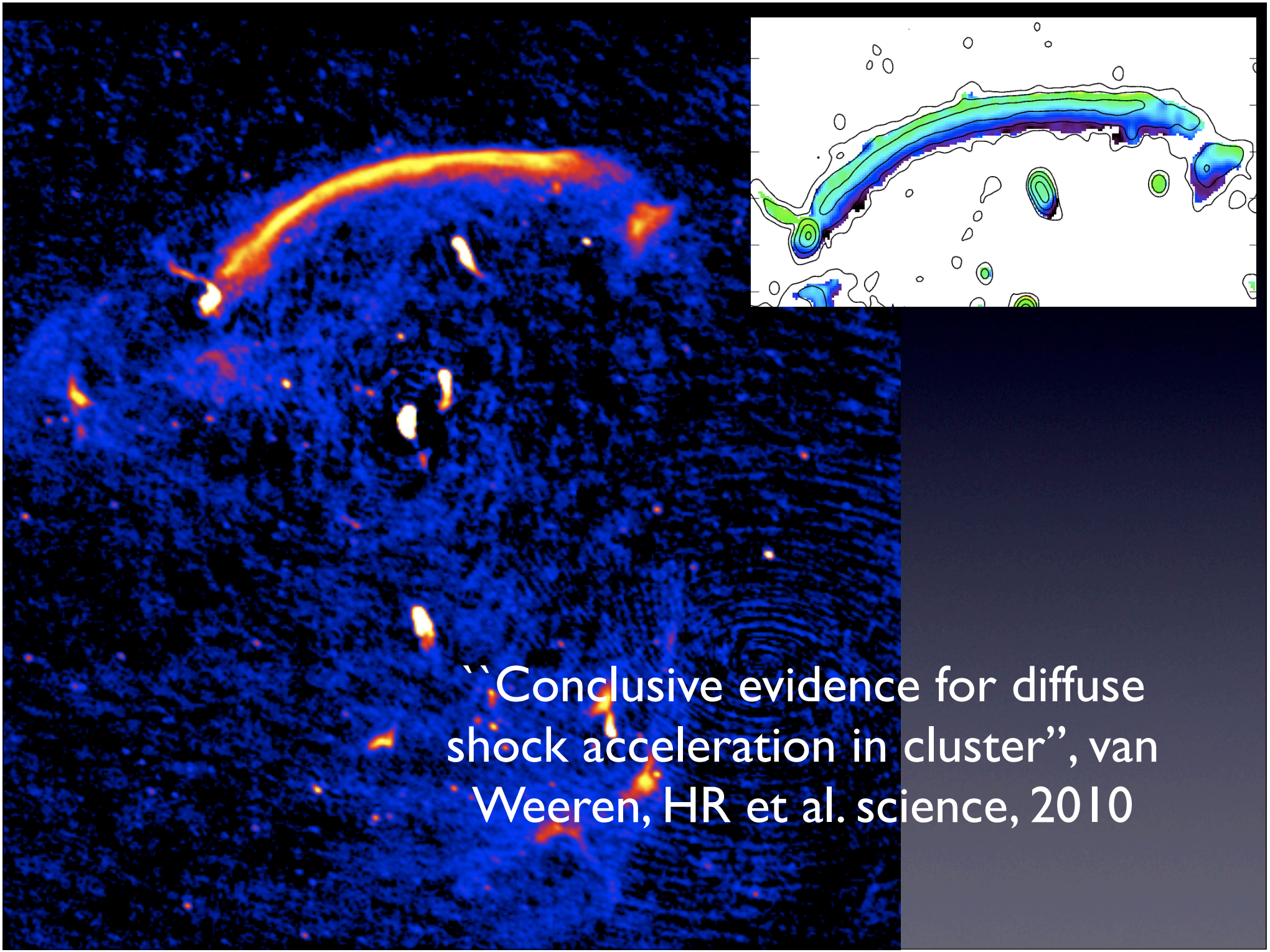
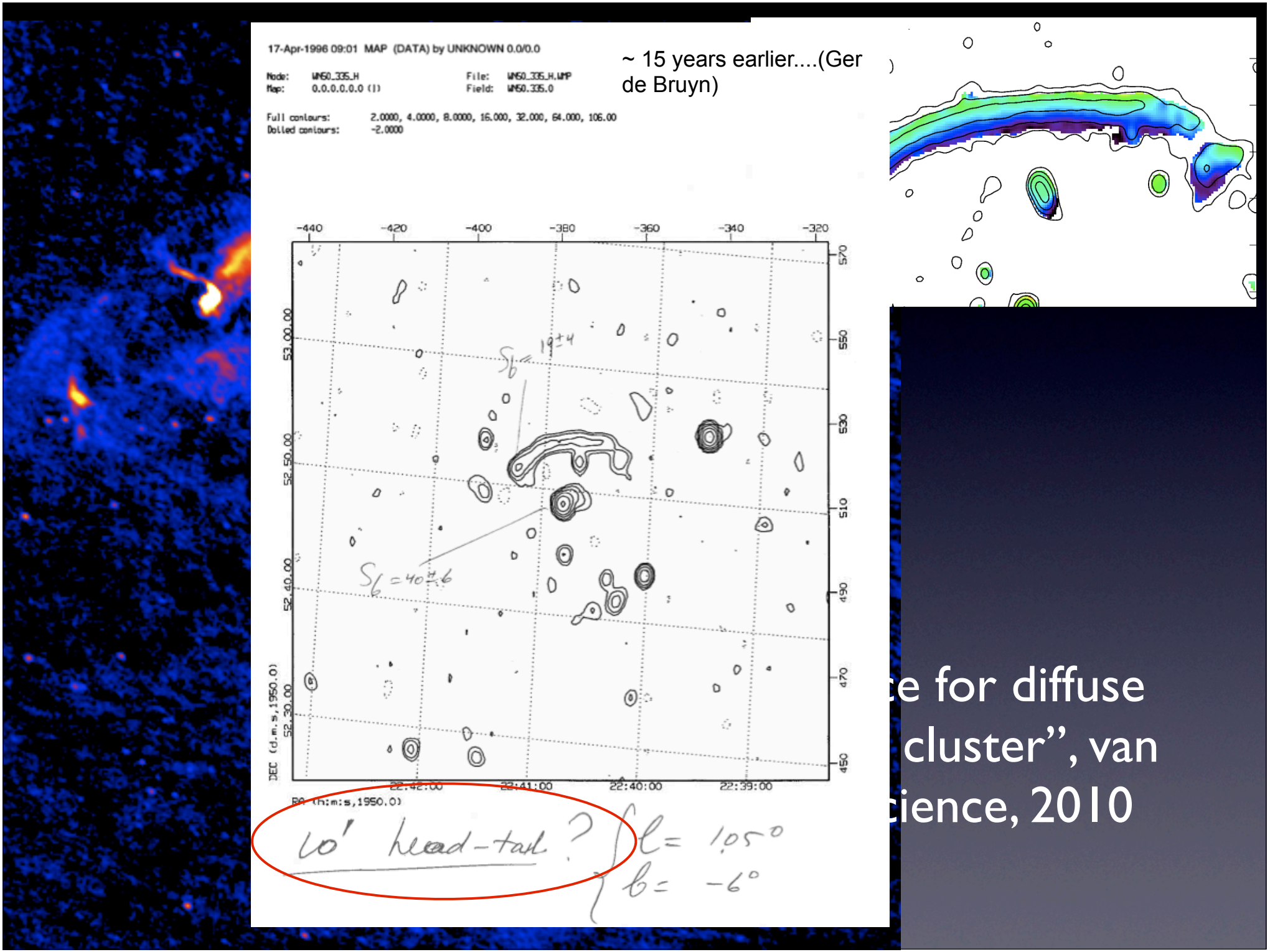
Fig. 39 Het resultaat van een uitgebreid radio-onderzoek aan de cluster Abell 2256 onthult dat hier vele stelsels een bron van radiostraling vormen. Er zijn enkele kop/staart-stelsels zichtbaar. De metingen werden gedaan met de WSRT. Schaalaanduidingen zijn zowel die van declinatie en rechte klimming

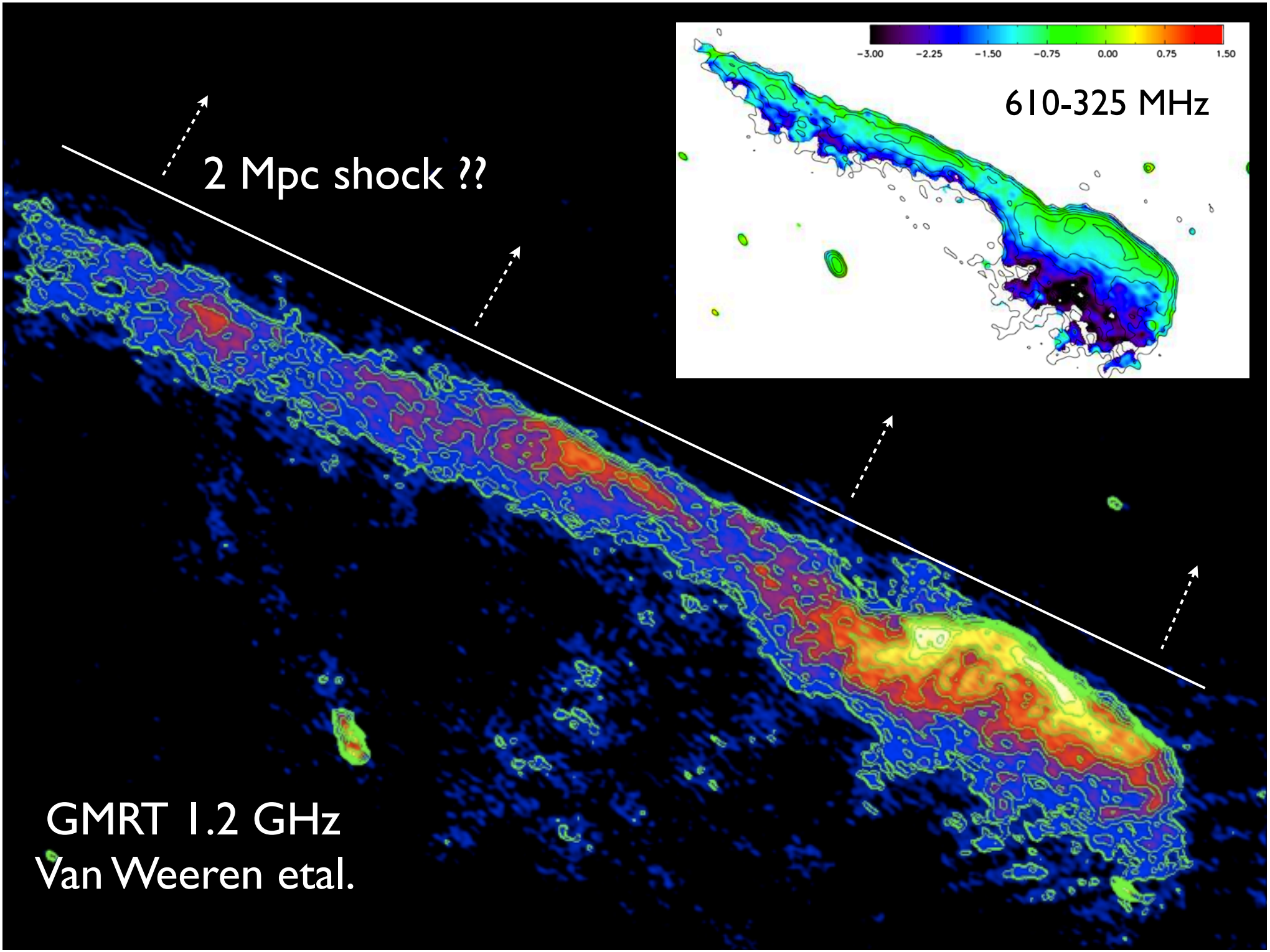






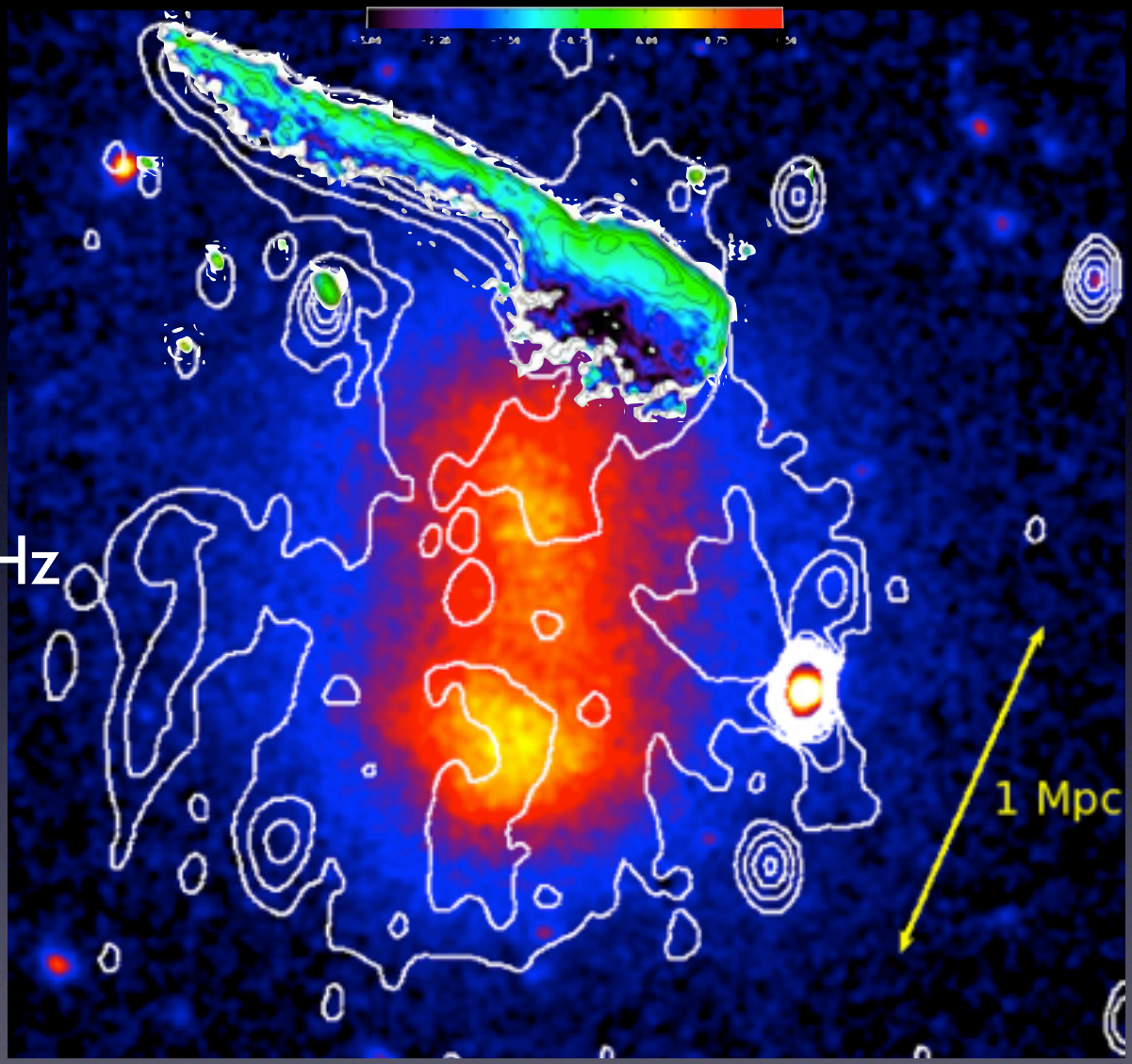
``Conclusive evidence for diffuse shock acceleration in cluster", van Weeren, HR et al. science, 2010


17-Apr-1996 09:01 MAP (DATA) by UNKNOWN 0.0/0.0
Node: WN60_335_H
Map: 0.0.0.0.0.0 (I)
File: WN60_335_H.IMP
Field: WN60_335_0
Full contours: 2.0000, 4.0000, 8.0000, 16.000, 32.000, 64.000, 106.00
Dotted contours: -2.0000
~ 15 years earlier....(Ger de Bruyn)
-440
-420
-400
-380
-360
-340
-320
570
550
530
510
490
470
450
53.00.00
52.50.00
52.40.00
52.30.00
DEC (d.m.s,1950.0)
22:42:00
22:41:00
22:40:00
22:39:00
RA (h:m:s,1950.0)
10' head-tail ?
l = 105°
b = -6°
ce for diffuse
cluster", van
cience, 2010

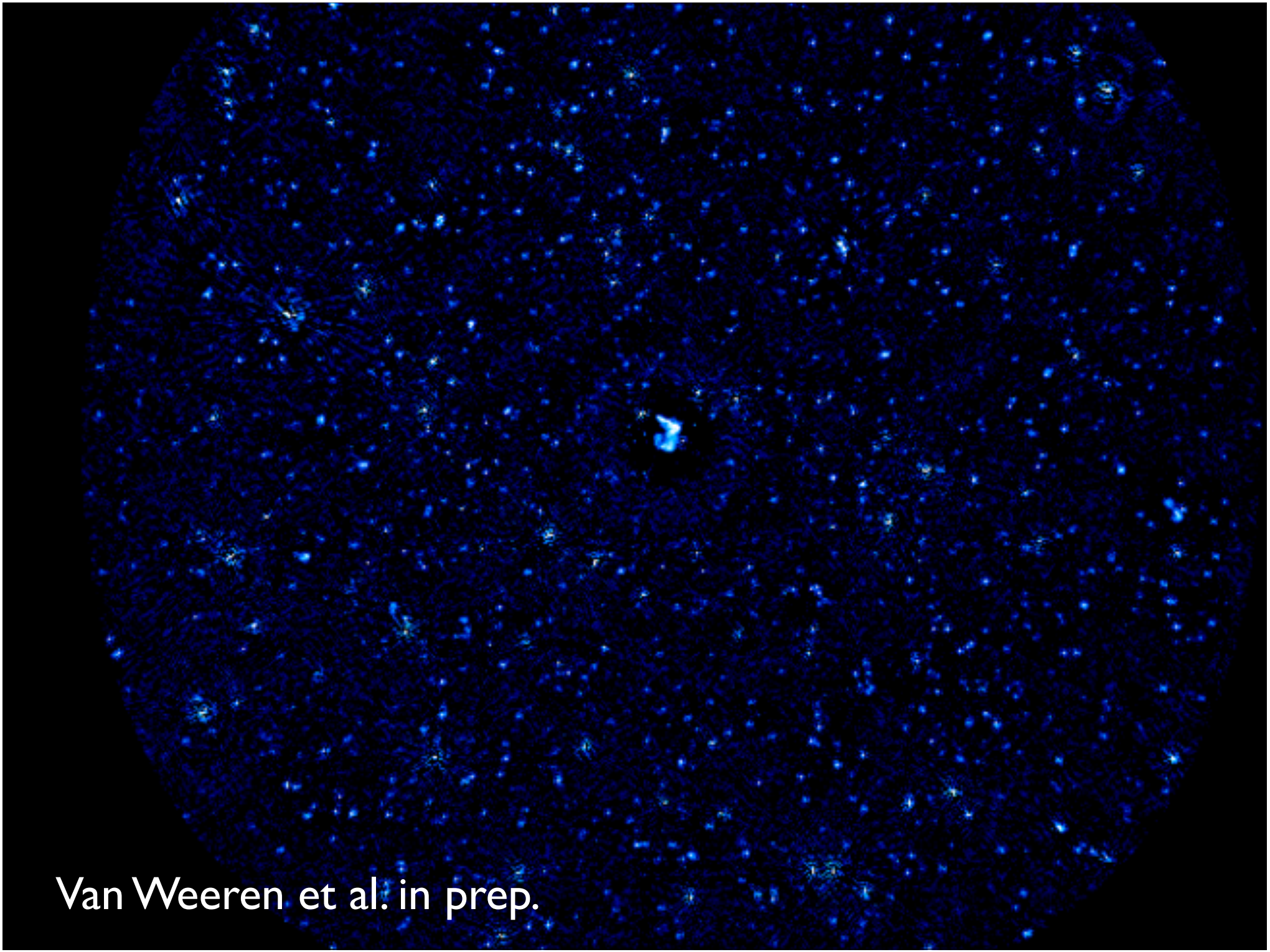

2 Mpc shock ??
610-325 MHz
−3.00
−2.25
−1.50
−0.75
0.00
0.75
1.50
GMRT 1.2 GHz
Van Weeren etal.

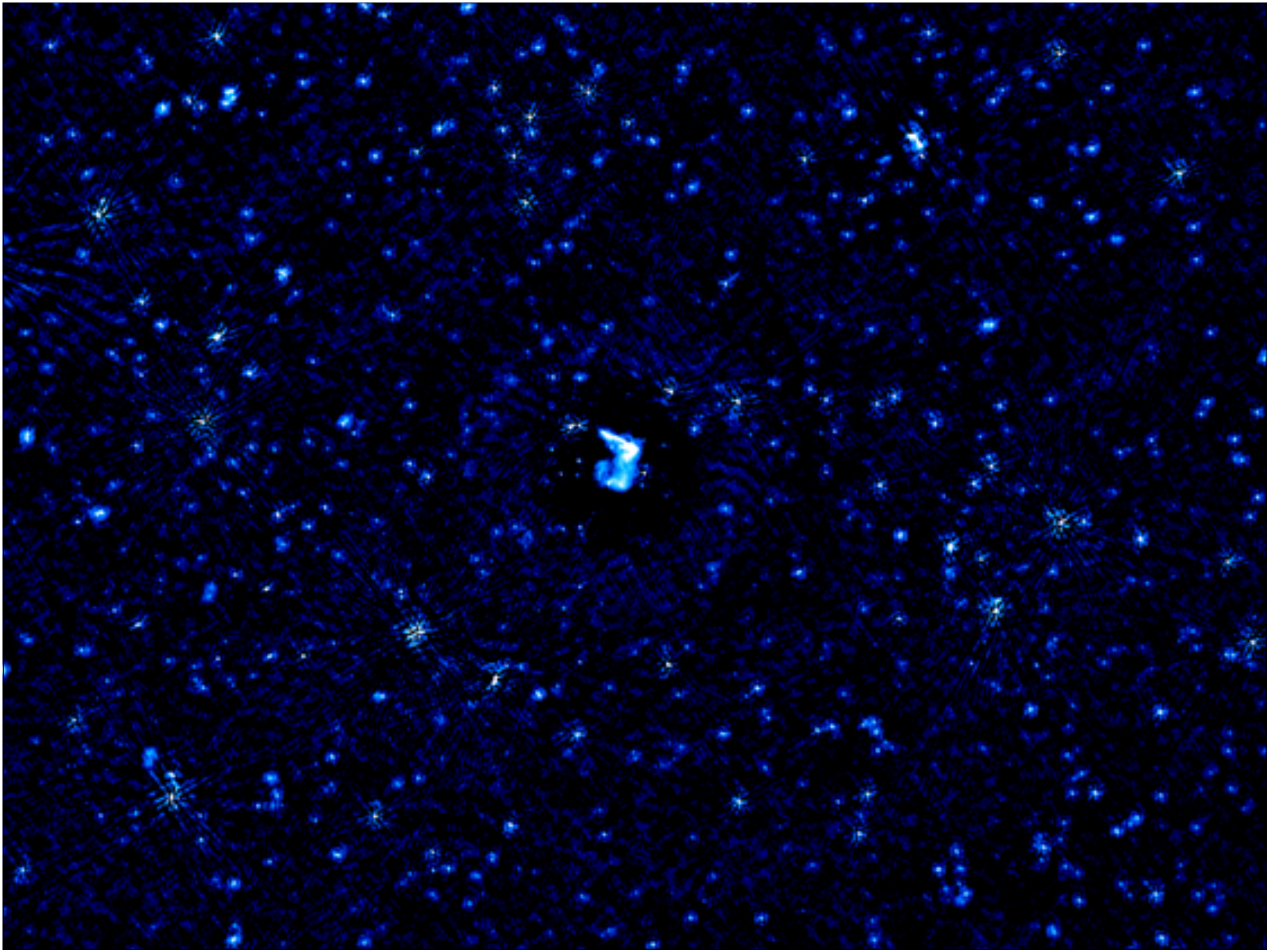
Tooth-brush puzzle:

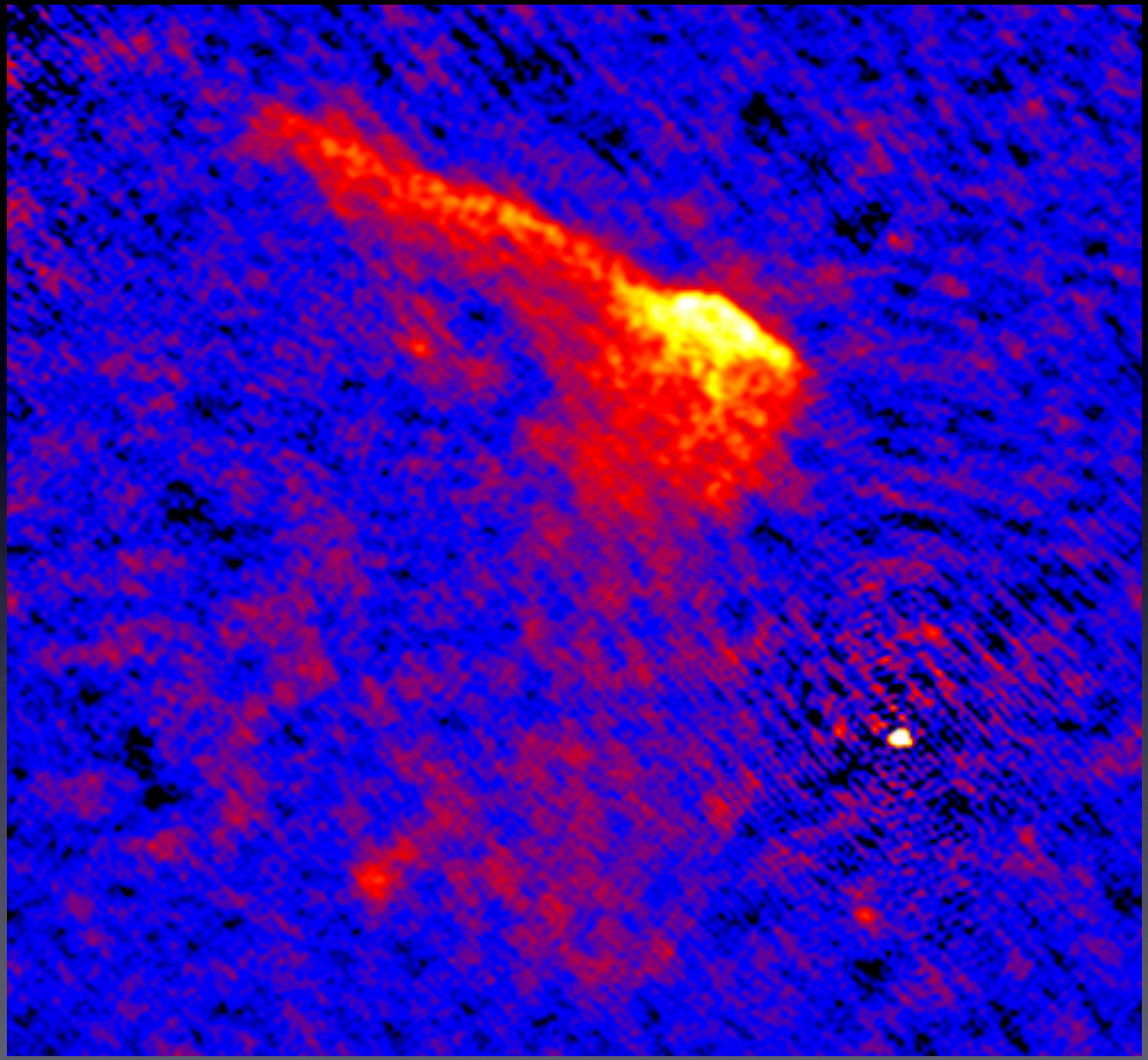
Colours: XMM
Contours: GMRT 610 MHz
green -> blue
spectral index map



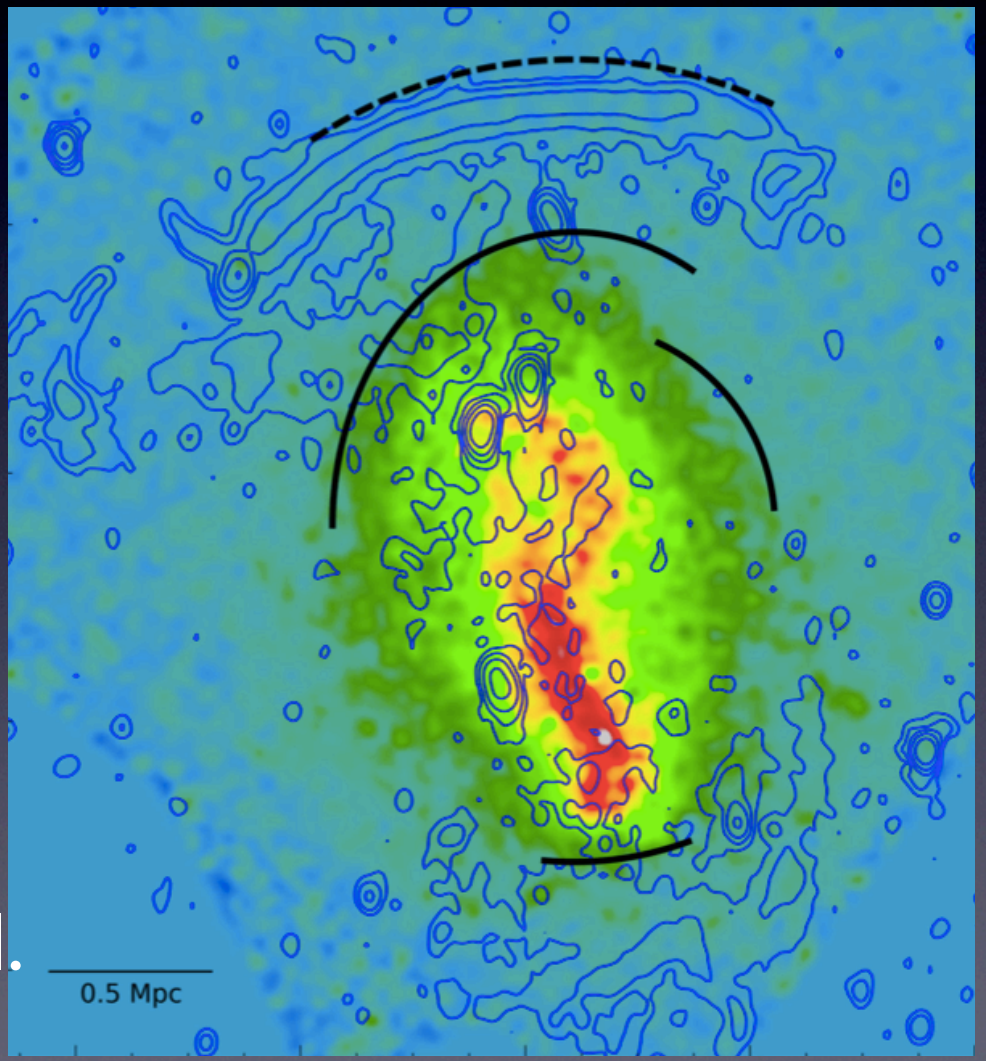
How to produce a linear shock during a merger?


Van Weeren et al. in prep.





- Recent results
  - shock induced starformation (Stroe et al. 2013)?
  - X-ray shocks not at the same location as radio shock
  - LOFAR:
    - thousands of merging clustres up to z=1



Ogrean et al. 2013

Conclusion

- Great work has been done
- Future is bright
  - LOFAR/SKA