



A look through the Faraday fog of the M87 jet on kiloparsec scales

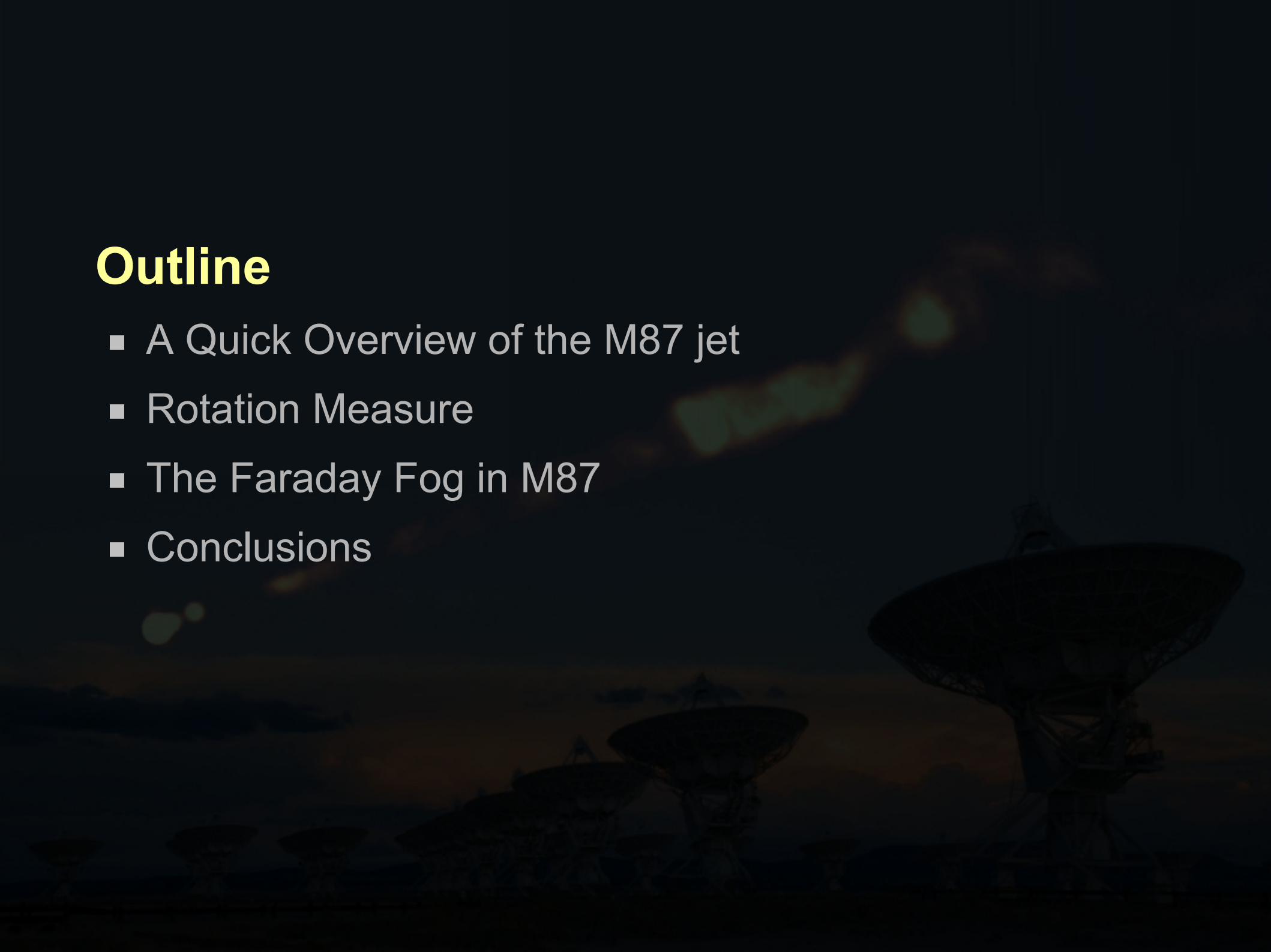
Juan Carlos Algaba (KASI)

EA AGN 2016 September 23rd 2016



Outline

- A Quick Overview of the M87 jet
- Rotation Measure
- The Faraday Fog in M87
- Conclusions



M87 (M 87 - NGC 4486)

Type: Galaxy

Magnitude: 8.60

RA/DE (J2000): 12h30m48.0s/+12°24'00.0"

RA/DE (of date): 12h30m54s/+12°23'22"

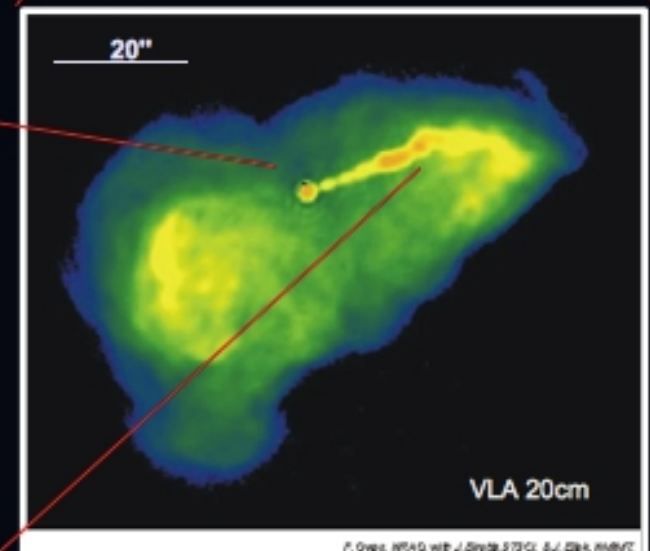
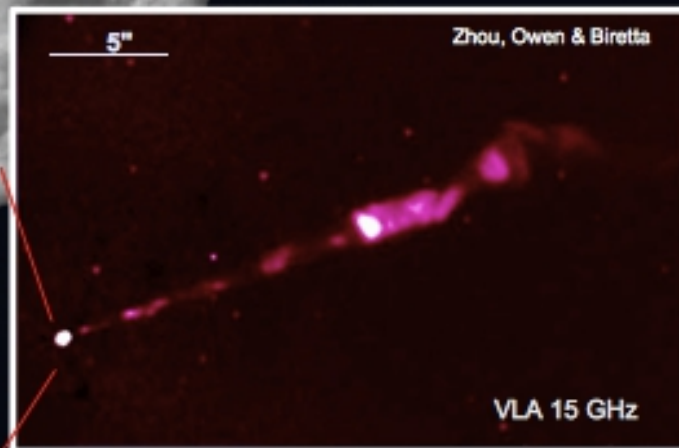
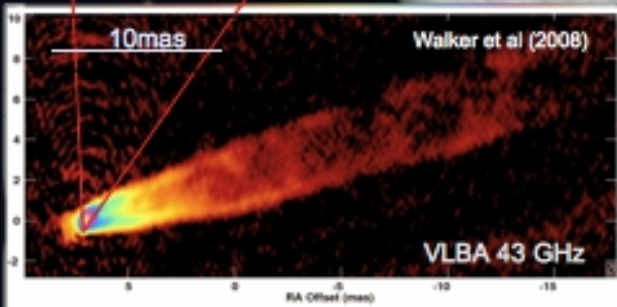
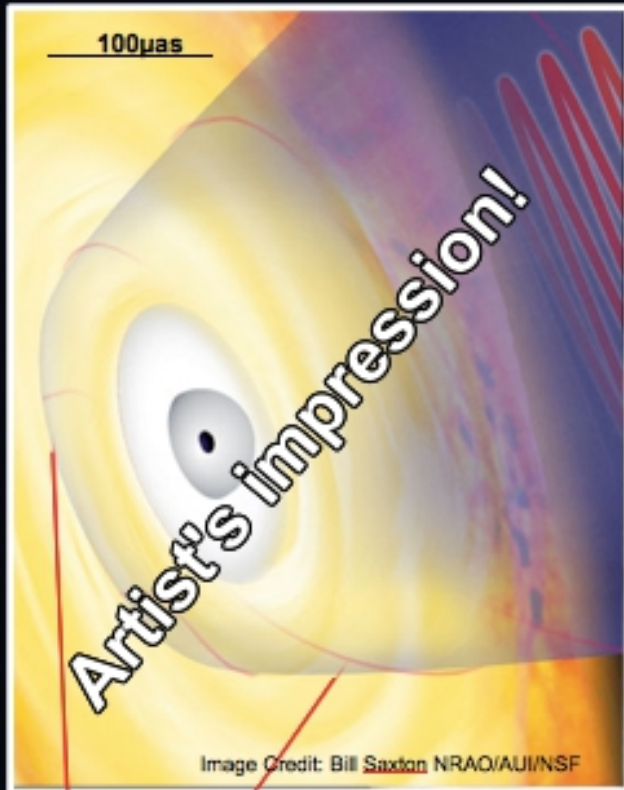
Hour angle/DE: 19h19m8s/+12°23'22" (geometric)

Hour angle/DE: 19h19m14s/+12°24'58" (apparent)

Az/Alt: +96°41'29"/+22°16'38" (geometric)

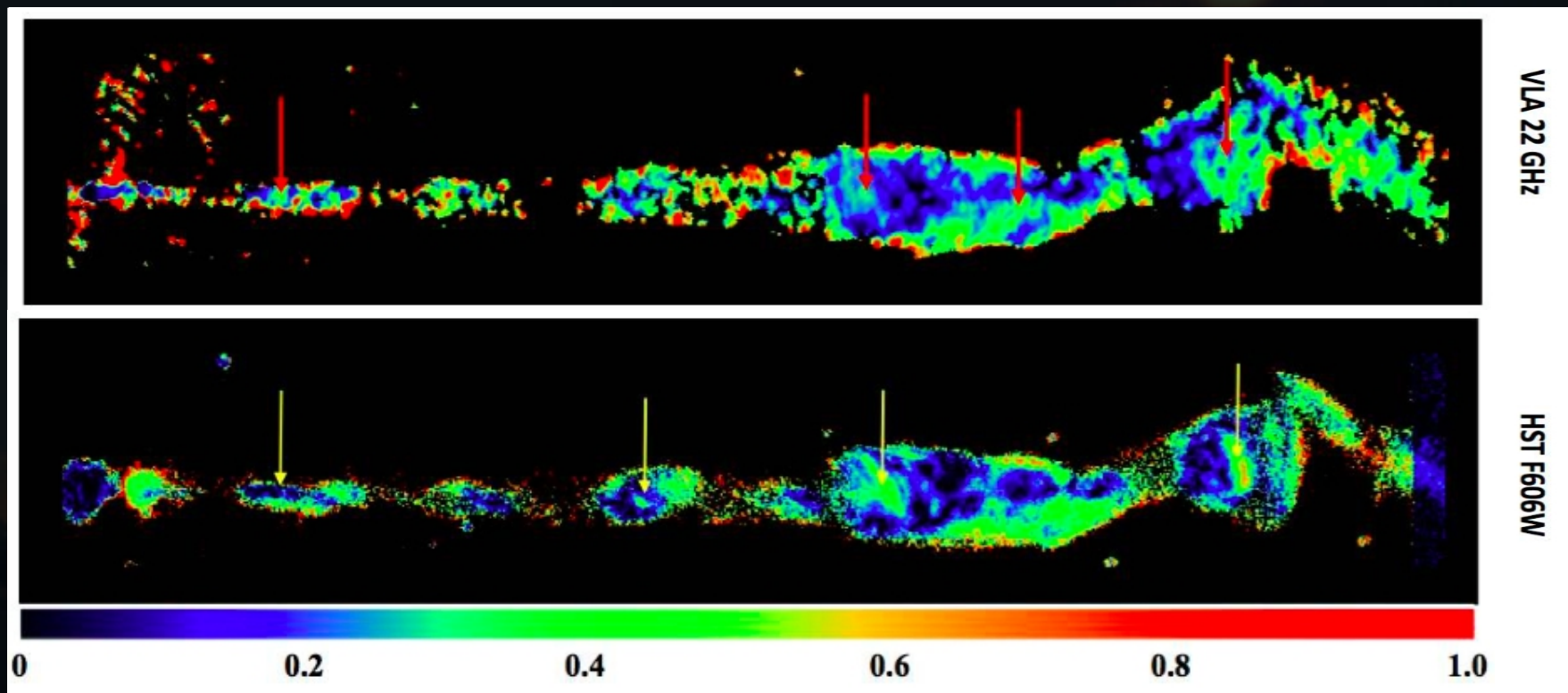
Az/Alt: +96°41'29"/+22°18'47" (apparent)

Size: +0°07'12"



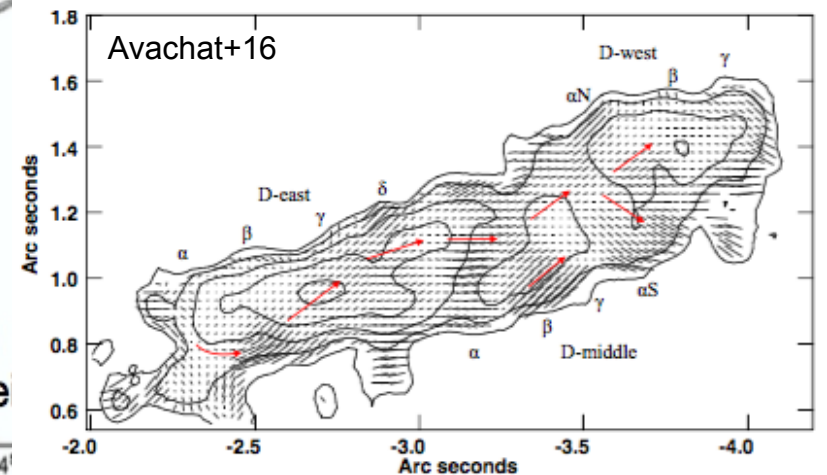
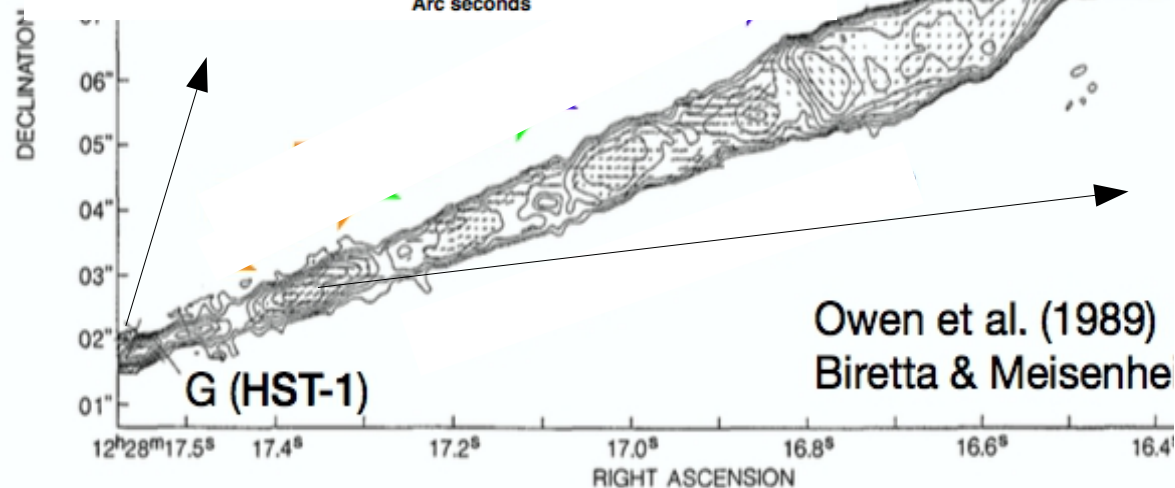
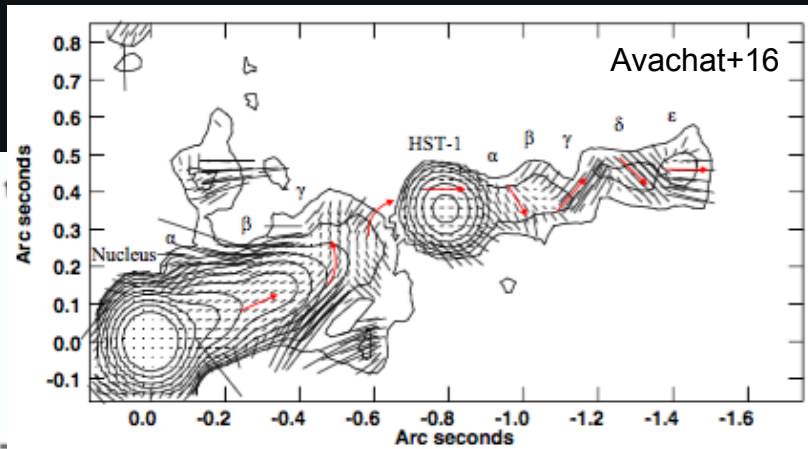
A Quick Overview of the M87 jet

- M87's jet complex morphology cannot be explained by pure hydrodynamics.
 - High degree of polarization ($\sim 60\%$)



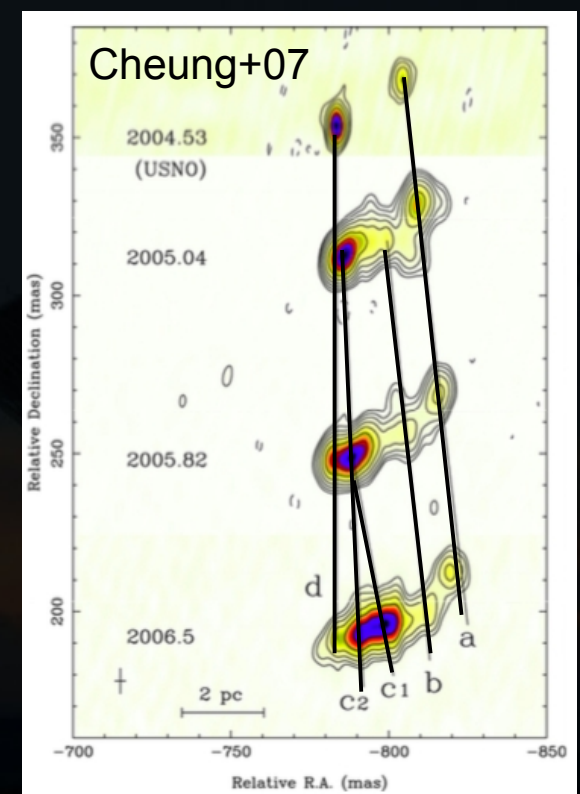
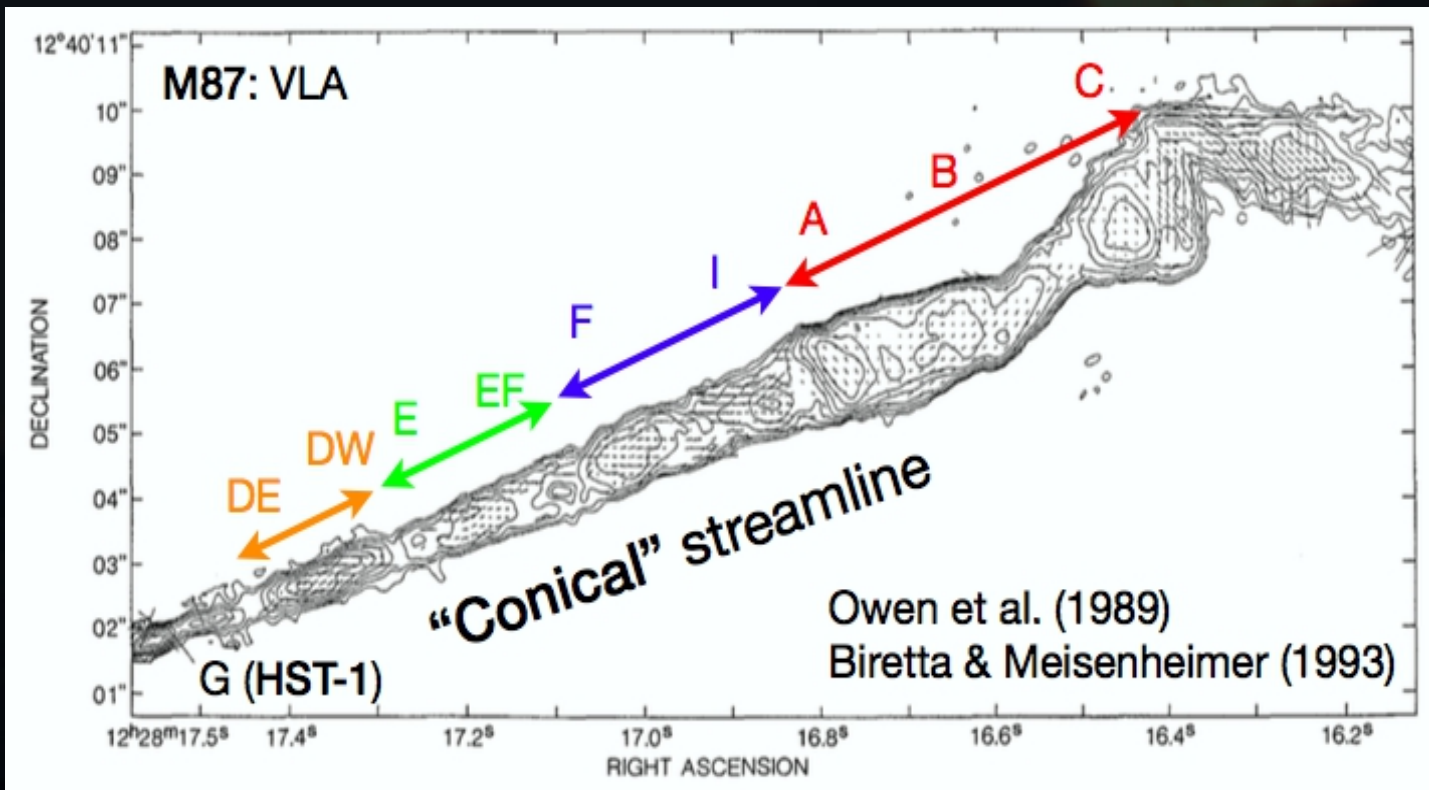
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- M87's jet complex morphology cannot be explained by pure hydrodynamics.
 - Transverse field component dominant in some knots



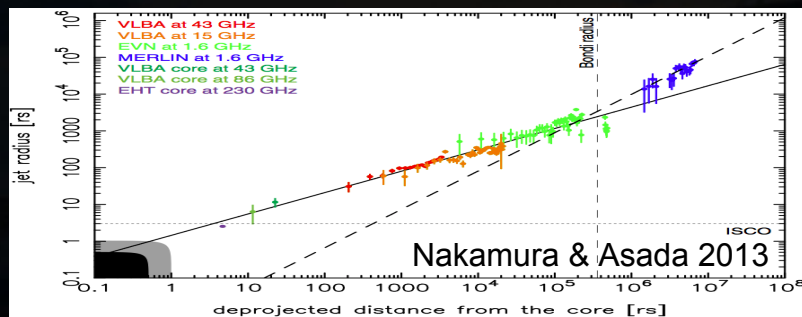
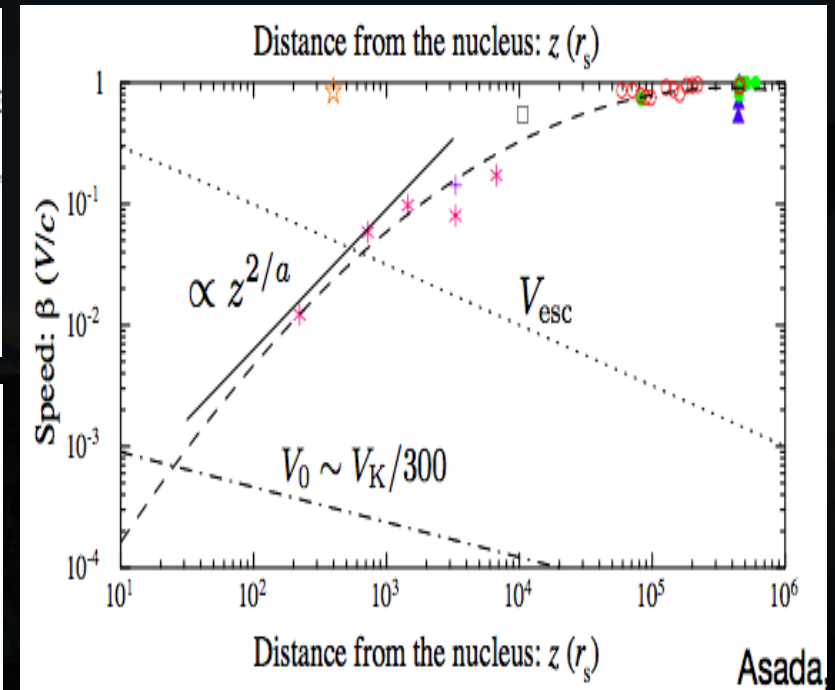
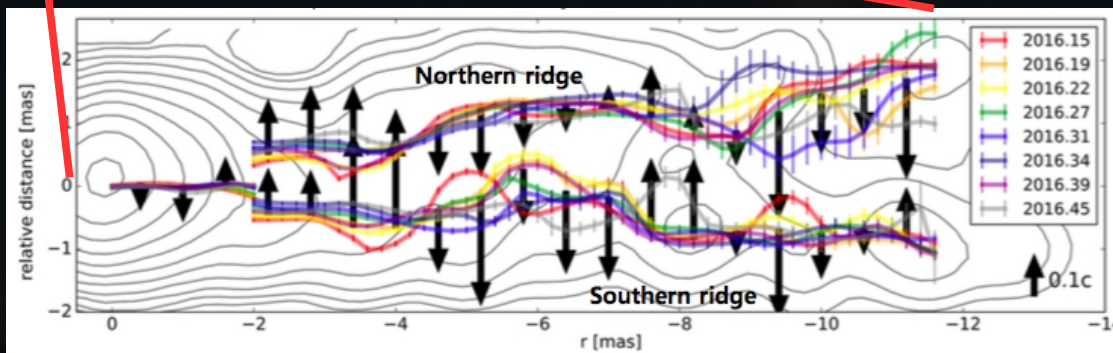
A Quick Overview of the M87 jet

- M87's jet complex morphology cannot be explained by pure hydrodynamics.
 - Transverse field component dominant in some knots
 - Trails of quad MHD shock components



A Quick Overview of the M87 jet

- M87's jet complex morphology cannot be explained by pure hydrodynamics.
 - Magnetic acceleration and collimation



See Ro Hunwook's poster P-2 upstairs

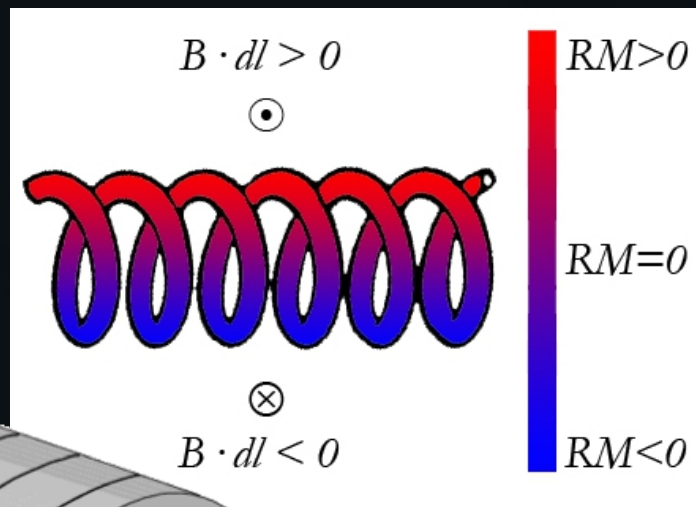
A Quick Overview of the M87 jet

- M87's jet complex morphology cannot be explained by pure hydrodynamics
- Need MHD
 - Magnetic fields are playing an important role on jet morphology/dynamics even on kilo-parsec scales
- M87, “Rosetta stone” for AGNs, one of the best candidates to host a helical B-field on its jet!



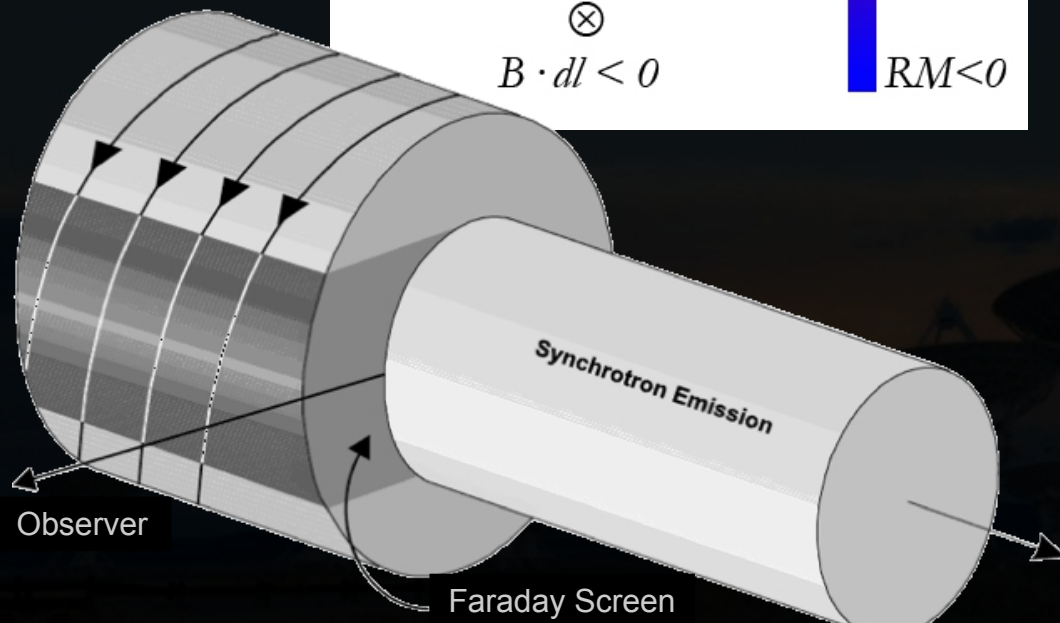
Rotation Measure

- Investigate the B field morphology with RM observations
 - Helical B-fields can give rise to RM gradients



$$\chi = \bar{\chi}_0 + \text{RM}\lambda^2$$

$$\text{RM} \propto \int n_e B_{los} \cdot dl$$



(Adapted from Papageorgiou & Cawthorne)

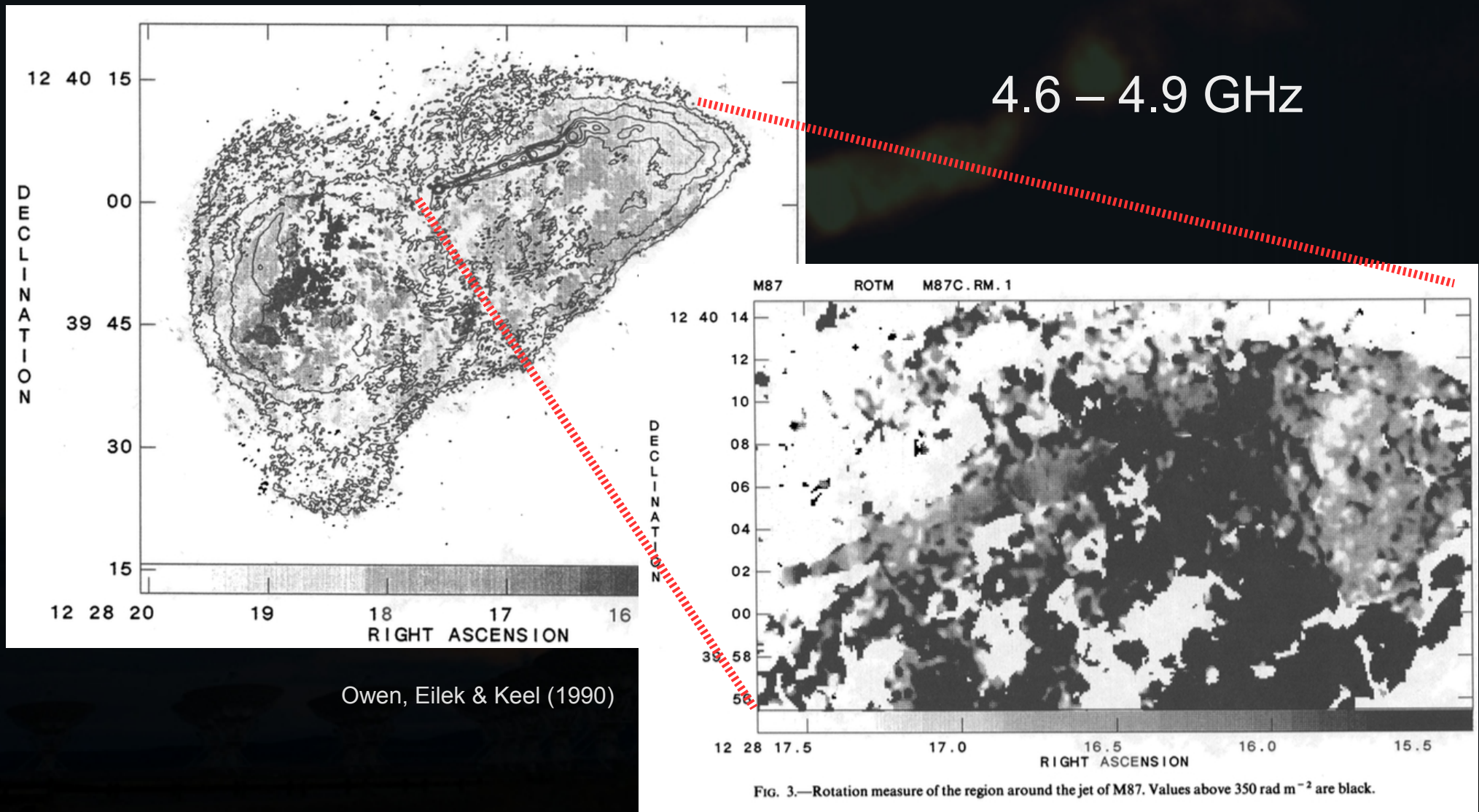
Rotation Measure

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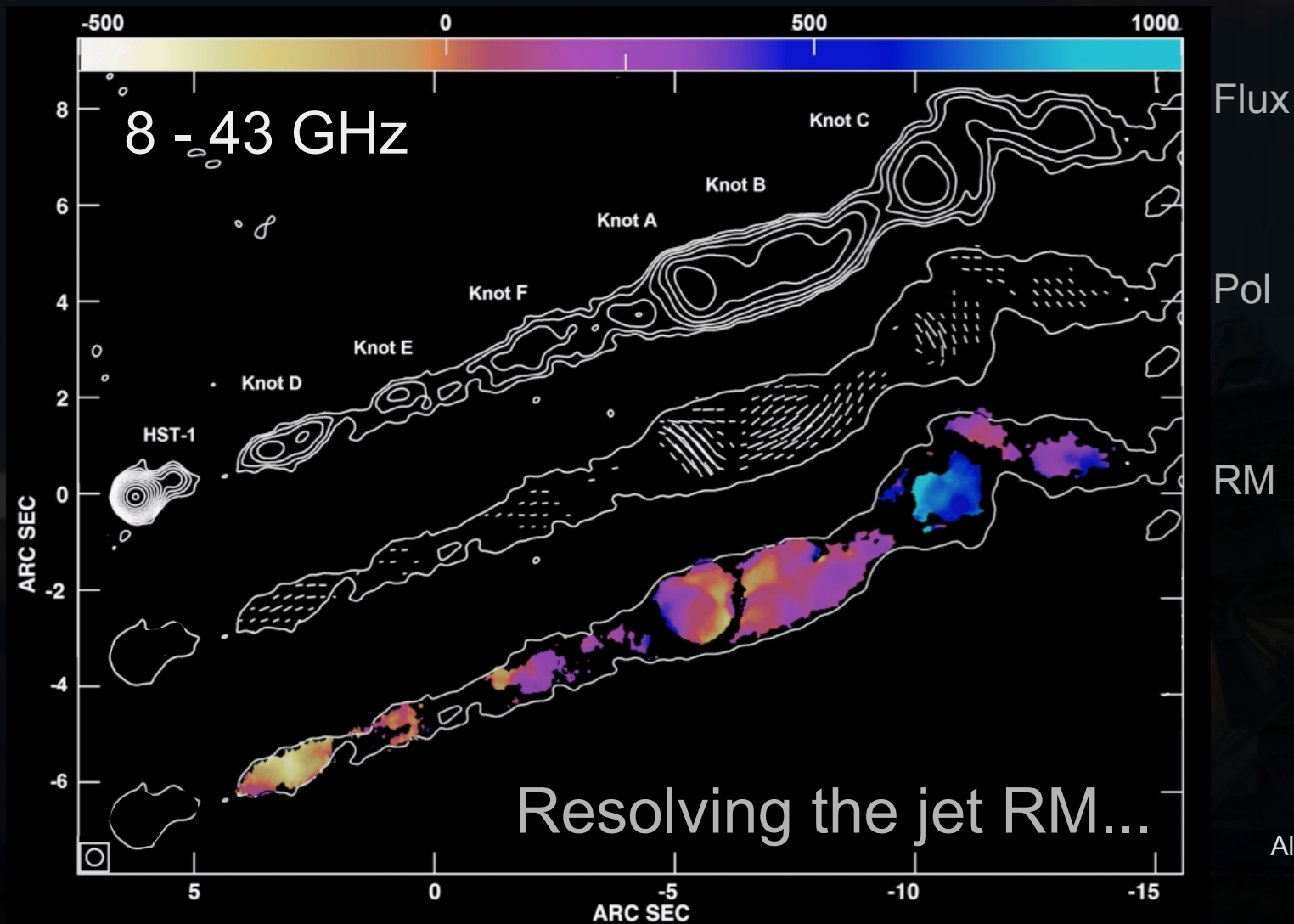
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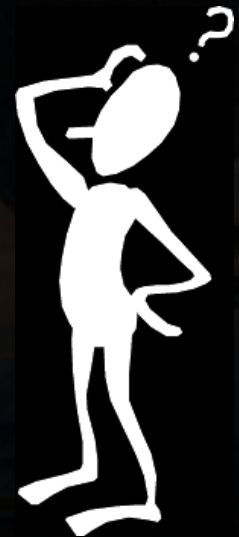
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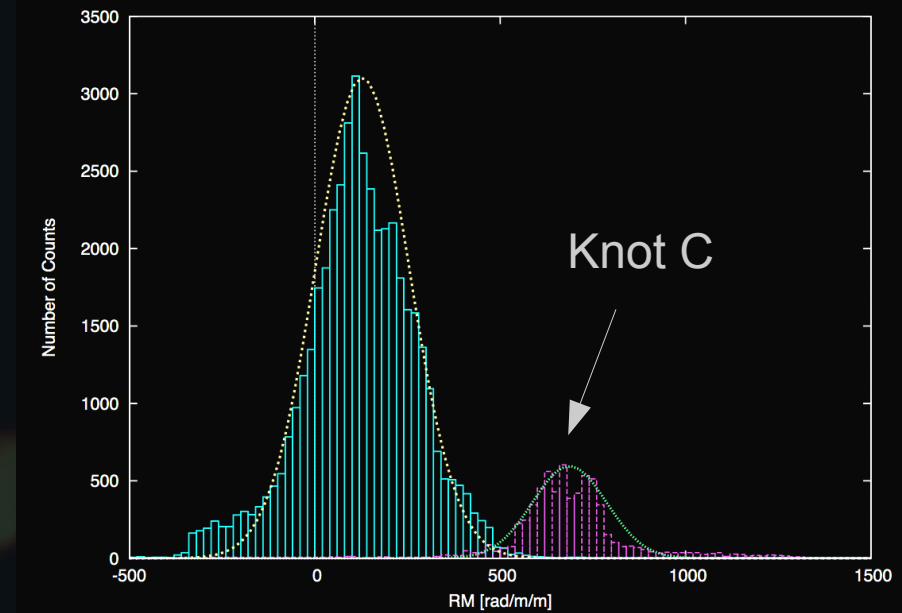
The Faraday Fog in M87

- No reliable RM gradient has ever been found!
 - One of the most complicated questions ahead, unsolved for decades
 - Are we really probing regions near the jet in M87?
 - Are the M87 jet B-fields not helical after all?
- Where is the RM actually happening?
 - Depending on the location of the Faraday Fog, different properties can be probed



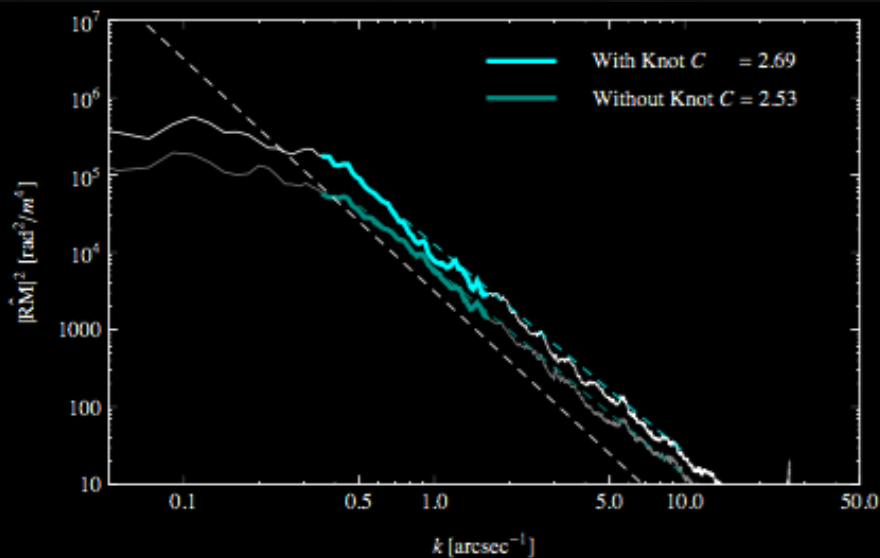
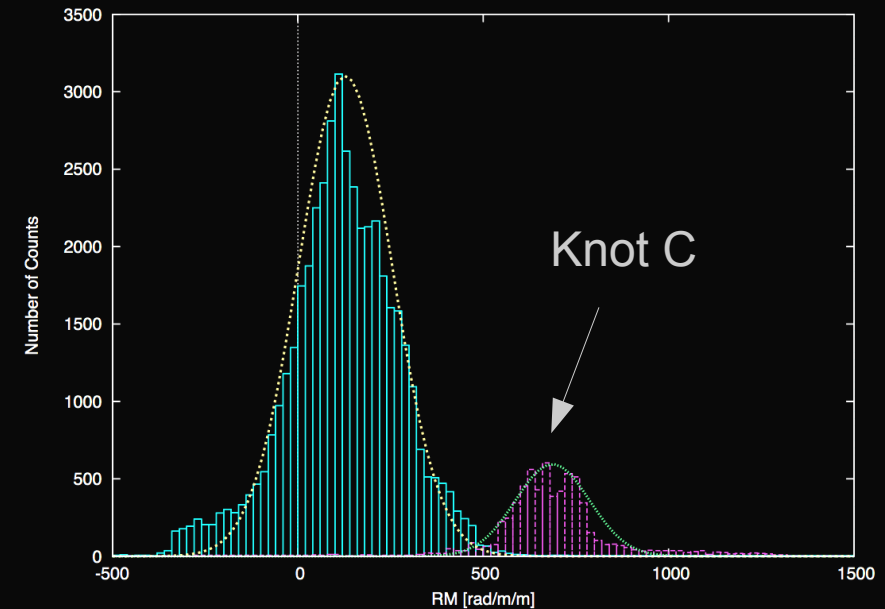
The Faraday Fog in M87

- Bi-modal distribution of RM
 - Gaussian
 - Off-centered
 - In agreement with turbulent isotropic B-field with larger scale structure



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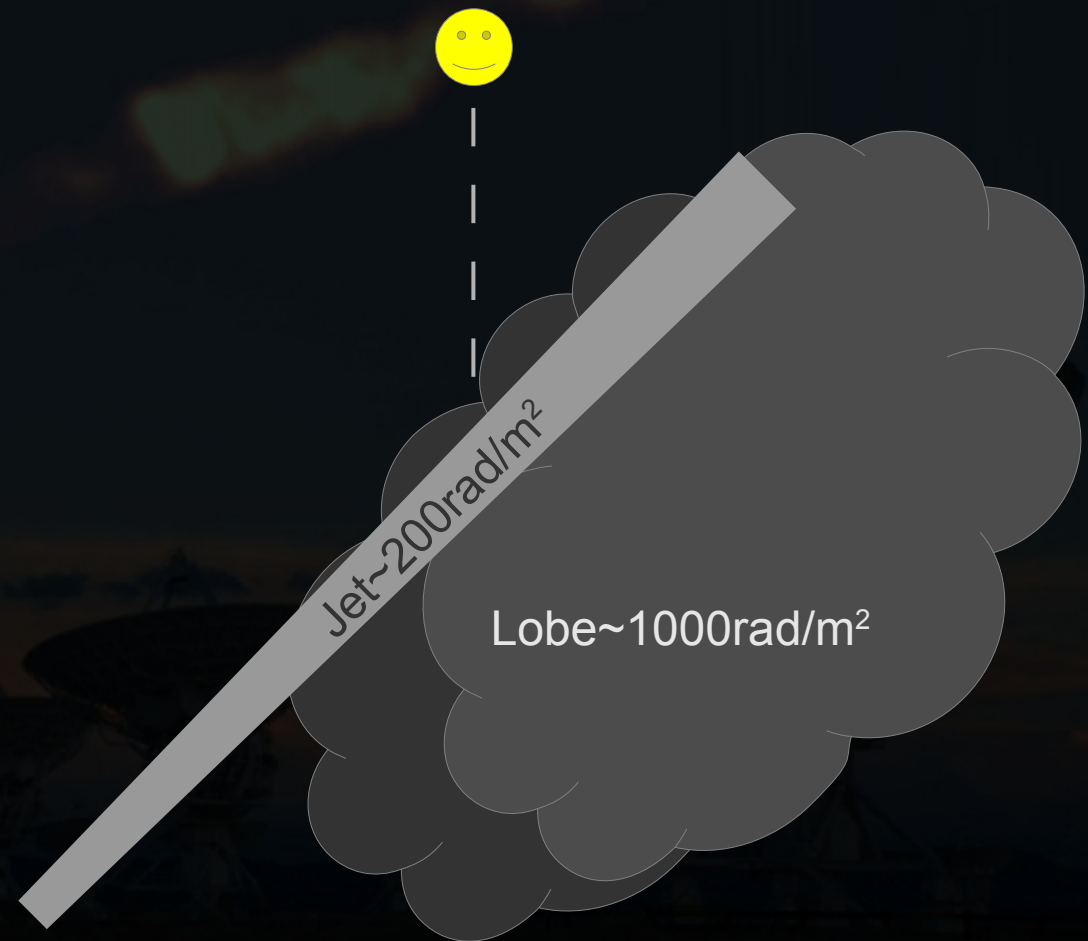
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- However, power spectrum...
 - $2.5 < 3.0$ (Guidetti+12) < 3.6
 - Flatter than 3D Kolmogorov
 - Incompatible with 2D K.
 - More complex morphology, more ordered B-fields

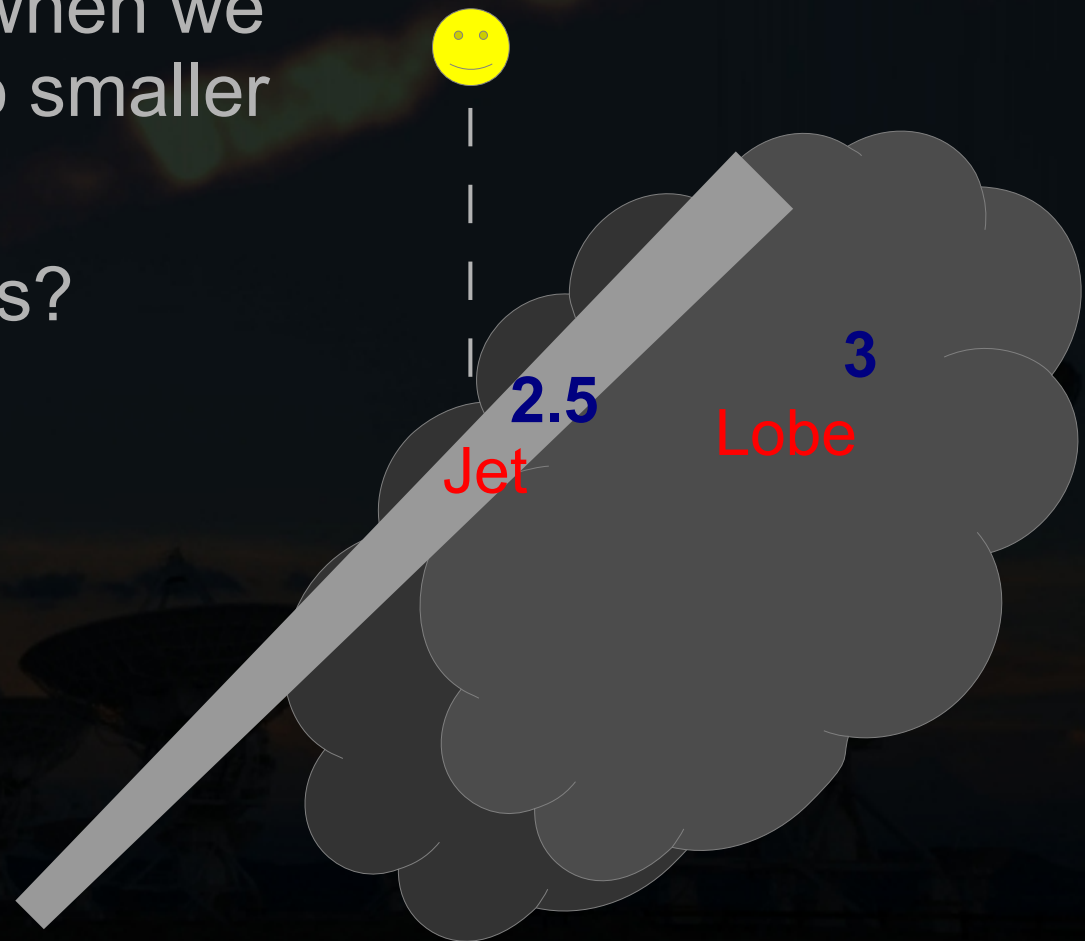
The Faraday Fog in M87

- Owen+90: “The jet shows the lowest RM. The foreground screen is associated with the lobes [...] and most of the lobe structure should be behind the jet”



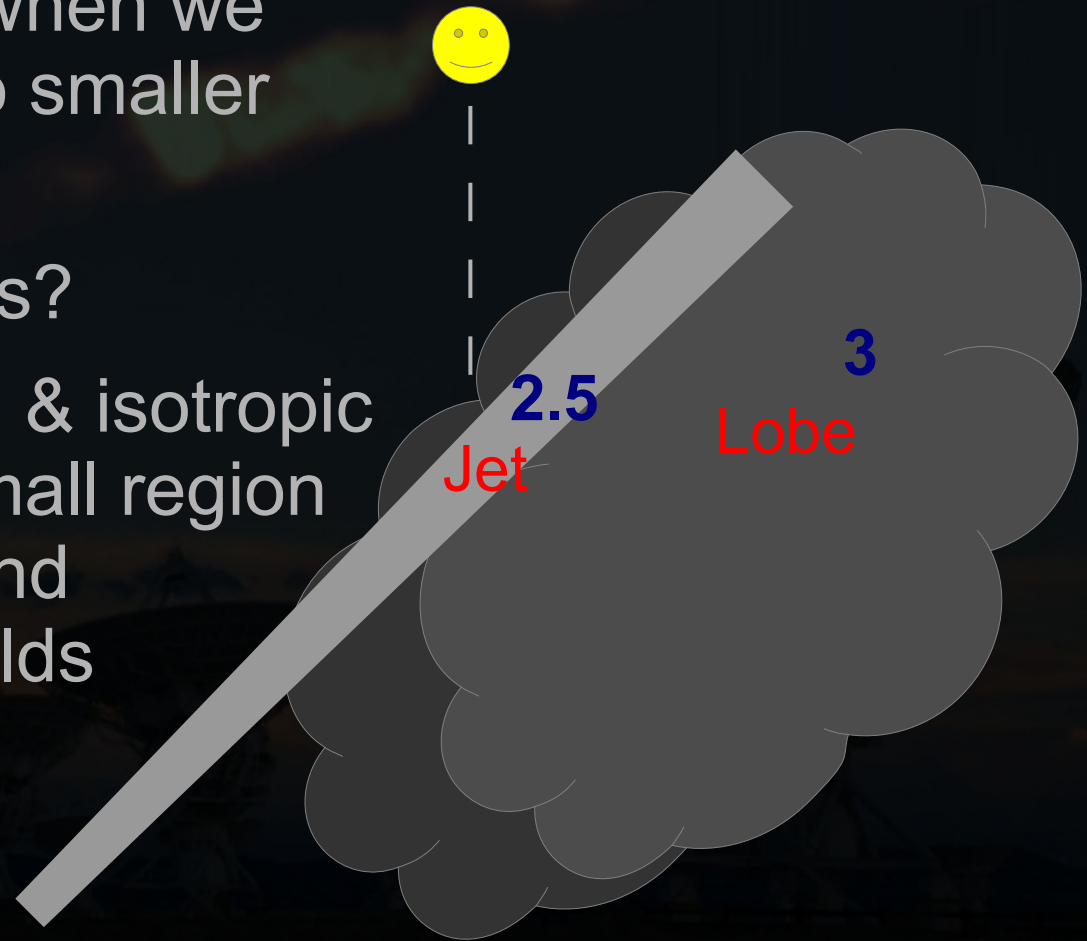
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- Power index decreases when we compare larger (lobes) to smaller (jet) scales
 - Ordering of the B-fields?



The Faraday Fog in M87

- Owen+90: “The jet shows the lowest RM. The foreground screen is associated with the lobes [...] and *most* of the lobe structure should be behind the jet”
- Power index decreases when we compare larger (lobes) to smaller (jet) scales
 - Ordering of the B-fields?
- Combination of i) tangled & isotropic magnetic fields from a small region of the lobes in our l.o.s and ii) the more ordered B-fields from the jet?
- Connexion with the MHD properties of the jet



Conclusions

- RM structure of M87 is not simple
 - Various components may appear superposed on our l.o.s
 - Combination may prevent to directly observe the jet RM gradient 'smoking gun" for helical B-fields in the jet
 - Filaments or structures from the lobes may cross sections of the jet, such as knot C



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- Magnetic structure of the M87 jet
 - Well ordered, possibly helical B-fields, in the kpc scale jet
 - B-field dissipates into more turbulent towards the lobes

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- Magnetic structure of the M87 jet
 - Well ordered, possibly helical B-fields, in the kpc scale jet
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- Lessons learned
 - For VLA ppl: not all integrated obs. are jet-disconnected
 - For VLBI ppl: care needed in interpreting RM properties.

Thanks

- Questions/comments

