

Observations of AGN with MIDI

or

„How to cope with faint targets with MIDI“

EuroSummer School

Observation and data reduction with the VLTI

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Contents



- Introduction:
AGN, unified scheme, SED, key questions, why MIDI?
- Observations:
acquisition, tracking and photometry for weak targets
- Data reduction:
EWS
- Results for observed sources:
NGC1068, Circinus, Centaurus A, weaker sources
- Prospects and advice

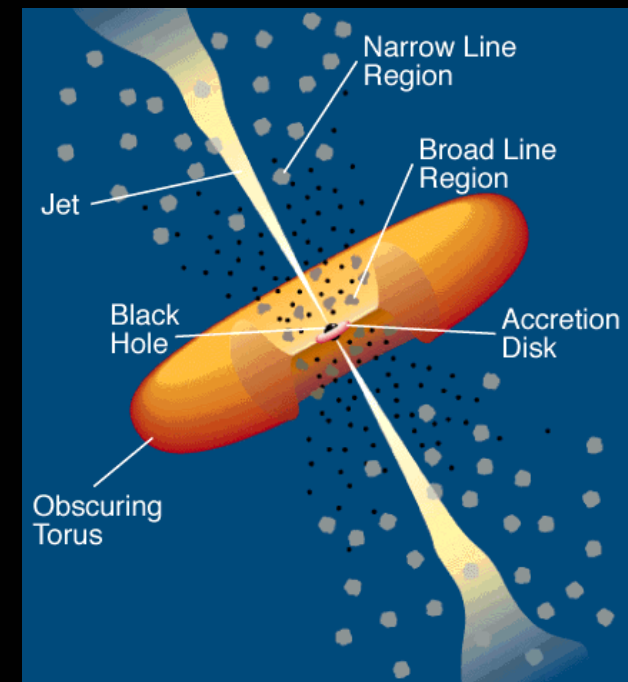
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- **Prospects and advice**

Introduction: What are AGN?

- AGN (Active Galactic Nucleus): supermassive black hole ($M > 10^6 M_{\odot}$) at the centre of a galaxy actively accreting
- Large range of energetic phenomena:
 - X-ray emission
 - Ionisation cones
 - broad and narrow line regions
 - jets
 -

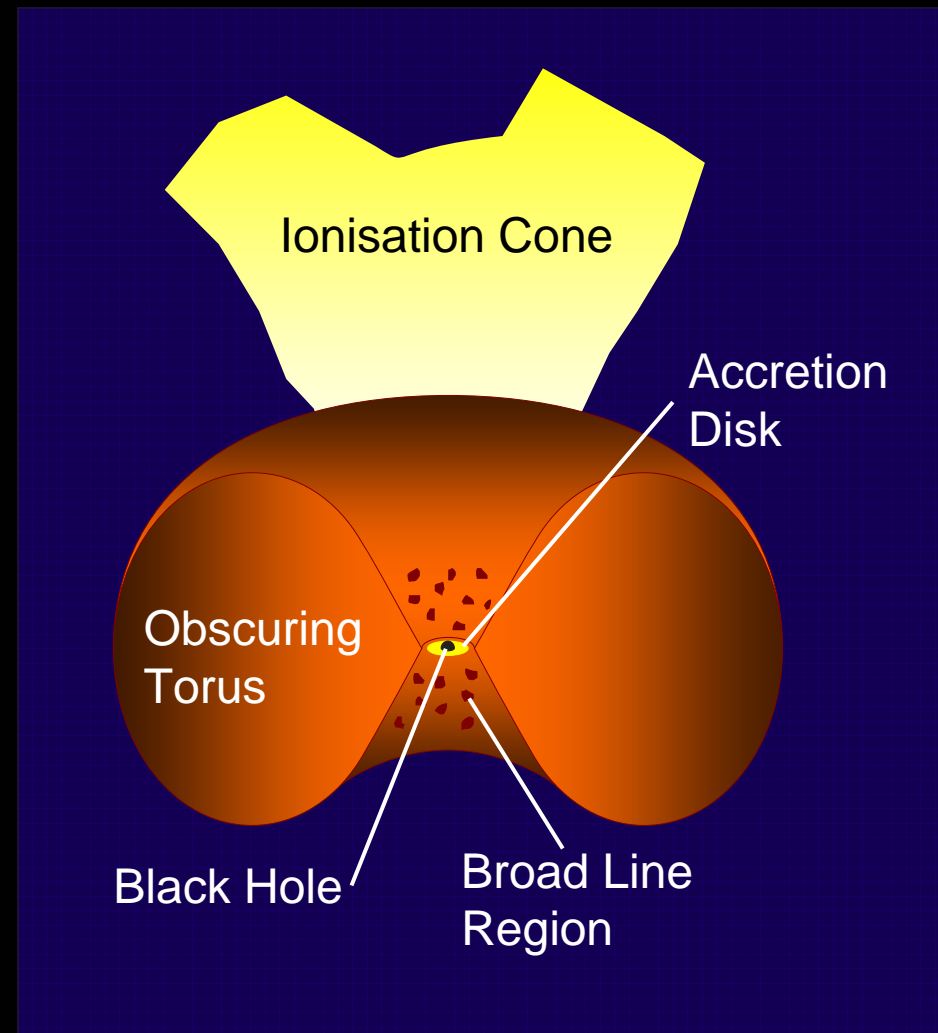


Urry and Padovani, 1995

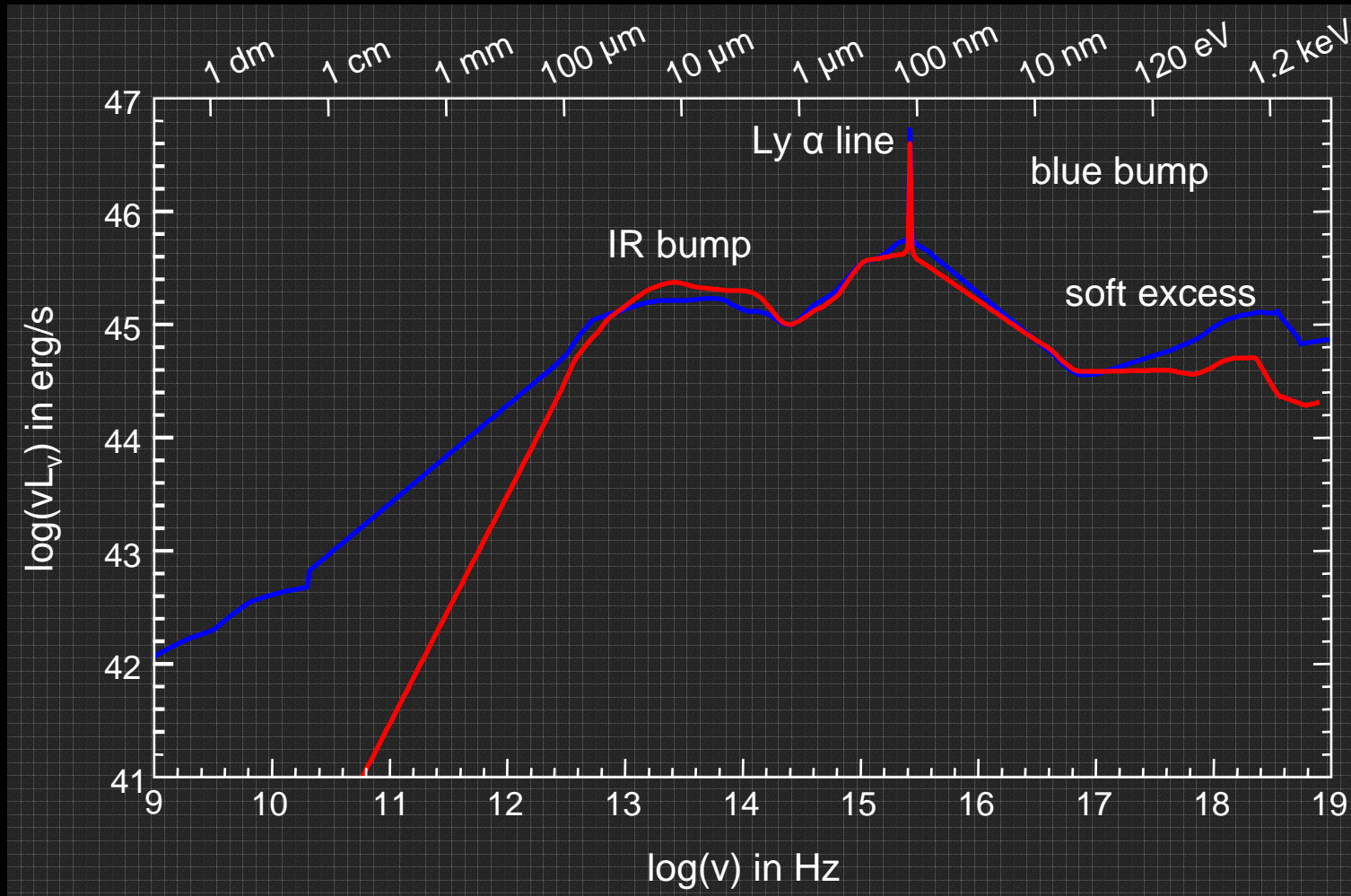
Introduction: The Unified scheme



- Unified AGN model:
Geometrical effects lead to different manifestations (e.g. Seyfert 1 & 2)



Introduction: The SED of AGN



Elvis et al., 1994

Introduction: Key questions



- Key questions:
 - What is history and evolution of AGN?
 - How is the accretion energy released?
 - What is the interplay between black hole and its host?
 - Is the picture of the unified scheme true?
- Search for direct evidence for dust torus
 - Observations in the MIR
 - Sufficient spatial resolution

Introduction: Nearby AGN



<u>Name</u>	<u>Type</u>	<u>Distance</u> [Mpc]	<u>1 pc</u> [mas]	<u>Flux</u> [Jy]
NGC 1068	Sy 2	17	12	18.0
Circinus	Sy 2	4	52	9.7
NGC 4151	Sy 1.5	14	15	1.2
NGC 5128	Sy 2	4	52	1.2
NGC 5506	Sy 2	28	7	0.9
NGC 1365	Sy 1.8	25	8	0.6
MCG -05-23-016	Sy 2	38	5	0.6
Mrk 1239	Sy 1	92	2	0.6
NGC 3783	Sy 1	45	5	0.6
NGC 3281	Sy 2	50	4	0.6
IRS 0518-25	Sy 2	200	1	0.5

Introduction: Why MIDI?

- Need MIR instruments with highest resolution!
→ Find this only at the VLT: MIDI
- Goal for MIDI:
 - Resolve the putative dust torus directly for nearby active galaxies!

VLT with the Residencia
February 2005



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Observations: Target list



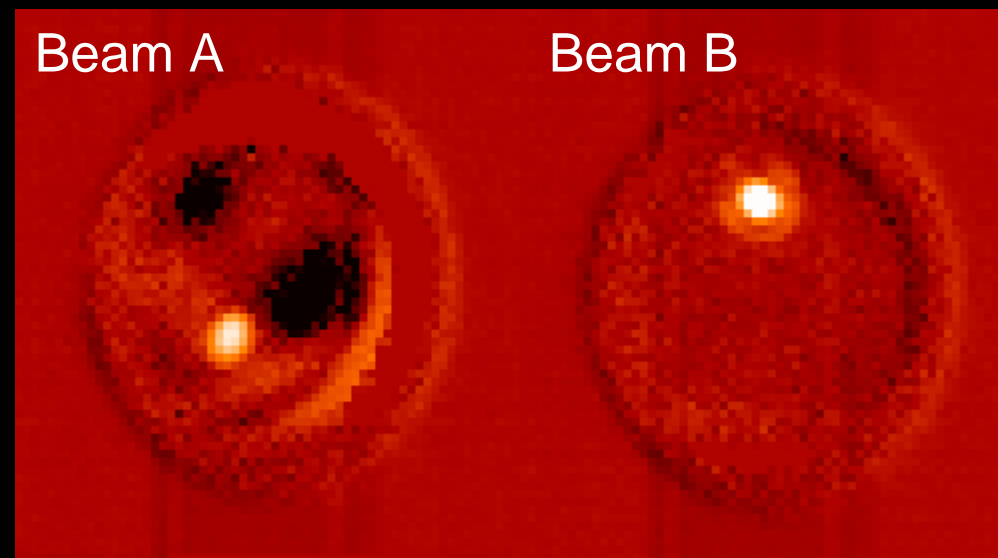
List of all AGN observed to date:

<u>Name</u>	<u>Flux (10μm)</u>	<u>Time</u>	<u>In charge</u>
NGC 1068 (M77)	13 Jy	SDT / OT	Raban
Circinus	5 Jy	GTO	Tristram
NGC 5128 (Centaurus A)	0.6 Jy	GTO	Meisenheimer
NGC 3783	0.5 Jy	OT	Beckert
Mrk 1239	0.4 Jy	GTO	Cotton
MCG -05-23-016	0.3 Jy	GTO	Cotton

Observations: Acquisition

- Example for a bright calibrator:
HD120404
- First iteration

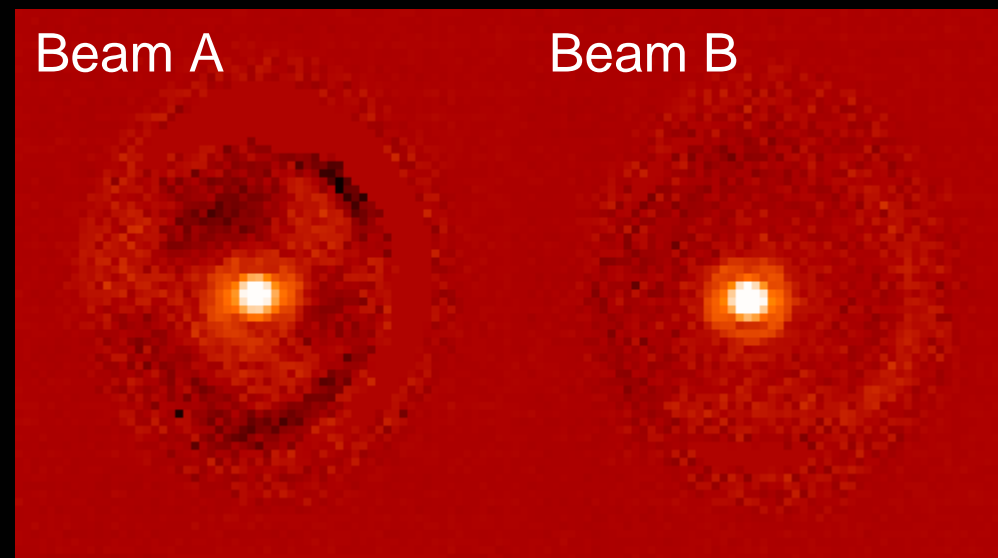
Flux: 10 Jy
Filter: N8.7
DIT = 0.0040
NDIT = 1000



Observations: Acquisition

- Example for a bright calibrator:
HD120404
- Second iteration

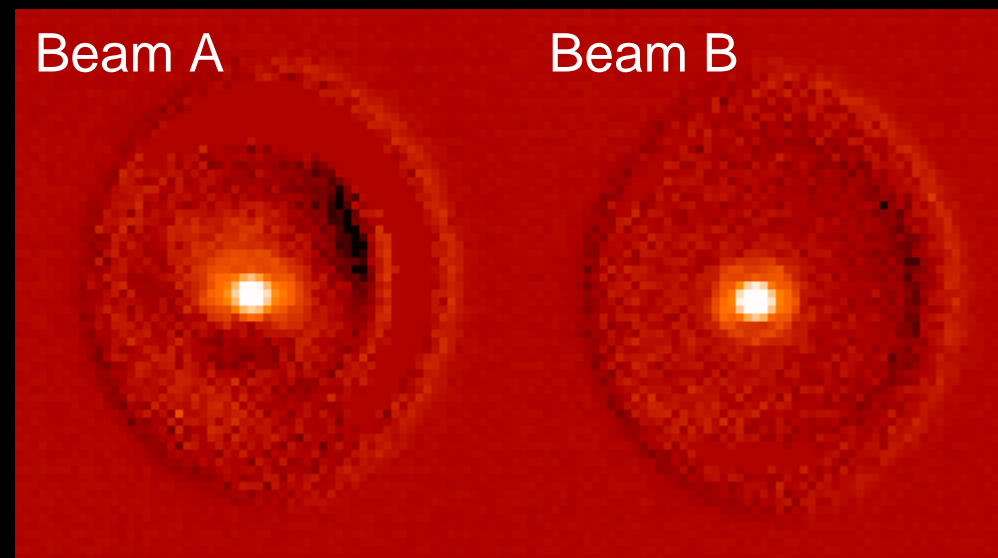
Flux: ~ 10 Jy
Filter: N8.7
DIT = 0.0040
NDIT = 1000



Observations: Acquisition

- Example for a bright calibrator:
HD120404
- Third iteration

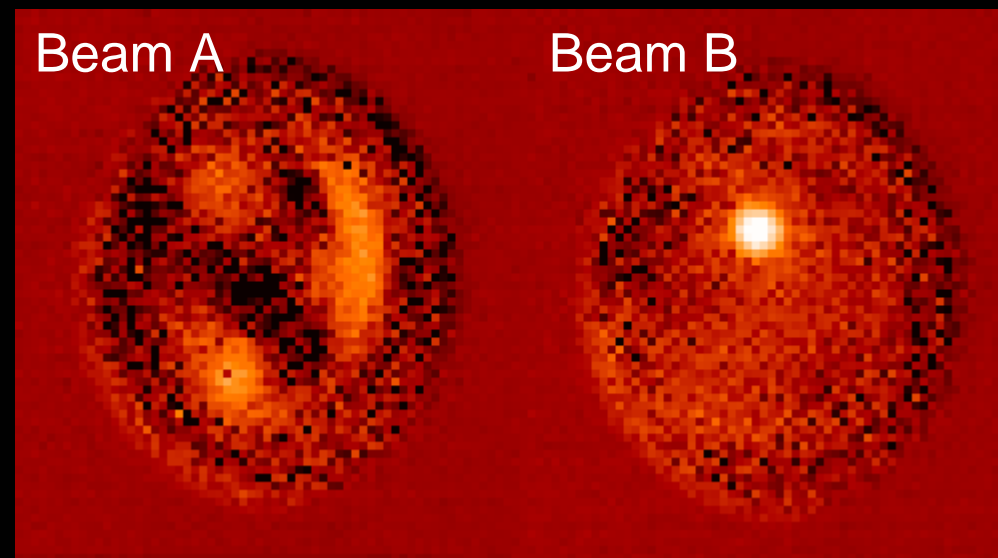
Flux: ~ 10 Jy
Filter: N8.7
DIT = 0.0040
NDIT = 1000



Observations: Acquisition

- Example for a 'bright' AGN:
Circinus galaxy
- First iteration

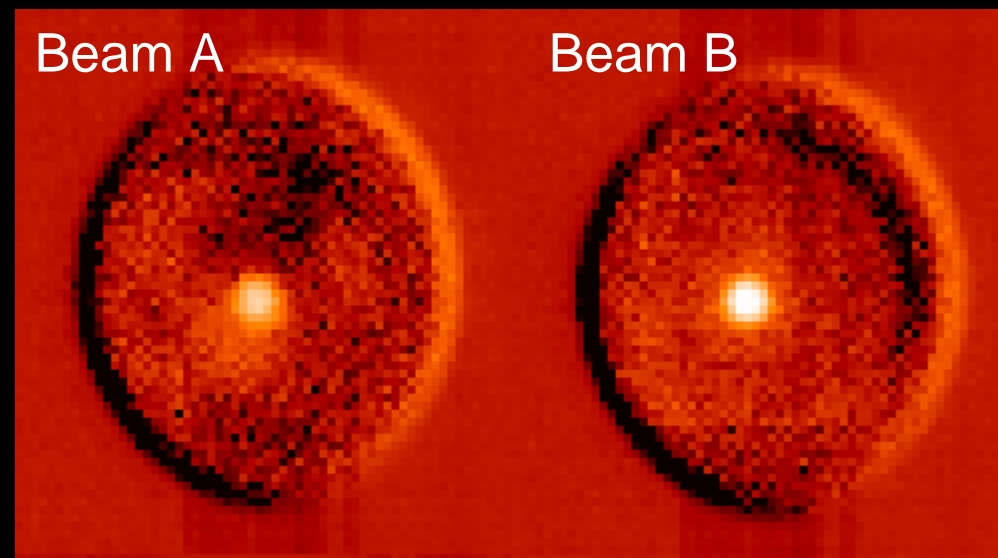
Flux: 5 Jy
Filter: SiC
DIT = 0.0017
NDIT = 1000



Observations: Acquisition

- Example for a 'bright' AGN:
Circinus galaxy
- Second iteration

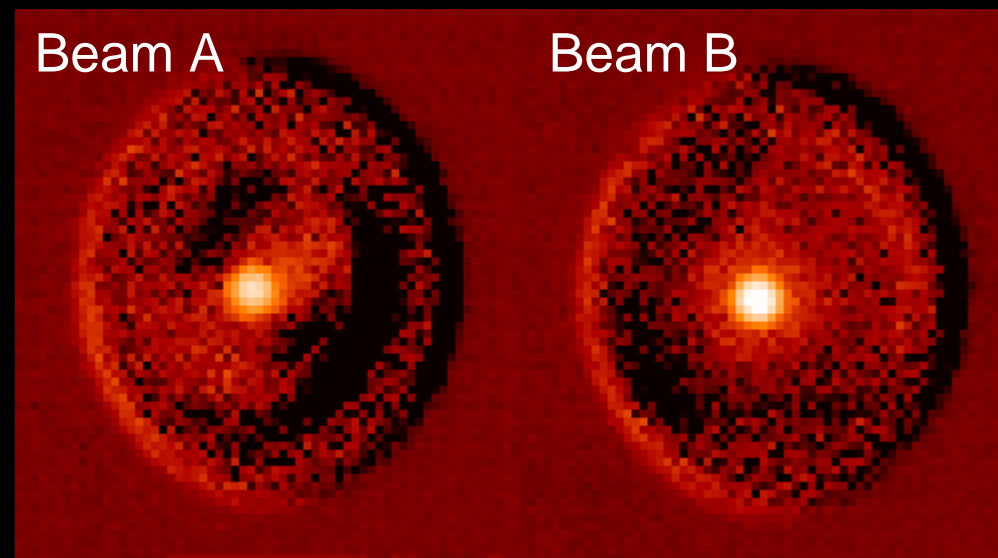
Flux: 5 Jy
Filter: SiC
DIT = 0.0017
NDIT = 2000



Observations: Acquisition

- Example for a 'bright' AGN:
Circinus galaxy
- Third iteration

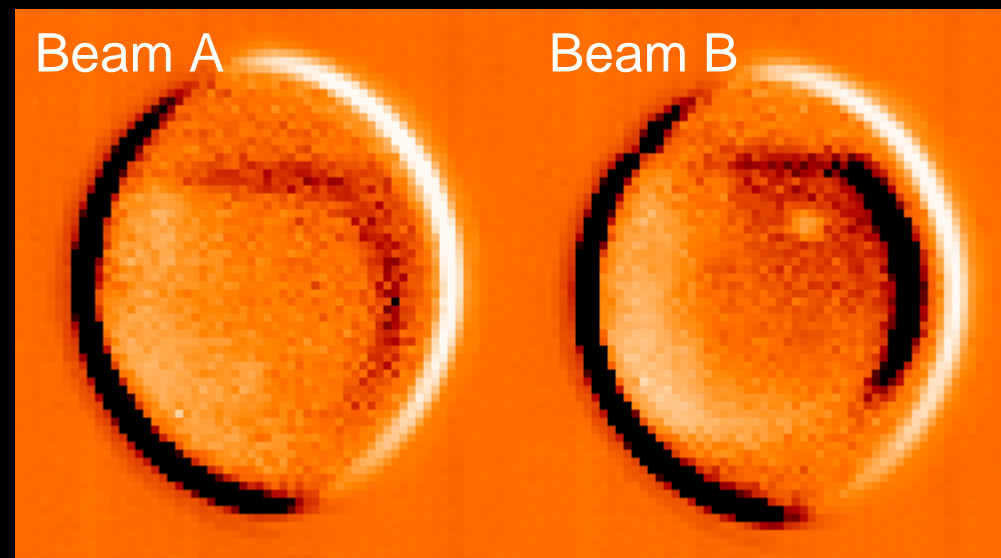
Flux: 5 Jy
Filter: SiC
DIT = 0.0017
NDIT = 2000



Observations: Acquisition

- Example for a faint AGN:
Mrk1239
- First iteration

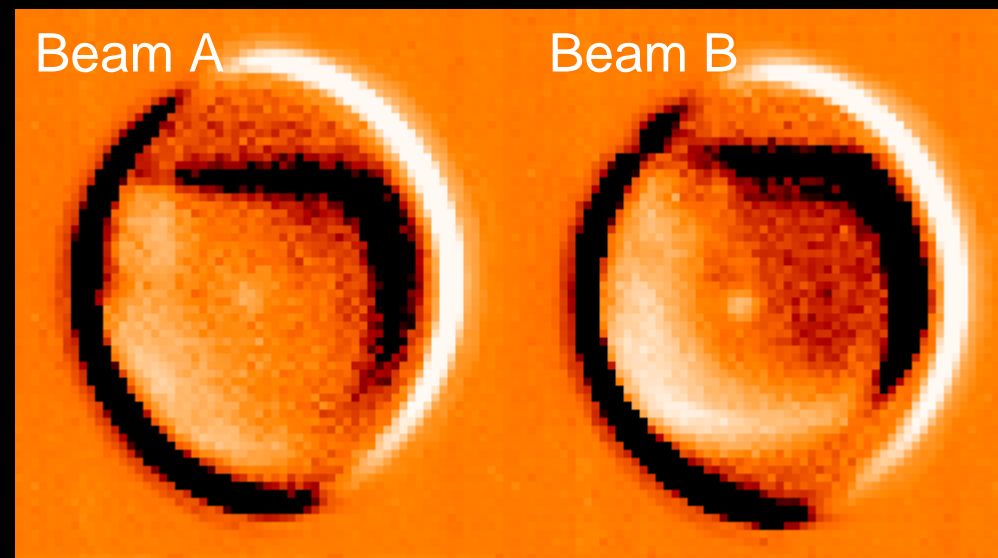
Flux: 0.6 Jy
Filter: SiC
DIT = 0.0017
NDIT = 8000



Observations: Acquisition

- Example for a faint AGN:
Mrk1239
- Second iteration

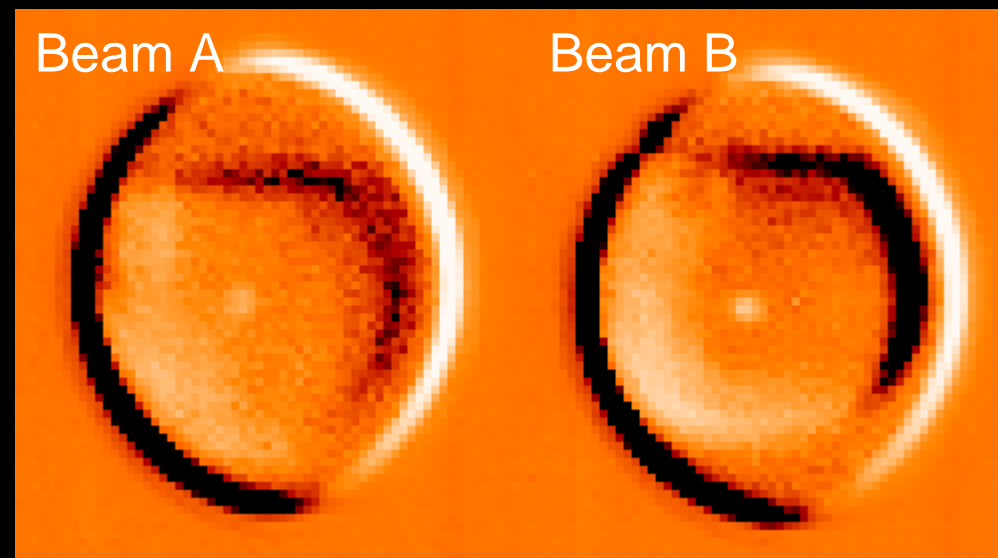
Flux: 0.6 Jy
Filter: SiC
DIT = 0.0017
NDIT = 8000



Observations: Acquisition

- Example for a faint AGN:
Mrk1239
- Third iteration

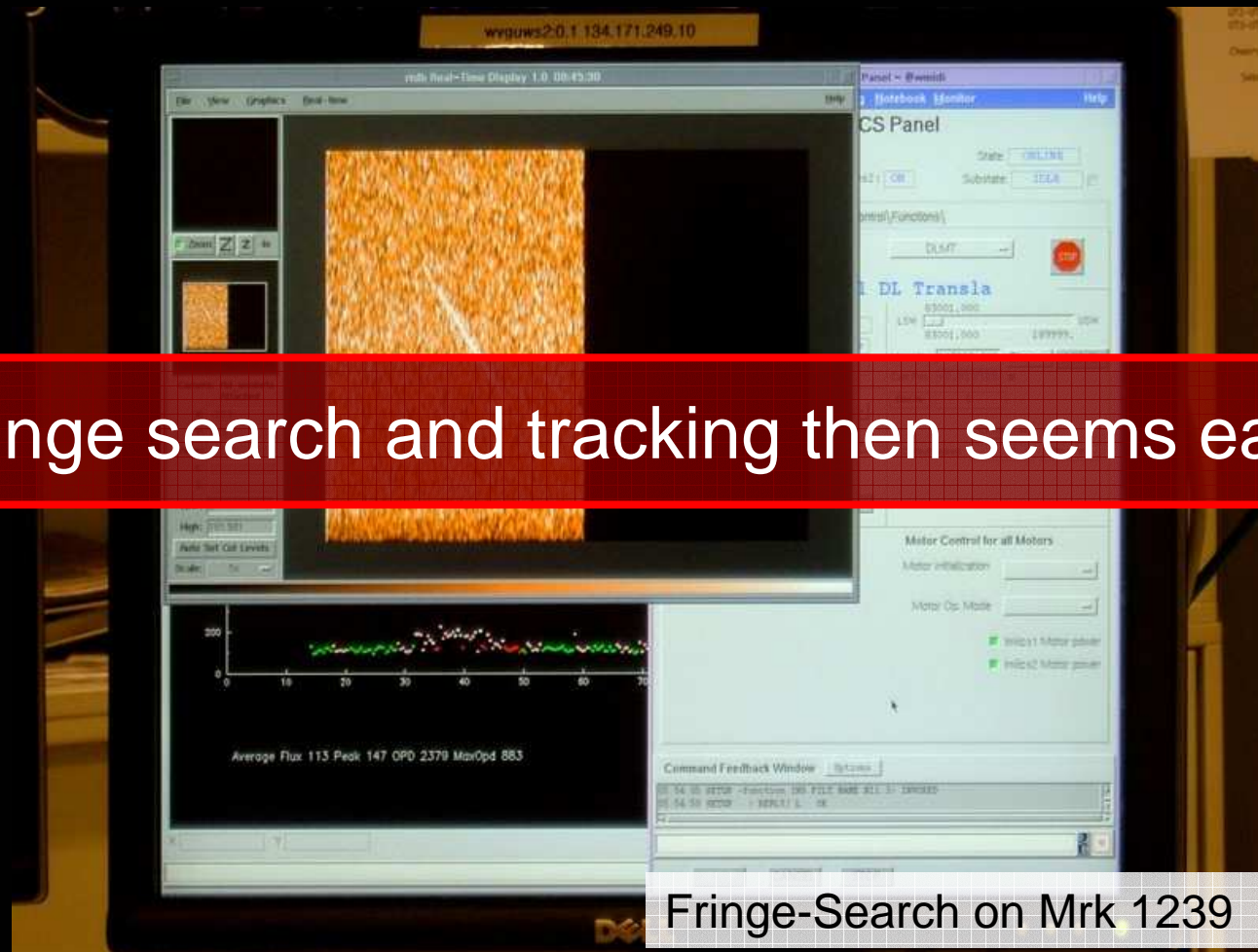
Flux: 0.6 Jy
Filter: SiC
DIT = 0.0017
NDIT = 12000



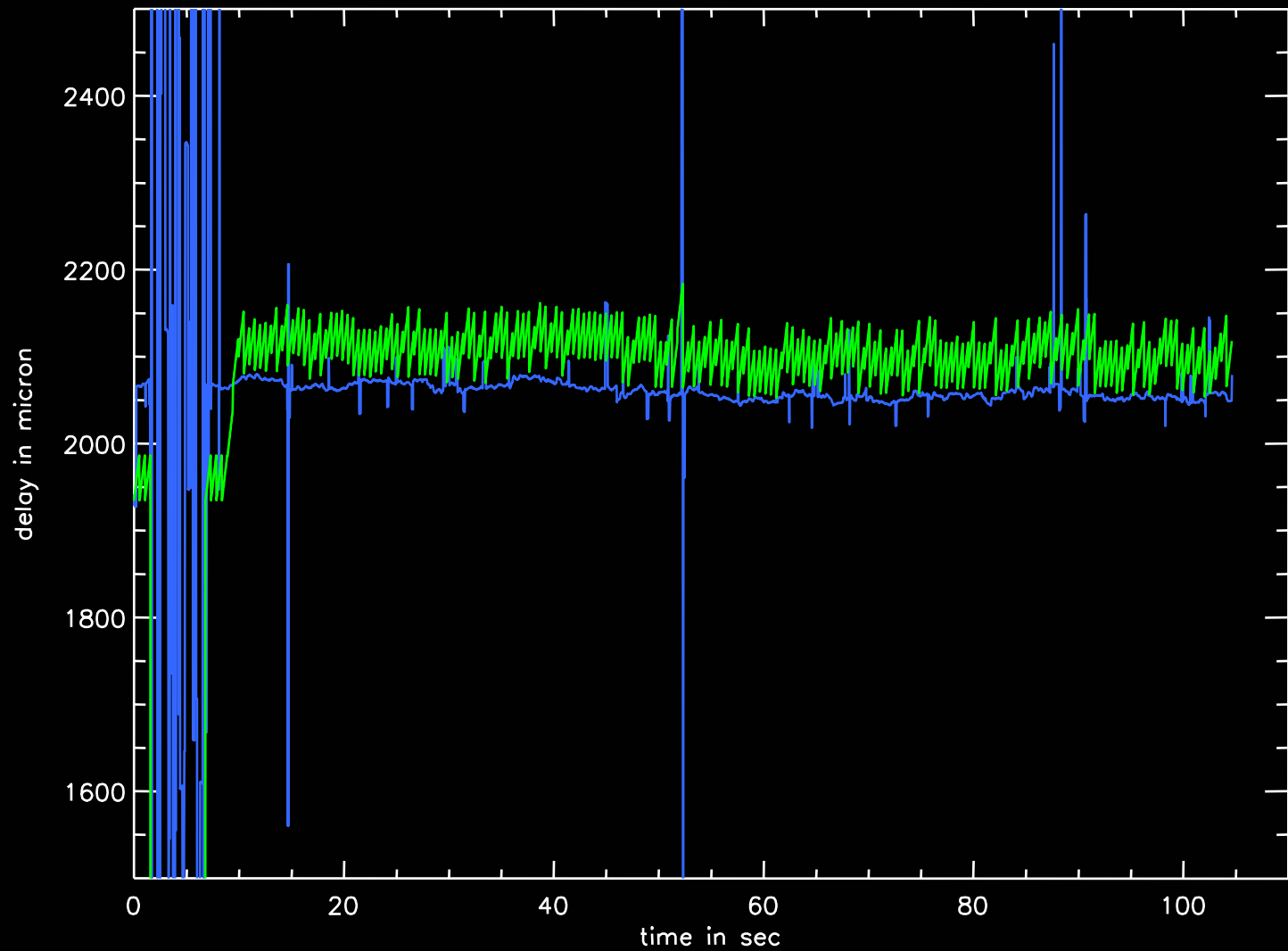
Observations: Fringe search



Fringe search and tracking then seems easy!

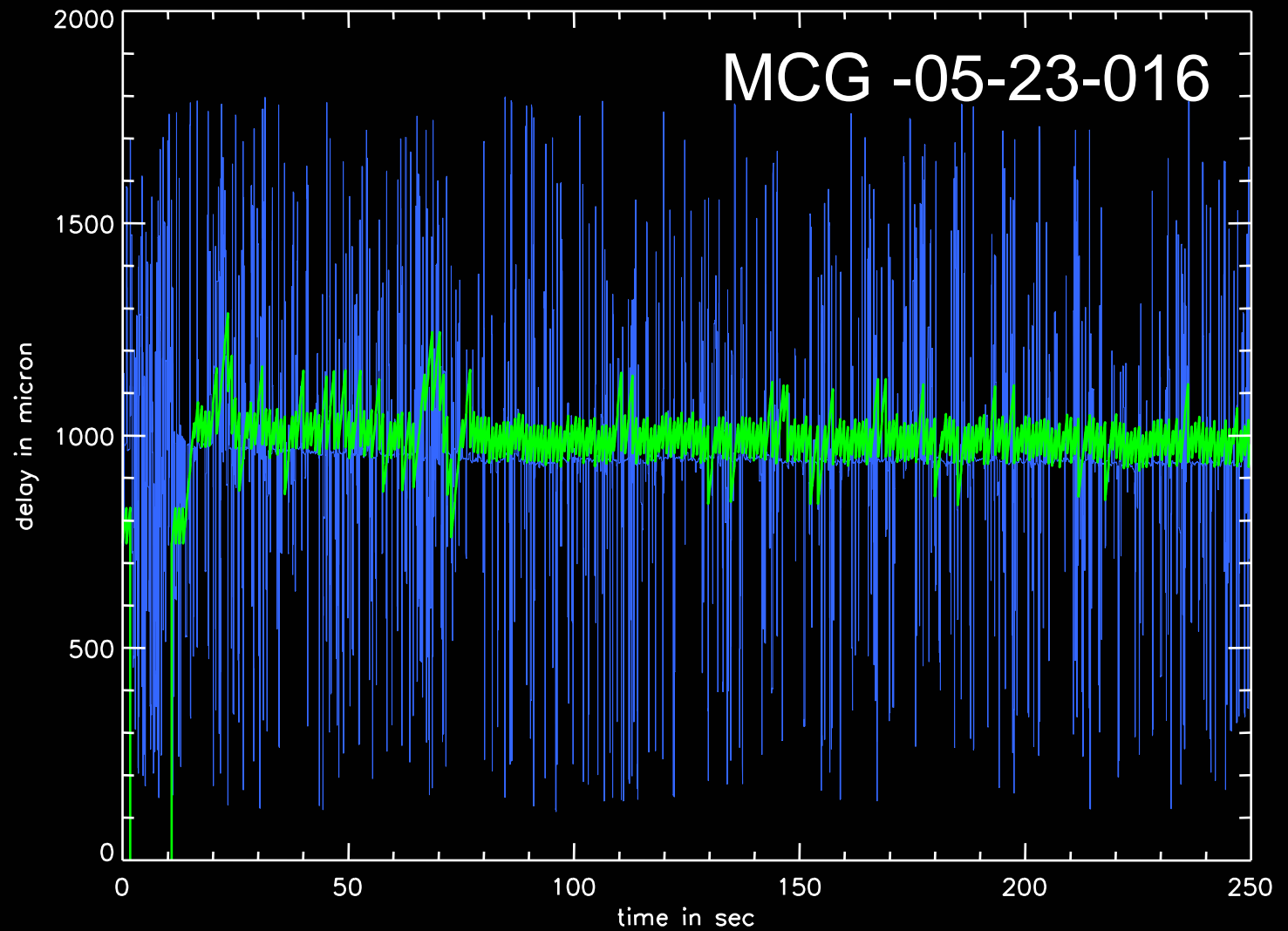


Observations: Fringe tracking



Circinus

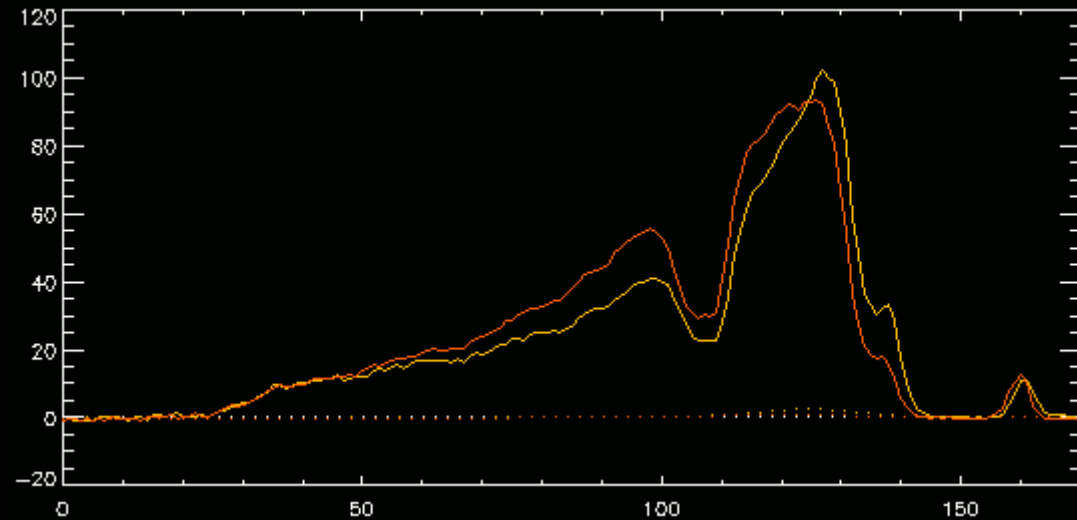
Observations: Fringe tracking



Observations: Photometry



- HD 120404
- Beam A
- without additional sky subtraction



Window 1

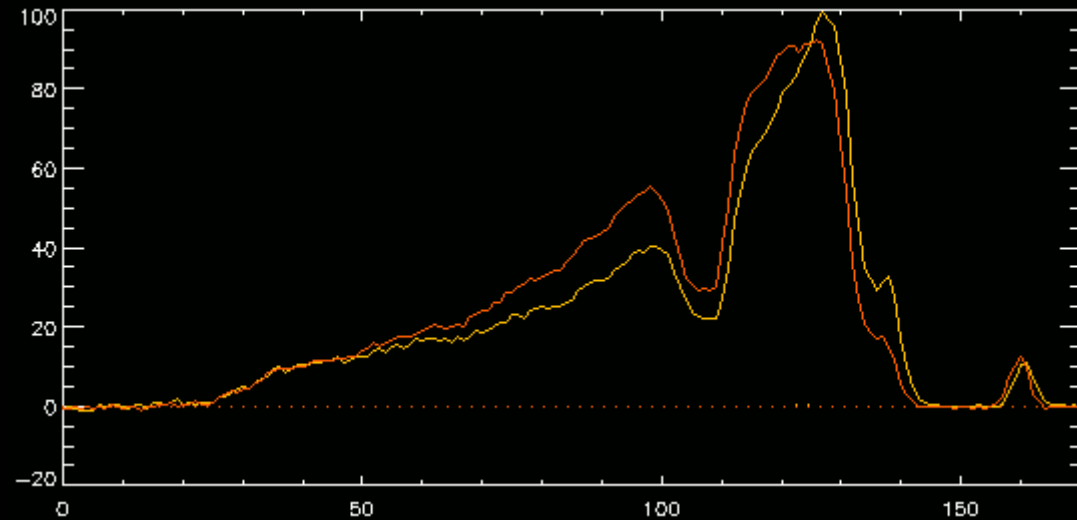
prism
DIT = 0.012
NDIT = 1500

Window 2

Observations: Photometry



- HD 120404
- Beam A
- with additional sky subtraction



Window 1

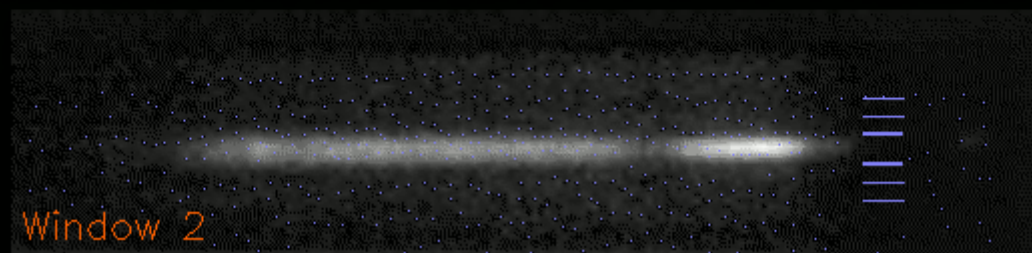
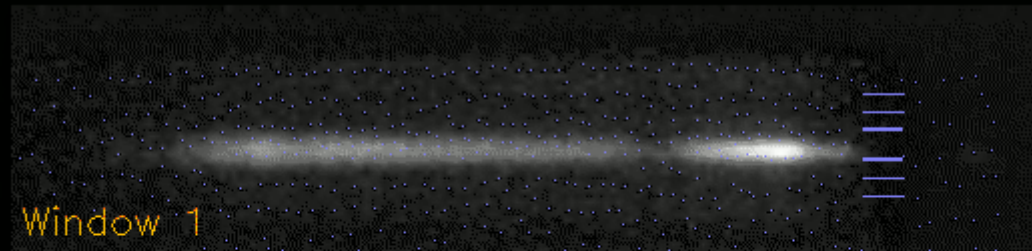
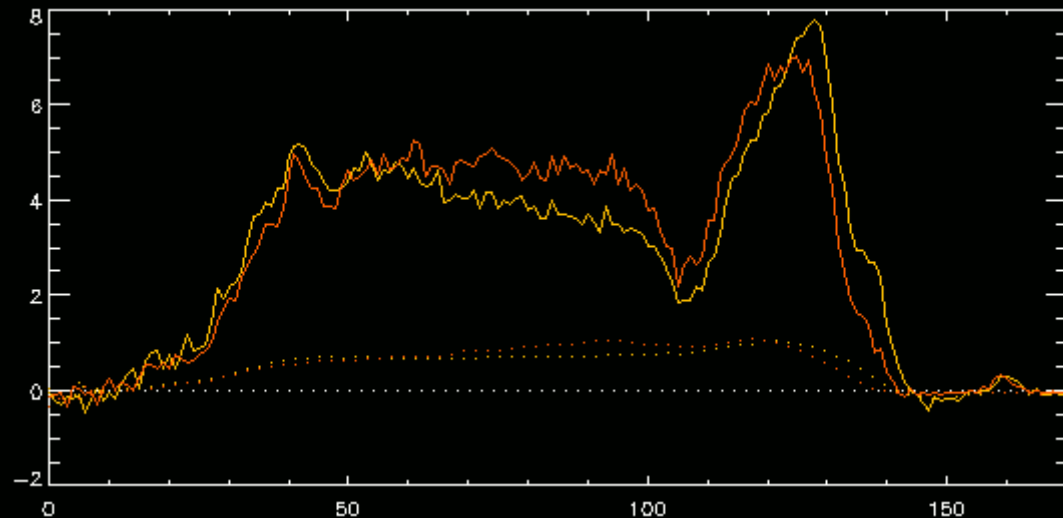
prism
DIT = 0.012
NDIT = 1500

Window 2

Observations: Photometry



- Centaurus A
- Beam A
- without additional sky subtraction

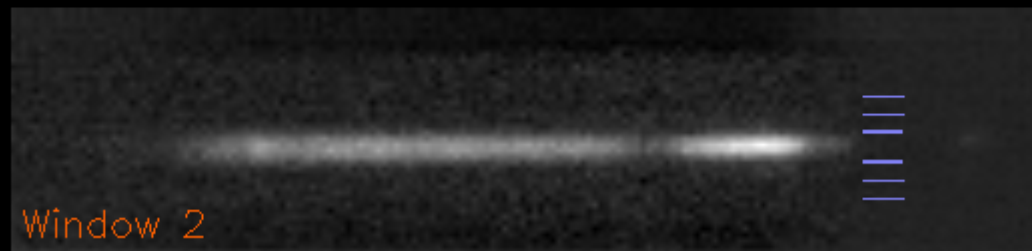
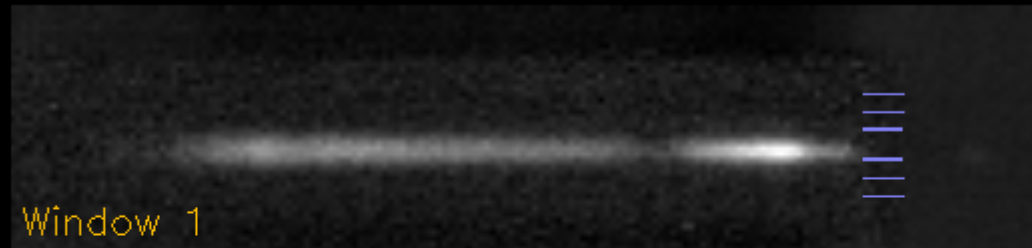
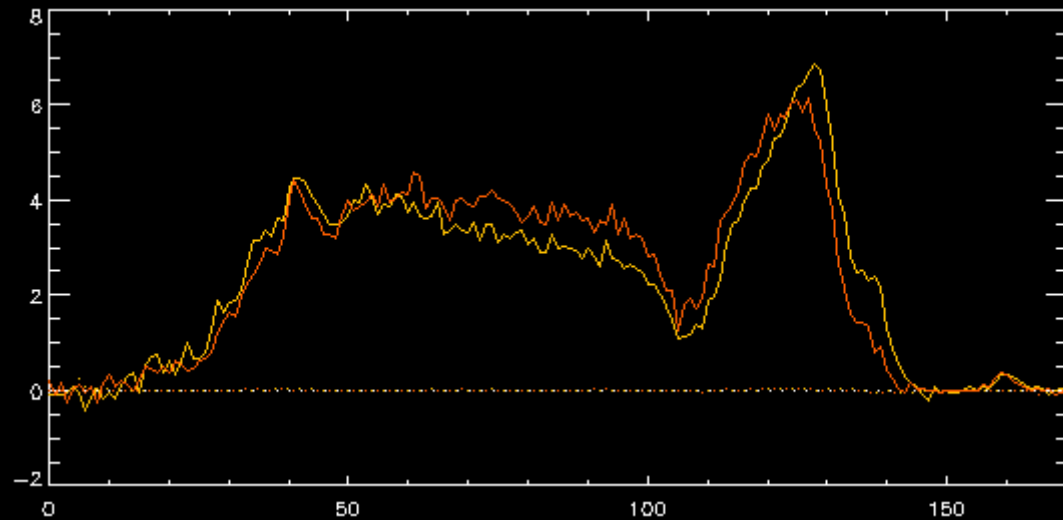


prism
DIT = 0.018
NDIT = 10000

Observations: Photometry



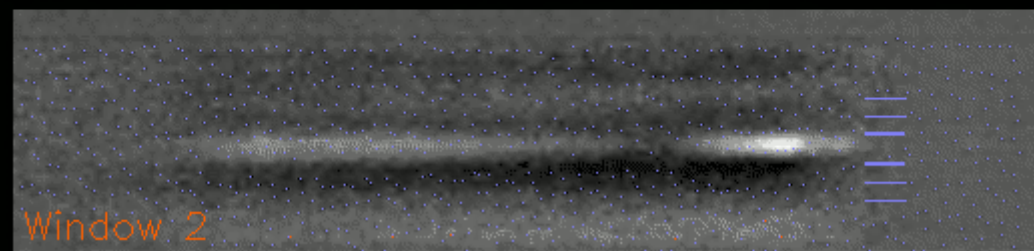
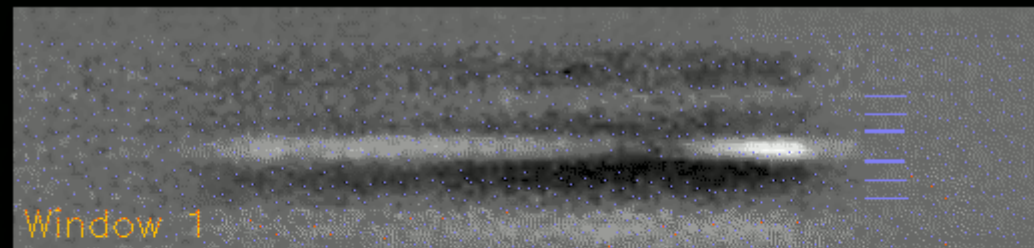
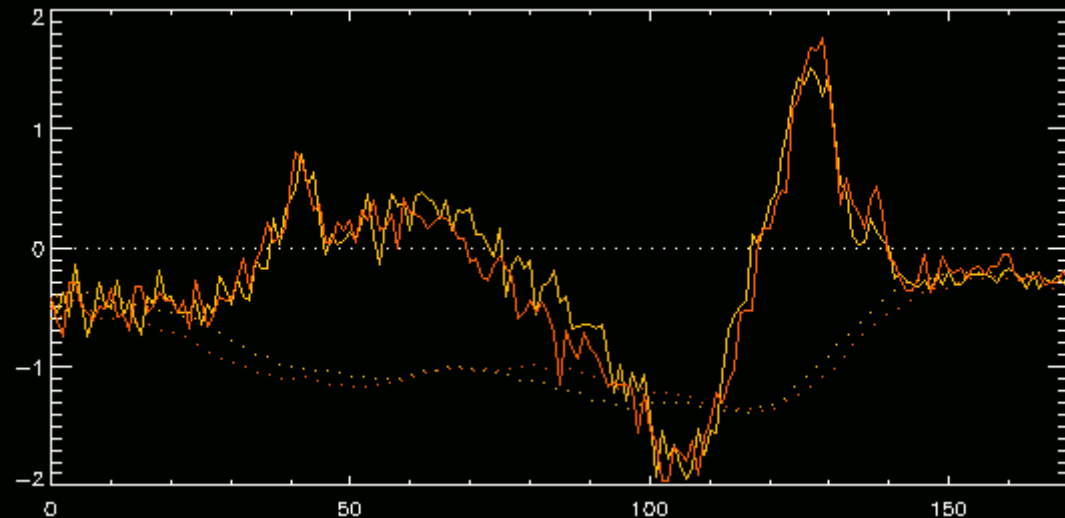
- Centaurus A
- Beam A
- with additional sky subtraction



prism
DIT = 0.018
NDIT = 10000

Observations: Photometry

- Centaurus A
- Beam B
- without additional sky subtraction

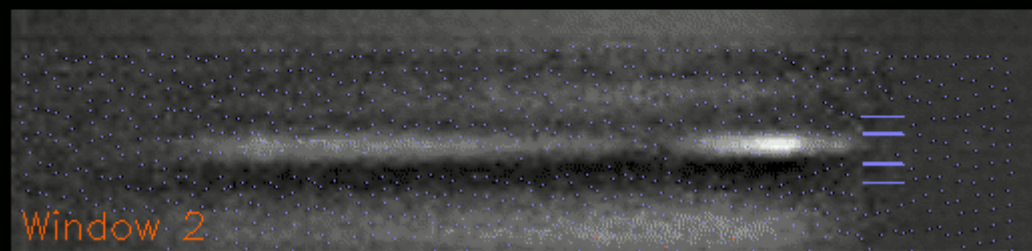
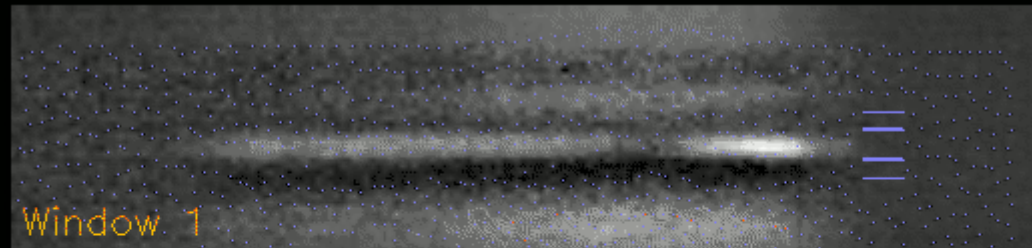
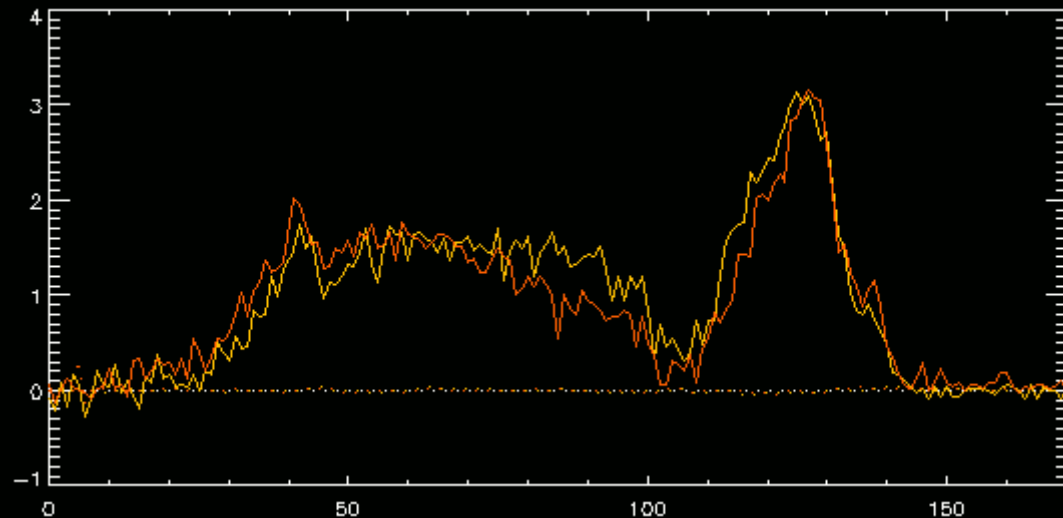


prism
DIT = 0.018
NDIT = 10000

Observations: Photometry



- Centaurus A
- Beam B
- with special sky subtraction



prism
DIT = 0.018
NDIT = 10000

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Data reduction

- What does EWS do?
 1. data compression
 2. background removal
 3. instrumental OPD demodulation
 4. atmospheric delay removal
 5. determination of the differential phase
 6. coherent integration→ visibility and differential phase
- How to run EWS?

```
IDL> midipipe, tag, files
IDL> midicalibrate, scitag, caltag
```

Data reduction

- Almost exclusively with EWS
- Usage of optional settings
(smooth, gsmooth, /dave)
- Calibrations problems:
 - usage of geometric or arithmetic photometry
 - Non detections → midsearch

Contents

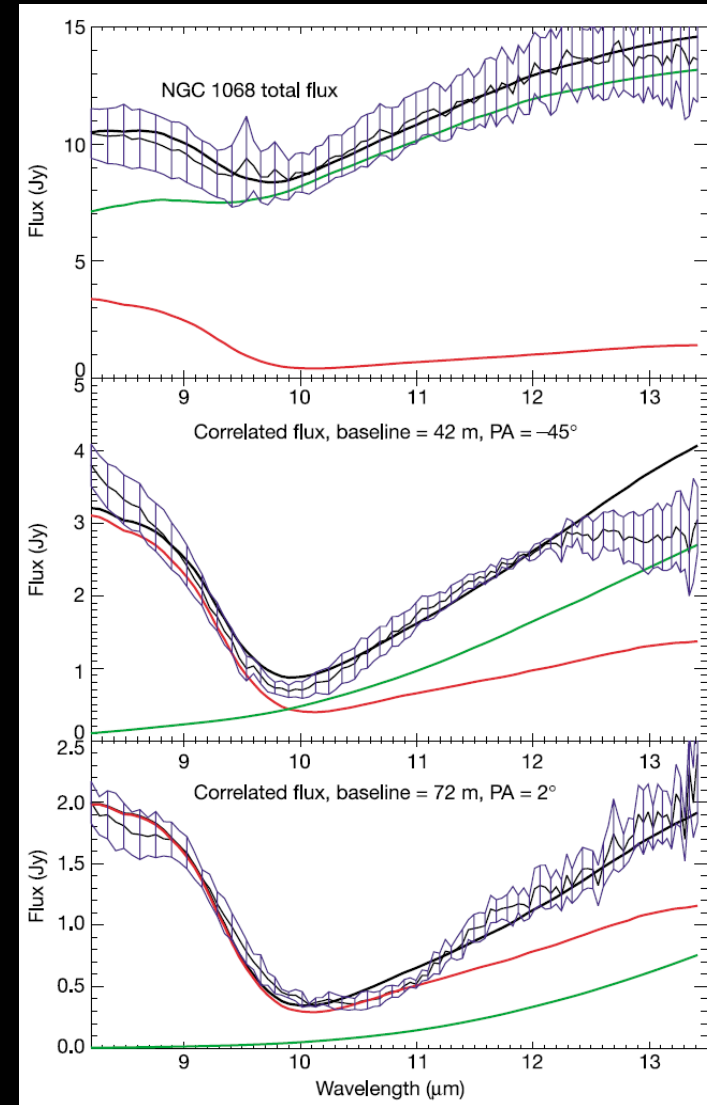


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NGC 1068: first results

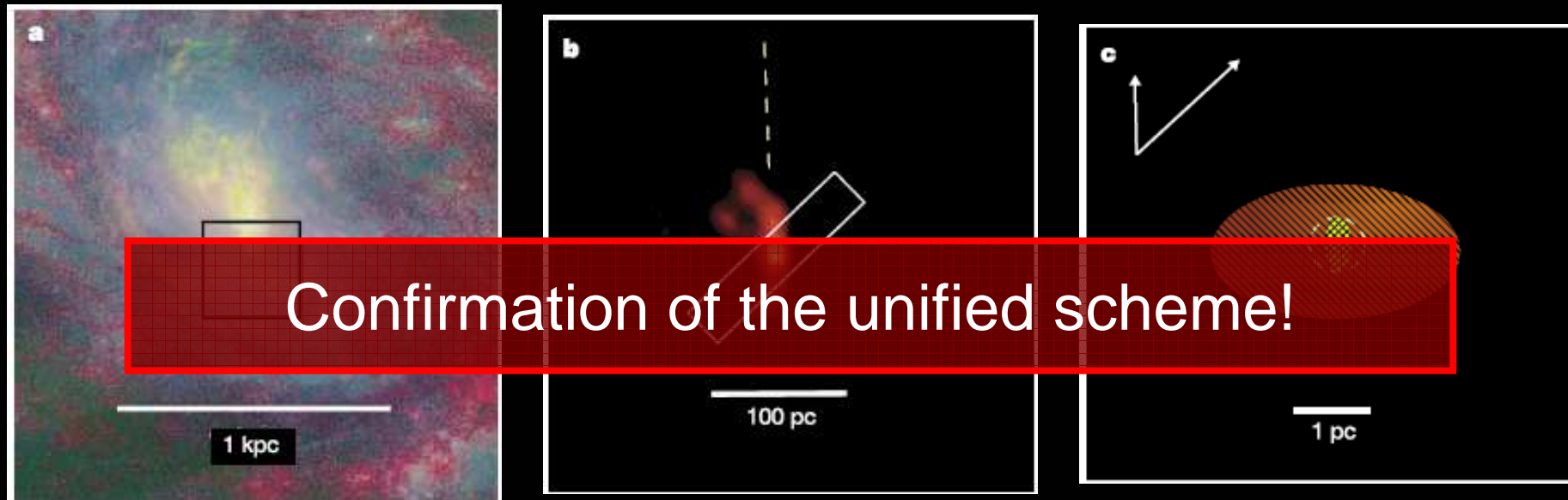


- Two baseline orientations
- Modelled by two elliptical Gaussians:
 - Hot and cold component
 - Different silicate absorption



Jaffe et al. 2004

NGC 1068: first results

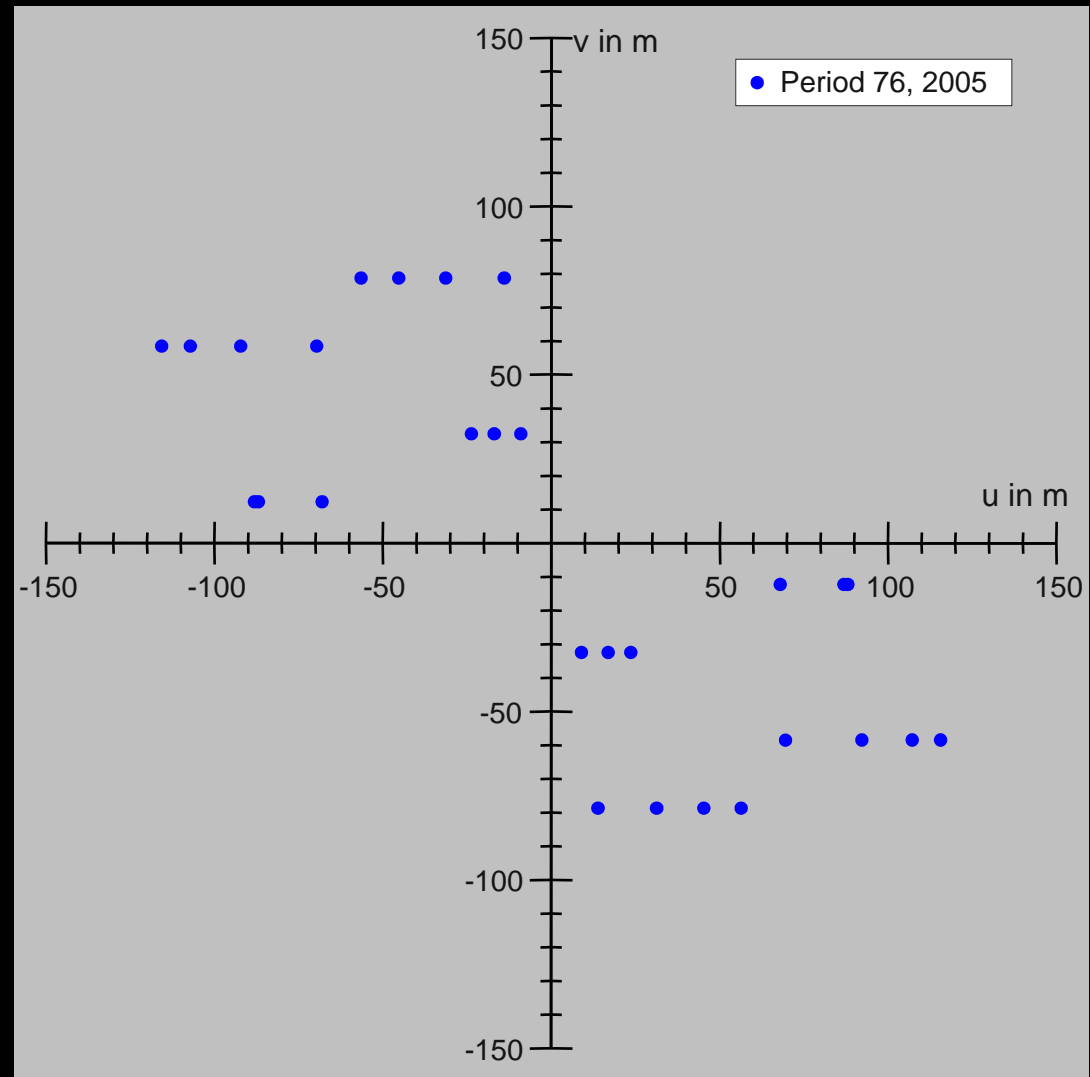


Jaffe et al. 2004

NGC 1068: new observations



- Grism observations
- Open time
- 2005
- 13 independent visibility points



Circinus: properties



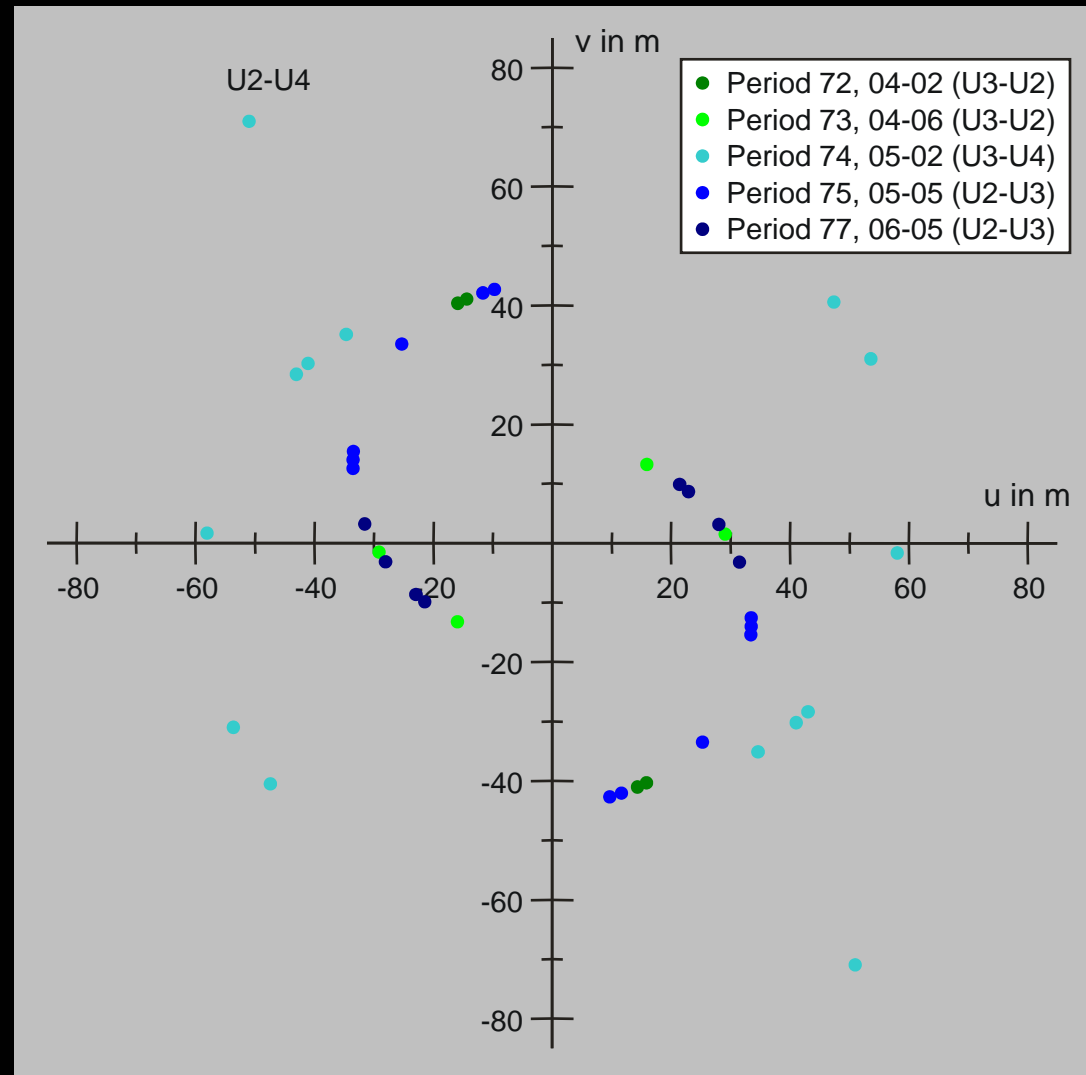
- Spiral galaxy SA(s)b, $i = 65^\circ$
- Seyfert type 2
- $4 \times 10^6 M_\odot$ nucleus
- Distance ~ 4 Mpc
→ $50 \text{ mas} \sim 1 \text{ pc}$

2MASS J, H, K_s colour mosaic

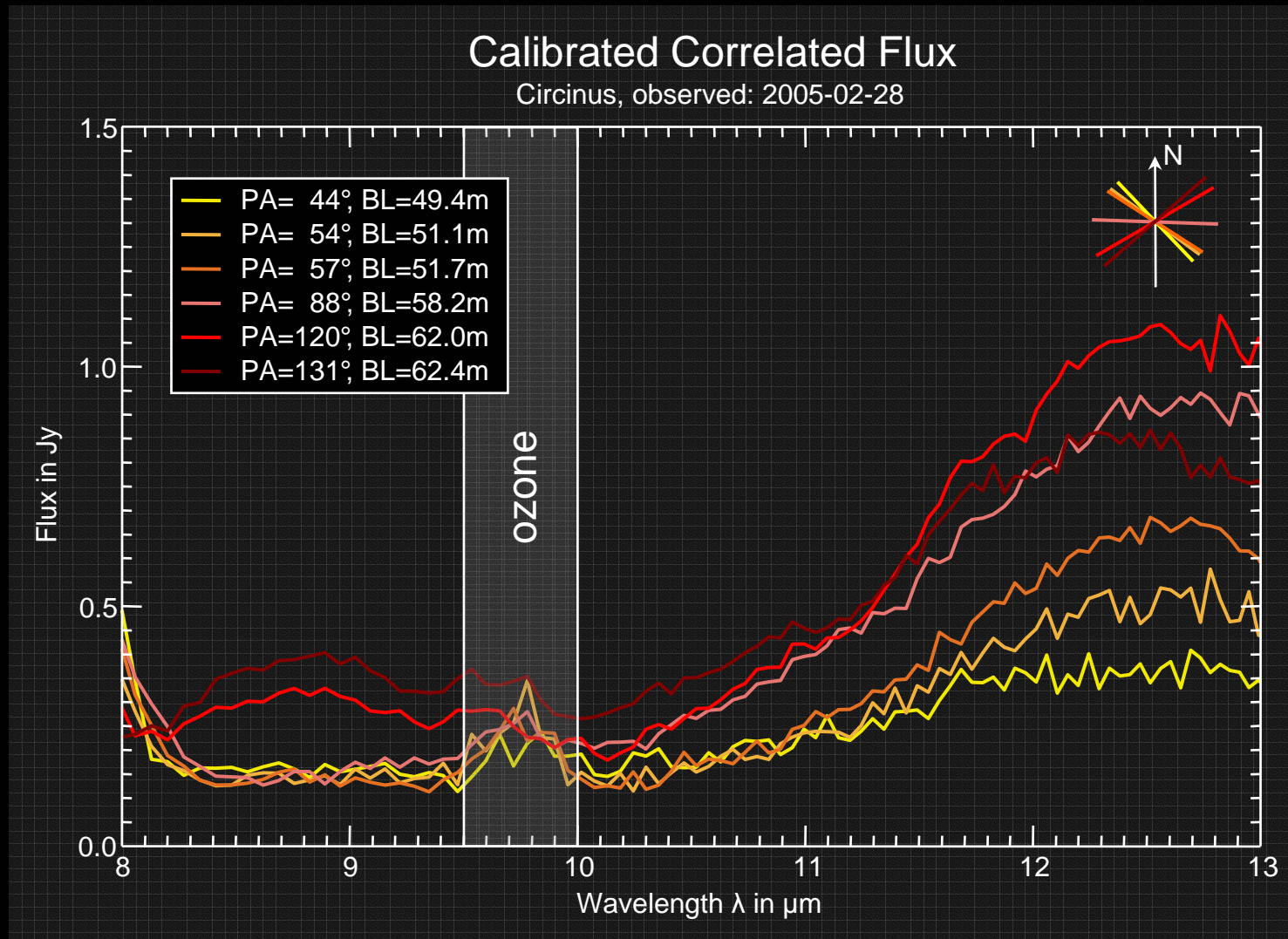
Circinus: UV plane



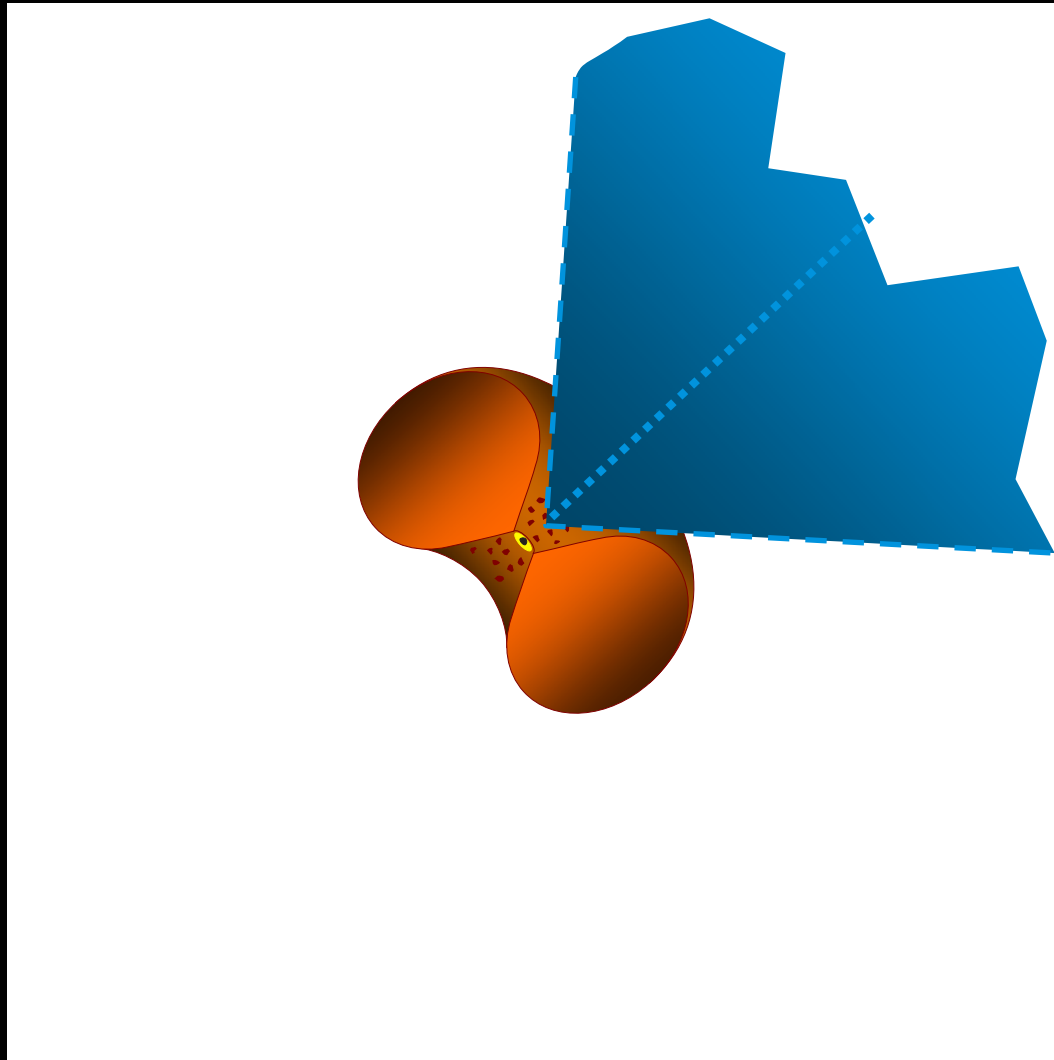
- GTO observations from P72 to P77
- 15 independent visibility points (several ‘double’)
- some of these rather “dodgy”



Circinus: Correlated flux



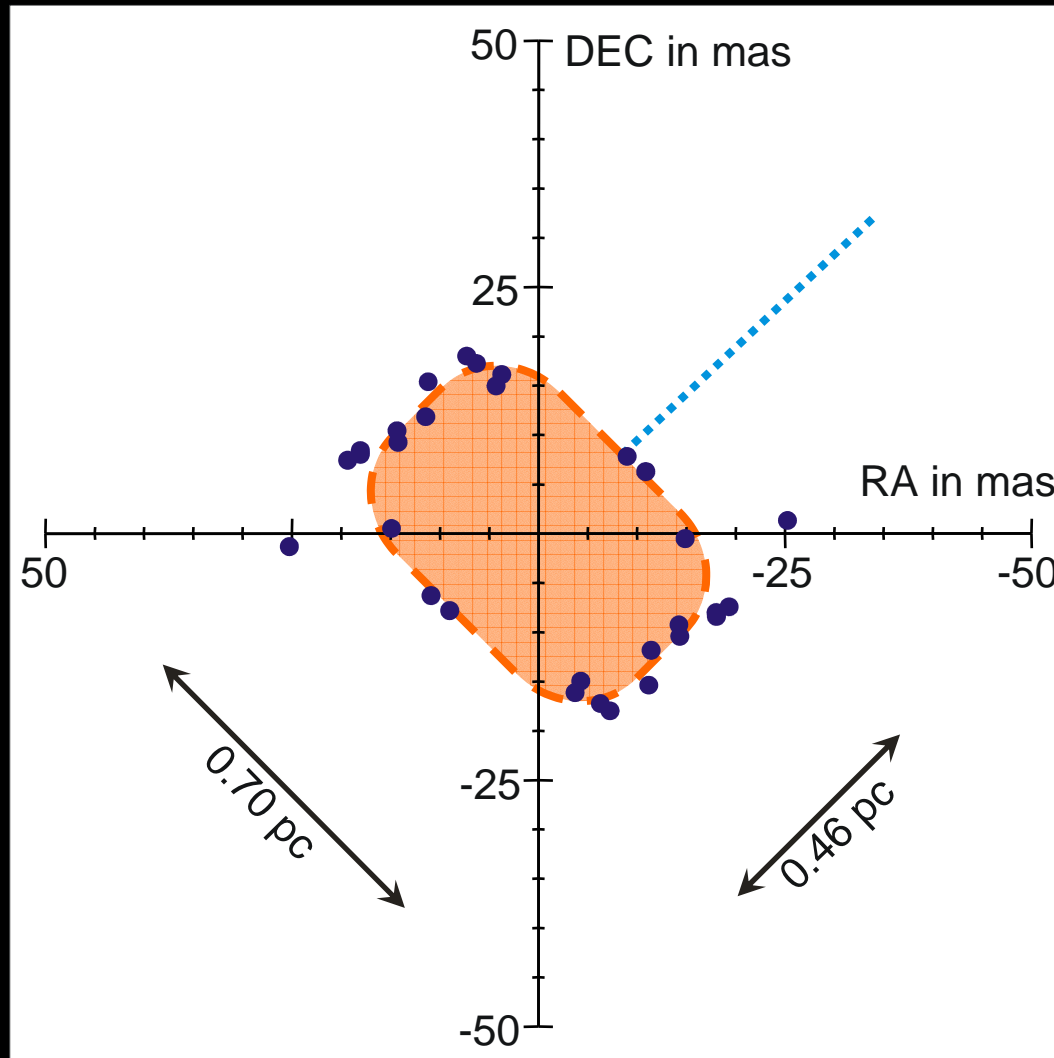
Circinus: Results



Expected geometry
configuration

Tristram et al. 2006

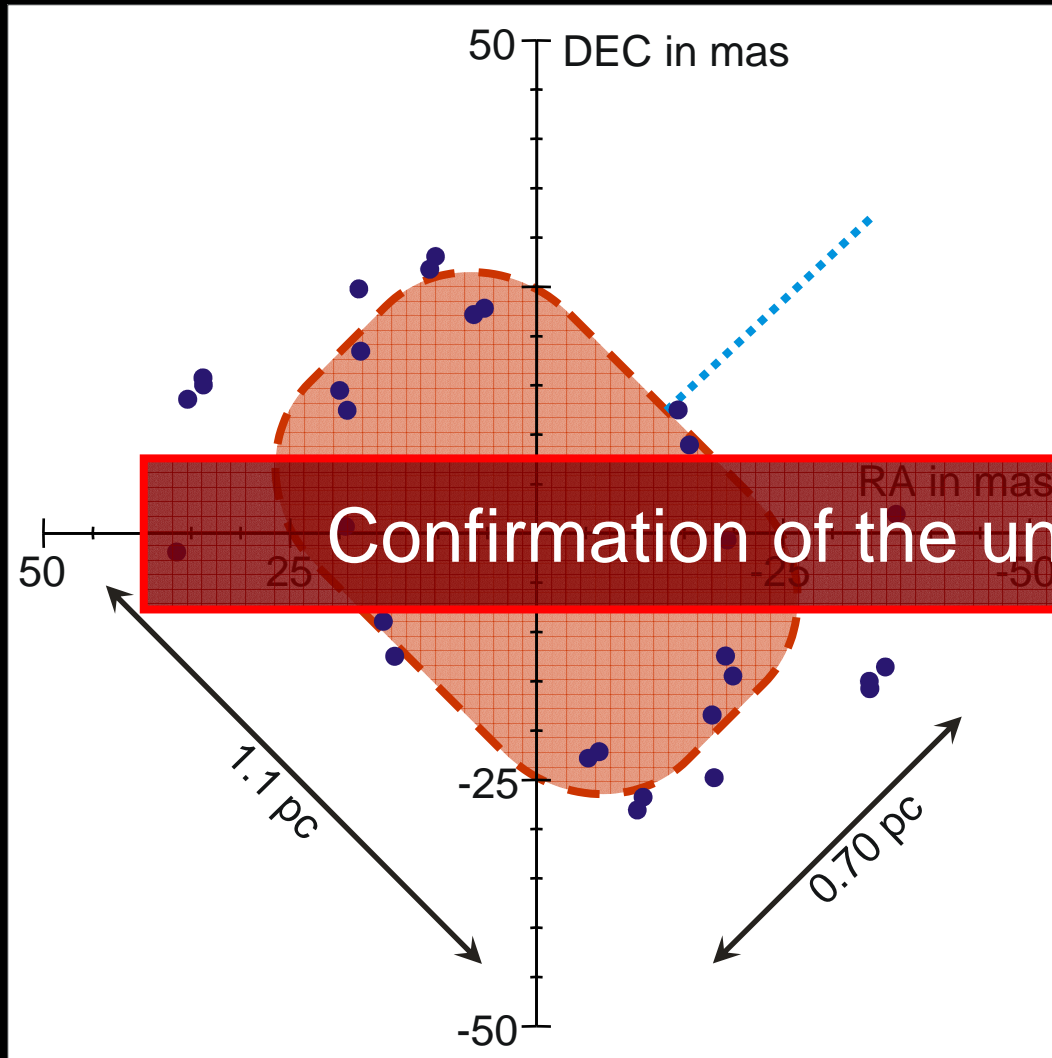
Circinus: Results



Measured geometry at $8.5 \mu\text{m}$

Tristram et al. 2006

Circinus: Results

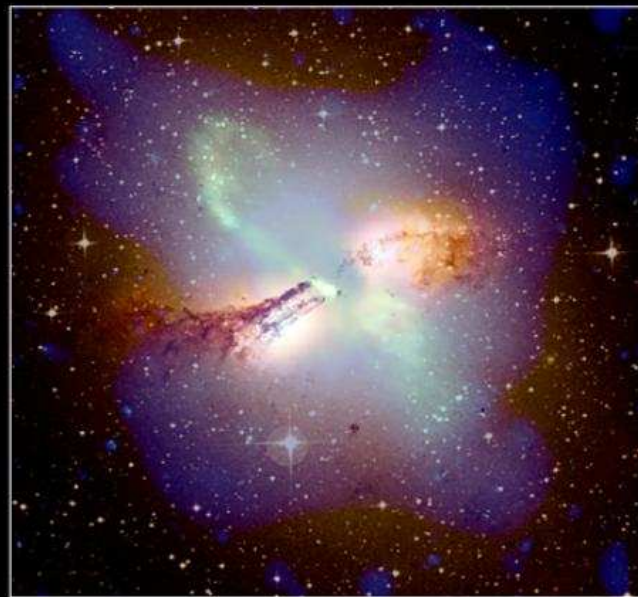


Measured geometry at 13 μm

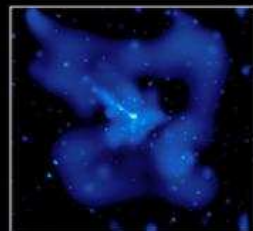
Confirmation of the unified scheme!

Tristram et al. 2006

Centaurus A: properties



- Elliptical galaxy
- dust lane edge-on
- Seyfert type 2
- FR 1 radio galaxy
- $6 \times 10^7 M_{\odot}$ nucl.
- Distance ~ 4 Mpc
→ $50 \text{ mas} \sim 1 \text{ pc}$



CHANDRA X-RAY



DSS OPTICAL



NRAO RADIO
CONTINUUM

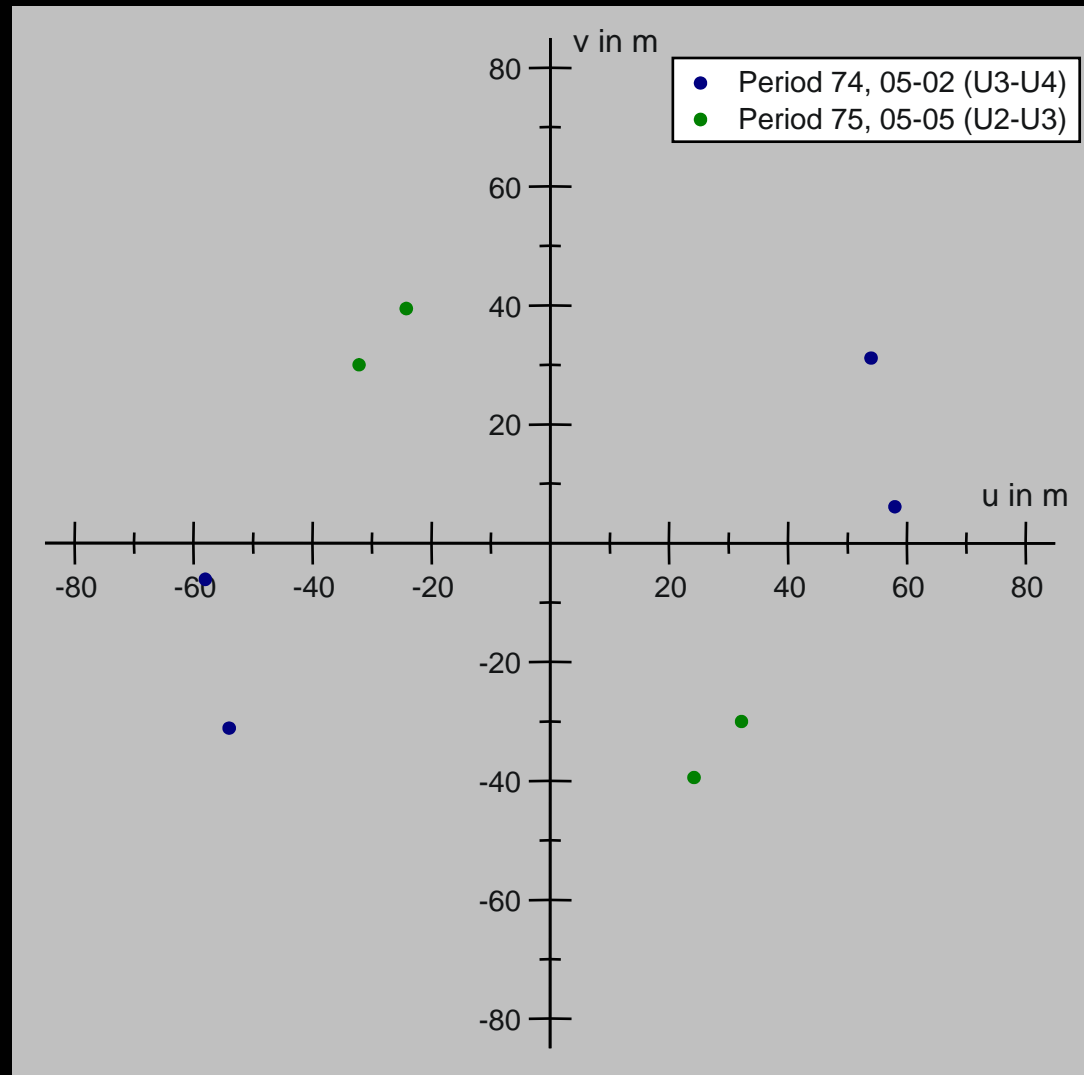


NRAO RADIO
(21-CM)

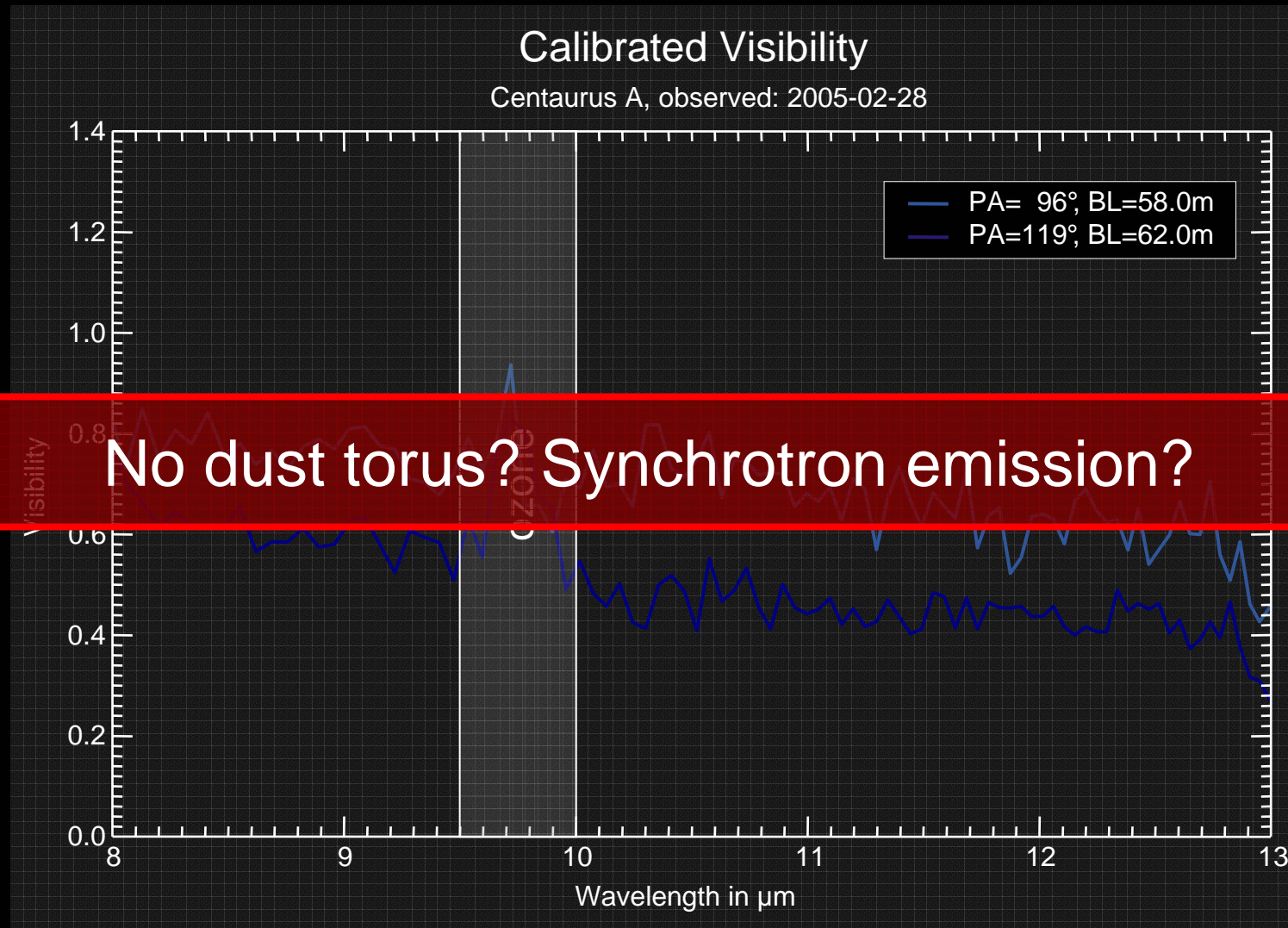
Centaurus A: UV plane



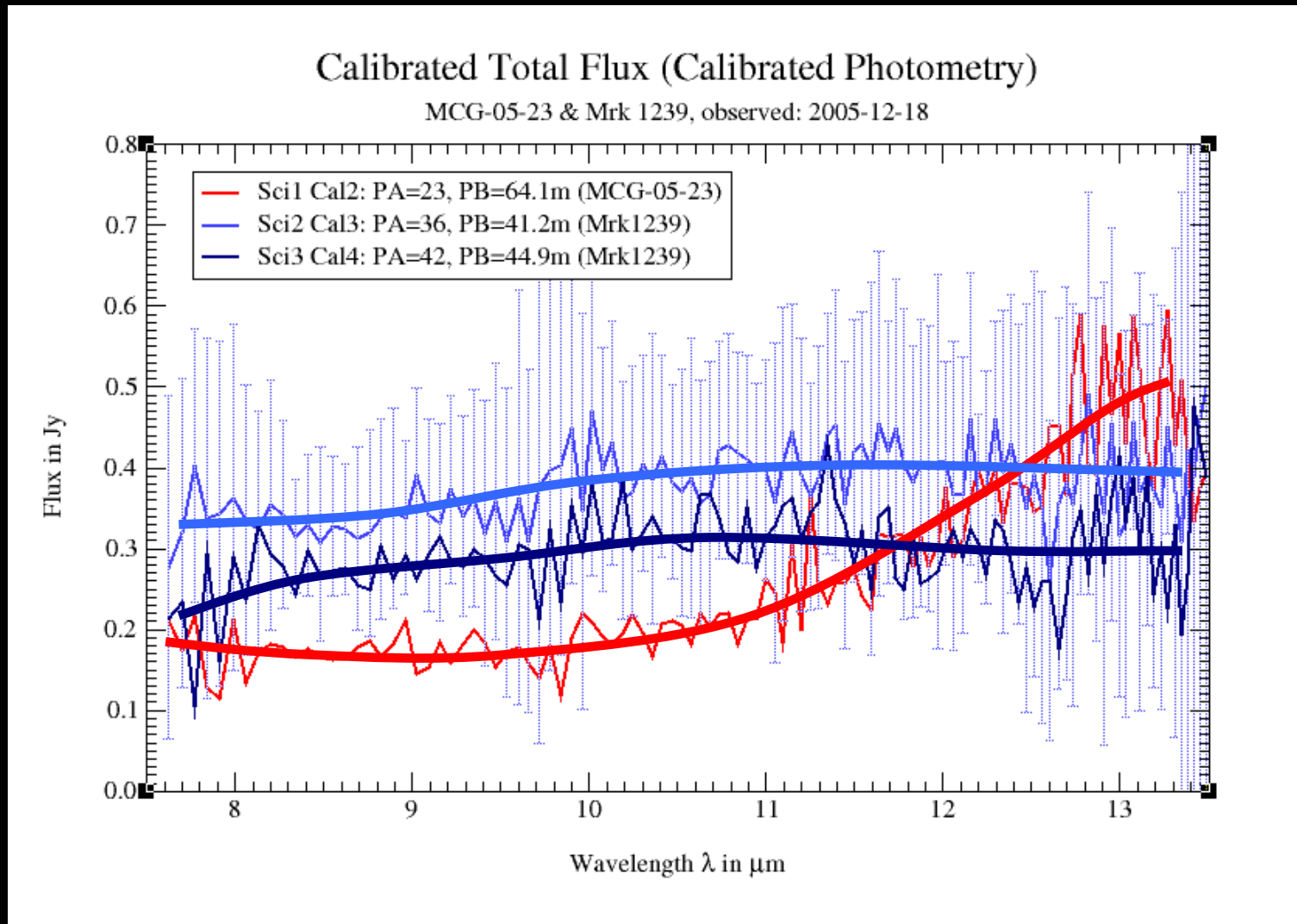
- GTO observations in P74 and P75
- 4 independent visibility points
- problems with photometry



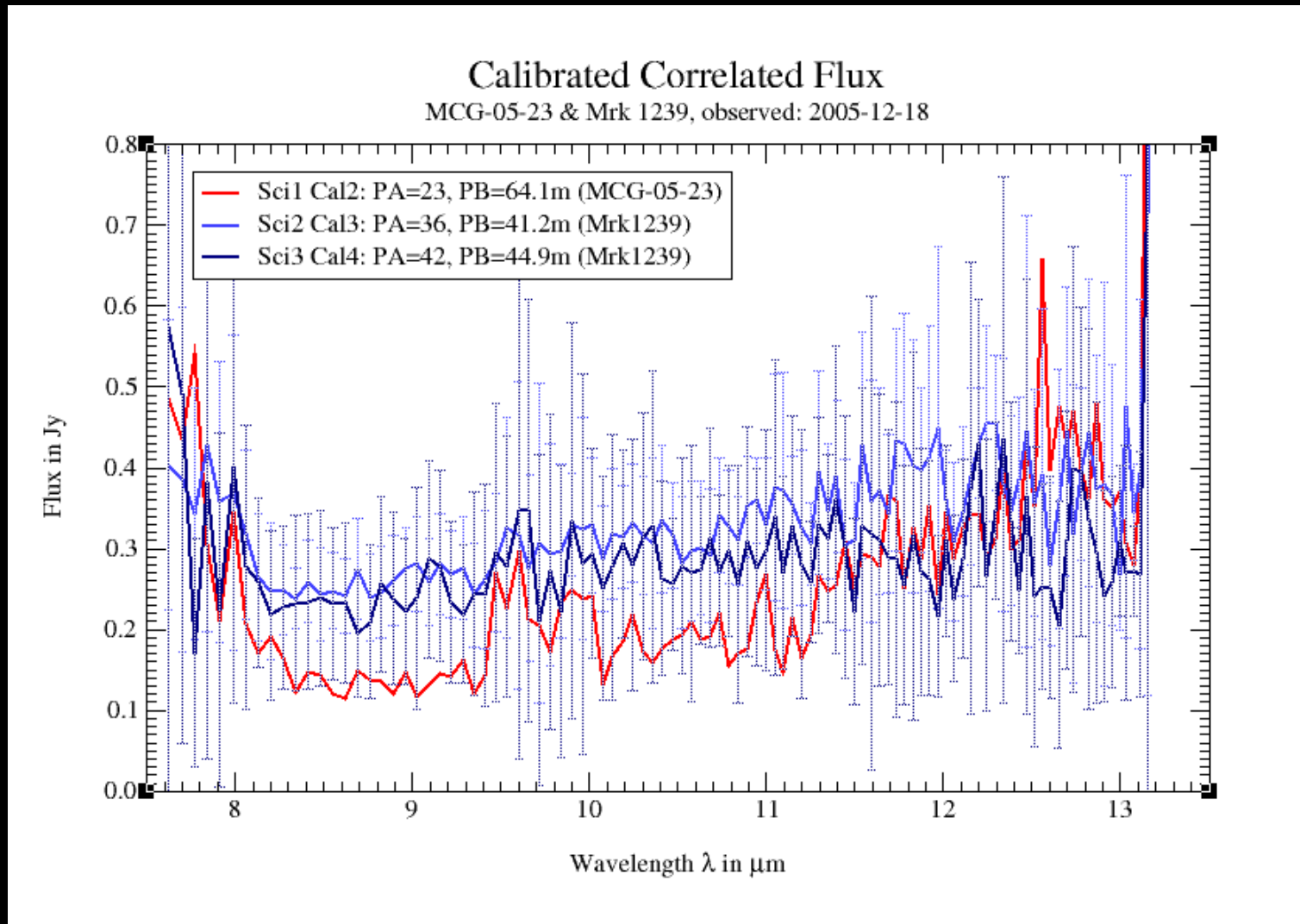
Centaurus A: visibilities



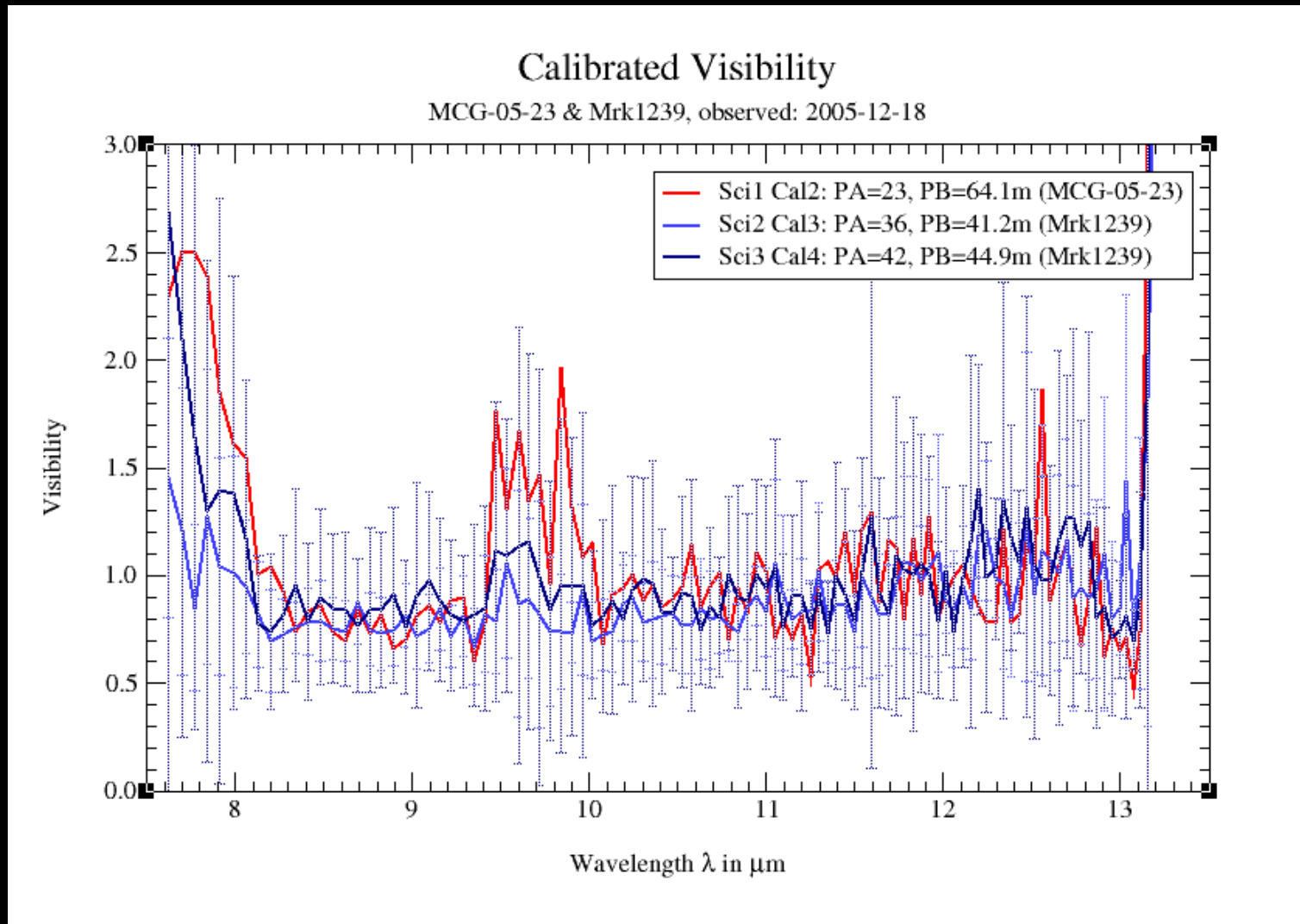
Faint AGN



Faint AGN



Faint AGN



Faint AGN

- Observation time for faint targets:

MCG -5-23-016 — 57 min

Mrk 1239 — 53 min

Mrk 1239 — 50 min

↳ **1 hour** for faint target + $\frac{1}{2}$ for calibrator.

- No problem tracking **200 mJy** correlated flux.
- High visibility on sources

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Prospects

- Long baselines for unresolved targets
- Shorter baselines for highly resolved targets
 - ↳ try ATs (?)
- Extension of sample (need FINITO)

Conclusions

- Only limited sample of observable AGN
- “Inconclusive” results
- To study more objects an increase of sensitivity needed