Thüringer Landessternwarte, Tautenburg (Germany)

VLMs/BDs

Stanislav Melnikov
Jochen Eislöffel

Oct 2005 – Nov 2007

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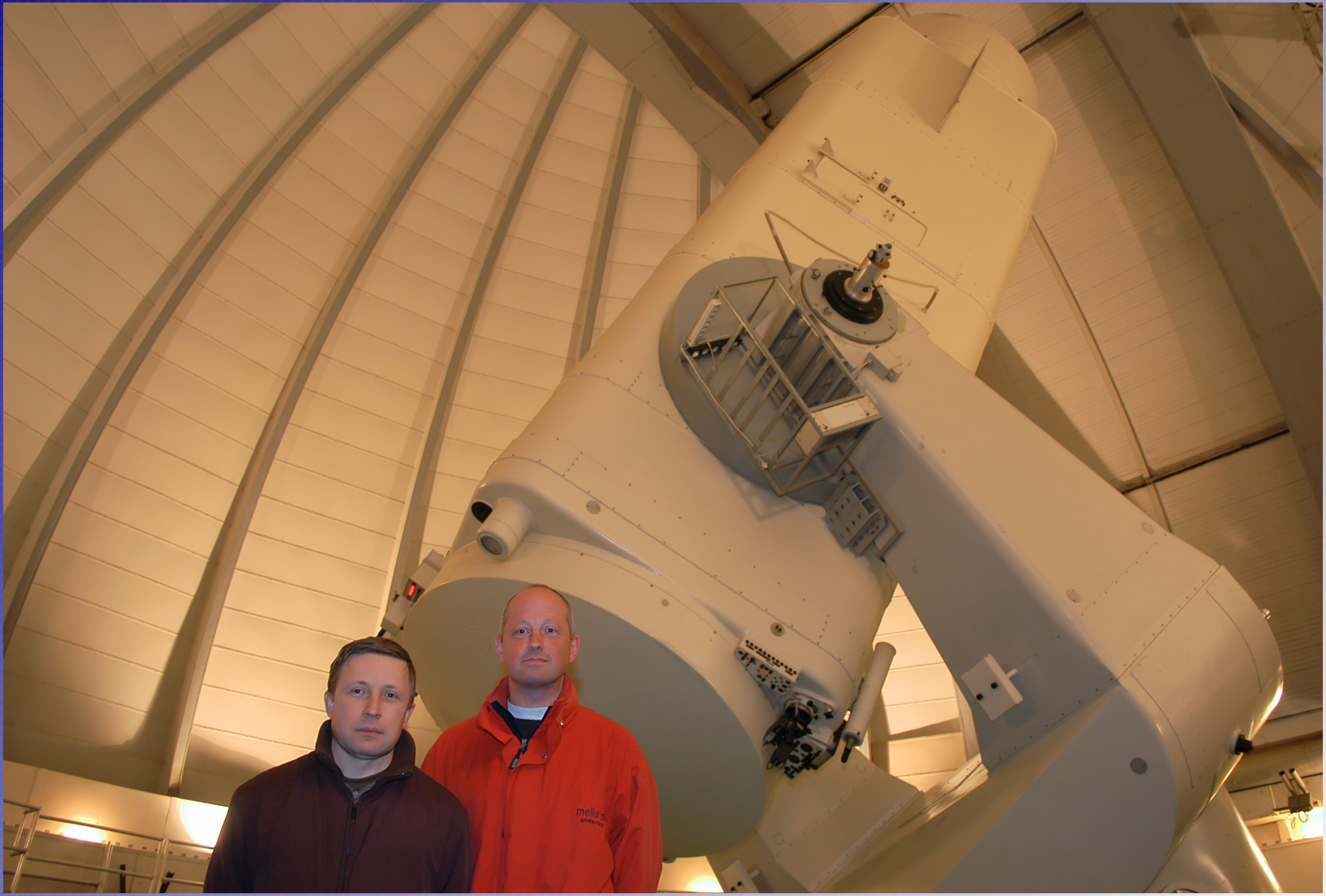

2-m Schmidt telescope

- Schmidt CCD camera

  CCD Site 2k x 2k, 42'x42', UBVR, Ha, [SII]
- Coude Eschelle Spectrograph

  CCD 2k x 2k, 3400-9270 A, 0.027-0.073 A/pix
- Nasmyth Faint Object Spectrograph

  CCD 1024x800 pixs, 1200-11500 A, 1.5-3.5 A/pix

- Multi-object Spectrograph, 1.35 m
- CCD Plate Scanner

2-m Schmidt telescope

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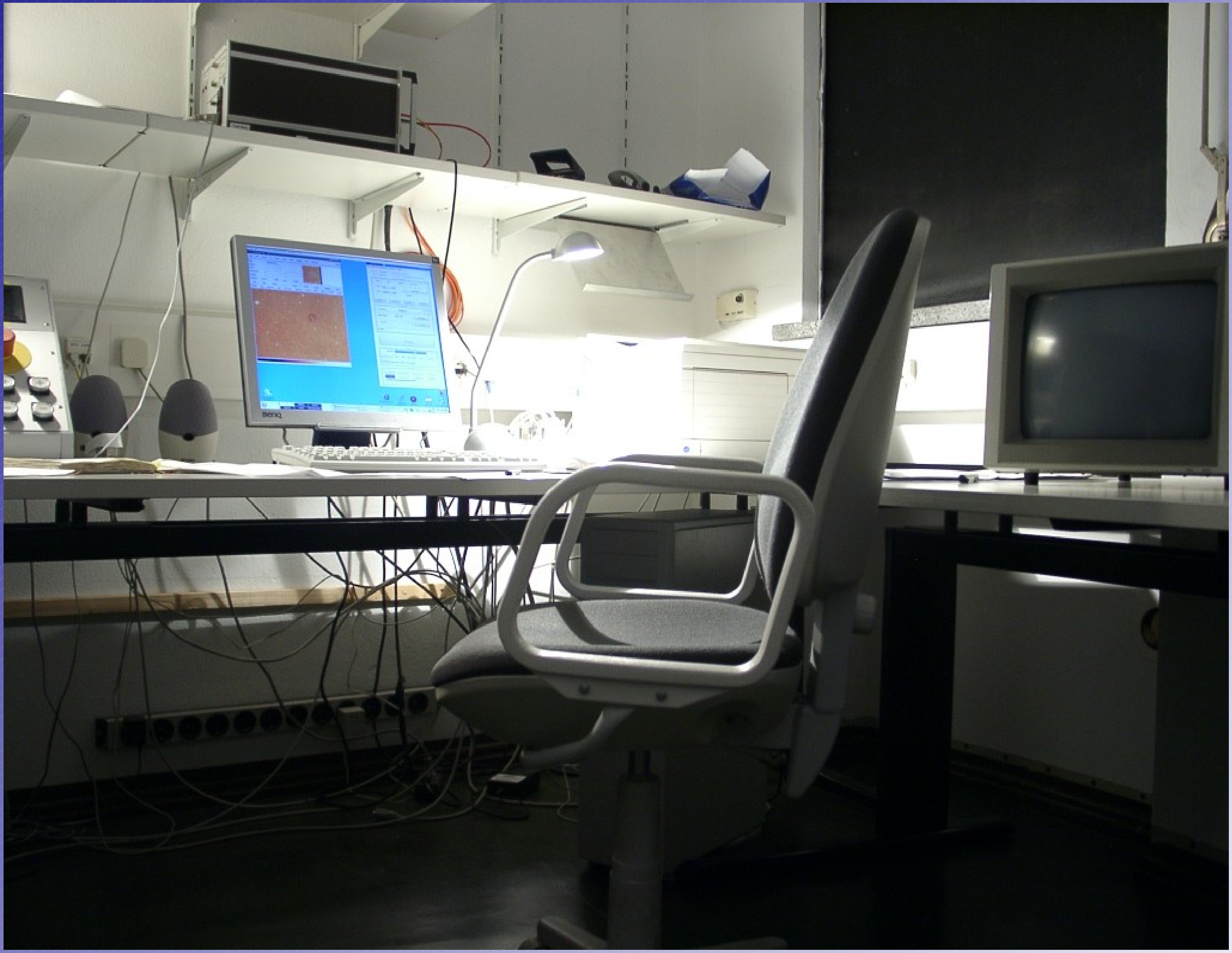

2-m Schmidt telescope

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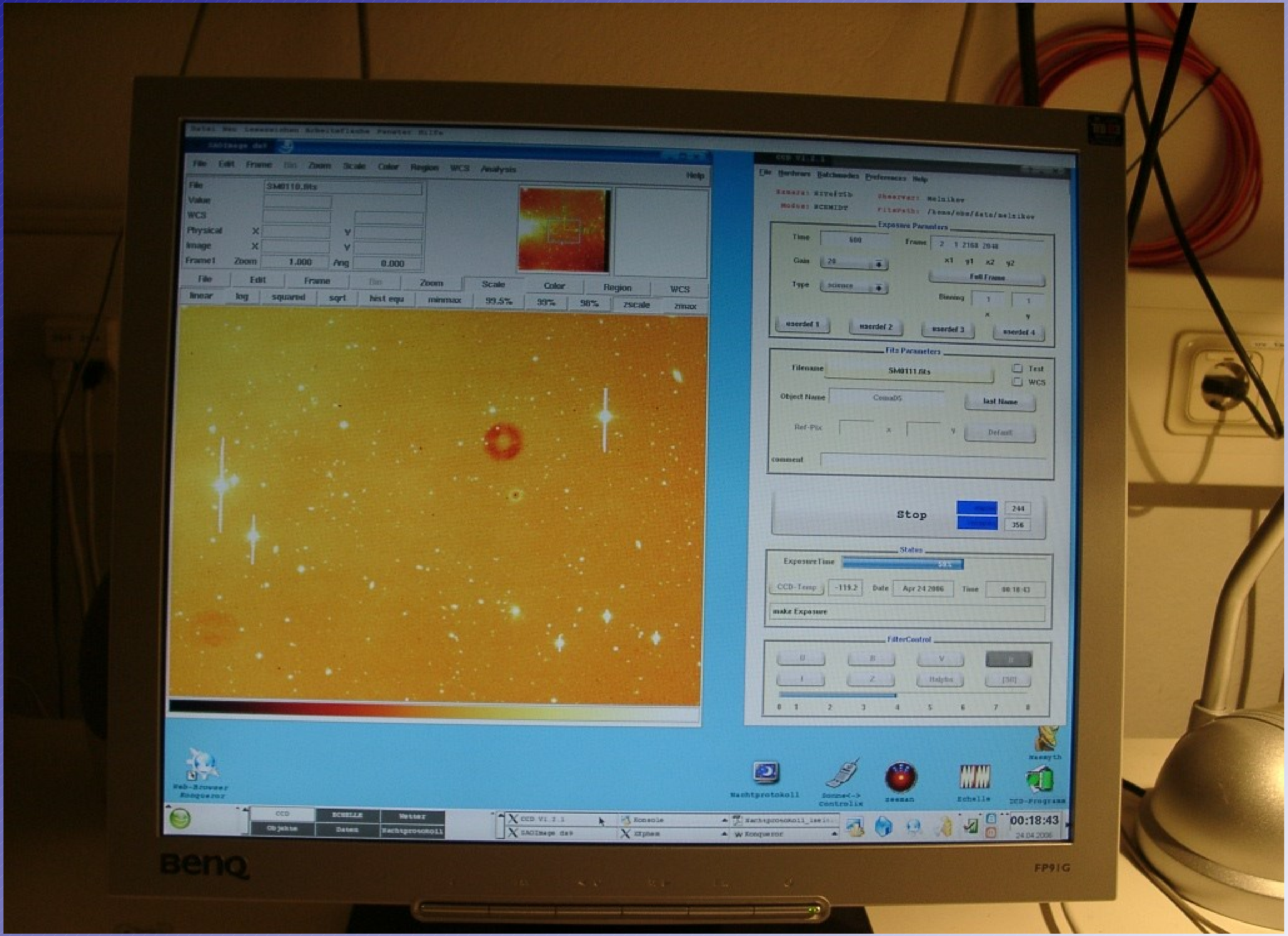


Thüringer Landessternwarte, Tautenburg (Germany)

- Extra-solar planets

  RV detections, photometric transits, CoRoT
- Extragalactic

  Gamma Ray Bursts, Active Galaxies
- Stars

  Stellar oscillations, Doppler Imaging

  Stellar Magnetic Activity
- Star Formation

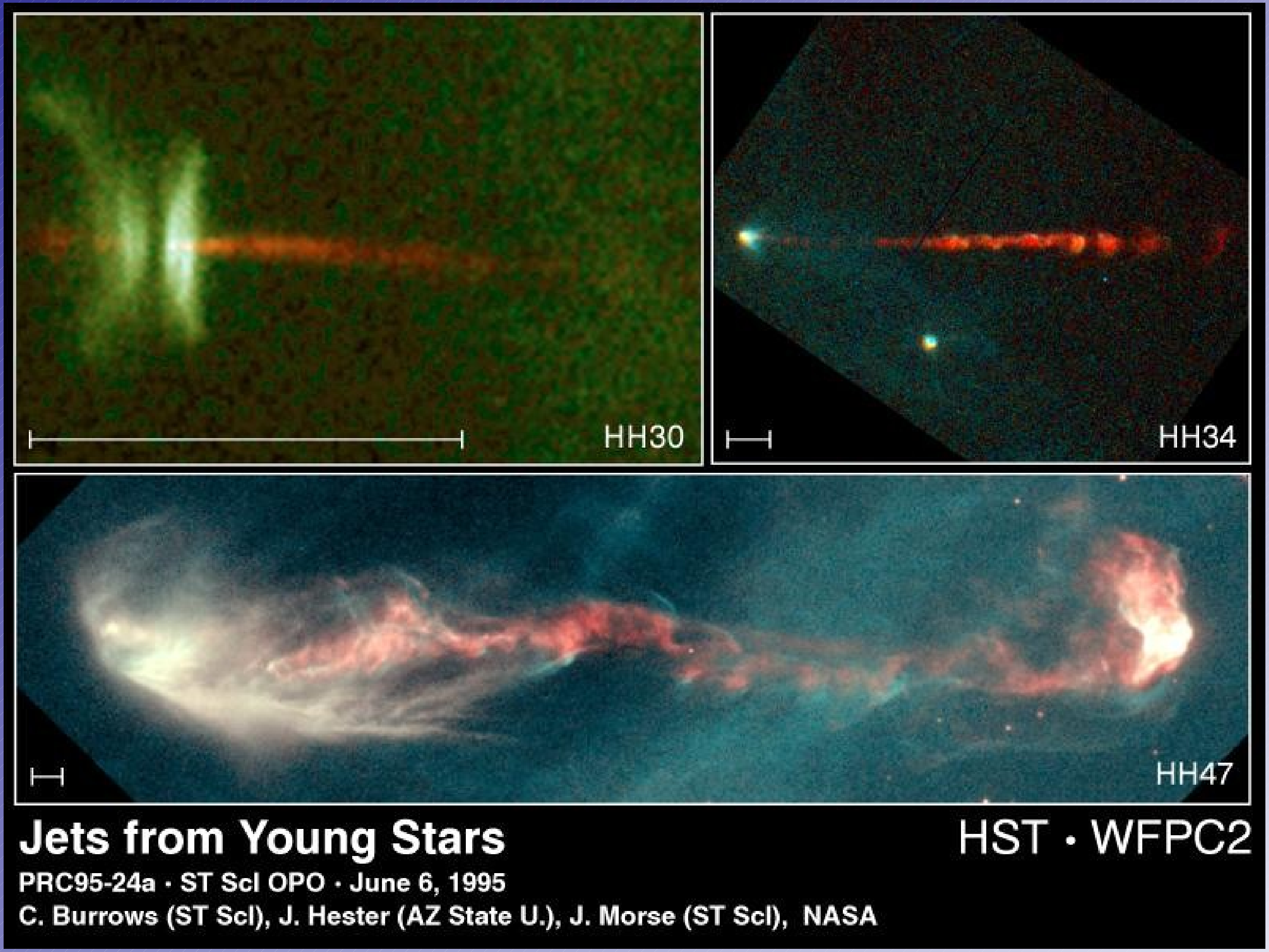
  Jets and Outflows from YSOs, Brown Dwarfs

Jetset

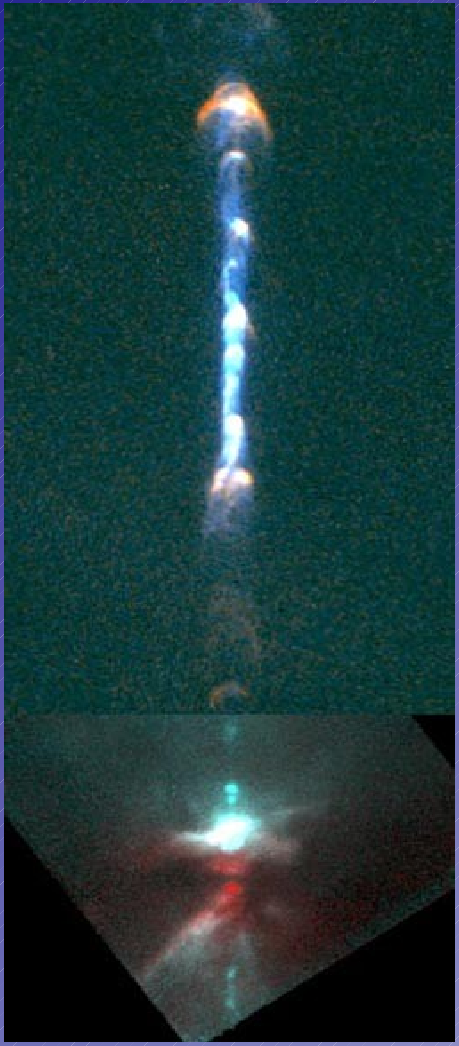
European Research and Training Network on JET Simulations, Experiments and Theories

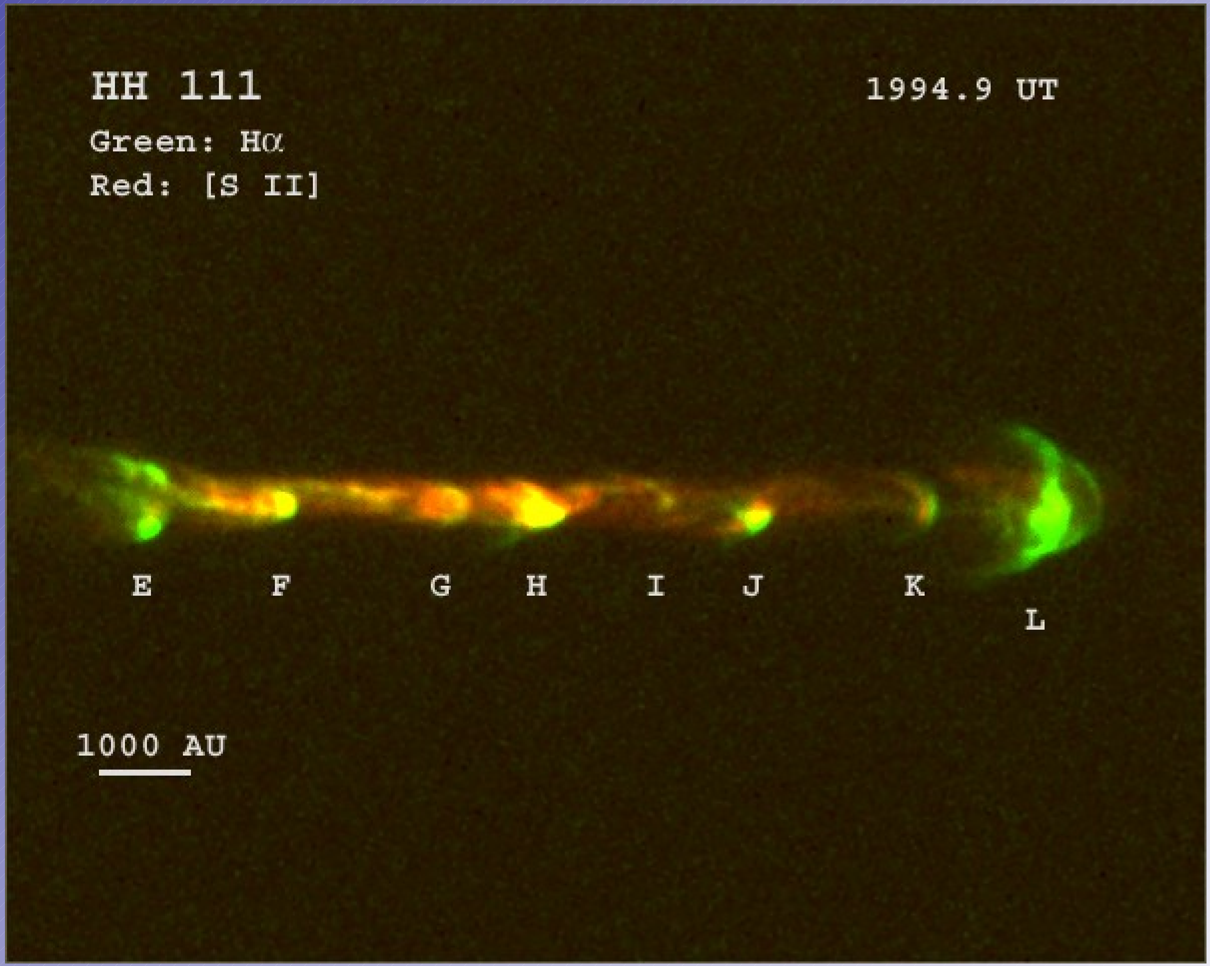
- WP1: The models of MHD Jet in Young Stars
- WP2: The Observed Structure, Propagation and Heating/Cooling of Stellar Jets
- WP3: The Molecular Counterparts, and Effects of Jets on their Environment
- WP4: The Structure, Propagation, and Heating/Cooling of Laboratory Jets
- WP5: Large Numerical Simulations of Jets using Grid Technology

JETSET:
JET Simulations, Experiments, Theories



JETSET:
JET Simulations, Experiments, Theories





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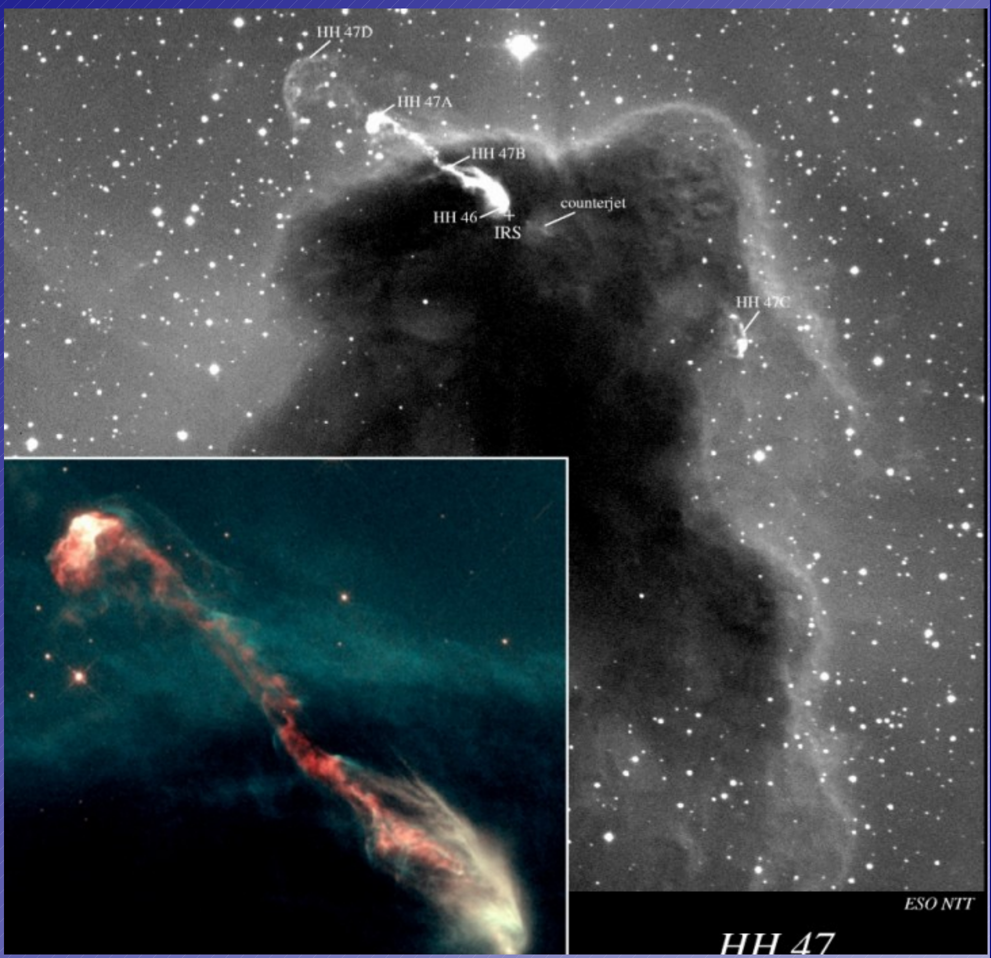
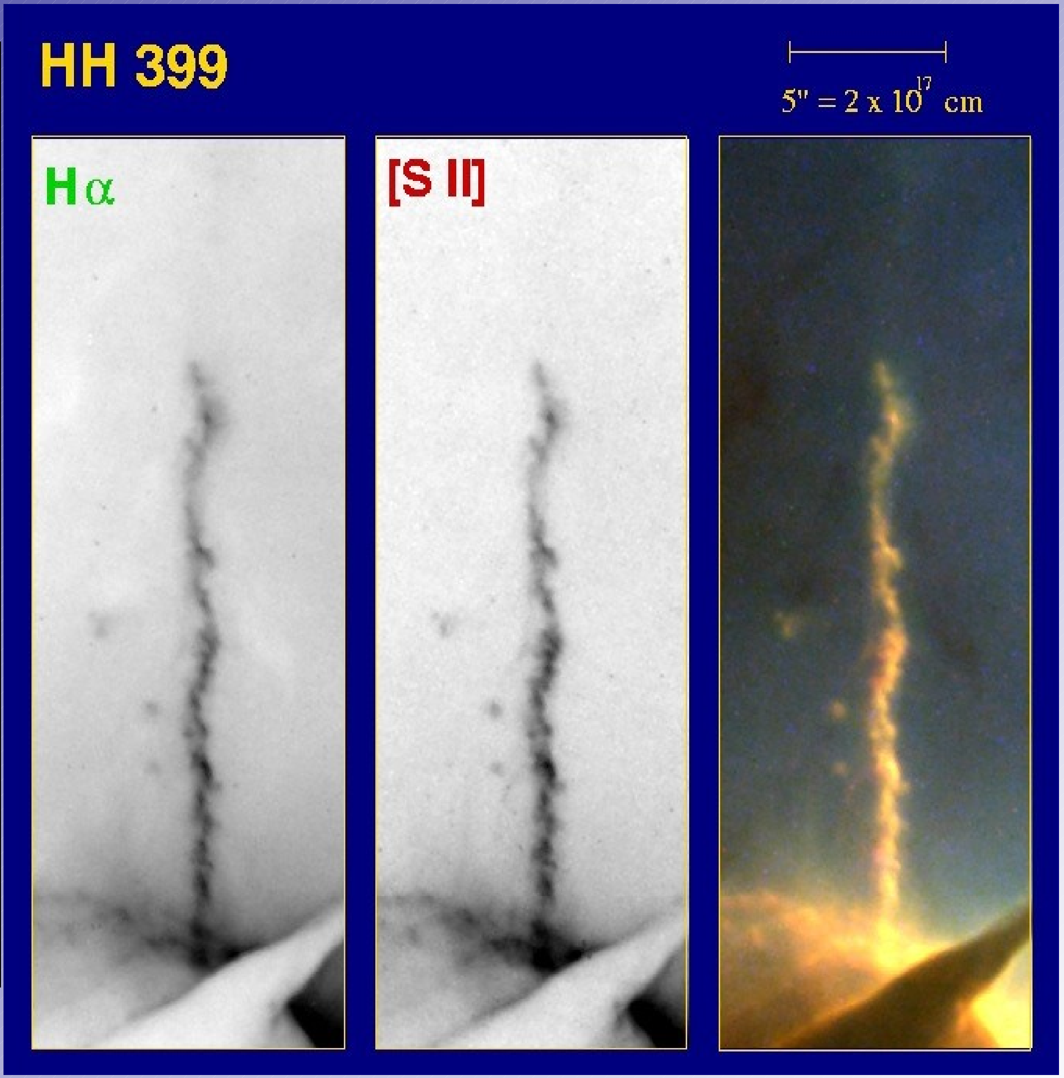
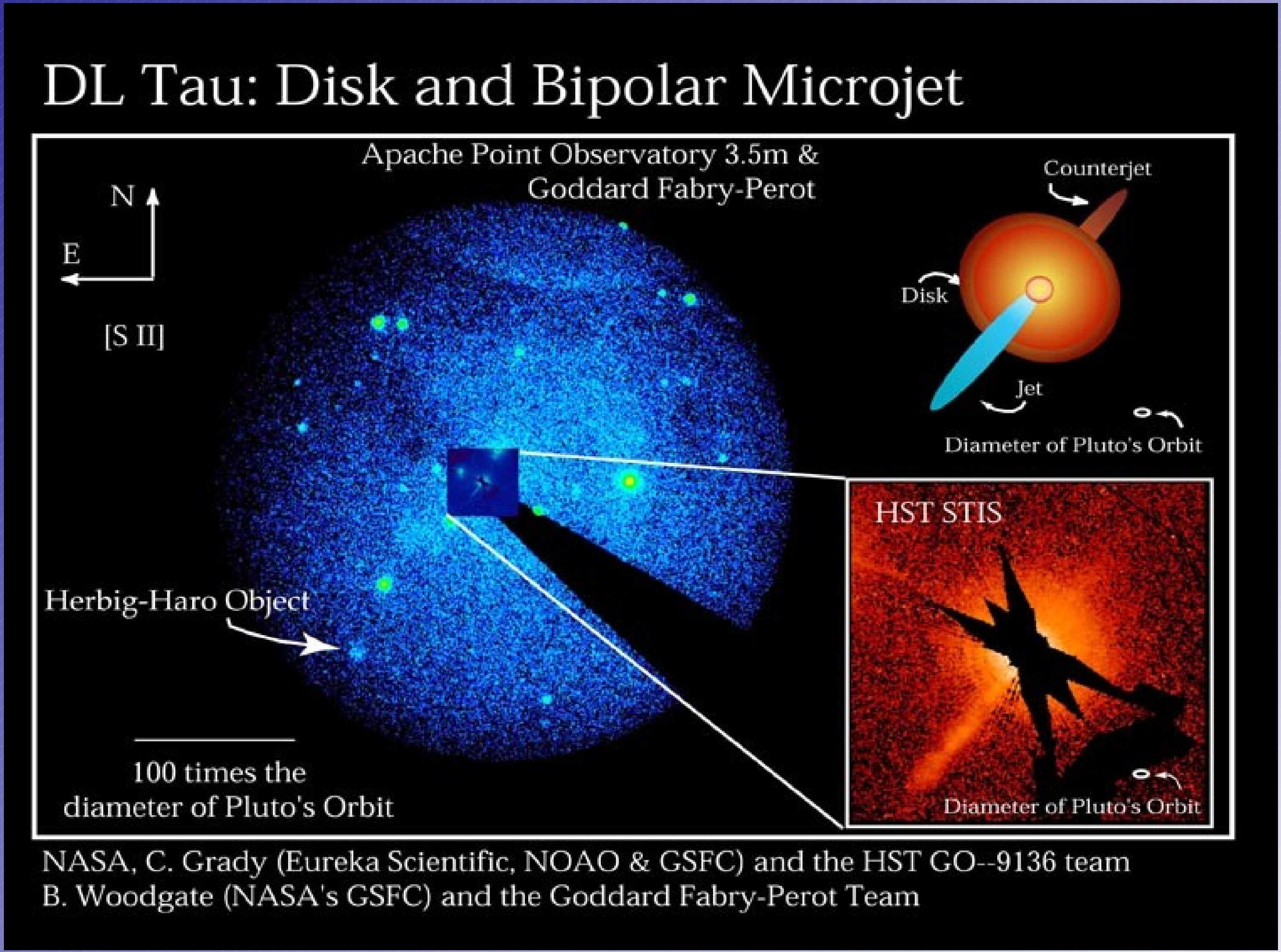
JET Simulations, Experiments, Theories





JETSET:
JET Simulations, Experiments, Theories



JETSET:
JET Simulations, Experiments, Theories

Comparison of parameters of the jets from the T Tauri star RW Aur and the Herbig star LkHα 233 from high-resolution HST spectra

Stanislav Melnikov

Thüringer Landessternwarte, Tautenburg (Germany)

Jochen Eislöffel, Francesca Bacciotti,
Tom Ray, Jens Woitas

Marciana Marina, Italy
4-8 September 2006

Outline:

- Hubble Space Telescope (HST) observations of jets
- Review of the RW Aur and the LkHα 233 properties
- Analysis of T Tauri jets using HST long-slit high-resolution spectra: 'BE method'
- The Herbig star LkHα 233 jet vs. RW Aur jet and other T Tauri jets
- Conclusions

HST observations of young stars jets:

Cameras: STIS Grating: G750M
WFPC2 Filters: F673N, F631N, F547M

Angular resolution: 0".1 Spatial sampling: 0".05/pix

T Tauri stars and low mass objects:

published data

• HH 30
• RW Aur (preliminary results)
• DG Tau

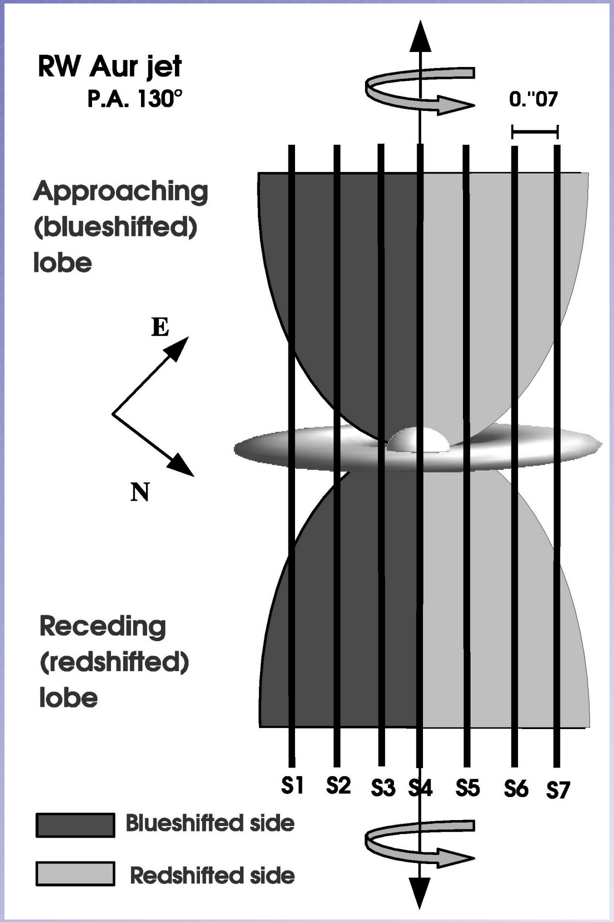
submitted data

• CW Tau
• TH 28

Herbig Ae/Be stars:

none

HST observations of young stars jets:



Woitas et al 2005

General characteristics of RW Aur & LkHα 233

RW Aur: Sp – K1-K4
features: double

main component:

$M_* = 1.3\ M_\odot$

$L_* = 3.4\ L_\odot$

$T_* = 4000$ K

$\dot{M}_{\mathbf{acc}} = 1.6\ 10^{-6}\ M_\odot/y$

$V_{\mathbf{mag}} = 10.1$

Av=1.5

d = 140 pc

LkHα 233: Sp – A5e
features: X-shaped nebula (0.1pc)

$M_* = 2.6\ M_\odot$

$L_* = 28\ L_\odot$

$T_* = 8500$ K

$\dot{M}_{\mathbf{acc}} = ?$

$V_{\mathbf{mag}} = 13.5$

Av=2.6

d = 880 pc

Method:

- Long-slit high-spatial resolution spectra with STIS/HST, grating G750M (FWHM = 0".1).

RW Aur, Dec 2000 LkHα 233, Oct 1999

- Extraction of jet parameters with BE technique: Bacciotti & Eislöffel 1999, Osterbrock 1989

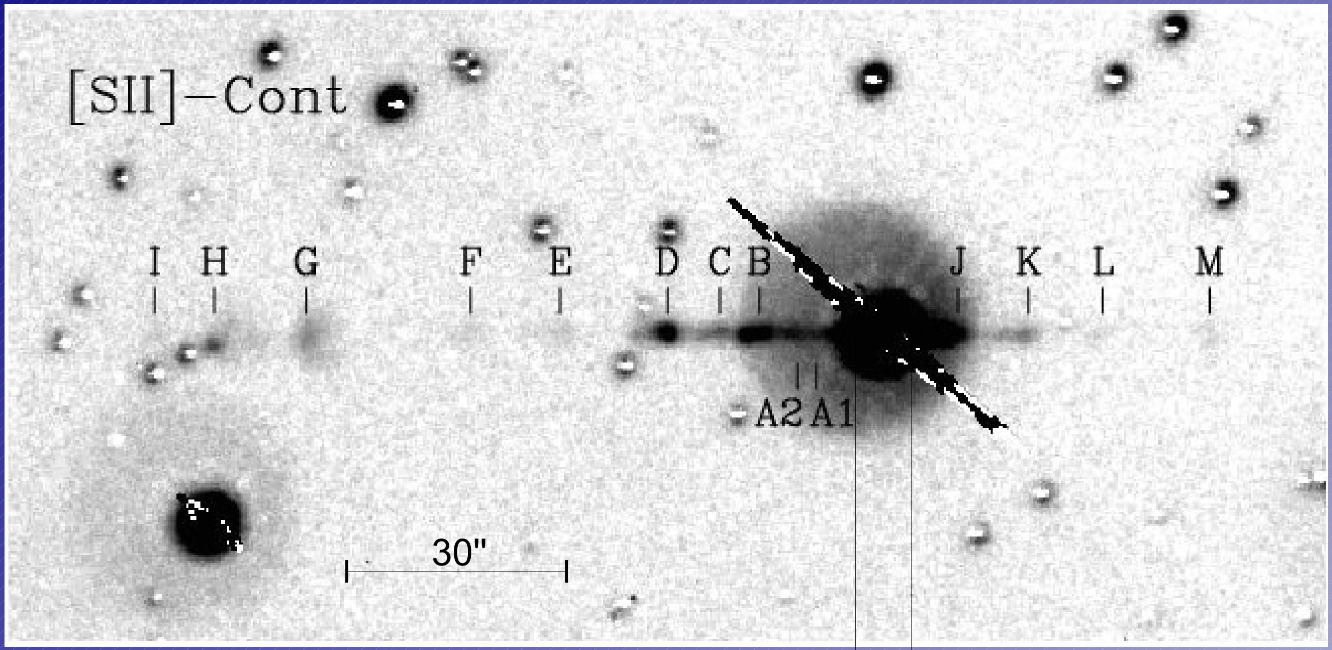
Basic ratios:

- S[II] λ 6716/6731 Å → N_e
- $\frac{\text{O[I] (6300+6363)}}{\text{N[II] (6548+6583)}}$ → X_e
- $\frac{\text{S[II] (6716+6731)}}{\text{O[I] (6300+6363)}}$ → T_e

Additional parameters:

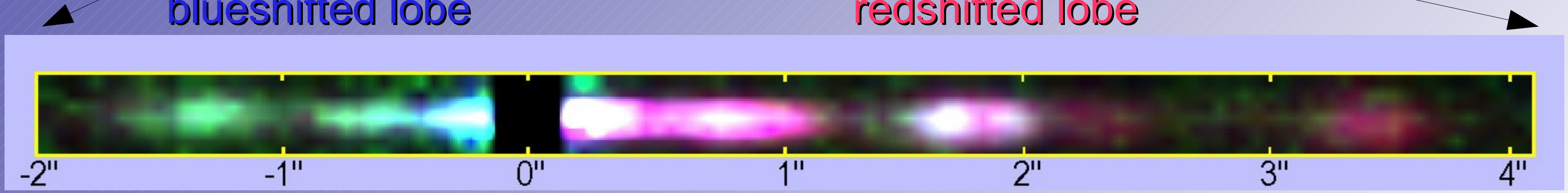
- $N_H = N_e / X_e$
- V_{rad}
- $\dot{M}_{jet}$ & $\dot{P}_{jet}$

RW Aur A: modern scale



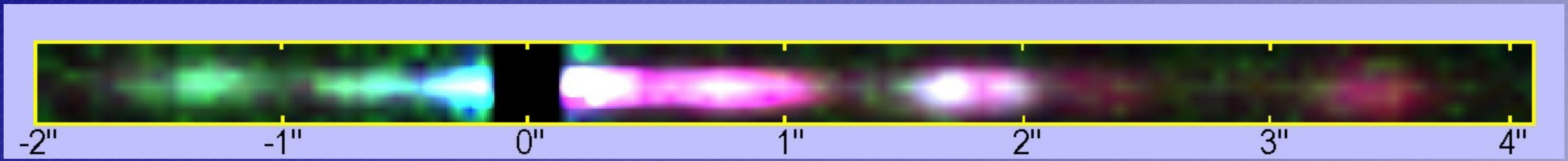
Discovery:
Hirth et al 1994

Eislöffel & Mundt
(1998)

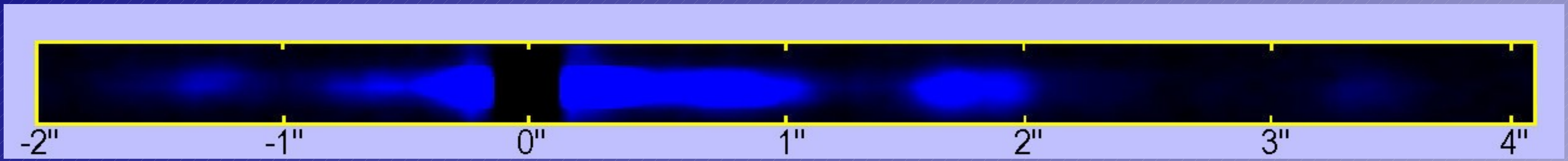


HST data (2000): [OII]6300+6363 – blue, [NII]6548+6583 – green, [SII] 6716+6731 – red

RW Aur: jet parameters



RW AUR: jet parameters

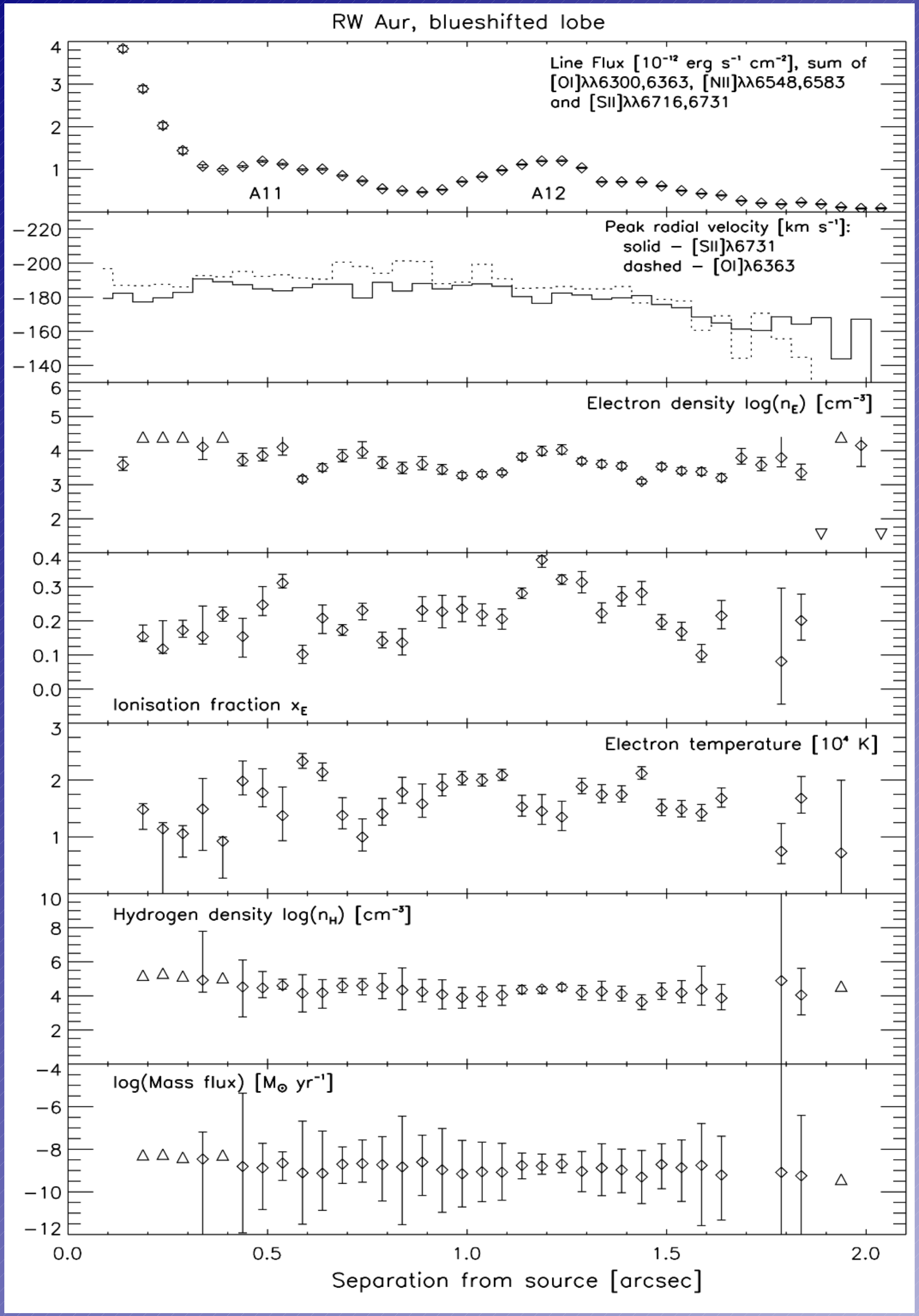


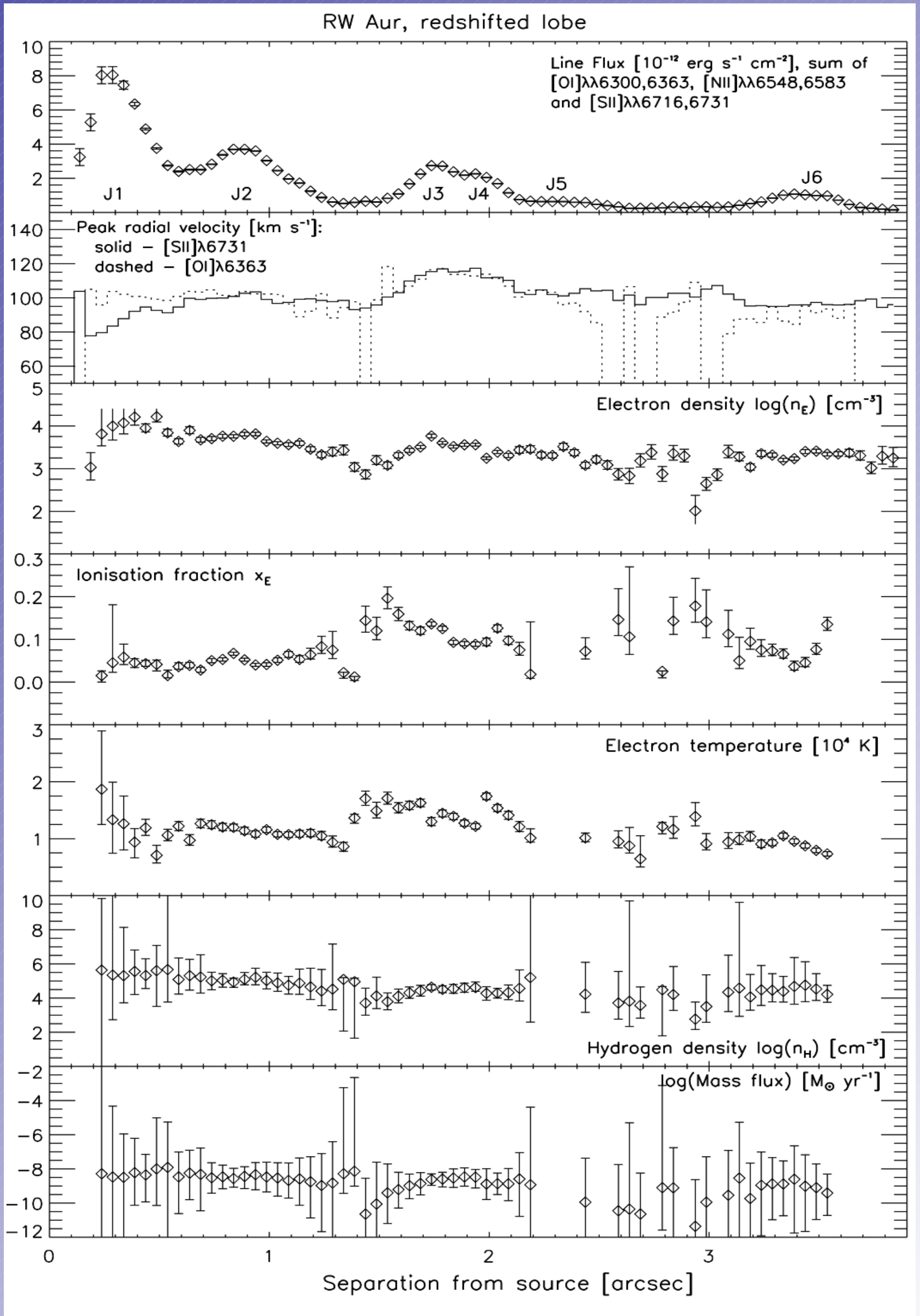
SII 6716+6731

NII 6548+6583

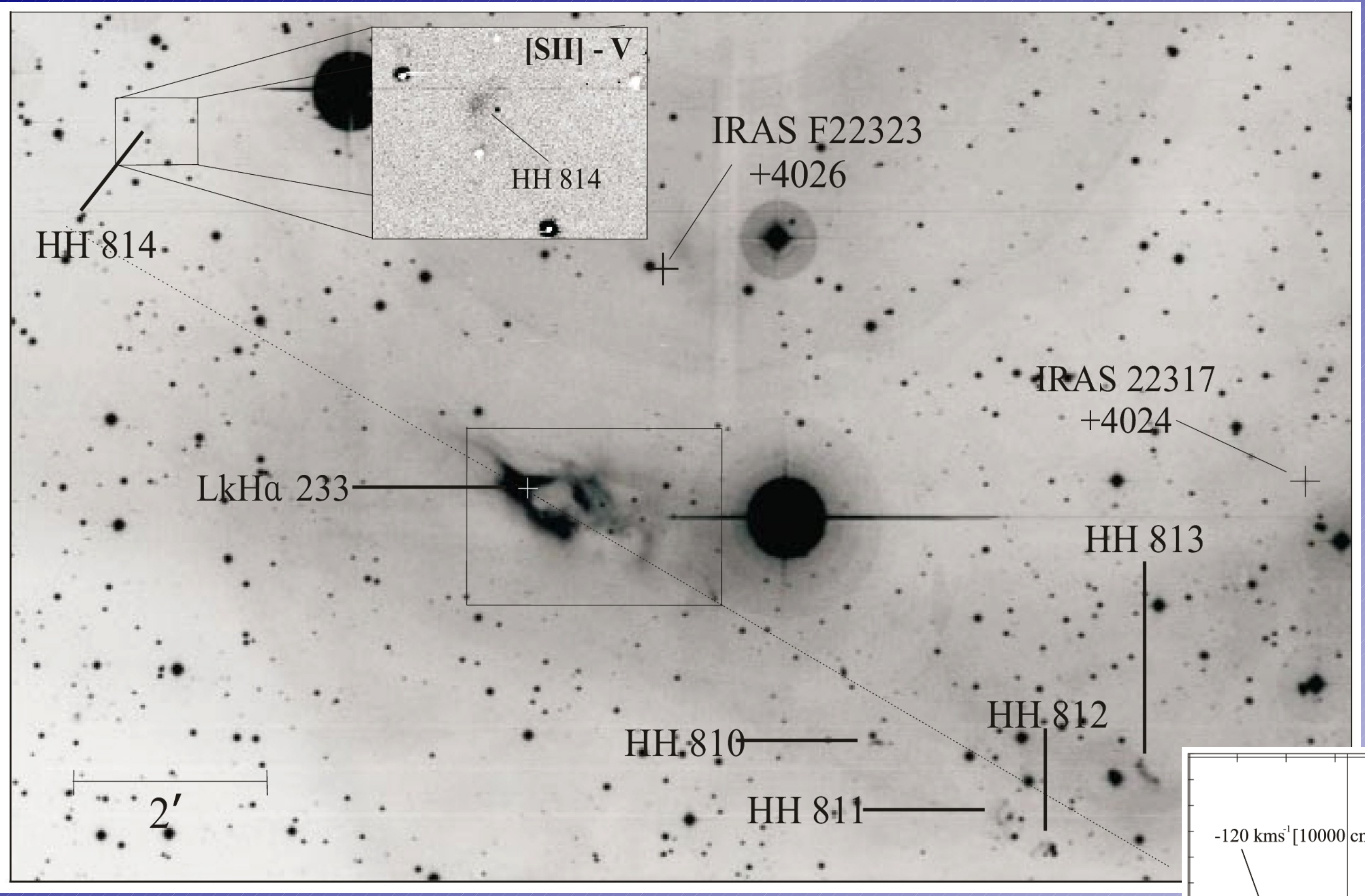
OI 6300+6363

RW AUR: jet parameters

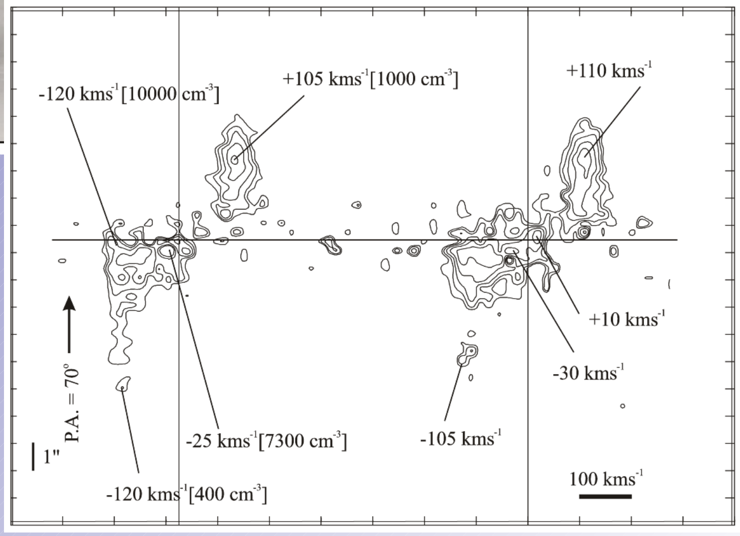




Herbig star LkHα 233 jet

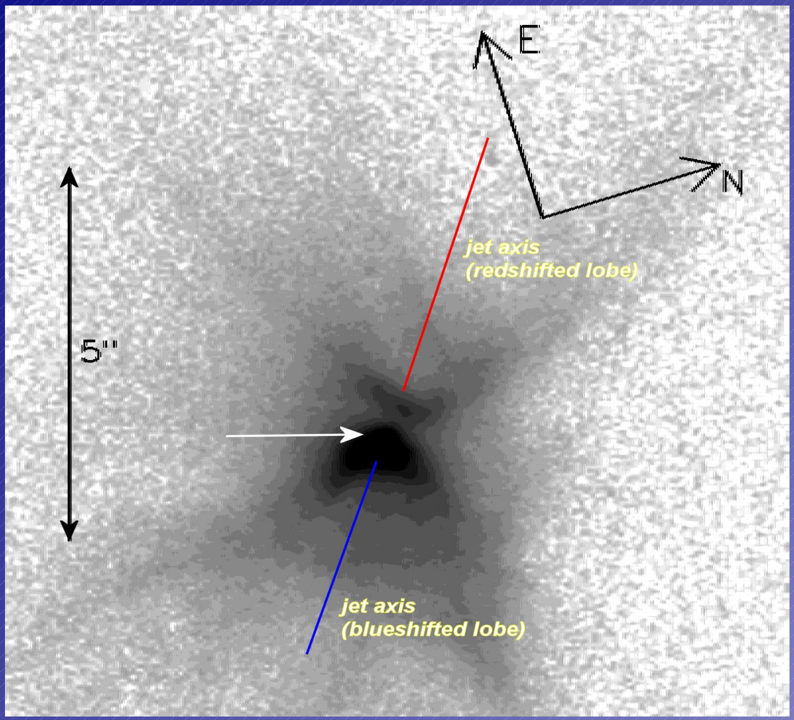


McGroarty et al 2004



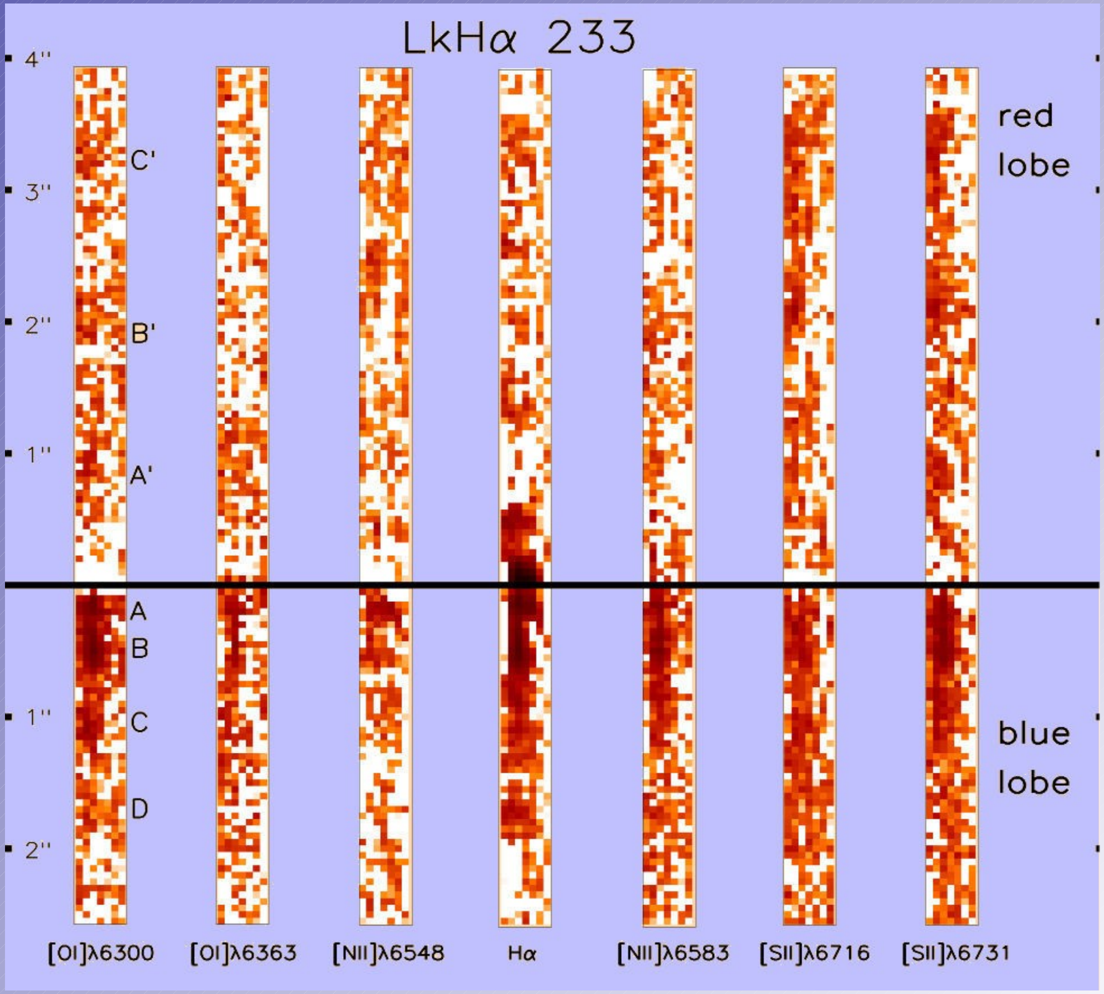
Corcoran & Ray 1998

Herbig star LkHα 233 jet

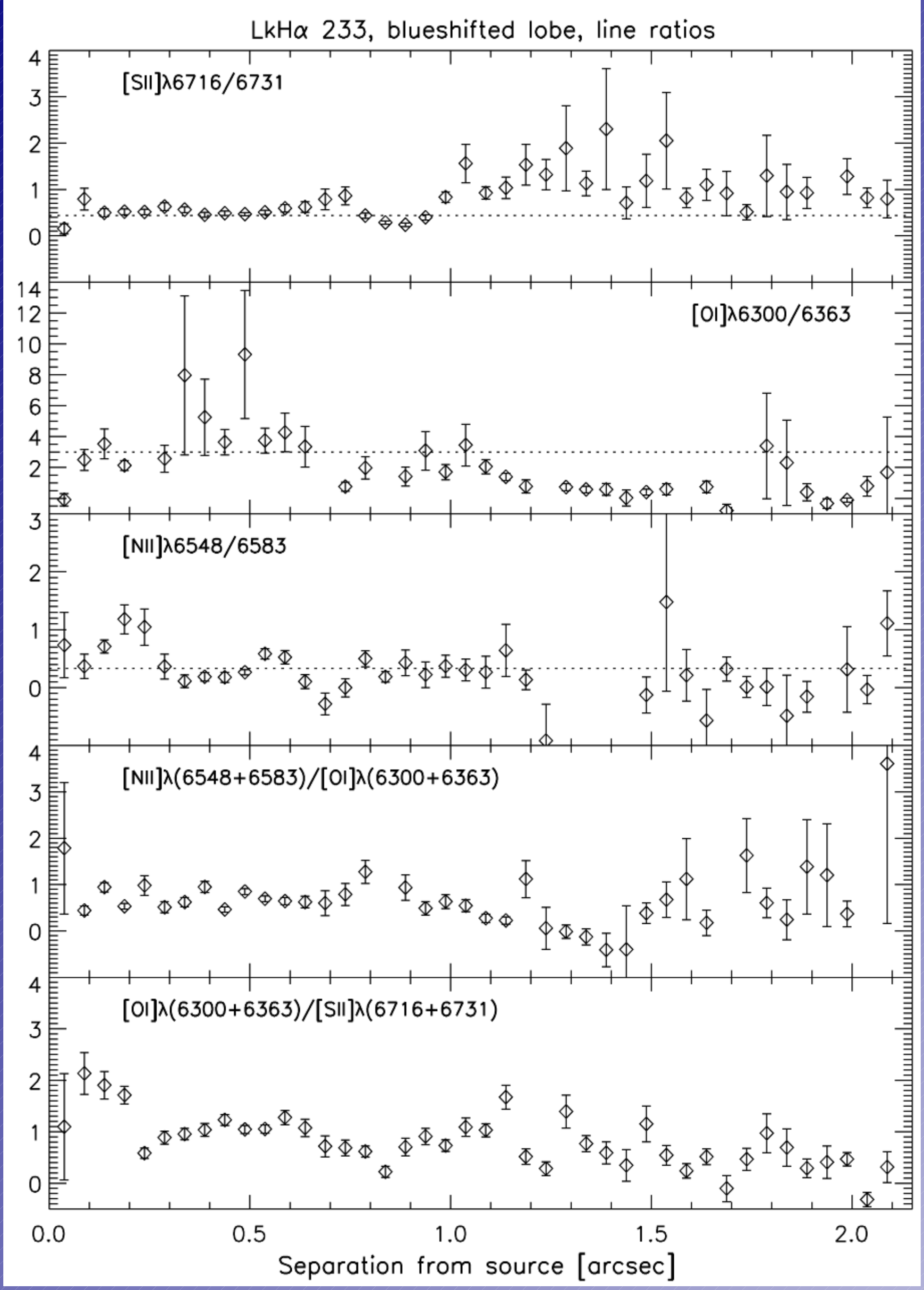


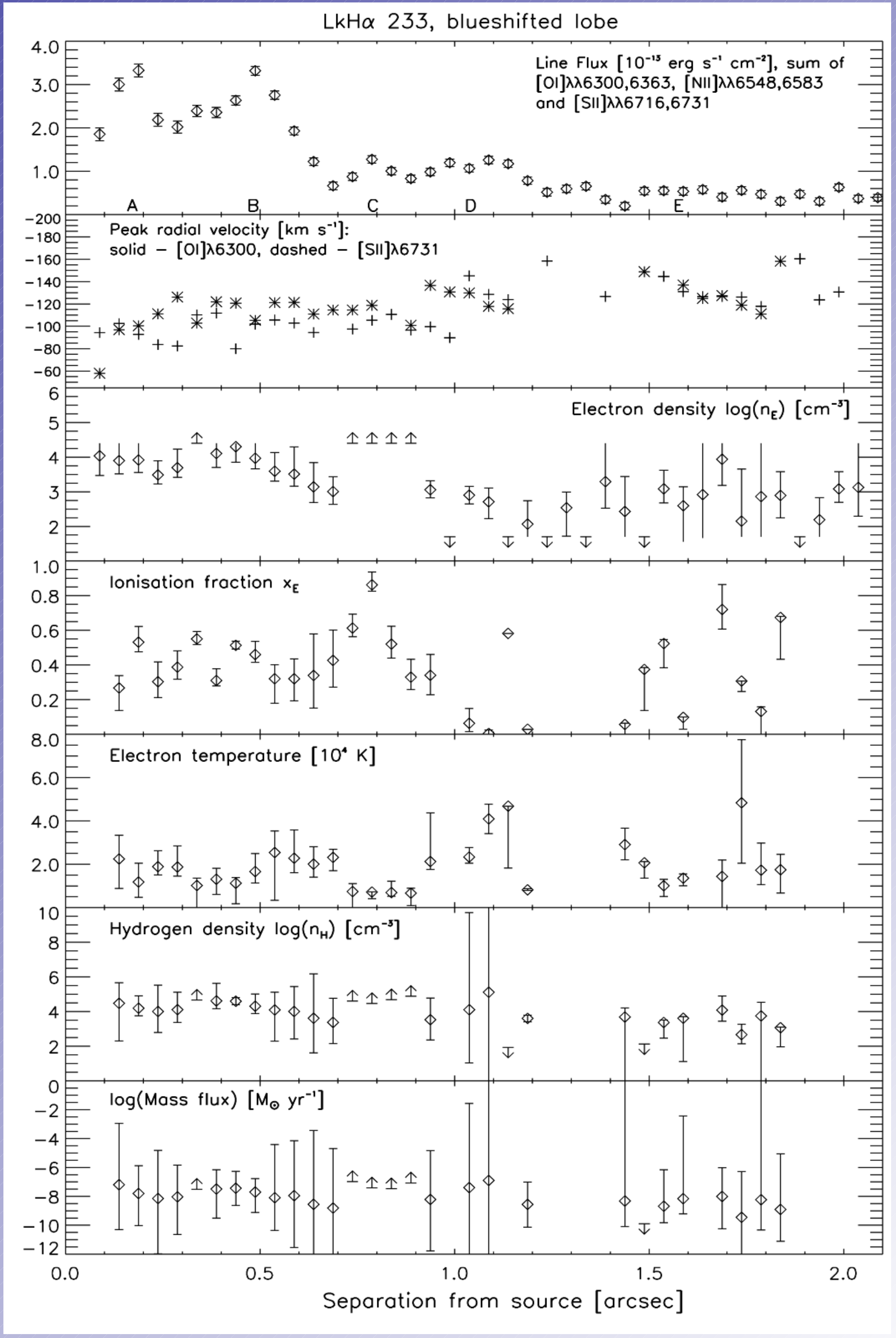
HST / WFPC2 image, 1999,
W814 filter (7900 angstrom)

HST / STIS 1999, G750M



Herbig star LkHα 233 jet





The LkHα 233 jet vs. T Tauri jets

Parameters of jets.

Name	Region (arcsec)	N_e ($\times 10^2 cm^{-3}$)	X_e	T_e ($\times 10^4$ K)	N_H ($\times 10^3 cm^{-3}$)
HH 1	2–22	6–28	0.02–0.28	2.05–1.12	2.0–101.1
HH 24C	14–35	1.8–8.8	0.2–0.34	1.0–1.5	0.6–3.8
HH 24E	-2– -29	2.0–14	0.06–0.38	0.5–1.5	0.7–12
HH 24G	37–66	0.8–6.0	0.1–0.31	0.8–1.12	0.7–2.3
HH 34*	2–27	3.7–10	0.015–0.145	0.6–1.0	20–58
HH 34**	3–27	8	0.04	0.14	16.2
HH 46/47	3–45	1.1–12	0.05–0.23	1.1–2.0	4.3–16.9
HH 73	19–49	6	0.31	0.18	1.7
HH 83	22–45	5	0.38	0.18	0.9
HH 111	15–150	10	0.1	0.13	11.3
HL Tau	18–50	2.0–6.0	0.06–0.36	0.9–1.9	1.0–6.6
Th 28	2–11	1.7–25	0.04–0.61	1.3–2.4	1.0–3.9
HST					
HH 30	0.1–5.5	10–65	0.065–0.12	0.6–2	10–100
DG Tau	0.1–2	37–100			
RW Aur	0.1–4	4.4–160	0.01–0.2	0.64–1.9	3.2–460
LkHα 233	0.1–2.1	1.15–250	0.03–0.6	0.8–3	0.2–130

	LkHα 233	RW Aur
dist (pc)	880	140
size (au)	2 700	760
N_e (cm^{-3})	1 800	2 750
X_e	0.4	0.08
T_e (K)	19 000	12 000
N_H (cm^{-3})	7 900	40 000

* - Bacciotti & Eislöffel 1999, ** - Podio et al. 2006; Nisini et al. 2005, Bacciotti et al. 1999, 2000

Conclusion:

- The RW Aur jet has larger density (N_H = 4 10^4 cm^{-3}) and lower excitation (X_e = 0.08) than other T Tau jets
- The LkHα 233 jet has higher T_e than the T Tauri jets
- The mean density of the LkHα 233 jet (N_H=10^4) is similar to the HH 30 jet investigated with the same resolution
- The jet temperature might be controlled by the radiation from the jet source, whereas the jet density may be linked to the intensity of the accretion processes

What real differences are between Herbig star and T Tauri jets?