Jet kinematics

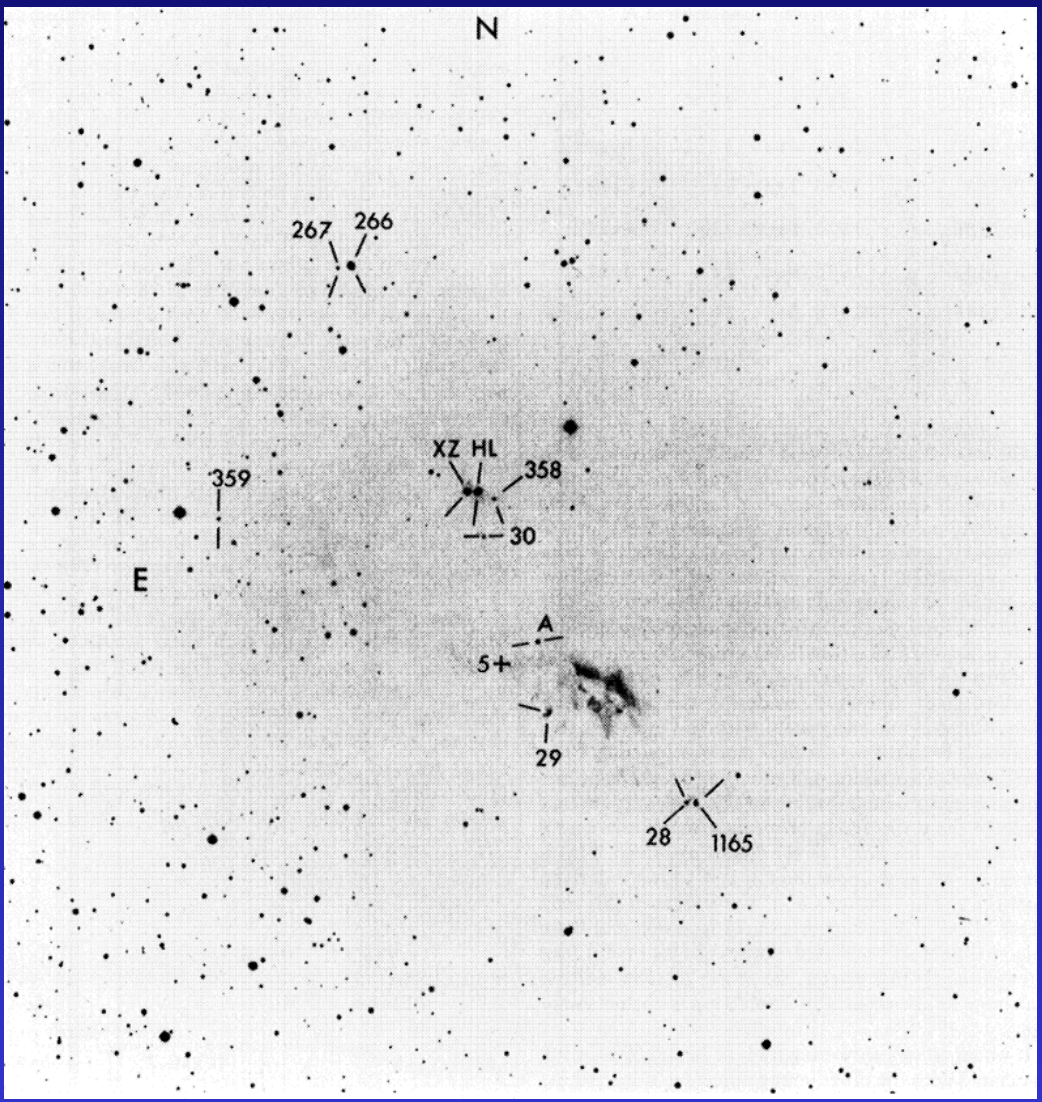
Jochen Eislöffel

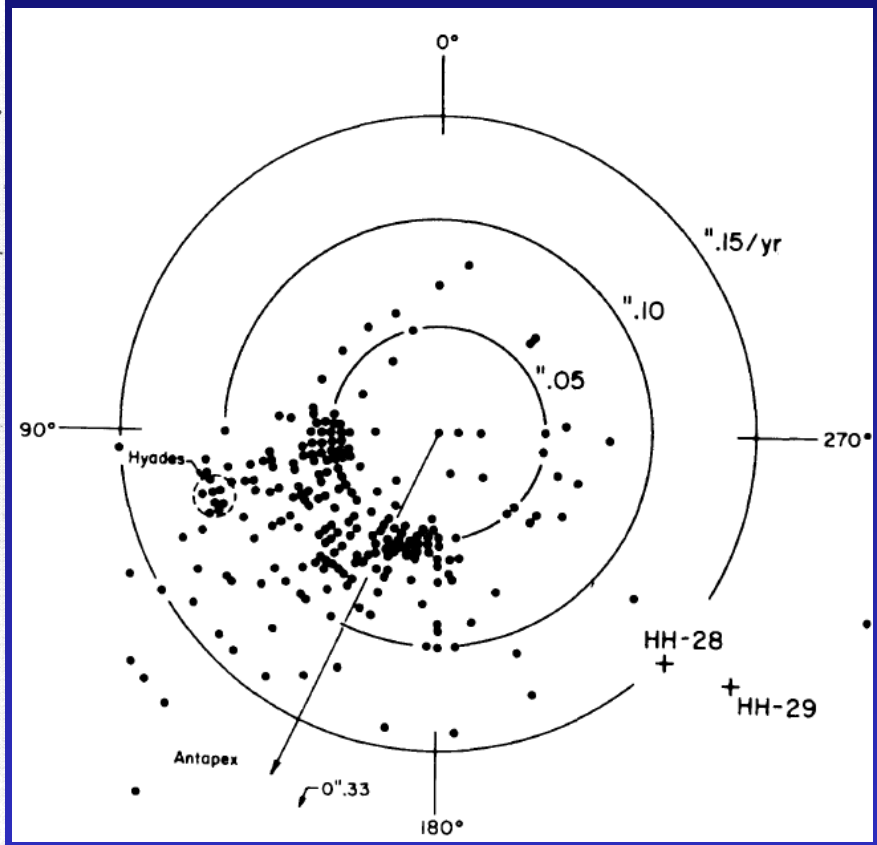
Thüringer Landessternwarte Tautenburg

XZ Tau - with HST - HH30

„Eppur si muove“ Galilei, 1633

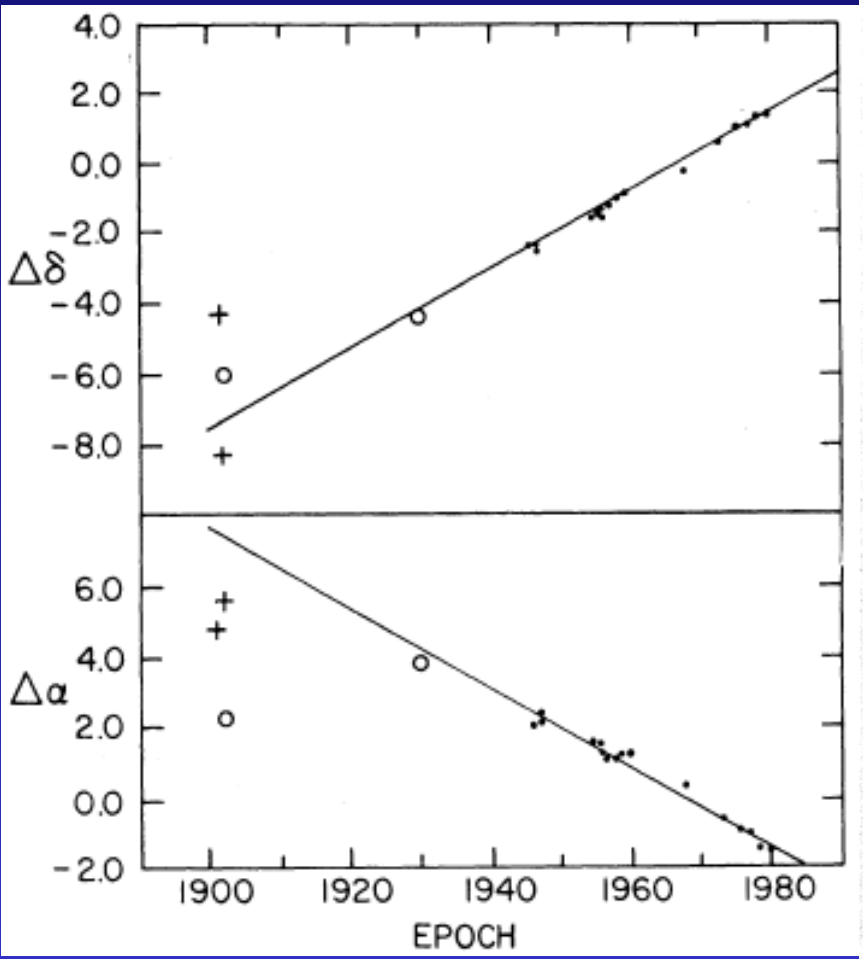
First proper motions of HH objects – HH28/29

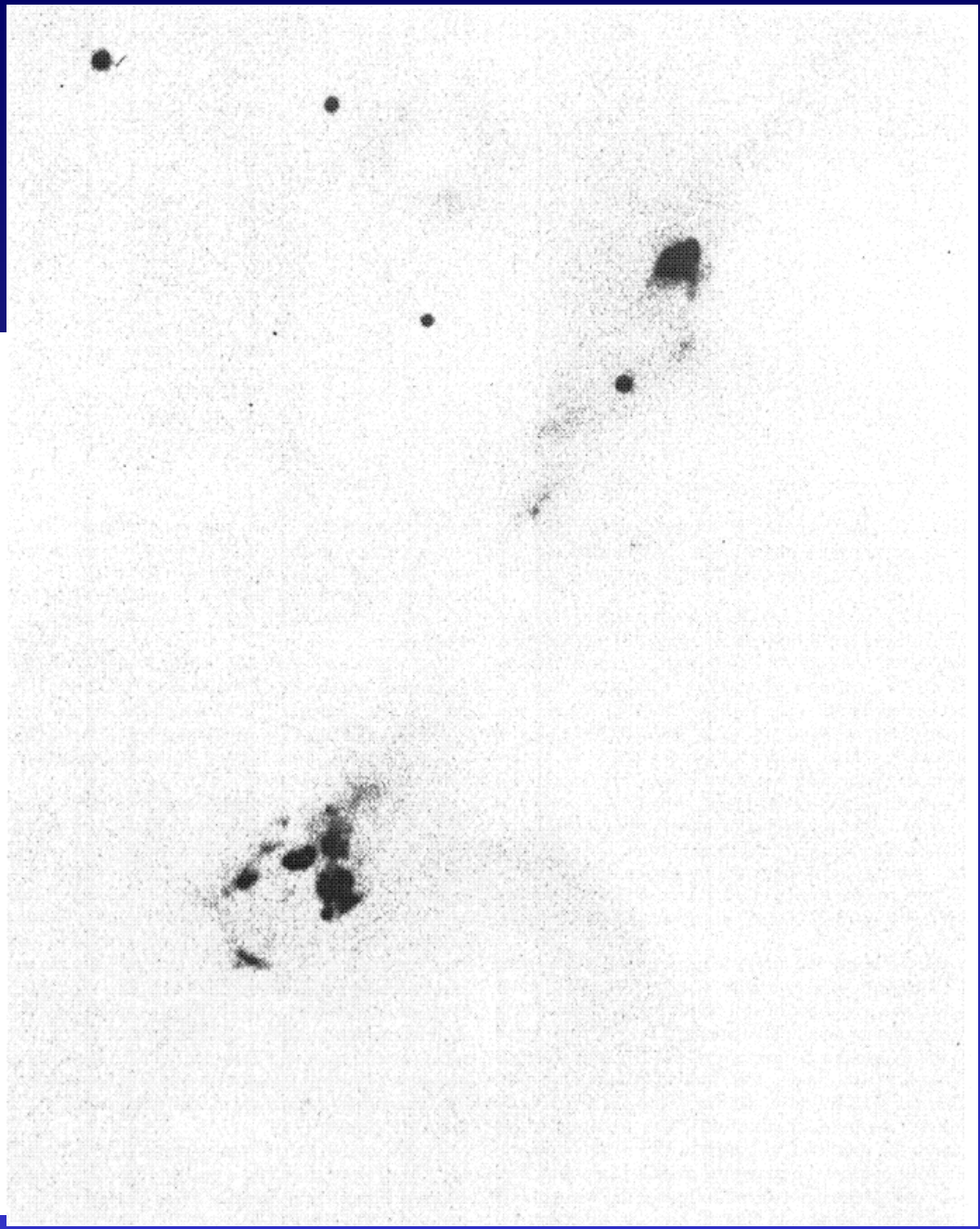




Cudworth & Herbig 1979

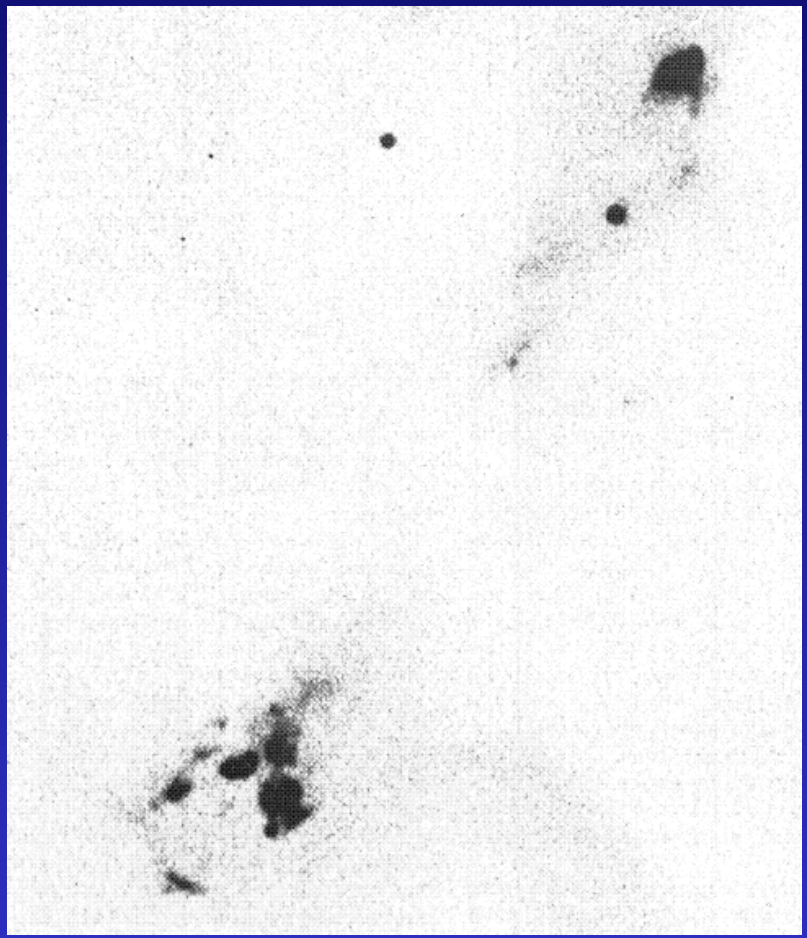
Proper motions of HH1

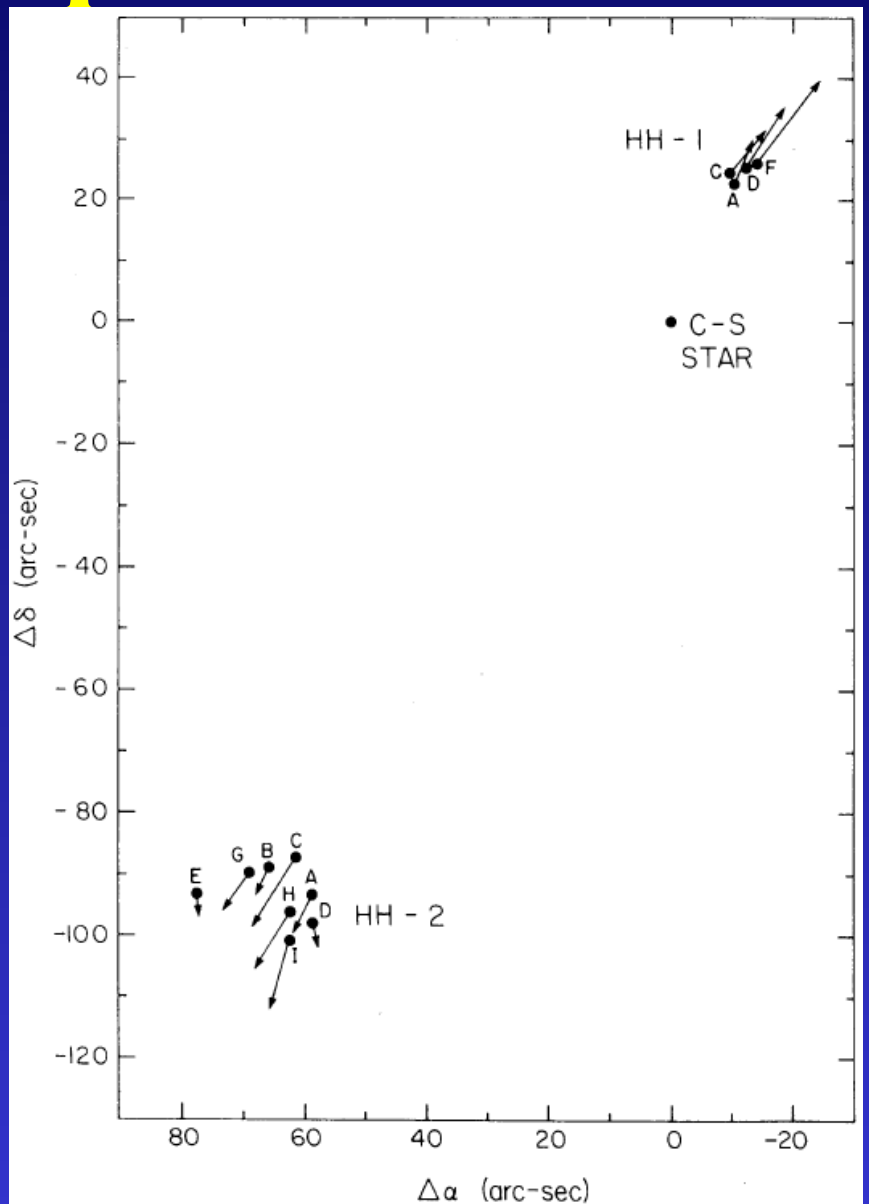




Herbig & Jones 1981

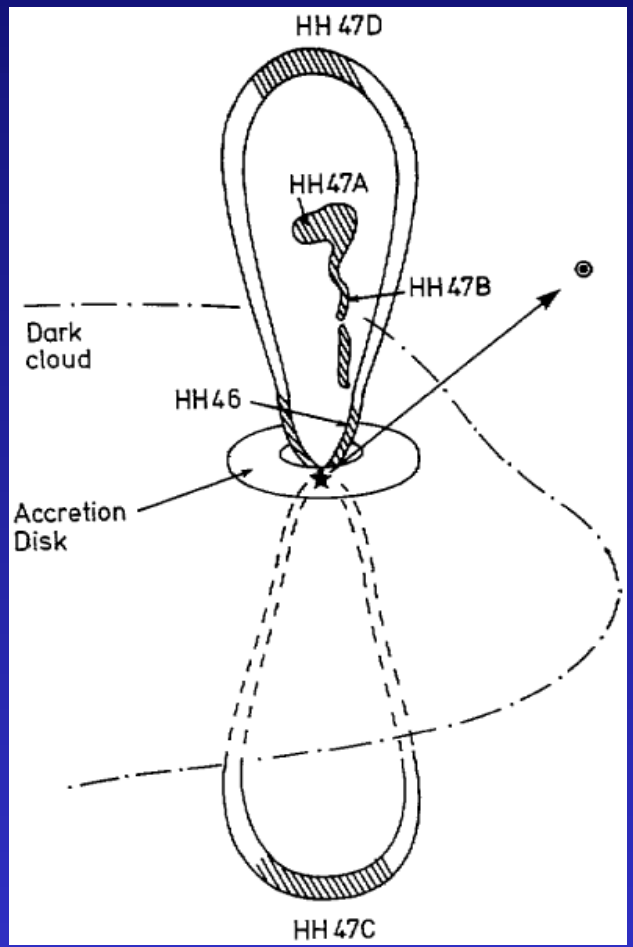
HH1/2 – a bipolar flow

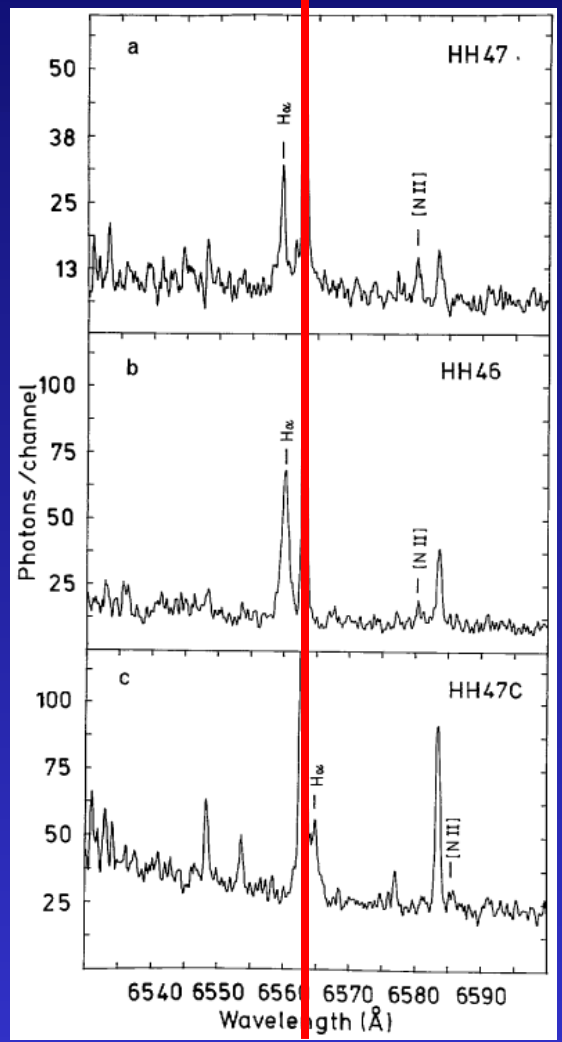




Herbig & Jones 1981

HH46/47 spectroscopy – a bipolar flow



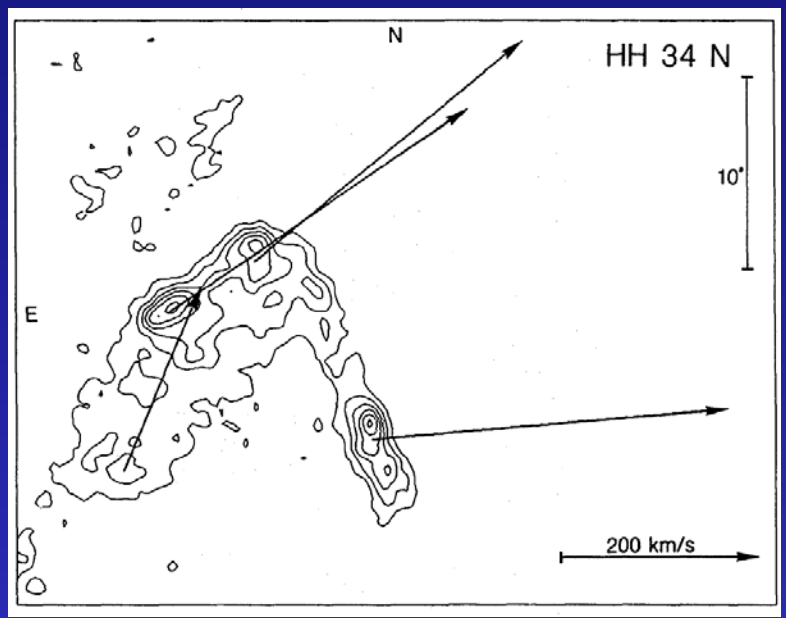


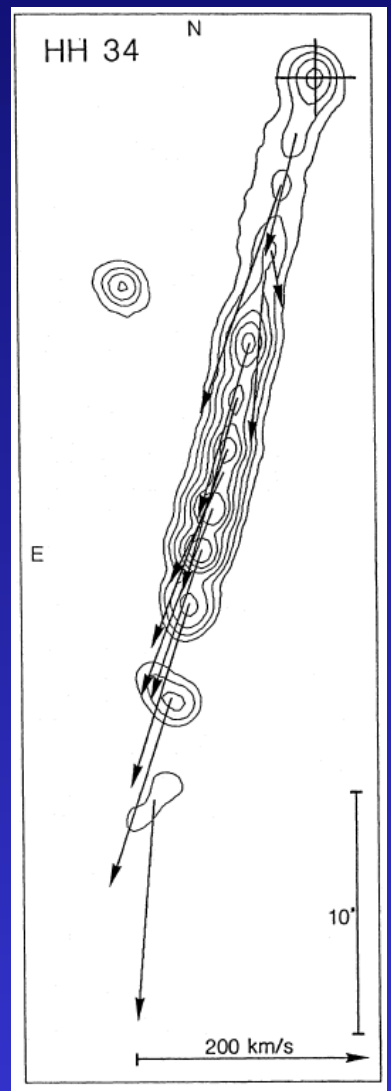
Dopita, Schwartz, Evans 1982

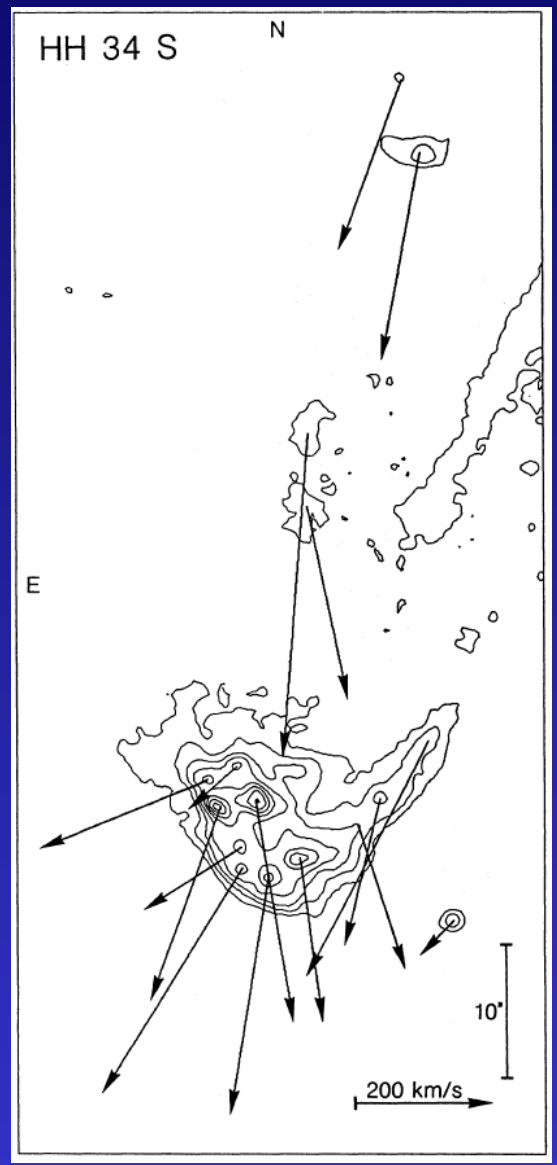
Proper motions / spectroscopy

- flows are bipolar
- sources

Proper motions in jet beams – HH34

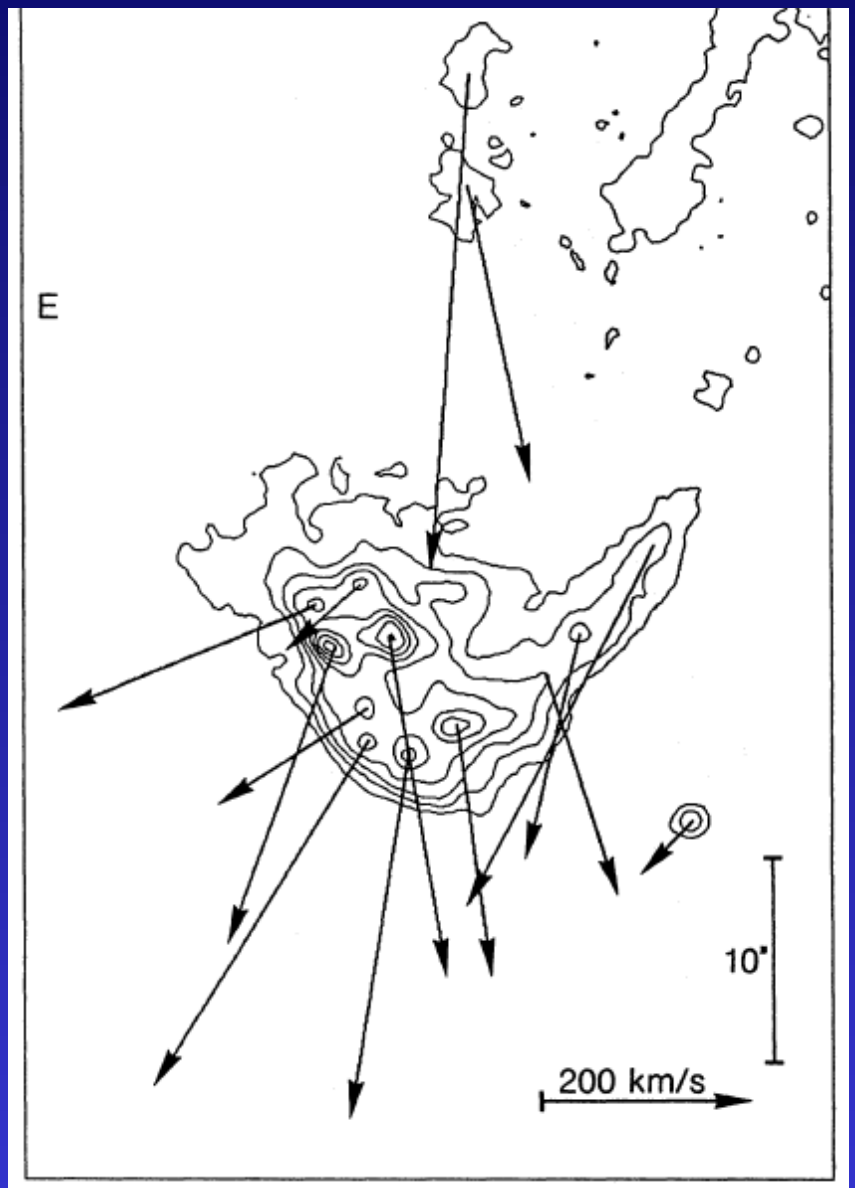


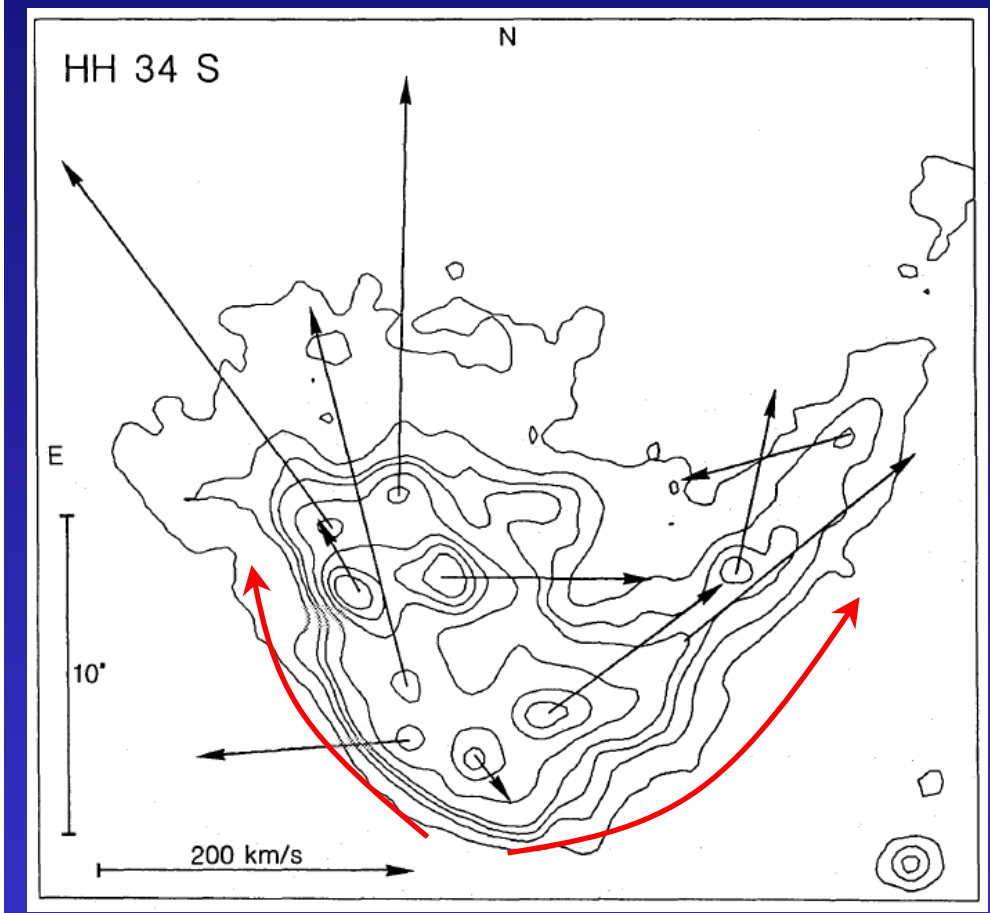




Eislöffel & Mundt 1992

Internal structure of bow shocks





Eislöffel & Mundt 1992

Shocks along the flow – internal working surfaces

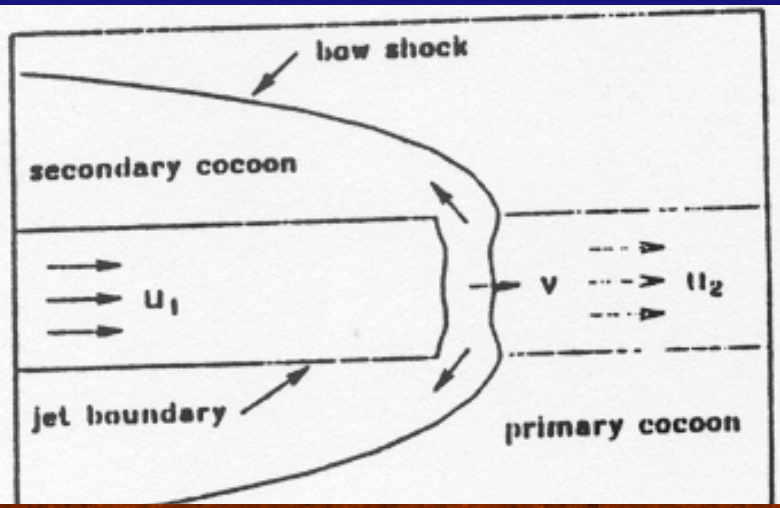
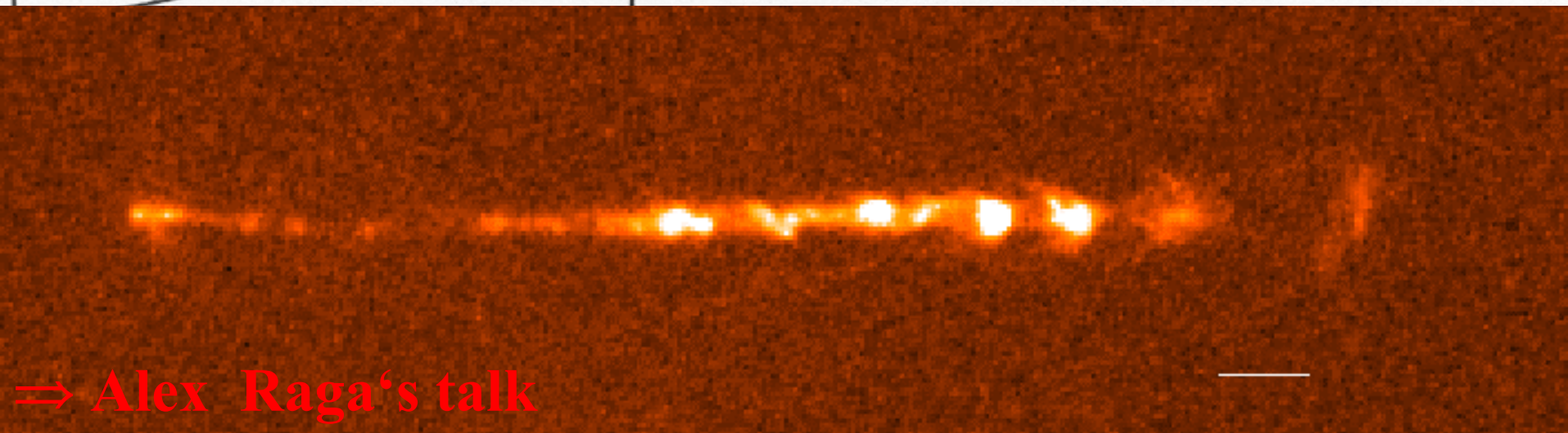
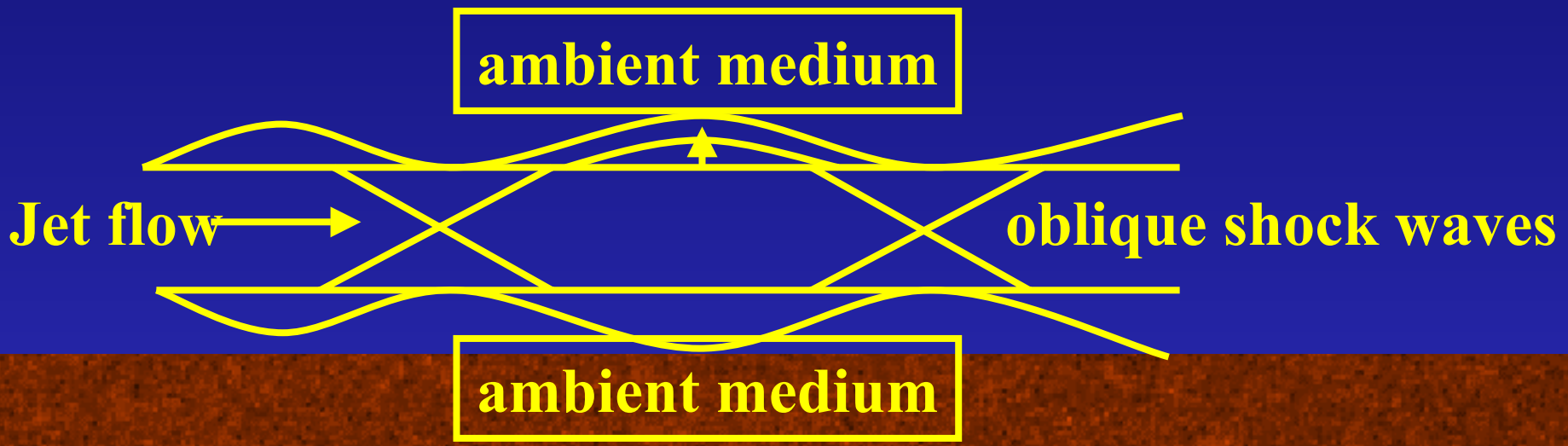


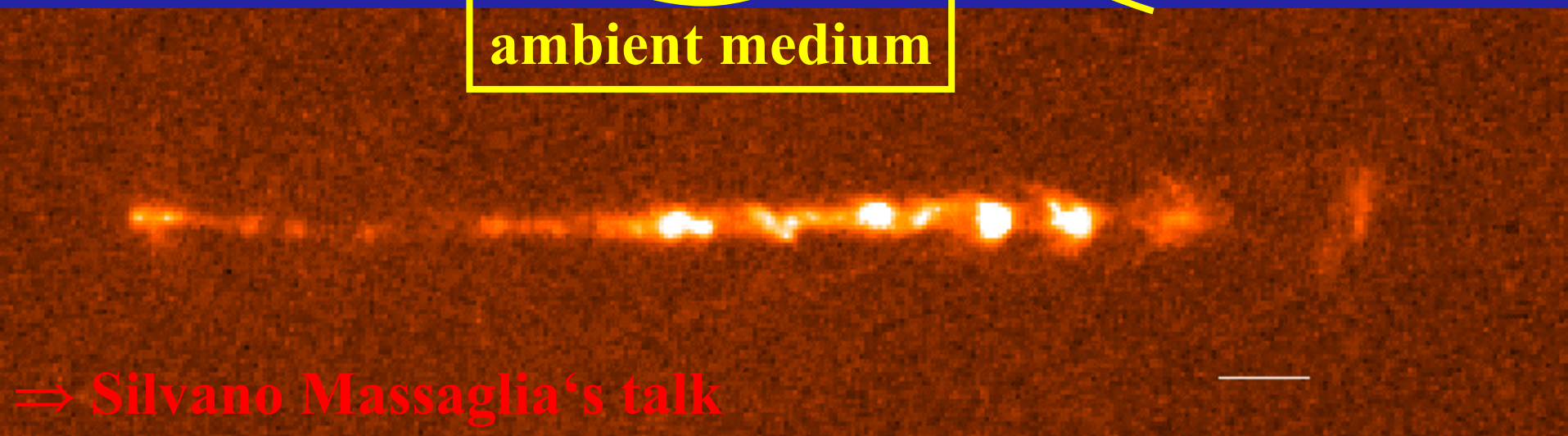
FIG. 1.—Schematic diagram showing the structure of an internal working surface in a jet flow. A two-shock structure is formed as the faster, upstream material (of velocity u_1) catches up with the slower, downstream material (of velocity u_2). The gas trapped in between the two shocks is ejected sideways by the on-axis overpressure (resulting from the compression in the shocks), forming a "cocoon" (possibly of cool gas, see the text) with a possibly very complex structure around the jet. This diagram has been taken from Raga et al. (1990).



⇒ Alex Raga's talk

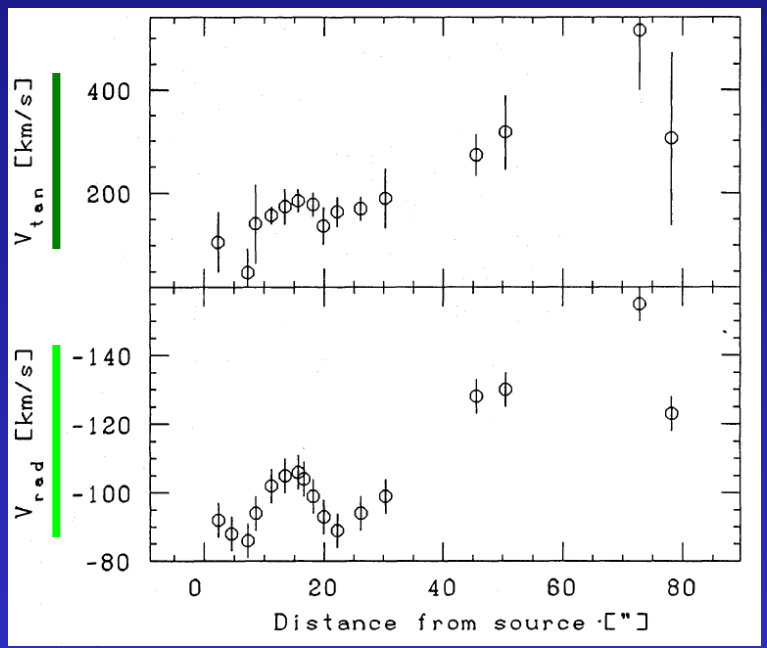
Shocks along the flow – Kelvin-Helmholtz instabilities

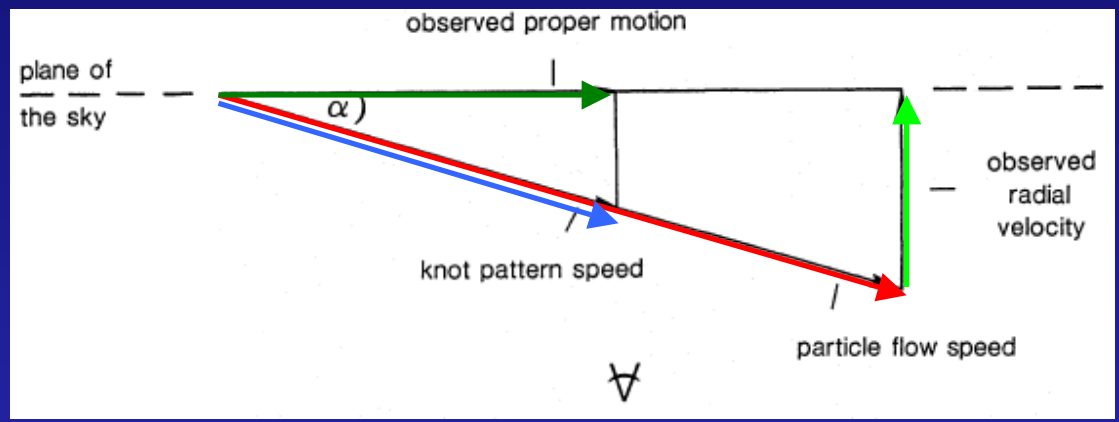


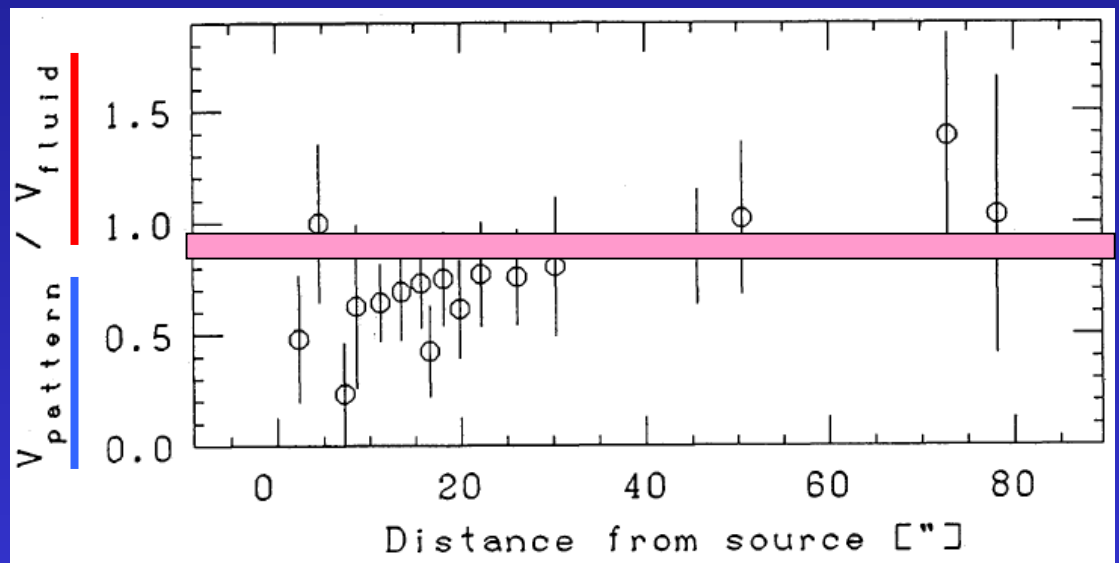


⇒ Silvano Massaglia‘s talk

Knot pattern speed – HH34

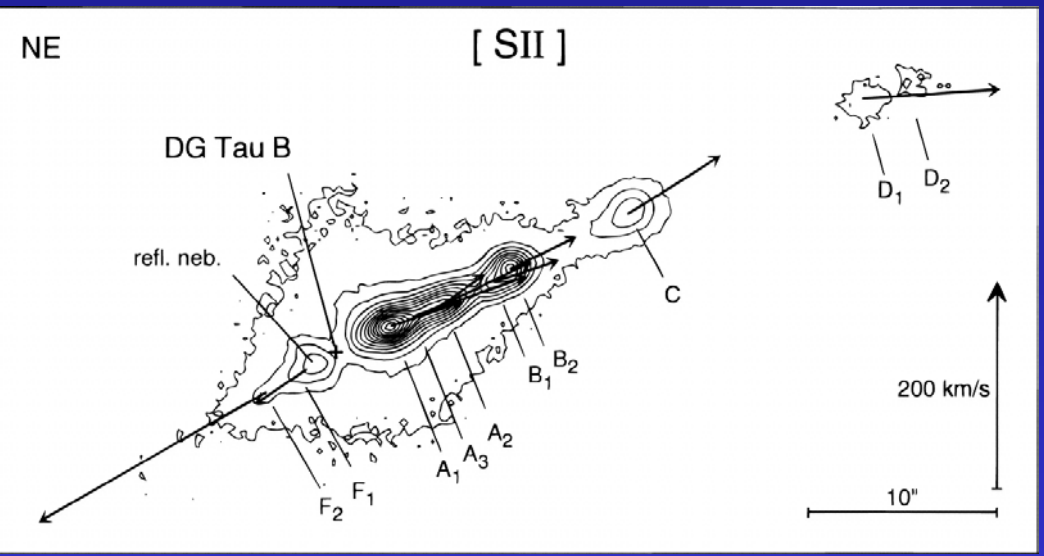


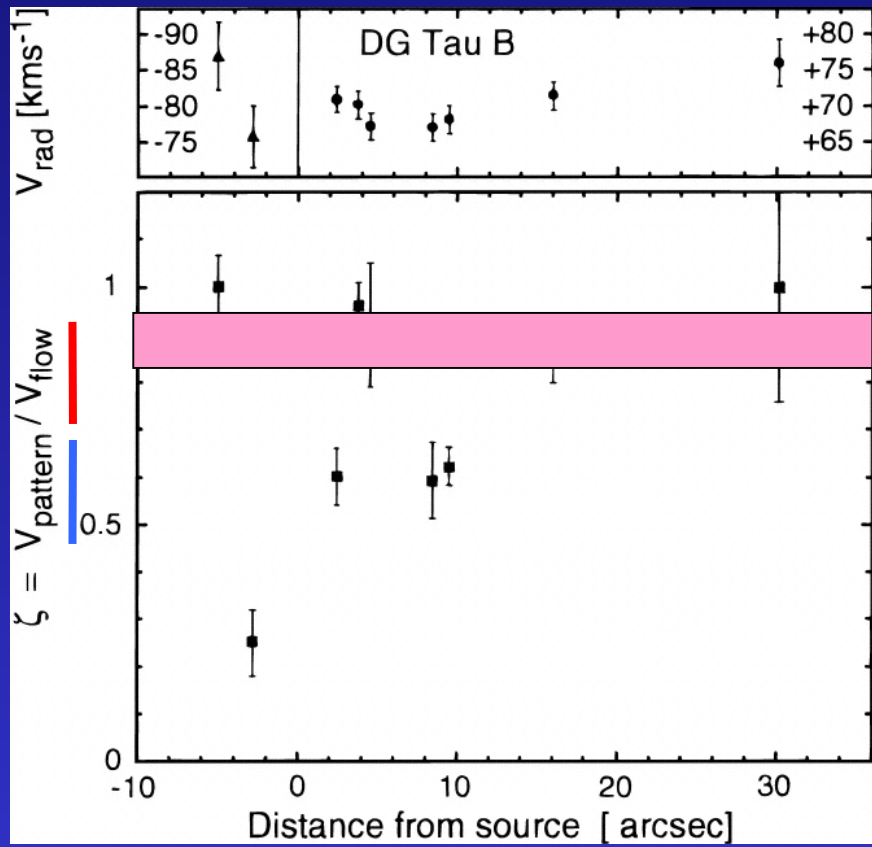




Eislöffel & Mundt 1992

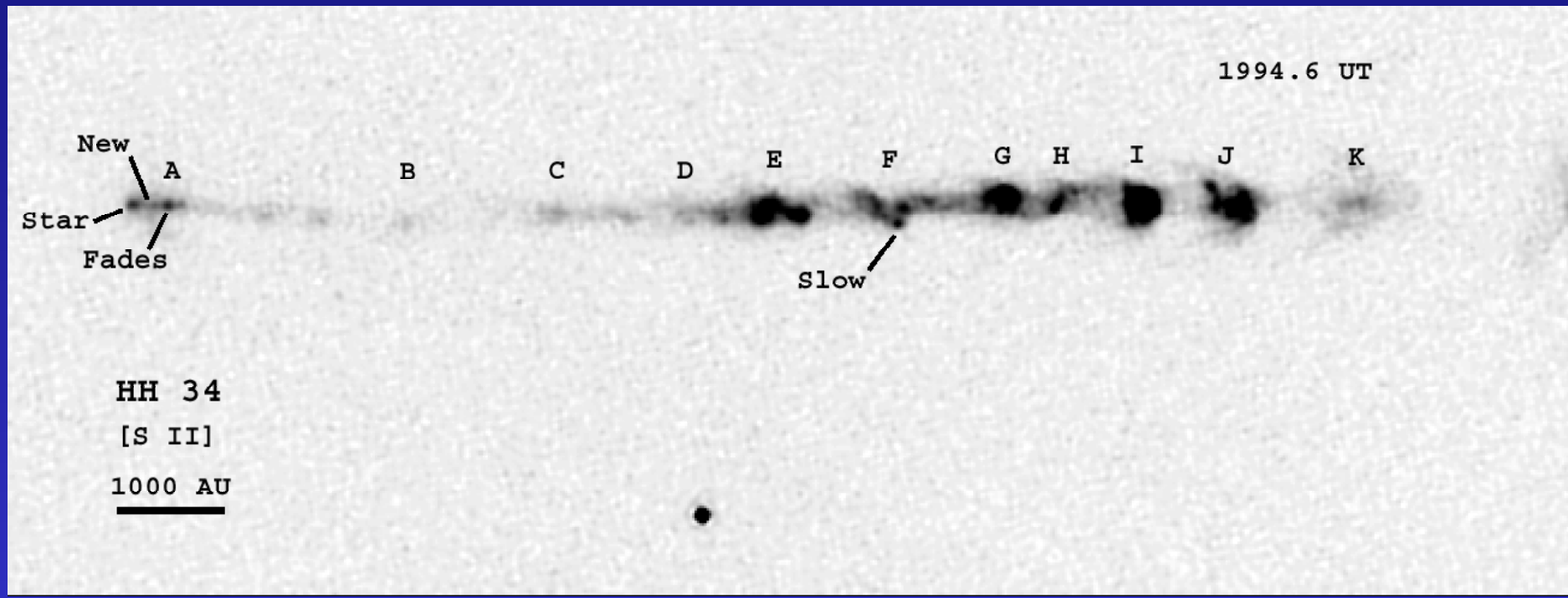
Proper motions and pattern speed in DG Tau B





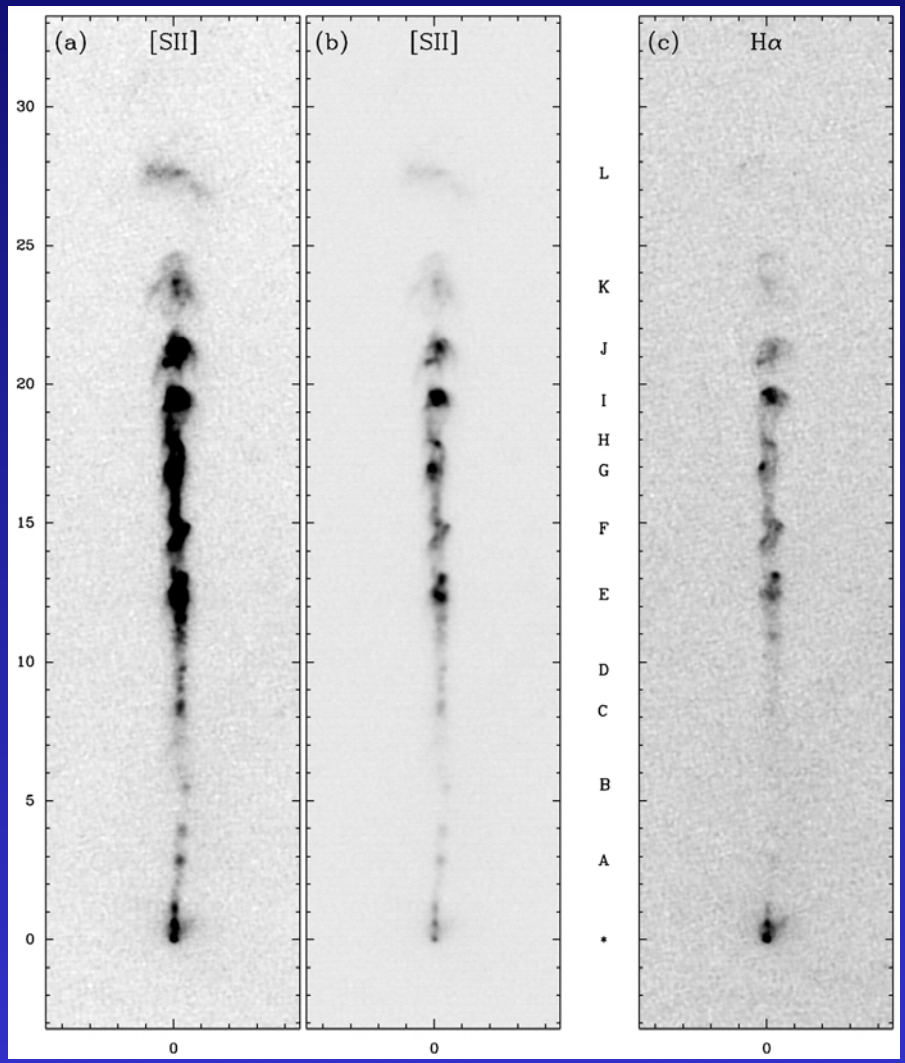
Eislöffel & Mundt 1997

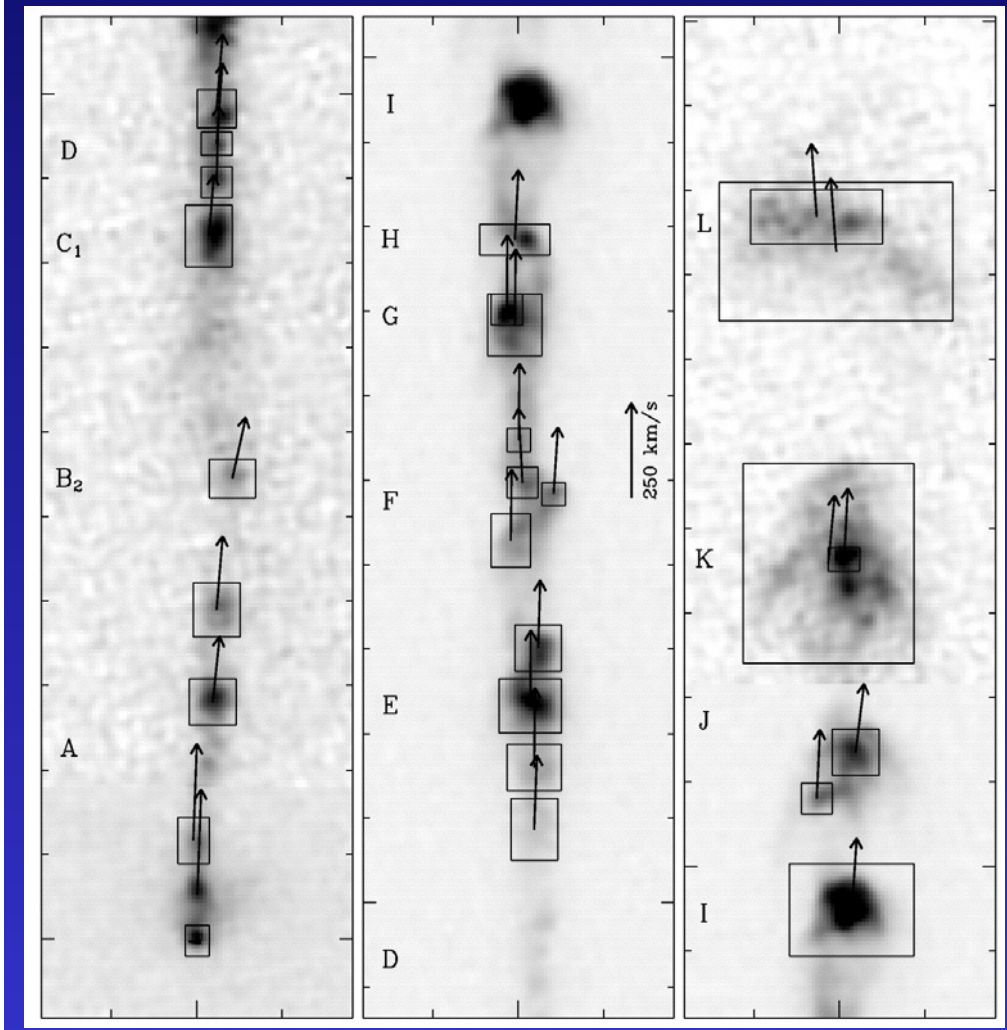
Proper motions with HST – HH34



Pat Hartigan's website

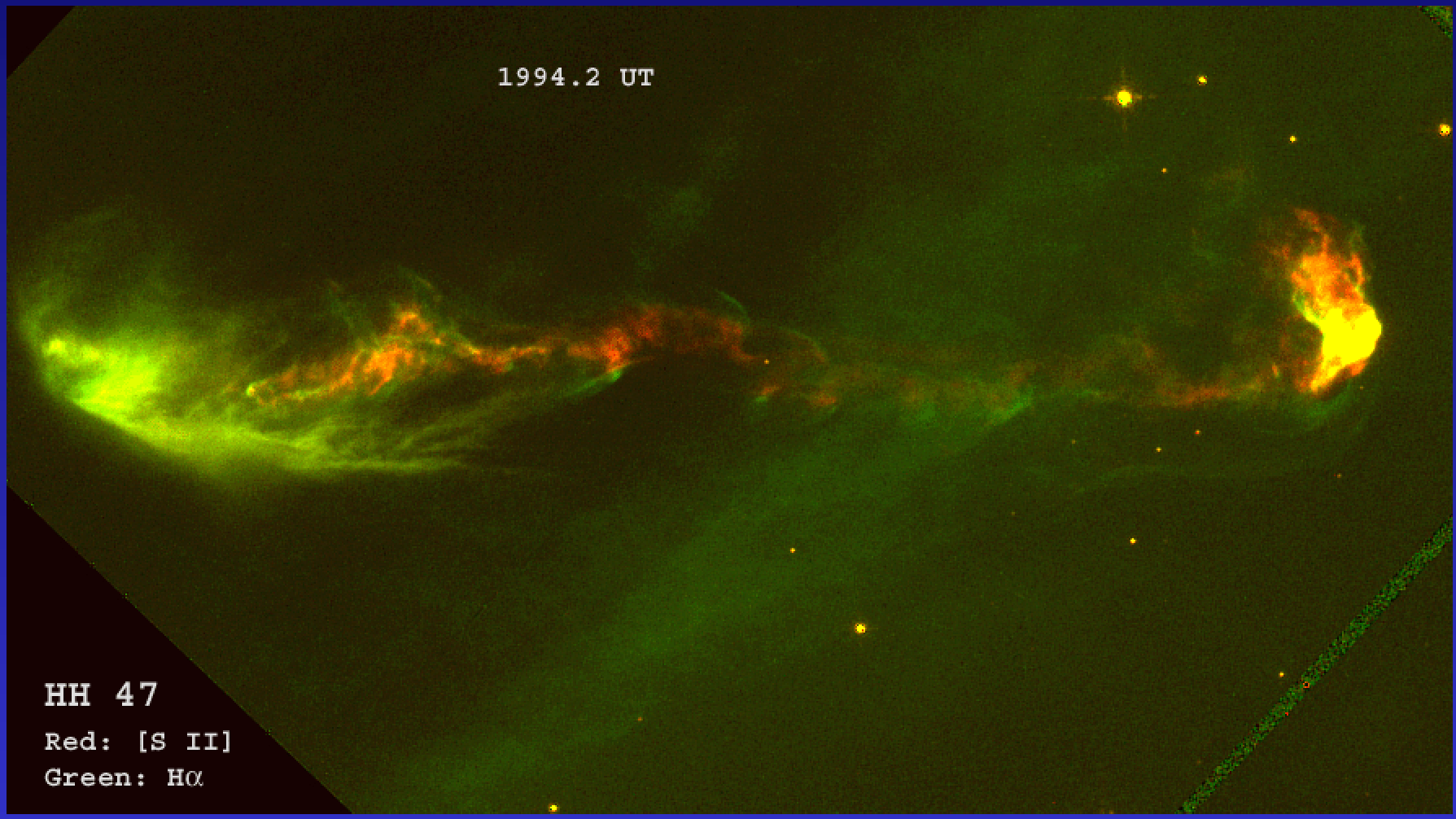
Proper motions with HST - HH34





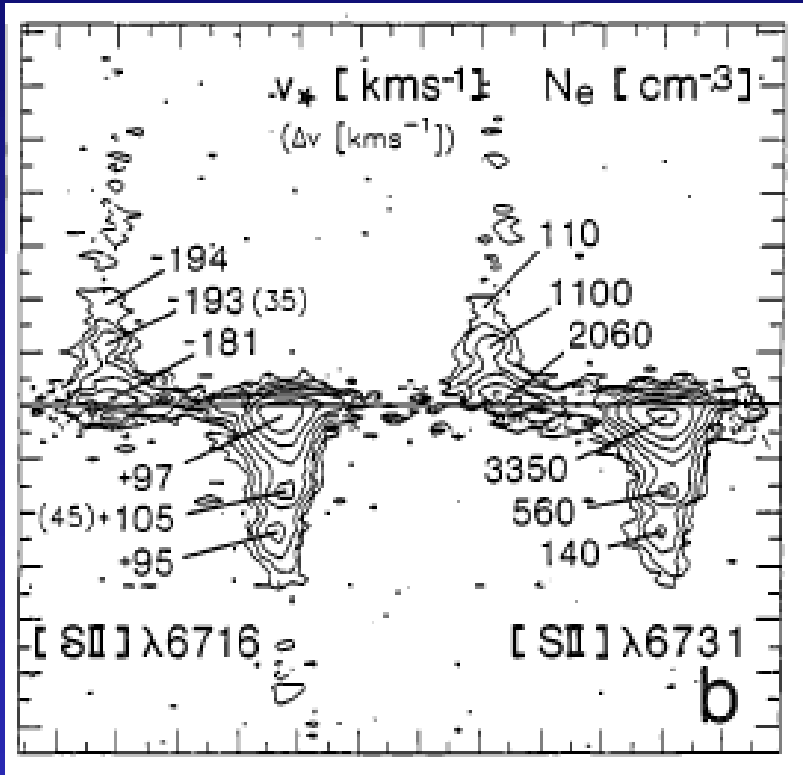
Reipurth, Heathcote, Morse, Hartigan, Bally 2002

Proper motions with HST – HH46/47

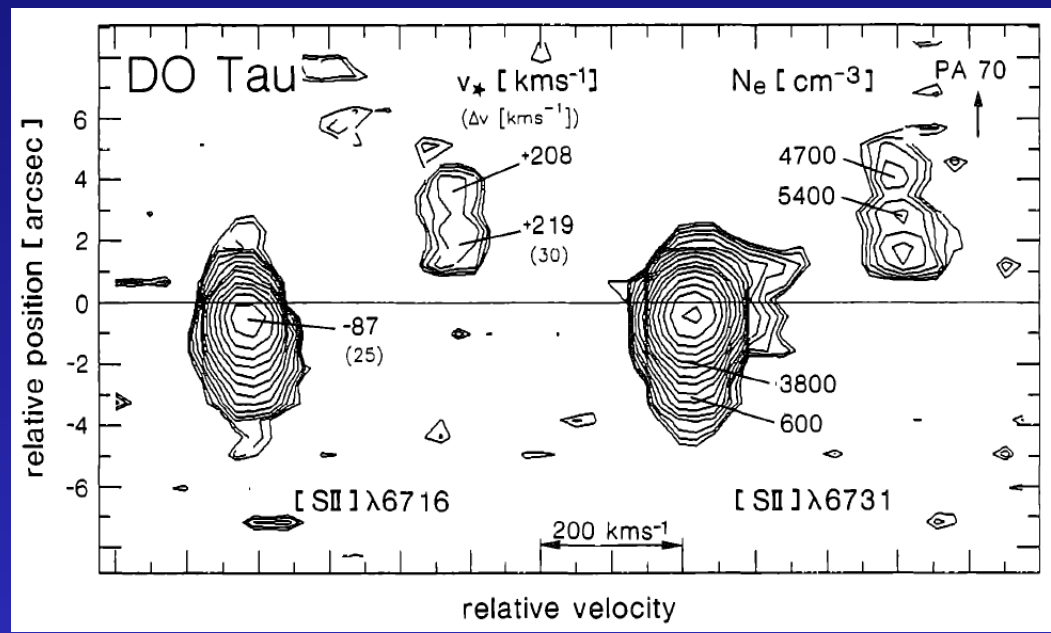


Pat Hartigan's website

Velocity asymmetry in jets



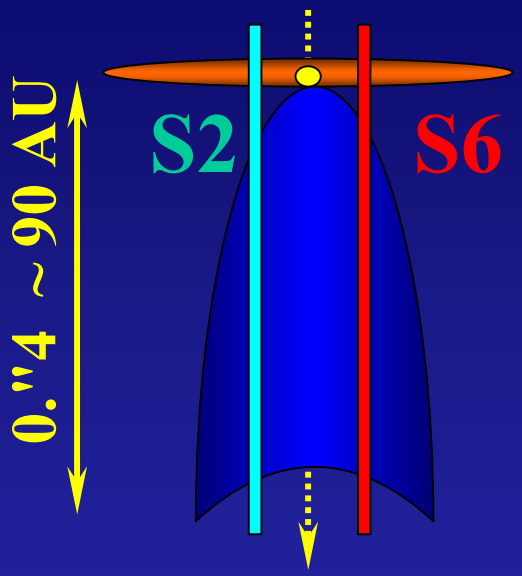
RW Aur

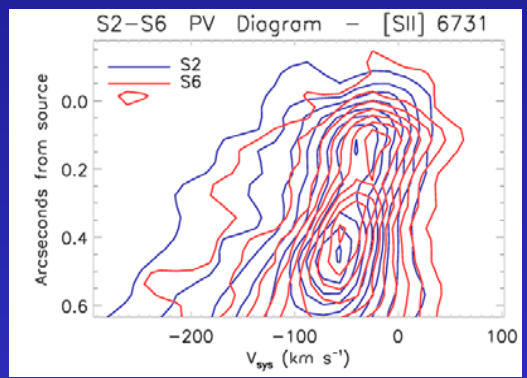


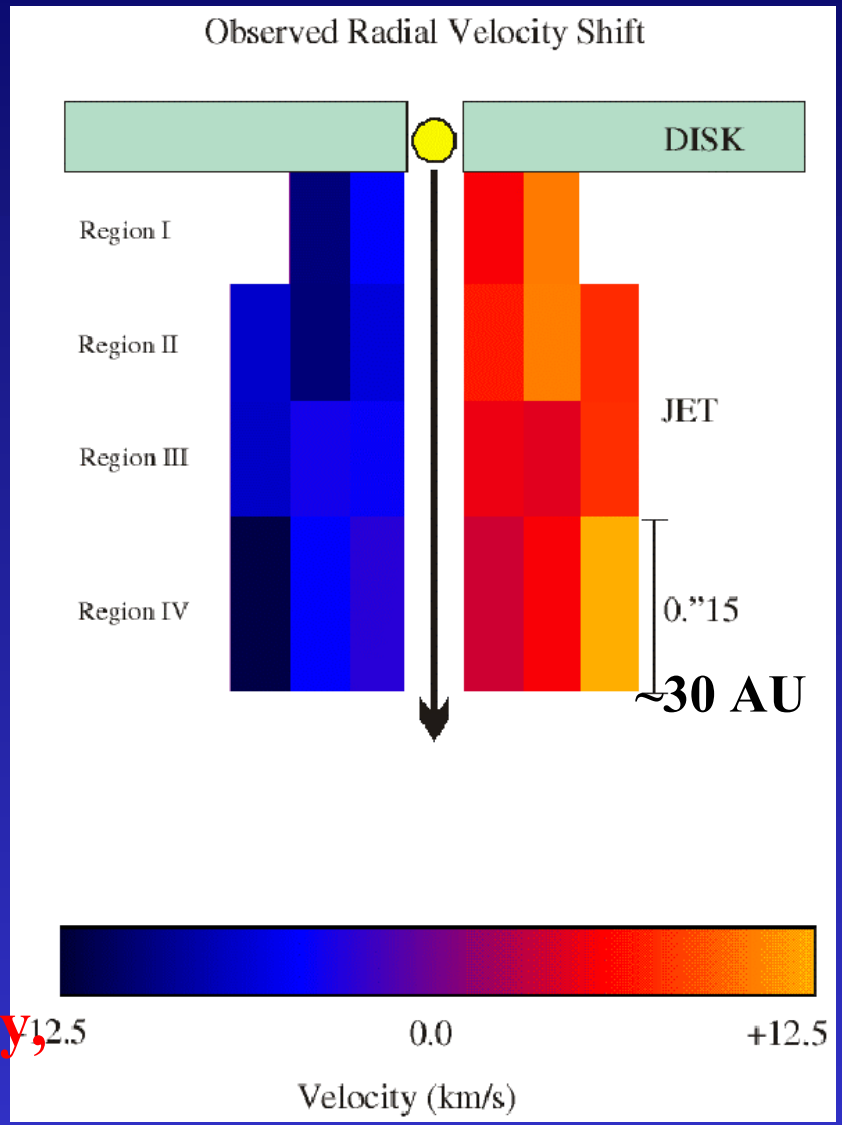
7 objects with velocity ratio 1.0-1.2,
8 with 1.4-2.6

Hirth, Mundt, Solf, Ray 1994

Jet rotation: DG Tau







⇒ Francesca Bacciotti, Deirdre Coffey, Johannes Schmid-Burgk's talks

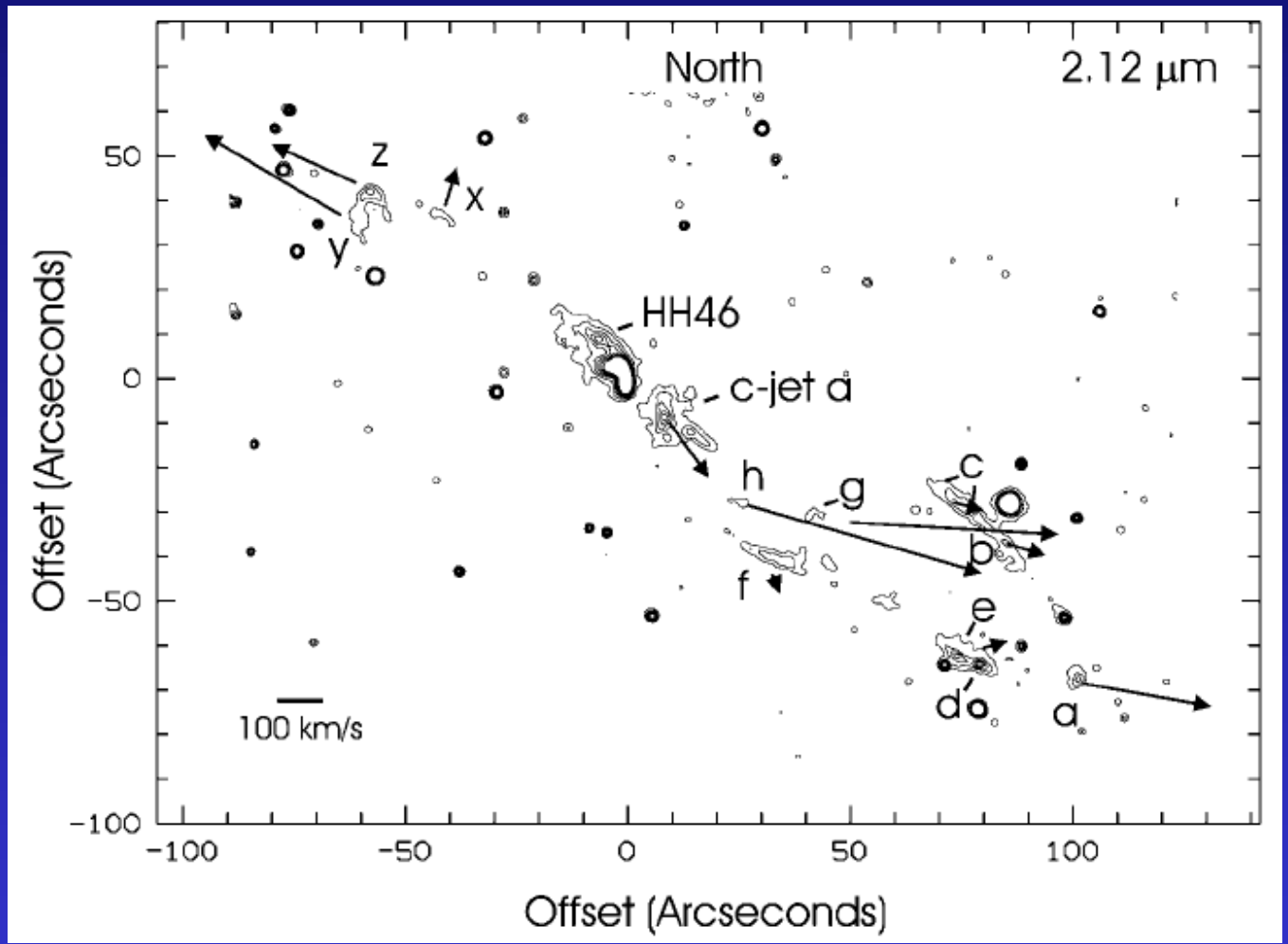
⇒ poster by Serge Correia et al.

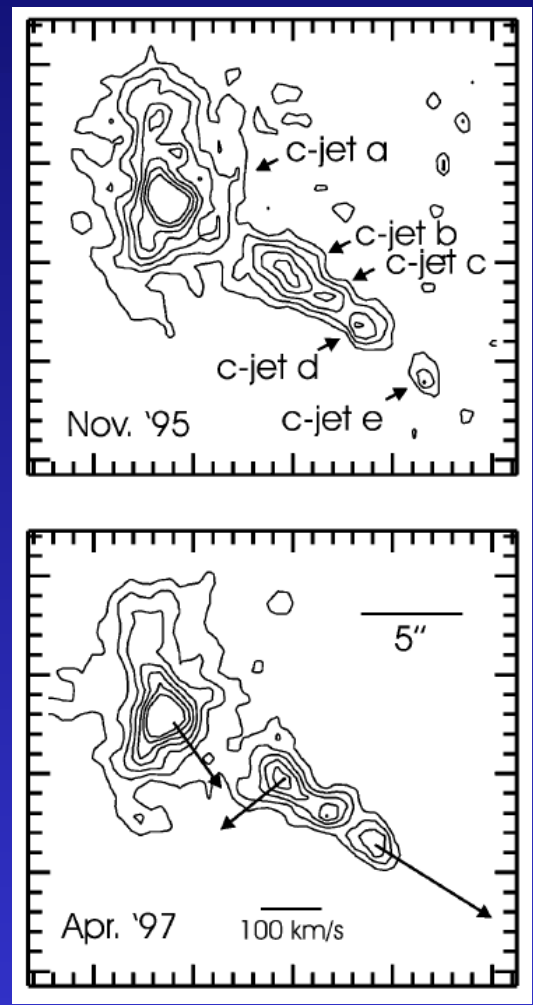
Bacciotti, Ray, Mundt, Eislöffel, Solf 2002

Internal jet structure

- motion within beams (50 – 400 km/s)
- bow shock structure
- physical reason for knot formation
- velocity asymmetries in bipolar jets
- transverse velocity decrease
- jet rotation
- needed for mass flux rates!

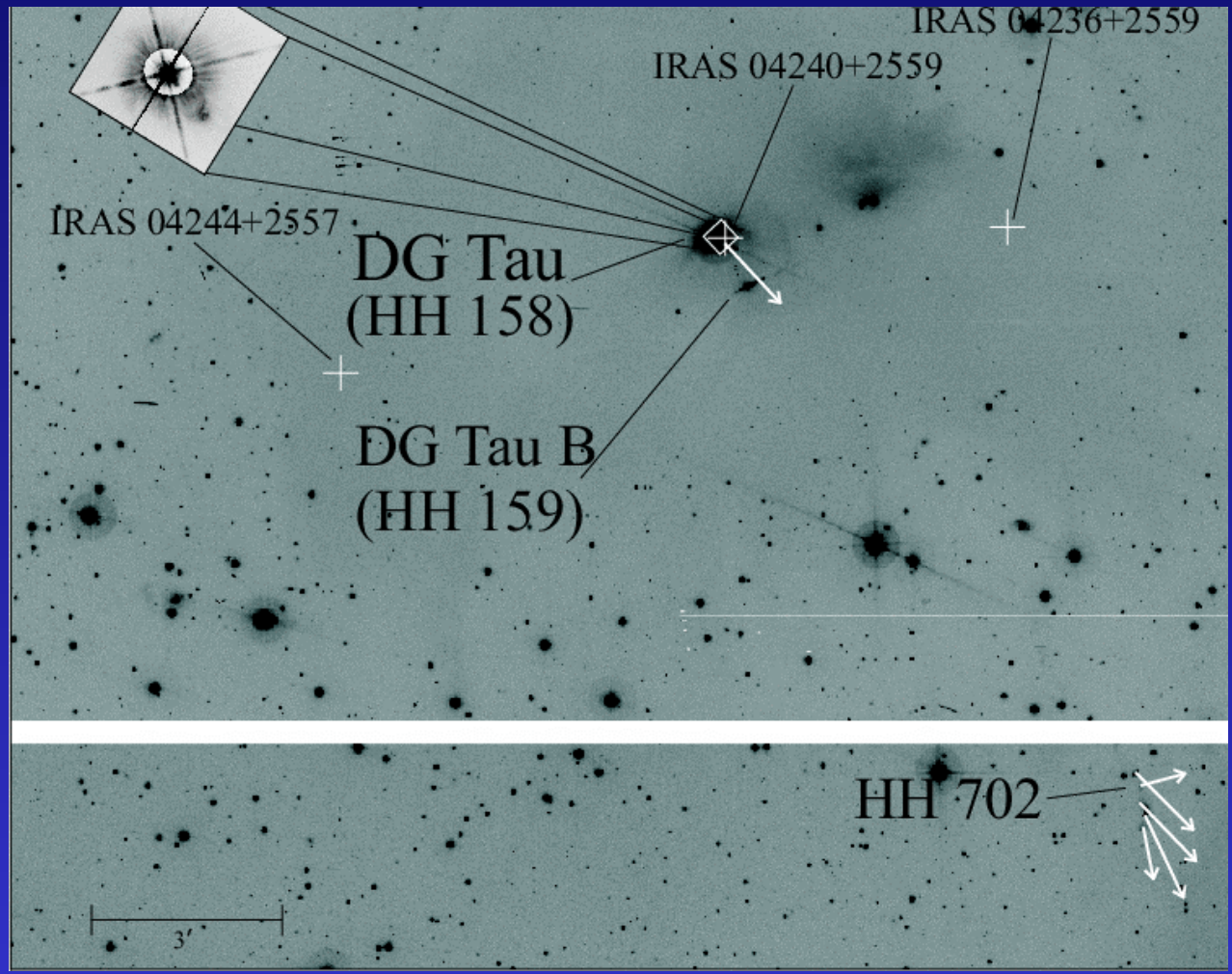
Proper motions in molecular hydrogen - HH46/47





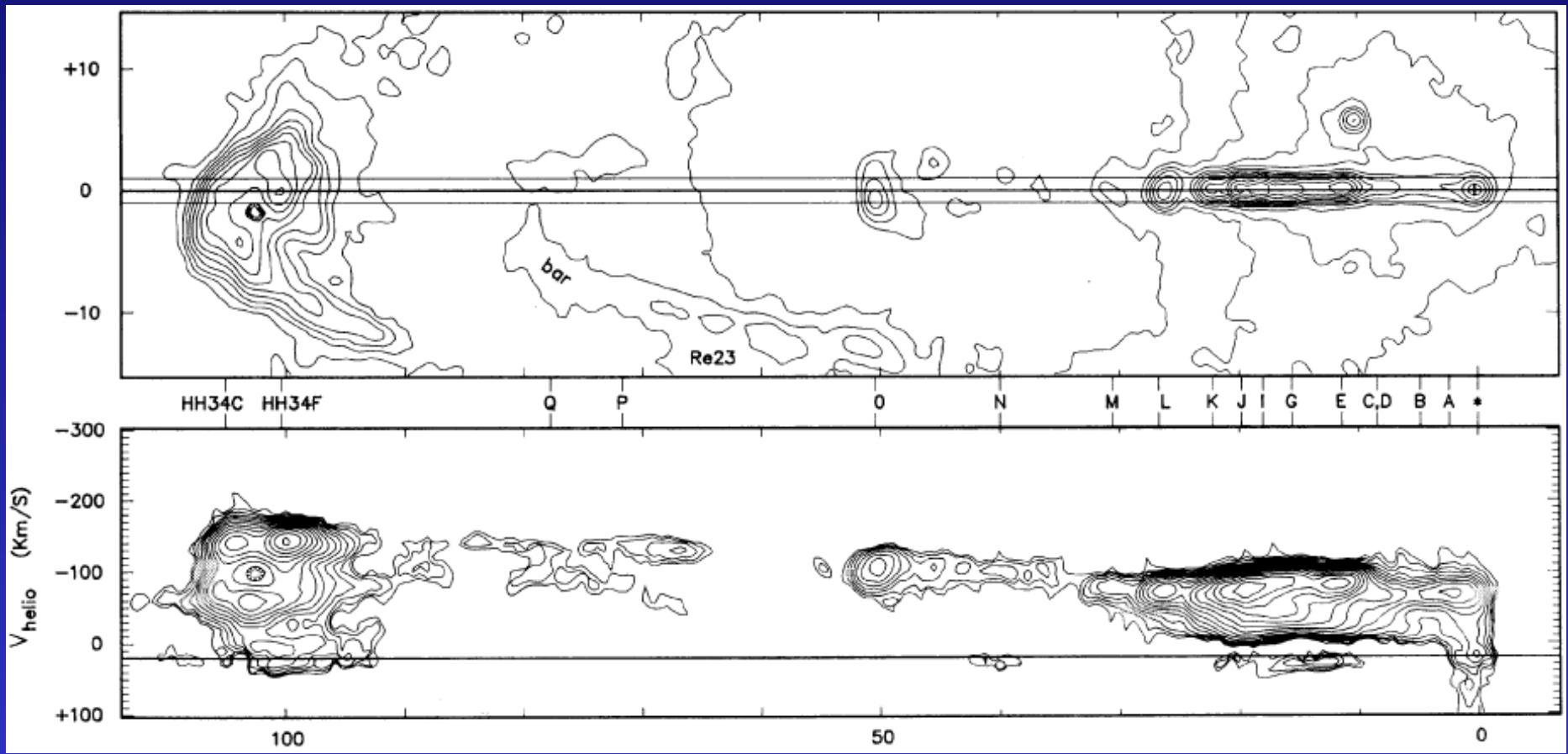
Micono, Davis, Ray, Eislöffel, Shetrone 1998

Proper motions in parsec-scale flows



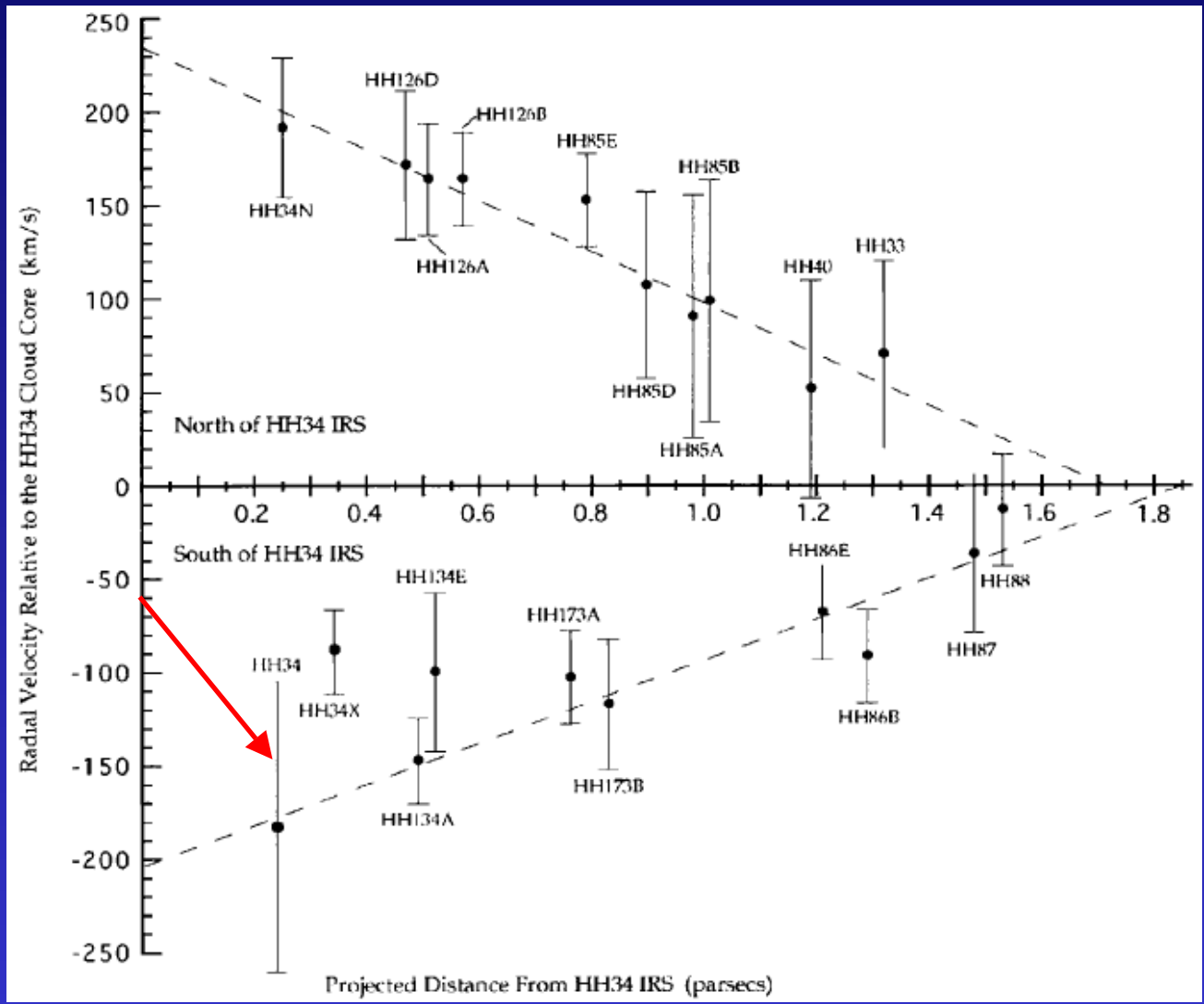
McGroarty, Ray, Froebrich 2007

Jet kinematics - Hubble law



Heathcote & Reipurth 1992

Large scale kinematics – HH34



Devine, Bally, Reipurth, Heathcote 1997

Jet precession

⇒ Alessio Caratti o Garatti's talk

⇒ poster by McCoey et al.

Eislöffel, Smith, Davis, Ray 1996

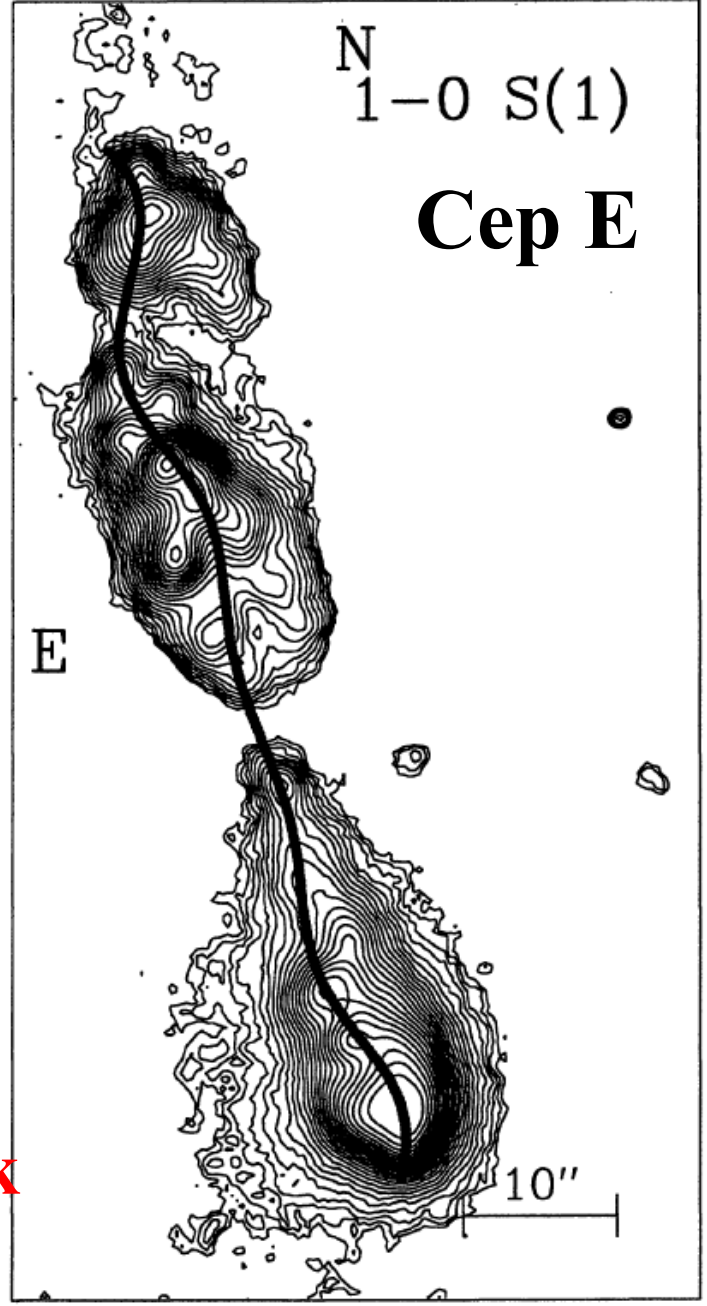
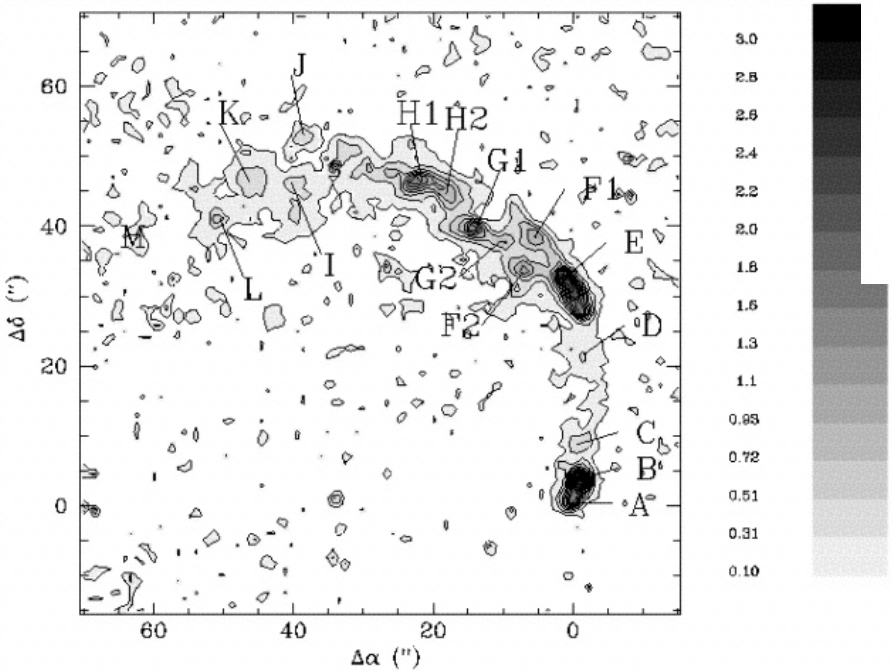
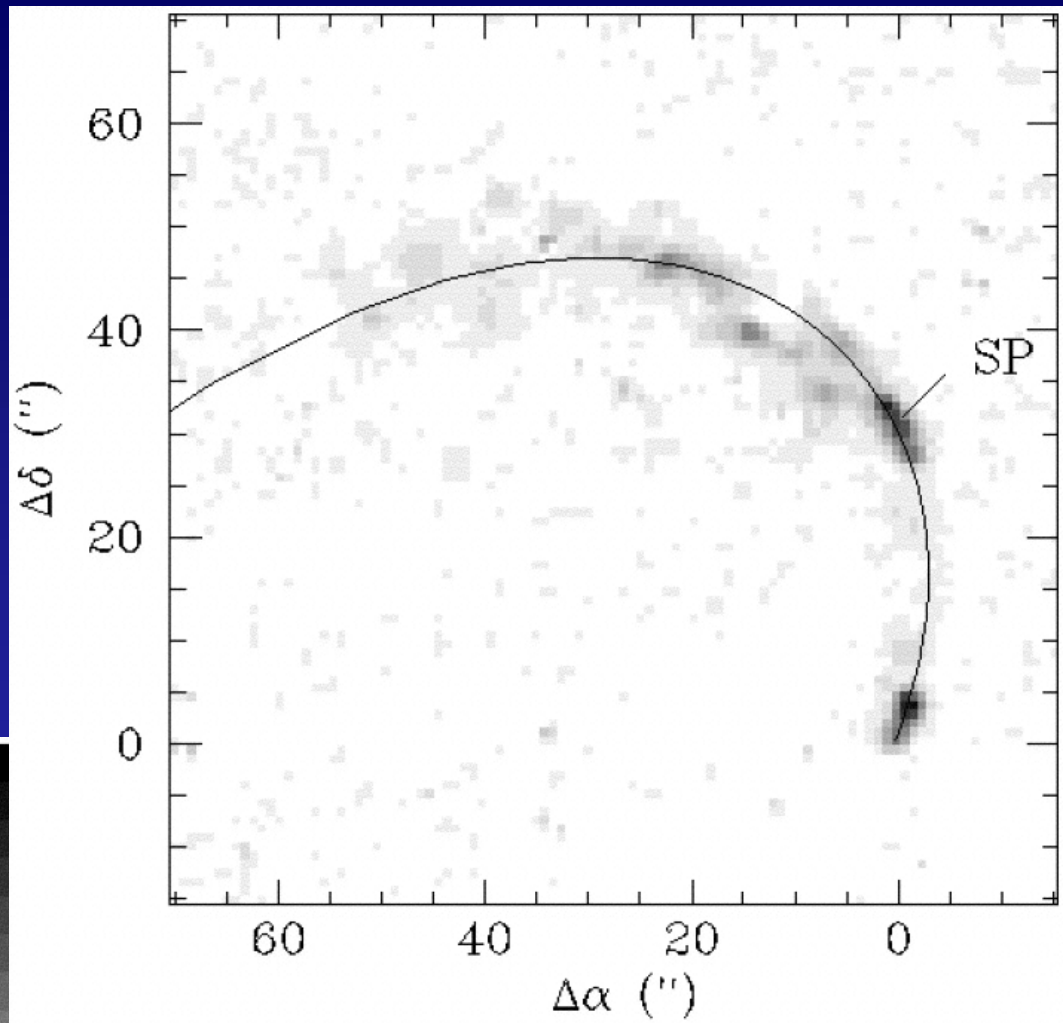


FIG. 3. Precession model plotted over the 1−0*S*(1) line contours of Cep E. The model is for a precession angle of 4°, and a precession length scale of 22.″8.

S187:SCP1 – jet bending by side winds?





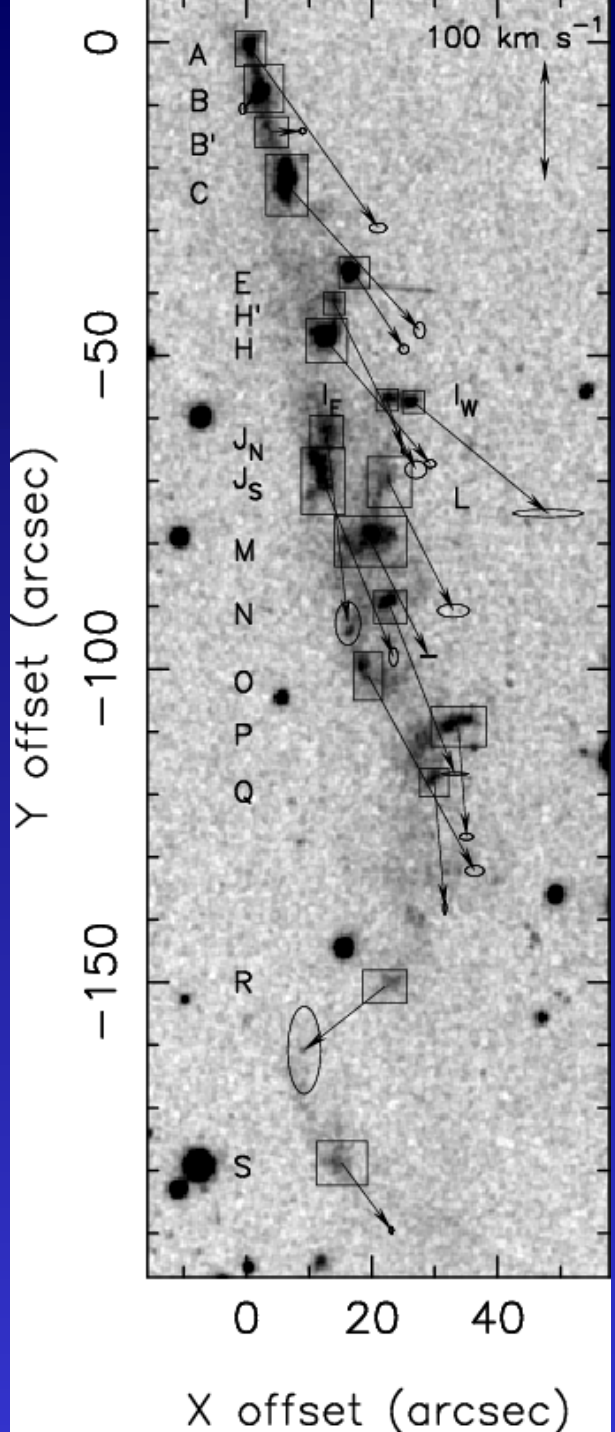
⇒ Andrea Ciardi's talk

Salas, Cruz-Gonzalez, Porras 1998

HH110 - jet deflection in a jet/cloud collision?

⇒ Mario Livio's talk

Lopez, Estalella, Raga, Riera, Reipurth, Heathcote 2005



Large-scale flow motion

- Interaction with companion star/ interlooper/core/cloud/ISM

Jet kinematic

- now entering the era of internal jet variability studies

⇒ Sara Bonito‘s talk

⇒ poster by Fabio de Colle and Alessio Caratti o Garatti