Outflows and jets from massive star-forming clusters

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Introduction

Outflow morphologies and kinematics (the mm regime)

Radio jets

Outflow parameters --> energy!

Extinction --> x-ray detections?

Future studies

Introduction

Prototypical massive outflow
in Orion KL NOT typical

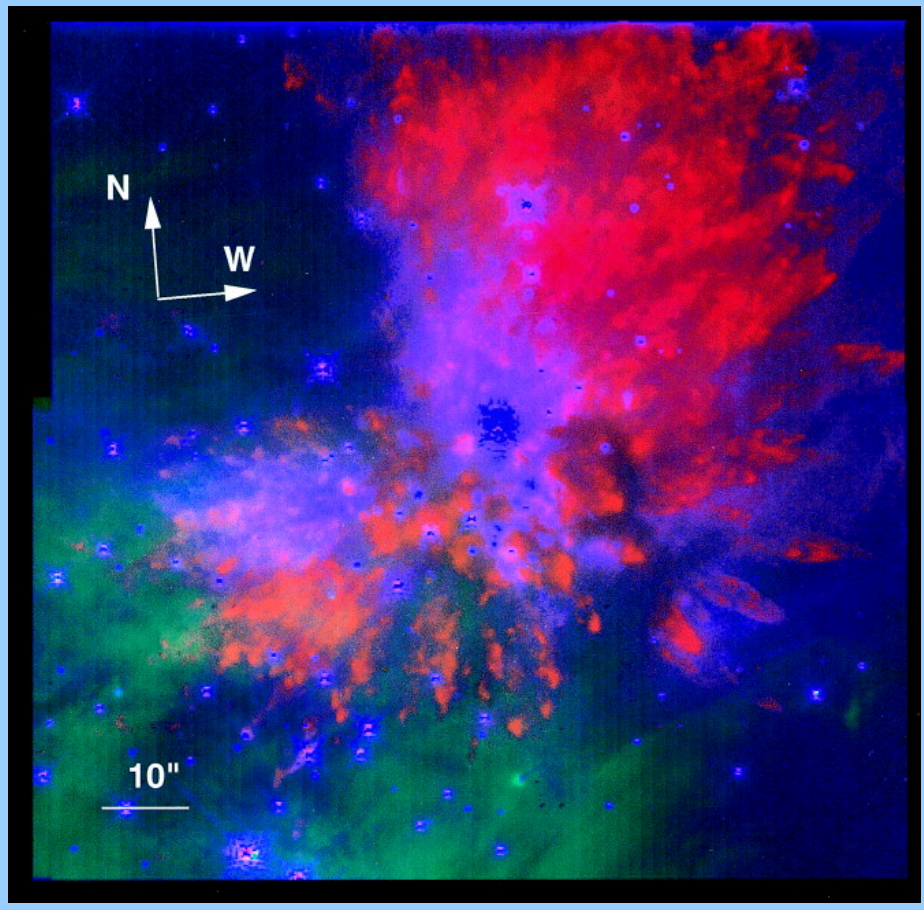
Focus on earliest evolutionary
stages prior to UCHII regions

Best observed in the (sub-)mm band

Early single-dish studies claimed
large differences to low-mass flows

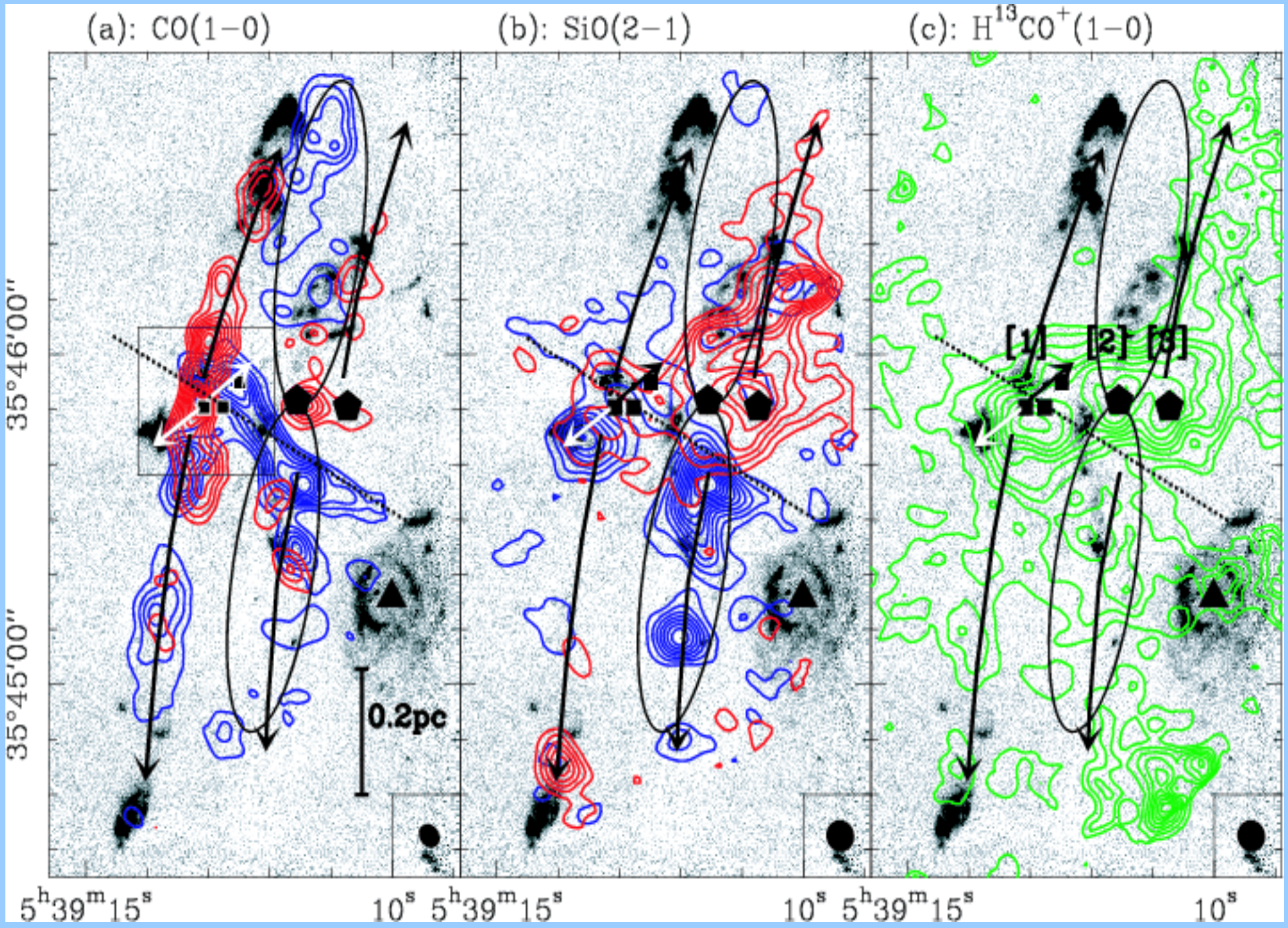
Recent studies indicate many simi-
larities between flows of all masses

High-spatial resolution essential



Near-infrared image of Orion outflow:
red H_2, green Paα, blue 2.15μm cont.
(Schultz et al. 1999)

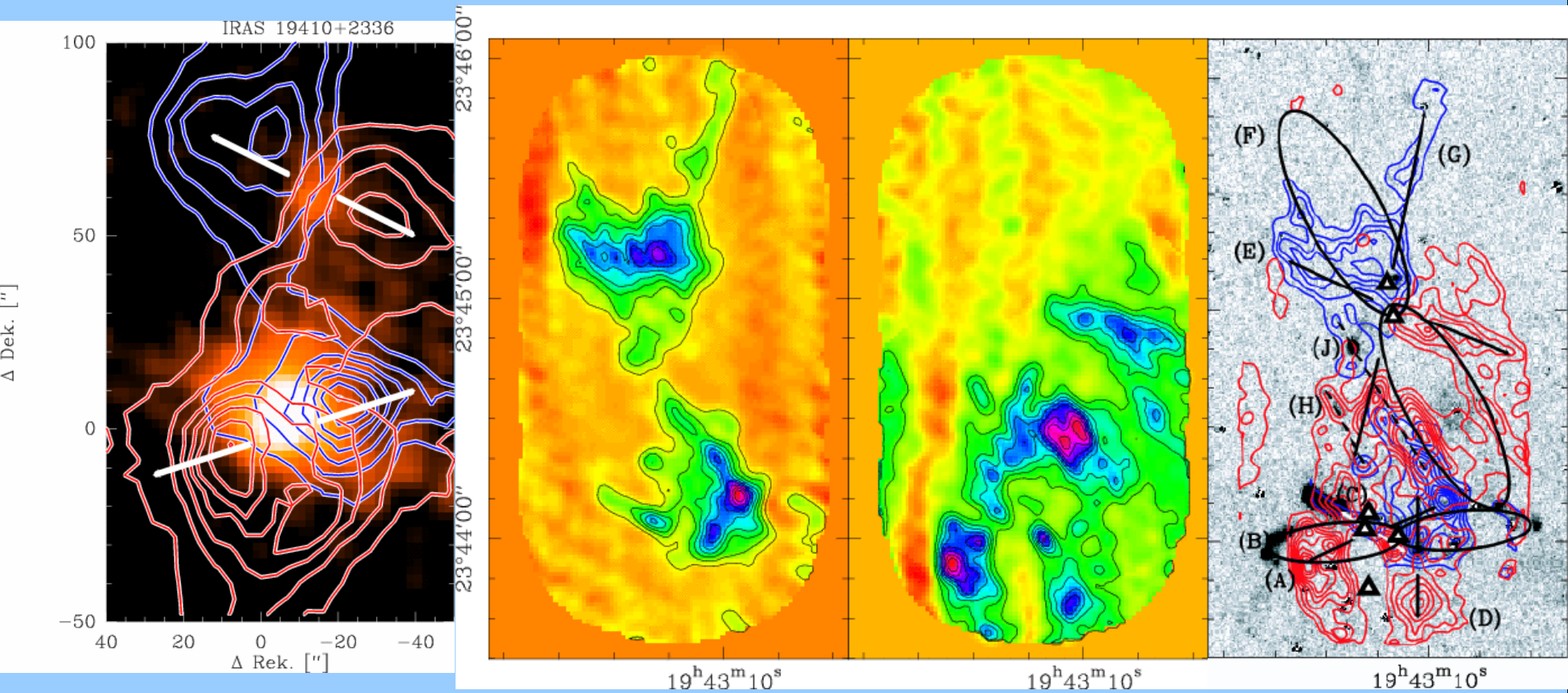
IRAS 05358+3543



IRAS 19410+2336

IRAM 30m

Plateau de Bure Interferometer



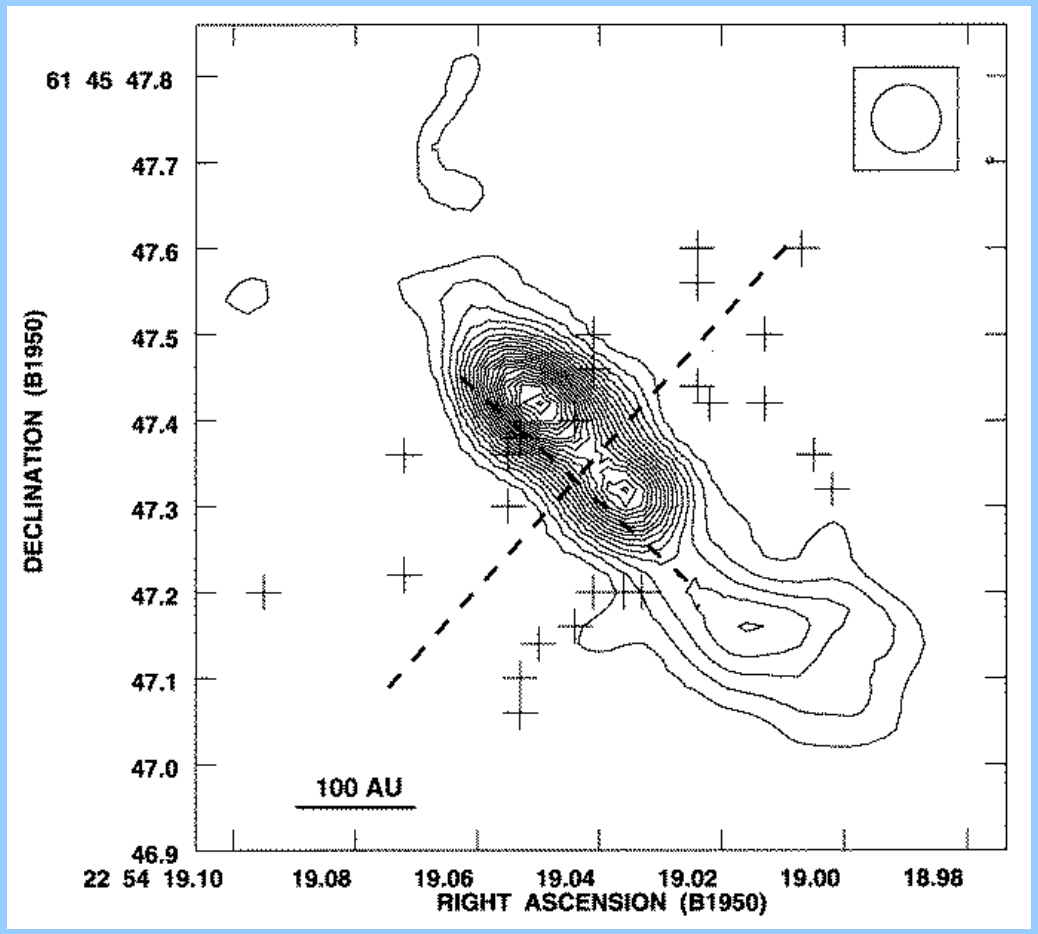
Color: 1.2mm cont.
Contours: CO(2-1)

CO(1-0) blue

CO(1-0) red

blue and red + H_2

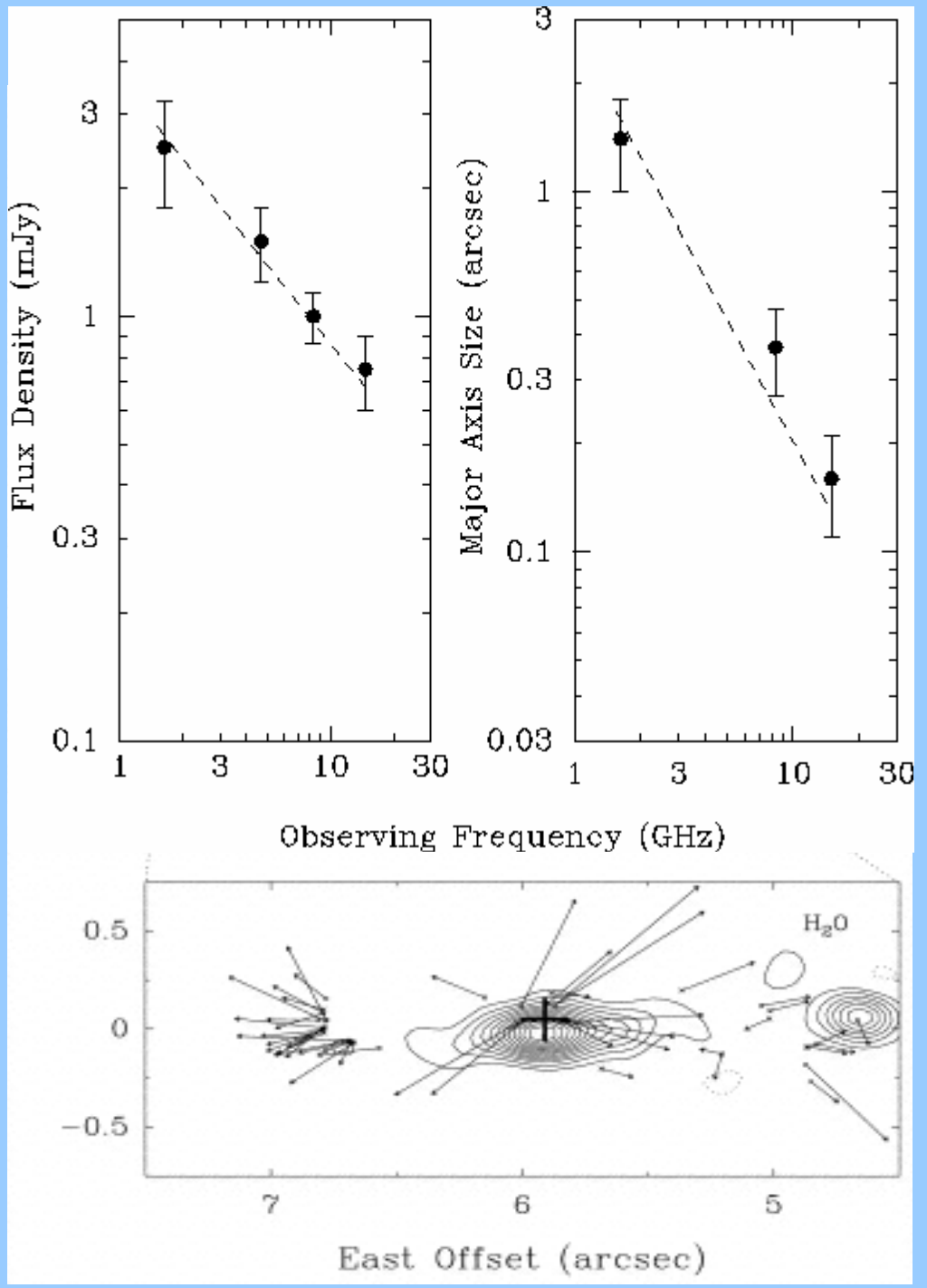
Radio Jets



Thermal jets (Torrelles et al. 1996)

Synchrotron jet

Assuming the power law to hold to X-ray:
e.g., S(7keV)~0.01μJy~10^{-23} erg cm^{-2}
--> to weak to be detected by CHANDRA



Reid et al. 1995, Wilner et al. 1999

Outflow parameters

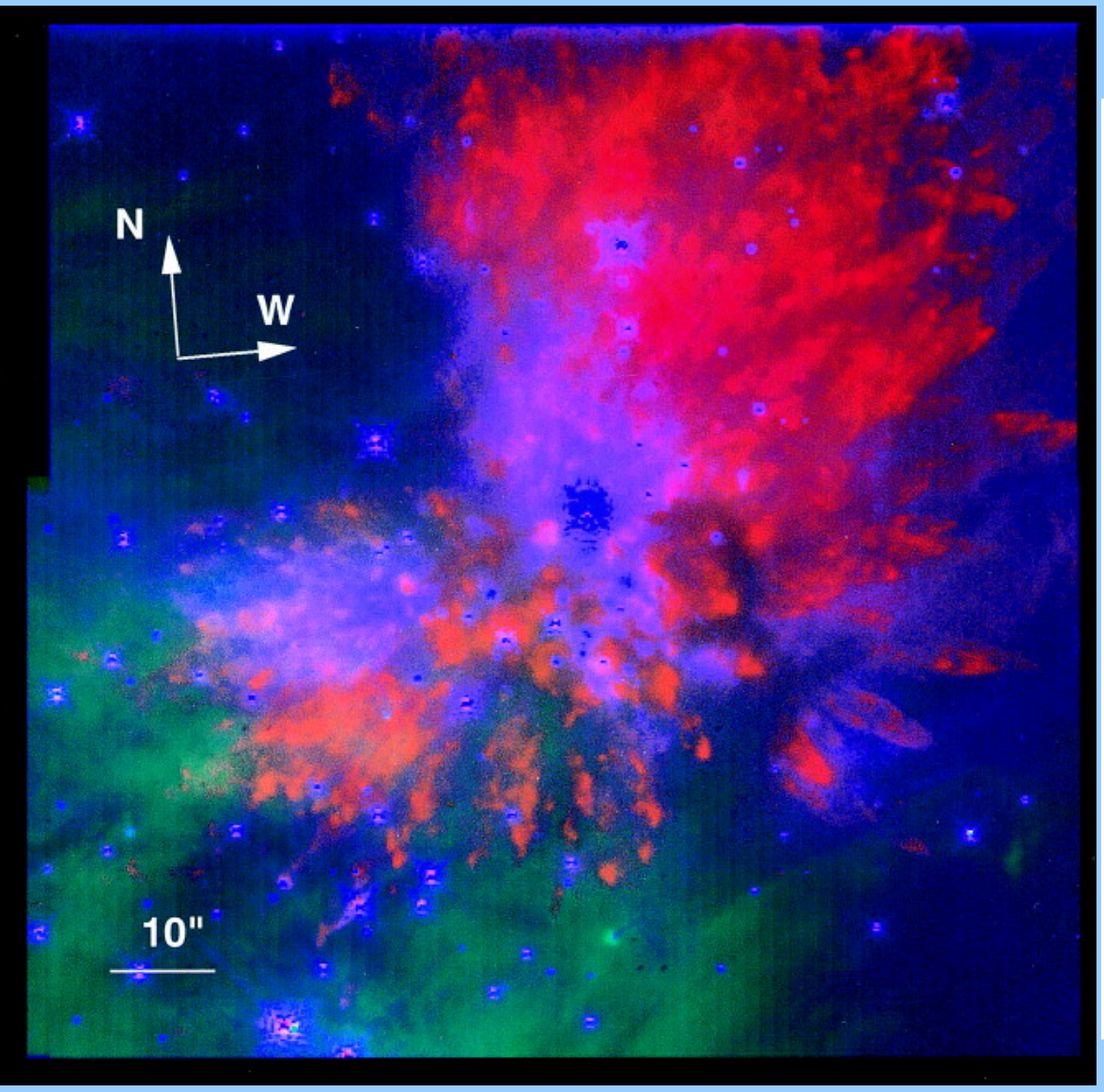
		Range	Mean
Mass	[M_{sun}]	3 - 140	45
Momentum	[M_{sun}km s^{-1}]	30 - 6000	1800
Energy	[erg]	4e44 - 4e47	9e46
Time	[yr]	3.000 - 180.000	65.000
Rate	[$M_{sun}yr^{-1}$]	6e-5 – 2e-3	7e-4

Previous low-mass correlations hold well into the high-mass regime

Beuther et al. 2002

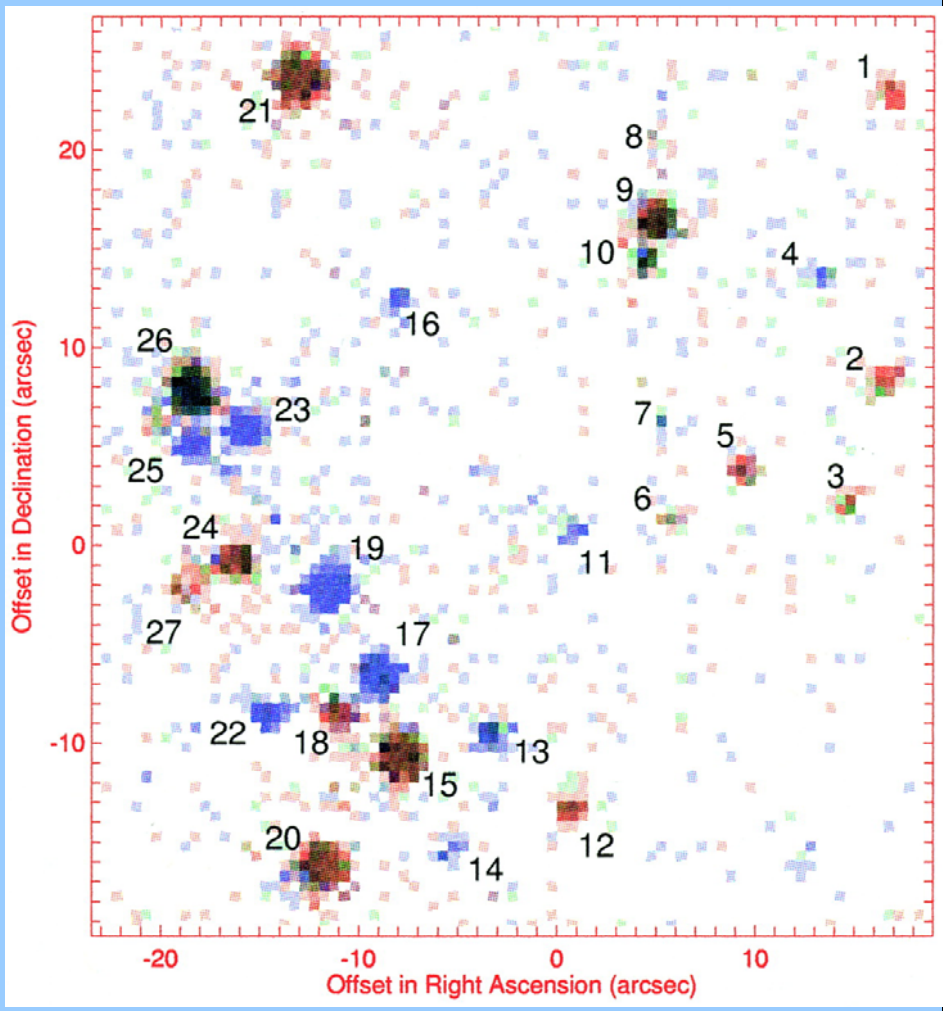
CHANDRA observations toward Orion KL

Near-infrared



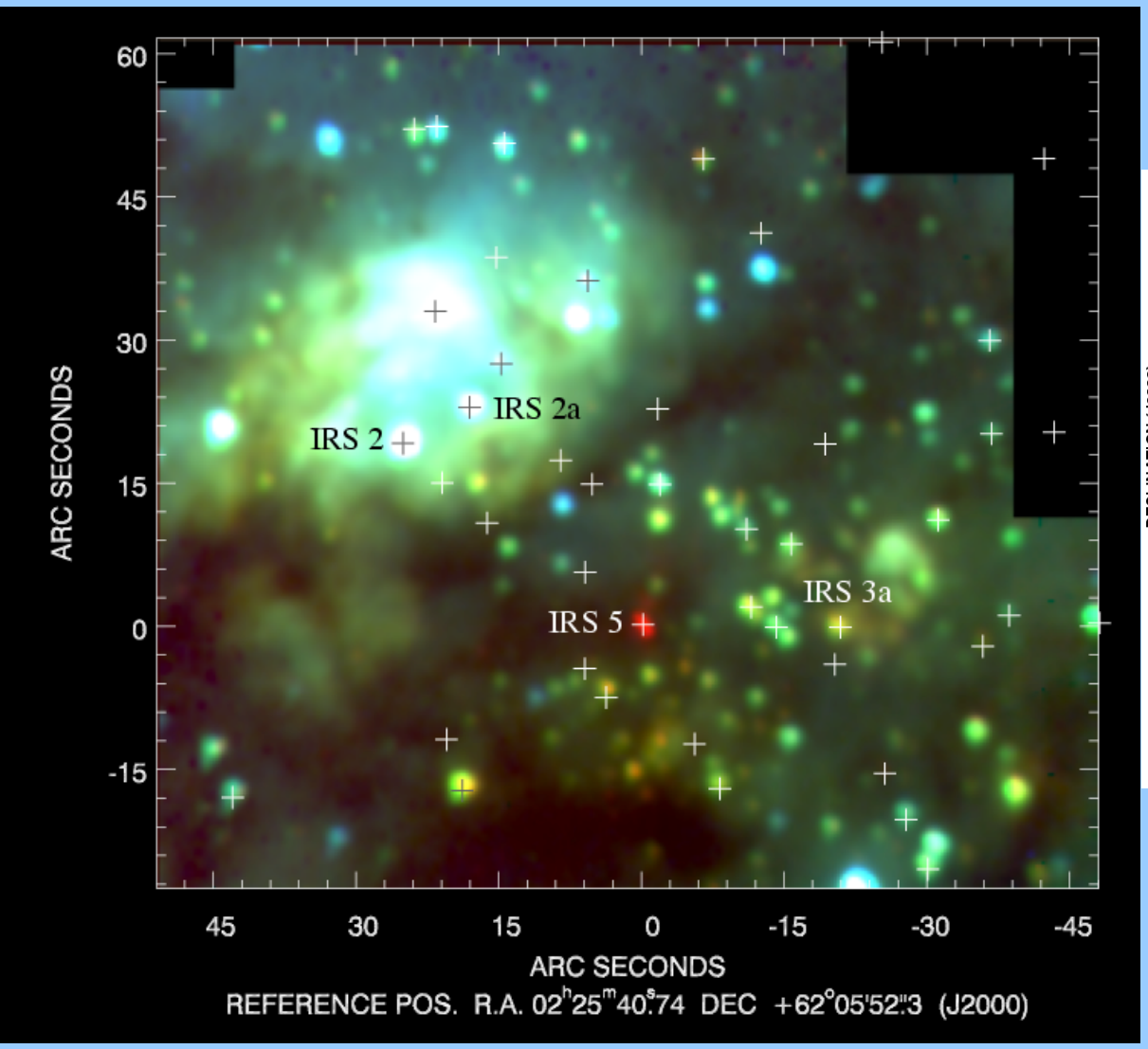
(Schultz et al. 1999)

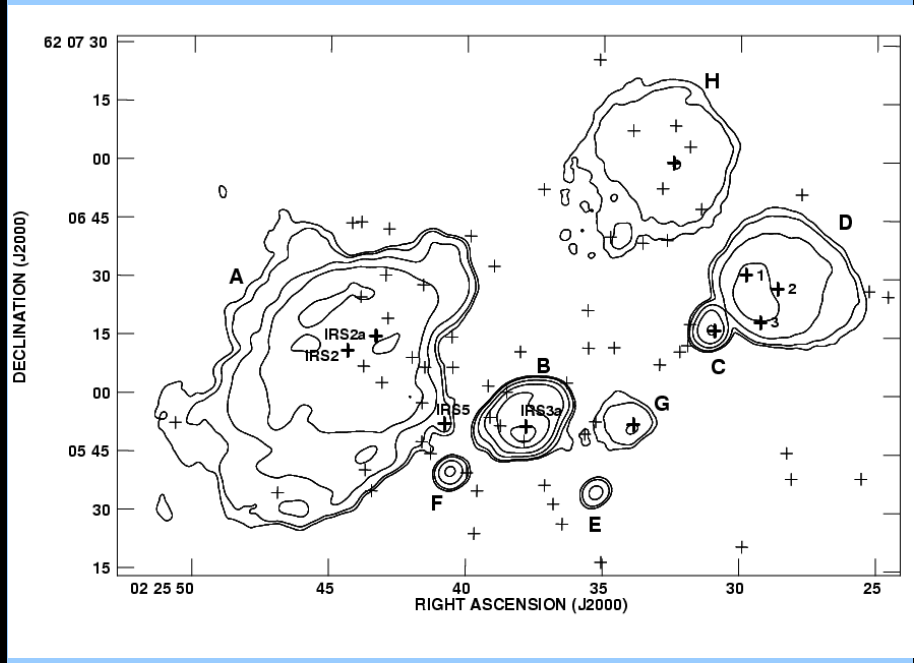
X-ray



(Garmire et al. 2000)

CHANDRA observations toward W3

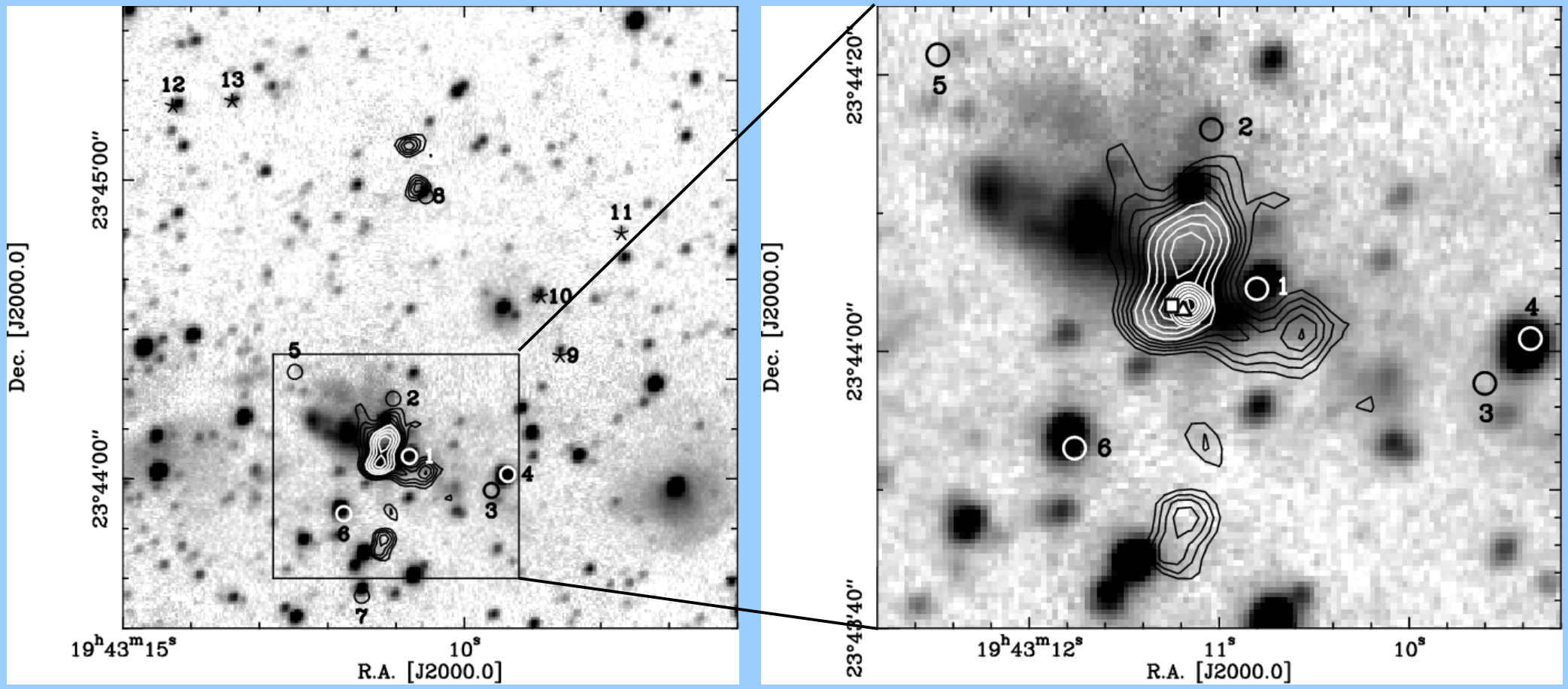




(Hofner et al. 2000)

19410+2336: The CHANDRA data

Grey: K-band, contours: 3mm cont., circles and stars: X-ray



(Beuther et al. 2002)

Questions and future prospects

Massive outflows are a domain of the mm and not the xray regime!

- Deeper analysis of the energy budget and feedback process to the natal clouds
- Modeling of massive outflows and comparison with low-mas flows
- Try to derive a unified picture for outflows of all masses

- Detect the deepest embedded sources in X-ray emission?
  --> extinction too high
- Detect the syncrotron jet in X-ray?
  --> emission too weak
- Detect the bow shocks in X-ray?
  --> could be tried, was already done in low-mass sources
  (e.g., Favata et al. 2002)