High energy (X-ray) emission from HD 163296

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Overview

- FUV & optical emission from the jet
  (many photons)
- X-ray emission from the jet
  (a few photons)
- X-ray emission from the central component
  (some photons)

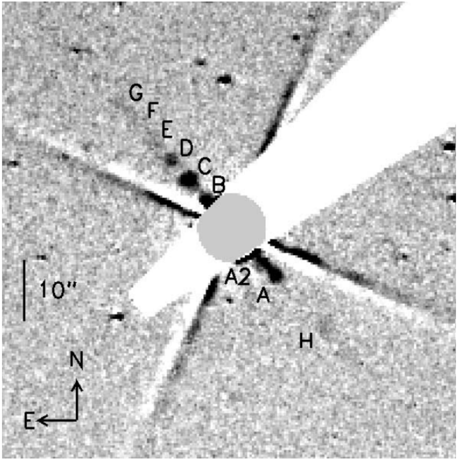
HD 163296

- spT: A2, Age: 4 Myr

  Montesinos et al. (2009)
- $d = 122\,\mathrm{pc}$ van Leeuwen 2007
- No detected stellar magnetic field

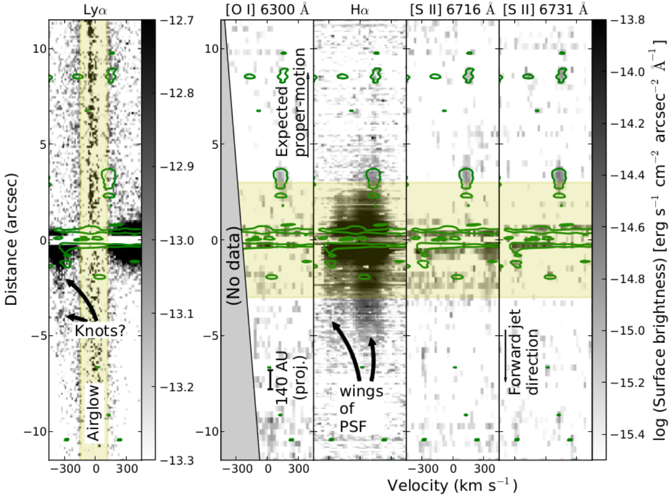
  Hubrig et al. (2007), Wade et al. (2007), Alecian et al. (2013)
- $\log \dot{M}_{\rm accr.} \sim -7$

  Mendigutía et al. (2014), Ellerbroek et al. (2014)
- Well-known jet Devine et al. (2000), Grady et al. (2000)



From Wassell et al. (2006)

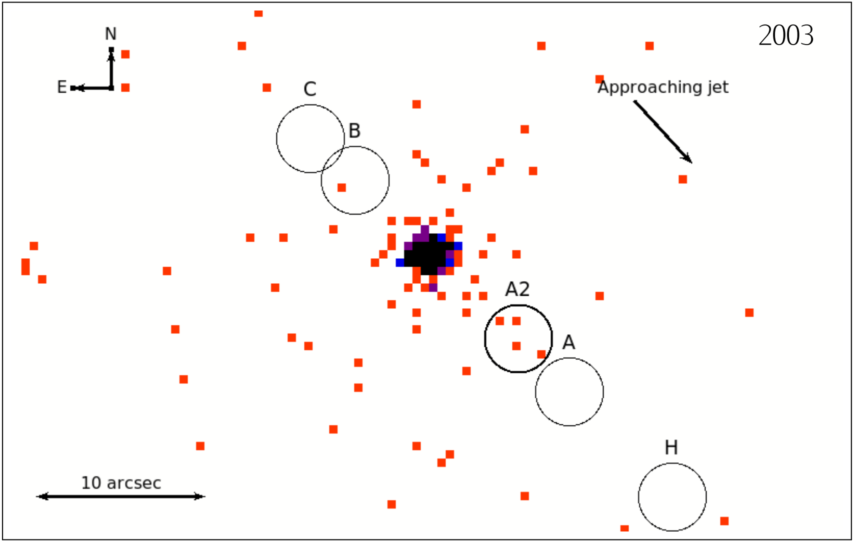
The jet in Lyα and in optical lines



STIS long-slit data from 2011: $\dot{M}_{\mathrm{out}} \sim 10^{-9}\, M_{\odot}\,\mathrm{yr}^{-1}$

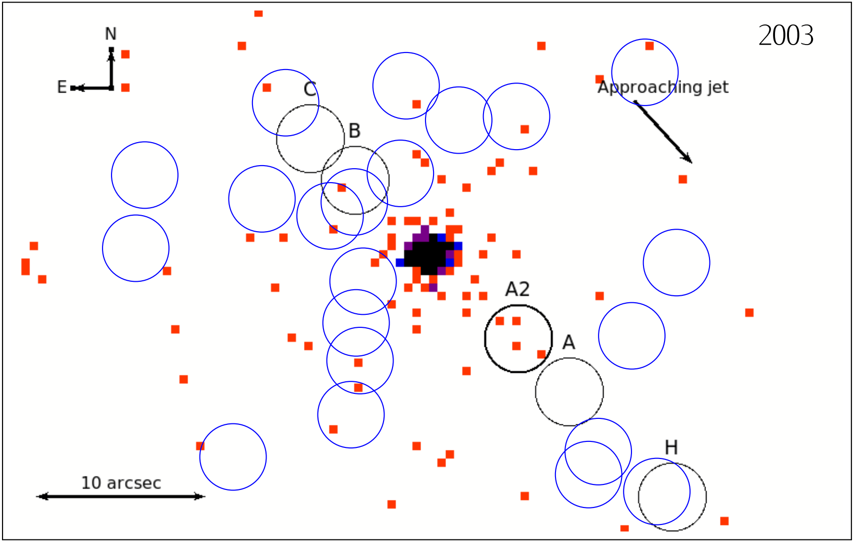
From Günther, Schneider & Li (2013)

. . . and in X-rays!



Adapted from Swartz et al. (2005)

...and in X-rays!



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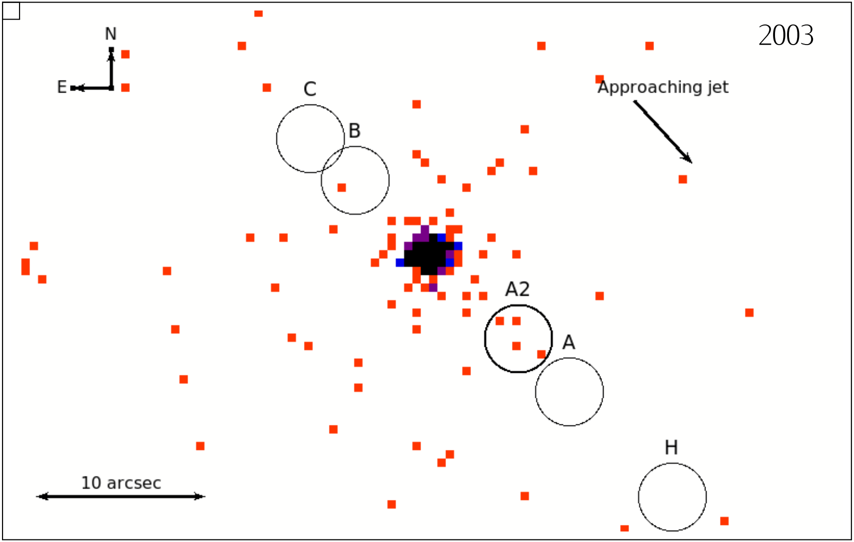

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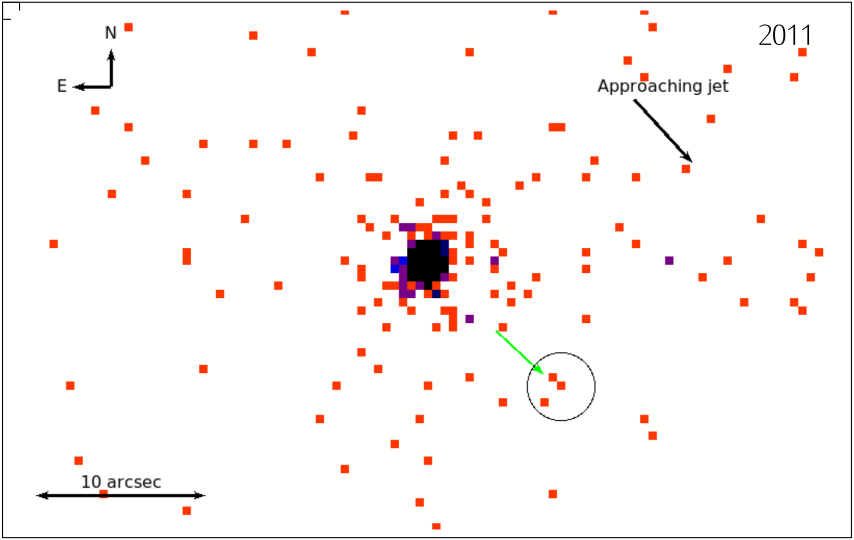

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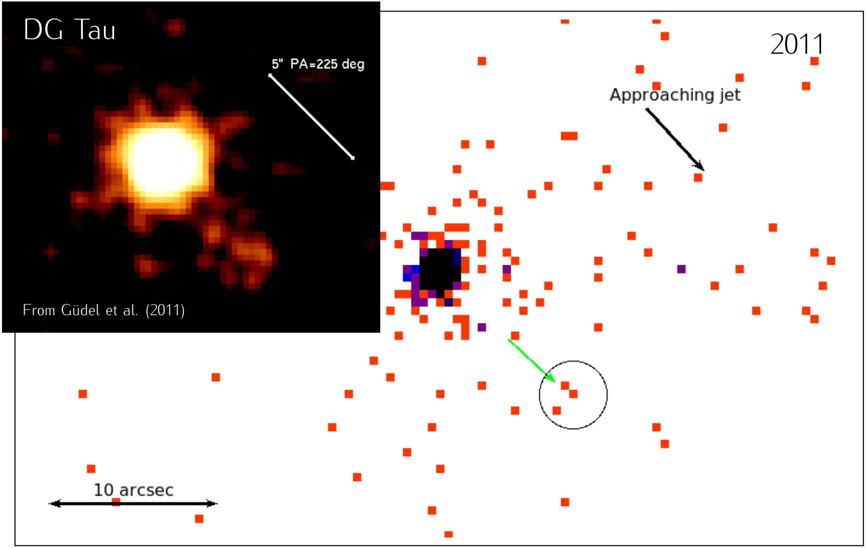


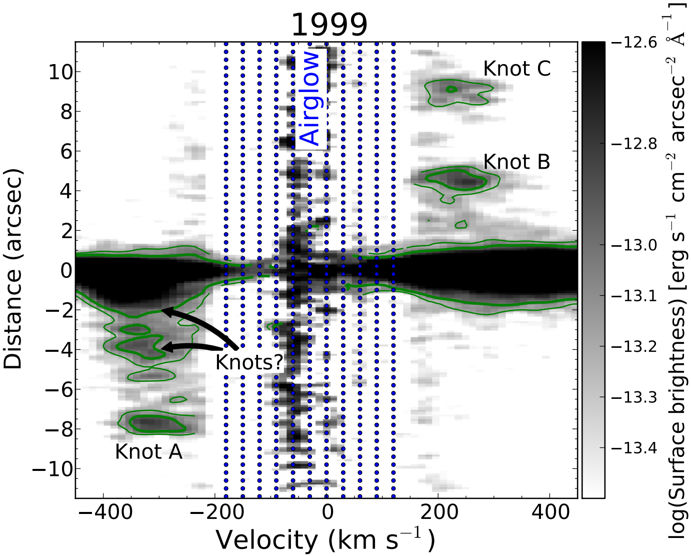
Adapted from Günther, Schneider & Li (2013)

What does that mean?

- Highly significant detection
  (conf. 97 % in 2003, 93 % in 2011)
- X-rays require $T \gtrsim 3 \times 10^6$ K
- translates to **shock** velocities of 500 km s^{-1}
- Evidence for high shock velocities?
  "classical" jet tracers indicate $v_s < 100$ km s^{-1}
  (e.g., Ellerbroek et al. 2014)

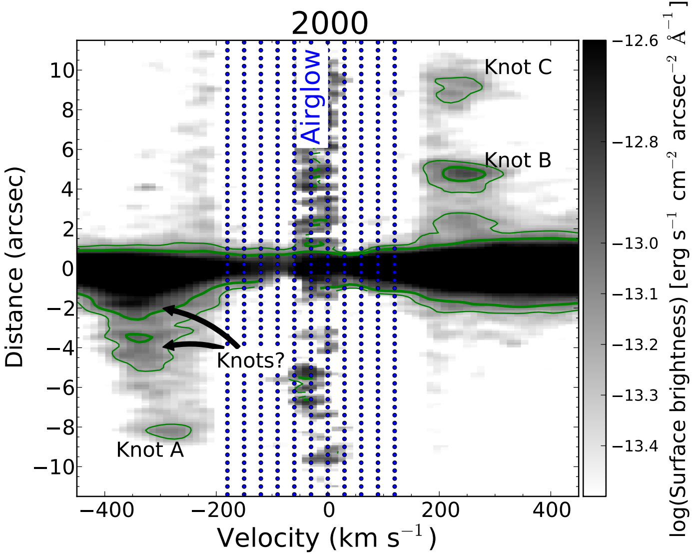
→ Look at Lyα

Lyα - Emission from forward & counter-jet



Data from Devine et al. (2000)

Lyα - Emission from forward & counter-jet



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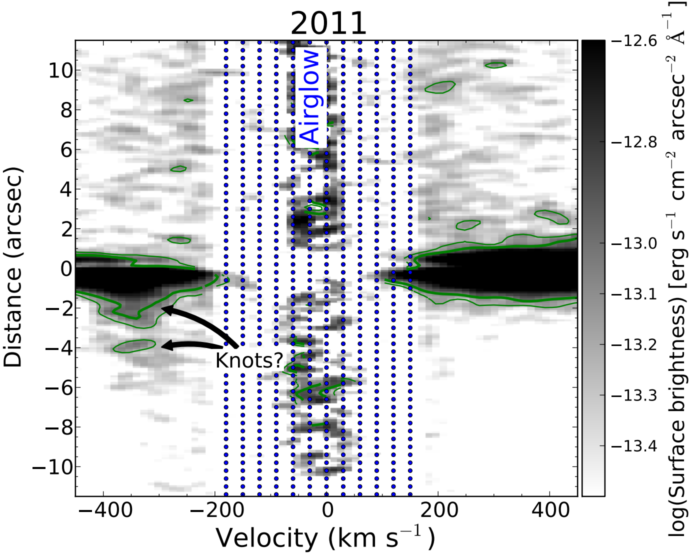
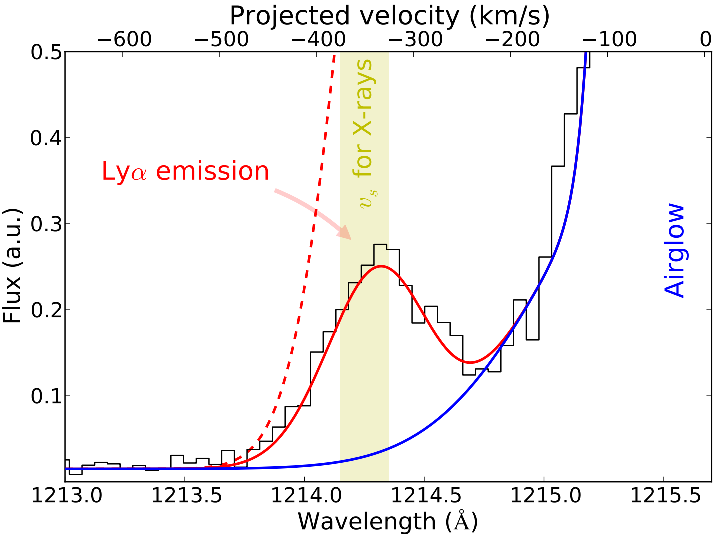


From Günther, Schneider & Li (2013)

X-ray vs. Lyα emission

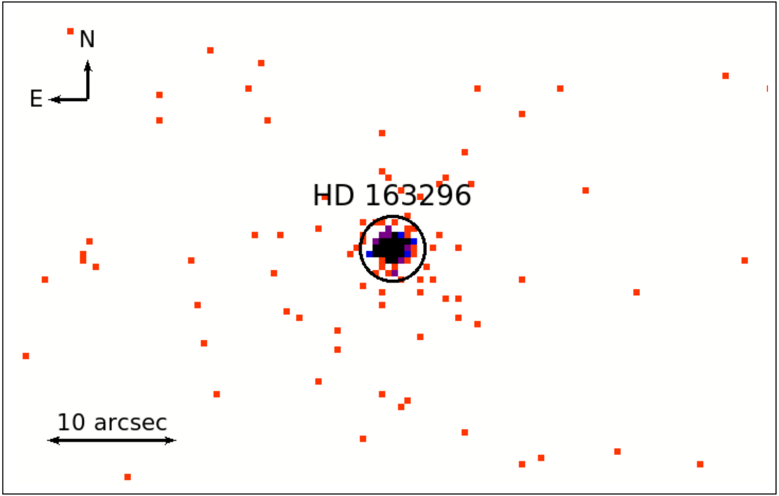


Adapted from Günther, Schneider & Li (2013)

Origin of the X-ray emission?

- Bulk velocities too low to explain X-rays
- Minimum *flow* velocity required:
  ca. 600 $\mathrm{km\,s^{-1}}$ which implies a launching region close to 0.1 AU for MHD disk winds
- Possibility: Stationary shock at the base of the jet

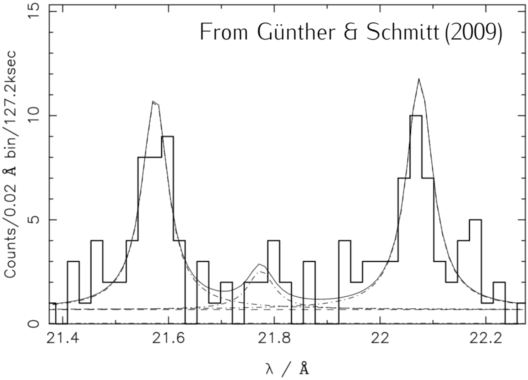
The central source in X-rays



Adapted from Günther, Schneider & Li (2013)

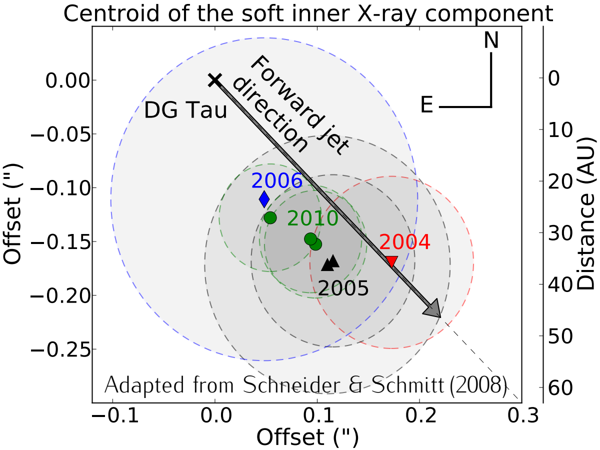
Stellar X-ray properties of HD 163296

- $\log L_X = 29.4$
- Soft spectrum (mean energy 0.5 keV)
- O VII triplet → soft X-rays come $\gtrsim 2\,R_\star$ above the photosphere (**No** signs of accretion)



Non-stellar X-rays in YSOs

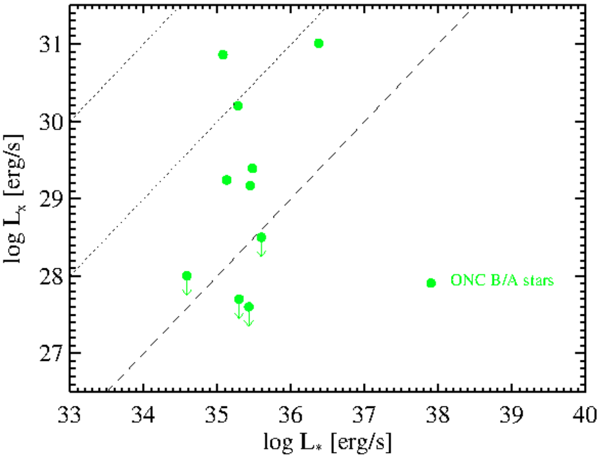
- Jet driving sources often show particular X-ray spectrum (TAX-sources, Güedel et al. 2007)
- Prime example: DG Tau
- However, no offset in HD 163296 (X-rays within 30 AU)



Conclusions I

- Non-stellar, but "central" X-ray component
- 10 % of the jet mass loss required to power X-ray emission (10^{-10} vs. $10^{-9}\,M_\odot\,\mathrm{yr}^{-1}$)
- X-ray properties similar to (some) CTTS
  → X-rays related to innermost jet component
  → Similar magnetic jet launching mechanism

X-rays from HD 163296 in context



From Stelzer et al. (2009)

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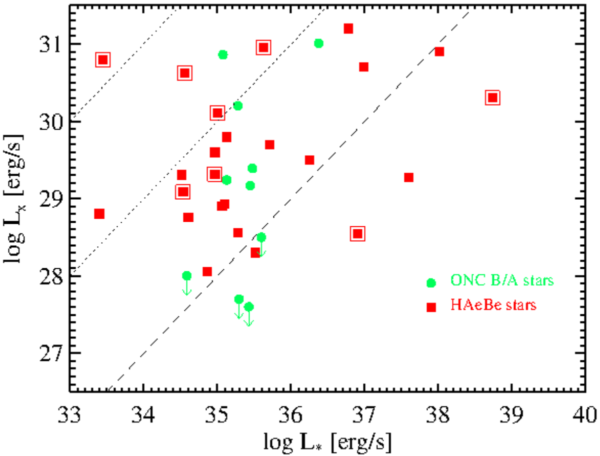

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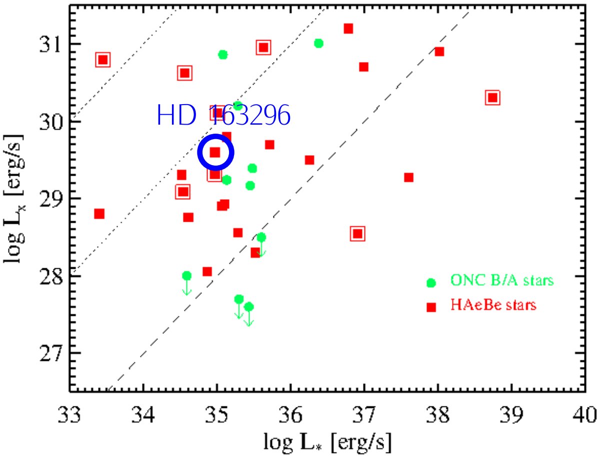

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Conclusions II

- No unique X-ray emission mechanism in HAeBe stars
- HD 163296 is among the X-ray brightest HAeBe stars
- Outflow emission probably represents an additional X-ray generating process
- Comparison with CTTS
  $\rightarrow$ Jet launching probably similar even for the highest velocities