

The small-scale structure
of the Interstellar Medium and
IHVCs via FLAMES
CaK observations of open clusters

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Talk outline

- A very brief introduction: Intermediate and High velocity clouds and probing structure in the ISM.
 - Some twin-epoch data towards early type stars to search for tiny-scale structure.
 - Some UVES POP data towards Galactic Open clusters looking for small-scale structure (early-type stars).
 - Presentation of FLAMES (interstellar) CaK spectra towards clusters in the Magellanic clouds and IHVCs.
 - Future work.
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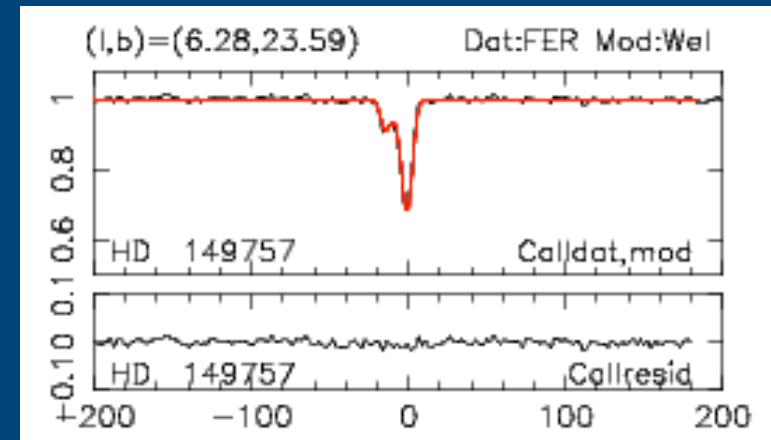
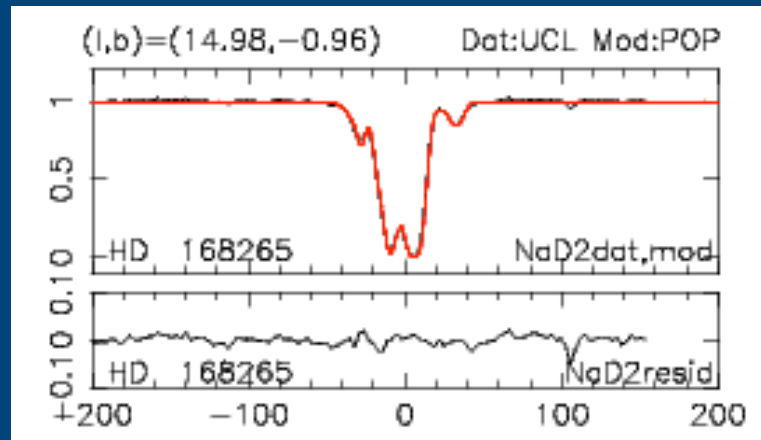
Introduction: Distances to IHVCs

- Intermediate and High velocity clouds are objects with velocities not explained by normal Galactic Rotation.
 - To get an UPPER distance limit to an IHVC we simply look for absorption in a stellar/QSO probe – if this absorption is seen then $d(\text{IHVC}) < d(\text{probe})$.
 - For a LOWER distance limit we interpret the LACK of IS absorption being caused by the cloud being further away than the star, depending on clumpiness...
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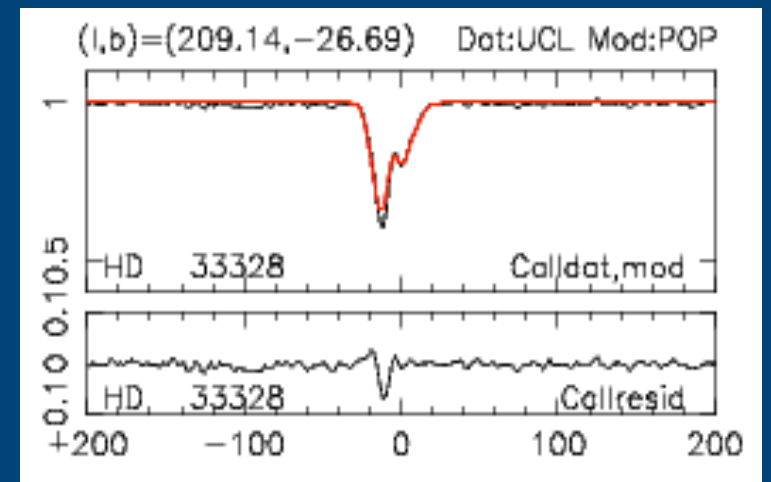
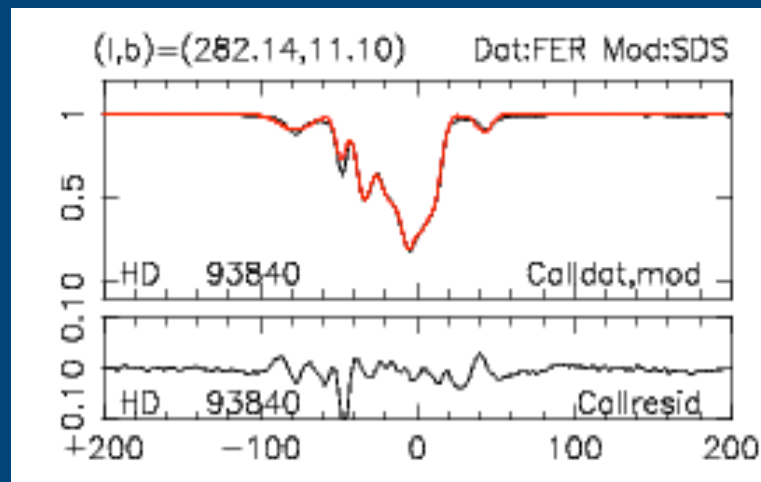
Intro: Tiny scale structure in the ISM

Multiple-epoch observations of stars enables us to probe AU-scale structure:

No variation:



Variation?:



Intro: Small scale structure in the ISM

- “Small” (pc) scale structure (or “clumpiness”) in the ISM/IHVCs can be probed using binary stars, Globular clusters or ***Open Clusters***.
 - For SSS variation is always seen in NaD.
 - In CaK there are fewer observations although normally less variation is observed.
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UVES POP IC2391 & NGC 6475

- The clusters are nearby at 175 and 301-pc.
- In each species (TiII, CaII, NaD and KI) there are typically 10-20 good spectra per cluster towards early-type stars, that is 10-20 different pointings!
- The S/N ratio ranges from ~100-600, depending on the star and wavelength region.

What do we see?

UVES IC2391 CaII K profiles – big variation!

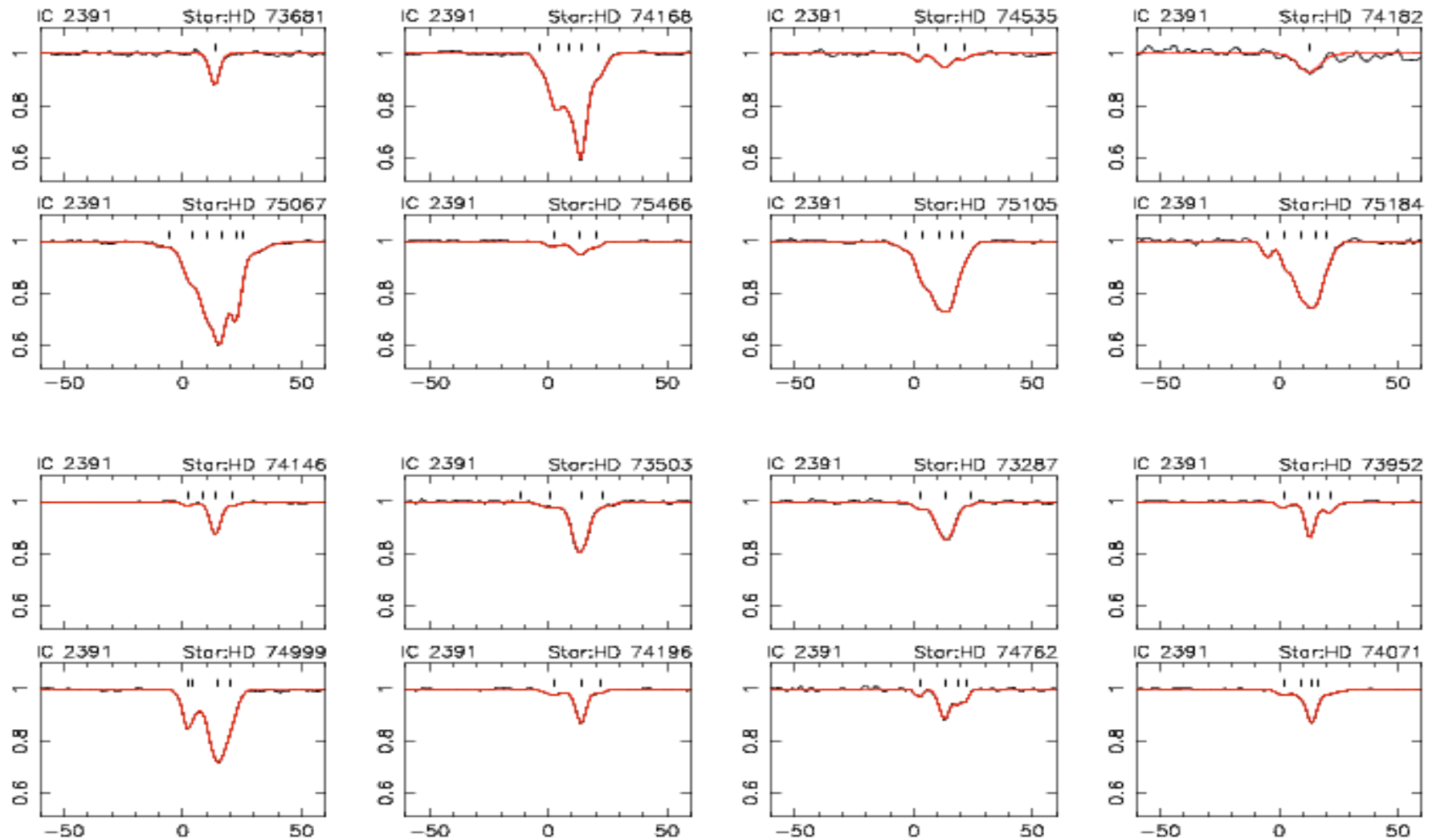


Figure 8. Ca II K spectra towards IC 2391 showing the spectra of 8 star-to-star pairs in which the maximum difference in the equivalent width was detected between a velocity of -50 and $+50$ km s^{-1} in the LGR. Each star is only plotted once.

NGC 6475 CaII K profiles – smaller variation!

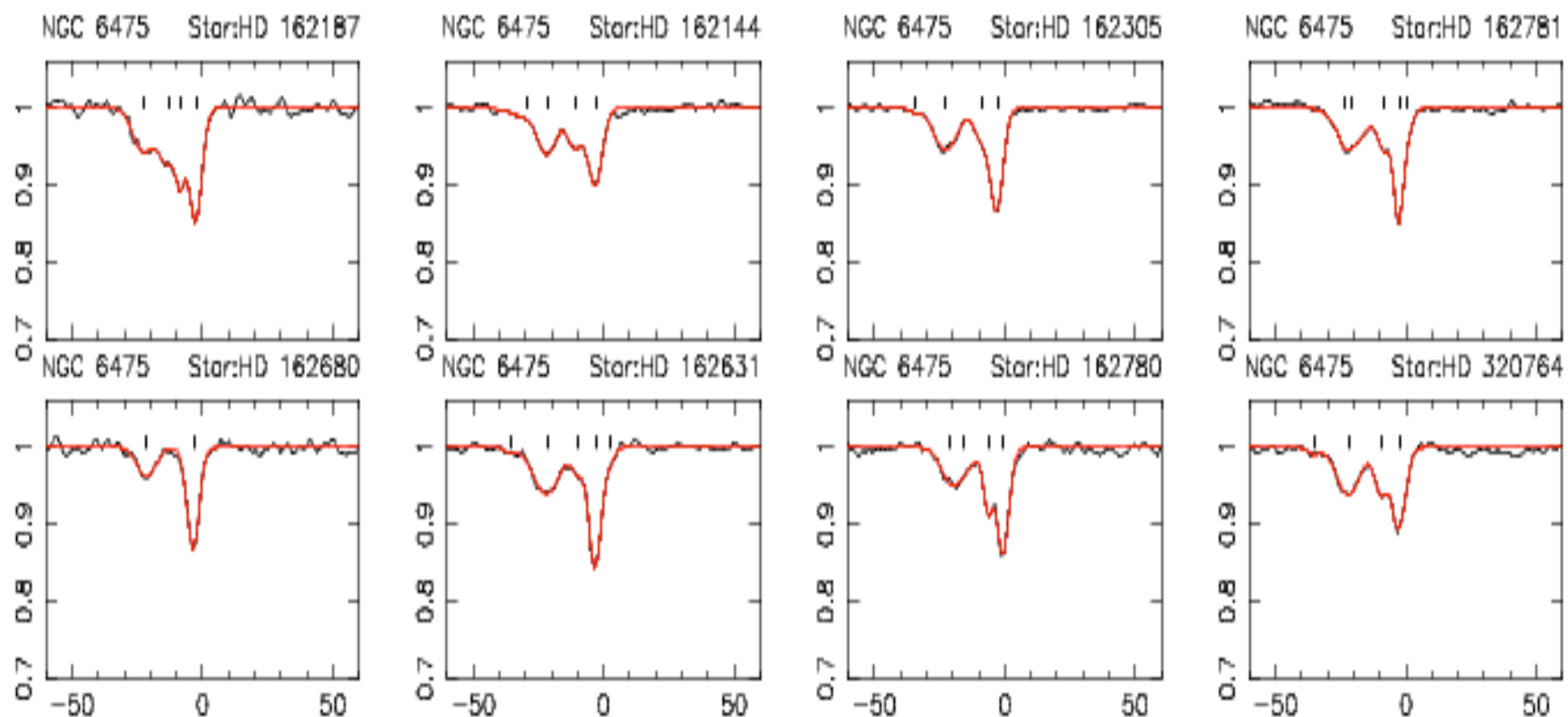
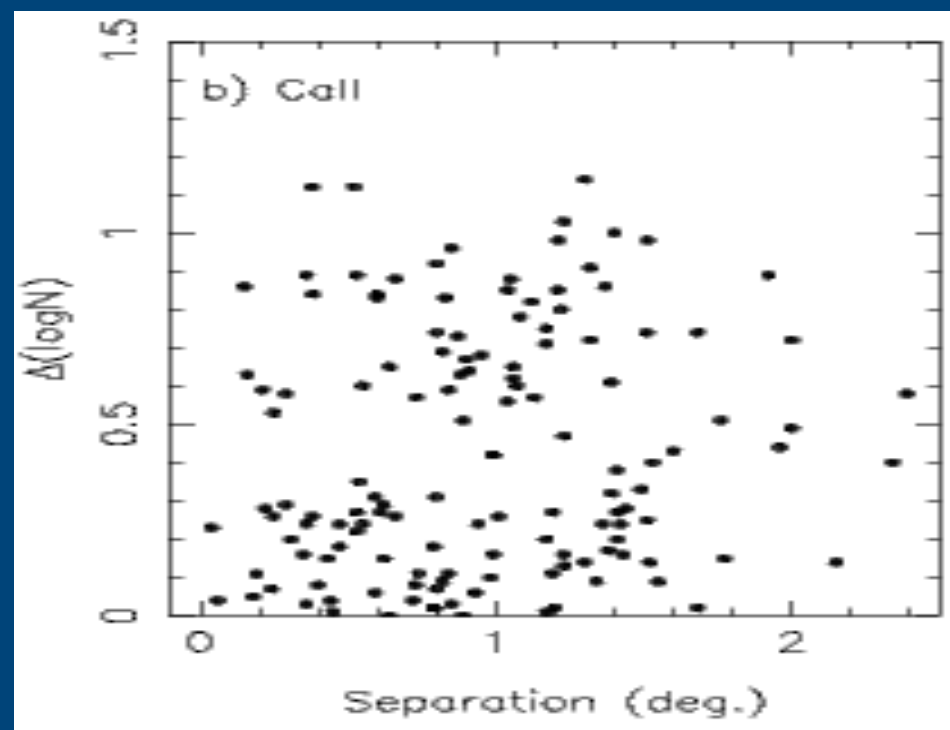
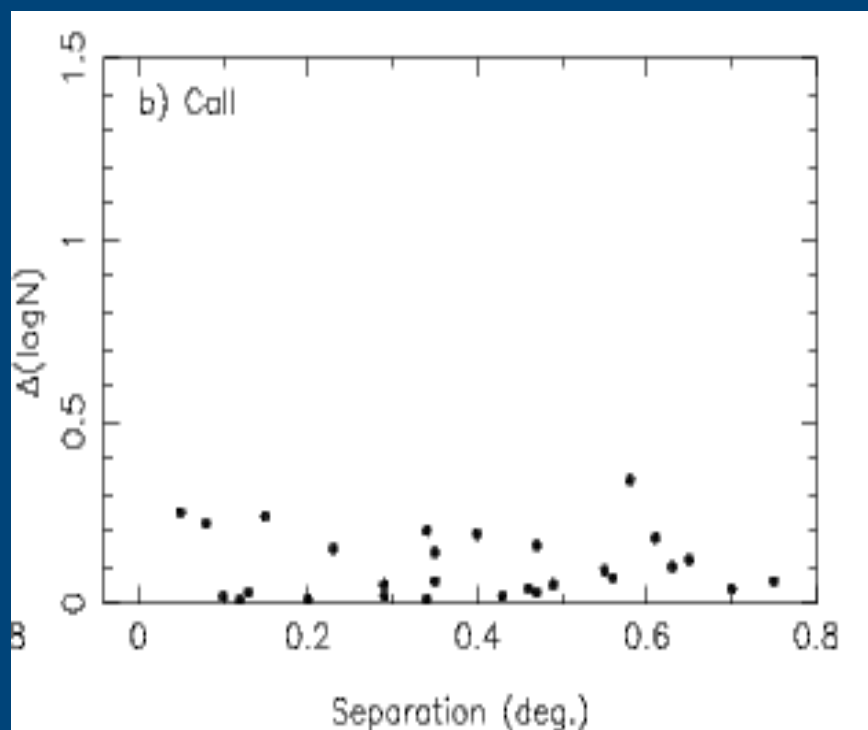


Figure 11. CaII K spectra towards NGC 6475 showing the spectra of 4 star-to-star pairs in which the maximum difference in the equivalent width was detected between a velocity of -50 and $+50$ km s^{-1} in the LSR. Each star is only plotted once.

UVES point-to-point CaK coldens differences

For NGC 6475 (LH plot) the difference in $N(\text{CaK})$ is within $\sim 40\%$. For IC 2391 (RH plot), it is huge...



Cluster results and what to do about distance uncertainty?

This work and Megier et al. (2005,2008) find that in some **Galactic cluster** sightlines there are large variations in observed CaK column density, in some not.

It seems that there could be the problem either of non-cluster contamination or the local bubble to worry about.

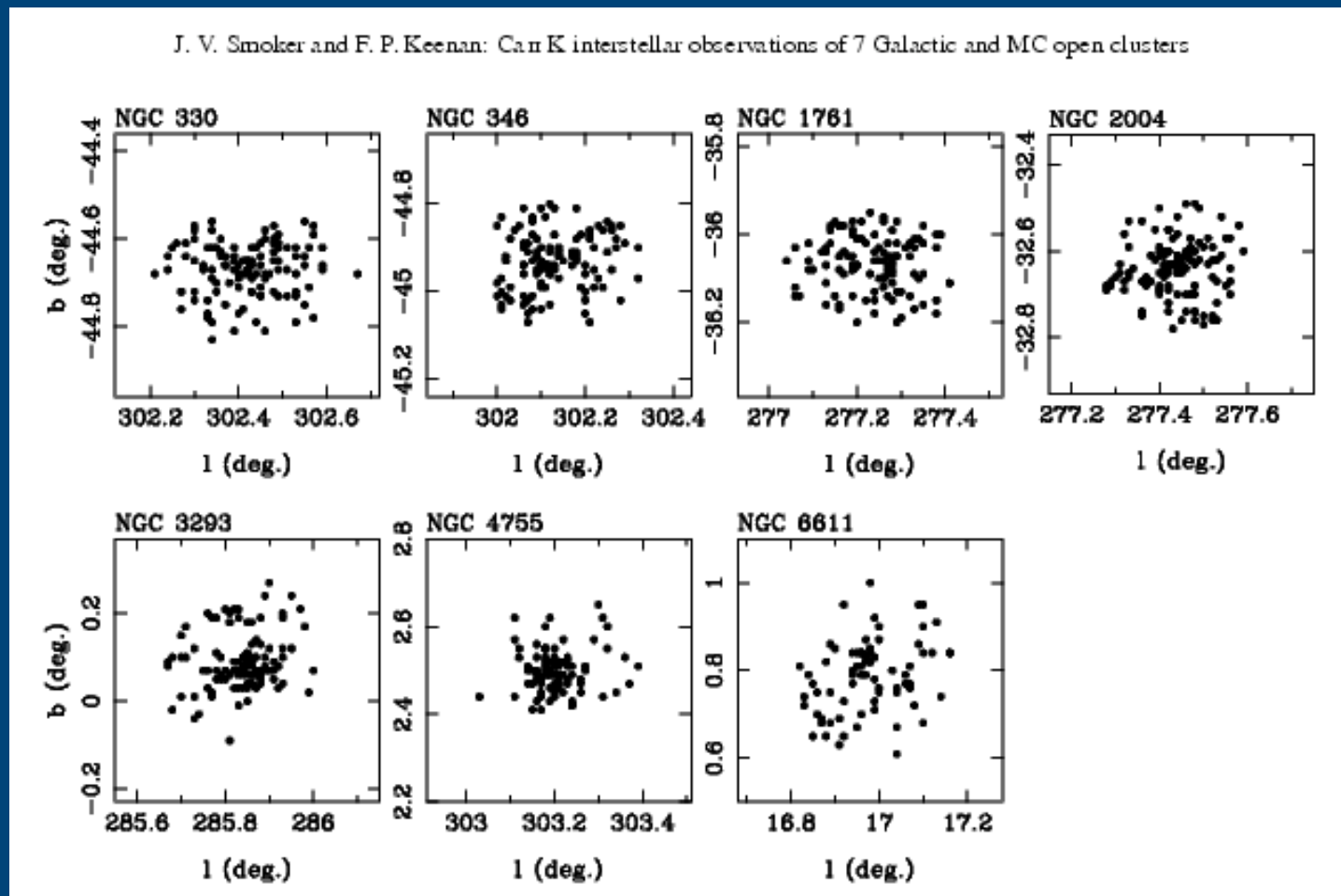
Hence....

Look at extragalactic targets – FLAMES!!

- Extragalactic targets are good because the distance uncertainty is not an issue (...for the Galactic part..)
 - Used 4 open clusters in the ESO archive (Smartt Large Programme) that had been observed with FLAMES at CaK, two in the LMC and two the SMC (plus 3 Milky Way open clusters). Spectral resolution about 16 km/s with the field-size around half a degree.
 - FLAMES lets us look at ~100 stars in a single shot...
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FLAMES sightlines

There are a total of 609 stars with good CaK FLAMES data with S/N of 50-140. Taken from Smartt et al. LP.



Data reduction

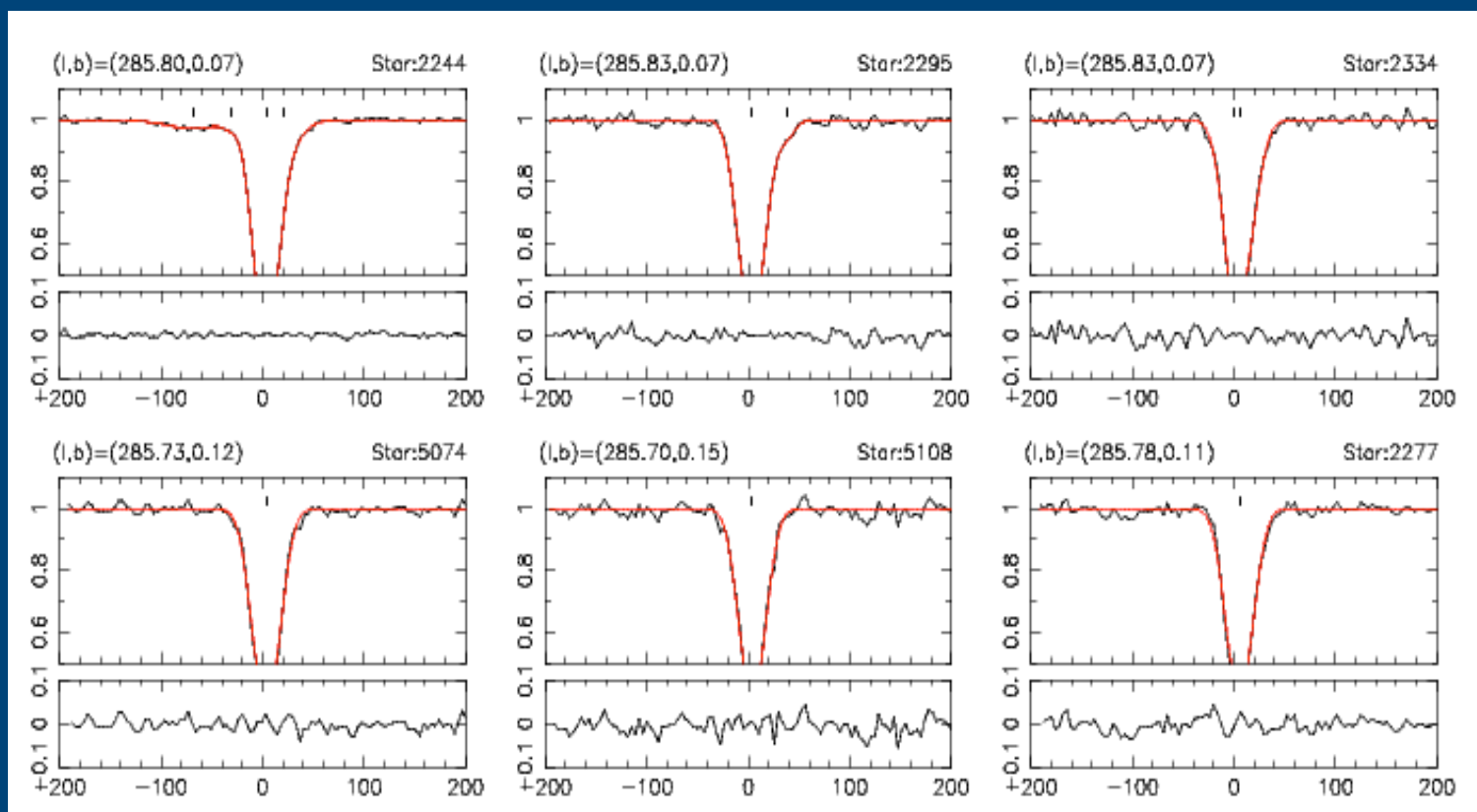
Data reduction was done using the ESO/Giraffe pipeline, at some point I will compare with Chris Evans reduction which was done using IRAF.

Only problem was that I jumped in without thinking and therefore had to do the association of the stars with the fibre numbers by hand! AARGH! (by using their known magnitudes, position of sky fibres).

AARGH!

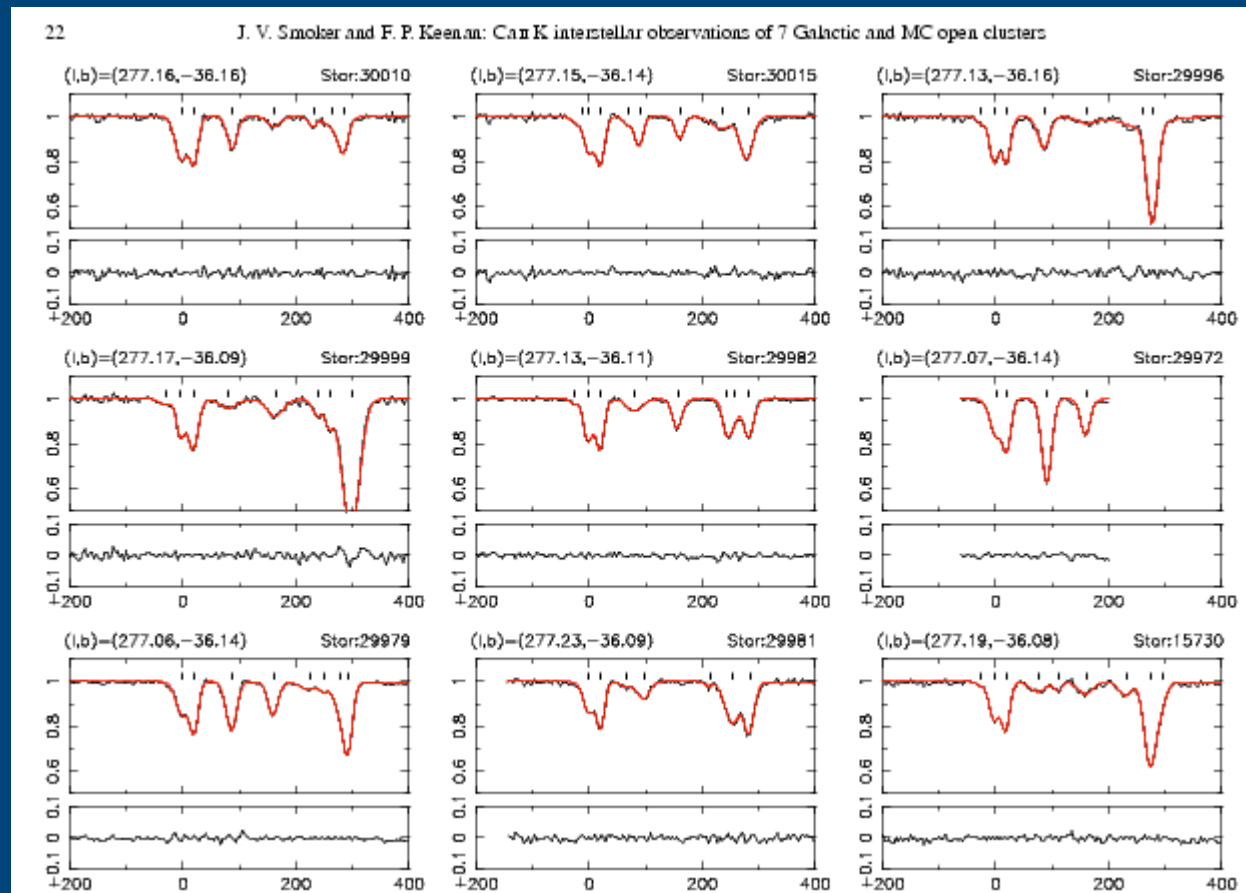
FLAMES Galactic Open clusters: NGC 3293

Have simple profiles, with typically 1 or 2 components seen in the FLAMES spectra. No IHVCs seen.



FLAMES Magellanic clusters: NGC 1761

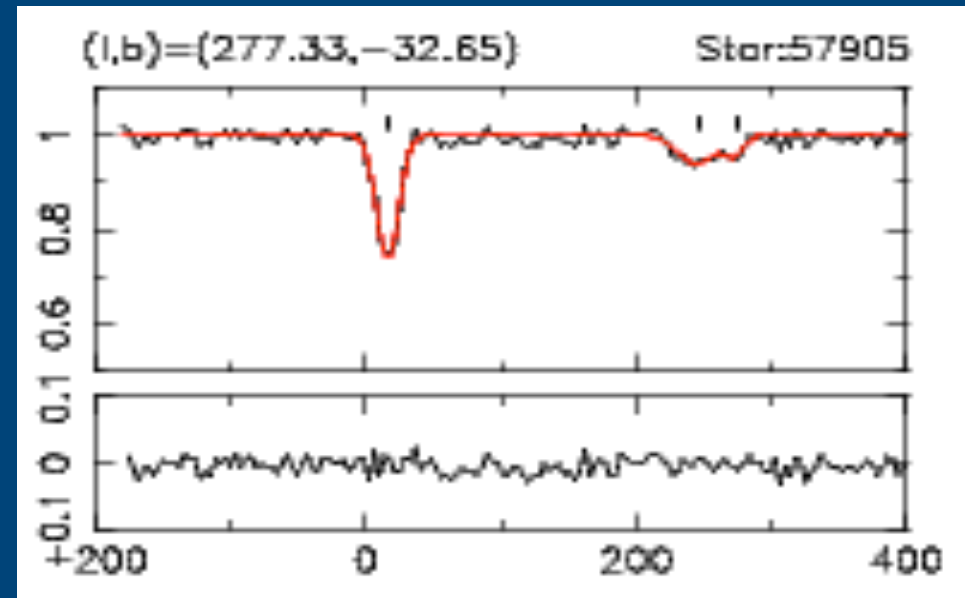
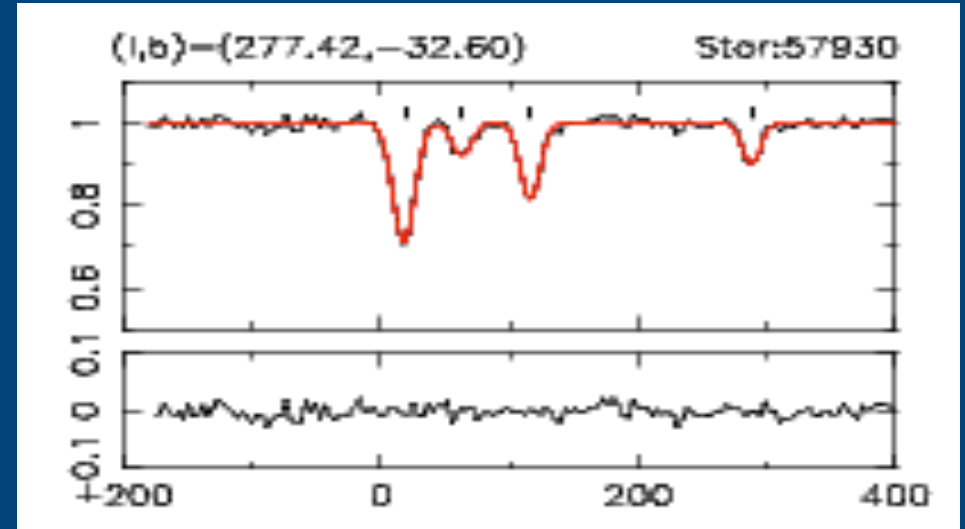
These show multicomponent structure, from the Milky Way, IHVCs and the Magellanic Clouds themselves.



FLAMES Magellanic clusters: NGC 2004

- We see a factor 10 difference in CaK line strength in the IHVC components of lines of sight separated by only ~8 arcminutes!

-implications for lower distance limits to HVCs



Conclusions and future work

- We find that in HV gas the FLAMES-observed CaII EW can vary by factors of 10 over only ~ 8 arcmin, hence care is needed in determining lower-distance limits to IHVCs.
- Future work will entail looking at the CaI data and observing the same sightlines in NaD, thus exploring the Routly-Spitzer effect.

*****THE END*****

Star 57930 (with IHVCS). Top panel, NII line at 3995 Angstroms shows the star has $V=315$ km/s and $\text{FWHM}=58$ km/s. Bottom panel, Lehner et al B-type narrow line star showing in any case no SII features at velocities of IHVCSs of -180 and -230 km/s relative to the stellar velocity.

