12mm Overlap with Galactic TeV emission

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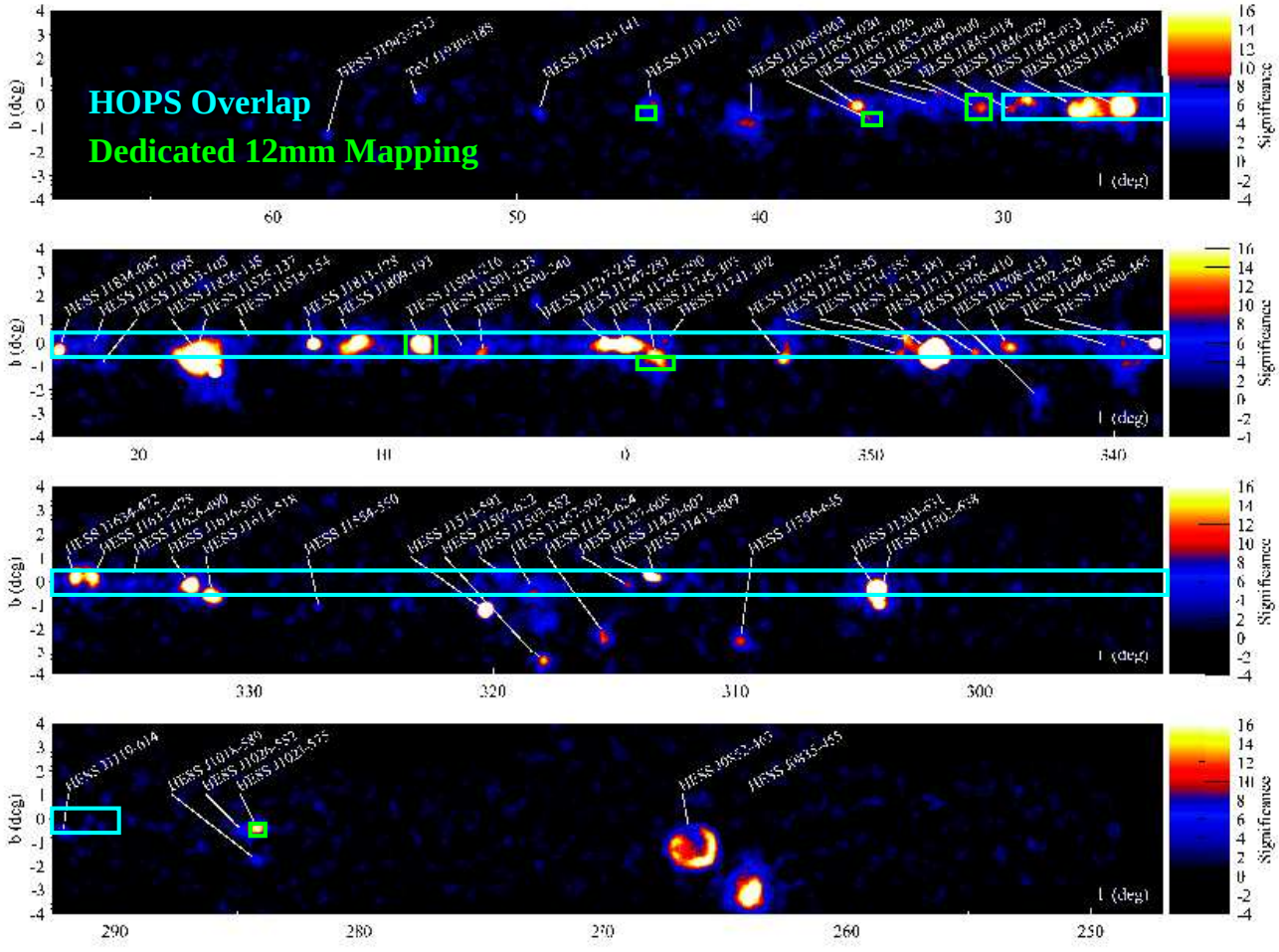


HESS/HOPS overlap

Survey Outline

What can we do with this survey?

Further Observations

Ortho vs Para Ammonia

NH_3 Ortho-to-Para abundance ratio enhancement in shocked gas

Galactic TeV sources with enhanced OPR

W28

HESS J1745-303

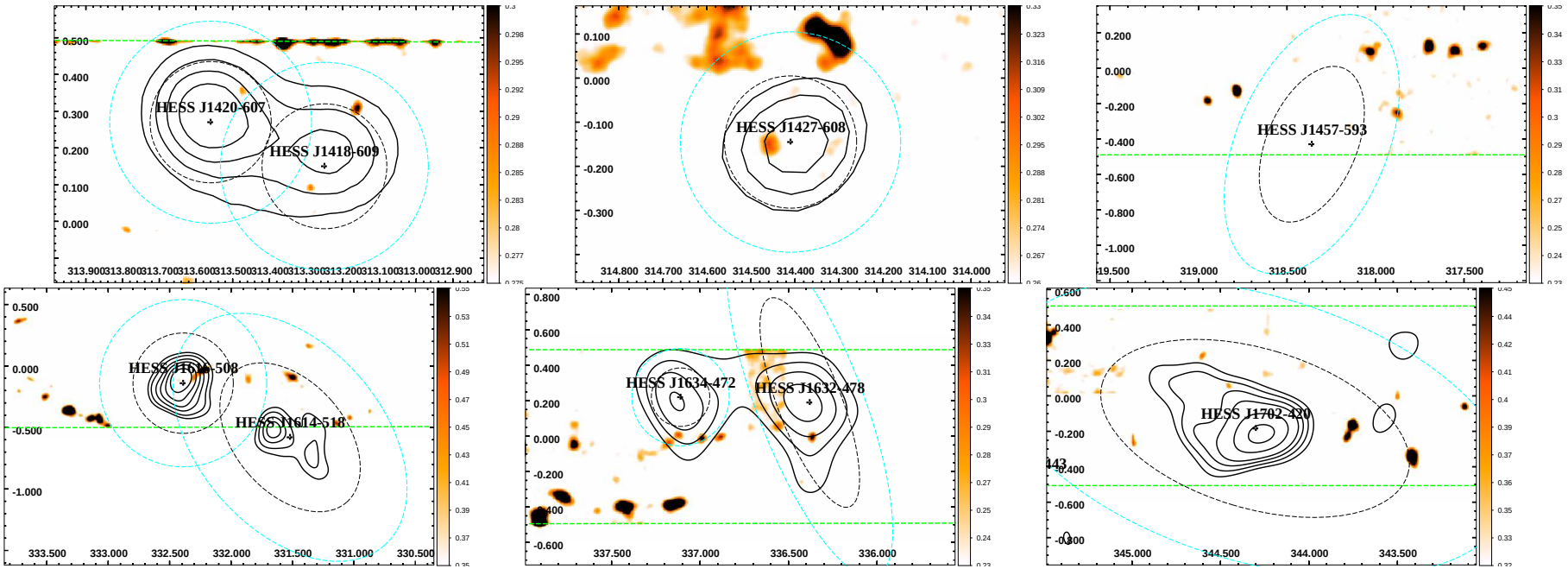
Conclusions/Further Work

- Largest fraction of Galactic TeV sources still unidentified (Puhlhofer et al. 2015)
- Dense gas (e.g. NH_3) along with CO and HI emission can help identify source of gamma-rays
- e.g W28 (SNR/MC interaction) - see Nicholas et al. 2010, Maxted et al. 2015, Nigel's talk
- HESS J1825-137 (Assymmetric PWN) - see Fabien's talk, Blondin 2001
- HESS J1745−303 (still unclear although appears hadronic due to gas morphology)

- 43 Galactic TeV sources covered by 12mm observations
- NH_3 (1,1) emission seen (in HOPS equivalent coverage) towards or adjacent to 35 of these 43 sources (1/3 of these TeV sources are still classed as unidentified objects)
- NH_3 (2,2) emission detected towards 1/2 of these gas clumps, and NH_3 (3,3) emission detected towards 1/3
- Gas parameters (mass, density, temperature) calculated towards all gas clumps displaying NH_3 (1,1) and (2,2) emission
- HC_3N detected in 1/3 of gas clumps
- H_2O detected in 1/3 of gas clumps (some of these without detectable NH_3 (2,2) emission)

Starting point for further studies

- Understanding density profiles of gas towards TeV studies -¿ cosmic ray diffusion (Maxted et al. 2012) (Voison et al. in prep)
- Population studies of gas towards Galactic TeV sources (de Wilt et al. in prep)
- Morphology studies of individual sources with complete gas picture (e.g. RXJ1713 - Fukui et al. 2014)



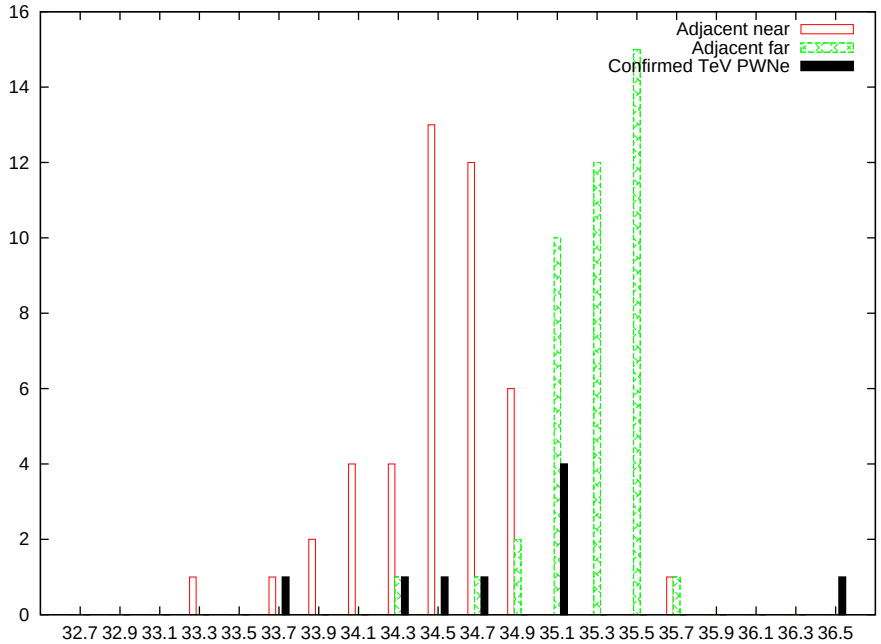
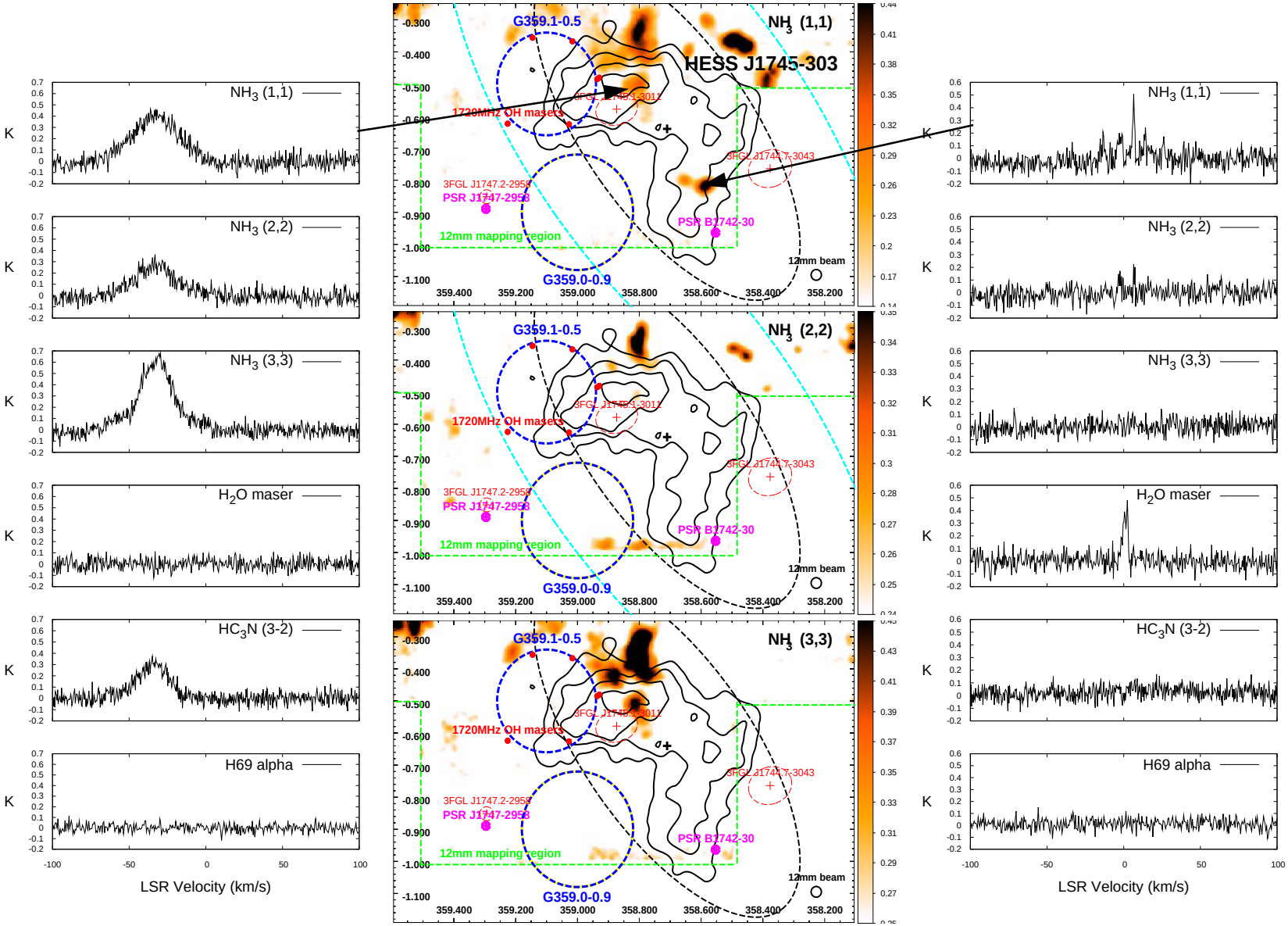
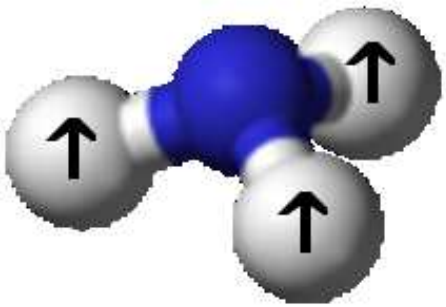
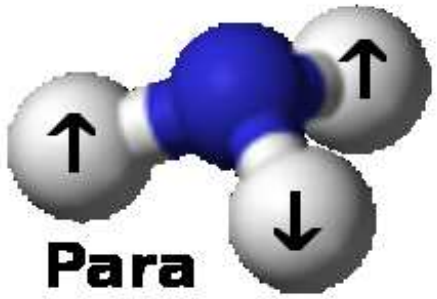


Figure: TeV luminosities of Galactic TeV sources, with NH_3 (1,1) emission detected adjacent to the TeV emission, scaled according to the kinematic distance of each molecular clump adjacent to the TeV emission. The luminosities scaled according to the near distance are displayed with a red, unfilled histogram, those scaled according to the far distance with a green, hatched histogram, and those sources which have been confirmed as TeV PWNe are displayed as a solid, black histogram.



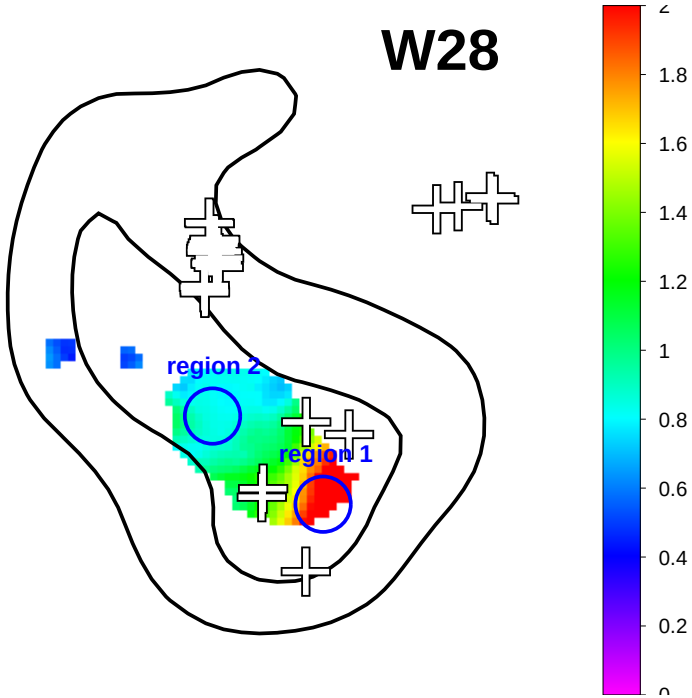
12 mm peak pixel maps (-200 to 200 km/s) of molecular line emission towards the TeV source **HESS J1745−303**.

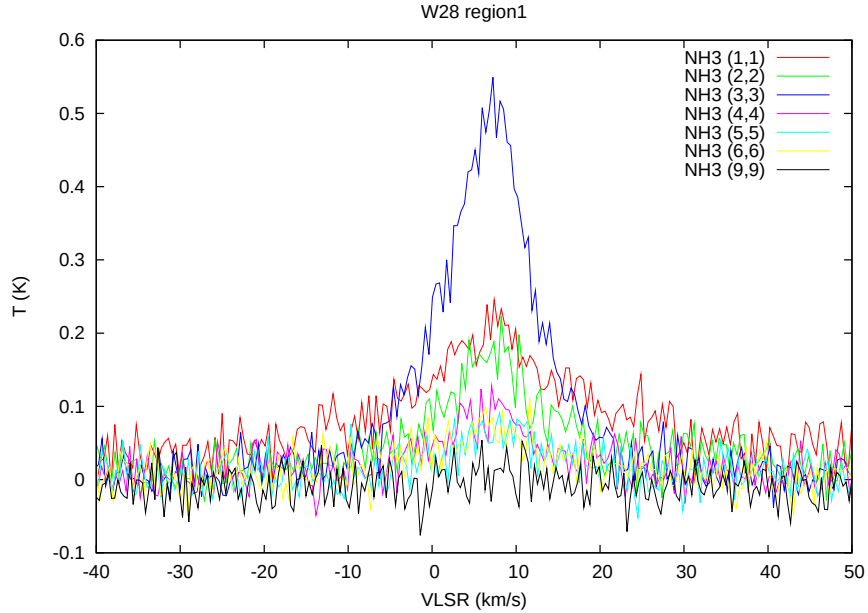


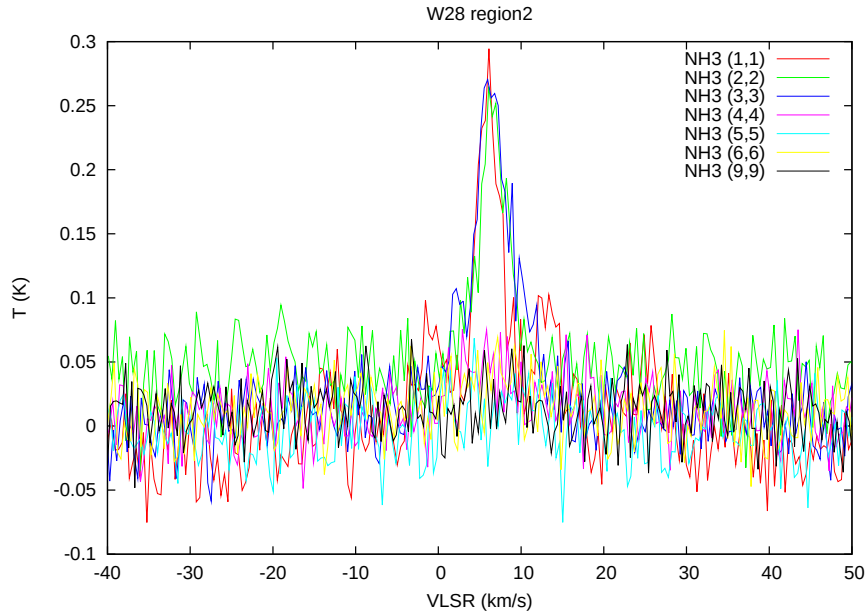


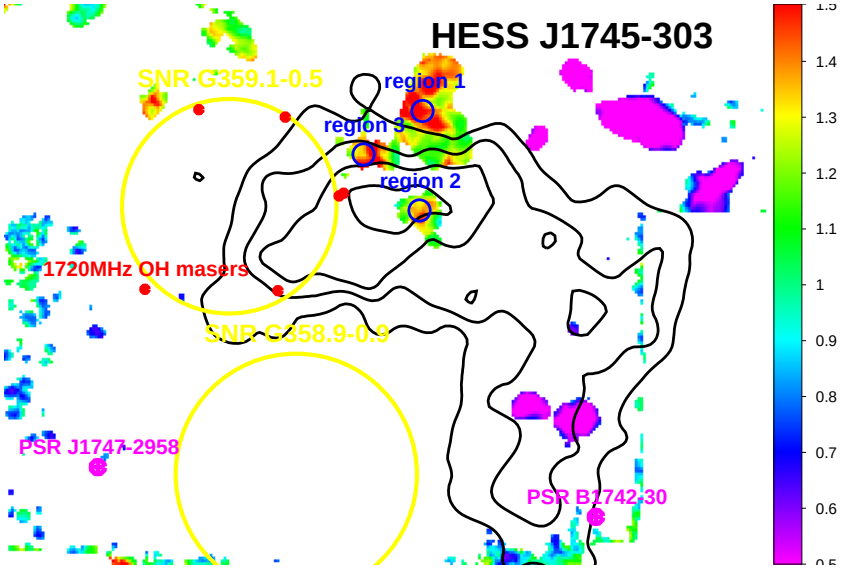
- Ortho transitions - NH_3 (J,K), K = 3n
- Para transitions - NH_3 (J,K), K $\neq$ 3n, n=1,2,3...
- The time scale of conversion processes between spin species is considered to be of the order of 10^6 yr in the gas phase (Cheung et al. 1969)
- NH_3 Ortho-to-Para abundance Ratio (OPR) controlled by H_2 OPR due to gas phase formation of NH_3 (but through this, NH_3 OPR expected to be ≤ 1 (Faure et al. 2013) - for interstellar analysis, generally assumed to be 1)

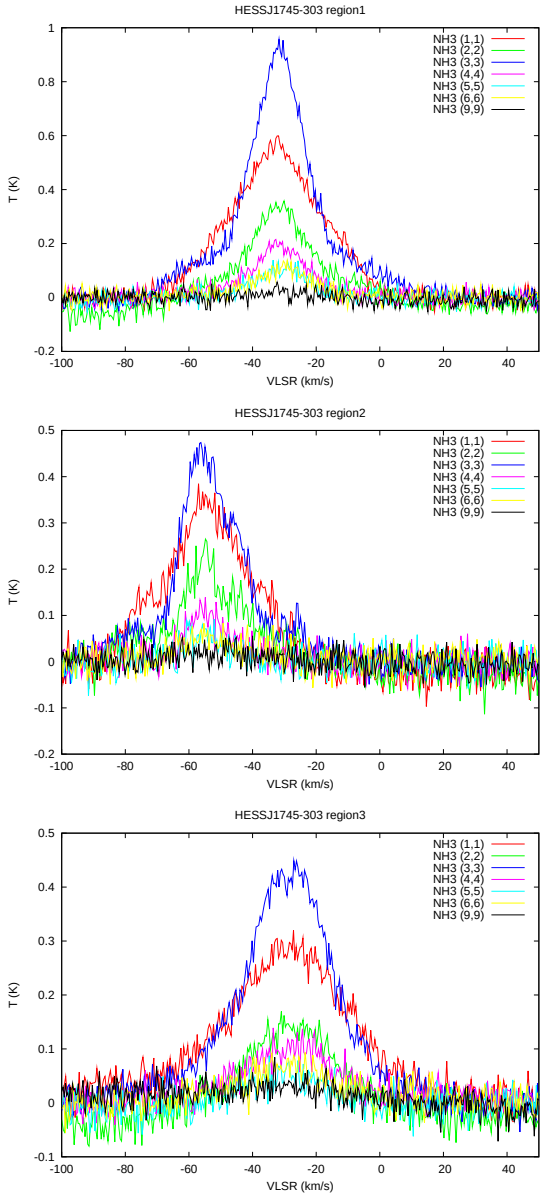
- The spin temperature (or the rotational temperature between ortho-para species) is not considered to reflect the kinetic temperature of NH_3, but instead reflect formation conditions of the NH_3
- Ortho preferentially formed on dust grains at low temps (Faure. et al 2013)
- Ortho preferentially desorbed from dust grains (Umemoto et al. 1999)
- Therefore the NH_3 OPR is expected to be enhanced in shocked regions - In addition, the NH_3 to H_2 abundance ratio is also expected to be enhanced
- If the OPR can be accurately estimated from observations, it could be used to provide information about physical conditions and chemical processes when the NH_3 molecules are released into the gas phase, and to search for regions of gas with previous shock activity

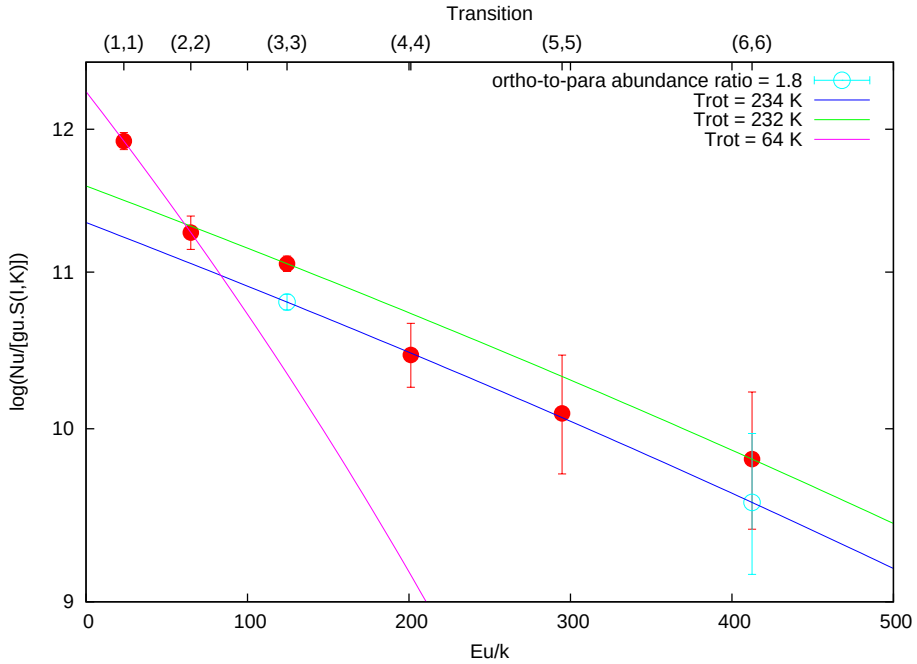

W28
region 2
region 1
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2


W28 region1
NH3 (1,1)
NH3 (2,2)
NH3 (3,3)
NH3 (4,4)
NH3 (5,5)
NH3 (6,6)
NH3 (9,9)
T (K)
VLSR (km/s)


W28 region2
NH3 (1,1)
NH3 (2,2)
NH3 (3,3)
NH3 (4,4)
NH3 (5,5)
NH3 (6,6)
NH3 (9,9)
T (K)
VLSR (km/s)


HESS J1745-303
SNR G359.1-0.5
region 1
region 3
region 2
1720MHz OH masers
SNR G358.9-0.9
PSR J1747-2958
PSR B1742-30
1.4
1.3
1.2
1.1
1
0.9
0.8
0.7
0.6


HESSJ1745-303 region1
HESSJ1745-303 region2
HESSJ1745-303 region3
NH3 (1,1)
NH3 (2,2)
NH3 (3,3)
NH3 (4,4)
NH3 (5,5)
NH3 (6,6)
NH3 (9,9)
T (K)
VLSR (km/s)



TeV Source and region	T_{rot} para (1,1),(2,2) (K)	T_{rot} ortho (3,3),(6,6) (K)	T_{rot} para (4,4),(5,5) (K)	T_{rot} (3,3)-(6,6) (reduced ortho) (K)	OPR best fit
HESS J1745−303					
region 1	68	222	239	224	1.5 ± 0.3
region 2	64	256	232	234	1.8 ± 0.6
region 3	91	247	181	239	$1.7^{+0.3}_{-0.4}$
W28					
region 1	108	285	360	291	1.5 ± 0.5
region 2	143	259	-	-	$> 2.0^{*}$

The T_{rot} given for NH_3 (3,3)-(6,6) with reduced ortho is 1/slope of the line fit to the (adjusted) column densities of the transitions for NH_3 (J,K) J=K=3,4,5,6. The OPR given is that with the best fit to the NH_3 (J,K) J=K=3,4,5,6 column densities. The * indicates a region where the apparent OPR fitted could be due to the method rather than an enhanced OPR

Conclusions/Further Work

- Mopra observations can be used to estimate an ortho-to-para NH_3 abundance ratio
- An enhanced ortho-to-para NH_3 abundance ratio is seen towards shocked regions in two Galactic TeV sources
- An initial look at NH_3 (3,3)-to-NH_3 (1,1) Brightness temperature ratios across the Galactic Plane has revealed a few other TeV sources with a potentially enhanced NH_3 OPR
- Further observations targeting the higher J ((4,4) and (5,5)) NH_3 transitions towards these sources to estimate an OPR would be useful (as would a look at all molecular clouds within the HOPS region)

Thank you

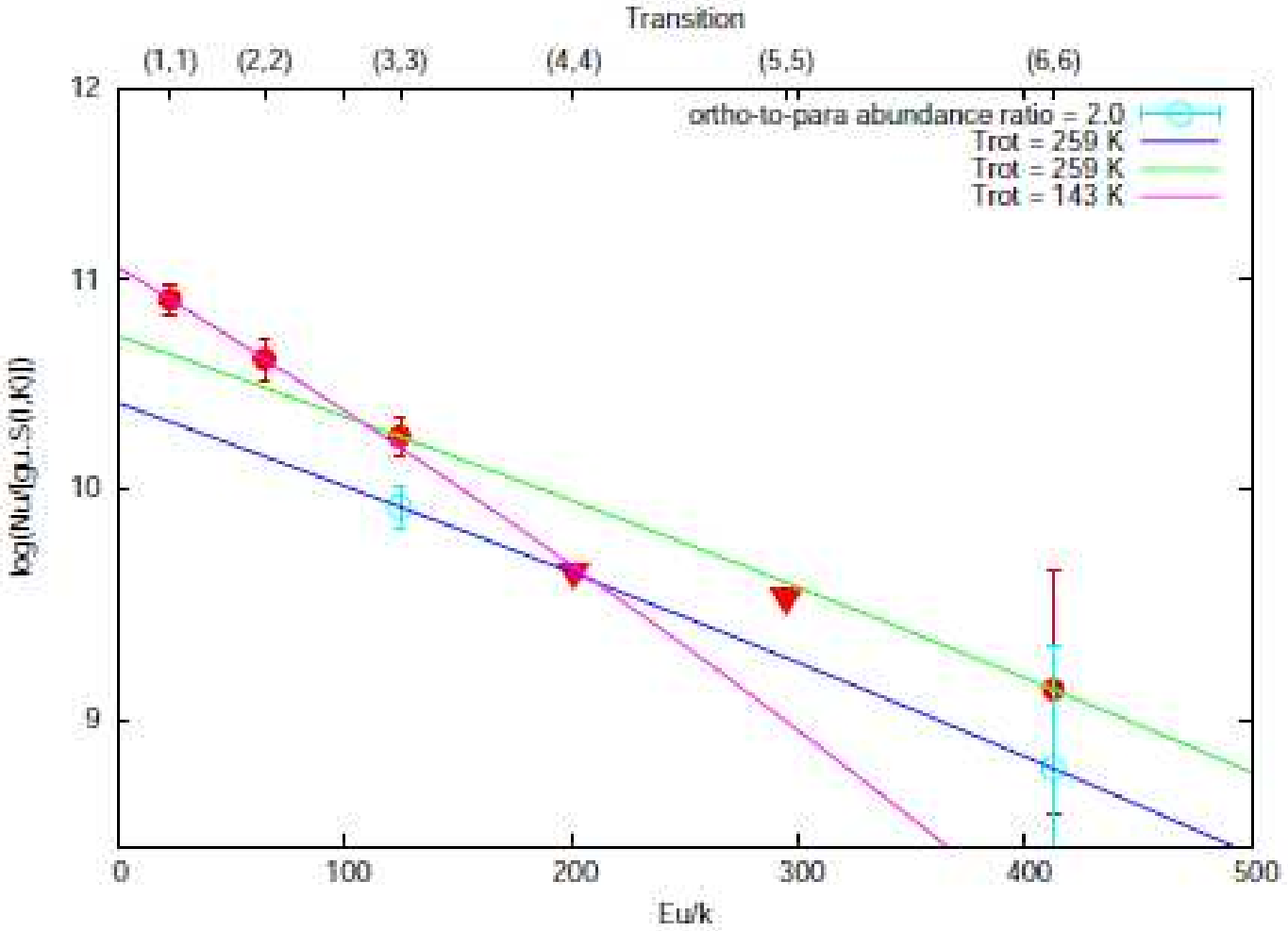


Figure 12: As in Fig. 3, for region 2 (shown in Fig. 8). For this region an OPR of 1.5 was assumed. A lower limit OPR has been found (due to upper limits of NH_3 (4,4) and (5,5) emission). This method indicates an OPR of > 2.0. As can be seen in this image however, the NH_3 (3,3) and upper limit NH_3 (4,4) column densities, with an OPR of 1.0, lie on the rotational temperature fit to the NH_3 (1,1) and (2,2) emission (magenta line) indicating that the gas traced by these transitions may have an OPR of 1.0 and have a rotational temperature of that given by the NH_3 (1,1) and (2,2) transitions. The NH_3 (5,5) and (6,6) emission would then be tracing higher temperature gas, and the derived OPR would not reflect the conditions of this gas.