Gas structure towards supernova remnants suspected of cosmic-ray acceleration

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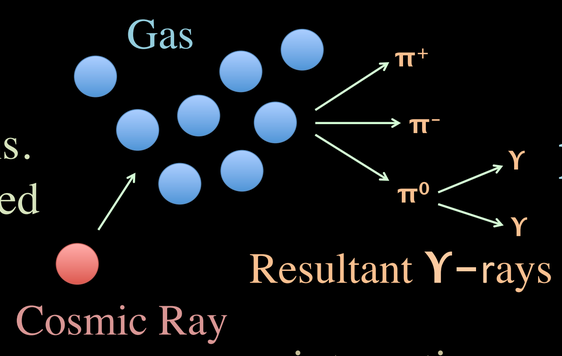
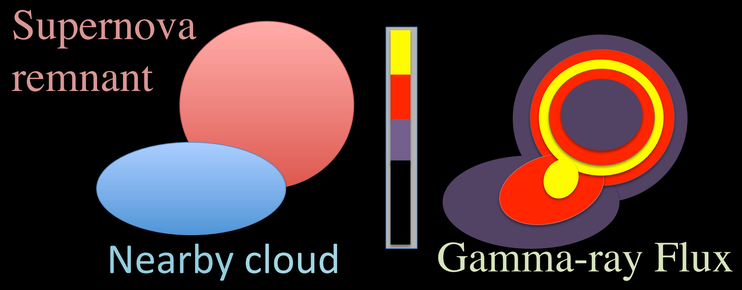
Gas signatures of Cosmic Ray accelerators:

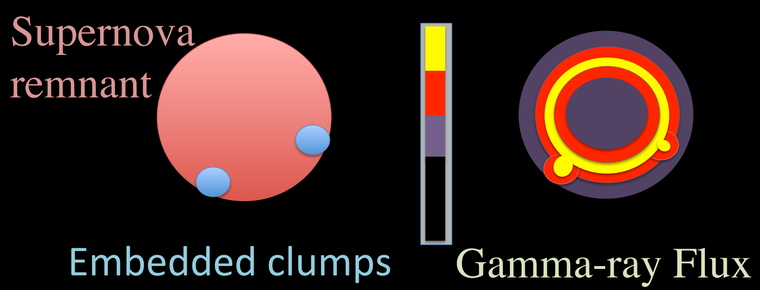
We are searching for gamma-rays from neutral pions. These are produced when cosmic ray hardons interact with gas.

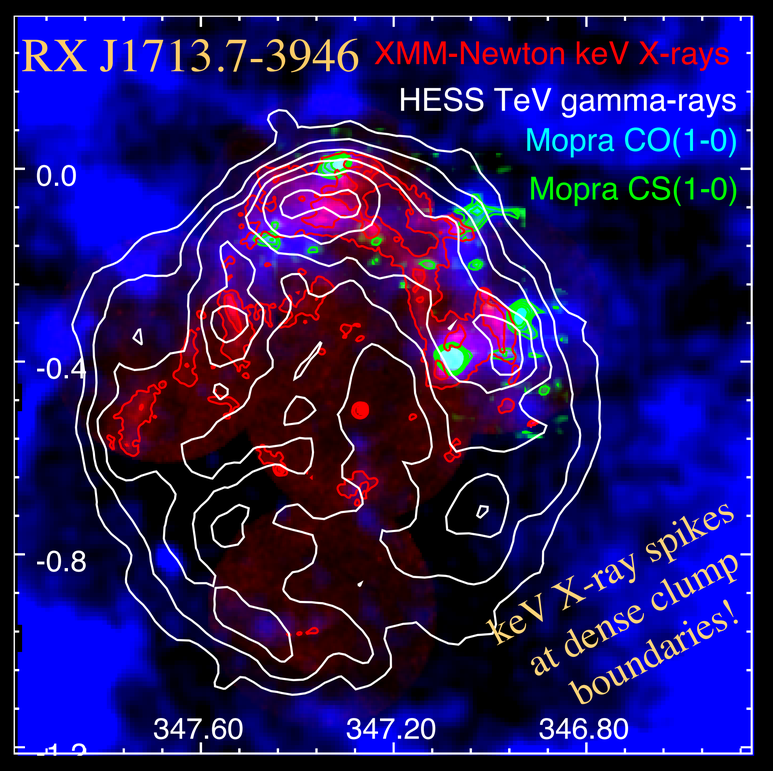


What might proof of cosmic-ray acceleration look like?

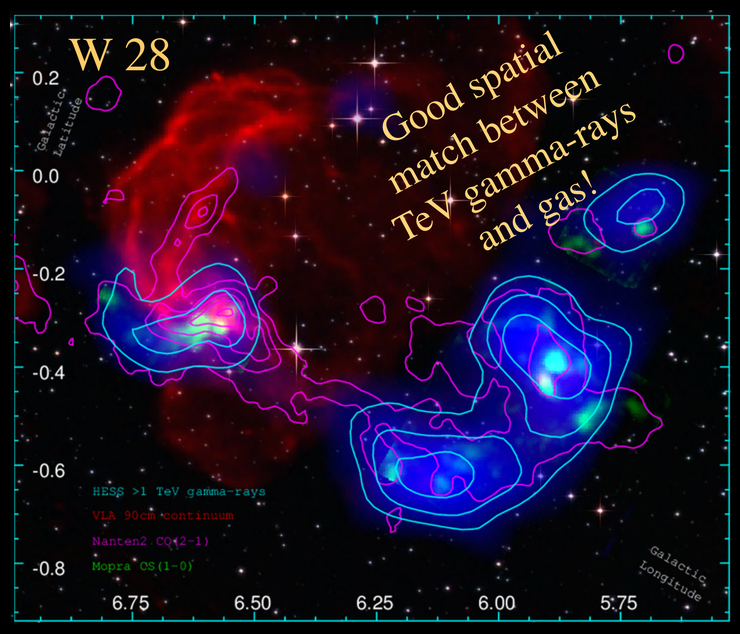
Gamma-ray flux peaking towards high molecular clumps embedded within a supernova remnant, and/ or a nearby cloud illuminated by gamma-ray emission



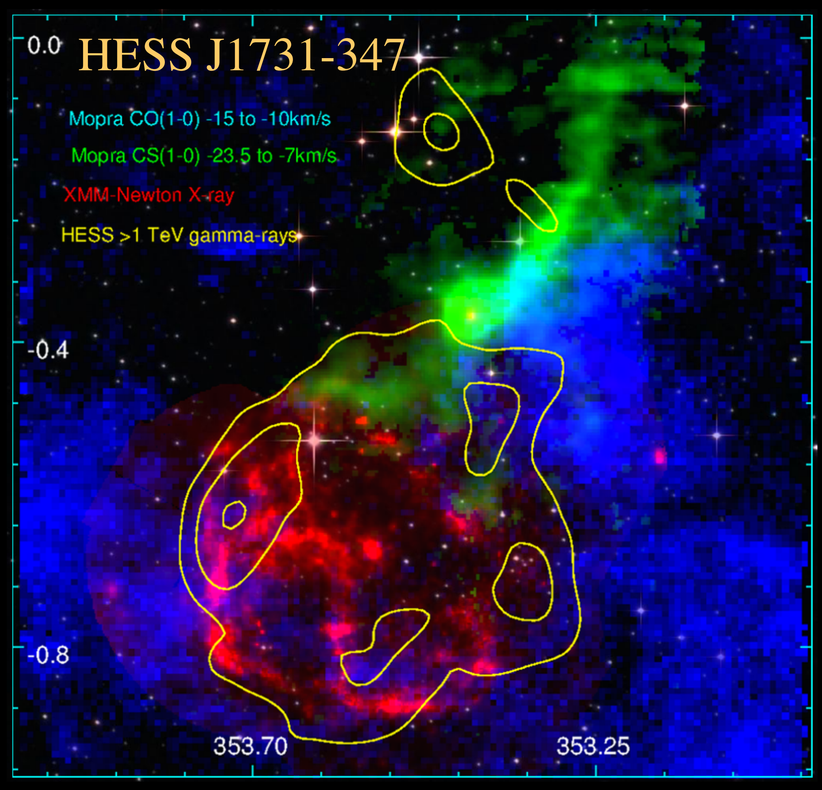




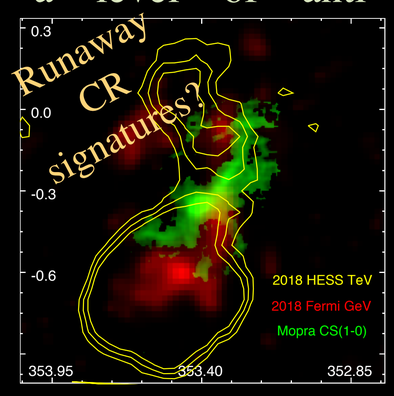
Embedded clumps: Small-scale anti-correspondence between X-ray synchrotron and dense gas clumps (e.g. traced by CS) indicates shock-gas interactions in SNR RXJ1713.7-3946 (e.g. Fukui:2008, Sano: 2010/2015, Maxted:2013). This may harden the gamma-ray spectral shape from p-p interaction (e.g. Maxted:2012, Inoue:2018, Celli:2019). Also, the RXJ1713.7-3946 gamma-ray flux peaks towards dense clumps (Moriguchi:2015). H*ow many TeV gamma-ray shell SNRs contain dense clumps?*

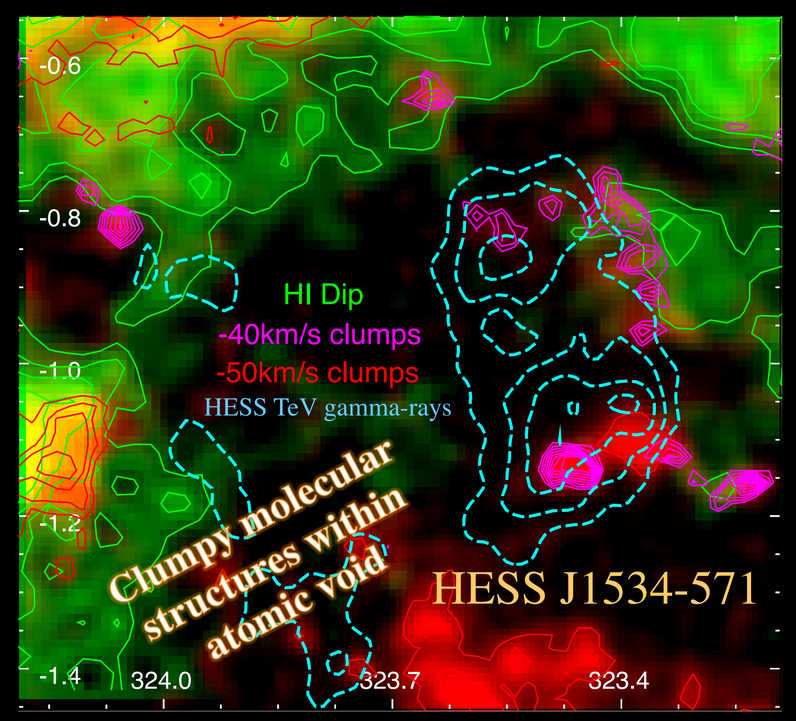


Molecular clouds near the SNR W28 are probably bombarded by cosmic ray protons to create the gamma-ray sources that correspond remarkably well to the gas structure, as traced by CO, CS and NH3 (e.g. Fukui:2008, Aharonian:2008, Nicholas 2011, Maxted:2016/2017). In this way nearby clouds expose the SNR as a likely CR accelerator. If this 10^4-year SNR can accelerate CRs, then *what about the potential of the more powerful shocks of 10^3-year SNRs?*



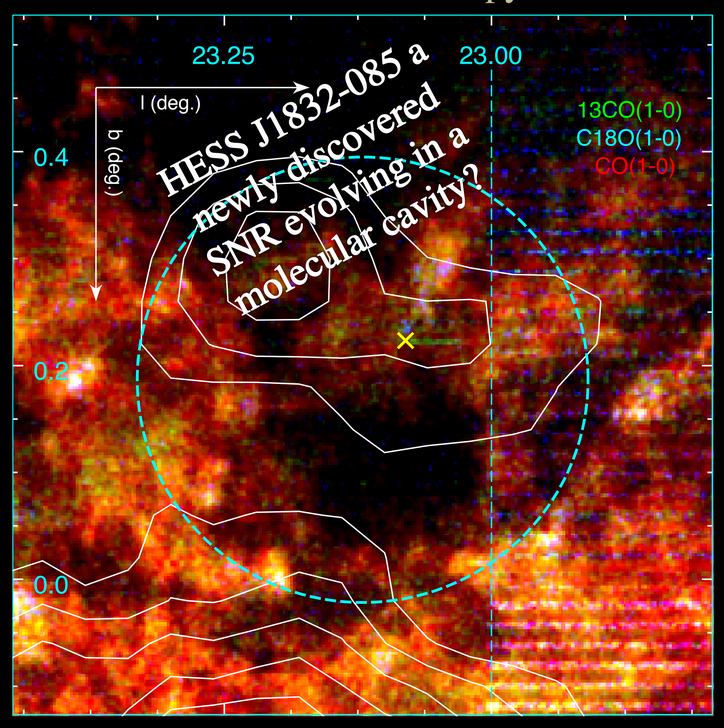
Maxted:2018a showed that SNR HESSJ1731-347 is likely embedded within molecular gas at 3.2 kpc, consistent with diffusion modeling by Cui:2016/2019. A very dense filament traced by CS is in the remnant's north, and this gas may have a gamma-ray counterpart from run-away CRs (e.g. Capasso: 2017). Furthermore, the keV X-rays (Doreshenko:2017) and GeV gamma-rays (Condon:2018) exhibit a level of anti-correspondence with CS, suggesting respectively, shock-gas interactions at clump boundaries and a population of sub-TeV particles that cannot penetrate dense gas.



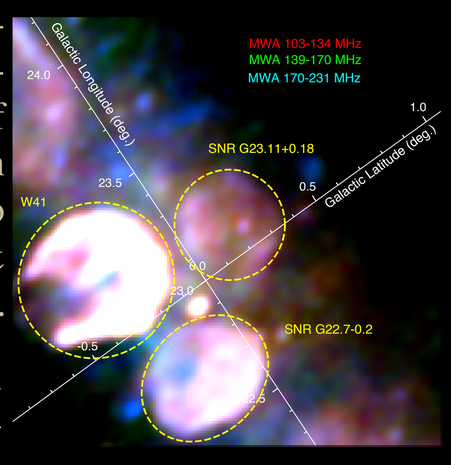


With the knowledge that gamma-ray shell SNRs have been found towards atomic voids and contain clumpy molecualr structures, we targeted clumpy CO towards new SNR HESSJ1534-571. We found such structures at a distance of 3.5 kpc (see Maxted:2018b). We use SNR evolution modelling to estimate an age that is between that of RXJ1713 and W28, consistent with an observed lack of non-thermal X-rays and TeV spectrum steeper than RXJ1713.

The newly discovered supernova remnant candidate, G23.11+0.18, may also be evolving within an evacuated cavity, seen in FUGIN CO data, while a clumpy medium in the remnant's north provides cosmic-ray target material for the gamma-rays of HESSJ1832-085. Details in Maxted:prep2019 - radio spectrum, morphology & proposed high energy nature.



New Murchison Widefield Array radio data ->



Please visit:
www.physics.adelaide.edu.au/astrophysics/MopraGam/
for more details about gas studies towards TeV gamma-ray sources.