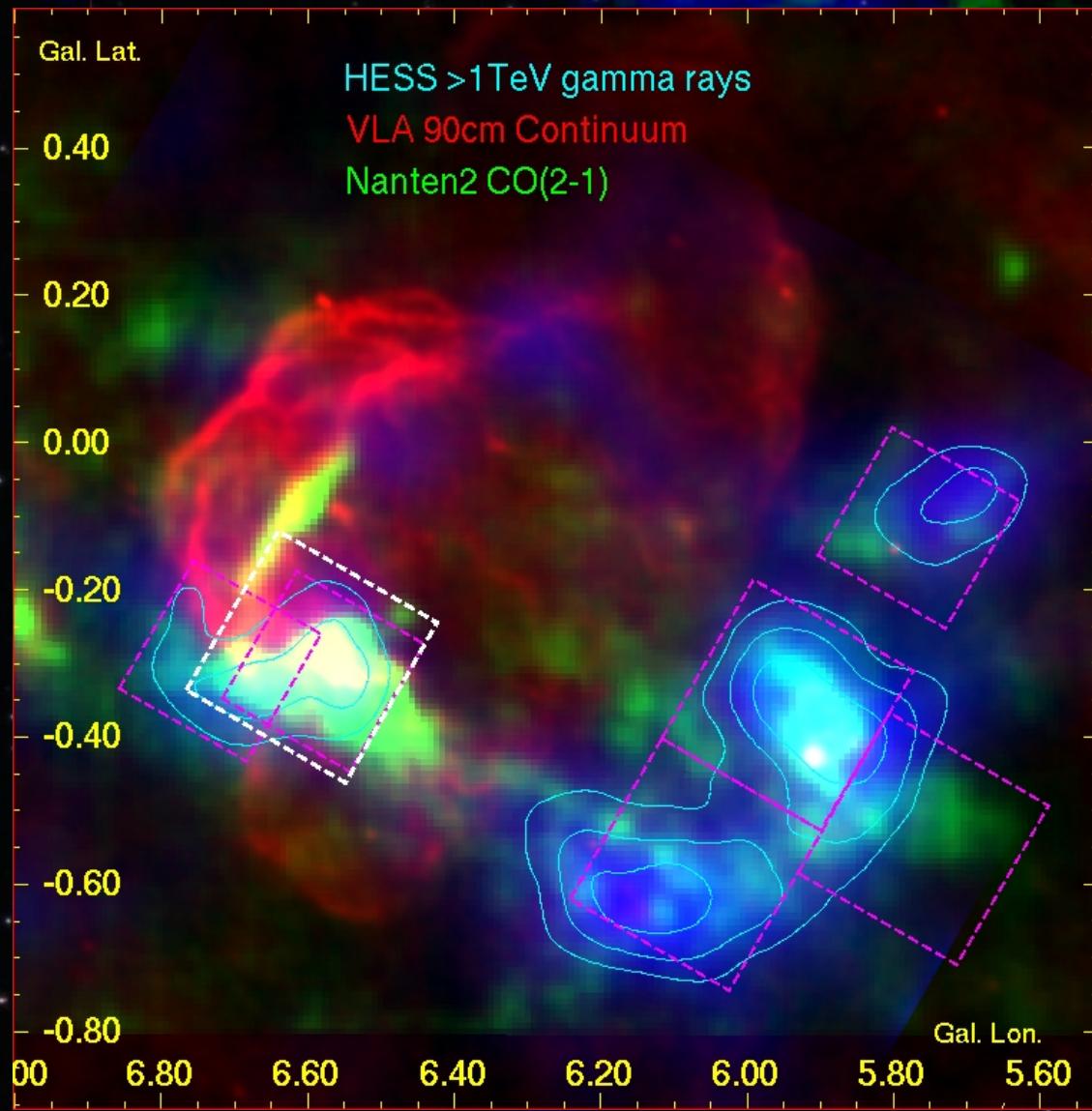


Gas towards the Gamma-ray-Emitting Supernova Remnants

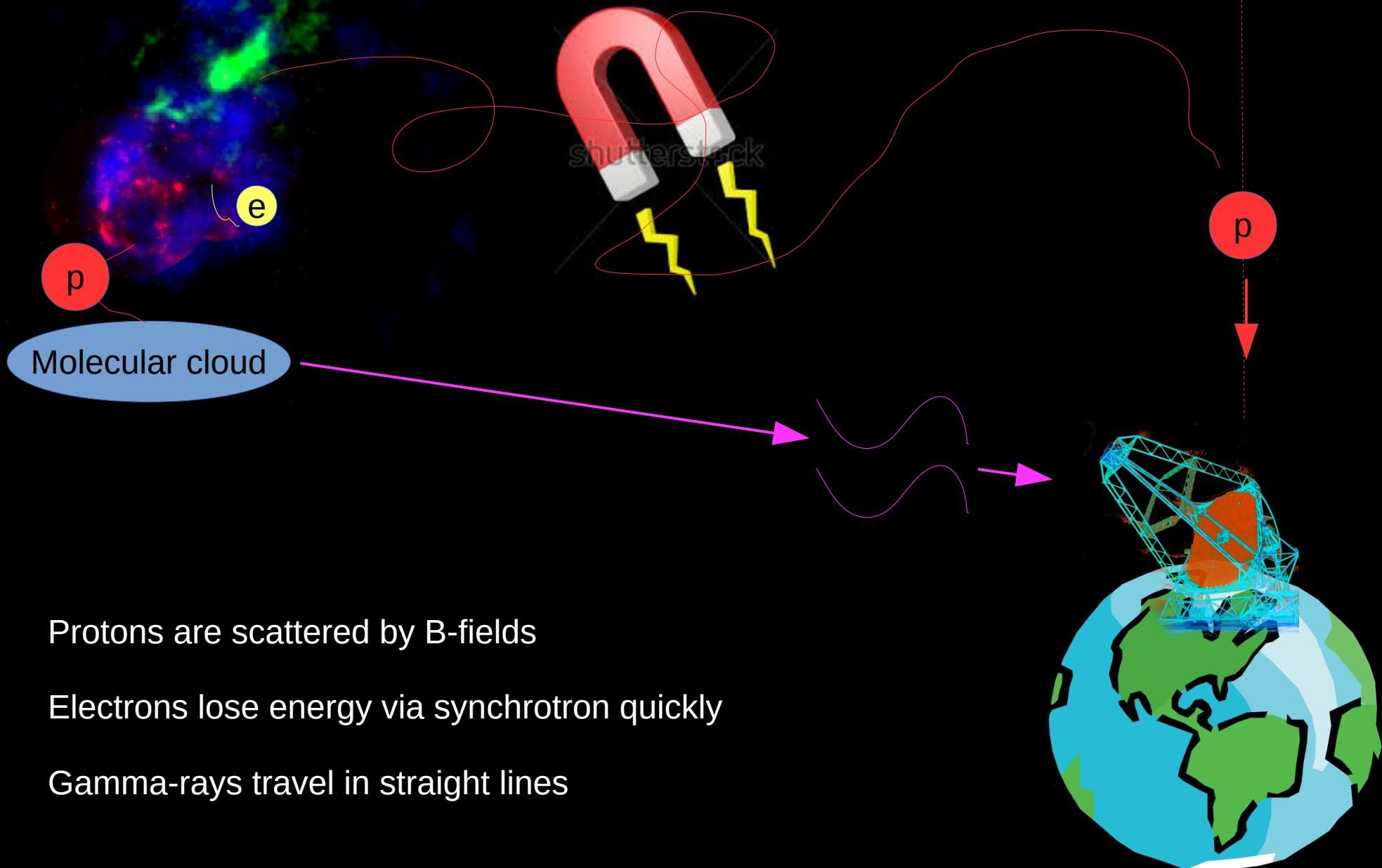
Nigel Maxted

CosPA 2016

THE UNIVERSITY OF
NEW SOUTH WALES



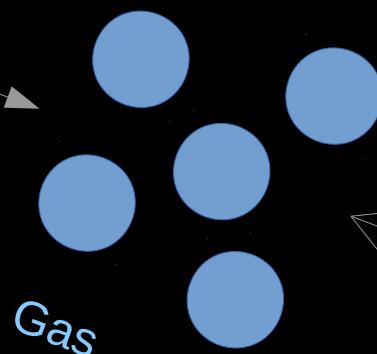
Galactic cosmic ray origin



Gamma-ray emission from particles

p
Tev Proton

e
Tev electron



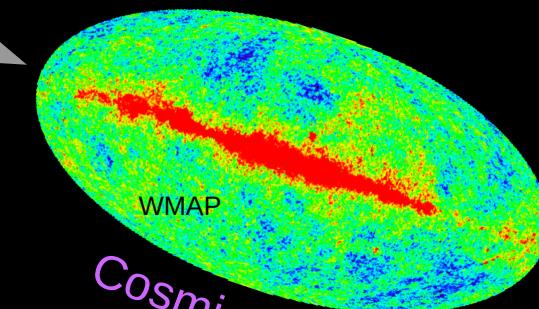
π^+
 π^-
 π^0

Tev gamma-rays

e^-

Tev gamma-ray

Inverse Compton Scattering:



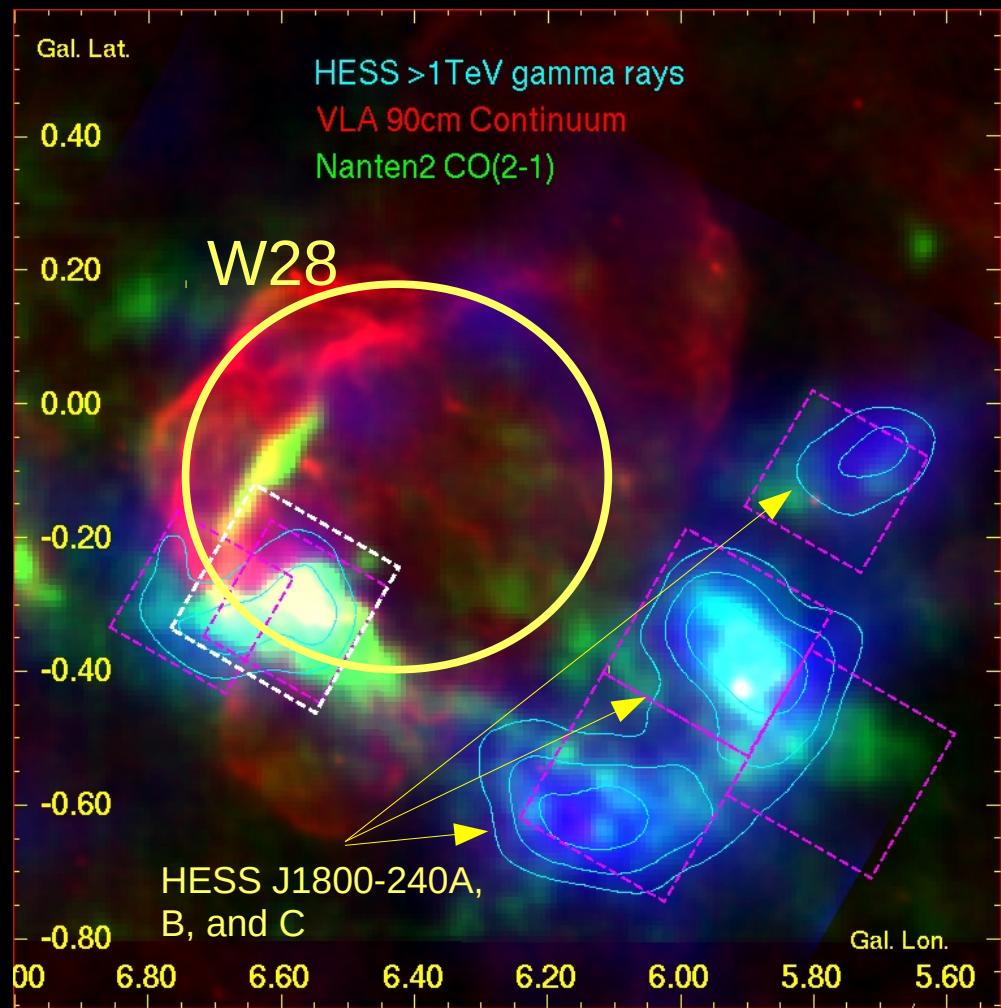
Cosmic
microwave
background
(& other
radiation!)

p
Tev Proton

e
Tev electron

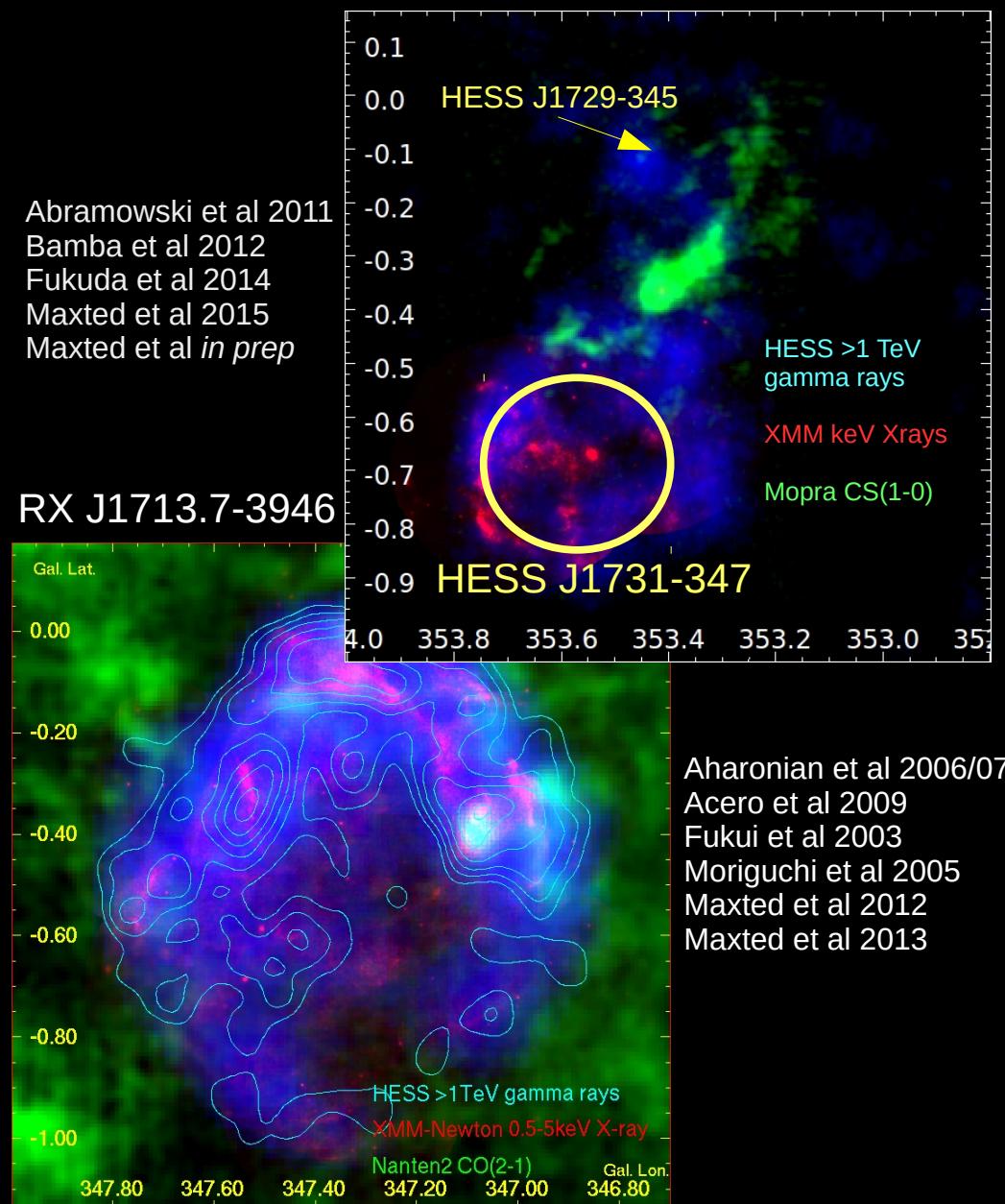
Gamma-ray emitting Supernova Remnants

W28



Dubner et al. 2000, Brogan et al. 2006, Fukui 2008,
Abdo et al 2010, Nakamura et al. 2014
Nicholas et al 2011, Nicholas et al 2012,
Maxted et al 2016a,b

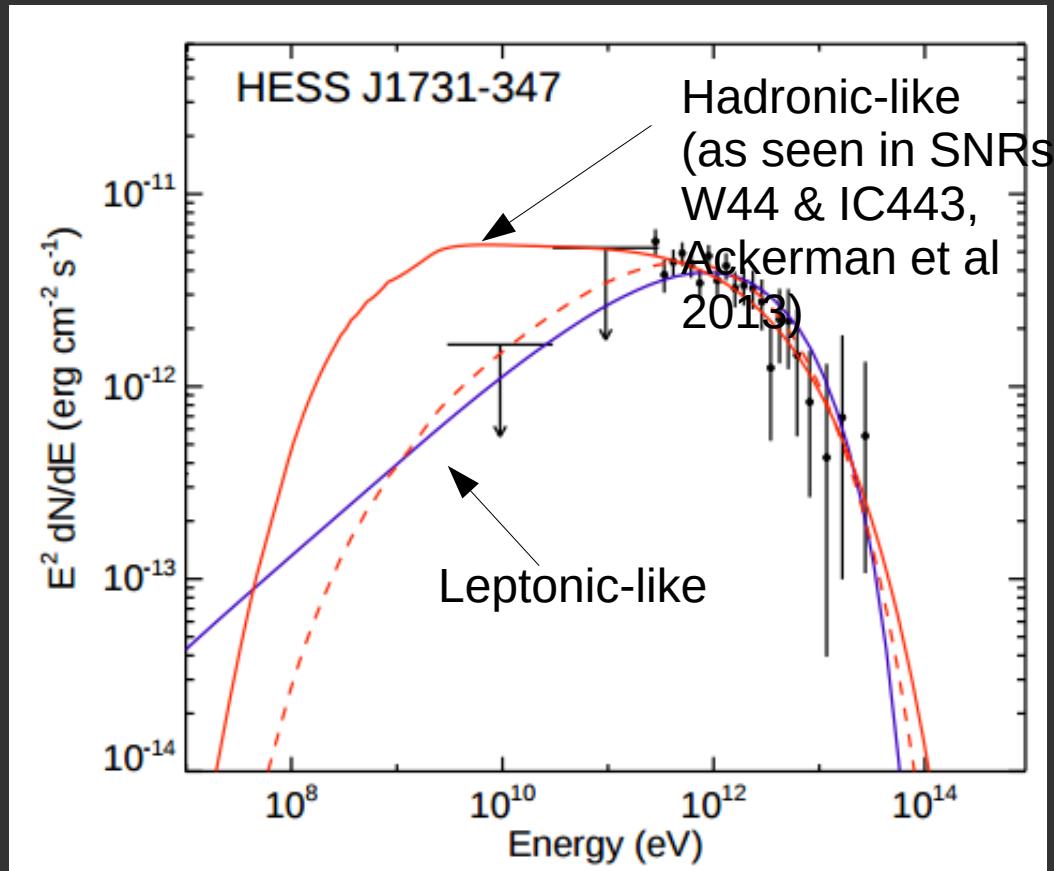
HESS J1731-347



Young ($\sim 10^3$ yr) SNRs

Young SNRs, such as RX J1713.7-3946 and HESS J1731-347 have spectra which suggest leptonic gamma-ray emission (e.g. Acero et al 2015).

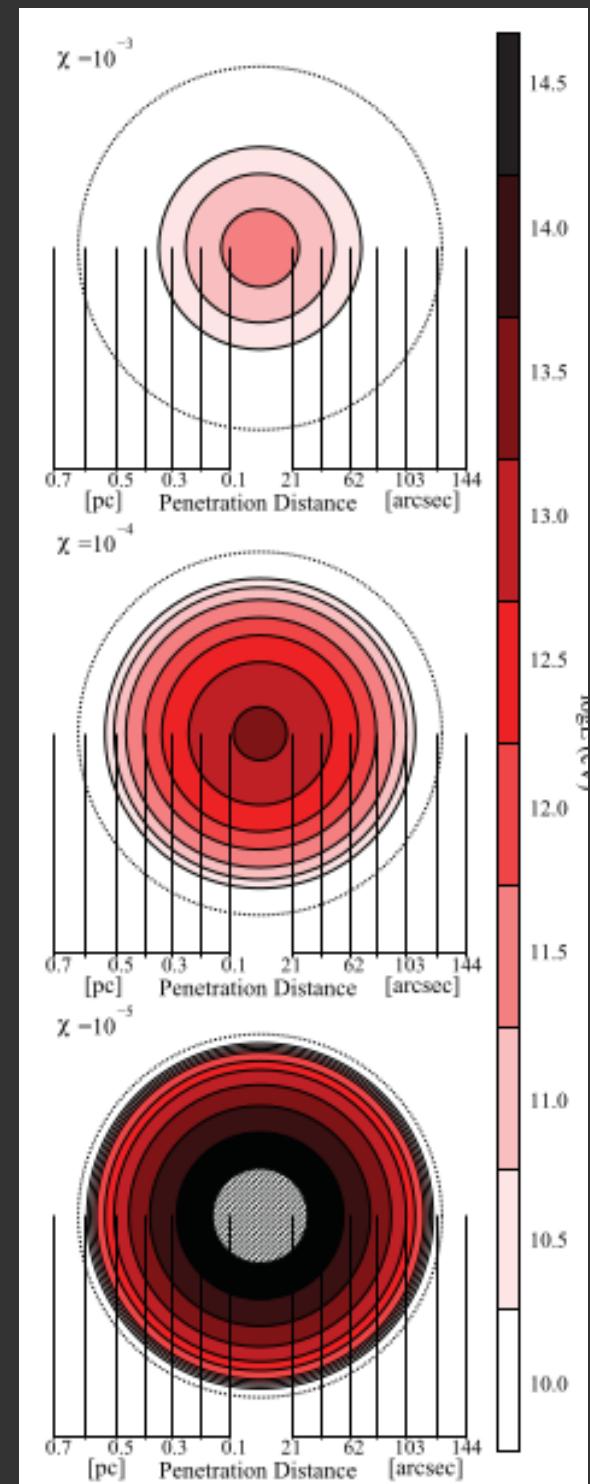
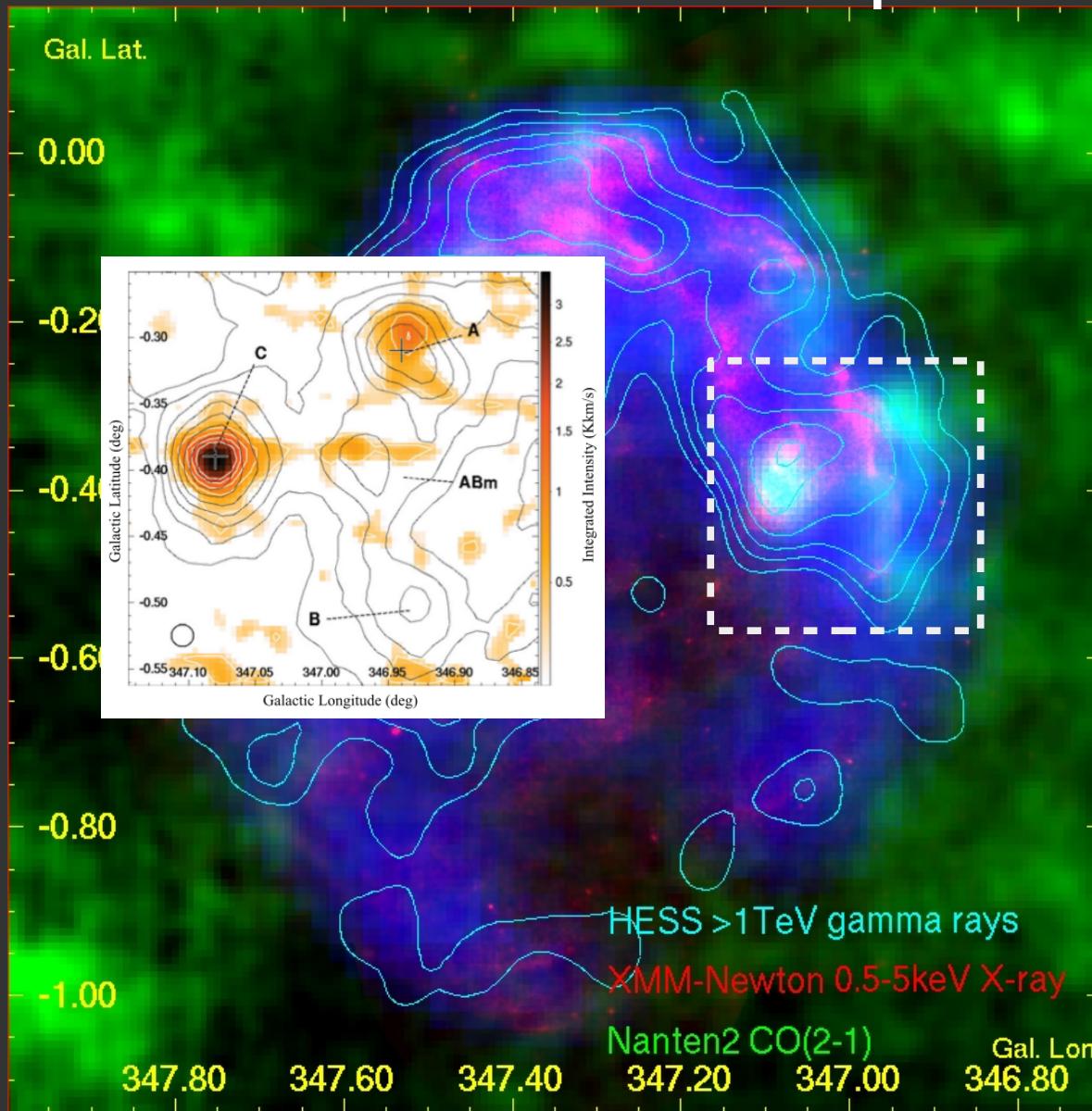
But some argue that the existence of dense clumps might lead to a lack of a distinct 'pion bump' in gamma-ray spectra (e.g. Gabici & Aharonian 2014/2015).



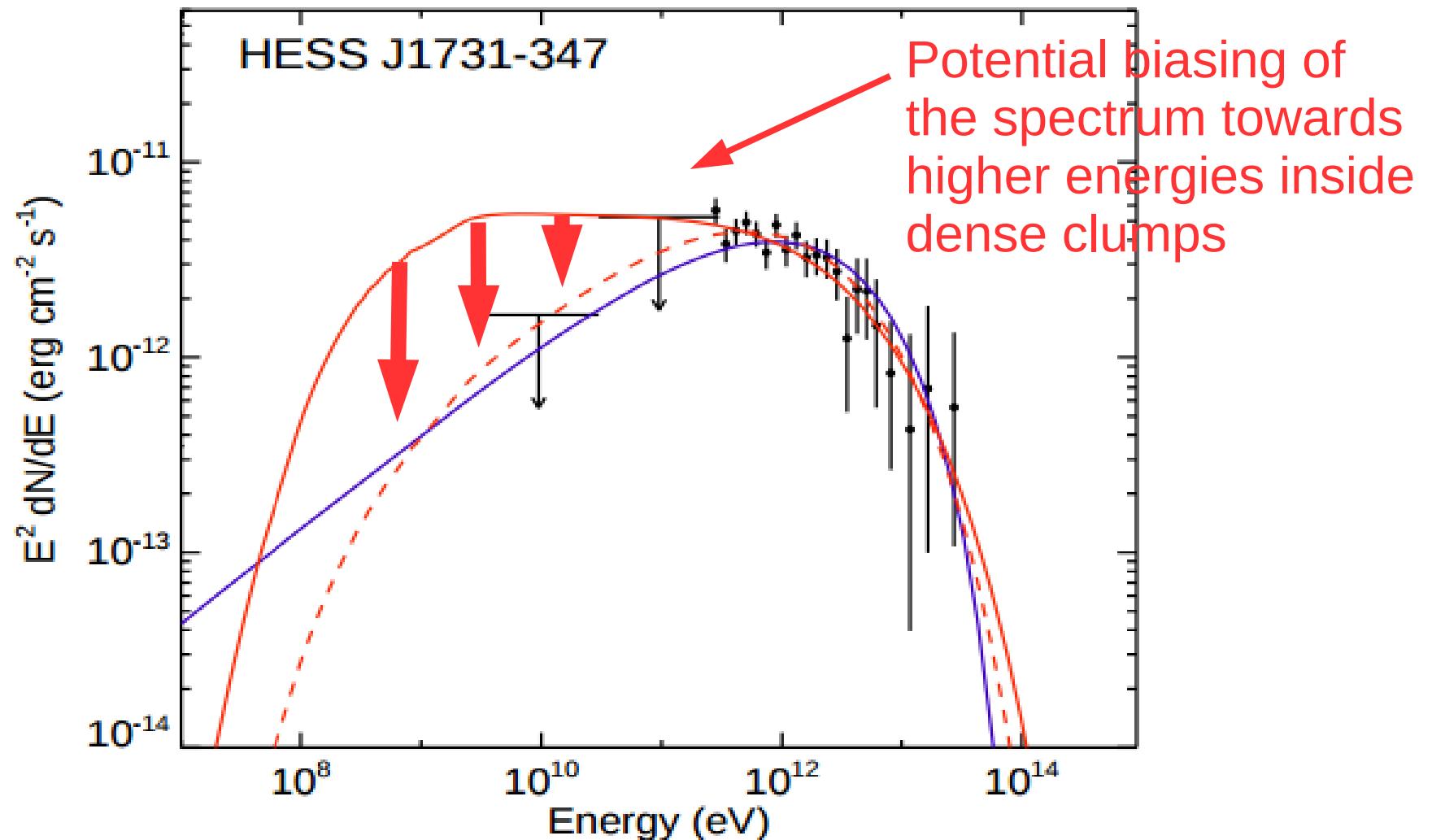
Acero et al 2015

RX J1713.7-3946

Diffusion into clumps?



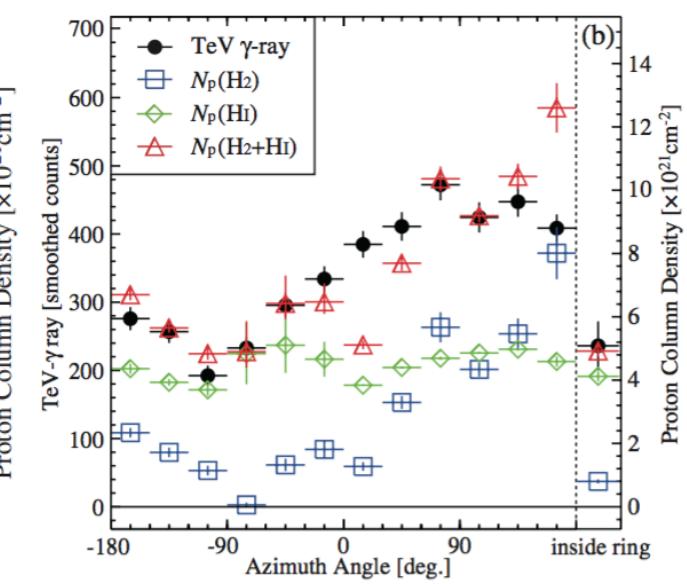
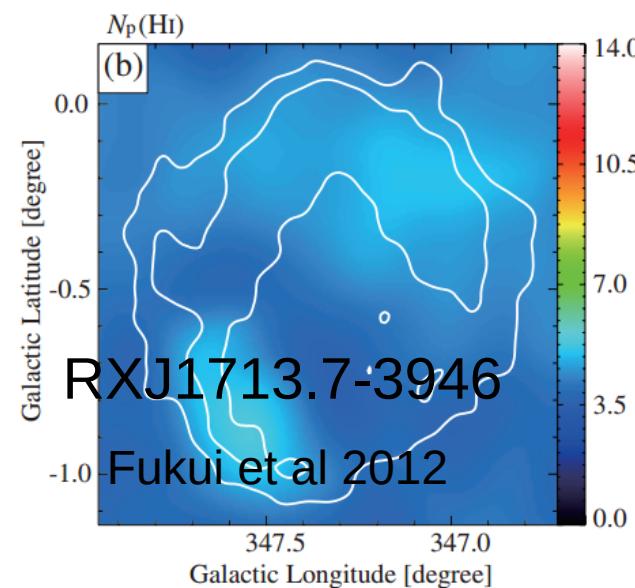
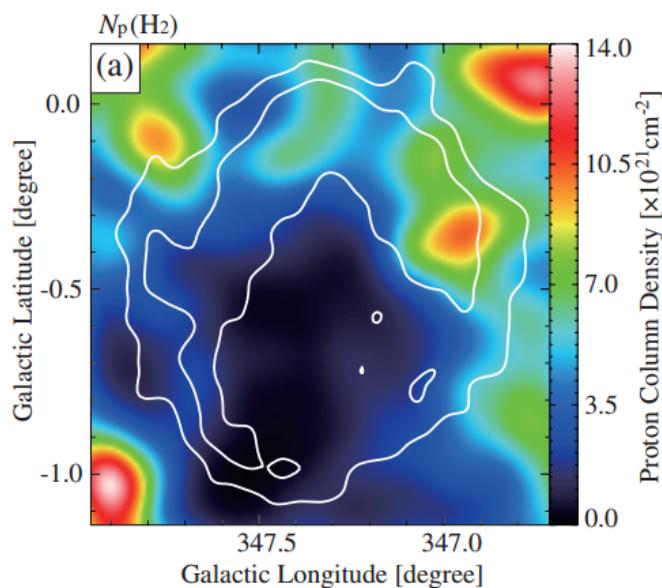
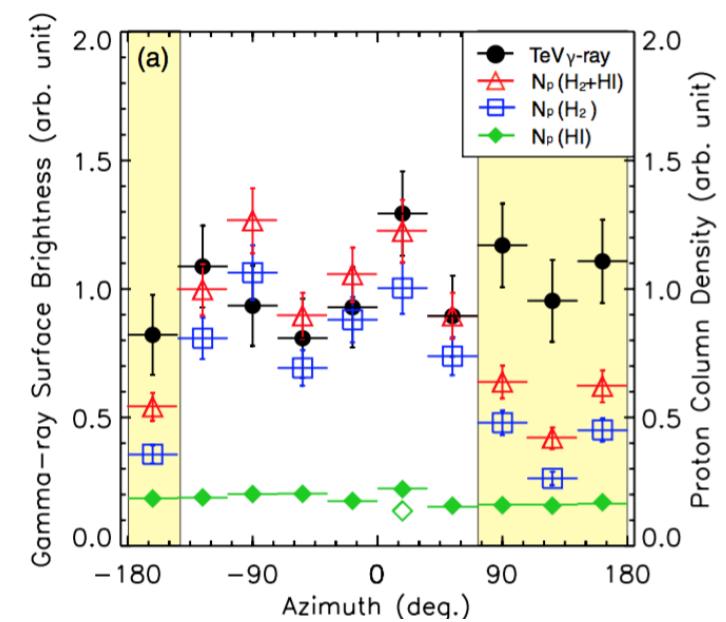
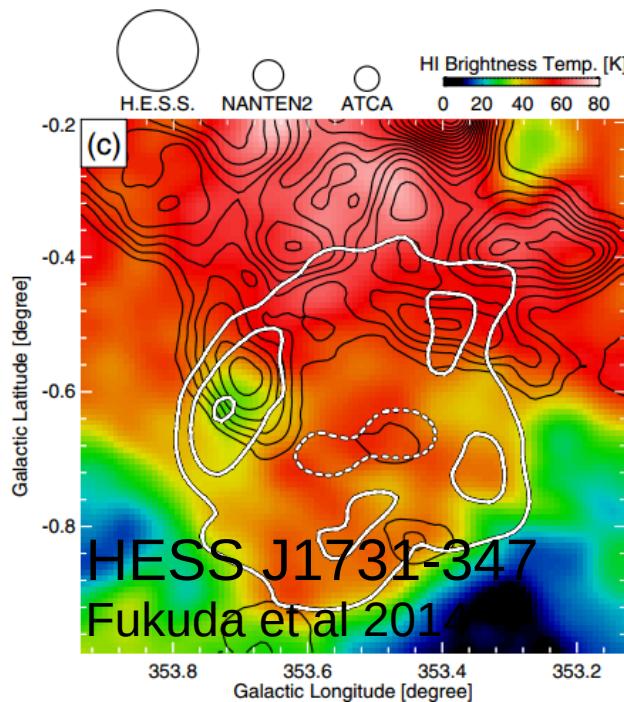
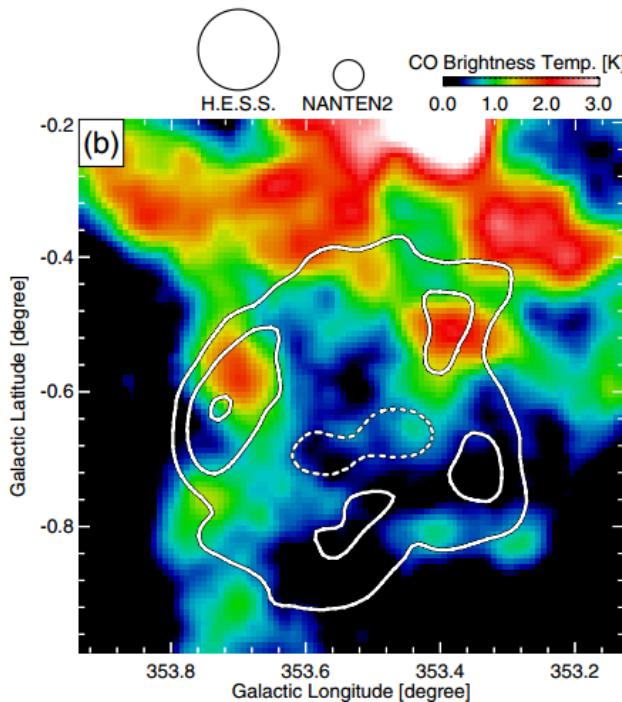
Young ($\sim 10^3$ yr) SNRs



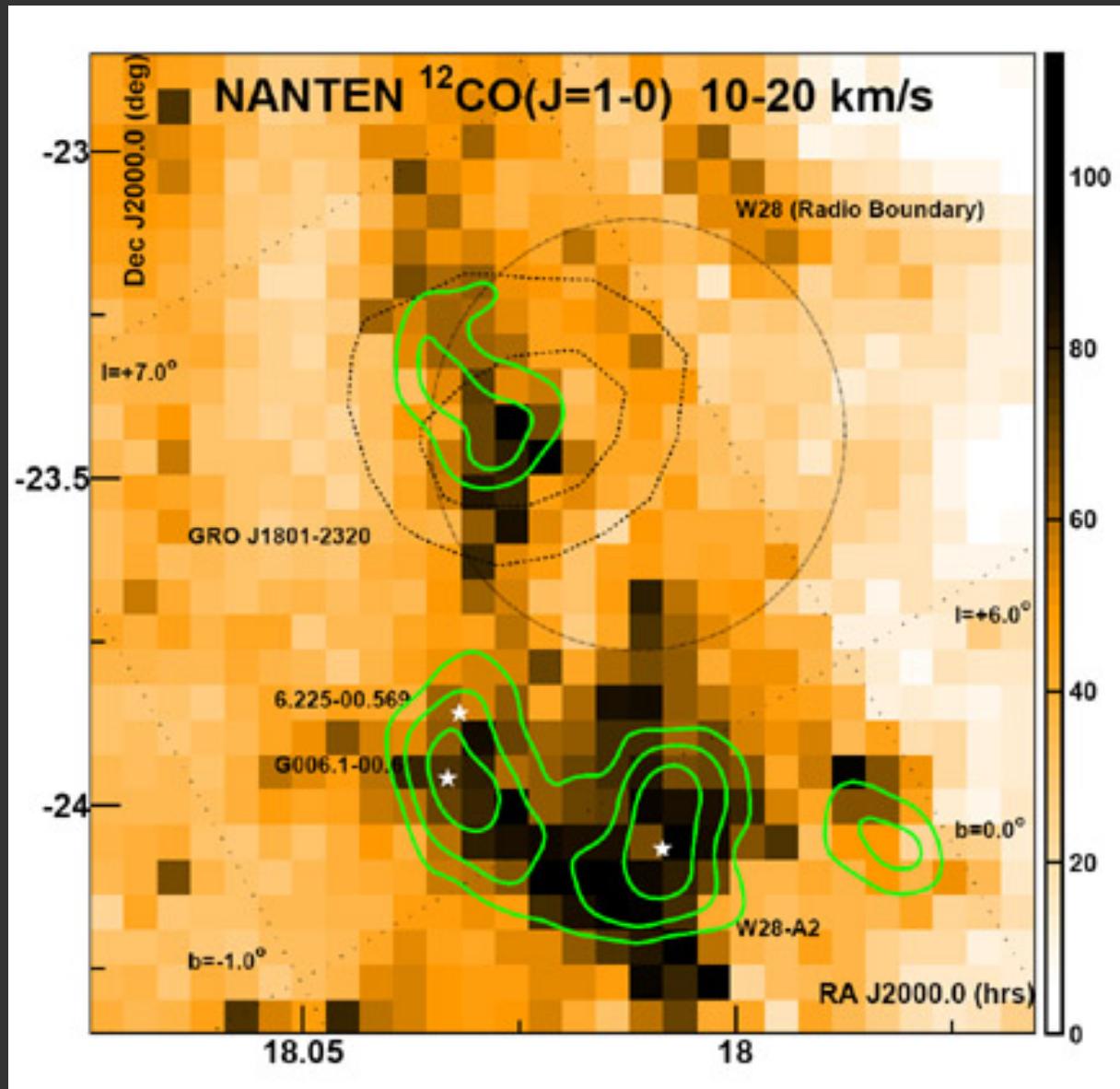
Acero et al 2015

HESS J1731-347 & RXJ1713.7-3946

CO and HI



W28 Gamma-ray emission (and CO)

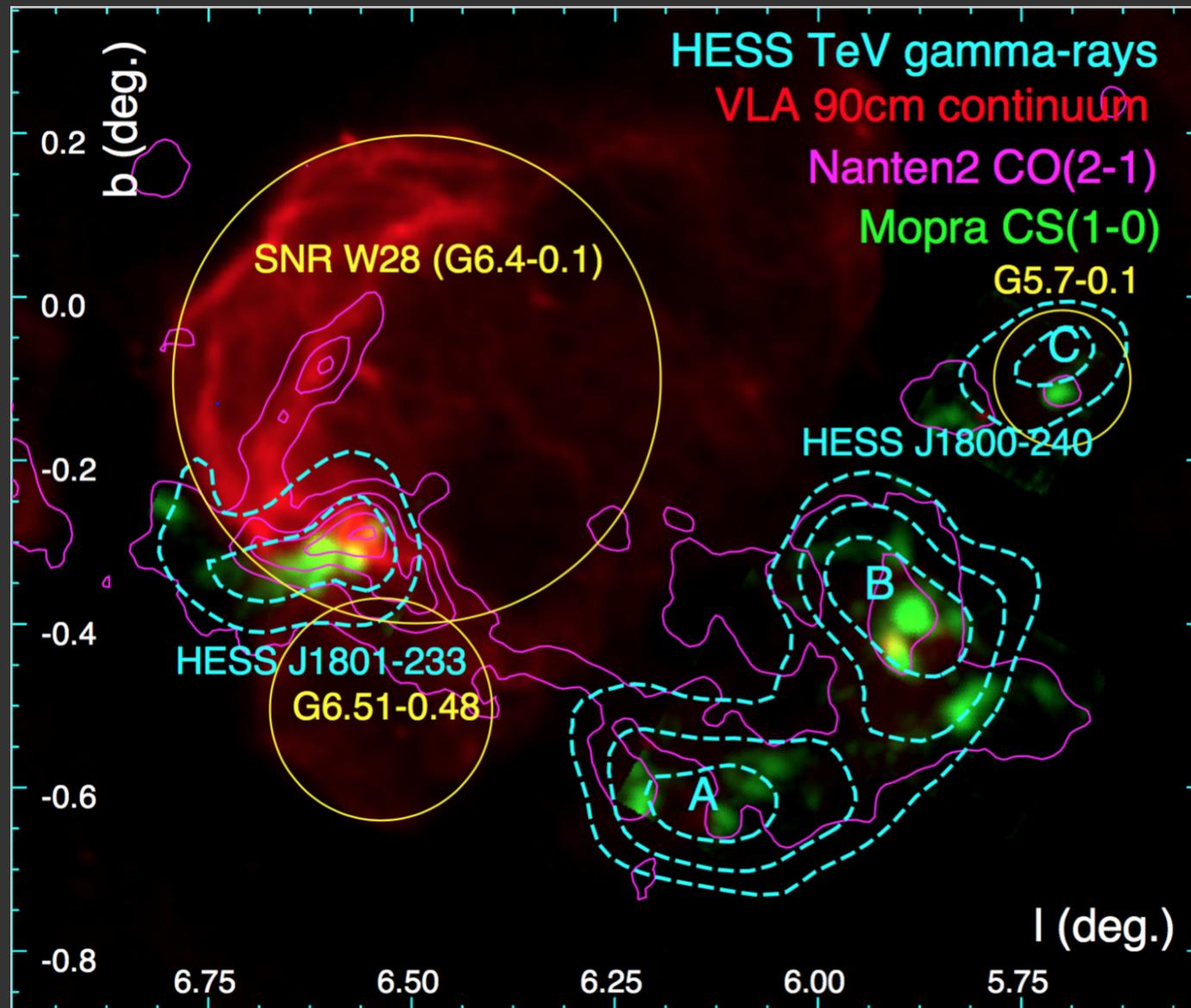


Good correlation between CO(1-0) emission and gamma-rays.

Suggestive of high energy protons (cosmic rays) interacting with gas.

Great evidence that W28 is a source of Cosmic rays!

W28 Gamma-ray emission (and CS)



Fukui et al 2008

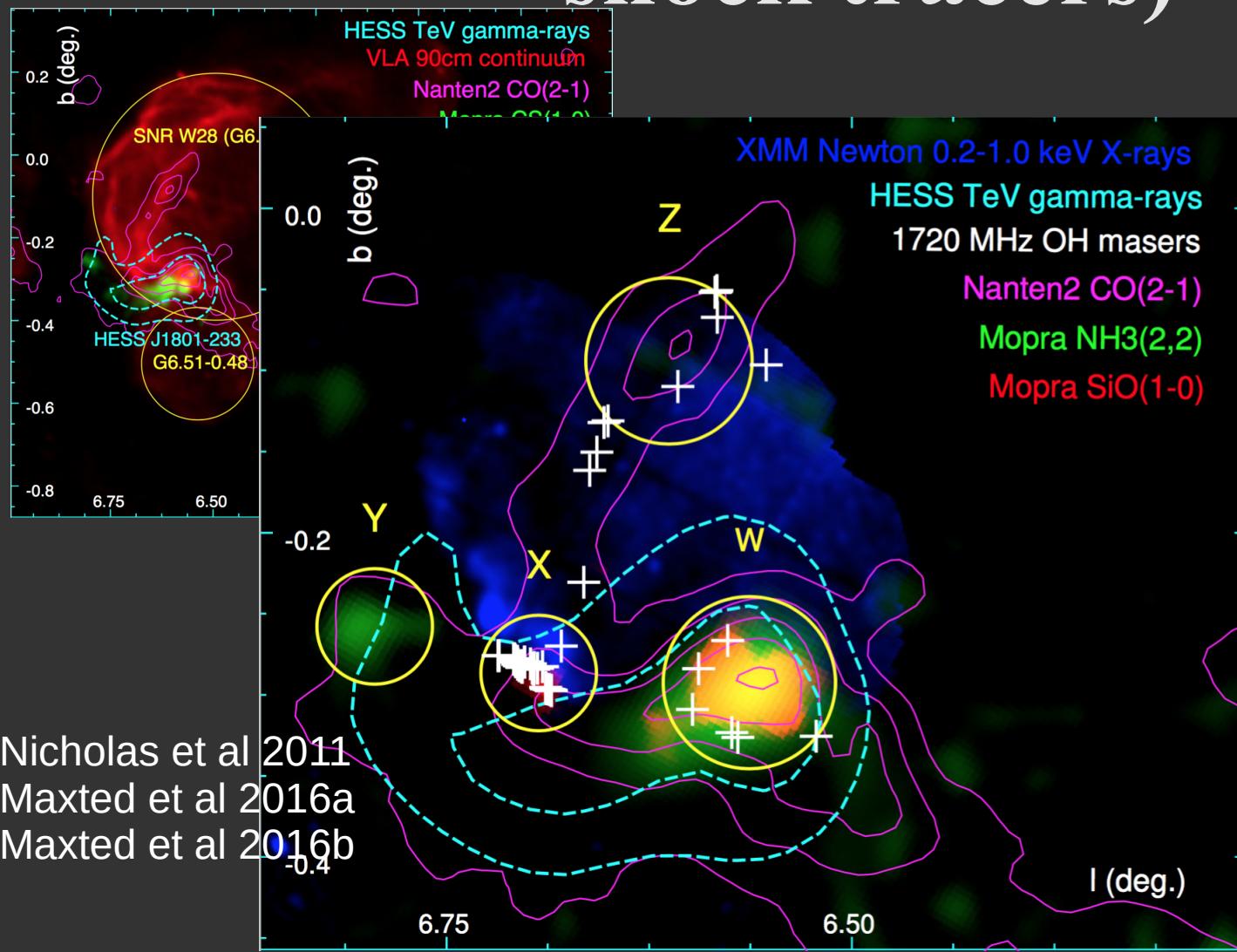
Nicholas et al 2012

Pic: Maxted et al 2016b

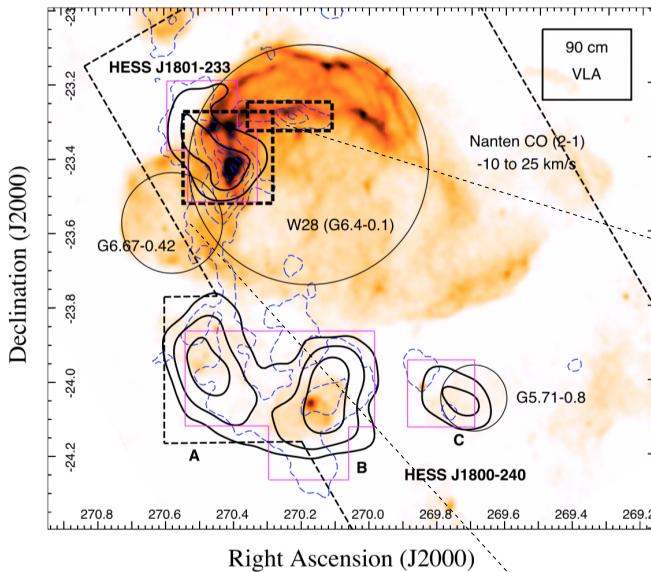


Mopra,
Warrumbungles,
Australia

W28 Gamma-ray emission (and shock tracers)



W28 NH₃ study

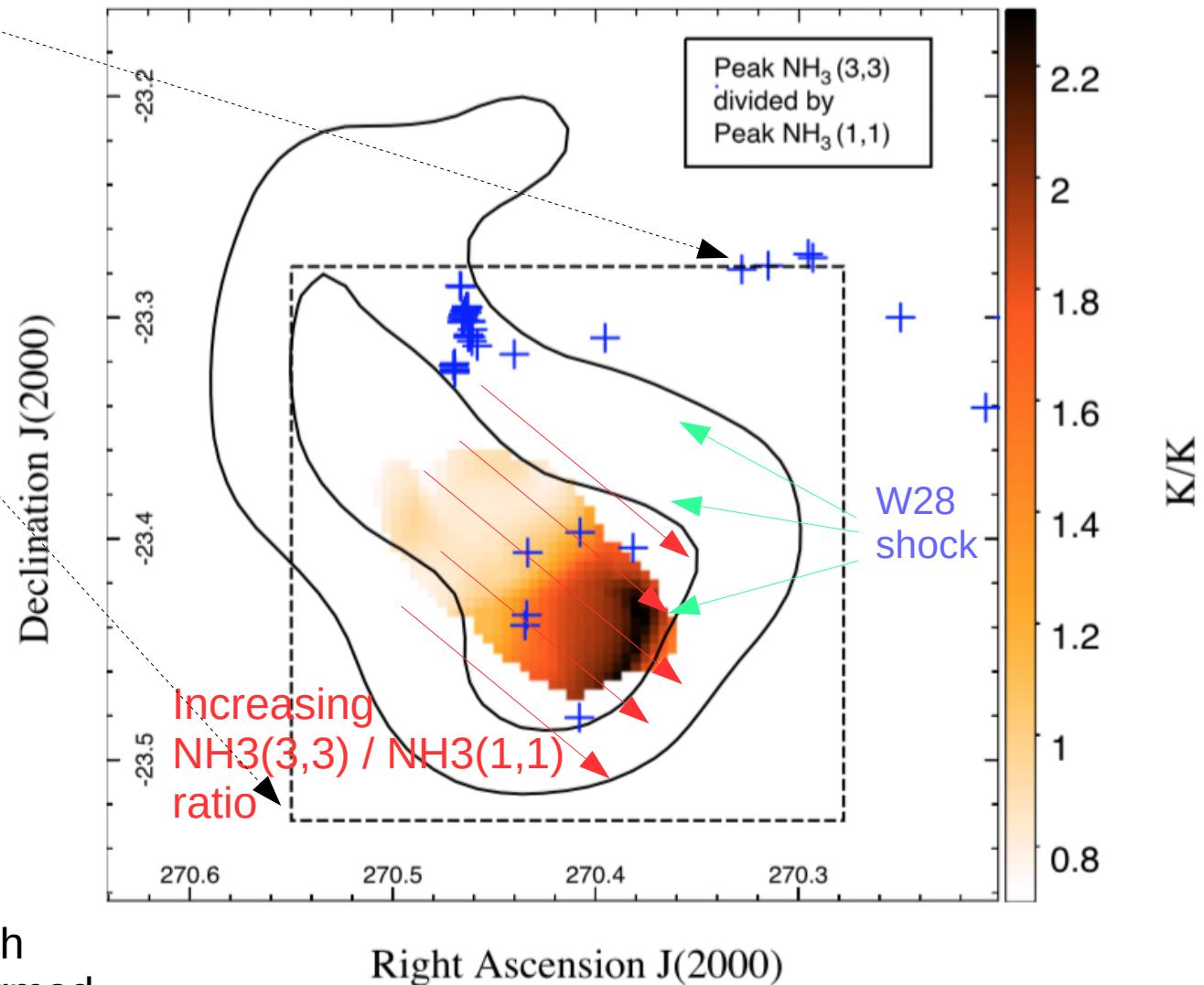


Transition Energies

NH₃(1,1) : 22.7 K
 NH₃(3,3) : 123 K

Other evidence for shocked NH₃ include:

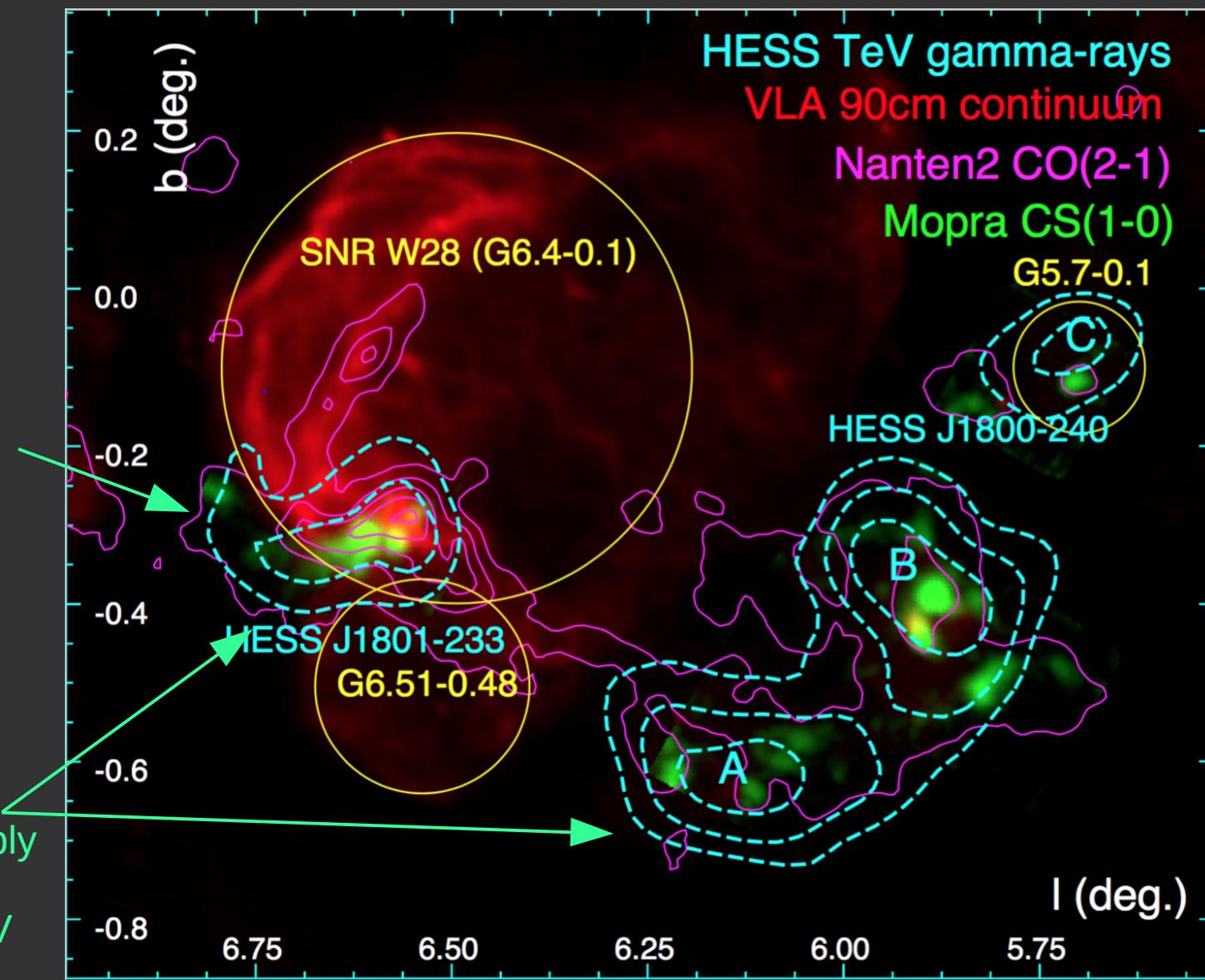
- *velocity dispersion maps
- *high 'ortho-para-NH₃' ratio, which suggests that most of the NH₃ formed on dust grains → see Maxted et al 2016, de Wilt et al (in prep).



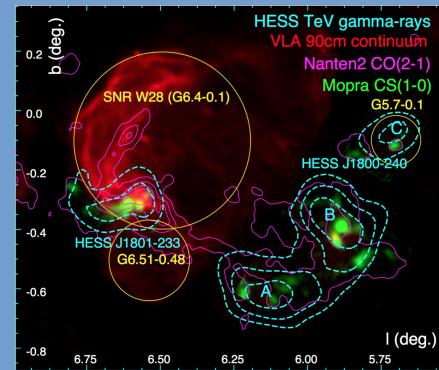
W28 Gamma-ray emission (and CS)

Clear physical connection between shock and cloud

Gas probably bombarded by GeV-TeV CRs

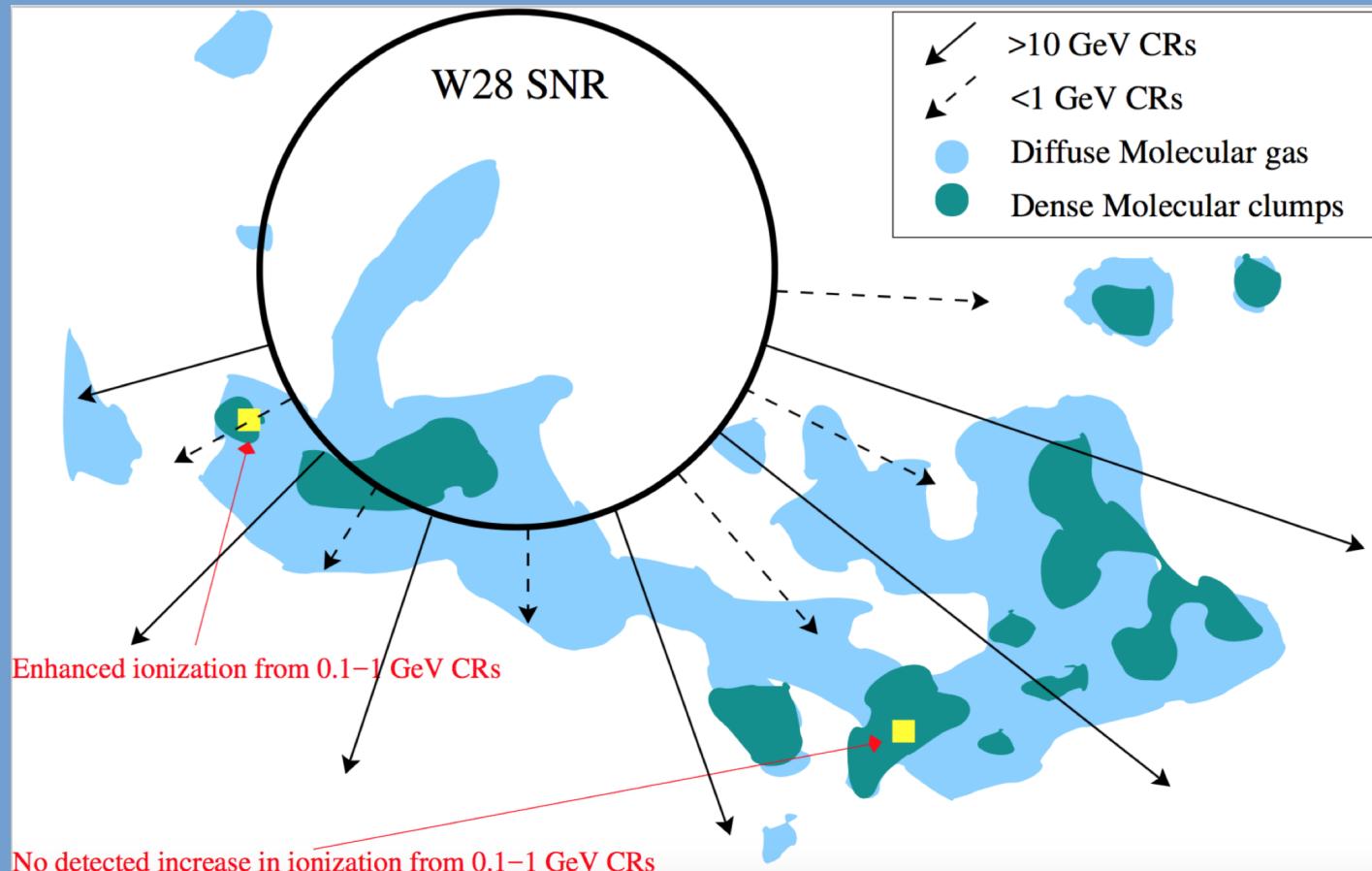


CR diffusion in the W28 region



Ionisation measurements are new CR diffusion constraints.

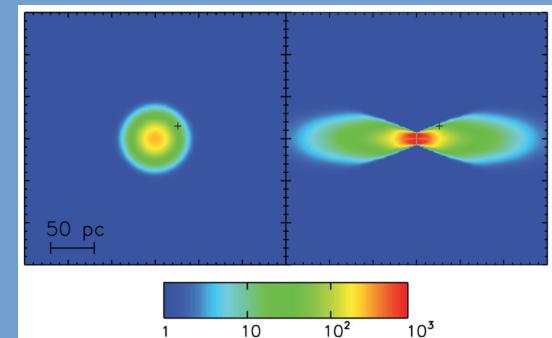
CR ionisation from <1 GeV CRs \sim 100 times larger than in quiescent clouds (Vaupre et al 2014)



Pic: Maxted et al 2016b

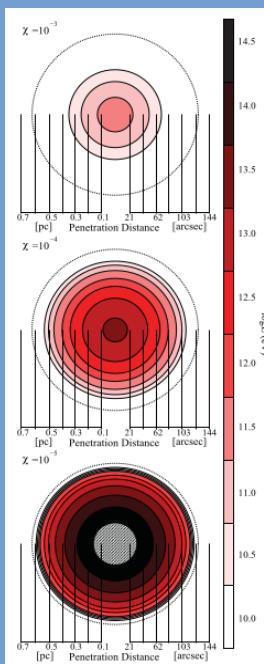
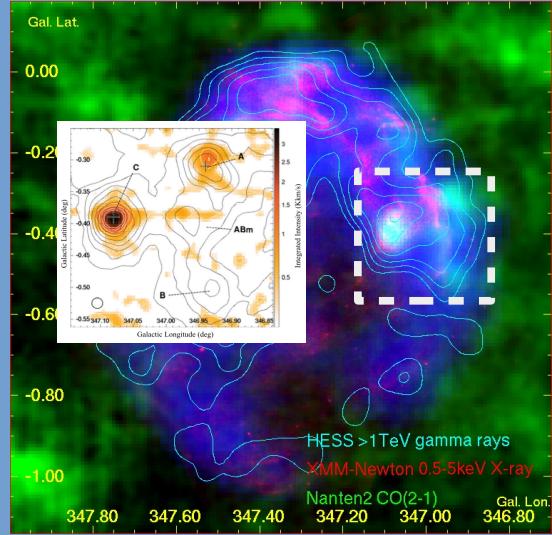
The W28 gamma-ray emission already puts strong constraints on isotropic diffusion in the region (Gabici, Cassanova et al 2010, Hanabata et al 2014). Ionisation measurements a step further (Gabici & Montmerle 2015)

Anisotropic diffusion may be playing a role (Nava & Gabici et al 2013)



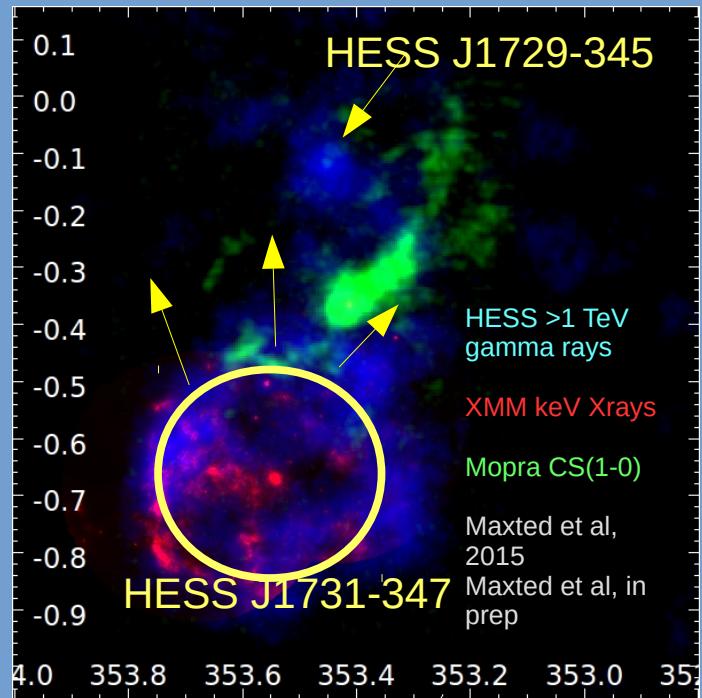
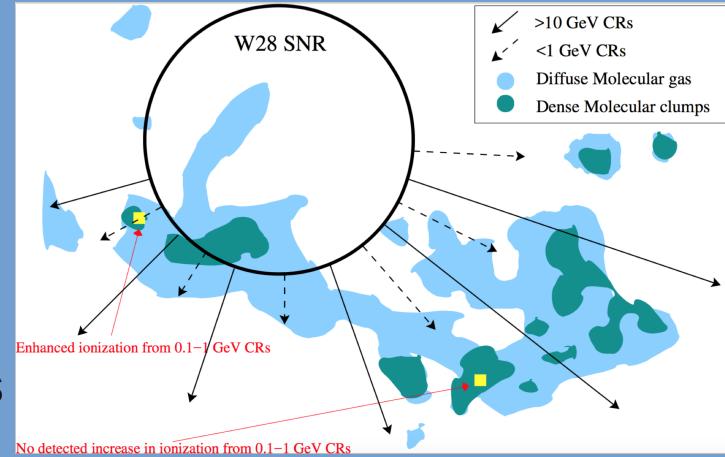
CR diffusion in W28, RX J1713.7-3946 & HESSJ1731-347

RXJ1713.7-3946



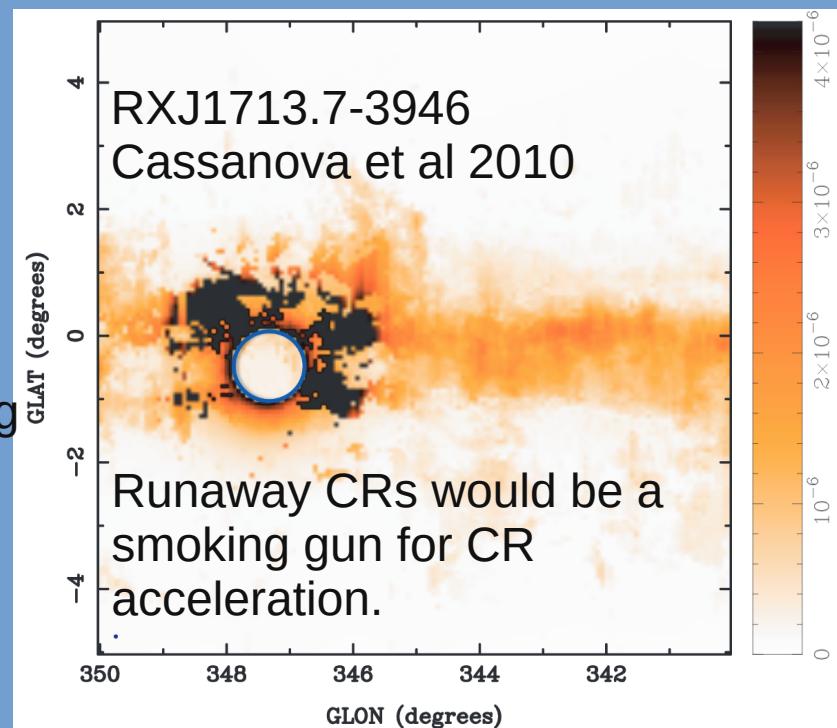
← Dense gas may alter the gamma-ray spectrum at small scales

Gas observations can give constraints for CR diffusion →



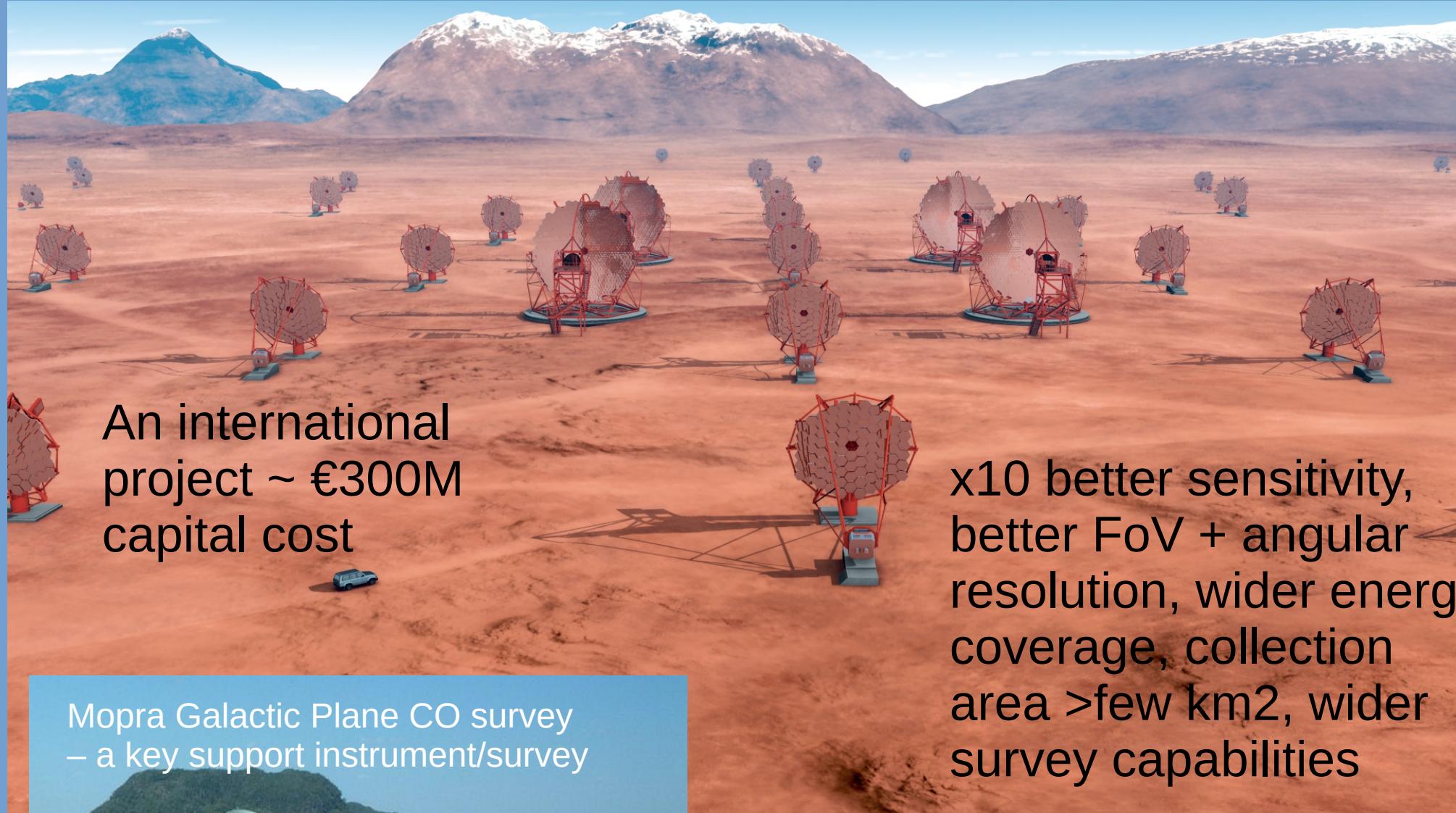
← Unidentified gamma-ray sources caused by runaway CRs?

Using gas maps as a template, modeling predicts signatures of runaway PeV CRs at gamma-ray wavelengths →



Cherenkov Telescope Array CTA

-The next generation of gamma-ray (~20 GeV – 200+ TeV) telescope



An international
project ~ €300M
capital cost

Mopra Galactic Plane CO survey
– a key support instrument/survey

x10 better sensitivity,
better FoV + angular
resolution, wider energy
coverage, collection
area >few km², wider
survey capabilities

See Gavin Rowell's talk on Friday!

Thank you