The Magellanic Clouds
Galactic Science outside the Milky Way

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on behalf of the Fermi/LAT collaboration

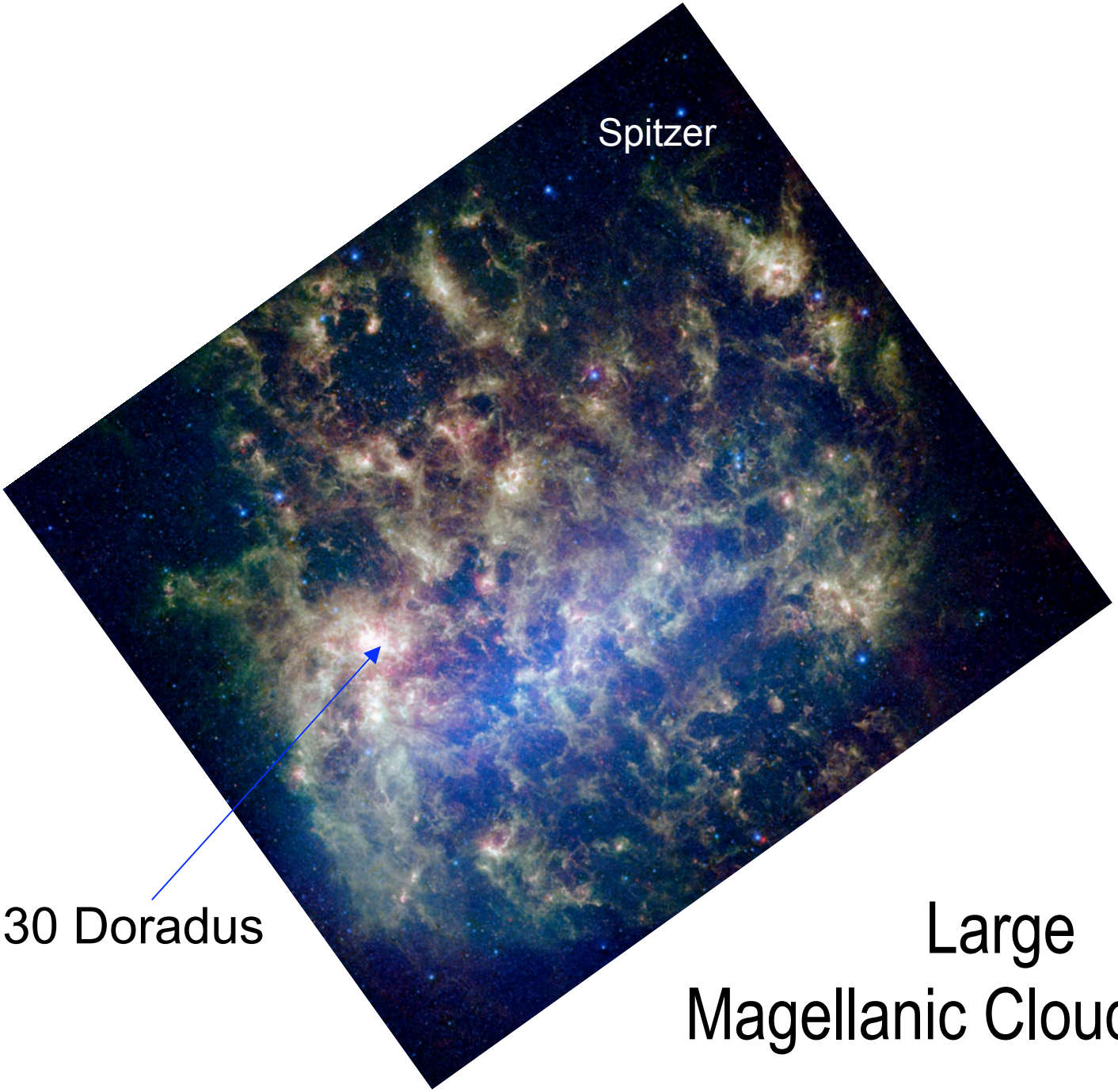
Introduction

Content

- A tour of the sources now accessible from more/improved LAT data
- Some details on data analysis
- Open questions on the interpretation of some sources
- Many results from LMC
- Interesting comparison with SMC
- Conclusions

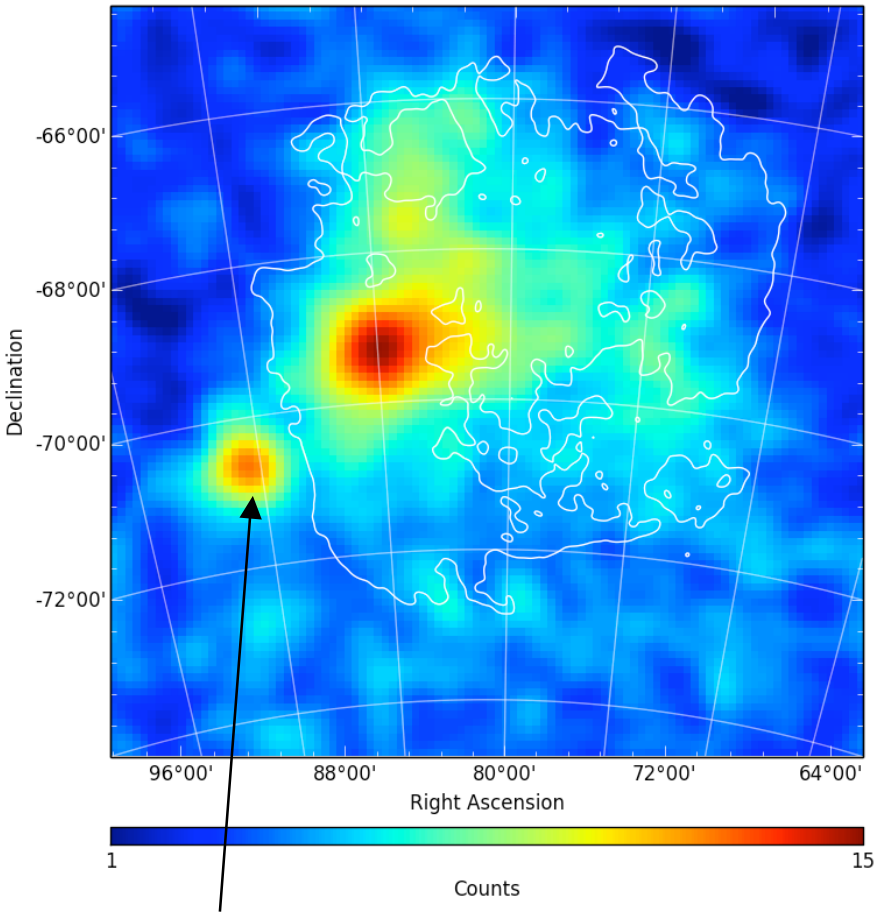
Analysis setup

- Most is based on Pass 7 reprocessed data, SOURCE class
- Using 5.5 years of data
- 2FGL catalog
- 200MeV-100GeV



Large
Magellanic Cloud (LMC)

LMC: counts maps **800MeV-8GeV and 8-80GeV** (smoothing with gaussian of 0.2°)



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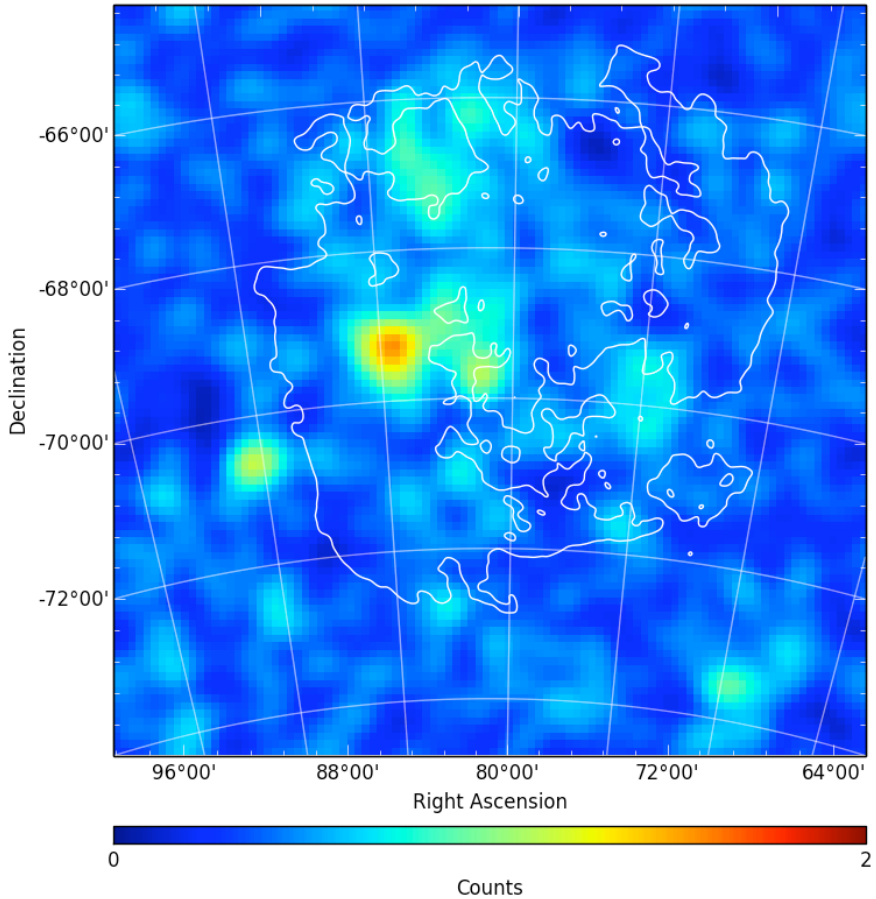


- A bright region, 30 Dor : what lies behind ?
- Extended emission not filling the galaxy or following the gas
- A few hard sources

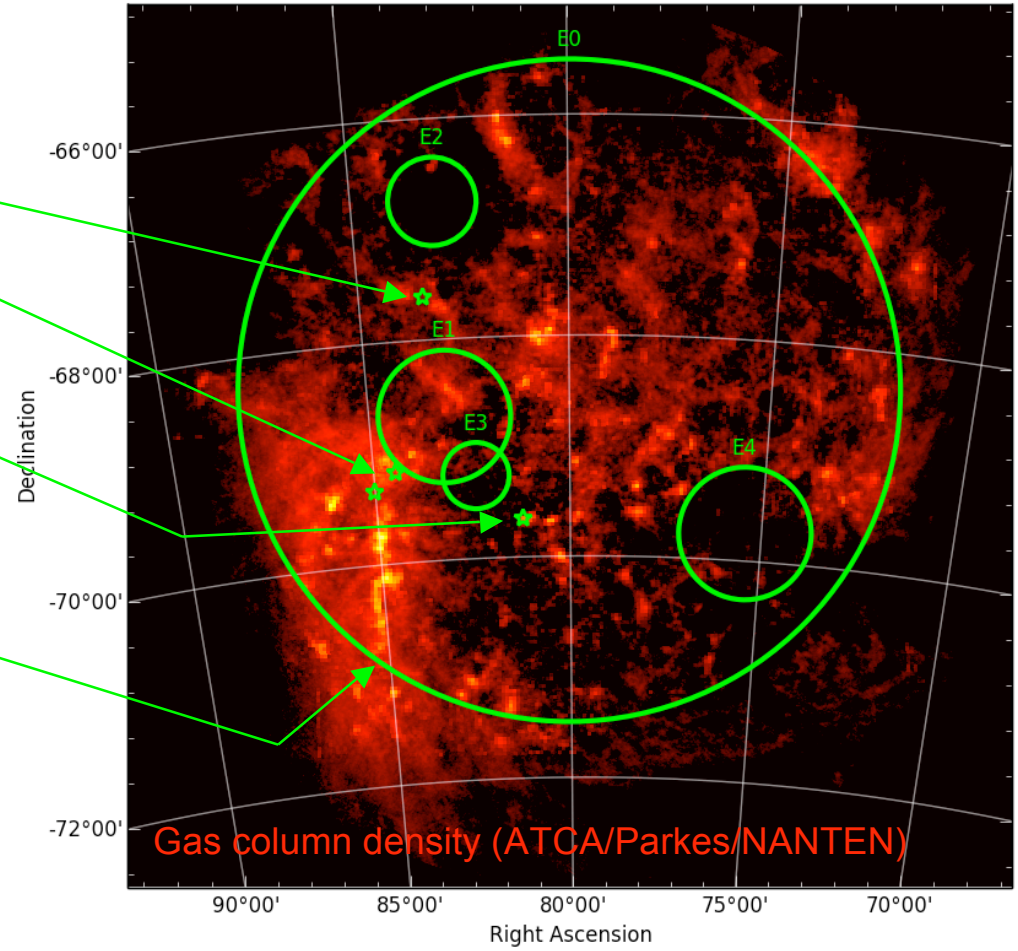
LMC: model

What are the emission components ?

- Model-fitting over 200MeV-100GeV
- Iteratively add point sources and gaussians until fit stops improving

The global LMC picture

- 4 point sources
  - 1 unid
  - 2 pulsars (J0540 and J0537)
  - 1 SNR (N132D)
- 4/5 extended sources
  - Disk (E0)
  - North (E2)
  - West (E4)
  - Near 30Dor (E1/E3)



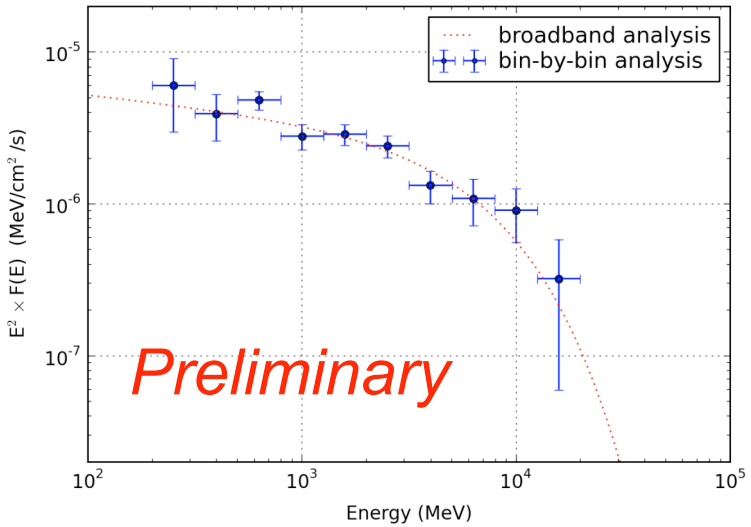
LMC: PSR J0540-6919

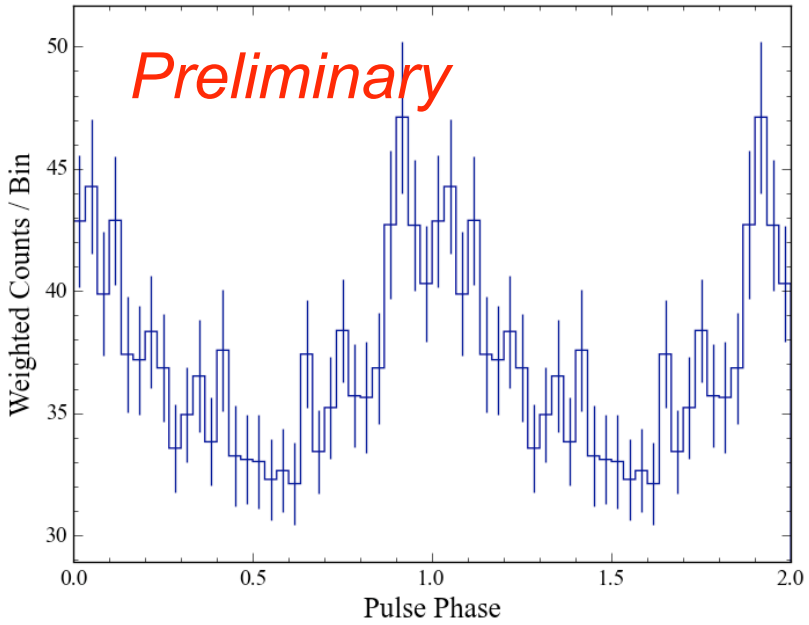
Done in collaboration with Lucas Guillemot and Frank Marshall

First «extragalactic» gamma-ray pulsar !

- Power law with exp. cutoff spectrum
- Pulsation search using photon weighting based on model
- Ephemeris from RXTE over 3.5 yrs
- Pulsations at 6.8σ (facilitated by Pass 8)

- The Crab twin, giant spin-down power
- Rare extreme case useful to test emission models
- Helpful to understand γ-ray emission from 30Dor



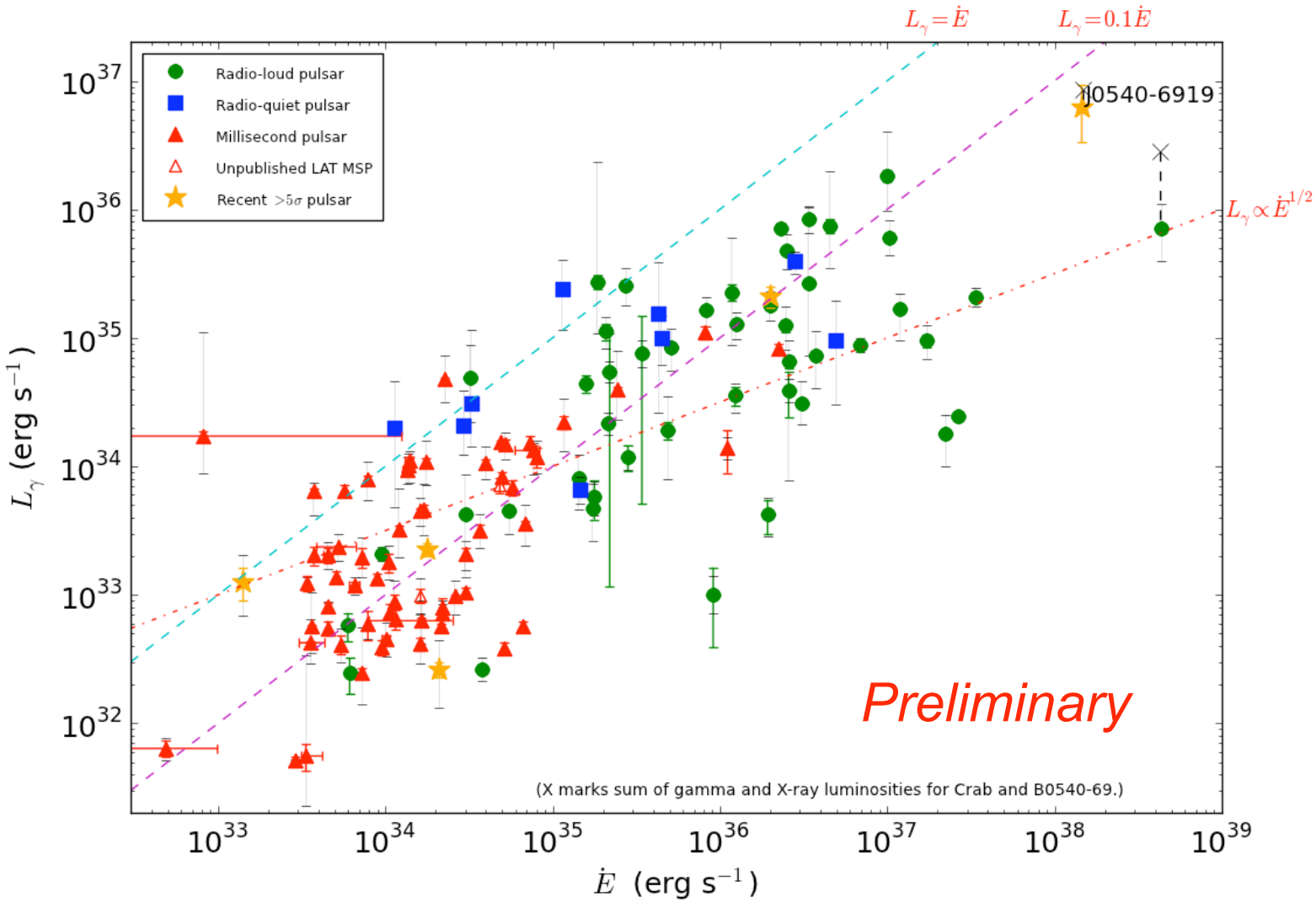


Currently checking profile alignment in optical/X/γ…

LMC: PSR J0540-6919

Gamma-ray luminosity 6.3 10^{36} erg/s
~10 times more luminous than Crab
(also more luminous in pulsed X-rays)

Thanks to David Smith



LMC: PSR J0537-6910

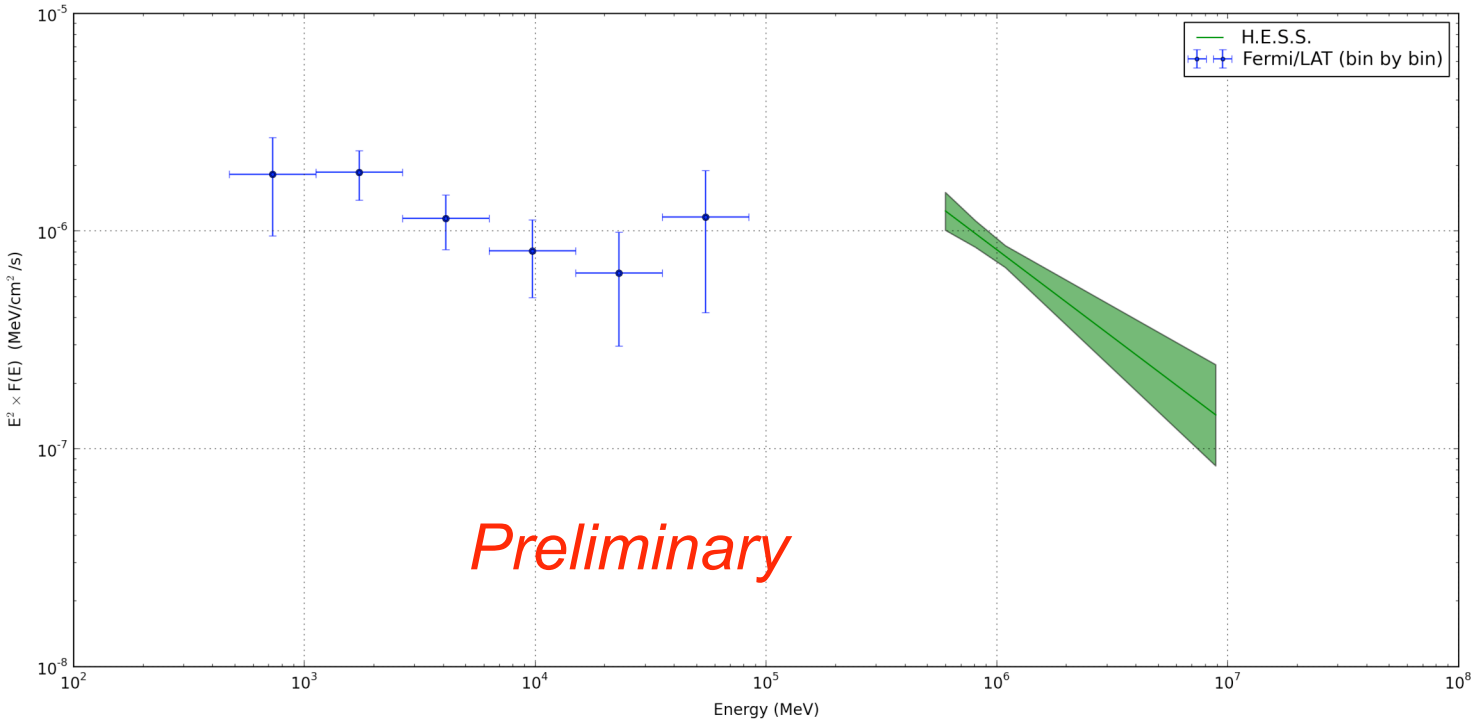
The most powerful pulsar known

(5000 yr, spin-down ~4.9 10^{38} erg/s)

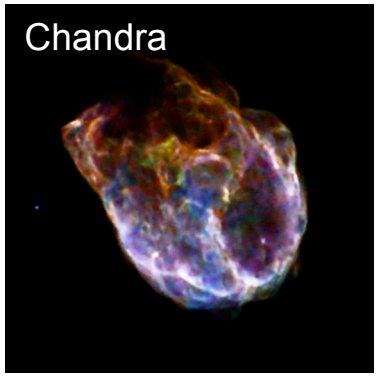
- Luminosity 1-100GeV ~2.4 10^{36} erg/s
- Flat spectrum over ~1-100GeV …up to 800GeV ?

Unclear origin of the emission

- GeV counterpart to TeV PWN N157B ? *Too flat ?*
- Pulsar+PWN ? *No pulsations detected…*
- SNR ? Too luminous in GeV range ? *Interacting ? Enough material for pp interactions ?*



LMC: SNR N132D

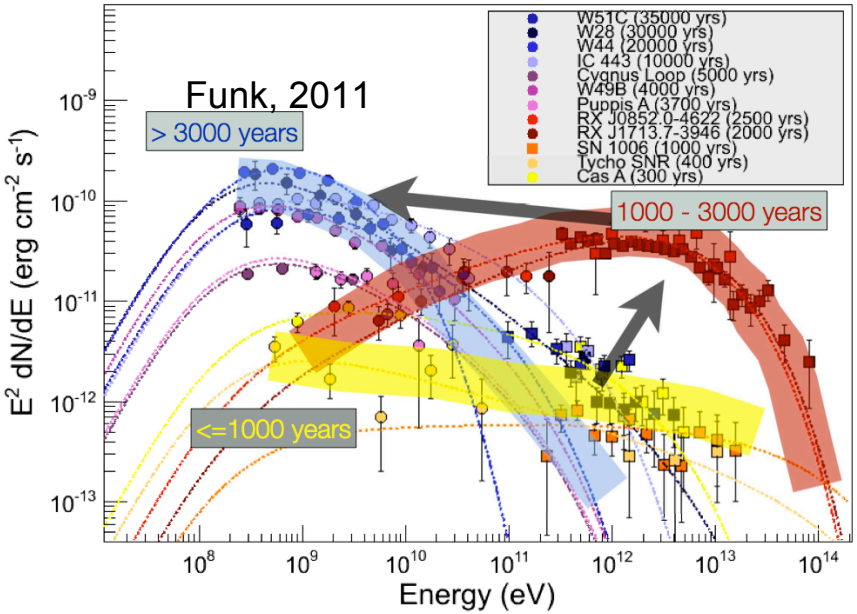


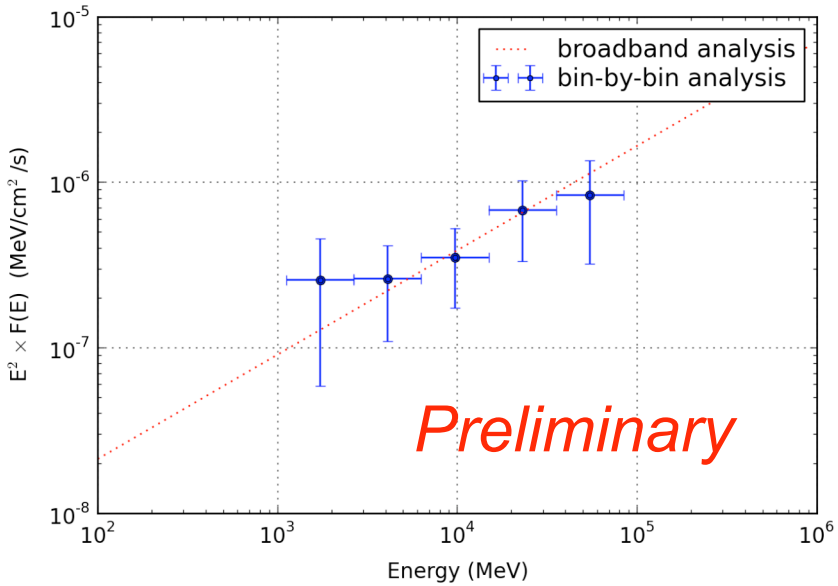
The brightest supernova remnant in the LMC

- Luminosity 1-100GeV ~1.3 10^{36} erg/s
- Hard spectrum
- Marginally detected by HESS from 200h observations
- Spectral match ? see N. Komin's talk

- Transition between middle-aged and old SNRs ?

Core-collapse SN
2500yr
O-rich
Interacting with cloud

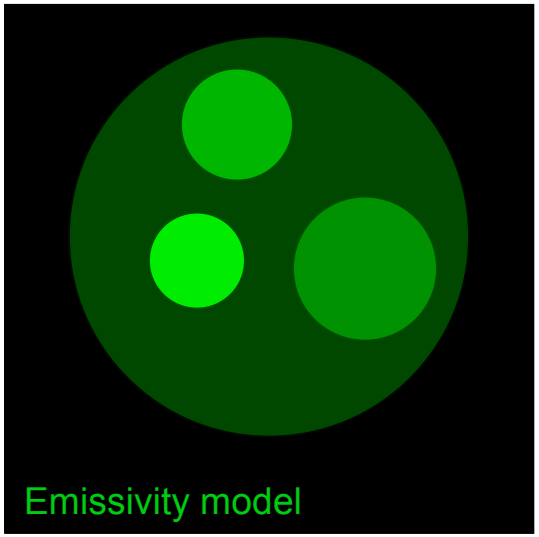




LMC: cosmic-ray population

Method

- Assumption : extended emission is CR-ISM hadronic interactions
- $I(E_\gamma,\mathbf{r}) = q(E_\gamma,\mathbf{r}) \,.N_H(\mathbf{r})$
- Iteratively add emissivity Gaussian-like projected regions, each time optimizing position/size
- … multiply by gas column density map, fit as templates with given spectral model
- Direct way to estimate emissivities



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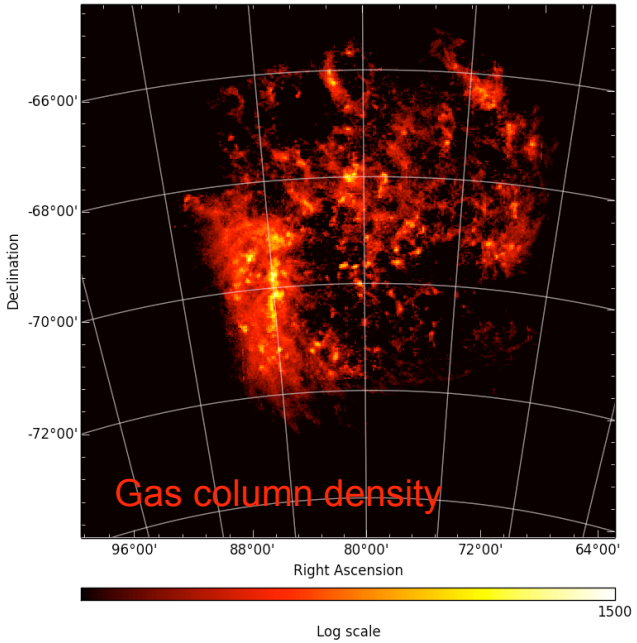
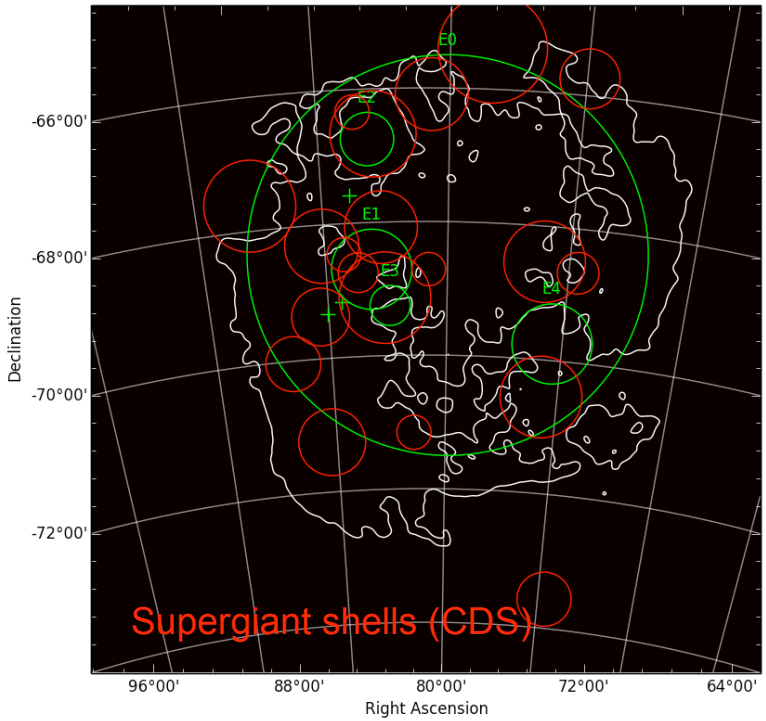


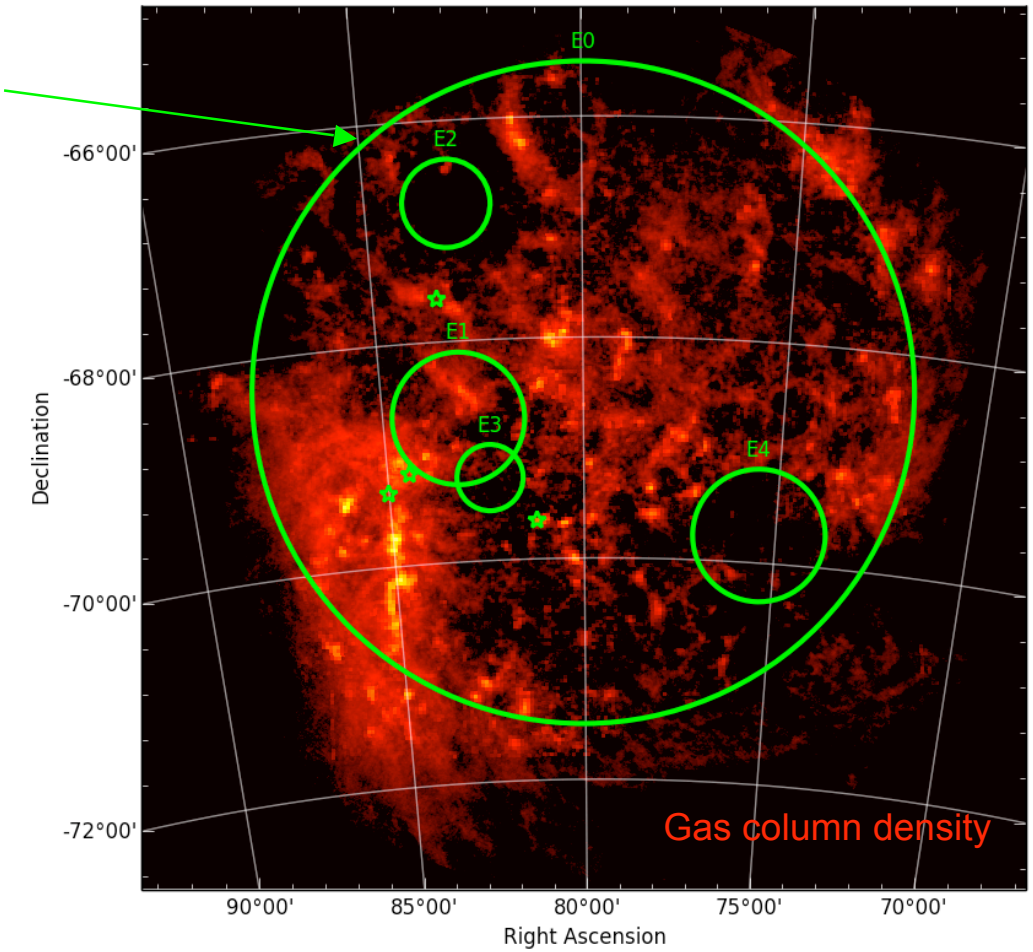
Ex: 4 regions with different emissivities

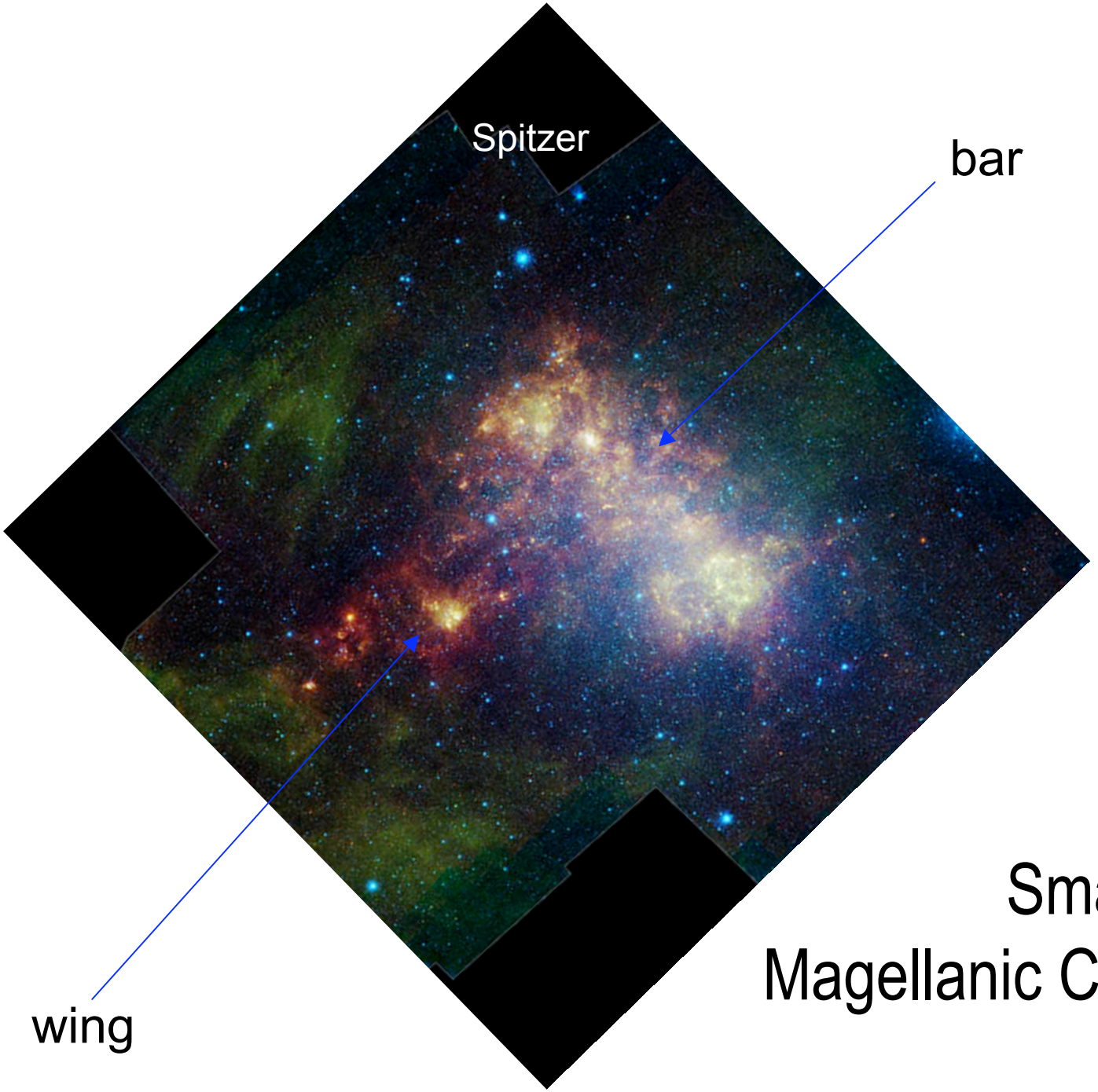
LMC: cosmic-ray population

An inhomogeneous distribution

- CR sea has 1/3 the local CR density
- CR enhancements by factors 2-8
- No CR enhancement in 30 Dor…
- … but >0.5° offset from it
- Correlation with cavities and shells

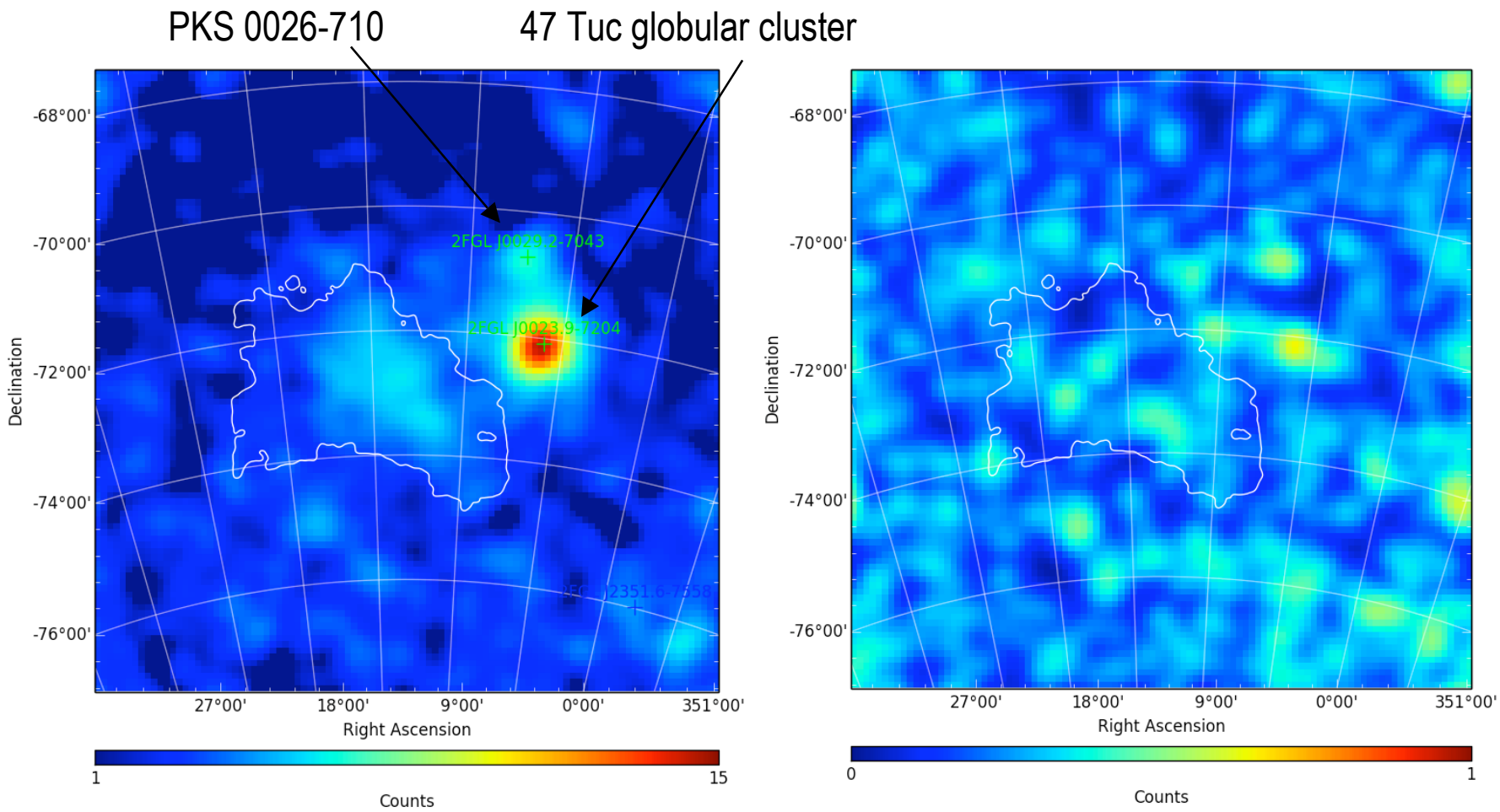






Small
Magellanic Cloud (SMC)

SMC: counts maps **800MeV-8GeV and 8-80GeV** (smoothing with gaussian of 0.2°)

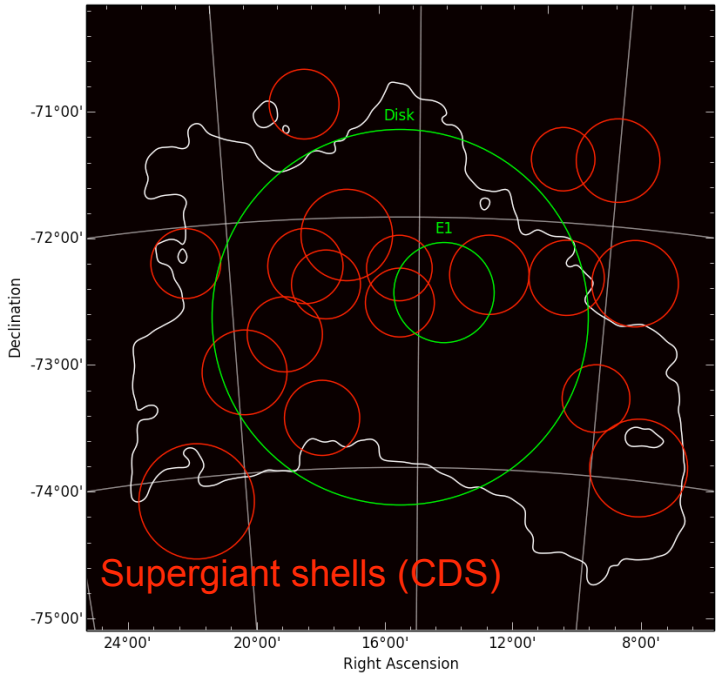


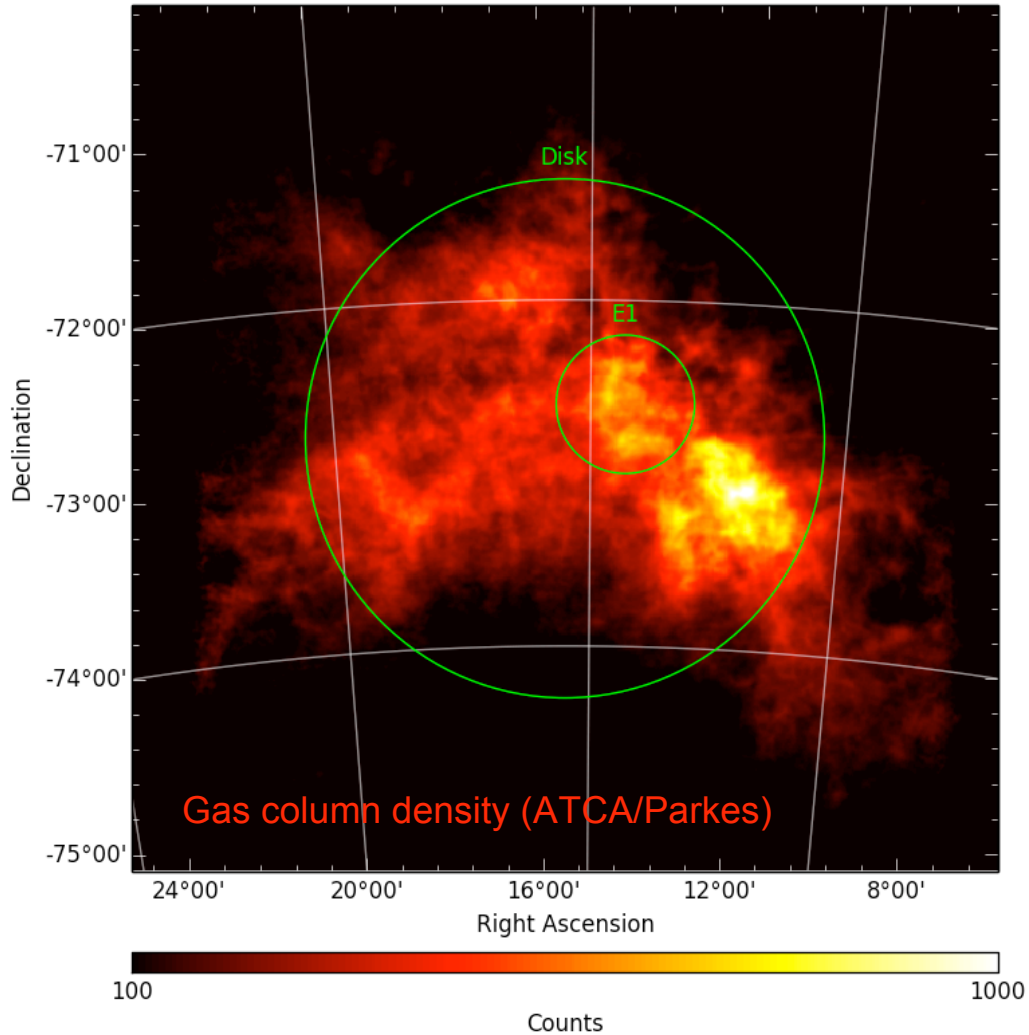
- Extended emission following the bar of the SMC
- No hard sources within SMC boundaries

SMC: cosmic-ray population

Global picture differs from LMC

- No point-like source in SMC
- CR sea has ~5% the local CR density
- CR enhancement in the bar by ~4
- No obvious correlation with cavities
  …or star forming regions
  (but geometry is different)





Conclusions

Galactic science in the Magellanic Clouds

- Providing extreme objects to complement studies of Galactic HE and VHE sources
  - Two of the most powerful pulsars known
  - One X-ray bright SNR of the rare O-rich class
- Probing the cosmic-ray population of star-forming galaxies seen from outside/above
  - CR seas with smaller densities than local in SMC and LMC
  - Inhomogenous distributions with enhancements in places by factors 2-8
  - Possible correlation with cavities in LMC, but nothing obvious in SMC
  - Relation of CRs/γ-rays to star-forming regions is not straightforward

- Combined with the latest HESS results: good prospects for CTA !

Currently writing papers…