Probing proton acceleration in W51C with MAGIC

Julian Krause, Emiliano Carmona and Ignasi Reichardt
on behalf of

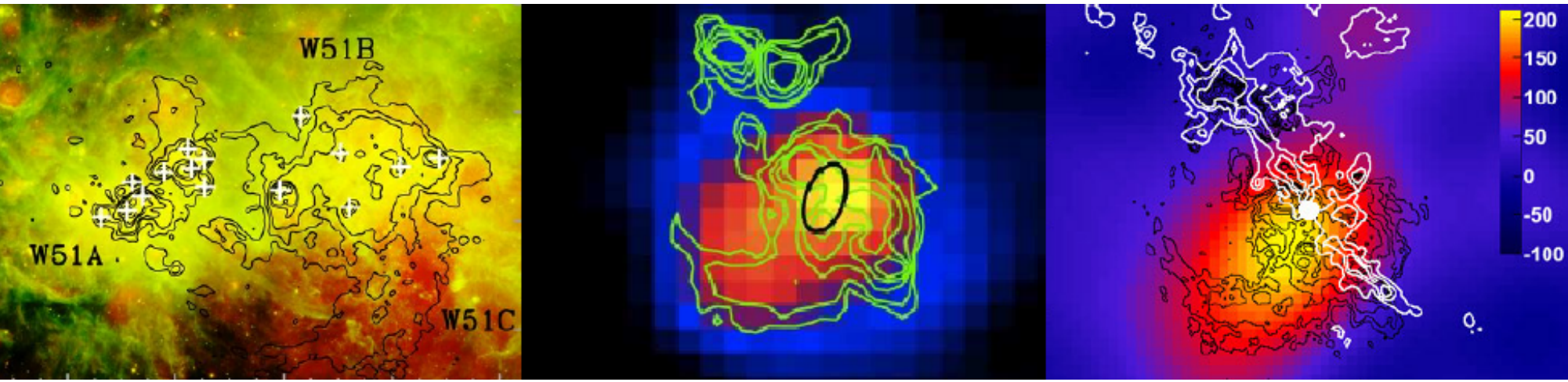
III FERMI Symposium 2011, ROME, 9-12 May 2011

The W51 complex

MIPS & IRAC
24 (red) & 8.0 (green) μm
Miju Kang et al. 2009 ApJ 706 83

Fermi / LAT
2-10 GeV
arXiv:1104.1197v1

H.E.S.S.
$>$1 TeV
ICRC 2009



- One of the most luminous star forming regions (distance $\sim$ 6kpc)
- W51C is a medium age ($\sim$ 30kyr) supernova remnant [SNR]
- The shell of the remnant interacts with the surrounding molecular clouds
- Discovered by *Fermi* / LAT ($\sim$ GeV) and H.E.S.S. (4.4σ, flux > 1 TeV)

Promising candiate to test and study cosmic ray acceleration in SNR's

The MAGIC Telescopes

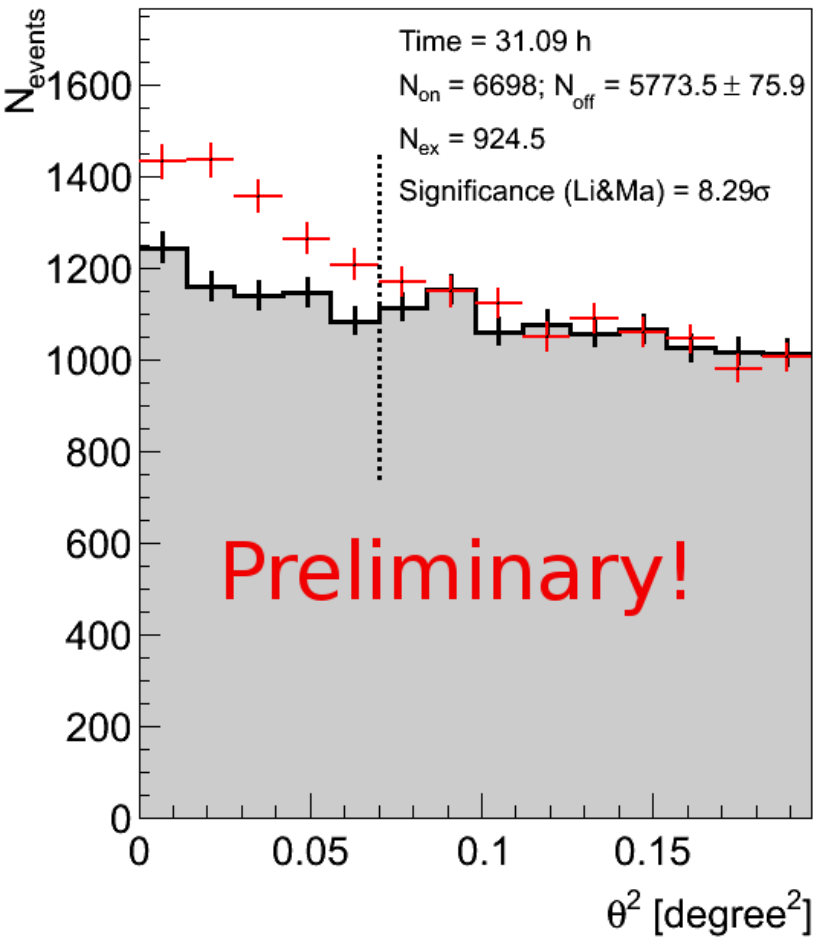
Located on La Palma (Canaries)
Roque de los Muchachos
2200 meter a.s.l.

Stereoscopic system of two IACT's

Reflector diameter 17 m

- Energy treshold 50 GeV
- Performance > 300 GeV:
  - sensitivity $\sim 0.8\%$ Crab [50 h]
  - angular resolution ~ 0.07 deg
  - energy resolution $\sim 17\%$

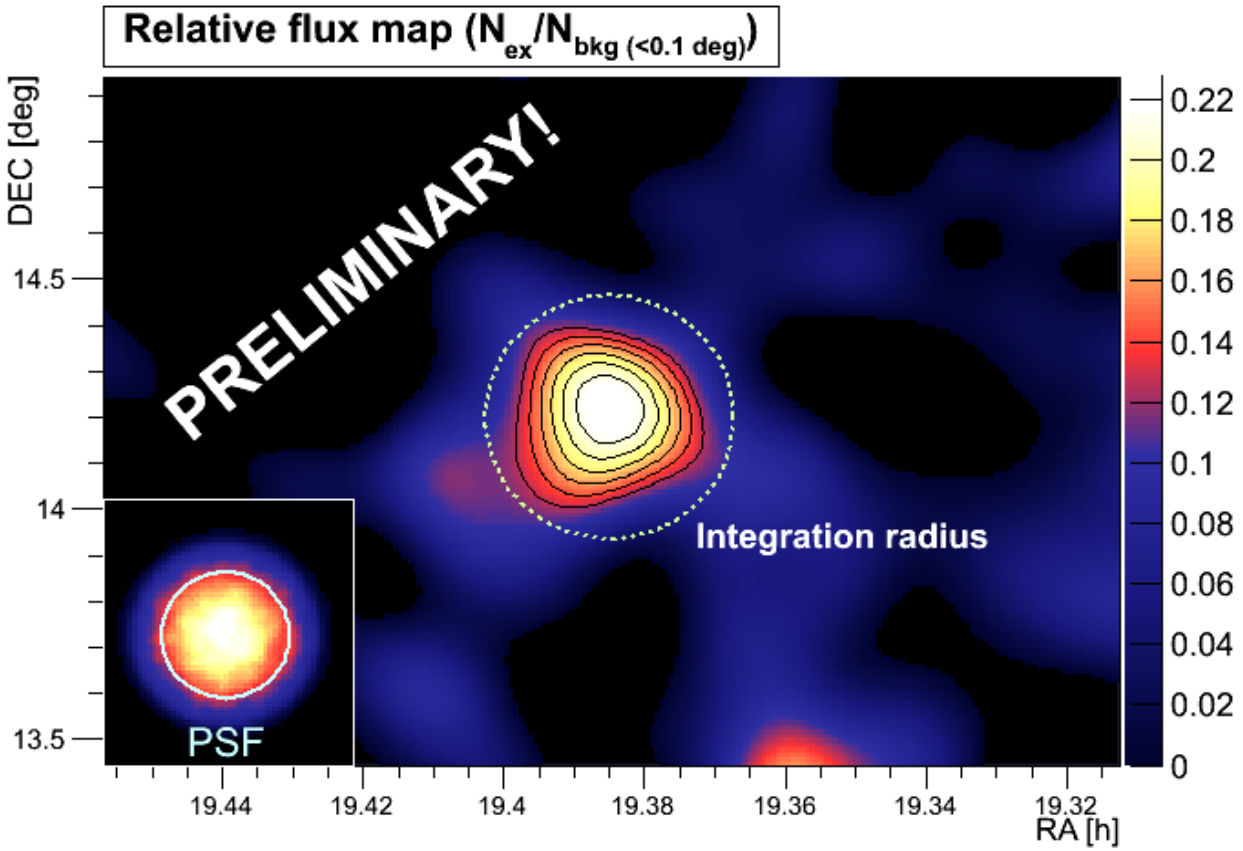
Observations of W51C with MAGIC



- center of observations:
  Ra $= 19.385\,[\mathrm{h}]$
  Dec $= 14.19\,[\mathrm{deg}]$
- stereoscopic wobble data
- data from May to August 2010
- zenith angle 14-35 degree
- total of 31.09 h effective time

- 8 σ detection $>$ 150 GeV
- Extended emission region

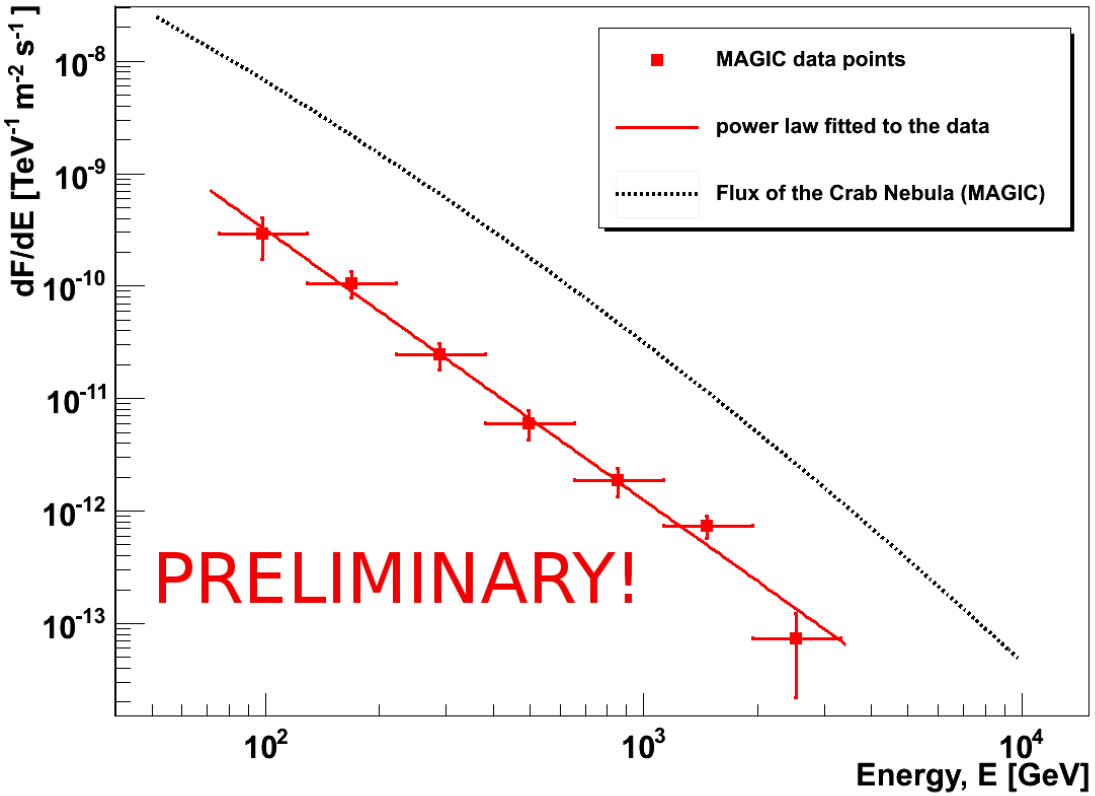
Source position and extension > 150 GeV



- angular resolution 0.085 deg
- smearing kernel 0.1 deg
- contour levels from test statistics
  Starting at 3.5 ($\approx 3.5\,\sigma$)
  in steps of 0.5

- Source position:
  Ra: $19.387 \pm 0.002\,\mathrm{h}$
  Dec: $14.18 \pm 0.02\,\mathrm{deg}$
- Extension
  0.16 ± 0.02 degree

MAGIC high energy γ-ray spectrum of W51C



- integration radius 0.26 deg
- from 75 up to 3300 GeV
- well fitted by power law $\chi^2/\mathrm{d.o.f.} = 4.51/5$
- flux $\sim 3.8\%$ crab

hard index suggests only small propagation effects $\rightarrow$ CR source spectrum

PRELIMINARY spectral energy distribution:

$$\frac{\mathrm{dF}}{\mathrm{dE}} = (1.25 \pm 0.18_{\mathrm{stat}}) \times 10^{-12} \left(\frac{\mathrm{E}}{\mathrm{TeV}}\right)^{(-2.40 \pm 0.12_{\mathrm{stat}})} [\mathrm{TeV}^{-1}\mathrm{cm}^{-2}\mathrm{s}^{-1}]$$

Revisiting models based on *Fermi* / LAT and radio

Astrophys.J.706:L1-L6,2009

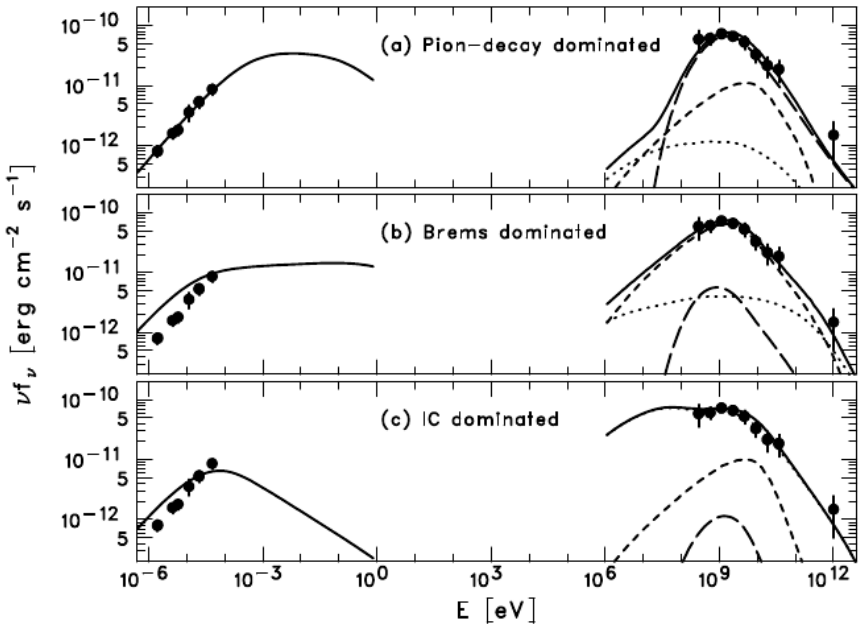


Fig. 4.— Three different scenarios for the multiwavelength modeling (see Table 1). The radio emission (from Moon & Koo 1994) is explained by synchrotron radiation, while the gamma-ray emission is modeled by different combinations of π^0-decay (long-dashed curve), bremsstrahlung (dashed curve), and IC scattering (dotted curve). The sum of the three component is shown as a solid curve.

Pion decay dominated

- known cloud interaction
- agrees with radio

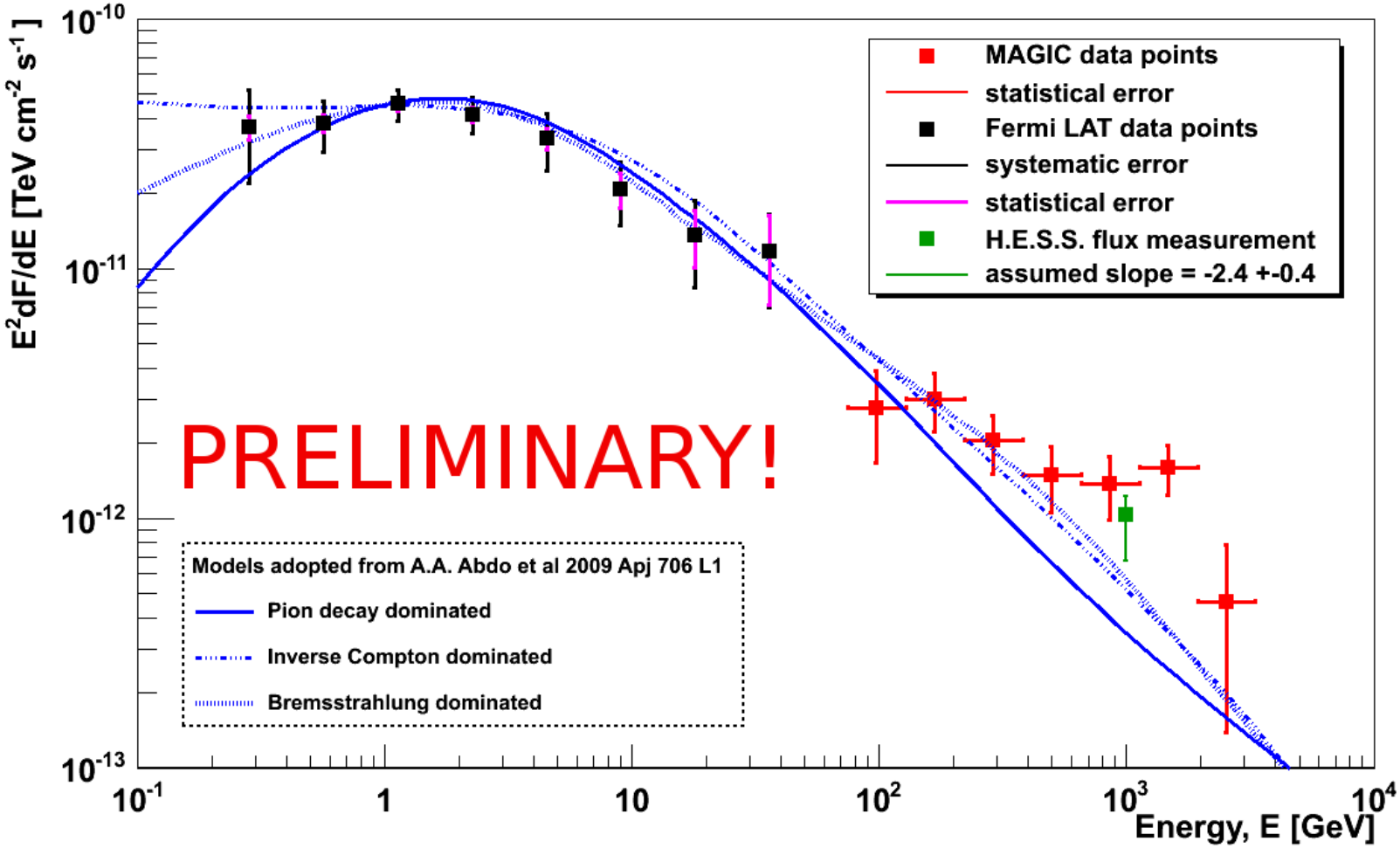
Bremsstrahlung dominated

- needs e/p ~ 1
- disagrees with radio

Inverse Compton dominated

- needs e/p ~ 1
- needs $\mathrm{n_H} < 0.1\mathrm{cm}^{-3}$
- needs $\mathrm{W_e} \sim 10^{51}\mathrm{erg}$
- disagrees with radio

Spectral energy distribution in the γ-ray regime



VHE-γ-ray flux (> 800 GeV) harder than the model predictions

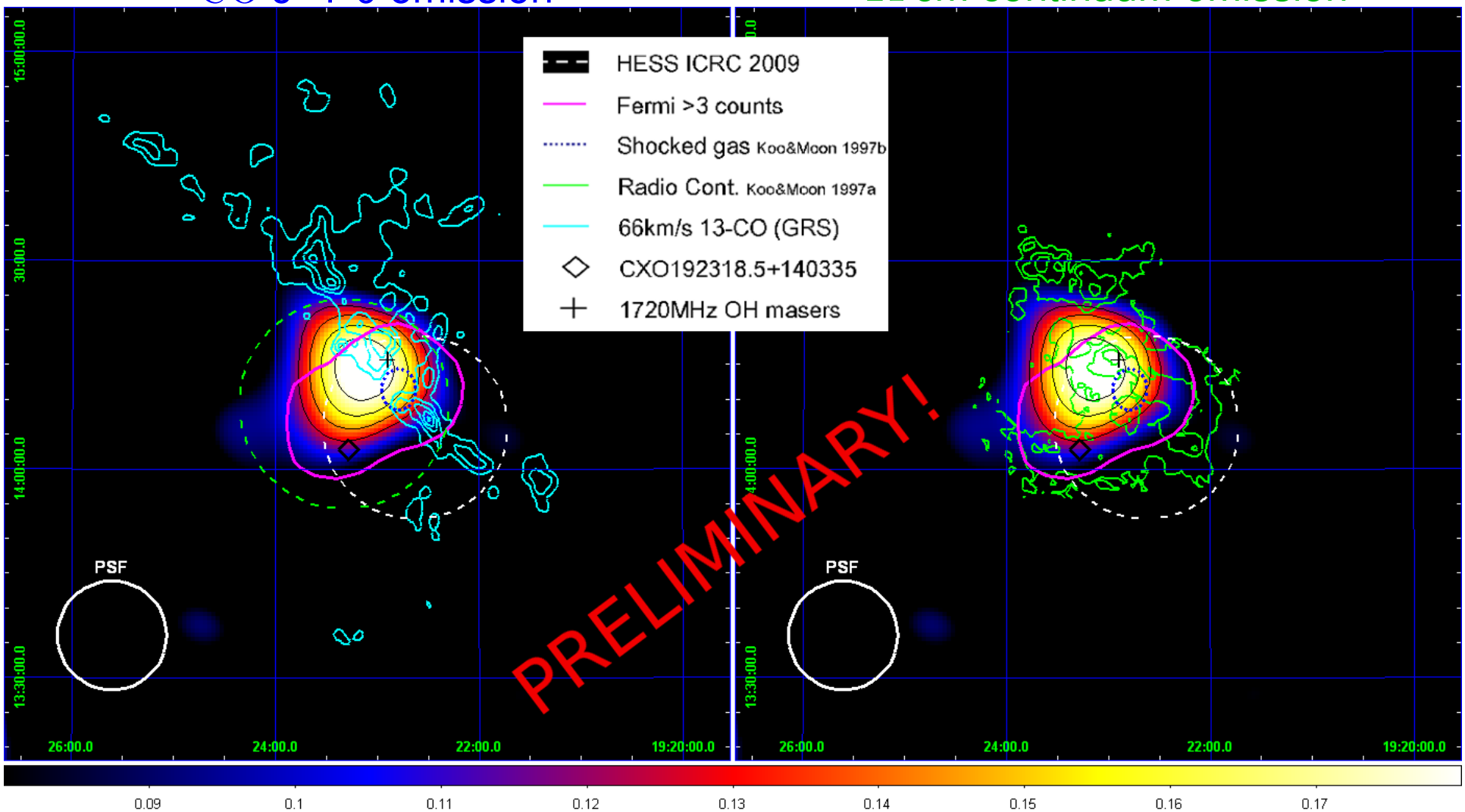
Possible explanations:

- particle spectrum hardens at high energies
- possible contribution from other sources at high energies

Relative flux map from 150 to 700 GeV

^{13}CO J=1-0 emission

21 cm continuum emission

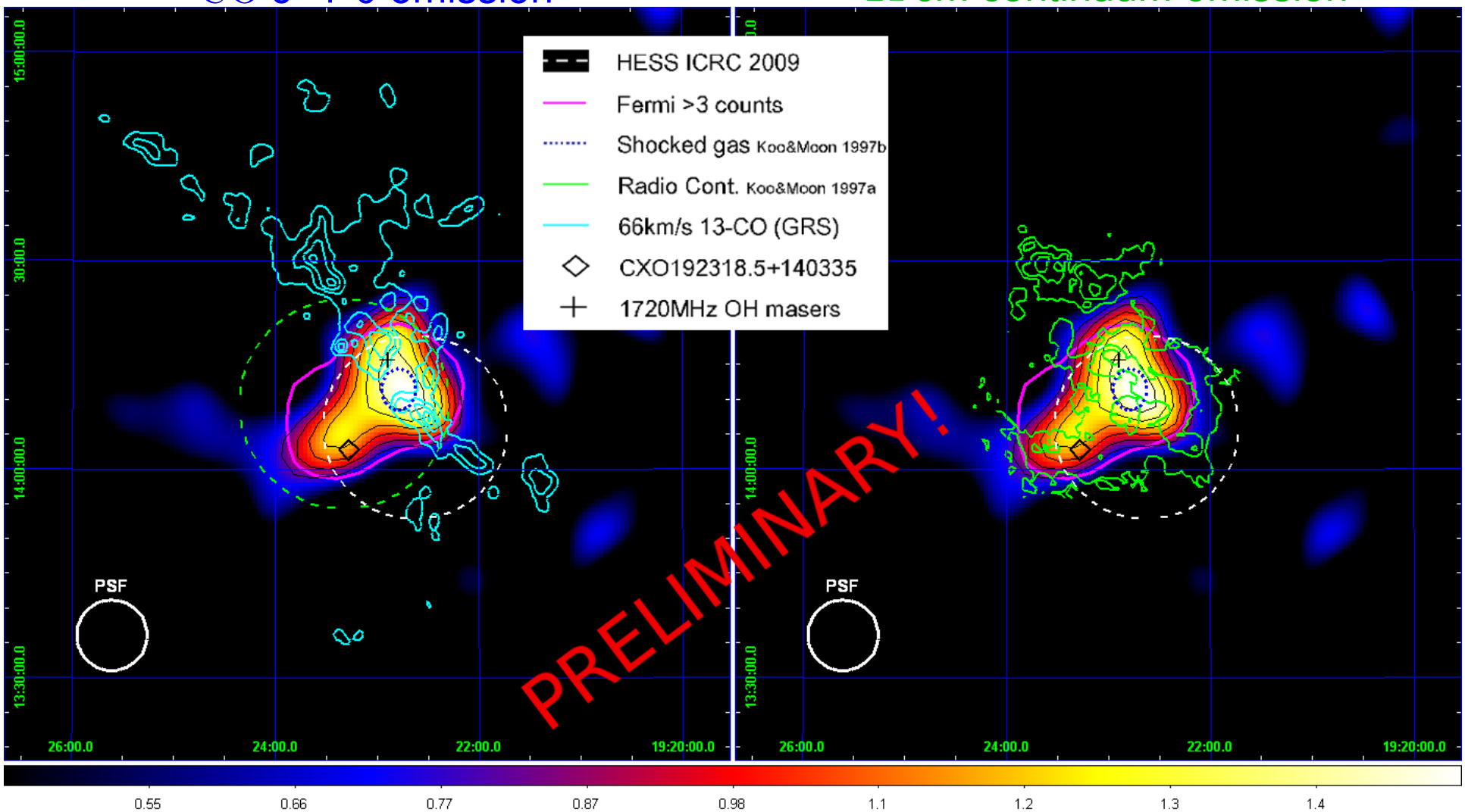


- angular resolution ~ 0.085 deg
- smearing kernel $= 0.1$ deg

Relative flux map > 700 GeV

^{13}CO J=1-0 emission

21 cm continuum emission



- angular resolution ~ 0.054 deg
- smearing kernel $= 0.065$ deg

Summary

MAGIC results

- MAGIC detected W51C above 150 GeV in 31 h with $> 8\sigma$
- Source position compatible with H.E.S.S. and *Fermi* / LAT
- The extension of the integrated flux map is 0.16 ± 0.02 degree
- Maximum of the emission coincides with the shocked cloud regions
- First VHE γ-ray spectrum of W51C (from 75-3300 GeV) showing:
  - a spectral index ~ -2.4
  - a flux $\sim 3.8\%$ crab

Conclusions

- Models based on *Fermi* / LAT + radio data predict too soft a VHE-spectrum
- The source morphology suggests a hadronic origin of the main emission
- The spectral index is compatible/close to the CR source spectrum
- W51 is an important candidate to be looked at by IceCube
- MAGIC publication soon