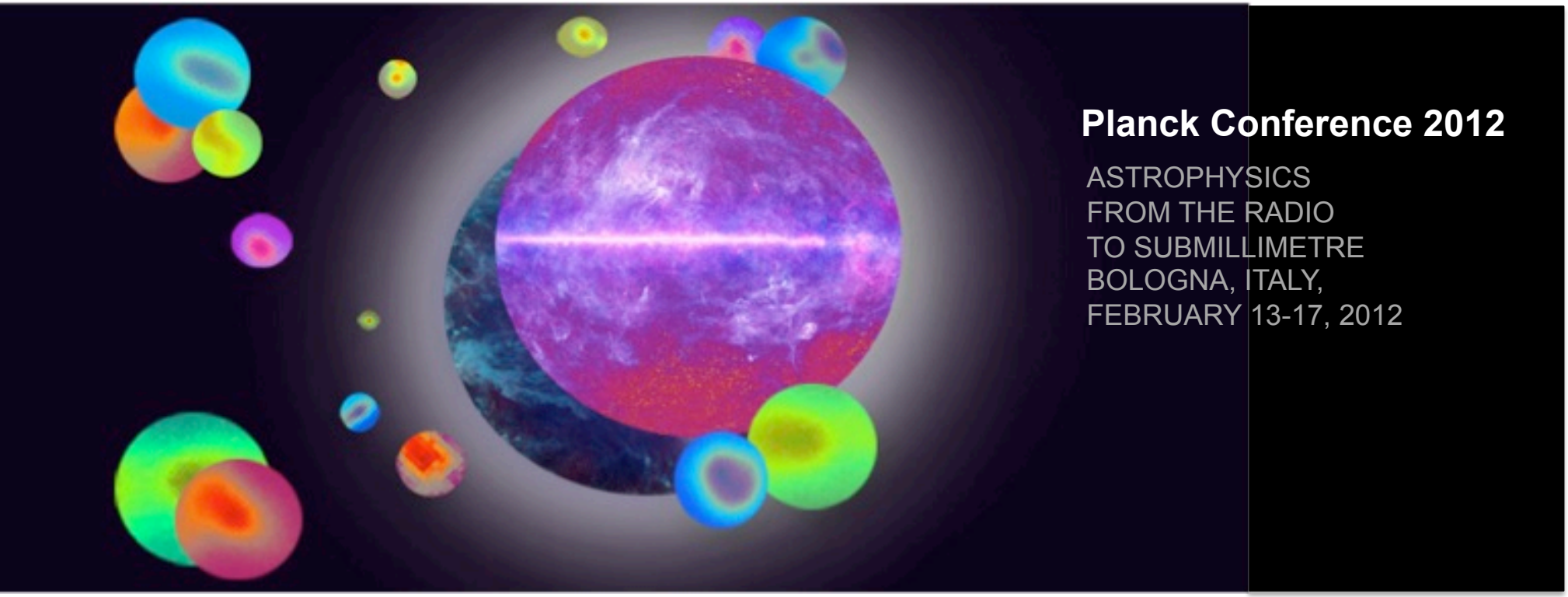


Planck Conference 2012

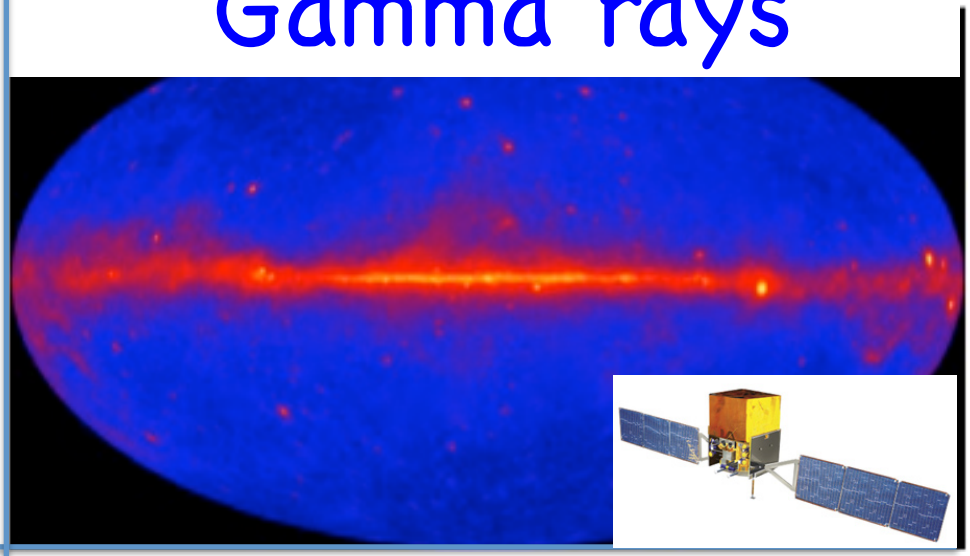
ASTROPHYSICS
FROM THE RADIO
TO SUBMILLIMETRE
BOLOGNA, ITALY,
FEBRUARY 13-17, 2012

Synchrotron radiation, magnetic fields and cosmic rays

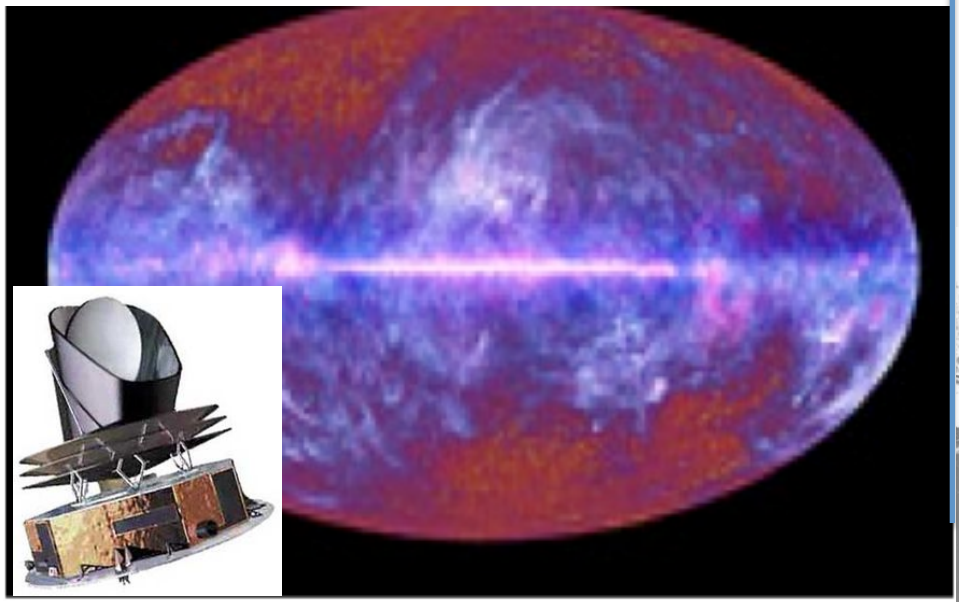
Elena Orlando (Stanford University) & Andy Strong (MPE Garching)

Connection

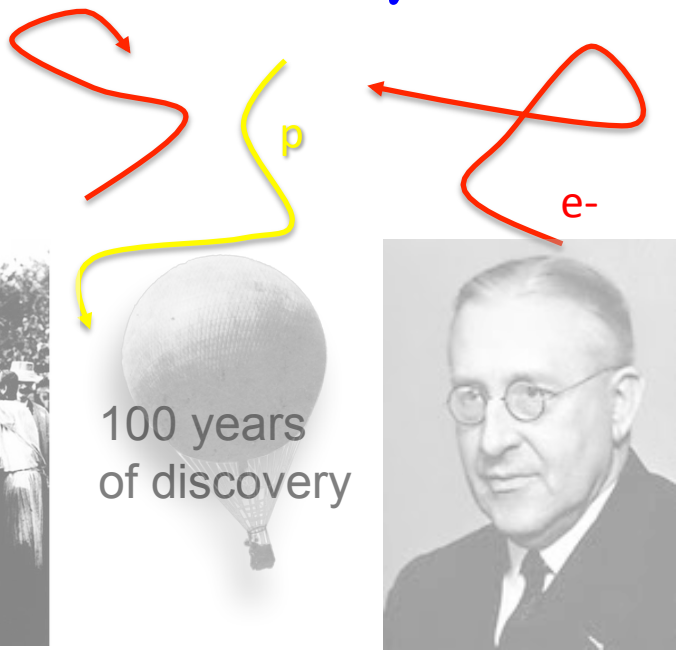
Gamma rays



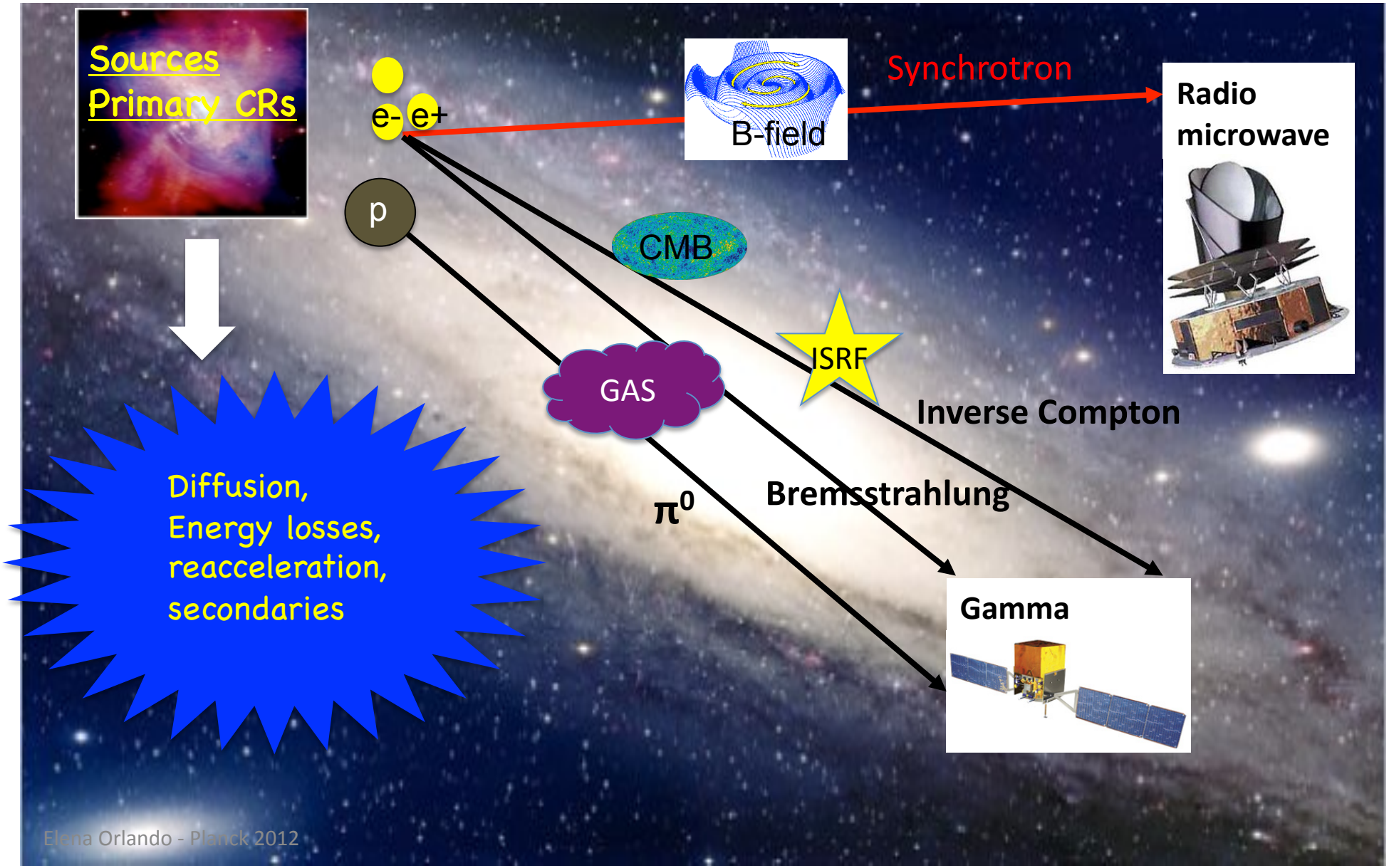
Synchrotron



Cosmic rays



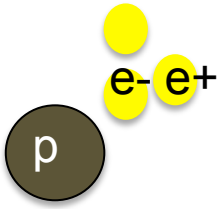
Cosmic-ray propagation in the Galaxy



Overview: Modeling diffuse emissions with GALPROP

THE TEAM:
I. Moskalenko and A. Strong (original creators),
S. Digel, G. Johannesson, T. Porter, A. Vladimirov and me
http://*galprop.stanford.edu*

Recipe:

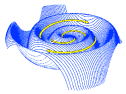


- cosmic-ray spectra p , He , e- , e+ (including secondaries)
  (NB recently using Fermi-measured electrons)

- cosmic-ray source distribution follows SNR/pulsars

- Interstellar radiation field

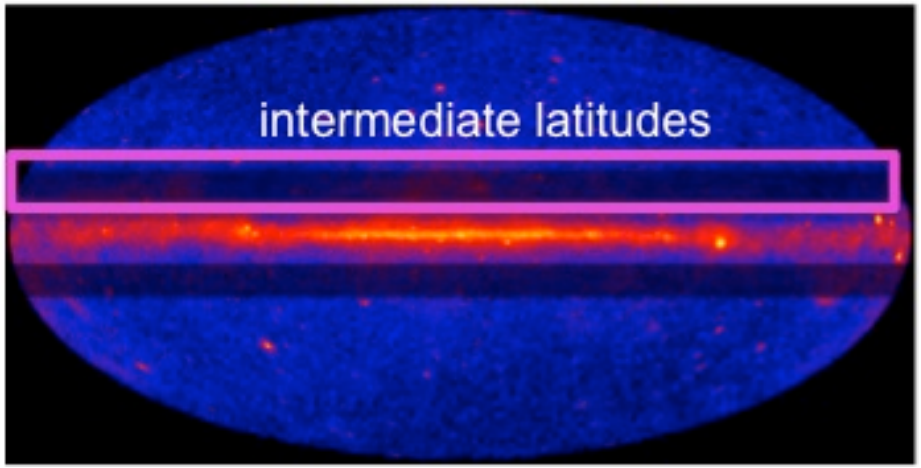
- HI, CO surveys

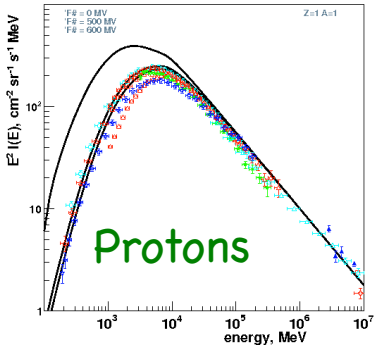


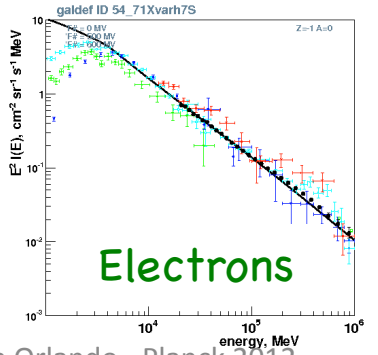
- Galactic magnetic field

Solve transport equation (energy losses, diffusion, acceleration, convection, fragmentation, radioactive decay) for all CR species

Review: Diffuse γ rays with Fermi/LAT

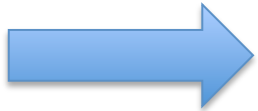


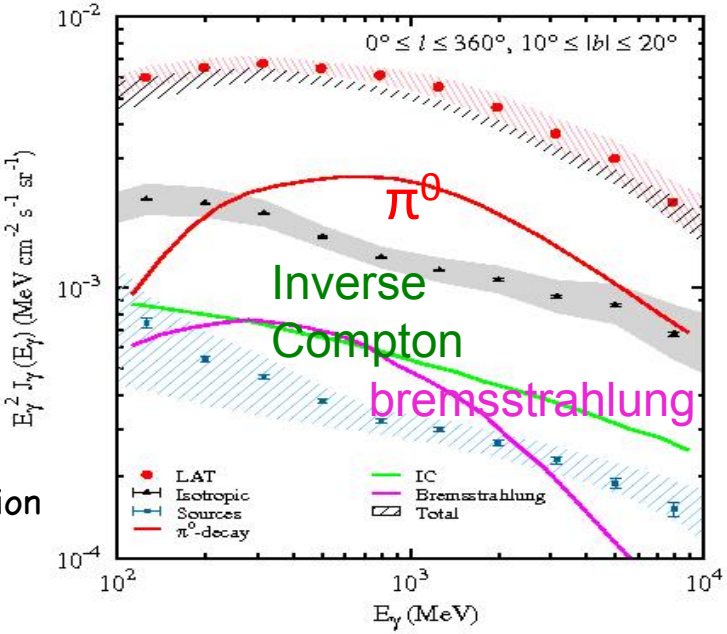




See also talk by L.TIBALDO on Fermi-LAT

GALPROP Model based on local cosmic-ray spectra agrees with Fermi !

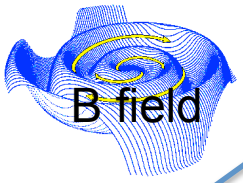


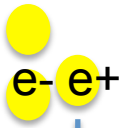


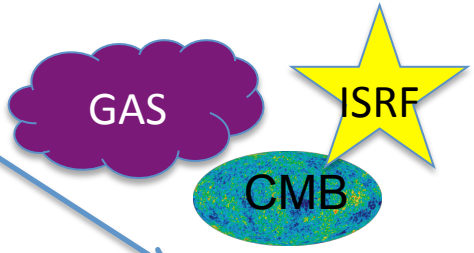
On behalf of the fermi collaboration
Abdo et al. PhRevLett.103.251101

Synergy radio/gamma rays

See also talk by L.TIBALDO on Fermi-LAT



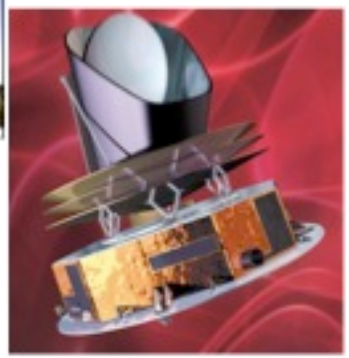




Synchrotron

Gamma rays

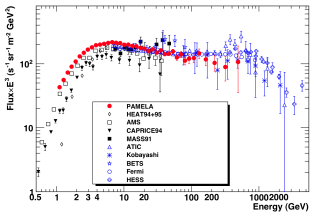
PLANCK



PAMELA, FERMI, AMS, HEAT, HESS, ATIC, MAGIC

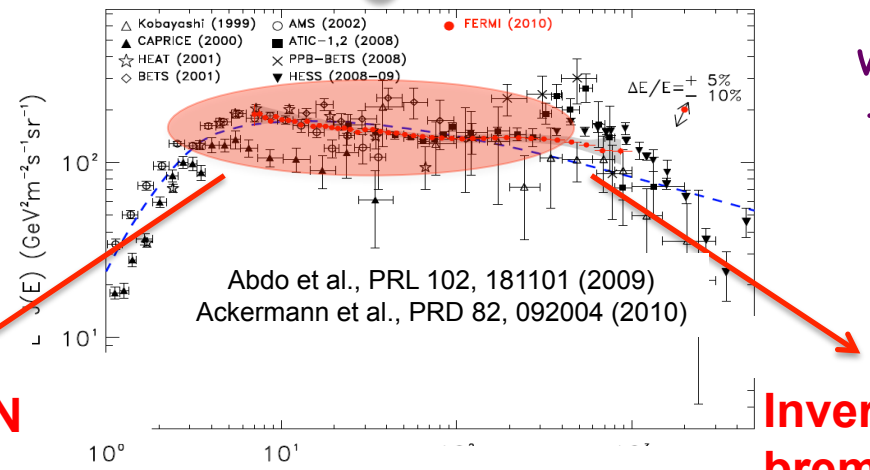
FERMI

Synergy radio/gamma rays



Adriani for the PAMELA collaboration
PRL 106, 2011

e- e+

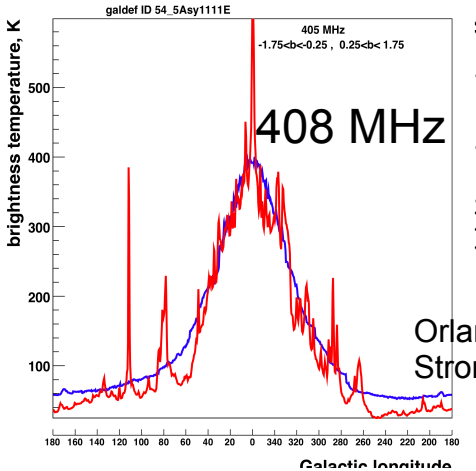


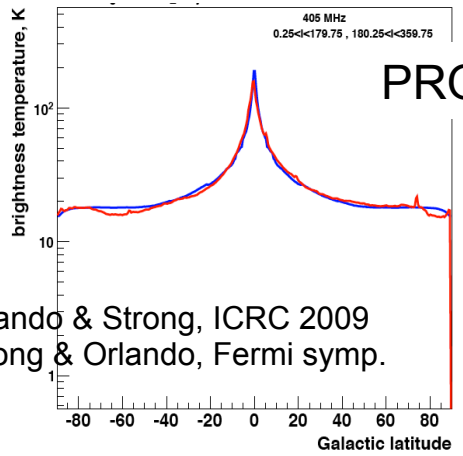
Abdo et al., PRL 102, 181101 (2009)
Ackermann et al., PRD 82, 092004 (2010)

For gammma rays with Fermi refer to talk by L.TIBALDO this morning

SYNCHROTRON

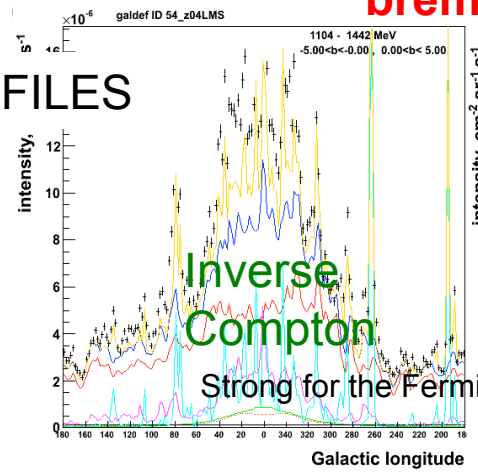
Inverse Compton & bremsstrahlung



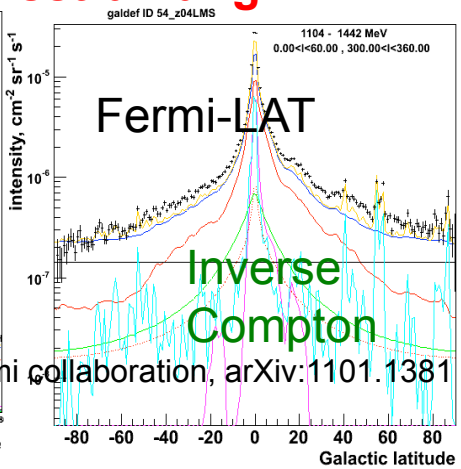


PROFILES

Orlando & Strong, ICRC 2009
Strong & Orlando, Fermi symp.



Inverse Compton



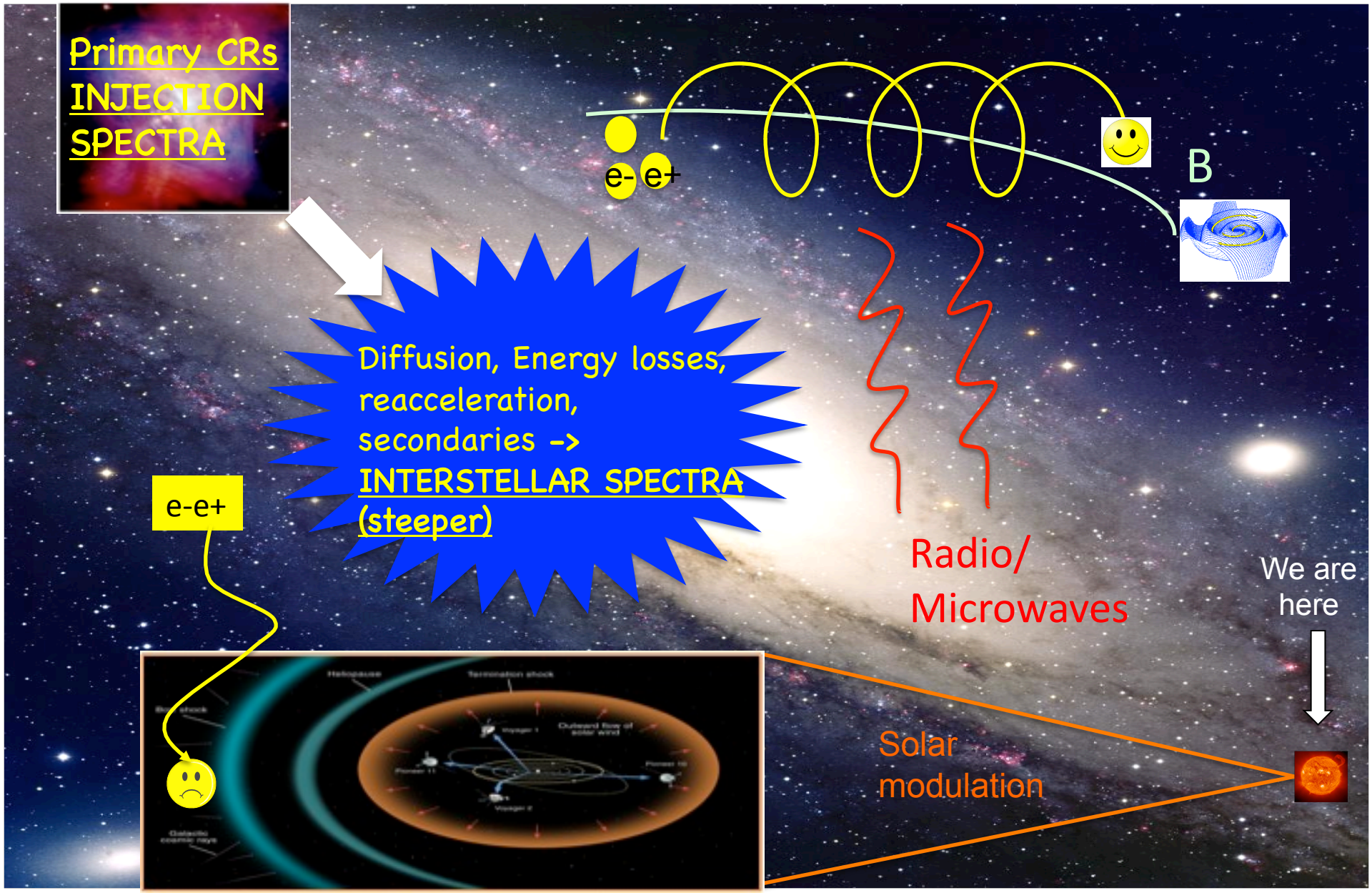
Fermi-LAT

Inverse Compton

Strong for the Fermi collaboration, arXiv:1101.1381

Interstellar electrons and positrons are better constrained by radio than gamma rays !

Synchrotron emission from the Galaxy



Synchrotron emission from the Galaxy

- Synchrotron spectral Index -> electron spectral index
- Synchrotron Intensity -> B-field intensity and electron flux
- e^- 0.5 - 20 GeV -> 20 MHz - 100 GHz

SYNCHROTRON PROBES :

- Galatic magnetic field
-CR eletron spectrum (local and injected)
- CR source distribution
- Galactic Halo size

IMPORTANT FOR :

- Separation template for CMB studies
- Gamma ray studies with Fermi/LAT (see also talk by L. Tibaldo this morning)
- Dark Matter searches

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Strong, Orlando & Jaffe
A&A 534, 54 (2011)

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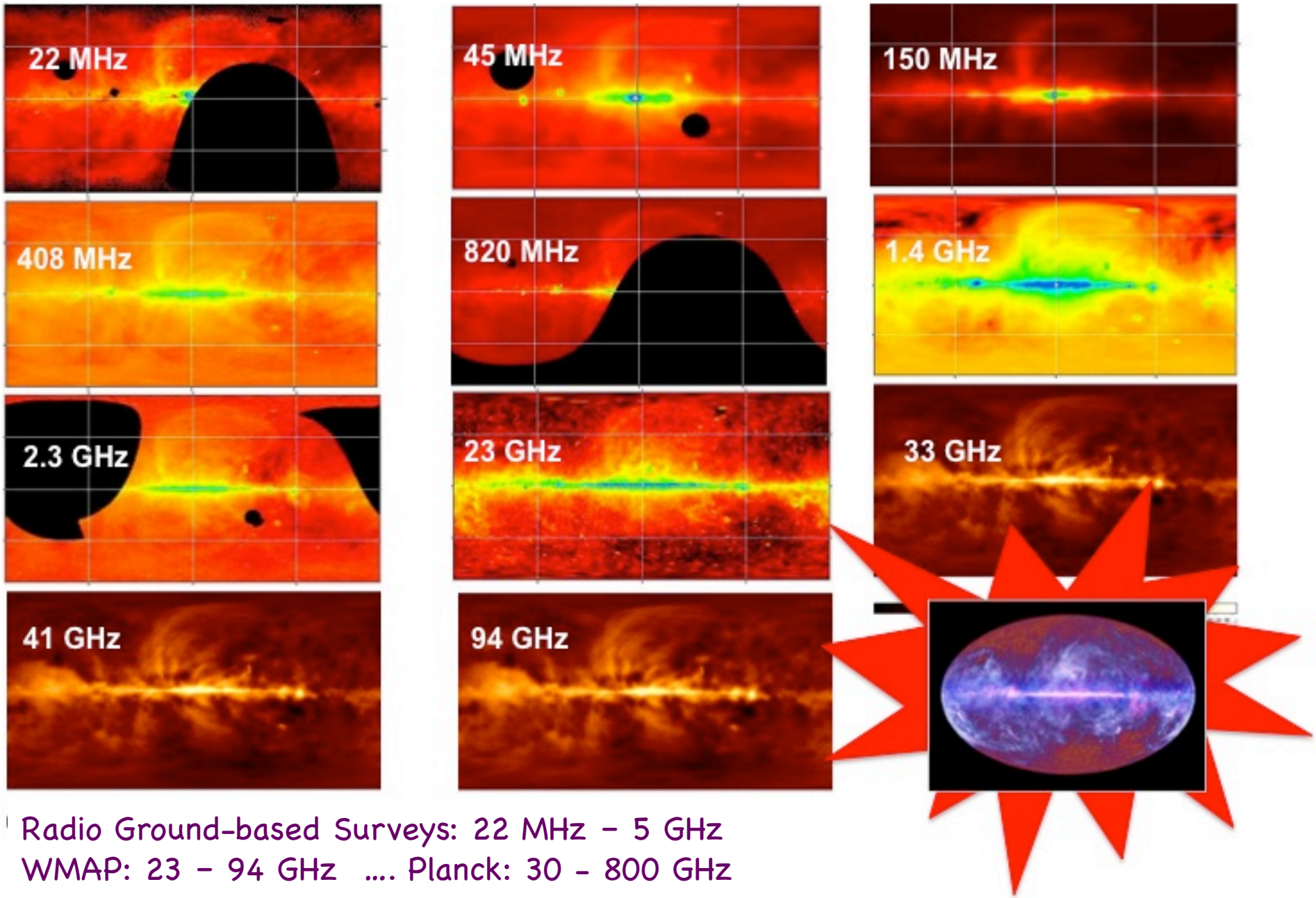
Radio surveys & WMAP



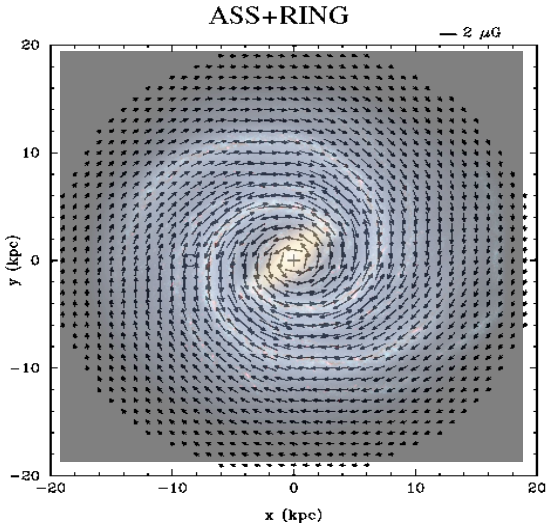
Radio Ground-based Surveys: 22 MHz – 5 GHz
WMAP: 23 – 94 GHz .... Planck: 30 – 800 GHz

1. Probing Galactic Magnetic fields

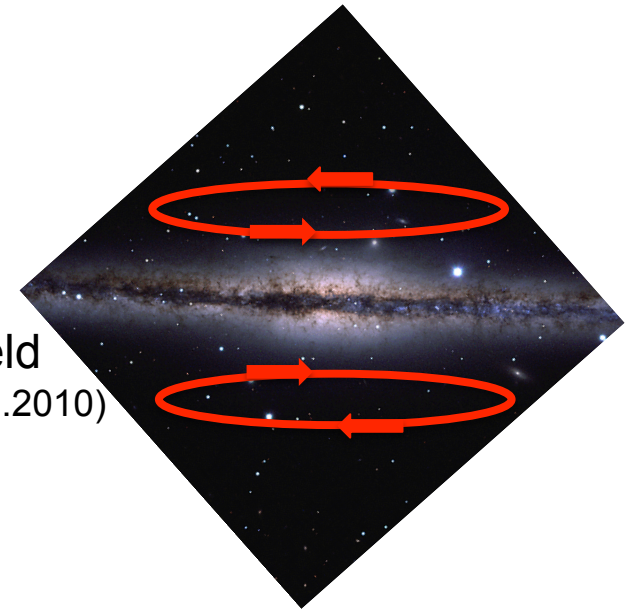
(Using Cosmic rays and total synchrotron)

REGULAR COMPONENTS:

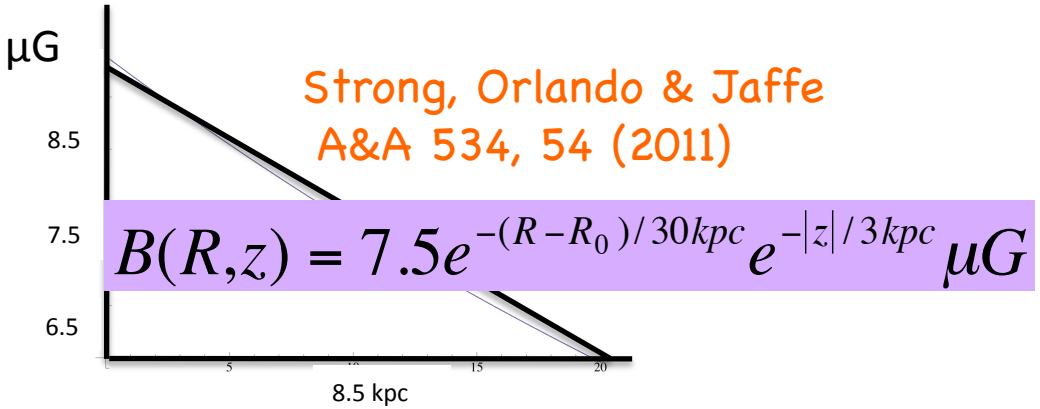
Disc field
(Sun et al.2008)



Halo field
(Sun et al.2010)

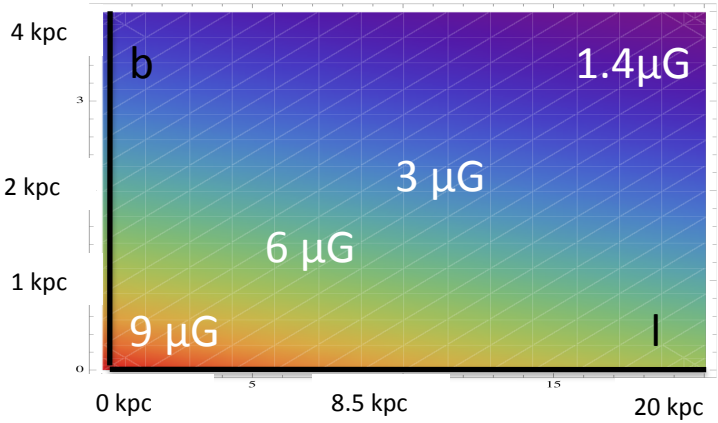


RANDOM COMPONENT (from our work):



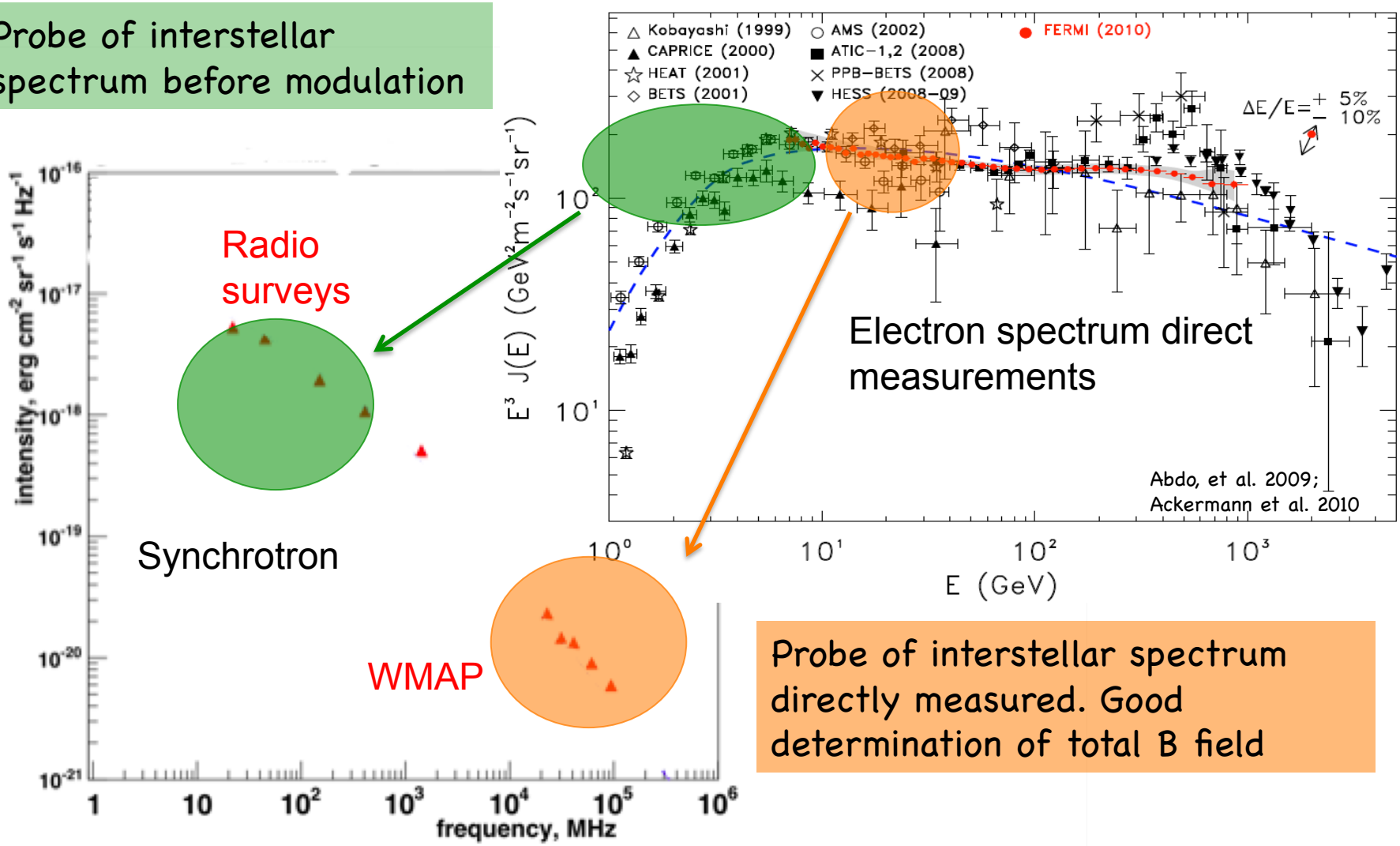
Strong, Orlando & Jaffe
A&A 534, 54 (2011)

$$B(R,z) = 7.5 e^{-(R-R_0)/30kpc} e^{-|z|/3kpc} \mu G$$



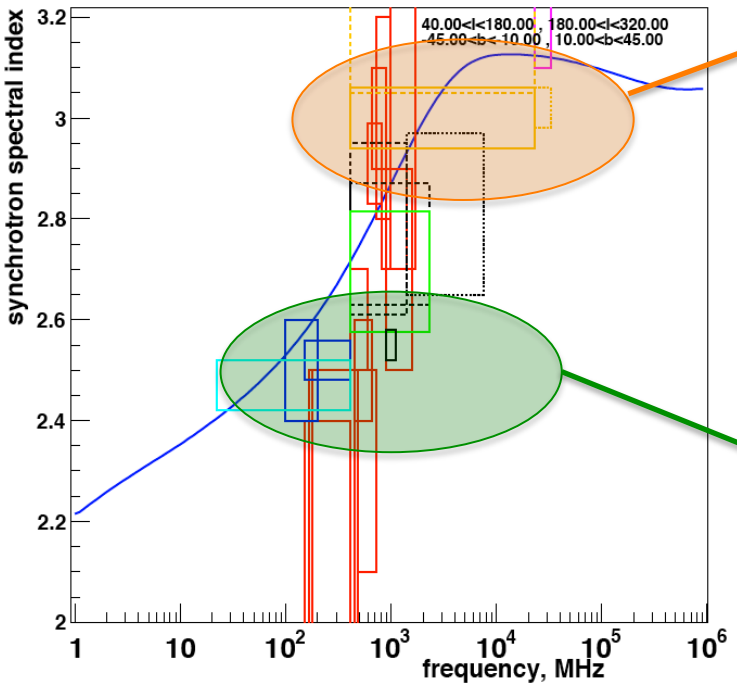
2a. Probing Interstellar electron spectrum

Probe of interstellar spectrum before modulation



Probe of interstellar spectrum directly measured. Good determination of total B field

Synchrotron spectral index measurements …



β~3.0 → P~3.0

β=2+(p-1)/2
(p=interstellar electron spectral index)
(β= synchrotron temperature index)

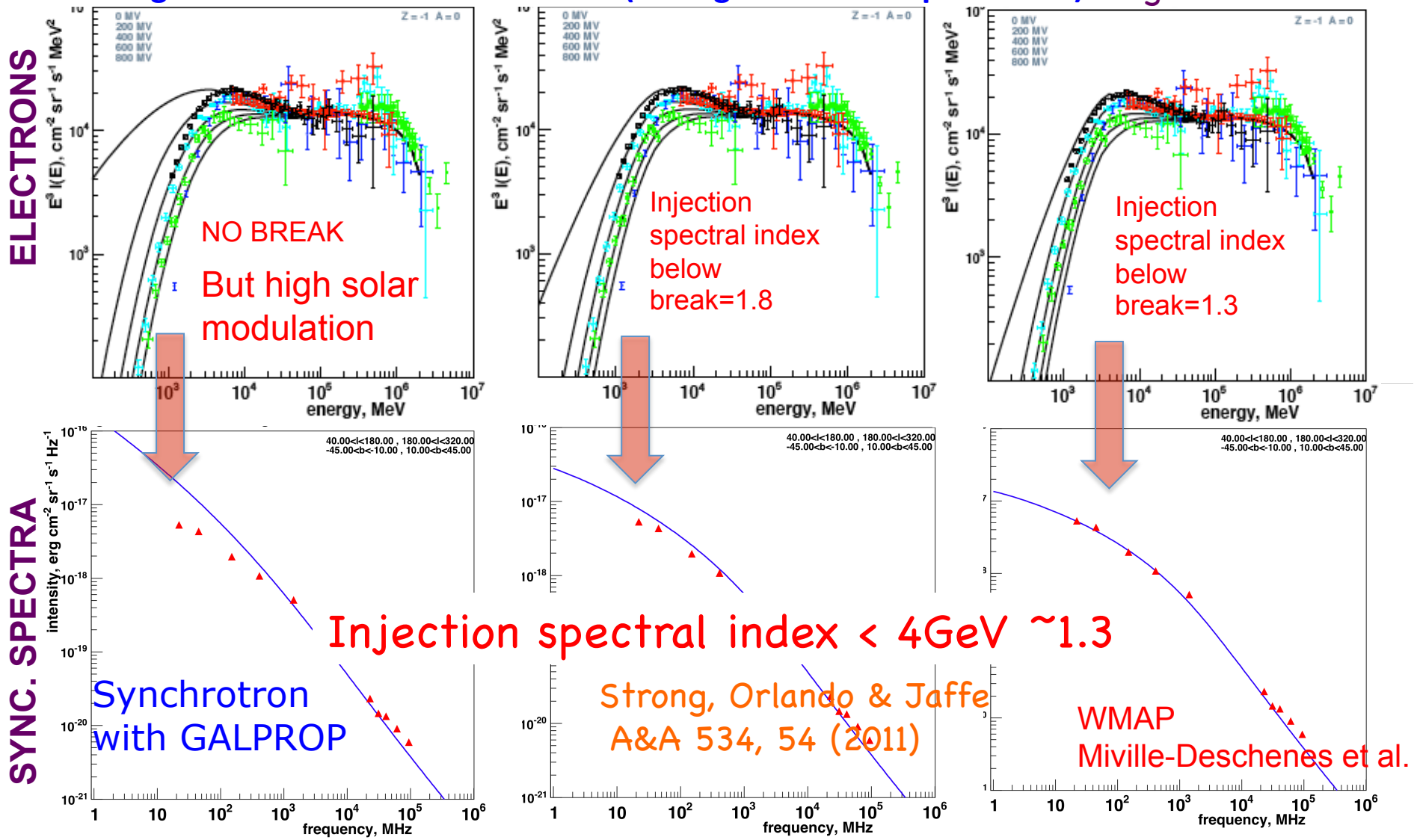
β~2.5 → p~2.0

Strong, Orlando & Jaffe
A&A 534, 54 (2011)

… need of a break in interstellar electron spectrum independent of propagation models !

2b. Probing electron injection spectrum

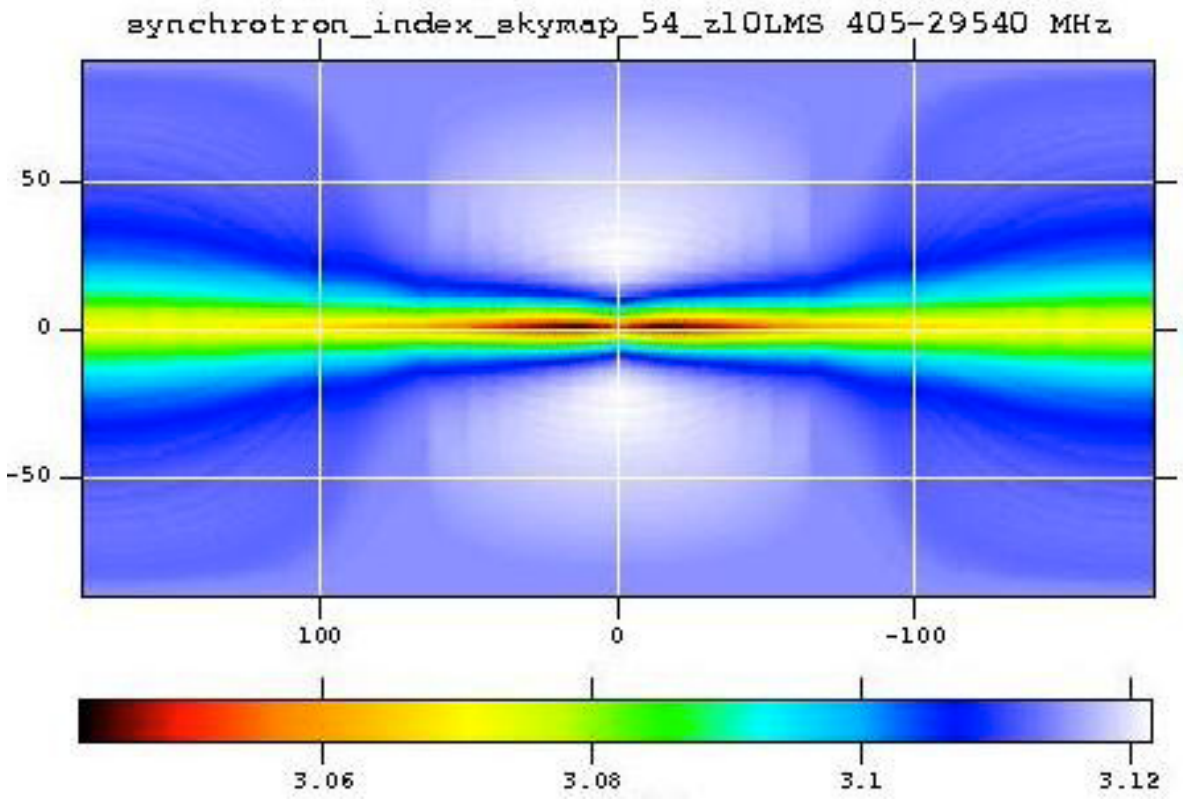
Using GALPROP: Pure Diffuse model (Strong et al. 2010 ApJ 722L 58) - High latitudes



Injection spectral index < 4GeV ~1.3

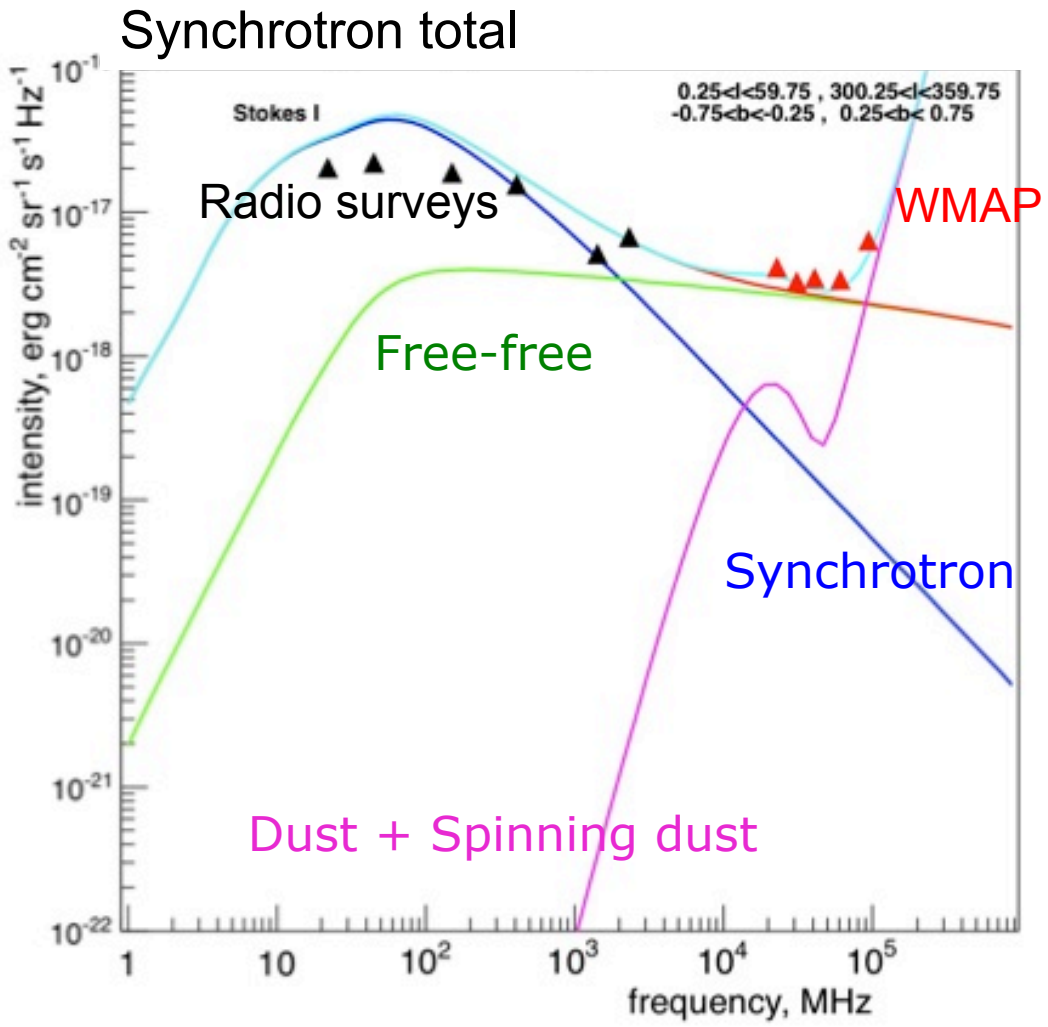
*injection spectral index above break at 4 GeV = 2.5

Synchrotron spectral index model (408MHz-23GHz)



Small variations but systematic, reality is more complicated but good start, since physical model of electron propagation.

First attempt including all components



Also with absorption

Now also synchrotron polarized

Preliminary result: regular B-field component few times higher than usually assumed

Paper in preparation !

In short

With our approach we can do detailed modeling of:

- Large scale Galactic synchrotron emission
- Both regular and random magnetic fields
- Synchrotron spectral index variations over the sky in Planck range

… and the key future goal is

Exploiting Planck, Fermi-LAT & cosmic rays data simultaneously