Emissions diffuses galactiques
Du voisinage solaire aux galaxies starbursts

Pierrick Martin (IPAG)

(with preliminary results from the Fermi/LAT collaboration)

Plan

Préliminaires

- Définition et intérêt du phénomène
- Processus radiatifs
- Mécanismes de transport
- Le milieu interstellaire

Les émissions diffuses

- Le voisinage solaire
- Au delà du bras local
- La Voie Lactée
- Les galaxies externes (non-AGN)
- Le diffus extragalactique

Fermi Gamma-ray Space Telescope

Most references are:
Abdo et al. 2009-2010-2011

Positionnement du phénomène

Existence de populations galactiques de particules non-thermiques (matière et antimatière / e, p, He, C, O,… / du MeV au PeV)

Origines ?

Phénomènes violents

Interactions ondes-particules dans les plasmas, chocs et turbulence

Décroissance / annihilation de matière noire

→ **X** →

Effets ?

Formation stellaire et chimie interstellaire,

Equilibre et dynamique du système galactique

Génération de champ magnétique galactique

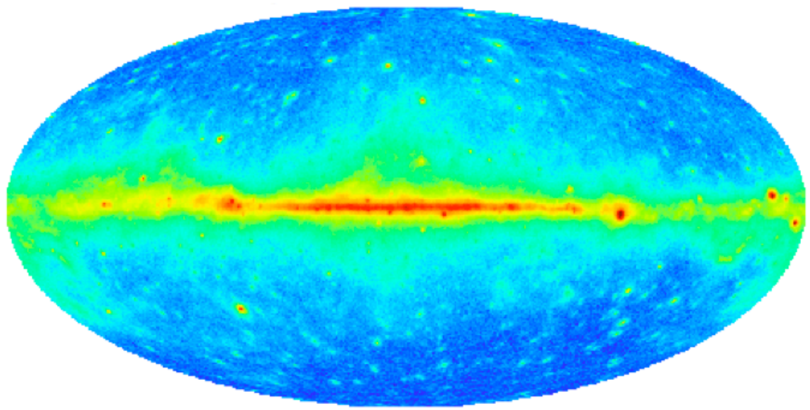
↓

Etude de la construction des populations galactiques de RC depuis les accélérateurs jusqu'à devenir un composant essentiel de la galaxie

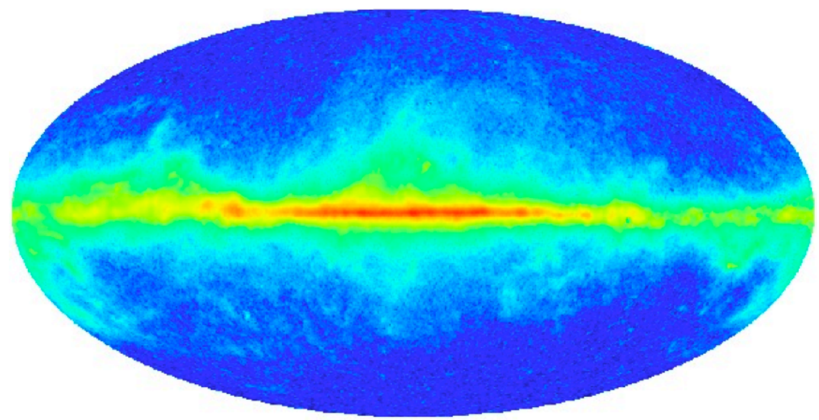
Définition

Emissions associées à IPM, ISM, IGM (gaz, photons, poussière, champ B)
… à distinguer des émissions non-résolues pour raisons instrumentales

LAT counts above 300 MeV



LAT counts minus sources and isotropic



Dans le domaine gamma (> 100keV), origine non-thermique, illumination des composantes de l'ISM par le RC (~70-80% du flux >100GeV).

Intérêts:

- **Sonder le RC en plus d'un point (surtout hadrons): origine, transport,…**
- **Etudier l'ISM (pas d'absorption): composition, distribution,…**

Processus radiatifs: CRp

Interactions hadroniques (IH)

Production de mésons π,η,K

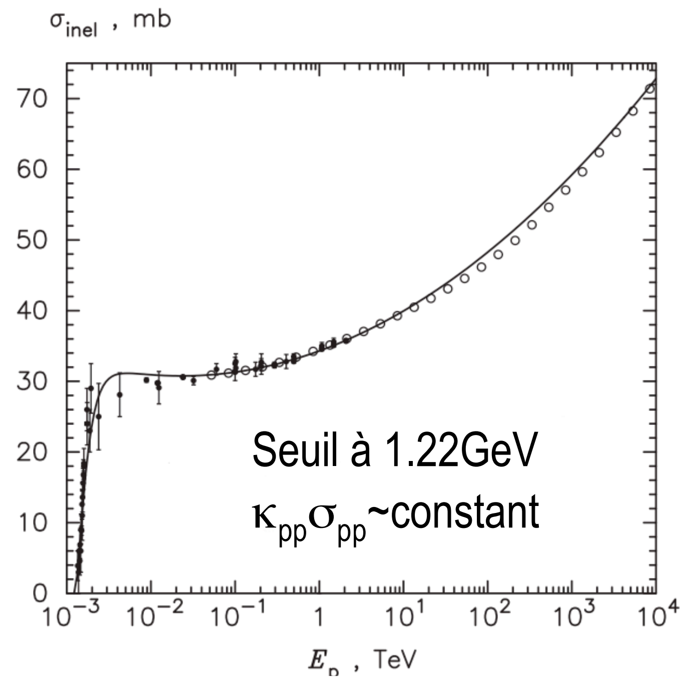
$\pi^0,\eta \rightarrow \gamma$ $\pi^\pm$,K$^\pm \rightarrow e^\pm$

$$\frac{dE_p}{dt} = cn_H\sigma_{pp}\kappa_{pp}E_p \propto E_p$$

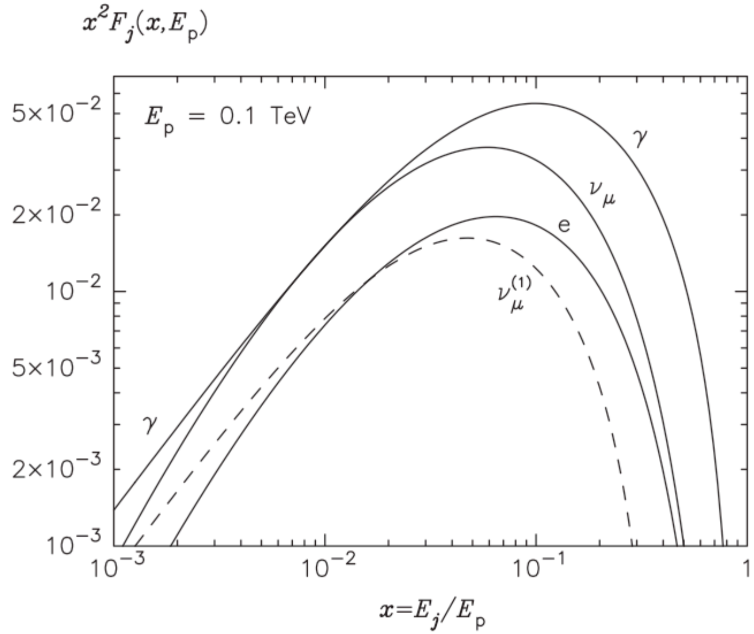
$$E_p \rightarrow E_\gamma \approx 0.1 E_p$$

$$N_p(E) \propto E^{-s} \rightarrow I_{pp}(E_\gamma) \propto E_\gamma^{-s}$$

De même, le spectre des leptons secondaires reflète le spectre parent



Kelner-2006



Autres processus radiatifs / concurrents

- Ionisation domine pour CRp < 1GeV

Processus radiatifs: CRe

Inverse-Compton (IC)

$$\frac{dE_e}{dt} \propto E_e^2 \qquad N_e(E) \propto E^{-s} \rightarrow I_{IC}(E_\gamma) \propto E_\gamma^{\frac{1-s}{2}}$$

$$E_e \rightarrow E_\gamma \approx \frac{E_e^2}{m^2c^4} E_0$$

(Pour photons mono-énergétiques E_0)
(Effets Klein-Nishina à haute énergie)

Bremsstrahlung (Br)

$$\frac{dE_e}{dt} \propto E_e \qquad N_e(E) \propto E^{-s} \rightarrow I_{Br}(E_\gamma) \propto E_\gamma^{-s}$$

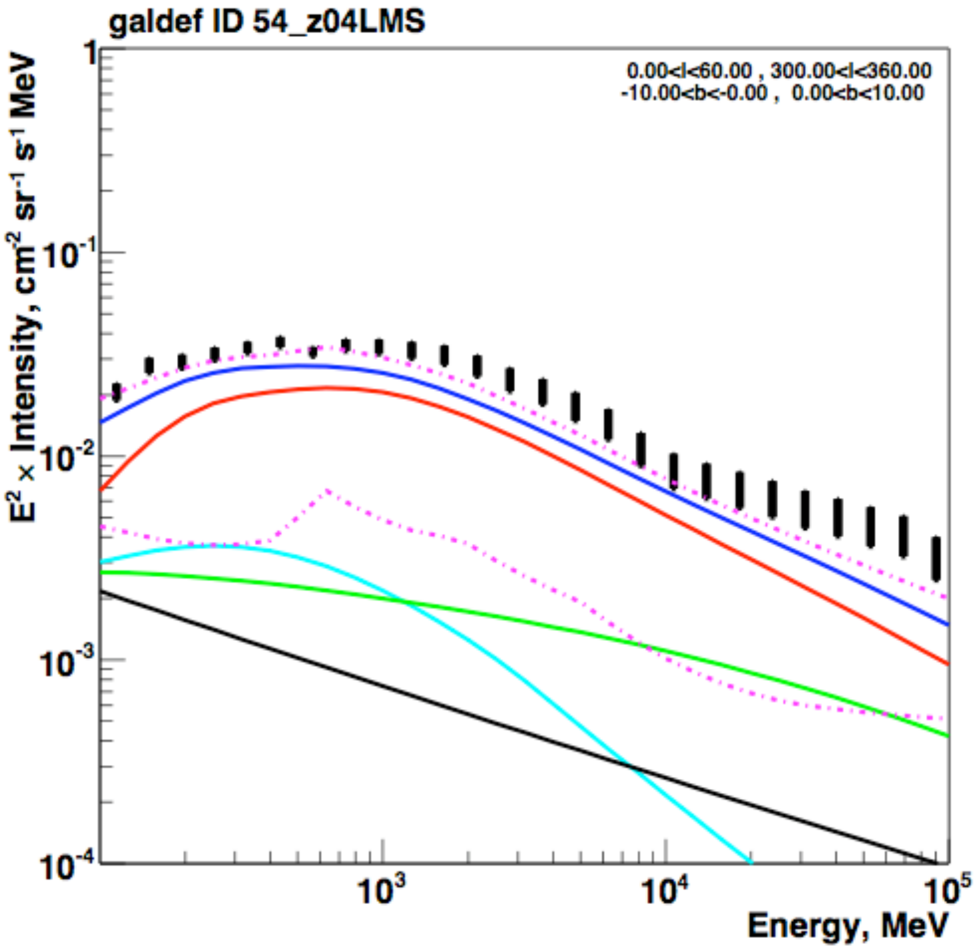
$$E_e \rightarrow E_\gamma \approx 0.5 E_e$$

Autres processus radiatifs / concurrents

- Ionisation domine pour CRe < 1GeV
- Synchrotron similaire à IC

Processus radiatifs: CRe+CRp

Illustration: spectre typique interactions RC-ISM



Le rayonnement cosmique: transport

Positions

Diffusion / Scattering
- Interactions résonantes avec δB
- Rigidity-dependent (p/Ze)
- Anisotrope (parallel/perpendicular B)
- Inhomogène (arm/interam, disk/halo)
- Spectre turbulence: coupure, indice ?
- Topologie champ B ?

$$D_{xx} = \beta D_0 \left(\frac{R}{R_0} \right)^{\delta}$$

Convection / advection
- Vents galactiques (CR-driven…)
- Energy-independent
- Profil radial/vertical de vitesse ?

Impulsions

Energy losses
- Ionisation (<1GeV)
- Pertes radiatives (IC,Br,IH)
- Pertes adiabatiques (vent)

Catastrophic losses
- Fragmentation
- Décroissance

Réaccélération diffusive
- Version initiale du processus de Fermi
- Stochastic, second-order
- Cibles à la vitesse d'Alfven
- Diffusion dans l'espace des impulsions

$$D_{pp} \propto \frac{V_A^2}{D_{xx}}$$

Le rayonnement cosmique: transport

Lien entre spectre injection et stationnaire pour des cas particuliers

Injection $q(E) \propto E^{-\alpha}$

Equilibre $N(E) = q(E) \times \tau(E)$

Diffusion-dominated $\tau(E) = \frac{L^2}{D_{xx}} \propto E^{-\delta} \rightarrow N(E) \propto E^{-\alpha-\delta}$

Convection-dominated $\tau(E) = \frac{L}{V_w} \rightarrow N(E) \propto E^{-\alpha}$

Energy-loss-dominated Protons : $\tau(E) = \frac{E}{\left(dE/dt\right)_{pp}} = \frac{1}{n_H \sigma_{pp} \kappa_{pp} \beta c} \rightarrow N(E) \propto E^{-\alpha}$

Electrons : $\tau(E) = \frac{E}{\left(dE/dt\right)_{IC,synch}} \propto \frac{1}{E} \rightarrow N(E) \propto E^{-\alpha-1}$

Notes

- Flattening at low-energies <1GeV due to energy-independent ionisation and/or Bremss.
- Different regimes across energy range (especially for electrons)
- For IC losses, KN effects at high energies (hardening of CR spectra)

Le transport affecte le spectre d'injection du RC

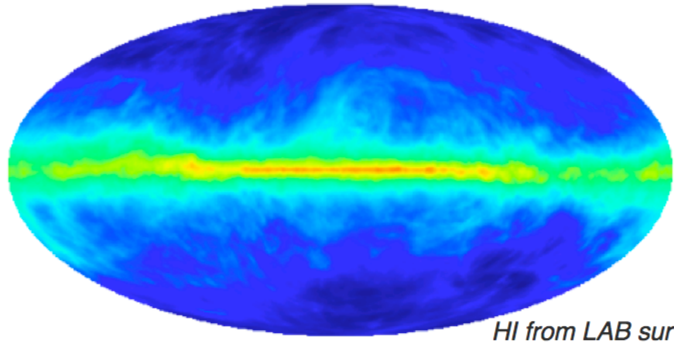
Le milieu interstellaire: gaz

Gaz atomique / moléculaire

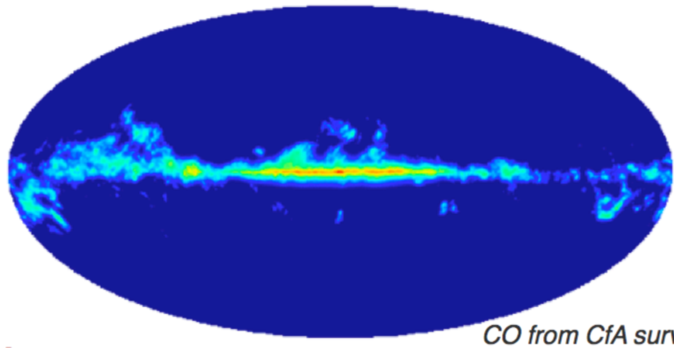
- Observations des raies 21cm et 2.6mm
- Distribution 3D via rotation curve
- Densité HI via Ts=40-400K (non-linear)
- Densité H_2 via $Xco=N(H_2)/W_{co}$ (linear)

Gaz sombre

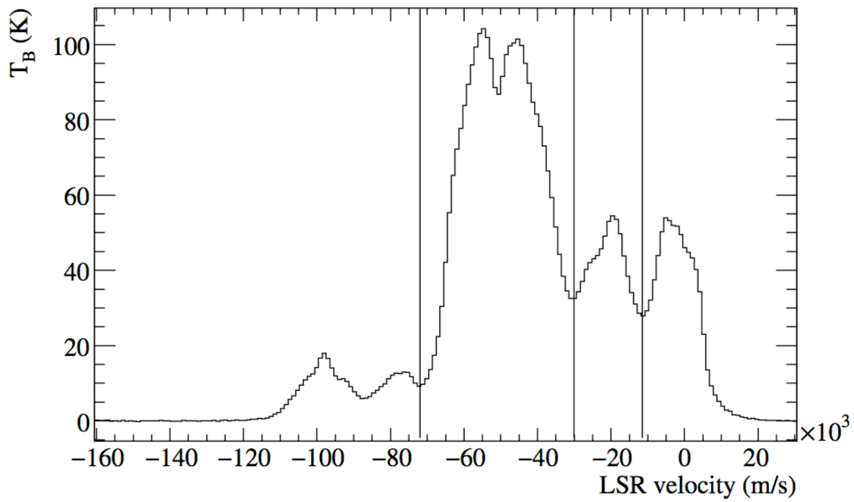
- Non tracé par raies radio/mm (cold, optically-thick, little dust/CO,…)
- Accessible par IR dust emission
- Temperature correction: reddening E(B-V)
- Densité H via gas-to-dust ratio
- Pas d'information spatiale



HI from LAB survey



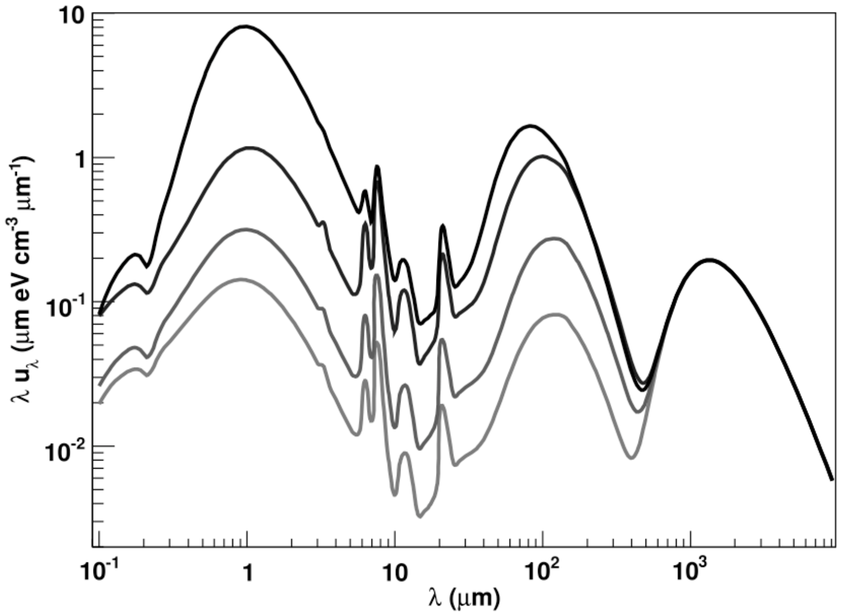
CO from CfA survey



Le milieu interstellaire: ISRF

Trois contributions principales

- UVO stellaire (graybodies à ~10^3-10^4 K)
- IR poussière (graybody à ~10-50K)
- CMB (blackbody à 2.7K)
- Note: extensions verticales différentes !



Modèle galactique (Porter-2005)

- Modèle stellaire (6 composantes spatiales; 87 types stellaires)
- Modèle poussière (distribution spatiale; taille, type, abondance grains/PAHs)
- Séquence de calcul: UVO absorbed, UVO scattered, UVO→IR, IR reabsorbed

Effets locaux

- Etoiles OB et amas proches (Orlando-2008)

Le milieu local

Objectifs / Intérêts

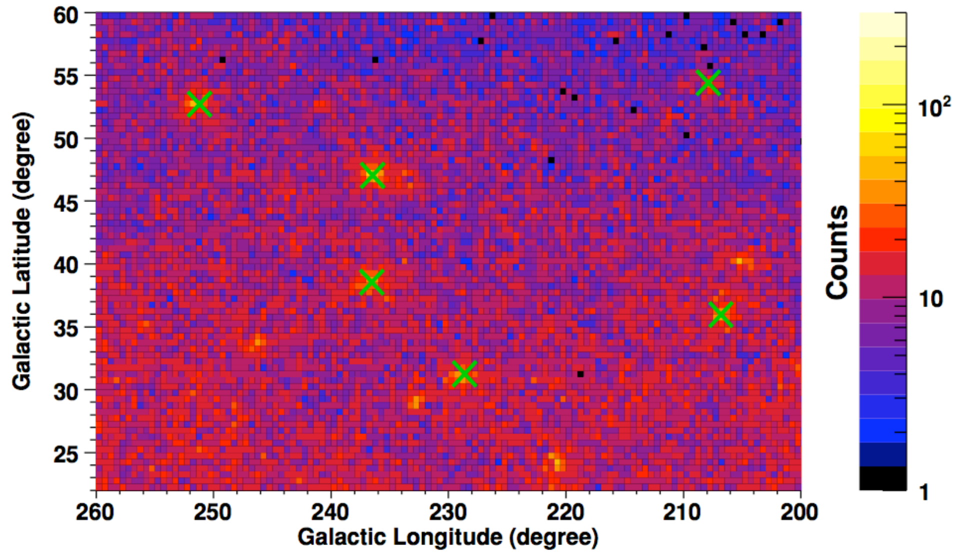
- Sonder le RC au-delà du milieu interplanétaire
- Calculer la masse de nuages proches
- Etudier la pénétration du RC
- …

L'émission diffuse à haute latitude

Contact: Tsunefumi Mizuno

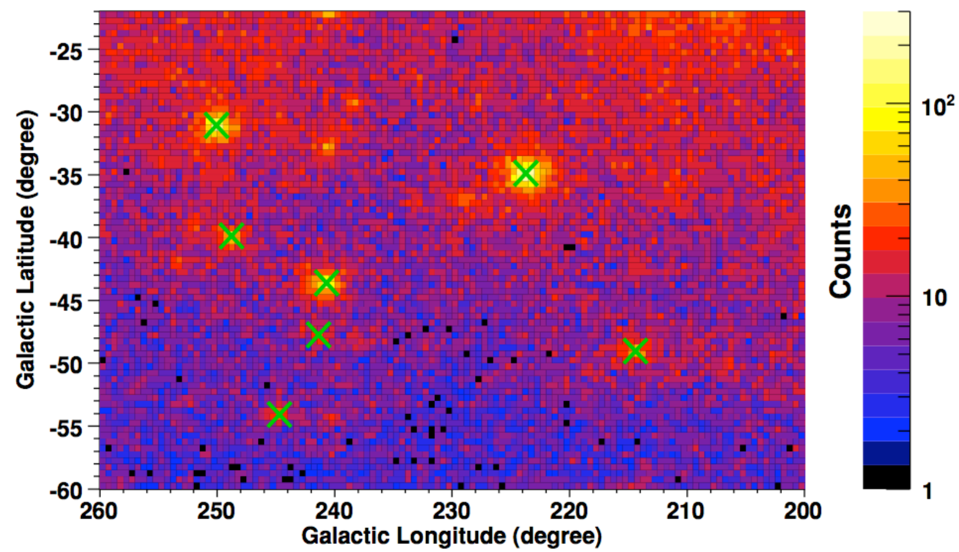
Points principaux

- Fermi/LAT, 6 months, 100MeV-10GeV
- l ∈ [200°,260°] et |b| ∈ [22°,60°]
- Region free of H_2 clouds
- 80-85% of HI within 1kpc

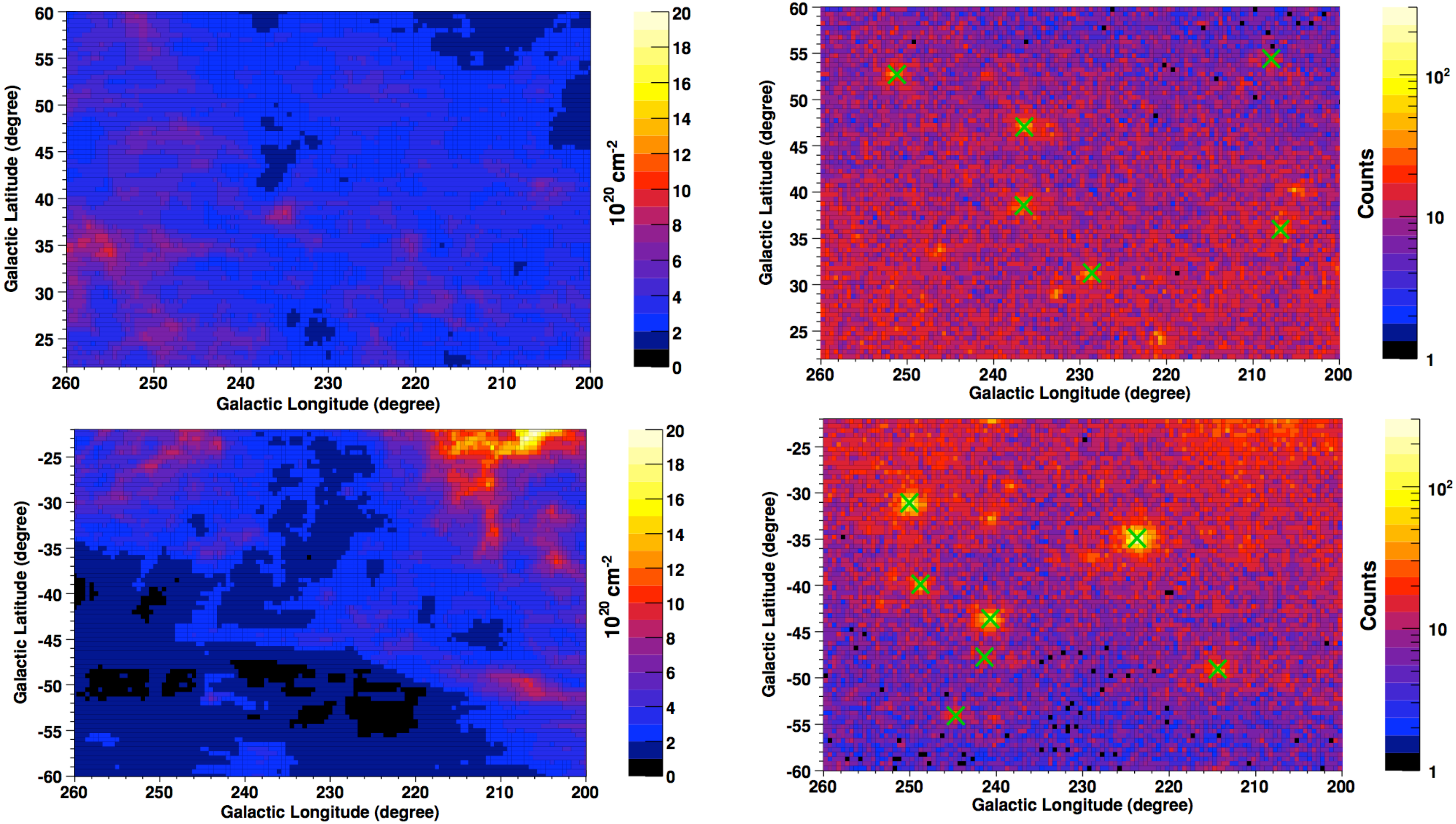


Emission est la somme de

- Pion decay and Bremsstrahlung in HI
- Inverse-Compton
- Isotropic background
- 52 sources ponctuelles



L'émission diffuse à haute latitude

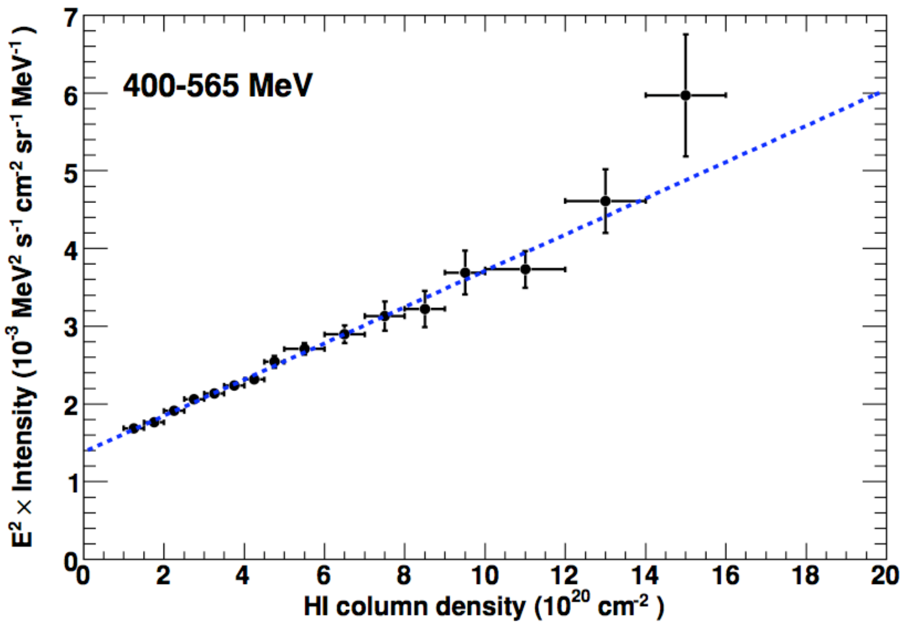


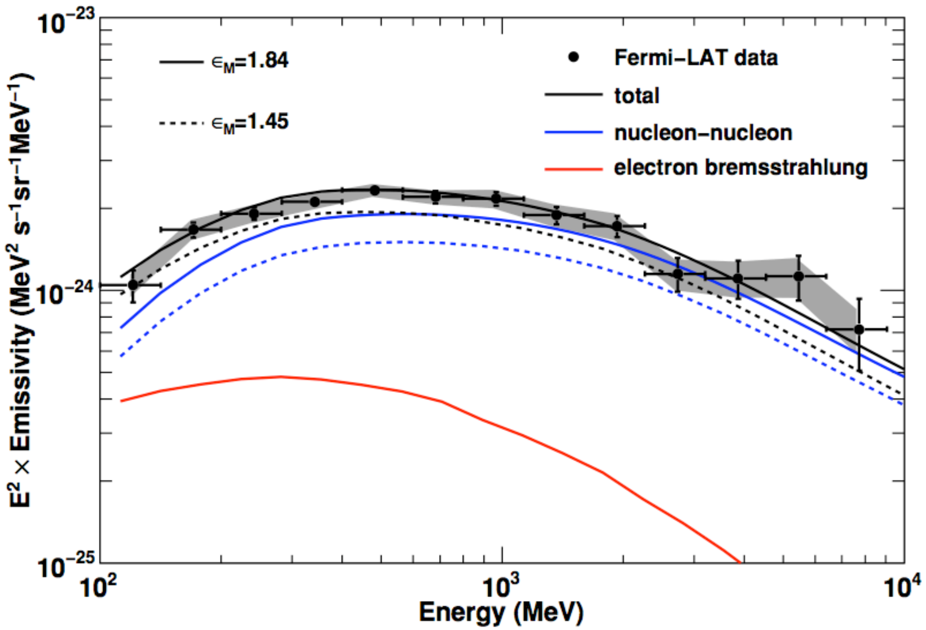
Comparaison column density N(HI) (Ts=125K) et counts maps (> 100MeV)

L'émission diffuse à haute latitude

Résultats principaux

- Linear relationship N(HI) - I_γ at all energies (after subtracting IC et sources)
- Offset gives isotropic contribution, slope gives emissivity
- Emissivity $q(E_\gamma>100MeV) = (1.63 \pm 0.05)\ .10^{-26}$ ph/s/sr/H
- Agrees at ±10% with emissivity computed from locally-measured CR spectrum
- CR intensity and spectral distribution >1GeV within 1kpc close to those at Earth



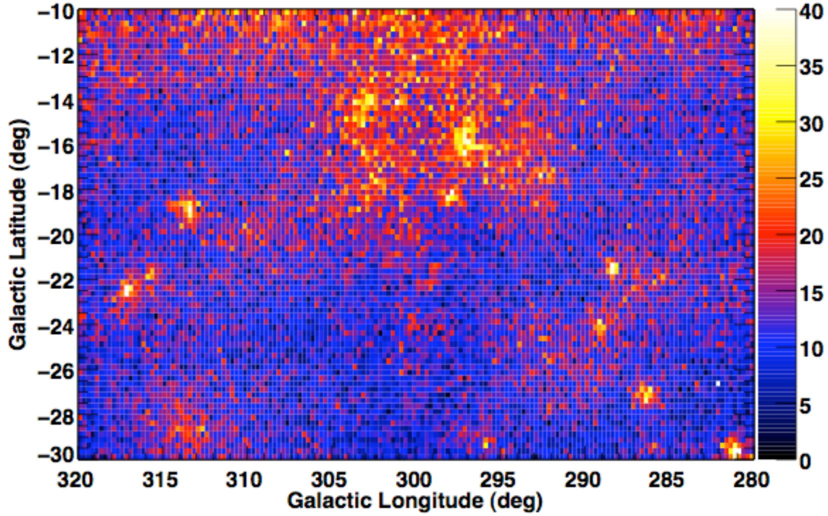


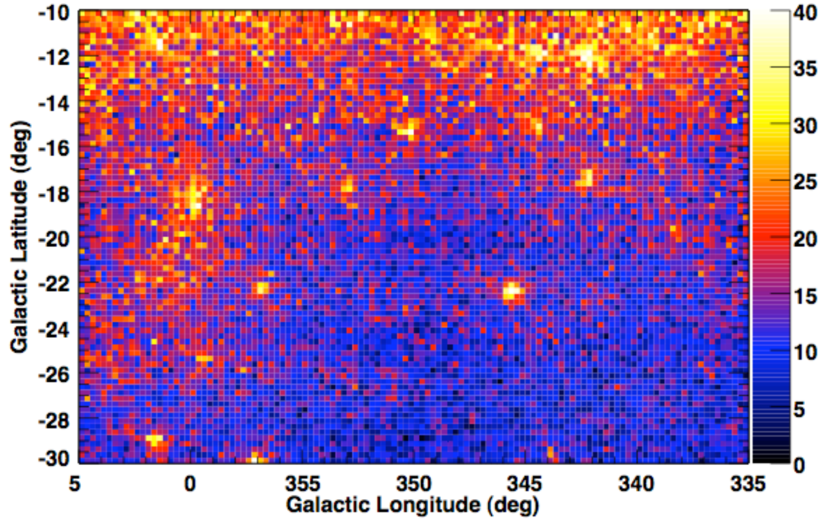
Les nuages moléculaires locaux

Preliminary !

Points principaux

- Fermi/LAT, 21 months, 250MeV-10GeV
- Cloud complexes within 200pc
- Chamaleon and R Coronae Australis

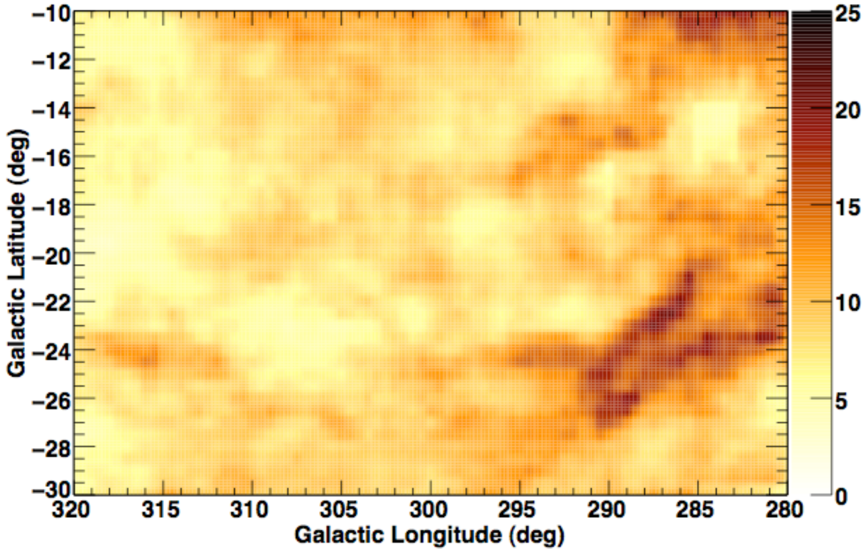




Contact: Katsuhiro Hayashi

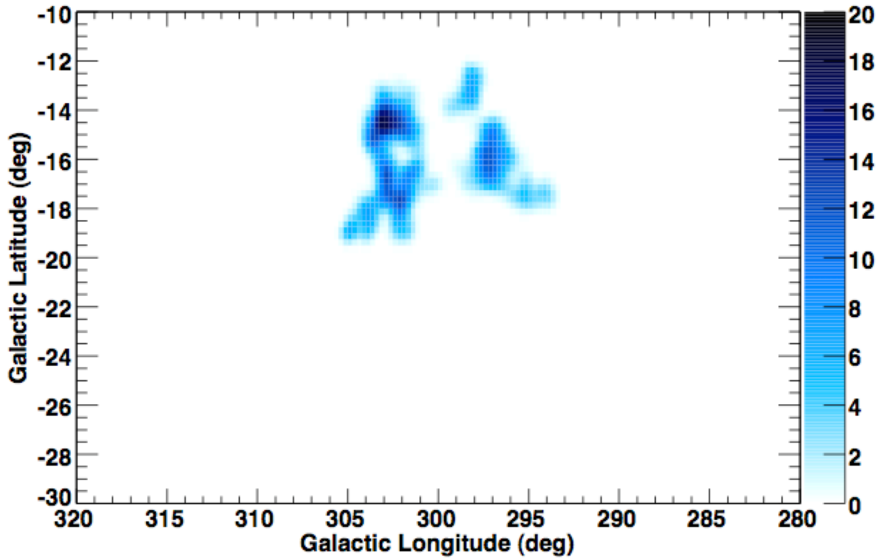
Les nuages moléculaires locaux

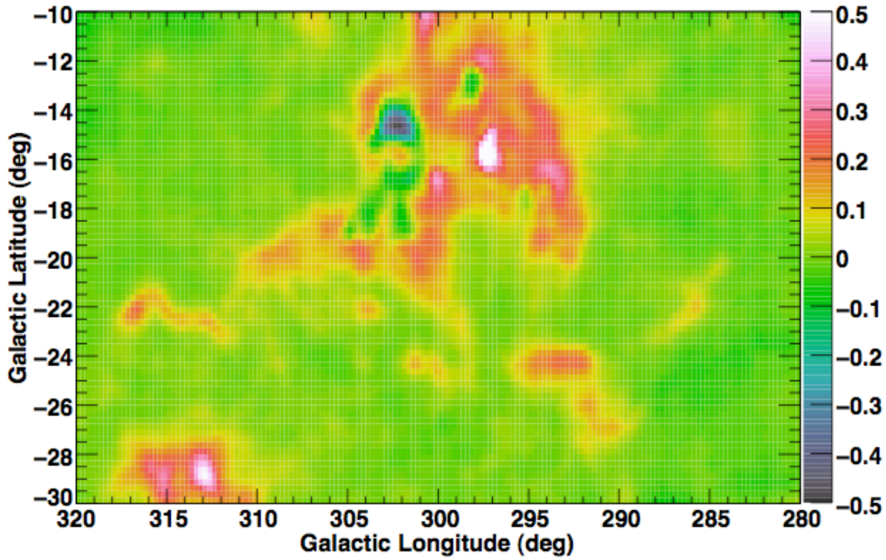
Preliminary !



Gas templates

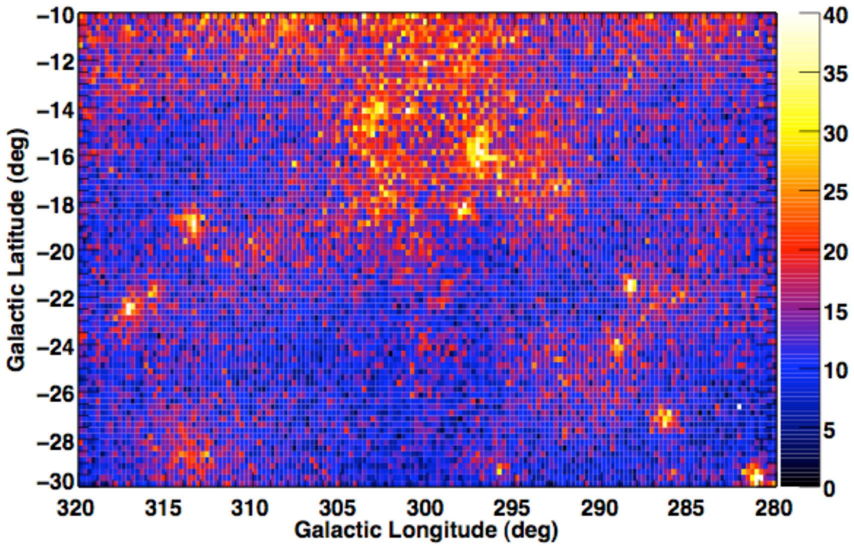
- HI column densities with Ts=125K
- W_{CO} intensities in K.km/s
- $E(B\text{-}V)_{res}$ after subtraction of HI/CO (negative residuals due to saturation)

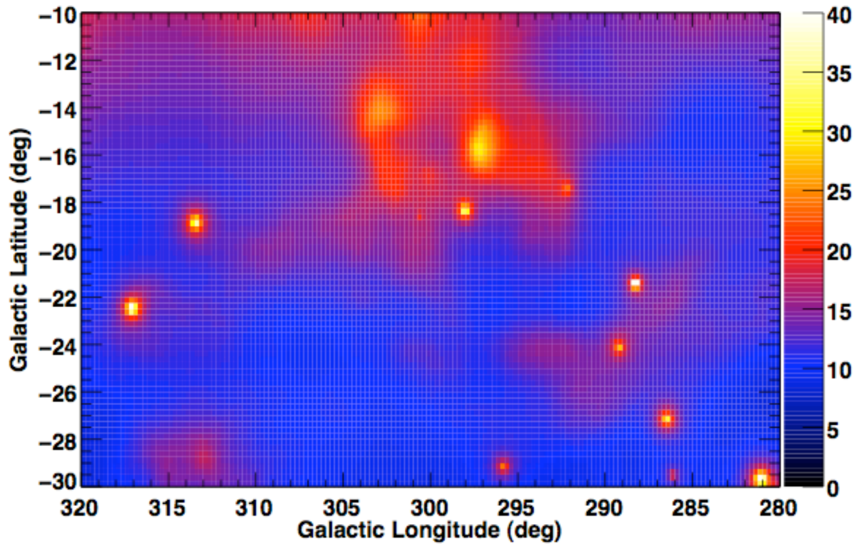


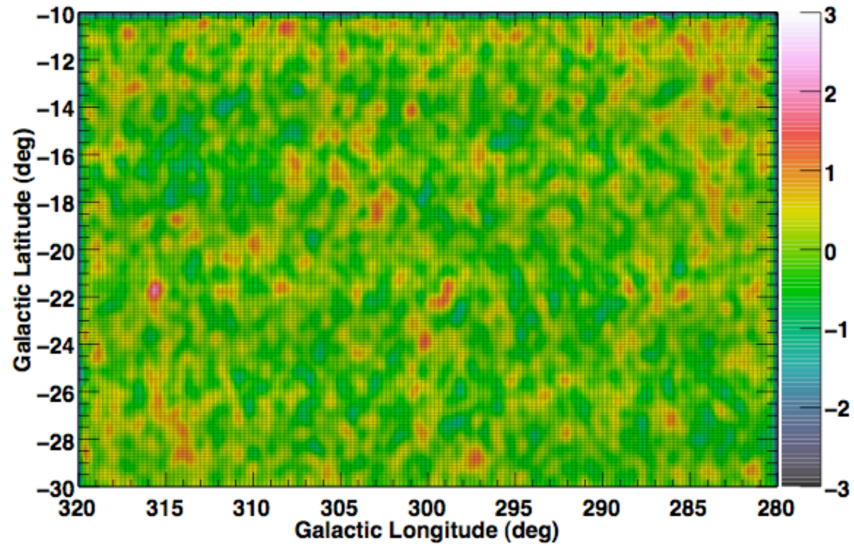


Les nuages moléculaires locaux

Preliminary !







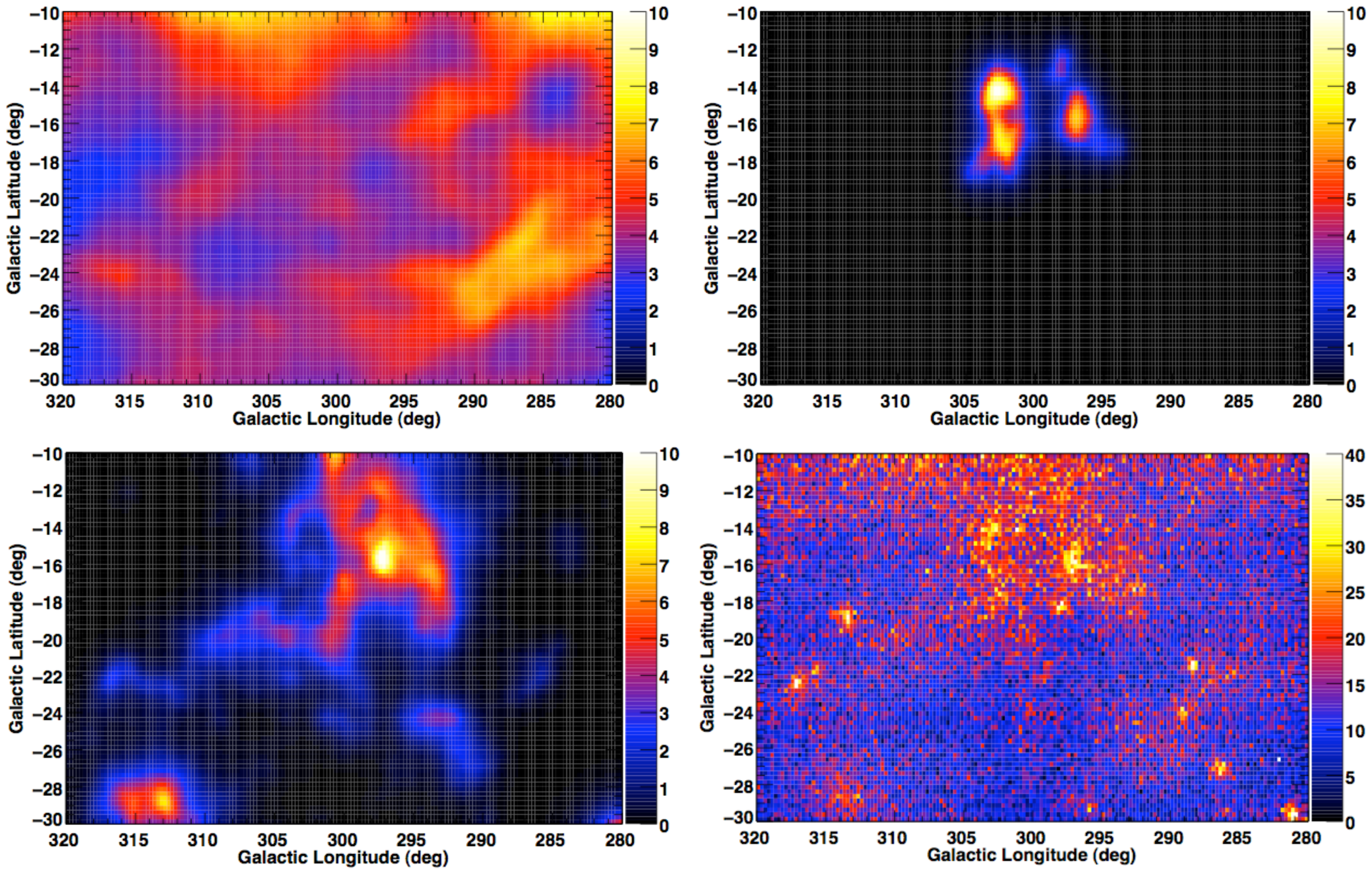
Données / Modèle / Résidus

$$I(l,b) = \sum \left[q_{\mathrm{H\,I},\,i} \cdot N(\mathrm{H\,I})(\mathrm{l},\mathrm{b})_i + \mathrm{q}_{\mathrm{CO},\,i} \cdot \mathrm{W}_{\mathrm{CO}}(\mathrm{l},\mathrm{b})_i \right]$$
$$+ q_{\mathrm{EBV}} \cdot E(B-V)_{\mathrm{res}}(l,b) + I_{\mathrm{iso}}$$
$$+ \sum S_j \cdot \delta(l - l_j, b - b_j)$$

Les nuages moléculaires locaux

Preliminary !

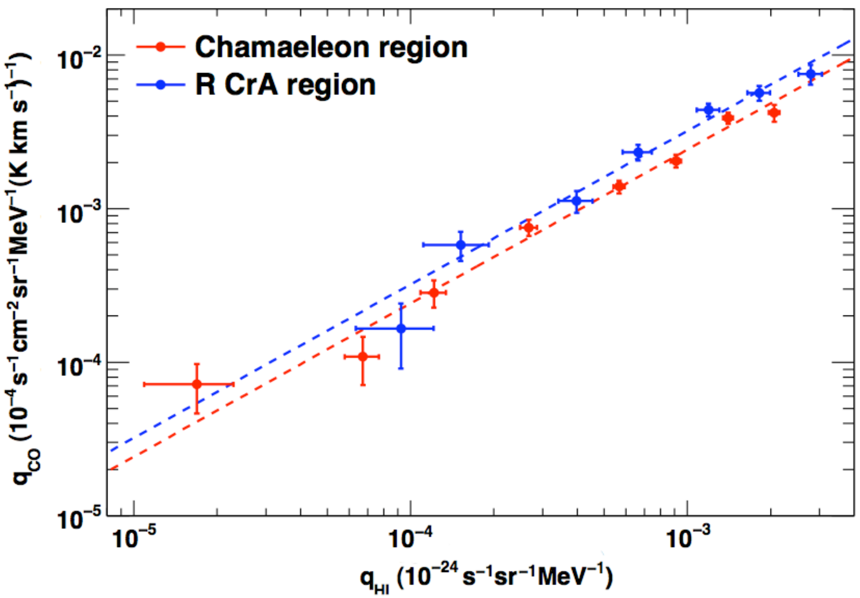
Contribution des différentes phases gaz à l'émission gamma

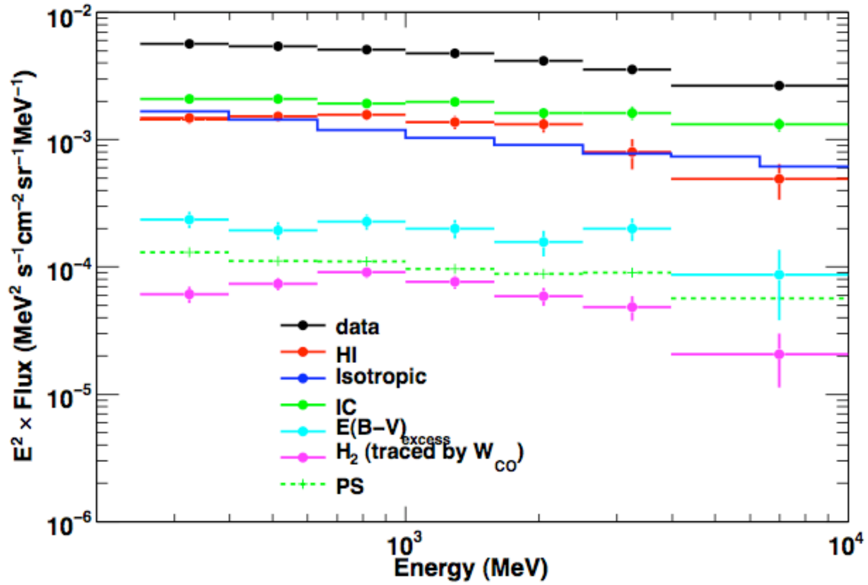


Les nuages moléculaires locaux

Résultats principaux

- Linear relationship $q_{co}=2.X_{co}.q_{HI}$ suggests uniform penetration of CRs
- … and gives $X_{co}= N(H_2)/W_{co}=(1.1\text{-}1.6 \pm 0.1)\ .10^{20}\ cm^{-2}\ (K\ km/s)^{-1}$
- … implying 6000/1500$M_\odot$ of H_2 in Cham/RCrA
- Similar approach for $E(B\text{-}V)_{res}$ tracer: 6000/1000$M_\odot$ of dark gas in Cham/RCrA





Au delà du milieu local…

Objectifs / Intérêts

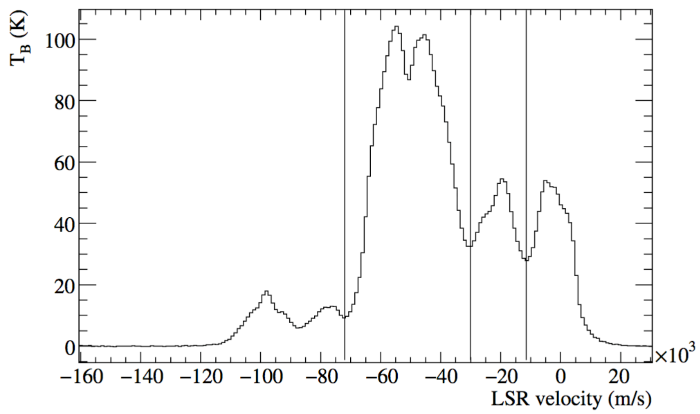
- Sonder le RC au-delà de 1kpc du système solaire
- Le problème du gradient
- …

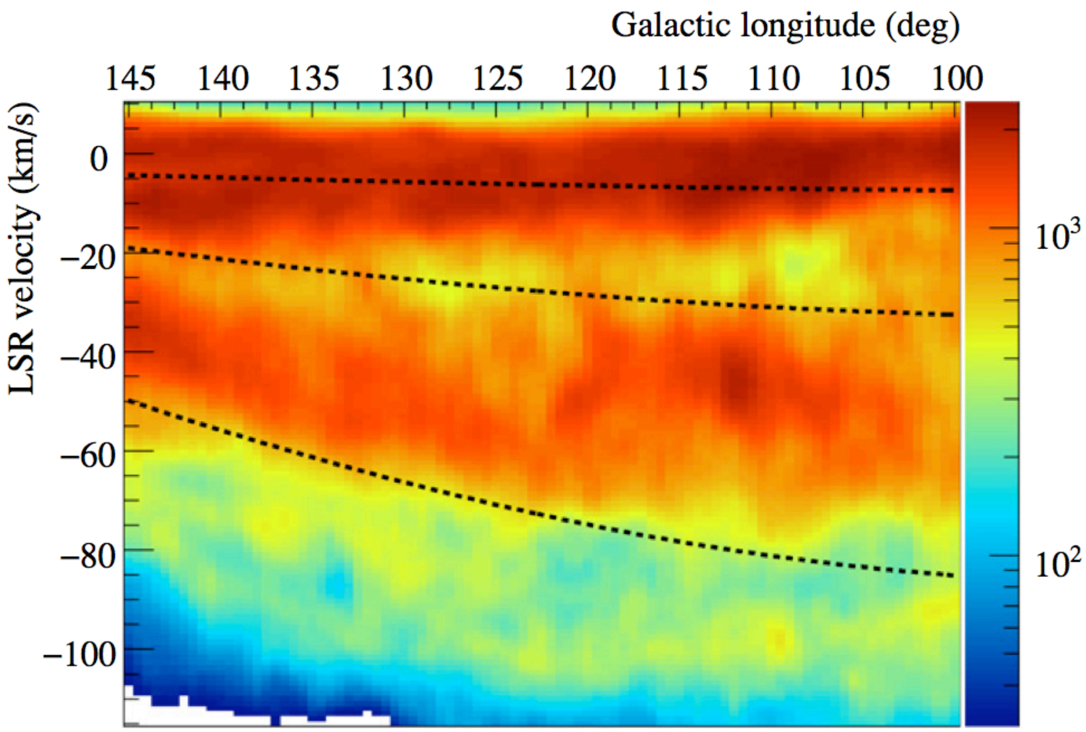
Les 2ème/3ème quadrants

Contacts: Luigi Tibaldo / Isabelle Grenier

Points principaux

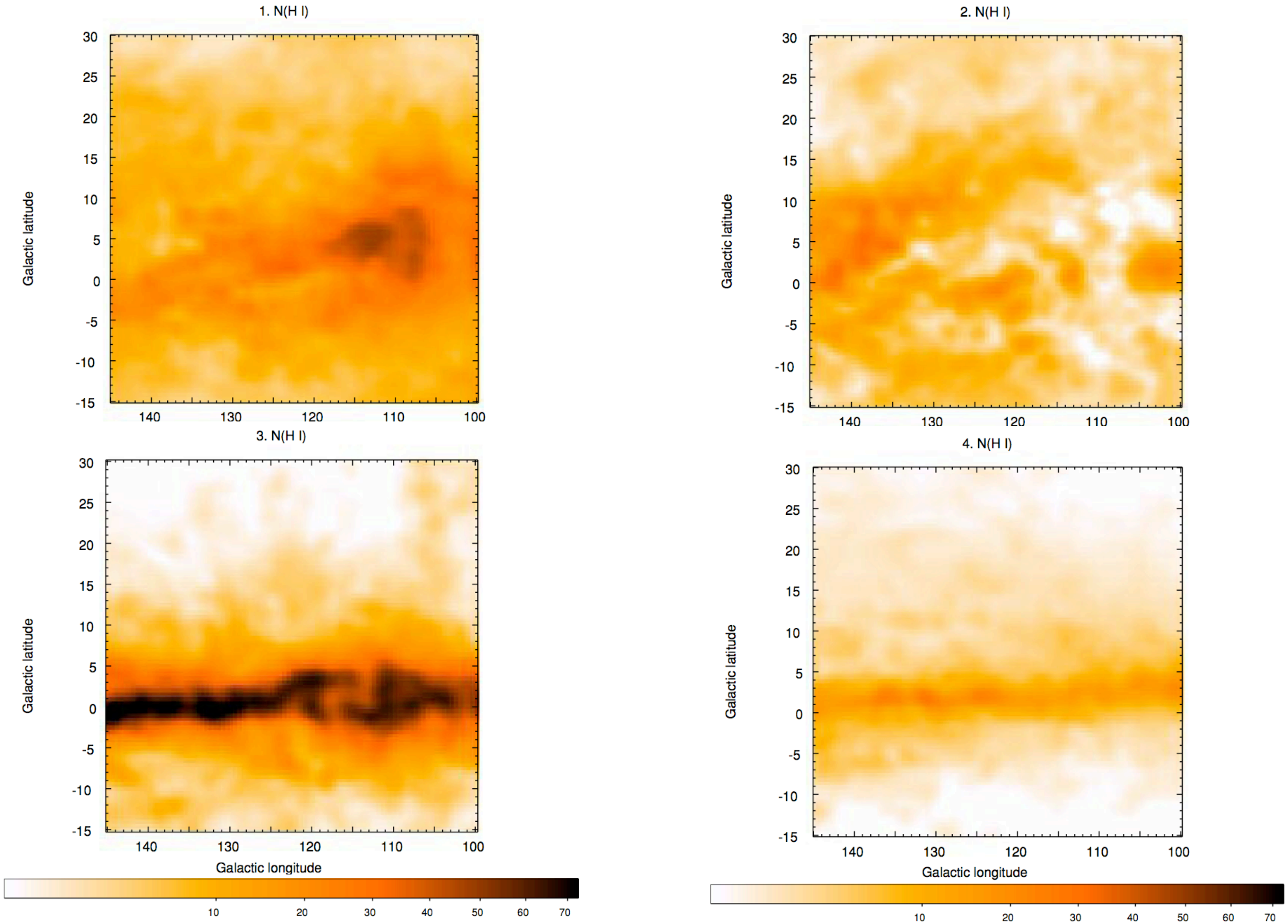
- Steep velocity gradient, good kinematic separation along line-of-sight
- In 2nd quadrant: Gould Belt, local arm, Perseus arm, outer arm





Les 2ème/3ème quadrants

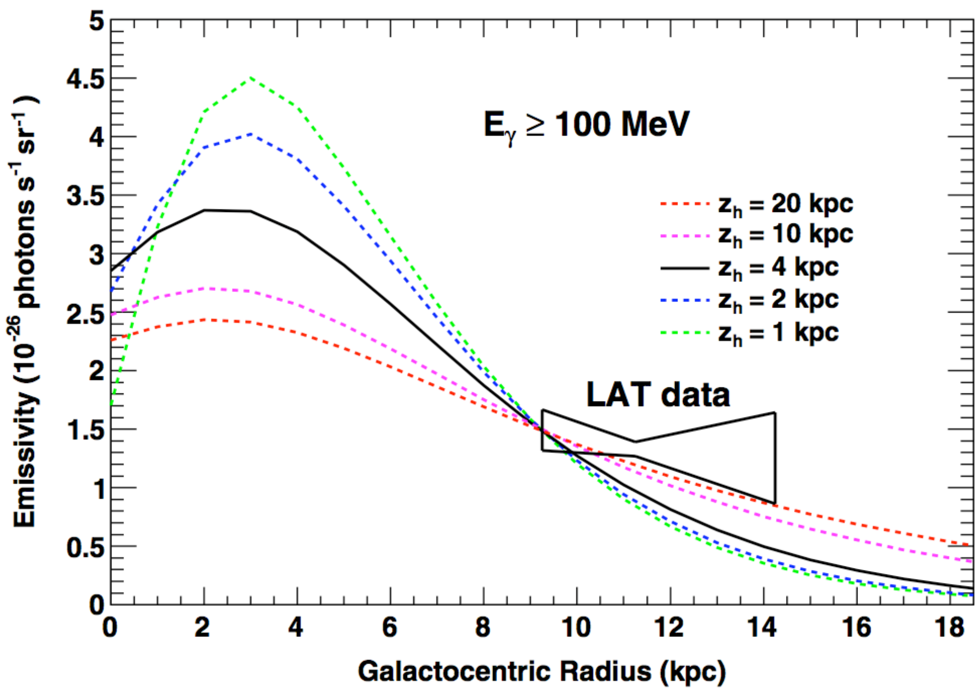
HI components



Les 2ème/3ème quadrants

Résultats principaux

- HI emissivity decrease from 8 to 16kpc is flatter than predicted
- Mo marked drop in interarm region
- Main uncertainty on CR gradient: derivation of N(H)
- Modest increase of X_{co} in outer Galaxy
- In Gould Belt clouds, dark gas represents ~50% of the CO-traced mass



The famous gradient problem:

Poorly-known CR source distribution ?
Inhomogeneous CR diffusion ?
More gas in outer galaxy ?
Larger halo ?

La Voie Lactée

Objectifs / Intérêts

- Prise en compte dans l'analyse des données Fermi/LAT
- Outil de modélisation: GALPROP
- Régions particulières ?
- …

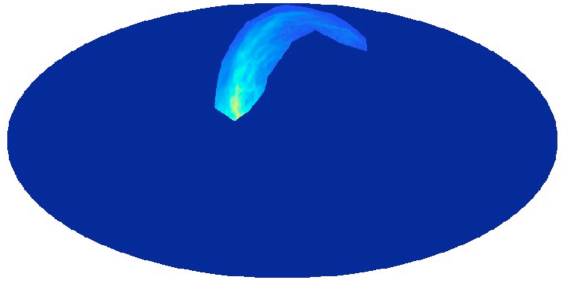
Le modèle diffus de la collaboration

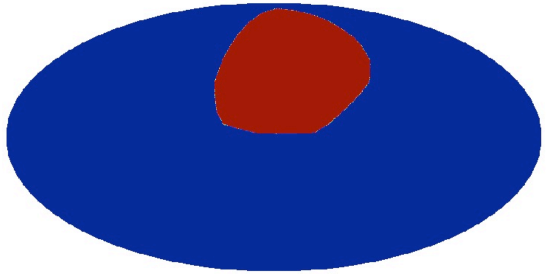
Contact: Jean-Marc Casandjan

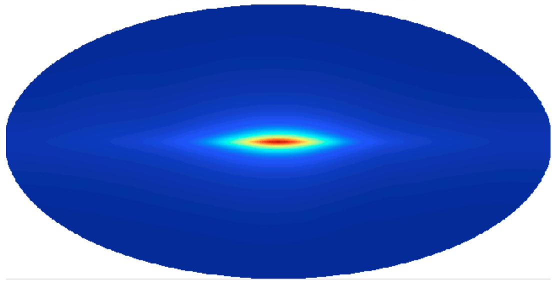
Method and ingredients

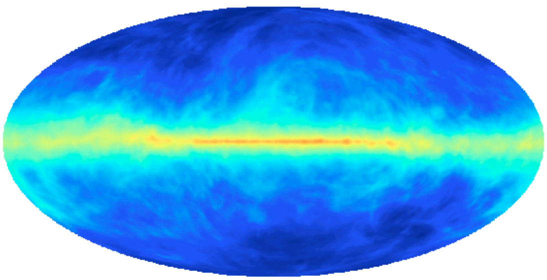
- Multi-template fitting
- 7 HI and 4 CO galactocentric rings
- E(B-V) residual map
- Removal of M31, SMC/LMC, Magellanic stream,…
- IC model from GALPROP
- Patches for Loop I or unknown excesses
- Isotropic
- Source catalog

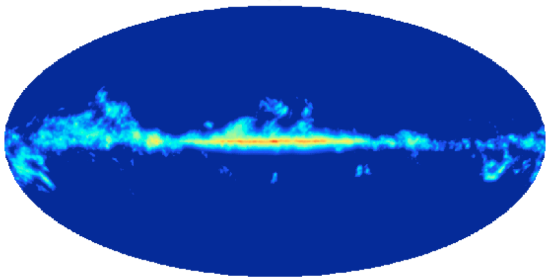
- Fit all that to Fermi/LAT data !

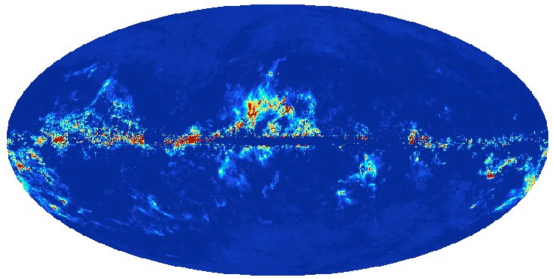






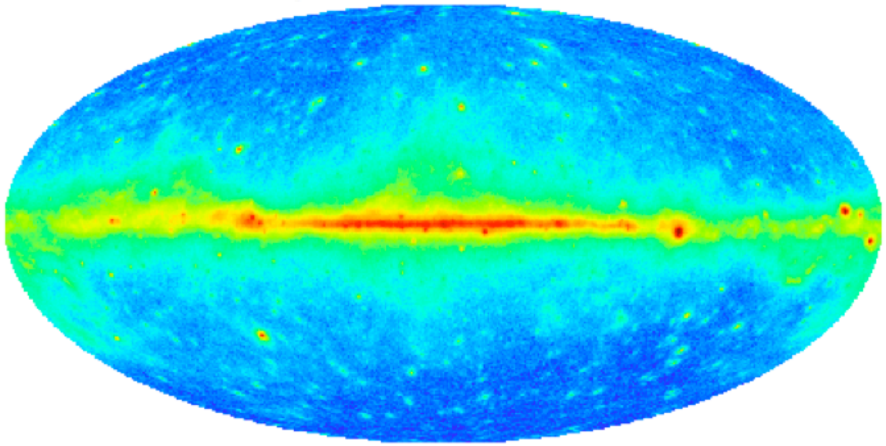




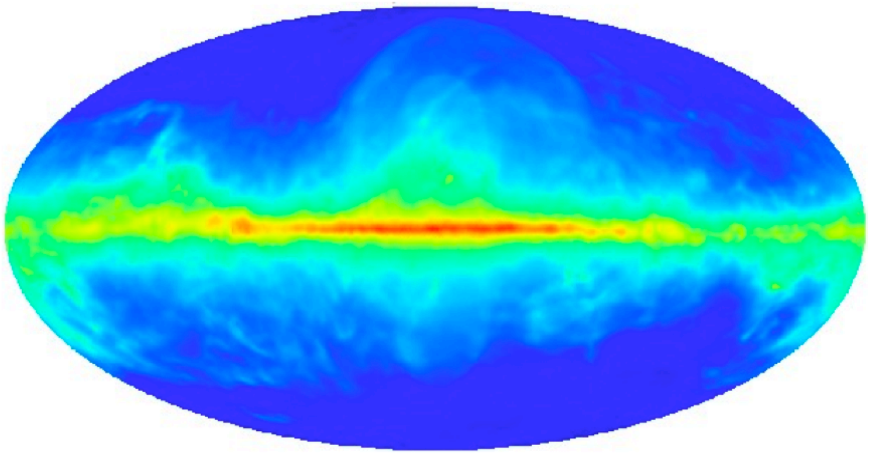


Le modèle diffus de la collaboration

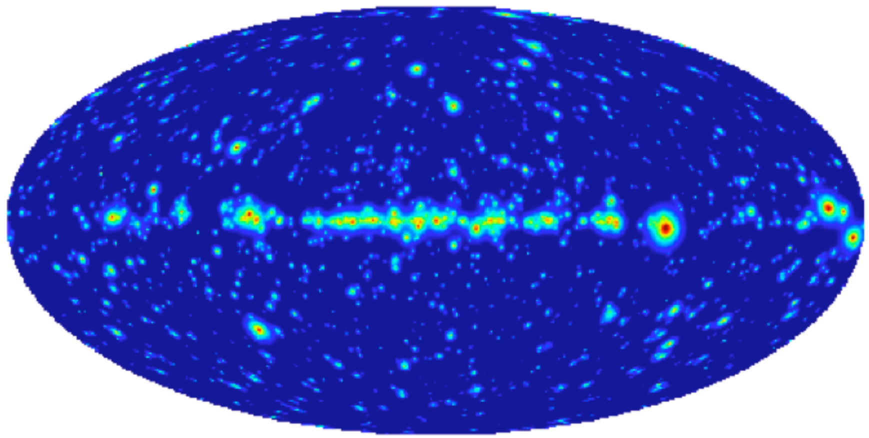
LAT counts above 300 MeV



Template model



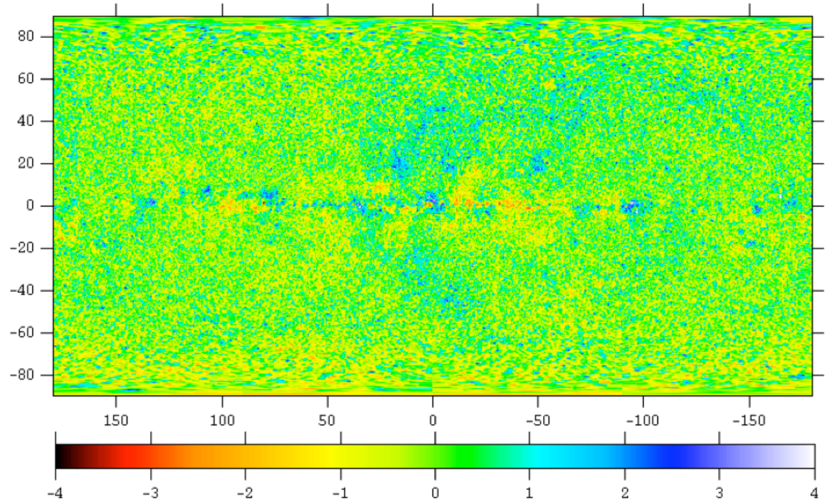
Sources, 2FGL early version



Le modèle diffus de la collaboration

Limitations and caveats

- Clumped residuals at low-latitude
- Low-level large-scale deviations



- Inhomogeneous CR density (beyond radial gradient)
- Non-uniform gas properties (Tspin)
- Uncertain gas distribution at center/anticenter (loss of kinematic resolution)
- Dark gas correction uncertain near star-forming regions (temperature correction)
- Populations of unresolved sources may contribute ~10% (especially in plane/GC)
- ISRF has angular distribution and uncertainties (factor of ~2 if anisotropic IC)

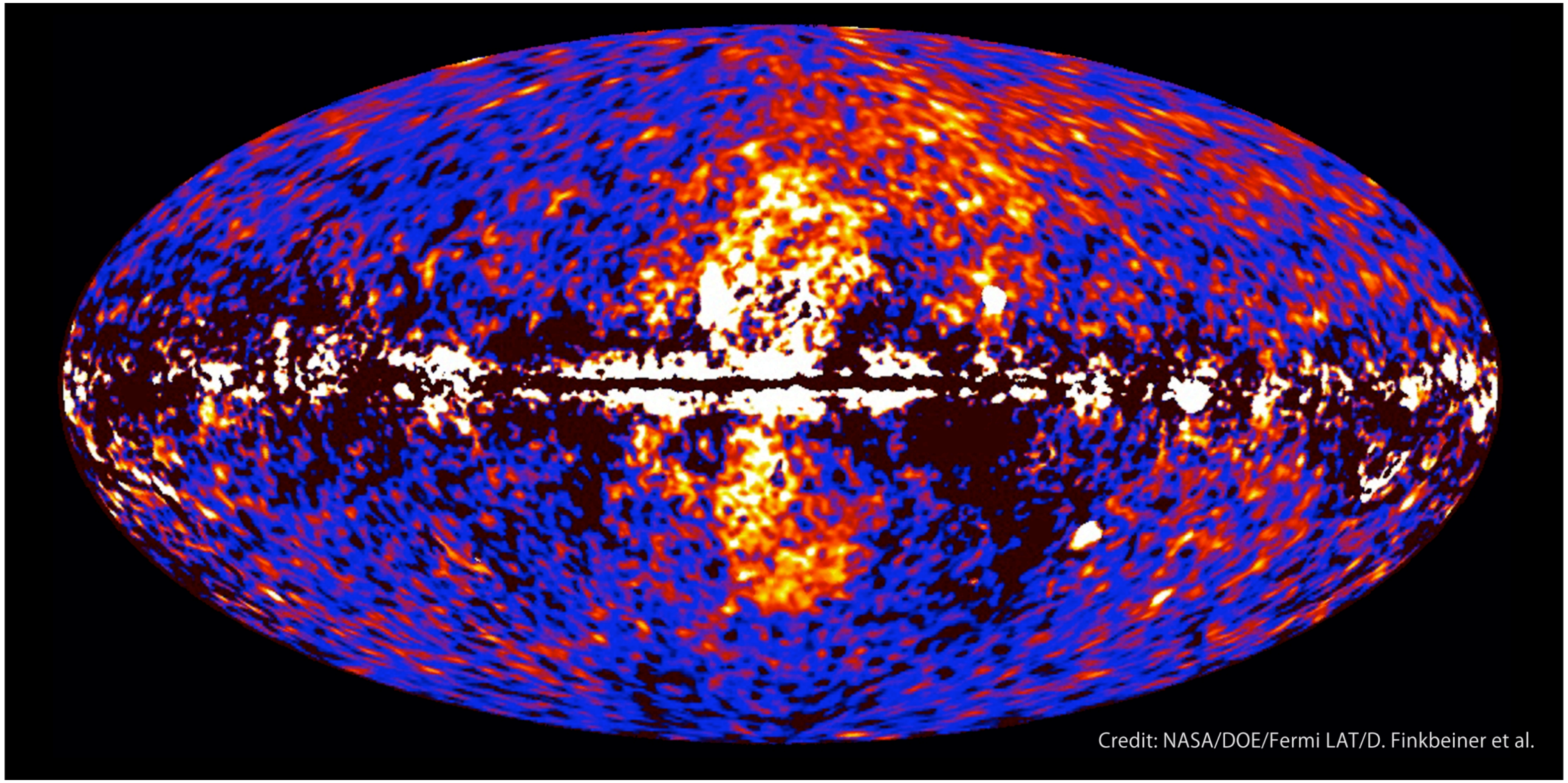
Global model to be used mostly for point-source analyses

(but preparation reveals insteresting regions ! Ex: bubbles…)

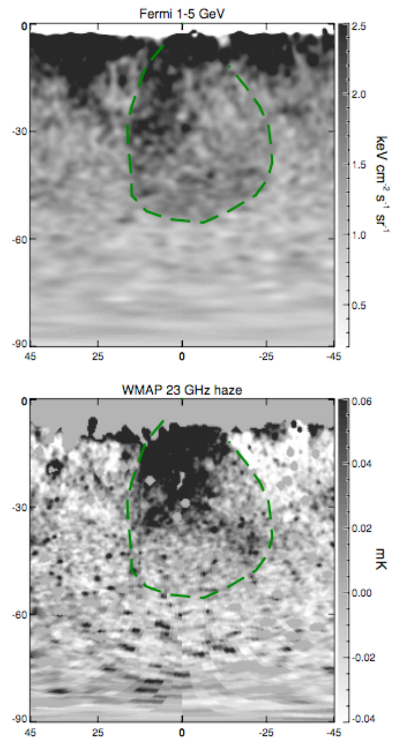
Les Fermi bubbles

Su-2010 (from outside the Fermi/LAT collaboration)

- After subtraction of multi-templates
- Two γ-ray lobes extending ±50° in latitude and ~40° in longitude (and loop I)
- Robust analysis



Les Fermi bubbles

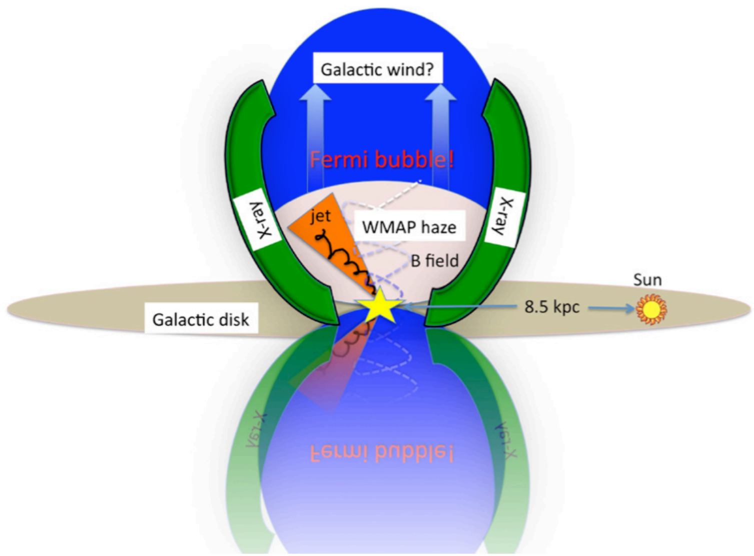


Striking features

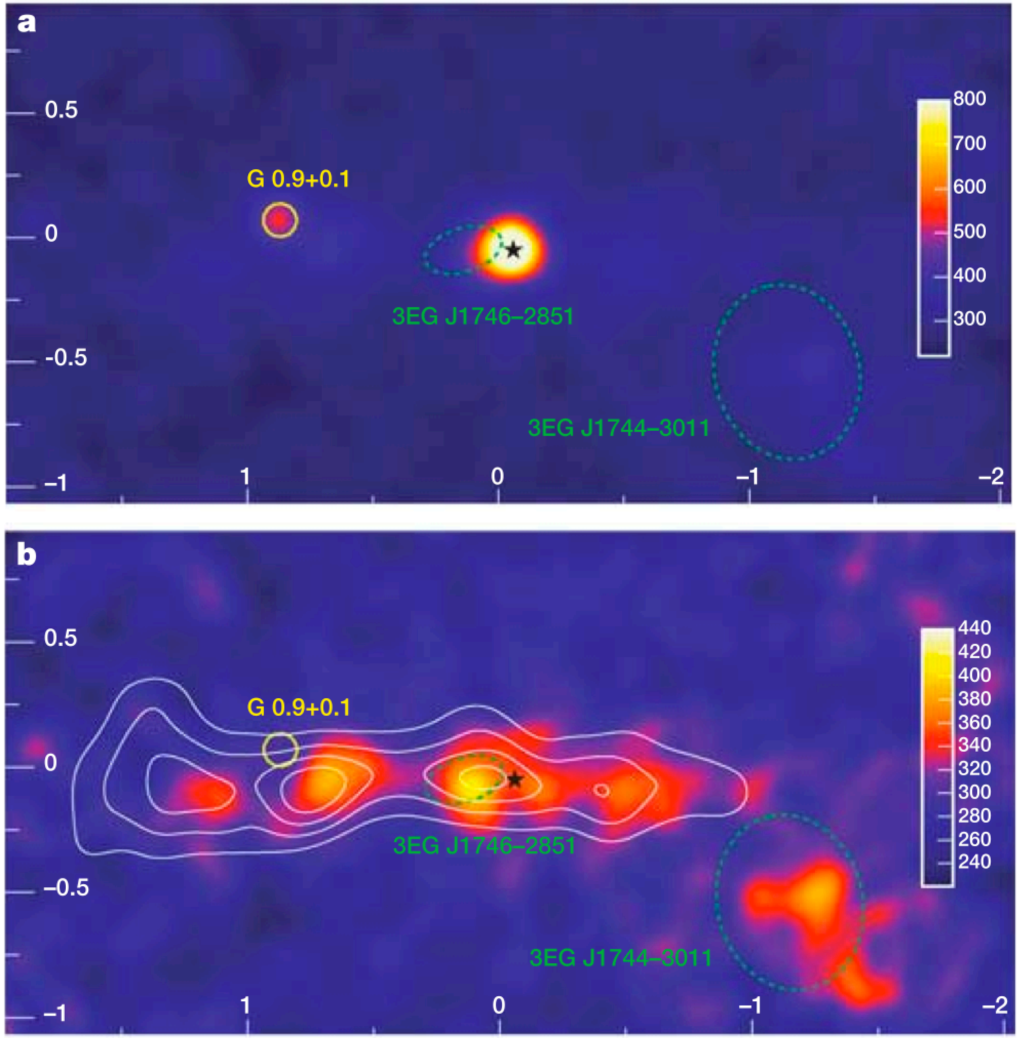
- Sharp edges (even before template subtraction)
- No limb-brightening, flat intensity distribution
- Bubbles' centers at 5kpc above/below the GC
- Hard emission over 1-100GeV (CR injection index)
- 4.10^{37} erg/s (5% of Galactic diffuse)

Towards an explanation

- Similarities with WMAP haze (also hard emission)
- Similarities with ROSAT features
- Leptonic / hadronic ? (cooling ? density ?)
- Past AGN activity or nuclear starburst ?
- Formation of bubble ?
- CR acceleration ?



Le centre galactique



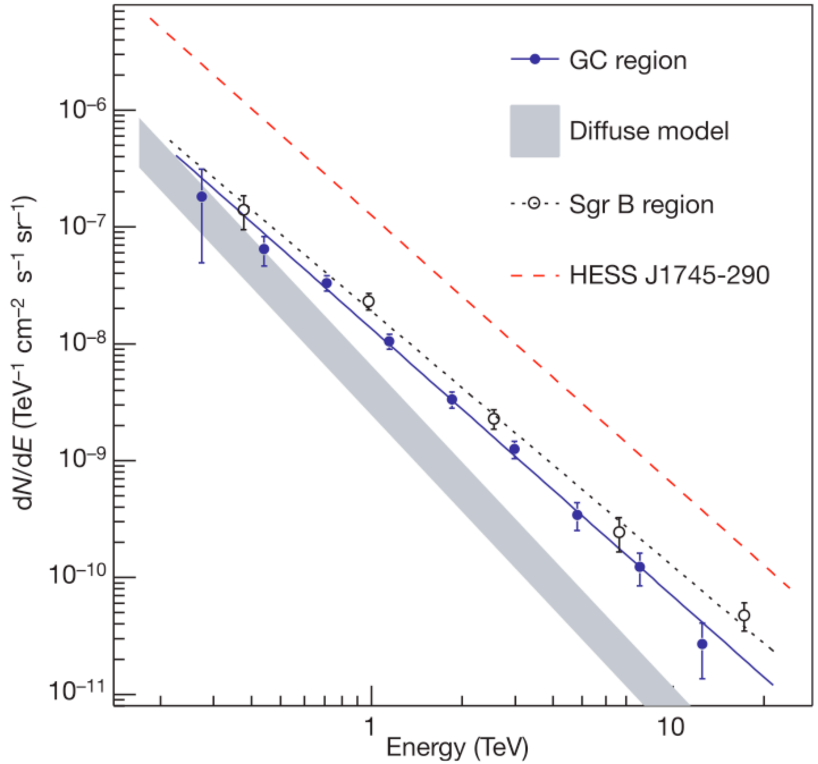
Aharonian-2006

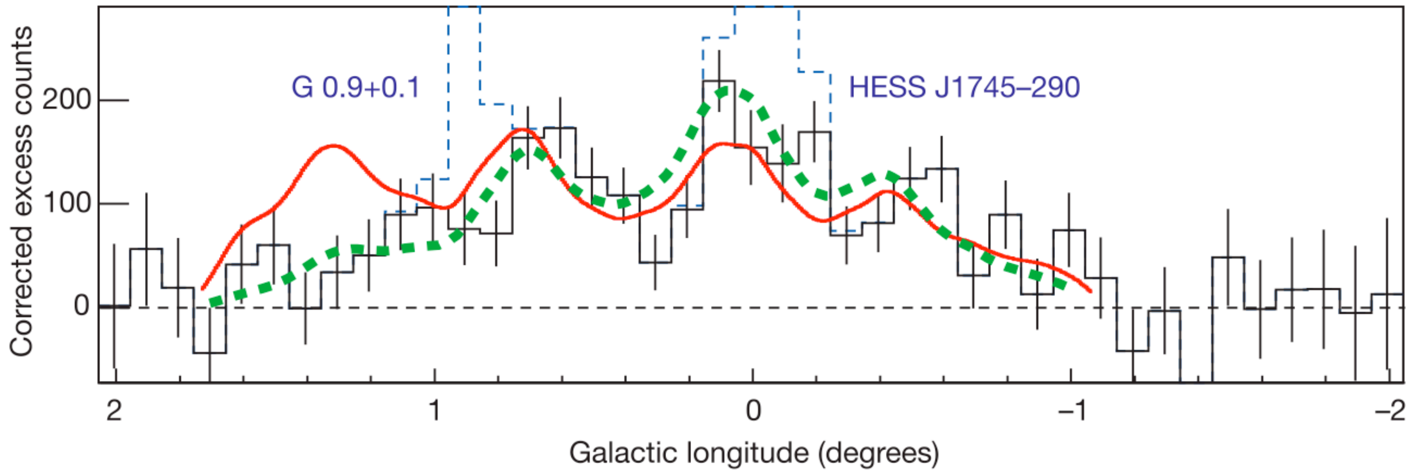
- After subtraction of HESS J1745-290 (Sgr A* or A east or …) and G0.9+0.1 (PWN)
- Significantly-extended ~TeV emission from l ∈ [-1.2°,1.5°], b ∈ [-0.3°,0.3°]

Le centre galactique

Key points

- Close correlation with molecular material
  → hadronic scenario
  → uniform CR density
- Deficit of gamma-rays for l>1°
  → diffusion in progress ?
- Hard photon index -2.3 ±0.2
  → freshly-accelerated 1-10TeV nuclei
  → 1 SN 10000 yrs ago ?

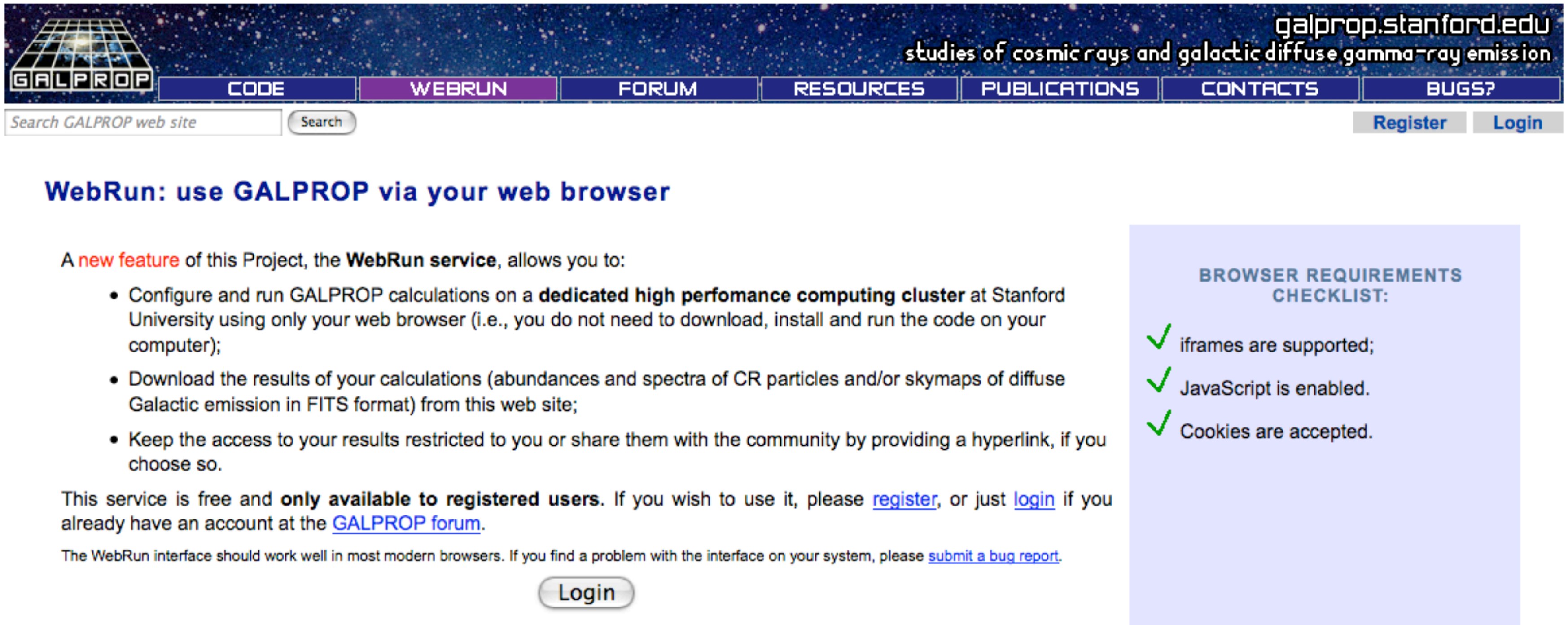




Le modèle GALPROP

General features

- Global/consistent frame for interpretation of CR data (direct, radio, gamma)
- Began in 1996 with Andy Strong and Igor Moskalenko (now at MPE and SLAC)
- Public version of the code can be obtained from http://galprop.stanford.edu/code
- … or run it online via http://galprop.stanford.edu/webrun



Le modèle GALPROP

Input

- Space and momentum grids definition (3D/4D)
- Gas model (several 2D axisymmetric distributions for HI, HII, H_2)
- Magnetic field models (from the literature or parametric)
- Choose ISRF (or input yours…)
- Source spatial/spectral/chemical distribution (SNRs, PSRs, parametric / broken power-laws)
- Rigidity-dependent spatial diffusion coefficient $D_{xx} = D_0 \beta (\rho/\rho_0)^{\delta}$ (with breaks)
- Switch on/off reacceleration $D_{pp} \propto v_A^2/D_{xx}$ (specify Alfven speed)
- Switch on/off convection (specify v_0 and dv/dz)

Then…

- Solves a transport equation numerically on grid
- Computes skymaps of related emissions

$$\frac{\partial \psi}{\partial t} = q(\vec{r}, p) + \vec{\nabla} \cdot (D_{xx} \vec{\nabla} \psi - \vec{V} \psi) + \frac{\partial}{\partial p} p^2 D_{pp} \frac{\partial}{\partial p} \frac{1}{p^2} \psi - \frac{\partial}{\partial p} \left[\dot{p} \psi - \frac{p}{3} (\vec{\nabla} \cdot \vec{V}) \psi \right] - \frac{1}{\tau_f} \psi - \frac{1}{\tau_r} \psi$$

Le modèle GALPROP

Inner working

- Computes network of primary, secondary, tertiary species starting from heaviest
- Computes steady-state in most runs (or specify time scheme)
- Normalizes CRp/CRe populations to locally-observed values
- Computes emissivities from the propagated CR distributions
- Makes skymaps by integration along line-of-sight in all directions (from Solar System)
- For gas-related emissions, use column density Galactic rings from HI/CO surveys

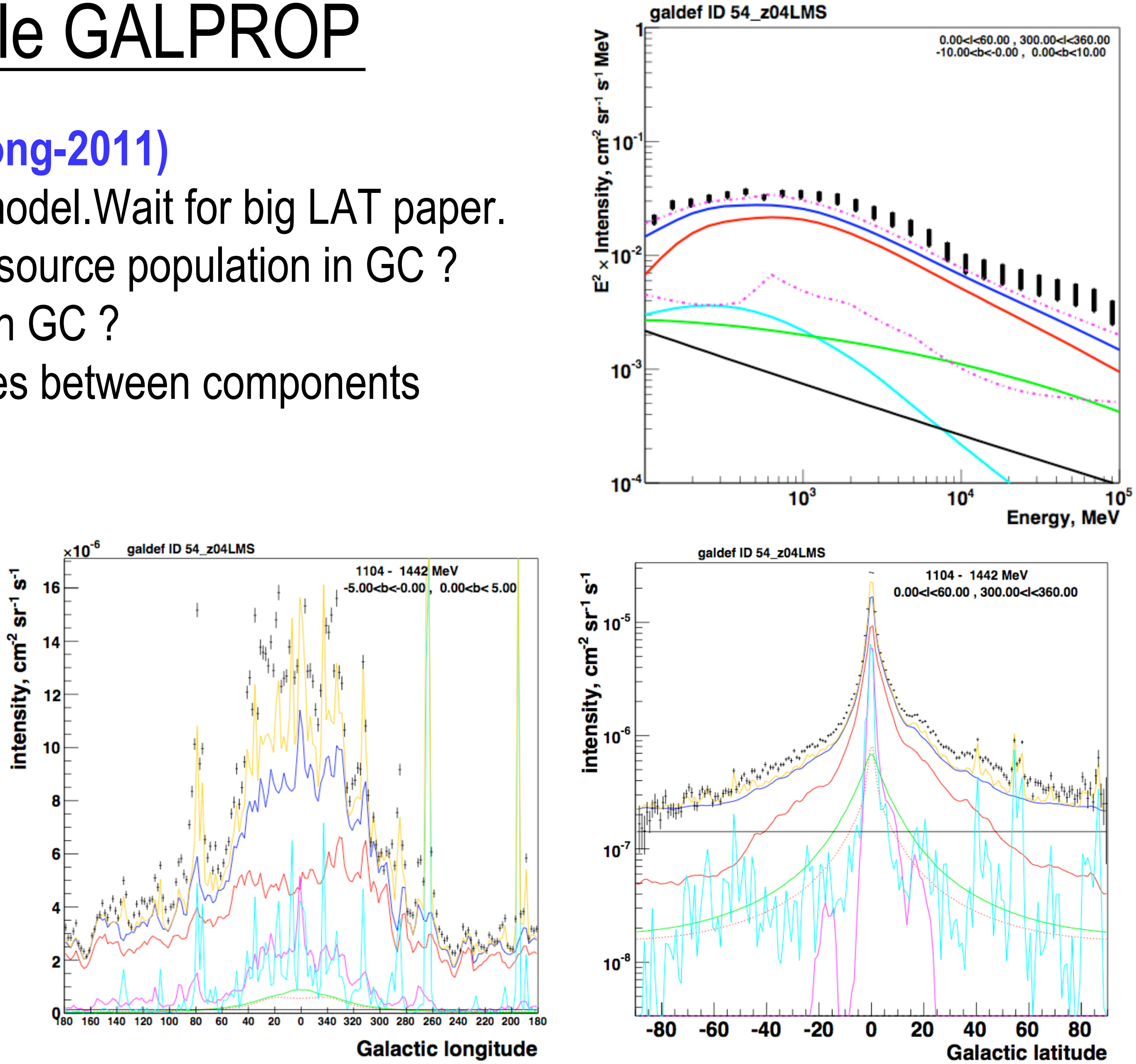
Current limitations / Things to have in mind

- Isotropic diffusion and D_{xx} independent of all other inputs (like magnetic field…)
- Propagation computed in 2D gas distributions (no spiral arms…)
- Typical spatial step ~100pc in most runs
- Fitted D_{xx} for halo size and propagation scheme
- Injection spectra chosen to reproduce local measurements after propagation

Le modèle GALPROP

Results (Strong-2011)

- Illustrative model.Wait for big LAT paper.
- Unresolved source population in GC ?
- Fresh CRs in GC ?
- Degeneracies between components

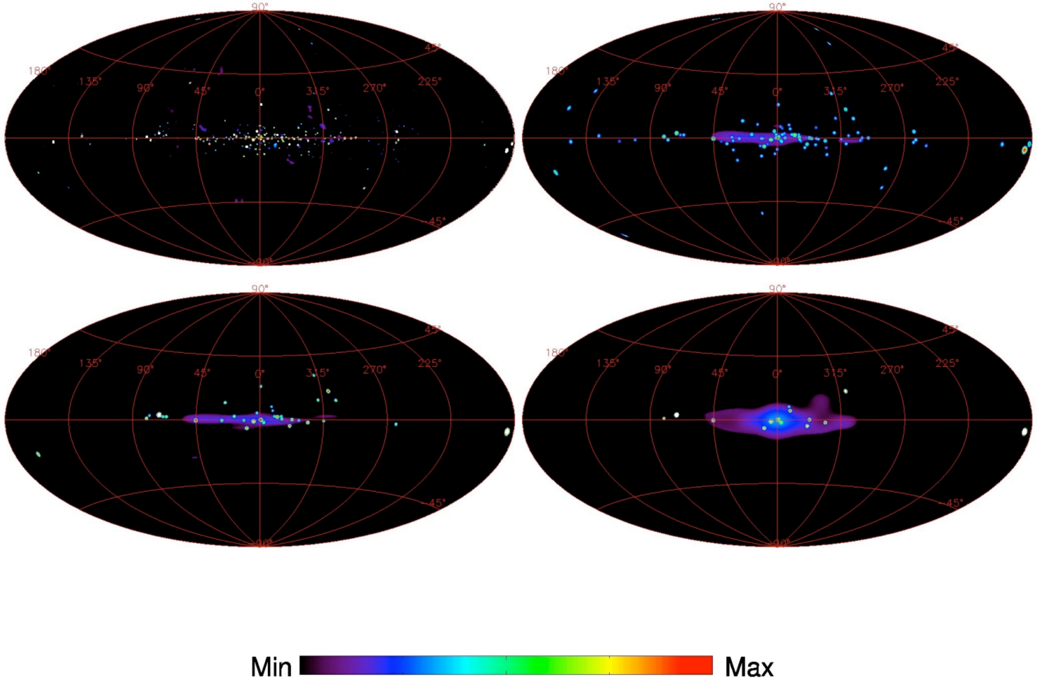


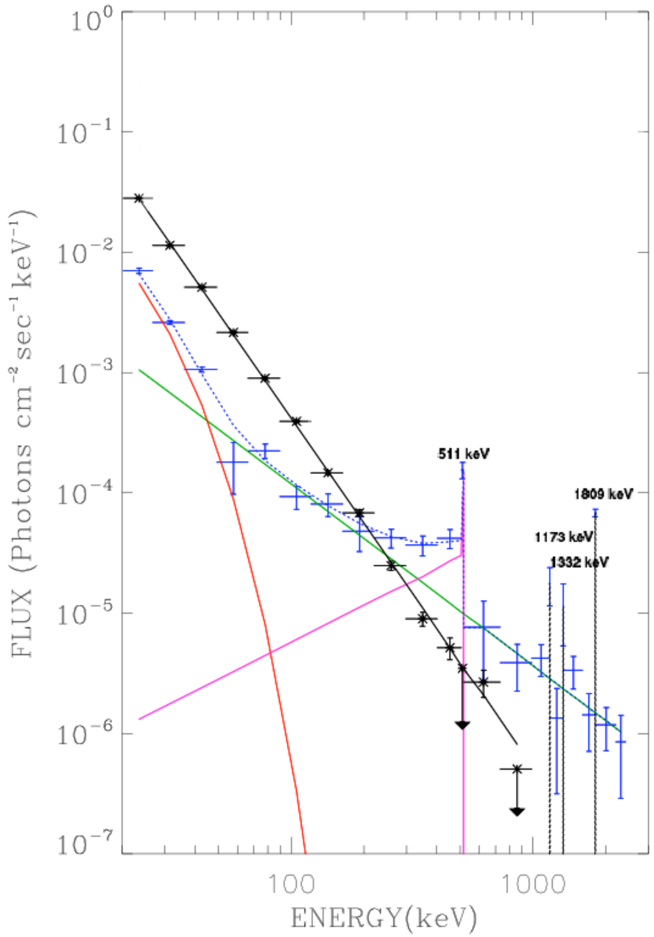
Lines show components of the model; red solid: HI, red dashed: HII, magenta: H_2, green: inverse Compton, cyan: Fermi-detected sources, black: extragalactic/isotropic, blue : total without sources, orange : total including sources.

Hard X-rays / Soft γ-rays

As seen by INTEGRAL/SPI (Bouchet-2008/2011)

- Up to ~200keV, emission dominated by discrete sources (resolved/unresolved)
- Then, diffuse emission
- Annihilation and radioactivities: ask Pierre Jean
- The rest is interstellar IC

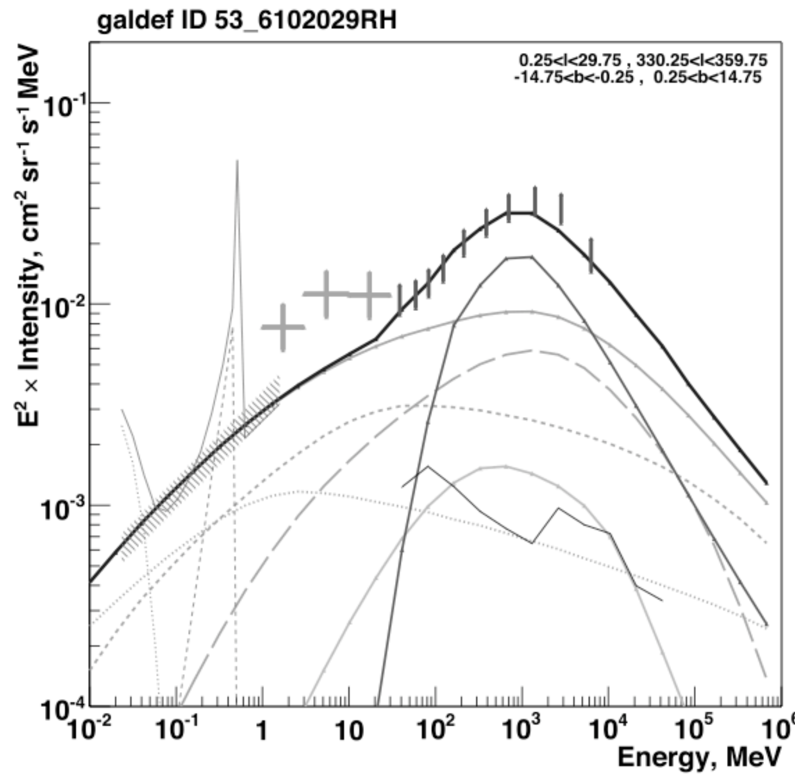


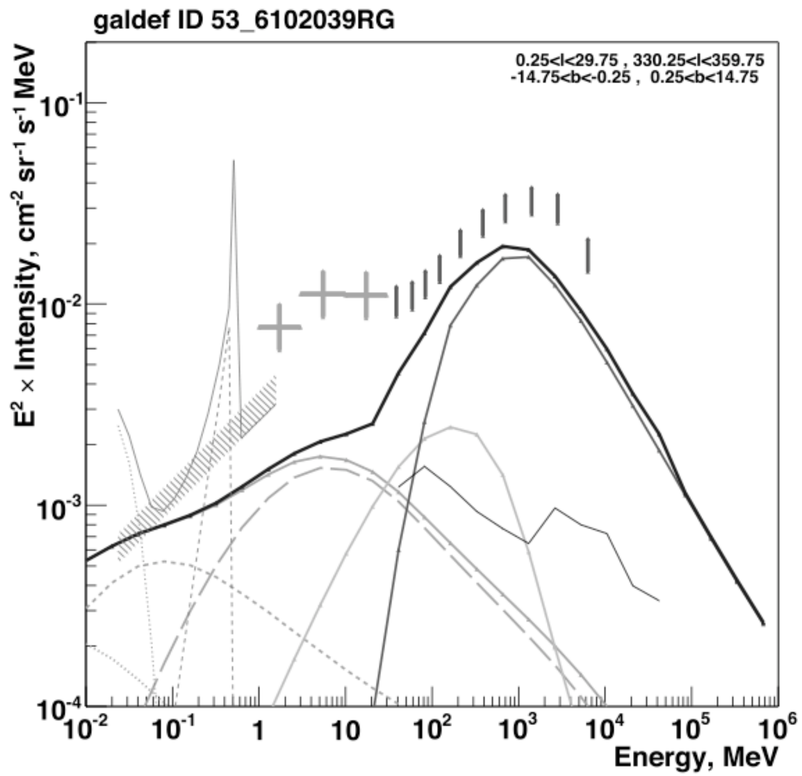


Hard X-rays / Soft γ-rays

As modelled by GALPROP (Porter-2008, for bad EGRET data)

- Secondary leptons exceed primary electrons <1GeV (large ratio CRp/CRe)
- Scatter ISRF to different energy ranges, increase IC emission <100MeV by ~2
- Secondary leptons directly seen in hard-X/soft-γ !
- Connects low-energy leptonic and high-energy hadronic components in spectrum

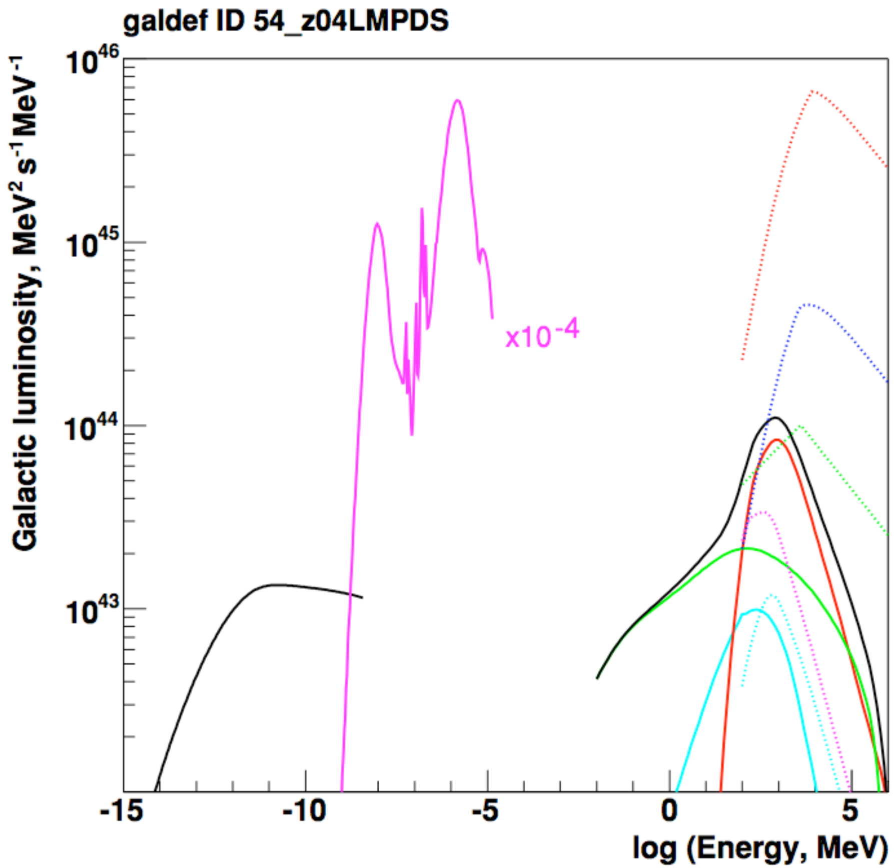




Luminosité globale et budget énergétique

Strong et al. 2010

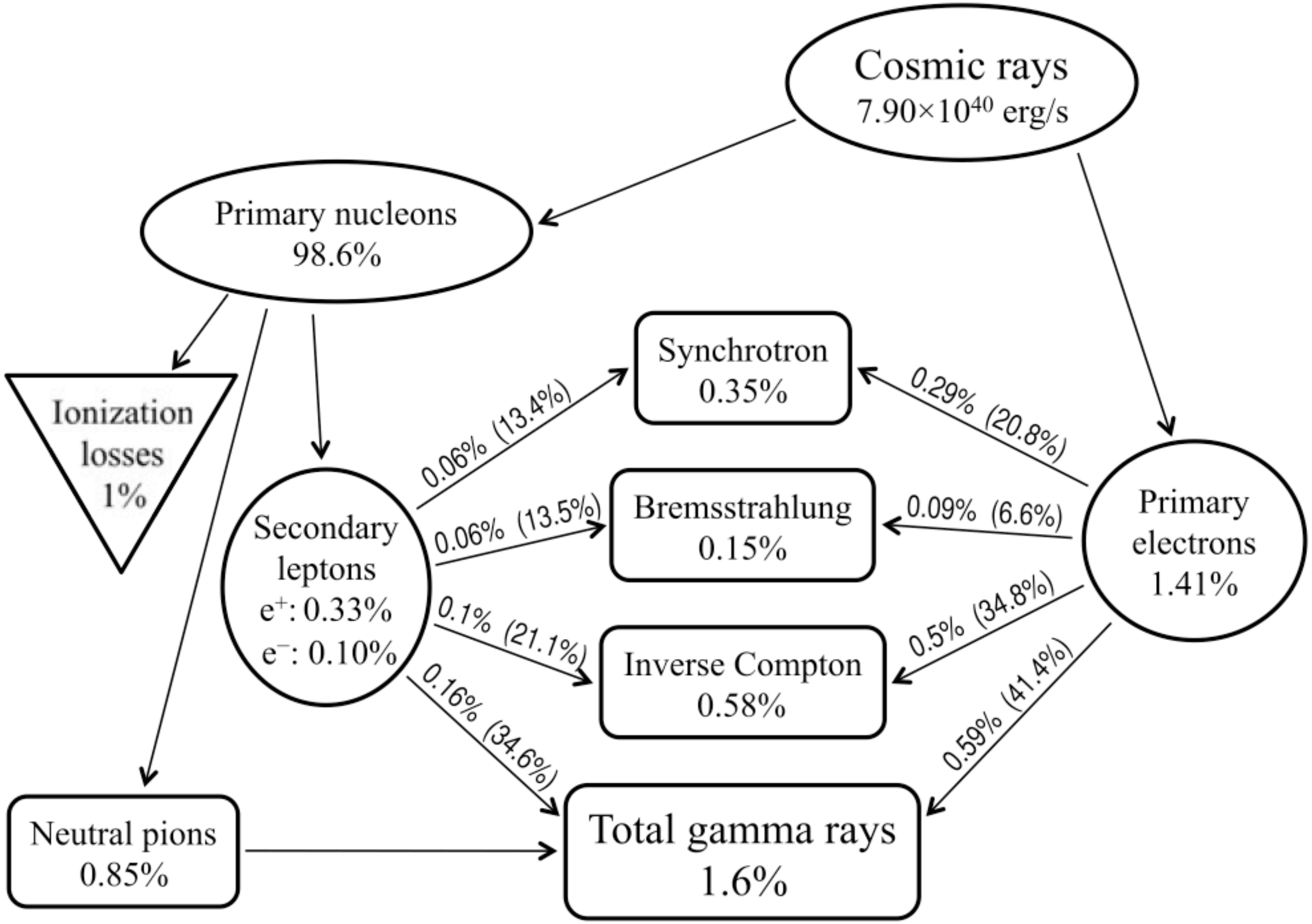
- Two propagation models: plain diffusion and diffusive reacceleration
- Three confinement volume sizes (halo height): 2-4-10kpc
- Model parameters that reproduce lots of data
- No discrete sources
- No line emission



Luminosité globale et budget énergétique

Notes

- DR model
- 4kpc



Luminosité globale et budget énergétique

Other interesting results

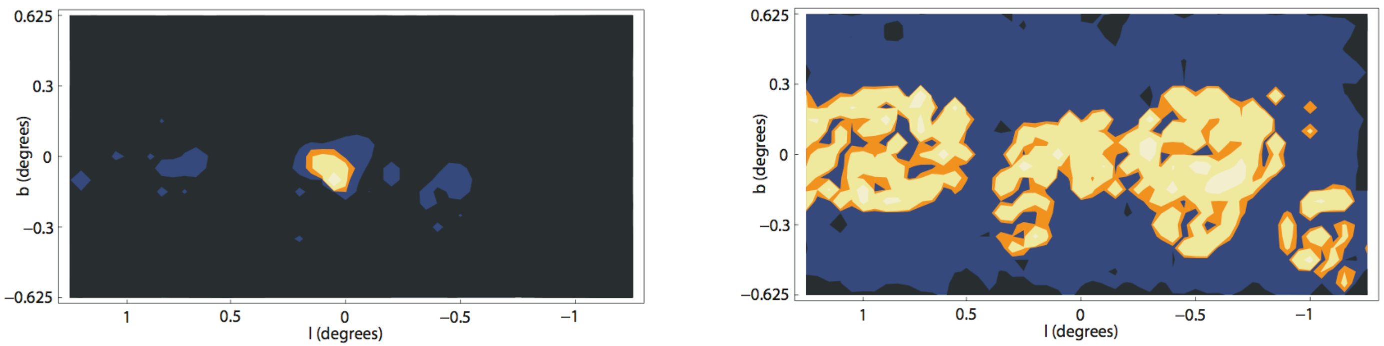
- CR injection power corresponds to ~5-10% CR acceleration efficiency in Sne
- Larger halos require lower CR nuclei input, the opposite for CR electrons
- Lepton calorimetric efficiency 40-80% (higher for larger halos)
- Br/IC responsible for ~2/3 of the losses, synchrotron ~1/3
- Contribution of Br/IC to total luminosity 100MeV-100GeV can be up to ~50%
- Milky Way far from being a proton calorimeter

- Will be useful later for comparison with external galaxies…

Le centre galactique

Wommer-2008 / Melia-2010

- Protons from a handful of accelerators cannot account for the HESS observations
- Too slow diffusion, most TeV emission confined to injection sites
- Solution: diffusive acceleration in the ISM



Crocker-2010abc (prudence…)

- Transport of CRs out of GC by powerful wind driven by star formation (400-1200 km/s)
- Explains GeV/TeV hard spectrum in GC and bubbles (energy-independent transport)
- Deficit of non-thermal radio/gamma emission compared to SFR (10% &1% respectively)
- Hadronic scenario for the bubbles

Les galaxies extérieures

Objectifs / Intérêts

- Ligne de visée dégagée, recherche de corrélations spatiales
- Réalisation du phénomène RC sous conditions différentes
- Etude de population
- …

Une nouvelle dimension dans l'étude du RC

Previously, in CR experimental physics

- Local particle measurements (p,$e^{\pm}$,B/C,^{10}Be/^{9}Be,…)
- Milky Way diffuse emission (MHz → TeV)
- Accelerator studies (SNRs, PWNe,..)

Up to Fermi, only one other system detected

- Only LMC detected by CGRO/EGRET
- Historical role of SMC non-detection: CRs are not metagalactic !
- Now we have 6-7 star-forming galaxies (2 resolved, 2TeV)

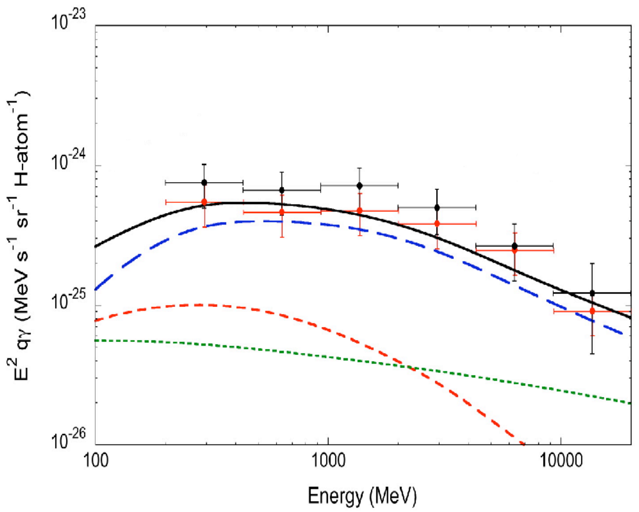
With Fermi, a new research area: galaxy population study !

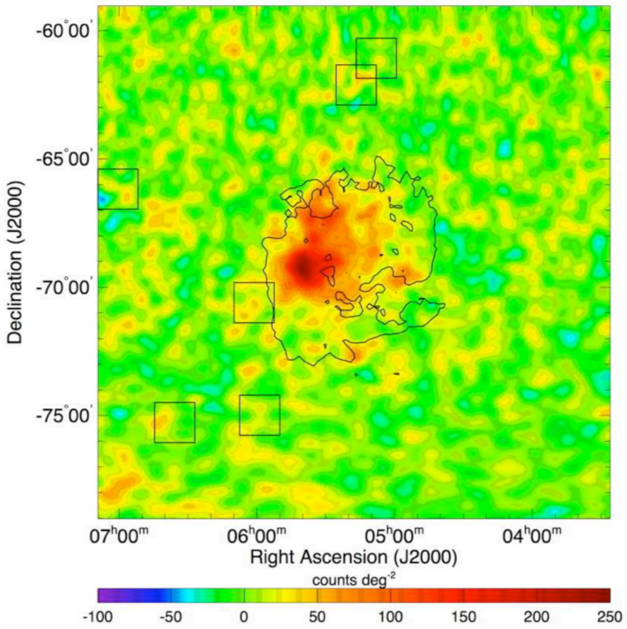
- Morphology: Correlation of emission with…?
- Photometry: CR density (injection rate, calorimetric efficiency)
- Spectrometry: CR spectrum shaped by transport (TeV lever arm)
- Population: how CR population depends on global properties
- Source and transport aspects closely connected

Large Magellanic Cloud (LMC)

Major observations

- Two significantly-extended components
- Strong γ-ray emission from star-forming region 30Dor
- Good correlation with massive star tracers (even without 30Dor)
- Poor correlation with gas (contrasts with MW ?)
- Average emissivity ~25-50% local value (upper-limit)
- Spectrum similar to MW





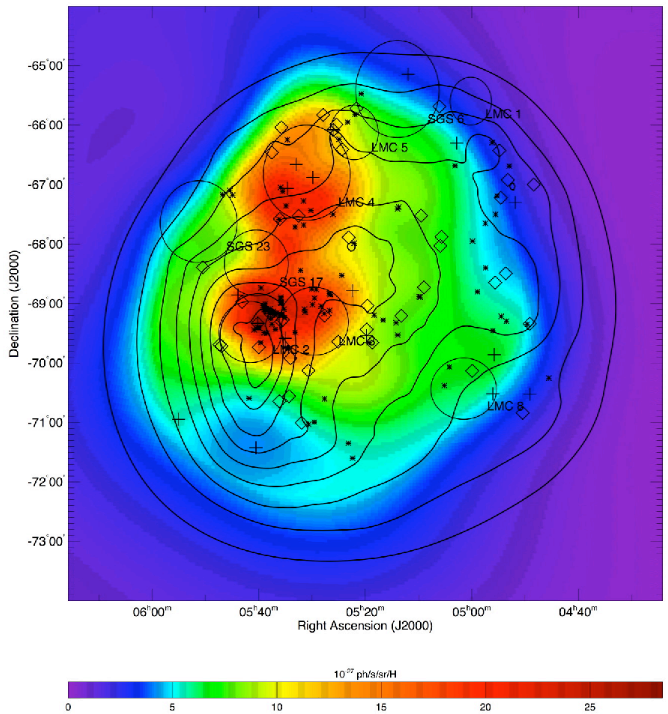
Large Magellanic Cloud (LMC)

About CR sources

- Massive stars and their derivatives are the accelerators
- First evidence at galactic scale
- Recent injection, steady-state, stochasticity of star formation ? (30Dor active on 10Myr)

About CR transport

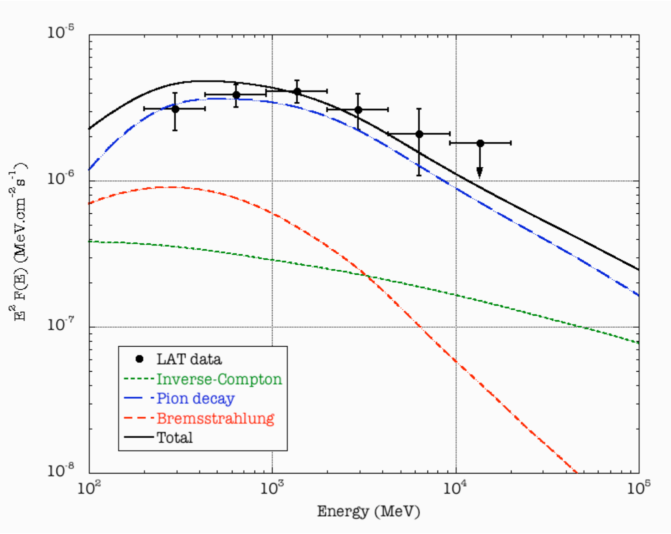
- Short diffusion lengths ? Confinement in bubbles ?
- Problem of penetration in H_2 clouds ?
- Easier escape to get lower mean emissivity ?
- … but look at the emissivity map !

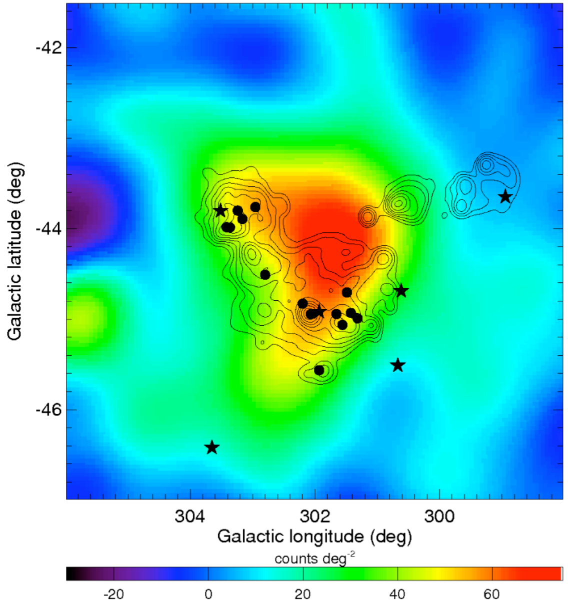


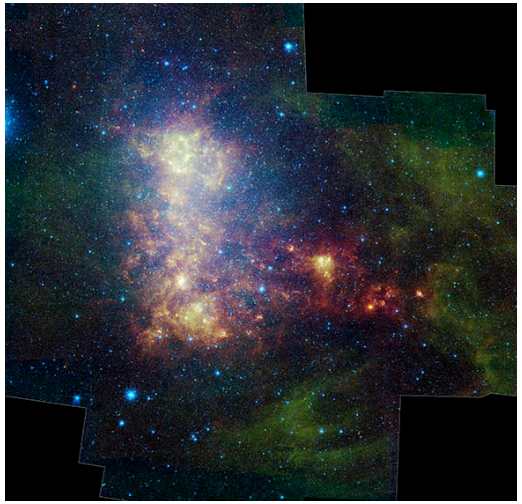
Small Magellanic Cloud (SMC)

Major observations/conclusions

- Significantly-extended emission (one component)
- No clear correlation with gas or massive stars (low statistics)
- Average emissivity ~10-15% local value (upper-limit)
- Spectrum similar to MW
- Pulsars could account for most of emission (unlike MW)



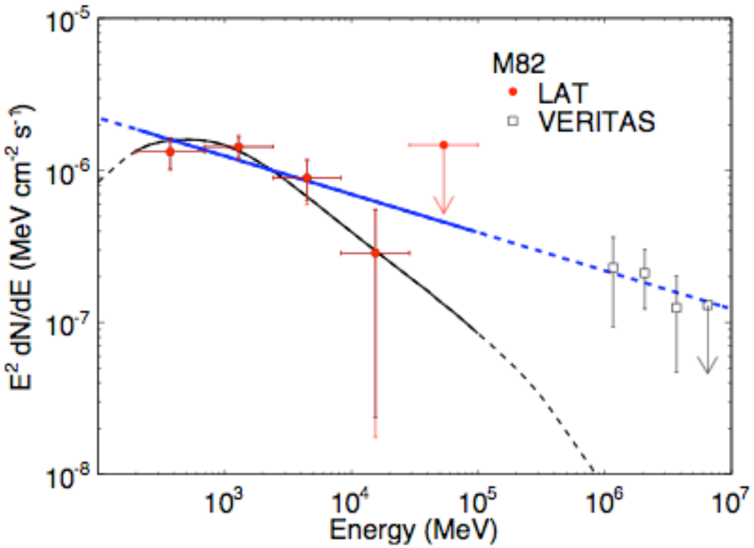


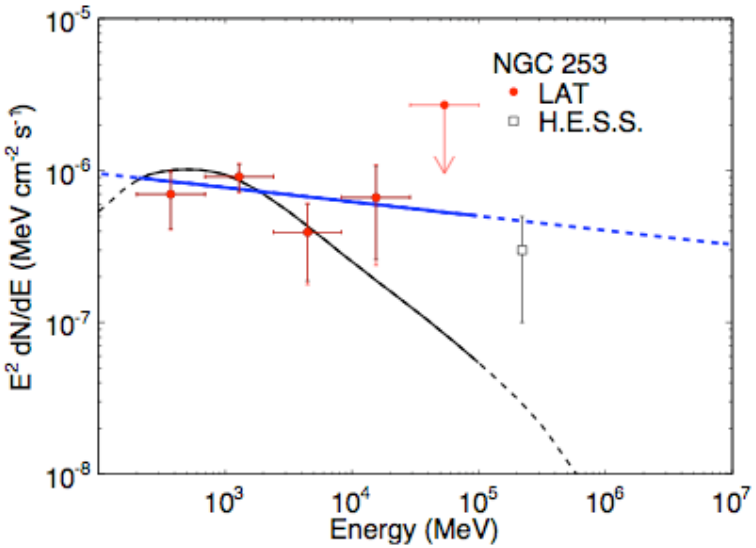


M82 and NGC253

The first starburst galaxies seen in GeV and TeV rays

- Very active, concentrated star formation (x10 MW within ~200pc)
- TeV detections: flat γ-ray spectrum n=2.2 (implies underlying CR injection spectrum)
- Suggest energy-independent transport: convection or energy-losses (for CRp)
- CR densities ~100-1000 times the MW value
- But seem to be inefficient TeV CRp calorimeters (5% for NGC253)

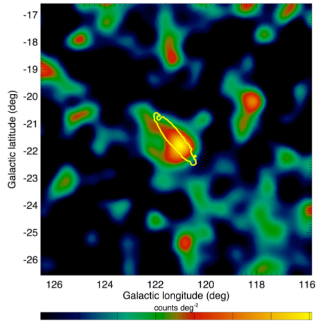


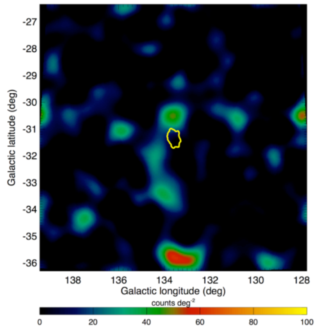


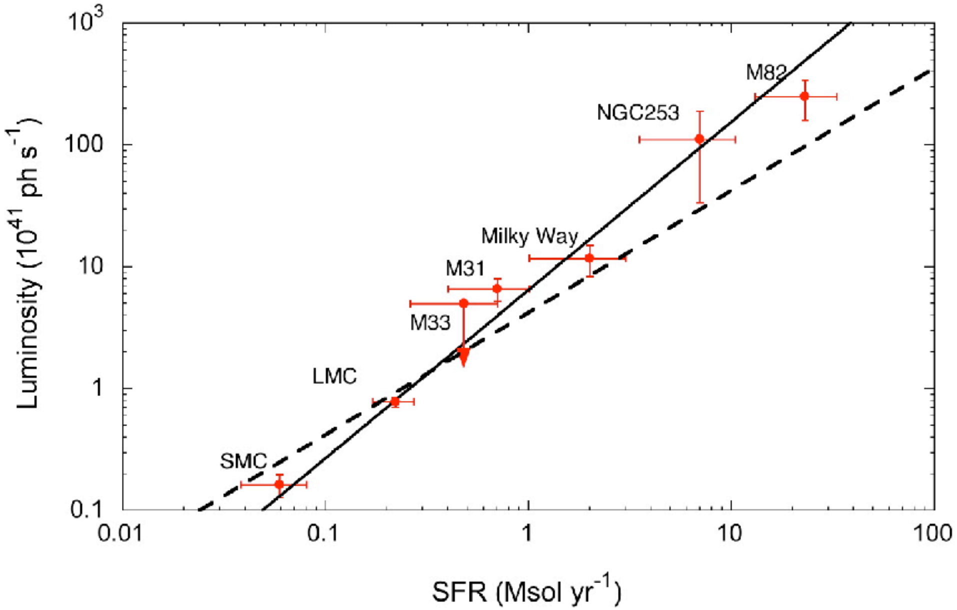
M31 and M33

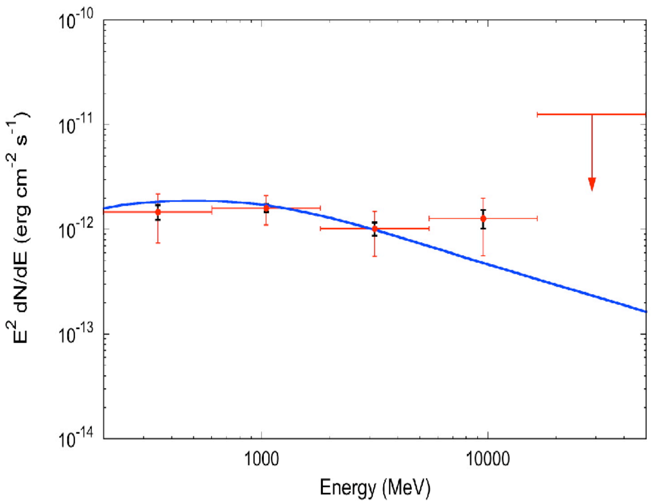
Main results

- Detection of M31 at sensitivity threshold (point-like object)
- … M33 may follow in a couple of years
- Average CR density is 35% that of MW
- Total γ-ray luminosity is 50% that of MW
- Spectrum again consistent with MW
- An almost-linear correlation found (for widely-differing objects)









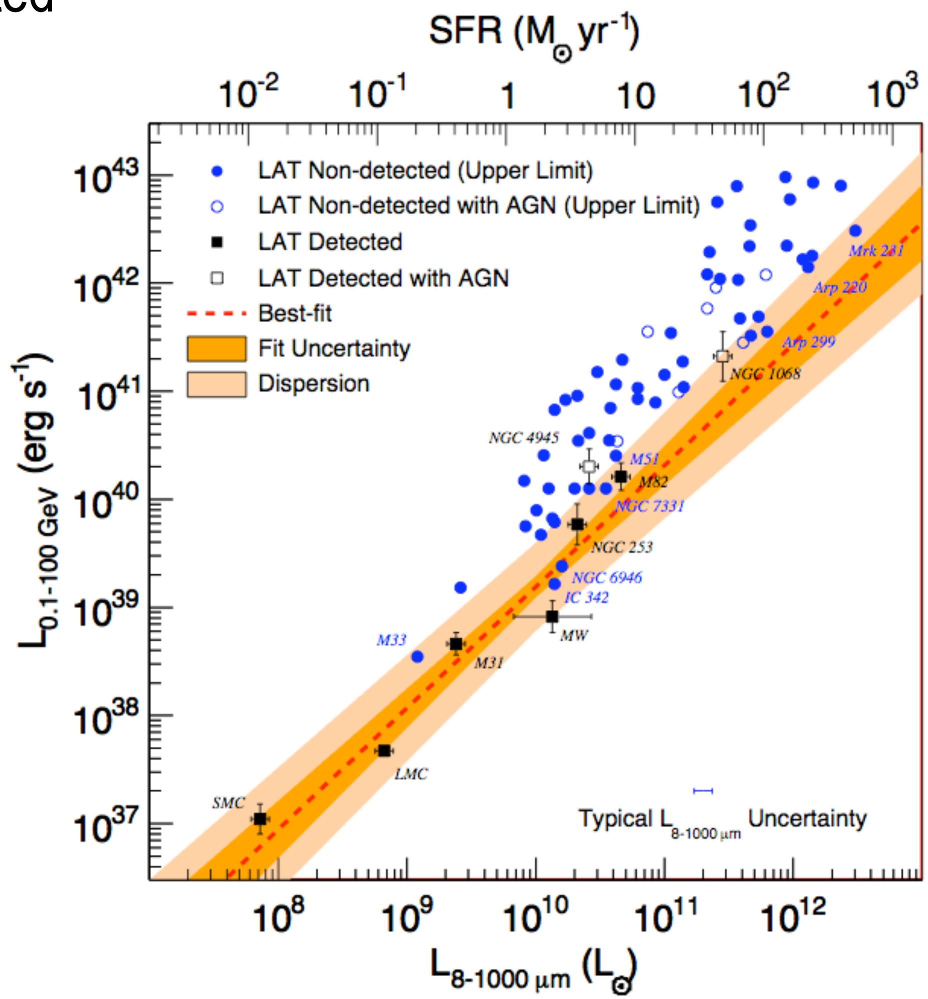
The complete sample

Preliminary !

Contact: Keith Bechtol

Observations

- 64 HCN-selected objects (dense H_2 tracer)
- Only 4 detected at GeV, 1 AGN-dominated
- ...and lots of upper-limits
- Almost linear correlation (n=1.10-1.15)
- ULIRGS prevent stronger non-linearity



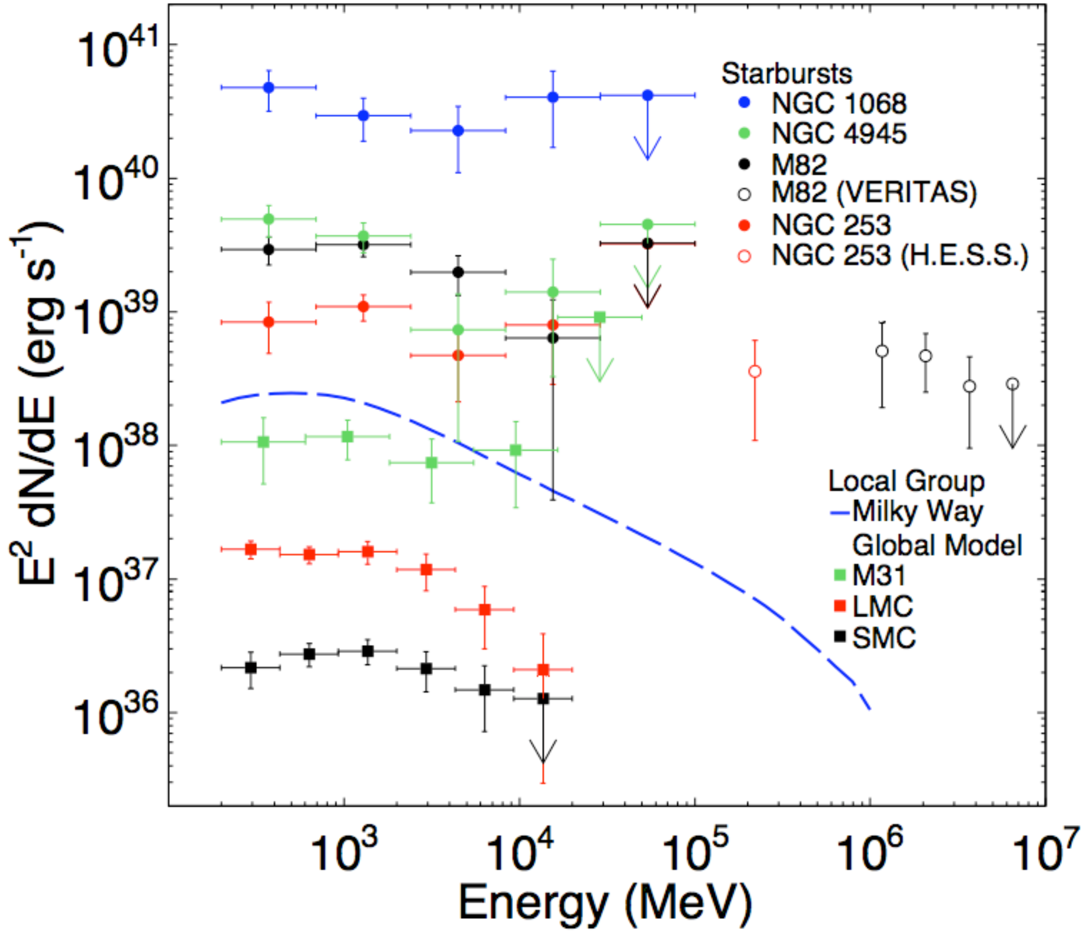
Only 2 orders of magnitude in flux and 3 orders of magnitude in distance, but not a distance-scaling effect !

The complete sample

Preliminary !

Comparison of all spectra

- Pretty similar in GeV range
- Importance of TeV points



The complete sample

Towards an understanding: hadronic aspects

- Some correlation with SFR expected (traces CR injection rate)
- Linear dependence expected for CRp calorimeter
- but MW-like galaxies are not, and starbursts do not seem to be good at that either
- Slight increase of calorimetric efficiency across the galaxy range ?
- Transition from diffusion-dominated to convection-dominated ?

Towards an understanding: leptonic aspects

- CRe can account for up to 50% of the MW luminosity >100MeV
- … and CRe is thought to be achieved for most galaxies
- In starbursts, secondaries may dominate over primaries
- … but in pp interactions, more energy goes to γ-rays than to leptons
- Relative contributions of synchrotron/IC across galaxy range ?

Other considerations

- Contribution of discrete sources
- Evolution of correlation from GeV to TeV (CTA prospects ?)

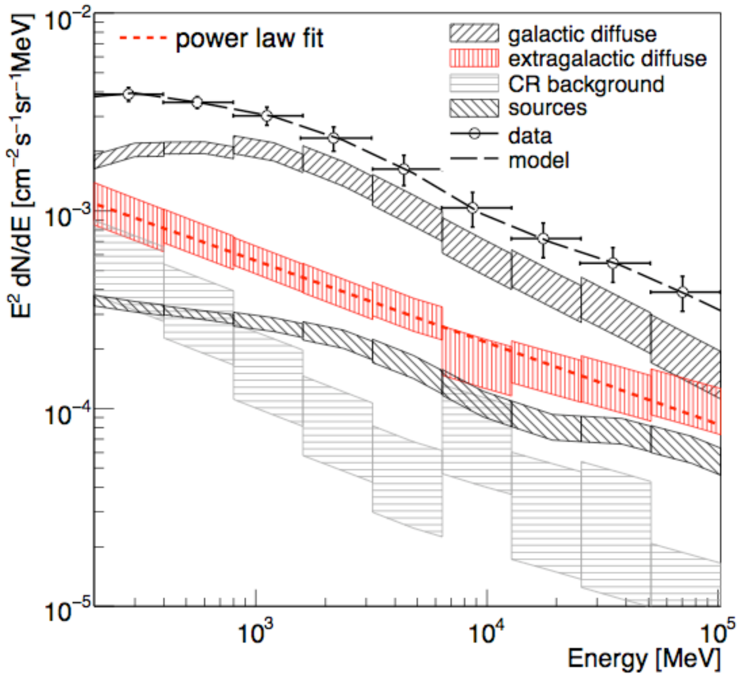
Le diffus extragalactique

En deux mots…

L'EGB

La composante isotrope, superposition de

- Unresolved populations of extragalactic objects (AGNs, GRBs, starbursts,…)
- Signals from large-scale structure formation
- UHECRs interactions with cosmic backgrounds
- Annihilation or decay of dark matter
- …. but can also include/absorb…
- IC emission from the Milky Way
- Vertically-extended Galactic sources (MSPs)
- (Fermi/LAT residual background)



Observations

- Single power-law with index 2.41 ±0.05
- No spectral features
- Apparently not dominated by the high-latitude source classes already detected !