Summary of the GDR PCHE Workshop on the Diffuse Galactic Gamma-ray emission

1. Aims of the workshop
2. Sources of cosmic rays
3. Interstellar medium and radiation field
4. Cosmic ray propagation and open questions
5. Summary of all processes at stake
6. Experiments : Fermi, HESS-CTA, Planck

http://indico.in2p3.fr/conferenceDisplay.py?confId=1259

password: GDRlpta

Julien LAVALLE

University of Torino (theory group) & INFN

GDR SUSY

LAL Orsay – 03/12/2008

GDR Phénomènes Cosmiques de Haute Energie

- Appel d'offres au printemps et à l'automne
- 2 types de projets financés : ateliers, écoles ou conférences & sous-groupes de recherche thématique (e.g. pulsars)
- Financement obtenu pour l'atelier : 3 k euros
- Organisateurs : J.L., A. Marcowith & D. Maurin
- Nombre de participants : ~ 25

Aims of the workshop

The **unprecedented achievements in radio, optical, X-ray, γ-ray astronomies** and the forthcoming precision measurements of the local cosmic rays make possible a **self-consistent picture** of the Galaxy **high energy contents and processes**. In more details:

- **Galactic sources of cosmic rays**: acceleration mechanisms, leptonic/hadronic origin of accelerated particles, medium effects, etc.
- **Interstellar medium (ISM)**: composition, spatial distribution, emissivity, dynamics, etc.
- **Interstellar radiation field (ISRF)**: origin (stars, dust, magnetic fields, CMB), spatial distribution, spectral features, etc.
- **Propagation of cosmic rays** through the Galaxy: spatial diffusion, interactions with the ISM and ISFR (spallations, energy losses, etc), convection, reacceleration, etc.
- **Interactions between cosmic rays / matter /photons**.
- Obvious links to **galaxy modeling**, and **galaxy formation and evolution** theory.

Diffuse Galactic γ-ray emission

$Fermi - LAT$ will widely enlarge the observed full sky electromagnetic spectrum and with much better precision compared to EGRET (sensitivity + field of view + precision), up to ~ 200 GeV. Other experiments are operating in the same time (intercalibration, etc). In space: INTEGRAL, AGILE (+ X-rays satellites). At ground: HESS, VERITAS, CANGAROO, As-γ etc.

The situation is very good to carefully test the models associated with most of topics in high energy astrophysics.

The diffuse Galactic γ-ray emission offers a kind of test of self-consistency of the gathering of all topics mentioned above. More generally, a better understanding will open larger, or maybe close, the door to new physics in astropaticle physics.

The aims of the workshop are to:

- **review** these topics
- offer a framework for **learning** and **discussing** in an interdisciplinary spirit
- understand the **experimental potentials** / the **theoretical predictions and uncertainties**
- **favor collaborations** in view of "gluing" together the separate fields and expertnesses required in the undestanding of the diffuse γ-ray emission — **Experiments + Theory**

Timetable

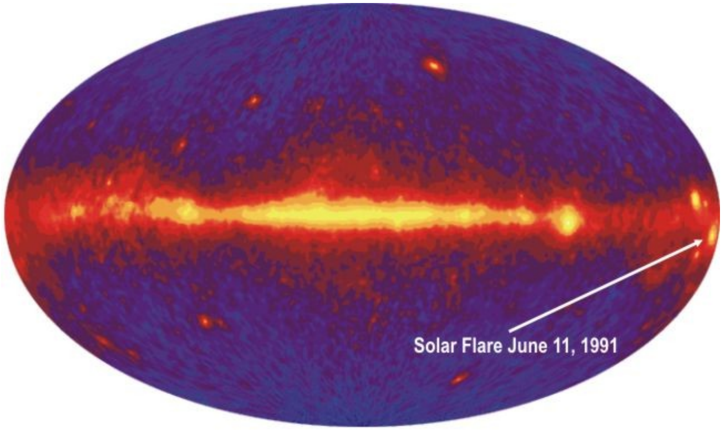
The timetable:

- Understanding the gas distribution in the Galaxy (P. Englmaier)
- What MeV emission already says (J. Knodlseder)
- Operating and future experiments
  - HESS and avatars (R. Terrier)
  - Fermi-LAT (J. Cohen-Tanugi)
- Flash session
  - HESS & DM clumps (A. Charbonnier) – II$^{\rm ary}$ positrons (T. Delahaye) – HESS & molecular clouds (A. Fiasson) – Cosmic ray acceleration (V. Tatischeff)
- Cosmic ray propagation (D. Maurin, JL, S. Gabici)
- Turbulence (Y. Gallant, P. Hennebelle, A. Marcowith)
- Sources (A. Marcowith, Y. Gallant)

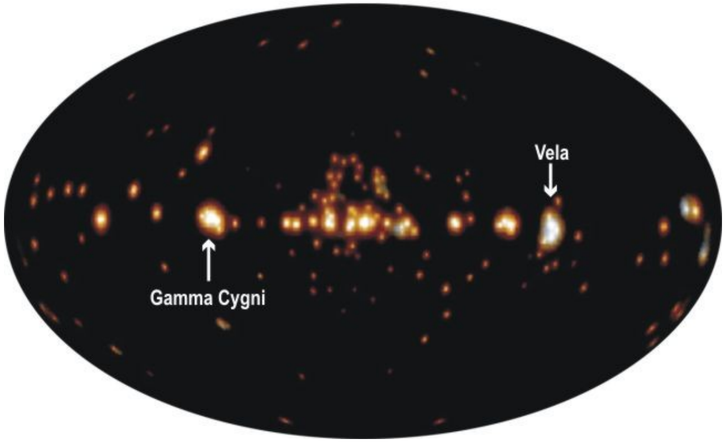
Diffuse emission for dummies

EGRET >100 MeV

1) Count the number of (photons-instrument background)



2) Subtract point sources



=> Hopefully, what remains is the diffuse emission

D. Maurin

But…

IBIS-ISGRI (20-60 keV)

simplex, complex or multiplex?

1) Astrophysical point of view

- point-like sources (e.g., SN remnants, AGN…)
- extended emission (e.g. plerions, GMC in the vicinity of a source…)
- diffuse-like emission (DE from the galactic disk, ridge, extragalactic DE…)

2) Experimental issues

DE can me mismatched from unresolved point sources! This depends on:

- the angular resolution and/or sensitivity

1999: OSSE find that 50% DE for soft γ-ray (<300 keV) [Kinzer *et al.*, ApJ **515**, 215]

2000: Hint at unresolved point sources

HIREGS [Boggs et al., ApJ **544**, 320] + OSSE&RXTE [Valinia *et al.*, ApJ **534**, 277]

2004: INTEGRAL find almost no diffuse emission [Lebrun, Terrier *et al.*, Nature **428**, 293]

- Analysis method and/or assumptions

2008: new EGRET analysis, 188 sources instead of 271! [Casandjian & Grenier, A&A **489**, 849]

A working definition for diffuse emission

Dictionary:

Diffuse = widely spread; not localized or confined; with no distinct margin

Astronomer:

“all emission that I cannot resolve into individual (point-) sources”

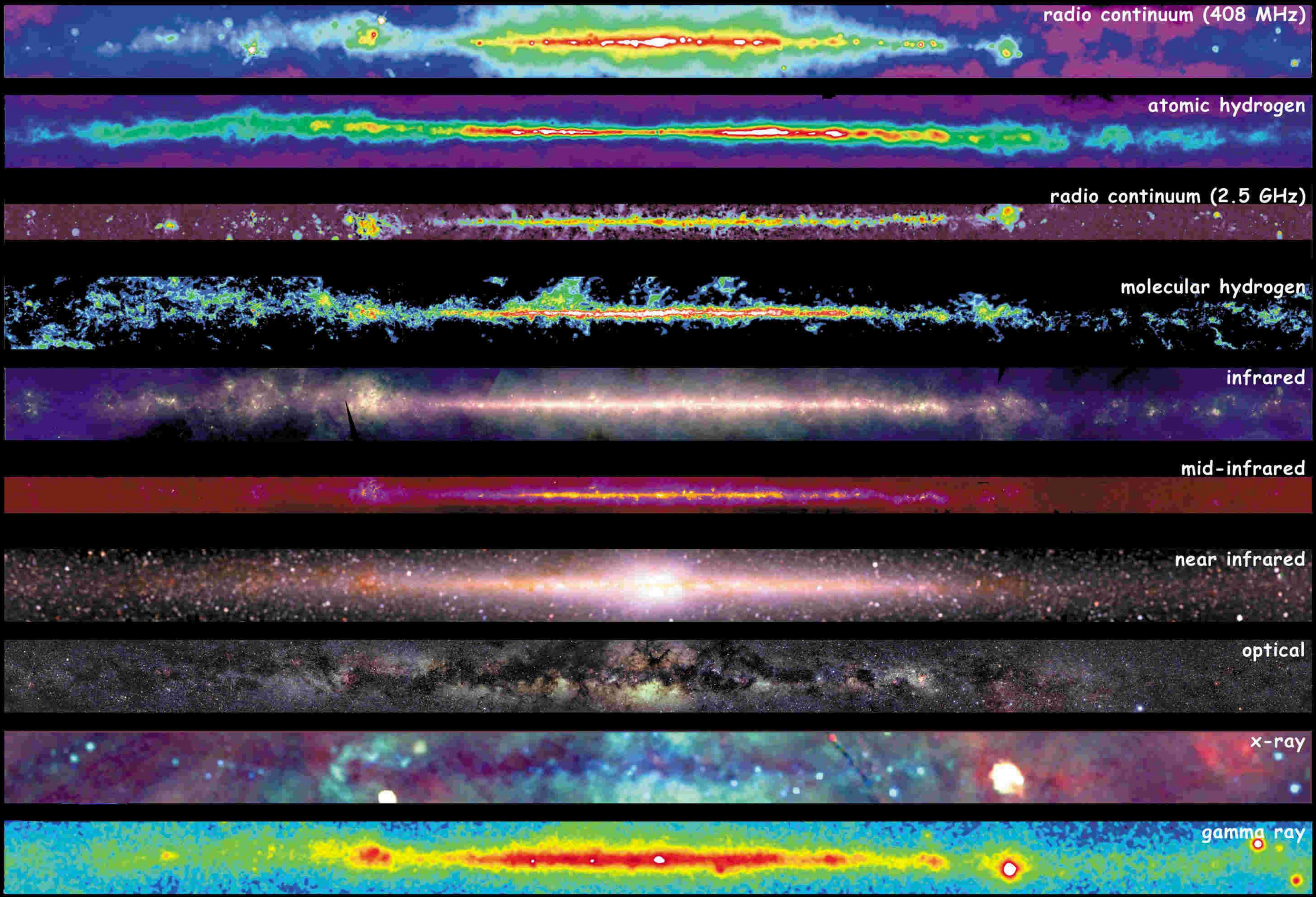
- depends on instrument characteristics (angular resolution, sensitivity)
- is not of much help for an astrophysicist

Astrophysicist:

“all emission processes that are related to interstellar (-planetary, -galactic) matter”

- emission of gaz and dust (thermal, non-thermal)
- emission related to magnetic fields (synchroton)
- emission related to diffuse stellar ejecta (particle diffusion)
- also applicable to extragalactic diffuse (e.g., intergalactic matter in clusters)
- also applicable for cosmic backgrounds (e.g., primordial matter for CMB)

A multi-wavelength view



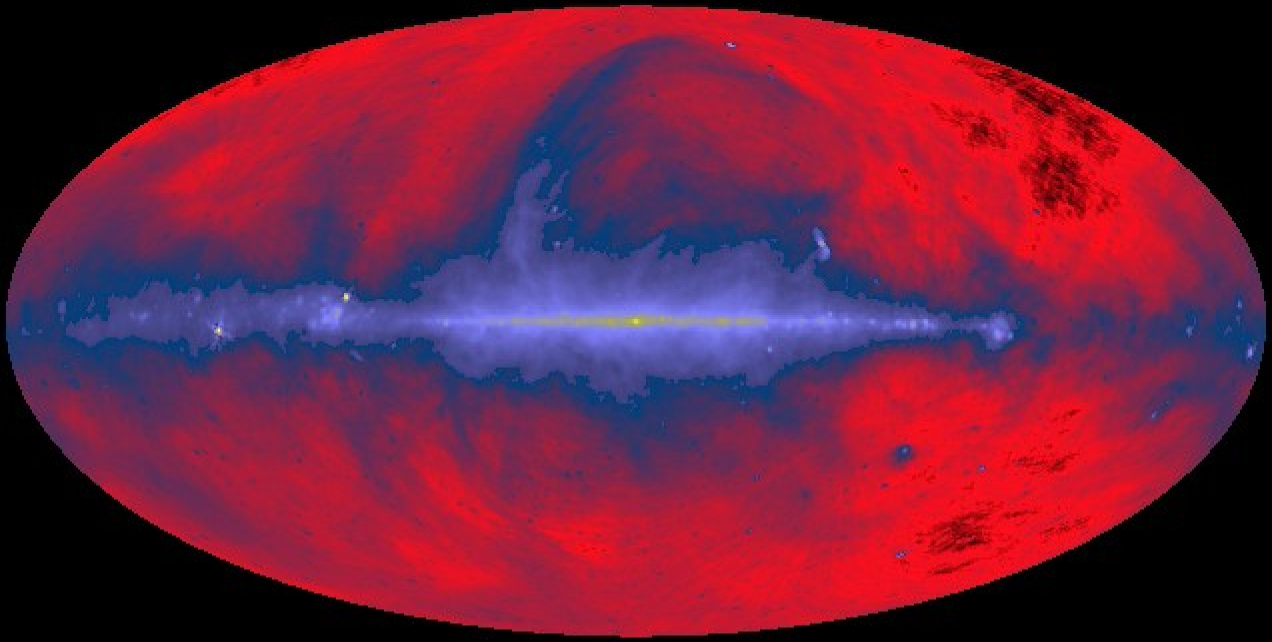
NASA website

=> Each wavelength brings a piece of information to the Milky-Way jigsaw

A multi-wavelength view

The diffuse radio sky (408 MHz)

APOD website (ap011020.html)



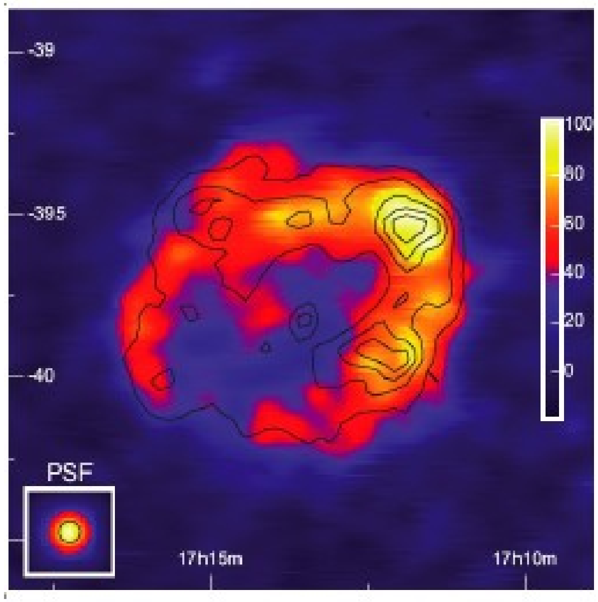
Near this frequency, cosmic radio waves are generated by high energy electrons spiraling along magnetic fields. Many of the bright sources near the plane are distant pulsars, star forming regions, and SN remnants. The grand looping structures are pieces of bubbles blown by local stellar activity

=> Proof that cosmic rays pervade a volume larger (~ few kpc) than the disc height

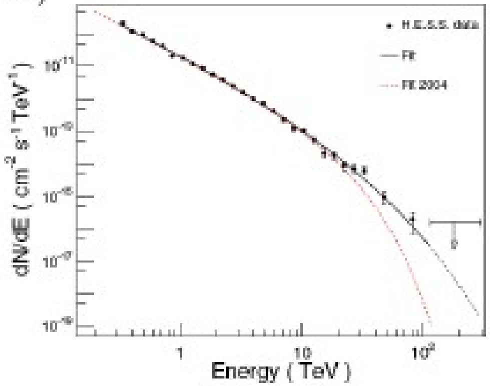
The standard sources of cosmic rays

SNRs with shell morphology in VHE γ-rays

RX J1713.7-3947 (or **G347.3-0.5**)



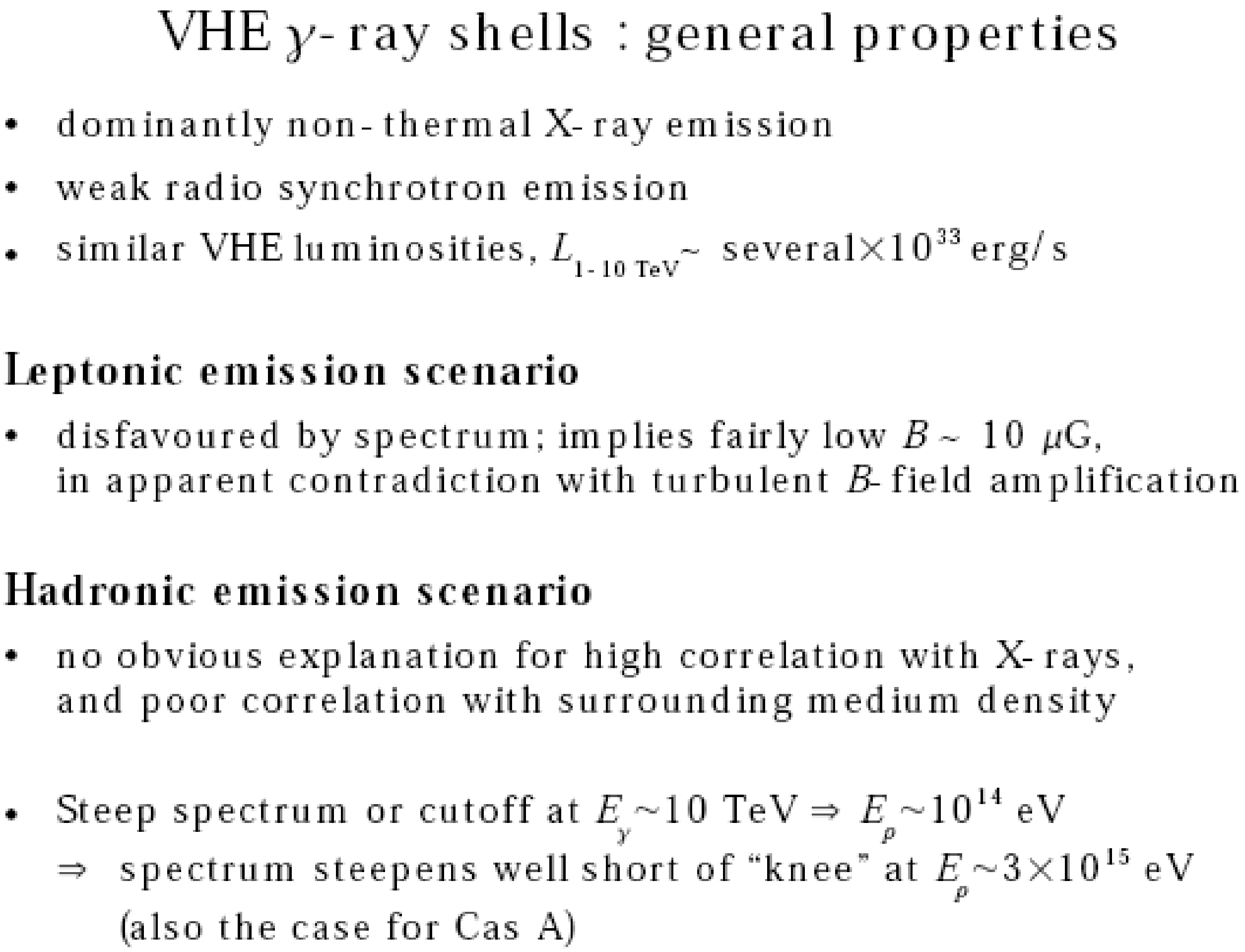
- VHE γ-ray emission discovered by *CANGAROO* (Muraishi et al. 2000)
- first resolved SNR shell in VHE γ-rays (*H.E.S.S.* 2004, *Nature* **432**, 75)
- very good spatial correlation with (non-thermal) X-rays (ASCA 1-3 keV) (*H.E.S.S.* 2006, *A&A* **449**, 223)
- large zenith angle observations ⇒ spectrum 0.3–100 TeV (*H.E.S.S.* 2007, *A&A* **449**, 223)



- power law $\Gamma \approx 2.0$ with cutoff or break at $E_\gamma \sim 10$ TeV (depending on model)
- $L_{1-10\ \mathrm{TeV}} \sim 10^{34}$ erg/s (assuming $D \approx 1.3$ kpc)
- leptonic emission scenario ⇒ $B \sim 9\ \mu\mathrm{G}$

Y. Gallant & V. Tatischeff

Properties of SNRs



VHE γ-ray shells : general properties

- dominantly non-thermal X-ray emission
- weak radio synchrotron emission
- similar VHE luminosities, $L_{1-10\ \mathrm{TeV}} \sim$ several$\times 10^{33}$ erg/s

Leptonic emission scenario

- disfavoured by spectrum; implies fairly low $B \sim 10\ \mu$G, in apparent contradiction with turbulent B-field amplification

Hadronic emission scenario

- no obvious explanation for high correlation with X-rays, and poor correlation with surrounding medium density

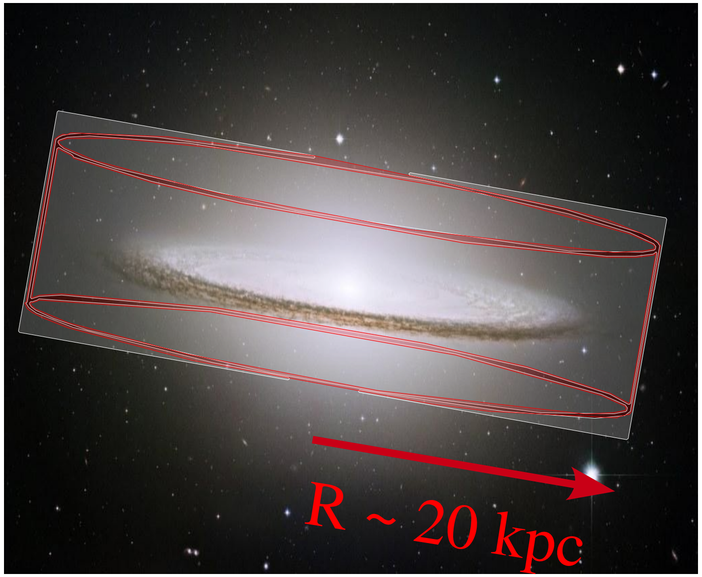
- Steep spectrum or cutoff at $E_\gamma \sim 10$ TeV $\Rightarrow$ $E_p \sim 10^{14}$ eV
  $\Rightarrow$ spectrum steepens well short of “knee” at $E_p \sim 3\times 10^{15}$ eV
  (also the case for Cas A)

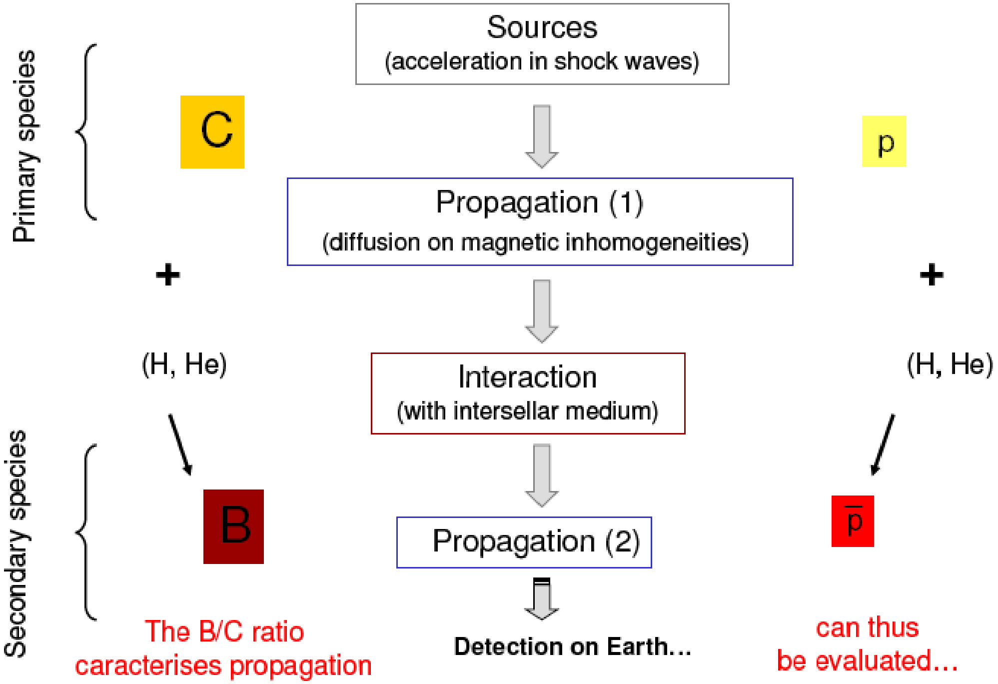
Y. Gallant & V. Tatischeff

Cosmic ray propagation

1. Parameters

Updated study of B/C to re-evaluate the antiproton flux





Primary species

C

Sources
(acceleration in shock waves)

p

Propagation (1)
(diffusion on magnetic inhomogeneities)

+

(H, He)

Interaction
(with intersellar medium)

+

(H, He)

Secondary species

B

Propagation (2)

$\bar{p}$

The B/C ratio
caracterises propagation

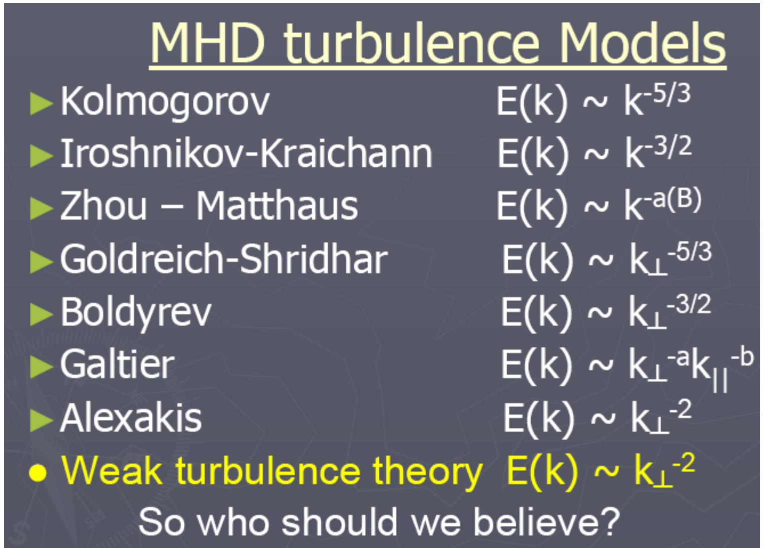
Detection on Earth…

can thus
be evaluated…

D. Maurin

Cosmic ray propagation

1. Parameters … from transport theory (MHD)



MHD turbulence Models

▶ Kolmogorov	$E(k) \sim k^{-5/3}$
▶ Iroshnikov-Kraichann	$E(k) \sim k^{-3/2}$
▶ Zhou – Matthaus	$E(k) \sim k^{-a(B)}$
▶ Goldreich-Shridhar	$E(k) \sim k_\perp^{-5/3}$
▶ Boldyrev	$E(k) \sim k_\perp^{-3/2}$
▶ Galtier	$E(k) \sim k_\perp^{-a} k_{\|\|}^{-b}$
▶ Alexakis	$E(k) \sim k_\perp^{-2}$
● Weak turbulence theory	$E(k) \sim k_\perp^{-2}$

So who should we believe?

- $E \sim k_\perp^{-5/3}$

  Cho, J., & Vishniac, E. T. (2000)
  Muller, W.-C. & Biskamp, D., (2000)

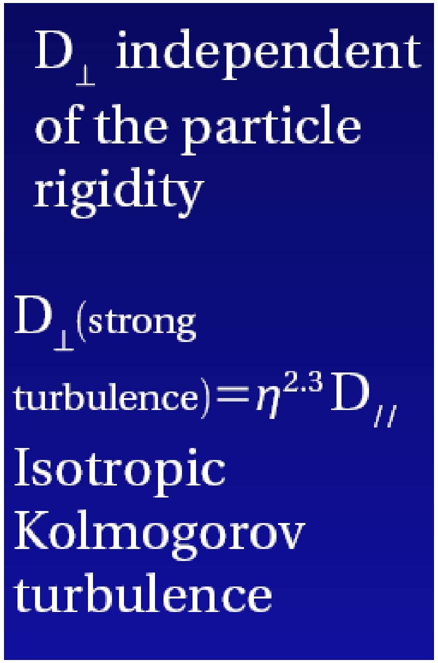
- $E \sim k_\perp^{-3/2}$

  Maron, J., & Goldreich, P. (2001)
  Muller, W.-C., Biskamp, D., & Grappin, R., (2003)
  Muller, W.-C. & Grappin, R., (2005)

- $E \sim k_\perp^{-2}$

  Ng, C. S., & Bhattacharjee, A. (1996)
  Dmitruk, P., Gomez, D. O., & Matthaeus, W. H. (2003),
  J. C. Perez and S. Boldyrev (2008).

Diffusion on magnetic turbulences not yet well understood. Anisotropy issue, while anisotropy may be inefficient to confine cosmic rays.



$D_\perp$ independent of the particle rigidity

$D_\perp$(strong turbulence)$=\eta^{2.3} D_{//}$

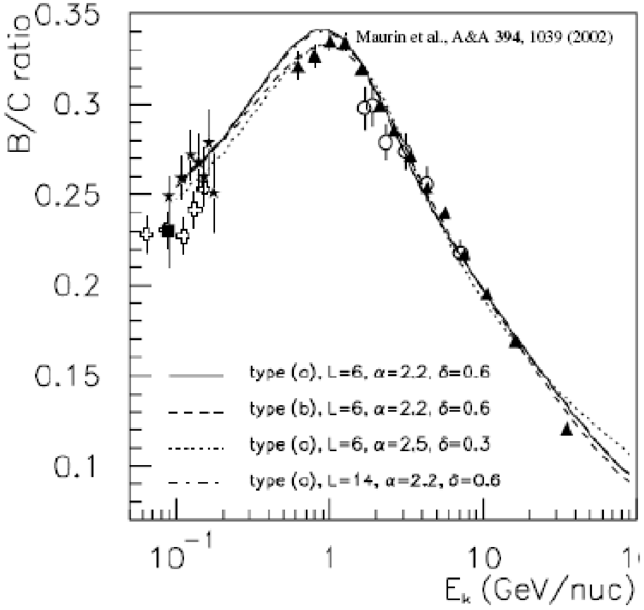
Isotropic Kolmogorov turbulence

A. Marcowith & A. Alexakis

Cosmic ray propagation

1. Parameters ... from II^{ary}/I^{ary} data

Propagation parameters
adjusted to fit the data



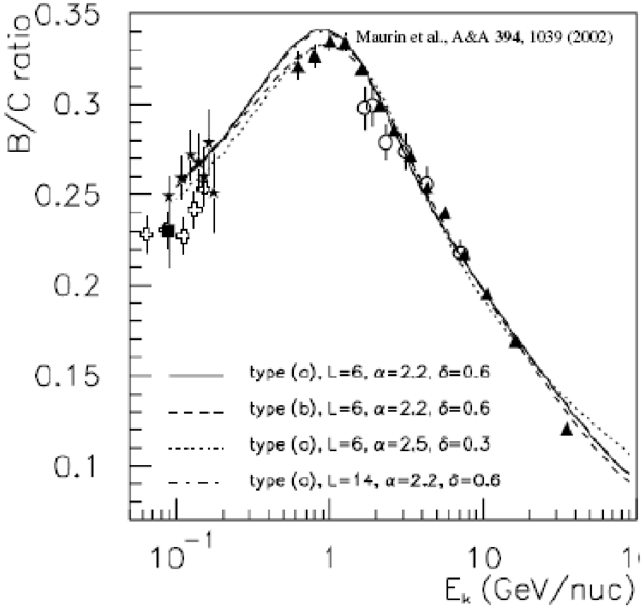
No more free parameters

D. Maurin

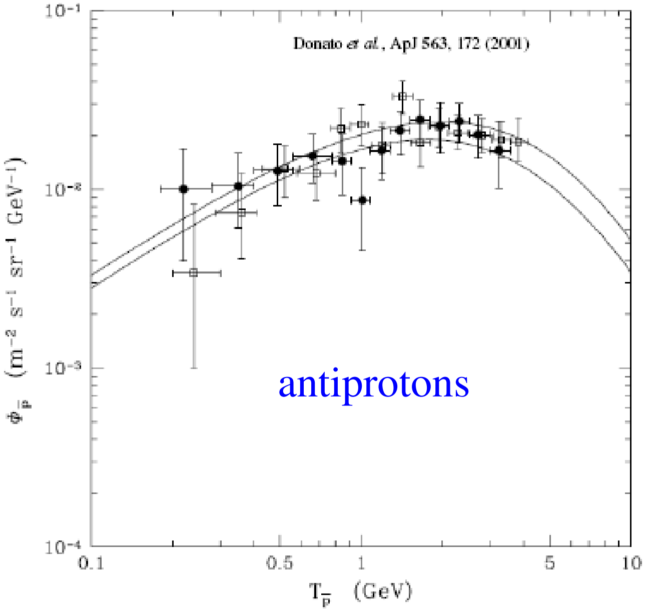
Cosmic ray propagation

2. ... to predictions (anti-nuclei)

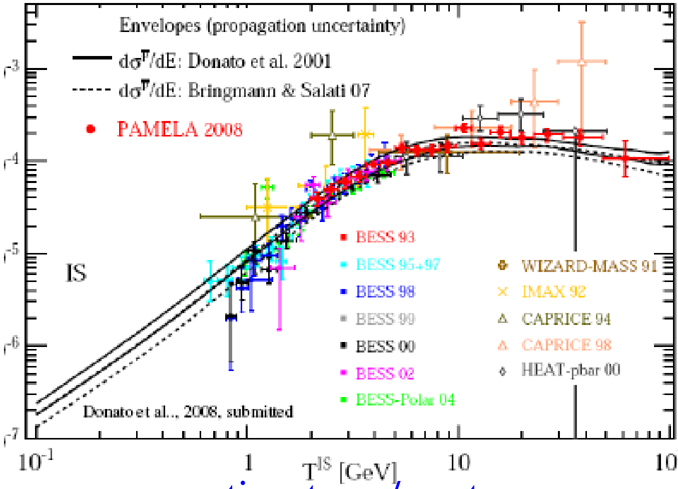
Propagation parameters adjusted to fit the data



No more free parameters



antiprotons

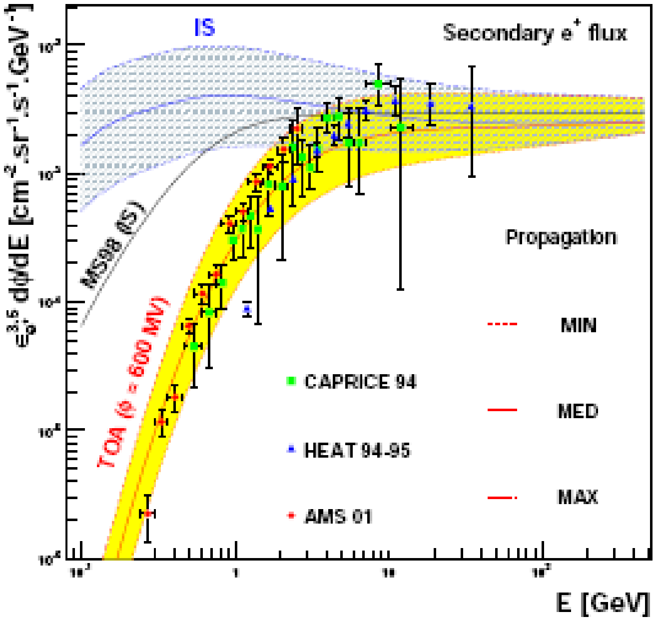


antiprotons / protons

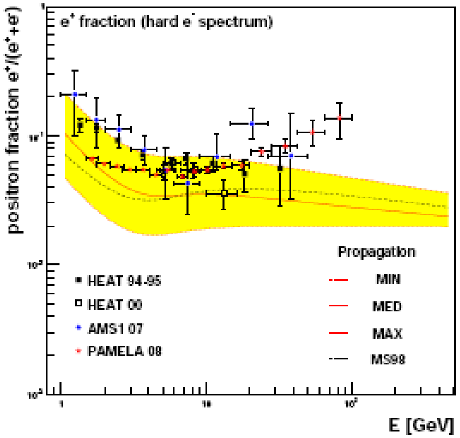
D. Maurin

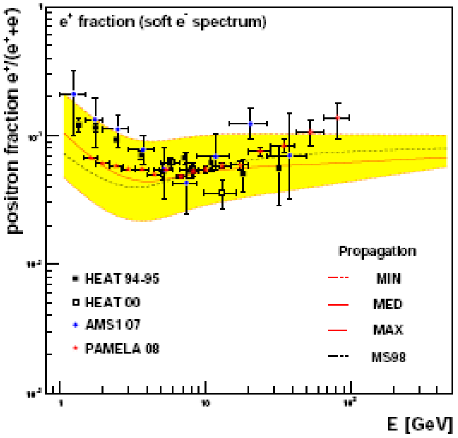
Cosmic ray propagation
2. ... to predictions (positrons)

arXiv:0809.5268



the Alpine connection model
(Annecy & Torino)

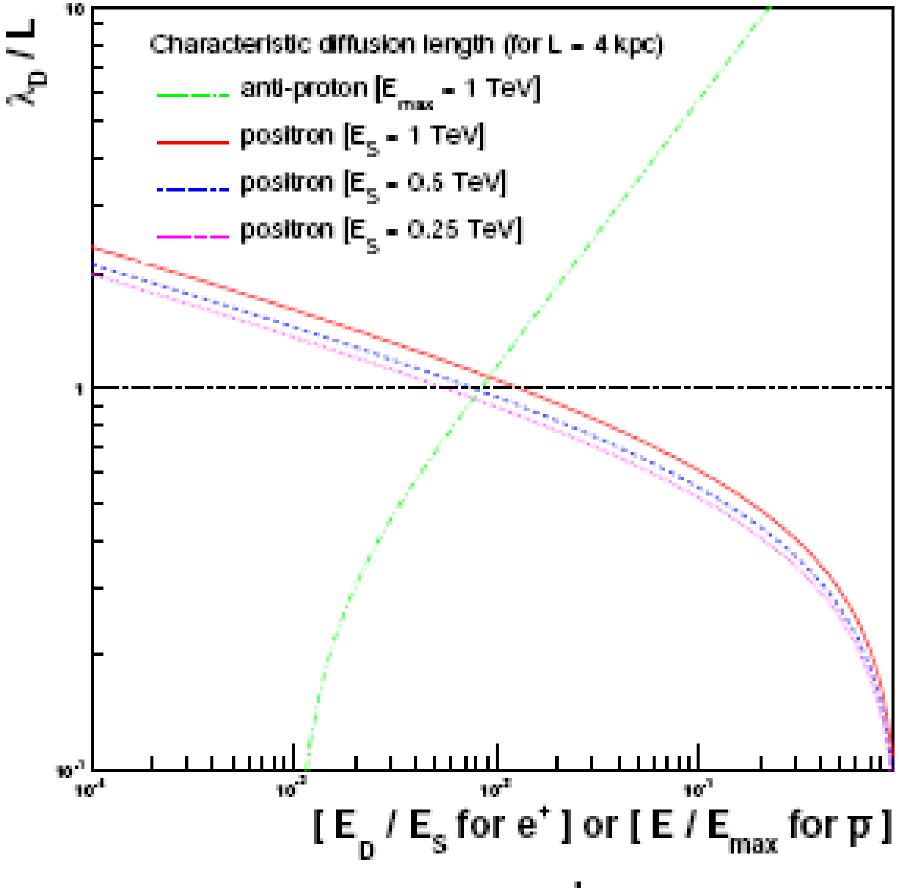




by Oscar Wilde

T. Delahaye

Cosmic ray propagation
3. Relevant scales and processes for diffuse γ-ray emission



Above few GeV, **protons can diffuse very far without losing energy**. Their spectrum is **not expected to vary much** in the Milky Way.

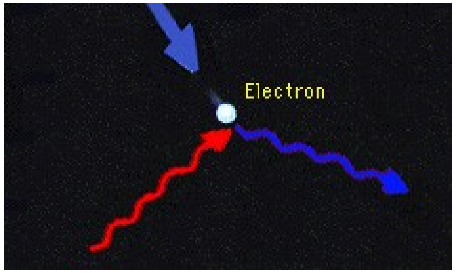
On the contrary, **high energy electrons lose very quickly their energy, which limits their horizon.** Their spectrum is essentially local, and **may vary from place to place** with respect to the distribution on nearby sources.

Diffuse emission processes

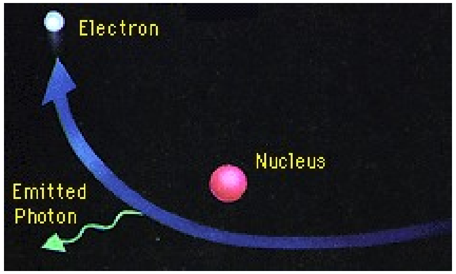
Continuum emission

Interaction of high-energy CR **electrons** and **nucleons** with gas and radiation in the ISM:

Inverse Compton **electron** scattering



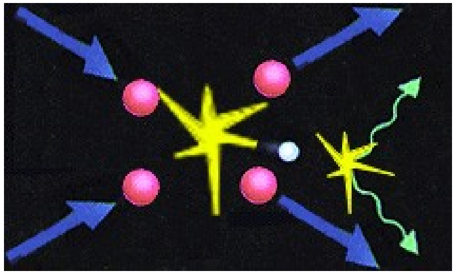
electron Bremsstrahlung



Pion (π^0) production and decay

$p + p \rightarrow p + p + \pi^0 \rightarrow$

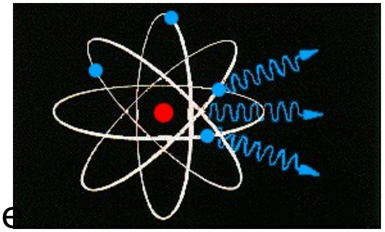
$E_p > 300$ MeV



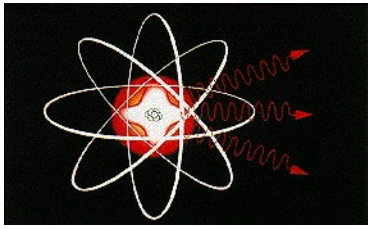
Line emission

Excitation of **electrons** and **nucleons** in an atom; antimatter **annihilation**:

ionic lines (below 10 keV)

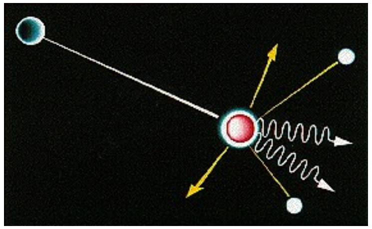


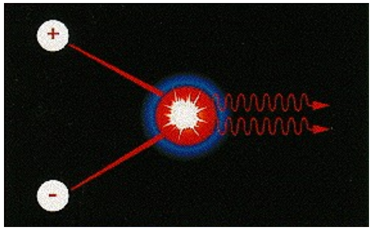
nuclear radioactive decay



nuclear excitation

positron-electron **annihilation** (511 keV line)





J. Knodlseder

$\gamma - e^{+/-}$ interactions

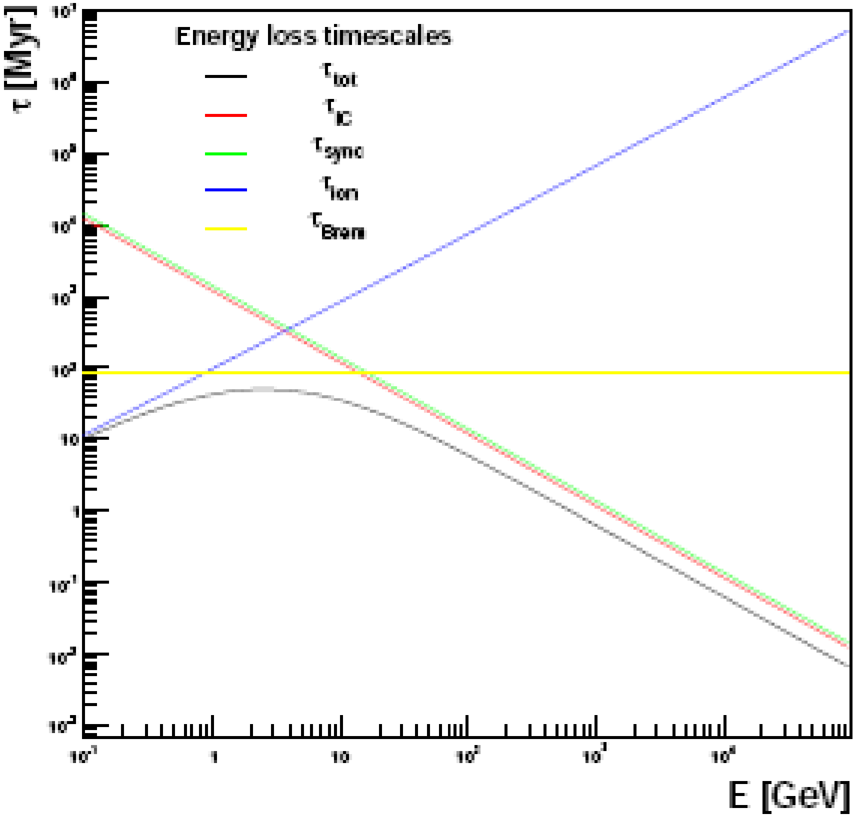
Generating photons from $e^{+/-}$: **Bremsstrahlung**

- electron - electron — $\propto E\ln(E)$
- electron - nuclei — $\propto E$

Boosting up a low energy photon (IR, CMB, virtual)

- **Inverse Compton** (CMB, IR)
  $E \to E' \propto \gamma^2 E$
  CMB $\sim 10^{-4}$ eV $\xrightarrow{1\ \mathrm{TeV}\ e^-}$ 1 GeV
  IR $\sim 10^{-1}$ eV $\xrightarrow{1\ \mathrm{TeV}\ e^-}$ 1 TeV
- **Synchrotron** off magnetic field (virtual photons) $E \to E' \propto \gamma^2 B^2 E$ — Sub-MeV
- **Electrostatic Bremsstrahlung** (electrostatic waves in plasma) $E \to E' \propto \gamma^2 E$

⇒ **The knowledge of the spatial dependence of the gas and radiation field is of paramount importance.**



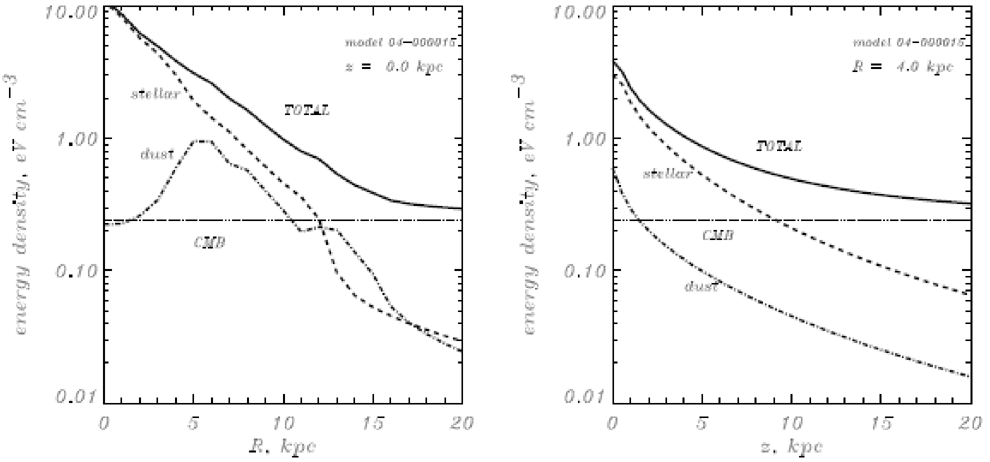
The interstellar radiation field (ISRF)

The Galactic ISRF is the result of emission by stars, and the scattering, absorption, and reemission of absorbed starlight by dust in the ISM.

Strong, Moskalenko, and Reimer, ApJ **537**, 763 (2000)

Major components:

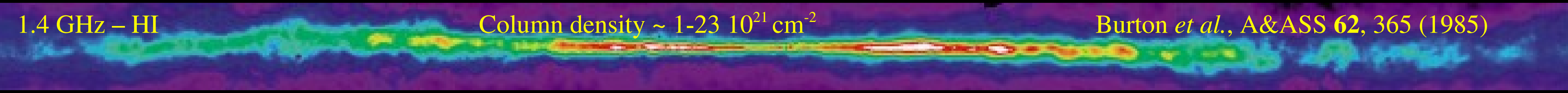
- CMB @ 2.7 K
- FIR (from cold dust emission)
- NIR, optical and UV



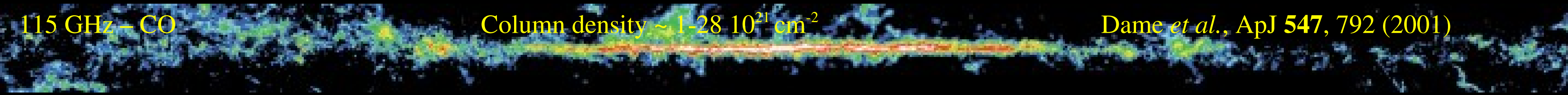
Spatial distribution: ~ stellar disk

A multi-wavelength view

Atomic (21 cm) and molecular hydrogen (CO)



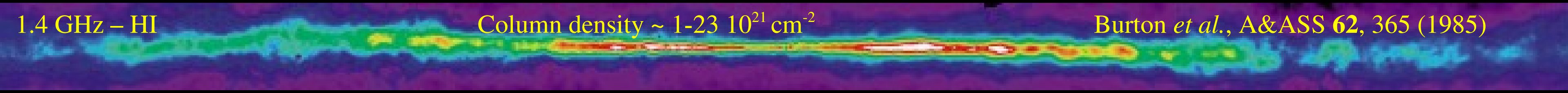
The 21-cm emission traces the "cold and warm" interstellar medium, which on a large scale is organized into diffuse clouds of gas and dust that have sizes of up to hundreds of light-years



H2 inferred from the intensity of the J =1-0 spectral line of CO, a standard tracer of the cold, dense parts of the ISM. The molecular gas is pre-dominantly H2, but H2 is difficult to detect directly at interstellar conditions. CO, the second most abundant molecule, is observed as a surrogate.

A multi-wavelength view

Atomic (21 cm) and molecular hydrogen (CO)



1.4 GHz – HI

Column density ~ 1-23 10^{21} cm^{-2}

Burton *et al.*, A&ASS **62**, 365 (1985)

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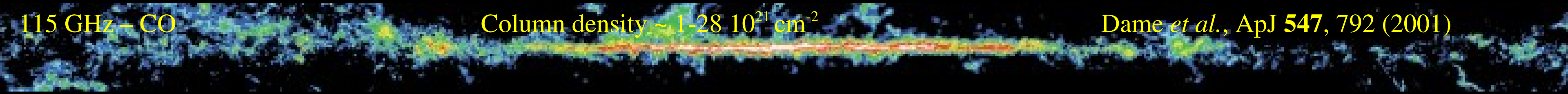


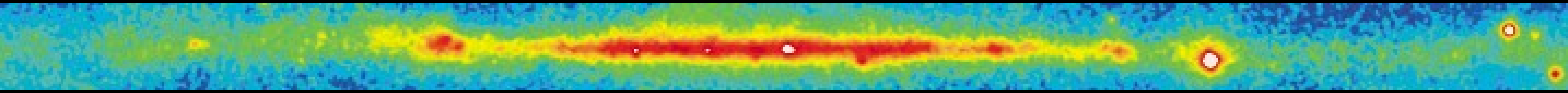
115 GHz – CO

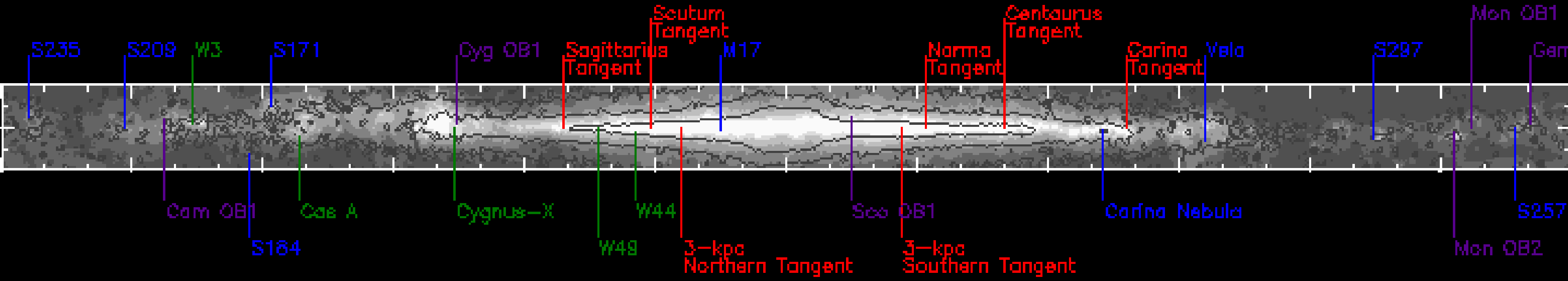
Column density ~ 1-28 10^{21} cm^{-2}

Dame *et al.*, ApJ **547**, 792 (2001)

H2 inferred from the intensity of the J =1-0 spectral line of CO, a standard tracer of the cold, dense parts of the ISM. The molecular gas is pre-dominantly H2, but H2 is difficult to detect directly at interstellar conditions. CO, the second most abundant molecule, is observed as a surrogate.

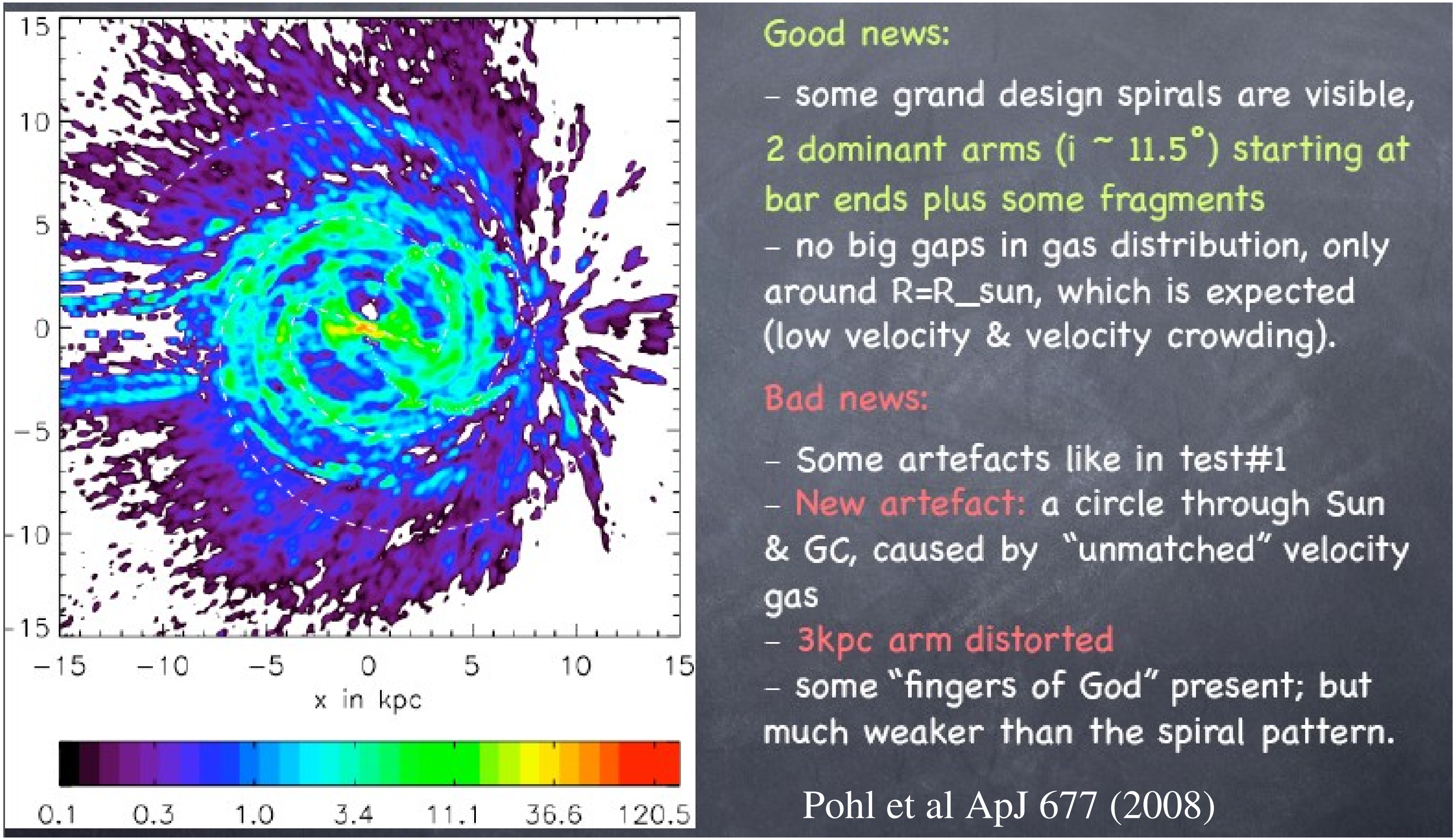
=> The HI and CO maps are strongly correlated to the γ-ray map (> 100 MeV)





Model of gas distribution in the Milky Way

CO data + gas flow modelling



Good news:

- some grand design spirals are visible, 2 dominant arms (i ~ 11.5°) starting at bar ends plus some fragments
- no big gaps in gas distribution, only around R=R_sun, which is expected (low velocity & velocity crowding).

Bad news:

- Some artefacts like in test#1
- New artefact: a circle through Sun & GC, caused by "unmatched" velocity gas
- 3kpc arm distorted
- some "fingers of God" present; but much weaker than the spiral pattern.

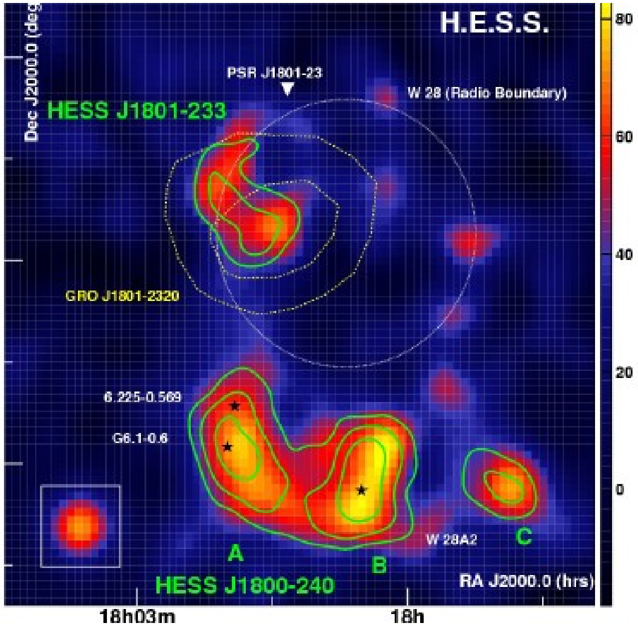
Pohl et al ApJ 677 (2008)

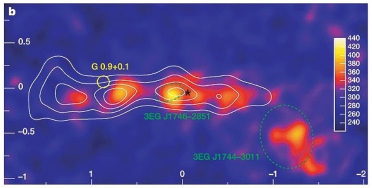
P. Englmaier & K. Ferrière

TeV observations of molecular clouds ?

W28 proton-shooting molecular clouds ?

- Molecular clouds in the vicinity of SNRs could help disentangle leptonic and hadronic scenarios





GC center ridge
(Aharonian et al 06)

SNR

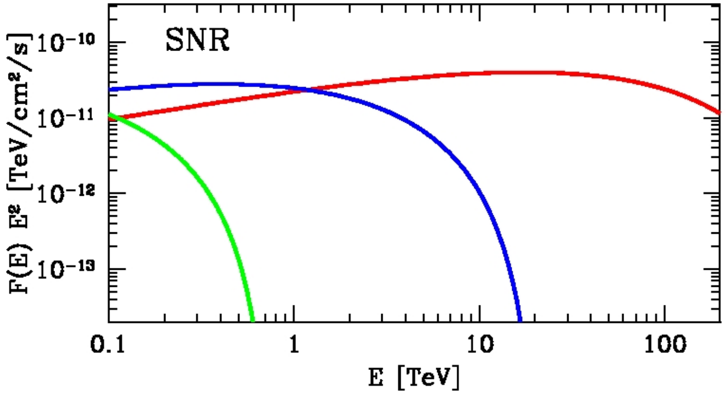
CLOUD

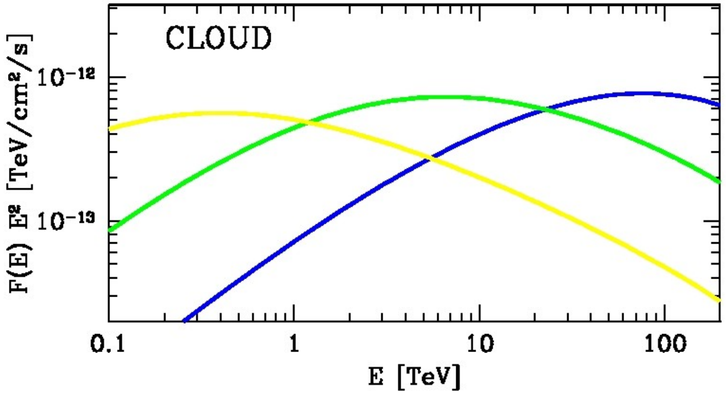
400 yrs

2000 yrs

8000 yrs

32000 yrs





S. Gabici & A. Fiasson

Linking the 3D gas distribution to the spectrum ...

- *Calculating the Emissivity $Q_\gamma(E,\mathbf{r})$ requires astrophysical inputs in 3+1 D*

  - 3D spatial coordinates
  - E coordinate

  ⇛ Data hypercube...

=>3D distributions are not easy to obtain!

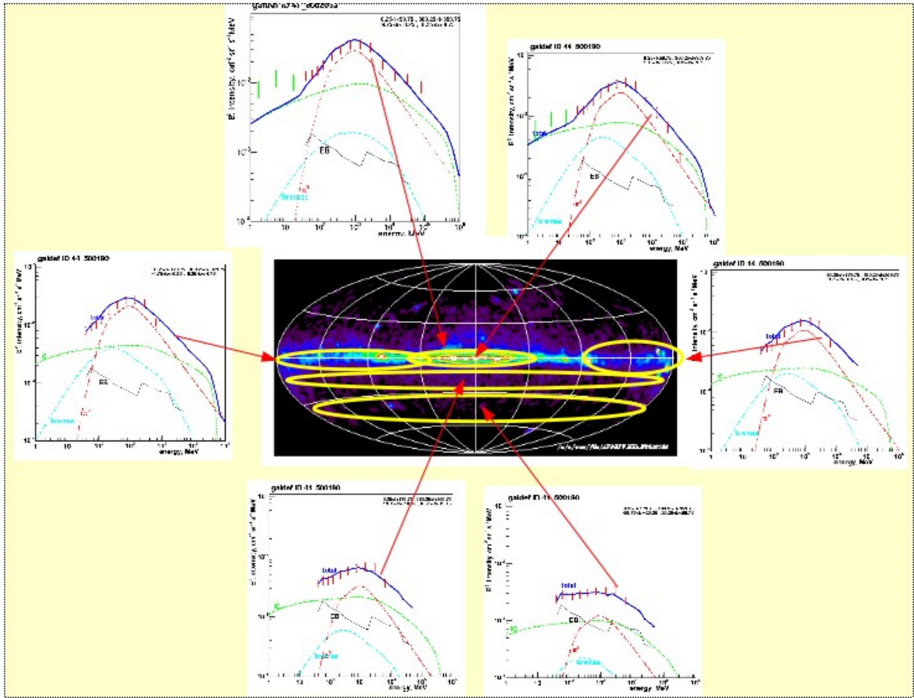
- *Vizualizing the intensity $I_\gamma(E,l,b)$ requires displays in 2+1 D*

  - 2D directions
  - E coordinate

  ⇛ Data cube

=> Only 2D representation!

- One spectrum in each direction
- One sky map for each energy

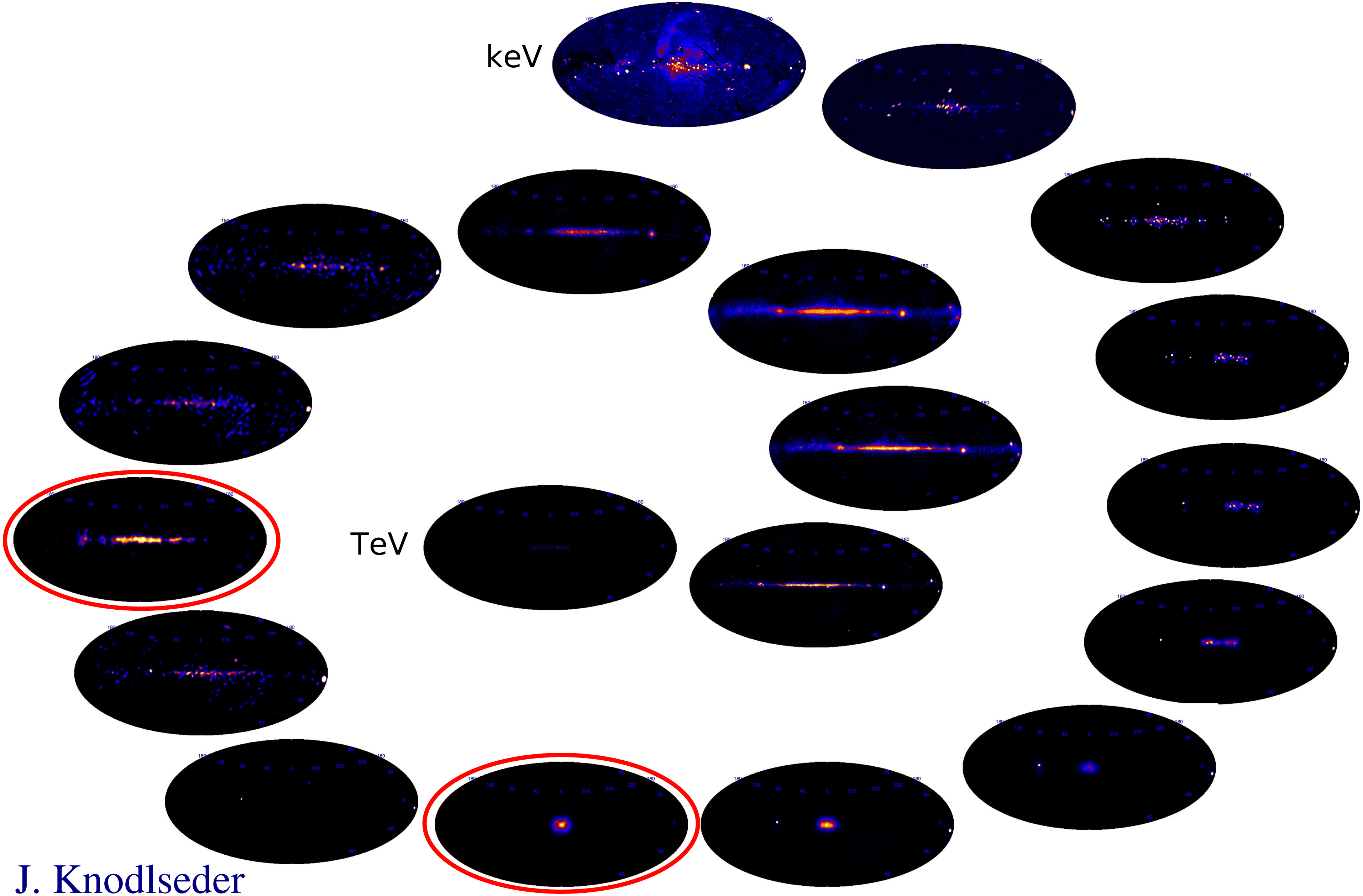


Galactic coordinates *(l,b)*

Gal. Center: GC = (*0°, 0°*)
Gal. Anticenter: GA = *(180°, 0°)*
North Gal. Pole: NGP = (*0°,90°*)

D. Maurin

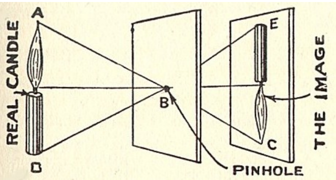
A high-energy gallery of the sky

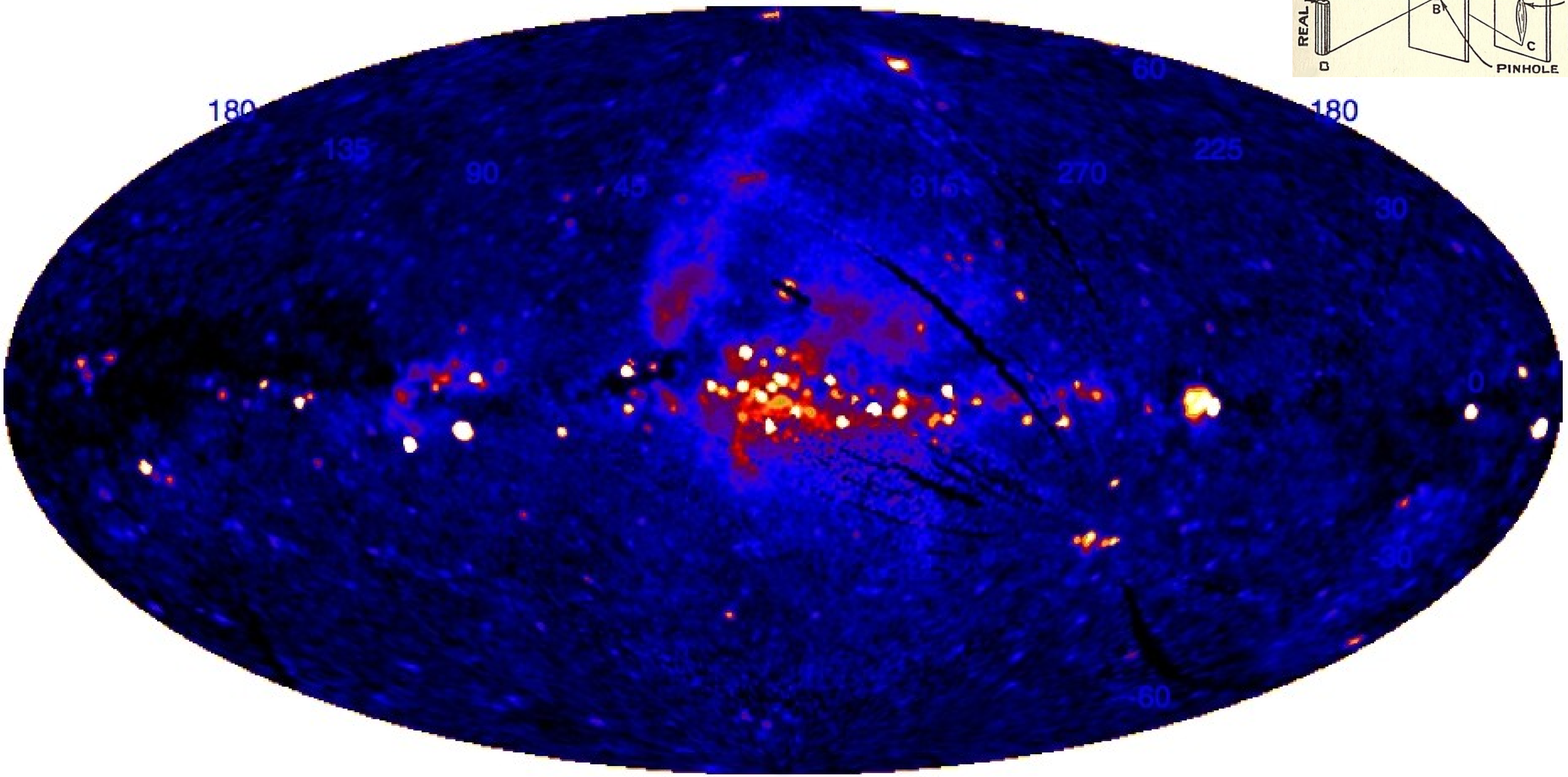


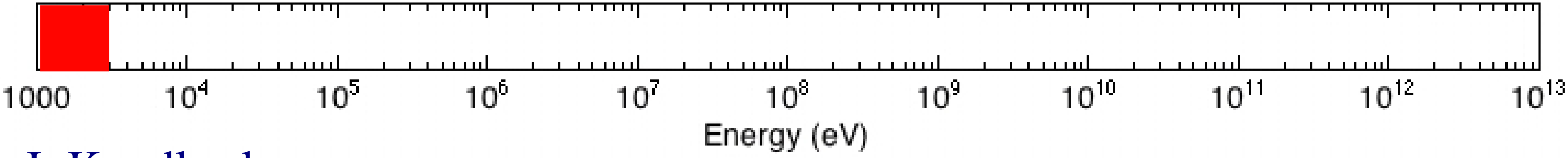
J. Knodlseder

The Soft X-Ray Sky (1 - 3 keV)

ROSAT



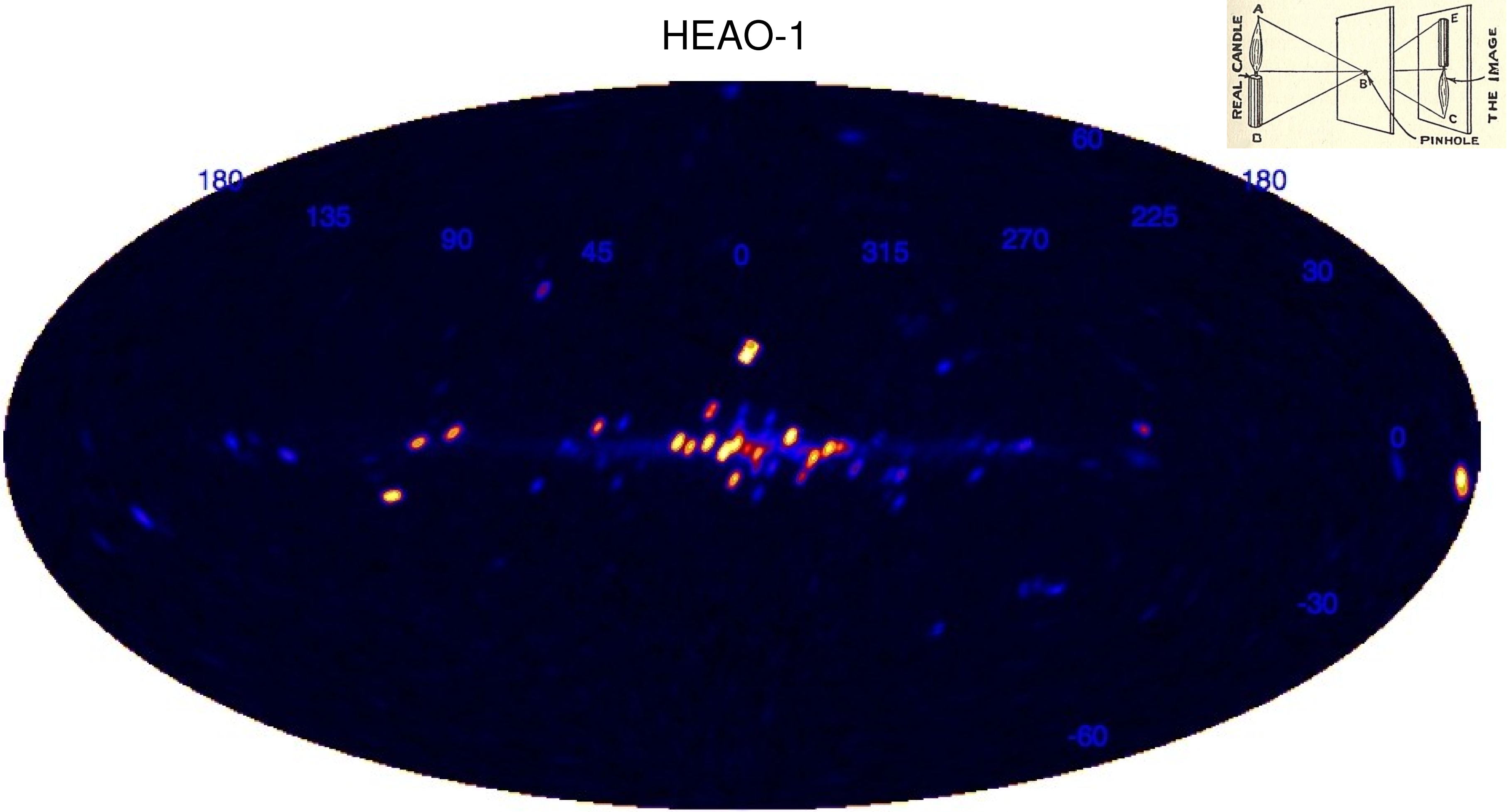


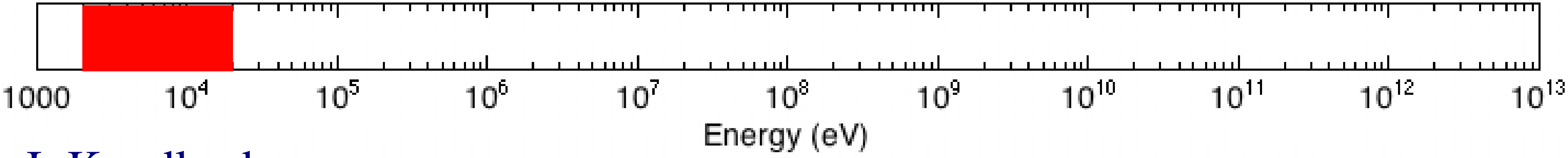


J. Knodlseder

The X-Ray Sky (2 - 20 keV)

HEAO-1

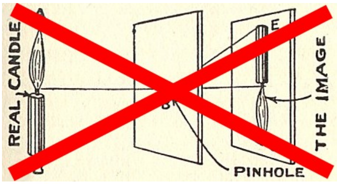


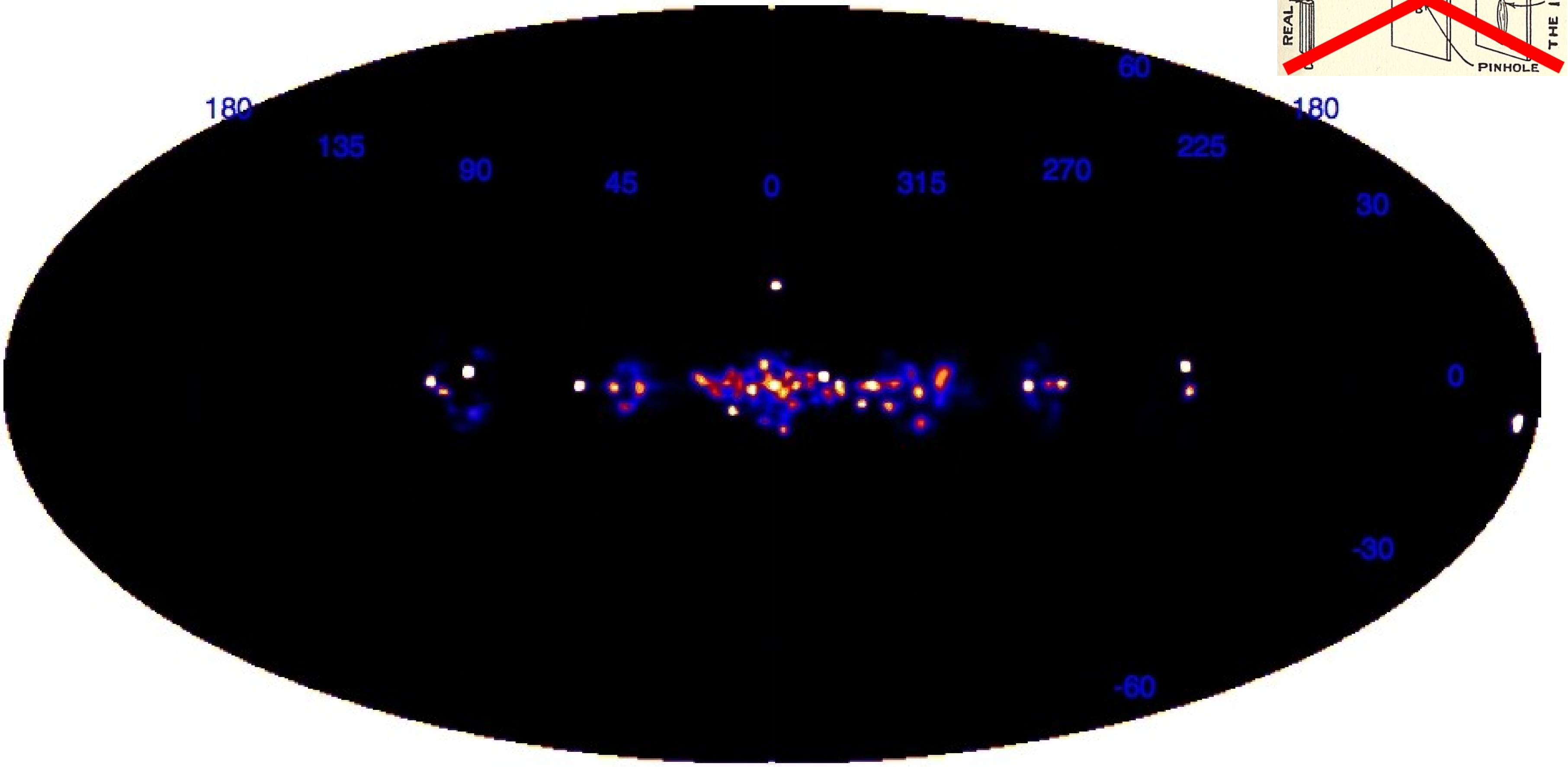


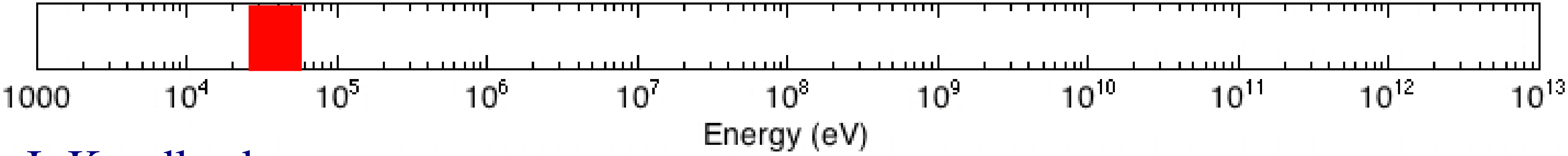
J. Knodlseder

The Hard X-Ray Sky (25 - 50 keV)

SPI / INTEGRAL (2 yr)



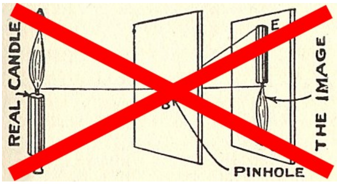


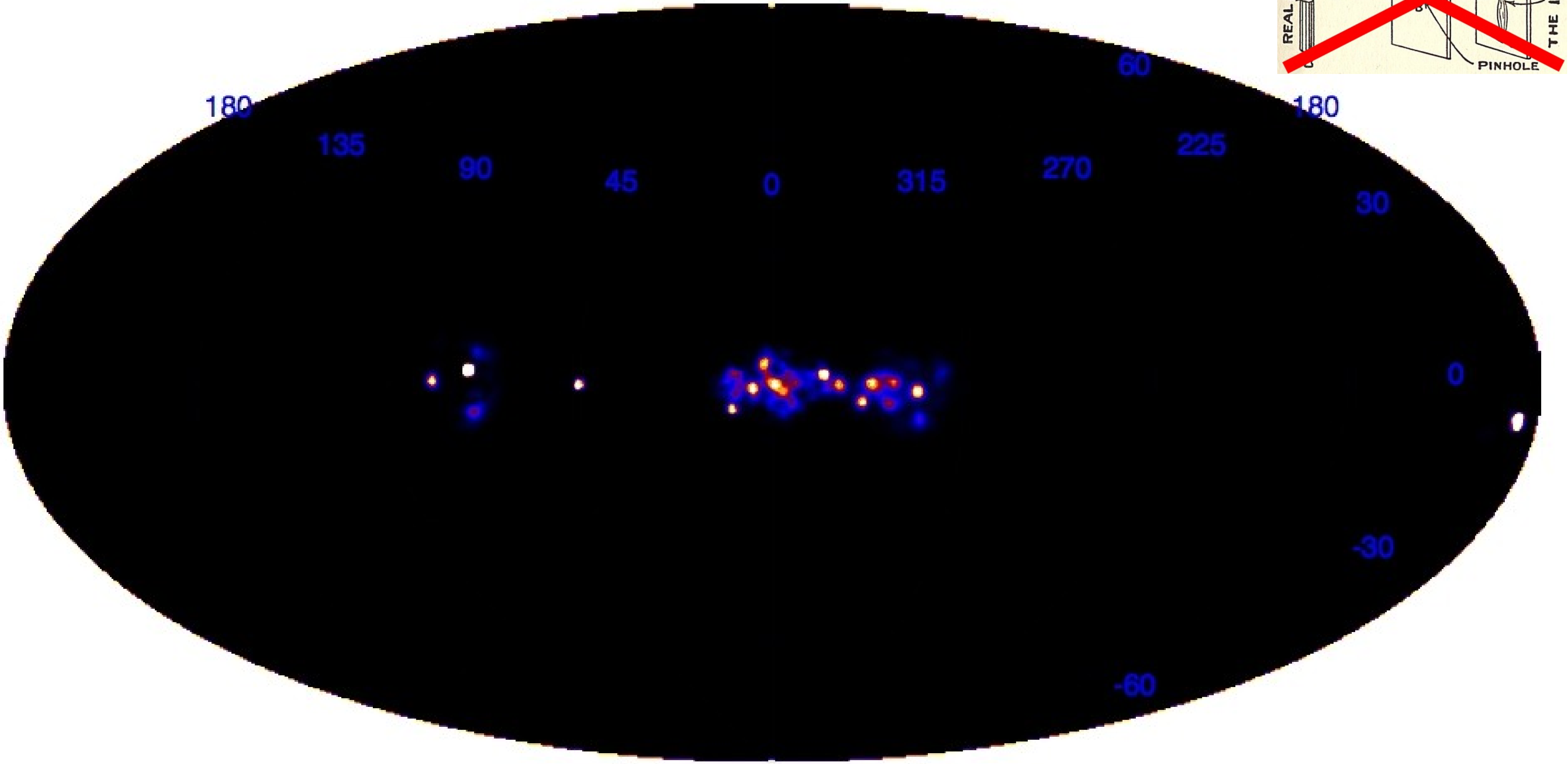


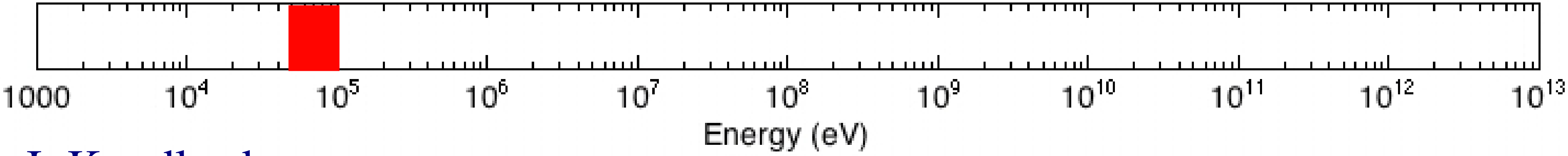
J. Knodlseder

The Hard X-Ray Sky (50 - 100 keV)

SPI / INTEGRAL (2 yr)



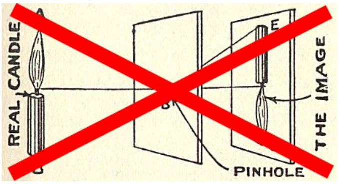


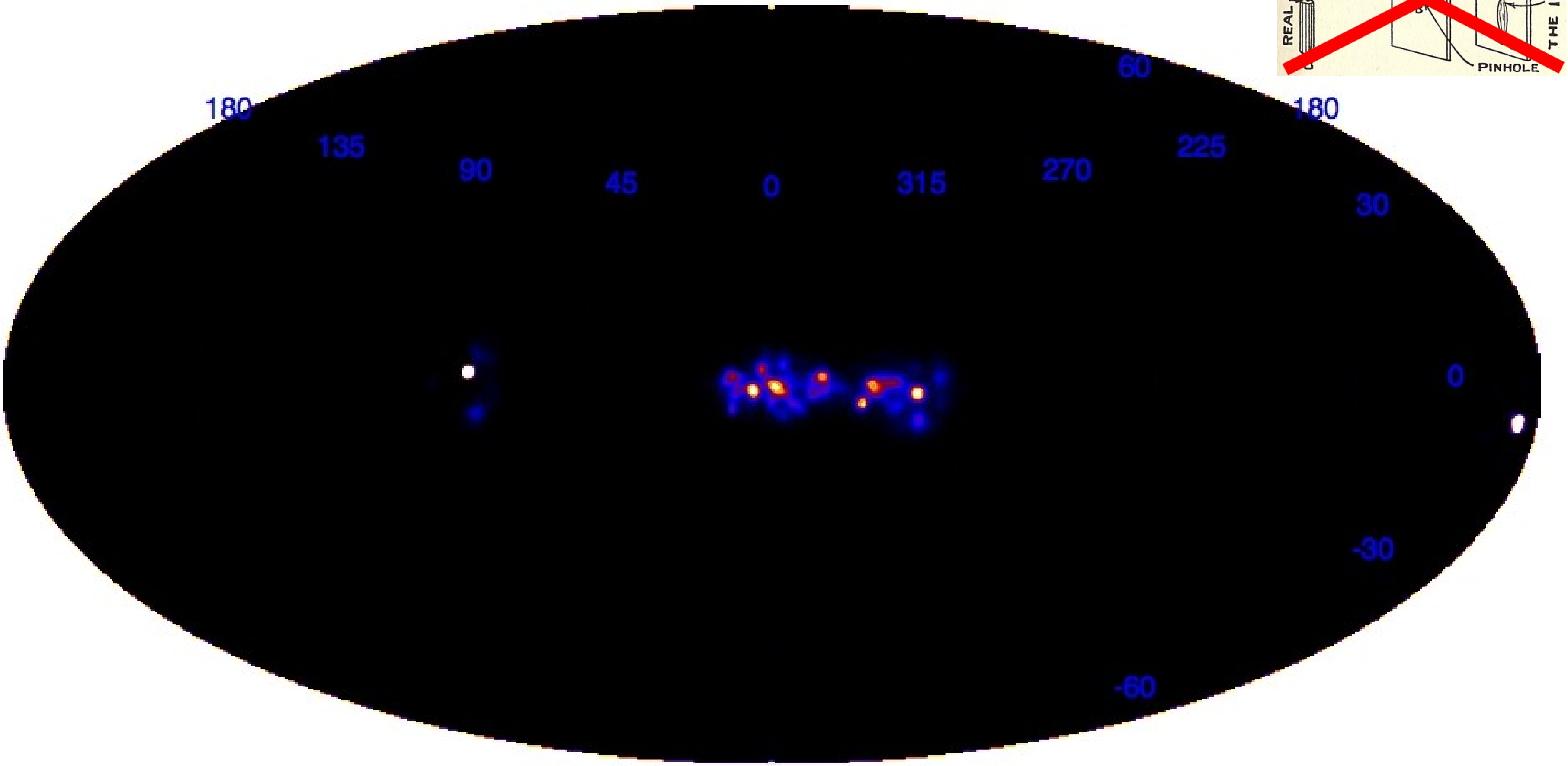


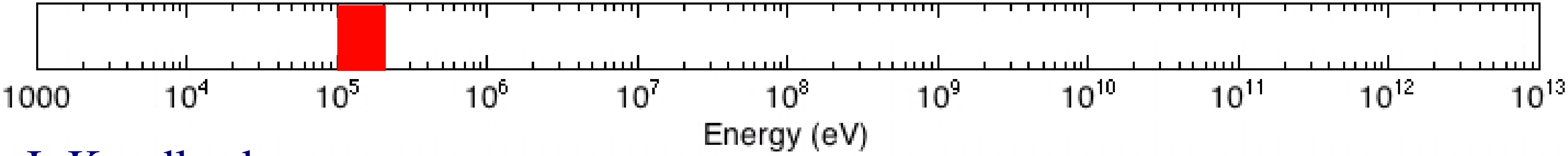
J. Knodlseder

The Hard X-Ray Sky (100 - 200 keV)

SPI / INTEGRAL (2 yr)



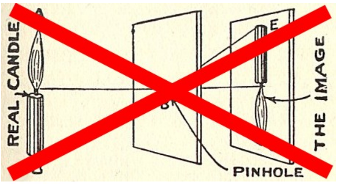


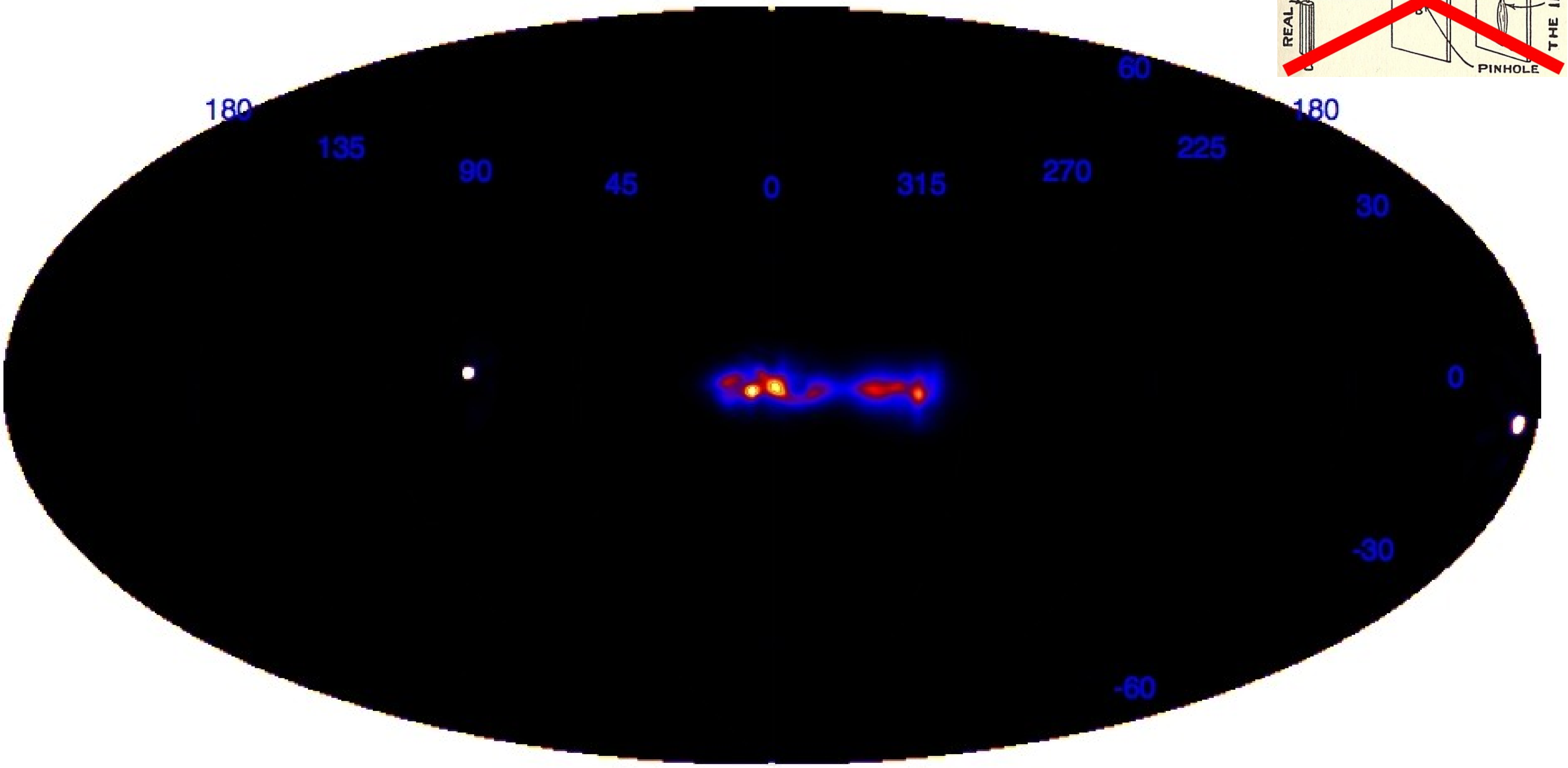


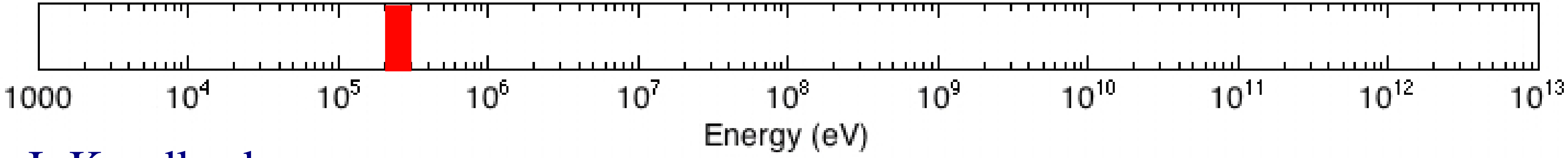
J. Knodlseder

The Hard X-Ray Sky (200 - 300 keV)

SPI / INTEGRAL (2 yr)



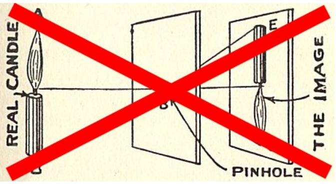


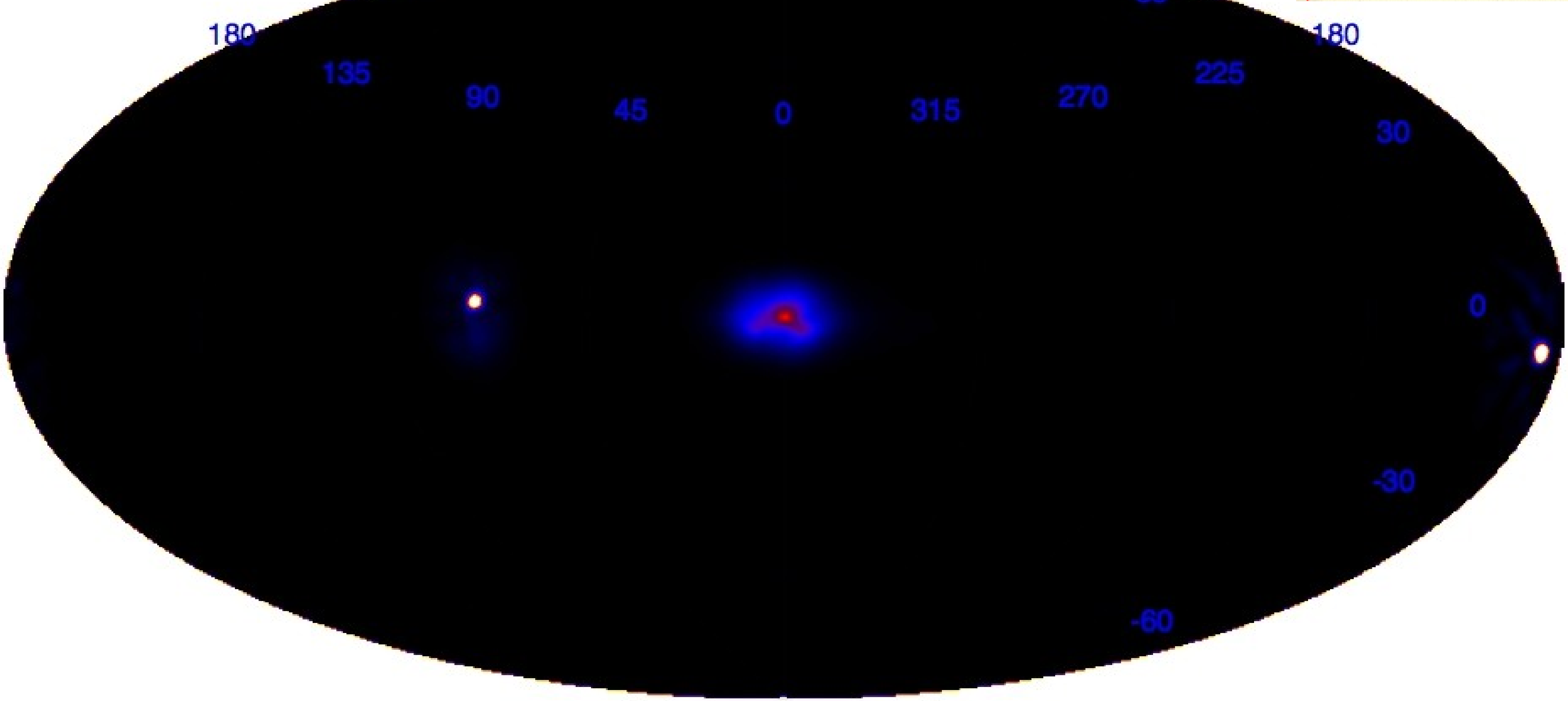


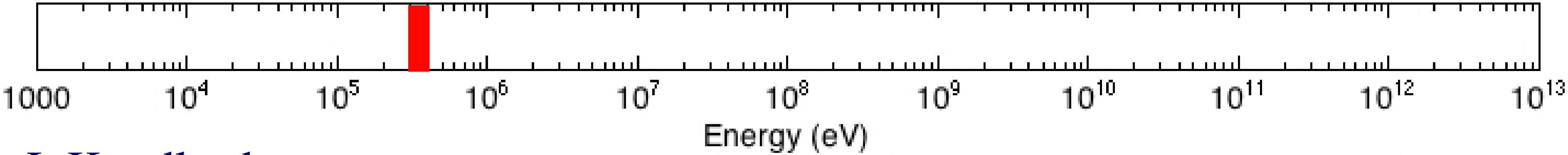
J. Knodlseder

The Gamma-Ray Sky (300 - 400 keV)

SPI / INTEGRAL (2 yr)

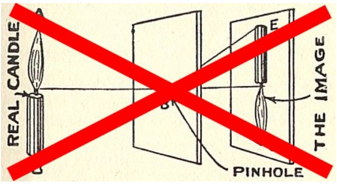




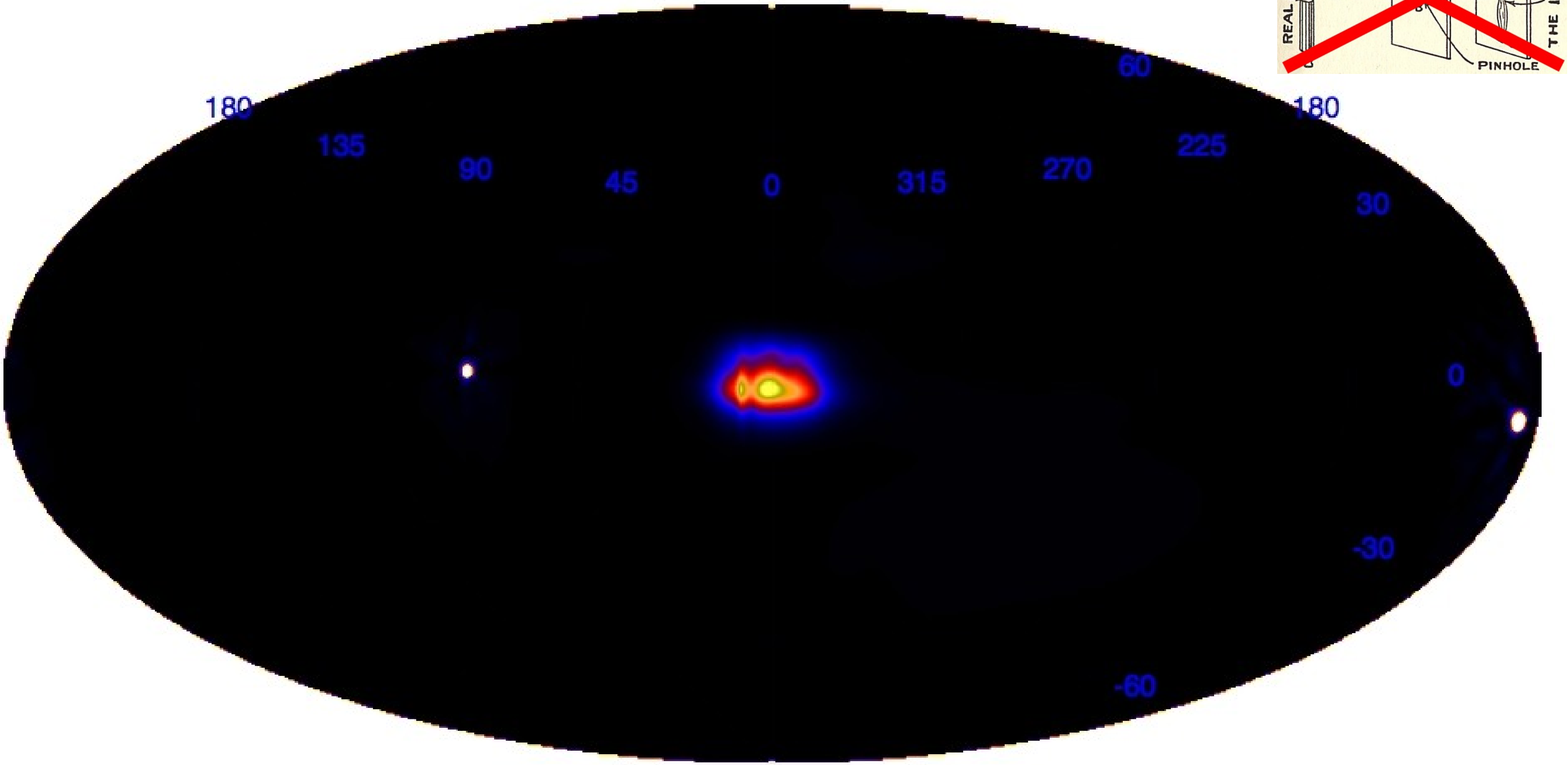


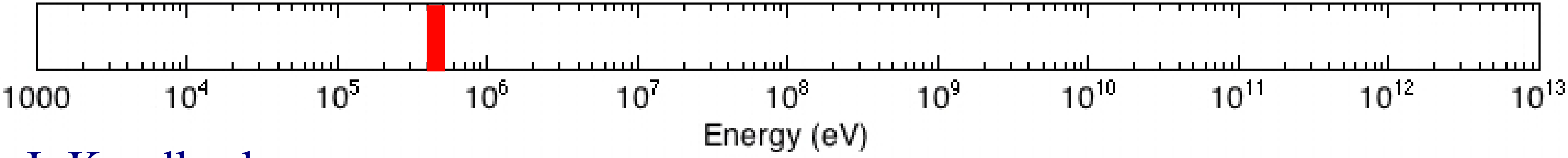
J. Knodlseder

The Gamma-Ray Sky (400 - 500 keV)



SPI / INTEGRAL (2 yr)

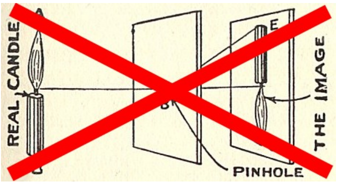


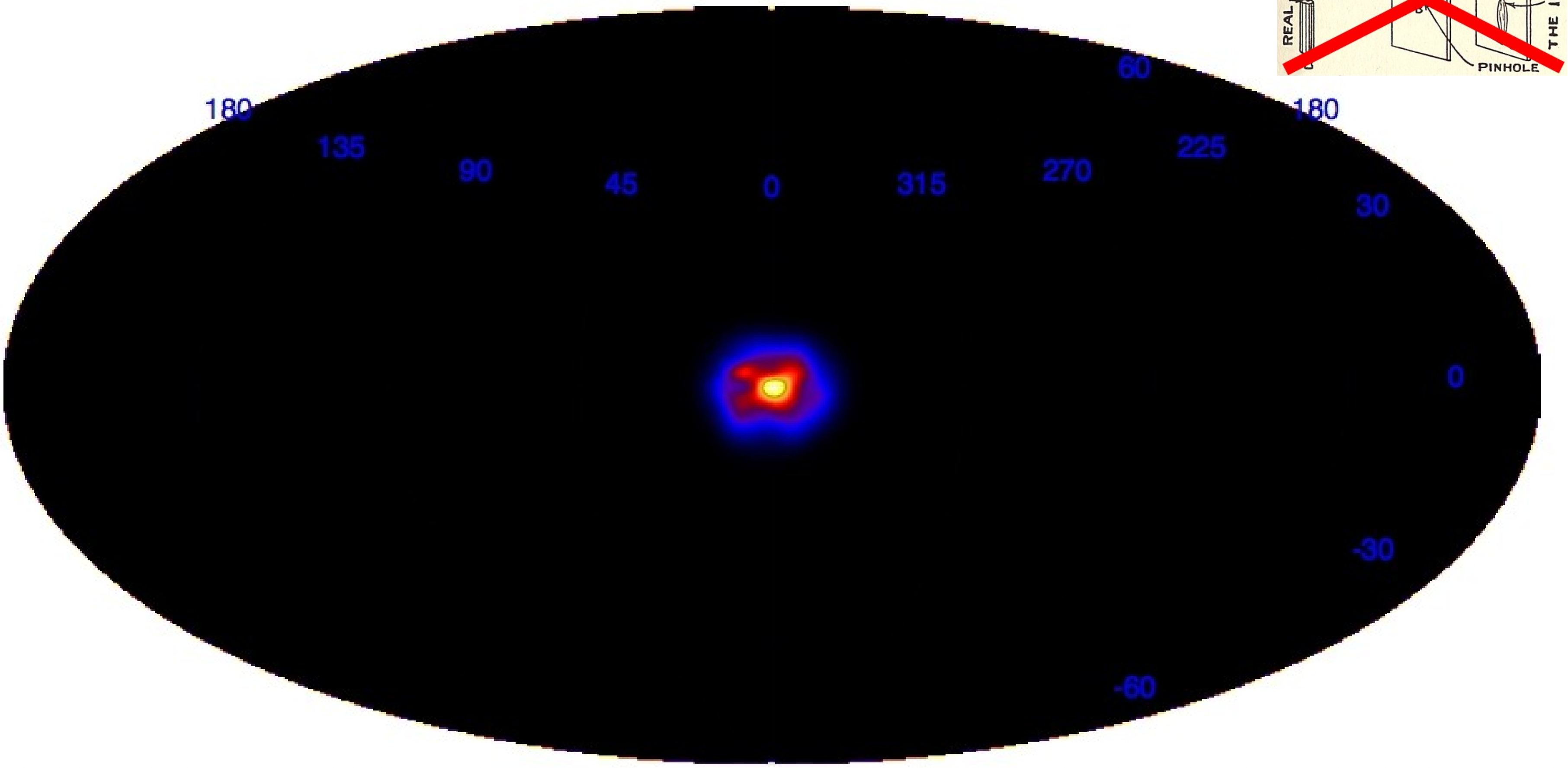


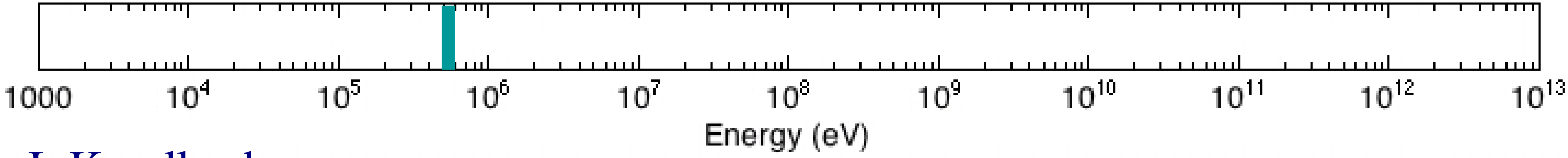
J. Knodlseder

The Gamma-Ray Sky (511 keV line)

SPI / INTEGRAL (2 yr)



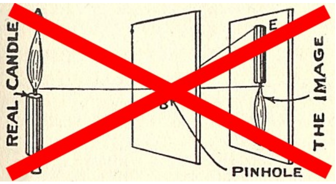


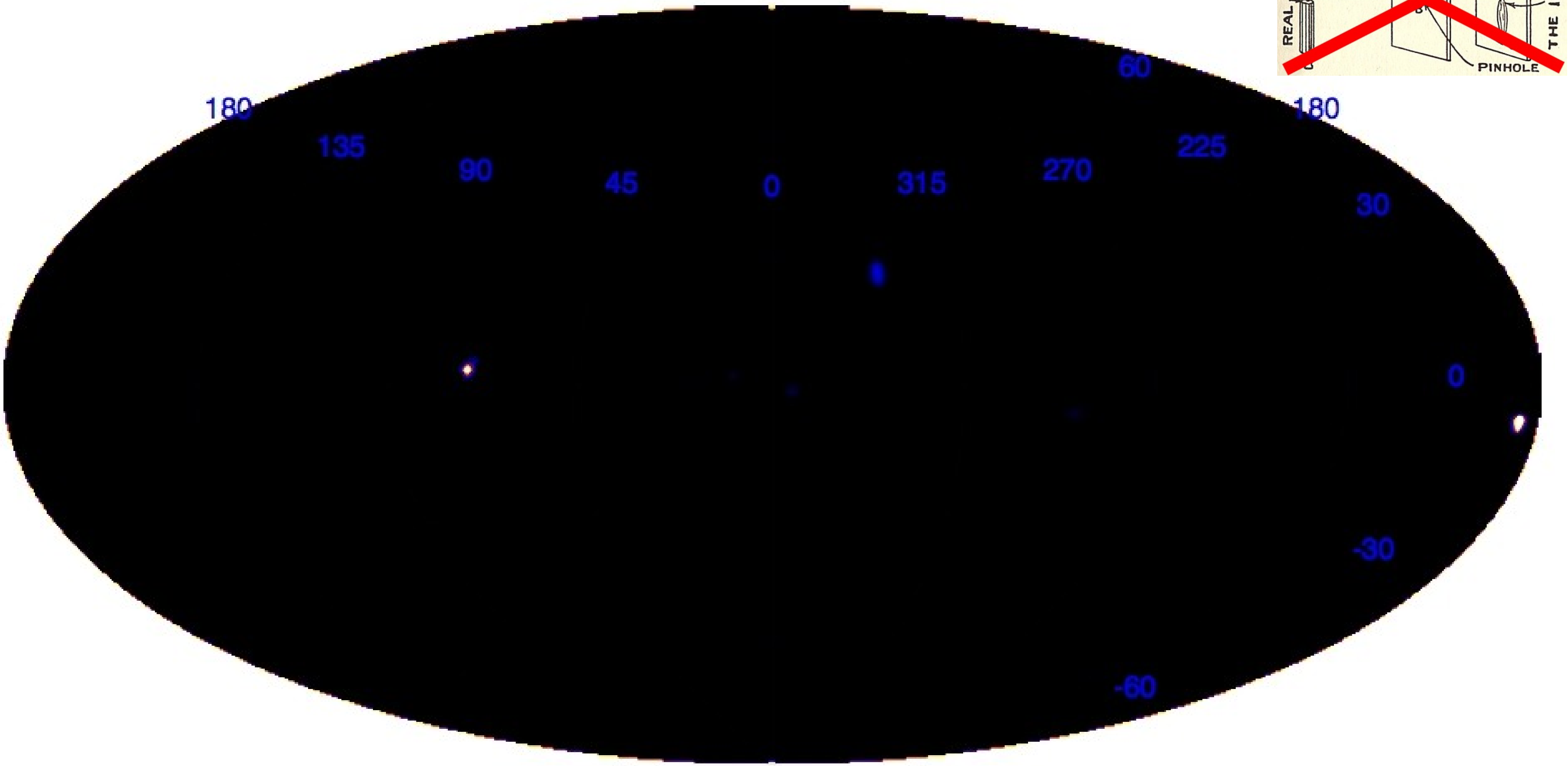


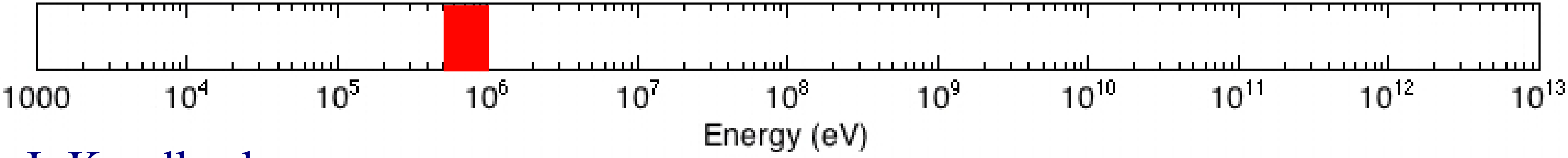
J. Knodlseder

The Gamma-Ray Sky (514 - 1000 keV)

SPI / INTEGRAL (2 yr)



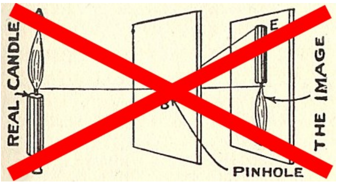


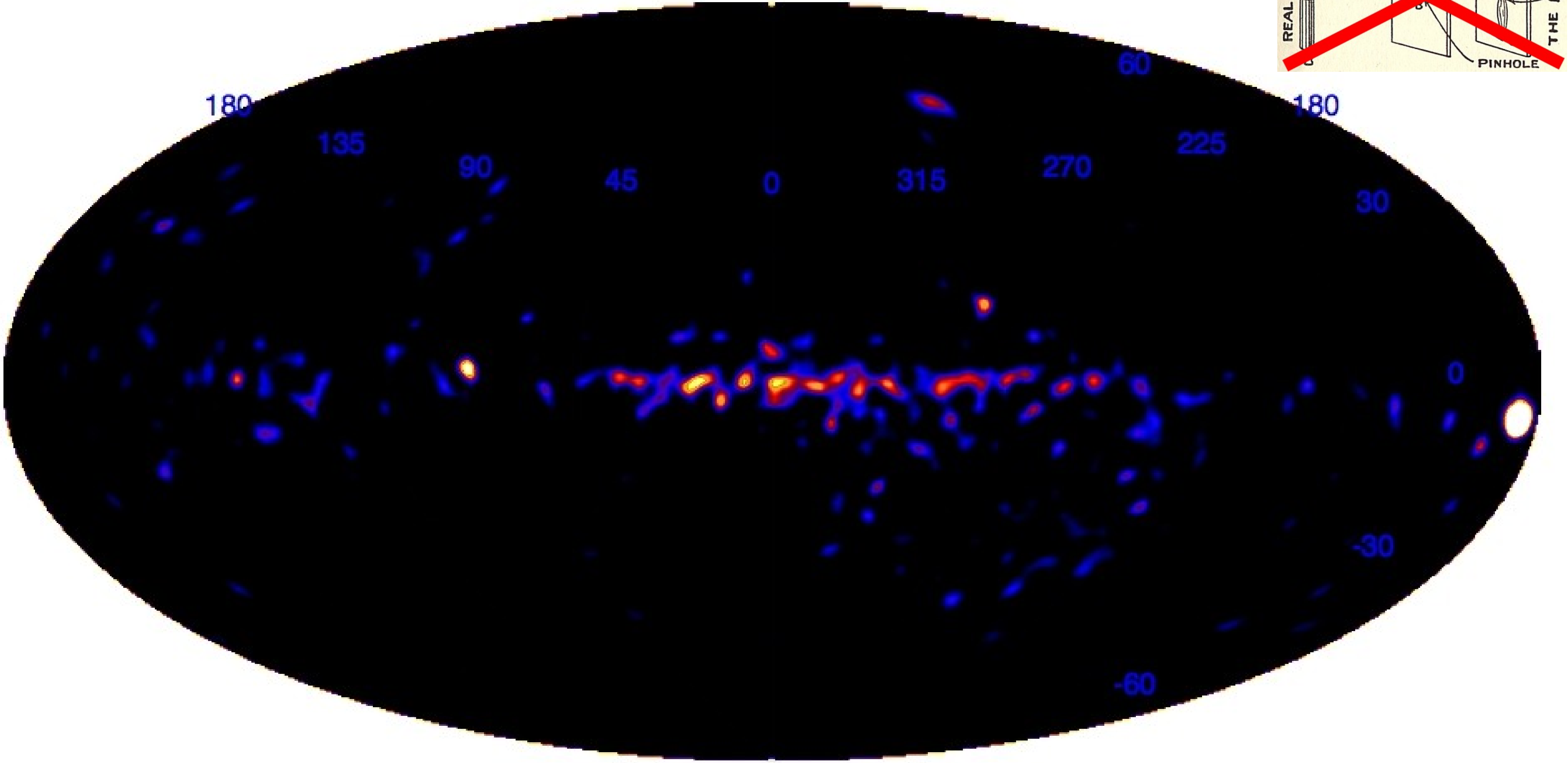


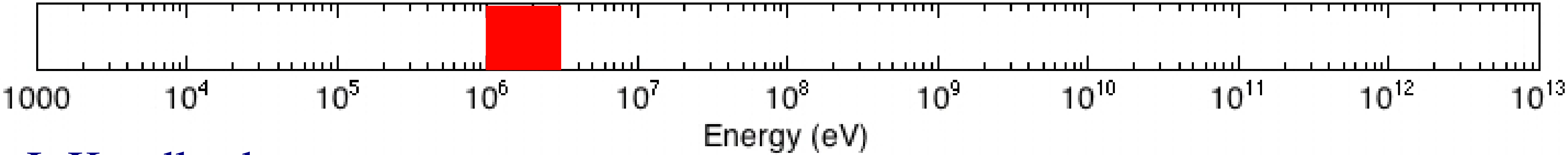
J. Knodlseder

The Gamma-Ray Sky (1 - 3 MeV)

COMPTEL / CGRO (6 yr)







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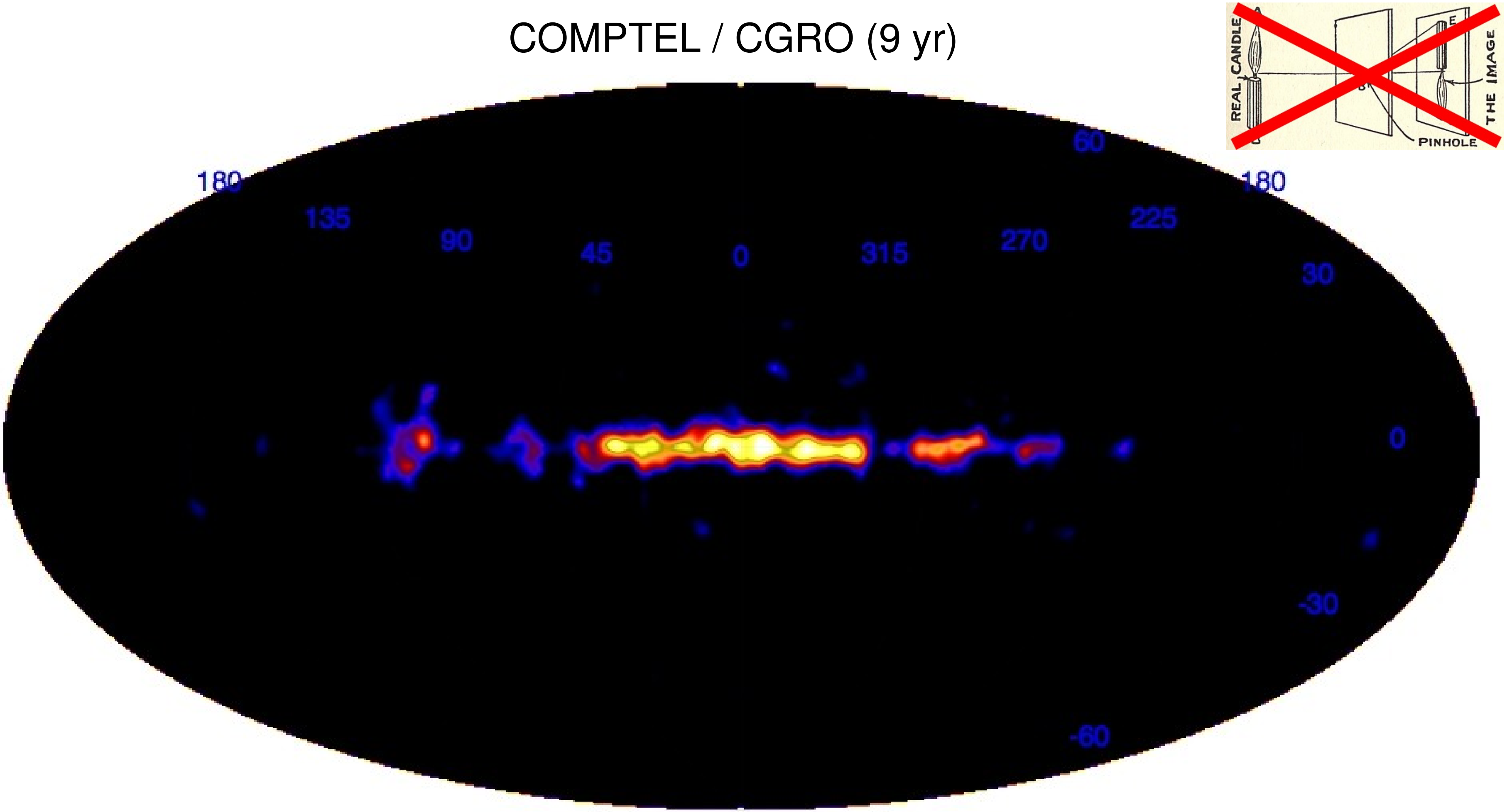
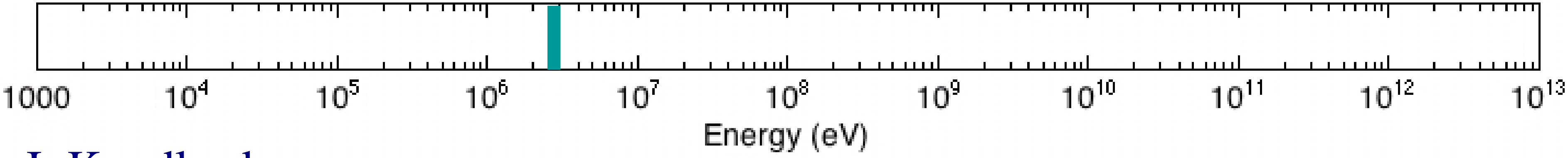
The Gamma-Ray Sky (1.809 MeV line)

COMPTEL / CGRO (9 yr)

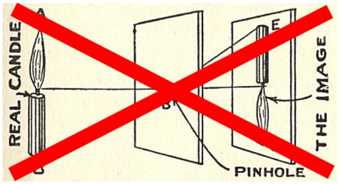


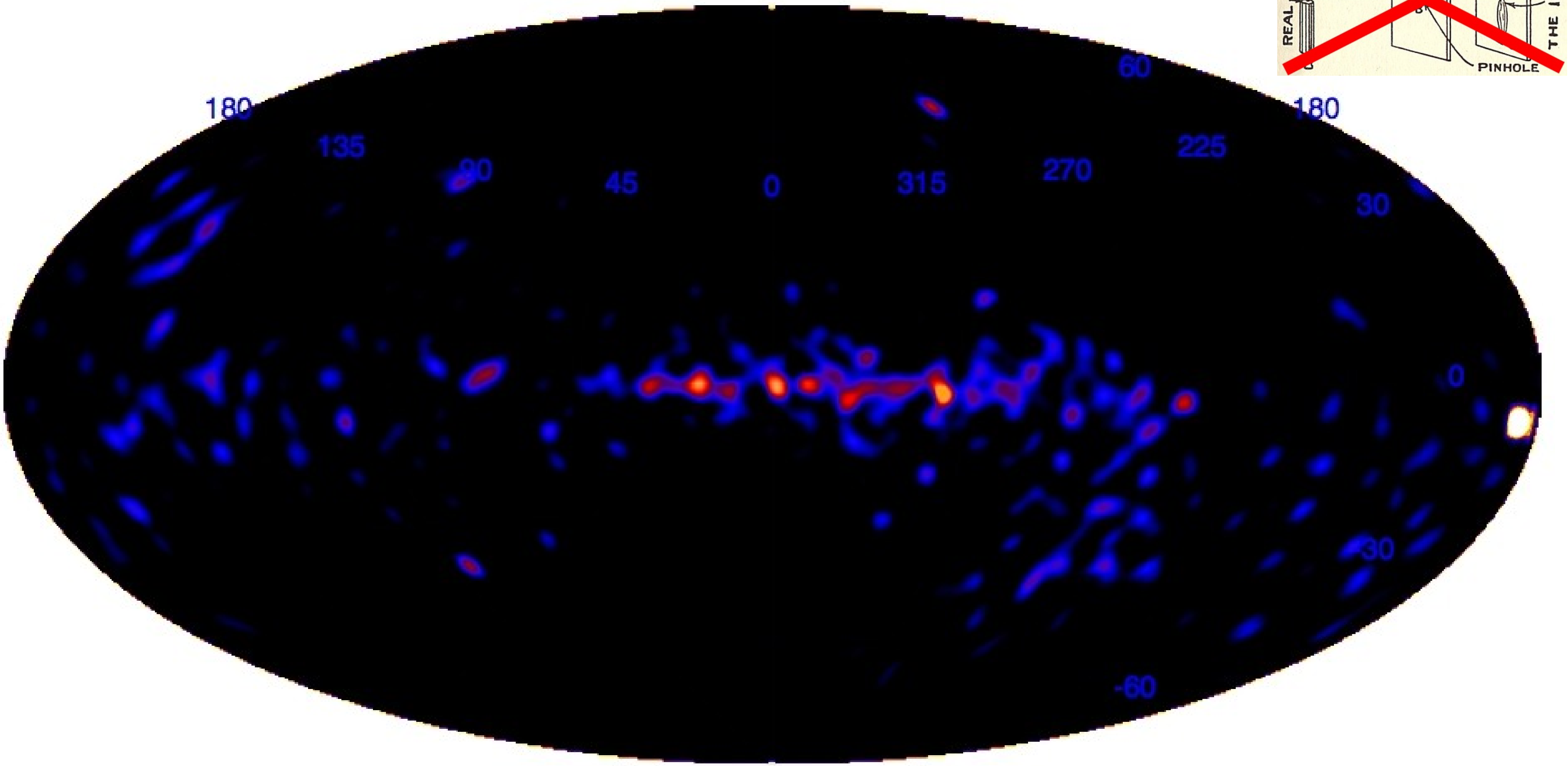


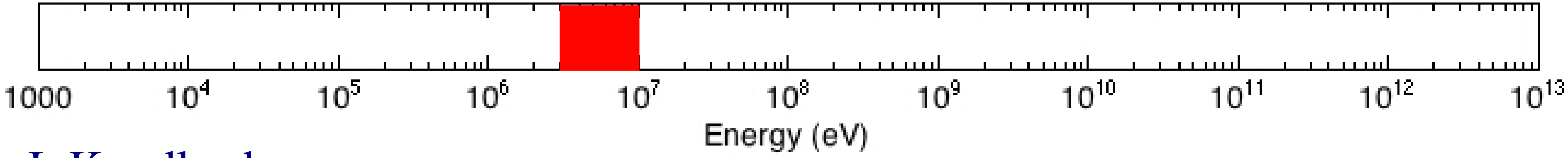
J. Knodlseder

The Gamma-Ray Sky (3 - 10 MeV)

COMPTEL / CGRO (6 yr)







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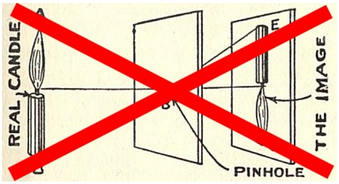
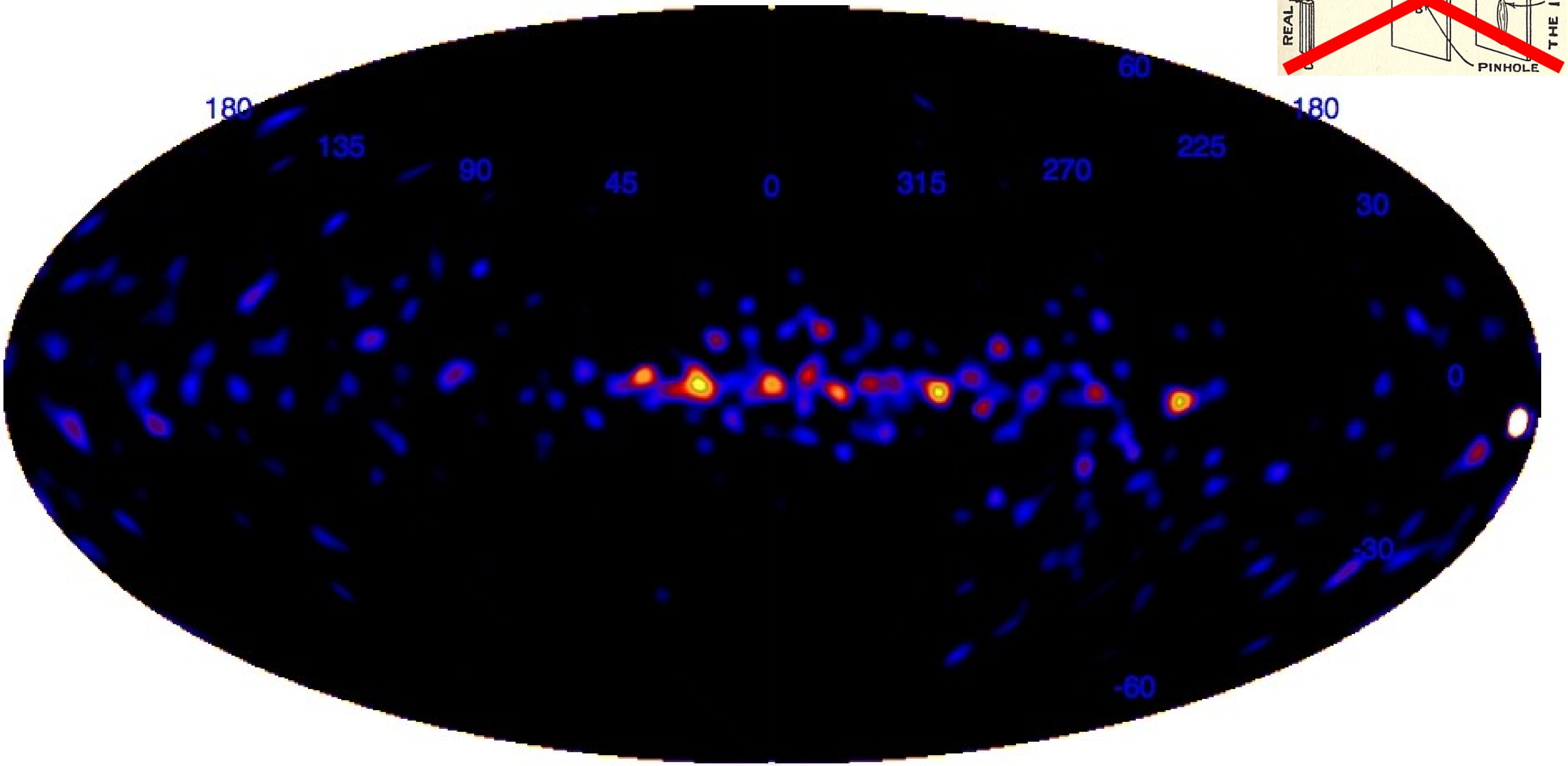
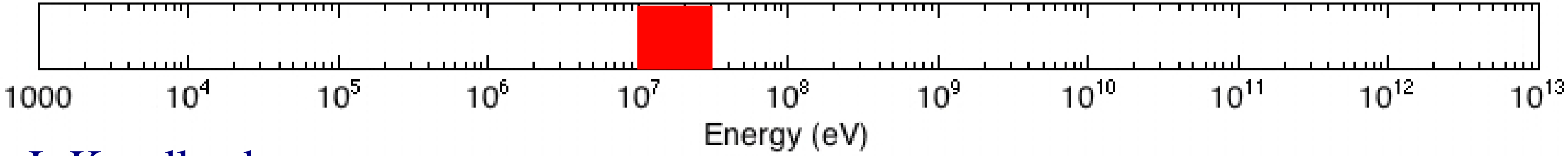
The Gamma-Ray Sky (10 - 30 MeV)

COMPTEL / CGRO (6 yr)



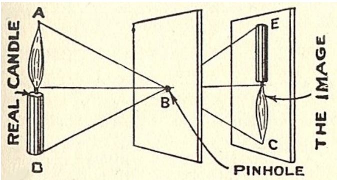


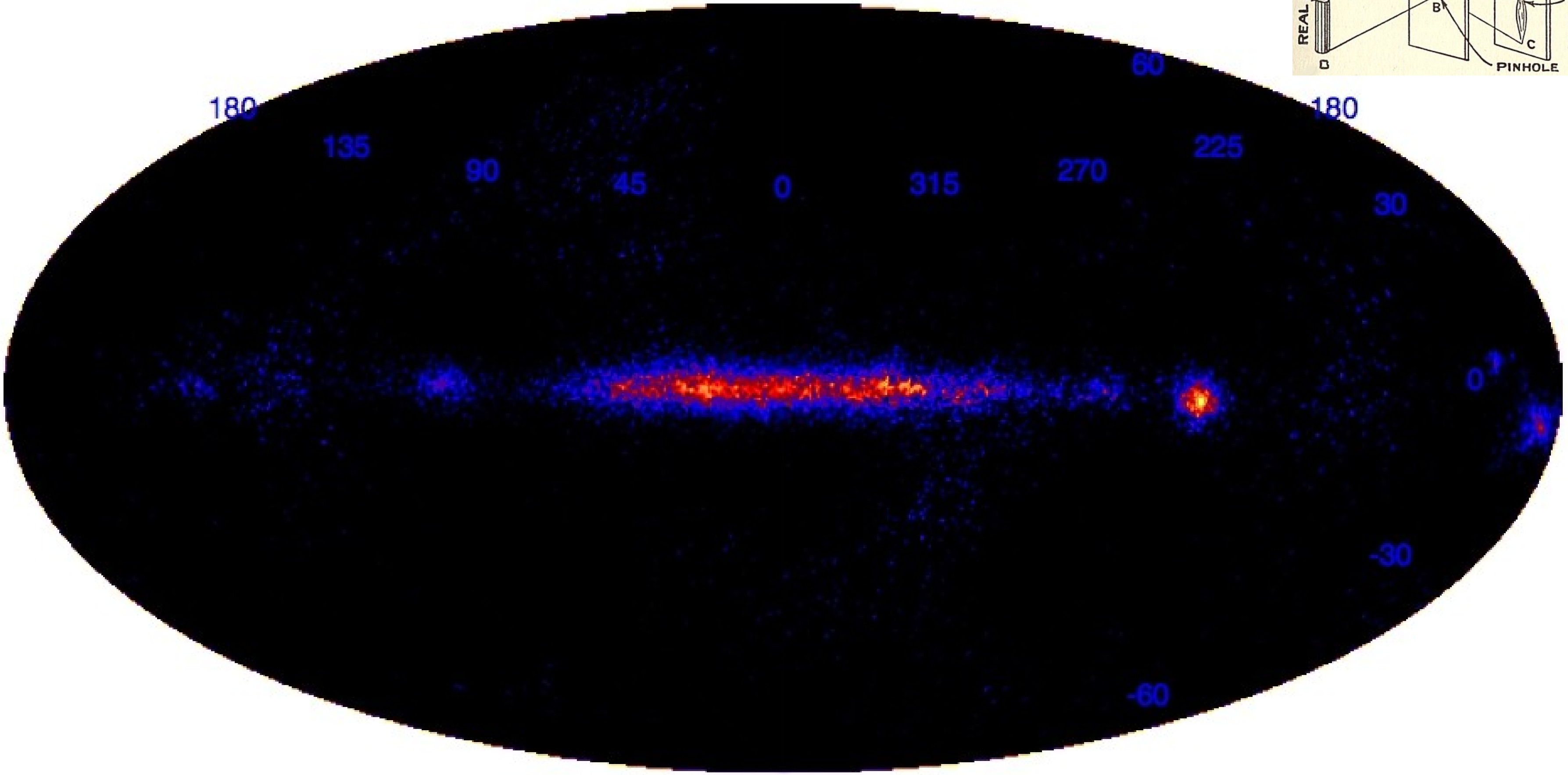


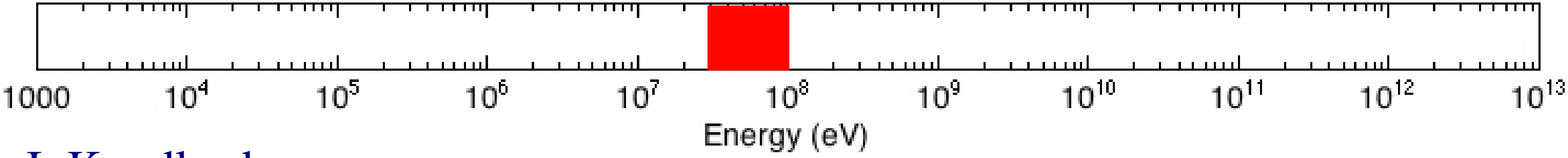
J. Knodlseder

The HE Gamma-Ray Sky (30 - 100 MeV)

EGRET / CGRO (4 yr)



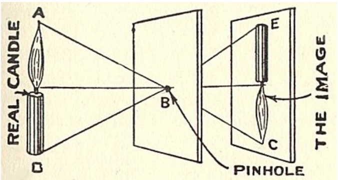


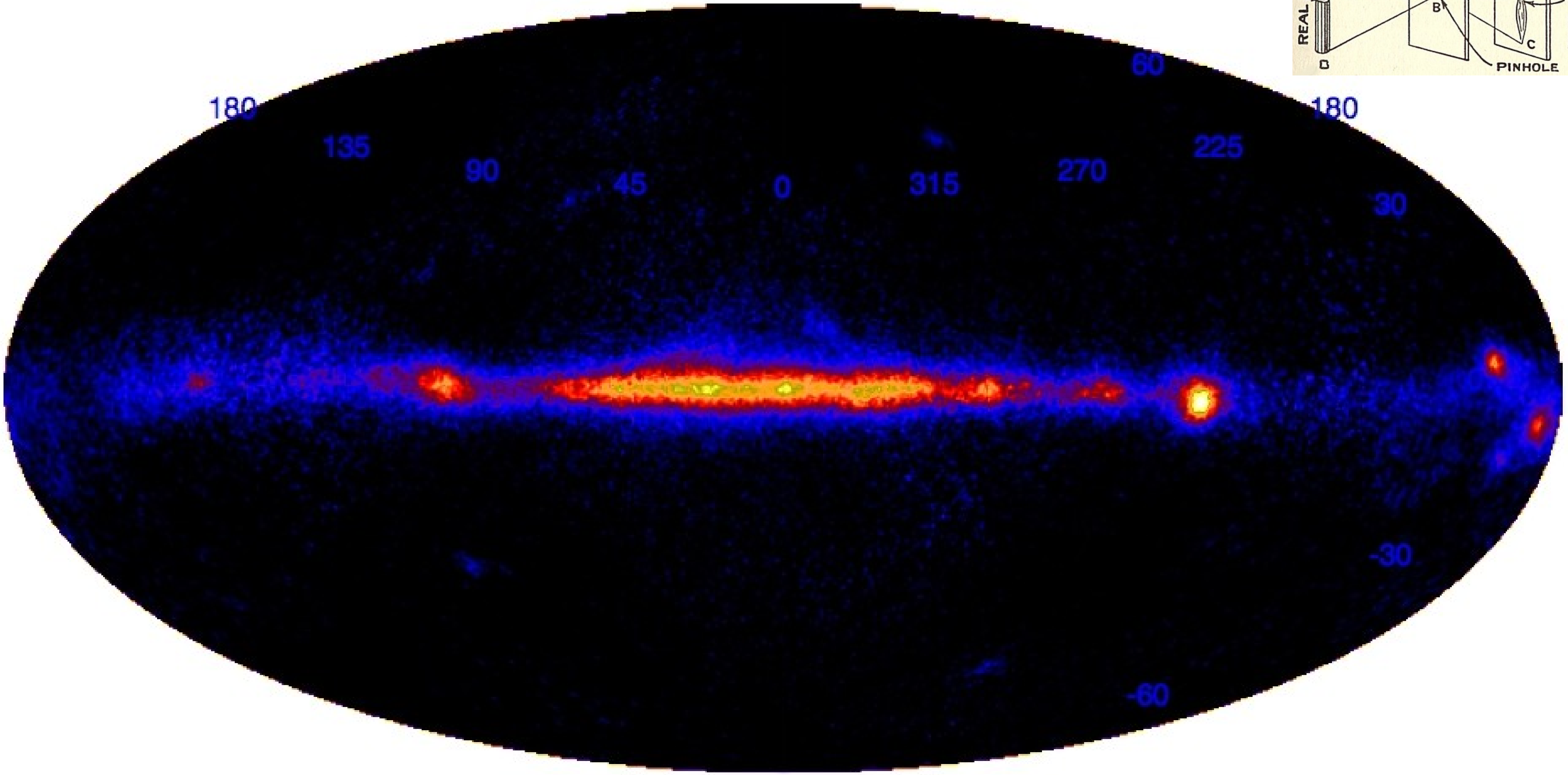


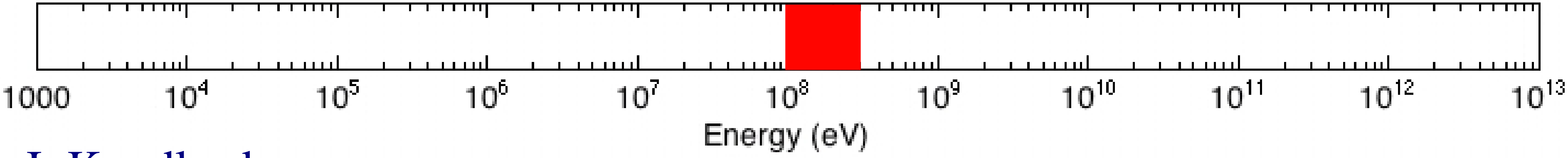
J. Knodlseder

The HE Gamma-Ray Sky (100 - 300 MeV)

EGRET / CGRO (4 yr)



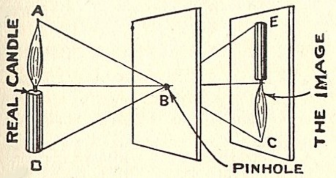


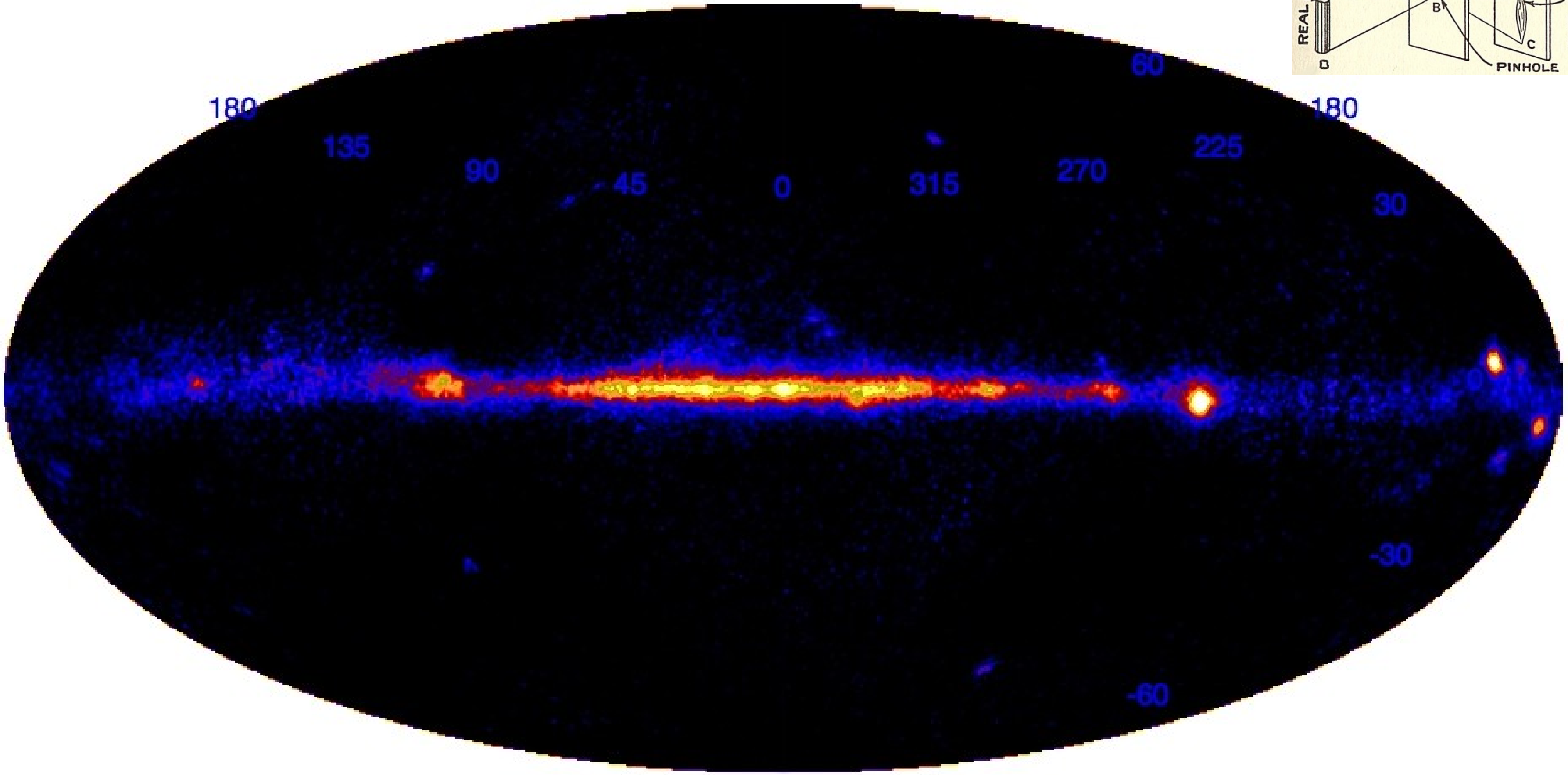


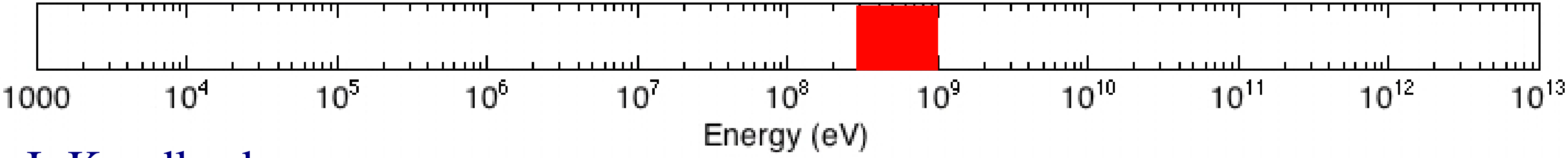
J. Knodlseder

The HE Gamma-Ray Sky (300 - 1000 MeV)

EGRET / CGRO (4 yr)



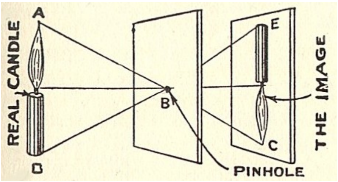


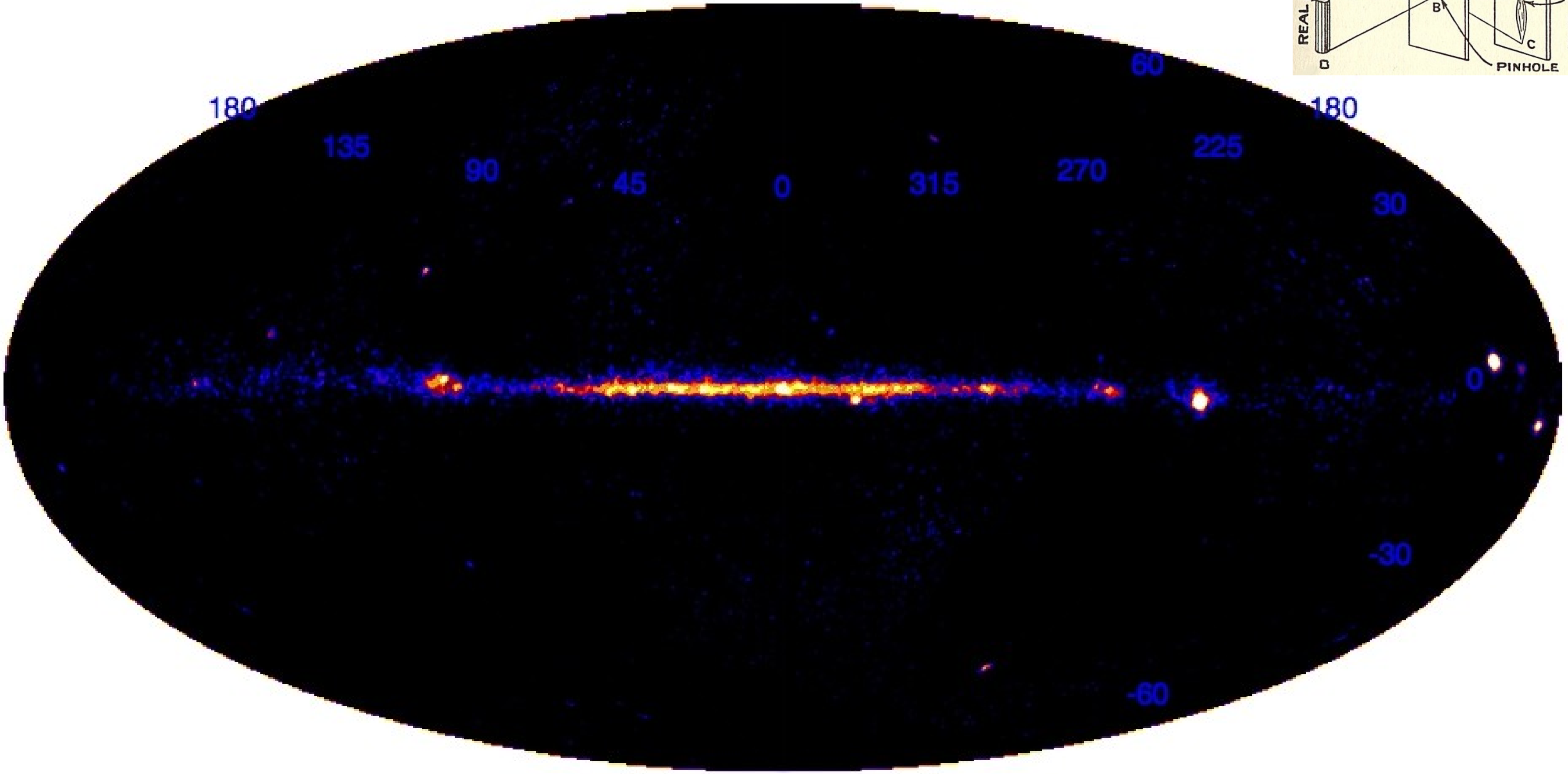


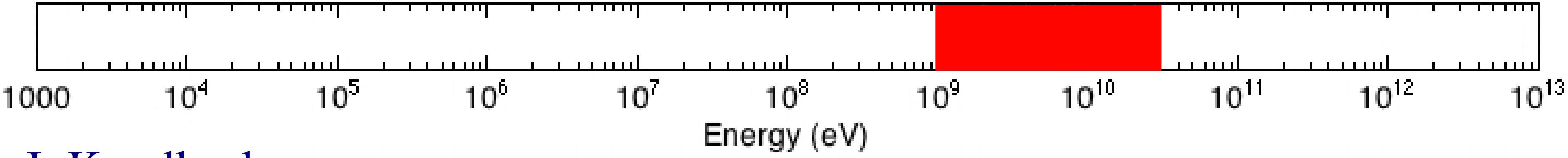
J. Knodlseder

The HE Gamma-Ray Sky (1 - 30 GeV)

EGRET / CGRO (4 yr)



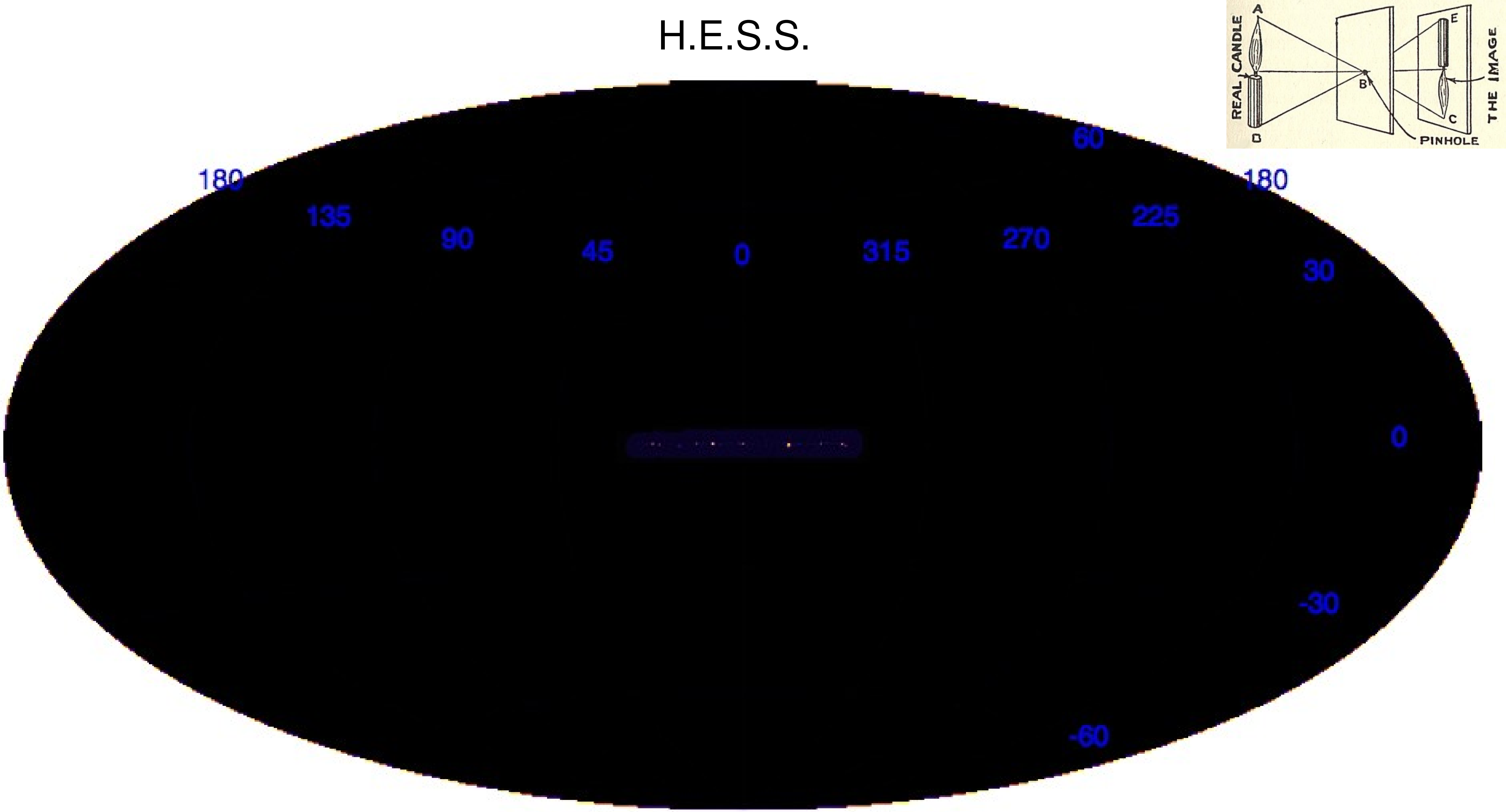


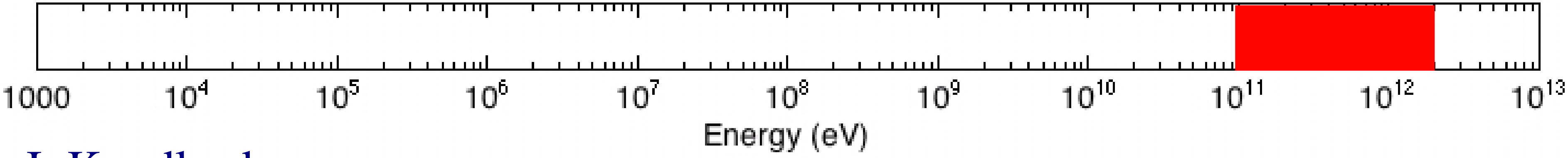


J. Knodlseder

The VHE Gamma-Ray Sky (0.1 - 20 TeV)

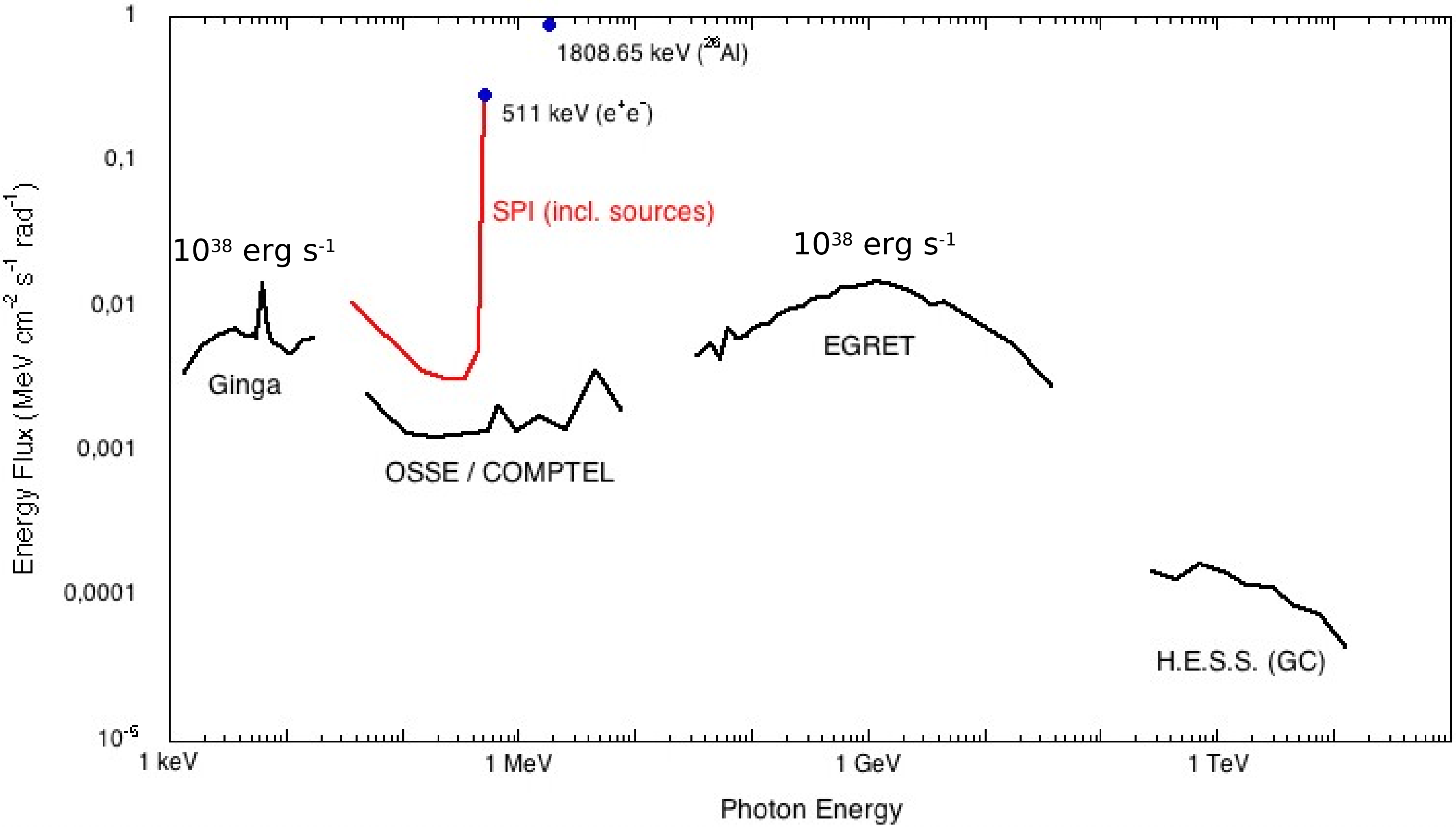
H.E.S.S.





J. Knodlseder

The galactic diffuse emission spectrum



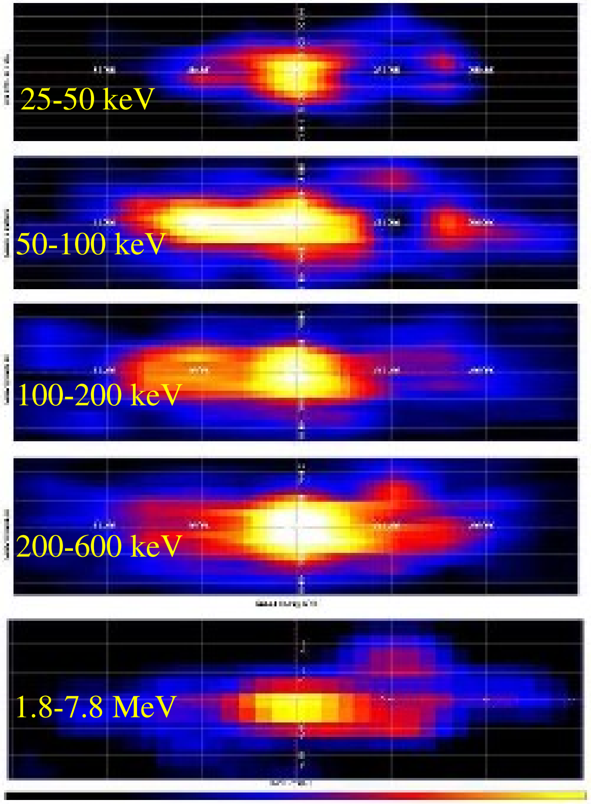
J. Knodlseder

Galactic ridge: the soft γ-ray sky

Continuum emission

SPI results

Bouchet *et al.*, ApJ **679**, 1315 (2008)



Lebrun *et al.*, Nature **428**, 293 (2004)

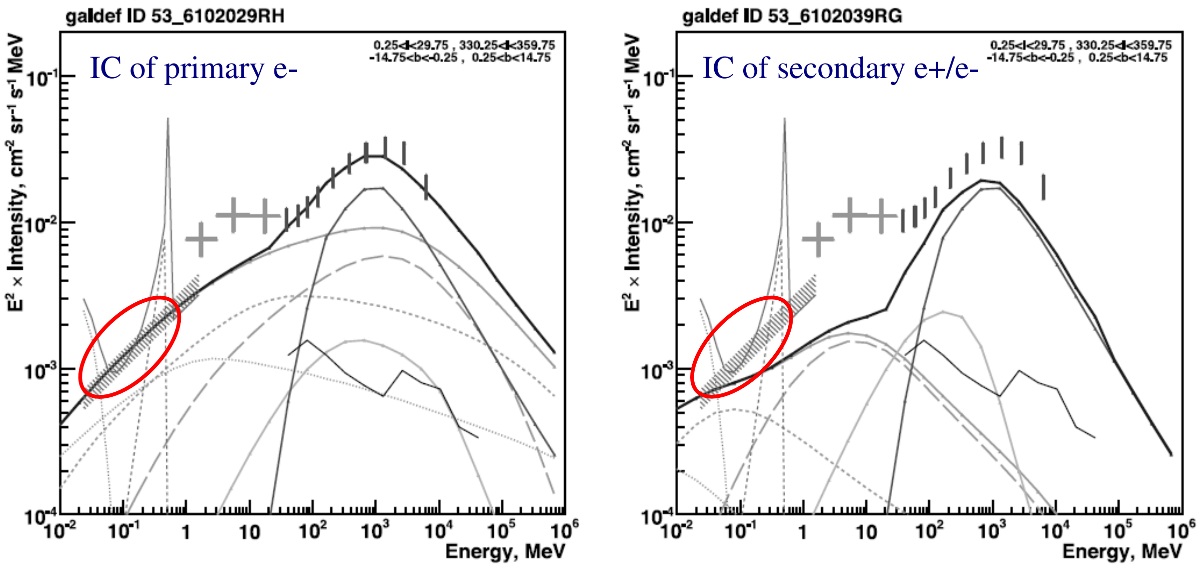
Bouchet *et al.*, ApJ **635**, 1115 (2005)

Strong *et al.*, A&A **444**, 495 (2005)

Krivonos *et al.*, A&A **463**, 957 (2007)

GALPROP interpretation

Porter *et al.*, ApJ **682**, 400 (2008)



Revnitsev & Sazonov, A&A **471**, 159 (2007)

Revnitsev *et al.*, A&A ***452***, 169 (2007)

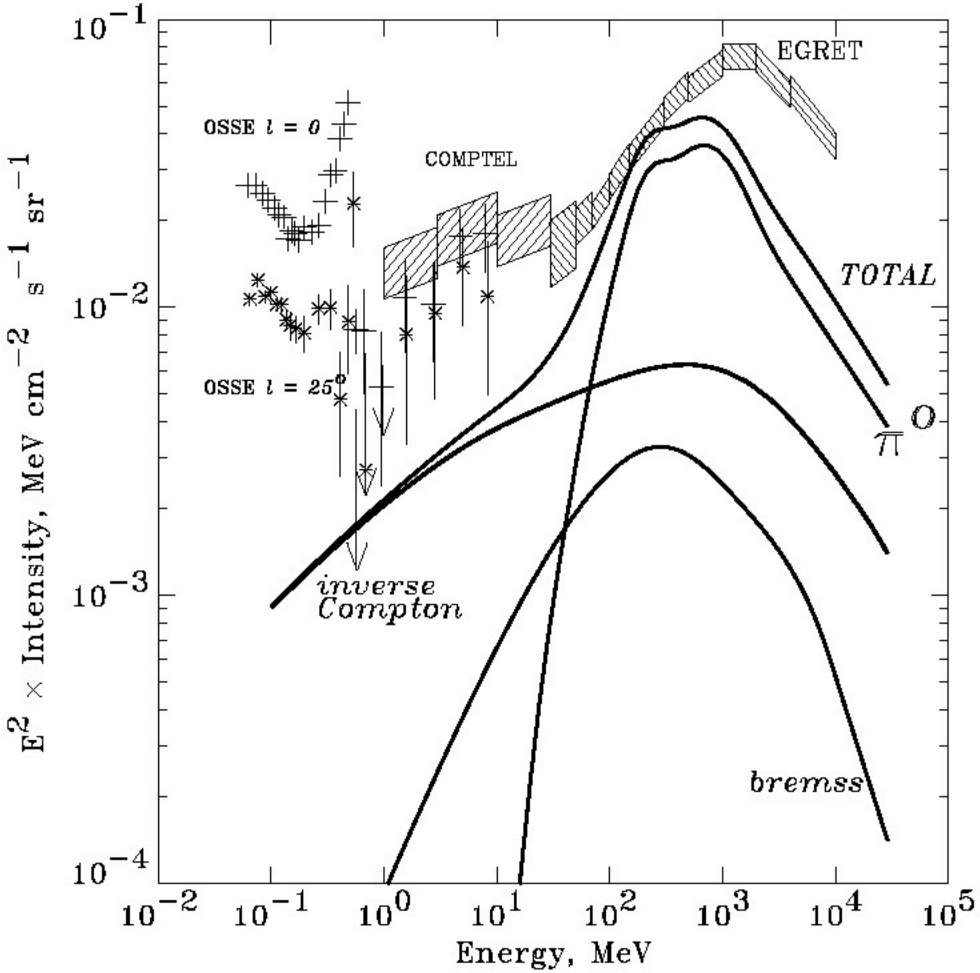
=> SPI data well reproduced by IC emission

[good for model wzde-1ggt566d6mmde004.truc!]

=> Both primary e^- and secondary $e^{-/+}$ contribute

D. Maurin

Spectral modelling: The conventional model



C model (Strong et al. 2000)

Model

- based on non γ-ray data only
- **fits only between 30 - 500 MeV**

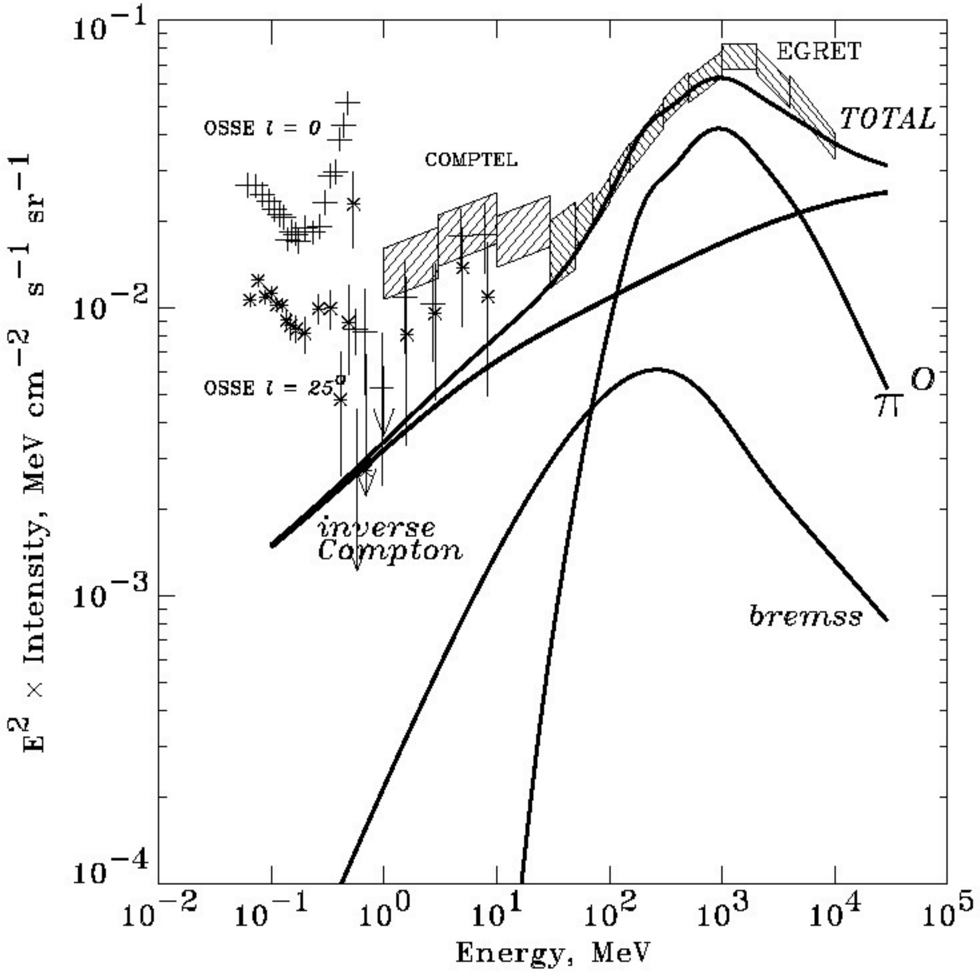
Electron spectrum

- E $^{-1.6}$: E < 10 GeV
- E $^{-2.6}$: E > 10 GeV
- agrees with locally measured spectrum
- satisfies synchrontron spectrum

Proton spectrum

- E $^{-2.25}$
- agrees with locally measured spectrum

Spectral modelling: Hard CR spectrum model



HEMN model (Strong et al. 2000)

Model

- allow for harder e^- and p specturm
- **does not fit <30 MeV (& GeV bump)**

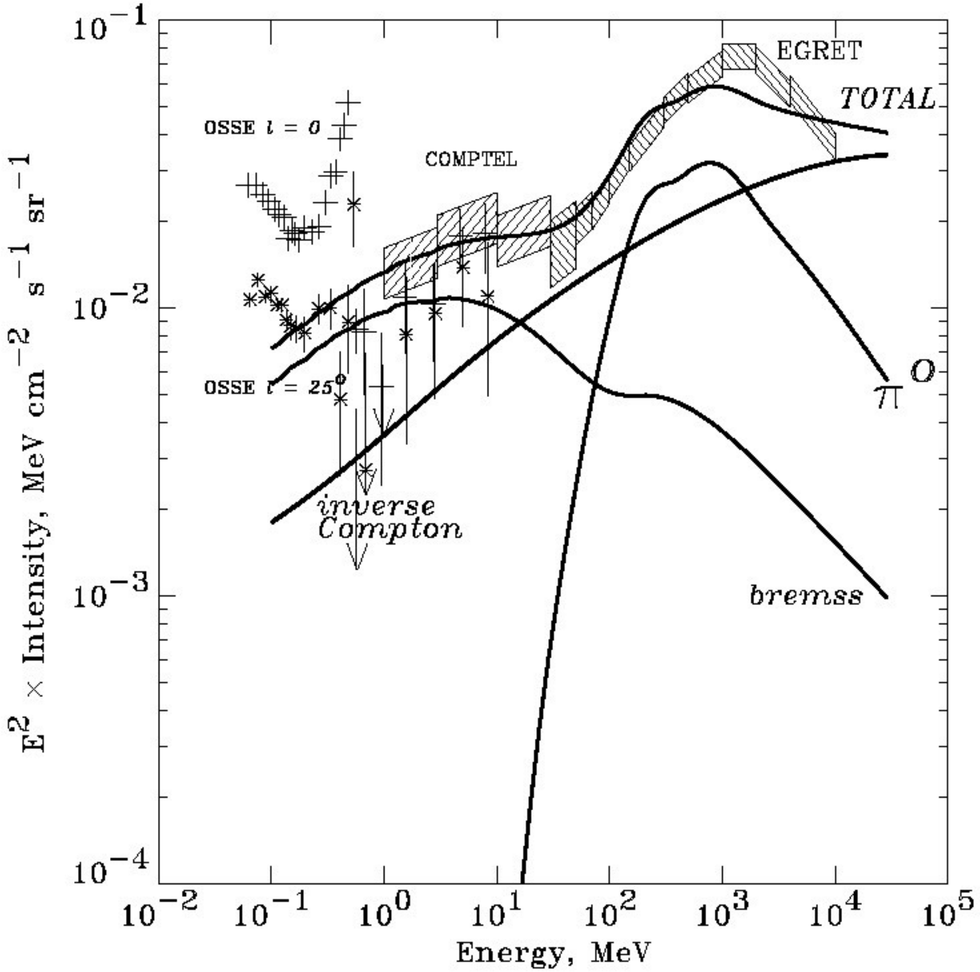
Electron spectrum

- $E^{-1.8}$ (harder w/r C-model above 10 GeV)
- differs from locally measured spectrum
  (high-energy e^- undergo rapid E-loss)
- satisfies synchrontron spectrum
  (> 10 GeV spectrum unconstrained)

Proton spectrum

- $E^{-1.8}$: E < 20 GeV (harder w/r C-model)
- $E^{-2.5}$: E > 20 GeV
- agrees with locally measured spectrum
  (solar modulation allows for some freedom at low energies)

Spectral modelling: Steep low-energy e^- model



SE model (Strong et al. 2000)

Model

- allows for more low-energy e^-
- **ad hoc (no observational evidence)**
- **large power input into ISM (ionisation)**

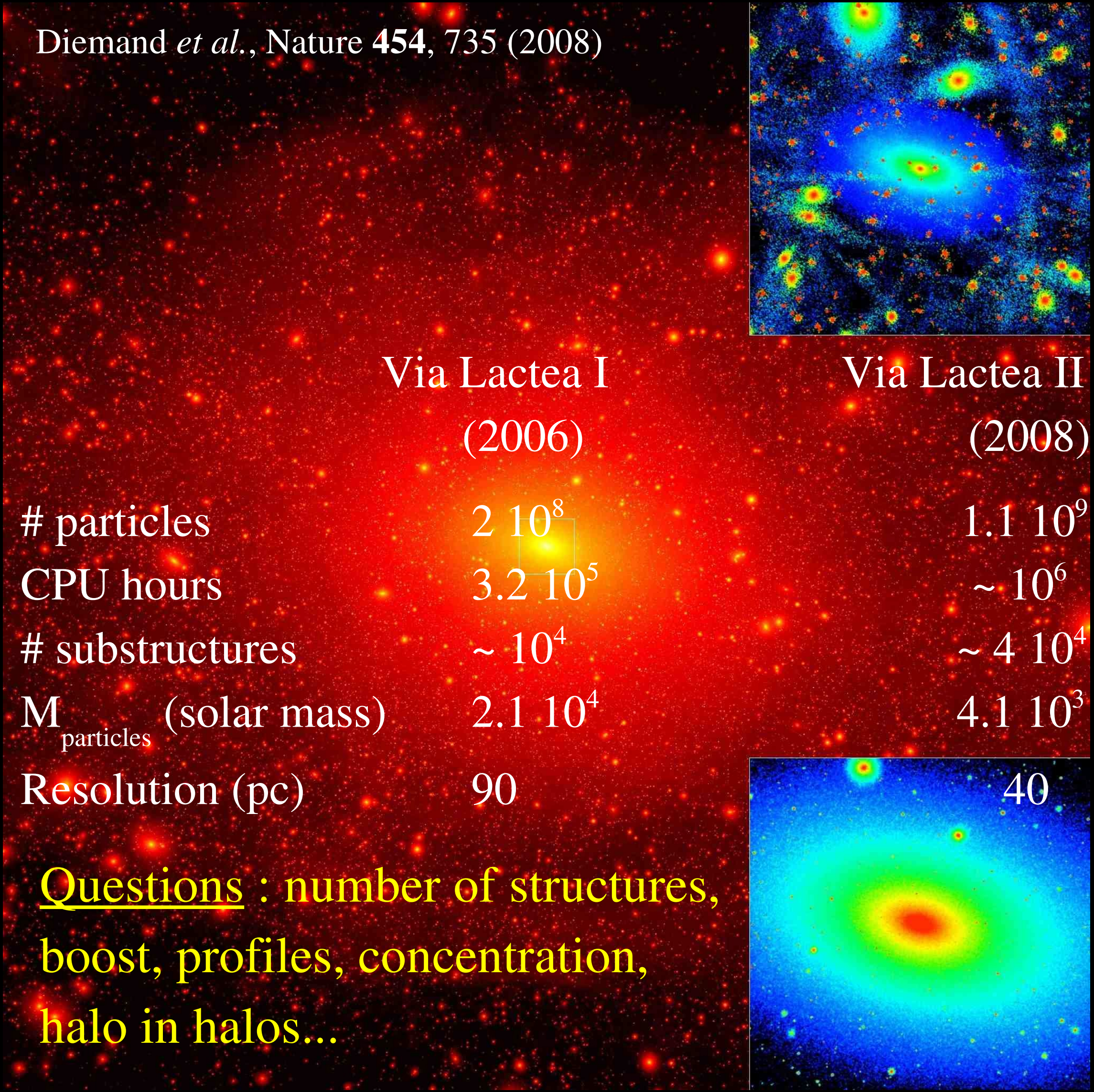
Electron spectrum

- $E^{-3.2}$: E < 200 MeV (steeped w/r C-model)
- $E^{-1.8}$: E > 200 MeV (like HEMN model)
- differs from locally measured spectrum (high-energy e^- undergo rapid E-loss)
- satisfies synchrontron spectrum (< 1 GeV spectrum unconstrained)

Proton spectrum

- $E^{-2.25}$ (C-model)
- agrees with locally measured spectrum

Clumps and streams of dark matter



Diemand *et al.*, Nature **454**, 735 (2008)

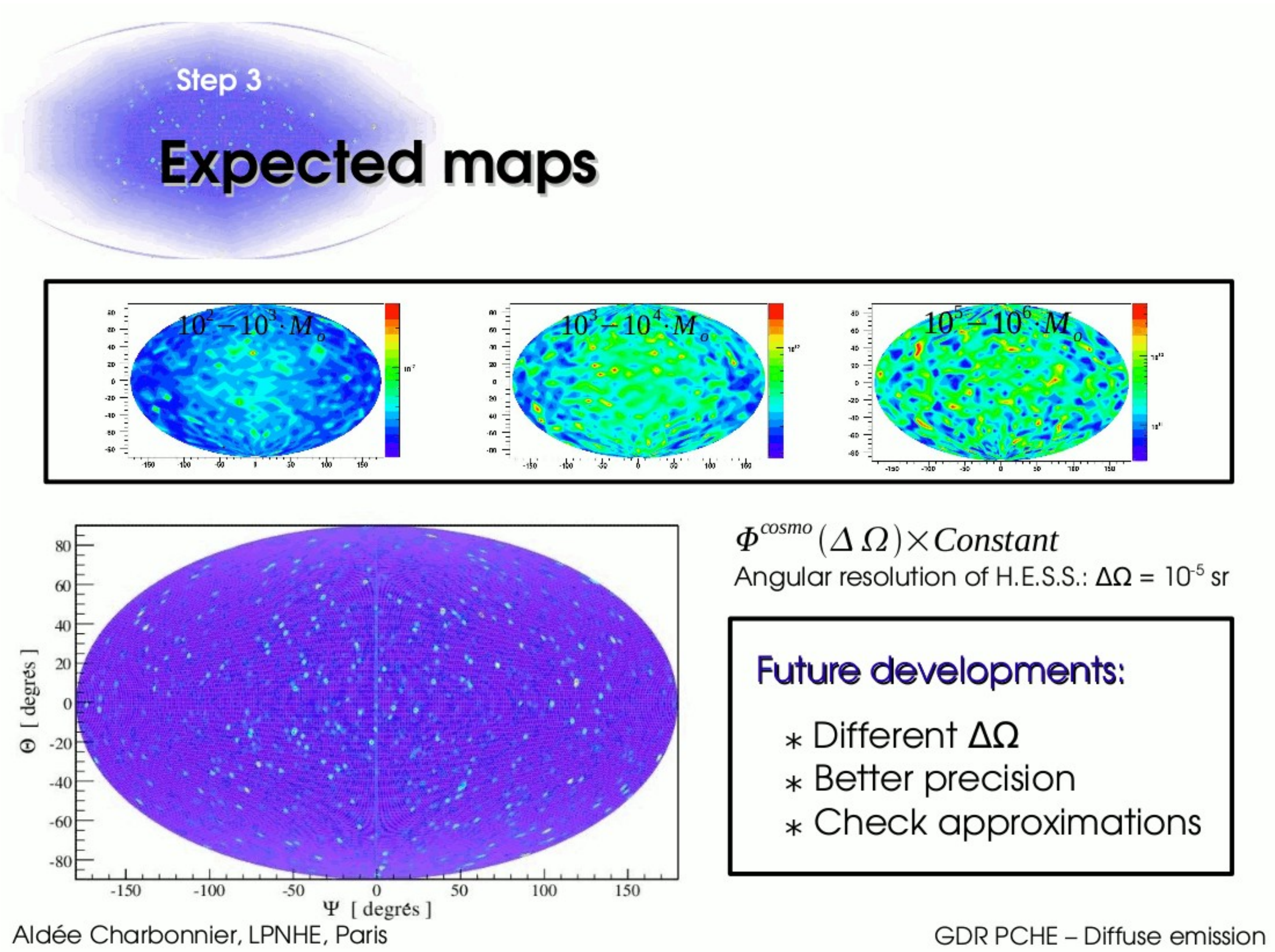
	Via Lactea I (2006)	Via Lactea II (2008)
# particles	$2\ 10^8$	$1.1\ 10^9$
CPU hours	$3.2\ 10^5$	$\sim 10^6$
# substructures	$\sim 10^4$	$\sim 4\ 10^4$
$M_{\text{particles}}$ (solar mass)	$2.1\ 10^4$	$4.1\ 10^3$
Resolution (pc)	90	40

Questions : number of structures, boost, profiles, concentration, halo in halos...

Fermi-GLAST could see ~ 10 clumps

Kuhlen, Diemand & Madau, ApJ **686**, 278 (2008)

Skymaps for clumps in Fermi or HESS



Step 3

Expected maps

$\Phi^{cosmo}(\Delta\,\Omega)\times Constant$

Angular resolution of H.E.S.S.: $\Delta\Omega = 10^{-5}$ sr

Future developments:

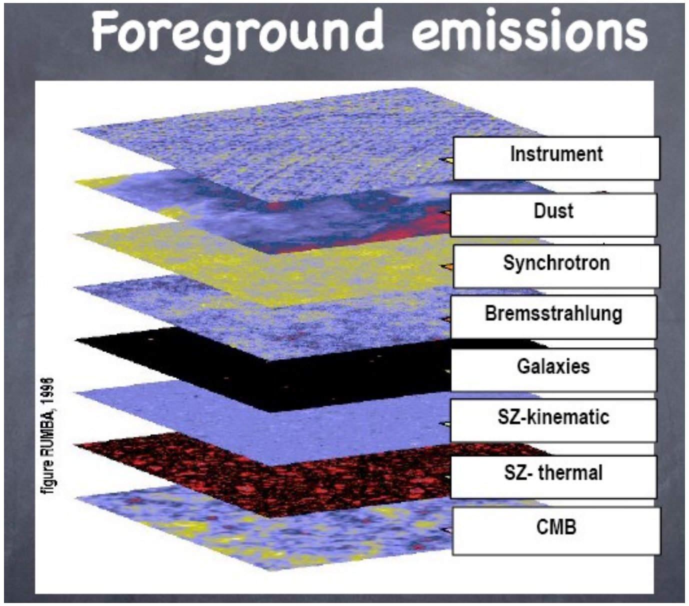
- Different ΔΩ
- Better precision
- Check approximations

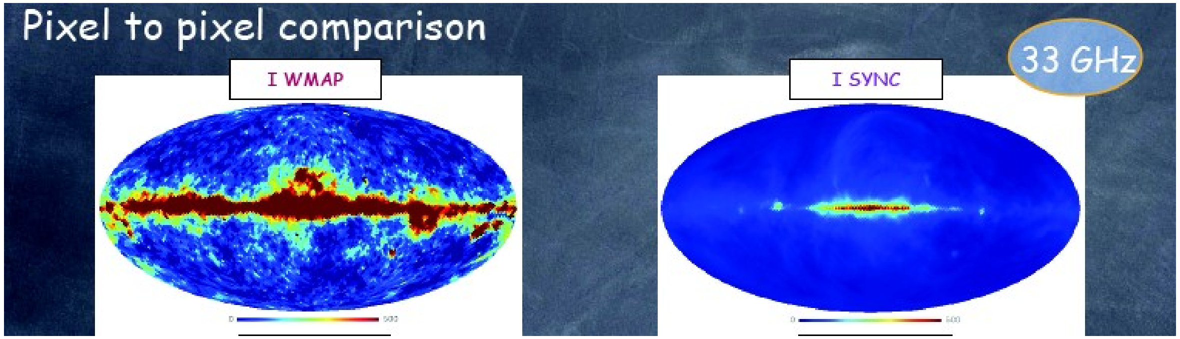
Aldée Charbonnier, LPNHE, Paris

GDR PCHE – Diffuse emission

A. Charbonnier

Constraints and insights from CMB





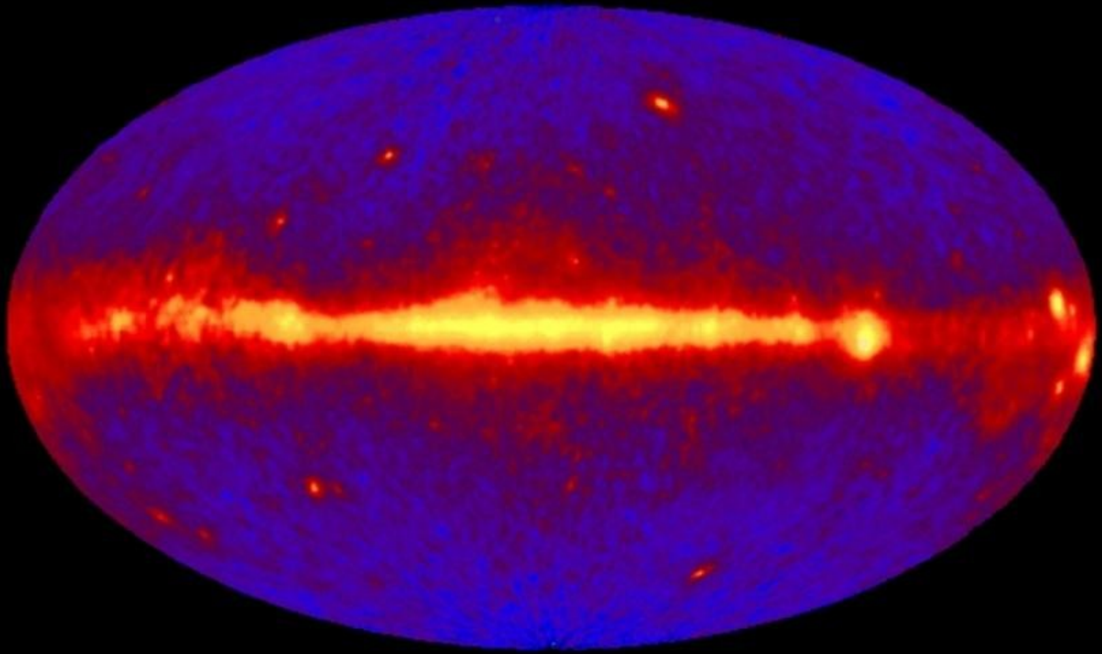
but ...

- Different electromagnetic spectrum
- Different spatial distribution

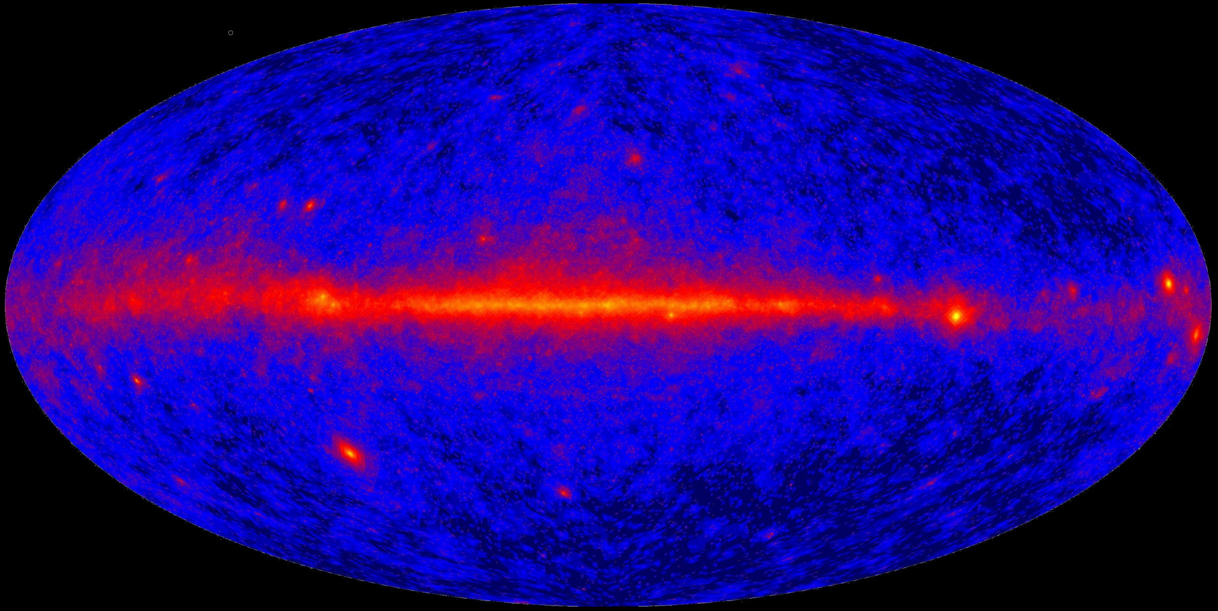
Large effects coming from synchrotron emission : constraints on the electron populations and on the magnetic field (normal and turbulent components).
Planck people are pushing for collaborations with cosmic ray people.

J.-F. Macias Perez & L. Fauvet

We are living in interesting times…



EGRET (7 years)



FERMI (94h)

Conclusions

- Diffuse photon emission is well measured from radio to GeV, Fermi will provide an unprecedent measure between MeV - 300 GeV
- Diffuse emission provides lots of insights AND/OR constraints on the physics at stake (standard astrophysical as well as exotic)
- It is of paramount importance to bracket the theoretical uncertainties affecting the standard astrophysical processes, and the game is far from easy : sources, acceleration, propagation, ISM, ISRF, etc.
- The road is long, but we have some expertness to tackle these issues (the aim of the GDR is to gather the interested people). We have started to work, and everybody is welcome.