A Consistent Model of the Interstellar Gamma-Ray Emission to Interpret Fermi LAT Observations of Diffuse Emissions

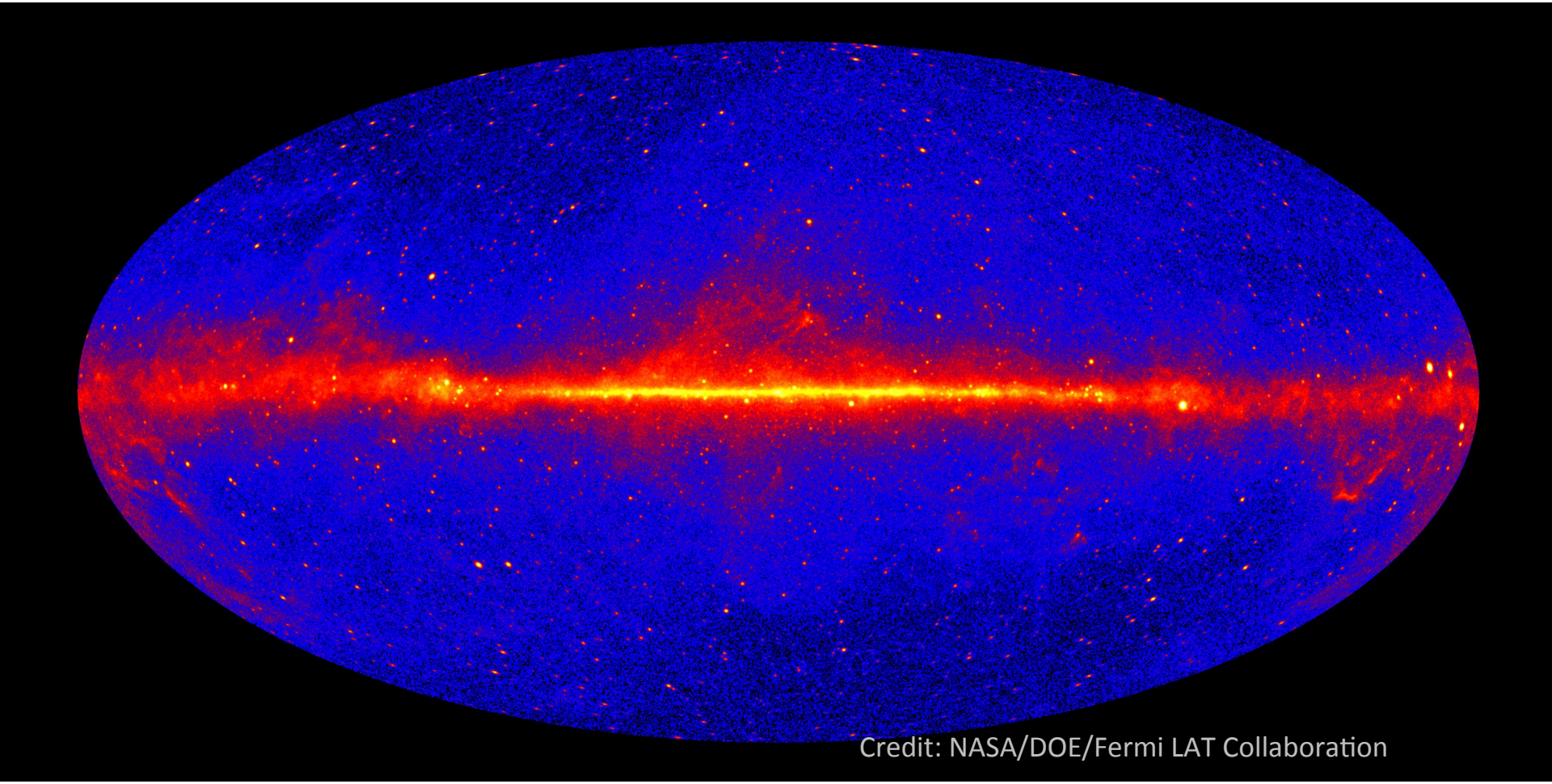
From E.O. (2019) Phy.Rev.D & E.O. (2018) MNRAS

Elena Orlando
(Stanford University)

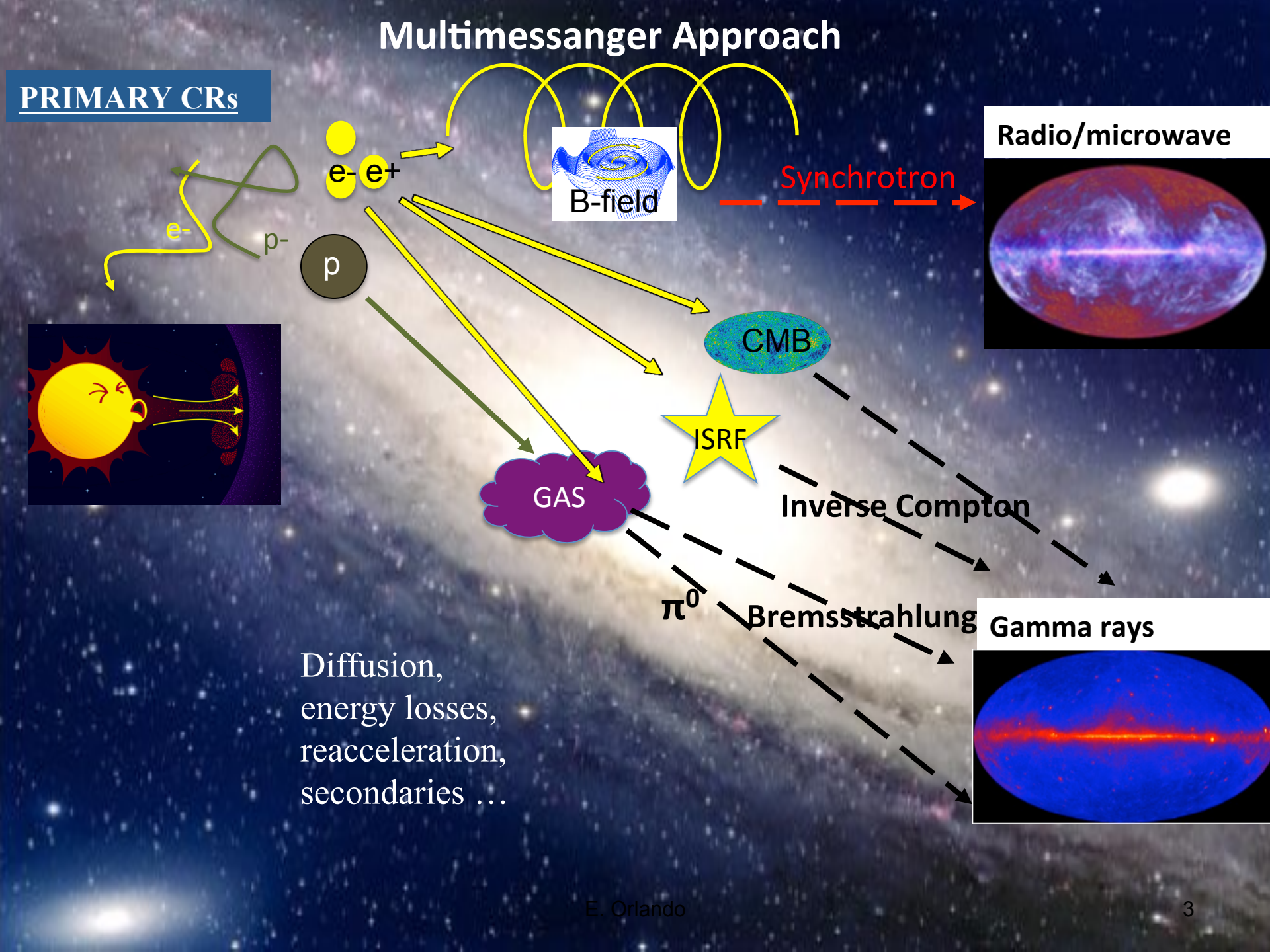
ICRC2019 – Madison, WI

Interstellar Emission

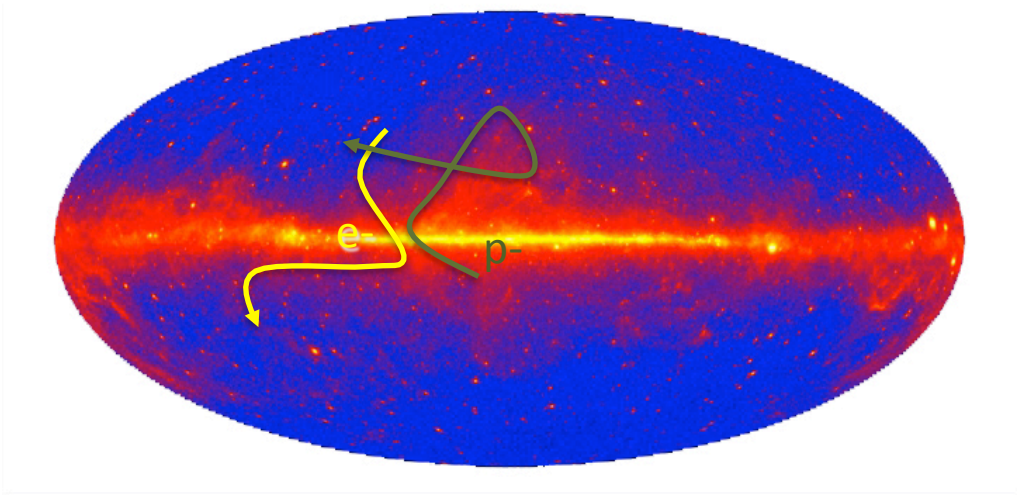
Fermi LAT > 1 GeV



Multimessanger Approach



Present Fermi LAT Interstellar Models



From *Abdo et al (2012) ApJ*: Extensive study; Great physically based models! Many models! Based on GALPROP!

But:

- only standard reacceleration models for CR propagation
- not consistent with radio and microwave data
- not updated with new CR measurements

This talk will show

1) Consistent local interstellar spectrum and CR propagation models

2) Effects on gamma-ray interstellar spectral and spatial templates accounting for synchrotron constraints

3) Predictions at MeV energies

by using a variety of multimessenger data

Improvements in GALPROP: synchrotron modeling

Strong, A., Orlando, E., Jaffe, T., 2011 A&A, 534, 54

Orlando & Strong 2013 MNRAS 436, 2127

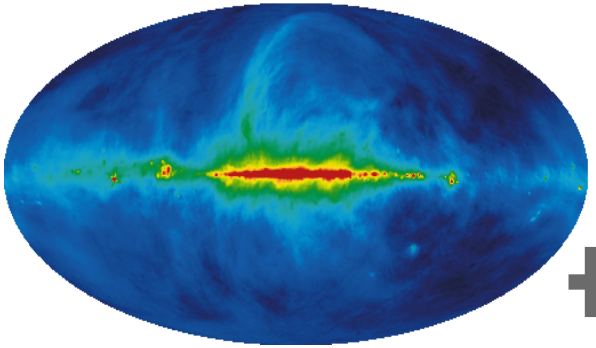
- 3D B-field configuration: random + regular + anisotropic random components

- total and polarized synchrotron emission

- free-free emission model

- free-free absorption

Multimessenger Data



Radio at 408 MHz

+

Microwaves at 30 GHz

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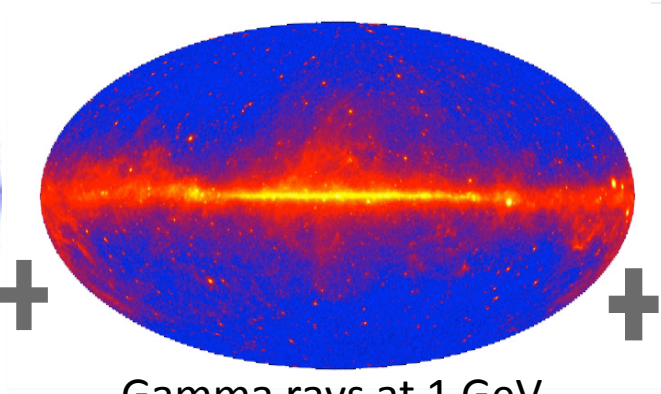

Gamma rays at 1 GeV

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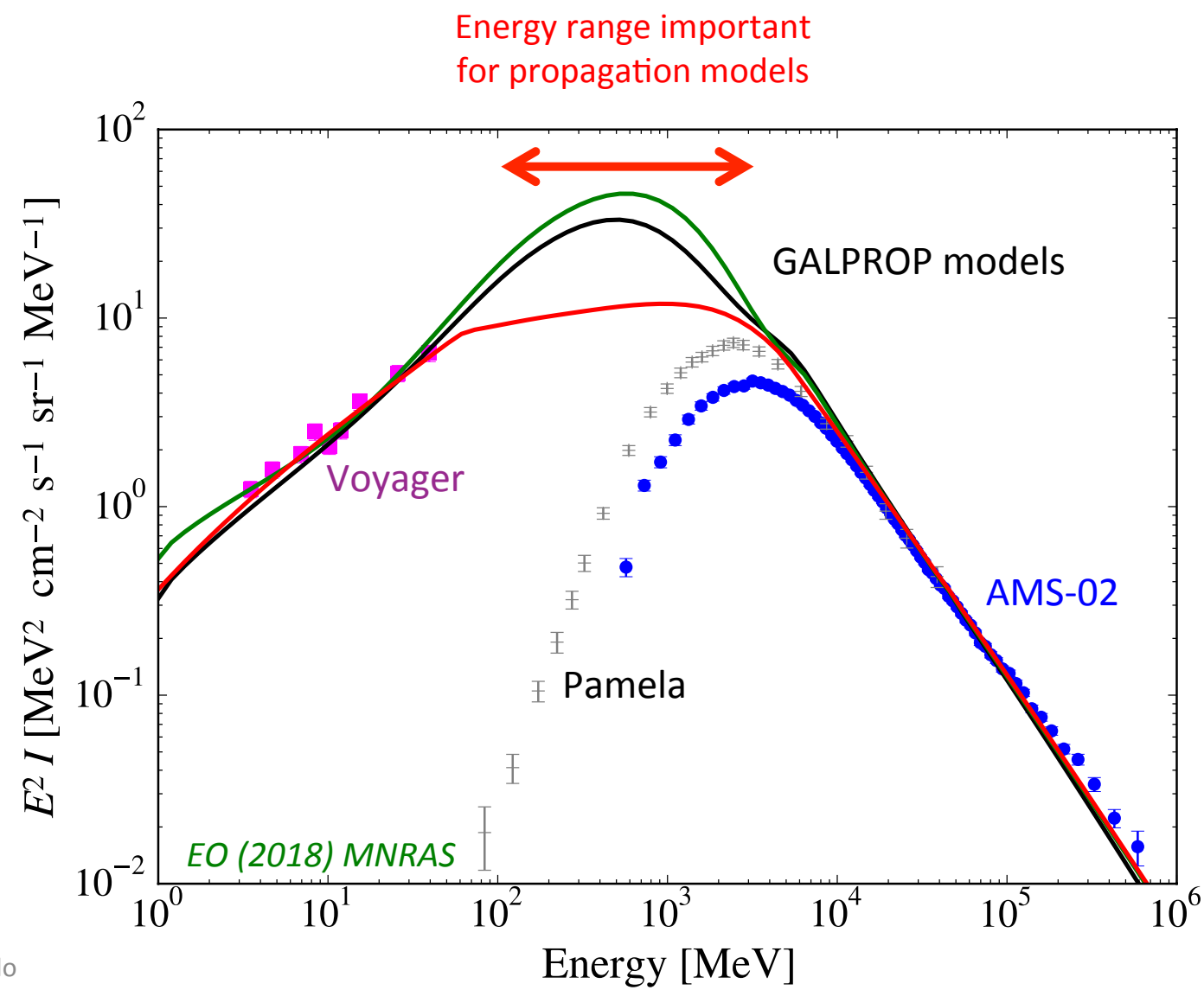
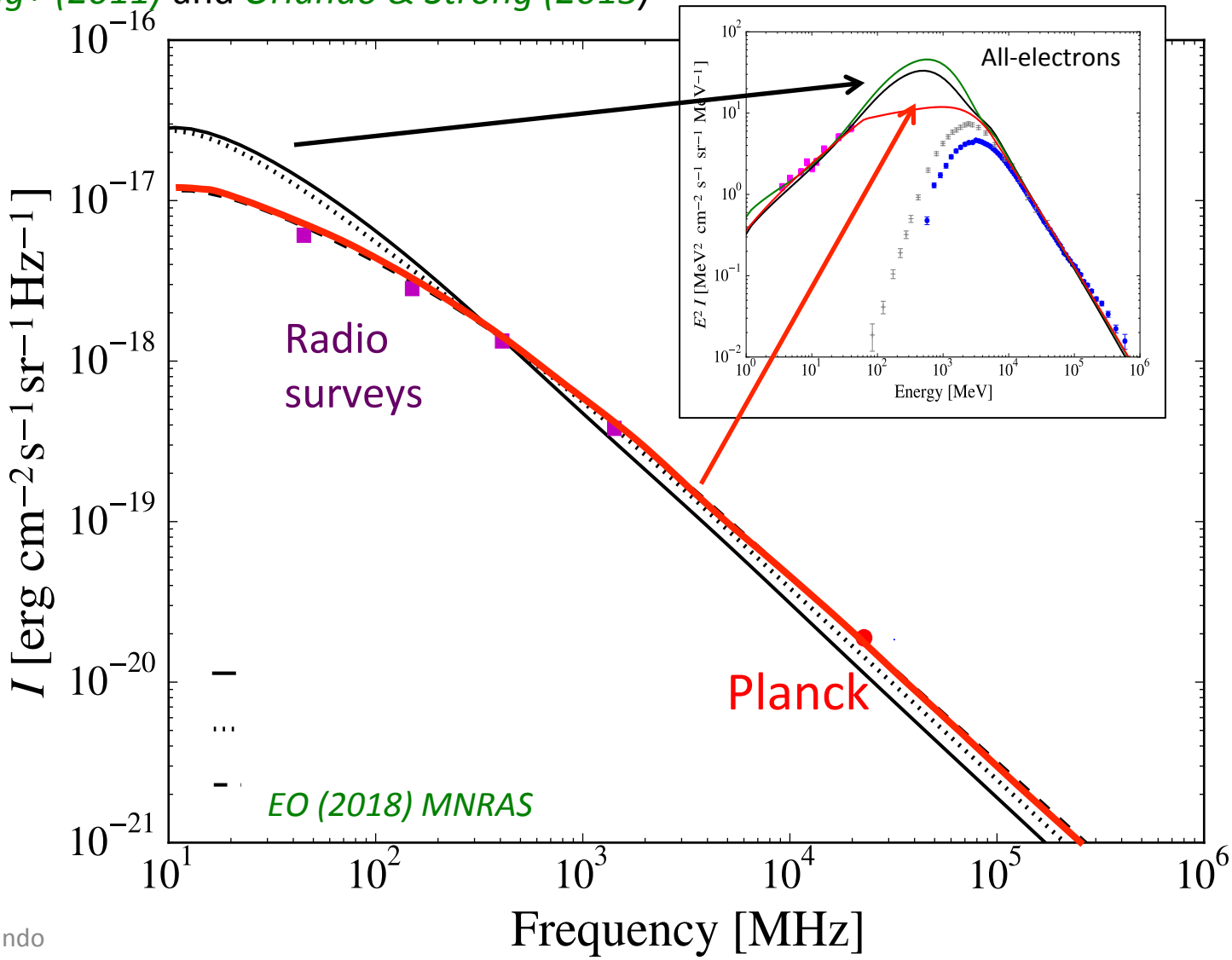
GALPROP

All-Electron Spectrum

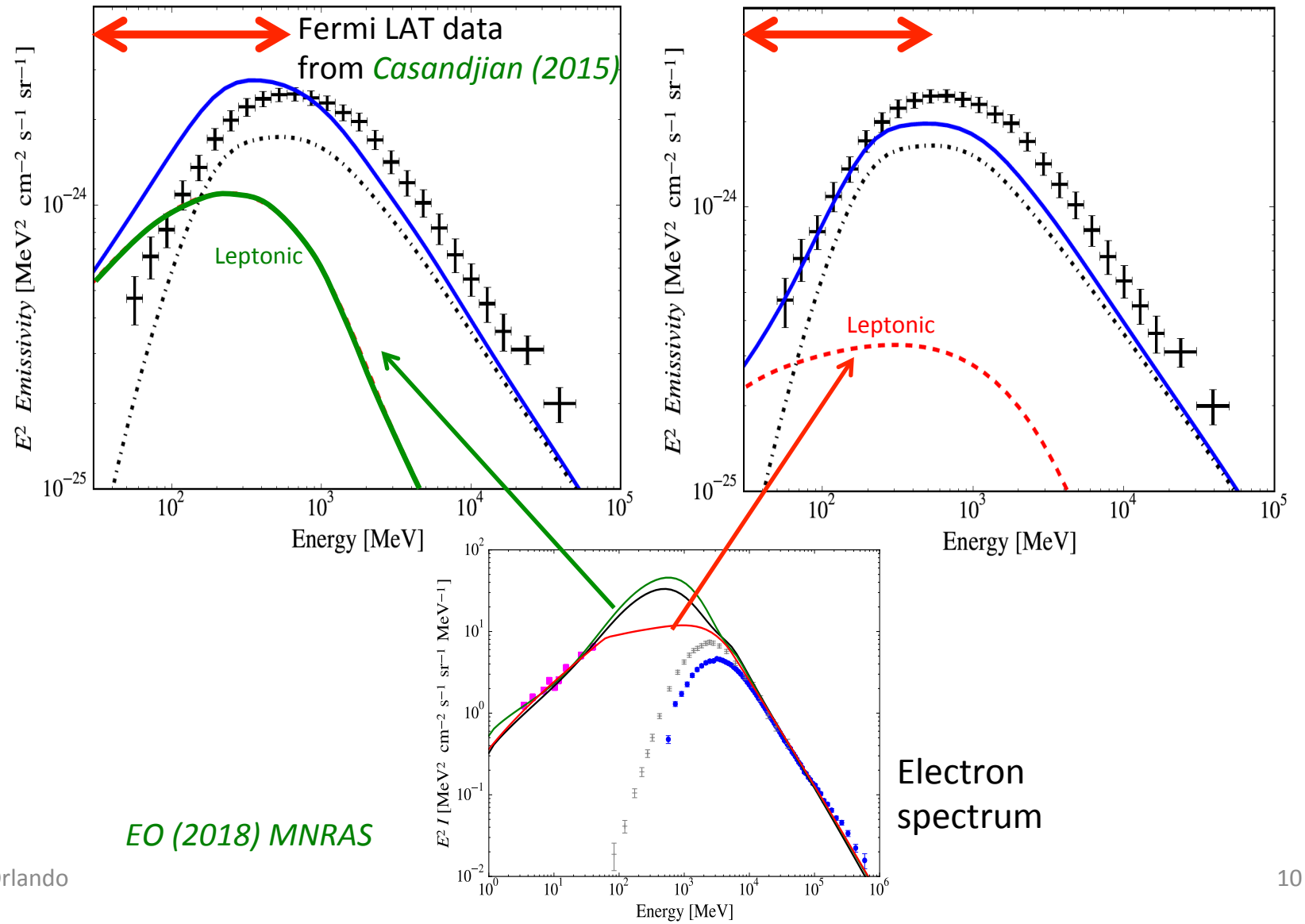


Synchrotron Spectrum

CR & B-field intensity and data updated with respect to previous works by *Strong+ (2011)* and *Orlando & Strong (2013)*

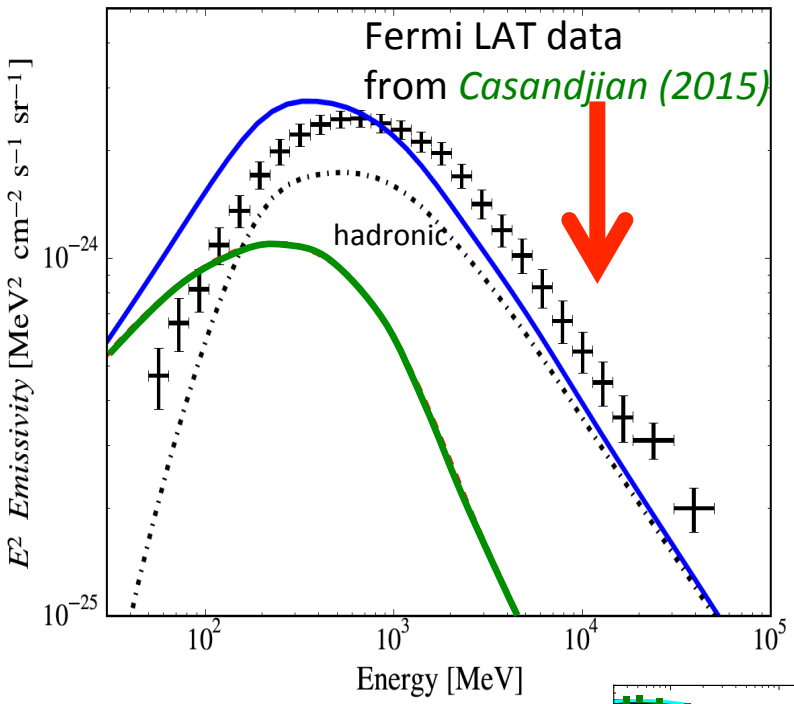


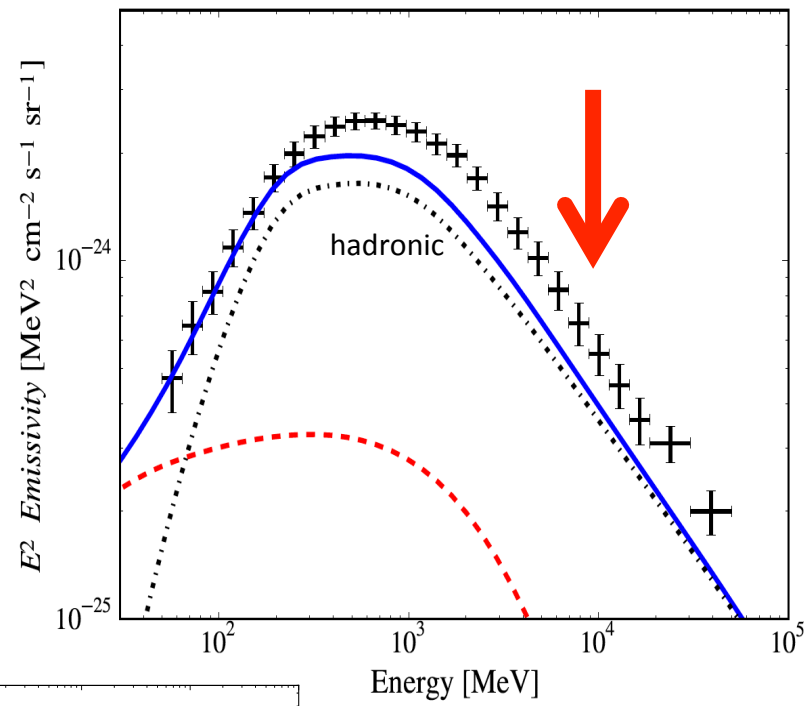
Local HI Gamma-Ray Emissivity

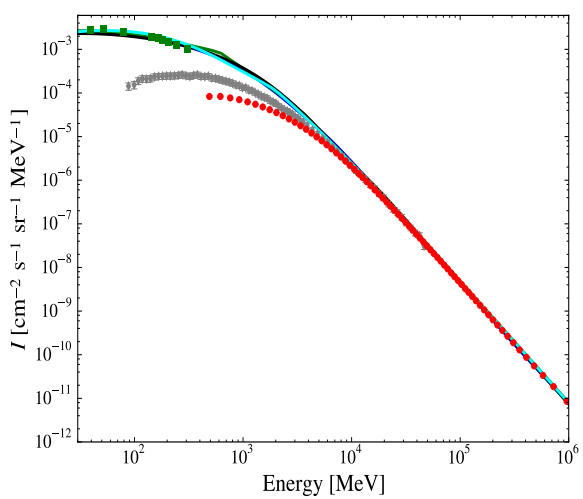


EO (2018) MNRAS

Local HI Gamma-Ray Emissivity





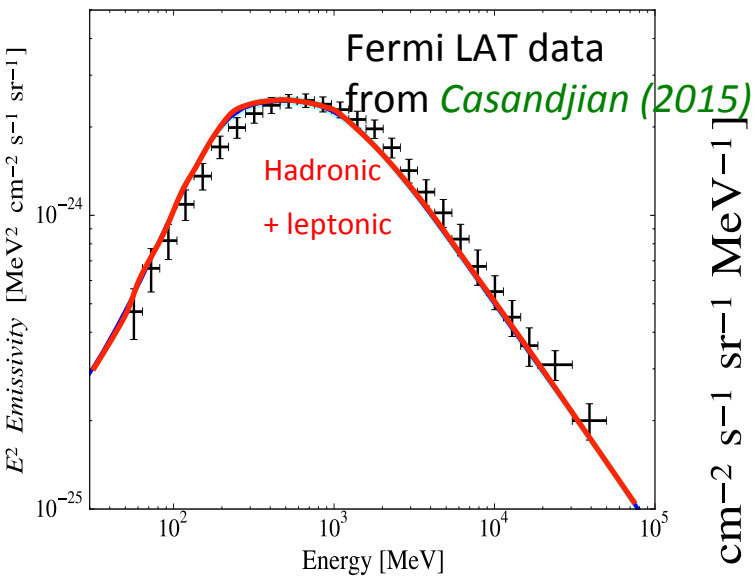


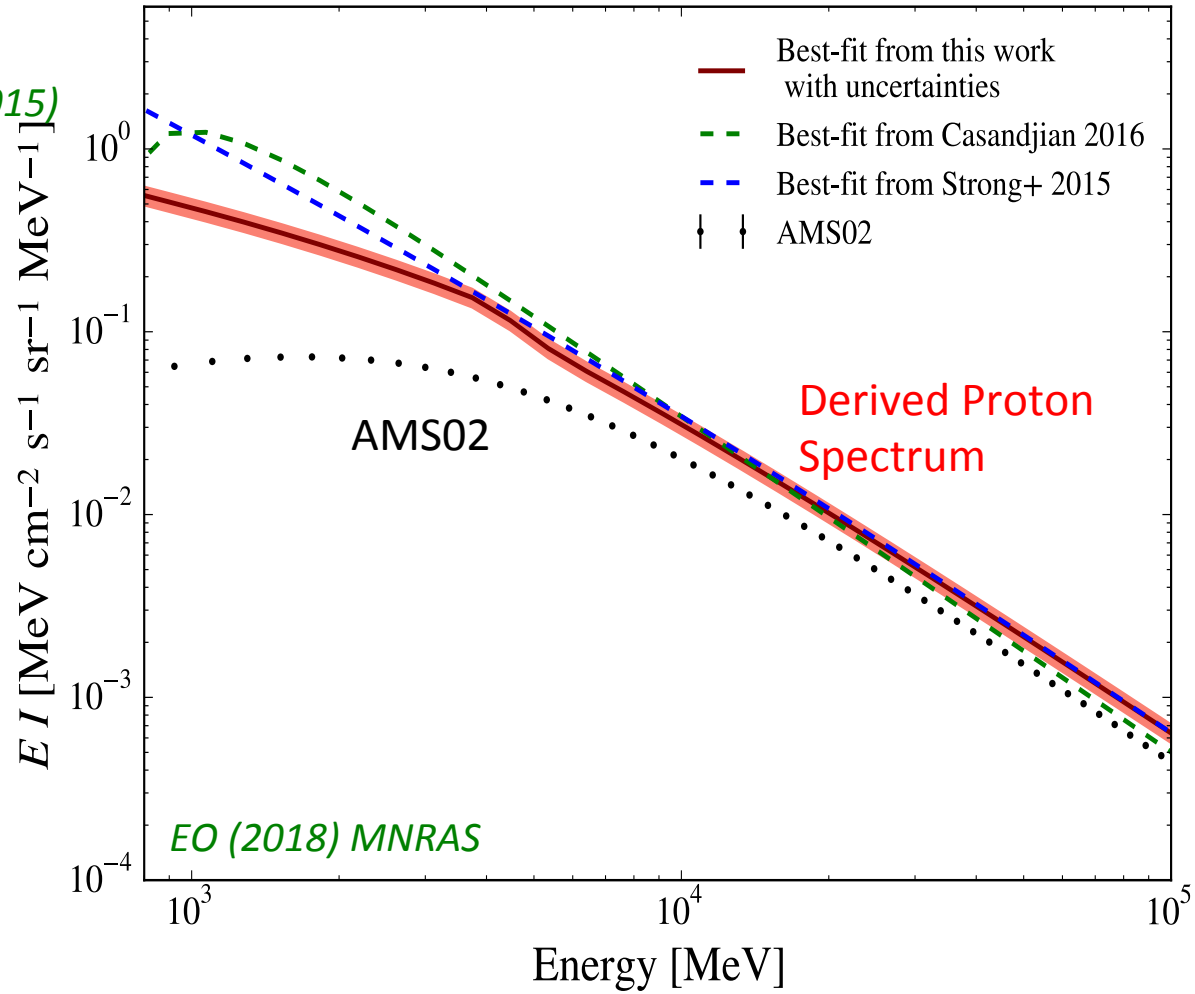
EO (2018) MNRAS

Proton spectrum consistent with *Cummings+ (2016) ApJ* and *Boschini+ (2017) ApJ*

Derived Proton Spectrum

Fit to local HI Gamma-Ray Emissivity





The direct measured proton spectrum may not resemble the local interstellar one

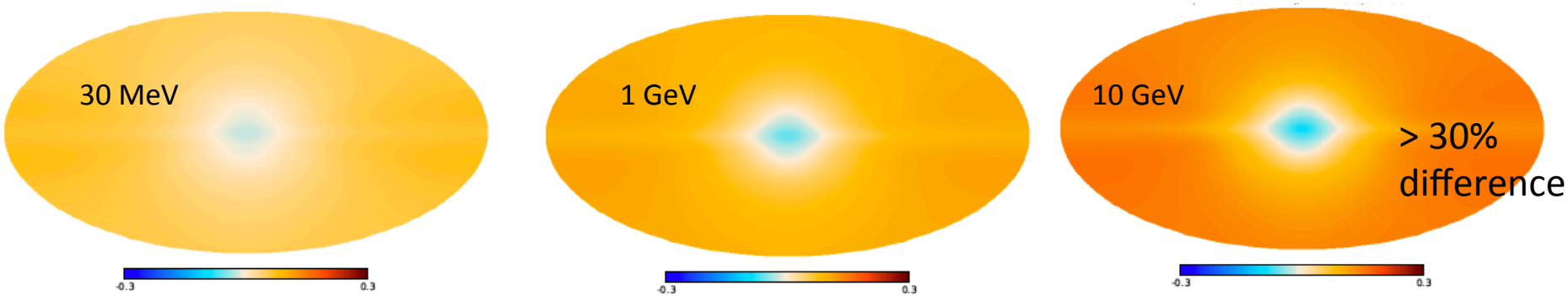
Effects on Inverse Compton (IC) spatial templates of the gamma-ray interstellar emission

Important for the interpretation of Fermi LAT data and also for the generation of the interstellar template used for any analysis of the Fermi LAT data.

Effects on Inverse Compton (IC) spatial templates of the gamma-ray interstellar emission

Updated B-fields produces brighter IC in the inner Galaxy than predicted by previous models for any photon field model

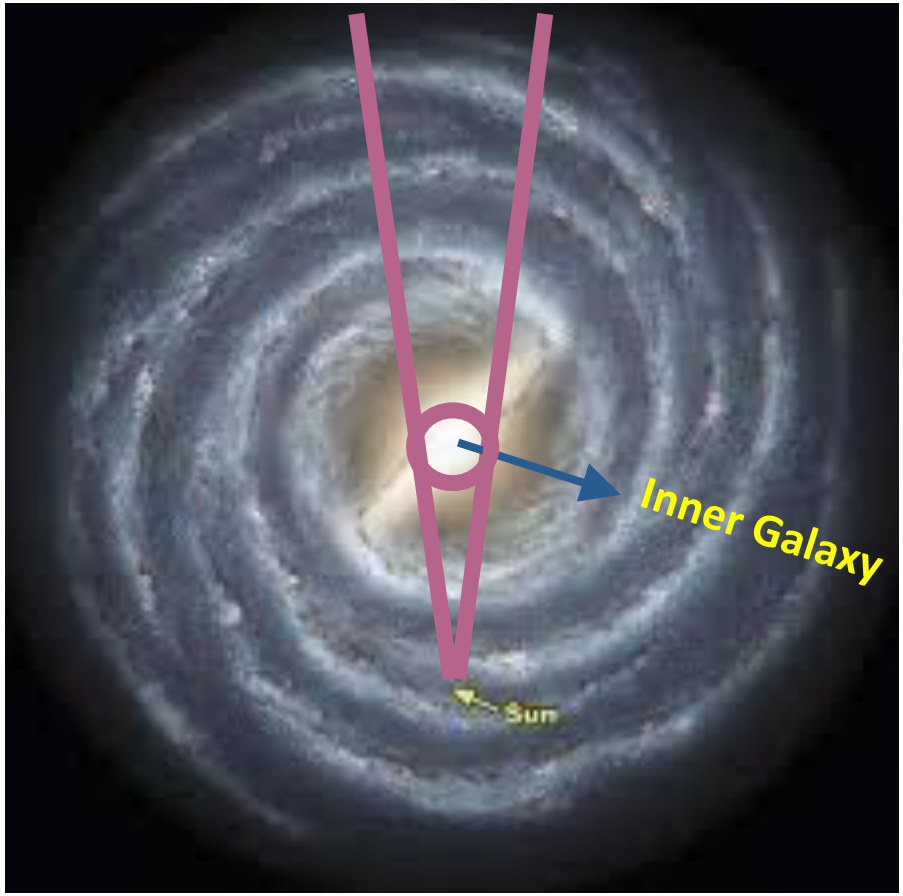
(IC old – IC new) / IC old



EO (2019) Phys.Rev.D

Flashback: CRs toward the Galactic center

Ajello et al. (2016) ApJ



1) IC dominant and brighter than predicted by standard models
2) Hardening in the inner Galaxy with respect to standard models

- CRs? – ISRF? - Unresolved sources? - Dark Matter? -

Effects on Inverse Compton (IC) spatial templates of the gamma-ray interstellar emission

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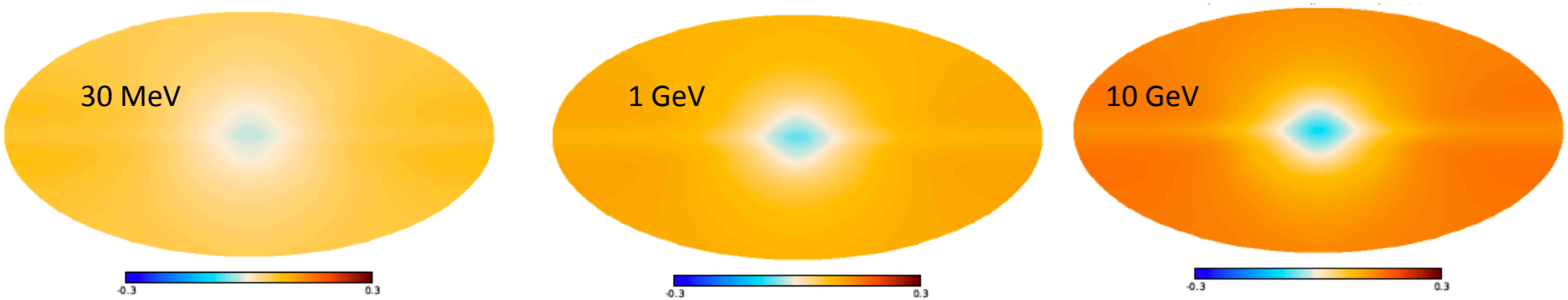


EO (2019) Phys.Rev.D

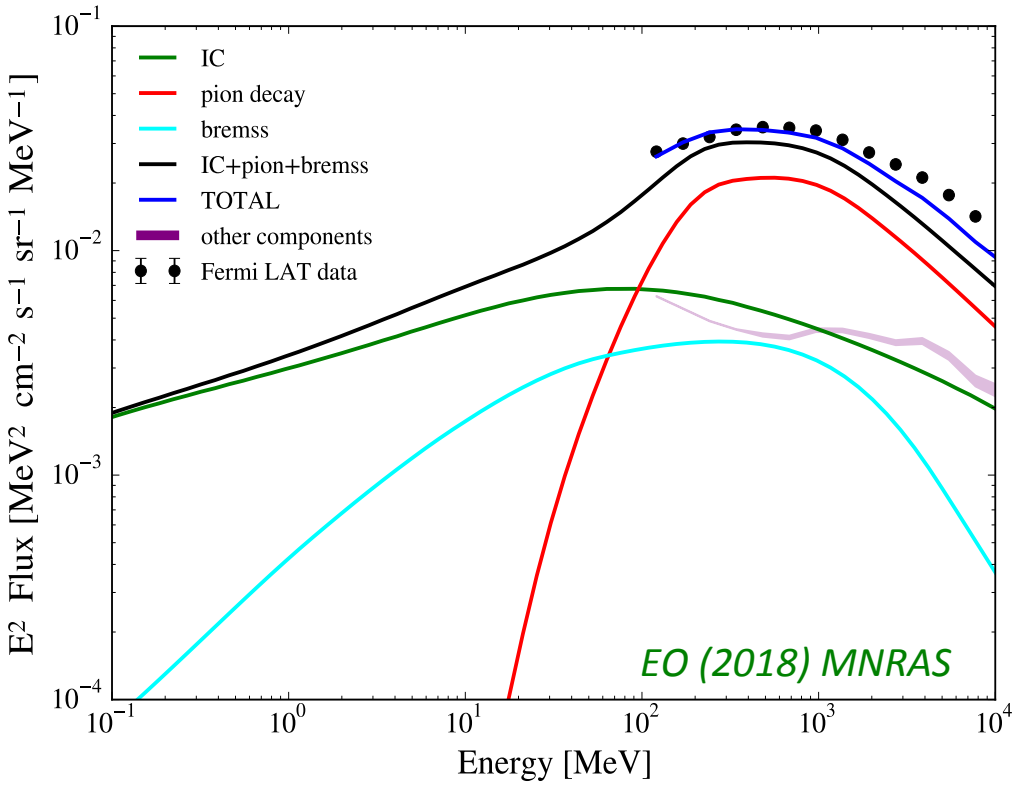
With respect to the standard models, these models:

- provide alternative propagation scenarios
- are consistent with radio and microwave data
- are updated to recent CR measurements

Next step: to be tested with Fermi LAT data

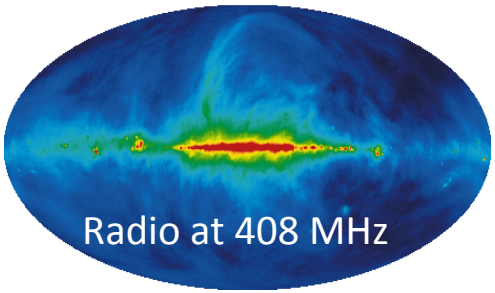
Predictions – MeV Gammas

AMEGO (*GAD3b by Moiseev*)
All-Sky-ASTROGAM (*PS1-252 by De Angelis*)
GalCenEx (*PS1-254 by Moiseev*)



See also *Orlando et al 2019* "*Cosmic Rays and Interstellar Medium with Gamma-Ray Observations at MeV Energies*" ASTRO2020 Decadal Survey on Astronomy and Astrophysics, Science white paper 151 (also Poster *PS3-247*)

Summary



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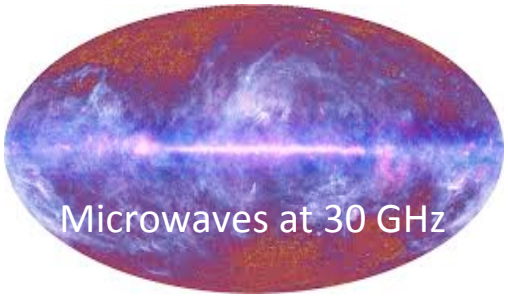

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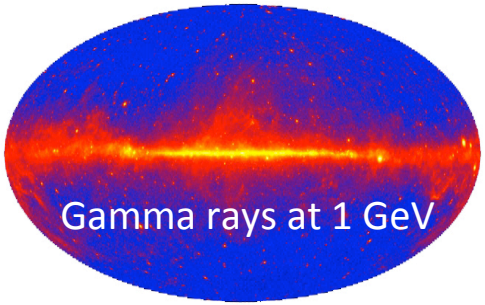

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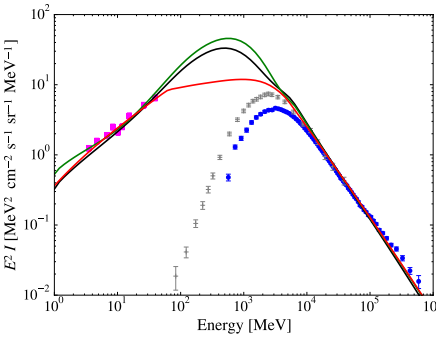
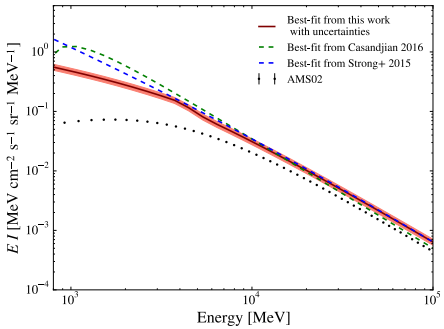
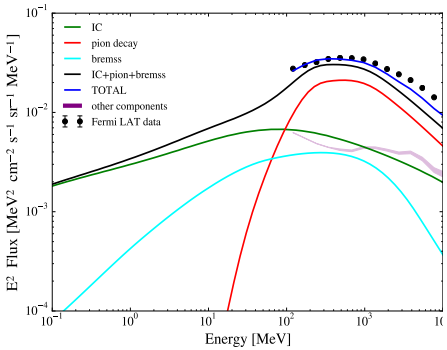


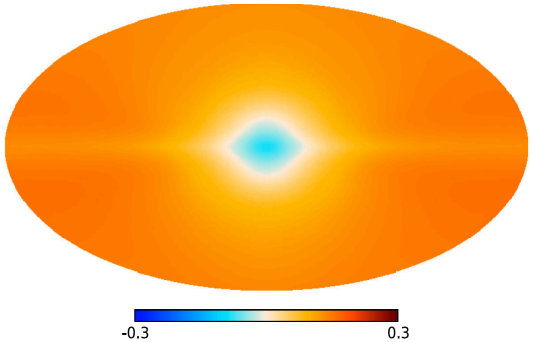
Electron LIS



Proton LIS



Predictions of Interstellar emission at MeV



Residuals on Inverse Compton Template

From Orlando (2019) Phy.Rev.D & Orlando (2018) MNRAS