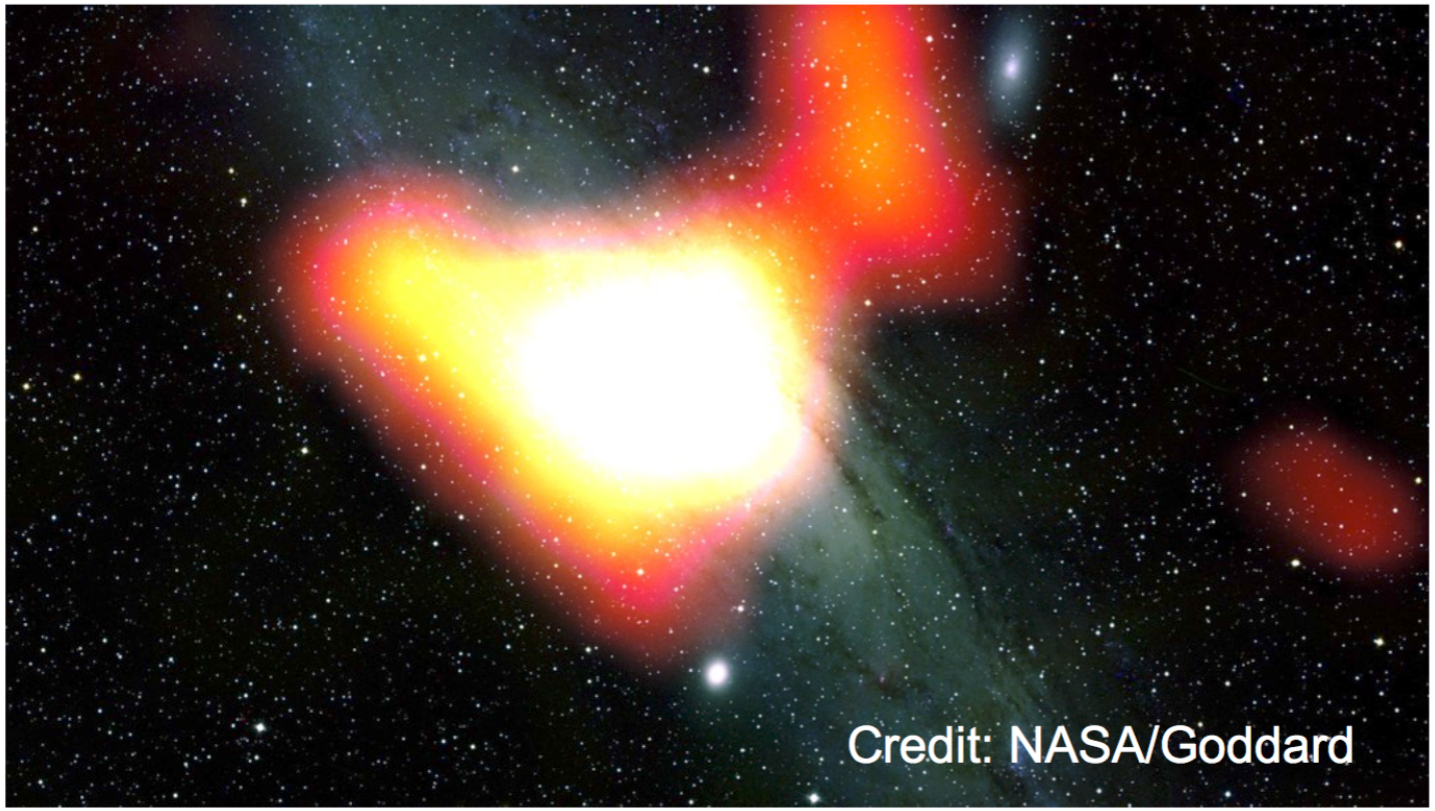
A Galactic Center Excess in the Andromeda Galaxy
M31 Seen with the *Fermi*-LAT

(Ackermann et al. 2017)



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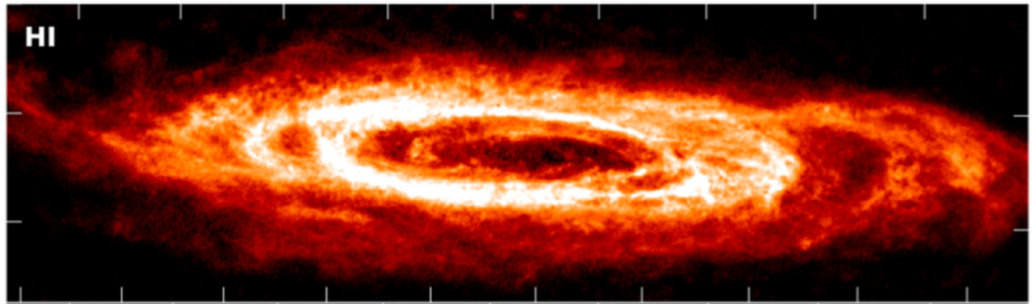
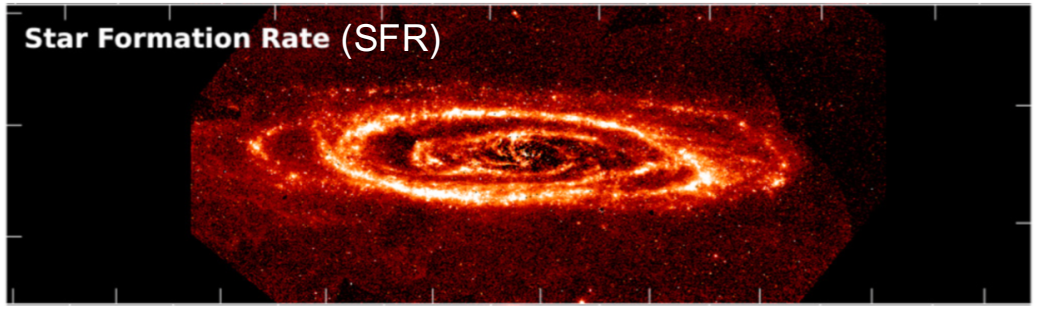
NASA news: https://www.nasa.gov/feature/goddard/2017/nasas-fermi-finds-possible-dark-matter-ties-in-andromeda-galaxy/

Intro

- ✓ How galaxies shine in gamma rays?
  - Interactions of cosmic rays (CR) with interstellar medium (π^0 decay, inverse-Compton, bremsstrahlung)
  - astrophysical sources (supernova remnants, pulsars and pulsar wind nebulae, binaries…)
  - dark matter
- ✓ LAT detected 7 extragalactic star-forming or starburst galaxies and performed systematic studies of more than 60 galaxies.
- ✓ **M31**: only other large spiral local galaxy, close =>best target for resolved analysis





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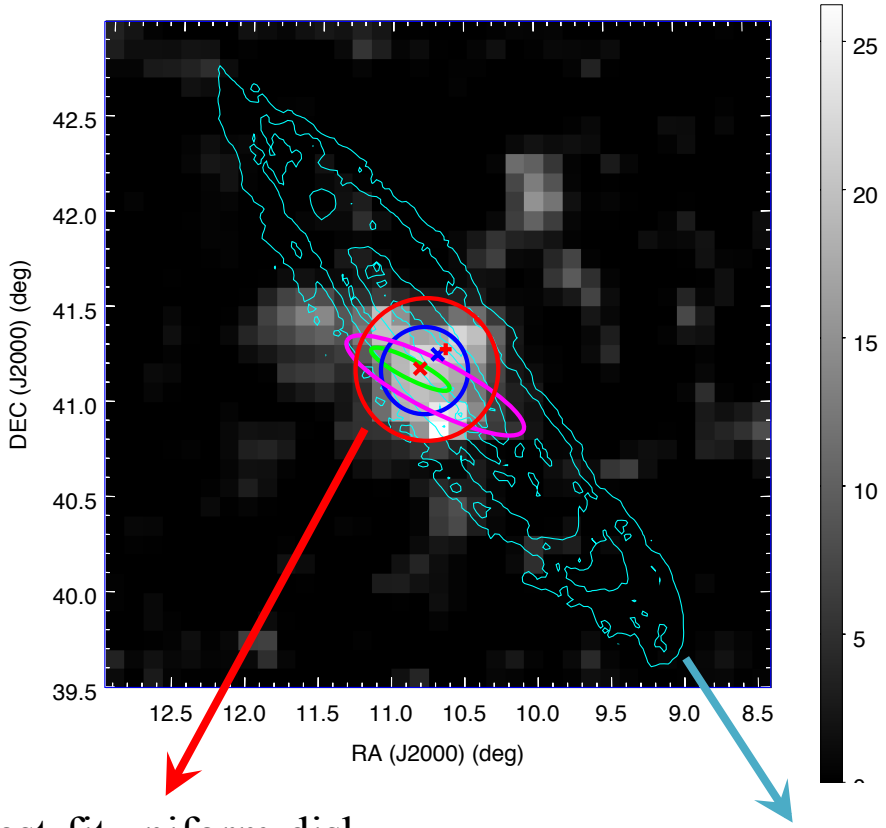
Analysis and Results

Spatial analysis (>1 GeV)

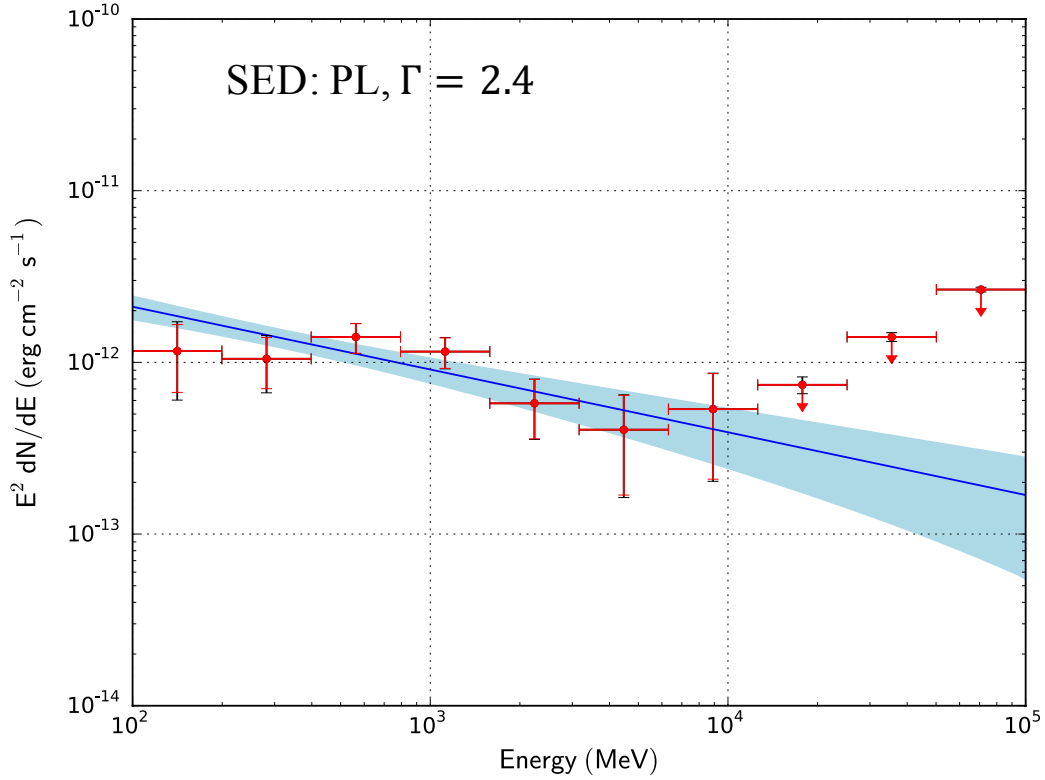


best-fit uniform disk

M31 gas column density (N_H) map

- Gamma-ray emission is confined to inner regions (R~5 kpc)
- Not correlated with interstellar gas and star-formation sites
- Disk (plane) of the galaxy is not detected

Spectral analysis (>100 MeV)



- ✓ Adding cutoff: no significant improvement
- ✓ Consistent with the total interstellar emission or pion decay of the MW
- ✓ Less consistent with IC component of the MW
- ✓ Model difference: not significant

Discussion

I. Interstellar emission

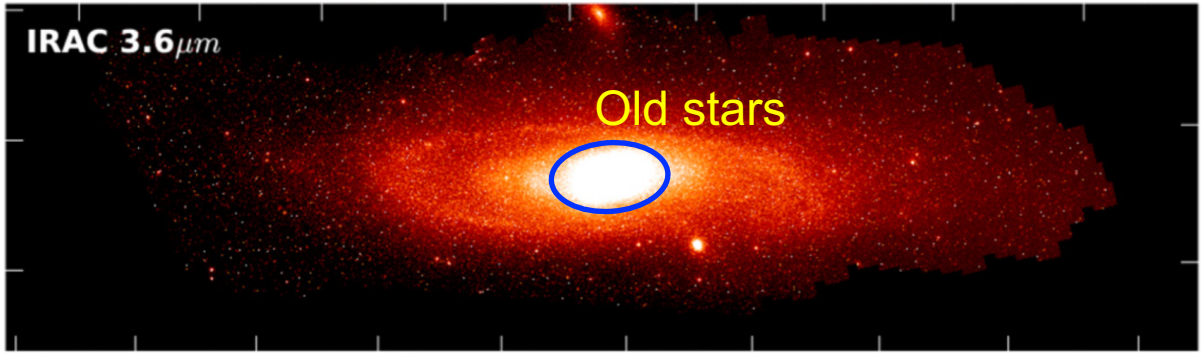
- π^0 decay
  - Low gas content to be compensated by high CR density at the galaxy center (similar to some regions in LMC)
  - But far from typical gas and star-formation regions (not detected in gamma rays)
- inverse-Compton (IC)
  - IC dominates the emission of M31: π^0 decay < 50% IC
  - Opposite to what is inferred for the MW: IC = 45% π^0 decay

II. Population of millisecond pulsars (MSPs)

- Related to old star populations in the disk and bulge of galaxies
- Suggested to be the origin of the Galactic Center Excess (GCE) (e.g. Brandt & Kocsis 15)
- Case of M31
  - Center: many old stars and X-ray binaries (Barmby+06, Voss & Gilfanov 07, Stiele+10)
  - Possible large population of MSPs at the center
  - Spatial distribution consistent with old stars (IRAC map)
  - SFR_M31 ~ 0.1x SFR_MW —— decrease the disk emission
  - Bulge mass_M31 ~ (5-6)xMW —— increase the center emission
  - Gamma-ray luminosity of M31 ~ 4-5x GCE

III. Dark matter (DM) annihilation/decay

- Smooth halo : Navarro–Frenk–White (NFW) profile
- Take GCE as reference
- J-factors
  - MW: 2×10^{22} GeV^2/cm^5
  - M31: 8×10^{18} GeV^2/cm^5
- Expected DM signal from M31: ~5x below observed value
  - But uncertainties on J-factor of M31…
  - And uncertainties on the GCE flux …



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