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

(Ackermann et al. 2017)

Xian Hou
YNAO, Kunming, China
and
Pierrick Martin
CNRS/IRAP, Toulouse, France

On behalf of the *Fermi*-LAT Collaboration

7th International *Fermi* Symposium
Garmisch-Partenkirchen, Germany
15-20 Oct 2017

How galaxies shine in gamma rays?

- Interactions of cosmic rays (CR) with interstellar medium ($\pi^0$ 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
Analysis and Results

Spatial analysis (>1 GeV)

- 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)

- SED: PL, $\Gamma = 2.4$
- 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
I. Interstellar emission

- $\pi^0$ 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: $\pi^0$ decay < 50% IC
  - Opposite to what is inferred for the MW: IC = 45% $\pi^0$ 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 $\sim$ 0.1x SFR_MW —— decrease the disk emission
  - Bulge mass_M31 $\sim$ (5-6)xMW —— increase the center emission
  - Gamma-ray luminosity of M31 $\sim$ 4-5x GCE

III. Dark matter (DM) annihilation/decay

- Smooth halo: Navarro–Frenk–White (NFW) profile
- Take GCE as reference
- J-factors
  - MW: $2 \times 10^{22}$ GeV$^2$/cm$^5$
  - M31: $8 \times 10^{18}$ 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 …