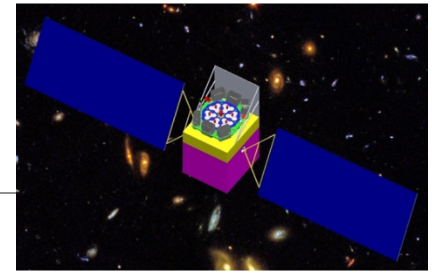
中国科学院高能物理研究所
INSTITUTE OF HIGH ENERGY PHYSICS

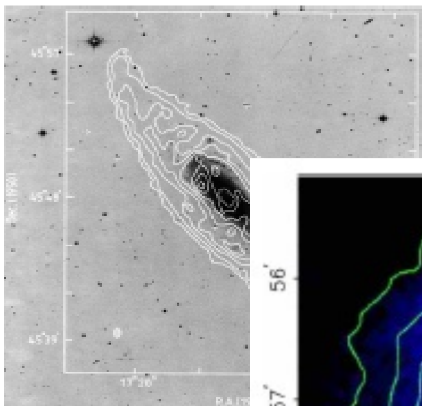


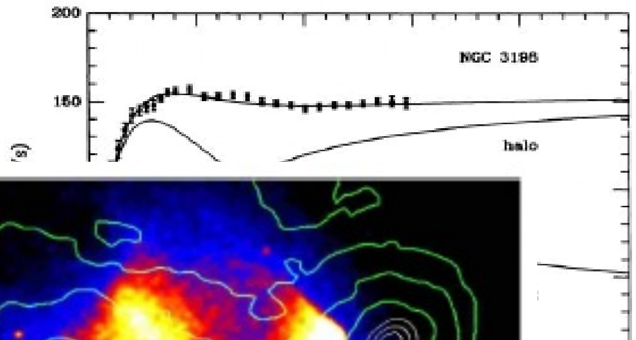
Constraints on the cross-section of dark matter annihilation from Fermi observation of M31

Zhengwei Li

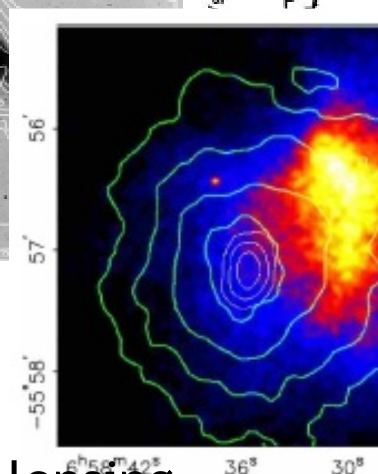
Payload working Group of HXMT

Evidence of dark matter

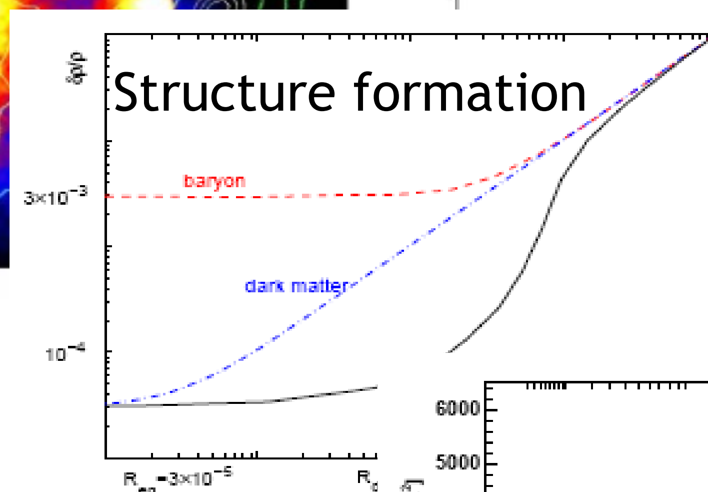


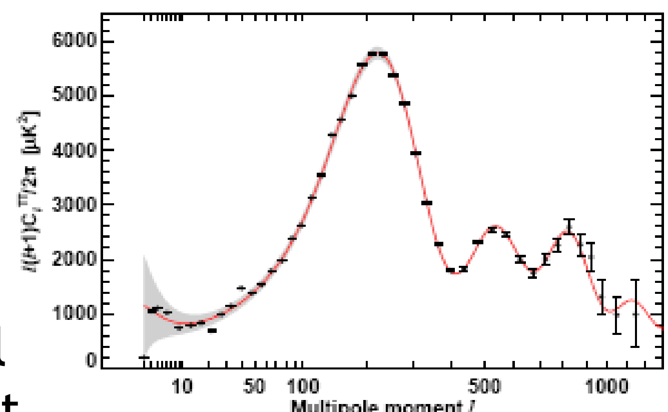


Rotation curve of galaxy
van Albada et al. (1985)

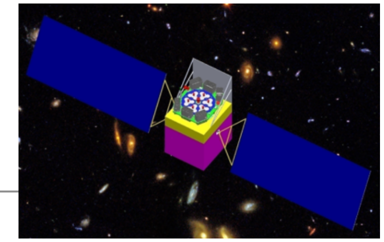


Gravitational lensing
Clowe et al. (2006)



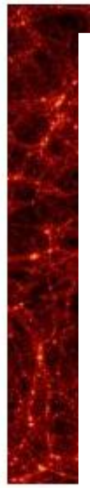


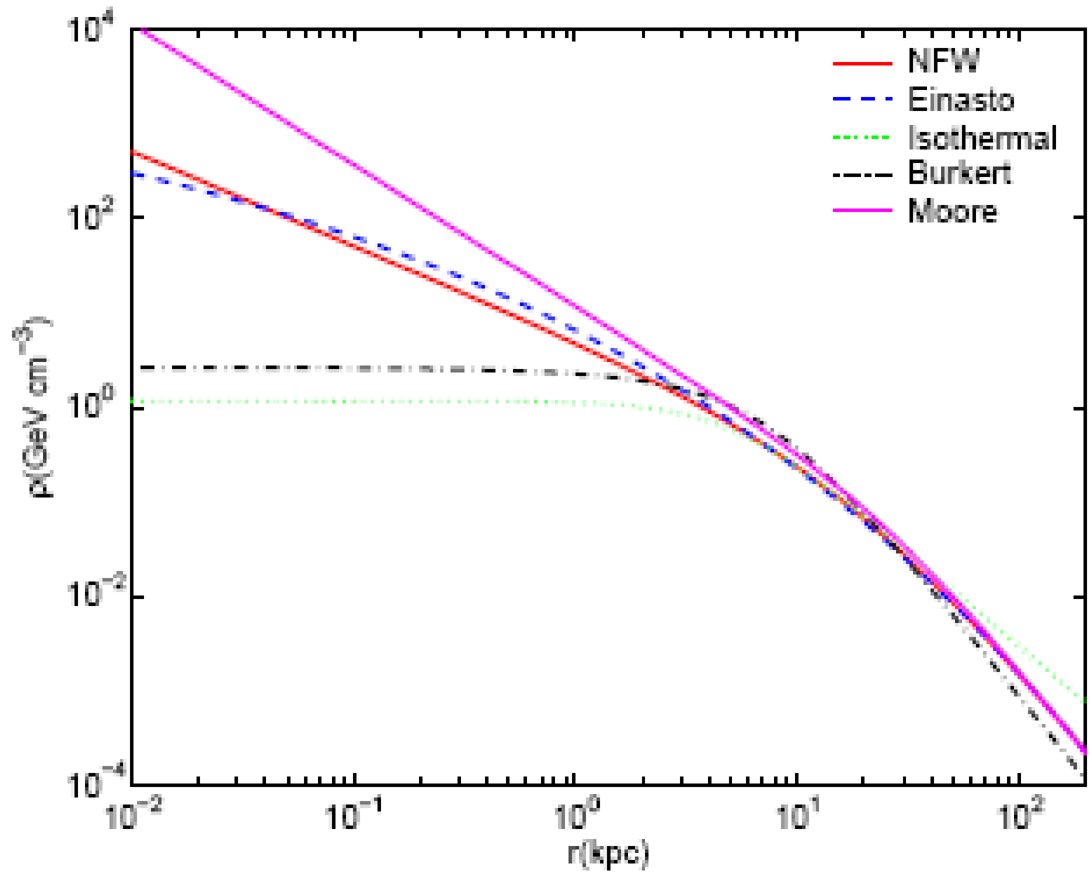
Cosmological
measurement
(WMAP7)



Dark matter structure (observation + simulation)

STAGES: Abell901/902





At galactic level, dark matter distribution is in the form of extended halo, with sub and sub-sub halos (hierarchy).

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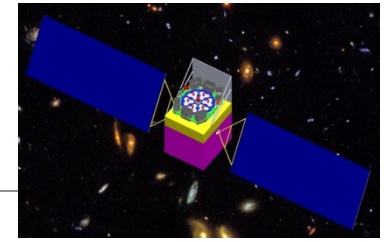
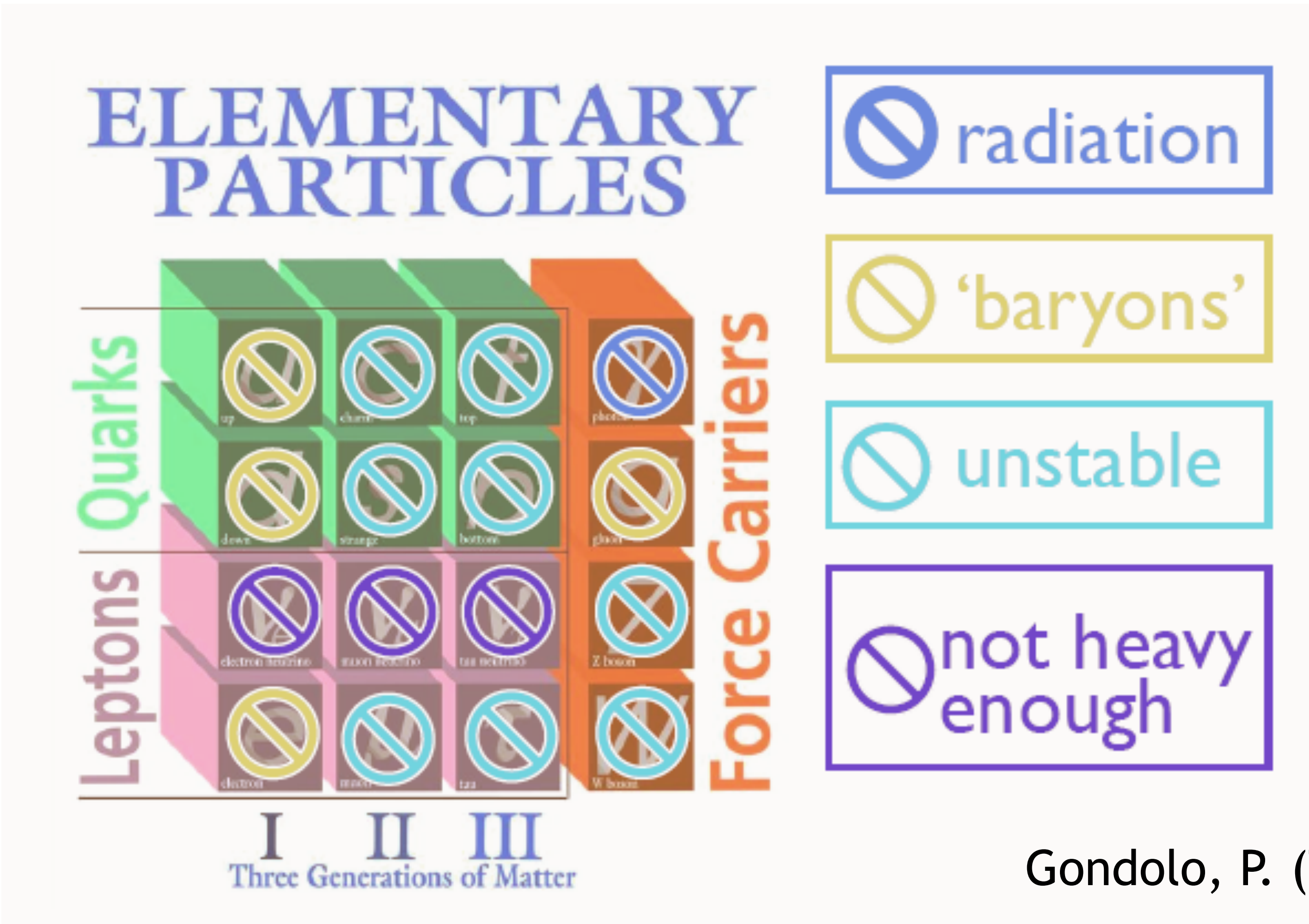
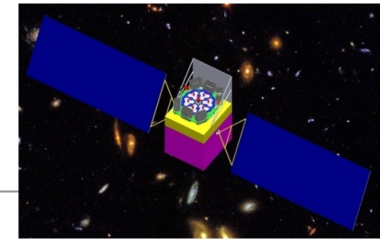


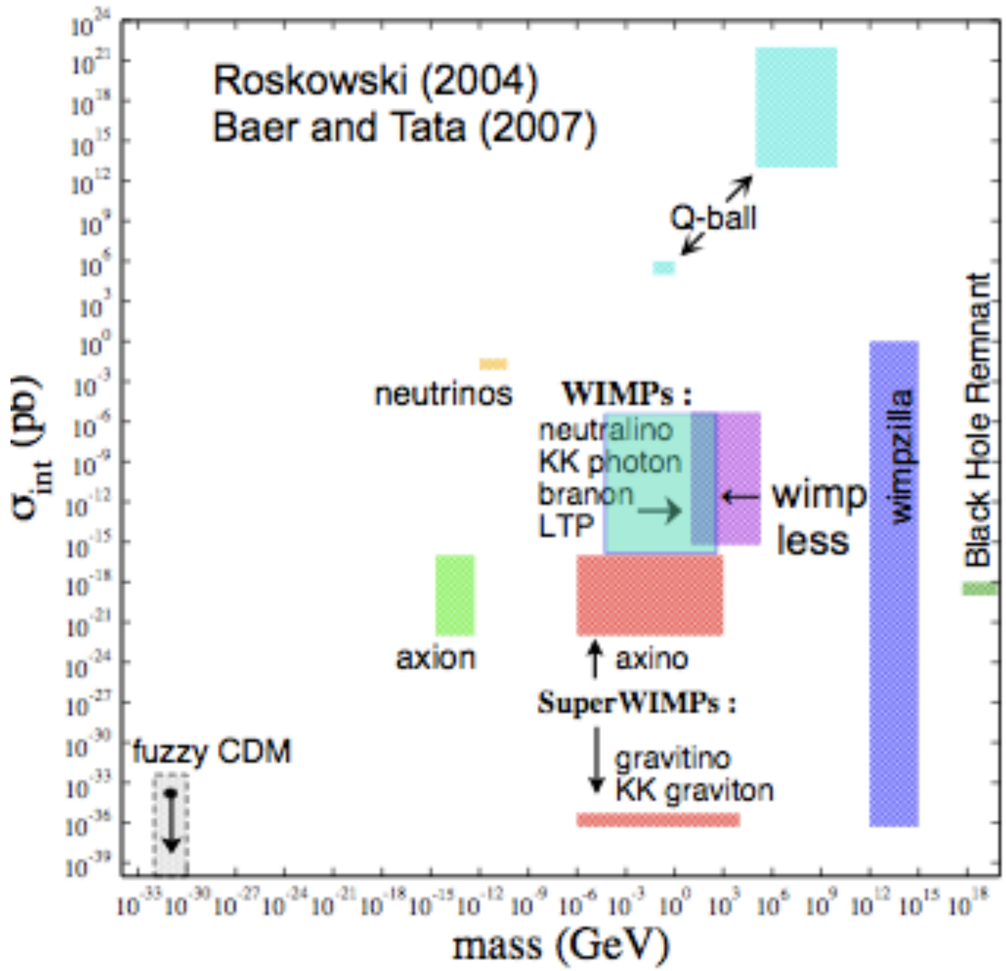
Beyond standard particle physics: no matching standard particles

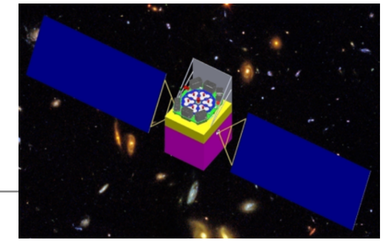


Gondolo, P. (TeVPA08)

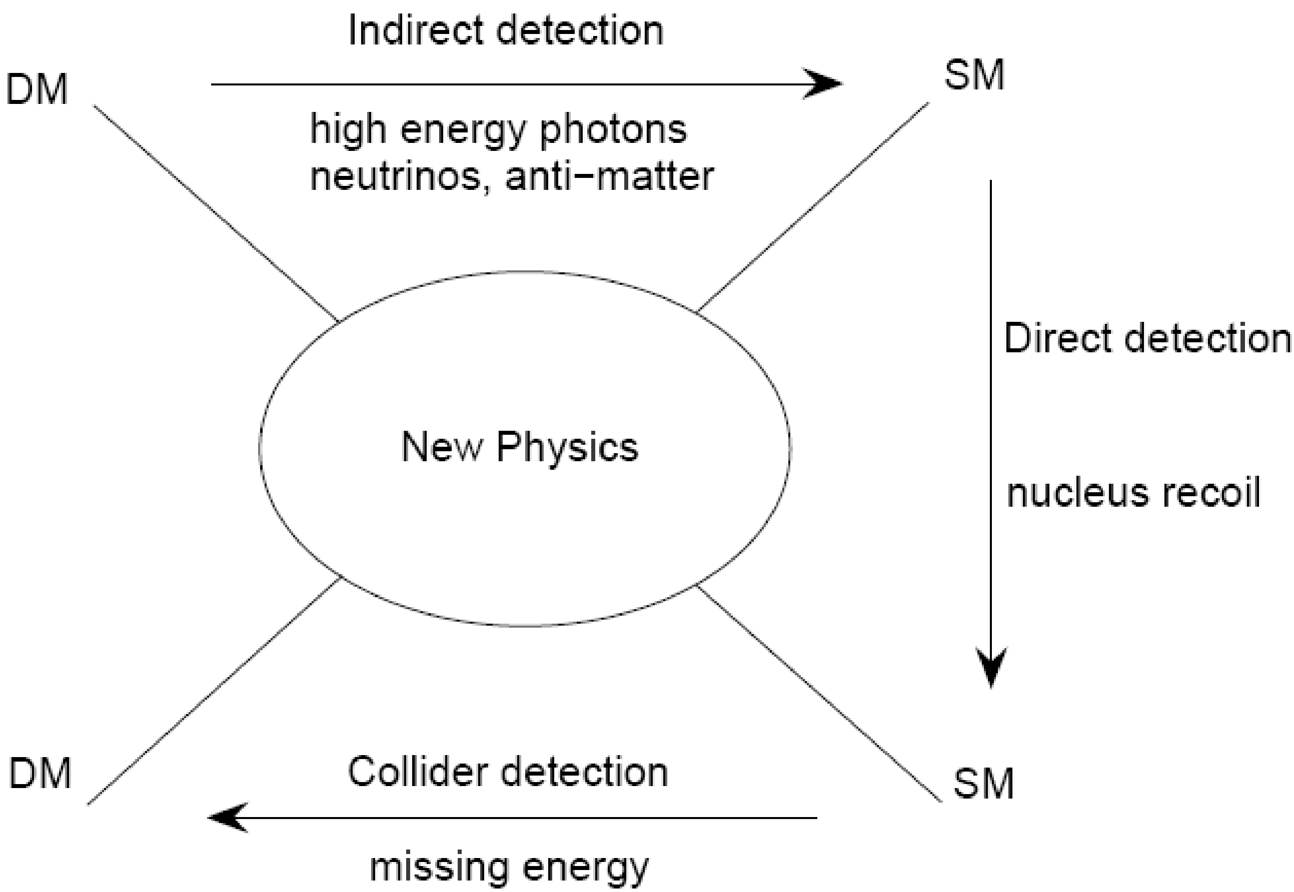


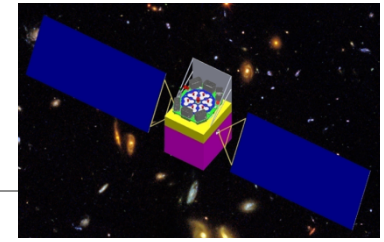
Particle candidate of dark matter



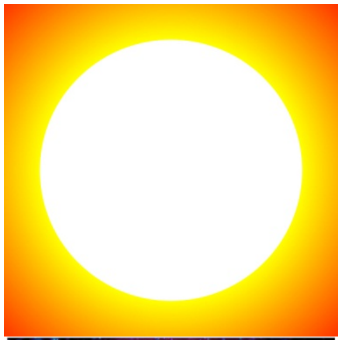


Detection of particle dark matter

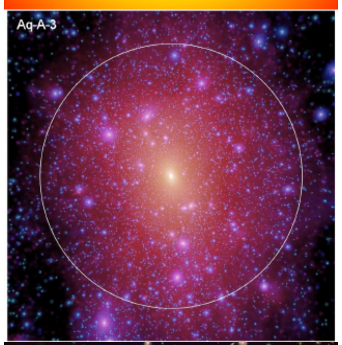




Indirect detection of dark matter

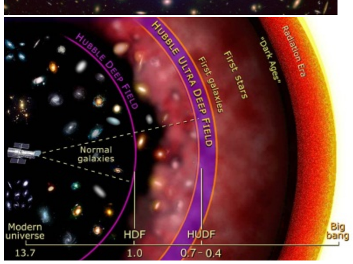


Sun

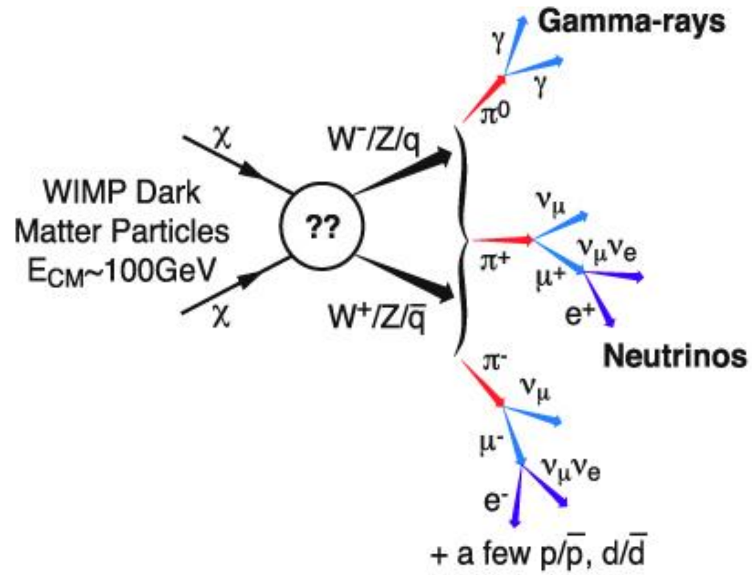


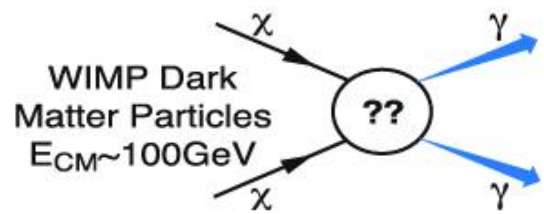
Galaxy

Cluster

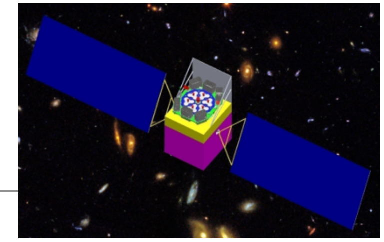


Deep extragalactic space and early Universe





Baltz et al. 2008



Annihilation scenario of dark matter

Observed flux:

$$\Phi(\psi) = \frac{1}{4\pi} \int_{\text{los}} \xi(\mathbf{x}, E)\, dl(\psi)$$

$$\xi(\mathbf{x}, E) = Q_{\text{anni}}(\mathbf{x}, E) = \frac{\langle \sigma v \rangle}{2m_\chi^2} \left(\frac{dN}{dE} \right) \rho^2(\mathbf{x})$$

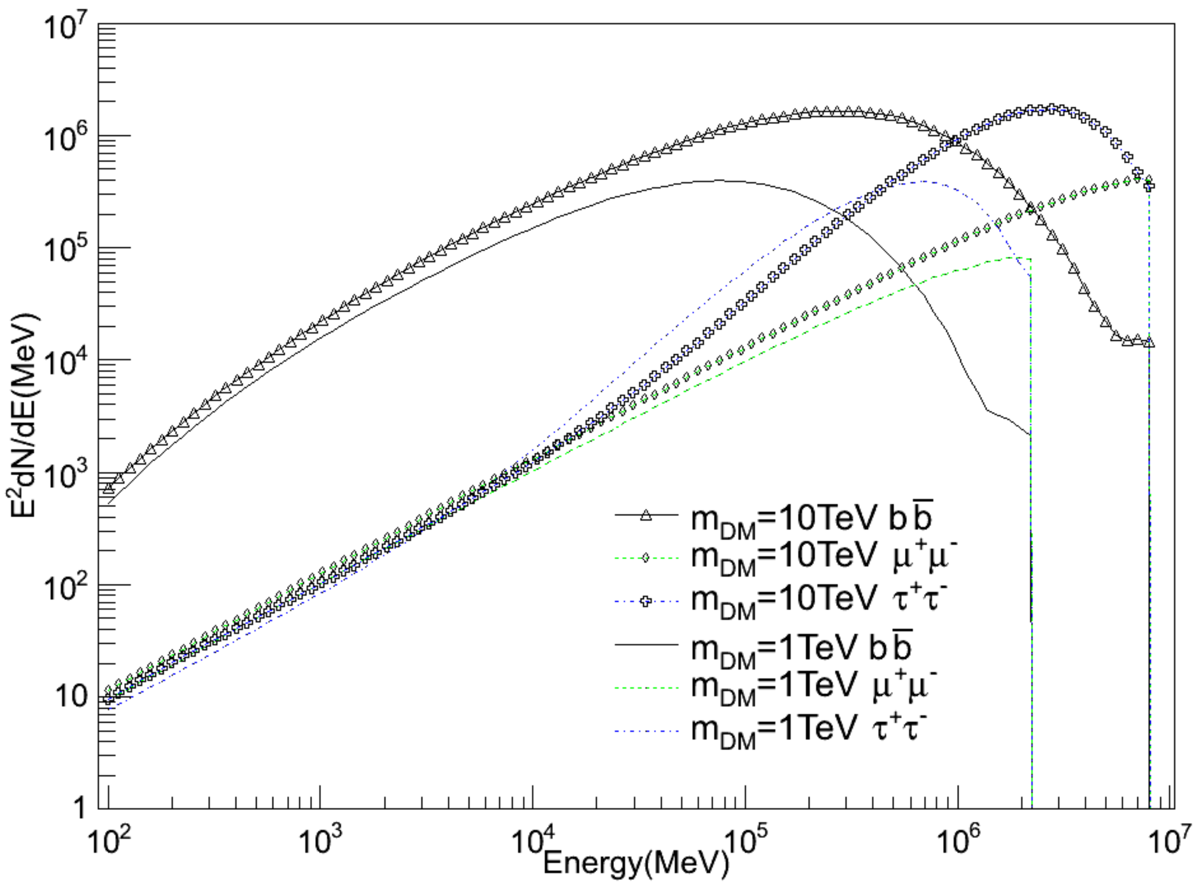
particle physics factor (from DM particle model)

density distribution (from gravitational observation and/or numerical simulation)

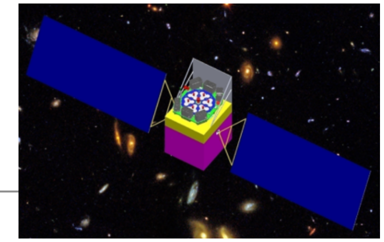
J-factor:

$$J(\psi) = \int_{\text{los}} \rho^2(\mathbf{x}(\psi))\, dl(\psi)$$

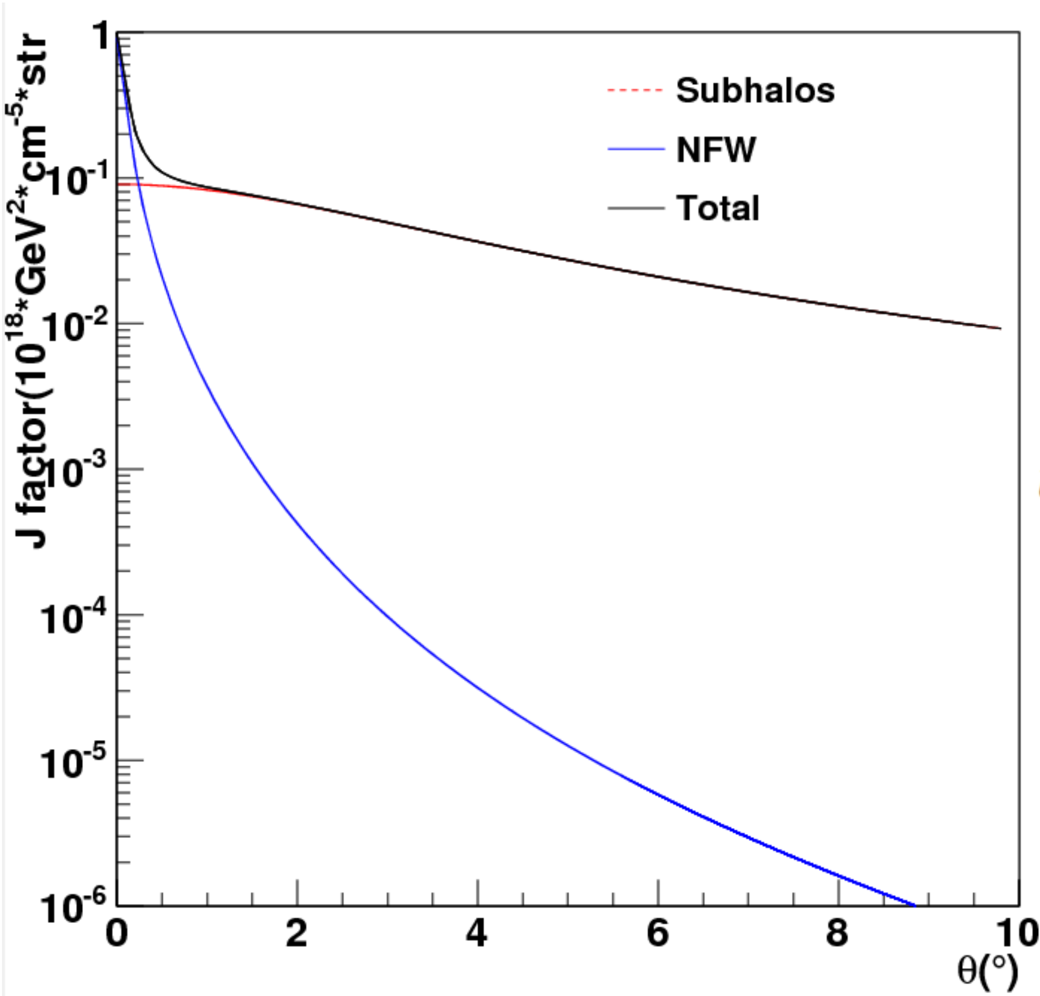
Some preliminary work



- Final state radiation
- No Inverse compton scatter
- Cut-off at mass of dark matter



J-factor of galaxy M31:



Dark matter distribution:NFW

$$\rho(r) = \frac{\rho_s}{(r/r_s)(1+r/r_s)^2}$$

Subhalo boost factor:

$$b(M_{200}) = \mathcal{J}_{sub}/\mathcal{J}_{NFW} = 1.6 \times 10^{-3} (M_{200}/M_{\odot})^{0.39}$$

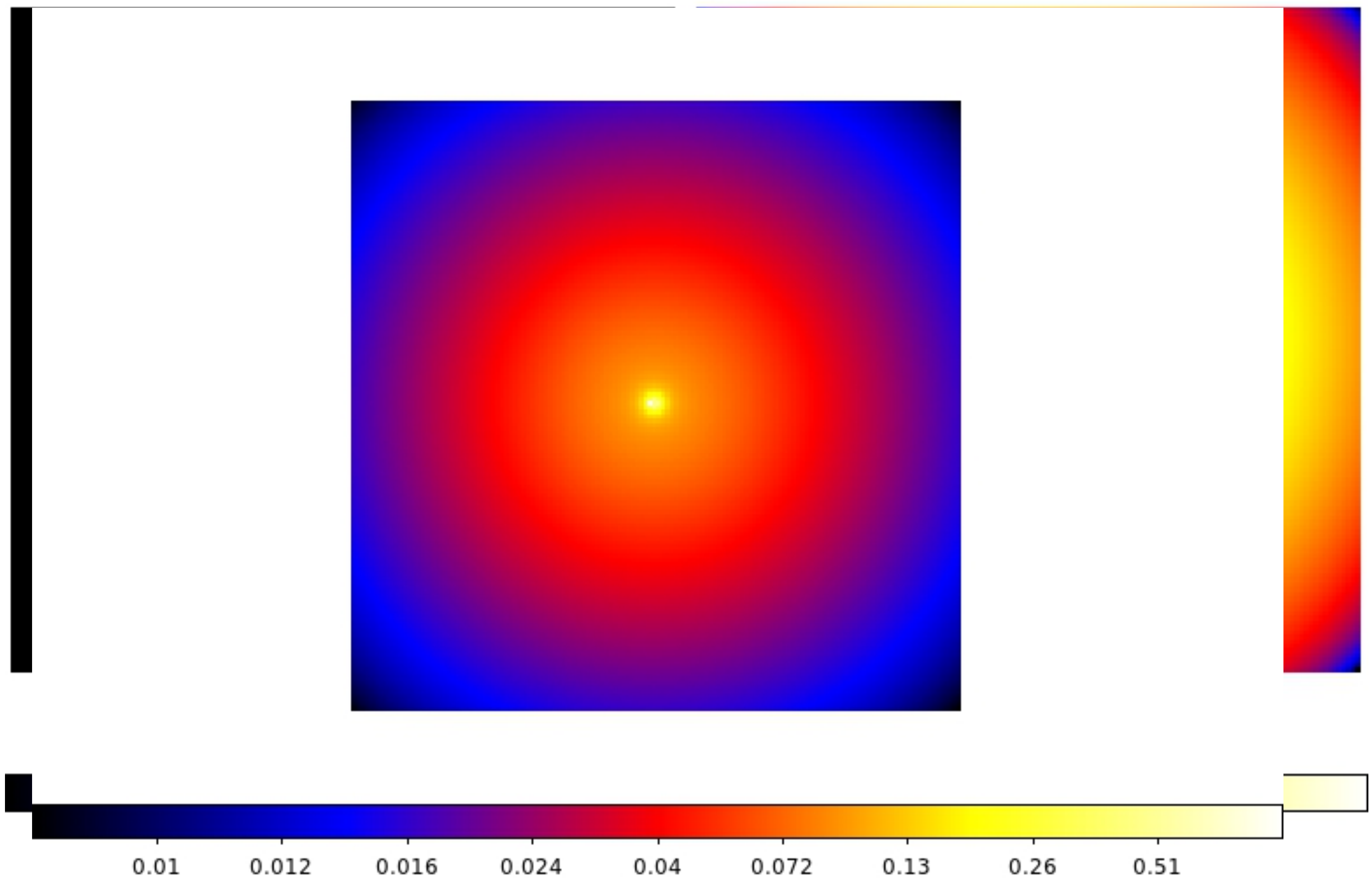
J-factor from subhalo:

$$J_{sub}(r) = \frac{16 b(M_{200}) \mathcal{J}_{NFW}}{\pi \ln(17)} \frac{1}{r_{200}^2 + 16 r^2} \quad (r \le r_{200})$$

Jiaxin Han et al, 2012

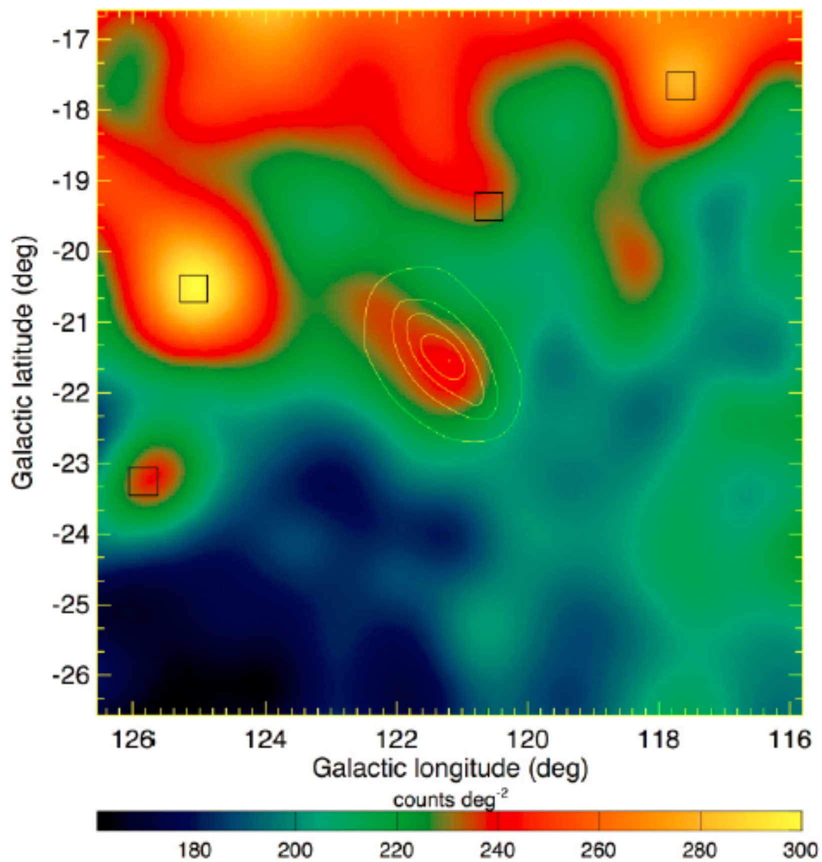
Spatial distribution of J-factor: $14^o * 14^o$

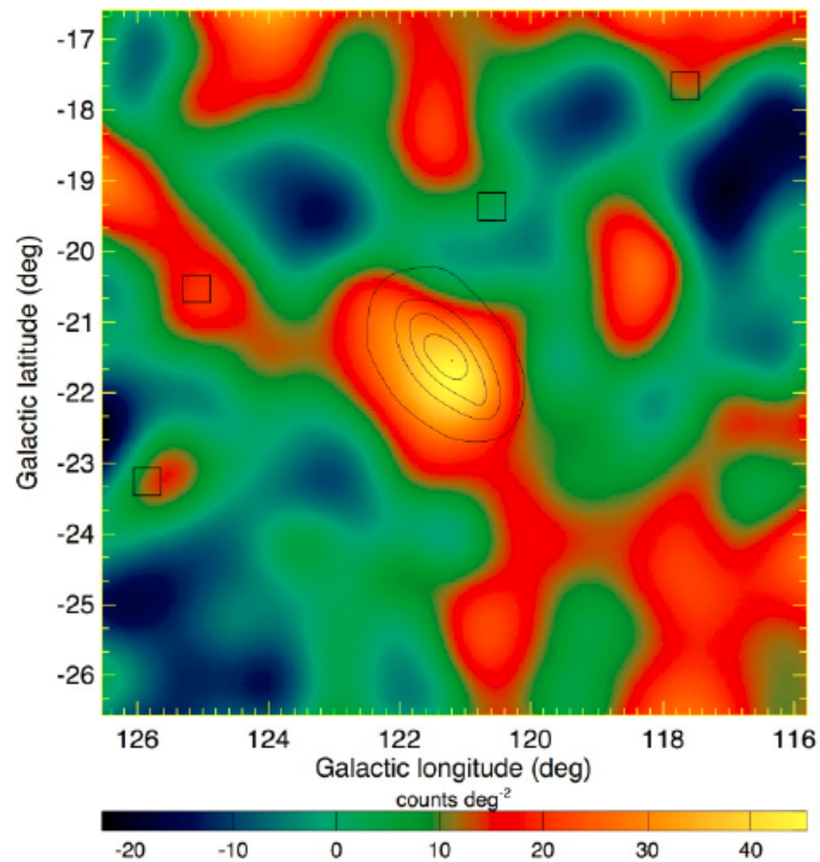
NFW halo Subhalo



Gamma ray in M31

Abdo et al, 2010

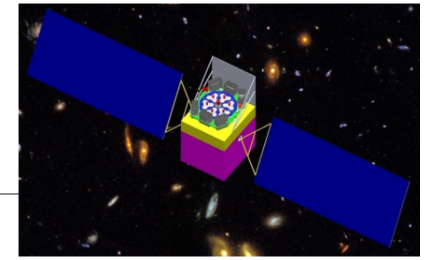




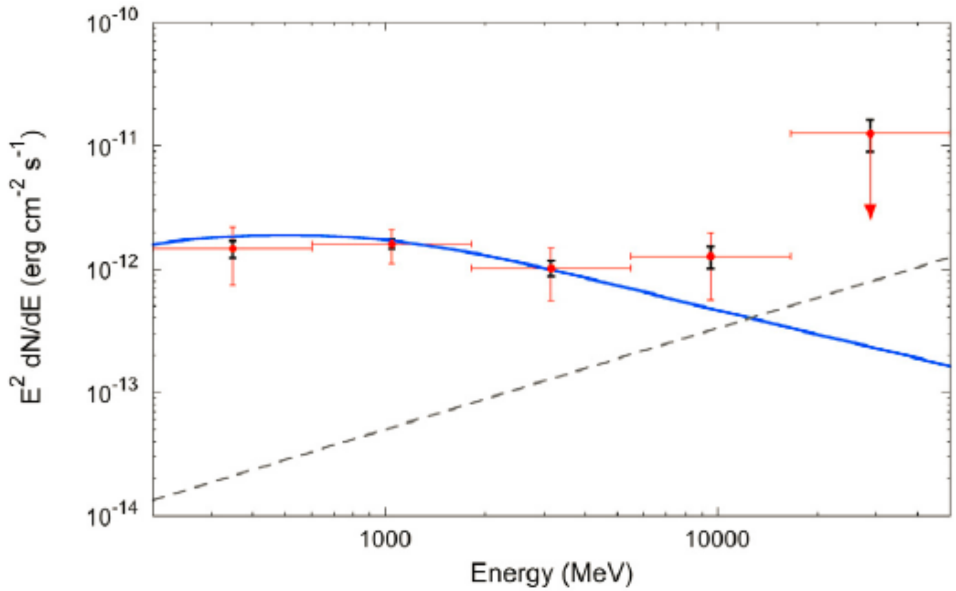
Four point sources in the model

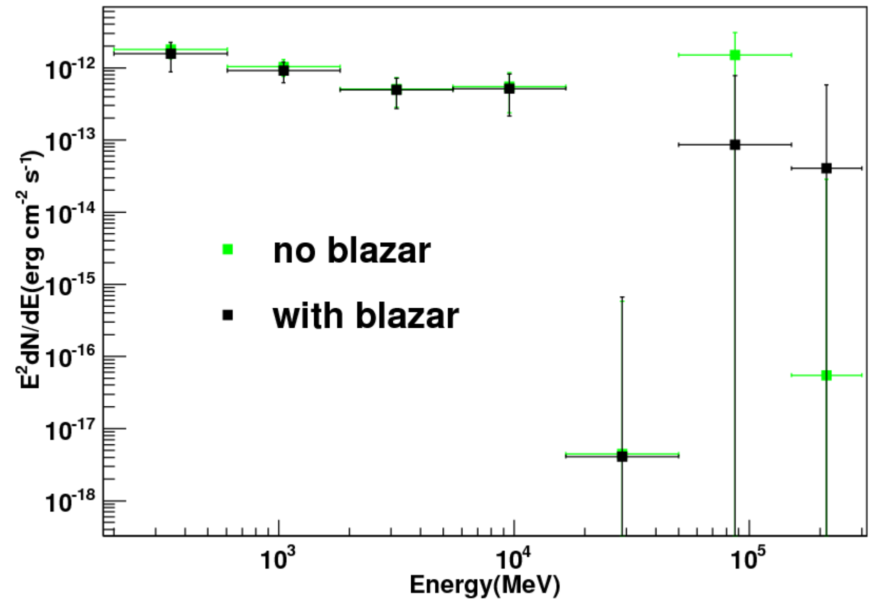
Gamma detection: 5σ significance in 200MeV – 20GeV

Flux(>100MeV):(9.1±1.9stat±1.0sys) $\times 10^{-9}$ phcm^{-2}s^{-1}

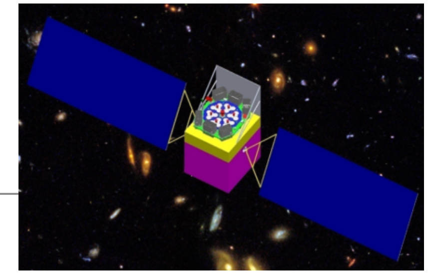


Abdo et al, 2010

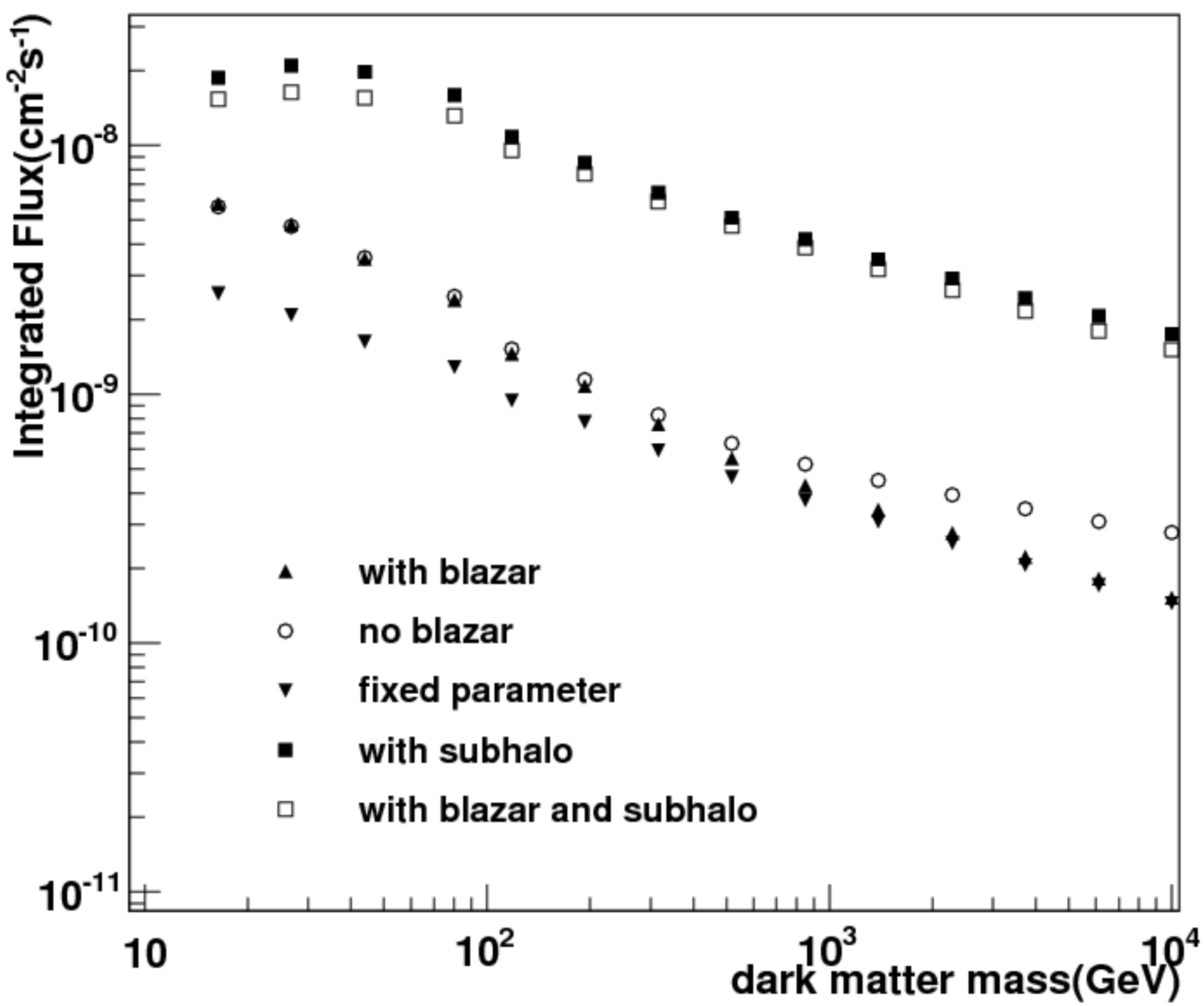




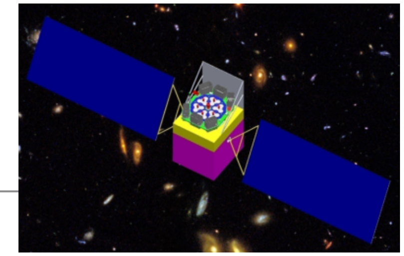
Using 2FGL catalog with more sources in the model
Model the M31 as a point source with power-law spectrum
BL Lac 1ES0037+405 affect the energy spectrum when energy > 70GeV



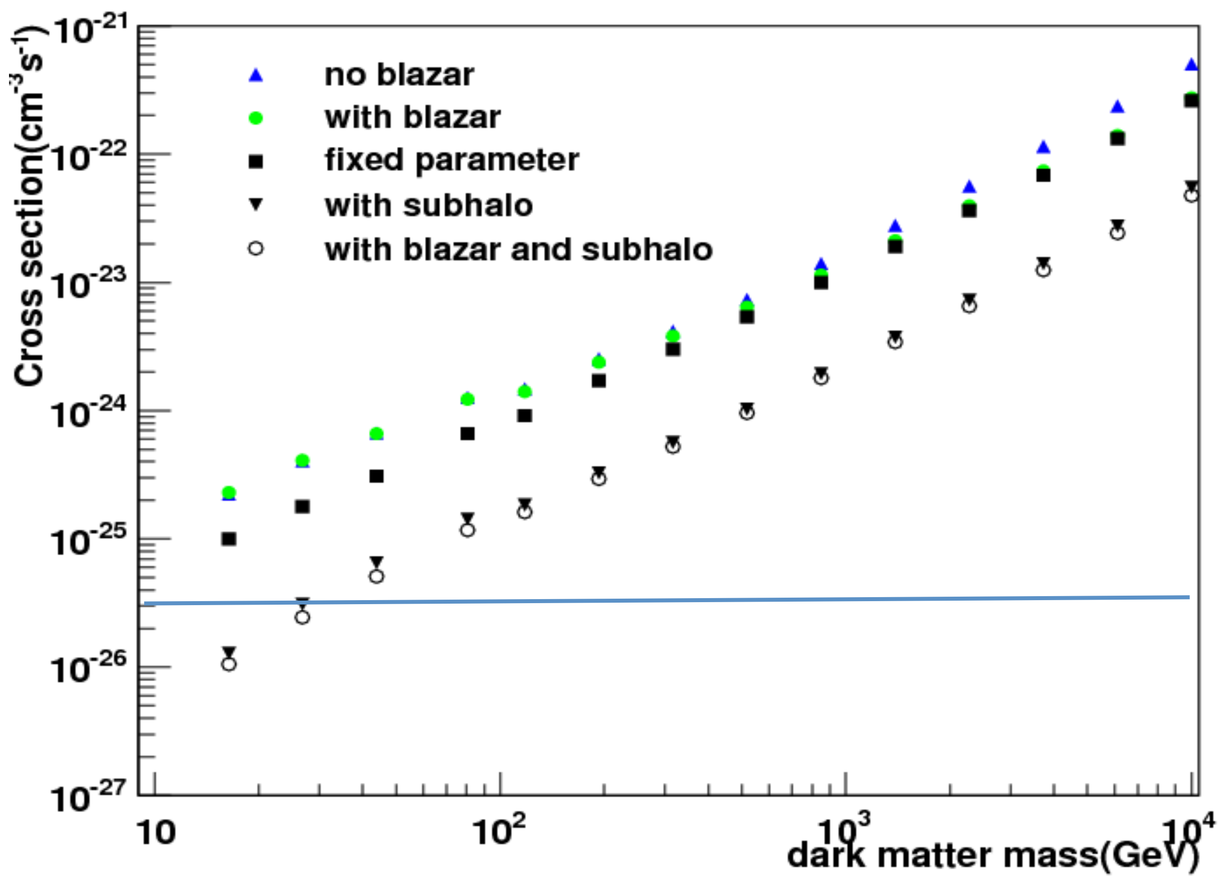
DM annihilation flux upper limits



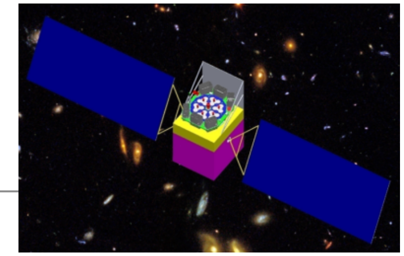
- Model the M31 as a point source with power-law spectrum
- Free the normalization parameter of the sources in the ROI
- With subhalos , the 1ES0037+405 do not effect the uppler limit



Upper limits for the DM annihilation cross-section



Cross-section drop below the thermal cross –section of $3\times10^{-26}cm^{3}s^{-1}$when dark mass <20GeV



Summary

- Subhalos give strong limits on the cross-section of dark matter annihilation
- Model the dark matter distribution in Einstao, isothermal profile
- Consider the effect of inverse compton scatter of the secondary particles from annihilation