XXVIII Cracow EPIPHANY Conference

Ultra-high energy cosmic rays luminosity from multi-messenger analysis

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Summary

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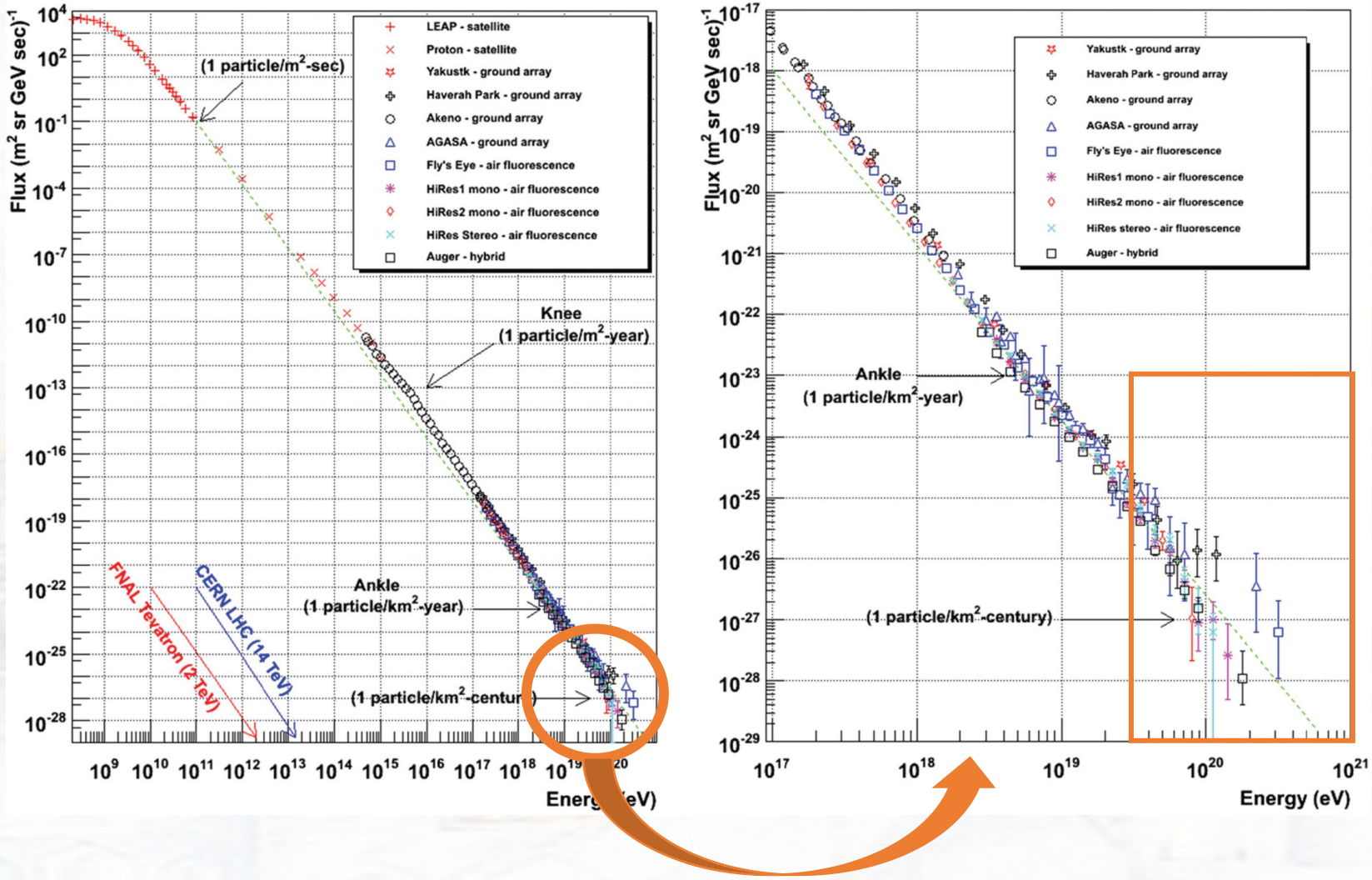
3. Measurements
4. Starbursts and UHECR
5. Some preliminary results
6. Conclusions

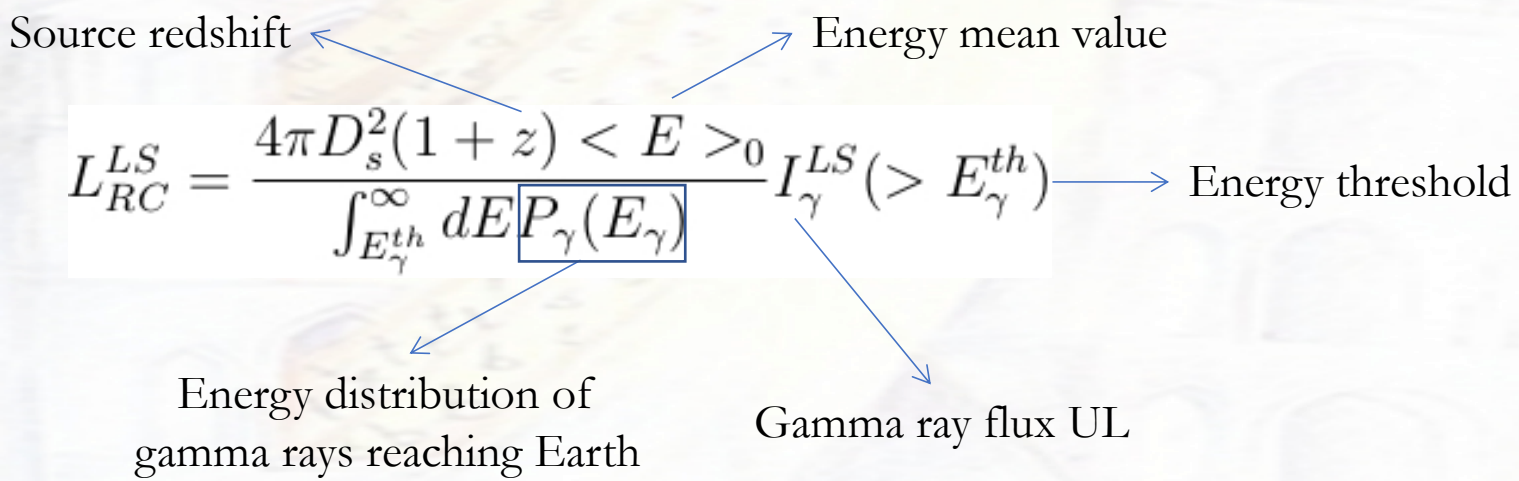
Introduction - Cosmic Ray Spectrum

Source: https://web.physics.utah.edu/~whanlon/spectrum.html



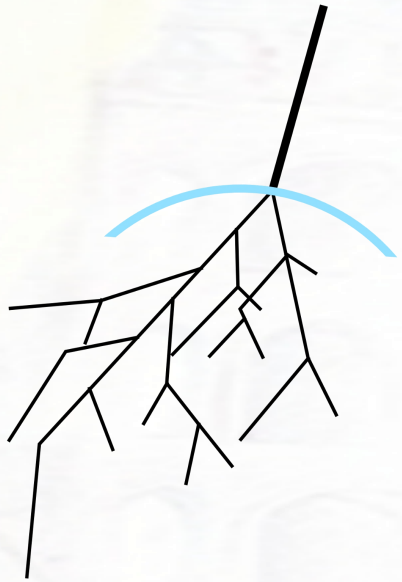
Luminosity of CR Sources from Gamma Rays

- We obtain upper limits on the luminosity of a cosmic ray source from upper limits on the gamma ray flux, measured by several gamma ray experiments.
- These limits are obtained from individual sources, based on the measurement in GeV-TeV energies, applying the following expression:

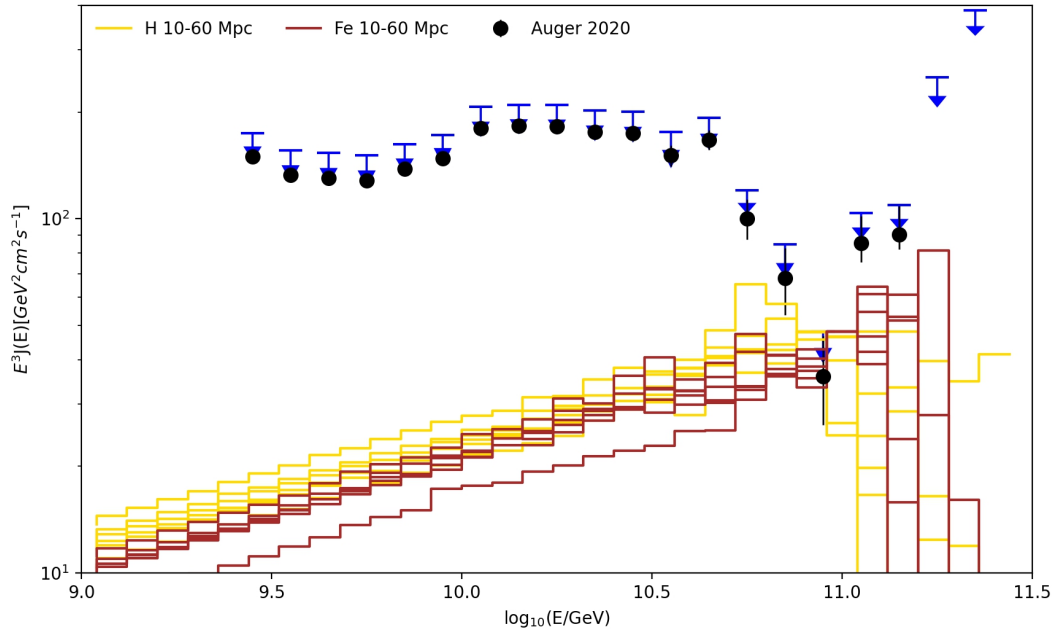


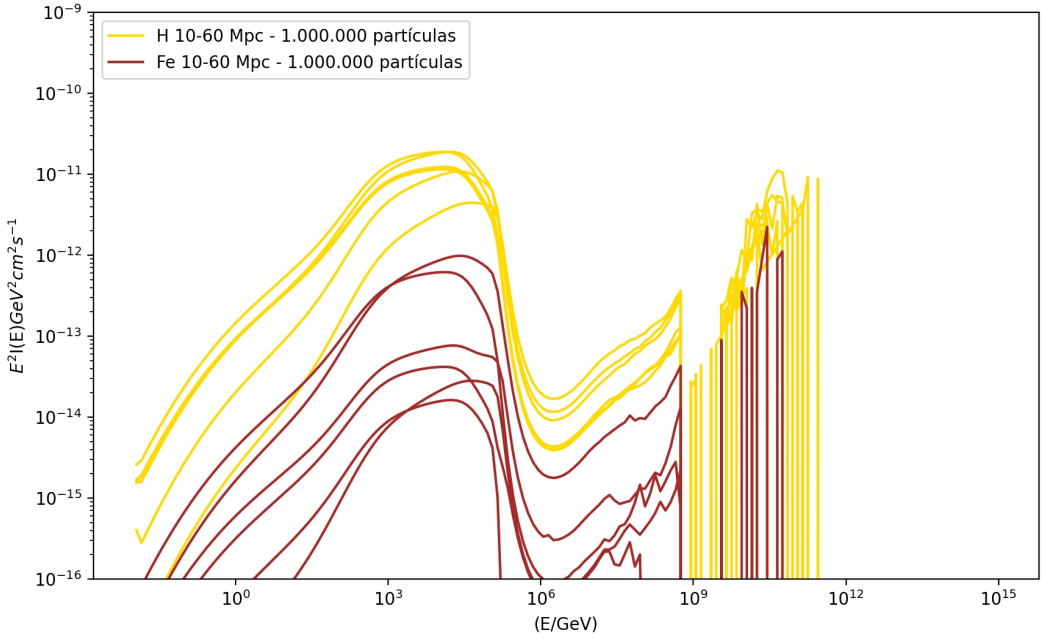
Luminosity of CR Sources from Gamma Rays

- The total luminosity may not always be affirmative since the calculation may not be always restrictive enough.
- The upper limit on the integral of gamma rays flux depends on the cosmic ray injection spectrum, the source distance and the limit of energy used to integrate the gamma rays flux.



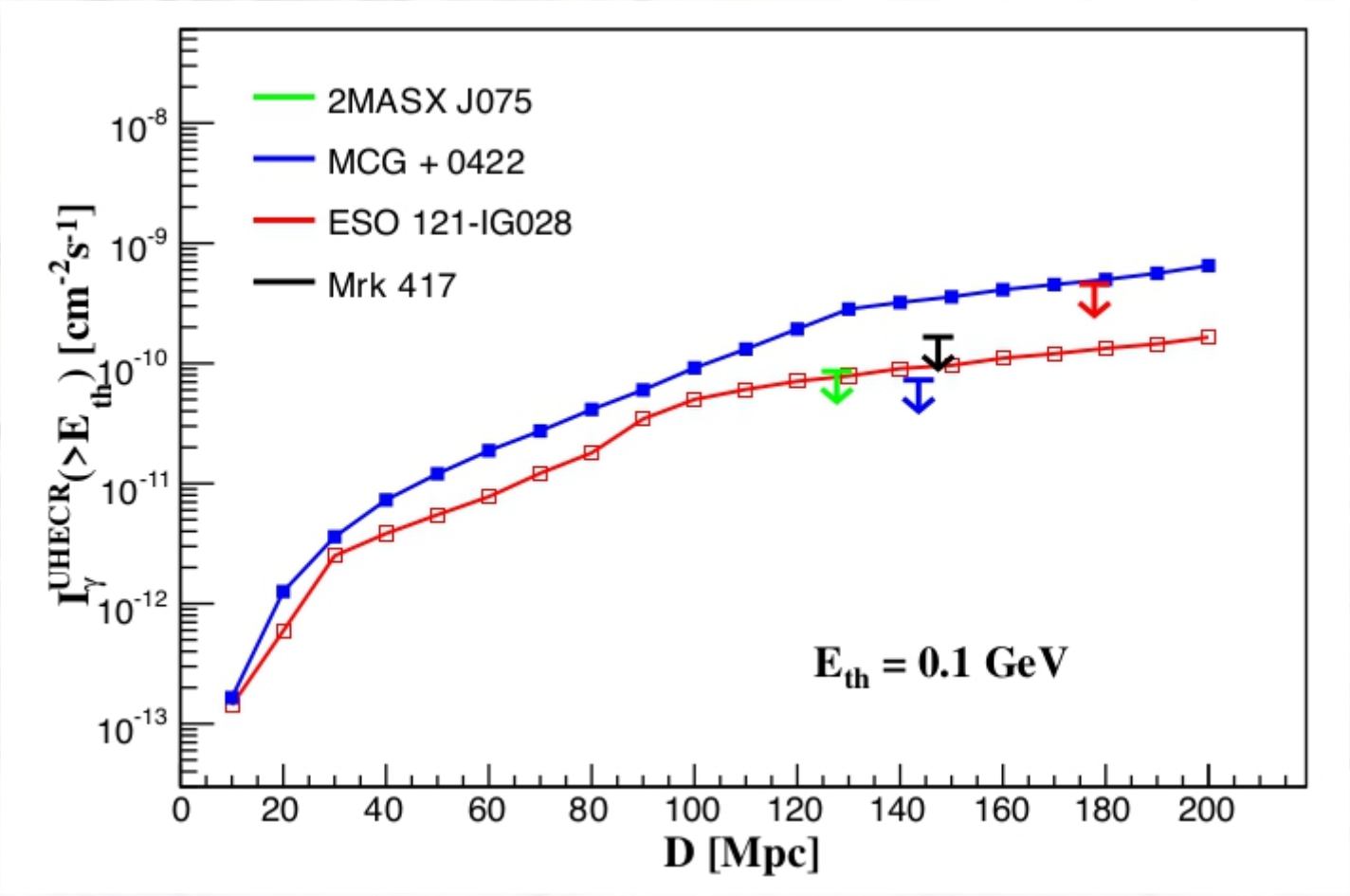
Measurements





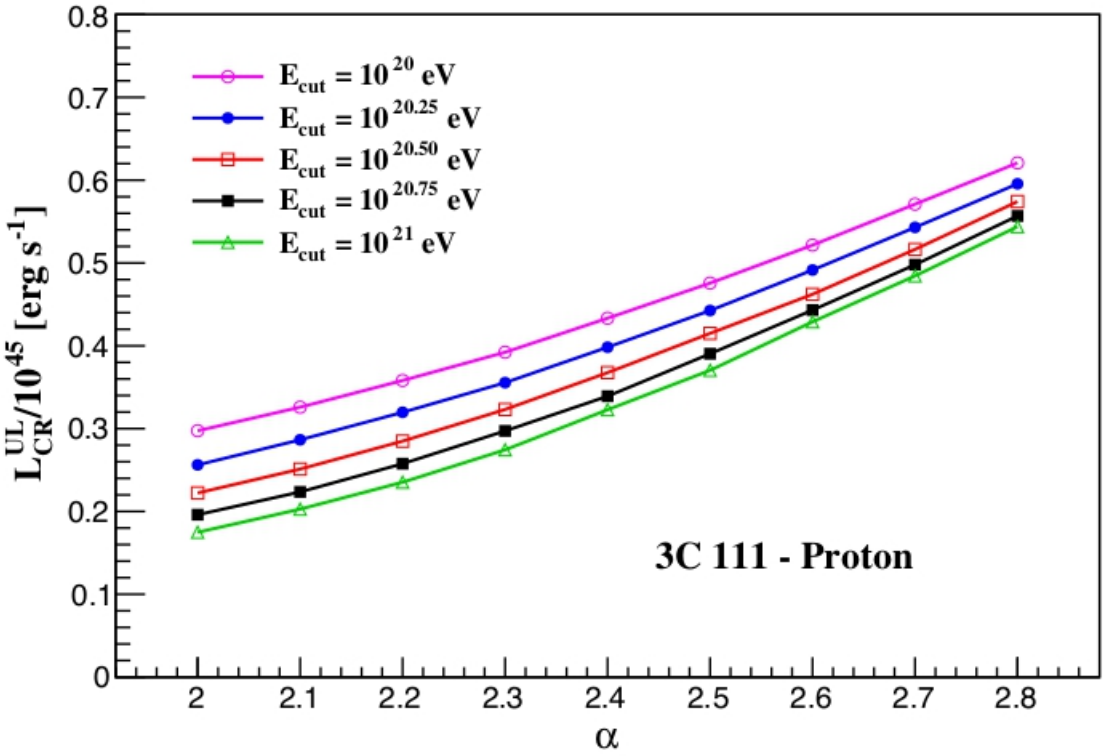
Source: Author

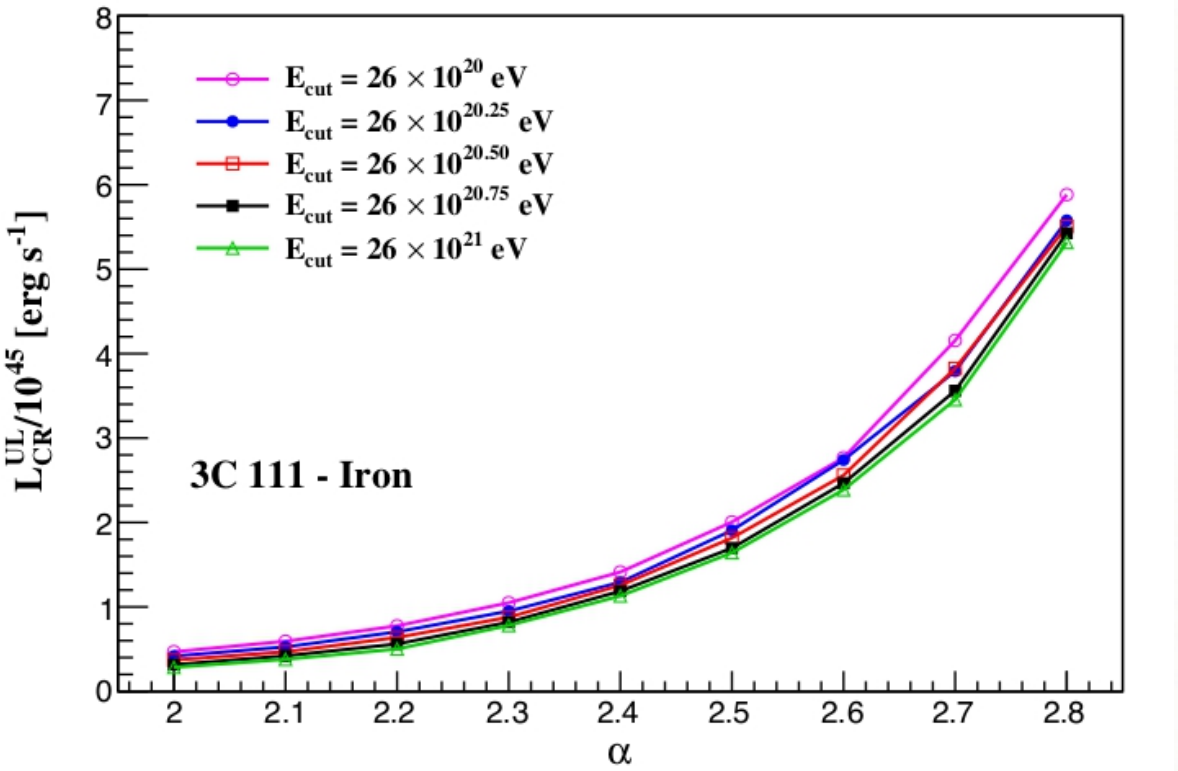
Measurements



Source: Anjos

Measurements





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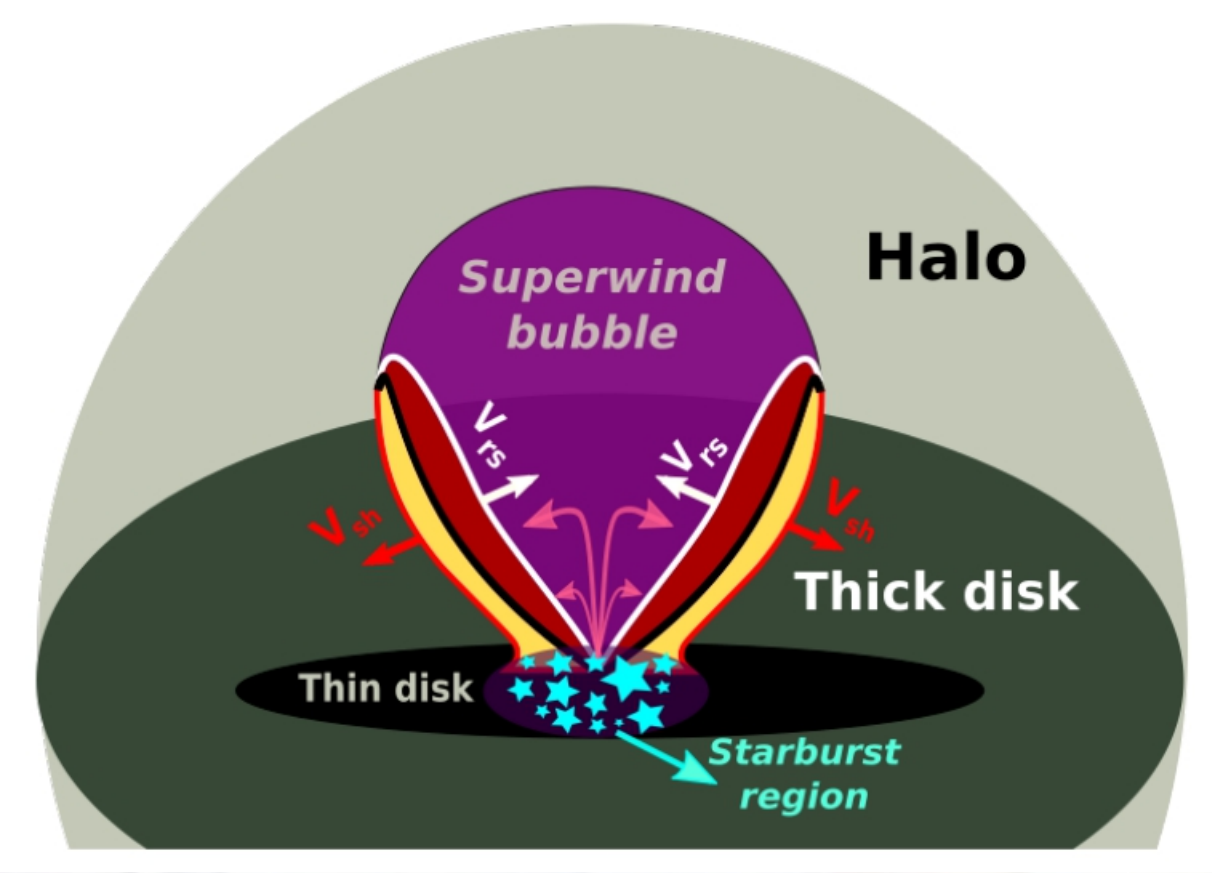
Starbursts and UHECR



Source: https://doi.org/10.1051/0004-6361/201832666

- The large extent of the superwind region of nearby starbursts can accommodate high-energy cosmic rays with equipartition magnetic fields;

- The photon density in the halo, is sufficiently low as to prevent photodisintegration of the nuclei during the acceleration by diffusive processes;

- The high metallicity of the wind provides a pool of nuclei from which acceleration mechanisms can operate;

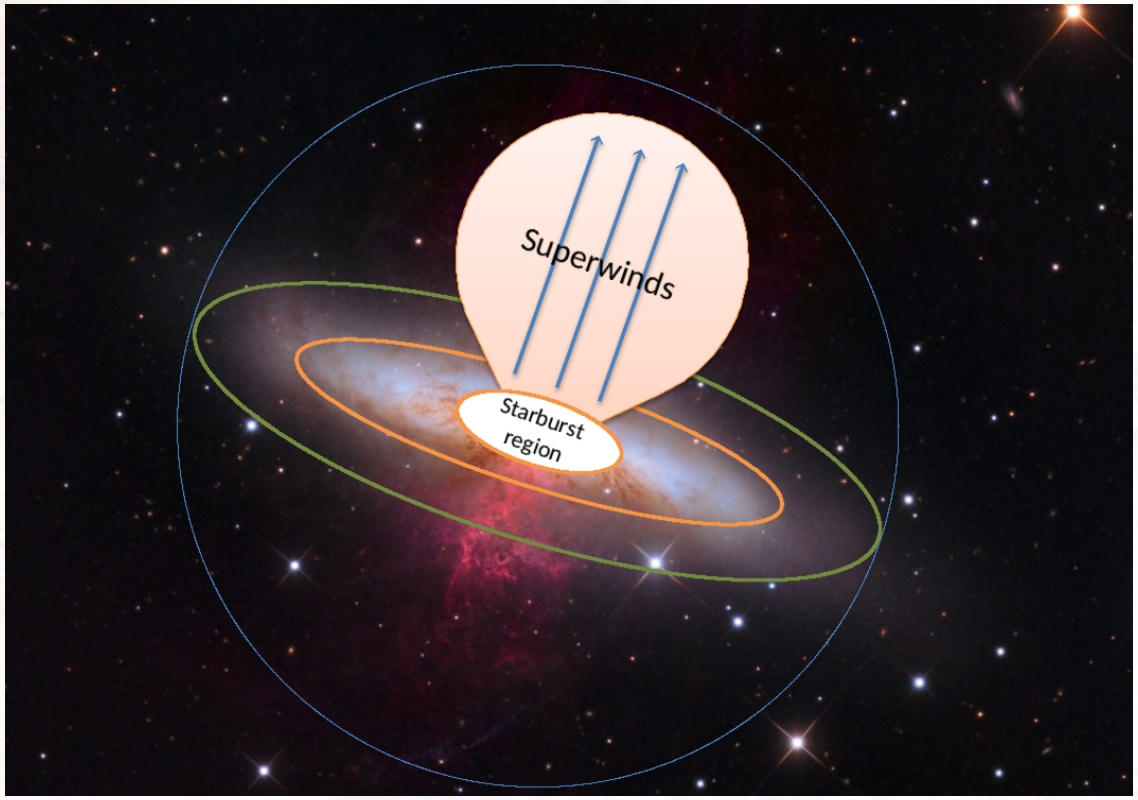
Starbursts and UHECR

- Gas ejection and supernova explotions;

- Metals created in the Universe in the interstellar medium on the way of the superwind;

- The existence of superwinds was speculated ~20 years ago;

- All starburst galaxies seem to have superwinds, making them strong candidates for particle acceleration with very high speeds.



Source: Author

Starbursts and UHECR

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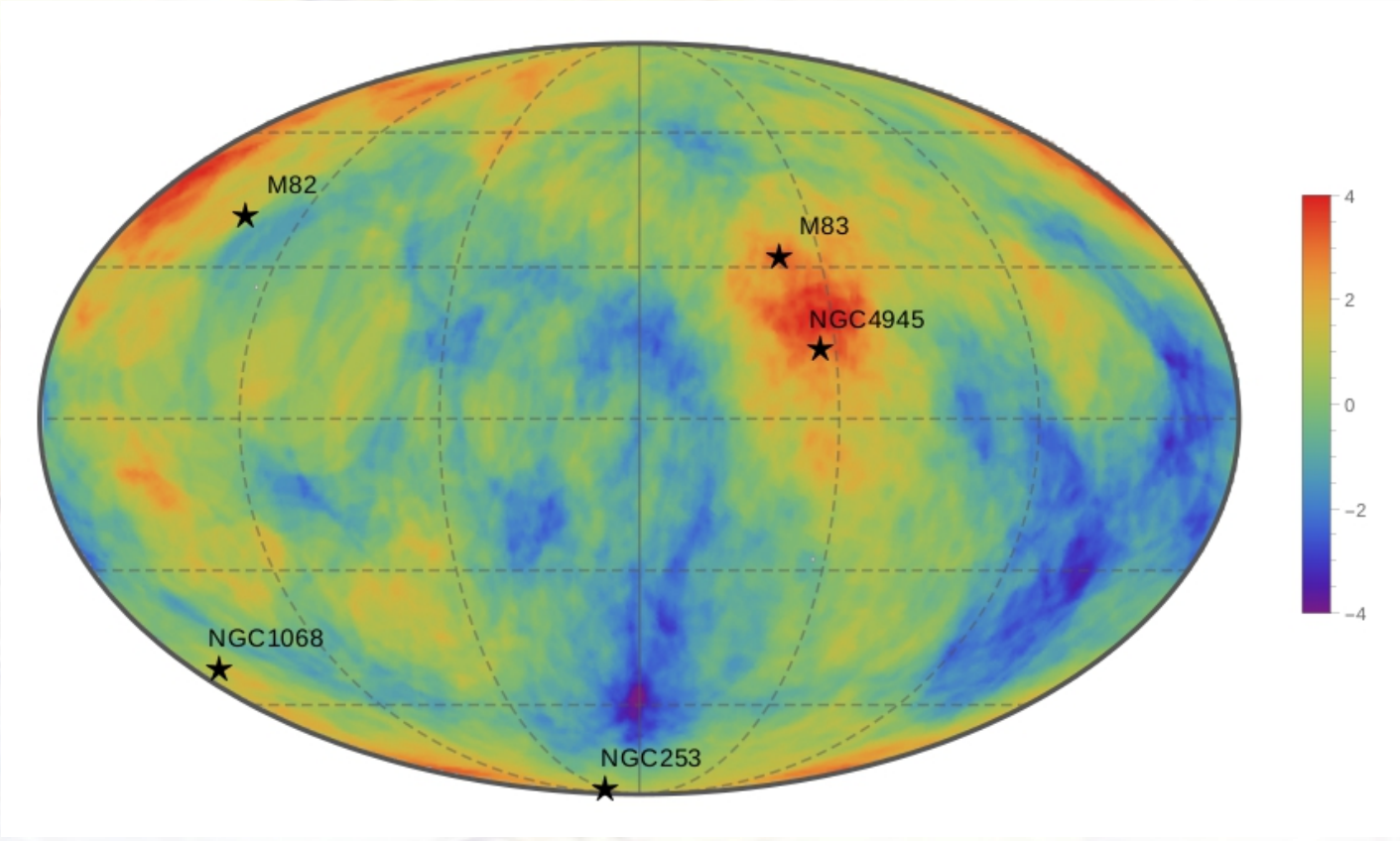

Skymap in Galactic coordinates of the Li-Ma significances. The color scale indicates the significance in units of standard deviations. The most significant hot spot is near the location of starburst galaxies NGC 4945 and M83.

Gamma Flux Upper Limits

Sources	D (Mpc)	UL: F (> 1 TeV) [10^{-14} ph cm^{-2} s^{-1}]
NGC 253	3.52	0.0471
Arp 220	77	2.95

Preliminary

Proton Luminosity of UHECR

Sources	D (Mpc)	Proton Luminosity [erg $s^{-1} \times 10^{42}$]
NGC 253	3.52	1.6
Arp 220	77	68

Preliminary

Conclusions

- Upper limits on the UHECR luminosity were calculated using the measured upper limit on the GeV–TeV integral flux and a model on the propagation of UHECR particles from the source to Earth.

- The luminosity of UHECR is a fundamental restriction to the proposed models and the combination of these multimessenger information to come is certainly going to shed light on the puzzle of UHECR generation.

- Actual acceleration in Starburst galaxies will depend on the efficiency of the acceleration process, the age of the accelerator, and the losses suffered by the particles. The result might be a much lower maximum energy, that might depend on several local factors.

- All results obtained are effects of UHECR propagation, showing how essential is propagation analysis to infer theoretical models for a better understanding of cosmic ray physics.

Thank you!

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