What can we learn from neutral particles in cosmic rays?

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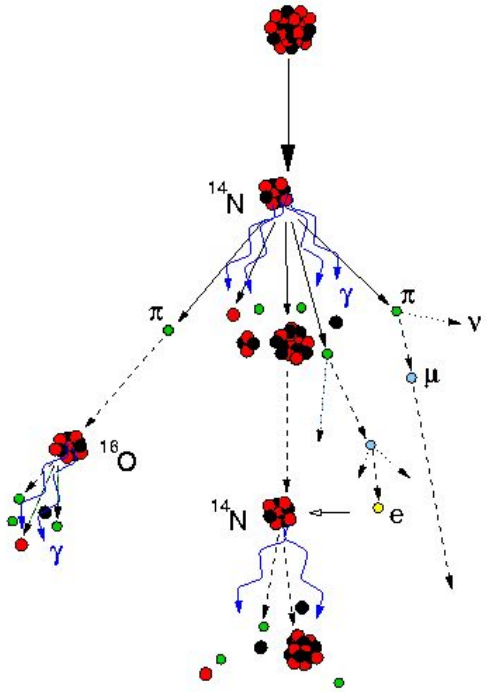
What are cosmic rays?

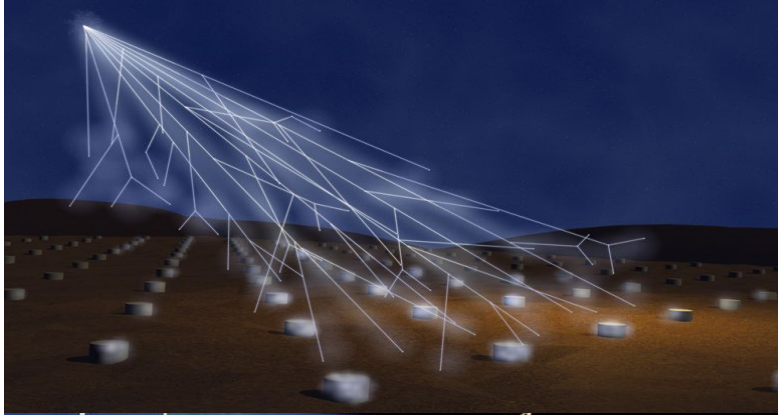
~ 90% hydrogen nuclei

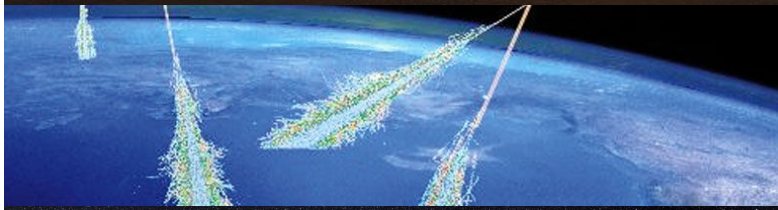
~ 9% helium nuclei

~ 1% heavier nuclei

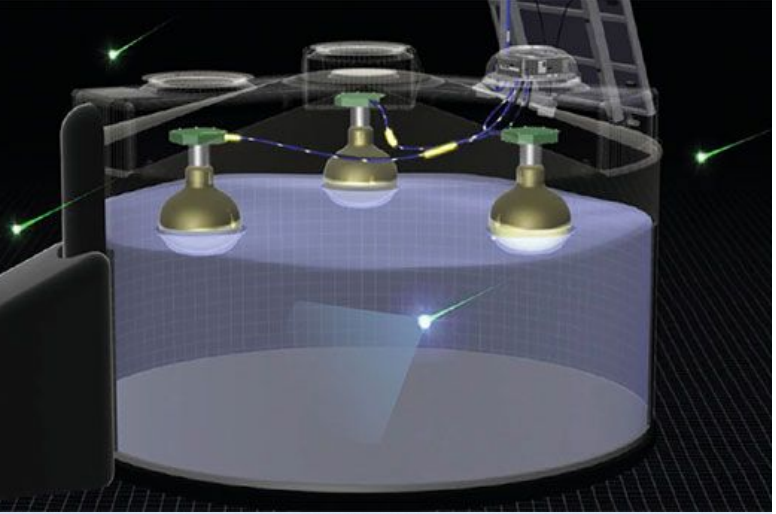
Air showers

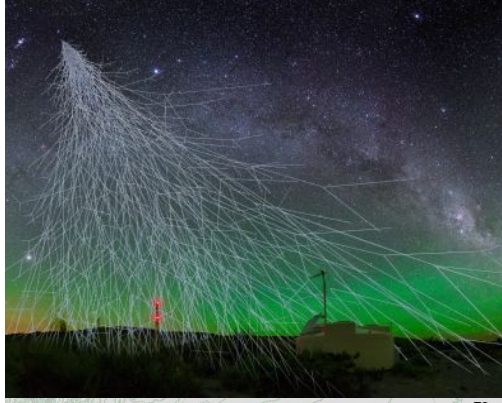


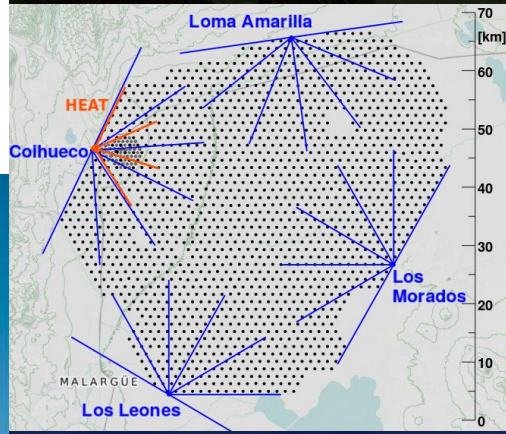


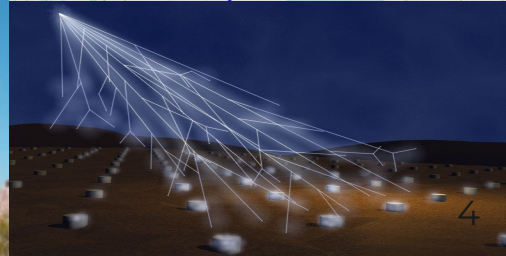


The Pierre Auger Observatory



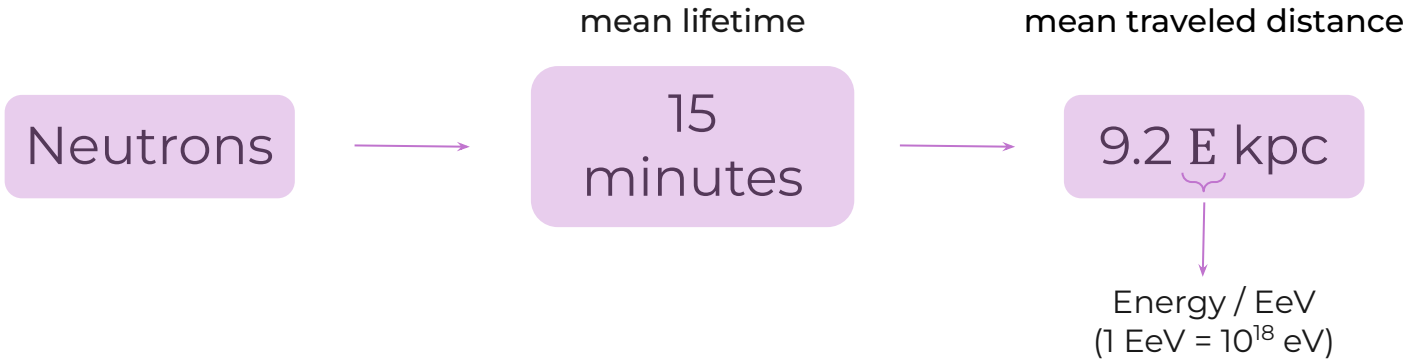




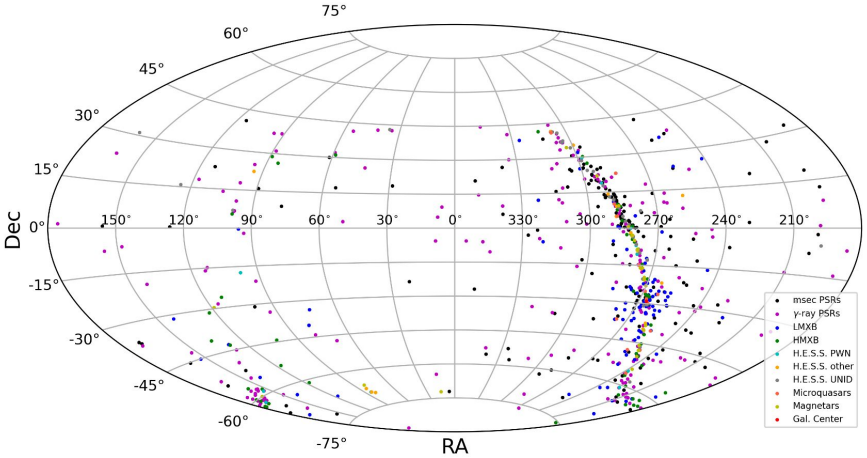


Why neutral particles?

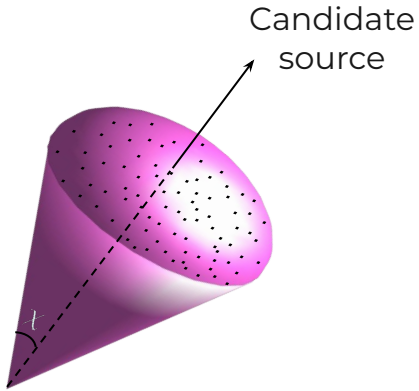
They are not deflected by magnetic fields



Galactic center: 8.3 kpc from Earth

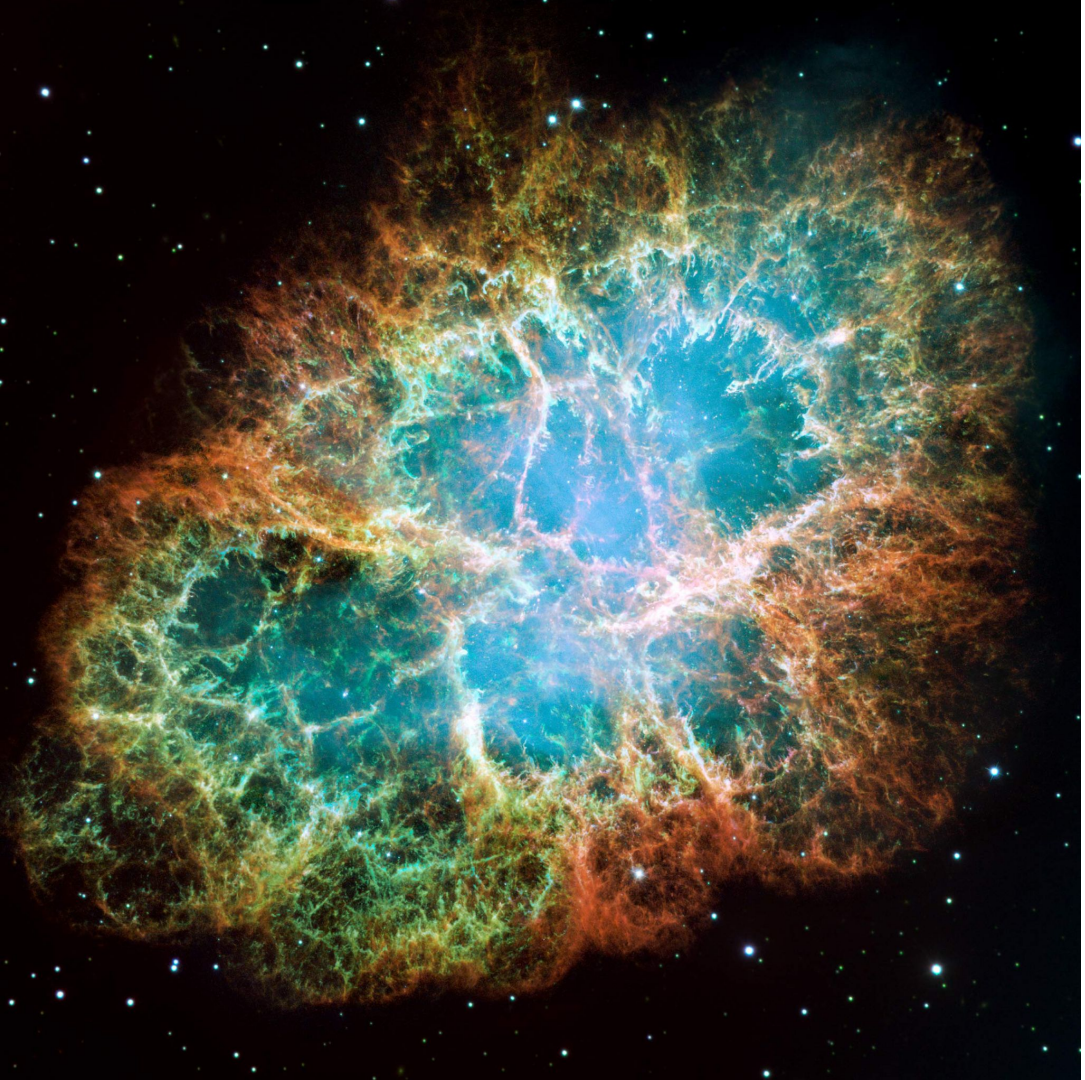


We are looking for an **excess** of cosmic ray events



We compare

Observed × Expected



Candidate sources

Neutron stars

Millisecond pulsars

γ-ray pulsars

Microquasars

Magnetars

etc...

What can the results tell us?

Positive detection

Identification of a cosmic ray source in the range of EeV

Negative detection

Do neutrons propagate in a more diffusive way?

Are neutrons not produced in the Galaxy?

Are neutrons produced in transient events?

Thank you!

Backup

Results published in 2014

Results for the Most Significant Target from Each Target Set

Class	R.A. [°]	Decl. [°]	Obs	Exp	Flux U.L. (km^{-2} yr^{-1})	E-Flux U.L. (eV cm^{-2} s^{-1})	p-value	p-value (penalized)
msec PSRs	260.27	−24.95	237	214	0.019	0.14	0.058	0.98
γ-ray PSRs	8.59	−5.58	176	149	0.024	0.18	0.016	0.70
LMXB	264.57	−26.99	265	219	0.028	0.20	0.0012	0.10
HMXB	152.45	−58.29	283	248	0.019	0.14	0.014	0.49
H.E.S.S. PWN	128.75	−45.60	275	248	0.018	0.13	0.043	0.53
H.E.S.S. other	269.72	−24.05	235	211	0.019	0.14	0.054	0.59
H.E.S.S. UNID	266.26	−30.37	251	227	0.018	0.13	0.055	0.57
Microquasars	262.75	−26.00	247	216	0.022	0.16	0.020	0.23
Magnetars	81.50	−66.08	268	241	0.016	0.11	0.040	0.48
Gal. center	266.42	−29.01	234	223	0.014	0.10	0.24	...
Gal. plane	|Gal. lat.| < 1°.17		16965	17197	0.077	0.56	0.96	...

A. Aab *et al* 2014 *ApJL* **789** L34