



Muografía en la Industria Petroquímica

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LA-CoNGA **physics**



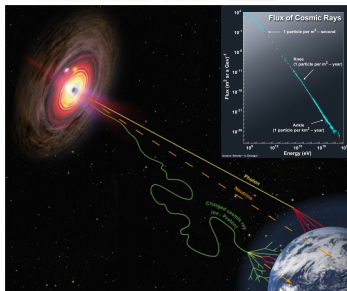
Introducción

- **Astropartículas**
 - Confirmados por V. Hess 1911.
 - Núcleos atómicos y fotones provenientes de fuentes astrofísicas.
 - Partículas secundarias: producidas por la interacción de los rayos primarios.
- **Muones**
 - 1936 por Carl Anderson y S. Neddermeyer.
 - $K^+ \rightarrow \mu^+ + \nu_\mu$ (Branching Ratio 63%).
 - Mas penetrantes que la componente E-M de la Cascada.

	masa carga espín				
QUARKS	$\approx 2.2 \text{ MeV}/c^2$ $\frac{2}{3}$ $\frac{1}{2}$	$\approx 1.28 \text{ GeV}/c^2$ $\frac{2}{3}$ $\frac{1}{2}$	$\approx 173.1 \text{ GeV}/c^2$ $\frac{2}{3}$ $\frac{1}{2}$	0 0 1	$\approx 124.97 \text{ GeV}/c^2$ 0 0 0
	u up	c charm	t top	g gluon	H higgs
	$\approx 4.7 \text{ MeV}/c^2$ $-\frac{1}{3}$ $\frac{1}{2}$	$\approx 96 \text{ MeV}/c^2$ $-\frac{1}{3}$ $\frac{1}{2}$	$\approx 4.18 \text{ GeV}/c^2$ $-\frac{1}{3}$ $\frac{1}{2}$	0 0 1	0 0 1
d down	s strange	b bottom	γ fotón		
LEPTONES	$\approx 0.511 \text{ MeV}/c^2$ -1 0	$\approx 105.66 \text{ MeV}/c^2$ -1 0	$\approx 1.7768 \text{ GeV}/c^2$ -1 0	$\approx 91.19 \text{ GeV}/c^2$ 0 1	
	e electrón	μ muon	τ tau	Z bosón Z	
	$< 1.0 \text{ eV}/c^2$ 0 $\frac{1}{2}$	$< 0.17 \text{ MeV}/c^2$ 0 $\frac{1}{2}$	$< 18.2 \text{ MeV}/c^2$ 0 $\frac{1}{2}$	$\approx 80.39 \text{ GeV}/c^2$ ± 1 1	
	ν _e electrón neutrino	ν _μ muon neutrino	ν _τ tau neutrino	W bosón W	

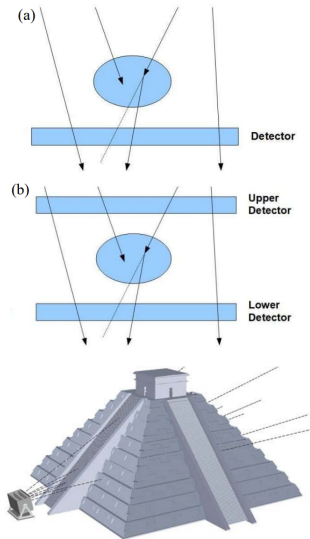
BOSONES DE GAUGE
BOSONES VECTORIALES

BOSONES ESCALARES



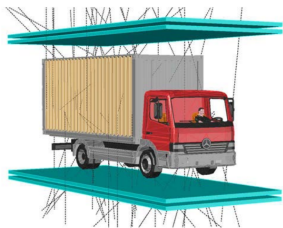
Muografía - Origen y aplicaciones

- **E.P. George, 1955.** Cosmic rays measure of overburden of tunnel.
- **Alvarez LW et al. 1970.** Search for hidden chambers in the pyramids
- **G. Saracino et al. 2018.** Applications of muon absorption radiography to the fields of archaeology and civil engineering.
- **H. Miyadera et al. 2019.** Imaging Fukushima Daiichi reactors with muons.



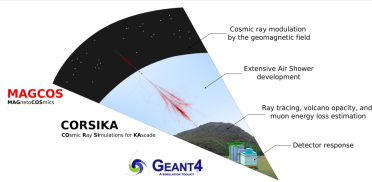
Muografía - Origen y aplicaciones

Explorar la implementación en la Ind. Petroquímica.



Entorno de Simulación

- MAGCOS
- CORSICA
- GEANT4

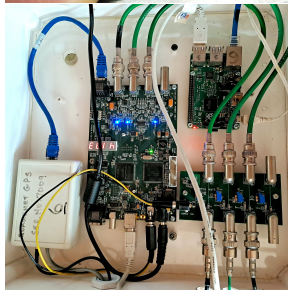
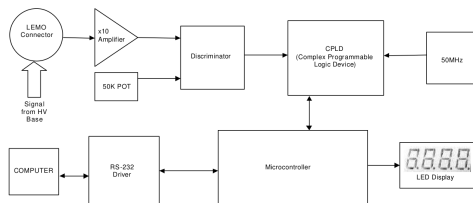
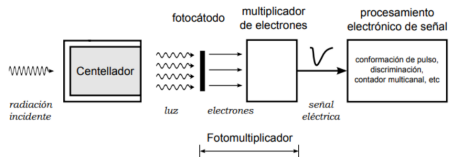


Sistema de detección

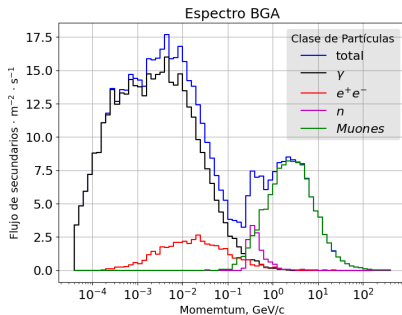
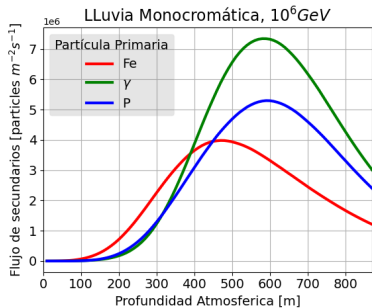
- Centelladores EJ-200, Eljen Technology
- MicroFC-60035-SMT, SensL Technologies, Ltd.
- QuarkNet 6000 Data Acquisition (DAQ) board.
- Raspberry Pi 2 Modelo B.



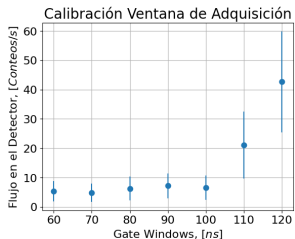
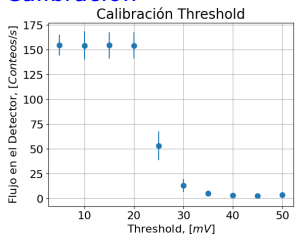
Sistema de Medición



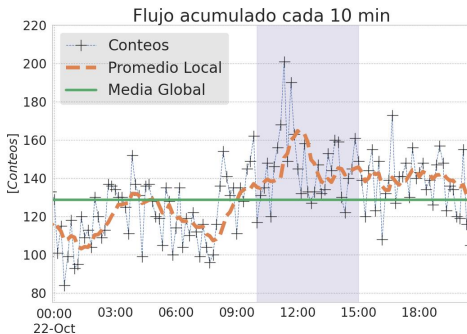
Lluvia monocromática



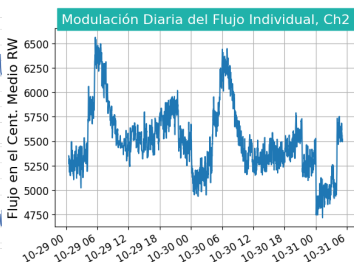
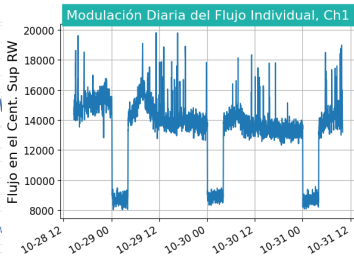
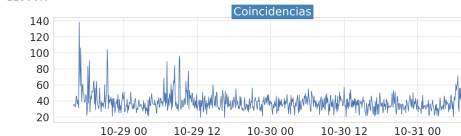
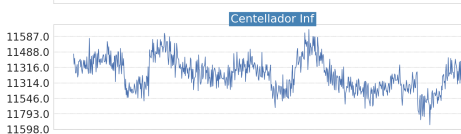
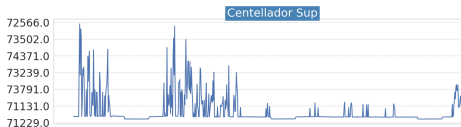
Calibración



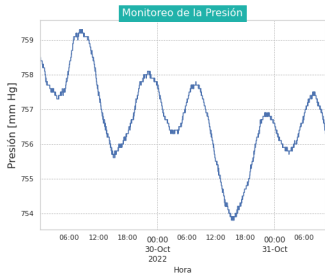
Medición del Flujo



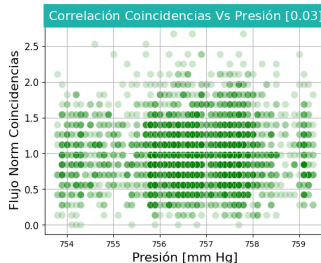
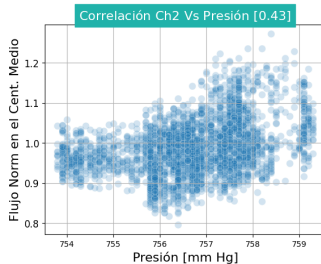
Análisis del Flujo por Canal



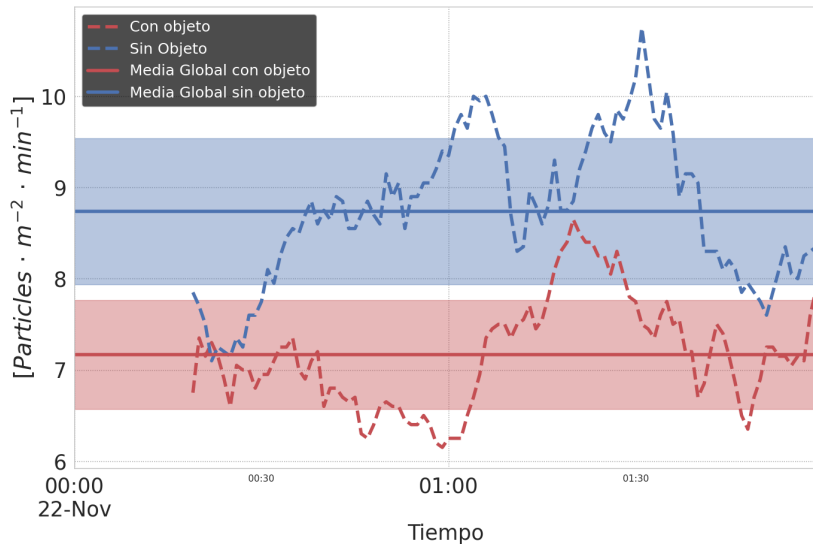
Correlación



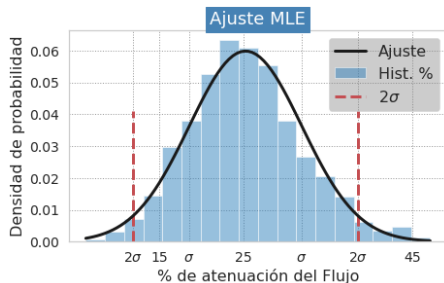
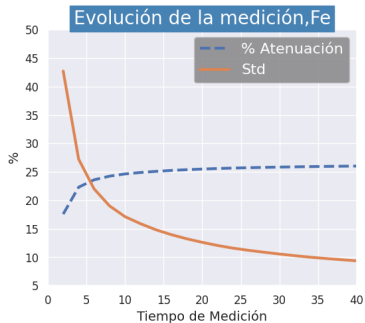
- El flujo en cada panel padece modulaciones diurnas y barométricas.
- El flujo de coincidencias no presenta correlación con el tiempo o presión Atm.



Visualización del Flujo



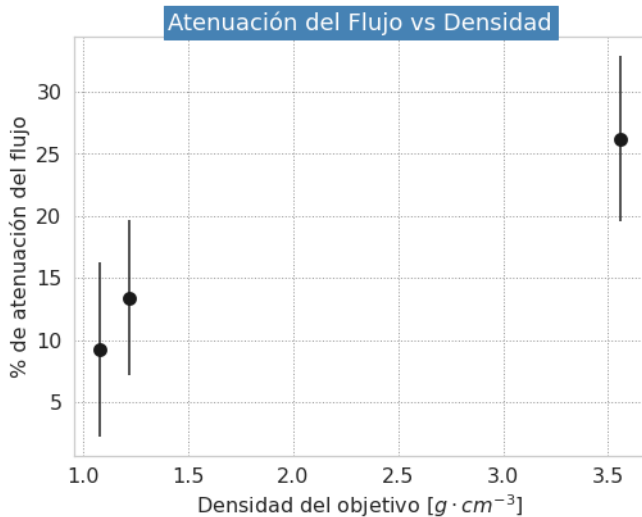
Evolución de la incertidumbre



$26,6 \pm 6,6\%$ de atenuación
 $\chi^2 = 0,17$

Valor del % de Atenuación vs densidad

Ajuste





Muón antes de interactuar

Muón después de interactuar