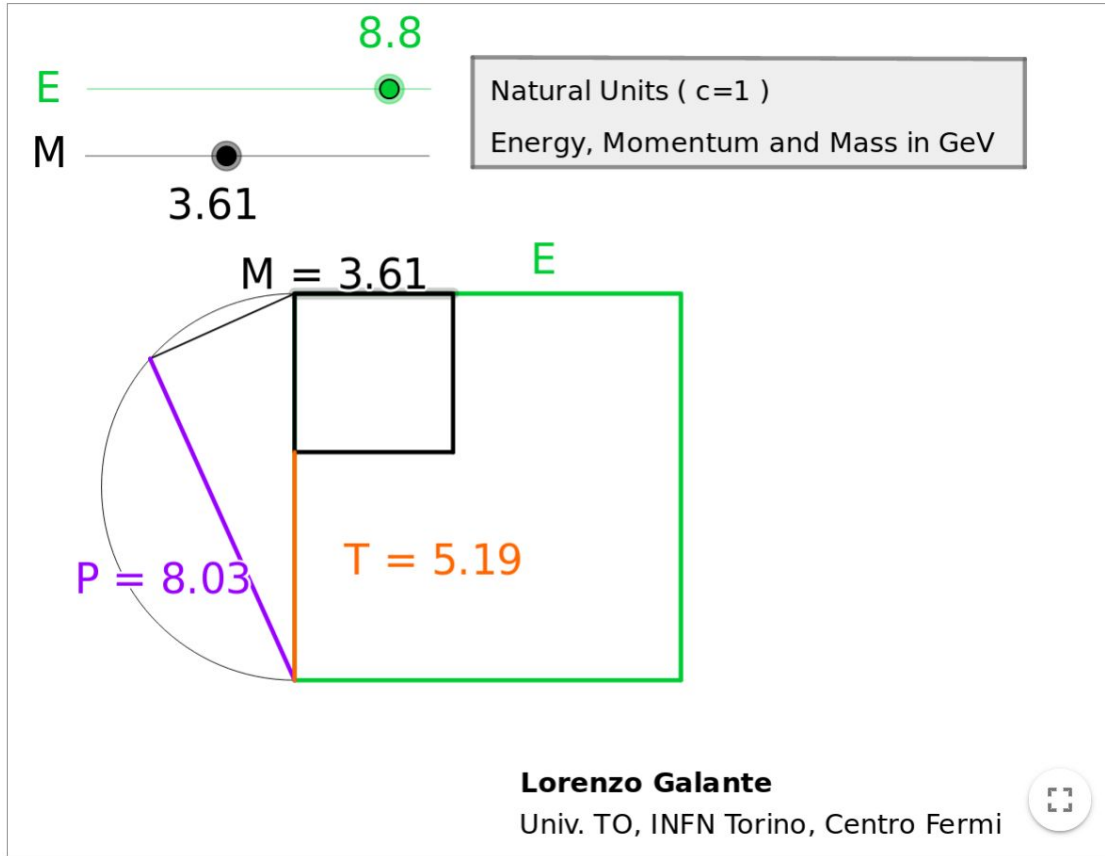


The Invariant Mass



10 Aprile 2019
Lorenzo Galante



A UN SISTEMA
FISICO POSSIAMO
ASSOCIARE

E, p
dipendono da
osservatore

$$E^2 - p^2 = m^2$$

INVARIANTE!

Teaching Astroparticle Physics



Educational Activities to teach Astroparticle Physics

This site is a collection of ideas, approaches and educational methods to introduce Astroparticle physics concepts to secondary school and undergraduate students.

PART 1. [Magnetic Field of Astrophysical objects and Cosmic Ray Energy](#)

PART 2. [Neutrino 170922: the IceCube event](#)

PART 3. [The relativistic relation between Energy, Mass and Momentum](#) [Key Concepts in Cosmic Rays physics]

PART 4. [The Invariant Mass](#) [Key Concepts in Cosmic Rays physics]

PART 5. Many from one: the Cosmic Ray Showers.

PART 6. The GZK Cutoff.

<https://sites.google.com/view/physedu/teaching-astroparticle-physics?authuser=0>

DUE SISTEMI FISICI

SISTEMA 1

$$E_1, \vec{p}_1$$



SISTEMA 2

$$E_2, \vec{p}_2$$



Sistema Unico

$$E_{\text{TOT}} = E_1 + E_2$$

$$\vec{p}_{\text{TOT}} = \vec{p}_1 + \vec{p}_2$$

e la Massa ?

Sistema Unico

$$E_{\text{TOT}} = E_1 + E_2$$

$$\vec{p}_{\text{TOT}} = \vec{p}_1 + \vec{p}_2$$

$$E_{\text{TOT}}^2 - \vec{p}_{\text{TOT}}^2 = m^2$$

Ecco la Massa!

- INVARIANTE -

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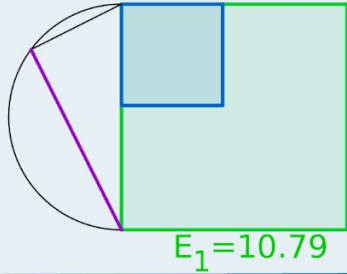
Se andate nella PART 4 del sito, trovate:

- APP Geogebra per esplorare il significato fisico della MASSA INVARIANTE,
- documenti che presentano i concetti fisici chiave,
- TUTORIAL che possono essere svolti in classe, a gruppi, progettati per un coinvolgimento attivo degli studenti.

Particle 1

m_1 4.841716

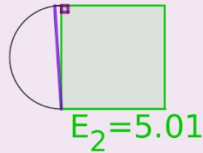
p_1 9.642809



Particle 2

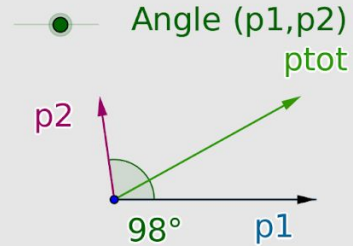
m_2 0.318587

p_2 5

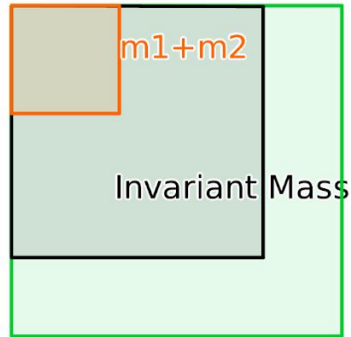


Define Energy Units:

Determine the incidence angle



Two Particles System:



Sum of the two particles masses = 5.160303 $E_{tot} = E_1 + E_2$

System Properties

$$p_{tot} = 10.23$$

$$E_{tot} = 15.8$$

$$\text{Invariant Mass} = \sqrt{E_{tot}^2 - p_{tot}^2} = 12.05$$

Lorenzo Galante

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