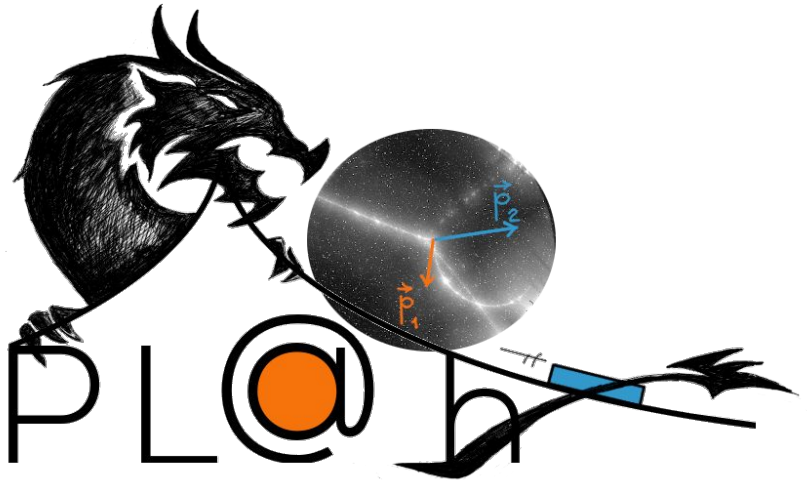
Particle Physics Role-Playing Games in introductory Physics Courses.

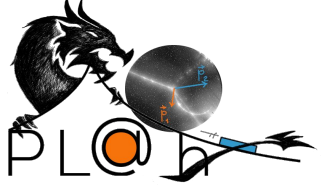


Lorenzo Galante[1, 2], Ivan Gnesi[2, 3, 4]

lorenzo.galante@polito.it

1. *Politecnico di Torino, Torino, It.*
2. *Centro Ricerche Enrico Fermi, Rome, It.*
3. *INFN, Cosenza, It.*
4. *CERN, Geneva, CH*

NUFACT Sept. 2021 - Cagliari

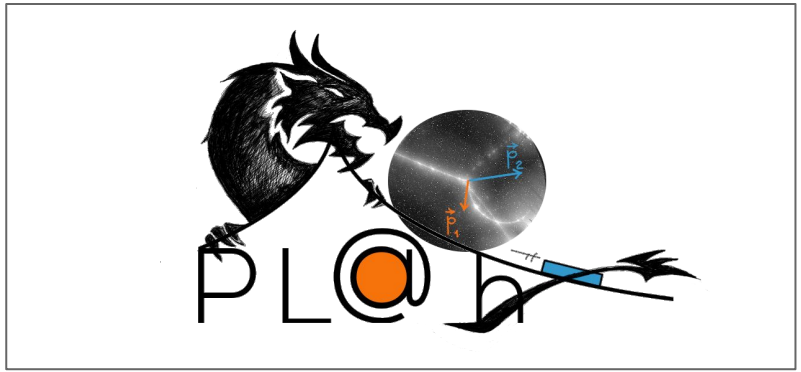


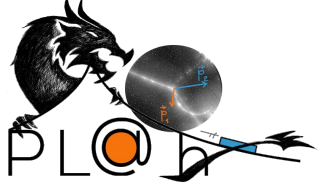
Particle Physics Role-Playing Games in introductory Physics Courses.

lorenzo.galante@polito.it
Politecnico di Torino

18-hours course

“From Conservation Laws to Scientific Discovery”



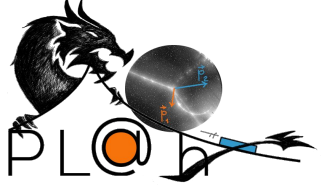


Particle Physics Role-Playing Games in introductory Physics Courses.

lorenzo.galante@polito.it
Politecnico di Torino

“From Conservation Laws to Scientific Discovery”

In-depth course of the Physics I course



Particle Physics Role-Playing Games in introductory Physics Courses.

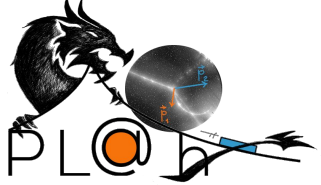
lorenzo.galante@polito.it
Politecnico di Torino

“From Conservation Laws to Scientific Discovery”

(May 2021)

Distance learning

Role-Playing Game (RPG)



Particle Physics Role-Playing Games in introductory Physics Courses.

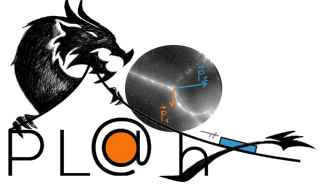
lorenzo.galante@polito.it
Politecnico di Torino

Experiment with innovative educational methods

Active Learning

Identification with what is being studied

Motivation in the study of introductory Physics



Particle Physics Role-Playing Games in introductory Physics Courses.

lorenzo.galante@polito.it
Politecnico di Torino

Experiment with innovative educational methods

Active Learning

Identification with what is being studied

Motivation in the study of introductory Physics

Particle Physics Role-Playing Games in introductory Physics Courses.

lorenzo.galante@polito.it
Politecnico di Torino

Experiment with innovative educational methods

Active Learning

Identification with what is being studied

Motivation in the study of introductory Physics

lorenzo.galante@polito.it
Politecnico di Torino

Why Role-Playing Games?

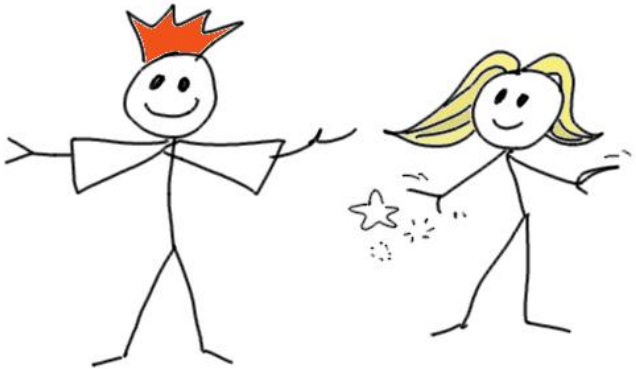
Active Learning

Identification with what is being studied

Motivation in the study of introductory Physics

lorenzo.galante@polito.it
Politecnico di Torino

Why Role-Playing Games?



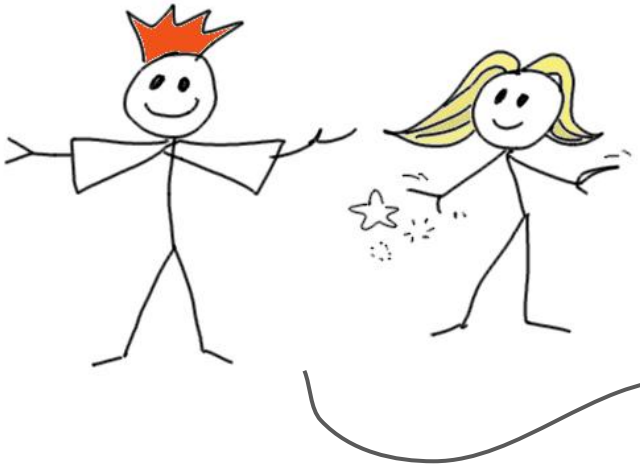
Active Learning

Identification with what is being studied

Motivation in the study of introductory Physics

lorenzo.galante@polito.it
Politecnico di Torino

Why Role-Playing Games?



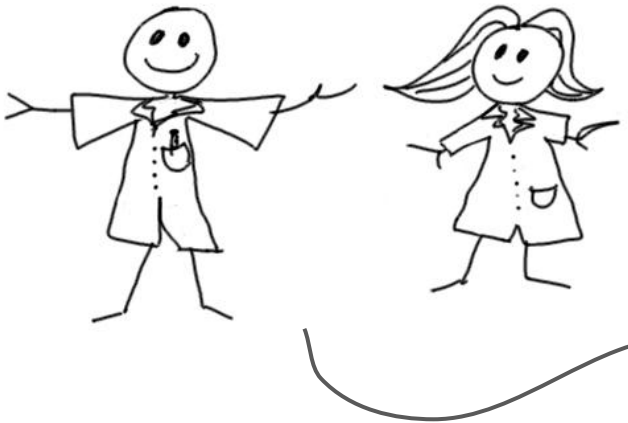
Active Learning

Identification with what is being studied

Motivation in the study of introductory Physics

lorenzo.galante@polito.it
Politecnico di Torino

Why Role-Playing Games?



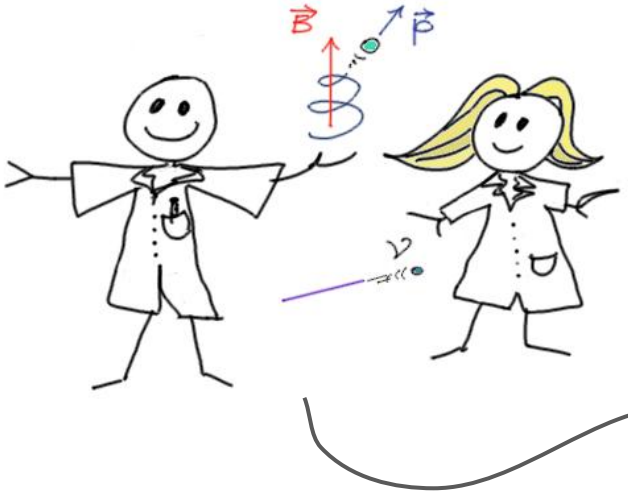
Active Learning

Identification with what is being studied

Motivation in the study of introductory Physics

lorenzo.galante@polito.it
Politecnico di Torino

Why Role-Playing Games?



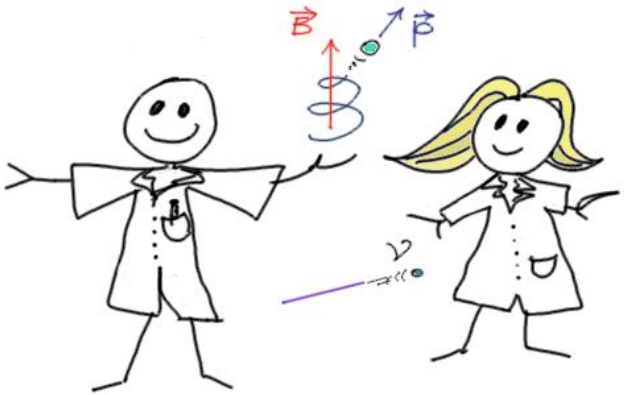
Active Learning

Identification with what is being studied

Motivation in the study of introductory Physics

lorenzo.galante@polito.it
Politecnico di Torino

Why Role-Playing Games?



STORY

OVERCOME CHALLENGES

GAIN COMPETENCES

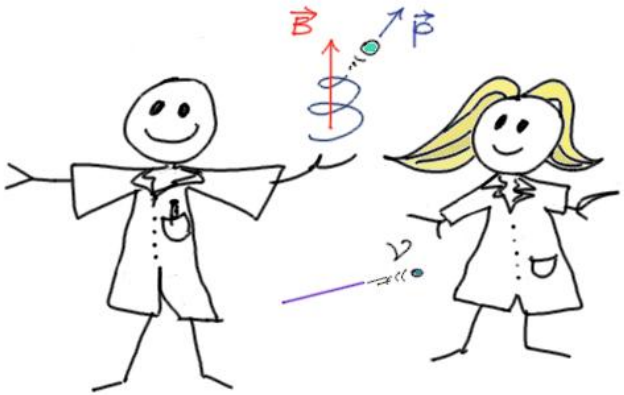
Active Learning

Identification with what is being studied

Motivation in the study of introductory Physics

lorenzo.galante@polito.it
Politecnico di Torino

Why Role-Playing Games?



STORY

OVERCOME CHALLENGES

GAIN COMPETENCES

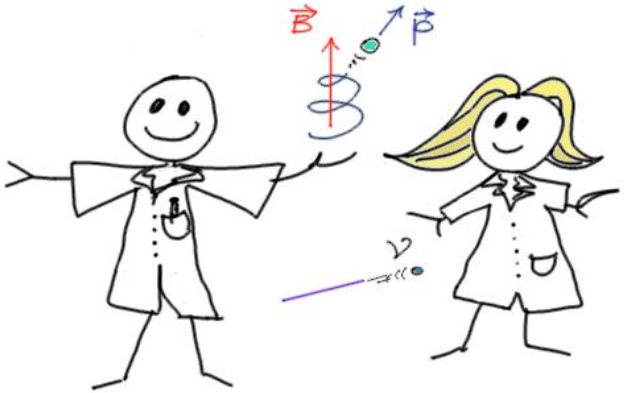
Active Learning

Identification with what is being studied

Motivation in the study of introductory Physics

lorenzo.galante@polito.it
Politecnico di Torino

Why Role-Playing Games?



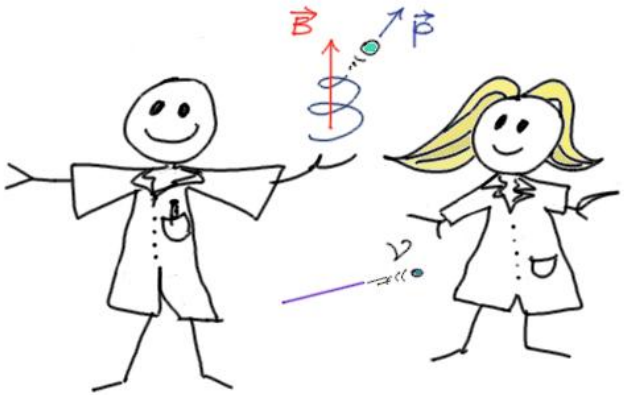
Active Learning

Identification with what is being studied

Motivation in the study of introductory Physics

lorenzo.galante@polito.it
Politecnico di Torino

Why Role-Playing Games?



Break typical educational pattern

Study to solve exercises

Pass the exam

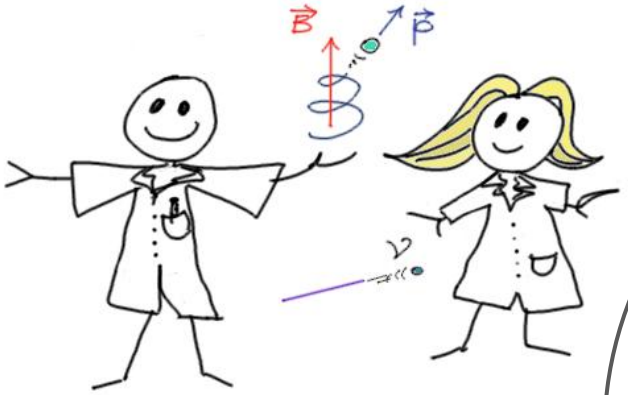
Active Learning

Identification with what is being studied

Motivation in the study of introductory Physics

lorenzo.galante@polito.it
Politecnico di Torino

Why Role-Playing Games?



Explore the beauty of what you are studying

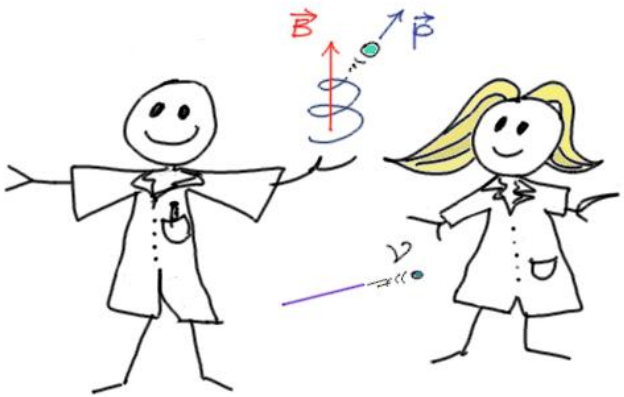
Active Learning

Identification with what is being studied

Motivation in the study of introductory Physics

Particle Physics Role-Playing Games in introductory Physics Courses.

lorenzo.galante@polito.it
Politecnico di Torino



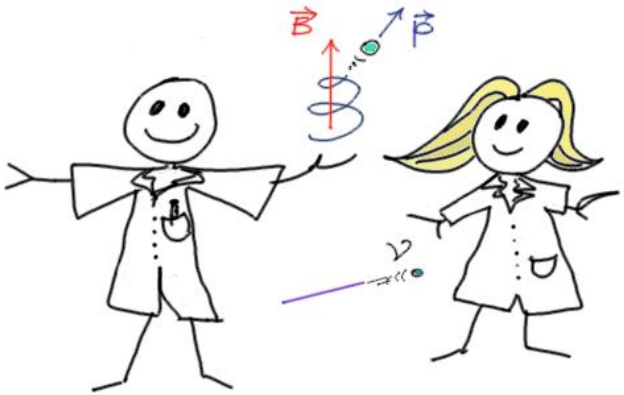
“ From Conservation Laws to Scientific Discovery ”

(18 hours)

2 Role-Playing Games

Particle Physics Role-Playing Games in introductory Physics Courses.

lorenzo.galante@polito.it
Politecnico di Torino



“ From Conservation Laws to Scientific Discovery ”

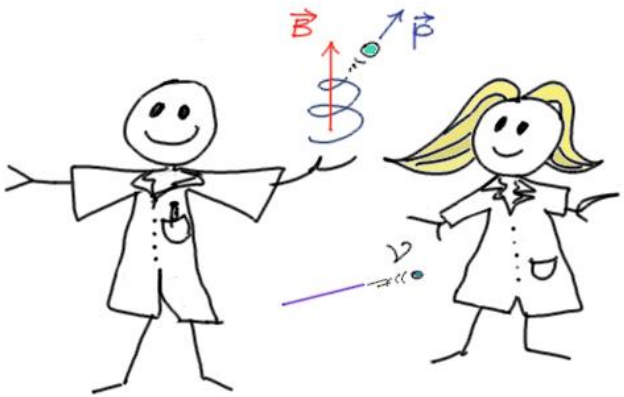
(18 hours)

2 Role-Playing Games

1. A case from 20th century physics

Particle Physics Role-Playing Games in introductory Physics Courses.

lorenzo.galante@polito.it
Politecnico di Torino



“ From Conservation Laws to Scientific Discovery ”

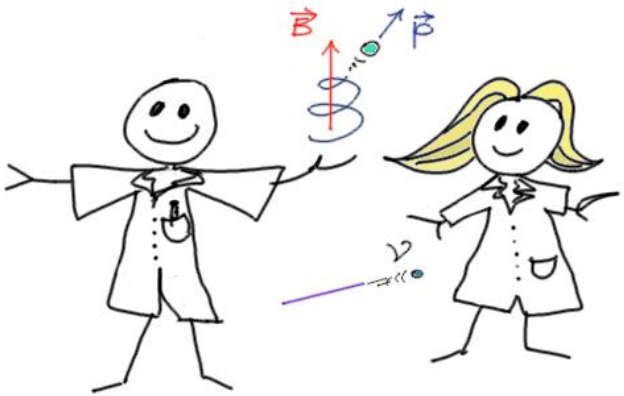
(18 hours)

2 Role-Playing Games

1. A case from 20th century physics
   - Momentum and Energy Conservation Laws
   - The neutrino hypothesis (neutron beta decay in the 30s).

Particle Physics Role-Playing Games in introductory Physics Courses.

lorenzo.galante@polito.it
Politecnico di Torino



“ From Conservation Laws to Scientific Discovery ”

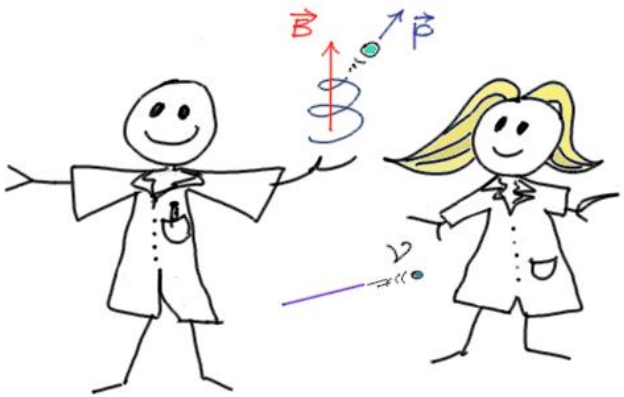
(18 hours)

2 Role-Playing Games

2. Nuclear Collisions

Particle Physics Role-Playing Games in introductory Physics Courses.

lorenzo.galante@polito.it
Politecnico di Torino



“ From Conservation Laws to Scientific Discovery ”

(18 hours)

2 Role-Playing Games

2. **Nuclear Collisions**

Momentum and Energy Conservation Laws

Discover the undetected particle emitted in a (π - He) collision

lorenzo.galante@polito.it
Politecnico di Torino

Distance Learning Supporting Technology

lorenzo.galante@polito.it
Politecnico di Torino

Distance Learning Supporting Technology

1. Zoom Meetings

lorenzo.galante@polito.it
Politecnico di Torino

Distance Learning Supporting Technology

1. Zoom Meetings

2. Interactive supporting site

Particle Physics Role-Playing Games in introductory Physics Courses.

lorenzo.galante@polito.it
Politecnico di Torino

Interactive supporting site

POLITECNICO DI TORINO

POLI-Lab @ home

FISICA I | FISICA II | Dalle leggi di Conservazione... | Tovagliette della Fisica | CosmoPoliTo

Home > Dalle leggi di Conservazione...

Categoria: Dalle leggi di Conservazione...

"Dalle leggi di Conservazione alla Scoperta scientifica" è un corso sull'importanza delle leggi di Conservazione nelle scoperte scientifiche. Si parte dalle conoscenze acquisite nel corso di Fisica I e, attraverso attività di Problem Solving, esperimenti e giochi di ruolo, si porta lo studente a tu per tu con situazioni sperimentali provenienti dalla Fisica delle Particelle. A loro il compito di interpretare la situazione sperimentale, provare a risolverla e il brivido di giungere a "piccole" scoperte scientifiche. Nella parte finale un collegamento multidisciplinare con l'Intelligenza Artificiale. Grazie a un codice scritto in Python, condiviso sulla piattaforma Google Colab, gli studenti potranno addestrare una rete neurale alla classificazione di eventi di urto tra particelle analoghi a quelli su cui hanno lavorato durante il corso.

Il Metodo Didattico.
Il corso è progettato per far sì che lo studente sia parte attiva del processo di apprendimento.

Esercizi Svolti (Fisica I)

Segui

Scrivi qui

Particle Physics Role-Playing Games in introductory Physics Courses.

lorenzo.galante@polito.it
Politecnico di Torino

Interactive supporting site

One page for each session of the Game

7 pages in total

Dalle leggi di Conservazione...

Un caso dalla Fisica del '900 (2)

Lorenzo Galante 25 Marzo 2021

Dalle leggi di Conservazione...

Collisioni nucleari (1)

Lorenzo Galante 25 Marzo 2021

Dalle leggi di Conservazione...

Collisioni nucleari (2)

Dalle leggi di Conservazione...

Collisioni nucleari (3)

Esercizi Svolti (Fisica I)

Segui

Scrivi qui

Articoli recenti

- La Strumentazione di CosmoPoliTO
- CERN per ingegneri
- Le trasformazioni di Lorentz
- Reti Neurali
- Cilindro su Piano Inclinato

Particle Physics Role-Playing Games in introductory Physics Courses.

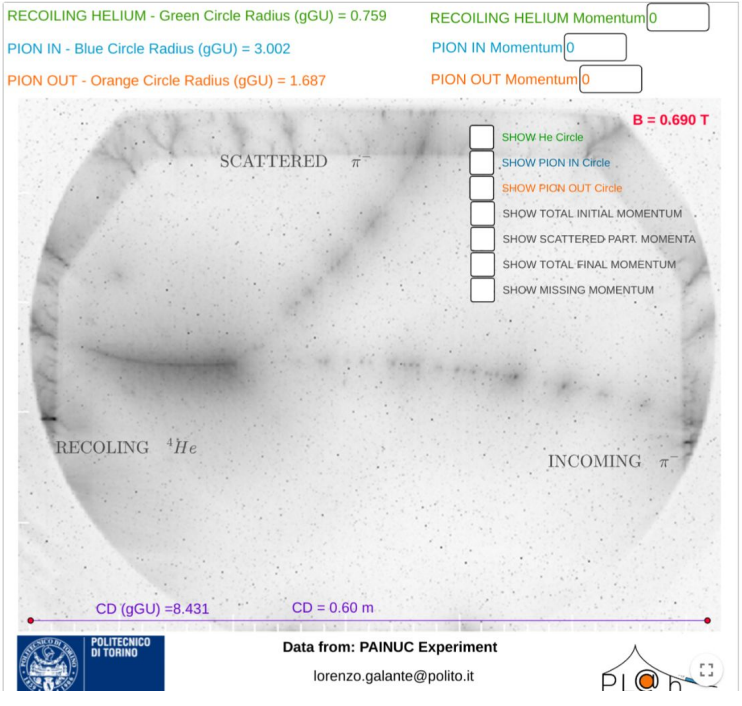
lorenzo.galante@polito.it
Politecnico di Torino

Interactive supporting site

The site is full of interactive sections

Applicazione interattiva per la misura

Questa è l'**applicazione** interattiva introdotta nei video tutorial, da adesso in poi sarà il tuo ambiente di lavoro.



Esercizi Svolti (Fisica I)

Segui

Scrivi qui

Articoli recenti

- La Strumentazione di CosmoPoliTO
- CERN per ingegneri
- Le trasformazioni di Lorentz
- Reti Neurali
- Cilindro su Piano Inclinato

Particle Physics Role-Playing Games in introductory Physics Courses.

lorenzo.galante@polito.it
Politecnico di Torino

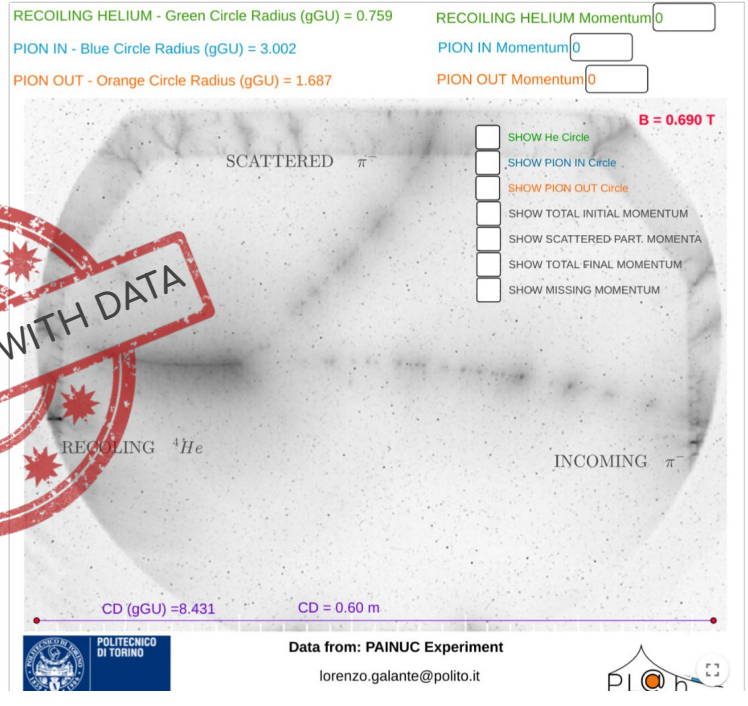
Interactive supporting site

The site is full of interactive sections

Active Learning

Applicazione interattiva per la misura

Questa è l'**applicazione** interattiva introdotta nei video tutorial, da adesso in poi sarà il tuo ambiente di lavoro.



Esercizi Svolti (Fisica I)

Segui

Scrivi qui

Articoli recenti

- La Strumentazione di CosmoPoliTO
- CERN per ingegneri
- Le trasformazioni di Lorentz
- Reti Neurali
- Cilindro su Piano Inclinato

Particle Physics Role-Playing Games in introductory Physics Courses.

lorenzo.galante@polito.it
Politecnico di Torino

Interactive supporting site

The site is full of interactive sections

Scorgi qualche problema nei dati sperimentali raccolti a riguardo del decadimento proposto per la particella d? *

- ◯ Sì
- ◯ No
- ◯ Non saprei

Sapresti descrivere brevemente il perché della risposta che hai dato alla domanda precedente? *

Your answer

Proponi una possibile spiegazione all'eventuale problema che hai riscontrato. (Qui scrivi la spiegazione che trovi più convincente e motivala. Nella Presentazione che preparerai cita anche le ipotesi scartate e il perché le hai scartate) *

Your answer

Submit Clear form

Esercizi Svolti (Fisica I)

Segui

Scrivi qui

Articoli recenti

- La Strumentazione di CosmoPoliTO
- CERN per ingegneri
- Le trasformazioni di Lorentz
- Reti Neurali
- Cilindro su Piano Inclinato

Particle Physics Role-Playing Games in introductory Physics Courses.

lorenzo.galante@polito.it
Politecnico di Torino

Interactive supporting site

The site is full of interactive sections

Scorgi qualche problema nei dati sperimentali raccolti a riguardo del decadimento proposto per la particella d? *

- Sì
- No
- Non saprei

Sapresti descrivere brevemente il perché della risposta che hai dato alla domanda precedente? *

Your answer

Proponi una possibile spiegazione all'eventuale problema che hai riscontrato. (Qui scrivi la spiegazione che trovi più convincente e motivala. Nella Presentazione che preparerai cita anche le ipotesi scartate e il perché le hai scartate) *

Your answer

Submit Clear form

Esercizi Svolti (Fisica I)

Segui

Scrivi qui

Articoli recenti

- La Strumentazione di CosmoPoliTO
- CERN per ingegneri
- Le trasformazioni di Lorentz
- Reti Neurali
- Cilindro su Piano Inclinato

lorenzo.galante@polito.it
Politecnico di Torino

Assessment of Game Sessions

Particle Physics Role-Playing Games in introductory Physics Courses.

lorenzo.galante@polito.it
Politecnico di Torino

Assessment of Game Sessions

Players gain experiences

Converted in Experience Points

Table of Experience Points

CORSO 1 - Galileo Ferraris - Lunedì : Vene
Lorenzo Galante

	Nome del Team	n°	I	II	III	IV	V	VI	VII	VIII	P.ti Esp	LIVELLO*
				(Form)	(Elaborati	sura Impu	(Pr.Solv1)	r. Solv.2	rticle Hunt	ANN		
TEAM 1	Perseverance	4	90	85	80	90	95	98	95		633	5
TEAM 2	Fermioni	4	95	105	100	100	100	95	90		685	5
TEAM 3	I figli di Lussardi	4	90	85	85	100	110	98	85		653	5
TEAM 4	Tony Manero	4	90	95	95	100	100	100	100		680	5
TEAM 5	Saturn V	4	90	80	85	90	105	100	95		645	5
TEAM 6	Non è molto ma è un lavoro one	4	100	80	80	100	105	95	85		645	5
TEAM 7	SRnI(ntraprendenti)	4	100	80	80	100	90	100	100		650	5
TEAM 8	Little Einsteins	4	100	80	80	100	110	100	95		665	5
TEAM 9	Vogliamo andare in presenza	4	90	85	85	100	105	100	97		662	5
TEAM 10	Team Neon(ati)	4	100	80	85	100	105	98	95		663	5
TEAM 11	Regola di Hund-ici	5	85	80	80	100	95	100	98		638	5
TEAM 12	C'era una Volt	5	95	80	85	85	95	98	85		623	5
TEAM 13	Apollo 13	5	100	85	95	90	100	95	100		665	5
TEAM 14	Carbonio 14	5	60	85	85	100	100	100	98		628	5
TEAM 15	Maffe	5	85	80	85	90	95	100	93		628	5
TEAM 16	I bosoni pigri	5	100	80	85	95	95	95	85		635	5
TEAM 17	The Big Bang Team	5	100	80	80	100	95	93	95		643	5
TEAM 18	18, accetta?	5	85	80	80	100	95	100	90		630	5
TEAM 19	Fisici bestiali	5	100	100	95	100	95	95	95		680	5
TEAM 20	I 20 cosmici	4	100	100	100	100	100	95	100		695	5

lorenzo.galante@polito.it
Politecnico di Torino

How a Game session works

1. Students are divided in Teams
2. The instructor asks the students to play the role
3. The instructor describes the settings and tells a story

lorenzo.galante@polito.it
Politecnico di Torino

How a Game session works

4. **Teams** are asked to face a challenge concerning a specific problem of the setting " in which they act "

5. The **Teams** are given a certain amount of time to play the game. They work inside a **Zoom Breakout room**

6. The **Teams** have to report their actions and conclusions in a **form** or a **pdf** which is collected by the **instructor**

lorenzo.galante@polito.it
Politecnico di Torino

How a Game session works

7. Plenary discussion (Instructor + Teams) about the actions and conclusions each team have performed

8. The Instructor assesses the reports of all the Teams and refreshes the table of the Experience Points of all the participants

lorenzo.galante@polito.it
Politecnico di Torino

A case from 20th century physics

Physics Role-Playing Game on the neutrino hypothesis

The Physics of the Game

lorenzo.galante@polito.it
Politecnico di Torino

A case from 20th century physics

Physics Role-Playing Game on the neutrino hypothesis

The Physics of the Game

PART 1

Preparatory meeting for the Role-Playing game

PART 2

The Game

lorenzo.galante@polito.it
Politecnico di Torino

A case from 20th century physics

Physics Role-Playing Game on the neutrino hypothesis

The Physics of the Game

PART 1

Preparatory meeting for the Role-Playing game

Simple situations in which Conservation Laws hold.

Focus on:

1. the **number equations** from Conservation Laws
2. The **number of unknowns**

lorenzo.galante@polito.it
Politecnico di Torino

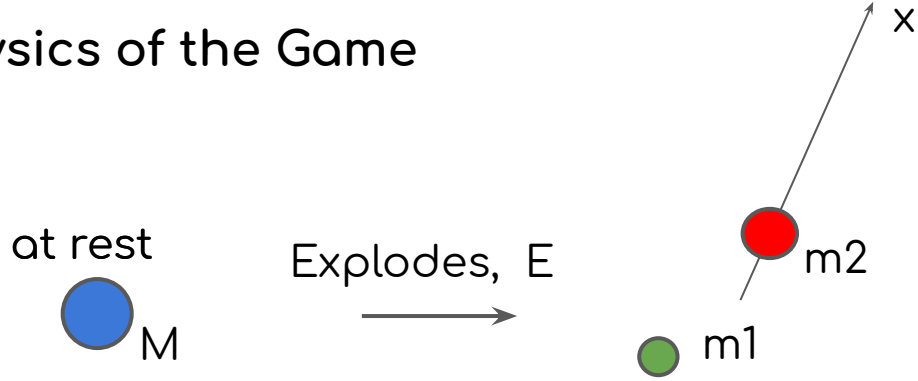
A case from 20th century physics

Physics Role-Playing Game on the neutrino hypothesis

The Physics of the Game

PART 1

Preparatory meeting for the Role-Playing game



- Write the equations
- The momenta are uniquely determined
- Explain why?

lorenzo.galante@polito.it
Politecnico di Torino

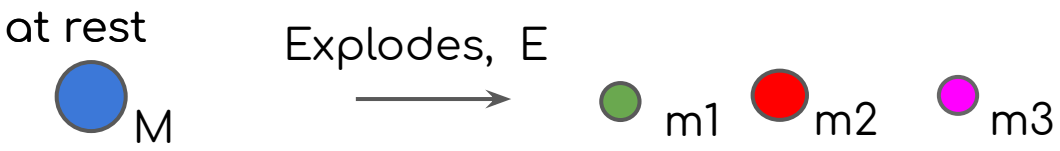
A case from 20th century physics

Physics Role-Playing Game on the neutrino hypothesis

The Physics of the Game

PART 1

Preparatory meeting for the Role-Playing game



- Write the equations
- Can you tell something about how momenta are disposed in space?
- Explain why?

lorenzo.galante@polito.it
Politecnico di Torino

A case from 20th century physics

Physics Role-Playing Game on the neutrino hypothesis

The Physics of the Game

PART 1

Preparatory meeting for the Role-Playing game

TEAMWORK / PROBLEM SOLVING

lorenzo.galante@polito.it
Politecnico di Torino

A case from 20th century physics

Physics Role-Playing Game on the neutrino hypothesis

The Physics of the Game

PART 2

The Game

$$d \rightarrow e^- + f^+$$

lorenzo.galante@polito.it
Politecnico di Torino

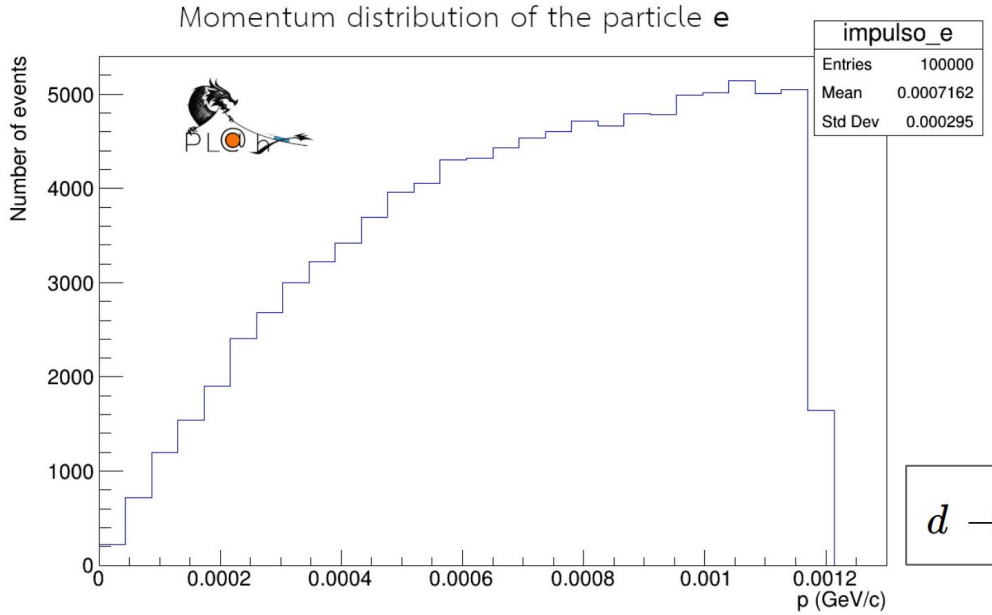
A case from 20th century physics

Physics Role-Playing Game on the neutrino hypothesis

The Physics of the Game

PART 2

The Game



$$d \rightarrow e^- + f^+$$

lorenzo.galante@polito.it
Politecnico di Torino

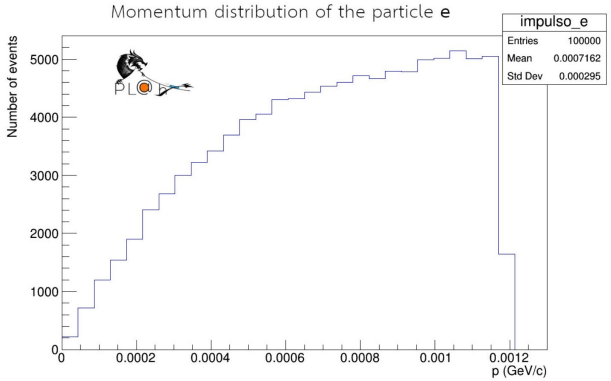
A case from 20th century physics

Physics Role-Playing Game on the neutrino hypothesis

The Physics of the Game

PART 2

The Game



$$d \rightarrow e^- + f^+$$

Interpret the experimental data.

Discover if there is any problem in the experimental data

If any, discuss possible solutions

lorenzo.galante@polito.it
Politecnico di Torino

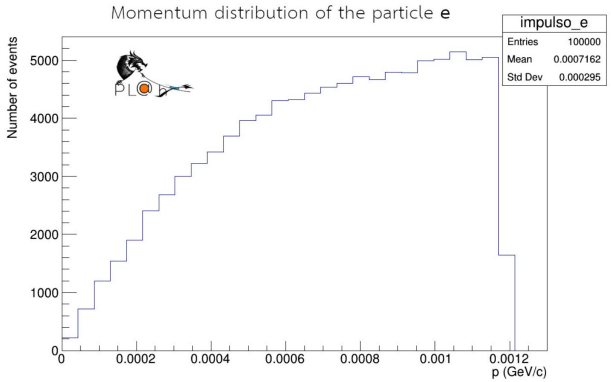
A case from 20th century physics

Physics Role-Playing Game on the neutrino hypothesis

The Physics of the Game

PART 2

The Game



$$d \rightarrow e^- + f^+$$

Special Powers:

Physics I course

Preparatory meeting (Part 1)

lorenzo.galante@polito.it
Politecnico di Torino

A case from 20th century physics

Physics Role-Playing Game on the neutrino hypothesis

The Physics of the Game

PART 2

The Game

Preparatory meeting.

Explosion in two fragments

The momenta of the two parts are uniquely determined

lorenzo.galante@polito.it
Politecnico di Torino

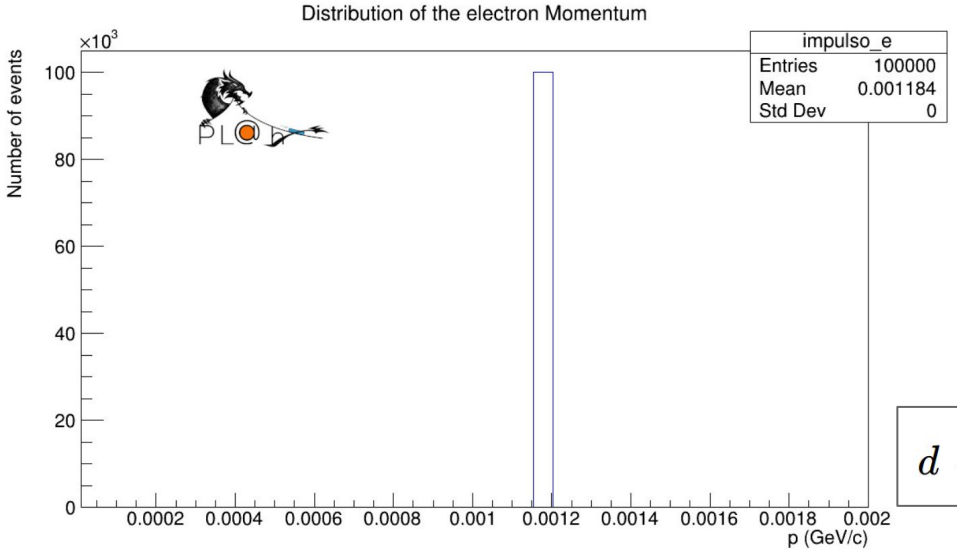
A case from 20th century physics

Physics Role-Playing Game on the neutrino hypothesis

The Physics of the Game

PART 2

The Game



$$d \rightarrow e^- + f^+$$

lorenzo.galante@polito.it
Politecnico di Torino

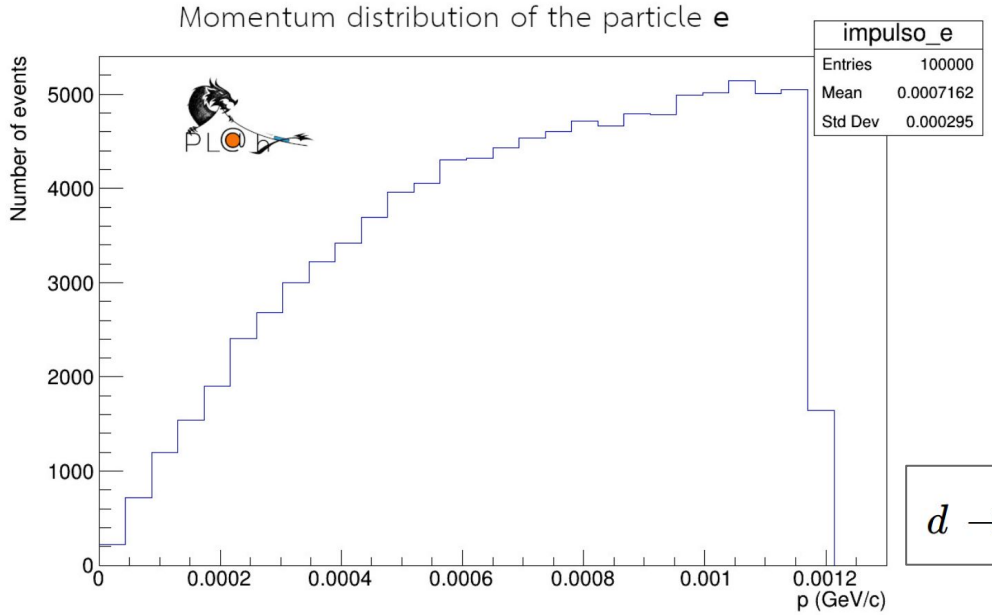
A case from 20th century physics

Physics Role-Playing Game on the neutrino hypothesis

The Physics of the Game

PART 2

The Game



$$d \rightarrow e^- + f^+$$

lorenzo.galante@polito.it
Politecnico di Torino

A case from 20th century physics

Physics Role-Playing Game on the neutrino hypothesis

Results of the Game

48 Teams ~ 200 Students

98% of the Teams reported something was wrong in the experimental distribution.

lorenzo.galante@polito.it
Politecnico di Torino

A case from 20th century physics

Physics Role-Playing Game on the neutrino hypothesis

Results of the Game

33% of the Teams realised that, in the case of a 2-particle decay, the distribution should have been centered on a single value

lorenzo.galante@polito.it
Politecnico di Torino

A case from 20th century physics

Physics Role-Playing Game on the neutrino hypothesis

Results of the Game

33% of the Teams proposed, as a possible solution to the problem, the **existence of an undetected neutral particle**.

lorenzo.galante@polito.it
Politecnico di Torino

A case from 20th century physics

Physics Role-Playing Game on the neutrino hypothesis

The Physics of the Game

Post-Game Discussion

'Nothing venture, nothing win. And the **gravity of the situation** with regard to the **continuous beta spectrum** ... "

Pauli

$$n \rightarrow p^+ + e^- + \bar{\nu}_e$$

lorenzo.galante@polito.it
Politecnico di Torino

A case from 20th century physics

Physics Role-Playing Game on the neutrino hypothesis

Student's feedback

Please rate on a scale of 1-5 your appreciation of the first part of the course "A Case from 20th Century Physics".

lorenzo.galante@polito.it
Politecnico di Torino

A case from 20th century physics

Physics Role-Playing Game on the neutrino hypothesis

Student's feedback

What do you think about using a role-playing game for a physics course?

99 Answers All with a positive feedback

" It made everything more exciting "

" I think it is very useful to push for deeper thinking. "

" It appeared to be a very 'light' and engaging way of approaching complex topics. "

lorenzo.galante@polito.it
Politecnico di Torino

A case from 20th century physics

Physics Role-Playing Game on the neutrino hypothesis

Student's feedback

How much did you enjoy working with the team?