

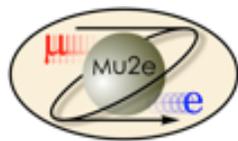
My path into Particle physics: Hunting muons!

Raffaella Donghia

LNF-INFN

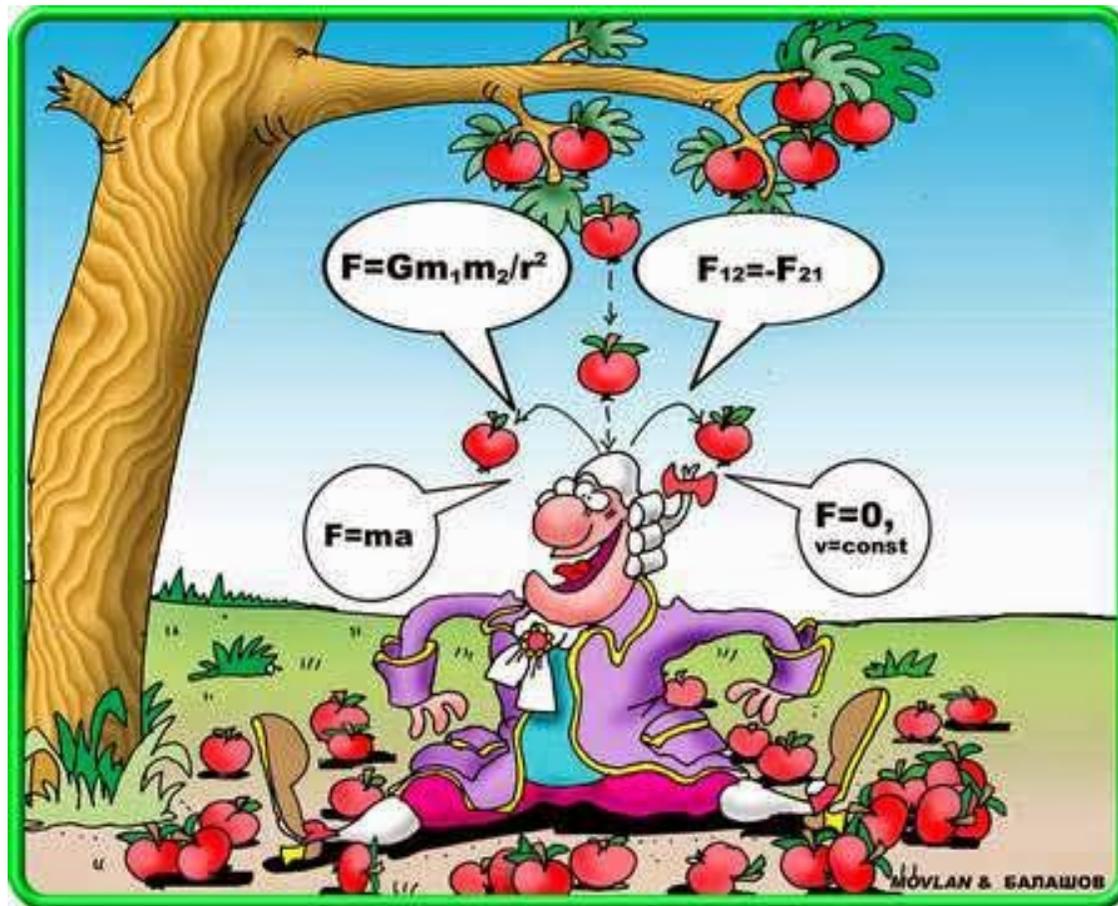
INSPYRE 2019 - International School on modern PhYsics and Research

April 2nd, 2019



AFTER THE HIGH SCHOOL?

- 2010: Science high school diploma
- What's next???



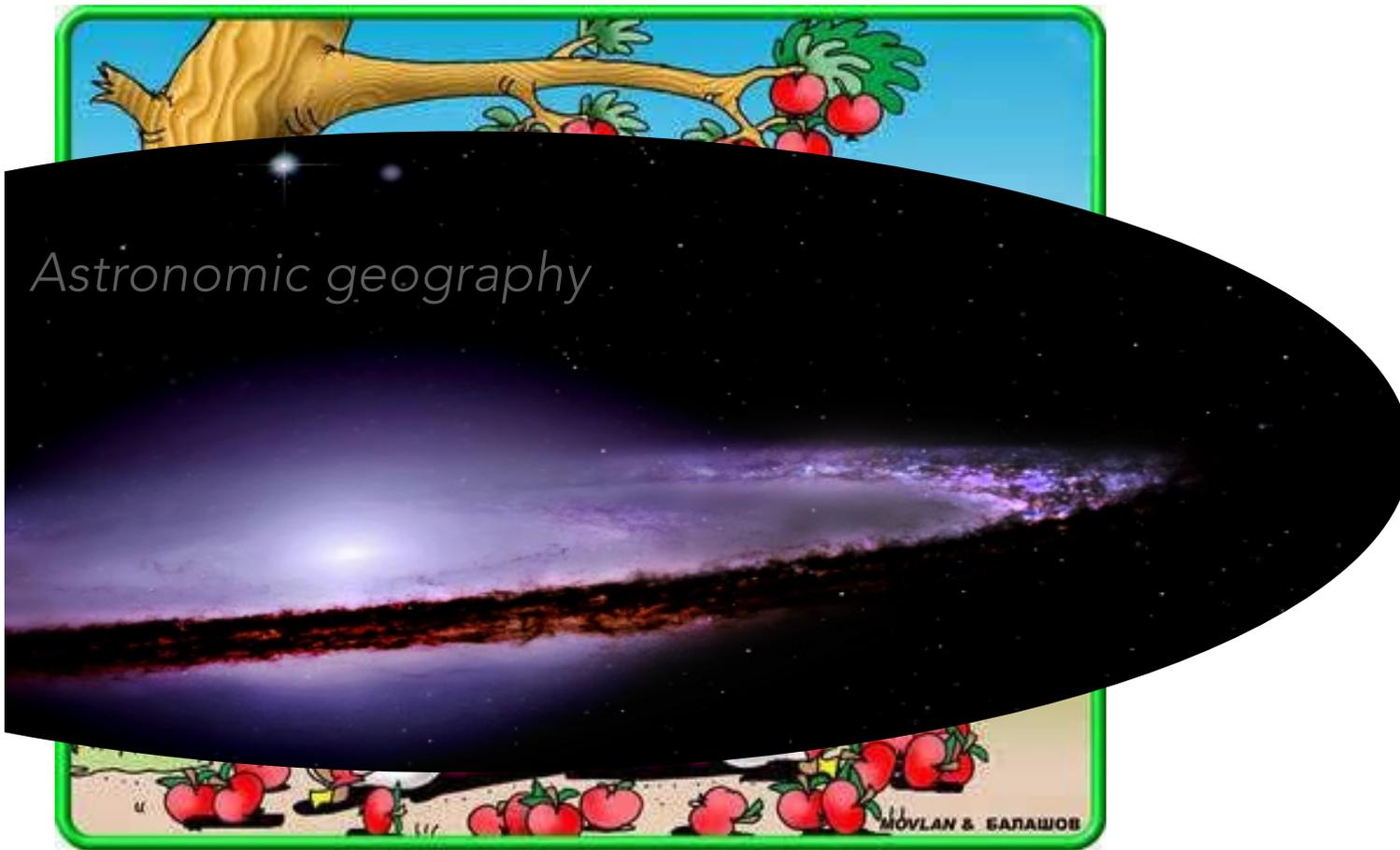
14/01/19



R. Doughia, MSP.

AFTER THE HIGH SCHOOL?

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14/01/19



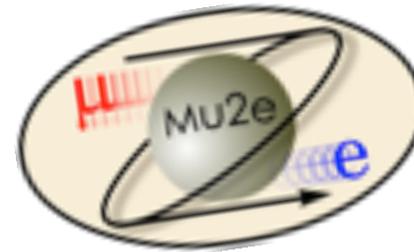
- 2010: I started the physics degree, leaded by curiosity
- 10/2013: BSc thesis on the *"Measurements of the muon life-time"*
- Particle physics!

1410119

TROUGH PP IN US



- Summer School @ FNAL (Chicago, US)
- 10/2015: MSc degree and start of the PhD

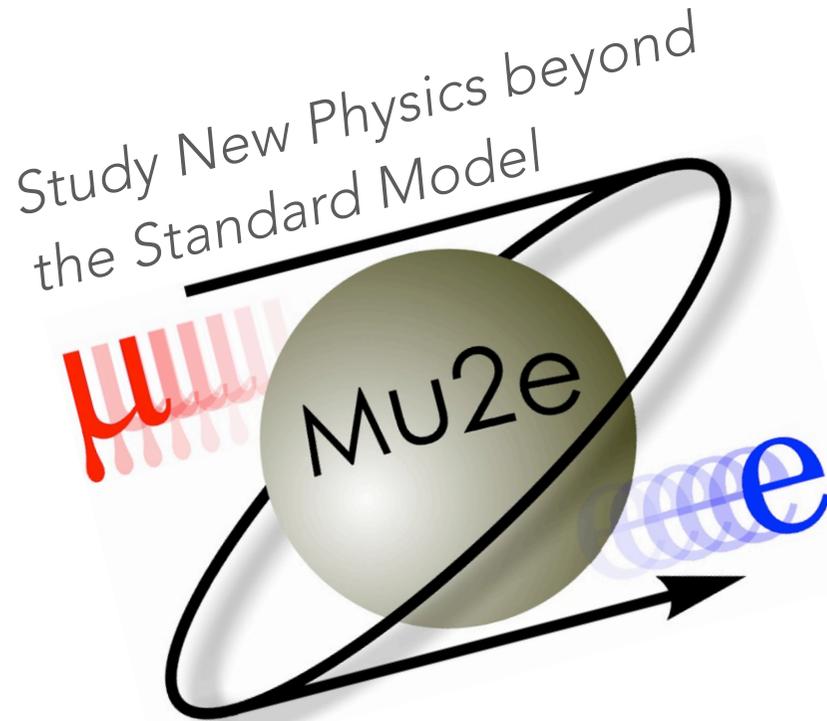
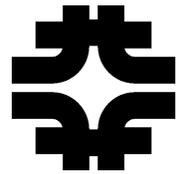


 **Fermilab**

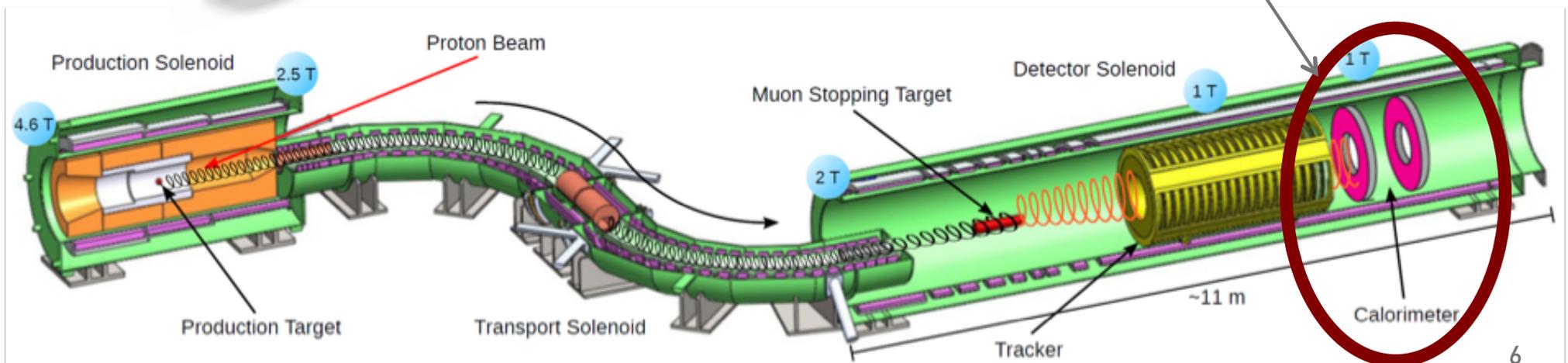
**INFN**
Istituto Nazionale di Fisica Nucleare
Laboratori Nazionali di Frascati



MU2E EXPERIMENT

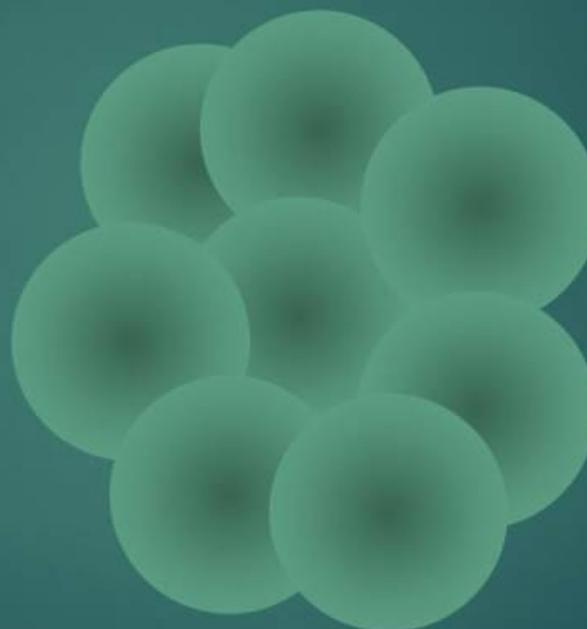


Electromagnetic calorimeter:
Detector needed to measure particles energy
(electrons, photons)



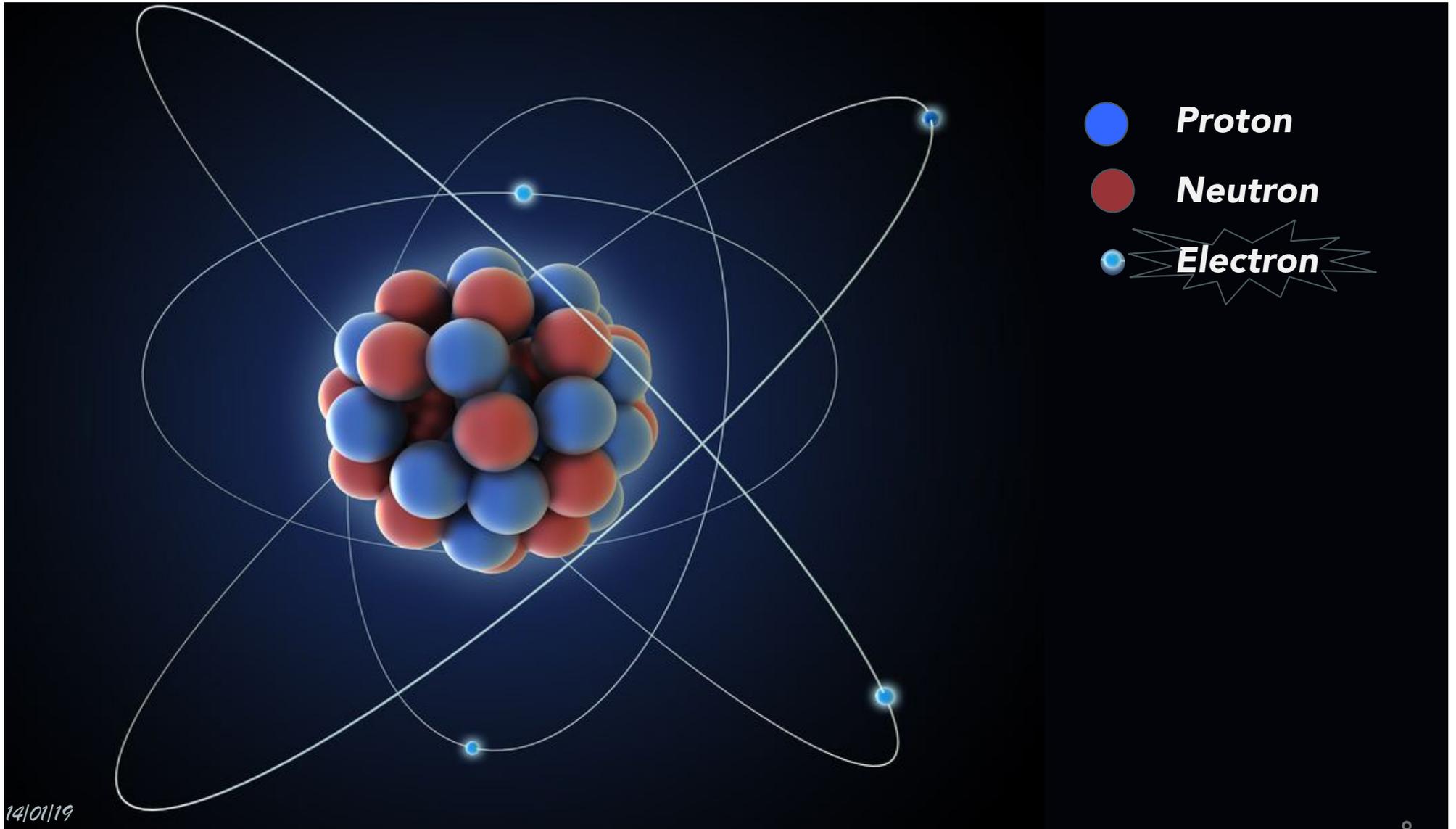
WHAT IS A PARTICLE?

How the matter is made?

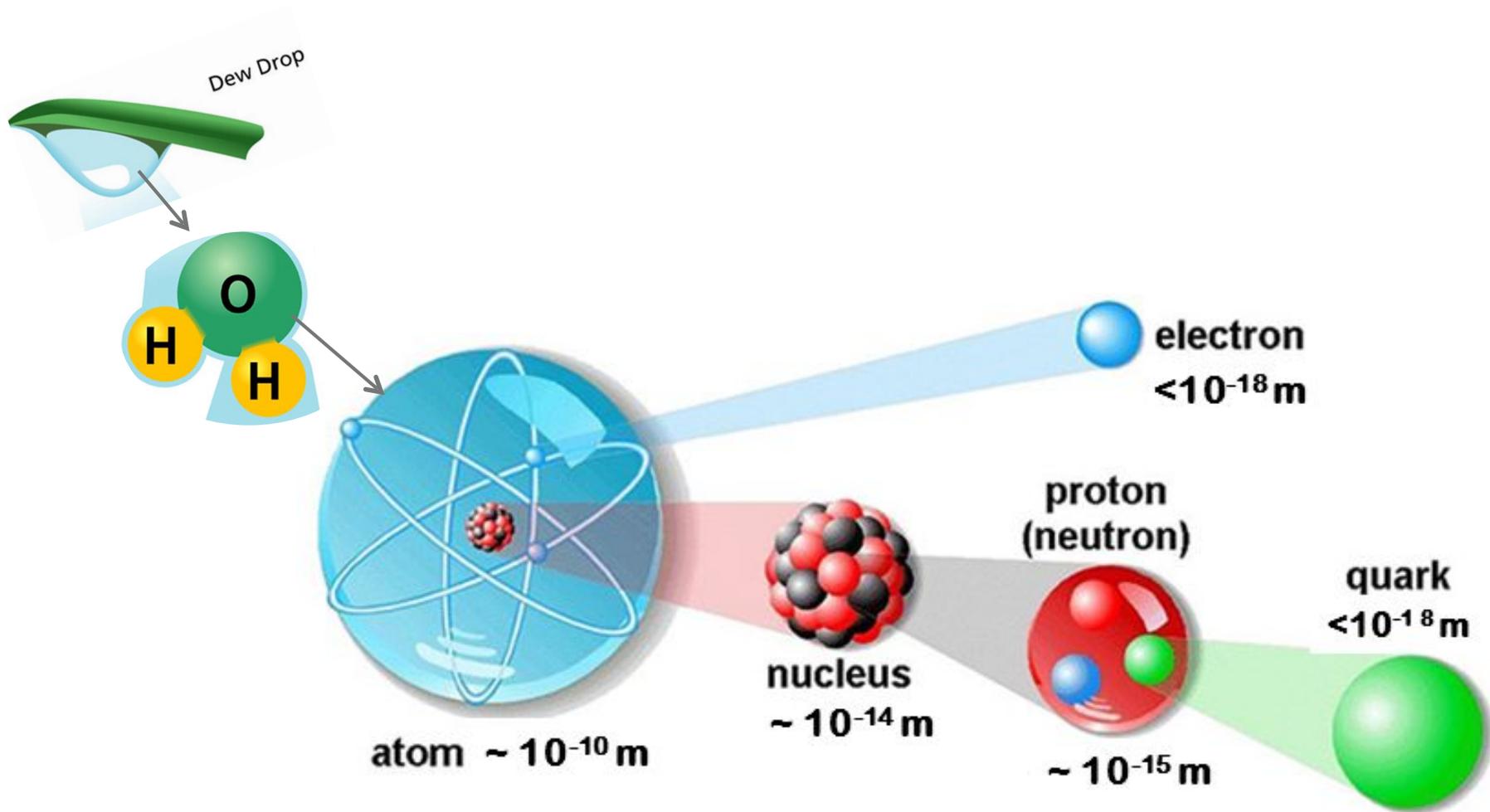


Atom

WHAT IS A PARTICLE?

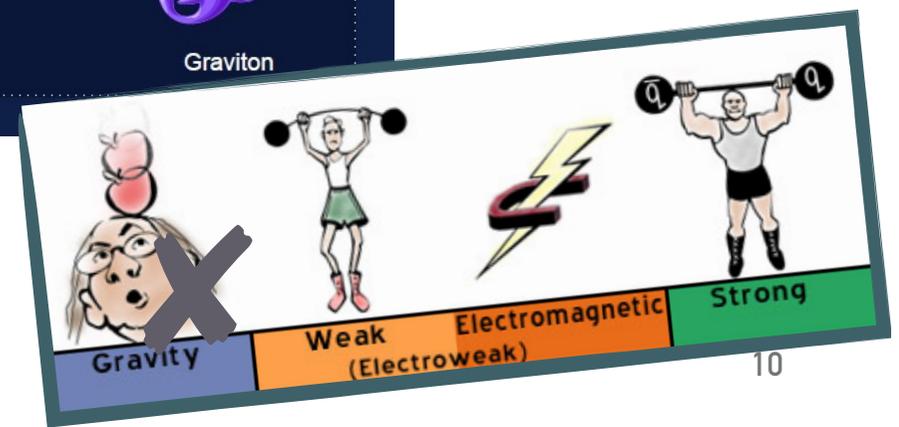


ELEMENTARY PARTICLES



HOW MANY?

Quarks		Leptons		Bosons		
						
Up	Down	Electron	Neutrino	Photon	Gluon	
						
Charm	Strange	Muon	Neutrino Muon	Z ⁰	W ⁻	W ⁺
						
Top	Beauty	Tau	Neutrino Tau	Higgs	Graviton	



Gravity Weak Electromagnetic Strong

(Electroweak)

STANDARD MODEL



- **12 "fermions": matter building blocks**
- **5 "bosons": forces carriers**
- **Higgs boson gives everything else in the universe mass**

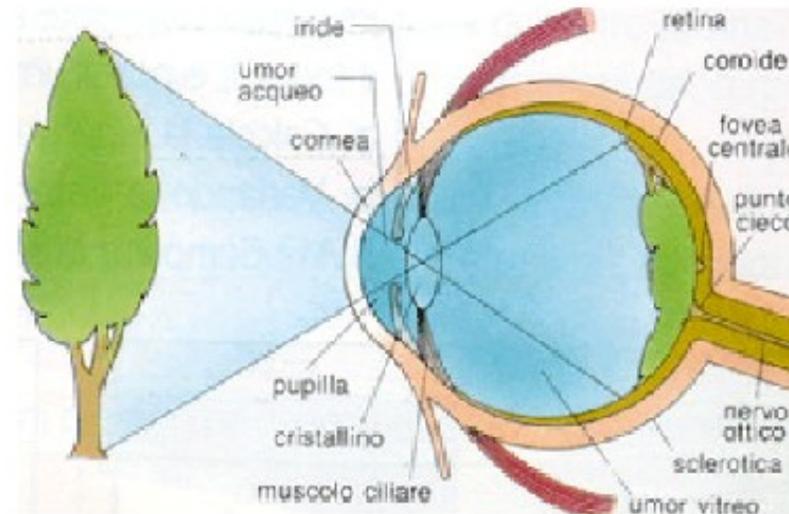
HOW DO WE KNOW THE PARTICLES?

Particles cannot be seen by human eyes!



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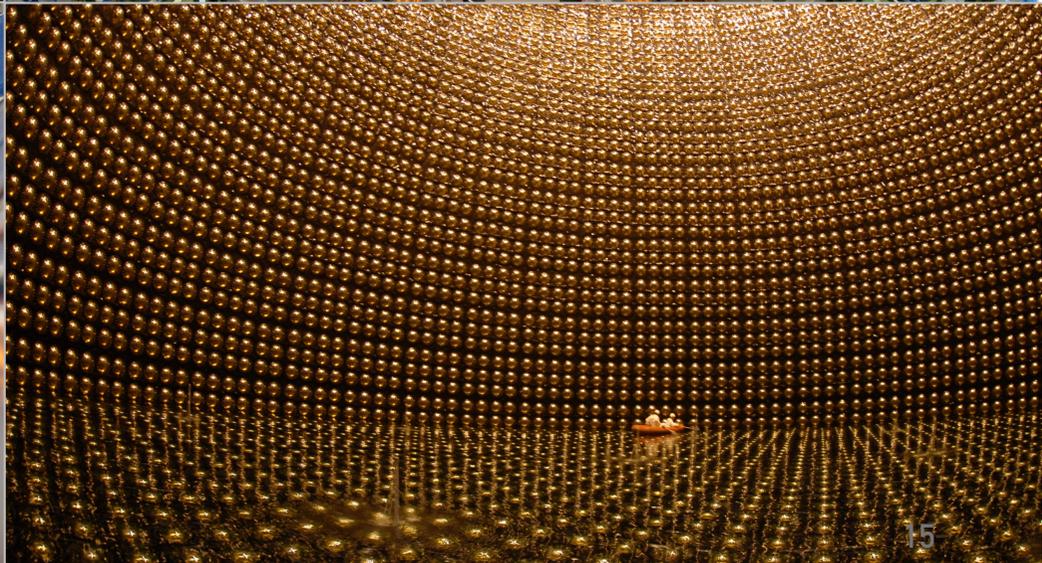
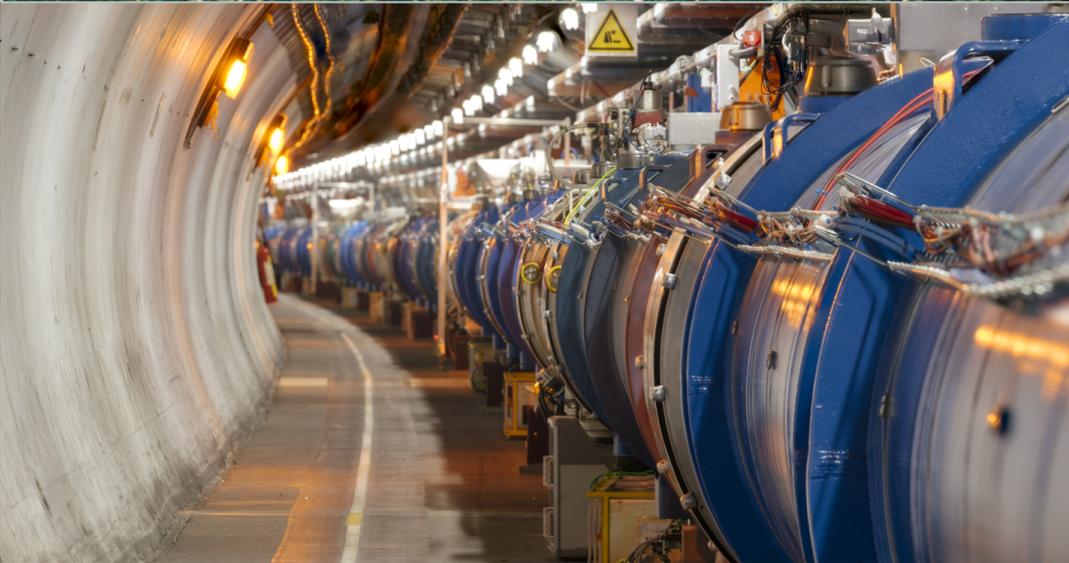
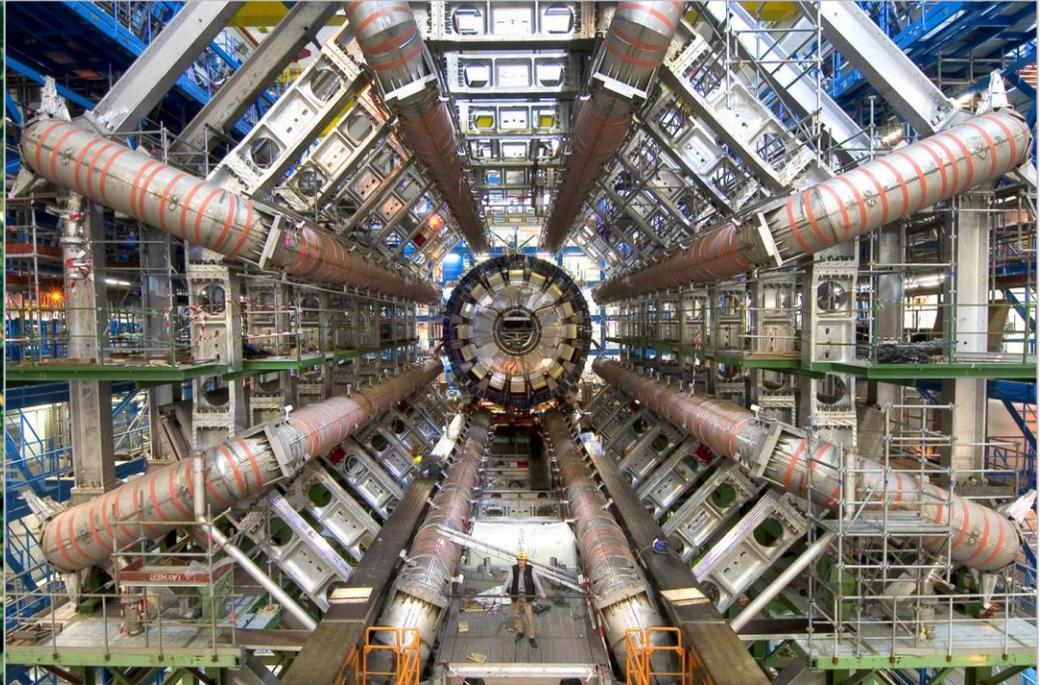
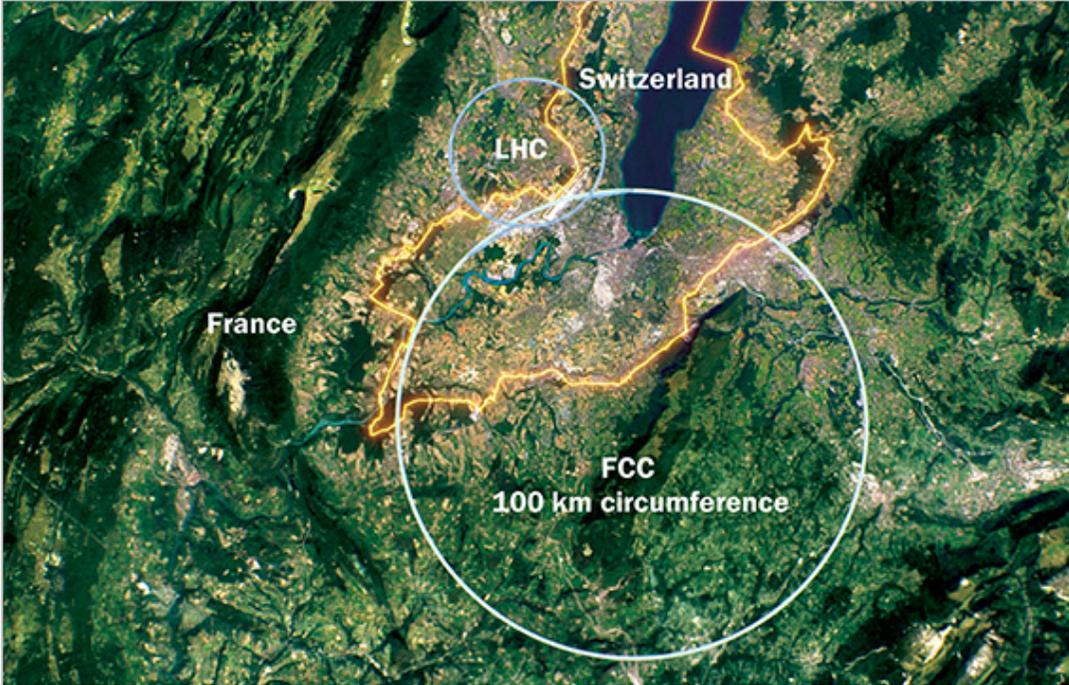
HOW DO WE KNOW THE PARTICLES?

Particles cannot be seen by human eyes!

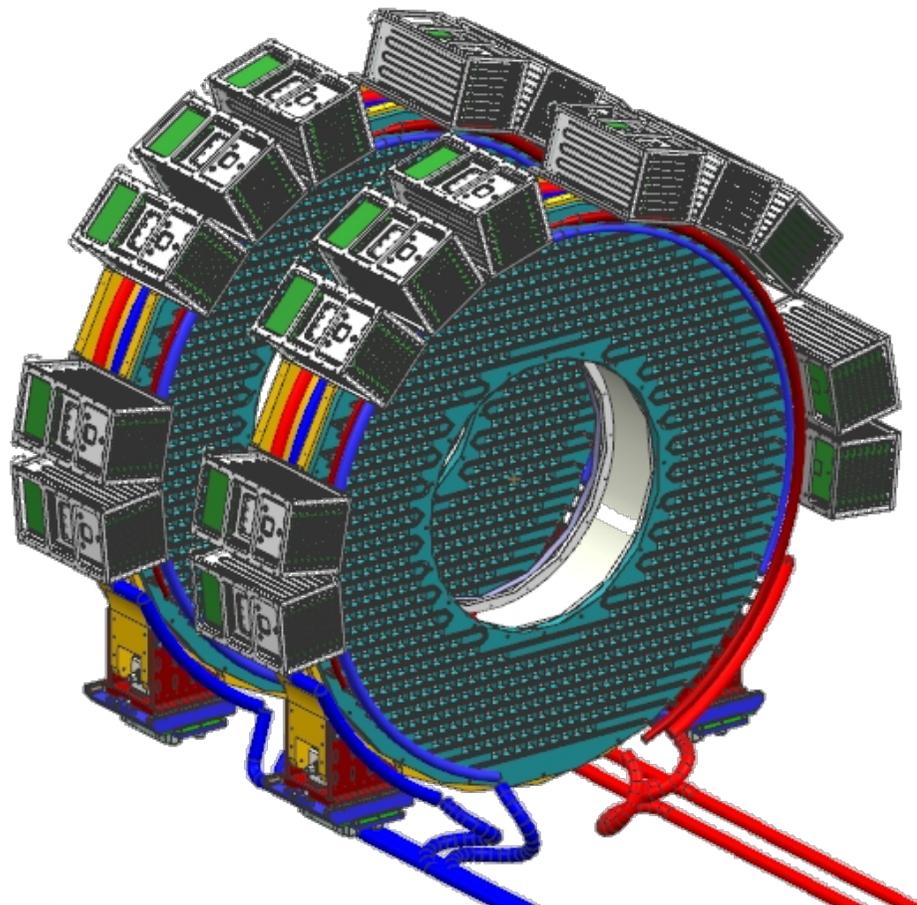
We can study their traces/interactions
with matter



SOME EXPERIMENTS - OUR EYES ON PARTICLES



WHAT DO I DO?



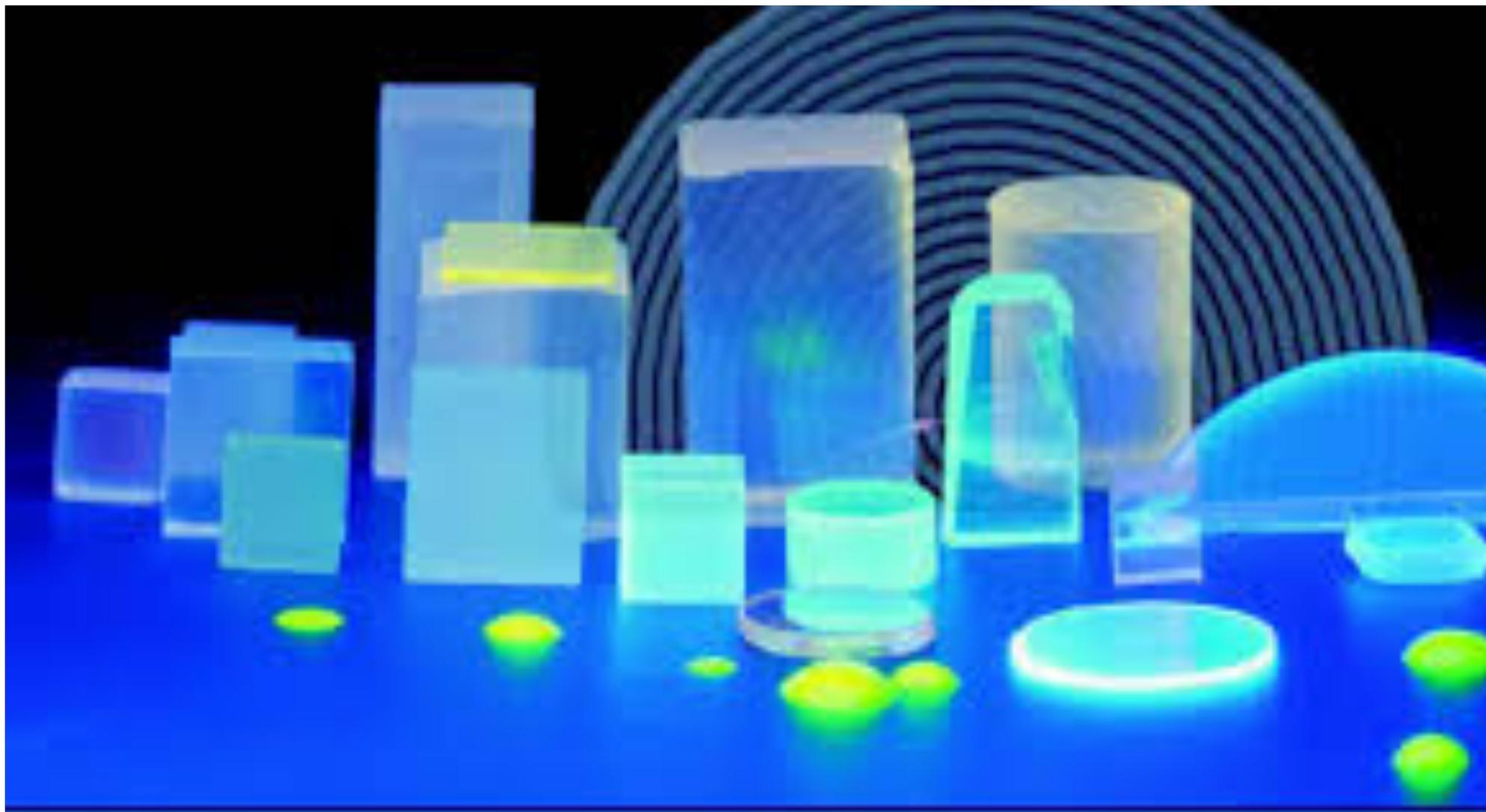
Amerys C0015	S-G C0046	SIC C0038
Amerys C0016	S-G C0048	SIC C0039
Amerys C0019	S-G C0049	SIC C0040
Amerys C0023	S-G C0051	SIC C0041
Amerys C0025	S-G C0057	SIC C0042
Amerys C0026	S-G C0058	SIC C0043
Amerys C0027	S-G C0060	SIC C0068
Amerys C0030	S-G C0062	SIC C0070
Amerys C0032	S-G C0063	SIC C0071
Amerys C0034	S-G C0065	SIC C0072
Amerys C0036	S-G C0066	SIC C0073



Research and development of detectors

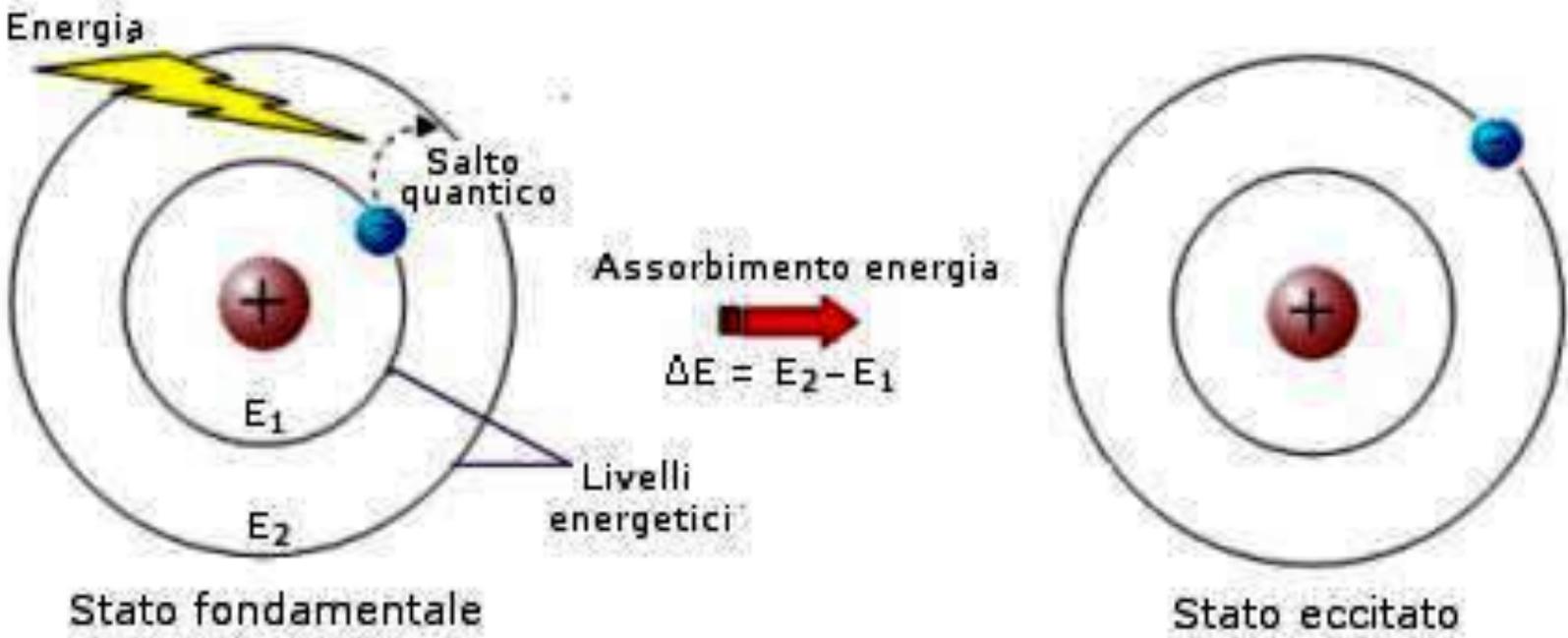


CRYSTALS



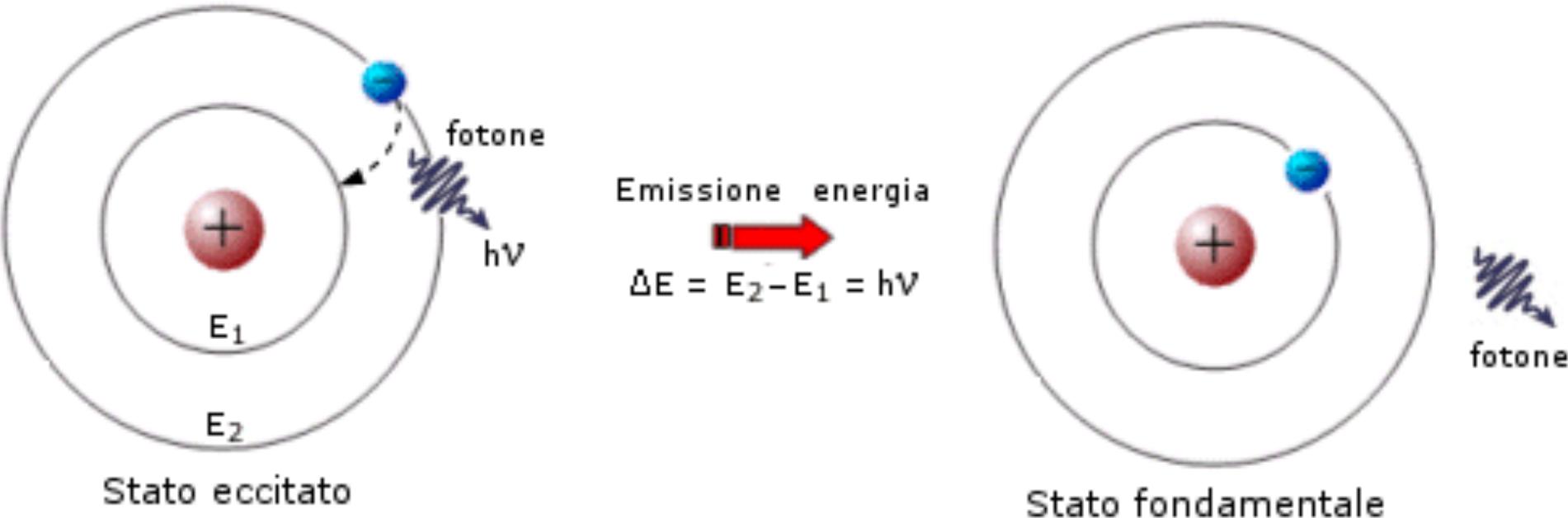
SCINTILLATION

De-excitation of single atoms excited by the passage of an incoming particle

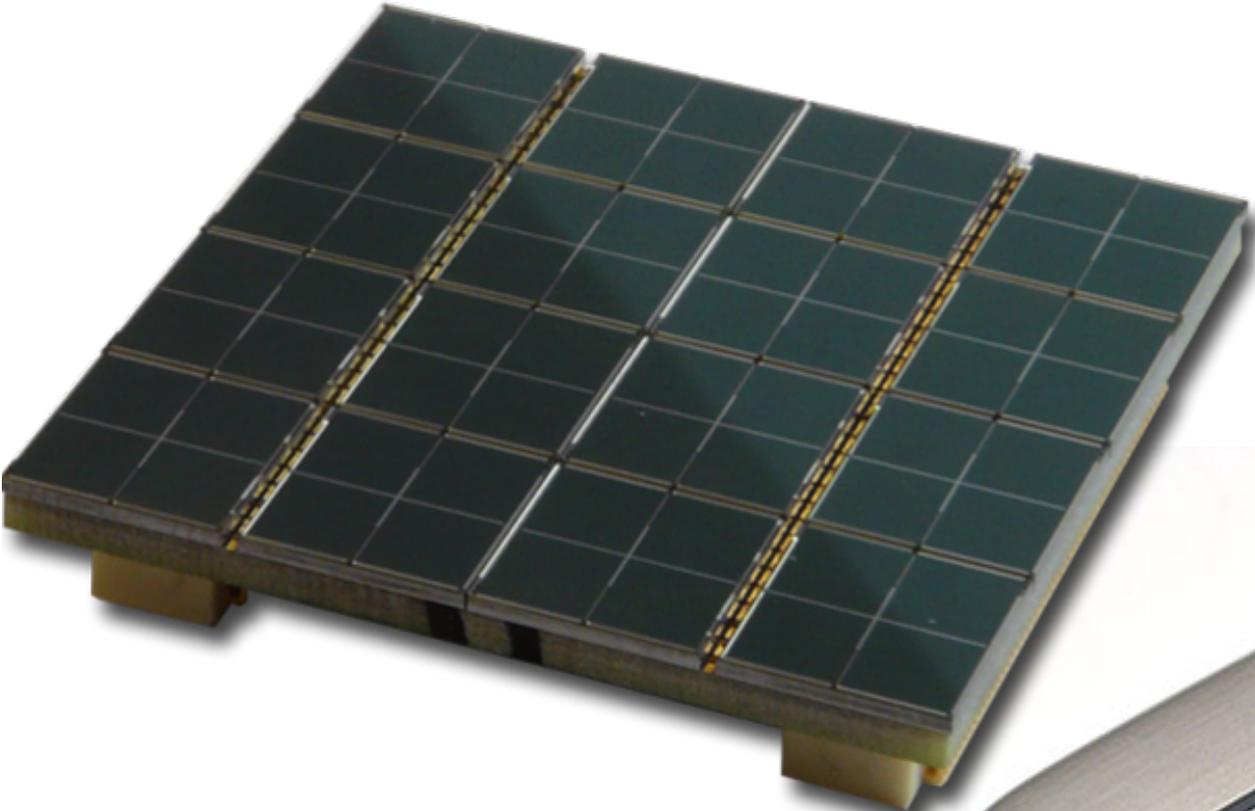


SCINTILLATION

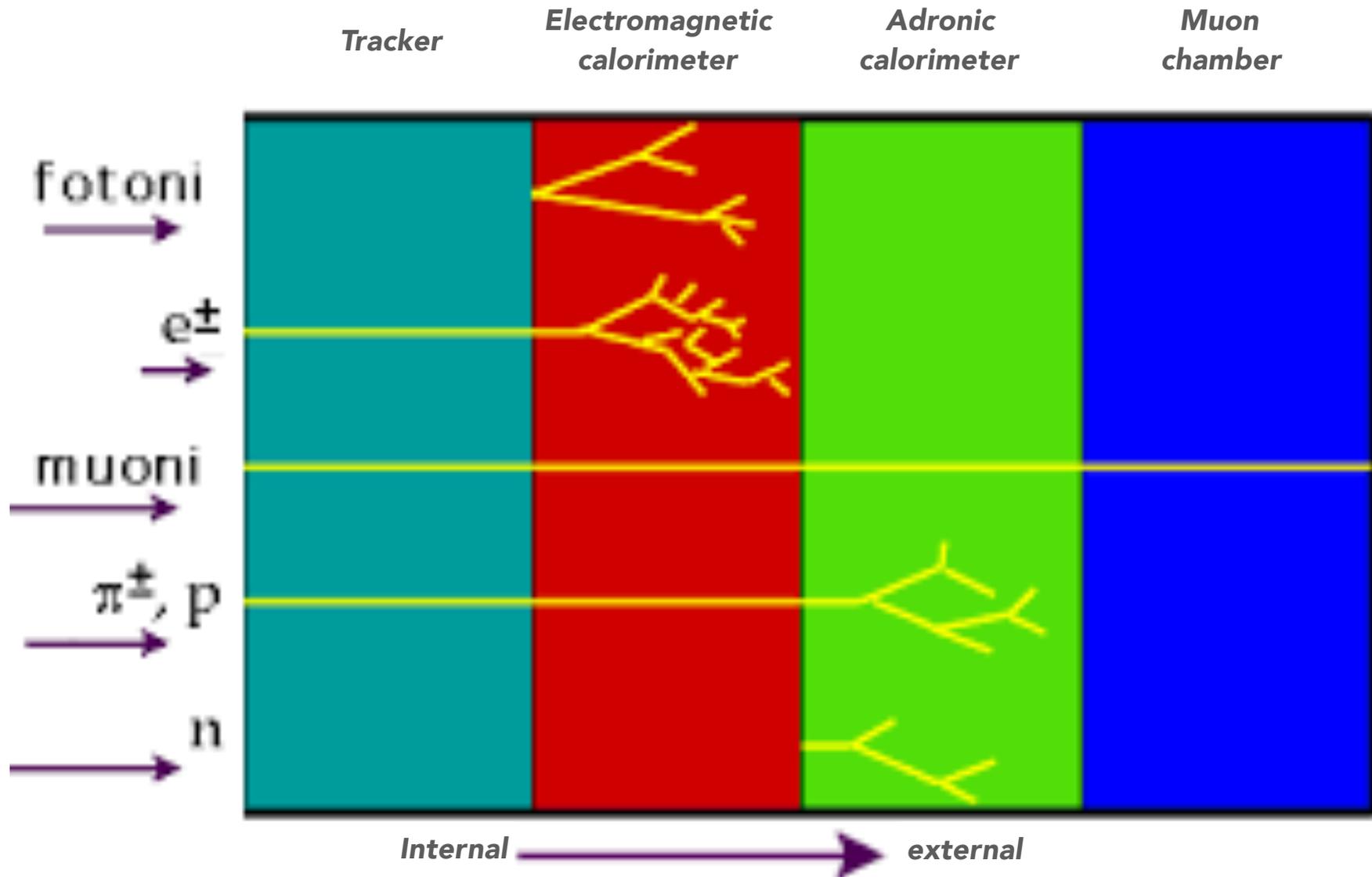
De-excitation causes light emission



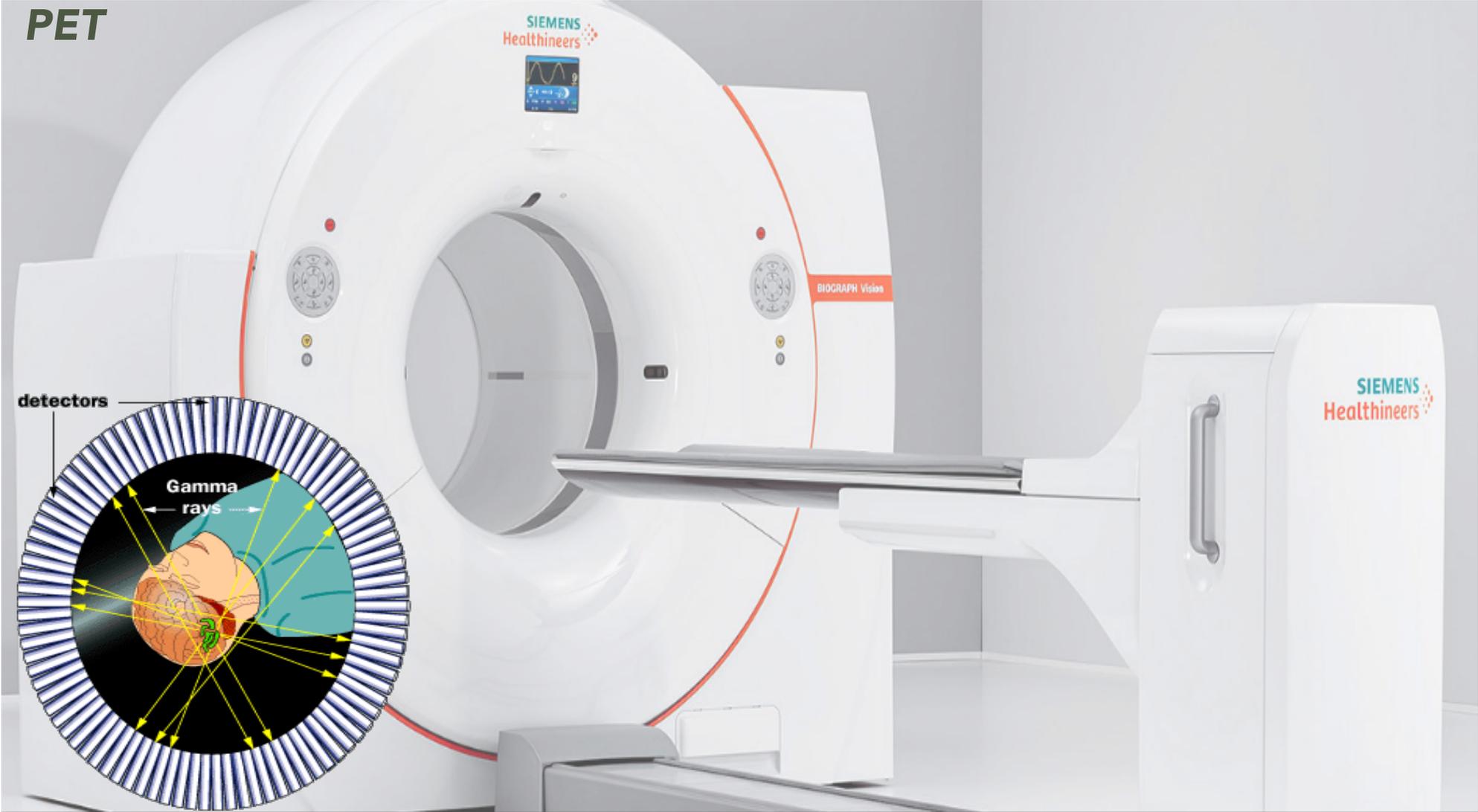
PHOTOSENSORS



TRACES

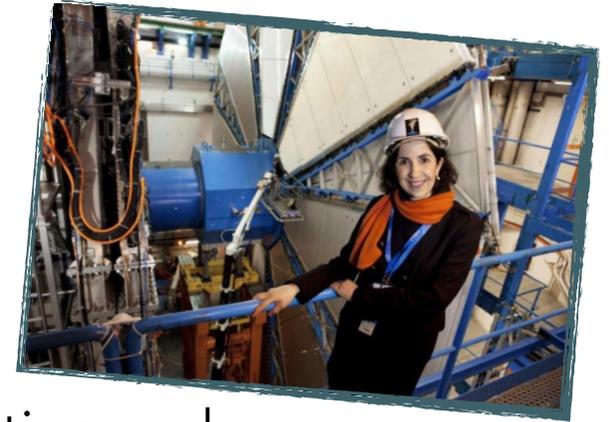


DETECTORS APPLICATIONS



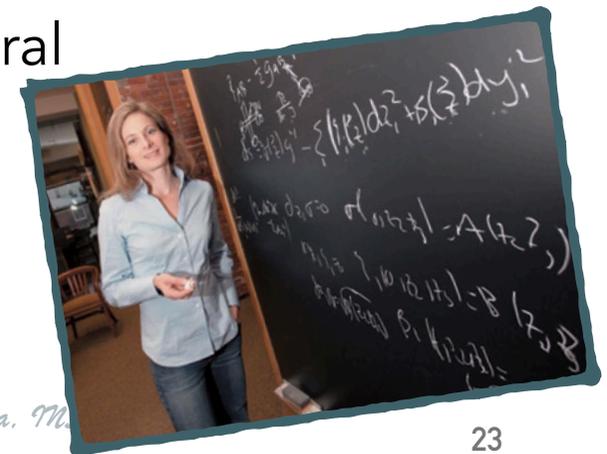
THE *PHYSICIST* JOB

Observing the behavior and properties of matter:
how it moves, its behavior through space and time...



Two main disciplines:

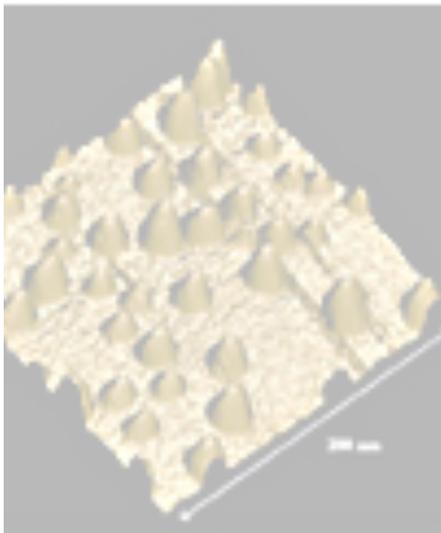
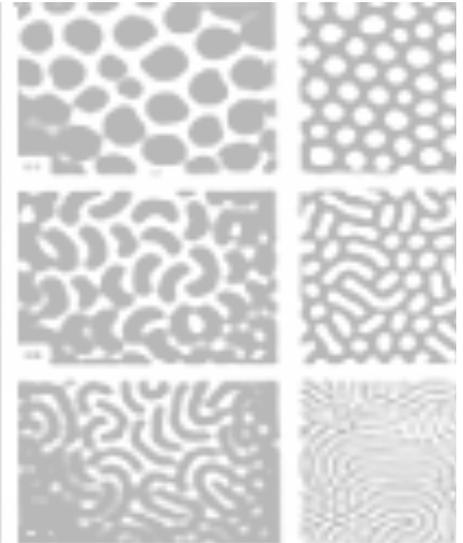
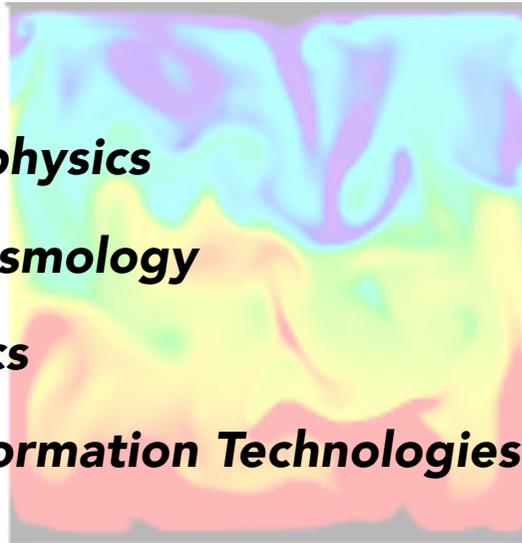
- 1) **Experimental Physics**, concerned with the observation and study of physical phenomena and conducting experiments;
- 2) **Theoretical Physics**, which uses mathematical models and simulations to understand, explain, and predict natural phenomena.



RESEARCH FIELDS



- **Particle physics**
- **Condensed matter physics**
- **Astrophysics and cosmology**
- **Mathematical physics**
- **Cybernetics and Information Technologies**



- **Biophysics**
- **Medical physics**
- **Geophysics**
- **Physics of cultural heritage**
- **History of physics**
- **Physics education**



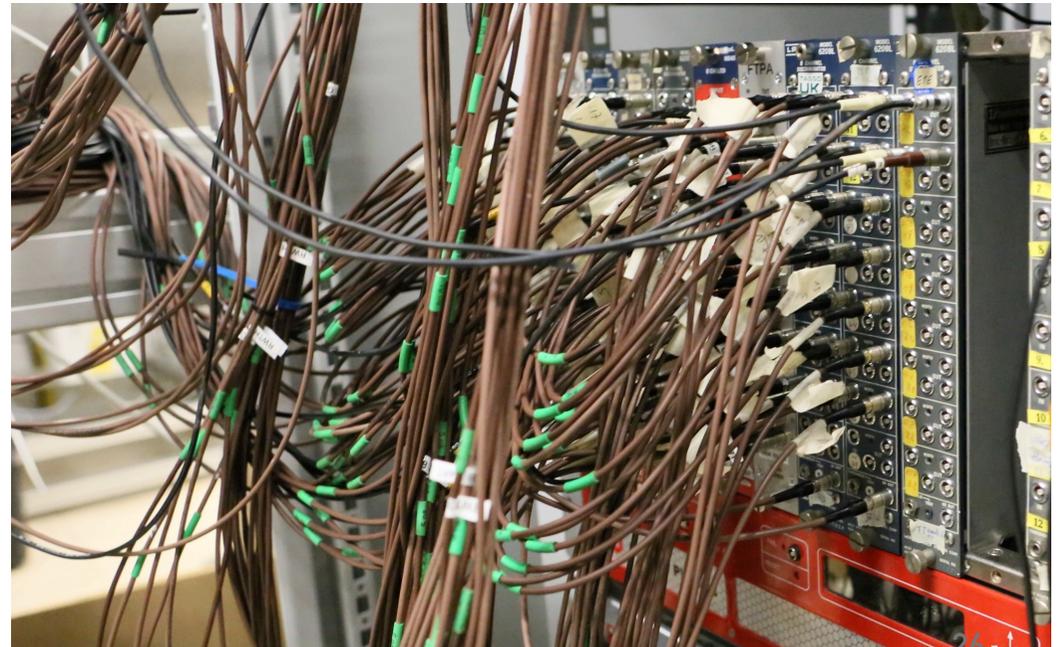
A TYPICAL DAY

Coding, coding, coding

```
    ...train(InputArrayOfArrays _in_src, InputArray _in_labels, bool preserveData) {
if(_in_src.kind() != InputArray::STD_VECTOR_MAT || _in_src.kind() != InputArray::STD_VECTOR_VECTOR) {
    string error_message = "The images are expected as InputArray::STD_VECTOR_MAT or InputArray::STD_VECTOR_VECTOR";
    CV_Error(CV_StsBadArg, error_message);
}
if(_in_src.total() == 0) {
    string error_message = format("Empty training data was given. You'll need more than one sample to train a model");
    CV_Error(CV_StsUnsupportedFormat, error_message);
} else if(_in_labels.getMat().type() != CV_32SC1) {
    string error_message = format("Labels must be given as integer (CV_32SC1). Expected %d, but got %d.", CV_32SC1, _in_labels.getMat().type());
    CV_Error(CV_StsUnsupportedFormat, error_message);
}
// get the vector of matrices
vector<Mat> src;
_in_src.getMatVector(src);
// get the label matrix
Mat labels = _in_labels.getMat();
// check if data is well-aligned
if(labels.total() != src.size()) {
    string error_message = format("The number of samples (src) must equal the number of labels (labels). Got %d samples and %d labels.", src.size(), labels.total());
    CV_Error(CV_StsBadArg, error_message);
}
// ...
}
```

A TYPICAL DAY

- *Laboratory test*
- *Electronics*
- ...



A TYPICAL DAY

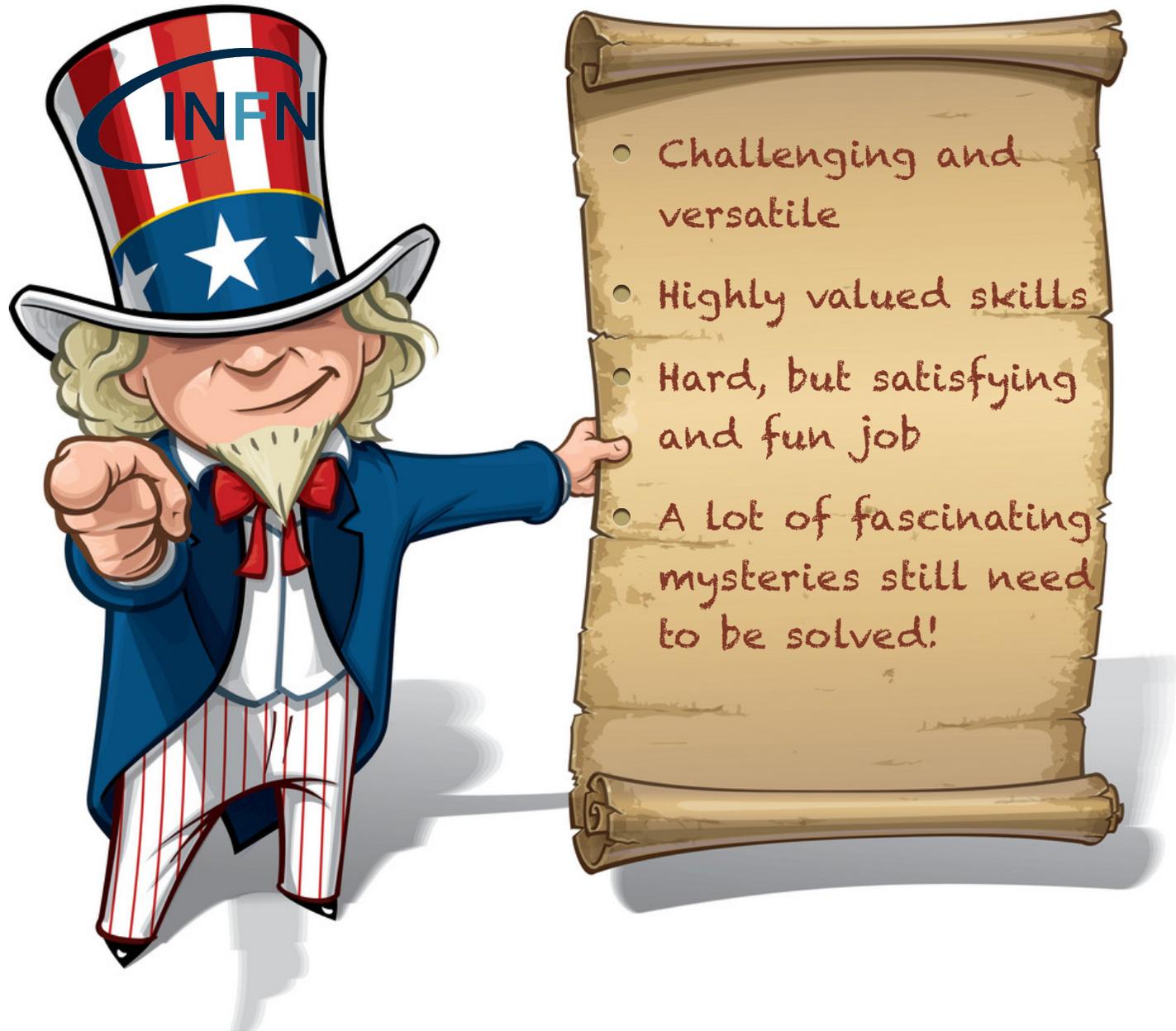
- Presentations, emails, meetings, discussions
- Study, popular events, travel



OUTSIDE RESEARCH WORLD



IS BECOMING A PHYSICIST DIFFICULT?



Thanks for listening!

Raffaella Donghia
LNF-INFN

