A week in the H→ττ group

"Una settimana nel gruppo H→ττ"

High school students in a research center

Nadia Padovani
Gabriele Pomponi

Tutor:
Andrea Cardini

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Istituto Statale di Istruzione Secondaria Superiore
"Federigo Enriques"

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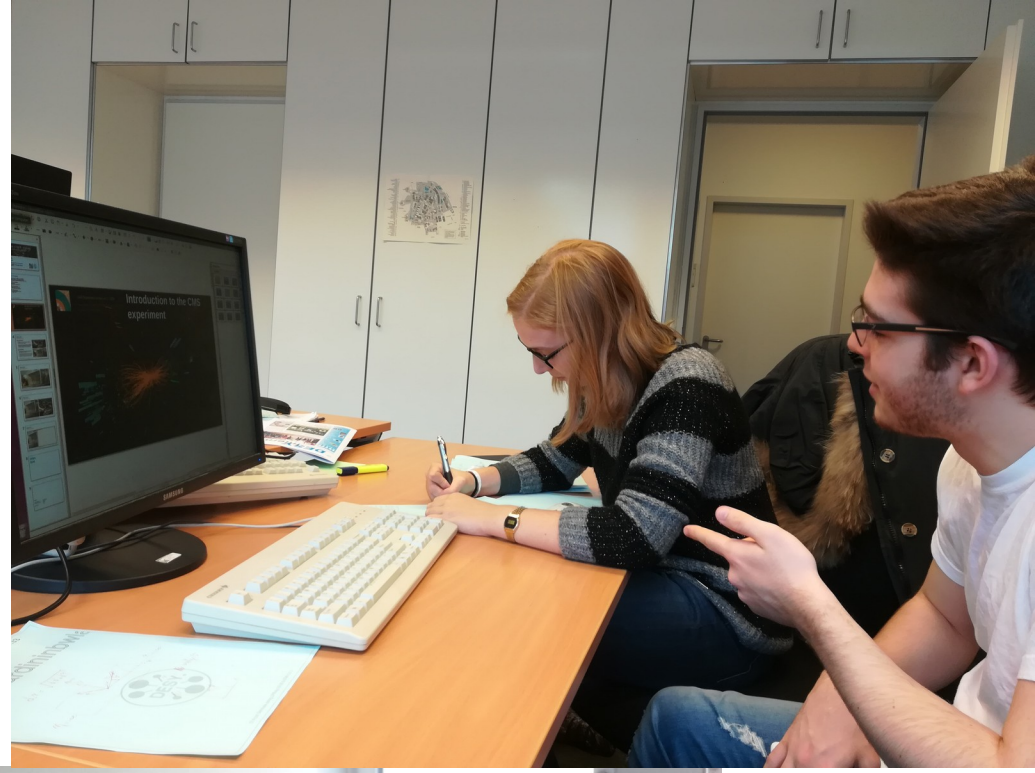
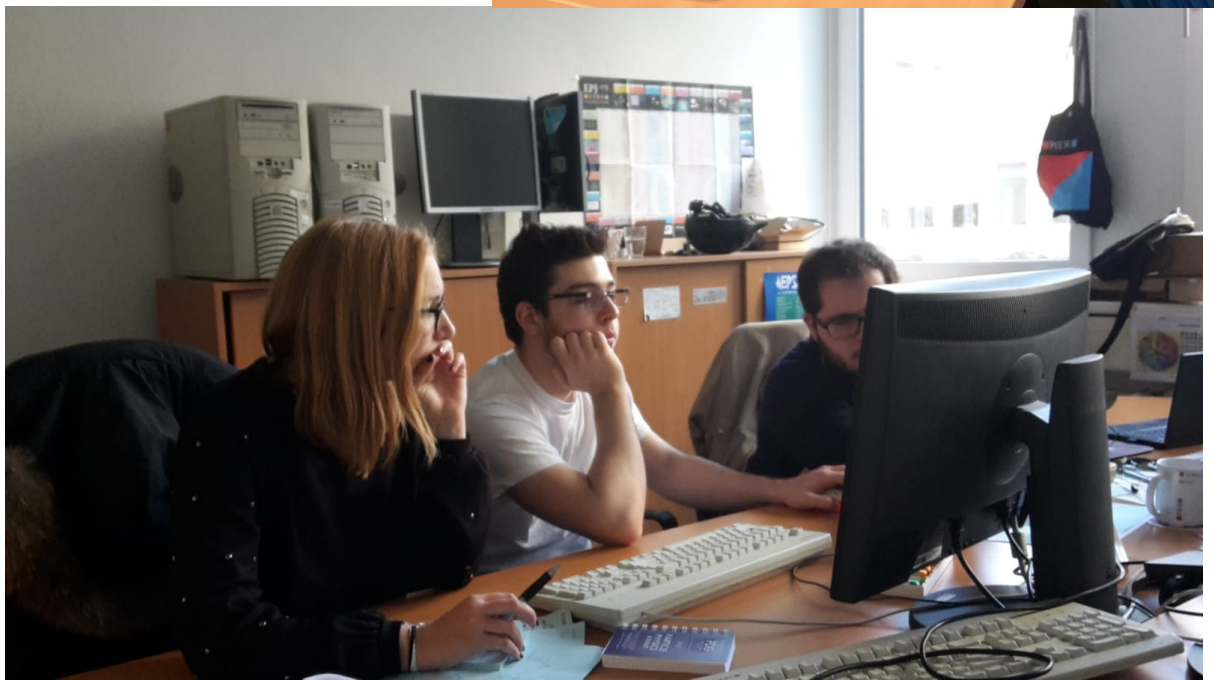
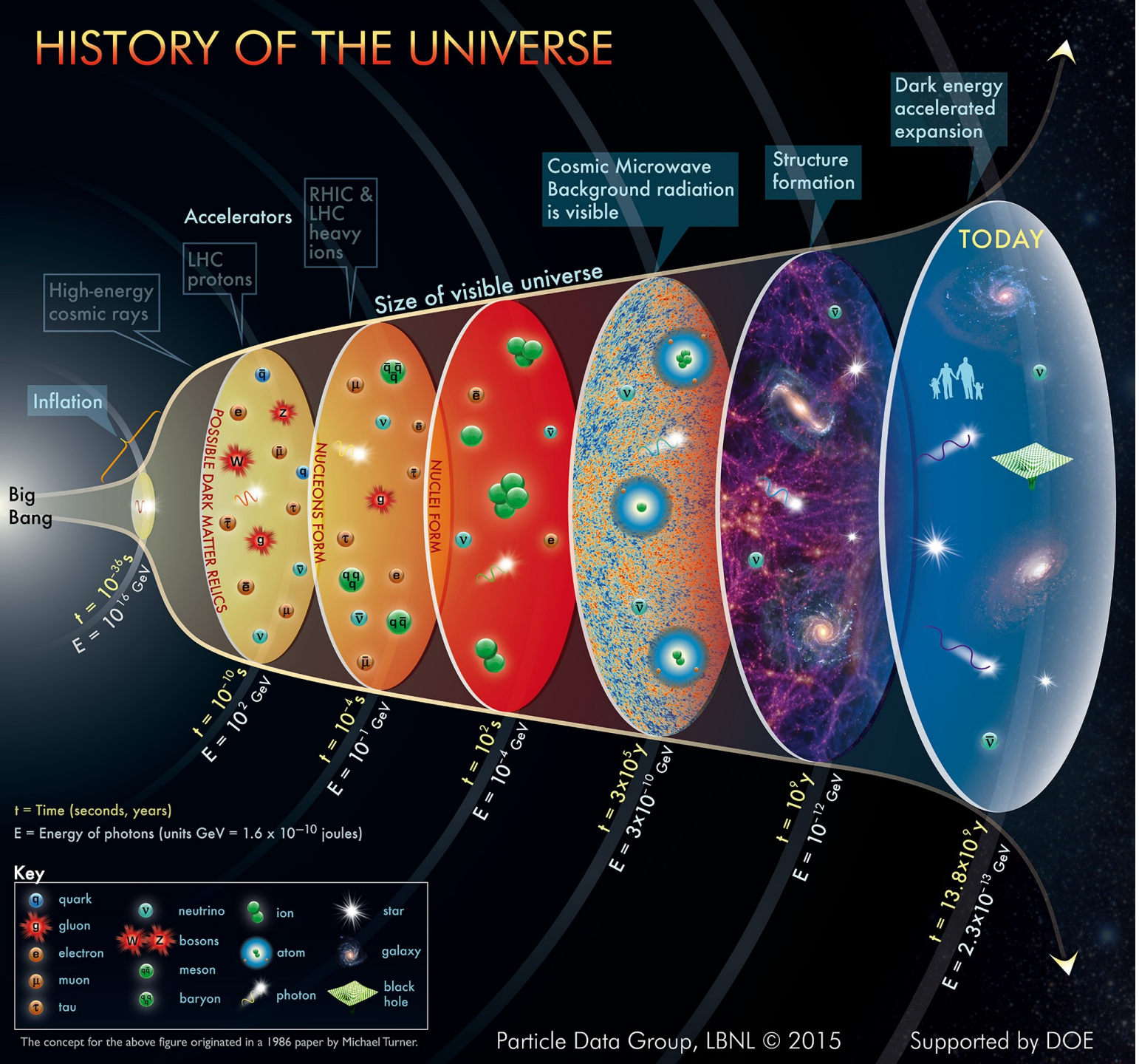






Introduction to HEP

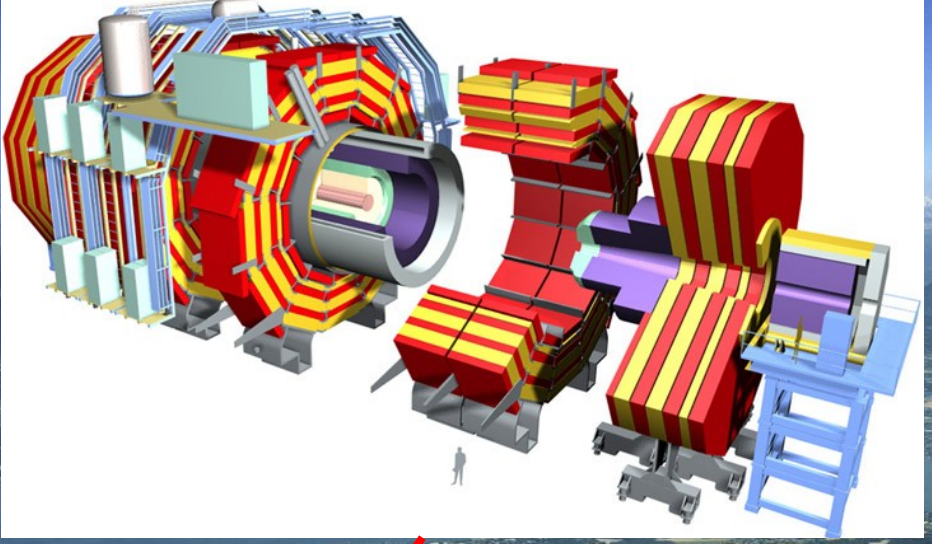
The standard model

Elementary particles in the SM are:

- 6 quarks
- 6 leptons (3 charged and 3 neutral)
- 4 bosons which mediate the strong and electroweak interactions
- 1 scalar boson: the Higgs boson

	1st	2nd	3rd		
Quarks	u up	c charm	t top	γ photon	H Higgs Boson
	d down	s strange	b beauty	$W^{\pm}$ W boson	
Leptons	e electron	μ muon	τ tau	Z^0 Z boson	Gauge Bosons
	ν_e neutrino electron	ν_μ neutrino muon	ν_τ neutrino tau	g gluon	

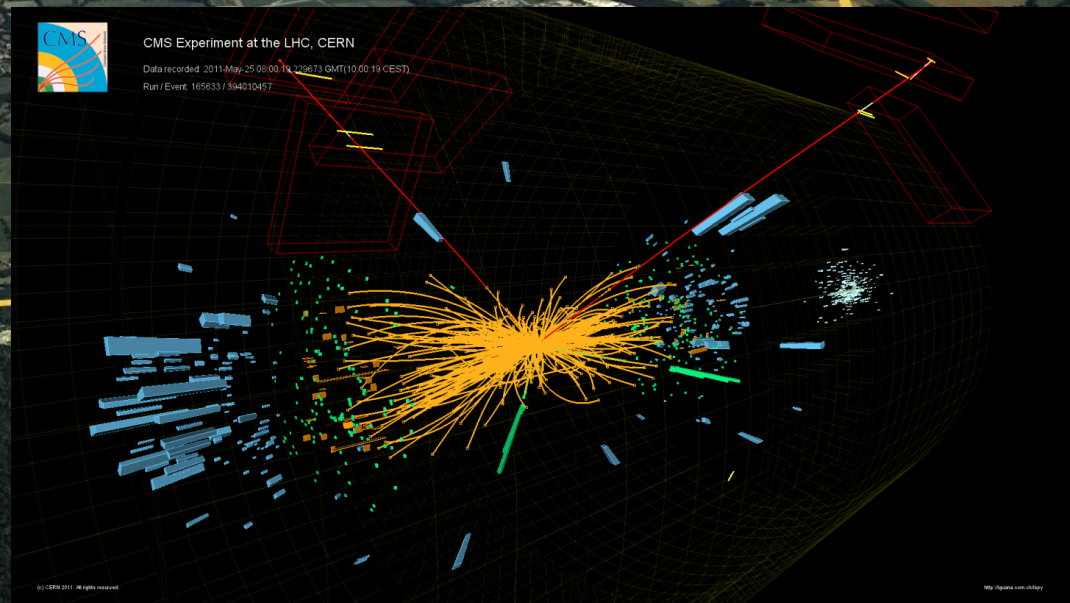
Compact Muon Solenoid



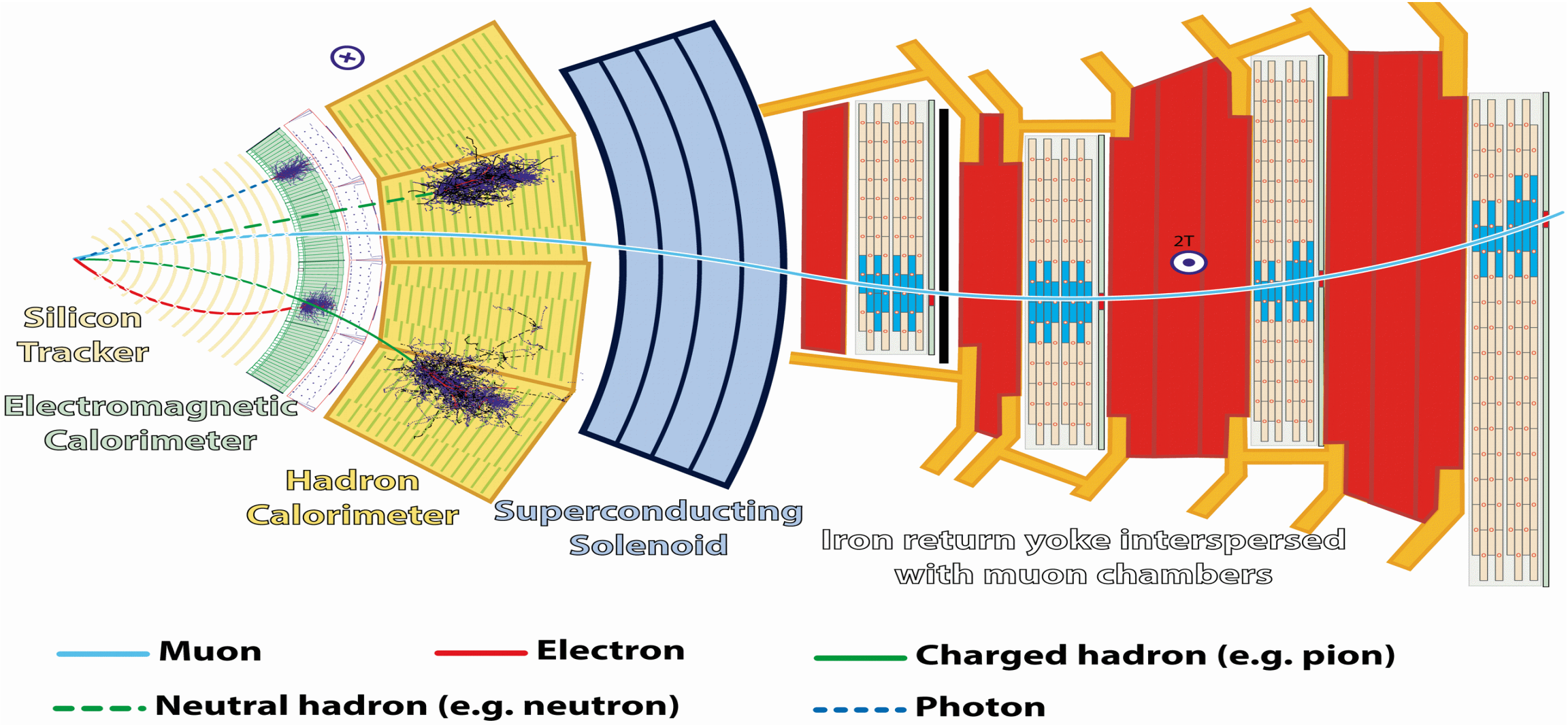
Total weight: 14,000 ton
Overall diameter: 15.0m
Overall length: 28.7m

Optimized for muon identification

Solenoidal magnetic field with intensity 3.8T

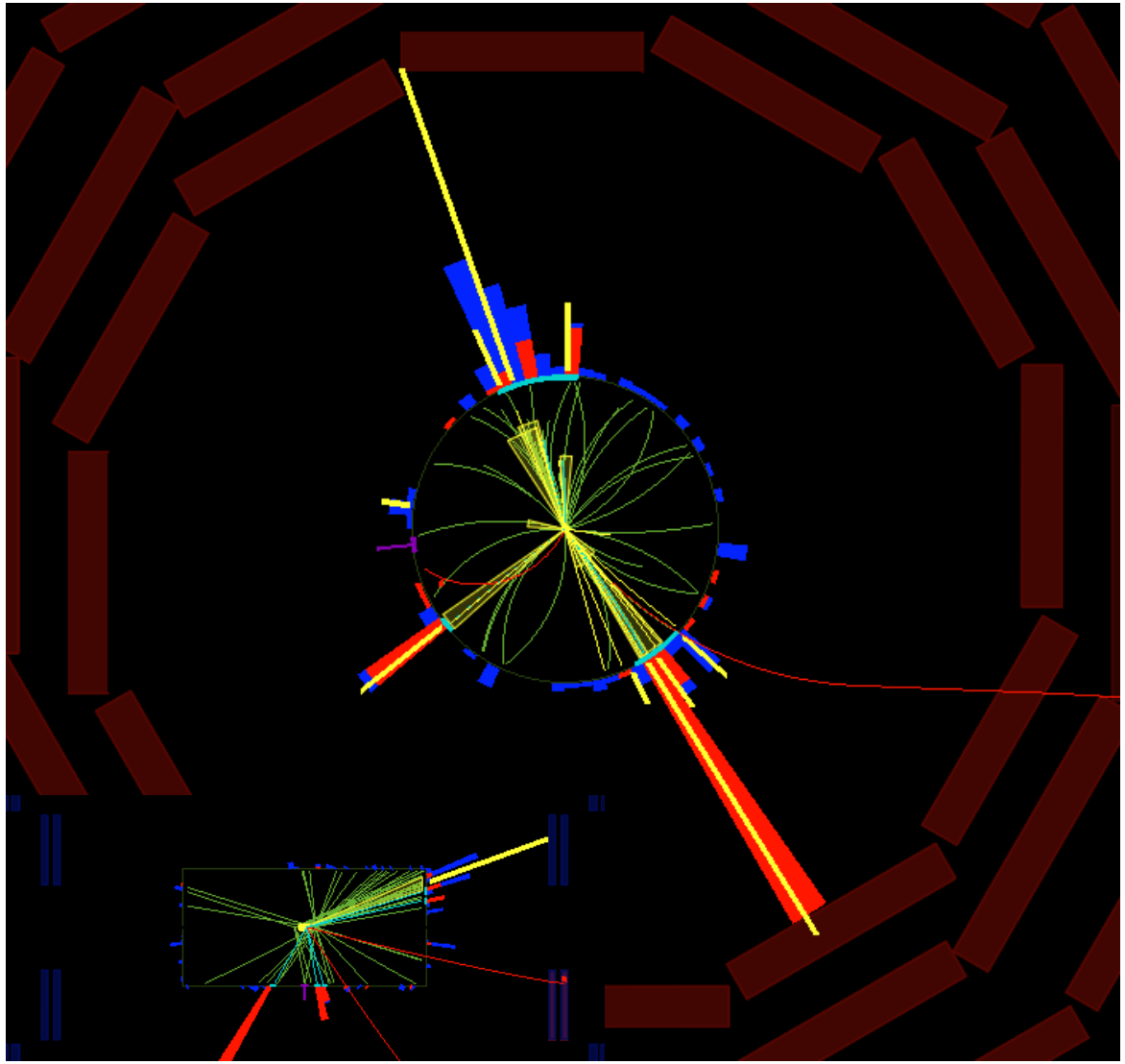


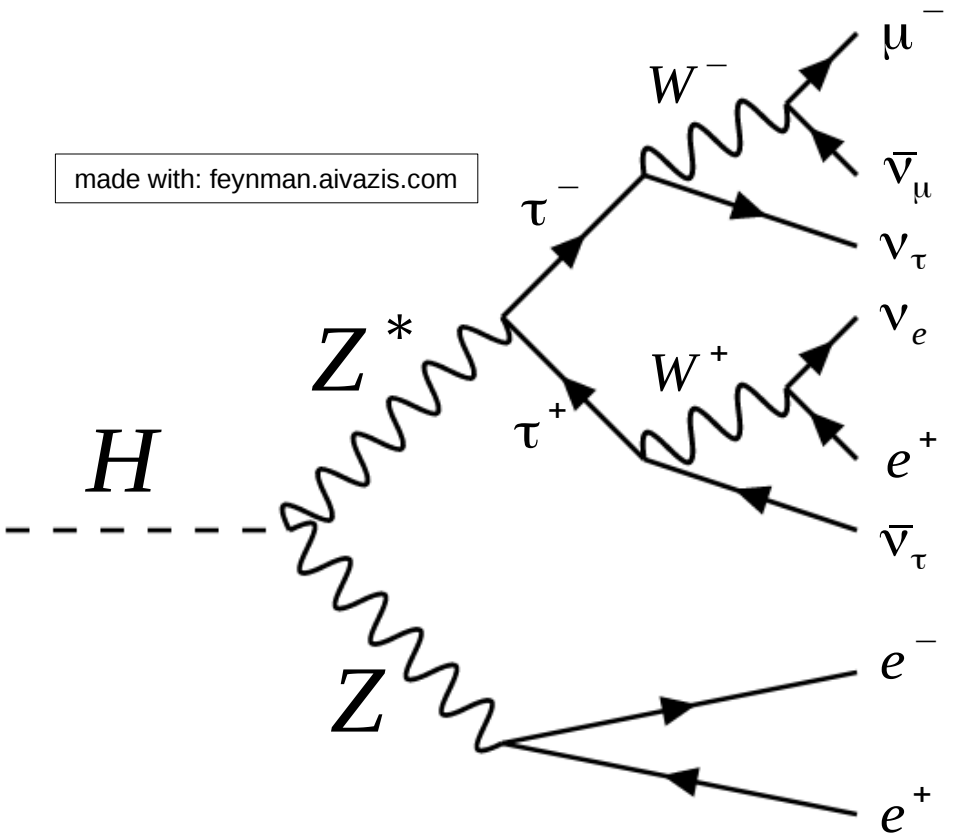
Particles in a detector



A closer look to a peculiar event

H→ZZ* → 3 e, 1 μ and neutrinos





While looking at the events we found one where:

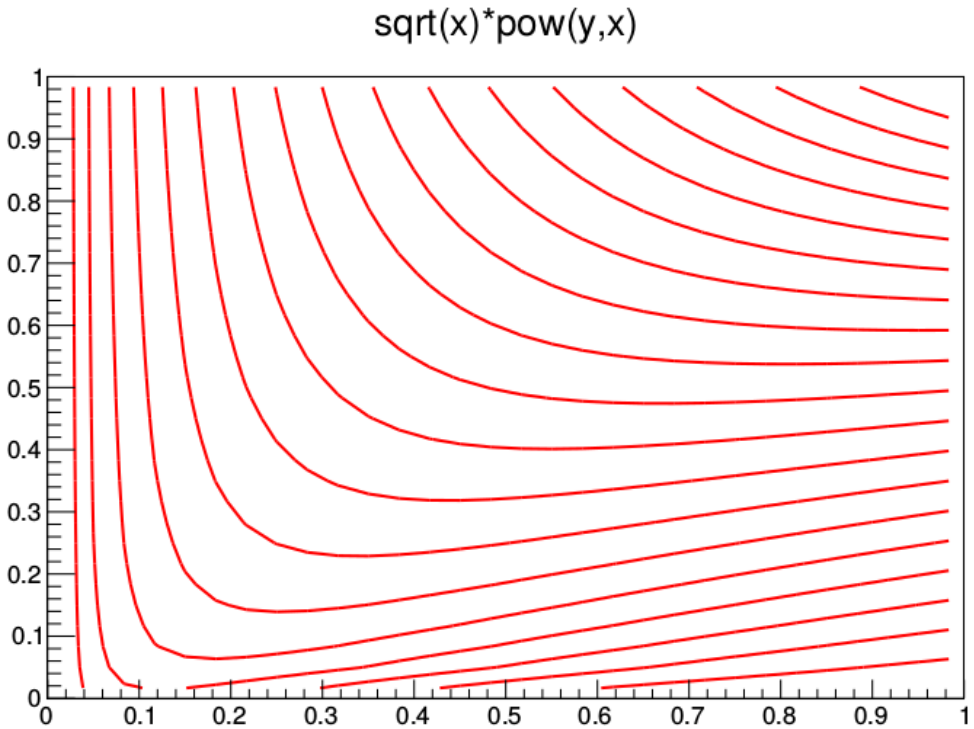
- Electron positron pair with m=89.350 GeV
- The invariant mass of the system made by 3 electrons, a muon and the met was 127.315 GeV

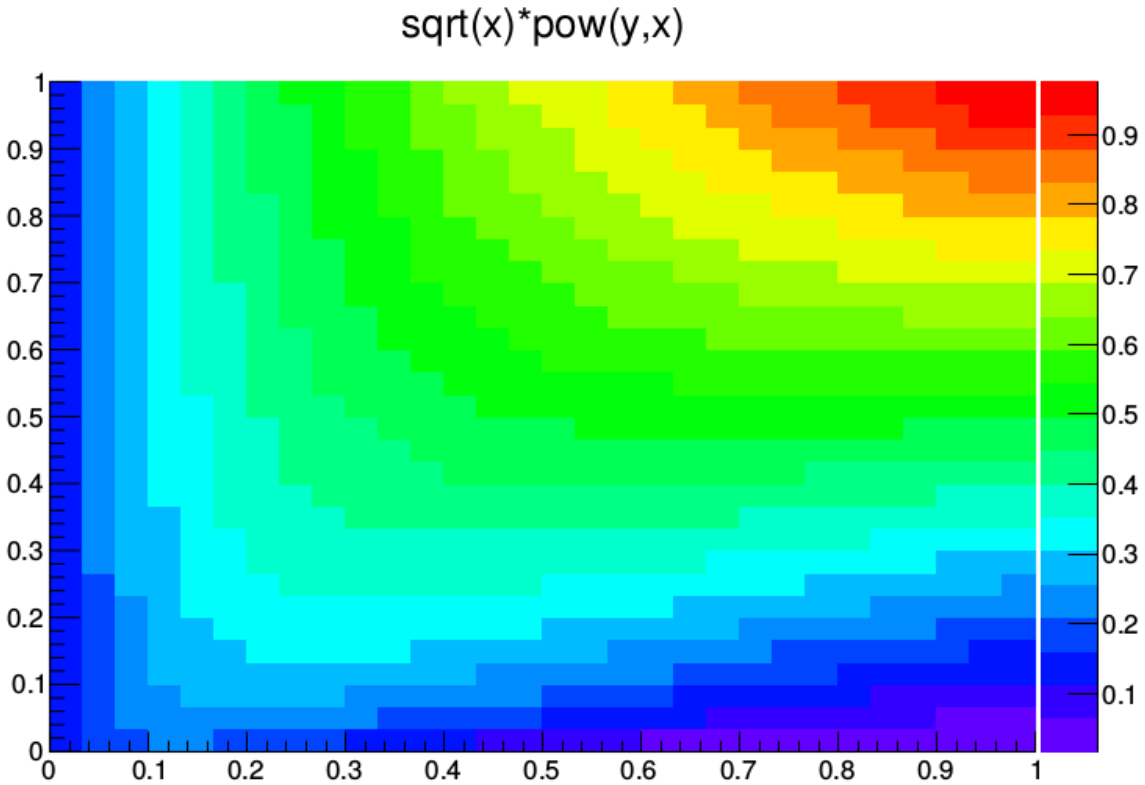
⟹ this could be a Higgs boson decaying in two Z of which one decays into e^+ e^- and the other in τ^+ τ^-

Introduction to ROOT

Some of the things we learnt:

- Shell commands, like cd, ls, mkdir, cp, pwd ...
- Some basic C++, like using cout, putting “;” at the end of lines, making a function, etc. ;



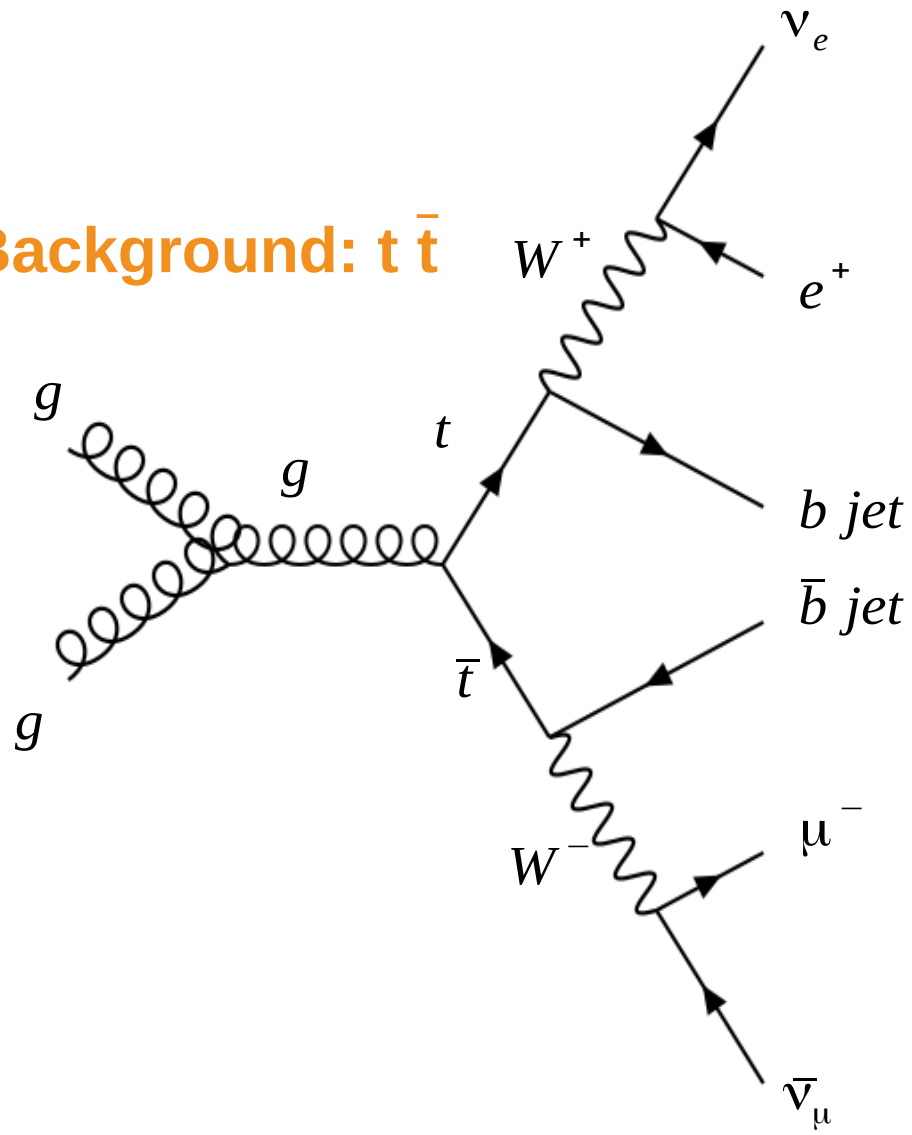


Some of the things we did with ROOT:

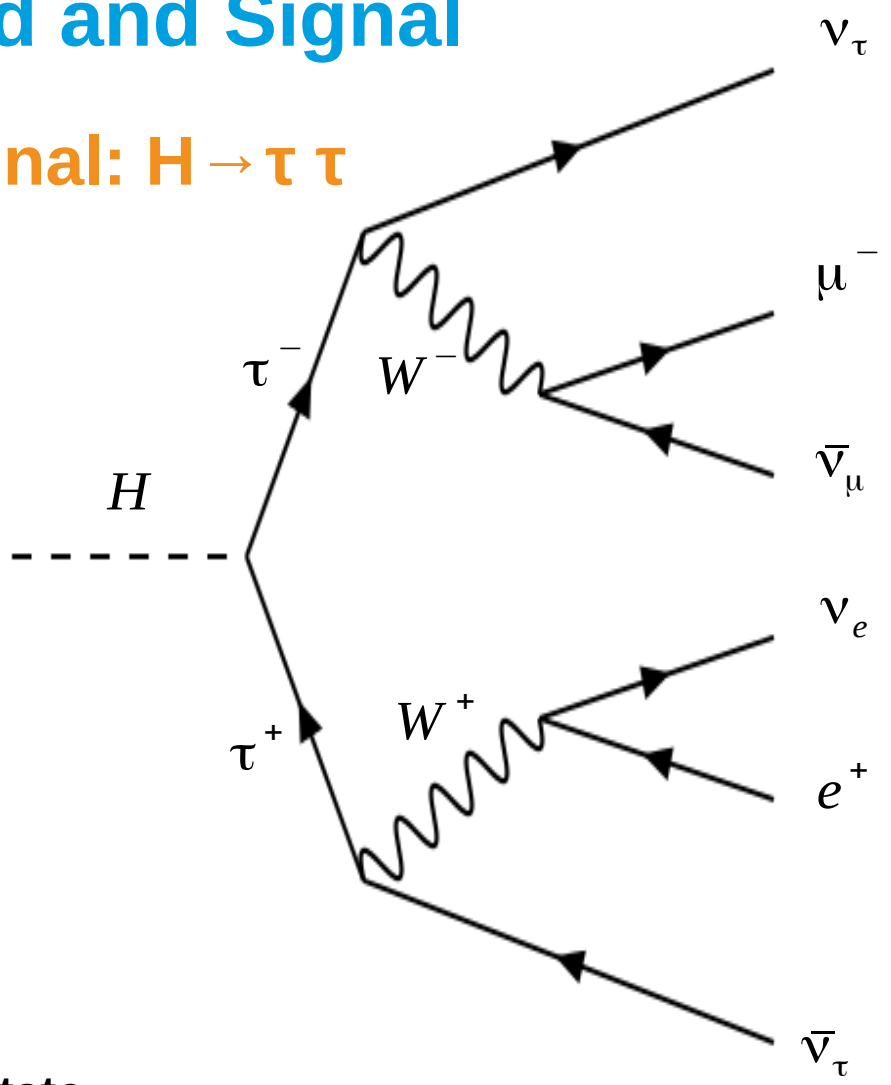
- Define functions
- Plot quirky functions in both 1d and 2d
- Plot histograms
- Use drawing options

Comparison between Background and Signal

Background: t $\bar{t}$



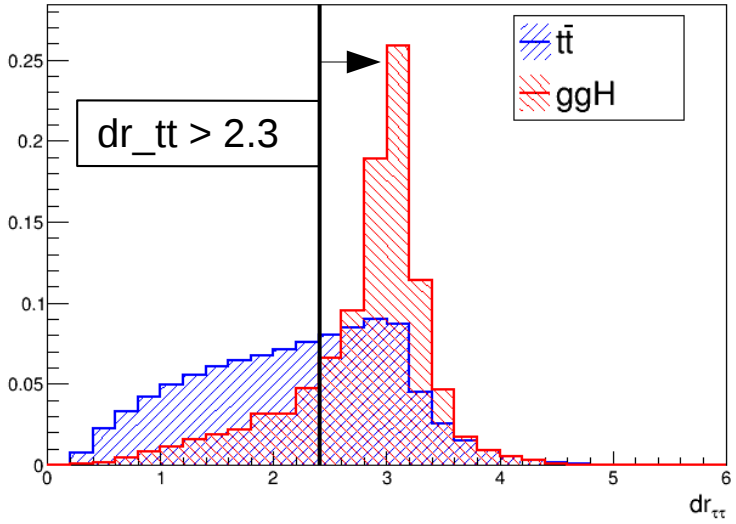
Signal: H → τ τ

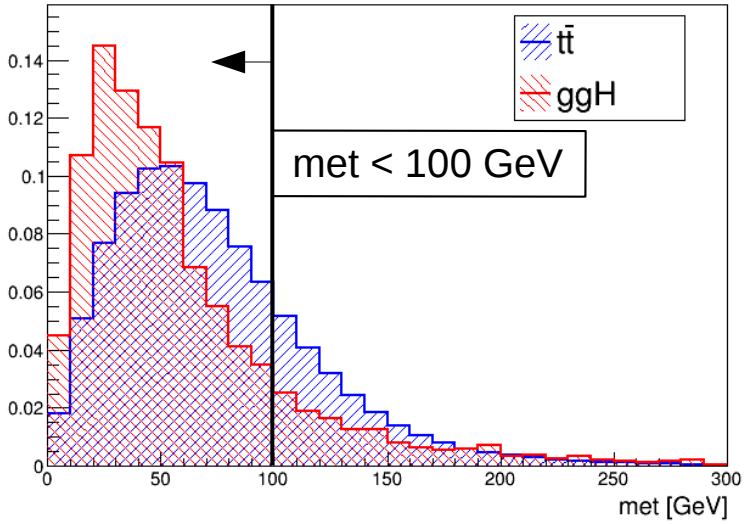


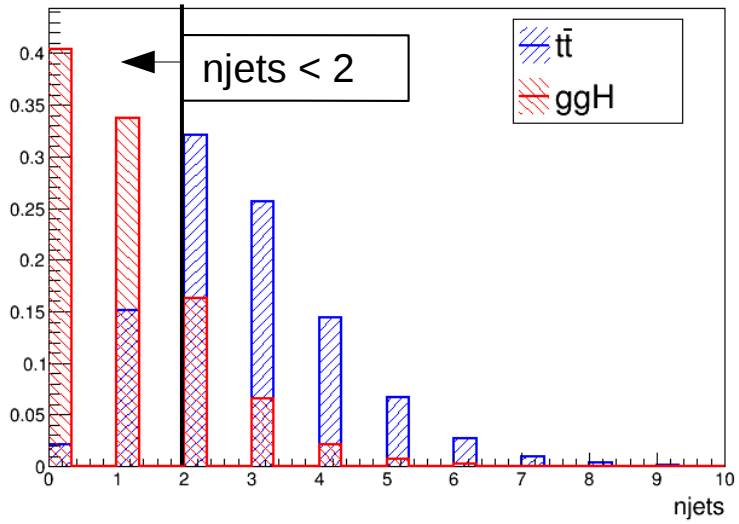
Final state:

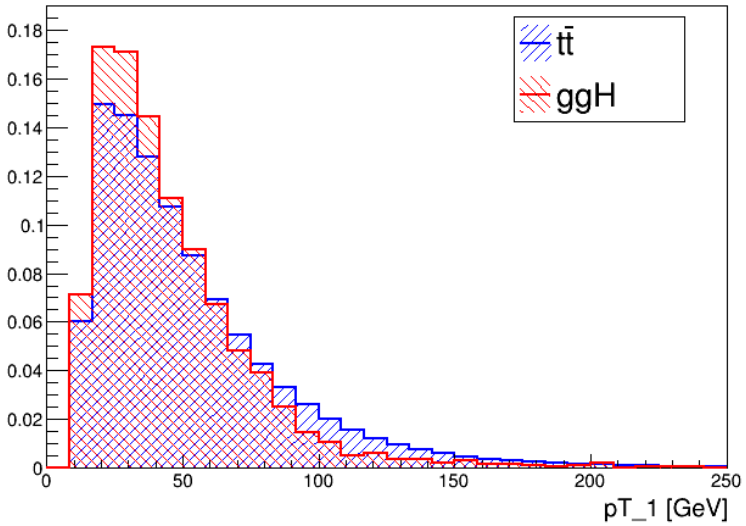
- One electron and one muon with opposite signs

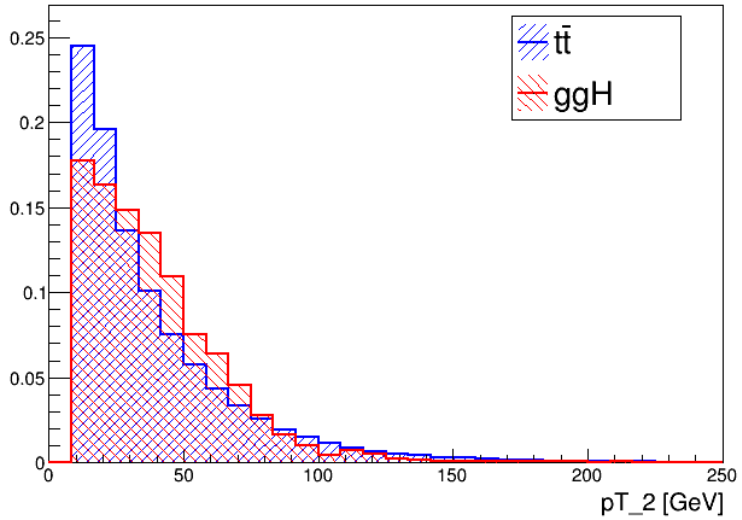
Comparison between Background and Signal

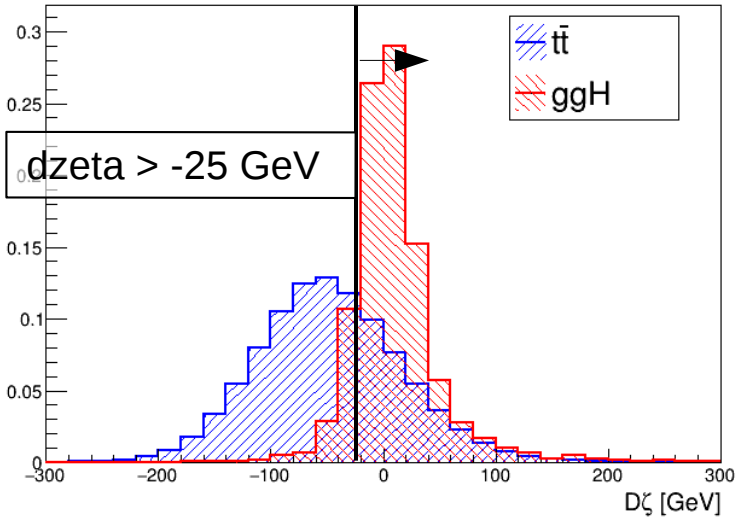




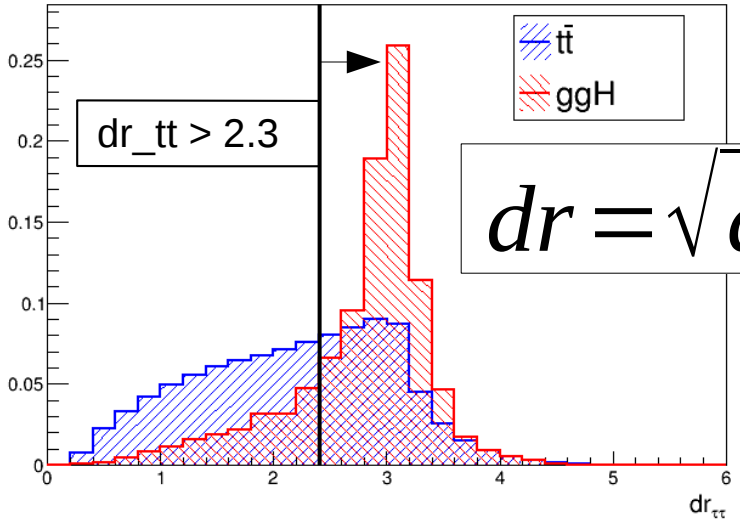




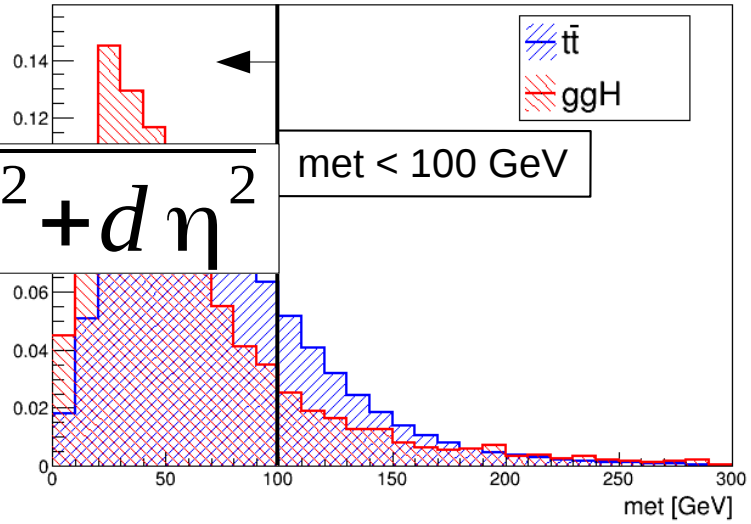


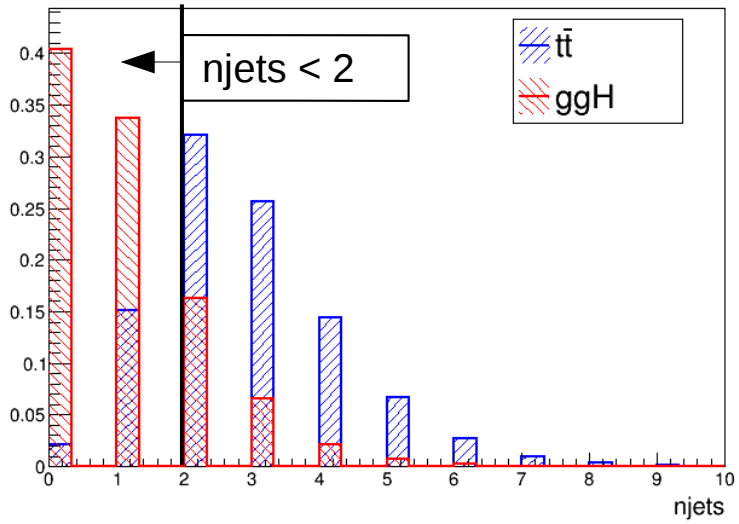


Comparison between Background and Signal

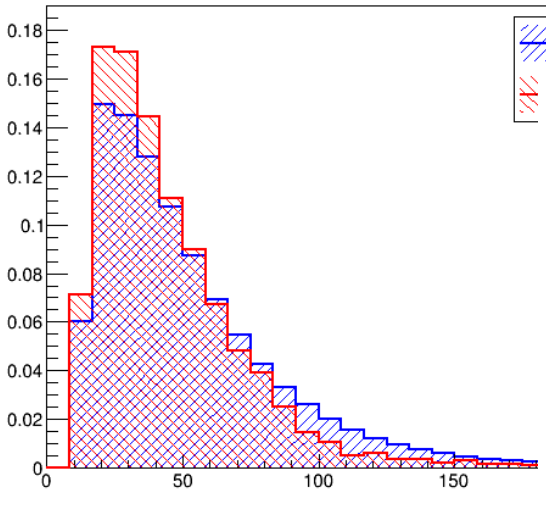


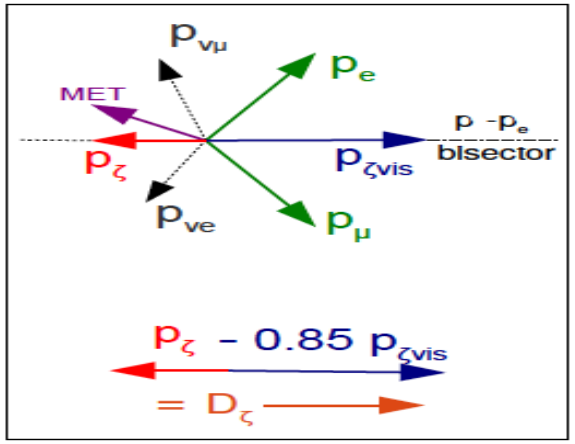
$$dr = \sqrt{d\phi^2 + d\eta^2}$$

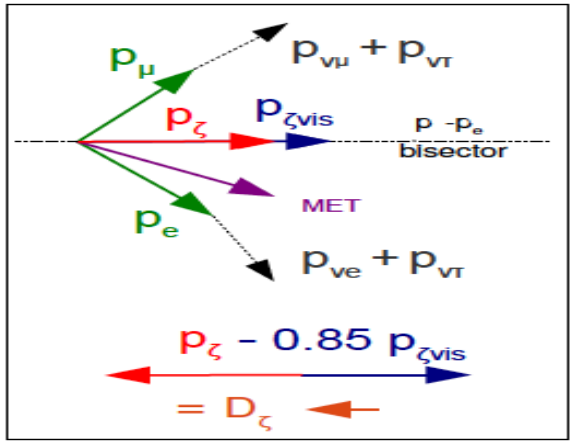


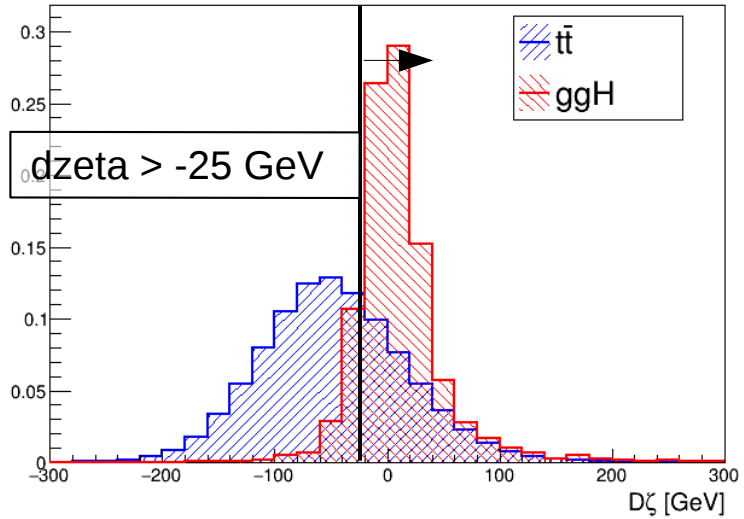


$$D\zeta = \overrightarrow{E\!\!\!/_T} \cdot \hat{\zeta} - \alpha\left(\overrightarrow{P_{T,e}} + \overrightarrow{P_{T,\mu}}\right) \cdot \hat{\zeta}$$

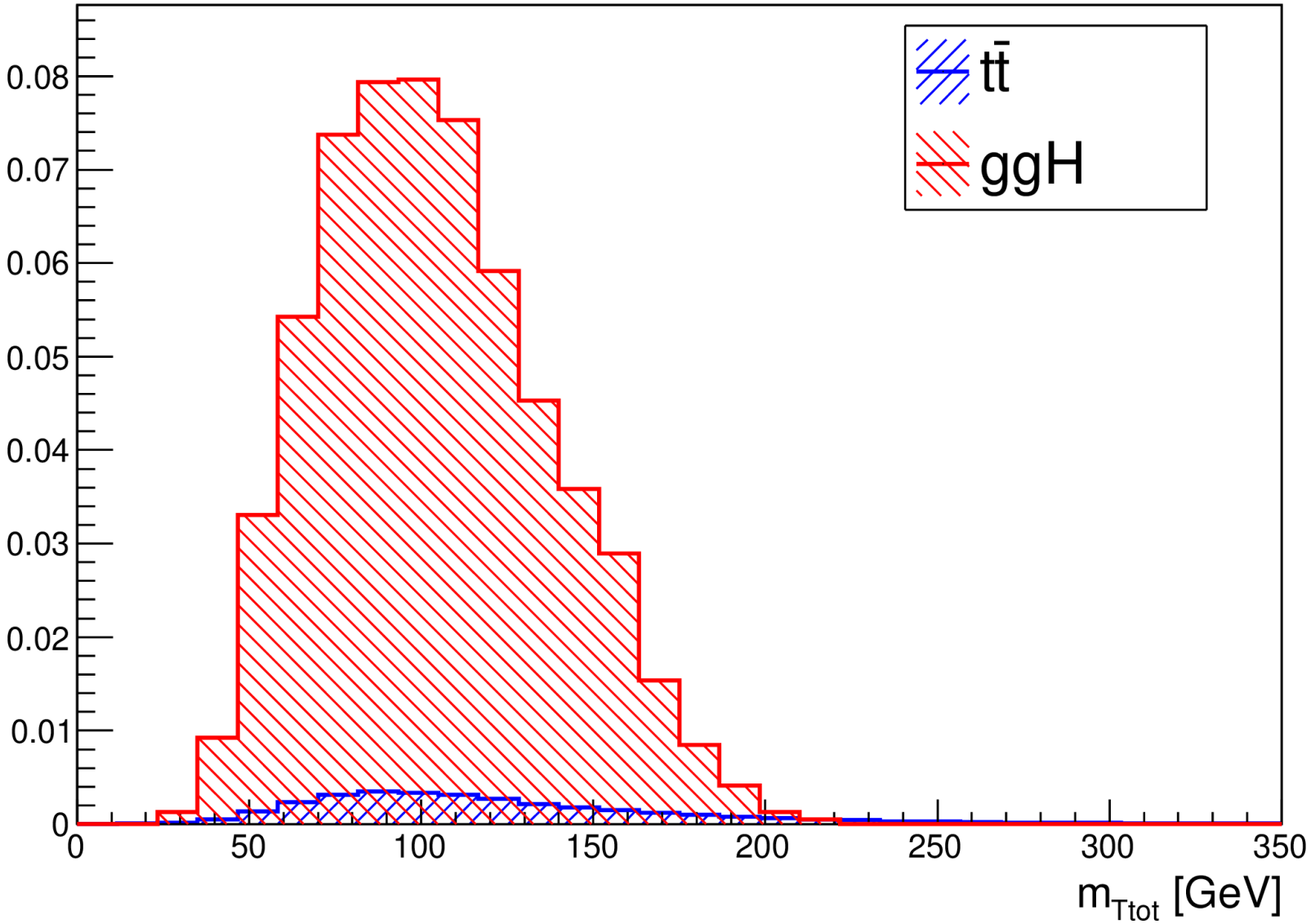








Improving event selection to identify the Higgs



Through cuts made using the variables in the previous slide, we were able to cut a lot of noise while keeping most of the signal

$$\varepsilon_S = \frac{n_S}{N_S} \sim 60\,\%$$

$$R_{BKG} = 1 - \frac{n_{BKG}}{N_{BKG}} \sim 97\,\%$$

$$\sigma = \frac{n_S}{\sqrt{n_{BKG}}} \sim 5.28$$

Conclusions

Thanks for the attention.

Grazie per l’attenzione