

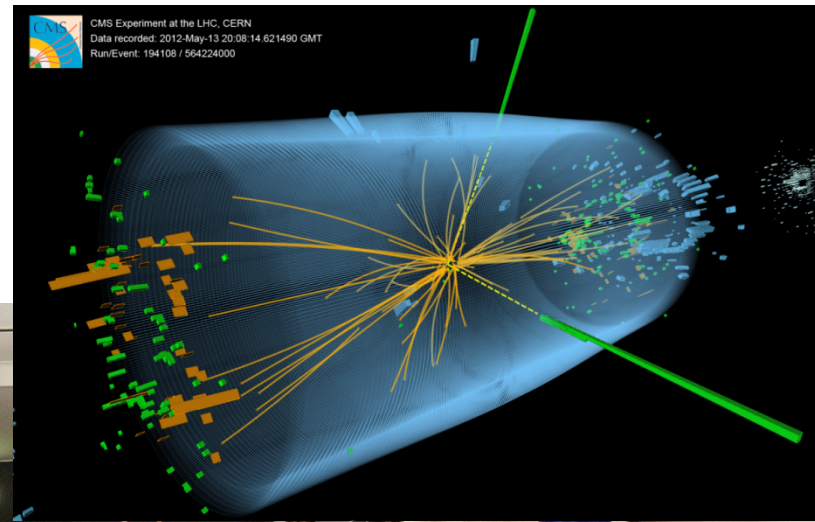
# LIP 2022



Mário Pimenta  
Coimbra, Julho 2022

# Higgs boson discovery

## 4 July 2012, CERN





# The SM (Particle Physics)

Three Generations  
of Matter (Fermions) spin  $\frac{1}{2}$

	I	II	III
mass →	2.4 MeV	1.27 GeV	173.2 GeV
charge →	$\frac{2}{3}$	$\frac{2}{3}$	$\frac{2}{3}$
name →	<b>u</b> up	<b>c</b> charm	<b>t</b> top
	Left Right	Left Right	Left Right
Quarks	4.8 MeV	104 MeV	4.2 GeV
	$-\frac{1}{3}$	$-\frac{1}{3}$	$-\frac{1}{3}$
	<b>d</b> down	<b>s</b> strange	<b>b</b> bottom
	Left Right	Left Right	Left Right
	$0$ <b><math>\nu_e</math></b> electron neutrino	$0$ <b><math>\nu_\mu</math></b> muon neutrino	$0$ <b><math>\nu_\tau</math></b> tau neutrino
Leptons	0.511 MeV	105.7 MeV	1.777 GeV
	-1	-1	-1
	<b>e</b> electron	<b><math>\mu</math></b> muon	<b><math>\tau</math></b> tau
	Left Right	Left Right	Left Right

Bosons (Forces) spin 1	0	<b>g</b> gluon
	0	<b><math>\gamma</math></b> photon
	91.2 GeV	$0$ <b>Z</b> weak force
	80.4 GeV	$\pm 1$ <b>W<sup>±</sup></b> weak force

126 GeV	<b>H</b> Higgs boson
0	
0	
0	
spin 0	

# SM (Particle Physics) extensively tested

10 years of LHC

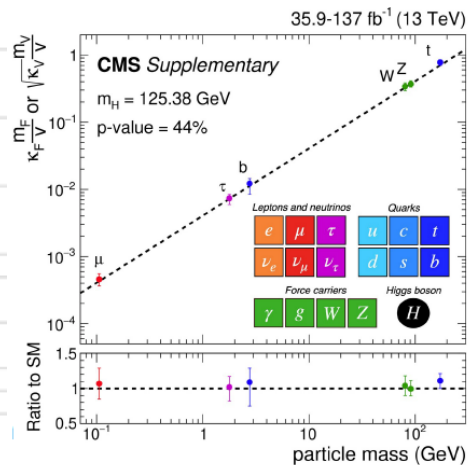
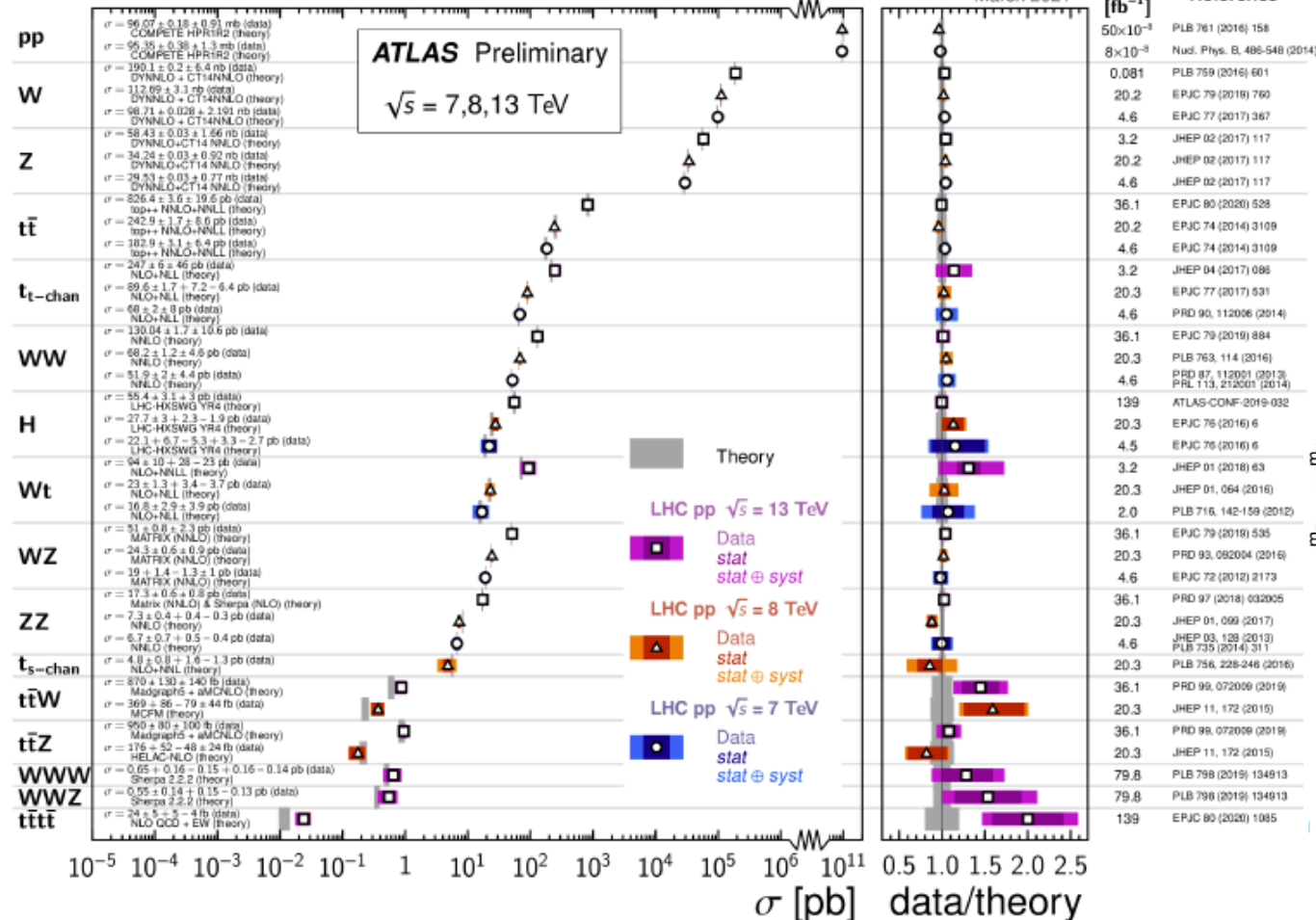
## Standard Model Total Production Cross Section Measurements

Status:

March 2021

$\int \mathcal{L} dt$   
[fb<sup>-1</sup>]

Reference



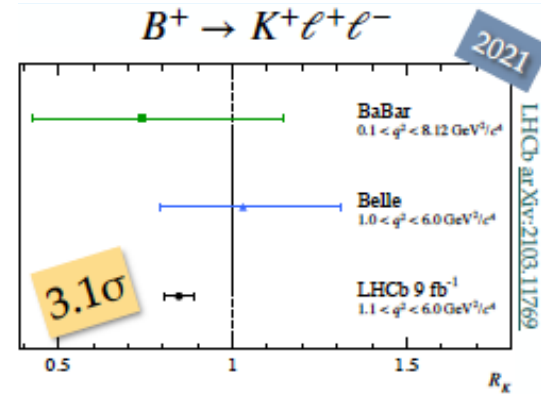
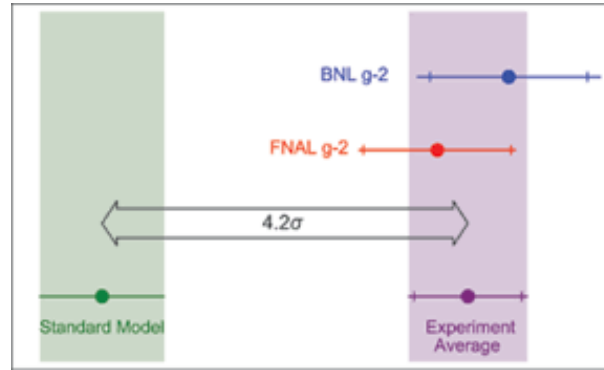
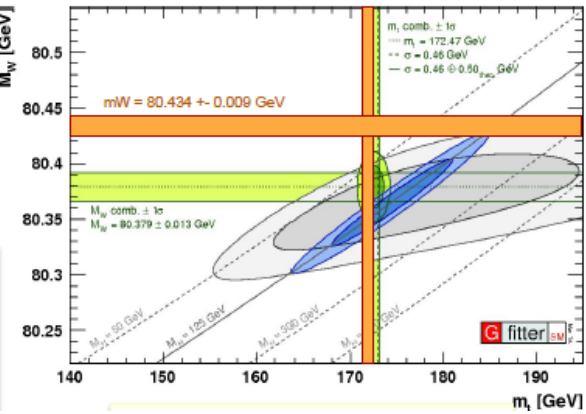


## But some “Tensions” and Discoveries

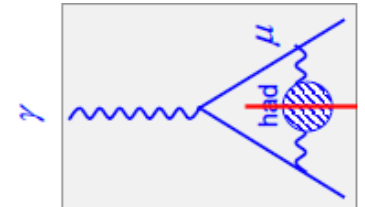
$$M_w \sim 7 \sigma$$

**g-2**  $\sim 4\sigma$

## Heavy decays $\sim 3\sigma$



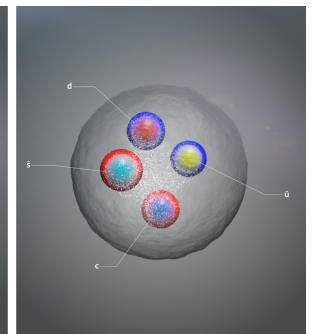
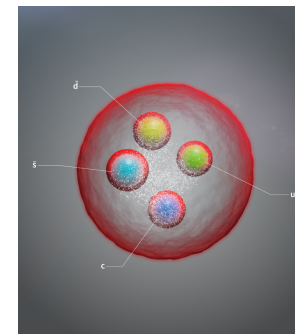
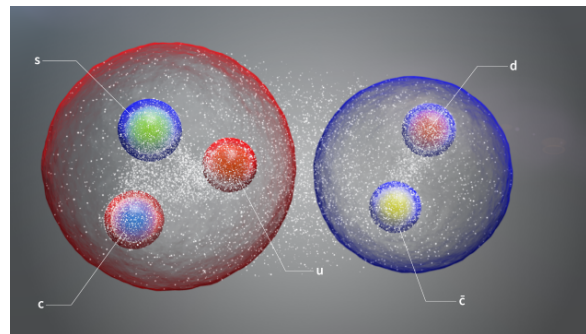
But be aware of the experimental and theoretical systematics, namely of the Hadronic Vacuum Polarization:



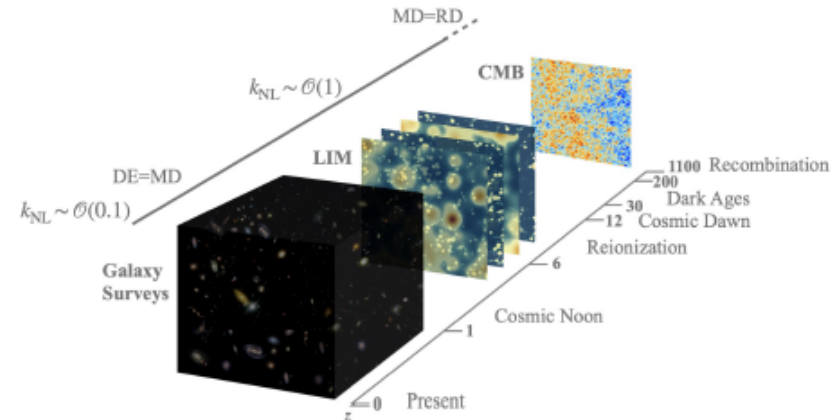
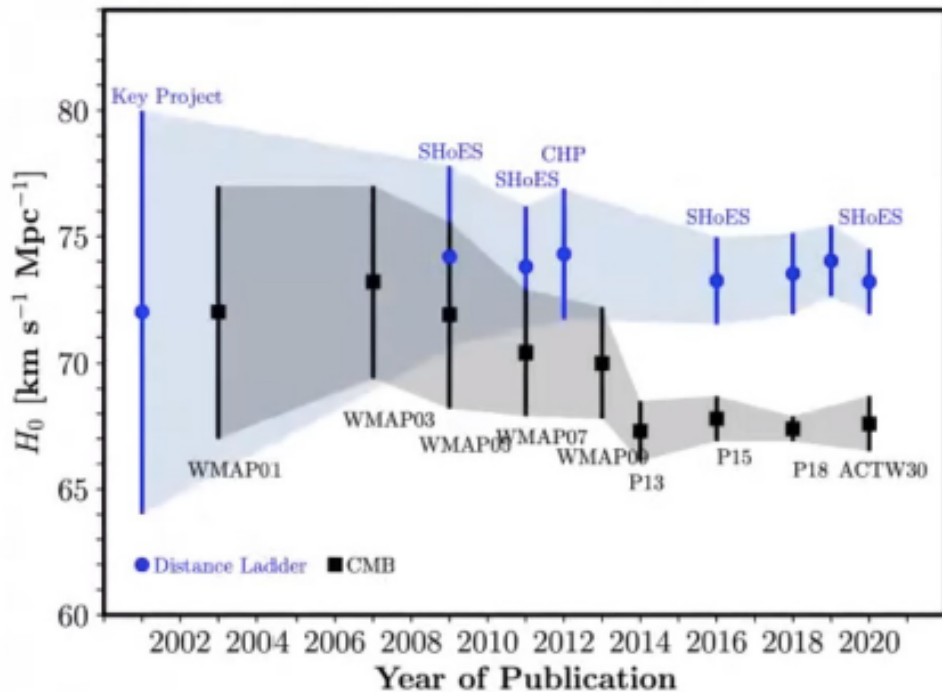
# Tetra and Penta quarks

e.g. LHCb - this week announcement ...

# A zoo of Exotic hadrons



# “Tensions” also in the Skies ...



Euclid mission (ESA)  
launch planned for 2023.

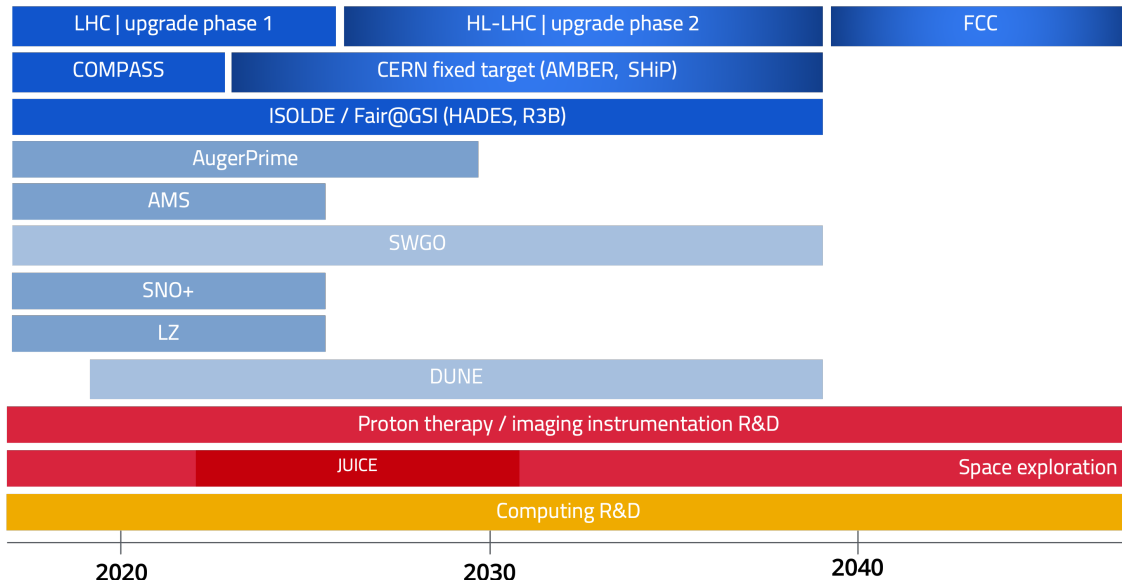
The crisis of the Hubble constant: CMB  
vs Expansion rate measurements.

Problems with the measurements or New  
Physics?



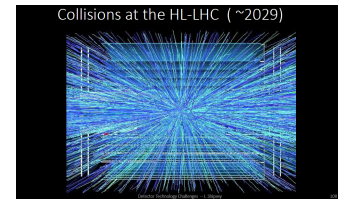
# Frontiers of knowledge: many open questions

- What is the origin of the masses and mixing parameters?
- How quarks and gluons interact to form nuclei?
- Why matter dominates (locally...) over anti-matter?
- What is dark matter made of?
- What is the nature of Dark Energy?
- What is the complexity of the Higgs Field sector?
- How inflation started and stopped?
- How to couple GR and QM?
- What is the origin of the highest energy cosmic rays?

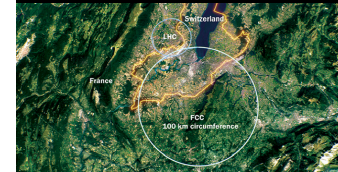


2030-2050

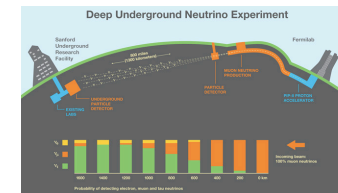
HL-LHC



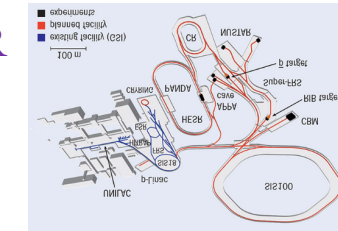
FCC



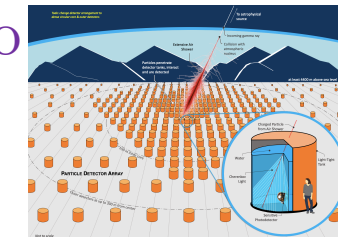
DUNE



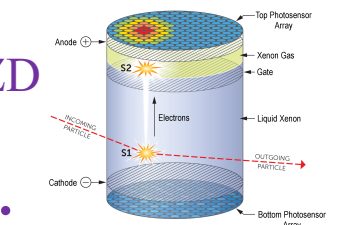
FAIR



SWGO



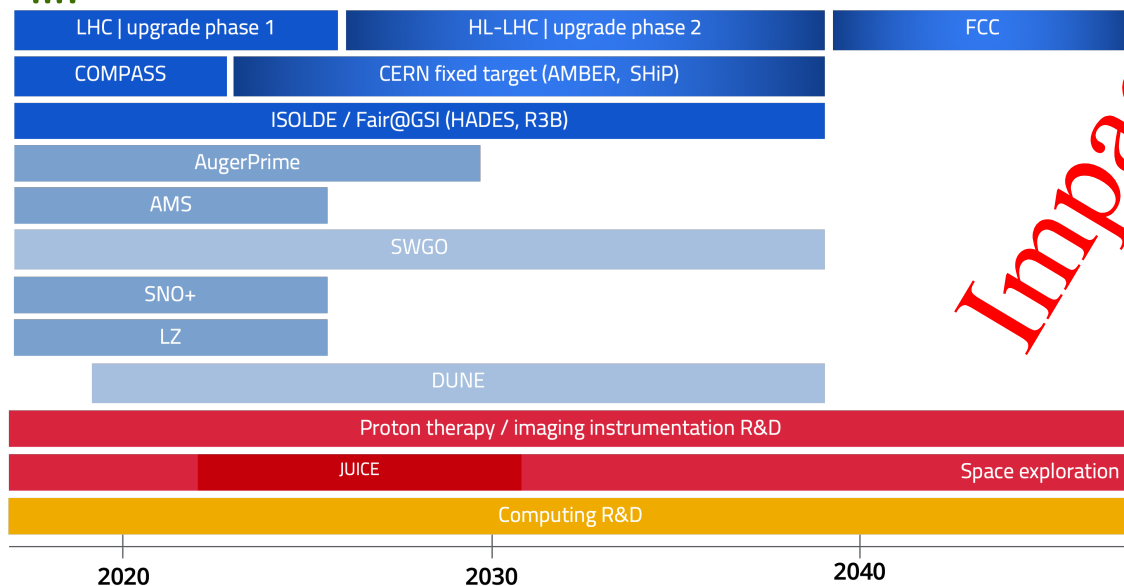
XLZD





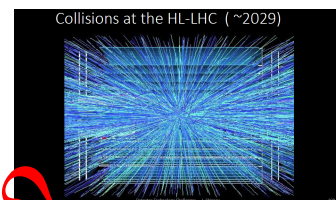
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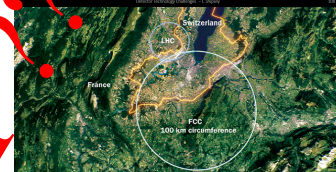


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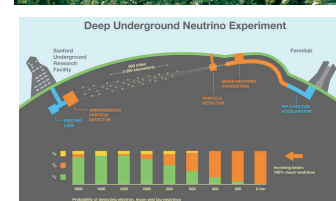
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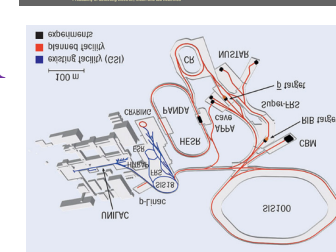
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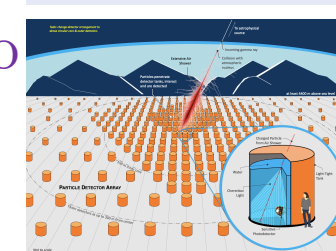
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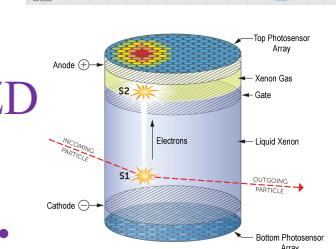
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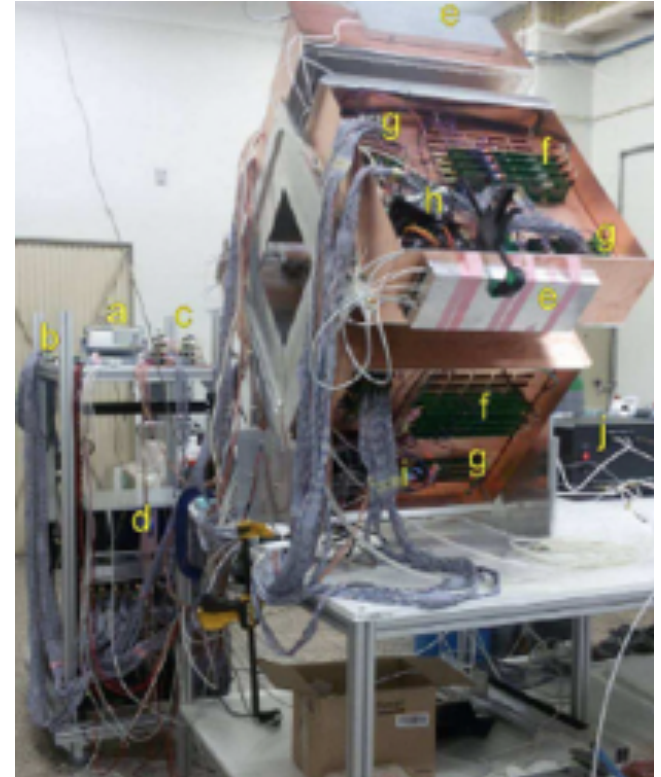


Impact of the War?

# Impact in the Society

- Computing and Information Technologies
- Health applications
- Space (including Earth Observation)
- Social Physics
- Knowledge Transfer
- Advanced training
- Education and public outreach
- ...

Brain PET



# All we need is ...

- People
- Infrastructures and Support
- Multidisciplinarity
- Management
- Communication
- Funding

Lots of enthusiasm and resilience



# Human Resources

**2022: Total 241 (+39)**

**Researchers: 104 (+3)**

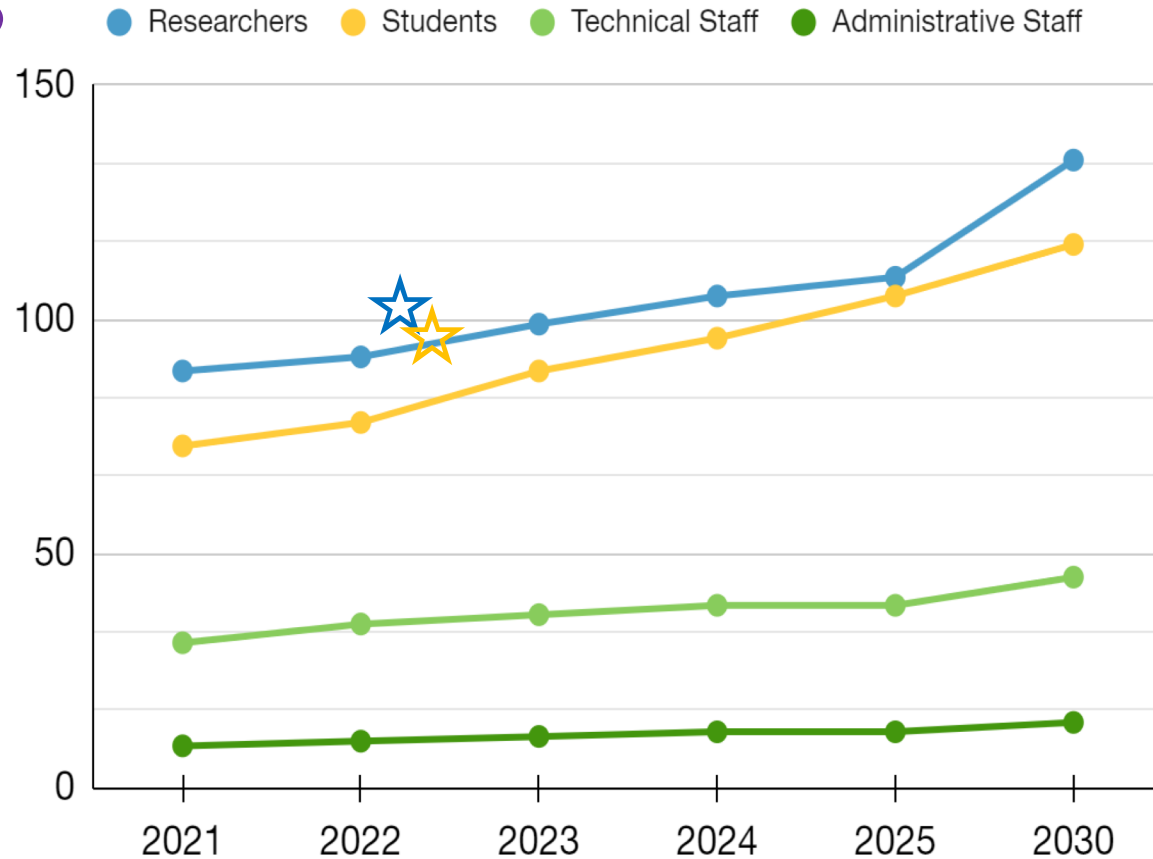
**Students: PhD 45 (+12) ; Master 50 (+17)**

**Technicians/ engineers: 32 (+3)**

**Administrative staff: 9 (=)**



evolution scenario  
(2020)



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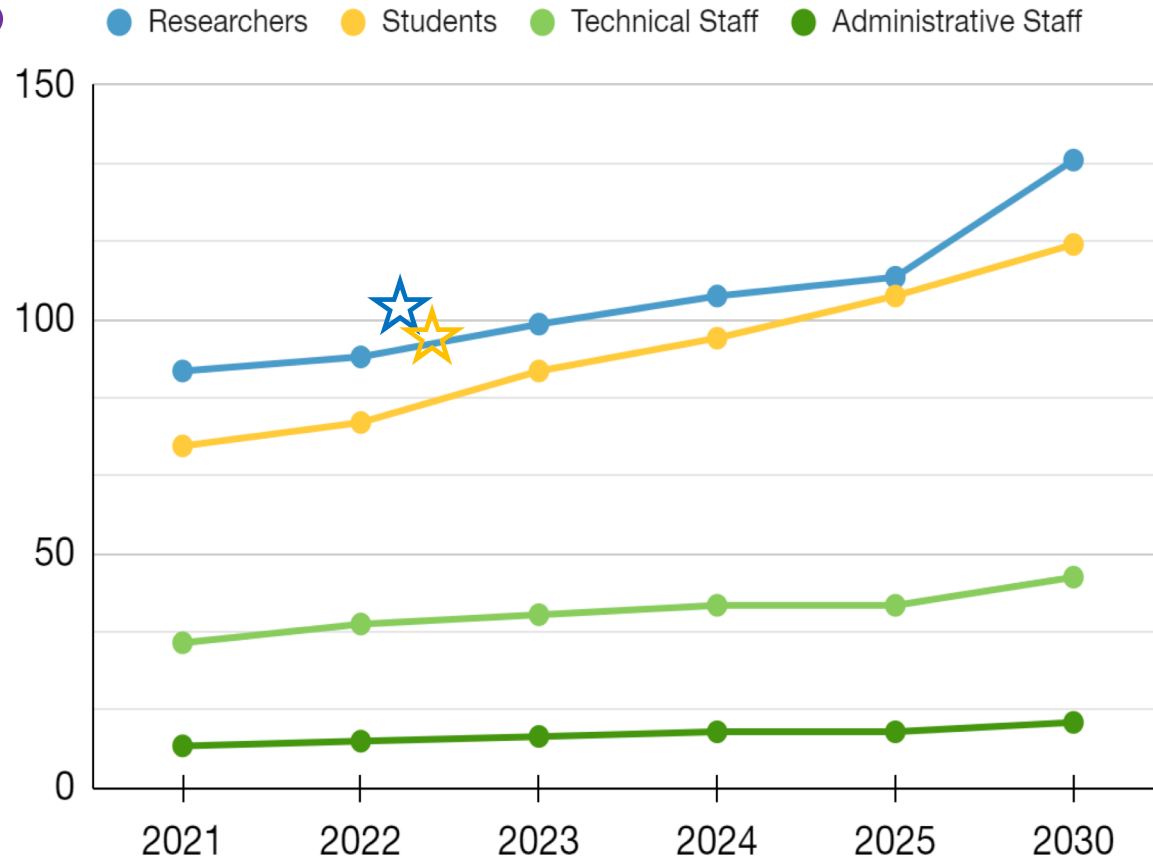
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**we hope that until end 2025:**

- to open 5 new permanent contracts
- to have about 6 new 5/6 years FCT contracts
- to have about 3/4 new positions at University.

evolution scenario  
(2020)

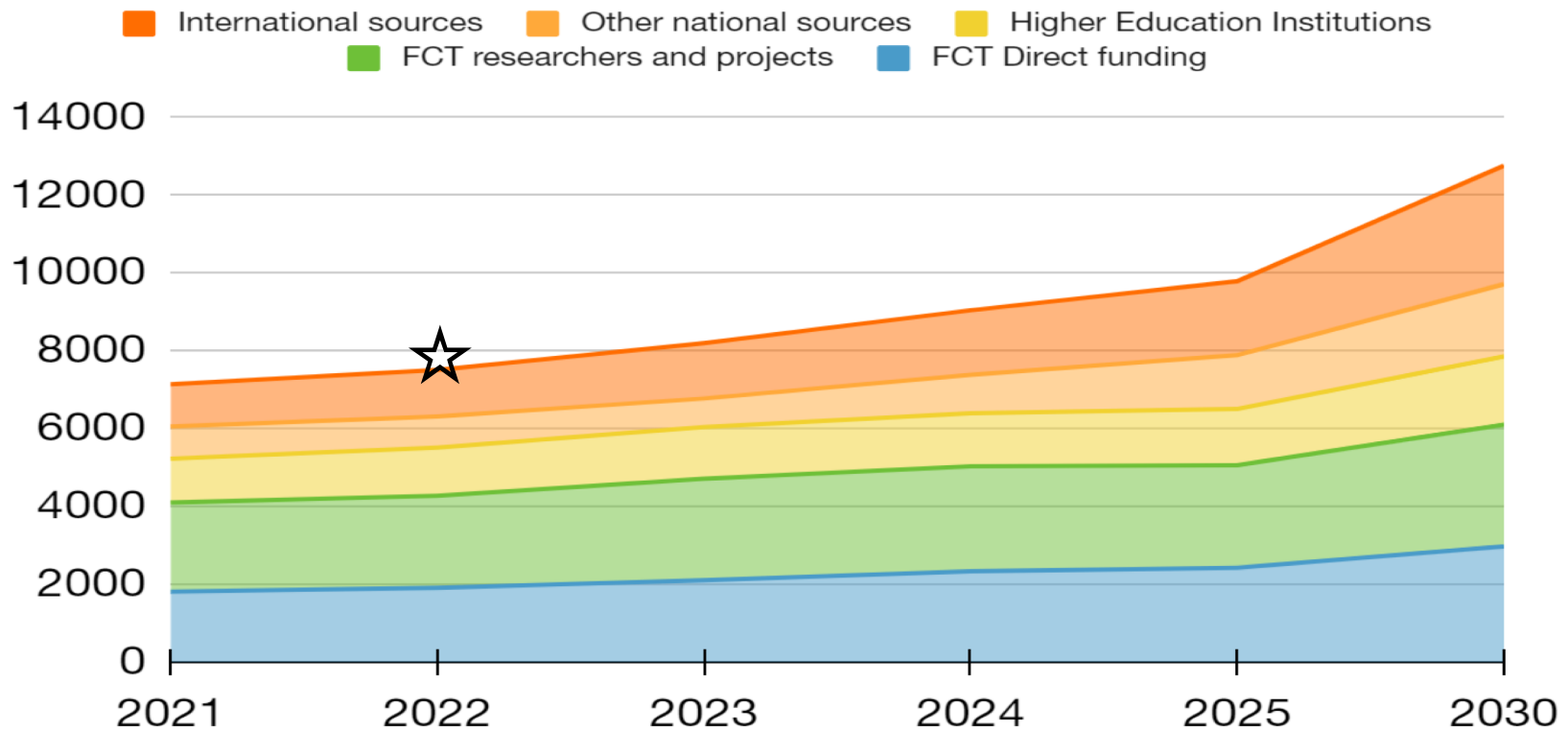


# Funding: evolution scenario (2021-2030)

**TOTAL (without university salaries )**

**2020: 6.1 M€**

**2022: 6.7 M€**





# Funding: evolution scenario (2021-2030)

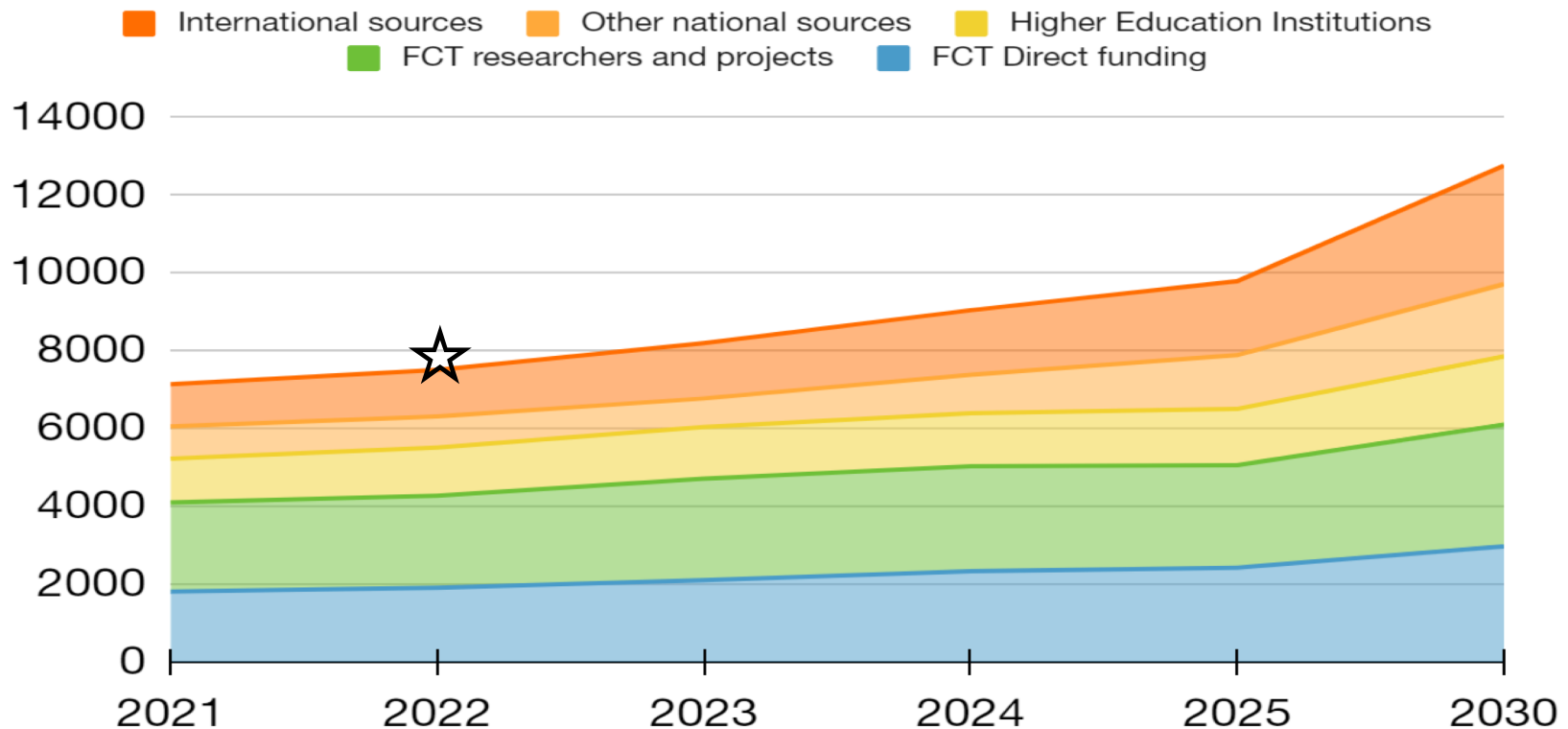
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**Diversify (in sources and type):**

- FCT
- European
- Partnerships
- Contracts and Services
- ...



# Bridge over troubled waters

