
Postdoctoral position on ALAS EFT and Higgs measurements

<https://emploi.cnrs.fr/Offres/CDD/UMR5814-LOUDAI-042/Default.aspx?lang=EN>

Introduction

ATLAS Heavy Particle Searches* - 95% CL Upper Exclusion Limits

Status: July 2022

ATLAS Preliminary

$$[\mathcal{L} dt = (3.6 - 139) \text{ fb}^{-1} \quad \sqrt{s} = 8, 13 \text{ TeV}$$

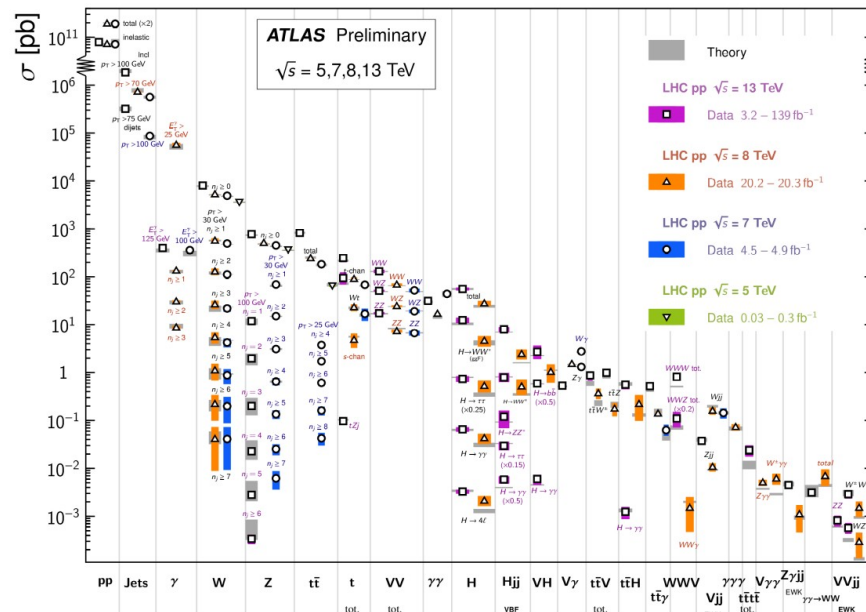
Model	ℓ, γ	Jets †	E^{miss}	$[\mathcal{L} dt [\text{fb}^{-1}]$	Limit	Reference
Extra dimensions	ADD $G_{\text{UV}} + \ell/\gamma$	$0, e, \mu, \tau, \gamma$	1-4	Yes	139	2102.10874
	ADD non-resonant $\gamma\gamma$	-	-	-	367	1707.04147
	ADD QH	-	2	-	139	1910.08447
	ADD BH multiplet	-	2	-	139	1912.05069
	RS1 $G_{\text{UV}} + \gamma\gamma$	-	2	-	139	2102.13495
Gauge bosons	Bulk RS $G_{\text{UV}} + WW/ZZ$	multi-channel	-	Yes	363	1906.05659
	Bulk RS $G_{\text{UV}} + WW \rightarrow \nu\nu q\bar{q}$	multi-channel	-	Yes	363	2004.14636
	Bulk RS $G_{\text{UV}} + \gamma\gamma$	multi-channel	-	Yes	363	1804.18823
	Bulk RS $G_{\text{UV}} + \gamma\gamma$	multi-channel	-	Yes	363	1903.09676
	ZUED/PPP	multi-channel	-	Yes	361	-
Gauge bosons	SSM $Z' \rightarrow \ell\ell$	$2, e, \mu$	-	-	139	1903.06248
	SSM $Z' \rightarrow \tau\tau$	$2, \tau$	-	-	361	1709.07242
	Leptophobic $Z' \rightarrow b\bar{b}$	$2, b$	-	-	361	1805.05059
	Leptophobic $Z' \rightarrow \tau\tau$	$0, e, \mu, \tau, \gamma$	$\geq 1b, \geq 2J$	-	139	2005.09139
	SSM $W' \rightarrow \ell\nu$	$1, e, \mu, \tau$	-	-	139	1906.05659
Gauge bosons	SSM $W' \rightarrow \tau\nu$	$1, \tau$	-	-	139	1906.05659
	SSM $W' \rightarrow \nu\bar{\nu}$	$1, \nu$	-	-	139	1906.05659
	HVT $W' \rightarrow WZ \rightarrow \nu\nu q\bar{q}$ model B	$1, e, \mu, \tau, \gamma$	$\geq 1b, \geq 1J$	Yes	139	1906.05659
	HVT $W' \rightarrow WZ \rightarrow \nu\nu \ell\ell$ model C	$3, e, \mu, \tau, \gamma$	$\geq 1b, \geq 1J$	Yes	139	1906.05659
	HVT $W' \rightarrow WZ \rightarrow \nu\nu b\bar{b}$ model B	$1, e, \mu, \tau, \gamma$	$\geq 1b, \geq 1J$	Yes	139	1906.05659
CI	HVT $Z' \rightarrow ZH \rightarrow \ell\ell \nu\bar{\nu} b\bar{b}$ model B	$0, 2, e, \mu, \tau, \gamma$	$\geq 1b, \geq 1J$	Yes	139	1906.05659
	LRSM $W_{\mu} \rightarrow \mu N_{\mu}$	$2, \mu, \tau$	$1, J$	-	80	1904.12679
	CI $e\bar{e}e\bar{e}$	$2, e, \mu, \tau, \gamma$	-	-	370	1703.09127
	CI $e\bar{e}\nu\bar{\nu}$	$2, e, \mu, \tau, \gamma$	-	-	139	2006.12946
	CI $e\bar{e}b\bar{b}$	$2, e, \mu, \tau, \gamma$	-	-	139	2105.13847
DM	CI $\mu\bar{\mu}b\bar{b}$	$2, \mu, \tau, \gamma$	-	-	139	2105.13847
	CI $\tau\bar{\tau}b\bar{b}$	$2, \mu, \tau, \gamma$	-	-	139	2105.13847
	CI $\tau\bar{\tau}t\bar{t}$	$\geq 1, e, \mu, \tau, \gamma$	$\geq 1b, \geq 1J$	-	361	1811.02205
	Axisial-vector med. (Dirac DM)	$0, e, \mu, \tau, \gamma$	1-4	Yes	139	1906.05672
	Pseudo-scalar med. (Dirac DM)	$0, e, \mu, \tau, \gamma$	1-4	Yes	139	2102.10874
LO	Vector med. Z' -2HDM (Dirac DM)	$0, e, \mu, \tau, \gamma$	2b	Yes	139	2106.13391
	Pseudo-scalar med. 2HDM+s	multi-channel	-	Yes	139	1811.02205
	Scalar LO 1^{st} gen	$2, e, \mu, \tau, \gamma$	$\geq 2J$	Yes	139	2006.05872
	Scalar LO 2^{nd} gen	$1, \tau, 2, b$	$\geq 2J$	Yes	139	2108.07665
	Scalar LO 3^{rd} gen	$0, e, \mu, \tau, \gamma$	$\geq 2b$	Yes	139	2004.46000
Vectorlike fermions	Scalar LO 3^{rd} gen	$\geq 2, e, \mu, \tau, \gamma$	$\geq 1b, \geq 1J$	Yes	139	2101.1582
	Scalar LO 3^{rd} gen	$0, e, \mu, \tau, \gamma$	$\geq 1, \tau, 2, b$	Yes	139	2101.15227
	Vector LO 3^{rd} gen	$1, \tau, 2, b$	-	Yes	139	2108.07665
	VLL $TT \rightarrow Zt + X$	$2e, 2\mu, 2e, \mu, \tau, \gamma$	$\geq 1b, \geq 1J$	-	139	1808.02343
	VLL $BB \rightarrow Wt, Zb + X$	multi-channel	-	Yes	361	1807.11883
Excited fermions	VLL $T \rightarrow Ht, Zt$	$1, e, \mu, \tau, \gamma$	$\geq 1b, \geq 1J$	Yes	139	1807.11883
	VLL $Y \rightarrow Wb$	$1, e, \mu, \tau, \gamma$	$\geq 1b, \geq 1J$	Yes	361	1807.11883
	VLL $Y \rightarrow Hb$	$0, e, \mu, \tau, \gamma$	$\geq 2b, \geq 1J, \geq 1J$	Yes	139	1807.11883
	VLL $\ell\ell \rightarrow Z\ell/H\ell$	multi-channel	≥ 1	Yes	139	1807.11883
	Excited quark $q^* \rightarrow qz$	-	2	-	139	1910.08447
Other	Excited quark $q^* \rightarrow q\gamma$	$1, \gamma$	1	-	367	1709.04040
	Excited quark $b^* \rightarrow b\gamma$	-	1b, 1J	-	139	1910.08447
	Excited lepton $\ell^* \rightarrow \ell\gamma$	$3, e, \mu, \tau, \gamma$	-	-	203	1411.2921
	Excited lepton $\nu^* \rightarrow \nu\gamma$	$3, e, \mu, \tau, \gamma$	-	-	203	1411.2921
	Type III Seesaw	$2, 3.4, e, \mu, \tau, \gamma$	$\geq 2J$	Yes	139	2002.00339
Magnetic monopoles	LRSM Majorana ν	$2, 3.4, e, \mu, \tau, \gamma$	$\geq 2J$	Yes	361	1809.11105
	Higgs triplet $H^{\pm\pm} \rightarrow W^{\pm}W^{\pm}$	$2, 3.4, e, \mu, \tau, \gamma$	various	Yes	139	2101.11961
	Higgs triplet $H^{\pm\pm} \rightarrow \ell\ell$	$2, 3.4, e, \mu, \tau, \gamma$	(SS)	Yes	139	1809.11105
	Higgs triplet $H^{\pm\pm} \rightarrow \tau\tau$	$3, e, \mu, \tau, \gamma$	-	Yes	203	1411.2921
	Multi-charged particles	-	-	-	139	1809.11105
Magnetic monopoles	-	-	-	34.4	1905.10130	

*Only a selection of the available mass limits on new states or phenomena is shown.

†Small-radius (large-radius) jets are denoted by the letter J (L).

Standard Model Production Cross Section Measurements

Status: February 2022



No new physics found so far, mass limits reaching $O(1 \text{ TeV})$ in many cases...

... but the LHC is maturing into a precision measurement machine!

LHC past, present, future

Run 2
2015-2018

13 TeV

140 fb⁻¹

Run 3
2022-2025

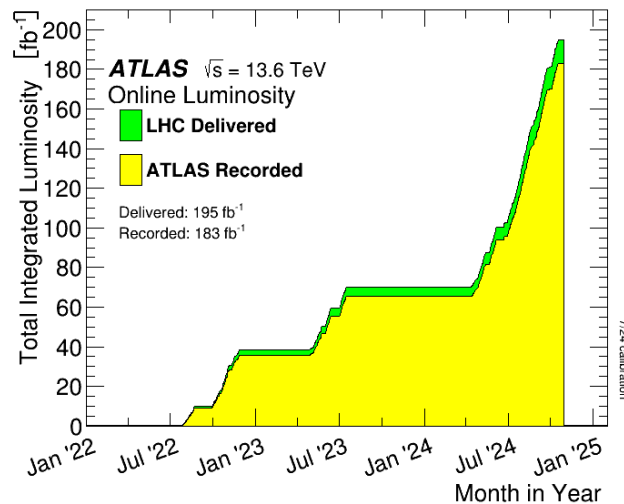
13.6 TeV

300-400 fb⁻¹

Run 4+
2029-...

14 TeV

4000 fb⁻¹



Already more Run 3 than
Run 2 data collected!

Collision energy won't increase much, but a lot more data is coming!

→ Even more precision (if we can control systematics, theory...)

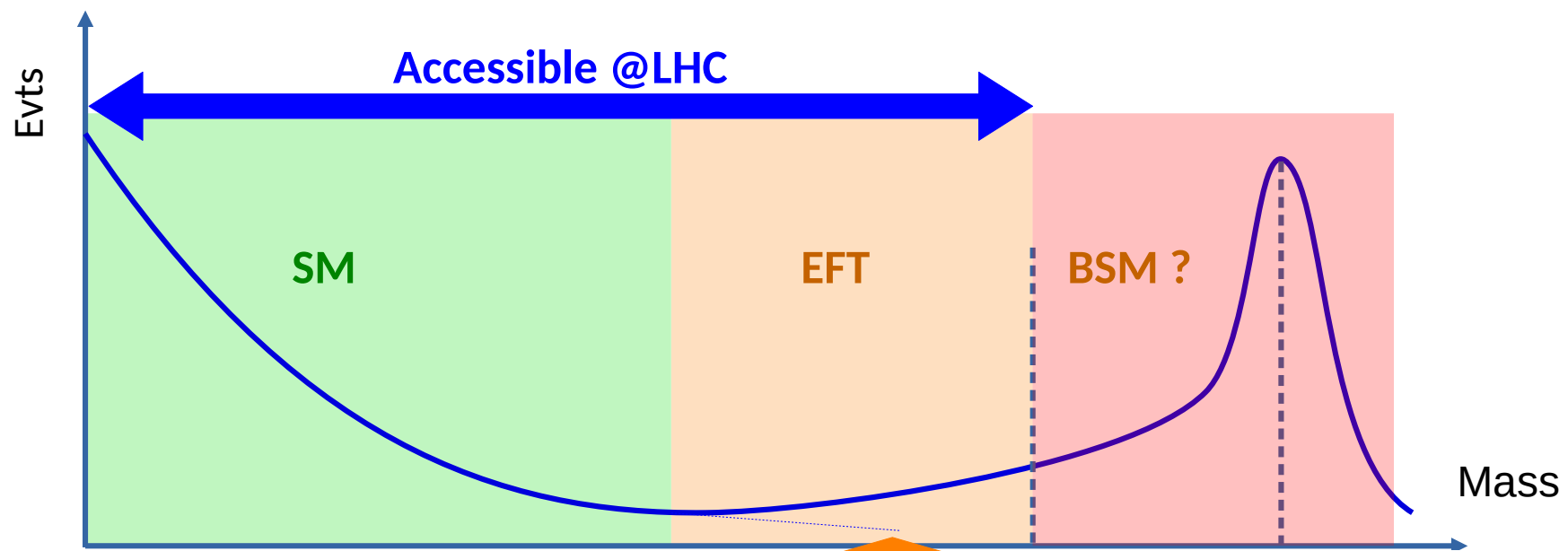
→ Opportunity to develop better analysis techniques (“ML revolution”)

⇒ Look for BSM **indirectly**, through deviations from SM predictions

EFTs: a generic framework for to search from deviations from SM

Relevant to all sectors of the SM, in particular **Weak bosons, Higgs, Top, DY, ...**

→ Effects typically rise with energy, but low- Q^2 precision measurements also contribute

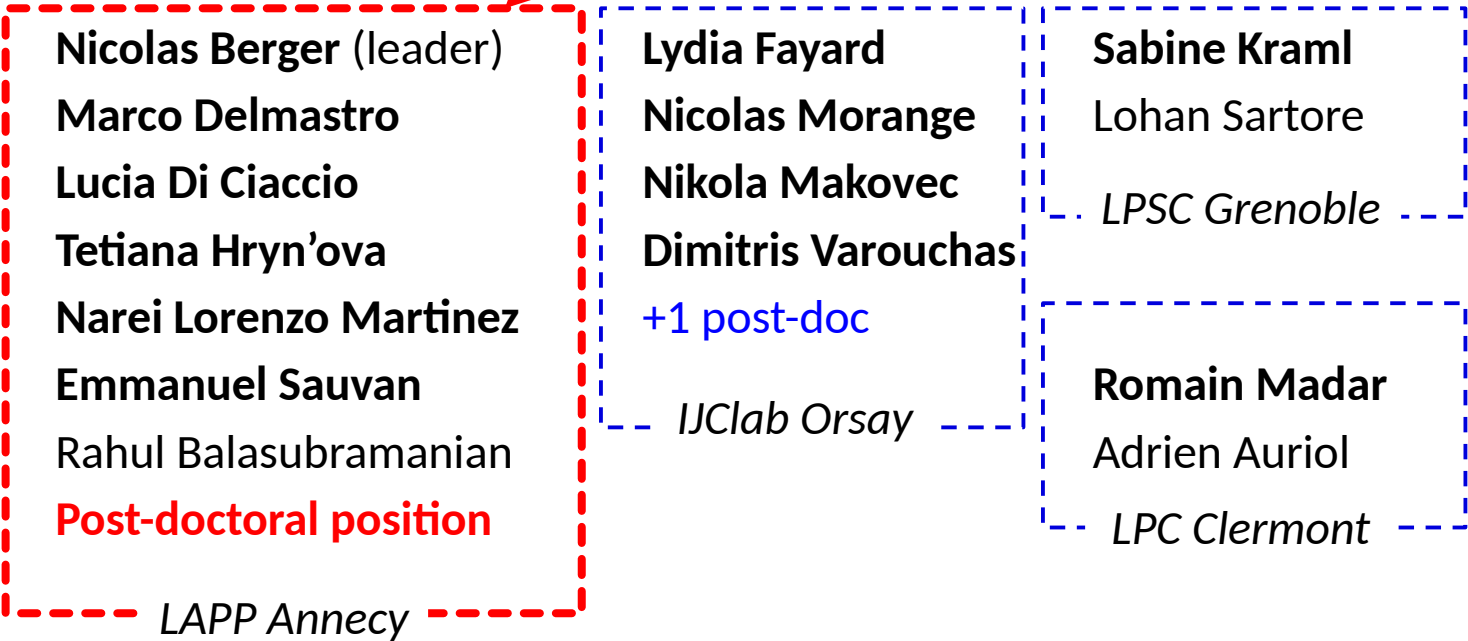


$$\mathcal{L}_{EFT} = \mathcal{L}_{SM} + \sum_i \frac{c_i^{(6)}}{\Lambda^2} O_i^{(6)} + \dots$$

X^3	φ^6 and $\varphi^2 D^2$	$\varphi^2 \varphi^2$
$Q_{\phi\phi}$ $f^{ABC} G^A_\mu G^B_\nu G^C_{\rho\sigma}$	$Q_{\phi\phi}$ $(\varphi^\dagger \varphi)^3$	$Q_{\phi\phi}$ $(\varphi^\dagger \varphi)(\varphi_\mu \varphi^\mu)$
$Q_{\phi\phi}$ $f^{ABC} \tilde{G}^A_\mu \tilde{G}^B_\nu \tilde{G}^C_{\rho\sigma}$	$Q_{\phi\phi}$ $(\varphi^\dagger \varphi) \square (\varphi^\dagger \varphi)$	$Q_{\phi\phi}$ $(\varphi^\dagger \varphi)(\phi_\mu \phi^\mu)$
$Q_{\phi W}$ $f^{ABC} W^A_\mu W^B_\nu W^C_{\rho\sigma}$	$Q_{\phi W}$ $(\varphi^\dagger D^\mu \varphi)^\dagger (\varphi^\dagger D_\mu \varphi)$	$Q_{\phi W}$ $(\varphi^\dagger \varphi)(\phi_\mu \phi^\mu)$
$Q_{\phi W}$ $f^{ABC} \tilde{W}^A_\mu \tilde{W}^B_\nu \tilde{W}^C_{\rho\sigma}$		
$X^2 \varphi^2$	$\varphi^2 X_\mu \varphi$	$\varphi^2 \varphi^2 D$
$Q_{\phi\phi}$ $\varphi^\dagger \varphi G^A_\mu G^A_{\nu\sigma}$	$Q_{\phi W}$ $(\phi_\mu \phi^\mu)^\dagger \varphi^\dagger W^\mu_\nu \varphi$	$Q_{\phi\phi}^{(1)}$ $(\varphi^\dagger \tilde{D}_\mu \varphi)(\varphi_\nu \varphi^\nu)$
$Q_{\phi\phi}$ $\varphi^\dagger \varphi \tilde{G}^A_\mu \tilde{G}^A_{\nu\sigma}$	$Q_{\phi B}$ $(\phi_\mu \phi^\mu)^\dagger \varphi^\dagger B_\nu \varphi$	$Q_{\phi\phi}^{(2)}$ $(\varphi^\dagger \tilde{D}^2_\mu \varphi)(\varphi_\nu \varphi^\nu)$
$Q_{\phi W}$ $\varphi^\dagger \varphi W^A_\mu W^A_{\nu\sigma}$	$Q_{\phi W}$ $(\phi_\mu \phi^\mu)^\dagger \varphi^\dagger W^\mu_\nu \varphi$	$Q_{\phi W}$ $(\varphi^\dagger \tilde{D}_\mu \varphi)(\varphi_\nu \varphi^\nu)$
$Q_{\phi W}$ $\varphi^\dagger \varphi \tilde{W}^A_\mu \tilde{W}^A_{\nu\sigma}$	$Q_{\phi W}$ $(\phi_\mu \phi^\mu)^\dagger \varphi^\dagger \tilde{W}^\mu_\nu \varphi$	$Q_{\phi W}^{(1)}$ $(\varphi^\dagger \tilde{D}^2_\mu \varphi)(\phi_\nu \varphi^\nu)$
$Q_{\phi B}$ $\varphi^\dagger \varphi B_\mu B_{\nu\sigma}$	$Q_{\phi B}$ $(\phi_\mu \phi^\mu)^\dagger \varphi^\dagger B_\nu \varphi$	$Q_{\phi W}^{(2)}$ $(\varphi^\dagger \tilde{D}_\mu \varphi)(\phi_\nu \varphi^\nu)$
$Q_{\phi B}$ $\varphi^\dagger \varphi \tilde{B}_\mu \tilde{B}_{\nu\sigma}$	$Q_{\phi B}$ $(\phi_\mu \phi^\mu)^\dagger \varphi^\dagger \tilde{B}_\nu \varphi$	$Q_{\phi B}$ $(\varphi^\dagger \tilde{D}_\mu \varphi)(\phi_\nu \varphi^\nu)$
$Q_{\phi W B}$ $\varphi^\dagger \varphi W^A_\mu \tilde{B}_{\nu\sigma}$	$Q_{\phi W B}$ $(\phi_\mu \phi^\mu)^\dagger \varphi^\dagger W^\mu_\nu \tilde{B}_\sigma \varphi$	$Q_{\phi W B}$ $(\varphi^\dagger \tilde{D}_\mu \varphi)(\phi_\nu \varphi^\nu)$
$Q_{\phi W B}$ $\varphi^\dagger \varphi \tilde{W}^A_\mu \tilde{B}_{\nu\sigma}$	$Q_{\phi W B}$ $(\phi_\mu \phi^\mu)^\dagger \varphi^\dagger \tilde{W}^\mu_\nu \tilde{B}_\sigma \varphi$	$Q_{\phi W B}$ $i(\tilde{D}^2_\mu \varphi)(\phi_\nu \varphi^\nu)$

Project members

The candidate would join LAPP Annecy



Kyle Cranmer
U. of Wisconsin

Ilaria Brivio
Bologna U.

Veronica Sanz
U. of Valencia

Tevong You
King's college London

Project funded by the French National Research agency from 2022 to 2027.

Axis 1 : Improving EFT measurements

- High E sensitivity + new variables (CP)
 - Make use of modern ML tools
- Apply to Higgs, dibosons (WW, WZ, ZZ, Z γ), top and Drell-Yan (pp \rightarrow ll)

Axis 2 : EFT predictions

- State-of-the art predictions and tools
- Higher orders in loops, EFT
- Uncertainties

Axis 3 : FAIR publication of results

- Publish results beyond Gaussian approximation : Poisson effects in tails, correct treatment of systematics.
- Publish likelihoods (full or simplified)

Axis 4 : Combined fits

- Perform Diboson+Higgs+Top+DY fits within and outside ATLAS
- Investigate less flavor symmetries (DY, Top + flavor measurements), CP even/odd

Axis 1 : Improving EFT measurements

Axis 3 : FAIR publication of results

Overarching goals

- Improve EFT global combinations in several directions (hoping to see first hints of BSM!)
- Train junior researchers in interesting topics at the crossroads of theory and experiment
- Promote better theory/experiment links in the EFT sector: improve sharing of experimental results and collaboration on analysis and fitting techniques, tools, ...

→ Higher orders in loops, EFT
→ Uncertainties

within and outside ATLAS

→ Investigate less flavor symmetries (DY, Top + flavor measurements), CP even/odd

LAPP is located in **Annecy**, about 50 km south of CERN
~150 staff working mainly on particle and astroparticle physics



The ATLAS group is involved in several physics topics:

- Higgs boson physics ($H \rightarrow \gamma\gamma$ in particular)
- Dibosons/VBS
- Drell-Yan
- EFT analyses

Hardware: Involvement in LAr Calorimeter and ITk Pixels Upgrade projects



Position details

The position is for **2 years** (likely not extendable), starting in **Spring 2025**

Ph. D. in particle physics, **received <2 years before the start of the position** is required.

Candidates will contribute to ATLAS EFT and Higgs measurements.

Looking in particular for :

- **A strong background in experimental particle physics, in particular LHC experiments**
- **Excellent collaboration and team-building abilities**
- **Experience with modern software tools (data analysis, machine learning, etc.)**

Some experience with Higgs and EFT physics analysis can also be useful.

The candidate is expected to be based in the Annecy area, with frequent travel to CERN

Some knowledge of French is a plus, but not required.

Starting salary ~3000€/month (before tax)