

LHC experiments - Physics, Phase I Upgrades and Operations



Michele Gallinaro
RECFA, September 15, 2023

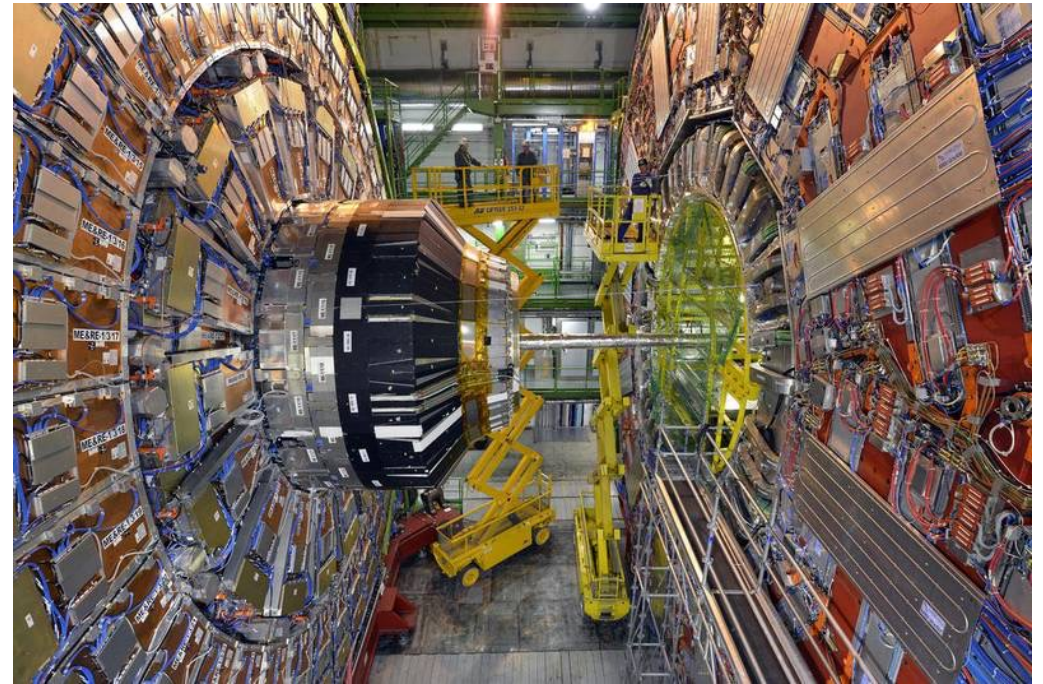
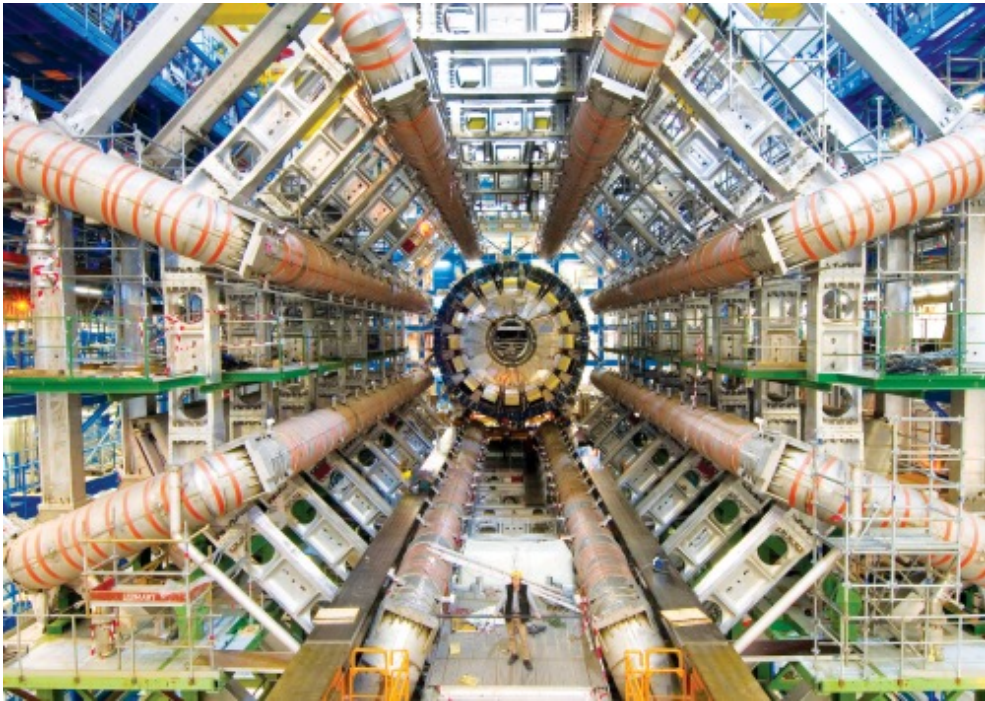


- Participation in the LHC experiments (ATLAS, CMS) and COMPASS
- LIP and the LHC experiments, and the People
- Portuguese contributions: Detectors, Physics, and Phase-I upgrades
- Coordination and Awards
- Participation of Portuguese Industry
- Funding sources
- Remarks

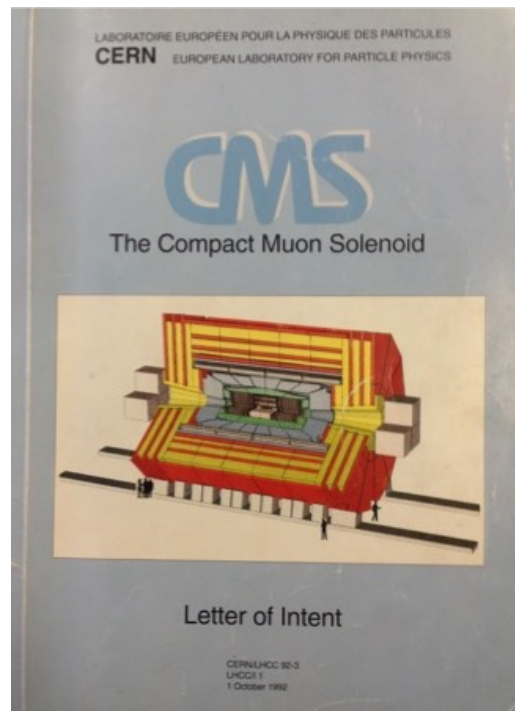
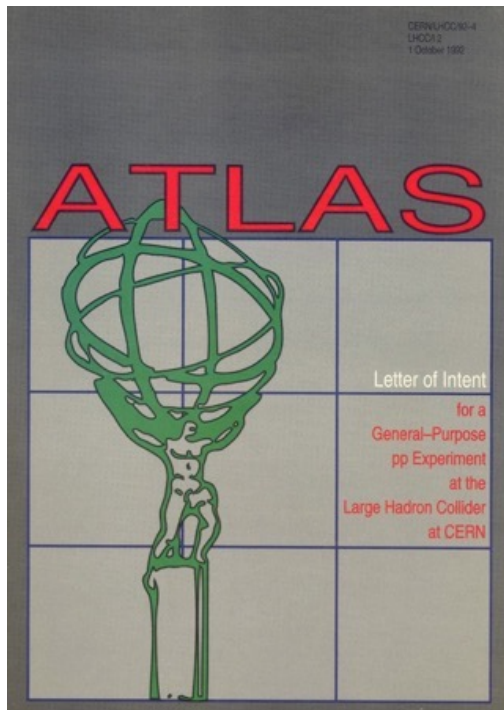


The experiments

- LIP is involved in the ATLAS and the CMS experiments



ATLAS and CMS Letters of Intent (1992)



ATLAS Letter of Intent, CERN/LHCC/92-4, 1992, with the participation of LIP (A. Amorim, A. Henriques, G. Barreira, A. Maio, A. Gomes, L. Peralta).

CMS Letter of Intent, CERN-LHCC-92-003, 1992, with the participation of LIP (P. Bordalo, C. Lourenço, R. Nóbrega, S. Ramos, J. Varela).

The People



CMS

Total FTE: 12.9 (PhD 6.9)

7 Researchers (3 permanent)

6 PhD students

2 Master students

1 Technician

ATLAS

Total FTE: 20.2 (PhD 7.1)

16 Researchers (7 permanent)

7 PhD students

8 Master students

5 Technicians

Annual Report (2023)

ATLAS

Collaboration in the ATLAS experiment at CERN

Principal Investigator:

Patrícia Conde (70)

15 Researcher(s):

Agostinho Gomes (80), Amélia Maio (30), António Onofre (20), António Pina (30), Filipe Veloso (80), Guiomar Evans (30), Helena Santos (75), Helmut Wolters (60), Inês Ochoa (60), João Gentil (20), Marcin Stolarski (30), Miguel Fiolhais (30), Nuno Castro (25), Ricardo Gonçalves (60), Rute Pedro (15)

5 Technician(s):

Filipe Martins (100), Gabriela Pinhão (100), Luís Gurrjana (80), Luís Seabra (100), Rui Fernandez (100)

7 PhD Student(s):

Ana Luísa Carvalho (100), Beatriz Pinheiro Pereira (25), Luis Coelho (60), Maura Teixeira (100), Nuno Fernandes (100), Ricardo Barrué (100), Rudnei Machado (40)

8 Master Student(s):

António Caramelo (21), Catarina Pereira (16), João Pedro Pires (50), Maria Miguel (21), Patrícia Ferreira (100), Pedro Lagarelhos (50), Rúben Inácio (24), Simão Costa (3)

19 Undergraduated Student(s) and Trainee(s):

Afonso Azenha, Artur Semião, Beatriz Rosalinho, Beatriz Silva, Bruna Lima, Carolina Costa, Catarina Oliveira, Filipe Costa, Guilherme Gaspar, Inês Pinto, Joan Kladnik, Joana Ramos, Mariana Ribeiro, Nuno Gonçalves, Sinead Eley, Tiago Prates da Costa, Ulrich Willemsen, Vanessa Pinto, Vicente Mendes

12 External collaborator(s):

Ana Peixoto, André Wemans, Daniel Neacsu, Helena Macedo, José Cordeiro, José Rufino, José Soares Augusto, Mikael Chala, Pedro Jorge, Rui Santos, Susana Sérgio, Tiago Vale

Total FTE:

20.2 (PhD 7.1)

Articles in international journals: 3 Direct contribution
39 Indirect contribution
Notes: 4 Collaboration notes
3 LIP Students notes
International conferences: 10 Oral presentations
1 Poster
5 Proceedings
National conferences: 1 Oral presentation
Nat. & Internat. meetings: 6 Oral presentations
6 Posters
Collaboration meetings: 89 Oral presentations
Advanced Training Events: 7 Oral presentations
3 Student presentations
Seminars: 1 Seminar
3 Outreach seminars
Completed theses: 1 MSc
Organized Events: 1 Collaboration Meeting

CMS

Collaboration in the CMS experiment at CERN

Principal Investigator:

Michele Gallinaro (100)

7 Researcher(s):

Alessio Boletti (100), Cristóvão Silva (100), Jonathan Hollar (100), João Varela (100), Nuno Leonardo (65), Pietro Faccioli (25), Tahereh Niknejad (100)

2 Technician(s):

José Carlos Silva (100), Rui Pereira da Silva (50)

6 PhD Student(s):

Diogo de Bastos (100), Giacomo Da Molin (42), Giovanni Marozzo (17), Johan Wulff (34), Mariana Araújo (35), Matteo Pisano (100)

2 Master Student(s):

Henrique Legoinha (100), Simão Costa (25)

9 Undergraduated Student(s) and Trainee(s):

Alexandre André, Beatriz Amorim, Jean Luo, Leonardo Rodrigues, Luisa Roesler, Manuel Abreu, Manuel Afonso Ratola, Pedro Batista, Sónia Paulo D'Azevedo

8 External collaborator(s):

Carlos Lourenço, Giles Strong, João Seixas, Luis Ferramacho, Miguel Silveira, Pedrame Bargassa, Pedro Ferreira da Silva, Ricardo Bugalho

Total FTE:

12.9 (PhD 6.9)

CMS Deputy Spokesperson,
2012-13 (J. Varela)

Articles in international journals: 6 Direct contribution
55 Indirect contribution
Notes: 5 Internal notes
3 Collaboration notes
4 LIP Students notes
International conferences: 7 Oral presentations
2 Poster
5 Proceedings
National conferences: 1 Poster
Nat. & Internat. meetings: 4 Oral presentations
Collaboration meetings: 32 Oral presentations
Advanced Training Events: 24 Oral presentations
2 Student presentations
Seminars: 3 Seminars
2 Outreach seminar
Articles in Outreach Journals: 1 Article in Outreach Journal

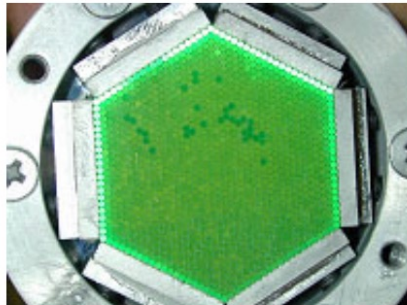
Portuguese contributions to ATLAS

TileCal: Tile Calorimeter

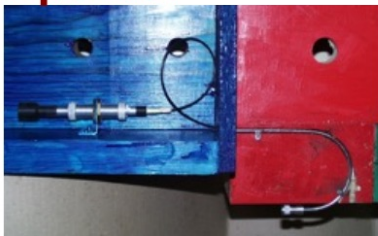
Scintillators



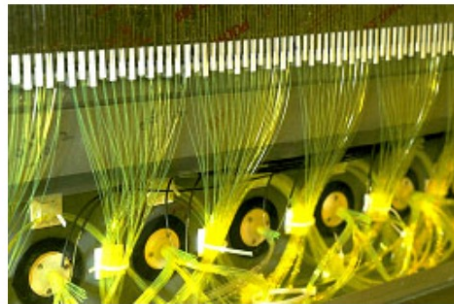
**600 k WLS fibers
aluminized**



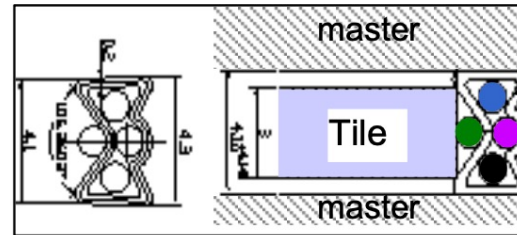
**Laser monitoring
system: connectors,
fibers, beam
expander**



**Design of the cells and
fibers routing**



150000 plastic profiles



**PMT blocks
supports**



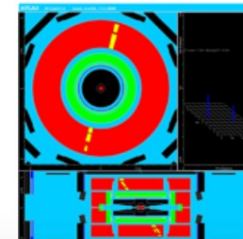
Fibers insertion with robot



**PMT quality
control**

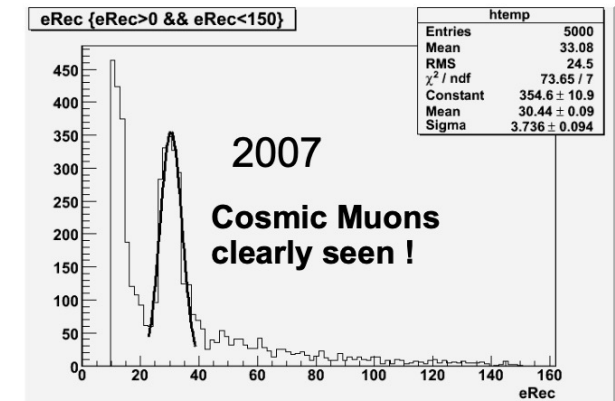
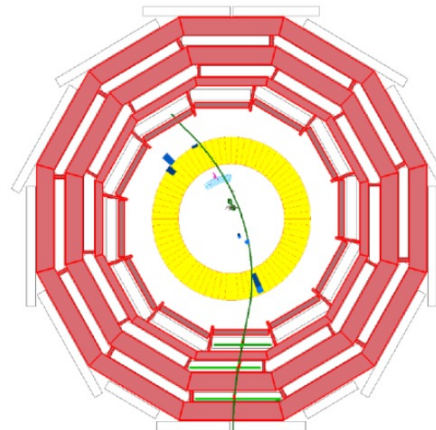
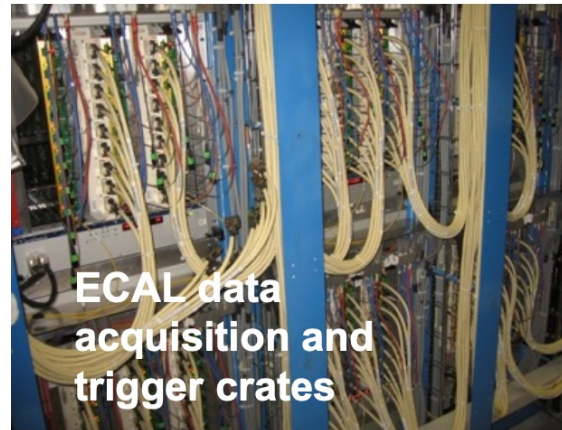
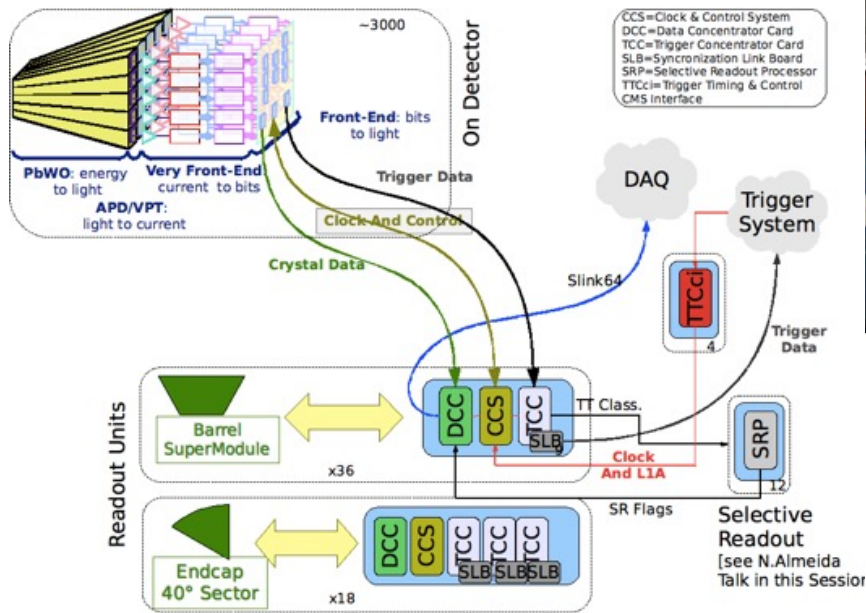


**Instrumentation of the
modules, calibration,
certification and
commissioning**



Portuguese contributions to CMS

ECAL Data Acquisition and Trigger System



ECAL Electronics Coordinator (L2), 2011-2023 (J.C.Silva)

The LHC Computing

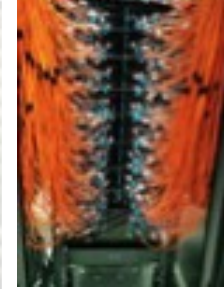
See talk by Jorge Gomes

GRID center in Portugal



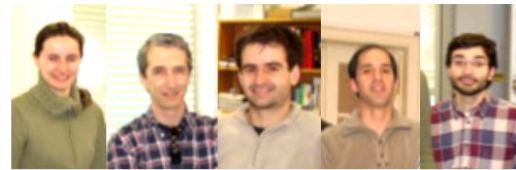
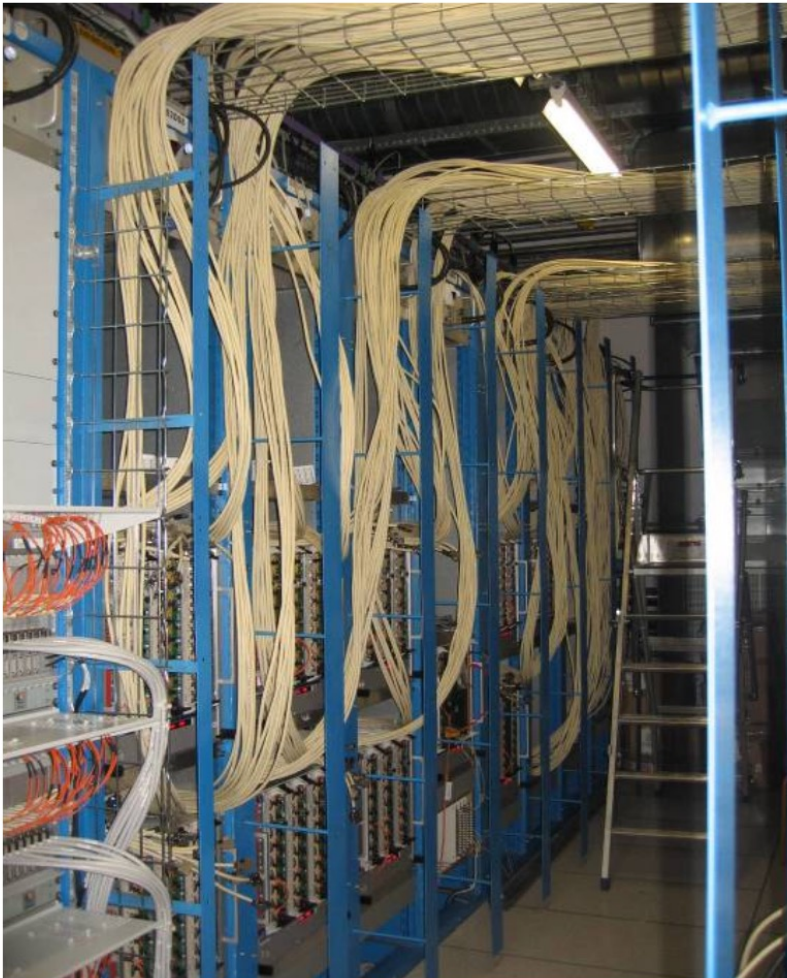
The Portuguese federated Tier-2 is composed of three data centers located in Lisbon and Coimbra

The development of the LHC GRID had a major impact in the development of scientific computing in Portugal



LIP in the construction of the LHC experiments

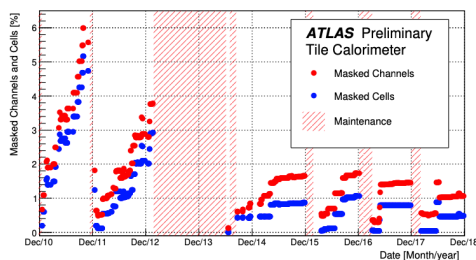
CMS ECAL trigger integration in 2006-2007



Operation of LHC experiments: ATLAS

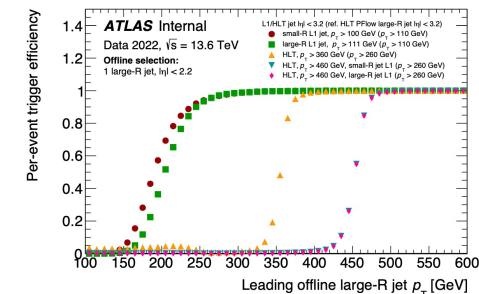
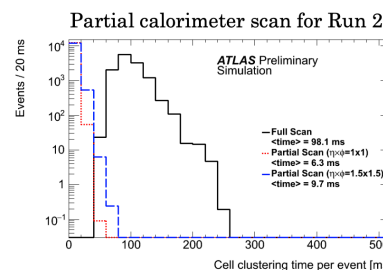
TileCal

- DCS, operation, performance, calibration
- Leading roles:
 - DCS
 - Calibration
 - Data preparation



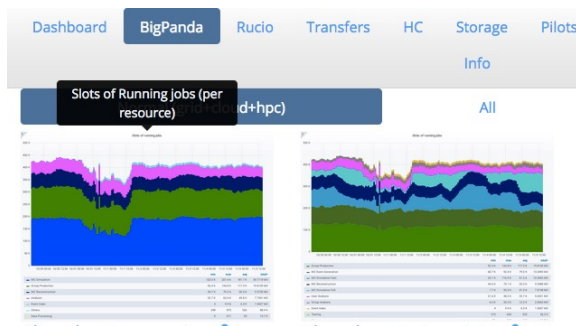
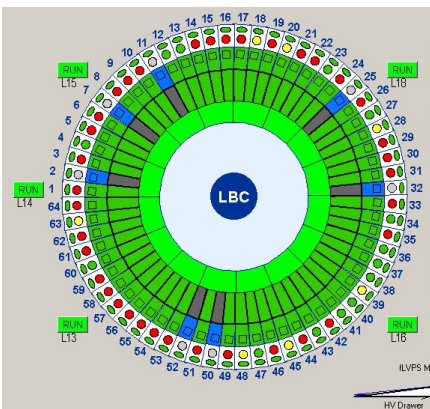
Jets HLT

- Long time commitment
- Performance, operations, improvement
- Coordination: 2014-15, 2023-24



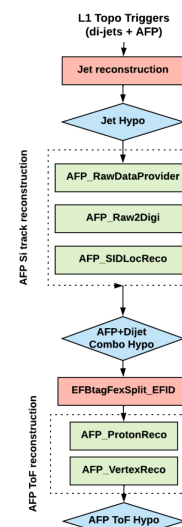
Distributed computing

- Iberian Cloud Coordination
- Monitoring tools development



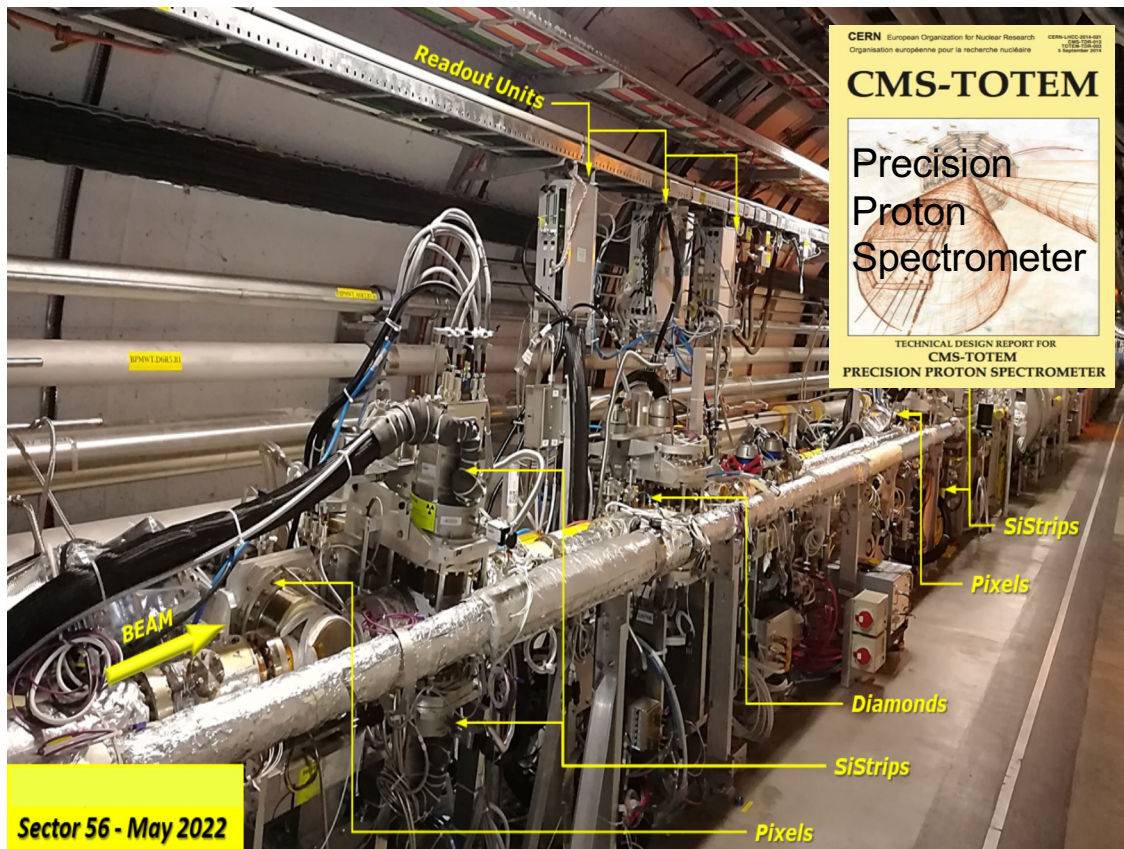
ATLAS Forward Detectors

- Leading role in ALFA/AFP DCS
- Development of Central Exclusive Production (CEP) triggers



Operation of LHC experiments: CMS

Participation in the CMS Phase-I upgrades: PPS and ECAL



Optical links
of the ECAL
Trigger
System



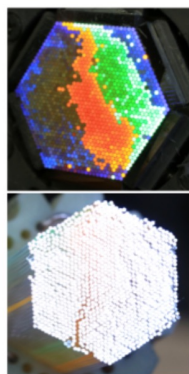
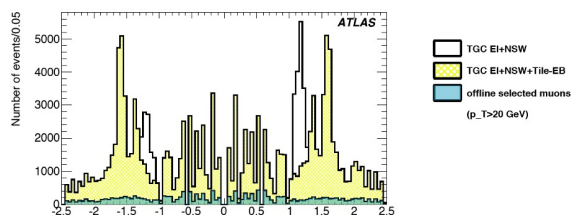
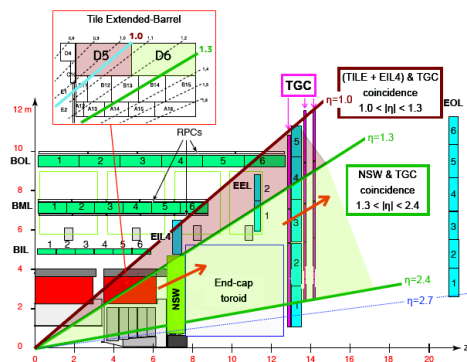
PPS Project Manager (L1), 2014-18 (J. Varela)
PPS Project Manager (L1), 2021-present (J.Hollar)
Timing Detector coord (L2), 2014-2018 (M.Gallinaro)
DAQ coord (L2), 2014-2018 (J.Hollar)

ECAL Electronics Coordinator (L2),
2011-2023 (J.C.Silva)

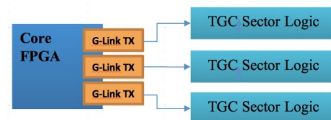
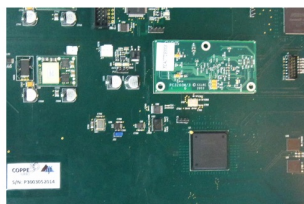
Phase-I Upgrades: ATLAS

TileCal

- Aluminium and characterisation of WLS fibers for gap/crack scintillators
- TileCal muon trigger
 - TTC decoder
 - Bytestream converters



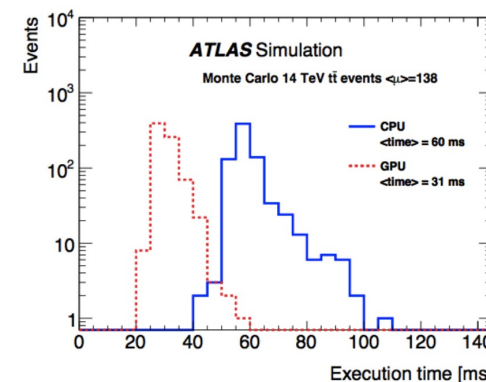
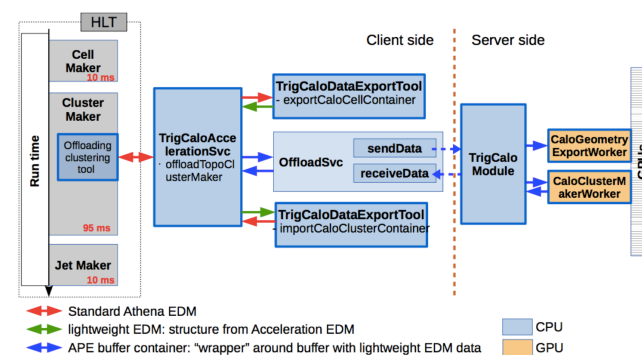
✓ Production of 38 TTCdec boards at HFA in Portugal (28 Tile-Mu Trigger+10 L1Calo).



- ✓ Implementation and test of G-Link TX (TMDB-SL), emulated on TMDB Core FPGA (Xilinx Spartan-6).
- ✓ Emulator of the TMDB board response.
- ✓ Bytestream converters.

HLT software

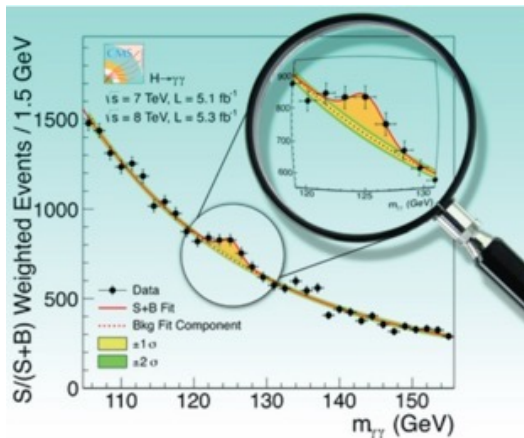
- 1st GPU Calorimeter trigger prototype
- Client-server architecture
- Acceleration of a factor of 1.3-2



LIP contributions: CMS Physics Results

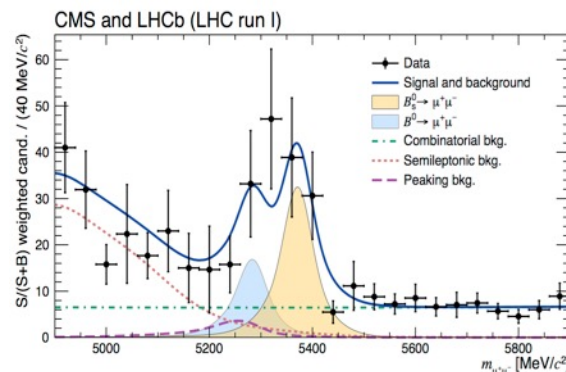
Higgs

- Discovery in $H \rightarrow \gamma\gamma$ decay
- Study of Higgs properties



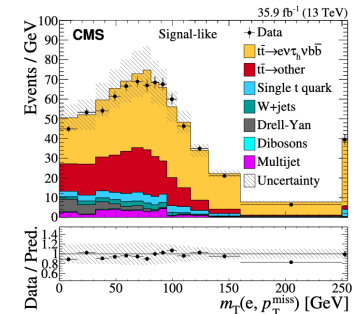
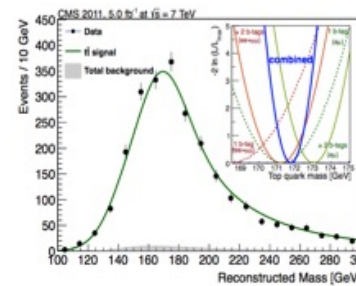
Rare B decays

- $B_{s,d} \rightarrow \mu\mu$ rare decay



Top quark

- x-section: PLB695(2011)424
- x-section&mass: JHEP07(2011)049
- x-section w/taus: PRD85(2012)112007, PLB739(2014)23, JHEP02(2020)191
- Mass: EPJC72(2012)2202
- Heavy-flavor (xsec, Vtb, width): PLB736(2014)33



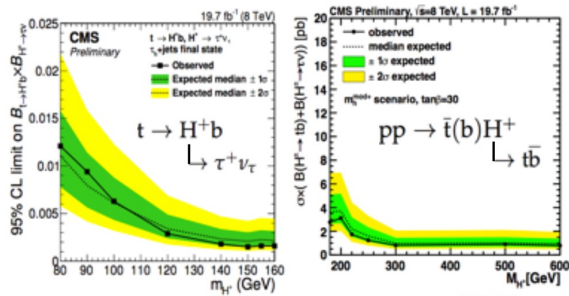
- Convener B Physics Group, 2014-15 (N.Leonardo)
- Convener Top Physics Group, 2015-16 (P.Silva*)
- Convener Higgs Physics Group, 2015-16 (A.David*)

* now with CERN

LIP contributions: CMS Physics Results

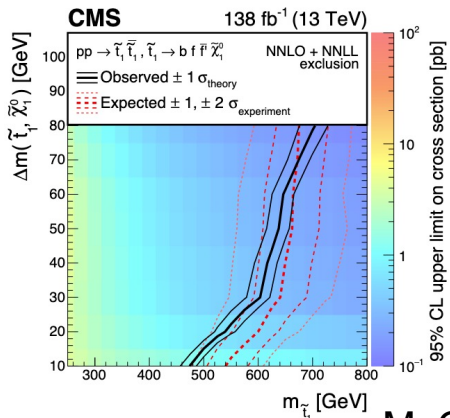
Charged Higgs

- In top decays
- Heavy Higgs



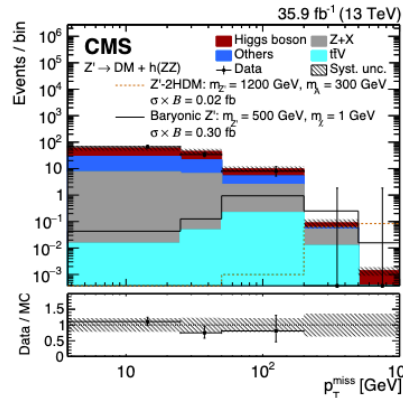
SUSY: stop search

- Single lepton channel, 3- and 4-body decays: JHEP09(2018)065, JHEP06(2023)060



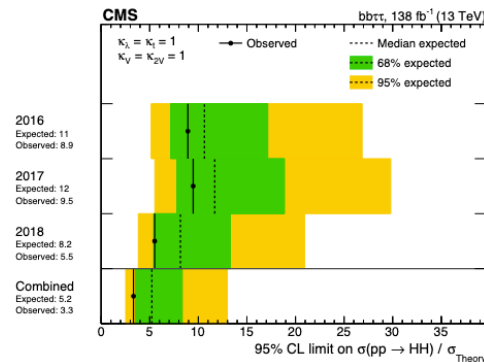
Dark Matter search

- Higgs associated production: JHEP03(2020)025



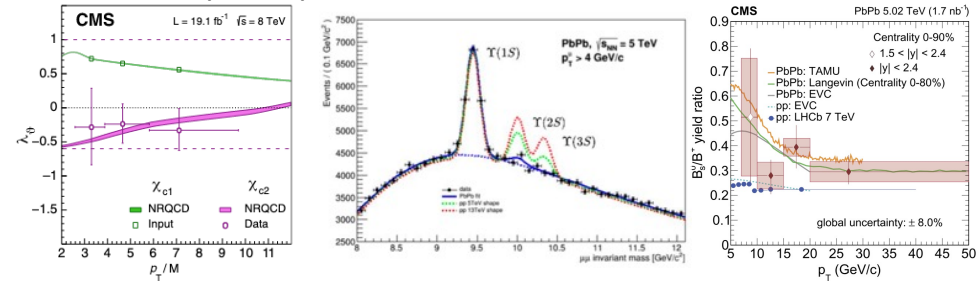
Di-Higgs search

- bb tau tau final state: PLB842(2023)137531



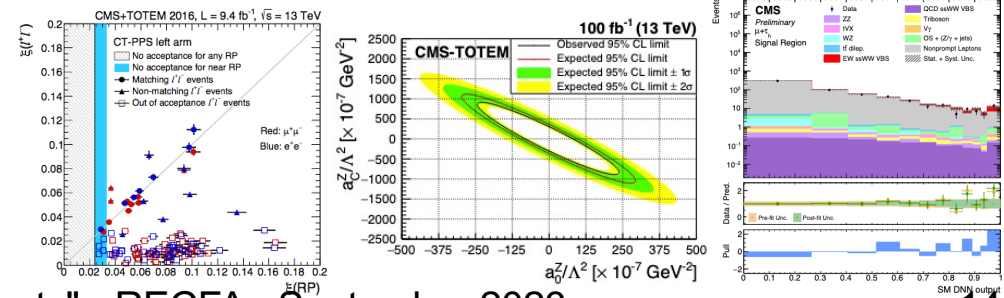
Quarkonia and Heavy Ions

- Polarization measurements: PRL110(2013)081802, PLB727(2013)381, PLB761(2016)31, PRL124(2020)162002
- B mesons in HI: PLB796(2019)168, PLB829(2022)137062



SM and exclusive processes

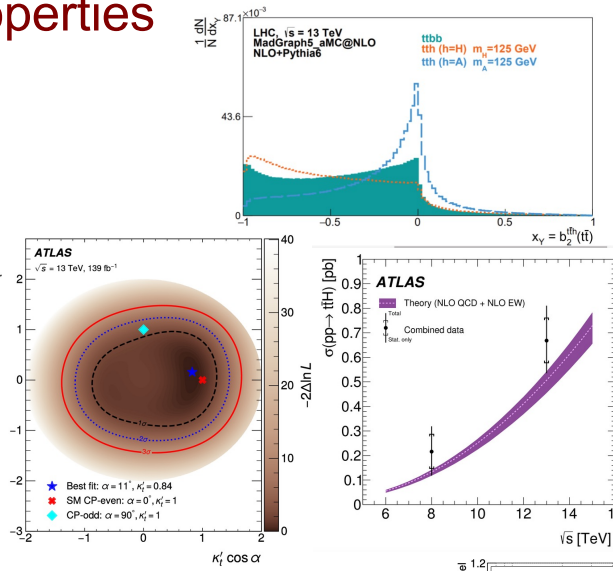
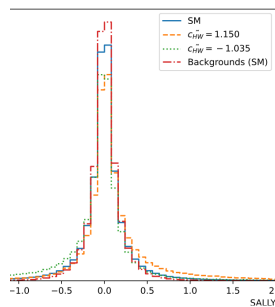
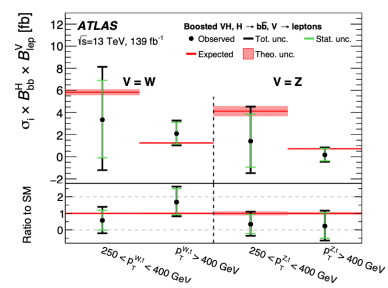
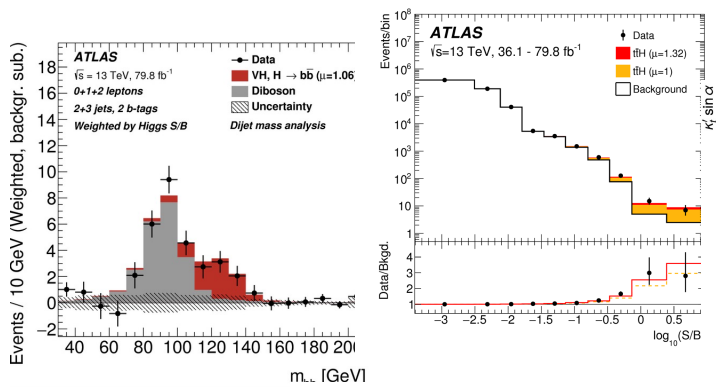
- Inclusive photon xsec: PRL106(2011)082001
- WW cross section: EPJC76(2016)401
- Exclusive processes (dileptons, ttbar, WW/ZZ): JHEP07(2018)153, JHEP07(2023)229
- VBS w/tau final state: RevPhys8(2022)100071



LIP contributions: ATLAS Physics Results

Higgs boson discovery and properties

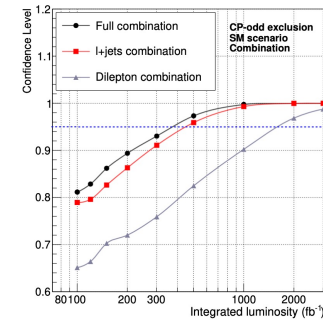
- $H \rightarrow WW$, $H \rightarrow bb$, $t\bar{t}H$ observation
- Spin/CP properties



ATLAS $\sqrt{s} = 13$ TeV, 139 fb⁻¹, $m_H = 125$ GeV
 SM compatibility: 8.5%

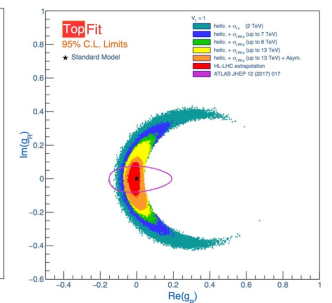
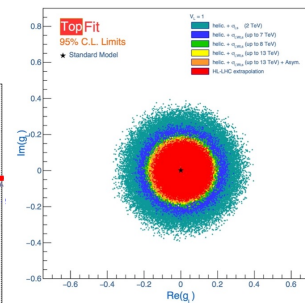
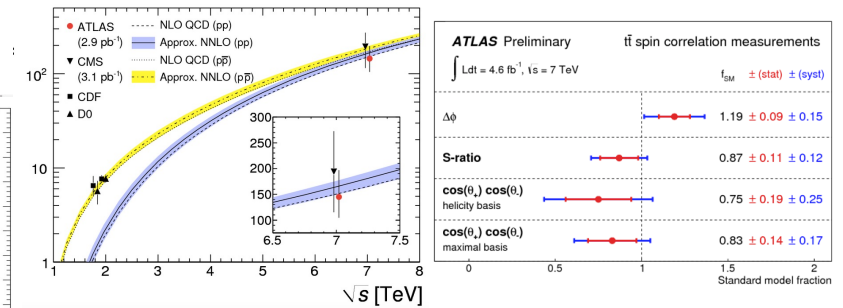
	Total	Stat.	Tot. (Stat. Syst.)
I-jets resolved	0.30	+0.43 -0.41	(+0.22 -0.21, +0.37 -0.34)
I-jets boosted	0.32	+0.61 -0.57	(+0.45 -0.42, +0.41 -0.38)
Dilepton	0.60	+0.69 -0.65	(+0.40 -0.39, +0.56 -0.52)
Inclusive	0.35	+0.36 -0.34	(+0.20 -0.20, +0.30 -0.28)

$\mu_{t\bar{t}H} = \sigma^{t\bar{t}H} / \sigma_{SM}^{t\bar{t}H}$



Top quark properties

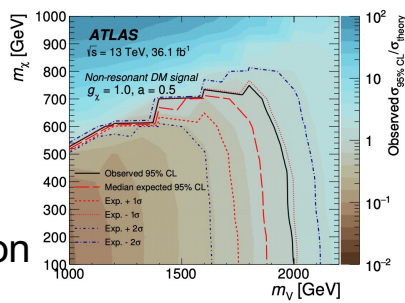
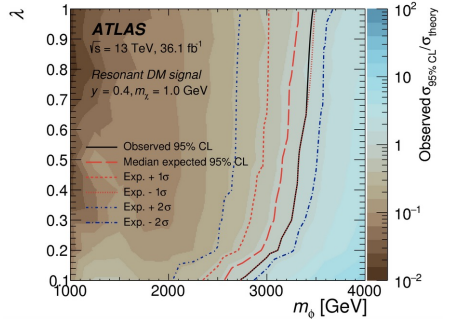
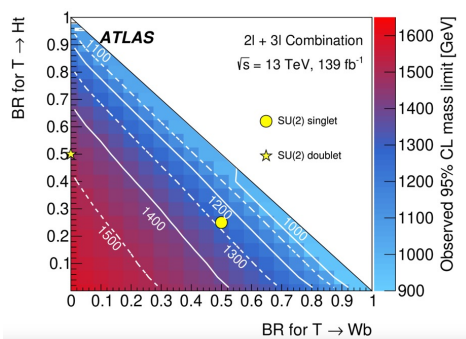
- Comprehensive program of property measurements
- Spin correlations, $t\bar{t}$ cross section, EFT interpretations



LIP contributions: ATLAS Physics Results

Search for vector-like quarks

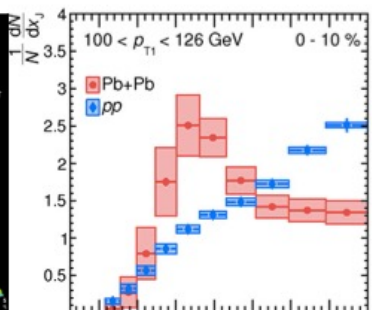
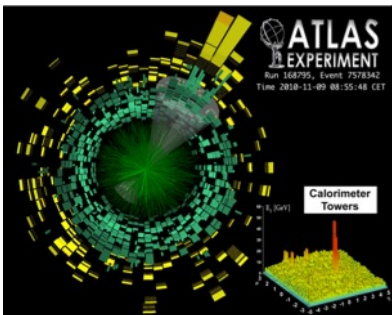
Leading role on searches for VLQs and interpretations



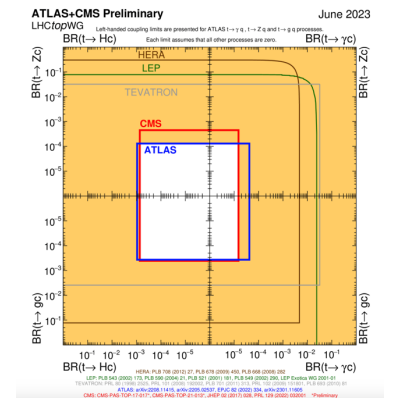
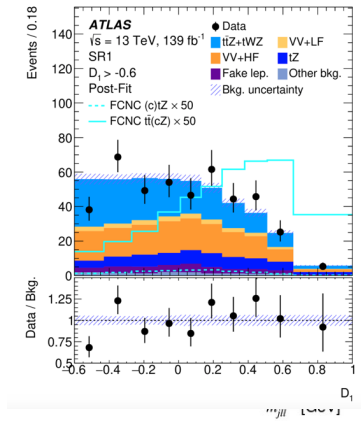
DM searches in monotop events

Heavy Ions

- jet production and fragmentation
- (b)-jet triggers
- b-tagging in HI collisions

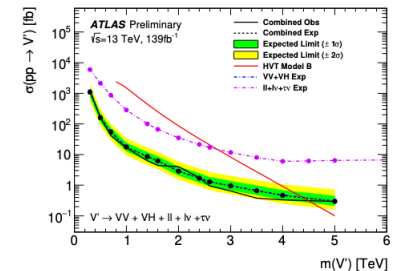
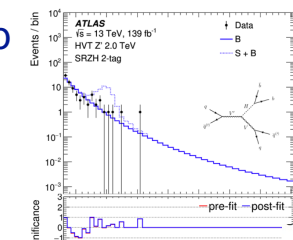


FCNC searches in top quark production and decay

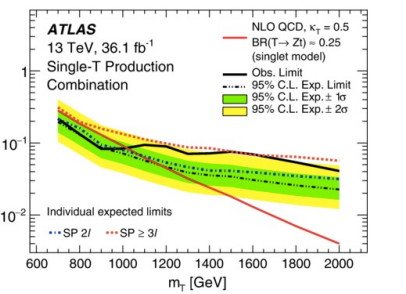
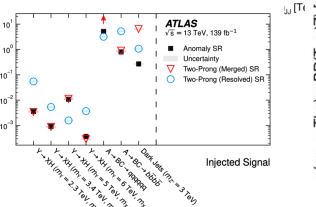


Di-boson searches

Led DBL subgroup



Model	Channel	Strategy	Limit	Reference
...

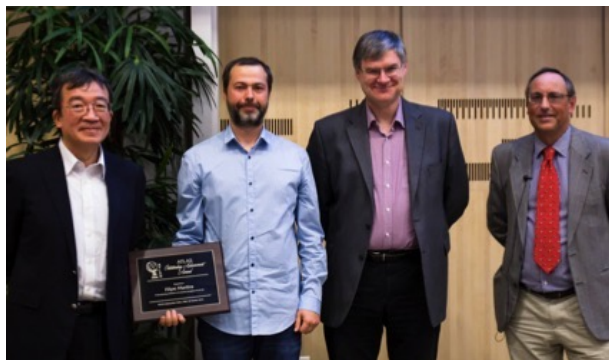


Publications, etc.: Statistics

Scientific Output

Type	ATLAS	CMS
Publications	328	413
Articles in international journals (with direct contribution from team)	117	114
Articles in international journals (with internal review by the team)	21	56
International Conference Proceedings	65	107
National Conference Proceedings	6	0
Collaboration notes with internal referee	96	107
Proposals and related studies	11	8
Articles in Outreach Journals	1	3
LIP Students Notes	11	18
Presentations	550	593
Oral presentations in international conferences	97	145
Poster presentations in international conferences	48	6
Seminars	80	152
Outreach seminars	148	59
Presentations in national conferences	50	41
Oral presentations in national or international meetings	40	93
Poster presentations in national conferences	18	3
Oral presentations in advanced training events	35	79
Poster presentations in national or international meetings	19	10
Student presentations in advanced training event	15	5
Theses	66	18
Master	48	8
PhD	18	10
Events	12	12
International Conferences or Workshops	7	7
Collaboration Meetings	2	2
Workshops	3	3

Awards for special contributions



F.Martins: Outstanding achievement award
TileCal for his contribution to TileCal DCS



CMS thesis award 2011, P.Musella (IST):
“Measurement of the inclusive photon production cross section and study of associated W-photon production in pp collisions at the LHC”

L.Carvalho: ATLAS PhD grant



J.Miguéns: ATLAS PhD prize



A.Peixoto: ATLAS PhD grant



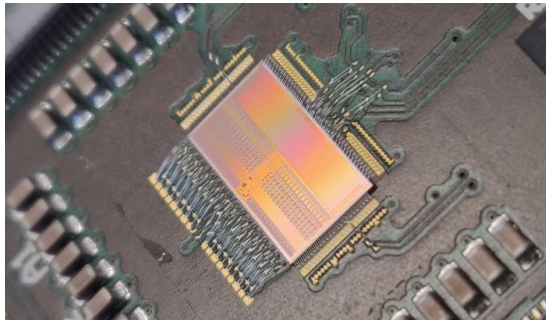
CMS achievement award 2014, M.Gallinaro:
”For his strenuous effort to assure the timely completion of the CT-PPS TDR and for the excellent coordination of its physics studies”

Awards for special contributions



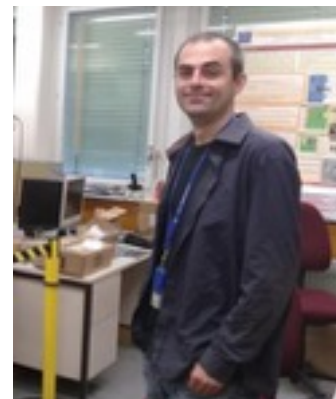
CMS Lifetime Achievement Award, J.Silva:
"For his outstanding contributions to the construction of the ECAL data acquisition and trigger systems"

CMS Gold Award 2023, PETSys:
Development of TOFHIR front-end ASIC for precise timing detector



CMS Achievement Award 2021, K.Schelina:
" For her contribution to the exclusive di-lepton analysis which has allowed important improvements of the PPS calibration. In her role as Proton POG co-convenor, she is contributing in an essential way to making the proton information available to analyzers outside the PPS community"

CMS Achievement Award 2021, T.Niknejad:
" for important simulation work in the development of the front-end chip for the Barrel Timing Layer readout"



CMS Achievement Award 2021, J.Hollar: " his role as PPS Deputy Project Manager; he has followed the data-taking, the calibration, as well as the ongoing analyses with inexhaustible energy, competence, and tact"



Coordination positions in ATLAS

- R. Gonçalo, Jet Trigger coordinator (2014-2015)
- R. Gonçalo, HGTD Speakers Committee member (2023-now)
- F. Martins, TileCal DCS coordinator (2015- now)
- H. Wolters, coordinator of the Iberian Cloud (2015- now)
- H. Wolters, responsible for the Portuguese Federated Tier2 in the Iberian Cloud Squad (2015- now).
- N. Castro, member of the ATLAS Speakers Committee (2020-2023)
- N. Castro, convener of the LHC EFT working group (2020-2022)
- N. Castro, member of the Physics Office (2016 - now)
- N. Castro, convener of the physics group Heavy Quark, Tops and Composite Higgs (2015-16)
- P. Conde, member of the Panel for Operations Task Sharing (2017-2020)
- P. Conde, member of the ATLAS Executive Board (2019-2021)
- P. Conde, member of the Collaboration Board Chair Advisory Group (2022-now)
- R. Pedro, TileCal Calorimeter Calibrations Coordinator (2019-2023)
- R. Pedro, TileCal Calorimeter Phase II Upgrade Software and Performance Coordinator (2023-now)
- I. Ochoa, Physics Validation Coordinator (2019-2021)
- I. Ochoa, Convener of the physics group Diboson, Multileptons and Extra Dimensions (2020-2022)
- I. Ochoa, Jet Trigger Signature Coordinator (2023-now)

- L. Seabra, ARP Deputy DCS coordinator (2022-now)
- L. Seabra, AFP DCS co-coordinator (2016-2022)
- L. Seabra, AFP DCS co-coordinator, ALFA DCS responsible (2015-now)
- H. Santos, Publications Committee member (2022-now)
- H. Santos, Authorship Committee member (2022-now)
- H. Santos, Tile Calorimeter Data Preparation and Performance Coordinator (2023-now)
- A. Peixoto, ATLAS Early Career Scientist Board (2018-2020)

Physics Analysis

Name	EdBoard member	EdBoard Chair	Contact Editor
N. Castro	1	3	2
F. Veloso	1	1	1
H. Santos	2	6	
R. Pedro			2
P. Conde	2	1	
I. Ochoa (since 2020)	1	1	2
R. Gonçalo	1	1	2
L. Carvalho			1
J. P. Araque	1		1
Total	9	13	11

Coordination positions in CMS

Group members have presently the following coordination positions in the CMS collaboration

- PPS Deputy Coordinator (Level-1), 2018-22 (J.Hollar)
- PPS Project Manager (Level-1), since 2022 (J.Hollar)
- ECAL Electronics Coordinator (Level-2), 2011-2023 (J.C.Silva)
- B-Physics Exotica and Rare Decays (ERD) coordinator (Level-3), since 2021 (A.Boletti)
- MTD/BTL electronics systems coordinator, since 2018 (J.Varela)
- MTD/BTL front-end electronics coordinator, 2018-2023 (J. C. Silva)

- CMS Collaboration Board (M.Gallinaro, J.Varela)
- CMS Finance Board (J.Varela)
- CMS Management and Executive Boards (J.Hollar)
- CMS Publication Board (N.Leonardo, P.Faccioli)
- ECAL, MTD, HGCal Institution Boards (J.Varela)
- PPS Institution Board (M.Gallinaro)
- MTD Steering Committee (J.Varela)

Group and its members regularly participate in paper refereeing in Analysis Review Committees (ARCs)

Event organization (a few of them)

22nd edition
PANIC Lisbon Portugal
Particles and Nuclei International Conference



PANIC2021 Conference
5-10 Sept 2021
Online
Europe/Lisbon timezone

Enter your search term



International Workshop on
BSM models in Vector Boson Scattering processes
4-5 December 2019, Lisboa, Portugal

BSM models in Vector Boson Scattering processes



IDTM
Innovative Detector Technologies and Methods

Lisboa
12-14 Sept 2023

Overview Call for Abstracts Timetable Contribution List Accommodation
Venue and practical information Book of Abstracts Registration Participant List

ATLAS WEEK
LISBON 10-14 OCTOBER 2022



Home Registration Timetable (restricted) Venue Getting to and around Lisbon Accommodation
Social Programme Public events Contacts Poster Participants

7th
ATLAS single top-quark workshop

10-12 December 2018
@ Instituto de Física
University of Minho
Braga, Portugal

https://indico.infn.it/event/784119

LIP INTERNSHIP PROGRAM
COIMBRA LISBOA MINHO

since 2012
COURSE ON PHYSICS at the LHC

6 March 2023 to 14 July 2023
Europe/Lisbon timezone


25 **ATLAS**

Discover the infinitely small

CELEBRATING THE 25TH ANNIVERSARY OF THE ATLAS EXPERIMENT AND THE CAREER OF AMÉLIA MAIO

16 OUT LISBOA - 17 OUT BRAGA - 18 OUT COIMBRA

REGISTER NOW: LISBOA BRAGA COIMBRA



BEACH 2018

Research Line Strategy Discussion #1: LHC Experiments and Phenomenology

Thursday 25 Mar 2021, 09:30 → 13:00 Europe/Lisbon

Liliana Apolinário (LIP), Michele Gallinaro (LIP)

CARREIRAS e TECNOLOGIA
na física de partículas

LIP Careers Day
Dia da carreira (LIP)
1 Março, IST
17:00 Anfiteatro Complexo Interdisciplinar

CERN Technology Day
Dia da Tecnologia (CERN)
2 Março, FCUL
17:00 Anfiteatro 8-2-30

À procura do bóson de Higgs

Quê é que vamos procurar?

- Os fétons provenientes do bóson de Higgs
- Os fétons com cargas opostas e do mesmo sabor (os $\gamma\gamma$ e $\mu\mu$)



É da luz se fez... Matéria!



sessão pública
FILME + DEBATE

UNE AVENTURE HUMAINE VERS L'INFINIMENT PETIT
PARTICLEFEVER
LA FIEVRE DES PARTICULES

IST, anfiteatro de Mecânica
4 de Julho - 18h

12th MPI at LHC

12th International workshop on Multiple Partonic Interactions at the LHC

11-15 Oct 2021
LIP Lisbon
Europe/Lisbon timezone

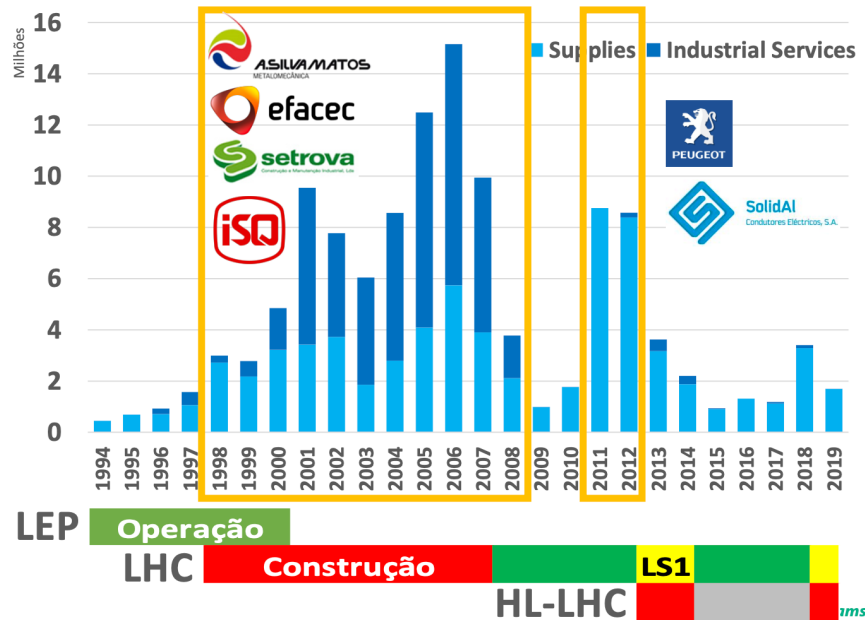
Enter your search term

M. Gallinaro - "LIP and the LHC experiments" - RECFA - September 2023

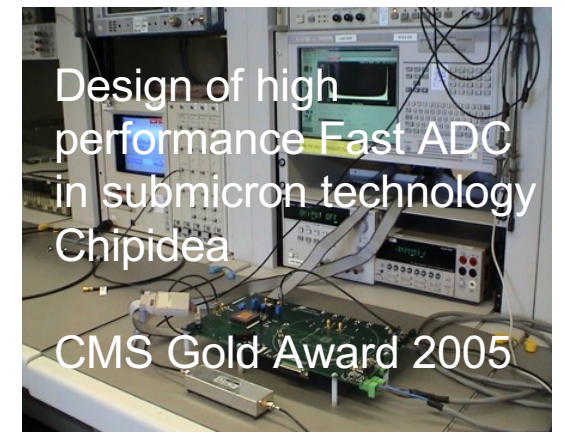
Participation of Portuguese Industry

Contribution to the Accelerator and the Experiments

See talk by José Antão



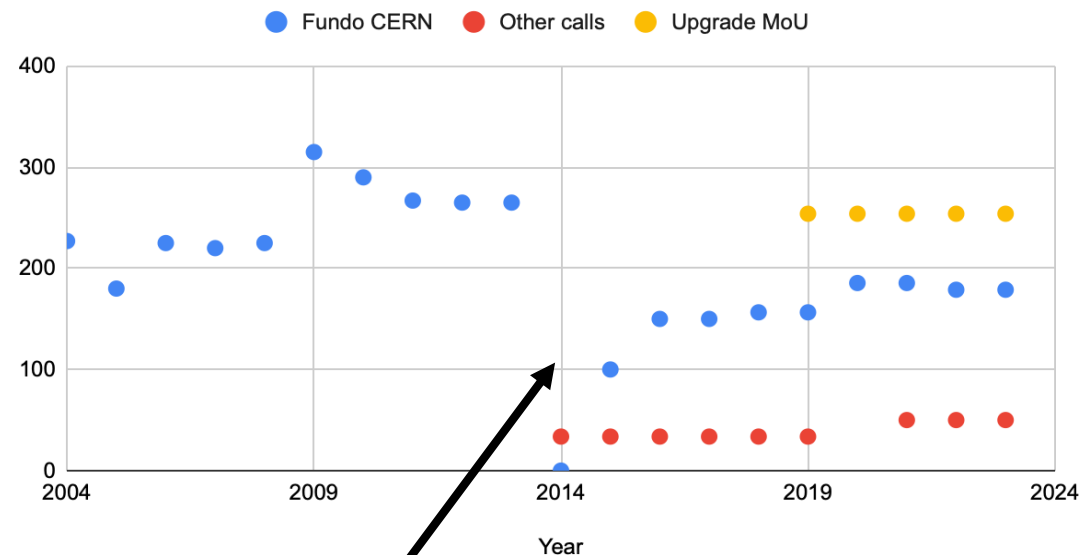
- Sales of services and goods by Portugal to CERN
- More than 100 entities



Funding

- “Fundo CERN”
 - Includes Operations & Upgrades
 - Includes some human resources: grants, etc.
 - Used for travelling, operations, conferences, prototypes, etc.
 - Essential funds to capitalize on MoU investment
 - Both scientifically and in industrial return
- Other funds: opportunistic resources
 - Grants associated to a PI, with dedicated resources for a specific topic
- In addition (for each expt, approx):
 - M&O funds: ~140k€/year
 - MoU for initial construction: 2.5M€
 - MoU for Phase-I (construction): 75k€
 - MoU for Phase-II (construction): 1.6M€/6years

Funding (kEUR) - ATLAS example



Last ECFA visit

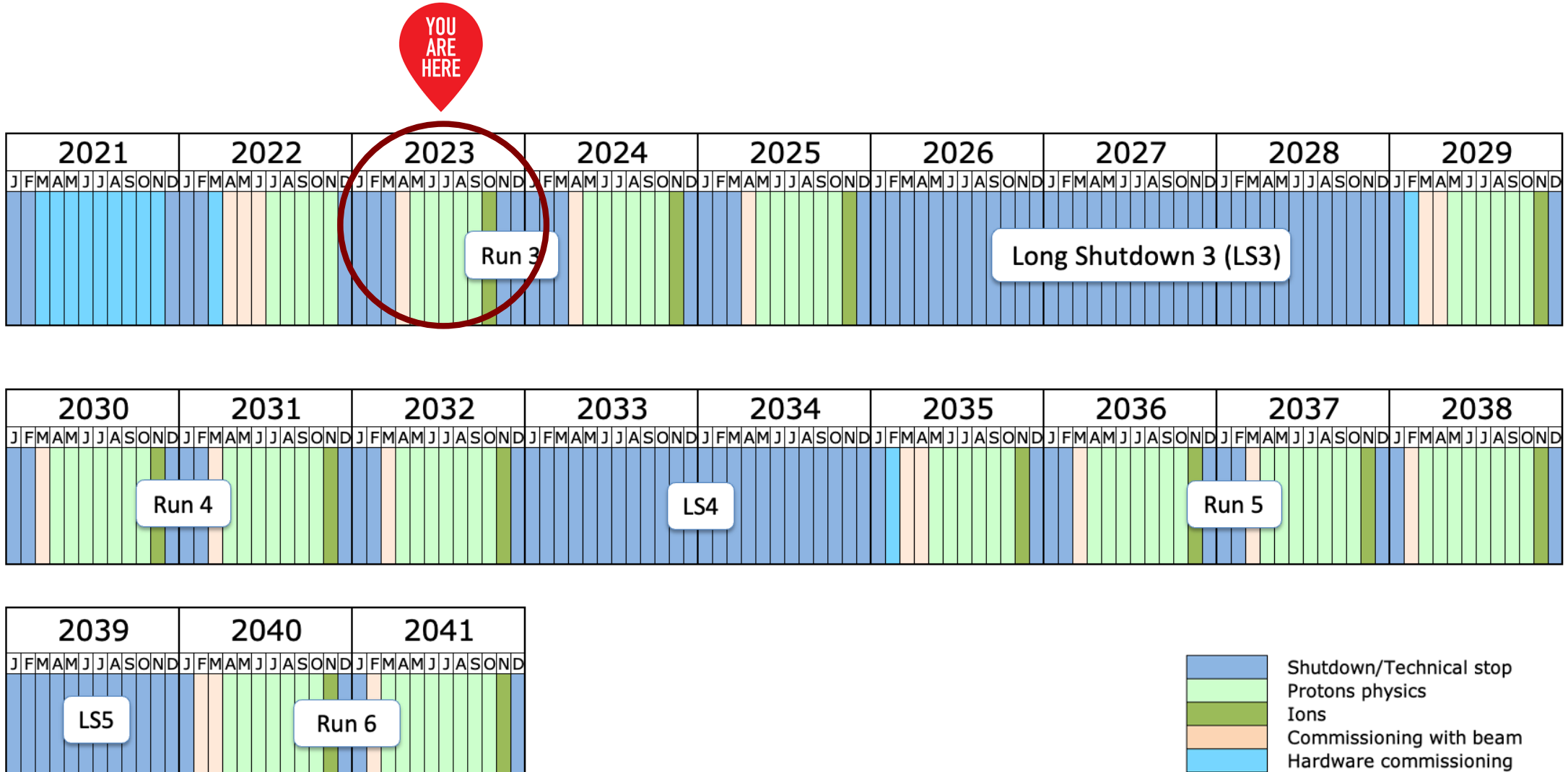
Funding: ATLAS (2003-)

code	name	funding	start date	end date	source	PI	co-PI	
POCTI/FNU/49527/2002	Collaboration in the ATLAS experiment at...	€227 000	21/03/2003	31/07/2004	FCT	Amélia Maio		ATLAS
POCTI/FP/FNU/50206/2003	Colaboração na experiência ATLAS	€180 000	04/07/2004	30/09/2005	FCT	Amélia Maio		ATLAS
POCI/FP/63422/2005	Colaboração na experiência ATLAS	€225 000	01/06/2005	30/09/2006	FCT	Amélia Maio		ATLAS
POCI/FP/63936/2005	Collaboration in the ATLAS experiment at...	€220 000	01/09/2006	31/08/2007	FCT	Amélia Maio		ATLAS
GRID/GRI/81727/2006	GRID para simulação e análise de dados d...	€140 000	12/04/2007	11/04/2011	FCT	João Carvalho		ATLAS GRID
POCI/FP/81934/2007	Collaboration in the ATLAS experiment at...	€225 000	01/07/2007	30/09/2008	FCT	Amélia Maio		ATLAS
POCI/FP/81940/2007	Sistemas de informação e aquisição de da...	€95 000	01/07/2007	30/06/2008	FCT	António Amorim		ATLAS TDAQ
CERN/FP/83551/2008	Collaboration in the ATLAS experiment at...	€285 000	01/10/2008	31/12/2009	FCT	Amélia Maio		ATLAS
CERN/FP/83515/2008	Information Systems and Data Acquisition...	€30 000	01/11/2008	31/10/2009	FCT	António Amorim		ATLAS
CERN/FP/109309/2009	Collaboration in the ATLAS experiment at...	€290 000	02/11/2009	31/12/2010	FCT	Amélia Maio		ATLAS
CERN/FP/116346/2010	Collaboration in the ATLAS experiment at...	€267 000	01/01/2011	31/03/2012	FCT	Amélia Maio		ATLAS
CERN/FP/123595/2011	Collaboration in the ATLAS Experiment at...	€530 000	01/04/2012	30/04/2014	FCT	Amélia Maio		ATLAS
IF/00955/2013/CP1172/CT0004	Expl. 2014 PM - IF/00050/2013/CP1172/CT0...	€50 000	01/12/2013	30/11/2018	FCT	Patricia Conde		ATLAS
IF/00050/2013/CP1172/CT0002	Expl. 2014 NC - IF/00050/2013/CP1172/CT0...	€50 000	01/01/2014	31/08/2018	FCT	Nuno Castro		ATLAS
EXPL/FIS-NUC/1705/2013	Estudo do bosão de Higgs em produção ass...	€49 485	07/04/2014	06/08/2015	FCT	Ricardo Gonçalo		ATLAS
FCG	Top Quark Flav. Chang. Neutral Currents ...	€10 000	01/01/2015	31/12/2015	LIPL	Nuno Castro		ATLAS
IF/01586/2014/CP1248/CT0003	Expl. 2015 HS - IF/01586/2014/CP1248/CT0...	€42 000	01/01/2015	31/12/2019	FCT	Helena Santos		ATLAS
CERN/FIS-NUC/0005/2015	Colaboração na Experiência ATLAS	€400 000	01/03/2015	30/06/2017	FCT	Patricia Conde		ATLAS
CERN/FIS-PAR/0008/2017	Collaboration in the ATLAS experiment	€313 000	01/07/2017	31/08/2019	FCT	Patricia Conde		ATLAS
CERN/FIS-PAR/0002/2019	Collaboration in the ATLAS Experiment at...	€180 000	01/09/2019	31/08/2021	FCT	Patricia Conde	Nuno Castro	ATLAS
CERN/FIS-PAR/0033/2019	ATLAS Upgrade 2019/20	€191 250	01/09/2019	30/09/2021	FCT	Ricardo Gonçalo	Agostinho Gomes	ATLAS
Fundação La Caixa - Inês Ochoa	Bolsa Pós-doc Progama Júnior Leader R...	€297 900	01/07/2020	27/11/2023	EU	La Caixa Inês Ochoa		ATLAS
CERN/FIS-PAR/0010/2021	Collaboration in the ATLAS experiment at...	€165 000	01/09/2021	31/12/2023	FCT	Fundo CERN Patricia Conde	Nuno Castro	ATLAS
CERN/FIS-PAR/0026/2021	C-ATLAS Upgrade 2021/23	€192 672	01/10/2021	30/09/2023	FCT	Fundo CERN Ricardo Gonçalo	Agostinho Gomes	ATLAS

Funding: CMS (2003-)

code	name	funding	start date	end date	source	PI	co-PI
RTN2-2001-00571	PRSATLHC	€166 320	01/03/2003	30/09/2006	EU	João Varela	CMS
POCTI/FNU/49481/2002	Collaboration in the CMS experiment at C...	€260 000	21/03/2003	31/07/2004	FCT	João Varela	CMS
POCTI/FNU/50131/03	Colaboração na Experiência CMS	€170 000	04/07/2004	30/09/2005	FCT	João Varela	CMS
POCI/FP/63434/2005	Colaboração na experiência CMS no CERN	€225 000	01/08/2005	30/09/2006	FCT	João Varela	CMS
POCI/FP/63922/2005	Collaboration in the CMS experiment at C...	€255 000	01/09/2006	31/10/2007	FCT	João Varela	CMS
POCI/FP/81930/2007	Colaboração na Experiência CMS do CERN	€260 000	01/09/2007	31/10/2008	FCT	João Varela	CMS
CERN/FP/83516/2008	Collaboration in the CMS experiment at C...	€290 000	01/10/2008	31/12/2009	FCT	João Varela	CMS
CERN/FP/109343/2009	Collaboration in the CMS experiment at C...	€300 000	01/11/2009	31/12/2010	FCT	João Varela	CMS
CERN/FP/116367/2010	Collaboration in the CMS experiment at C...	€277 000	01/01/2011	31/03/2012	FCT	João Varela	CMS
CERN/FP/123601/2011	Collaboration in the CMS Experiment at C...	€550 000	01/04/2012	31/03/2015	FCT	João Varela	CMS
IF/01454/2013/CP1172/CT0003	Expl. 2014 NL - IF/01454/2013/CP1172/CT0...	€50 000	01/01/2014	31/12/2018	FCT	Nuno Leonardo	CMS
IF/00772/2014/CP1248/CT0002	Expl. 2015 PB - IF/00772/2014/CP1248/CT0...	€50 000	01/01/2015	31/12/2019	FCT	Pedrame Bargassa	CMS
CERN/FIS-NUC/0029/2015	Colaboração na Experiência CMS no CERN	€400 000	01/04/2015	31/05/2017	FCT	João Varela	CMS
AMVA4NewPhysics - 675440	Advanced Multi-Variate Analysis for New ...	€238 356	01/09/2015	31/08/2019	EU	João Varela	CMS
CERN/FIS-PAR/0006/2017	Collaboration in the CMS experiment at C...	€345 000	01/08/2017	31/07/2019	FCT	João Varela	CMS
CERN/FIS-INS/0032/2019	Collaboration in the Phase 2 Upgrade of ...	€200 000	01/08/2019	15/09/2021	FCT	João Varela	Michele Gallinaro CMS
CERN/FIS-PAR/0025/2019	Collaboration in the operation and physi...	€200 000	01/08/2019	31/10/2021	FCT	Michele Gallinaro	Nuno Leonardo CMS
CERN/FIS-INS/0029/2021	Collaboration in the Phase 2 Upgrade of ...	€200 000	16/09/2021	15/09/2023	FCT	Fundo CERN João Varela	Michele Gallinaro CMS
CERN/FIS-PAR/0005/2021	Collaboration in the operation and physi...	€185 000	01/11/2021	31/10/2023	FCT	Fundo CERN Michele Gallinaro	Nuno Leonardo CMS
PTDC/FIS-PAR/1214/2021	Precision timing with forward protons ...	€248 366	01/01/2022	31/12/2024	FCT	PTDC Jonathan Hollar	Michele Gallinaro CMS
aAmuse - Project 101006726	aAmuse - advanced Muon Campus in US and ...	€115 000	01/01/2022	31/12/2025	EU	EU Michele Gallinaro	FCC

Long-term LHC schedule



Last update: April 2023

COMPASS and AMBER

Annual Report 2023

P&QCD

Participation in the COMPASS and AMBER experiments at CERN

Principal Investigator:
Catarina Quintans (100)

2 Researcher(s):
Marcin Stolarski (70), Pietro Faccioli (25)

1 Technician(s):
Christophe Pires (100)

1 Master Student(s):
Rita Silva (100)

3 Undergraduated Student(s) and Trainee(s):
Catarina Corte-Real, Guilherme Almeida, Guilherme Amaral

3 External collaborator(s):
Frantisek Voldrich, Márcia Quaresma, Sofia Nunes

Total FTE:
4 (PhD 2)

COMPASS/AMBER
Total FTE: 4 (PhD 2)

3 Researchers (1 permanent)
1 Master student
1 Technicians

Responsibilities

- DCS and Physics (LIP)
- Drift Chambers (Aveiro)

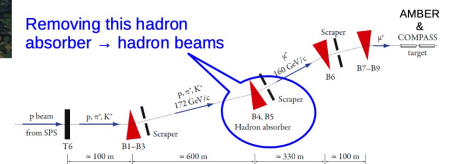
Analyses

- DY group coordination
- Hadron multiplicities
- Simulations DY@AMBER

Articles in international journals:	1 Direct contribution
Notes:	1 LIP Students note
International conferences:	3 Oral presentations 1 Proceeding
Nat. & Internat. meetings:	1 Oral presentation 1 Poster
Collaboration meetings:	4 Oral presentations
Advanced Training Events:	1 Student presentation
Completed theses:	1 MSc 1 BSc



M2 beamline:
The same beamline can provide muon and hadron beams



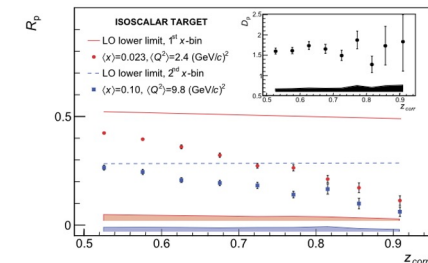
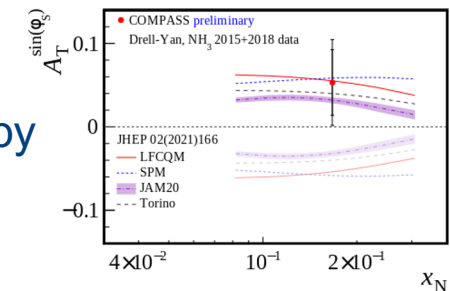
Hadron Structure and Spectroscopy

COMPASS:

- (Un)polarized TMD PDFs and GPDs
- Fragmentation functions

AMBER:

- Proton, pion and kaon charge radius
- Meson PDFs
- Meson spectroscopy (strange-sector)



Funding: COMPASS/AMBER (2003-)

code	name	funding	start date	end date	source	PI	co-PI
POCTI/FNU/49501/2002	Collaboration in the COMPASS experiment ...	€104 000	21/03/2003	31/07/2004	FCT	Paula Bordalo	P&QCD
010.6/B009/2005	I3HP - Hadron Physics Contrato	€252 000	01/01/2004	31/12/2008	EU	Paula Bordalo	P&QCD
POCTI/FNU/50192/2003	Collaboration in the COMPASS experiment	€110 000	04/07/2004	30/09/2005	FCT	Paula Bordalo	P&QCD
POCI/FP/63431/2005	Colaboração na experiência COMPASS do CE...	€120 000	01/05/2005	30/09/2006	FCT	Paula Bordalo	P&QCD
POCI/FP/63939/2005	Collaboration in the COMPASS experiment ...	€130 000	01/09/2006	31/10/2007	FCT	Paula Bordalo	P&QCD
POCI/FP/81973/2007	Collaboration in the COMPASS experiment ...	€150 000	01/07/2007	30/09/2008	FCT	Paula Bordalo	P&QCD
CERN/FP/83542/2008	Collaboration in the COMPASS experiment ...	€140 000	01/10/2008	31/12/2009	FCT	Paula Bordalo	P&QCD
CERN/FP/109323/2009	Collaboration in the COMPASS experiment ...	€150 000	01/11/2009	31/12/2010	FCT	Paula Bordalo	P&QCD
CERN/FP/116376/2010	Collaboration in the COMPASS experiment ...	€137 000	01/01/2011	31/12/2011	FCT	Paula Bordalo	P&QCD
CERN/FP/123600/2011	Collaboration in the COMPASS Experiment ...	€300 000	01/01/2012	30/09/2014	FCT	Paula Bordalo	P&QCD
CERN/FIS-NUC/0017/2015	Colaboração na Experiência COMPASS do CE...	€200 000	01/04/2015	31/05/2017	FCT	Paula Bordalo	P&QCD
CERN/FIS-PAR/0007/2017	Collaboration in the COMPASS experiment ...	€144 500	01/09/2017	31/08/2019	FCT	Catarina Quintans	P&QCD
CERN/FIS-PAR/0022/2019	Collaboration in the COMPASS and AMBER e...	€155 000	01/09/2019	30/09/2021	FCT	Catarina Quintans	Carlos Azevedo
CERN/FIS-PAR/0016/2021	COMPASS/AMBER_Colaboração nas Experiênci...	€165 000	01/10/2021	30/09/2023	FCT	Fundo CERN Catarina Quintans	Carlos Azevedo

N.B. Common funds are included

Considerations

- LHC represents an incredible scientific global network
- **Long term** commitment: LIP is contributing to the LHC experiments since the beginning (LoI, 1992)
 - Main source of funding is FCT
 - Contributions to detector construction and operations and physics results
 - Several PhD and young researchers have been formed
 - Researchers in **key positions**
- **Investment in the future** for a new generation of scientists
- However, many leave due to lack of stable positions, to higher paying jobs elsewhere, etc.

Concerns - I

Funding

- “*Fundo CERN*”
 - **Unstable**, we never know *how much* we have nor *when*
 - Current funding goes until October and new call not open yet
- Other funds not adequate for long-term projects
 - EU funds are explored for specific projects but cannot guarantee the **long-term** goals with stable participation
- Timescale of funding must **match timescale** of experiments
- Long-term plan requires **stable funding at regular intervals**
- Funding not matched to increasing prices



Concerns - II

Students

- PhD grants: IDPASC program finished
 - Last calls very successful to attract students (particularly for R&D and detector-related activities)
- Lack of continuation of this program threatens the possibility to attract new students

Researchers

- Difficulty in attracting researchers to Portugal
 - Project funding insufficient to pay for researchers (ECI)
 - ~yearly FCT call for 6-yr (**temporary**) positions in the last few years
 - Lengthy evaluation process (last year: call closed in Mar.2022, results in Dec.2022)
 - ...for this year, results are not out yet
- Need to assure support for qualified people with **permanent positions**

backup

ATLAS Physics Results: References

Searches and observation of the $H \rightarrow bb$ decays and VH production

- JHEP 1501, 069 (2015)
- JHEP 1712, 024 (2017)
- Phys. Lett. B 786, 59 (2018)

Searches and observation of ttH production

- Phys. Rev. D 97 (2018) 072016
- Phys. Lett. B 784 (2018) 173

ttH STSX measurement:

- Phys. Rev. D 106 (2022) 052001

Measurement of boosted $H \rightarrow bb$ decays

- Phys. Lett. B 816 (2021) 136204

Measurement of spin/CP properties of the ttH vertex (phenomenology and ATLAS measurements)

- Phys.Rev. D98 (2018) 033004
- Phys. Rev. D 96 (2017) 013004
- Phys. Rev. D 100, 075034
- J. High Energy Phys. 6 (2022) 097
- arXiv:2303.05974

Searches for vector-like quarks

- Phys. Rev. D 91 (2015) 112011
- J. High Energy Phys. 8 (2015) 105
- JHEP 1511 (2015) 120
- Phys. Rev. D 92 (2015) 112007
- Phys. Lett. B 758 (2016) 249-268
- Eur. Phys. J. C 76 (2016) 442
- Phys. Lett. B 843 (2023) 138019
- arXiv:2305.03401 (submitted to JHEP)
- arXiv:2307.07584 (submitted to PRD)

Studies and searches for FCNC in top quark production and decays

- Eur. Phys. J. Plus 135 (2020) 339
- J. High Energy Phys. 12 (2015) 061
- Eur. Phys. J. C76 (2016) 12
- J. High Energy Phys. 7 (2018) 176
- Phys.Rev.D 108 (2023) 3, 032019

Top quark properties

- Spin correlations -JHEP 03 (2017) 113
- W polarization in ttbar events- EPJC79 (2019) 19

EFT interpretation

- Eur. Phys. J. C. (2016) 76:432
- arXiv:2211.08353

Di-boson searches

- Phys. Rev. D 102, 112008 (2020)
- HDBS-2019-23, submitted to PRD (2023)
- ATLAS-CONF-2022-028

New Physics Searches in mono-top events

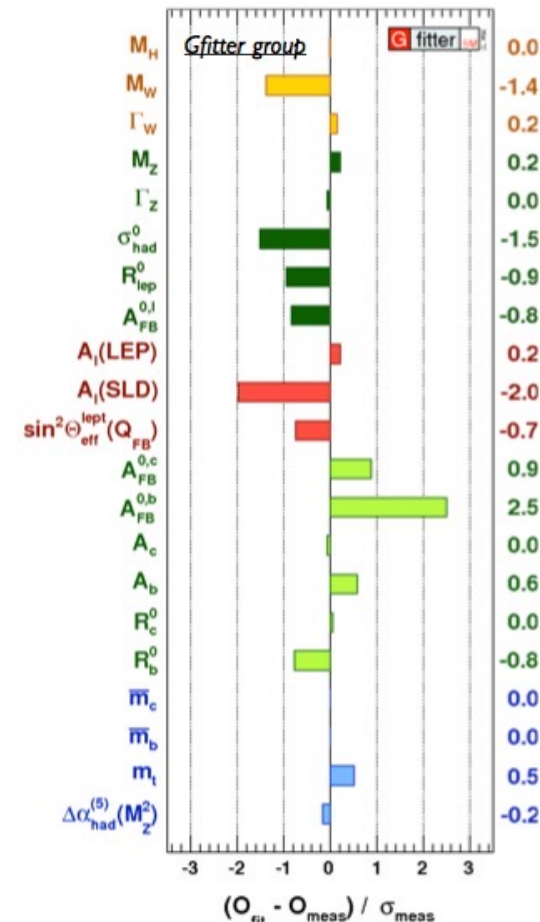
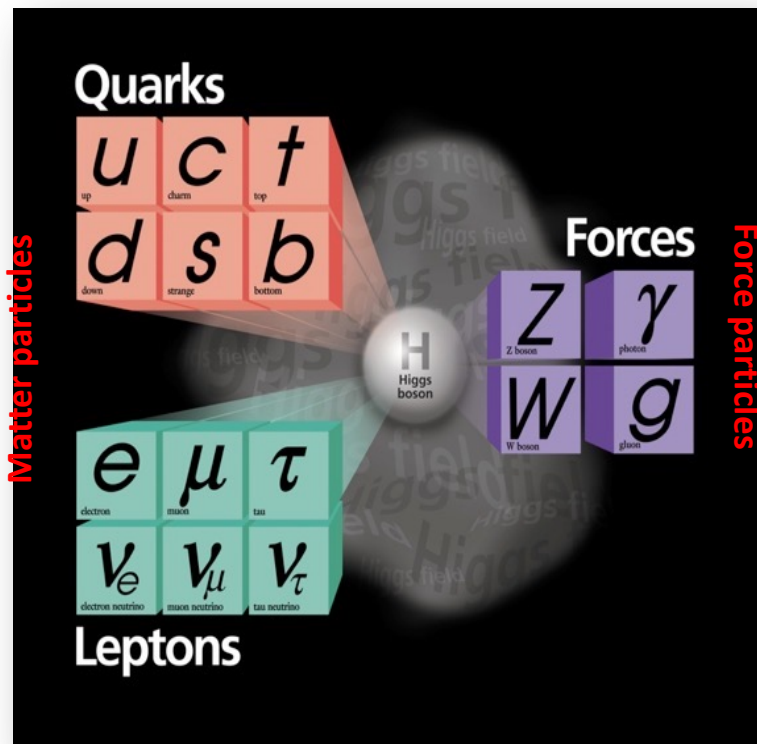
- JHEP10(2020)038,
- JHEP 05 (2019) 41
- ATLAS-CONF-2022-036
- Phys. Rev. D 101, 115027 (2020)
- Phys. Rev. D 101, 035042

Anomaly detection

- EPJC 81(2021)1,27

Standard Model of Particle Physics

Over the last ~100 years the Standard Model of Particle Physics was established



confirmed at <1% level

One of the greatest achievements of the 20th century in Science

The TeV scale and the LHC

- The SM would fail at high energy without the Higgs boson or other “New Physics”

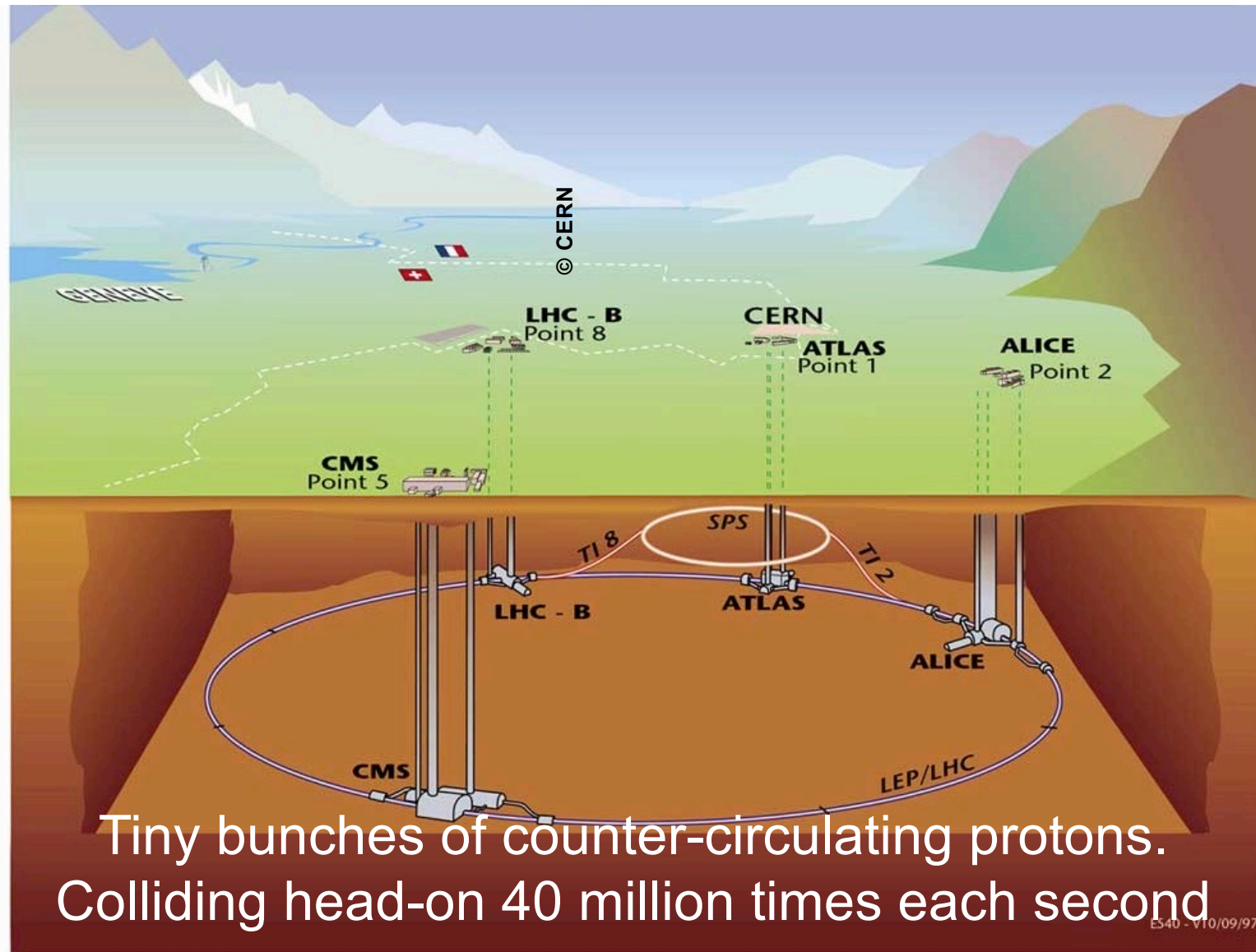


The Large Hadron Collider

- What are the elementary constituents of matter ?
- What are the forces that control their behavior at the most basic level?



Accelerator and experiment layout



Harvesting the results

LHC \Rightarrow the experiment \Rightarrow the data \Rightarrow results

