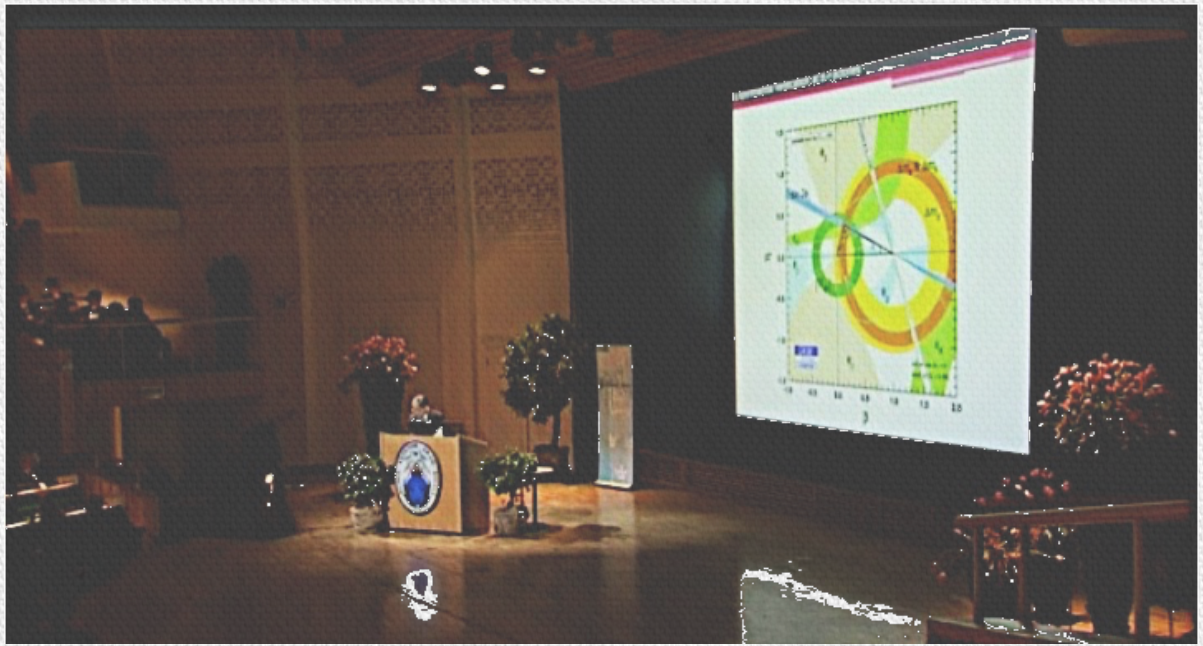
Laboratoire de Physique de Clermont

Pôle Univers & Particules

Physique des Saveurs



Flavor physics @ LPC

« L'avenir est un présent que nous fait le passé »

Historical thematic at LPC

- DM2 @ DCI
- ALEPH @ LEP
  EW & saveurs lourdes
  R_b, R_c, A^c_{FB}, A^b_{FB}, $D^{(*(*))}$, V_{ub}
  b-tagging, MLP NeuralNet (J.Proriol)

Cornelius multivariate toolkit (BaBar)➔ TMVA (root)

8.10.1 Booking options

The Clermont-Ferrand neural network

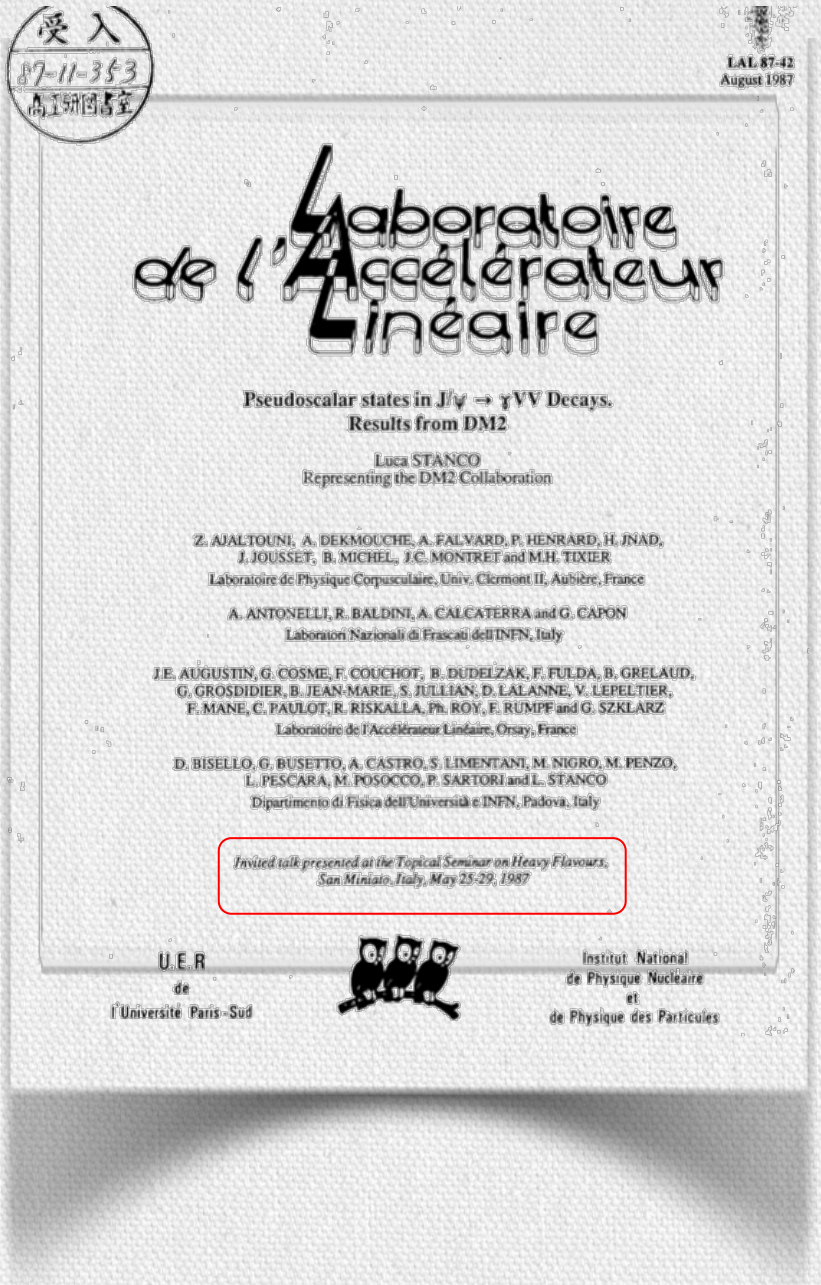
The Clermont-Ferrand neural network is booked via the command:

```
factory->BookMethod( Types::kCFMlpANN, "CF_ANN", "<options>" );
```

Code Example 46: Booking of the Clermont-Ferrand neural network: the first argument is a predefined enumerator, the second argument is a user-defined string identifier, and the third argument is the options string. Individual options are separated by a ':'. See Sec. 3.1.5 for more information on the booking.

The configuration options for the Clermont-Ferrand neural net are given in Option Table 17. Since

[29] The original Clermont-Ferrand neural network has been used for Higgs search analyses in ALEPH, and background fighting in rare B-decay searches by the BABAR Collaboration. For the use in TMVA the FORTRAN code has been converted to C++.



受入 87-11-363 高工研図書室

LAL 87-42
August 1987

Laboratoire de l'Accélérateur Linéaire

Pseudoscalar states in $J/\psi \to \gamma VV$ Decays. Results from DM2

Luca STANCO
Representing the DM2 Collaboration

Z. AJALTOUNI, A. DEKMOUCHE, A. FALVARD, P. HENRARD, H. JNAD, J. JOUSSET, B. MICHEL, J.C. MONTRET and M.H. TIXIER
Laboratoire de Physique Corpusculaire, Univ. Clermont II, Aubière, France

A. ANTONELLI, R. BALDINI, A. CALCATERRA and G. CAPON
Laboratori Nazionali di Frascati dell'INFN, Italy

J.E. AUGUSTIN, G. COSME, F. COUCHOT, B. DUDELZAK, F. FULDA, B. GRELAUD, G. GROSDIDIER, B. JEAN-MARIE, S. JULLIAN, D. LALANNE, V. LEPELTIER, F. MANE, C. PAULOT, R. RISKALLA, Ph. ROY, F. RUMPF and G. SZKLARZ
Laboratoire de l'Accélérateur Linéaire, Orsay, France

D. BISELLO, G. BUSETTO, A. CASTRO, S. LIMENTANI, M. NIGRO, M. PENZO, L. PESCARA, M. POSOCCO, P. SARTORI and L. STANCO
Dipartimento di Fisica dell'Università e INFN, Padova, Italy

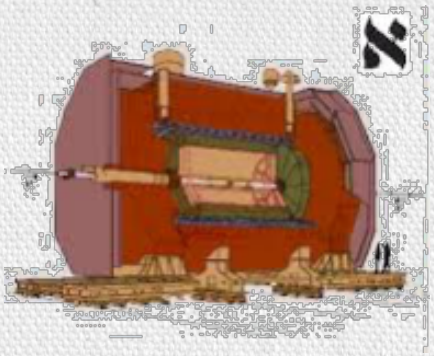
Invited talk presented at the Topical Seminar on Heavy Flavours, San Miniato, Italy, May 25-29, 1987

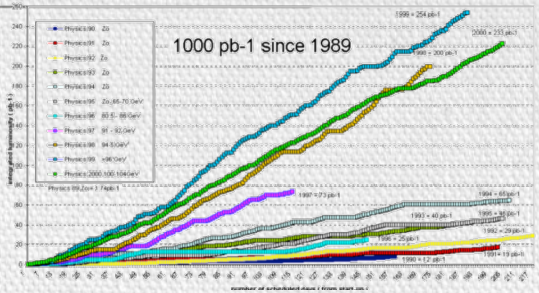
U.E.R de l'Université Paris-Sud

Institut National de Physique Nucléaire et de Physique des Particules

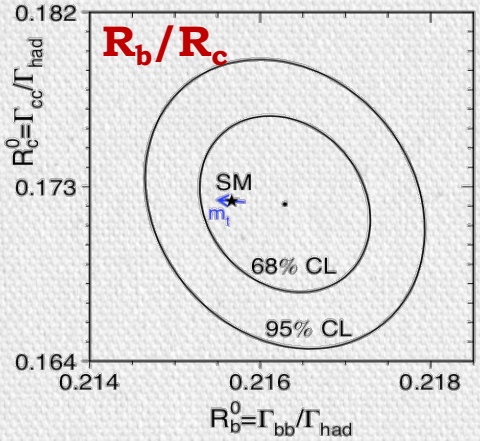
ALEPH @ LEP

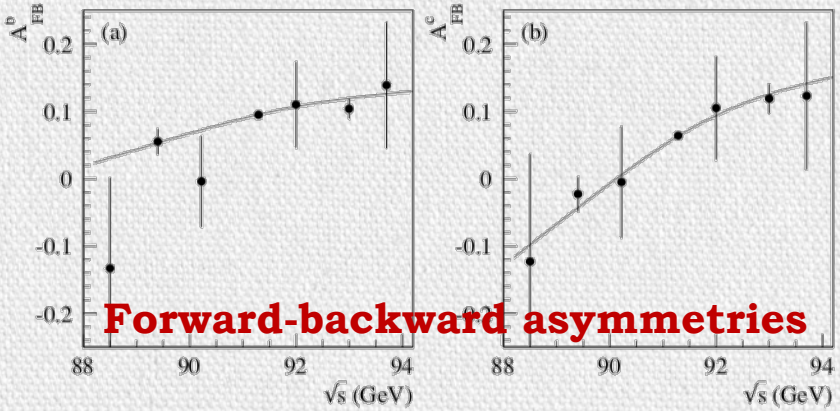
1989-2002



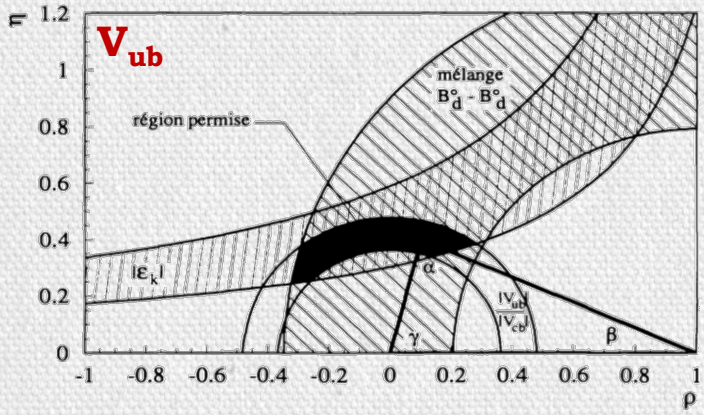


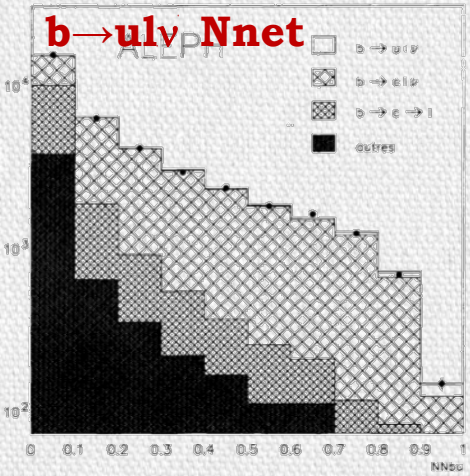
(c) S.Monteil HDR





(c) P.Rosnet thesis





LHCb @ LHC

LEGENDAIRE Depuis 1997

[2DR,2PR,3MCF]

2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029
Run 1 7-8 TeV, 0.7×10^{34} (μ≈20), 25 fb^{-1}			LS1		Run 2 13-14 TeV, 1.6×10^{34} (μ≈43), 150 fb^{-1}				LS2 Phase-I Install	Run 3 14 TeV, 2-3×10^{34} (μ≈50-80), 350 fb^{-1}			LS3 – Phase-II Install			Run 4 14 TeV, 5-7×10^{34} (μ≈140-200), 3000 fb^{-1}			LS4

Dedicated flavour experiment w/ wide physics spectrum

UT measurement, CP violation, rare decays & ind. NP search, spectrometry new baryon states, charm, tau physics,

Technical contribution @ LPC

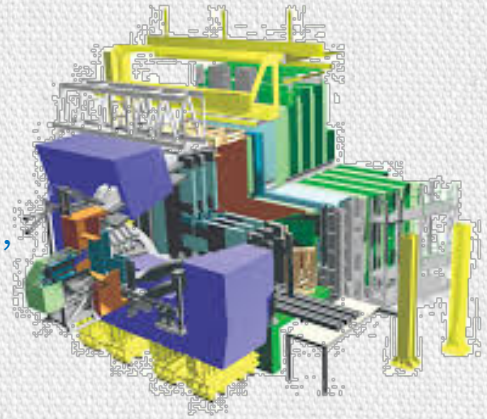
Preshower optics & readout (V)FE
Trigger decision Unit, Calorimeters software
at the origin of micro-elec @ LPC

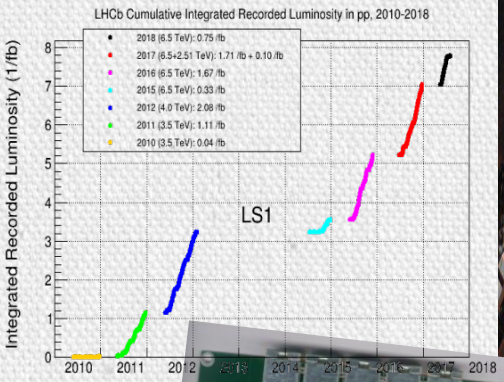
Run1&2 analysis @ LPC

Charmless, radiative, semi-leptonic decays of b-hadrons. T-violation phenomenology

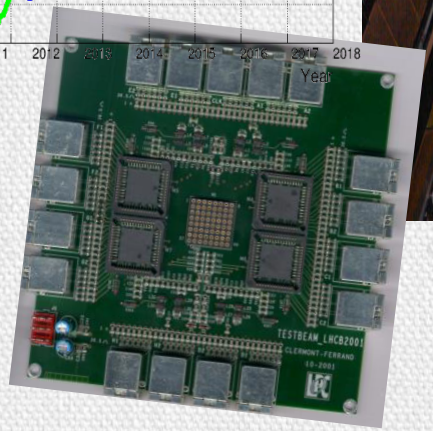
Near future

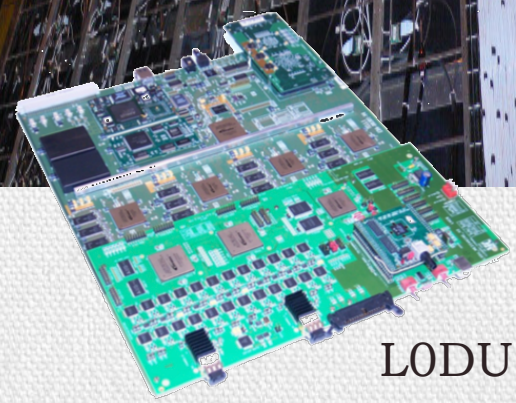
Upgrade 1
SciFi tracking readout





PS VFE





L0DU

[CPPM,LAL,LAPP,LPC,LPNHE]

CKMFitter

Since 2005

[1DR,2PR,1MCF]

Phenomelogy studies

Global CKM fit combining B and K data.
Coherence tests. Observable prediction.
Prospective studies. Interpretation in NP scenario

Exp./theorist collaboration

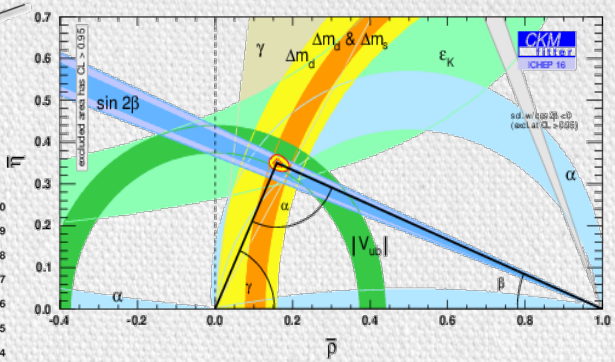
~15 members from LHCb, Babar, Belle(II) + LPT / CPT / LPC theorists
Secondary activity for all members

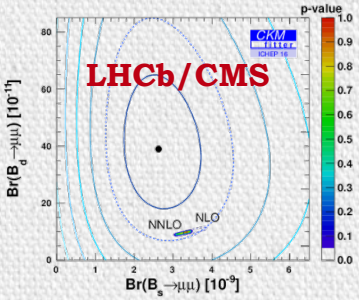
Technical contribution @ LPC

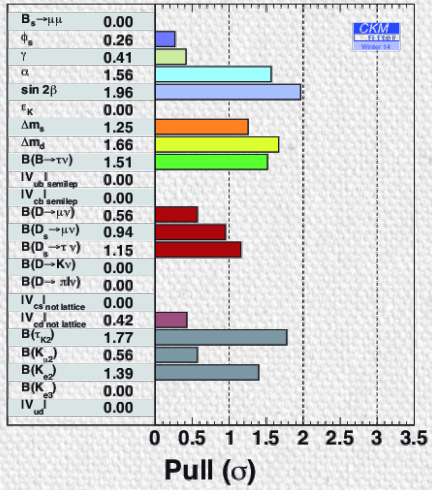
CKM live

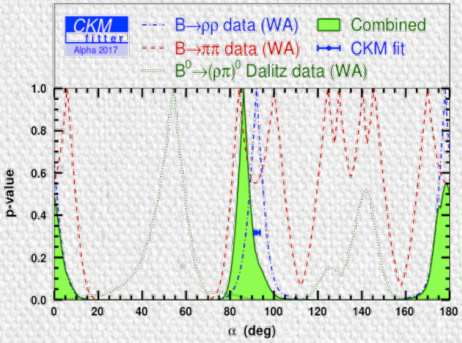
[CPT,LAPP,LPC,LAPP LPNHE, LPT]

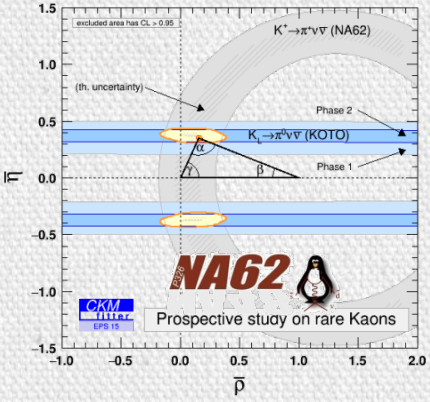
University of California, San Diego CKM 2005

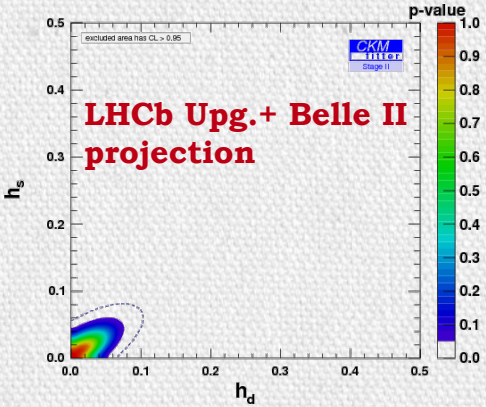


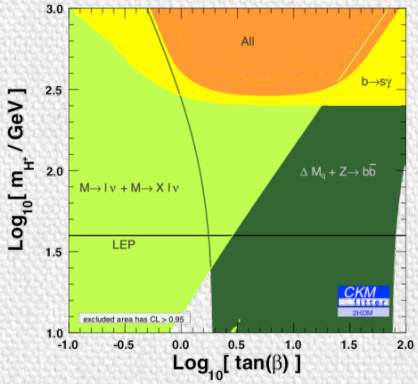












SoLid @ Mol

[2DR, 1PR, 1MCF, 1 IR]

Search for Oscillations with a ^{6}Li Detector

(very) short baseline neutrino experiment aimed at searching for small distance oscillation patterns of $\bar{\nu}_e$ issued from a nuclear reactor.

The $\bar{\nu}_e$ are detected from their inverse β–decay in a granular scintillating device. The detector technology is a PVT scintillating cube (for the positron signal) supplemented with two thin layers of ZnS scintillator doped with 6Li (for the neutron signal).

It is installed at the 95% pure 235U fuel experimental reactor BR2 in Mol (Belgium).

About 50 physicists from UK, Belgium and France.

History in Clermont:

Expression of Interest to join SoLid collaboration in Summer 2016

Acceptation by the Collaboration in October 2016.

LPC scientific council hold in January 2017 (group's birth date).

Members: S. Binet, D. Boumediene, H. Chanal, P. Crochet, S. Monteil

Main instrumental realisations:

Design, tests and construction of the 207Bi calibration head (opt. system).

Radon detector to control the airborne BiPo background.

Environmental sensors to monitor the physical conditions of the DAQ.

DAQ software survey.

Main Physics / reconstruction contributions:

Definition of topological categories of the electromagnetic signal

Energy reconstruction: from fibres to cube signals.

Reconstruction of the two annihilation gammas (algorithm for).

cnrs IN2P3 Les deux infinis

[LAL, LPC,LPCc,Subatech]

Search for Oscillations with a ^{6}Li Detector

Miscellanea:

Laureate of the UCA Emergence call (20 kE).
Organisation of a collaboration week in Clermont (March 2018).
Participation to shifts.
Collaboration web site (A. Claude).

Timeline

The experiment takes data steadily since January 2018.
First Physics paper can be reasonably envisaged at the end of 2018.
The data taking is foreseen for three full years. A good opportunity for a PhD.
Final publication: around 2023.

Perspectives

The Physics program is well-contained in time.
We are trying (and succeeding to imo) to make a difference.

There is no anticipation by members of the group to have a continuation of this activity beyond the baseline program. This statement might / must be revised if the search is positive.

Flavor physics @ LPC

Experiments : LHCb, Solid + Alice (quarkonia) + Atlas (top)
+ FCC-ee (Flavour physics WG – Stéphane)

Phenomenology : CKMFitter

Theory : Invisibles ITN (http://invisibles.eu)
Comet (http://comet.kek.jp/Introduction.html), …
Lattice

13 Chercheurs permanents du LPC (5 CNRS+8UCA)
Thématique principale pour 11 / 7 contribuent à plusieurs projets
Effectif stable (et vieillissant) sur les 20 dernières années
Aucun recrutement sur toute la phase 1 de prise de données de LHCb

Evaluation LPC - CS 2014

"For its first overview of the research in particle physics at the LPC, **the committee was further struck by the coherent interest in flavour physics** weaving links between all presentations of the first day: from neutrino and BSM phenomenology, to the special role of heavy quarks in Lattice QCD developments as well as in the ALICE program for the quark-gluon plasma, or LPC-ATLAS' focus on the top quark, through of course LHCb's and CKMfitter's central interests. **Such widespread coherence around flavour physics is quite unique among HEP laboratories**, and could be used by the LPC, both as an identifying flagship to the outside, and as an inside **source of inspiration for original collaborations between various groups.**"

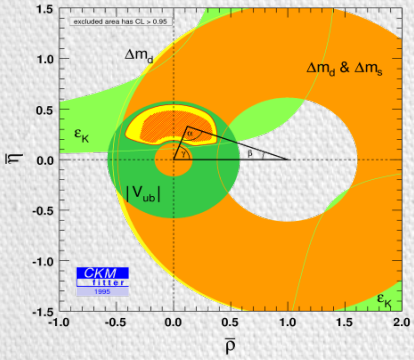
IN2P3 support

- GDR neutrino http://gdrneutrino.in2p3.fr/
  « Beyond the SM WG » - Ana
- GDR intensity frontier http://gdrintensityfrontier.in2p3.fr
  « Future experiment WG » – Stéphane
  « Lepton / Quark flavour interplay WG » - Ana

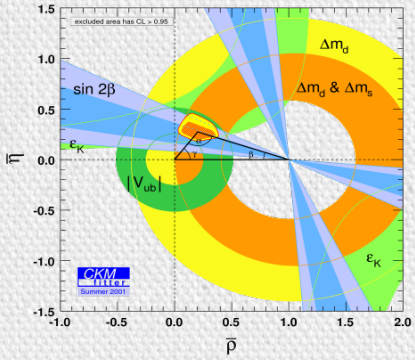
GDR-INF Input for the European Strategy for Particle Physics in preparation

Flavor Physics : CKM metrology - state of the art

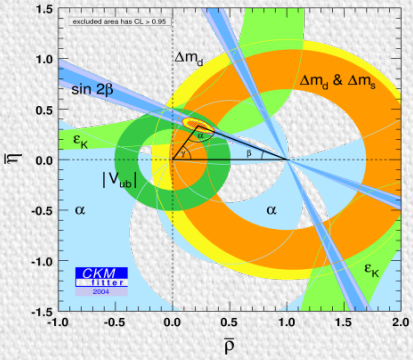
1995 : CDF, LEP, CLEO



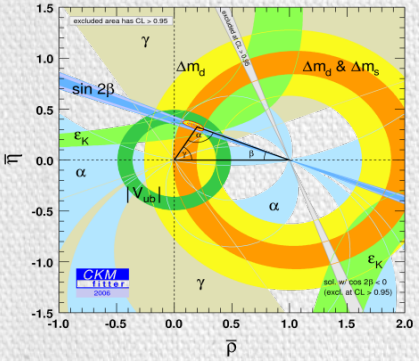
2001 : the B-factory era



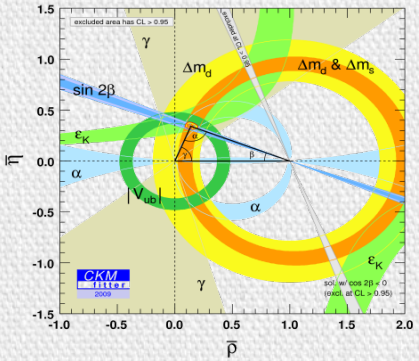
2004 : adding charmless



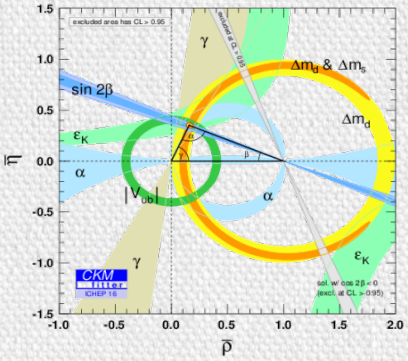
2006 : B_s oscillation at CDF



2009 : B-fact. legacy (σ_J/J~5%)



Now : LHC(b) era (σ_J/J~2%)



Global consistency of all the observables

The KM mechanism is the dominant source of CP violation in the B and K systems

5% precision on UT apex

$$\begin{pmatrix} \bar{\rho} \\ \bar{\eta} \end{pmatrix} = \begin{pmatrix} 0.1598^{+0.0076}_{-0.0072} \\ 0.3499^{+0.0063}_{-0.0061} \end{pmatrix}$$

$$A = 0.8250^{+0.0071}_{-0.0111}$$

$$\lambda = 0.22509^{+0.00029}_{-0.00028}$$

2% on Jarlskog invariant

$$J_{CKM} = (3.099^{+0.052}_{-0.063}) \times 10^{-5}$$

Impressive progresses from both experimental and lattice QCD sides

Imagine if Fitch and Cronin had stopped at the 1% level, how much physics would have been missed – A.Soni

Flavor Physics : Lepton Flavor Universality anomalies

Recent heavy flavour data exhibit intriguing anomalies related to the assumed Lepton Flavour Universality (LFU).

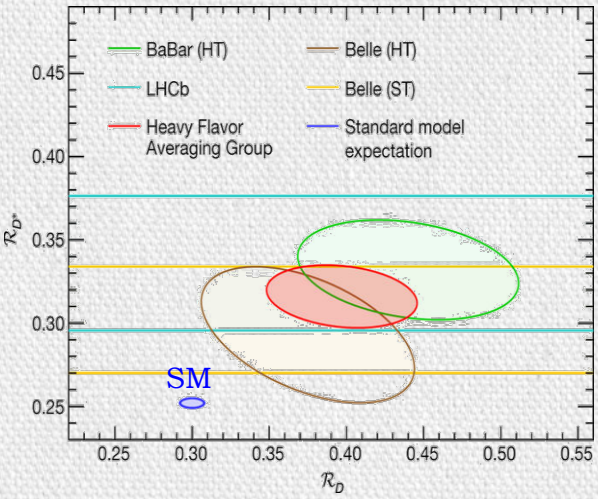
Anomalies accumulate in **several** semi-leptonic decays, both

Tree-level Charged currents : $B^- \to D^{(*)} l^- \nu$ ($l = \tau/e,\mu$)

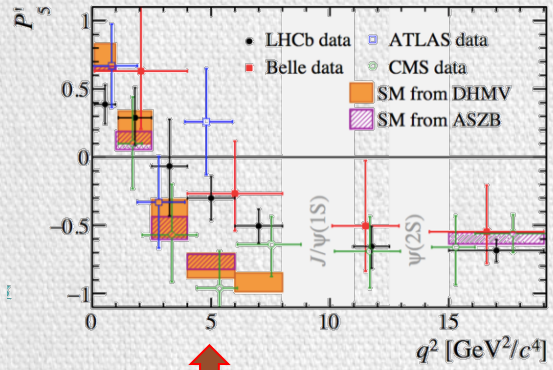
Flavour-Changing Neutral currents : $B^0 \to K^{(*)} l^+ l^-$ ($l = e/\mu$)

None of the single anomaly is large enough to claim for a non-standard observation; But taken together they seemingly provide a coherent set of deviations from SM expectation.

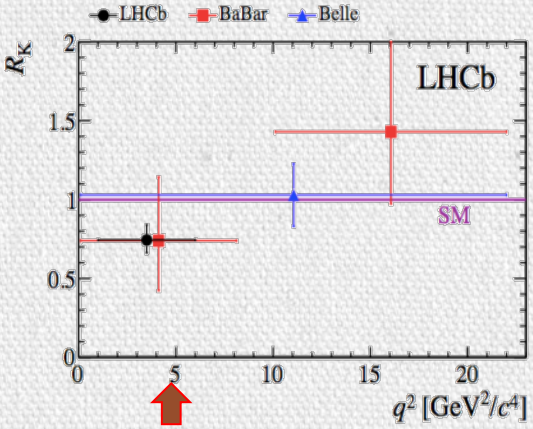
World-average R_D versus R_{D^*}



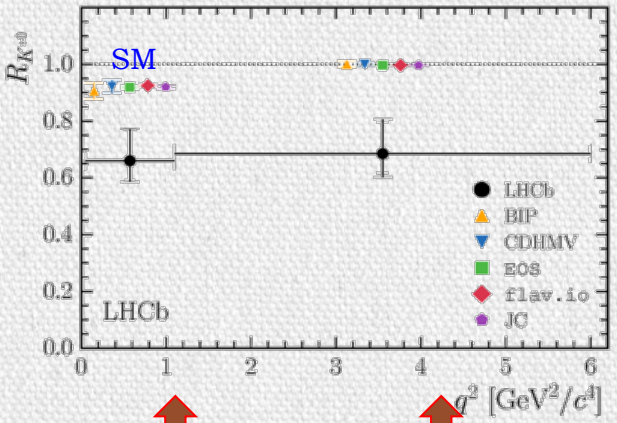
4σ deviation from SM



+3.0σ



-2.6σ



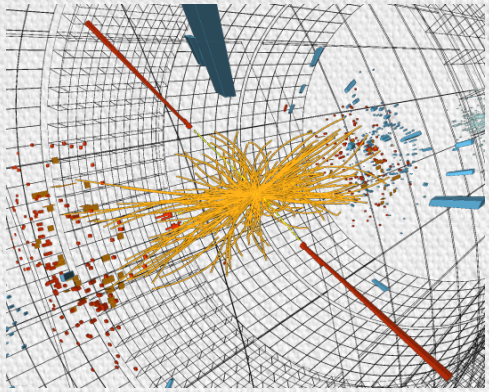
-2.1σ -2.3σ

Flavor Physics : the intensity frontier

Direct search

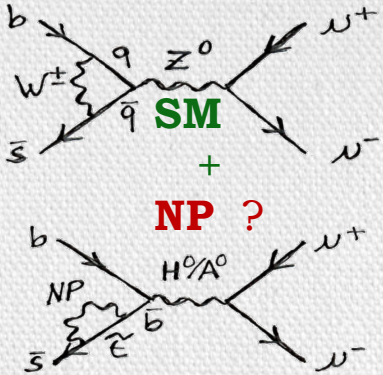
Energy limited

$E=MC^2$

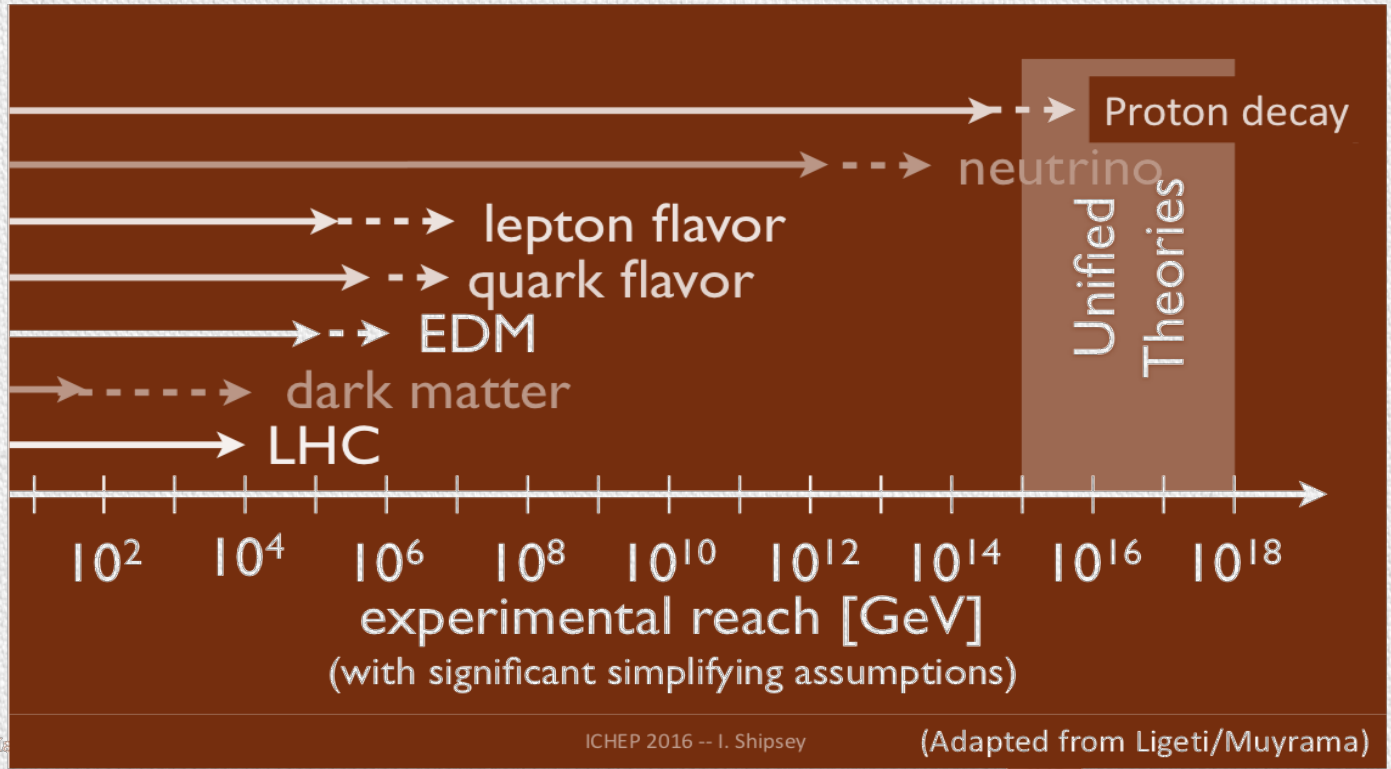


Indirect search

Intensity limited

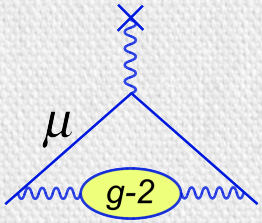


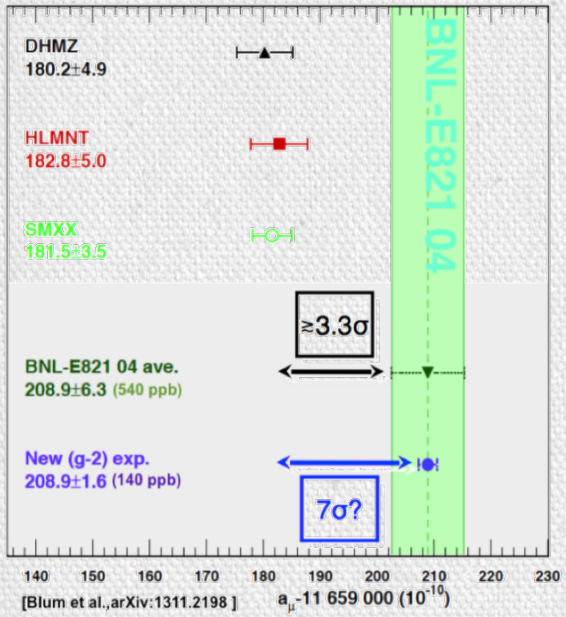
The next decade: the power of quantum loops



Other (lepton flavour conserving) loop effects

Muon Anomalous Magnetic Moment



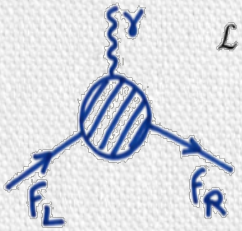


E989 @ FNAL : 140 ppb (2020)

E34 @ JPARC : 340→100 ppb (>2021)

[LPNHE,CCIN2P3]

Electric dipole Moment
CP violation



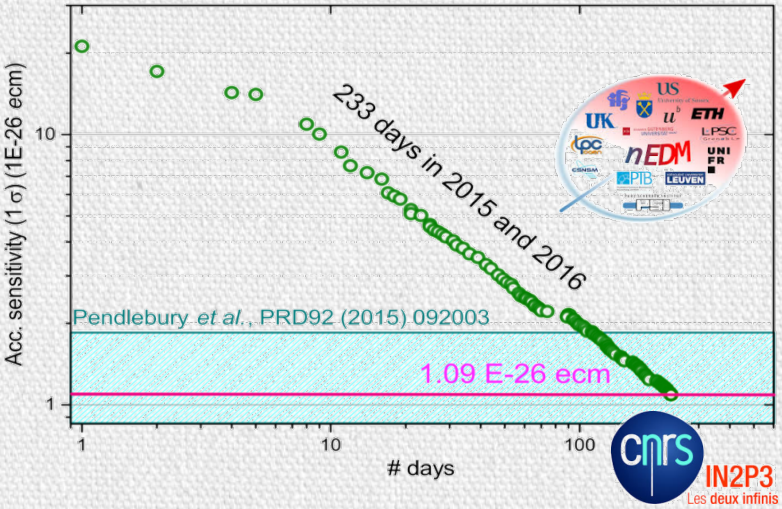
$$\mathcal{L} = -\frac{id}{2}\bar{f}\sigma_{\mu\nu}\gamma_5 f\, F^{\mu\nu}$$

$$\rightarrow \hat{H} = d\,\hat{\boldsymbol{\sigma}}\boldsymbol{E}$$

Leptons

EDM (e cm)	Current bounds	Future sensitivity
$\lvert d_e \rvert$	8.7×10^{-29} [ACME]	$\mathcal{O}(10^{-30})$ [ACME]
$\lvert d_\mu \rvert$	1.9×10^{-19} [Muon g-2]	$\mathcal{O}(10^{-21})$ [g-2/EDM Coll.]
$\lvert \mathrm{Re}(d_\tau) \rvert$	4.5×10^{-17} [Belle]	–
$\lvert \mathrm{Im}(d_\tau) \rvert$	2.5×10^{-17} [Belle]	–

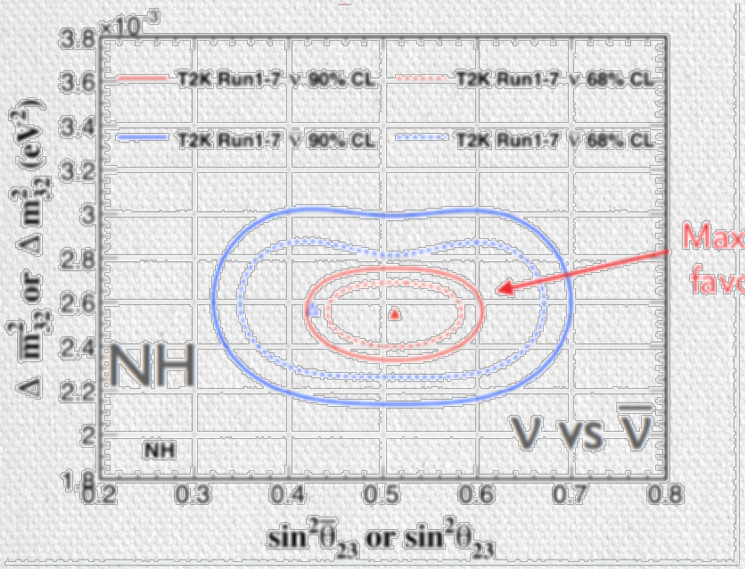
Neutrons



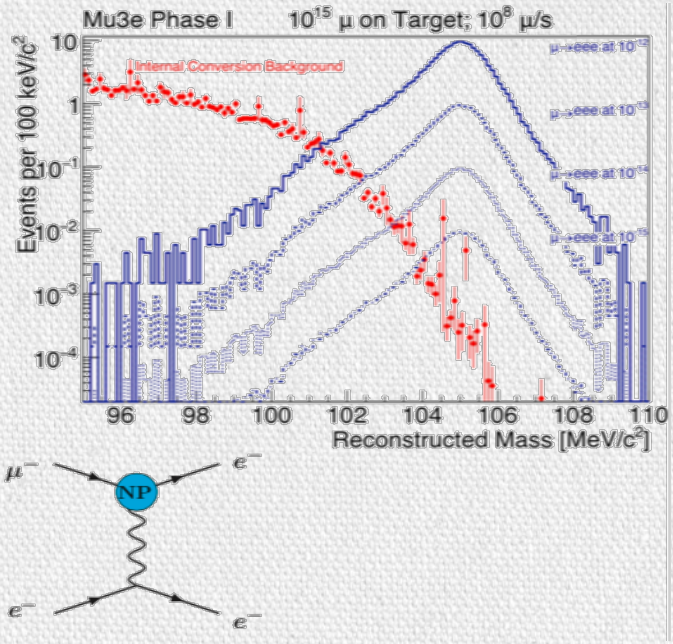
[LPCc,LPSC,CSNSM]

Lepton Flavour Violation

Neutrinos



Charged



Osc., mixing & CP : Δm^2, θ_{ij}, δ_{CP}

absolute mass, mass origin, 4th family

	present	*(near) future*
SBL	D-Chooz, Reno, Daya Bay	Juno (2020), **Solid**, Stereo
LBL	T2K , Opera, Minos(+), Nova	Dune, HK
	Antares,SuperNemo,Kamland	KM3Net/Orca, Lucifer

	present	*(near) future*
μ→eγ	MEGII	
μ→eee		Mu3e (PSI, 2018)
μN→eN		Mu2e (FNAL, 2019), **Comet**

Prospectives in flavour physics

Large facilities with a wide physics program

Belle II, LHC Upgrade I, HL-LHC

Beam dump experiments at SPS

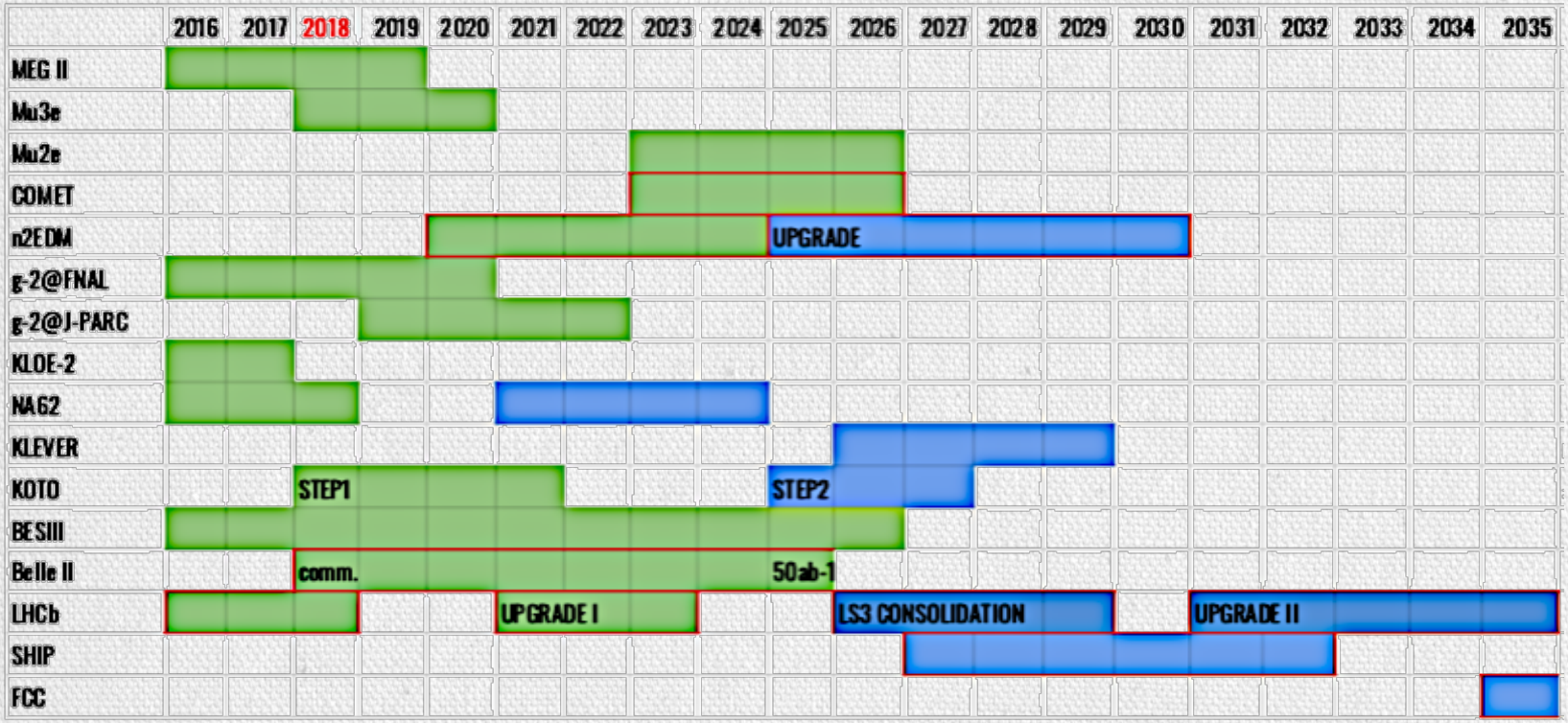
Longer term future colliders

ee: FCCee (Flavour physics WG – Stéphane), CEPC, ILC, CLIC

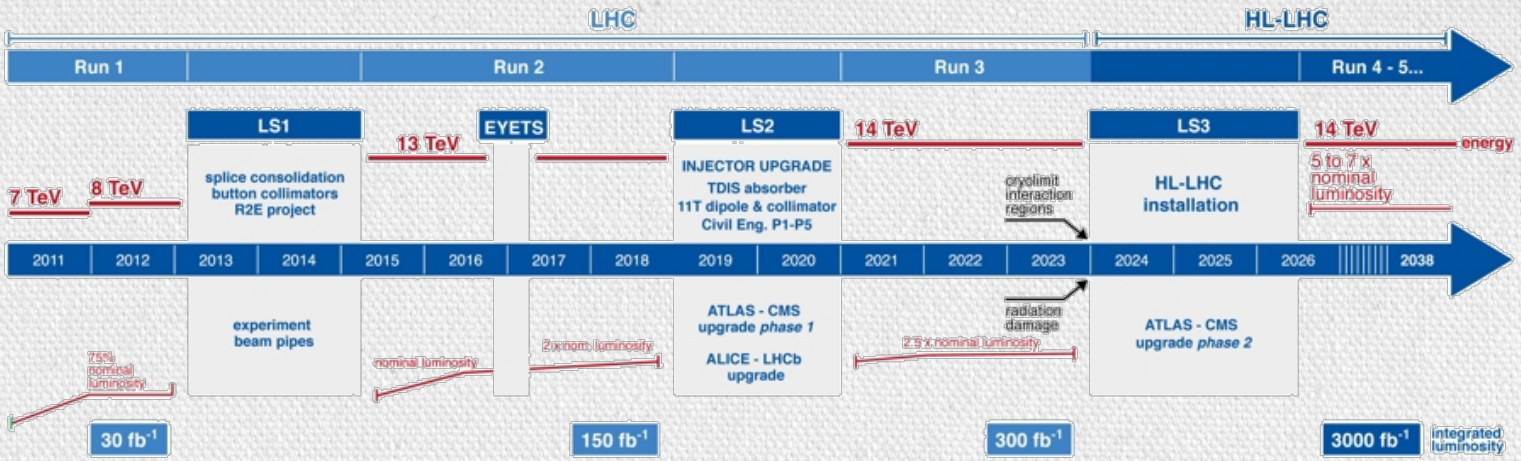
pp: HE-LHC, SppC, FCC-hh

Small scale experiments dedicated to specific relevant measurements

EDM, g-2, lepton flavor violating experiments



LHC / HL-LHC Plan



LHCb run3 (2021-2023), run4 (2026-2029)

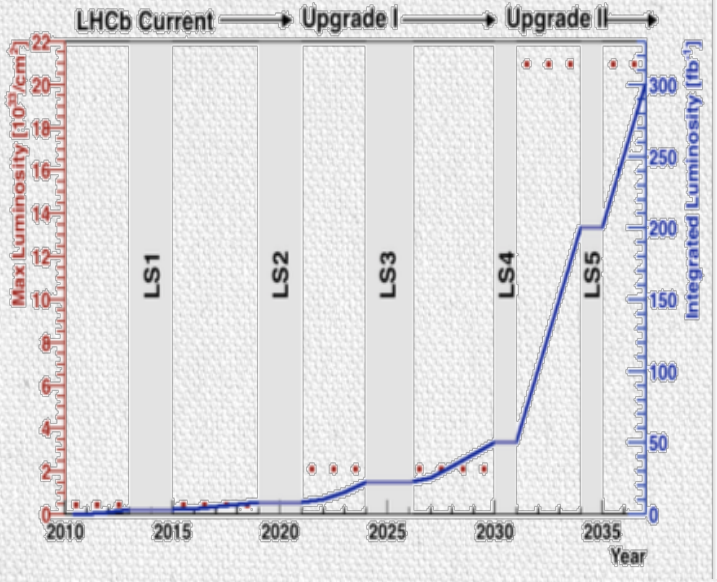
$L = 2 \times 10^{33}$ cm-2s-1, integrated 50fb^{-1}

LHCb run5 (2031-...)

Upgrade II EOI in preparation

$L = 2 \times 10^{34}$ cm^{-2}s^{-1}, integrated 300fb^{-1}

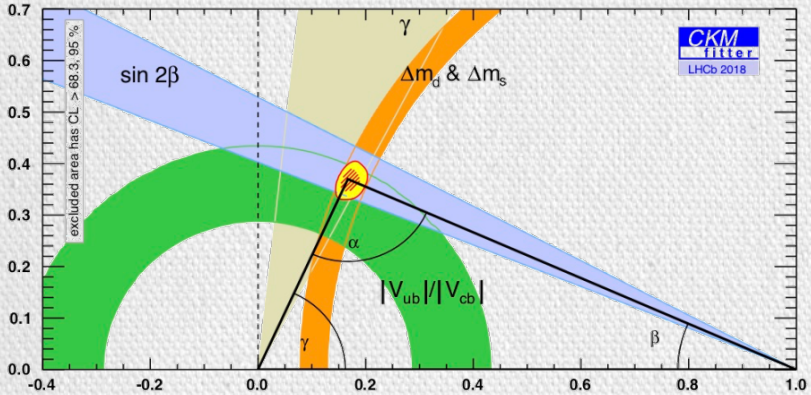
May be only general heavy flavour experiment on this timescale



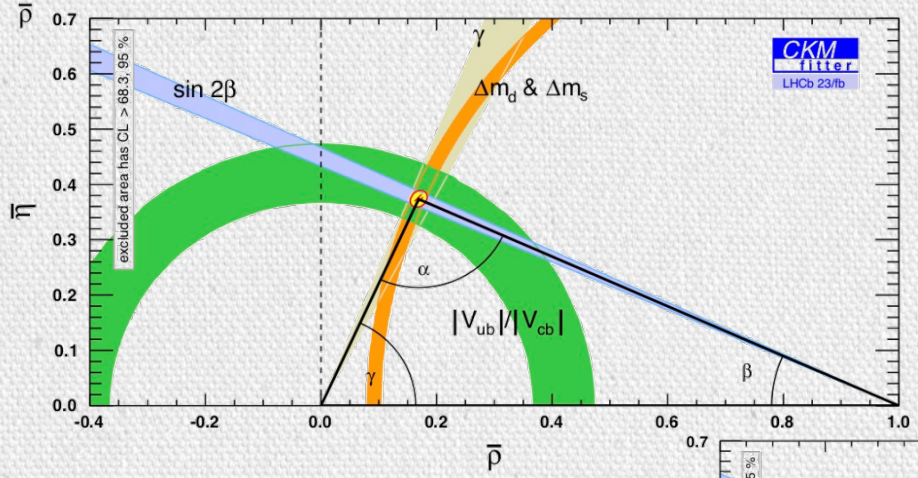
CMS & ATLAS to extend their flavour capabilities
HL-LHC CERN Yellow Report for the end of 2018 (incl. Flavour WG)

LHCb projections

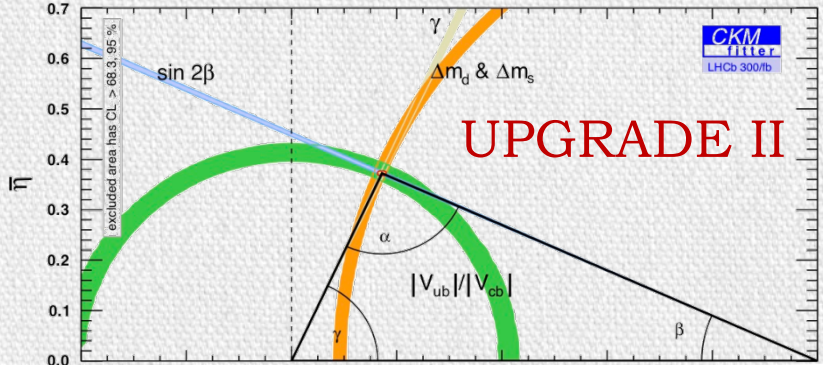
LHCb-only CKM metrology



NOW



AFTER RUN3 (2024)



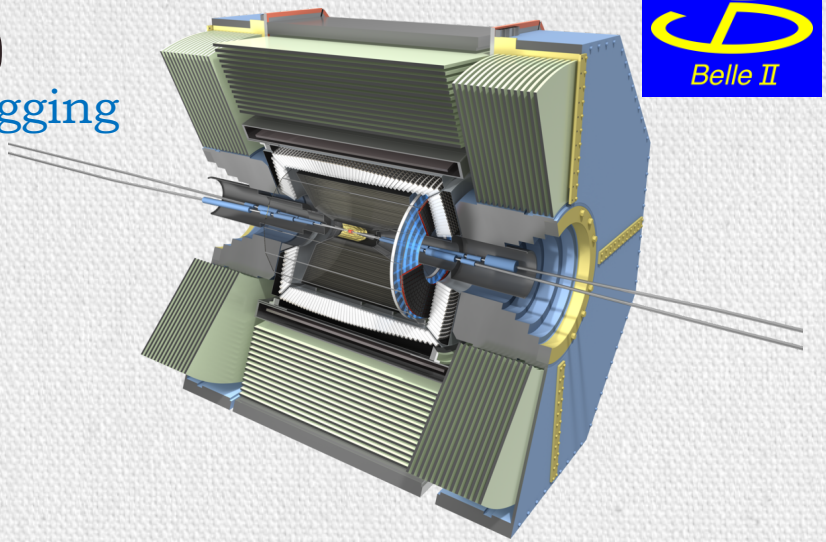
UPGRADE II

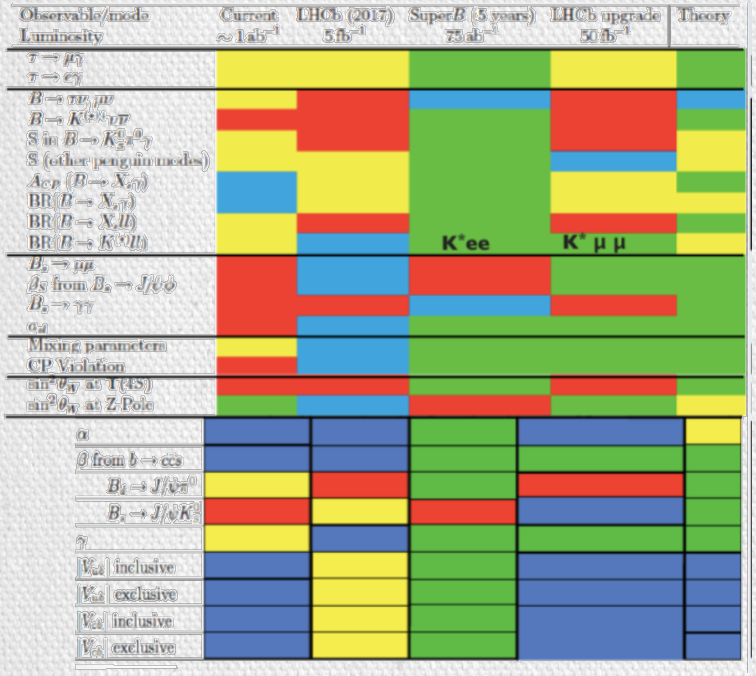
Belle II @ SuperKEKB

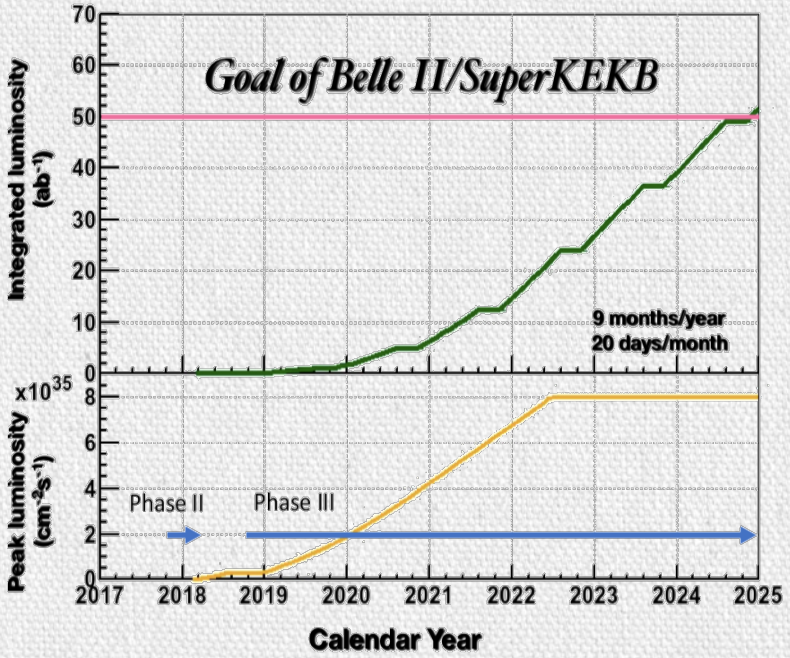
DEPUIS 2018

Complementary physics with LHC(b)

Clean e^+e^- environment, efficient flavour-tagging







IN2P3 joining in 2017 [IPHC, LAL]

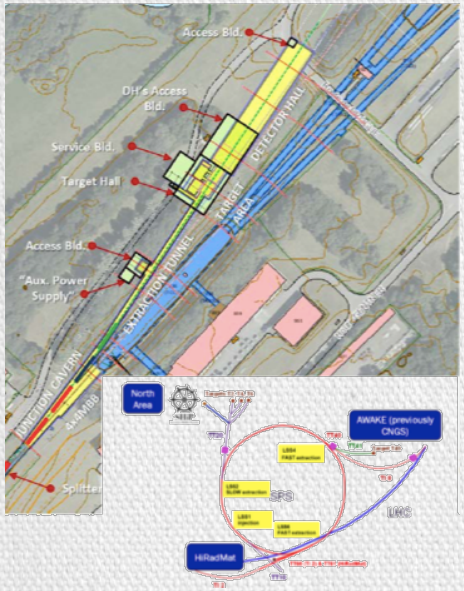
French community working on radiative mode $B^0 \to (K_S\pi\pi)\gamma$ as LHCb@LPC

Mid-term upgrade for DAQ

Proposal to use LHCb Upgrade DAQ (LAL, CPPM)

Exotics search

Long Living Particle below O(10) GeV/c^2
dark photons, light scalars and pseudo-scalars, heavy neutrinos, …

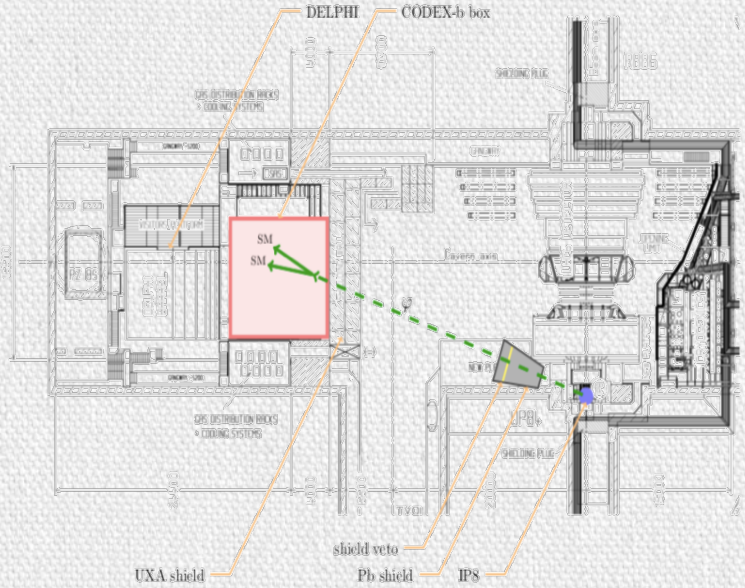


SHIP @ SPS

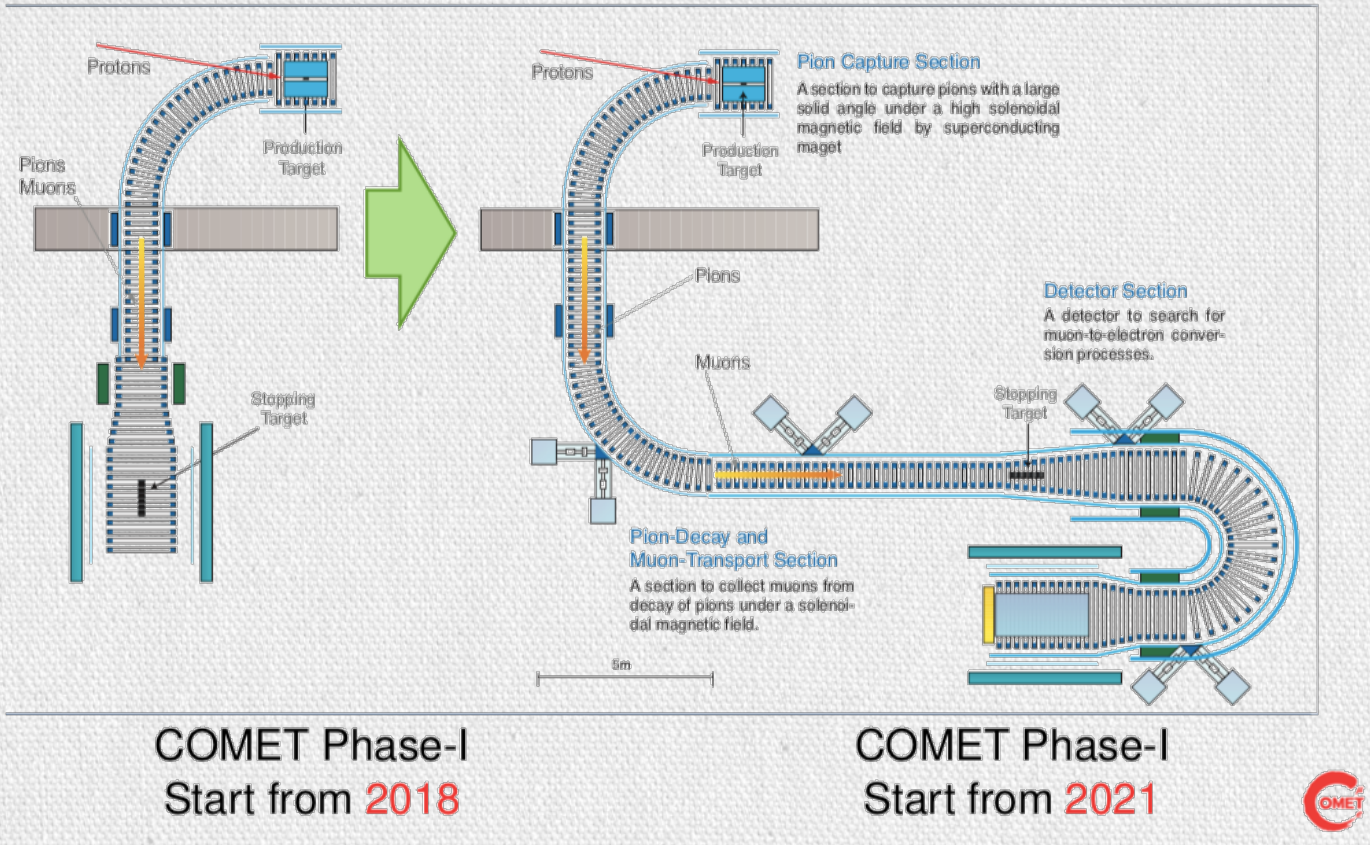
[LAL,LPNHE]

CODEX-b @ LHC(b)

[LPNHE]



COMET @ JPARC



Expression of interest to have an experimental contribution on COMET at LPC (C.Carloganu, V.Niess)

Muon cosmics background control

With possible instrumental contribution

CONCLUSION

Progrès impressionnants dans le domaine des saveurs au cours de la dernière décennie. La prochaine sera cruciale.

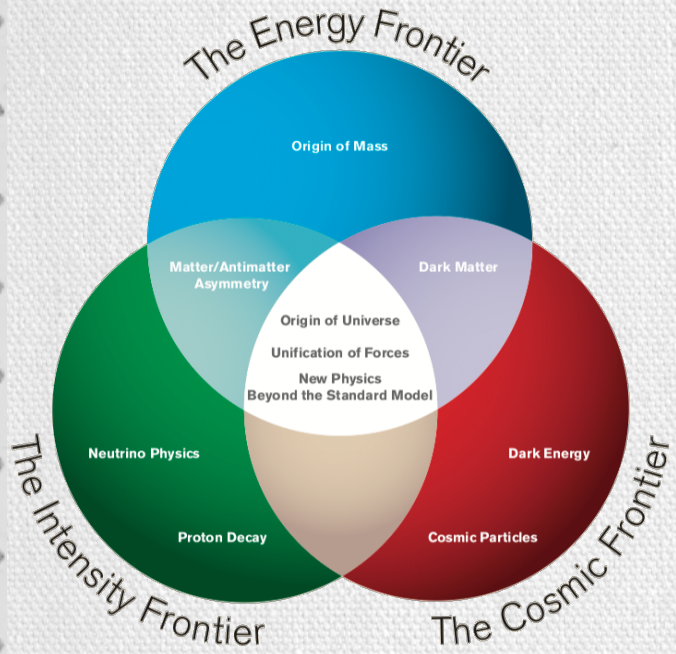
Importante production scientifique du laboratoire sur cette thématique.

Continuation naturelle auprès du (HL-)LHC et préparation au futures expérience à plus long terme (FCC-ee).

Renouvellement nécessaire pour la 2nde phase du LHC. Souhaits exprimés de diversification (Belle II ?)

Contribution expérimentale à l'expérience COMET en discussion

Prix Nobel dans le Pôle UP depuis la création du labo



2017 : *Ligo*	**Gravitational Waves**
2015 : *Kajita, McDonald*	**LFV / neutrinos oscillations**
2013 : *F.Englert, P.W.Higgs*	**BEH mechanism**
2011 : *Perlmutter, Schmidt, Riess*	**Universe expansion**
2008 : *Nambu, Kobayashi, Maskawa*	**Third quark familly & CP-violation**
2006 : *Mather, Smoot*	**CMB anisotropy**
2004 : *Gross, Politzer, Wilczek*	**Asymptotic freedom**
2002 : *Davis, Koshiba, Giacconi*	**Cosmic neutrinos & X-ray sources**
1999 : *'t Hooft, Veltman*	**Quantum Structure of SM**
1995 : *Perl & Reines*	**Tau discovery & neutrino detection**
1993 : *Hulse, Taylor Jr*	**Pulsar**
1992 : *G. Charpak*	**Multiwire proportional chamber**
1990 : *Friedman, Kendall, Taylor*	**DIS**
1988 : *Lederman, Schwarz, Steinberger*	**Doublets familly structure**
1984 : *Rubbia, Van der Meer*	**Intermediate bosons**
1983 : *Chandrasekhar*	**Stars evolution**
1980 : *Cronin, Fitch*	**CP violation**
1979 : *Glashow, Salam, Weinberg*	**Electroweak Model**
1978 : *Penzias, Wilson*	**CMB**
1976 : *Richter, Ting*	**Charm discovery**
1974 : *Sir Ryle, Hewish*	**Astro radio**
1969 : *M.Gell-Man*	**Quarks**
1968 : *Alvarez*	**Bubble chamber**
1967 : *H.A.Bethe*	**Nuclear reactions in star**
1965 : *Tomonaga, Schwinger, Feynman*	**QED**
1963 : *Wigner*	**Symmetry**
1960 : *Glaser*	**Bubble chamber**
1957 : *Yang, Lee*	**Parity violation**