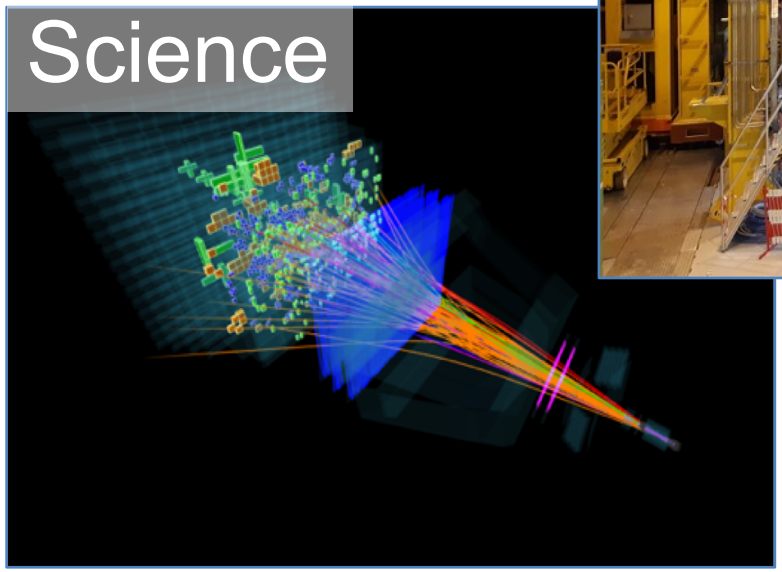
Large Hadron Collider Beauty Experiment

- Scientific Mission
- Technological Opportunities

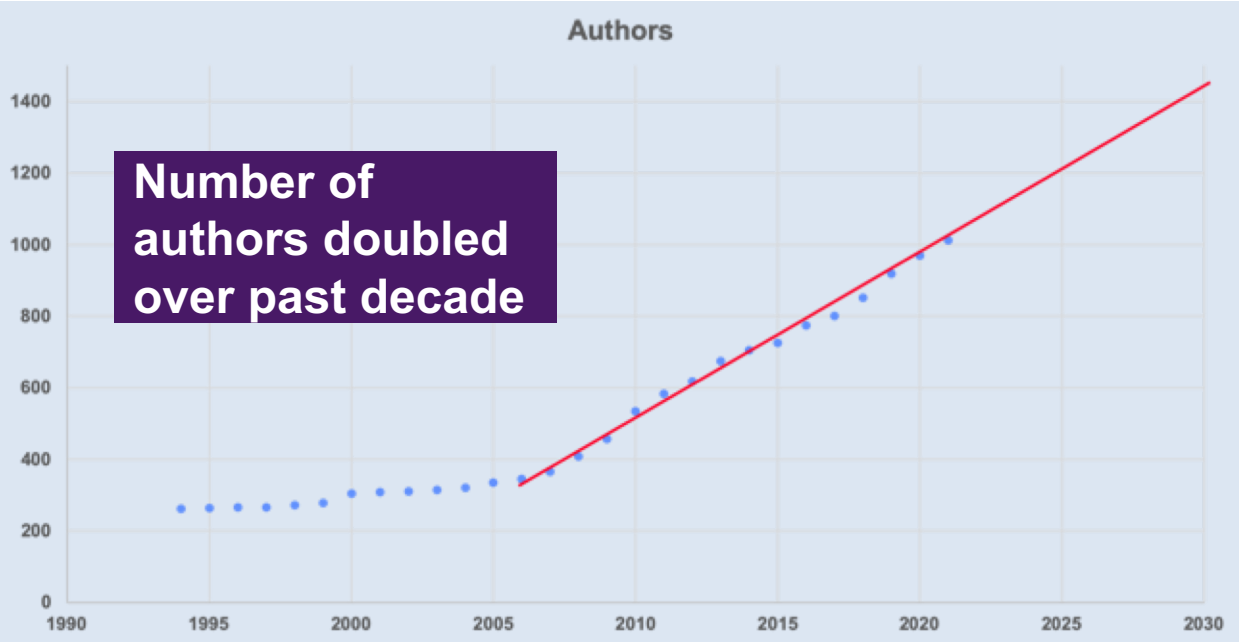


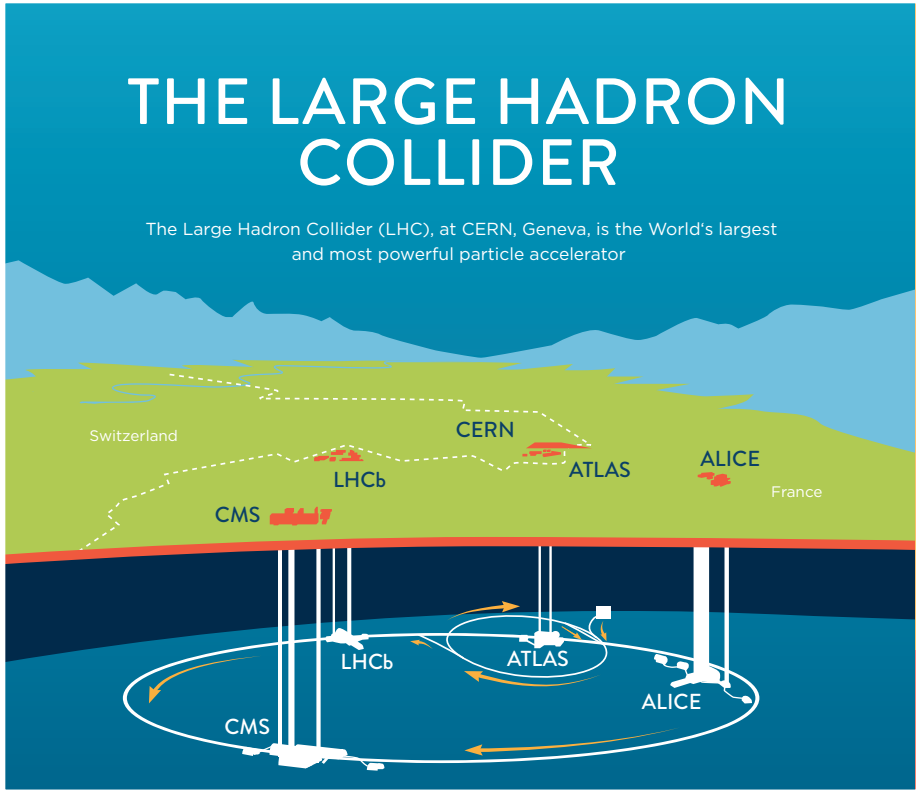
Chris Parkes,
Spokesperson LHCb Collaboration

LHCb Community

- 1500 members
- 1000 authors
- 90 Institutes
- 20 Countries

- **Europe, Asia, N. America, S. America, Australasia**
- **Currently no group in Africa**

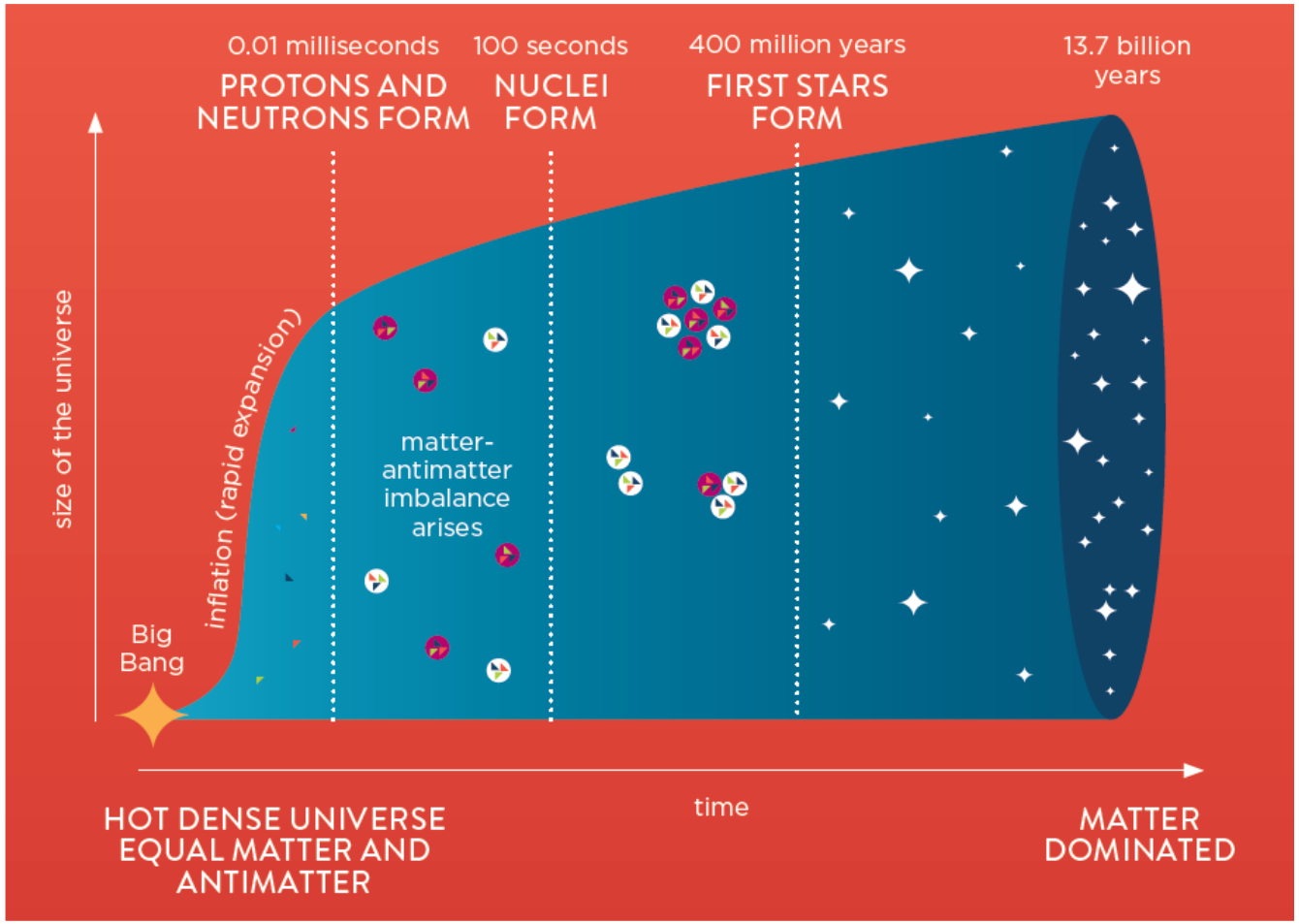


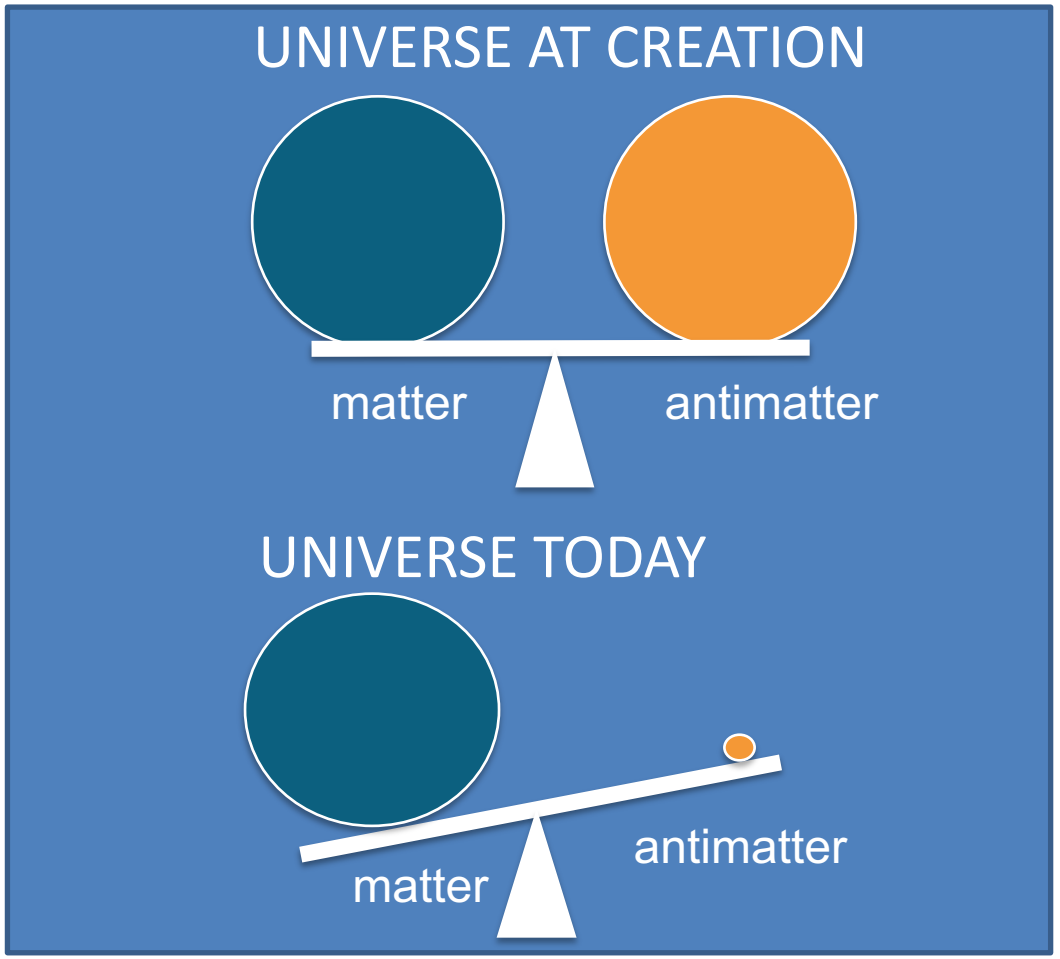


Scientific Mission

- Understanding fundamental scientific questions, such as

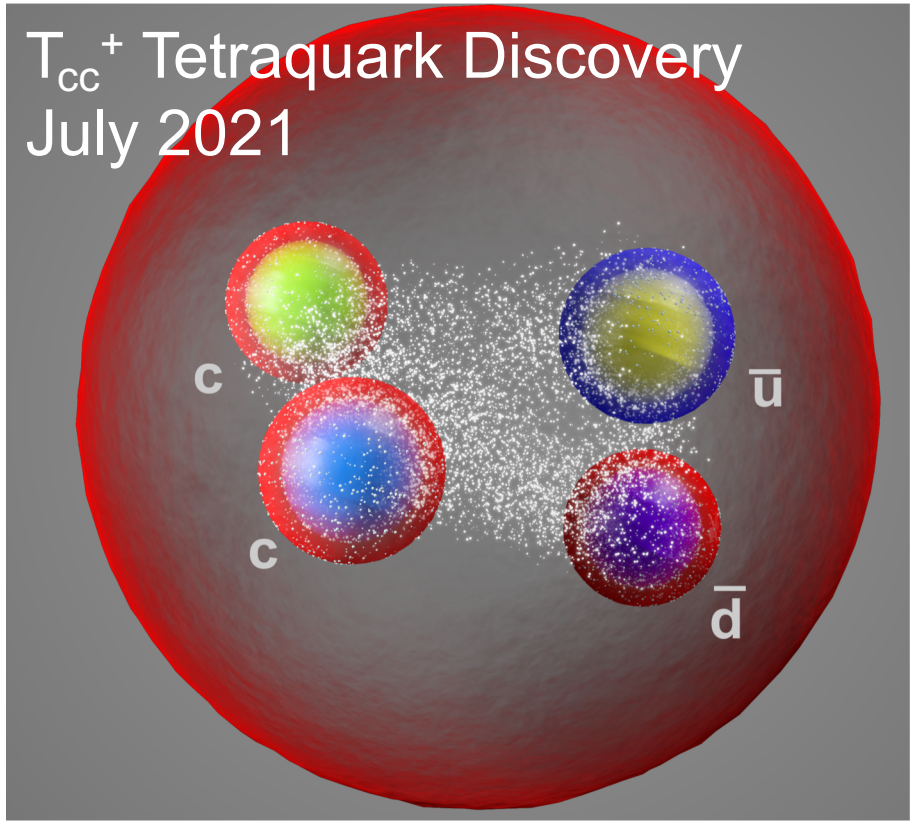
the behaviour of antimatter (CP Violation)



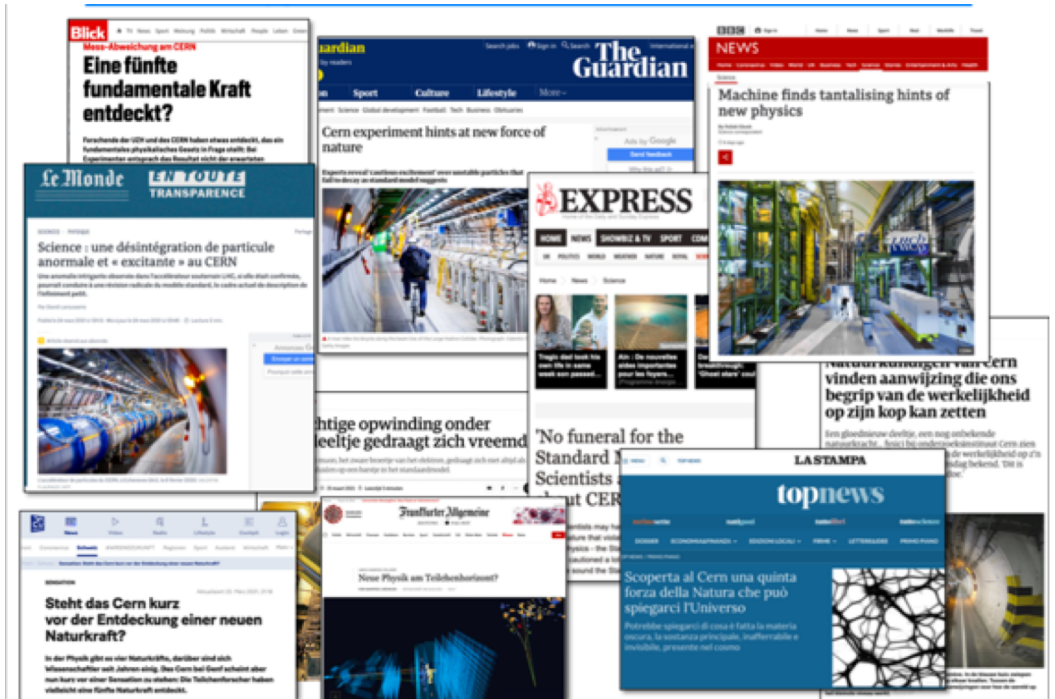


Scientific Publications

- > **550 publications** to date
- ~50 / year in prestigious journals in the field
- Authors of the collaboration are authors on **all** publications

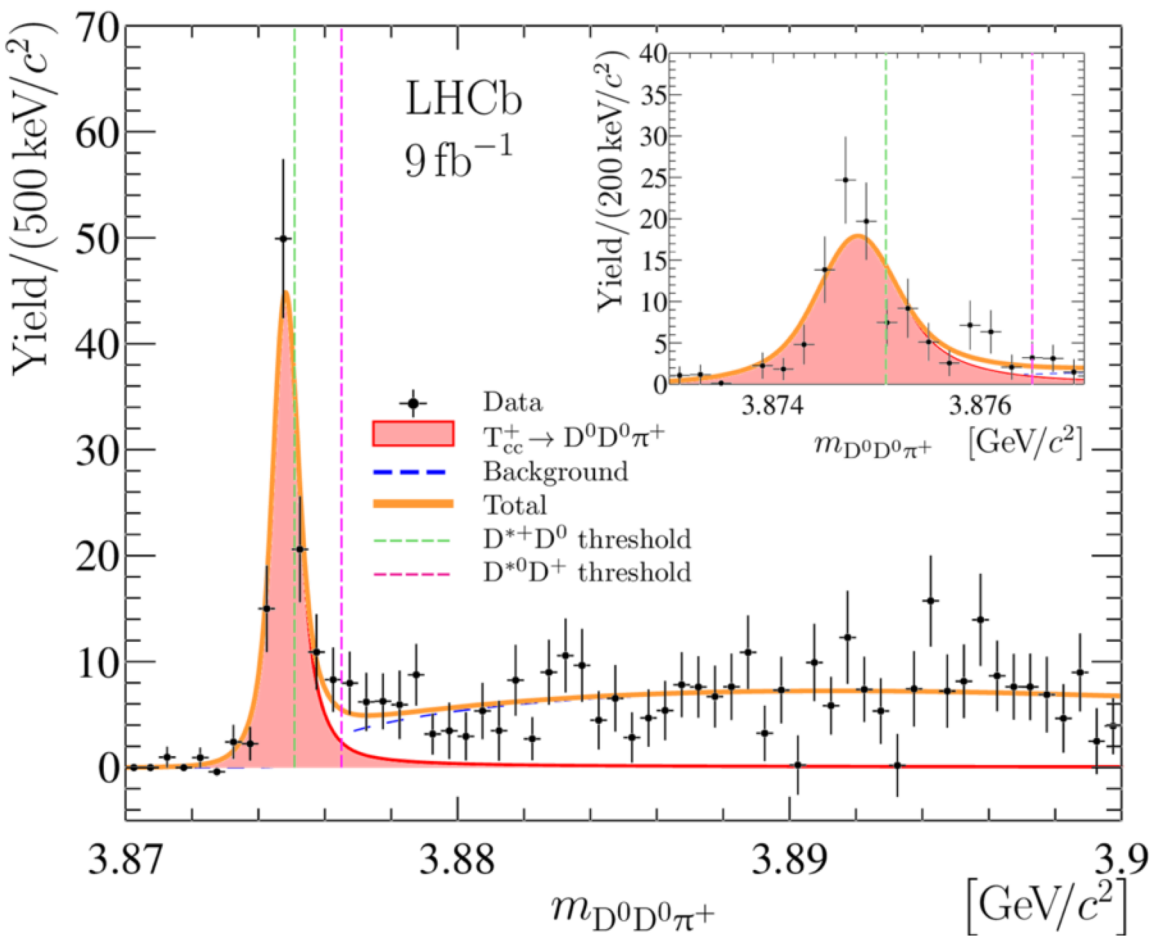


Hints of new fundamental physics phenomena
March 2021



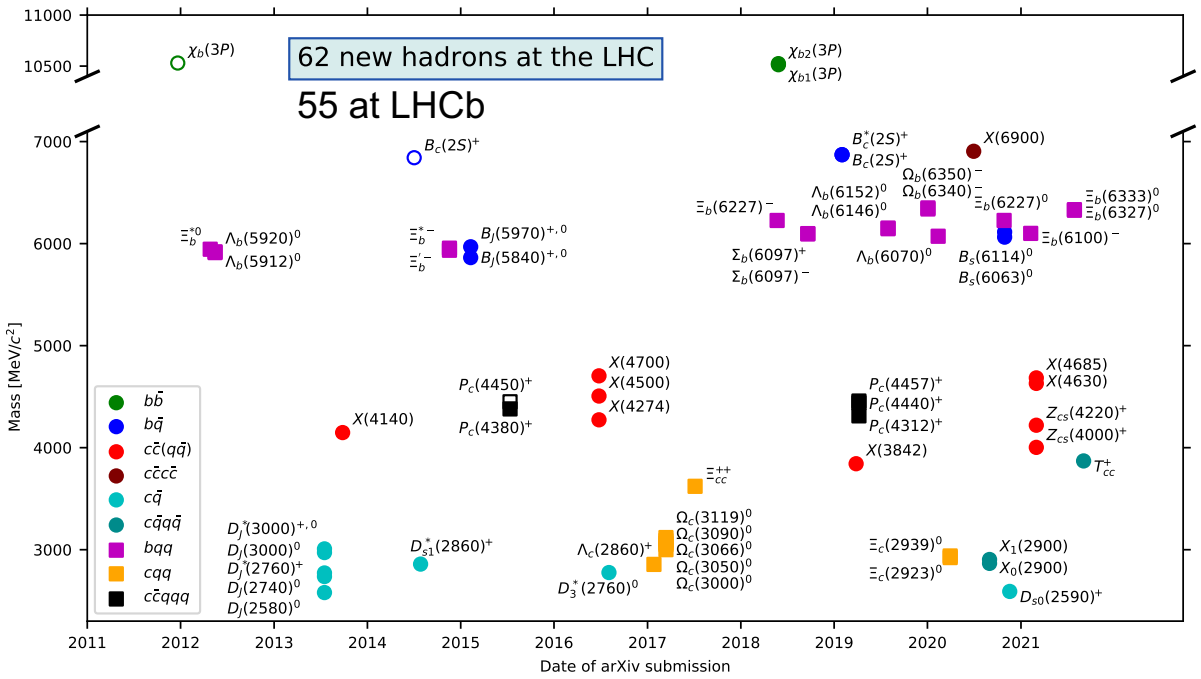
New in 2021: T_{cc}^+

LHCb-PAPER-2021-031/032



- Doubly charmed: ccud
- Just below $D^{*+}D^0$ threshold
  - bbud expected to decay weakly !

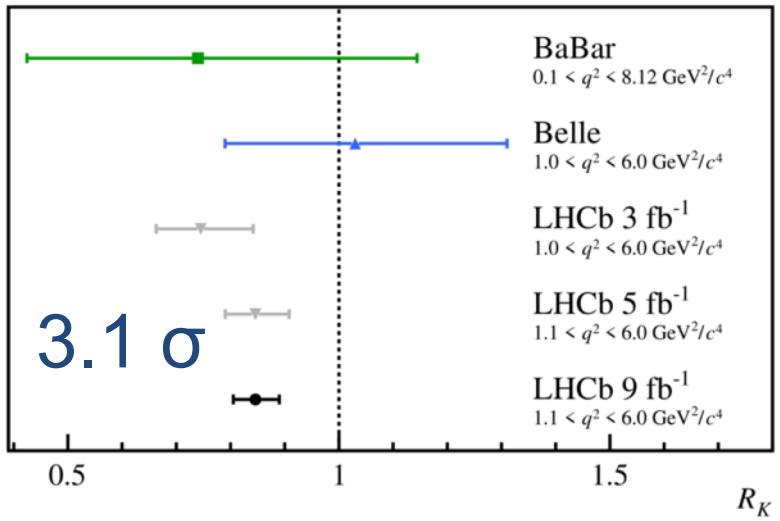
LHCb-FIGURE-2021-001, with updates P. Koppenburg



- > 50 hadrons discovered at LHC for 50th anniversary of hadron colliders
- 17 Exotic states (16 LHCb)
  - A new era – clarity starting to emerge, formation of multiplets

$b \to s l^+ l^-$: an extensive programme

FCNC decay powerful probe for New Physics



Report	Title	Observ.	Comment
	2020		
2003.04352	Search for the lepton flavour violating decay $B^+ \to K^+ \mu^- \tau^+$ using B^{*0}_{s2} decays	Limit	Lepton Flavour Viol.
2003.03999	Search for the rare decays $B^0_s \to e^+e^-$ and $B^0 \to e^+e^-$	Limit	Rare decay
2003.04831	Measurement of *CP*-averaged observables in the $B^0 \to K^{*0}\mu^+\mu^-$ decay	P_5'	Angular asymmetry
2010.06011	Strong constraints on the $b \to s\gamma$ photon polarisation from $B^0 \to K^{*0}e^+e^-$ decays	C_7'	Wilson coefficient
2012.13241	Angular analysis of the $B^+ \to K^{*+}\mu^+\mu^-$ decay	P_5'	Angular asymmetry
	2021		
2103.11769	Test of lepton universality in beauty quark decays	R_K	Lepton Flavour Non-Univ.
2108.09284	Improved measurement of $B^0_{(s,d)} \to \mu^+\mu^-$ decays	BR	Rare decay
2108.09283	Measurement of $B^0_s \to \mu^+\mu^-$ and search for $B^0 \to \mu^+\mu^-$ and $B^0_s \to \mu^+\mu^-\gamma$ decays	BR	Rare decay
2105.14007	Differential branching fraction of $B^0_s \to \varphi\,\mu^+\mu^-$ and search for $B^0_s \to f'_2\mu^+\mu^-$	$d\Gamma/dq^2$	Decay rate
2107.13428	Updated angular analysis of the rare decay $B^0_s \to \varphi\,\mu^+\mu^-$	F_L , A_{FB}	Angular asymmetry
2108.07678	Search for the $\Xi_b \to \Xi\gamma$ radiative decay	Limit	Rare FCNC decay
PAPER-2021-030	Measurement of the photon polarization in $\Lambda^0_b \to \Lambda\gamma$ decays	Pol.	Photon polarization

+ NEW! RKs /RK*+

- A notable part of our programme over the last decade
  - first two papers in 2011, eight FCNC this year
  - Ratios (R_K, R_{K^*},R_{PK}), Angular asymmetries, Branching Fractions, LFV Searches

$$R_K = 0.846\,^{+0.044}_{-0.041}$$

LHCb-PAPER-2021-004

$$\mathcal{B}(B^0_s \to \mu^+\mu^-) = \left(3.09\,^{+0.46+0.15}_{-0.43-0.11}\right) \times 10^{-9}$$

LHCb-PAPER-2021-007/008

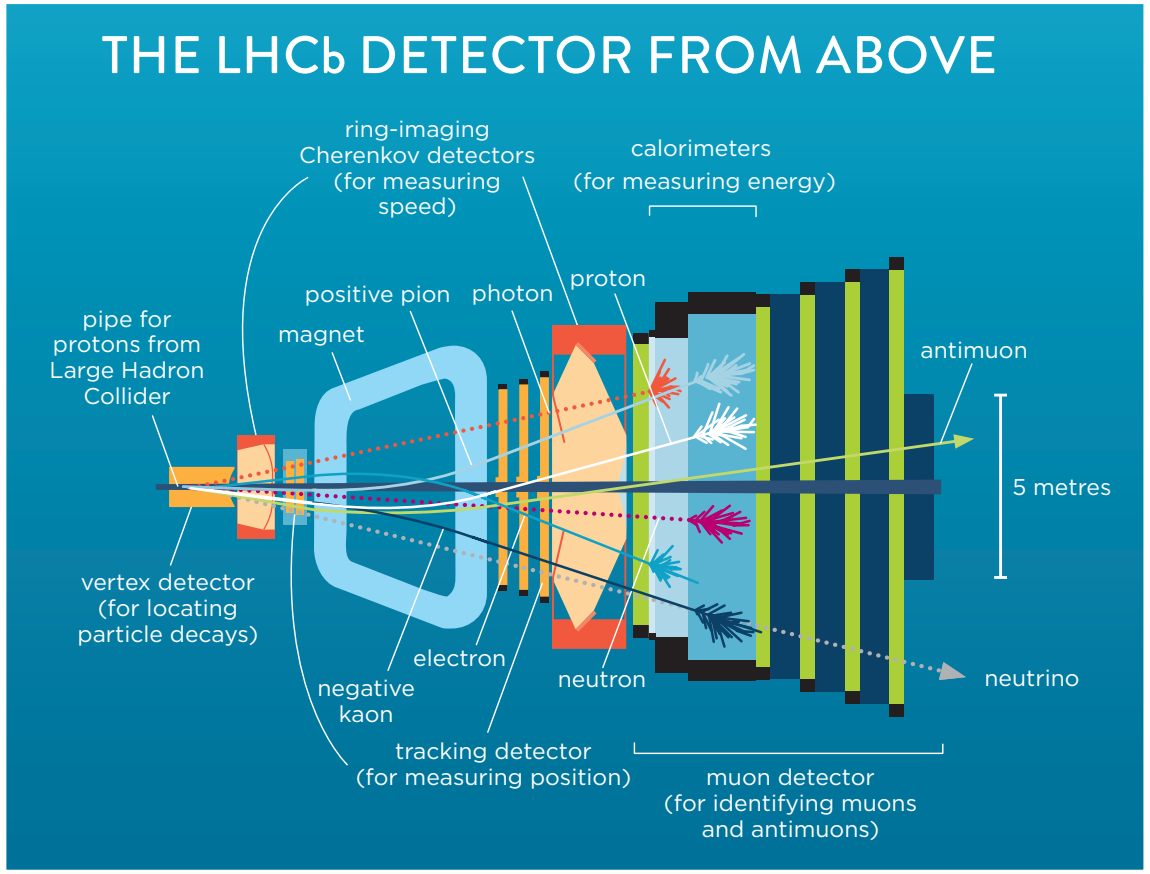
Also f_s/f_d LHCb-PAPER-2020-046

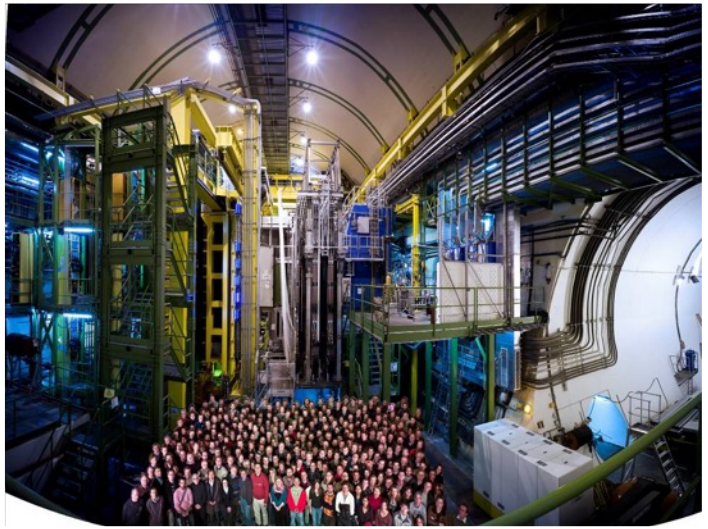
LHCb Detector

Original 2009-2018

Upgrade I 2021-2029

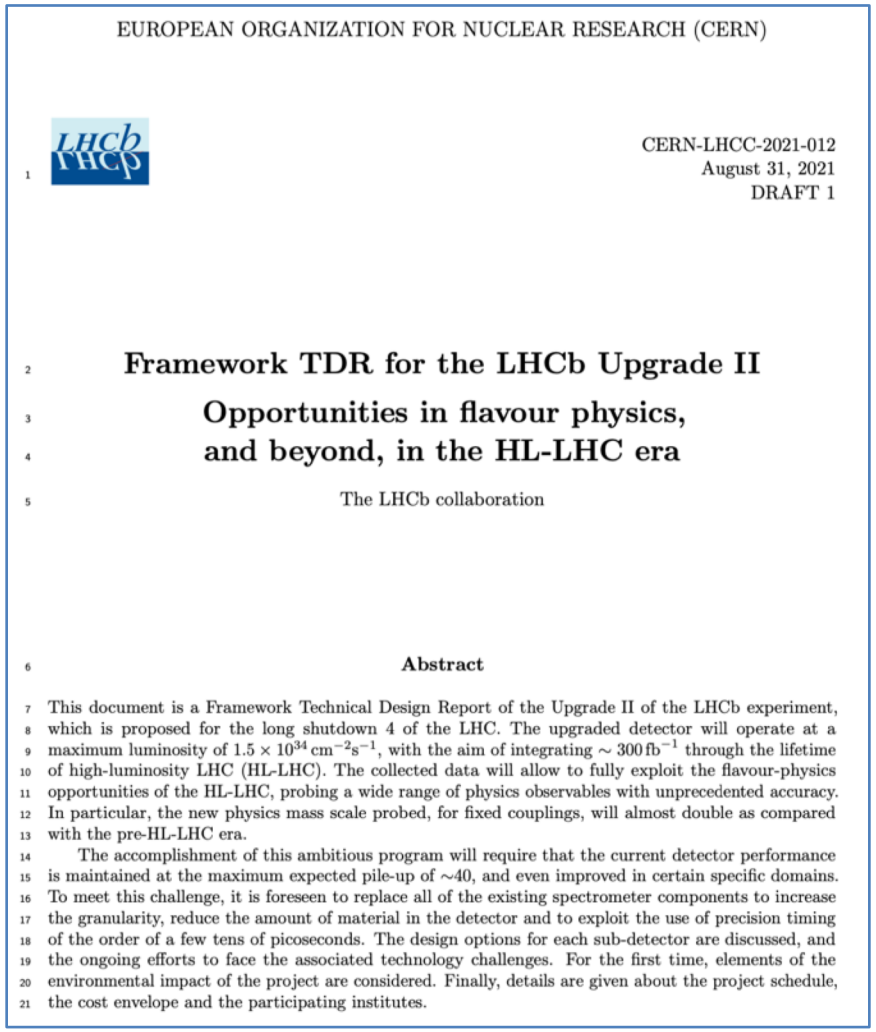
Upgrade II 2031-





- Exploiting LHCb data
- Commissioning/Operating LHCb Upgrade I
- Planning Upgrade II

Upgrade II Framework TDR



EUROPEAN ORGANIZATION FOR NUCLEAR RESEARCH (CERN)

CERN-LHCC-2021-012
August 31, 2021
DRAFT 1

Framework TDR for the LHCb Upgrade II

Opportunities in flavour physics, and beyond, in the HL-LHC era

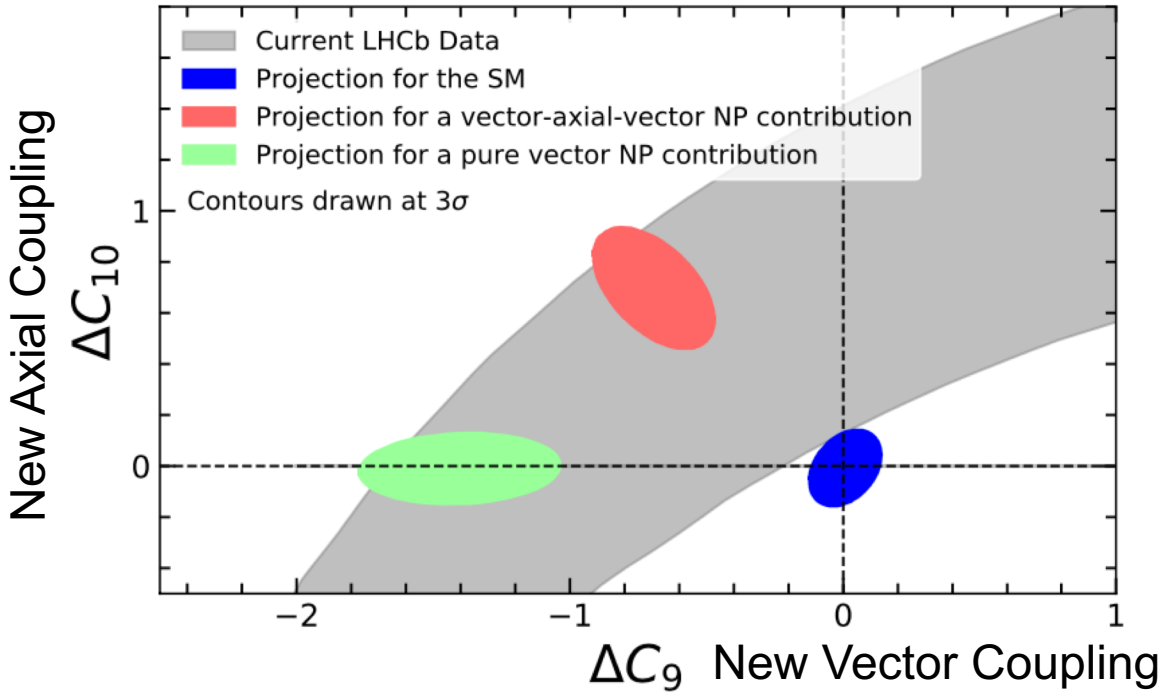
The LHCb collaboration

Abstract

This document is a Framework Technical Design Report of the Upgrade II of the LHCb experiment, which is proposed for the long shutdown 4 of the LHC. The upgraded detector will operate at a maximum luminosity of $1.5 \times 10^{34}\,\mathrm{cm}^{-2}\mathrm{s}^{-1}$, with the aim of integrating $\sim 300\,\mathrm{fb}^{-1}$ through the lifetime of high-luminosity LHC (HL-LHC). The collected data will allow to fully exploit the flavour-physics opportunities of the HL-LHC, probing a wide range of physics observables with unprecedented accuracy. In particular, the new physics mass scale probed, for fixed couplings, will almost double as compared with the pre-HL-LHC era.

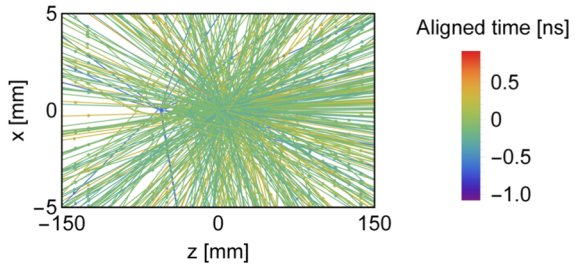
The accomplishment of this ambitious program will require that the current detector performance is maintained at the maximum expected pile-up of ∼40, and even improved in certain specific domains. To meet this challenge, it is foreseen to replace all of the existing spectrometer components to increase the granularity, reduce the amount of material in the detector and to exploit the use of precision timing of the order of a few tens of picoseconds. The design options for each sub-detector are discussed, and the ongoing efforts to face the associated technology challenges. For the first time, elements of the environmental impact of the project are considered. Finally, details are given about the project schedule, the cost envelope and the participating institutes.

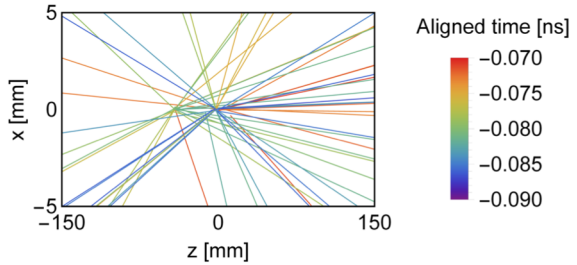
- Ambitious project for LS4
- Draft presented to LHCC 31st August
  - Following from Expression of Interest 2017, Physics Case 2018, European Strategy 2020
  - LHCC Review currently ongoing

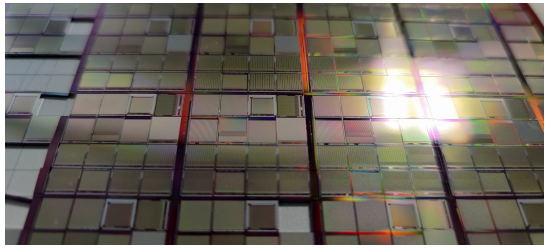


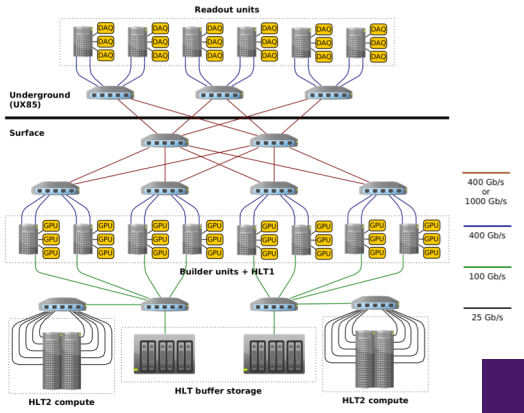
Selected key technologies for the future

- 10-50 Picosecond (trillionth of second) timing
  - "camera" with an extra dimension, time of particle
  - Scientific and medical applications
- DMAPS (CMOS) sensors
  - Sensor and electronics in single piece of silicon
  - Photon, X-ray and gamma ray applications
- New computing/software paradigms
  - Heterogeneous Computing
    - Graphical Processing Units (GPGPUs), FPGA….
  - Real-time Analysis
  - Data mining / analysis applications









Membership Types

- Full Member Groups
  - Sizeable member groups, sit on Collaboration Board
- Associate Member Groups
  - Smaller member groups

- Technical & Software Associate Groups
  - Groups not producing particle physics results
  - Developing new technologies (hardware & software)
  - Can be members of other competing projects
  - no/limited financial obligations

Summary

- Scientific Mission
  - Fundamental science objectives
  - ~ 50 publications/year
- Technological Opportunities
  - Upgrade for 2030s
  - Developing new detector and computing solutions with universities and industry
- Keen to attract groups from Africa
  - Friendly, open spirit of collaboration
  - Rapidly growing collaboration