

LLP13

19-23 June 2023

CERN

James Beacham
Duke University

Thirteenth
workshop
of the
Long-Lived Particle Community



LLP13 — Practical info

Rooms

Monday

- **Theory Conference Room** (you're here now)
- CERN Colloquium by Jonathan Feng: **Main Auditorium**

Tuesday

- Morning: **Salle Dirac** (B40)
- Afternoon: **Salle Anderson** (B40)

Wednesday

- All day: **Salle Curie** (B40)

Thursday

- Afternoon: **Filtration Plant** (B222)

Friday

- **Salle Curie** (B40)

LLP13 — Practical info

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- **Theory Conference Room** (you're here now)
- CERN Colloquium by Jonathan Feng: **Main Auditorium**

Monday welcome
reception (18:30):
Foyer outside
Main Auditorium

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- Morning: **Salle Dirac (B40)**
- Afternoon: **Salle Anderson (B40)**

Tuesday workshop dinner (19h):
Luigia Academy restaurant

Wednesday

- All day: **Salle Curie (B40)**

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LLP13 — CERN Colloquium today

CERN Colloquium

Long-Lived Particles and the Future of Particle Physics

by Jonathan Lee Feng (University of California Irvine (US))


Monday 19 Jun 2023, 16:30 → 17:30 Europe/Zurich

500/1-001 - Main Auditorium (CERN)


Description The gold standard for progress in particle physics is the discovery of new elementary particles. For decades the search for new particles focused on heavy particles with short lifetimes. More recently, however, there has been a paradigm shift, with a new focus on long-lived particles that can be either heavy or light. Such particles appear in many theories designed to address the outstanding questions of neutrino mass and dark matter, and the possibility that they exist has led to an explosion of new ideas for particle searches through a wide variety of experiments. This talk will place the paradigm shift toward long-lived particles in its historical context, highlight some of the ongoing experiments that are already yielding interesting results, and provide an outlook for the future.

Organised by Albert de Roeck, James Beacham

Videoconference

 CERN Colloquium - 19 June 2023 [▶ Join](#)

Webcast

 There is a live webcast for this event [▶ Watch](#)

Contact

 ep-seminars.colloquia@cern.ch



Jonathan Feng (UC Irvine)

LLP13 — Blue-sky session Wednesday

What would we do with 200 MCHF
(or more) for LLPs, at the LHC
and beyond?

Imagine that LLP enthusiasts around the globe were handed 200 MCHF and told to build whatever experiments they wanted.

What would we do to optimally and definitively ensure we don't miss BSM LLPs?

What are the highest priorities?

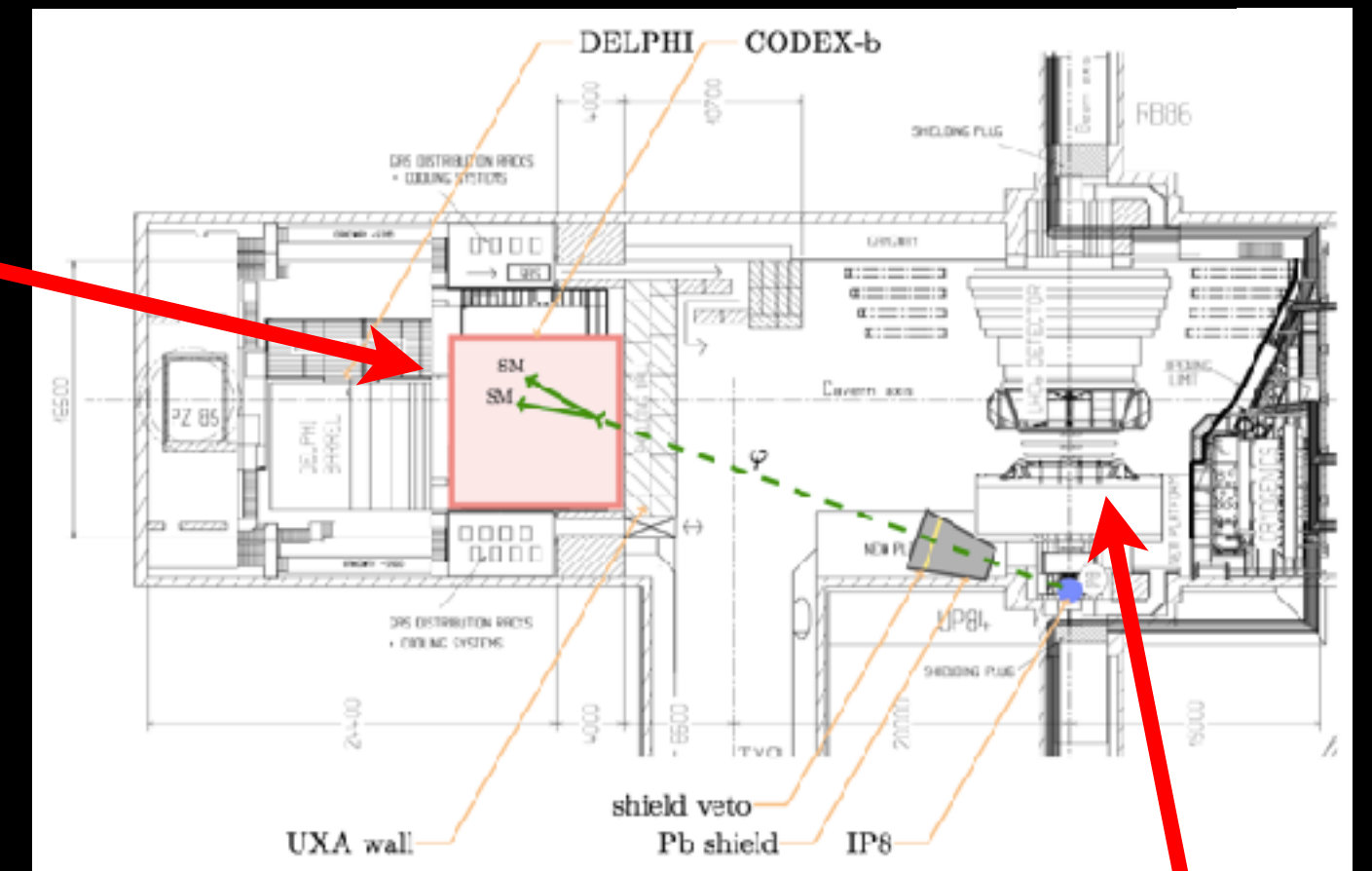
LLP13 — Experiment visits

Thursday morning

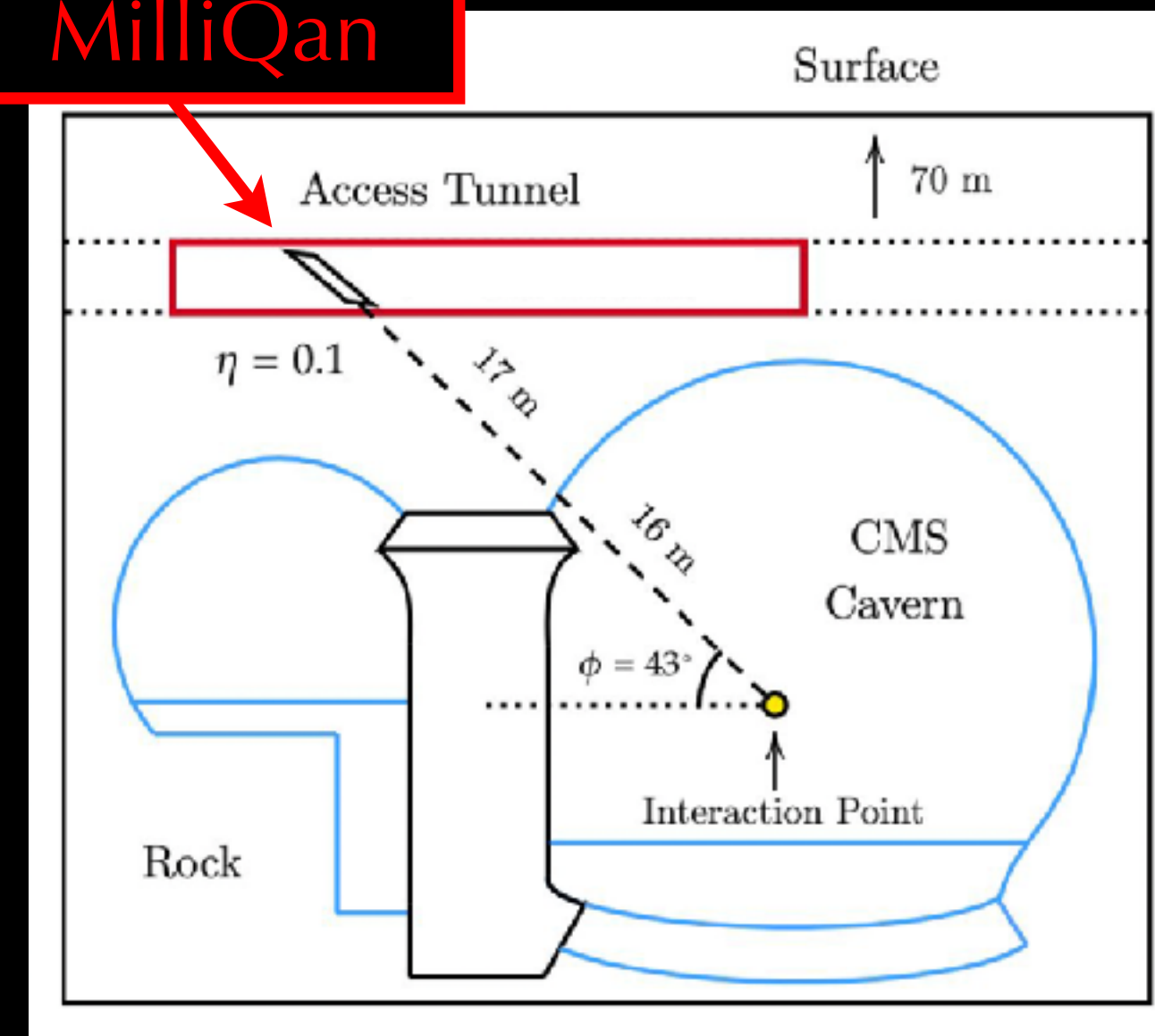
Two separate groups:

- Visit to **LHC Point 8**, where LHCb is and where **CODEX-b** is proposed to be installed
 - 36 slots (filled!)
 - Bus leaves from B39 at 9 AM, returns at 11:30
- Visit to **LHC Point 5**, where CMS and **MilliQan** are
 - 15 slots (filled!)
 - Individual cars leaving from B39 at 9 AM

CODEX-b

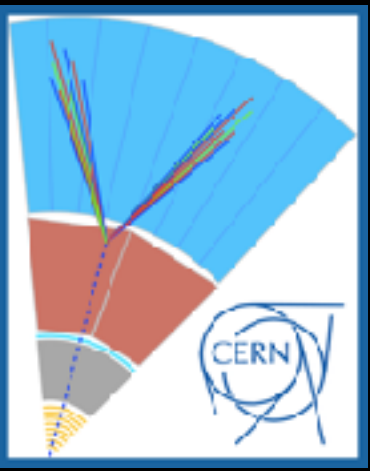


MilliQan



LHCb

The LLP Community



The Long-Lived Particle (LLP) Community is an independent, grassroots platform for the study of beyond-the-Standard-Model long-lived particle signatures around the globe

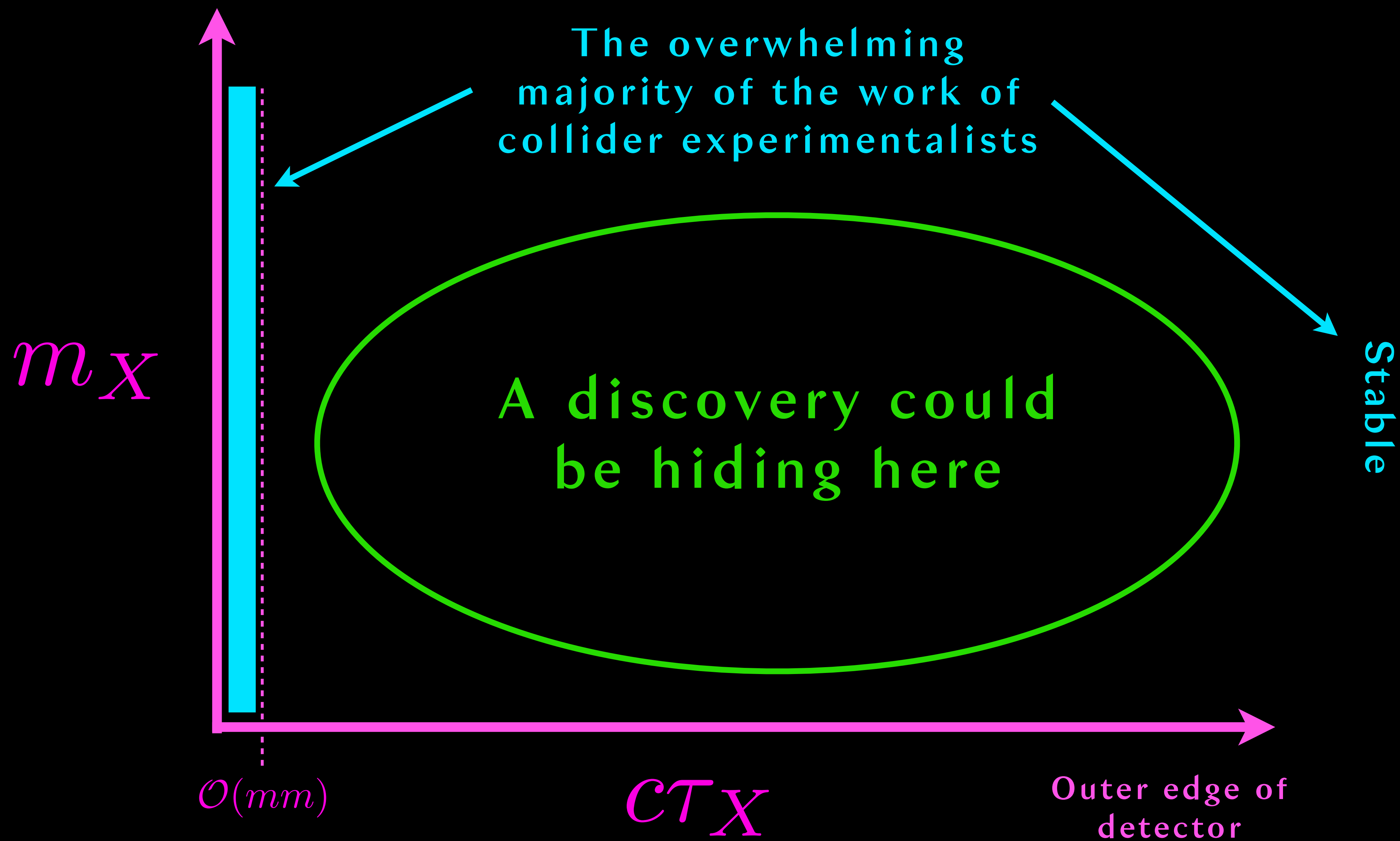
cern.ch/longlivedparticles

Began at the LHC but is much more now

Egroup: [lhcllp](#)

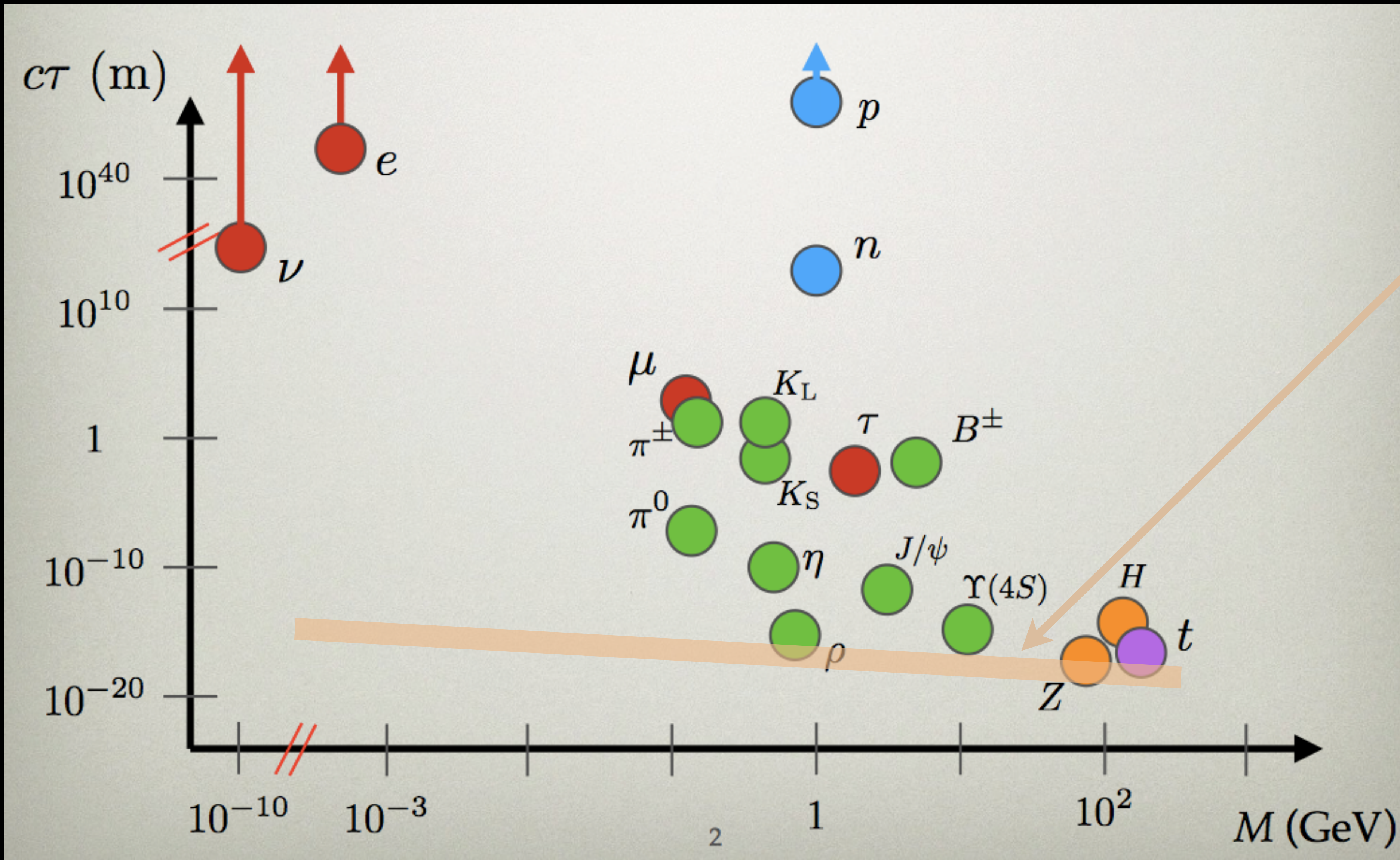
For further discussion during the workshop:
[Mattermost channel](#)

New physics “X” at colliders



Long-lived particles in the Standard Model

Diagram Shuve, additions Knapen, Craig, me

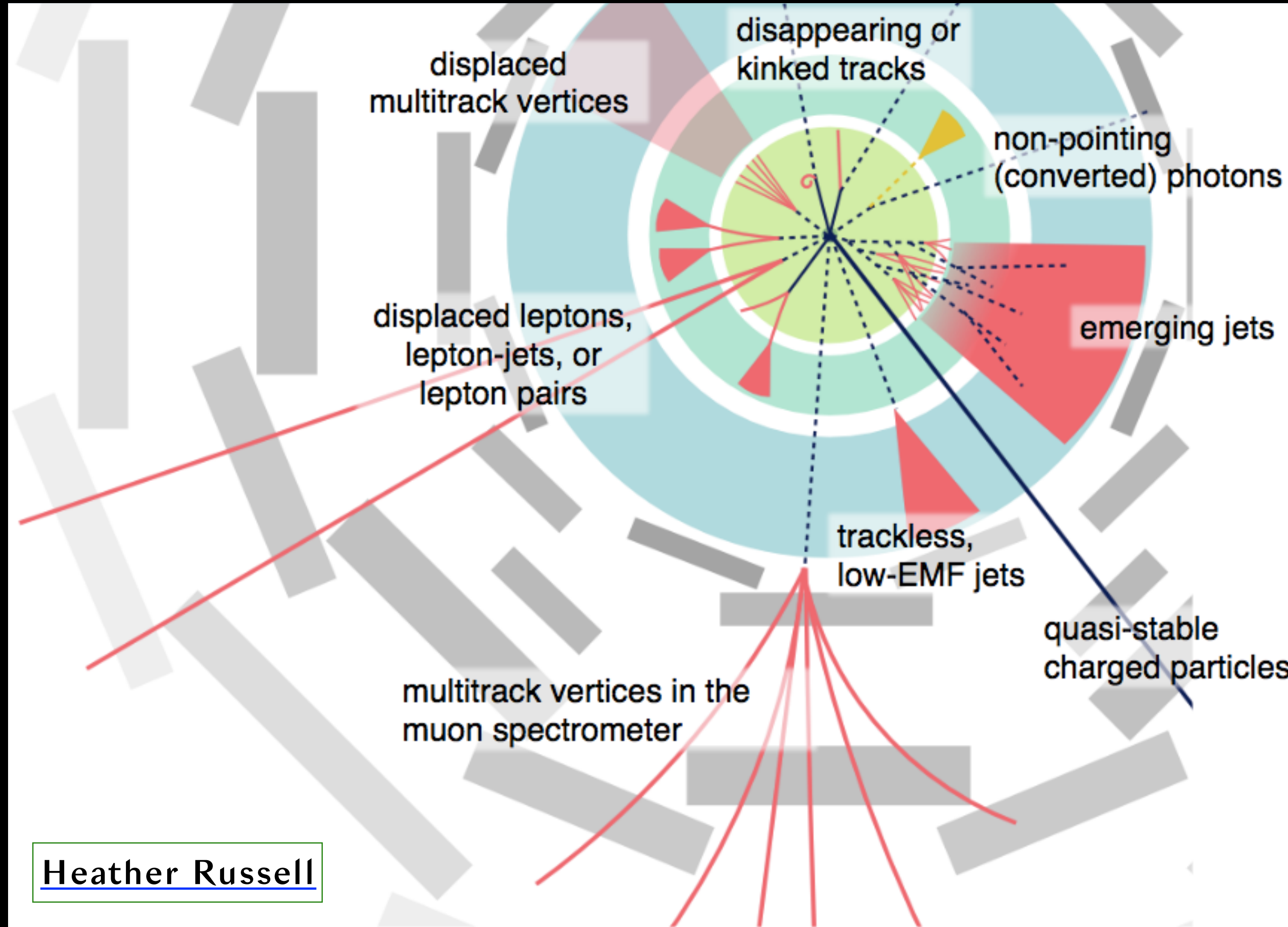


Naive
dimensional
analysis

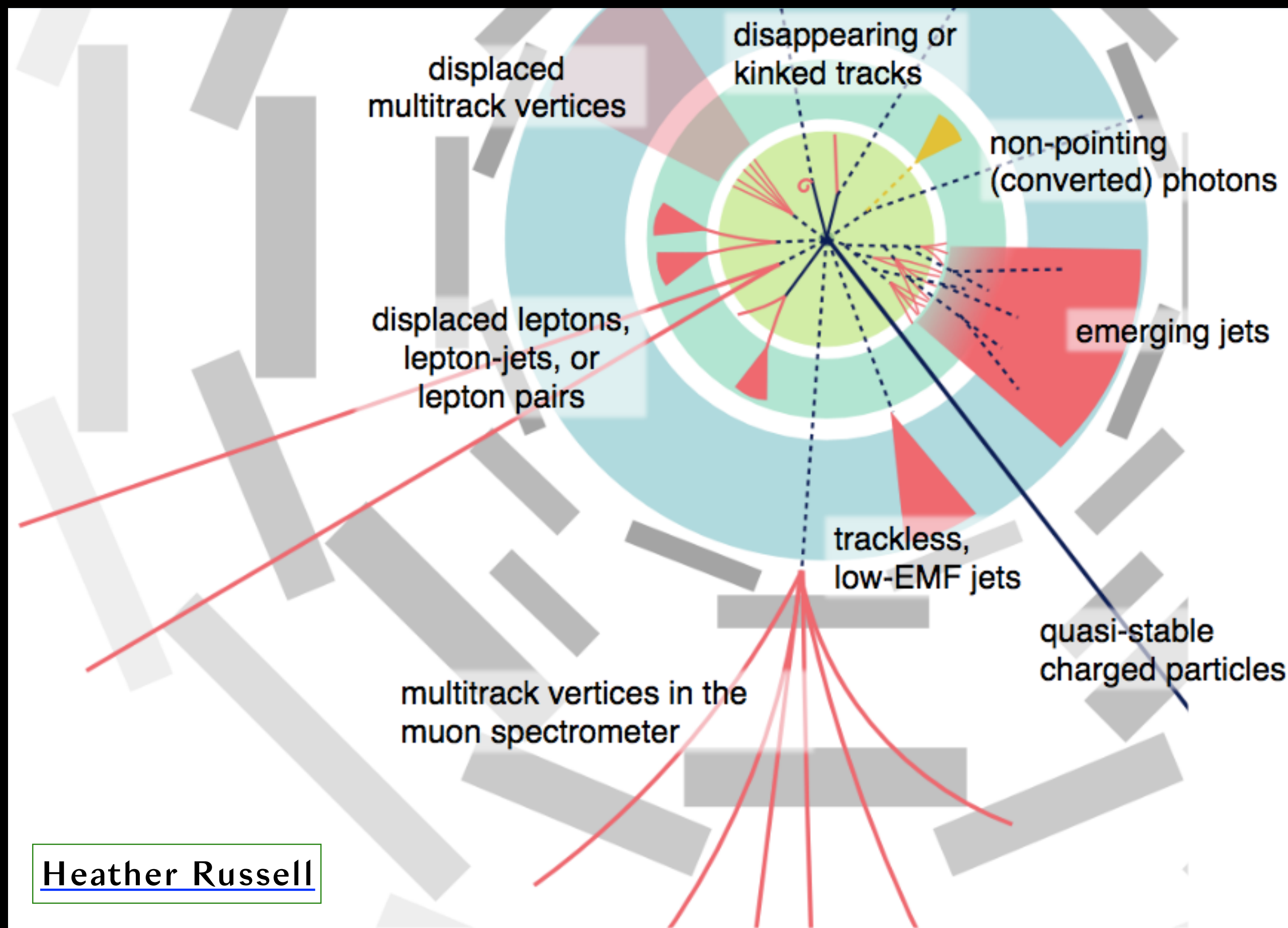
$$\tau = \frac{\hbar}{M}$$

Same
principles
that yield
LLPs in the
SM can
generically
apply in BSM
theories

Long-lived particles from the main interaction points of the

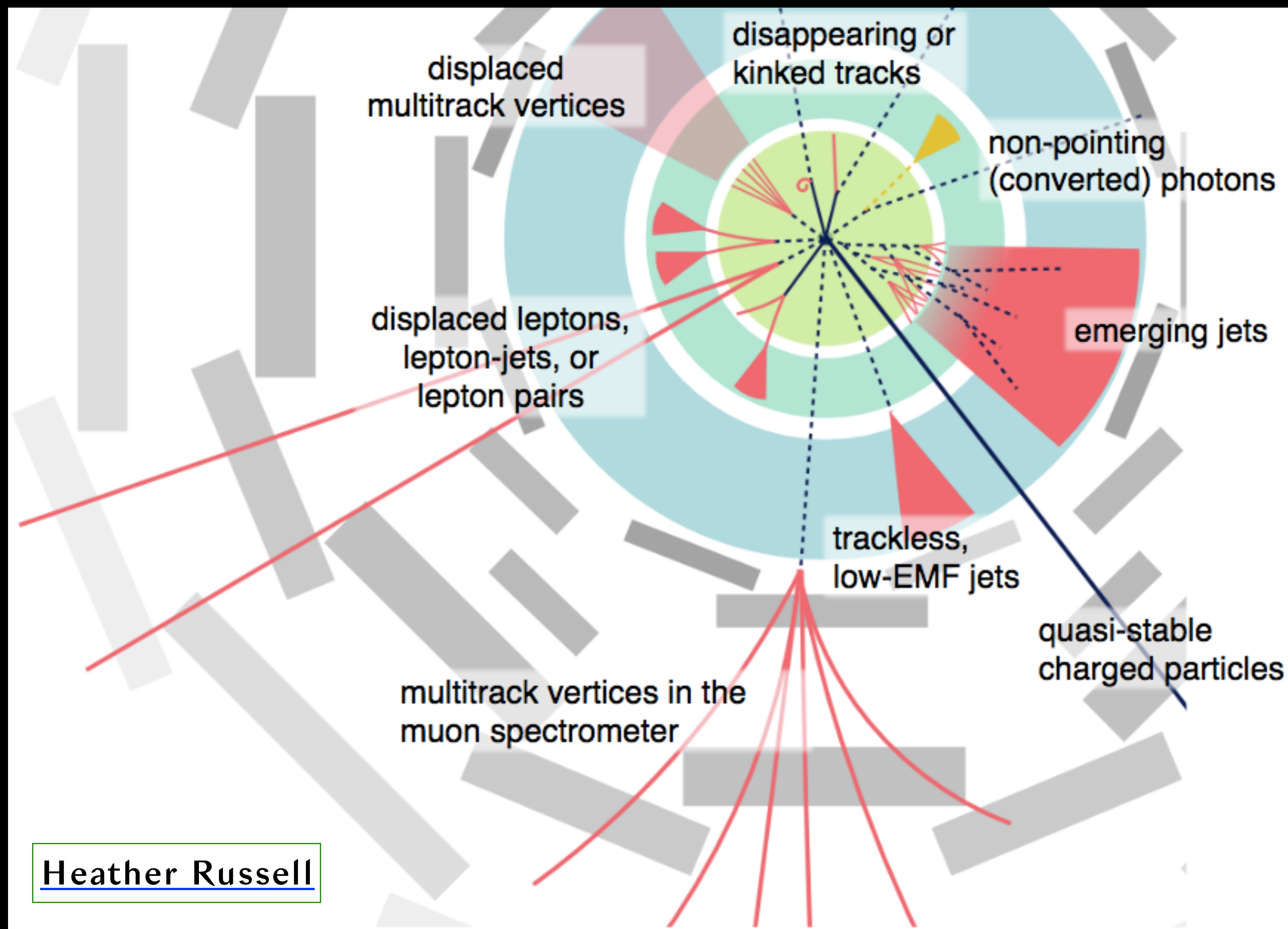


Long-lived particles from the main interaction points of the



For an exhaustive discussion of long-lived particles at the LHC, see the **LLP** Community white paper [[J. Phys. C 47 090501 \(2020\)](#)] and the MATHUSLA physics case document [[Rept.Prog.Phys. 82 \(2019\) no.11, 116201](#)]

Long-lived particles from the main interaction points of the



These searches have been done since day one of the LHC (and at LEP, & Tevatron), but until ~2016, they were always considered fringe, and they still make up less than 10% of our “exotic” searches

Public results with the central LHC detectors

CMS Exotica LLP

CMS SUSY RPV

LHCb Public Results

ATLAS Exotics

ATLAS SUSY

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Long-Lived Particle Community



One question:
How do we best ensure that we don't miss BSM
long-lived particle signatures at collider
experiments around the globe?

Workshops –
historically two per year

Long-lived particle white paper:
Public March 2019 – J. Phys. G 47 090501 (2020)

Join the CERN egroup: lhc-llp

cern.ch/longlivedparticles

Long-lived particles beyond the LHC

Our ability, as a field, to discover BSM physics is not defined only by the interaction points of the LHC

- Many other experimental projects search for, are potentially sensitive to, or could be designed to be sensitive to **LLPs**
- If it's a BSM particle you can produce in an experiment that has a $c\tau$ in the cm to km range before it decays and its decay products hit your detector, then it's a **long-lived particle**
- This leads to obvious and clear connections among multiple projects around the globe, complementary to those at the LHC

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- For example, it's crucial that future projects like the FCC, CEPC, CLIC/ILC, adopt accelerator and detector designs that maintain sensitivity to **LLPs** from the beginning

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- Thus, the **LLP** Community workshops have become a regular platform to discuss, compare, and collaborate on **LLP** searches around the world and ideas to maintain discovery potential now and in the future

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The message is clear:

Don't overlook the lifetime frontier



...ple projects around the
...example, it's crucial that
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...beginning

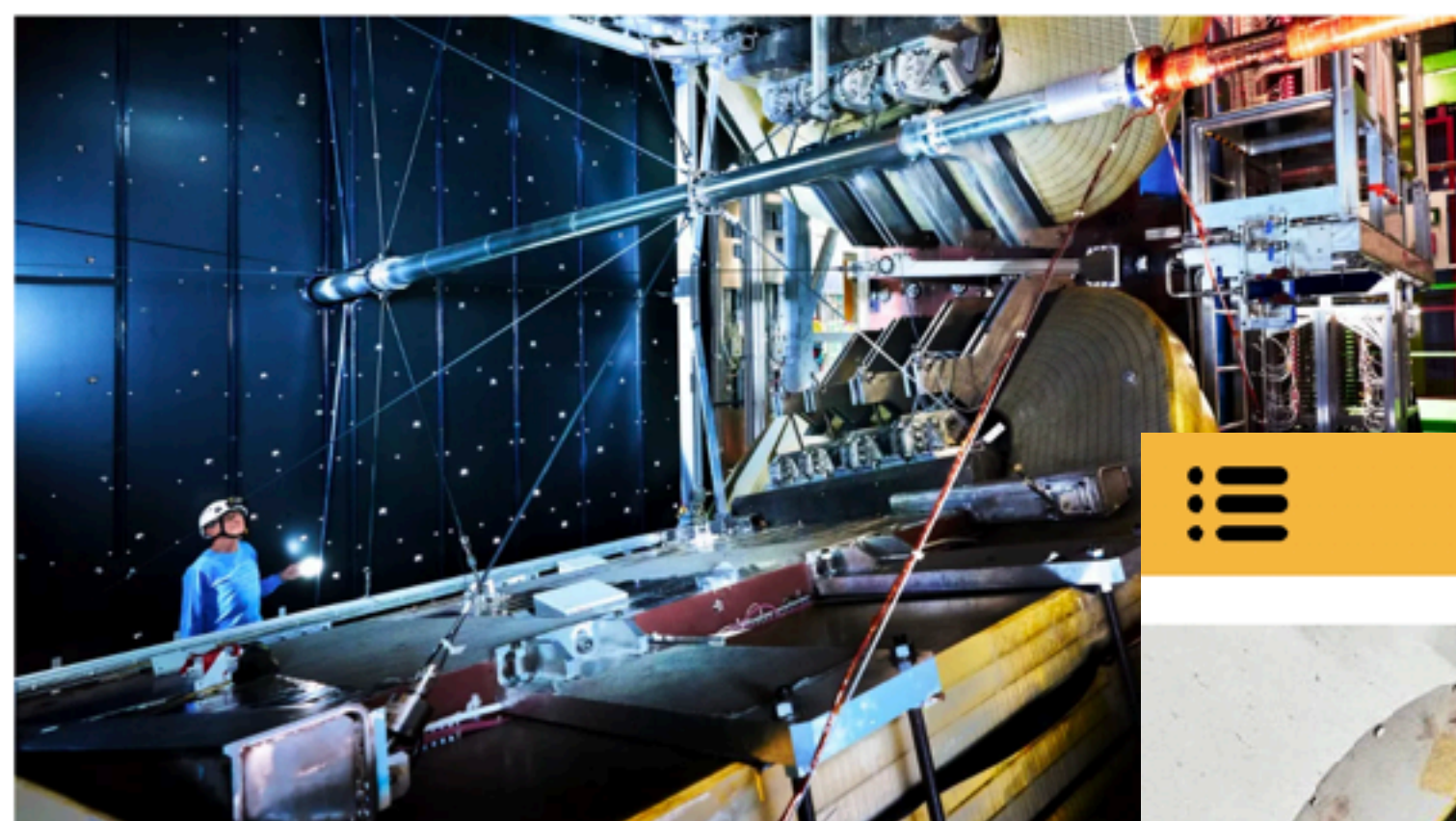
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Large Hadron Collider may be closing in on the universe's missing antimatter

By Keith Cooper published 2 days ago

'Through more precise measurements, large improvements have been made in our knowledge.'

f t l r p f e Comments (1)



The LHCb experiment at the Large Hadron Collider. (Image credit: CERN)

Physicists at the Large Hadron Collider (LHC) are closing in on an explanation for why we live in a universe of matter and not antimatter.

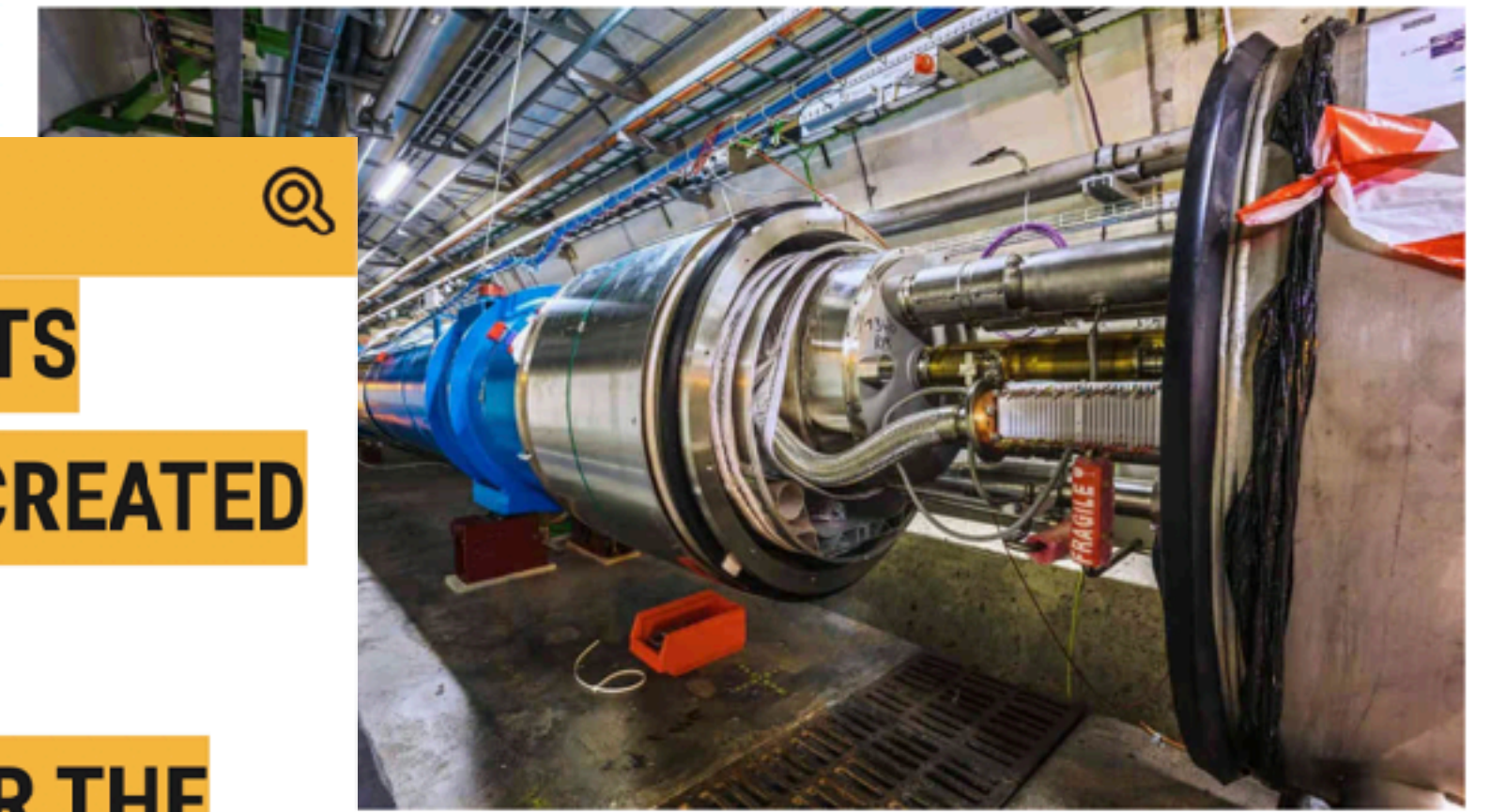
Matter and [antimatter](#) are two sides of the same coin. Every particle has an anti-particle, which is its equal and opposite. For instance, every electron has a positron.

LHC Run 3 is in full swing

30 May 2023 / Evrim Yazgin

First evidence of rare Higgs boson decay at CERN's Large Hadron Collider

f Share t Tweet



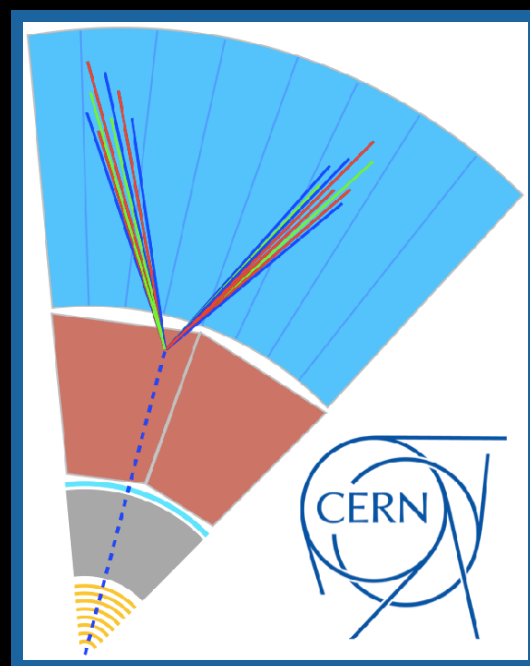
der tunnel. Credit: CERN.

FUTURITY

TEAM DETECTS NEUTRINOS CREATED BY PARTICLE COLLIDER FOR THE FIRST TIME

MARCH 21ST, 2023
POSTED BY [LUCAS VAN WYK](#) [JOEL-UC IRVING](#)

The **FASER** particle detector, located deep underground at CERN's Large Hadron Collider, was mostly built out of spare parts from other experiments at CERN. (Credit: CERN)



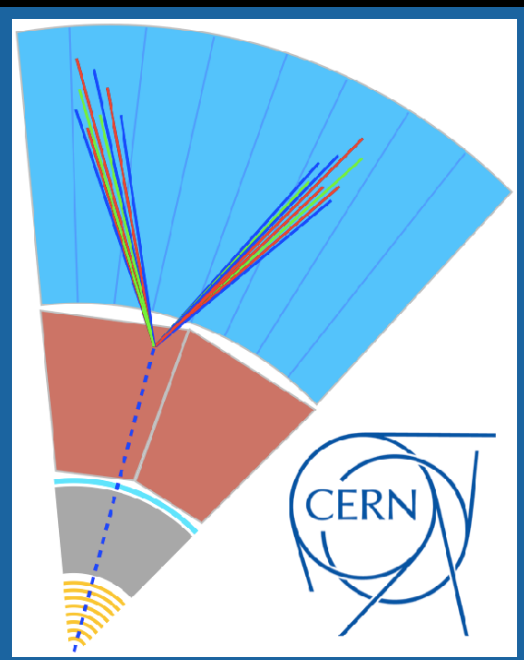
Long-Lived Particle Community: Into the future

LLP Community next steps:

Multitude of opportunities to explore the edges of our knowledge and detector capabilities for LLPs around the globe and in the future

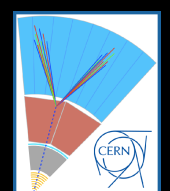
Still an opportunity to propose a series of **LLP Community white papers** to follow up on the first

The LLP Community is the place for both new, practical ideas and speculative, boundary-stretching initiatives



Long-Lived Particle Community: The future is bright

The LHC LLP WG: Focused on the short-term needs of the approved LHC experiments
Sign up for the lhcllpwg list here



LLP Community



Established in 2016 for any new LLP experiment, idea, or project at all, around the globe

LHC LLP WG



Established in 2020 to serve as a formal bridge with the relevant physics groups of the approved LHC experiments

Some projects and ideas that arise in the LLP Community workshops can be naturally executed under the LHC LLP WG banner

Other projects are better served within the broader LLP Community

Take-home message: There is plenty to be explored and many tools with which to explore!

LLP Community: Emphasis on community

Community is open to all

- By being here and participating, you're already a member; welcome!

Workshop is informal and collaboration-centered

- Discussion is of the highest priority



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To all community members:

- Yes, ask a question and make a suggestion!

To all session chairs:

- Give ample space in discussion periods for those who haven't had a chance to talk!

We're radically inclusive and radically anti-harrassment



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We're here to find new physics

- Both science and society suffer when ideas and thoughts aren't heard because someone feels threatened, unwelcome, or marginalized
- This applies whether virtually or in person
- Harrassment is antithetical to the intention of this workshop
- We endeavor to create a positive and welcoming space!



LLP₁₄

Stay tuned

LLP₁₄



Stay tuned

LLP13

19-23 June 2023

CERN

Organizers

Lisa Benato
Louis Henry
Louie Corpe
Audrey Kvam
Nishita Desai
Mason Proffitt
Andrii Usachov
James Beacham
Matthew Citron
Juliette Alimena
Albert De Roeck
Sai Neha Santpur
Federico Leo Redi
José Francisco Zurita
Carlos Vazquez Sierra
Karri Folan Di Petrillo

A woman with long brown hair, wearing a yellow sleeveless top and a floral skirt, is kneeling in a field of yellow and purple flowers. She is holding a grey ball in her hands. In the background, there are some grey structures and a green hill under a cloudy sky.

Thirteenth
workshop
of the
Long-Lived Particle Community

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Organizers

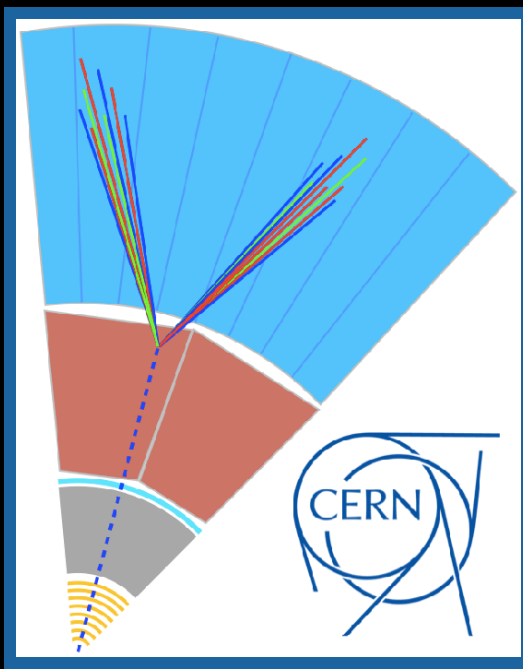
Lisa Benato
Louis Henry
Louie Corpe
Audrey Kvam
Nishita Desai
Mason Proffitt
Andrii Usachov
James Beacham
Matthew Citron
Juliette Alimena
Albert De Roeck
Sai Neha Santpur
Federico Leo Redi
José Francisco Zurita
Carlos Vazquez Sierra
Karri Folan Di Petrillo

Workshop goal:
Chart a course for
the future of the
lifetime frontier.
You're doing it
right now.

Welcome!

Thirteenth
workshop
of the
Long-Lived Particle Community



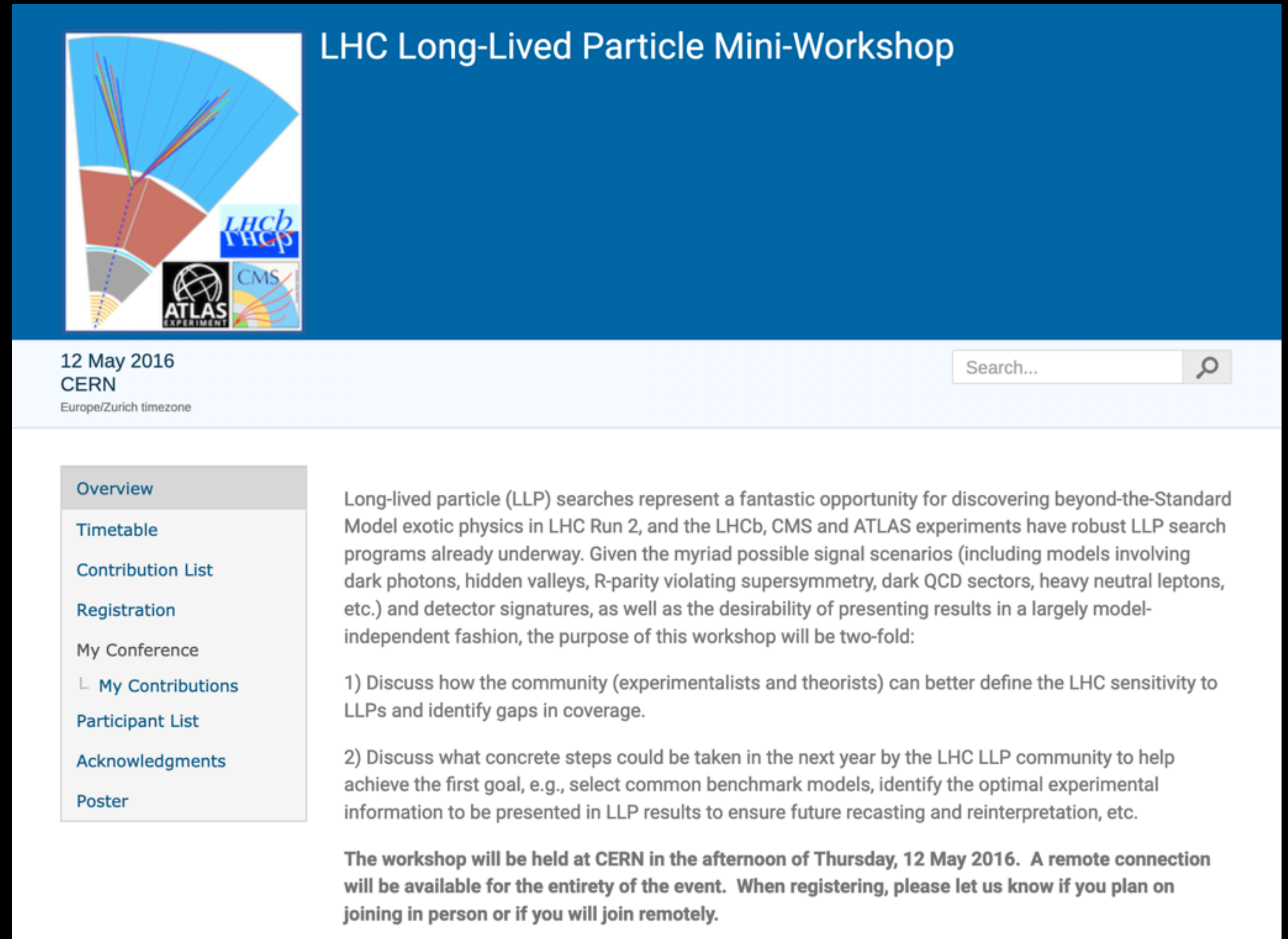


Seven years of the **Long-Lived Particle** Community

12 May 2016

The first LLP Mini-Workshop

indico.cern.ch/event/517268/



The screenshot shows the Indico event page for the "LHC Long-Lived Particle Mini-Workshop". The header includes the event title, date (12 May 2016), location (CERN), and time zone (Europe/Zurich). A search bar is visible in the top right. The main content area features a navigation menu on the left with links for Overview, Timetable, Contribution List, Registration, My Conference, My Contributions, Participant List, Acknowledgments, and Poster. The main text describes the workshop's purpose and goals, mentioning the involvement of LHCb, CMS, and ATLAS experiments. It outlines two main objectives: discussing community coverage and defining concrete steps for the next year.

LHC Long-Lived Particle Mini-Workshop

12 May 2016
CERN
Europe/Zurich timezone

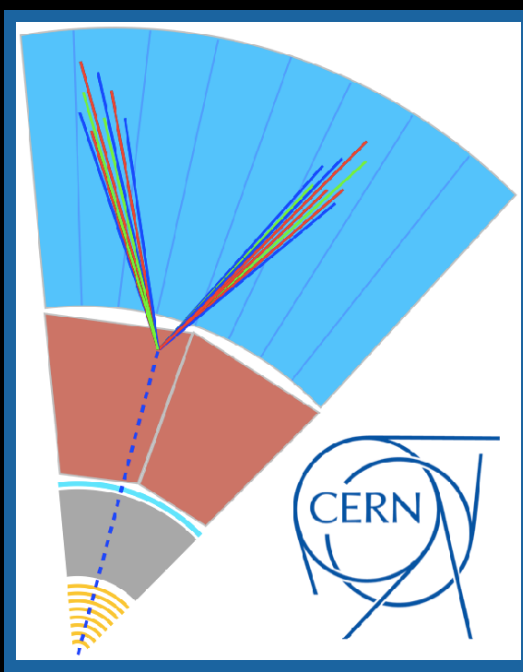
Search...

- Overview
- Timetable
- Contribution List
- Registration
- My Conference
- My Contributions
- Participant List
- Acknowledgments
- Poster

Long-lived particle (LLP) searches represent a fantastic opportunity for discovering beyond-the-Standard Model exotic physics in LHC Run 2, and the LHCb, CMS and ATLAS experiments have robust LLP search programs already underway. Given the myriad possible signal scenarios (including models involving dark photons, hidden valleys, R-parity violating supersymmetry, dark QCD sectors, heavy neutral leptons, etc.) and detector signatures, as well as the desirability of presenting results in a largely model-independent fashion, the purpose of this workshop will be two-fold:

- 1) Discuss how the community (experimentalists and theorists) can better define the LHC sensitivity to LLPs and identify gaps in coverage.
- 2) Discuss what concrete steps could be taken in the next year by the LHC LLP community to help achieve the first goal, e.g., select common benchmark models, identify the optimal experimental information to be presented in LLP results to ensure future recasting and reinterpretation, etc.

The workshop will be held at CERN in the afternoon of Thursday, 12 May 2016. A remote connection will be available for the entirety of the event. When registering, please let us know if you plan on joining in person or if you will join remotely.



Seven years of the Long-Lived Particle Community

1

Searches for long-lived particles at the LHC: Workshop of the LHC LLP Community

24-26 April 2017
CERN

7

Searching for long-lived particles at the LHC: Seventh workshop of the LHC LLP Community

05-07 May 2024
Virtual workshop

Searches for long-lived particles at the LHC: Second workshop of the LHC LLP Community

17-20 October 2017
CERN, Italy

2

Searching for long-lived particles at the LHC and beyond: Eighth workshop of the LHC LLP Community

30-31 November 2020
Virtual workshop

8

3

Searching for long-lived particles at the LHC: Third workshop of the LHC LLP Community

26-31 May 2019
CERN

9

Searching for long-lived particles at the LHC and beyond: Ninth workshop of the LLP Community

26-28 May 2021
Virtual workshop

Searching for long-lived particles at the LHC: Fourth workshop of the LHC LLP Community

23-25 October 2018
American Science Park

4

Searching for long-lived particles at the LHC and beyond: Tenth workshop of the LLP Community

9-12 Nov 2021
Virtual workshop

X

5

Searching for long-lived particles at the LHC: Fifth workshop of the LHC LLP Community

27-29 May 2019
CERN

11

Searching for long-lived particles at the LHC and beyond: Eleventh workshop of the LLP Community

30 May 2022 to 3 June 2022
Virtual workshop

Searching for long-lived particles at the LHC: Sixth workshop of the LHC LLP Community

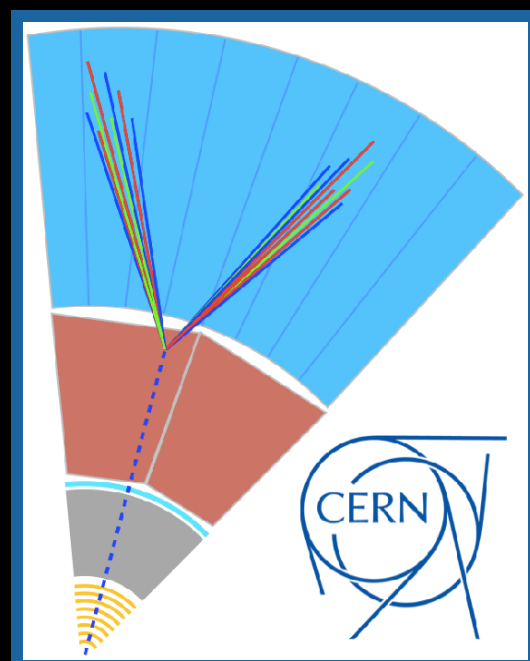
27-28 November 2018
University of Ghent

6

Searching for long-lived particles at the LHC and beyond: Twelfth workshop of the LLP Community

31 October 2022 to 7 November 2022
CERN

12



Long-Lived Particle Community white paper

Public March 2019

Published September 2020

J. Phys. G 47 090501 (2020)

Major community effort

Two document editors,
Beacham & Shuve

19 additional chapter editors

201 authors / contributors / endorsers

>100 citations in first year

>300 citations to date

OPEN ACCESS

IOP Publishing

Journal of Physics G: Nuclear and Particle Physics

J. Phys. G: Nucl. Part. Phys. 47 (2020) 090501 (226pp)

<https://doi.org/10.1088/1361-6471/ab4574>

Searching for long-lived particles beyond the Standard Model at the Large Hadron Collider

Juliette Alimena
(Experimental Coverage, Backgrounds, Upgrades)¹,
James Beacham
(Document Editor, Simplified Models)², Martino Borsato
(Backgrounds, Upgrades)³, Yangyang Cheng
(Upgrades)⁴, Xabier Cid Vidal
(Experimental Coverage)⁵, Giovanna Cottin
(Simplified Models, Reinterpretations)^{6,7,8}, David Curtin
(Simplified Models)⁹, Albert De Roeck
(Experimental Coverage)¹⁰, Nishita Desai
(Reinterpretations)¹¹, Jared A Evans
(Simplified Models, Experimental Coverage)¹²,
Simon Knapen
(Dark Showers)¹³, Sabine Kraml
(Reinterpretations)¹⁴, Andre Lessa
(Reinterpretations)¹⁵, Zhen Liu
(Simplified Models, Backgrounds, Reinterpretations)¹⁶,
Sascha Mehlhase
(Backgrounds)¹⁷, Michael J Ramsey-Musolf
(Simplified Models)^{18,19}, Heather Russell
(Experimental Coverage)²⁰, Jessie Shelton
(Simplified Models, Dark Showers)²¹, Brian Shuve
(Document Editor, Simplified Models, Simplified Models
Library)^{22,23}, Monica Verducci
(Upgrades)²⁴, Jose Zurita
(Experimental Coverage)^{25,26}, Contributors & Endorsers:
Todd Adams²⁷, Michael Adersberger²⁸, Cristiano Alpigiani²⁹,