



# Parameter Report

**01/10/24** One week until parameters & report frozen

Tables from Spreadsheet will be transferred to Overleaf on this day.

**11/10/24** End of Editing Period

**22/10/24** MuCol Management Board

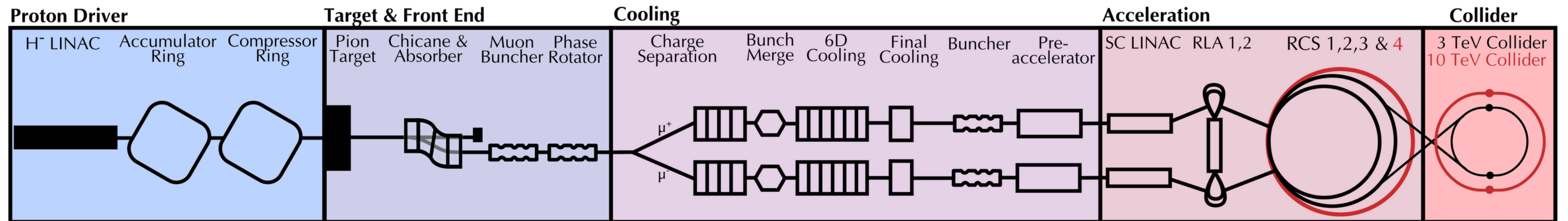
**30/10/24** EU Milestone Deadline

Subsystem	Parameters	Report
Proton Driver	✓	✓
Target & Front End	✗	✗
Cooling	✓	✗
Acceleration	✓ except LINAC	✓
Collider	✓	✓
MDI	✓	✗
Detectors	✗	✗
Magnets	✓	✗
RF	✓	✓
Radiation	✗	✗
Demonstrator	✓	✗

# Muon Collider Schematic

Community feedback on the schematic is welcome  
Easily adjustable .svg file (Inkscape)

- Version 1.1 has already been in circulation
- Version 1.2 released and has some minor corrections
- png and pdf forms uploaded on Indico. Ask for more file formats



R. Taylor v1.2 (2024)



# Report from the IMCC Early Career Researcher's Event

**R. Taylor**

*23rd September 2024*

Accelerator Design Meeting



**Funded by  
the European Union**

# About the event



**Early Career Researchers  
& Muon Colliders**

**Wed 28th August 2024 - Via Zoom**  
14:00-18:00 (CEST) & 08:00-12:00 (EST)  
Open for the public

  
[indico.cern.ch/e/muoncollider\\_ecr](https://indico.cern.ch/e/muoncollider_ecr)

Q&A with experts

Discussions on physics & the future

Design Overview of the Muon Collider

Call for External Speakers to present research

Open to:

- Undergraduates
- Masters
- PhDs
- Postdocs
- Students etc.

Interested in:

- Physics
- Engineering
- Computing
- Mathematics
- Communication etc.

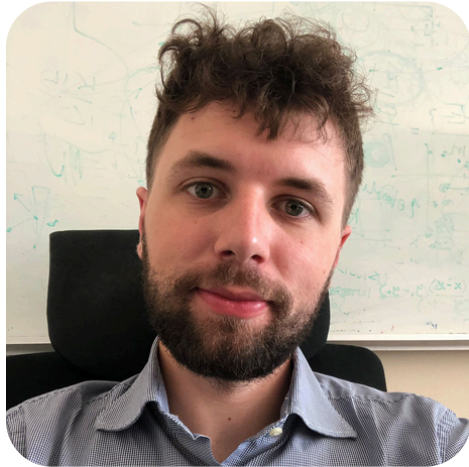


Funded by the European Union (EU). Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the EU or European Research Executive Agency (REA). Neither the EU nor the REA can be held responsible for them.

- Held on 28th August 2024.
  - After holidays, but before term starts
- Fully online, to maximize accessibility

1. Muon collider overview from 7 IMCC ECRs
2. Q&A from 3 IMCC representatives
3. Research talks from 7 external ECRs

# Organising Team



Daniele Calzolari  
CERN, PhD Student



Rodolfo Capdevilla  
Fermilab, Postdoc



Paula Desire Valdor  
CERN, PhD Student



Bernd Stechauner  
CERN, PhD Student

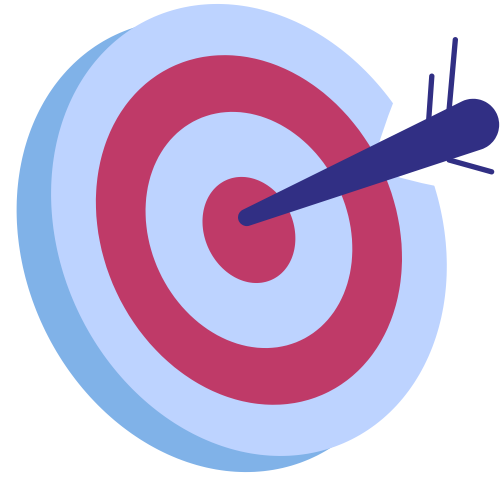


Michela Lancellotti  
CERN, Administrative  
Assistant



R. Taylor  
CERN, Senior Fellow

# Aims of the event



- To gain an indication of the **interest** of the Muon Collider for Early Career Researchers.
- To **showcase** the contributions of current Early Career Researchers to the Muon Collider design.
- To provide an opportunity for external Early Career Researchers to **share their questions and thoughts** to the Muon Collider Coordinators.



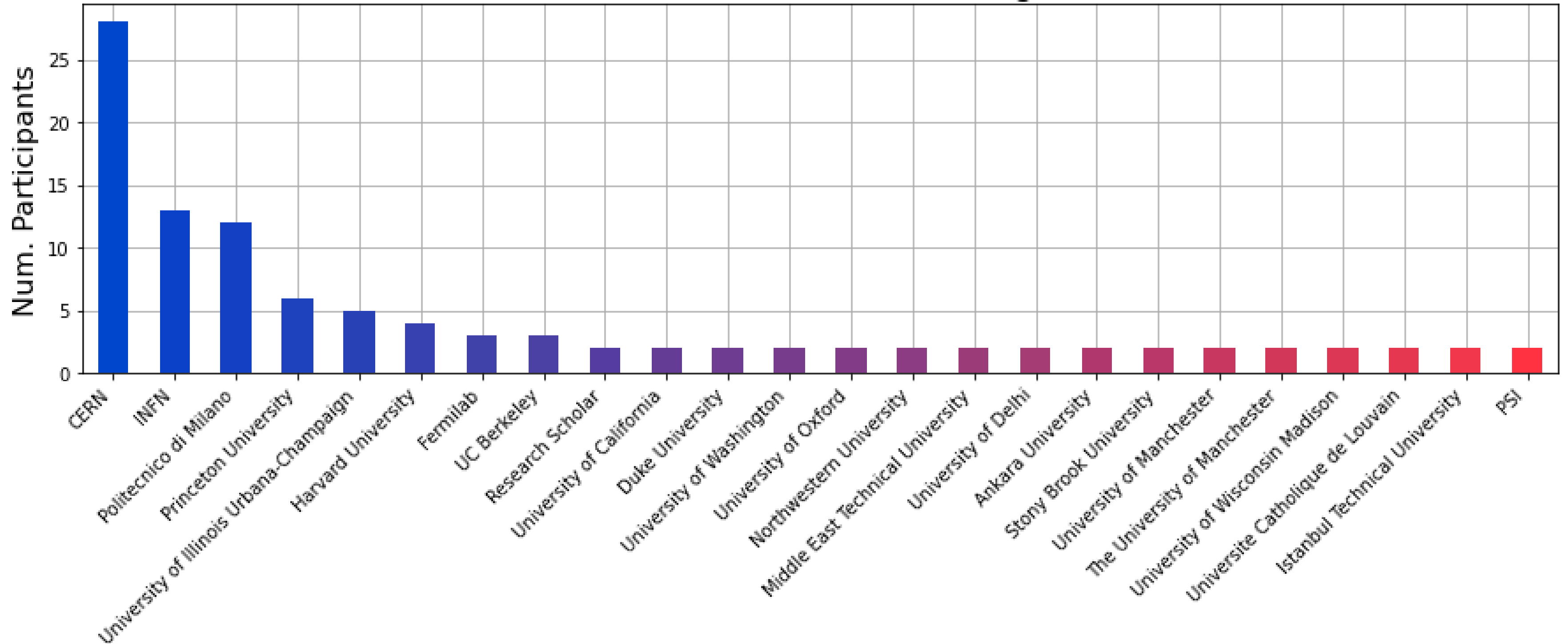


# Participant Demographics



Significant interest: **188** registrants from **38** countries and **103** institutes

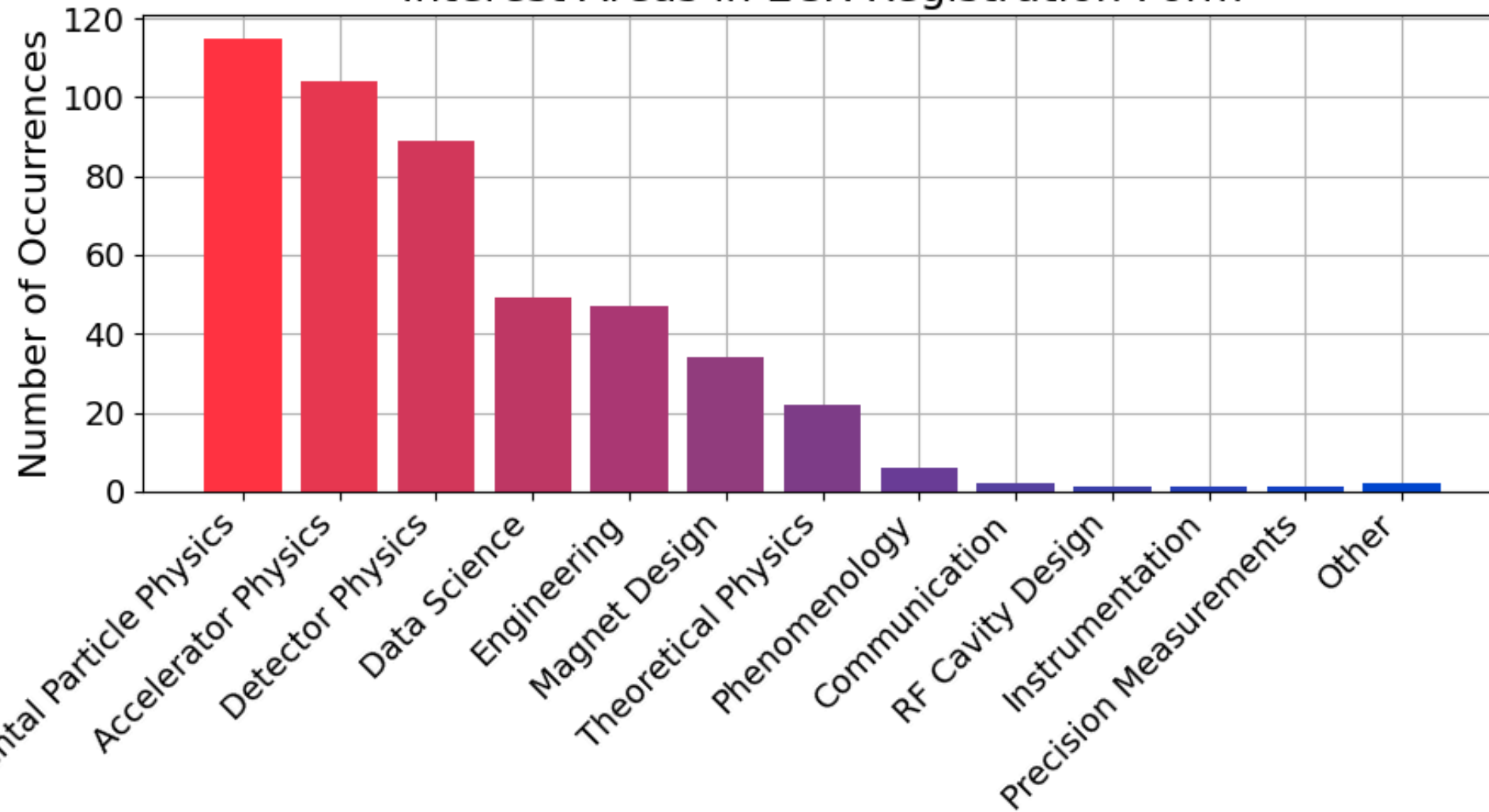
Institutes with more than one registrant



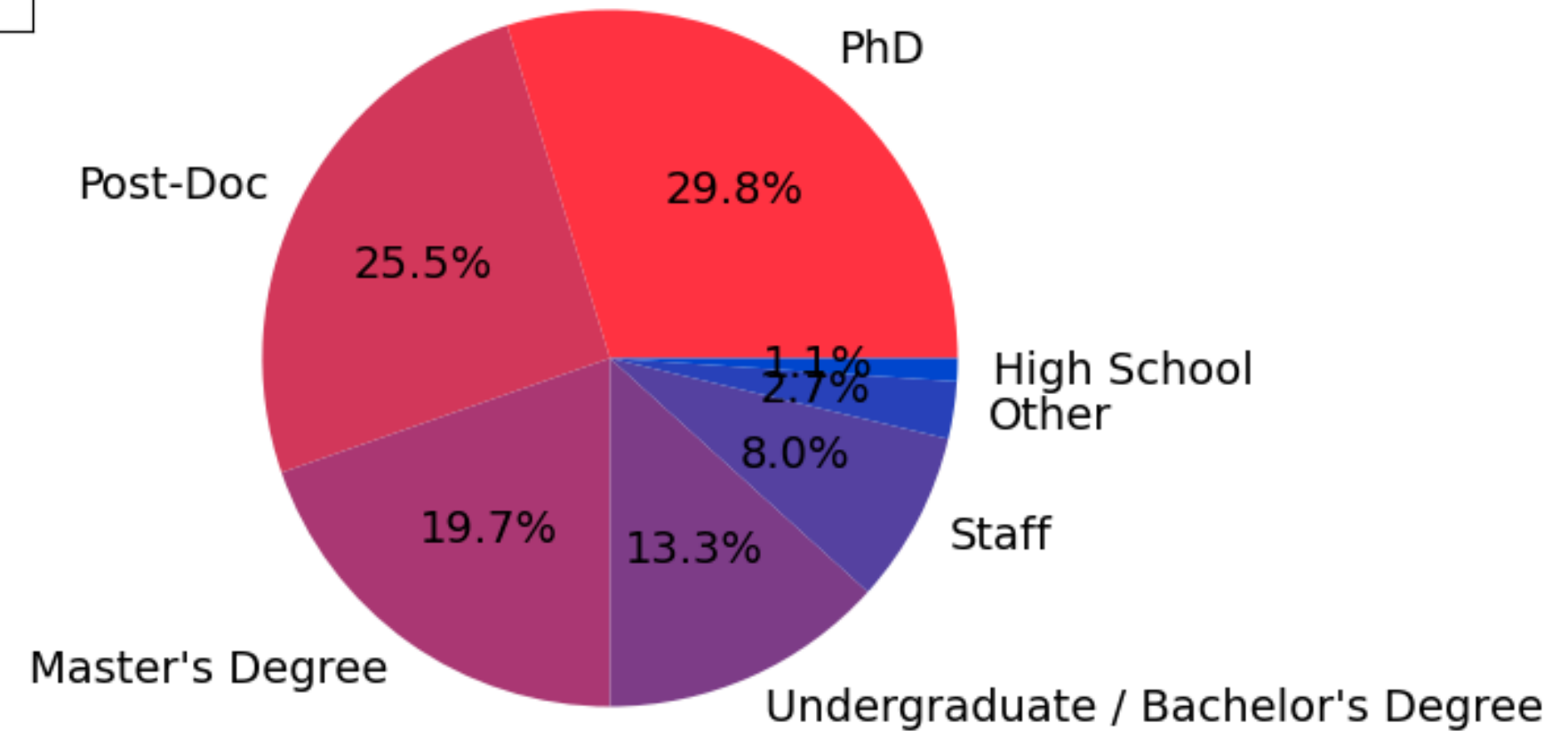


# Participant Demographics

Interest Areas in ECR Registration Form



Demographics

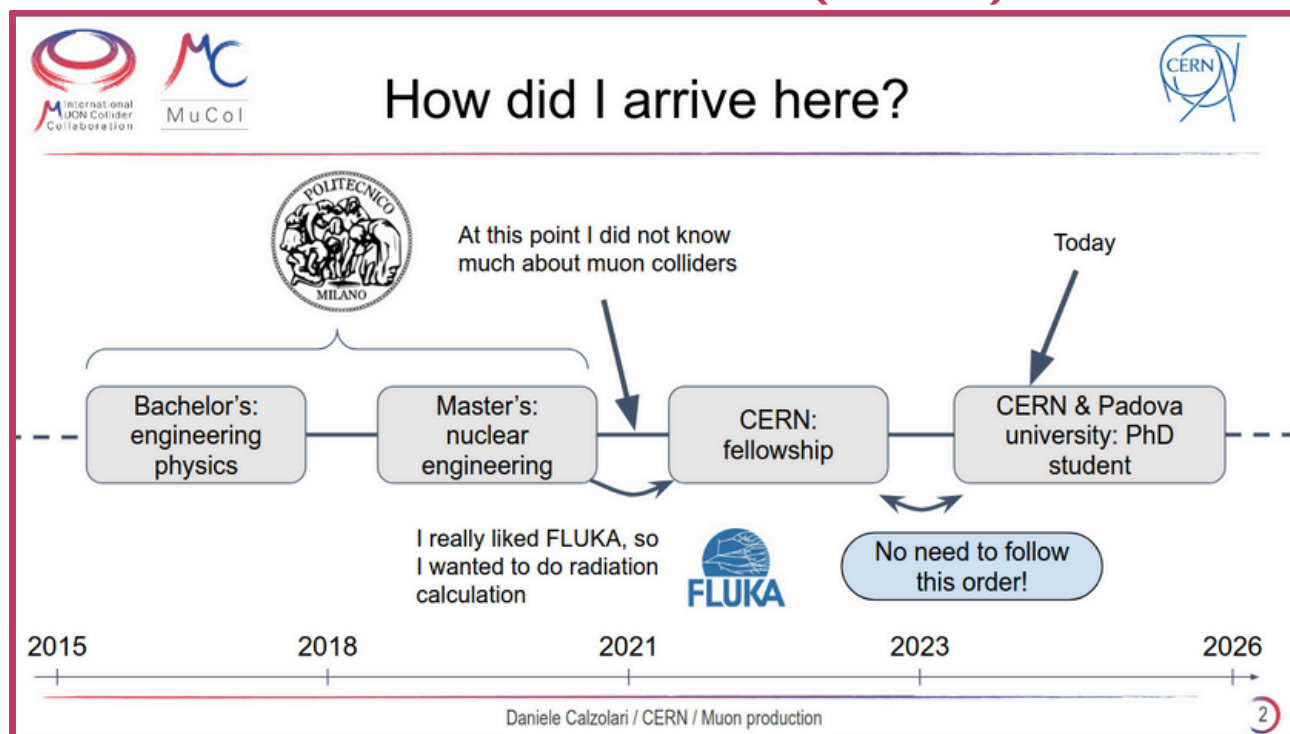


Attendee gender ratio ~40:60 (F:M)

Speaker gender ratio- 50:50

# Presentation Spotlight

## Production - Daniele Calzolari (CERN)



“Sustainable approach”

“Synergies”

## Acceleration - David Amorim (CERN)

**Muon acceleration challenges**

Proton Driver: H<sup>+</sup> LINAC, Accumulator Ring, Compressor Ring

Target & Front End: Pion Target, Chicanes & Absorber, Muon Phase Buncher Rotator

Cooling: Charge Separation, Bunch Merge, 6D Cooling, Final Cooling, Buncher, Pre-accelerator

Acceleration: SC LINAC, RLA 1,2, RCS 1,2,3 & 4

Collider: 3 TeV Collider, 10 TeV Collider

Picture from R. Taylor

Machine parameters

	RLA 1	RLA 2	RCS 1	RCS 2	RCS 3	RCS 4
Circumference [km]			6	6	10.7	35
Injection energy [GeV]	1.5	5	63	313.8	750	1500
Energy increase per pass/per turn [GeV]	0.7	11.6	14.7	7.9	11.3	63.6
Bunch intensity at injection [10 <sup>12</sup> muons]			2.7	2.4	2.2	2.0
$\epsilon_x$ [ $\mu\text{m rad}$ ] / $\epsilon_y$ [eV s]			25 / 0.025			

• **Fast acceleration** is required to **counter-balance the muon decay** while preserving bunch properties

• This requires a **unique accelerator chain and associated technologies**

2024-08-28 David Amorim - Acceleration

“Unique accelerator chain”

“No showstoppers”

## Muon Cooling - Bernd Stechauner (CERN)

**The ideal collider recipe**

- Heavy in mass (avoid radiation)
- Periodic collision structure (ring)
- Fundamental particle (no hadrons)

What about muons? **BUT: Lifetime 2.2  $\mu\text{s}$**

-> it needs new technologies

“New technologies”

“Time is now”

## Magnets - Giuseppe Scarantino (INFN)

**Design Considerations**

The muon collider as future machine at the energy frontier needs:

- **High fields** (dipoles, quadrupoles 16T-20T, solenoids up to 40T).
- **Energy efficiency** (increase operating temperature to 20K, minimize cryogen usage).
- **Economics** (consider high  $J_e$ , compact magnets to reduce construction, maintenance and operation cost).

**Synergies**

- **Important synergies with many technological applications:** thermonuclear fusion, next gen MRI, wind energy generators...

The muon collider promises a sustainable approach to the energy frontier:  
→ Limited power consumption, cost, land use.

HTS may be the enabler technology!!

Upper limit of Nb3Sn (LTS)

field (T)

year (-)

Credits: L. Bottura

ITER central solenoid model coil

MIT/CES SPARC TF Coil prototype

ASG UHF MRI magnet

LNCMI/CEA Nougat

## Physics - Cari Cesarotti (MIT)

**CHALLENGES OF MUC**

*Recent Improvements*

COOLING: MICE, Simulation, Timescales

MAGNETS: 20 T DIPOLES, 30 T SOLENOIDS, 10<sup>3</sup> T/S RAMPING

COMMUNITY INTEREST: IMCC + US R&D

“NEED N MIRACLES”

“NO SHOWSTOPPERS IDENTIFIED”

ESPPU + P5  $\Rightarrow$  TIME IS NOW!

## Detector - Kiley Kennedy (Princeton)

**Let's Build a Detector!**

**Tracker**

- Charged particles leave tracks
- Measure particle position & momentum, vertices

**Calorimeters**

- Dense materials stop particles
- Separate ECAL and HCAL systems
- Measure particle position, energy

**Muon Spectrometer**

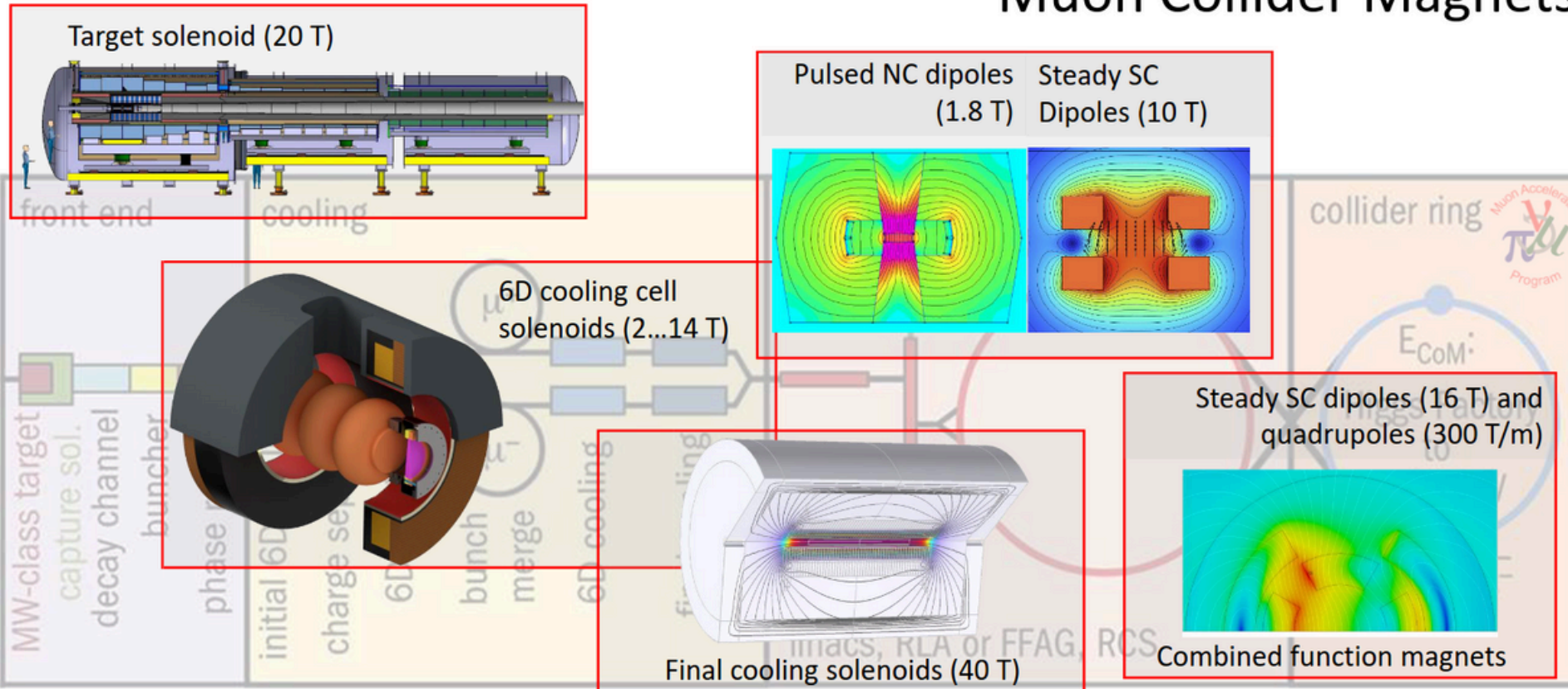
- Muon tracks escape detector
- Measure position & momentum

**Magnet System (not shown)**

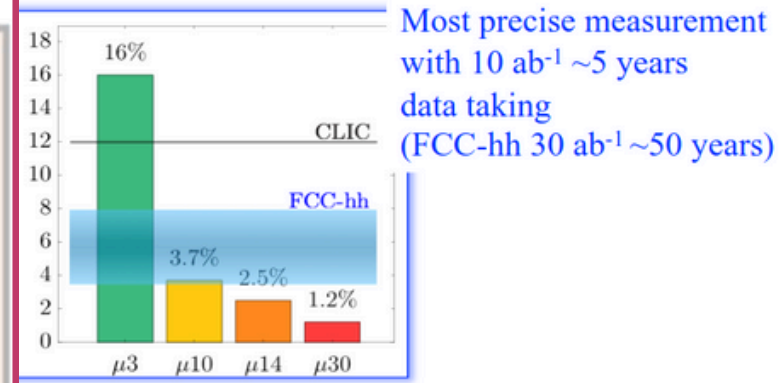
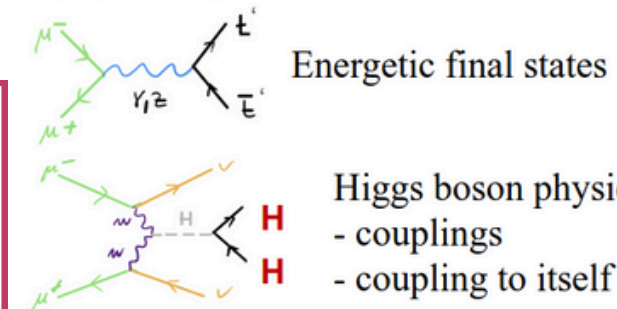
- Superconducting magnets provide B-field in tracker, muon spec.

# Q&A Spotlight

## Muon Collider Magnets



Multi-TeV muon collider opens a completely new physics regime



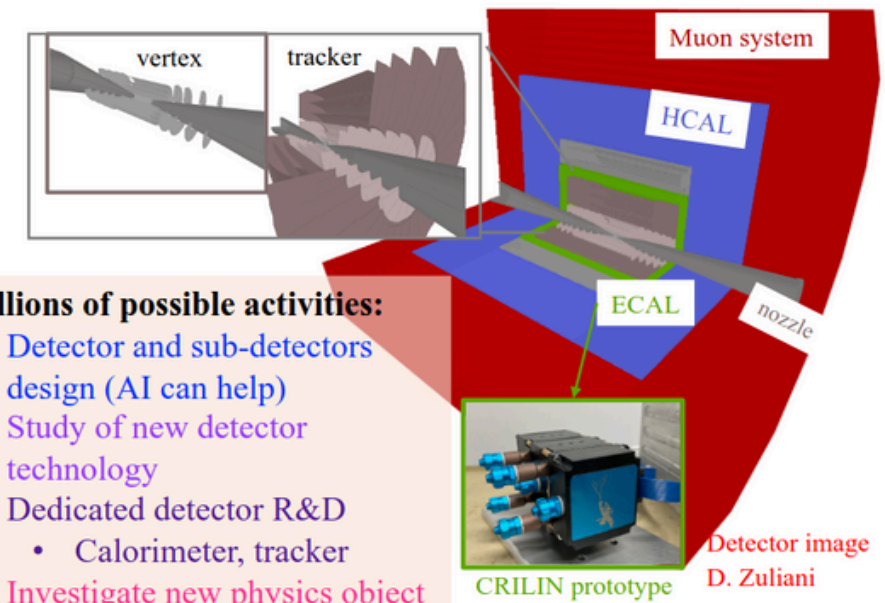
Meeting every Tuesday at 4:00PM CET  
MUONCOLLIDER-DETECTOR-PHYSICS@cern.ch



Donatella Lucchesi

First  $\sqrt{s} = 10 \text{ TeV}$  detectors concept design MUSIC and MAIA (presented in other talks)

### MUSIC Detector



### Zillions of possible activities:

- Detector and sub-detectors design (AI can help)
- Study of new detector technology
- Dedicated detector R&D
  - Calorimeter, tracker
- Investigate new physics object reconstruction (AI, QC)
- Propose new creative physics measurements

These are truly **frontier technology realizations**, the most challenging and promising you can imagine in our field !

Final question: "Can you provide an insights into the **daily working environments** of research groups working on muon colliders?"

Lots of fun  
**D. Lucchesi**

Research freedom  
**D. Schulte**

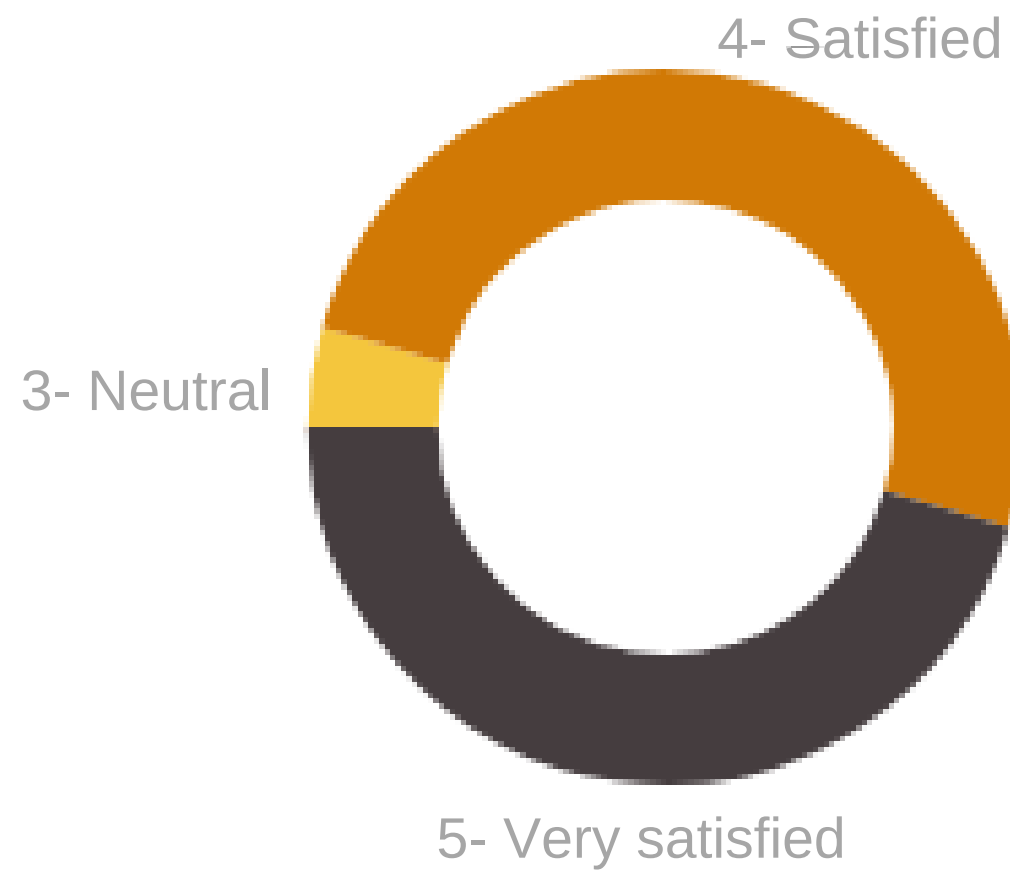
Dynamic environment

**L. Bottura**

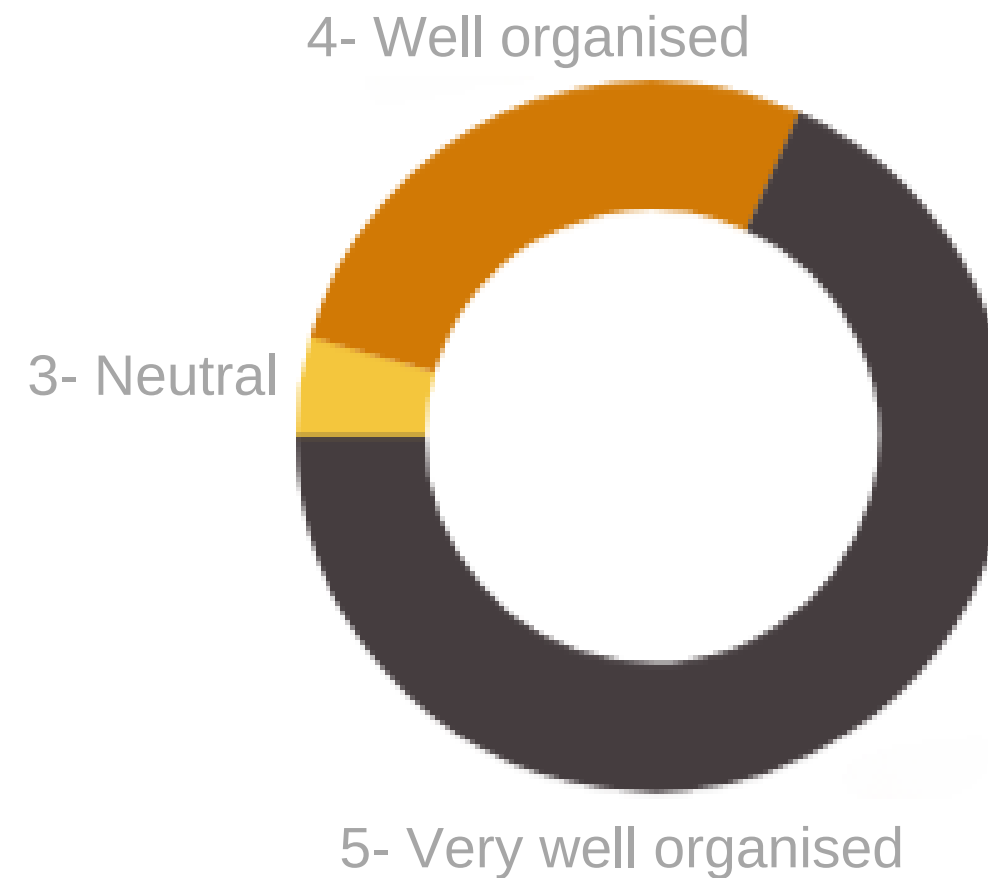
# Survey Results

## Sample of 22

- 95% of people satisfied or very satisfied with the event
- 95% of people said it well organised or very well organised
- 50% said it was the correct level, 50% said it was technical
- 100% said they would attend the event in the future. Equal mix would prefer online vs in-person.



Accelerator Design Meeting



R. Taylor



CERN

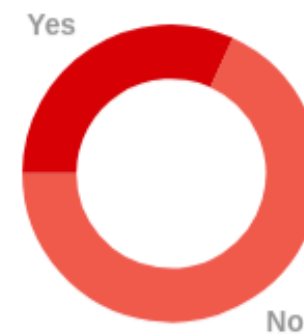
# Survey Results

- **31% of attendees currently work for the muon collider**
- **100% of those not currently working would like to work on it in the future**

Are you currently working or doing research for the muon collider?

A. Yes: 7 (31.82%)

B. No: 15 (68.18%)



If no, would you like to work on the muon collider in the future?

A. Yes: 15 (100.00%)

B. No: 0 (0.00%)



# Survey Results

- 30% of attendees currently work for the muon collider
- 100% of those not currently working would like to work on it in the future

Are you currently working or doing research for the muon collider?

A. Yes: 7 (31.82%)

B. No: 15 (68.18%)



If no, would you like to work on the muon collider in the future?

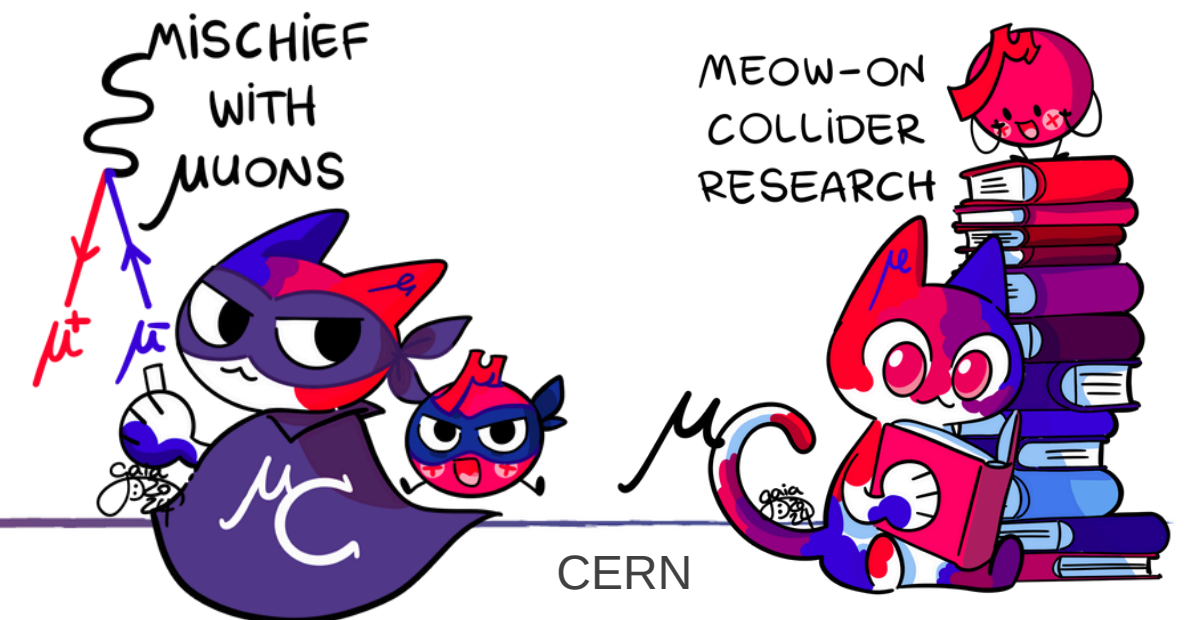
A. Yes: 15 (100.00%)

B. No: 0 (0.00%)



Other comments:

- Strong demand for a list of involved institutes and their **research scope**
- Demand for more frequent events but **discipline-focused**
- Multiple requests for a **Mattermost** channel
- Interest in **merchandise** (80%) of participants





# Mailing List for IMCC ECRs



*muoncollider-early-career@cern.ch*

European Laboratory for Particle Physics

[Report an error](#) | [Suggest new functionality](#)

Rebecca TAYLOR | Group Memberships: 231 | [Logout](#)

## e-groups

e-group name begins with

All e-groups  ALICE  ATLAS  CMS  FASER  LCG  LHCb  LHCF  MoEDAL  SND@LHC  TOTEM  
 Only groups I own or manage |  Only groups I am on | Page Size:

Quick Search  
All groups I own or manage  
All groups my accounts are on  
All e-group archives

[+ Create new static group](#) [+ Create new dynamic group](#) [Show groups for one member](#) [Manage groups for one member](#) [Manage owner/admin](#)

E-groups									
Goto <input type="text" value="1-1"/>									
	Name	Type	Topic	Description	Status	Owner	Actions	Archive	
	<a href="#">muoncollider-early-career</a>	Static	IMCC	Informational list for external ECR interested in IMCC	Active	taylor.r@cern.ch	<input type="button" value="Subscribe"/>		

Or contact me ([taylor.r@cern.ch](mailto:taylor.r@cern.ch)) to add you



# ECFA ECR Upcoming Events



The ECFA ECR panel is organising an early-career researcher white paper to submit to the strategy, similar to the ECR response to the last strategy update in 2020. This process is open to all European early-career researchers. We will discuss our vision for the future of HEP in Europe, focusing on the question of the next collider.

9th - 11th October

## Town Hall Meeting at ECFA Workshop in Paris

Registration deadline tomorrow

14th - 15th November

## Plenary ECFA Meeting at CERN

Hybrid meetings adjacent to these meetings

**Muon Collider  
Attendance Encouraged**

Early Career Researcher white paper submitted by 31st March 2025

Updates if you subscribe to [esppu-ecr](#) CERN e-group.

Mattermost channel: [https://mattermost.web.cern.ch/signup\\_user\\_complete/?id=ocewxrmyjjyymeftrbg3bsoaa&md=link&sbr=su](https://mattermost.web.cern.ch/signup_user_complete/?id=ocewxrmyjjyymeftrbg3bsoaa&md=link&sbr=su)



# Conclusions

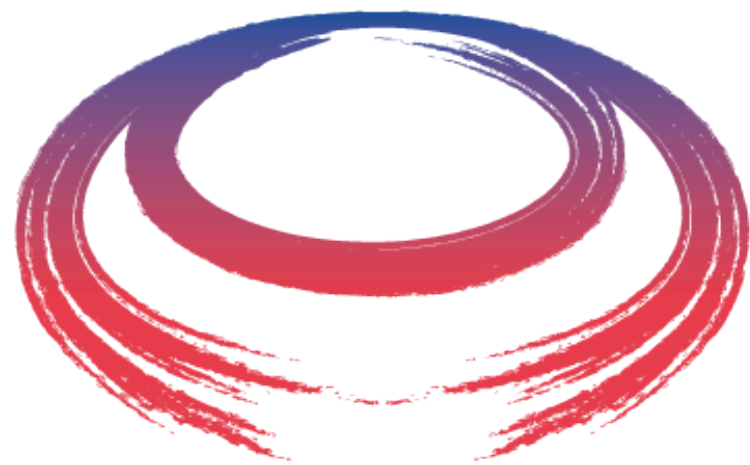
- **High interest** from the community, including those not currently working on muons
- Event will be **repeated**, both online and in-person.
- New **mailing list** created ([muoncollider-early-career@cern.ch](mailto:muoncollider-early-career@cern.ch)) for future engagement
- Most participants got their news from **LinkedIn** posts prior to event
  - Feedback from participants is being relayed into the communication strategy
- Reached attention of **Accelerating News** - article in preparation



- It is commonly said “the next generation are interested in the muon collider”
  - **Now we can back this up!**
- Important to relay into the ESPPU strategy



# Thank you



 International  
UON Collider  
Collaboration



M u C o l



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