UiO : Department of Physics
University of Oslo

Evaluation of ATLAS Z Masterclasses 2024

IMC Steering group meeting

Monday 25 November 2024

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Introduction

- a survey with some questions was distributed to IMC participants doing the `Z-path` exercise in spring 2024
  - testing their prior awareness of particle physics
  - testing their understanding of some of the most relevant topics of the `Z-path` masterclass
  - asking what they liked/disliked about the programme
  - their view on fundamental research and what we are doing at CERN
  - what they think about their own (possible) future in academia
- a link to the survey was distributed through the *hosts*, in one of the regular e-mails from Uta after all the IMC events were done this spring
- 100% anonymous

Responses

- **Internationally**: got answers from 13/87 institutes which did the `Z-path` exercise in 2024
  - in total **61 submissions**
- **Norway**: got answers from **40**/200 pupils who did the `Z-path` exercise at the University of Oslo in 2024

Will mostly show the results from international survey today

Who answered?

Date	Place	Num.
25th March	Zaragoza	5
26th March	Parma	1
27th March	Opava	4
22nd March	Timisoara	3
15th March	Granada	5
25th March	Milan	13
25th March	Bratislava	1
16th March	Heraklion	1
15th February	Žilina	8
15th February	Lecce	3
16th February	Naples	4
11th March	Milan	1
29th February	Pavia	1
23rd March	Iasi	1
Unknown		10
Total		61

-	Boys	Girls	Age > 19	Age 18-19	Age 16-17
Internationally	63%	25%	0%	65%	30%
Norway	70%	24%	8%	87%	3%

What do they know about particle physics before they participate in IMC?

Have you learnt about particle physics in the classroom at school?

Antall svar: **60**

Svar	Antall	% av svar	Diagram
Yes	33	55%	55%
No	27	45%	45%

Number of submissions: **40**

Submissions	Count	% of submissions	Chart
Ja	35	87.5%	87.5%
Nei	5	12.5%	12.5%

Have you learnt about particle physics outside of the classroom (school trip, online, TV, ...)

Antall svar: **60**

Svar	Antall	% av svar	Diagram
Yes	45	75%	75%
No	15	25%	25%

Number of submissions: **40**

Submissions	Count	% of submissions	Chart
Ja	22	55%	55%
Nei	18	45%	45%

Where do they learn about particle physics (outside school)?

- Inmersion Week and Hands on Particle Physics Activity at the Faculty of Sciences of Zaragoza
- My parents.
- Mainly reading and watching scientific content from people like QuantmFracture or Sonia Fernández Vidal among others
- TV shows and encyclopaedias
- Youtube videos and books
- Online, reading books
- Online, Netflix, Youtube
- Youtube
- Youtube
- Youtube
- in that activitie
- Books, Online
- In social media
- A Youtube chanell called Cuantum fracture and Javier Santaolalla
- online, video, news paper
- tv
- online, documentaries, school trip
- Youtube, internet, science books
- Youtube
- online
- social and family
- Youtube
- I watched many films About it
- TV shows and Youtube videos
- online
- cern
- Books and online
- Youtube videos
- online
- Watching Youtube divulgative videos, reading books, visiting CERN (1 year ago)
- School trip, we went to CERN
- Youtube
- School trips, Youtube videos and wikipedia
- By reading about it
- Online
- There are many Youtubers who make videos about these themes
- a stage
- Youtube
- online
- haut energies
- I learnt with books and with my friend bcs we talked about it

Understanding of particle physics

Understanding of particle physics

A down quark has spin...

Number of submissions: **58**

Submissions	Count	% of submissions	Chart
-1	5	8.6%	8.6%
1/2	22	37.9%	37.9%
2/3	4	6.9%	6.9%
-1/3	27	46.6%	46.6%

Number of submissions: **39**

Submissions	Count	% of submissions	Chart
-1	2	5.1%	5.1%
1/2	22	56.4%	56.4%
2/3	1	2.6%	2.6%
-1/3	14	35.9%	35.9%

- a mix-up of spin and charge, but it is not something they really need to know when doing the `Z-path` exercise
- however, in the lecture we give in Oslo we talk quite a lot about *spin*

Understanding of particle physics

An electron can be detected in the..

Number of submissions: **58**

Submissions	Count	% of submissions	Chart
Electromagnetic calorimeter	48	82.8%	82.8%
Hadronic calorimeter	0	0%	0%
Tracking detector	7	12.1%	12.1%
Muon spectrometer	3	5.2%	5.2%

A neutron can be detected in the...

Number of submissions: **56**

Submissions	Count	% of submissions	Chart
Electronic calorimeter	5	8.9%	8.9%
Hadronic calorimeter	34	60.7%	60.7%
Tracking detector	15	26.8%	26.8%
Muon spectrometer	2	3.6%	3.6%

Understanding of particle physics

A positron can be annhilated by...

Number of submissions: **59**

Submissions	Count	% of submissions	Chart
Electron	49	83.1%	83.1%
Negatron	4	6.8%	6.8%
Muon	5	8.5%	8.5%
Cyclotron	1	1.7%	1.7%

Ordinary matter is made up of which quarks?

Number of submissions: **59**

Submissions	Count	% of submissions	Chart
Muon & Tau	2	3.4%	3.4%
Up & Down	50	84.7%	84.7%
Proton & Neutron	5	8.5%	8.5%
Top & Bottom	2	3.4%	3.4%

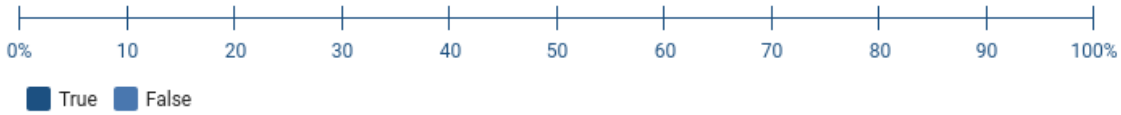
Understanding of particle physics

The photon is responsible for...

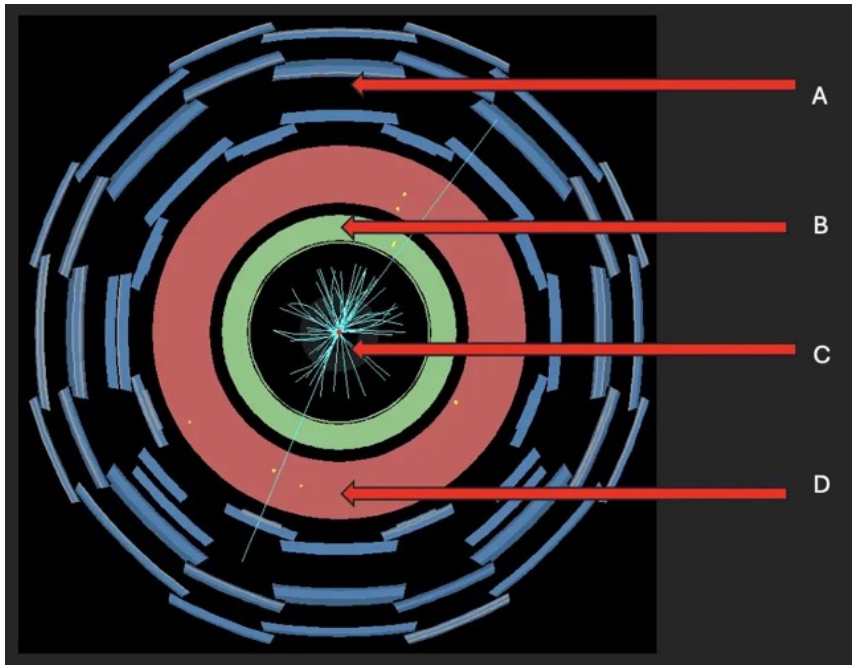
Number of submissions: **56**

Submissions	Count	% of submissions	Chart
The weak force	6	10.7%	10.7%
Giving mass to Z and W bosons	4	7.1%	7.1%
The electromagnetic force	43	76.8%	76.8%
The strong force	3	5.4%	5.4%

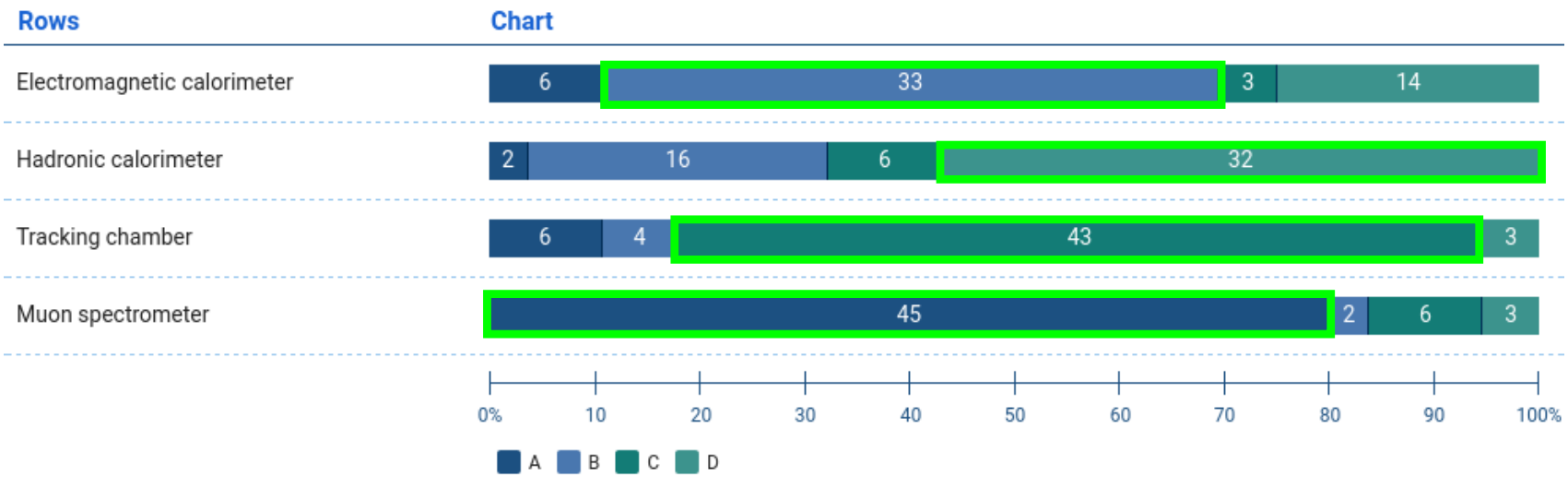
Rows	Chart	
The higgs boson can decay to two neutrons	17	41
Z-prime can decay to two protons	19	39
The graviton can decay to two photons	23	34
The Z-boson can decay to an electron and a muon	32	26
The Z-boson can decay to two leptons with the same charge	23	34



Understanding of particle physics



Match the labels (A, B, C and D) to the names for different parts of the detector



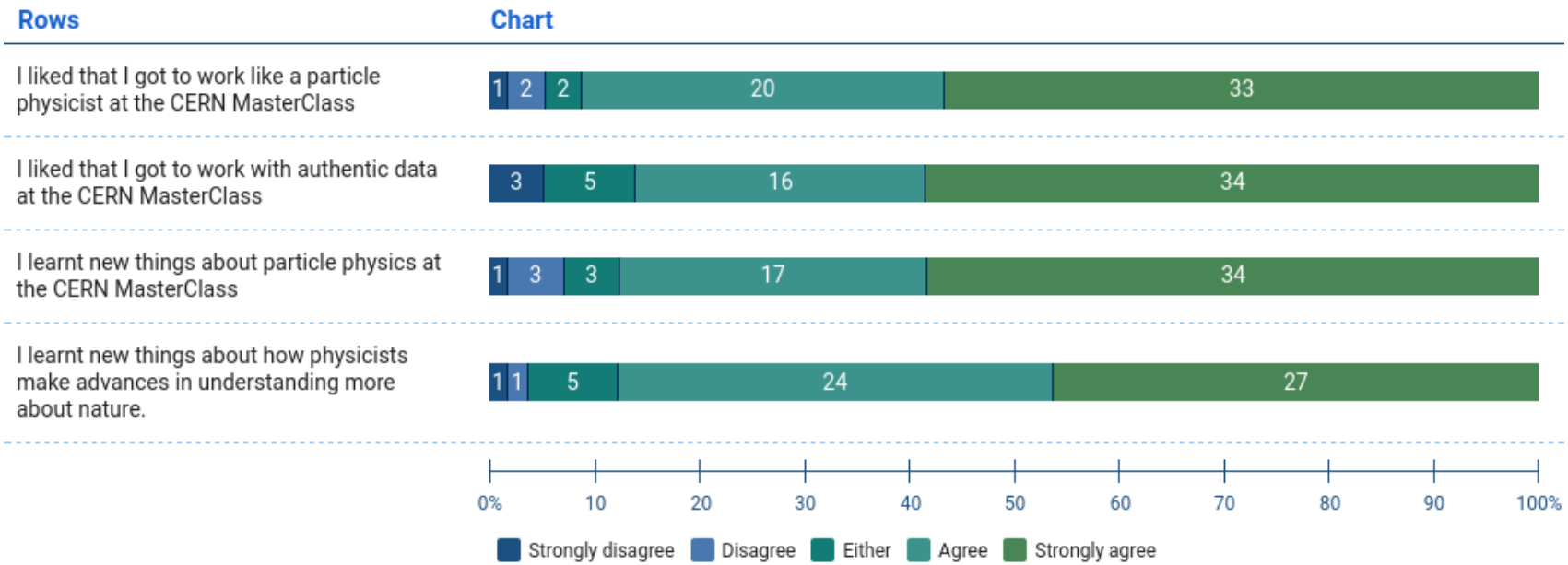
Some remarks about the knowledge part

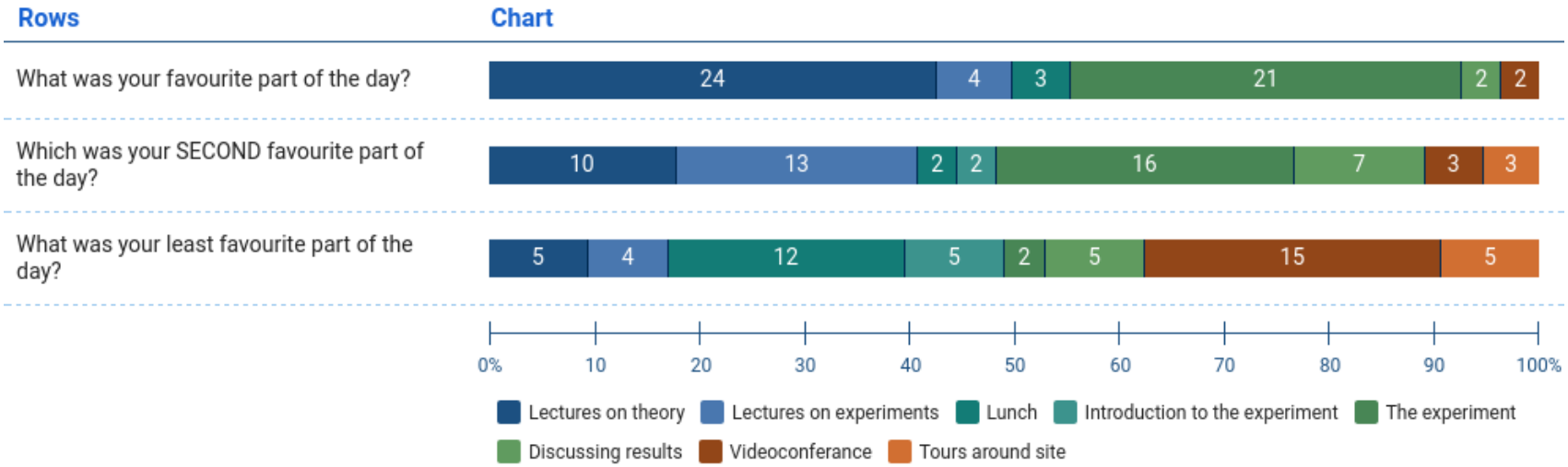
- several of the questions were about things which they just need to learn *by heart* and does not really test too much of what they have actually understood about particle physics or of the experimental activity
- we don't know what they knew in advance of the IMC
- if we will repeat the survey we plan on adding more questions on the understanding of what they did in the practical exercise (i.e. identify electrons, muons and photons) and interpreting of the results (statistics, signal and background etc.)
- the learning goals in physics at Norwegian high schools does not include anything specific about particle physics, they rather focus on that the pupils should be able to
  - plan, conduct, and further develop experiments, analyze data, and calculate uncertainty to assess the validity of findings
  - present key elements of new knowledge in physics resulting from international research collaboration, and assess how such collaboration contributes to the development of knowledge
  - explore and analyze a self-chosen theoretical or practical problem in physics, and present important principles, relationships, and consequences

How did the pupils find the whole IMC day?

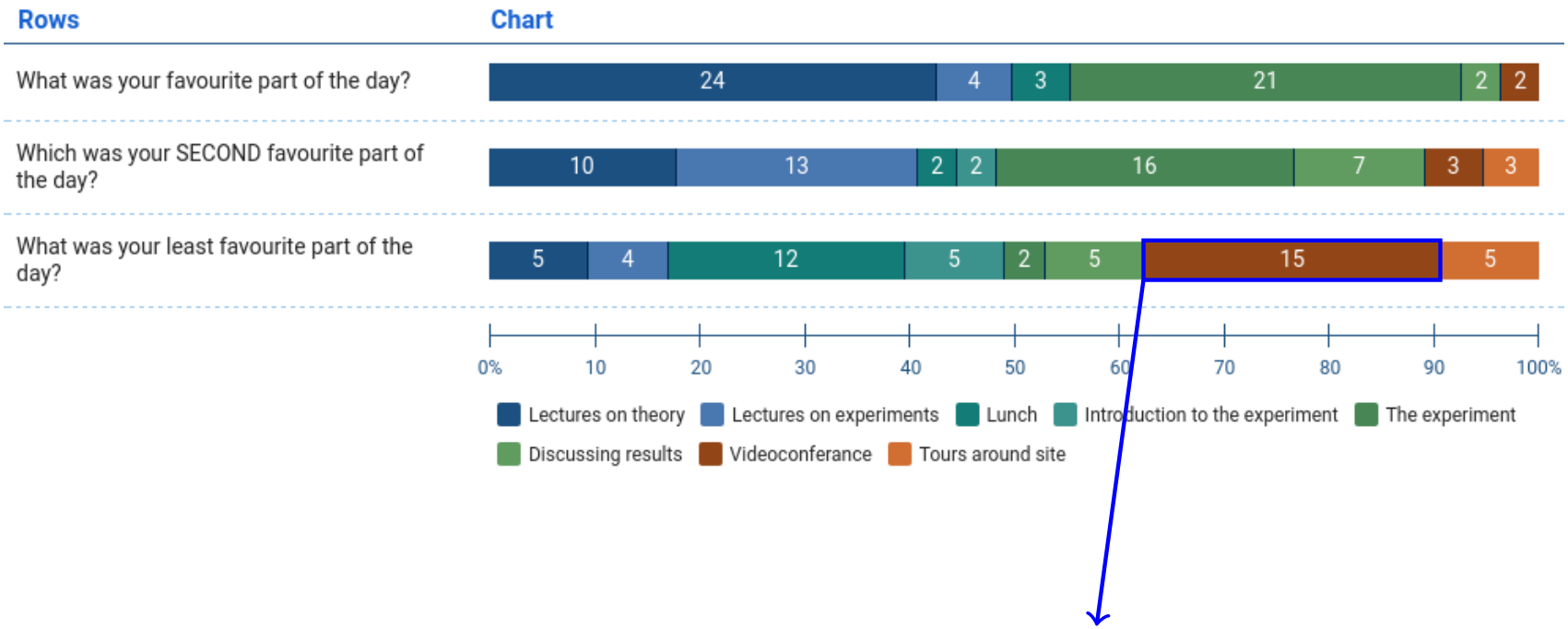
What did they like/dislike about IMC

About the CERN masterclass:





What did they like/dislike about IMC



- The videoconference: I think it should be more focused on CERN and some related curiosities. I also think that a smaller number of participants would allow better communication.
- I'd recommend making the historical part smaller.
- More time to show research of the university.
- It should take less time...
- It should take less time.
- Maybe the experiment could be a little longer so people could take it with more calm.

Mention something from the CERN Masterclass event that you recommend keeping the same next year

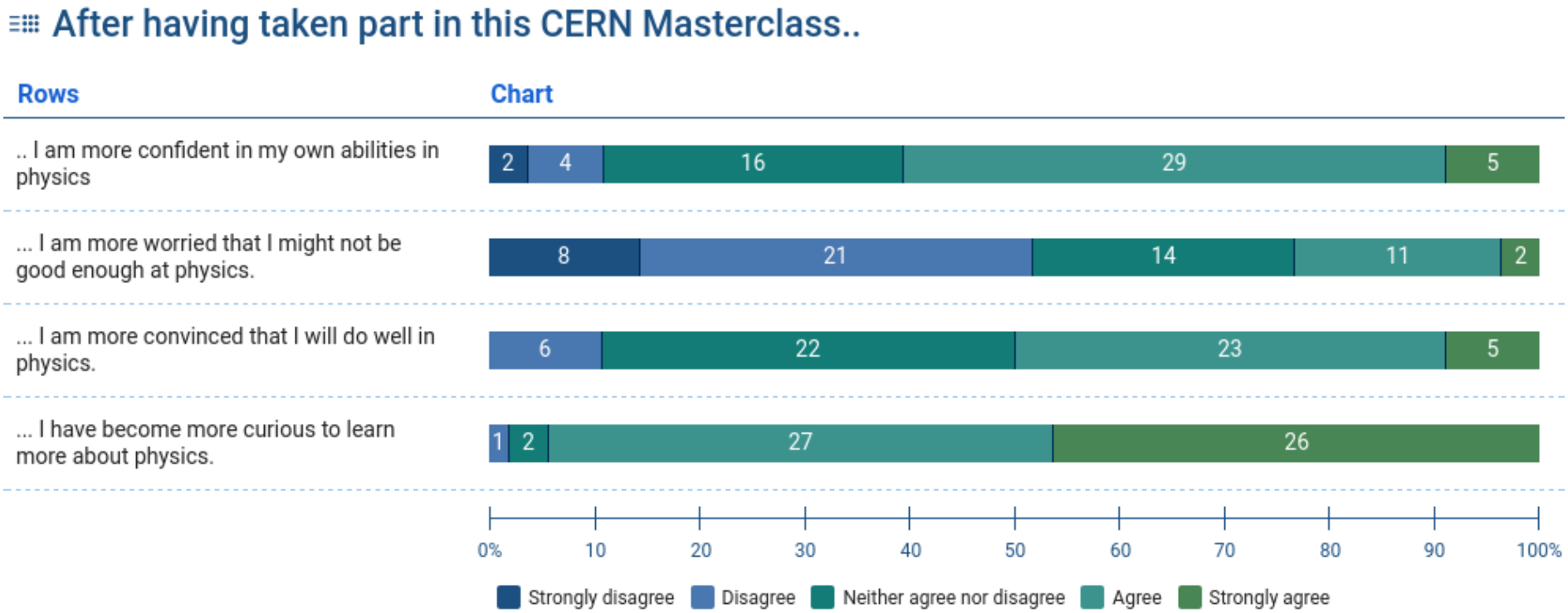
- videoconference with other countries
- The theory lecture.
- It was really cool to have a videoconference with CERN researchers, I would keep that for the following years.
- The video call with other universities at the same time so we can share experiences
- The international videoconference discussing data and exchanging questions to professionals.
- The experimental activity
- Interesting lectures
- The video conference
- Parte experimentall
- The talk about all kinds of particles that have been found and the particles that are been searched.
- lectures
- Some caracteristic of CERN
- The possibility to access actual data collected at CERN
- La parte práctica estuvo muy bien, al igual que la orientación sobre la carrera
- The experiments
- The structure of the lessons and the final experiment
- The experiment part was really interesting.
- The theory lectures at the beginning.
- lectures on relativity
- the experiment and the conference
- Idk
- lectures, doing an experiment with real data.
- Working with real data and practicing with experiments.
- The data processing
- The experiment with real data
- The lunch...
- Analyzing data and understanding what the different parts mean
- The discussion with other schools
- People who presented the theory
- I don't know.
- The lunch! Also, the fake data in the experiments were a nice plot twist
- The tour around site and all the lectures on theory, specially that one about physics' career
- lectures and lunch
- refaire exactement ce que nous avons fait.
- The visioconference

Mention something from the IMC that you recommend changing next year - and how you would change it

- Improving the audio system for the videoconference
- I would change the videoconference giving more time for questions per country.
- It was perfect.
- nothing
- I'd recommend making the historical part smaller.
- Maybe give us even better and more detailed explanation of how to evaluate the experiment data.
- the programme used for experiments
- maybe explain a little more of theory
- Avoid making an apology for the standard model
- Maybe the experiment could be a little longer so people could take it with more calm.
- Introduction to Hypatia can be more clear
- nothing really
- Overall pace was a bit too fast
- more empty on explaining the different types of quarks
- Mejoraría la parte teórica
- The experiment, it would be cool to use real data instead of computer generated one
- Te prectic, it spend a lot of time
- The videoconference: I think it should be more focused on CERN and some related curiosities. I also think that a smaller number of participants would allow better communication.
- Menos teoria más práctica. Mayores turnos de palabra. Quizá lo alargaría a dos días o reduciría el tiempo de descanso. Pero definitivamente cambiad el menú
- nothing it was good
- The introduction
- To make an experiment little shorter, after the lectures and other programe we were little tired and there were too many data to analyze.
- Having more questions answered during the video conference.
- More time to show research of the university.
- I recommend going a little faster on the theory section, since it felt very slow and some of us had already learned that topic in school
- It should take less time...
- I really enjoyed everything, I don't have any recommendation for changes
- nothing
- It should take less time.
- Maybe, choosing a group of speaker for the conference instead of just one person, would be preferrable

How did IMC influence the pupil's view on fundamental research, particle physics, CERN and their own career?

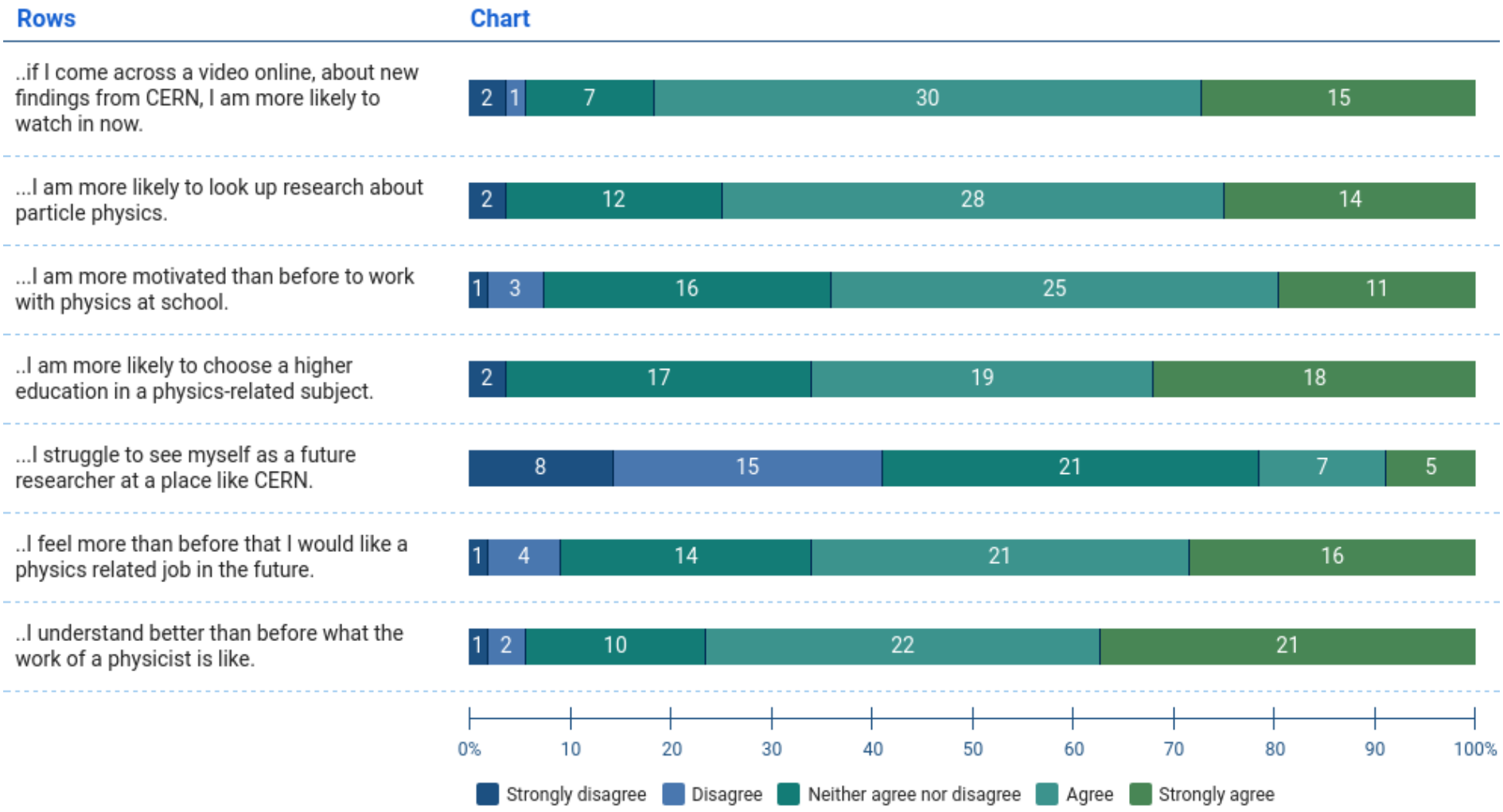
Thoughts on their own capabilities in physics after IMC



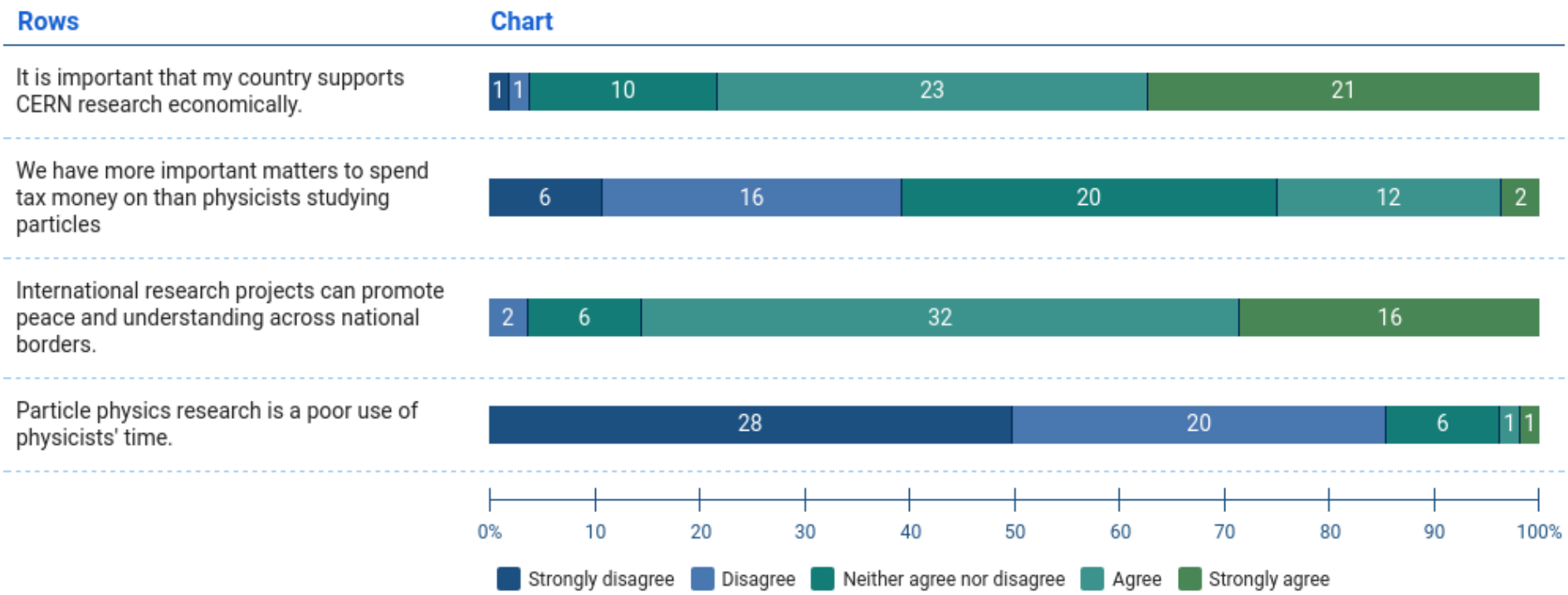
- in general very positive answers
- IMC seems to have given them additional motivation in doing physics

Interest in CERN, physics and particle physics?

After having taken part in this CERN Masterclass..



Support of fundamental research



Conclusions

- most pupils seem to find the IMC really interesting and that it has increased their interest in fundamental research, particle physics and CERN
  - however, maybe too few responses to draw any clear conclusions
  - maybe just the more motivated students who actually took the time to answer the survey
  - would also be interesting to know how the participants are recruited each place (whole classes, only physics students, smaller group of pupils ...)
- the survey was originally meant to be part of a MSc project at the University of Oslo (collaboration between the group of High Energy Physics and the Research Section for Physics Education), but seems unlikely that this will happen
- we are planning on making a new and improved version of the survey for the Norwegian `Z-path` participants in 2025
- would be great to also have an international version (if interest)
  - try to advertise it better and have a survey ready before the IMC starts
- happy to share the results if anyone's interested (just contact me)!

Thanks!

What is `Z-path`?

- The students go through events using event displays
  - Looking for good electron, muon, and photon candidates
  - Identifying events with dileptons ($e^+e^-/\mu^+\mu^-$), diphotons ($\gamma\gamma$), or 4 leptons ($e^+e^-e^+e^-$, $e^+e^-\mu^+\mu^-$, $\mu^+\mu^-\mu^+\mu^-$)
  - Calculating invariant masses and uploading these in the end to a plotting tool
- In the end, results are combined, and invariant mass distributions are built, where the students may have
  - Identified and measured masses(/widths) of well-known particles such as the J/ψ, Υ, and Z^0
  - Identified good Higgs-boson candidates
  - Discovered new particles (Z', Graviton)