



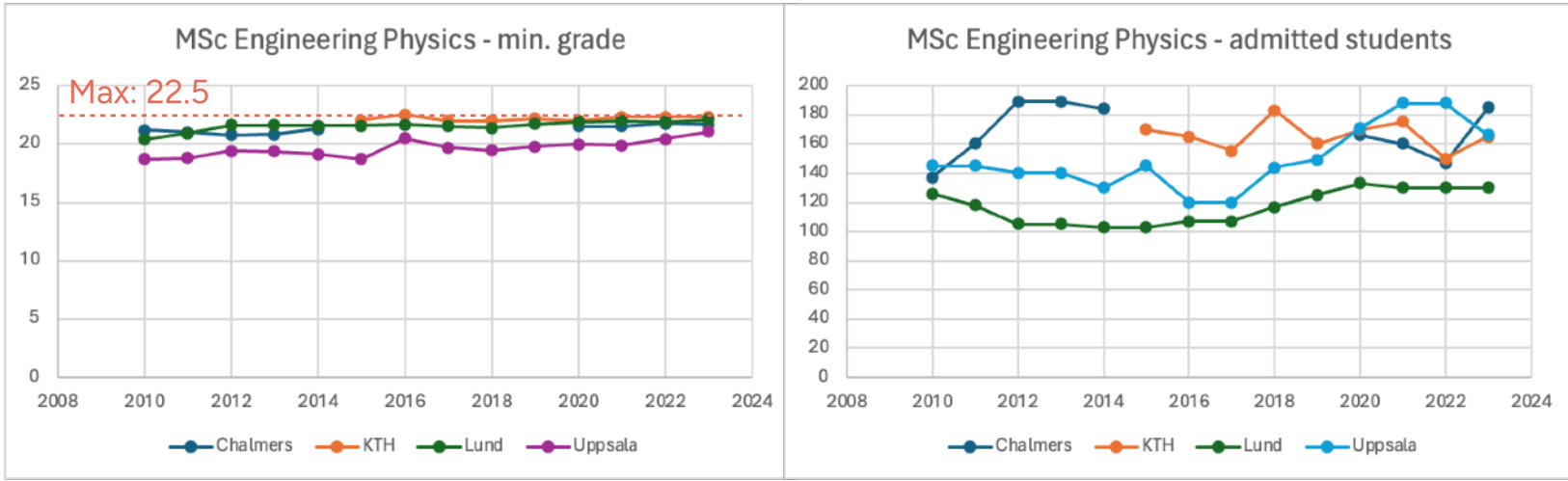
Education and outreach

Christian Ohm (KTH), with material from *many*
RECFA meeting, Lund, May 16, 2024

University system in Sweden - with an eye towards HEP

- Swedish higher education implements the Bologna system, first and second cycle:
 - BSc: 3 years, thesis is one semester at 50%
 - MSc: 2 years, *thesis is one semester* full-time
- Two main paths to research in physics related to accelerators
 - MSc in Physics
 - MSc in Engineering Physics
- PhD is 4 years full-time, up to 5 years with $\leq 20\%$ teaching
 - One year of courses (often spread out over PhD)
 - Fully employed, full social security benefits (e.g. parental leave), decent salary
⇒ competitive for attracting strong international candidates

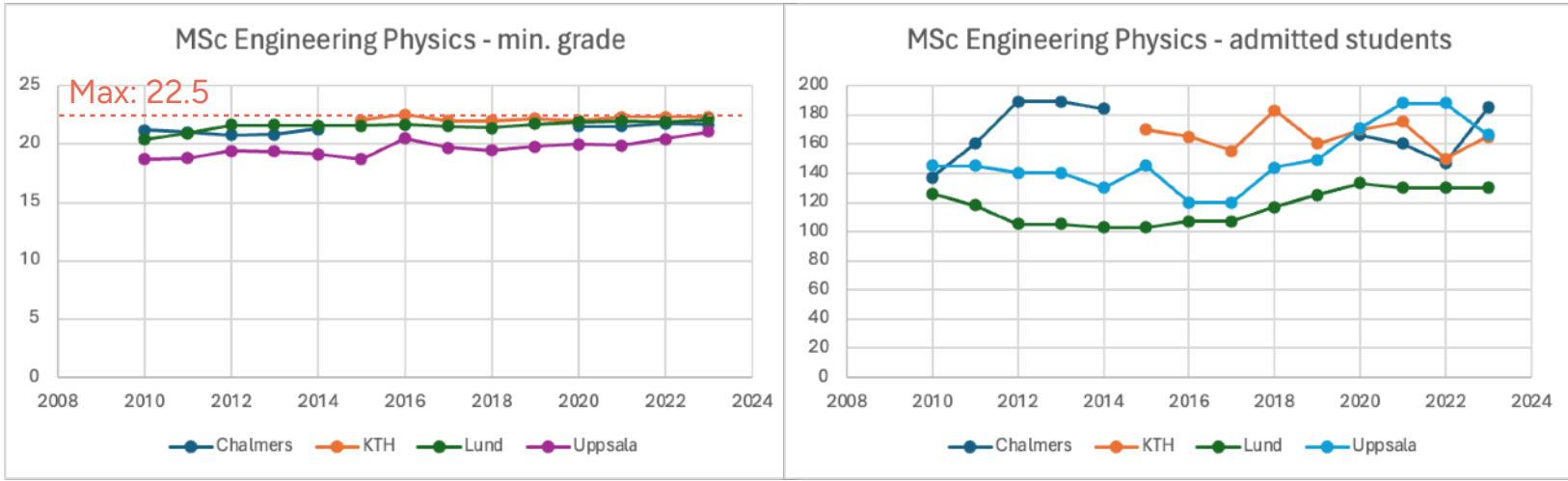
University system in Sweden - with an eye towards HEP



- Grades required and number of admitted students for the Engineering Physics BSc+MSc program (admission from HS)
- Attractive program, with possibilities to select tracks with QFT, SM, LHC physics courses
 - Gender diversity better in pp-related courses (50/50) than overall (~80% male)

(These programs also exist at several more universities, just showing examples here)

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Pure physics MSc:

- **Dedicated programs** relevant to HEP exist, e.g.
 - Lund: Particle Physics
 - Uppsala: Nuclear & Particle
 - Sthlm: Particles & Cosmos
- BSc and MSc admission is separate, so less obvious connection to high school grades

(These programs also exist at several more universities, just showing examples here)

Outreach

- Swedish community is *very active in outreach*
 - Strong interest!
 - Experience \Rightarrow creativity and improved skills

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 - Experience ⇒ creativity and improved skills
- Many reasons!
 - **Inspire** the next generation of scientists!
 - Our **responsibility** to inform the general public, they help pay for it — we need to nurture their trust
 - Inform about what our research **gives back to society**
 - Explain **how** we do research
 - **Fun!** Reminds us of the big picture, rewarding on a personal level
 - It's our job! Outreach is the **third task** for faculty (law since 1977)
⇒ Despite this, **very little/no resources and funding** are available for it

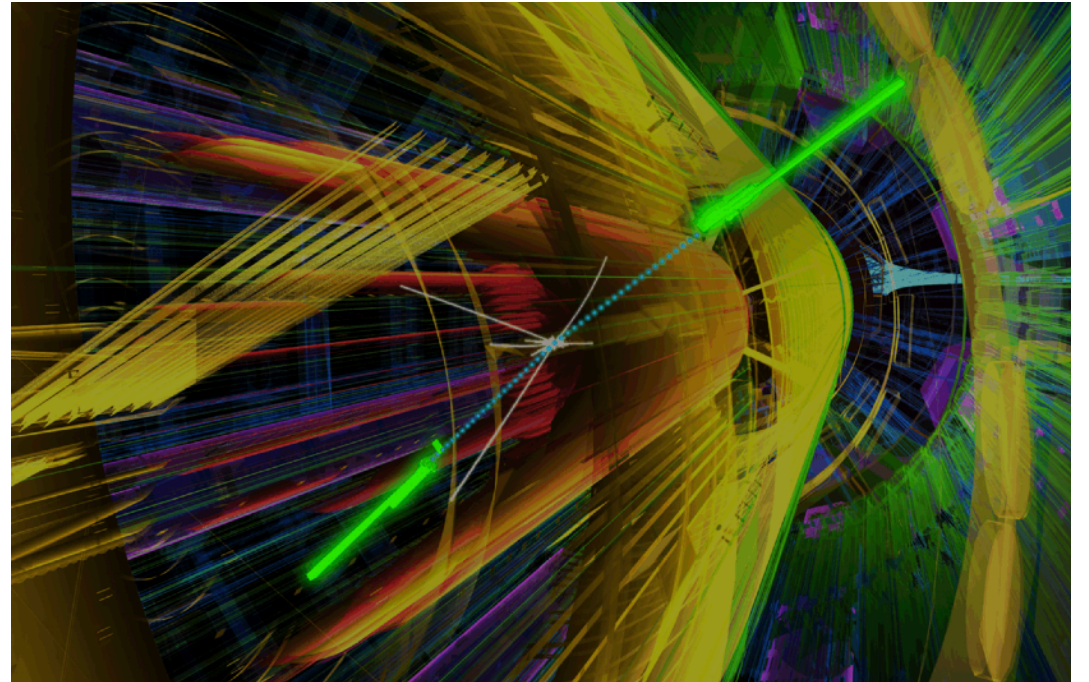
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Will showcase recent examples of outreach activities - and particle physics in education!

International Masterclasses (high school students)

- Driven and supported through IPPOG, reaching over 10k students/year
- Full day with 20-50 students + teachers, video conference with CERN and schools in other countries
- [ATLAS](#) (W^\pm/Z) and [IceCube](#)
- Given in all cities with experimental HEP research (Lund, Uppsala, Stockholm), and also Gothenburg
 - Challenging during COVID, need to ramp up again, but e.g. Lund very active recently, twice per year



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Quote from high school teacher (sent to Korinna Zapp, LU):

"Thanks for giving us the possibility to send students to the masterclasses in particle physics. Last year three students attended, and today two of them study physics and one mathematics at LTH"



Visits to CERN

- Frequently organize visits for high school and university groups at CERN
- Gives **strong and lasting impression**, not unusual that these visits lead to longer term goal of working in physics
- But: As CERN's visit capacity has grown, so has bureaucracy - now both **more time consuming and stressful to organize** visits as Member of Personnel at CERN

HS visiting from Strängnäs (April 2024)



Group incl. HS students from Falun in 2023

23 physics students at CERN, Jan 2024



Open data in teaching

- Labs created at our universities to let students use **open CERN data** and explore the subatomic world
- Example (KTH): 3rd-year students **measure mass of the Z** using real ATLAS data
 - ~600 students since 2018
 - Great task for teaching signal vs. bg, modeling, fitting, and stat. analysis — **key general skills** for science and engineering

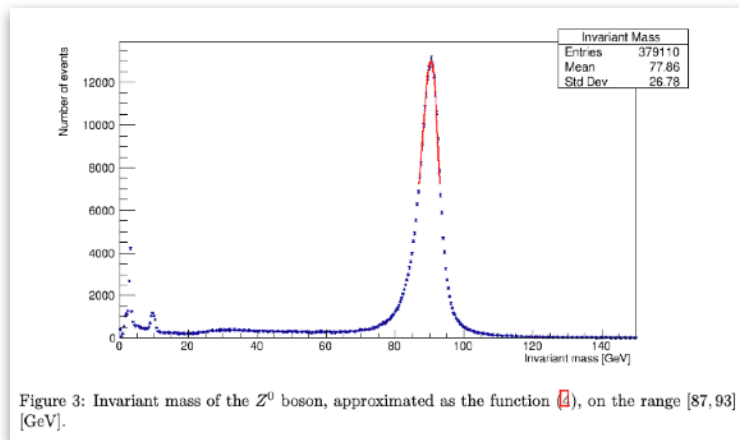
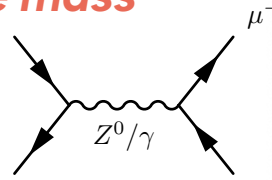
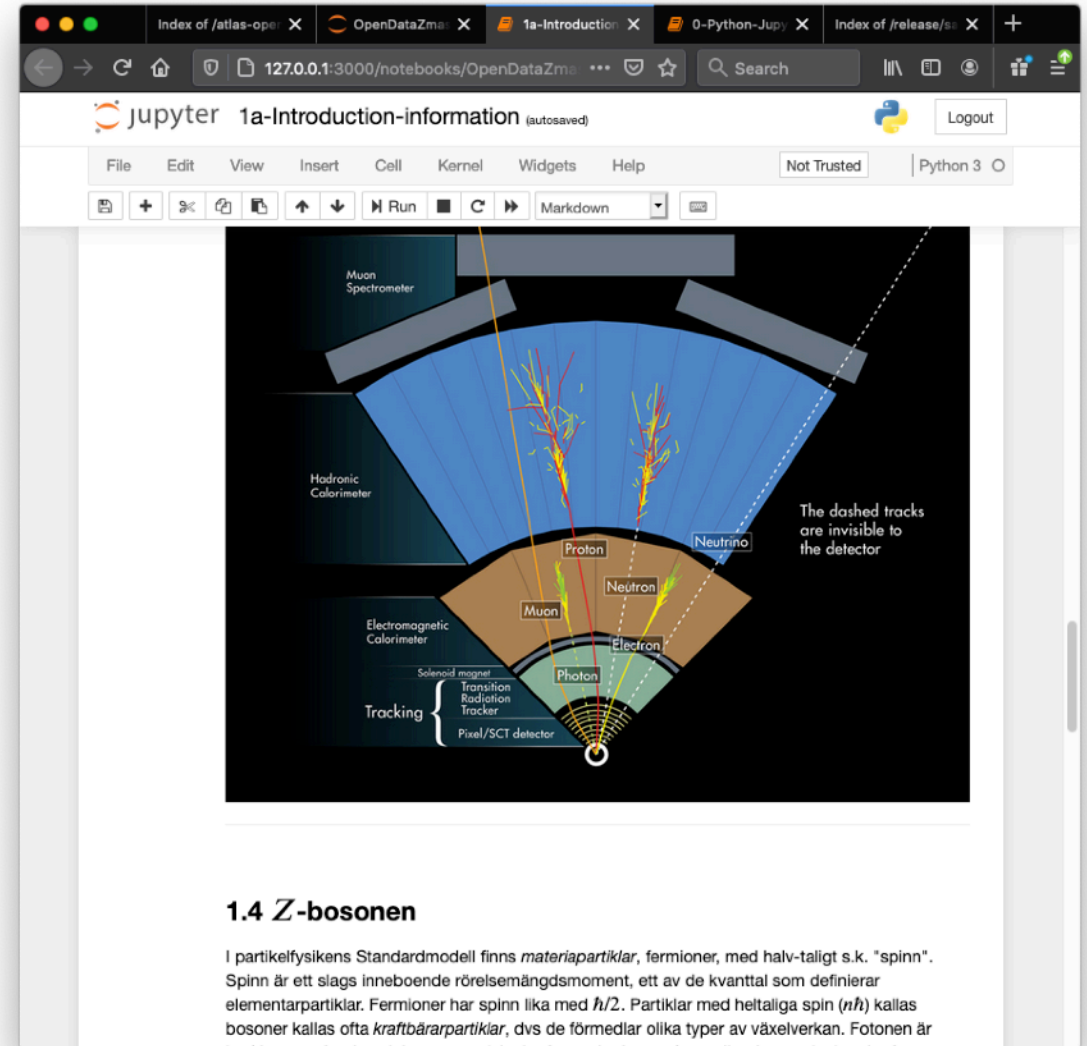


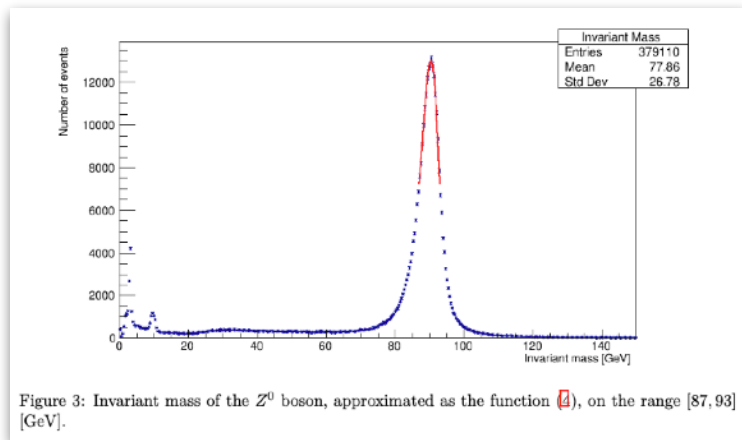
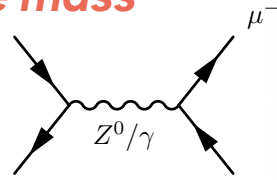
Figure 3: Invariant mass of the Z^0 boson, approximated as the function (4), on the range [87, 93] [GeV].



The screenshot shows a Jupyter Notebook titled '1a-Introduction-information'. The main content is a diagram of the ATLAS detector, a large cylindrical particle detector. The diagram is divided into several regions: the Muon Spectrometer at the top, the Hadronic Calorimeter in the middle, and the Electromagnetic Calorimeter at the bottom. A central region is labeled 'Tracking' and includes the Solenoid magnet, Transition Radiation Tracker, and Pixel/SCT detector. Particle tracks are shown originating from the center and passing through these layers. Labels include Muon, Neutrino, Proton, Neutron, Muon, Electron, and Photon. A note states: 'The dashed tracks are invisible to the detector'. Below the diagram is a section titled '1.4 Z-bosonen' with text in Swedish explaining the Standard Model and fermions.

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High School Project in 2019!

Accuracy and Precision of the Z Boson Mass Measurement with the ATLAS Detector

Mariam D'Ciofalo Khodaverdian

Supervisors at the Royal Institute of Technology (KTH):
 Christian Ohm, Giulia Ripellino
 Teachers of the Natural Science Specialization Course:
 Felicia Dinnétz and Per-Olof Freerks
 Kungsholmen's Gymnasium
 27/05-2019



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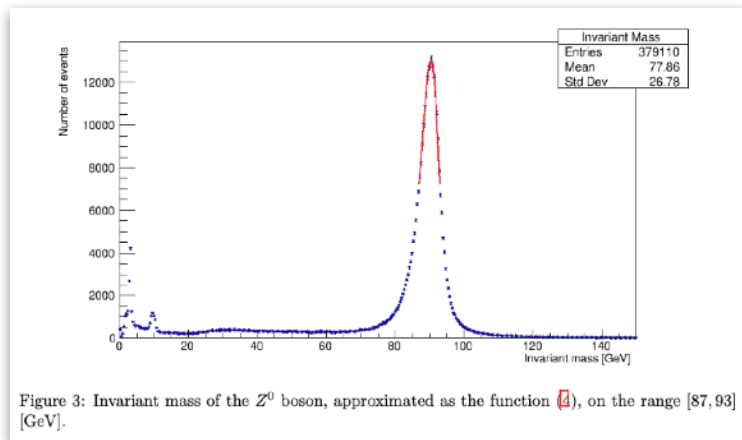
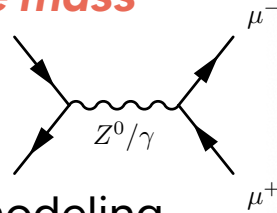


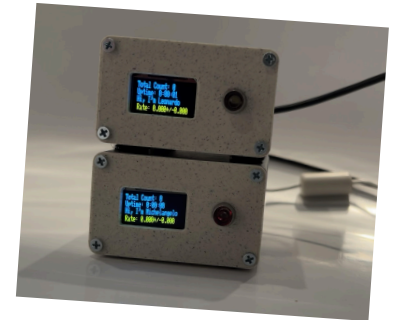
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High School Project in 2019!

Measurement of the Z Boson Mass
 HS Project in 2024 - now competing for Sweden in LA!

berzan
 BERZELIUSSKOLAN

Gymnasiearbete
 Läsåret 2023/2024



J. Andersson, J. Friberg, J. Lyreborn

Analys av atmosfäriskt myonflöde

Myonflödets energispridning och materialinteraktioner samt rymd- och zenitvinkelns påverkan på detektionsfrekvensen

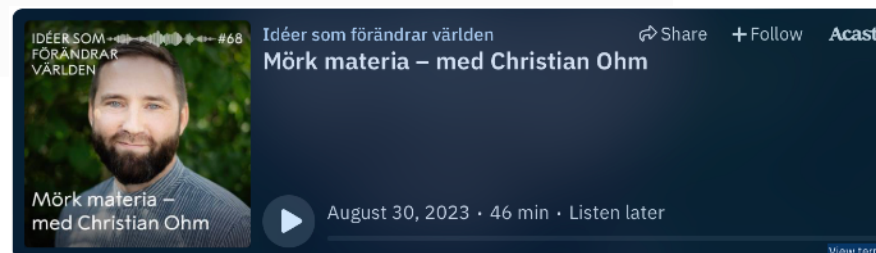
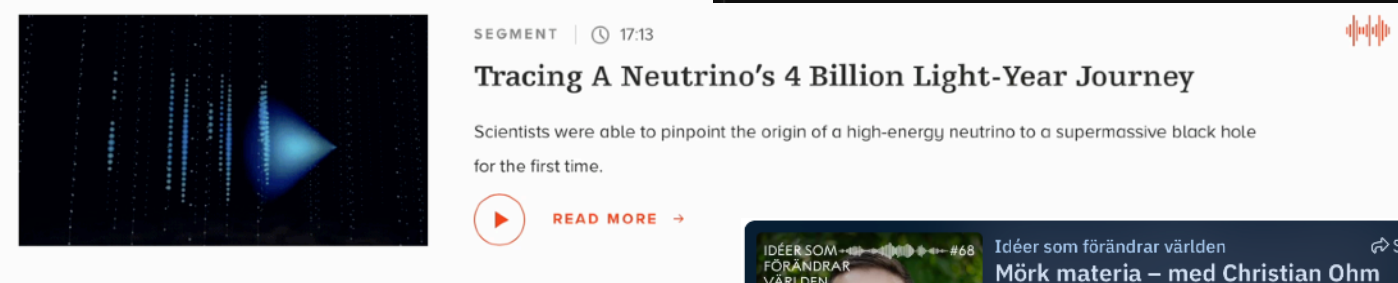
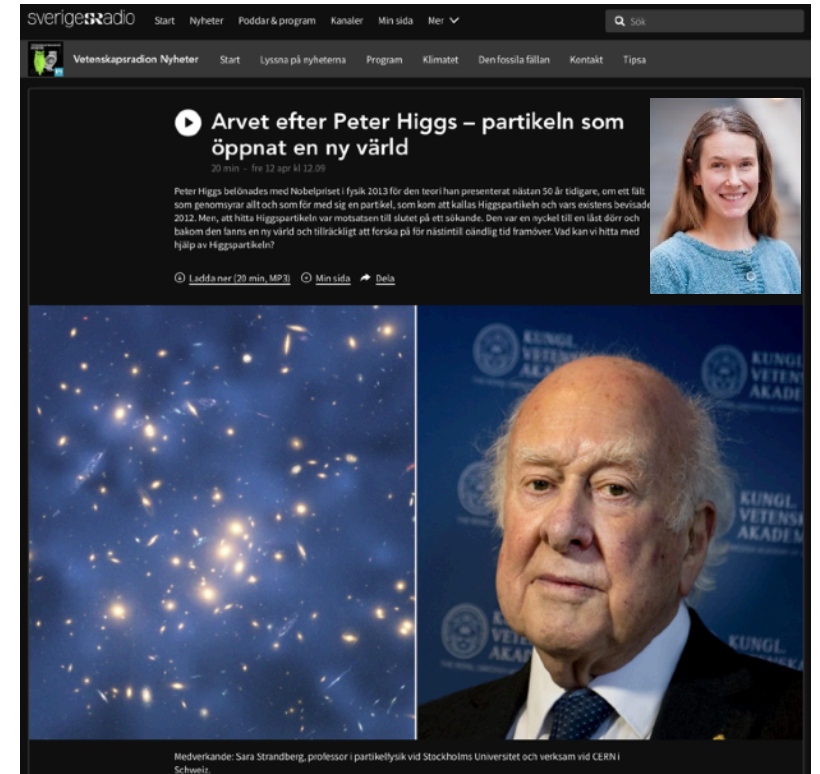
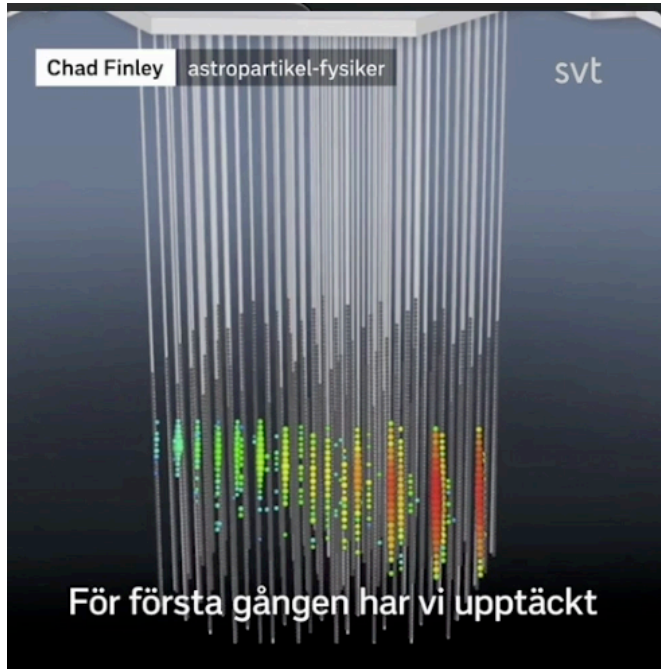
Berzeliusskolan
 Naturvetenskapsprogrammet
 Mikael Rydfalk

Museum events (general public)

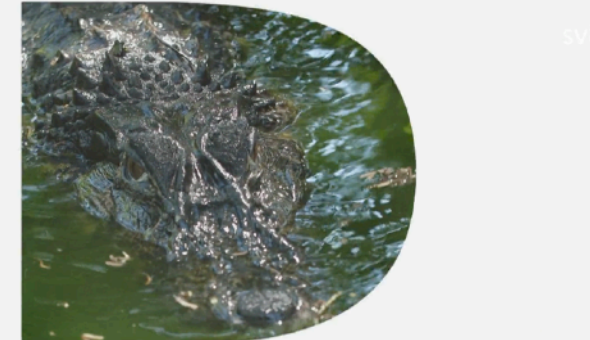
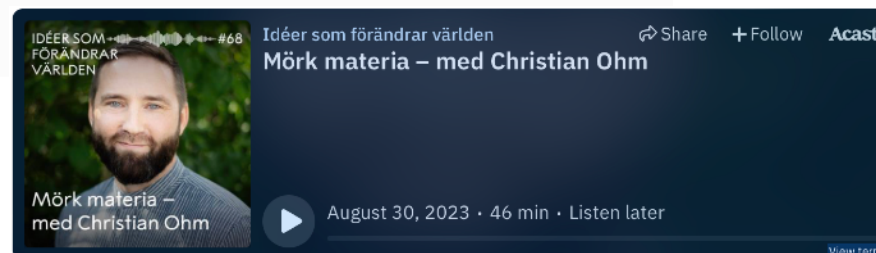
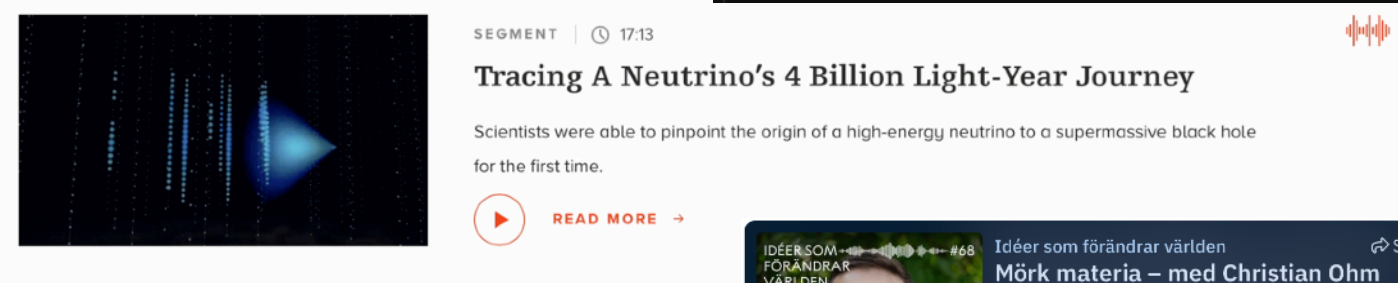
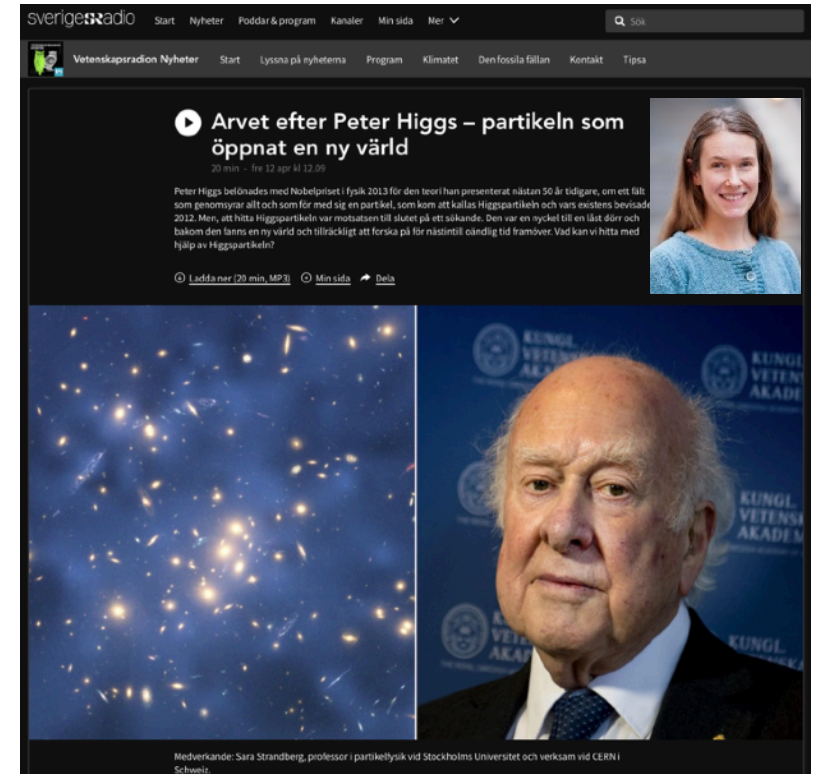
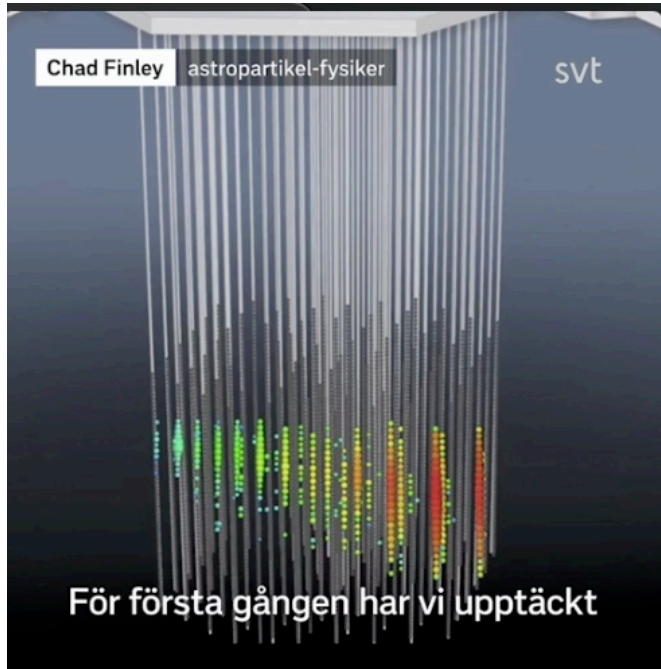


- Organized “researcher holiday” at Technology Museum in Stockholm three years in a row, during November school break — lots of families visit (~3k visitors/day)
- Children can win prizes if they **meet and talk to researchers** and check off if they find ones who
 - have lived in a different country
 - made a mistake
 - ...
- Fantastic setting to **practice explaining what we do** to different people — ideal training ground!
- Also organized popular science lectures at “Life Eternal” exhibition by Nobel Prize Museum and Liljevalchs art gallery ([link](#))

Media: TV, radio, magazines, podcasts, etc

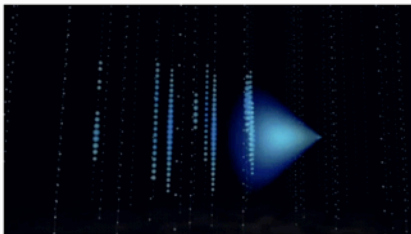


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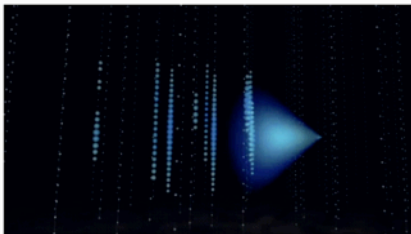
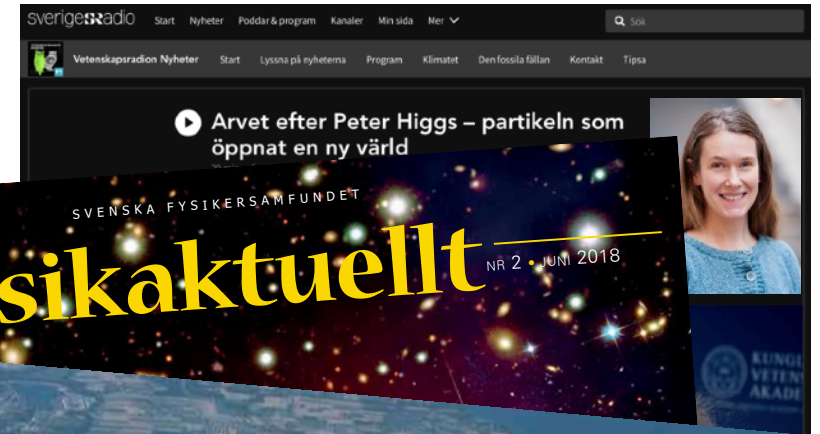
Tracing A Neutrino's 4 Billion Light-Year Journey

Scientists were able to pinpoint the origin of a high-energy neutrino to a supermassive black hole for the first time.





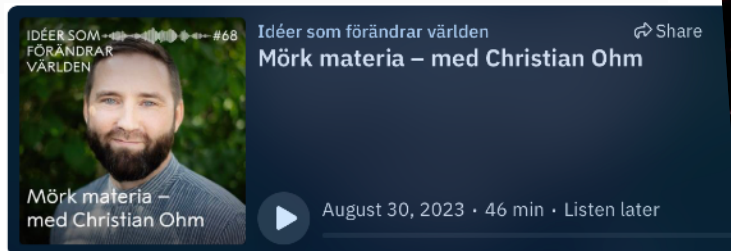
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Public talks and science festivals

Öppna föreläsningar Stockholm U.

SciFest in Uppsala



Many of these lectures are recorded and available online!

11 OKT Neutrino Astronomy with a Telescope in Antarctica's Ice



Two kilometres deep in the glacial ice at the South Pole lies what is perhaps the world's strangest telescope. This is the IceCube Neutrino Observatory: thousands of detectors spaced throughout a cubic kilometre of ice, looking for the light made by subatomic particles that are streaming through the Earth. Neutrinos are unique particles that pass easily through matter, and they can reach us from hidden places like the interiors of stars and from the most powerful particle accelerators in the cosmos. In this talk I will describe how we do neutrino astronomy at the South Pole, and the universe that neutrinos reveal to us.

Meet Chad Finley, lecturer

7 MAR Dark Matter: How to bring light into the dark universe



From astrophysical observations over the last 100 years we have learned that the stars, planets and all the matter which surrounds us only make up 5% of the total energy density in the universe. The unknown 95% consist of the invisible dark matter and the even more mysterious dark energy. I will discuss how we try to find dark matter using a big detector 1400 m under a mountain in Italy with the most sensitive light detectors in the world, which we test here in Stockholm.

Meet Jörn Mahlstedt, postdoc
Tid: kl 18.15 - 19.15



NMT days in Lund



Kunskapsfesten in Eskilstuna

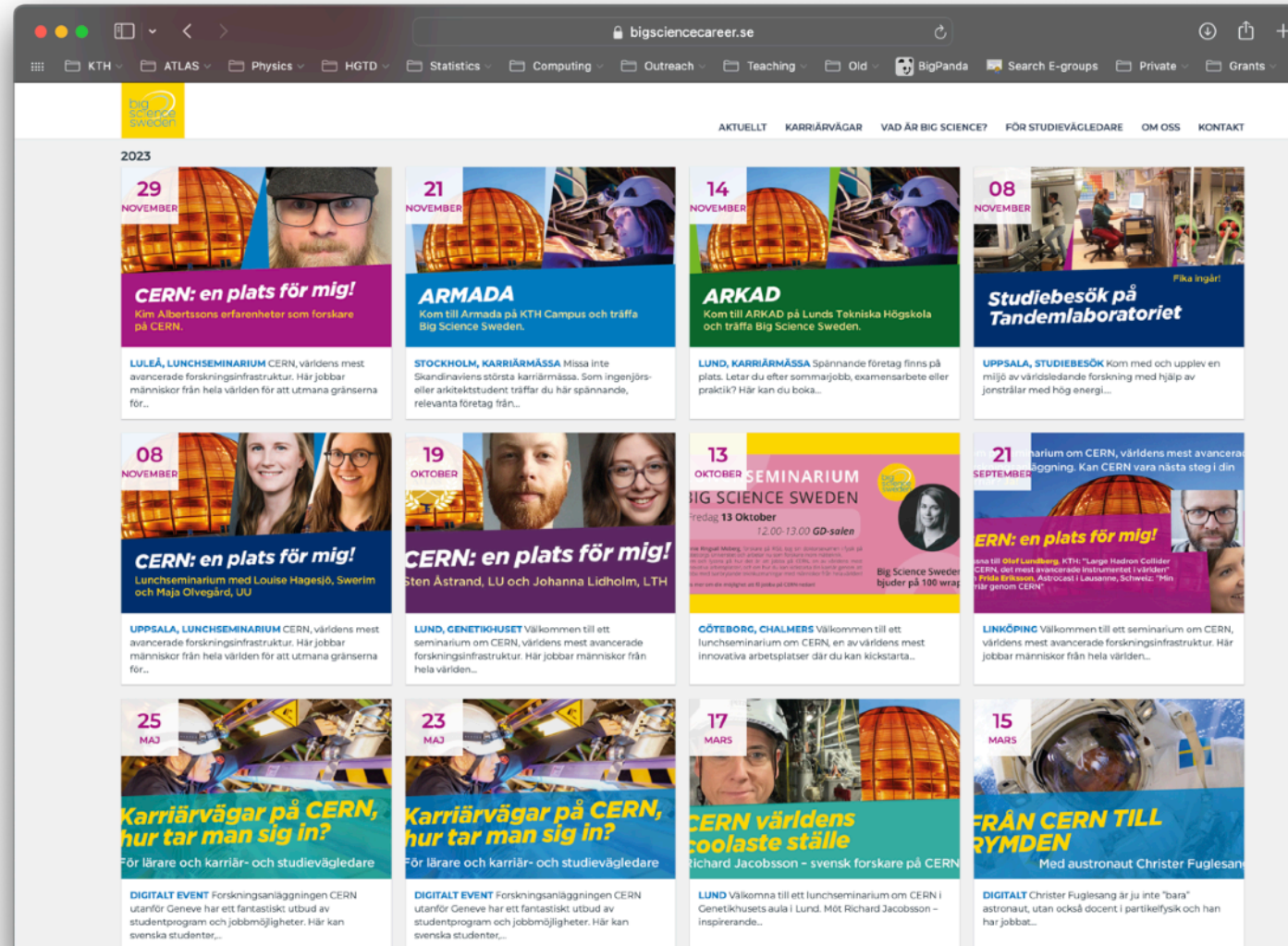


Lise Meitner Days in Stockholm



Big Science Sweden (ILO) - advertises career opportunities

- Helping greatly to inform about **university students opportunities** at CERN
- In 2023 alone, 14 events were organized to advertise student programs and careers at various student fairs, lunch lectures, etc
 - Hope that this will increase the number of Swedish applications
- Big Science Sweden **now receives funding from VR** to help with this — would be great if this support continued!



CERN 70 outreach tour - first leg this week!

- Repeat of successful tour for 60th anniversary!
 - **Advertise CERN student programs** at universities, especially those without hep-ex research
 - Lectures for **general public** — in varying settings
- Organized in collaboration with Big Science Sweden

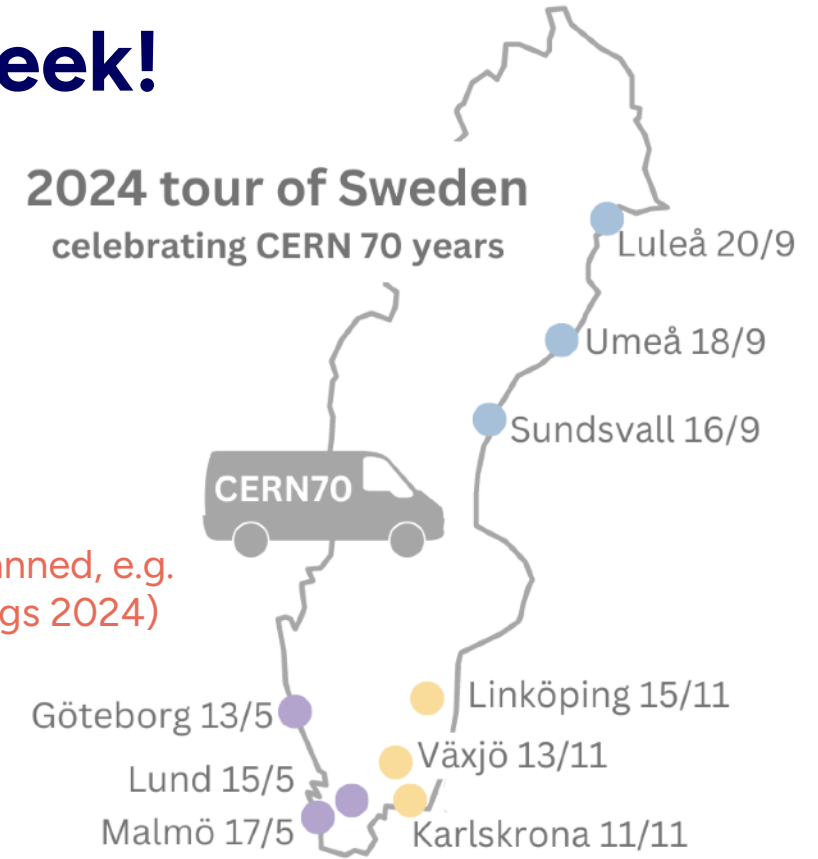


CELEBRATE CERN 70 YEARS

GÖTEBORG CHALMERS	LUND UNIVERSITY ASTRONOMIHUSET	MALMÖ UNIVERSITY ORKANEN
Exhibition 10:00-16.00	Exhibition 10:00-16.00	Exhibition 13:00-16.00
Lunch seminar 12.15 About CERN, and the opportunities available to Swedish students	Lunch seminar 12.15 About CERN, and the opportunities available to Swedish students	Lunch seminar 12.15 About CERN, and the opportunities available to Swedish students
Evening lecture 19.00 Pitchers sports bar in Majorna	Evening event 18.00 Science Showcase at Stadshallen	Evening lecture 17.30 The Wisdome Malmö Teknikens och Sjöfartens hus

www.bigsciencecareer.se
 Register for the lunch seminar
 LUNCH IS INCLUDED IF YOU REGISTER IN ADVANCE

2024 tour of Sweden celebrating CERN 70 years



(More events planned, e.g. Uppsala for Higgs 2024)

- PhD students, postdocs, faculty all contributing enthusiastically and significantly
- Fun and rewarding — also serves as team building

CERN 70 outreach tour - Gothenburg (Monday)



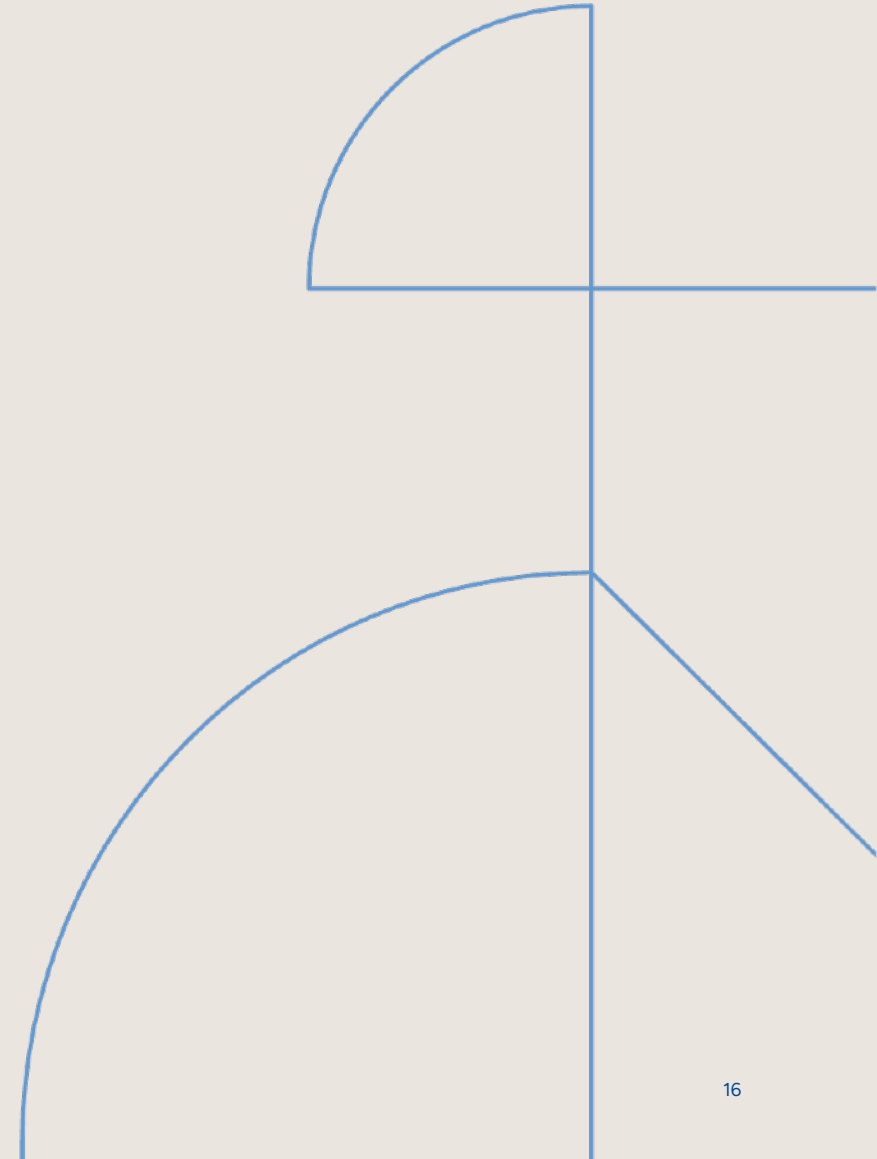
CERN 70 outreach tour - Lund (Wednesday)



Concluding remarks

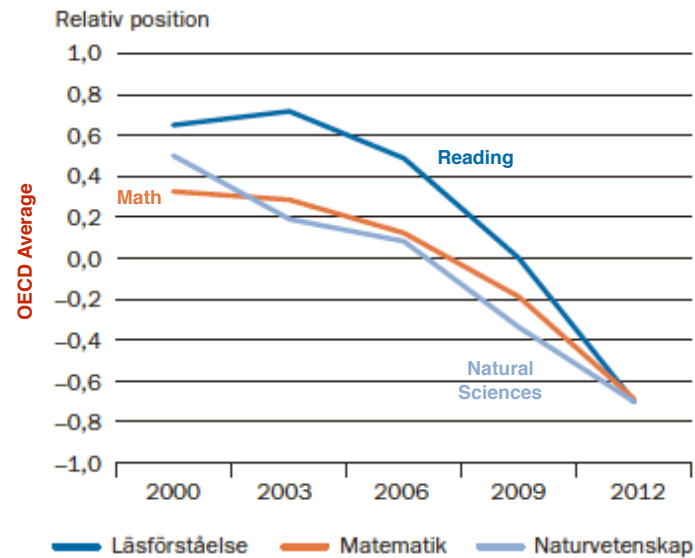
- The Swedish particle physics community is quite active in communicating with various groups, *inspiring the younger generation* and *explaining the value of our research* to the general public
- [IPPOG](#): *formal international collaboration* collecting resources and best-practice examples of good outreach in particle physics - Sweden long-time member, nat. rep. Jonas Strandberg ⇒ CO (2024)
- Responsibility roles: *Rebeca Gonzalez Suarez (Uppsala) was Education & Outreach coordinator in ATLAS 2021-2023* (physics briefings, YouTube, social media, open data, ...)
- All universities with active research groups in HEP also offer a *broad range of courses at BSc, MSc and PhD level* — and also supervise interested high school students with various projects
- Many of us very much enjoy doing outreach, but *wish it was more recognized* (time & merit value), and that there were *more (flexible) funding possibilities* for projects (law requires us to do outreach!)
 - Example: IPPOG membership fee is EUR 3k/year, but a *time-consuming struggle every year* to find funds we're *allowed* to pay it with
- Started several new initiatives for reaching more people
 - Big Science Sweden (students), science festivals and museums (general public) — *good partnerships* make for *more effective outreach*, and we can build further on this!

Back-up slides



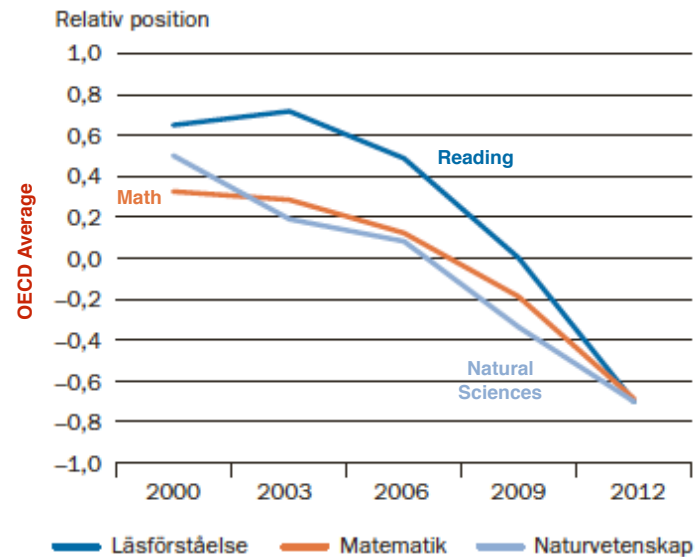
Follow-up from 2016: Physics and Math in school, results over time (PISA)

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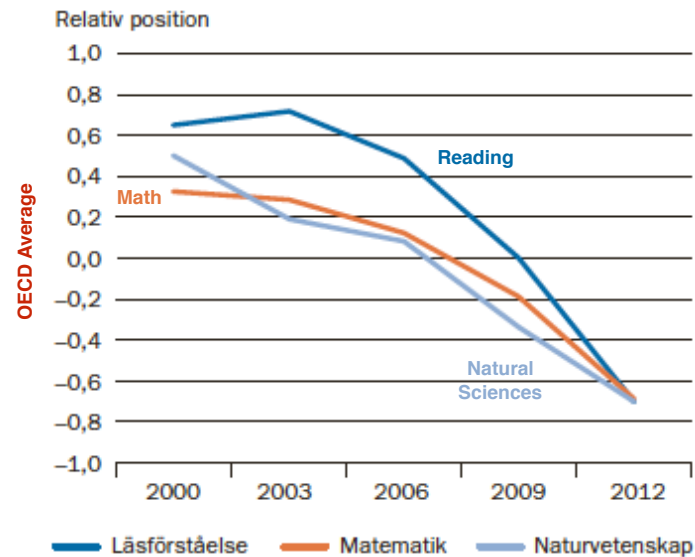
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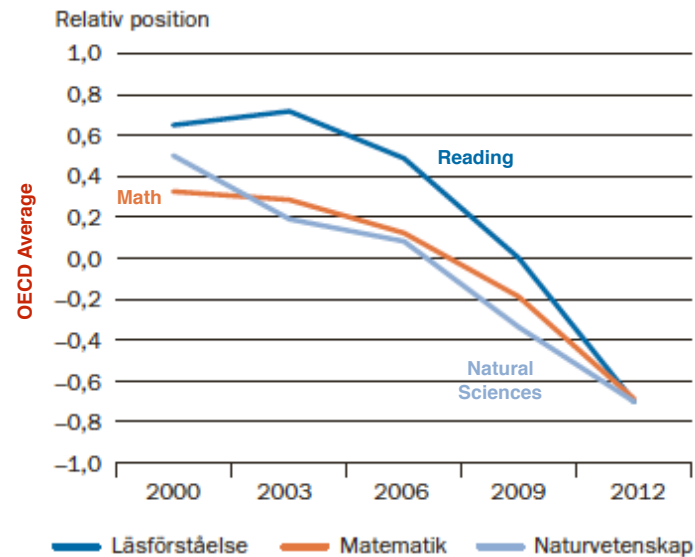
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- Overall, Sweden in 15th place of 37 in OECD

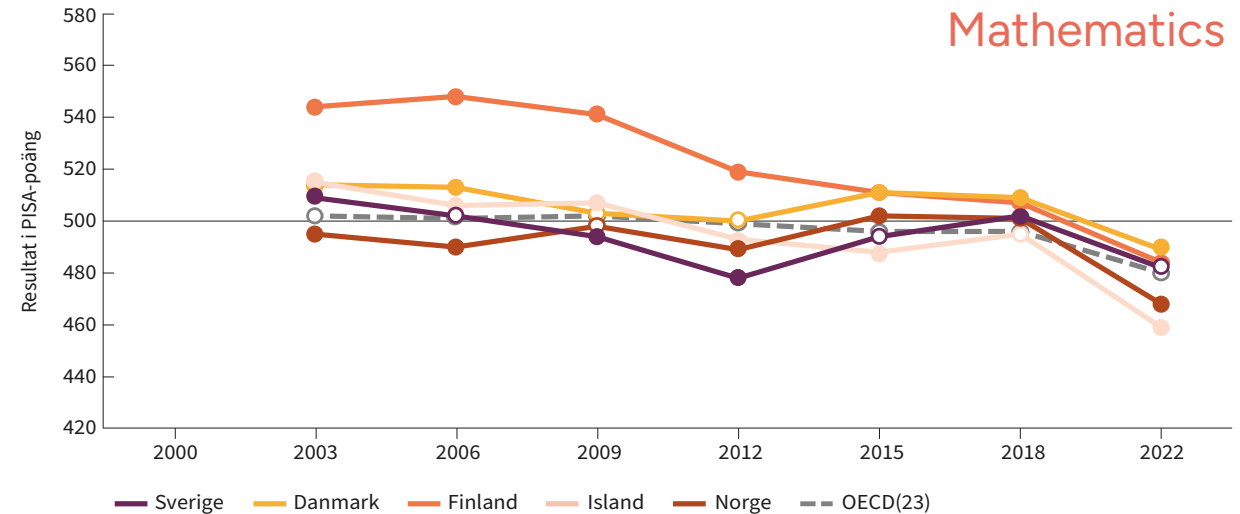
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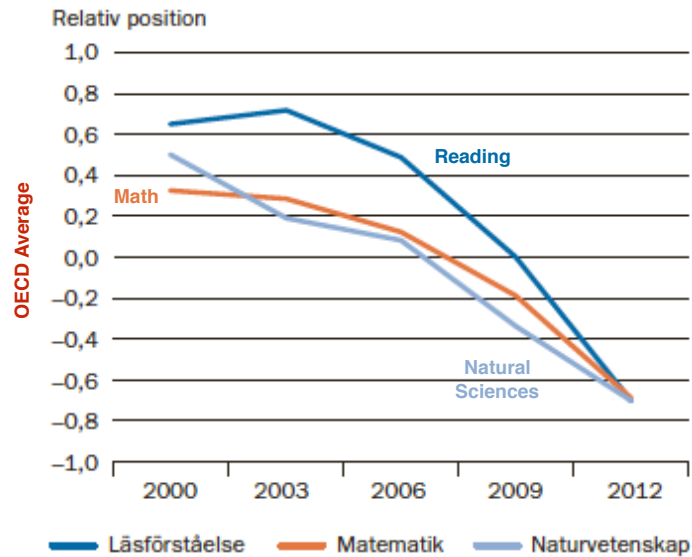
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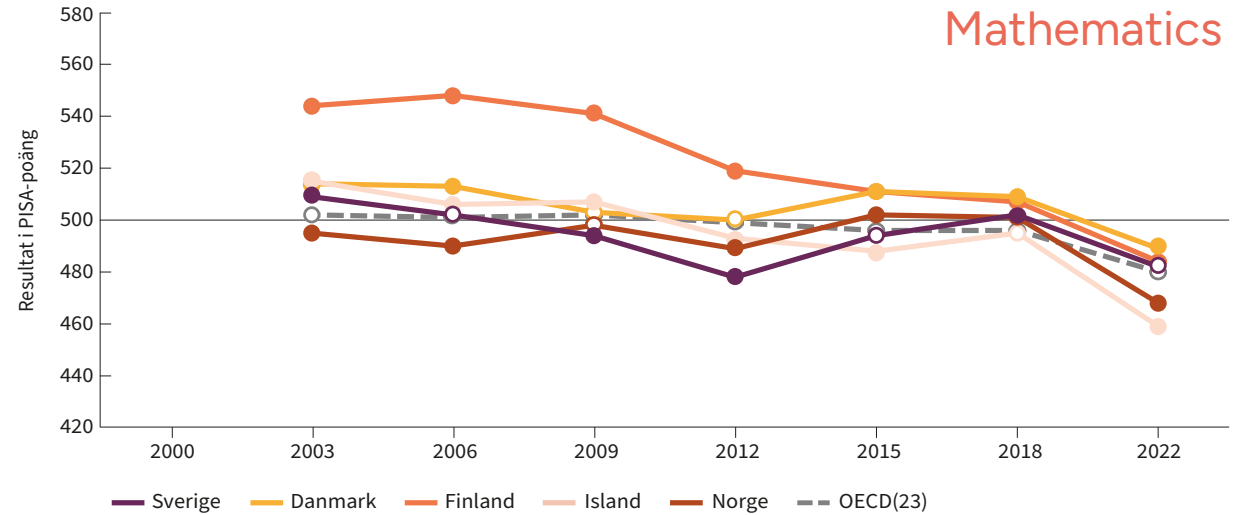
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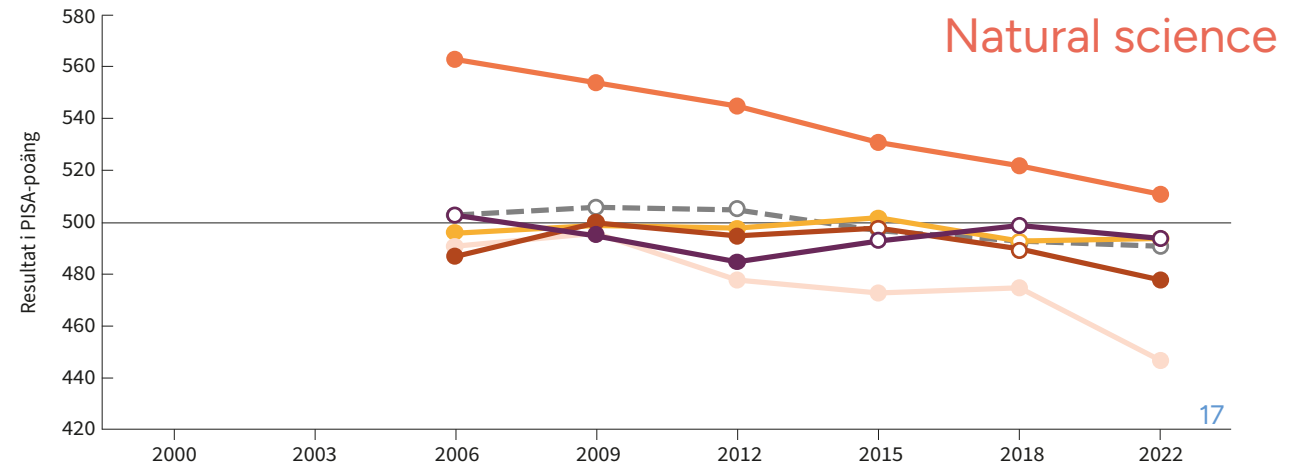


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c. Naturvetenskap



IPPOG meeting in Madrid, April 2024

