MAGIC

and other running initiatives on education and outreach

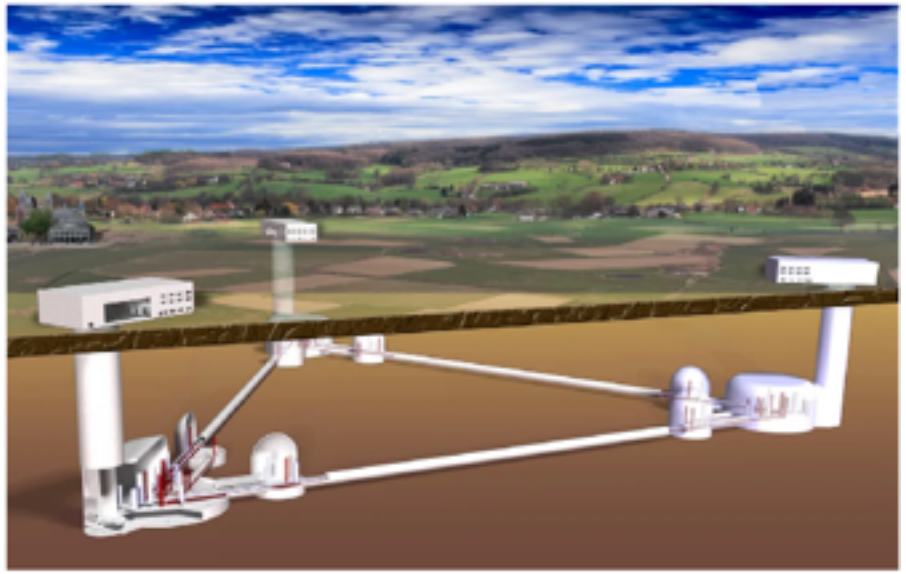
4th ET Consortium Meeting
12th of November 2025.

Gideon Koekoek

Maastricht University

Why is outreach so important?

What we say:



An artistic view of the proposed Einstein Telescope observatory. (Image credit: ASPERA)

"We're going to learn a lot more black holes and neutron stars!"

What people (might) hear:

We will swamp you with gravitational radiation.

We'll build a factory complex in your beautiful landscape.

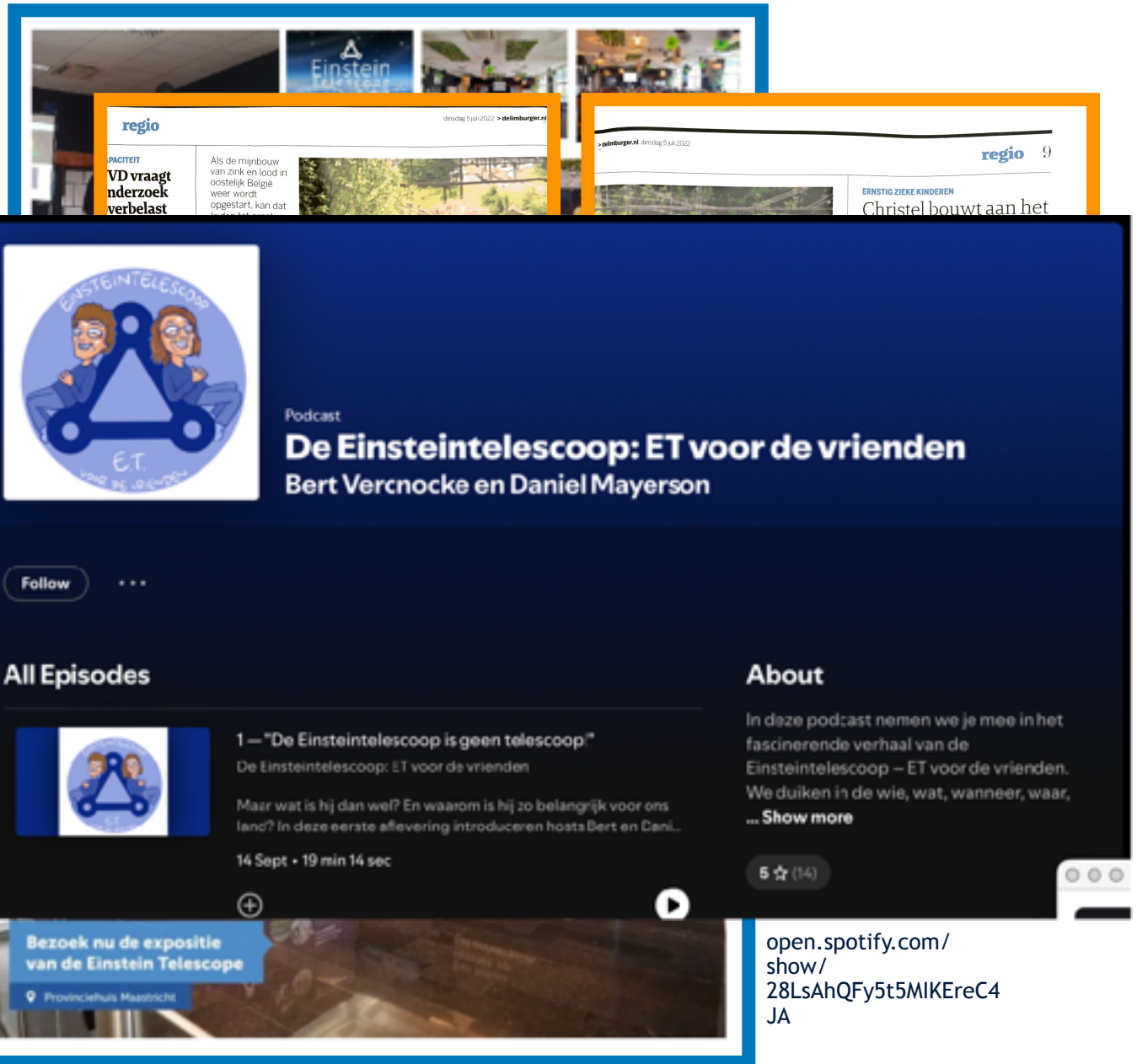
Your living costs will become much more expensive!

We will put dangerous materials in the ground, making your cows sick!

We are going to use your money to study things only we understand.

dr. Gideon Koekoek: gideon.koekoek@maastrichtuniversity.nl

Smörgasboard of activities (from ET@EMR)



open.spotify.com/show/28LsAhQFy5t5MIKEreC4JA

* Regular townhall meetings in municipalities
* Science festivals
* Presentations to professional stakeholders (representatives of Governement, etc.)
* Visits by ambassadors, members of parliament, regional/national/international politicians
* Visits to/from schools, teachers, etc.
* Contributions to tv-items, radio,
* ETroadshow (starts next week in Belgium)
* Many, many more.

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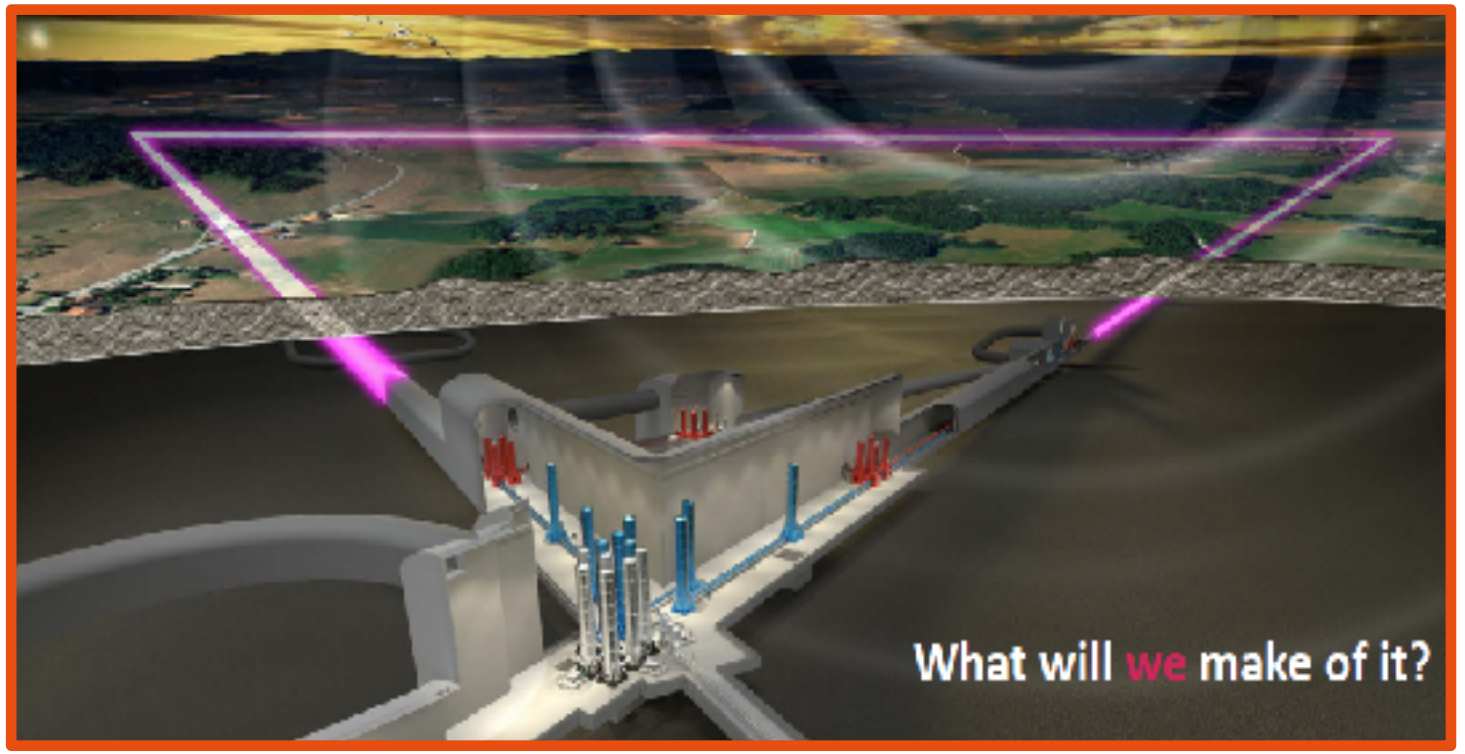
What to convey about gravitational wave science

- .. A new window to the universe
- .. technological spin-off
- .. collaboration between countries
- .. attractor and connecting point for talent



Connection

- Academia
- Technology & industry
- Education

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www.dbhc.nl/

www.einsteintelescope-emr.eu/blog/2024/06/26/einstein-telescope-education-centre-officieel-geopend/

www.maastrichtuniversity.nl/events/maastricht-gravitational-inspiration-curriculum-magic

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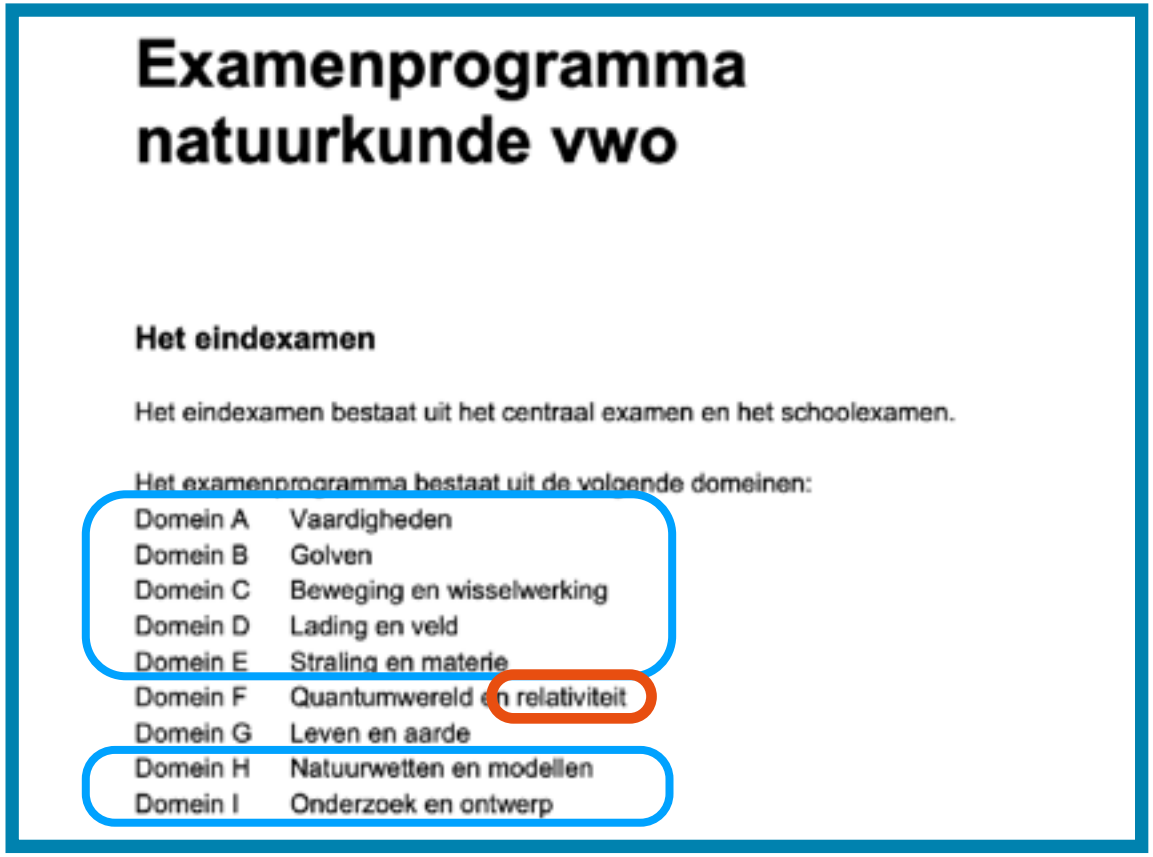
Can we offer gravitational wave science to (secondary) education?

Two misconceptions to be removed:

"GW science is too difficult for secondary education."

"GW science is too niche."



Examenprogramma natuurkunde vwo

Het eindexamen

Het eindexamen bestaat uit het centraal examen en het schoolexamen.

Het examenprogramma bestaat uit de volgende domeinen:

Domein A	Vaardigheden
Domein B	Golven
Domein C	Beweging en wisselwerking
Domein D	Lading en veld
Domein E	Straling en materie
Domein F	Quantumwereld en relativiteit
Domein G	Leven en aarde
Domein H	Natuurwetten en modellen
Domein I	Onderzoek en ontwerp

A typical curriculum has ~ 80% overlap with gravitational wave science!

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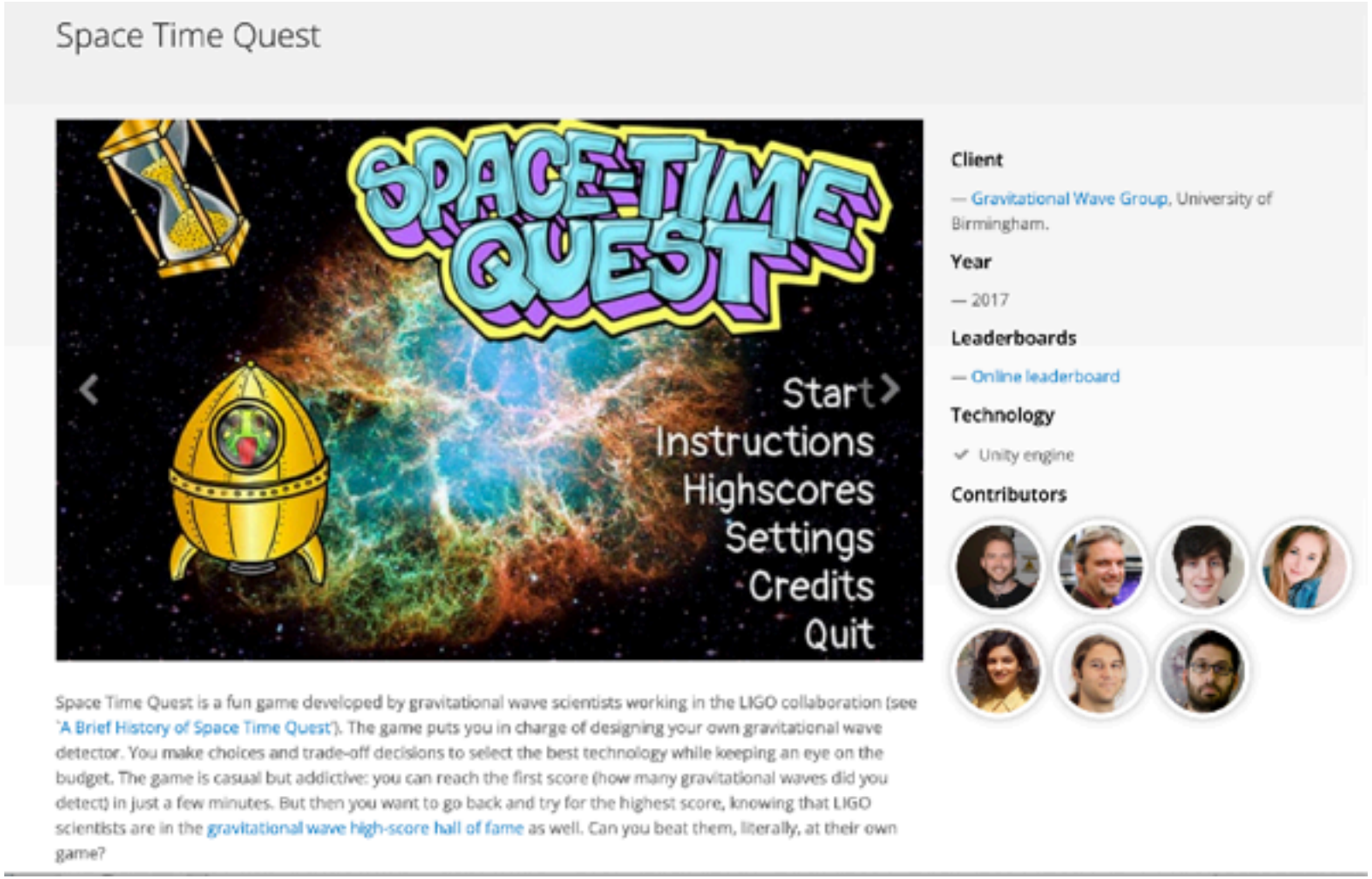
Example: Spacetime Quest



https://www.laserlabs.org/spacetimequest.php

Build your own GW detector.

Toggle mirror weight, suspensions, temperature, location, lasers, etc.

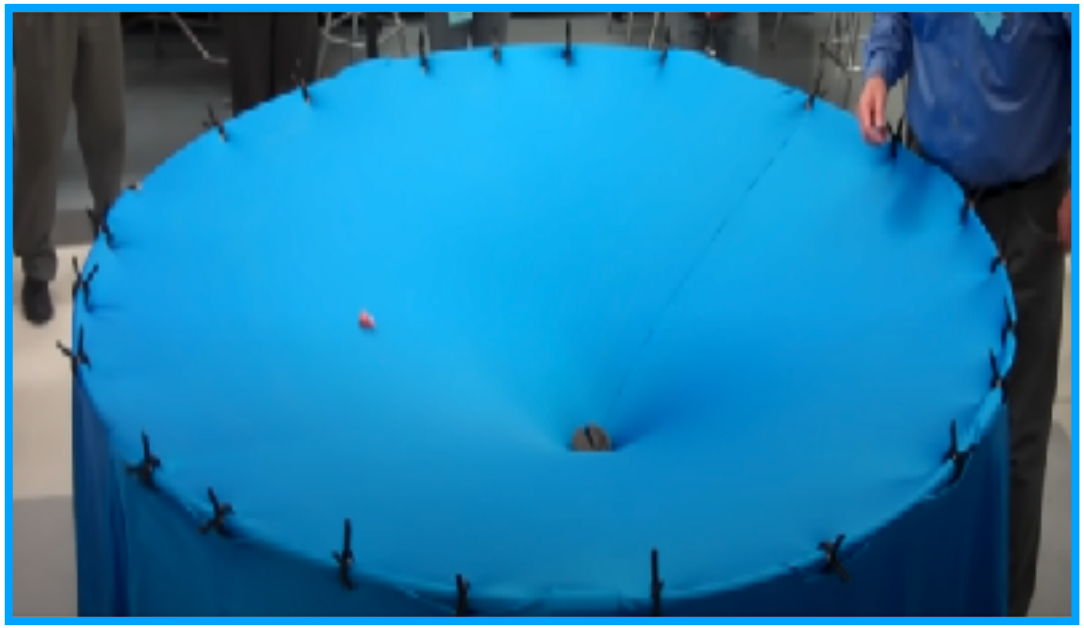
All concepts are high-school physics based

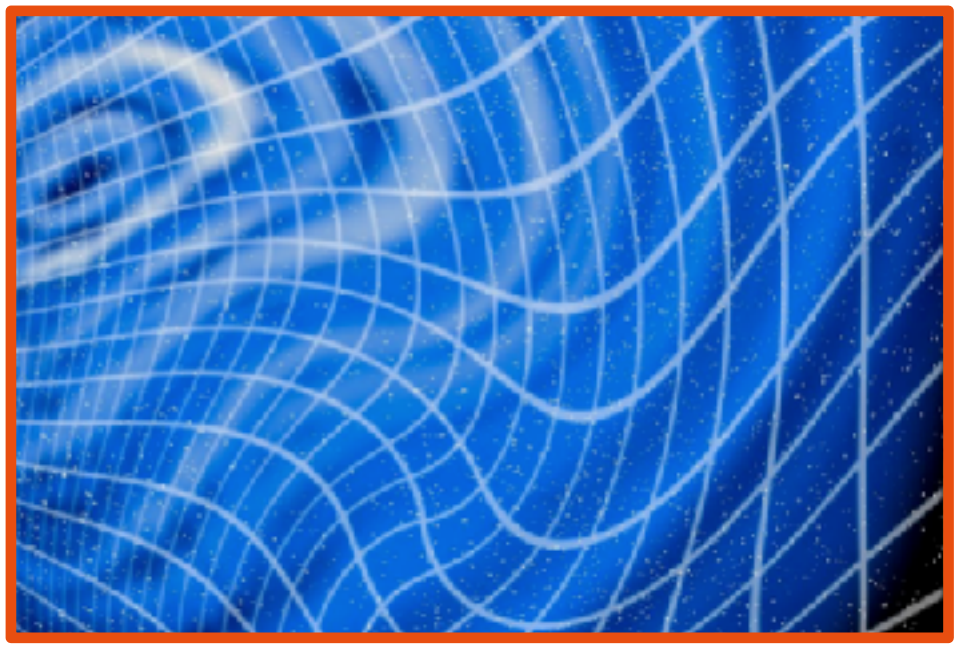
Finite resources, so choose wisely!

After choices made, app presents Mpc

(more examples to follow, *e.g.* ETEC)

The *theory* is difficult, so what method to use?





- **Metaphors**

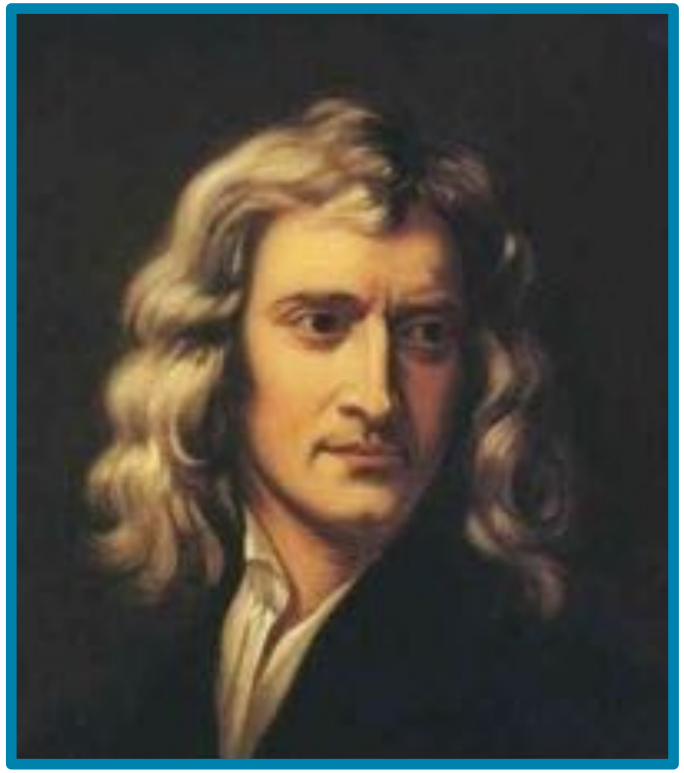
  "Gravity is a stretched surface, like a heavy object on a trampoline"

- **Let the mathematics do the talking!**

$$S = \int d^4x \sqrt{-g}\, R \qquad \frac{\partial S}{\partial g_{\mu\nu}} = \partial_\lambda \left(\frac{\partial S}{\partial_\lambda g_{\mu\nu}} \right)$$

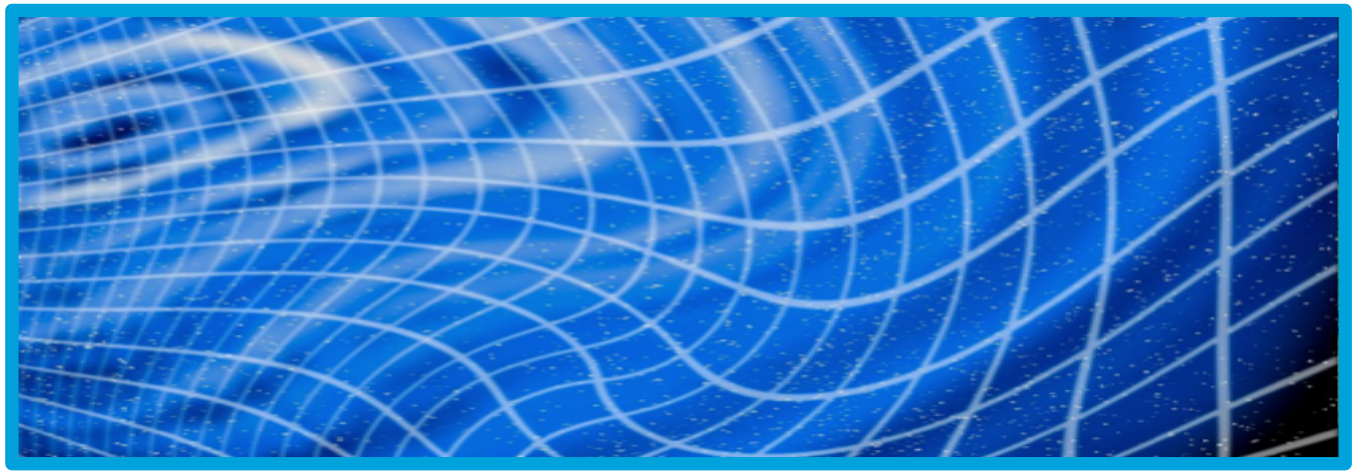
Reconnecting dots

Reconnecting dots:



Mass measures how much an object speeds up due to gravity

Mass measures how much an object does not like to speed up

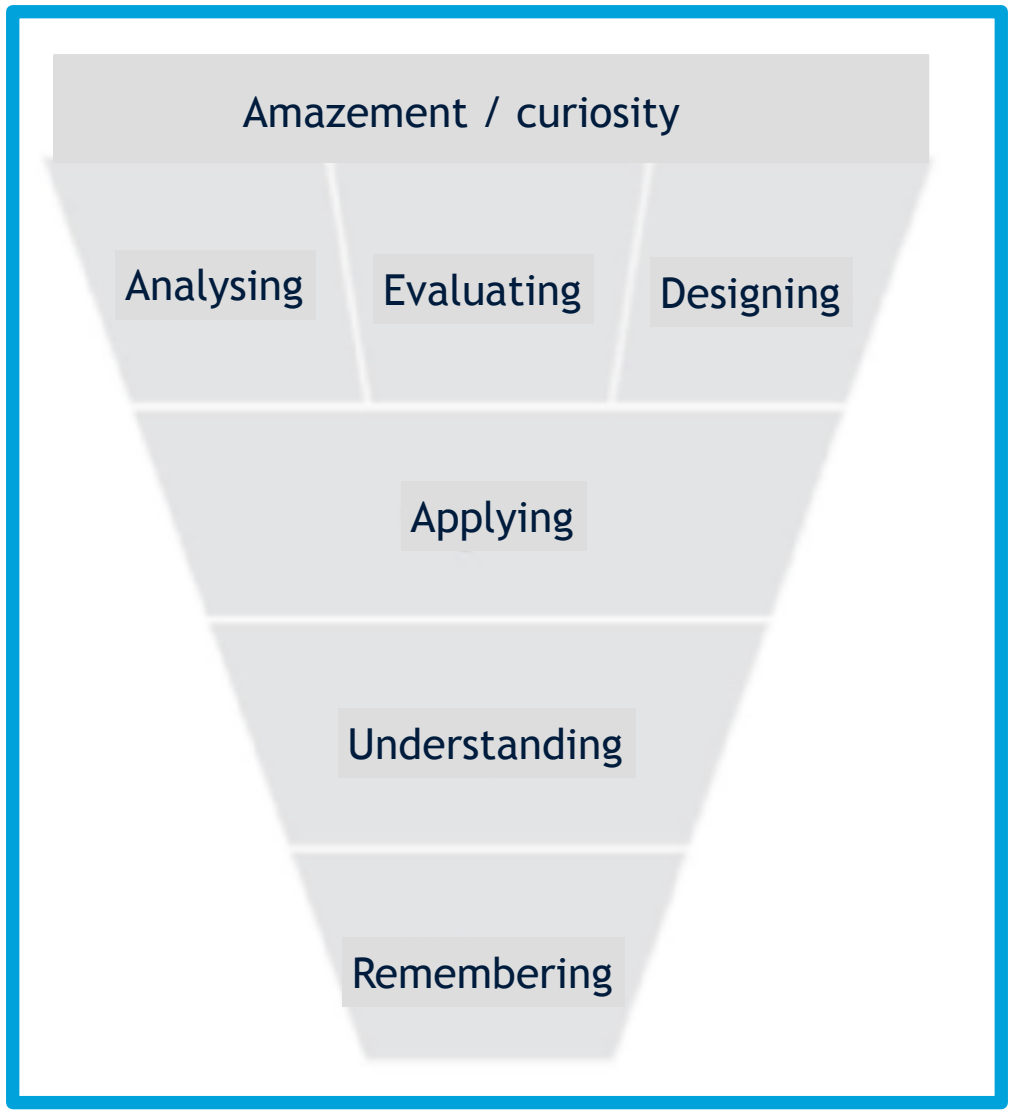


Gravitational motion is universal!

Reconnecting dots:

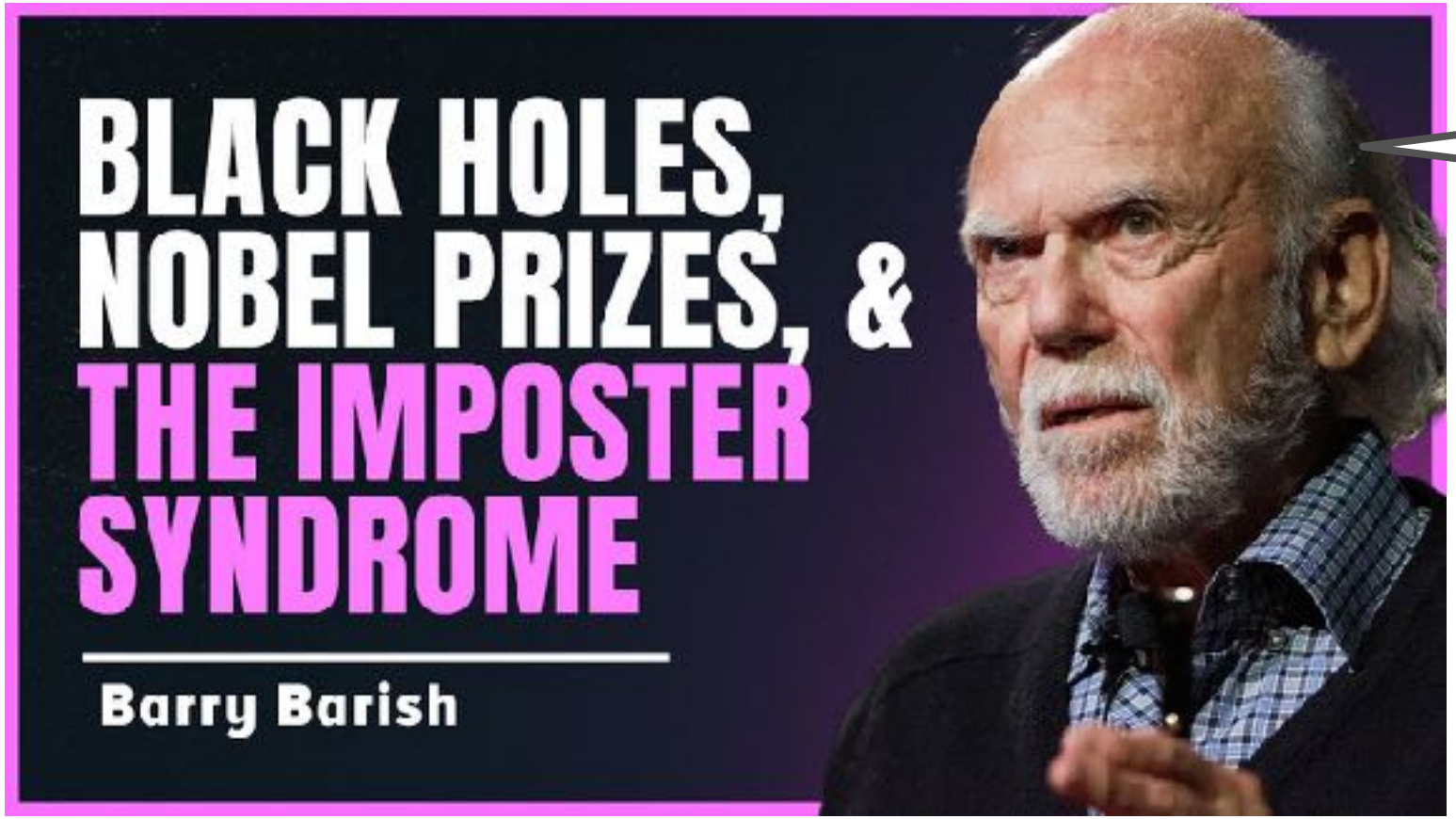
What did we do here?

Learning



Reconnecting dots

How to reconnect dots: start with curiosity.



www.youtube.com/watch?app=desktop&v=2JgatLA6pJM&t=0s

I think that the thing that is singularly the biggest problem, (….) that is so obvious to me is that young kids, five-seven years old are incredibly curious, they keep pestering you with questions and they want to know everything. But then the kids who come to CalTech, they don't ask questions anymore. They ask questions on how to do their homework. Somehow in our educational system, we kill curiosity.

Around 1:10:00 mark

The Einstein Telescope Education Centre


Einstein Telescope

News

Discovery Museum Kerkrade gets education centre about the Einstein Telescope

The 'Einstein Telescope Education Centre', or ETEC for short: this is the name of the education centre that the Dutch Discovery Museum Kerkrade will set up in its five-storey Cube building. Schoolchildren can work there on teaching materials based on current research on the Einstein Telescope. In addition, ETEC will provide a stage for at least three years from school year 2024-2025 to get acquainted with engineering and science education.

www.einsteintelescope-emr.eu/blog/2024/06/26/einstein-telescope-education-centre-officieel-geopend/

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Part 1:
Watch 3D-movie

Part 2:
Follow interactive lecture

Part 3: do workshops

Part 4: Report on findings

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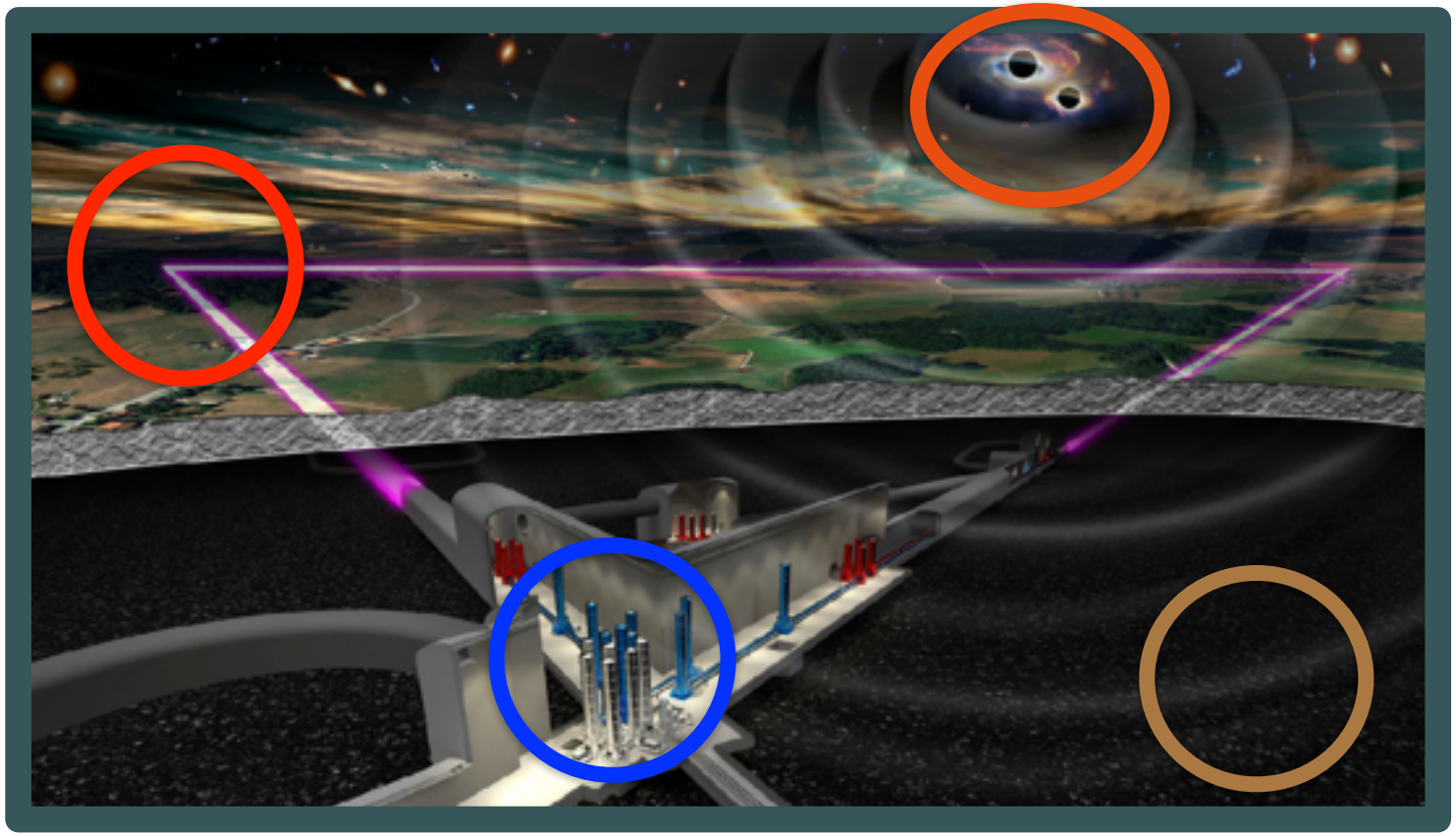
- **Interferometry**
  Perform distance measurements using laser light
- **Noise mitigation**
  Use Newtonian mechanics to dampen vibrations
- **Data-analysis**
  Find and identify black hole collisions in data (we'll see it in a bit)
- **Geophysics**
  Acoustic investigations of soil



Einstein Telescope is perfectly suitable for school classes!

ETEC: been running for a year+ now.

- About 25 classes have visited ETEC, mostly from the Netherlands/Limburg. This amounts to about 500 students (and counting).
- Reactions have been very positive, both from teachers as from students.
- ETEC is in talks to have structural visits from Germany and Belgium classes as well.
- ETEC has recently been opened to general public as well.
- (prospective): ETEC @ home is being developed by UM and the Leuven Gravity Institute.
- (prospective): Grant (GK, Flemish parties) is pending to hire a researcher to do measuring of efficacy of ETEC.
- (prospective): Build hosting of students all over Europe (AI, but will also require native speakers).

..to great success!

How much?
Ask PhD candidate Emma Prins in ~year

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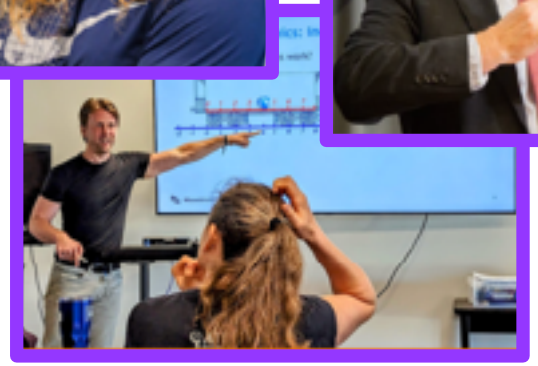
MaGIC: European teacher training

- ~ 30 high school teachers from the countries in ET-consortium.
- 7 days, 6 nights,
  local hosting in EMR region.
- Training in physics, technology, and didactics.
- Back home: start local teacher communities.

Funded locally by the Gouvernement of the Province of Limburg

MaGIC week programme: themes and activities

- **Mornings:** Theory ("what is the physics"?).
- **Afternoons:** Didactics ("How do I tell this to my students"?).
- **Evenings:** Social activities ("Building learning communities").



PERIMETER INSTITUTE

+ Many more contributors, to build European community.

(Feel welcome to contribute! If so, contact me @ fse-magic@maastrichtuniversity.nl)

MaGIC week programme: themes and activities

Day	Theme/Topics	Activities	Location(s)
Sunday	Arrival and Welcome	⦿ Reception and registration of MaGIC participants ⦿ Welcome dinner	Maastricht
Monday	Relativity Theory and Gravitational Waves	⦿ Visit to Discovery Museum and ETEC ⦿ Lectures on relativity theory and gravitational waves, and their history ⦿ Workshops on didactics	ETEC
Tuesday	Practicals in Class	⦿ Viewing of the film *SpaceTime* ⦿ Workshops on in-class practicals (interferometry, data analysis, geophysics, noise reduction ⦿ Practical discussion	ETEC
Wednesday	Measuring Gravitational Waves	⦿ Tour of ETpathfinder and laboratories ⦿ Lectures on measurement techniques and instrumentation ⦿ Workshops on instruments and educational app on measurement techniques ⦿ Dinner in Maastricht	ETpathfinder, Onze Lieve Vrouwe Plein
Thursday	Scientific Maastricht & Limburg	⦿ Guided tour of Gouvernement ⦿ Lectures on diversity and the societal role of research ⦿ Workshops on overcoming student barriers ⦿ Guided tour of Maastricht	Gouvernement, Het Pesthuysp, City Park
Friday	Multimessenger Astronomy & Local Learning Communities	⦿ Lectures on *multimessenger astronomy* ⦿ Workshops on sharing best practices and curricula ⦿ Workshop on *Local Learning Communities* ⦿ Farewell dinner	ETEC, Maastricht
Saturday	Farewell and Departure	⦿ Conclusion of the MaGIC week program	Hotel

Last ET meeting, preparations being done

- **Programme written with didactical experts**
  Collaboration between UM, LIGO, Perimeter, UCLL.
  Programme, speakers, and registration information on our website:
  www.maastrichtuniversity.nl/events/maastricht-gravitational-inspiration-curriculum-magic
- **Communications have been distributed**
  Created by the graphical professionals, distributed widely (e.g. by the Netherlands embassy's). *MaGIC* is Ministry of Education endorsed
- **Registrations are now open**
  Taking in first registrations; about 90% of the spots are now filled.
- **Official kick-off event: 19th of June**
  Opening by deputy governor Stephan Satijn and GK, at Chateau Neercanne at the Belgian border.

MaGIC summer school: physics teachers dive deep into gravitational waves

25 August 2025

l take place in Maastricht. The event brought together
n more about gravitational waves and the Einstein

→ Faculty of Science and Engineering

re the imagination, precisely because they are surrounded by so many mysteries. Yet the physics behind them is n
l the most exciting mysteries of the universe. We must share that with everyone, even in the classroom!" says Dr
osely involved in the Einstein Telescope. The telescope provides teachers with an ideal hook to introduce their pupi

sics teachers came to Maastricht last week for the first MaGIC Summer School for secondary school teachers (Maa
vitational waves, the methods used to measure them, and how to pass on this knowledge to their pupils at an acc

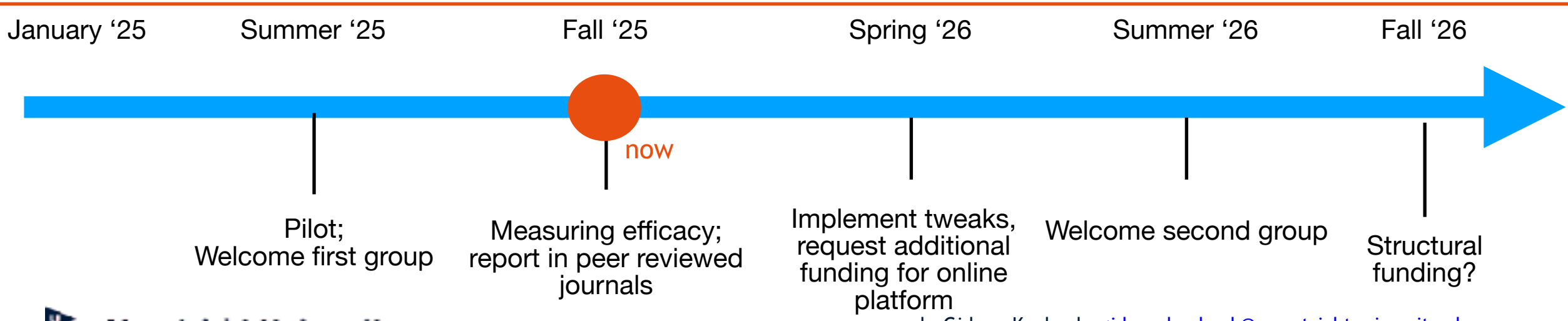
Triangular measurements were done:

* Pre- and post misconceptions
* Understanding and willingness/ applicability
* Panel discussion afterwards.

BARRIERS REMOVED

The future of *MaGIC*

- *MaGIC* has funding for two years (2025, 2026), but is intended to obtain structural funding.
- I expect this to happen when the location for Einstein Telescope has been decided and construction begins.
- This gives two years to show a successful proof of principle. Measurements of efficacy will be performed.
- Discussion currently with Perimeter institute, to share best practices with their E+ programme, to make intercontinental connections.



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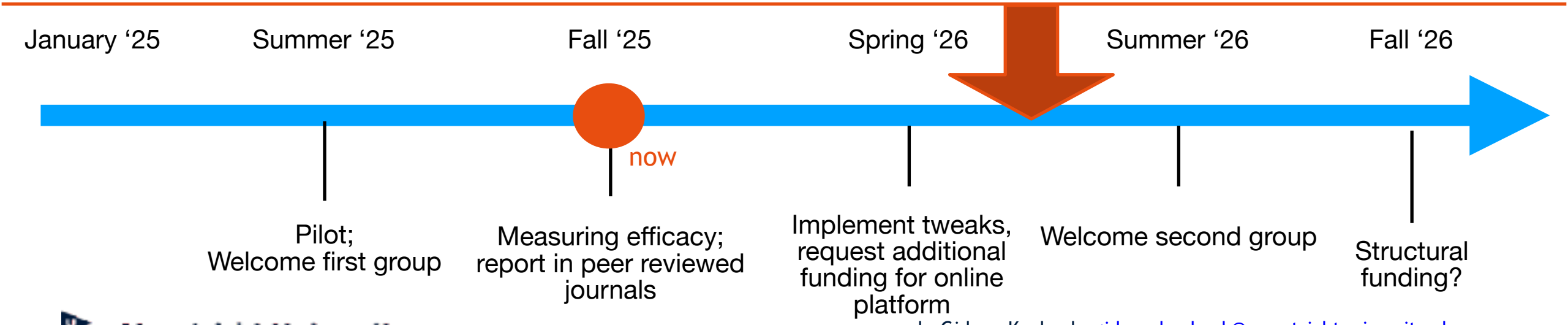
Winter MaGICs

- Local *MaGIC* initiatives in ET countries, 3 days each.
- Removing language barriers and allowing tweaking to local communities
- Off-season: take place in Jan, Feb 2026.
- Local organisers get to become *MaGIC* Ambassadors (*MaGICians*), and return to the Summer editions in Maastricht to help train next cohort
- Overarching goal: create European network of trainers, with online shared resources. Proposal for funding for *MaGIC* network is pending.

Winter-*MaGICs* in Flanders, Netherlands have been funded; the Winter-MaGICs in Germany and Wallonia are bing discussed as we speak.

Update next ET Consortium Meeting.



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DA workshop: Home/classroom version

- More waveforms, more signals, false positives, additional physical parameters
- Additional practice exercises and built-in explanations
- Translations into German, English, French, Italian, Polish , ..
- Measuring of retention and go-backs
- Data collected by ETEC; provide input for research on efficacy, longitudinal retention, and improvement of workshop

Funded!

Universiteitsfonds Limburg | SWOL |

https://staging.dataworkshop.discoverymuseum.nl/en

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Conclusions & prospects

- **Outreach is a vital part of our jobs:**
  to connect stakeholders, attract talent, and to maintain goodwill from the general public.

- **Education is the gift that keeps on giving:**
  Remove the barriers by creating ownership, making them feel like explorers and scientists, and actively stimulate curiosity (*e.g.* by using the reconnecting dots methodology)

- **Examples include:**
  - Einstein Telescope Education Centre:
  - Data-analysis workshop across Europe
  - International teacher professionalisation *MaGIC*
  - Many more from other ET members

- **Prospects:** - *Winter-MaGICs* are coming, starting first iteration of European network, with funding pending. I invite other parties to join.
  ETEC @ Home, international online platform for GW education

Gravitational wave science and Einstein Telescope offer great opportunities for GW outreach, STEM education and teacher professionalisation, strengthening our position in society, and hugely boosting the goodwill of general public and stakeholders, to the benefit of all the GW community.

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Thank you!

Einstein Telescope Education Centre:

www.discoverymuseum.nl/activiteiten/etec/

MaGIC durriculum:

www.maastrichtuniversity.nl/events/maastricht-gravitational-inspiration-curriculum-magic

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