

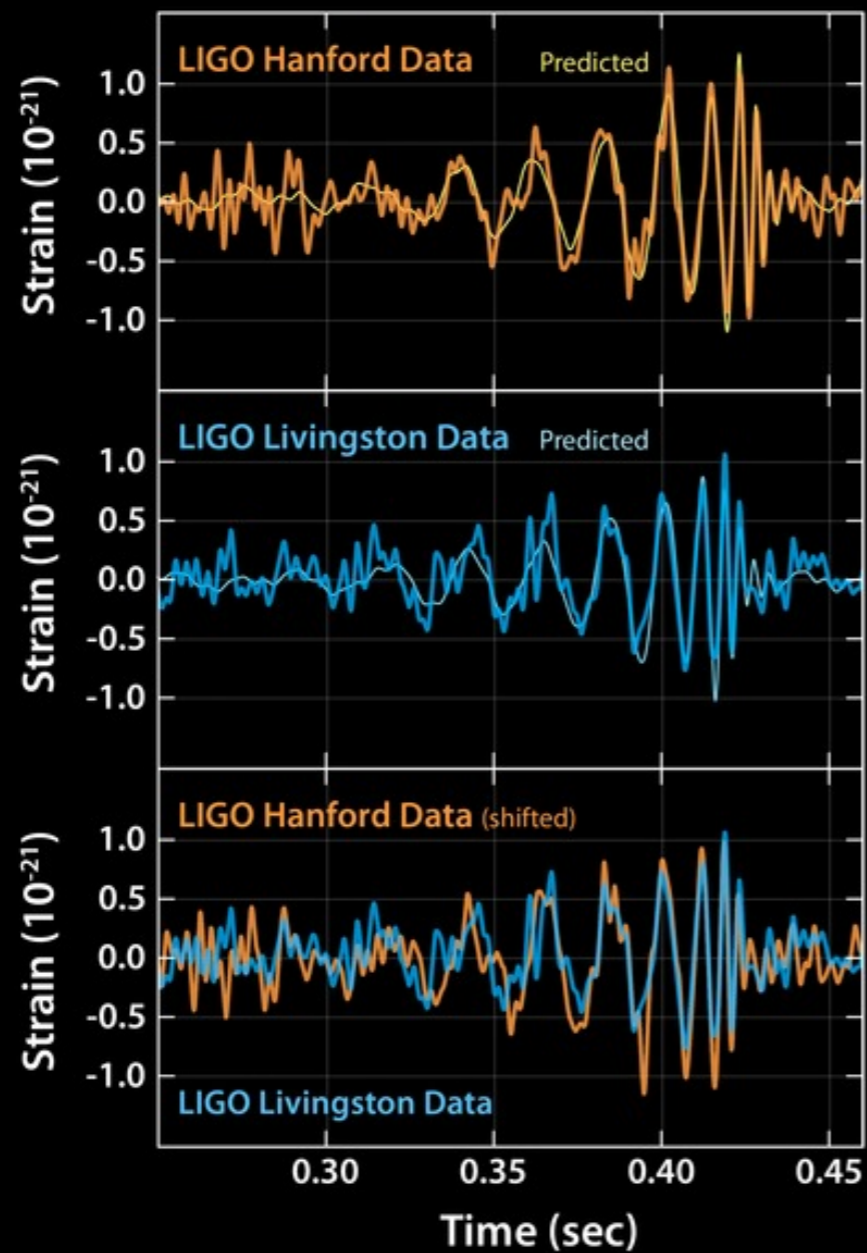


**ET.be**

**Jean-René Cudell**  
June 21, 2018



# 14/09/2015



## LIGO Black-hole merger



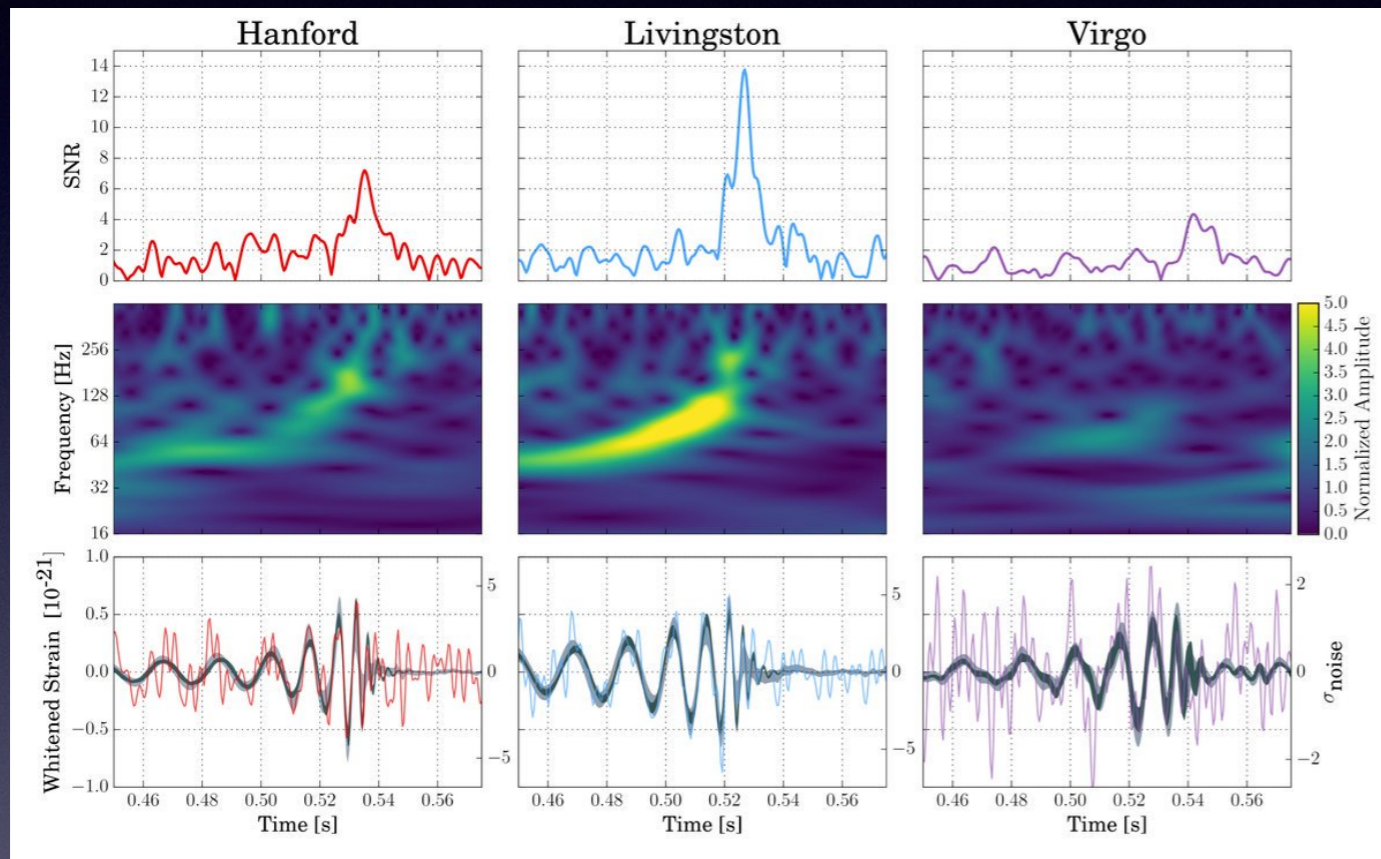
**The Nobel Prize in Physics 2017**

Rainer Weiss, Barry C. Barish and Kip S. Thorne

"for decisive contributions to the LIGO detector and the observation of gravitational waves"

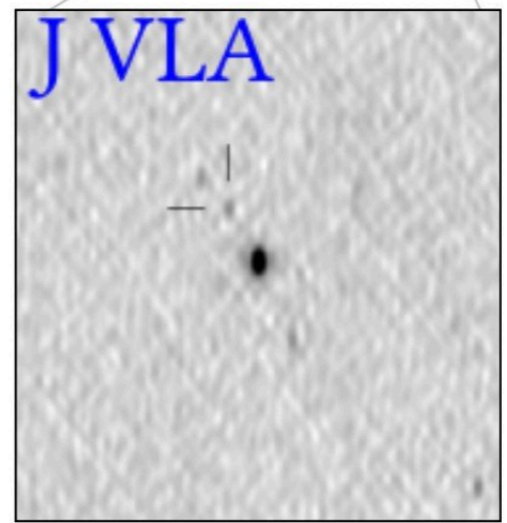
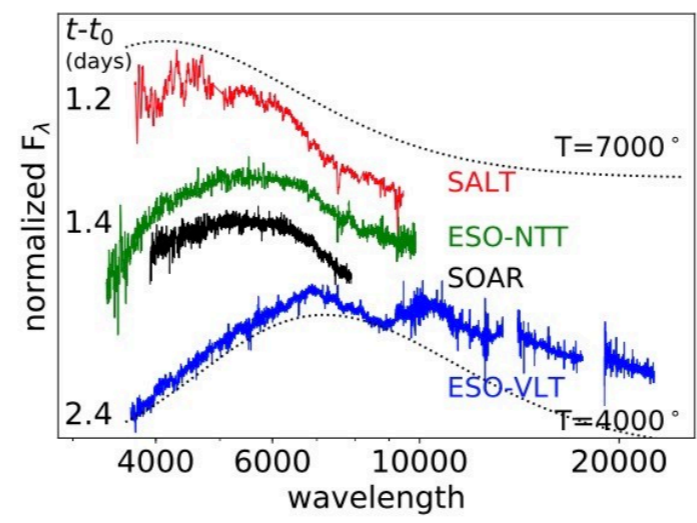
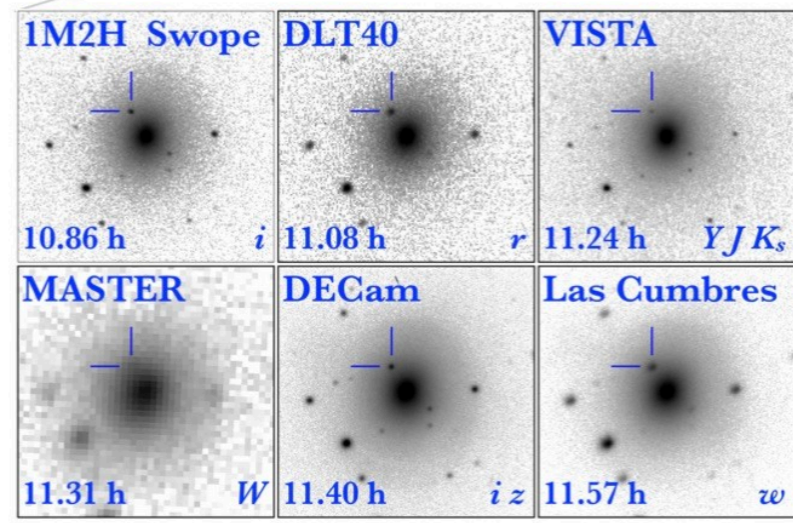
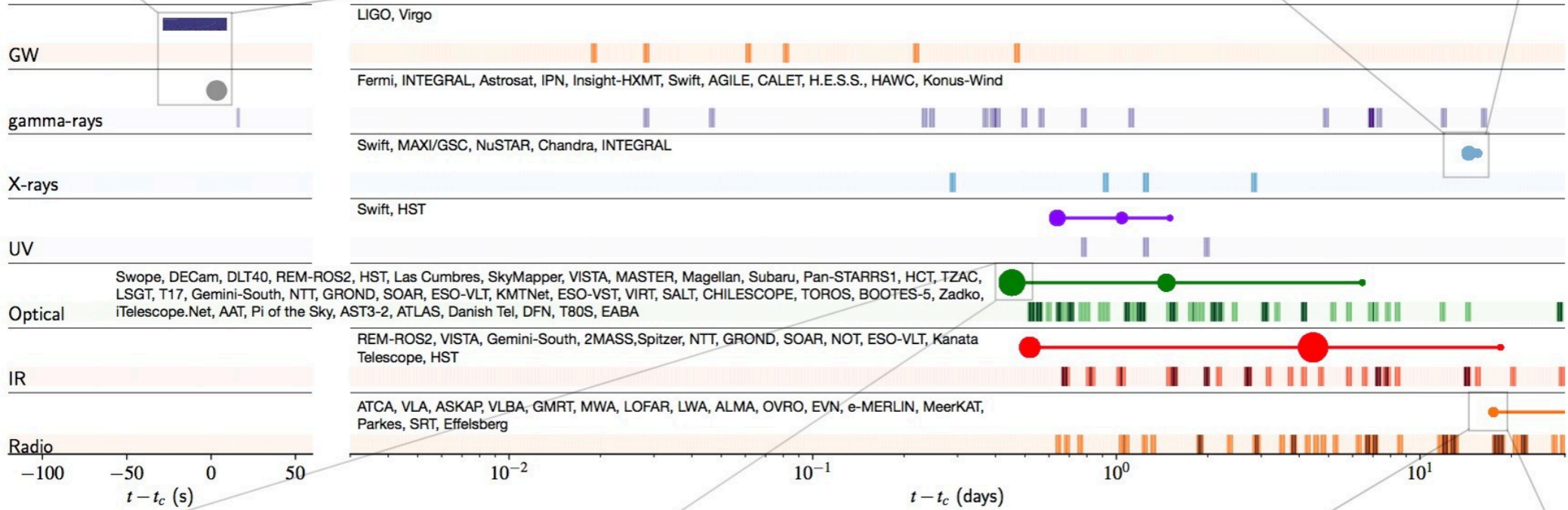
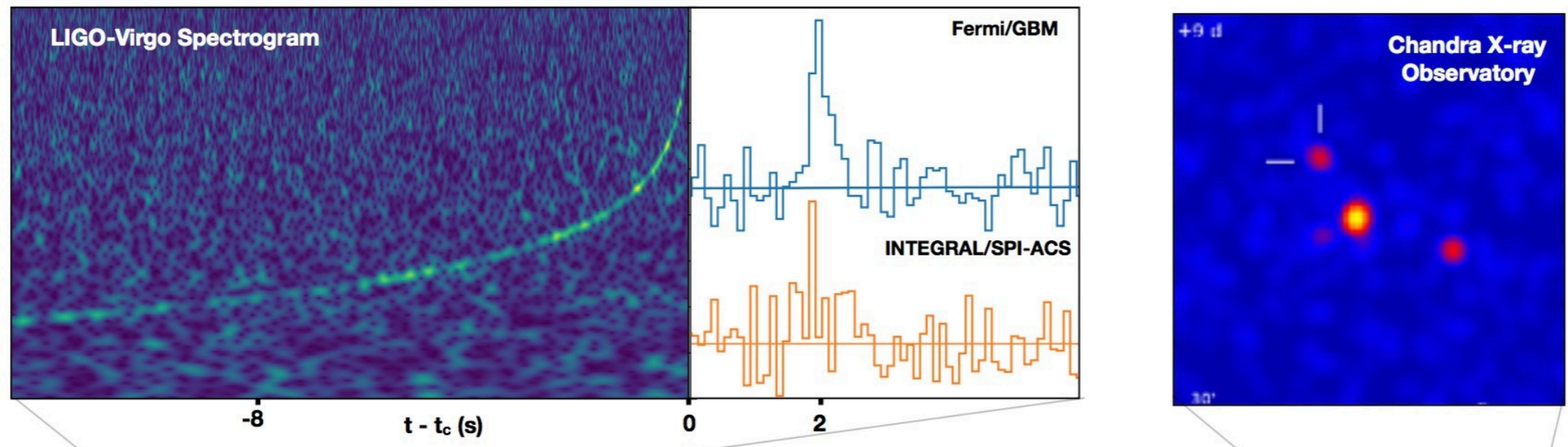
# Birth of gravitational wave astronomy

# 08/06/2017



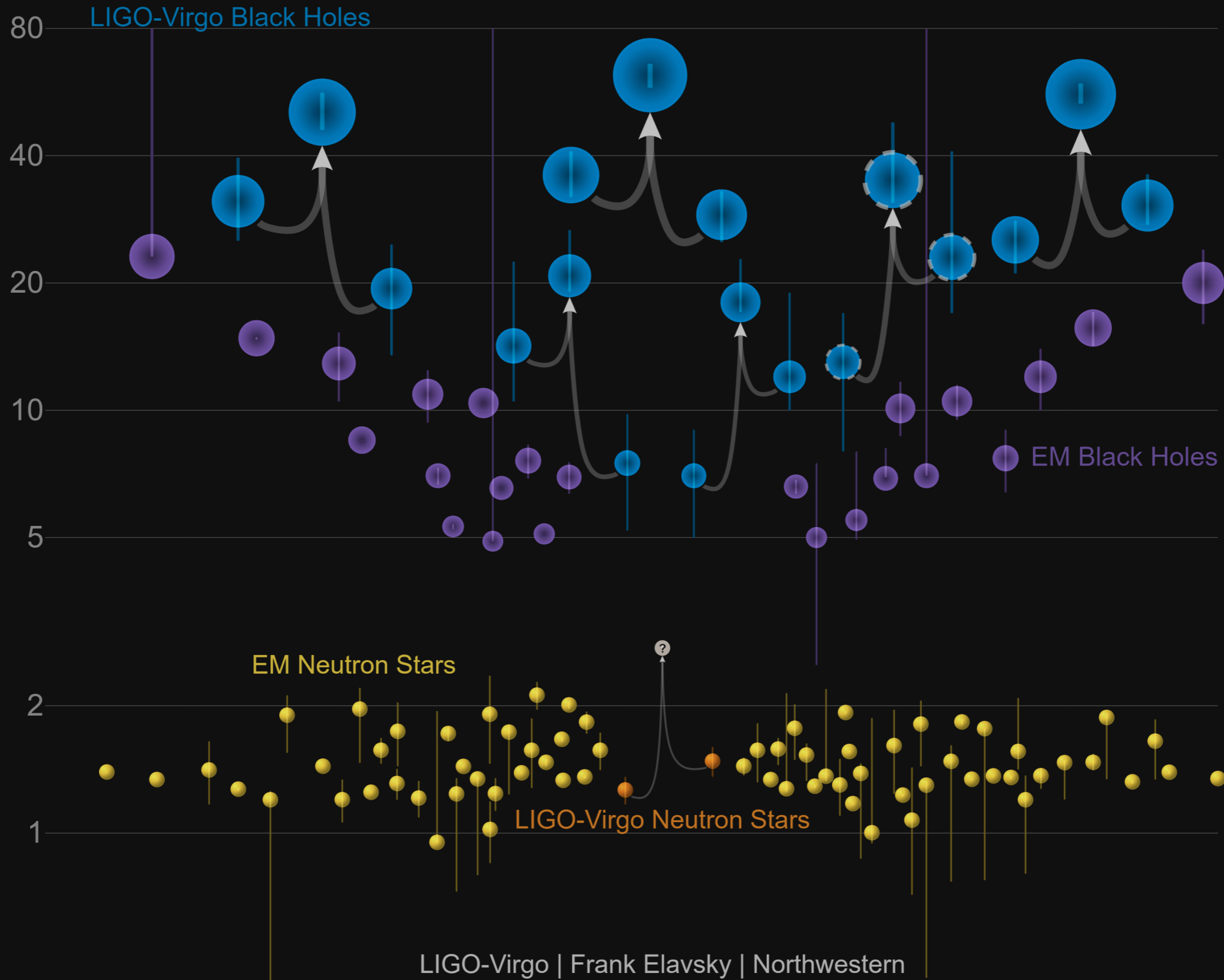
## LIGO+Virgo Neutron-star merger

# Birth of multi-messenger astronomy



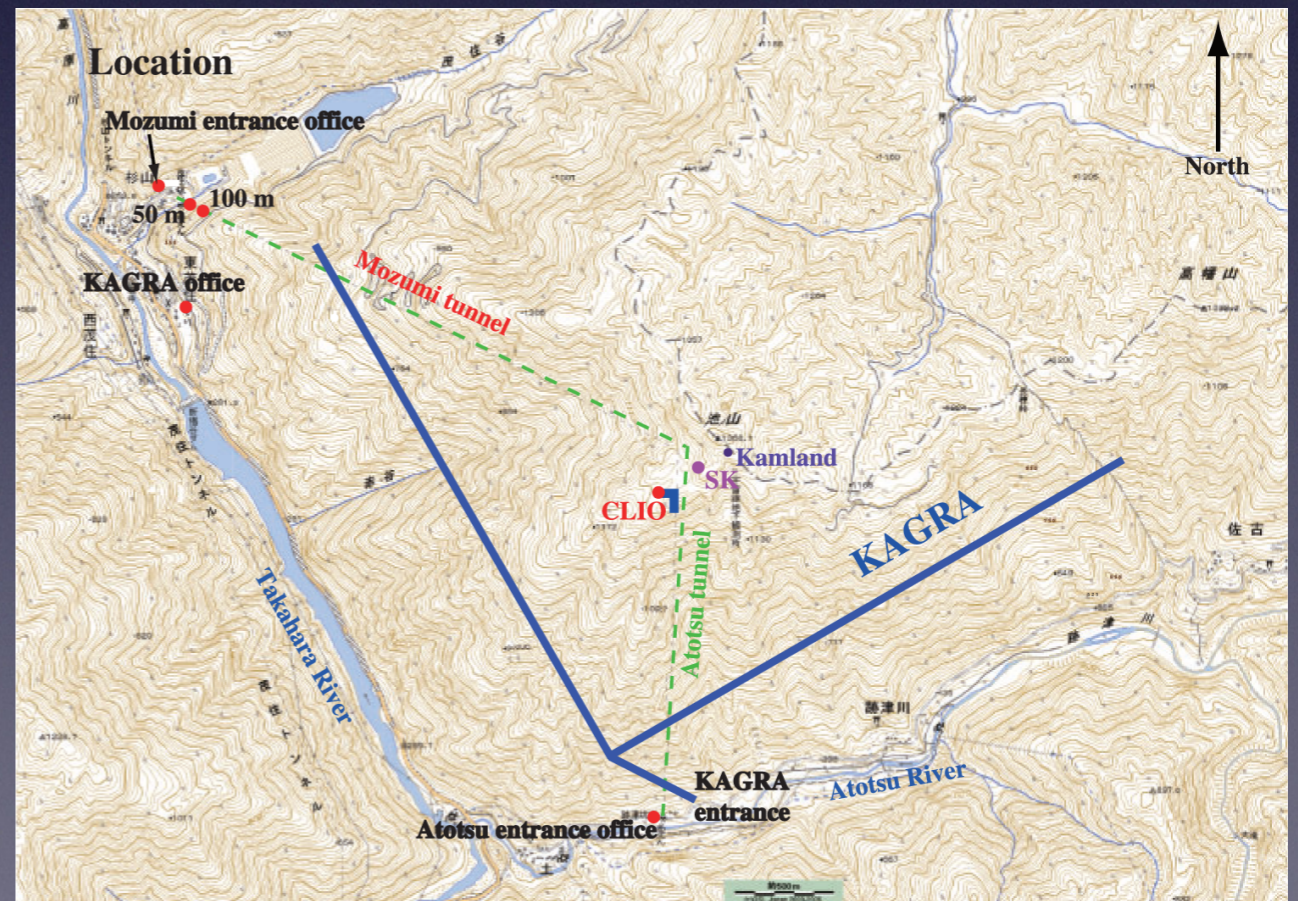
# Masses in the Stellar Graveyard

*in Solar Masses*



# Future

- Early 2019 : O3 run, squeezed photons
- 2020 (?) : KAGRA joins in. Cryogenic, underground.



# The full advanced GW Network (>2024)



Advanced LIGO  
Hanford, 4 km



GEO600

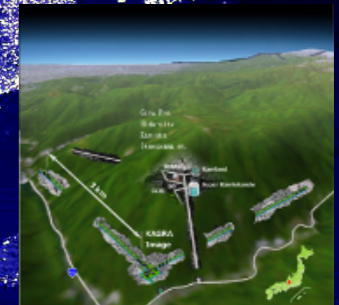


Advanced LIGO  
Livingston  
4 km



Advanced Virgo  
3 km

(Advanced LIGO  
INDIA, 4 km)



KAGRA, 3km

from H. Lück

- better sensitivity to polarisation of GWs
- better triangulation
- better statistics
- event rate  $\approx 500$  events/year





# The Next Generation

Better sensitivity at low frequency  
Better statistics  
Faster alarms

longer  
cryogenic

Lower Newtonian noise

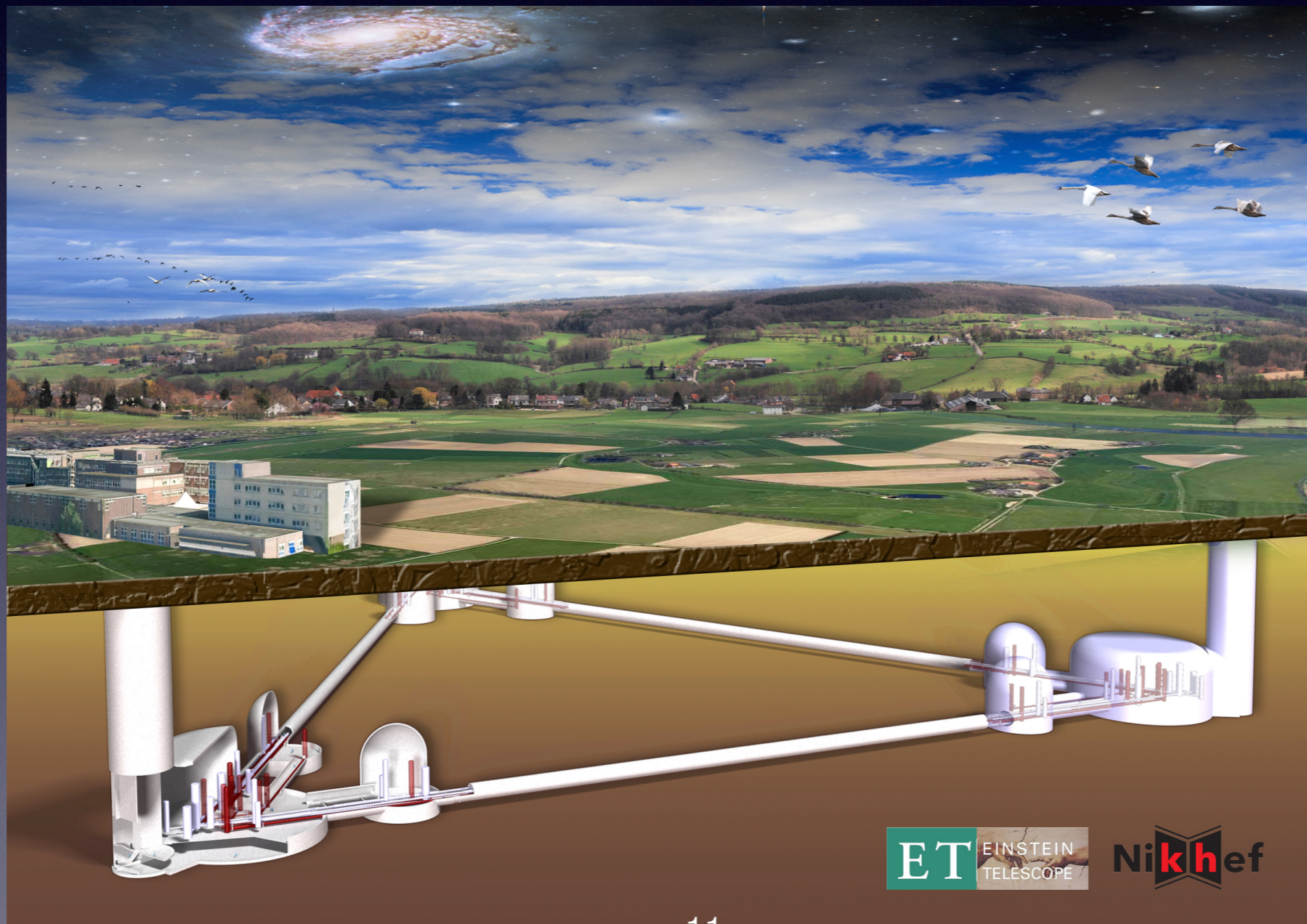
underground

Lower quantum noise HF

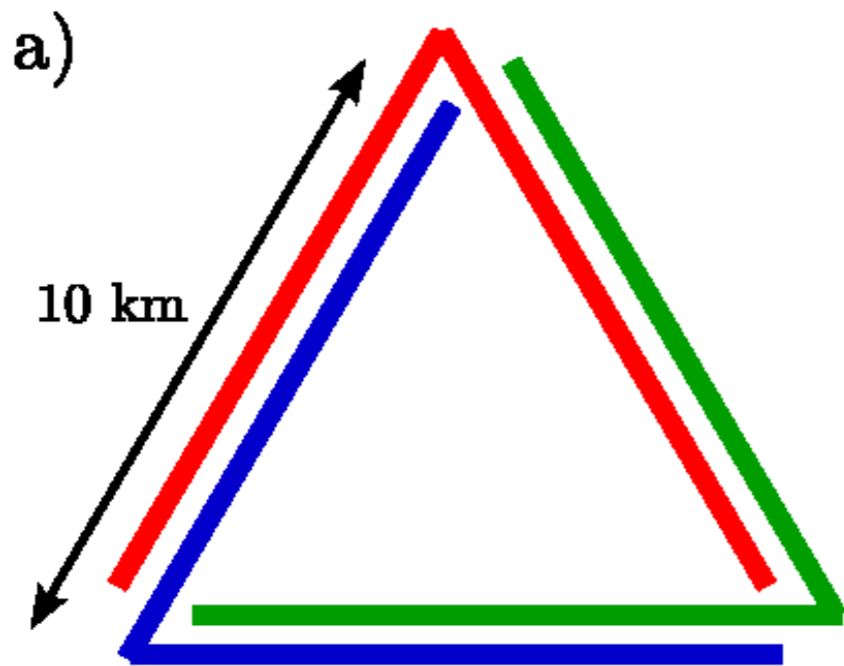
higher power

2 simultaneous interferometers HF and LF

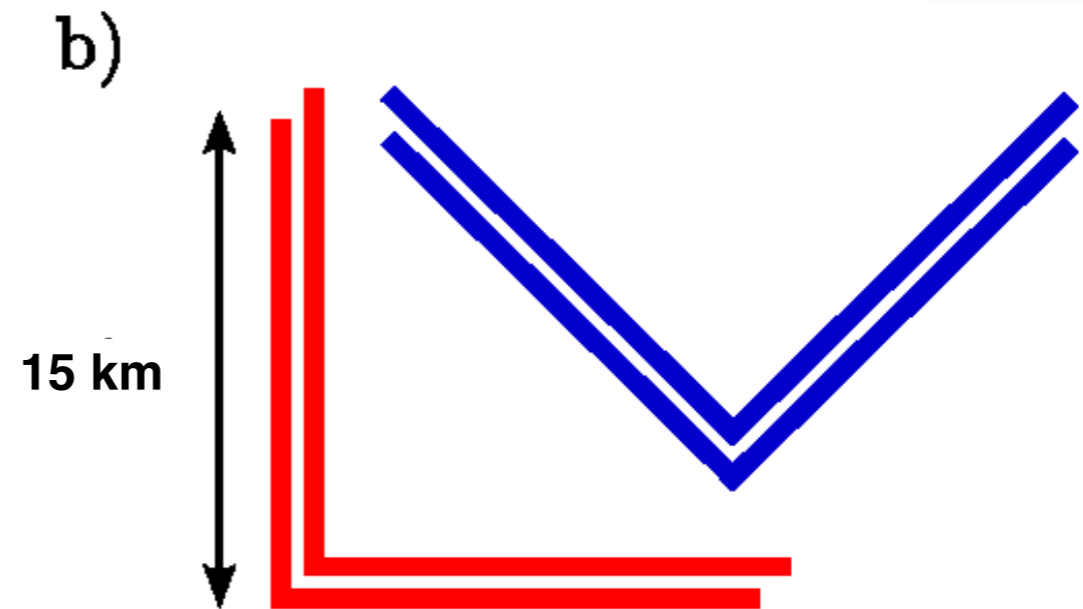
European project: Einstein Telescope  
triangle, 10 km side, underground  
> 100 000 events/year



# Possible topologies

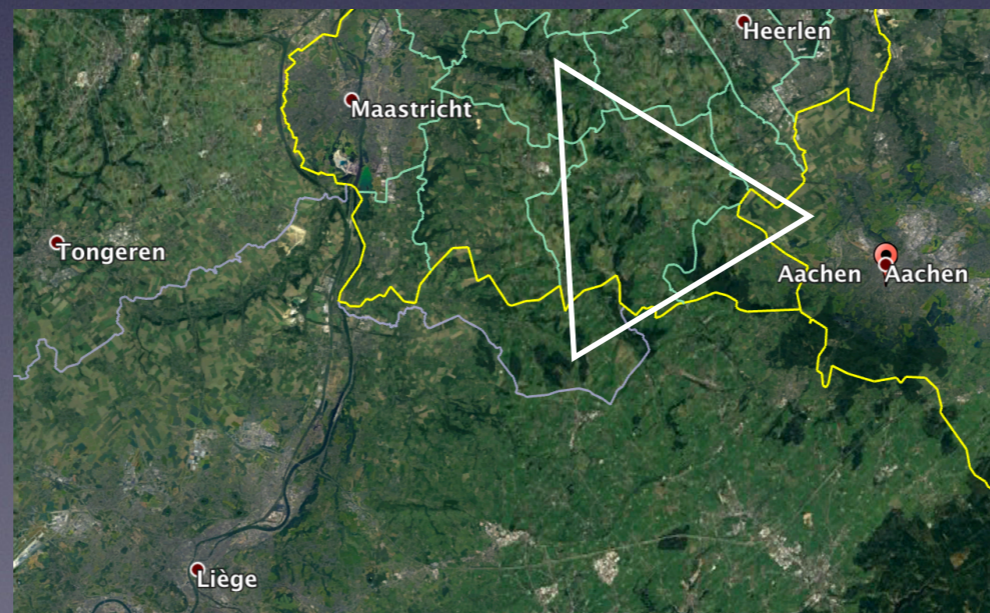
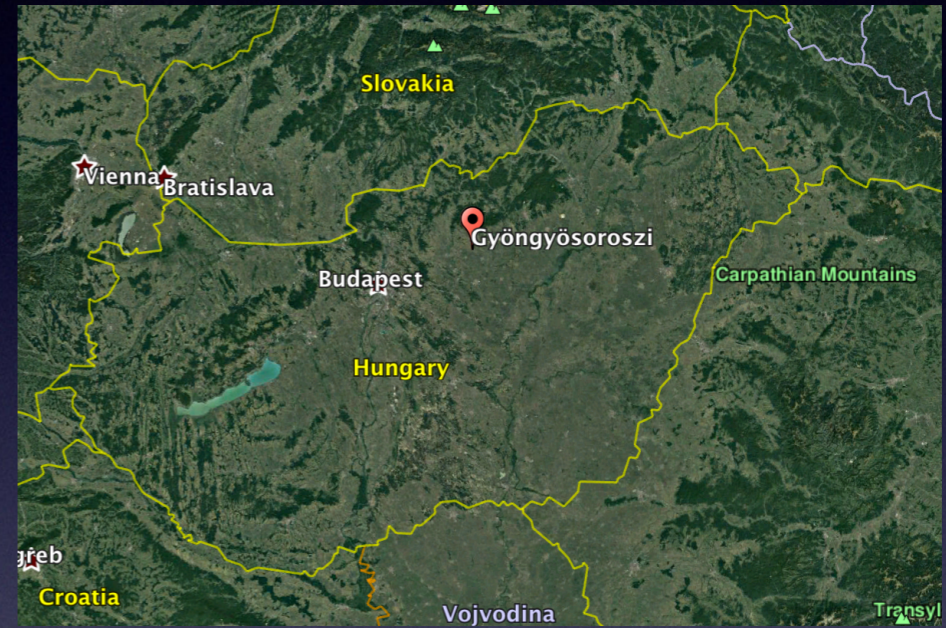
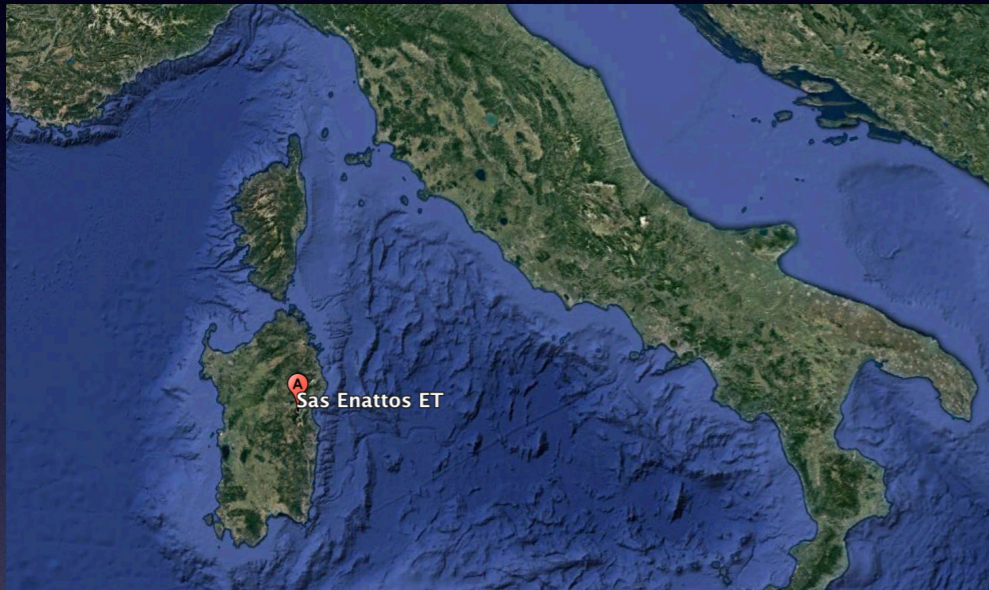


1 site

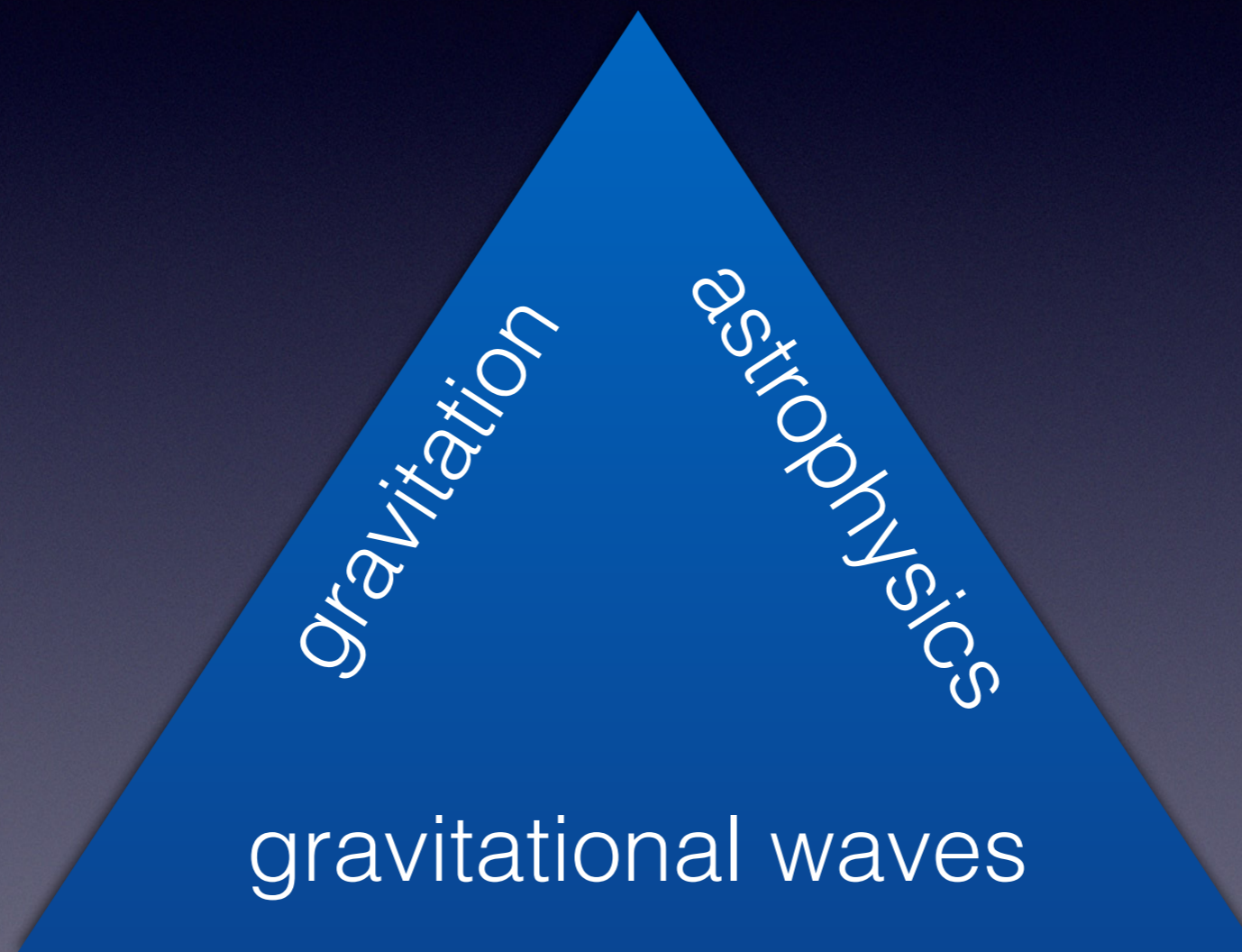


2 sites (as LIGO)

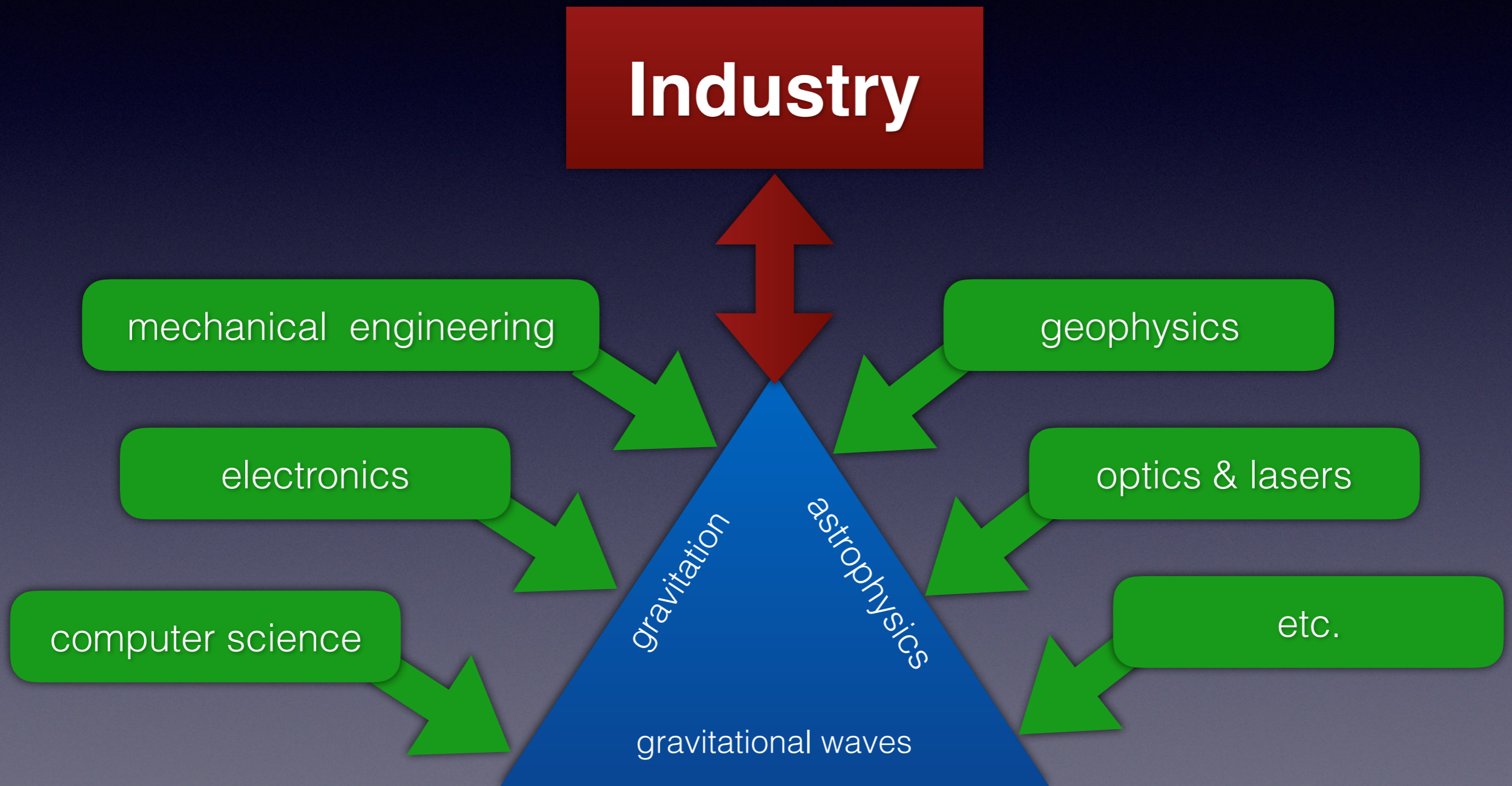
# Candidates



# The science case



# The bigger picture



# Roadmap

- Submission of an ESFRI (European Strategy Forum on Research Infrastructures) proposal in March 2019 with possible sites (and funding - commitment of host countries  $> 0.6$  G€).
- Final decision on the site 2020-early 2021
- Construction starts 2022
- Scientific operation starts 2030



The background of the slide is a 3D visualization of a gravitational well. It features a blue grid that curves downwards into a deep well. Two bright blue spheres are positioned in the upper right part of the well, representing objects in orbit. The text 'Belgian situation' is centered in a white box with a thin black border.

# Belgian situation

# Belgian involvement

- End of January 2018: workshop @ ULiège

First Name	Last Name	Lab/ Department / Faculty	University
Bert	Vercnocke	Gravitational Wave Center, Institute for Theoretical Physics	KU Leuven
Geert	Degrande	Civil Engineering/ Engineering	KUL
Michel	Van Camp	Seismologie-Gravimetrie	Royal Observatory of Belgium
Vincent	Lemaître	Centre for Cosmology Particle Physics ans Phenomenology CP3/IRMP/SST	UCL
Andrea	Giammanco	Centre for Cosmology Particle Physics ans Phenomenology CP3/IRMP/SST	UCL
Claude	Duhr	Centre for Cosmology Particle Physics ans Phenomenology CP3/IRMP/SST	UCL
Chrisophe	Delaere	Centre for Cosmology Particle Physics ans Phenomenology CP3/IRMP/SST	UCL
Fabio	Maltoni	Centre for Cosmology Particle Physics ans Phenomenology CP3/IRMP/SST	UCL
Christophe	Ringeval	Centre for Cosmology Particle Physics ans Phenomenology CP3/IRMP/SST	UCL
Jan	Govaerts	Centre for Cosmology Particle Physics ans Phenomenology CP3/IRMP/SST	UCL
Krzysztof	Piotrkowski	Centre for Cosmology Particle Physics ans Phenomenology CP3/IRMP/SST	UCL
Eduardo	Cortina	Centre for Cosmology Particle Physics ans Phenomenology CP3/IRMP/SST	UCL
Jean-Marc	Gérard	Centre for Cosmology Particle Physics ans Phenomenology CP3/IRMP/SST	UCL
Marco	Drewes	Centre for Cosmology Particle Physics ans Phenomenology CP3/IRMP/SST	UCL
Giacomo	Bruno	Centre for Cosmology Particle Physics ans Phenomenology CP3/IRMP/SST	UCL
Clément	Lauzin	Institute of condensed matter and nanosciences	UCL
Sebastien	Clesse	CP3 and naXys	UCLouvain and UNamur

Dirk	Ryckbosch	Physics and Astronomy	UGent
Stephane	Detournay	Fundamental and Mathematical Physics	ULB
Arnaud	Deraemaeker	BATir	ULB
Ioana	Maris	Astroparticle Physics (Auger, IceCube)	ULB
Laurent	Favart	IIHE-ULB director (IceCube, Auger)	ULB
Michel	Tytgat	Service de Physique Théorique	ULB
Petr	Tinyakov	Service de Physique Théorique	ULB
Laura	Lopez Honorez	Service de Physique Théorique	ULB
Nicolas	Chamel	Institut d'Astronomie et d'Astrophysique	ULB
Alain	Jorissen	Institut d'Astronomie et d'Astrophysique	ULB
Stephane	Goriely	Institut d'Astronomie et d'Astrophysique	ULB
Sophie	Van Eck	Institut d'Astronomie et d'Astrophysique	ULB
Frédéric	Robert	Embedded Electronics/BEAMS/Ecole Polytechnique de Bruxelles	ULB
Geoffrey	Compère	Fundamental and Mathematical Physics	ULB
Christophe	Collette	Precision Mechatronics Laboratory	ULB and ULiège
Jean-René	Cudell	STAR Intitute/fundamental interactions	ULiège
Gregor	Rauw	STAR Intitute	ULiège
Nazé	Yaël	STAR Institute	ULiège
Michaël	De Becker	STAR Institute	ULiège
Jérôme	Loicq	CSL&Applied sciences	ULiège
Frédéric	Nguyen	Applied Geophysics/UEE/Engineering	ULiège
Alain	DAssargues	Hydrogeology and Env. Geology/UEE/Engineering	ULiège
Hans-Balder	Havenith	Georisks_ and_ Environment/Geology/Sciences	ULiège
André	Füzfa	naXys	UNamur
Pierre	Van Mechelen	Particle Physics group	University of Antwerp

41 persons (all fields) marks their interest

April 2018

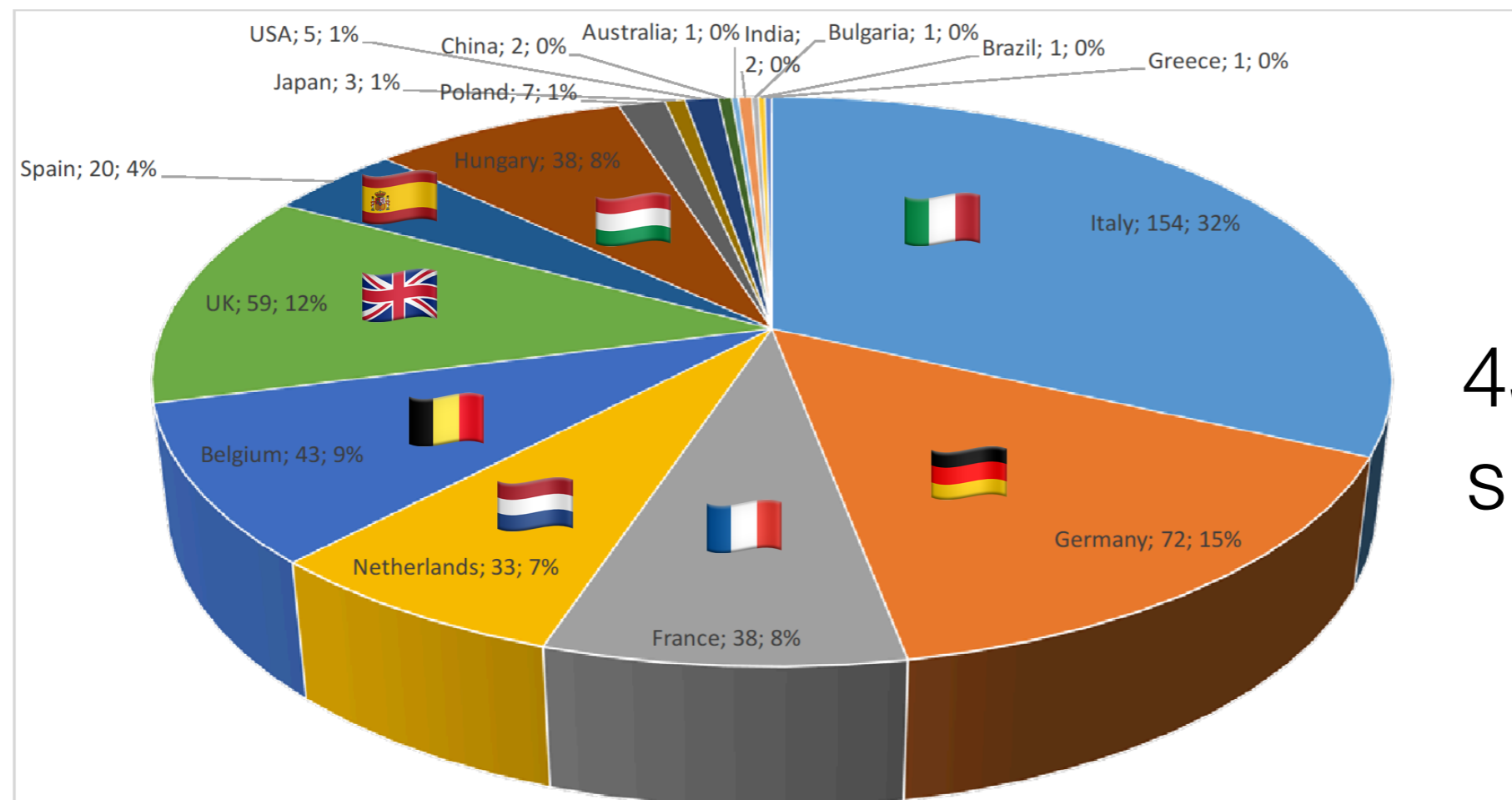
- Start of geology studies at ULiège to determine best location for site
- 9th ET symposium in Cascina (Virgo site) and official ET LOI

# ET Letter of intent signatories

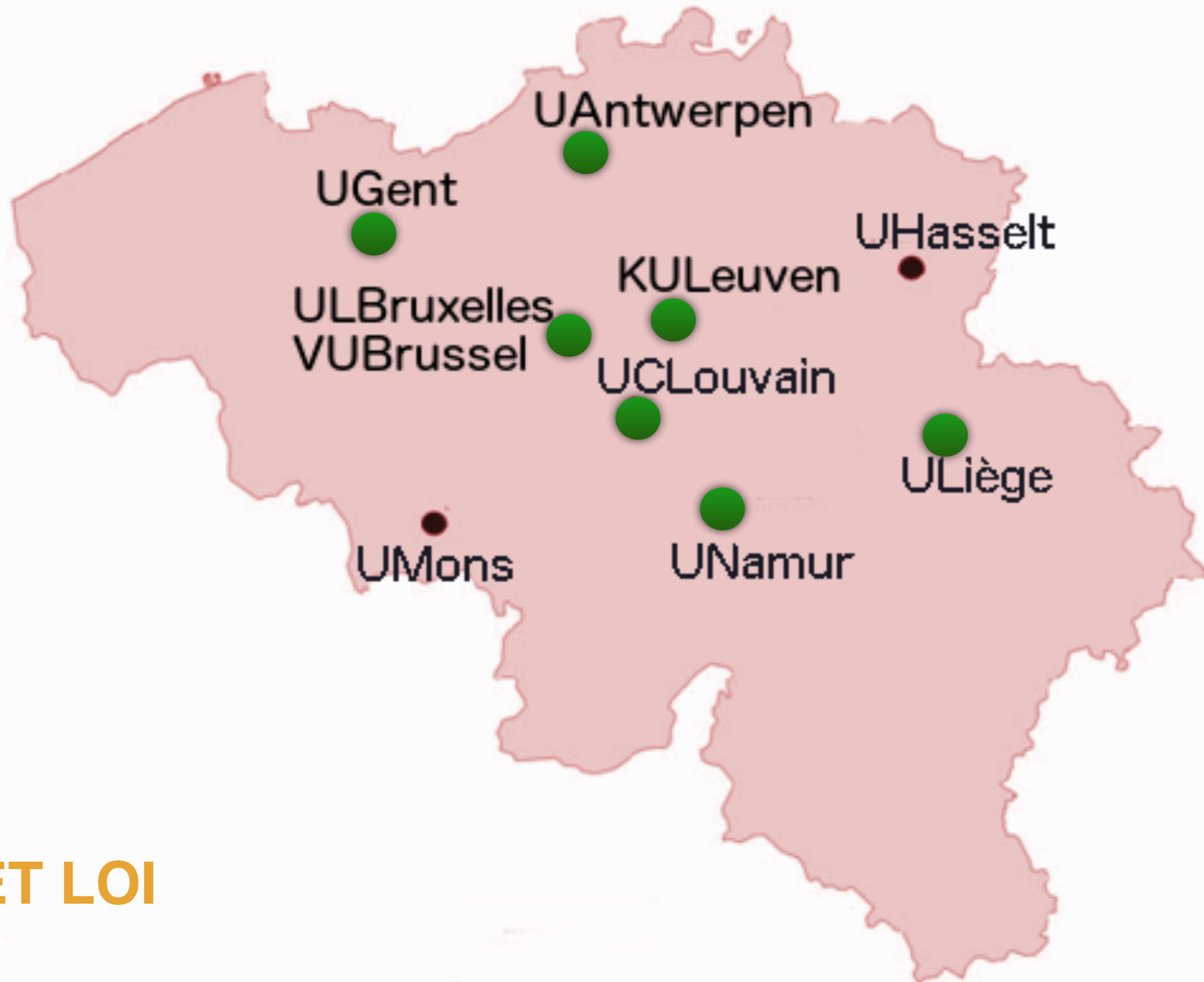
## Einstein Telescope (ET) Letter of Intent (LOI) signatures

This document reports the signatures of the ET LOI collected by the online system at the date 03/06/2018 18:09:00. Please, note that some of the subscribers declared to belong to more than one country; this info is stored in the database, but the output is created selecting just one of the two or more selection.

Currently there are 480 valid signatures.



43 Belgian signatures



**ET LOI**

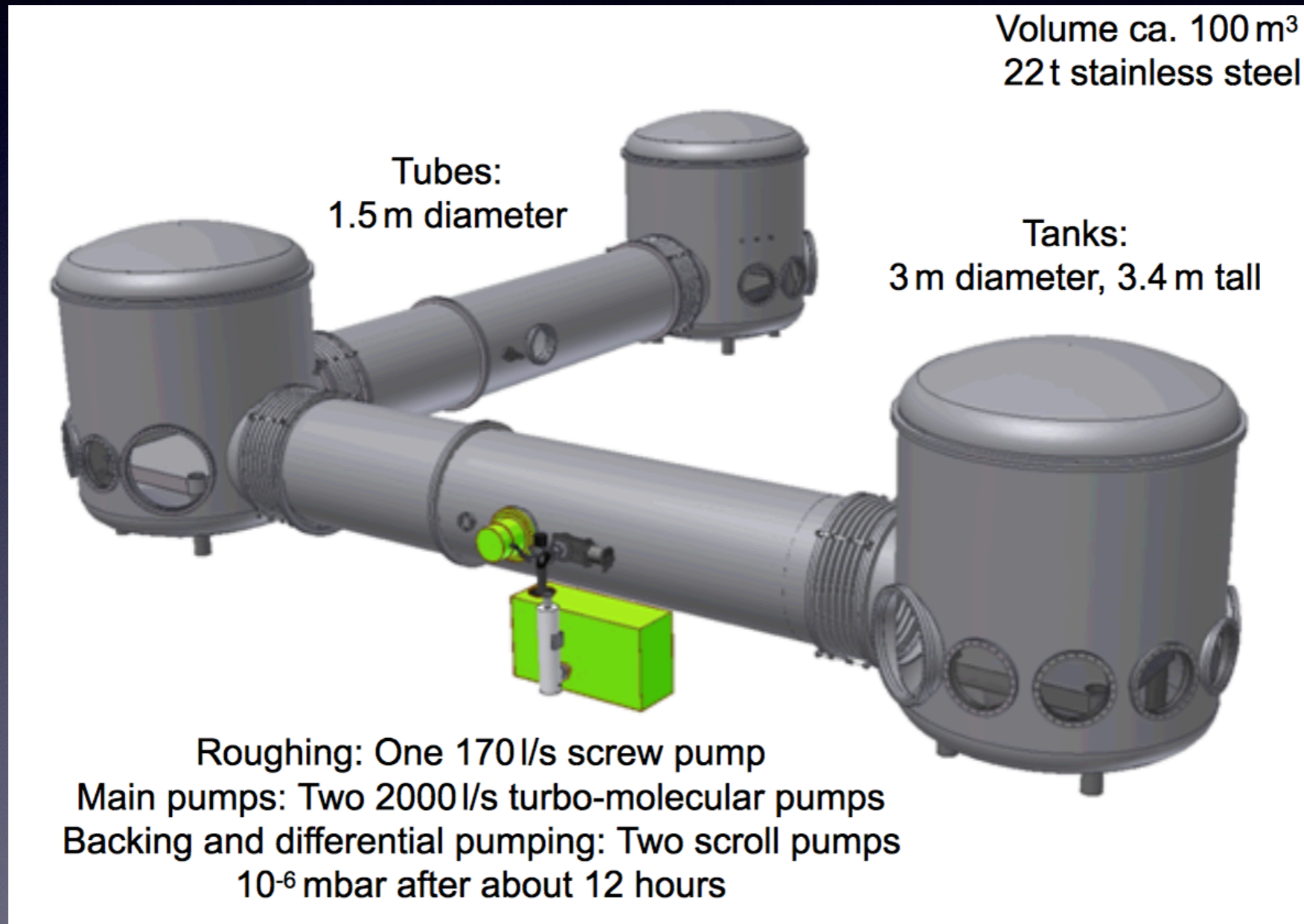
Geert	Degrande	KULeuven	geert.degrande@kuleuven.be	structural mechanics
Thomas	Hertog	KULeuven	Thomas.Hertog@fys.kuleuven.be	theoretical physics
Michael	Kraft	KULeuven	Michael.Kraft@esat.kuleuven.be	micro-electro-mechanical systems
Filip	Tavernier	KULeuven	Filip.Tavernier@esat.kuleuven.be	micro-electronics
Nick	van Remortel	UAntwerpen	Nick.VanRemortel@ua.ac.be	experimental physics
Giacomo	Bruno	UCLouvain	Giacomo.Bruno@cern.ch	experimental physics
Sebastien	Clesse	UCLouvain	sebastien.clesse@uclouvain.be	theoretical physics
Marco	Drewes	UCLouvain	marco.drewes@uclouvain.be	theoretical physics
Vincent	Lemaitre	UCLouvain	vincent.lemaitre@uclouvain.be	experimental physics
Krzysztof	Piotrkowski	UCLouvain	Krzysztof.Piotrkowski@uclouvain.be	experimental physics
Chris	Ringeval	UCLouvain	christophe.ringeval@uclouvain.be	theoretical physics
Dirk	Ryckbosch	Ugent		experimental physics
Guoying	Zhao	ULB	guoying.zhao@ulb.ac.be	opto-mechatronics
Geoffrey	Compere	ULB	gcompere@ulb.ac.be	theoretical physics
Arnaud	Deraemaeker	ULB	Arnaud.Deraemaeker@ulb.ac.be	computational mechanics
Stéphane	Detournay	ULB	Stephane.Detournay@ulb.ac.be	theoretical physics
Johan	Gyselinck	ULB	Johan.Gyselinck@ulb.ac.be	mechatronics
Stephane	Goriely	ULB	Stephane.Goriely@ulb.ac.be	astrophysics
Alain	Jorissen	ULB	Alain.Jorissen@ulb.ac.be	astrophysics
Gauthier	Lafruit	ULB	gauthier.lafruit@ulb.ac.be	image analysis and computer graphics
Laura	Lopez Honorez	ULB	llopezho@ulb.ac.be	theoretical physics
Petr	Tiniakov	ULB	petr.tiniakov@ulb.ac.be	theoretical physics
Michel	Tytgat	ULB	mtytgat@ulb.ac.be	theoretical physics
Jennifer	Watchi	ULB	jwatchi@ulb.ac.be	opto-mechatronics
Christophe	Collette	ULiege&ULB	ccollett@ulb.ac.be	opto-mechatronics
Atri	Bhattacharya	ULiege	A.Bhattacharya@uliege.be	theoretical physics
Jean-René	Cudell	ULiege	jr.cudell@uliege.be	theoretical physics
Alain	Dassargues	ULiege	Alain.Dassargues@uliege.be	geophysics
Michael	De Becker	ULiege	Michael.DeBecker@uliege.be	astrophysics
Christophe	Geuzaine	ULiege	cgeuzaine@uliege.be	computational mathematics
Eric	Gosset	ULiege	gosset@astro.ulg.ac.be	astrophysics
Hans-Balder	Havenith	ULiege	HB.Havenith@uliege.be	geology
Damien	Hutsemékers	ULiege	D.Hutsemekers@uliege.be	astrophysics
Jerome	Loicq	ULiege	J.Loicq@uliege.be	optics
Gilles	Loupe	ULiege	G.Loupe@uliege.be	artificial intelligence
John	Martin	ULiege	jmartin@uliege.be	quantum optics
Yael	Naze	ULiege	naze@astro.ulg.ac.be	astrophysics
Frederic	Nguyen	ULiege	F.Nguyen@uliege.be	geophysics
Gregor	Rauw	ULiege	G.Rauw@uliege.be	astrophysics
Pierre	ROCHUS	ULiege&CSL	prochus@uliege.be	engineering
Ben	Craps	VUB	Ben.Craps@vub.be	theoretical physics
Alexandre	SEVRIN	VUB	Alexandre.Sevrin@vub.be	theoretical physics

# May 2018

## ESFRI roadmap

- Belgium is the only country with no ESFRI roadmap !
- Flanders has an FWO International Research Infrastructure call for it
- May 4: KUL entered an IRI proposal
- We contacted so far Marcourt, Jeholet, Borsus, Michel, Demotte, Paasch

# ET pathfinder

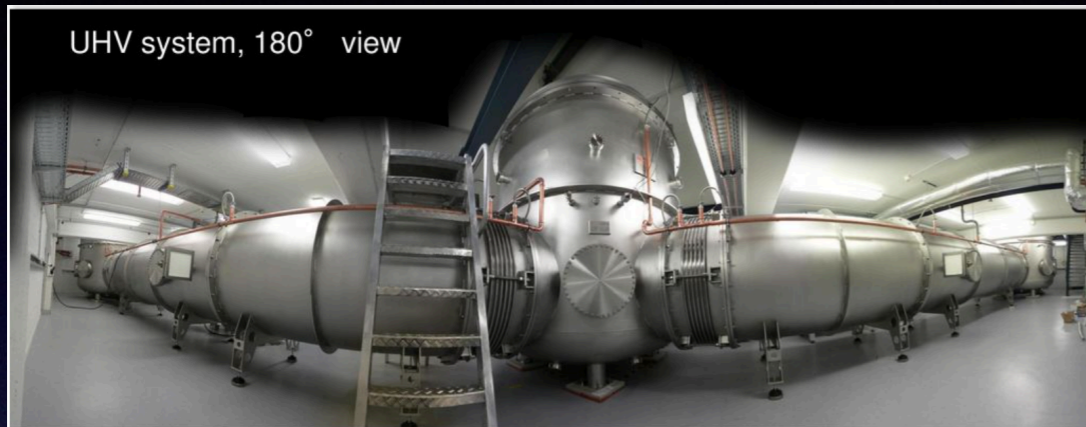




# Interests

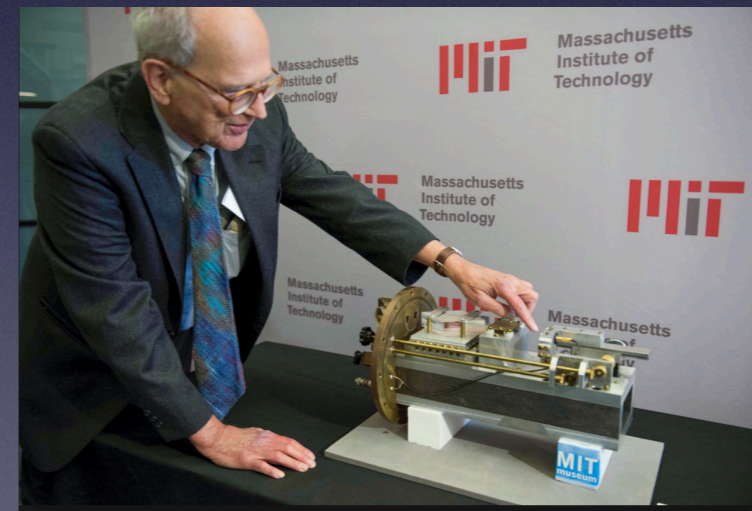
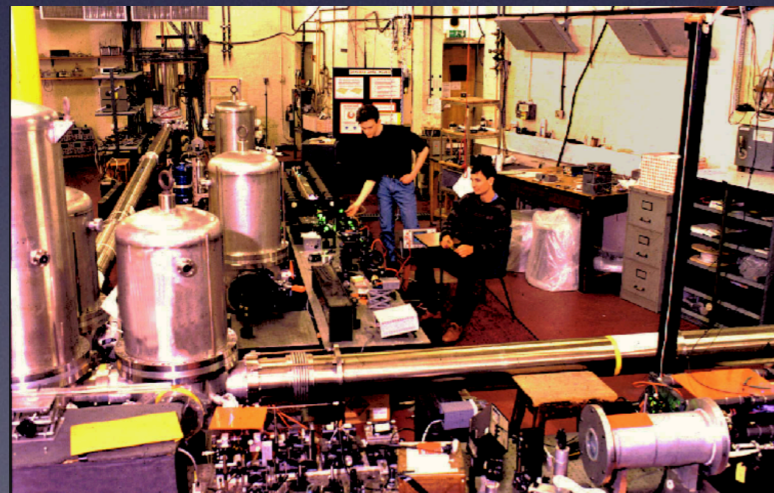
- Test mirrors (Si for cryogenic, SiO<sub>2</sub> for HF)
- Test the idea to cool the HF Si to 120 K
- Test suspensions
- Test cryogeny
- etc.

# Previous prototypes



Albert Einstein Institut

Kamioka



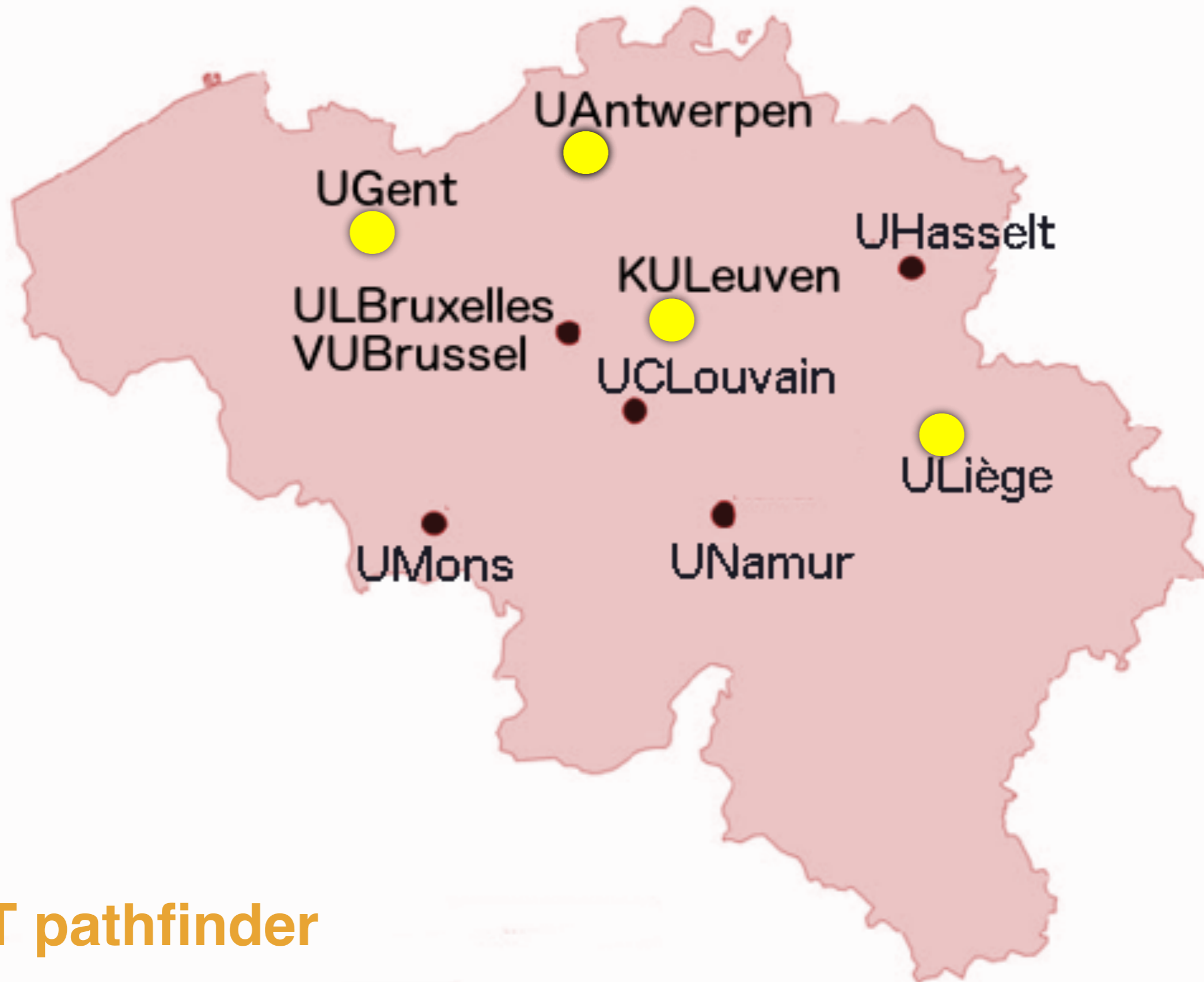
Glasgow

MIT

# Funding: INTERREG

- Vlaanderen-Nederland: submitted May 18 (Antwerpen, Gent, Leuven)
- Euregio Meuse-Rhein: to be submitted in November (Liège, Leuven), coupled with geophysical studies Liège-Aachen

Site(s) undecided



**ET pathfinder**

# June 2018

- Meetings in Hannover (June 18) and Aachen (today!) where Germany will define its position on ET and ET pathfinder.

# Join in!

- <http://www.et-gw.eu/index.php/letter-of-intent>