TUDOMÁNY ÜNNEPE
A MAGYAR
MESSZE LÁTÓ TUDOMÁNY

ET: Einstein Telescope

A new gateway to knowledge

T. Csörgő
MTA Wigner RCP, Budapest,
KRF, Gyöngyös, Hungary

WPCF 2014 Gyöngyös, Hungary

http://www.et-gw.eu/

http://wpcf2014.karolyrobert.hu/

http://epiphany.ifj.edu.pl/

Einstein Telescope
or the sounds of a Big Bang

How to make a perfect new telescope?

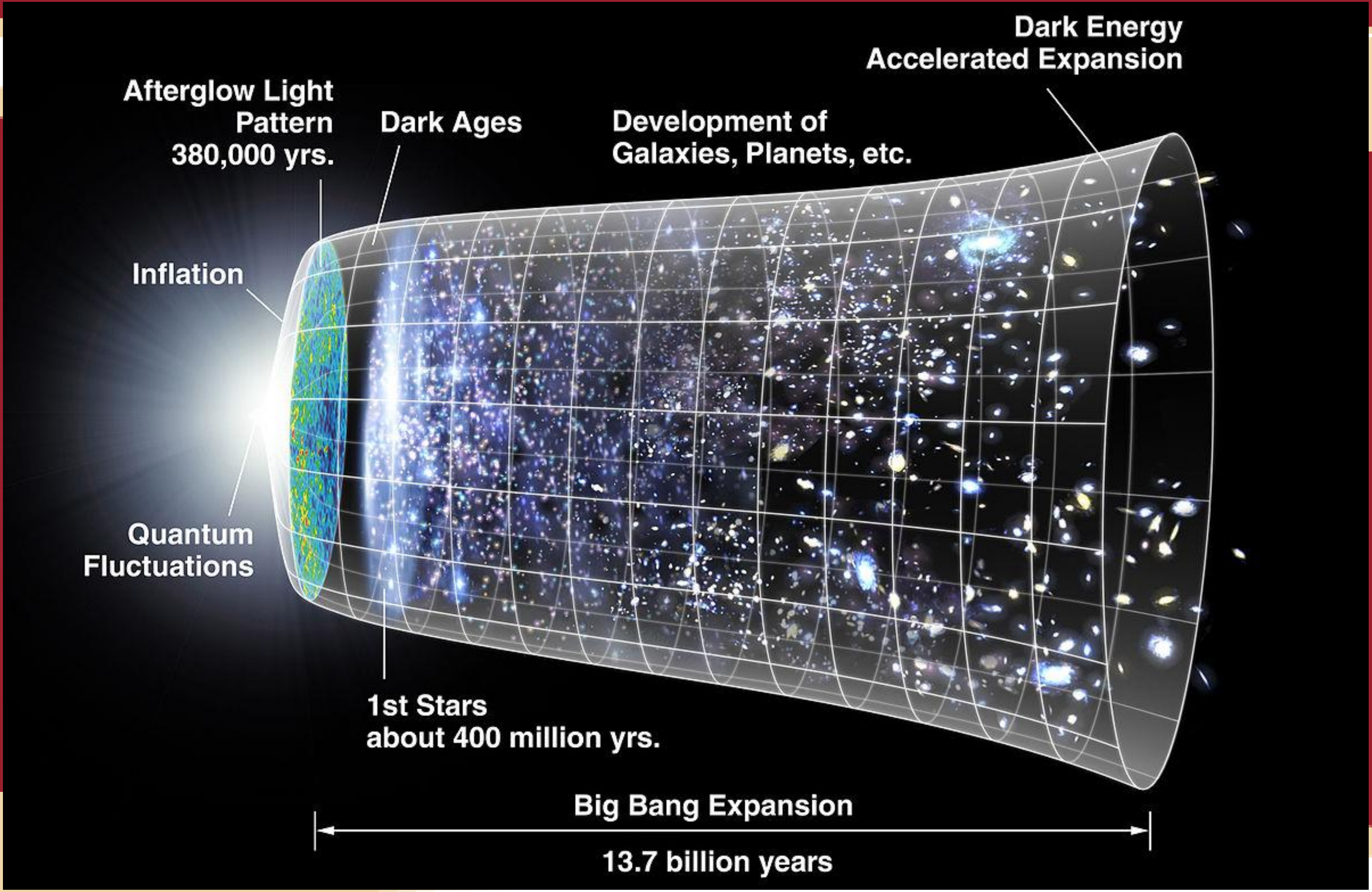
Far away mountain:

without scattered background light

- **must be high elevation**
- **(min. moisture and noise from air conditions)**
- **giant mirror needed**
- **most modern light sensors**
- **must look for primordial light sources**

However…

Our Universe becomes transparent to light only ~ 380 000 years after the Big Bang



Einstein „Stetoscope" or the „sounds" of the Big Bang

How to observe the Early Universe?

Light cannot shed more light on the first 380 000 years: but gravitational waves can!

- a need for a place where there is minimal noise
  - underground (with minimal seizmic noise)
  - large facility (10x10x10 km)
  - laser interferometer as sensor
  - to detect the tiniest ripples of space-time

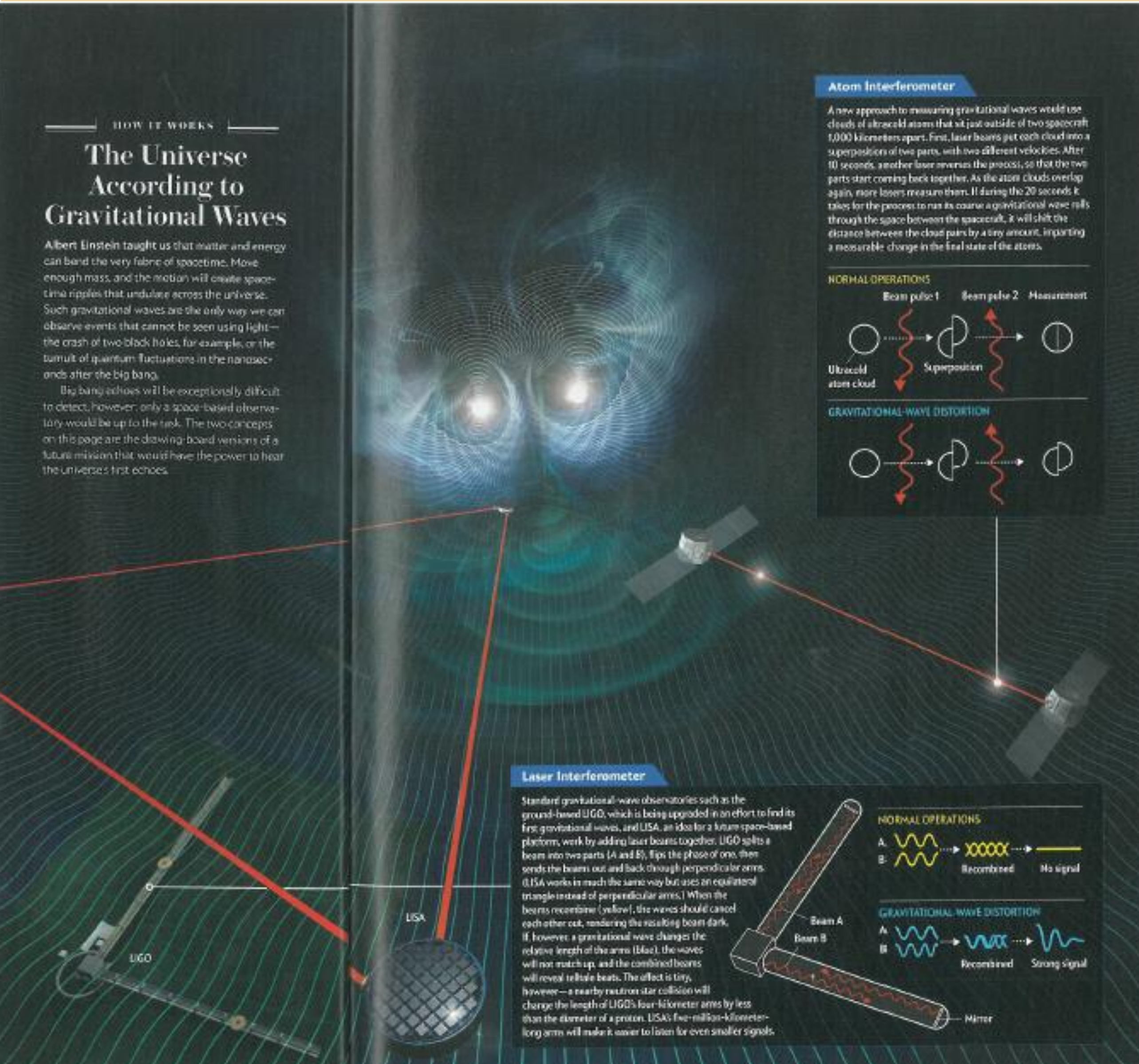
However...

Site can be also located on satellites...

Perhaps also on the South Pole ...

Einstein Telescope:
R+D+I possibility nearby, too…

LISA: satellite system, an „ear"
To listen to the Big Bang



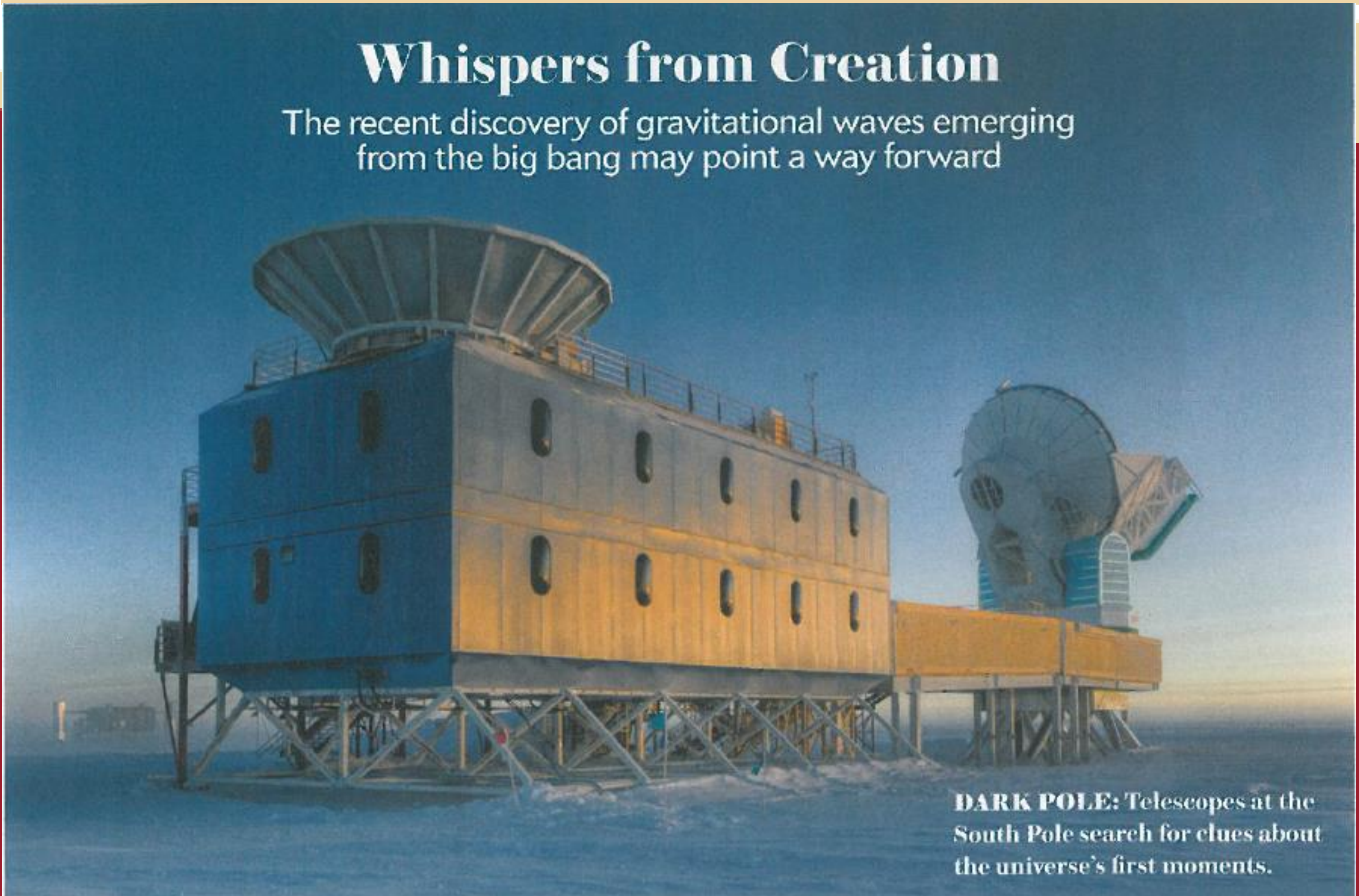
Length scales: 5 million km equilateral triangle

Laser or atom interferometer

Design phase (NASA)

Main advantage: sensitivity
Drawback: expensive & far away

BICEP2: On the South Pole
First indirect observation of GW



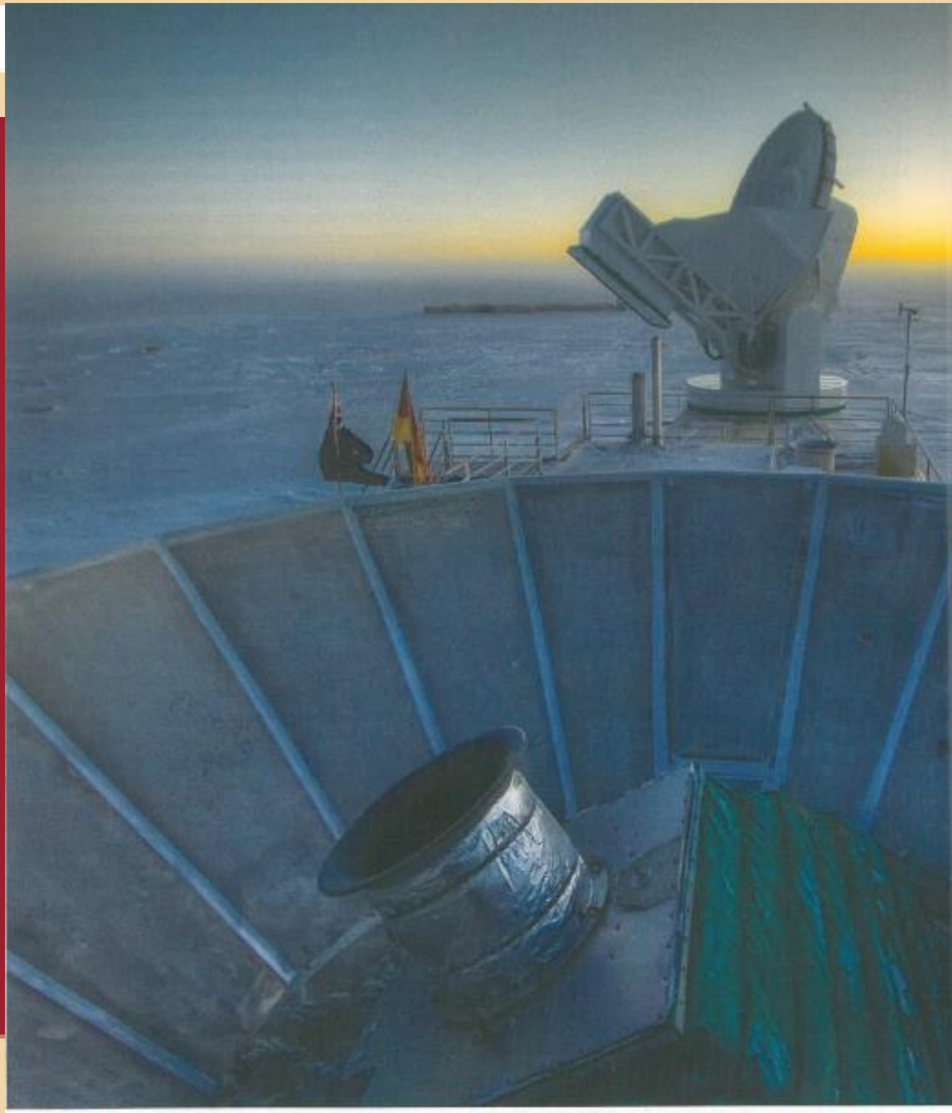
Start of a new era?

Main result:
First indirect observation of Early Universe

Drawback:
Results to be confirmed

1-2 years from now:
Control measurements to be published

BICEP2:
Polarized light: indirect observation



POLAR EYES: The BICEP2 telescope at the Amundsen-Scott South Pole Station observed the same small patch of sky from January 2010 through December 2012, searching for signatures of primordial gravitational waves in ancient light.

Discovery potential:

UNIverse?

Or, possibly, a

MULTIverse, World of Worlds?

Big Bang, or
Big Bangs?

1-2 years from now:
Control measurements to be analyzed

Back to Europe: „GW-Stetoscope" The VIRGO GW detector in Italy

Olaszország, Tuscany, Cascina
2 arms, 3 km each, laser interferometer realized
First generation stage passed, no discovery yet

1-2 years: 2nd generation

Existing GW detectors: LIGO, VIRGO, GEO, Indigo, KAGRA

America, Germany, Italy, India, Japan:
Who will be the first to observe gravitational waves directly?

EU: a chance for Central Europe

Favourable geography nearby

Why the 3rd Generation?

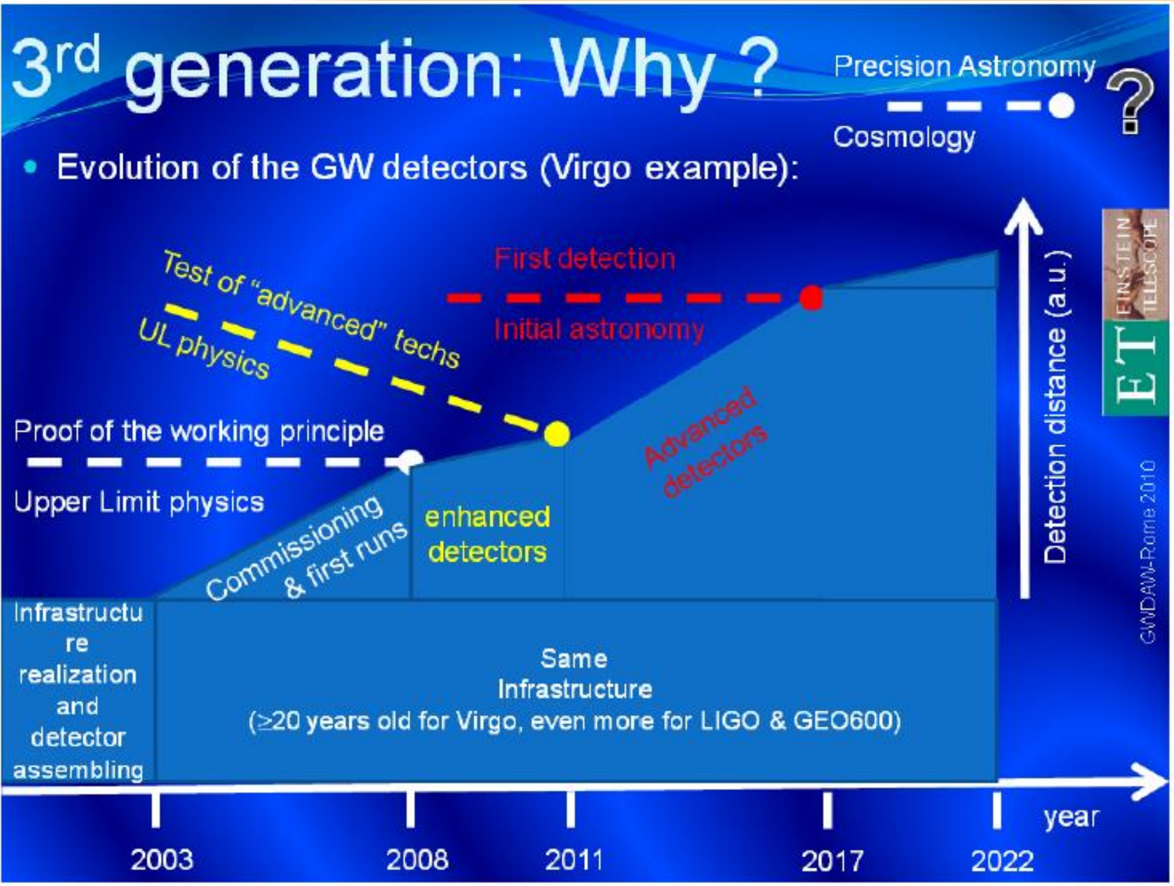


Figure 1: Evolution of the first and second generation GW detectors. Time is on the horizontal axis, detector performance in the vertical one. When the advanced detectors will be operative the hosting infrastructures will be more than 20 years old and any further improvement of performance (sensitivity) will be suppressed by the limitation imposed by the infrastructures. (slide presented by M. Punturo at the GWDAW meeting, Rome Jan. 2010).

First generation:
Goal: test of operation (worked)

Second generation
Goal: direct observation, discovery

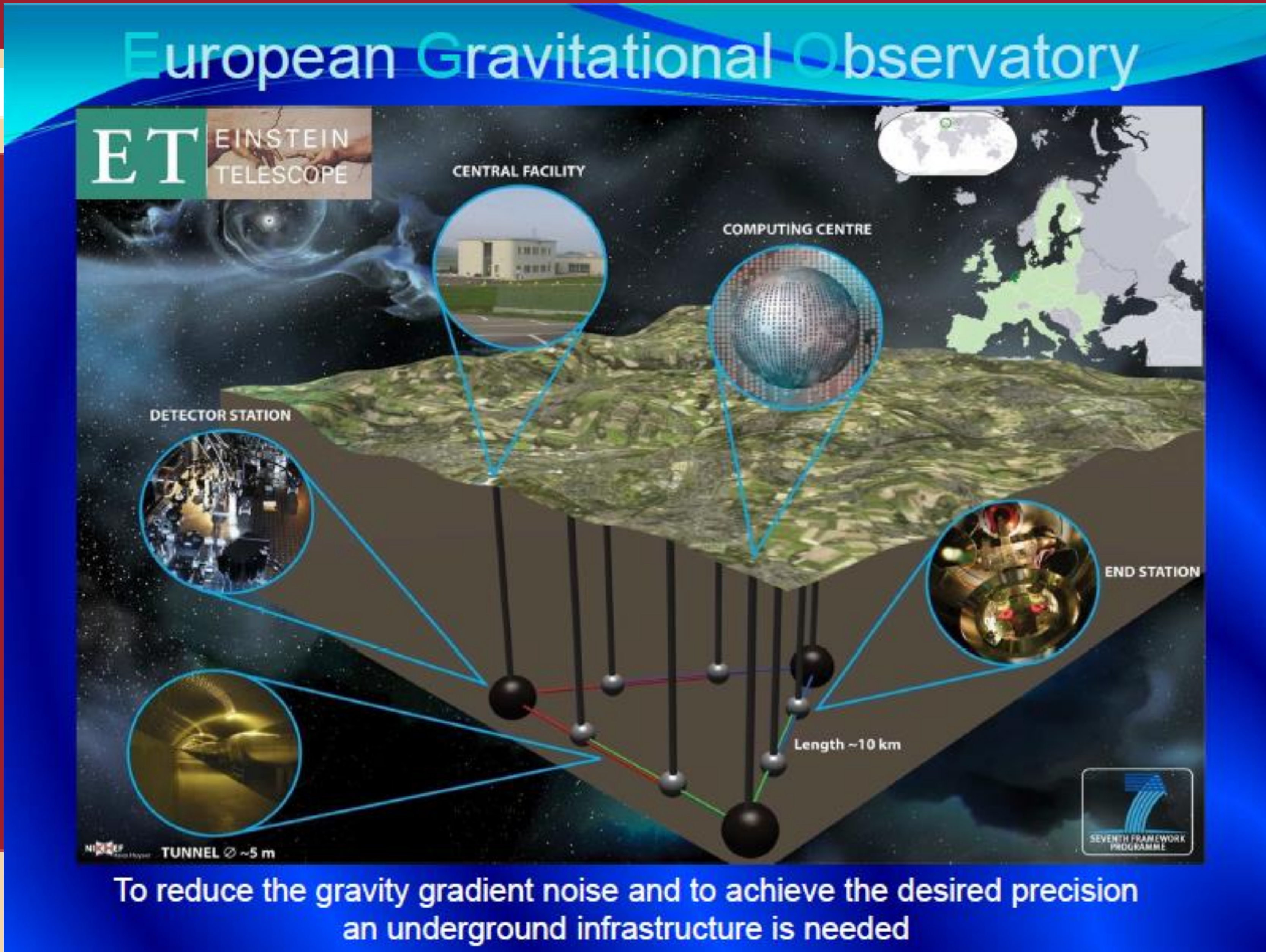
Very precise detectors are needed to study some of the basic questions, e.g.

How boils the Quark Gluon Plasma in the Early Universe?

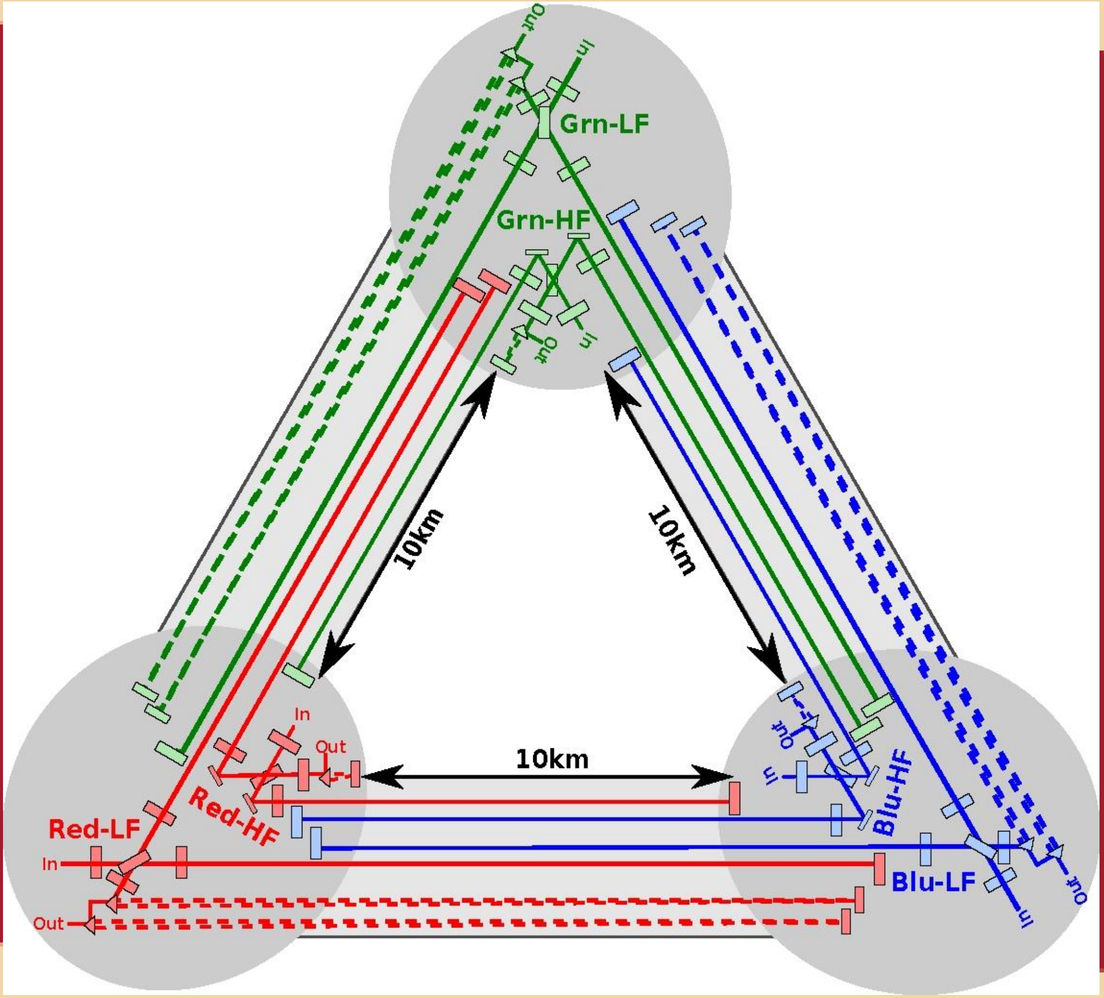
1 -> 2 -> 3rd generation of detectors

Einstein Telescope: site selection in progress

EGO and the ET project



Technical details



VIRGO: 3 km + 3 km
LIGO: 2x(4 km + 4 km)

ET: 10 km x 10 km x 10 km

2nd generation:
Few events / 10 years

3rd generation:
Few hundreds of events / year

For example, collisions of
Black holes

ET: site selection in progress
Shortlisted:
Corsica (France)
Pirennians (Spain)
Mátra hills (Hungary)

A possilibity for top level V4 collaboration for
Visegrad counties
(Czech R., Hungary, Poland, Slovakia)

ET project, roadmap

The usual steps of constructing a research infrastructure

- **Preparatory Phase – A 2008–11**

  Conceptual Design Study
  (Published on 20 May 2011, Cascina, Italy)
  Funded by EC FP7 by 3 M€

- **Preparatory Phase – B 2012–16**

  Aspera, Elites, GraWIToN

- 3rd ASPERA common call:
  The project officially started May 2013 and lasts for three years
  Essential R&D tasks in preparation for a technical design phase
  Funded by Aspera 1.2M€

- Elites: for 4 years, March 2012 – February 2016
  Focused on the common aspects of KAGRA and ET

- GraWIToN is a FP7 ITN (Initial Training Network)
  Starts February 2014 for 4 years, Funded by EC with ~ 3.7M€

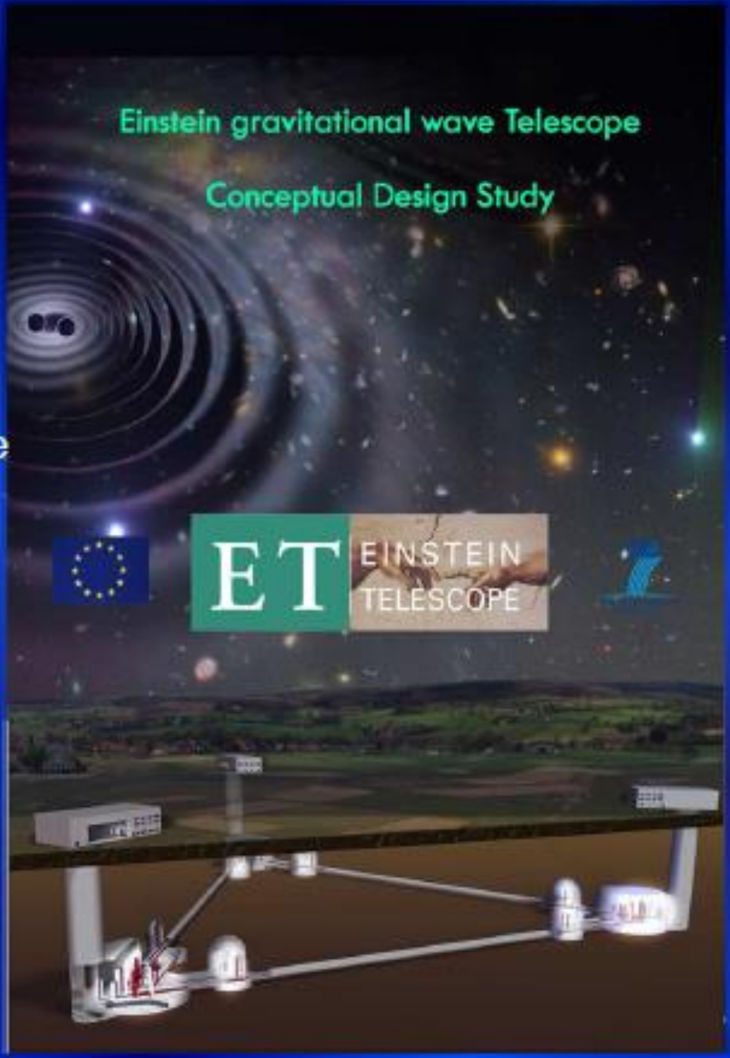
- **Implementation Phase 2017–21**

  Supporting funds ??? and licenses

  The ESFRI list is going to be refreshed: 2016-17
  ET is an excellent candidate but feasibility report will require guaranties from involved States

- **Construction Phase 2022–26 (???)**

  We have to be prepared in time!



http://www.et-gw.eu

ET R&D Participants

Participants	Country	Legal Entity Name	Department/Division/laboratory
Full Partners	Netherlands	NIKHEF: National Institute for subatomic Physics	
	Germany	LUH-AEI: Leibniz Universität Hannover, Albert Einstein Institut	Institut für Gravitationsphysik
		FSU: Friedrich-Schiller-Universität Jena	Institut für Festkörperphysik
	Russia	The Russian ET Consortium	MSU-SAI: Moscow State University, Sternberg Astronomical Institute (lead) MSU-PD: Moscow State University, Physics Department INR RAS: Institute of Nuclear Research Russian Academy of Science
	Poland	The Polish ET Consortium	University of Warsaw (lead), University of Zielona Gora, University of Bialystok, Warsaw University of Technology, Polish Academy of Science (Inst. of Mathematics), Polish Academy of Science (Nicolaus Copernicus Astronomical Centre)
	United Kingdom	UNIBHAM: Birmingham University	School of Physics and Astronomy
		UNIGLASGOW: University of Glasgow	Institute for Gravitational Research
		UNICARDIFF: Cardiff University	School of Physics and Astronomy
		UWS: University of the West of Scotland	

Participants	Country	Legal Entity Name	Department/Division/laboratory	Scientist in Charge
Associated Partners	Italy	EGO: European Gravitational Observatory		M. Punturo
		UNIROMA1: University di Roma La Sapienza	Dipartimento di Fisica	F. Ricci
		INFN Napoli		F. Barone
		INFN Pisa		C. Bradaschia
	France	LMA: Centre national de la recherche scientifique	LMA Lyon	R. Flaminio
		ARTEMIS : Observatoire de la Côte d'Azur, Nice		T. Regimbau
	Hungary	RMKI: Hungarian Academy of Sciences	KFKI Research Institute for Particle and Nuclear Science	I. Racz (KFKI)
			Geodetic and Geophysical Research Institute	G. Papp (Geophys.)
	Russia	BNO RAS: Russian Academy of Science	Baksan Neutrino Observatory INR	V. V. Kuzminov

Poland: full member, participants from Warsaw
Hungary: associated member
Participation in Hungary: to be increased (Miskolc University, KRF)

ET plans for implementation

The implementation phase could be financed by Horizon 2020 framework.

HORIZON 2020 – WORK PROGRAMME 2014-2015
European research infrastructures (including e-Infrastructures)

"**Integrating gravitational wave research.** This activity aims at integrating the communities of researchers studying gravitational waves and their astrophysical sources: both laser and atom interferometers with their extreme technological requirements; observations of gravitational-wave sources through electromagnetic waves and high-energy particles; numerical/theoretical studies of such sources. It should address also the computing and data handling needs of these communities."

The EU – GW community, preparing a joint proposal

- Expected amount of € per project:
  - In FP7, 9-10M€
  - In H2020, ? (rumors 8M€)

The community:

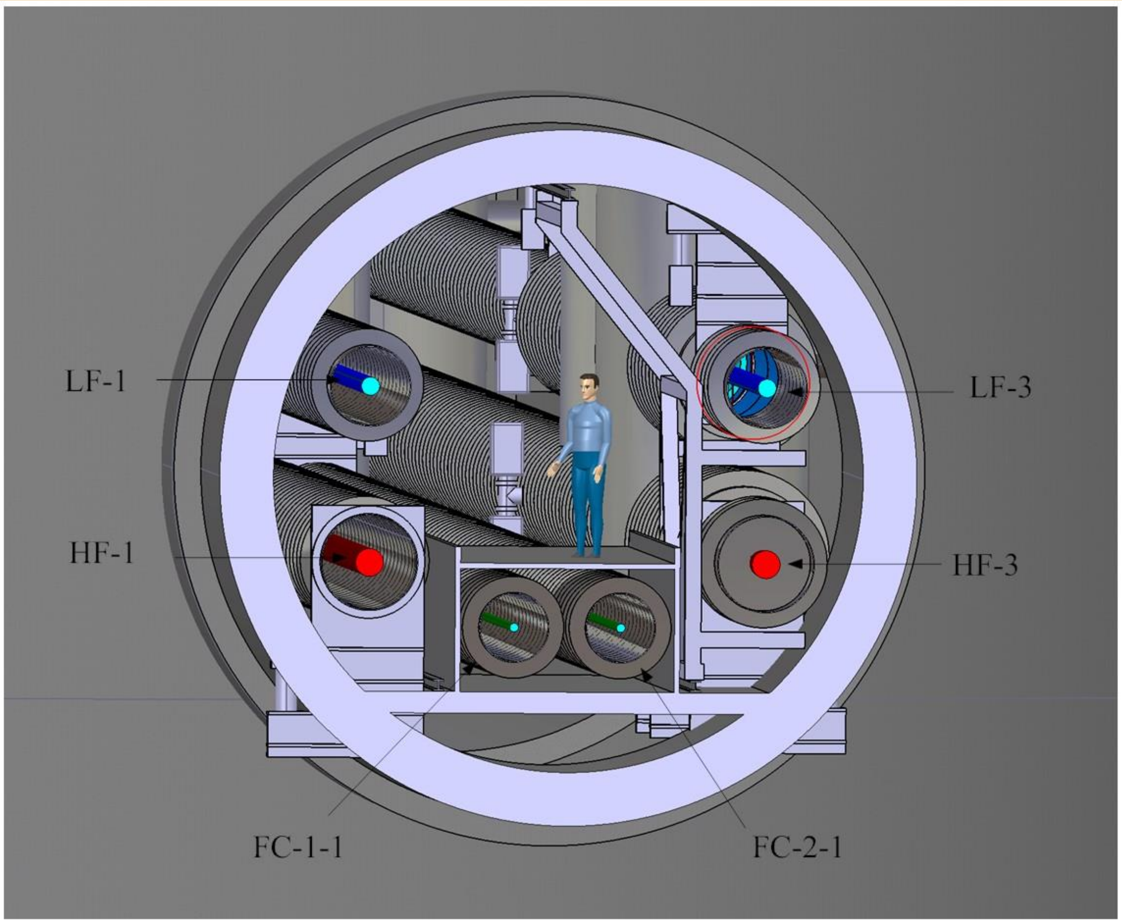
- EGO – European Gravitational Observatory: VIRGO detector, INFN & CNCR
- AEI – Albert Einstein Institute, Hanover: GEO600
- NIKHEF – National Institute for subatomic Physics, Amsterdam
- UNIGLASGOW – University of Glasgow
- UNICARDIFF – Cardiff University
- FSU – Friedrich-Schiller-Universität Jena
- POLGRAW – Polish Academy of Sciences (12 – 15)
- WIGNER RCP (since 2009) – Hungarian Academy of Sciences
  - (8 – 10) → HUNGRAW to increase our contribution

Germany
Netherlands
Russia
Poland
United Kingdom
Italy
France
Hungary

(250 – 300)

Local S3 projects:
Eger, Gyöngyös, Hatvan Regions (Mátra region) site support confirmed
ET: Hungarian S3 project for regional development

SUMMARY



ET: Einstein Telescope

Instead of looking for light
Listening to gravitational waves from the early Universe

Biggest possible discovery:

Universe?

Or, possibly

MULTIverse, Word of Worlds?

Big Bang, or Big Bangs?

Promise:

completion of Copernican idea, in the broadest possible sense

SUMMARY: ET for V4