



LABORATORIO  
DEL  
SILENZIO





# IL LABORATORIO DEL SILENZIO

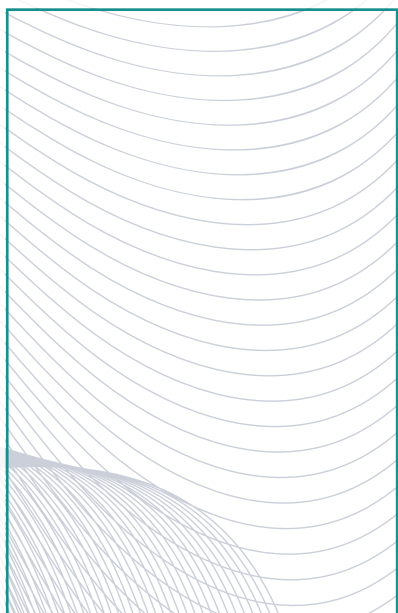
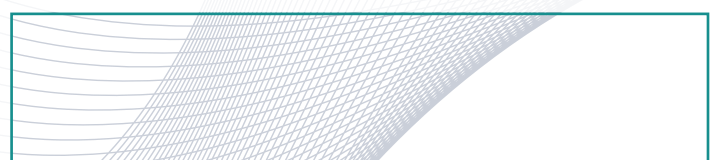
## LdS

### Listening to the cosmos, the environment and people

Laboratorio del Silenzio will be a research and public engagement hub with two closely connected and communicating goals:

A laboratory for fundamental research and technological development accompanying the gravitational-wave scientific revolution and, at the same time, monitoring and studying the environment.

A public engagement centre for frontier science, developing practices of inclusion through education to a multi-sensorial exploration of reality, imagining new forms of communication between art and science, stimulating critical thinking.



### A multi-sensorial understanding of the cosmos

The so-called Multi Messenger Astronomy explores the cosmos through the study of signals other than light and electromagnetic waves, such as gravitational waves, cosmic rays and neutrinos. The data from these cosmic signals, as well as those from the environmental background, can be analysed with acoustic and vibrational representations, beyond the visual ones historically established, with a sort of multi-sensorial approach.

A multi-sensorial analysis of data naturally leads to the inclusion of people with disabilities, who often have heightened perceptive abilities. This amplifies our ability to perceive and analyse, multiplying and enriching the ways in which we separate signals from background noise and, ultimately, increasing the scientific and technological potential of humanity.







# LISTENING TO THE ENVIRONMENT



Gravitational waves in large interferometers, such as Virgo, generate extremely faint signals, which can easily be lost in the multitude of vibrations and acoustic and electromagnetic waves that are generated by atmospheric and seismic phenomena, human activities and even the waves of the sea as they break along the coast. In order to shield the detector as much as possible and to isolate gravitational signals from environmental noise, it is necessary to identify and measure these noises with extreme precision.

This noise hunting turns the detector and the environmental sensors surrounding it (over 1000 for Virgo) into an extraordinary ear, listening not only to the cosmos, but also to the environment, with extremely

valuable applications for environmental monitoring, such as the one of seismic and atmospheric phenomena or climate change.

## Signal and noise

Identifying gravitational signals, isolating them from background noise, is a crucial and extremely complex task: really like looking for a needle in a haystack.

LdS research will develop advanced software instruments for the analysis of experimental data, with different methods of sensorial representation and through the employment of a combination of human-perception practices and automated-learning methods.

Neurobiological and epigenetic studies will explore internal representation of the senses, including the experience of music, and the emotional and artistic aspects of our space-time perceptions.

Furthermore, the measurements and methods developed can have a positive impact on the study of noise pollution and the design of new instruments in the fields of health and economy.

*On the right* - One of the Virgo arms - © Massimo D'Andrea / EGO.







# CUTTING-EDGE TECHNOLOGIES AND DATA INTELLIGENCE



Many advanced monitoring tools were developed for so-called noise hunting, developing maps of environmental background at different frequencies and distances.

This requires autonomous distributed grids of sensors (Industry 4.0), detectors for early seismic warning, robotic grids, fibre-distributed acoustic sensors (FDAS), cosmic-ray sensors and new GPS networks. These sensors are crucial to the study of sound, infrasound and vibrations, as well as of pressure differences and electromagnetic waves.


The need to go beyond traditional limits of quantum measurements, make some

of the technologies of the interferometer relevant to the development of new quantum sensors and computing and to the so-called “second quantum revolution”

To guarantee almost real-time access to gravitational-wave data to a global community of scientists, it is necessary to be able to process a large volume of rapidly evolving data. The European Gravitational Observatory is a multi-disciplinary and technological hub with expertise in data science, machine and deep learning for extremely complex data analysis.



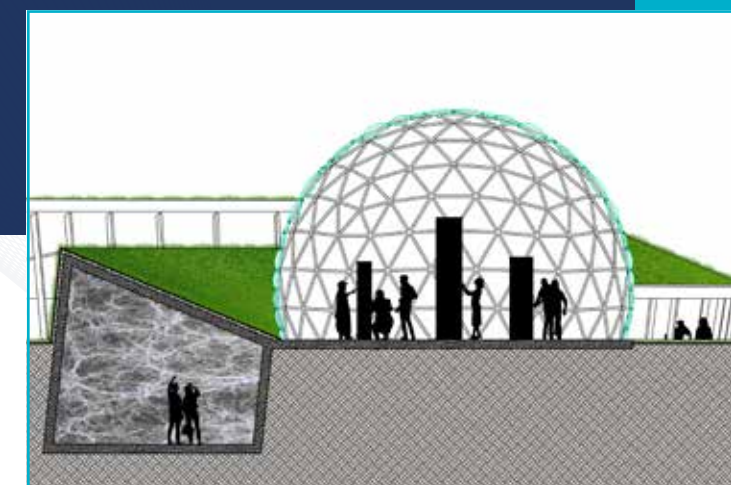
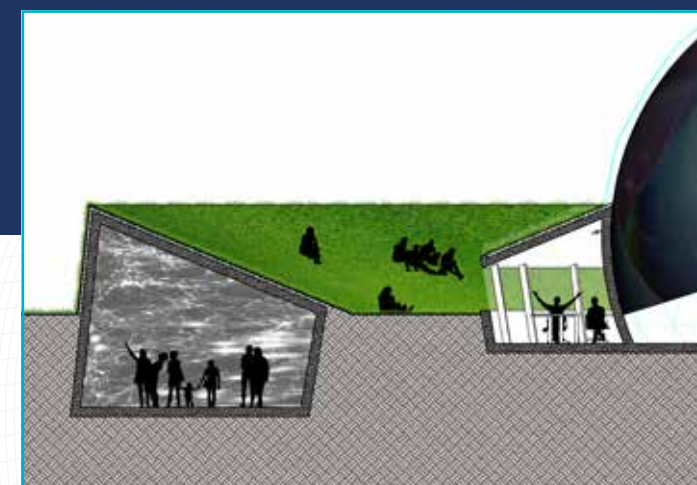
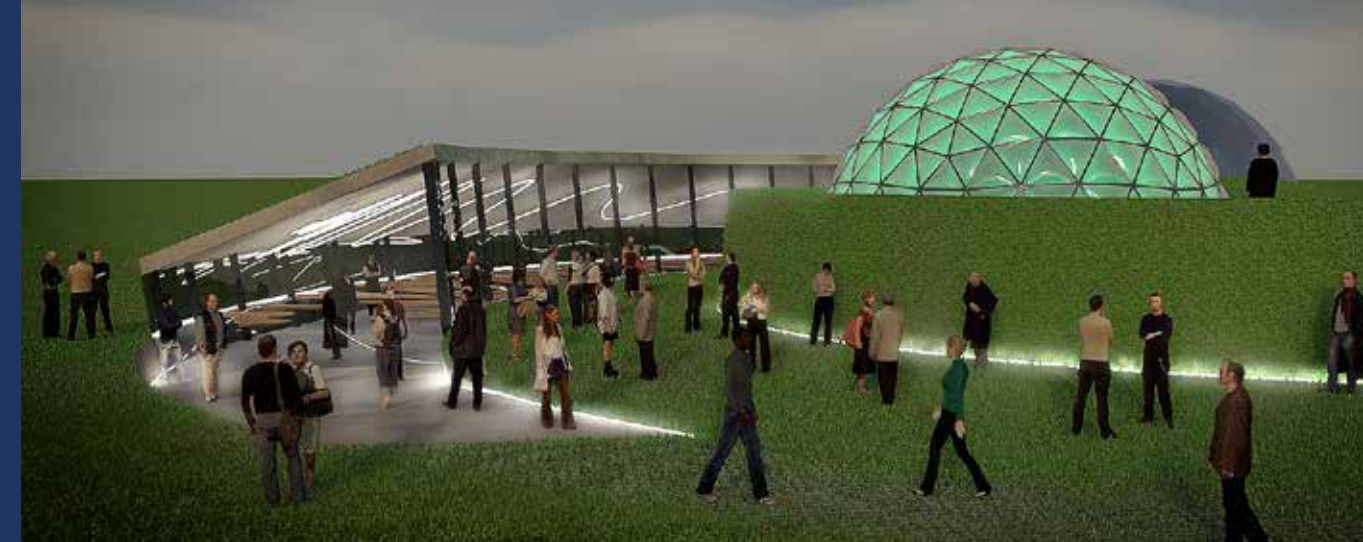
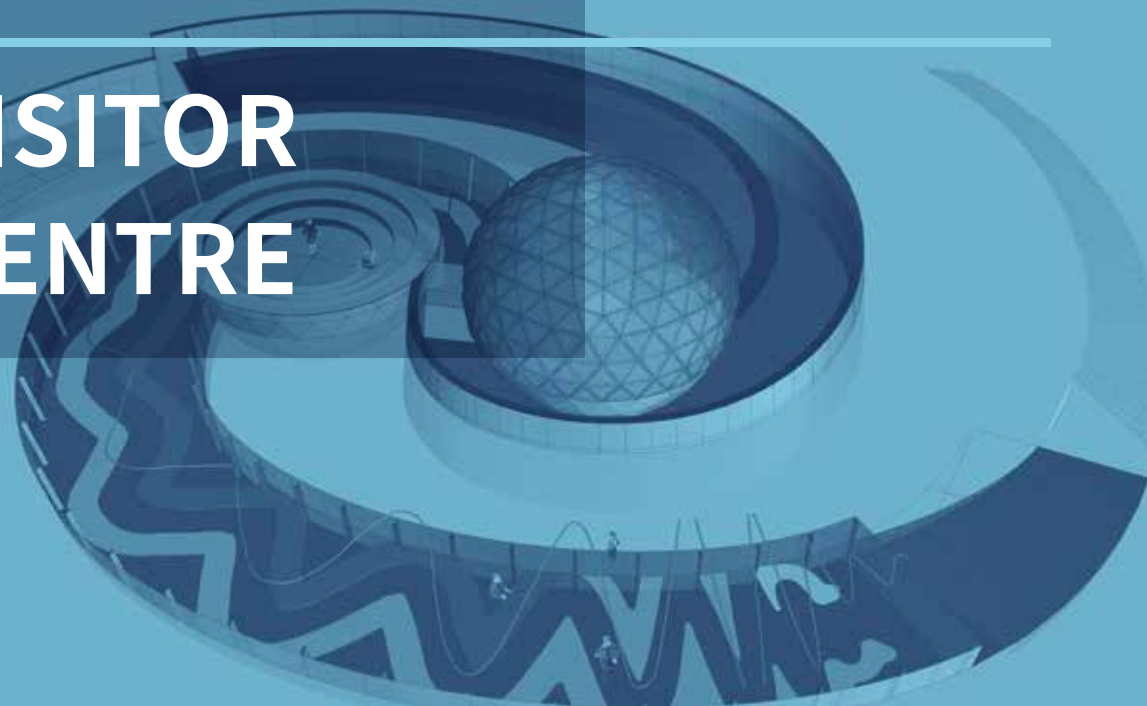
*On the upper right* - Control room of the Virgo experiment - © Massimo D'Andrea / EGO.



*Below on the right* - The image shows the rear-side view of one of the 42 kg mirrors of the detector. A scientist is removing safety locks used during installation - © Maurizio Perciballi / EGO.



# VISITOR CENTRE



The LdS architecture is based on the image of the fusion of two black holes or stars, reconstructed through the gravitational signals detected by Virgo. At the heart of the Laboratorio del Silenzio will be a visitor centre focused on the different ways to listen to the cosmos, with particular focus on the inclusion of people with disabilities.



*On the upper left* - EGO has developed a training programme for teachers in the context of an EU-funded project (ERASMUS+, Frontiers) in collaboration with the Italian National Coordinator of Digital Education - © Massimo D'Andrea/EGO.

*On top* - Visitor Centre Concept Rendering - © Ersi Krouska.

*Below on the right* - EGO welcomes around 10000 visitors every year. During the pandemic months a programme of remote visits was developed - © Massimo D'Andrea / EGO.





# CITIZEN SCIENCE, CRITICAL THINKING, ART AND SCIENCE

EGO coordinates the European Union program REINFORCE, aiming to involve citizens in frontier research, encouraged by the scientific revolution of gravitational waves and Multi Messenger Astronomy, and is particularly focused on data 'sonification'. Citizens are accompanied in this process through participatory initiatives, meetings and collective brainstorming with experts.

Engagement with scientific practice brings forward elements of critical thinking: planning and decision-making, management of biases and uncertainty, trust in experimentation, group thinking as an antidote to herd thinking. Skills that are even more necessary in times of media inflation and digital connectivity.

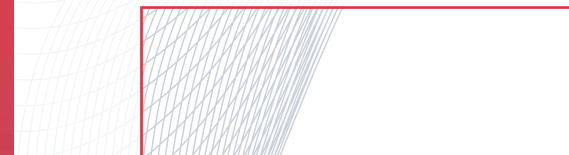
Finding new ways of expression and communication between the emotional and cognitive spheres and between Art and Science is at the heart of another one of the research programs of LdS.



*On top* - The installation *Algo-r(h)i(y)thms* by Tomas Saraceno, in interaction with the neighbouring multi-messenger room, curated by EGO is part of the exhibition "On Air" at Palais de Tokyo in Paris. It creates a sonic/vibrational landscape with synesthetic modes of perception.

*On the right* - EGO curated and co-organised the exhibition "The Rythm of Space" at Museo della Grafica in Pisa (2019) - An artwork by Letizia Reuss De Maigret.

*On the left* - A programme of research and citizen science, led by visually-impaired astronomer Wanda Diaz-Merced, is centred on 'data sonification' with the contribution of citizens in this process.





# THE EUROPEAN GRAVITATIONAL OBSERVATORY – EGO

EGO - the European Gravitational Observatory is the home of Virgo, one of the three largest and most sensitive gravitational wave detectors in the world, along with the two LIGOs in the USA.

Virgo is a large interferometer, located in the countryside near Pisa, in Cascina, with two perpendicular 3km long arms, in which two laser beams propagate in ultra-high vacuum tubes. When a gravitational wave passes through the detector the arm lengths vary by less than one thousandth of the diameter of a proton: an infinitesimal variation that this extraordinary experiment can measure and isolate from all of the perturbations that occur due to the environment and human activity.

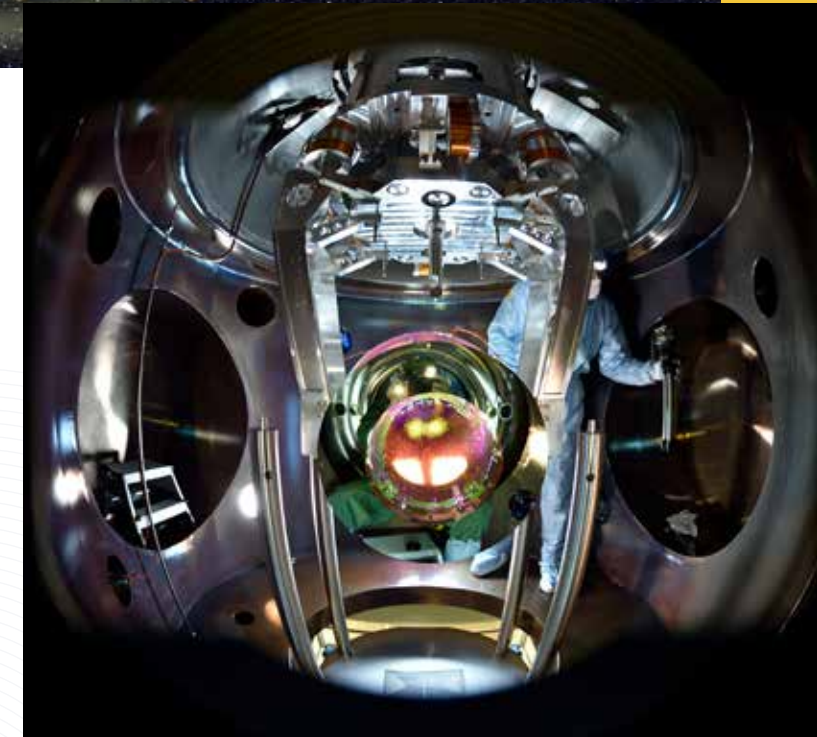
The detection of gravitational waves opened a new era in human observation of the cosmos, allowing us to study cosmic phenomena millions or billions of light years away from Earth: a revolution of knowledge comparable to that made possible by Galileo when he pointed his telescope to the sky.

*On the upper right* - Gravitational waves are generated by violent cosmic events, such as mergers of black holes or stars millions or billions light years away from Earth - © Alain R.

*Below on the right* - Installation of one of the Virgo mirrors in the seismic superattenuator - © Maurizio Perciballi / EGO.

The cutting-edge technology developed for Virgo has promising applications in various fields: from the study of the environment, climate change and seismic phenomena to artificial intelligence.

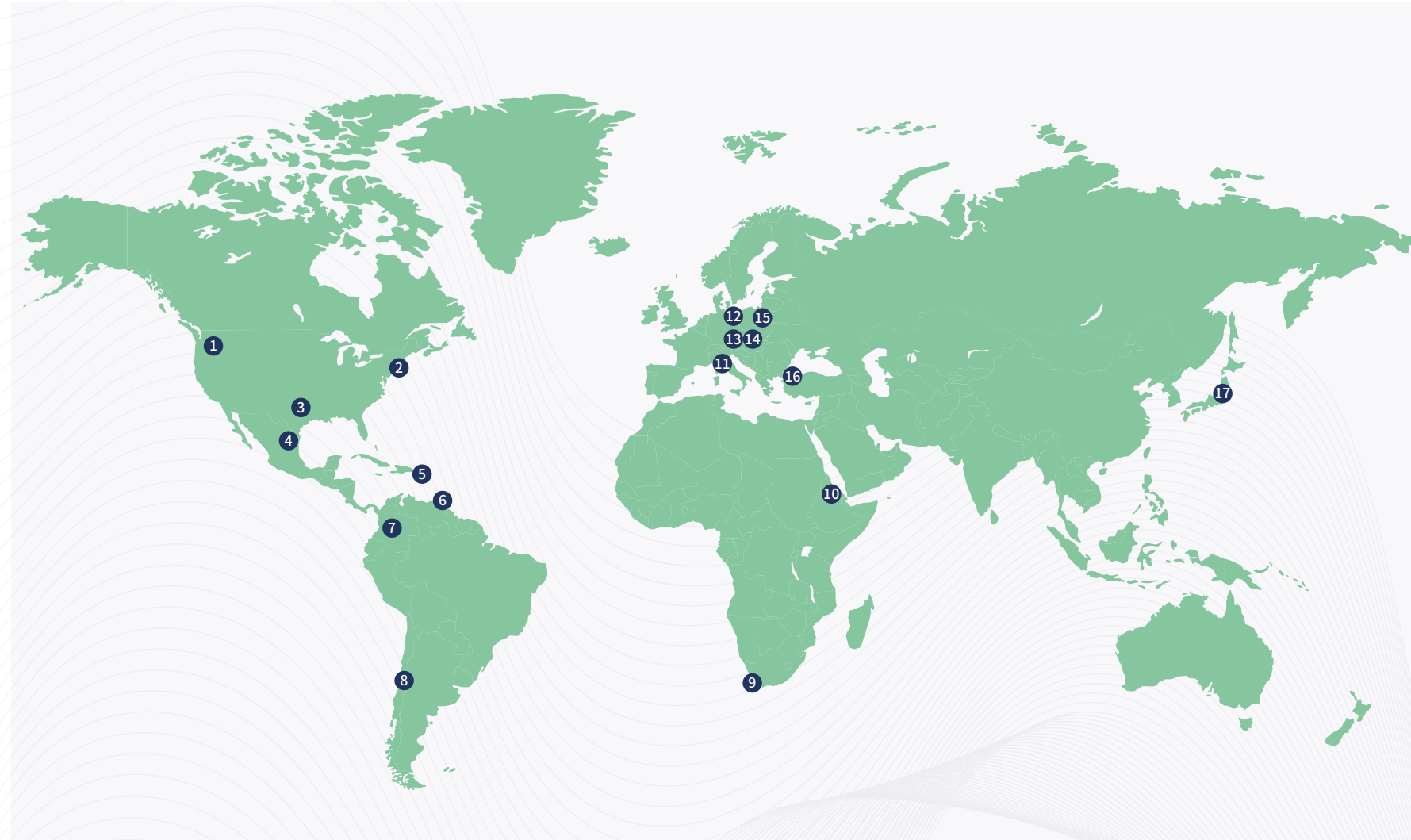
Virgo is operated by an international scientific collaboration involving 109 institutes from 13 countries. EGO, the European Gravitational Observatory, was founded in 2000 by the Italian Istituto Nazionale di Fisica Nucleare (INFN) and the French Centre National de la Recherche Scientifique (CNRS), joined in 2020 by the Dutch research institute NIKHEF.





# COLLABORATING ECOSYSTEM

1. LIGO Hanford, Richland, Washington (USA)
2. Perkins School for the Blind, Watertown, Massachusetts (USA)
3. ArtSci Lab UT, Dallas, Texas (USA)
4. Centro de Estudios Discapacidad, Monterrey, Mexico
5. Shirohisa Ikeda Project, San Juan, Porto Rico
6. Ciencia para la inclusion, Bogotá, Colombia
7. Astronomia Inclusiva, Santiago, Chile
8. W.I.S.H (Women In Science for Hope) Foundation, Trinidad e Tobago



9. Athlone School for the Blind, Città del Capo, Sudafrica
10. Mekelle University, Mekelle, Etiopia
11. EGO-VIRGO, Pisa, Italia
12. Studio Tomàs Saraceno, Berlino, Germania
13. United Nations Office for Outer Space Affairs (UNOOSA), Vienna, Austria
14. Hilfsgemeinschaft der Blinden und Sehschwachen Österreichs, Vienna, Austria
15. Polish Association of the Blind, Varsavia, Polonia
16. Association of Barrier-Free Access, Istanbul, Turchia
17. Fukushima prefecture school for the Visually Impaired, Fukushima, Giappone



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