What is GLORIA?

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GLORIA Community Open Day, Bologna, 15 Maggio 2014

On behalf of the GLORIA collaboration

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44 people, **14** institutions, **8** countries

Outline

1. Robotic Astronomical Observatories

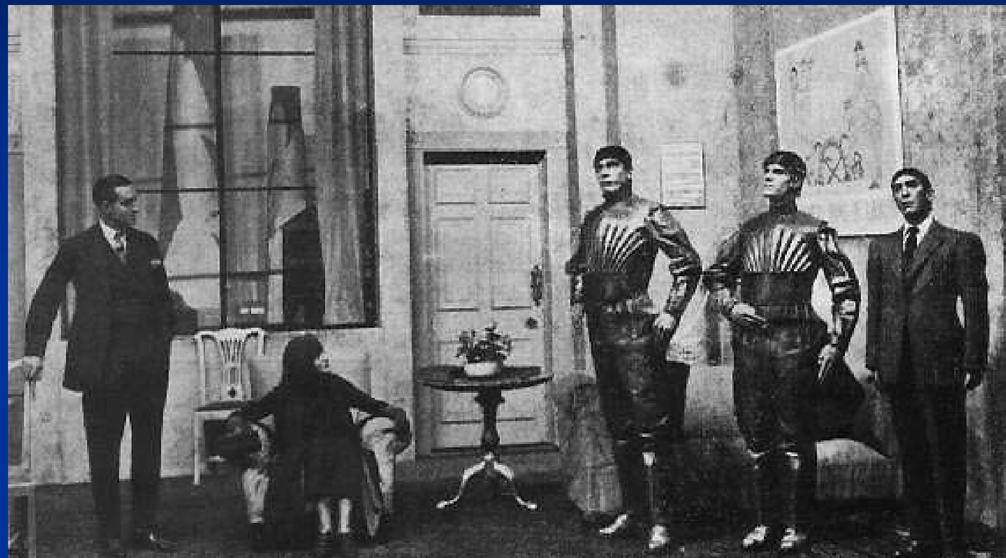
2. RAOs: a brief history

3. The GLORIA Project

4. Conclusions

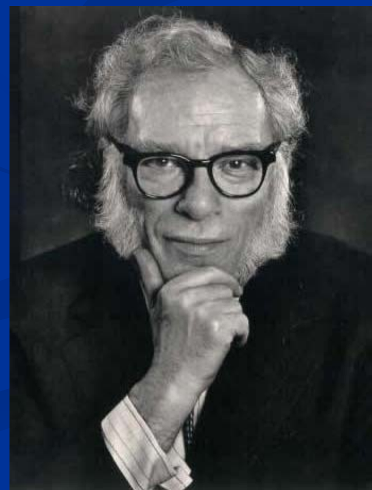
1. Robotic Astronomical Observatories (I)

Who coined the word "robot" ?



The word robot was coined in 1921 by the Czech writer Karel Ĉapel (1890-1938) in his play "Rosum's Universal Robots" (R.U.R.) in which three robots were despited. The new word was suggested by his brother Josef Ĉapel (cubist painter).

Isaac Asimov (1920-1992) coined in 1941 the word Robotics in his play "Liar!": as the branch of the science and technology related to "robots": design, manu-facturing and applications.



1. Robotic Astronomical Observatories (II)

(RAOs from now on). Some definitions…

Robot

A mechanical system which executes repetitive tasks with good accuracy with human assistance. Example: Industrial robotic arm.

Teleoperated Robot

A mechanical system which executes a given task with good accuracy and that can be modified with human assistance. Example: Submarine research robots.

Intelligent Robot

A mechanical system which executes a task with good accuracy and is able to adapt itself to changes during the task execution without any kind of human assistance. Example: Rovers devoted to planetary research.

1. Robotic Astronomical Observatories (III)

…applied to Astronomy [as ***agreed on the Málaga 2009 Workshop***]

Automated scheduled telescope (Robot)

A mechanical system which executes repetitive predefined tasks with good accuracy with human assistance. Telescope which performs observation without the astronomer actually moving the mount by hand.

Remotely operated (remote) telescope Robot

A mechanical system which executes a given task with good accuracy and that can be modified with human assistance.

Autonomous Robot (observatory)

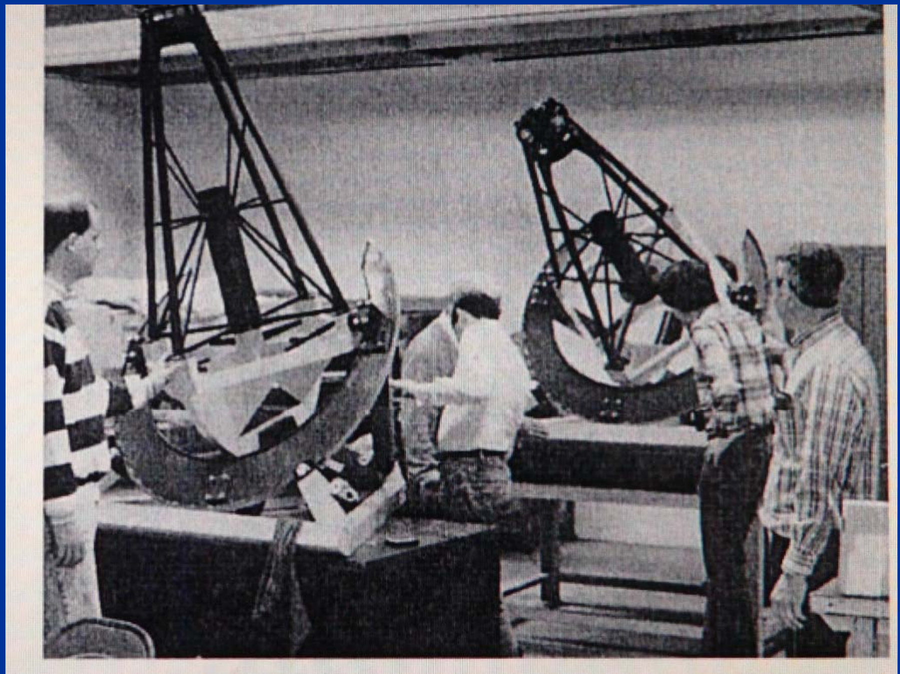
A mechanical system which executes a task with good accuracy and is able to adapt itself to changes during the task execution without any kind of human assistance. Weather control. Must not kill a human !.

2. RAOs: A brief history (I)

First attempts to robotize telescopes were first developed by astronomers after electromechanical interfaces to computers became common at observatories. Computer control is the most powerful technique for research today. But computer systems are inheriently low voltage and are very suspectable to electrical noise. Thus putting electromechanical devices under computer control can be particularly challenging. Early examples were expensive, had limited capabilities, and included a large number of unique subsystems, both in hardware and software. This contributed to a lack of progress in the development of robotic telescopes early in their history.

2. RAOs: A brief history (II)

The first automated telescopes were able to start on a pre-programmed sequence of photometric measurements if the sky was clear. This was the case of the Automated Telescope Photoelectric (APT) service, a computer driven system in Mt. Hopkins (AZ, USA) which knew when the Sun set and checked for rain, snow, etc.

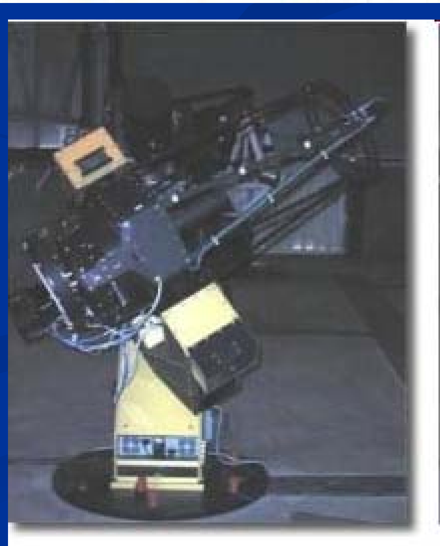


In an ideal world, the computer will report the astronomer on the next morning how beautiful the night was. But we know that us do not leave a telescope unattended for the whole night …

2. RAOs: A brief history (III)

The Bradford Robotic Telescope (UK) was operating in the web since 1993. It's located in England, where the weather isn't optimal, but it accepts requests from anyone (Baruch's talk).

The Perugia University Automated Imaging Telescope (0.4m) in Italy and the University of Iowa Robotic Telescope Facility (0.37m diameter Rigel telescope at Winer Observatory in AZ) joined later (1994). The former was devoted to Blazar and CV monitoring. The second one was devoted to education, is operated primarily by undergraduates, many of whom are involved in independent research projects.



2. RAOs: A brief history (IV)

By the end of the 90's the number of automated telescopes increased with many of the devoted to gamma-ray burst (GRB) follow-up:

GROSCE (1993), LOTIS (1997) and ROTSE (1998): wide-field lens systems (USA)

BOOTES (1998) , 0.2m telescope + wide-field system (Spain)

BART (2000) , 0.2m telescope + wide-field system (Czech Rep)

TAROT (France), RAPTOR (USA), REM (Italy), MASTER (Russia) joined in the early 2000's.

And we should not forget all development by amateur astronomers since 1998.

All these achievements implied a change in the technology (See the book *Unusual telescopes*, by Peter L. Manly). For instance, for wide-field system, fast mount and dew control is most essential. For telescopes, open tube design is desirable: lighter and better stabilization of the temperature (but this requires a large central baffle to prevent straylight), etc.

2. RAOs: A brief history (V)

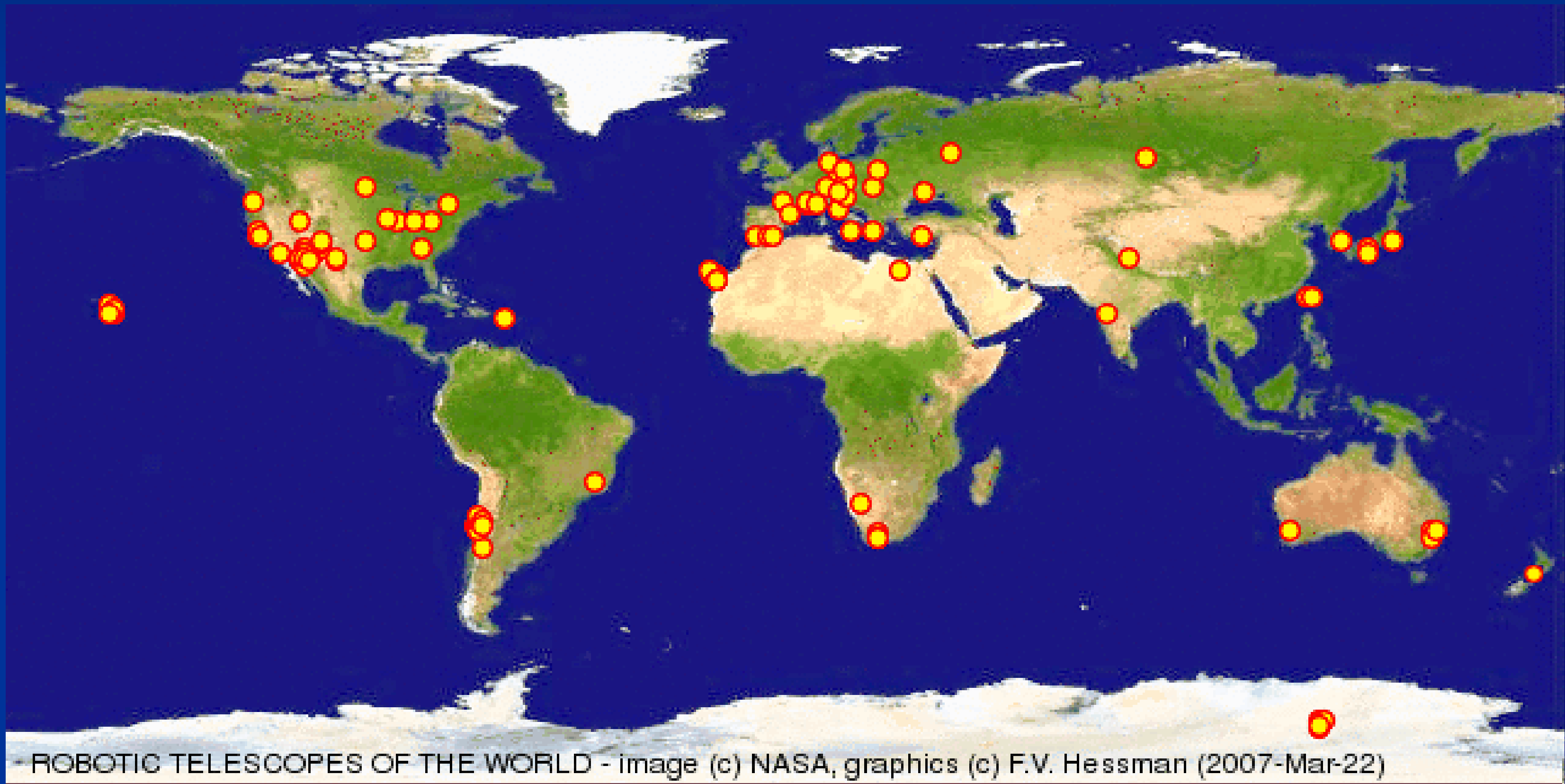
The first robots were the telescopes with an absolute positioning control and guiding systems, and the automatic weather stations, introduced in astronomical observatories.

The first robotic astronomical observatories are those ones which are able to integrate and coordinate the different automatic subsystems at the observatory (telescope, dome, weather stations). But they require human assistance (teleoperation) for the taking of decisions regarding a given task and/or its supervision.

The intelligent robotic astronomical observatories are the following step, where human assistance in the taking of decissions is replaced by an artificial intelligent system. They are being developed nowadays.

3. RAOs: A brief history (VI)

RAOs worldwide: around 100 so far



3. RAOs: a brief history (VII)

RAOs in Europe: around 35

3. RAOs: a brief history (VIII)

Scientific Use (aprox. statistical based on provided info by F. Hessman)

Description	Number of Ref.'s	Percentage
Gamma-Ray Bursts	29	22.3%
Service observations	21	16.2%
Photometric monitoring	14	10.8%
Education	15	11.5%
All-sky surveys	12	9.2%
Exoplanet searches	10	7.7%
Supernovae search	9	6.9%
Asteroids	7	5.4%
Spectroscopy	4	3.1%
Astrometry	4	3.1%
AGN, Quasars	3	2.3%
(Micro-)Lensing	1	0.8%
Other uses	8	6.2%

3. RAOs: a brief history (IX)

Range of apertures (included expected instruments by 2010)

aperture ≤ 0.25m	77	45.3%
0.25 < aperture ≤ 0.50m	37	21.8%
0.50 < aperture ≤ 0.75m	14	8.2%
0.75 < aperture ≤ 1.00m	17	10.0%
1.00 < aperture ≤ 1.25m	7	4.1%
aperture > 1.25m	18	10.6%

3. RAOs: a brief history (X)

Observatory Managers

AUDELA: Developed by A. Klotz et al. (Toulouse), starting in 1995. Open source. Linux/Windows.

ASCOM: Diesigned in 1998, by B. Denny (USA), as a standard interface for astronomical observatories based on model of object componments (under MS), which he dubbed "the Astronomy Common Object Model". Widespread amongts amateur astronomers, but also use amongs profesional astronomers. Windows. Used in SNs y MPs searches.

RTS2: "The Robotic Telescope System version 2", developend by P. Kubánek, (Ondrejov/Granada) and started in 2000. Open source code. Linux (command line and graphical interface). Used in GRBs follow-ups. **rts2.org**

INDI: "The Instrument Neutral Distributed Interface" (INDI) started in 2003. When comparing with the stnadard ASCOM (MS), INDI is an independent protocol plataform developed by E. C. Downey (USA). Open source code but not widely spread due to the lack of upper layer interface.

ACP: Comercial and developed for DC-3 dreams in 2000-13 by R. Denny (USA).

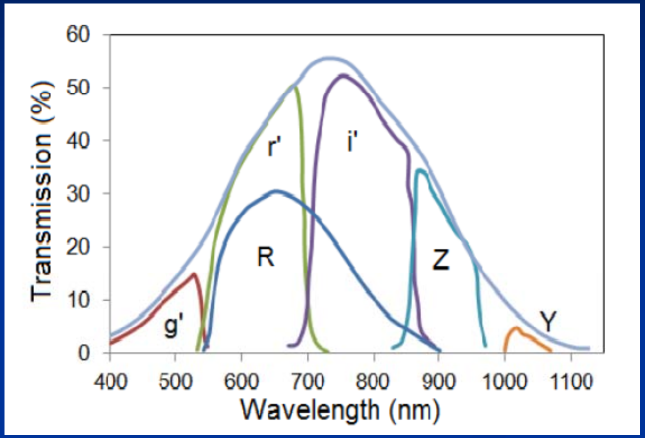
3. RAOs: a brief history (XI)

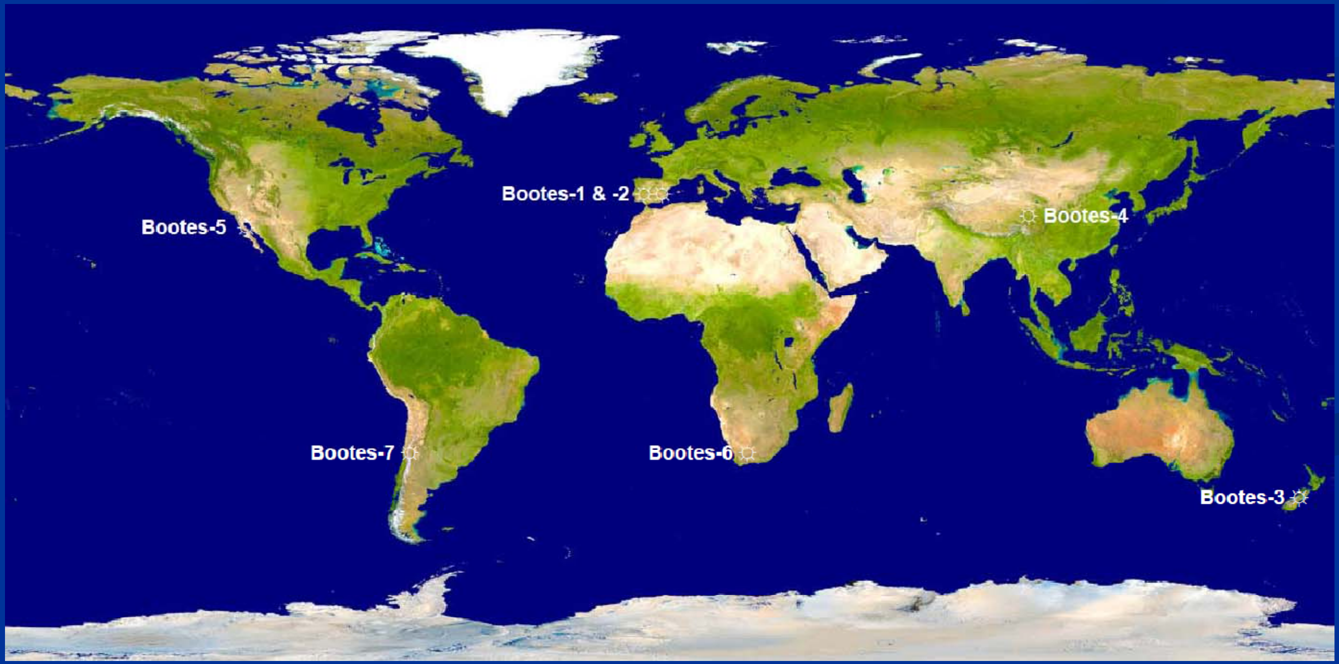
One of such systems using rts2 is BOOTES (Burst Observer and Optical Transient Exploring System)

Identical Ø 0,6m telescopes spaced worldwide

Identical filterset (u')g'r'i'ZY

Identical EMCCD cameras



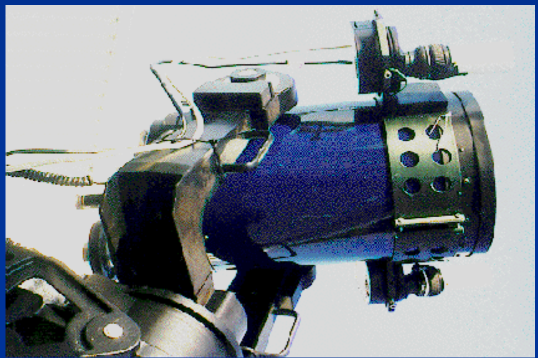


bootes.iaa.es

The BOOTES Network (I)

BOOTES-1 (INTA/CSIC/ASU/CVUT) in El Arenosillo (Huelva).

Jun 1998: 0,3m Ø *Robotic* telescope and wide-field cameras.



1998

Database of images down to I = 13 sicne 1998. The BOOTES-1 site in ESAt is becoming a reference place for wide-field Astronomy.

2000

2009: Spanish Patrol Meteor Network - collaboration with UHU

2013: Pi-of-the-Sky North - collaboration with UWAR (Poland)

The BOOTES Network (II)

BOOTES-2 (INTA/CSIC/UMA/ASU) in Algarrobo-Costa (Málaga)

Nov 2001: 0,3m Ø *Robotic Telescope* and wide-field cameras

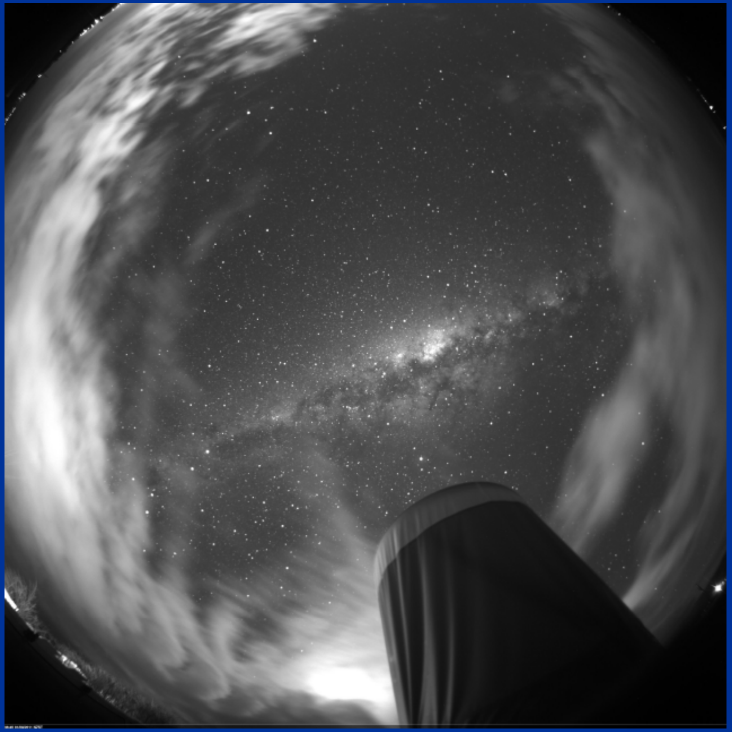
Jun 2008: 0,6m Ø *Robotic Telescope* (TELMA) with v = 100 g/s and a = 10 g/s^2 in imaging mode (g'r'i'ZY filters) and limiting magnitude r' = 20

Nov 2011: COLORES imaging spectrograph

The BOOTES Network (III)

BOOTES-3 (CSIC/UoA) in Blenheim (Nueva Zelanda)

Feb 2009: 0.6m Ø *Robotic telescope* (YA), twin of BOOTES-2 (TELMA), in imaging mode (g'r'i'ZY filters)



3. The GLORIA Project

Is it possible to obtain observing time at the BOOTES-1, -2 and -3 telescopes for anybody unrelated to the BOOTES collaboration?

The answer is YES, thanks to …

FP7-INFRASTRUCTURES-2011-2 (Call 9)

INFRA-2011-1.2.1: e-Science environments

Global Robotic Telescopes Intelligent Array For Citizen Science

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Consejo Superior Investigaciones Científicas

3. The GLORIA Project (II)

GLORIA Partners

POLITÉCNICA	**UPM** Universidad Politécnica de Madrid SPAIN
	ASU-CAS Astronomical Institute, Academy of Sciences of the Czech Republic CZECH REPUBLIC
CSIC	**CSIC** Consejo Superior de Investigaciones Científicas SPAIN
	CTU Czech Technical University in Prague CZECH REPUBLIC
	FZU-CAS Institute of Physics of the Academy of Sciences of the Czech Republic CZECH REPUBLIC
	IAC Instituto de Astrofísica de Canarias SPAIN
	INAF Istituto Nazionale di Astrofisica ITALY
	SAO Special Astrophysical Observatory of Russian Academy of Sciences RUSSIA
	UCD University College Dublin IRELAND
	UCH University of Chile CHILE
	UMA University of Malaga SPAIN
	UOX University of Oxford UNITED KINGDOM
	UWAR Uniwersytet Warszawski POLAND

GLORIA is funded by the European Commission under the 7th Framework Programme

e-infrastructure

SEVENTH FRAMEWORK PROGRAMME

GLORIA is a collaborative web 2.0 based on a robotic telescopes network including *many* telescopes with open access and focused towards the public outreach of Astronomy and Citizen Science.

3. The GLORIA Project (III)

GLORIA is resting onto 4 pillars

Pillar I: the GLORIA goals

Goal 1: To build up a network for astronomical research

3. The GLORIA Project (IV)

Pillar I: the GLORIA goals

Goal 1: …establishing synergies amongst the different "astronomical" communities

3. The GLORIA Project (V)

Pillar I: the GLORIA goals

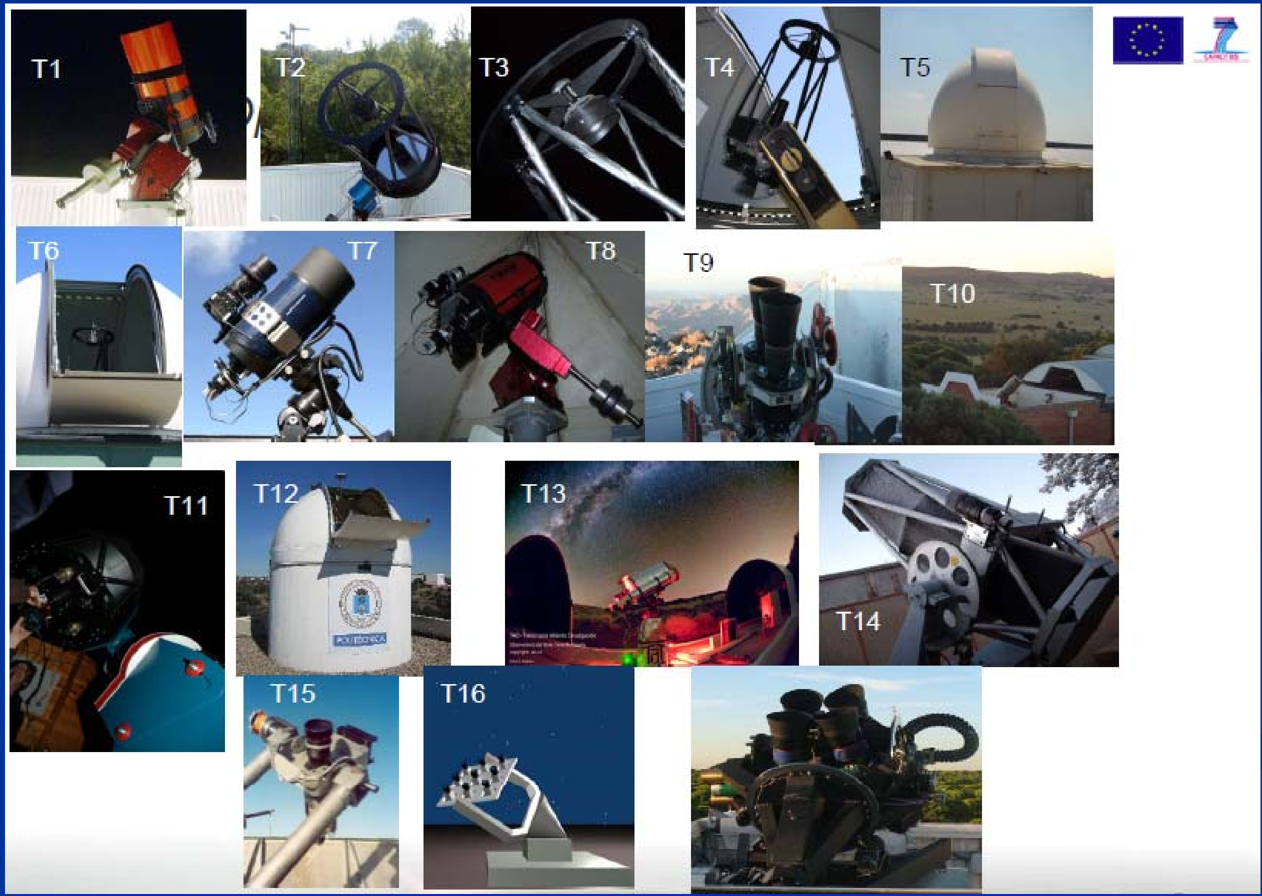
Goal. 1: …and making use of the GLORIA telescopes. Which ones? (I)

Name	Location	Aperture size (m)
BOOTES-1	Andalucia, Spain	0.3
BOOTES-2/TELMA	Andalucia, Spain	0.6
BOOTES-3/Yock-Allen	New Zealand	0.6
CAB-EVA1	Avila, Spain	0.5
CAB-CAHA	Almeria, Spain	0.5
BART	Czech Republic	0.254 & 0.1
FRAM	Argentina	0.3
Pi of the Sky I	Chile	0.07
Pi of the Sky 2	Huelva, Spain	0.07
Watcher	South Africa	0.4
C. Tololo	Chile	0.5
OM	Madrid, Spain	0.25
TAD	Tenerife, Spain	0.26
D50	Czech Republic	0.5
FAVOR	Russia	0.15

3. The GLORIA Project (VI)

Pillar I: the GLORIA goals

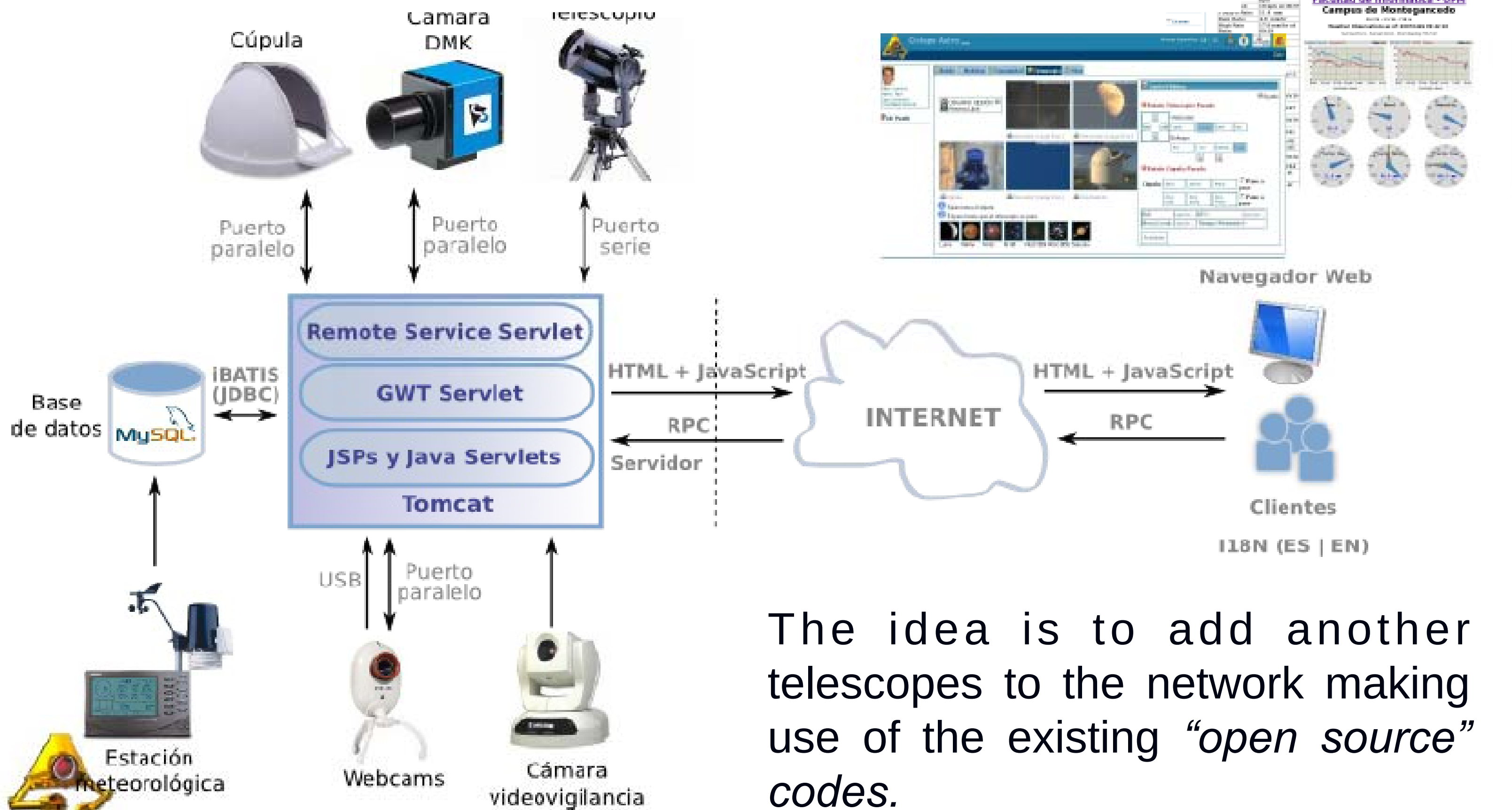
Goal 1: … and making use of the GLORIA telescopes. Which ones? (II)



3. The GLORIA Project (VII)

Pillar I: the GLORIA goals

Goal 2: To increase the number of telescopes in the future



The idea is to add another telescopes to the network making use of the existing *"open source" codes.*

3. The GLORIA Project (VIII)

Pillar I: the GLORIA goals

Goal 3: To research in "citizen Science", allowing users at every level to participate at each level by means of experiments.

"On-line" Experiments (Interactive)

Solar Activity (in real time)
Night observation (in real time)

"Off-line" Experiments

Personal Space (**personal-space.eu**)
Solar Activity (using archival data)
Estrellas Variables (using archival data)
Batch observations (under previous requests)

3. The GLORIA Project (IX)

Pillar II. Infraestructure for e-Science

Comunity of Citizens able to perform scientific activities around GLORIA

Meritocratic methodology: the Karma policy

Collaborative tools to share astronomical information (e.g. the SADIRA database)

Pillar III. Free Software and SW Architecture

Open standards and methodology for interactive ("on-line") experiments and experiments based on queu observations or making use of archive data products (i.e. "off-line" experiments). **souceforge.net**

Public access to astronomical data.

3. The GLORIA Project (X)

Pillar IV. To attract new users

Educational Public Activities.

UCD, November 2013 - Emer O Boyle and Lorraine Hanlon at the 'Spark at the Ark'

CSIC, December 2013, Observing the Sun with GLORIA in Parque de las Ciencias in Granada

IAC, December 2013 - children around the GLORIA planetarium in Tenerife, Canary Islands, more than 9000 visitors

University of Chile – Astrobus (5400 school children, January & March 2014)

3. The GLORIA Project (XI)

Pillar IV. To attract new users (2)

Life broadcast of astronomical events for the general public also focused to schools.

Solar Eclipses: Australia (13 Nov 2012) y Kenia (3 Nov 2013).

Lunar Eclipse (15 Apr 2014)

Venus transit (6 Jun 2012): Noruega, Japan & Australia.

Northern Lights (2012, 2013, 2014)

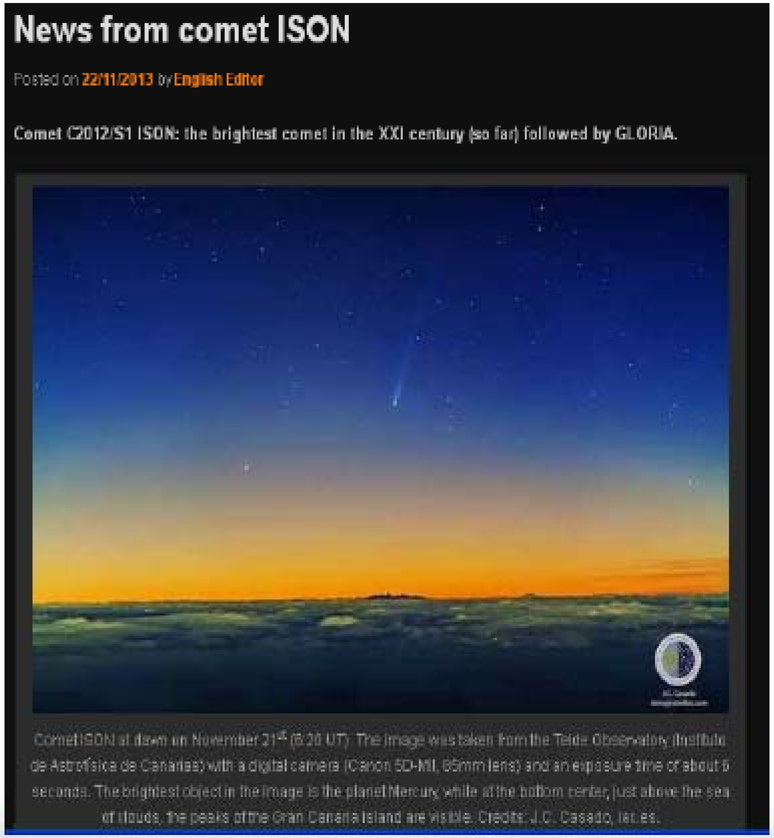
(In collaboration with Shelios (IAC) expeditions)

3. The GLORIA Project (XII)

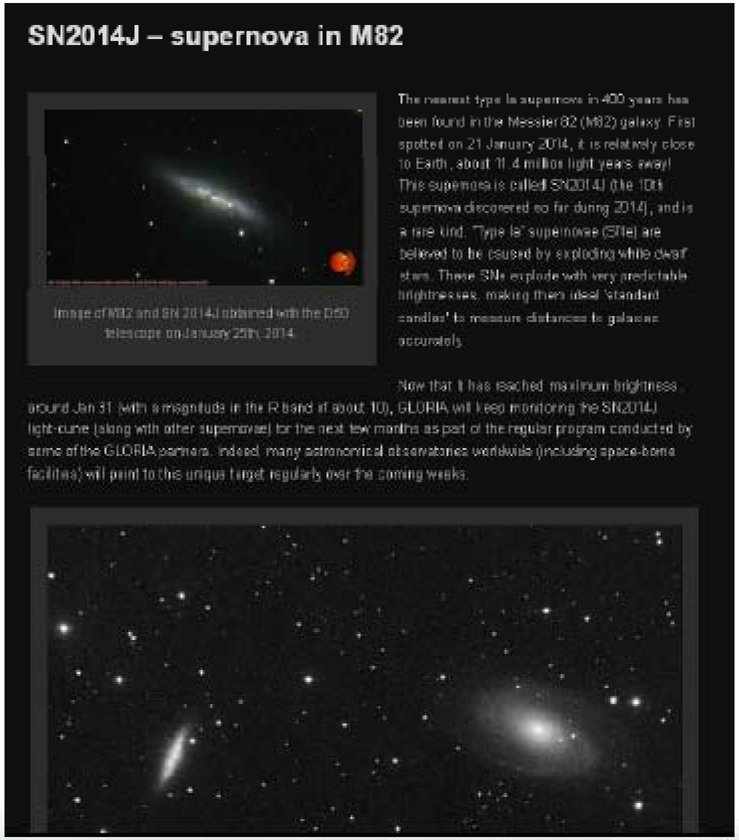
Pillar IV. To attract new users (3)

Participating in worldwide observational campaings.

Comet ISON in late 2013



Supernova SN2014J/M82 in early 2014

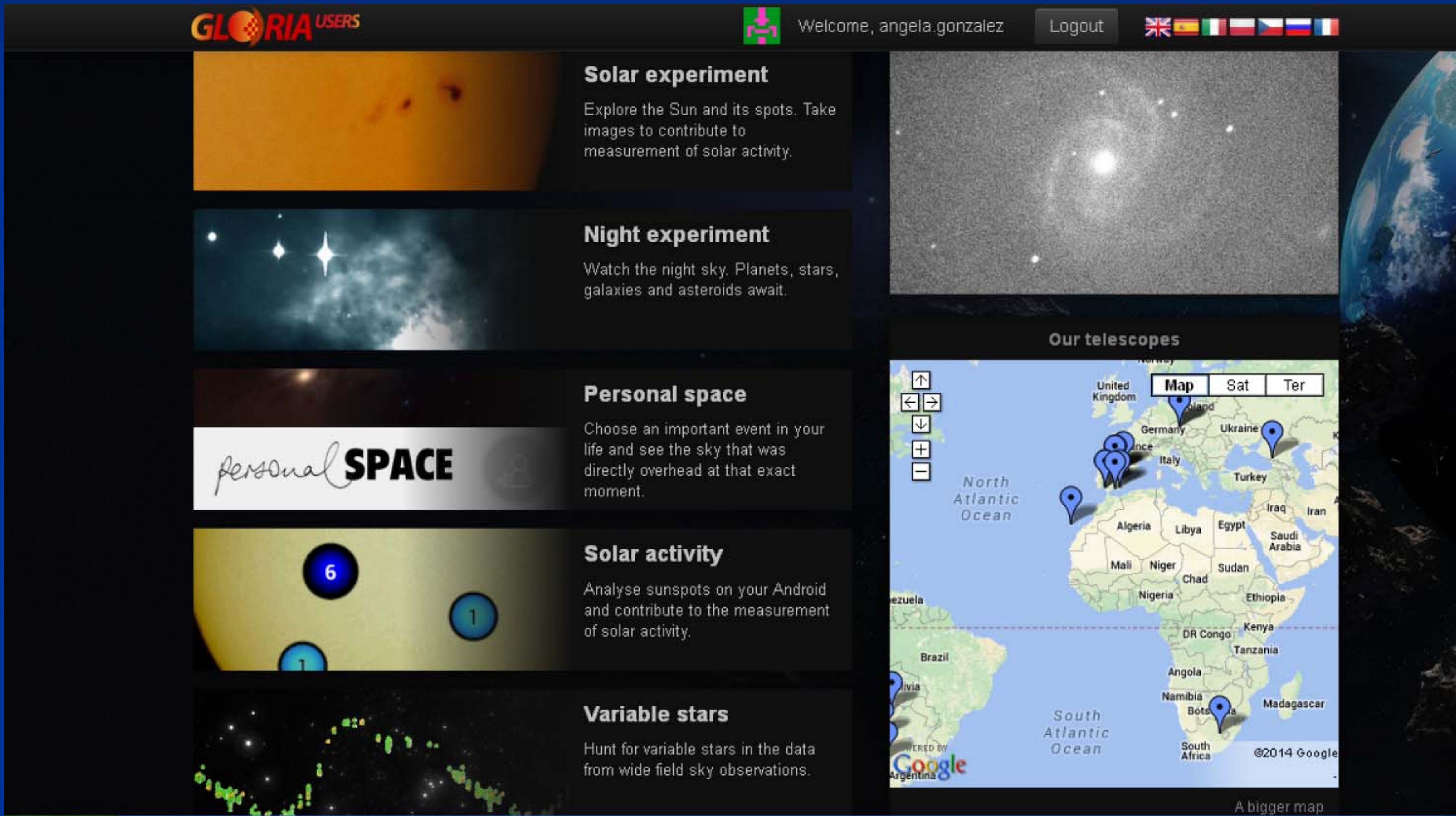


3. The GLORIA Project (XIII)

Project website: gloria-project.eu

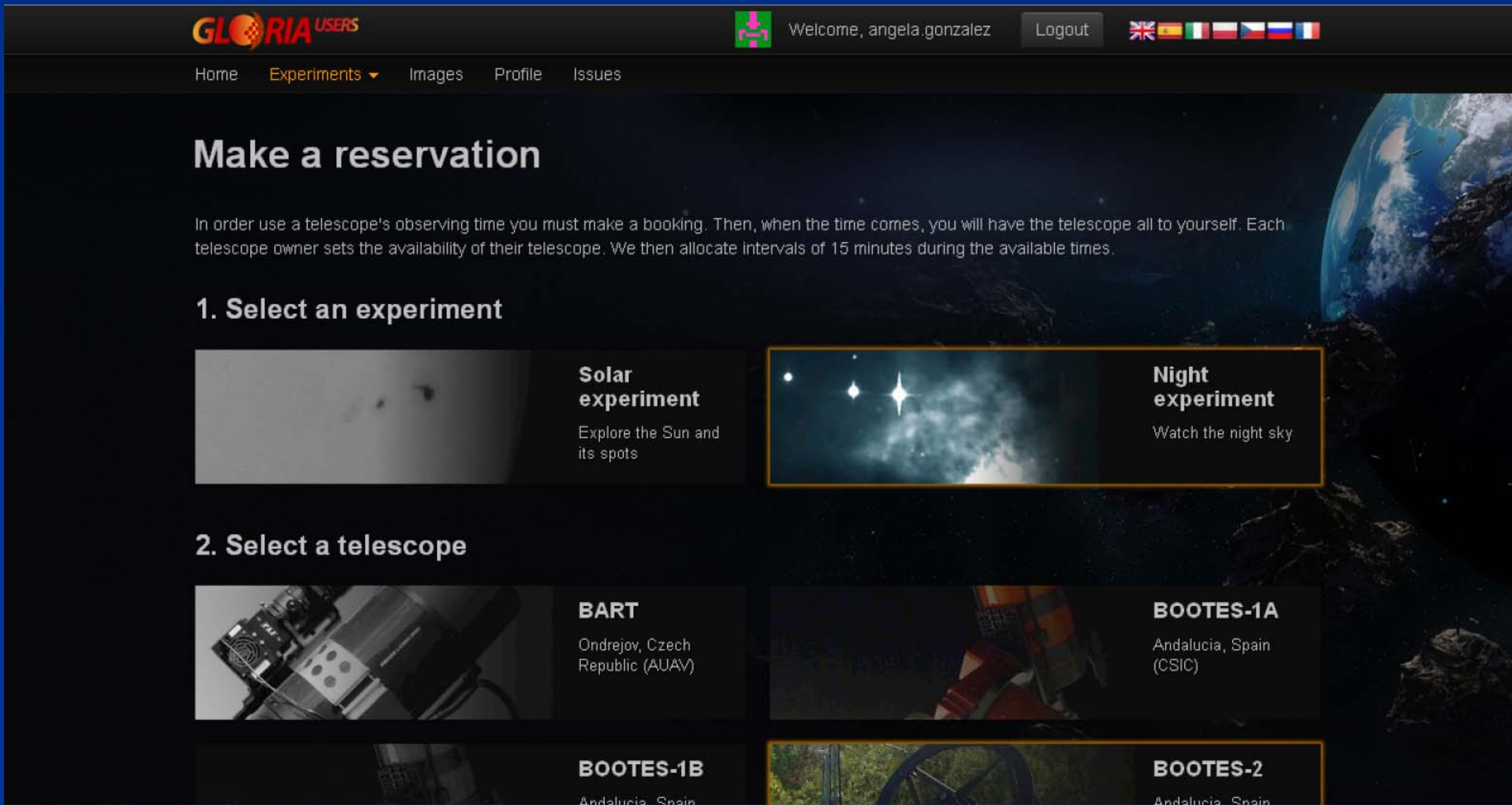
3. The GLORIA project (XIV)

users website: users.gloria-project.eu



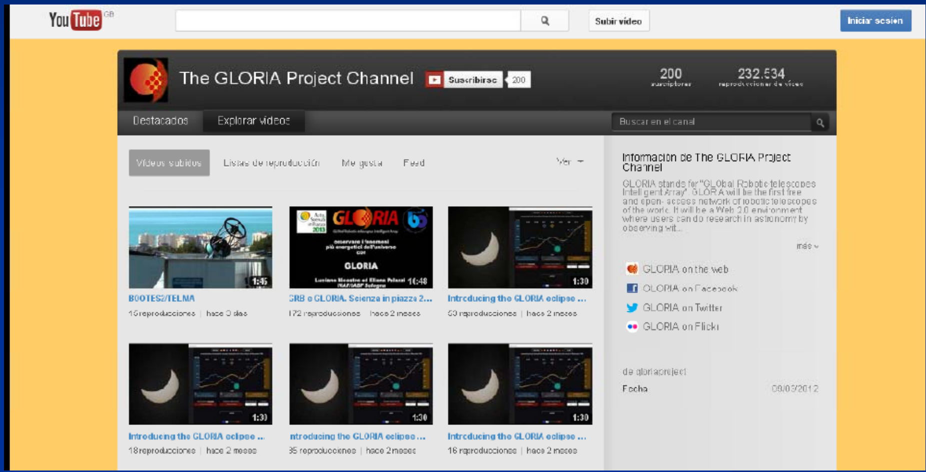
3. The GLORIA Project (XV)

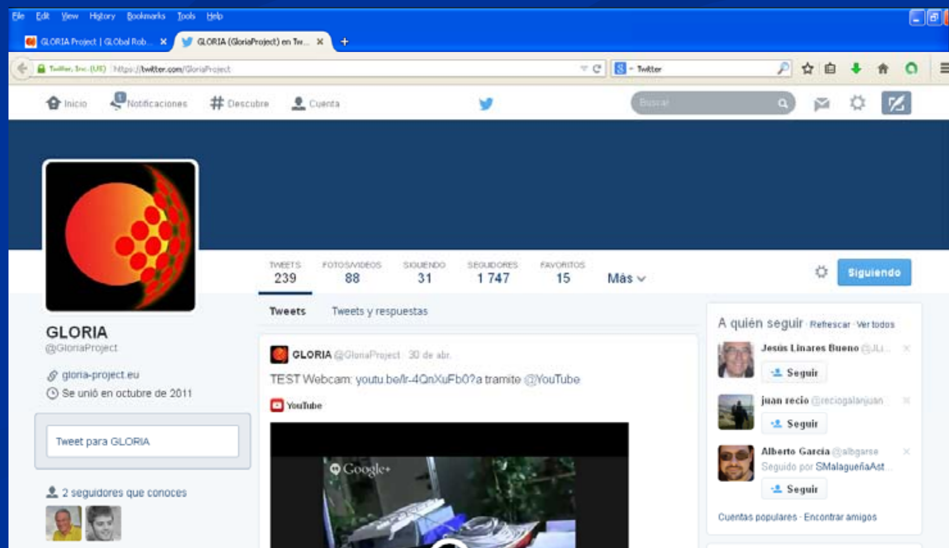
users website: users.gloria-project.eu



3. The GLORIA Project (XVI)

GLORIA in the social networks





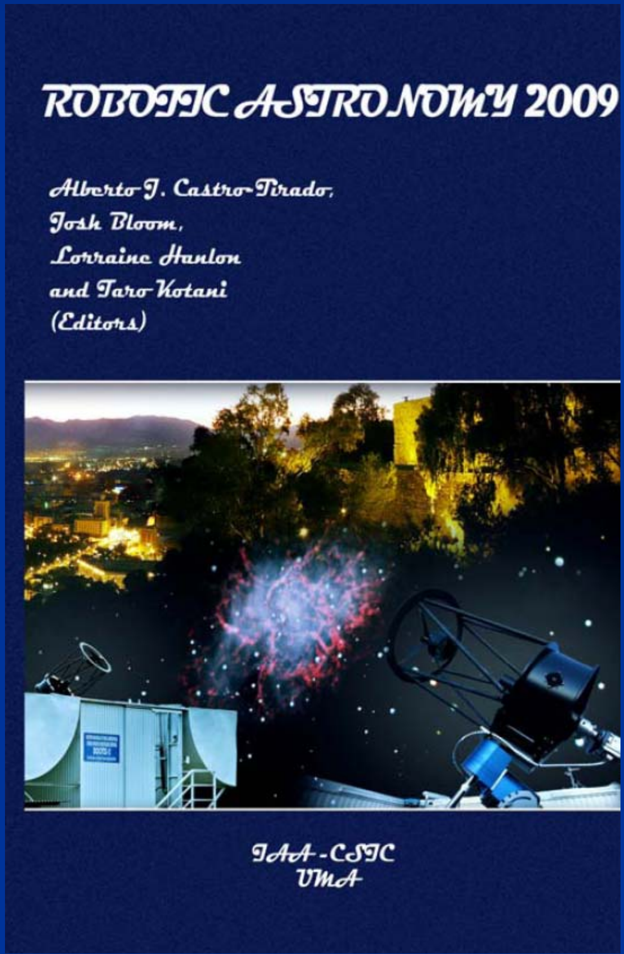
Conclusions

The application of Robotic to Astronomical Observatories (and network of Astronomical observatories, such as **BOOTES,** bootes.iaa.es), started to opening a new field of research in the last two decades.

GLORIA (gloria-project.eu) is a project funded by the FP7 European Union programe, and started in 2011. Its main goal is to make available a fraction of the onbserving time for 17 telescopes, thru a meritocratic system. Real-time ("On-line") experiments as well and programmed experiments (making use of archive data products, "Off-line" experiments) are also available.

As BOOTES Project Scientist and Deputy Coordinator, on behalf of the GLORIA Collaboration (44 people, 14 institutions, 9 countries) I encourage you to make use of GLORIA as of today! In the near future you will be able to join your telescope to GLORIA, to design your own experiment, and much more… Stay tuned!

IV Workshop on Robotic Astronomical Observatories



Málaga (Oct 2015)

astrorob.iaa.es