Introduction: LIGO-Virgo Event Follow-up Program

Gabriela González (LSC spokesperson)
Jean-Yves Vinet (Virgo spokesperson)
Amsterdam, August 29 2013
Chicago, September 10 2013

Why ?

- Almost exactly a century after GR, gravitational wave detectors will reach sensitivities allowing expected first detections

- Science return will be strongly enhanced if there are simultaneous EM observations.

- Since there have been no gravitational wave detections yet, everything is unexplored (and exciting) territory – we need to be both proactive and cautious.

Who (people) ?

- The gravitational waves « triggers » to be `followed up' in the EM spectrum are detected by the LIGO-Virgo Collaboration with LIGO and Virgo detectors.
- LIGO denotes the LIGO Laboratory and the LIGO Scientific Collaboration (LSC) : about 900 scientists+engineers
- Virgo denotes the Virgo Collaboration and the European Gravitational Observatory (EGO) : about 200 scientists +engineers

LIGO and Virgo scientists work together on the joint analysis of LIGO and Virgo data (online and offline, searching for many different sources). People leading the collaboration and the data analysis working groups are represented here [Introductions].

Who (detectors)?

- LIGO : 2 interferometers (4km arm lengths) built in Livingston (Louisiana) and Hanford (Washington) by Caltech and MIT. Funding agency : NSF with contributions of SFTC, MPG, ARC…

- Virgo : 1 interferometer (3km arm lengths) built in Cascina (near Pisa) by Italy, France, The Netherlands, Hungary, Poland. Funding Agencies : CNRS, INFN, NIKHEF

- Also (current): GEO600, 1 interferometer (600m arm lengths) built in Hannover. Funding by British and German institutions. LIGO and GEO are linked by an agreement such that GEO is included in « LIGO » in a wide sense.

- Also (future): 4km LIGO detector in India.

- Also (future): 3km Japanese detector (KAGRA) – will have collaboration agreements with LSC and Virgo when operational.

The Virgo Collaboration : 19 European teams

EGO Council (CNRS, INFN, NIKHEF)

RMKI,
Academy of sciences
Budapest
HUNGARY

NIKHEF, Amsterdam
Radboud University , Nijmegen
The NETHERLANDS

EGO Site Cascina

Institute of Mathematics
Polish Academy of Sciences
Varsaw
POLAND

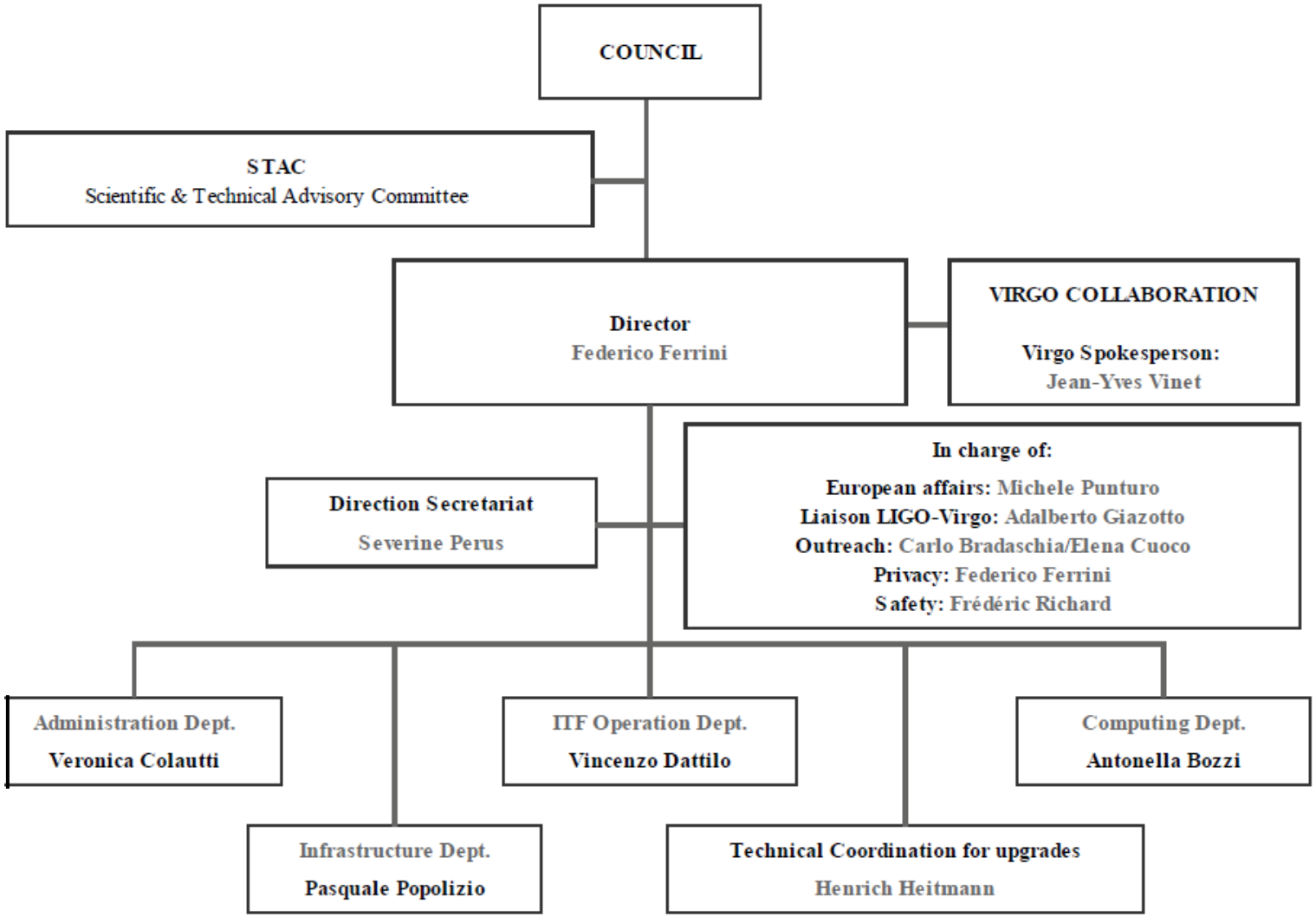
ITALY:

INFN + Universities of
Firenze-Urbino
Genova
Napoli
Perugia
Roma La Sapienza
Roma Tor Vergata
Pisa
Padova-Trento

FRANCE :
Laboratoire de l'Accélérateur Linéaire (U. Paris-Sud+CNRS)
Laboratoire d'Annecy de Physique des Particules (CNRS)
Astroparticules et Cosmologie (U. Paris 7+CNRS)
Laboratoire des Matériaux Avancés (Lyon-CNRS)
Laboratoire Kastler-Brossel (ENS – U. Paris 6 - CNRS)
Observatoire de la Côte d'Azur (CNRS, Nice)
ESPCI (Paris)

North Atlantic Ocean
North Sea
Baltic Sea
Irish Sea
English Channel
Bay of Biscay
Adriatic Sea
Tyrrhenian Sea
Ionian Sea
Aegean Sea
Mediterranean Sea
Black Sea
UNITED KINGDOM
IRELAND
DENMARK
LATVIA
LITHUANIA
BELARUS
POLAND
GERMANY
NETHERLANDS
BELGIUM
LUX.
FRANCE
SWITZ.
AUSTRIA
CZECH REPUBLIC
SLOVAKIA
HUNGARY
UKRAINE
MOLDOVA
ROMANIA
BULGARIA
SLOVENIA
CROATIA
BOSNIA AND HERZEGOVINA
Serbia
ITALY
SPAIN
PORTUGAL
ANDORRA
GREECE
ALB.
TURKE
MALTA
TUNISIA
ALGERIA
MOROCCO
Scale 1:19,500,000
Lambert Conformal Conic Projection, standard parallels 40° N 56° N
300 Kilometers
300 Nautical Miles

EGO


COUNCIL
STAC
Scientific & Technical Advisory Committee
Director
Federico Ferrini
VIRGO COLLABORATION
Virgo Spokesperson:
Jean-Yves Vinet
In charge of:
European affairs: Michele Punturo
Liaison LIGO-Virgo: Adalberto Giazotto
Outreach: Carlo Bradaschia/Elena Cuoco
Privacy: Federico Ferrini
Safety: Frédéric Richard
Direction Secretariat
Severine Perus
Administration Dept.
Veronica Colautti
ITF Operation Dept.
Vincenzo Dattilo
Computing Dept.
Antonella Bozzi
Infrastructure Dept.
Pasquale Popolizio
Technical Coordination for upgrades
Henrich Heitmann

The Virgo Collaboration

Virgo Editorial Board
G. Gemme (chair)

P. Hello
F. Marion
E. Majorana

Virgo Steering Committee
(spokesperson : J-Y.Vinet)

Advanced Virgo Project Leader
G. Losurdo

Data Analysis Coordinator
(P. Astone)

Commissioning Coordinator
B. Swinkels

CCB :
J-Y. Vinet (Chair)
G. Losurdo
B. Mours
F. Ferrini
F. Ricci
J. Van Den Brand

IPRB :
B. Mours (Chair)

Physics Groups :

Bursts (G. Prodi)
CBC (C. Van Den Broeck)
CW (A. Krolak)
Stoch (T. Regimbau)
VDQ (D. Verkindt)
Noise stud. (E. Cuoco)

Technical Manager
H. Heitmann

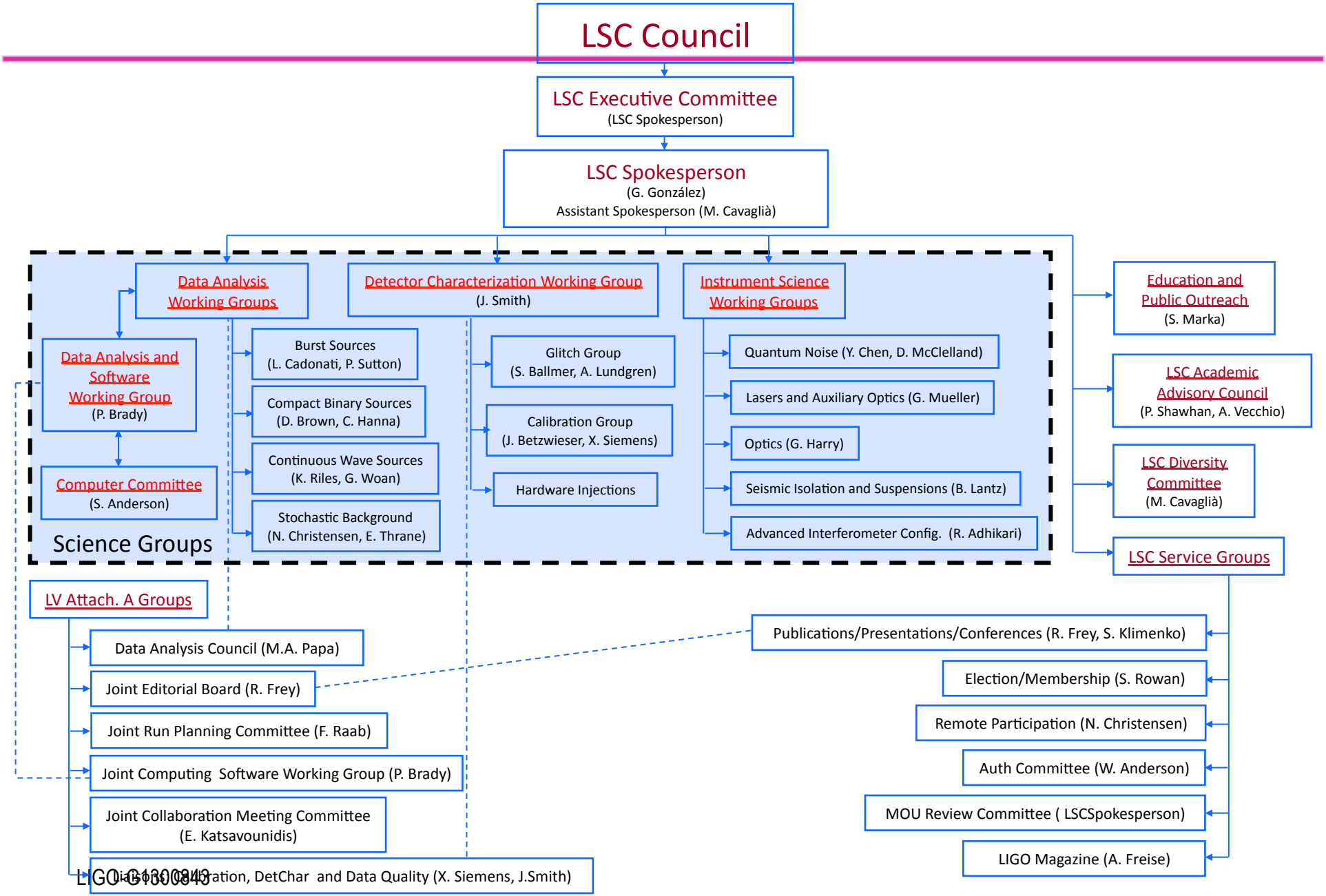
Detector WBS : SSMs

DAQ (L. Rolland)	LAPP
DET (R. Gouaty)	LAPP
INF (A. Paoli)	EGO
INJ (E. Genin)	EGO
ISC (B. Swinkels)	EGO
MIR (L. Pinard)	LMA
OSD (J. Degallaix)	LMA
PAY (P. Rapagnani)	RomaLS
PSL (N. Man)	ARTEMIS
SAT (R. Passaquieti)	Pisa
SBE (A. Bertolini)	Nikhef
SLC (J. Marque)	EGO
TCS (V. Fafone)	RomaTV
VAC (A. Pasqualetti)	EGO

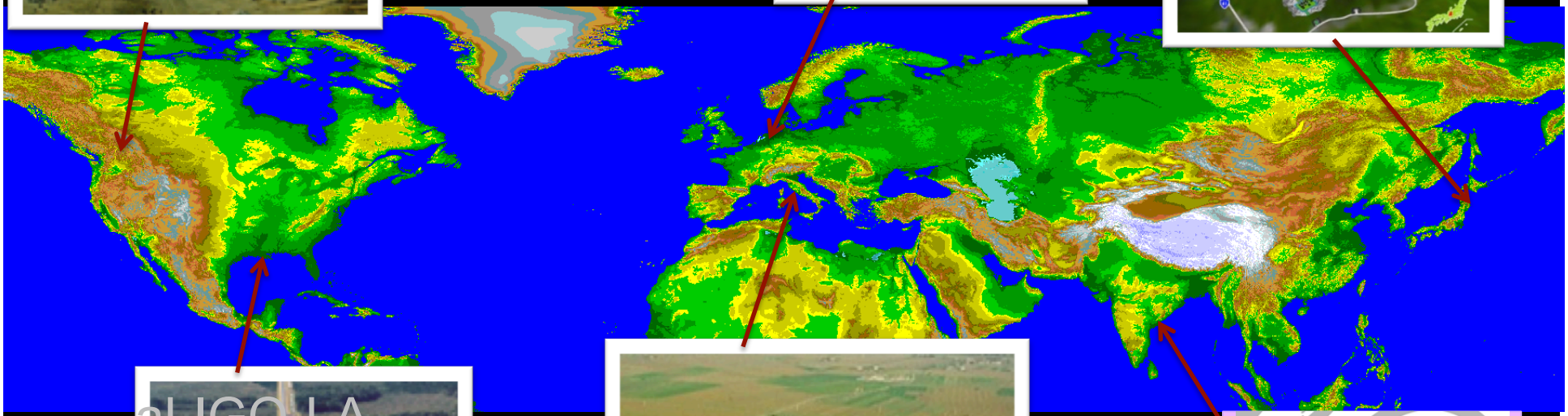
LIGO Scientific Collaboration

>900 members, >80 institutions, 17 countries

LIGO Scientific Collaboration



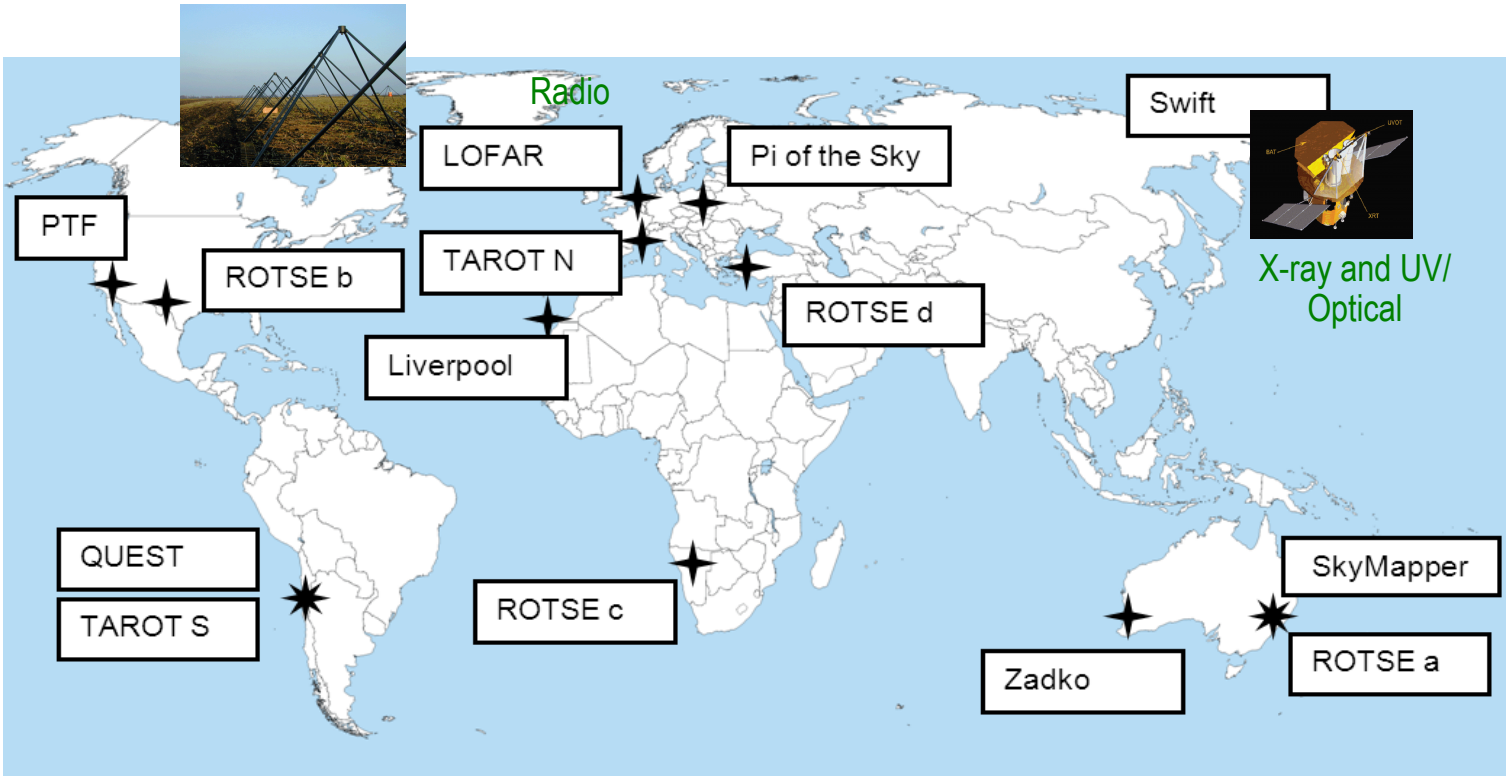
Where ?



aLIGO-India

LSC, Virgo past collaborations

- Observing partners in S6/VSR3:



Astron Astrophys **541** (2012) A155
Astron Astrophys **539** (2012) A124

GW-EM follow up: two eras

- After the published discovery of four gravitational events with data from LSC and/or Virgo detectors, both the LSC and Virgo will begin releasing especially significant triggers (with FAR< 1/100 yrs) promptly to the entire scientific community to enable a wider range of follow-up observations. This may happen after 2018 (?).

- Before that (staring in 2015); LVC will partner with astronomers to carry out an inclusive observing campaign for potentially interesting GW triggers, with MoUs to ensure coordination and confidentiality of the information. They are open to all requests from interested astronomers or astronomy projects which want to become partners through signing an MoU. Partners who have signed an MoU with the LSC and Virgo will have access to GW triggers with a lower significance threshold and/or lower latency, according to the terms of the MoU, in order to carry out a more systematic joint observing campaign and combined interpretation of the results.

dcc.ligo.org, LIGO-M1200055

When ?

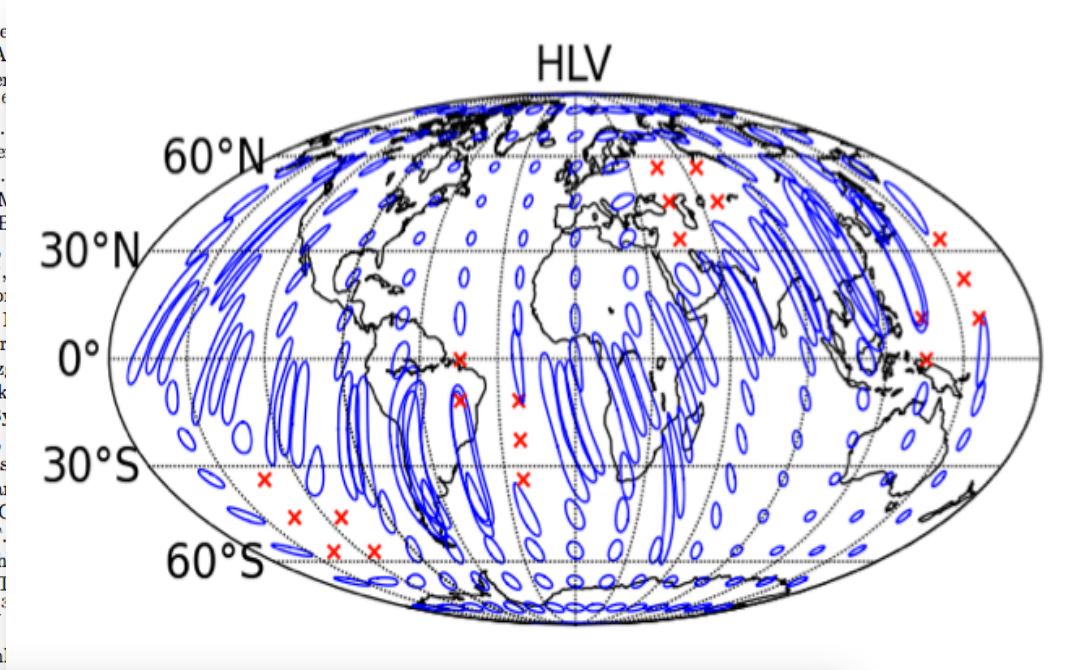
arXiv:1304.0670

Aiming to source localization in the sky

Prospects for Localization of Gravitational Wave Transients by the Advanced LIGO and Advanced Virgo Observatories

J. Aasi[1], J. Abadie[1], B. P. Abbott[1], R. Abbott[1], T. D. Abbott[2], M. Abe
F. Acernese[5ac], C. Adams[6], T. Adams[7], P. Addesso[8], R. X. Adhikari[1], C. A
O. D. Aguiar[12], P. Ajith[1], B. Allen[9,13,10], A. Allocca[14ac], E. Amador Ce
S. B. Anderson[1], W. G. Anderson[13], K. Arai[1], M. C. Araya[1], C. Arceneaux[1
P. Astone[17a], D. Atkinson[18], P. Aufmuth[10,9], C. Aulbert[9,10], L. Austin[1], B.
P. Baker[21], G. Ballardin[22], S. Ballmer[23], Y. Bao[15], J. C. Barayoga[1], D. Barke
L. Barsotti[24], M. Barsuglia[25], M. A. Barton[18], I. Bartos[26], R. Bassiri[3,27], M.
J. Batch[18], J. Bauchrowitz[9,10], Th. S. Bauer[11a], M. Bebronne[4], B. Behnke[20], M
A. S. Bell[3], C. Bell[3], G. Bergmann[9,10], J. M. Berliner[18], A. Bertolini[9,10], J. B
P. T. Beyersdorf[29], T. Bhadbade[27], I. A. Bilenko[30], G. Billingsley[1], J. Birch[6],
M. A. Bizouard[31a], E. Black[1], J. K. Blackburn[1], L. Blackburn[32], D. Blair[33],
O. Bock[9,10], T. P. Bodiya[24], C. Bogan[9,10], C. Bond[19], F. Bondu[34b], L. Bo
R. Bork[1], M. Born[9,10], V. Boschi[14a], S. Bose[36], L. Bosi[37a], B. Bouhou[25], J.
P. R. Brady[13], V. B. Braginsky[30], M. Branchesi[38ab], J. E. Brau[39], J. Br
D. O. Bridges[6], A. Brillet[34a], M. Brinkmann[9,10], V. Brisson[31a], M. Britz
D. A. Brown[23], D. D. Brown[19], F. Brueckner[19], K. Buckland[1], T. Bulik
A. Buonanno[41], J. Burguet–Castell[42], D. Buskulic[4], C. Buy[25], R. L. By
G. Cagnoli[35,44], E. Calloni[5ab], J. B. Camp[32], P. Campsie[3], K. Cannon[45],
C. D. Capano[41], F. Carbognani[22], L. Carbone[19], S. Caride[47], A. D. Cas
M. Cavaglià[16], F. Cavalier[31a], R. Cavalieri[22], G. Cella[14a], C. Cepeda[1], E. Cesar
S. Chao[101], P. Charlton[50], E. Chassande-Mottin[25], X. Chen[33], Y. Chen[51], A. C
H. S. Cho[53], J. Chow[54], N. Christensen[55], Q. Chu[33], S. S. Y. Chua[54], C. T.
F. Clara[18], D. E. Clark[27], J. A. Clark[43], F. Cleva[34a], E. Coccia[49ab], P.-F. Coh
A. Colla[17ab], M. Colombini[17b], M. Constancio Jr.[12], A. Conte[17ab], D. Cook[18], T
N. Cornish[21], A. Corsi[103], C. A. Costa[2,12], M. Coughlin[57], J.-P. Coulon
P. Couvares[23], D. M. Coward[33], M. Cowart[6], D. C. Coyne[1], K. Craig[3],
T. D. Creighton[44], A. Cumming[3], L. Cunningham[3], E. Cuoco[22], K. Dahl

1304.0670v1 [gr-qc] 2 Apr 2013



Epoch	Estimated Run Duration	$E_{GW} = 10^{-2} M_{\odot} c^2$ Burst Range (Mpc) LIGO	Virgo	BNS Range (Mpc) LIGO	Virgo	Number of BNS Detections	% BNS Localized within 5 deg^2	20 deg^2
2015	3 months	40 – 60	–	40 – 80	–	0.0004 – 3	–	–
2016–17	6 months	60 – 75	20 – 40	80 – 120	20 – 60	0.006 – 20	2	5 – 12
2017–18	9 months	75 – 90	40 – 50	120 – 170	60 – 85	0.04 – 100	1 – 2	10 – 12
2019+	(per year)	105	40 – 80	200	65 – 130	0.2 – 200	3 – 8	8 – 28
2022+ (India)	(per year)	105	80	200	130	0.4 – 400	17	48

Plausible Observing Scenario

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2022+ (India)	(per year)	105	80	200	130	0.4 – 400	17	48

Table 1: Summary of a plausible observing schedule, expected sensitivities, and source localization with the advanced LIGO and Virgo detectors, which will be strongly dependent on the detectors' commissioning progress. The burst ranges assume standard-candle emission of $10^{-2} M_{\odot} c^2$ in GWs at 150 Hz and scale as $E_{GW}^{1/2}$. The burst and binary neutron star (BNS) ranges and the BNS localizations reflect the uncertainty in the detector noise spectra shown in Fig. 1. The BNS detection numbers also account for the uncertainty in the BNS source rate density [28], and are computed assuming a false alarm rate of $10^{-2}\,\mathrm{yr}^{-1}$. Burst localizations are expected to be broadly similar to those for BNS systems, but will vary depending on the signal bandwidth. Localization and detection numbers assume an 80% duty cycle for each instrument.

How?

- Current plan (http://www.ligo.org/science/GWEMalerts.php), on advice of internal and external experts:
  - Before defining MOU templates, open call for "Letters of Interest" from any astronomer or group of astronomers or collaboration who wants to follow up GW triggers. Received >60 responses!
  - Meet with LOI submitters for input on MOUs, modes of partnership ("independent" and "coordinated"), and publication models. *(This meeting!)*
  - LVC defines the MOUs, and makes a call for signing MOUs (Oct?), publishing criteria for evaluation.
  - LVC evaluates proposals, and decides on signing MOUs (~March).

Introductory talks

	WELCOME **Daniel Holz, Vicky Kalogera**
1:35 PM - 2:00 PM	**Gabriela Gonzalez**, Louisiana State University *OVERVIEW OF PROJECT AND MEETING GOALS* [PDF, 8.36 MB]
2:00 PM - 3:00 PM	**SHOTGUN SESSION** *presentations by LOI submitters (1 slide, 2 minutes each)*
3:00 PM - 3:45 PM	*COFFEE BREAK*
3:45 PM - 4:15 PM	**David Reitze**, LIGO Laboratory, Caltech *ADVANCED DETECTOR ERA OVERVIEW* [PDF, 10.08 MB]
4:15 PM - 4:45 PM	**Maria Alessandra Papa**, Max Planck Inst. for Gravitational Physics (Germany) and Univ. Wisconsin Milwaukee *BACKGROUND AND FOREGROUND IN GW SEARCHES* [PDF, 10.14 MB]
4:45 PM - 5:15 PM	**Peter Shawhan**, University of Maryland *GW EVENT ALERTS* [PDF, 2.2 MB]
5:15 PM	*BREAK FOR DINNER*

SEPTEMBER 11, 2013 - WEDNESDAY

9:00 AM - 9:30 AM	**Peter Shawhan**, University of Maryland *MOU FRAMEWORK PRESENTATION* [PDF, 0.48 MB]

Goals for this meeting

- Meet all who expressed interest in GW-EM astronomy!
- Explain status of GW detectors and prospects for GW events in the next several years.
- Hear and understand opinions and constraints on partnerships, agreements, publications,…

Expected result after discussions in Amsterdam, Chicago and within LVC: a call for MOUs that results in many partnerships leading to new astrophysics.