IndIGO and LIGO-Australia

Unnikrishnan. C. S.
Gravitation Group & Fundamental Interactions Lab
Tata Institute of Fundamental Research
Homi Bhabha Road, Mumbai 400005

On behalf of the IndIGO Consortium


Srinagar
Jammu
Ludhiana
Chandigarh
Bathinda
Dehradun
New Delhi
Gurgaon
Agra
Jaipur
Lucknow
Kanpur
Allahabad
Patna
Jodhpur
Gwalior
Bhopal
Indore
Jabalpur
Ranchi
Dhanbad
Kolkata
Gandhinagar
Ahmadabad
Rajkot
Surat
Nagpur
Raipur
Aurangabad
Mumbai
Pune
Hyderabad
Vishakhapatnam
Vijayawada
Panaji
Bangalore
Mangalore
Kozhikode
Coimbatore
Kochi
Madurai
Tuticorin
Nagercoil
Thiruvananthapuram
Mt. Everest
8848 m
Kathmandu
Gangtok
Thimphu
Itanagar
Guwahati
Dispur
Shillong
Kohima
Imphal
Agartala
Dhaka
Khulna
Chittagong
Bhubaneshwar
Arabian Sea

Achievements:

1) **Completed a road-map** and initiated feasibility study for **participation in advanced large scale gravitational wave detector** proposed in southern Asia (3 international meetings and 3 national meetings).

2) **Formation of a consortium** of about 30 researchers from 10 institutes/univ., in gravitational, optical and vacuum physics, to lead and implement the Indian Initiative in Gravitational wave Observations (IndIGO) + participation in 3 joint meetings for discussion on a major Indo-Australian collaboration of GW physics and astronomy.

3) **Major initiative for GW research in India** with, ensuring significant international presence in GW scientific collaborations in the coming years. MOU with ACIGA.

4) **Enabled participation** in the major developments in 2009-11 on the planning of gravitational wave research initiatives like the region cooperation meeting in Shanghai and the discussion on **LIGO-Australia** in Perth.

5) Proposal for a **3-m scale advanced prototype interferometer** with ultra-fine displacement sensitivity, and **obtained support, funding and lab space** for completion by 2015 (first institutional initiative and leading support).

6) New initiatives in **training and teaching in the field (UG/doctoral), reviving experimental gravitational physics** in India. **IndIGO school in Delhi, Dec. 2010.**

DST/INT/AUS/P-26/08 Establishing Australian-Indian collaboration on Gravitational Wave Astronomy (2008-11)

Progress:

1) Road map and preliminary proposal supported by GWIC, leading physicists in GW research and major GW research teams.

2) International Advisory Committee, National Steering Committee and Program Advisory Committee already in place.

3) MOU signed with ACIGA/UWA to pursue funding and manpower development to participate in the large scale detector effort in Australia.

4) Positive feedback and suggestions obtained from Office of Principal Science Advisor, Govt. of India, based on Dr Bhawalkar's report encouraging to seek funding of the order of $20M for IndIGO participation in large scale detector.

5) Indo-US virtual centre for exchange program and collaboration in GW research approved in principle.

6) Growing national and international support for participation in the global GW astronomy program.

GRAVITATIONAL-WAVE INTERNATIONAL COMMITTEE
GWIC

June 7, 2010

GWIC Support for the IndIGO Consortium for Gravitational-wave Physics and Astronomy

On behalf of GWIC, the Gravitational Wave International Committee, I am writing to express our strong support for the IndIGO Consortium for Gravitational-wave Physics and Astronomy, a collaborative effort to expand the participation of the Indian gravitational wave community in the global search for these elusive waves. The

In summary, the membership of GWIC urges the host research institutes and funding agencies to support the IndIGO consortium and its efforts to bring this important scientific opportunity to reality.

Yours sincerely,

James Hough

Prof. James Hough FRS, FRSE, FAPS, FInstP
Chair, Gravitational Wave International Committee,

Memorandum of Understanding between the Indian Consortium for Gravitational Astronomy (IndIGO) and The Australian Consortium for Gravitational Astronomy (ACIGA)

The purpose of this MOU is to initiate a collaboration between scientists in India and Australia in the field of gravitational wave detection, which is one of the most important scientific challenges of the 21st century. Gravitational wave detection and the subsequent use as a new spectrum for the exploration of our Universe provide exciting scientific opportunities. These opportunities will be made possible by an emerging global network of gravitational wave detectors.

3. IndIGO and ACIGA propose to develop a long-term collaboration, which will facilitate Indian participation in AIGO. Both sides recognize that building AIGO gives our scientists and students a unique opportunity to participate in the early exploration of the gravitational wave spectrum and to make a significant impact on the field. This collaboration will link the

a) ACIGA will intensively seek funding for AIGO and for research in Australia on advanced gravitational wave detectors.
b) IndIGO will apply for funding to enable the participation of 15-20 scientific staff in the installation and operation of the AIGO Observatory and associated research programs. It is anticipated that this will allow on average 3-5 scientific staff from IndIGO to be at AIGO Lab at any given time to participate in the installation and operation of the instrument, and to supervise students from IndIGO.

CALIFORNIA INSTITUTE OF TECHNOLOGY
THEORETICAL ASTROPHYSICS 350-17
PASADENA, CALIFORNIA 91125
Telephone: (626) 395-4597 Fax: (626) 796-5675 Internet: kip@tapir.caltech.edu

Dear Professor Kembhavi,

I write this letter after recent discussions with Professor Jayant Narlikar regarding the IndIGO (Indian Initiative in Gravitational-wave Observations) consortium and its objectives (www.gw-indigo.org). Most importantly, I write to endorse strongly the IndIGO collaboration with with ACIGA and the LIGO Laboratory in the construction and operation of the LIGO South gravitational-wave interferometer in Australia.

In summary, I strongly urge the research institutes and funding agencies in India to support the IndIGO consortium and its efforts and to help bring this important scientific opportunity to reality.

Sincerely,

Kip S. Thorne
The Feynman Professor
of Theoretical Physics, Emeritus

Professor **N. Kumar**
Homi Bhabha Distinguished Professor

1. The case for AIGO is strong - it will provide an "all-sky coverage" taken in conjunction with the existing GW network such as LIGO.
2. The idea of plan - A (to construct a clone of the advanced LIGO (to begin with) is a good and realistic one.

5. Overall, I think there is a compelling reason for India to go ahead and get involved in this consortium to construct a GW interferometer in the Asia-Pacific region. It is a challenge

Comments on the proposal " Indian Initiative in Gravitational Wave Astronomy"

Office of the Principal Scientific Adviser to the Government of India

D.D.Bhawalkar

3. Specific recommendations are-

a. India should embark on a programme to construct Laser Interferometric Gravitational detectors in a phased manner. Collaboration in construction and operation of similar detector under construction should be encouraged. For the

c. India should participate in the construction of AIGO. However the contribution should be in kind and should be restricted to equivalent of US$ 20 Million. The model of India's participation in LHC can be kept in mind.

Through such collaboration, India should be allowed to have access to the frontline technologies involved.

What India should contribute should be carefully analysed by experts and only then committed.

d. A decision on construction of 4000M arm length Interferometer INDIGO should be taken after the above two phases are complete. However INDIGO should be an international effort with other countries contributing to its

Committees:

International Advisory Committee
Rana Adhikari (LIGO, Caltech, USA)
David Blair (AIGO, UWA, Australia)
Adalberto Giazotto (Virgo, Italy)
P.D. Gupta (Director, RRCAT, India)
James Hough (GEO, GWIC Chair; Glasgow, UK)
Kazuaki Kuroda (LCGT, Japan)
Harald Lueck (GEO, Germany)
Nary Man (Virgo, France)
Jay Marx (LIGO, Director, USA)
David McClelland (AIGO, ANU, Australia)
Jesper Munch (Chair, ACIGA, Australia)
B.S. Sathyaprakash (GEO, Cardiff Univ, UK)
Bernard F. Schutz (GEO, Director AEI, Germany)
Jean-Yves Vinet (Virgo, France)
Stan Whitcomb (LIGO, Caltech, USA)

National Steering Committee:
Kailash Rustagi (IIT, Mumbai) [Chair]
Bala Iyer (RRI) [Coordinator]
Sanjeev Dhurandhar (IUCAA) [Co-Coordinator]
D.D. Bhawalkar
P.D. Gupta (RRCAT)
J.V. Narlikar (IUCAA)
G. Srinivasan

Summary of present situation:

India	Australia
Readiness to participate and contribute significantly in GW research and experiments within the country and in an international collaboration. Very mature experience in all theoretical and data analysis aspects. Ample expertise available in certain relevant experimental techniques, but only the possibility of a concrete project can bring people together.	Good expertise in experimental techniques, and already a significant contributor to international GW research program. **LIGO-Australia** suggestion has revived well the possibility of a large scale detector. Will benefit significantly from international participation.
Timely entry and crucial deliverables are the most important factor. Both the long term national program for GW research and astronomy as well as international visibility requires significant participation now and in the next 3-5 years.	**Timely response to LIGO-Australia** proposal is the most important factor. Full efforts are on to ensure international collaboration and the discussion with India has a 20 year history and it is implementable now naturally, since we know each other well.
Expert User Community exists already with experience in data handling, simulations and observational strategies. Can easily be a significant long term partner in GW astronomy. Matches well with other astronomy initiatives like GMRT, TMT, SKA.	Will benefit significantly from long term association with Indian and Asian GW research community.

The LIGO-Australia Idea and Opportunity

The NSF approved grand decision to locate one of the planned LIGO-USA interferometer detector at Gingin site, W-Australia to maximize science benefits like baseline, pointing, duty cycle, technology development and international collaboration.

The proposal from Australian consortium envisages IndIGO as one of the partners to realize this amazing opportunity.

Primary Considerations:

1) **Identify definite deliverables**

2) **Build up the team for detector building in about 3 years**

3) **Prove credibility and establish research and training facility in the specific task of GW interferometers in about 3 years**

1) Deliverables: End Vacuum Stations, PID Control Tasks, Tests and Validation, Simulations, Data handling and analysis strategies.

2) Team: 3 Full time and 5 part time (30%) possible in 3 years + 10 technical/engineering people + 5 post-docs, if there is funding.

3) Credibility, research and training: Advanced prototype interferometer

IndIGO Experimenters: Unnikrishnan. C. S., Rajalakshmi, Jorge Fiscina, Rodrigues. P. G (TIFR), Suresh. D (Caltech post-doc), Saravanan (Univ. Pisa. Doctoral), Rajiv Kumar (IIT-R), Ajai Kumar, S. B. Bhatt (IPR) -vacuum), Ranjan Gupta (IUCAA, optics-operations).

Consultant support: P. K. Gupta, S. K. Shukla, Sendhil Raja (RRCAT), Raja Rao (ex-RRCAT)

Deliverables

Vacuum:
Technical knowledge as well as precious experience in handling UHV in smaller chambers (1000 litre), double viton seal technology to reach UHV etc.
Fabrication of large chambers for pressure vessels within Indian Industry.
Procedural knowledge and technical expertise adequately available within RRCAT and DAE. We might be able to identify a PI for this within the present team.
Judged as fully feasible with Industry help.

Control Systems: Extensive expertise exists in the space and DAE divisions. Possible to build up a team that can deliver – fabrication, assembly, software and test & validation. (A task specific PI needs to be identified and brought in).

Data handling/simulations: The team is already strong in principle. Need to come together and take up focused specific tasks. Data centre being planned.

Technological spin-offs

Areas that will benefit:

UHV:
New procedures for UHV, UHV compatible welding of large systems, new technology pumps (NEG, for example), serious long term industry engagement.

Control systems: Multi-channel fast PID loops with new card/chip development possibilities, GPU based systems.

Lasers: Long coherence length metrology grade solid state lasers, their stabilization, high power CW amplifiers (100+ watt).

Optics: Opportunity for low absorption, low scatter optics development, international market for local optics industries (as developing today in the context of TMT for example).

Computing and data handling: Major opportunity for development of new concepts I data storage, retrieval and analysis, complementing the HEP community's efforts.

“Of all the large scientific projects out there, this one is pushing the greatest number of technologies the hardest.”

“Every single technology they’re touching they’re pushing, and there’s a lot of different technologies they’re touching.”

Beverly Berger,
National Science Foundation Program director for gravitational physics.

The strength that motivates…

1) A 25-year history in experiments related to measurements in gravitation, including good familiarity with the developments in GW experiments.

2) All challenging experimental goals taken up so far in the group have been achieved well with innovative contributions (measurement of short range forces, Bose-Einstein Condensation, interferometry for fundamental physics…)

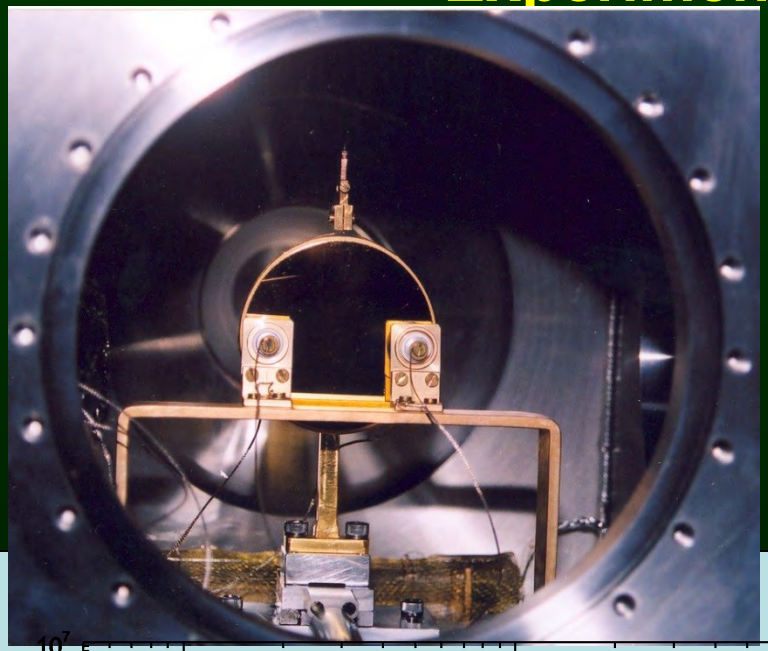
3) Enormous technical expertise available in the country (RRCAT/BARC, ISRO, IPR, IITs, TIFR…) for several aspects relevant for GW detectors – though scattered, can be brought together under a project.

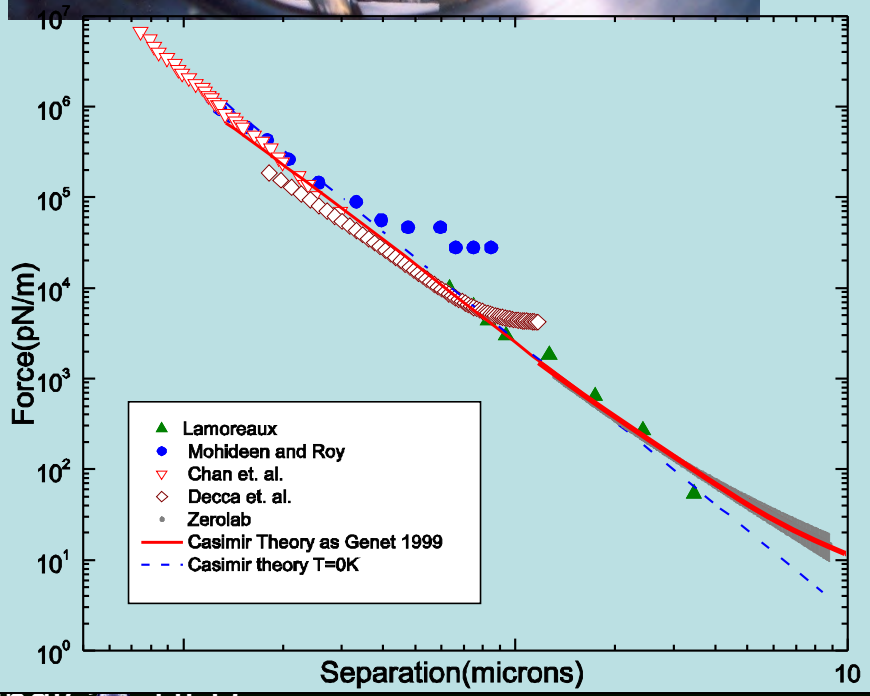
4) There is positive ambience and governmental support for medium scale and large scale fundamental physics initiatives in the country now and there is also a positive response from scientists to get together for larger long term goals.

5) Ready-to-go user and data analysis community in India with considerable experience from current large scale detectors.

TIFR Gravitation Laboratory
Gauribidanur, Karnataka

Experiment




Force(pN/m)
Separation(microns)
10
Lamoreaux
Mohideen and Roy
Chan et. al.
Decca et. al.
Zerolab
Casimir Theory as Genet 1999
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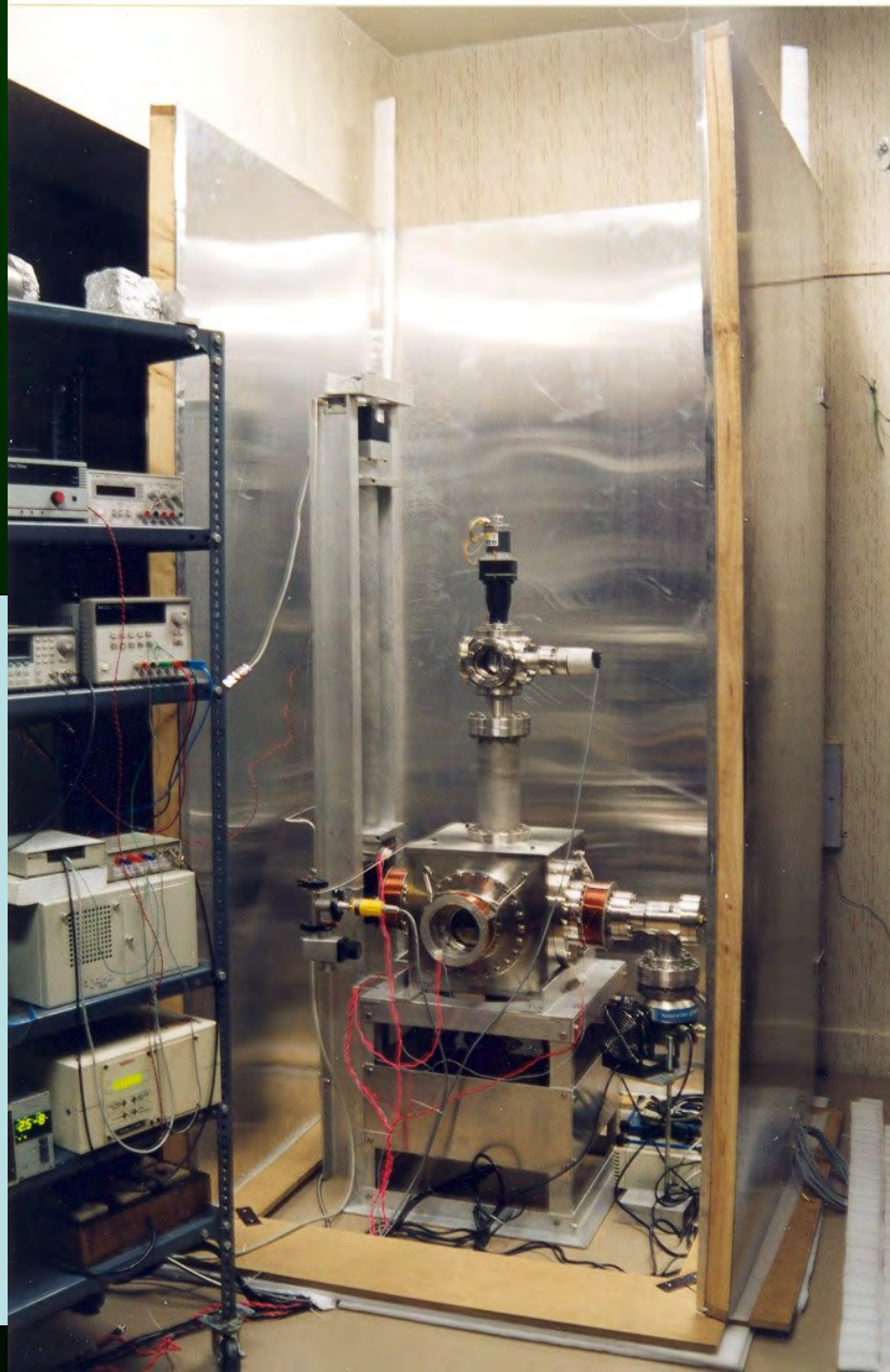
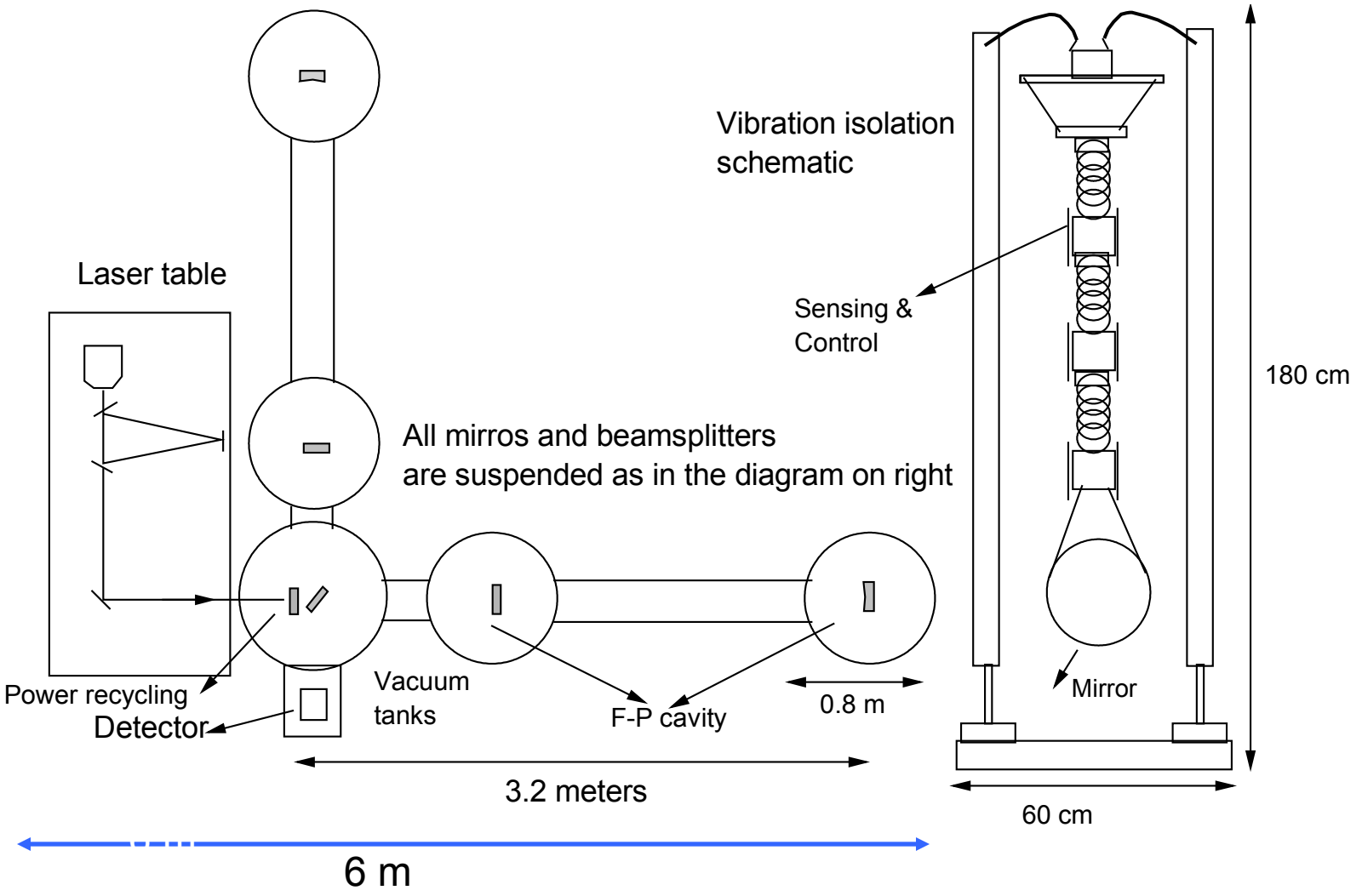
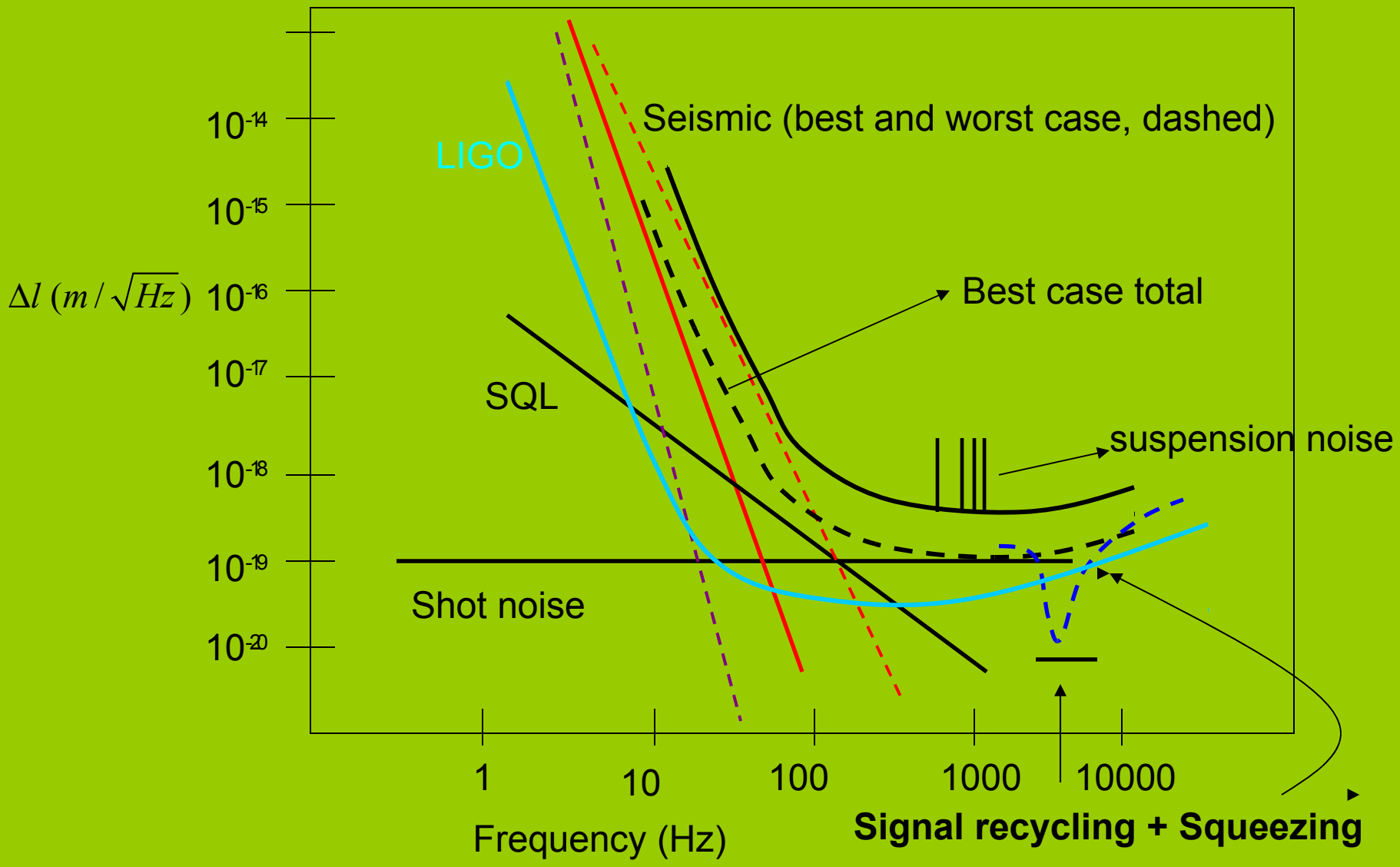
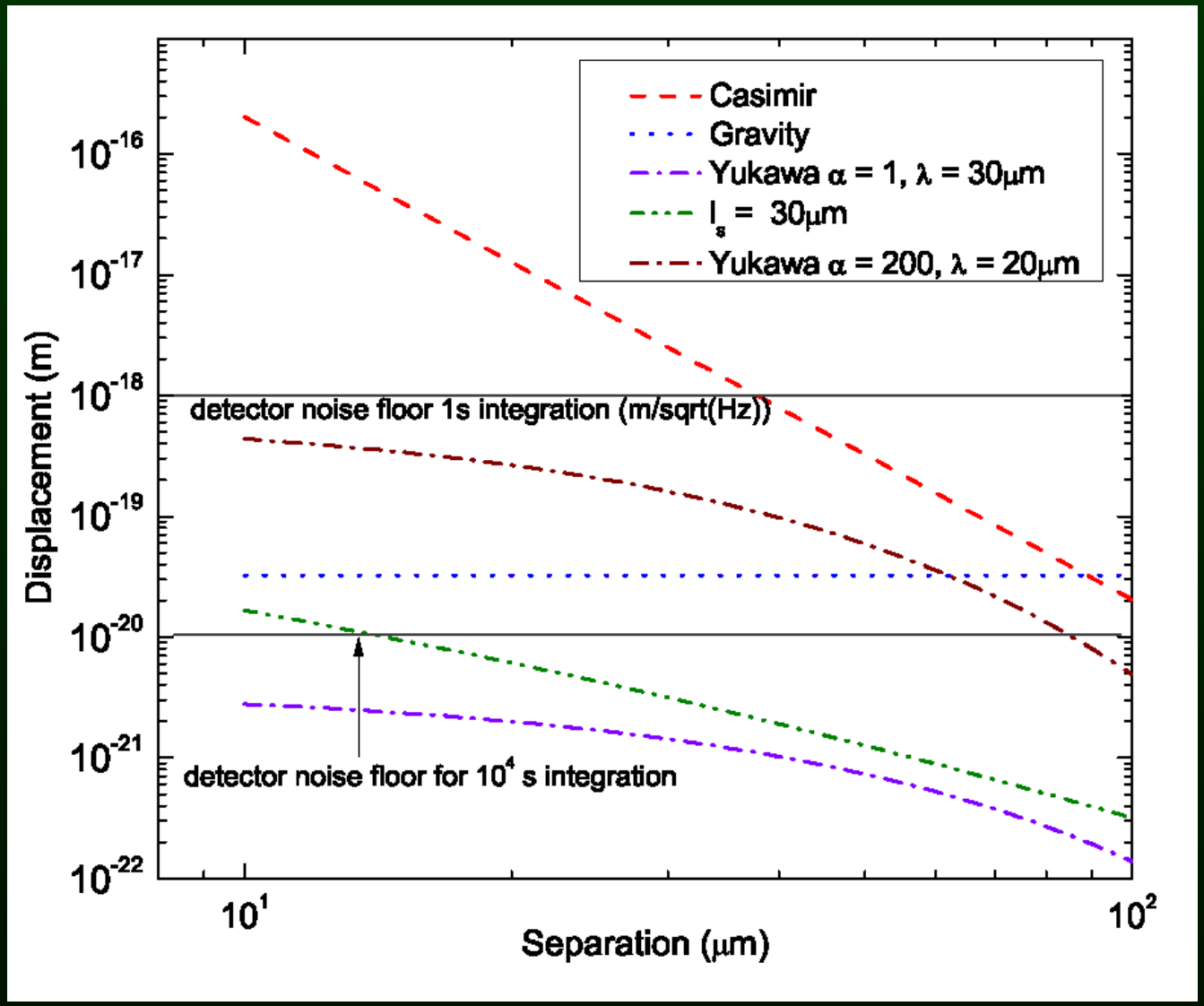


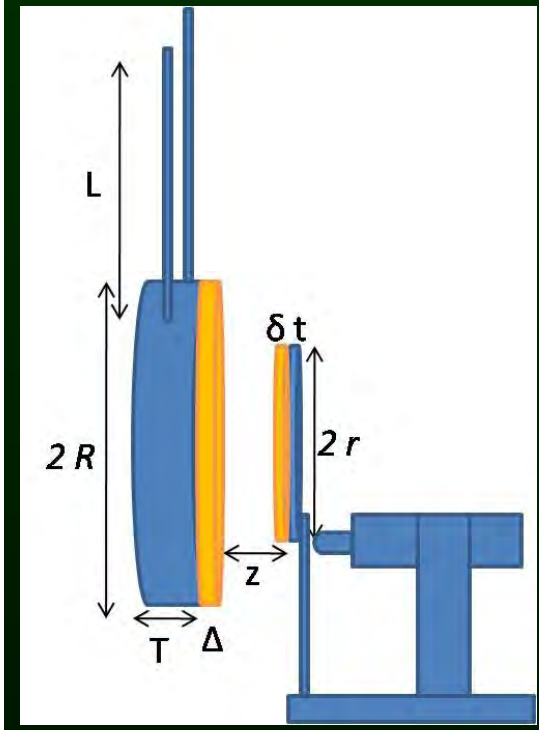

Vibration isolation
schematic
Laser table
Sensing &
Control
180 cm
All mirros and beamsplitters
are suspended as in the diagram on right
Power recycling
Detector
Vacuum
tanks
F-P cavity
0.8 m
Mirror
3.2 meters
60 cm
6 m

Sketch of expected sensitivity for 3-m prototype



Physics with the TIFR prototype: Short range forces and Casimir force





(G. Rajalakshmi & CS Unnikrishnan 2010, CQG, 2010)

Road-map towards IndIGO@LIGO-Australia

1) Discussion of division of tasks in deliverables with LIGO-Australia team

2) Main proposal to Dept. of Atomic Energy and Dept. of Science & Technology: 2011

3) If successful by March 2012, go ahead and expand the current team with specific recruitments for technical help.

There is an urgent need to act positively, by all of us and by the funding agencies.

With the present momentum and enthusiasm, rest will follow and India will be a significant partner and contributor in global GW research.

The IndIGO Consortium:

Sanjeev Dhurandhar (Spokesperson)	IUCAA, Pune
Tarun Souradeep (Council)	IUCAA, Pune
Bala Iyer (Council chair)	RRI, Bangalore
C. S. Unnikrishnan (Council)	TIFR, Mumbai
Badri Krishnan	Albert Einstein Institute, Germany
Rana Adhikari	Caltech, Pasadena
P Ajith	Caltech, Pasadena
B Sathyaprakash	Cardiff University
T R Seshadri	Delhi University
Patrick Dasgupta	Delhi University
Anand Sengupta	Delhi University (from Caltech)
Biplab Bhawal	Independent
Rajesh Nayak	IISER, Kolkata
Archana Pai	IISER, Trivandrum
Suresh Doravari	Caltech, Pasadena.
Ajai Kumar	IPR, Gandhinagar
Ranjan Gupta	IUCAA, Pune
Sanjay Jhingan	Jamila Milia, Delhi
Sanjit Mitra	JPL/LIGO, Caltech
Jiwan Mittal	RRCAT, Indore
S Shukla	RRCAT, Indore
G Rajalakshmi	TIFR, Mumbai
A Gopakumar	TIFR, Mumbai
Soumya Mohanty	UTB, Brownsville
Sukanta Bose	Washington University, Pullman
K G Arun	Chennai Mathematical Institute, Chennai