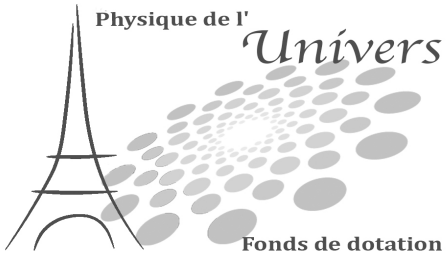


Virgo and LIGO in 7 words

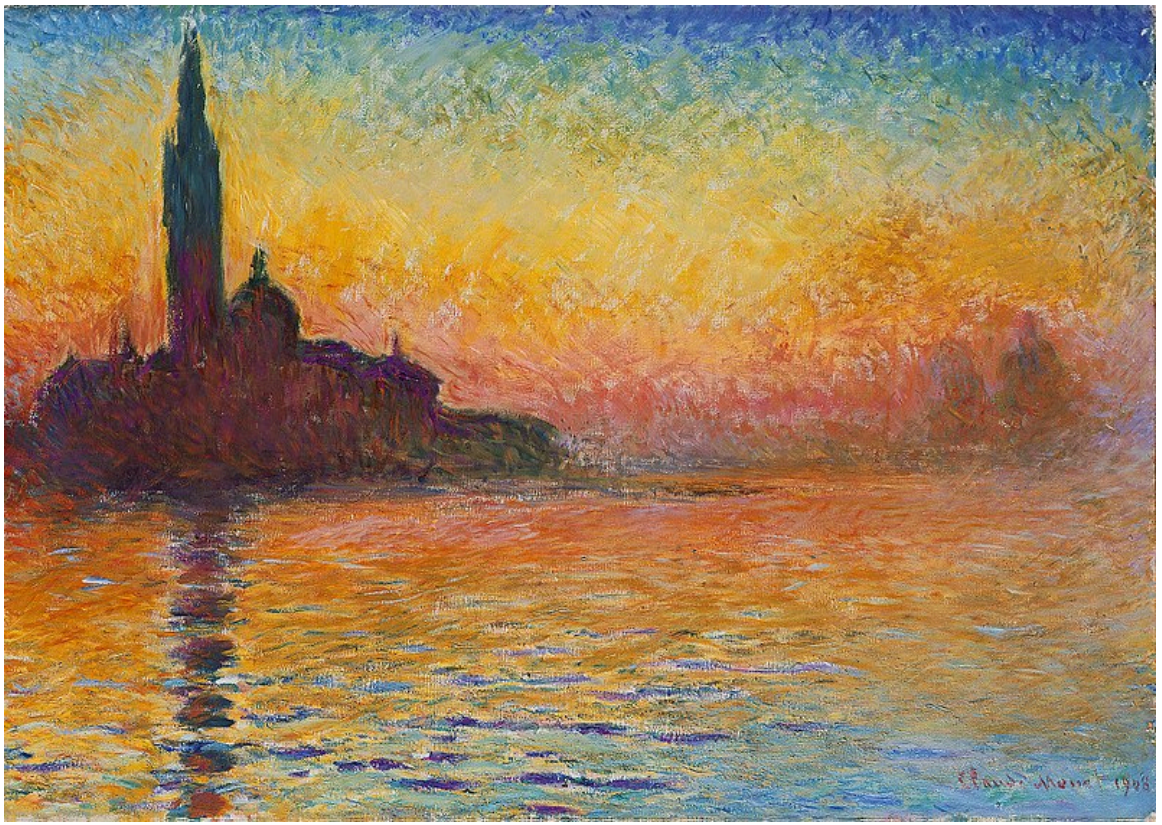
Project Art citoyen: UNIVERS 2.0
Fonds de Dotation Physique de l'Univers
13-15 May, Pisa

Matteo Barsuglia

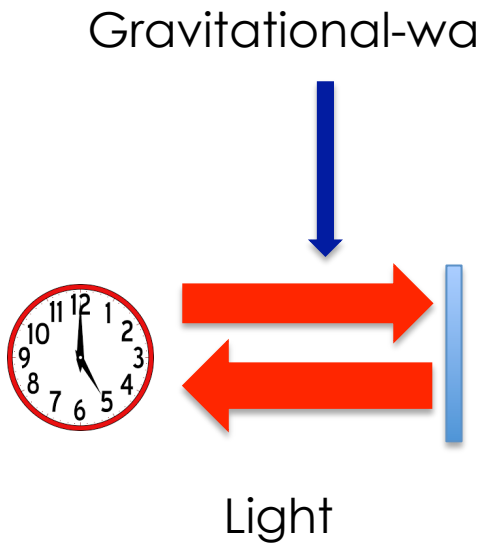
Laboratoire Astroparticule et Cosmologie

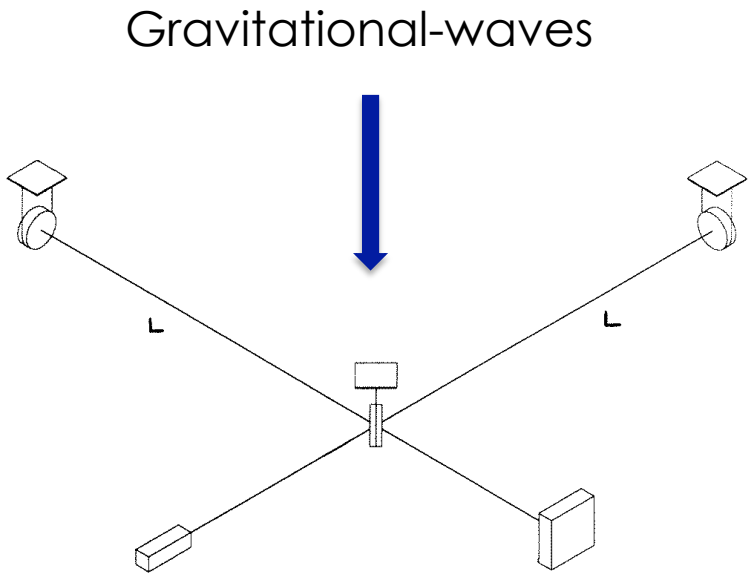
- Lightness
- Perseverance
- Detachment
- Power
- Emptiness
- Clarity
- Openness

Lightness



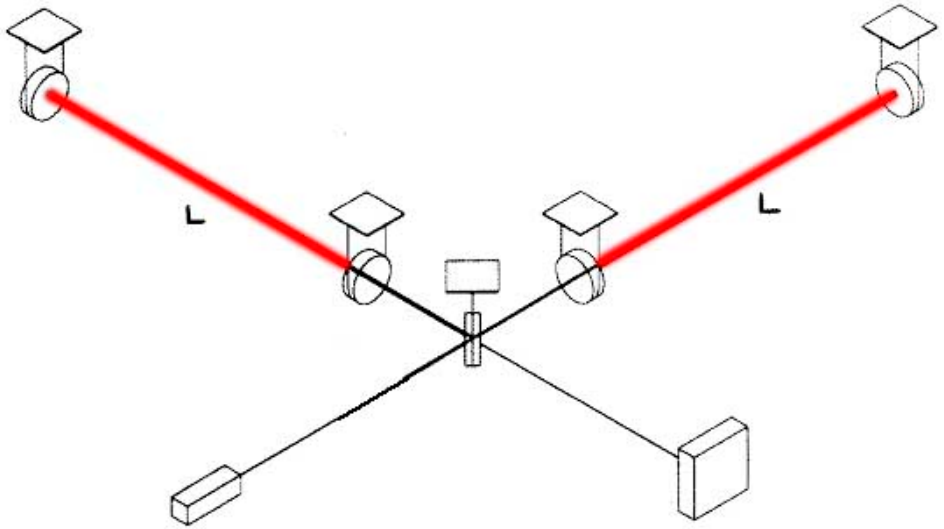
A *Light* detector



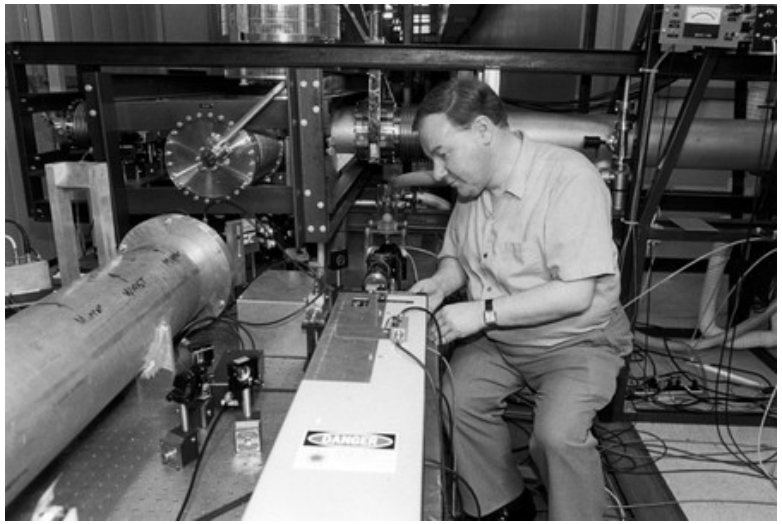


Light is used as a tool to measure the deformation of the spacetime between masses « freely falling »

Manipulate and « trap » the light



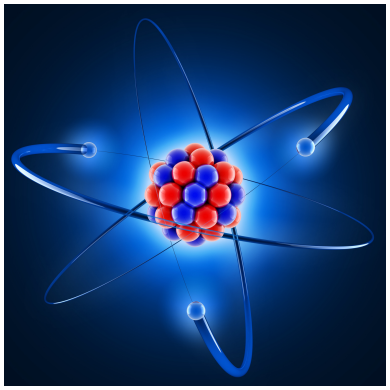
Ron Drever



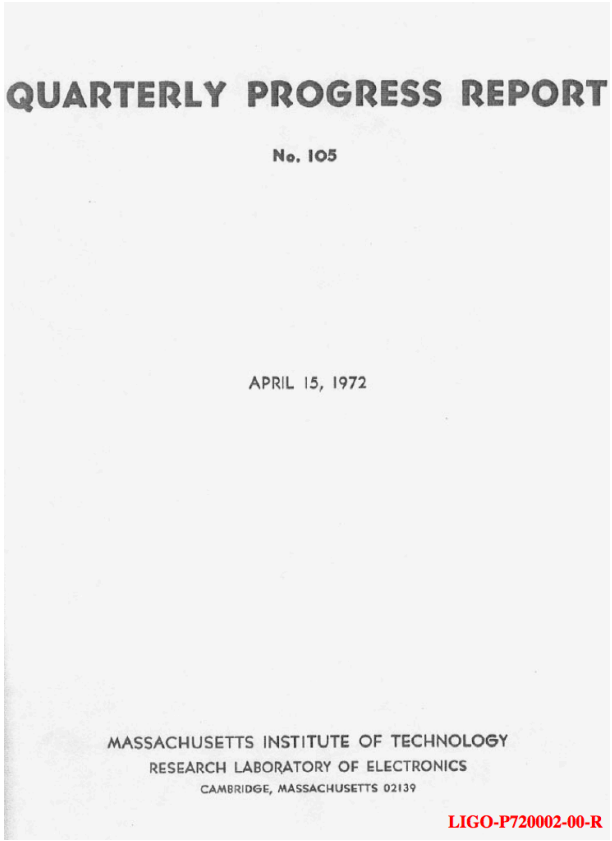
Perseverance

Measuring a variation of 10^{-18} m over 3 km

Equivalent to the size of an atom
over the distance Earth-Sun



Rai Weiss, 1972



QUARTERLY PROGRESS REPORT

No. 105

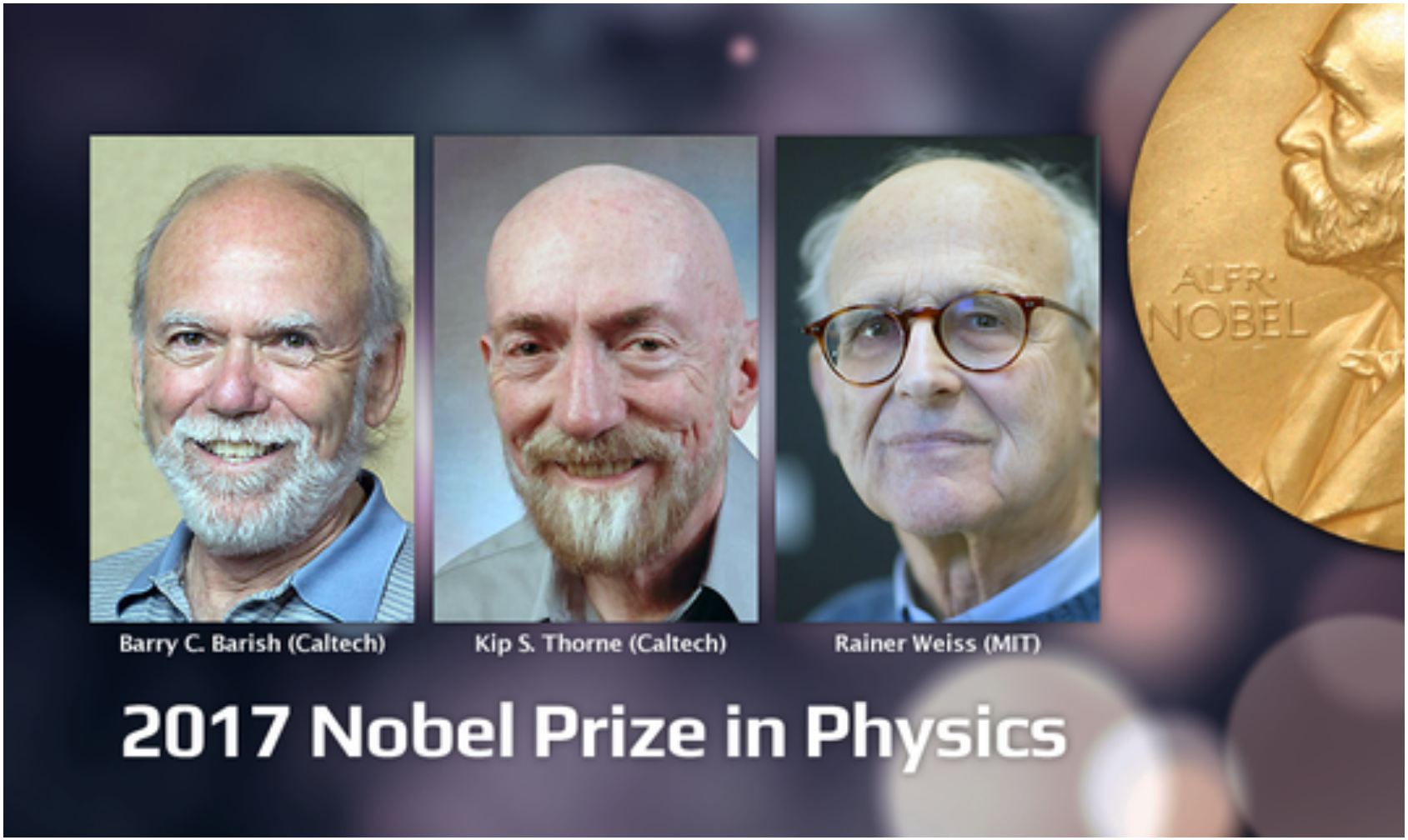
APRIL 15, 1972

MASSACHUSETTS INSTITUTE OF TECHNOLOGY
RESEARCH LABORATORY OF ELECTRONICS
CAMBRIDGE, MASSACHUSETTS 02139

LIGO-P720002-00-R

http://www.sciencemag.org/news/2016/08/meet-college-dropout-who-invented-gravitational-wave-detector

Barish, Thorne, Weiss…and many others



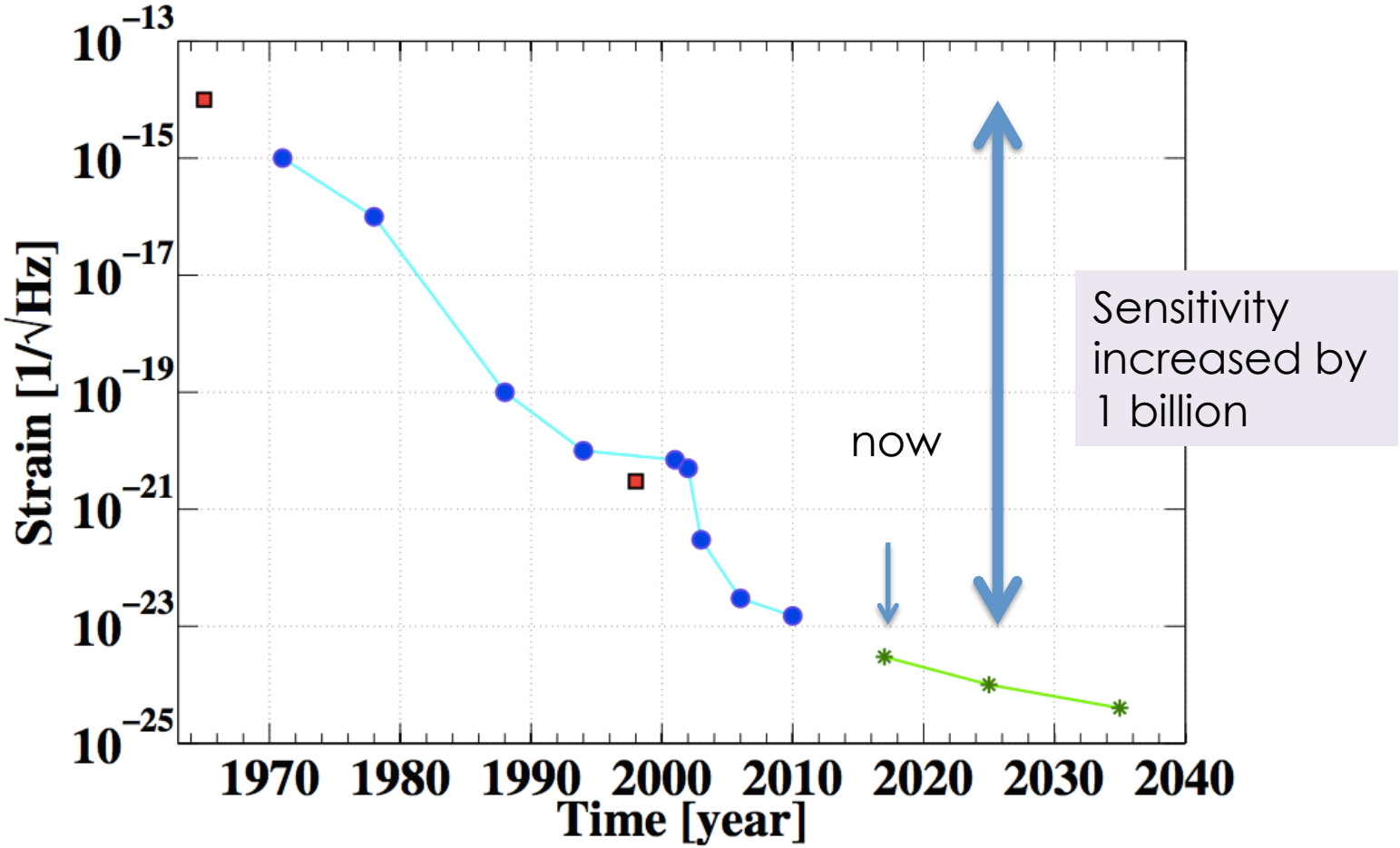
Alain Brillet, Adalberto Giazotto...and many others

Adalberto Giazotto (INFN)

Alain Brillet (CNRS)

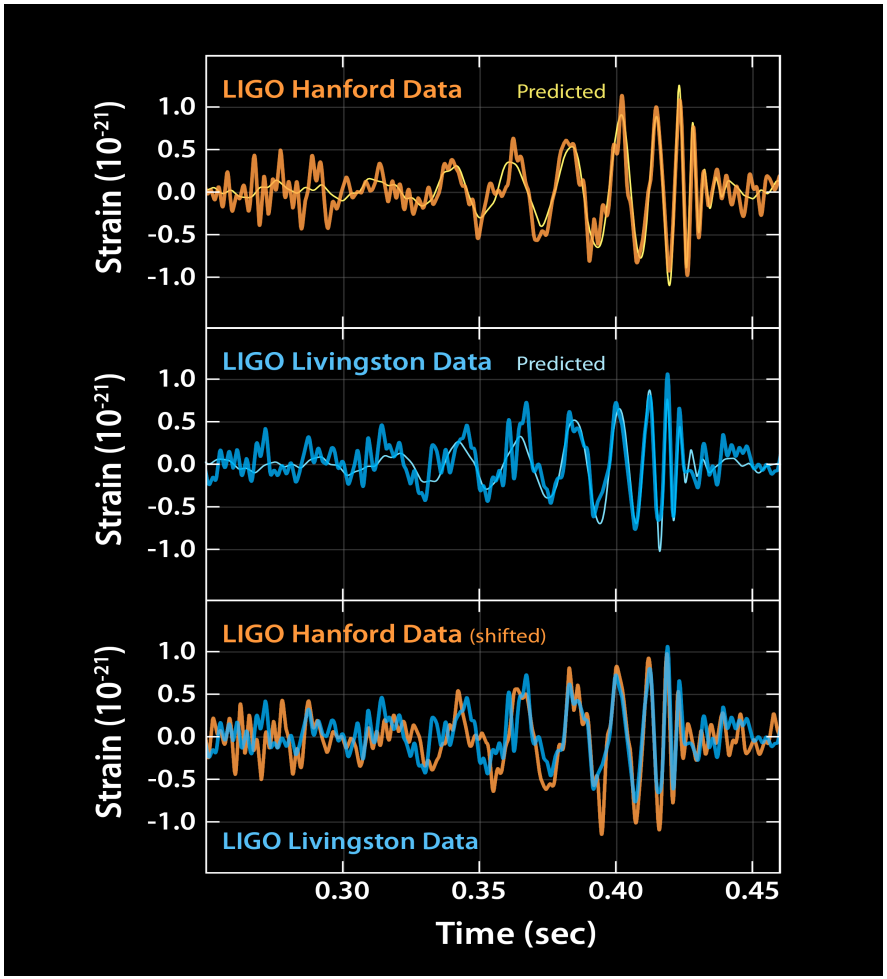
LIGO and Virgo, ~ 2000

The progress in 50 years



R.Adhikari, Gravitational Radiation Detection with Laser Interferometry, arXiv:1305.5188, 2013

14 September 2015: 10^{-18} m

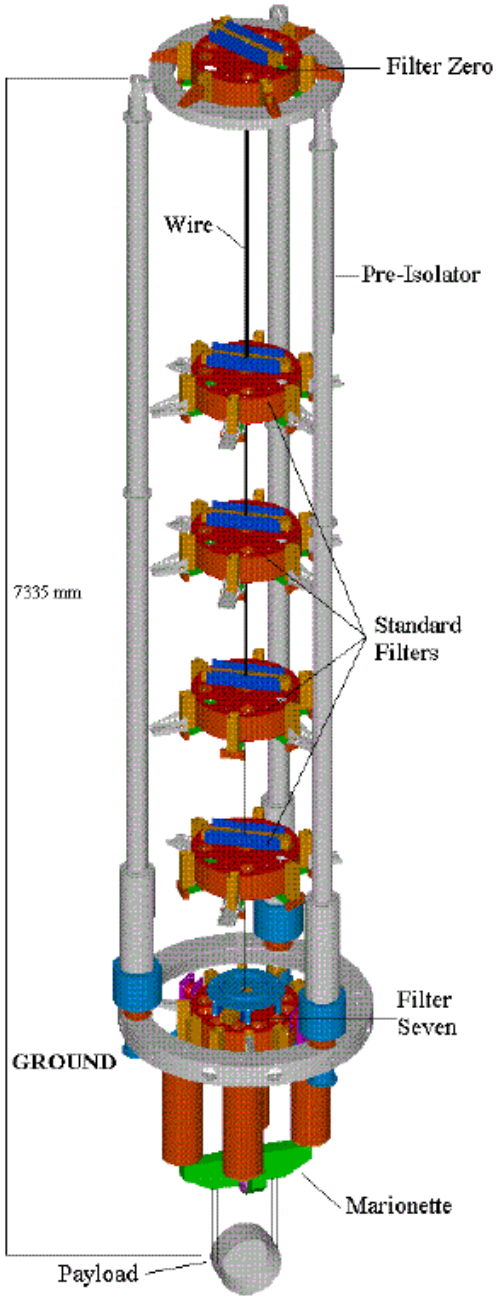


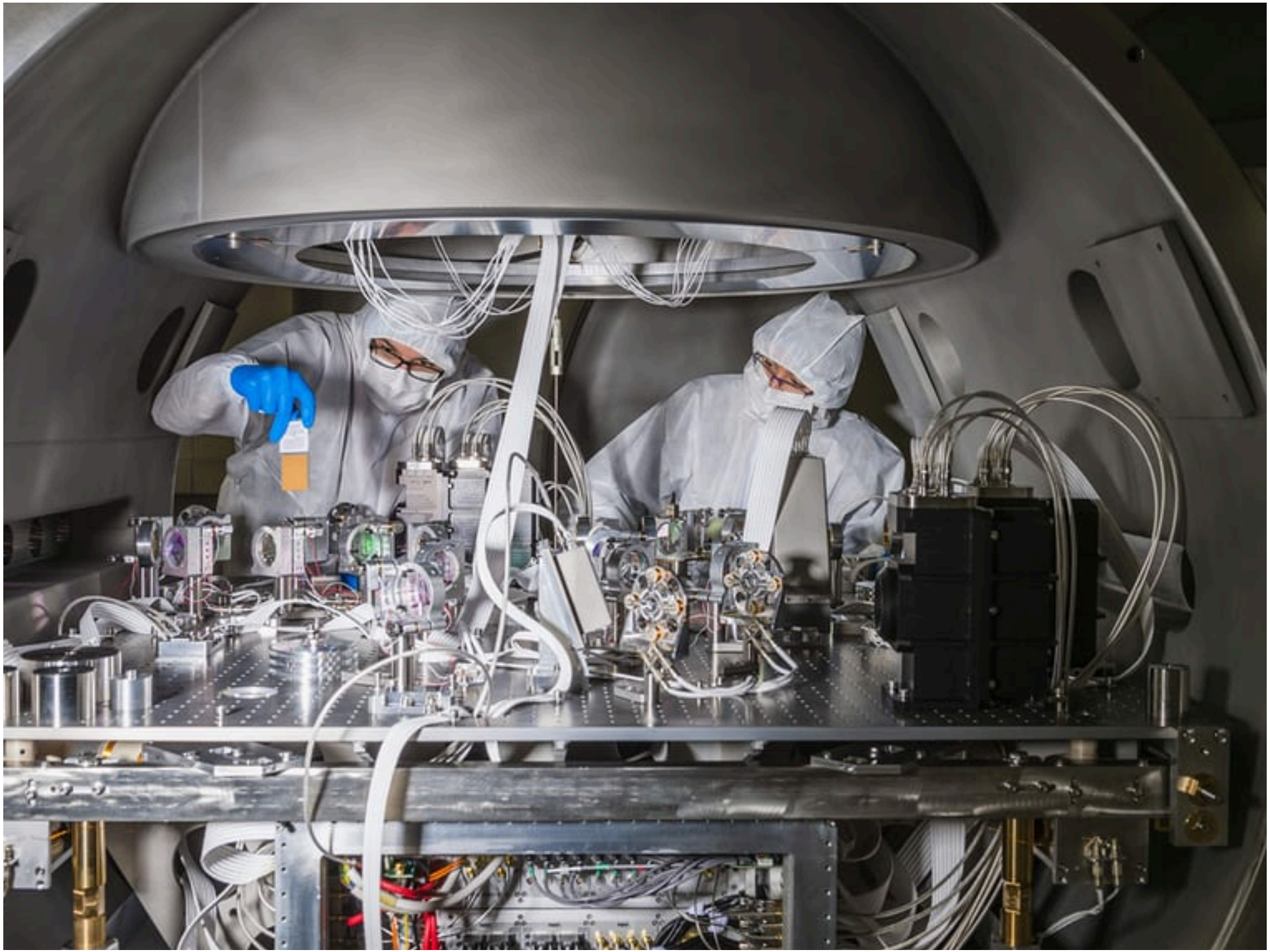
Detachement

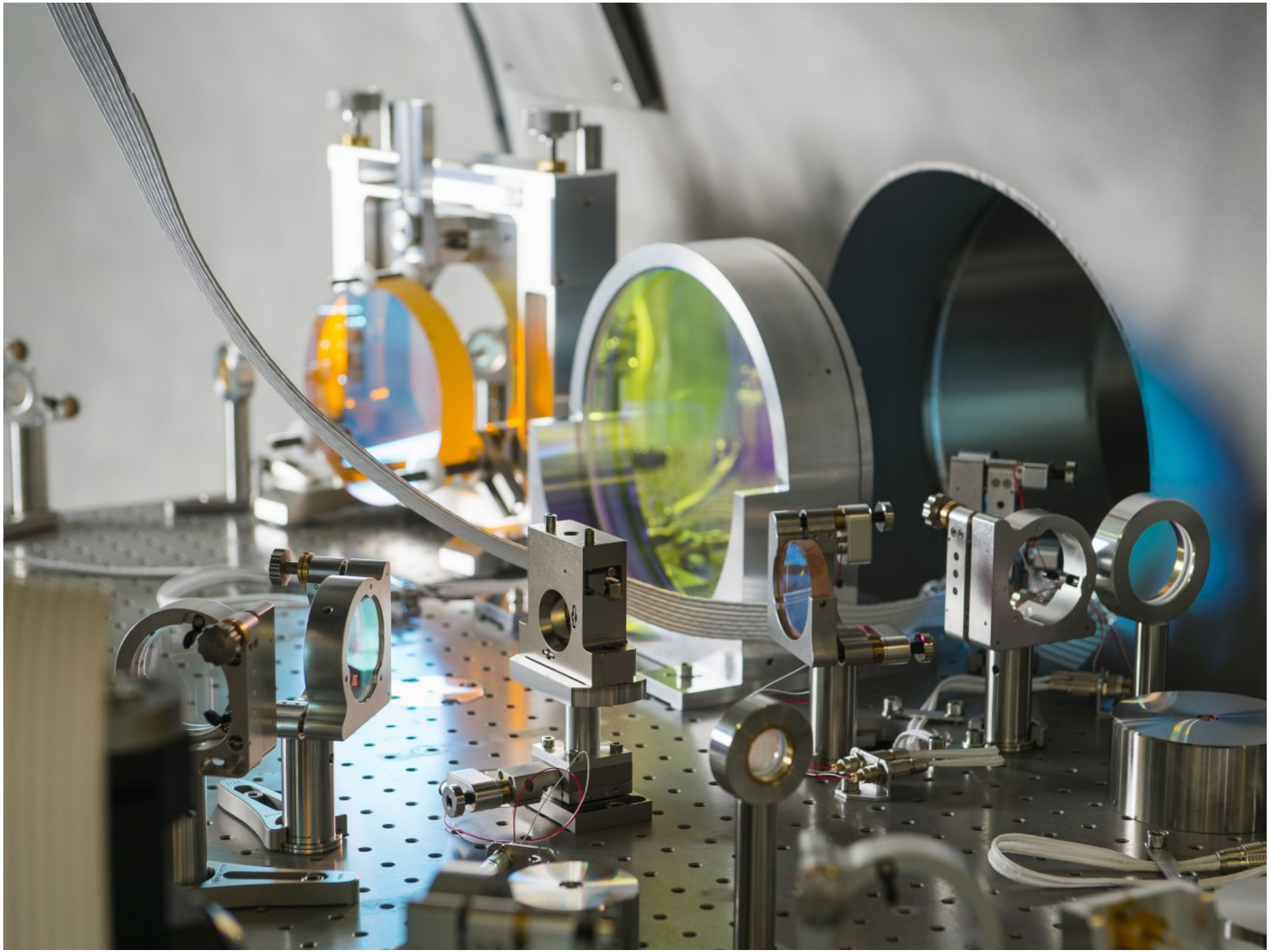
Sensitivity needed
~ 10^{-18} m over 3 km

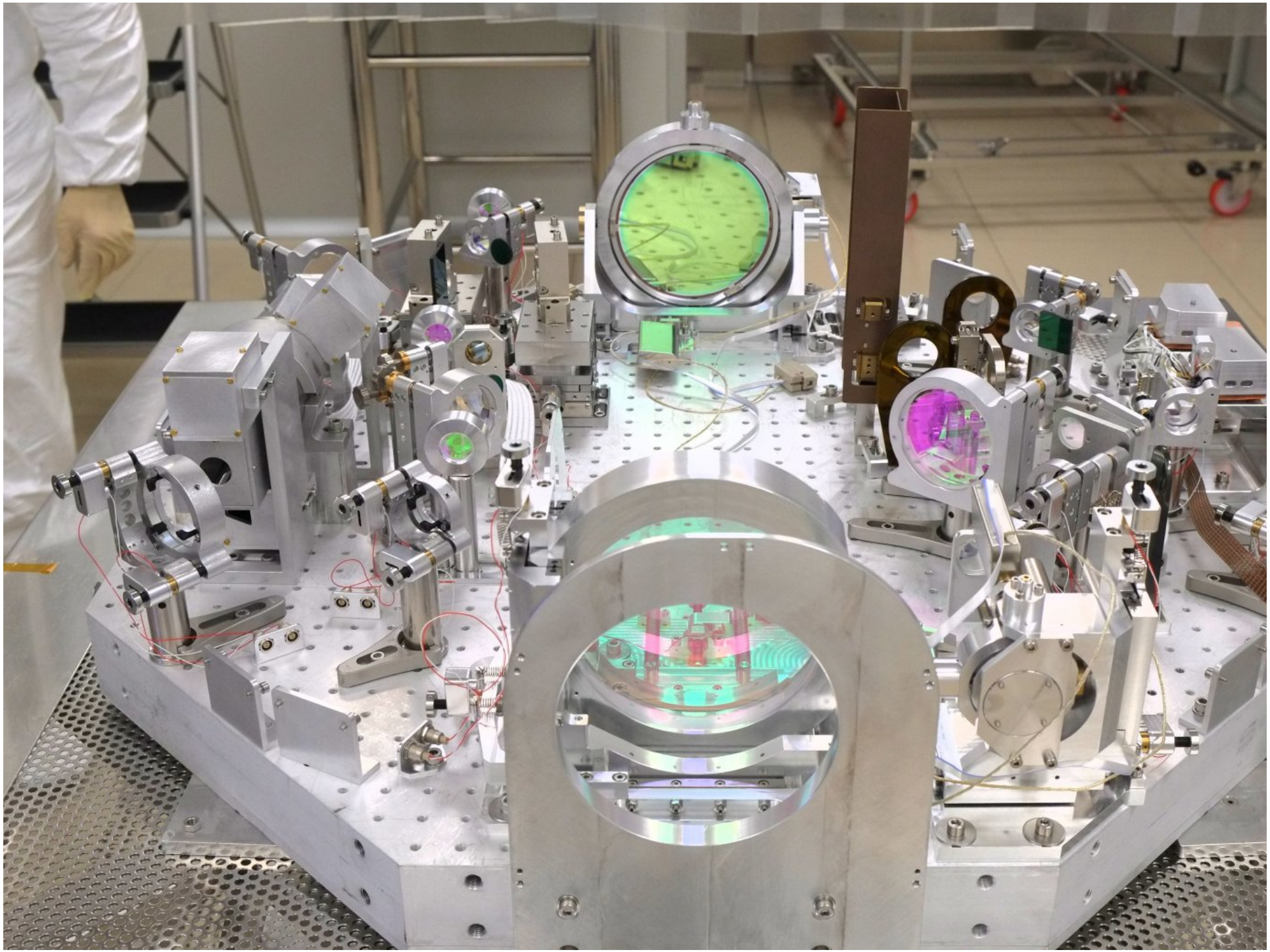
Seismic noise 10^{-6} m (factor 10^{12} to gain)

How to be detached from the Earth being on Earth?


Filter Zero
Wire
Pre-Isolator
7335 mm
Standard
Filters
Filter
Seven
GROUND
Marionette
Payload





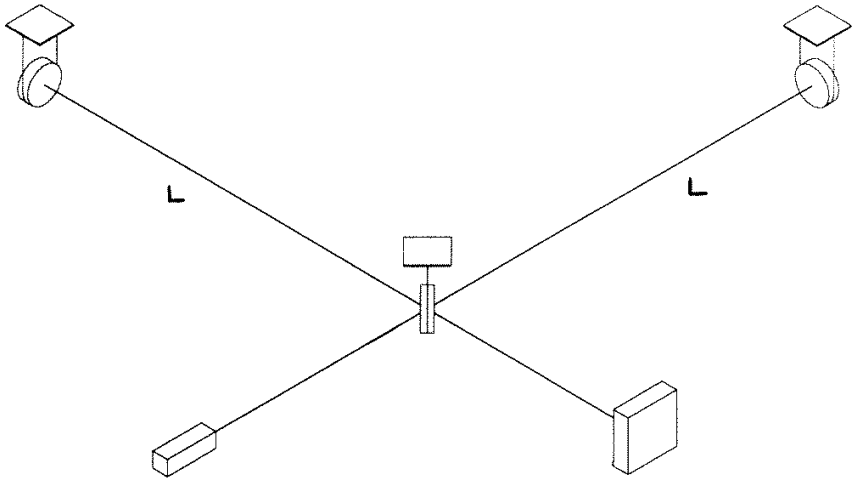


Power

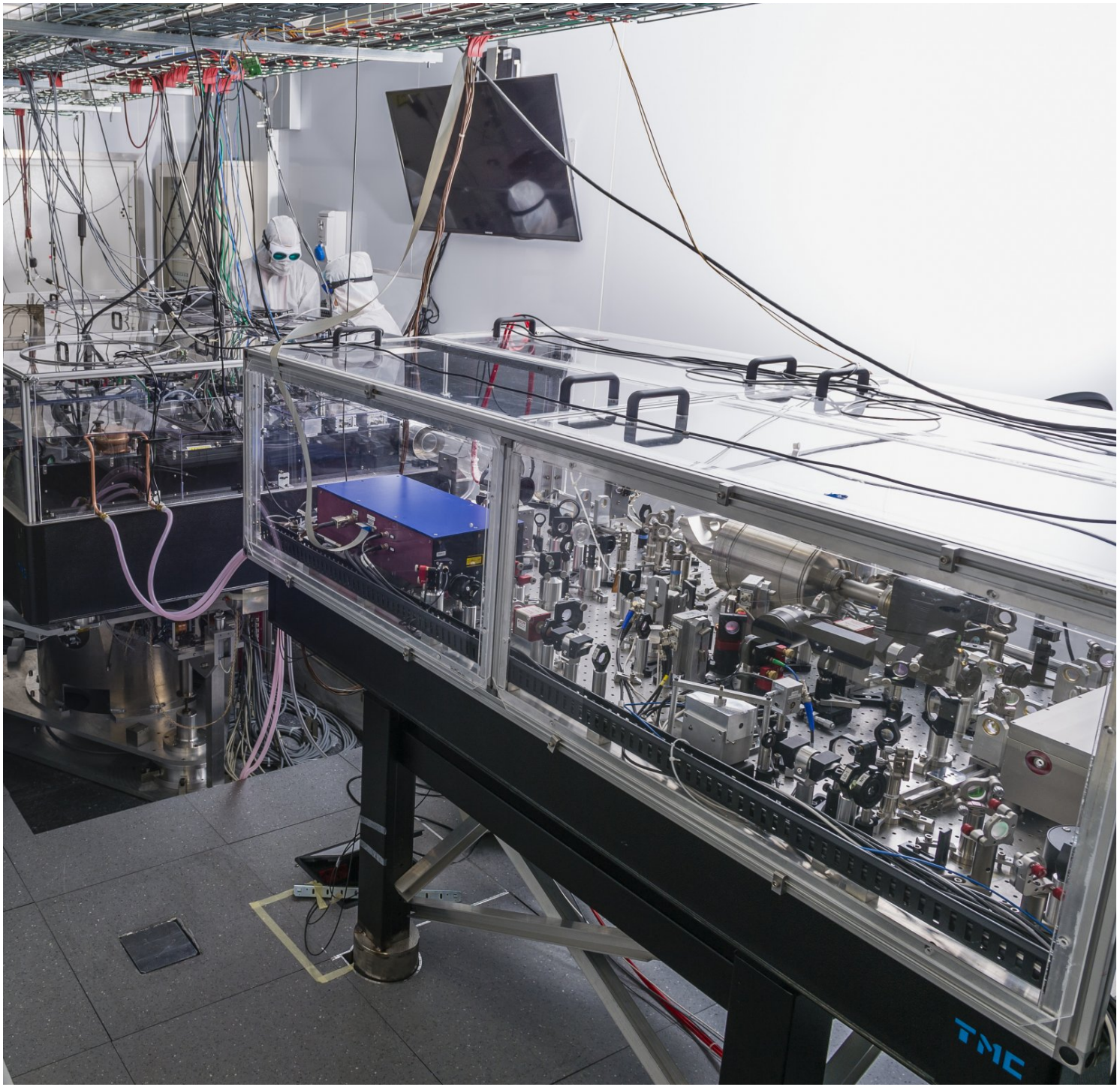
High power lasers

More photons (more power), less impact of the single photon time arrival randomness

- Photon counting noise, or *shot noise*
- *High power Laser*



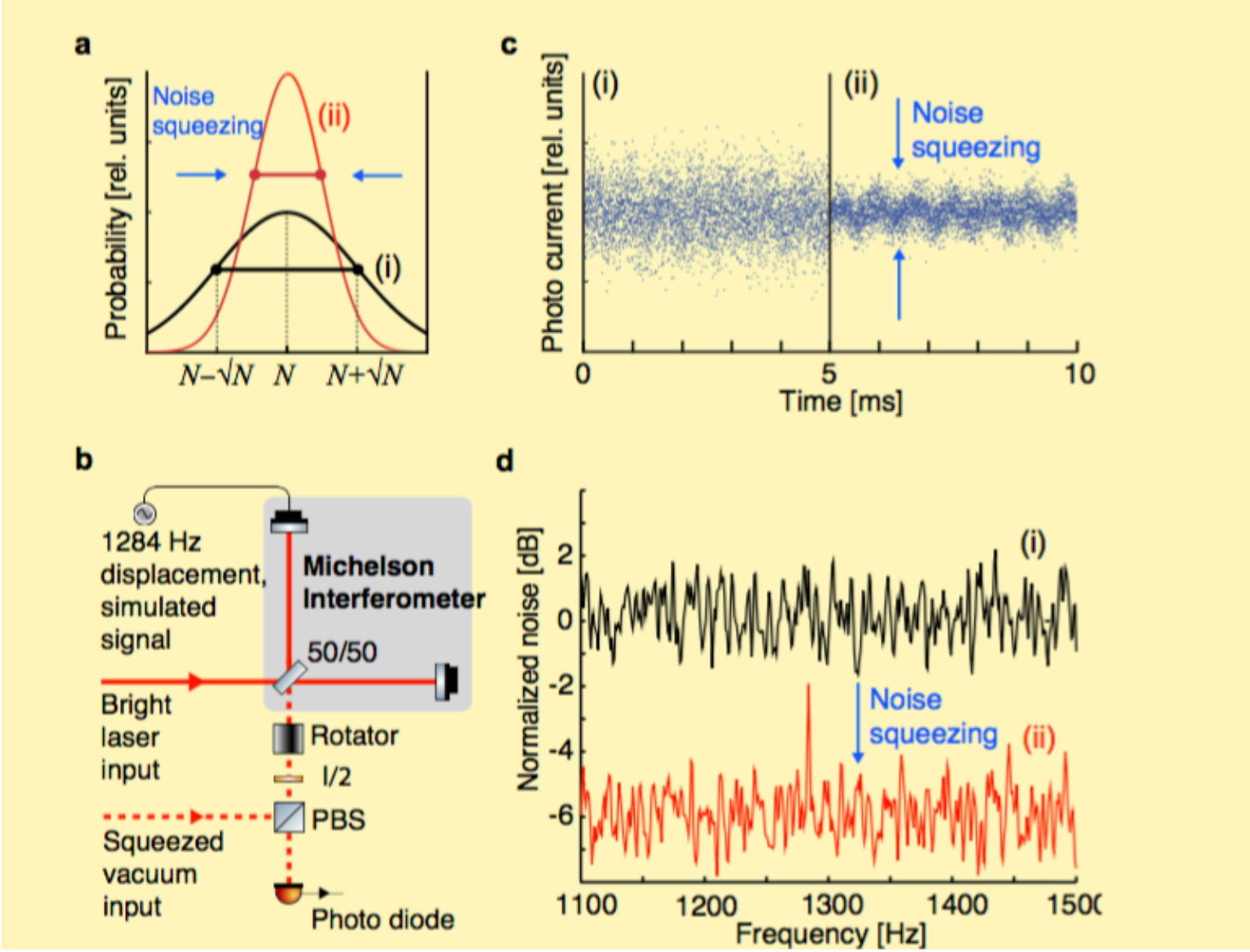
$$\frac{S}{N} \propto \frac{N}{\sqrt{N}}$$


TMC

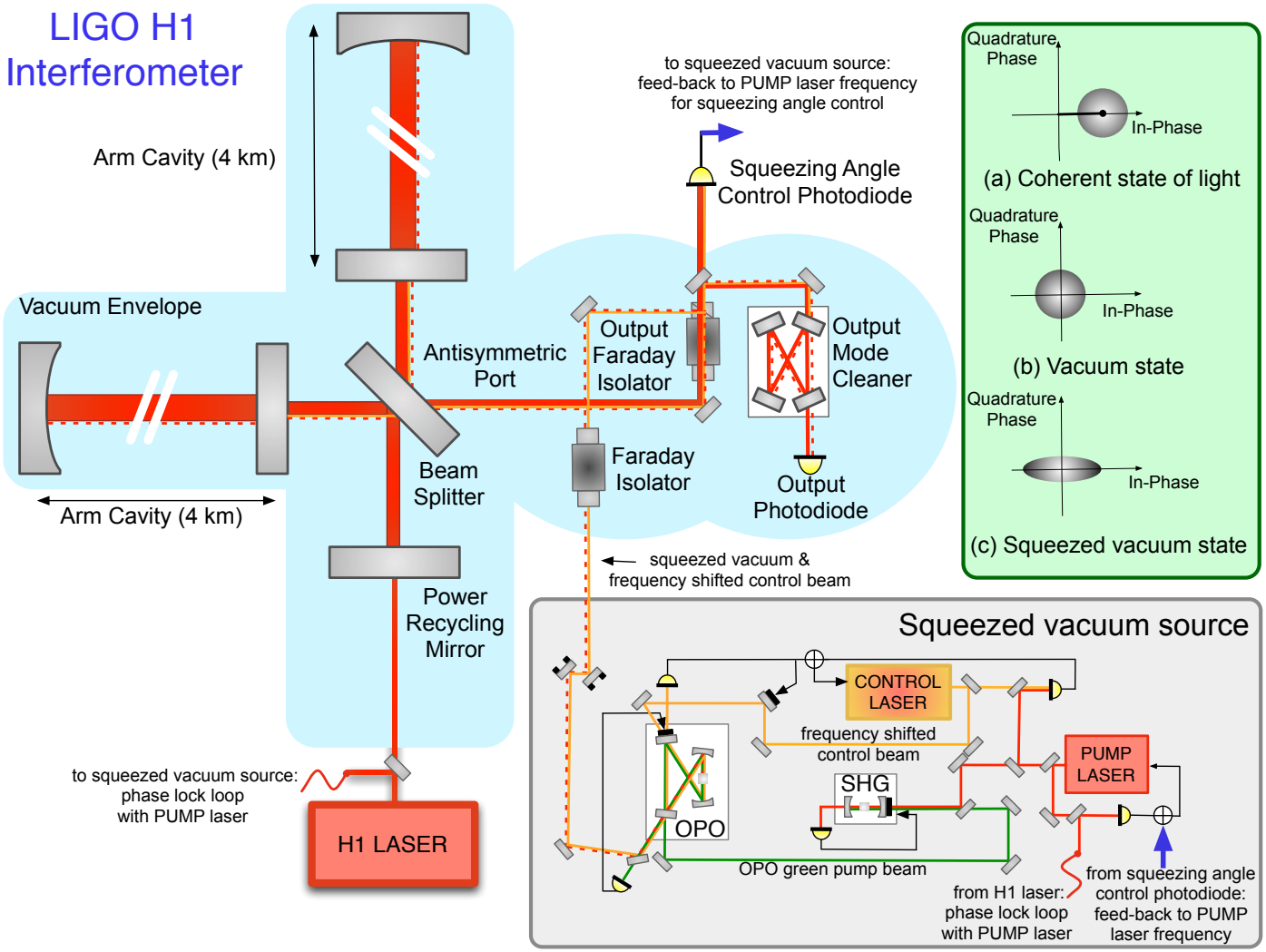
Emptiness

Pumping out the air

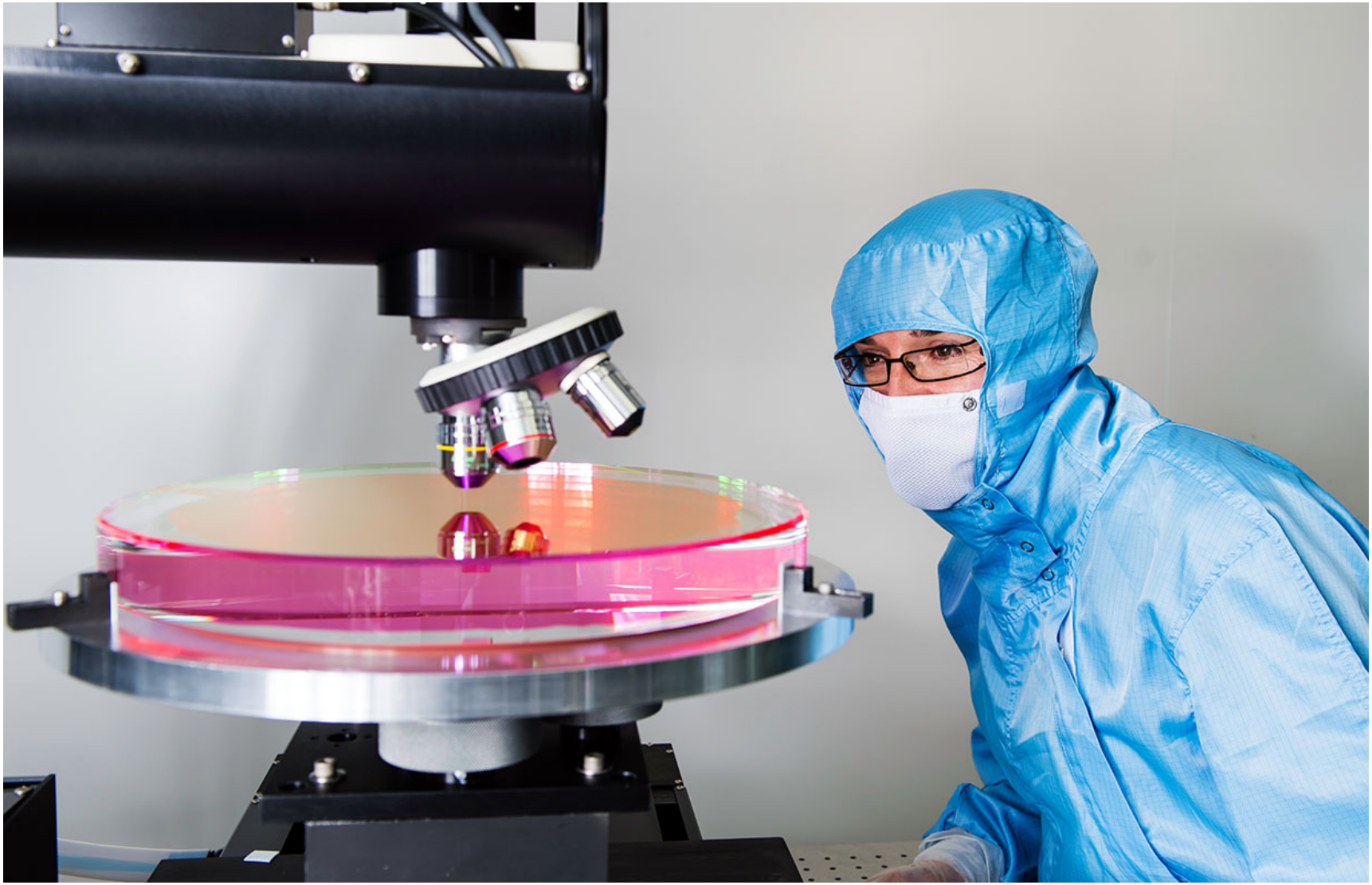
Injecting the (squeezed) vacuum

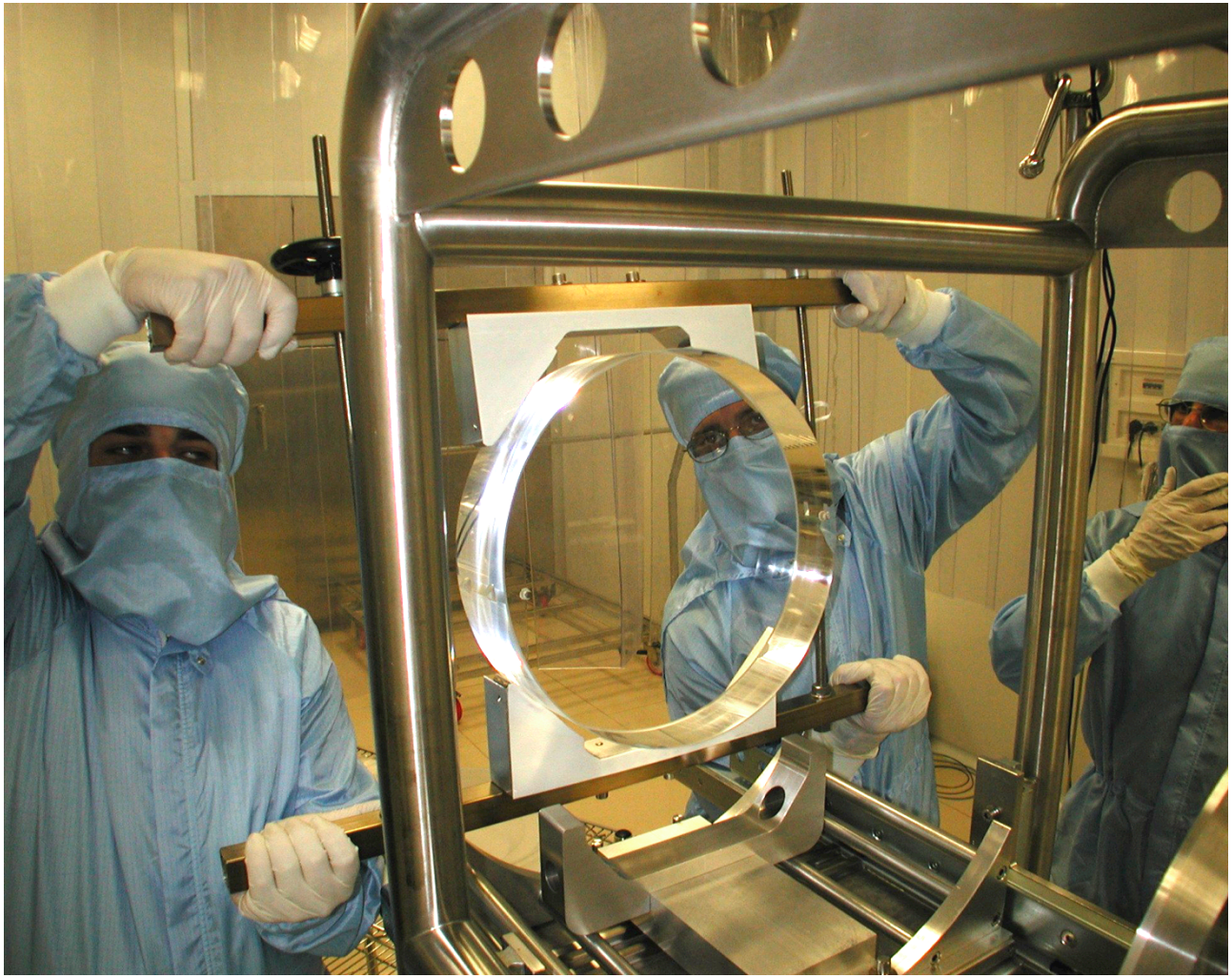


Injecting the (squeezed) vacuum



Clarity

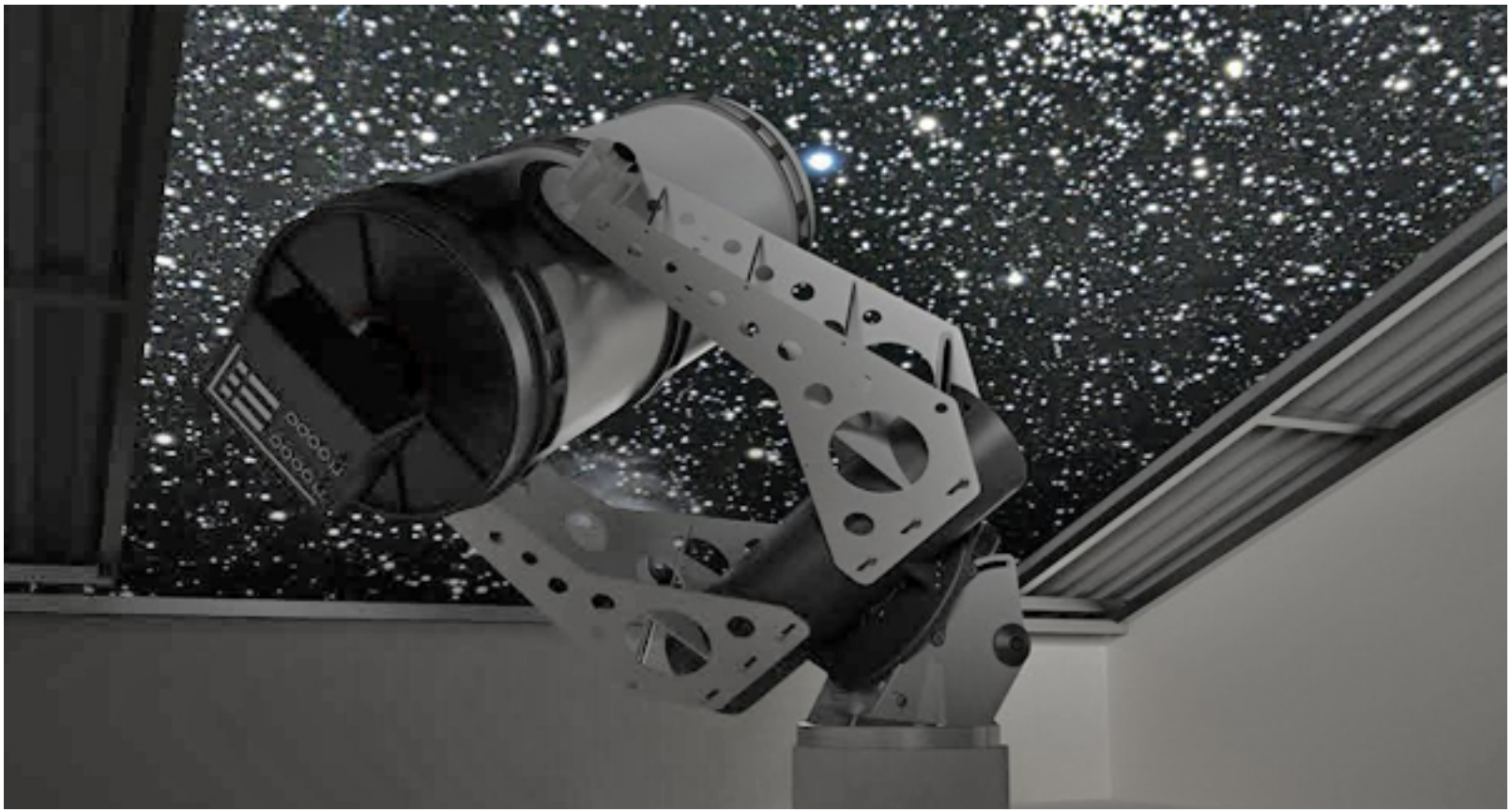




Video about Virgo mirrors:
https://lejournal.cnrs.fr/videos/les-miroirs-les-plus-parfaits-du-monde

Openness

All optical telescopes need to be pointed and need a clear sky and night



Source: wikipedia

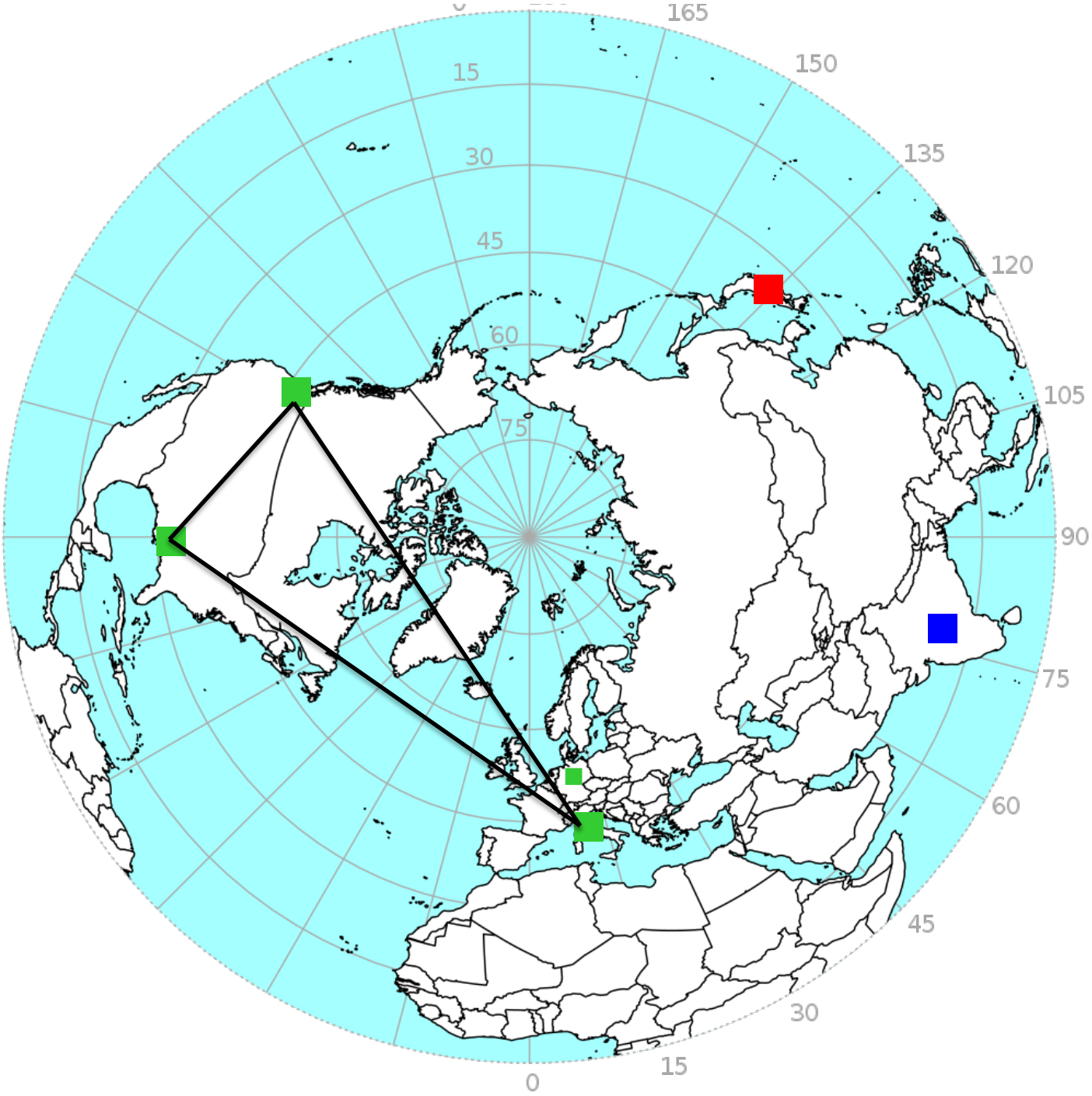
Source: wikipedia

OPERATION

COMMISSIONING

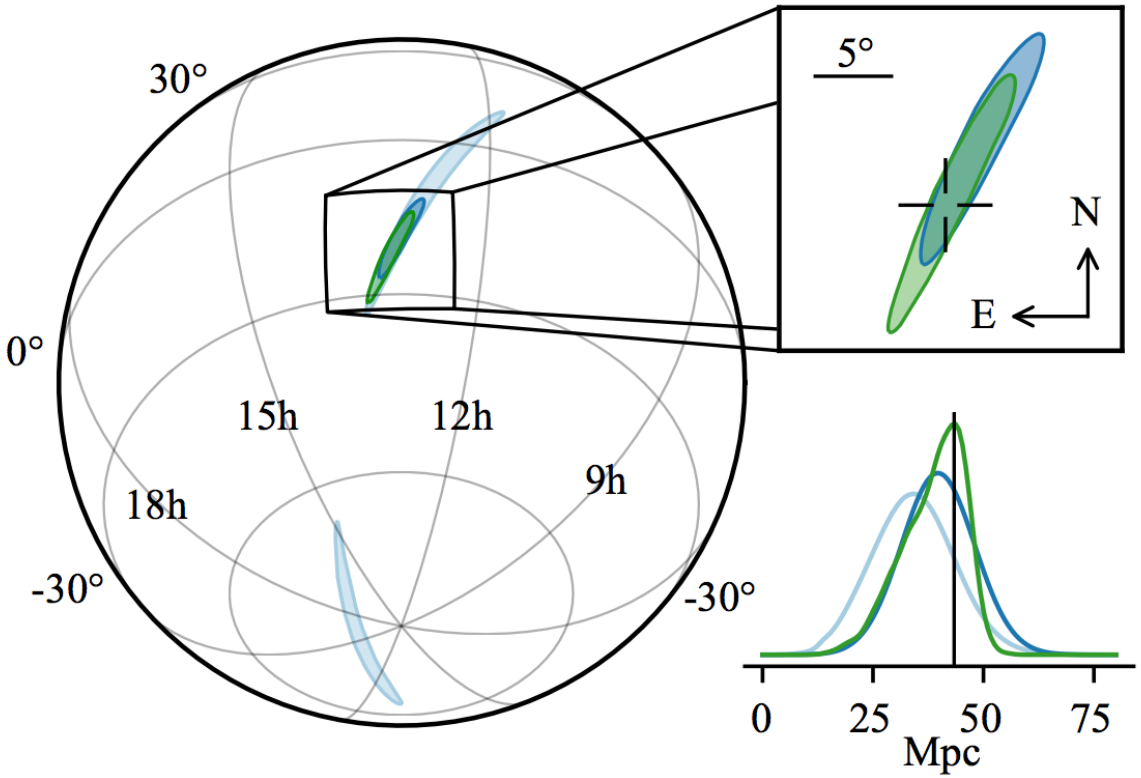
CONSTRUCTION

APPROVED

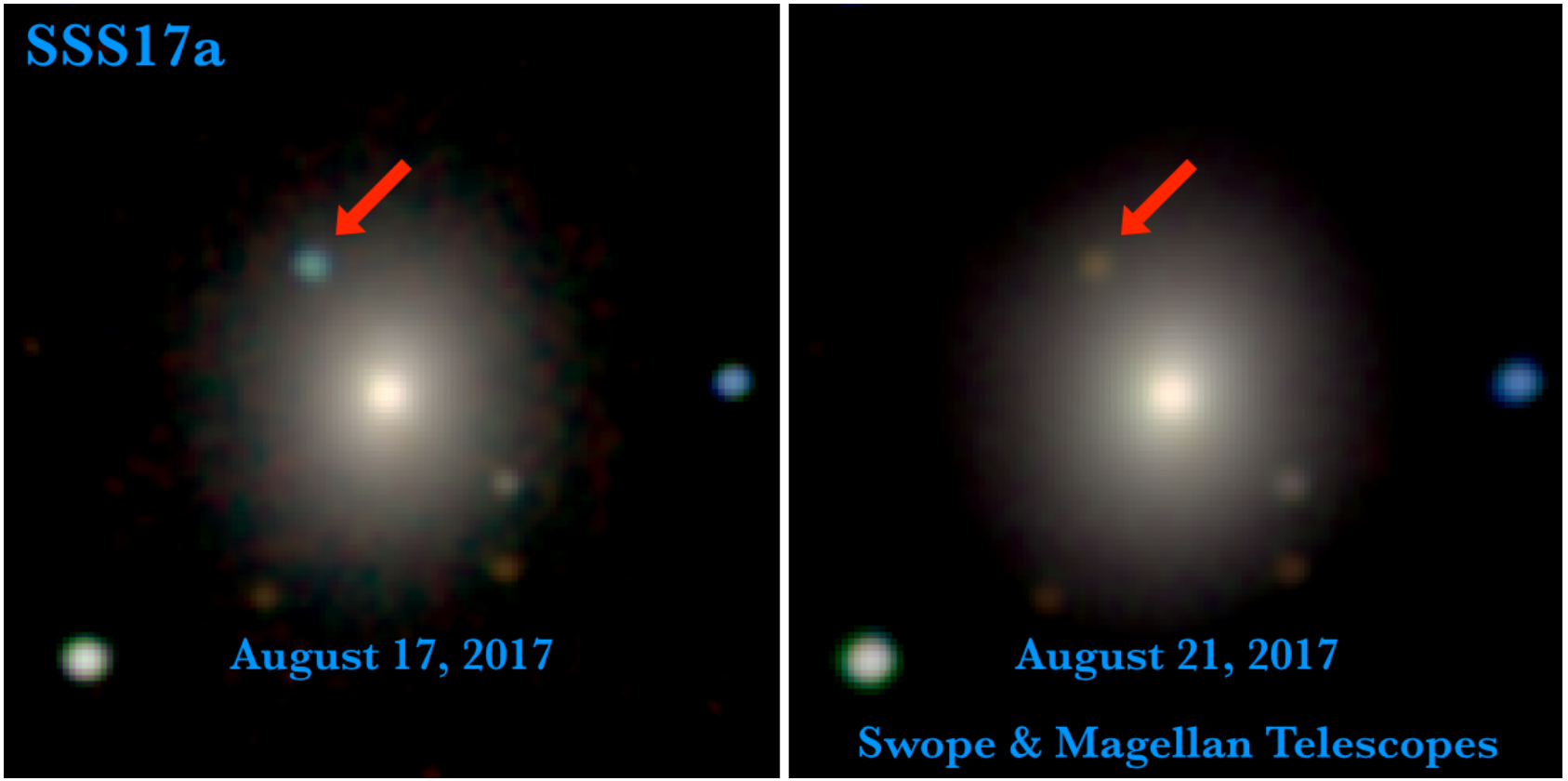


The LIGO-Virgo network observe (almost) the whole sky (almost) all the time

The dream of an astronomer



The kilonova discovery



A last word: Collaboration

B. P. Abbott,[1] R. Abbott,[1] T. D. Abbott,[2] M. R. Abernathy,[1] F. Acernese,[3,4] K. Ackley,[5] C. Adams,[6] T. Adams,[7] P. Addesso,[3] R. X. Adhikari,[1] V. B. Adya,[8] C. Affeldt,[8] M. Agathos,[9] K. Agatsuma,[9] N. Aggarwal,[10] O. D. Aguiar,[11] L. Aiello,[12,13] A. Ain,[14] P. Ajith,[15] B. Allen,[8,16,17] A. Allocca,[18,19] P. A. Altin,[20] S. B. Anderson,[1] W. G. Anderson,[16] K. Arai,[1] M. A. Arain,[5] M. C. Araya,[1] C. C. Arceneaux,[21] J. S. Areeda,[22] N. Arnaud,[23] K. G. Arun,[24] S. Ascenzi,[25,13] G. Ashton,[26] M. Ast,[27] S. M. Aston,[6] P. Astone,[28] P. Aufmuth,[8] C. Aulbert,[8] S. Babak,[29] P. Bacon,[30] M. K. M. Bader,[9] P. T. Baker,[31] F. Baldaccini,[32,33] G. Ballardin,[34] S. W. Ballmer,[35] J. C. Barayoga,[1] S. E. Barclay,[36] B. C. Barish,[1] D. Barker,[37] F. Barone,[3,4] B. Barr,[36] L. Barsotti,[10] M. Barsuglia,[30] D. Barta,[38] J. Bartlett,[37] M. A. Barton,[37] I. Bartos,[39] R. Bassiri,[40] A. Basti,[18,19] J. C. Batch,[37] C. Baune,[8] V. Bavigadda,[34] M. Bazzan,[41,42] B. Behnke,[29] M. Bejger,[43] C. Belczynski,[44] A. S. Bell,[36] C. J. Bell,[36] B. K. Berger,[1] J. Bergman,[37] G. Bergmann,[8] C. P. L. Berry,[45] D. Bersanetti,[46,47] A. Bertolini,[9] J. Betzwieser,[6] S. Bhagwat,[35] R. Bhandare,[48] I. A. Bilenko,[49] G. Billingsley,[1] J. Birch,[6] R. Birney,[50] O. Birnholtz,[8] S. Biscans,[10] A. Bisht,[8,17] M. Bitossi,[34] C. Biwer,[35] M. A. Bizouard,[23] J. K. Blackburn,[1] C. D. Blair,[51] D. G. Blair,[51] R. M. Blair,[37] S. Bloemen,[52] O. Bock,[8] T. P. Bodiya,[10] M. Boer,[53] G. Bogaert,[53] C. Bogan,[8] A. Bohe,[29] P. Bojtos,[54] C. Bond,[45] F. Bondu,[55] R. Bonnand,[7] B. A. Boom,[9] R. Bork,[1] V. Boschi,[18,19] S. Bose,[56,14] Y. Bouffanais,[30] A. Bozzi,[34] C. Bradaschia,[19] P. R. Brady,[16] V. B. Braginsky,[49] M. Branchesi,[57,58] J. E. Brau,[59] T. Briant,[60] A. Brillet,[53] M. Brinkmann,[8] V. Brisson,[23] P. Brockill,[16] A. F. Brooks,[1] D. A. Brown,[35] D. D. Brown,[45] N. M. Brown,[10] C. C. Buchanan,[2] A. Buikema,[10] T. Bulik,[44] H. J. Bulten,[61,9] A. Buonanno,[29,62] D. Buskulic,[7] C. Buy,[30] R. L. Byer,[40] M. Cabero,[8] L. Cadonati,[63] G. Cagnoli,[64,65] C. Cahillane,[1] J. Calderón Bustillo,[66,63] T. Callister,[1] E. Calloni,[67,4] J. B. Camp,[68] K. C. Cannon,[69] J. Cao,[70] C. D. Capano,[8] E. Capocasa,[30] F. Carbognani,[34] S. Caride,[71] J. Casanueva Diaz,[23] C. Casentini,[25,13] S. Caudill,[16] M. Cavaglià,[21] F. Cavalier,[23] R. Cavalieri,[34] G. Cella,[19] C. B. Cepeda,[1] L. Cerboni Baiardi,[57,58] G. Cerretani,[18,19] E. Cesarini,[25,13] R. Chakraborty,[1] T. Chalermsongsak,[1] S. J. Chamberlin,[72] M. Chan,[36] S. Chao,[73] P. Charlton,[74] E. Chassande-Mottin,[30] H. Y. Chen,[75] Y. Chen,[76] C. Cheng,[73] A. Chincarini,[47] A. Chiummo,[34] H. S. Cho,[77] M. Cho,[62] J. H. Chow,[20] N. Christensen,[78] Q. Chu,[51] S. Chua,[60] S. Chung,[51] G. Ciani,[5] F. Clara,[37] J. A. Clark,[63] F. Cleva,[53] E. Coccia,[25,12,13] P.-F. Cohadon,[60] A. Colla,[79,28] C. G. Collette,[80] L. Cominsky,[81] M. Constancio Jr.,[11] A. Conte,[79,28] L. Conti,[42] D. Cook,[37] T. R. Corbitt,[2] N. Cornish,[31] A. Corsi,[71] S. Cortese,[34] C. A. Costa,[11] M. W. Coughlin,[78] S. B. Coughlin,[82] J.-P. Coulon,[53] S. T. Countryman,[39] P. Couvares,[1] E. E. Cowan,[63] D. M. Coward,[51] M. J. Cowart,[6] D. C. Coyne,[1] R. Coyne,[71] K. Craig,[36] J. D. E. Creighton,[16] T. D. Creighton,[83] J. Cripe,[2] S. G. Crowder,[84] A. M. Cruise,[45] A. Cumming,[36] L. Cunningham,[36] E. Cuoco,[34] T. Dal Canton,[8] S. L. Danilishin,[36] S. D'Antonio,[13] K. Danzmann,[17,8] N. S. Darman,[85] C. F. Da Silva Costa,[5] V. Dattilo,[34] I. Dave,[48]

More than 1000 members

Thank you