QUANTUM LAB

Quantum Information Lab
Dipartimento di Fisica, Università di Roma La Sapienza

SAPIENZA
UNIVERSITÀ DI ROMA

ERC grant: from first attempts to "Unexpected" Impact

Fabio Sciarrino
Sapienza università di Roma

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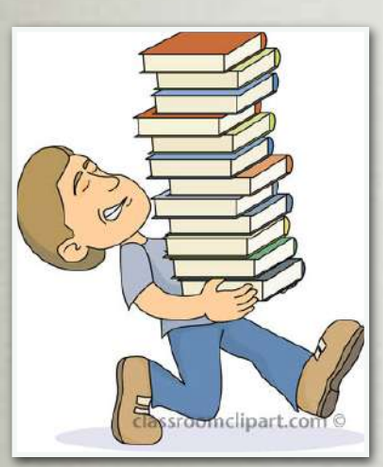
erc

www.quantumlab.it

The Proposal

High risk/High gain

Only criterion: quality of research aiming for excellence



Strong background

The "Idea" Ground-breaking nature

Timely proposal

Show that you are the right PI for your idea (eventually collaboration)

Vision

First: The Attempts without success...

2007 StG - Project HYTEQ - Hybrid Technologies for quantum information (PhD +3)

CV and proposal to be improved..

2009 StG - Project KETLAB - Pocket Quantum Lab

Panel comment: "While the panel is convinced that the proposed research is very likely to go significantly beyond state-of-the-art experiments, it expressed **some reservations regarding the ground-breaking nature of the proposed research**."

2010: StG- Project RISIQO - Rising of quantum dimensionality for loophole free non-locality tests

Panel comment: "The panel found that the proposal was based on original ideas, even if **not fully convinced by all the aspects of the project**. In view of the competition between a very large number of proposals, this project could not be retained."

Don't Give Up!

Loophole-free Bell test

Published: 21 October 2015

Loophole-free Bell inequality violation using electron spins separated by 1.3 kilometres

B. Hensen, H. Bernien, A. E. Dréau, A. Reiserer, N. Kalb, M. S. Blok, J. Ruitenberg, R. F. L. Vermeulen, R. N. Schouten, C. Abellán, W. Amaya, V. Pruneri, M. W. Mitchell, M. Markham, D. J. Twitchen, D. Elkouss, S. Wehner, T. H. Taminiau & R. Hanson ✉

Nature **526**, 682–686 (2015) | Cite this article

Event-Ready Bell Test Using Entangled Atoms Simultaneously Closing Detection and Locality Loopholes

Wenjamin Rosenfeld, Daniel Burchardt, Robert Garthoff, Kai Redeker, Norbert Ortegel, Markus Rau, and Harald Weinfurter

Phys. Rev. Lett. **119**, 010402 – Published 6 July 2017

Featured in Physics | Editors' Suggestion | Open Access

Strong Loophole-Free Test of Local Realism*

Lynden K. Shalm *et al.*

Phys. Rev. Lett. **115**, 250402 – Published 16 December 2015

Letter | Published: 09 May 2018

Challenging local realism with human choices

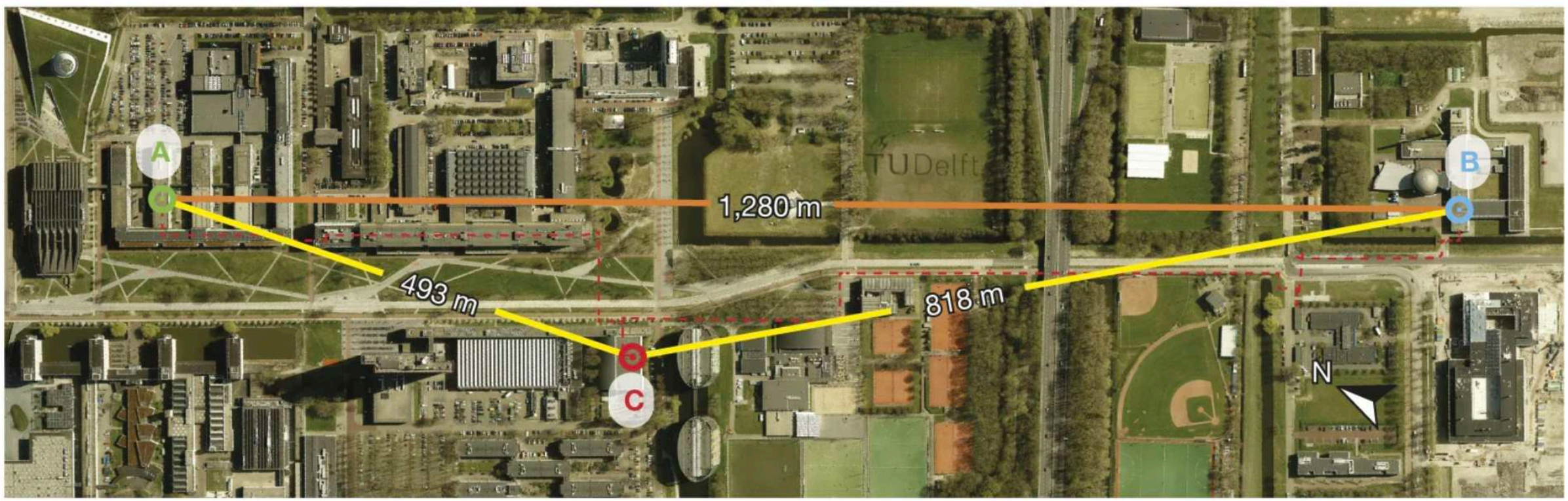
The BIG Bell Test Collaboration

Nature **557**, 212–216 (2018) | Cite this article

Significant-Loophole-Free Test of Bell's Theorem with Entangled Photons

Marissa Giustina, Marijn A. M. Versteegh, Sören Wengerowsky, Johannes Handsteiner, Armin Hochrainer, Kevin Phelan, Fabian Steinlechner, Johannes Kofler, Jan-Åke Larsson, Carlos Abellán, Waldimar Amaya, Valerio Pruneri, Morgan W. Mitchell, Jörn Beyer, Thomas Gerrits, Adriana E. Lita, Lynden K. Shalm, Sae Woo Nam, Thomas Scheidl, Rupert Ursin, Bernhard Wittmann, and Anton Zeilinger

Phys. Rev. Lett. **115**, 250401 – Published 16 December 2015



CV "Improvements"

- Have strong scientific production and expertise

- Show that you can work independently and possibly attitude to leadership

Awards

Medaglia le Scienze & Medaglia Presidenza della Repubblica

Le Scienze
EDIZIONE ITALIANA DI SCIENTIFIC AMERICAN

Award Sapienza Ricerca

SAPIENZA
UNIVERSITÀ DI ROMA

New collaborations

Invited talks at international conference

To increase international and independent collaborations

Support from Sapienza to increase international participation to conferences and workshops for grant application

Publications without PhD supervisor

First publications as last author

Patent

Grants

PI of project FIRB Futuro in Ricerca (350.000 €)

PI Sapienza project (20.000 €)

Local coordinator of European project on photonics (350.000 €)

FUTURO IN RICERCA

SAPIENZA
UNIVERSITÀ DI ROMA

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The Key Ingredient:

The IDEA

Strong commitment to setup the proposal
my own experience
to conceive the project: 1-2 months
to prepare the proposal: 1-2 months

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Some tips:

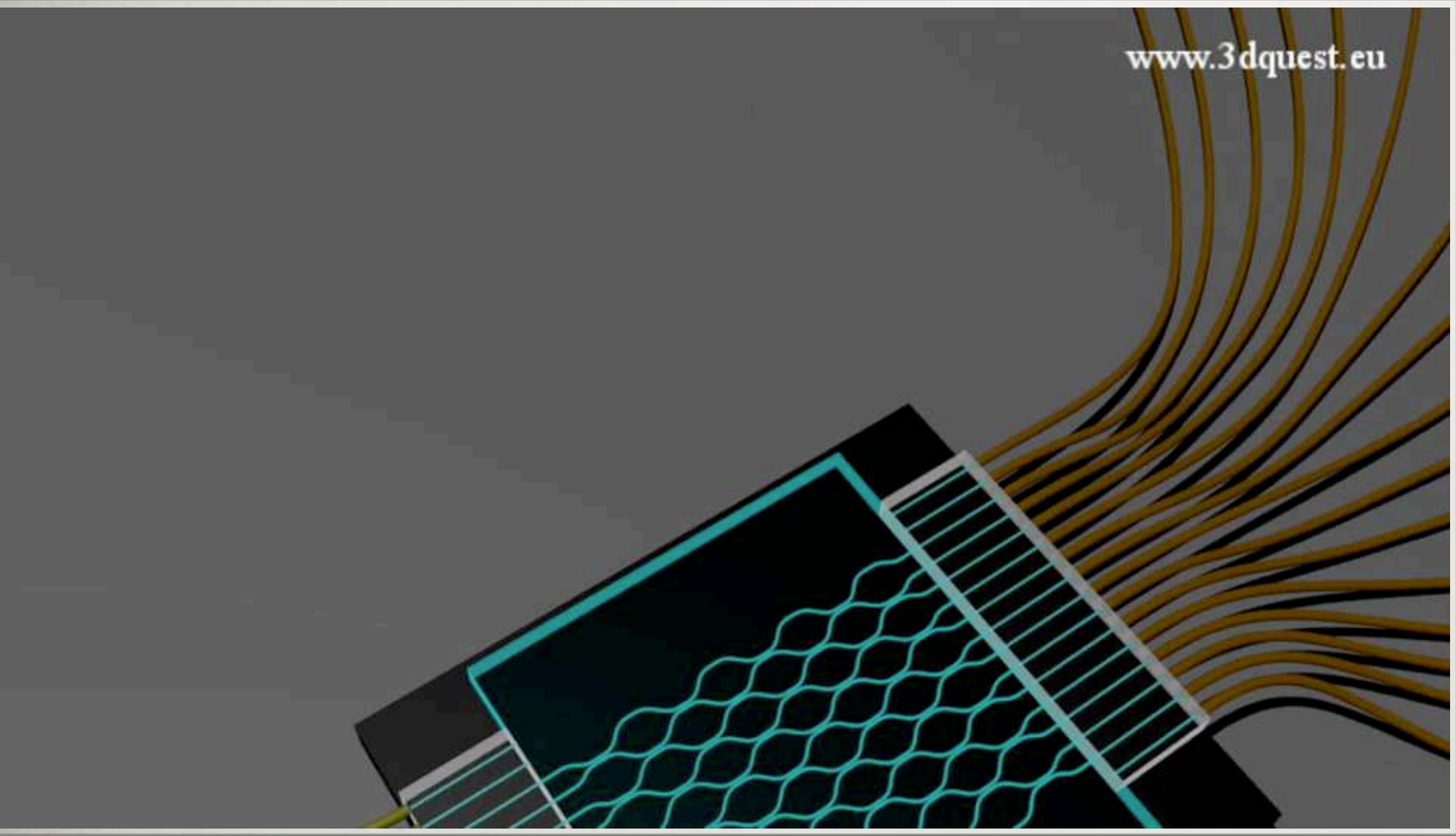
- to check on ERC website previously funded projects and PIs

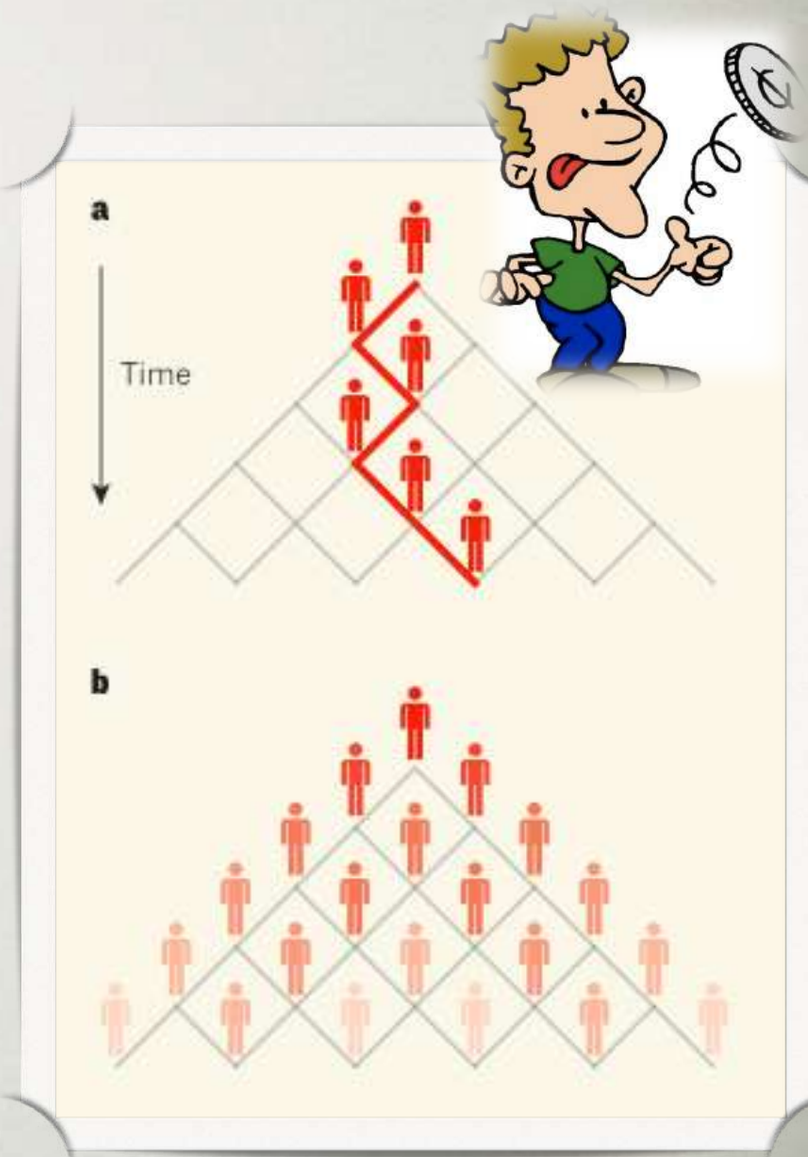
- strong attention in preparation of B1 and B2

3D-Quantum Integrated Optical Simulation (3D-QUEST)

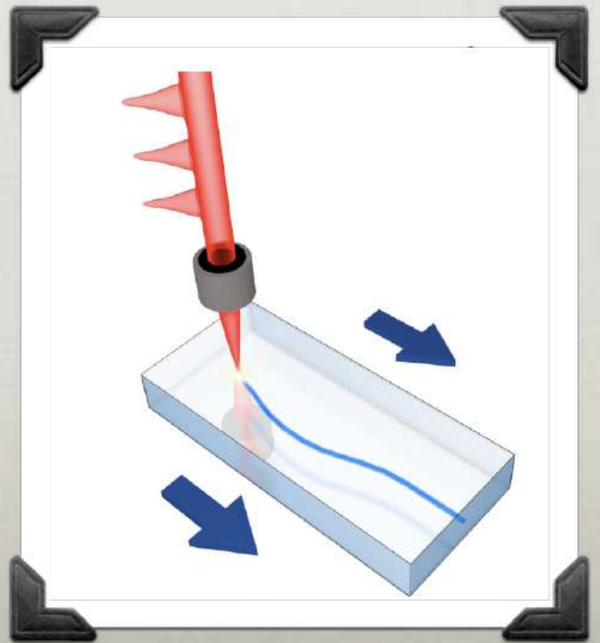
GOAL: to develop photonic integrated *hardware* for quantum simulation

Quantum Simulation via Photons on a chip





in partnership with



Some Extracts from the proposal

A key goal:

ambitious, well identified, with a clear vision

Quantum optics represents an excellent experimental test bench for various novel concepts introduced within the framework of QI theory. However the realization of complex interferometric optical schemes consisting of many elements requires the introduction of waveguide technology to achieve the desired scalability, stability and miniaturization of the devices.

The aim of 3D-QUEST is to develop and implement quantum simulation by exploiting 3-dimensional integrated photonic circuits. The two key elements are:

A. Quantum information processing: *to show that linear optics without adaptive measurements possesses computational power beyond that of classical computers*

Such "hard-to-simulate" scenario is disclosed when multiphoton-multimode platforms are realized.

B. Quantum technologies: *to develop new platform for integrated photonics*

Such a research program can be carried out by assessing a new optical quantum technology which takes advantage of the results recently obtained with integrated waveguides.

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WARNING!

- avoid vague project

- avoid incremental proposals (high gain/high risk)

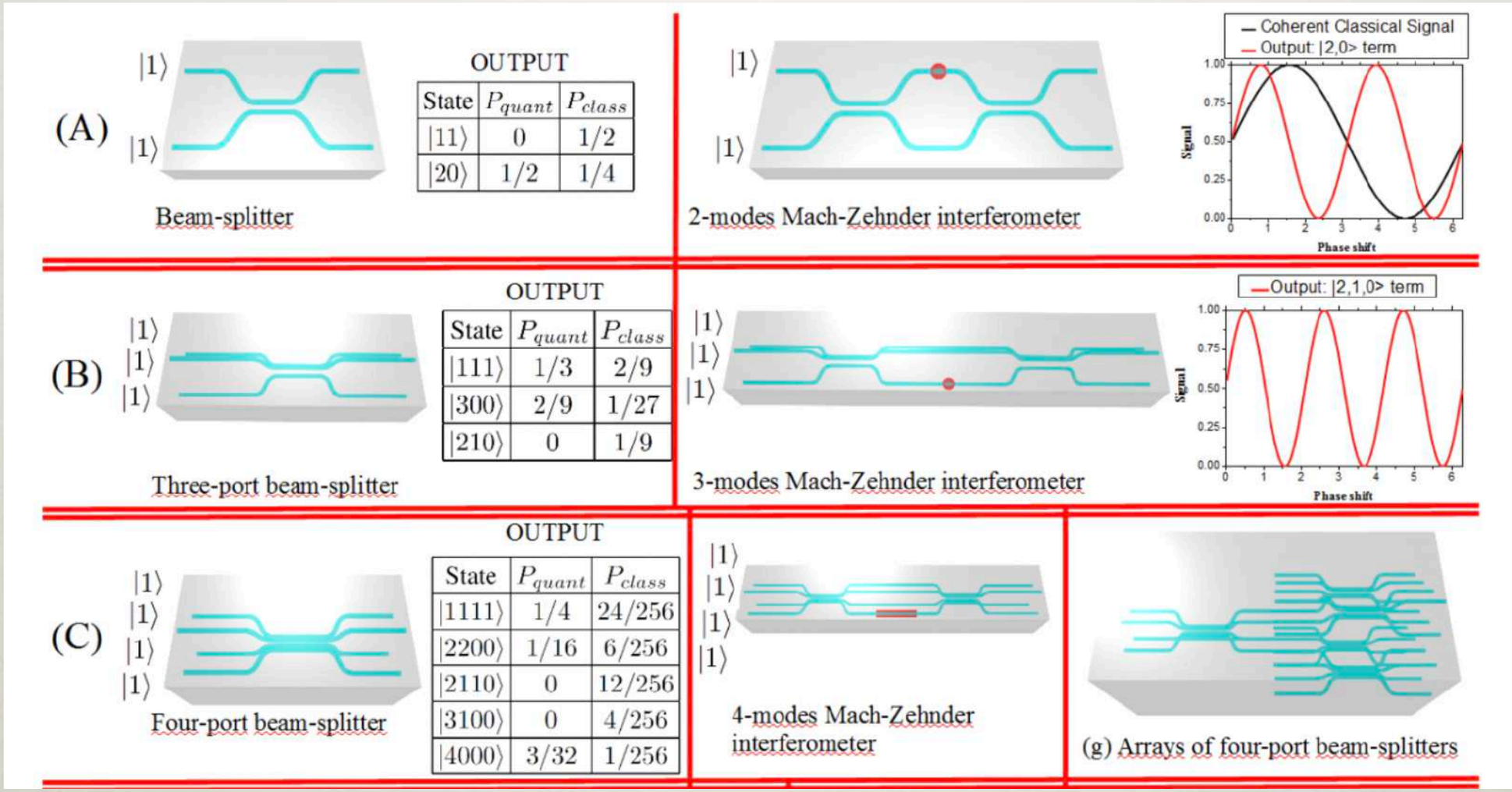
- easy to read

- right balancement between ambition and feasibility

- preliminary results, clear structure, contingency plan

Some Extracts from the proposal

Balancement of preliminary results, research plan, vision



experiment running in this day (2021)!

Some Extracts from the proposal

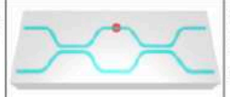
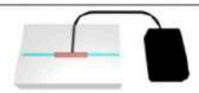
Combination of medium and long term goals:

the project must impress the panel and reviewers

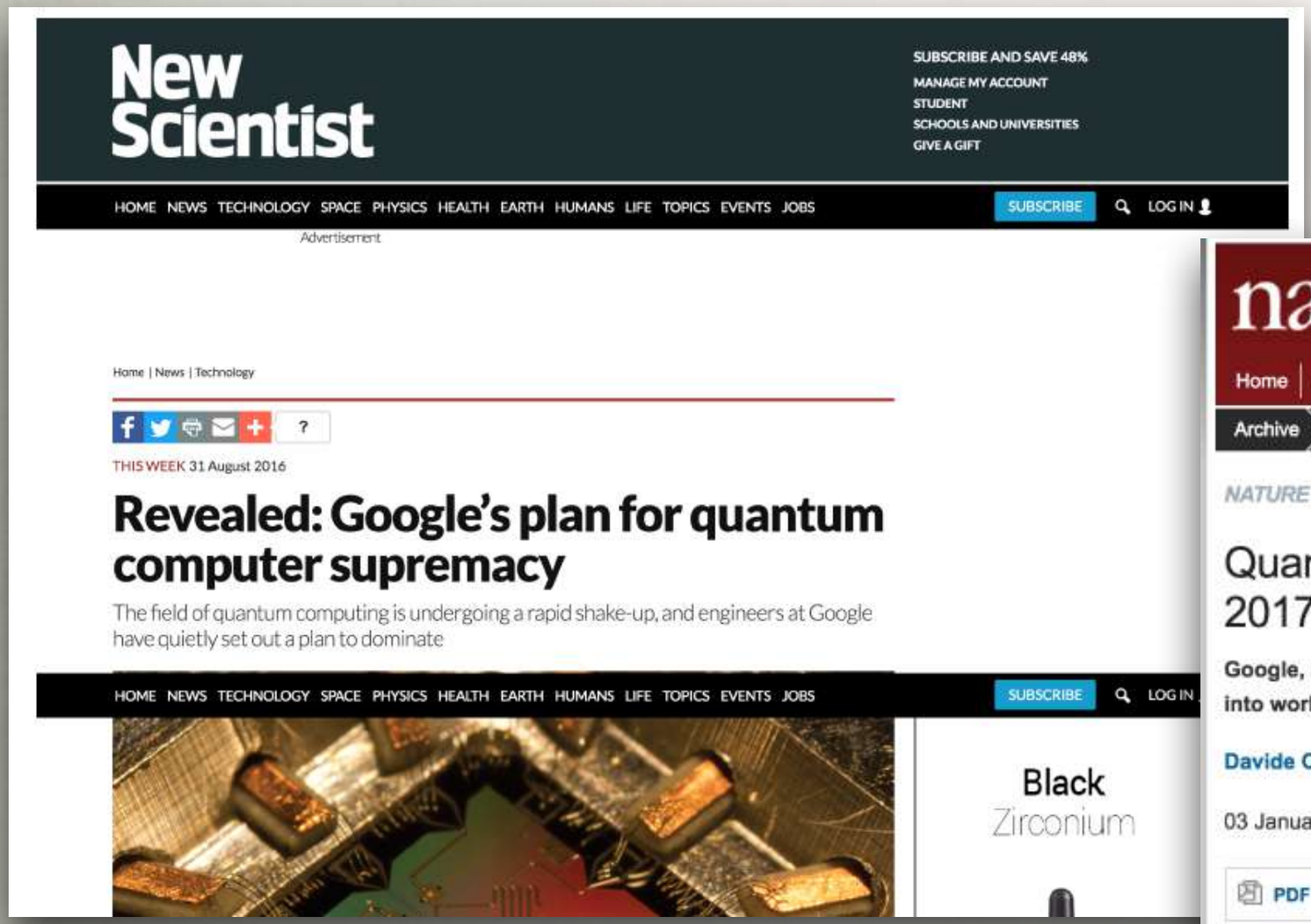
FIND YOUR "OWN" STYLE

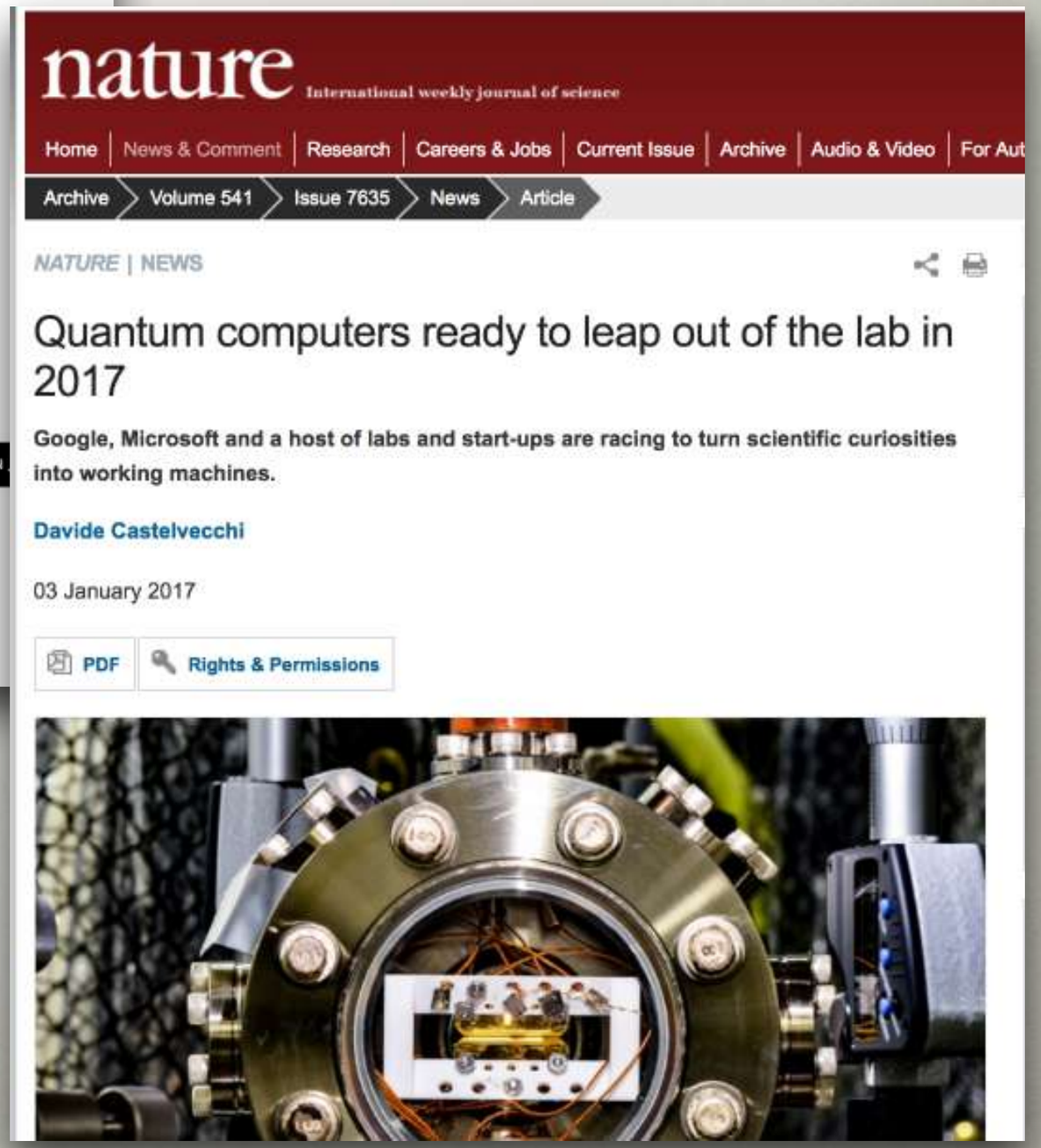
Long term vision but not yet a clear path to achieve all the proposed goals

established with the group of quantum information theory of the University of Rio de Janeiro Brasil.

Device	Figure	Features	State of the art
Directional coupler		Beamsplitter like operation are achieved by evanescent fields overlap. Any polarization independent splitting ratio is achievable by changing the interaction length.	Demonstrated by L. Sansoni et al. Phys. Rev. Lett. 105, 200503 (2010).
Partial polarizing beam splitter		Any polarization dependent splitting ratio can be achieved by suitably setting the length of the interaction region	Demonstrated by A. Crespi et al. quant-ph/1105.1454
Interferometer without phase shifting		Balanced Mach-Zehnder interferometer realized with 2 directional couplers (splitting ratio 50%)	Demonstrated by L. Sansoni et al. quant-ph/1106.5713
Interferometer with arbitrary phase		Unbalanced interferometer: the unbalancement between the two arms can be achieved by changing the writing speed of the circuit.	To be demontrated
Dynamic phase shifter		Achievable via thermo-electric control or by inserting liquid crystal on the chip.	To be demontrated
3D Geometry		3D geometries are easy realized with laser written technique.	Demonstrated by A. Crespi et al. quant-ph/1105.1454
Tritter		Directional coupler with 3 coupled waveguides in a 3D geometry [Preliminar result in the classical regime. Suzuki et al., Optics Express 14, 2335 (2006)]	To be demontrated
Quarter		Directional coupler with 4coupled waveguides in a 3D geometry: different splitting ratios can be achieved.	To be demontrated
Waveplate		Achievable by inserting a liquid crystal in the chip. By applying an electric field, the induced birifringence can be tuned.	To be demontrated
Microfluidic channel		Optofluidic device fabricated by femtosecond laser microfabrication as phase-shifter to introduce a different type of dynamic for the disorder.	Demonstrated by A. Crespi et al. quant-ph/1109.3128

The Vision:
to achieve Quantum Supremacy





GOOGLE AND CHINA ACHIEVEMENT IN 2020

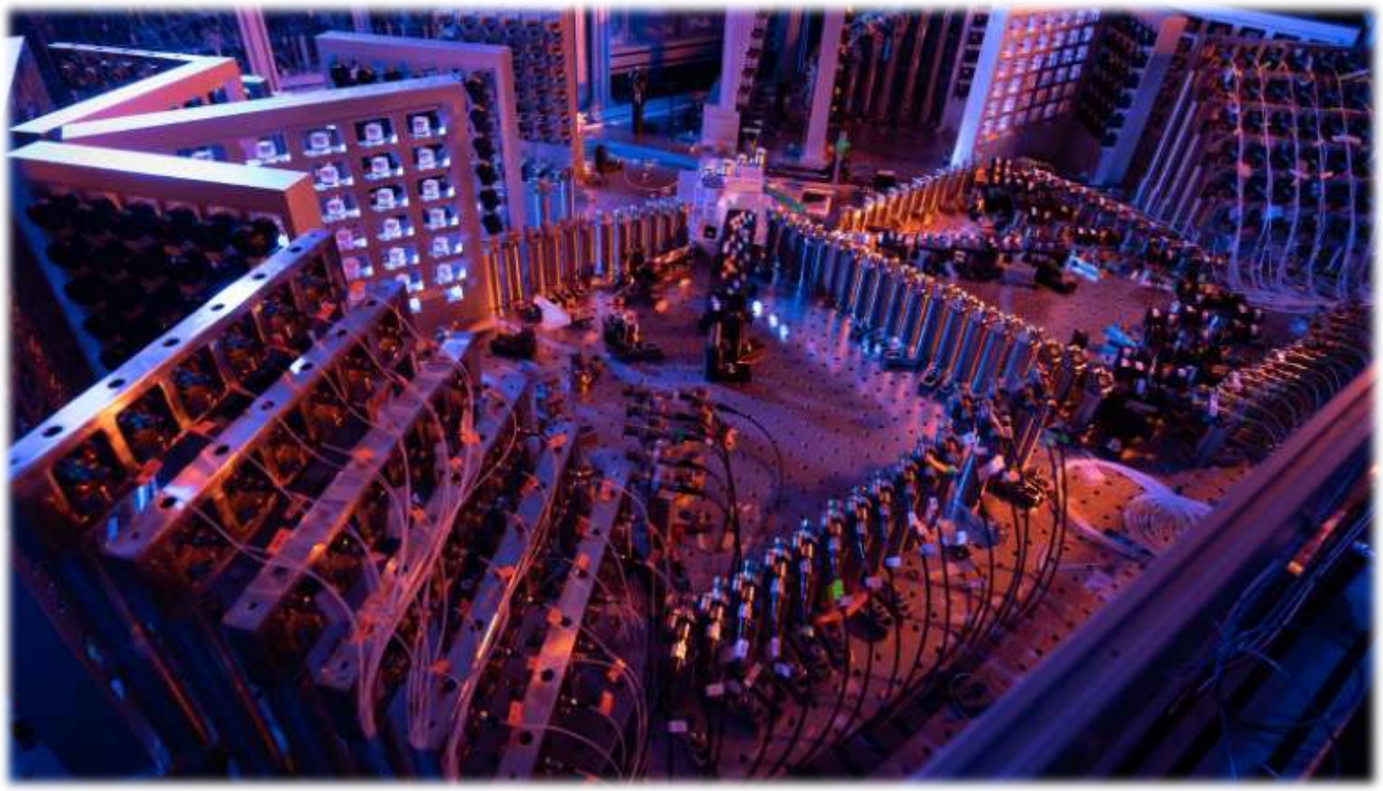
Experiments with up to 104 detected photons in 144 modes

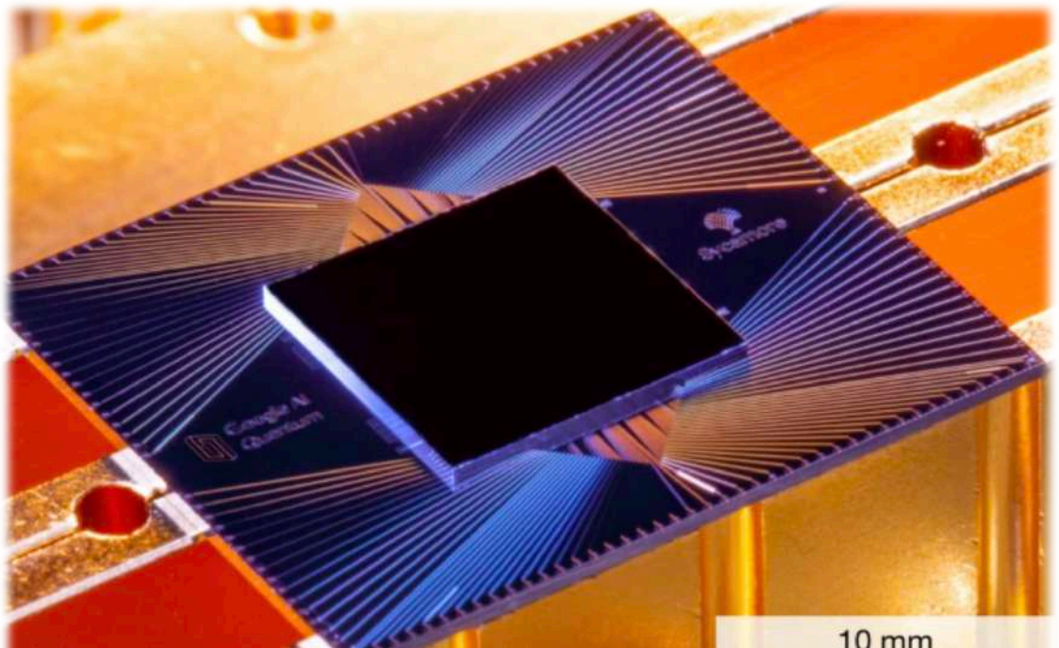
Quantum computational advantage using photons

HAN-SEN ZHONG, HUI WANG, YU-HAO DENG, MING-CHENG CHEN, LI-CHAO PENG, YI-HAN LUO, JIAN QIN, DIAN WU, XING DING, YI HU, PENG HU, XIAO-YAN YANG, WEI-JUN ZHANG, HAO LI, YUXUAN LI, XIAO JIANG, LIN GAN, GUANGWEN YANG, LIXING YOU, ZHEN WANG, LI LI, NAI-LE LIU, CHAO-YANG LU, AND JIAN-WEI PAN

fewer Authors Info & Affiliations

18 Dec 2020 • Vol 370, Issue 6523 • pp. 1460-1463 • DOI: 10.1126/science.abe8770





Article | Published: 23 October 2019

Quantum supremacy using a programmable superconducting processor

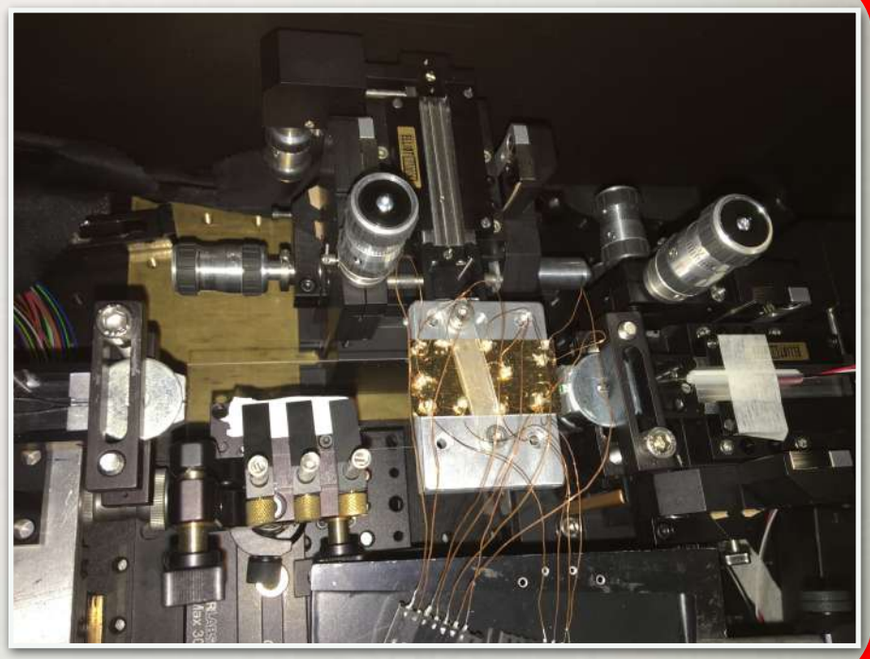
Frank Arute, Kunal Arya, [...] John M. Martinis

Nature **574**, 505–510 (2019) | Cite this article

Project Impact: the Labs

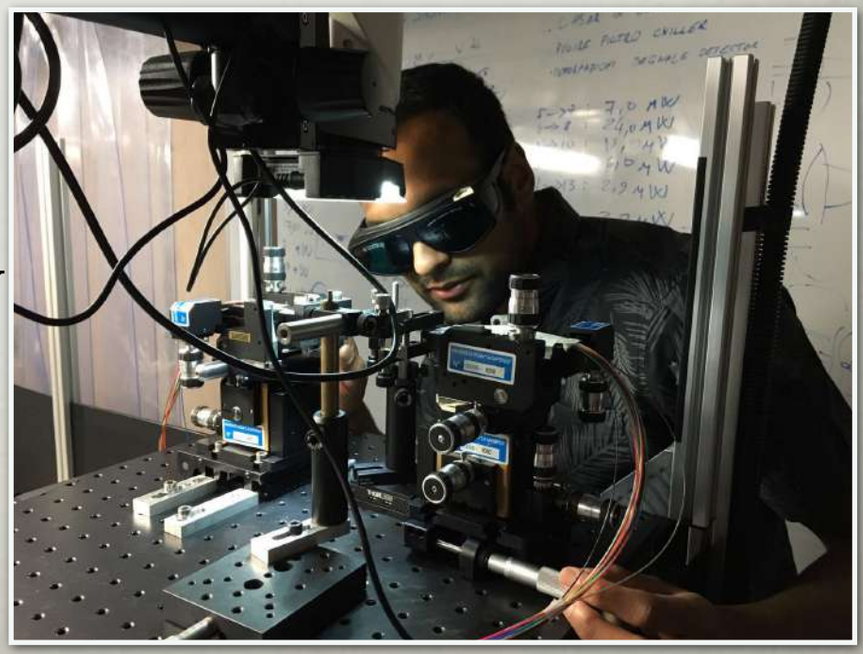
New Lab! 11/3/17

Enhanced Lab



Enhanced Lab

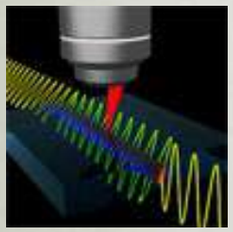
New Lab



Project Impact: The Research

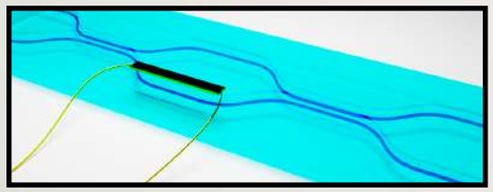
Integrated devices

Integrated waveplates



Nature Com.
5, 2549 (2014)

Controlled phase shifter

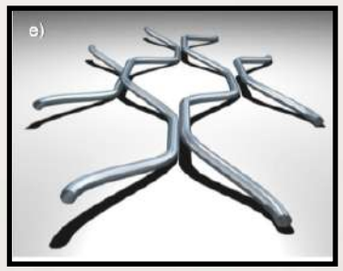


Light S&A (Nature)
4, e354 (2015)

Light S&A (Nature)
5, e16064 (2016)

Quantum simulation via quantum walk

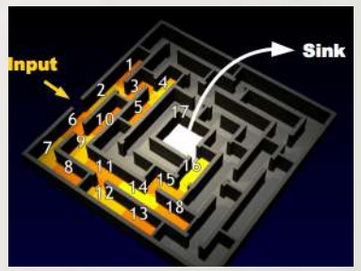
Ordered systems



Phys. Rev. Lett.
108, 010502 (2012)

Nature Photonics
7, 322 (2013)

Quantum transport



Science Advances
1, e1500087 (2015)

Nature Com.
6, 7706 (2015)

Phys. Rev. Lett.
114, 090201(2015)

Nature Com.
7, 11862 (2016)

Bosons Sampling

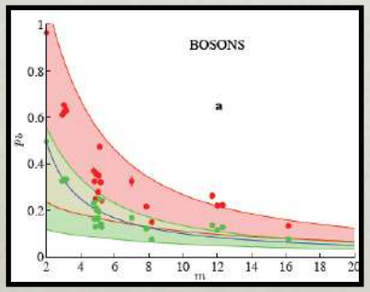
Boson Sampling On chip

Nature Photonics
7, 545 (2013)

Phys. Rev. Lett.
111, 130503 (2013)

Nature Photonics
8, 614 (2014)

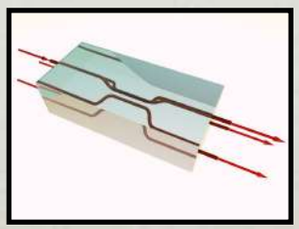
Scattershot Boson Sampling



Science Advances
1, e1400255 (2015).

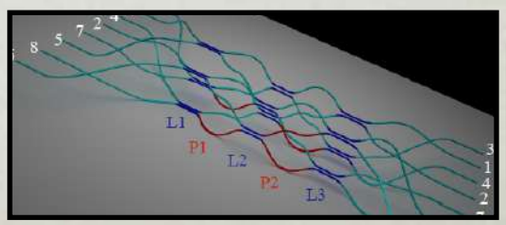
3D devices

Integrated tritter



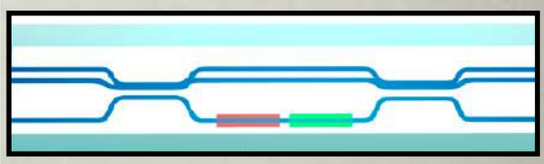
Nature Com.
4, 1606 (2013)

Fourier matrix



Nature Com.
7, 10469 (2016)

Interferometry



Sc. Reports
6, 28881 (2015)

Sc. Reports
2, 862 (2012)

ERC impact on my career (years ago..)

Grant application: October 2011
Start: August 2012

Associate professor, Physics Department Sapienza: July 2014
(per chiamata diretta)

Junior Fellow, Advanced School of Studies Sapienza: November 2013

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AWARDS: Honoured as Young Scientist (40 worldwide) at the "Summer Davos" - World Economic Forum in 2015 and 2016, Premio Sapio Junior per la Ricerca, Talent award by Pirelli

TRACK RECORD (2017):
130+ publications: 2 Nature, 5 Nature Photonics, 9 Nature Communication,
2 Science Advances, 2 Light Science & Applications, 1 Nature Physics, 2 PRX, 16 PRL, 26 PRA (5 RC),
120+ invited talks at conference and invited seminars,
30+ public outreach,…

Other Grant Applications...

Quantum technologies

MARIE CURIE ACTIONS

European coordinator of PICQUE project (2013-2017)

PICQUE

Quantum simulation on a chip

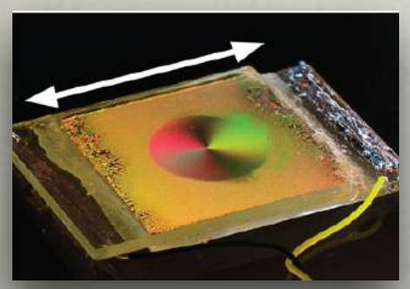
European coordinator of QUCHIP project (2015-2018)

QUCHIP
Quantum Simulation on a Photonic Chip

Spin-orbit coupling for quantum information

erc

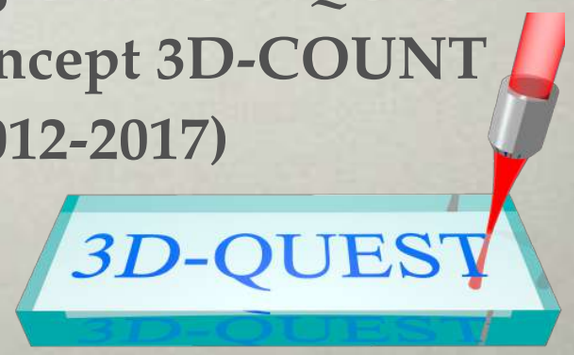
Partner of ERC Advanced Grant PHOSPHOR (2016-2020)



Integrated quantum photonics

erc

Principal investigator of ERC Starting Grant 3D-QUEST Proof-of Concept 3D-COUNT (2012-2017)



Participation to "Summer Davos" World Economic Forum

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Workshop on Young Scientist career
with Philip Campbell (Editor in chief - Nature)
and Jean-Pierre Bourguignon (President - ERC)

"Let researchers try new paths"
T. Oni, F. Sciarrino, G.Adesso and R. Knight,
Nature *538*, 451 (2016)

Workshop on Ethics in research
"Code of Ethics" under preparation
to be released in June