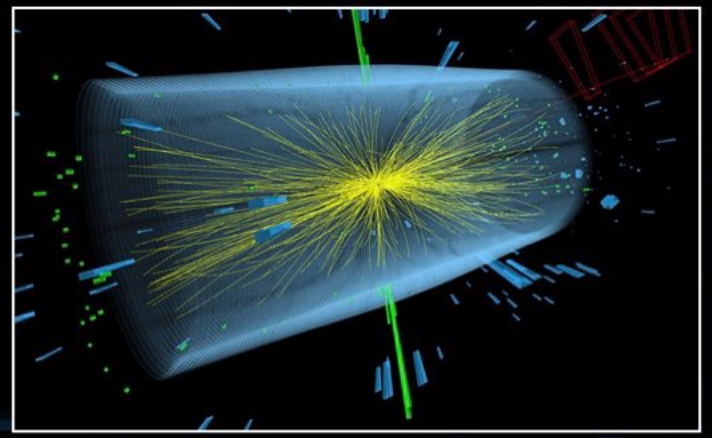
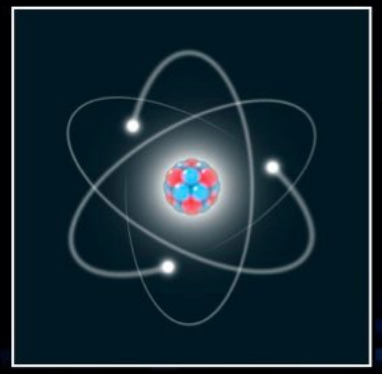
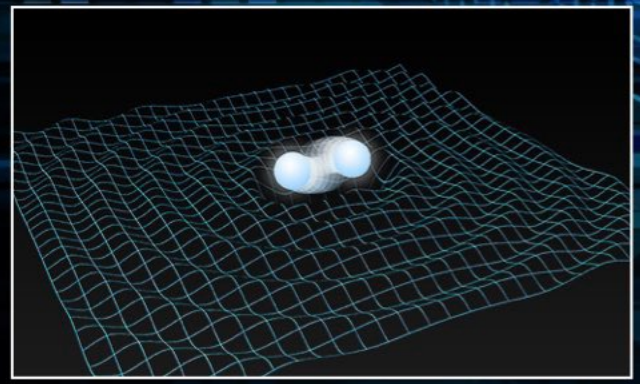


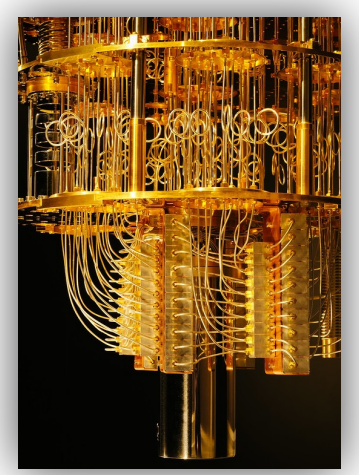


Physics Frontiers with Quantum Science and Technology

Participant > 130

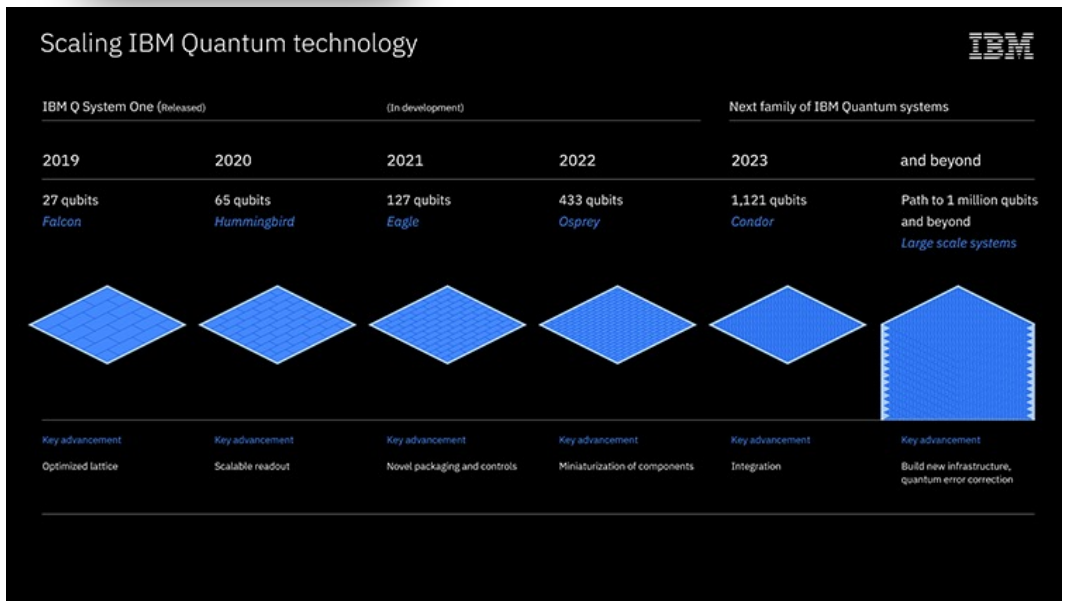


Quantum technology is the cutting edge and frontier

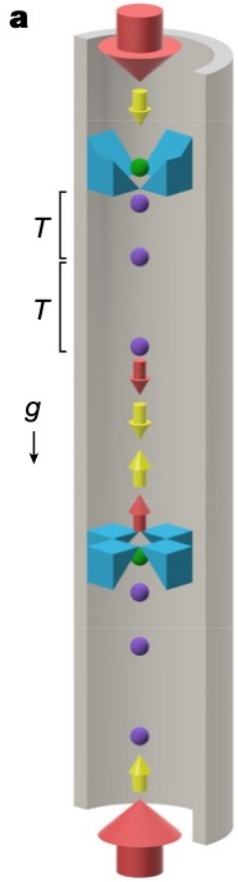


Recent development
of Quantum computer

Very fast!!



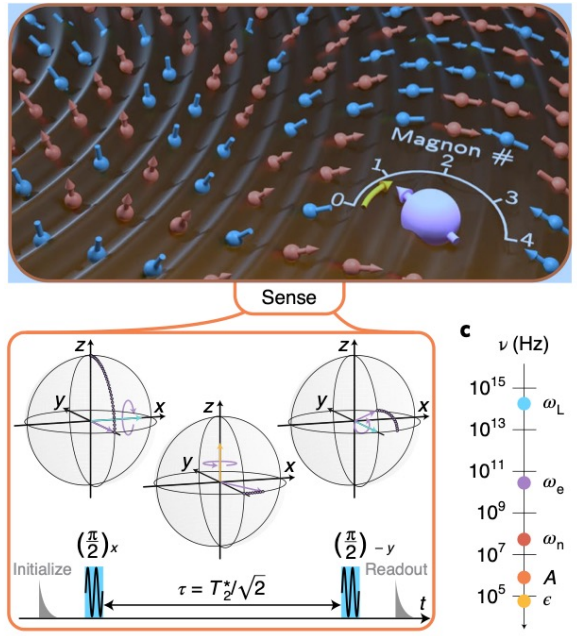
1K Qubit machine available soon (IBM)



High precise gravity meter
with atomic vapor

Quantum sensing
opens new experiments

For example,



Nature

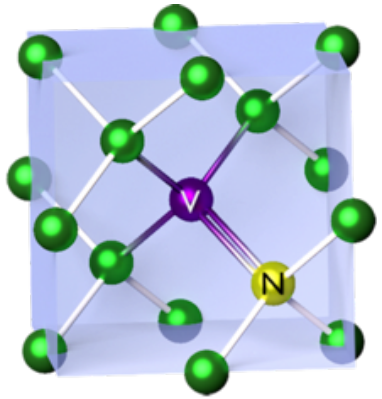
Detect magnon

TABLE I. Experimental implementations of quantum sensors.

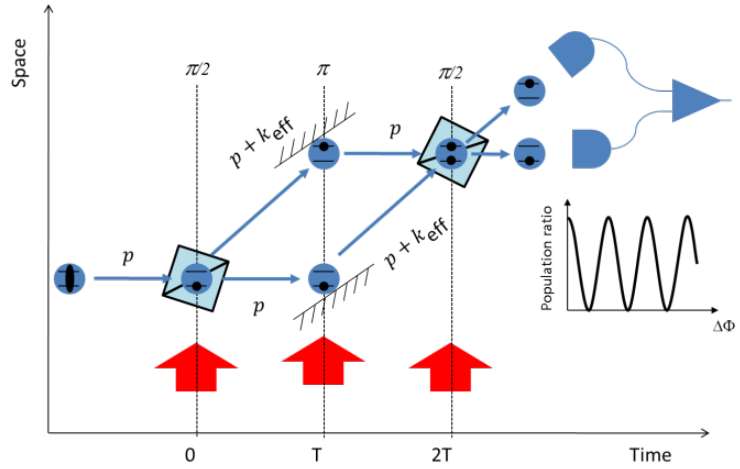
Implementation	Qubit(s)	Measured quantity(ies)	Typical frequency	Initalization	Readout	Type[a]
Neutral atoms						
Atomic vapor	Atomic spin	Magnetic field, rotation, time/frequency	dc-GHz	Optical	Optical	II, III
Cold clouds	Atomic spin	Magnetic field, acceleration, time/frequency	dc-GHz	Optical	Optical	II, III
Trapped ion(s)						
	Long-lived electronic state	Time/frequency	THz	Optical	Optical	II, III
		Rotation		Optical	Optical	II
	Vibrational mode	Electric field, force	MHz	Optical	Optical	II
Rydberg atoms						
	Rydberg states	Electric field	dc, GHz	Optical	Optical	II, III
Solid-state spins (ensembles)						
NMR sensors	Nuclear spins	Magnetic field	dc	Thermal	Pick-up coil	II
NV^b center ensembles	Electron spins	Magnetic field, electric field, temperature, pressure, rotation	dc-GHz	Optical	Optical	II
Solid-state spins (single spins)						
P donor in Si	Electron spin	Magnetic field	dc-GHz	Thermal	Electrical	II
Semiconductor quantum dots	Electron spin	Magnetic field, electric field	dc-GHz	Electrical, optical	Electrical, optical	I, II
Single NV^b center	Electron spin	Magnetic field, electric field, temperature, pressure, rotation	dc-GHz	Optical	Optical	II
Superconducting circuits						
SQUID[c]	Supercurrent	Magnetic field	dc-GHz	Thermal	Electrical	I, II
Flux qubit	Circulating currents	Magnetic field	dc-GHz	Thermal	Electrical	II
Charge qubit	Charge eigenstates	Electric field	dc-GHz	Thermal	Electrical	II
Elementary particles						
Muon	Muonic spin	Magnetic field	dc	Radioactive decay	Radioactive decay	II
Neutron	Nuclear spin	Magnetic field, phonon density, gravity	dc	Bragg scattering	Bragg scattering	II
Other sensors						
SET[d]	Charge eigenstates	Electric field	dc-MHz	Thermal	Electrical	I
Optomechanics	Phonons	Force, acceleration, mass, magnetic field, voltage	kHz–GHz	Thermal	Optical	I
Interferometer	Photons, (atoms, molecules)	Displacement, refractive index	...			II, III

[a]Sensor type refers to the three definitions of quantum sensing in Sec. II.A.
[b]*NV*: nitrogen vacancy.
[c]SQUID: superconducting quantum interference device.
[d]SET: single electron transistor.

Many types of Quantum sensor



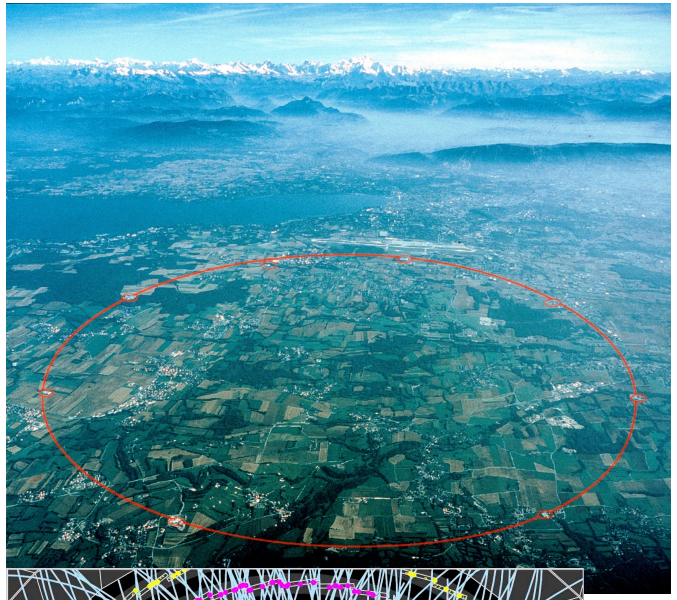
NV center widely used for magnetic,

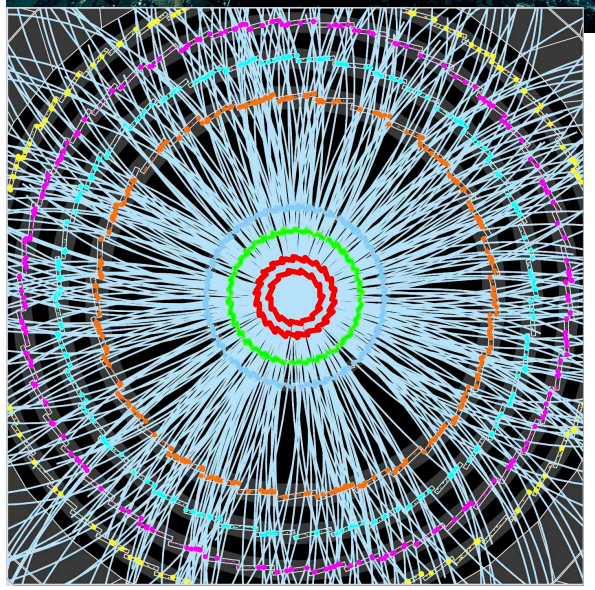


Interferometer may be used for gravity, berry phase

Rev. Mod Phys 89 035002 (2017)

For Particle Physics





LHC produces the
complicated data / big data size (500PB)

CERN Quantum Technology Initiative

For the next generation

New CERN activity in place

Communication channels (web site) being set up

Most Scientific Advisory Board members have been nominated

Invitation letters being prepared

Collaborations being established in the Member States, US (Fermilab, Oak Ridge) and Japan (Tokyo – ICEPP)

Signed Quantum Hub Agreement with IBM

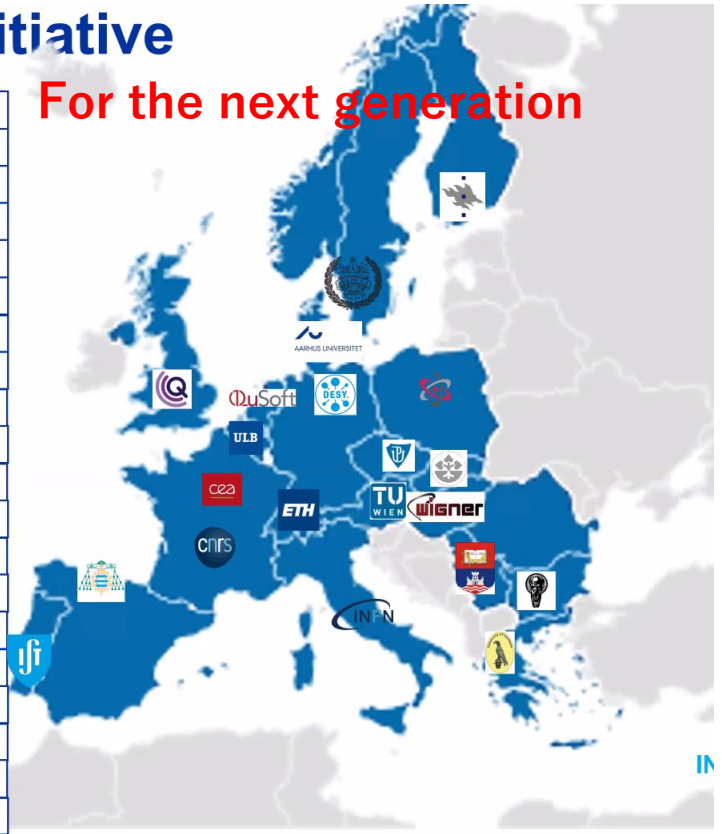
Working on roadmap white paper

A workshop on Quantum Technologies for HEP being organised tentatively in June

- Kick-off of the Advisory Board
- Presentation of the draft Roadmap
- First projects, activities, results

Affiliation of Advisory Board Members

Austria: Vienna University of Technology
Belgium: Université Libre de Bruxelles
Bulgaria: Sofia University
Czech Republic: Palacký University
Denmark: Aahrus University
Finland: University of Helsinki
France: CEA, CNRS
Germany: DESY
Greece: University of Ioannina
Hungary: Wigner Research Centre
Israel: Israel National Quantum Initiative
Italy: INFN
Netherlands: QuSoft
Norway: under discussion
Poland: National Centre for Nuclear Research
Portugal: IST Lisbon
Romania: under discussion
Serbia: University of Belgrade
Slovakia: Slovak Academy of Science
Spain: Universidad de Oviedo
Sweden: Chalmers University
Switzerland: ETHZ
United Kingdom: Quantum Sensing Hub



ICEPP
The University of Tokyo

interesting topics of our center

- Quantum AI (both software/hardware)
- Quantum sensors for DM/QG
- QC Application for FT, Tracking…

Open for the inter. Joint Research

Purpose of this workshop

With recent progress in quantum science and technologies,

foster new ideas to advance or **develop new fields in research** for high-energy physics, nuclear physics, astrophysics and condensed matter physics, empowered by quantum information technologies.

- Quantum-sensor applications for physics
- Quantum-computer applications for physics
- Developments of quantum computer and sensor technologies
- Theoretical development in fundamental physics with quantum information

If you obtain new idea/hint, this workshop is fruitful

Short Agenda

workshop timetable: world-wide workshop

9th

- US-Friendly time (8:30-11:10 JST)

Quantum sensor/computer developments and physics applications: 1¶
Quantum sensor/computer developments and physics applications: 2¶

- Europe-Friendly time (16:00-19:00 JST)

Quantum computer/sensor developments and physics applications: 1¶
Quantum computer/sensor developments and physics applications: 2¶

10th

- US-Friendly time (8:00-11:00 JST)

Quantum computer/sensor applications for physics: 1¶
Quantum computer/sensor applications for physics: 2¶

- Europe-Friendly time (16:00-19:10 JST)

Quantum computer applications for physics: 3¶
Quantum-computer applications for physics: 4¶