CNRS IN2P3 Les deux infinis

Omega

l'X École Polytechnique IP Paris

Technology and Industrial applications

convenors : Alessandro Montanari (INFN BO), Massimo Caccia (U.Insubria & INFN Milano), Hucheng Chen (BNL), Alexander Romanenko (Fermilab), Magnus Mager (CERN)

Ch. de LA TAILLE 13 july 2022

ICHEP 2022 BOLOGNA

ICHEP 2022 XLI International Conference on High Energy Physics Bologna (Italy)

6 13 07 2022

Technology and Industrial applications session

Session created in ICHEP2016. 15 talks at ICHEPP 2022 (6 in 2016, 8 in 2018, 8 in 2020)

from HEP to other fields and from other fields to HEP and from industry

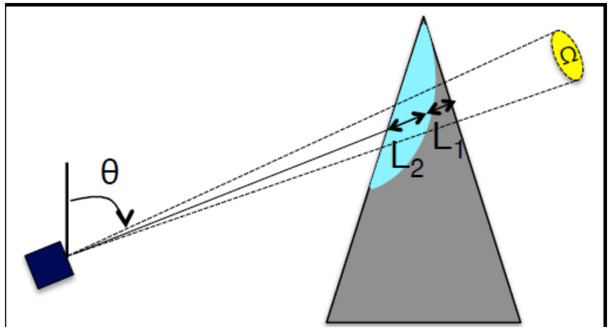
https://agenda.infn.it/event/28874/sessions/21498/#20220707

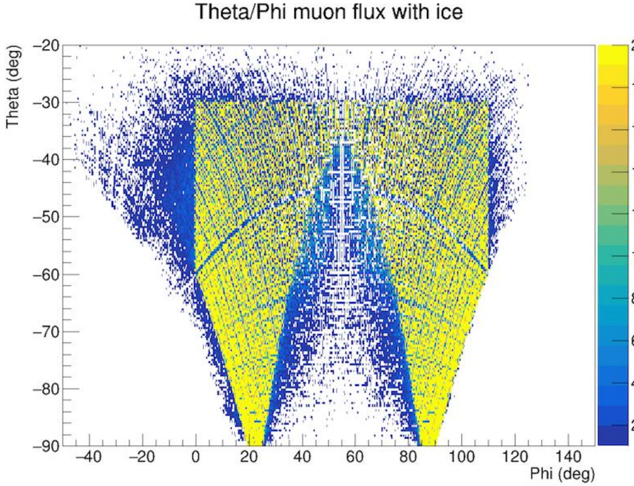
ICHEP 2022 / Programme — Thursday, 7 July 2022

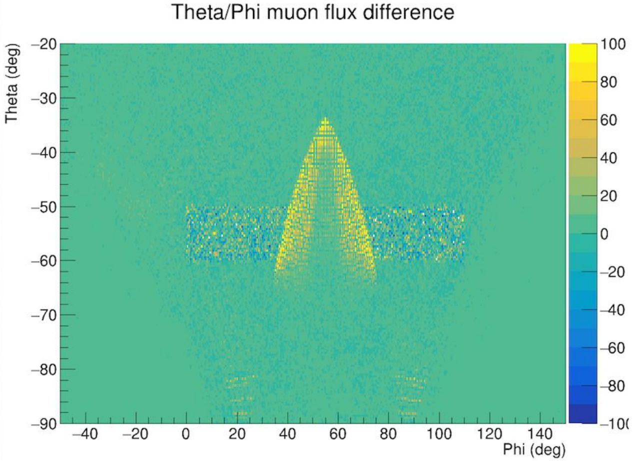
14:30	Innovation Ecosystems: The ATTRACT Example	GARCIA TELLO, Pablo
14:45	A new detector to muon tomography for glaciers melting monitoring	RABAGLIA, Sara
15:00	Multipurpose J-PET detector for tests of discrete symmetries and medical imaging	SHIVANI, Shivani SHIVANI, Shivani
15:15	Quantifying calcium concentration in living cells through detection of photoluminescence single photon trails	VESCO, Guglielmo
15:30	Worldwide industrial developments for compact accelerators based on the Nb3Sn superconducting radiofrequency (SRF) technology.	GRIGORY, Eremeev
15:45	A Silicon-photomultiplier based random bit streamer I	CACCIA, Massimo
16:00	Superconducting radio frequency technology enabling new transformative applications in QIS and dark matter searches	GRASSELLINO, Anna
16:15	Power electronics in HEP experimental caverns	GIORDANO, Ferdinando
17:00	Novel techniques for high density channel y measurements based on SiPM	PERRI, Marco
17:15	Towards efficient neutron spectroscopy with a Nitrogen-filled Spherical Proportional Counter	MANTHOS, Ioannis
17:30	MAPS for x-ray detection: trading high efficiency for low cost	GIUBILATO, Piero
17:45	ORIGIN, an EU project targeting real-time 3D dose imaging and source localization in brachytherapy: commissioning and first results of a 16-sensor prototype.	GIAZ, Agnese
18:00	Development of a new compact and 2D-multiplexed Time Projection Chamber for muon tomography	LEHURAUX, Marion
18:15	The Bergen proton-CT	ROEHRICH, Dieter
18:30	Quantum computing for particle physics applications	TAVERNELLI, Ivano

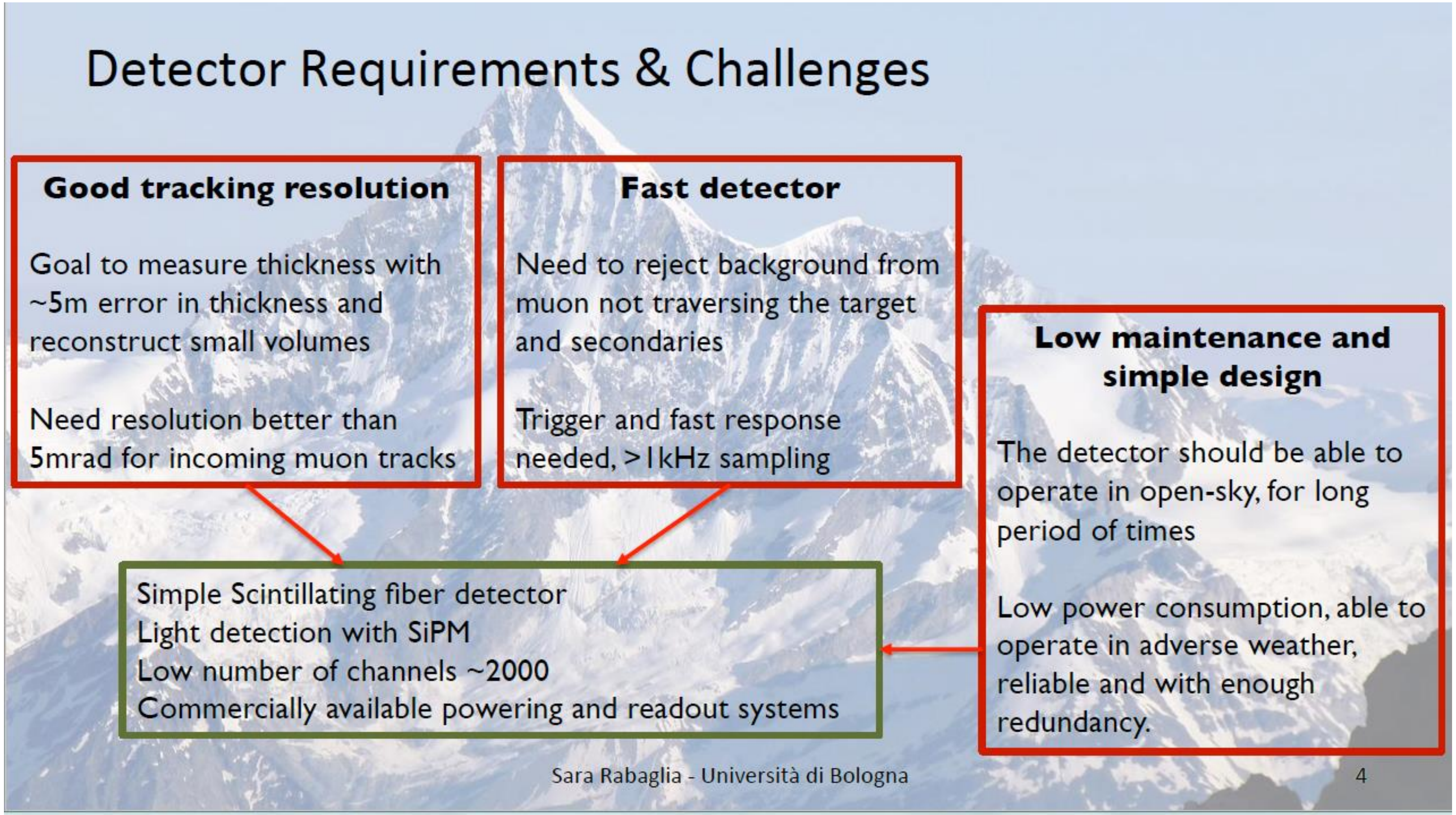
Muon tomography for glaciers melting monitoring

Sara RABAGLIA (U. Bologna)

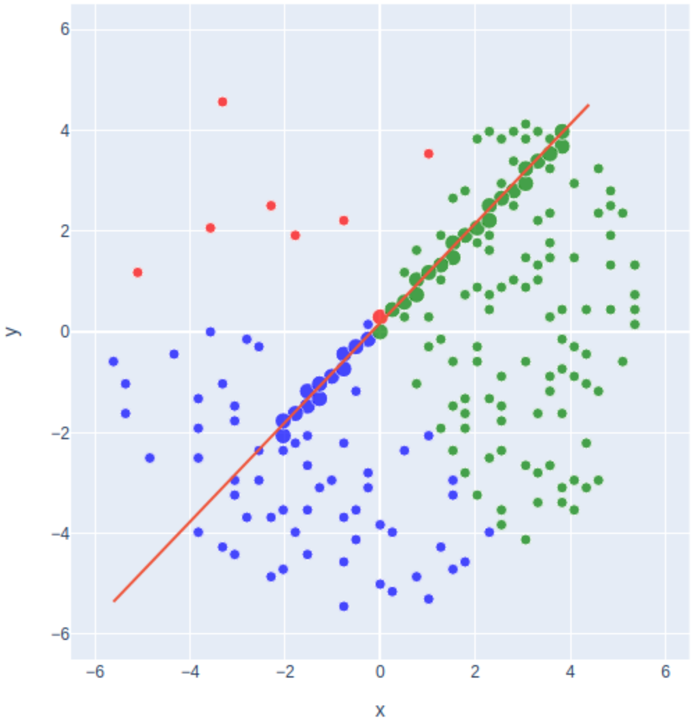






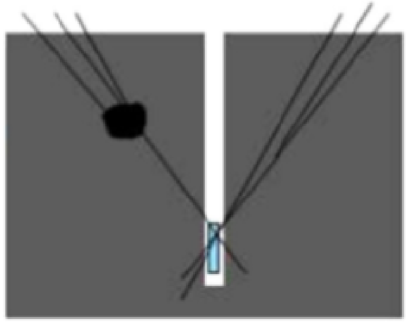


- Probing the underground with cosmic muons
- Micromegas TPC with 2D multiplexing



Motivations

Expanding the spectrum of applications



New applications: probing the underground

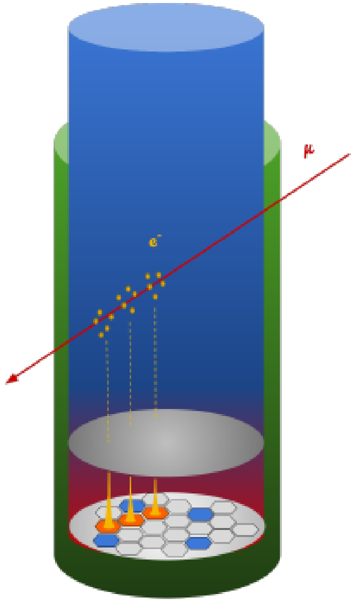
- Civil engineering (prospecting & monitoring)
- Geothermal fields sounding
- Mining exploration

Constraints & Requirements

- **Underground operation:** minimum electric consumption
- Use **existing drilling holes:** $\varnothing < 20$ cm
- Almost **2π angular acceptance**
- 3D reconstruction

Technical solution

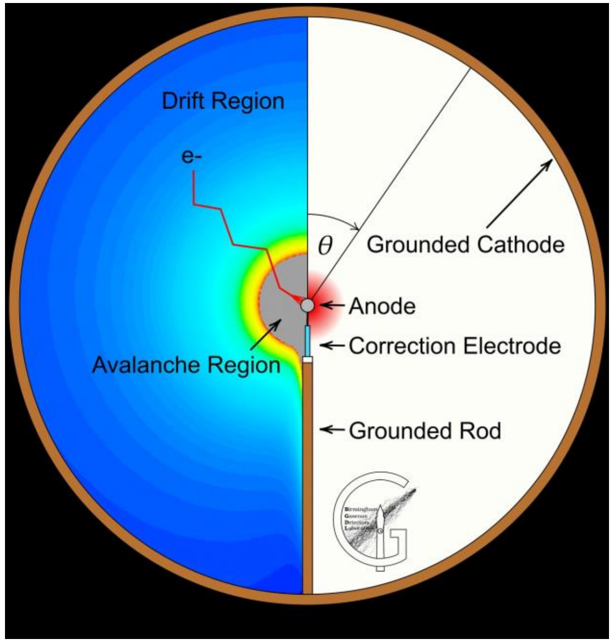
- a cylindrical Time Projection Chamber
- 2D-multiplexed
- 14 cm $\varnothing$ Micromegas readout plane

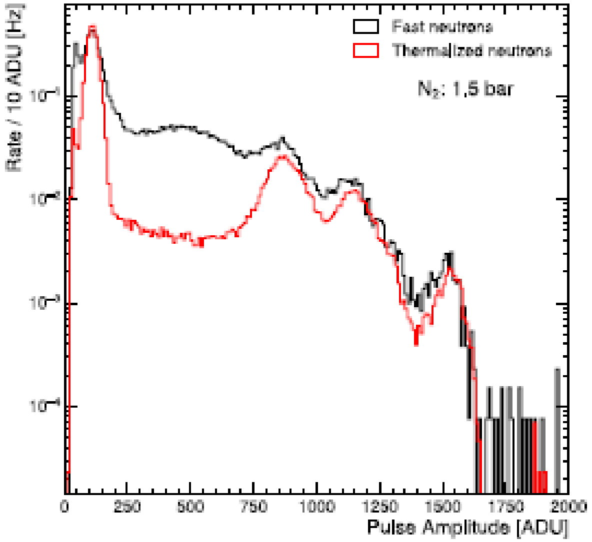


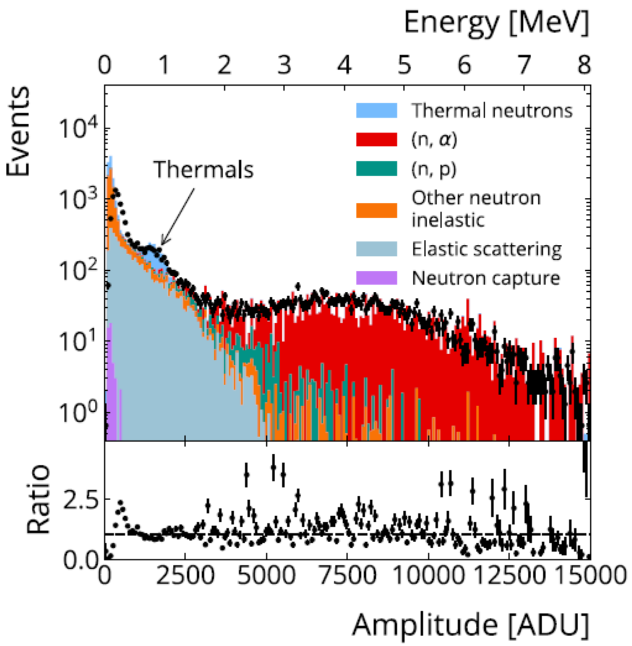
Neutron detection with the Spherical Proportional Counter

Ioannis MANTHOS (Birmingham)

- Replace ^{3}He by Nitrogen
- Use Spherical Proportional counter
  - Low noise and pulse shape analysis
  - Low pressure reduces wall effect
- Neutron detection performed
  - in the Graphite stack and at the MC40 cyclotron facility in Birmingham
  - Foreseen at Boulby underground facility
  - Spectroscopic capability
- Applications in neutron spectroscopy for dark matter







UKRI Science and Technology Facilities Council

Boulby Underground Laboratory

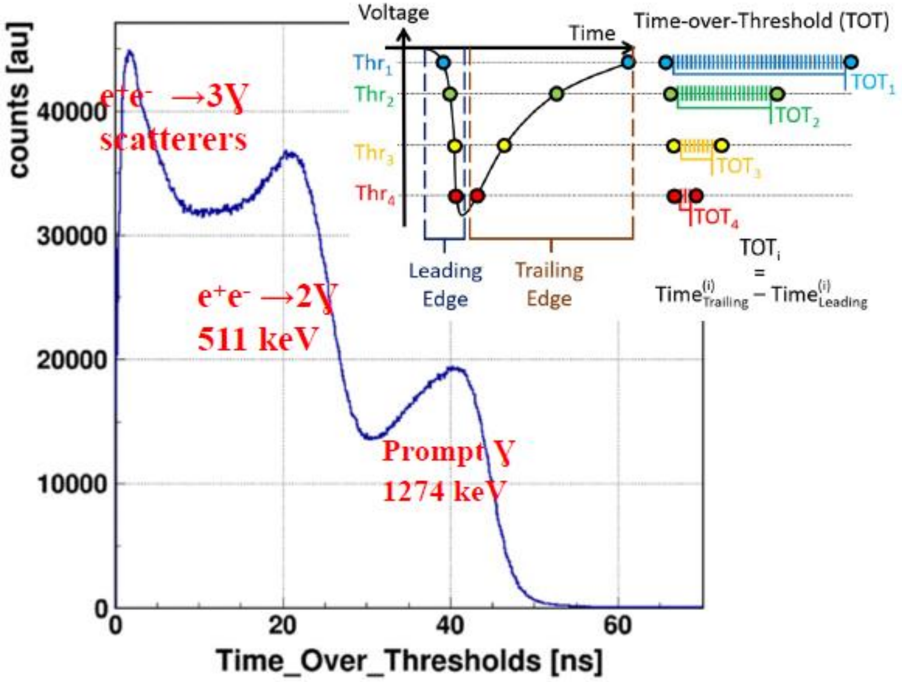
UNIVERSITY OF BIRMINGHAM | CYCLOTRON FACILITY

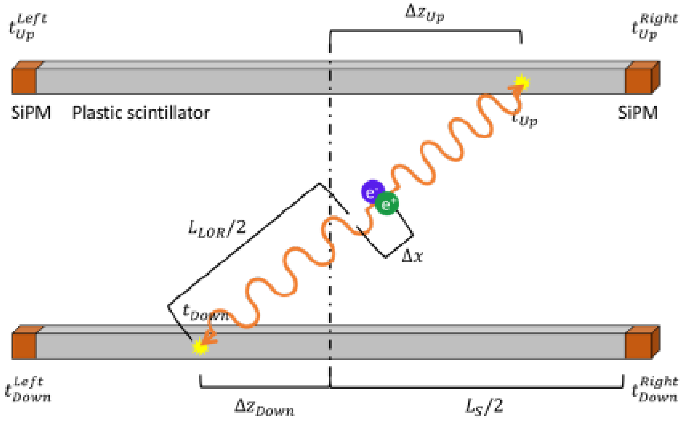
Multipurpose J-PET detector

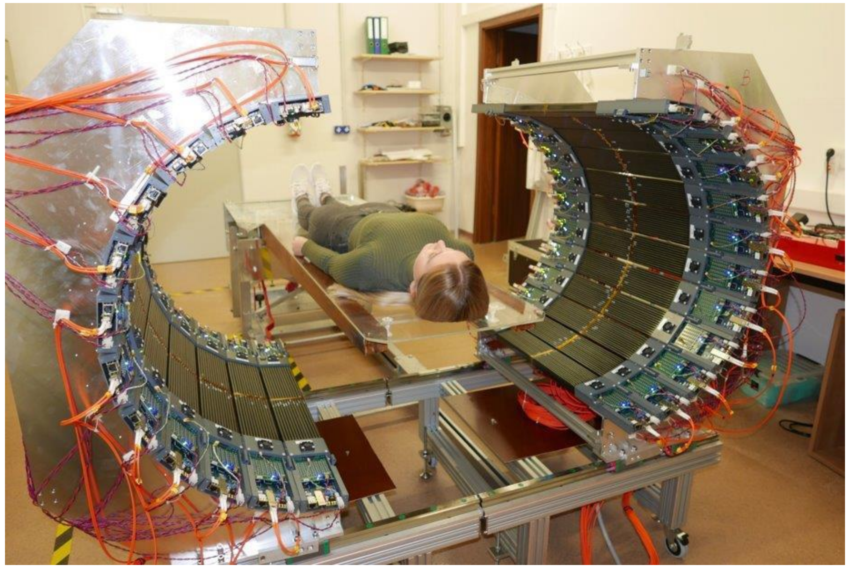
Shivani SHIVANI (Krakow)

- “Jagiellonian PET”
- The cost-effective total-body PET scanner based on plastic scintillators;
- PET scanner with positronium and multiphoton imaging capabilities;
- Modular and transportable PET scanner with the field of view adjustable to the patient size.
- Study of discrete symmetry

Parameters	Traditional PET	Strip J-PET
Type of scintillator	crystals LSO, LYSO, BGO	plastics BC-404, BC-420, EJ-230
Physical phenomenon	photoelectric effect	Compton scattering
Measured property	energy of gamma photon + time of flight	time of flight
Granularity of detector	high	low
Number of scintillators	13,824 to 32,444 crystals	192 strips
Scintillator size [mm³]	e.g. 4x4x20; 6.3x6.3x30	e.g. 6x24x500; 5x19x300
Photo-detector	PMT, SiPM, dSiPM, APD	PMT, SiPM
Number of PMTs	256 to 768	384
Detection efficiency	high	low
Detector’s acceptance	low	high
Axial length [mm]	157 to 260	500
Used electronics	analog	digital
Signal triggering	triggering	triggerless data acquisition
TOF resolution* [ps]	345 to 550	320
Simultaneous imaging of the whole human body	no	yes
Simultaneous imaging of PET-MRI	yes	yes
Simultaneous imaging of PET-CT	no	yes

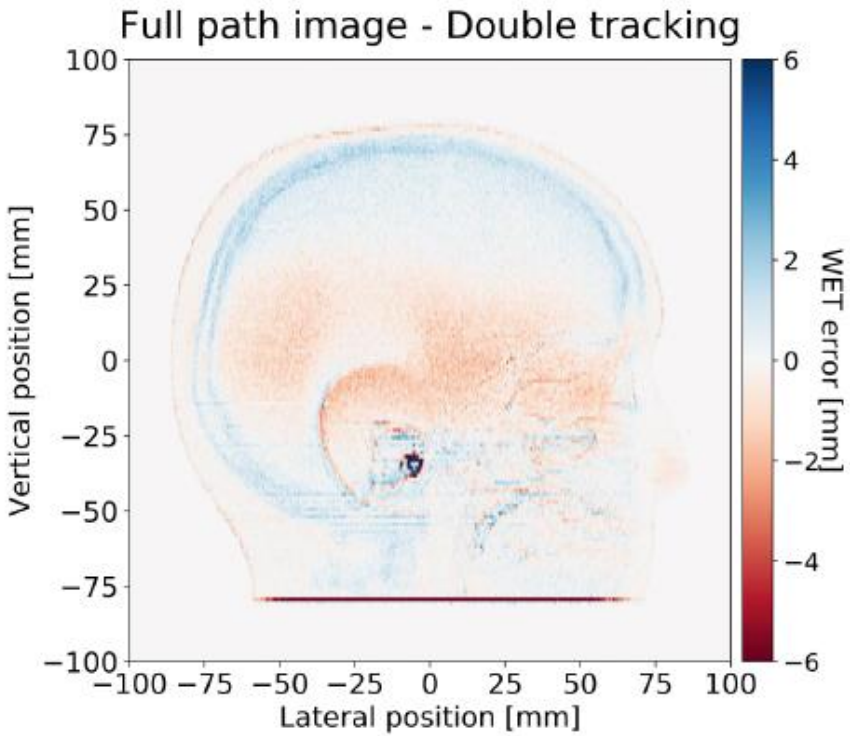






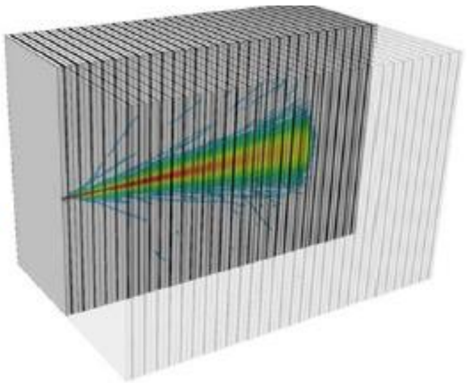
JAGIELLONIAN UNIVERSITY IN KRAKÓW

- On-line Bragg peak monitoring to ~1 mm

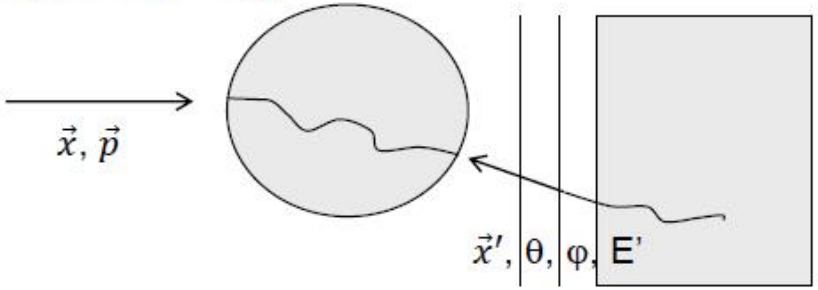


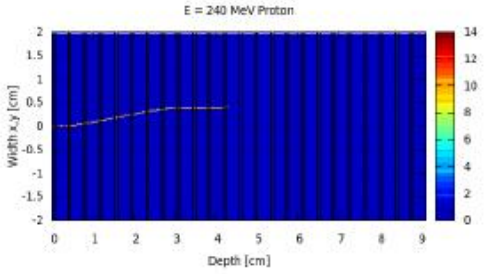
* WET: Water Equivalent Thickness

Clinical pCT - design



- **Conceptual design**

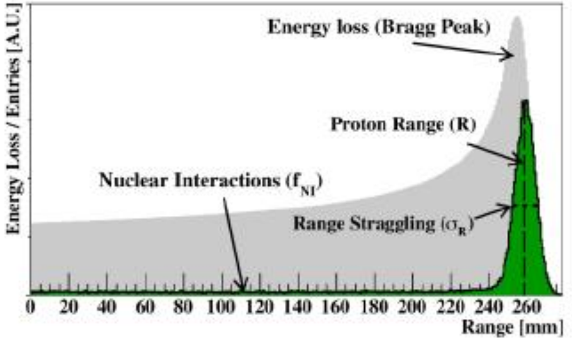




  - ***x,p*** **given by beam optics and scanning system**
  - ***x'***, θ, φ, E' **have to be measured with high precision**
    - **position resolution ~5 µm with minimal MS, i.e. first two tracking layers very thin**

→ **Extremely high-granularity digital calorimeter for tracking, range and energy loss measurement**

- **Technical design**
  - **Planes of CMOS sensors – Monolithic Active Pixel Sensors (MAPS) with digital readout– as active layers in a sampling calorimeter**



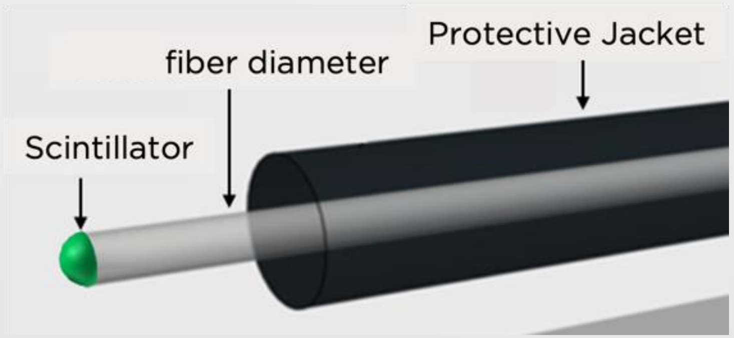
THE ORIGIN PROJECT

Agnese GIAZ (U. Insubria)

Optical Fibre Dose Imaging for Adaptive Brachytherapy [in-situ radiotherapy]

ORIGIN aims to deliver more effective, photonics-enabled, brachytherapy for cancer treatment through advanced **real-time radiation dose imaging** and source localisation. This will be achieved by the development of a new **optical fibre-based sensor** system to support diagnostics-driven therapy through enhanced adaptive brachytherapy.

The project's goal will be achieved by developing a **16 optical fiber**-based system with **scintillating light detected by SiPM** to reconstruct the dose map.



Scintillator	Gadox (LDR)	YVO (HDR)
τ [μs] *	500	500
λ_{max} [nm]	545	600 - 650
LY [ph/MeV]*	$7.1 \cdot 10^4$	$4.8 \cdot 10^4$
Transmittance*	10.2 %	4.2 %

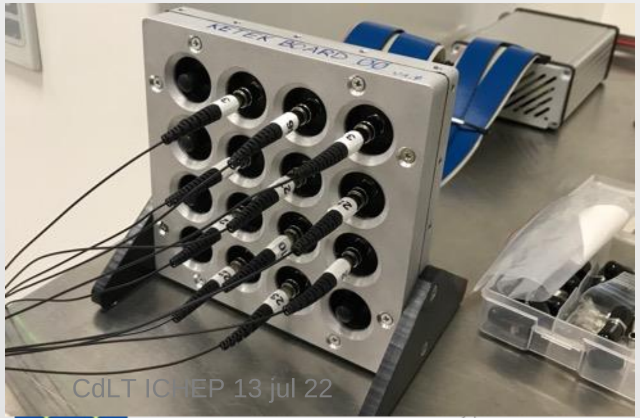
PHOTONICS[21]
PHOTONICS PUBLIC PRIVATE PARTNERSHIP

ORIGIN

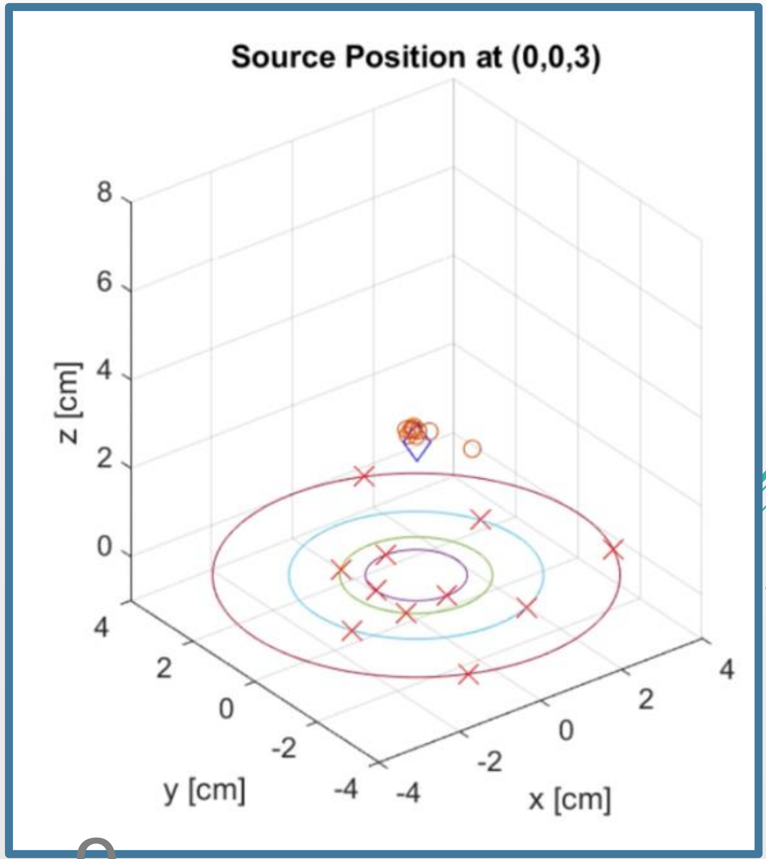
THE 16 CHANNEL READOUT SYSTEM

64-channel SiPM readout board (CAEN* FERS) equipped with 2 WEEROC CITIROC1A ASICs**

- ✓ Single p.e. counting capability
- ✓ Maximum counting rate: 20 MHz
- ✓ 1 HV power supply (20 – 100V) with temperature compensation
- ✓ Ethernet, usb2 and optical link interface for readout (up to 6.25 Gbit/s)



*https://www.caen.it/products/a5202/



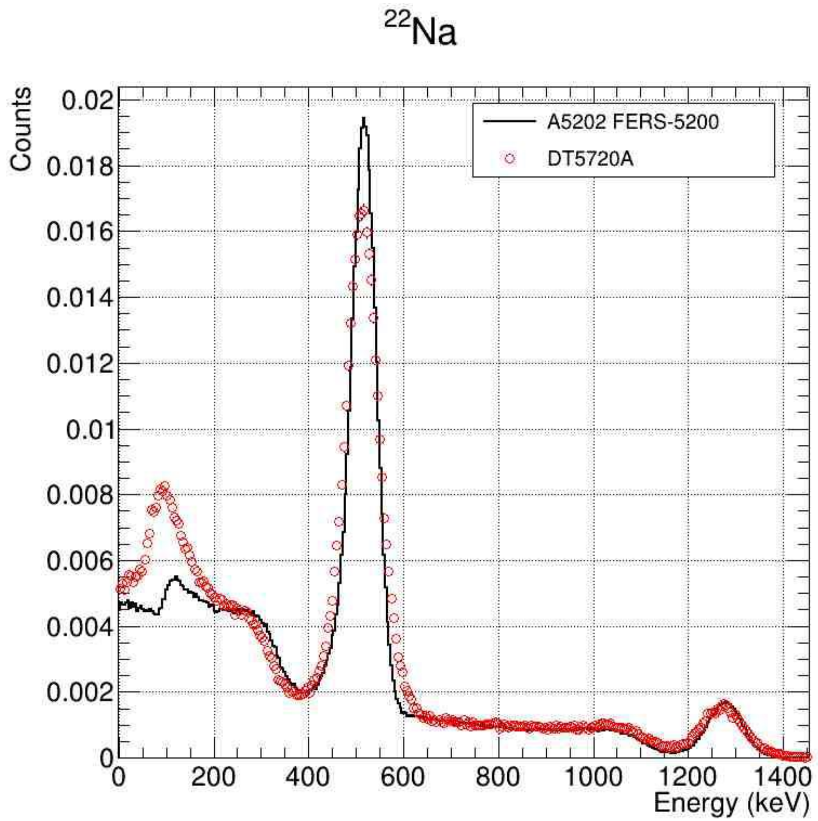
**https://www.weeroc.com/products/sipm-read-out/citiroc-1a

Marco PERRI (CAEN)

Novel techniques for high density channel γ measurements based on SiPM

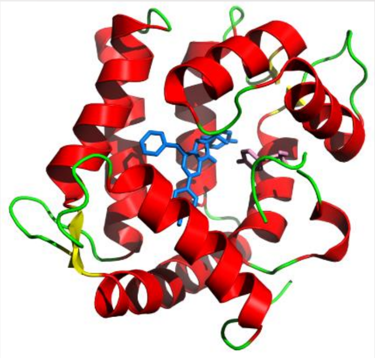
Comparing digitizer-based (D5720) to ASIC-based (A5202) readout

	^{22}Na (511 KeV)	^{137}Cs (662 KeV)	^{60}Co (1172 KeV)	^{60}Co (1332 Ke
A5202+LYSO	(9.5 ± 0.1)%	(9.3 ± 0.1)%	(5.8 ± 0.1)%	(5.0 ± 0.1)%
DT5720A+LYSO	(12.3 ± 0.1)%	(10.3 ± 0.1)%	(6.3 ± 0.4)%	(5.4 ± 0.2)%
A5202+CsI(Tl)	(11.9 ± 0.1)%	(10.9 ± 0.1)%	(5.8 ± 0.2)%	(5.6 ± 0.1)%
DT5720A+CsI(Tl)	(9.6 ± 0.1)%	(8.9 ± 0.1) %	(5.6 ± 0.2)%	(5.4 ± 0.1)%
A5202+BGO	(14.4 ± 0.1)%	(13.5 ± 0.1)%	(8.7 ± 0.1)%	(7.1 ± 0.1)%
DT5720A+BGO	(12.0 ± 0.1)%	(11.0 ± 0.1)%	(7.7 ± 0.3)%	(6.8 ± 0.4)%



Guglielmo VESCO (U. Insubria)

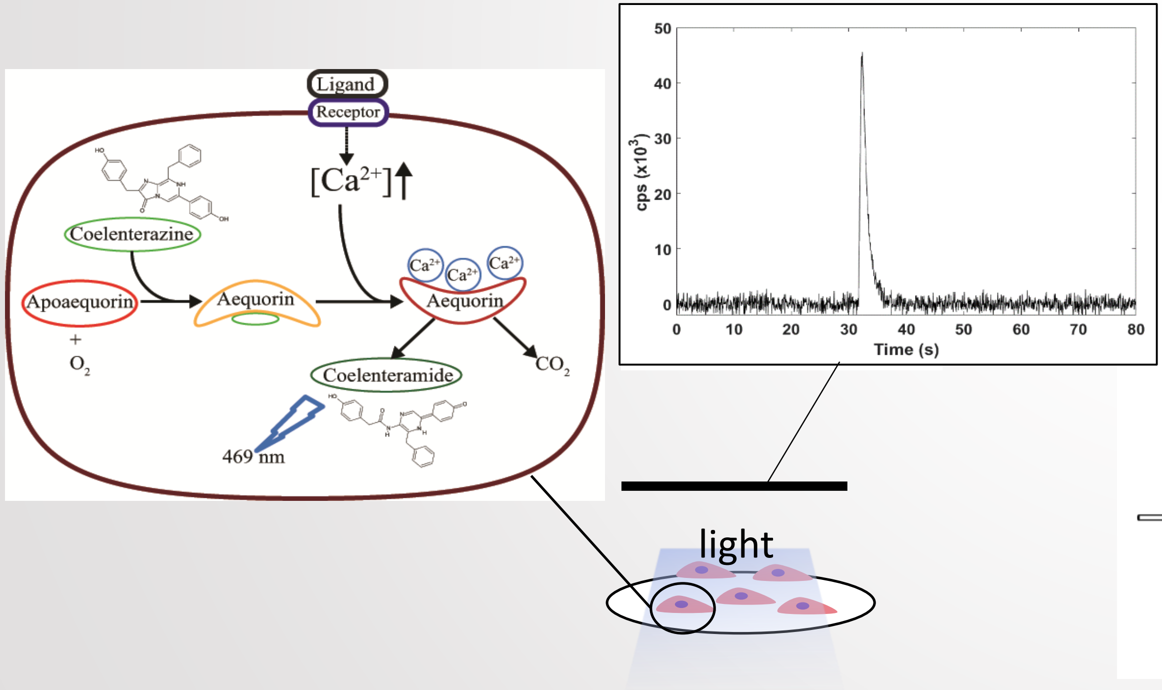
Aequorin: an useful bioluminescence sensor to measure calcium transients concentrations in living cells



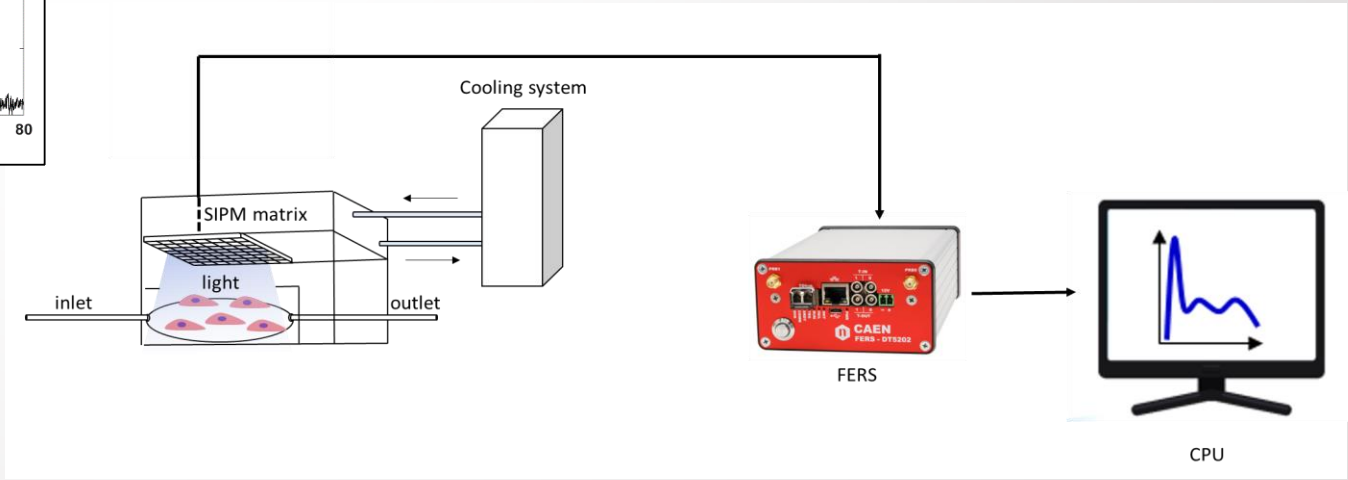
- Standard biotechnology methods for cellular Aequorin expression
- Wide dynamic range
- High signal-to-noise ratio
- Low Ca^{2+}-buffering effect

- **Upper limit extended by ≈ 25 times with respect to the single SiPM based system**

(Lomazzi *et al*., *ACS Sens.* 2020, 5, 2388−2397)



Experimental setup



Massimo CACCIA (U. Insubria)

HOW TO GENERATE AN UNPREDICTABLE RANDOM NUMBER?

PRNG
(PseudoRandom Number Generators)

Fast, cheap & reasonably easy. However:

- software Random Number Generation is PSEUDO
- code can be bugged
- and it may have a BACKDOOR

2006

Secret Documents Reveal N.S.A. Campaign Against Encryption

Documents show that the N.S.A. has been waging a war against encryption using a battery of methods that include working with industry to weaken encryption standards, making design changes to cryptographic software, and pushing international encryption standards it knows it can break. Related Article »

Excerpt from 2013 Intelligence Budget Request | Bullrun Briefing Sheet

This excerpt from the N.S.A.'s 2013 budget request outlines the ways in which the agency circumvents the encryption protection of everyday Internet communications. The Sigint Enabling Project involves industry relationships, clandestine changes to commercial software to weaken encryption, and lobbying for encryption standards it can crack.

2013

TRNG
(True Random Number Generators)

Extracting bits from the observation of natural phenomena is not trivial and you may suffer from

- “coin bias” by the embodiment of a great principle
- weakness against environmental parameters
- a significant “attack surface”, conditioning the device in use
- low bit rate

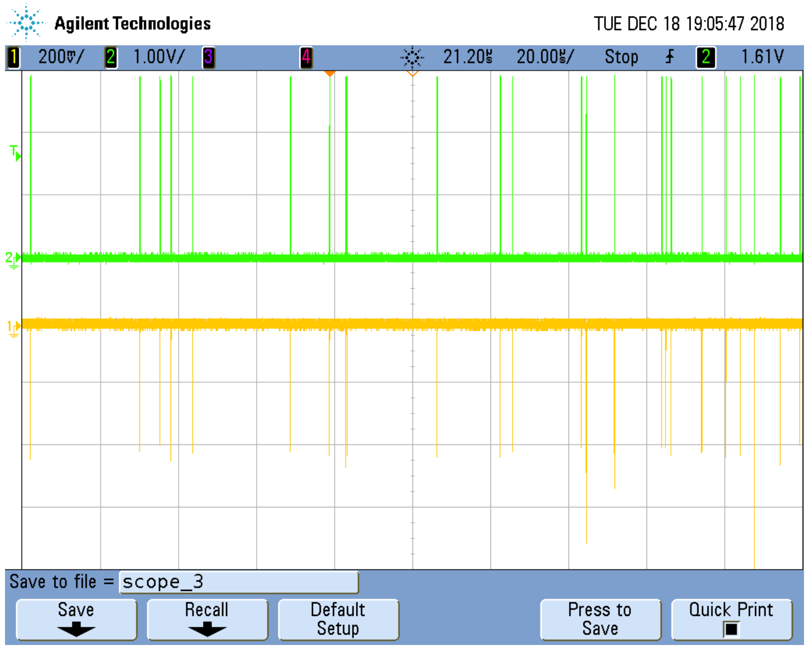
RANDOM POWER

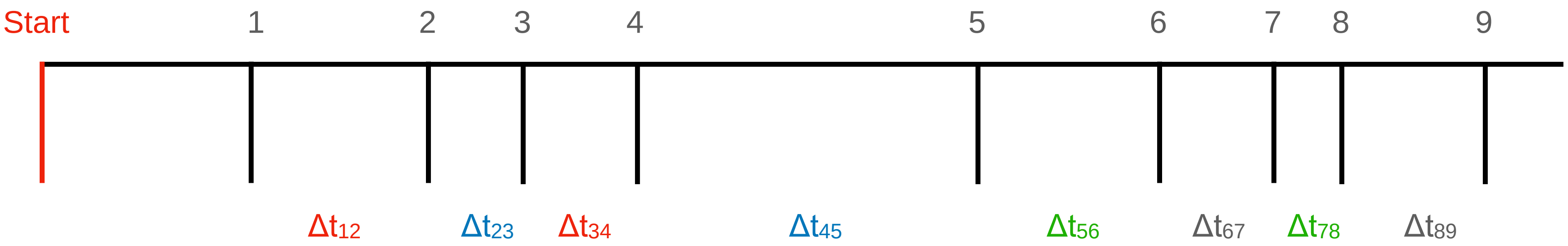
- The essence of :

turning unpredictable “Dark Pulses” into bits:

1. tagging & time stamping the occurrences of the random pulses

2. analysing the time series of the pulses:





- Italian Patent granted in Sept., 2020
- EU patent granted in April 2022
- extension in US, China, Korea, Jp ongoing

Ferdinando GIORDANO (CAEN)

CAEN Tools for Discovery — Electronic Instrumentation

Power electronics in HEP experimental caverns

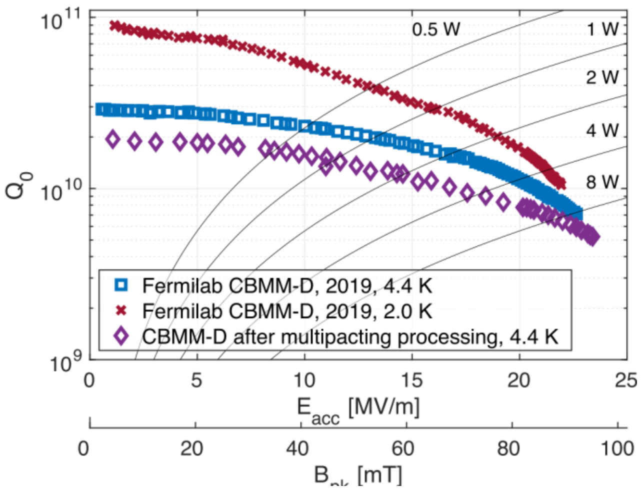
Ferdinando Giordano on behalf of the Power Supplies R&D group

Thanks to all these tests CAEN has developed a power supply with unprecedented power and channel density: 32 channels packed in less than 5 U 19" rack, capable of delivering up to 6 kW to the detector.

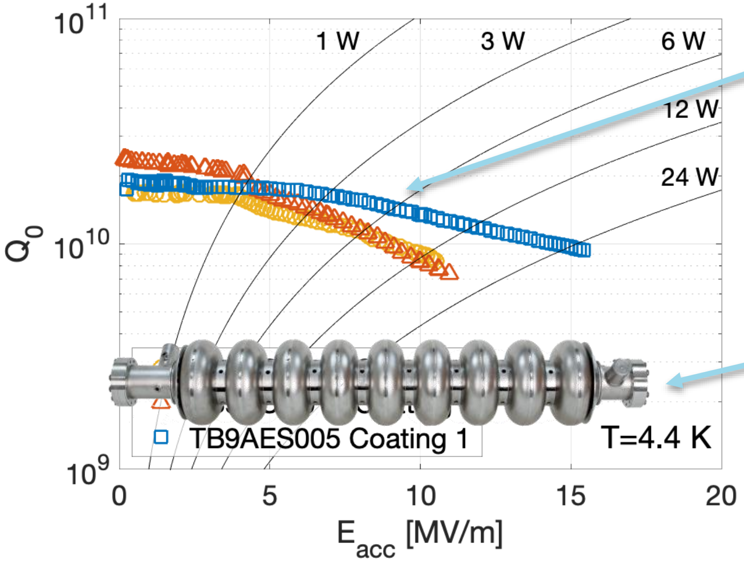
The first LV/HV mixed board has been delivered for testing. Again, the design is unprecedented improving both channel and power density with respect to the boards deployed ad the beginning of LHC. Moreover, the new boards weight less and are easier to maintain.

Nb_3Sn state-of-the-art

Grigory EREMEEV (FNAL)



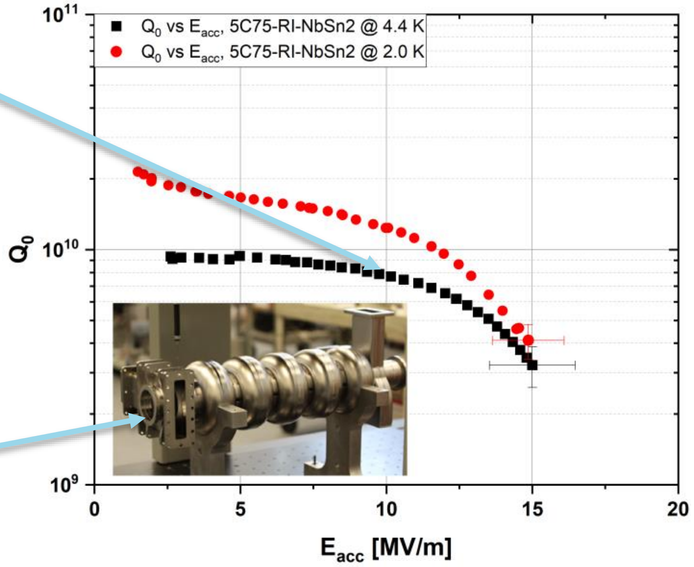
- Nb_3Sn SRF cavities are exciting for both high gradients (future) and high Q at higher temperatures (present)
- R&D Nb_3Sn SRF cavities reached 24 MV/m
- Accelerator cavities reached 15 MV/m with Q0 ~ 10^{10} at 4.4 K
- Conduction cooling tests are ongoing
- Key progress towards new applications such as compact **industrial accelerators**



Q_0 ~ 10^{10} @ E_{acc} ~ 10 MV/m @ 4.4 K in practical accelerator cavities

9-cell 1.3 GHz "ILC" cavity

5-cell 1.5 GHz CEBAF cavity



PAPER • OPEN ACCESS

Advances in Nb_3Sn superconducting radiofrequency cavities towards first practical accelerator applications

S Posen[1], J Lee[1,2], D N Seidman[2,3], A Romanenko[1], B Tennis[1], O S Melnychuk[1] and D A Sergatskov[1]

Published 11 January 2021 • © 2021 The Author(s). Published by IOP Publishing Ltd
Superconductor Science and Technology, Volume 34, Number 2
Citation S Posen et al 2021 Supercond. Sci. Technol. 34 025007

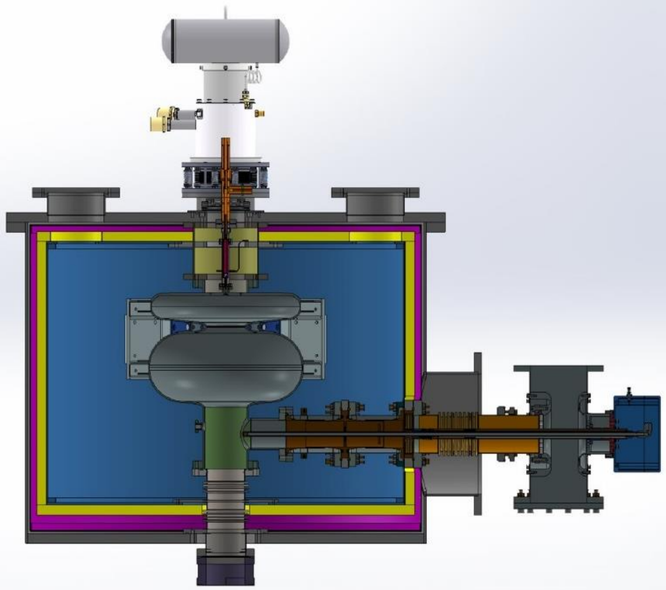
Nb_3Sn multicell cavity coating system at Jefferson Lab

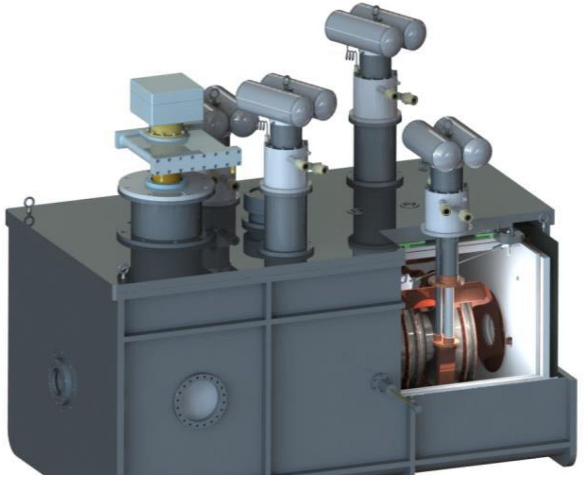
Cite as: Rev. Sci. Instrum. 91, 073911 (2020); doi: 10.1063/1.5144490
Submitted: 31 December 2019 • Accepted: 1 July 2020 •
Published Online: 27 July 2020

G. Eremeev,[1,a] W. Clemens,[1] K. Macha,[1] C. E. Reece,[1] A. M. Valente-Feliciano,[1] S. Williams,[1] U. Pudasaini,[2] and M. Kelley[2]

Summary

- An explosion of activities on Nb_3Sn development for SRF cavities
- High Q_0 at LHe temperatures with Nb_3Sn cavities is attractive for industrial applications
  - Potential for $Q_0 > 10^{10}$ at ~ 1 GHz at 4.4 K → compact cryomodules
  - Potential for using cryocoolers, cooling the cavities via conduction cooling
- Impacts high duty factor applications, especially small and medium-scale compact industrial applications (eg replace ^{60}Co for medical sterilization)
- Studies around the world to use conduction cooling of Nb_3Sn cavities for compact cryomodules
- Work to optimize the design of Nb_3Sn cavity – enabled cryomodules/accelerators
- Several cryostat/cryomodule tests are planned in the nearest future
  stay tuned!

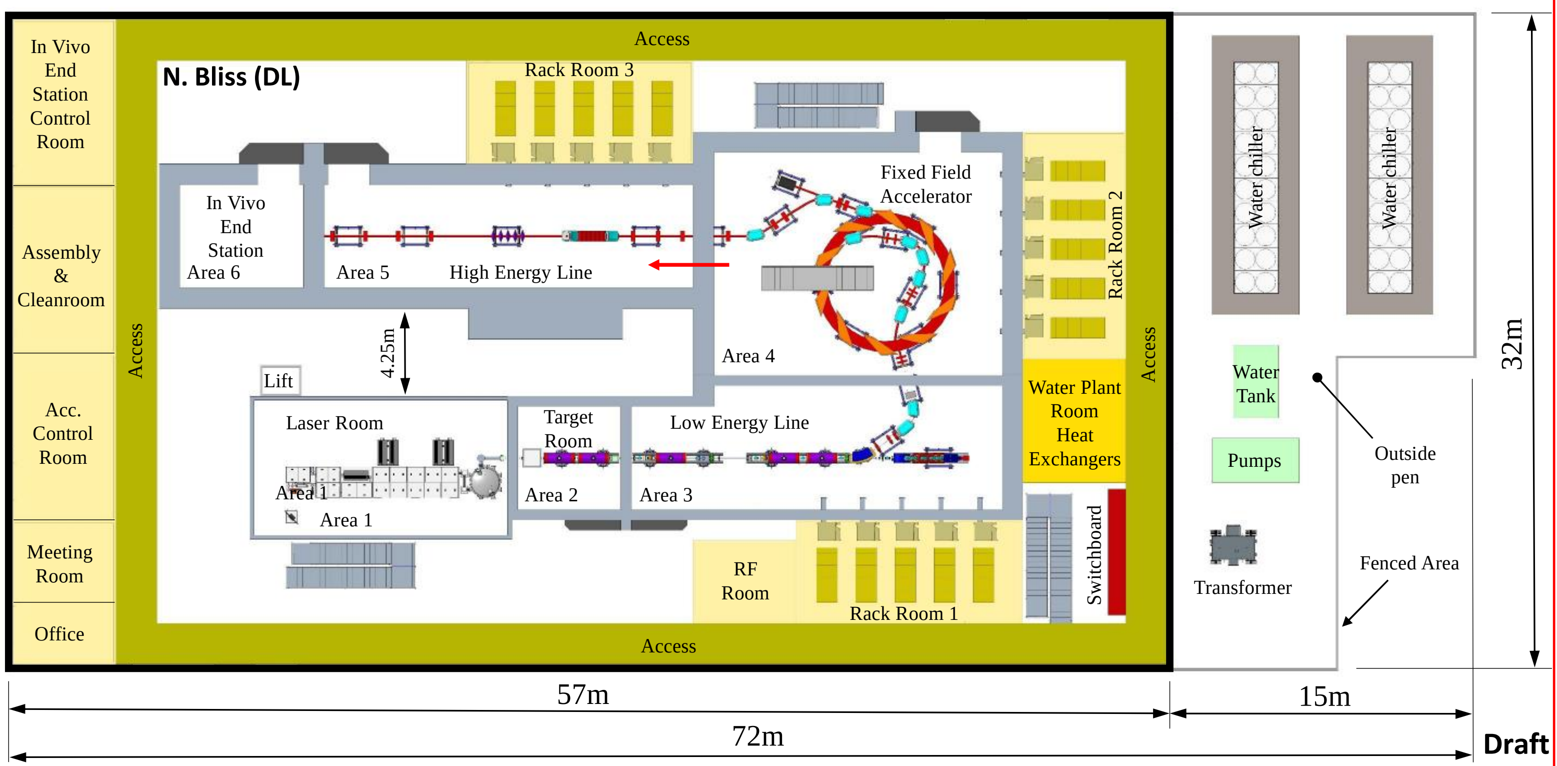




Poster by Ken LONG (Imperial)

LhARA: the Laser-hybrid Accelerator for Radiobiological Applications

- High-flux, laser-driven proton/ion source:
  - Instantaneous limitation of today's sources evaded
  - Very short pulses:
    - Pulse length 10 – 40 ns
  - Arbitrary pulse structure
- Electron plasma-lens capture & focusing:
  - Strong focusing without s/c solenoid
- Fast, fixed-field (FFA) post acceleration



Compact, uniquely flexible facility!

Ambition:

prove the principle of the techniques required to transform practice of particle-beam therapy …

…. using techniques that can be "spun back into" fundamental science

SRF technology enabling new transformative applications in quantum information science and dark sector searches

European XFEL ~1000 cavities
Q > 10^{10} @ 2K, 23.6 MV/m

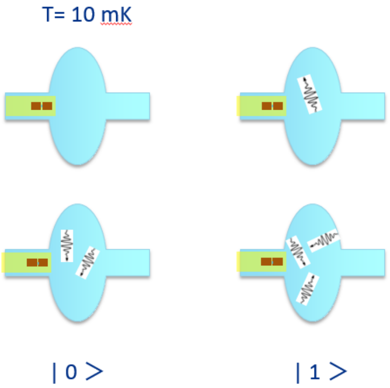
SRF Quantum Computing – where are the "bits"?

- How to encode a qubit (|0> and |1>) inside the cavity?

  Example 1: Call the ground state (**no photons**) as |0>, one **single photon** present as |1> (Fock state)

  Example 2: Call an **even** number of photons as |0>, **odd** number as |1>

- NOTE: Josephson-junction based transmon is used for state creation and quantum operations

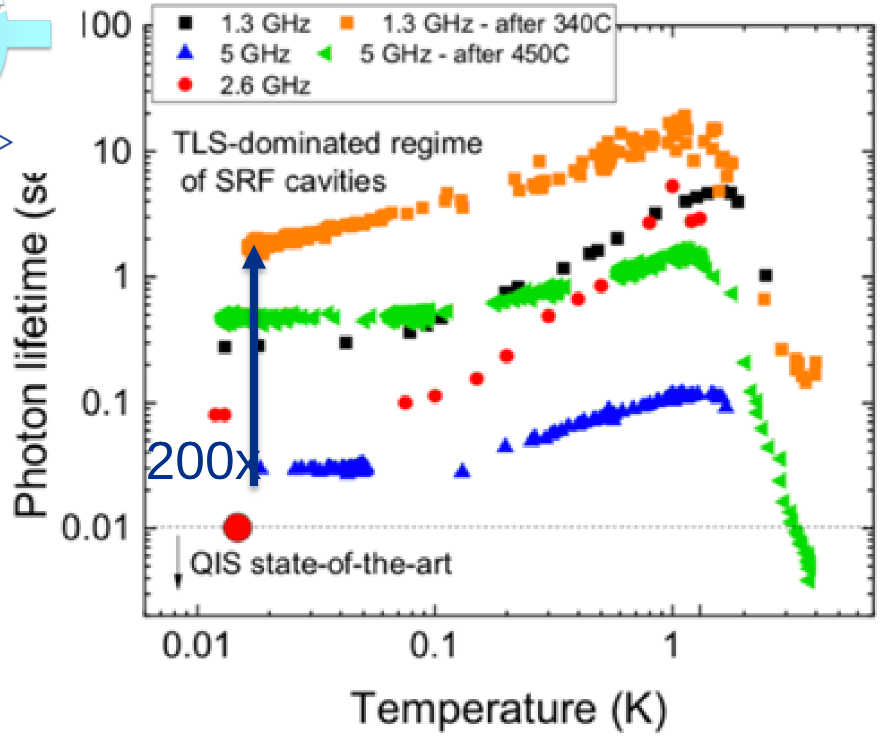


Dilution Fridge at FermilabAPS-TD Quantum Lab (QCL)

Anna GRASSELINO (FNAL)

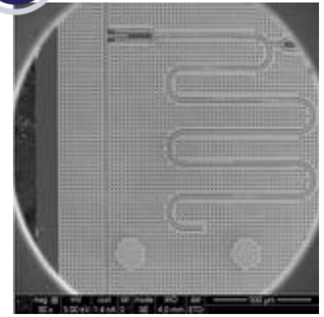
2 seconds of coherence demonstrated

A. Romanenko et al, Phys. Rev. Applied ***13****, 034032, 20*

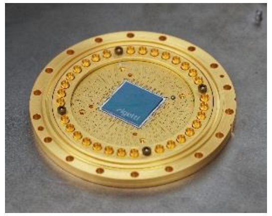


Superconducting Quantum Materials and Systems Center

10+ qubits prototype



Transmon qubit improvement in coherence > 10



100+ qubits prototype

Electronics/optimal controls development/scale up

1000+ qubits prototype @ Colossal Fridge

2023
Mid Term DOE Center Technical Review

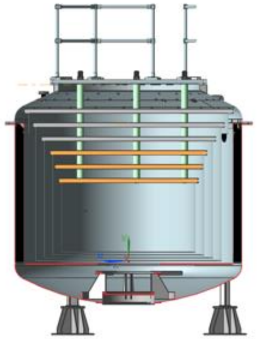
2025-6
Final Review and Center Renewal

2028
Second Term mid term review

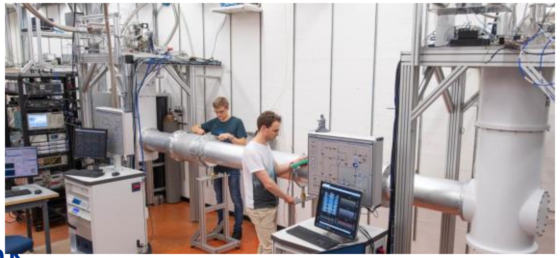
2031
Deployment of Quantum Facilities for National Research Program

New testbeds commissioned

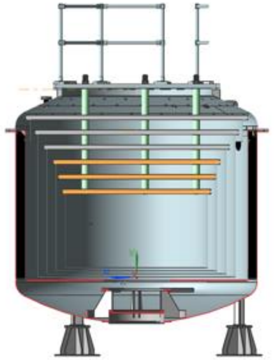
Quantum Sensors exploration for fundamental physics



Colossal fridge 50mK



Entangled multi-DR fridge system

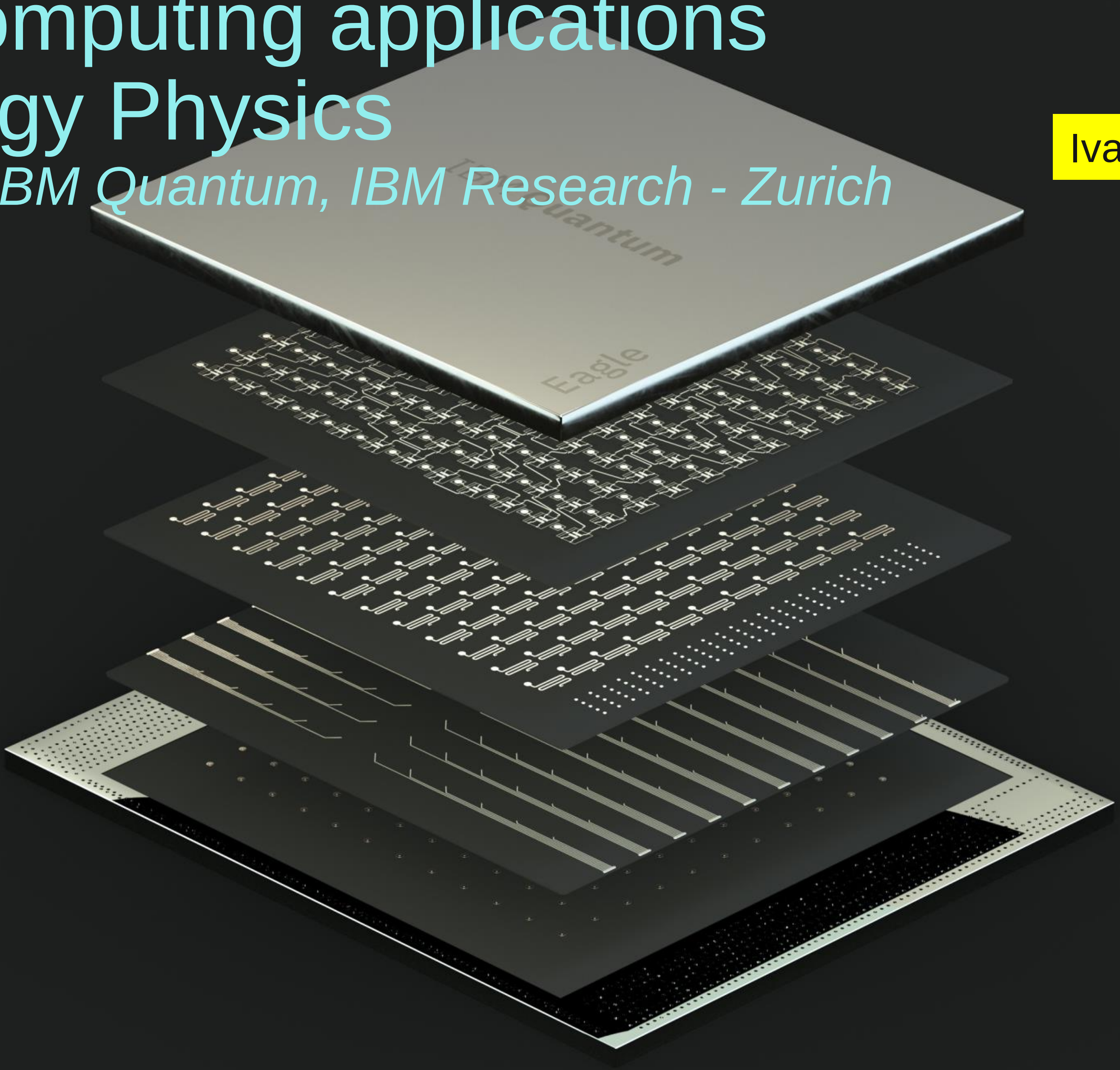


Colossal fridge 10mK commission ed

Quantum Computing applications in High Energy Physics

Ivano Tavernelli   IBM Quantum, IBM Research - Zurich

Ivano TAVERNELLI (IBM)



Eagle chip with 127 qubits released in 2021

Digital quantum computers are there!

Are we ready?

Development Roadmap

Executed by IBM ✓
On target

IBM Quantum

2019 ✓	2020 ✓	2021 ✓	2022	2023	2024	2025	2026+
Run quantum circuits on the IBM cloud	Demonstrate and prototype quantum algorithms and applications	Run quantum programs 100x faster with Qiskit Runtime	Bring dynamic circuits to Qiskit Runtime to unlock more computations	Enhancing applications with elastic computing and parallelization of Qiskit Runtime	Improve accuracy of Qiskit Runtime with scalable error mitigation	Scale quantum applications with circuit knitting toolbox controlling Qiskit Runtime	Increase accuracy and speed of quantum workflows with integration of error correction into Qiskit Runtime

Model Developers

- Prototype quantum software applications → Quantum software applications
  - Machine learning | Natural science | Optimization

Algorithm Developers

- Quantum algorithm and application modules ✓
  - Machine learning | Natural science | Optimization
  - Qiskit
- Quantum Serverless
  - Intelligent orchestration
  - Circuit Knitting Toolbox
  - Circuit libraries

Kernel Developers

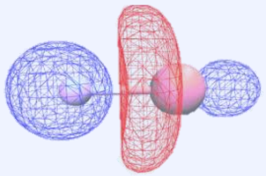
- Circuits ✓
- Qiskit Runtime ✓
  - Dynamic circuits (on target)
  - Threaded primitives
  - Error suppression and mitigation
  - Error correction

System Modularity

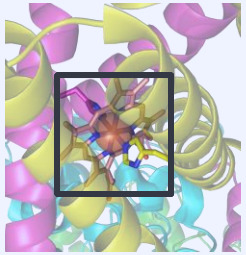
- Falcon ✓ — 27 qubits
- Hummingbird ✓ — 65 qubits
- Eagle ✓ — 127 qubits
- Osprey (on target) — 433 qubits
- Condor — 1,121 qubits
- Flamingo — 1,386+ qubits
- Kookaburra — 4,158+ qubits
- Scaling to 10K-100K qubits with classical and quantum communication
- Heron — 133 qubits x p
- Crossbill — 408 qubits

Overview of near-term applications in Qiskit

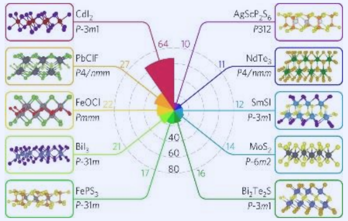
IBM Quantum



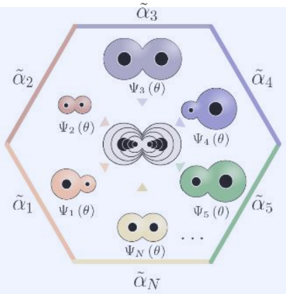
Electronic structure calculations: ground & excited states, vibronic structure



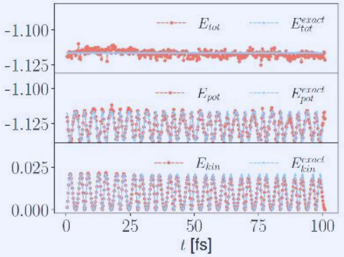
Scaling-up functionalities: towards the simulation of large molecular systems



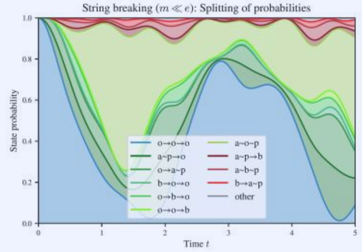
Quantum machine learning for material design



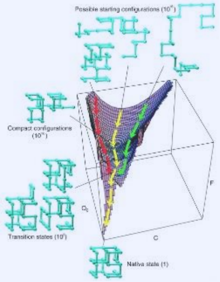
Ab-initio molecular design



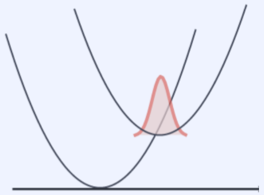
Ab-initio molecular dynamics, Langevin dynamics



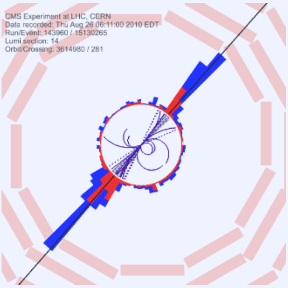
Lattice gauge theory: from Schwinger model to QED and beyond



Configuration space sampling and folding



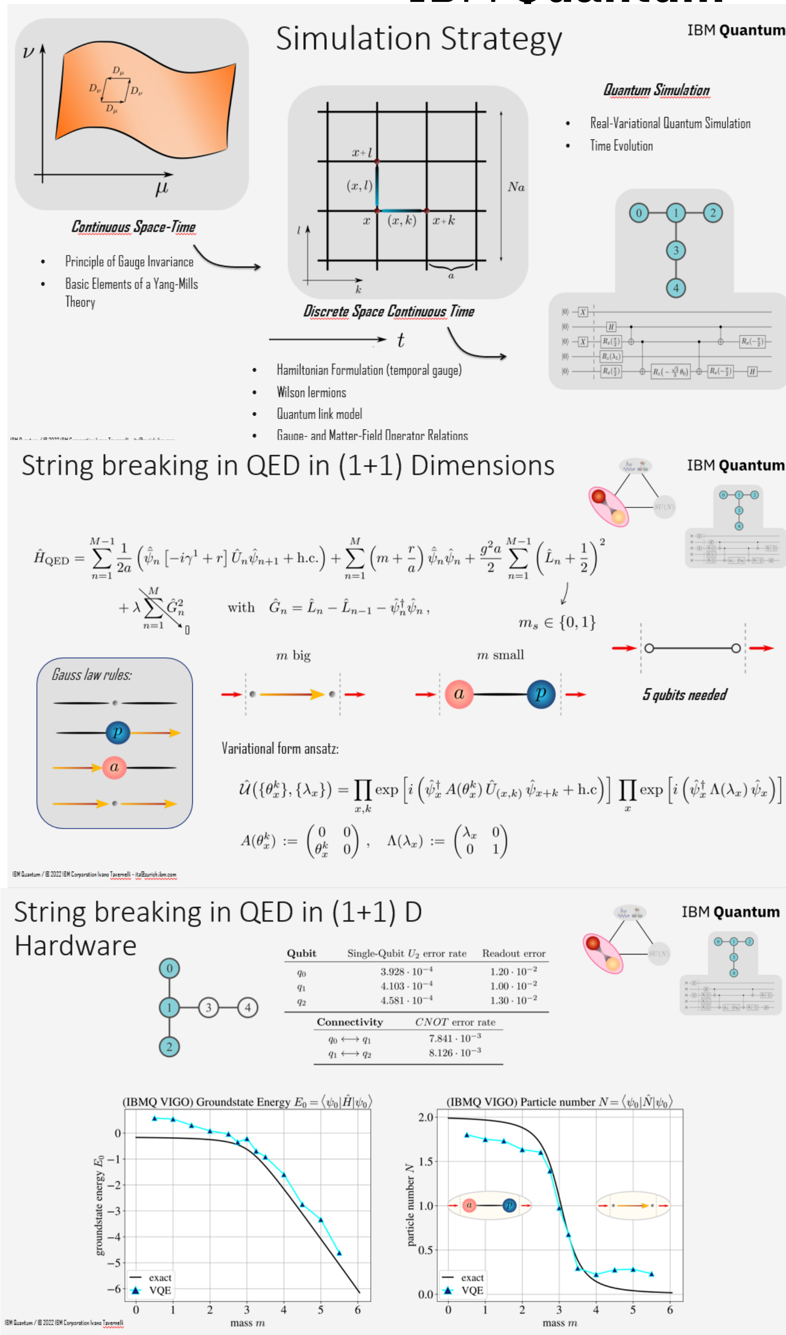
Quantum dynamics in photophysics and photochemistry



Quantum machine learning for high energy physics

Resources estimation

System size	Lattice QED	Lattice QCD
Proof of concepts [3x1 lattice]	10 qubits 3k CNOT gates	100 qubits
Non-trivial physics [6x6 lattice]	200 qubits 60k CNOT gates	2k qubits
QED/QCD applications [10x10x10 lattice]	16k qubits 6M CNOT gates	160k qubits

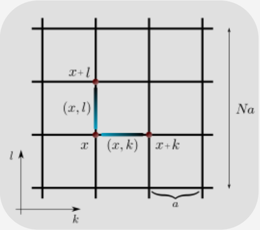


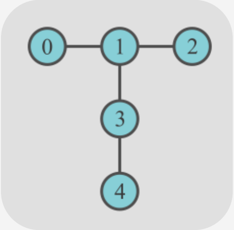
S.V. Mathis, G. Mazzola, I. Tavernelli , *Toward scalable simulations of lattice gauge theories on quantum computers,* Phys. Rev. D 102, 094501 (2020).

Conclusion

IBM **Quantum**

Quantum computers can provide quantum speed-up for Lattice Gauge Theory in the **fault-tolerant regime** starting from system sizes of the order of 10x10x10 +1 dimensions





Do we need to focus on fault-tolerant quantum algorithms?

We believe that there can be interesting problems in low dimensions, with

- extended entanglement
- complex dynamics

for which **near-term quantum approches** can potentially give a significant contribution

G Mazzola, SV Mathis, G Mazzola, I Tavernelli , Gauge-invariant quantum circuits for (1) and Yang-Mills lattice gauge theories, Phys. Rev. Res. 3, 043209 (2021).

S.V. Mathis, G. Mazzola, I. Tavernelli , *Toward scalable simulations of lattice gauge theories on quantum computers,* Phys. Rev. D 102, 094501 (2020).

ICHEP2018 SEOUL
XXXIX INTERNATIONAL CONFERENCE ON high Energy PHYSICS
JULY 4 - 11, 2018 COEX, SEOUL

Speakers from industry and research institutions covering the connections between industry and particle physics and addressing key topics such as:

- What are the best models to bring developments from HEP to the market?
- How can we lower the current barriers to realizing industrial opportunities?
  - Proof of Concept support for maturing technologies
- International collaborations and networks as facilitators for new developments
- Help developing entrepreneurs via spin-offs and start-ups

ATTRACT

Pablo Garcia TELLO (ATTRACT)

ATTRACT as an answer to the question : *is the potential of European Research Infrastructures as Innovation Engines fully exploited ?*

A novel Ecosystem focusing on breakthrough detection and imaging technologies

1. The innovation potential of European RIs is only partially exploited.
2. There is a clear need for identifying win-win R&D&I opportunities between the industrial communities and those behind RIs beyond the existing frameworks and practices.
3. A novel action framework was necessary for enabling those opportunities incorporating the paradigm of "Open Science, Open Innovation, Open to the World".
4. Such framework should be prone to be tested, by generating, gathering and analyzing data. Only then, it should be possible to corroborate its validity and consider a significant scaled-up deployment.

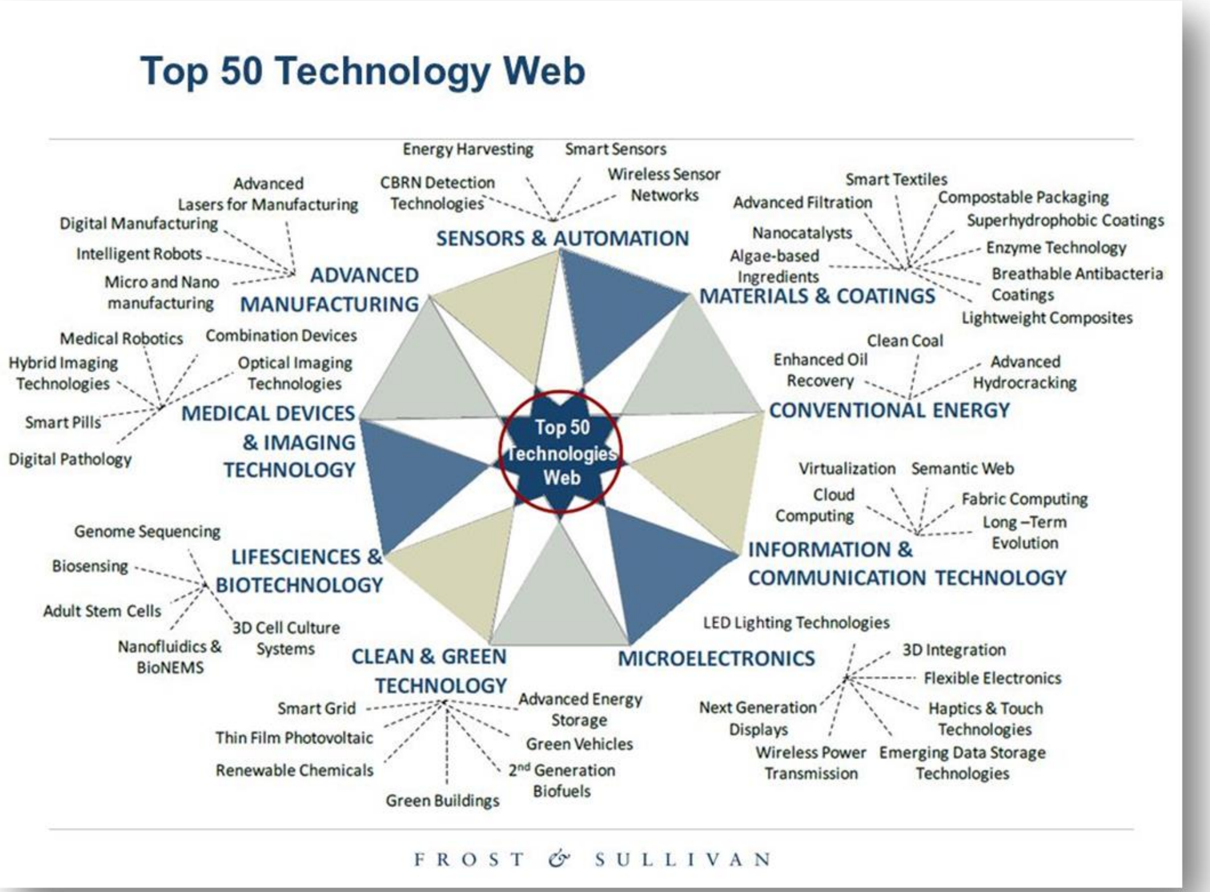
- Many of them have been reflected in the EC policy paper, *Sustainable Research Infrastructures,* https://ec.europa.eu/info/sites/default/files/research_and_innovation/research_by_area/documents/swd-infrastructures_323-2017.pdf

ATTRACT: Why Detection and Imaging?

Are you able to point a field in the picture with nothing to do with Detection and Imaging?

- The scientific mission of European RIs as well as their R&D associated communities is strongly coupled with detection and imaging technology instrumentation (including computing).

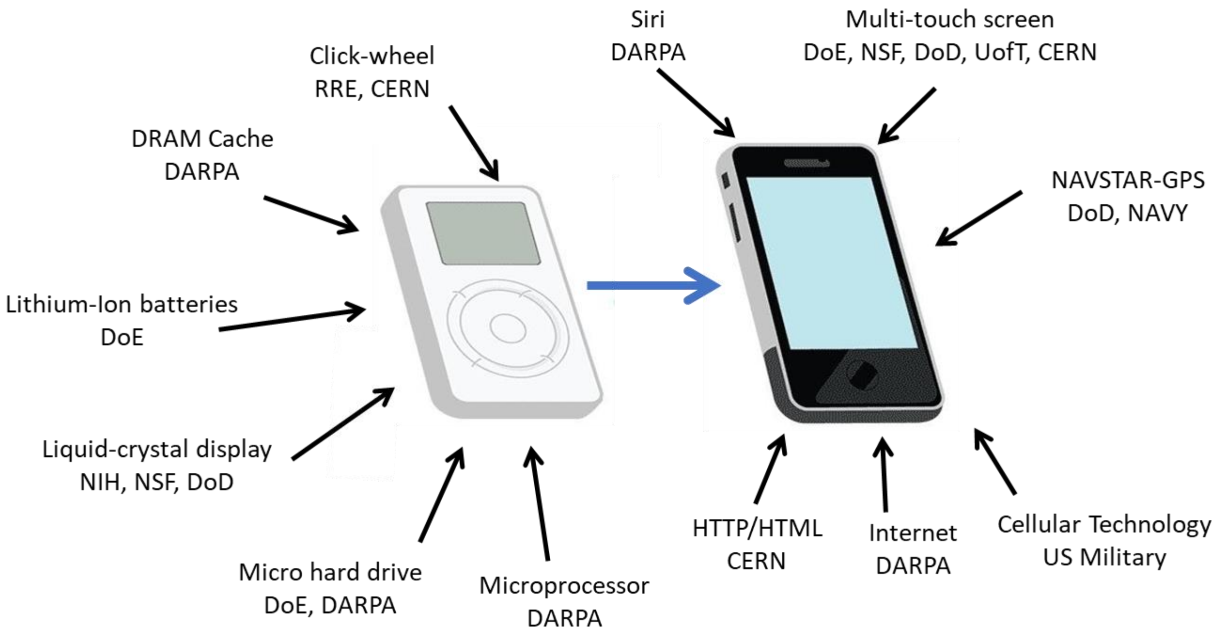
- Detection and Imaging technologies are and will be at the core of future industrial developments applications and business (e.g. IoT, Smart Cities, Autonomous Transport, Sustainable Agriculture, etc).



ATTRACT: Key pillars (1)

"Where does breakthrough Innovation come from?"

Public Funding: Key for helping nascent breakthrough technologies, many of them even at the conceptual level, mature for raising the interest of private capital .



DARPA: Defense Advance Research Project Agency
RRE: Royal Radar Establishment
CERN: European Organization for Nuclear Research
DoE: Department of Energy
NIH: National Institute of Health
NSF: National Science Foundation
DoD: Department of Defence
UofT: University of Toronto

ATTRACT: Key pillars (2)

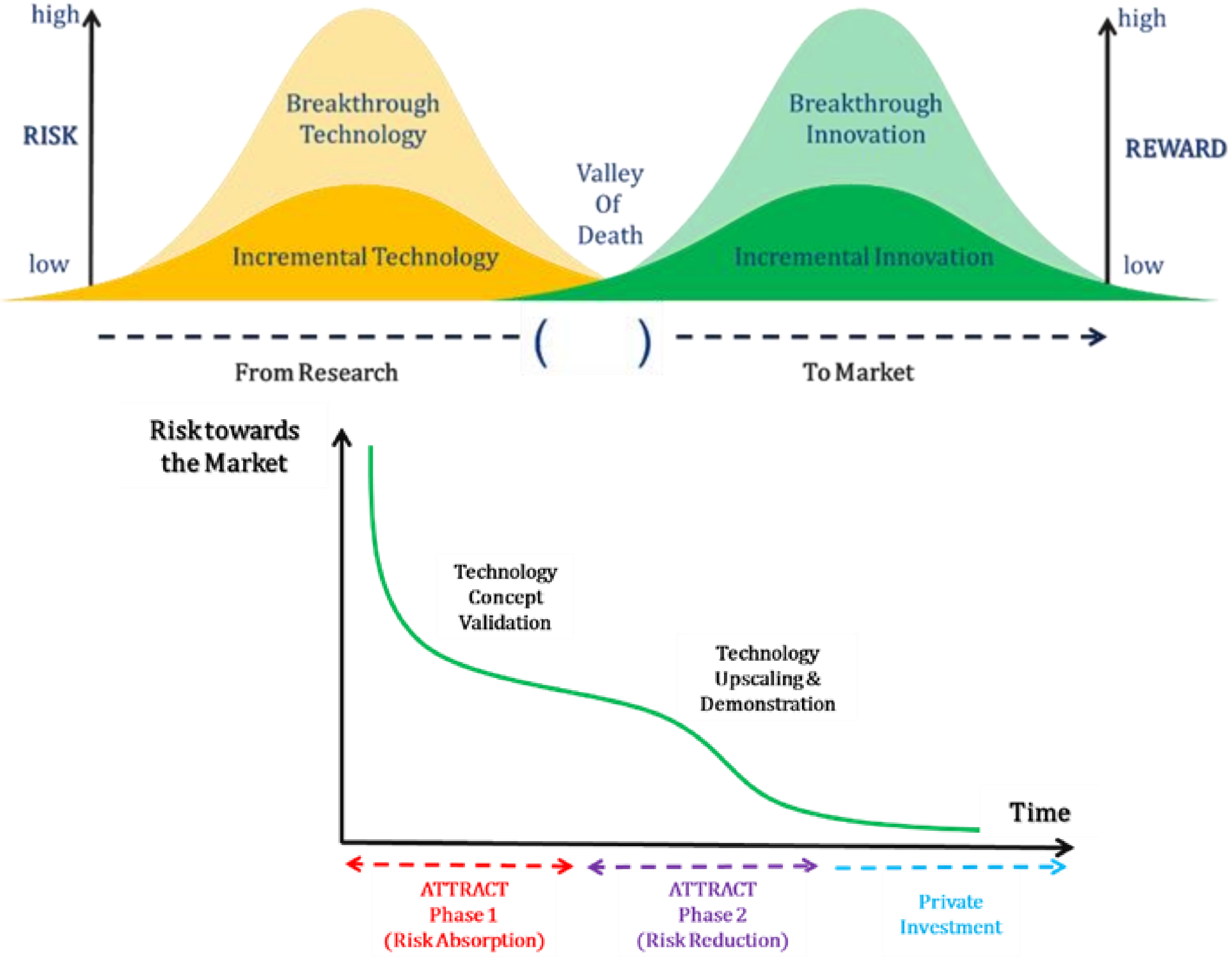
“Not two Valleys of Death look the same”

Phase approach to funding: Breakthrough Technologies (coming from Fundamental Research) are very risky to invest upon for private capital.

De-risking them needs public funding:

First, a **risk-absorption stage**, where ideas and concepts could reach a prototype level and technology concept validation.

Second, a **risk-mitigation stage**, where the most promising concepts are further helped raising towards a pre-market product.



ATTRACT: Key pillars (3)

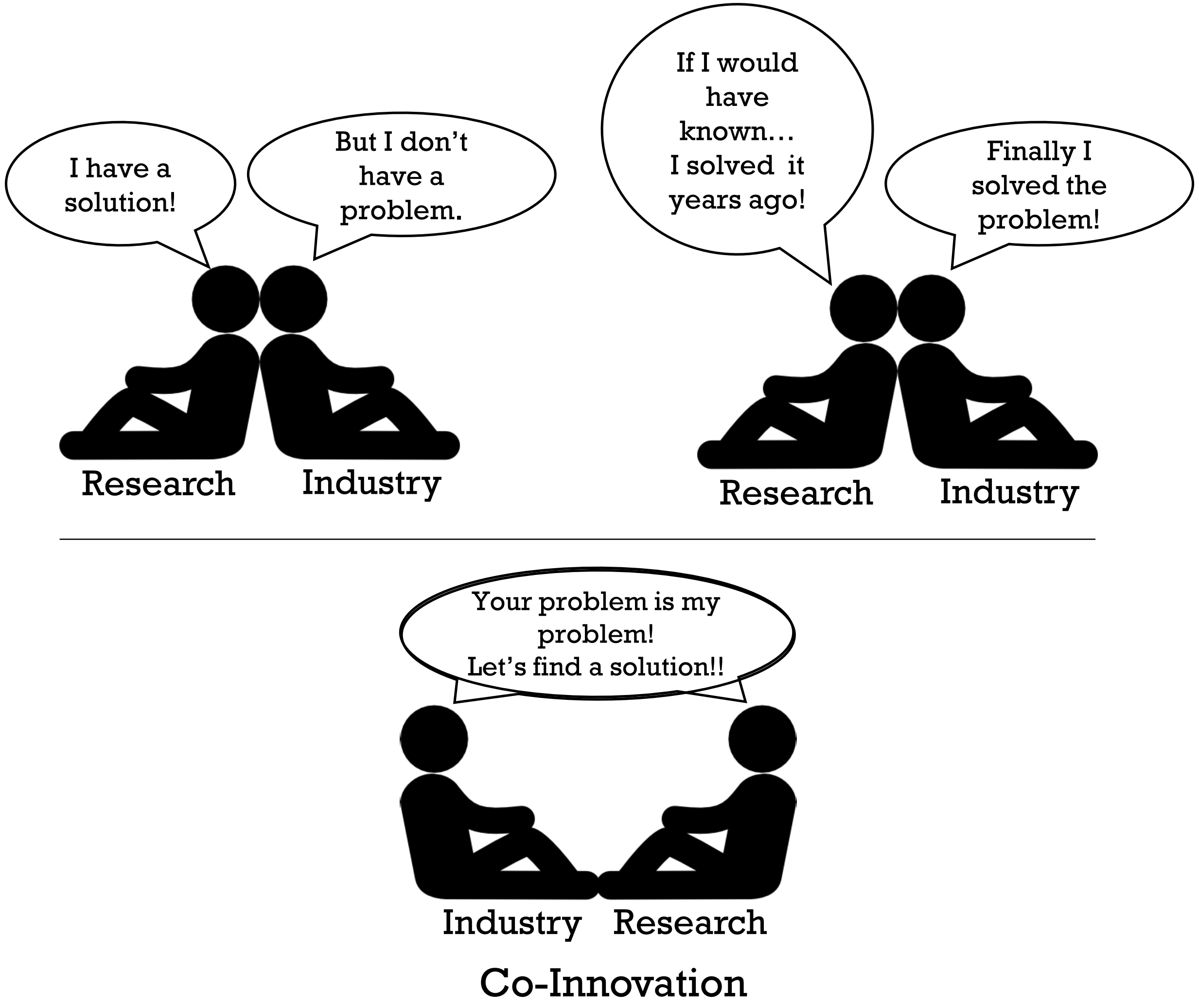
"Trust and shared know-how is not built in one day"

Co-Innovation:

- Bridge between two communities (research and industry) that in principle have different motivations and goals for undertaking R&D&I (capital and/or resource intensive) efforts .

- Entails the identification and collaboratively pursuing of win-win outcomes, starting already at the conceptual stages of a technology development and enduring them until the later stages of the innovation value chain (e.g. commercialization).

- Departs from research-industry relationships established as simply customer-supplier ones.



ATTRACT: Key pillars (4)

"Young people want to change the world"

Young Innovators Projects:

- ATTRACT is facilitating the integration of interdisciplinary MSc level students tems working side by side with professional researchers from academia and industry developing the R&D&I funded projects.

- These Young Innovators' goal is prototyping technology solutions specifically addressing the United Nations Sustainable Development Goals,

- They use a Design Thinking approach inspired by the technology developed by the projects.

Concluding remarks

- Steady progress on innovation and KT/TT
  - Many fruitful initiatives (CERN KT, ATTRACT, Aidainova…)
  - Fostering links with other fields
  - Important for public/political support of HEP
  - underlined by ICFA report

- Are we there or can we do better ?
  - High-level support but still some intermediate blockages
  - « Pure elevated » research *vs* « low earthly » applications !
  - Often stumbling also on (overvalued?) IP

- Engineering manpower is going down in many labs : could outsourcing be a solution ?
  - Attractiveness issues now in the public sector
  - Step already done in several domains (sensors, accelerators…)

IT'S THE LATEST GOVERNMENT GUIDANCE ON 'MANAGING PAPERWORK FOR SMALL BUSINESSES'

- Thank you for your attention and don’t hesitate to visit our industrial sponsors !