

# Forum Teratec 2021

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# Europe is on its way towards "Hybrid Qomputing"

Workshop organised and moderated by

*Prof. Kristel Michielsen, Jülich Supercomputing Centre*

*Dr. Guillaume Colin de Verdière, International Expert in HPC, CEA*

*Dr. Jean-Philippe Nominé, HPC Strategic Collaborations Manager, CEA*



- ▶ This workshop will demonstrate that the next step in high performance computing is the introduction of quantum accelerators (quantum processing units, in short QPU) into the computing centre in a modular fashion. Supercomputers and QPUs will allow scientists to perform hybrid quantum-classical computing which we will shorten as Hybrid Qomputing.
- ▶ We will first explain what kind of algorithms are possible with this new concept, what can be hoped for and what kind of limitations we will be facing. Then we will illustrate first (industrial) results on practical use cases showing the potential impact of Hybrid Qomputing.

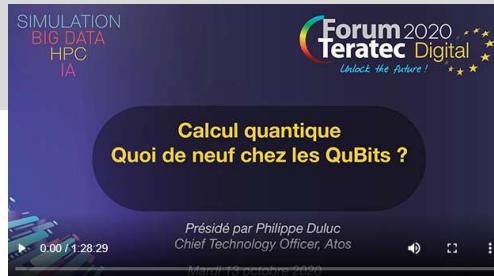
|             |   |
|-------------|---|
| <b>5mn</b>  | Introduction : CEA  |
| <b>20mn</b> | State of the Art: the promises and limitations of Hybrid Qomputing<br>K. Michielsen, FZJ  |
| <b>20mn</b> | Algorithms for Hybrid Quantum Computing & Applications<br>Prof. Göran Wendum –CHALMERS  |
| <b>15mn</b> | The Atos Quantum Program: Paving the way to quantum-accelerated HPC<br>Jean-Pierre Panziera, ATOS                               |
| <b>15mn</b> | Modular Computing & QPUs<br>Thomas Moschny, ParTec  |
| <b>15mn</b> | Use-cases to demonstrate the added value of Hybrid Qomputing: the HPCQS portfolio<br>Venkatesh Kannan , ICHEC                   |
| <b>15mn</b> | Quantum computing applications in natural sciences and material design<br>Ivano Tavernelli, IBM Research – Zurich               |
| <b>15mn</b> | Hamiltonian modelling of approximate path planning problems for hybrid algorithms<br>Romain Kukla, Léo Monbroussou, Naval Group |



DE LA RECHERCHE À L'INDUSTRIE

## CEA Standpoint





**Forum TERATEC 2020**  
Mardi 13 octobre - Ateliers techniques  
Atelier 3 - de 16h00 à 17h30

**Calcul quantique : Quoi de neuf chez les QuBits ?**  
Présidé par Philippe Duluc, Chief Technology Officer, Atos

**Premiers processeurs quantiques passant à l'échelle et leurs applications**  
Par Georges-Olivier Raymond, CEO, Pasqal

**Biographie : Georges OLIVIER RAYMOND** obtient son doctorat en physique quantique en 2002. Ses travaux pionniers et fondamentaux permettent d'isoler un atome unique dans une grappe optique, une étape clé vers le développement d'un ordinateur quantique. Il passe ensuite par la recherche dans les domaines de la physique des solides et des phototecnologies, la défense ou les semi-conducteurs. Depuis 2010, représentant ses travaux de thèse, il travaille à la création de la première entreprise française de nanotechnologie dédiée au calcul quantique. Il fonde Pasqal en mars 2019.

**After several workshops on/with quantum computing at TERATEC Forums, over the last years, organised or co-organised by CEA, with focus on emerging technologies, promising use cases....**

- ▶ 2020 Quantum computing: what's new in QuBits?
- ▶ 2019 Quantum computing : which applications will benefit ?
- ▶ 2018 Quantum revolution is here
- ▶ 2016 Specialised computing architectures : helpers or challengers ?

[https://teratec.eu/gb/forum\\_2020/atelier\\_3.html](https://teratec.eu/gb/forum_2020/atelier_3.html)

[https://teratec.eu/gb/forum\\_2019/atelier\\_2.html](https://teratec.eu/gb/forum_2019/atelier_2.html)

[https://teratec.eu/gb/forum\\_2018/atelier\\_3.html](https://teratec.eu/gb/forum_2018/atelier_3.html)

[https://teratec.eu/gb/forum\\_2016/atelier\\_4.html](https://teratec.eu/gb/forum_2016/atelier_4.html)

**... today we shift the gear and widen the scope towards a more global and European HPC/QC vision.**

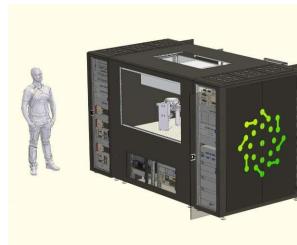
**We are active in the community and in close relationship with most speaking entities today!**

## Très Grand Centre de Calcul du CEA Two main components



### ► Research Computing Centre GENCI's Joliot-curie, 22 PF

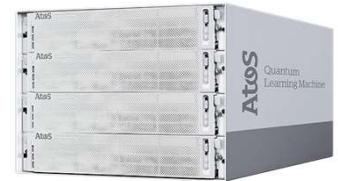
- Bound to be the French reference centre in terms of Quantum Computing public infrastructure, together with GENCI



### ► Industry computing centre: CCRT Topaze, 9PF – Cobalt, 3PF



- Hosting an ATOS QLM since 2018 (31 qubits), in particular for industrial partners use cases (↔TERATEC TQCI)



# Our next move: HPCQS with Pasqal, FZJ, GENCI... & more EU partners

## ► 1 pasqal machine @TGCC, 1 @ JSC/JUNIQ

- Quantum Simulator (analog)
- Neutral Rydberg atoms handled by laser (optical tweezers)



## ► Latest progress <https://pasqal.io>

- 100 qubits then 196 in the lab

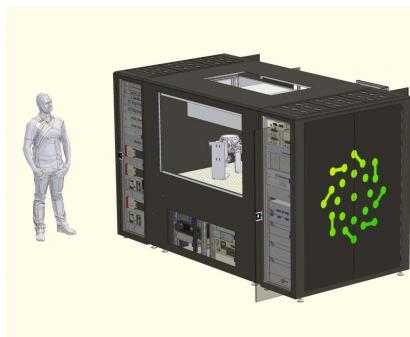
### ► 2021

- Henrique Silvério, Sebastián Grijalva, Constantin Dalyac, Lucas Leclerc, Peter J. Karalekas, Nathan Shammah, Mourad Beji, Louis-Paul Henry, Loïc Henriet  
*Pulser: An open-source package for the design of pulse sequences in programmable neutral-atom arrays*  
[arXiv](#)
- Giovanni Ferioli, Antoine Glicenstein, Loïc Henriet, Igor Ferrier-Barbut, and Antoine Browaeys  
*Storage and Release of Subradiant Excitations in a Dense Atomic Cloud*  
[Phys. Rev. X 11, 021031 \(2021\) \[arXiv\]](#)

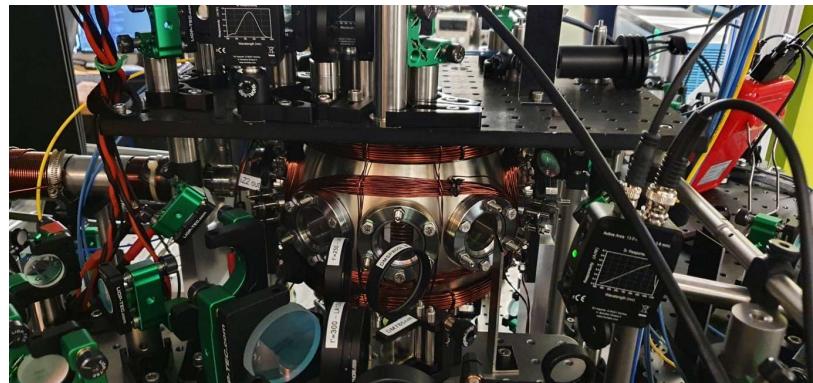
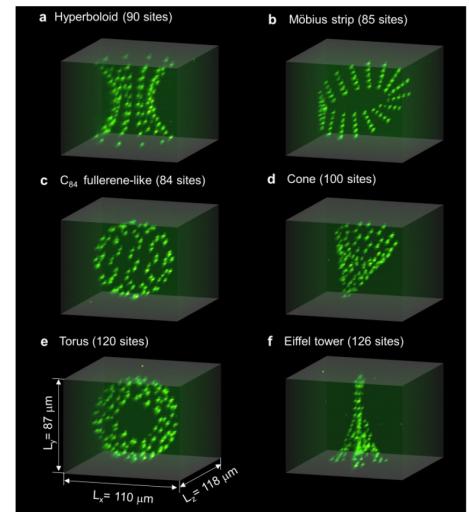
### ► 2020

- Constantin Dalyac, Loïc Henriet, Emmanuel Jeandel, Wolfgang Lechner, Simon Perdrix, Marc Porcheron, Margarita Veshchezerova  
*Qualifying quantum approaches for hard industrial optimization problems. A case study in the field of smart-charging of electric vehicles*  
[arXiv](#)
- Pascal Scholl, Michael Schuler, Hannah J. Williams, Alexander A. Eberharter, Daniel Barredo, Kai-Niklas Schymik, Vincent Lienhard, Louis-Paul Henry, Thomas C. Lang, Thierry Lahaye, Andreas M. Läuchli, Antoine Browaeys  
*Programmable quantum simulation of 2D antiferromagnets with hundreds of Rydberg atoms*  
[arXiv](#)
- ...

The path to Pasqal's first 200 qubits processors



Single-atom fluorescence in 3D arrays, in [Nature 561, 79 \(2018\)](#).





# Enjoy the workshop!

Credits / pictures: CEA, CEA/CADAM, P. Stroppa, Pasqal

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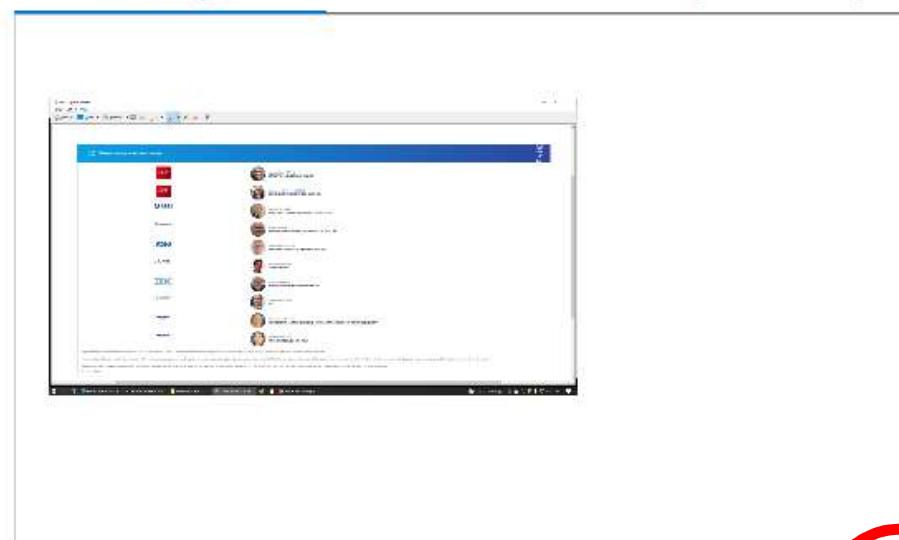
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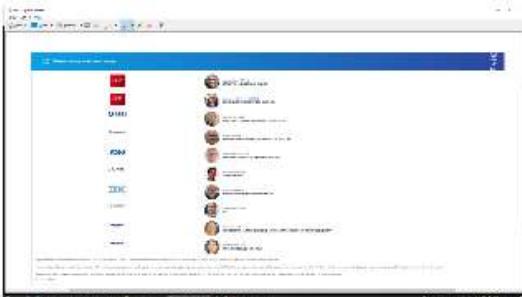
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CHAT QUESTIONS

Use the Questions feature for questions!

Jean-Philippe NOMINE CEA

A screenshot of a digital event interface showing a 'QUESTIONS' panel. A green arrow points from the text 'Audience' to the 'QUESTIONS' tab at the top of the panel. The panel displays a message encouraging users to use the questions feature, followed by a row of small icons. Below the panel is a text input field with placeholder text 'Ajoutez votre message...' and a 'PARTAGER' button at the bottom.

Audience

Use  
Questions  
Panel !



*Merci pour votre attention.*  
Thank you for your attention.

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