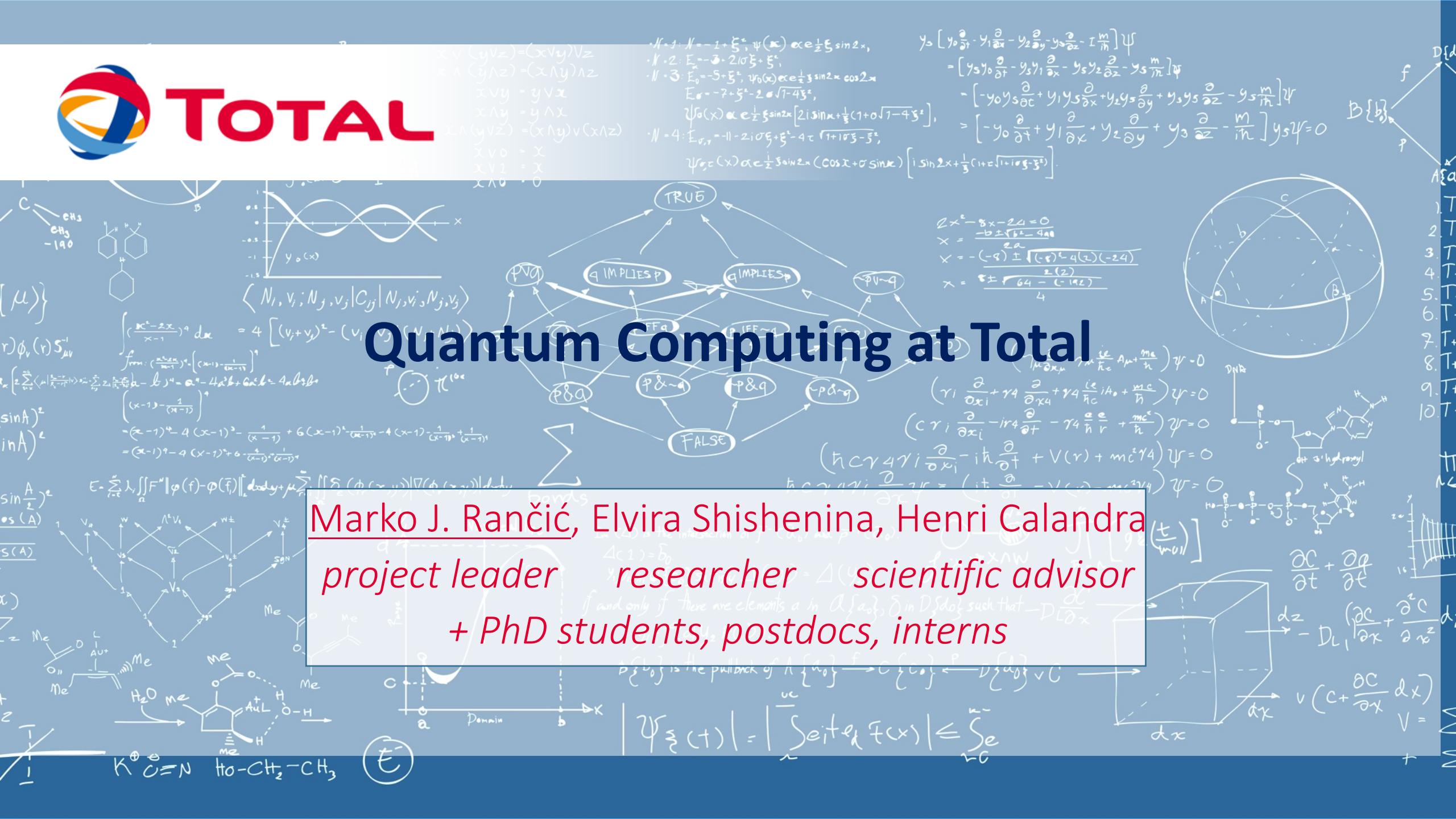


Quantum Computing at Total

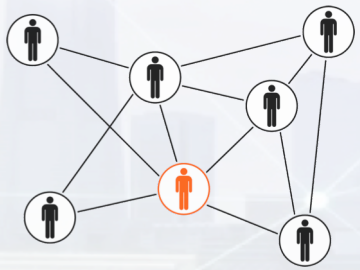
Marko J. Rančić, Elvira Shishenina, Henri Calandra

project leader *researcher* *scientific advisor*

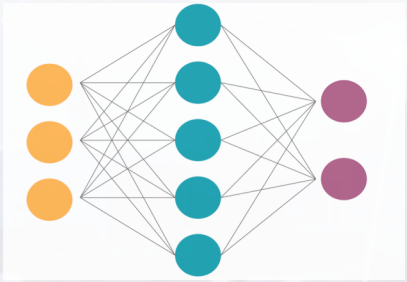
+ PhD students, postdocs, interns

Roadmap & potentital use cases

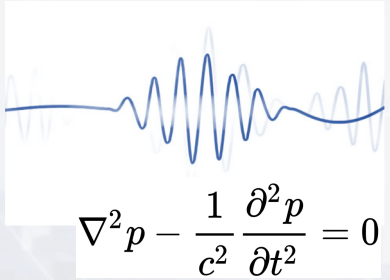
Quantum chemistry



Quantum combinatorial optimization



QML



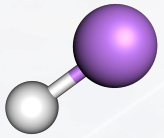
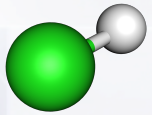
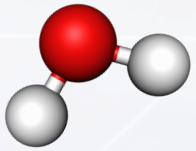
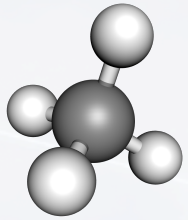
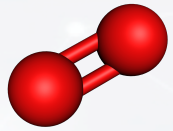
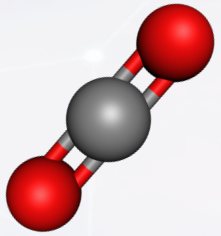
Linear algebra (ODEs, PDEs, inverse problems)

NISQ device ~ (10^2 qubits) 3-5 years

(pre)-QEC device ~ ($10^{3(-6)}$ qubits) 5++ years

Quantum Chemistry ground state problem with VQE

ATOS 35 qubit simulator

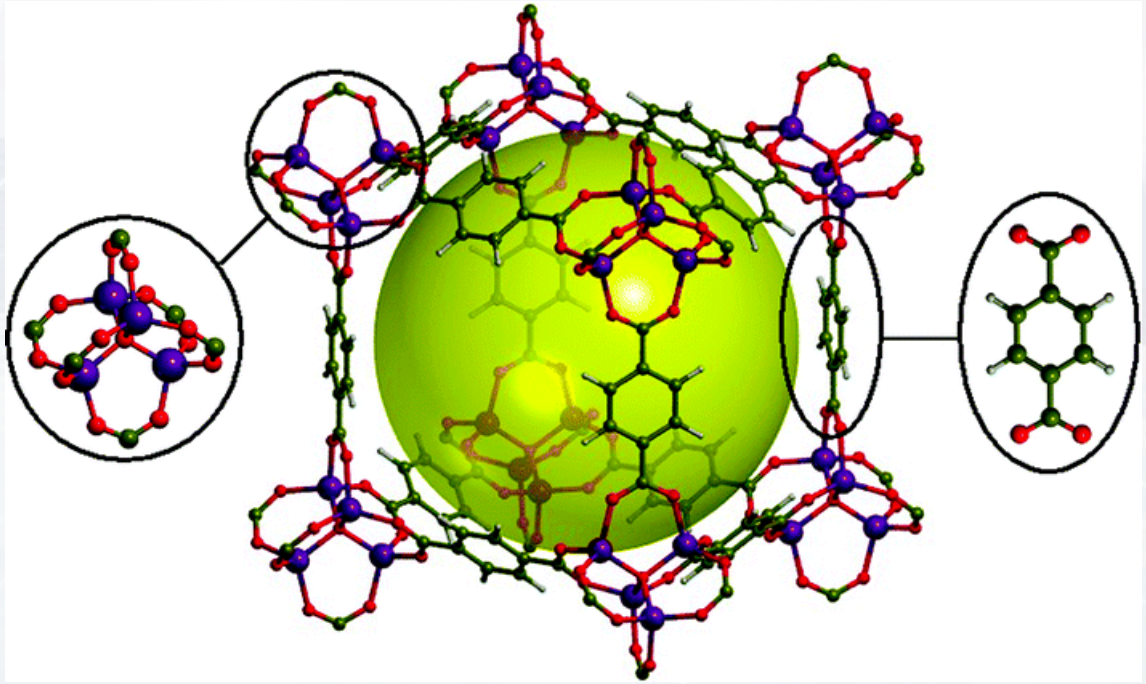
ground state energies	LiH	BeH	H2O	CH4	O2	CO2
						
VQE Total	-7.76	-14.44	-72.91	-38.97	-144.28	-179.93
VQE Atos	-7.79	-14.60	-73.15	-39.12	-144.15	-180.92
FCI OpenFermion	-7.87	-14.96	-74.99	-39.81	-147.74	-185.23

1 - 3 % difference with respect to classical algorithms

A.Peruzzo et al. A variational eigenvalue solver on a quantum processor (2014). arXiv:1304.3061

TOTAL

Quantum Chemistry ground state problem with VQE



CrystEngComm,8, 364-371 (2006(

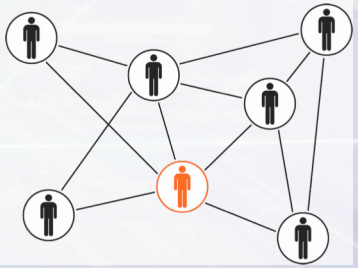
Quantum Combinatorial Optimization

with V. Dunjko and C. Moussa from Leiden

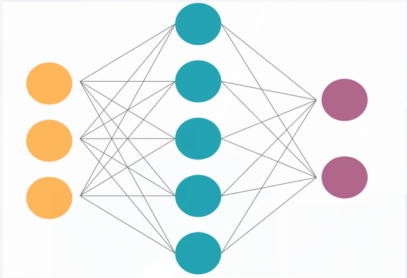
- **Knappsack problem -** Function Maximization with Dynamic Quantum Search. In International Workshop on Quantum Technology and Optimization Problems (pp. 86-95). Springer, Cham.

- **MaxCut (comparison between GW and QAOA for graph cuts)**

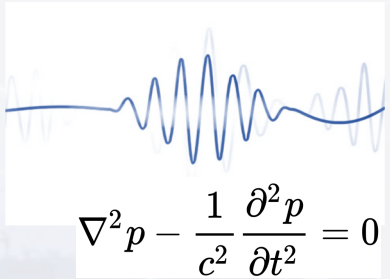
- **Scheduling, Traveling Salesman, Mesh segmentation**



ML and PDE's



Hydrocarbon well modelling



Seismic depth imaging (sesmic wave Eq.)

Quantum computing in 2020 at TOTAL

- Investigating the scalability of VQE + investigate further algorithms for chemistry
- Continue investigating combinatorial optimization (traveling salesman)
- Pursue exciting avenues to explore with quantum computing: differential equations, machine learning (pattern recognition)
- Run alhorithms on actuall hardware

Quantum computing in the next 5 years

- TOTAL is the global leader in quantum algorithm design