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EPSRC

EU

The ICON project and optical transportable clocks at Birmingham

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Innovate UK [dstl] NPL National Physical Laboratory esa

Sr &Yb lab

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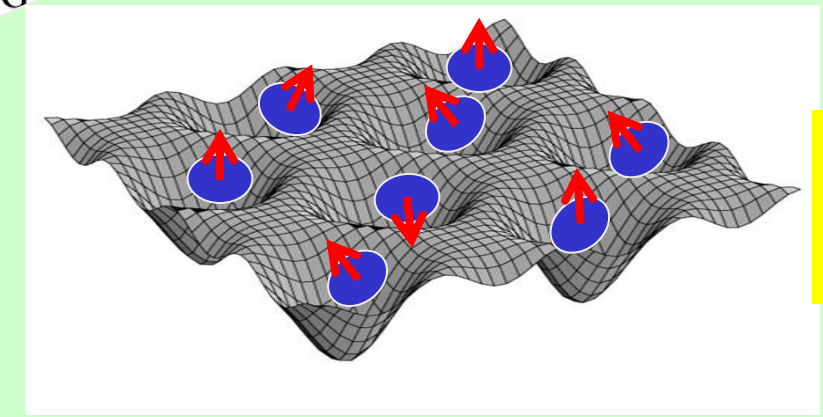
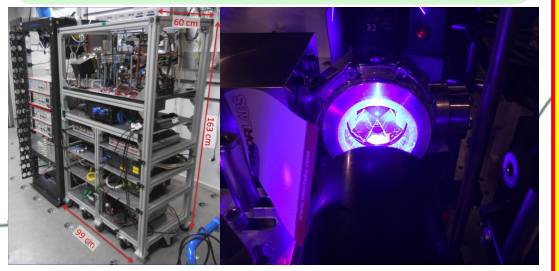


Ultra cold Sr/Yb atoms in optical lattices (1D/2D/3D)

Out of lab

In lab

Optical lattice clock: Portable, transportable, space



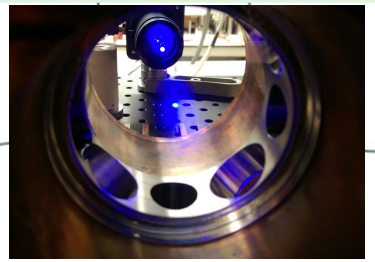
S. Origlia et al., arxiv:1803.03157 (2018) Nat Phys, 11, 605-696 (2015)

Strong Engagement with NPL & Industry partners-

1) Building supply Chain: UnikLasers, M2 etc..

2) Sensor integration and end user: M2, Te2v, DSTL, BAE, Leonardo, Thales, BT, Chronos….

Quantum simulations: Long range interaction & many body physics



Shengnan et. al., Jphys B (2020)

PRL 110, 143602 (2013)

Optical clocks: pathways

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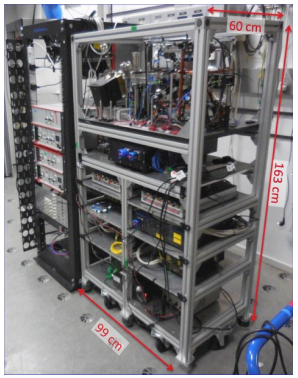
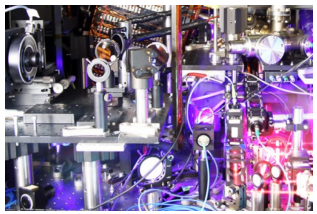
SWAP +Unprecedented precison



Transportable (SOC2)
Precision~10^{-18}
Volume~10^3 L

Miniature clock
Portable
Precision~10^{-16} -10^{-17}
Volume~100 L

Highest Precision
Highest Accuracy



10^{-18} -10^{-19}@ present
Volume~10^4 L

JILA, NIST,
Katori, NPL, PTB, SYRTE….

Others (mobile): Katori, Sussex (Ca ion), PTB (Sr), China (Ca ion), PTB & Toptica (Yb ion)

Scientific Reports 6, Article number: 33973 (2016)

arXiv.org > physics > arXiv:1807.11282

Current demonstrators at UoB

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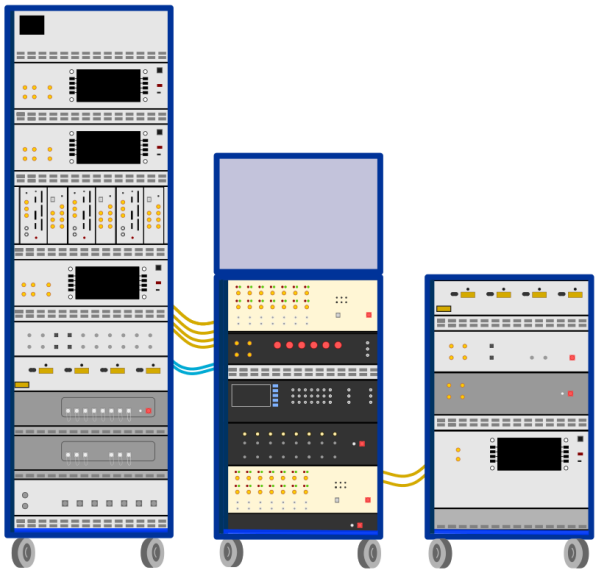
iqClock (EU)



Transportable
Precision~1x10^{-16}
Volume~10^{3} L

Gellesch, M., et. al., accepted in Advanced Quantum Tech (AQT) (2020)

Nat. Photonics 14, 408–409 (2020)

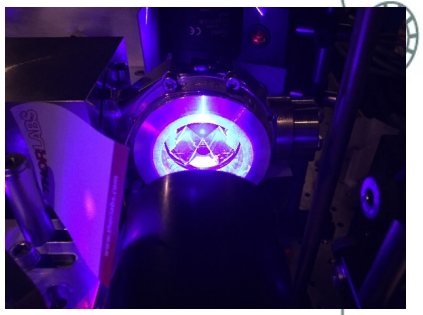
Space Optical Clock (SOC2; EU)

Transportable
Precision~1x10^{-18}
Volume~10^{3} L

Paulo Hisao Moriya et.al., Optics Express (2020). doi: 10.1364/OE.390982

S. Origlia et al., arxiv:1803.03157 (2018)

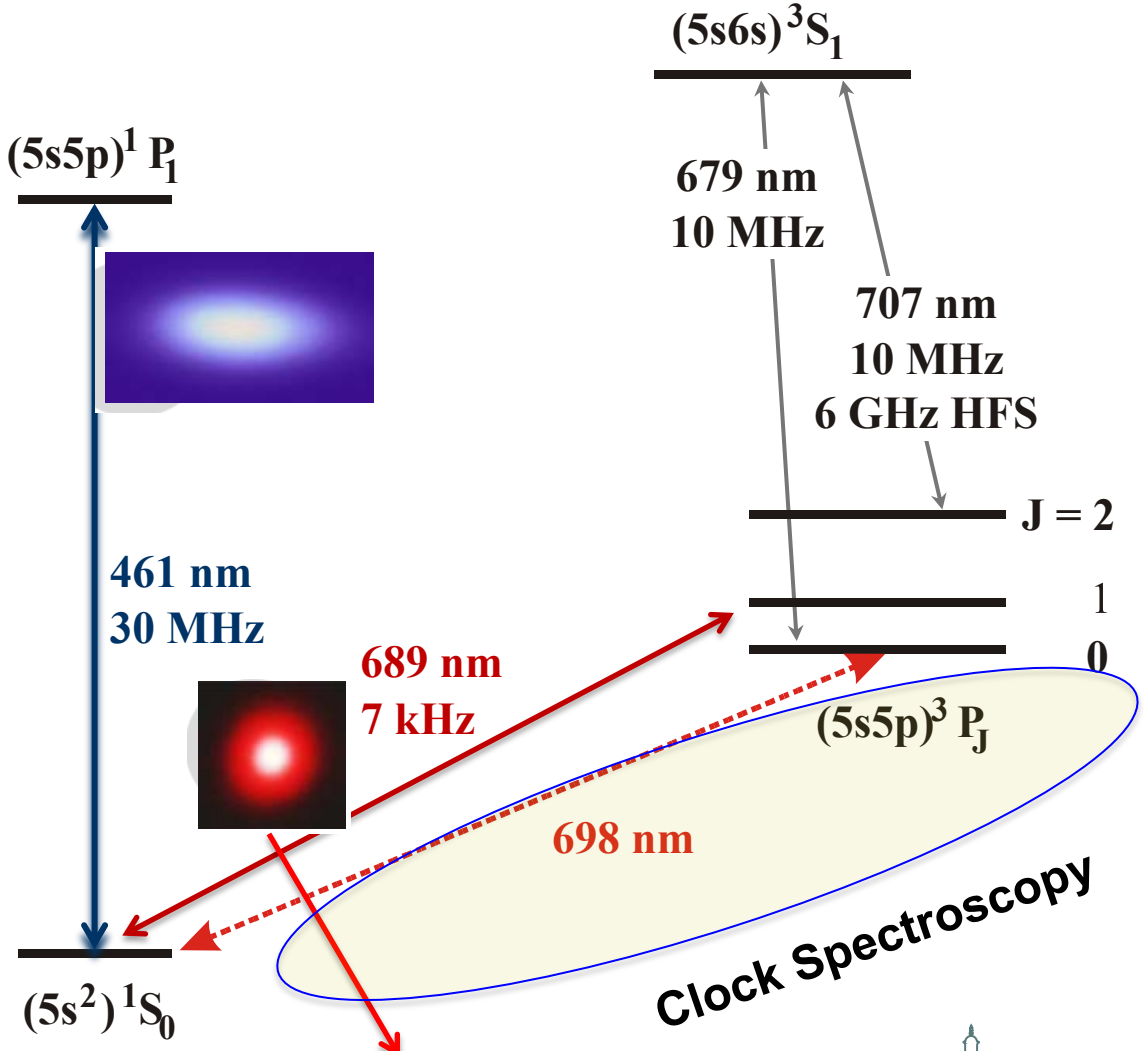
Miniaturised Lattice

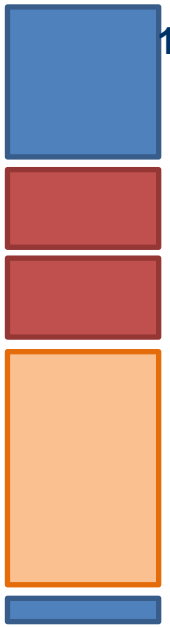


Portable
Aimed Precision~10^{-17}
Volume~100 L

https://www.iqclock.eu

Laser cooling of Sr and Sr clock



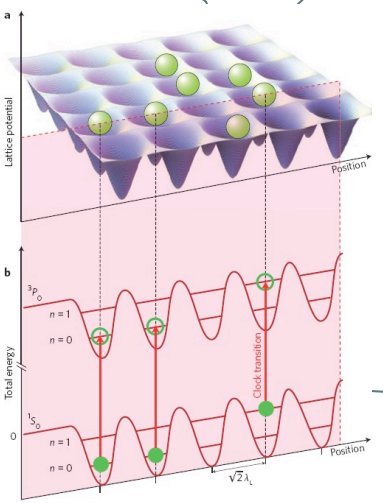


1. MOT phase (461 nm)
+
Zeeman slower

2. MOT phase (689 nm)

3. MOT phase (689 nm)

trapping in lattice
+
state preparation
+
interrogation (698 nm)
detection



Field deployable atomics package

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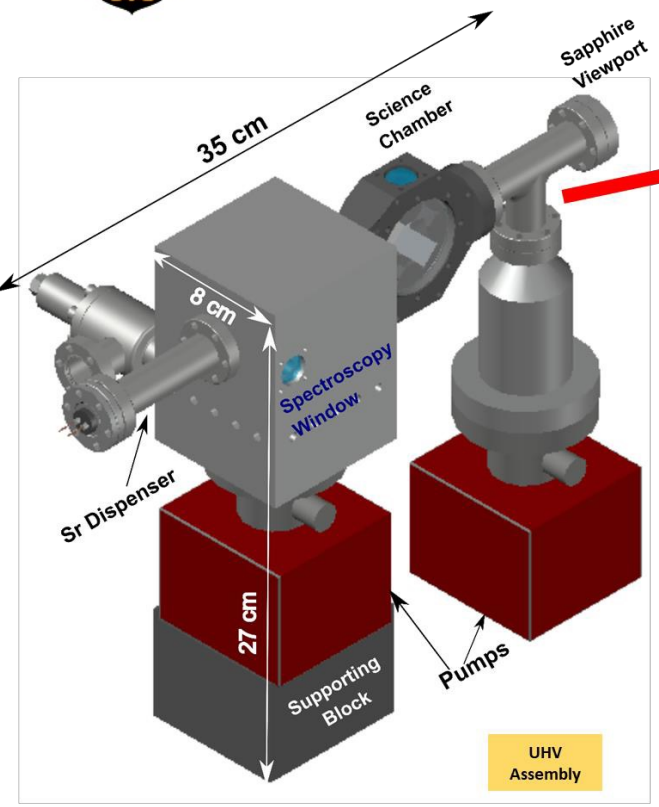
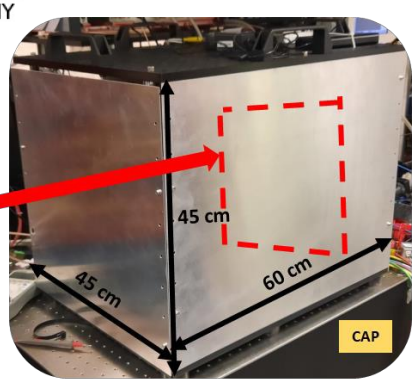
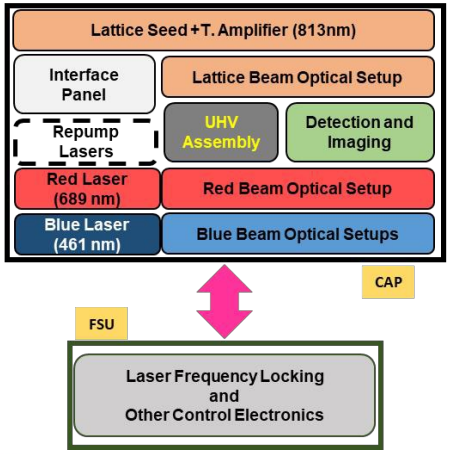
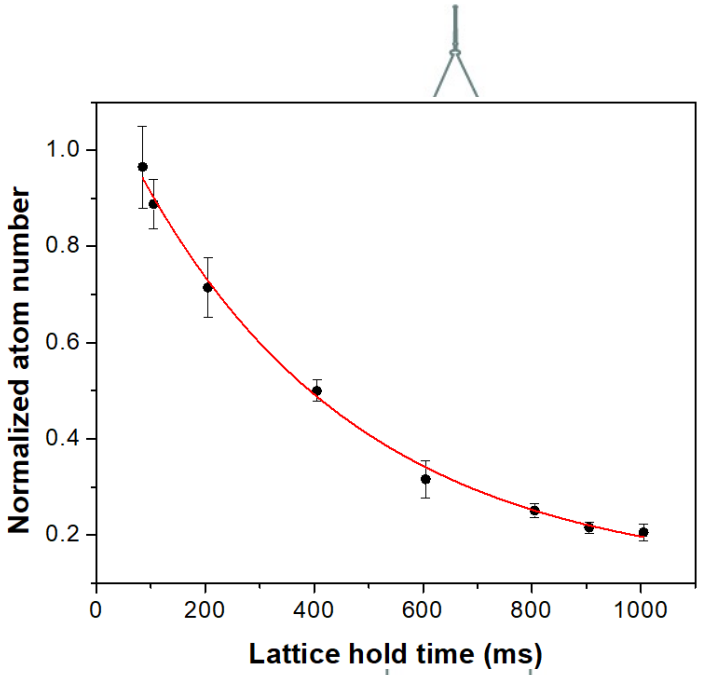
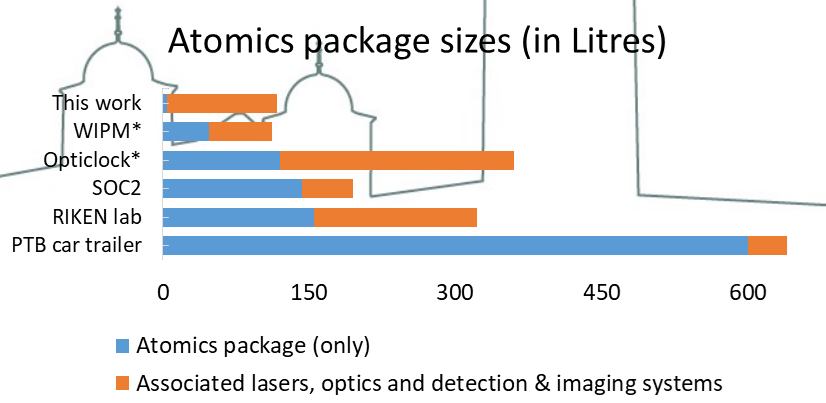




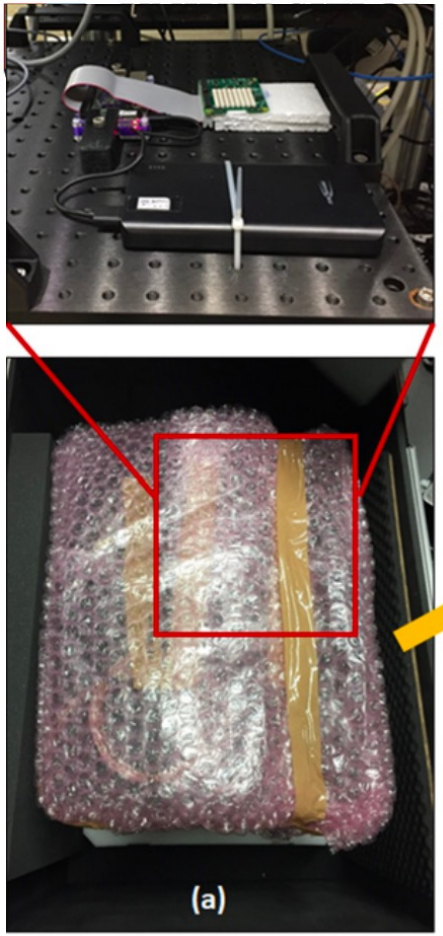


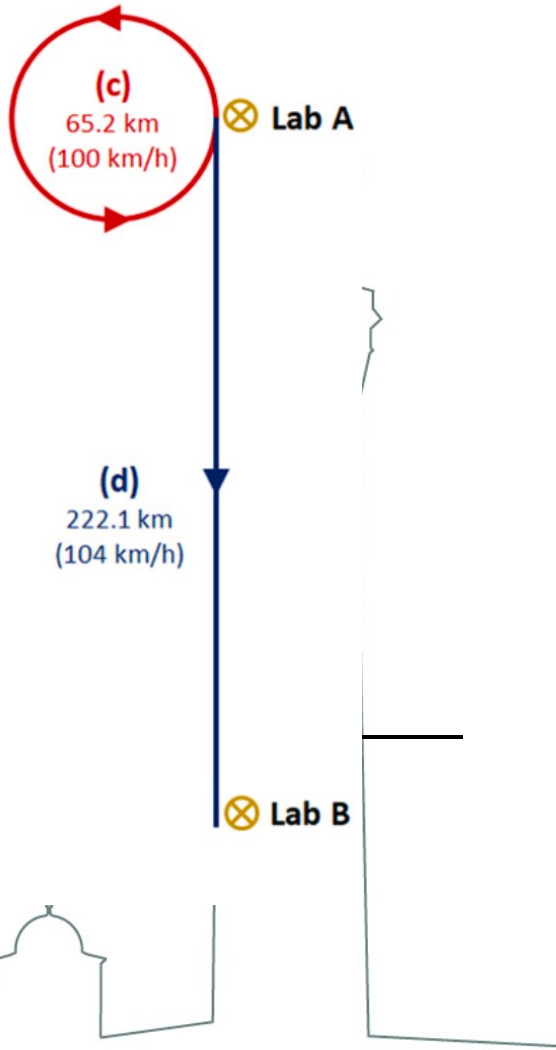


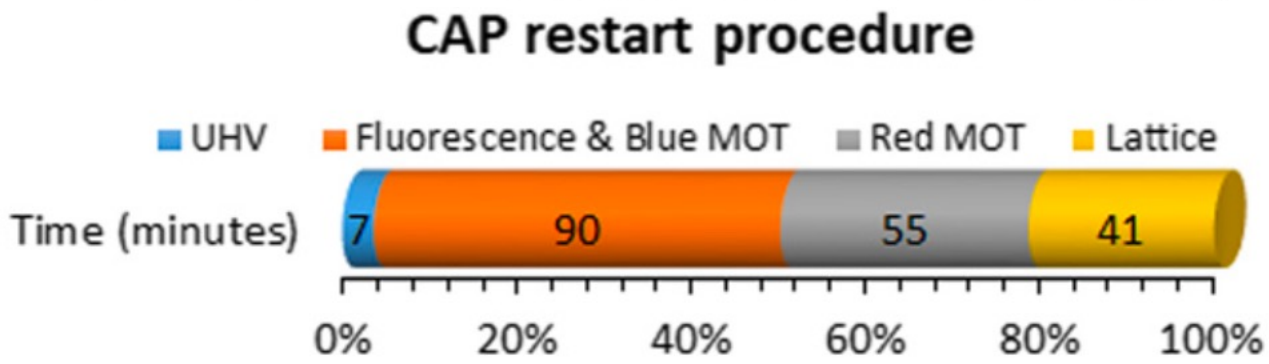


Quantum Sci. Technol. 7 (2022) 045004

Field deployable atomics package





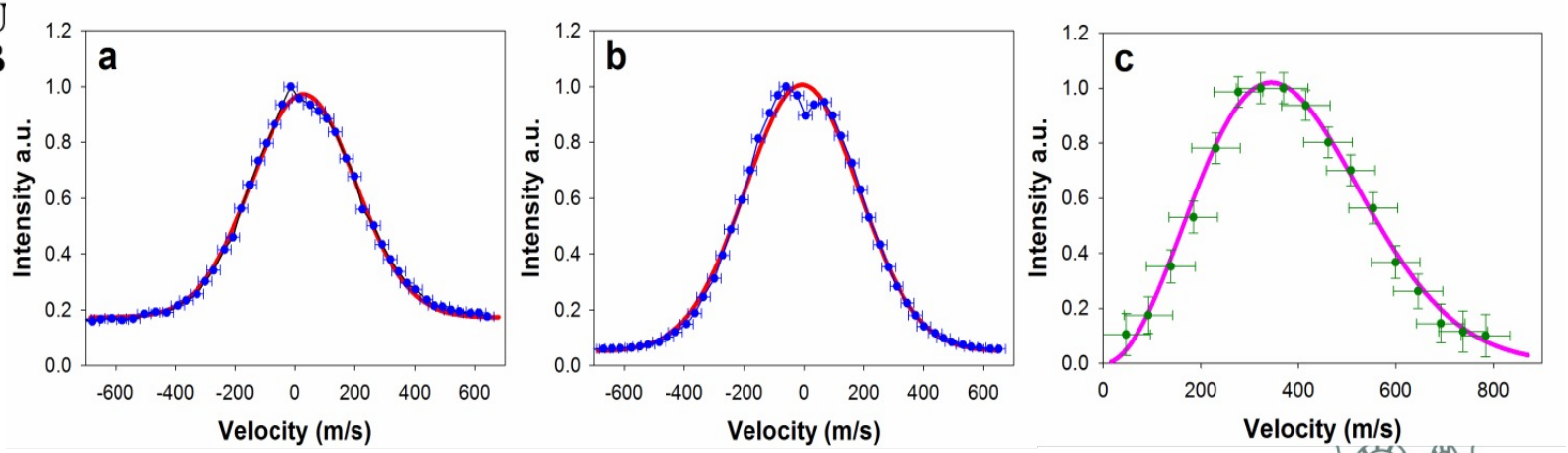


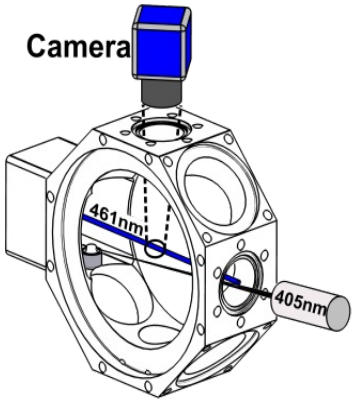
Quantum Sci. Technol. 7 (2022) 045004

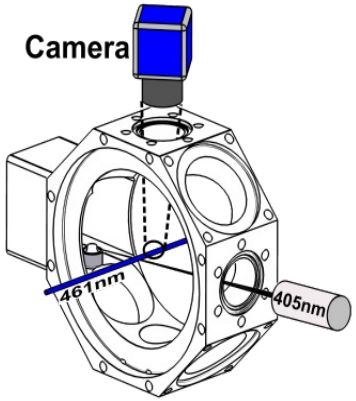
Novel source: velocity distribution

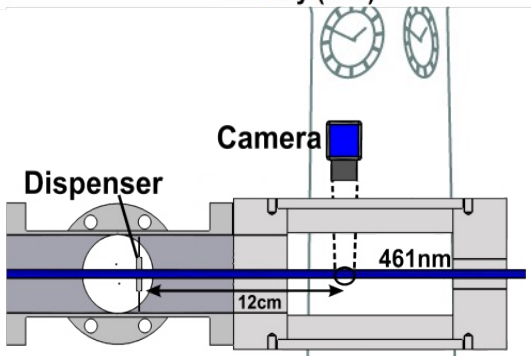
U
B

Sr88
82%









Symmetric Gaussian distribution centred on zero velocity, and a corresponding temperature of 319 K.

Indicates that the atoms undergo several collisions and thermalize with the walls of the vacuum chamber.

Novel source: SrO MOTs

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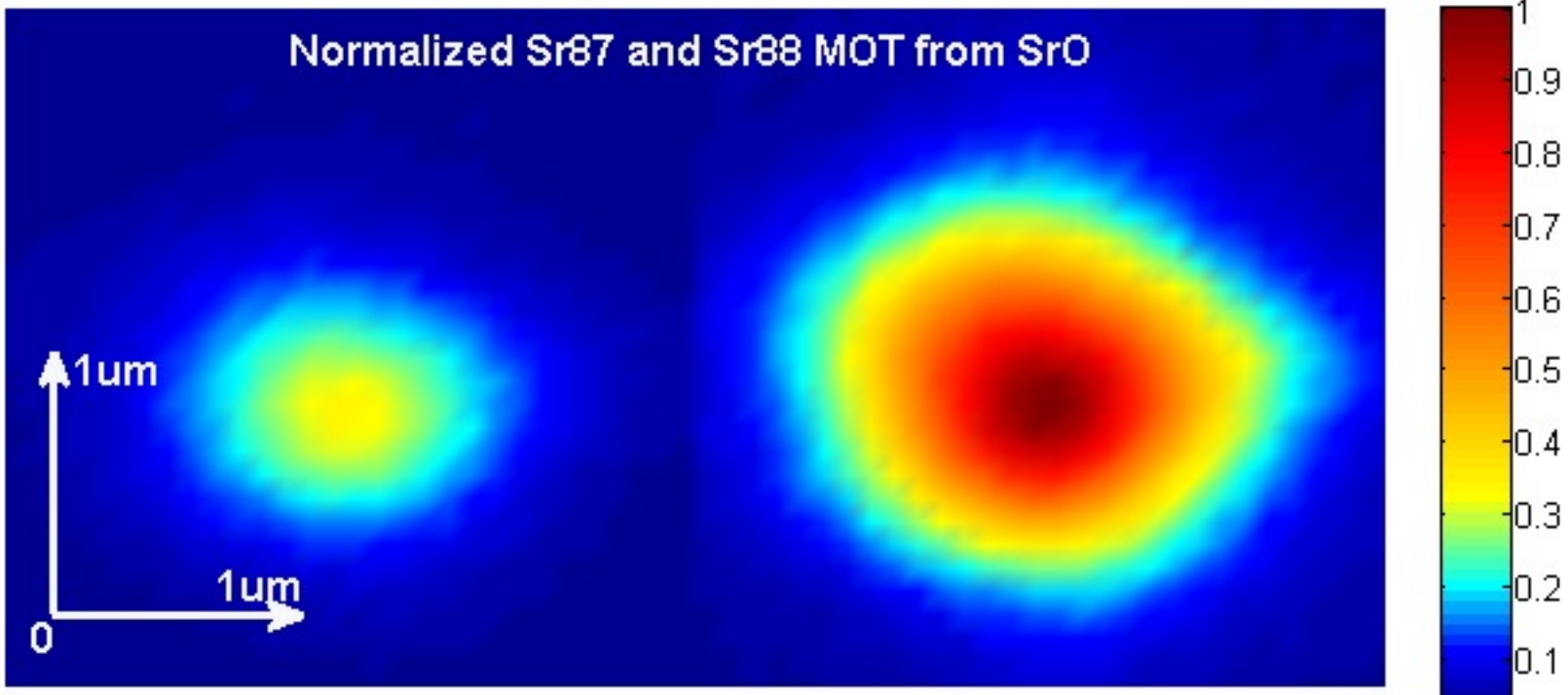
Sr87 7% **Life time~500ms** **Sr88 82%**



~1x10^6 atoms **55MHz** **~4x10^6 atoms**

Yb: Masami Yasuda of NMIJ (JAPAN)

Scientific Reports 6, 37321 (2016).

ICON: International Clock and Oscillator Networking

Intercontinental optical lattice clocks: from key technology to optical comparisons

UK Quantum Technology Hub Sensors and Timing

University of Nottingham

NPL National Physical Laboratory

University of Birmingham

RIKEN

The University of Tokyo

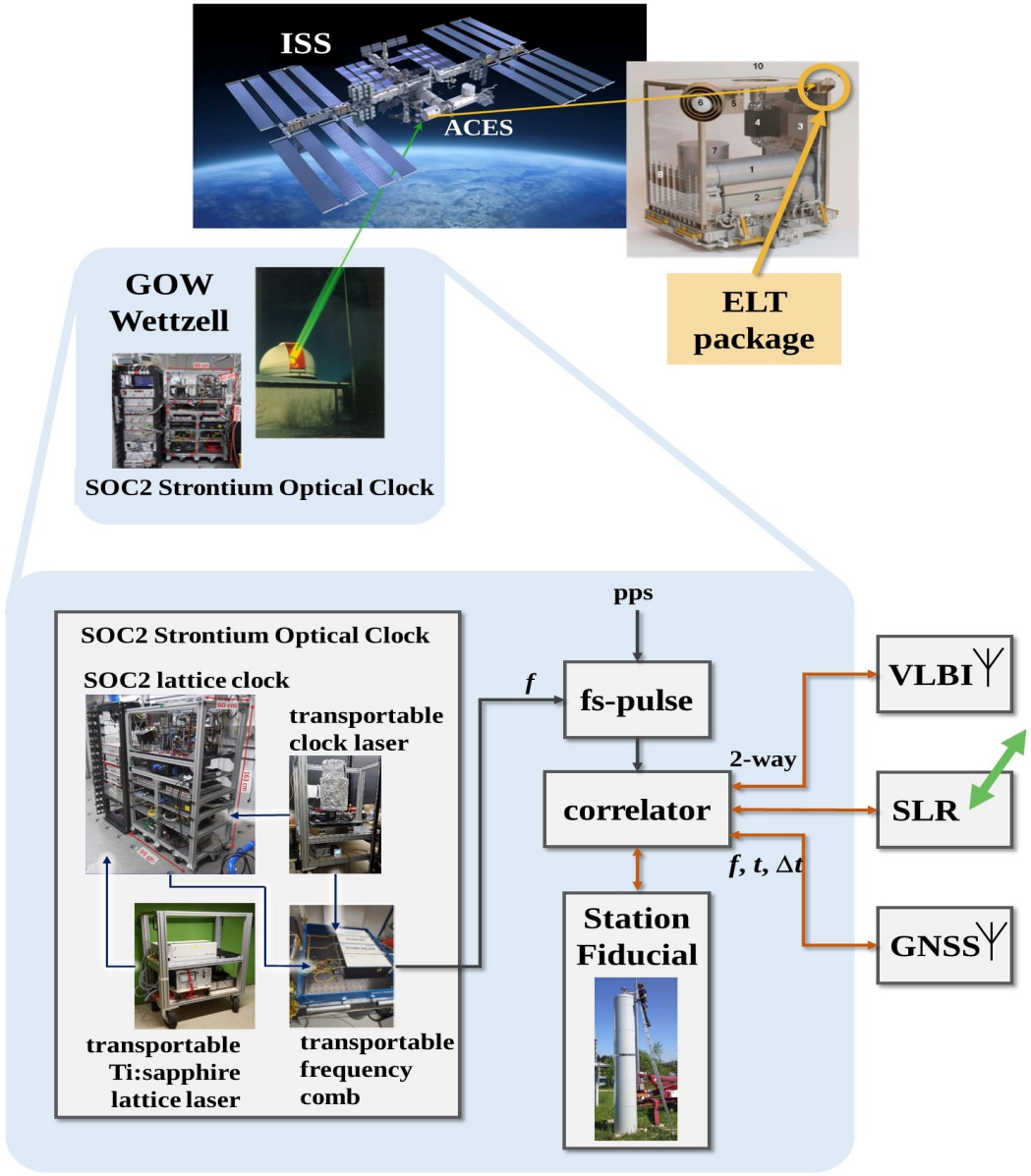
PTB

hhu Heinrich Heine Universität Düsseldorf

Technical University of Munich

ICON: International Clock and Oscillator Networking

frequency transfer via space links

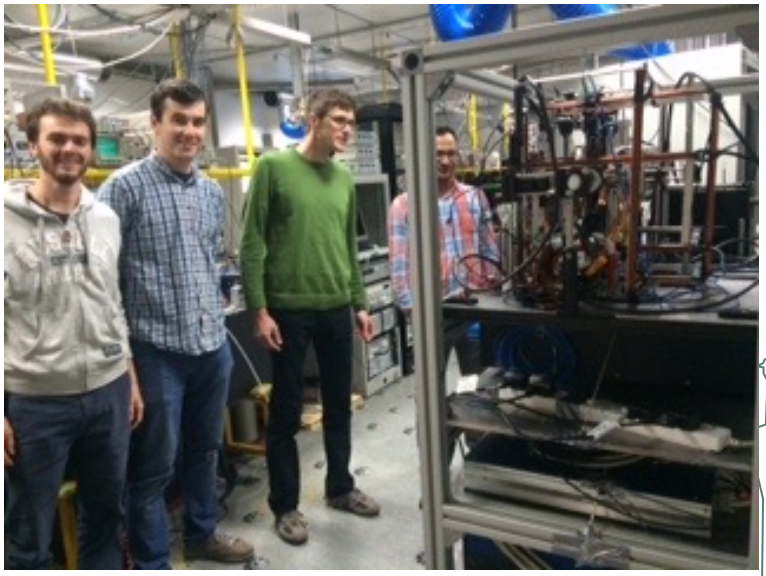


ICON: SOC2 transport

Fully functional after transport

Birmingham, 21/6/2015

PTB, 23/6/2015



Within EU Consortium

ICON: SOC2

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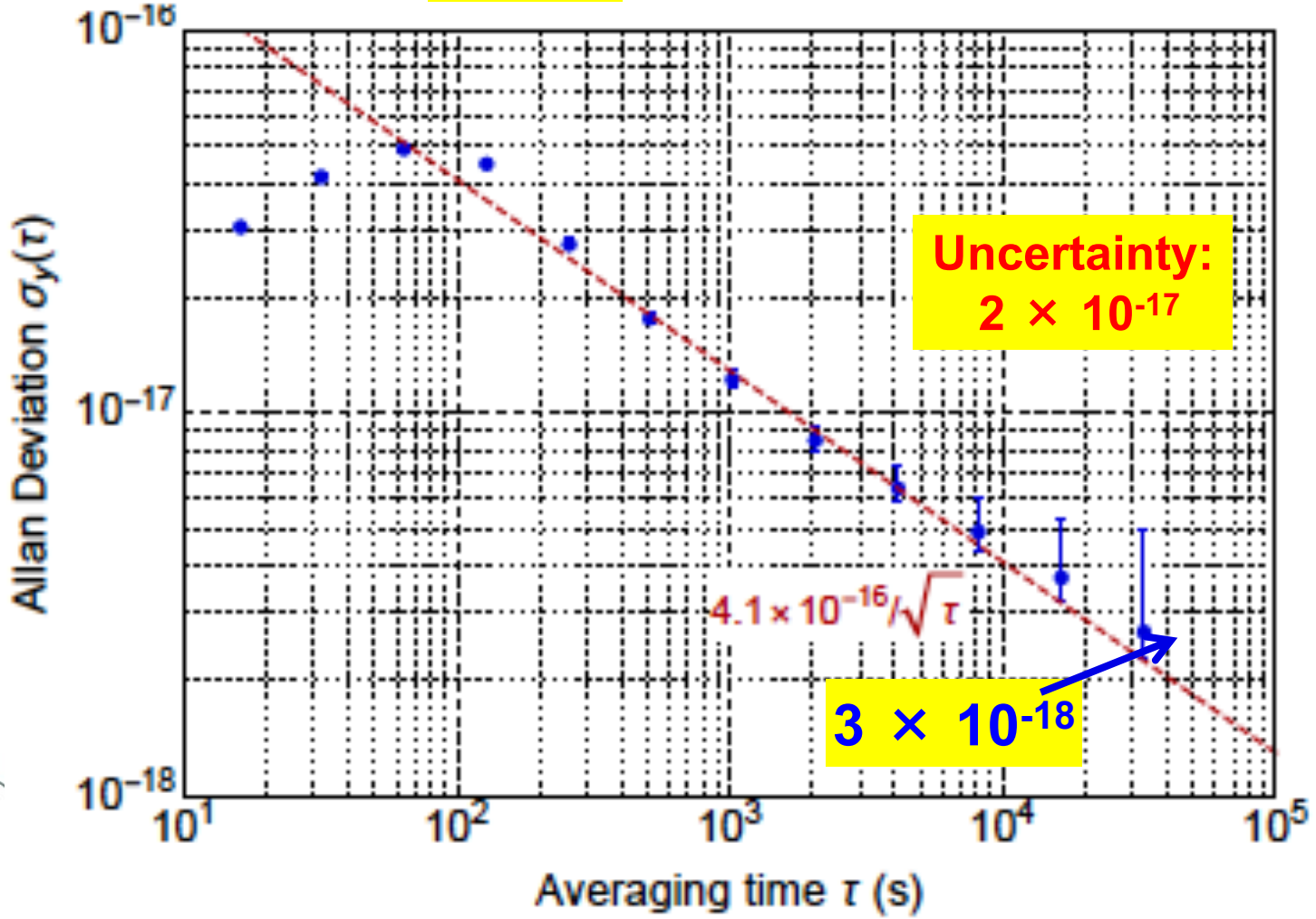
Clock instability @PTB



[1]S. Falke et al., New J. Phys. 16, 073023 (2014)

[2]A. Al-Masoudi et al., Phys. Rev. A 92, 063814 (2015)

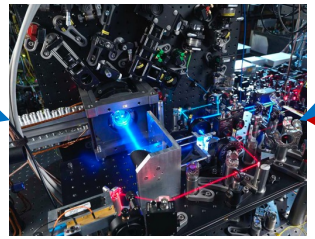
Stefano et. al, arXiv:1803.03157 (2018).

ICON: International Clock and Oscillator Networking

frequency transfer with transportable clocks at the 10^{-18} level

consideration of utilising EU fibre links: SYRTE, PTB, INRIM…

First campaign: March 2023



PTB clock @NPL

Riken clock @NPL

@NPL

Birmingham

PTB clock @PTB

Riken clock @PTB

@PTB

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