VECSEL SYSTEMS FOR QUANTUM TECHNOLOGY

- Founded in 2017, Tampere Finland
- In-house design, epitaxy, processing, and laser assembly
- Providing VECSEL-based laser systems for emerging applications in **quantum technology, industry, and medicine**
- Product lines addressing wavelengths on demand
  - ✓ **Gain mirrors** for scientific community
  - ✓ Watt-level tunable infrared single-frequency lasers
  - ✓ Visible/UV intracavity-doubled laser systems

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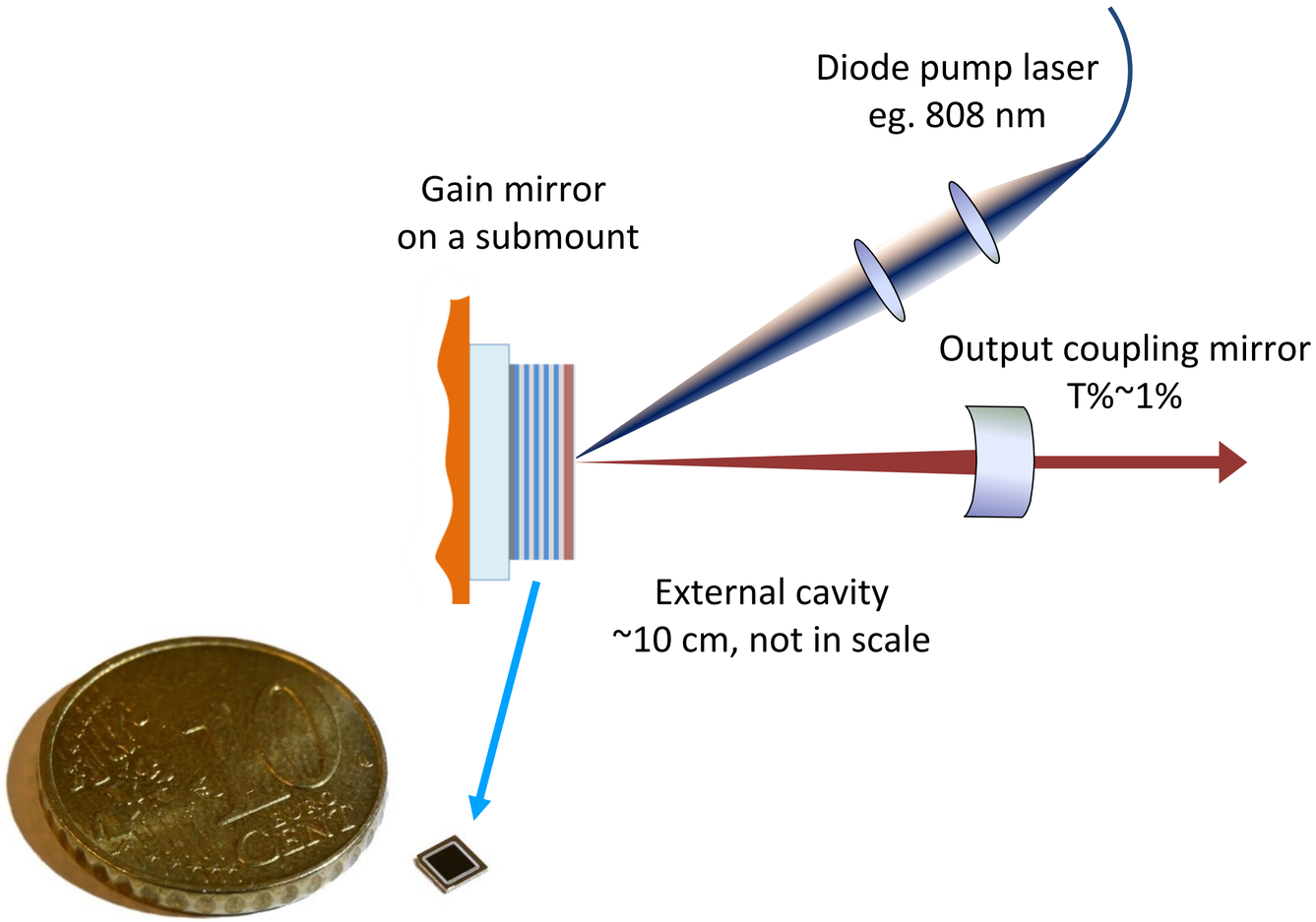
Vertical-external-cavity surface-emitting lasers (VECSELs)



Main features relevant for quantum technology:

- ✓ High power, high brightness disk laser architecture
- ✓ Wavelength versatile semiconductor gain mirror
- ✓ Tunable single-frequency
- ✓ Low intrinsic noise (no relaxation oscillations)
- ✓ Relatively compact and cost effective
- ✓ Efficient intracavity second harmonic generation

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VECSELs applications in quantum technology

- Quantum information processing (QIP) with trapped ions and neutral atoms

  + Well reproducible states

  – Demanding requirements for lasers (wavelength, linewidth, power, tunability, noise, pointing stability, polarization etc.)

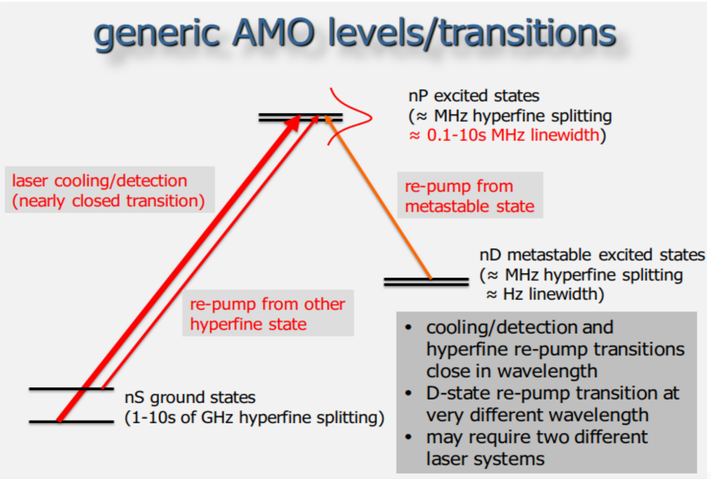
  → e.g. Honeywell quantum computer makes use of 10+ different wavelengths and 20+ frequency tones

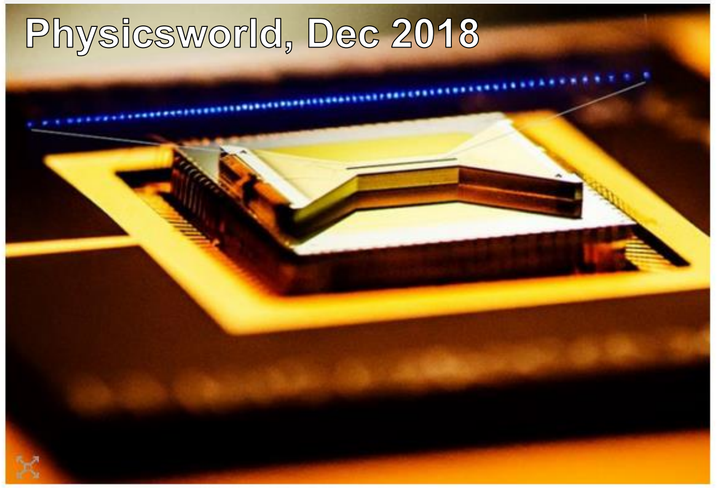
  ✓ Often the choice of ions is dictated by the availability of suitable lasers → need for the “right” wavelength

  ✓ Need for compact lasers to enable modularity

- Resonant excitation of solid-state QD systems

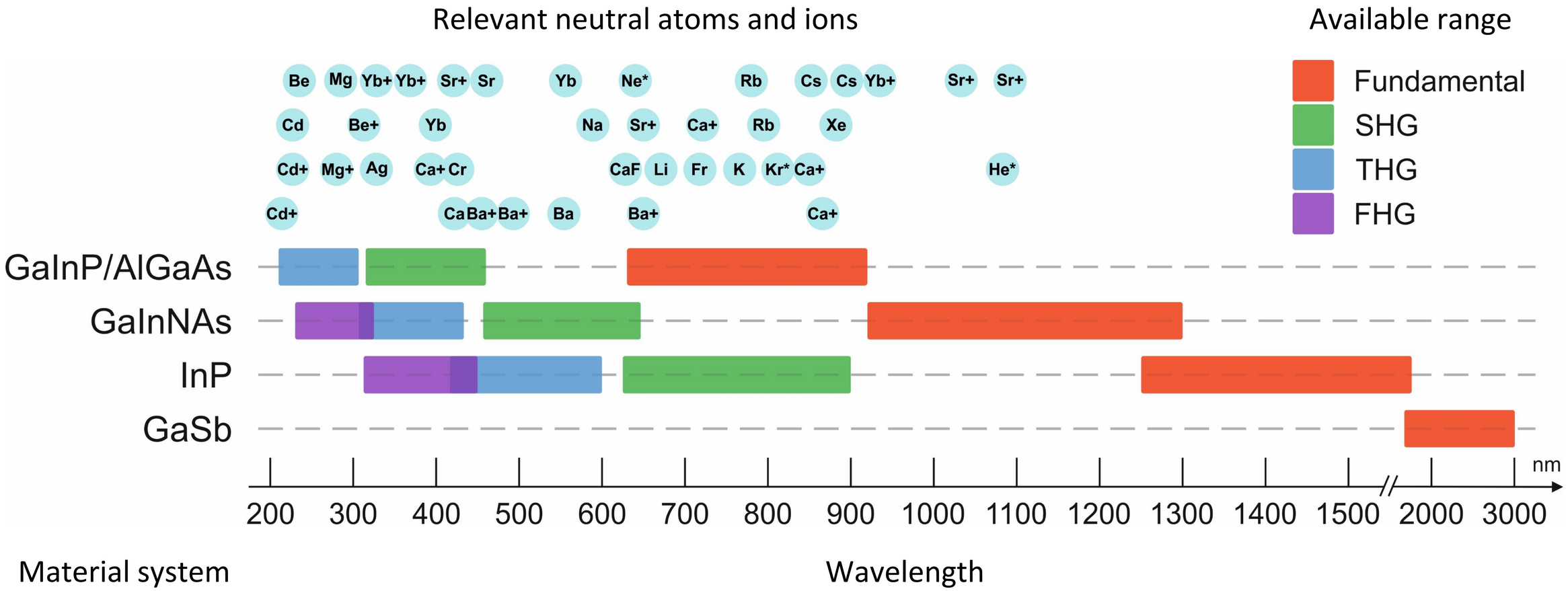
D. Leibfried, Boulder, USA, NIST





Linear computation: montage of a photo of the chip containing the trapped ions and an image of the ions in a 1D array (Courtesy: Christopher Monroe)

Wavelength tailored VECSELs



VECSEL-based systems for Be trapping

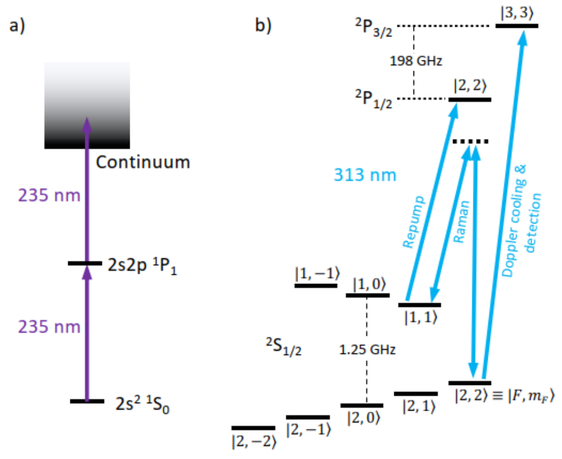
[Submitted on 20 Mar 2020]

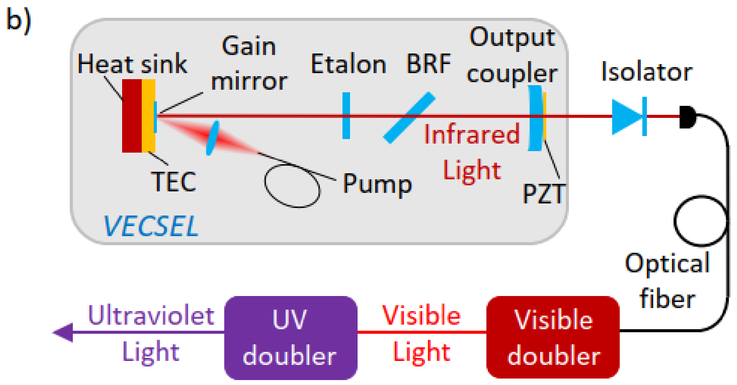
VECSEL systems for quantum information processing with trapped beryllium ions

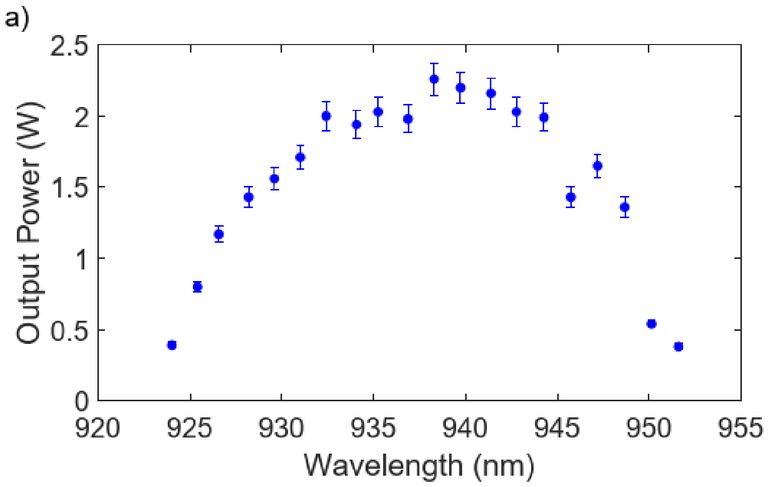
S. C. Burd, J.-P. Penttinen, P.-Y. Hou, H. M. Knaack, S. Ranta, M. Mäki, E. Kantola, M. Guina, D. H. Slichter, D. Leibfried, A. C. Wilson

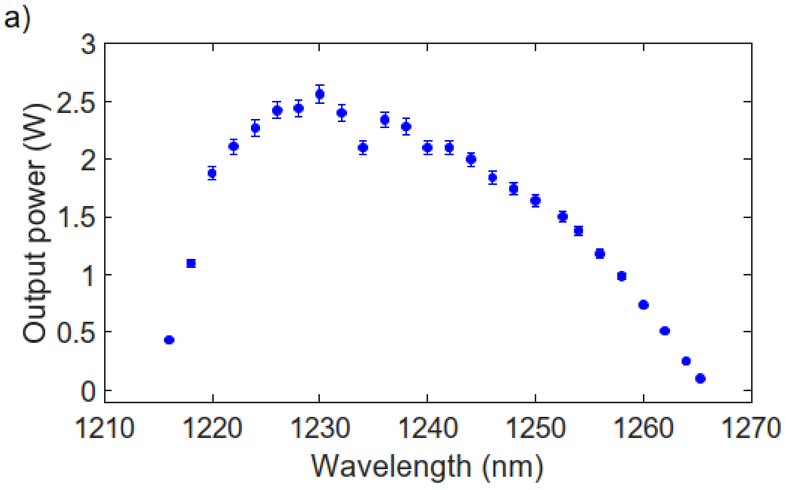
Two vertical-external-cavity surface-emitting laser (VECSEL) systems producing ultraviolet (UV) radiation at 235 nm and 313 nm are demonstrated. The systems are suitable for quantum information processing applications with trapped beryllium ions. Each system consists of a compact, single-frequency, continuous-wave VECSEL producing high-power near-infrared light, tunable over tens of nanometers. One system generates 2.4 W at 940 nm using a gain mirror based on GaInAs/GaAs quantum wells, which is converted to 54 mW of 235 nm light for photoionization of neutral beryllium atoms. The other system uses a novel gain mirror based on GaInNAs/GaAs quantum-wells, enabling wavelength extension with manageable strain in the GaAs lattice. This system generates 1.6 W at 1252 nm, which is converted to 41 mW of 313 nm light that is used to laser cool trapped $^{9}Be^{+}$ ions and to implement quantum state preparation and detection. The 313 nm system is also suitable for implementing high-fidelity quantum gates, and more broadly, our results extend the capabilities of VECSEL systems for applications in atomic, molecular, and optical physics.

Comments: 8 pages, 7 figures
Subjects: **Atomic Physics (physics.atom-ph)**; Optics (physics.optics); Quantum Physics (quant-ph)
Cite as: arXiv:2003.09060 **[physics.atom-ph]**
(or arXiv:2003.09060v1 **[physics.atom-ph]** for this version)









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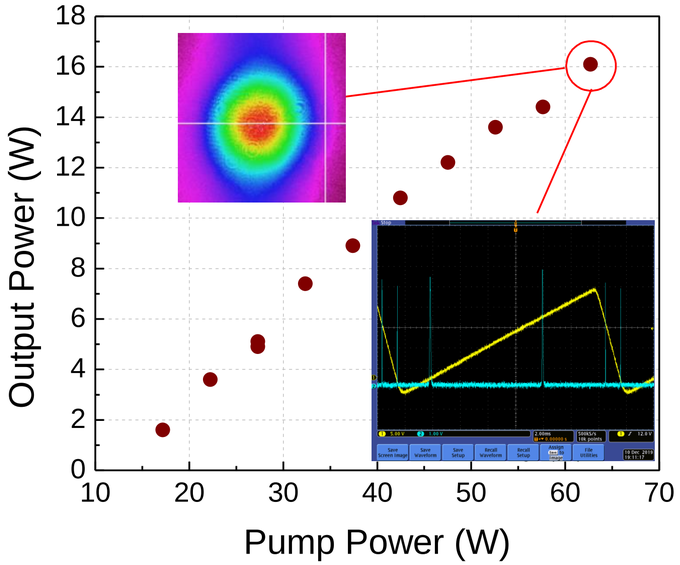
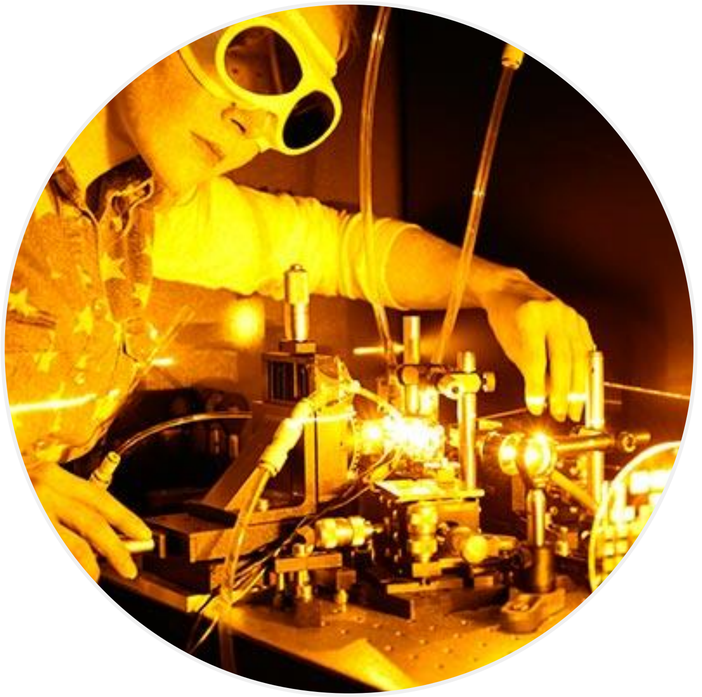
VEXLUM VECSELs

- VALO SF – Single-frequency NIR laser
  - ✓ Turn-key system
  - ✓ 910 – 1260 nm & 1950 – 2150 nm in stock (+ 700 – 910 nm)
  - ✓ CW power 1–4 W
  - ✓ Power scaling in the lab 16 W @ 1178 nm @ 20 ˚C
- VALO SHG – Single-frequency VIS/UV laser
  - ✓ Efficient intracavity second harmonic generation (SHG)
  - ✓ 350 – 700 nm
  - ✓ In development: >1 W single-frequency



How EPIC can help?

- More engagement with ion-trapping & neutral-atom QT community in Europe
- Identification of new partnerships with companies using lasers for QT
- Complementary expertise on the value chain, e.g. laser stabilization, low-noise pump etc.



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