Wafer Fabricated Atomic Reference Cells

SEMI Innovative Sensors Webinar Series

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16 years old, 12 employees

Magnetometer R&D

Commercial sales of sensors & accessories

Complete sensor fabrication in house

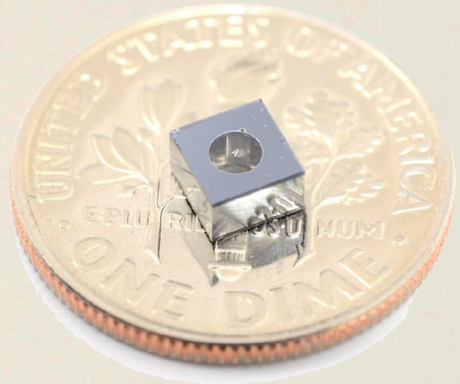
Patents owned and licensed from Princeton University

New 500 m2 facility in Plainsboro, NJ

Woman-owned small business

Alkali vapor cell

Wafer cells: smaller, mass-manufacturable



Glass cells: expensive, done one at a time

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Wafer-scale vapor cells

A unique capability

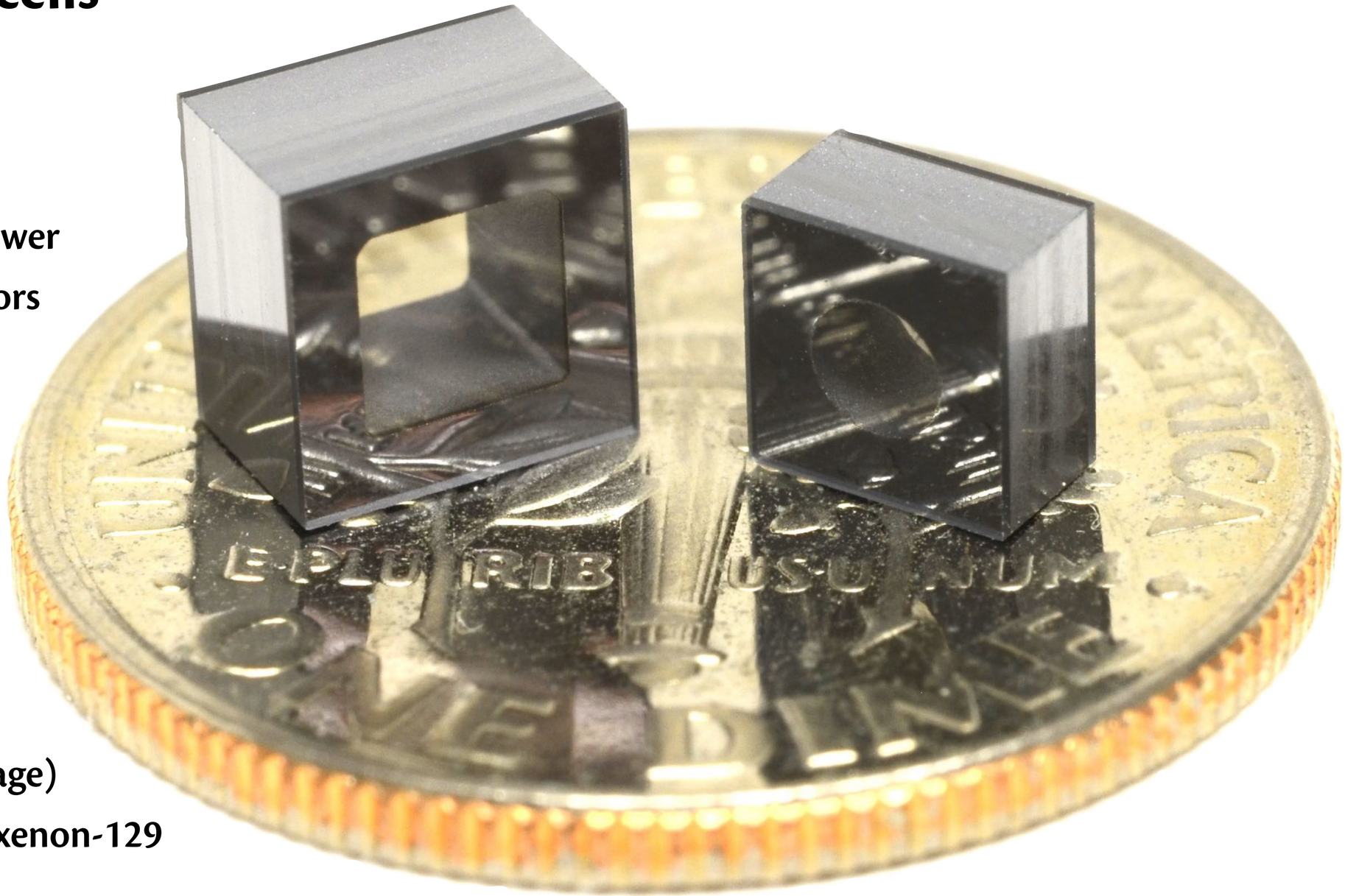
- Unprecedented control
- Enables lower heating power
- Enables tiny, robust sensors
- Enables low sensor cost

Fill any alkali metal

- including Rb-87

Fill any buffer gas

- Neon, Nitrogen
- Helium (special low leakage)
- Rare isotopes: helium-3, xenon-129



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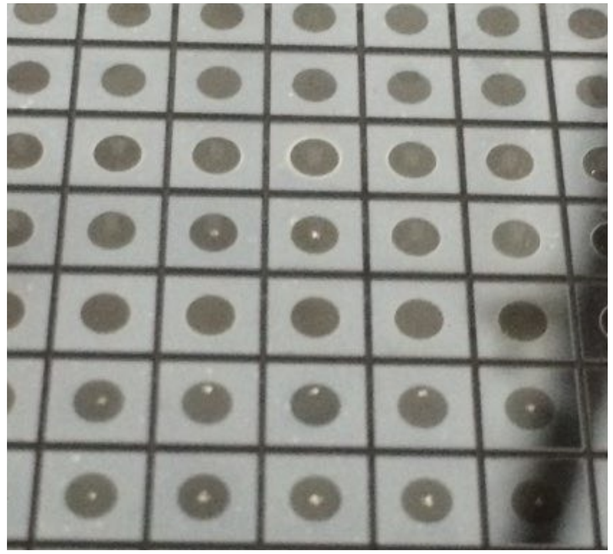
Wafer-scale process

Glass

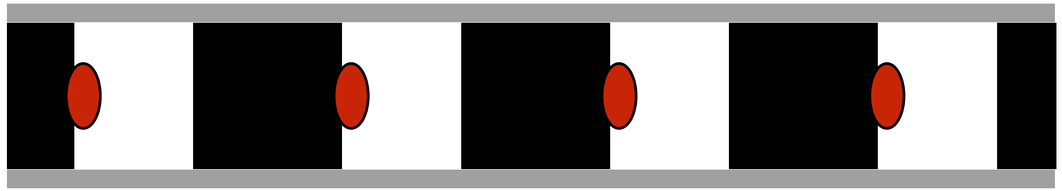
Silicon

Bond First Window

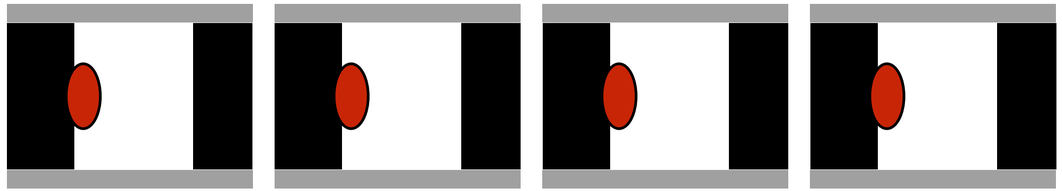
Add alkali metal



Bond Second Window



Singulate



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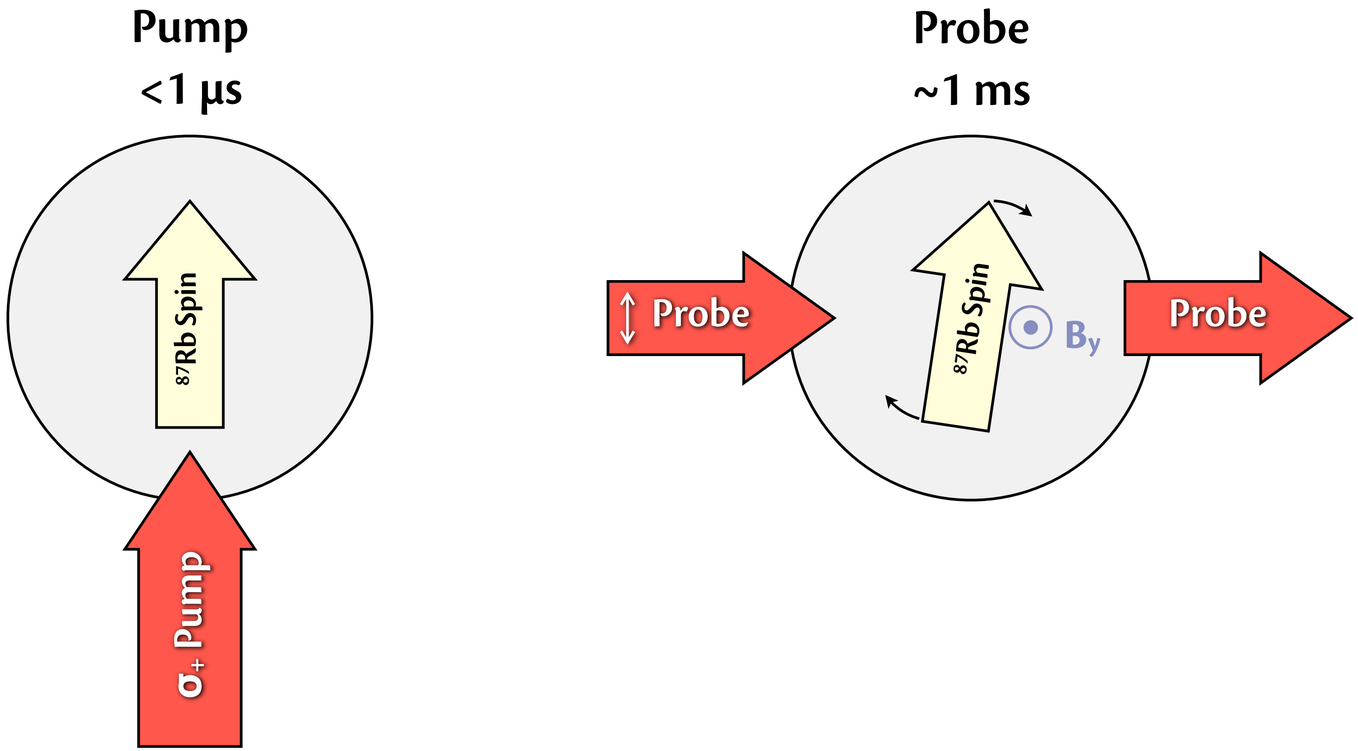
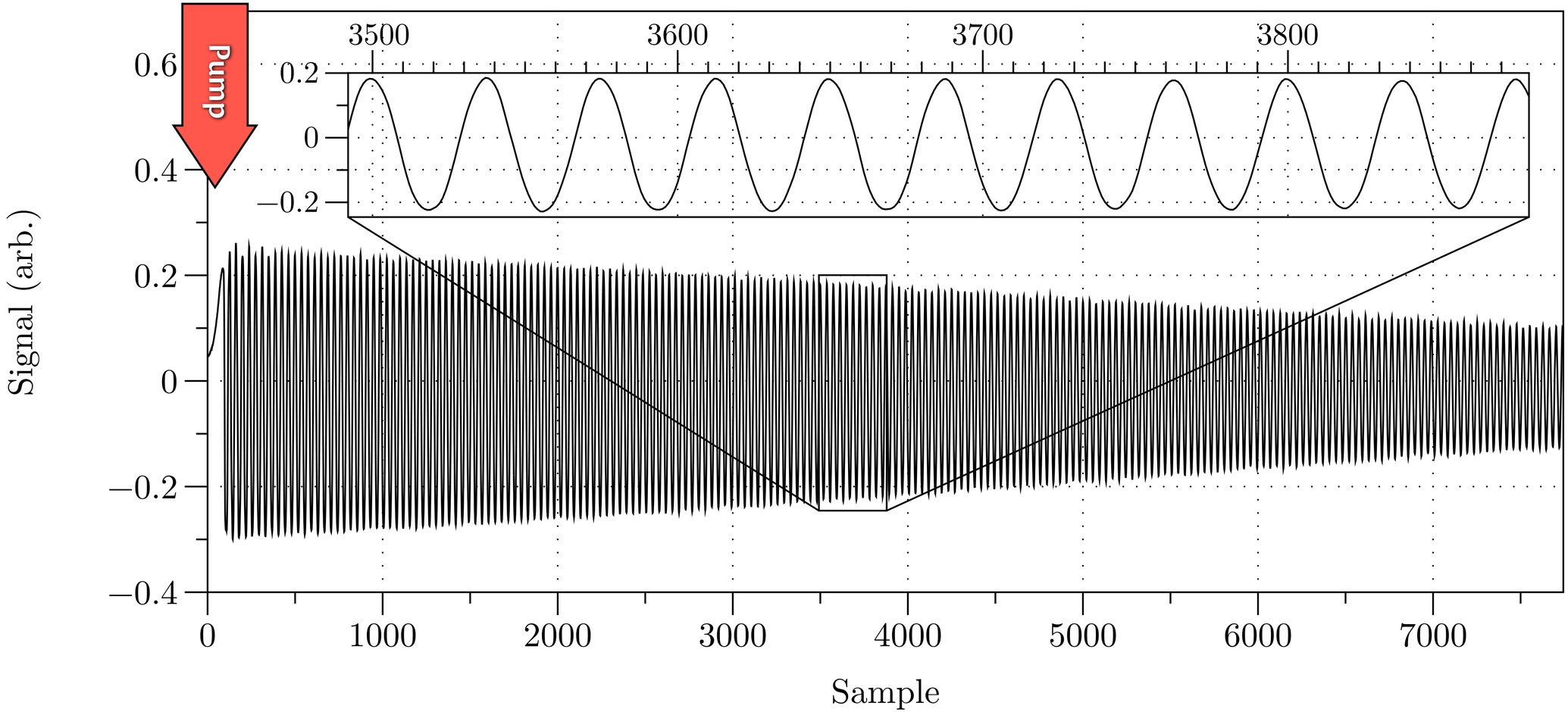
Pulsed Atomic Magnetometer



Pump: Short, intense pulse of light to polarize atoms

Probe: Monitor free precession of atoms using optical rotation.

Free precession



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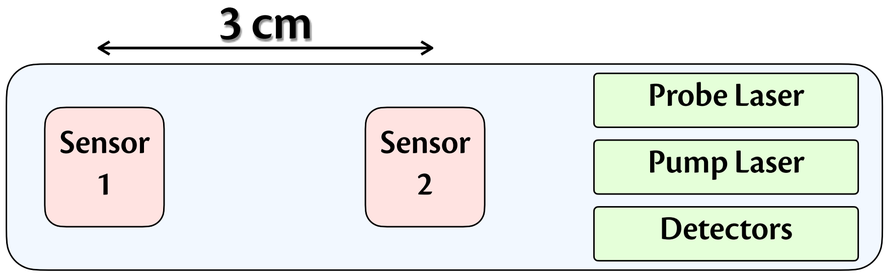
Optical Magnetic Gradiometer (OMG)

Two magnetometers

- 2.3 cm spacing

Wafer-scale cell fabrication

Magnetometer sensitivity:
< 100 fT/rtHz (2 ppb)



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SRI International
PRINCETON
UNIVERSITY
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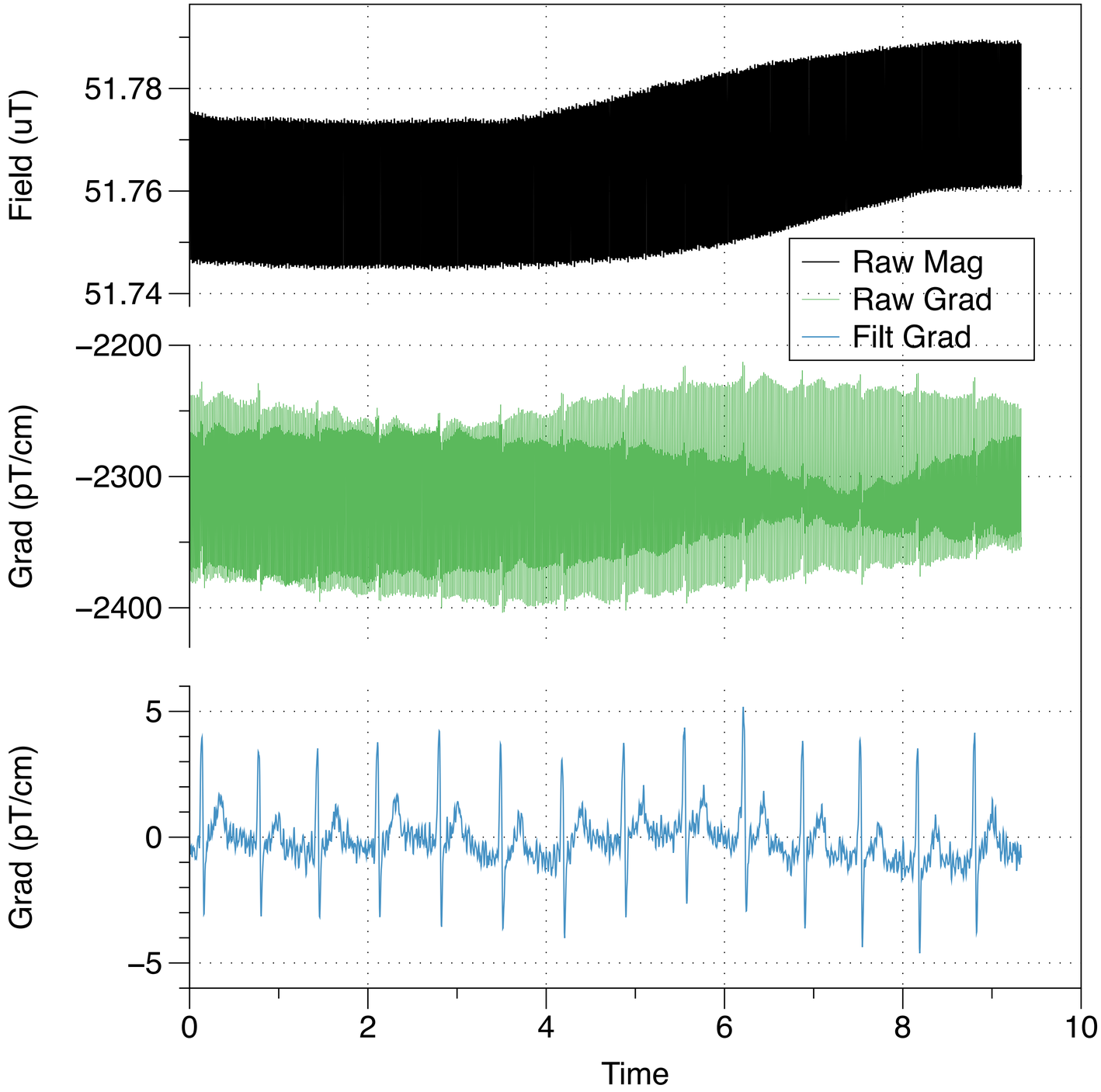
Unshielded MCG

Atomic systems:

- Perfect linearity and dynamic range
- Contrast with solid state sensors



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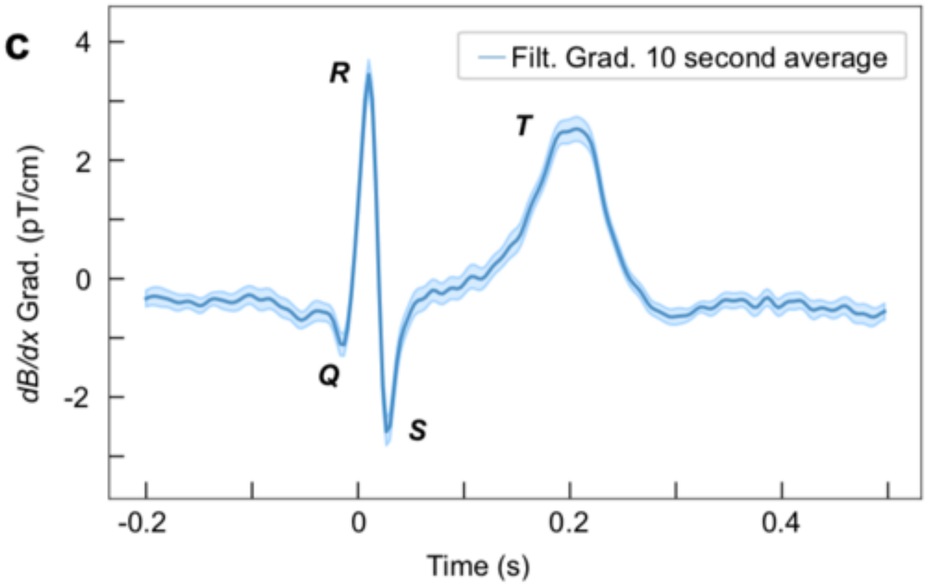
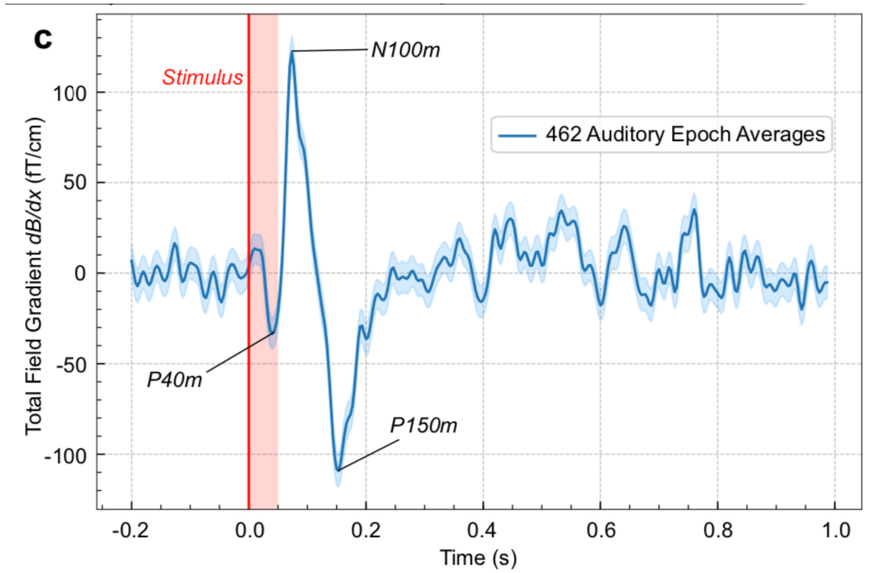
Field-deployable biomagnetic sensor



Heart signals



Brain Signal: Auditory Evoked Response

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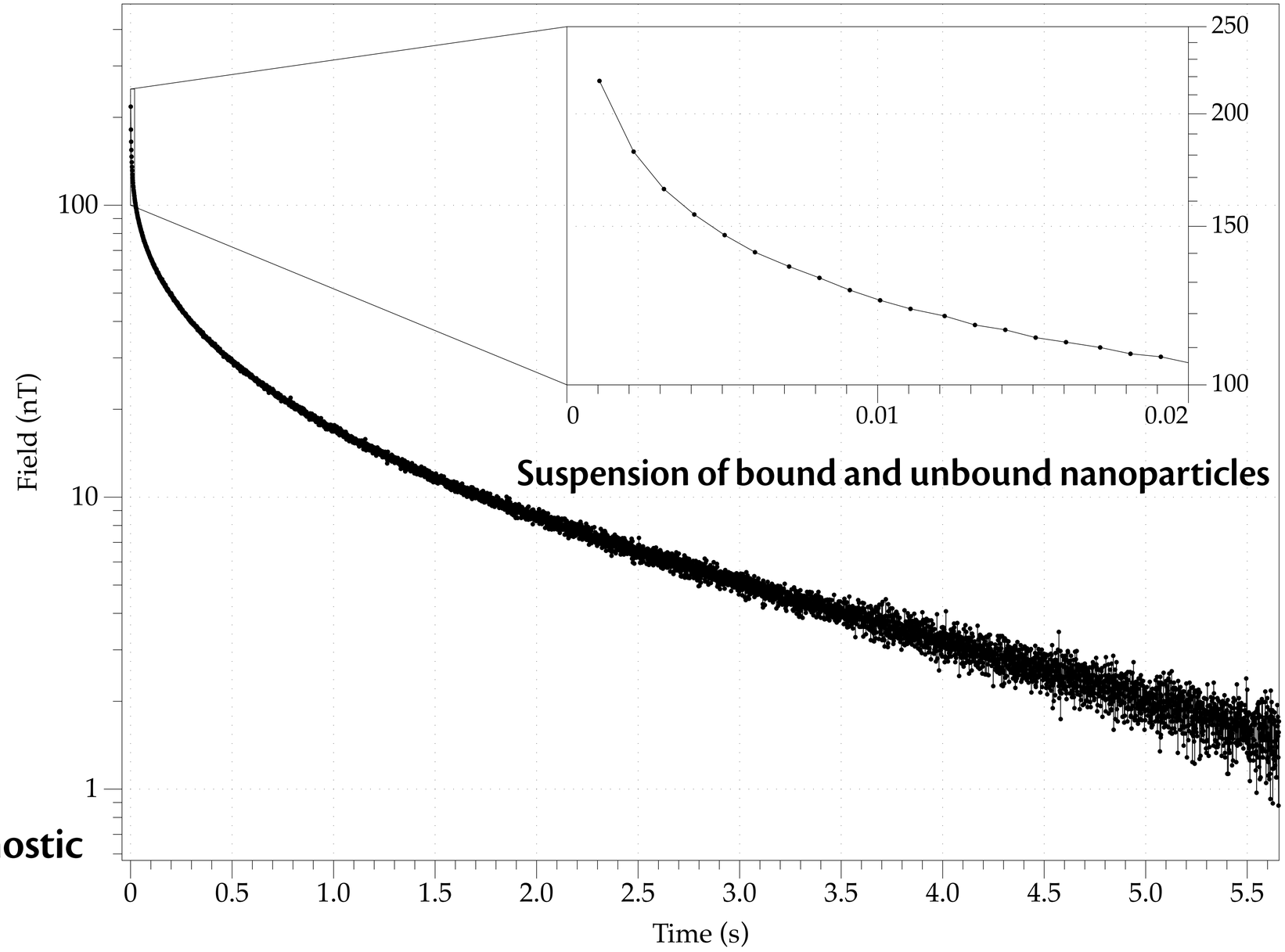
Magnetic relaxometry with a pulsed magnetometer



- Cancer diagnostic

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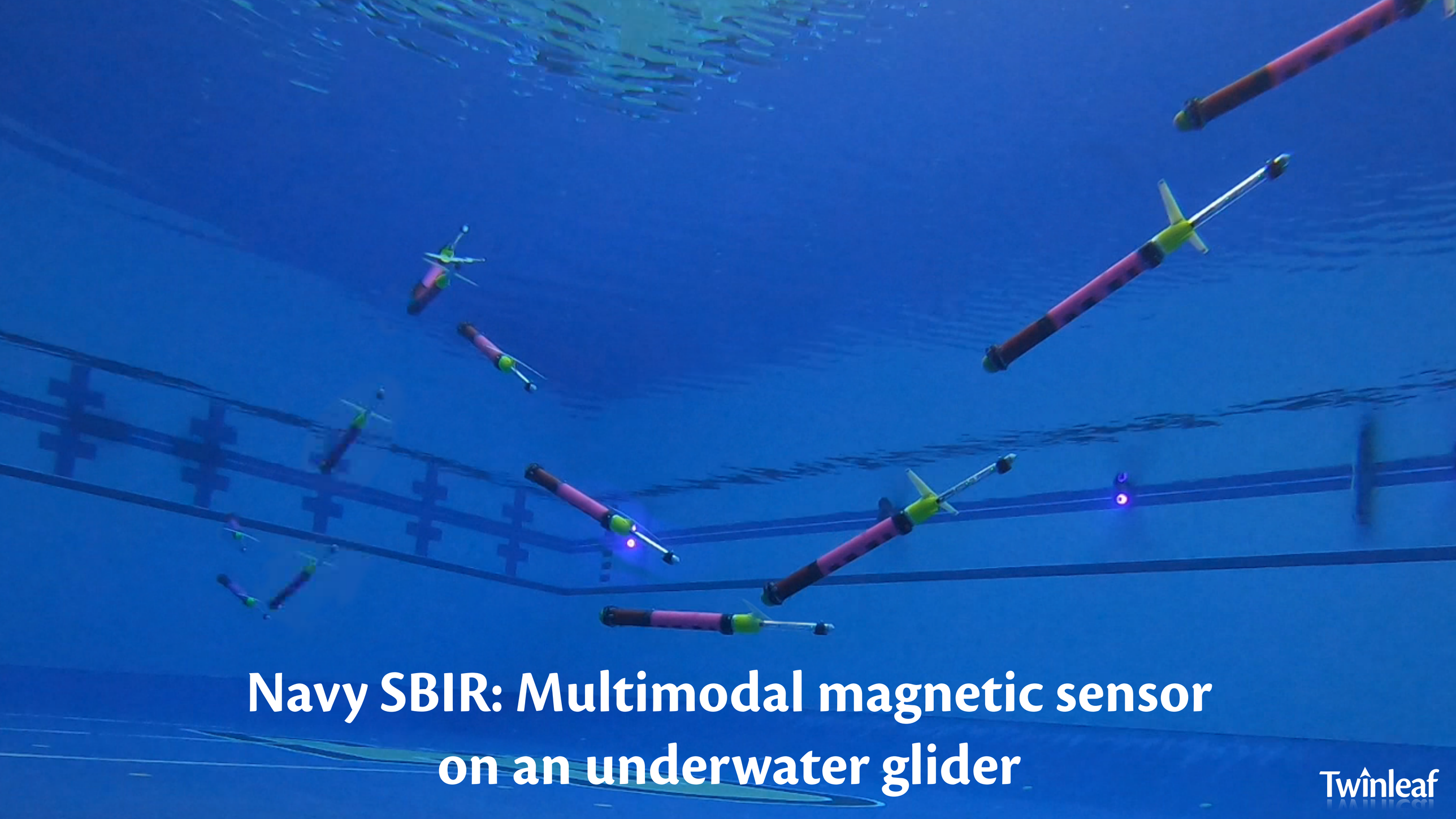

Navy SBIR: Multimodal magnetic sensor on an underwater glider

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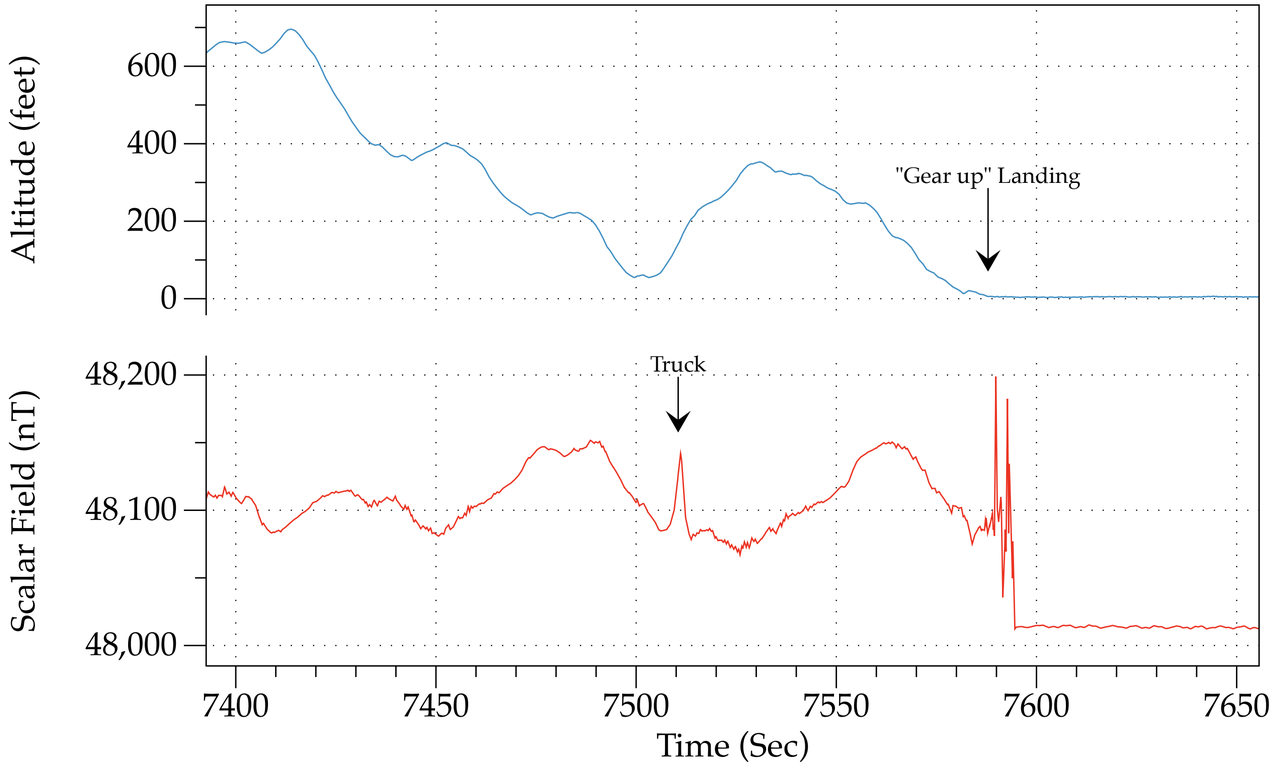
Tiny magnetometers



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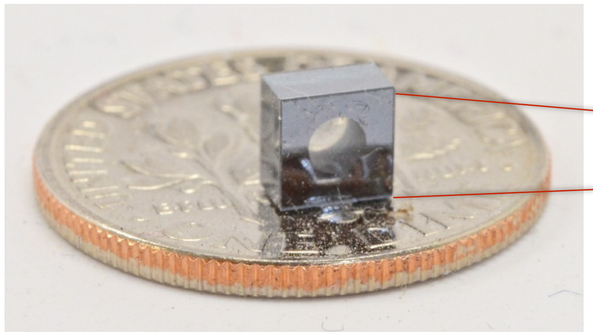
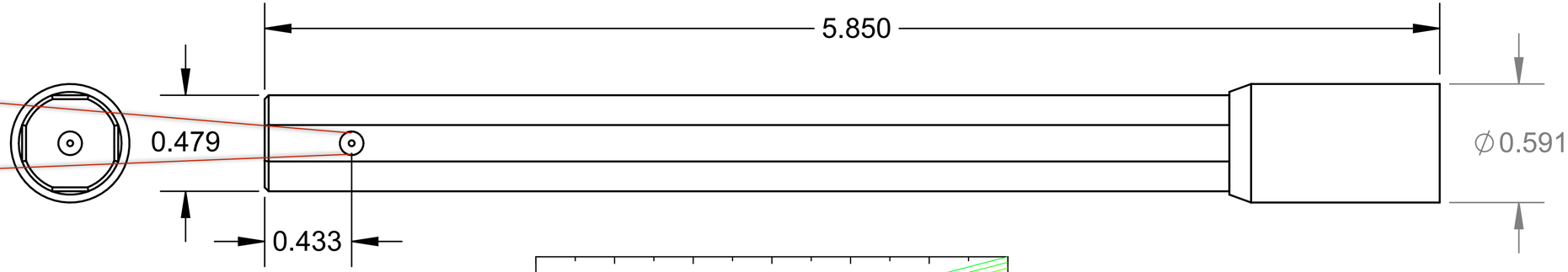
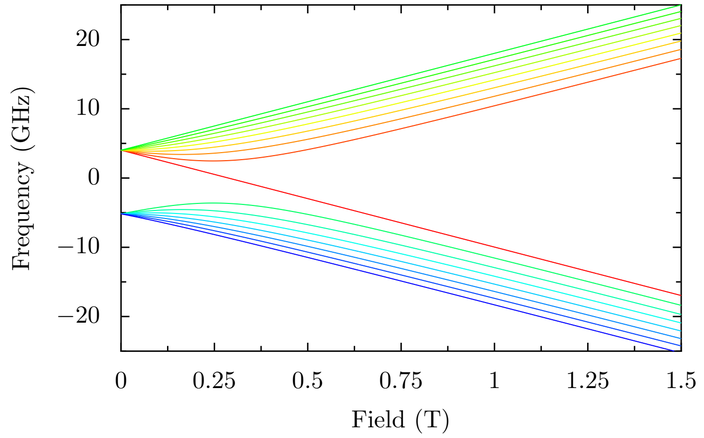
High field, high accuracy sensor





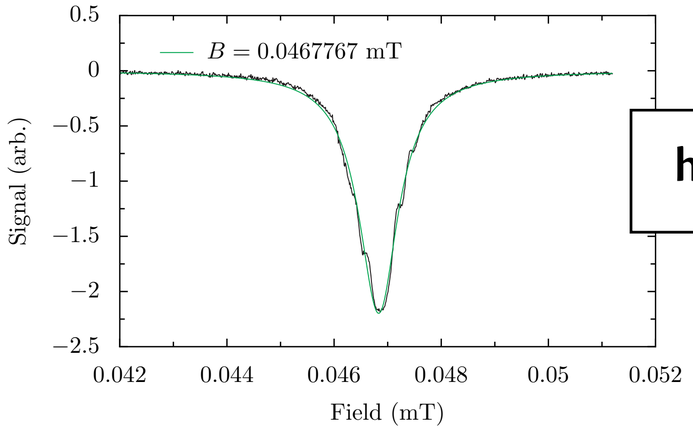
Microfabricated vapor cell

- Higher gradient tolerance

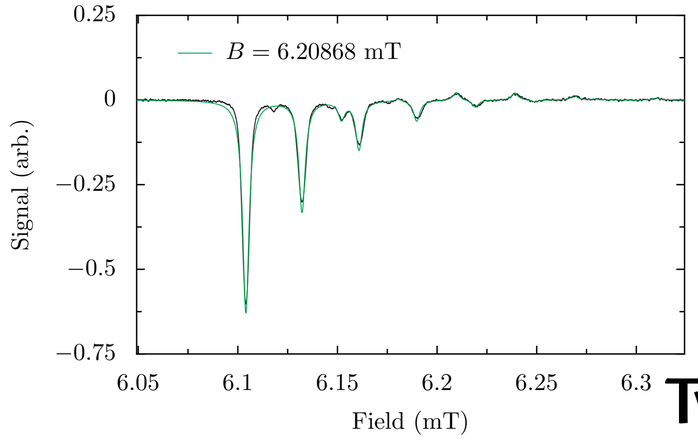


Sensor package

- 13 mm diameter
- Fits in reference coil



higher field



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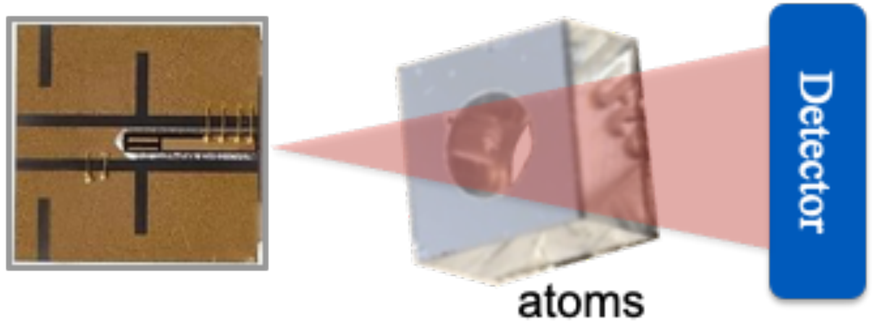
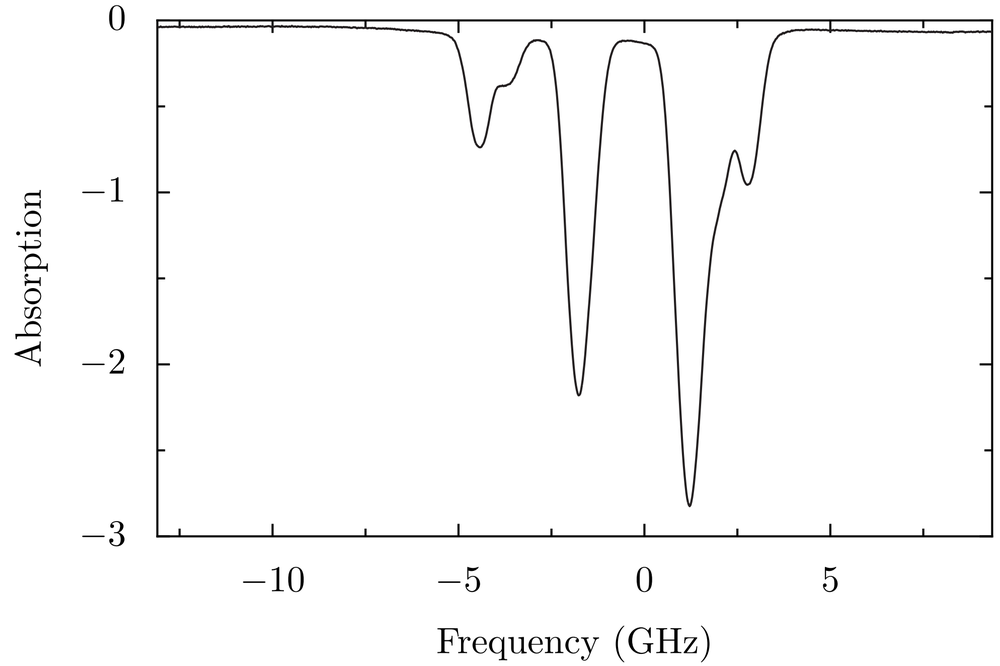
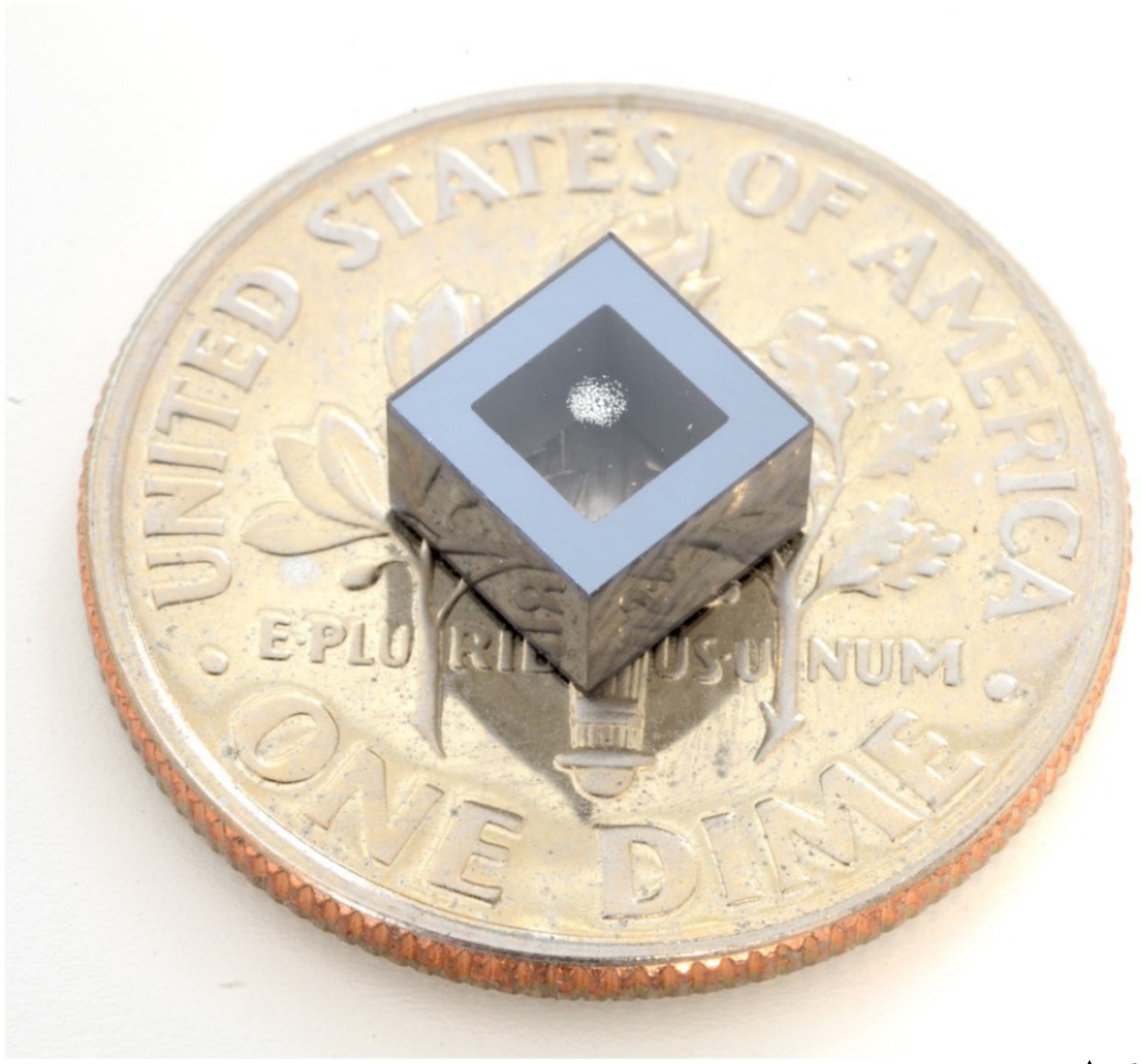
Vacuum Cell: Laser Lock

SEMI-funded R&D program:
Rubidium cell with no buffer gas

- Narrow lines for locking lasers







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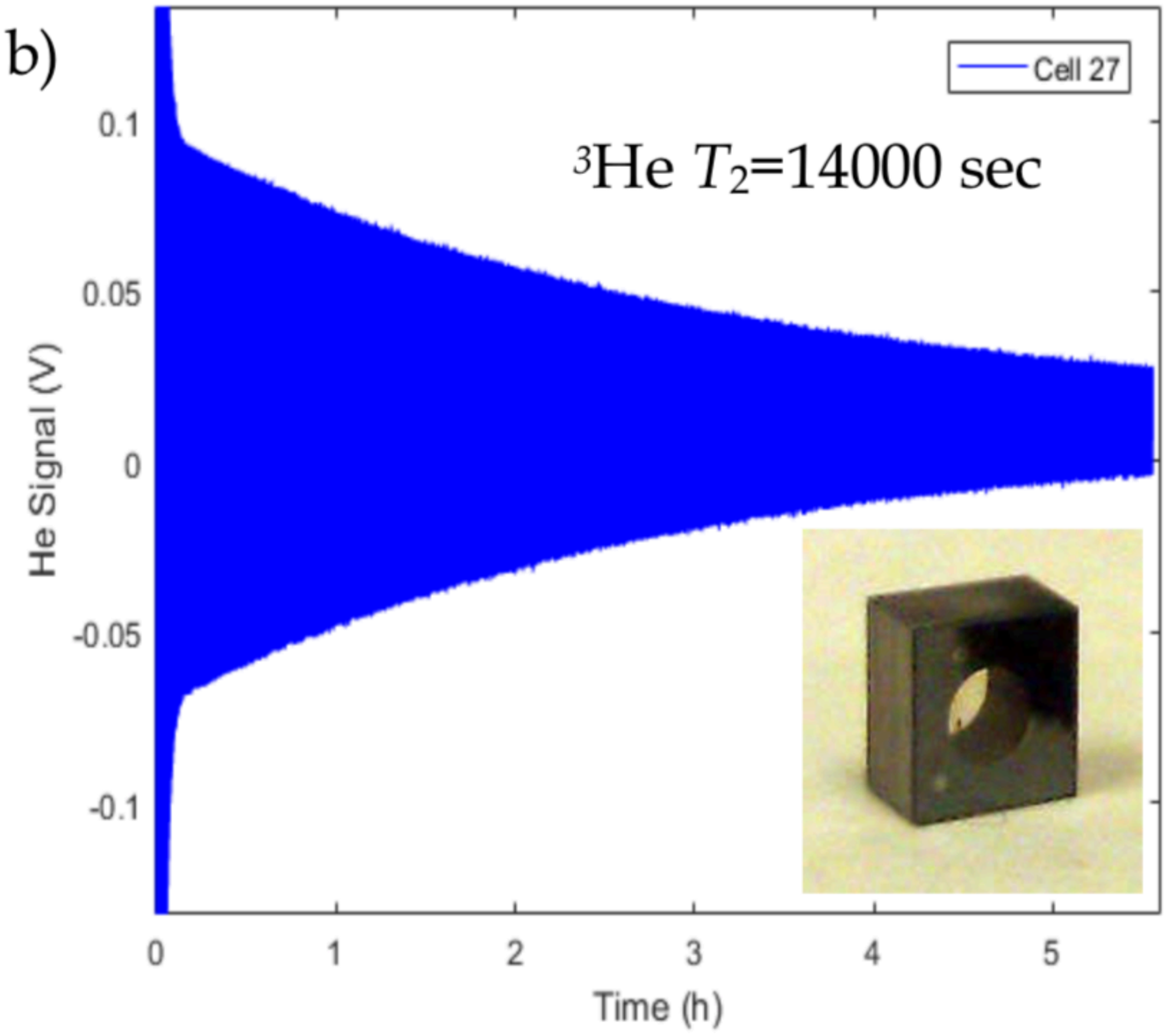
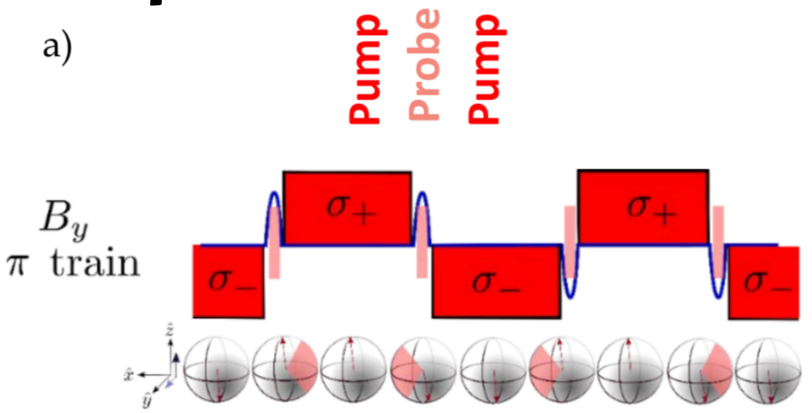
Ideal geometry for low gradient relaxation

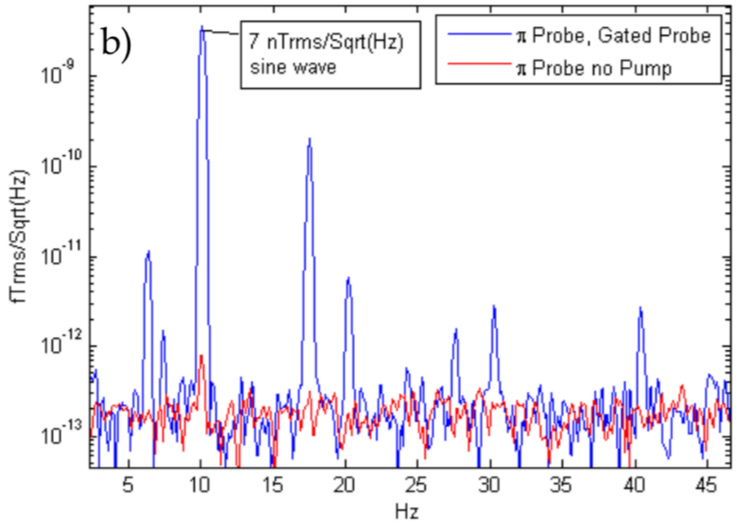


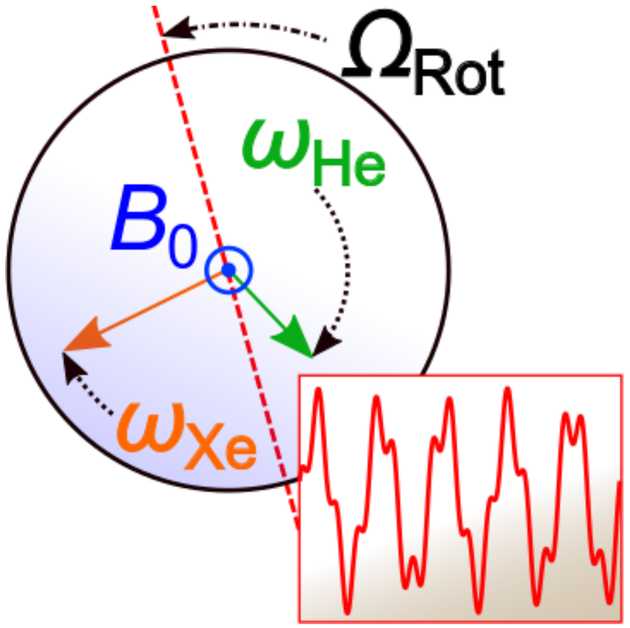
Dual noble-gas cells as gyroscope

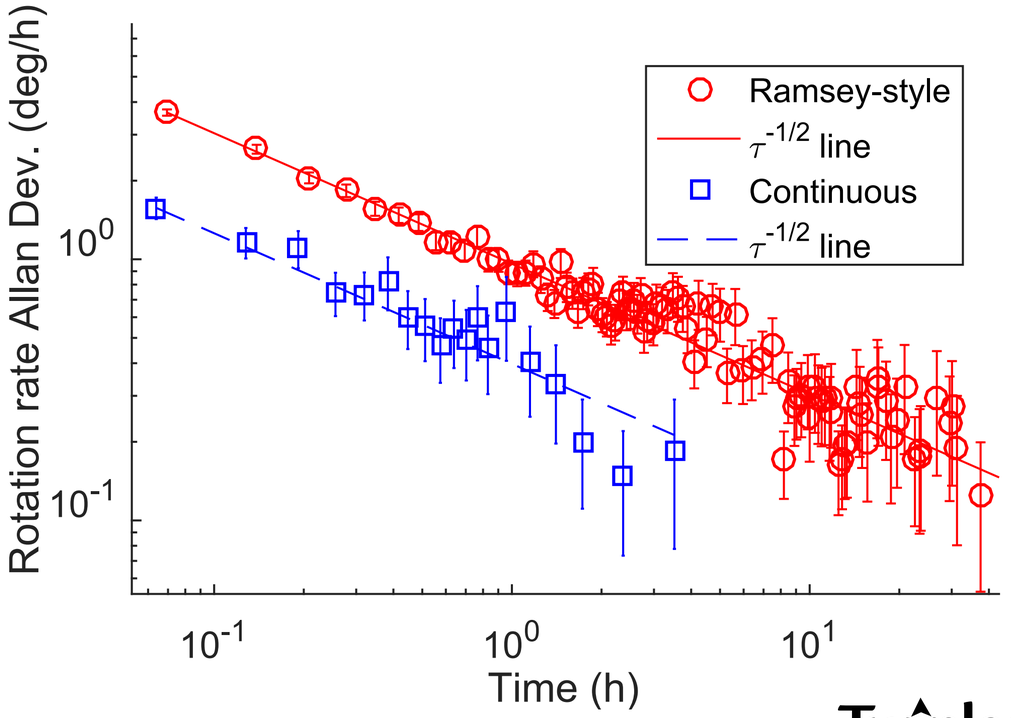
Single-axis pulse-train Rb magnetometer detection

- 0.5 uT bias field, Rb magnetometer sensitivity 300 fT/rtHz
- SNR indicates 0.005 deg/hr is achievable,
- Many systematics!









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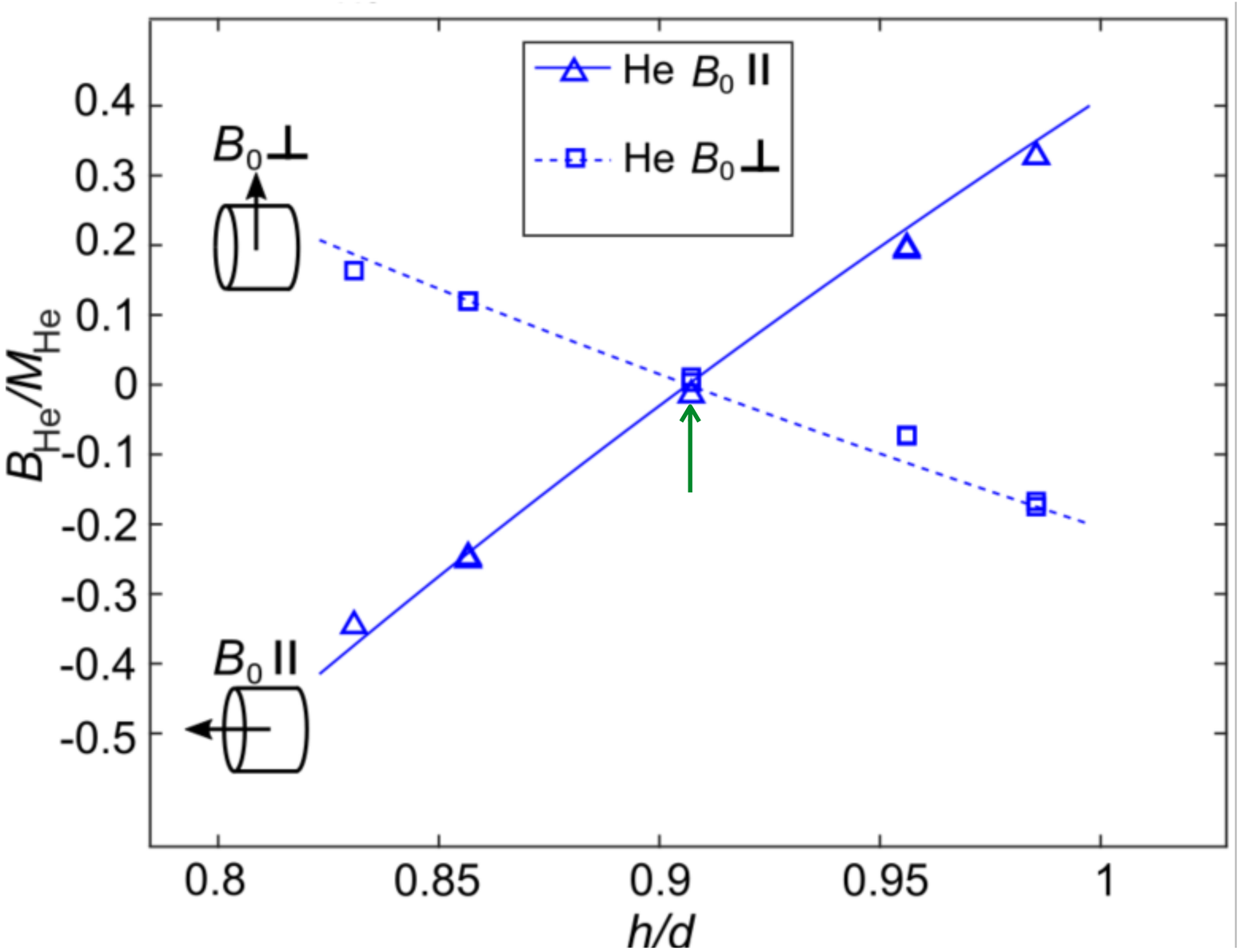
Accurate magnetometry with noble gases

h/d=0.9065 removes
NMR shape effect

First detection of
^{3}He-^{129}Xe J-coupling!



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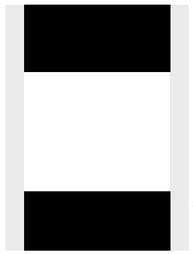
Standard sizes

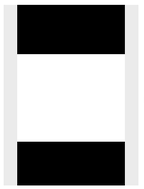
3.5×3.5×6 mm³

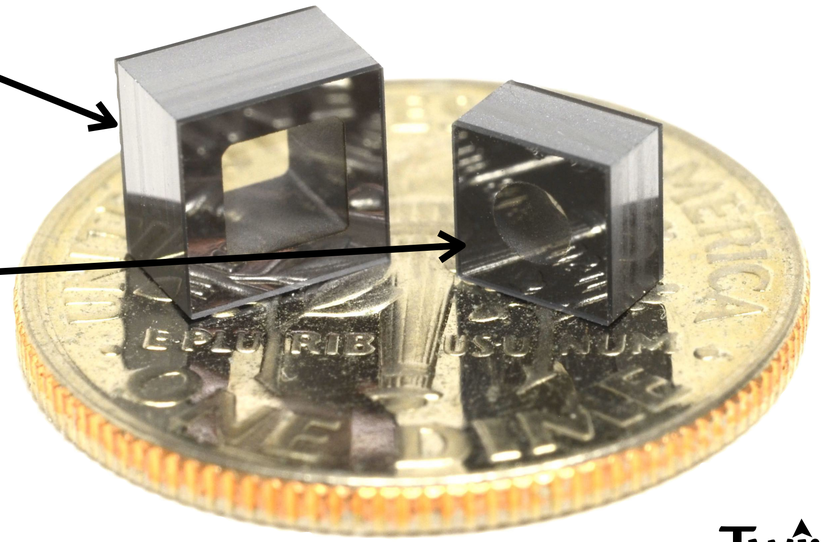
3×3×3 mm³



Stocked: Rb-87 & 500 Torr N2

Ø2x1.8 mm³





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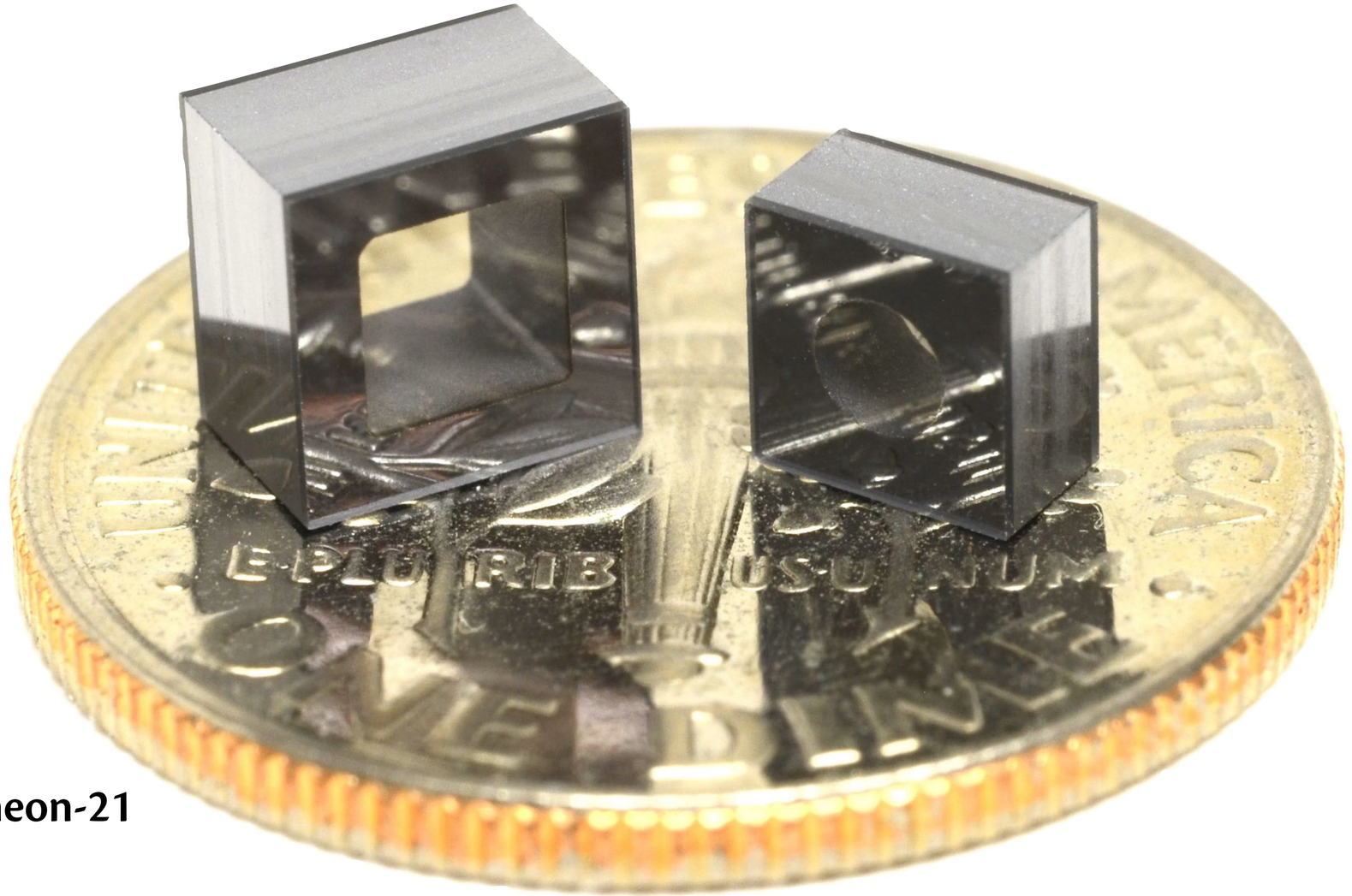
A review



Fill with any metal

- K, Rb, Cs, Ca?, Mg?

Fill any buffer gas

- Neon, Nitrogen
- Helium (special low leakage)
- Rare isotopes: helium-3, xenon-129, neon-21
- None

Thank you

Contact me with questions or ideas!

Tom Kornack

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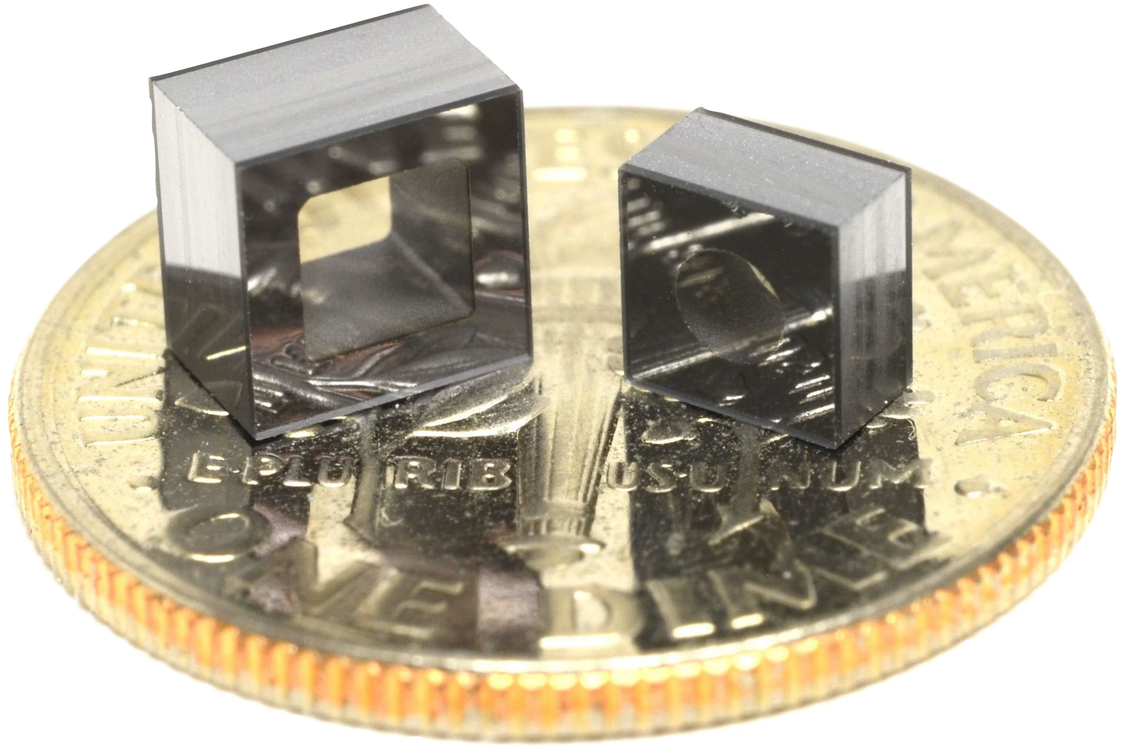

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