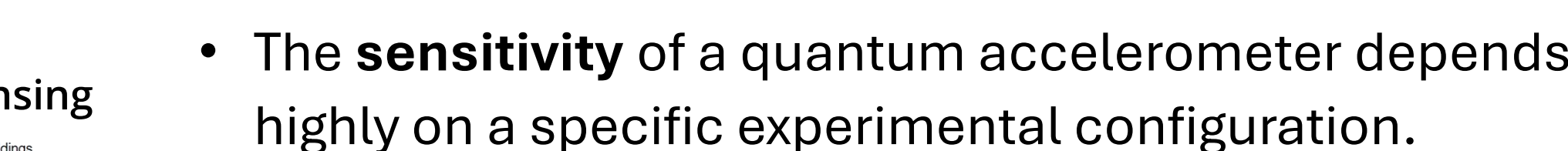


Benjamin D. Smith, Cody Bassett, Adrian Orozco, Christian Sanchez, Roger Ding, & Jongmin Lee

Acceleration Sensing via Light Pulse Atom Interferometry (LPAI)

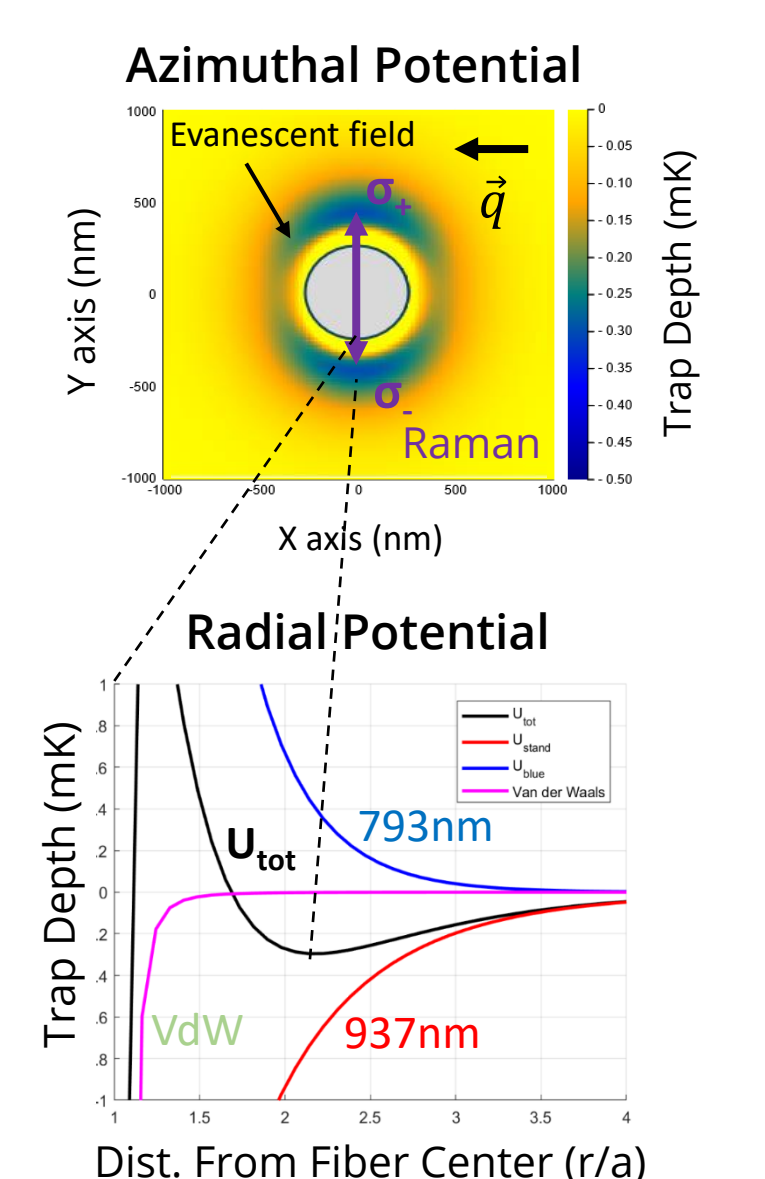
- ## Basics of Light Pulse Atom Interferometry:

3) The atom interferometer's **phase evolves as $S = k_{eff} a T^2$** , where a is the acceleration experienced by the atoms.



- We trap atoms in a two-color evanescent field around a **tapered optical nanofiber**.

Figure 1. Schematic diagram of the experimental setup for measuring the spin Hall effect of light. The atoms are launched vertically upwards with an initial velocity $v = gt$, where g is the acceleration due to gravity. The measurement axis is vertical. The Raman beams are directed horizontally, and the probe beam is directed vertically. The atoms are labeled ^{133}Cs (Cesium).



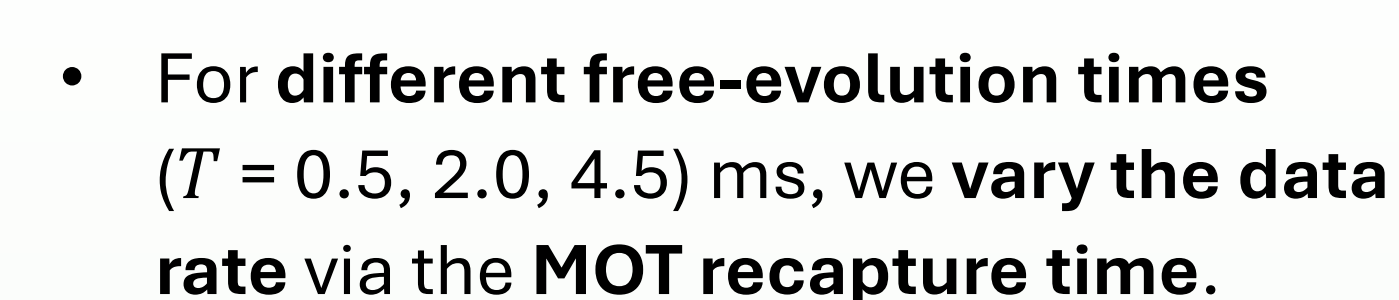
- Orozco, A., et al. (2023) *arXiv preprint arXiv:2311.07055*.

Bernard, J., et al. (2022) *Physical Review A*, 105(3), p.033318.

LPAI Performance versus Data Rate

- Measure the LPAI sensitivity and stability (for a given T):

-

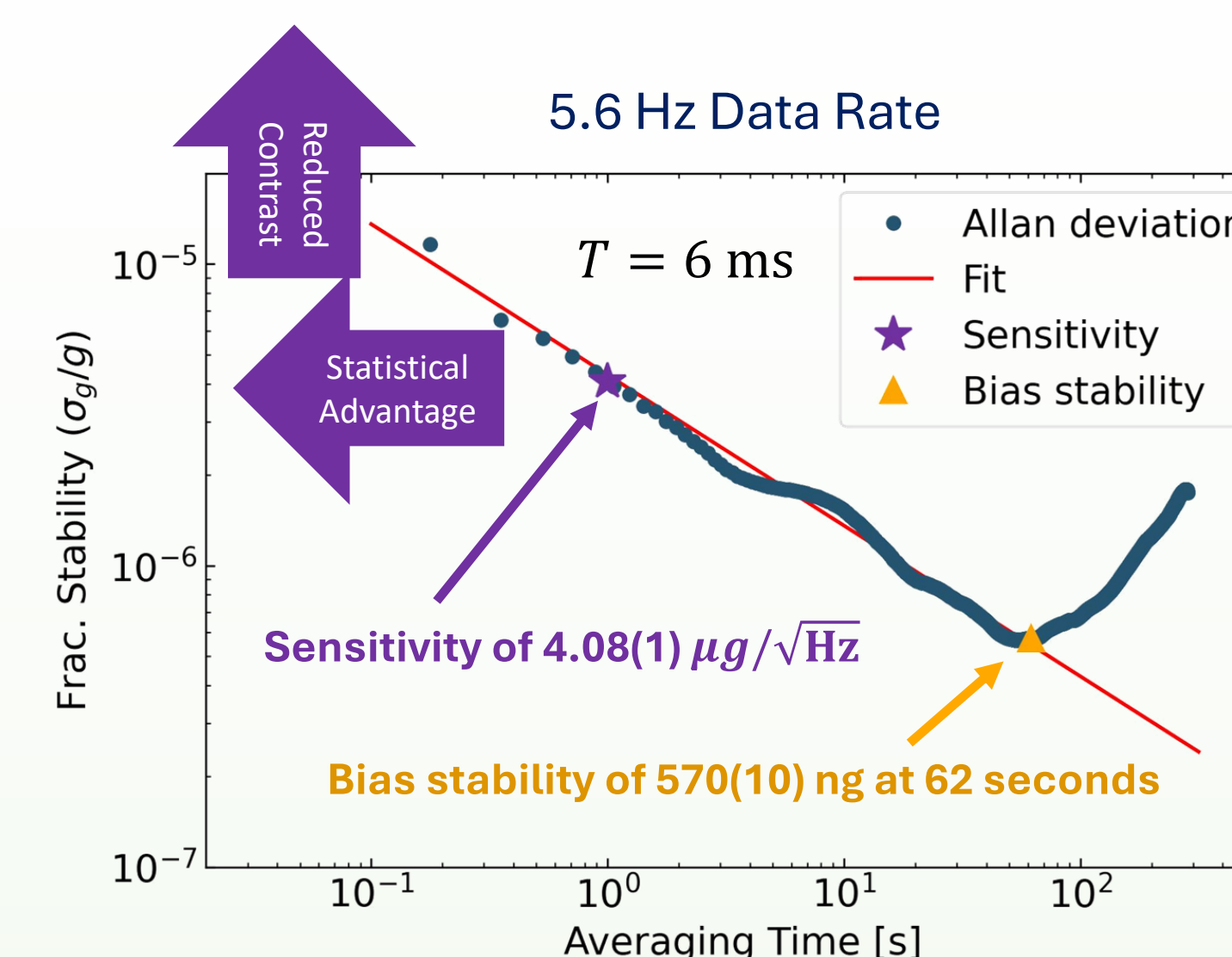


- We extract the **sensitivity** and the LPAI **fringe contrast**.

Timing diagram of the experimental sequence. The sequence consists of the following phases and durations:

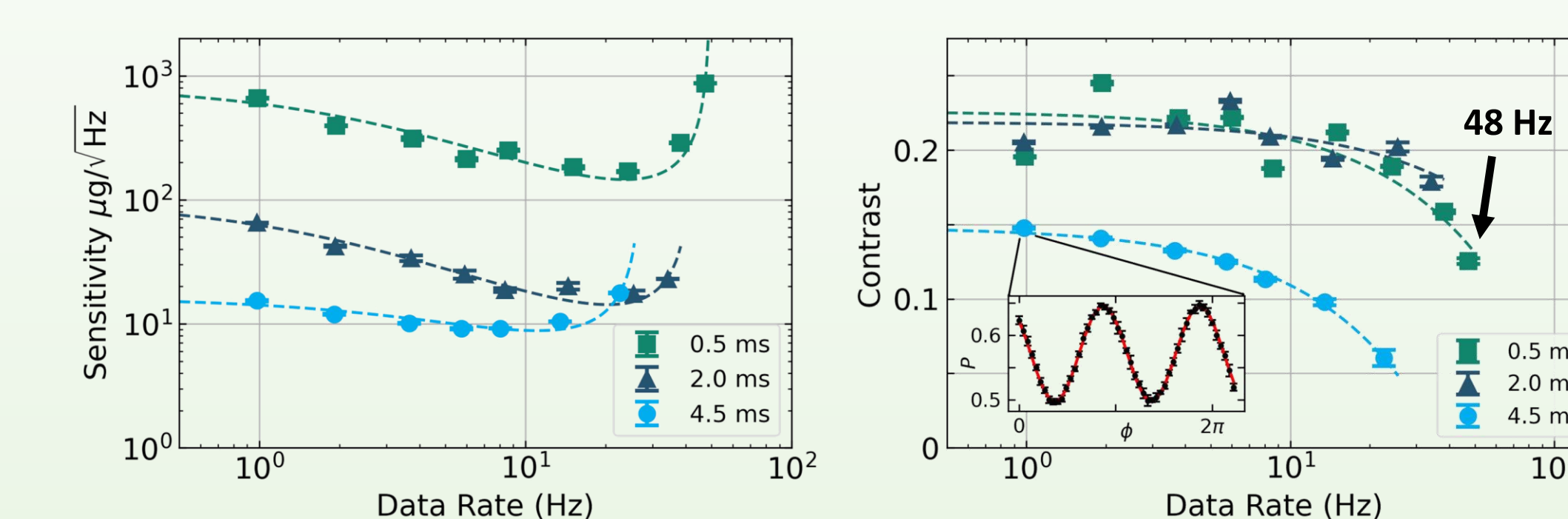
- MOT Load + Recapture (5 - 1000 ms)
- Drop (10 ms)
- SubD + Prep (3 ms)
- Raman (4 ms)
- Detection (1.7 ms)

The time intervals T are indicated between the Raman phase and the Detection phase.



- Competing processes affect the sensitivity at **increasing data rates** (for a fixed T):

1. **Statistical advantage** – faster averaging of white noise
2. **Reduced contrast** – fewer atoms completing the interferometer



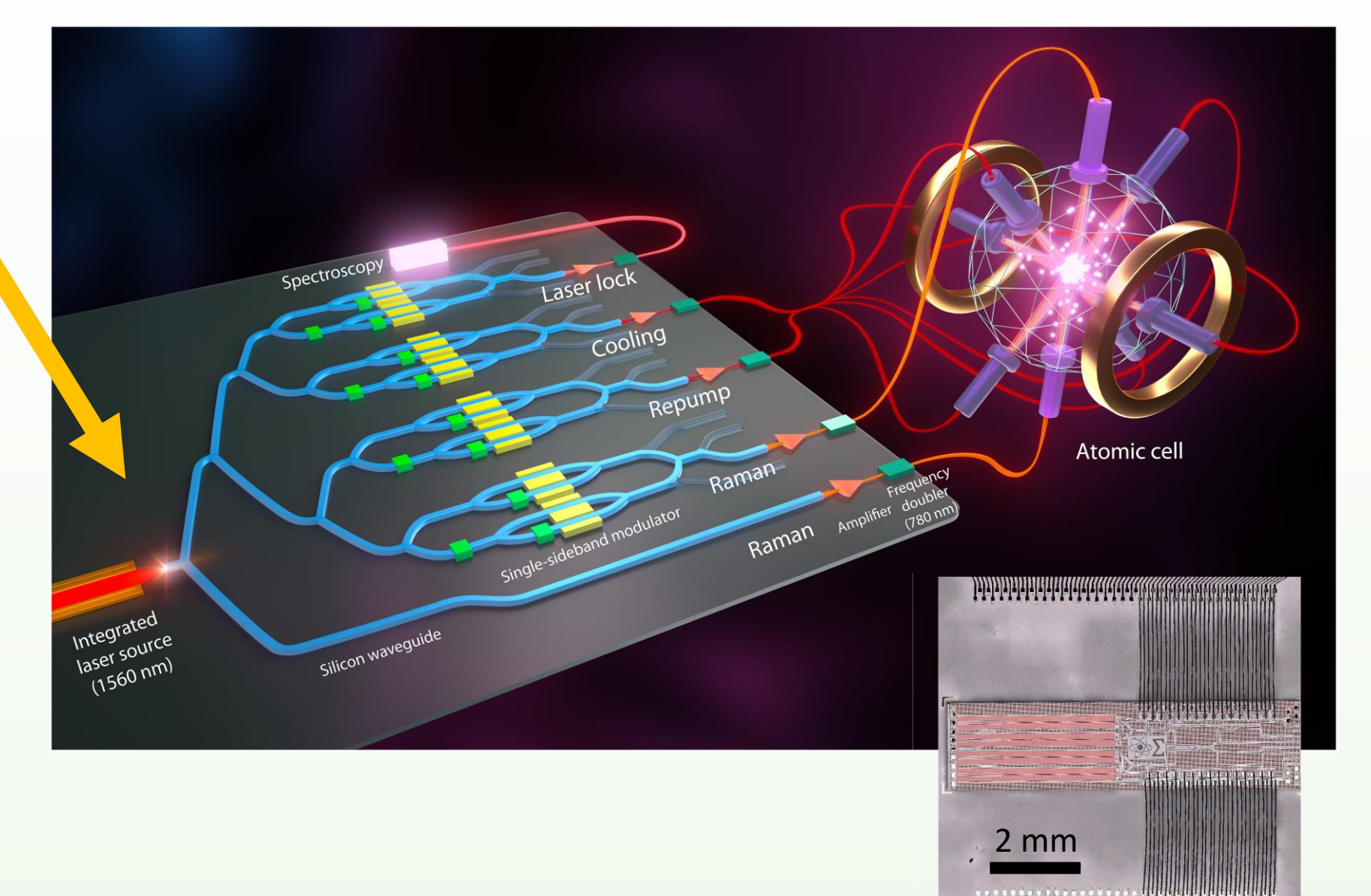
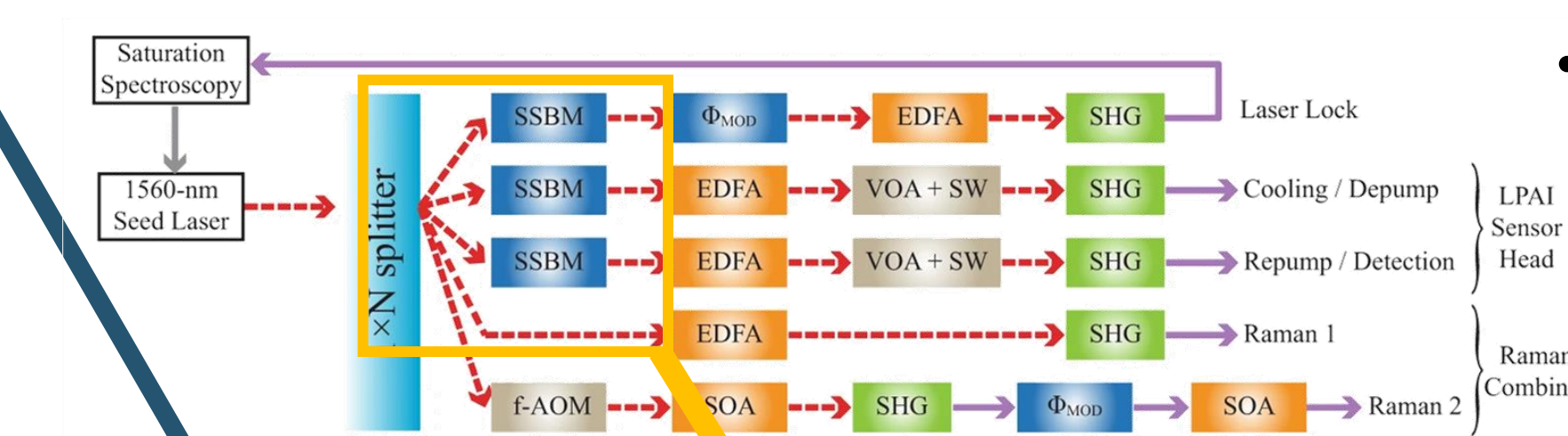
- At higher data rates, the **LPAI fringe contrast degrades** due to **fewer atoms** recaptured.

- The “**sweet spot**” data rate depends on T .

Photonic Integrated Circuit (PIC) Modulators

- **Laser systems** for cold atom platforms are typically **complicated and bulky**. For example, ours contains a single laser with:

- Acousto-optic modulators (AOM),
- Single-sideband IQ modulators (SSBM),
- Optical amplifiers (EDFA & SOA),
- Optical attenuators (VOA), and
- Frequency-doubling (SHG) devices.



- We have developed a **4-channel optical IQ-modulator device** (8 mm x 8 m) from integrated silicon photonics.

Kodigala, A., et al. (2024) *Science Advances*, 10(28), p.eade4454.