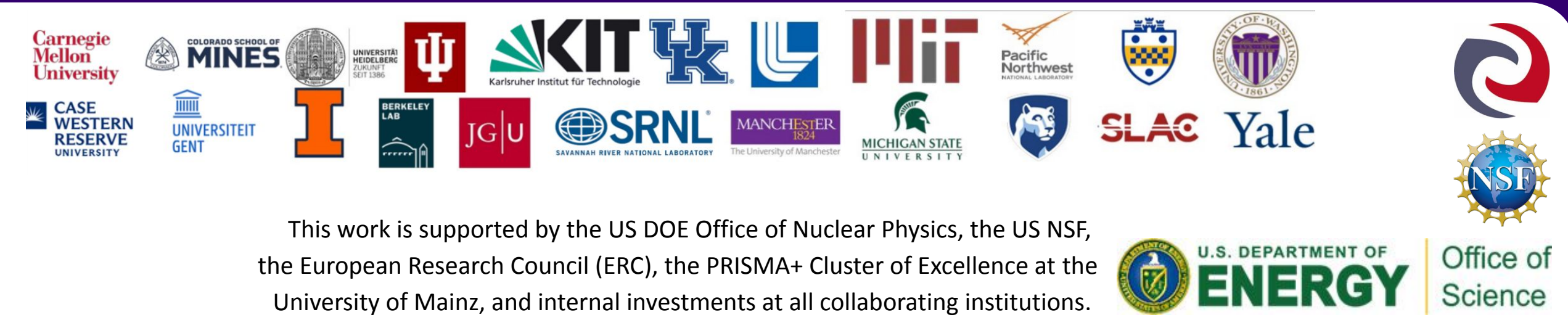




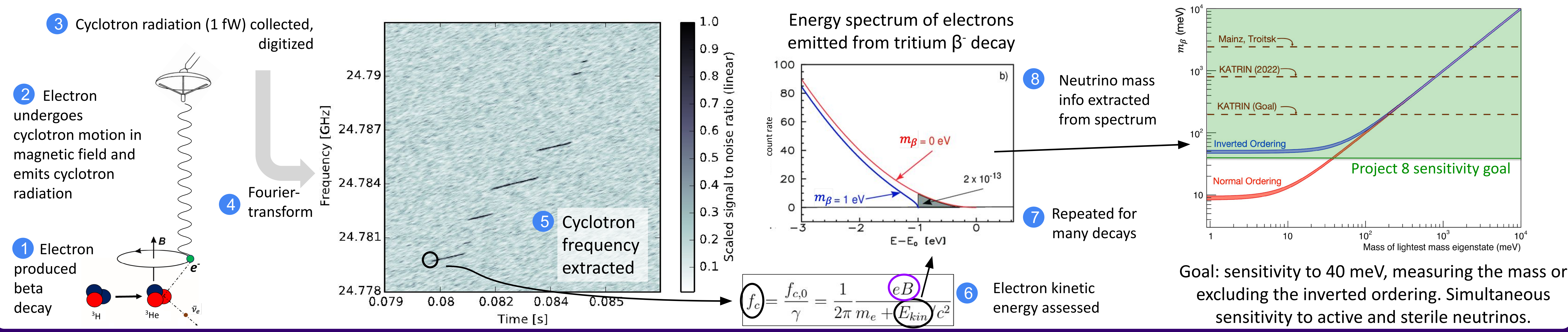
Developing Techniques for a Characterizing an Atomic Hydrogen-Isotope Beam

Meg Wynne (University of Washington) for the Project 8 Experiment



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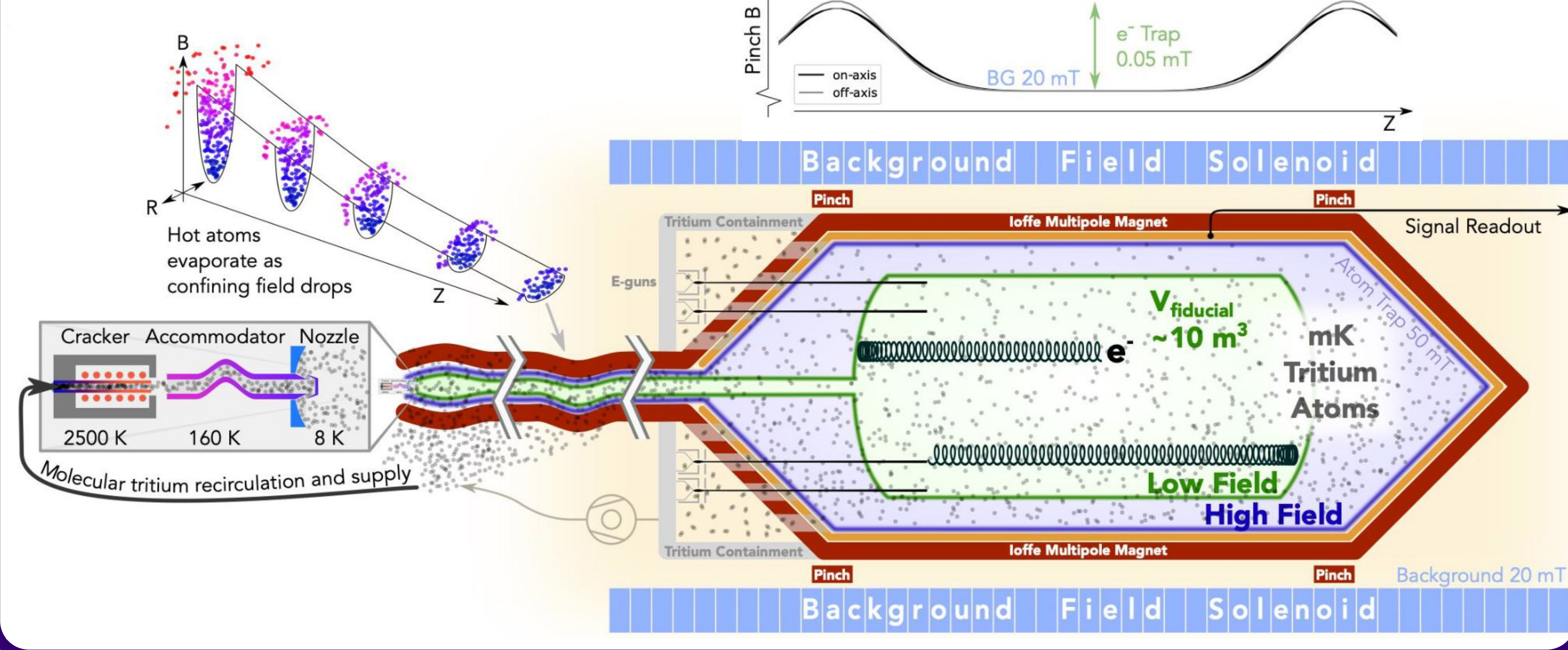
Project 8: measuring neutrino mass by observing tritium β^- decay with Cyclotron Radiation Emission Spectroscopy (CRES)



Why is a cold atomic tritium source needed?

- The endpoint of the electron spectrum from beta decay of molecular tritium is smeared by the variety of rovibrational states available.
- The atomic tritium endpoint is much narrower, enabling 40-meV sensitivity.
- Atomic tritium is difficult to produce and store, as it recombines into molecules if it comes into contact with the walls of a container.
- Atomic tritium must therefore be confined magnetically in a Ioffe or Halbach trap, which requires cooling it to mK-scale temperatures. A flux of $\sim 10^{15}$ atoms/s is required.
- We are developing techniques for producing and characterizing a beam of cold atomic tritium, beginning by testing them with other hydrogen isotopes.**

Concept for a beam source of cold atomic tritium for Project 8



The test stand at UW for production and characterization of a hydrogen isotope beam

Dissociation (atom production)

Molecules are dissociated into atoms by contact with a hot tungsten surface using a commercial cracker: the HABS hydrogen atomic beam source

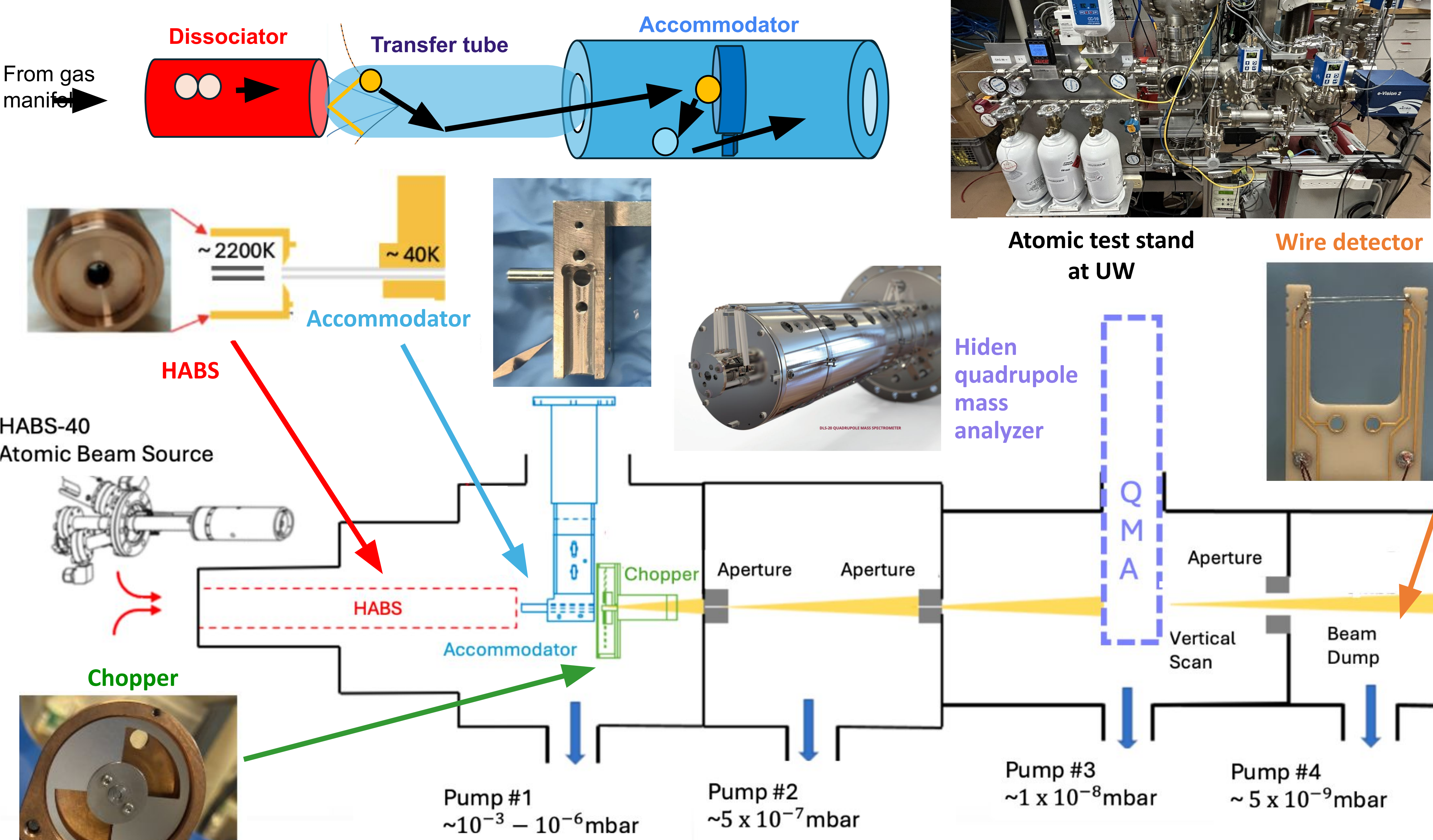
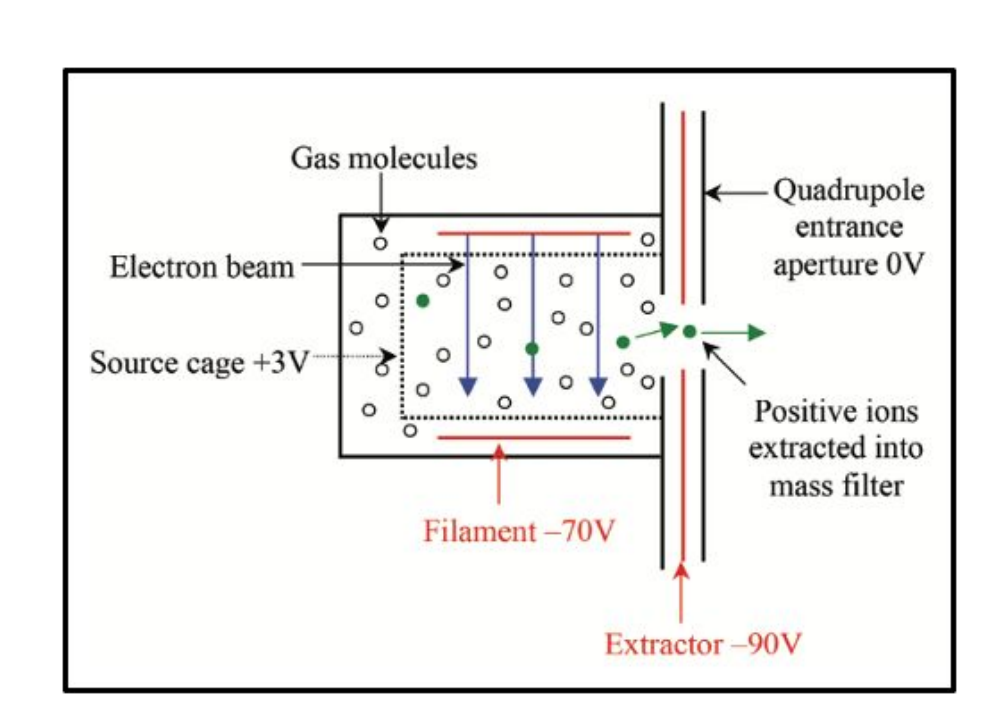
Accommodation (first cooling stage)

Atoms are cooled to 40 K by a limited number of bounces on a cold aluminum surface

Atom detection tools

Mass spectrometer

- A quadrupole mass analyzer specialized for low atomic mass (Hiden) can be inserted to intercept the beam or retracted to allow it to pass. It assesses gas density and composition.
- A separate QMA monitors the background gas density and composition.



Wire detector

- The wire detector measures atom flux.
- A low-mass wire is strung across the beam path, blocking a tiny fraction of the beam.
- Atoms hit the wire and recombine into molecules, releasing heat.
- Heating changes wire resistance, which is monitored with a lock-in amplifier set to the chopper frequency.
- The wire detector, unlike the mass spectrometer, can work in magnetic fields that are necessary for magnetic confinement of the atomic tritium in later stages of cooling.
- See Astachov et. al. *Eur. Phys. J. D* 79, 2025.

Characterizing the velocity distribution of the atomic beam with time-of-flight measurement

- Atom beam is interrupted at a controllable frequency by a rotating chopper wheel
- Later in the beamline, atoms are detected using the wire detector or quadrupole mass spectrometer
- Velocity distribution is determined from arrival-time data

