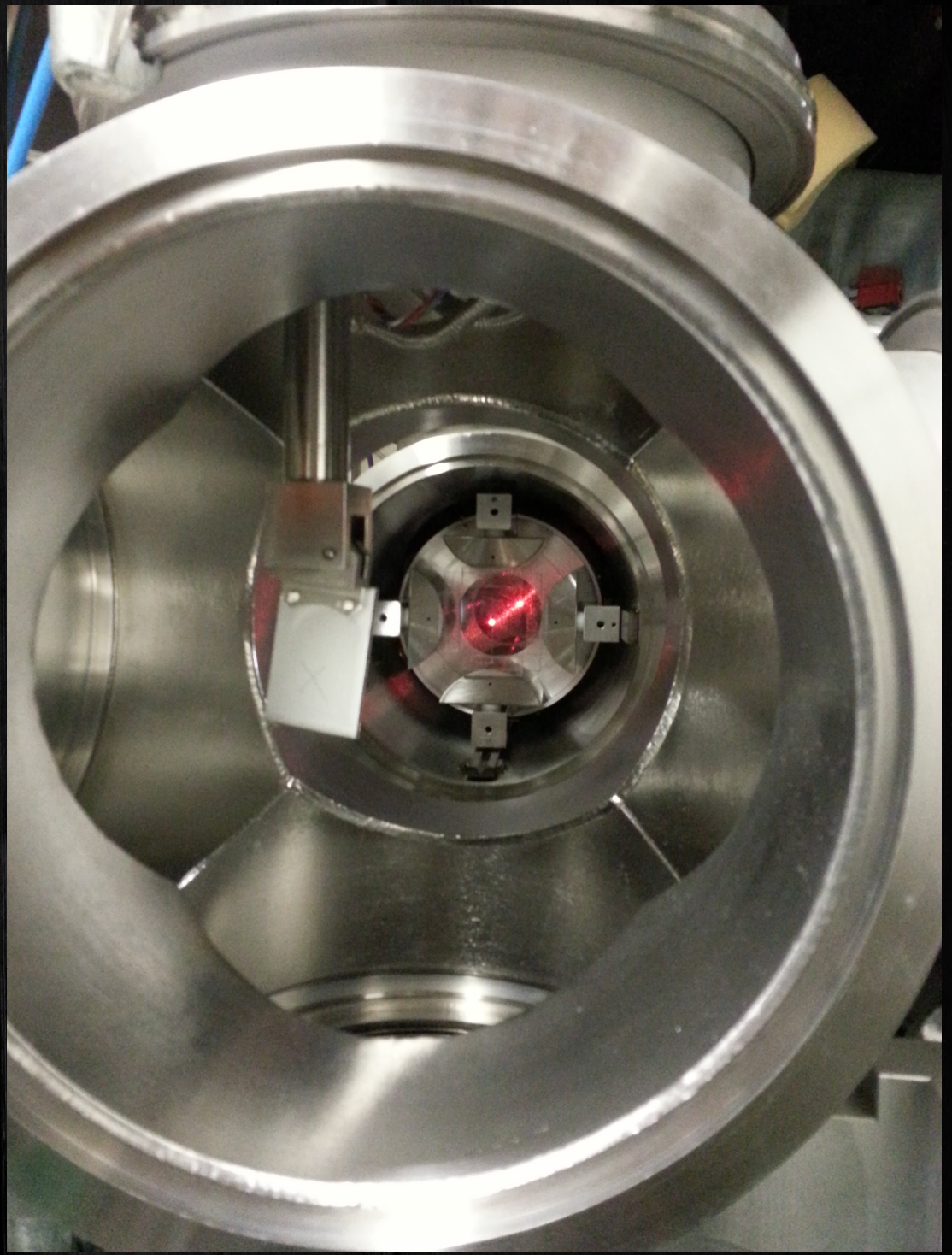
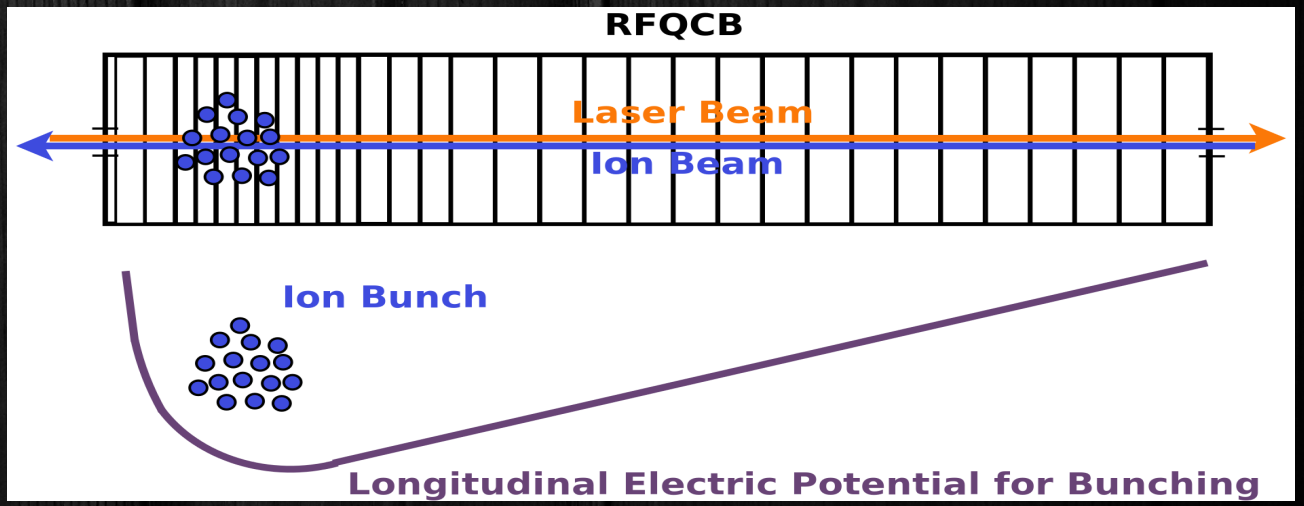
Beam Developments using Optical Pumping in ISCOOL



Optical Pumping Theory

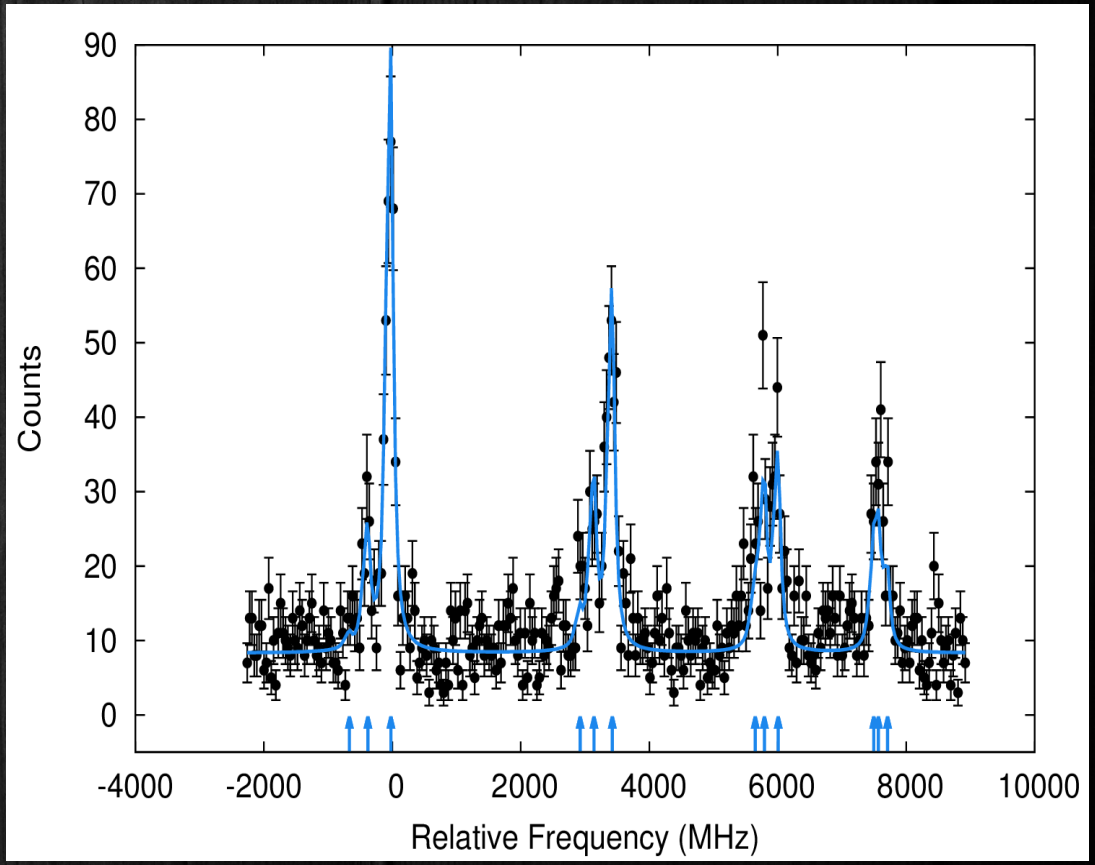
- Use laser light to excite ions out of the ground state
- This is most effective if done while the ions are trapped in the cooler → can use pulsed lasers and low power
- Was used successfully at the beginning of June to do spectroscopy on metastable ionic Mn



Why Optical Pumping: Atomic Mn

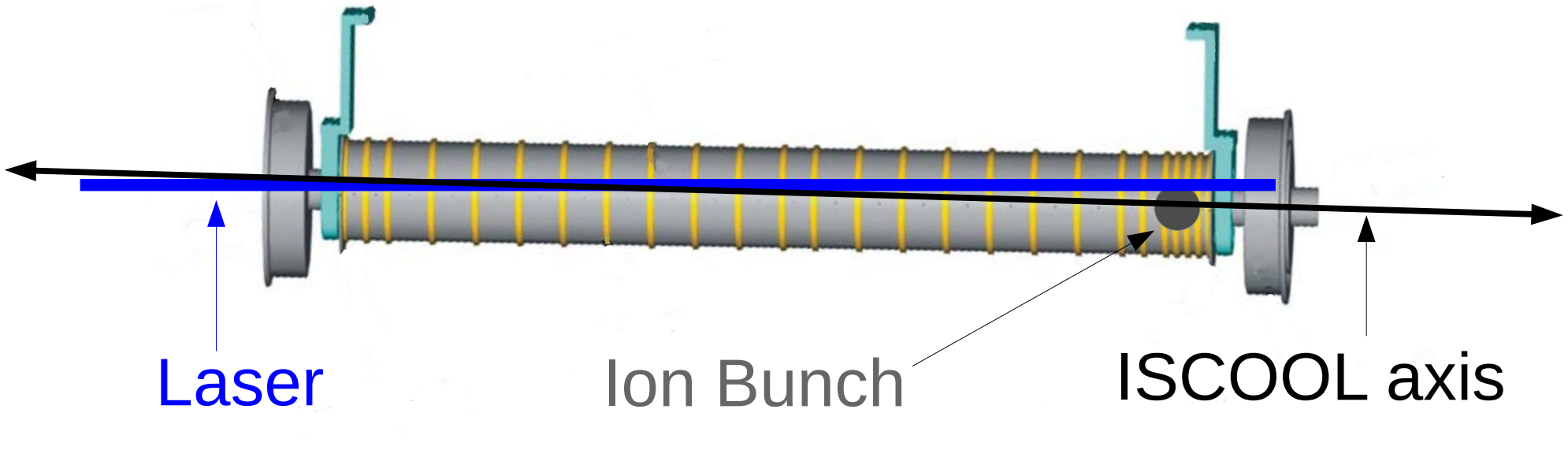
- Atomic Mn experiment carried out at COLLAPS in 2012

- Goal was to determine the spins, magnetic dipole and electric quadrupole moments → another transition needed!

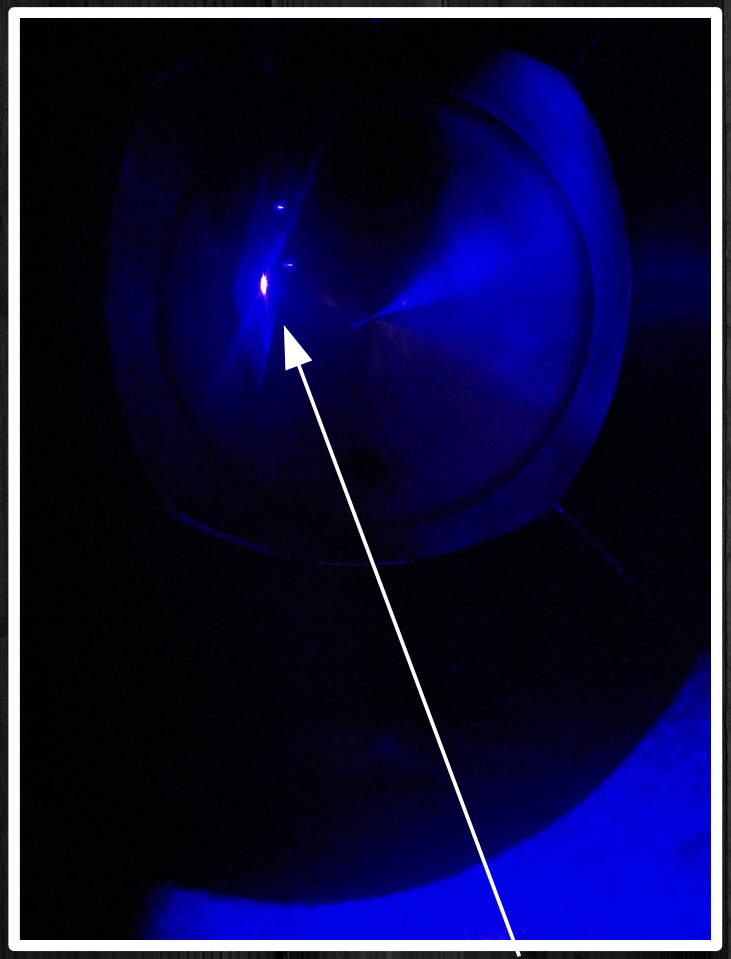


Challenges for Optical Pumping

The laser and the ion bunch were not overlapping due to the misalignment of ISCOOL



Re-aligned ISCOOL



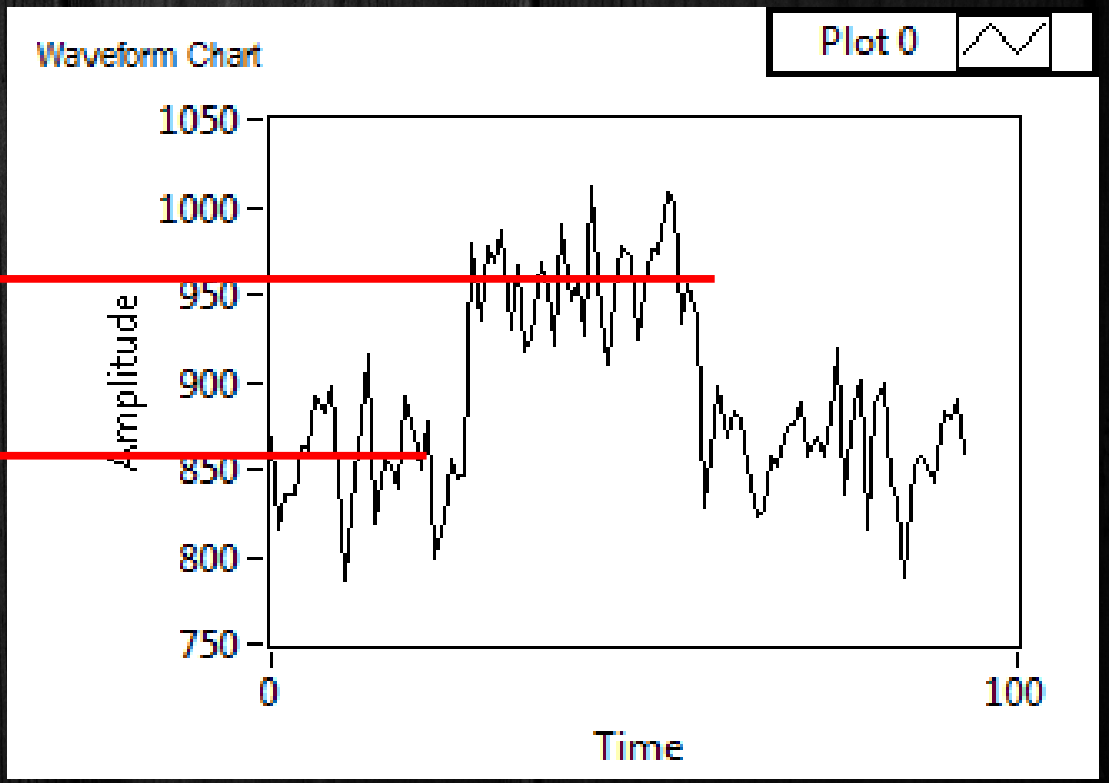
Laser spot after passing through the cooler

The Test Case: ^{88}Sr

- First tried optical pumping using a special property of ^{88}Sr – the excited state charge exchanges resonantly with the gas in the charge-exchange cell while the ground state does not

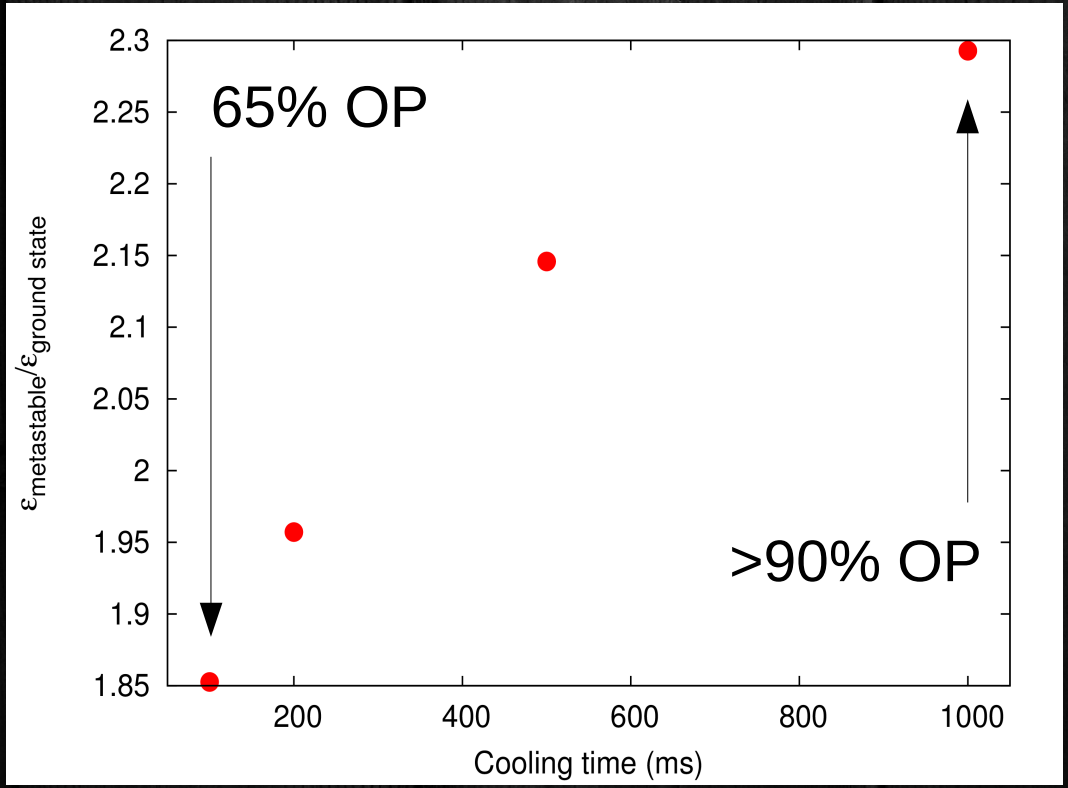
Neutral particles seen with optical pumping

Neutral particles seen without optical pumping



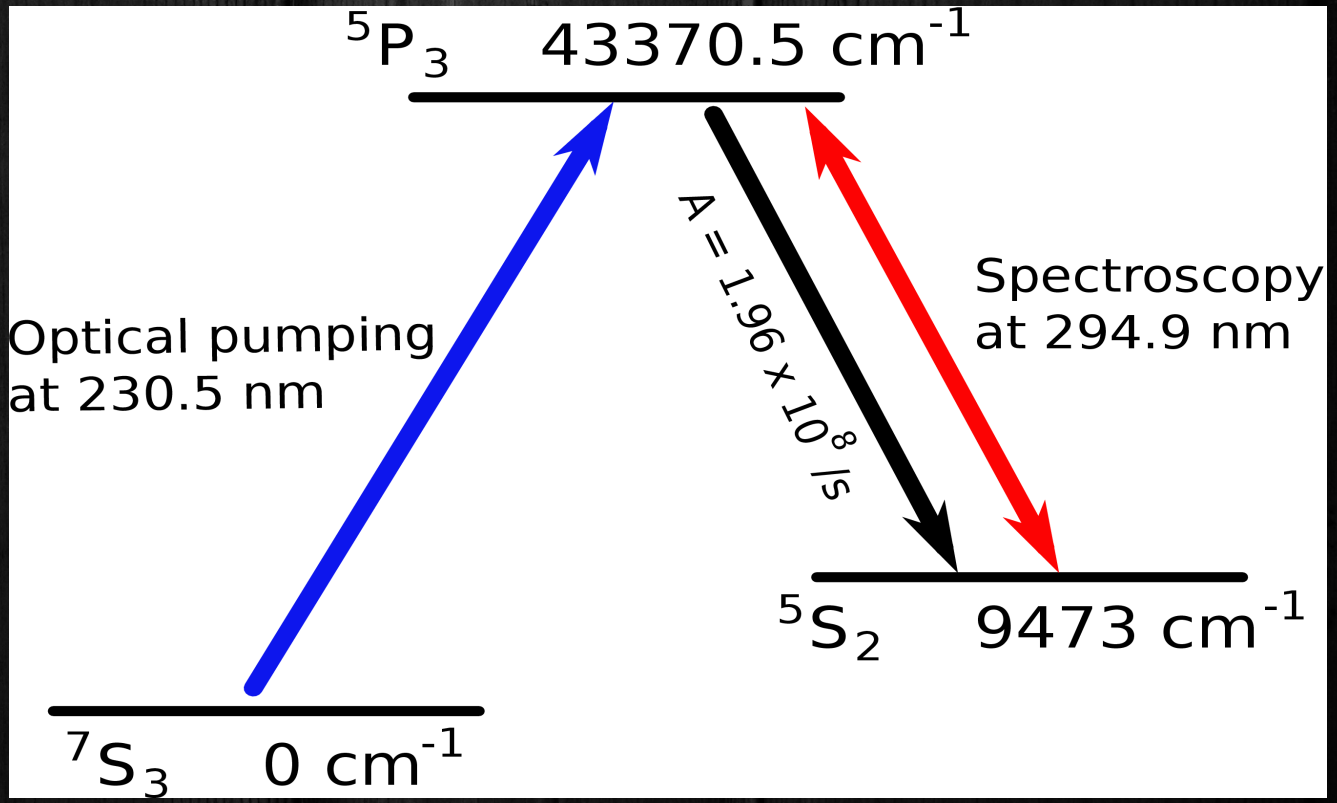
^{88}Sr Results

- Estimates of efficiency depend on three unknowns – the contaminants in the beam, the percentage of the beam optically pumped and the efficiency of the charge-exchange cell

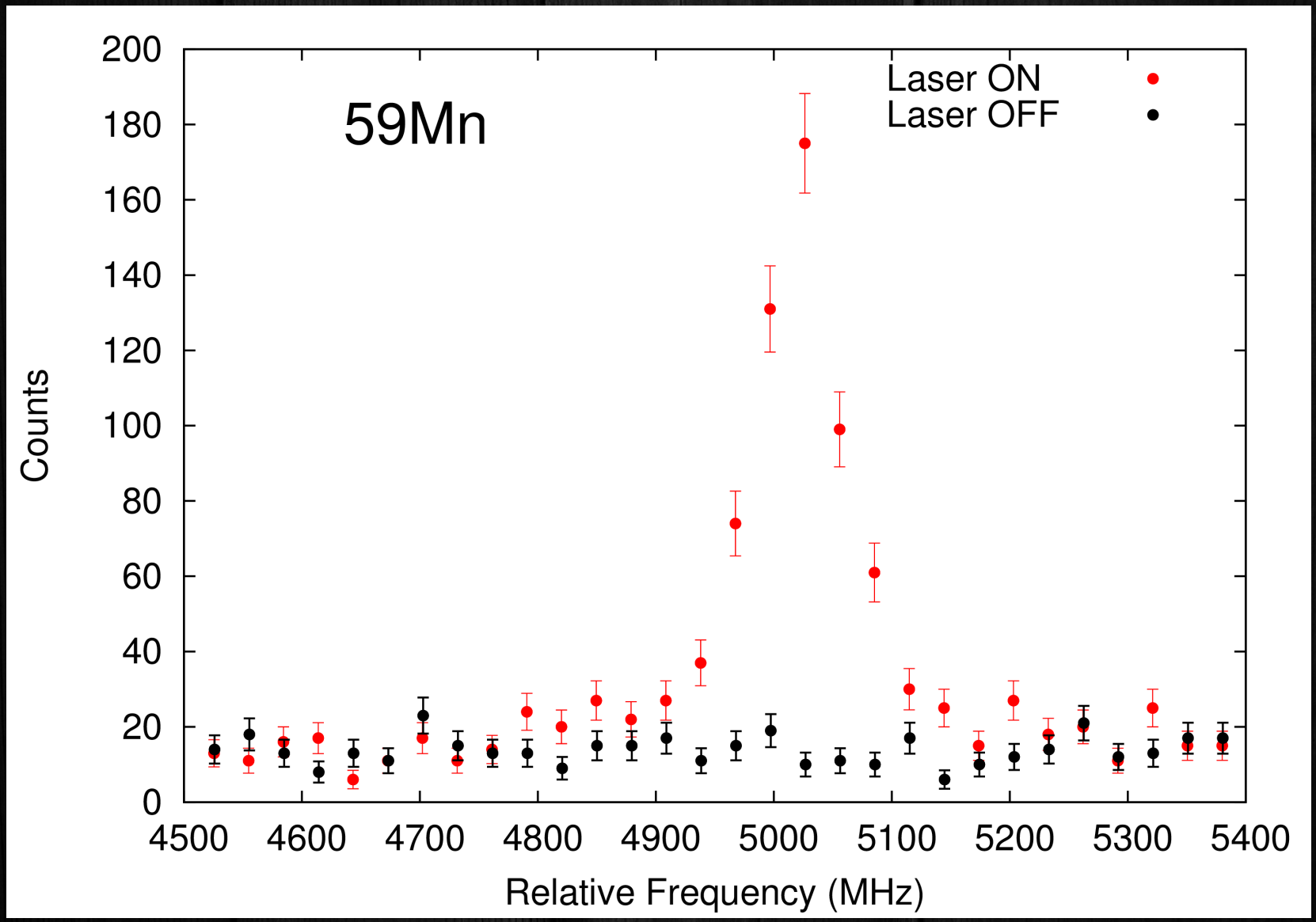


First OP Physics case: Ionic Mn

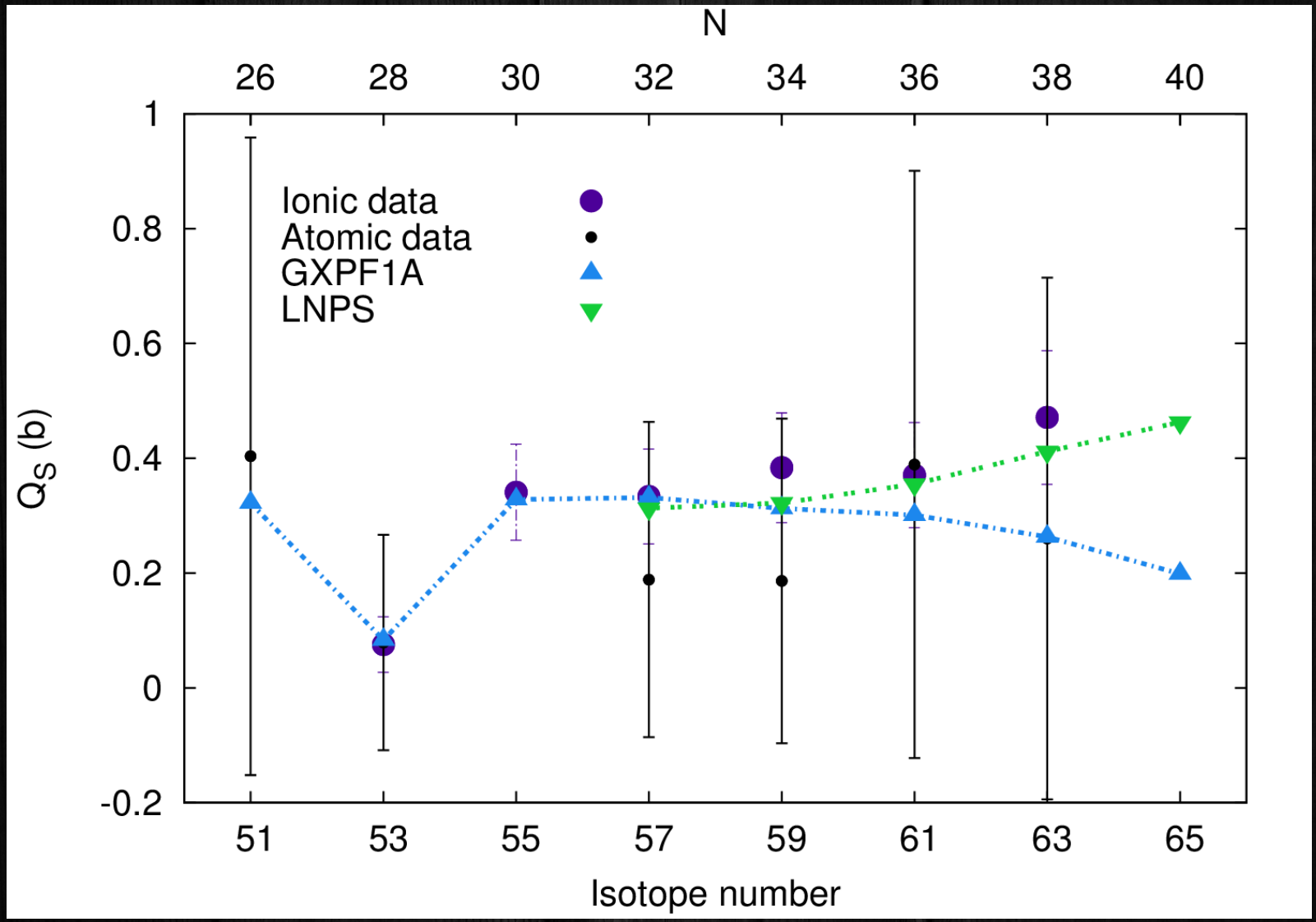
- With the ISCOOL re-aligned, spectroscopy was attempted on Mn ions using an optically pumped transition



Ionic Mn Results



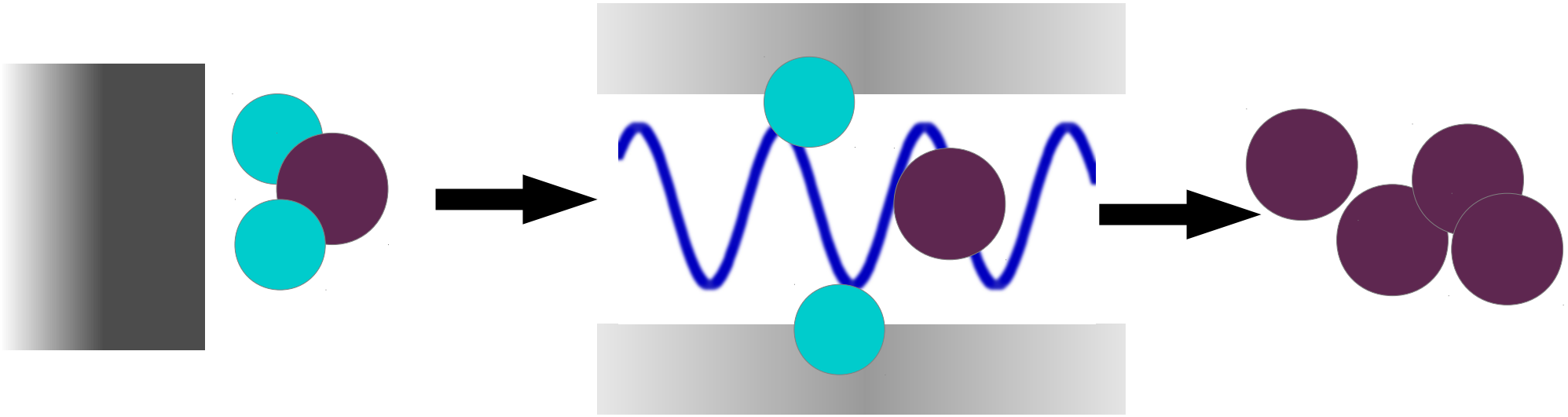
Quadrupole Moments



Very preliminary!

Future Physics Cases

- Refractory beams
  - Technique could be used to produce beams such as Hf or Ta



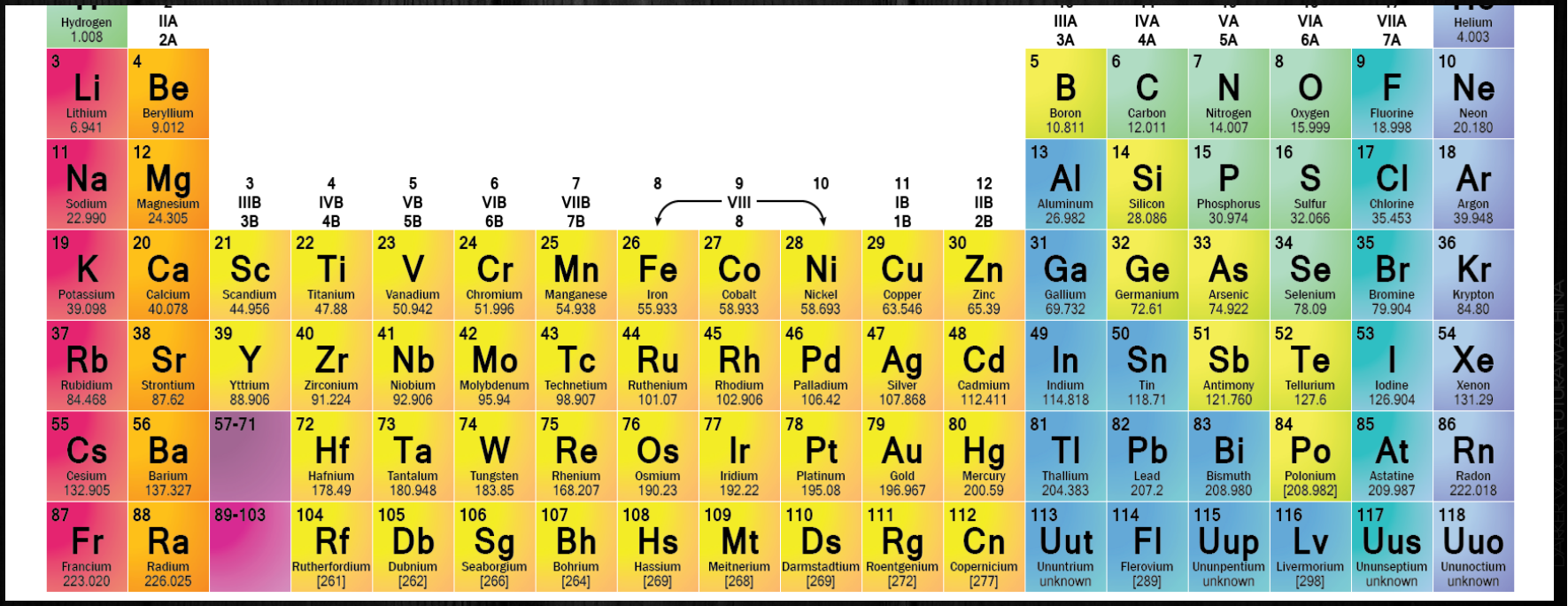
Element of interest extracted as a molecule

Laser induced disassociation in the cooler

Beam of the required element exits cooler

Future Physics Cases

- 2+ ionization
  - Extra ionization step taken in the cooler
  - Could be used for beam purification among other things
- Other optical pumping physics cases

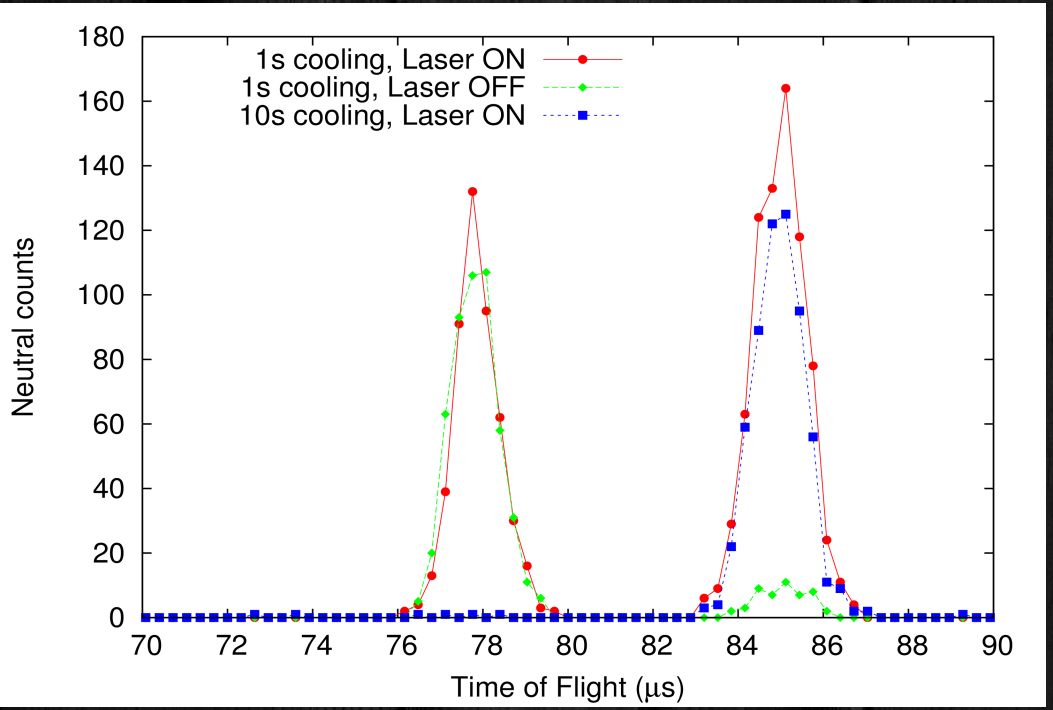


Future Developments

- In order to implement these physics cases, we need an estimate of the optical pumping efficiency in the cooler → dedicated beam time
- This depends on:
  - Laser/ion overlap
  - Trapping time
  - Saturation per laser pulse
  - Experimental setup factors (charge exchange efficiency, transition used, etc.)

Future Developments

- Molecular formation inside the cooler was observed during the 88Sr tests



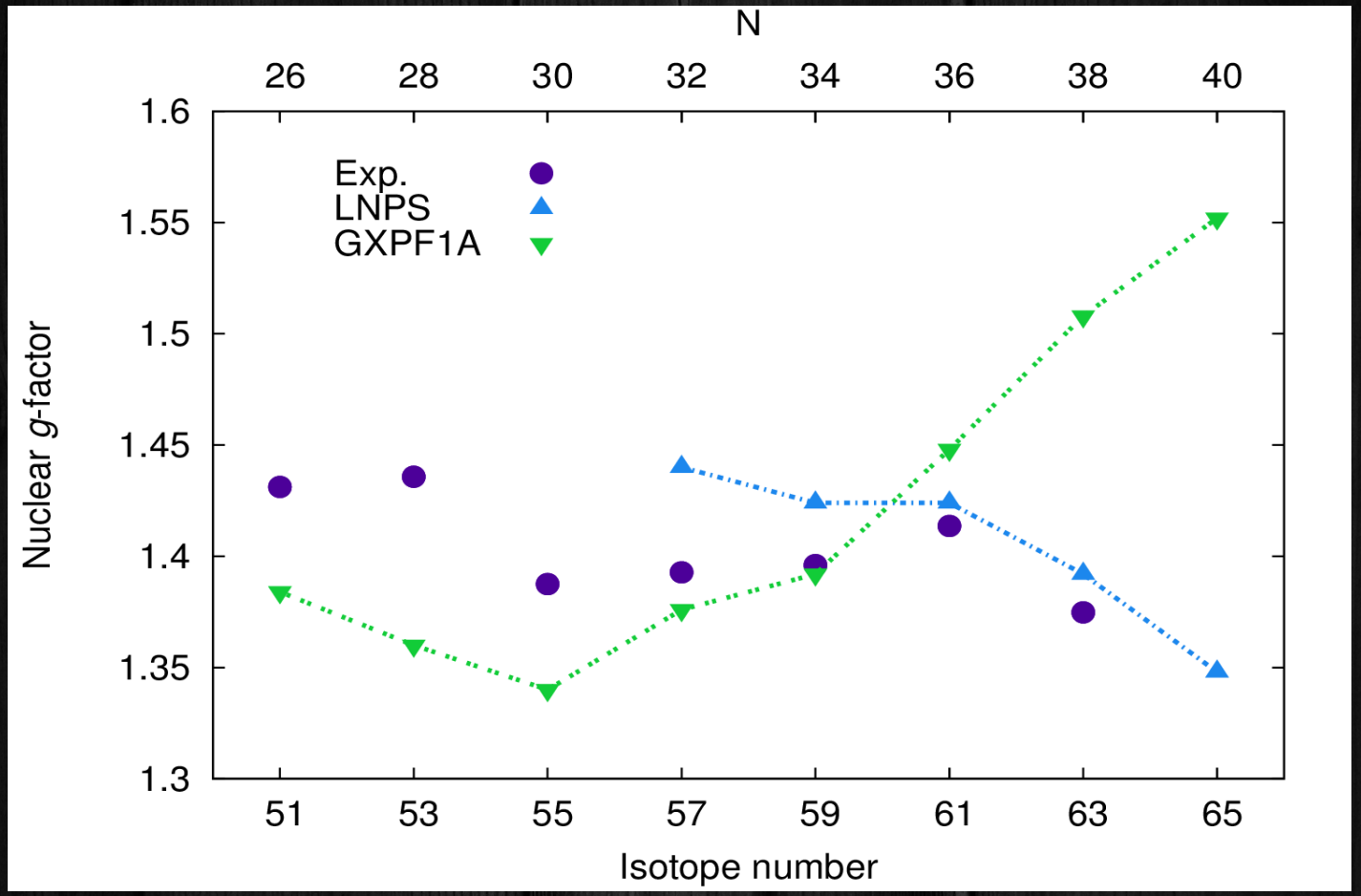
- Investigation of dynamics inside the cooler will shed light on the overall efficiency of the process under different circumstances

Conclusions

- Optical pumping has now been proven to work for physics cases at ISOLDE
- The quadrupole moments of neutron-rich Mn have been measured for the first time and results will soon be published
- More tests are needed to benchmark this technique for refractory beams and 2+ ionization
- The efficiency of the optical pumping process in the cooler should be investigated

Thank You

Atomic Mn Results

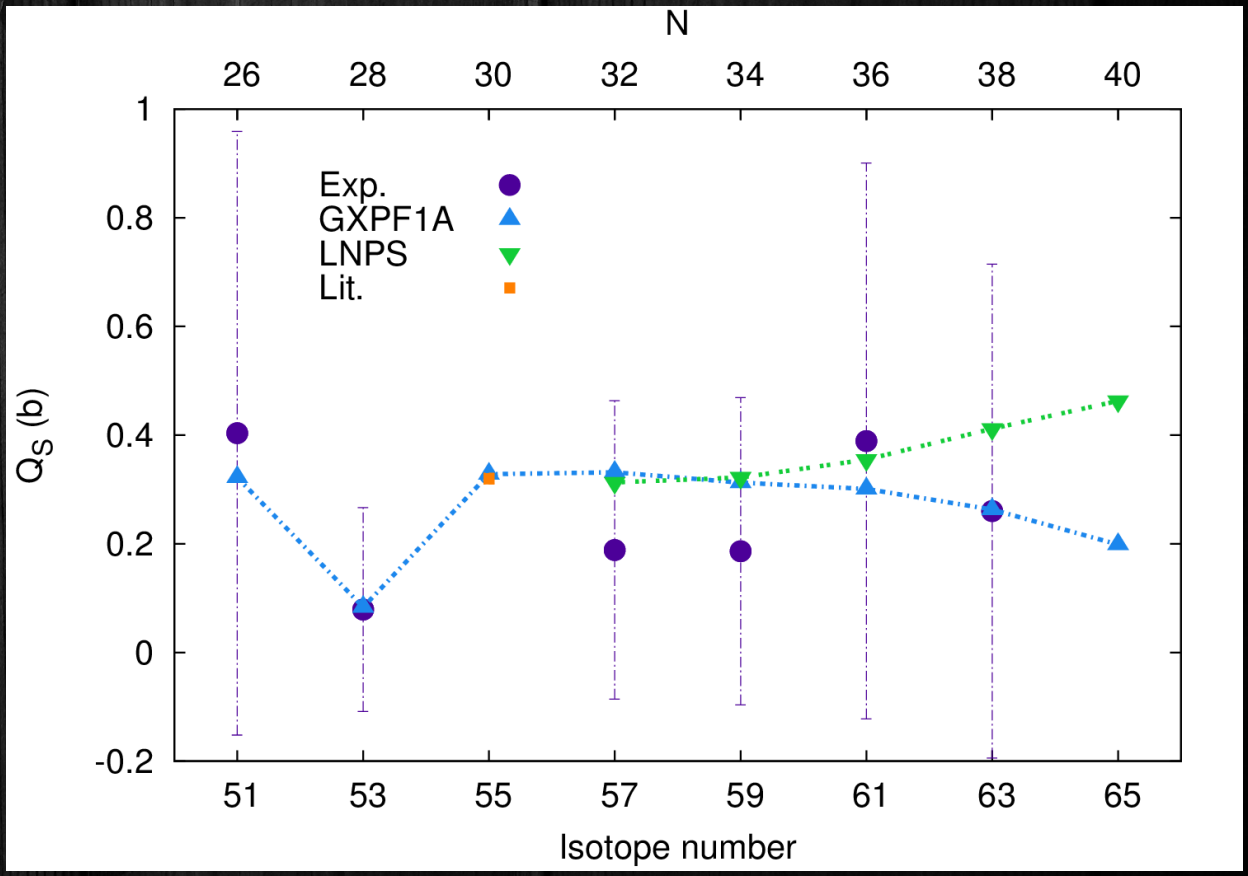


- Comparison of extracted g-factors (g = μ / I) to theory gives us insight into nuclear structure in this region

Atomic Mn Results

- No quadrupole moments extracted due to the transition used → we need a different transition

Ionic transition from an optically pumped state will provide measurable quadrupole moments



88Sr Results

- Measured the effect of OP vs various parameters, like cooling time, laser power and wavelength