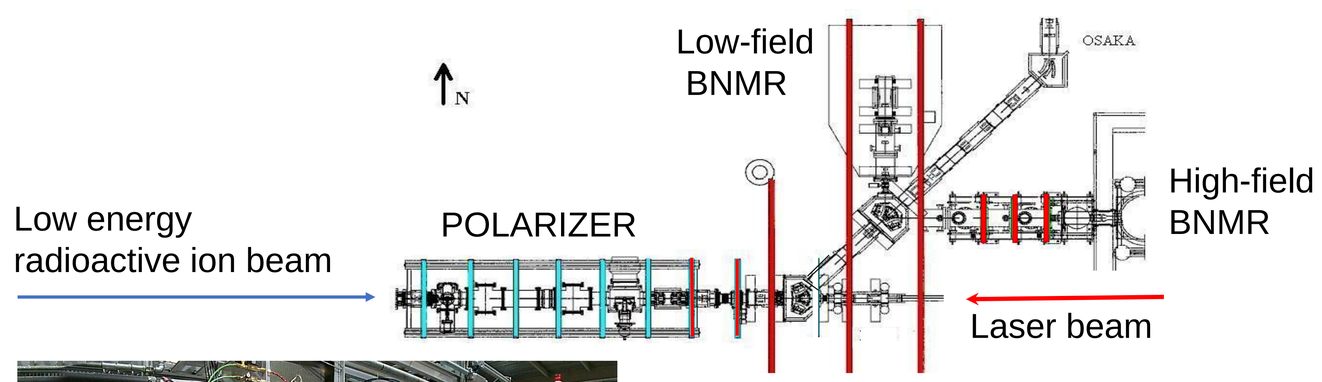
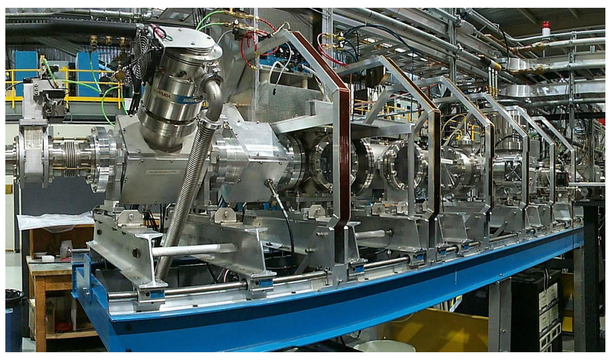
Laser nuclear polarization of radioactive isotopes at TRIUMF

Ruohong Li [a, b], C. D. Phil Levy [a], Matt Pearson [a], Rob F. Kiefl [a], Gerald D. Morris [a] and Jens Lassen [a,c]

[a] TRIUMF, Vancouver BC, Canada, V6T 2A3 [b] University of Windsor, Windsor, ON, Canada, N9B 3P4 [c] University of Manitoba, Winnipeg MB, Canada, R3T 2N2

NUCLEAR POLARIZATION FACILITY



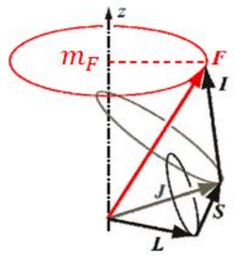


Motivation: provide hyperpolarized (polarization up to 80%) radioactive nuclei for beta nuclear magnetic resonance (BNMR) spectroscopy and nuclear structure study.

Method: collinear optical pumping

Nuclear-polarized beams: ^{8}Li, ^{31}Mg+ etc.

OPTICAL PUMPING

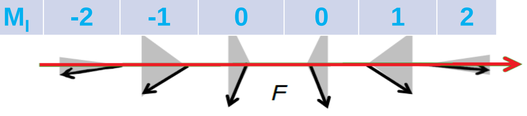


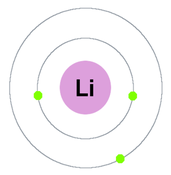
Total angular momentum of atom:
$\vec{F} = \vec{I}$ **(nuclear spin angular momentum)+**$\vec{J}$**(electron total angular momentum), where** $\vec{J} = \vec{L}$ **(electron orbital angular momentum)+**$\vec{S}$ **(electron spin angular momentum)**

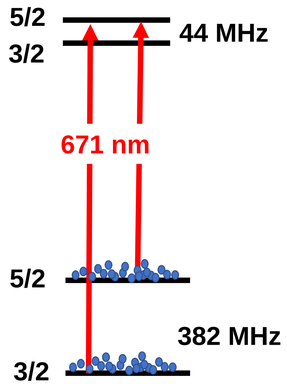
J=1/2

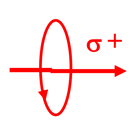
^{8}Li: nuclear spin I=2

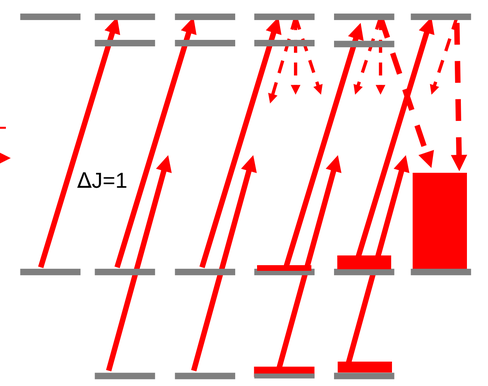
M_J	-1/2	1/2	-1/2	1/2	-1/2	1/2
M_I	-2	-1	0	0	1	2



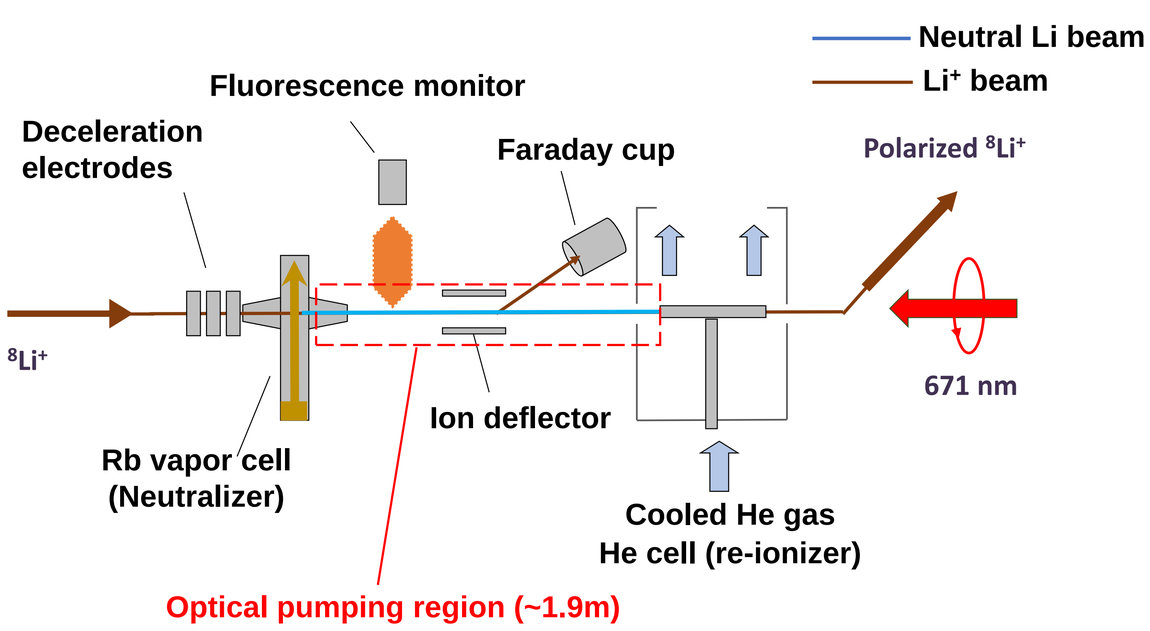


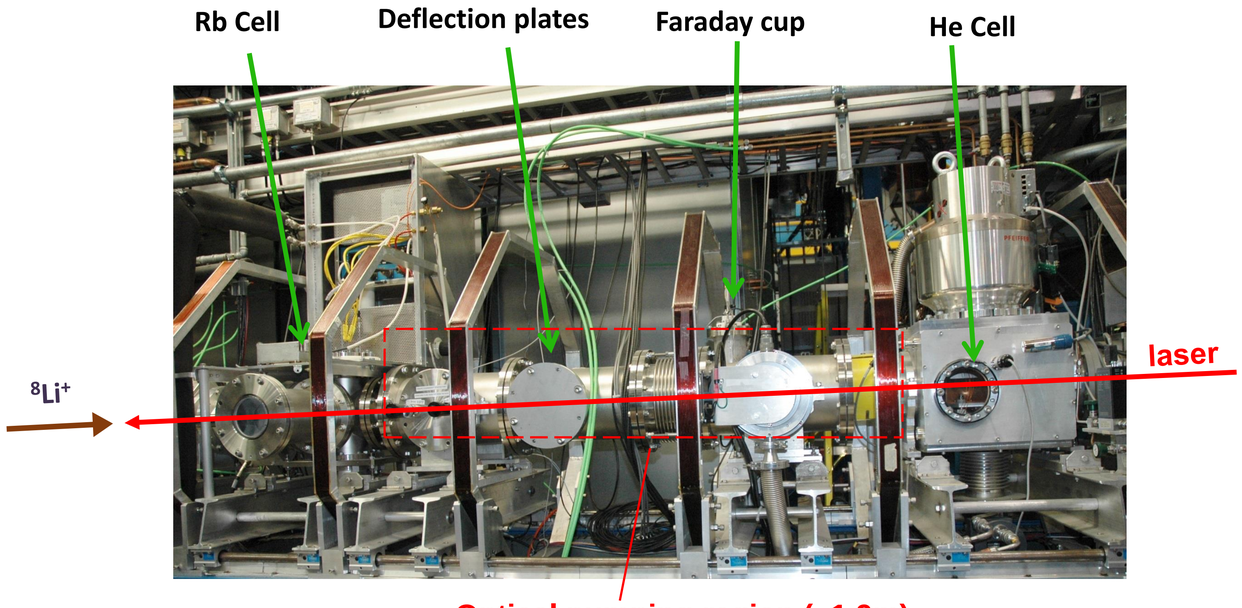




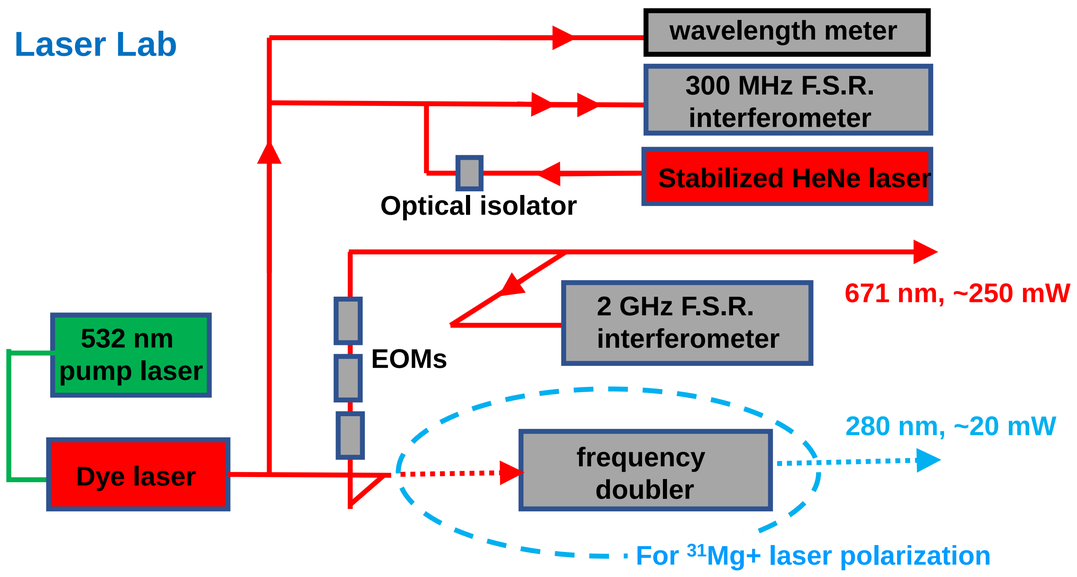


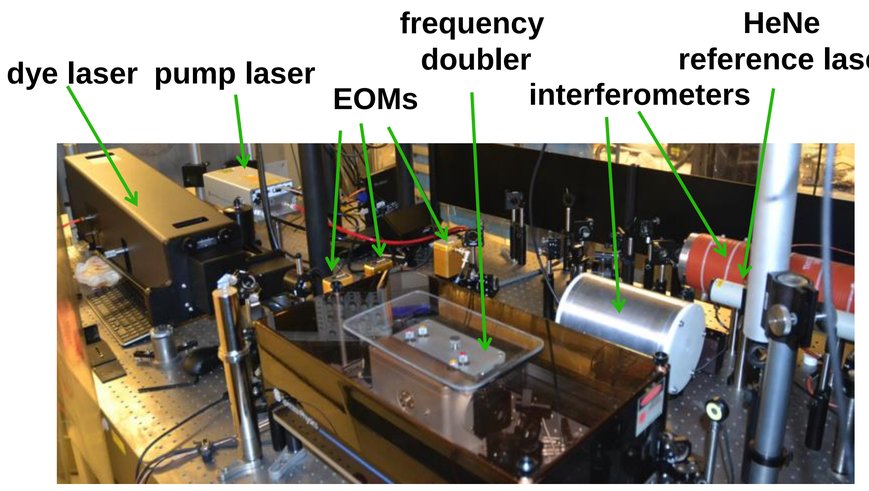
BEAMLINE CONGIGURATION

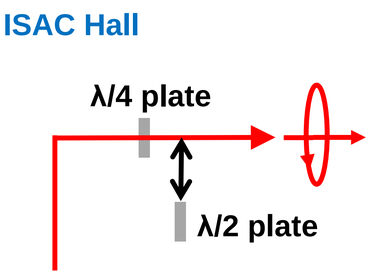


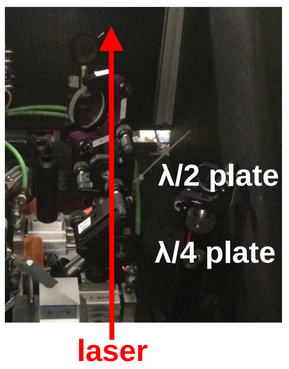


LASER SETUP





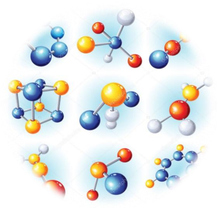




- ❑ Use 381 MHz EOM to generate frequency sidebands to pump both hyperfine ground states
- ❑ Use 19 MHz and 28 MHz EOMs to generate multiple frequency sidebands, therefore expand the laser bandwidth to ~100MHz to match with absorption profile linewdith.
- ❑ Lock the dye laser to a stabilized HeNe laser via a 300 MHz free-spectral-range interferometer temperature stabilized to 0.1 °C.

APPLICATIONS

Since its first commissioning in 2000, the polarizer has been routinely providing ^{8}Li, ^{9}Li and ^{31}Mg+ to β-NMR and β-NQR(magnetic quadrupole resonance) stations for the studies of material science and molecular science. But it also provides polarized beams to:

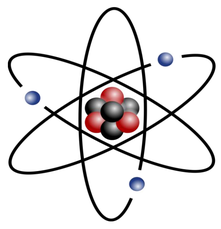


Material science

Investigate the magnetic and electronic properties of ultrathin films, nanostructures and interface properties of new materials, such as superconductors, quantum material and battery membranes with depth and spatial resolution

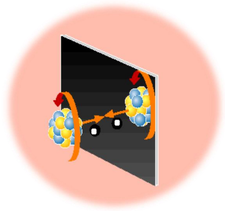
Life science

Apply β-NMR in aqueous environment to study the function of essential metal ions such as Mg or Cu in biophysical system. Study of Ac complexes in mimic biophysical environments to develop ^{225}Ac-based radiopharmaceuticals for cancer treatments



Nuclear science

Study of the nuclear structure by observing the nuclear decays. The polarization properties of parent-nuclei generated by the polarizer facility can help to distinguish the spins and parities of daughter-nuclei states.



Fundamental symmetries

β-decay, which is governed by weak interactions, is an ideal probe to study fundamental symmetries. For example: search for time reversal symmetry violation by measuring transverse polarization of β-decay from ^{8}Li

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