Boron-8 production at the ATLAS SCS facility

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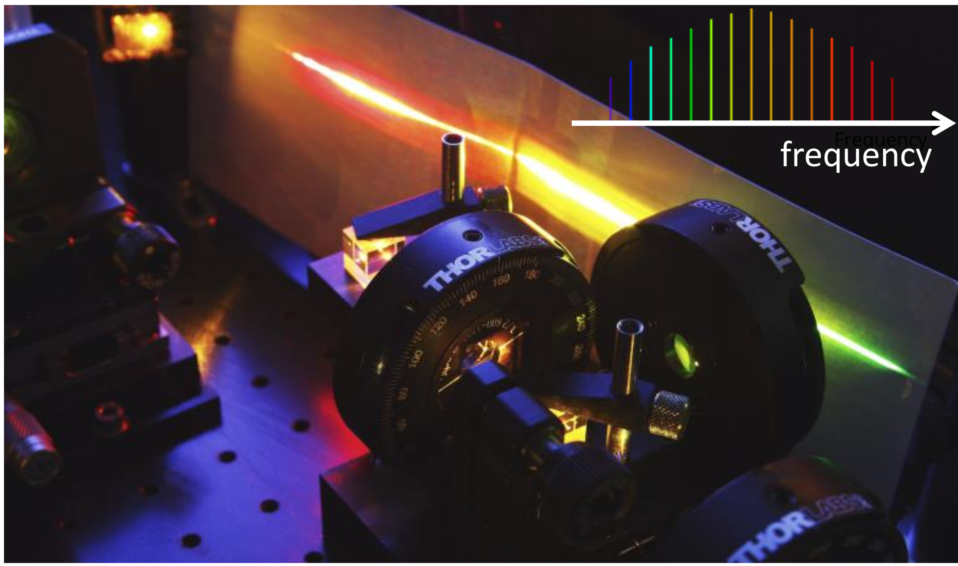

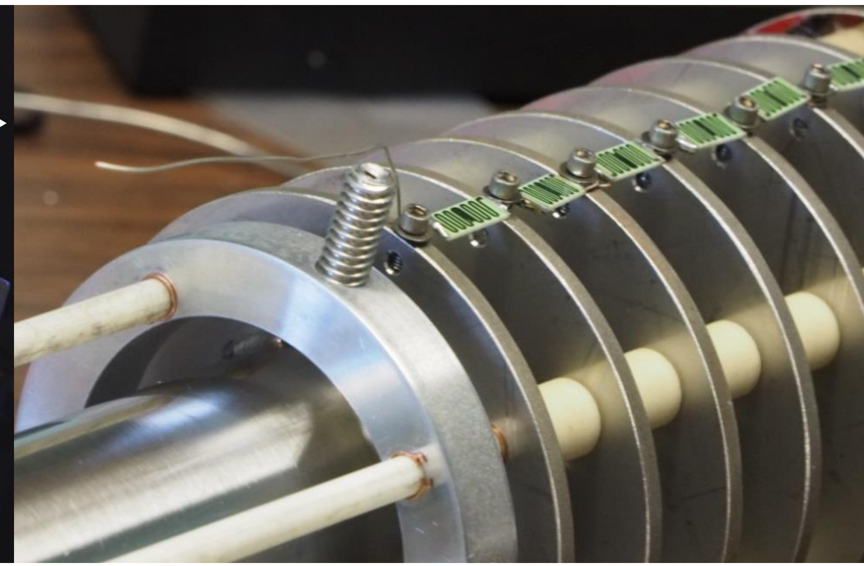

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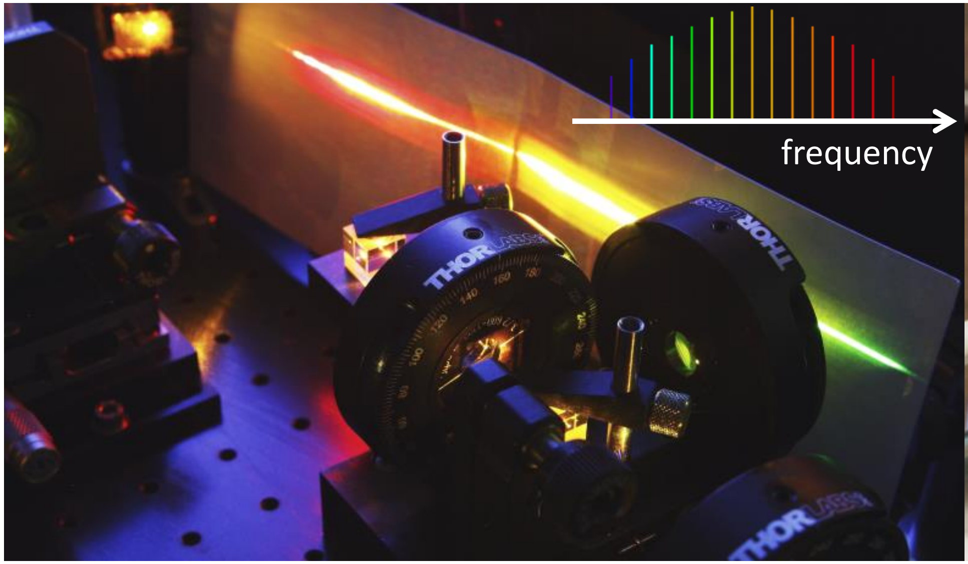

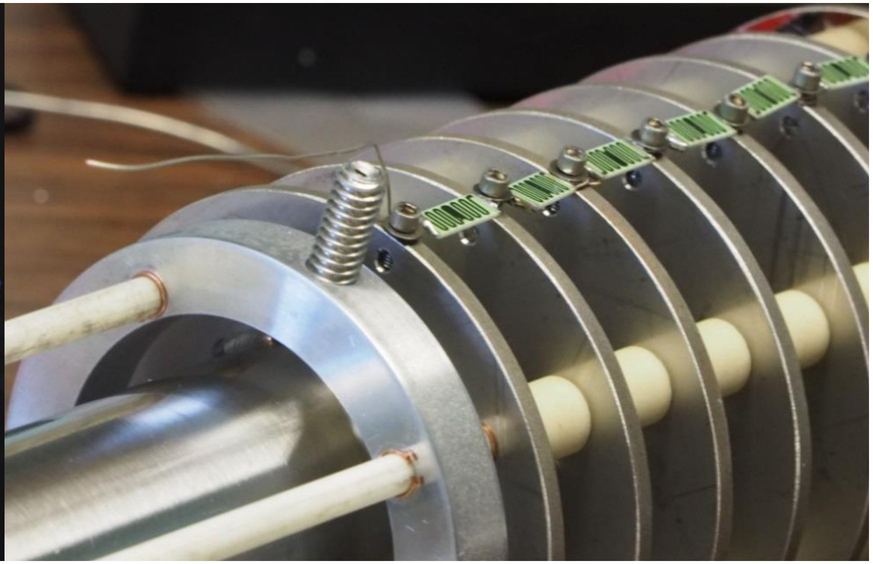

- What do we need high precision for?
- Boron-8 Production and molecular breakup
- Offline Production
- Status and Outlook

High precision Laser Spectroscopy

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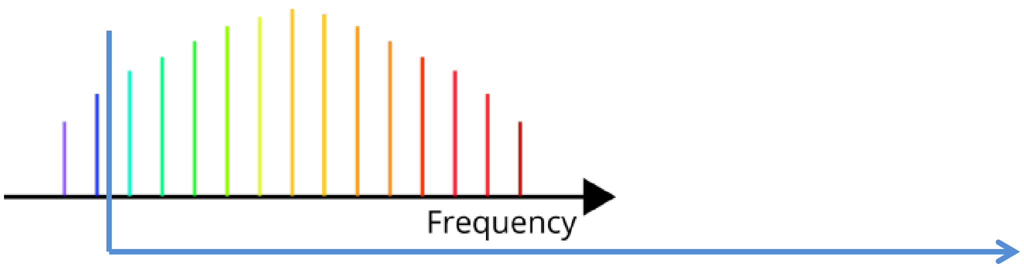
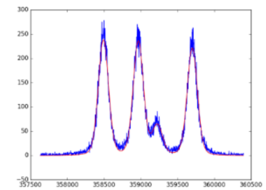
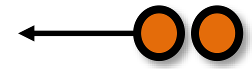


Stabilization of narrow-band cw-Laser
→exact (sub-MHz frequency determination)



optical spectra
→ FS
→ HFS



Velocity (Doppler shift!)

"Hidden Secrets" in optical spectra /HFS:
Nuclear Structure
e.g.: Number of Peaks ~ Nuclear Spin I

+ contribution which links frequency shift and mean-squared nuclear charge radius

Typical frequencies	
optical transition:	1.000.000.000 MHz
fine structure:	1.000.000 MHz
hyperfine structure:	100 MHz

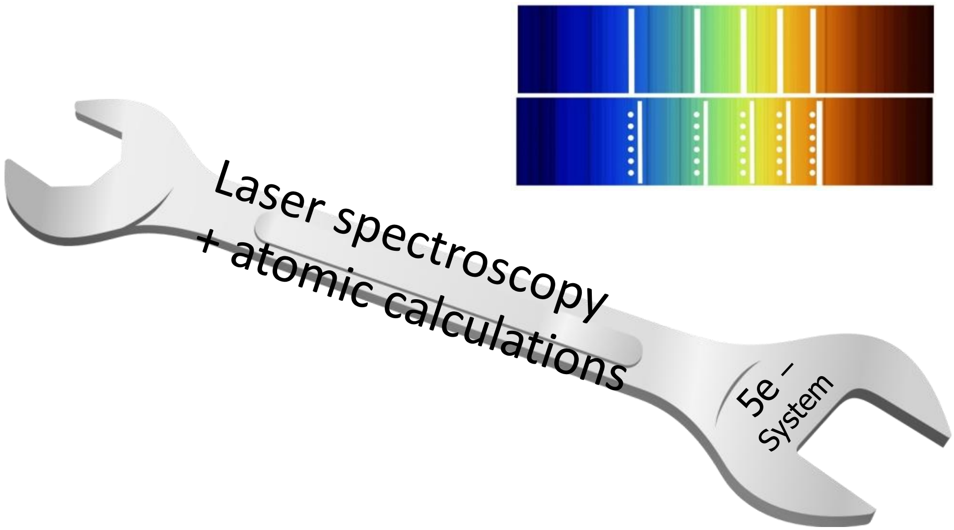
Atomic shell: 10^{-10} m / Nucleus: 10^{-15} m

Extracting the nuclear charge radius

...from **Isotope Shift** measurements!

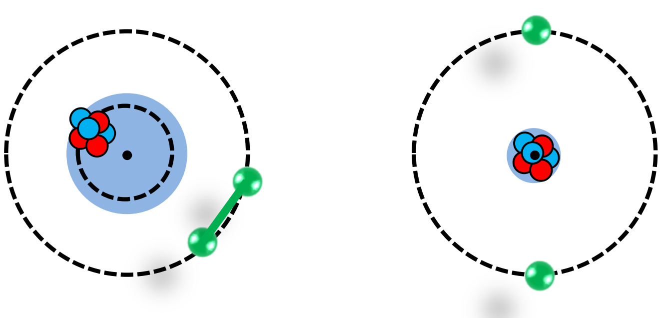
$$\delta\nu_{IS} = \delta\nu_{NMS} + \delta\nu_{SMS} + \delta\nu_{FS}$$

n x e – correlated
wave function

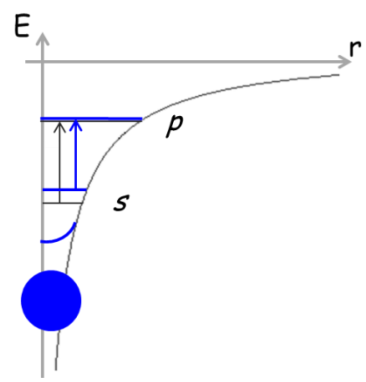


$$\delta\nu_{FS} = F_{el}\delta\langle r_c{}^2\rangle$$

mass shift: nuclear motion around center of mass



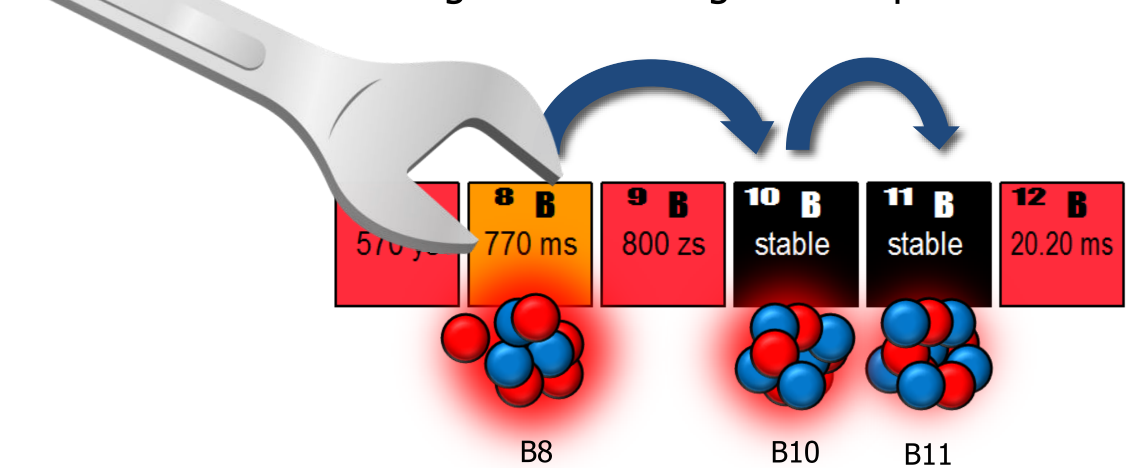
field shift: finite size of the nucleus



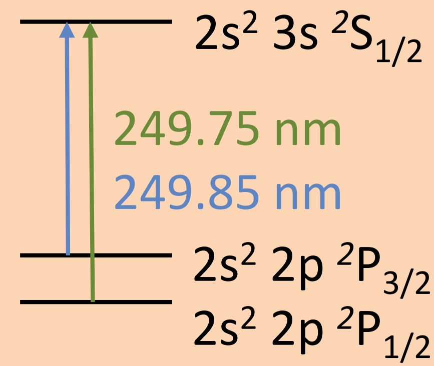
A tool to extract the change in mean-squared nuclear charge radius along an isotopic chain

Boron-8 – a proton halo candidate

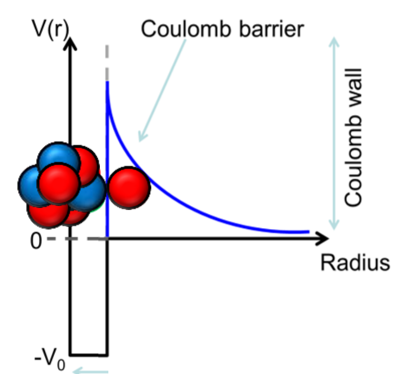
Measurement: Change in mean-squared nuclear charge radius along an isotopic chain



Atomic Boron-8 ground state transition



+ SMS calculations



Halo nuclei:

Large quadrupole moment	~r^2	✓
Nucleon in p-shell		✓
Low binding energy		✓ (137 keV)
Increased nuclear charge radius		?

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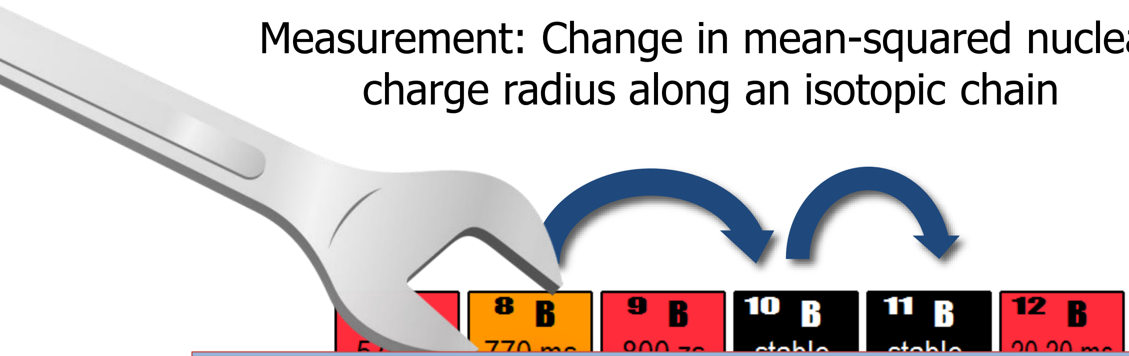
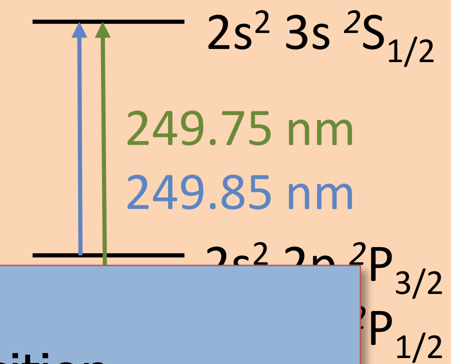
Boron-8 – a proton halo candidate

Measurement: Change in mean-squared nuclear charge radius along an isotopic chain



Atomic Boron-8 ground state transition



Short Summary:

- Use f-comb to measure $^{8,10,11}B^{0+}$ IS in p-s transition
- Extract change in nuclear charge radius along that isotopic chain
- Use known (→measurements at S-DALINAC) stable ^{11}B NCR to confirm proton halo character

Halo nu

Large q

Nucleo

Low bi

Increased nuclear charge radius **?**

Boron-8 – a proton halo candidate

Online Source of (atomic) B8

Offline Source of (atomic) B10, B11

Comb-stabilized laser system @ 250nm

Atomic Boron-8 ground ...ansition

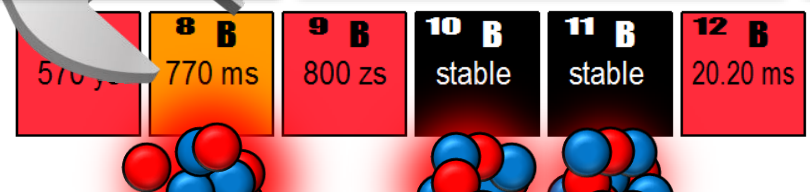
...s^2 3s $^2S_{1/2}$

...75 nm

249.85 nm

2s^2 2p $^2P_{3/2}$

2s^2 2p $^2P_{1/2}$



Laser Spectroscopy setup

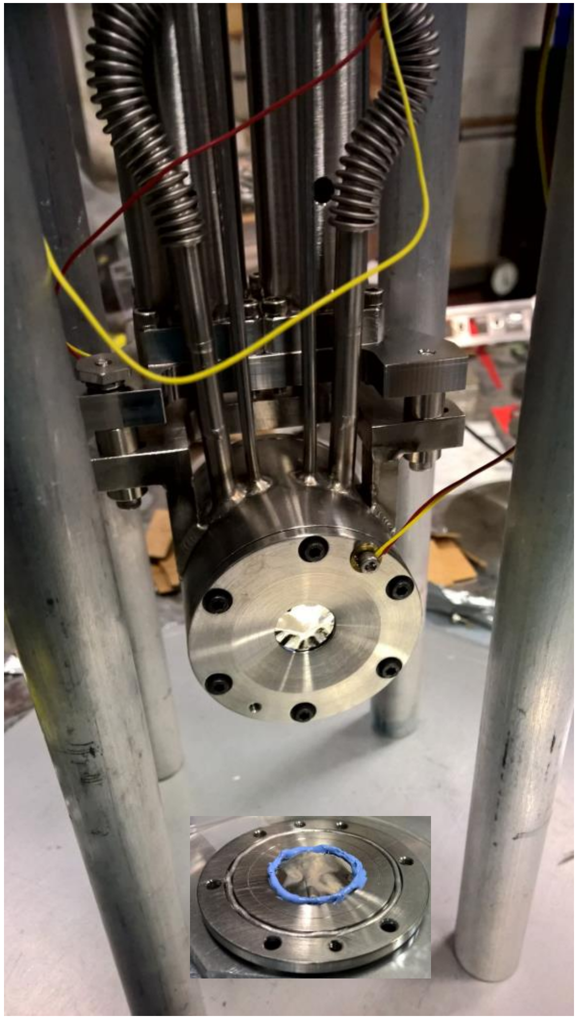
Verified 5e- calculations

SMS calculations

Halo nuclei:

Large quadrupole moment	✓
Nucleon in p-shell	✓
Low binding energy	✓ (137 keV)
Increased nuclear charge radius	?

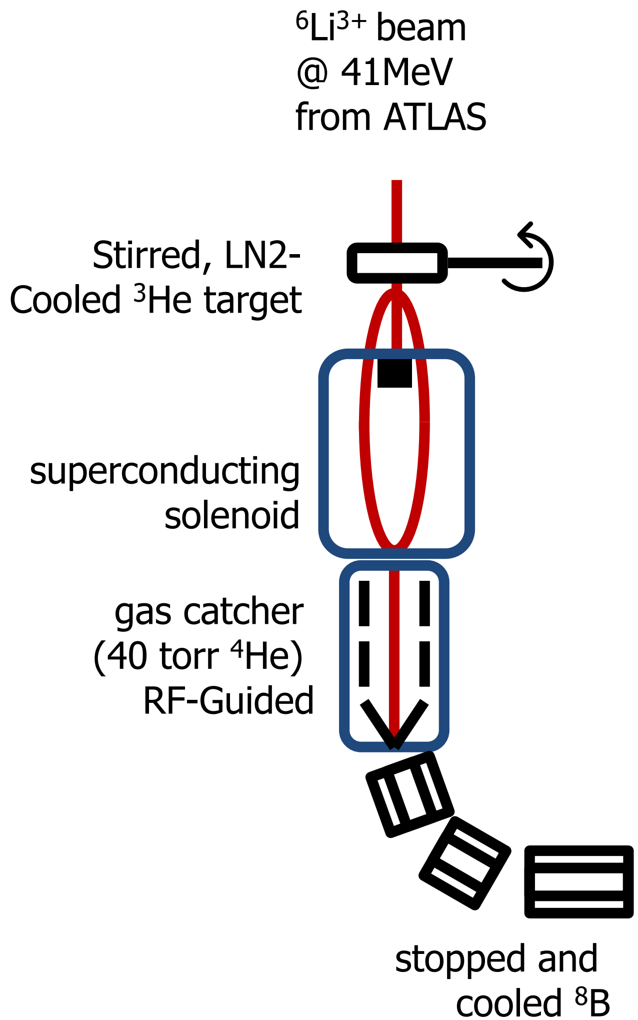
Boron-8 production scheme



Production mechanism:
$^{6}Li(^{3}He,n)^{8}B$

Beamtimes in 2017:

- Investigate saturation effects from target and gas catcher
- Test fan
- Implement molecule breakup (ongoing)



Boron-8 production

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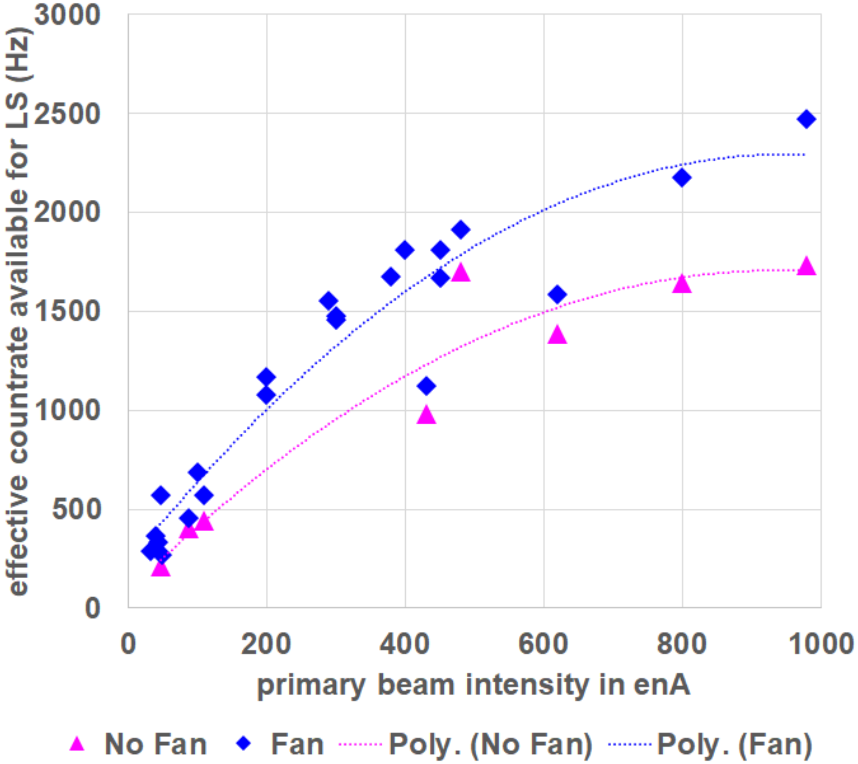
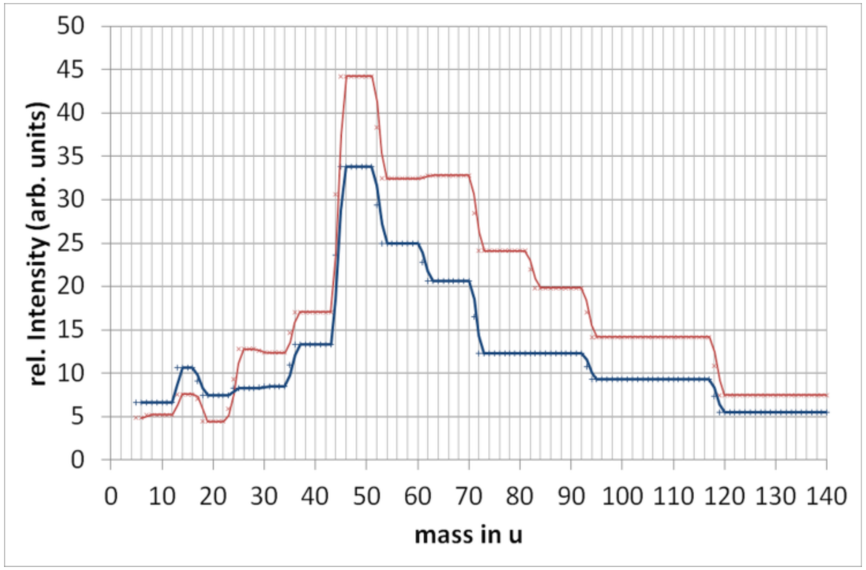
Production runs with and w/o fan



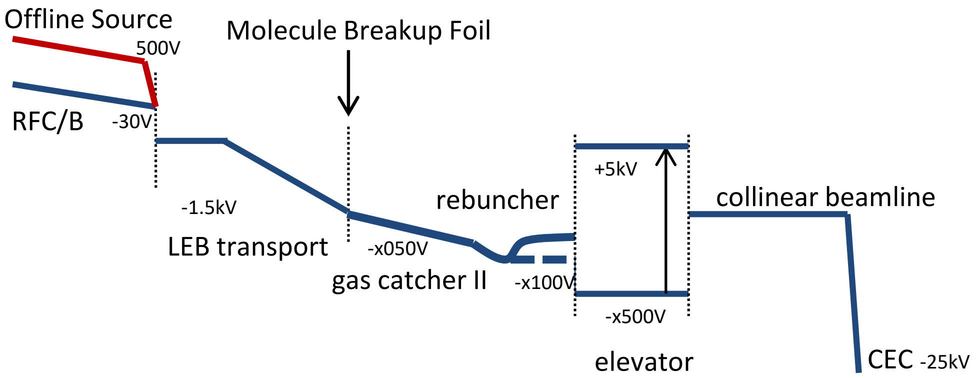
Production rates sufficient for laser spectroscopy…

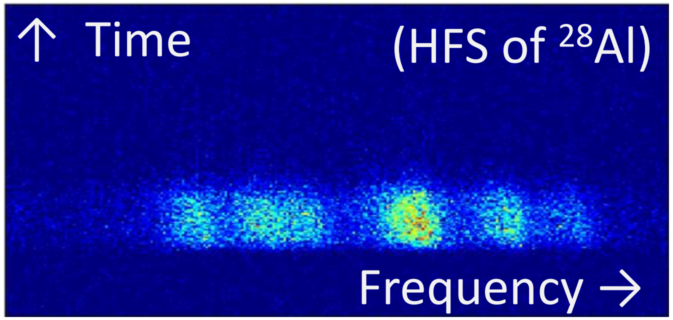
Molecule formation in the gas catcher



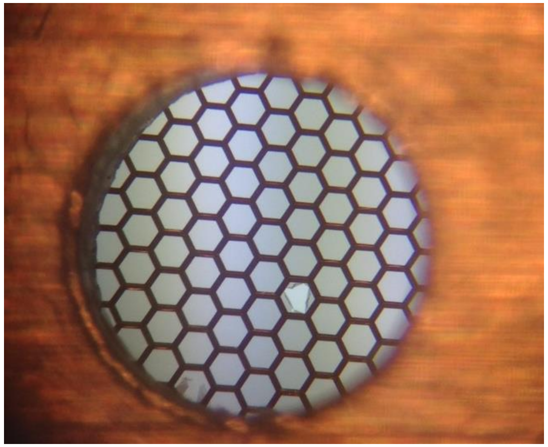
… but only in molecular form

Breakup and Rebuncher



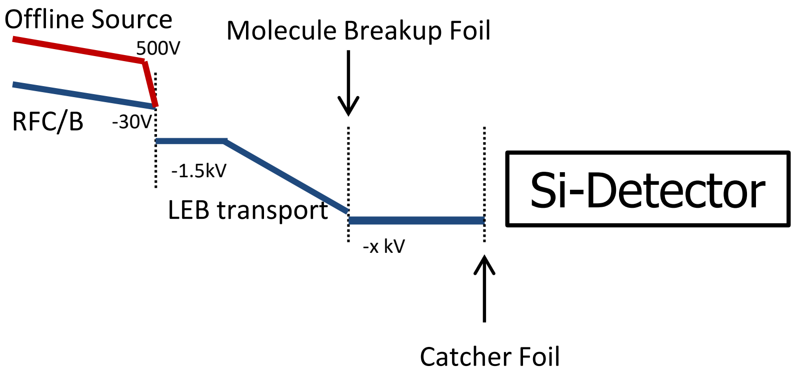


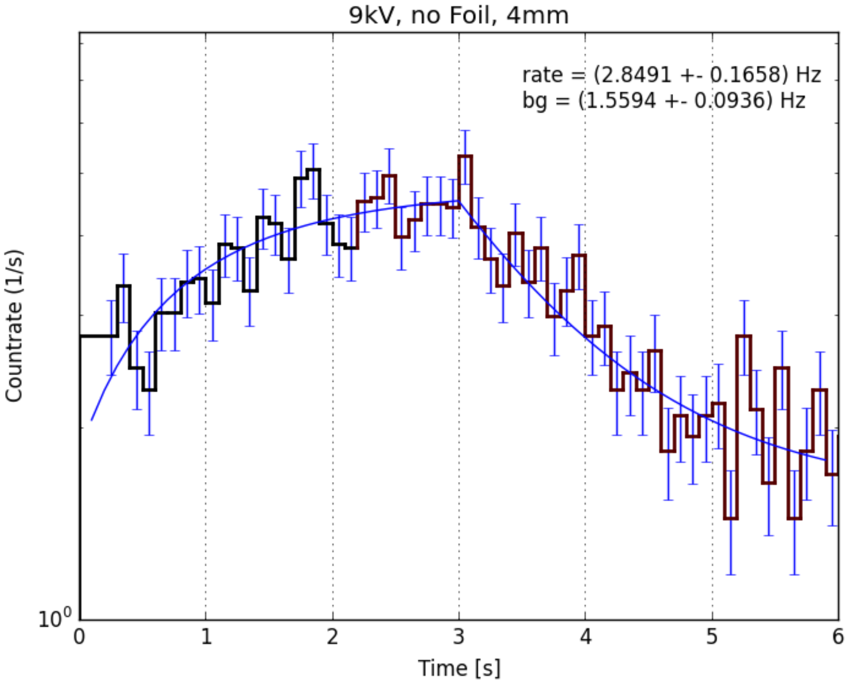
"Breakup" foils (originally for electron microscopy). Thickness ~3-4nm

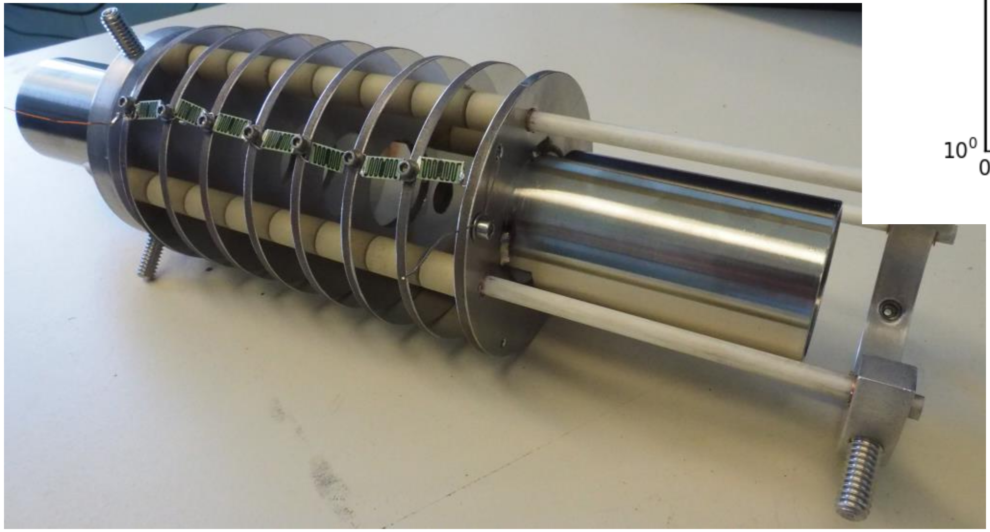


- Break up molecules in ulta-thin carbon foils
- Use bunched beam for Laser Spectroscopy

Molecule Breakup Section

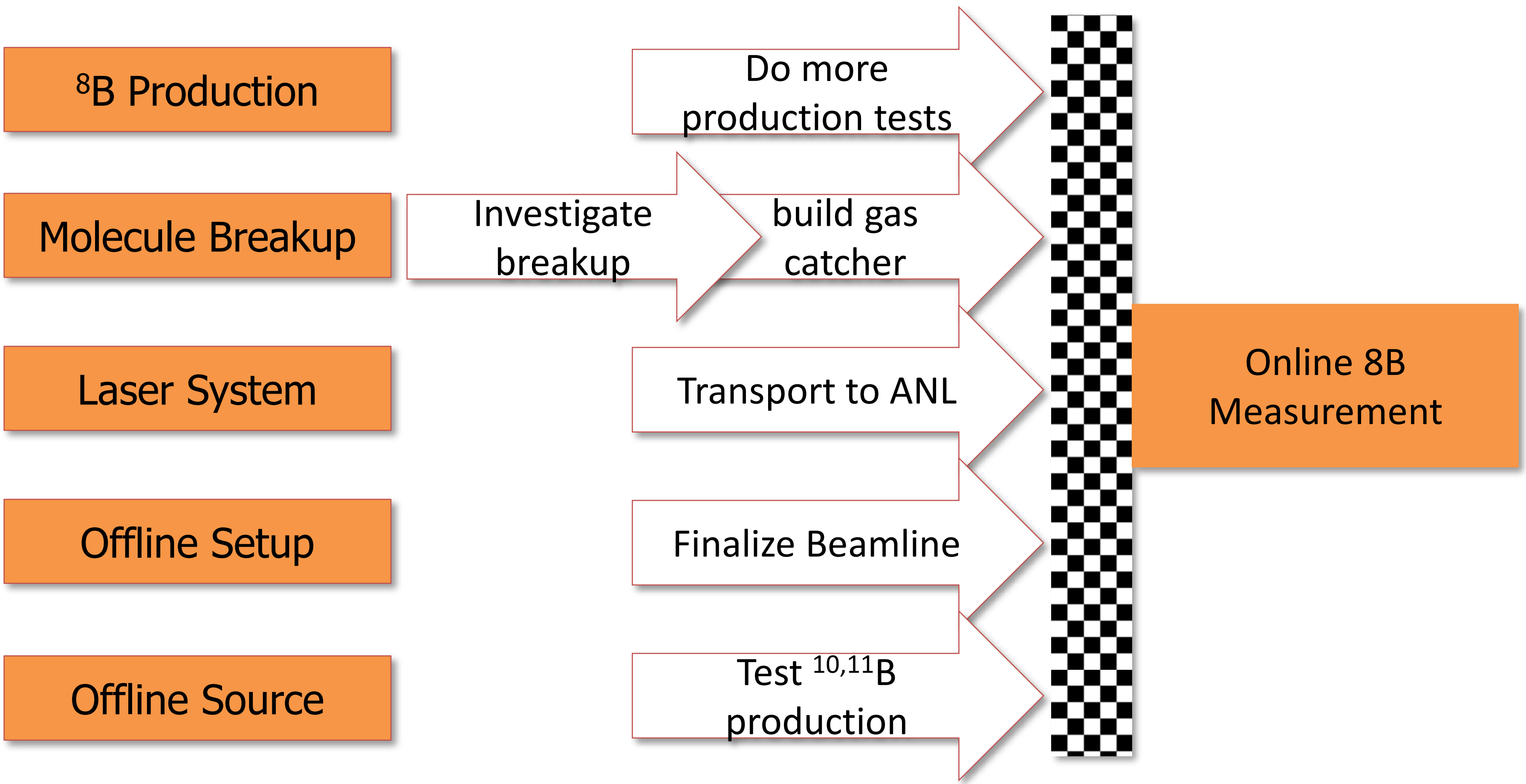






- Some indications for breakup at 9kV – statistics low
- Next run with improved setup: in two weeks

Status and Outlook



Thank you for your attention!

The LaserSpHERe Group
in collaboration with the ANL Physics Division

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