A route towards the nuclear charge radius of ^{8}B

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Outline

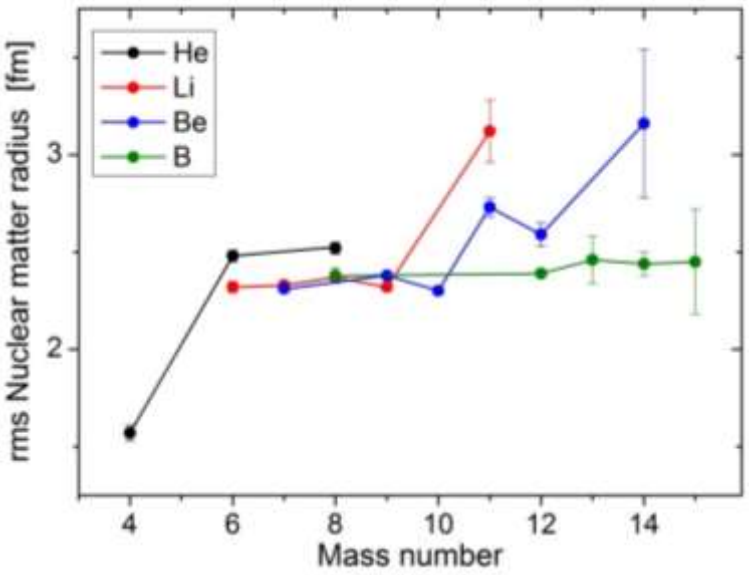
1 - Why 8-boron? → candidate for proton halo

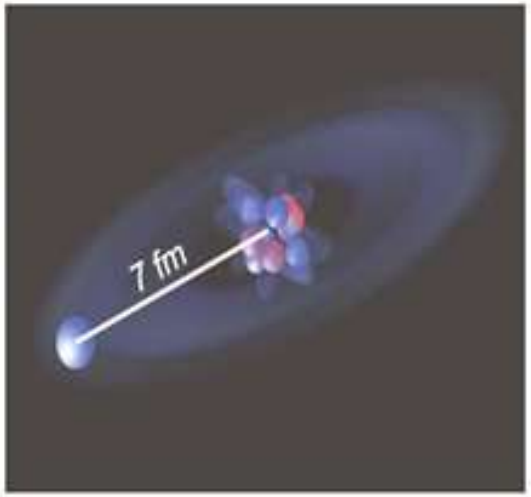
2 - Experimental approach → isotope shift measurement via collinear/anticollinear laser spectroscopy

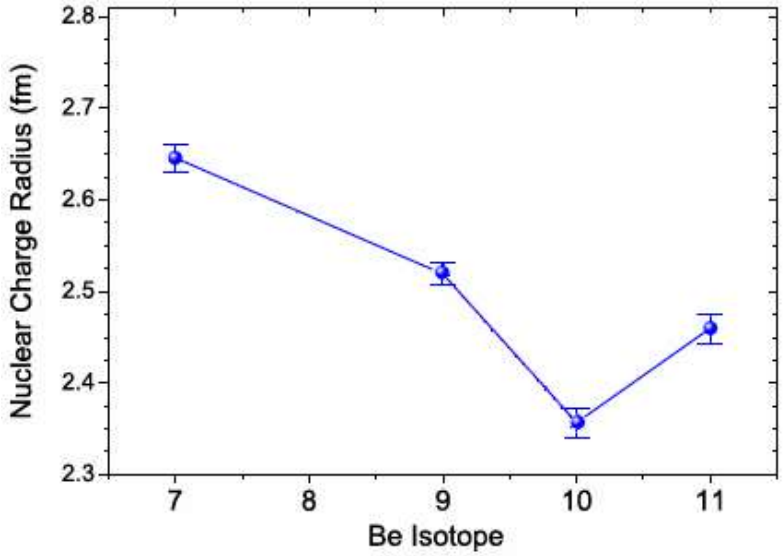
3 – Status of the project

→ warm-up phase

Halo nuclei

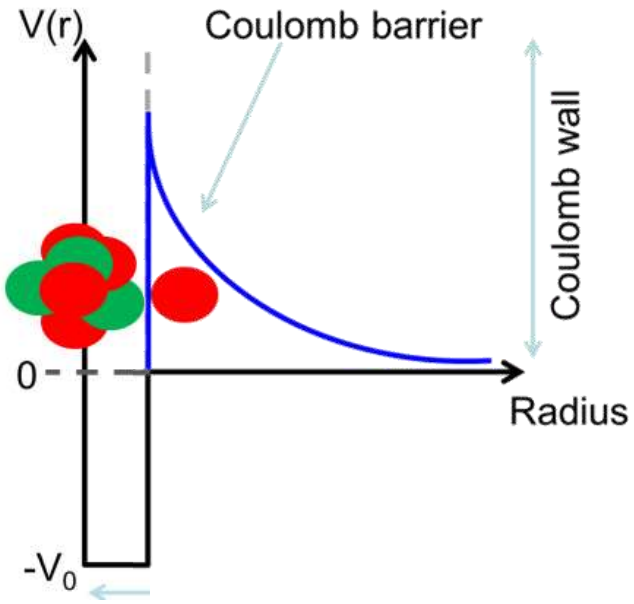


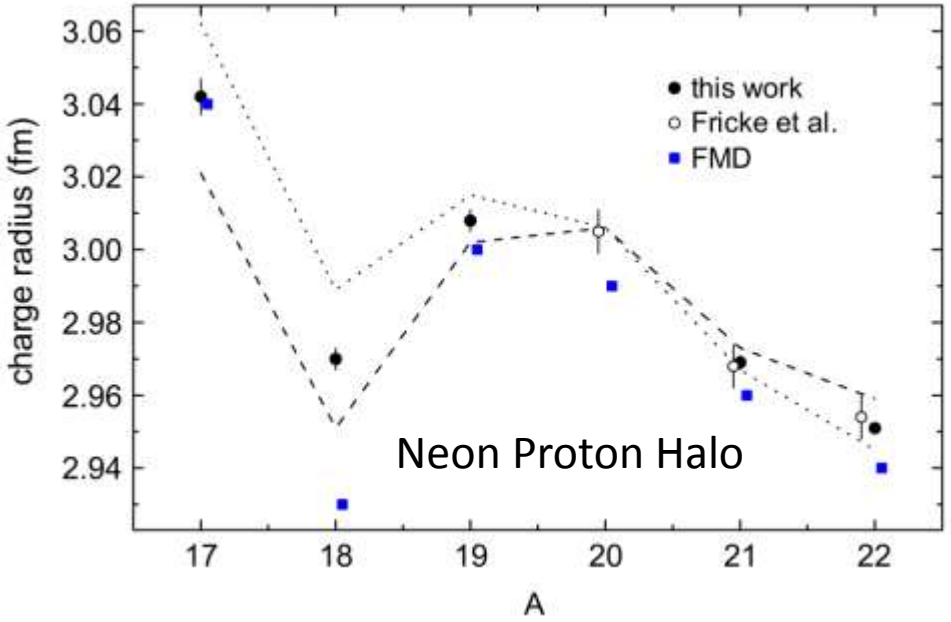




W. Nörtershäuser *et al.*, PRL **102**, 062503 (2009)

Proton Halo Nuclei





W. Geithner *et al.*, PRL **101**, 252502 (2008)

The Boron-8 Proton Halo

VOLUME 69, NUMBER 14 PHYSICAL REVIEW LETTERS 5 OCTOBER 1992

Proton Halo of ^{8}B Disclosed by Its Giant Quadrupole Moment

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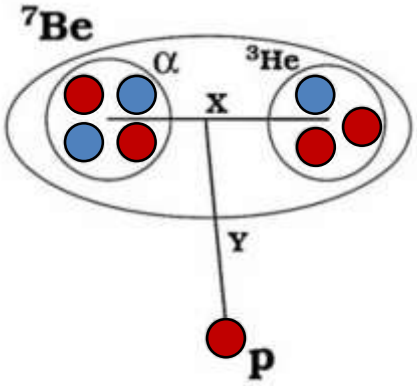
(Received 29 May 1992)

The quadrupole moment of the ^{8}B ($I^\pi = 2^+$, $T_{1/2} = 769$ msec) nucleus was measured as $|Q(^8\mathrm{B})| = 68.3 \pm 2.1$ mb by use of modified β-NMR. This value is twice as large as the prediction of the Cohen-Kurath shell model. It is found by subtracting the contribution of deeply bound neutrons that the protons in ^{8}B carry more than 90% of the observed moment. The anomalous value is accounted for fairly well by the proton halo due to the loosely bound valence configuration. This is the first experimental evidence for the existence of a proton halo covering a neutron core.

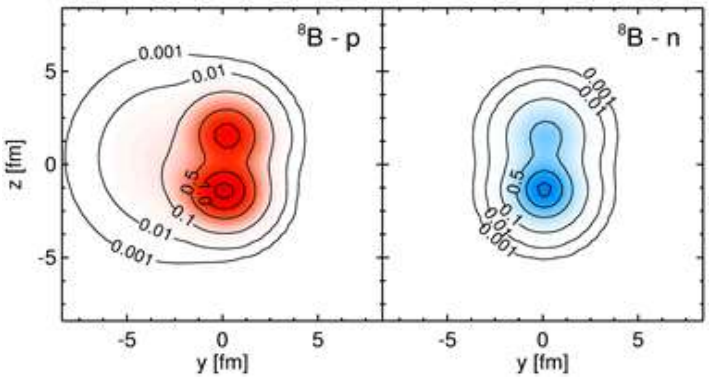
PACS numbers: 21.10.Ky, 21.10.Ft, 27.20.+n

Nuclear properties that depend upon isospin will be enhanced and clearly observed in high isospin states, i.e., in those nuclei located near the proton and neutron drip lines in the mass chart. One of the peculiar observables

detection of the quadrupole effects in the β-NMR of such unstable nuclei with a nuclear lifetime of about 1 sec is usually very difficult, and time consuming, because of the



M.H. Smedberg *et al.*, Physics Letters B 452 1999 1–7



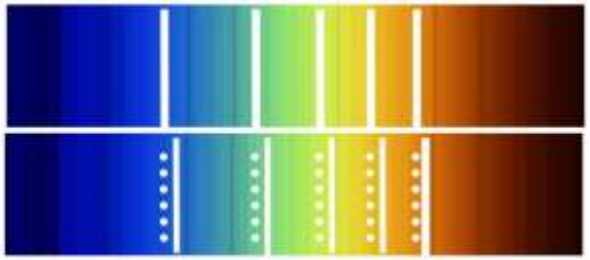
FMD Model calculation (T. Neff, GSI)

RMS charge radii

dr = 0.4 fm

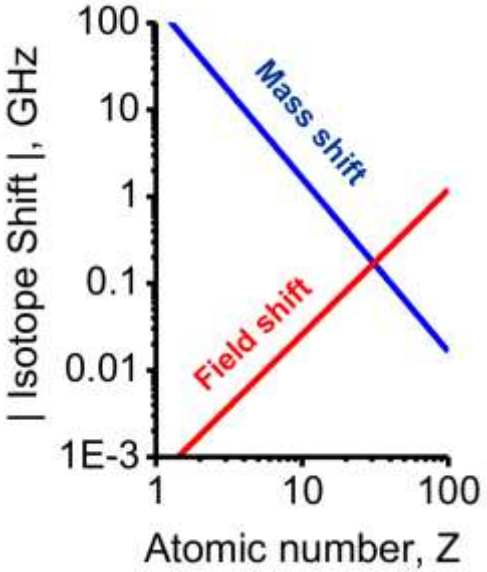
d(r²) = 2 fm²

Isotope Shift Measurement



Measure the line shifts between two isotopes

e.g. ^{8}B and ^{11}B



$$\delta\nu_{IS} = \delta\nu_{MS} + \delta\nu_{FS}$$

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

Theory: Accuracy of ~100kHz

$$\delta\nu_{MS} \approx 35\ GHz$$
$$\delta\nu_{FS} \approx 10\ \mathrm{MHz/fm^2}$$

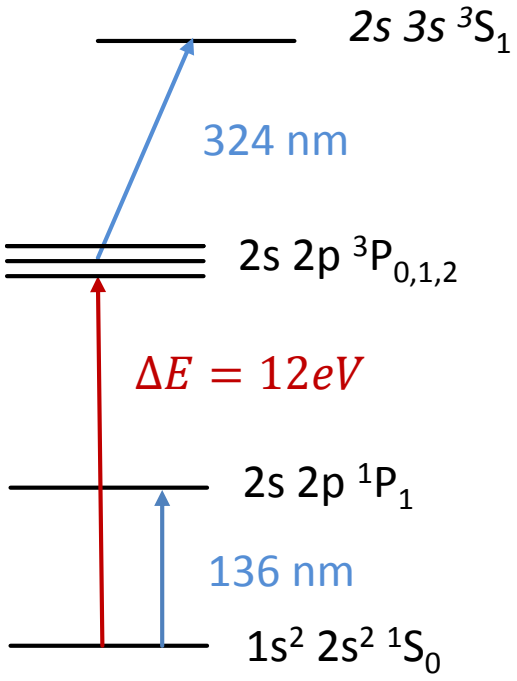
$$R_c(\,^{8}\mathrm{B}) = \sqrt{R_c{}^2\,(^{11}\mathrm{B}) + \delta\langle r_c{}^2\rangle^{11,8}}$$

What we need now:

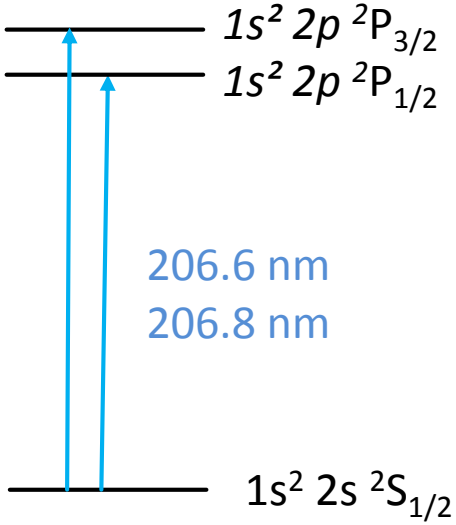
- suitable transitions in boron
- boron source
- laser spectroscopy

Suitable Transitions in Boron^{x+}

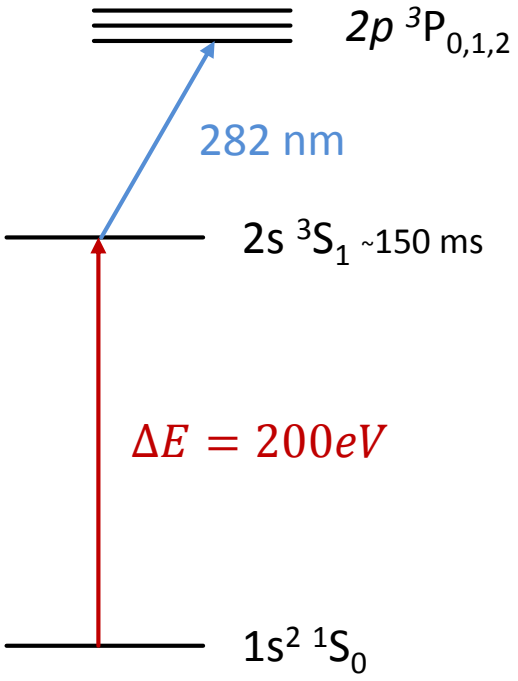
B^{+}: $4e^{-}$
Be-Like



B^{2+}: $3e^{-}$
Li -Like



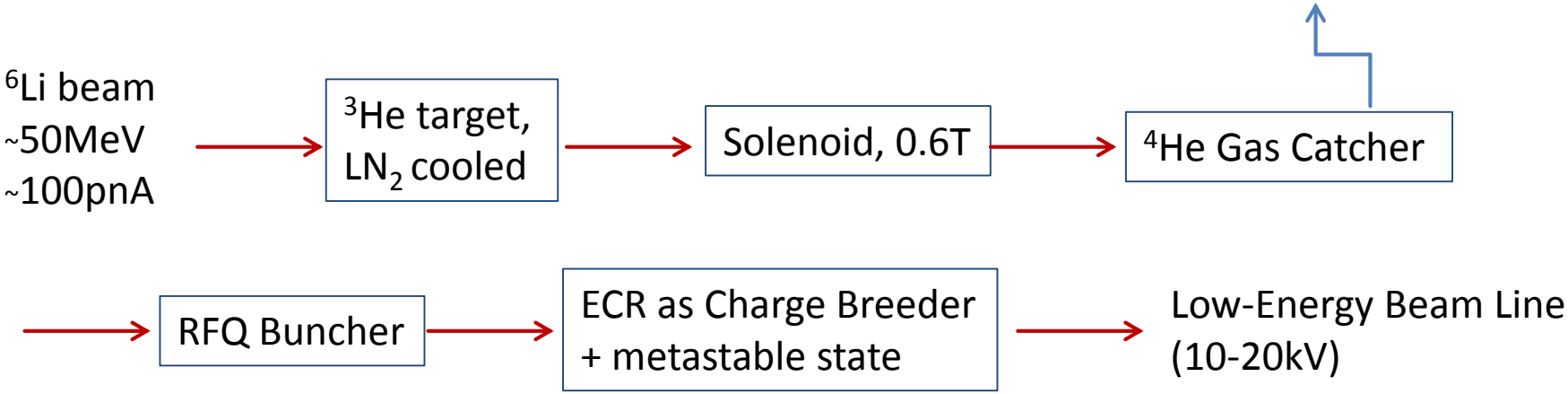
B^{3+}: $2e^{-}$
He-Like



A 8-Boron 3+ Source

In-flight-production: $^{6}Li(^{3}He,n)^{8}B$
at ATLAS / ANL

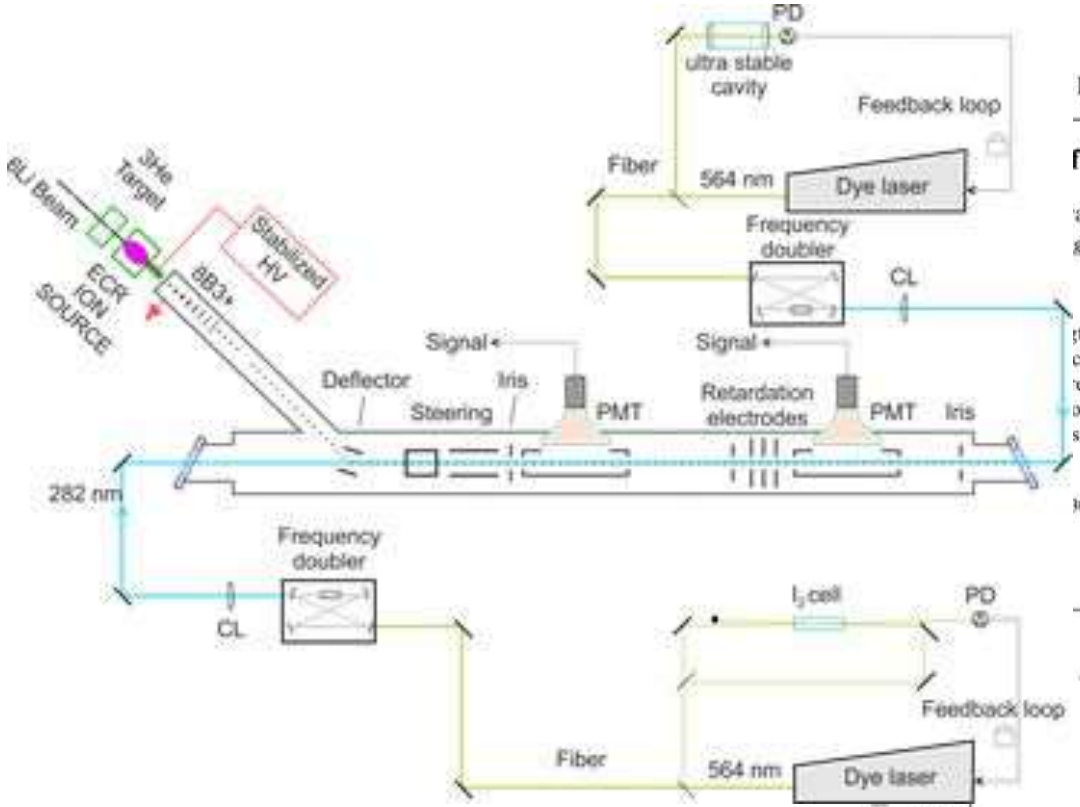
8-Boron yield:
1c/(s ppA)
*1pμA ATLAS max. Intensity
= 10^{6} 8B /s

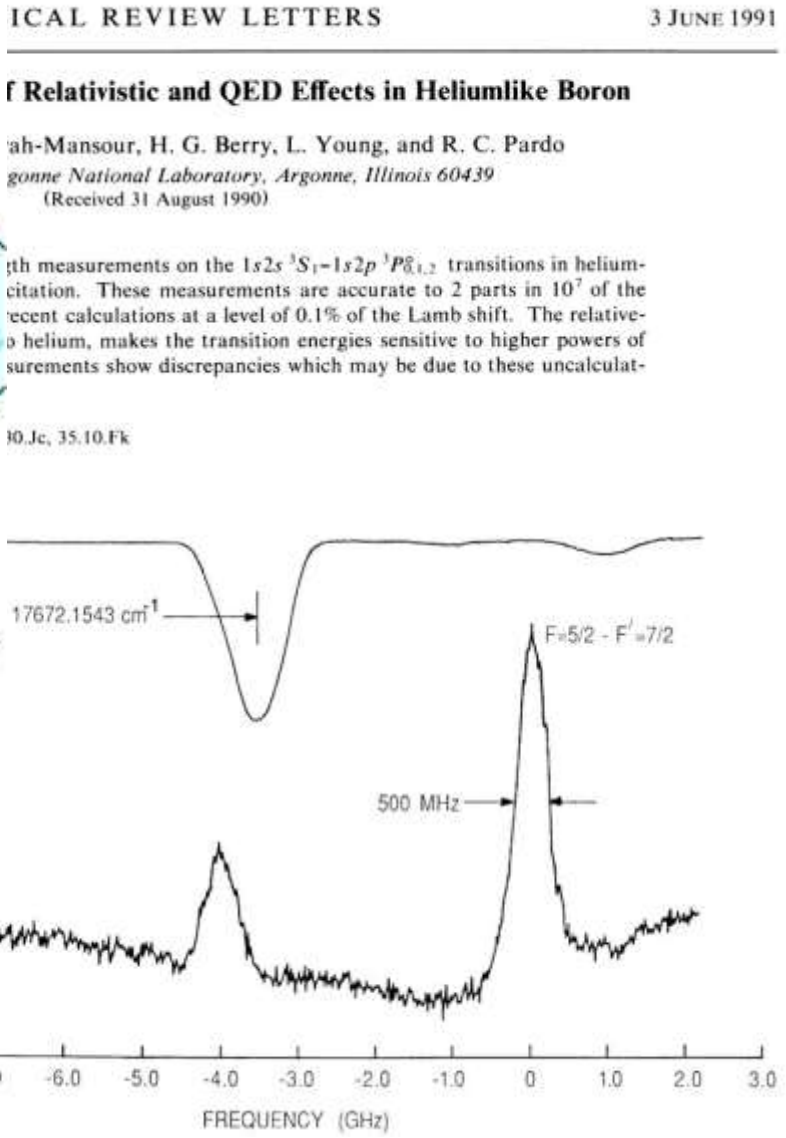


this process has already been performed – „ready to use“

Charge breeding in an ECR ion source:
suitable as offline-test-stand / ^{11}B reference measurement

The Spectroscopic Beam Line





ICAL REVIEW LETTERS 3 JUNE 1991

f Relativistic and QED Effects in Heliumlike Boron

ah-Mansour, H. G. Berry, L. Young, and R. C. Pardo

gonne National Laboratory, Argonne, Illinois 60439

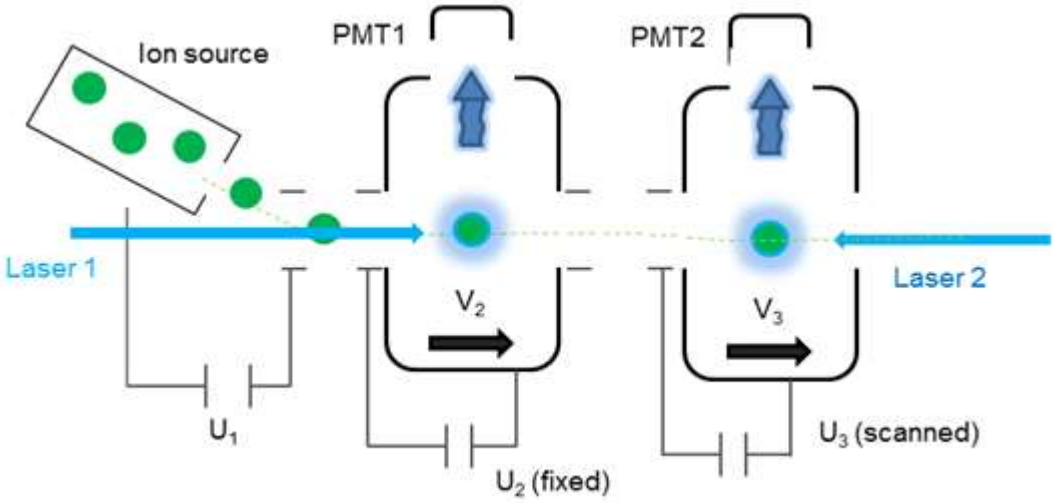
(Received 31 August 1990)

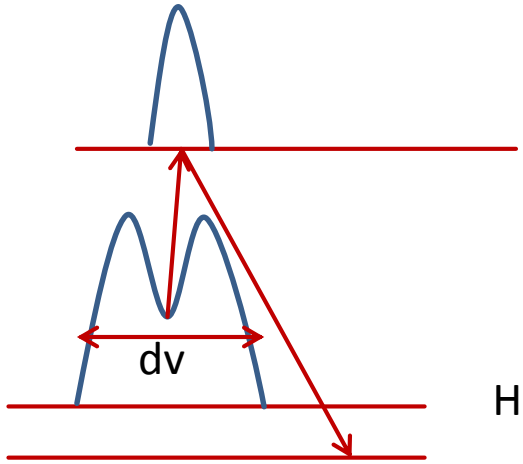
gth measurements on the $1s2s\ ^3S_1$–$1s2p\ ^3P^0_{1,2}$ transitions in helium-citation. These measurements are accurate to 2 parts in 10^7 of the ecent calculations at a level of 0.1% of the Lamb shift. The relative-o helium, makes the transition energies sensitive to higher powers of surements show discrepancies which may be due to these uncalculat-

30.Jc, 35.10.Fk

collinear/anticollinear geometry:
„pump-and probe“ technique

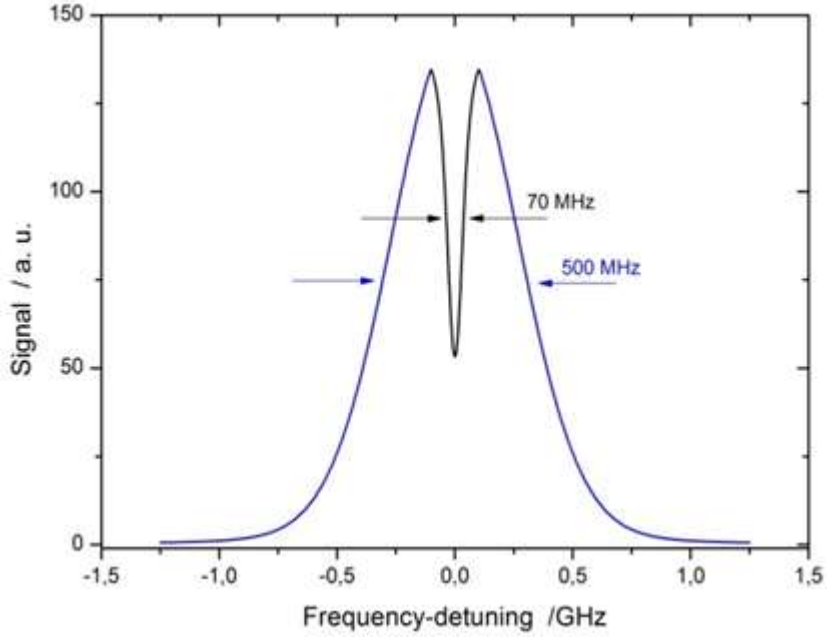
Pump and Probe

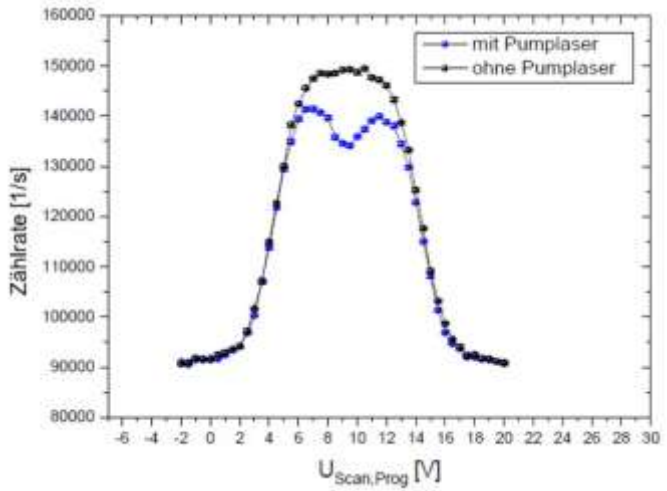




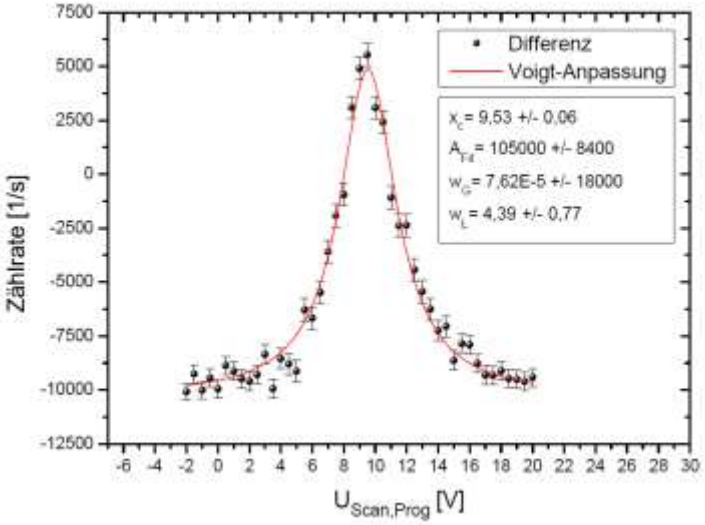
HF Levels

Experimental results



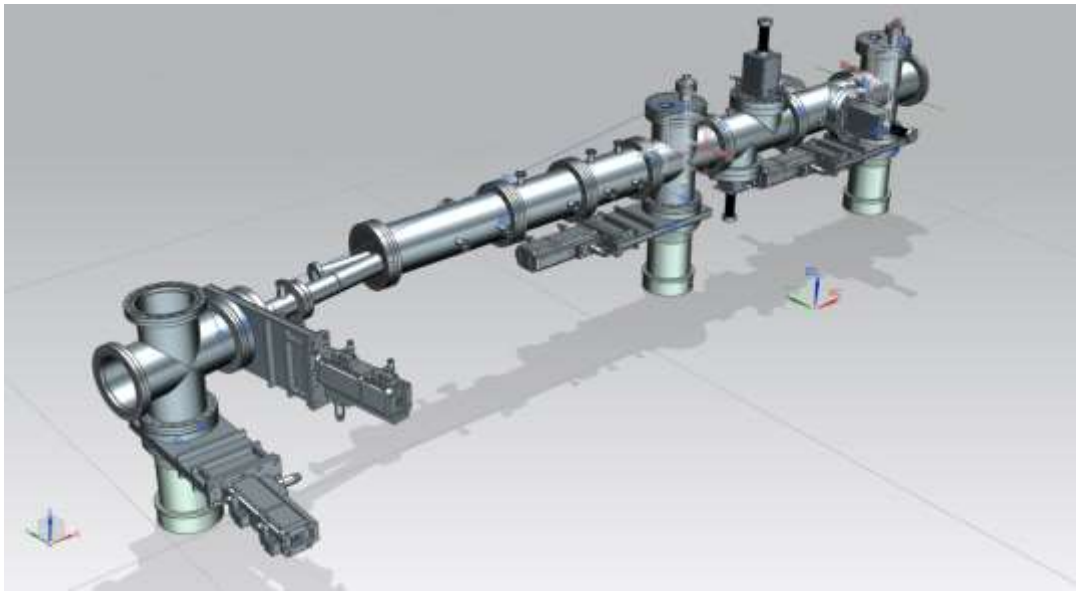


Diploma Thesis E. Will, Mainz 2013



pump-and-probe test measurement with calcium

Current State



2016: Setup of Beamline at ANL
2017: Setup of Laser systems at ANL
2018: Online-Measurements and Evaluation

- ✓ 8-boron 3+ production and supply – efficiency?
- ✓ nuclear and atomic calculations for He-like-Systems
- ✓ high-resolution laser spectroscopy technique

Thank you for your attention!