



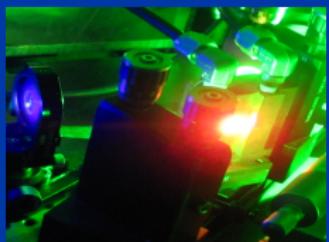
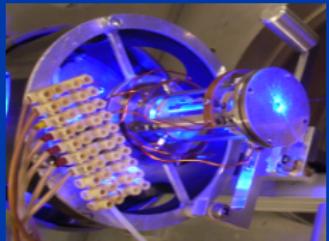
JYVÄSKYLÄN YLIOPISTO  
UNIVERSITY OF JYVÄSKYLÄ

## Status, Upgrades and Plans with CW Lasers at FURIOS

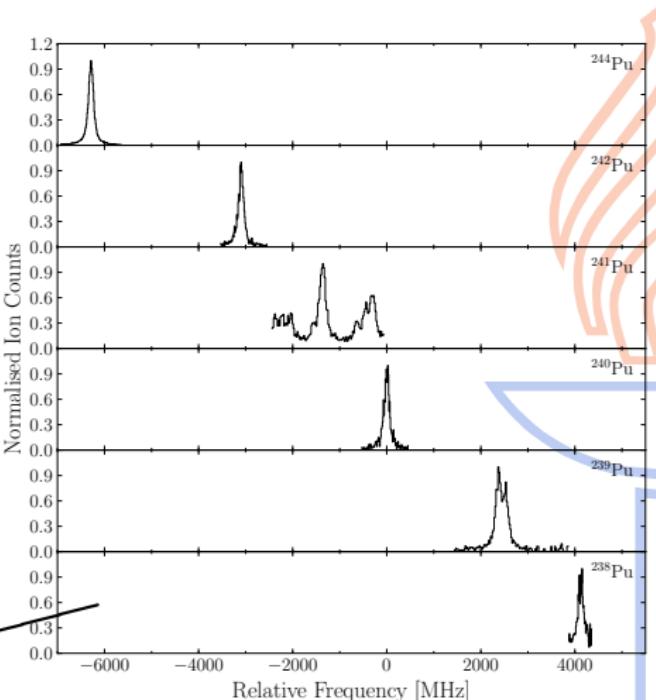
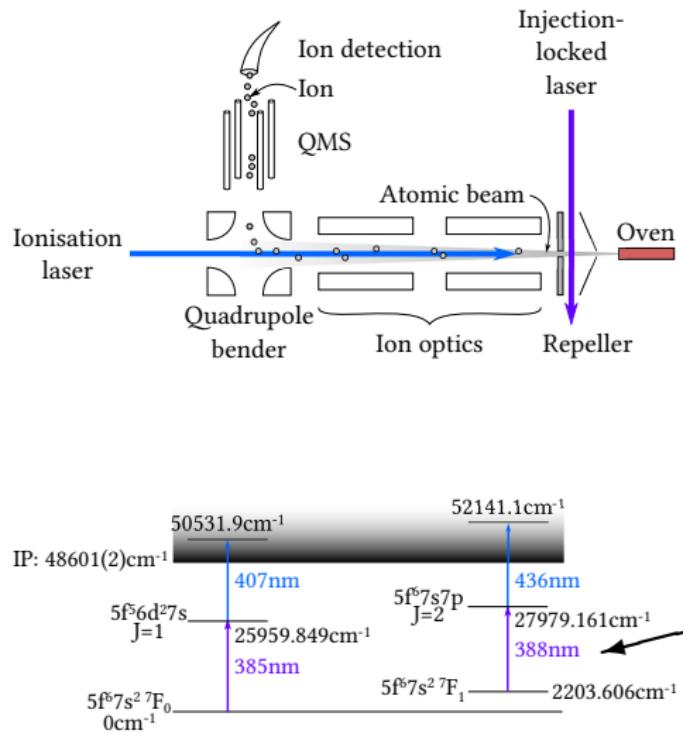
Annika Voss

University of Jyväskylä | Finland

Laser Ion Sources Workshop | October 2016



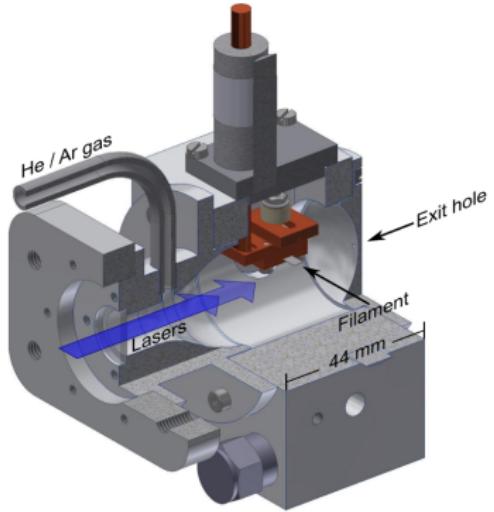
# Pu HR-RIS in Mainz using JYFL injection-locked Ti:Sa



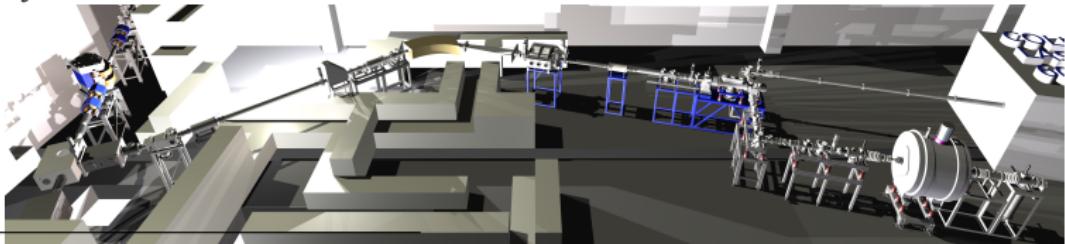
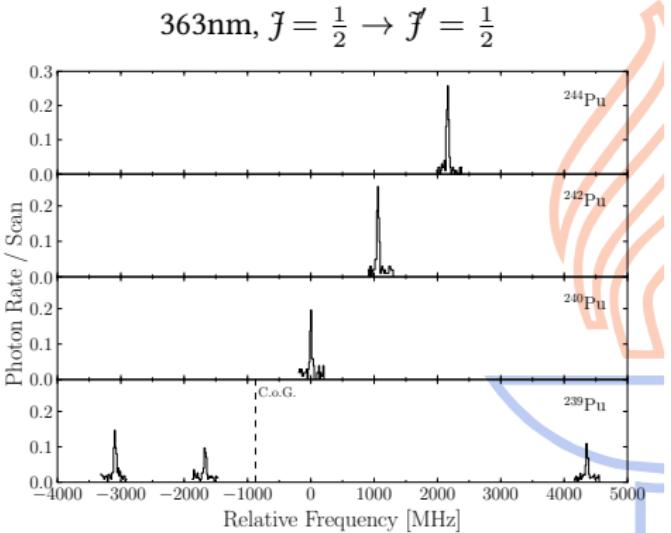
Volker Sonnenschein, PhD Thesis, University of Jyväskylä, 2016  
MABU Reminder: Dominik's talk yesterday

# $\text{Pu}^+$ CLS in JKL

CLS on heaviest Element thus far



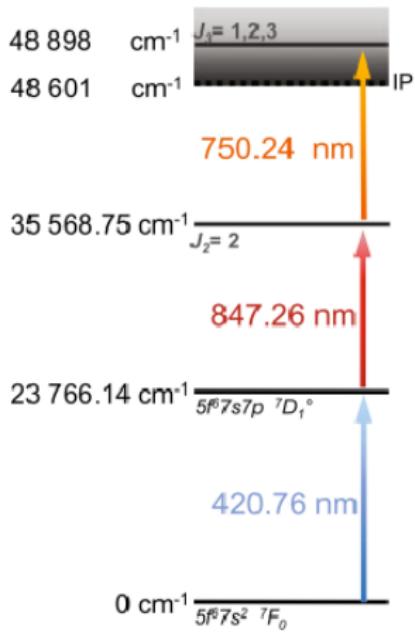
Pohjalainen, 2016, NIM B 376, 233



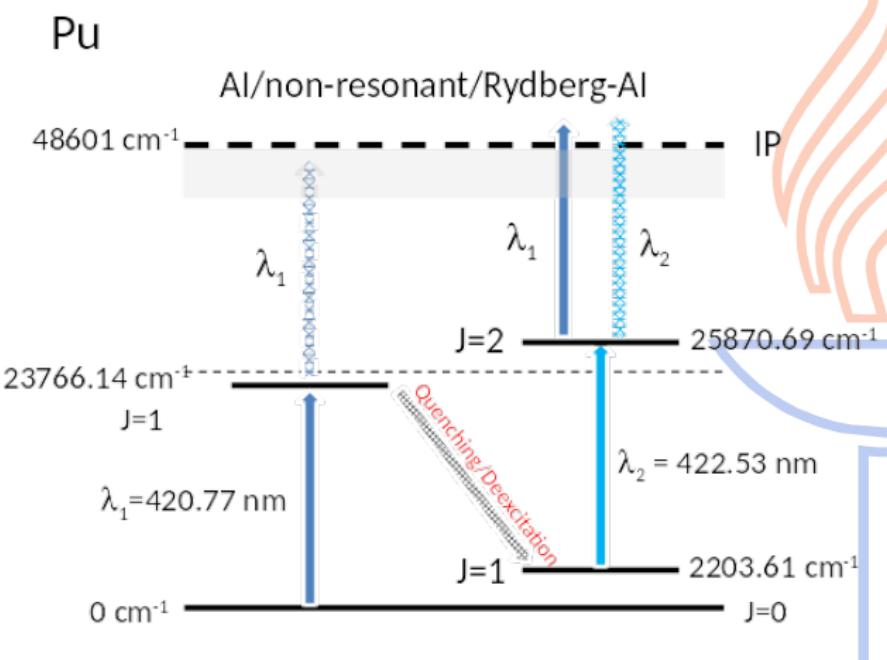
Gas Cell, General IGISOL and RFQ Reminder: Ilkka's talk yesterday & Philippou's this morning

# RIS Schemes

## ISOL vs. Gas Cell



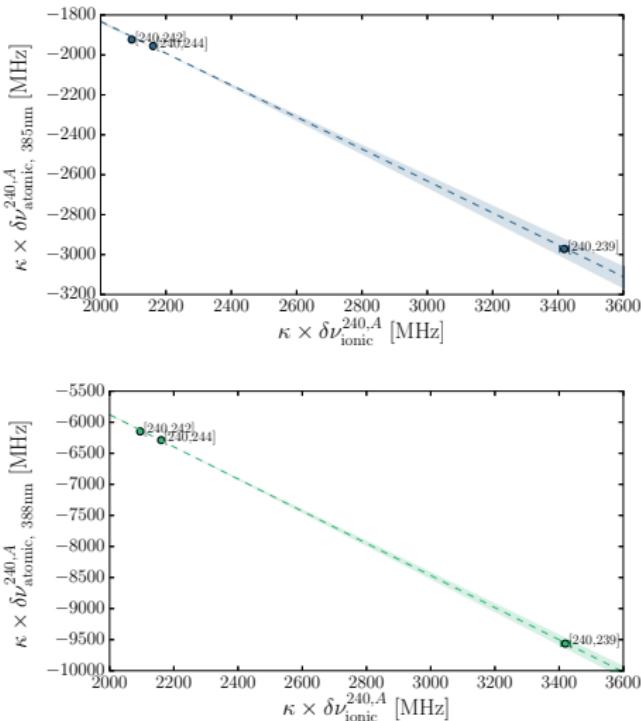
Raeder, 2012, Anal. Bioanal. Chem. 404, 2163



Pohjalainen, 2016, NIM B 376, 233

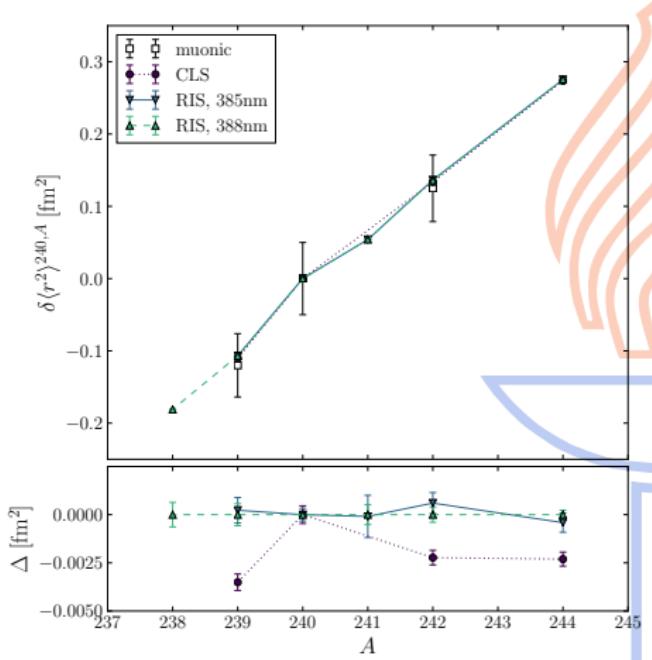
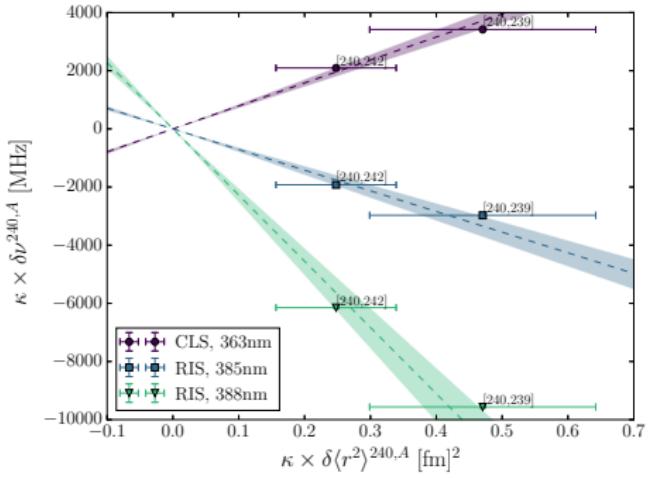
RIS Scheme Reminder: Ilkka's talk yesterday

# Consistency Check



King plot serves as a consistency check between HR-RIS and CLS

- comparison between two different atomic transitions
- nuclear properties identical for both transitions → straight line!
- allows determination of ratio of atomic factors
- here: check for abnormalities in HR-RIS and CLS



$\delta\langle r^2 \rangle$  discrepancy between CLS and RIS for both when accounting for both statistical and (standard) systematic uncertainties → ongoing investigations

$\delta\langle r^2 \rangle^{240,A}$  <sub>lit.</sub> from Zumbro, 1986, PLB 167, 383.

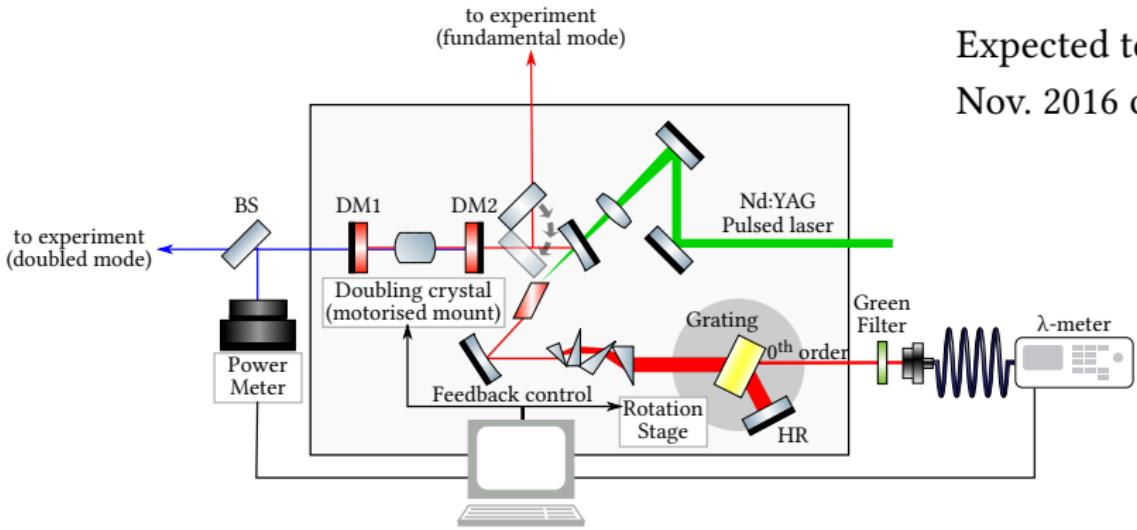
1. Different RIS schemes for ISOL and gas cells.

- Investigation of JYFL Pu-RIS scheme, **RESIST Task 2.3**, planned 2016
- Development of new gas cell for actinides, completed

2. Better frequency determination in RIS work?

- Development of frequency measurement via FPI, **RESIST Task 3.2**, ongoing

Expected test in JKL:  
Nov. 2016 on Pu

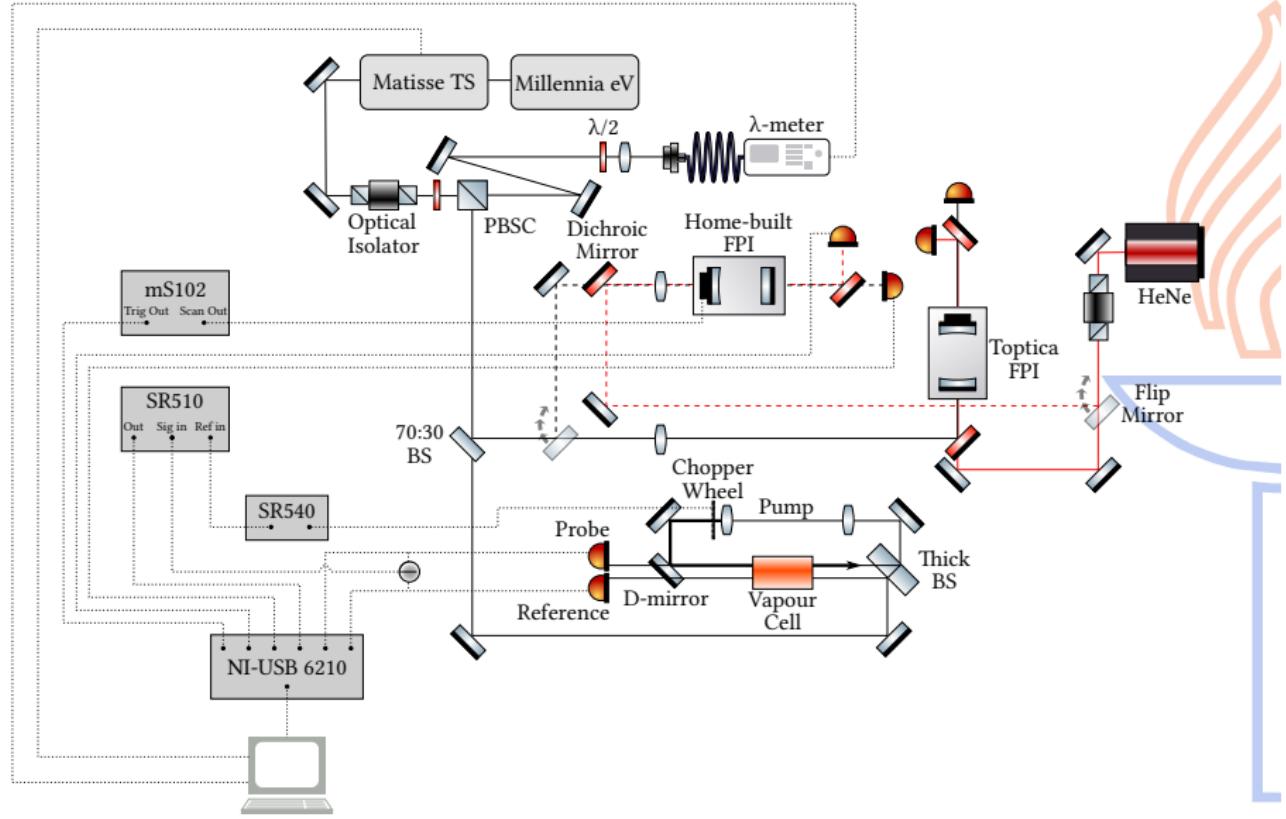


### Features:

- Automated grating stage
- Intra-cavity doubling
- Flip-mirror for switching between  $\nu$  &  $2\nu$  output

Hayashi Noriyoshi (Nagoya University), Summer Project

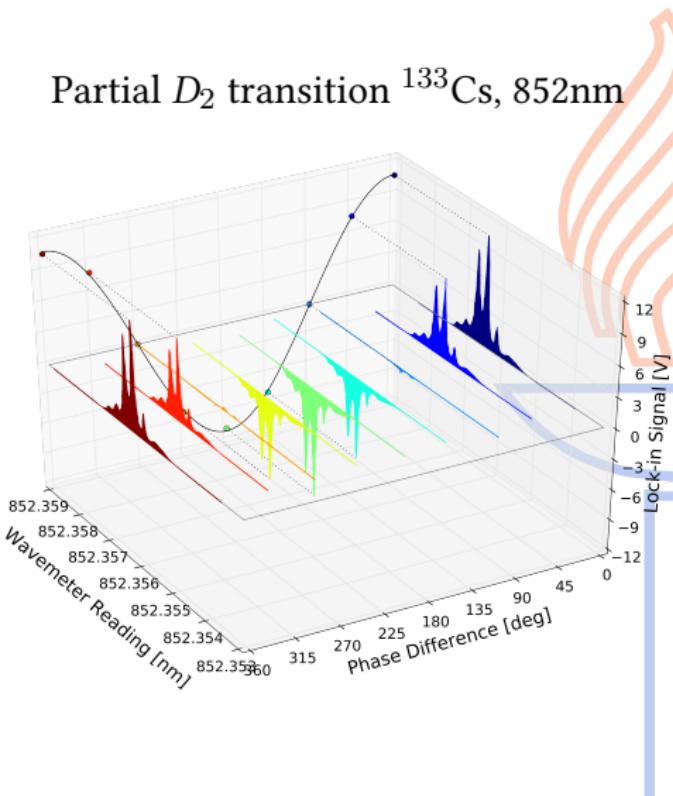
# Saturated Absorption Spectroscopy Setup



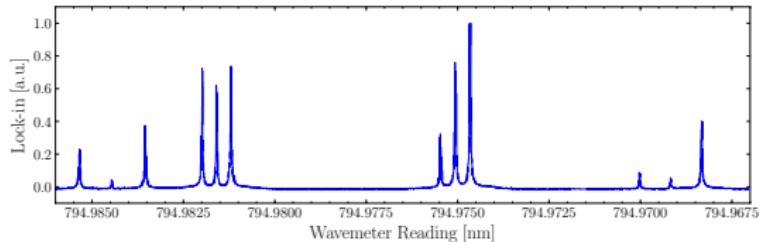
# Phase-Sensitive Detection (PSD)

- input signal mixed with reference signal in lock-in amplifier
- input and reference have identical time-dependence but different phases
- output signal of lock-in amplifier after mixing

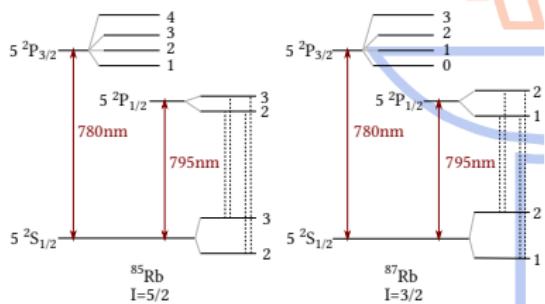
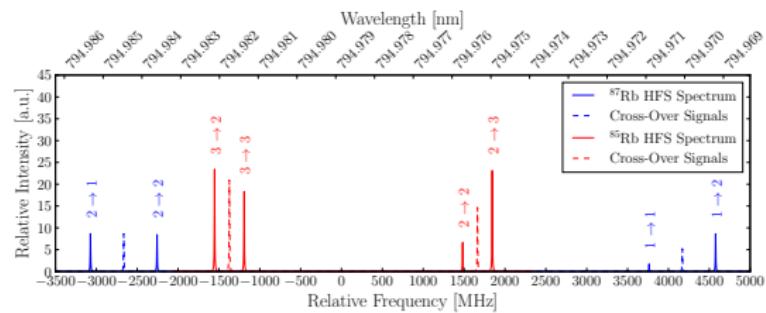
$$V_{\text{out}} = \frac{1}{2} V_{\text{sig}} V_{\text{ref}} \cos(\Delta\phi)$$



# Rb $D_1$ Spectra

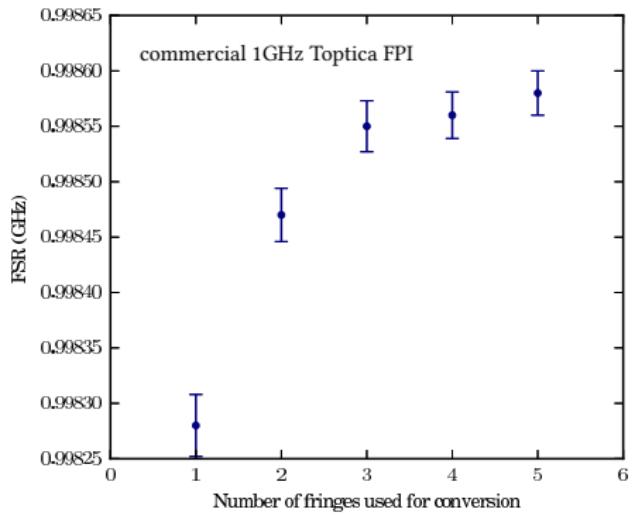


Phase-sensitive detection via lock-in amplifier “cleans up” spectrum and removes uncorrelated background



→ Cleaner spectra allow simultaneous fits of both  $^{85}\text{Rb}$  and  $^{87}\text{Rb}$  HFS and thus provide a wider calibration range for FPIs.

# Characterisation of FPIs via SatSpec of Rb and Cs



- 1GHz Toptica injection-locked Ti:Sa work
- 3GHz in-house dual-etalon Ti:Sa for RIS

Sarina Geldhof, Poznan Proceedings 2016

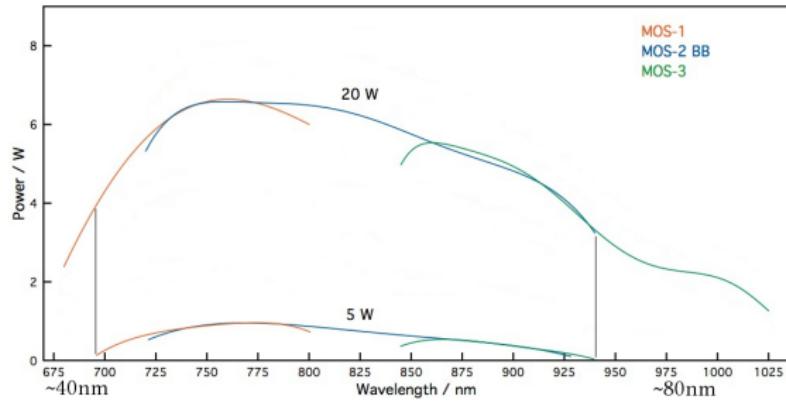
- record HFS spectrum and FPI transmission fringes of Ti:Sa and stabilised HeNe
- linearise FPI transmission fringes → non-linear piezo scanning
- correlate Ti:Sa fringe and HeNe fringe
- calculate Ti:Sa frequency change based on position differences (and accounting for transfer to next order transmission fringe when required)
- fit HFS structure with fixed parameters but allow scaling factor to determine FSR

# Lab Upgrade



“New” lab includes:

- upgraded optical table
- higher power pump laser
- frequency doubler unit
- new wavemeter (in tendering)



higher pump power increases:  
• Matisse output power &  
• accessible wavelength range

# Back to FSR Determination and the Unfortunate Issues of Temperature (In)Stabilities

FPI	Pulsed Lab Sonnenschein, PhD	FSR [GHz]		
		“Old” CW Lab no PSD	“Old” CW Lab PSD	“New” CW Lab PSD
Toptica	0.99850(15)[2]	0.99887(4)[630]	0.998569(15)[4783]	0.9985??[3116]
In-House		3.4765(2)[53]	3.46525(5)[490]	

## Differences between labs and notes:

pulsed – “old” CW: better temperature stability of the pulsed lab

“old” CW – “new” CW: shielding laser table from “blast” of AC

Temperature stability: not determined in either lab, but on the immediate ToDo list

Sarina Geldhof, partial PhD project

# Plans for the (near?) Future



- Pu
  - HR-RIS performed in Mainz utilising injection-locked Ti:Sa
  - CLS in Jyväskylä
- RIS schemes in ISOL and gas-cell different
  - in-gas-cell scheme tests with  $2\nu$  grating laser from Nagoya University
- ongoing investigation of uncertainties for  $\delta\langle r^2 \rangle$  discrepancy
  - characterise FPIs using SatSpec for better frequency determination
- CW lab upgrade (mostly) completed
  - measure temperature stability and “fix” AC unit
  - tendering for  $\lambda$ -meter
- SatSpec
  - investigate cause of “huge” systematic uncertainty on FSRs
  - probe different chopper wheel frequencies
- working towards using Matisse for CLS
  - roadmap to Ca IRIS
  - extending available transition range for  $^{229}\text{Th}$  CLS

Thank you!



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