BigBite Analysis

Target and Pumping Chamber Dinsities.

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Outline

Pressure Broadening

- The D1 and D2 absorption lines of Rb are broadened by the presence of ^{3}He
- Measuring the absorption spectrum, the ^{3}He density was measured

Density Equation

$$n_0 = \frac{\Gamma - \rho_{\mathrm{N_2}} \Gamma_{\mathrm{D1}}^{\mathrm{N_2}} \left(\frac{T}{353}\right)^{0.3}}{\Gamma_{\mathrm{D1}}^{^3\mathrm{He}} \left(\frac{T}{353}\right)^{0.1}} \tag{1}$$

- Γ = Half width
- $\rho_{\mathrm{N_2}}$ = N_2 filling density
- $\Gamma_{\mathrm{D1}}^{\mathrm{N_2}}$ = N_2 full D1 width
- $\Gamma_{\mathrm{D1}}^{^3\mathrm{He}}$ = ^{3}He full D1 width
- T = Temperature

Equilibrium ^{3}He Density, n_0

n_0 = 8.099 +/- 0.033 amg

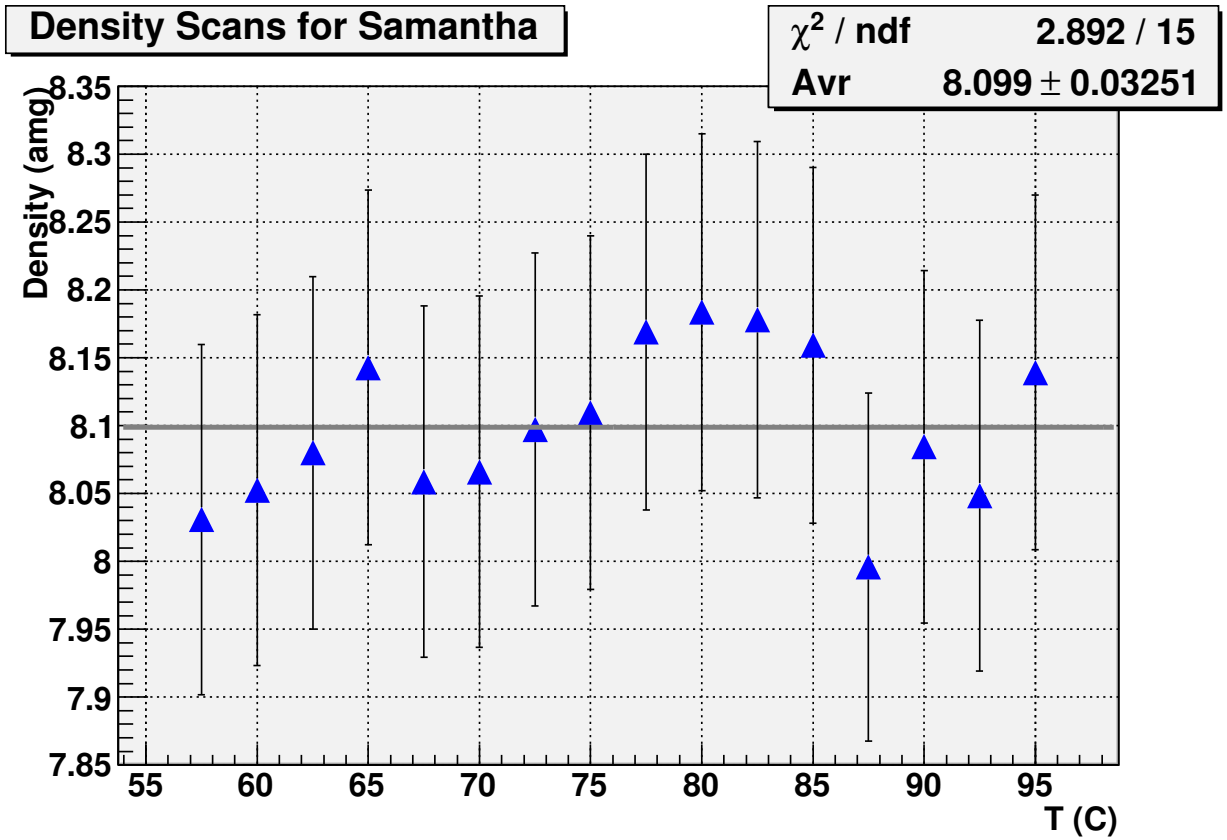


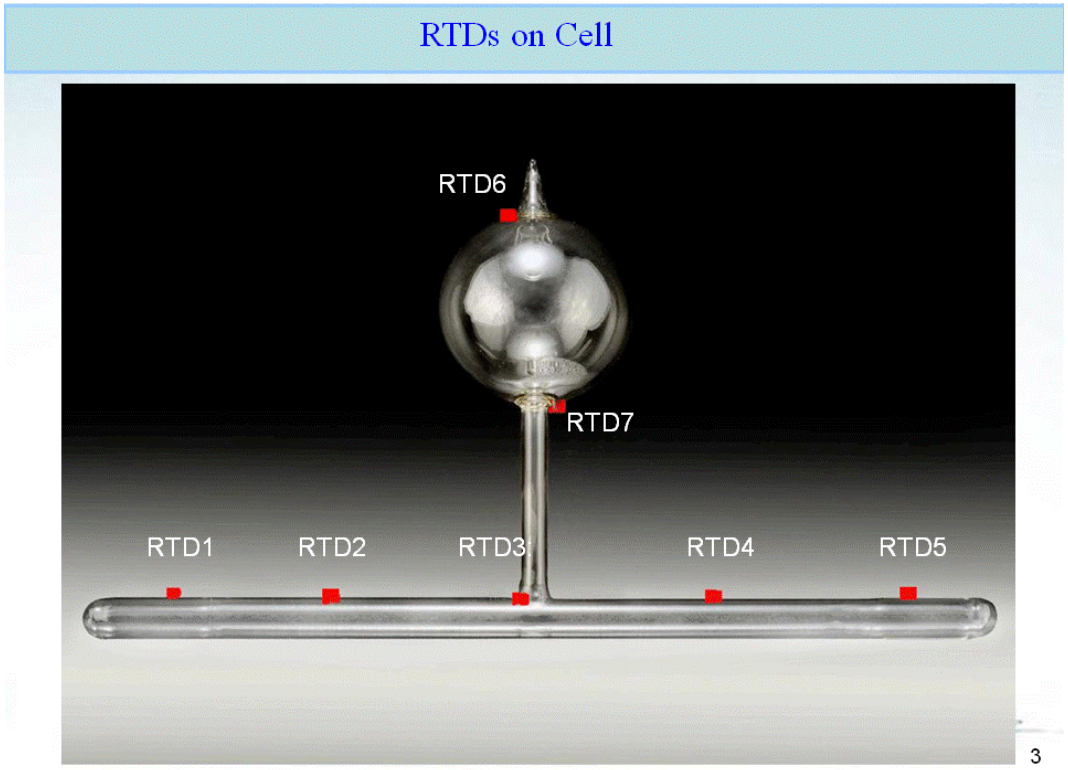
Figure: ^{3}He measured from pressure broadening by Lamiaa El Fassi

n_0 Error

Parameter	Value	Unit	Uncertainty(%)	Source
Half width of the peak	From fit	GHz/amg	0.3	Fit
^{3}He D1 full width	18.7	GHz/amg	1.60	ref
N_2 D1 full width	17.8	GHz/amg	1.69	ref
N_2 density in the cell	0.1125	amg	neg.	N_2 filling density
Temperature	353	$^\circ$F	neg.	Oven
Total			2.35	

Table: List of parameters used to calculate n_0

Samantha RTDs



- There are seven RTDs in total on the target cell
- Five along the target chamber
- Two in the pumping chamber

Figure: ^{3}He target cell RTD locations.

Target Chamber RTDs

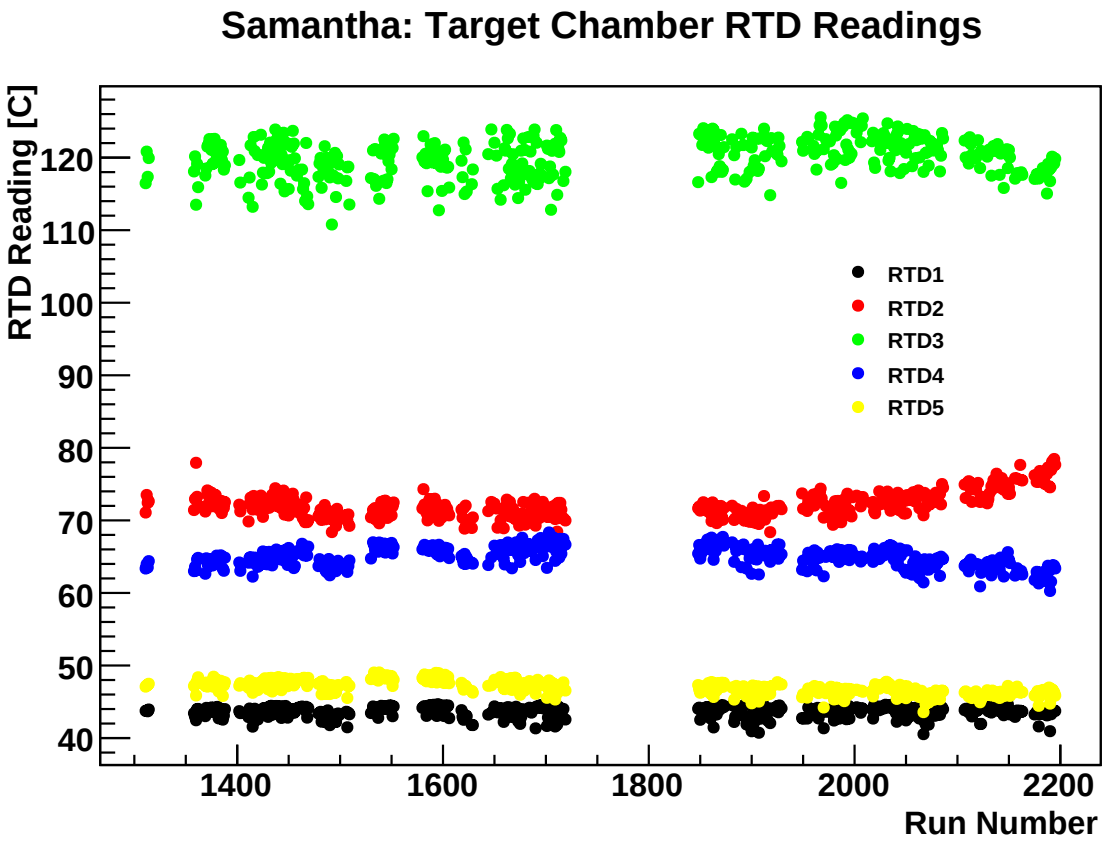


Figure: RTD temperatures along the target cell.

Pumping Chamber RTDs

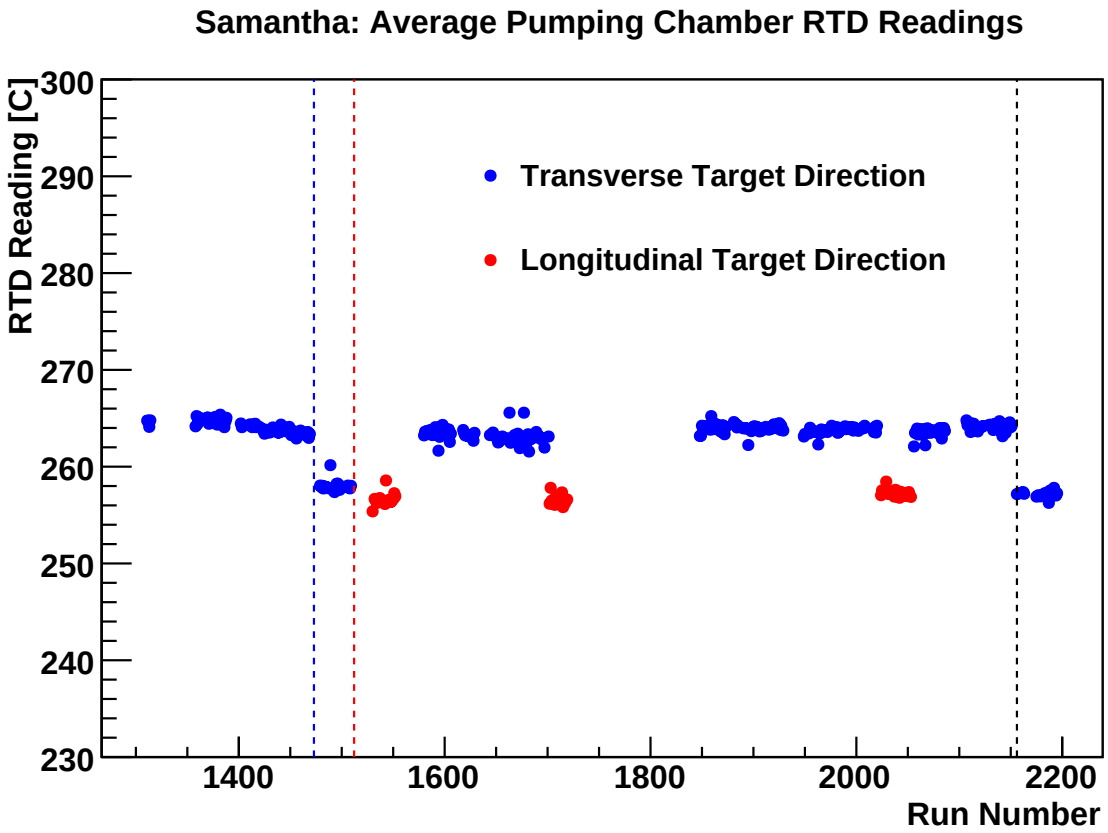


Figure: RTD temperatures in the pumping chamber. The blue dashed lines shows where the oven temperature was adjusted from 240$-$ $>$235 $^\circ$C.The red dashed line shows period where the oven temperature was adjusted from 235$-$ $>$240 $^\circ$C. The black dashed line shows where one of the oven heaters was replaced. The blue makers show the average transverse pumping chamber temperatures and the red markers show the longitudinal pumping chamber temperatures. The temperature differences between the longitudinal and transverse target directions are due to the target having a different laser alignment.

Temperature Test

- Due to lasers on the pumping chamber, the internal temperature is always higher than the RTD reading
- This is corrected for by doing a temperature test
- Temperature test involves taking RTD readings with pumping lasers on/off

Samantha Temperature Test Results

Temperature Summary

Date	Cell	Direction	T_Read	T_Calculated	ΔT
Feb 23th	Samantha	Longitudinal	257.21	263.39	6.18
Mar 16th	Samantha	Transverse	257.08	264.39	7.31
May 5th	Dominic	Vertical	246.55	262.41	15.86
May 19th	Moss	Longitudinal	238.75	249.14	10.39
June 9th	Moss	Transverse	247.59	264.51	16.92

Figure: Longitudinal and transverse results of Samantha target cell temperature results done by Yawei Zhang

Final RTD Temperatures

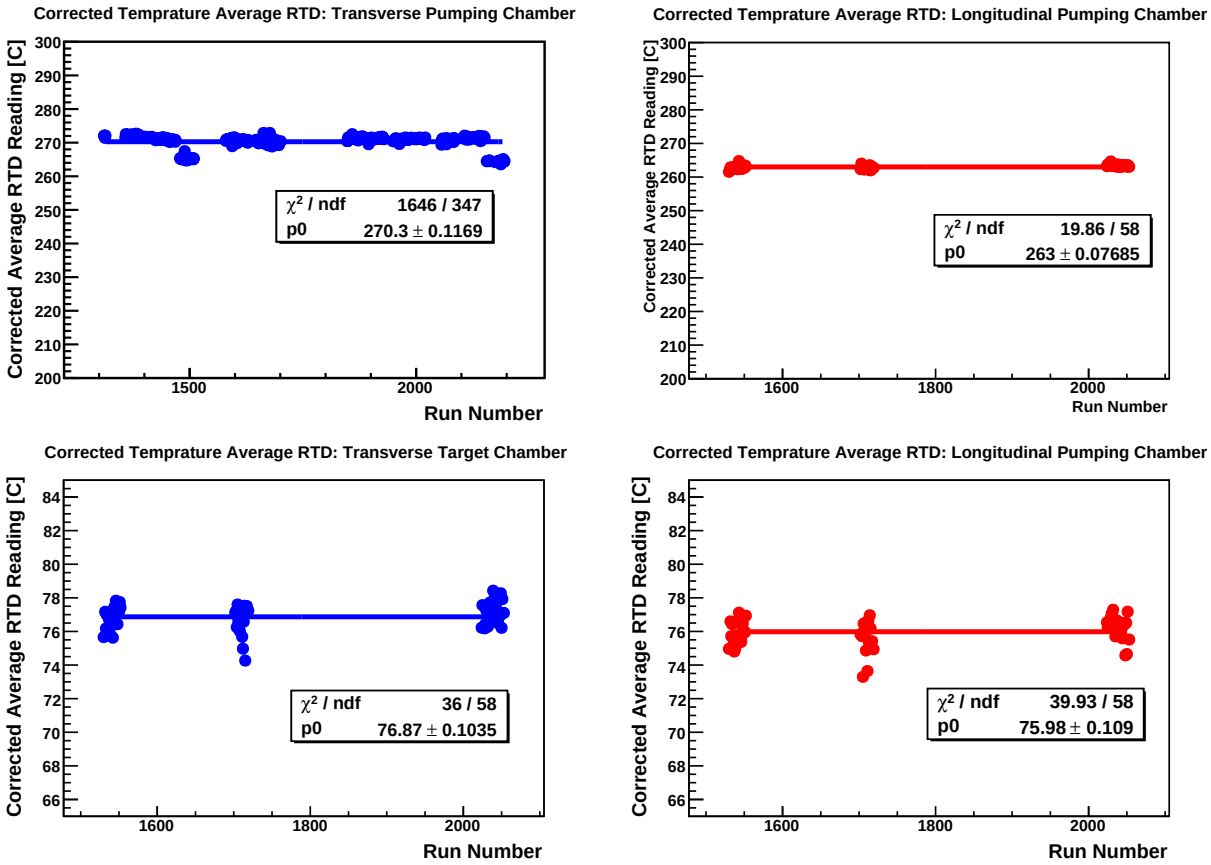


Figure: Corrected Average ^{3}He pumping chamber RTD and average target chamber RTD temperatures.

^{3}He Target and Pumping Chamber Densities

- Knowledge of the target and pumping chambers is when computing the ^{3}He polarization
- the density in the chambers is given as:

$$n_t = \frac{n_0}{1 + \frac{V_p}{V_{tot}}\left(\frac{T_t}{T_p} - 1\right)}, n_p = \frac{n_0}{1 + \frac{V_t}{V_{tot}}\left(\frac{T_p}{T_t} - 1\right)} \tag{2}$$

- n_t/n_p: Target/pumping chamber density
- n_0: Equilibrium ^{3}He density
- V_t/V_p: Target/pumping chamber volumes
- V_{tot}: Total target cell (pumping + target + transfer tube) volumes
- T_t/T_p: Target/pumping chamber temperatures

Samantha Target Cell Properties

UVa d2n Cell Properties from Gas System & Buoyancy

Longitudinal 42-deg cells in blue

Cell	ρ_{He} (amg)	ρ_{N_2} (amg)	V_{PC} (cc)	V_{TT} (cc)	V_{TC} (cc)
Alex	7.932±0.072	0.1133±0.002	193.85	6.92	77.29
Boris	7.993±0.072	0.1126±0.002	166.13	5.83	73.91
Moss	7.808±0.071	0.1132±0.002	184.13	6.54	78.23
Samantha	7.847±0.070	0.1125±0.002	176.90	6.51	75.47
Tigger	7.807±0.071	0.1124±0.002	186.94	6.35	78.36

PRELIMINARY: Al Tobias, May 5, 2009

Figure: Cell properties measured at UVa.

Chamber Density Error

Following errors were propagated through n_t and n_p density equations:

Parameter	Value	Unit	Uncertainty(%)	Source
V_{tt}	6.51	cc	1.0	-
V_t	75.47	cc	1.0	-
V_p	176.90	cc	1.0	-
V_{tot}	258.88	cc	1.73	-
T_t (trans.)	349.87	k	1.43	Fit and +/-5k variation
T_p (tran.)	543.3	k	0.92	Fit and +/- 5k variation
T_t (long.)	348.98	k	1.44	Fit and +/-5k variation
T_p (long.)	536.0	k	0.93	Fit and +/- 5k variation
n_0	8.099	amg	2.38	n_0 Fit and pressure broadening

Table: List of parameters used to calculate n_t and n_p

n_t and n_p Results

My values:

Parameter	Direction	Value	Unit	Uncertainty(%)
n_t	Long.	10.635	amg	2.82
n_p	Long.	7.005	amg	2.50
n_t	Trans.	10.703	amg	2.66
n_p	Trans.	6.975	amg	2.50

Table: Target and pumping chamber density results.

Y. Zhang values:

Parameter	Value	Unit	Uncertainty(%)
n_t	10.81	amg	2.68
n_p	6.93	amg	2.74

Table: Target and pumping chamber density results from Y. Zhang.

Target and Pumping Chamber Densities

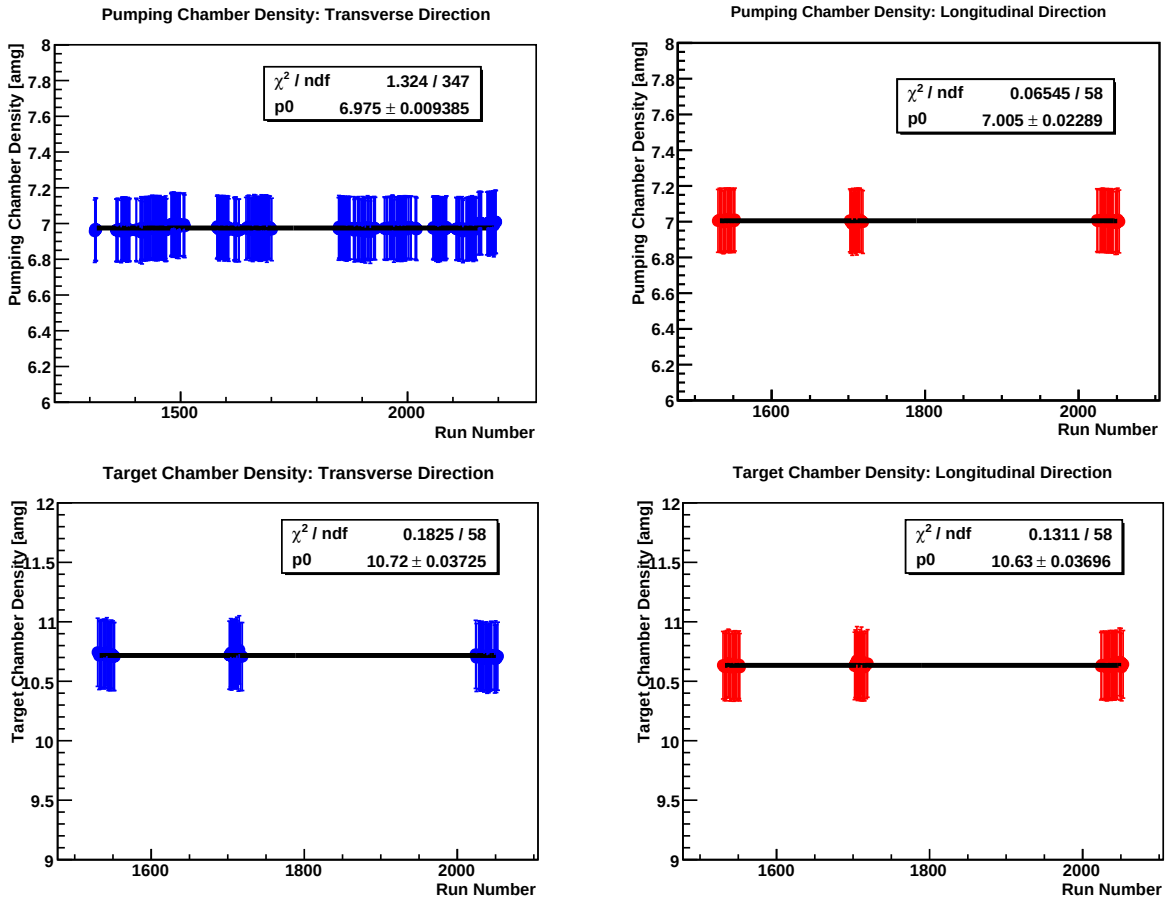


Figure: Target and pumping chamber densities with error applied.

What's Next

- Get EPR Polarizations
- Compute EPR/NMR ratio
- Apply EPR/NMR ratio to all NMR
- Interpolate EPR/NMR to BB runs
- Water Calibration