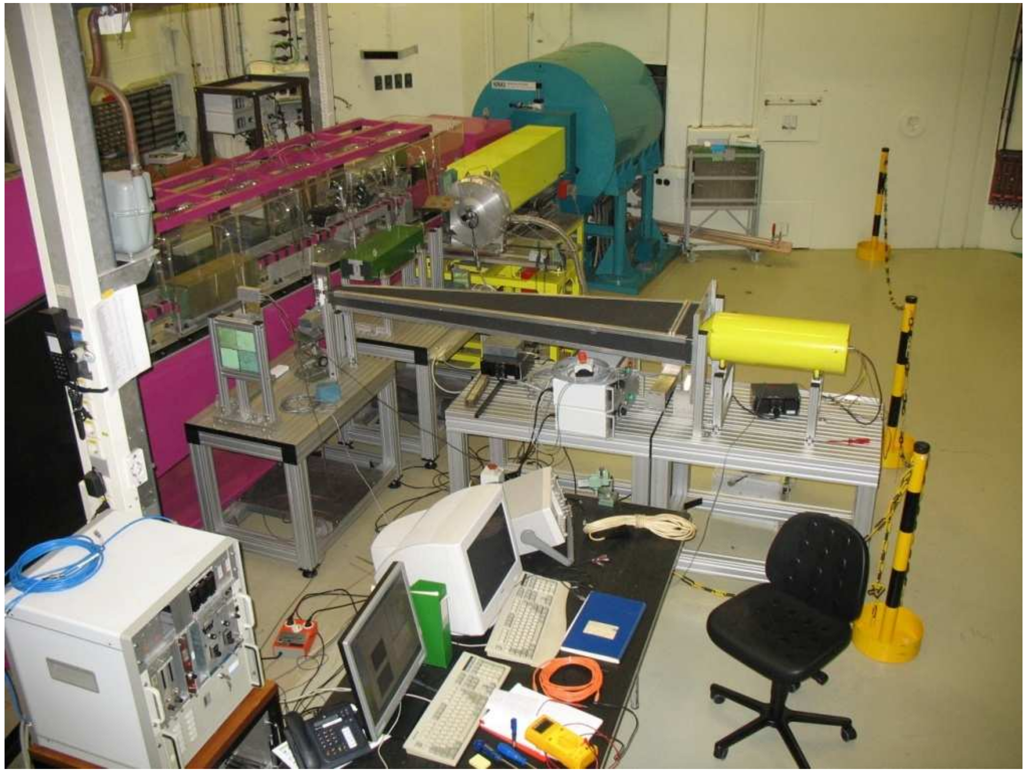
First Experiments with TOFLAR

(TOFLAR = Time Of Flight and LARmor Precession)

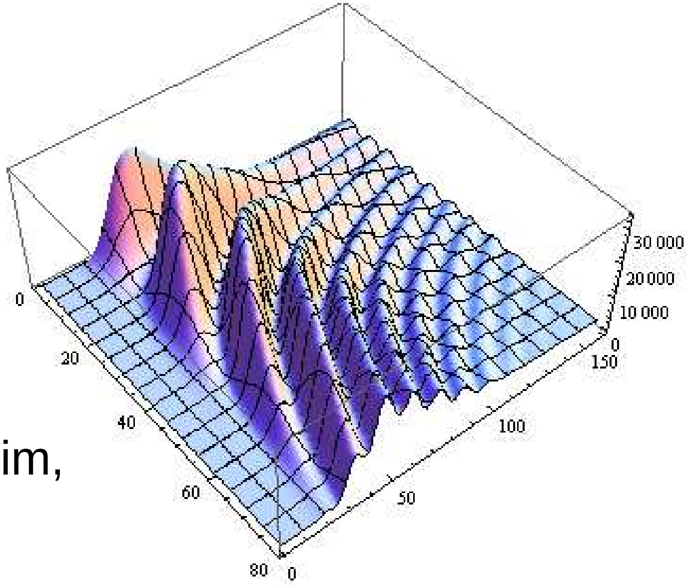
M. Bleuel, TU Delft



-Introduction / Comparison
with ToF

- Some experiments

- Summary



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also the technical support is excellent!
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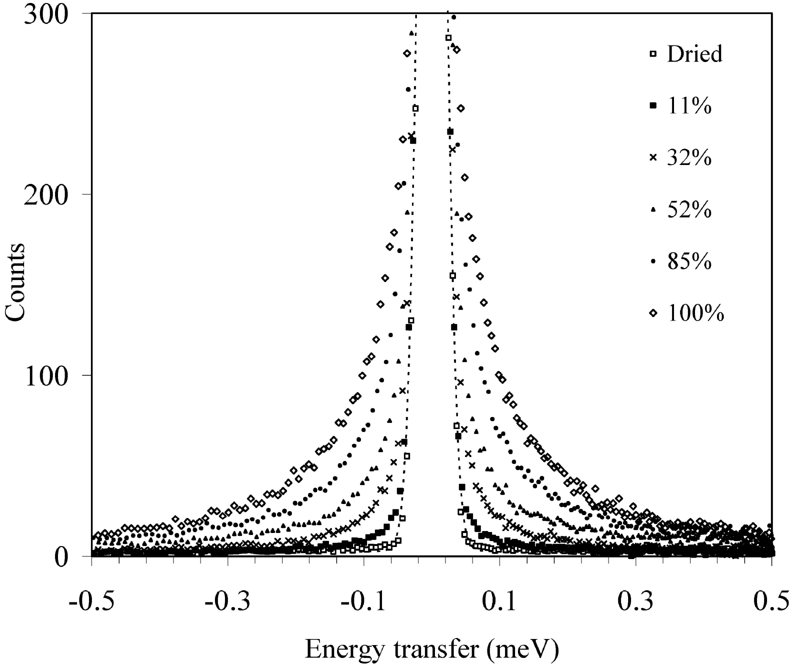
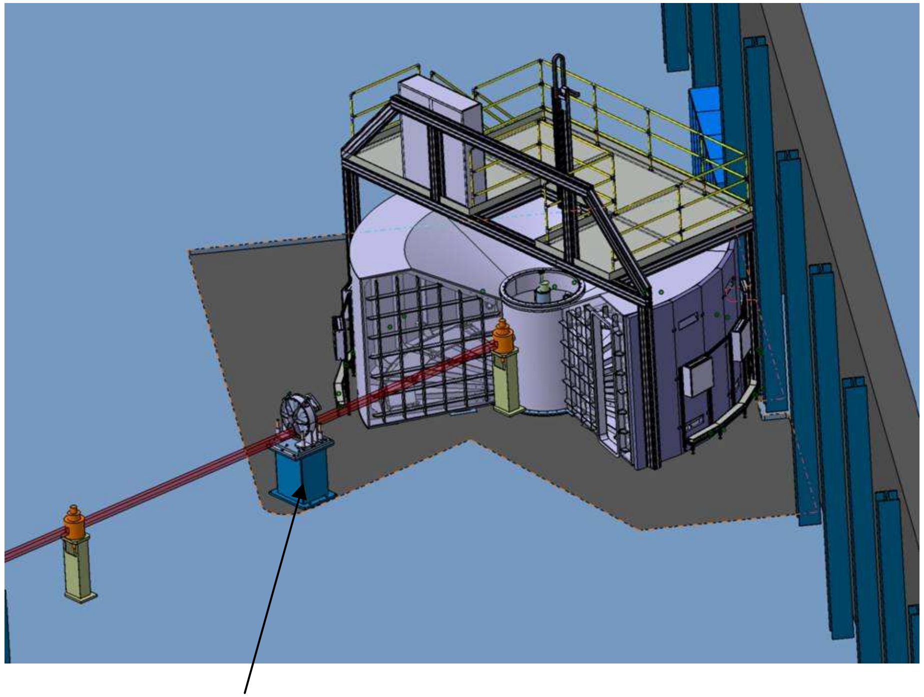
TOF- concept

Measures scattered direction and total time of flight,
Needs a very good collimation in time . . . (v_1 must be defined)

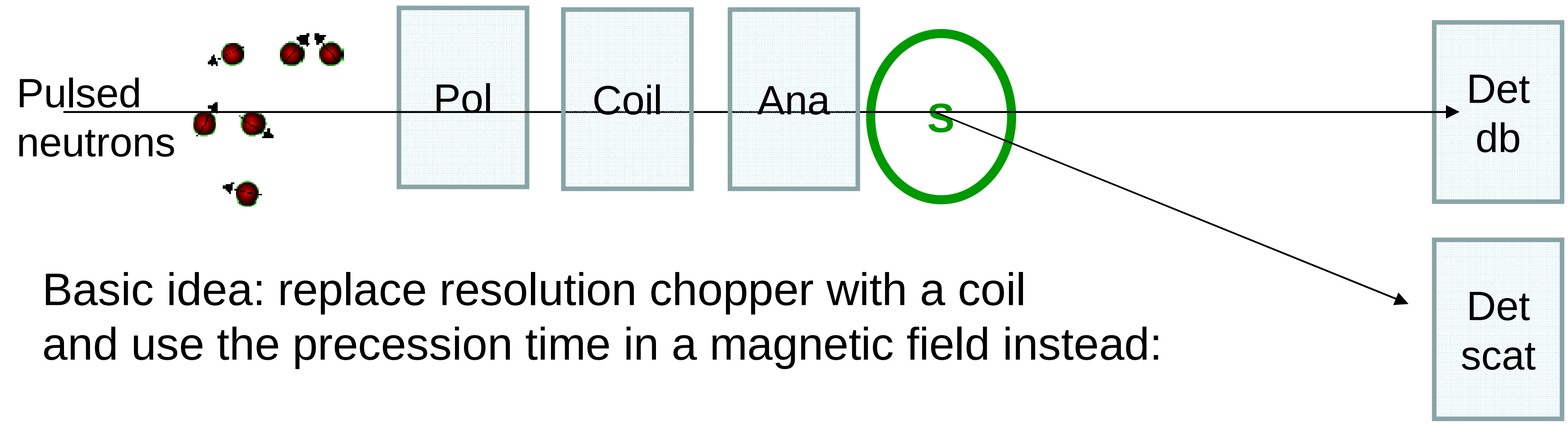


Example: J.-C. Perrin et al.
Water content in a membrane



Choppers are the most important part
of a ToF instrument, f≈1kHz

TOFLAR



Basic idea: replace resolution chopper with a coil and use the precession time in a magnetic field instead:

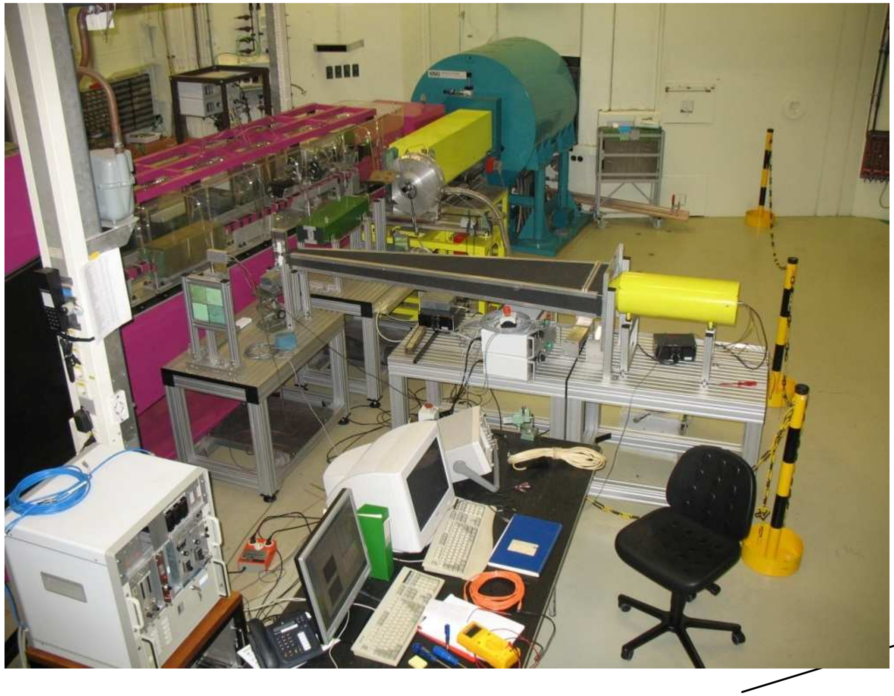
$$\varphi = \gamma BL/v_1$$

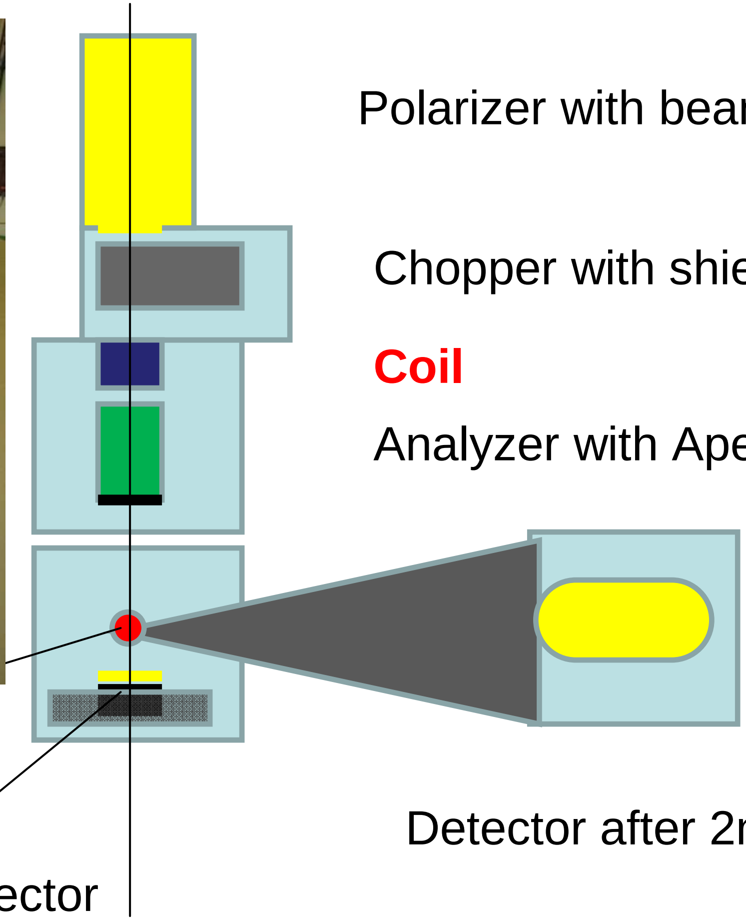
=> Each velocity gets a “phase stamp”

$$(\delta\Delta E)^2 = \left(\frac{h^3 L_2^2}{m^2\left(\frac{ht}{m} - L_1\lambda_1\right)^3}\right)^2 \delta t^2 + \left(\frac{h^2 L_2^2 L_1}{m\left(\frac{ht}{m} - L_1\lambda_1\right)^3} + \frac{h^2}{m\lambda_1^3}\right)^2 \delta\lambda_1^2 . \qquad B_{\max} l = \frac{2\pi}{c\delta\lambda_1}$$

It is a FT-technique, not energy states, but times scales are probed!

The Setup





Polarizer with beam monitor

Chopper with shielding

Coil

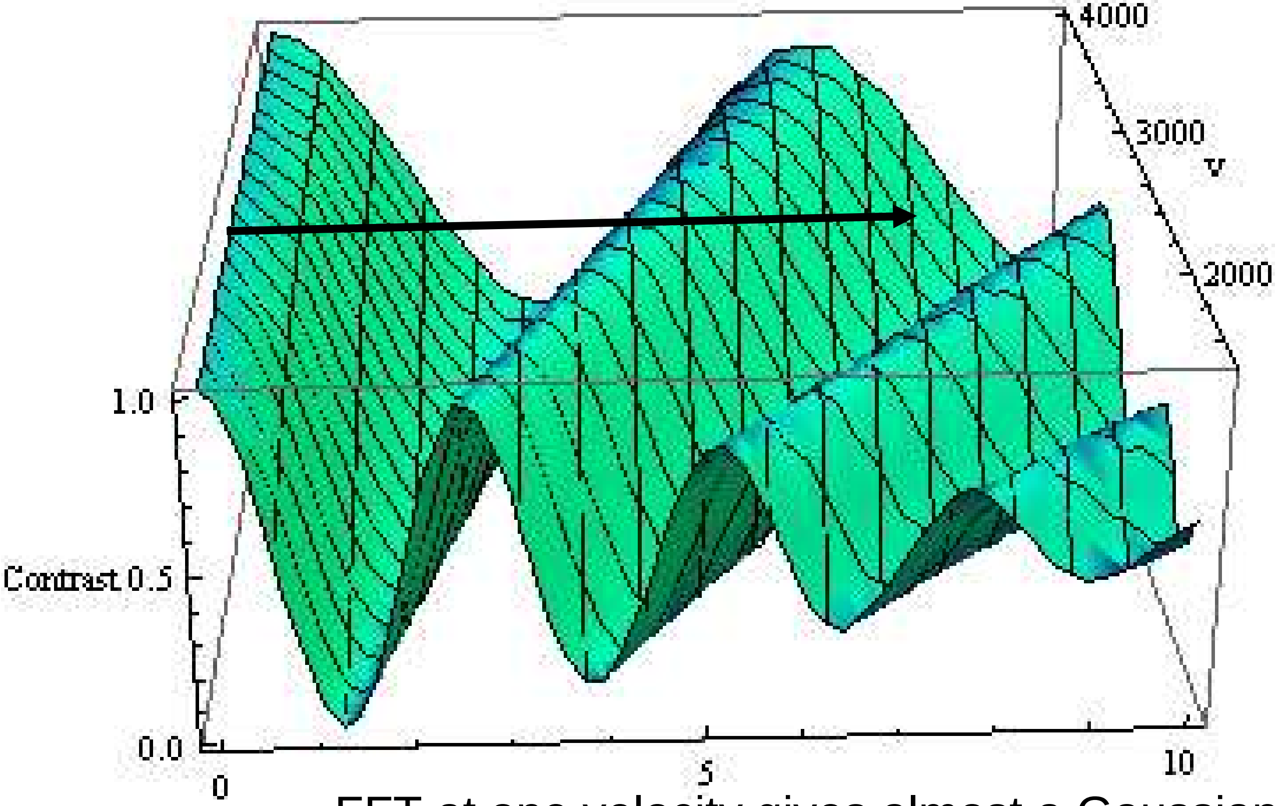
Analyzer with Aperture

Sample

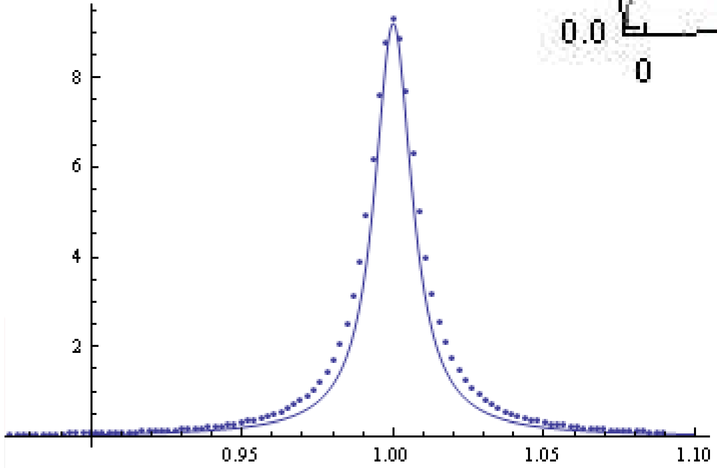
Beamstop with Detector

Detector after 2m Flight Path

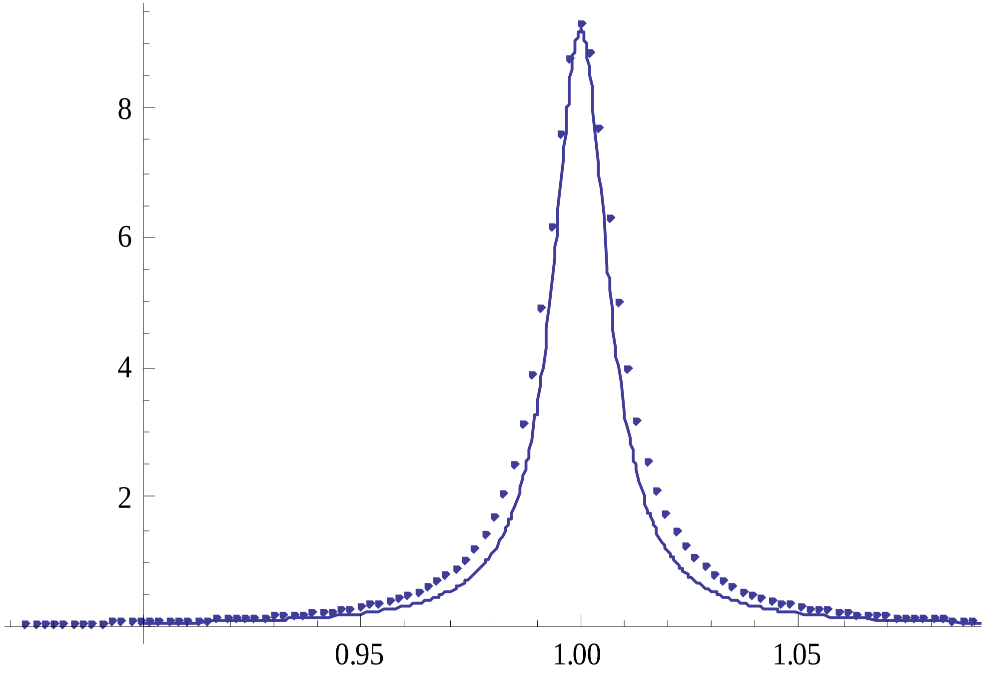
Back to cooking ..



FFT at one velocity gives almost a Gaussian -> beside the “box problem”, Γ is practically identical to ToF



Box problem



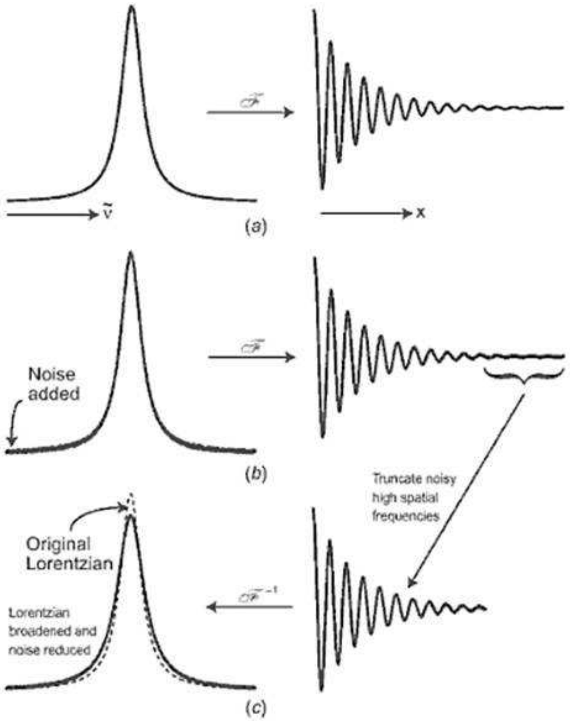
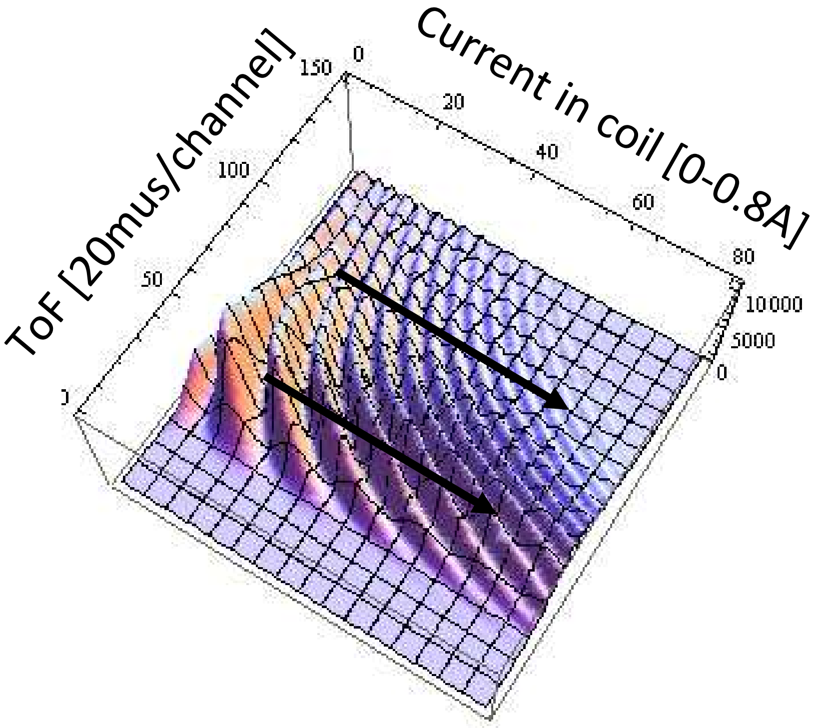


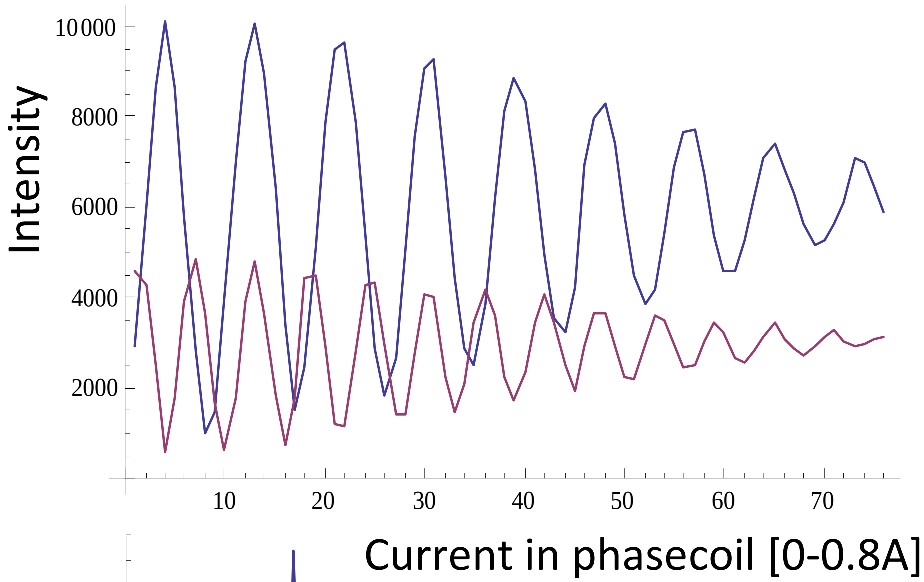
Figure 10.5. (*a*) Lorentzian band and its Fourier transform. (*b*) Same curves as in (*a*) but with a small amount of noise added; the noise is particularly recognizable in the region where the Fourier domain signal is low, that is, at the end of the decay function. (*c*) Result of truncation of the Fourier domain signal to remove the low-SNR region and its transformation back to the spectral domain; the noise on the Lorentzian band has been reduced at the expense of resolution.

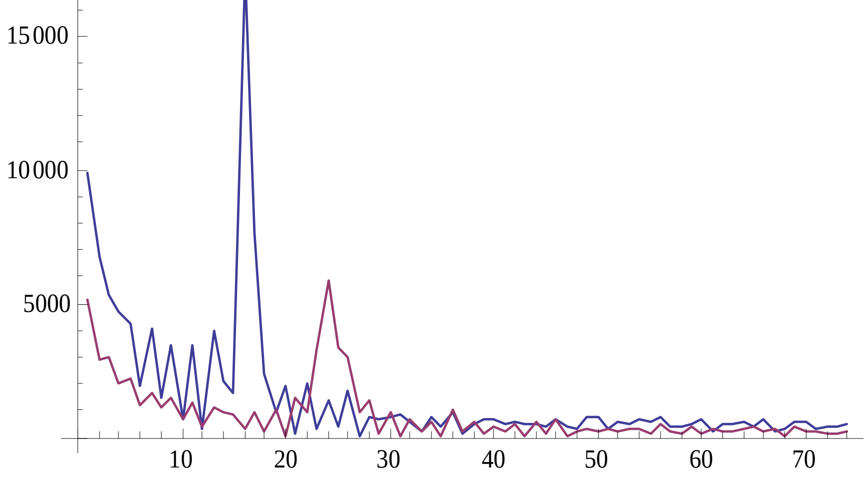
- Even the analytical world is not always perfect . .
- Be always careful with FT!!!

“Damping” gives the Wavelength Spread

(direct beam)

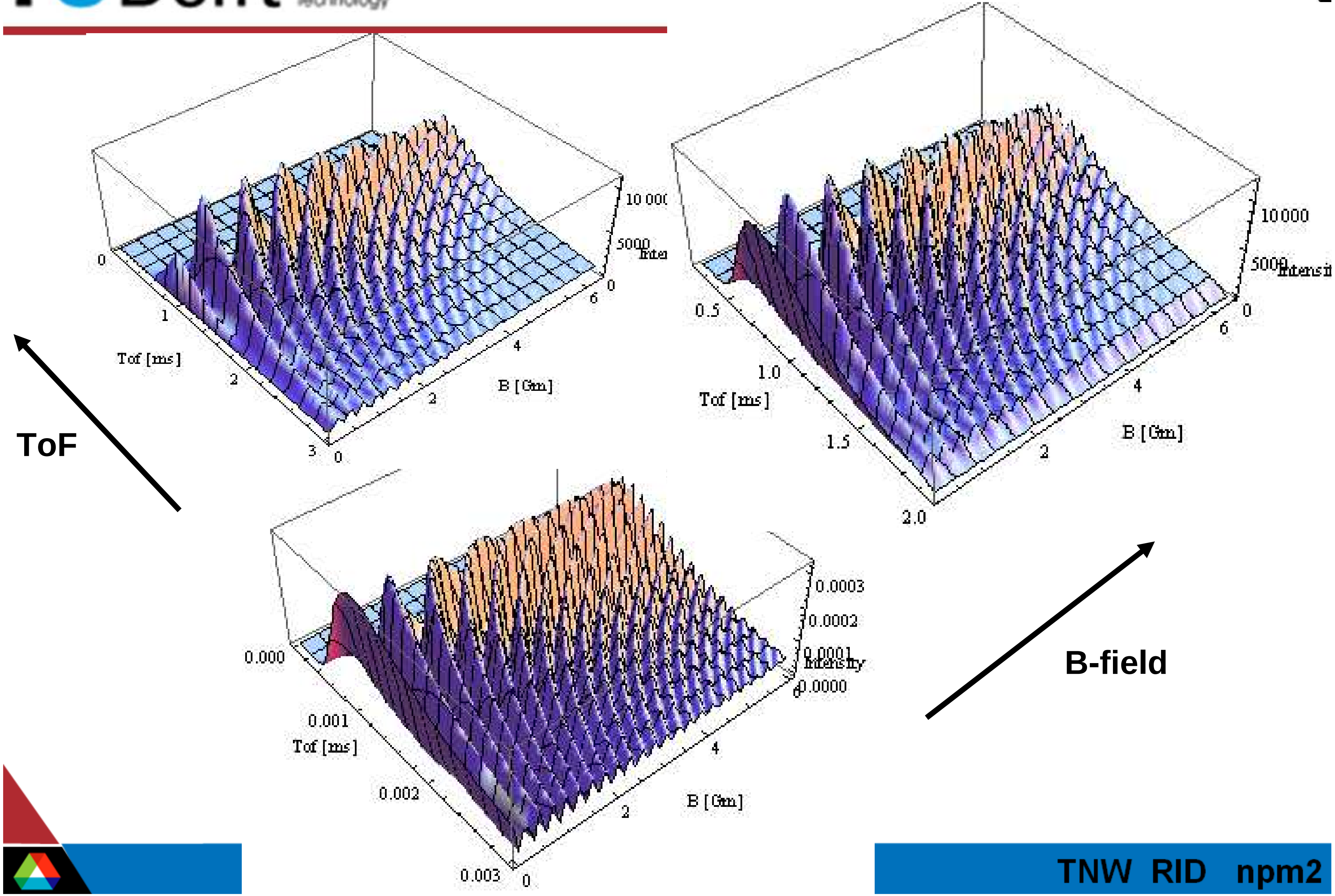




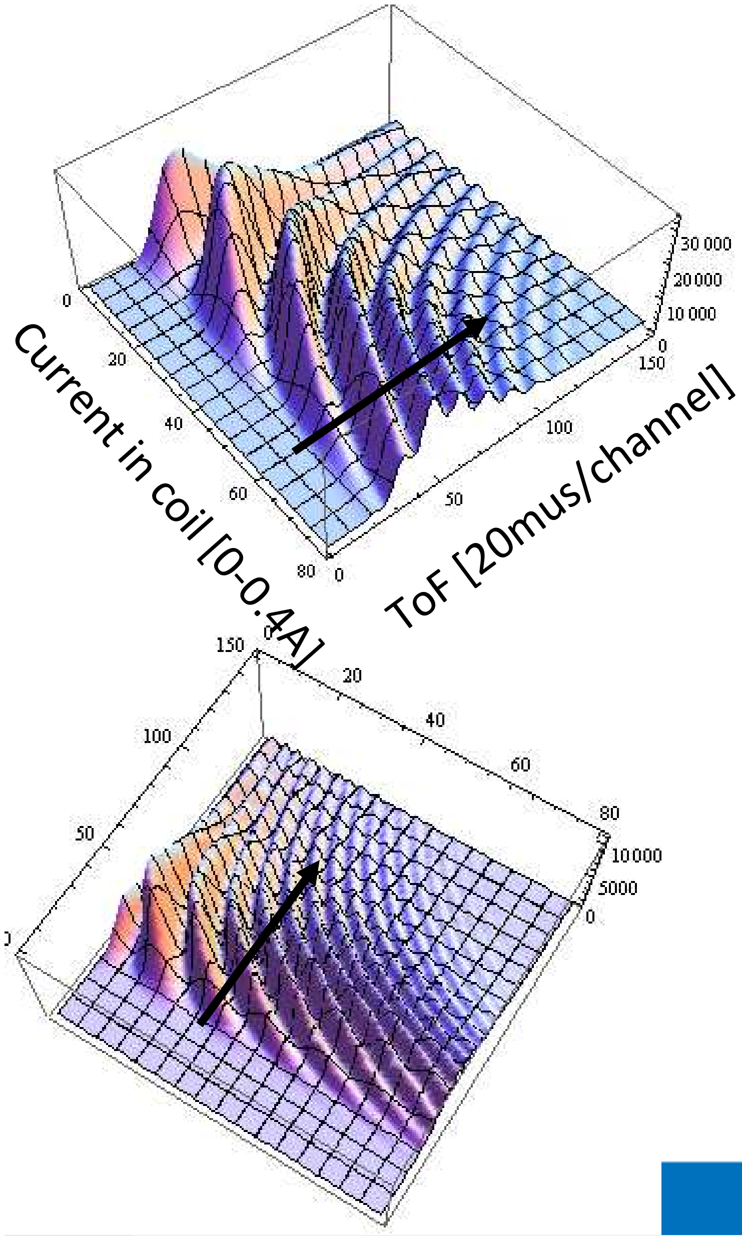


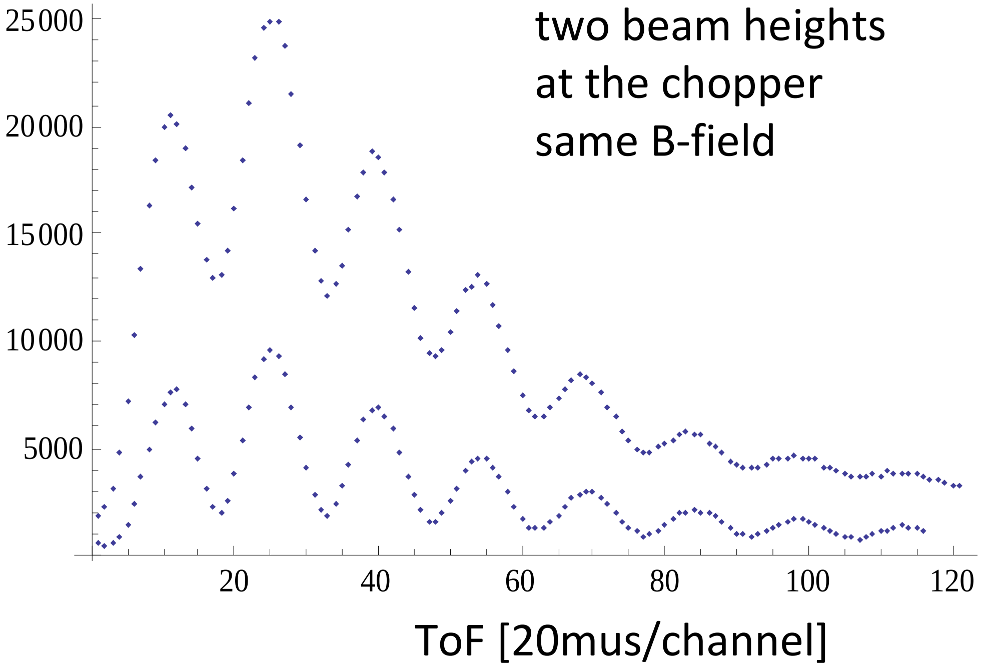
FT of “current” = const * λ_1

Data, McsTas, Analytical



Direct Beam Measurements

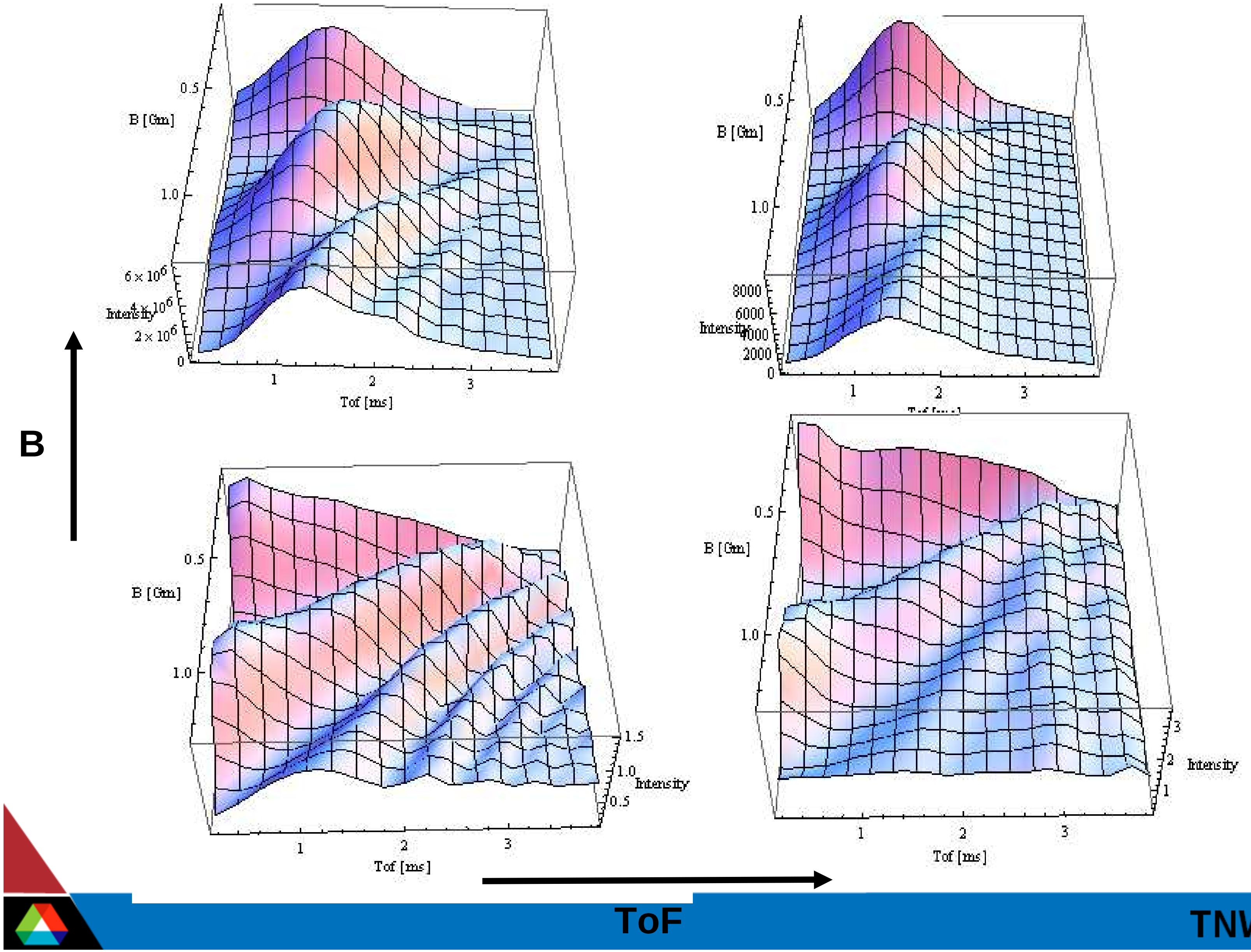




two beam heights
at the chopper
same B-field

A bigger beam at the chopper
gives more intensity, but less signal/noise,
because of the slower closing time

Direct Beam vs. Sample



Analysis/ Fitting:

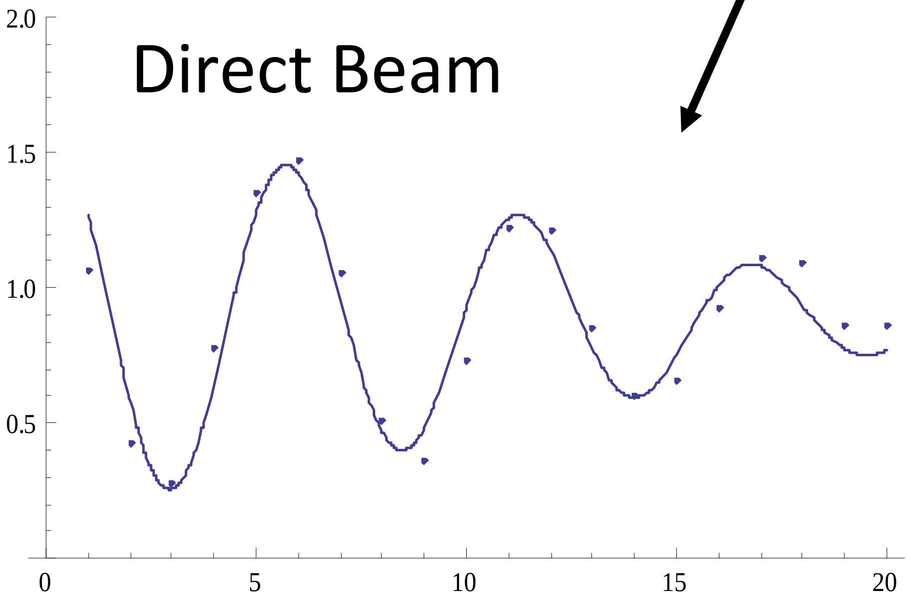
Measured in direct beam and sample signal

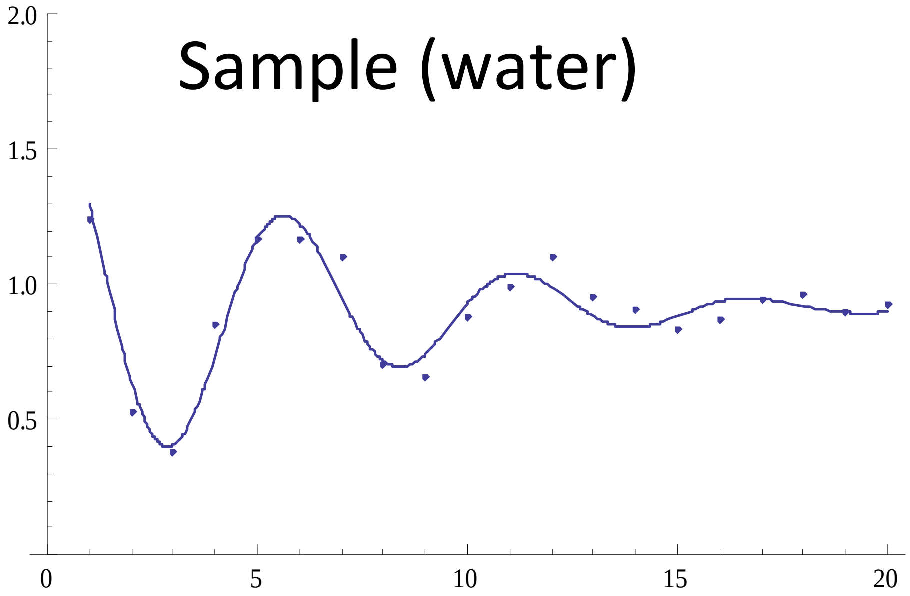
$$Bkg + A * Cos(c_{ToF} * B + \varphi_0) e^{-(c_{ab} * B^2 + c_{scat} * B)}$$

Fixed ToF

$e^{-(t/tau)^\beta}$

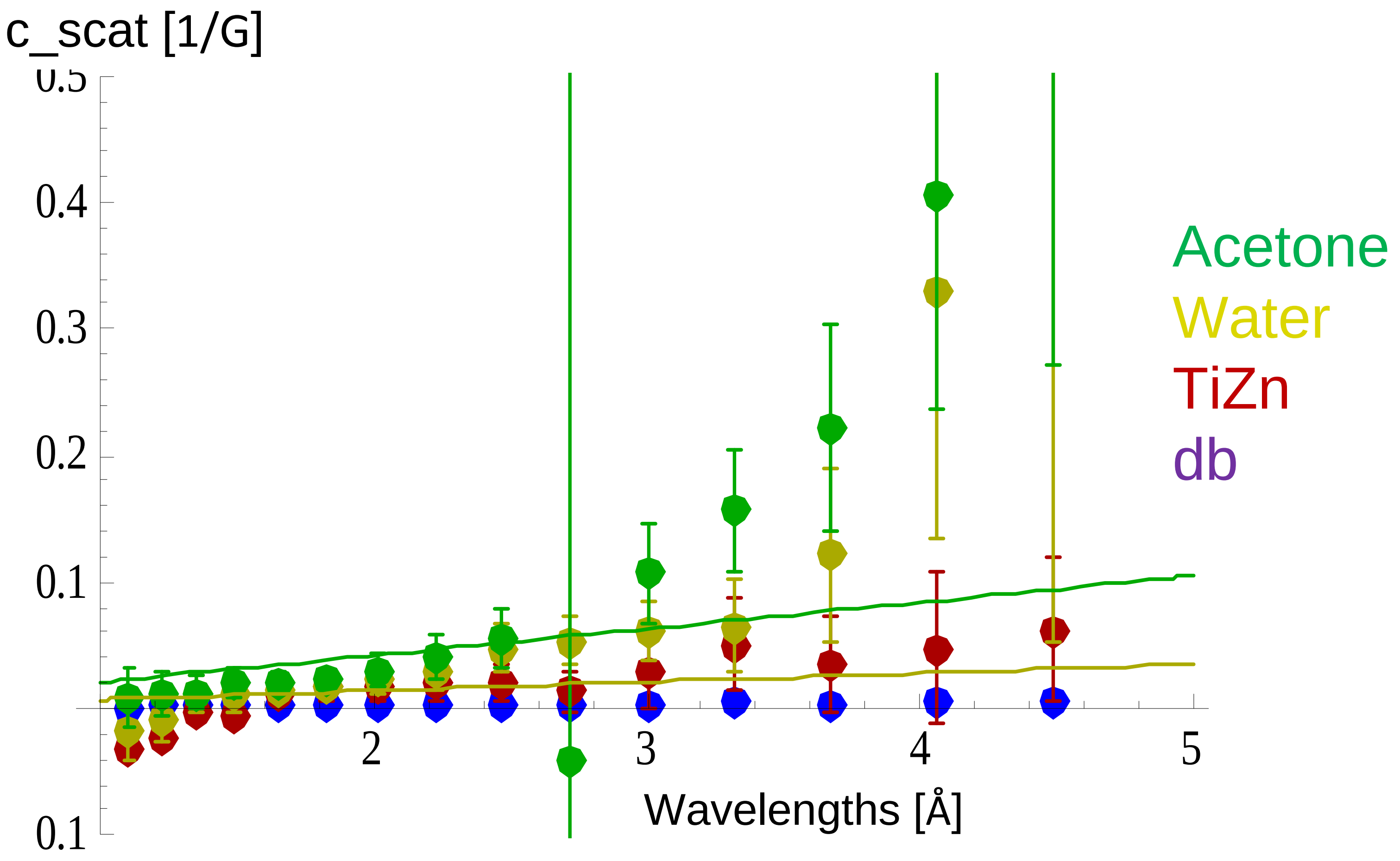
= self diffusion for $\beta=1$


Direct Beam


Sample (water)

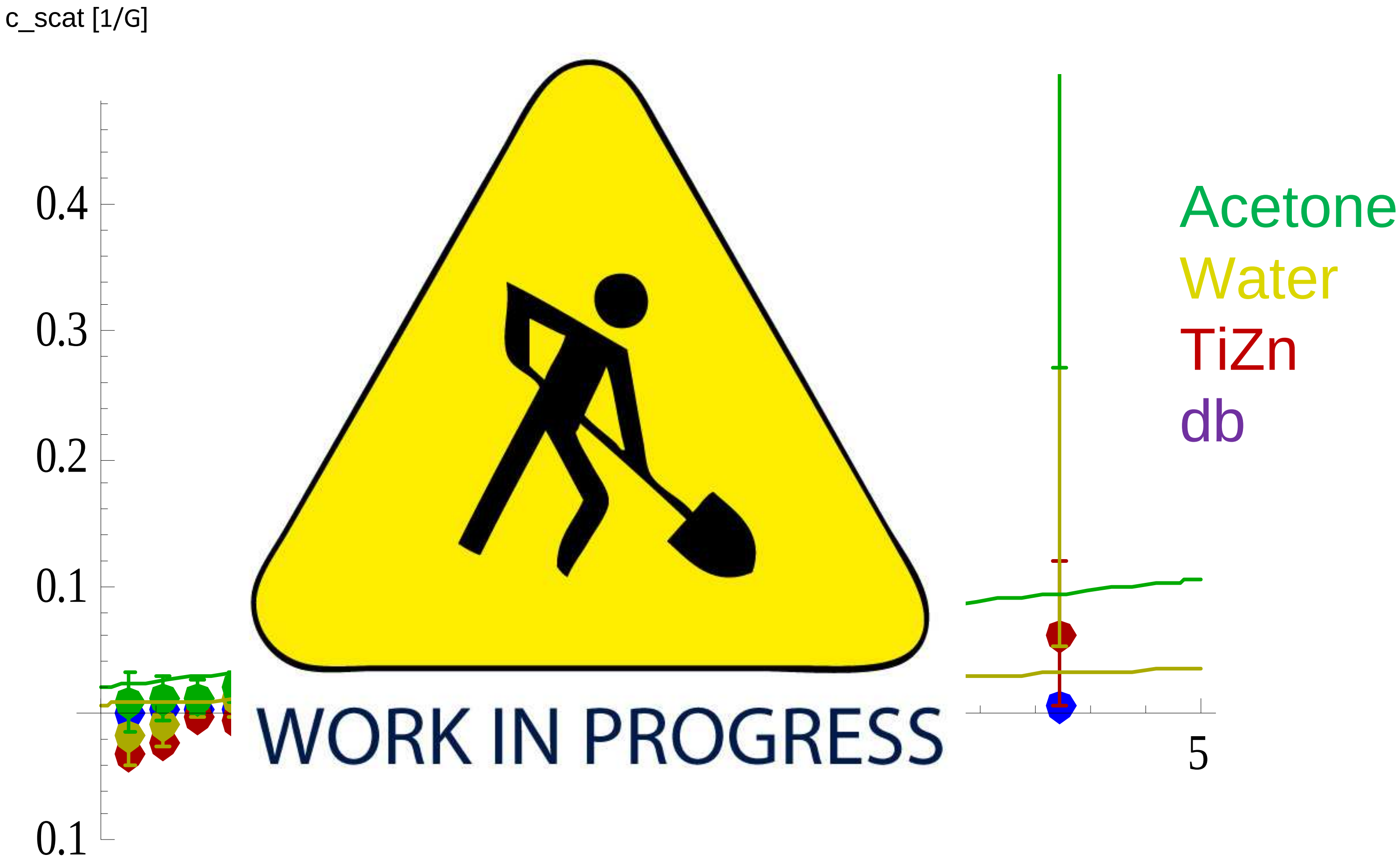
Current in TOFLAR-coil; “20” = 0.2A

Analysis/ Fitting:



Note: in the QE-limit c_scat should increase linear with lambda:
e^ -(c_scat(λ) B) = e^ -(Dq^2 tau) ∝ e^(-X λ B)

Analysis/ Fitting:



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Summary

Two possible applications:

- Addon for Neutron Spin Echo/ MIEZE instruments
- Stand alone instrument (high intensity, med resolution) for quasi-elastic scattering

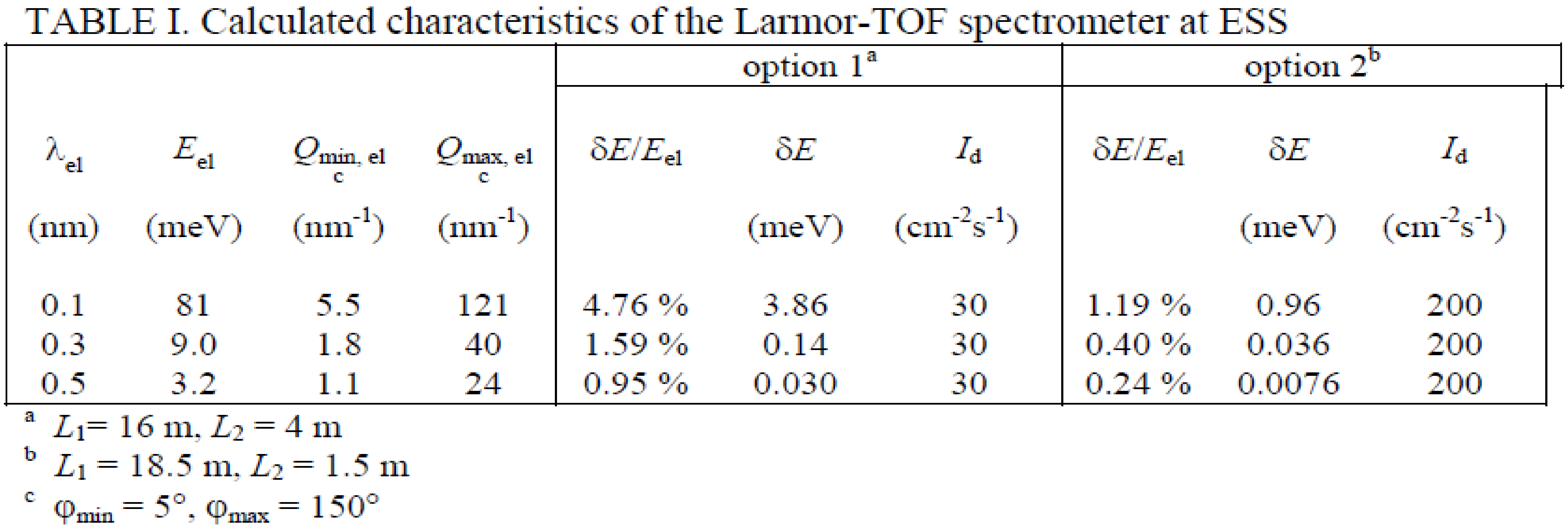


TABLE I. Calculated characteristics of the Larmor-TOF spectrometer at ESS

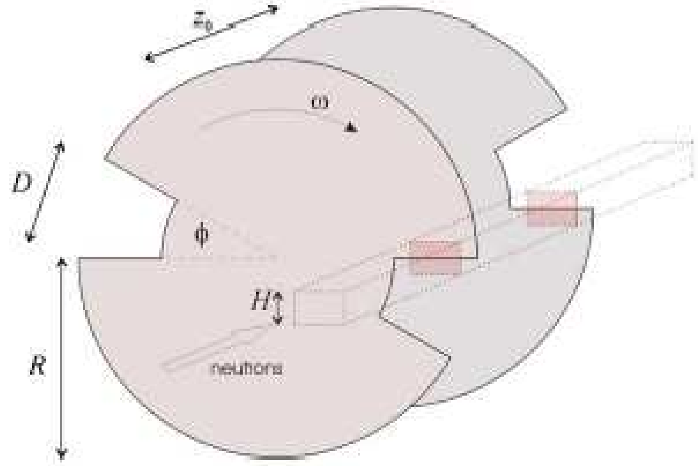
				option 1[a]			option 2[b]		
λ_{el} (nm)	E_{el} (meV)	$Q_{\text{min, el}}$[c] (nm^{-1})	$Q_{\text{max, el}}$[c] (nm^{-1})	$\delta E/E_{\text{el}}$	δE (meV)	I_{d} ($\text{cm}^{-2}\text{s}^{-1}$)	$\delta E/E_{\text{el}}$	δE (meV)	I_{d} ($\text{cm}^{-2}\text{s}^{-1}$)
0.1	81	5.5	121	4.76 %	3.86	30	1.19 %	0.96	200
0.3	9.0	1.8	40	1.59 %	0.14	30	0.40 %	0.036	200
0.5	3.2	1.1	24	0.95 %	0.030	30	0.24 %	0.0076	200

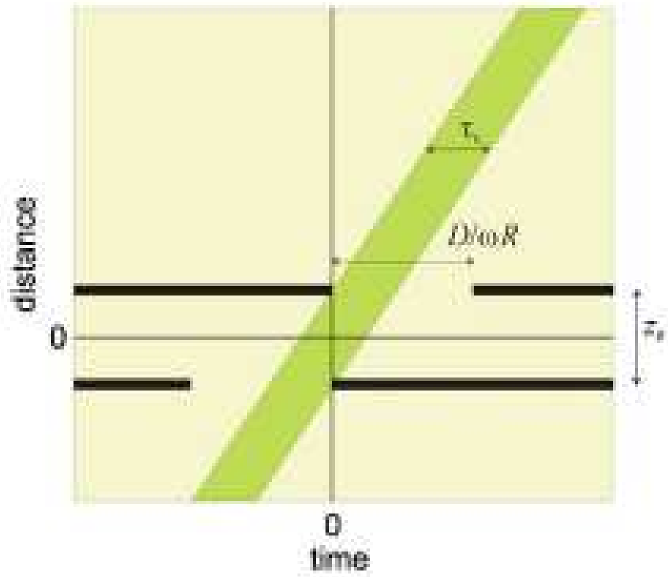
[a] $L_1 = 16$ m, $L_2 = 4$ m

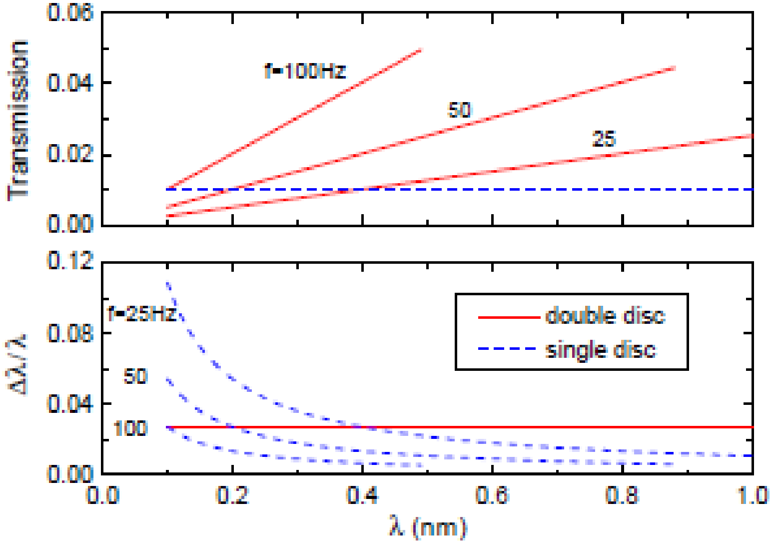
[b] $L_1 = 18.5$ m, $L_2 = 1.5$ m

[c] $\varphi_{\text{min}} = 5°$, $\varphi_{\text{max}} = 150°$

Doppel-Chopper







$$\left(\frac{\Delta\lambda}{\lambda}\right)^2 \approx 0.68^2\left(\left(\frac{z_0}{L}\right)^2+\left(\frac{D}{\omega R\, tof}\right)^2\right)$$

$$\approx (2\%)^2$$

- From the ToF we “know” the neutron wavelength

Data Cooking with Recipe