Part 2

Forschungszentrum Jülich

Neutron Spin-echo Spectroscopy

Part2: ...at a pulsed neutron source

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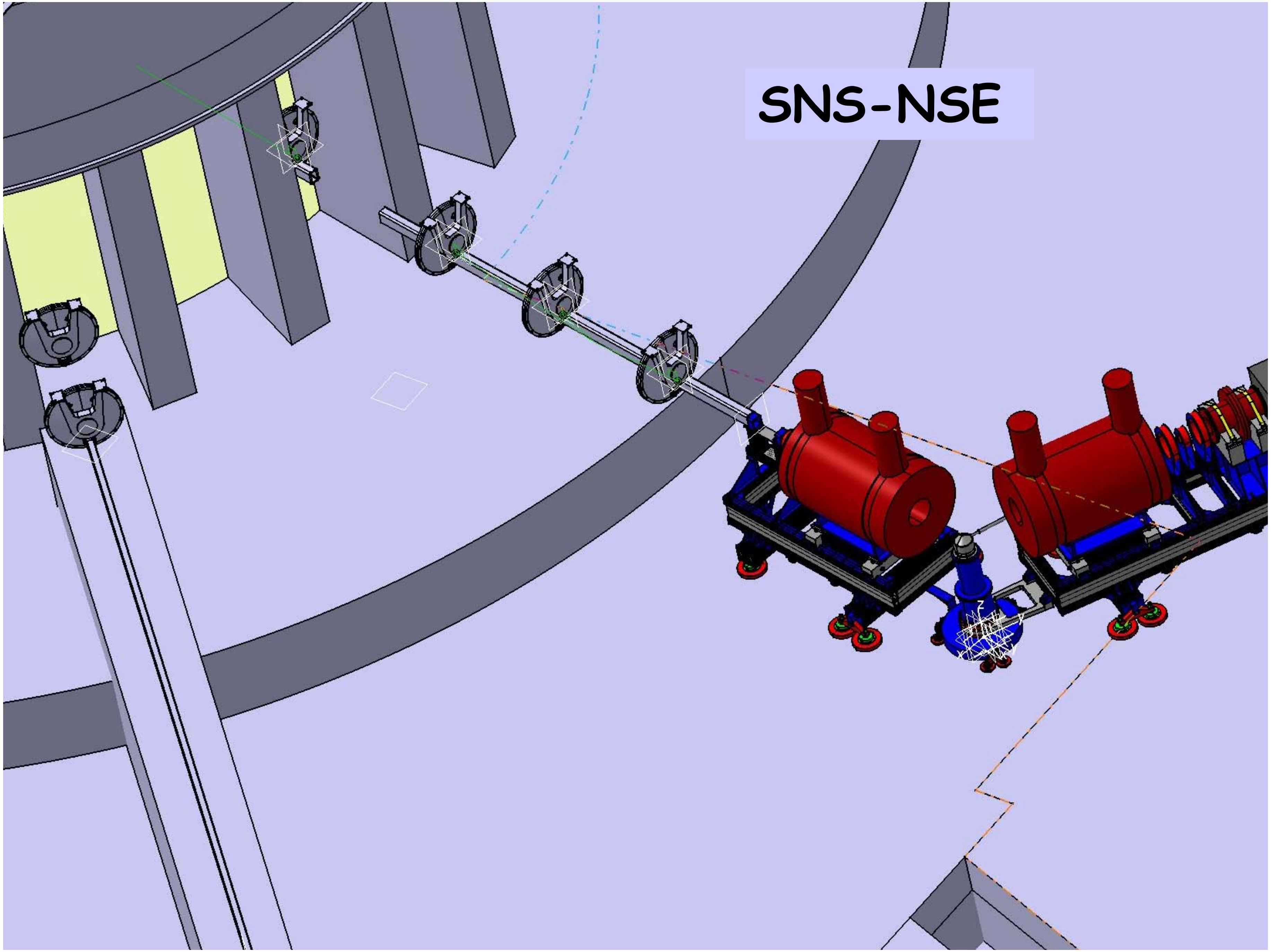
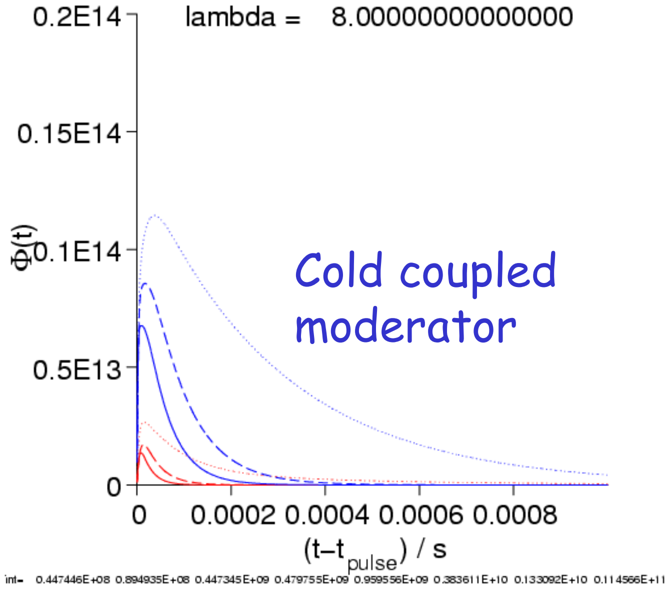
Neutron instrumentation for Soft matter at pulsed sources

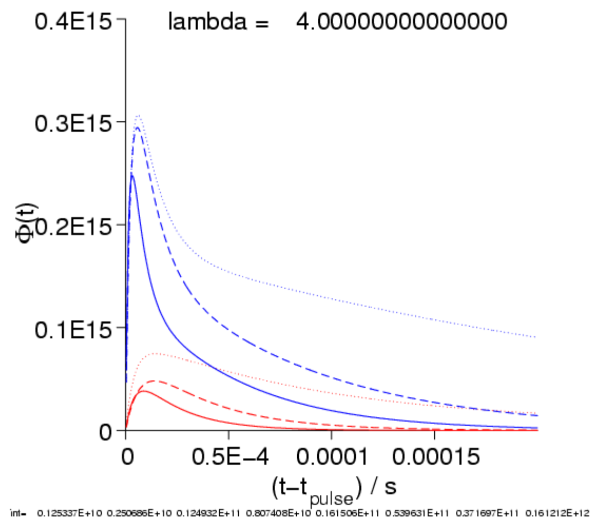
- SANS (KENS, IPNS, LANSCE, ISIS …. SNS …
- REFLECTOMETER (KENS, ISIS, …. SNS …
- NSE (**none yet**… SNS, ISIS-T2 ?

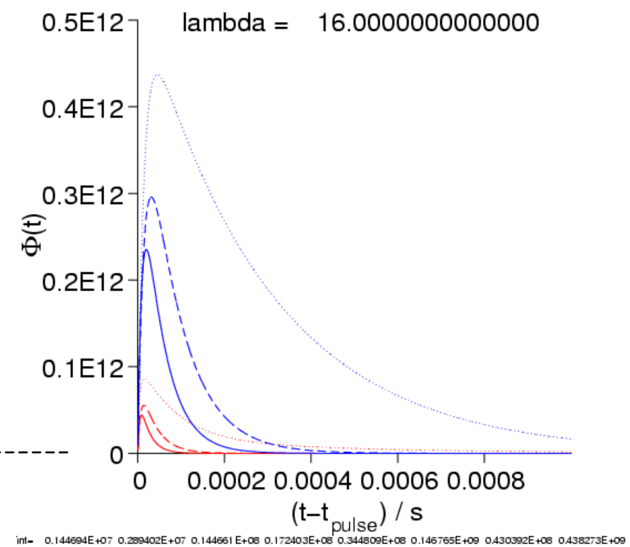

SNS-NSE

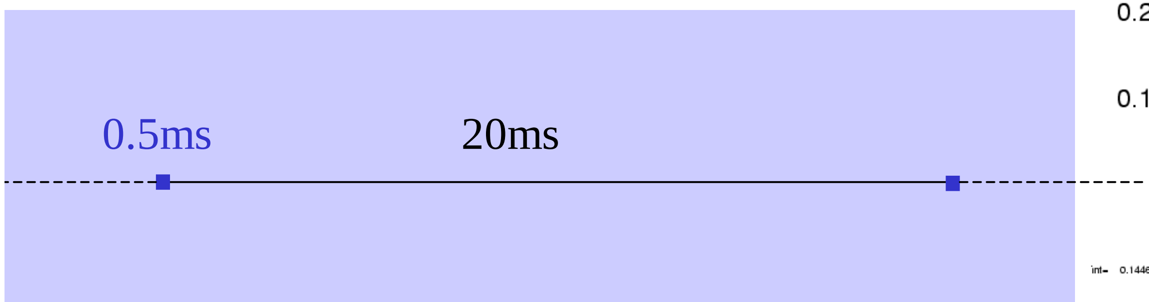
Pulse spallations source characteristics



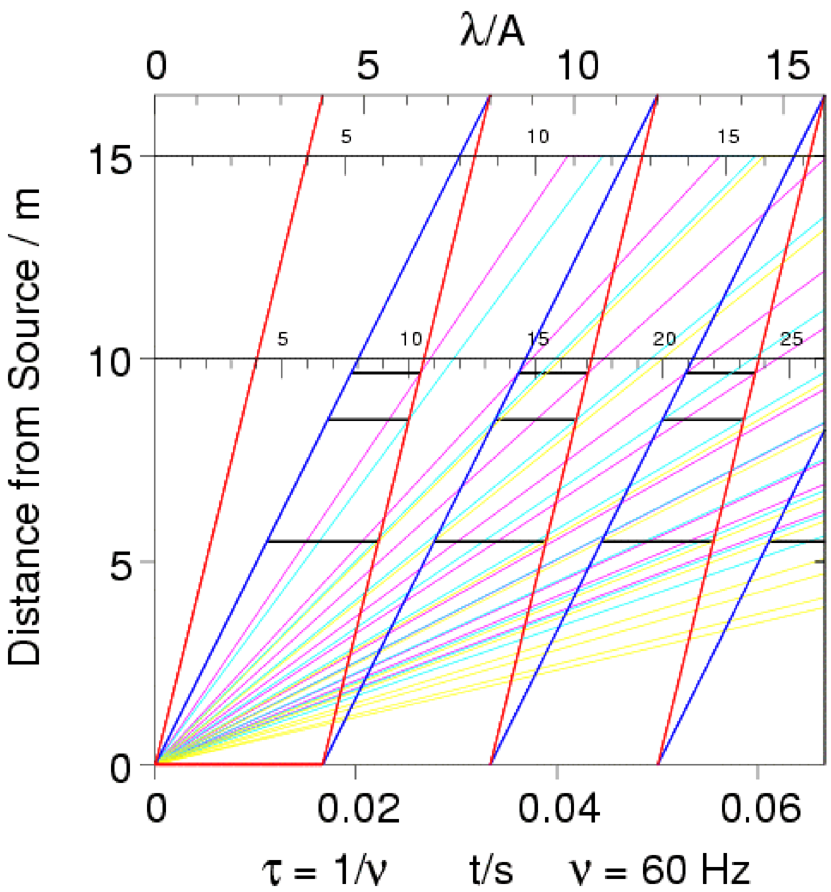
Cold coupled moderator

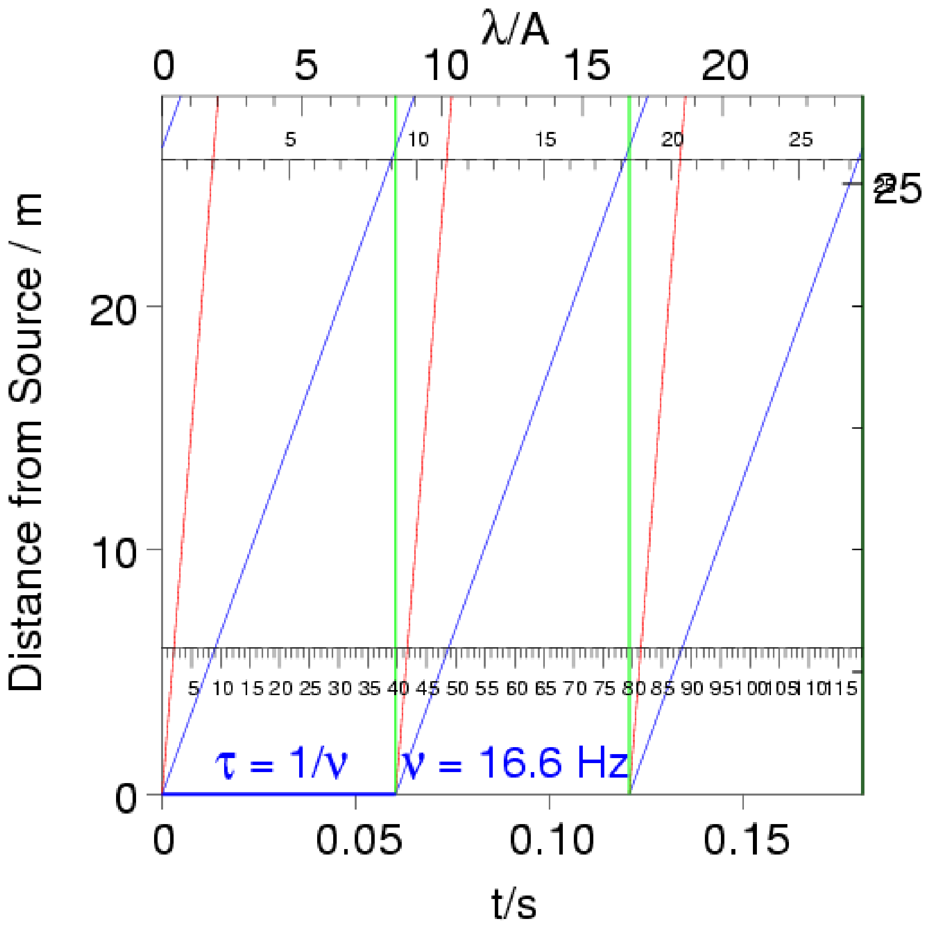




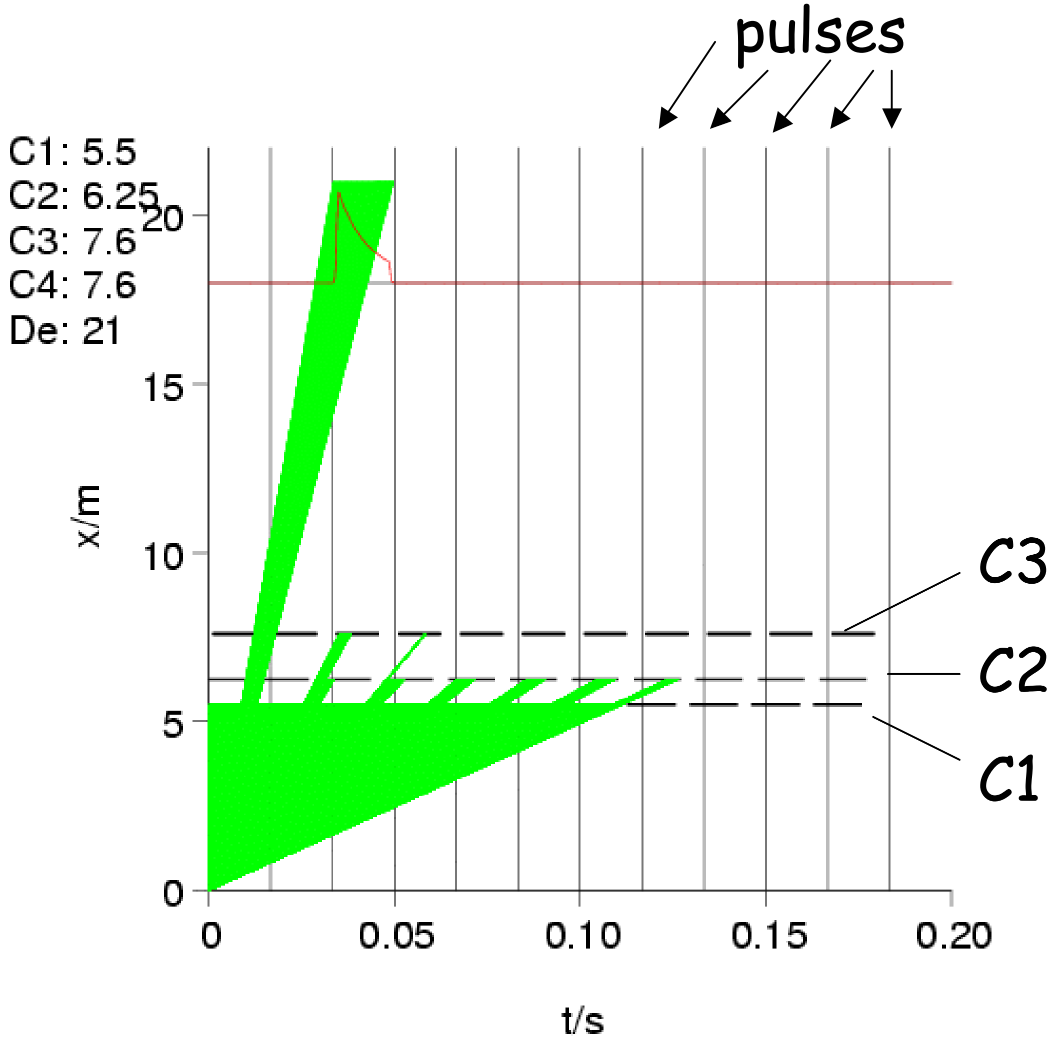


Repetition rate, distance and wavelength frame ….

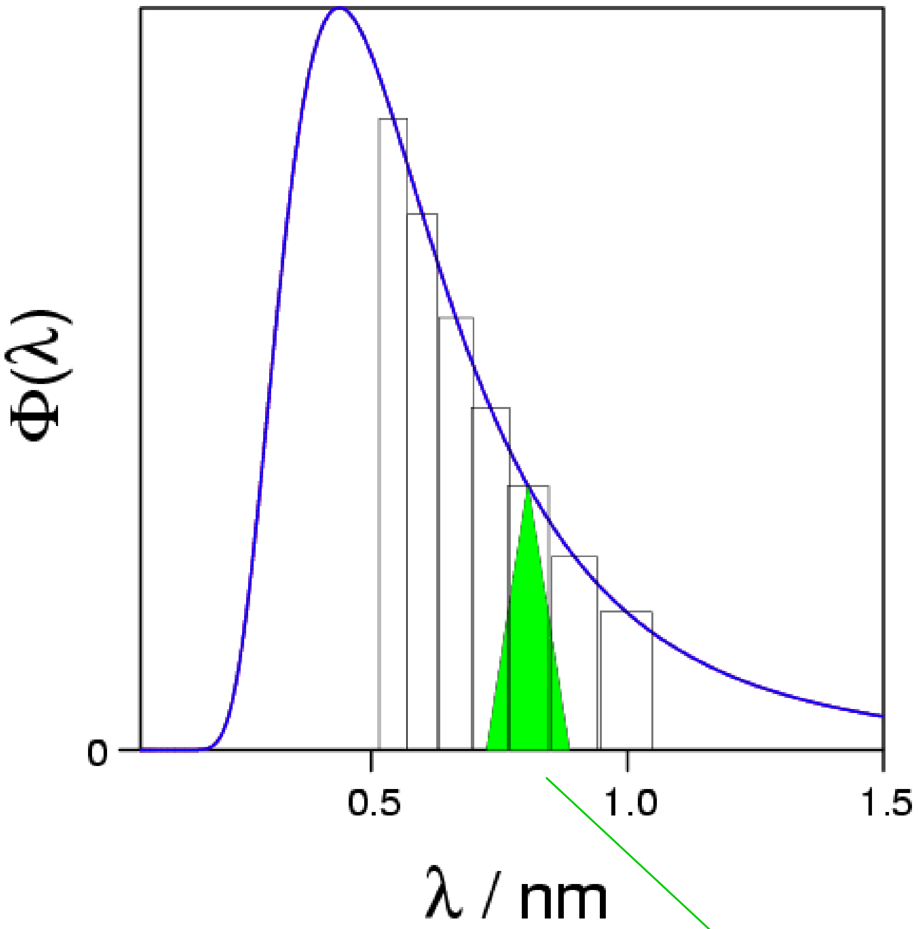




Chopper system is needed to avoid “frame overlap”



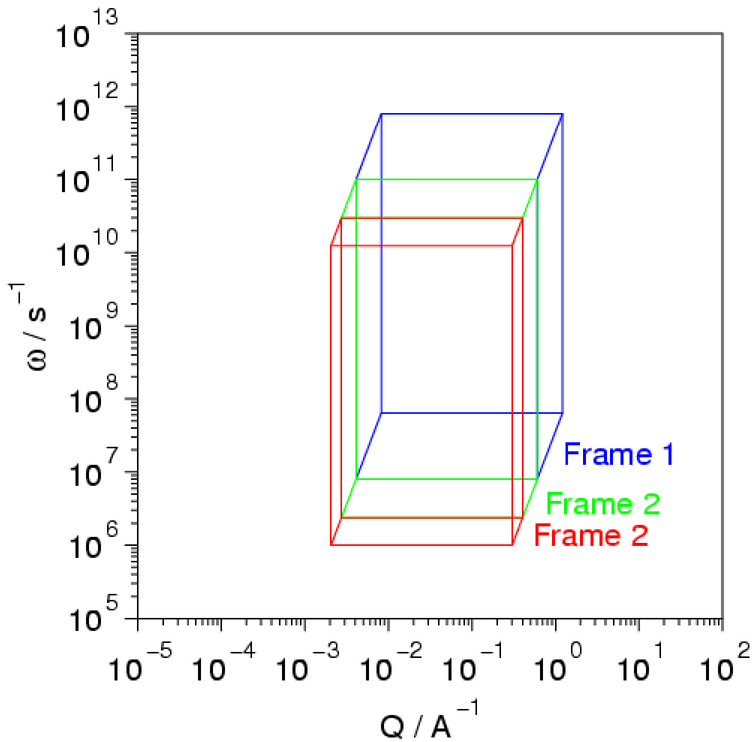
Possible gain factor due to multiple wavelength usage

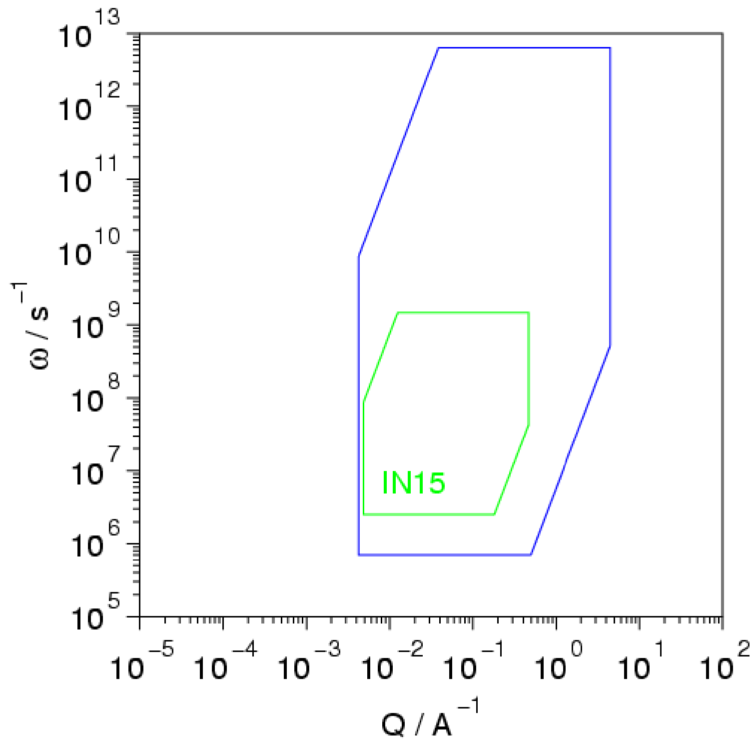


Selector FWHM 10%

$$g_0 = \frac{\ln(\lambda_{\max}/\lambda_{\min})}{w}$$

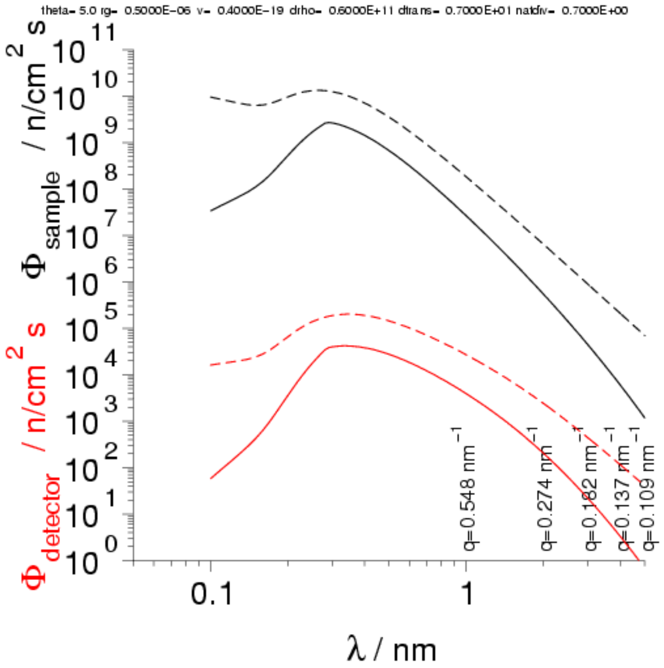
NSE range and resolution as function of wavelength frame

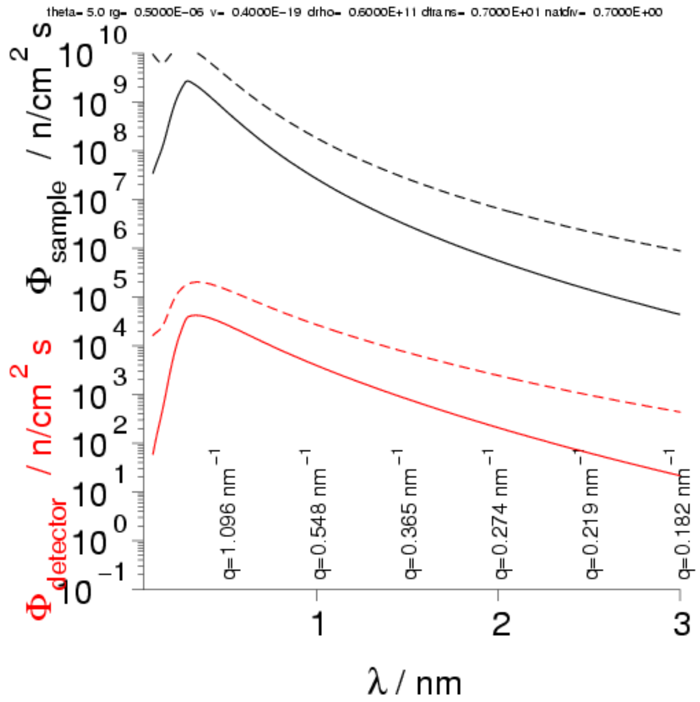


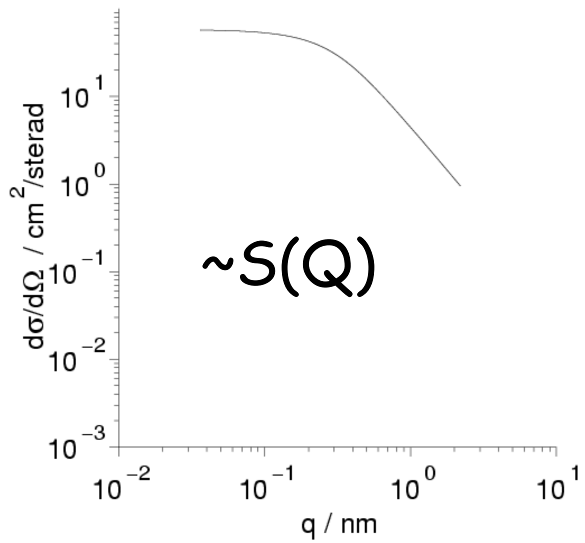


Wavelength "multiplexing": tradeoffs and limits…

$$Q \propto \lambda^{-1}$$
$$\Gamma(Q) \propto Q^{2\cdots 4} \propto \lambda^{-2\cdots -4}$$
$$\Phi(\lambda) \propto \lambda^{-5}$$
$$d\sigma(Q)/d\Omega \propto Q^{-\nu} \propto \lambda^{\nu}$$
$$t_{\max} \propto \lambda^{3}$$







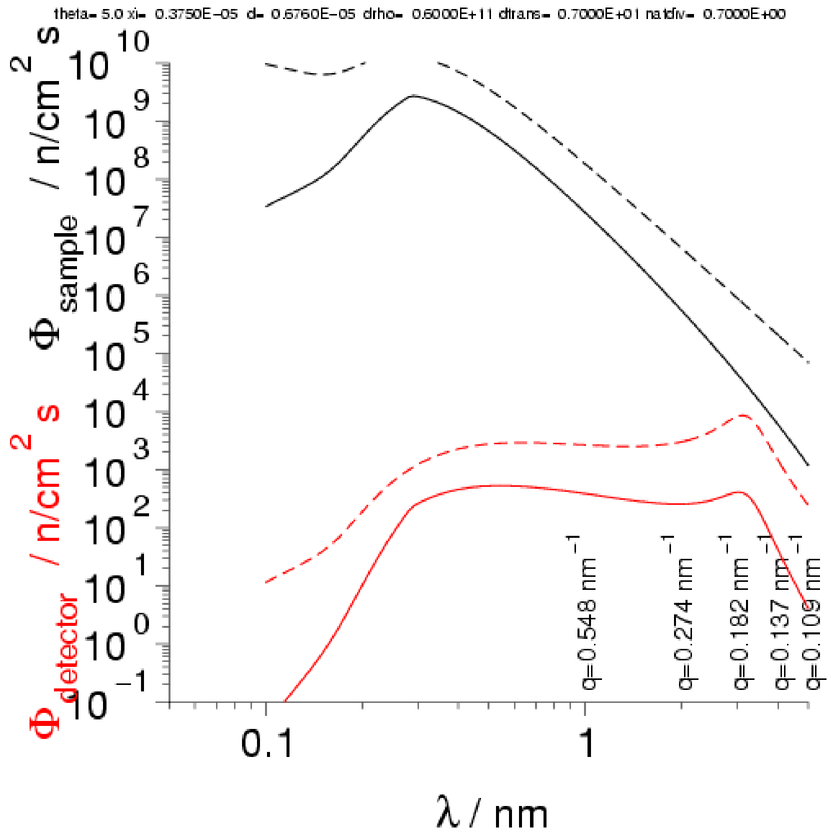
Example: intensity from a typical polymer coil (Debye function) on the detector as function of $\lambda(t)$

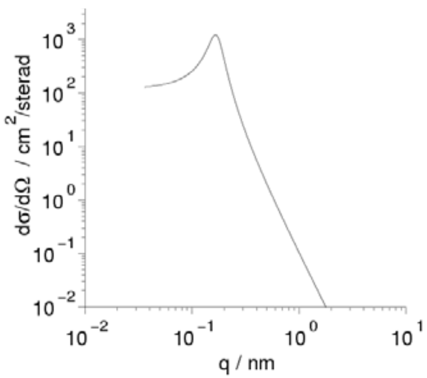
~S(Q)

Example 2:

Microemulsion scattering ,

Teubner-Strey S(Q)

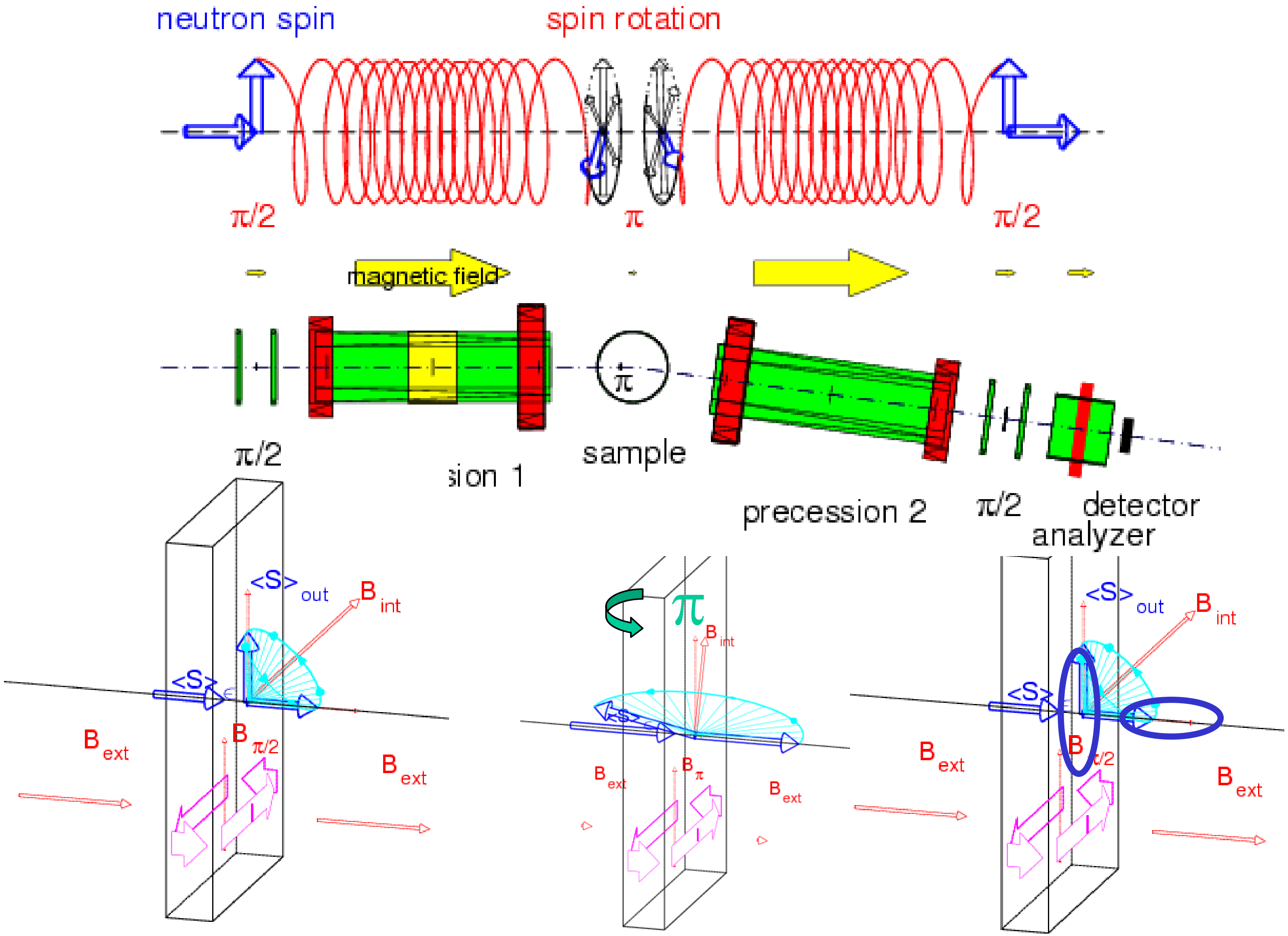




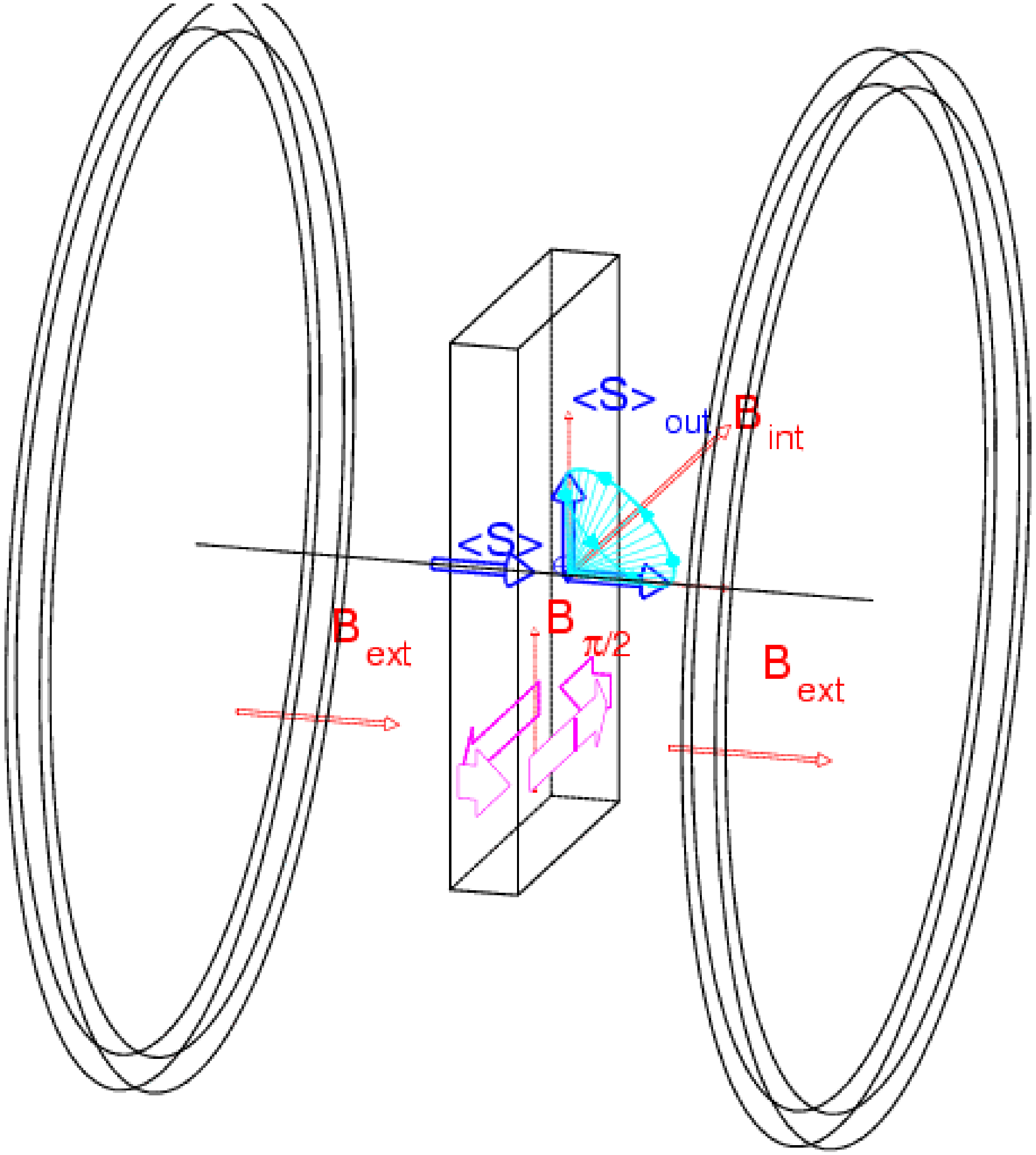
Technical problems due to fast changing incoming wavelength:

- flipper function depends on λ
- detector signal: $S(Q[\lambda\{t\}], \tau = \alpha\, \lambda\{t\}^3)$
- polarizer/analyzer must be “broadband“

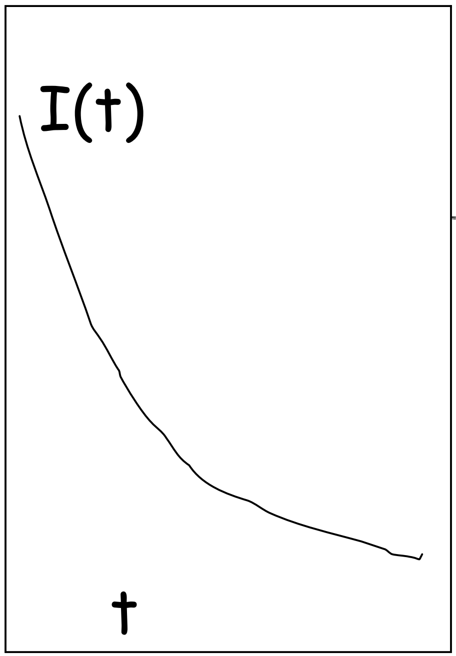
NSE spectrometer: technical aspects



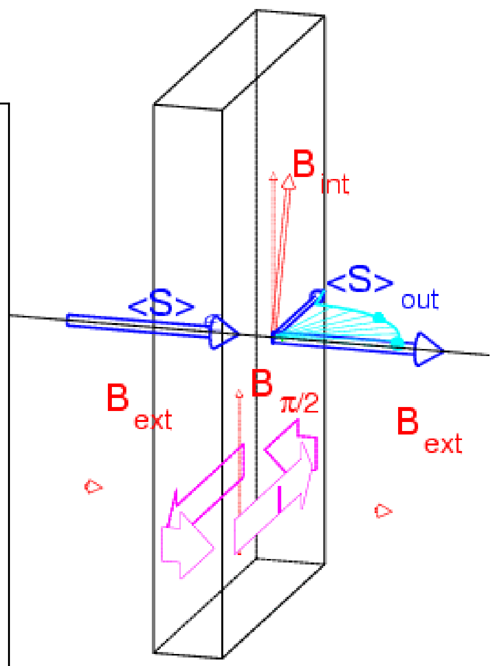
“Normal” operation setup of the π/2-flipper

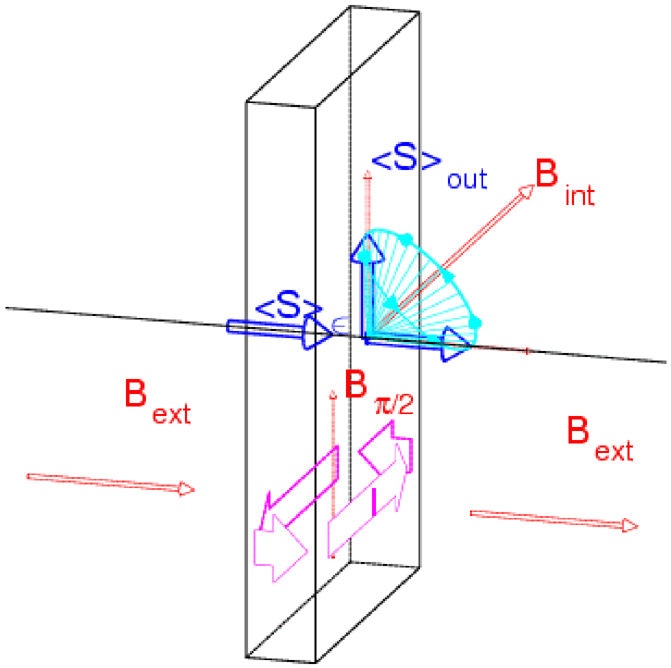


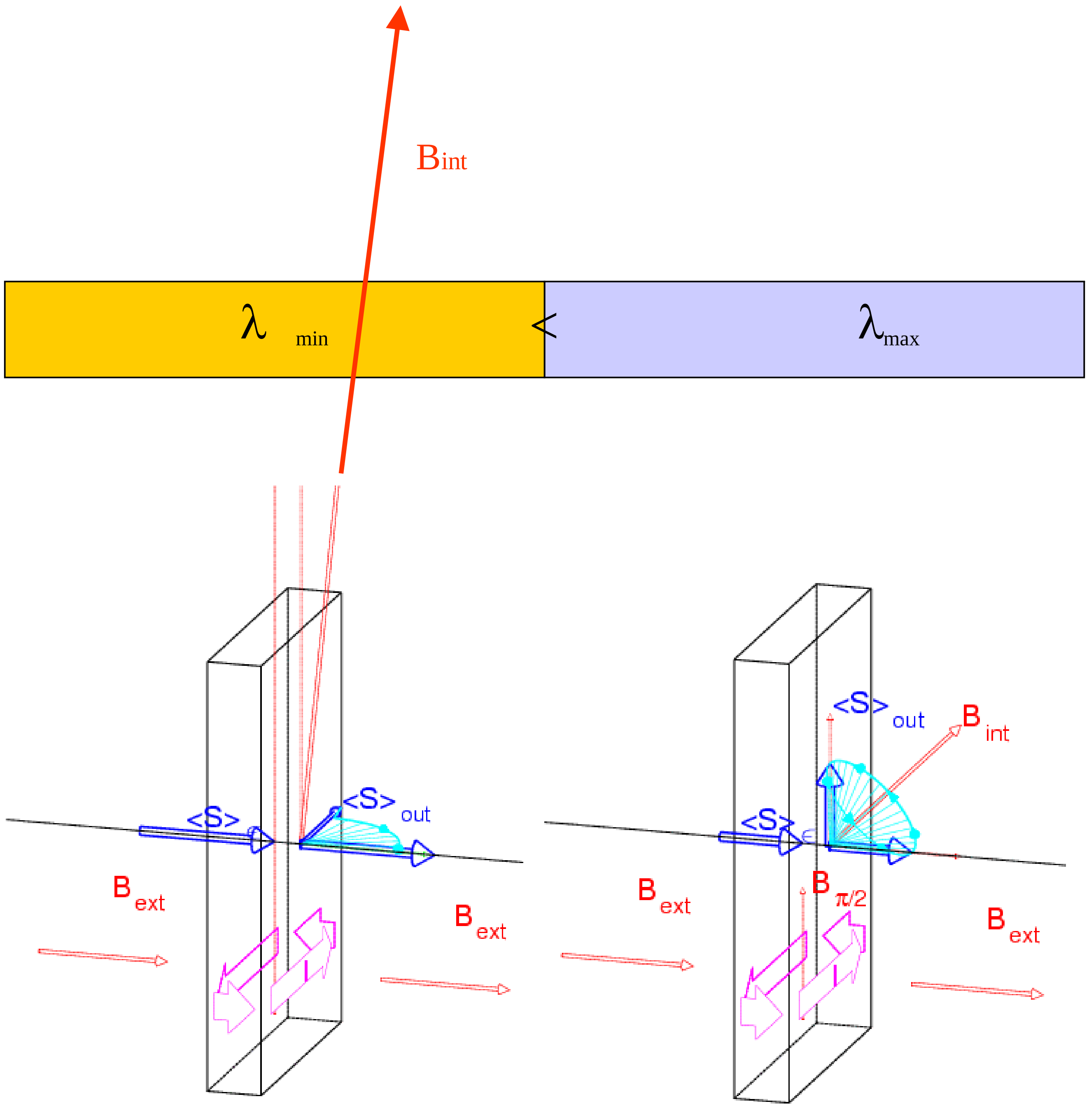
Variation of flipper current (increase at low wavelength) only [B. Farago, ILL]



$\lambda_{min} < \lambda_{max}$

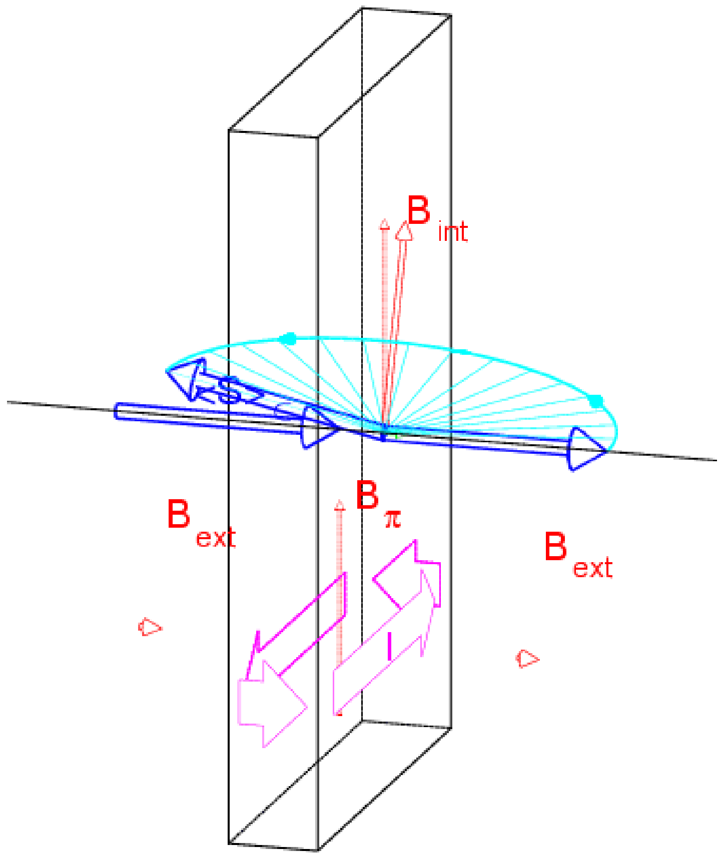




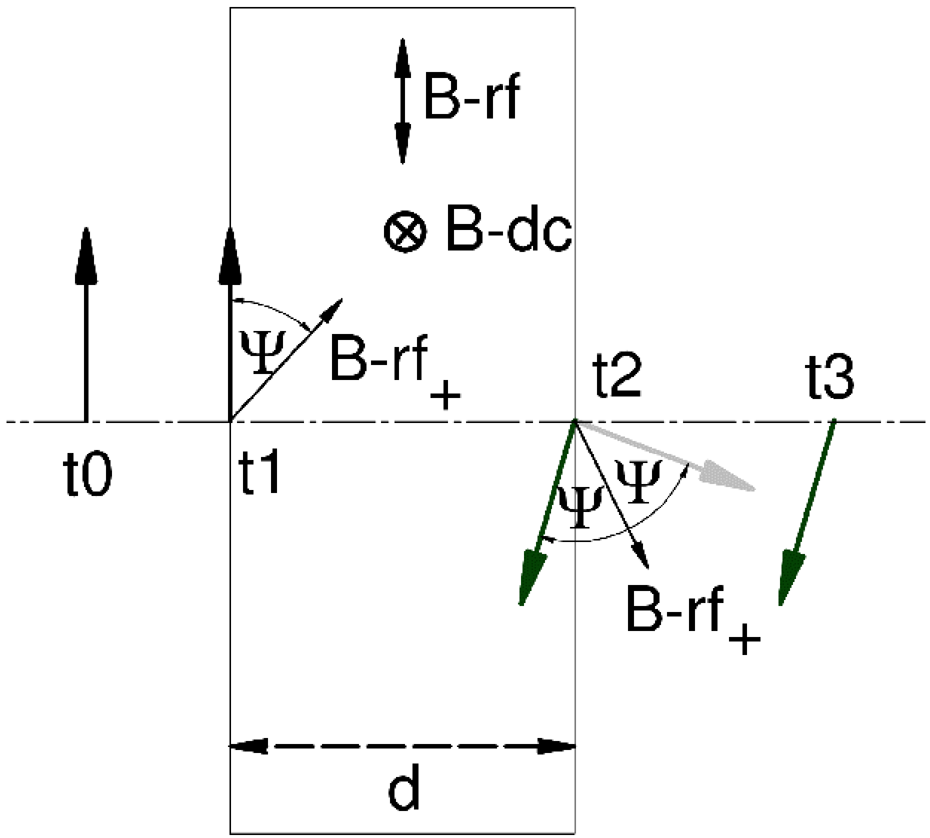


Bint
λ min
<
λmax
<S>
<S> out
B ext
B ext
<S>
<S> out
B int
B π/2
B ext
B ext

Pi-Flipper

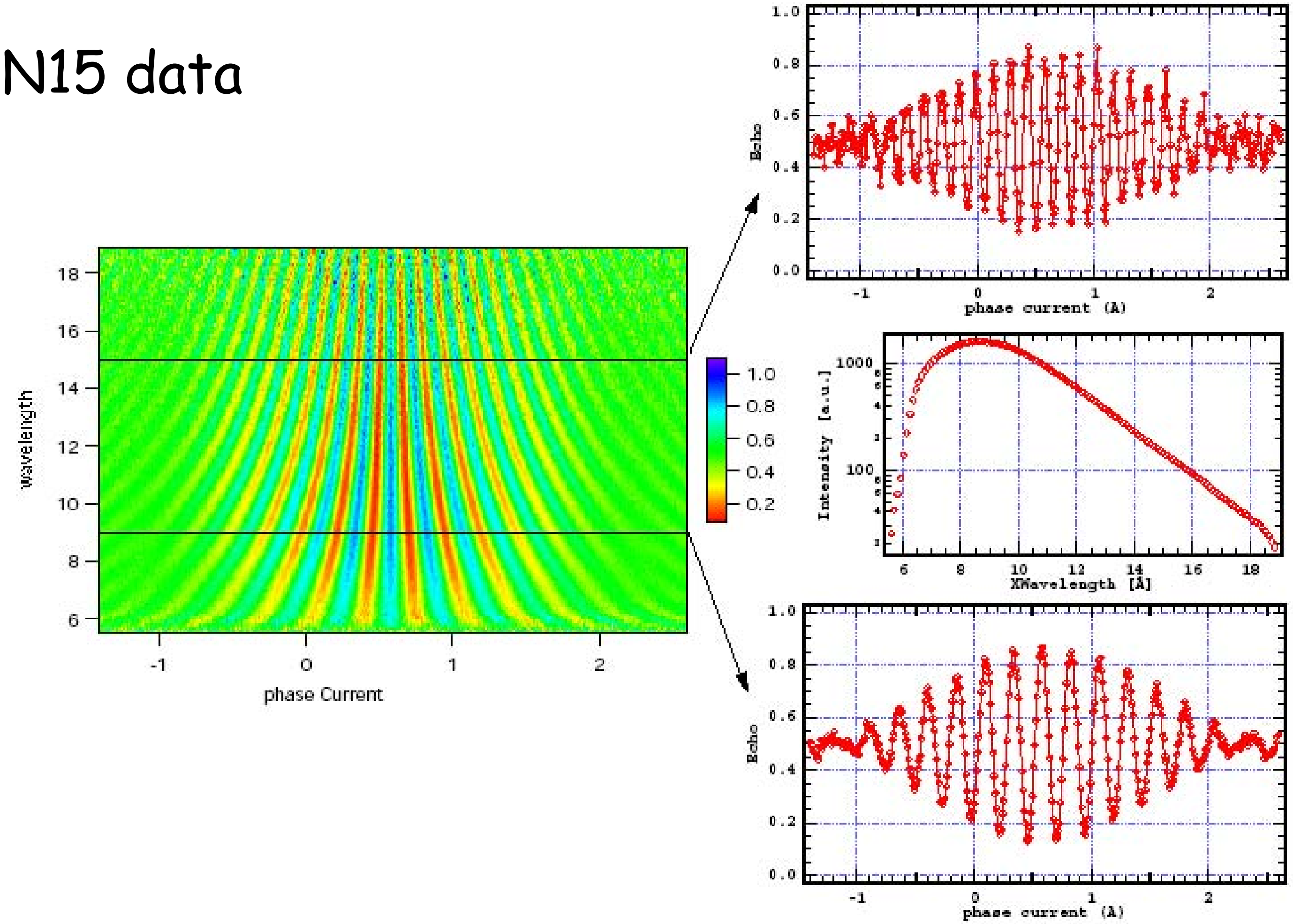


In a resonance NSE spectrometer the varying wavelength require (only) the time dependent reduction of the RF-amplitude.



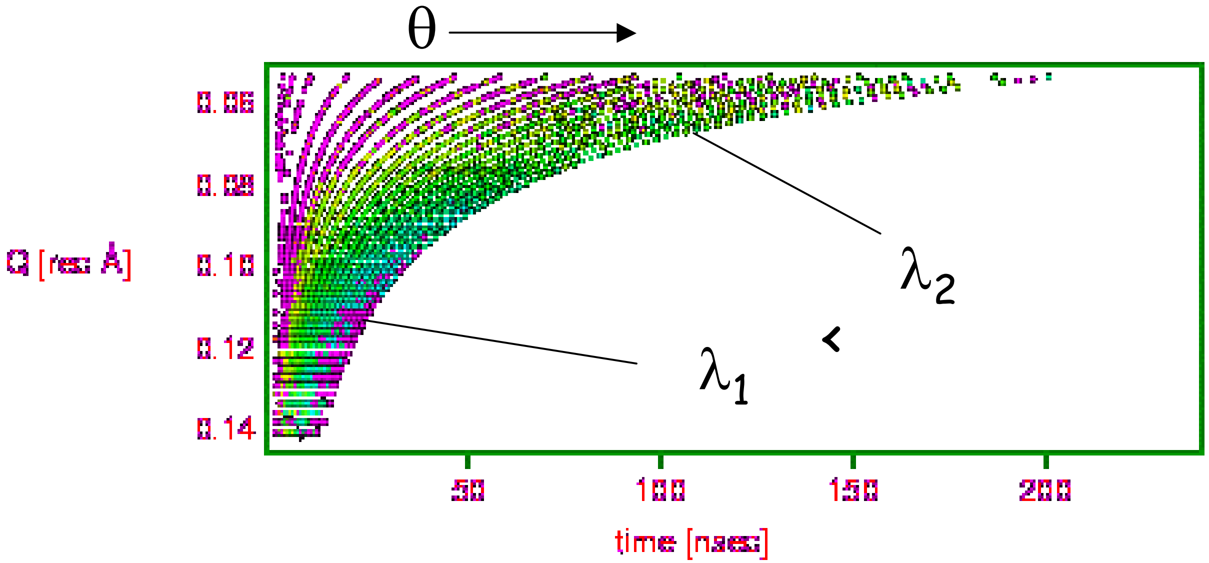
Detection as function of time-of-flight → $\lambda(t)$

IN15 data

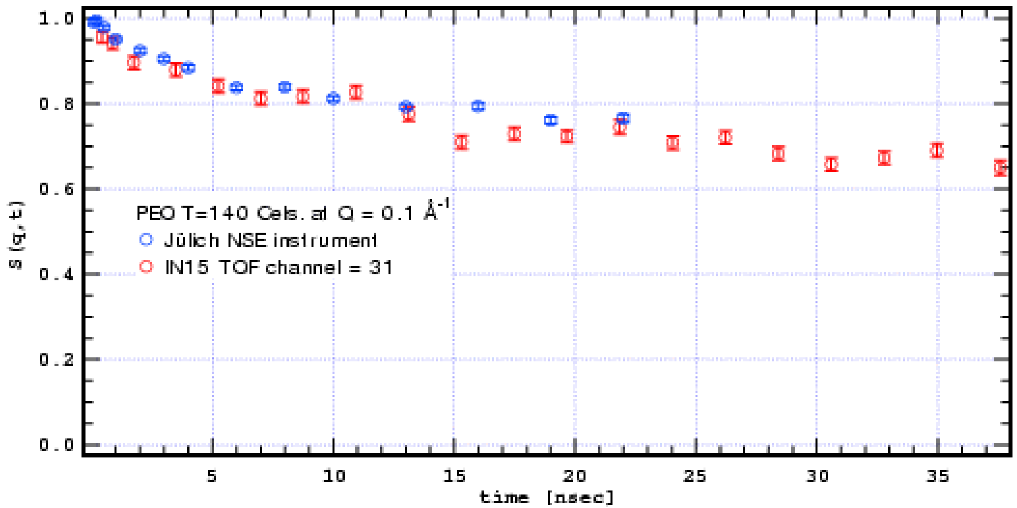


Bela Farago, ILL (see “Neutrons Spin Echo Spectroscopy, Eds/ F. Mezei, C. Pappas, T. Gutberlet, Springer 2003

Selection of a specific (Q,t) via software



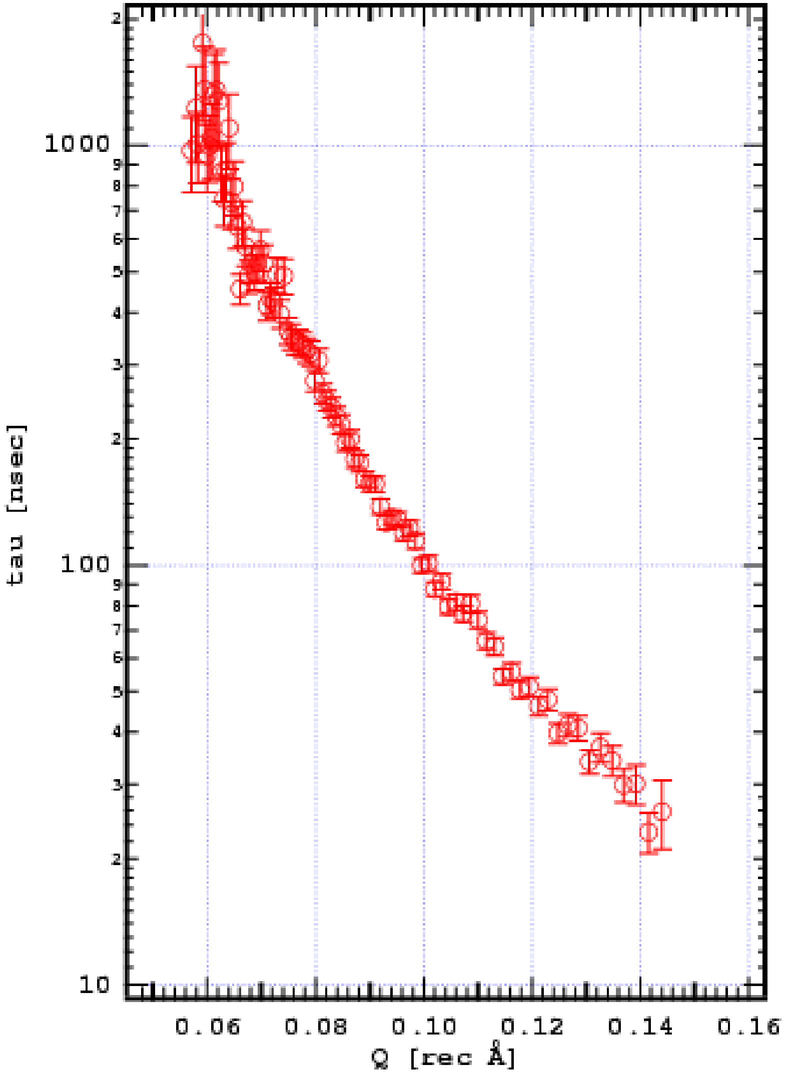
$S(Q,\tau)/$
$S(Q)$



Bela Farago, ILL

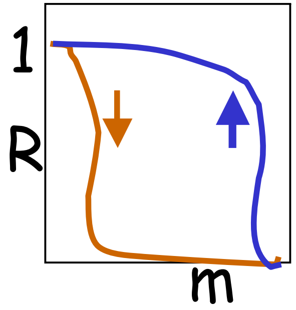
Combination of various λ yields a large dynamic range

1/relaxation rate

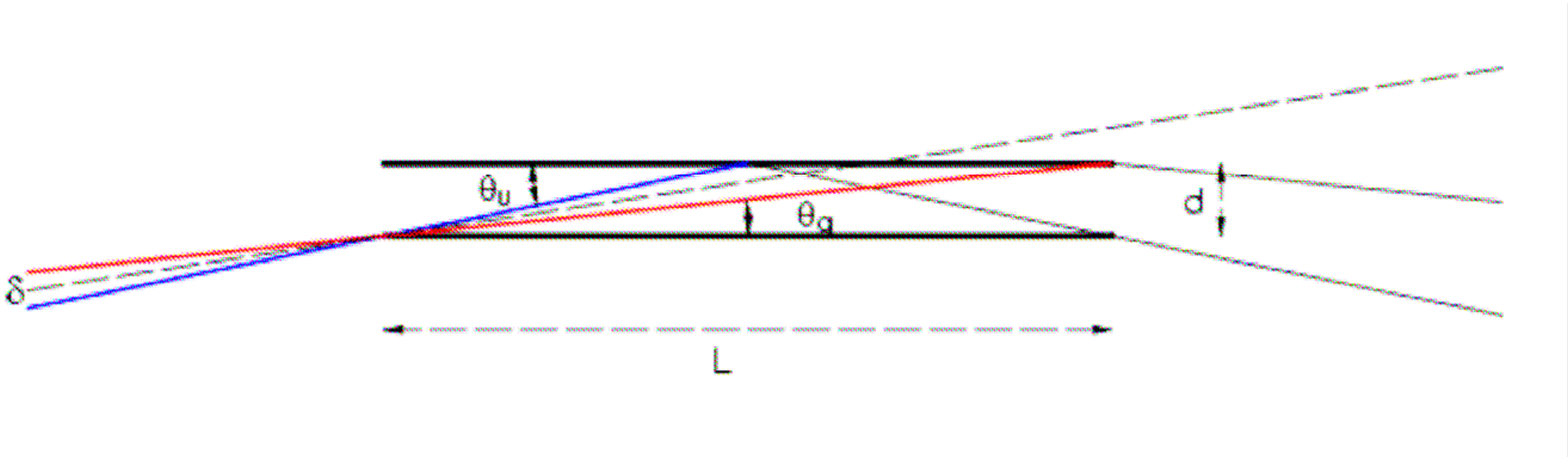


Bela Farago, ILL

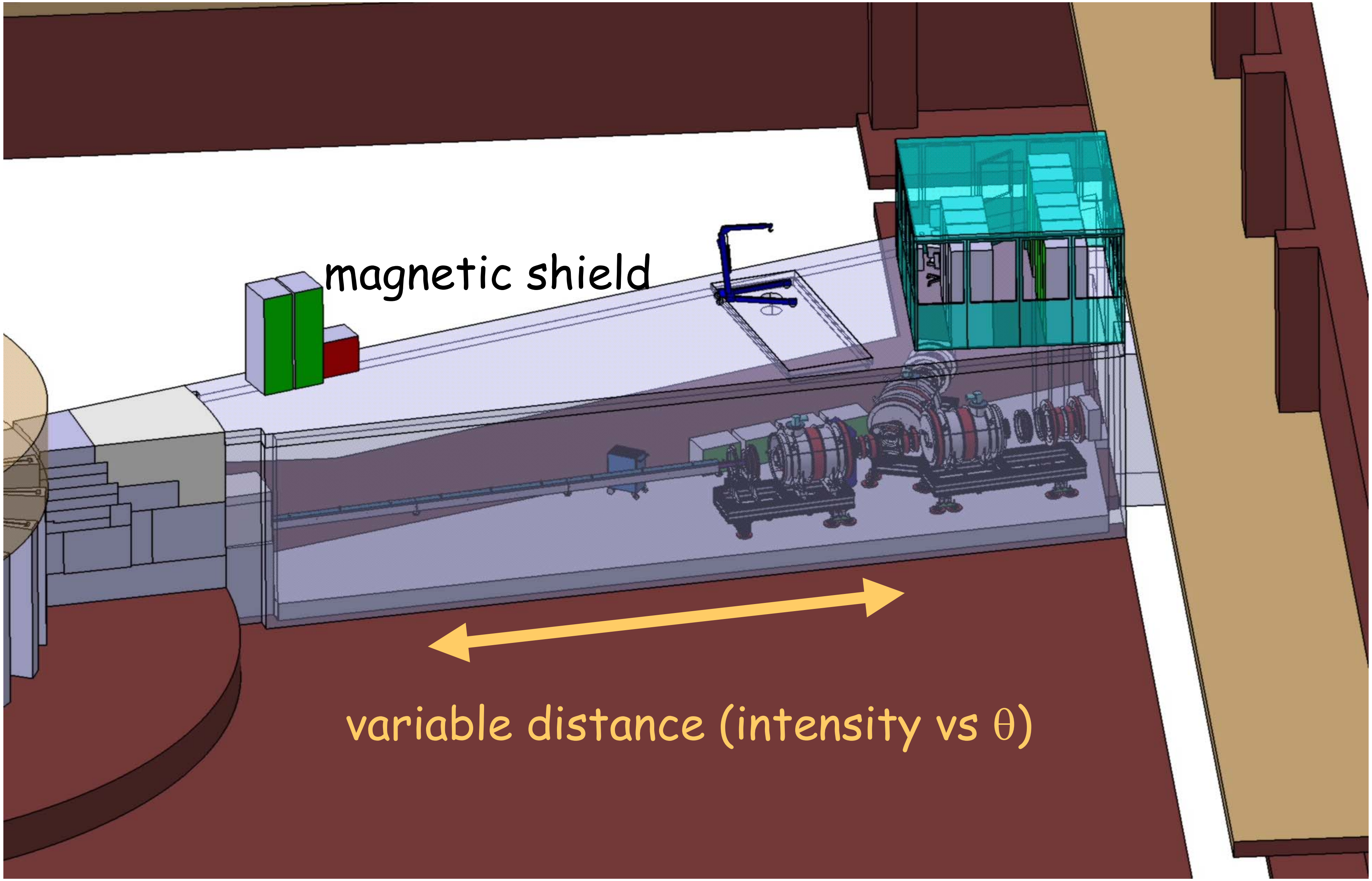
Broadband polarizers/analyzers (implicitly assumed)



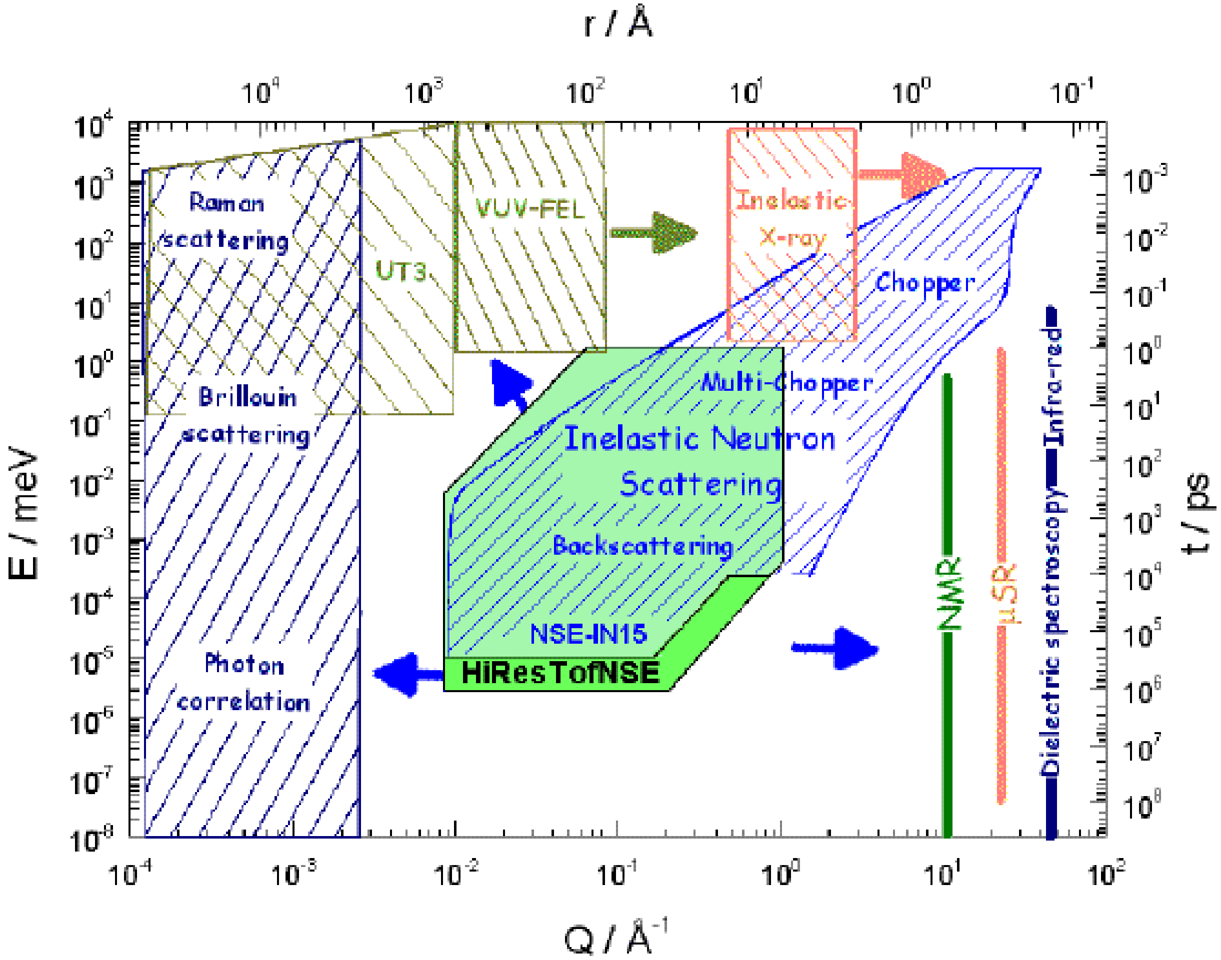
- **Large m (3..4) magnetic multilayers !**
- **readjustment/change depending on λ/t-frame**
- ^{3}He-polarizers (future ?)

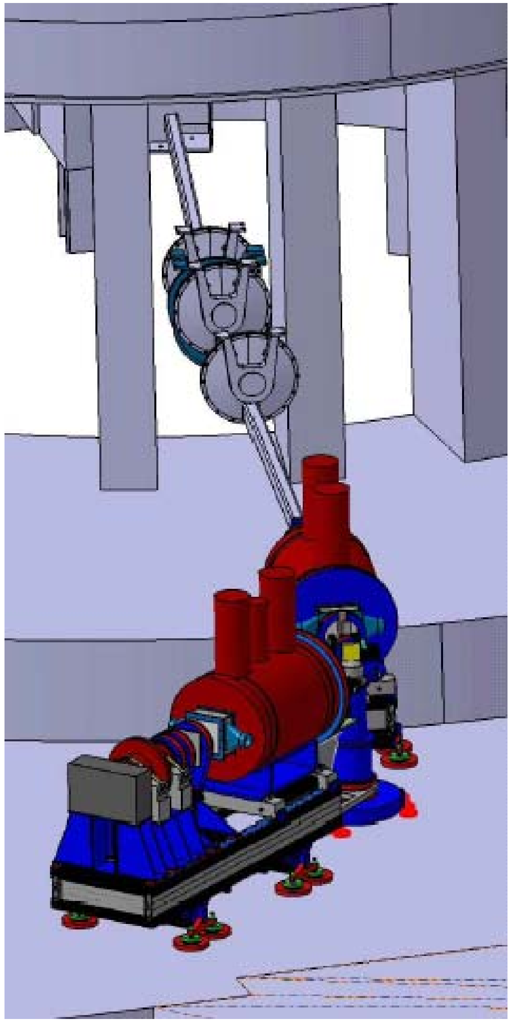


First NSE instrument at a pulsed source will be build by FZJ at the SNS in Oak Ridge



Ranges (to be) covered





SNS-NSE: 1ps < τ < 1μs