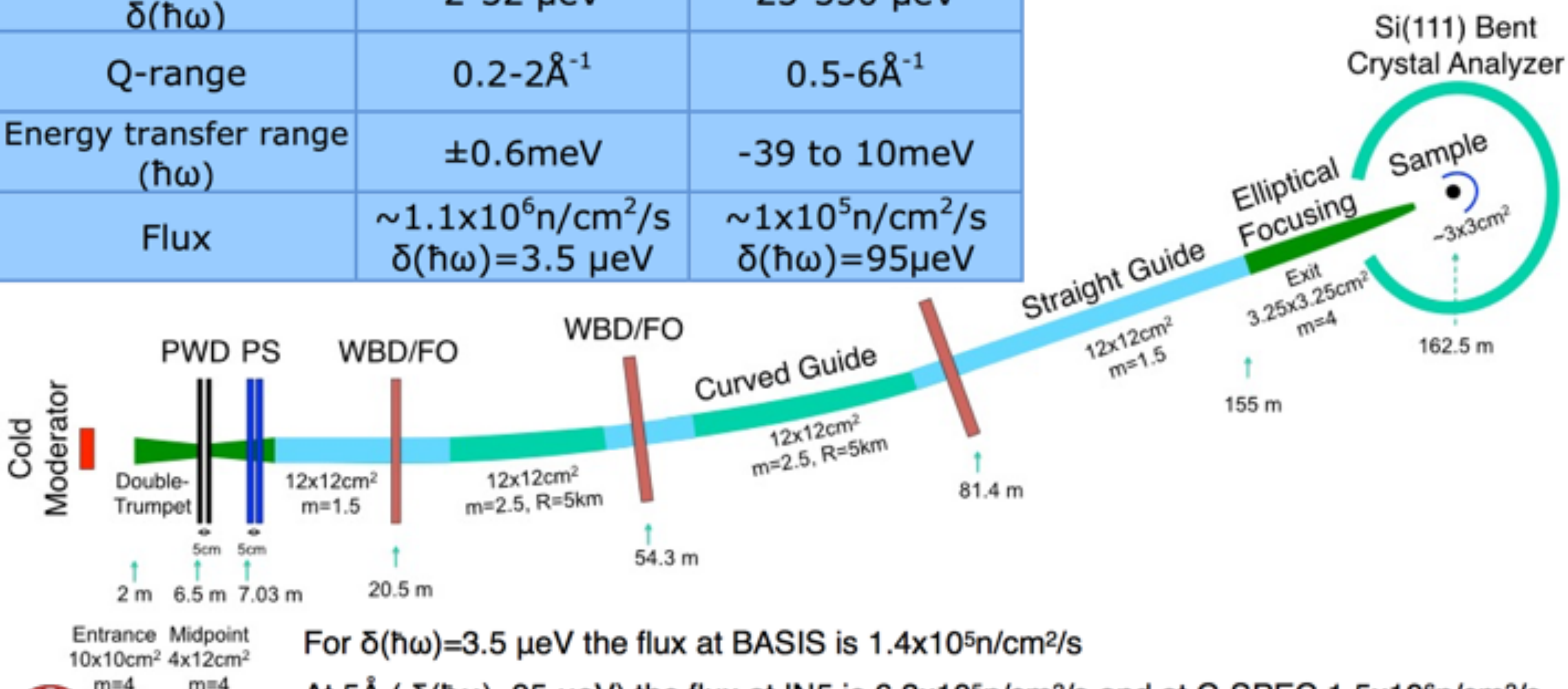
Disentangling time distribution

Analyzer crystals	Si(111) (6.267Å)	Si(333) (2.08Å)
energy resolution - δ(ħω)	2-32 μeV	25-350 μeV
Q-range	0.2-2$Å^{-1}$	0.5-6$Å^{-1}$
Energy transfer range (ħω)	±0.6meV	-39 to 10meV
Flux	~$1.1x10^6$n/cm^2/s δ(ħω)=3.5 μeV	~$1x10^5$n/cm^2/s δ(ħω)=95μeV



For δ(ħω)=3.5 μeV the flux at BASIS is $1.4x10^5$n/cm^2/s

At 5Å (δ(ħω)~95 μeV) the flux at IN5 is $6.3x10^5$n/cm^2/s and at C-SPEC $1.5x10^6$n/cm^2/s

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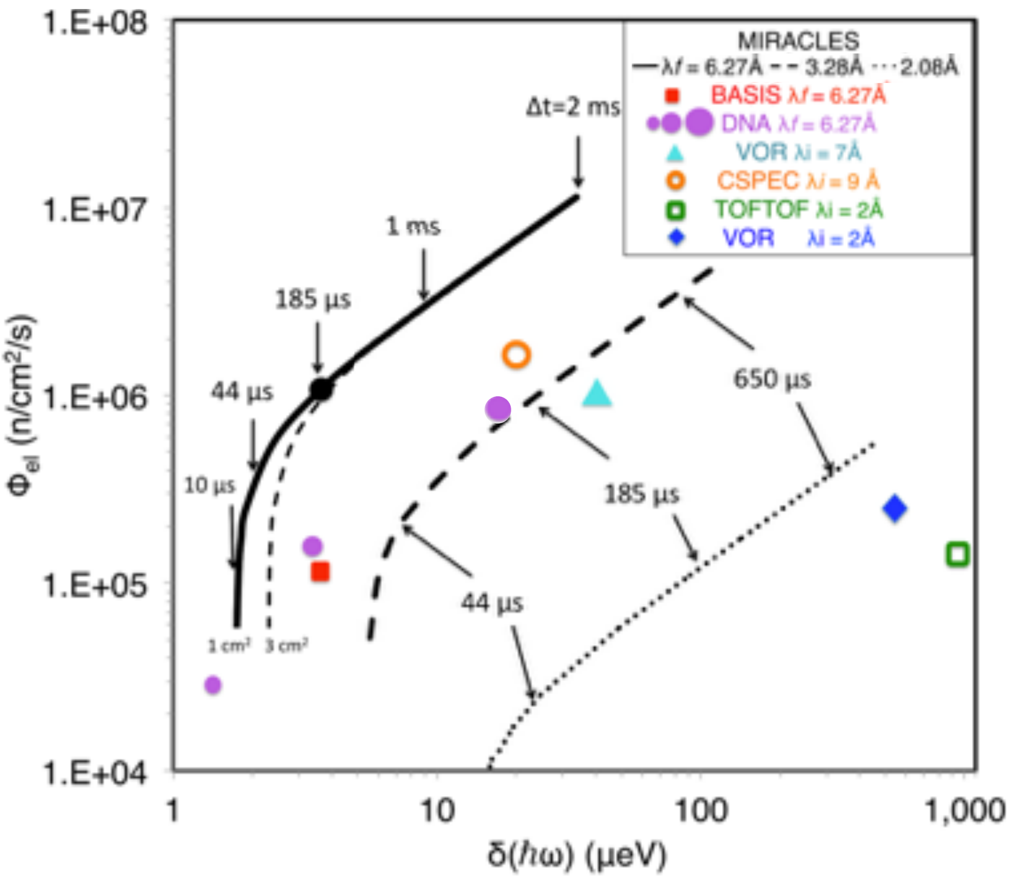
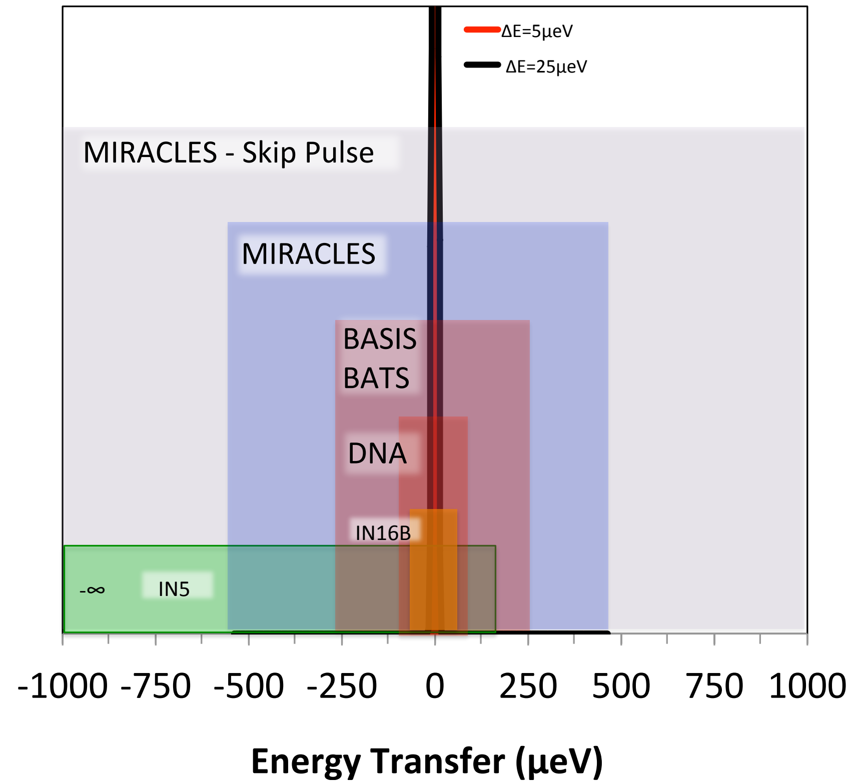
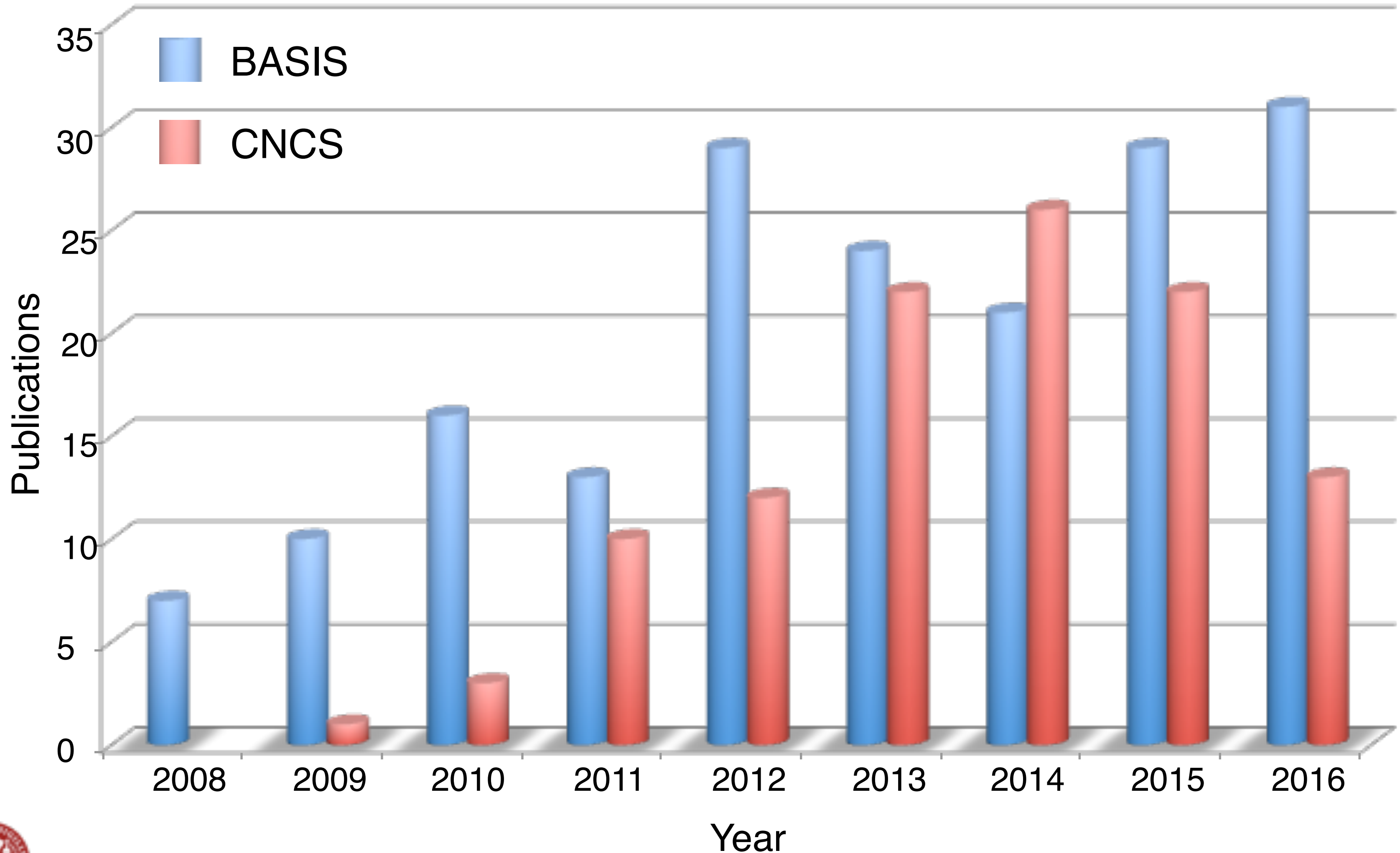
MIRACLES outstanding performance





Setting the world scenario: performance of two world leading spectrometers at SNS**



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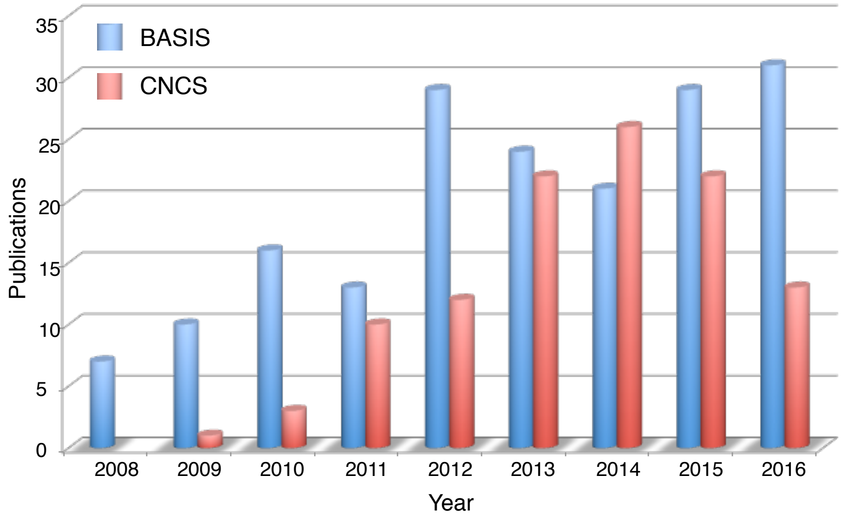
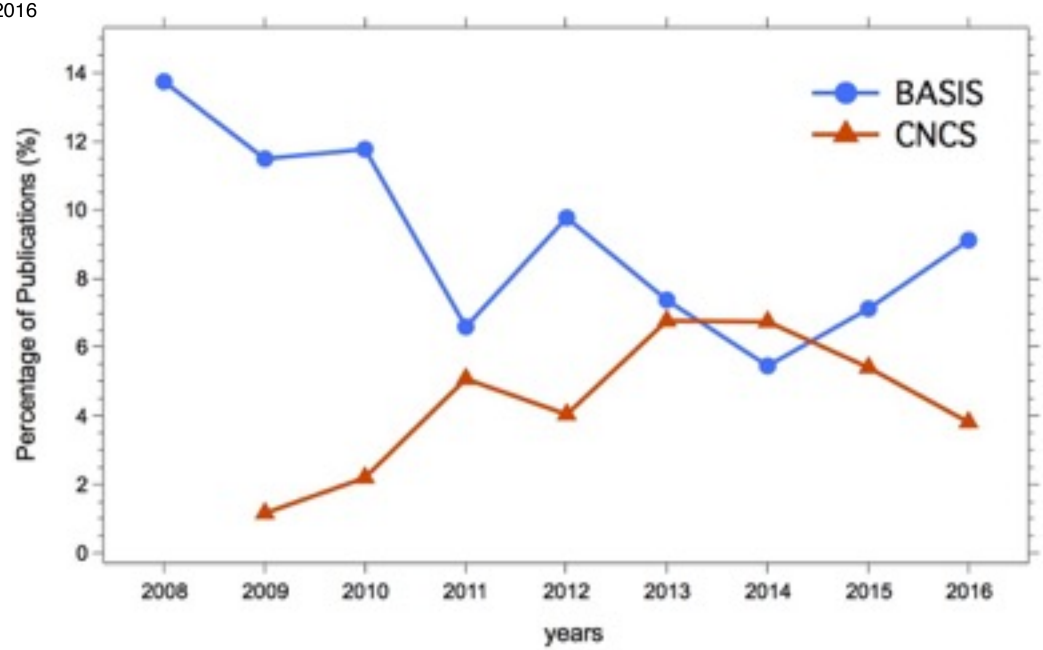
**https://neutrons.ornl.gov/publications

Setting the world scenario: performance of two world leading spectrometers at SNS**

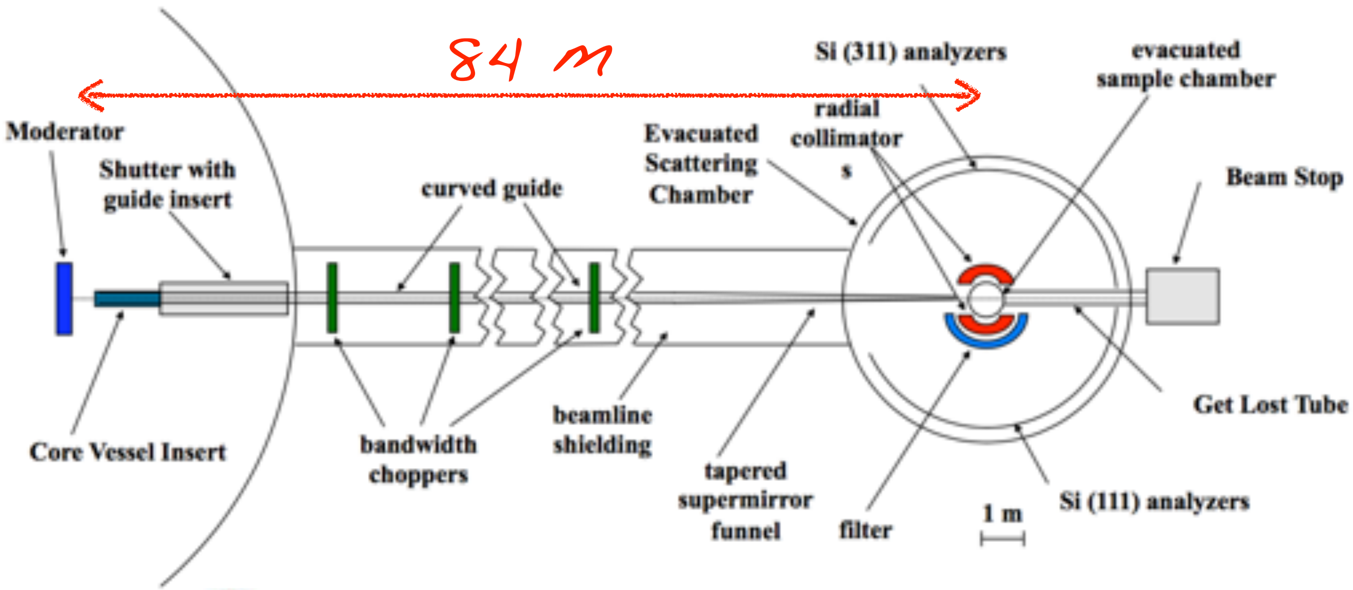




**https://neutrons.ornl.gov/publications

Success comes at a cost

1.07.04.01 - System Integration H R B S	1,159,245
1.07.04.02 - Data Acquisiton H R B S	318,651
1.07.04.03 - Detectors H R B S	273,198
1.07.04.04 - Choppers H R B S	671,624
1.07.04.05 - Sample Environment H R B S	37,643
1.07.04.06 - Optical Elements H R B S	1,940,026
1.07.04.07 - Shielding H R B S	1,941,570
1.07.04.08 - Instrument Specific H R B S	2,353,122
1.07.04.HIST - HIST - High Resolution Backscattering Sp	32,147
1.07.20.04 - Backscattering Spectrometer Installation	609,985
Total **in 2004** *	9,337,211



*Kenneth W. Herwig, private communication by e-mail also to the ESS

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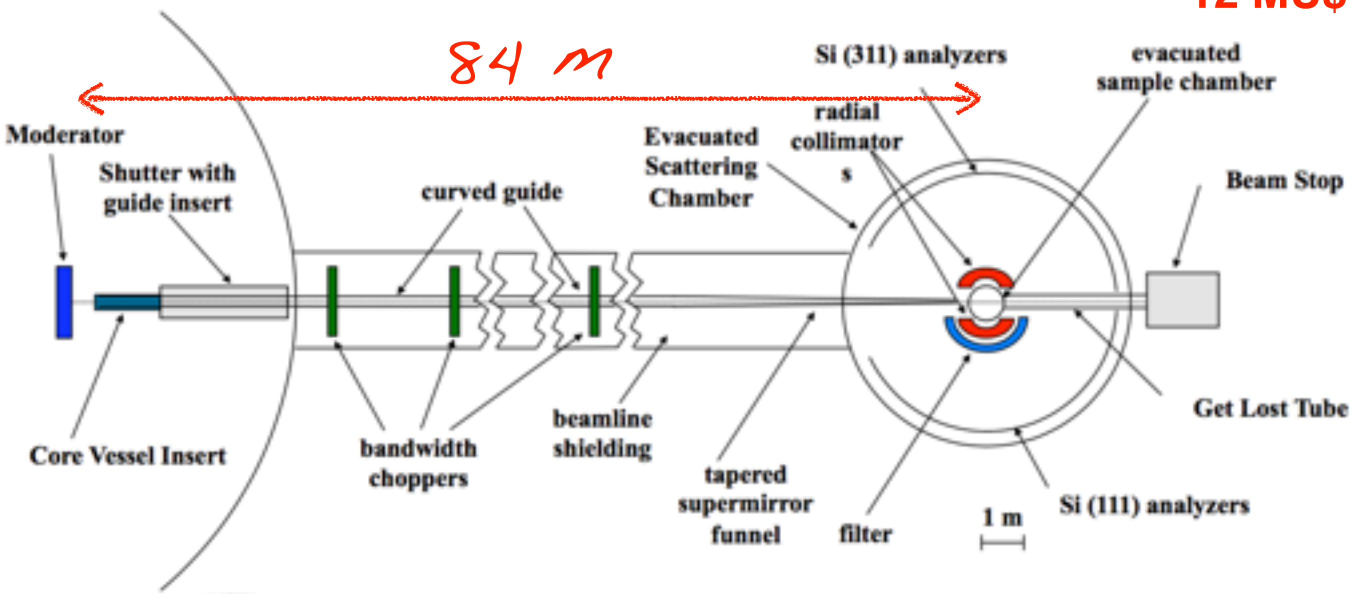
****12 MU$ = 11M€ in 2016**



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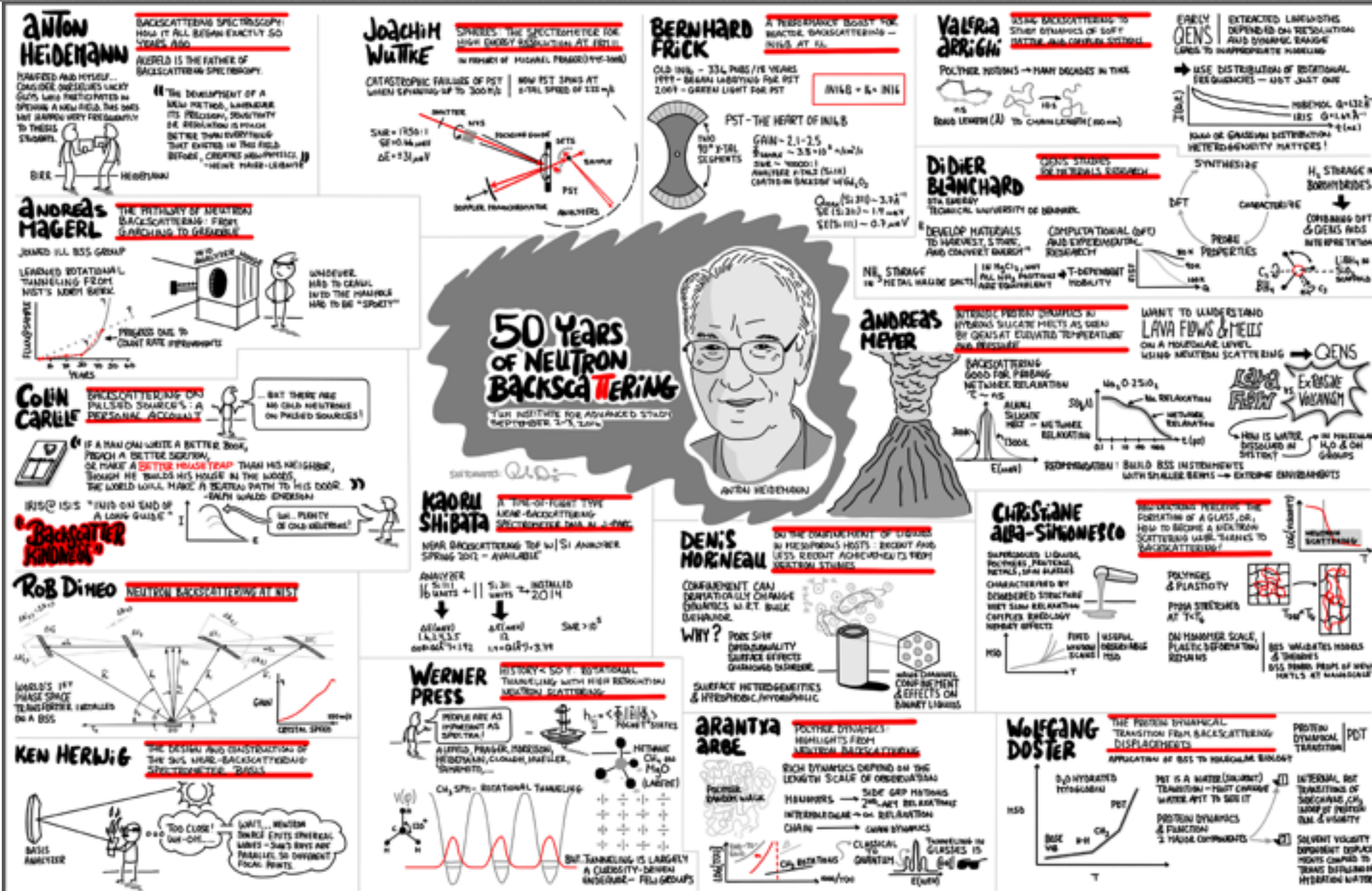
**http://fxtop.com/en/currency-converter-past.php?C1=USD&A=12259637.60966&DD=18&MM=10&YYYY=2016


50 Years of Neutron Backscattering
The Institute for Advanced Study September 2-3, 2014
Anton Heidemann
Anton Heidemann
Backscattering spectroscopy: How it all began exactly 50 years ago
Joachim Wuttke
Spheres: The spectrometer for high energy resolution at FRM II
Bernhard Frick
A performance boost for reactor backscattering – IN16B at ILL
IN16B ≈ 6× IN16
PST - The heart of IN16B
Valeria Arrighi
Using backscattering to study dynamics of soft matter and complex systems
QENS
Didier Blanchard
QENS studies for materials research
Synthesize
DFT
Characterize
Probe
Properties
Andreas Magerl
The pathway of neutron backscattering: from Garching to Grenoble
Andreas Meyer
Lava flows & melts
QENS
Colin Carlile
Backscattering on pulsed sources: a personal account
"Backscatter Kindness"
Kaoru Shibata
Denis Morineau
Why?
Christiane Alba-Simionesco
Rob Dimeo
Neutron backscattering at NIST
Werner Press
Ken Herwig
The design and construction of the SNS near-backscattering spectrometer "BASIS"
Too close!
Arantxa Arbe
Polymer dynamics: highlights from neutron backscattering
Wolfgang Doster
PDT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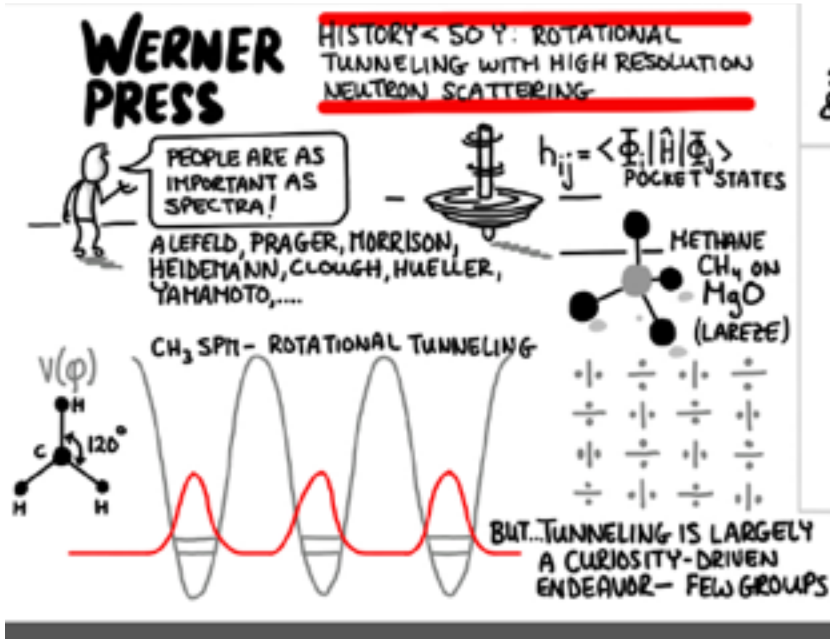
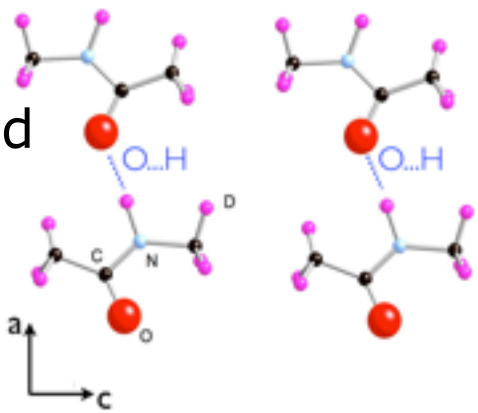
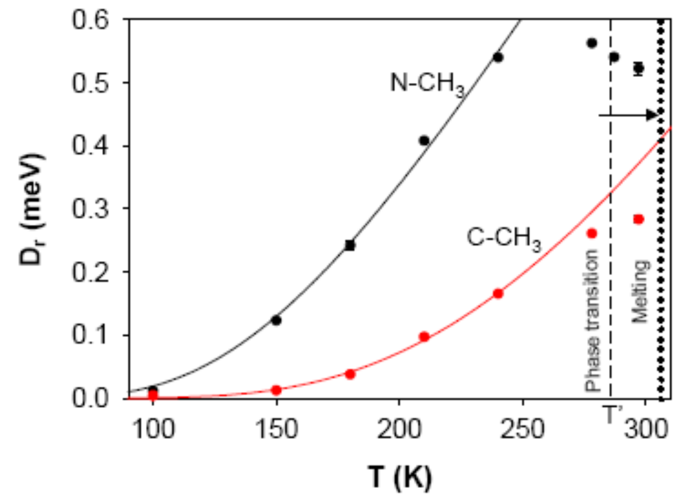
MIRACLES allows for **curiosity driven science** with 12M€



- ☑ Considerable reduction of analyser angle, as well as detector area.
- ☑ Critical loss of detection flux, with a subsequent significant increase of the measurement time.
- ☑ Lack of the collimator and Be-filter will result in low signal/noise ratio.





Rols, S.; Bordallo, H.N.; Herwig, K.W.; Barthès, M.; *Physica B* **2004**, 350, e-587.

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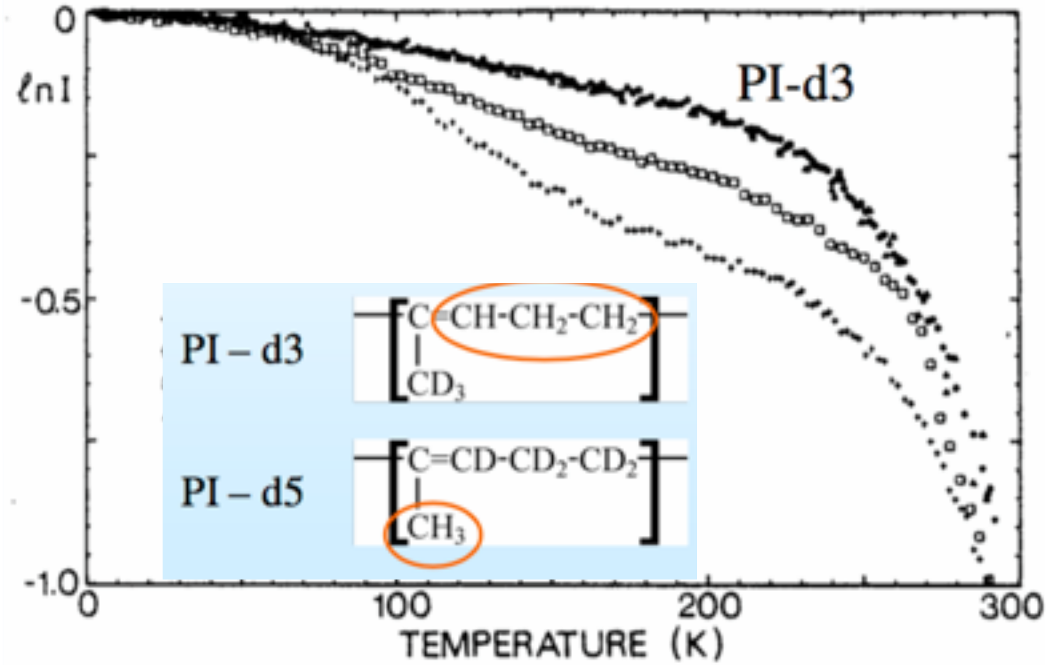
separating methyl group & main chain dynamics in polymers



Frick, B. and Fetters, L.J. ; *Macromolecules* **1994**, 27, 974.

Example inspired by A. Sokolov in http://cns.che.udel.edu/files/2014/03/Sokolov-reloyj.pdf

MIRACLES provides **outstanding science** with 15.9M€

- ☑ Almost full coverage of the analyser angle, as well as detector area.
- ☑ Increased flux and reduction of the measurement time.
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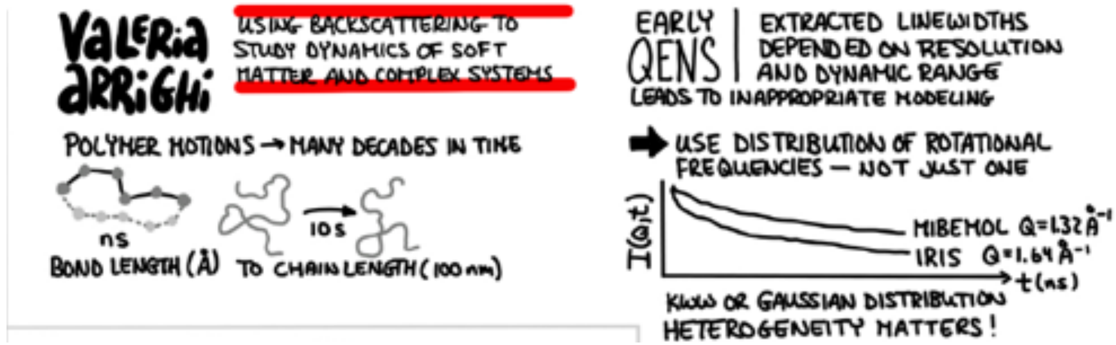

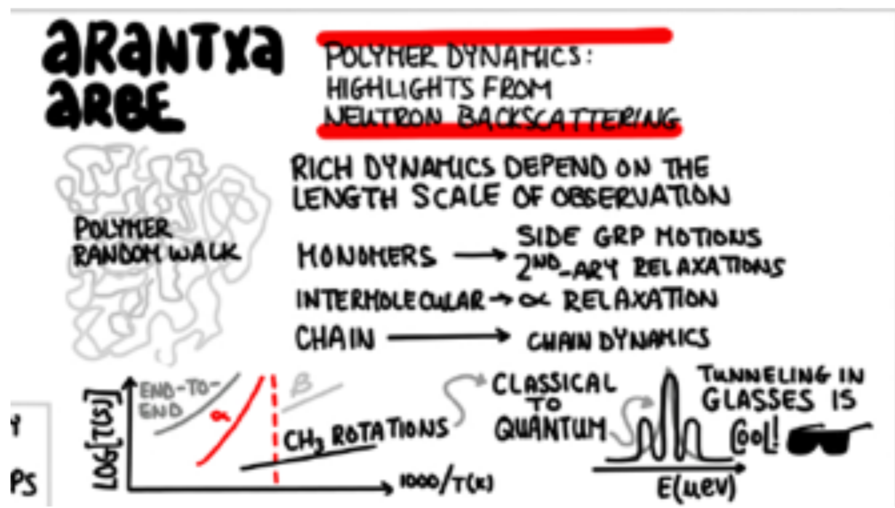

MIRACLES provides **outstanding science** with 15.9M€

describing methyl group & main chain dynamics in proteins

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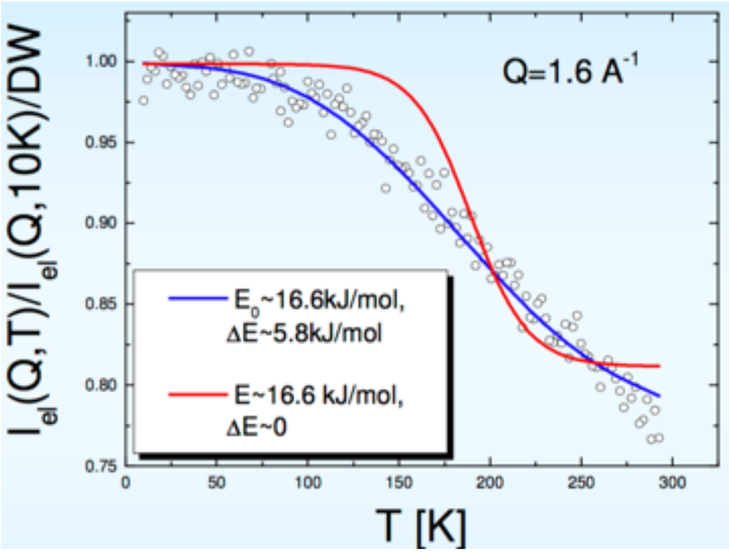


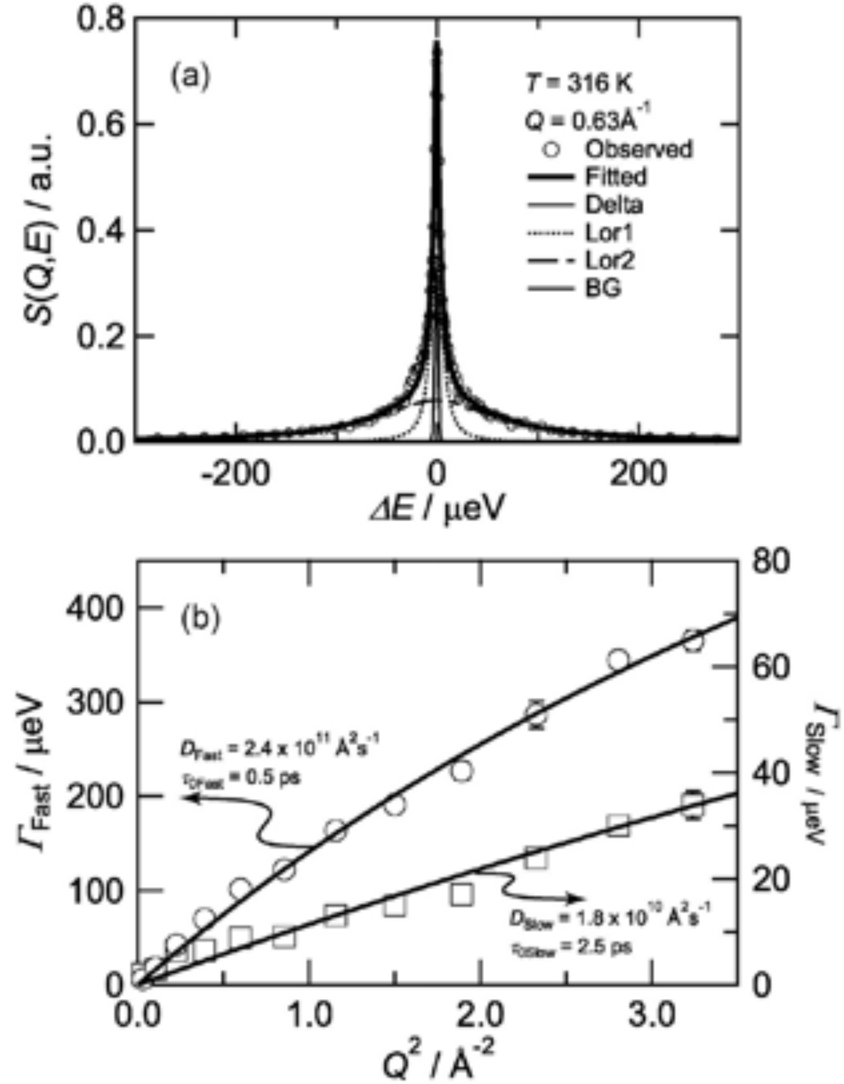
$$I_{el}(Q,T,\omega\sim 0)=DW(Q,T)\left[1-p_m+p_m\int_{-\infty}^{\infty}S_{met}(Q,\omega')R(\omega-\omega')d\omega'\Big|_{\omega=0}\right]\propto DW(Q,T)\left[const(Q)+\int_{-\infty}^{\infty}R(\omega-\omega')\int_0^{\infty}g(E_i)\frac{\tau_i}{1+\omega'^2\tau_i^2}dE_i\,d\omega'\Big|_{\omega=0}\right]$$

Zaccai G, Bagyan I, Combet J, et al. *Scientific Reports*. **2016,** 6, 31434.

Example inspired by A. Sokolov in http://cns.che.udel.edu/files/2014/03/Sokolov-reloyj.pdf

MIRACLES provides **outstanding science** with 15.9M€

broad range water dynamics in biological systems: DNA first results



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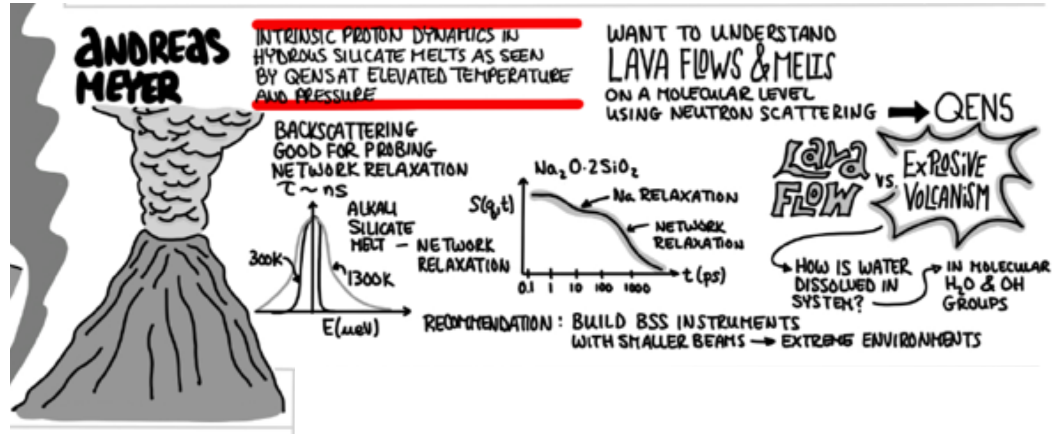
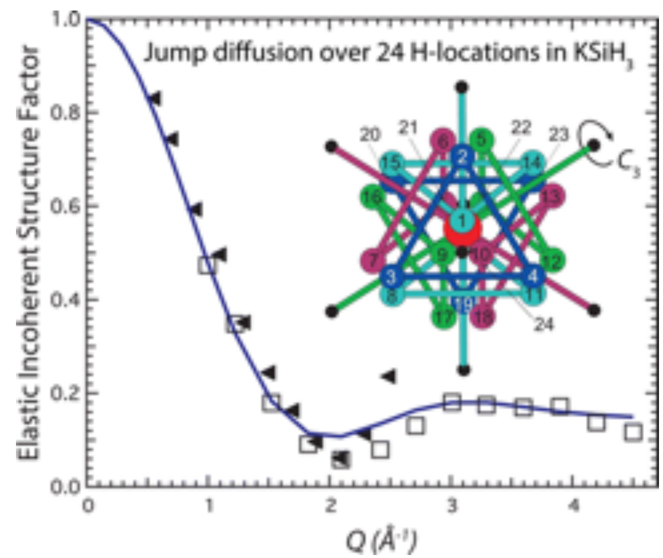
Seto, H. et al. *Biochimica et Biophysica Acta* **2016,** in press.

MIRACLES brings a **paradigm shift to neutron backscattering** with 17.7M€

- ☑ Full coverage of the analyser angle, as well as detector area.
- ☑ Matchless flux and excellent sample environment.
- ☑ Outstanding signal/ noise ratio.
- ☑ Very large Q-range and even broader elastic energy resolution coverage.



Hydrogen as an energy source



Österberg, C. et al. *J. Phys. Chem C* **2016,** 120, 6369.

Remember: Q-range determines the spatial properties that are observable.
A typical range (IN16, IN5) is 0.2 – 2 Å^{-1} 3 – 30 Å, a Q_{max} = 5 Å^{-1} gives d_{min} =1 Å.

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DSC data: M.L. Martins & H.N. Bordallo, private communication.

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A relative large number of intracranial diseases can show restricted diffusion and may therefore appear bright on diffusion-weighted images. An incomplete listing by category of disease is shown below, with the most common examples highlighted in red:

Category	Examples
Vascular	**Infarction (venous or arterial), diffuse hypoxic injury, posterior reversible encephalopathy (PRES)**
Neoplastic	**Lymphoma**, **epidermoid**, **xanthogranuloma** of choroid plexus, medulloblastoma, malignant glioma, malignant meningioma, primitive neuroectodermal tumor (PNET), atypical teratoid-rhabdoid tumor, metastases
Infectious	**Abscess**, **empyema**, meningoencephalitis (herpes), Creutzfelt-Jakob disease
Traumatic	**Hematoma**, **diffuse axonal injury (DAI)**, **Wallerian degeneration**, **status epilepticus**, contusion
Toxic/Metabolic	**Carbon monoxide (CO)**, **drugs** (heroin, vigabatrin, carbamazepine, methotrexate), **hypoglycemia**, hyperglycemia, Wernicke's, congenital biochemical disorders (phenylketonuria, glutaric aciduria, urea cycle defects, maple syrup urine disease, Canavan's, many others)
Demyelinating	**Acute disseminated encephalomyelitis (ADEM)**, osmotic demyelination, multiple sclerosis, delayed post-anoxic encephalopathy, Marchiava-Bignami

Intracranial diseases with restricted diffusion (bright on DW images)

The mechanisms responsible for restricted diffusion are incompletely understood and depend on the particular disease being considered. For many disorders several processes may act in concert to reduce the ADC.

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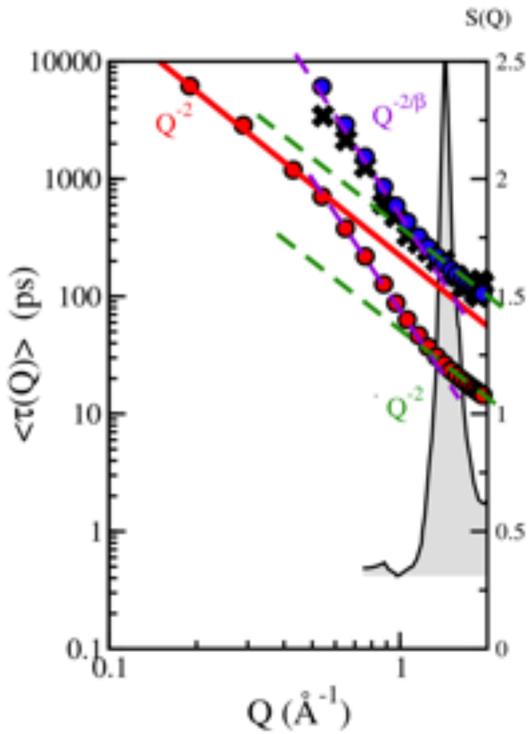
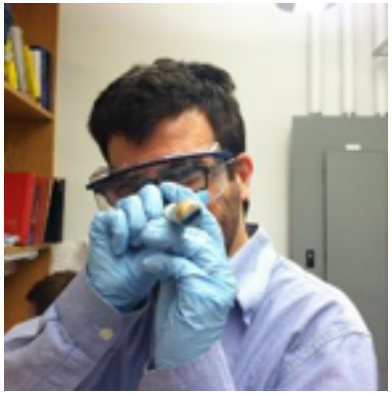
We have yet another benchmark: EMU



Busselez, R. et al. *J. Phys.: Condens. Matter* **2011,** 23, 505102.

Correct spectra of glycerol at 310K in blue and at 10K in red at Q=0.5 Å^{-1} measured for only 2 hours after one week of QENS data collection on EMU. Private communication.



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Mechanical Design and CAD