Mitglied der Helmholtz-Gemeinschaft

Time-of-flight **R**eciprocal space **EX**plorer

A bispectral chopper spectrometer for magnetism and material science

Jörg Voigt

Lund, 26.9.2013

WP I1: Chopper spectrometers

COLD HR spectrometer for soft matter:

- 125m, 2.26Å band

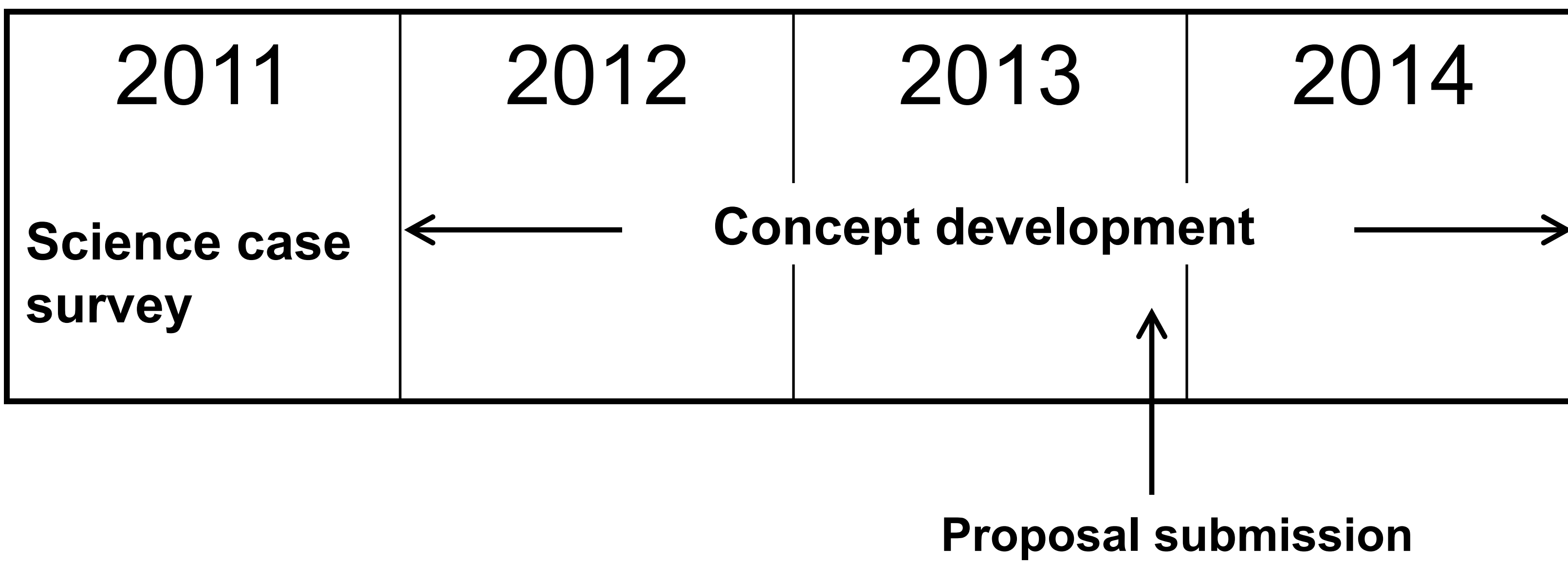
Technische Universität München

BISPECTRAL spectrometer for magnetism and material science:

- 79.3m 3.56Å band
- 154.3m 1.83Å band

Jülich Centre for Neutron Science

HZB Helmholtz Zentrum Berlin



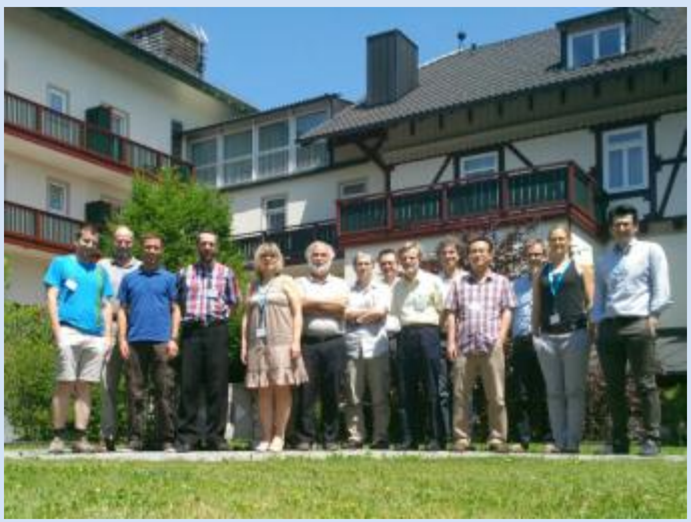
Users and experts interaction

Workshops

Berlin, 12.7.2011

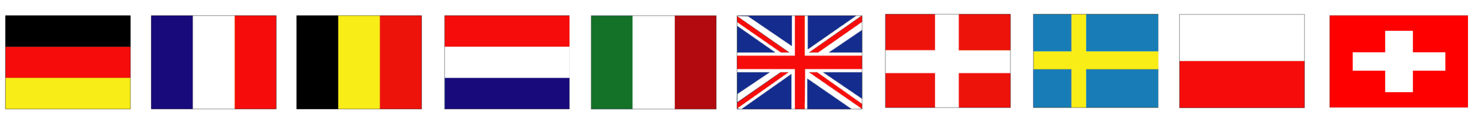
Berlin, 28.11.2011

Bernried, 17.-19.6.2013



People

Arbe, Arantxa; **Bech Christensen**, Niels; **Bendix**, Jesper; **Boothroyd**, Andrew T.; **Braden**, Markus; **Fennel**, Tom; **Fernandez-Alonso**, Felix; **Hayden**, Stephen; **Inosov**, Dmytro; **Juranyi**, Fanni; **Keimer**, Bernhard; **Perring**, Toby; **Petit**, Sylvain; **Ronnow**, Henrik; **Santini**, Paolo; **Schober**, Helmut; **Stockert**, Oliver; **Wildes**, Andrew; **Deen**, Pascale; **Freeman**, Paul; **Comez**, Lucia; **Ollivier**, Jacques; **Parker**, Stewart; **Rotter**, Martin; **Russina**, Margarita; **Saboungi**, Marie-Louise ; **Sacchetti**, Francesco; **Paciaroni**, Alessandro; **Steen Pedersen**, Kasper; **Su**, Yixi; **Hermann**, Raphael; **Krutyeva**, Margarita; **Balakrishnan**, Geetha; **Ballou**, Rafik; **Bator**, Grazyna; **Bennington**, Stephen; **Busch**, Sebastian; **Desmedt**, Aranud; **Dreiser**, Jan; **Ewings**, Russell; **Fak**, Bjoern; **Frick**, Bernhard; **Güdel**, Hans Ulrich; **Guidi**, Tatiana; **Halle**, Bertil; **Horsewill**, A. J. ; **Jobic**, Herve; **Kimber**, Simon; **Lake**, Bella; **Leclercq**, Francoise; **Lefmann**, Kim; **Meyer**, A.; **Mulder**, Fokko M. ; **Ondrejkovic**, P.; **Oppeneer**, Peter; **Pajzderska**, A. ; **Pappas**, Catia; **Paul**, Don McK.; **Paul-Bouncor**, Valerie; **Remhof**, Arndt; **Roth**, Georg; **Rovira-Esteva**, Muriel; **Smith**, Jeremy C.; **Suellow**, Stephan; **van Eijck**, Lambert; **Vogel**, Michael; **Waldmann**, Oliver; **Winpenny**, Richard; **Zielinski**, Piotr



Science Case Survey 2011

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	Soft matter	Material Science	Magnetism
Wavelength range	0.5-20 Å	0.5-20 Å	0.5-20 Å
Energy range resolution	QEL,VDOS, –200 meV<E<200meV 2-10 μeV	QEL -200meV<E<30meV 0.4meV-1.3meV @2Å	–200meV<E<200meV 30 μeV-2meV
Q- range resolution	< 0.1$Å^{-1}$ → 2-4$Å^{-1}$ 0.01 $Å^{-1}$ (SAS)→ relaxed	< 0.1$Å^{-1}$ → 5-6$Å^{-1}$ 0.01 $Å^{-1}$ (SAS)→ relaxed	< 0.1$Å^{-1}$ → 2-4$Å^{-1}$ 0.01 $Å^{-1}$ (SAS)→ relaxed **Mapping**
Sample: size environment	1x1, 10x10, 30x60mm^2 Liquids, Solutions high pressure,humidity cell, Laser irradiation T 10^0- $4\cdot10^2$ K	1x1, 10x10, 30x60mm^2 Powder, X-tals, melts high pressure, in-situ reaction chamber, levitation T 10^0-10^3 K	1x1, 10x10, 30x60mm^2 **Single X-tals** high pressure, high mag field, laser T 10^{-2}-10^3 K
Options	Polarization analysis	Polarization analysis	Polarization analysis

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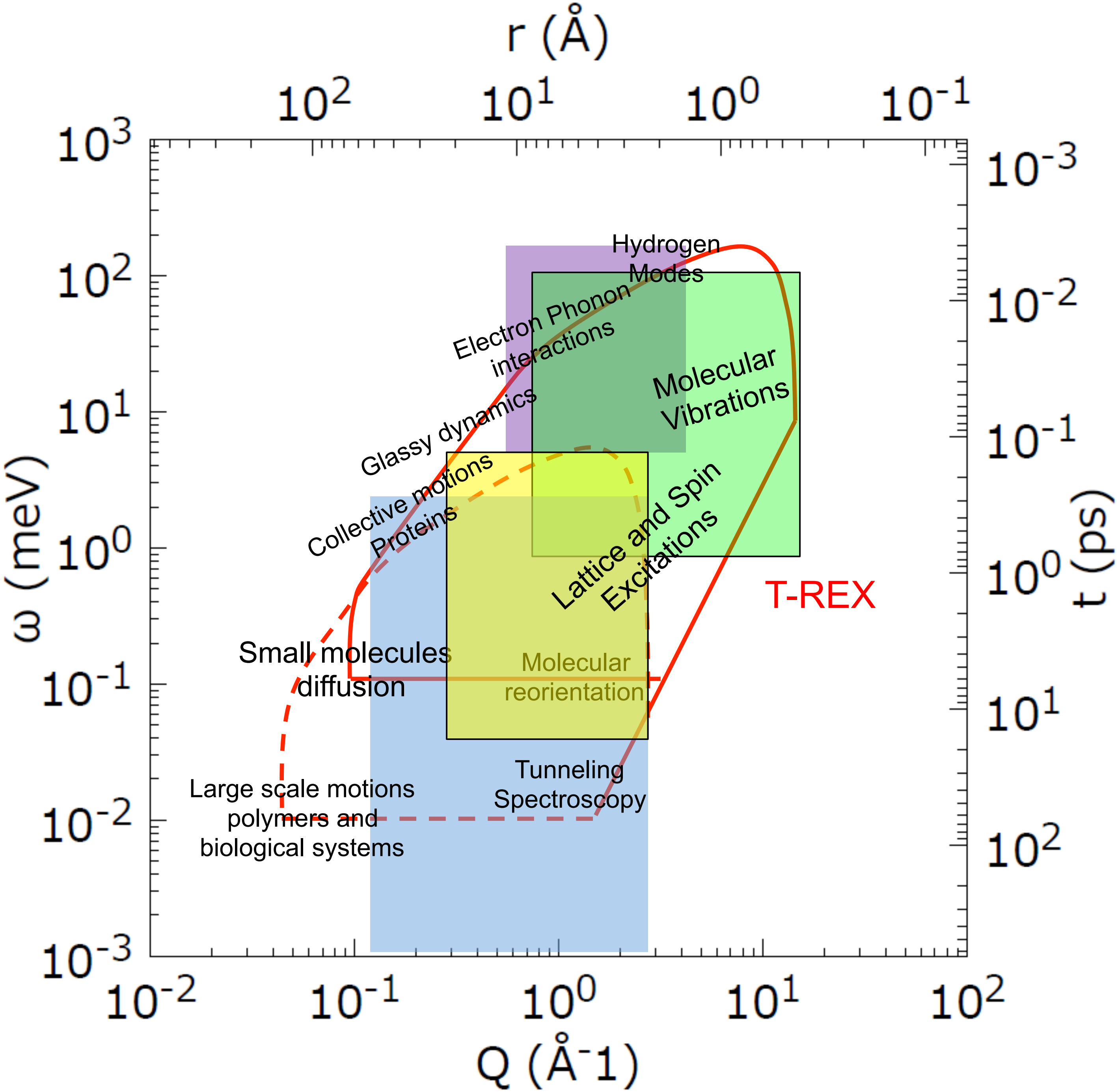
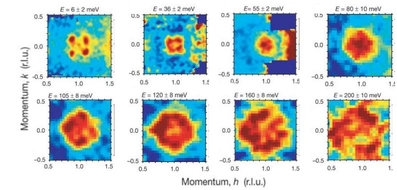
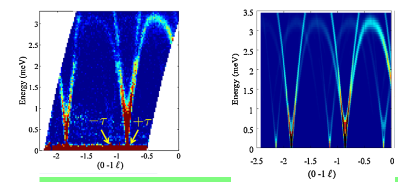


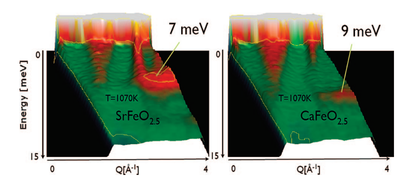
High T_C Superconductivity



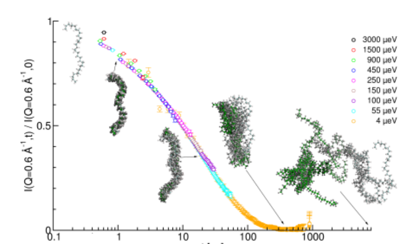
Multiferroics



Energy materials

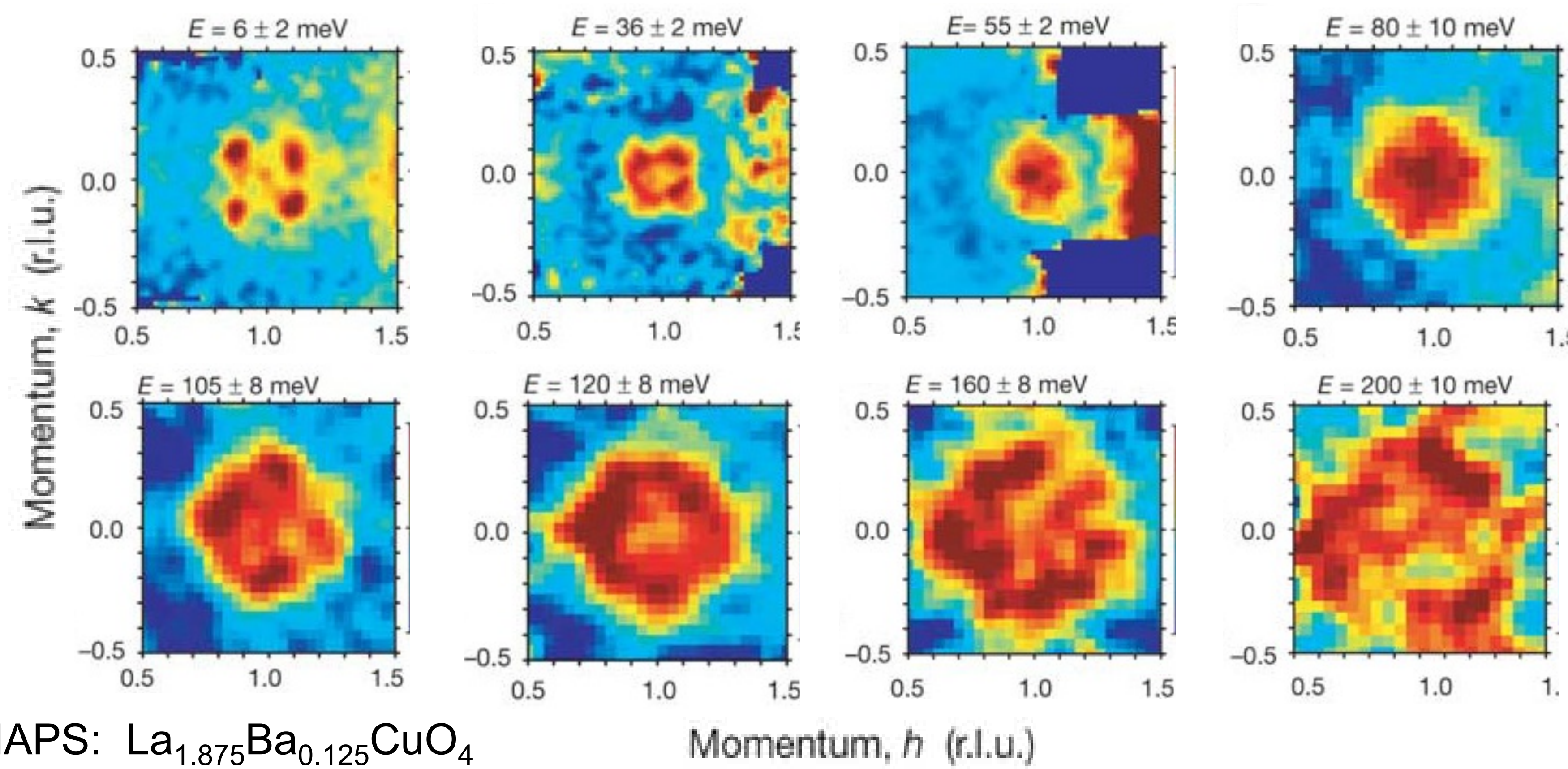


Diffusion in liquids



High T_C Superconductivity

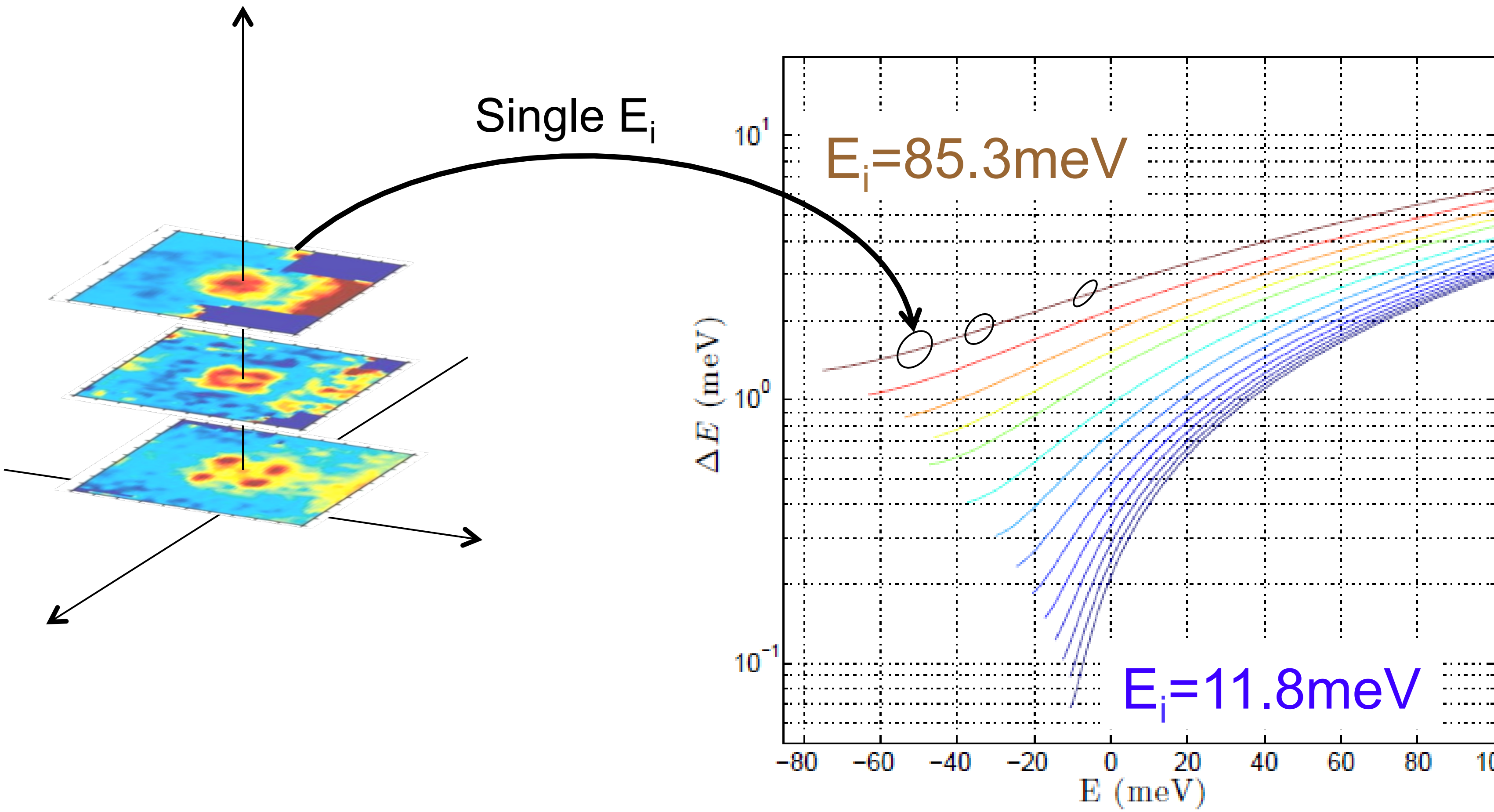
- Gap, incommensurate satellites + resonance at once
- Smaller single X-tals
- More details, lineshapes



MAPS: $La_{1.875}Ba_{0.125}CuO_4$

J. M. Tranquada *et al.*, Nature **429**, 534 (2004)

Benefits from many E_i's

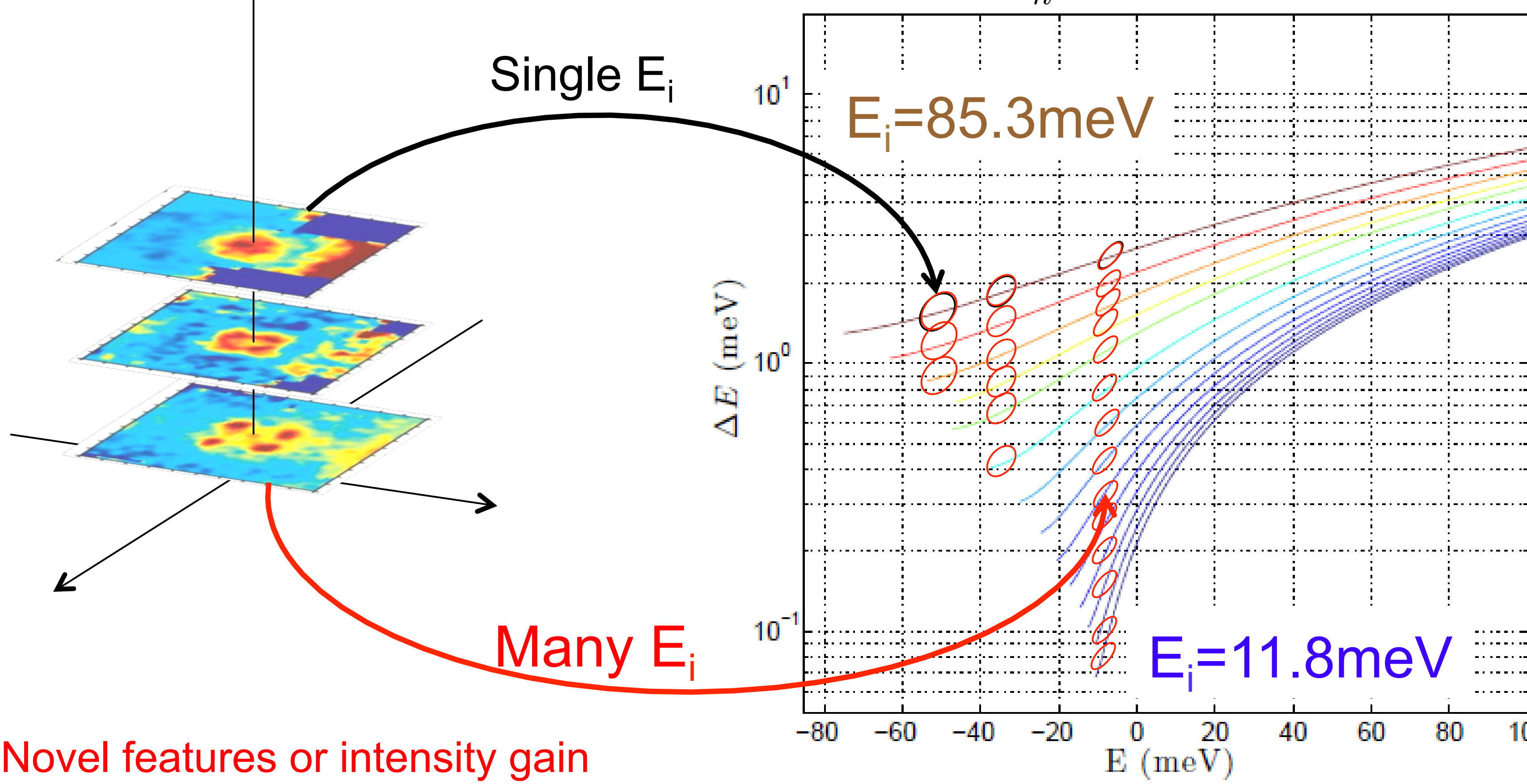


Benefits from many E_i

$$L = 155\text{m}, L_{\text{M}} = 150\text{m}$$

$$\Delta\lambda = \frac{h}{m_n}(L \times 14\text{Hz})^{-1} \approx 1.8\text{Å}$$

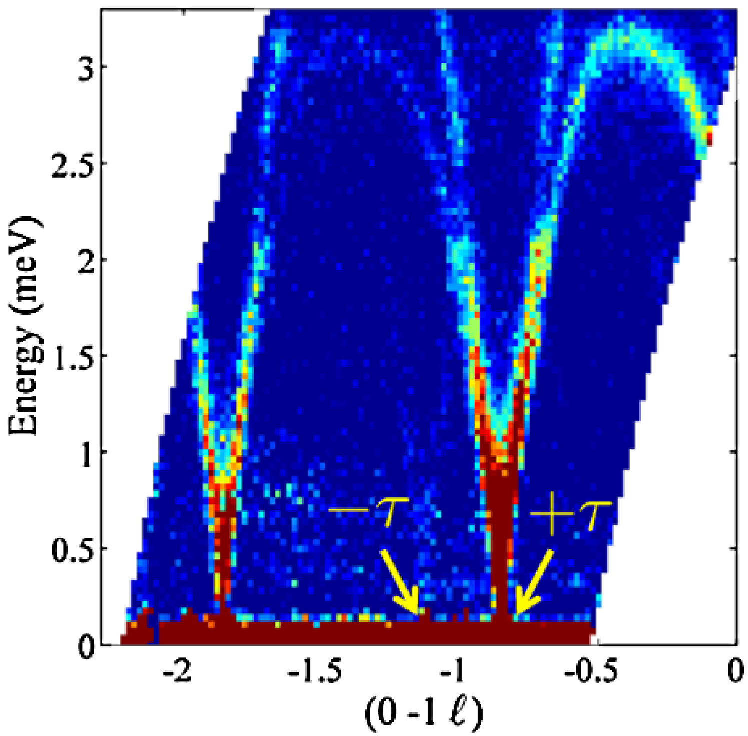
$$\delta\lambda = \frac{h}{m_n}(L_{\text{M}} \times f_{\text{M}})^{-1} \approx 0.075\text{Å}$$

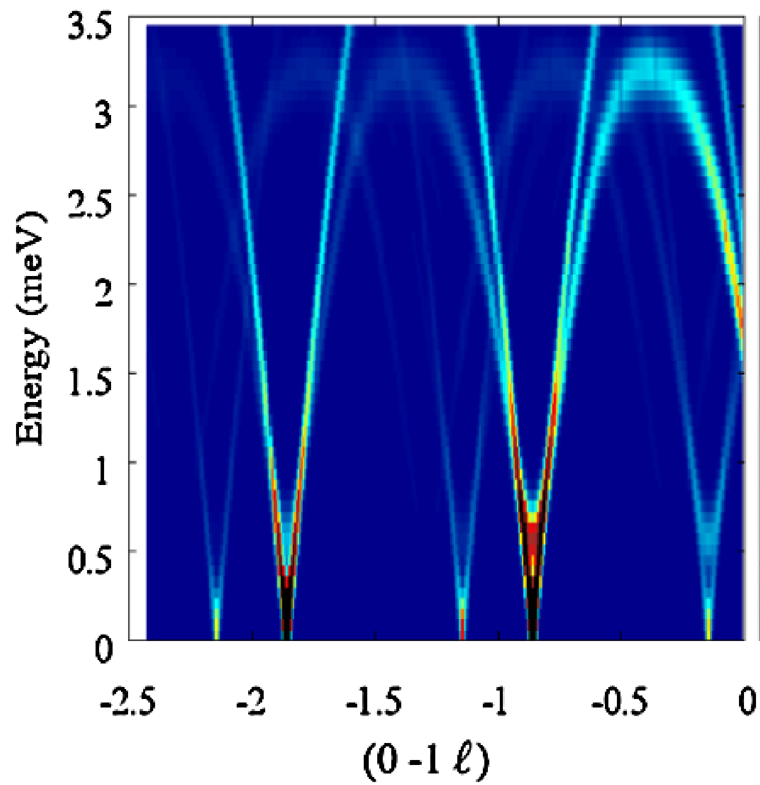


Novel features or intensity gain

Multiferroics

- Pixelized detector (3d)
- Very good energy resolution
- Divergence ± 1°
- Polarization

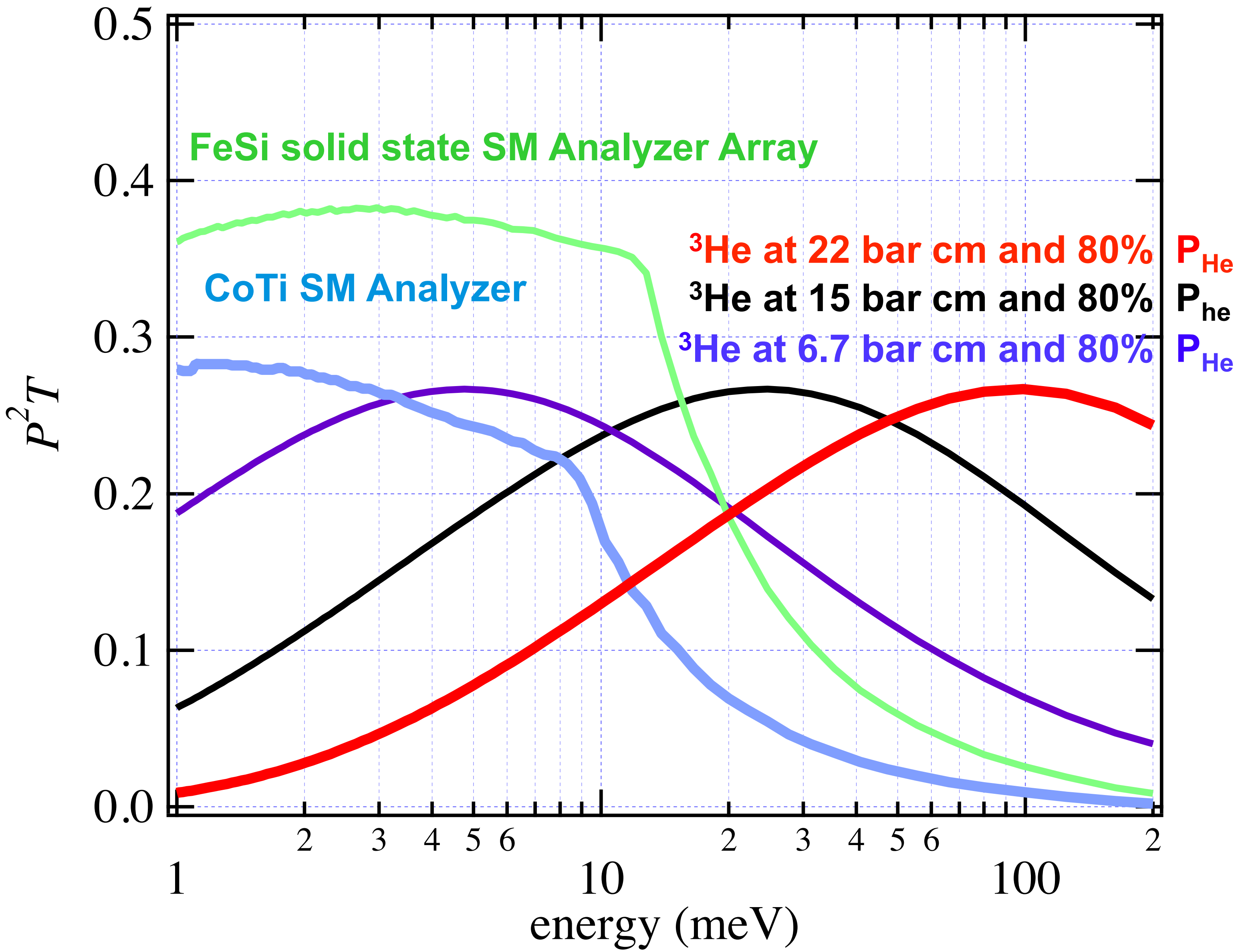




IN5: $Ba_3NbFe_3Si_2O_{14}$

Loire *et al.*, PRL **106**, 207201 (2011)

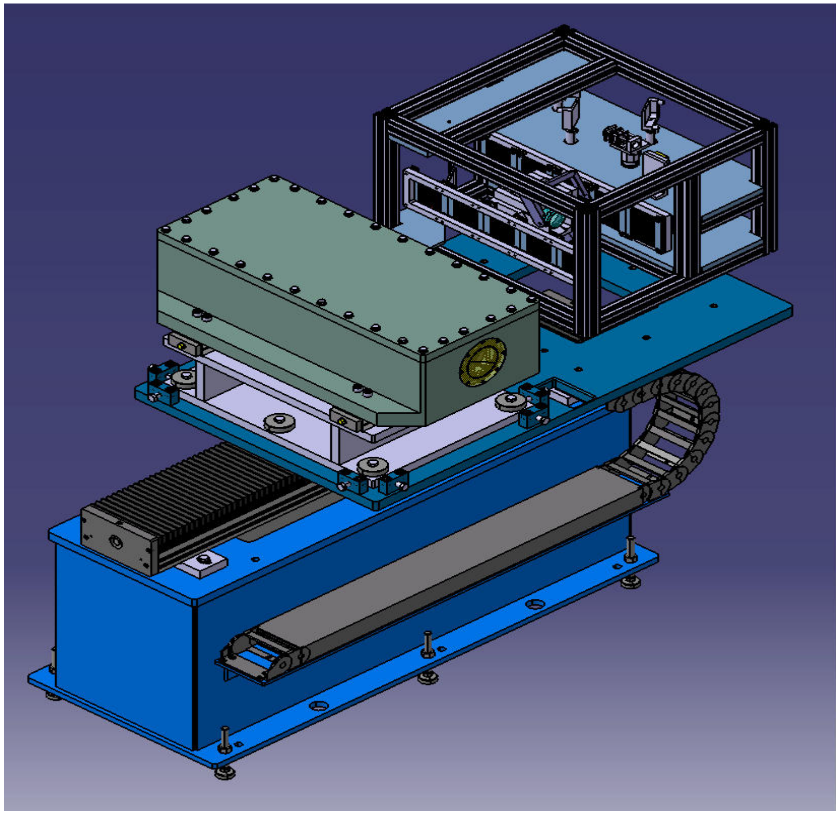
Polarisation and bandwidth



E. Babcock et al., Jour. Phys. Soc. Jap. S.E., proceedings of QENS/WINS 2012, Nikko Japan

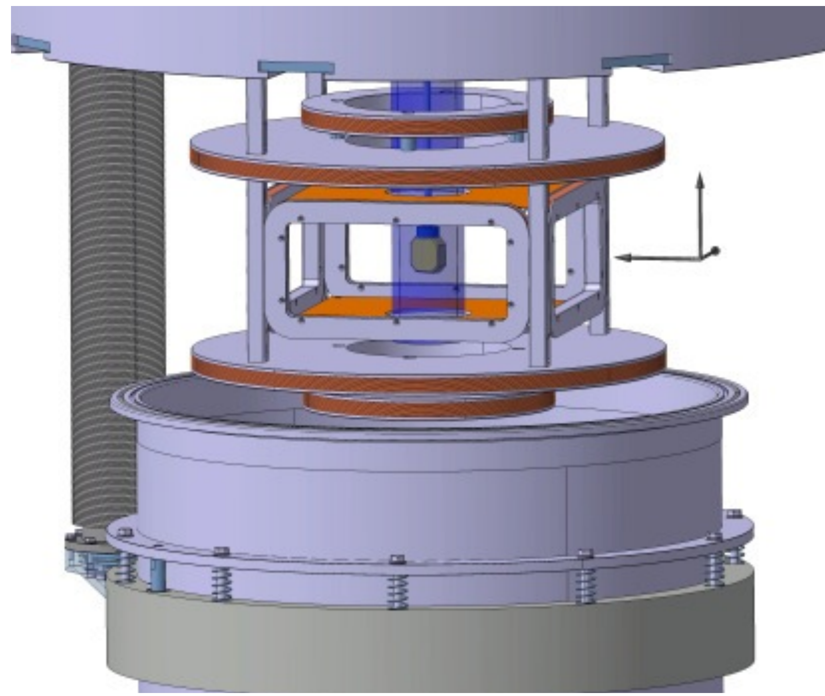
Polarization and Analysis for TOPAS

On-beam polarizer



- ✓ SEOP for thermal neutrons
  - ✓ Continuously pumped
- ✓ SM Cavity for cold neutrons

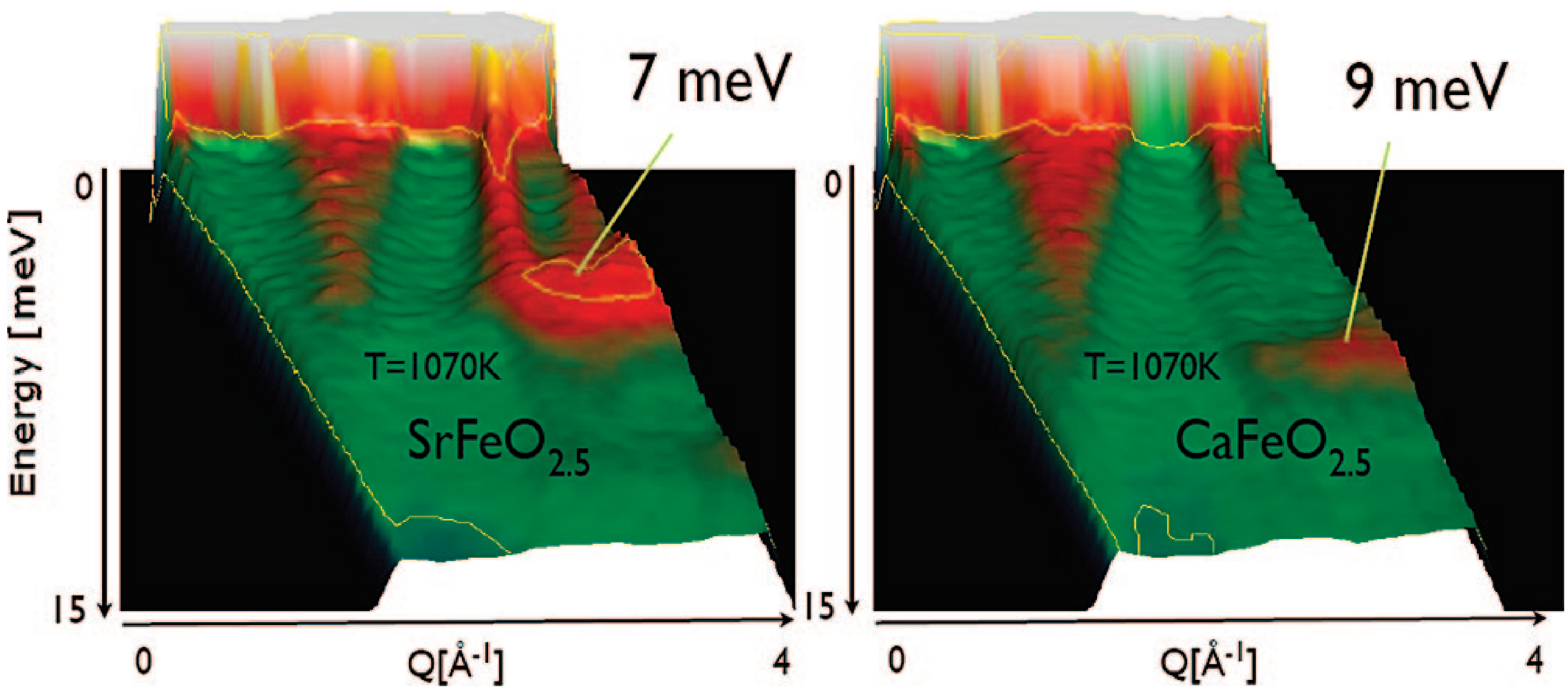
Analysis: magic PASTIS magnetic system



- ✓ Homogeneous field configuration
- ✓ Offline gas polarization
- ✓ Variable pressure

Energy materials

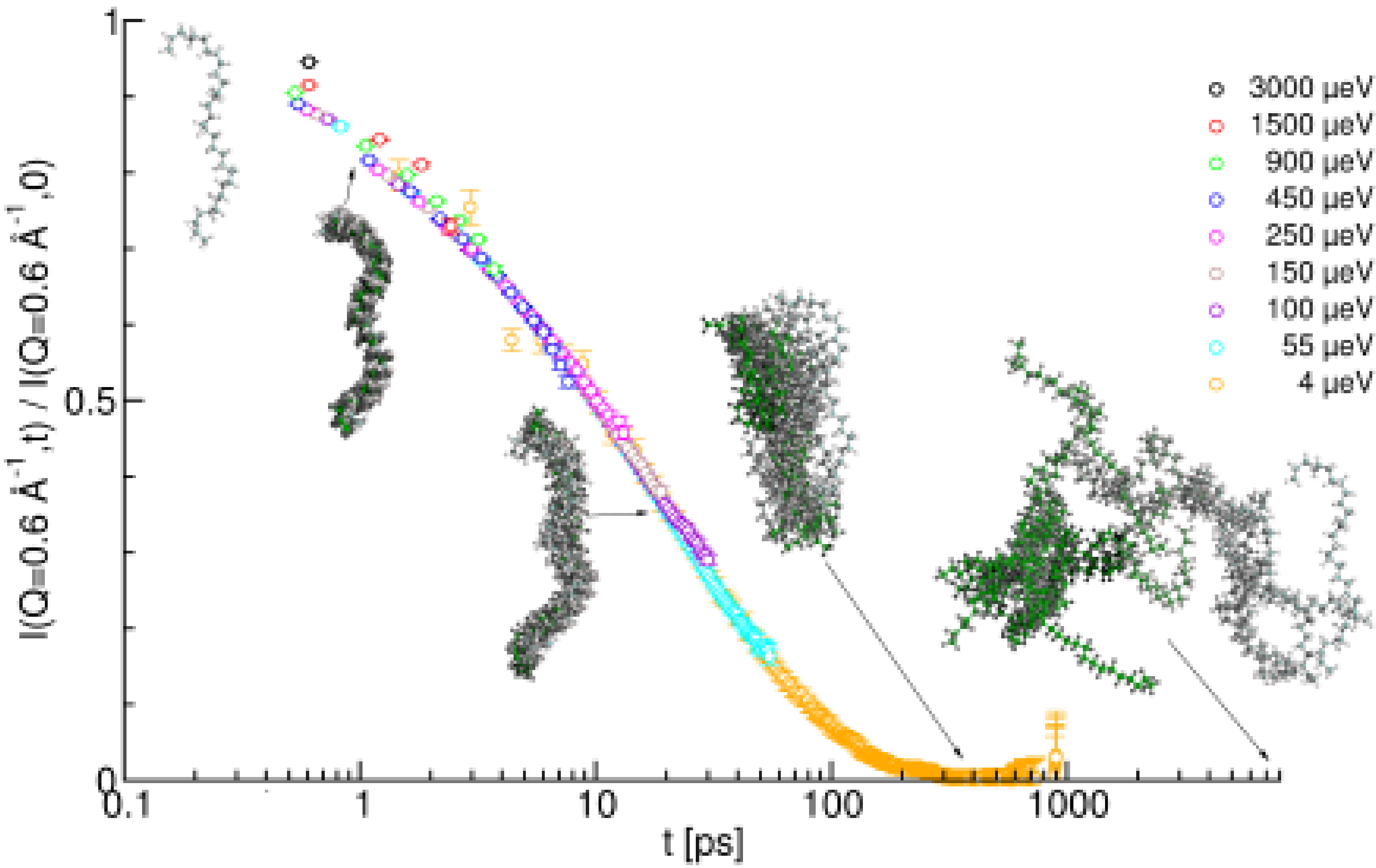
- Diffusive motion, acoustic and optical branches at once
- Good energy resolution to resolve atomic hopping



IN6: Oxygen mobility in SOFC
W. Paulus *et al*, JACS **130**, (2008), 16080

Diffusive motion in soft matter

- Extreme energy resolution
- Large dynamic range : momentum transfer!!



TofTof: n-alkane ($C_{32}H_{66}$) chain

T.Unruh et *al.*, J. Chem Phys. **129**, 121106 (2008)

Gaps

Chiral magnets

Frustration

Heavy fermions

Magnetic Monopoles

Correlated electrons

Low dimensional magnetism

HTSC

Magnetocaloric materials

Magnetic resonance

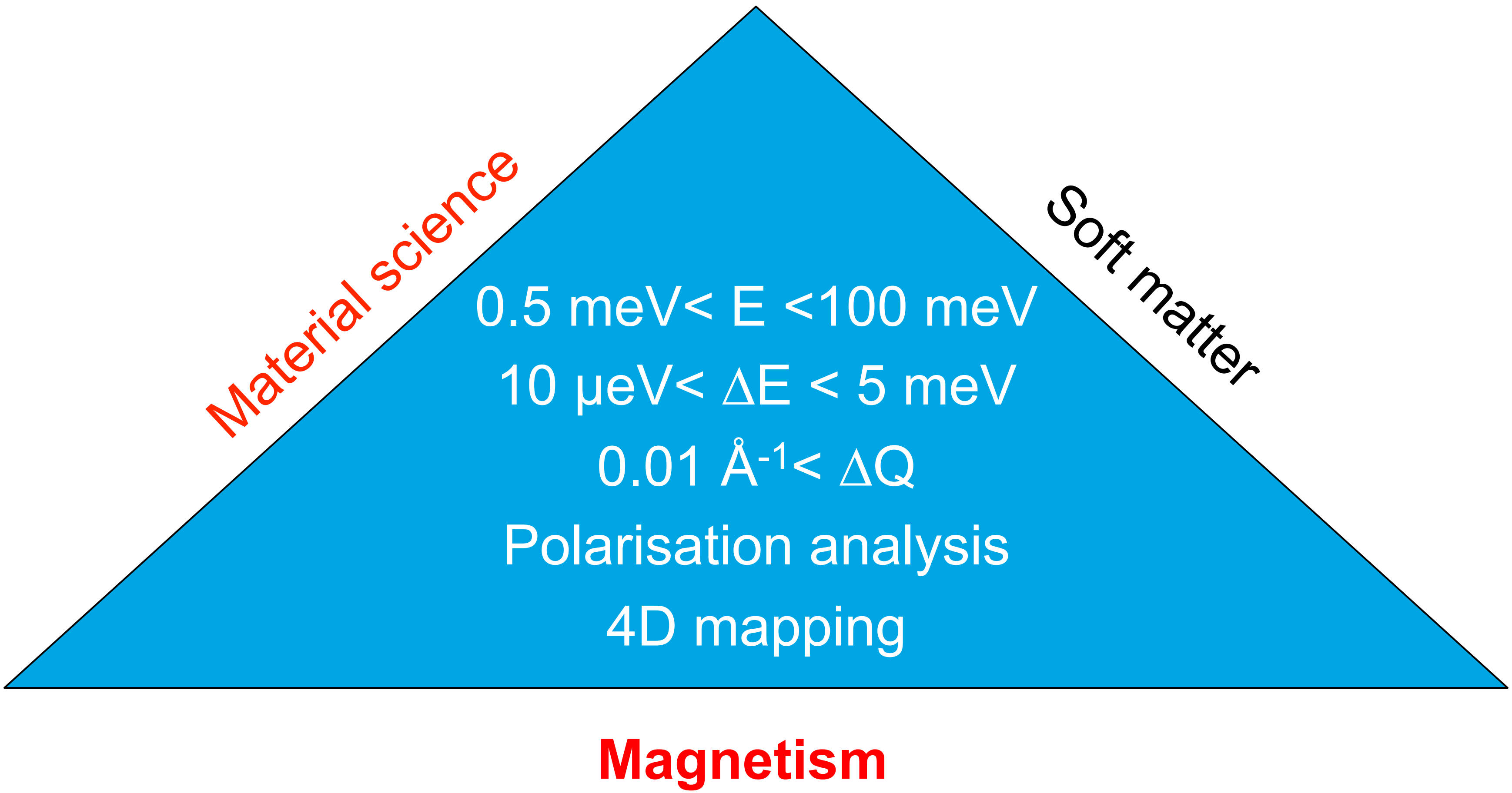
Thermoelectric materials

Ion transport

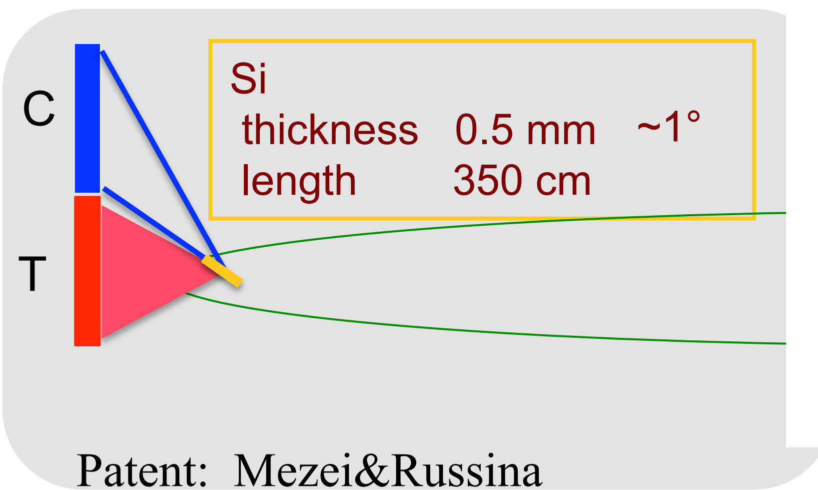
Hydrogen storage/mobility

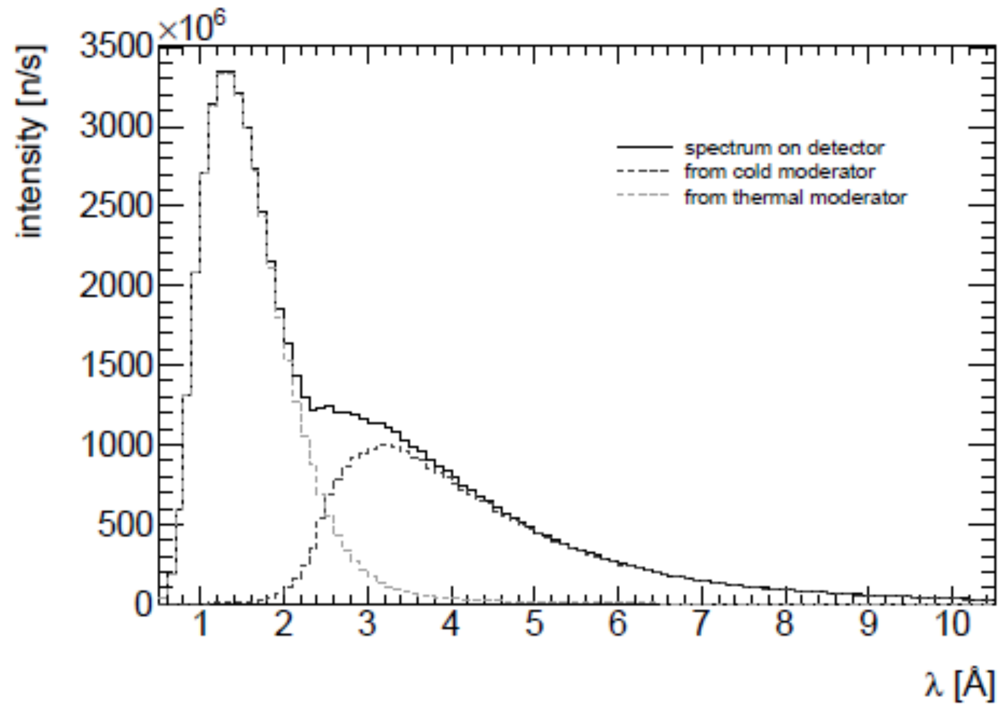
Batteries and fuel cells

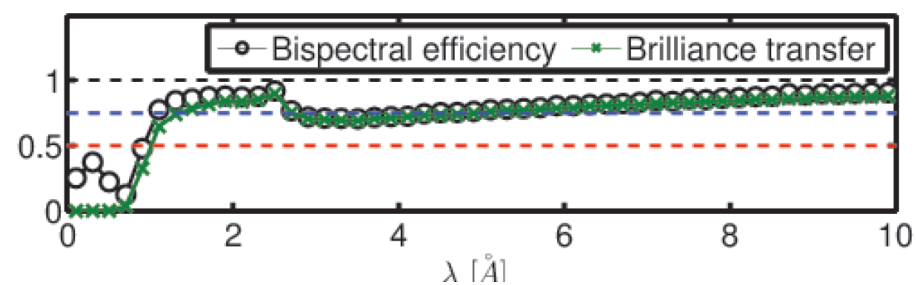
Design parameters



Large dynamical range → bispectral extraction







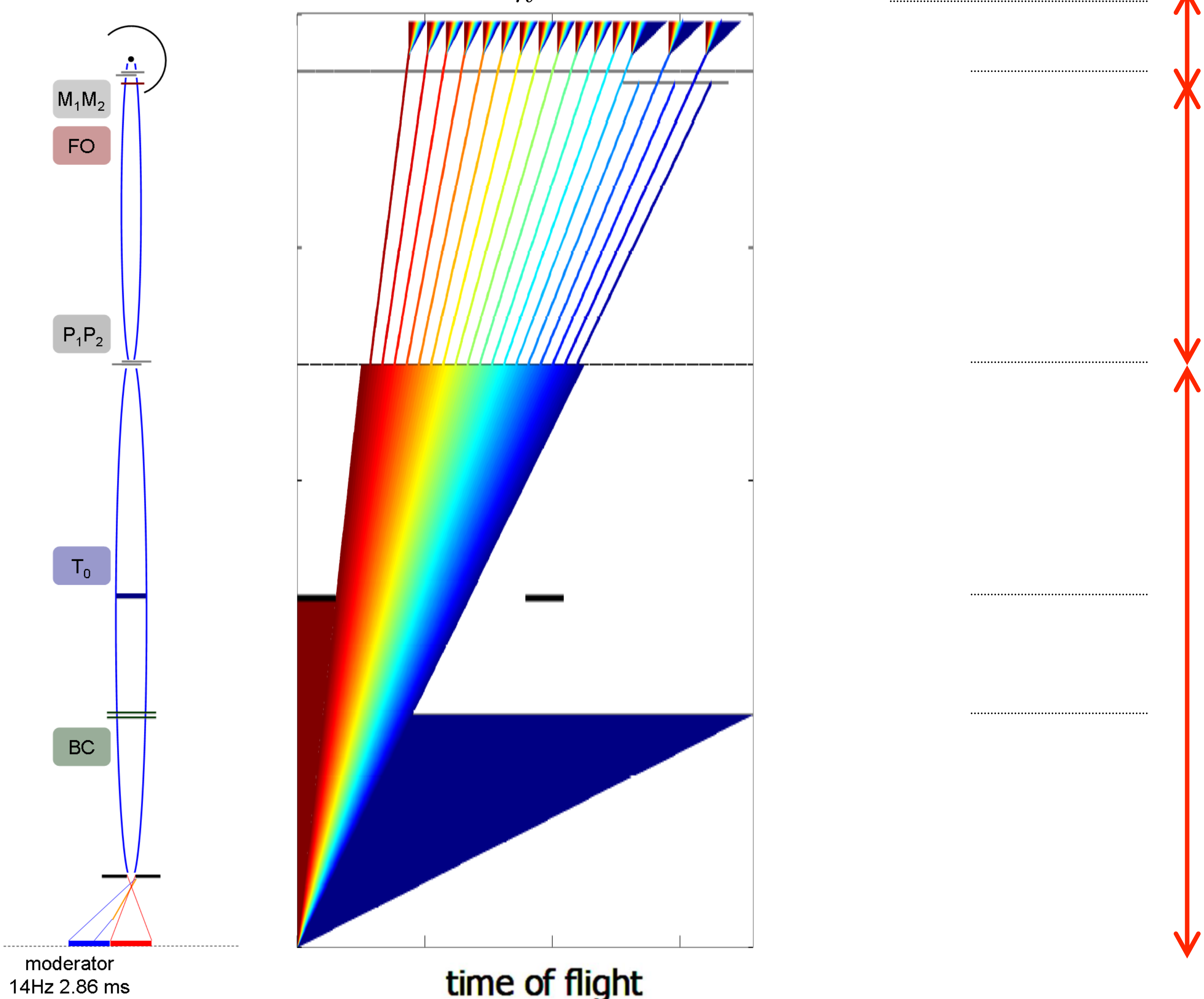
Berlin – Copenhagen simulations group

Geometry I:

$$\Delta\lambda = \frac{h}{m_n}(f_{\mathrm{source}} L_{\mathrm{total}})^{-1}$$

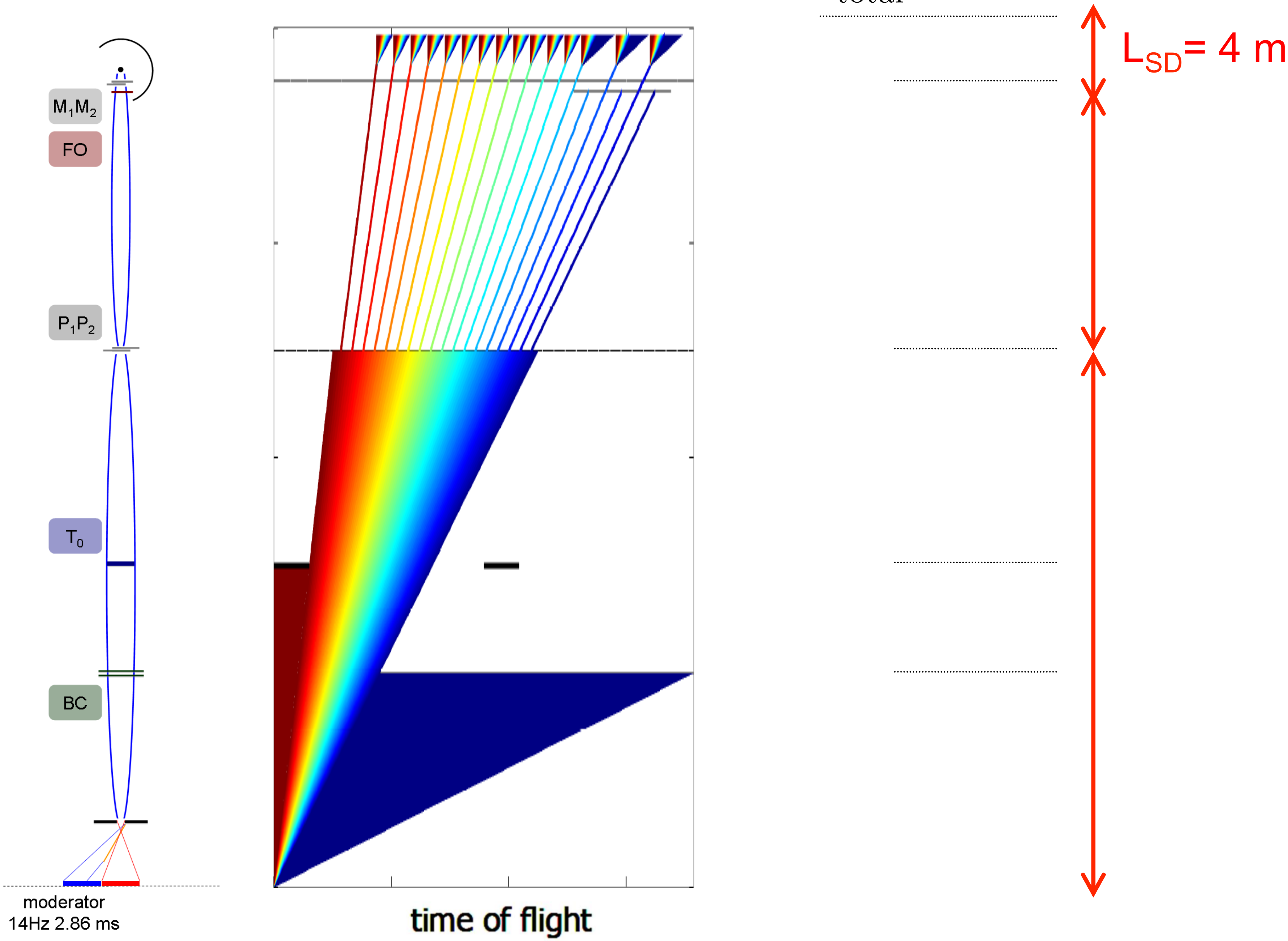
$$\delta\lambda = \frac{h}{m_n}(f_{\mathrm{M}} L_{\mathrm{total}})^{-1}$$

$L_{\mathrm{total}} \approx 150\mathrm{m}$



Geometry I: $\frac{\Delta L_{SD}}{L_{SD}} \leq 0.5\%$

$L_{\text{total}} \approx 150\text{m}$



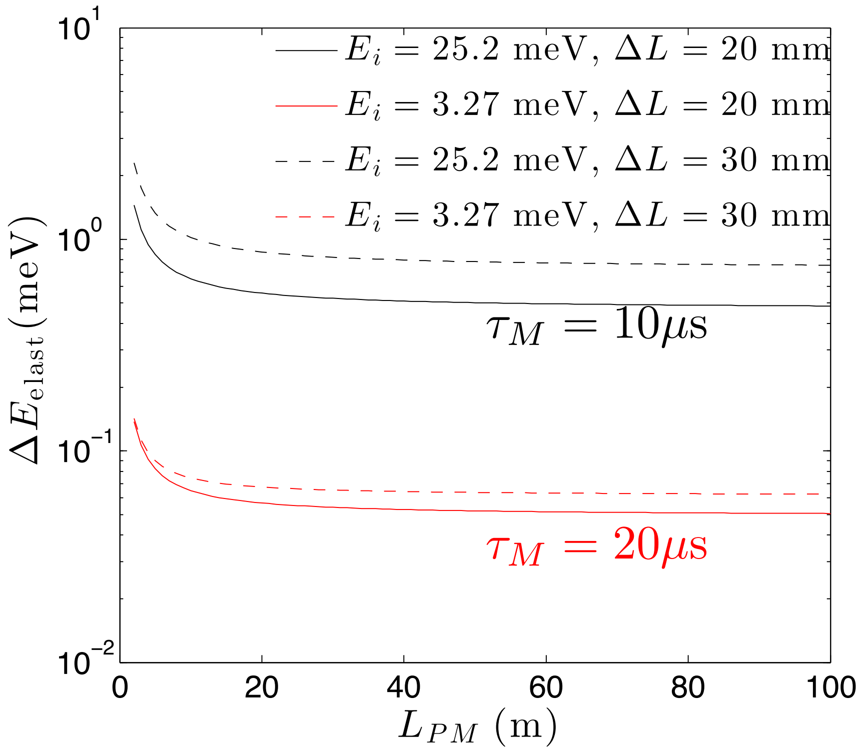
Energy resolution

$$\sigma_E^2 = \frac{(mv'^3)^2 \left(A^2 + B^2 + C^2\right)}{(L_{PM} L_{SD})^2}$$

$$A^2 = \left[L_{MS} + L_{SD}\left(\frac{v}{v'}\right)^3\right]^2 \tau_P^2$$

$$B^2 = \left\{\left[L_{MS} + L_{SD}\left(\frac{v}{v'}\right)^3\right]^2 + L_{PM}^2\right\} \tau_M^2$$

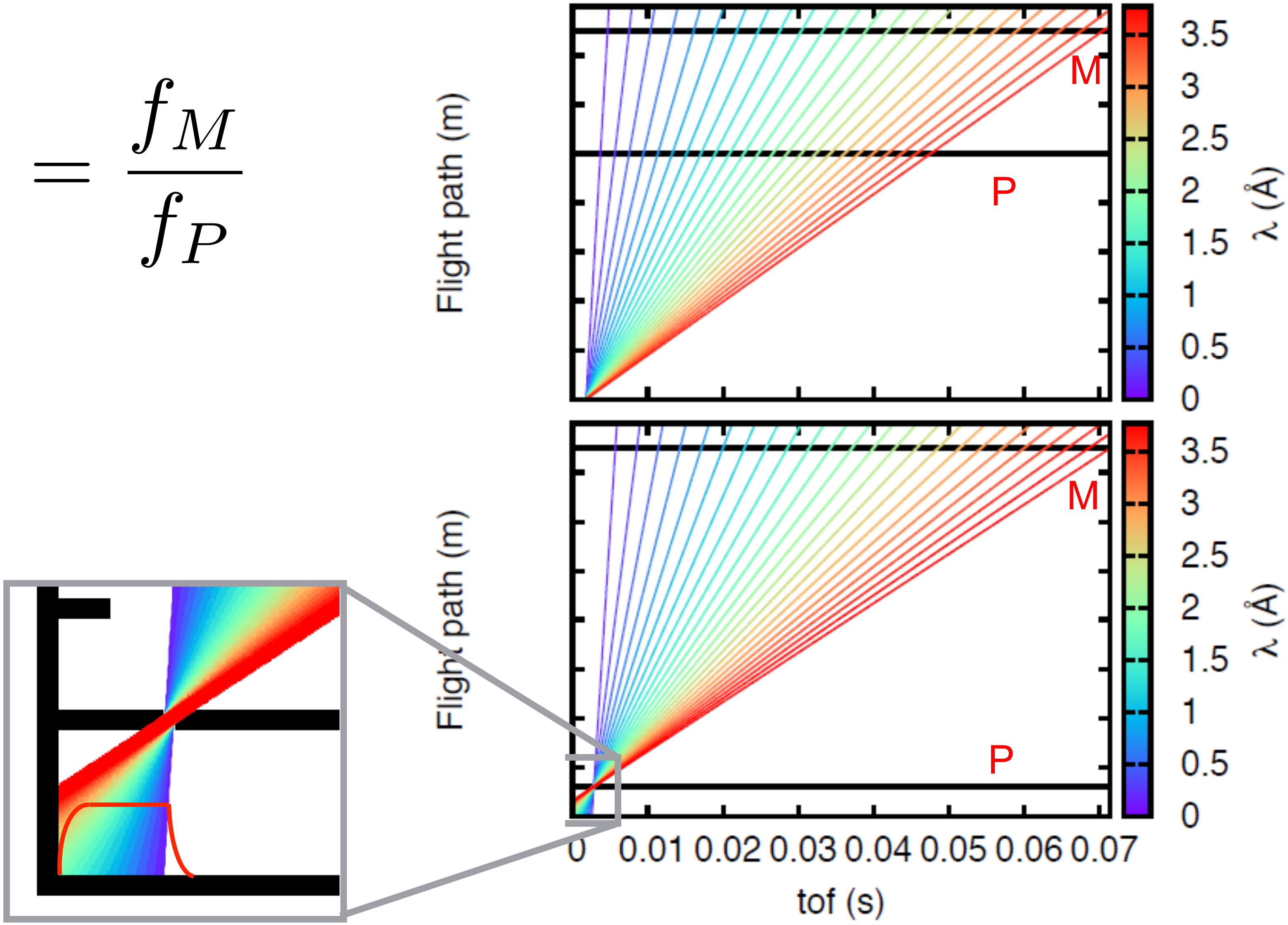
$$C^2 = \left(\frac{L_{PM}}{v}\right)^2 \sigma_{L_{MS}}^2$$



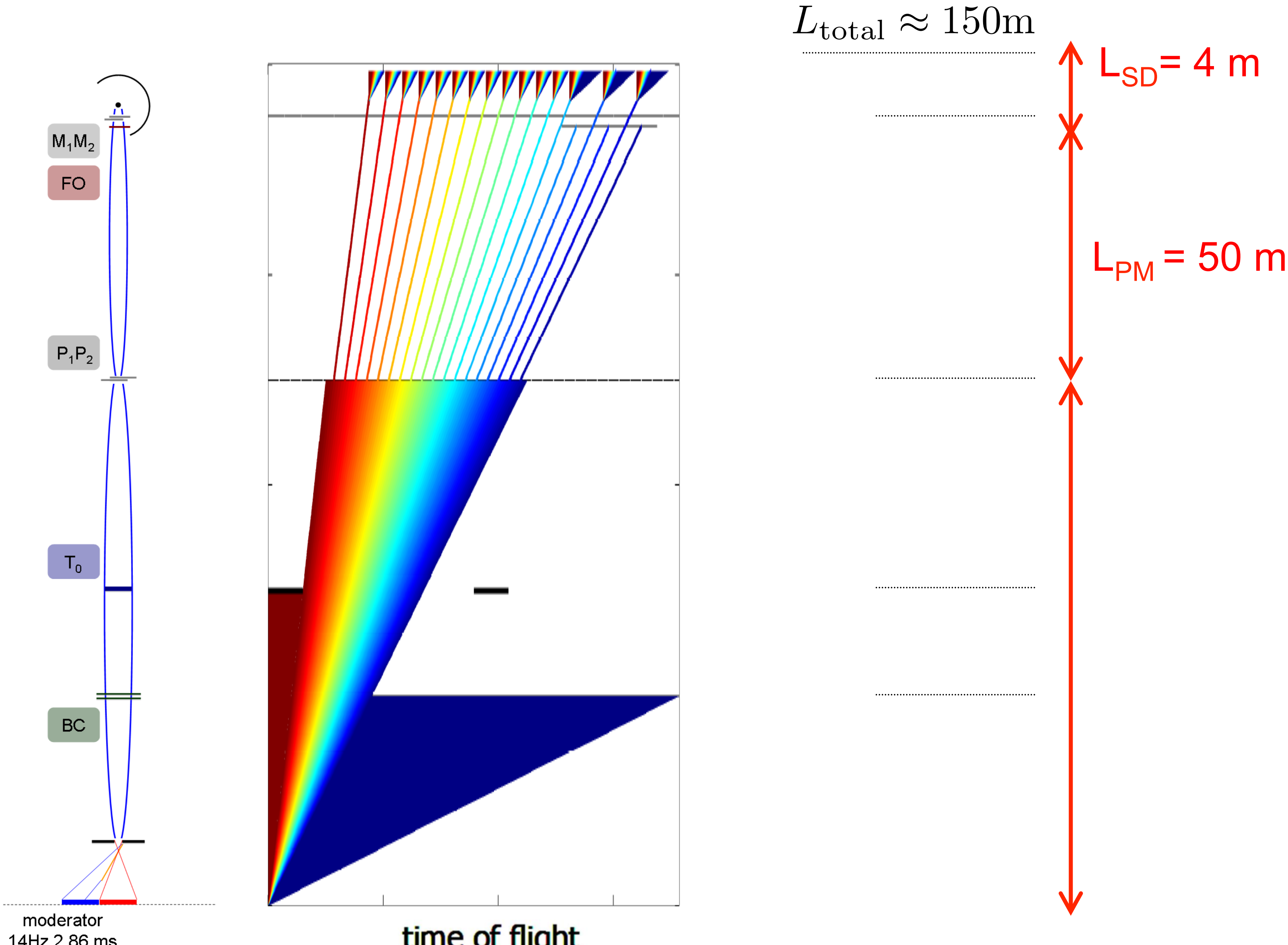
Important:
L_{PM}>20m
to match HR!!

Define the time origin

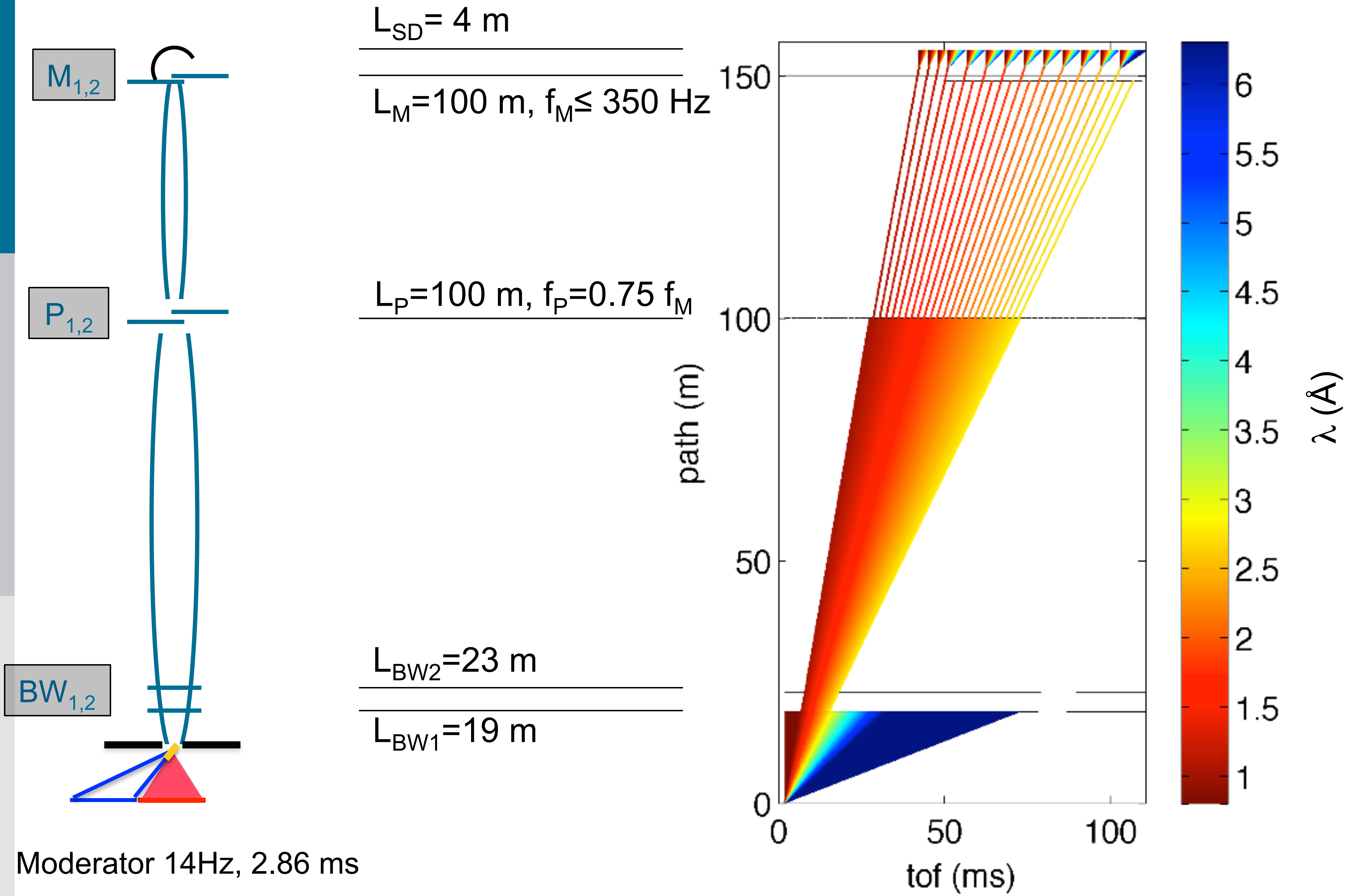
$$\frac{L_P}{L_M} = \frac{f_M}{f_P}$$



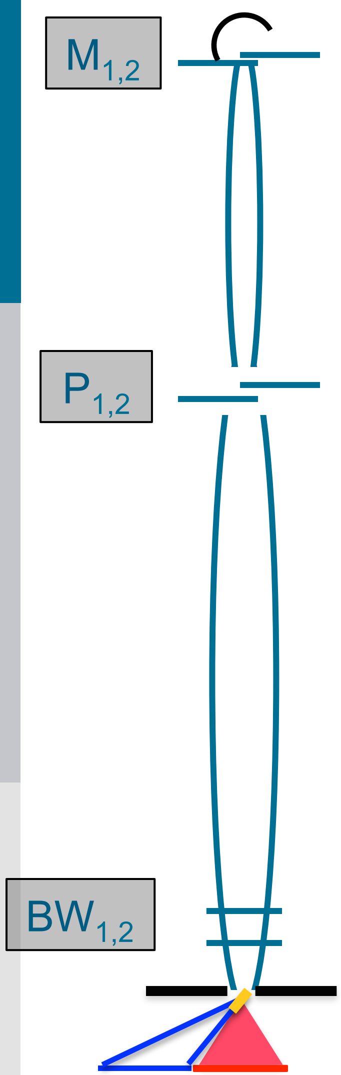
Geometry III



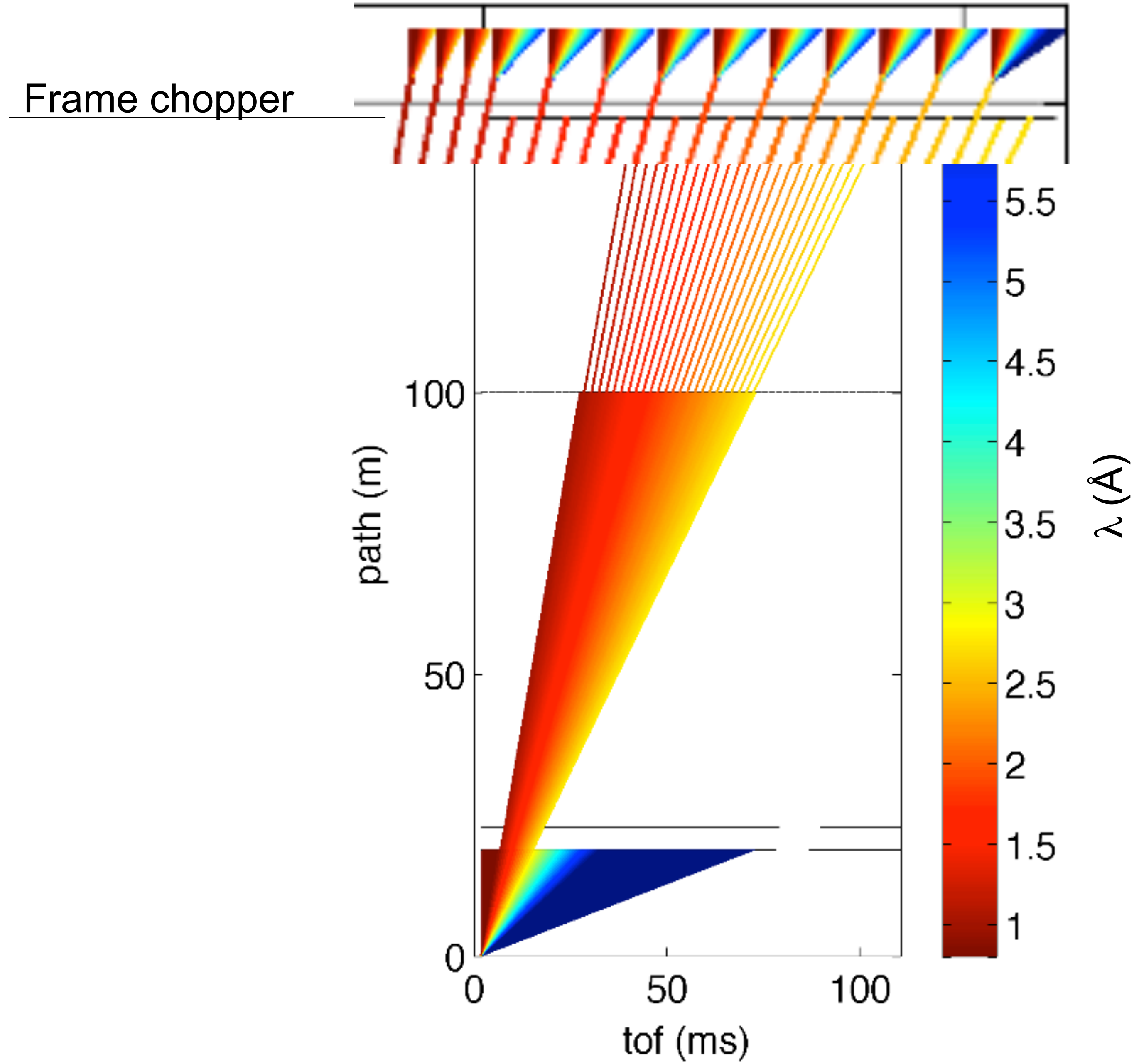
Chopper layout



Chopper layout



Moderator 14Hz, 2.86 ms

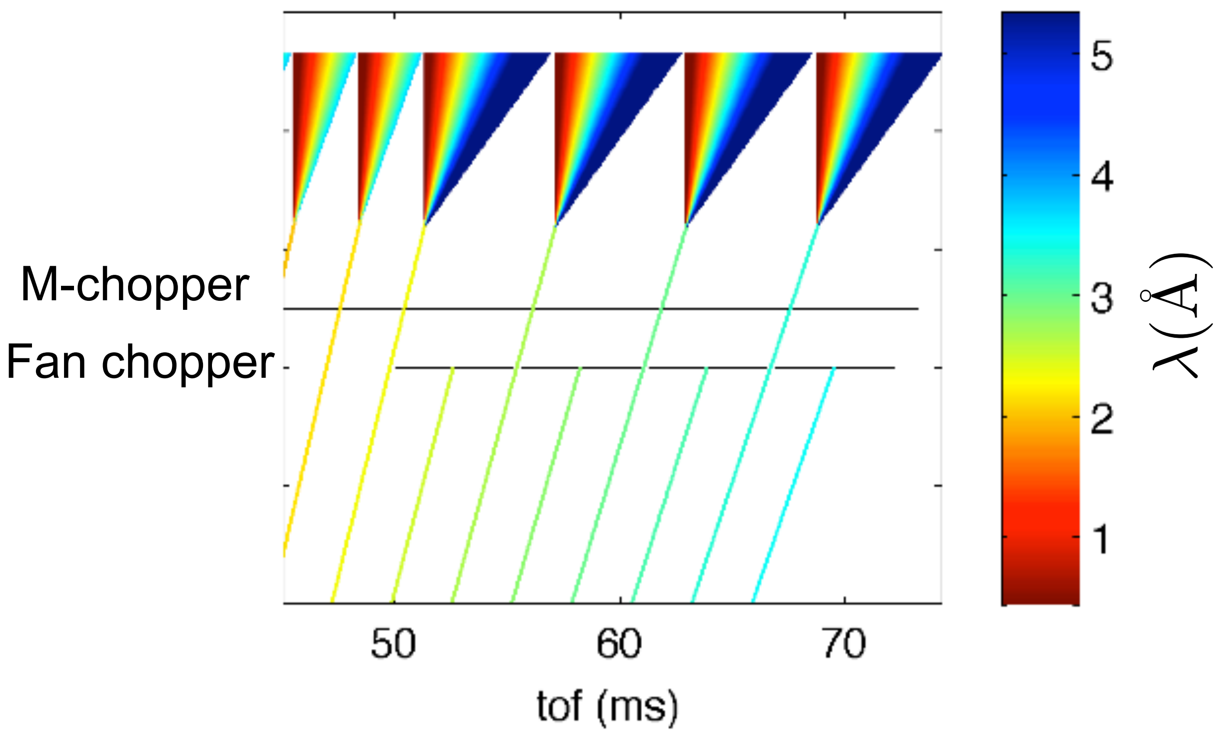


Time frames issues

$$T_{\text{frame}} = \frac{m_n}{h} L_{\text{SD}} \lambda' = \frac{m_n}{h} L_{\text{SD}} \lambda \sqrt{\frac{1}{\frac{\hbar\omega}{E} + 1}}$$

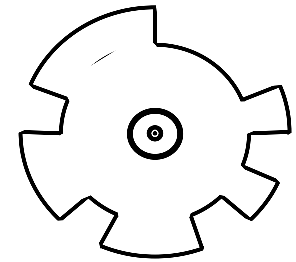
! Block beam 2x($T_M - \tau_M$)

! Fully opaque during τ_M



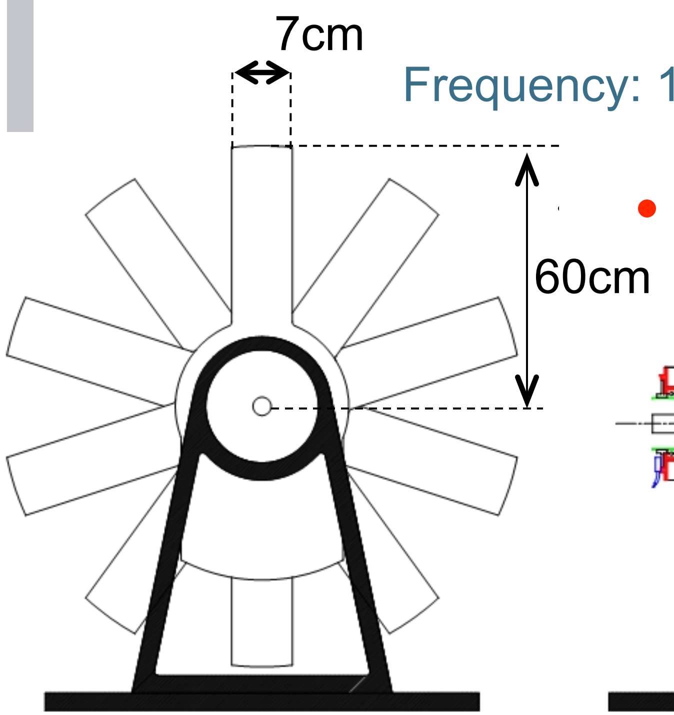
A Fan chopper with adjustable blades

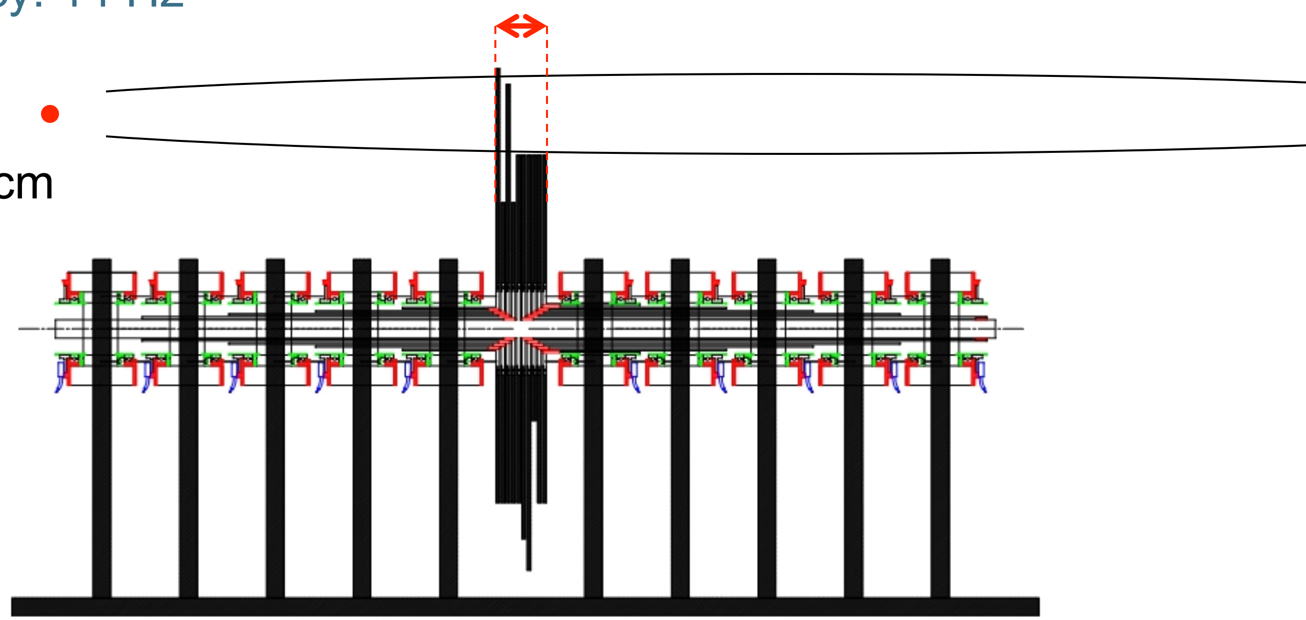
- ✓Mechanical parts manufactured
- ✓Drives procured
- ✓Control Hardware procured
- ✓Assembly March ’13



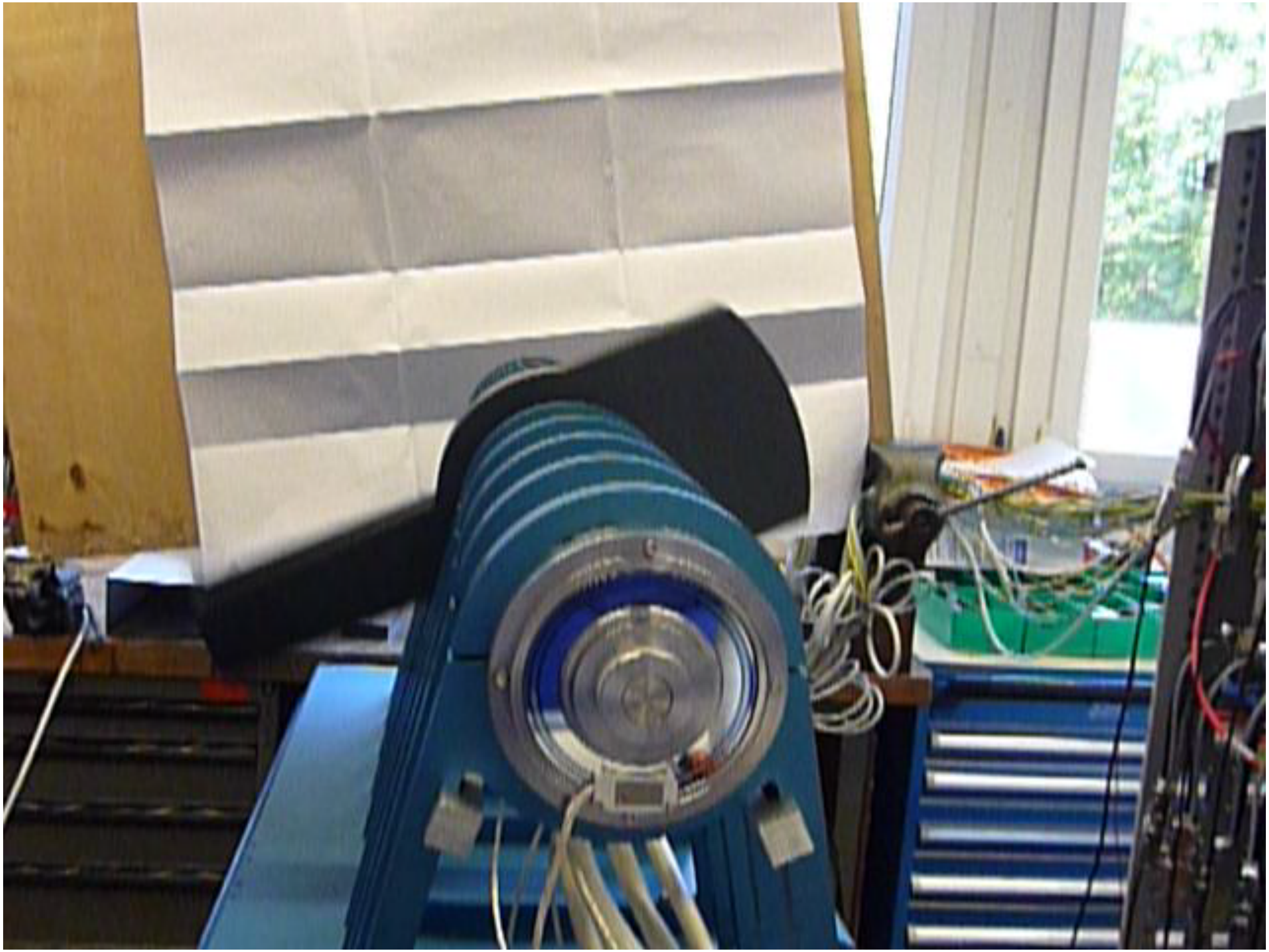
M. Russina, F. Mezei, J. Phys.: Conf. Ser. **251** (2010) 012079

Frequency: 14 Hz





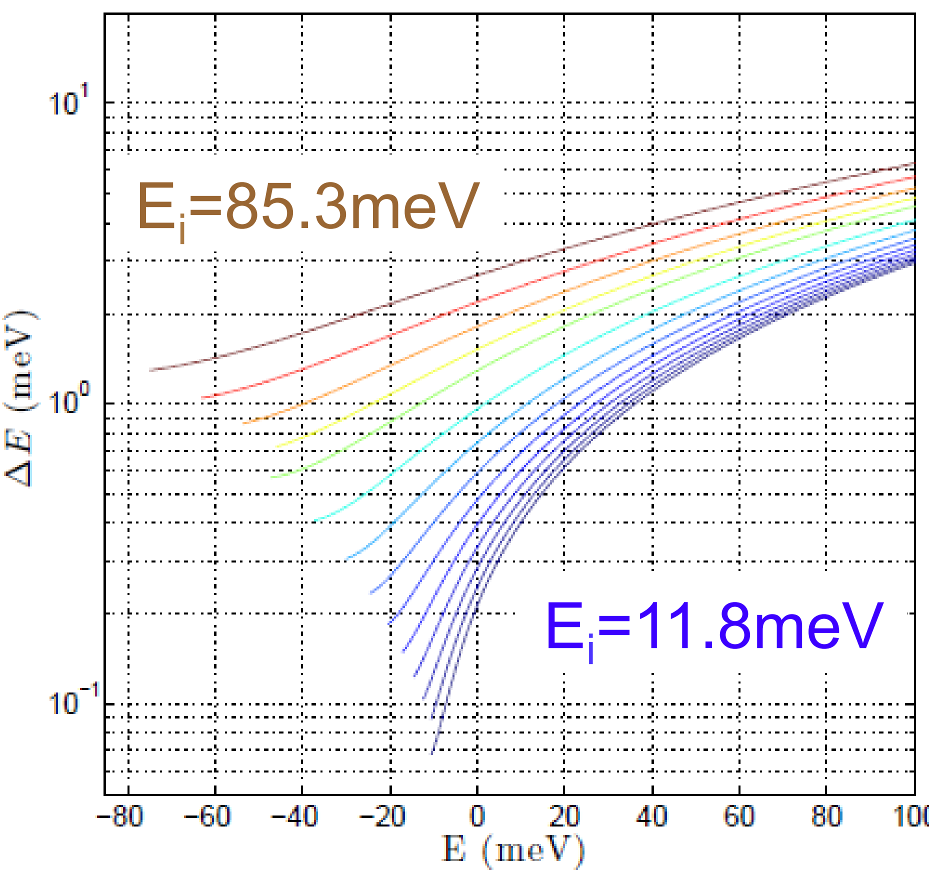
A Fan chopper with adjustable blades



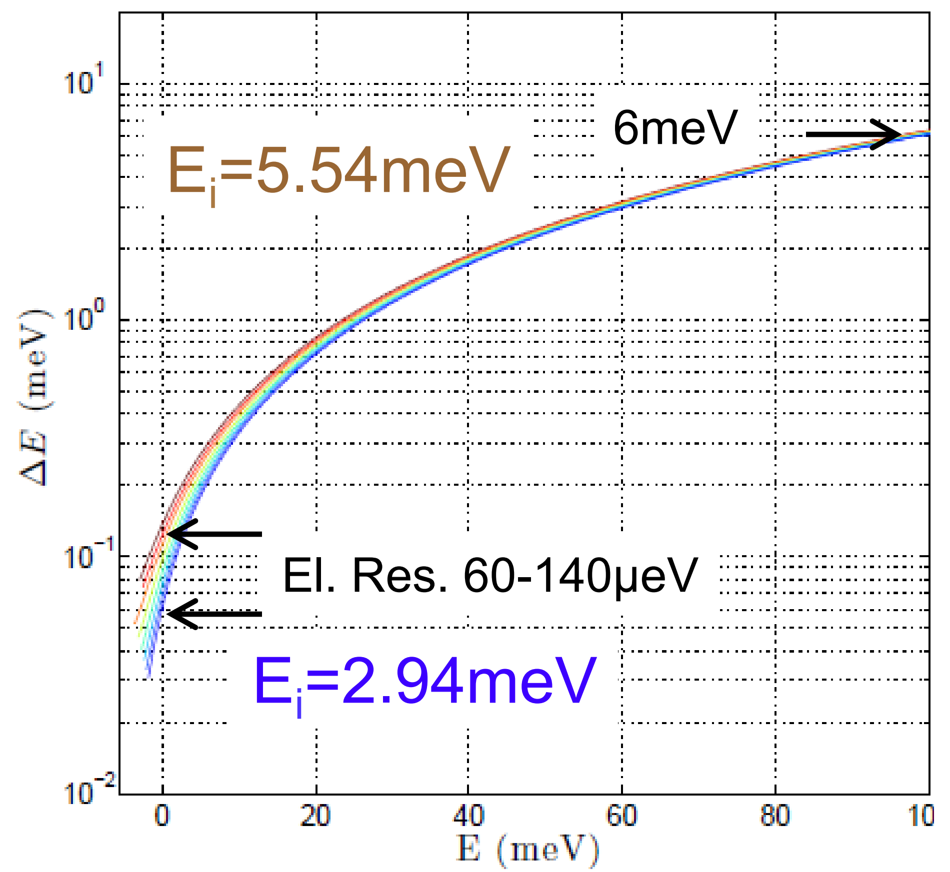
Dynamic range of a single target pulse

Pulse supression active

Band centered at 1.8 Å



Band centered at 4.5 Å

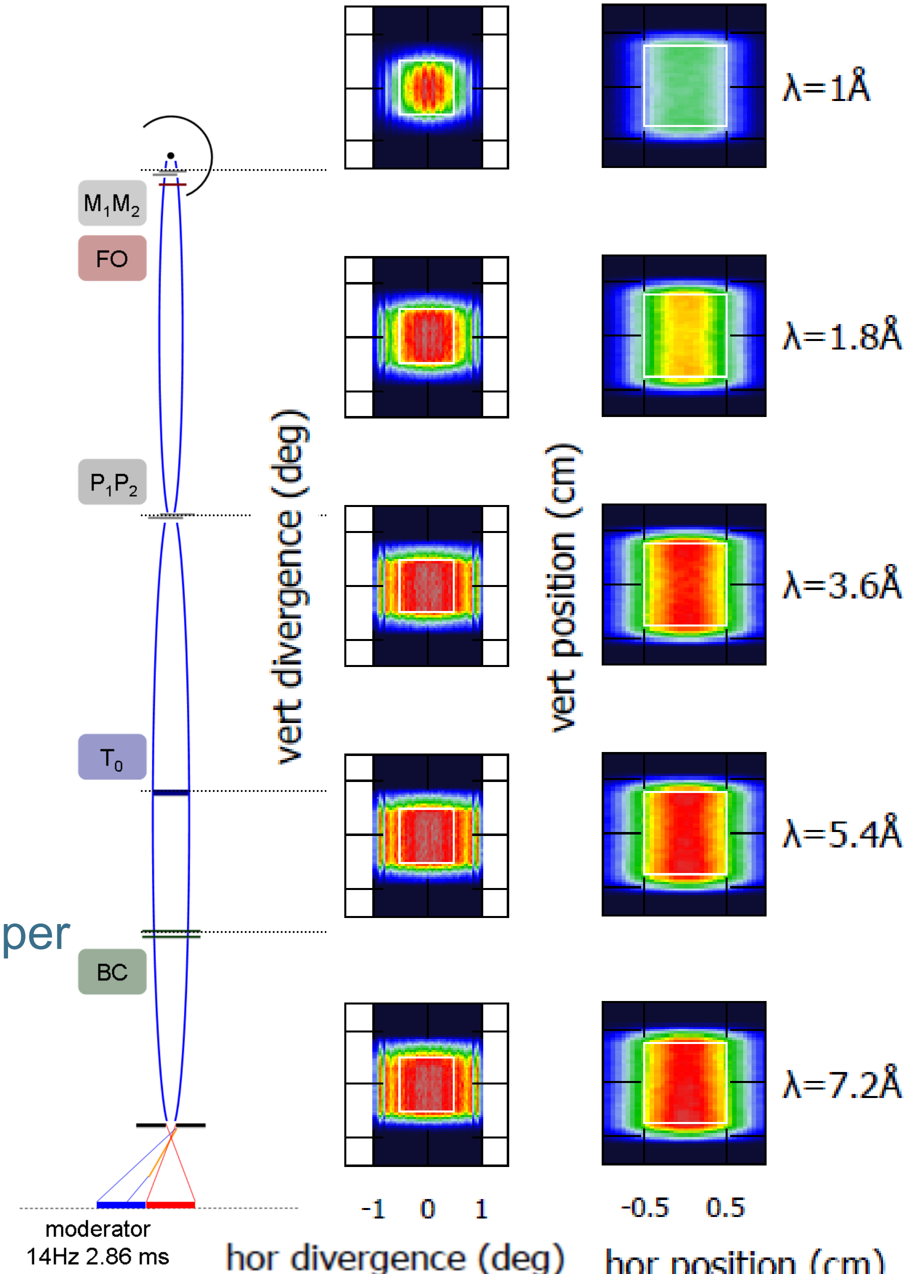


Neutron guide layout

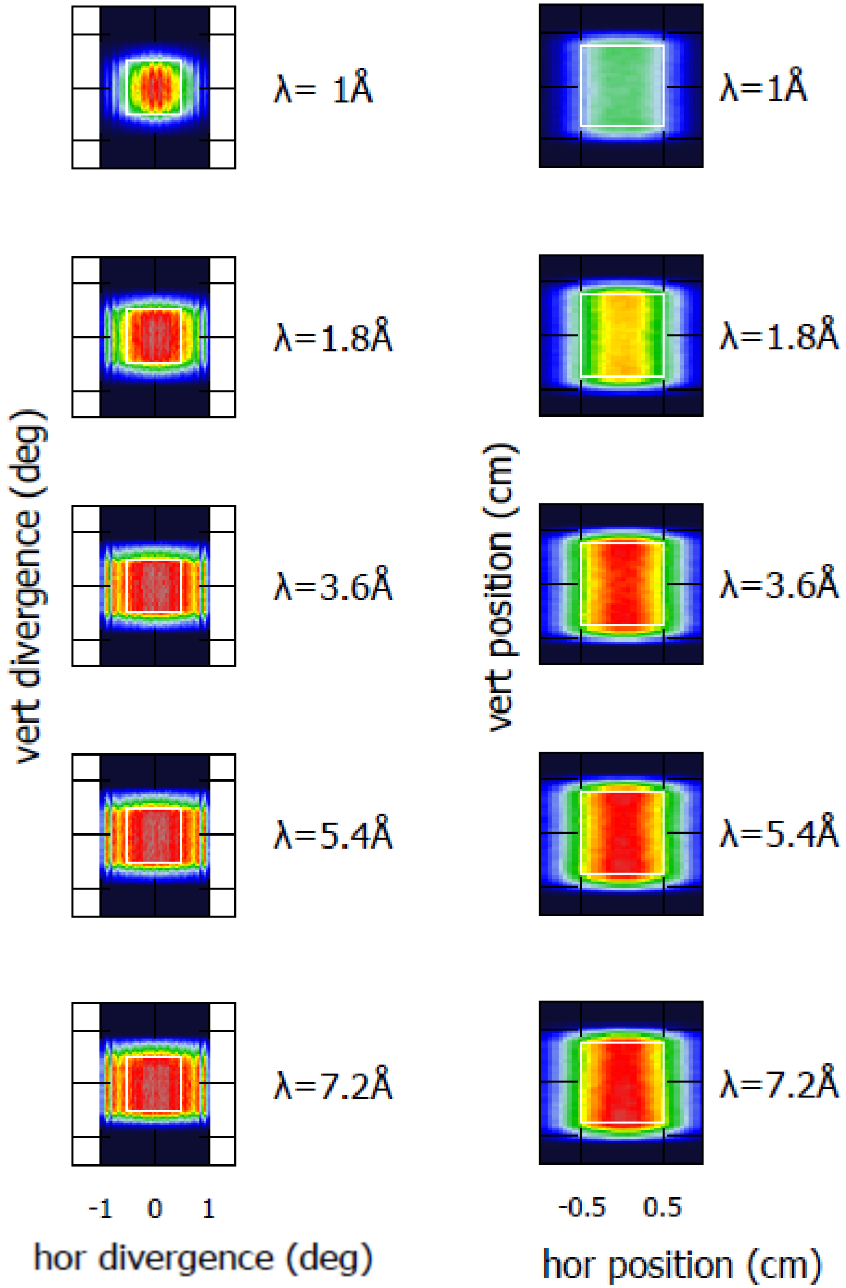
- Optimize the brilliance transfer
  1x3 cm beam spot
  ±1° divergence
- 2 ellipses
  - → small windows
  - → shorter burst times
  - → correct coma aberrations

- Homogeneous beam profile/sample dimensions
- Concentrator/Collimators

- Avoiding direct LoS
  - T0 chopper
  - Beam catcher at ellipse 1 and P chopper
  - Kinked ellipses

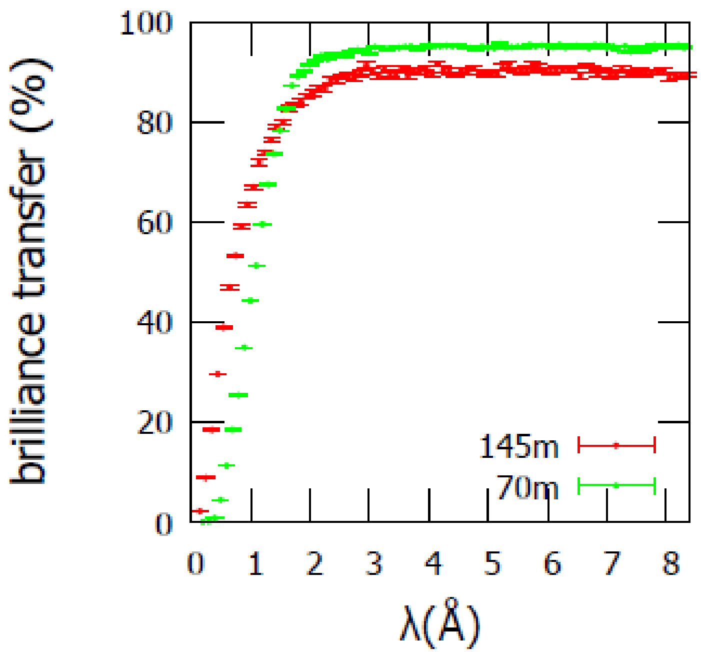


Beam profile and divergence on sample



Transport system performance

Figure of merit
1x3 cm^2
+/-0.5 °



4Å

	Short	Long
El.En.res. (μeV)	112	125
Flux (10^5 n/s/cm^2)	7	5.4

Comparison with existing instruments

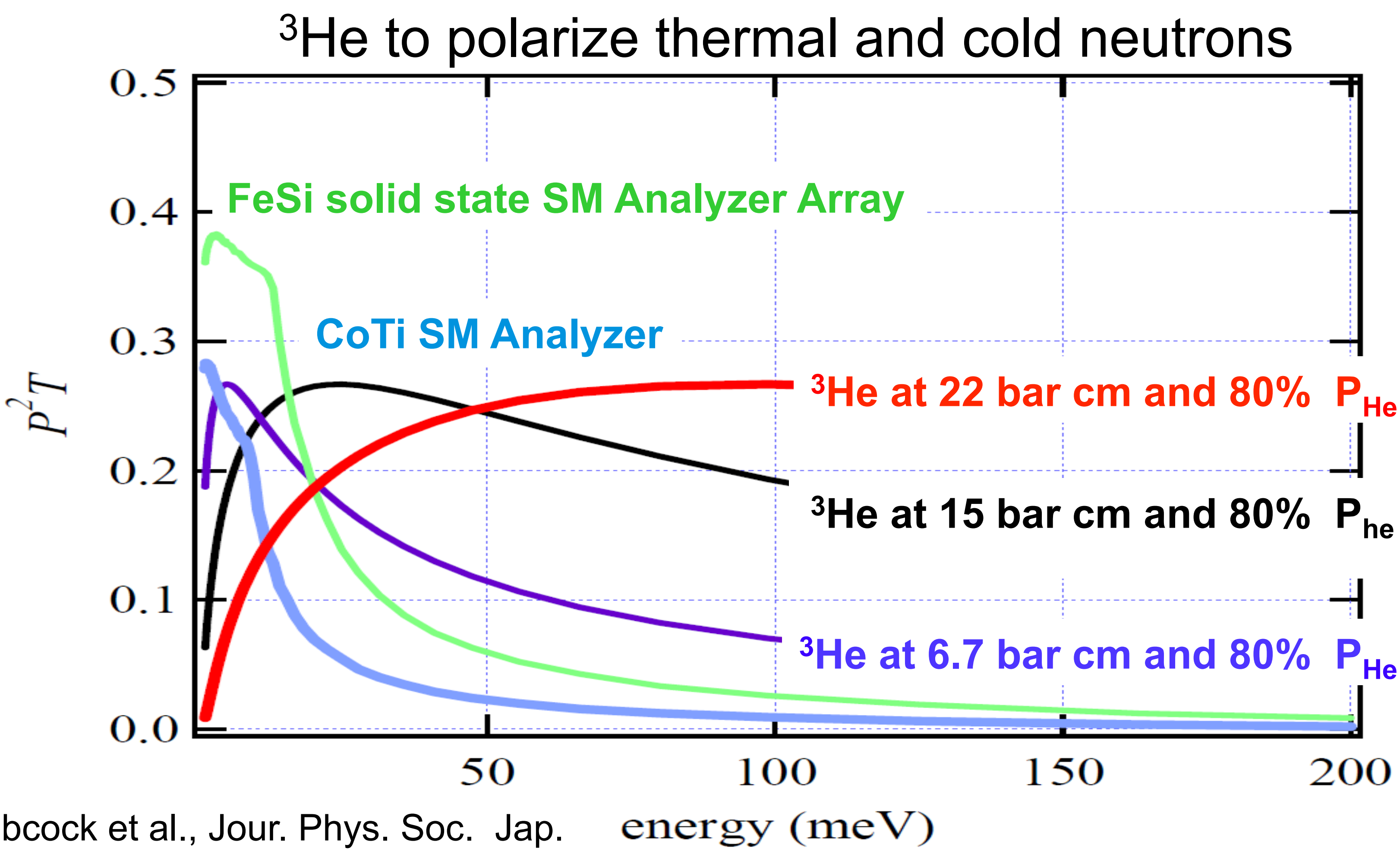
JÜLICH FORSCHUNGSZENTRUM

4Å

	Rep. rate (Hz)	El. En. Res (μeV)	Monochr. flux (n/s/cm^2)	Gain factor single pulse	Multiple pulses	Gain
T-REX	14	112 ± 2	$7\ 10^5$ Average over 1x3cm^2	9	4-16	36-144
LET	10	102 ± 2	$5.6\ 10^4$ Average over 4x4cm^2	1	4	4
IN5	70	105 ± 6	$8.9\ 10^4$ Average over 2x5cm^2	0.09	70	1.6

Polarisation and bandwidth

$$\Delta\lambda < 2\text{Å}$$



E. Babcock et al., Jour. Phys. Soc. Jap.
S.E., proceedings of QENS/WINS 2012, Nikko Japan

Cost estimate today

Item	Cost [k€]
Shielding	3500
Neutron guide system	1030
Choppers	1250
Detector	10000
Detector tank	1110
Polarization	370
	18000

Specifications
- 180º horizontal
- ±30º vertical
- 50 m^2 area

Cost estimate today

Item	Cost [k€]
Shielding	3500
Neutron guide system	1030
Choppers	1250
Detector	10000
Detector tank	1110
Polarization	370
	18000

Options
1. ^{3}He, 2. ^{10}B solid state, 3. WSF

Acknowledgements

JÜLICH
FORSCHUNGSZENTRUM


Thomas Brückel


Nicolo Violini

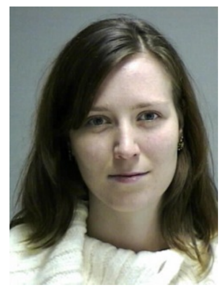

Andreas Wischnewski


Stefano Pasini


Sven Janaschke

HZB Helmholtz Zentrum Berlin


Margarita Russina


Katharina Rolfs

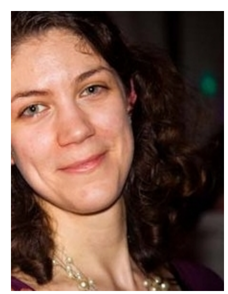

Pascale P. Deen


Kim Lefmann

TUM Technische Universität München


Wiebke Lohstroh


Luca Silvi


Giovanna Simeoni


Anette Vickery


Linda Udby

T-REX will be/have

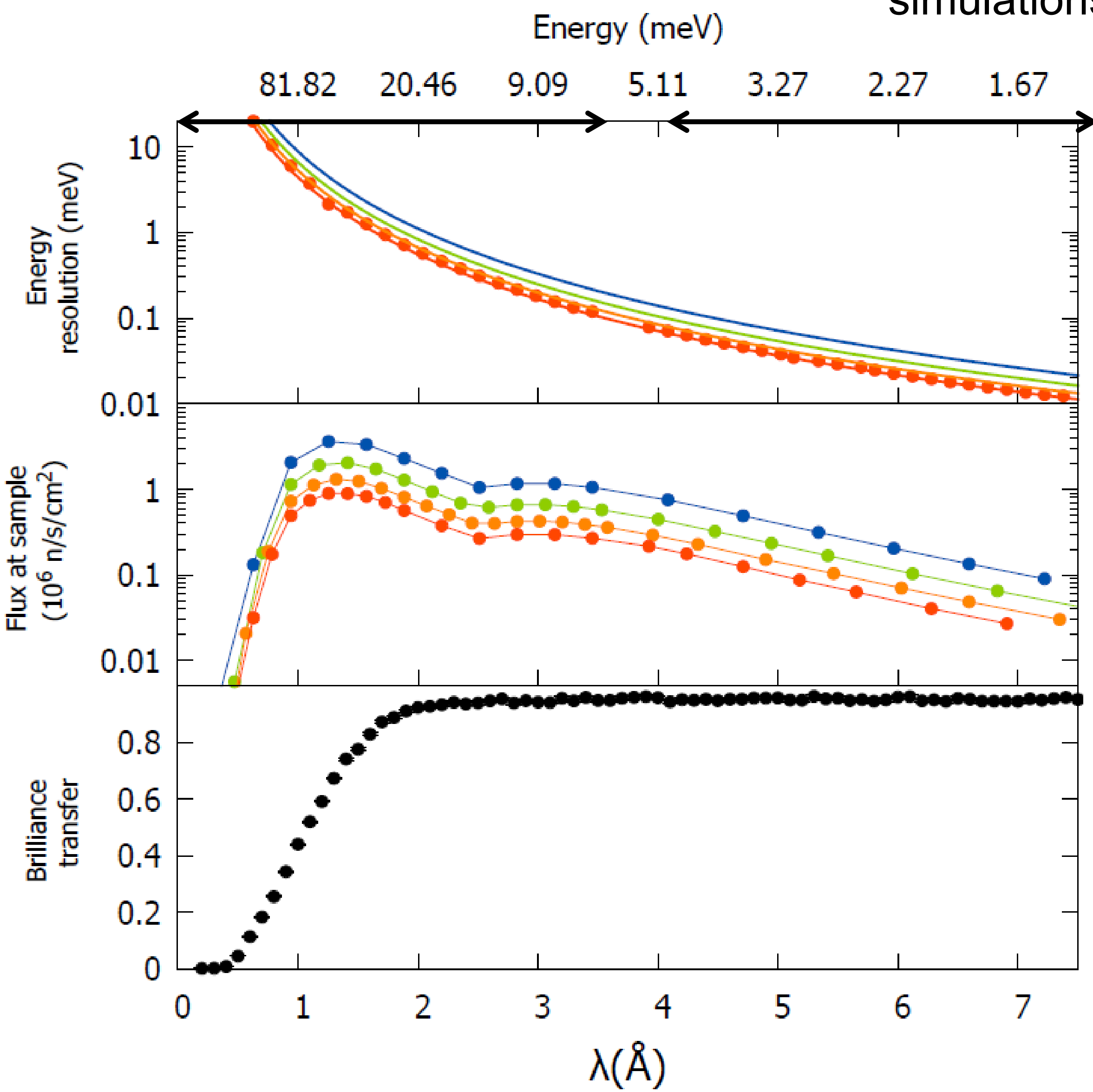
- ✓ Multispectral spectrometer
  - ✓ From extreme energy resolution to very high flux
  - ✓ 4 decades in energy/time on **one** instrument
- ✓ Polarization
- ✓ Pixel power
  - ✓ Adaptive collimation
  - ✓ $\Delta Q \geq 0.01$ Å^{-1} for small angle region
  - ✓ $Q \leq 12$ Å^{-1}
  - ✓ Mapping of coherent excitations

Looking forward meeting you there

Thank you for the attention

Versatile chopper configuration

simulations of the short layout



Up to 4 times higher flux

x14Hz				
f_{P1}	f_{P2}	f_{M1}	f_{M2}	Gain
9	9	12	12	
12	12	16	16	1.77
15	15	20	20	1.56
18	18	24	24	1.44

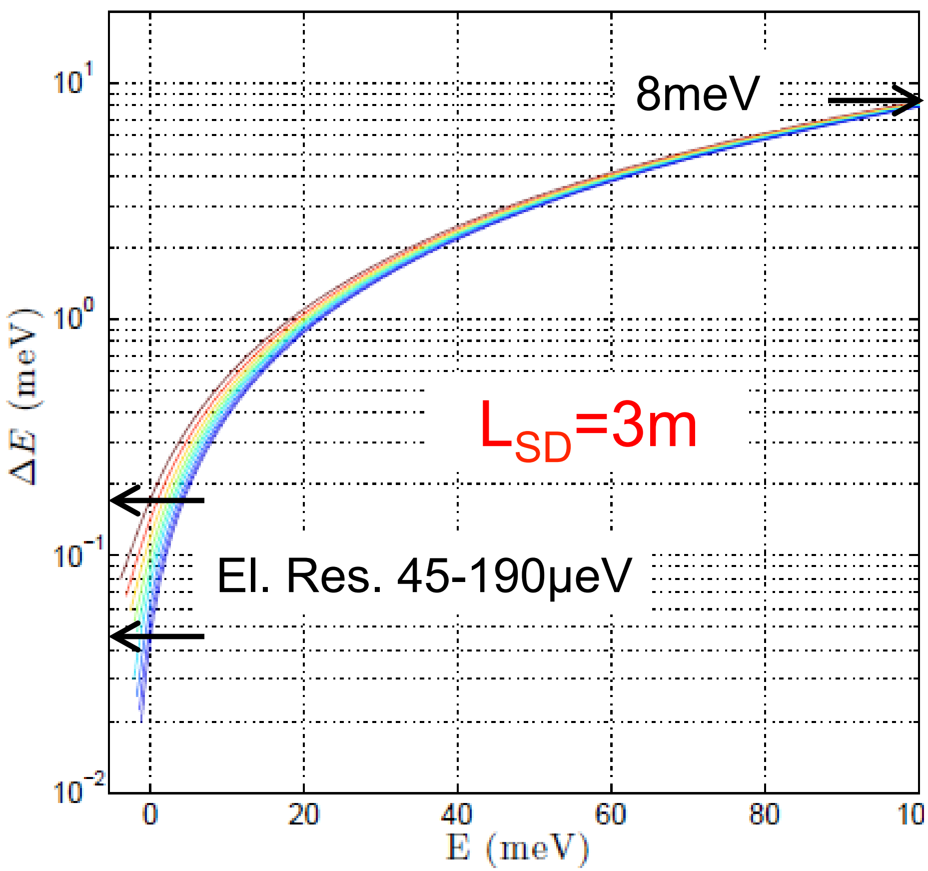
Short layout 79.3 length

Band centered around 3 meV – 5Å

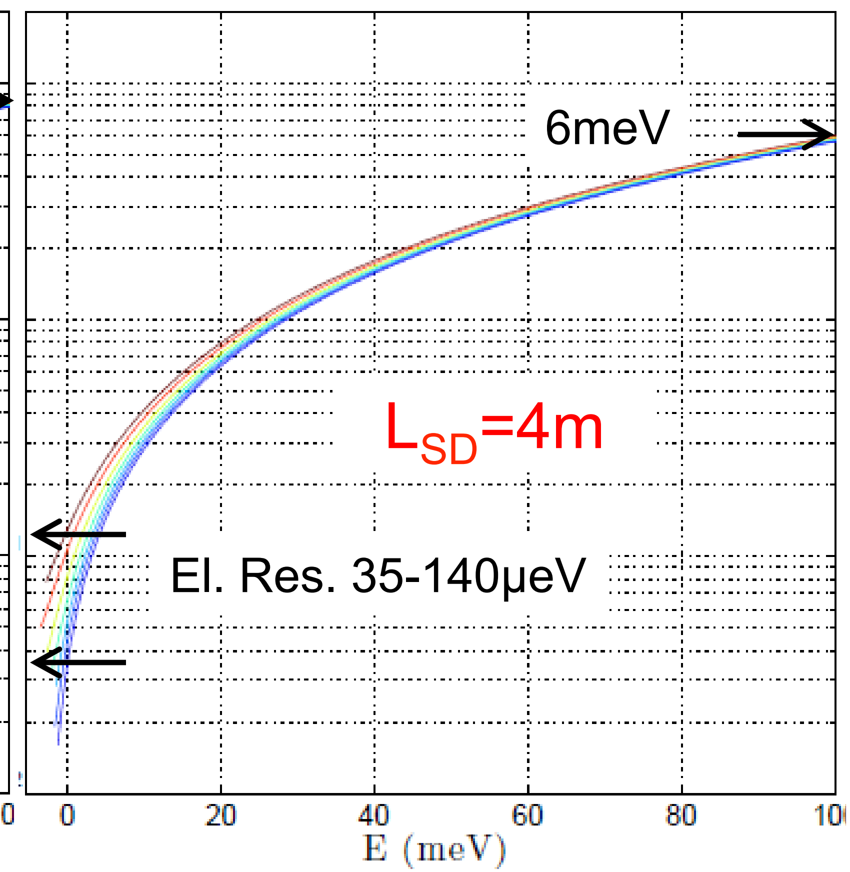
1.3 higher rep. rate

1.3 higher flux

higher acquisition rate



better resolution



Application of Matrix calculation to ToF spectrometers

$$Q = \frac{m}{\hbar}\left(v^2 + v'^2 - 2vv'\cos\theta\right)^{1/2}$$

$$E = \frac{m}{2}\left(v^2 - v'^2\right)$$

$$\delta Q = Q - Q_0 = \sum_{i=1}^{N} \left.\frac{\partial Q}{\partial x_i}\right|_{x_i=\hat{x}_i} \delta x_i$$

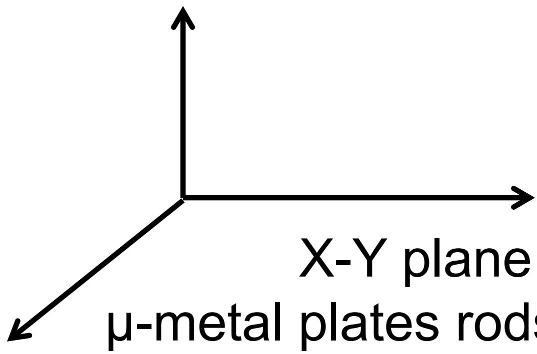
$$\delta E = E - E_0 = \sum_{i=1}^{N} \left.\frac{\partial E}{\partial x_i}\right|_{x_i=\hat{x}_i} \delta x_i$$

$$\mathrm{Cov}(Y) = \mathrm{Cov}(JX) = J\,\mathrm{Cov}(X)\,J^T$$

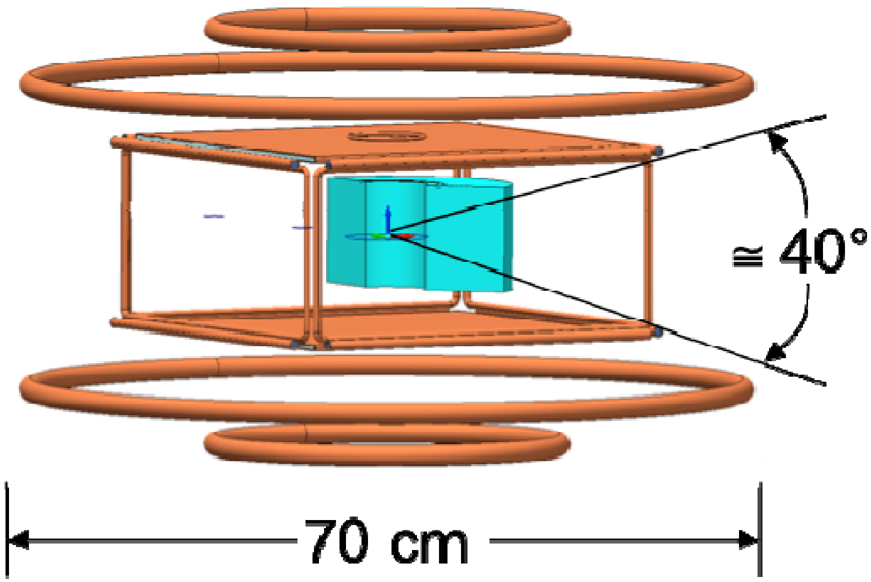
x_i
L_{PM}
L_{MS}
L_{SD}
τ_P
τ_M
τ_D
ω_M
σ_{θ_i}
σ_θ

MAGIC PASTIS LAYOUT

Z direction
compensated Helmholtz pair



X-Y plane
μ-metal plates rods + coils



Large solid angle coverage 90° (H) x 40° (V)
OFFLINE polarization

Energy resolution

$$\sigma_E^2 = \frac{(mv'^3)^2\left(A^2 + B^2 + C^2\right)}{\left(L_{PM}L_{SD}\right)^2}$$

$$A^2 = \left[L_{MS} + L_{SD}\left(\frac{v}{v'}\right)^3\right]^2 \tau_P^2$$

$$B^2 = \left\{\left[L_{MS} + L_{SD}\left(\frac{v}{v'}\right)^3\right]^2 + L_{PM}^2\right\}\left(\tau_M^2 + \frac{\sigma_{\theta_i}^2}{\omega_M^2}\right)$$

$$C^2 = \left(\frac{L_{PM}}{v}\right)^2 \sigma_{L_{MS}}^2$$

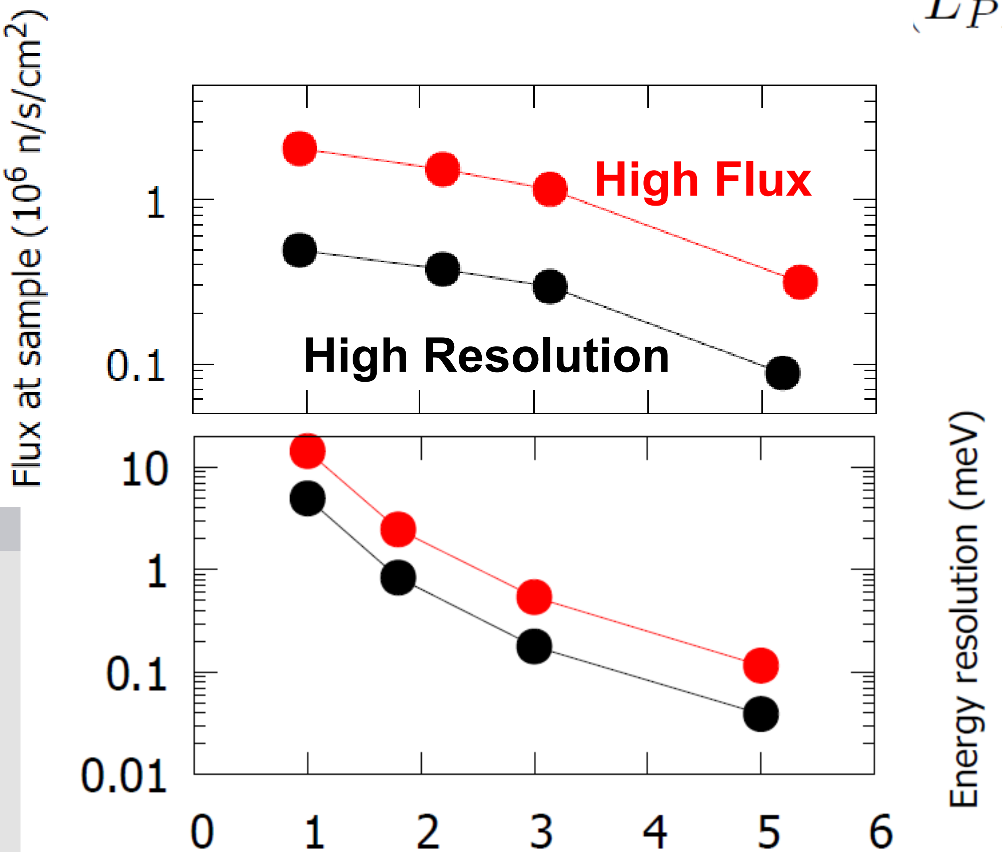
Energy resolution control

$$\sigma_E^2 = \frac{(mv'^3)^2 \left(a^2 \tau_P^2 + b^2 \left(\tau_M^2 + \frac{\sigma_{\theta_i}^2}{\omega_M^2} \right) + c^2 \sigma_{L_{MS}}^2 \right)}{(L_{PM} L_{SD})^2}$$

x2

$$F \propto \frac{\tau_\mathrm{P} \tau_\mathrm{M}}{L_\mathrm{PM} L_\mathrm{SD}}$$

x4



Vitess 2.11 simulations of the bispectral 79.3m instrument

Balanced condition

$$\tau_\mathrm{P} = \tau_\mathrm{M} \left(\frac{L_\mathrm{PM}}{L_\mathrm{MS} + (\lambda/\lambda')^3 L_\mathrm{SD}} + 1 \right)$$

< 2ms

R. E. Lechner, Proceedings of the ICANS-XV Meeting (2000) Tsukuba, Japan, JAERI-Conf 2001-002, pp. 357 – 376

Q resolution knowledge

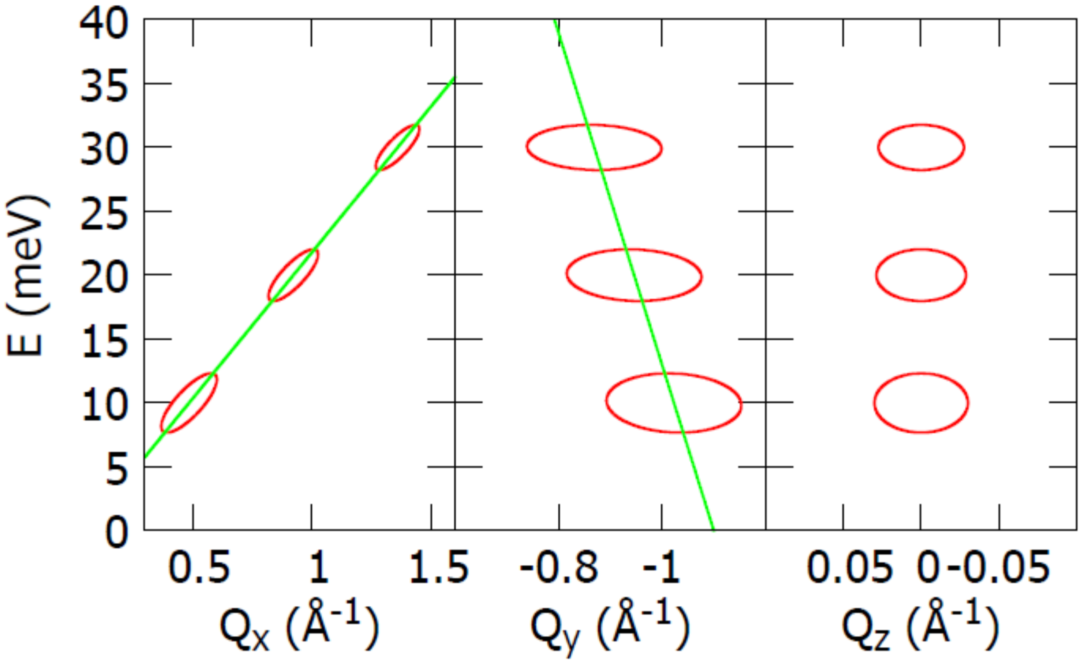
$$\sigma_Q^2 = \left(\frac{m}{\hbar}\right)^4 \frac{1}{Q^2} \left(A_Q^2 + B_Q^2 (\cos\theta - 1)^2 + C_Q^2 \sin^2\theta\right)$$

$$A_Q = \frac{v^3}{L_{PM}} \left(\frac{L_{MS}}{L_{SD}} - 1\right) \left(\tau_P^2 + \tau_M^2 + \frac{\sigma_{\theta_i}^2}{\omega_M^2}\right)^{1/2}$$

$$B_Q = \frac{v^2}{L_{SD}} \left[v^2 \left(\tau_M^2 + \frac{\sigma_{\theta_i}^2}{\omega_M^2} + \tau_D^2\right) + \sigma_{L_{MS}}^2\right]^{1/2}$$

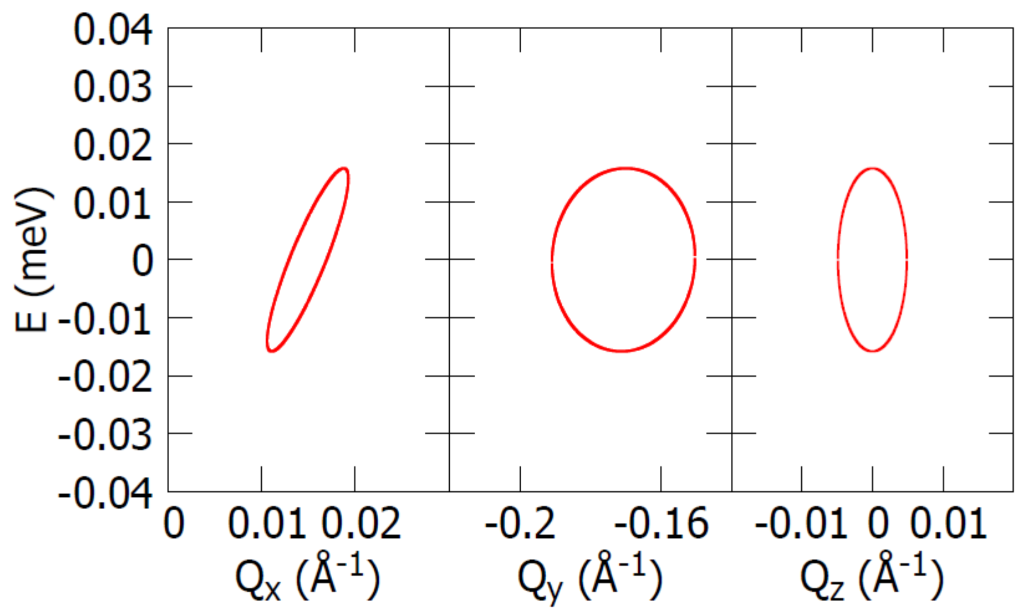
$$C_Q = v^2 \sigma_\theta$$

Q,E correlation knowledge

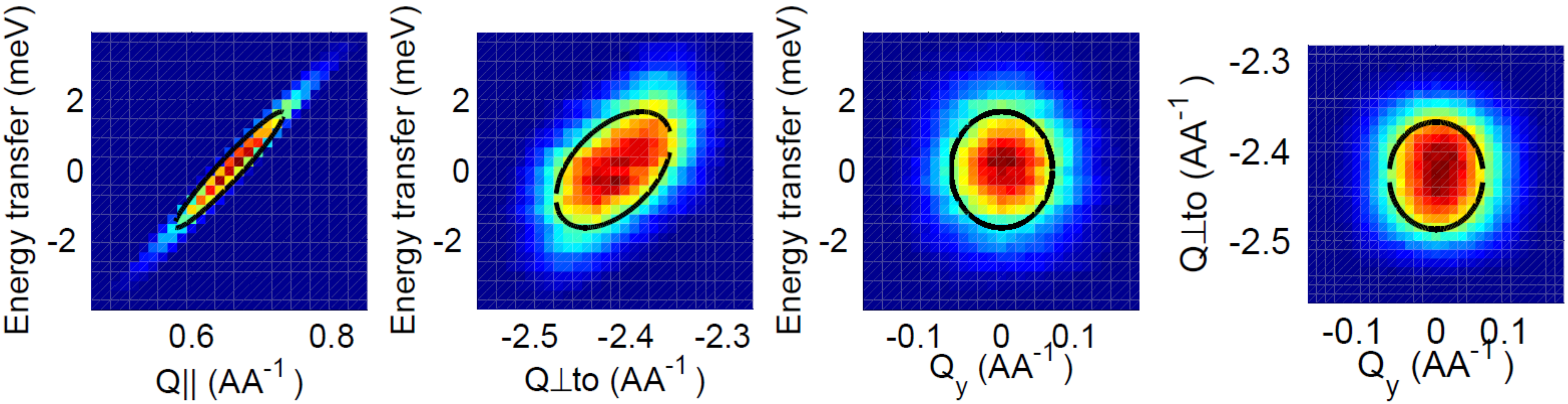


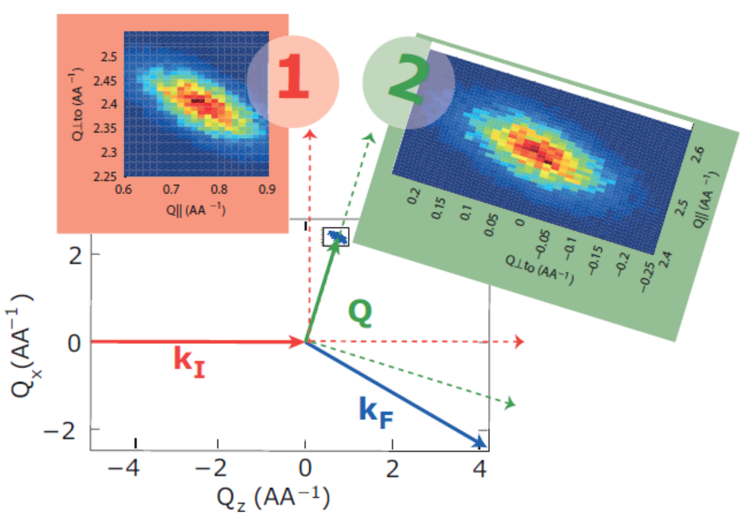
Following a phonon dispersion along selected directions

Quasi-Elastic investigations



McStas simulations vs Analytical calculations





A.Vickery, L. Udby, N. Violini, J. Voigt, P.P.Deen, K. Lefmann, in **Proceedings of QENS/WINS 2012**

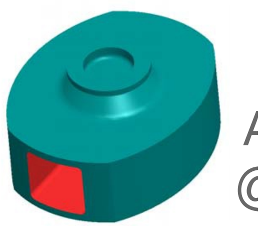
T0 choppers operation

$$L_{ST} \geq \frac{\tau_S - \tau_R + \frac{\Delta\theta}{2\pi f}}{\alpha \lambda_{MIN}}$$

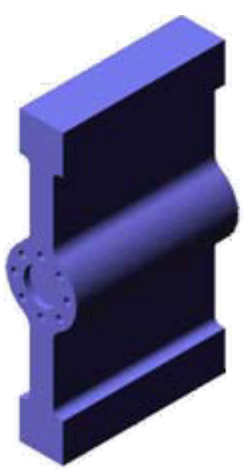
To allow λ_{MIN} pass through the chopper

$$L_{ST} \leq \frac{\frac{1}{f} - t_{fc} - 2\tau_0}{\frac{1}{f_s}} L$$

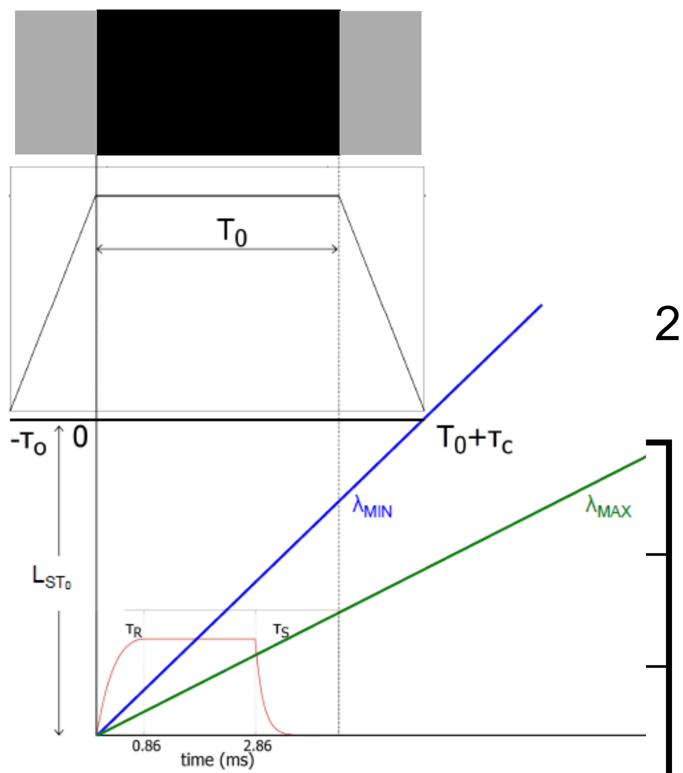
To fill the frame at detector position

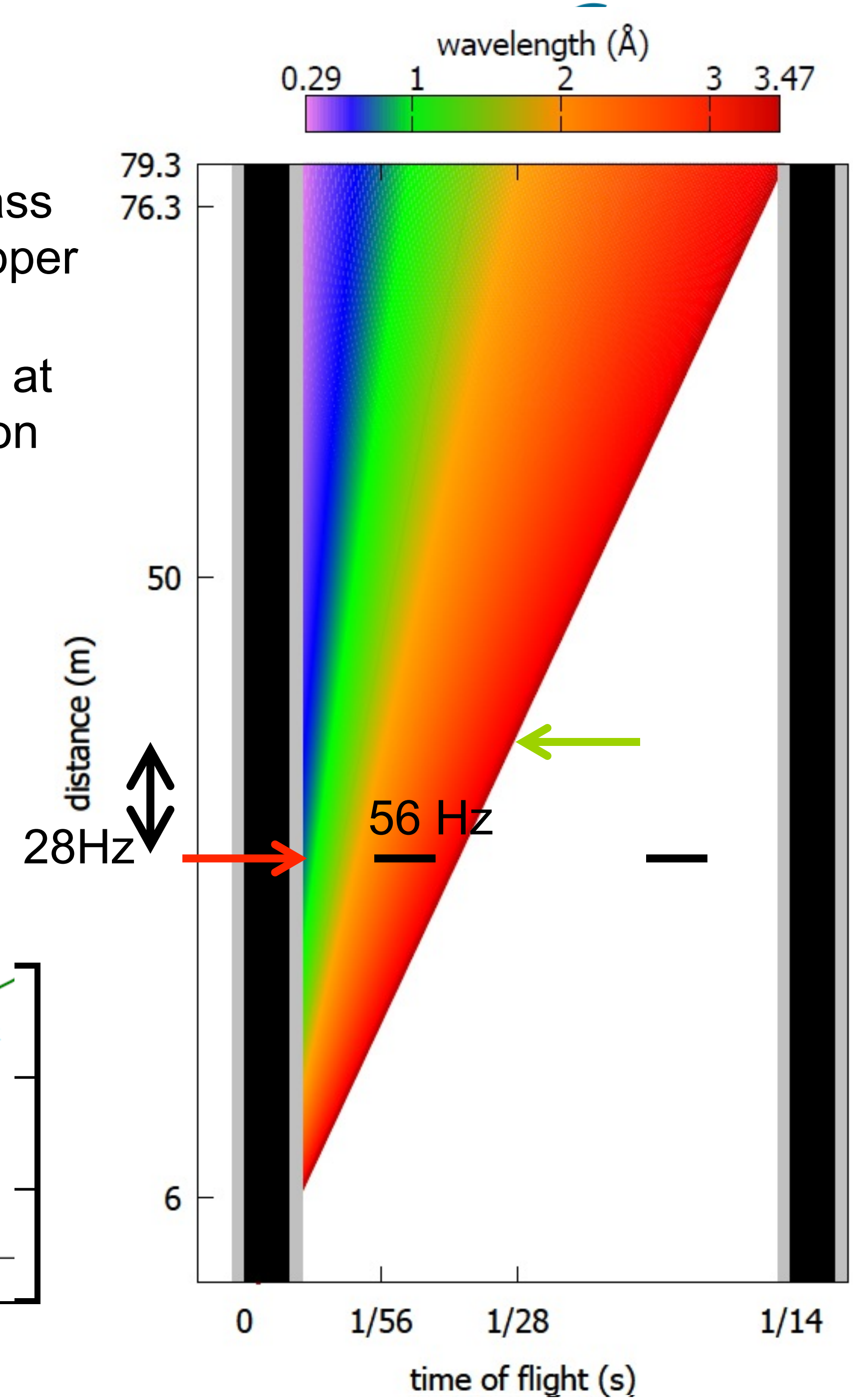


Rev. Sci. Instrum. 83



NIMA 661,1 (2012)

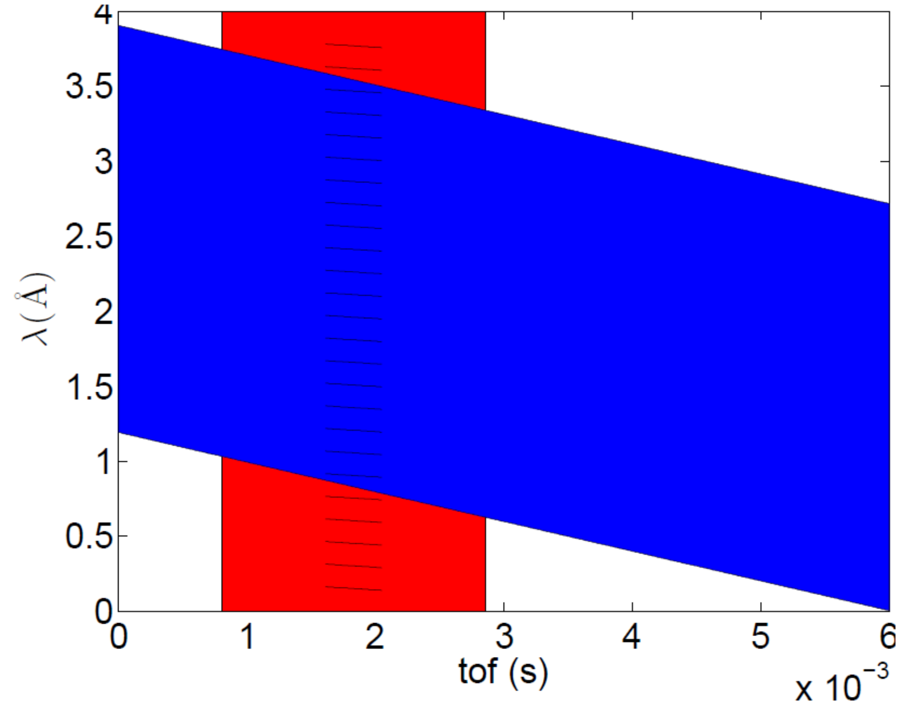




Wavelength selection

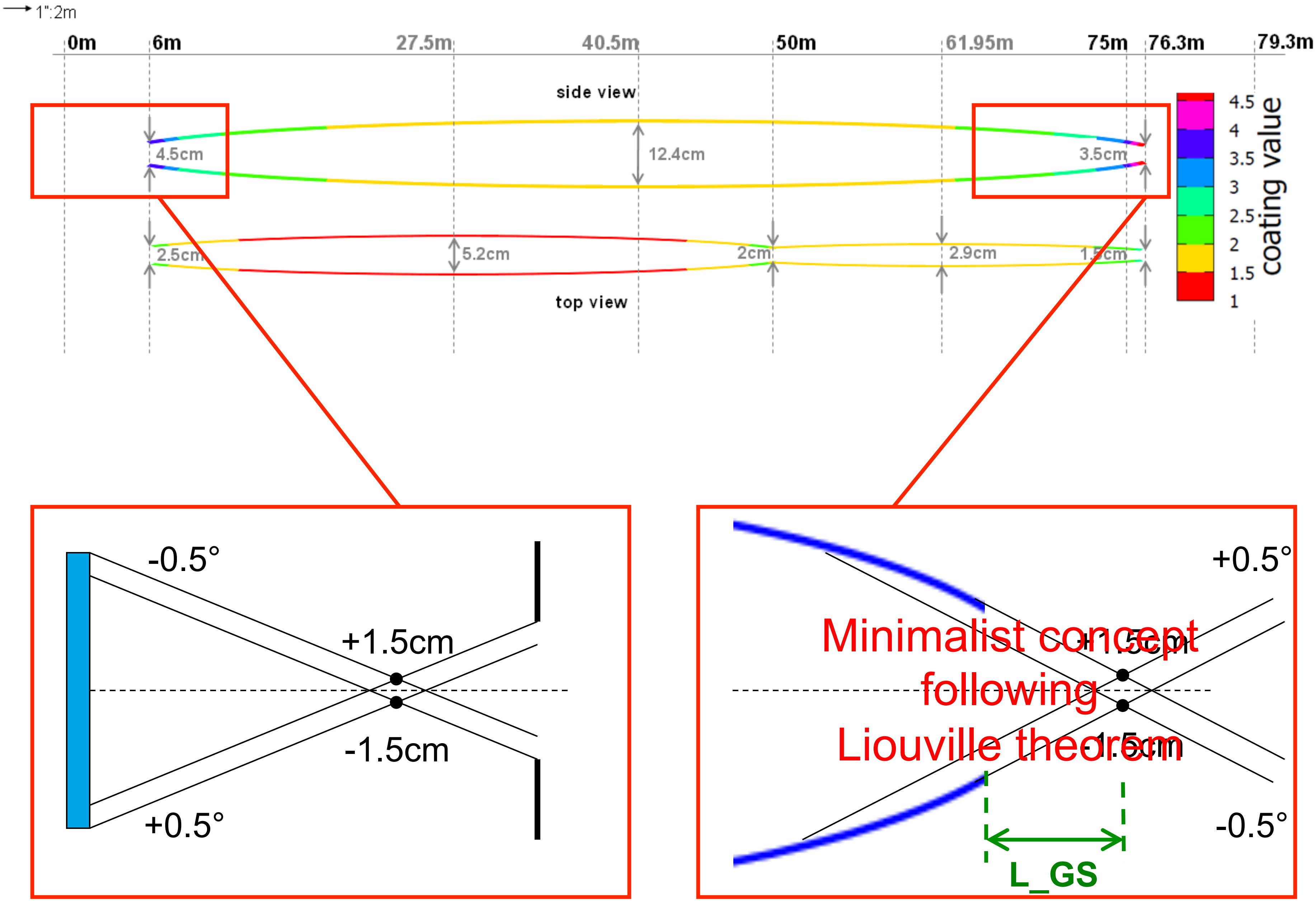
$$\Delta\lambda = \frac{h}{m_n}(f_{\text{source}} L_{\text{Det}})^{-1}$$

Issue: repetition after 16Å
Solved by $L_{P1\text{-}P2}$>5cm

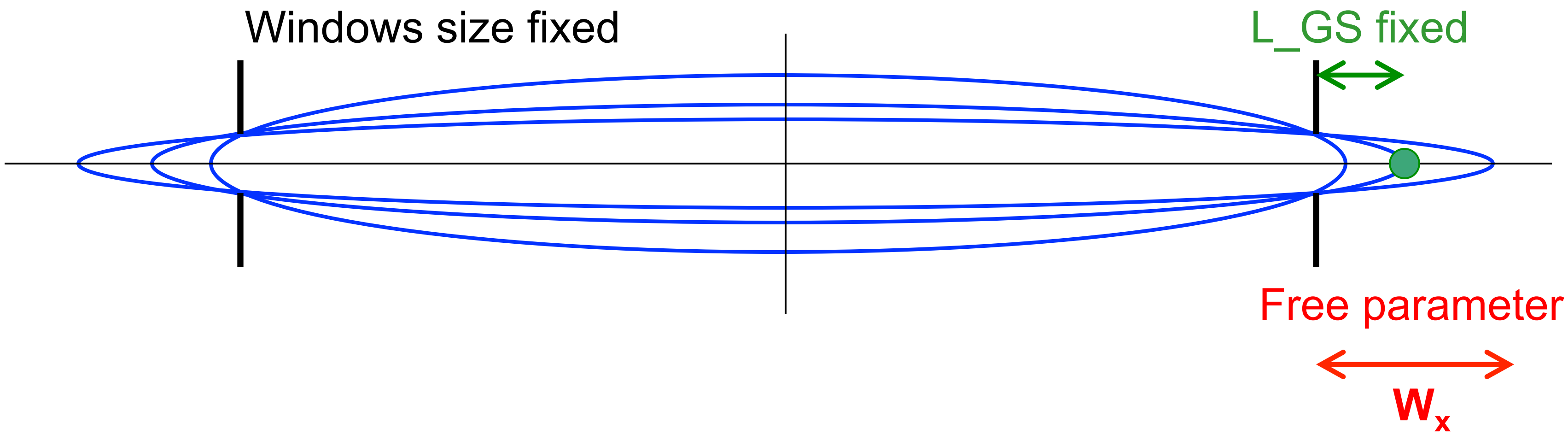


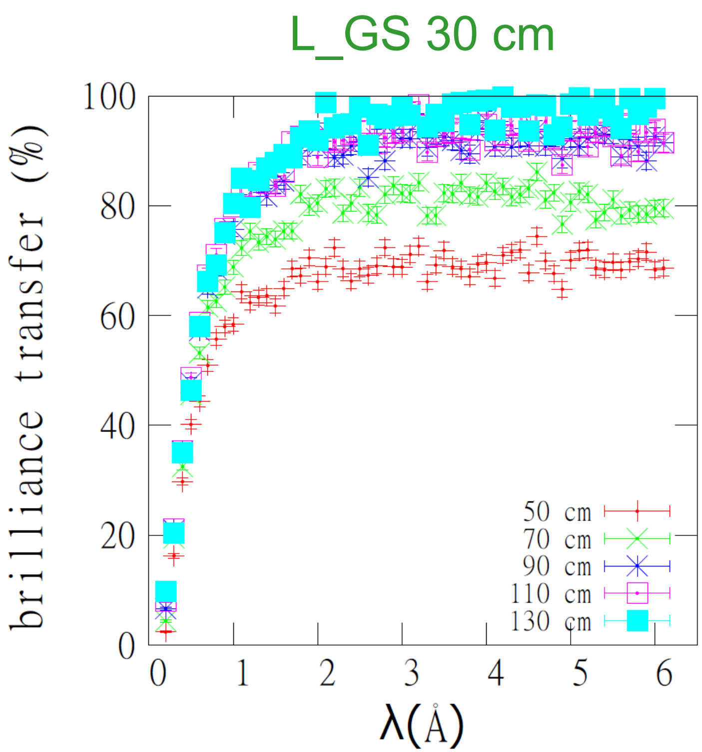
Flexible band-width
2 14Hz disks
0.7m radius
180° windows

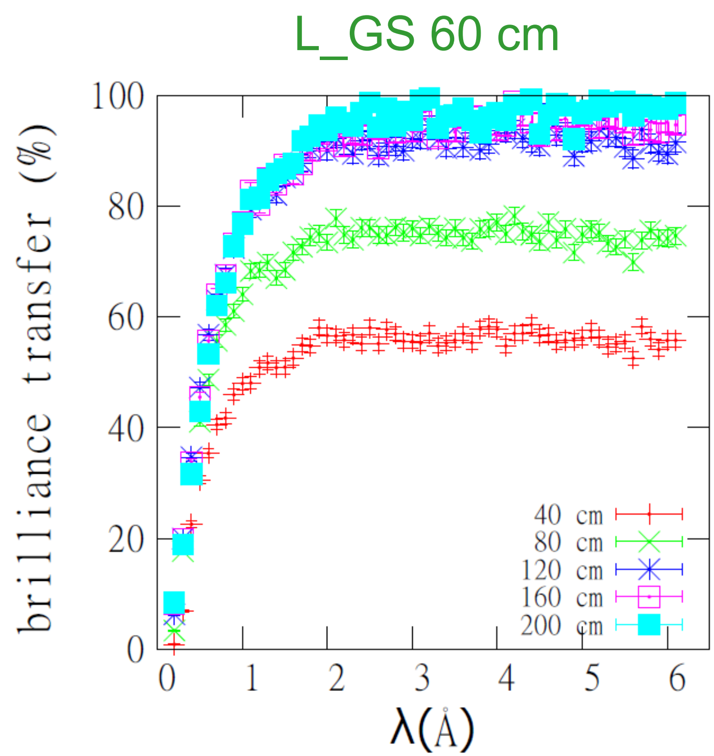
Transport system



Transport system optimization

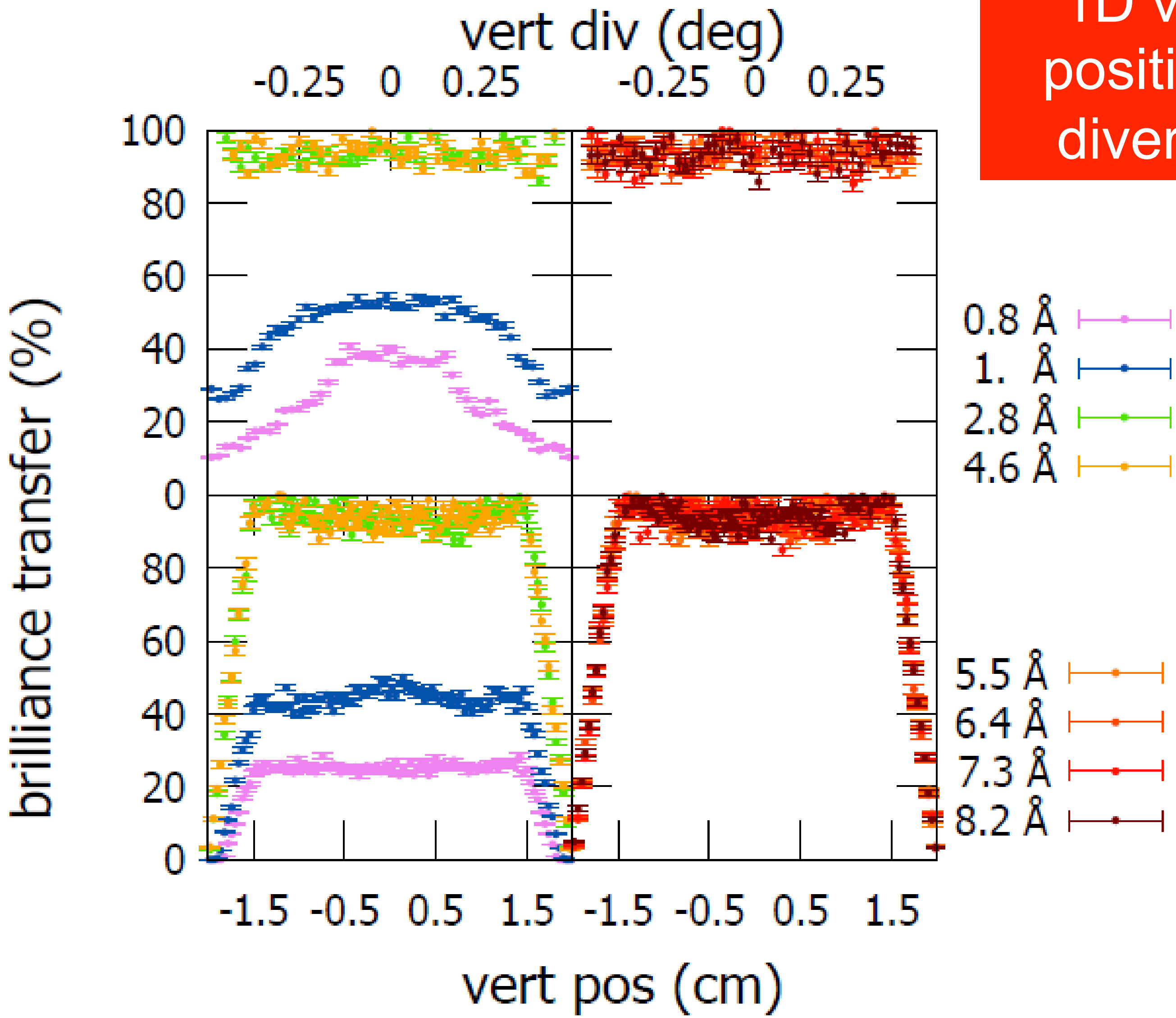






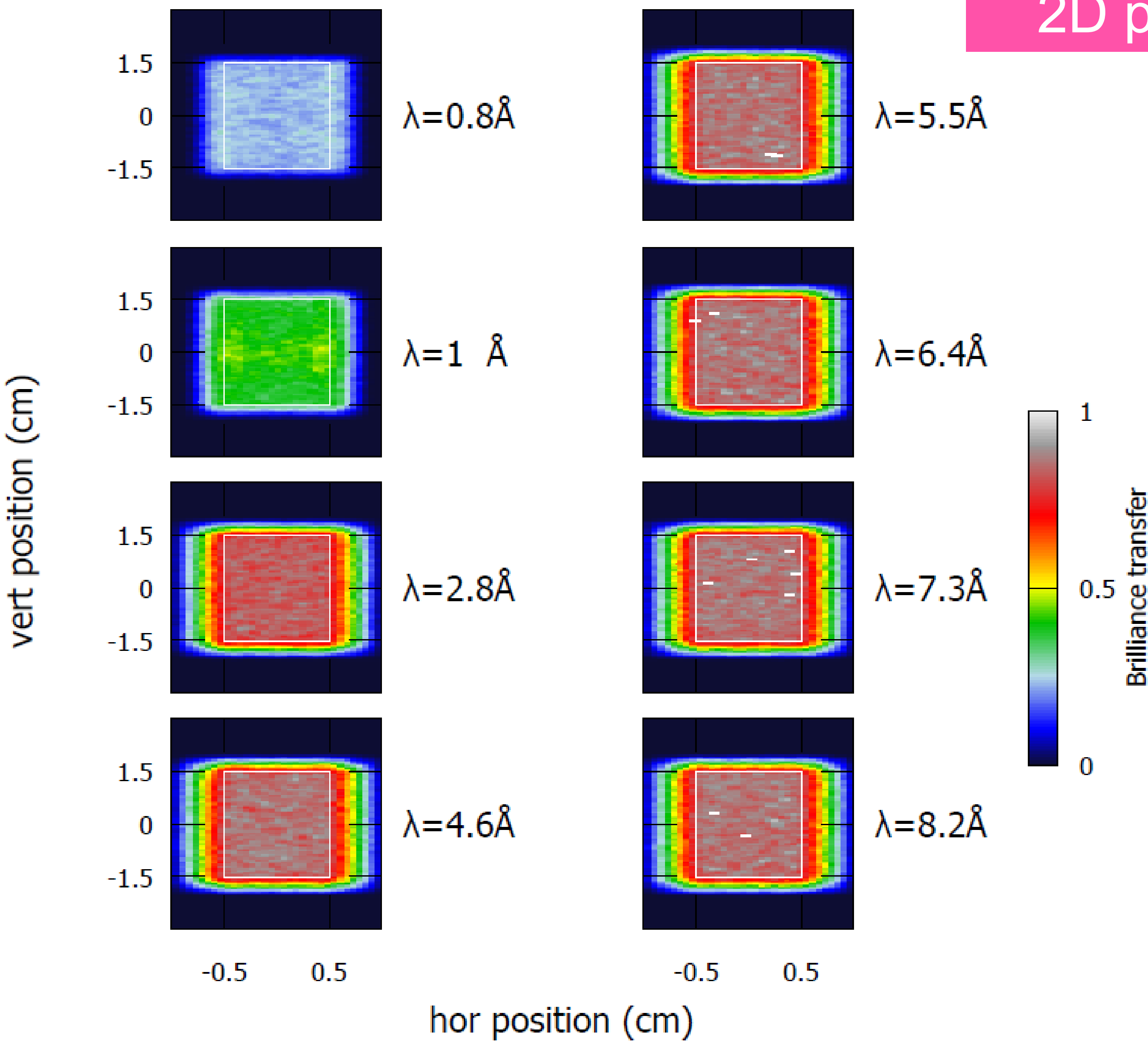
Transport system performance

1D vertical position and divergence



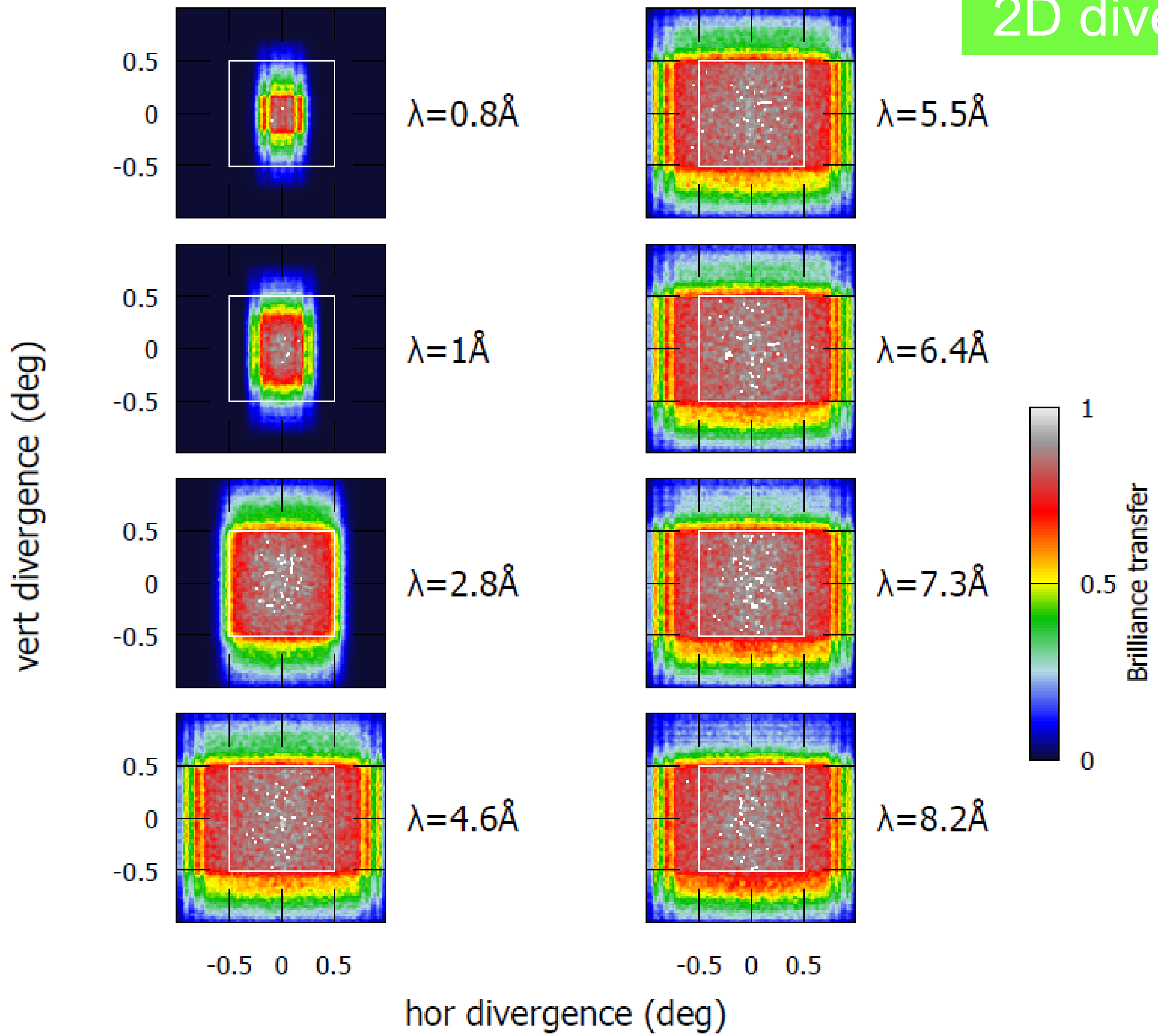
Transport system performance

2D position



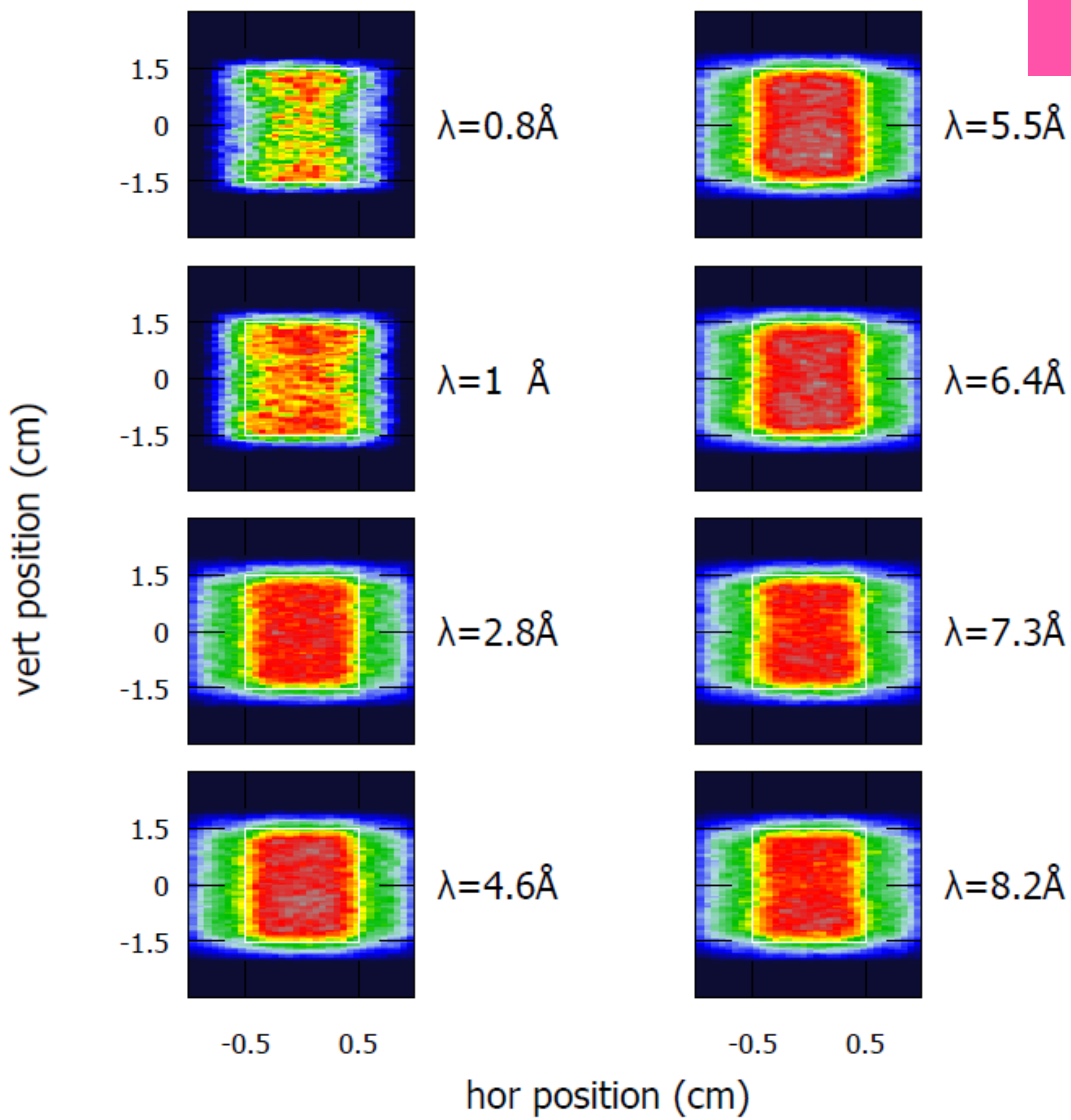
Transport system **performance**

2D divergence



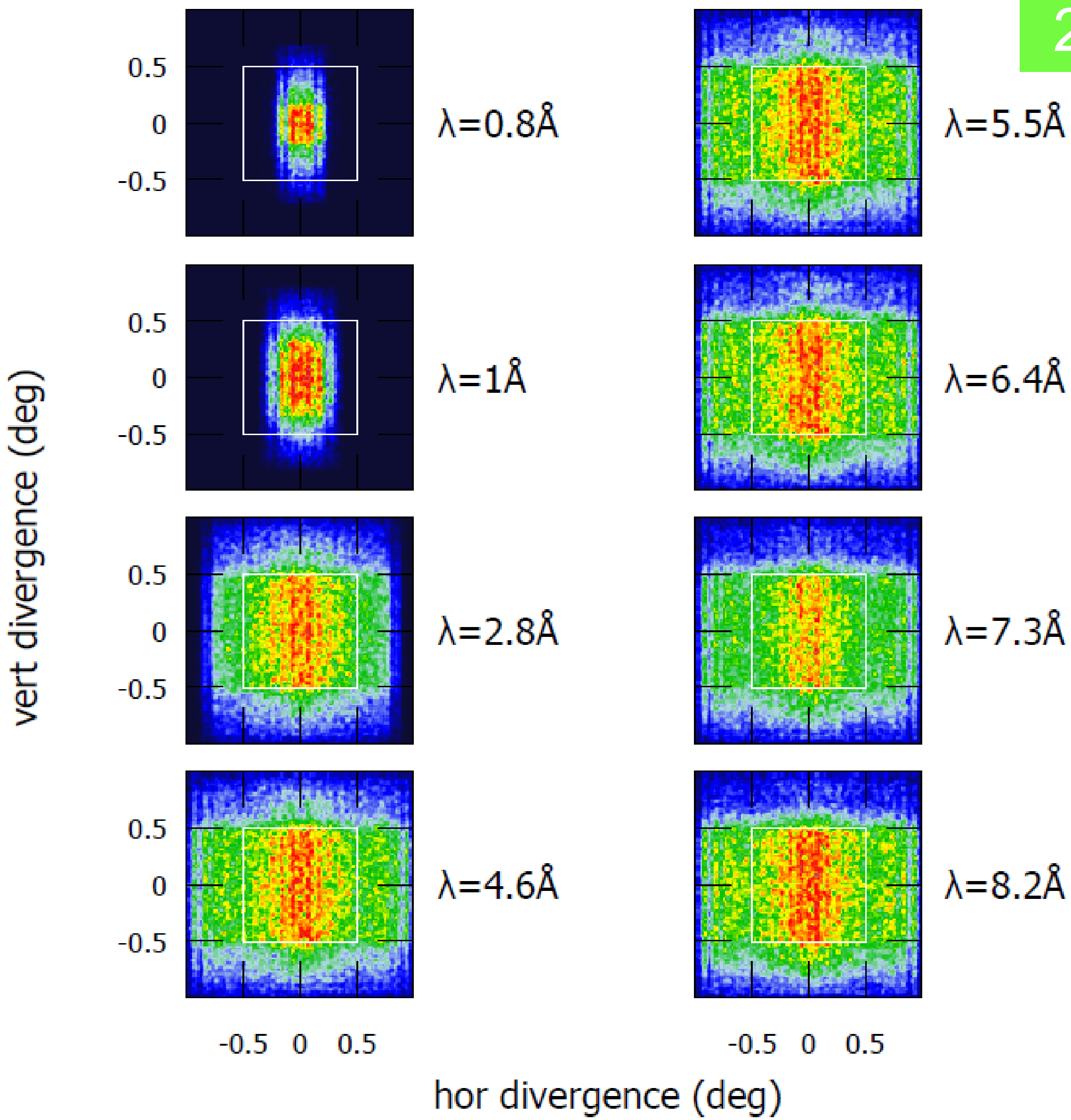
Transport system + choppers running

2D position

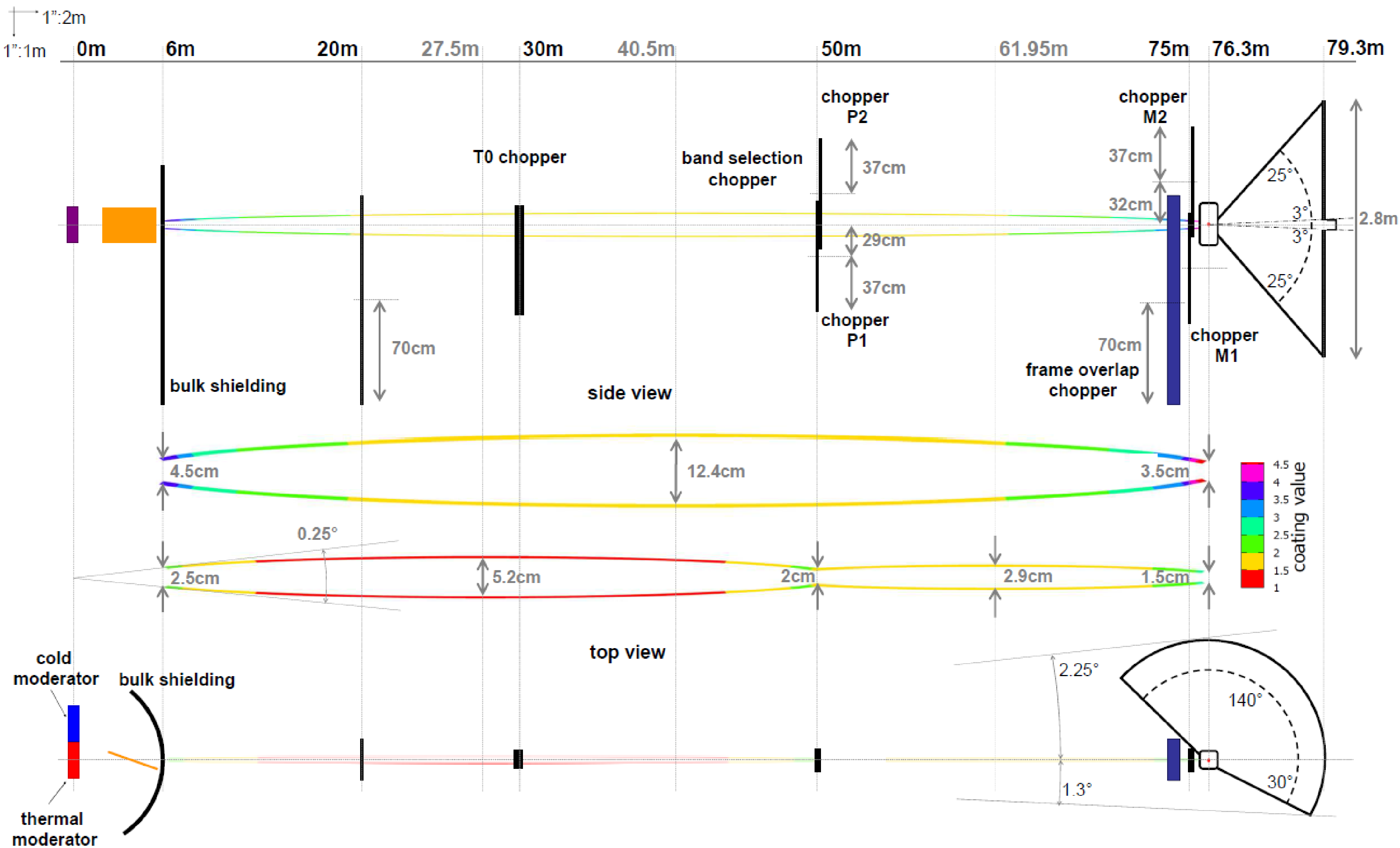


Transport system + choppers running

2D divergence



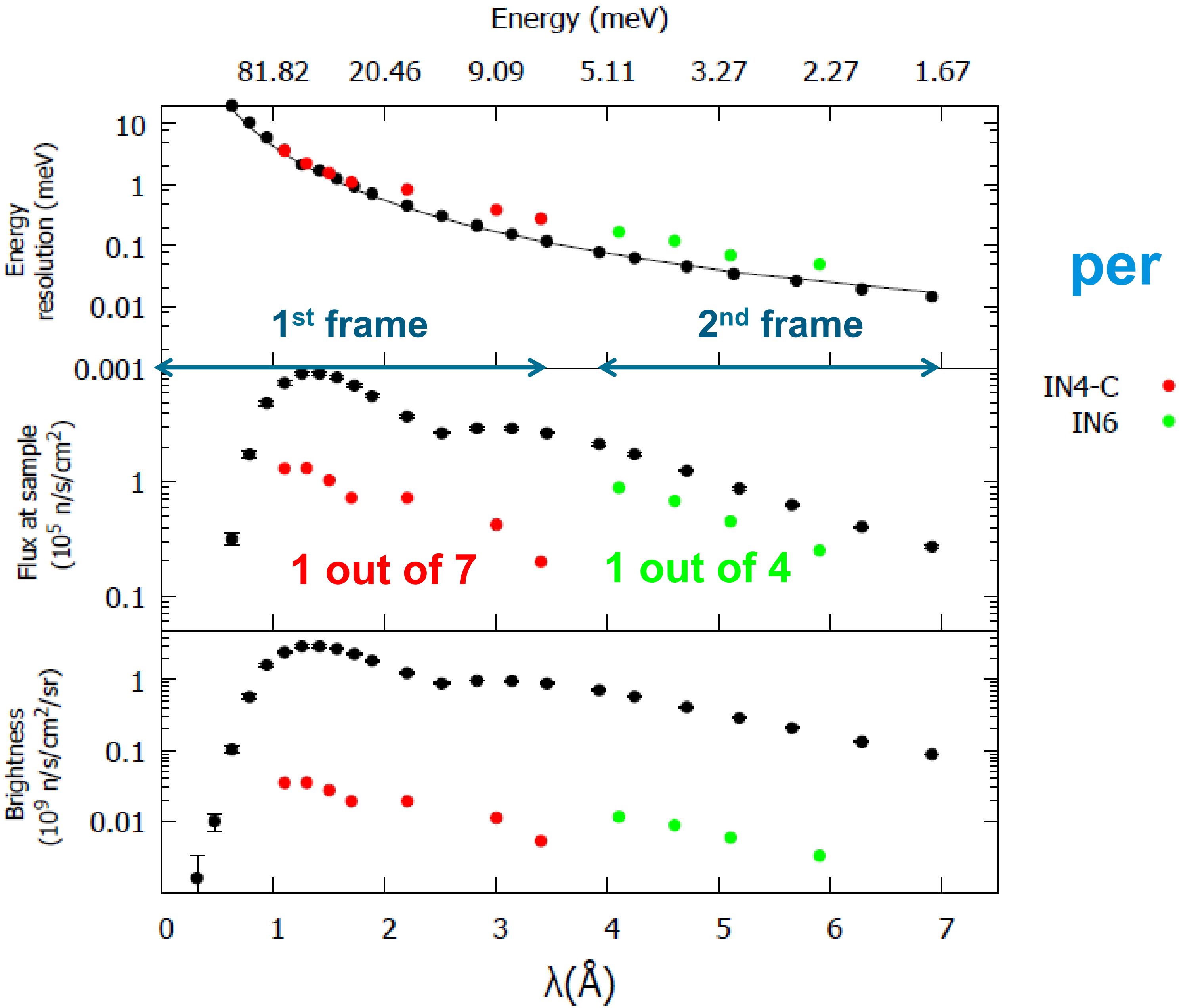
Schematic layout



Outline

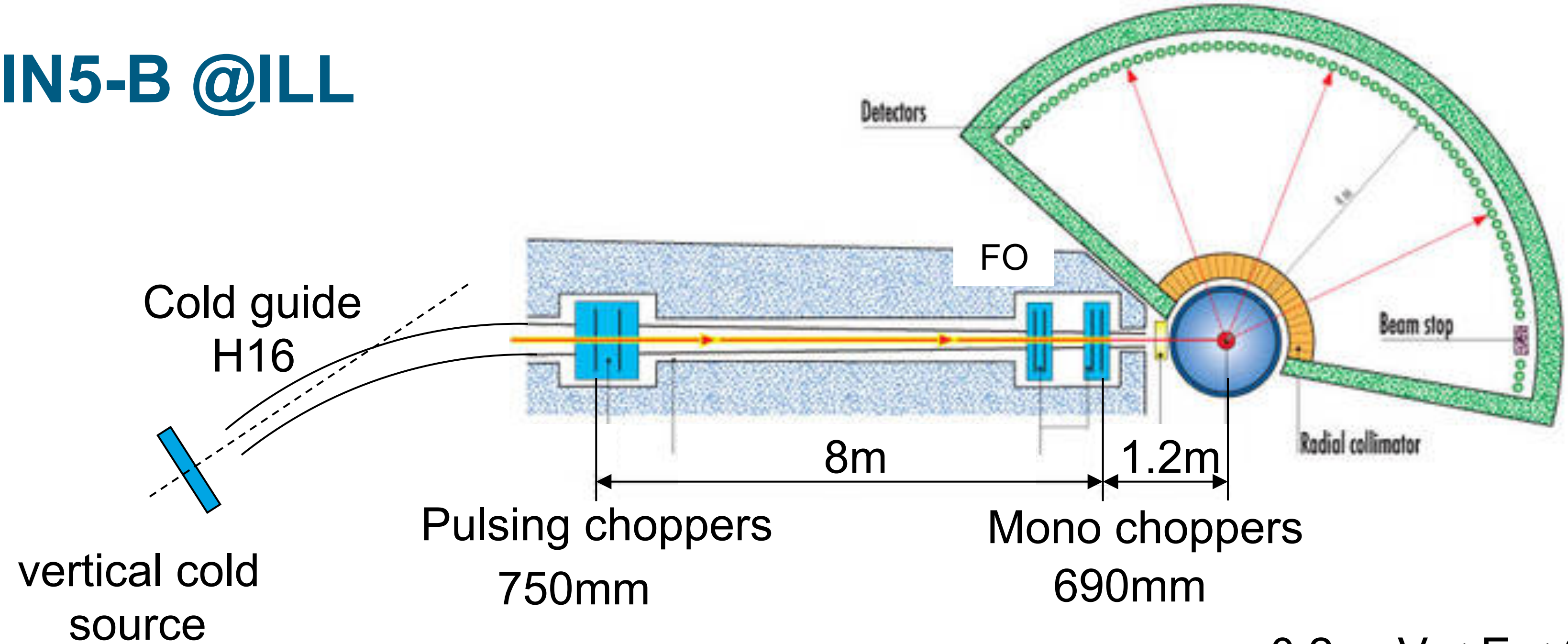
- Technical description of spectrometer layout
  Analytical investigation of Q,E resolution of a generic layout
  Characteristics of the present instrument
  Choice of instrumental parameters
  Technical realization of specific components
    polarization and p. analysis
    Implementation of poly-chromatic operation
    T0 choppers
    Fan choppers
- Instrument performance
- Scientific impact
- Costing

Comparison to existing instruments



per pulse

IN5-B @ILL



0.2meV < E < 25meV

Tunable en resolution and Q range

High Flux

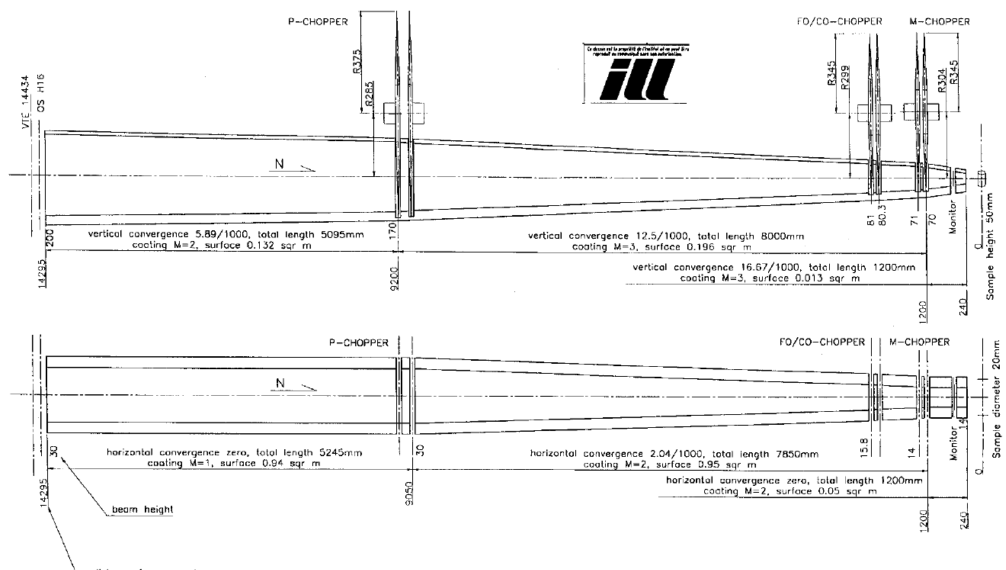
QEL solids, liquids, molecular crystals

INS

0.1meV < ħω < 250meV

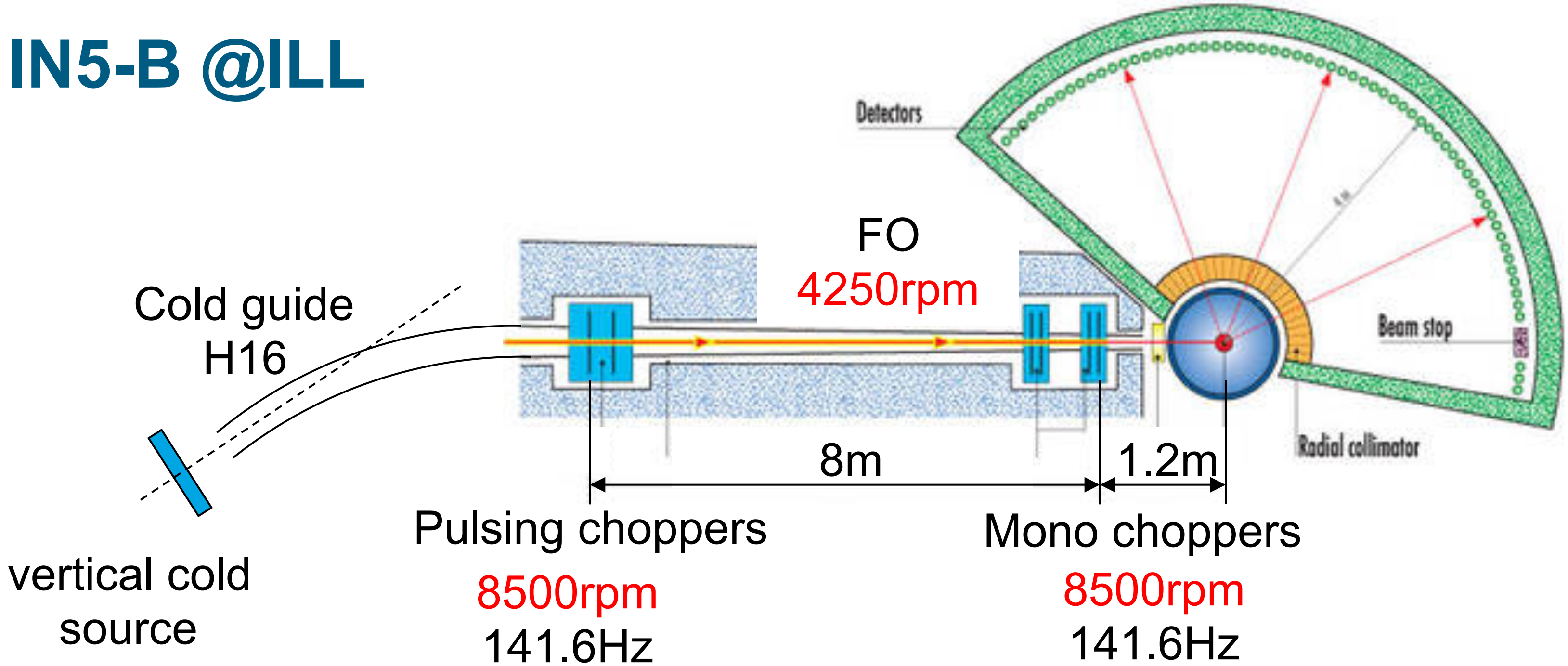
vertical

horizontal

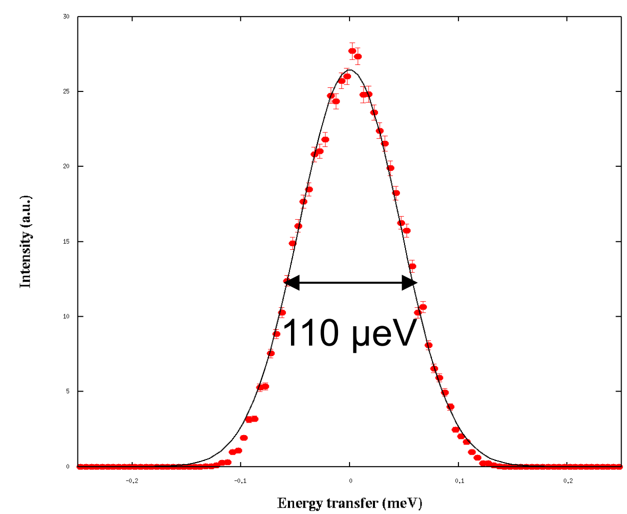


Appl. Phys. A 74 [Suppl.], S305–S307 (2002)

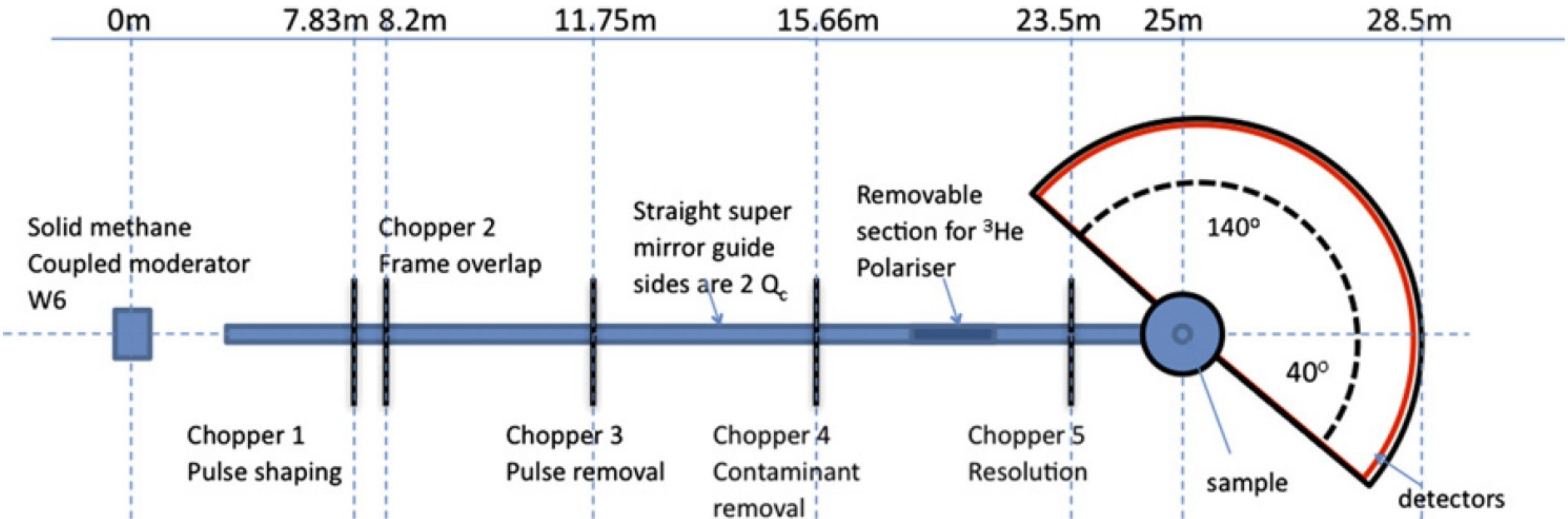
IN5-B @ILL



5Å	Measured	Vitess Sim	Analytical
El. En. Res (µeV)	103	110	102
Flux (10^5n/s/cm^2)	6.83	8.97	/

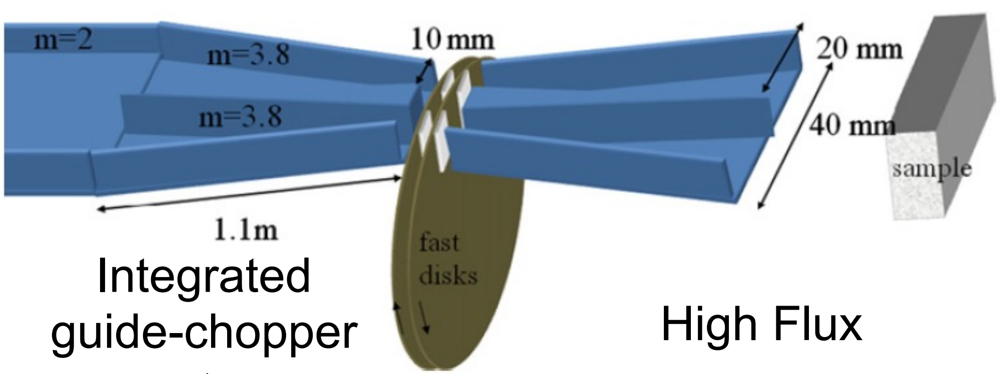


LET @ISIS TS2



0.5meV < E < 80meV

Polychromatic experiments



Integrated guide-chopper system

High Flux

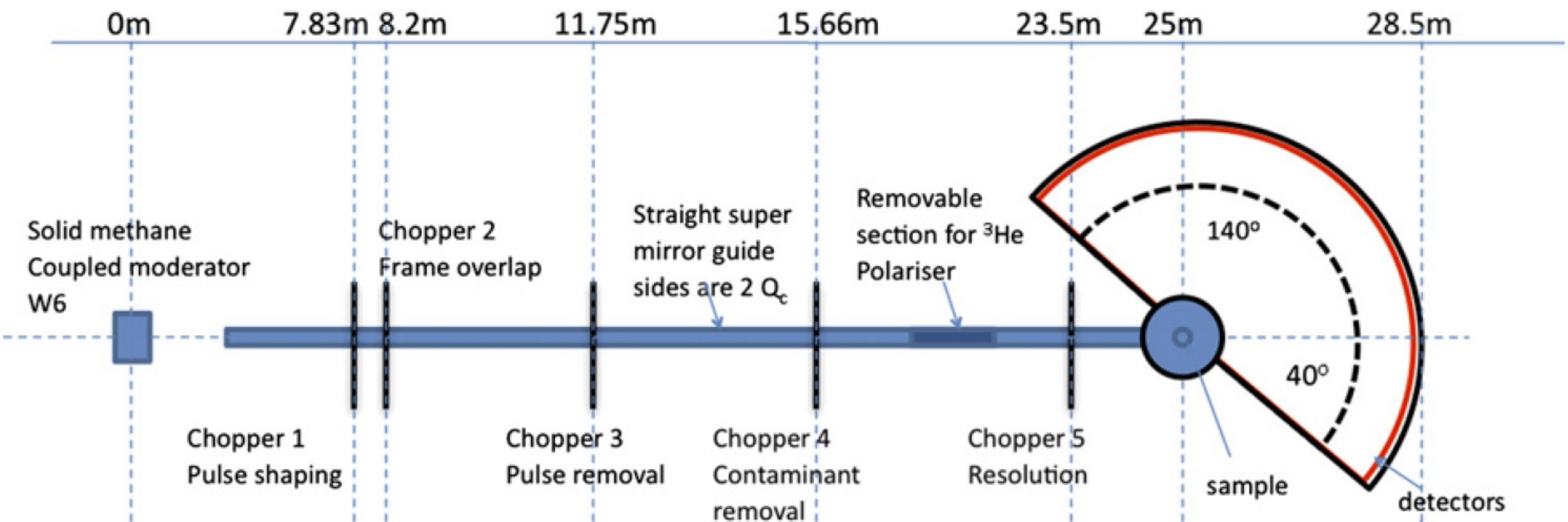
QEL in high resolution configuration

INS

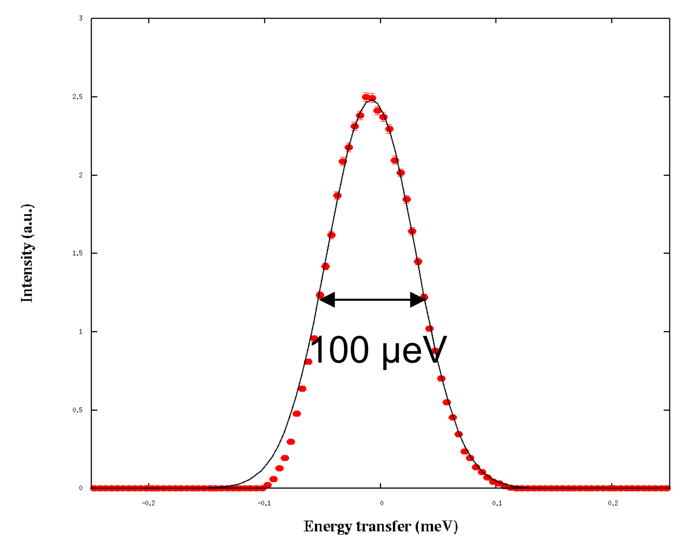
$0.08\text{meV} < \hbar\omega < 80\text{meV}$

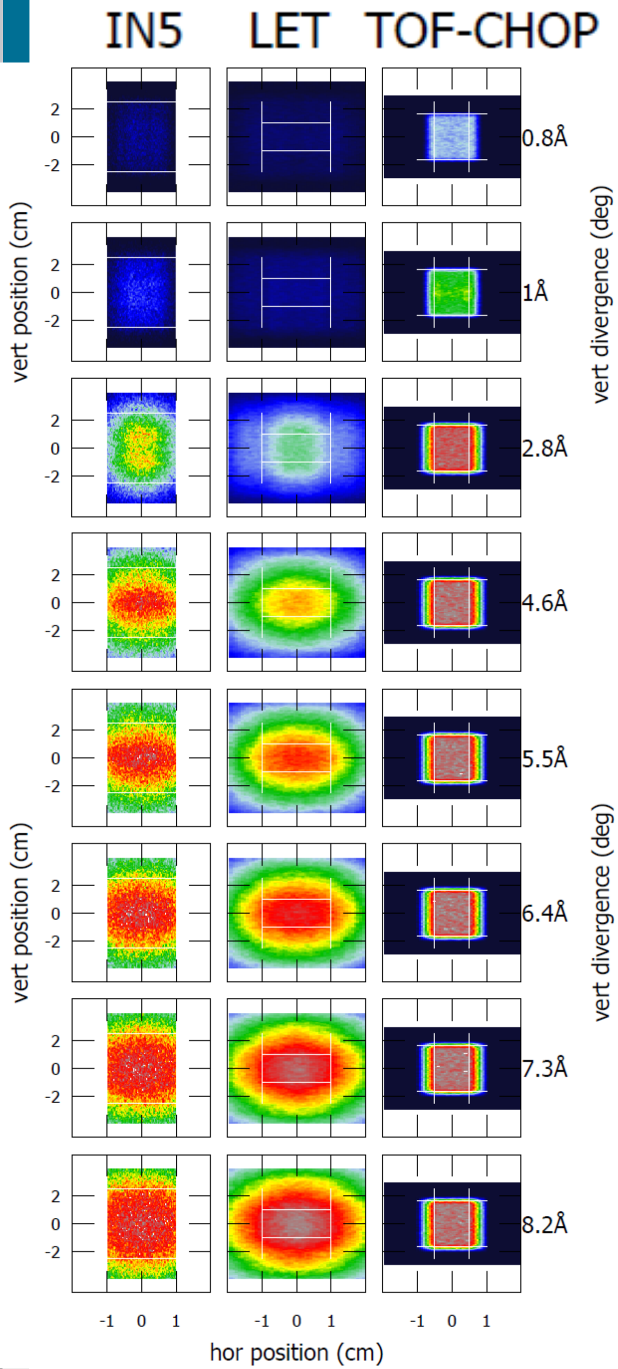
Magnetic excitations

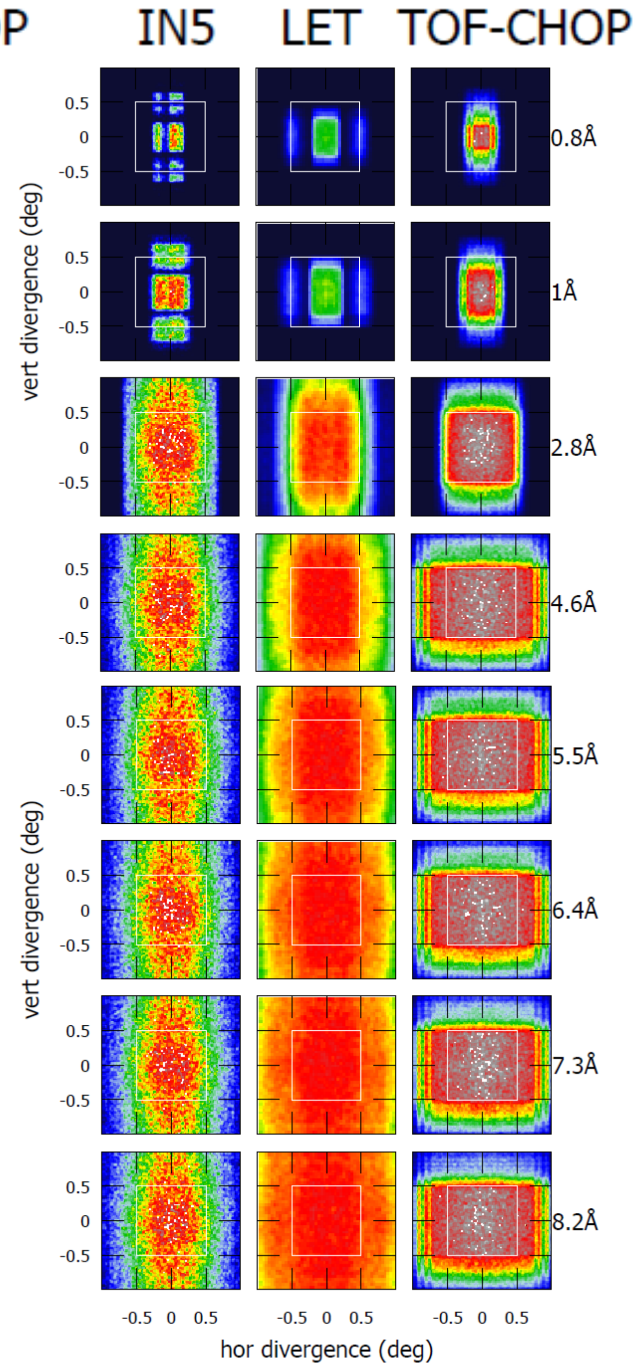
Nuclear Instruments and Methods in Physics Research A 637 (2011) 128–134

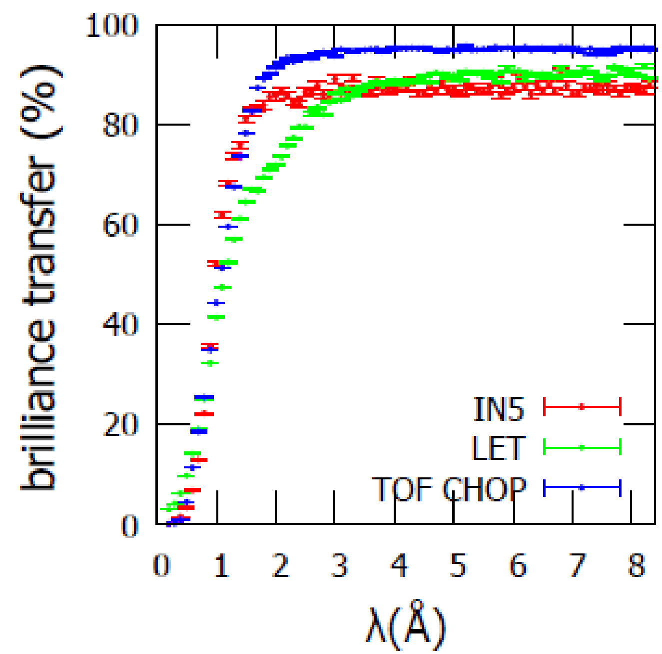


4Å	Measured	Vitess Sim	Analytical
El. En. Res (μeV)	100	100	102
Flux (10^4n/s/ cm^2)	5.6	7.7	/

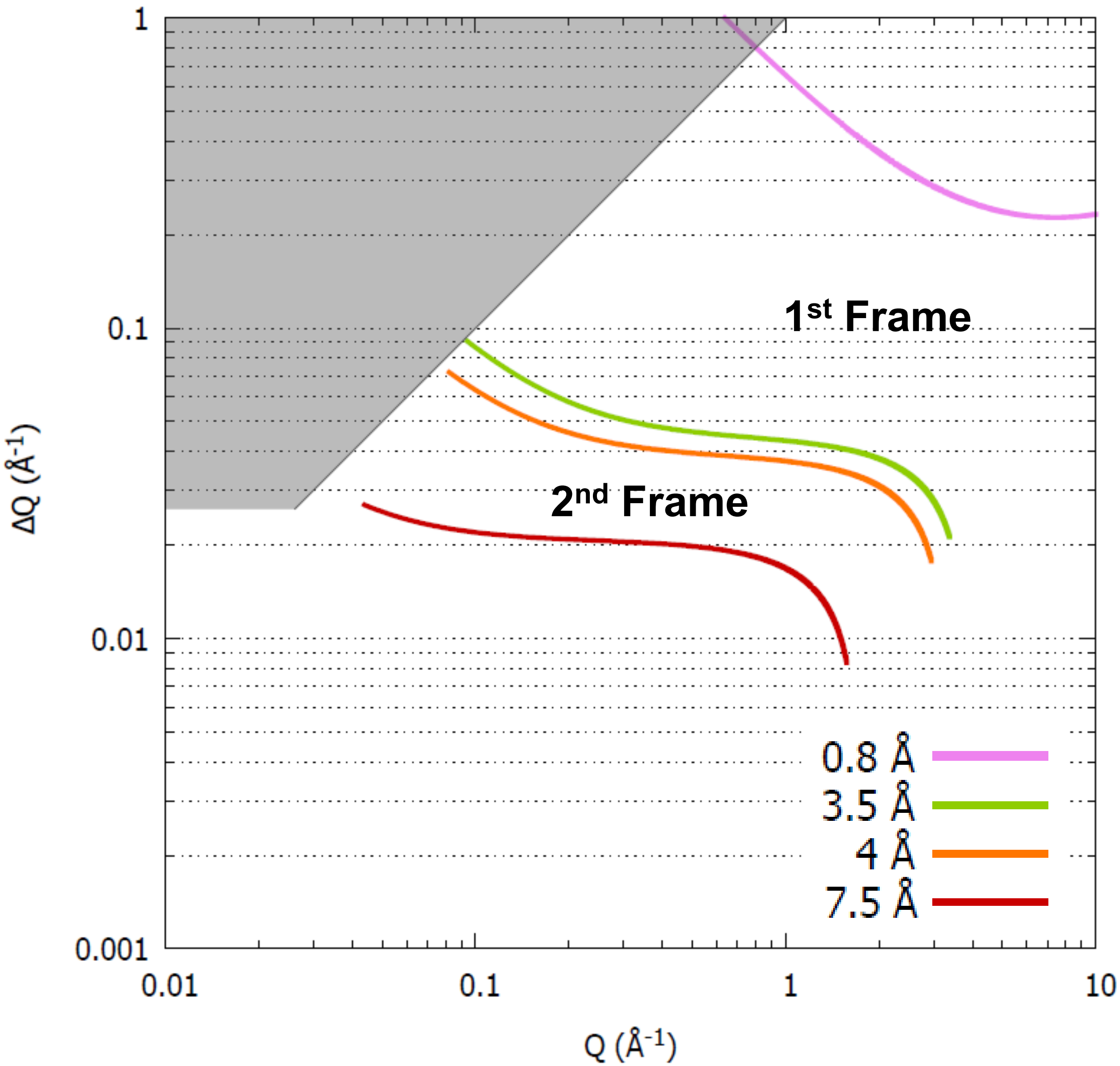



IN5
LET
TOF-CHOP
0.8Å
1Å
2.8Å
4.6Å
5.5Å
6.4Å
7.3Å
8.2Å
vert position (cm)
hor position (cm)


IN5
LET
TOF-CHOP
0.8Å
1Å
2.8Å
4.6Å
5.5Å
6.4Å
7.3Å
8.2Å
vert divergence (deg)
hor divergence (deg)


brilliance transfer (%)
λ(Å)
IN5
LET
TOF CHOP

Q performance 1°collimation



Scientific impact

	Flux	Collimation	Multi-chromatic investigations	Max Gain	Gain Range
Present Instrument	5	7	12	420	5-420
IN4-C	1	1	1	1	1

	Flux	Collimation	Multi-chromatic investigations	Max Gain	Gain Range
Present Instrument	2	10	7	240	2-240
IN6	1	1	1	1	1

Versatile choppers configurations

JÜLICH
FORSCHUNGSZENTRUM

x14 (Hz)					
f_{P1}	f_{P2}	f_{M1}	f_{M2}	pulses	Δλ (x 0.157Å)
9	9	12	12	12	2
			11	4	6
12	12	16	16	16	1.5
			15	4	6
			14	8	3
15	15	20	20	20	1.2
			19	4	6
18	18	24	24	24	1
			21	12	2
			20	8	3

constant flux
constant resolution
per monochromatic sub-pulse

Costing Estimation at present days

JÜLICH FORSCHUNGSZENTRUM

Item	Subitem	Cost [k€]	Remarks
Shielding		3500 (?)	MCNPX calculations required
Neutron guide system			
	Neutron guide	800	
	Vacuum housing	80	
	Vacuum system	30	
	Bi spectral extraction	100	
Choppers			
	Band Width pair	200	
	Pulse chopper pair	400	
	M chopper pair	400	
	Pulse suppression chopper	50	Estimated from Prototype
	T0 chopper	200	

Costing Estimation at present days

Item	Subitem	Cost [k€]	Remarks
Additional beam optics			
	Slit system	30	
	Adaptive optics		
Detector		10000	(?) (?) (?)
Detector tank			
	Vessel	800	
	Vacuum system	200	
	Sample goniometer	50	
	Shielding	60	
Monitors			
	Incoming beam	10	
	Beam diagonistic	40	2d Monitor to analyze the beam and to position the sample in the beam.

Costing Estimation at present days

JÜLICH
FORSCHUNGSZENTRUM

Item	Subitem	Cost [k€]	Remarks
Polarization			
	SEOP polarizer	50	Based on TOPAS experience
	Magic Pastis	80	Based on TOPAS experience
	Guide changer	50	Based on TOPAS experience
	^{3}He	150	3He price 3 k€/bar l
	^{3}He Recovery	40	For the wide angle PA a separate recovery would be used as the analysis volume is large
TOTAL		**17320**	

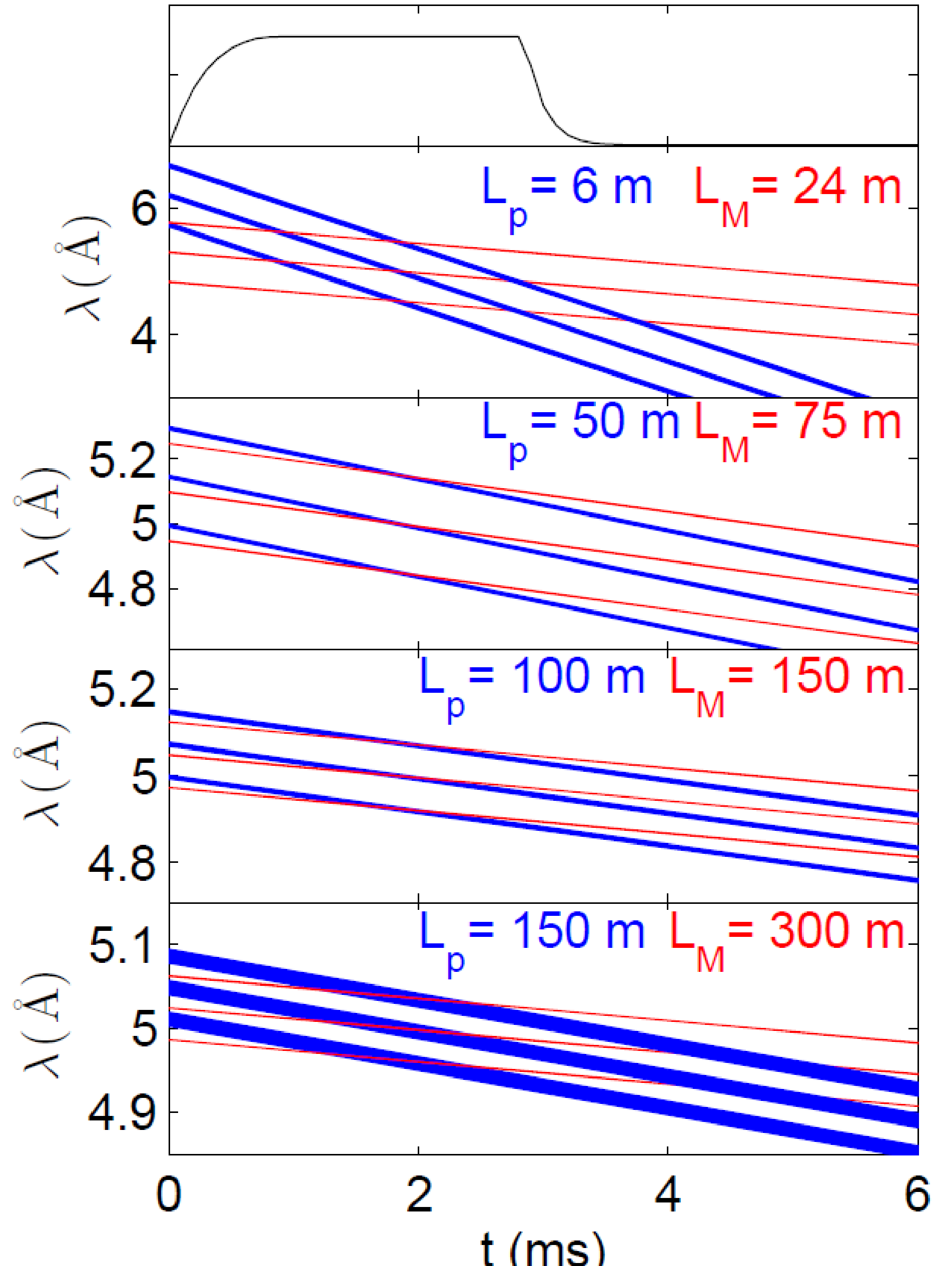
Human resources		PY	
	Scientists	12	
	Engineers	12	
	Technicians	15	

Wavelength selection

$$\delta\lambda = \frac{h}{m_n}(f_M L_M)^{-1}$$

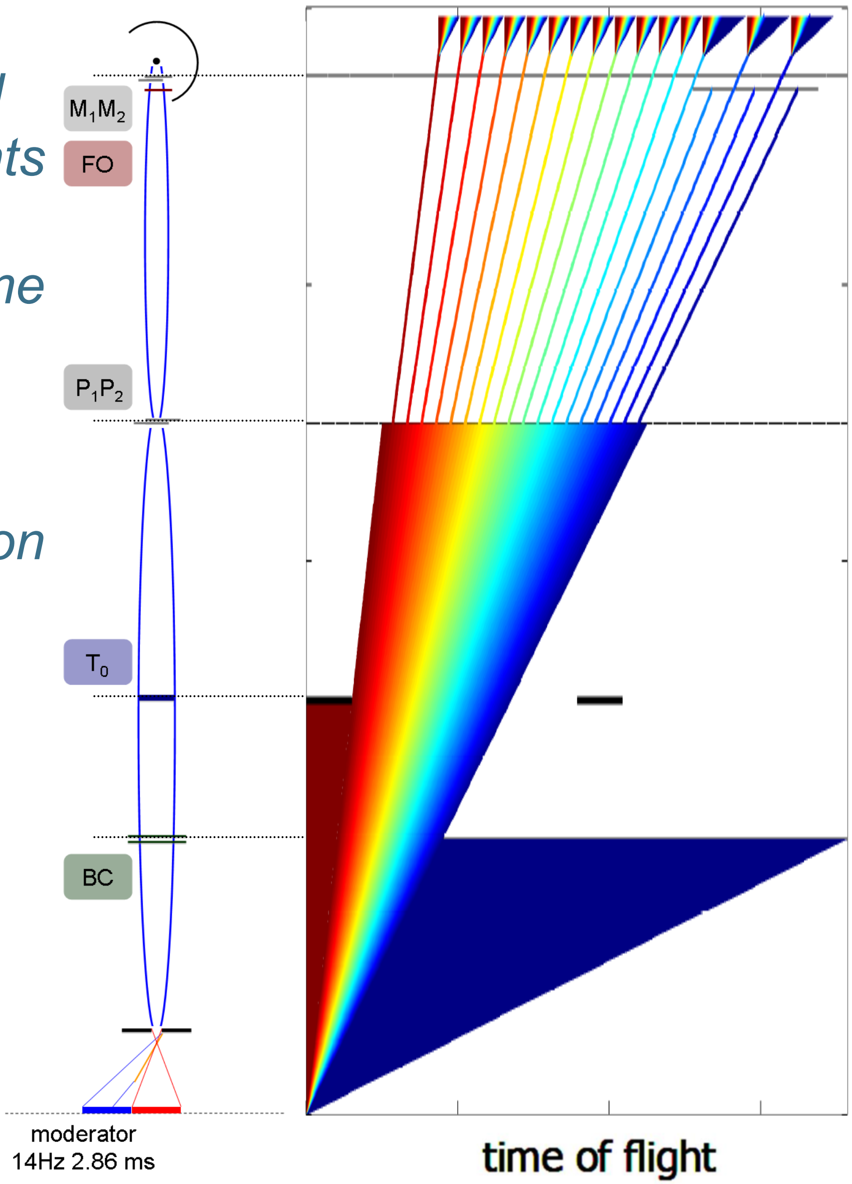
$$f_P = \frac{L_M}{L_P} f_M$$

Ratio 1.5 delivers a clean spectrum

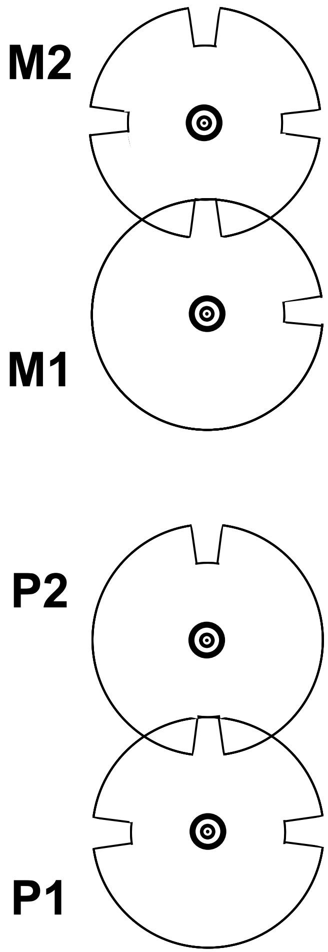


Requirements for choppers

- Multi-chromatic operation
- Useful incoming neutron wavelength band for experiments
- Adjustable elastic energy resolution/interaction time
- Flexible trading resolution for flux
- Keep back-ground low
- Adapt variable time frames due to multi-chromatic operation



Requirements for choppers



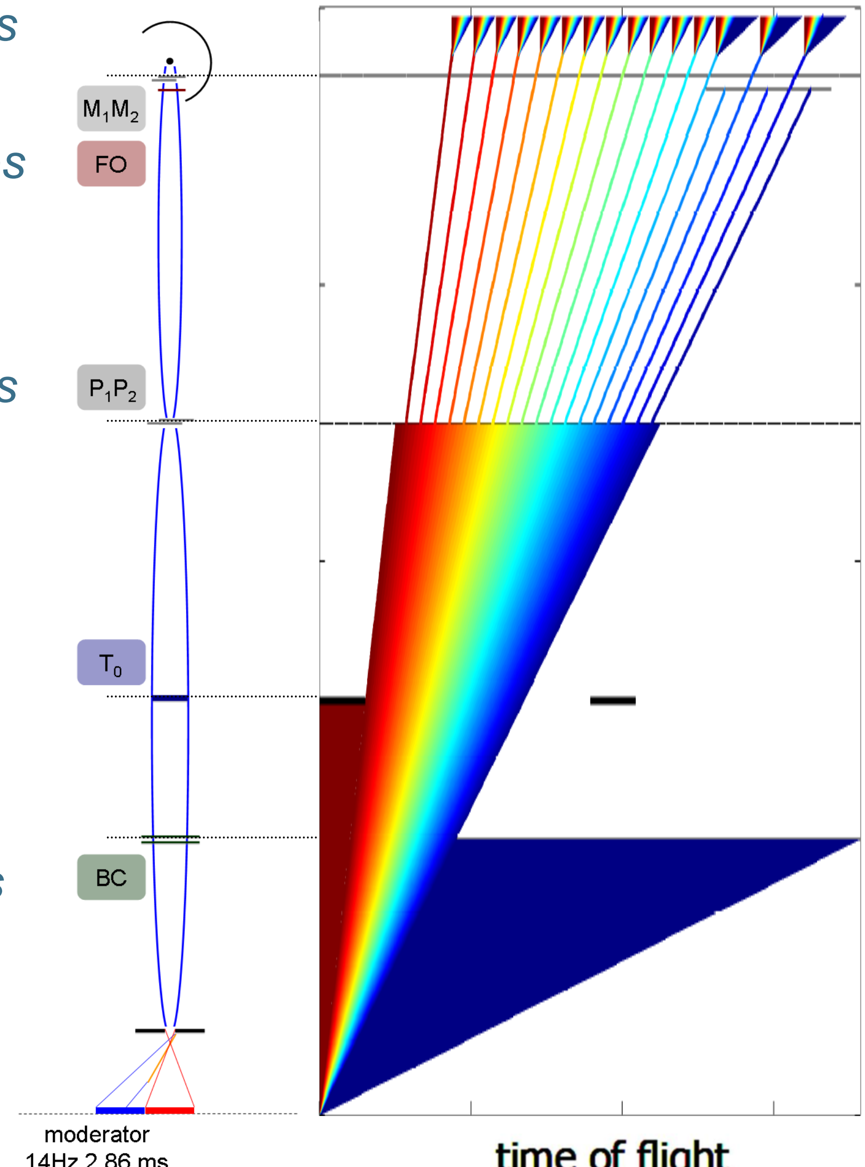
2x 350Hz 37cm radius disks

10x 14Hz 60cm radius blades

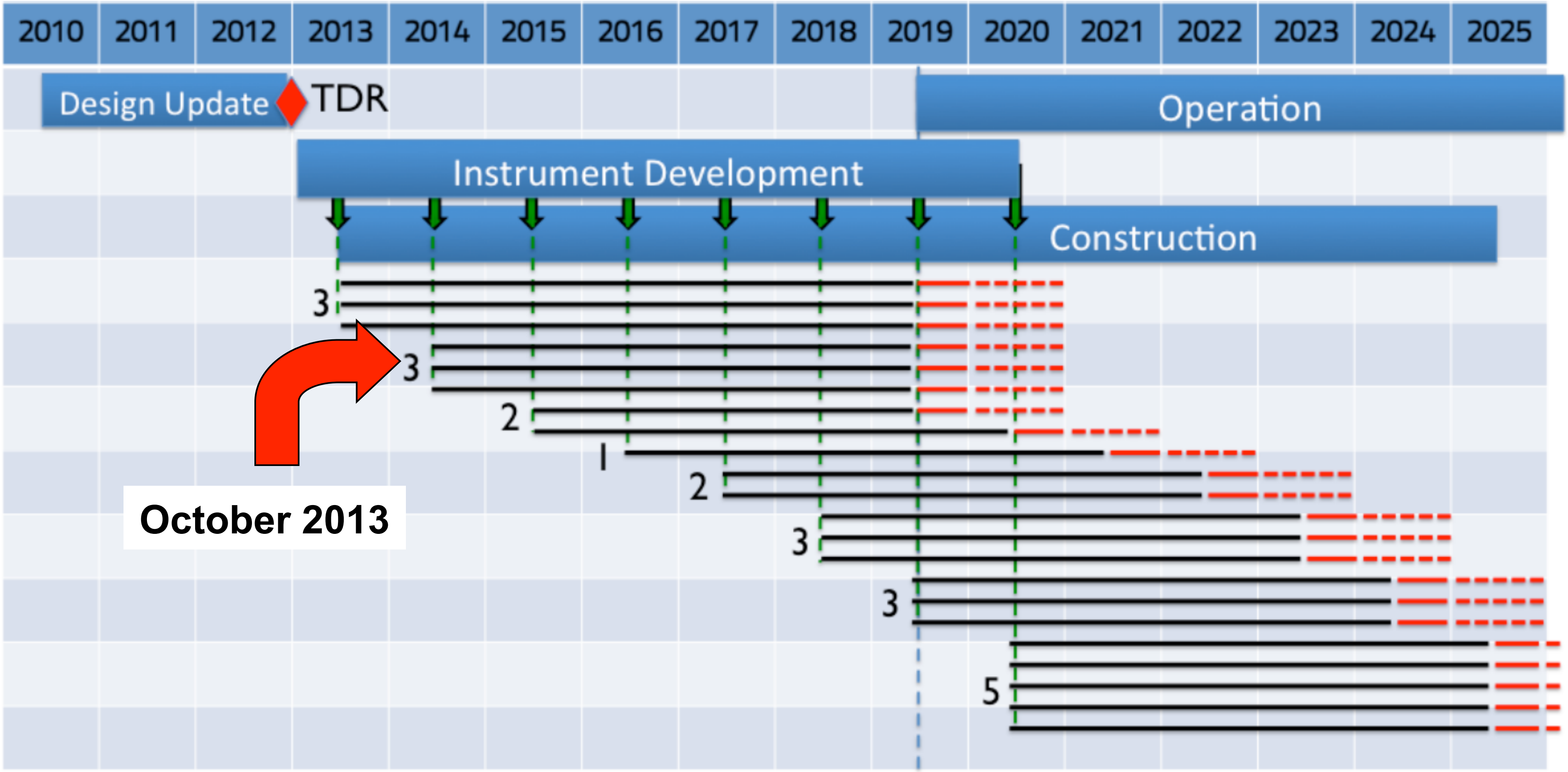
2x 252Hz 37cm radius disks

14/28 Hz 30cm radius
20.8-34.6° blade

2x 14Hz 70cm radius disks
180° openings



Time-line



concept

Instrument proposal

science case

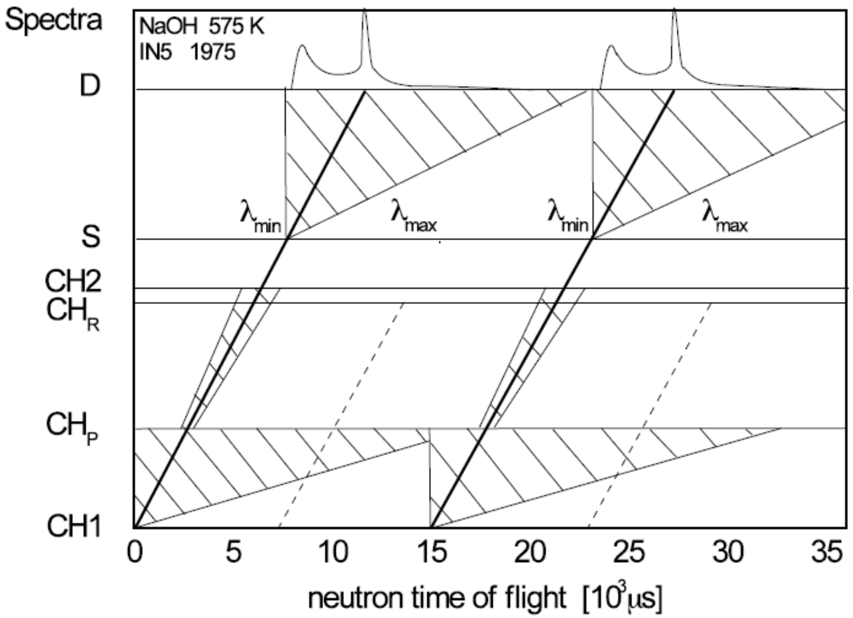
scientific impact

engineering design

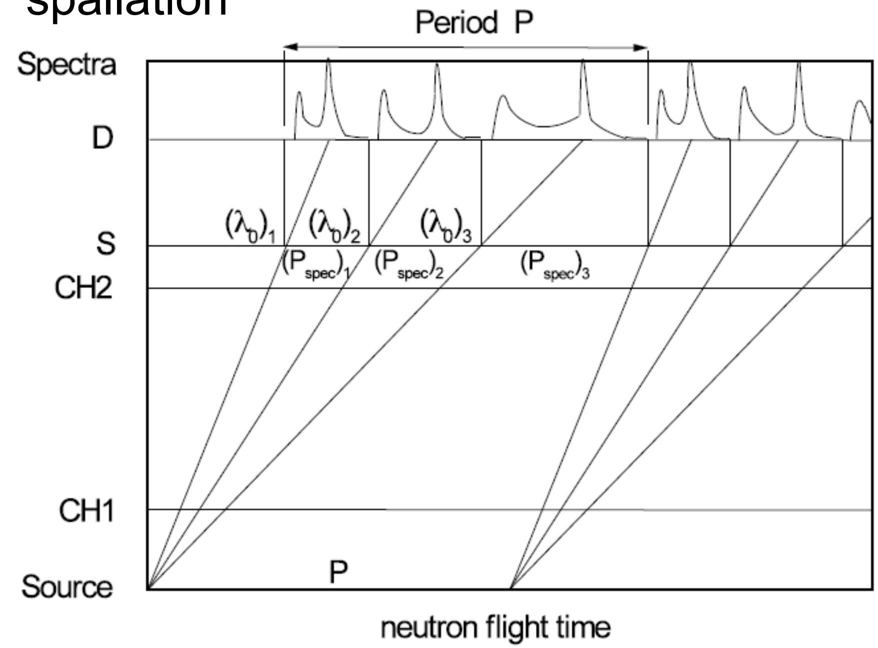
costing

TOF technique adaptation

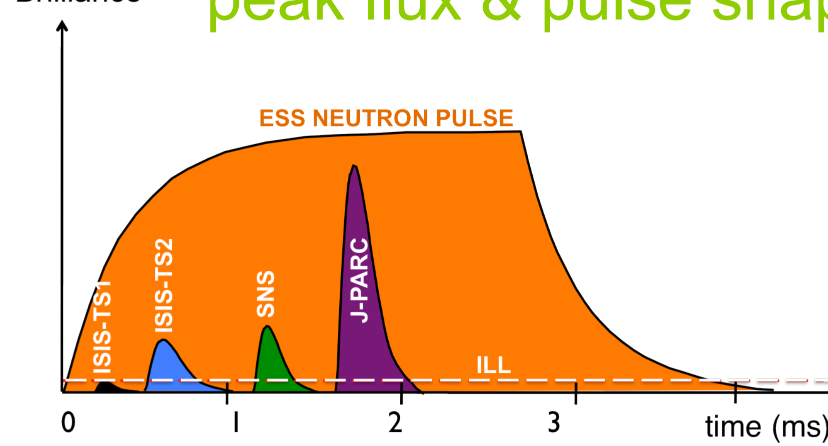
reactor



spallation



peak flux & pulse shape

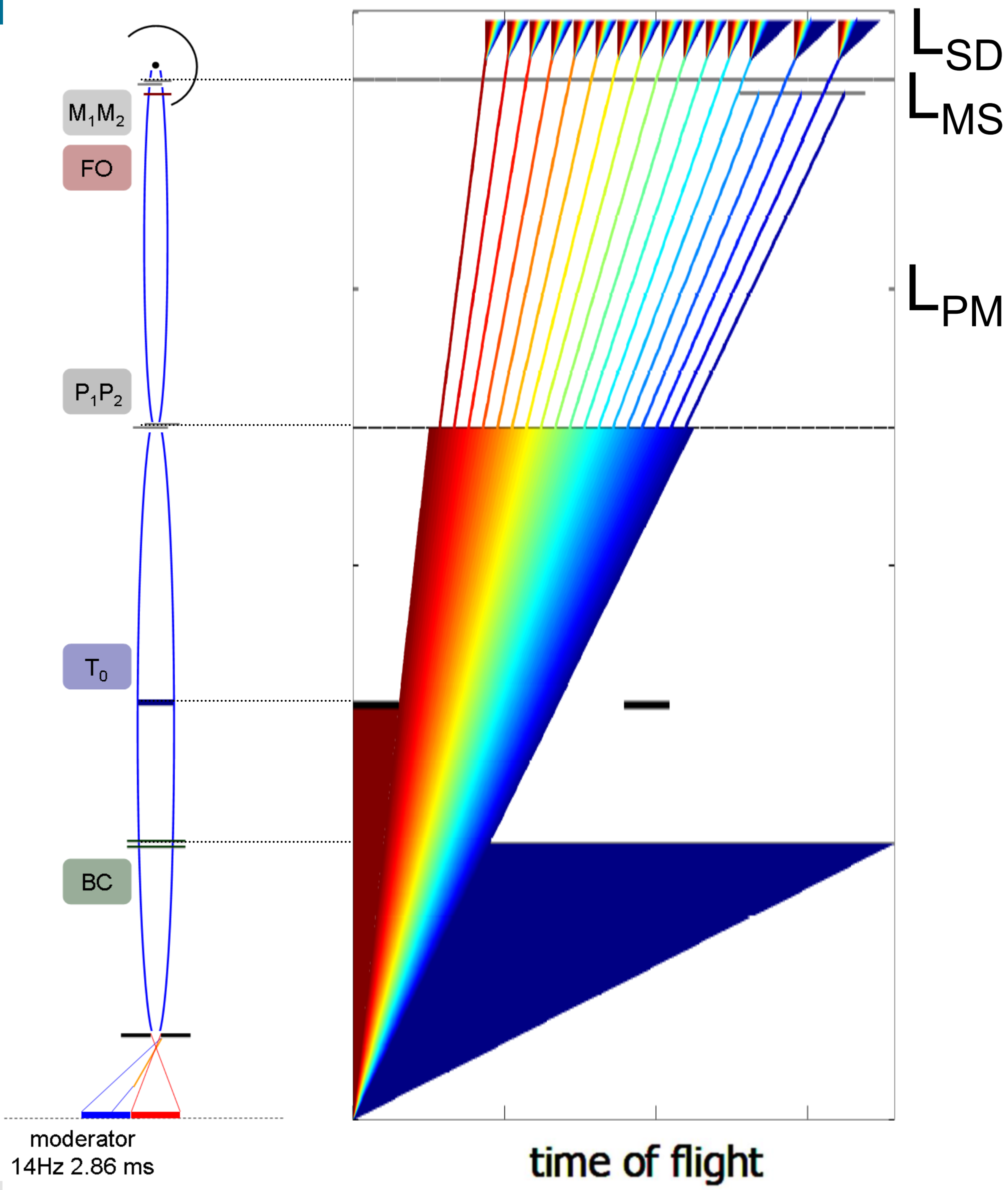


Currently nearly 20 TOF spectrometers operating in existing facilities

Outline

- Description of the spectrometer layout
- Instrument performance
- Scientific impact
- Costing

Design parameters



Secondary spectrometer
wide detectors ³He replacement
polarization analysis
add-ons

Primary spectrometer
moderator bi-spectral extraction
chopper system
neutron guide
polarization

Q resolution (req. 0.01Å^{-1} → relaxed)

$$\sigma_Q^2 = \left(\frac{m}{\hbar}\right)^4 \frac{1}{Q^2}\left(A_Q^2 + B_Q^2\left(\cos\theta - 1\right)^2 + C_Q^2 \sin^2\theta\right)$$

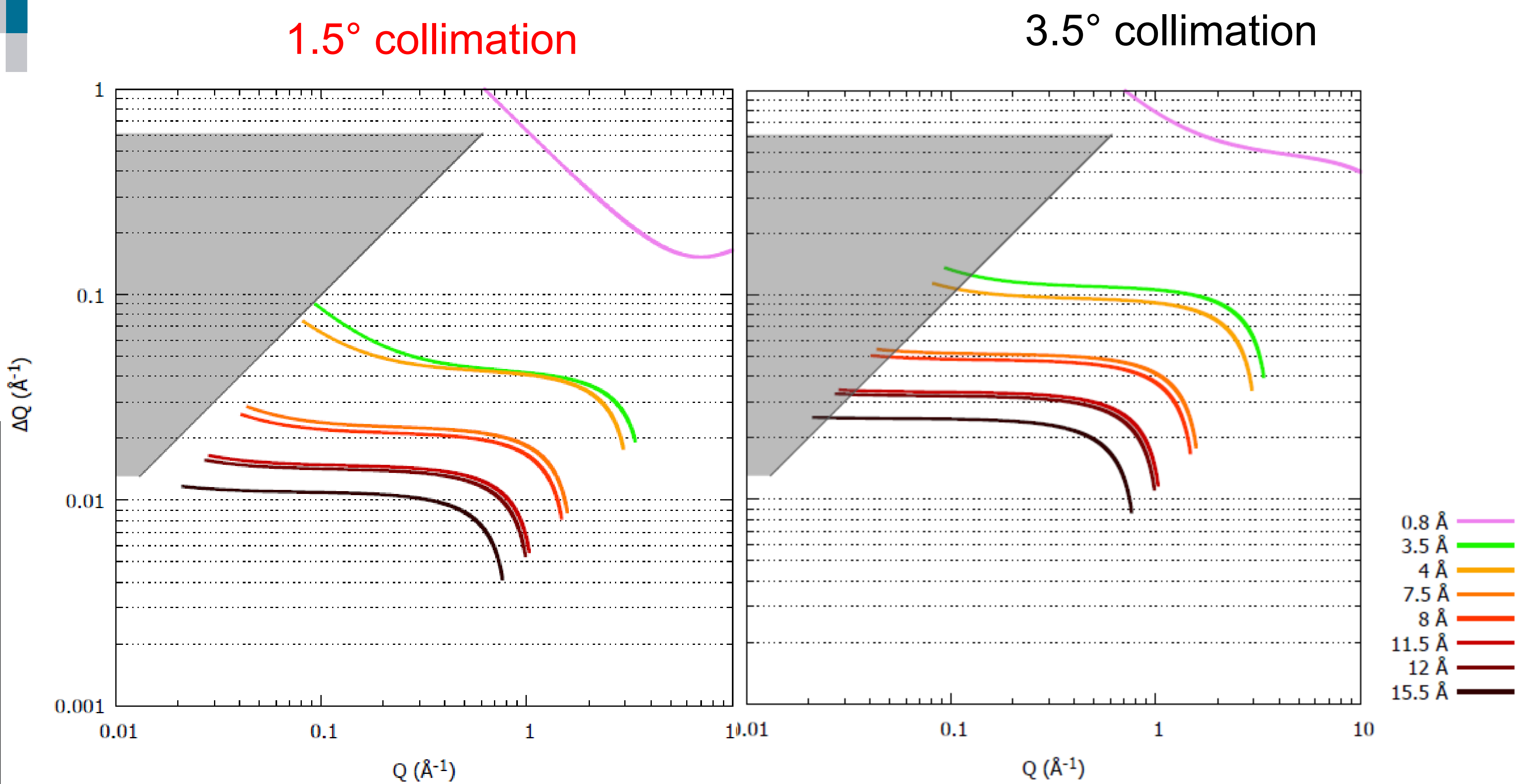
$$A_Q = \frac{v^3}{L_{PM}}\left(\frac{L_{MS}}{L_{SD}} - 1\right)\left(\tau_P^2 + \tau_M^2\right)^{1/2}$$

$$B_Q = \frac{v^2}{L_{SD}}\left[v^2\left(\tau_M^2 + \tau_D^2\right) + \sigma_{L_{MS}}^2\right]^{1/2}$$

$$C_Q = v^2 \sigma_\theta$$

Q resolution (req. 0.01Å^{-1} → relaxed)

$$\sigma_Q^2 = \left(\frac{m}{\hbar}\right)^4 \frac{1}{Q^2}\left(A_Q^2 + B_Q^2\left(\cos\theta - 1\right)^2 + C_Q^2\sin^2\theta\right)$$



Open issues

Verify requirements on energy and wave-vector transfer as from science case survey 2011.

Length: Larger band / narrower band

L_{SD}: Higher acquisition rate / better resolution

Space for the sample environment

Avoiding LoS