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Simulations of the ESS Diffractometer PowHow

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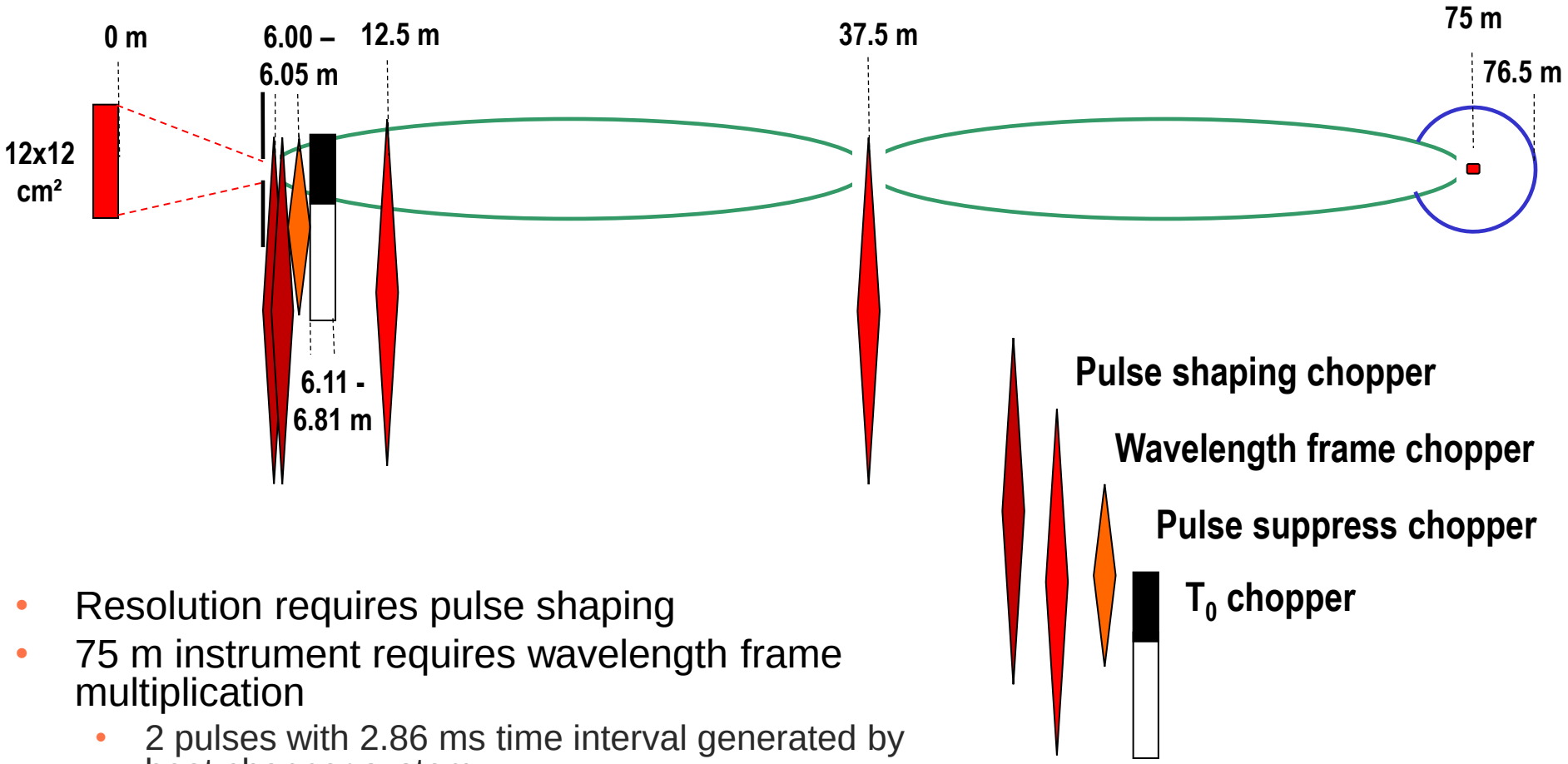
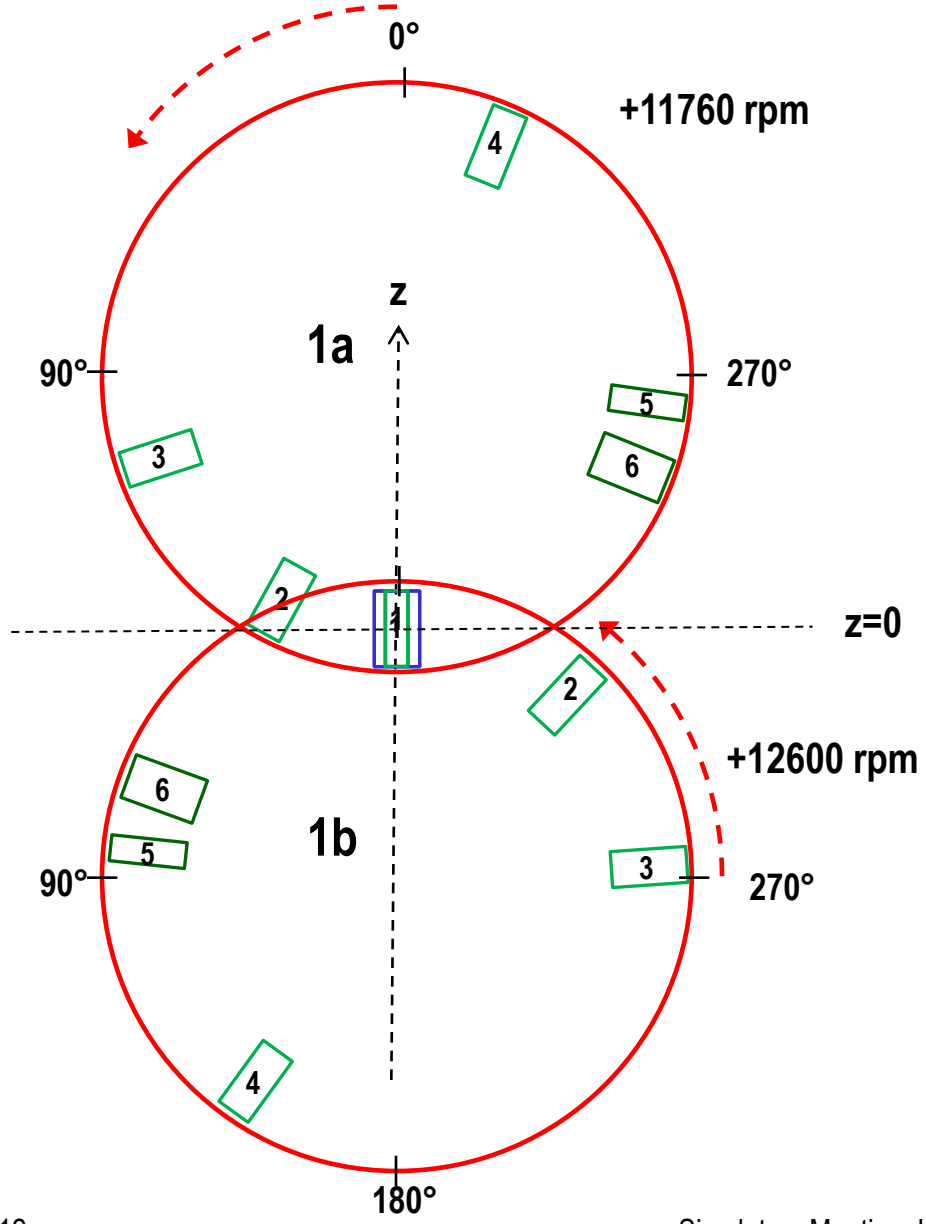
VITESS

PowHow: Guide and Chopper System



- Resolution requires pulse shaping
- 75 m instrument requires wavelength frame multiplication
  - 2 pulses with 2.86 ms time interval generated by beat chopper system
  - Suppression chopper removes unwanted neutrons e.g. from tail
- T_0 chopper for background reduction

Pulse Choppers



Short pulses - High resolution

Windows 1 + 4: 14 x 14 x 60 = 11760 rpm
15 x 14 x 60 = 12600 rpm

Windows 1 + 3: 5 x 14 x 60 = 4200 rpm
6 x 14 x 60 = 5040 rpm

Windows 1 + 2: 2 x 14 x 60 = 1680 rpm
3 x 14 x 60 = 2520 rpm

Windows 5 + 6: 1 x 14 x 60 = 840 rpm
1 x 14 x 60 = 840 rpm

Long pulses - Low resolution

Chopper Data

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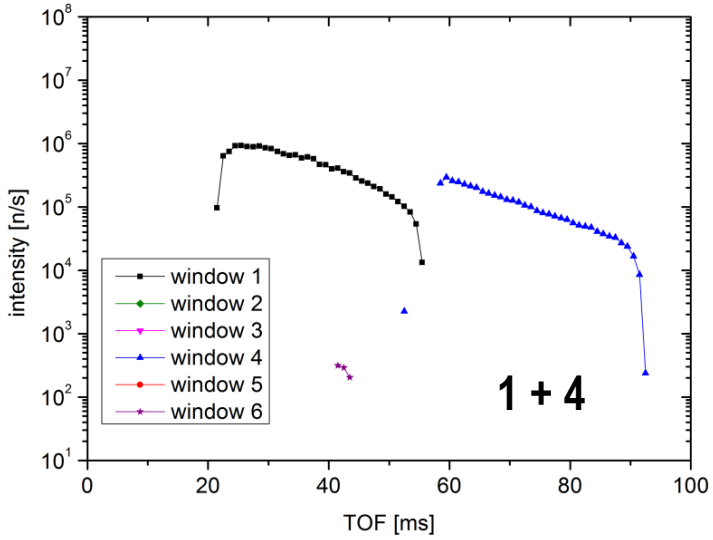
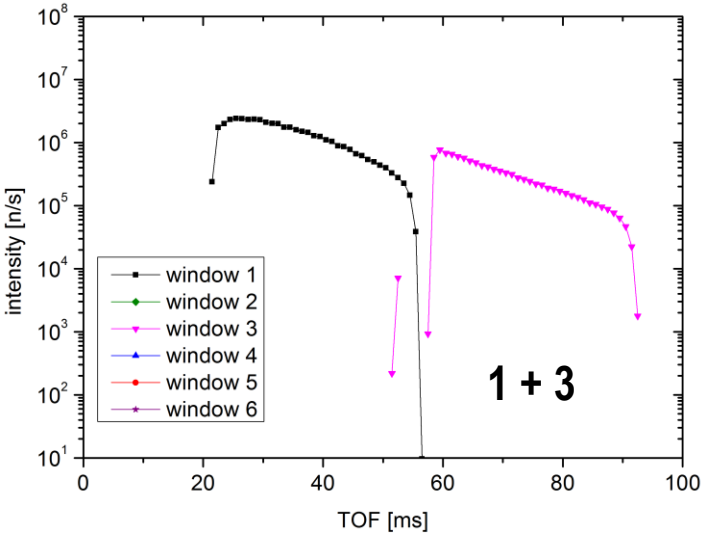
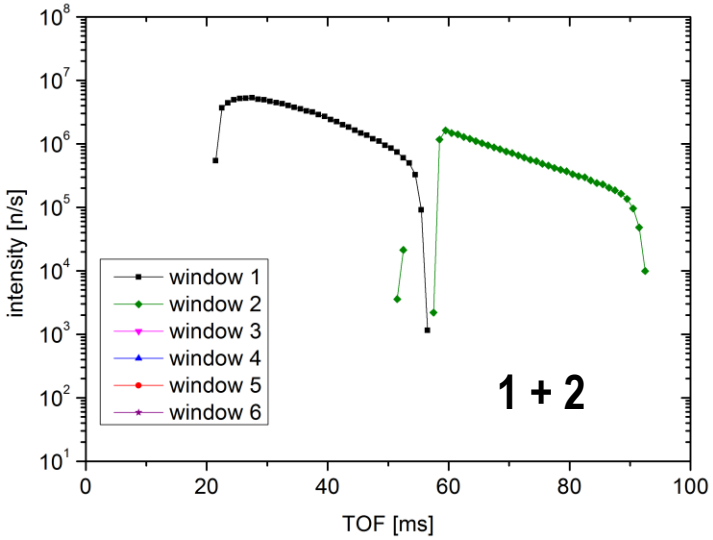
L [m]	Delλ [Å]		λ_1 [Å]	λ_2 [Å]	λ_{ave} [Å]
75.0	3.768		1.943	3.827	2.885

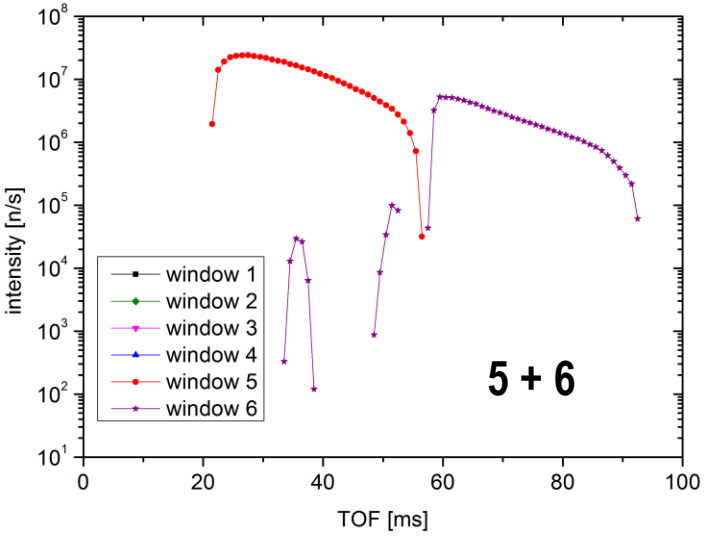
	Component		Chopper Parameters											Windows			TOF and Phase							
chop	description	N	position [m]	speed [rpm]	radius [mm]	DelH [cm]	H_{beam} [cm]	H_{wnd} [mm]	Pos_{axle} [cm]	absorp.	zero time	neutr. pass	set color	no	pos [deg]	width [deg]	shape	T [ms]	tof [ms]	t_0 [ms]	t_{ges} [ms]	t_{min} [ms]	t_{max} [ms]	φ_{run} [deg]	$\varphi_{0,red}$ [deg]
1a	pulse	14	6.000	11760	37.5	0.5	4.0	5.0	35.0	ideal	no	yes	no	1	**180.00**	1.637	rectang.	5.102	2.947	1.429	4.375			308.73	-308.73
	shaping	2	6.000	1680										2	151.20	3.274	rectang.	35.714	5.804	1.429	7.233			72.90	
		5	6.000	4200										3	108.00	3.274	rectang.	14.286	5.804	1.429	7.233			182.26	
	above	14	6.000	11760										4	338.40	3.274	rectang.	5.102	5.804	1.429	7.233			510.33	
		1	6.000	840										5	**262.08**	2.456	rectang.	71.429	2.947	1.429	4.375			22.05	-104.13
		1	6.000	840										6	247.68	4.911	rectang.	71.429	5.804	1.429	7.233			36.45	
1b	pulse	15	6.012	12600	37.5	0.5	4.0	5.0	-35.0	ideal	no	yes	yes	1	**0.00**	1.637	rectang.	4.762	2.953	1.429	4.381			331.22	-331.22
	shaping	3	6.012	2520										2	316.80	3.274	rectang.	23.810	5.816	1.429	7.244			109.53	
		6	6.012	5040										3	273.60	3.274	rectang.	11.905	5.816	1.429	7.244			219.06	
	below	15	6.012	12600										4	144.00	3.274	rectang.	4.762	5.816	1.429	7.244			547.66	
		1	6.012	840										5	**83.95**	2.456	rectang.	71.429	2.953	1.429	4.381			22.08	-106.03
		1	6.012	840										6	69.55	4.911	rectang.	71.429	5.816	1.429	7.244			36.51	
2	pulse suppr.		6.050	840	15.0	0.5	4.0	5.0	-12.5	ideal	no	yes	no		0.00	18.800	radial	71.429	4.412	1.429	5.840	3.975	7.706	29.44	-29.44
	below																								
3a	T0		6.110	1680	15.0	0.5	4.0	5.0	-12.5	ideal	no	yes	no	1	90.00	144.0	radial	35.714	0.000	1.429	1.429			14.40	-14.40
	below													2	270.00	144.0	radial								
3b	T0		6.460	1680	15.0	0.5	4.0	5.0	-12.5	ideal	no	yes	no	1	90.00	144.0	radial								-14.40
	below													2	270.00	144.0	radial								
3c	T0		6.810	1680	15.0	0.5	4.0	5.0	-12.5	ideal	no	yes	no	1	90.00	144.0	radial								-14.40
	below													2	270.00	144.0	radial								
4	FO		12.500	10080	37.5	2.0	12.0	14.5	-29.5	ideal	no	yes	no		0.00	240.0	radial	5.952	6.139	1.429	7.568			457.70	-97.70
	below																								
5	FO		37.500	3360	37.5	2.0	4.0	6.5	-33.5	ideal	no	yes	no		0.00	310.0	radial	17.857	18.418	1.429	19.846			400.10	-40.10
	below																								

Test Chopper System: TOF@Detector

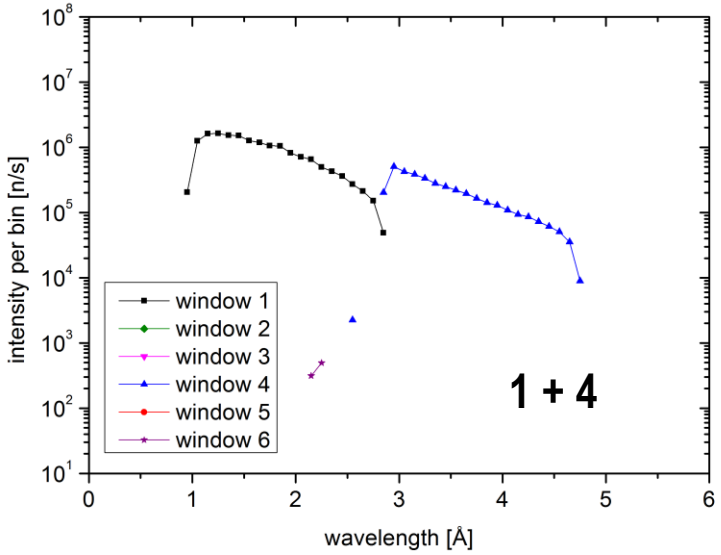


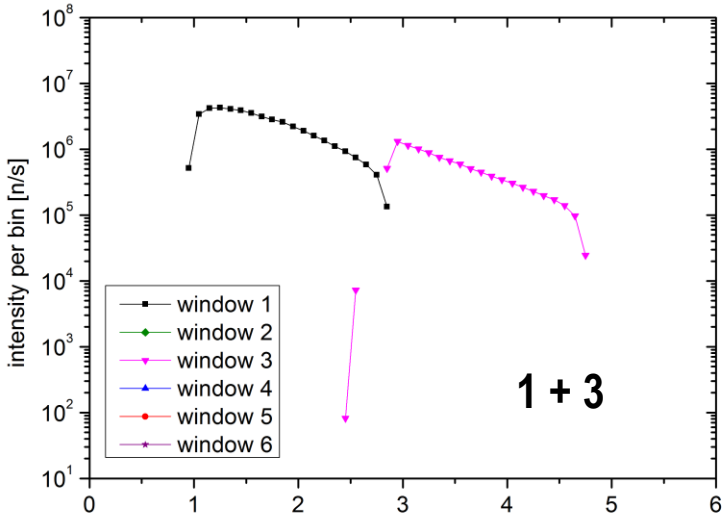


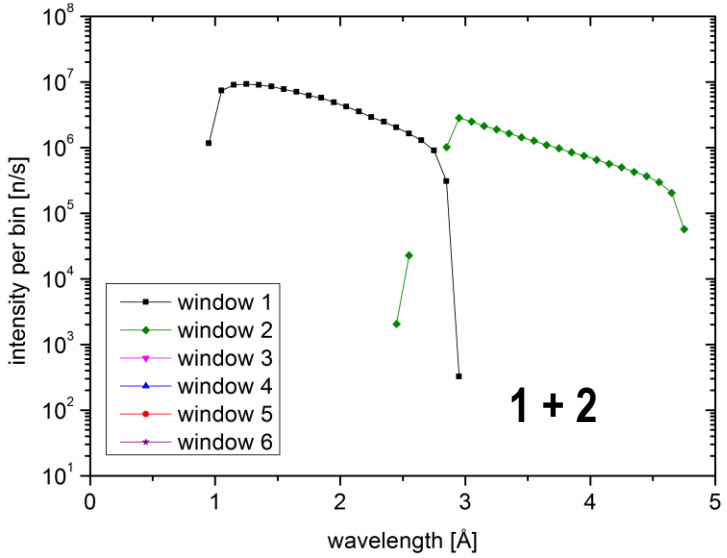


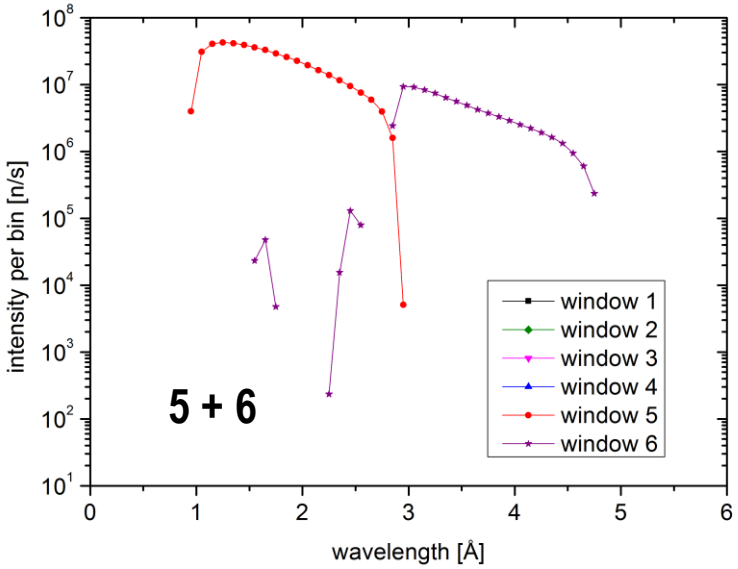


Test Chopper System: Wavelength Distribution at Sample









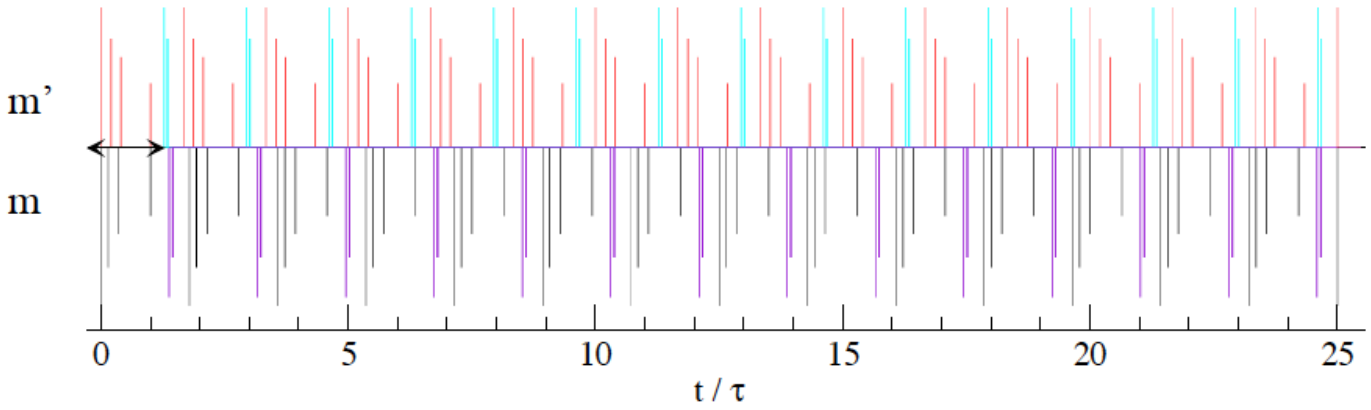
Test Chopper System: Summary

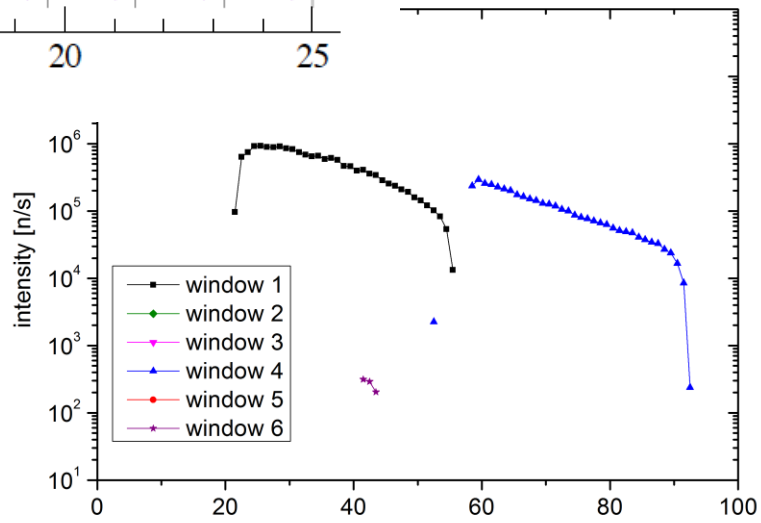
- TOF spectra well separated at the detector

- Wavelength spectra overlap

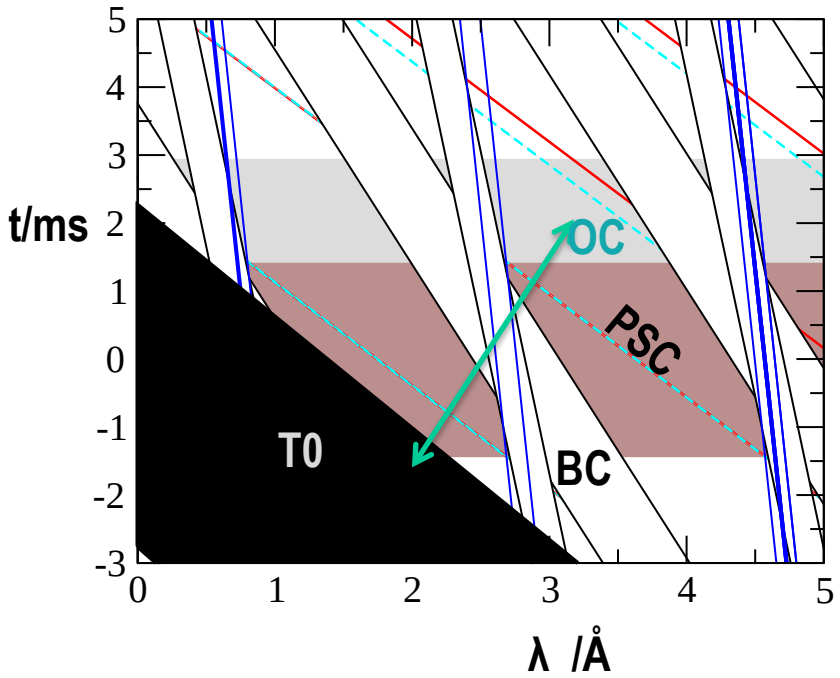
- The spectra have undesired contaminations <10^-3
  - needs analysis and improvements if possible

Chopper System: Contaminations

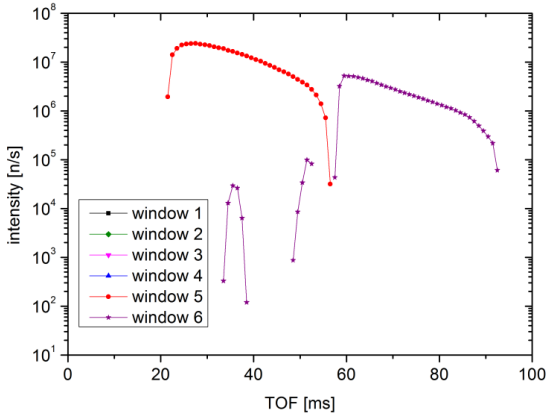




acceptance diagram



ESS pulse

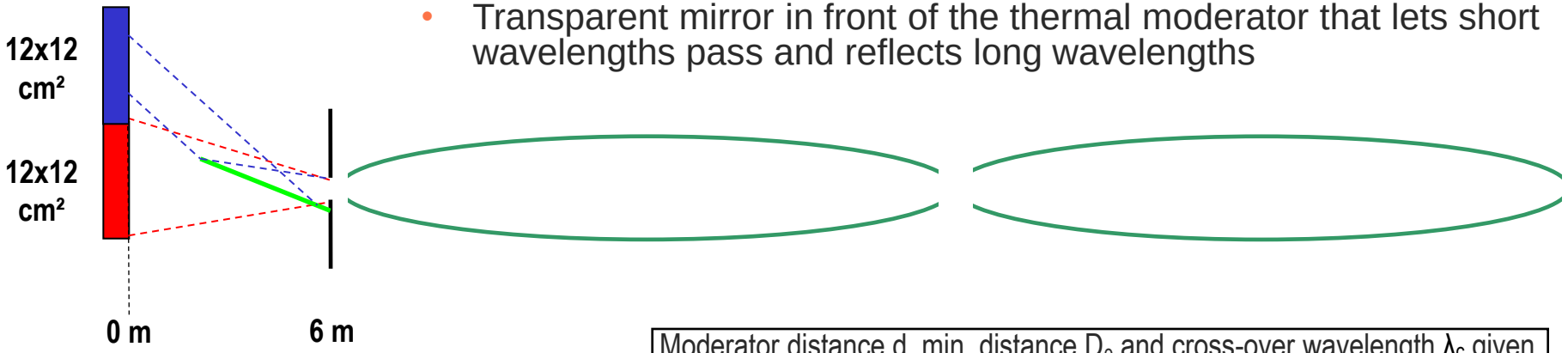


PowHow Guide System

- How to use both moderators ?

‘Traditional’ Extraction System

- Basic Idea
  - Transparent mirror in front of the thermal moderator that lets short wavelengths pass and reflects long wavelengths



Moderator distance d, min. distance D_0 and cross-over wavelength λ_c given
- choose mirror coating m

⟶ mirror inclination: $\alpha = 0.1\ m\ \lambda_c$

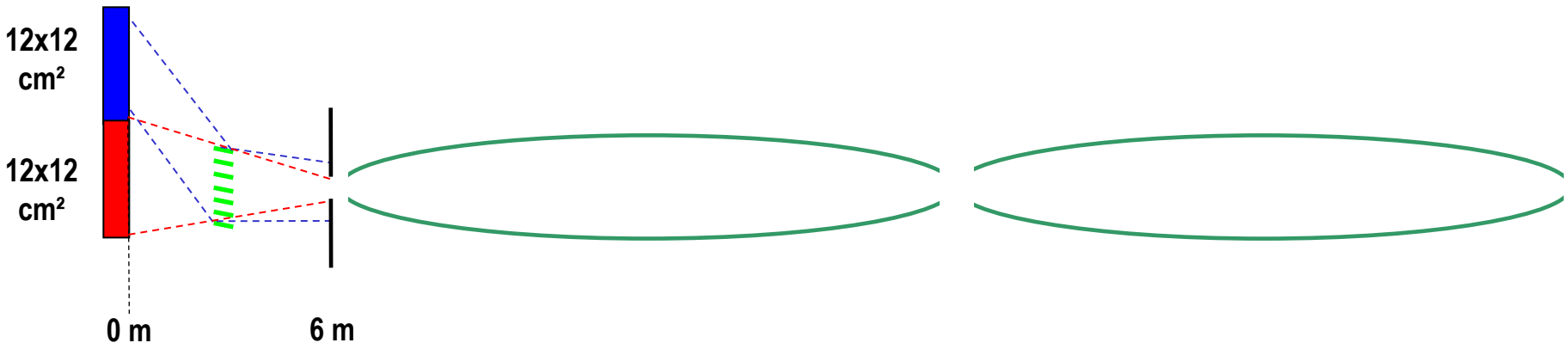
⟶ mirror center: $D_{mirr} = d/\tan(2\alpha)$

⟶ sym. mirror length: $L_{mirr} = 2(D_{mirr} - D_0)/\cos(\alpha)$

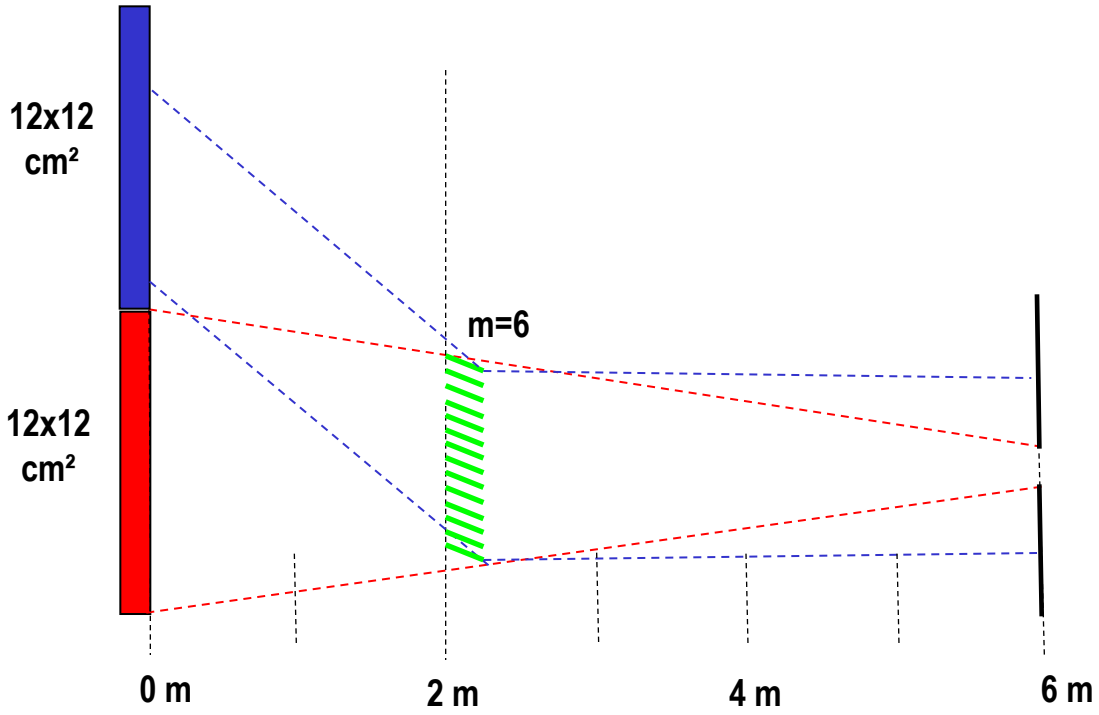
- Only 1 free parameter
  - Mirror coating and cross-over wavelength determines inclination angle (e.g. 1.175° for m=5 and 2.35 Ang cross-over wavelength)
  - => distance between moderator centers determines center position
  - => minimal distance fixes mirror size

- Drawbacks
  - Difficult installation and exchange

Compact Extraction System

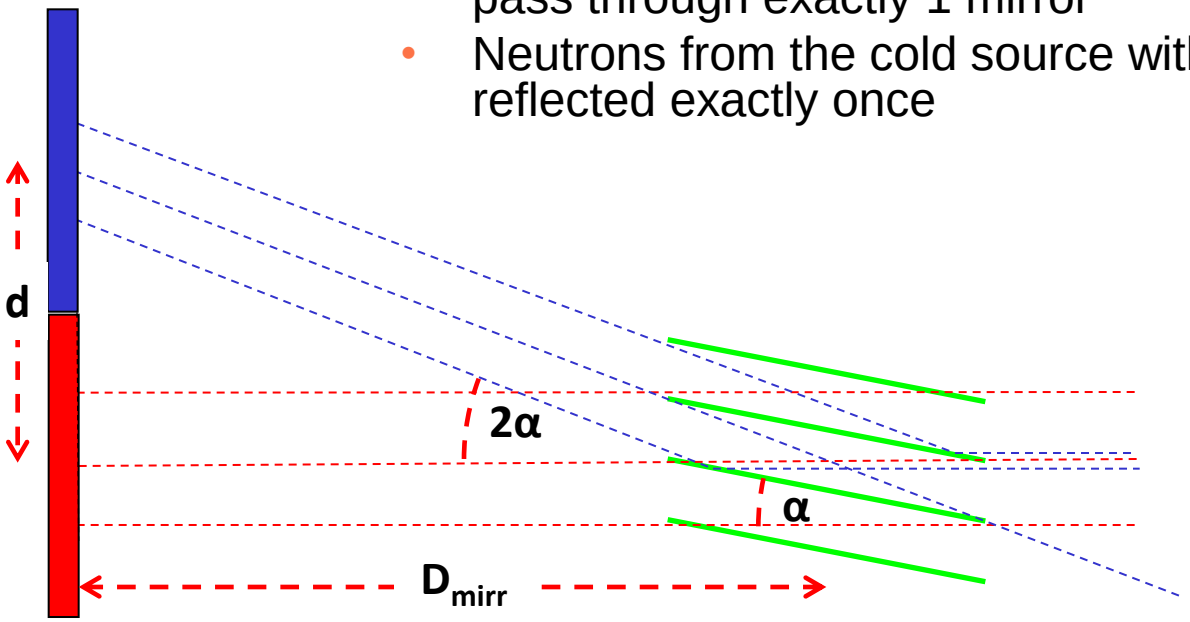


Usual Approach: As close as Possible to the Sample



Principle of Compact Extraction System

- Neutrons from the thermal source without divergence pass through exactly 1 mirror
- Neutrons from the cold source with divergence 2α are reflected exactly once

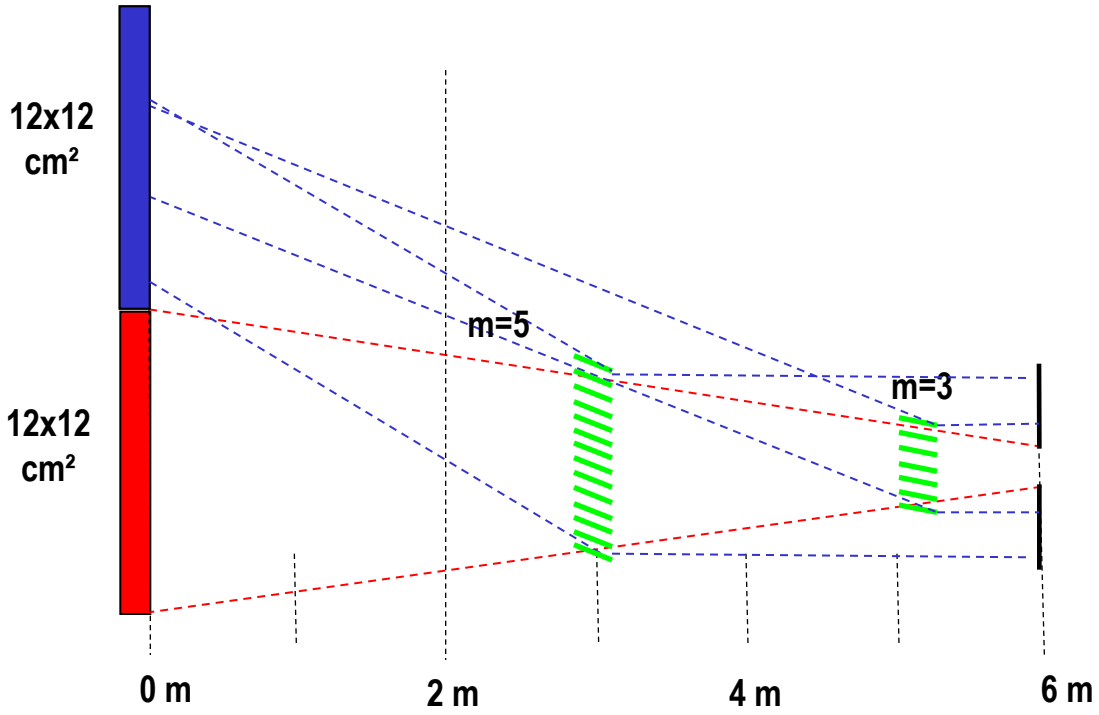


As for 1 mirror: $D_{mirr} = d/\tan(2*0.1\ m\ \lambda_c)$
Ideal distances for d=0.12 m, λ_c=2.35 Å:

m	D_{mirr} [m]
7	2.110
6	2.462
5	2.955
4	3.695
3	4.928
2	7.392

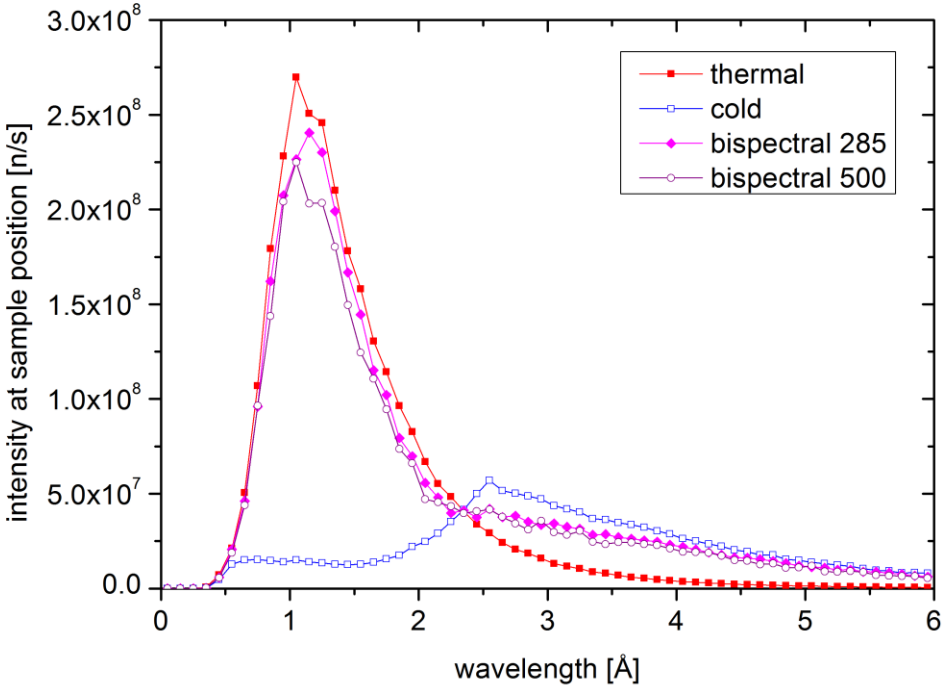
Chosen:
2.975 m, m=5
5.125 m, m=3

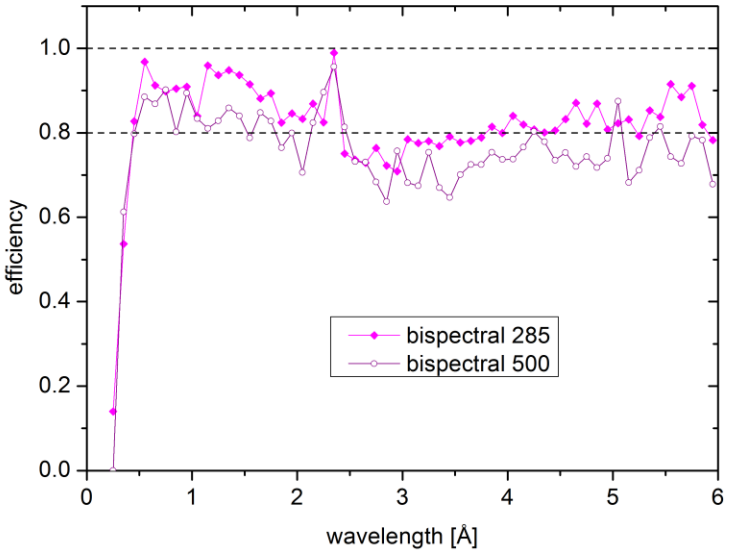
New Approach: further away from the Sample



- Advantages
  - Lower coating can be used
  - Extraction system can be protected from radiation by shutter
  - Easier access
- But how is the Performance ?

Performance of Compact Extraction Systems at Different Distances





- Result
  - Efficiency is higher, if mirror is closer to moderator
- Reasons
  - Higher probability of reflection for divergent thermal neutrons
  - Higher probability of transmission for divergent cold neutrons
  - Longer paths through mirror

Acknowledgement

Thank you for your attention

We like to thank the BMBF for their support through the contribution to the ESS update phase.
Work package K7: Simulationscode-Entwicklung, Helpdesk work package