International Atomic Energy Agency

Some Remarks on Compilation of Thermal Neutron Constants

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and

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History of ^{235}U Thermal Fission Cross Section

U-235 fission cross-section, 0.0253 eV

United Nations Conference on Peaceful Uses of Atomic Energy
Geneva 1955

USA:	580	+-	8 barns
UK:	638	+-	20 barns
USSR:	570	+-	15 barns

Geneva 1958

world:	582	+-	10 barns

Hanna, Westcott et al 1975: 580.2 +- 1.8 barns

1990 until today: 584.25 +- 1.11 barns

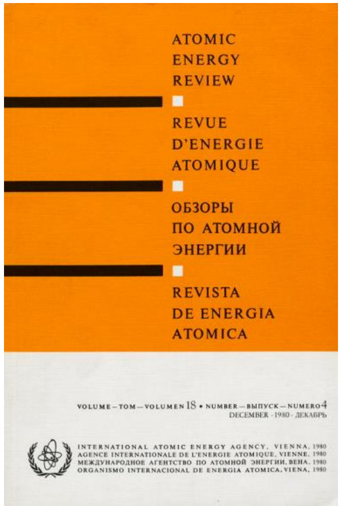
(Prepared by Hans Lemmel)

Thermal Neutron Constants (TNC)

- Cross sections, Westcott g-factor, total fission neutron multiplicities of $^{233,235}U$, $^{239,241}Pu$ and ^{252}Cf for thermal neutrons
- Pioneering evaluation at the IAEA by Westcott (1965), Hanna (1969) and Lemmel (1975).

Carl H. Westcott (First Head of IAEA NDU)

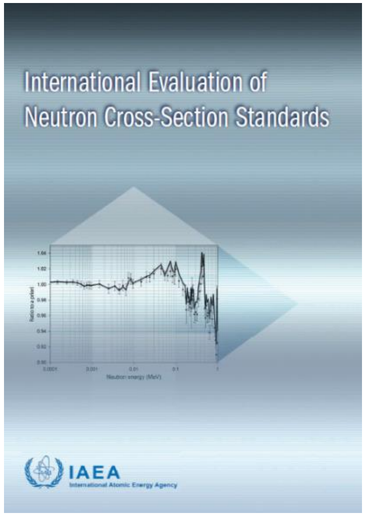
Hans Lemmel (Head of NDS NDSU)

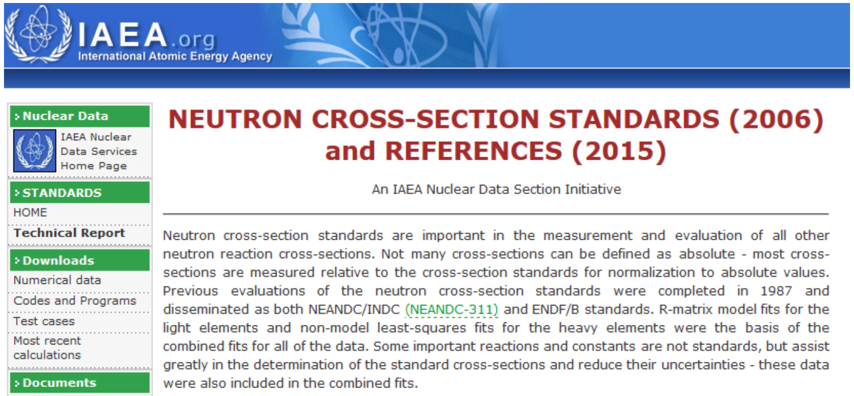


Thermal Neutron Constants (TNC)

- The evaluation performed at the IAEA was took over by **Axton** (1984-1986).

- Typical evaluation within the IAEA Neutron Standards is based on **Axton's database** containing 167 experimental values.





Axton's Experimental Database

Author	Reference	Measured Functions	Notes	Input Value	Uncert-tainty %	Weighted Residual	No.
LAPONCHE	1972(2)	(FA 39)÷FA 35	7	1.6491E00	.583	.329	1
CORNISH	1956(2)	CAP 39	8	3.1200E02	4.490	.179	2
HALPERIN	1963(2)	CAP 33	10	4.9530E01	6.400	.615	3
CABELL	1971(2)	FLEM	11	9.8270E-02	3.348	-.256	4
LEMMEL	1982(1)	CAP 34	3	9.5900E01	2.086	.032	5
POPOVIC	1953(2)	FF 35	13	5.7110E02	2.211	.119	6
POPOVIC	1955(2)	33 FFH 33	13	8.4472E02	3.147	.136	7
KEITH	1968(2)	33 FFH 33	14*	8.3415E02	1.371	-.608	8
KEITH	1968(2)	33 FFH 35	14*	8.8901E02	1.446	-1.383	9
KEITH	1968(2)	39 FFH 39	14*	1.8844E03	.949	-1.014	10
BIGHAM	1975(2)	33 FFH 33	15	8.3520E02	.659	-1.071	11
JAFFEY	1955(2)	(FF 41)÷FF 39	17	1.3552E00	1.424	.823	12
WHITE	1967(2)	(FF 39)÷FF 35	18	1.3583E00	2.139	-.932	13
WHITE	1967(2)	(FF 41)÷FF 35	18	1.8806E00	2.802	.477	14
VIDAL	1970(2)	(FF 33)÷FF 35	2	9.3200E-01	.966	.495	15
BIGHAM	1975(2)	(FF 33)÷FF 35	15	9.3230E-01	.450	1.134	16
SWEET	1973(2)	(39 FFH 39)÷34 F					
BIGHAM	1975(2)	(39 FFH 39)÷33 F					
BIGHAM	1975(2)	(39 FFH 39)÷33 F					

No.	Codes	Individual Uncertainties (Percent)		
2	↑	.161		
3	↑	.161		
6	Δ	.943		
7	Δ⊂	.943	.126	
8	ρ↑⊂	.935	.161	.126
9	ρ↑⊂	.935	.161	.126
10	ρ↑∩	.500	.161	.124
11	⊂	.126		
13	DJ	1.225	.940	
14	DK	1.225	2.140	
17	⊃∩	-.122	.124	
18	⊂∩	-.126	.124	
19	⊂∩	-.126	.124	
20	∪	.025		
21	Z	.226		
22	Z	.247		
23	Z	.818		
26	XY	-.660	.697	
27	XY	.237	.533	

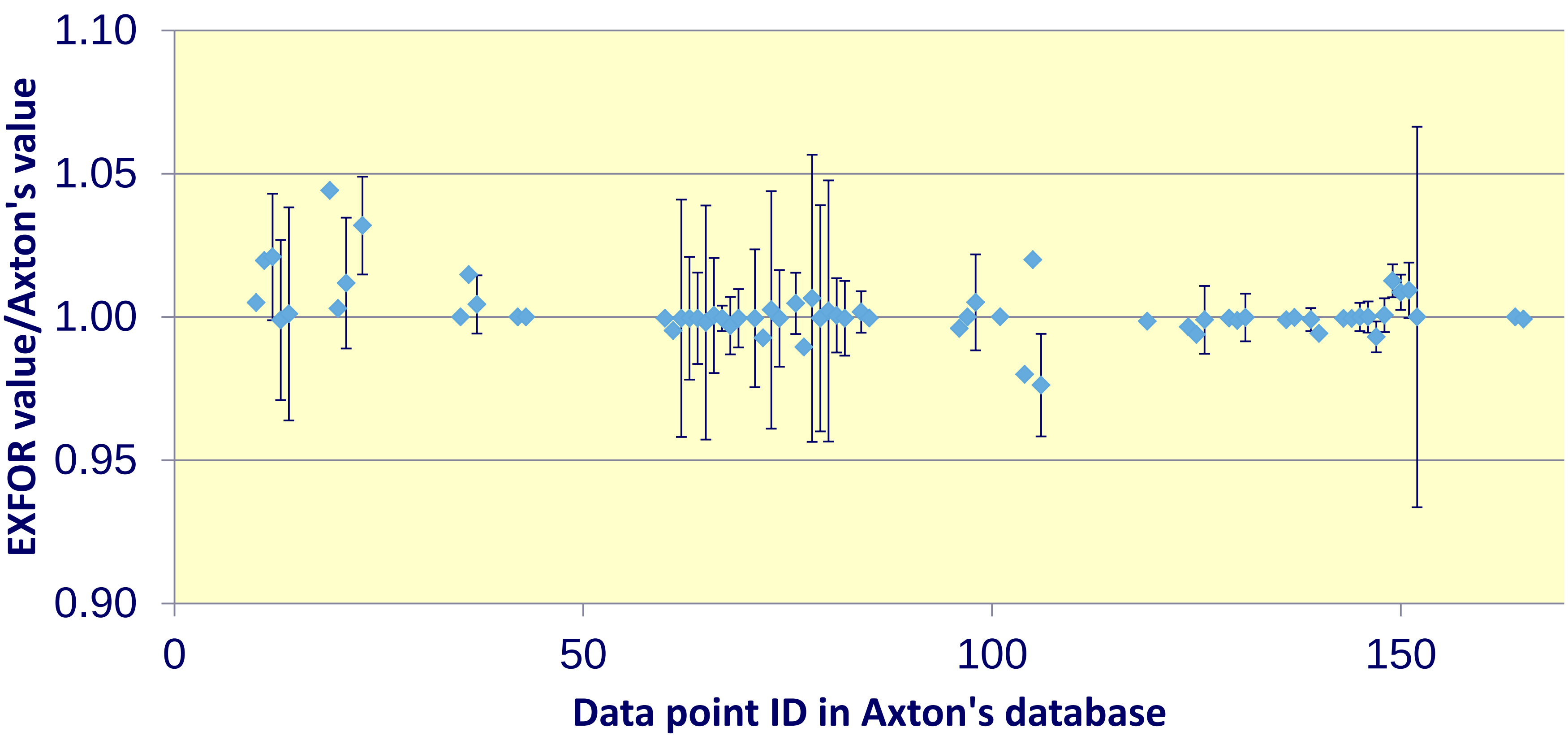
Experimental thermal constants and partial uncertainties assembled by Axton ('86)

Codes	Causes of Correlated uncertainty.
M	Cabell Fluence
N	Cabell Temperature
O	DIDO Reflector g+rs For CAP, ABS PU239
P	DIDO Reflector g+rs For CAP,ABS PU241
Q	CABELL 86° Spectrum Uncertainty
R	Cabell Uncertainty (Sjostrand and Story)
S	Cabell Uncertainty (Sjostrand and Story)
T	Gwin Uncertainty evaluated By Hardy
U	Muelhaus uncertainty evaluated by Axton
V	Spectral Uncertainties from IN1060
W	MTR 70° Spectrum Uncertainty
X	NRU 40° Temperature Uncertainty
Y	NRU Westcott r Uncertainty
Z	Lounsbury Temperature Uncertainty
Δ	Popovic Uncertainty (Na Cross Section)
ρ	Keith Uncertainty (Deruytter correction)
↑	Uncertainty in Co Cross Section
↓	+-20° Uncertainty in T
+	Common Uncertainty in U235 Reactivity
▪	Common Uncertainty in U235 Reactivity
⊂	Half-life U233
⊃	Half-life U234
∩	Half-life PU239
∪	Half-life AM241
α	Spencer Common Uncertainty

Problem

- Revision of the 2006 IAEA Neutron Standards is on-going.
- Axton’s inputs (167 experimental values) are being used in new evaluations performed independently by two least-squares fitting codes: GMA and CONRAD.
- However, “experimental data” in Axton’s database were often missing in EXFOR, or had a different value.
- We checked each experimental value in Axton’s database against EXFOR.

EXFOR Value/Axton's Value



Corresponding experimental values exist in EXFOR for 68 cases (out of 167 experimental values used by Axton's database)

Conclusions

- EXFOR irrelevant quantities (*e.g.*, $\sigma \cdot T_{1/2}$ value derived from σ and $T_{1/2}$ values in the literature) → *not for EXFOR*
- Values derived by the evaluator from values in the literature (*e.g.*, σ/σ_{ref} value derived from σ and σ_{ref}) → *not for EXFOR*
- Publications overlooked by EXFOR compilers. → *should be in EXFOR! (See Memo 4C-3/402)*
- Its entry exists but values missing in the entry. → *should be in EXFOR! (See Memo 4C-3/405)*

Experimental Works Requiring New Entries

Author	Reference	Lab	Centre	Remark
R.L.G.Keith+	J,JNE,22,477,1968	2UK ALD	NEA DB	23309 (in compilation)
F.W.Cornish	R,NRDC-129,1960	2UK HAR	NEA DB	23310 (in compilation)
F.Lisman+	R,IN-1178,1968	1USA MTR	NNDC	FY of this work in 13270.
D.R.deBoisblanc+	J,ANS,4,270,1961	1USAMTR	NNDC	
M.J.Cabell+	R,AERE-R-4946,1965	2UK HAR	NEA DB	23311 (in compilation)
R.L.Zimmerman+	(unpublished)	1USABNL	NNDC	52081 in the past
H.Muether+	(unpublished)	1USABNL	NNDC	50645 in the past

See also Memo 4C-3/402 (Rev.).

Experimental Works Requiring Revision of Entries

Author	Reference	EXFOR #	Lab.	Quant.	Value	Remark
R.L.G. Keith+	J,JNE,22,477,1968	23309	2UK ALD	σ_{f3}	534.6(53) b	Preliminary data in
				σ_{f5}	582.9(64) b	R,EANDC(UK)-92.
				σ_{f9}	742.0(67) b	Under compilation.
R. Vidal+	C,70HELSINKI,1,295,19 70	20552	2FR SAC	$\langle\sigma_{f3}\rangle/\langle\sigma_{f5}\rangle$	0.931(5)	
				σ_{f3}/σ_{f5}	0.914(5)	
F.W. Cornish	R,NRDC-129,1960	23310	2UK HAR	$\sigma_{\gamma5}/\sigma_{f5}$	0.194(8)	Under compilation
F. Lisman+	R,IN-1178,6,1968	(NNDC)	1USAMTR	$\sigma_{\gamma5}/\sigma_{f5}$	0.171(3)	FY in EXFOR 13270.
D.R. deBoisblanc+	J,ANS,4,270,1961	(NNDC)	1USAMTR	$(\eta_{3)})/(\eta_5)$	1.115(8)	Missing in CINDA.
M.J. Cabell+	R,AERE-R-4946,1965= TNCC(UK)-77,1960	23311	2UK HAR	η_3/η_5	1.102(14)	Preliminary data in 58GENEVA,16,34,1958, AERE-R/R-2457. Under compilation
				η_9/η_5	1.006(11)	
P.A. Egelstaff	R,AERE-NP/R-2104,1,1957	21179.009	2UK HAR	σ_{t5}	724(15) b	
J.R. Smith	R,EPRI-NP-3436,(4),1984	13019	1USAMTR	σ_{t1}	1395(20) b	
J.W. Boldeman	C,77NBS,,182,1977	31761.003	3AULAUA	ν_{52}	3.746(16)	
H. Conde	J,AF,29,293,1965	20025.003	2SWDFOA	ν_5/ν_{52}	0.6400(53)	
M.J. Cabell	R,AERE-R-5874,1968	21410	2UK HAR	$[\sigma_{a,9}]/[\sigma_{\gamma,9}]$	3.269(89)	

See also Memo 4C-3/405.

Remarks

- Add **DERIV** in REACTION SF9 for a 2200 m/s value obtained by interpolation or extrapolation of point-wise values.

- Code the temperature of the neutron field under **KT-K** etc. instead of **EN-DUMMY=0.0253 eV** when a Maxwellian averaged cross section at a temperature far from the room temperature is compiled.

- Describe the Westcott's g-factor assumed by the experimentalist to derive the 2200 m/s value compiled.

Remarks (cont)

- Describe the fission neutron mean neutron energy when it is assumed in neutron detector efficiency calibration for fission neutron multiplicity measurement.

- Describe the half-life of the sample material when it is assumed in quantification of the number of atoms (e.g., by α spectrometry).

International Atomic Energy Agency

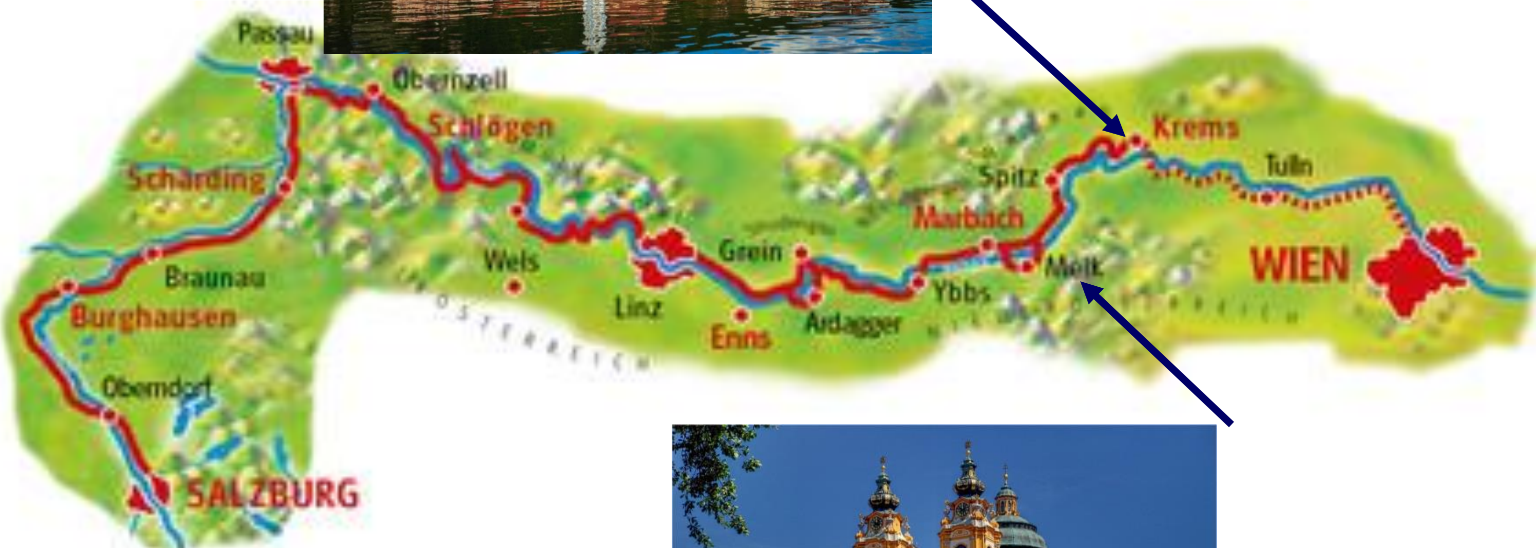
EXFOR Excursion

Naohiko Otsuka

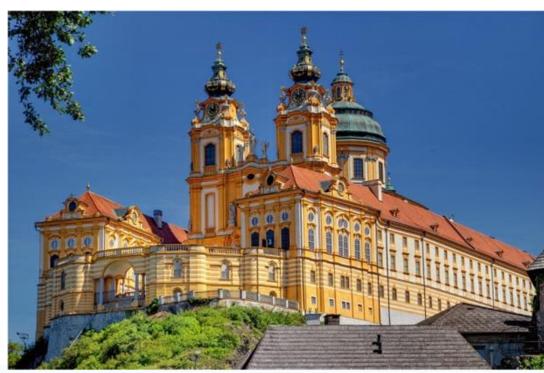
IAEA Nuclear Data Section

If it is fine,…

Dürnstein



Stift Melk



Two Options

	Option 1	Option 2
Wien West Bhf (Meeting)	**07:10**	**8:40**
Wien West Bhf	07:20	8:54
Melk Bhf	08:22	10:22
Stift Melk	(Free time)	
Melk Kremser Strasse	11:22	12:41
Emmersdorf a.d. Donau Bhf	11:30/11:40	
Dürnstein-Oberloiben	12:30	
Dürnstein	(Free time)	
Dürnstein Parkplatz Ost	15:26	13:26/15:26
Krems Bhf	15:44/15:51	15:44/15:51
Wien Franz-Josefs Bhf	16:58	16:58

Option 1

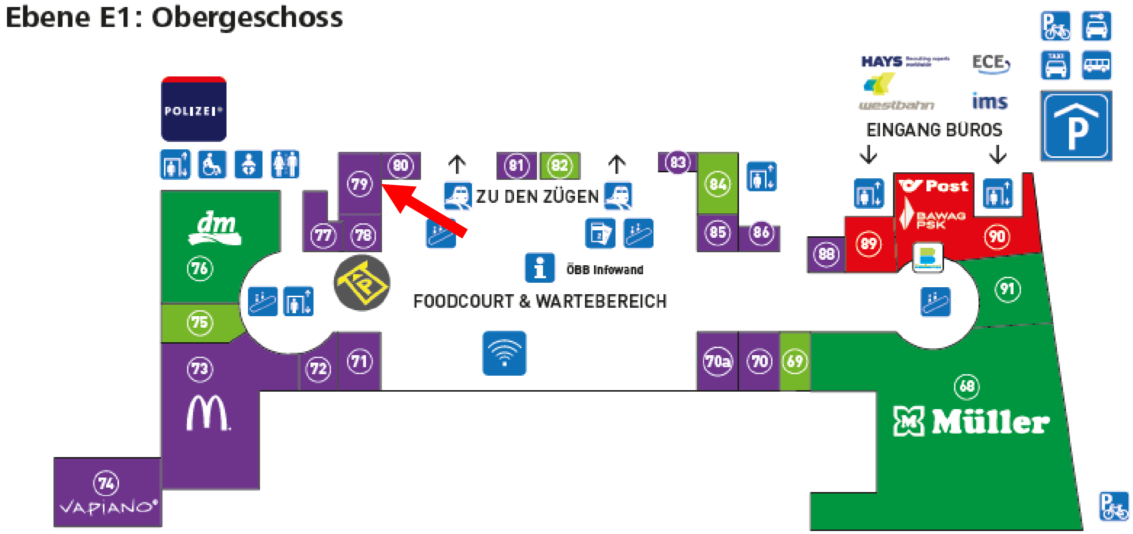
Option 2

Stift Melk

Dürnstein

Meeting (Wien West Bhf)

Wien West Bahnhof (level of the platforms)
Option 1 7:10
Option 2 8:40



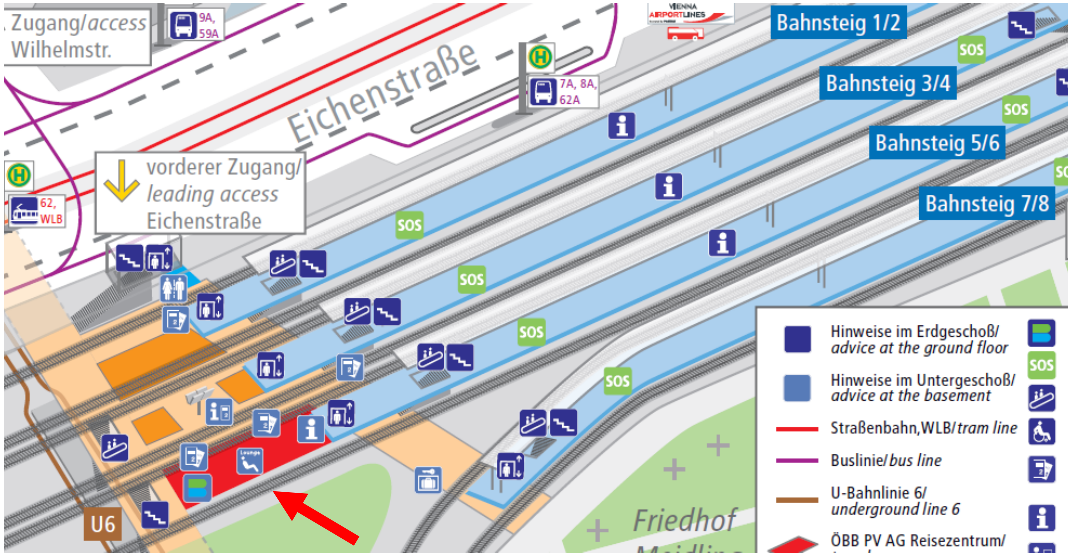
If it is rain…

Wien Meidling Bhf	10:00
Wien Meidling Bhf	10:09
Mödling Bhf	10:26/10:29
Hinterbrühl Seegrotte	10:44
Seegrotte	(Free time)
Hinterbrühl Seegrotte	12:57
Mödling Jasomirgottgasse	13:04
Mödling	(Free time)
Mödling Bhf	

Seegrotte

Meeting (Wien Meidling Bhf)

Wien Meidling Bahnhof (in front of ÖBB Lounge)
10:00



Remark

- We do not make any reservation for train, bus, restaurant. You can decide whether your attendance/cancellation without notification to me.

- If the weather is not clear (fine or rain), please call me freely.