Update on Channeling Exercise

May 2019

Presenter: Thomas Blumenstock
with contributions by many of you!

Contributions from

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Gothenborg U.	G. Persson	J. Mellqvist
KIT Garmisch	M. Rettinger	R. Sussmann
KIT Karlsruhe	F. Hase	T. Blumenstock
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Nagoya U.	T. Naghama	
NCAR Boulder	I. Ortega	J. Hannigan
NIES, Tsukuba	I. Morino	
NIWA, Lauder	J. Robinson	D. Smale
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Toronto U.	E. Lutsch, O. Colebatch	K. Strong
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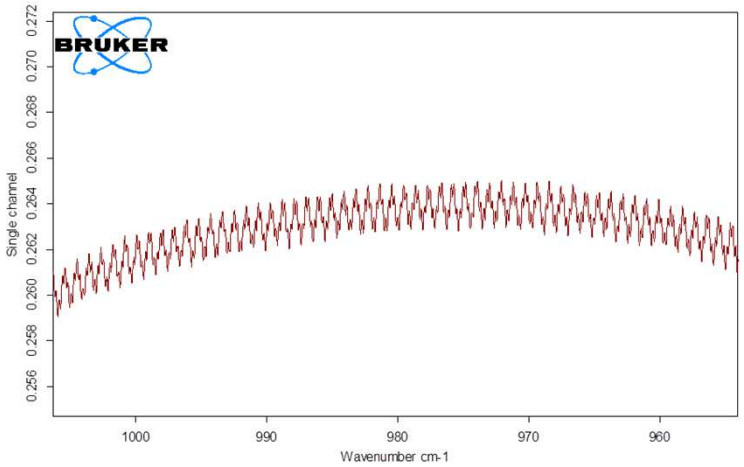
Thank you for your effort!

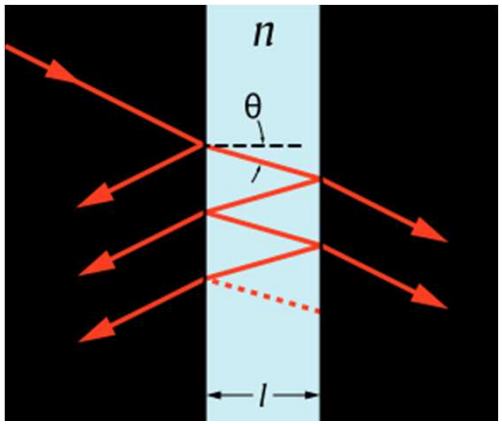
Outline

- Introduction + summary of last years talk
- Updates:
  - Additional sites
  - MCT spectra included
  - Amplitude calculation with FFT
  - Discussion of results

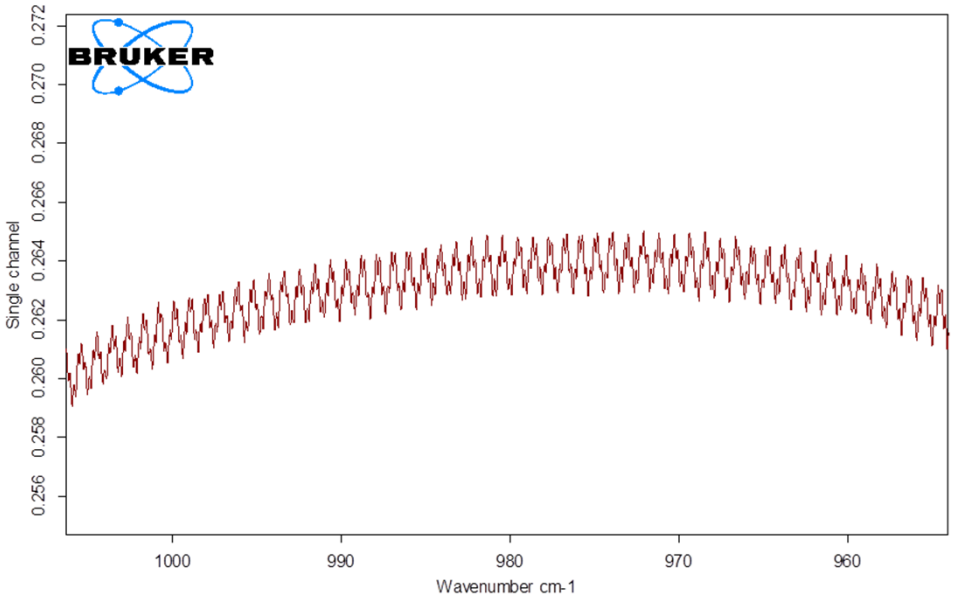
=> Channeling



Channeling



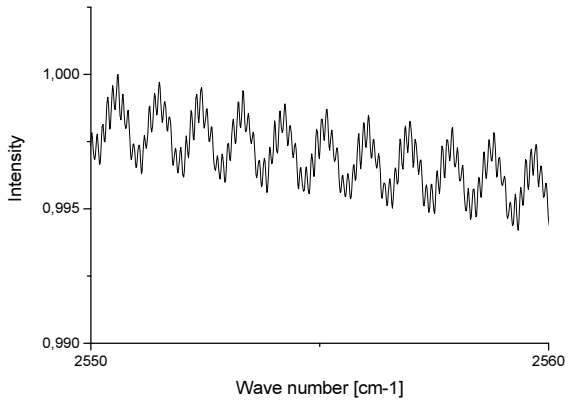
Taken from wikipedia.org



Intereference of multi-reflections at parallel surfaces

Channeling

Aim is to characterize
and of course to
reduce channeling:



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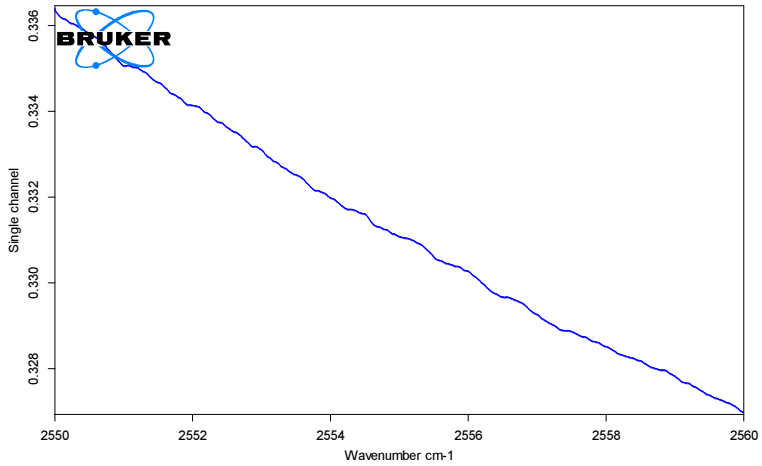

Summary of last year's report

- Exercise triggered by HCHO paper by C. Vigouroux et al.
- Omission of channeling in SFIT-4 error budget triggered discussion on channeling (F. Hase)
- Channeling test spectra recorded with external source at most sites
- Spectra of NDACC filter no. 3 was analysed last year:
  - Channeling (error) is not negligible!
  - Since wedge of beamsplitter and its gap is too small most spectra include channeling!
  - Dominant channeling frequencies are 0.9 & 0.1 cm^{-1}.
  - Amplitude (peak to peak) is typically 1-3 ‰.

BUG 2004

Forschungszentrum Karlsruhe
in der Helmholtz-Gemeinschaft

Comparison of different wedges of KBr beam splitters

KBr – BS		wedges	channeling frequencies:
I.	Original:	Sub.: 1', Gap ?, small	0.88 & 0.23 cm^{-1}
II.	New:	Sub.: 8', Gap ?	0.88 cm^{-1}
III.	New 2:	Sub.: 8', Gap ~1°	

1/(2*1.5*3cm) = 0.11 cm^{-1}

$\Delta\kappa = 1/(2ndcos\Theta)$:

- with n=1, d=5.7 mm: $\Delta\kappa$ = 0.88 cm^{-1}
- with n=1.5, d=14 mm: $\Delta\kappa$ = 0.23 cm^{-1}

- Signatures of lab air in BB spectra: CO_2, H_2O
- Much of 'noise' in atmospheric MCT spectra is due to channeling!
- Larger wedge important for NDSC-IRWG group
- No compatibility with FIR BS is the price to pay
- CaF_2 with 10' is compatible
- Alignment & ILS is still fine

BUG 2004

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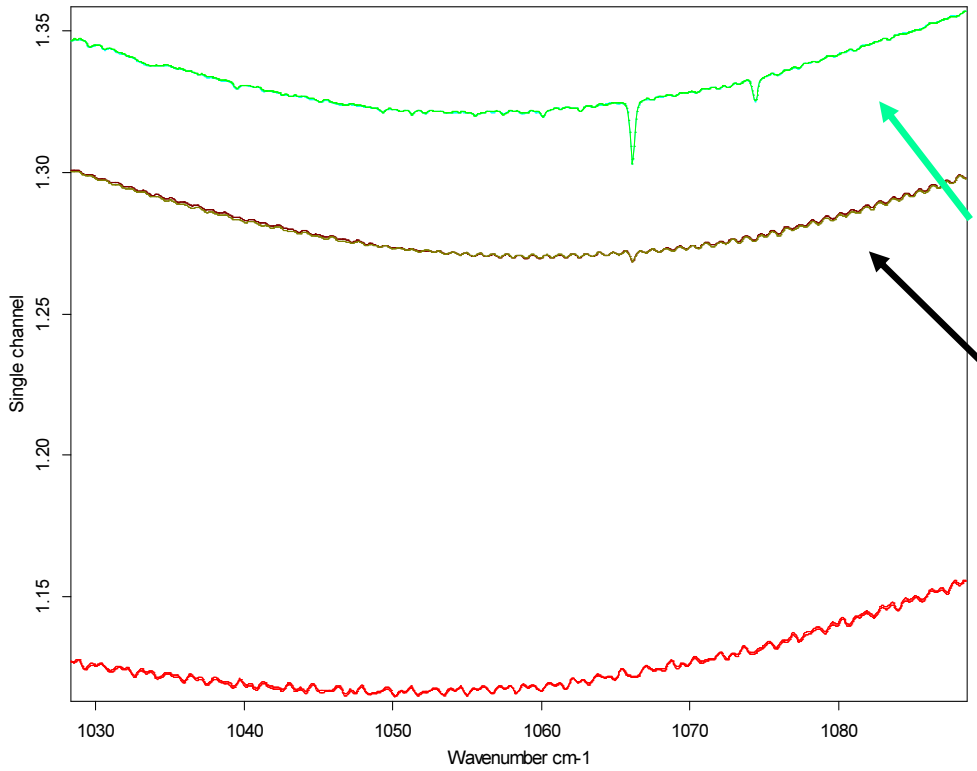
Comparison of BB spectra with different KBr beam splitters



KBr – BS:

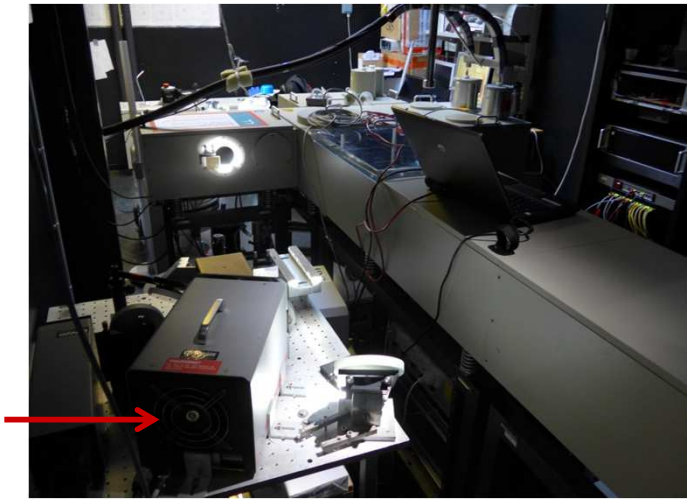
- Sub. 8',
  Gap ~1°
- Substrate: 8'
- Original:
  Sub. 1'

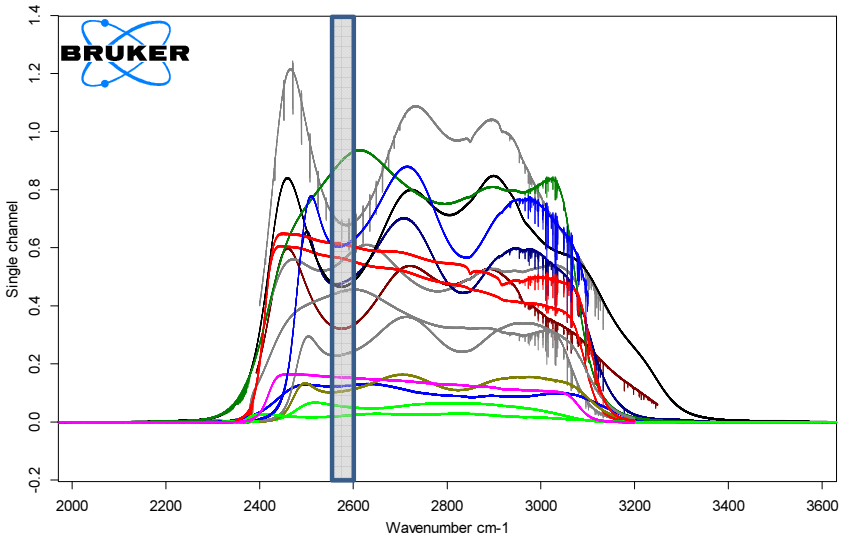
Outline of test

- Lab source without glass body if available:
- Globar or black body
- NDACC filters #3 and #6 (or #7/8)
- Spectral resolution of 0.05 cm^{-1}
- Co-add 1000 scans for a good signal to noise ratio

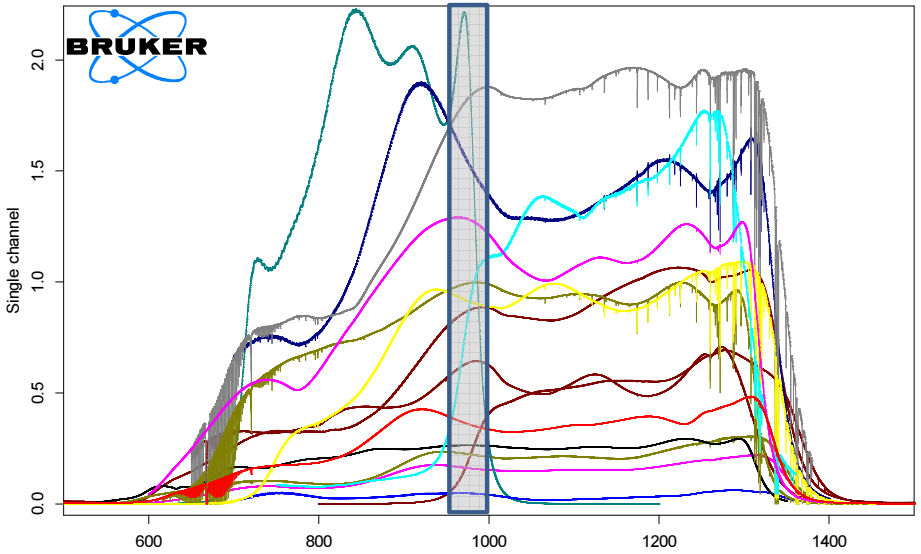
Kiruna setup for example

BB source

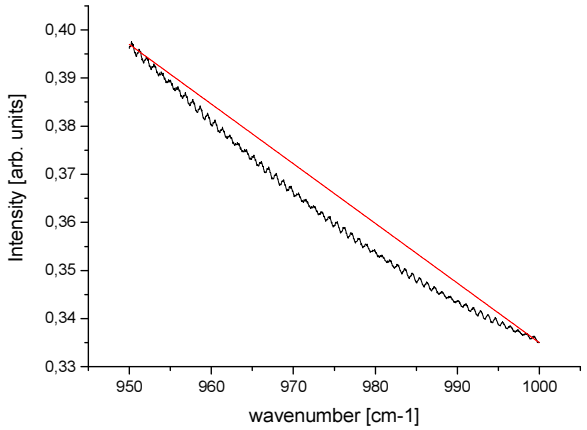




Transmission of filter #3 & #6

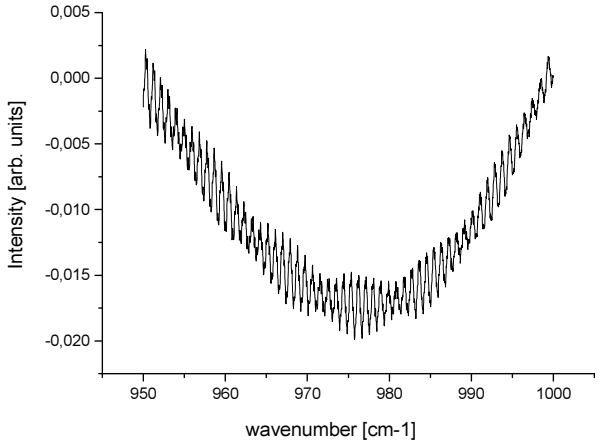


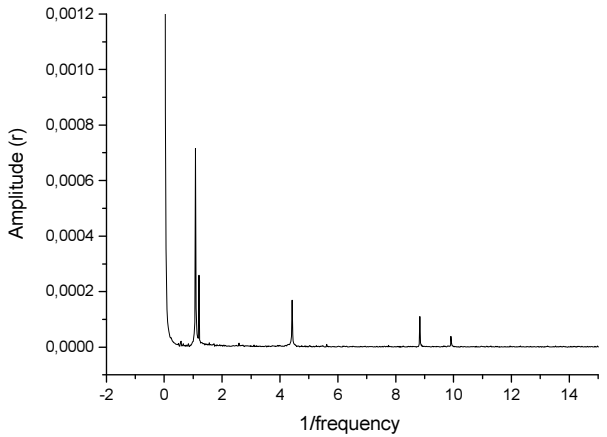
Analysis of test spectra



- Cut spectrum to approx. 50 cm^{-1} (OPUS)
- Normalize background and subtract straight line (Origin)
- (I)FFT (Origin)

Hase, PhD thesis, 2000





Results, InSb, F3

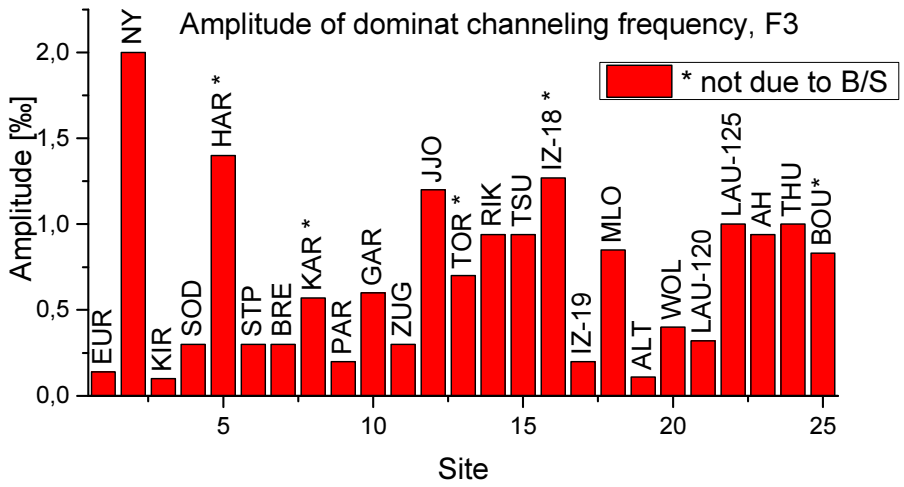
	F 1 [cm^{-1}]	A 1 [‰]	F 2 [cm^{-1}]	A 2 [‰]	F 3 [cm^{-1}]	A 3 [‰]	Comment
Eureka	0.93	0.14	0.23	0.05	0.11	0.004	
Ny-Ales.	0.90	**2.0**	0.11	0.08			
Kiruna	0.85	0.05	0.11	0.003	0.76	0.1	Lab air
Sodank.	0.93	0.3	0.12	0.03	0.11	0.024	0.01‰@0.25 cm^{-1}
Harestua	0.91	0.37	0.1	0.02	3.33	**1.36**	
St. Ptbg.	0.93	0.3	0.23	0.12	0.16	0.11	0.2‰ @0.77 cm^{-1}
Bremen	0.93	0.3	0.23	0.16	0.11	0.05	
Karlsruhe	0.87	0.14			1.29	0.57	Lab air
Paris	0.91	0.2	0.25	0.05			
Garmisch	0.91	0.6	0.1	<0.1	3.1	0.24	cell
Zugspitze	0.91	0.26	0.11	0.025	0.10	0.035	
JJoch	0.91	**1.24**	0.23	0.08	0.12	0.02	
Toronto	3.1	**0.68**	0.21	0.05	0.11	0.02	BOMEM

Results, F3, ctd.

	F 1 [cm^{-1}]	A 1 [‰]	F 2 [cm^{-1}]	A 2 [‰]	F 1 [cm^{-1}]	A 3 [‰]	Comment
Rikubetsu	0.90	**0.94**	0.25	0.22	0.11	0.11	0.17‰@3.2 cm^{-1}
Tsukuba	0.93	**0.94**	0.12	0.21	0.11	0.10	
Izana -18	0.76	0.42	0.10	0.09	0.11	0.06	**1.27‰@3.6 cm^{-1}**
Izana -19	0.83	0.07	0.10	0.02	0.11	0.03	0.2‰ @3.1 cm^{-1}
M. Loa	0.93	**0.85**	0.23	0.45	0.11	0.36	
Altzom.	0.64	0.11	1.82				
Wollong.	0.93	0.40	0.23				
Lauder HR120	0.91	0.32	0.23				
Lauder HR125	0.91	**1.0**	0.23				
A. H.	0.91	**0.94**	0.23	0.03	0.12	0.11	0.09‰@0.10 cm^{-1}
Thule	0.91	**1.0**	0.23	0.18	0.11	0.15	0.27‰@3.1 cm^{-1}
Boulder	0.93	**0.81**	0.23	0.75	0.11	0.11	0.83‰@3.6 cm^{-1}

- Most spectrometers show two dominant channeling freq.: 0.9 & 0.1 cm^{-1}!
- Frequencies fit to beamsplitter substrate and gap.

Results filter 3



- Amplitude is 0.1 to 2.0 ‰, mean: (0.68 +/- 0.48) ‰, median 0.60‰!
- Originally PROFFIT error calculation assumed 2 ‰ ampl. (FH) which would also cover the worst case.
- For the paper channeling ampl. was set to 0.5 ‰ in total: Freq.: (0.005), 0.2, 1.0, 3.0 cm^{-1}; 50% random/ 50% systematic
- This ampl. doubles the error of HCHO columns.
- Channeling is not negligible!
- The estimated ampl. is quite close to mean value.
- But large scatter: At some places the ampltude is 4 times the mean!

Results MCT

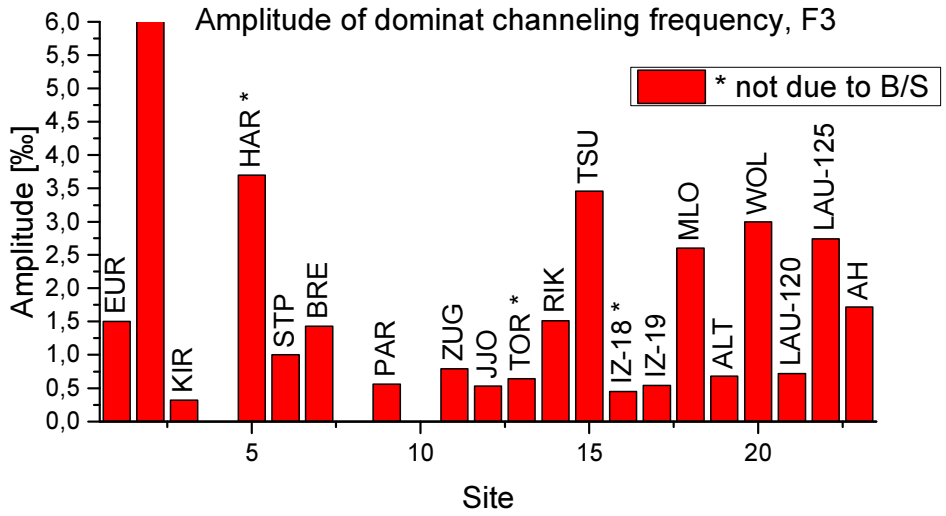
	F 1 [cm^{-1}]	A 1 [‰]	F 2 [cm^{-1}]	A 2 [‰]	F 3 [cm^{-1}]	A 3 [‰]	Comment
Eureka	0.93	**1.5**	0.23	0.2	0.11 0.10	0.14 0.05	
Ny-Ales.	0.91	**1.6**	0.23 0.21	0.89 **1.85**	0.11 0.10	0.60 0.62	**21 ‰ @ 2.17 cm^{-1}**
Kiruna	0.77	0.32	0.59	0.12	0.11	0.07	
Harestua	0.91	**3.7**	0.23 0.11	0.73 0.16	1.56 0.58	0.66 0.36	**4.2 ‰ @3.85 cm^{-1}**
St. Ptbg.	0.94	**1.0**	0.23 0.33	0.30 0.40	2.0 1.77	0.52 0.20	
Bremen	0.93 0.83	**1.43** 0.52	0.23	0.34	0.11 0.10	0.22 0.08	
Paris	0.83	0.56	0.26 0.23	0.23 0.37	0.21 0.12	0.13 0.23	
Zugspitze	0.91	0.79	0.23	0.25	0.11 0.10	0.18 0.19	0.36 ‰ @3.57 cm^{-1}
JJoch	0.91	0.53	0.23 0.21	0.60 0.12	0.11 0.10	0.17 0.06	
Toronto	0.96 0.48	0.64 0.12	0.21	0.20	0.10	0.10	BOMEM

Results MCT, ctd.

	F 1 [cm-1]	A 1 [‰]	F 2 [cm-1]	A 2 [‰]	F 1 [cm-1]	A 3 [‰]	Comment
Rikubetsu	0.93 0.83	**1.44** **1.51**	0.23 0.18	0.62 0.14	0.11 0.10	**2.18** **1.01**	0.21‰ @0.42 cm^{-1}
Tsukuba	0.93	**3.46**	0.23	0.67	0.11 0.10	0.38 0.33	0.27‰ @ 1.19 cm^{-1}
Izana -18	0.76	0.23	0.63 0.56	0.45 0.41	0.11 0.10	0.13 0.13	
Izana -19	0.75	0.48	0.63	0.54	0.11	0.17	
M. Loa	0.93	**2.60**	0.23	**1.35**	0.11 0.10	0.56 0.10	0.14‰ @ 0.61 cm^{-1}
Altzom.	0.88 0.63	0.25 0.68	1.67 1.43				
Wollong.	0.93 0.82	**3.00** 0.23	0.23 0.59				
Lauder HR120	0.91 1.51	0.72 0.08	0.23				
Lauder HR125	0.91 1.14	**1.69** **2.74**	0.23				
A. H.	0.91 1.16	**1.72** **1.15**	0.23	0.18	0.11 0.10	0.12 0.17	

- Most spectrometers show two dominant channeling freq.: 0.9 & 0.1 cm^{-1}!
- Frequencies fit to beamsplitter substrate and gap.
- Chan. amplitude MCT > InSb

Results MCT, ctd.



- Amplitude is 0.3 to 21 ‰, mean: (2.45 +/- 4.50) ‰, median 1.2‰!
- Even larger as compared to InSb filter 3!
- Channeling is not negligible!
- Needs to be reduced at many sites before analysing weak signatures, e.g. of $ClONO_2$, SF_6!
- *: Non BS channeling, due to det. window: PIs contacted directly
- BS channeling: Contact with Axel Keens, Bruker Optics

Phone call with Axel Keens, Bruker

Wish list:

- Focus on B/S gap and increase the wedge of the gap!
- Standardized mounting of the B/S and the wedge (manufacture a spacer) to reduce instr. to instr. diff.
- Specification of channeling amplitude and its check in acceptance tests

Thanks to Axel Keens!

Answer by Axel Keens:

- B/S gap currently ~ 0.5°
- Tests with gap of 0.7° & 0.9°
  - Compatibility
  - Channeling
- Specify & manufacture spacer
- Start with the next batch (2019/20)
- Bigger B/S gap possible:
  1.5° or 2° (KIT B/S 1.0 or 1.75°), but
  - Special part, not in price list!
  - Joint order, at least 8-10 pcs.
  - Realignment needed!
- Reluctant wrt to acceptance tests
  - B/S cannot be changed at this point
  - Windows typically free of channeling

Conclusions

- F3: Ampl. is 0.1 to 2.0 ‰, mean: (0.68 +/- 0.48) ‰, median 0.60‰!
- For the paper channeling ampl. was set to 0.5 ‰ in total: Freq.: (0.005), 0.2, 1.0, 3.0 cm^{-1}; 50% random/ 50% systematic
- (Revised) PROFFIT error estimate is quite realistic
- Channeling is not negligible for HCHO error estimate!
- But large scatter: At some places the ampltude is 4 times the mean!
- F6: Ampl. is 0.3 to 21 ‰, mean: (2.45 +/- 4.50) ‰, median 1.2‰!
- Even larger as compared to InSb filter 3!
- Channeling is not negligible!
- Needs to be reduced at many sites before analysing weak signatures, e.g. of $ClONO_2$, SF_6 …!
- Channeling mostly due to B/S, in part. due to the wedge of the gap!
- In contact with Axel Keens to improve this in the future.

Questions

- Bigger wedge of the gap in between beam splitter and compensator in the future!?

  To be discussed with Axel Keens and Gregor Surawicz, Bruker Opt.
- Implementation of channeling (error) in SFIT-4 error estimate planned?
- Documentation: Publication, for example in AMT?
- Your questions?

Thank you for attention and participation!