“A practical and pragmatic approach for detection of PFAS on skis.”

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A FIS and IBU project together with the industrial partner Bruker

Cross-Country Ski Jumping Nordic Combined Alpine Skiing
Ski Cross Free ski Park & Pipe Snowboard Cross
Snowboard Park & Pipe Alpine Snowboard Para Alpine
Para Nordic Para Snowboard Speed Skiing Grass Skiing Telemark
Masters

International Biathlon Union

Decision taken in 2019 by FIS and IBU to ban “Fluor” fully implemented for the season 2023-2024

ICR- International Competition Rules

222.8

Use of fluorinated wax or tuning products containing fluorine is prohibited for all FIS disciplines and levels. Fluorinated wax can be a competitive advantage and its use in competition will result in disqualification. (see competition rules and equipment specifications.)

Background to the decision taken in late 2019 by FIS and IBU to ban “Fluor”

After discussion mainly in Norway, Sweden and USA about health issues among the ski technicians, and reports about high level of PFAS in their blood plasma.

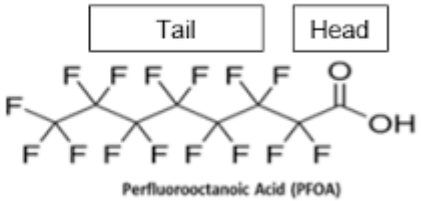
FIS and IBU created then an common expert group to work out all the details. The major work started first in 2021.

This group has developed the complete concept.

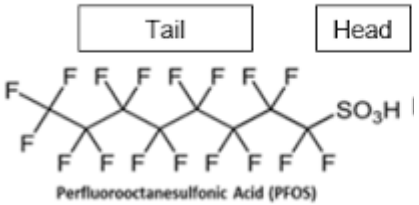
FIS/IBU decided also that the methods should be available for all nations/teams.

Why using Organic Fluor in Skiwax?

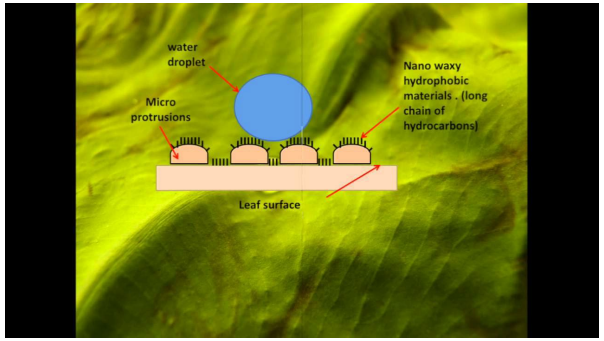
Fluorinated hydrocarbons create an extrem water and dirt repelant surface

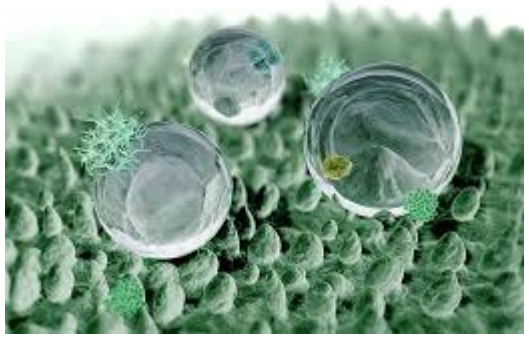


Perfluorooctanoic Acid (PFOA)

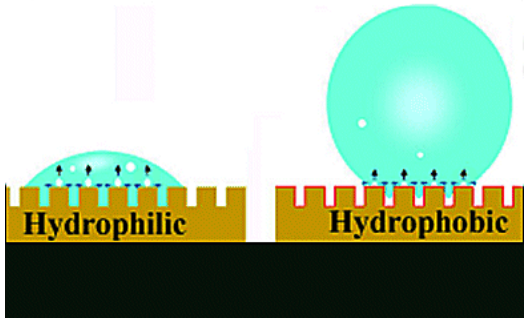


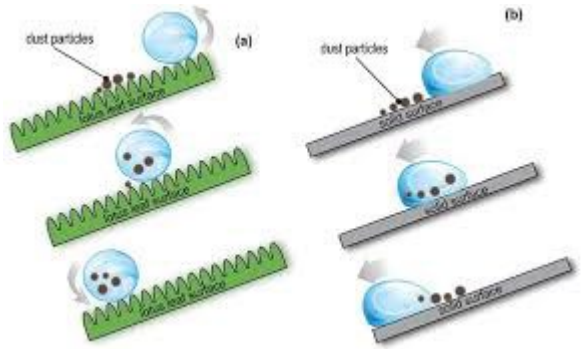
Perfluorooctanesulfonic Acid (PFOS)





The Lotus effect



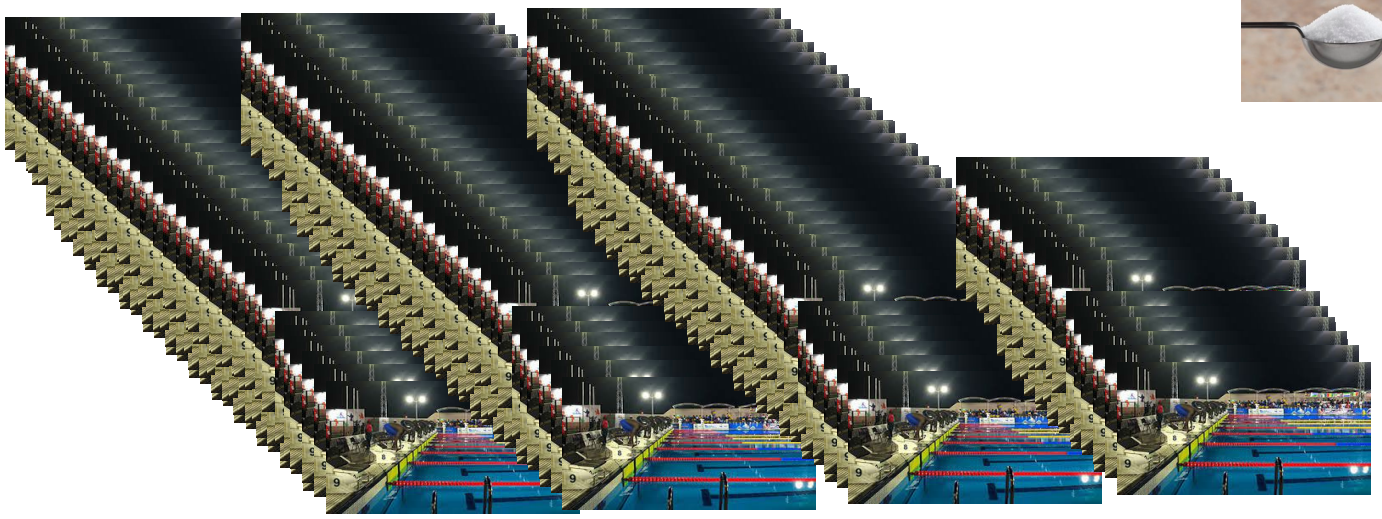


Experience indicate that using “fluor waxes” gave a 4-10% time advantage, i.e on a 5 km race 30-80 sec competitive advantage.

A concentration of more than 1% fluorinated substance in the wax has shown to give the competitive advantage.

Guidelines for drinking water quality, WHO

Hg	0,000 001	g/l
Cu	0,002	g/l
Pb	0,000 010	g/l
DDT	0,000 001	g/l
As	0,000 010	g/l
Cd	0.000 003	g/l
U	0,000 030	g/l
Dioxane	0,000 050	g/l
PFAS	0,000 000 004	g/l



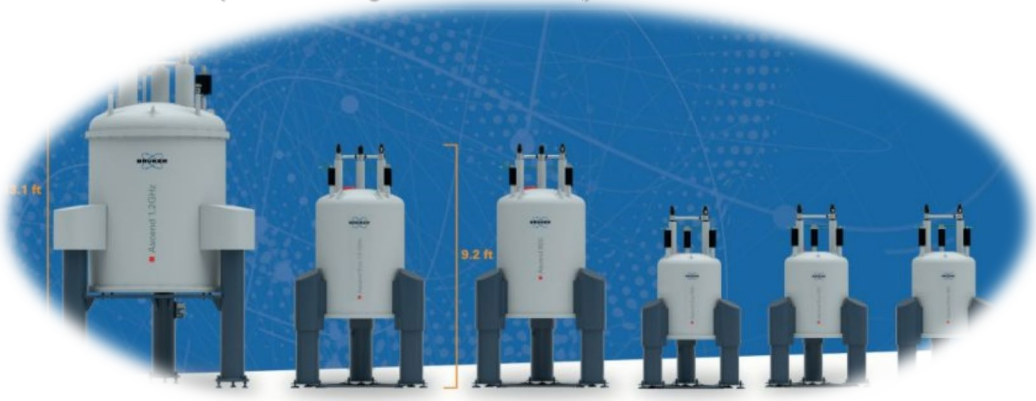
i.e. 4 g (a heaped tea spoon) PFAS per 333 Olympic-sized swimming pools

How to detect/measure fluorinated waxes?

XRF *(X-RayFluorescense)*

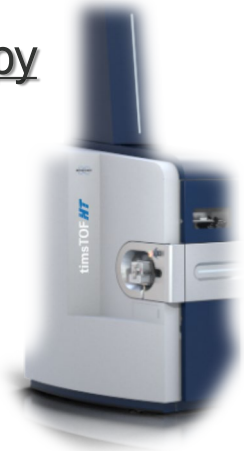
Fluorescence

NMR *(Nuclear Magnetic Resonance)*



Mass spectroscopy

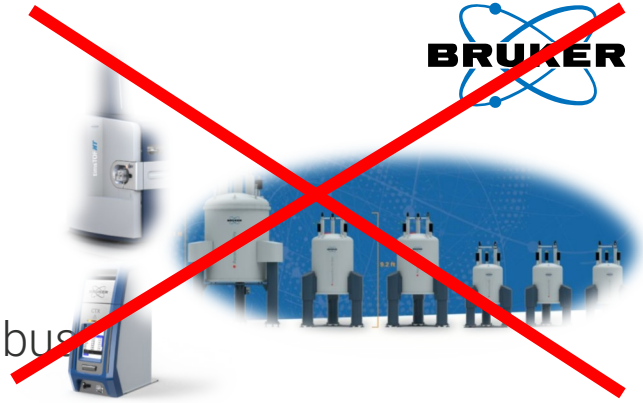
ICP-MS, LC-MS



Raman

FTIR *(Fourier Transformed Infra Red)*

What type of requirements from FIS/IBU are we faced with?



- Outdoors examination, sometimes in tent => none lab conditions, weather robust
- On site at the venues, easy transport between sites
- Operated by non-experts
- None contact, none disruptive method.
- Fast measurement, preferred 10 sec per ski, able to measure 100 skis before a competition
- Specific, Reliable and accurate
- Low cost (7 k€) purchase and maintenance

As a chemist

- The regulation state fluorinated products and with a total ban it equals to a zero limit also for other fluorine compounds than PFAS.
- All the above requirements, compromised requirements has to be used

What other type of challenge, in addition to the technical issues, can be expected?

What turned out to be the solution for this problem

FTIR set for contact less reflection measurements

Case to protect the instrument from weather conditions

Sliding system so the instrument can be moved along the ski as well as holding the ski during measurement

Computer to control the instrument Equipped with a dedicated calibration model constructed within this project

A detailed Standard Operational Procedure to ensure correct evaluation performed by none-expert operators

Facts about IR spectroscopy

IR light absorption due to changes in rotational and vibrational energy in molecule

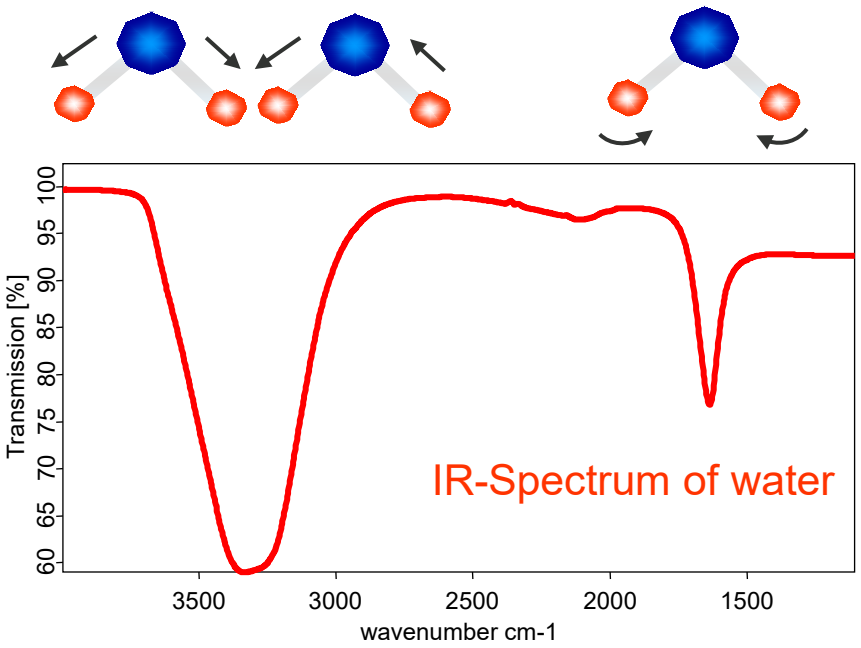
It provides identification and quantification information

No two chemical species exhibit the same spectrum, like a molecular finger-print

The components in a mixture can be identified

Sensitivity is, only on the low to medium range > 0.1%

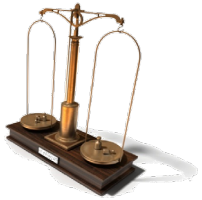
It is an indirect method, a calibration model is needed for quantitative measurements

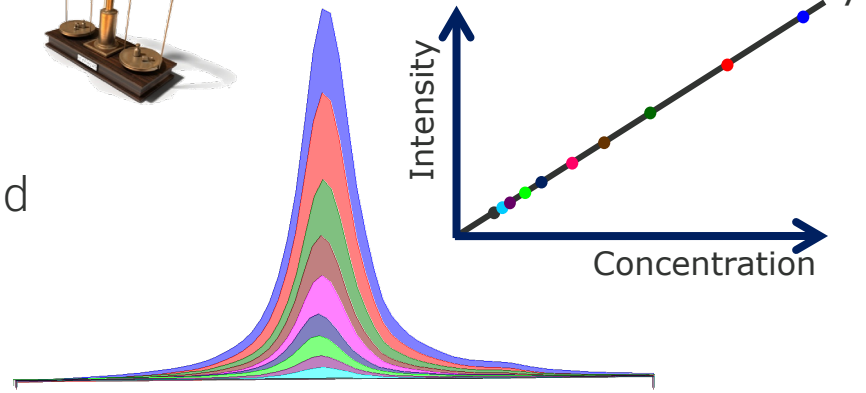


Typical applications of FT-IR

- Pharmaceutical research and QC
- Forensic investigations
- Polymer analysis
- Lubricant formulation and fuel additives
- Foods research
- Quality assurance and control
- Environmental and water quality analysis methods
- Archeology and cultural heritage
- Biochemical and biomedical research
- Coatings and surfactants, e.g bromide flame retardants
- .....

Facts about calibration





A quantitative calibration model is normally valid for one specific sample matrix. Here we have many different types of ski bases and ski waxes

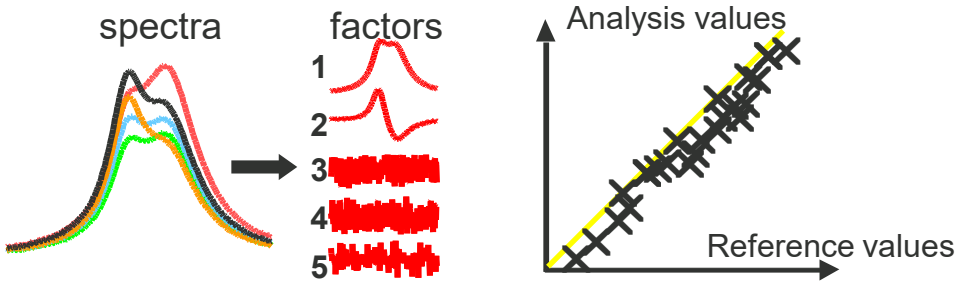
Traditional approach to data analysis is univariate

The world around us is multivariate.

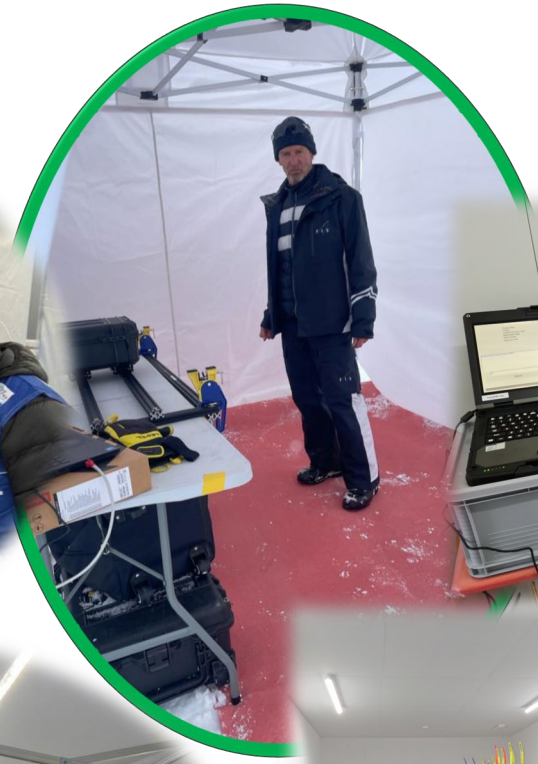
Considering one variable at a time neglects correlation.

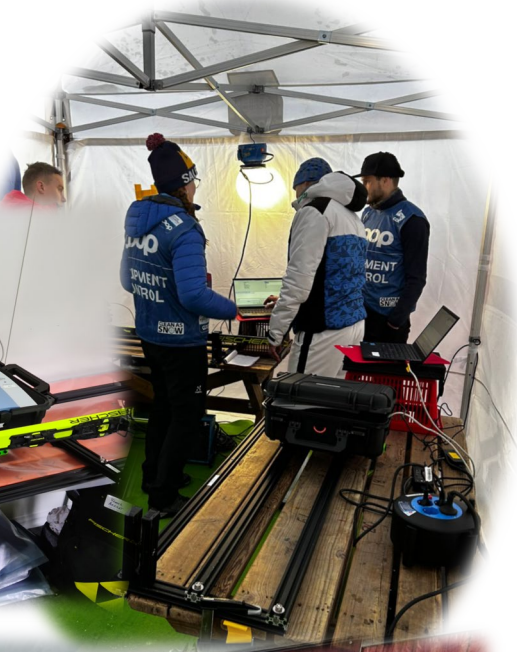
The multivariate advantage:

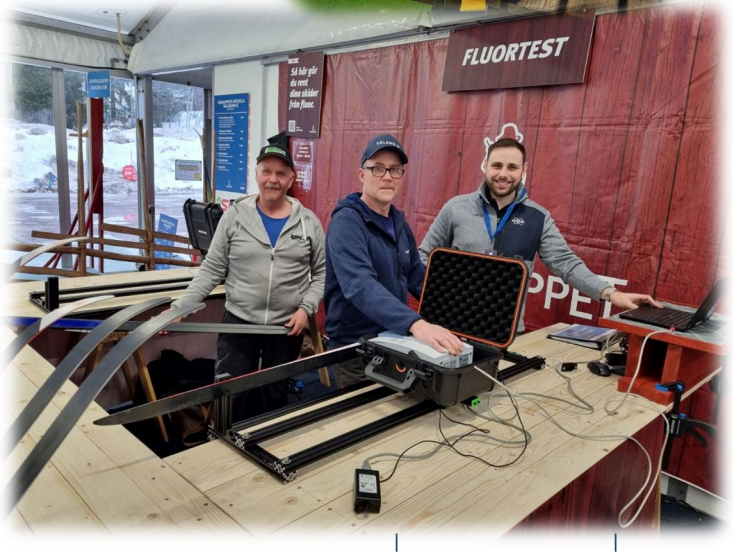
More information, in the form of correlation, is available when many variables are considered simultaneously.



Practically, how is this solved, and the logistic behind it







Results from the 2023/2024 season

First official testing, Great Slalom in Sölden-Aut by end of October 2023.
All skis was measured directly after the race

1 person was Disqualified, had used old technical equipment to apply the wax which contaminated the ski

Later during the season, at all Biathlon World Cup (WC) events and many of the FIS events on WC level tests were performed.
Approximate 100 000 spots on skis have been tested and more than 50 athletes were found with to high values of PFAS, mostly claimed to be due to “dirty” tools or old “dirty” skis.

During Vasaloppet, there were test stations open for the public during the week.

Thank you!

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