Bentley FTS: A new high potential method for the rapid determination of milk chemical composition in cow, sheep and goat milk

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Bentley Instruments

- Founded in 1983
- Headquarters: Chaska, Minnesota (USA)
- Present in + 40 countries
- 75 employees
- Over 1200 instruments installed worldwide
- # 80% of DHIA samples in USA analyzed on Bentley Combi systems
- Market: Dairy industry, exclusively
- 7 Subsidiaries in Europe + distributors
- All Instruments compliant with IDF/ICAR requirements

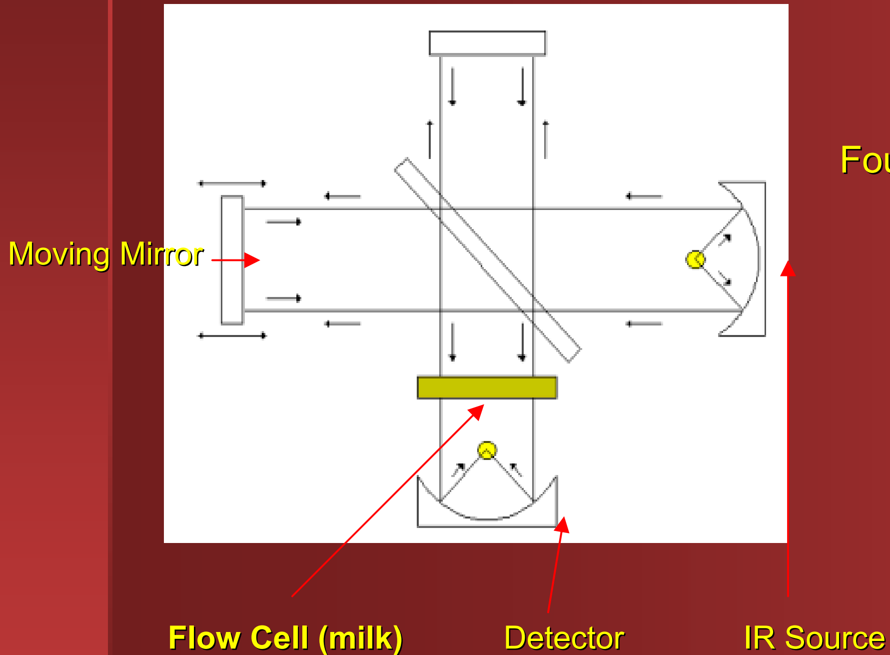
Overview

- FT-MIR Technology Principle & Benefits
- Application of FT-MIR to Milk Testing:
- - Traditional components (CECALAIT Evaluation)
  - New components (e.g. Fatty Acids Profile)
- Qualitative Analysis (spectral database development)
- On-going & Future developments
- Conclusion

FT-MIR Technology Principle

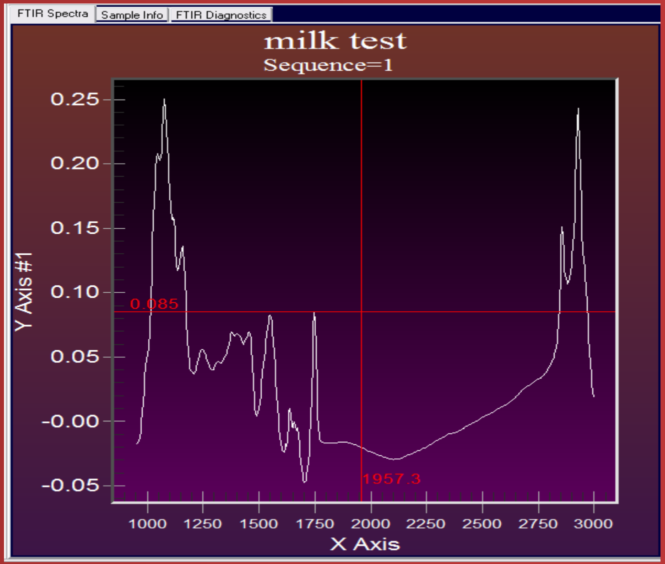
(Fourier Transform Mid Infrared)

INTERFEROMETER



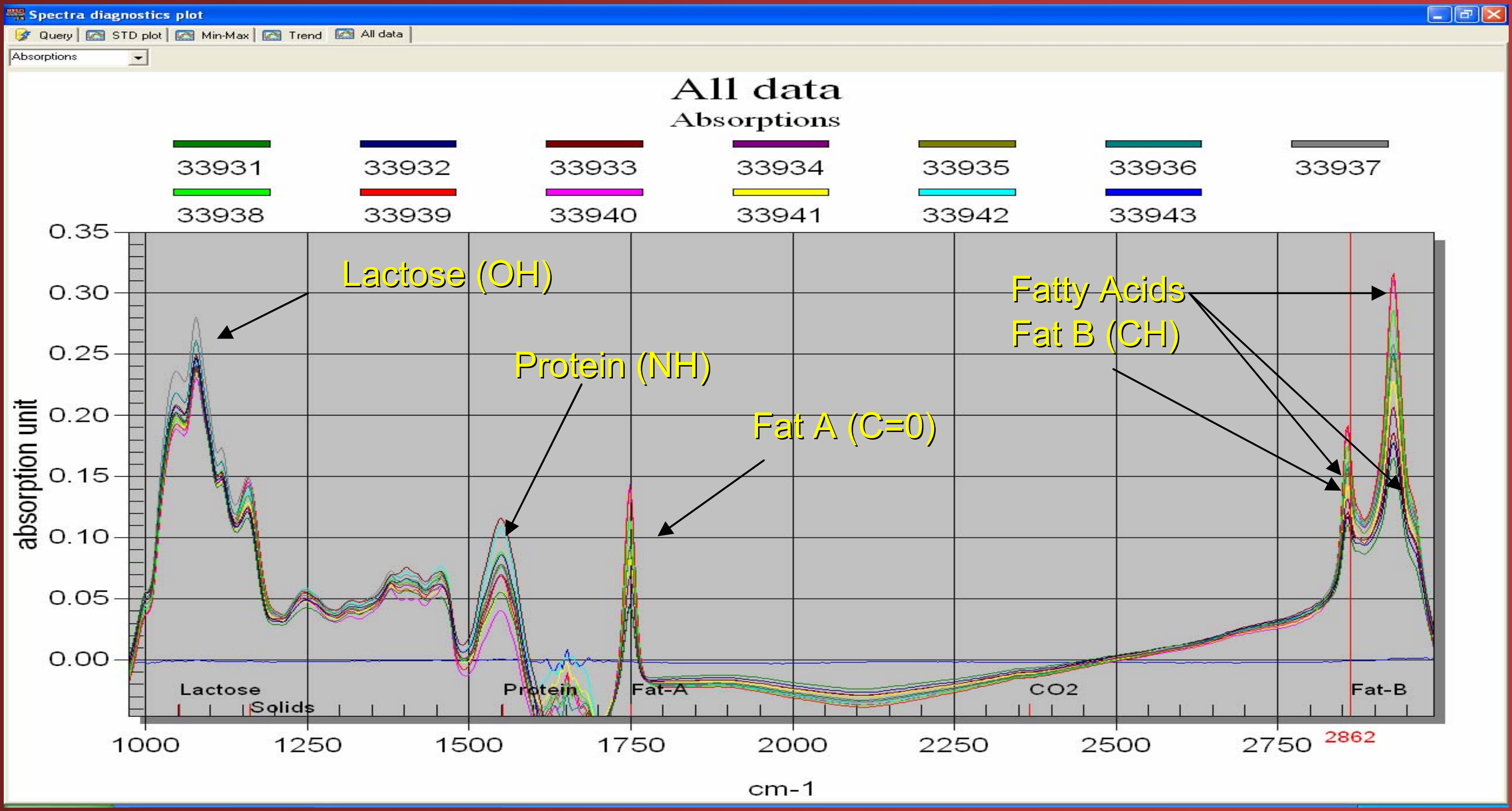
Fourier Transform

MILK SPECTRUM



Bentley FTS

Milk Components Absorption wavebands



Frequency of infrared radiation absorbed depending upon type of molecular bonds /vibration mode

FTIR Applications

BENTLEY INSTRUMENTS

- FTIR technology used for the rapid determination of milk chemical composition since 1990 (Aegis/Anadis) but scope limited to basic components for many years

- Traditional Applications:
  - Fat , Protein, Lactose
  - Solids/ Solids Non Fat
  - MUN/Citric Acid
  - FPD (screening)

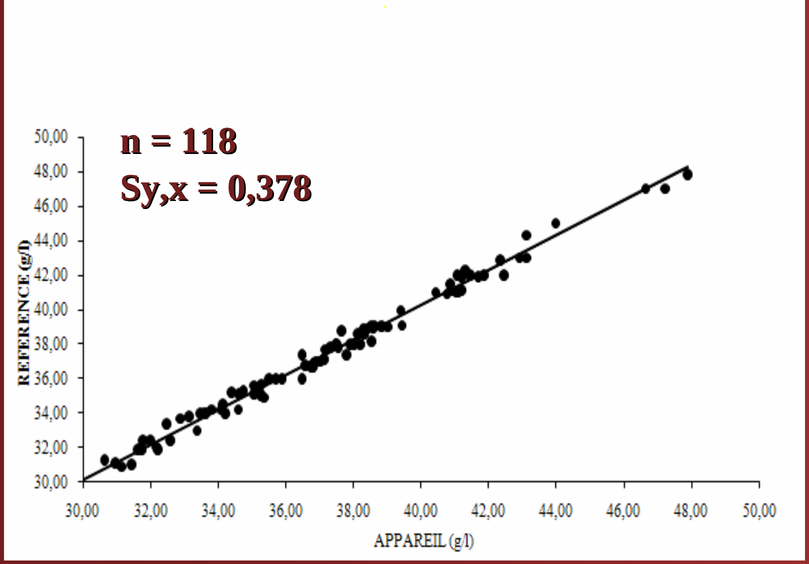
- Scope recently extended with new applications :
  - pH, FFA, Fatty Acids profile, ketone bodies (acetone, BHB)
  - Screening for potential adulteration (melamine…)
  - Qualitative analysis

Bentley FTS Accuracy
CECALAIT EVALUATION

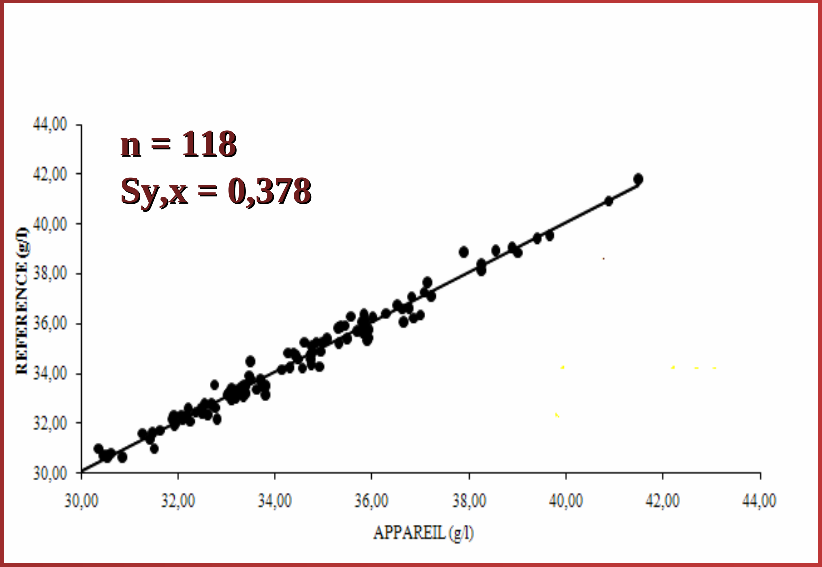
(cow, sheep and goat milk)

INDIVIDUAL COW MILK SAMPLES

FAT



PROTEIN



FTS ACCURACY RESULTS MEET ISO 9622/FIL 141 C: 2000/ICAR REQUIREMENTS ON COW, SHEEP AND GOAT MILK

New Applications
e.g. Milk Fatty Acids Profile (R-COOH)

Why testing for Fatty Acids?

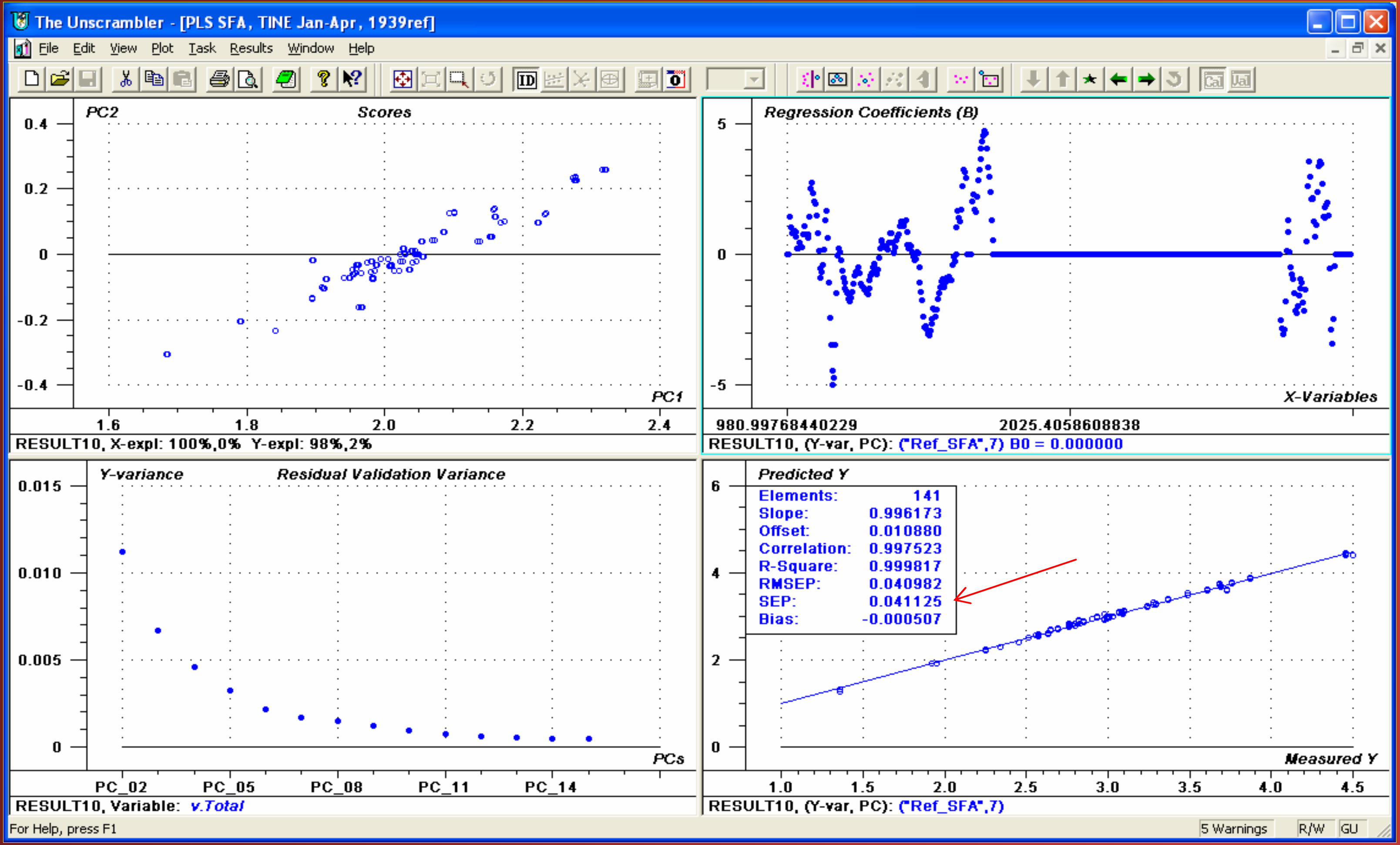
1) Improve milk fatty acid profile by optimizing the cows feeding or through genetic selection

2) Rewards the best fatty acid composition by introducing it as a payment parameter

3) Produce healthier milk with lower amount of saturated fat to meet consumers demands

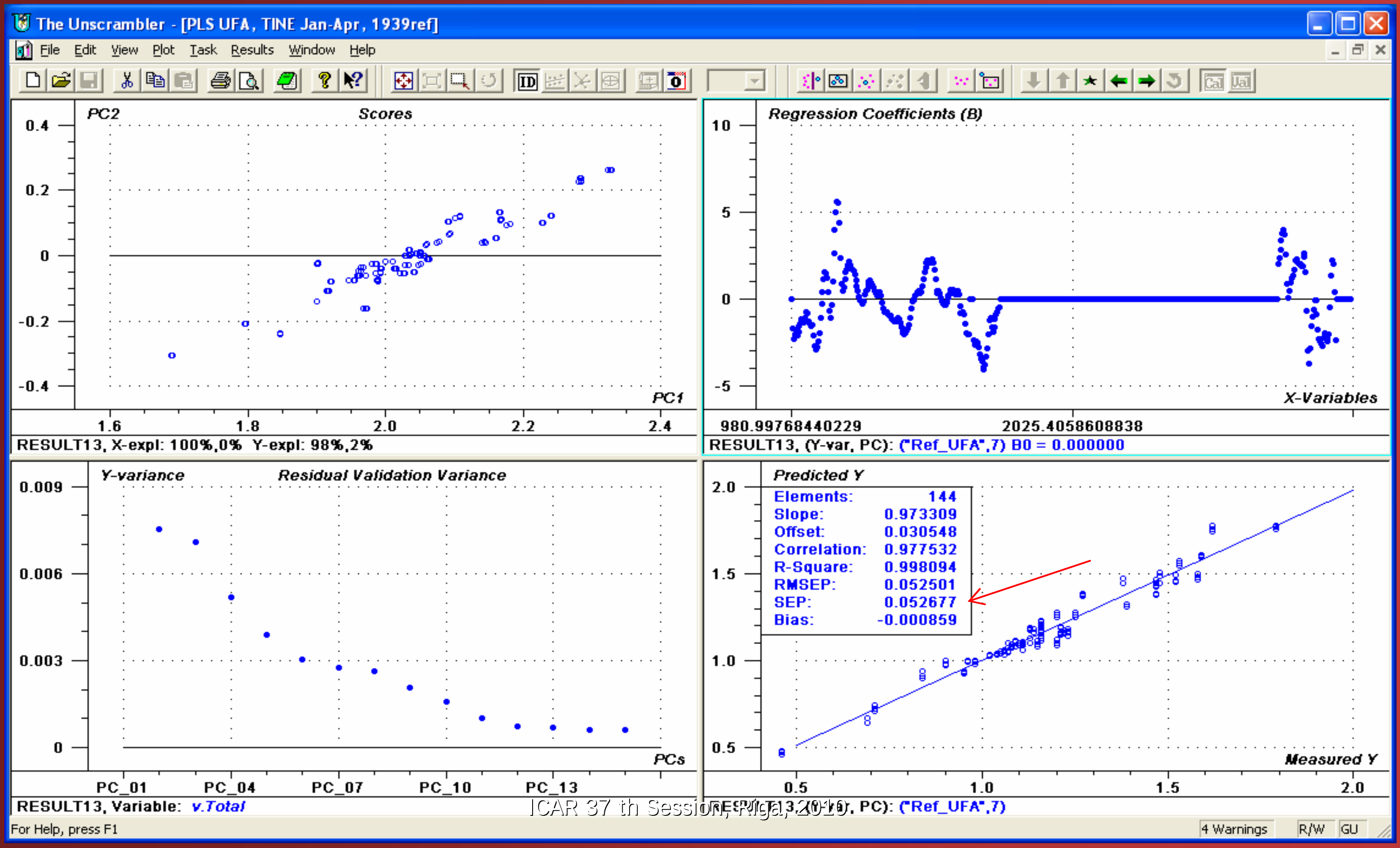
Milk Fatty Acids Profile

Saturated FA (cow milk/141 spectra)



Milk Fatty Acids Profile

Unsaturated FA (cow milk/144 spectra)



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Milk Fatty Acids Profile

COMPONENTS	n	SECV	SECV (%)	R^2	Sr	r	Y	Sy
Monounsaturated FA	48	0.046	4.35	0.998	0.012	0.033	1.057	0.226
Polyunsaturated FA	47	0.015	12.12	0.986	0.001	0.002	0.122	0.034
Saturated FA	48	0.041	1.39	1.000	0.012	0.033	2.955	0.597
Unsaturated FA	48	0.053	4.50	0.998	0.015	0.043	1.177	0.249
C16	48	0.060	4.63	0.998	0.017	0.049	1.287	0.292
C18:0	48	0.036	7.83	0.994	0.010	0.028	0.460	0.098
C18:1	48	0.049	5.11	0.997	0.016	0.044	0.958	0.205

N: number of samples
SECV: Standard Error of Cross validation
SECV%: relative Standard Error of Cross validation
Sr: Standard deviation of repeatability
Y: Mean value of the population
Sy: Standard deviation of the population

Also involved with PHENOFINLAIT and AGRAMIR research programs in France

Quantitative vs Qualitative Analysis

Limits of Quantitative Analysis :

- requires to know the target components to be measured
- requires to collect representative calibration samples and classical reference values

Advantages of the Qualitative Analysis (spectral database):

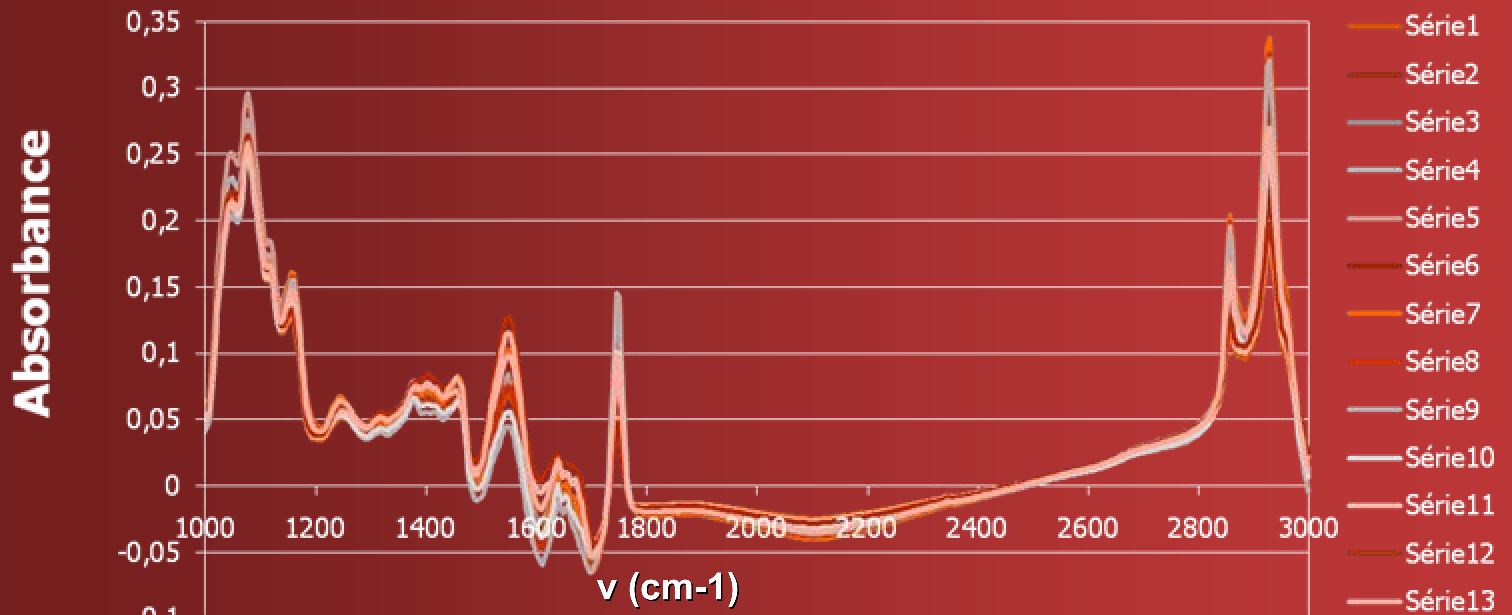
- No classical reference values required
- No need initially to know the target components/contaminants
- but requires developing a spectral database of "normal/target" samples

Qualitative Analysis can be used :

→ to detect abnormal samples
→ to detect adulterated samples (melamine…)
→ to improve calibration robustness (on-going calibration)

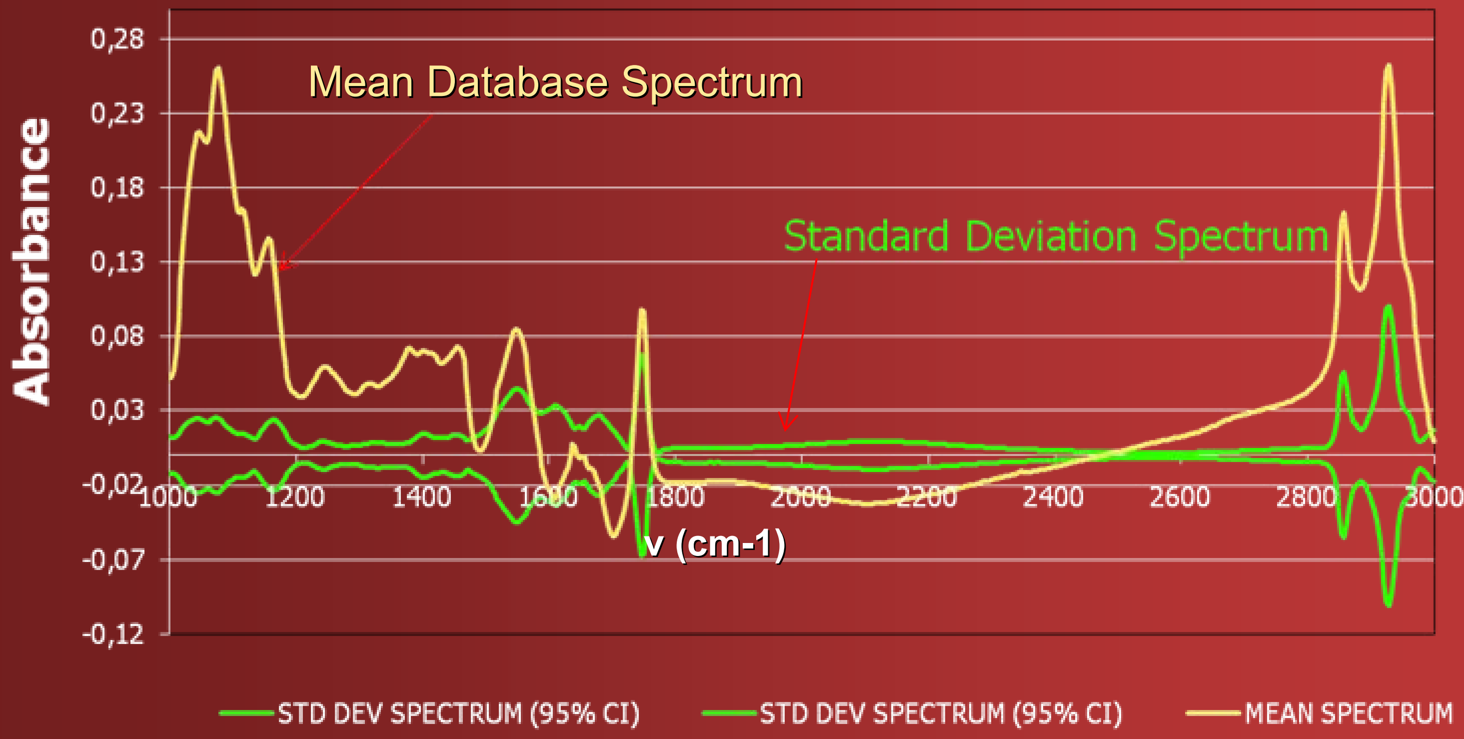
HOW TO DEVELOP A SPECTRAL DATABASE?

STEP1: SPECTRA COLLECTION OF « NORMAL /TARGET » SAMPLES



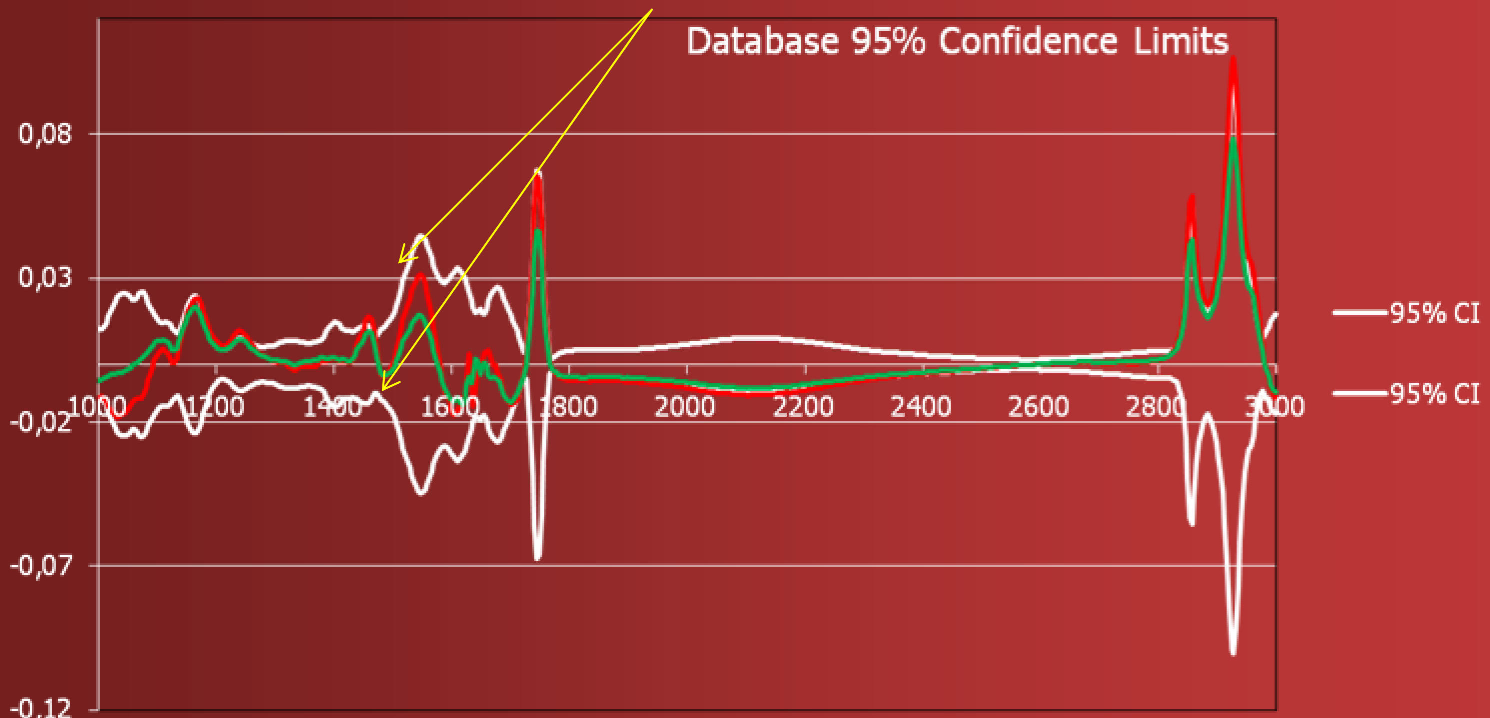
HOW TO DEVELOP A SPECTRAL DATABASE?

STEP2: CALCULATE DATABASE MEAN AND STANDARD DEVIATION SPECTRUM

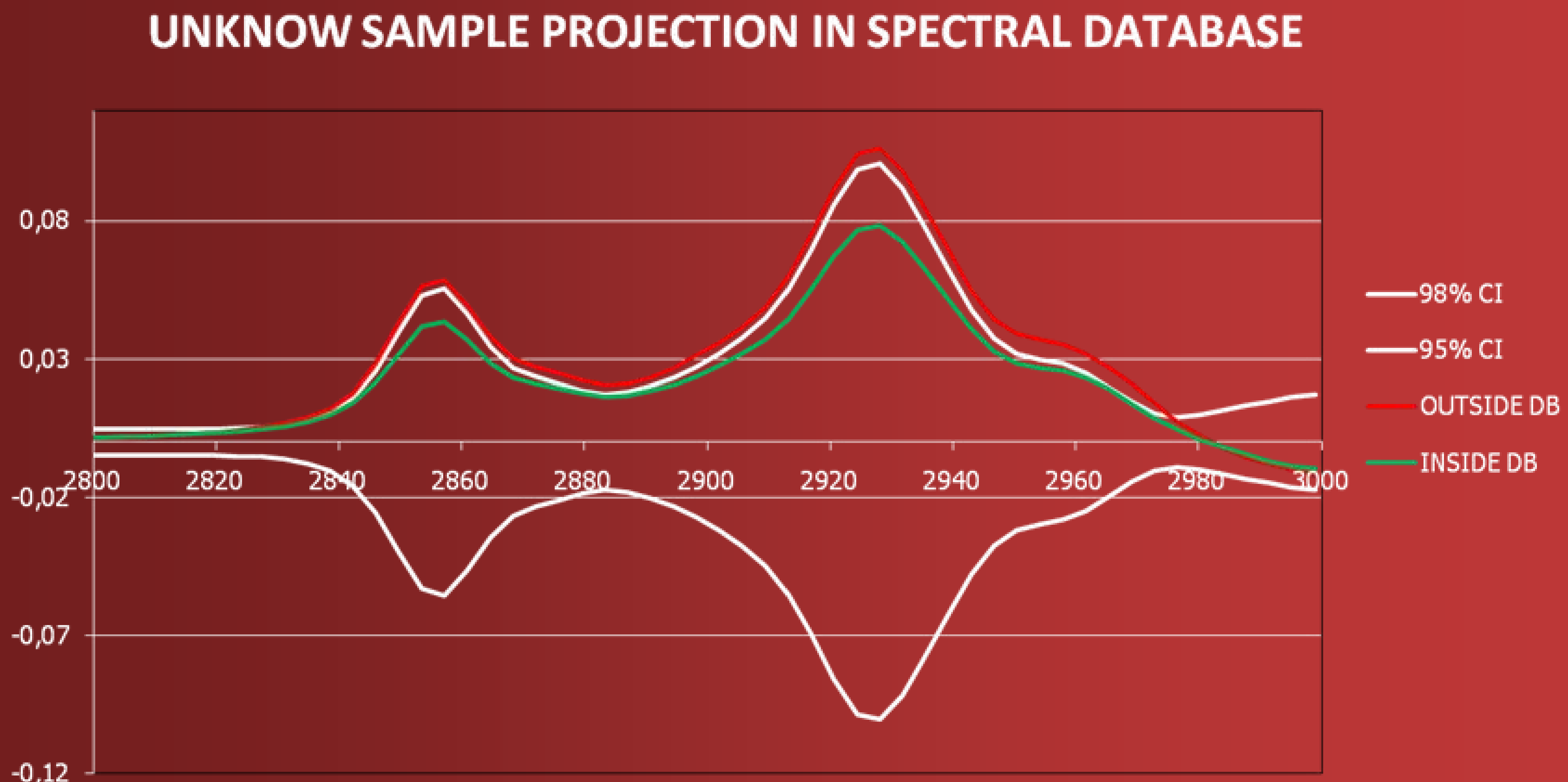


DETECTION OF ABNORMAL/ADULTERATED SAMPLES

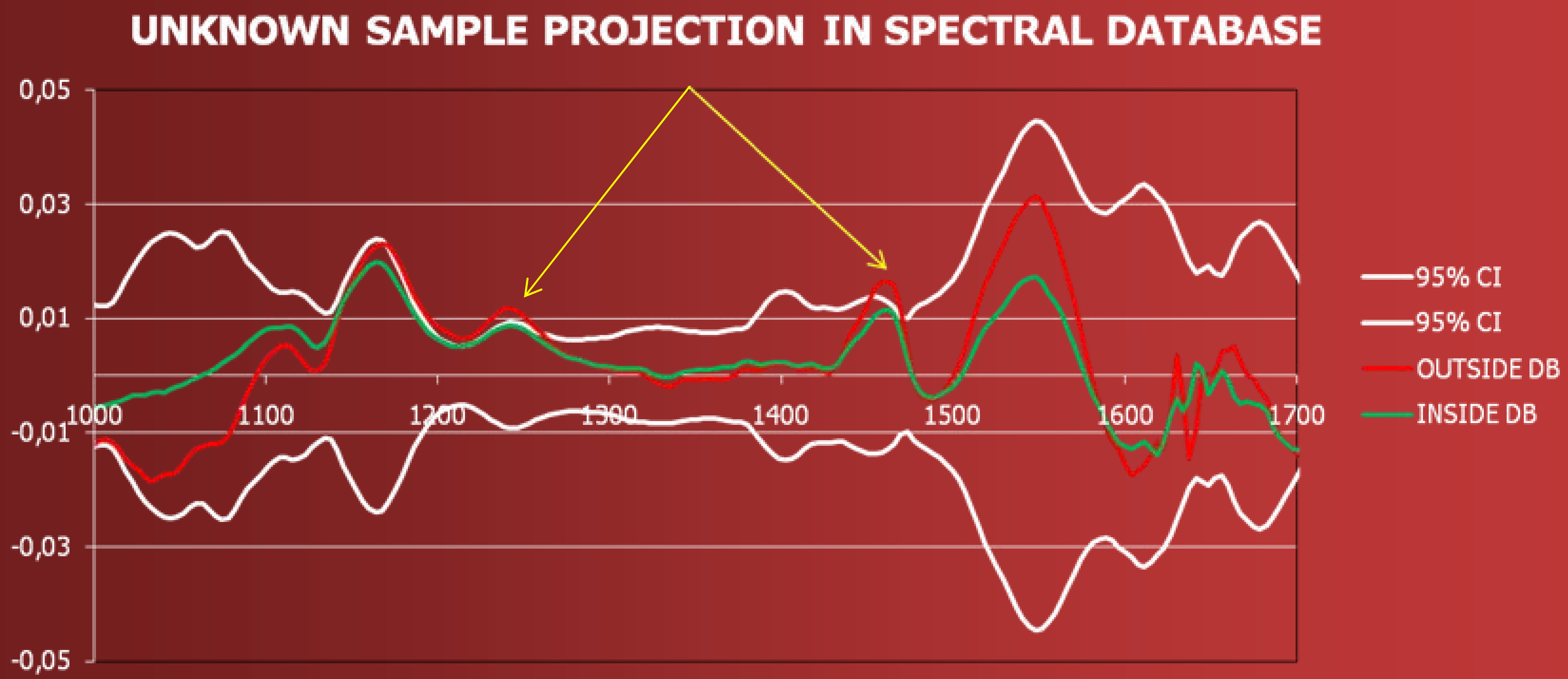
STEP3: PROJECTION OF NEW/UNKNOWN SAMPLES IN SPECTRAL DATABASE



DETECTION OF ABNORMAL/ADULTERATED SAMPLES



DETECTION OF ABNORMAL/ADULTERATED SAMPLES
Samples Conformity Assessment (%)



How is it implemented on the FTS?

OPEN PLATFORM:

1) Spectrum for each sample saved in local database

2) Spectra can be exported automatically together with the results on the laboratory network

3) Development of a local spectral database on « normal/target » samples

4) Spectra outside confidence limits can be detected automatically

5) Use of a spectral database to identify potential contaminants

Challenges

■ FTIR technology not sensitive enough at low concentration levels. Not possible to detect trace adulteration or contamination

(e.g. Melamine LOD 75-100 ppm)

→Trade-off between speed and detection limit

■ Need to define/select carefully the “normal” samples used to develop the spectral database.

→Development/update of a local spectral database

Bentley FTS
On-going & Future Developments

1) New calibrations/applications

- Quantitative (Fatty acids, FFA, Ketones bodies….)
- Qualitative (fingerprint)
- Automatic calibration selection (best fit)

2) Rapid determination of milk adulteration

- by contaminants
- by milk from different animal species

3) Detection of abnormal samples:

- Outside the calibration range
- Outside laboratory «normal » spectral database

Conclusions

- FTS is a powerful and rapid tool for the determination of milk chemical composition

- FTS can be used to detect accidental and economic milk adulteration

THANK YOU

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