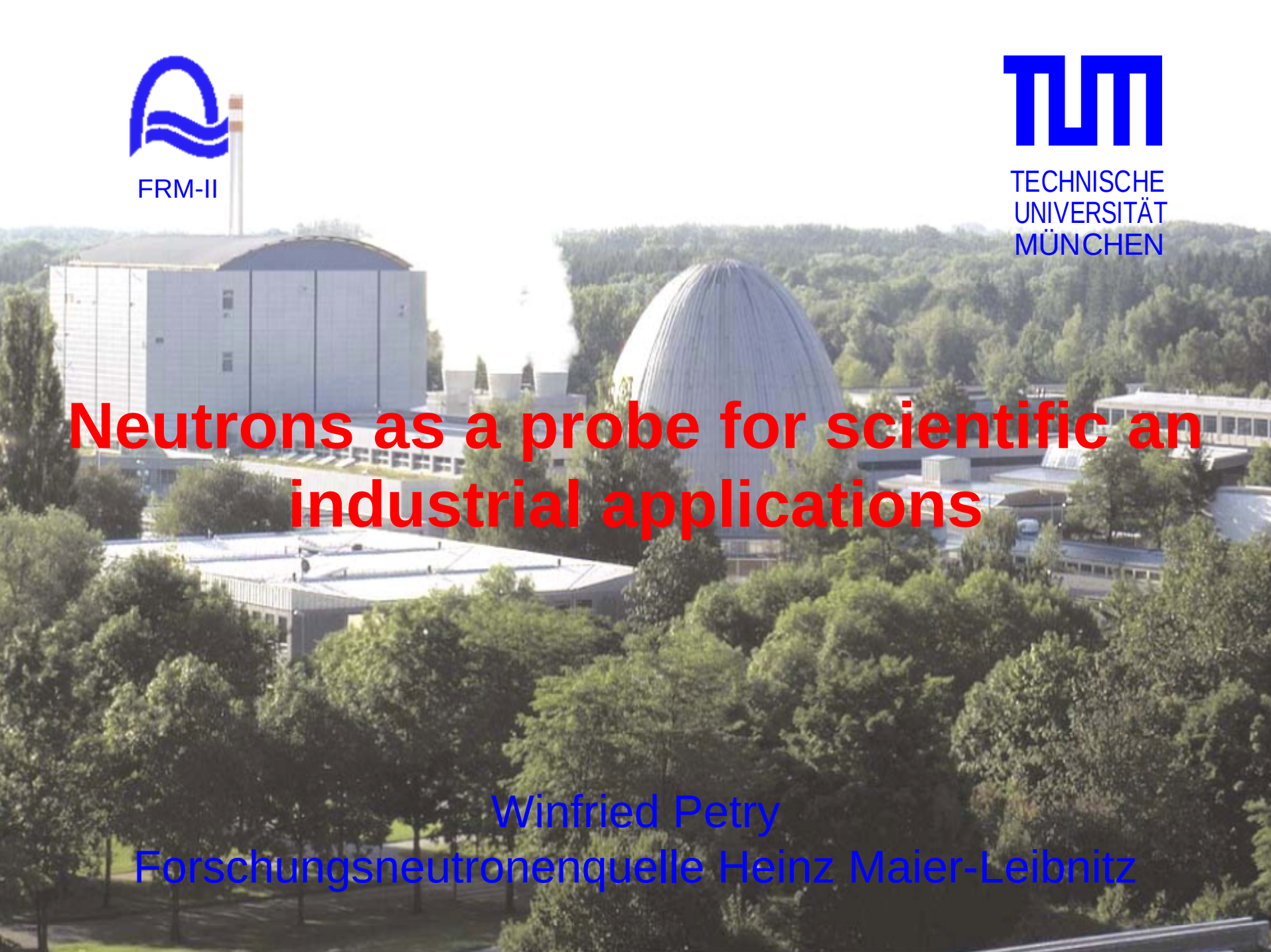


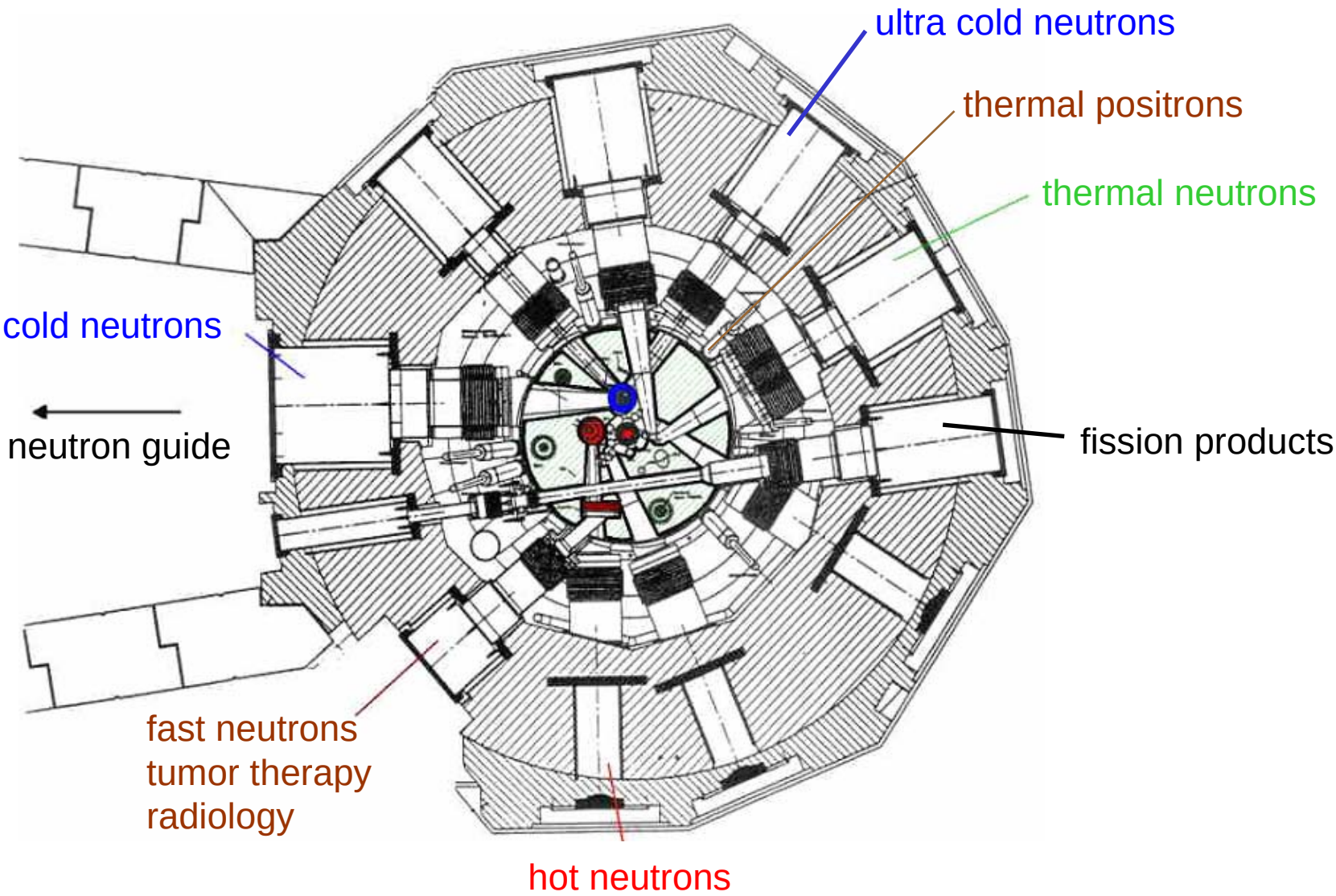
FRM-II

TECHNISCHE UNIVERSITÄT MÜNCHEN

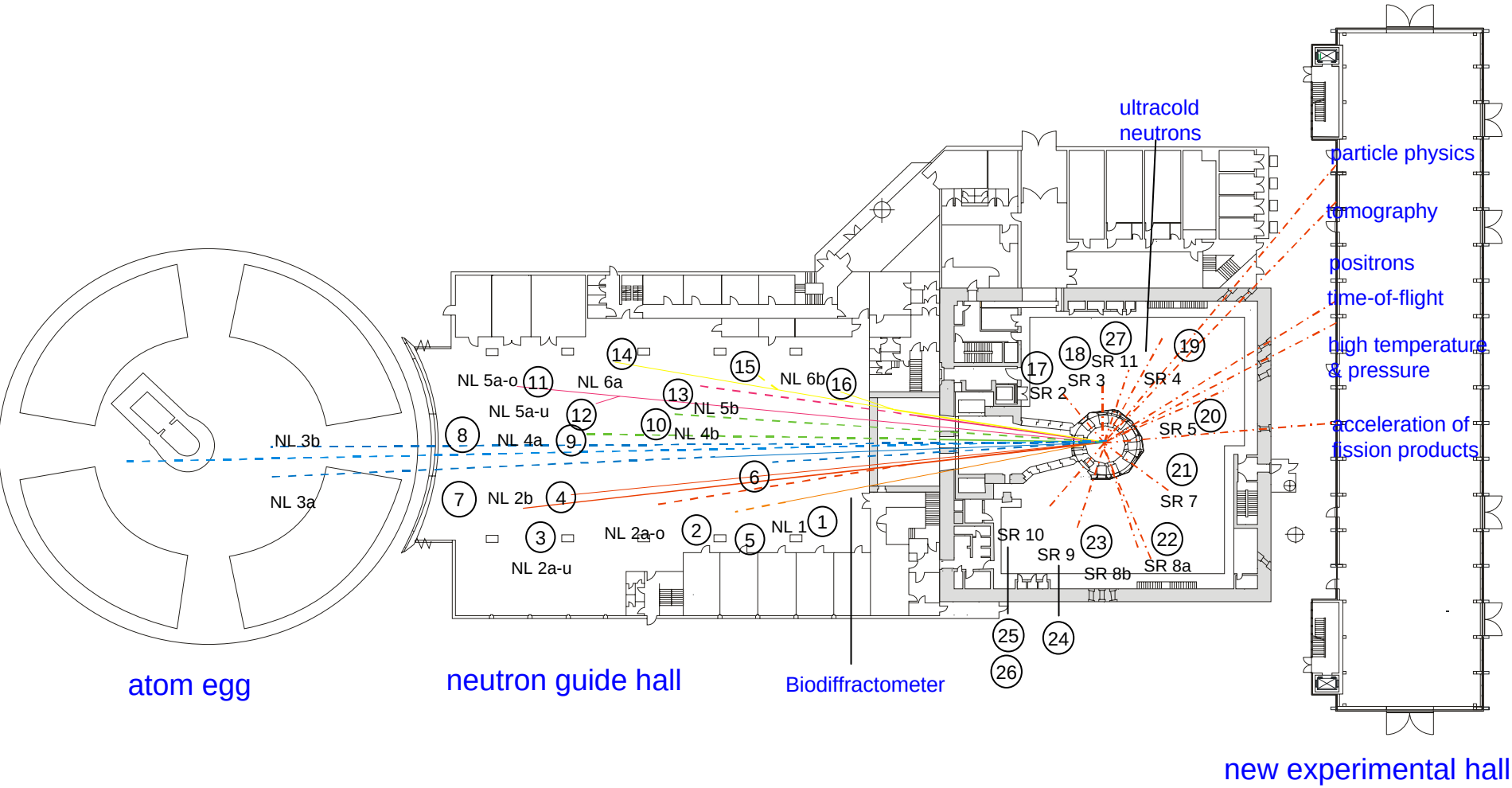
Neutrons as a probe for scientific an industrial applications

Winfried Petry
Forschungsneutronenquelle Heinz Maier-Leibnitz

Cut through the reactor containment



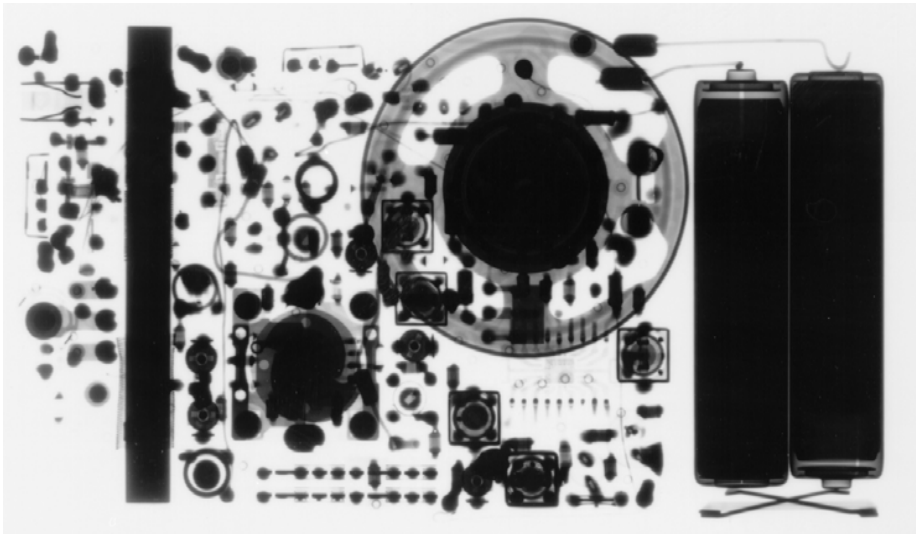
Current and future instruments at FRM II



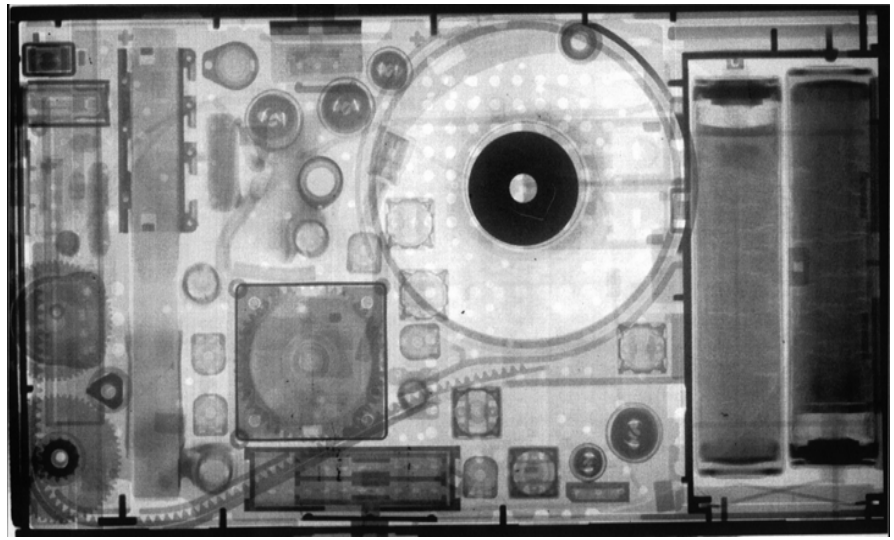
Instruments:

1. n-REX+	5. Mephisto	9. SANS-1	13. MARIA	17. PANDA	21. PUMA	25. MEDAPP
2. NSE	6. KWS-3	10. PGAA	14. SPHERE	18. STRESS-SPEC	22. SPODI	26. NECTAR
3. TOF TOF	7. KWS-2	11. RESEDA	15. DNS	19. ANTARES	23. RESI	27. NEPOMUC
4. REFSANS	8. KWS-1	12. NOSPEC	16. MIRA	20. TRISP	24. HEIDI	

Radiography, comparison between X-rays and neutrons



X-ray



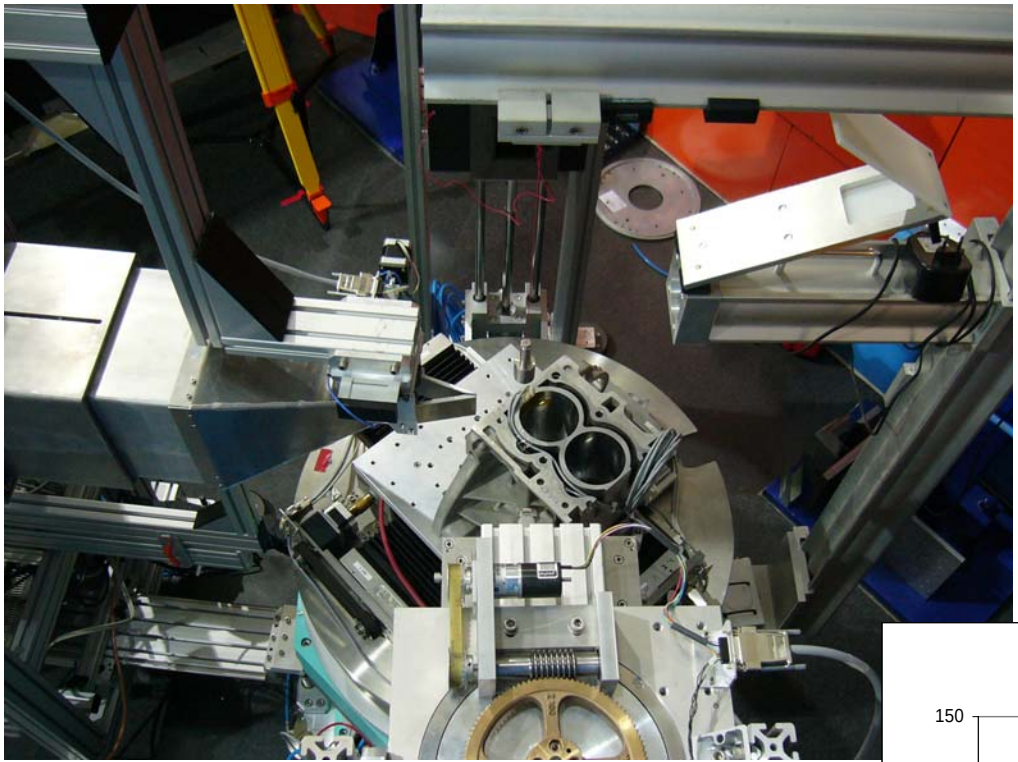
neutron

example: mini-transistor-radio

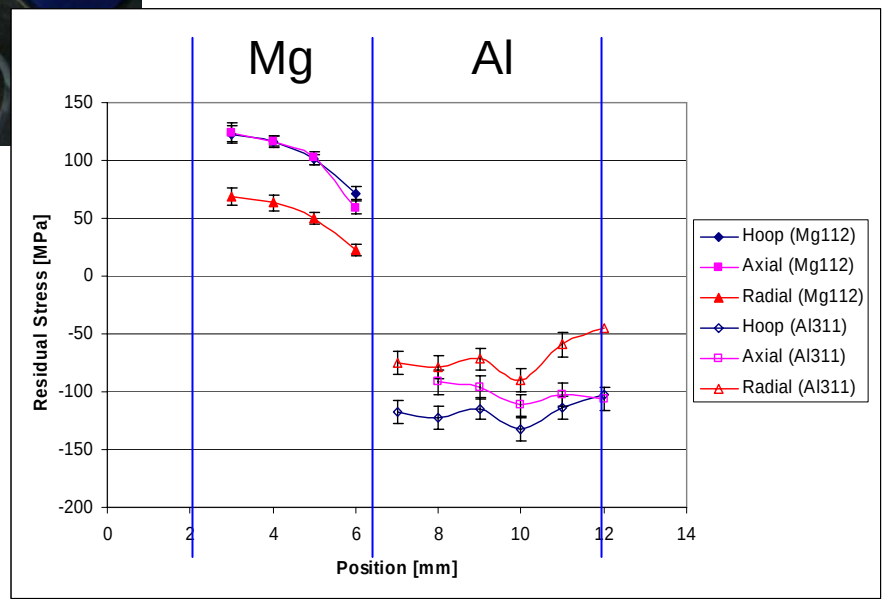
Radiography and tomography with thermal and fast neutrons

- penetrates bulk material
- contrast variation from isotope to isotope
- privileged contrast for hydrogen containing material
- contrast variation by using
  - thermal neutrons
  - fast neutrons
  - hard x-rays
  - gamma radiation
- fast processes < 1 μs
- 3-dim. picture by tomography

Residual stress in Mg-Al crank case



Residual stress down profile on light construction material (crank case of Mg/Al-monolithic)



U. Wasmuth, 2005

STRESS-SPEC
Turbokompressor für
Diesel engine

Stress & strain scanning

- penetrates bulk material
- large samples
- small probe volume < 1 mm^3
- stress & strain tensor
- non-destructive

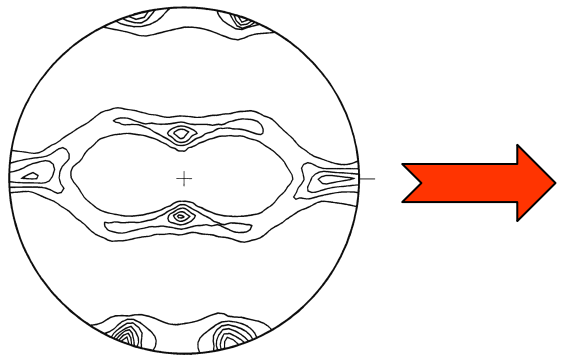
Texture determination

The texture of materials influences the material properties and their anisotropy during plastic flow.

Al-sheet

Al (111) pole figure

Al-can



typical Al – sheet texture after cold rolling

texture dependent deep drawing

HG Brokmeier
TEXMAT

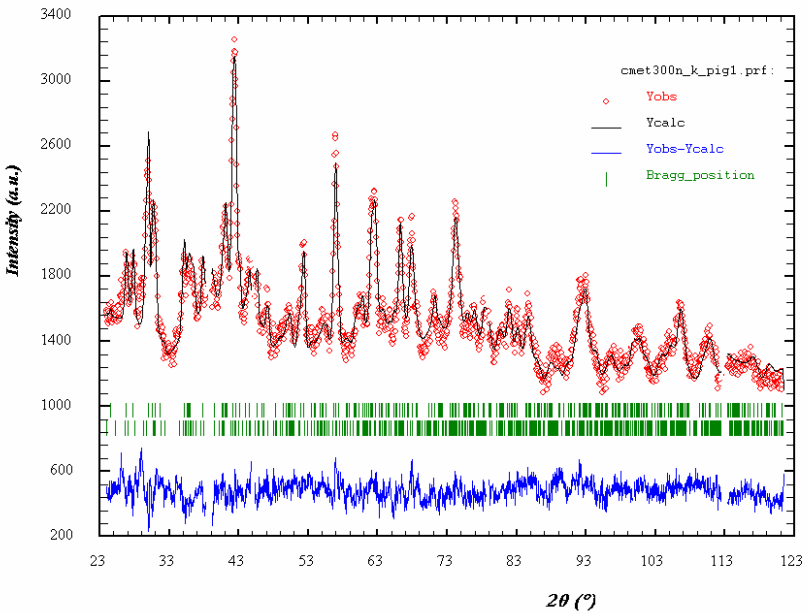
Texture determination

- true powder average

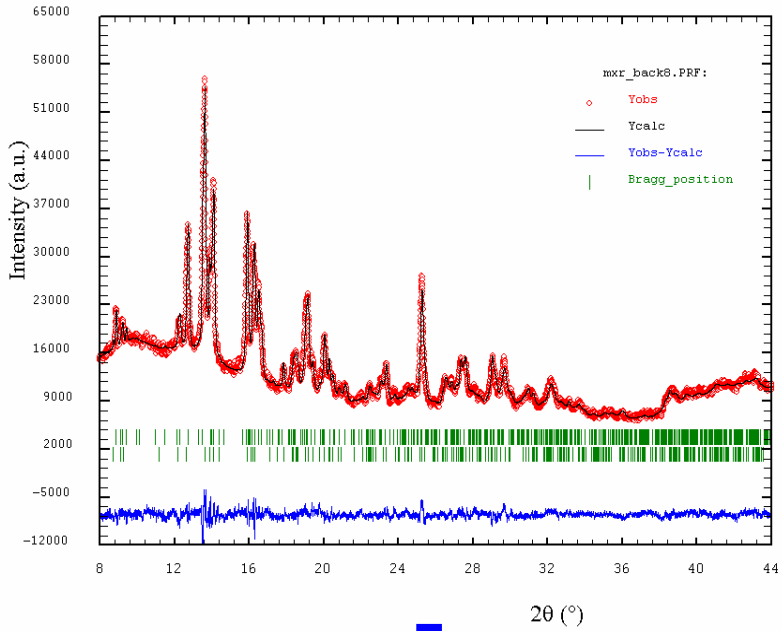
Mars-Meteorite: pyroxenes (Pigeonite + Augite)

only ≈ 100 mg
very similar structures of both phases
broadened reflections

Neutron diffraction at SPODI (FRM-II)
E. Weidner, M. Hoelzel



Synchrotron diffraction at B2 (DESY)
H. Boysen, E. Weidner, M. Knapp



quantitative phase analysis
Fe/Mn cation distribution

could not be analysed due to
missing information at high Q

Large angle diffraction

- structure information
- which kind of segregation
- where are the atoms

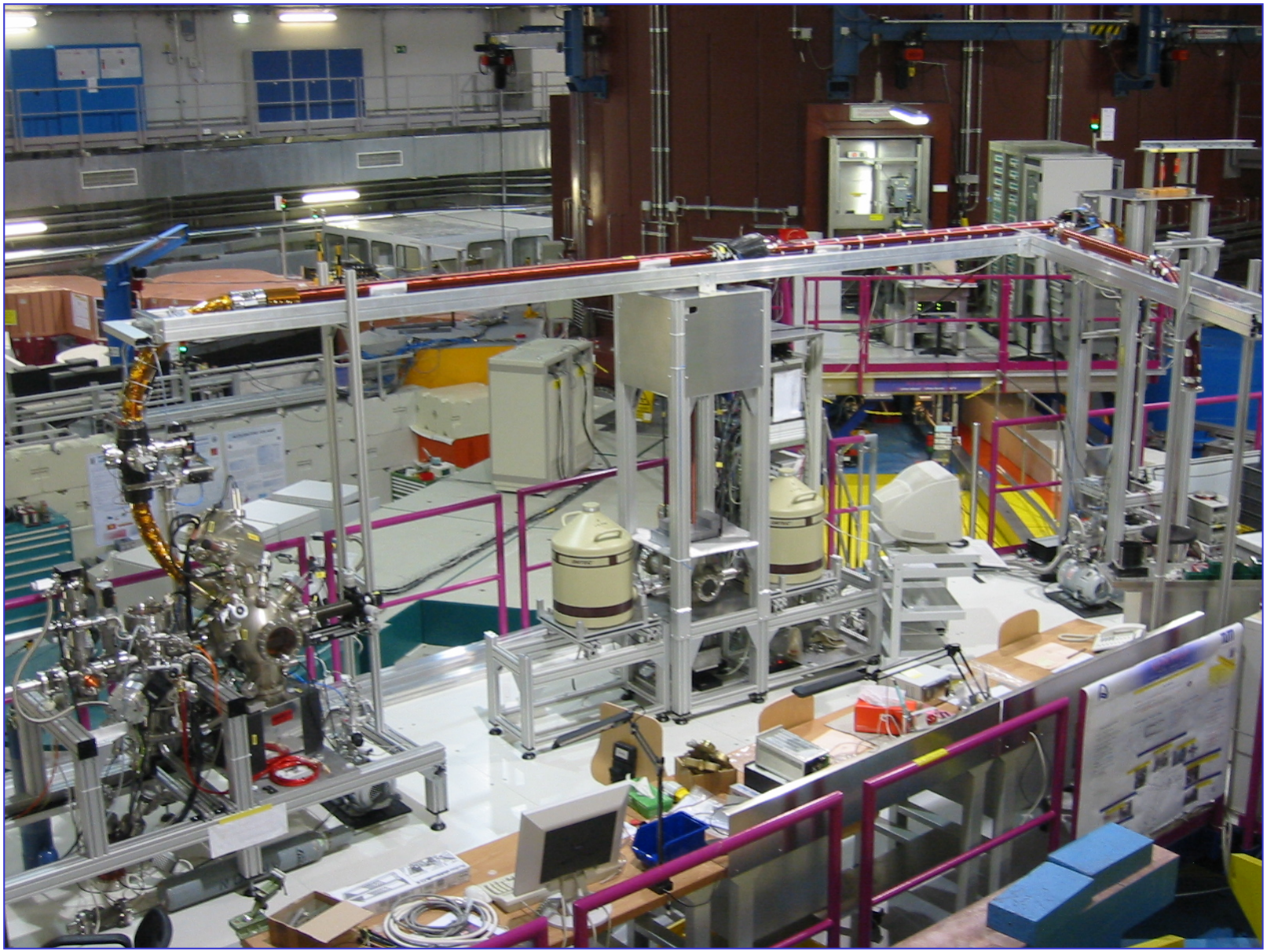
Small angle diffraction

- structure information on nanometer scale
- shape of segregation
- structural correlations on nanometer scale

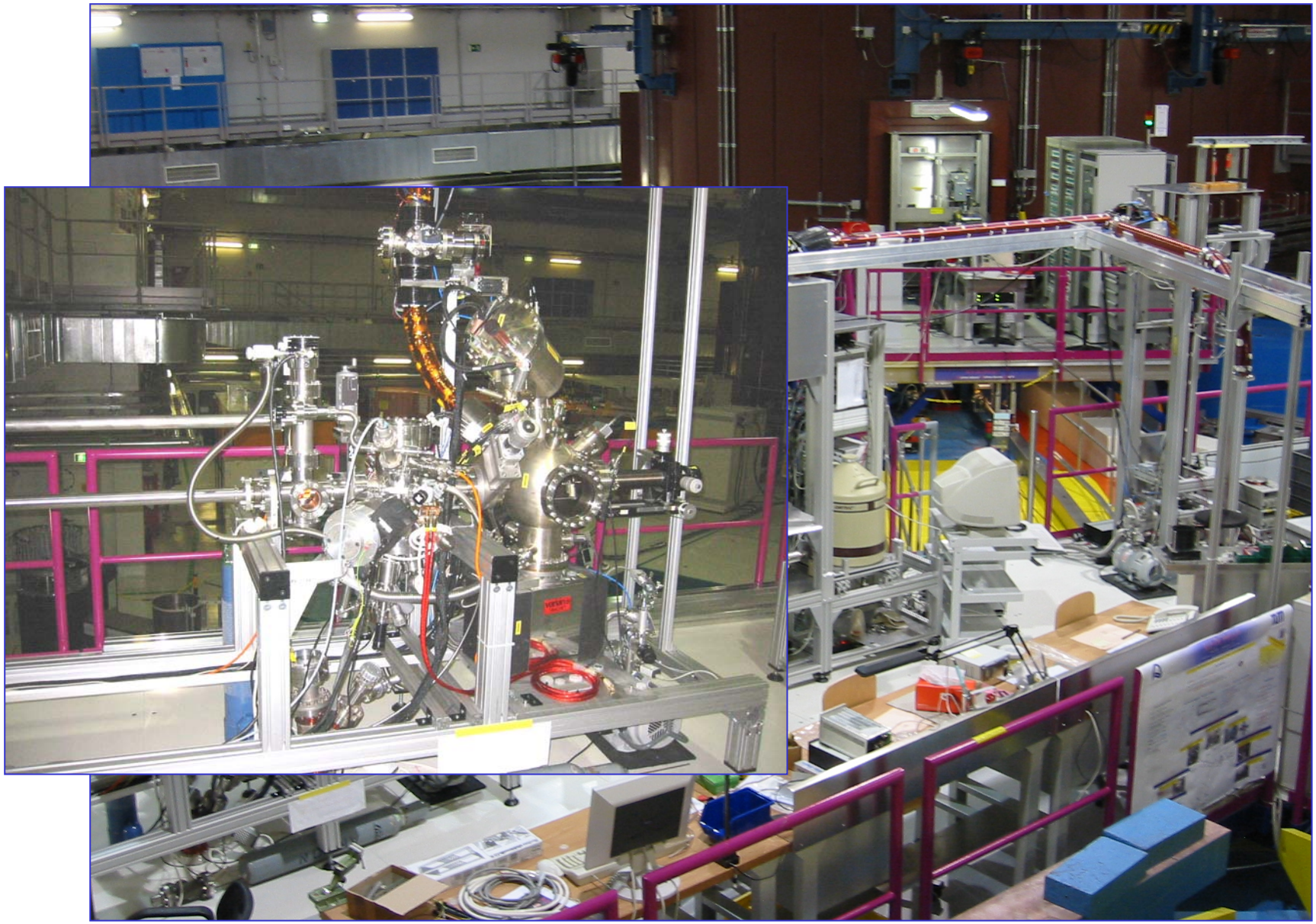
Refectometry

- structure of surfaces
  multilayers
  hidden surfaces

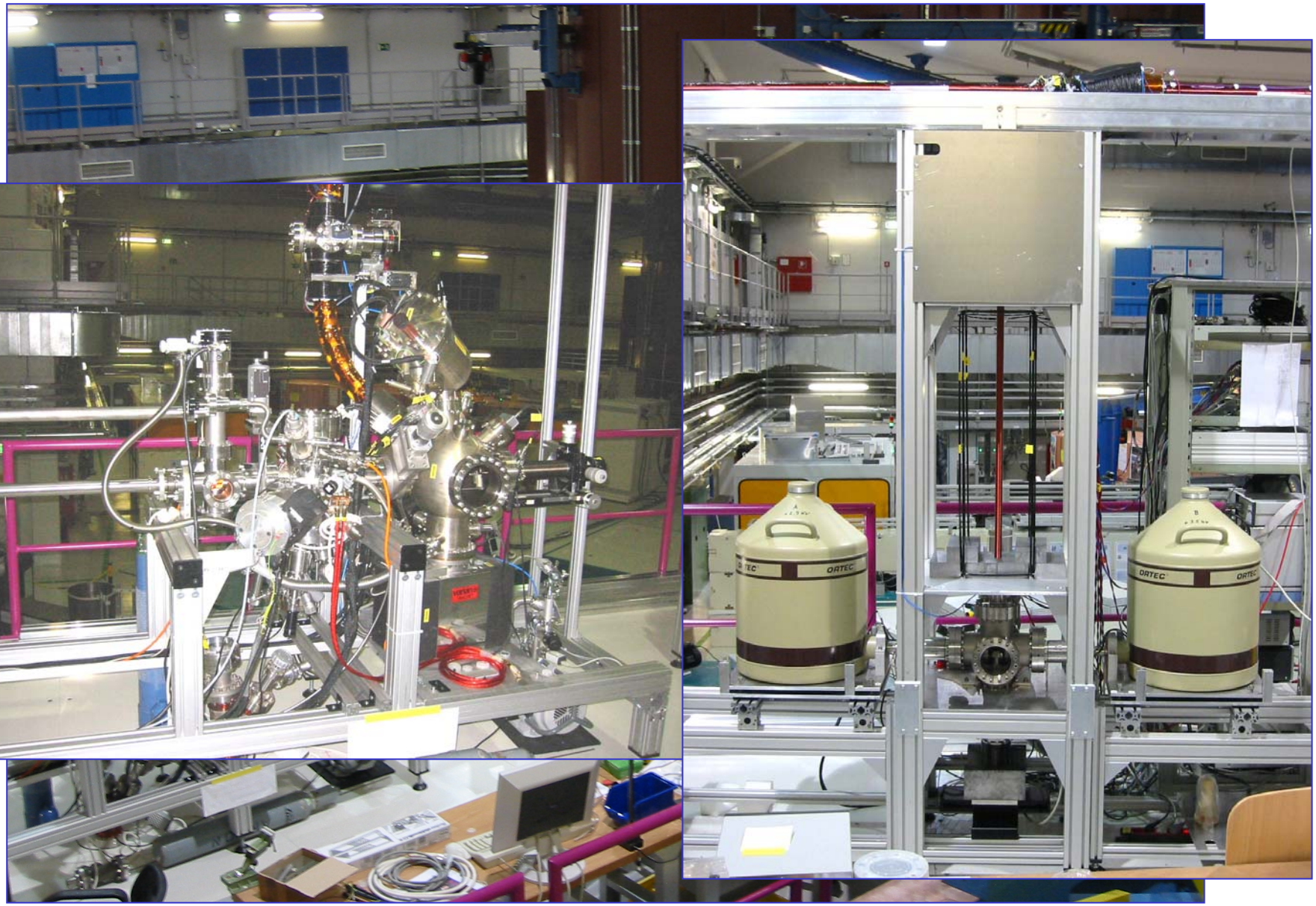
NEPOMUC beamtube and experiments



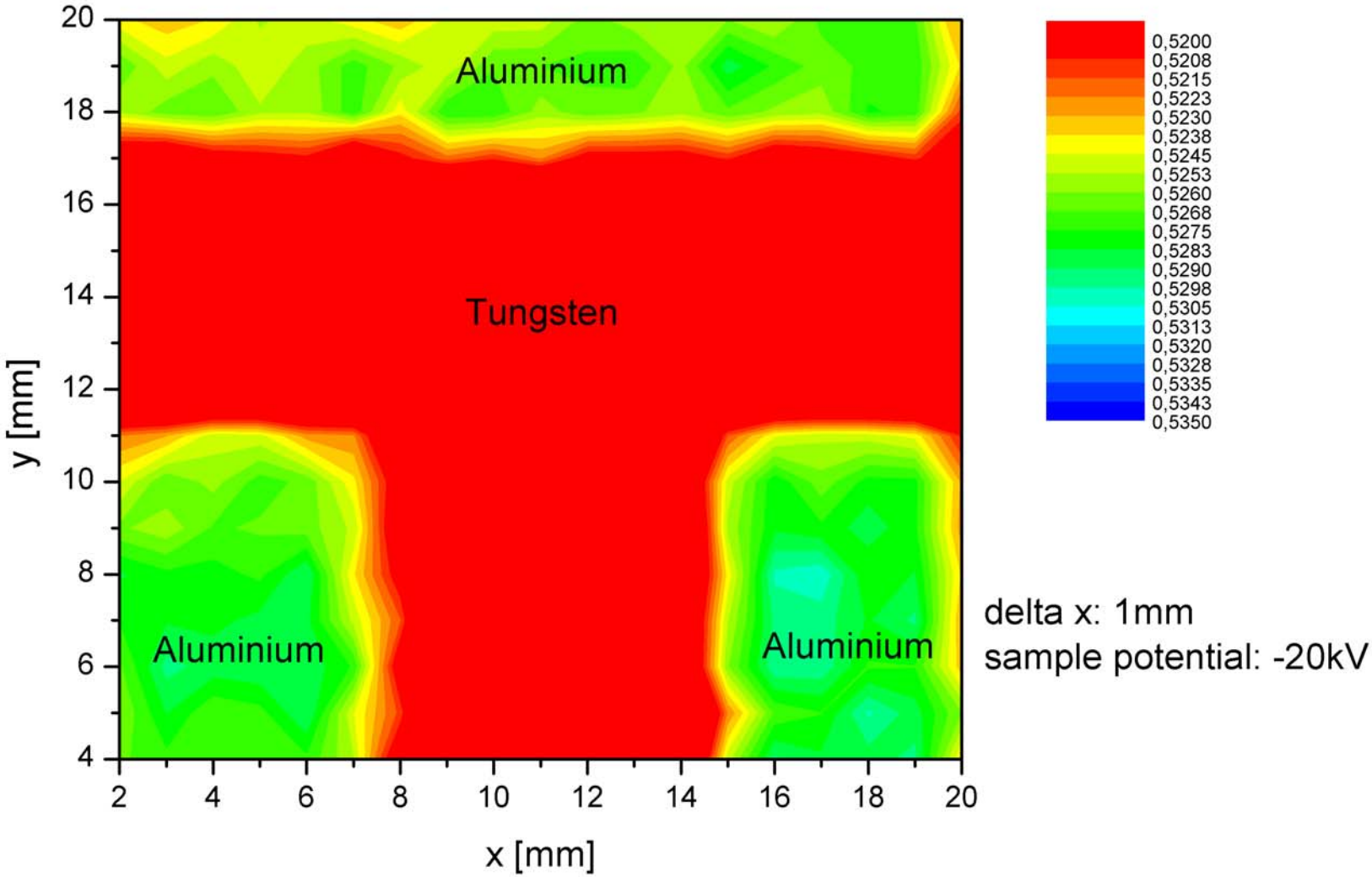
NEPOMUC beamtube and experiments



NEPOMUC beamtube and experiments



Tungsten on Aluminium

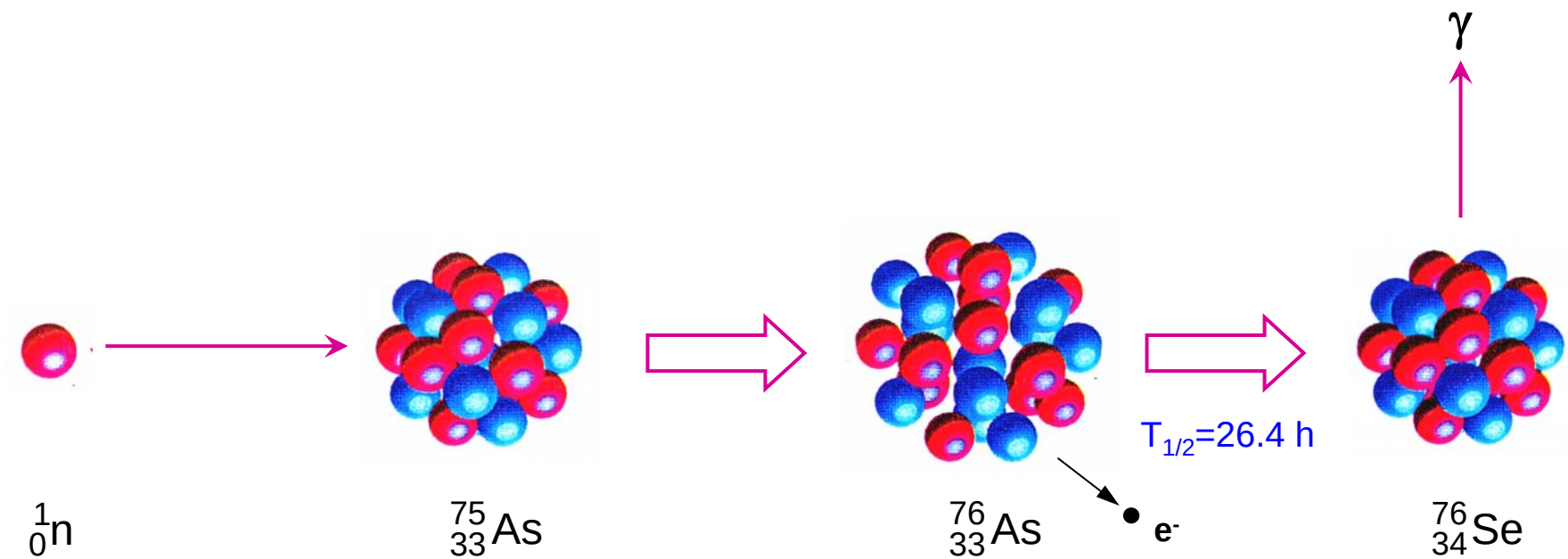


delta x: 1mm
sample potential: -20kV

Thermal positrons

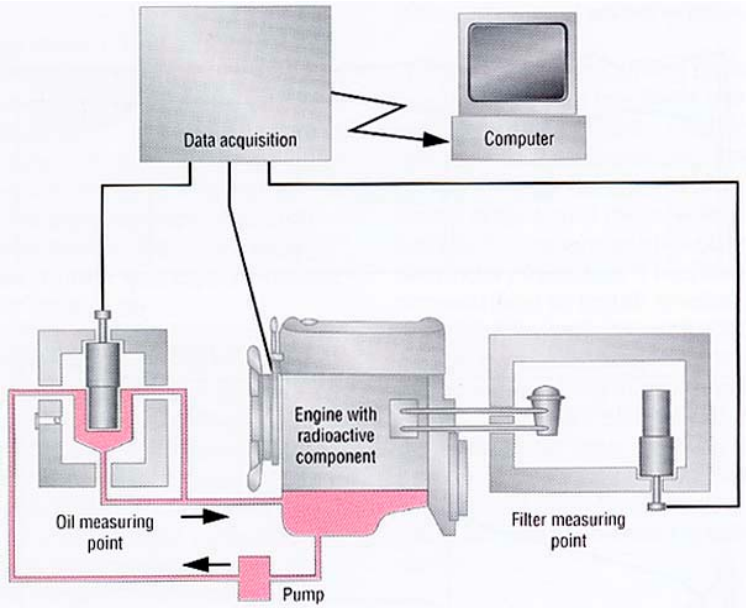
- element analysis at surfaces
- positron microscoopy for studying early stages of cracks

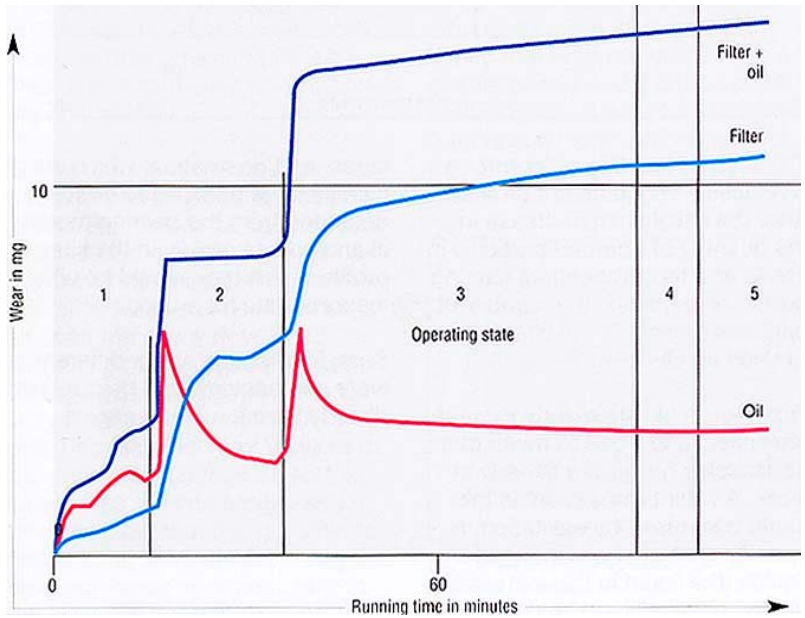
Activation by (n, γ) nuclear reaction



Tracer techniques for industrial research

in-situ measurement of abrasion in an engine





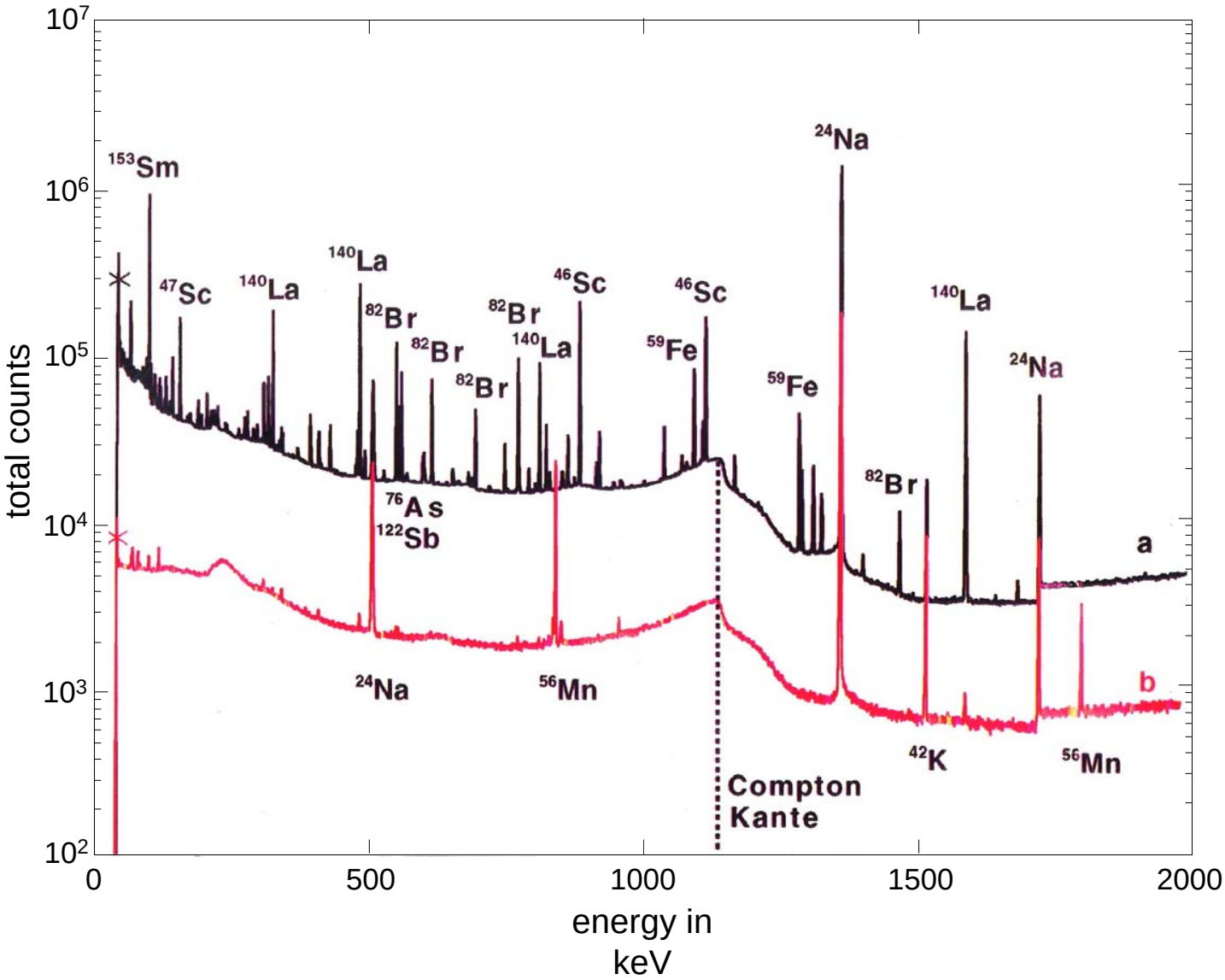
→ production of radio nuclides by irradiation of work pieces which are subject to potential abrasion

→ extreme sensitive measurements of wear debris by measuring radioactive traces

→ in-situ, real time measurement

Maisch, DaimlerChrysler

Element analysis by neutron activation



γ-spectra after 7 min and 1 h activation time

- Today 19 % of the available neutrons is used for industrial purposes.
- Aim: 30 % of available neutrons for industrial purposes.
- Access is free in case the results are published. Beam time is allocated according to scientific merit.
- Beam time is charged in case industry wants to keep the ownership of the results. FRM II delivers full service, i.e. including evaluation of the data. Data confidentiality is guaranteed. Privileged and fast access.