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X-ray detectors for the rest of us

Realistic detector requirements for high energy synchrotron X-ray nano-imaging

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Where from ?

X-ray spectroscopy of samples from:

- Environmental Sciences
- Material Sciences
- Life Sciences

Earth & Planetary Sciences

What for ?

To measure:

- ⋆ trace/ultratrace elements (*ppt*, 70 zg !)
- ⋆ kinetics (20 ms) and maps of 100 x 100 pixels
- ⋆ speciation but mainly in SIXES mode
- ⋆ morphology at different scales (nm – mm)

Why ?

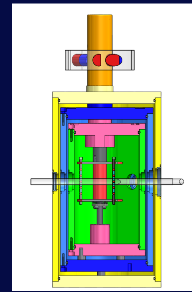
NATURE is: - *heterogenous, minute*
- *diluted*
- *chem-oriented*

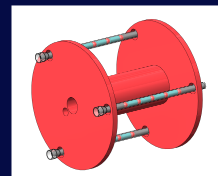
Unique, fragile, challenging samples

- ★ nondestructive, non-invasive analysis
- ★ *in situ*, HP, HT, bio
- ★ hyperspectral analysis: 2-3 XRF, XRD, XAS, XCT
- ★ 1D & 2D simultaneous probes
- ★ multiscale: nm to mm
- ★ time resolved : phase transition / kinetics

In situ

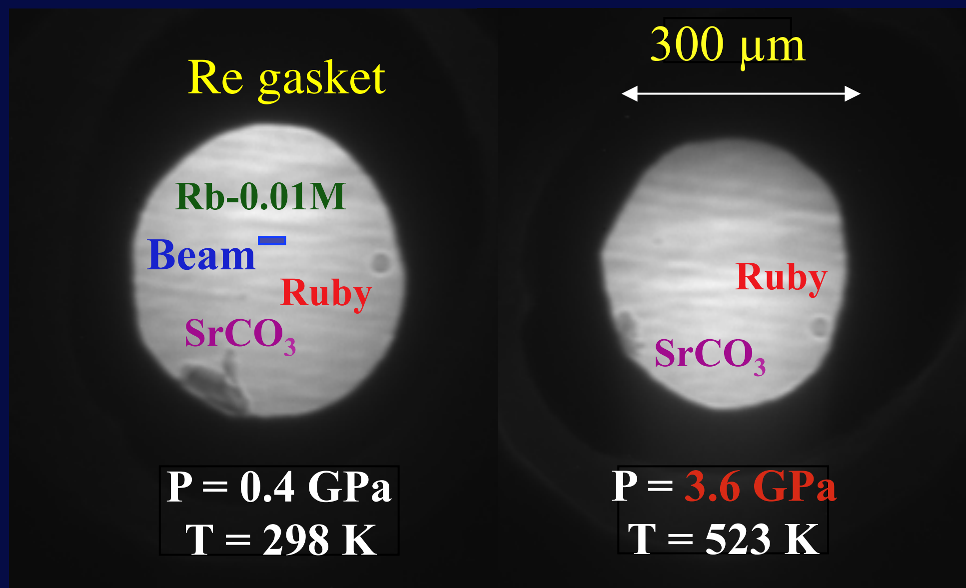
Mars Sample Return





100 mm

NASA STARDUST aerogel keystones



How ?

SDD : Röntec, Ketek, Vortex-Hitachi…

- $S = 50$ -100 mm^2
- peak/bkg ≈ 1000
- OCR ≈ 600 kcps
- thick. 0.3 mm
- effic. ε 90 – 10% (10-30 keV)
- multi-elements (4)
- annular geometry ?

PROS

-high count rates

- large $S_{det} \approx 50\ mm^2$

- no LN_2

- light, transportable

CONS

- small thickness - 300 μm
- only Si
- dedicated electronics

NEEDED:

- **GDD for HE**
- **ε 100–90% (10-30 keV)**
- **thickness ≥ 0.3 - 1 mm**
- **S ≥ 100 mm²**

High energy resolution (few eV)

WDX spectrometers

- not HR, bulky systems
- small, dedicated, simple
- interface to central acq.
- WDX - 1 Z, µXAS, SIXES

Bolometers

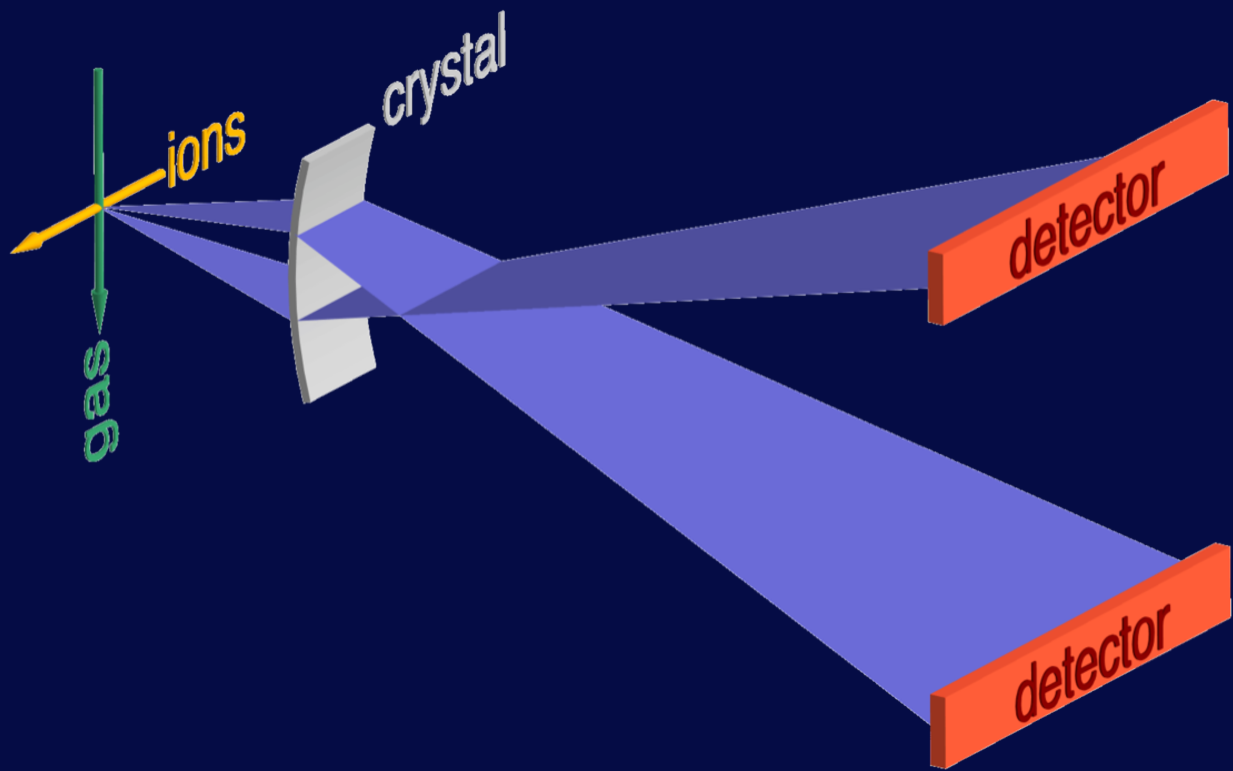
- easy to set up
- simple electronics
- **expensive**
- **low cps, sensitive**

HE-PSD

FOCAL

Environment with high level of noise – 1E4-5, low sig. 1E1

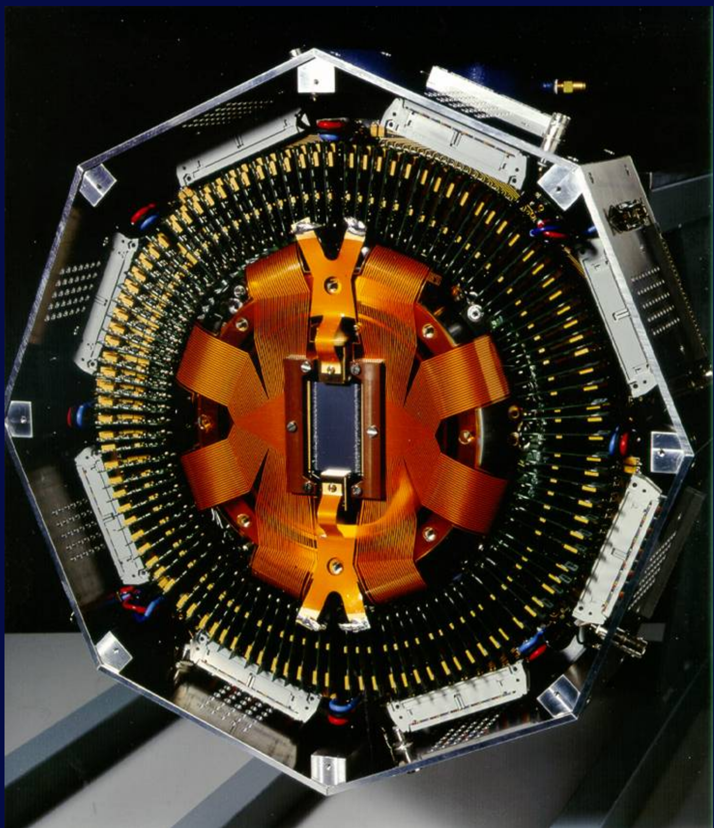
H. Beyer, GSI Darmstadt – 1 & 2 e^- QED on U



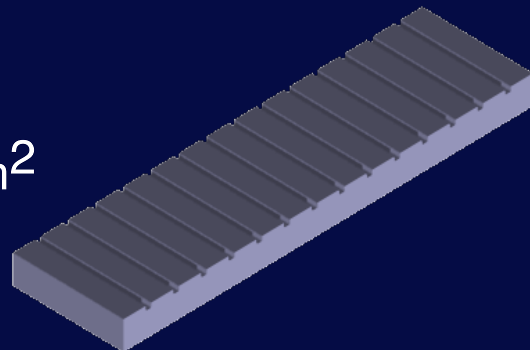
FOCAL Ge Strip Detector

Forschungszentrum Jülich

D. Protić et al.



10 – 100 keV
200 strips
area: 47 x 23.5 mm^2
4.1 mm thick
strip width: 200 µm
grooves: 35 µm



$\Delta x \approx 200$ µm
$\Delta E \approx 1.6$ keV
$\Delta \tau \approx 50$ ns

future: 2-dimensional
x: 160 strips (front)
y: 24 strips (back)

Imaging: 2D CCD w/ **EDX**

- high resolution (< 1 μm)
- energy dispersive
- affordable systems

Solution: Backlit CCD: CXC

XMAS list:

- GDD detectors
- thick. ≥1mm, S≥100 mm^2, SDD, GDD
- multi-element detectors, annular geometry
- FAST OCR ≥ 1Mcps
- P/B ≥ 2000
- efficient/clean collimators
- reliable (peak drift/OCR) electronics at high CR
- EDX PSD, cheap, demagnified (lenses)