Out of this world !

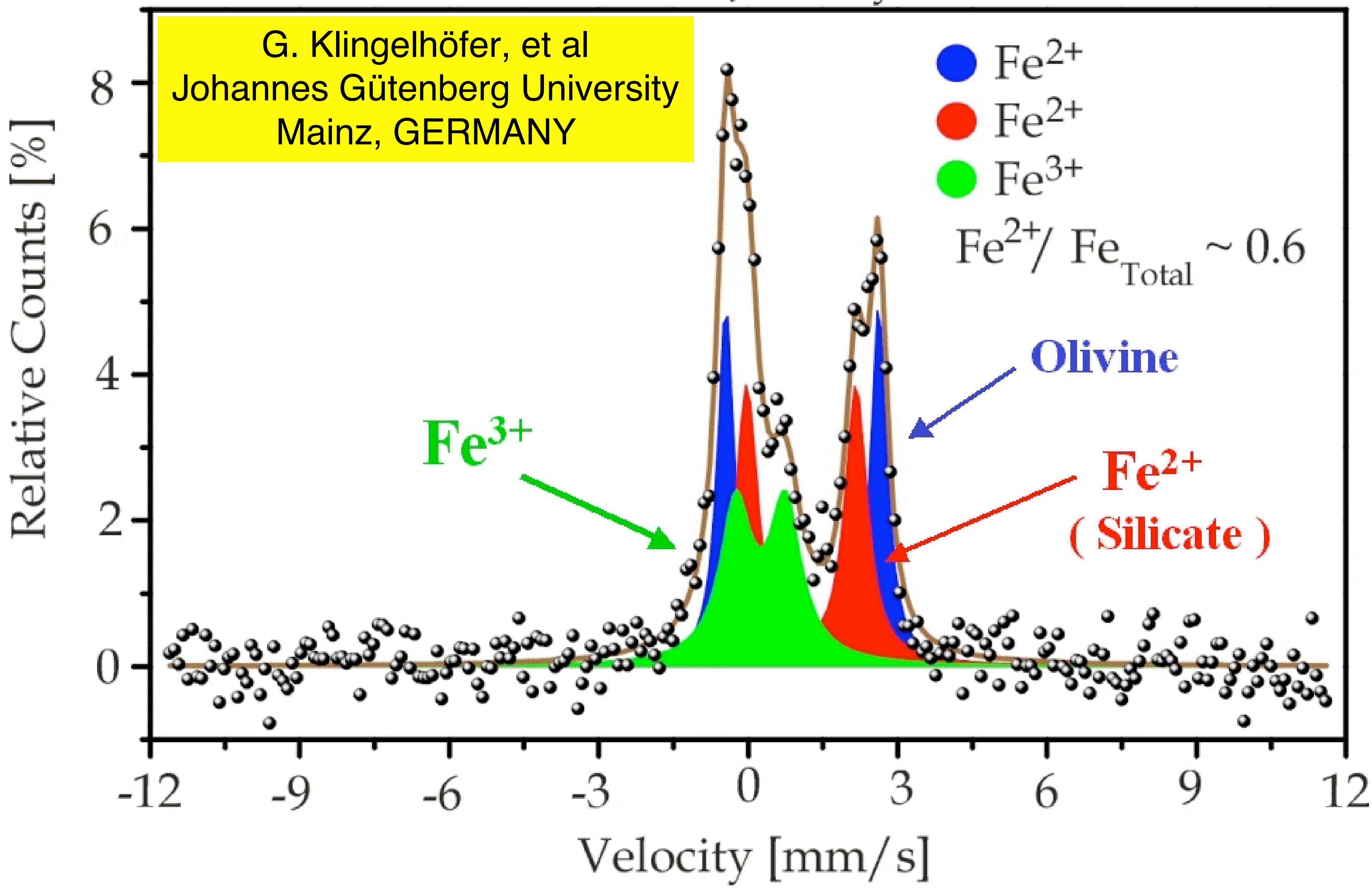
A short account of Mössbauer Spectroscopy on Mars

For further information visit

http://iacgu7.chemie.uni-mainz.de/klingelhoefer/mimos.html?d

http://mars.jpl.nasa.gov/

First Mössbauer Spectrum Recorded on Martian Surface
Gusev Crater, January 17, 2004



Scientific measurement objectives of the Mössbauer investigation

For rock, soil, and dust

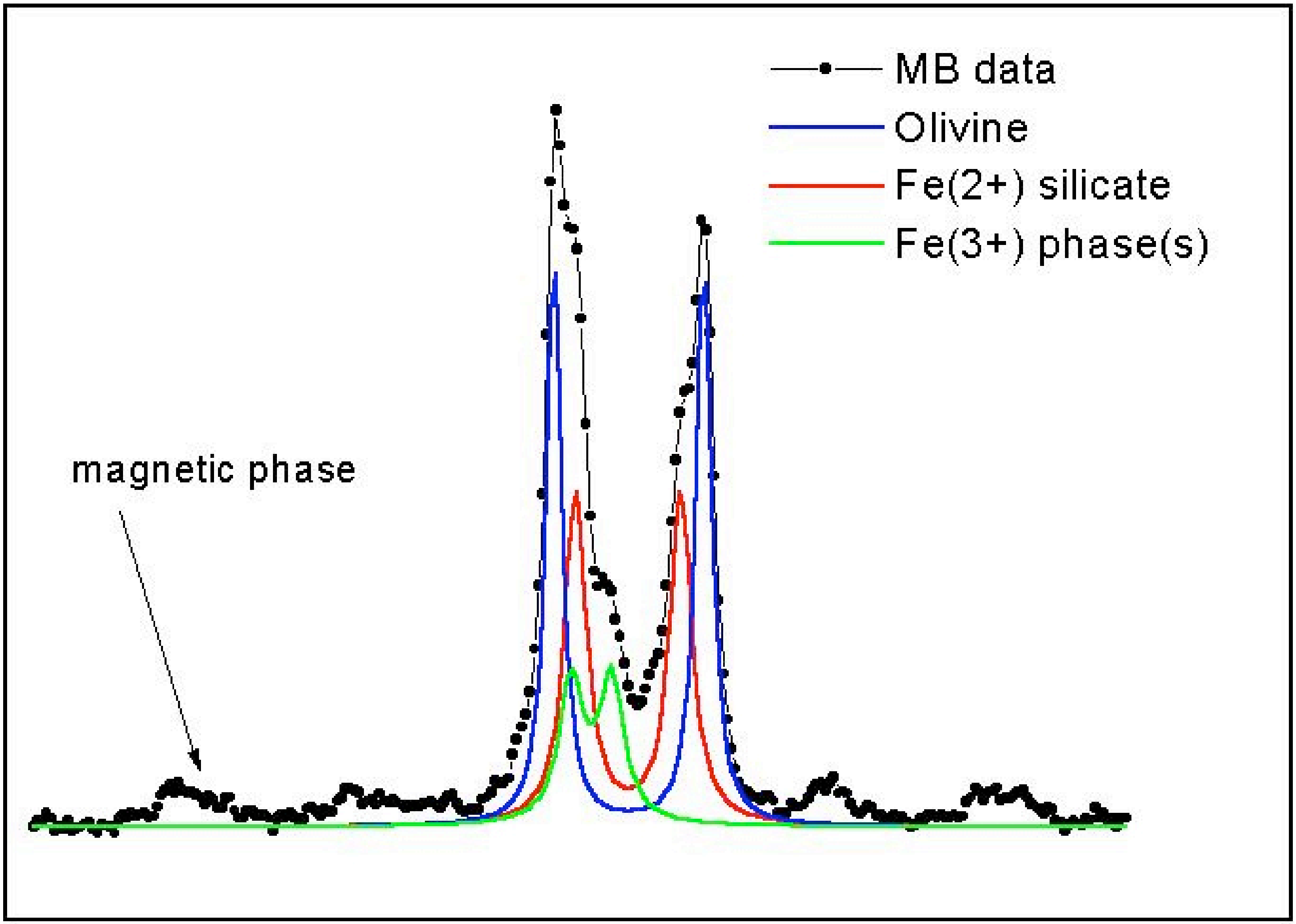
(1) the mineralogical identification of iron-bearing phases (e.g., oxides,silicates, sulfides, sulfates, and carbonates),

(2) the quantitative measurement of the distributionof iron among these iron-bearing phases (e.g., the relative proportions of iron in olivine, pyroxenes, ilmenite and magnetite in a basalt), and

(3) the quantitative measurement of the distribution of iron among its oxidation states (e.g., Fe^{2+}, Fe^{3+}, and Fe^{6+}).

Special geologic targets of the Mössbauer investigation are dust collected by the Athena magnets and exterior and interior rock and soil surfaces exposed by the Athena Rock Abrasion Tool and by trenching with rover wheels, respectively.

Mössbauer spectrum on Martian soil.
Meridiani Planum, Sol 11.



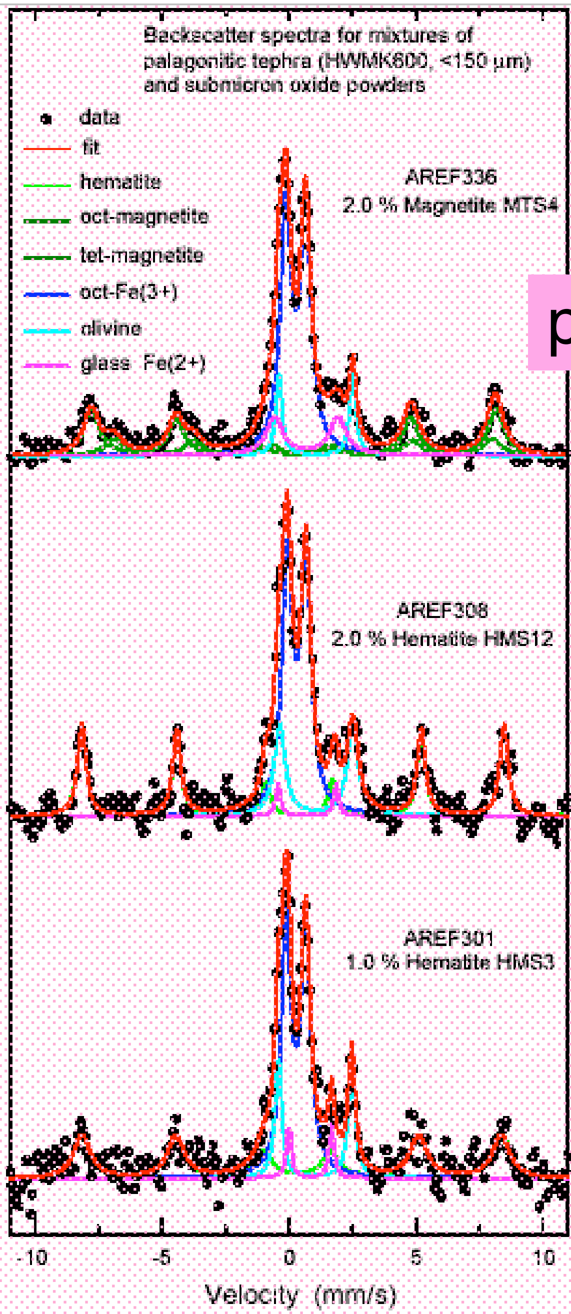
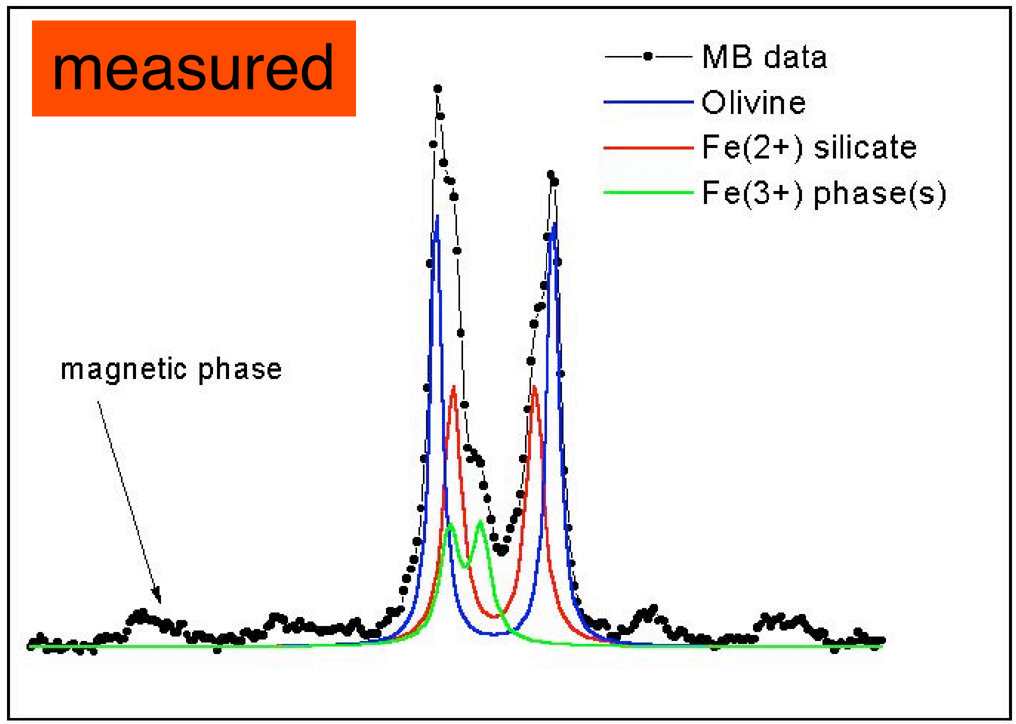


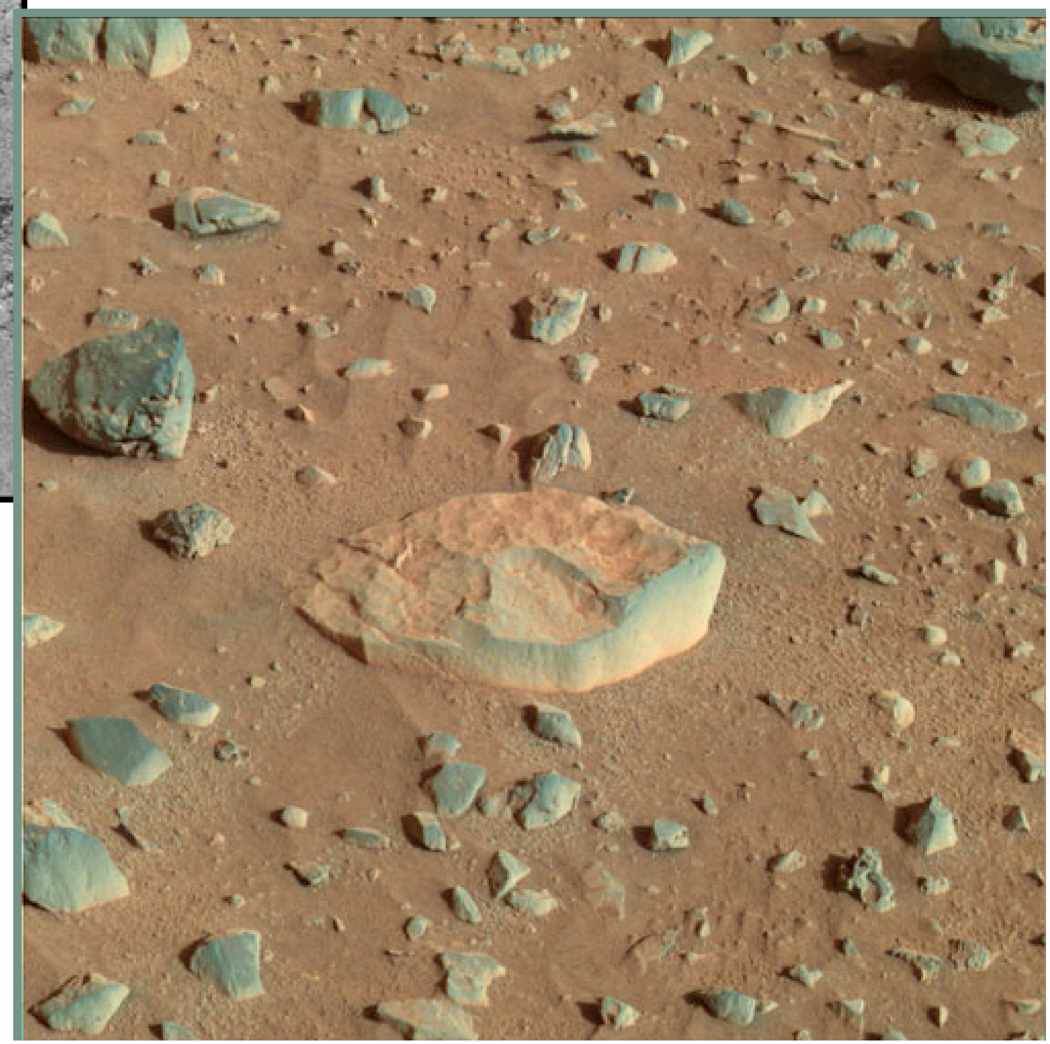
Figure 14. Klingelhoefer et al. [2003]

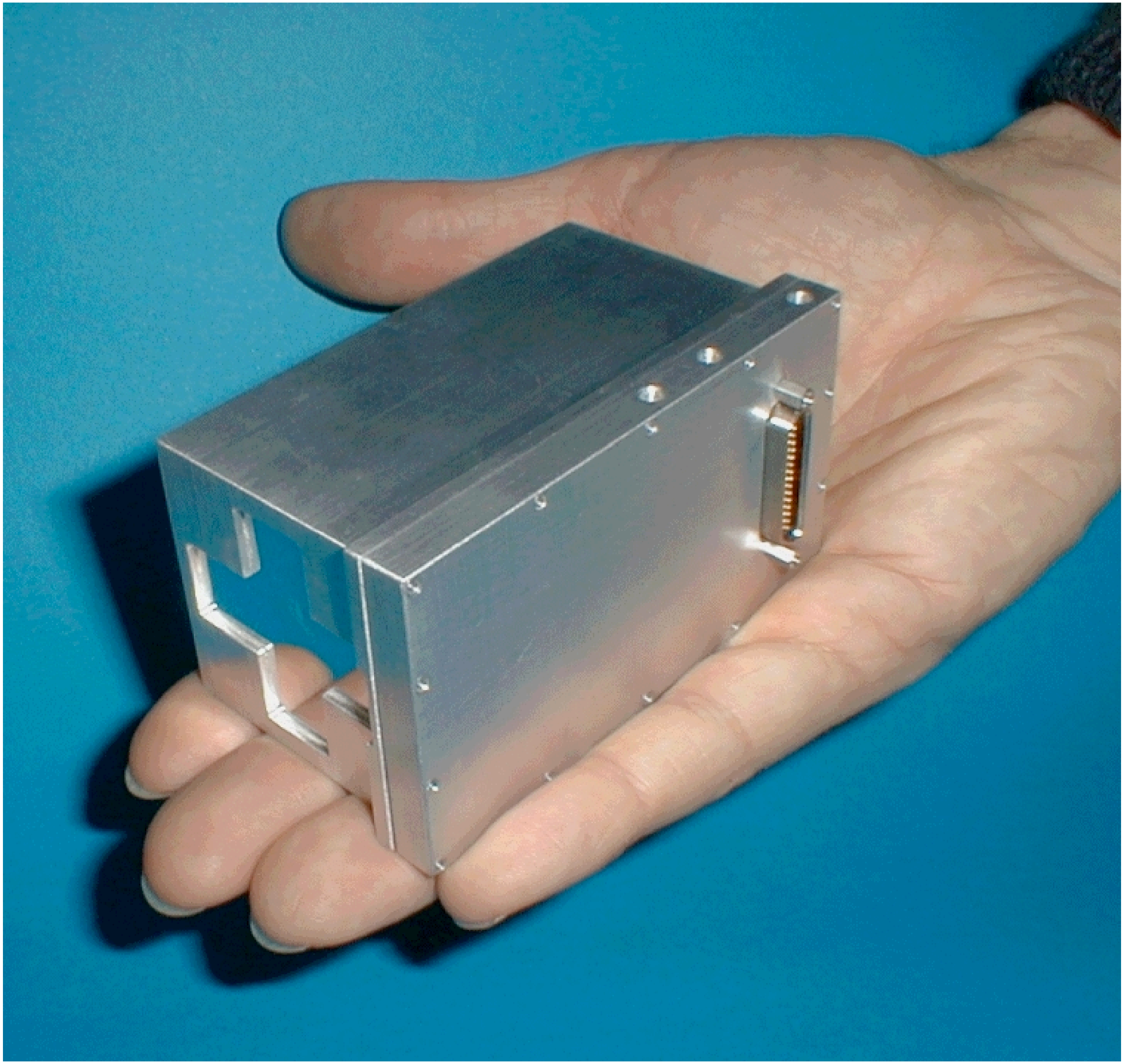
predicted

How good are they ?

Mössbauer spectrum on Martian soil.
Meridiani Planum, Sol 11.







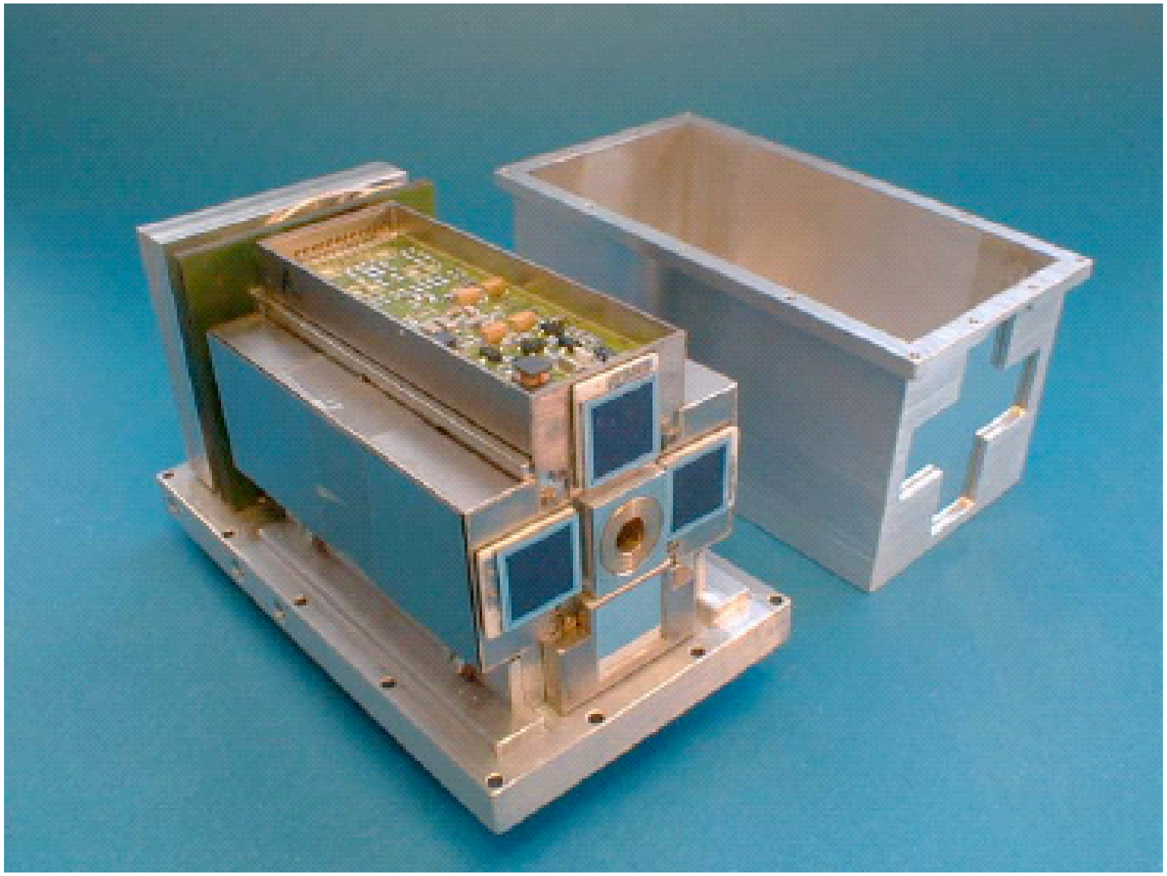
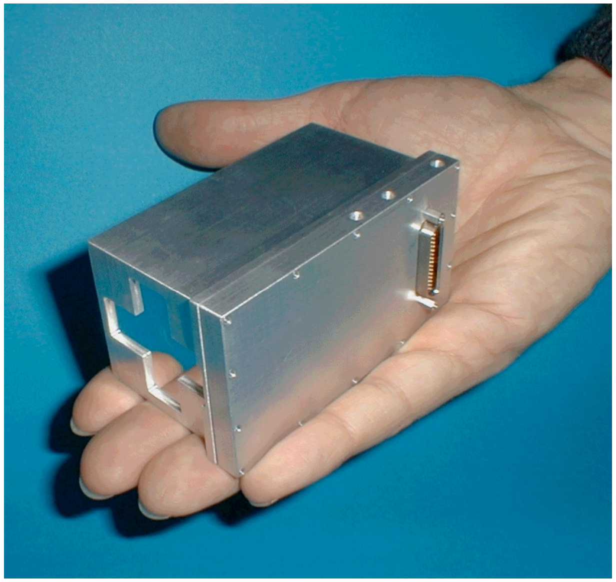
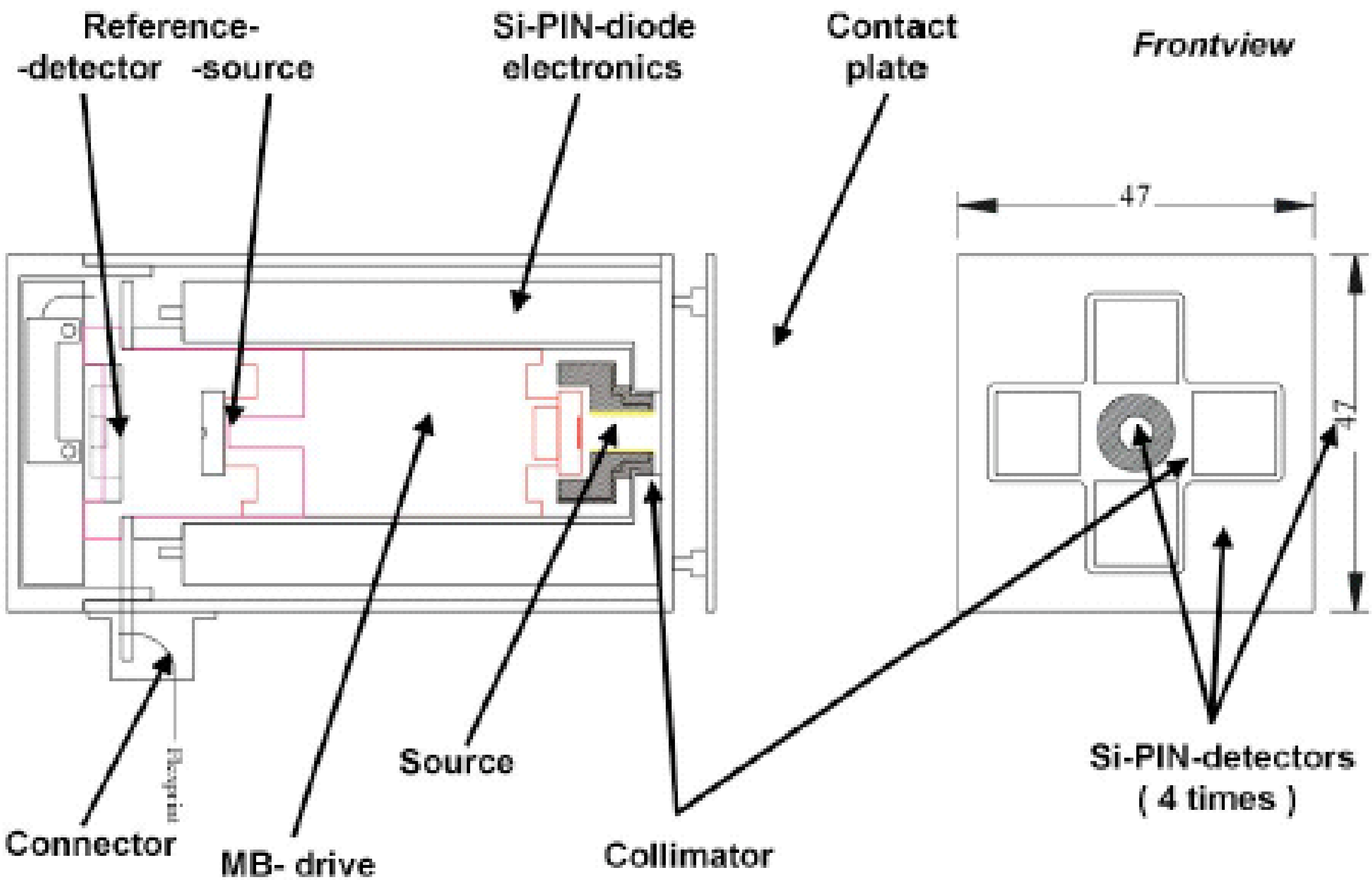


Figure 6b, Klingelhoefer et al. [2003]





Reference-
-detector
-source
Si-PIN-diode
electronics
Contact
plate
Frontview
47
47
Connector
MB- drive
Source
Collimator
Si-PIN-detectors
(4 times)

The Athena MIMOS II Mössbauer Spectrometer Investigation

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Special issue on the Mars Exploration Rover mission

IXS-CDT

Inelastic X-Ray Scattering Collaborative Development Team

Sector 30

presented by E. E. Alp

Feb 25, 2004

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- Cornell
- MIT
- Northeastern U.
- Princeton U.
- SUNY-Stony Brook
- U of California
- U of Pennsylvania
- U of Illinois (UIC-UIUC)
- U of Tennessee
- Western Michigan U.

- Argonne
- Brookhaven
- Carnegie Institute of Washington
- Lucent
- Oak Ridge

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A SHORT SUMMARY OF CURRENT INELASTIC X-RAY SCATTERING TECHNIQUES

Technique	Source of interaction	Typical resolution	DETECTION METHOD	Location at the APS
Momentum-resolved, high energy resolution IXS: HERIX	Collective excitations of atoms, ions, molecules, PHONONS	1-3 meV	Back-scattering, curved and diced crystal analyzer	3-ID
Momentum-resolved, medium energy resolution Resonant IXS: MERIX	Valence electrons near Fermi level	100-500 meV	Near-back-scattering, curved and diced crystal analyzer	9-ID, 12-ID, 33-ID
Momentum-integrated, nuclear resonant IXS: NRIXS	Collective excitations monitored through a nuclear resonance	0.5-2 meV	Nano-second time resolved detectors monitoring nuclear level decay	3-ID, 16-ID
Compton Scattering: CS	Core and valence electrons	1 eV	Solid state detector	11-ID
Magnetic Compton Scattering: MCS	Spin polarized electrons	100 eV	Solid state detector	11-ID
Energy loss XANES (Resonant Raman Spectroscopy)	Core electron excitations of low-Z elements	1 eV	Back-scattering curved flat analyzers	13-ID, 16-ID
X-Ray emission spectroscopy: XES	X-ray fluorescence by incident photons: photon-in/photon-out	0.5 eV	Back-scattering curved flat analyzers	10-ID
Soft-X-ray IXS : PEEM	x-ray induced photoemission: photon-in/electron-out	5 meV	Electron spectrometer	4-ID

Scientific Mission

- **HERIX:** Provide sufficient *flux and resolution* to measure collective or localized excitations of atoms, ions, molecules, or polymerized chains
  - **Goal: 1 meV @ 25 keV**

- **MERIX:** Provide sufficient *flux and resolution* to measure collective or localized excitations of valence electrons in primarily 3d-based correlated electron systems
  - **Goal: 50 meV at 5-12 keV**

IXS-CDT

A second generation beam line dedicated for inelastic x-ray scattering

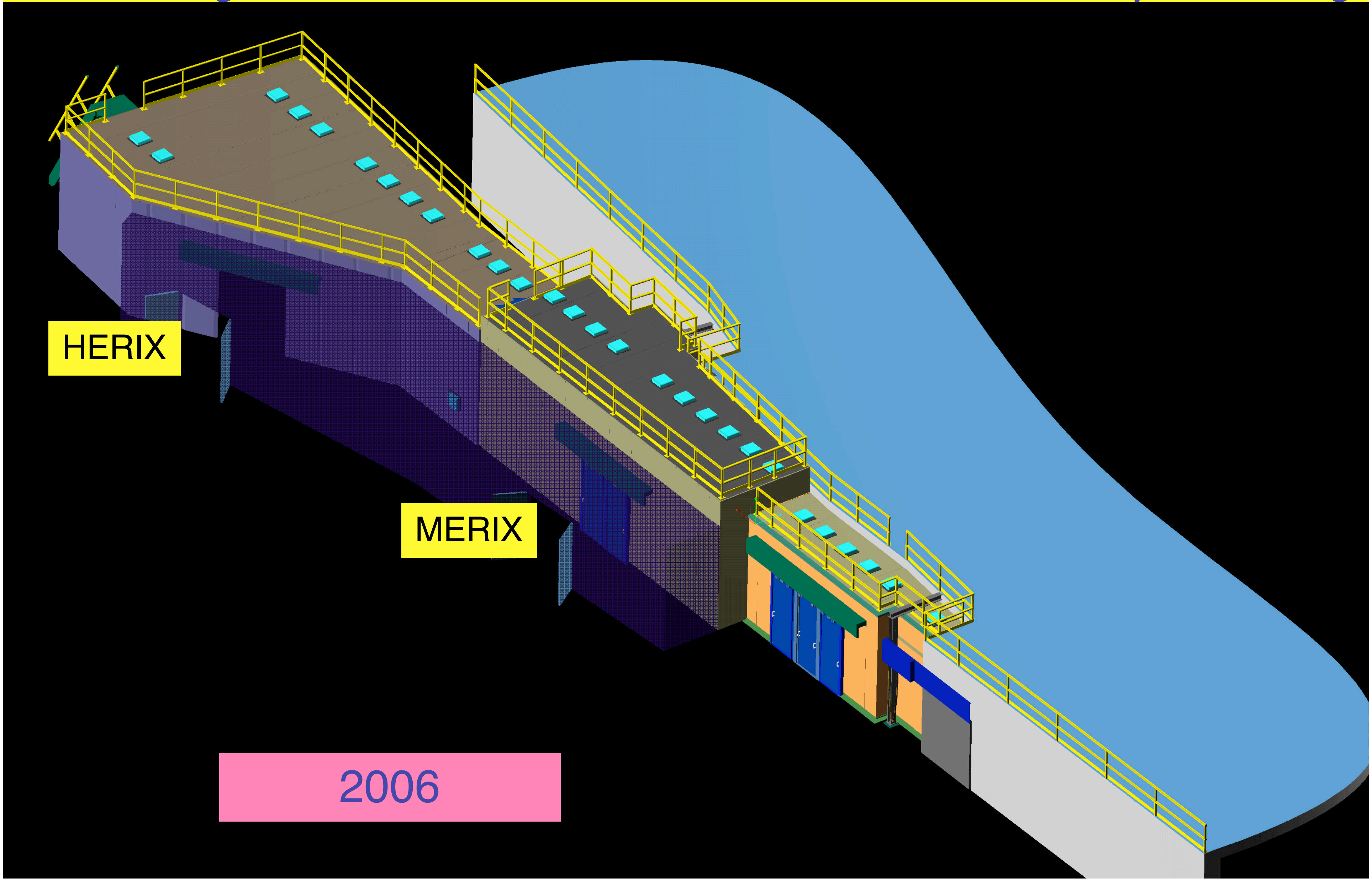


Figure B.2. Beamline Layout with Plan & Elevation View

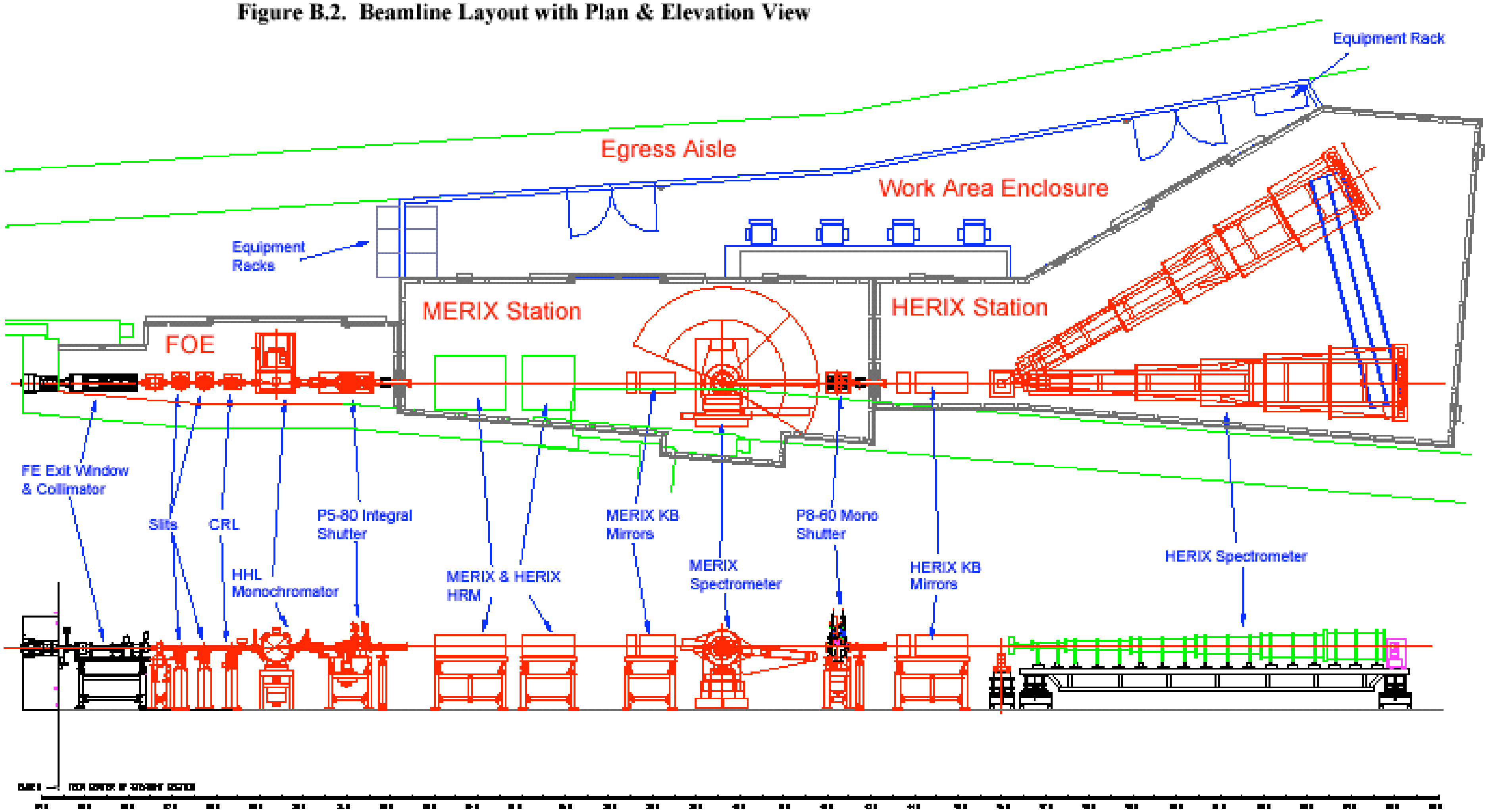
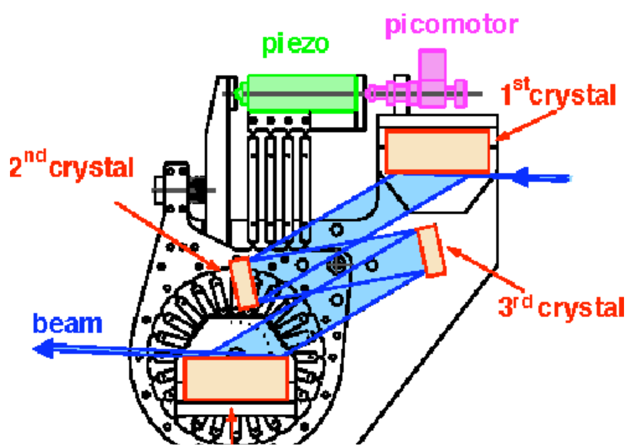
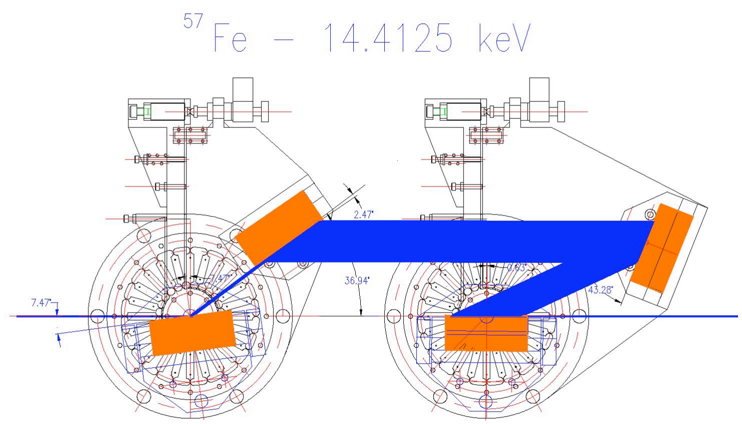


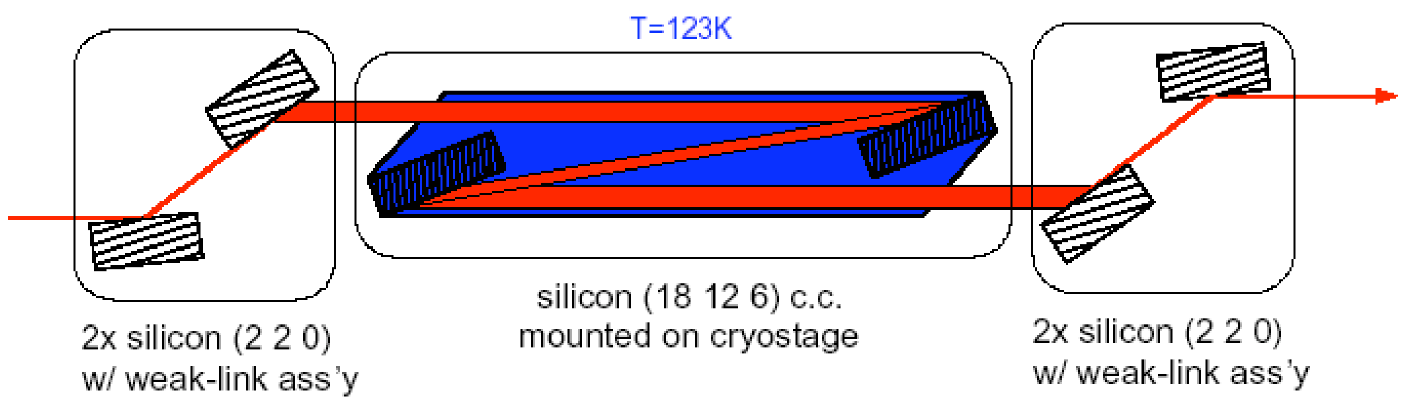
Photo: Jack Burke, Feb 25, 2004

Photo: Jack Burke, Feb 25, 2004

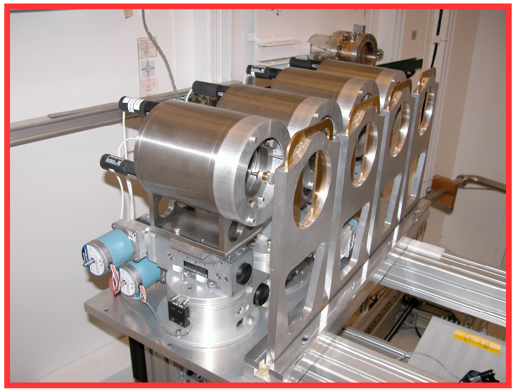
Generations of high resolution monochromators

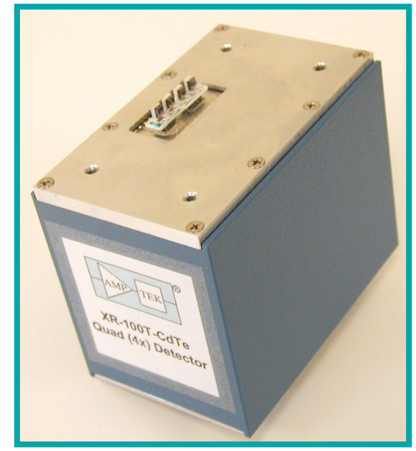






T. Toellner, D. Shu, W. Sturhahn

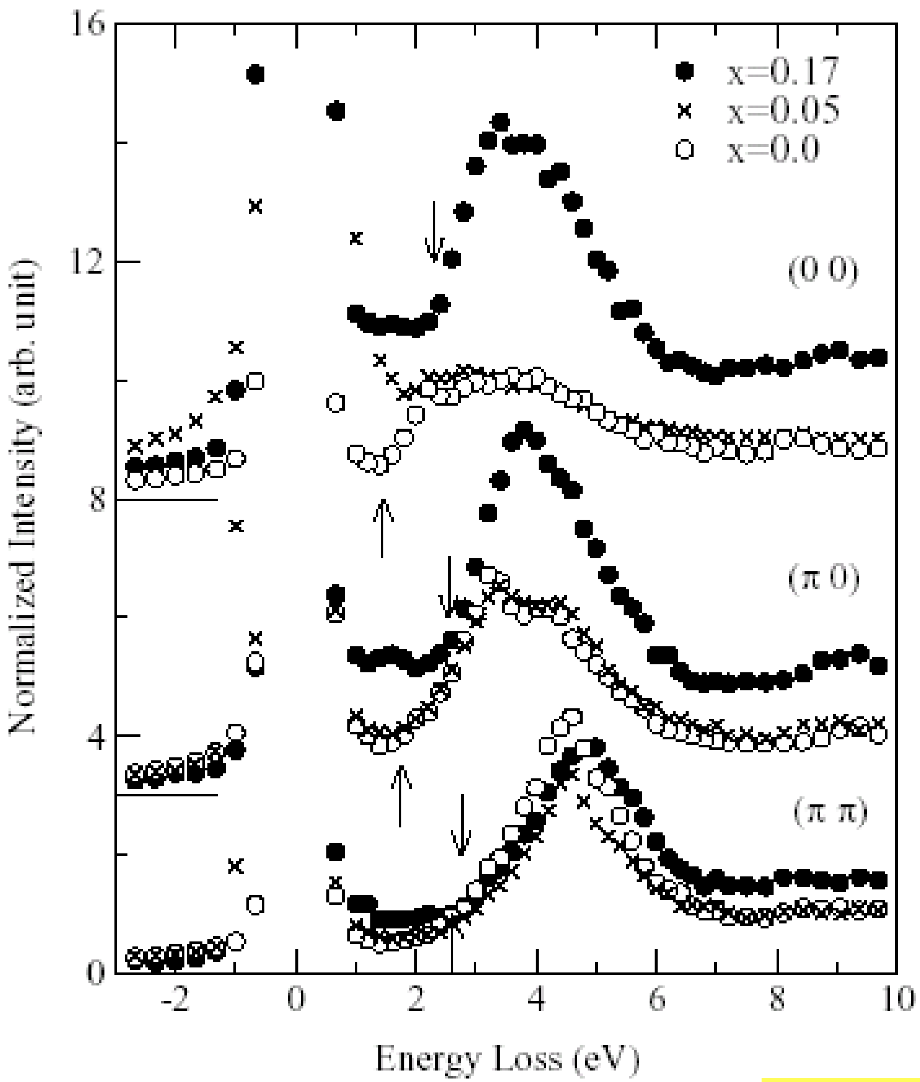



AMP
TEK
XR-100T-CdTe
Quad (4x) Detector

The need for 100 meV or better resolution for MERIX
Resonant Inelastic X-ray Scattering: RIXS
Example 1: Rare-earth cuprates

- On doping insulating cuprates may become metallic.
- The 2 eV gap is filled with a continuum of excitations.
- Known from optical conductivity measurements.
- With RIXS the momentum dependence can be studied.
- This reveals the charge dynamics of the doped holes.
- For optimum doping, intensity is observed below 2 eV
- This currently cannot be reliably studied below 1 eV
- The relevant dynamics all occur in this regime.
- Mid-IR states at 50 meV interesting,
- Potential new collective modes around 70 meV (P.A. Lee).

Doping Dependence



$La_{2-x}Sr_xCuO_4$

In x=0.17 sample see that the gap present at x=0.0 is filled.

Cannot study this in detail below ~ 1eV because of poor resolution.

Yet, this region contains information on doped hole dynamics. Plasmon is here, as are mid-IR states, possible new collective modes and ultimately superconducting gap.

CMC-CAT Y.-J. Kim, J.P. Hill *et al*., unpublished.

The need for 100 meV or better resolution for MERIX
Resonant Inelastic X-ray Scattering: RIXS
Example 2: Rare-earth manganites

The gap can fill as a function of temperature and doping:
metal-insulator transition.

The charge-transfer gap occurs around 2 eV.

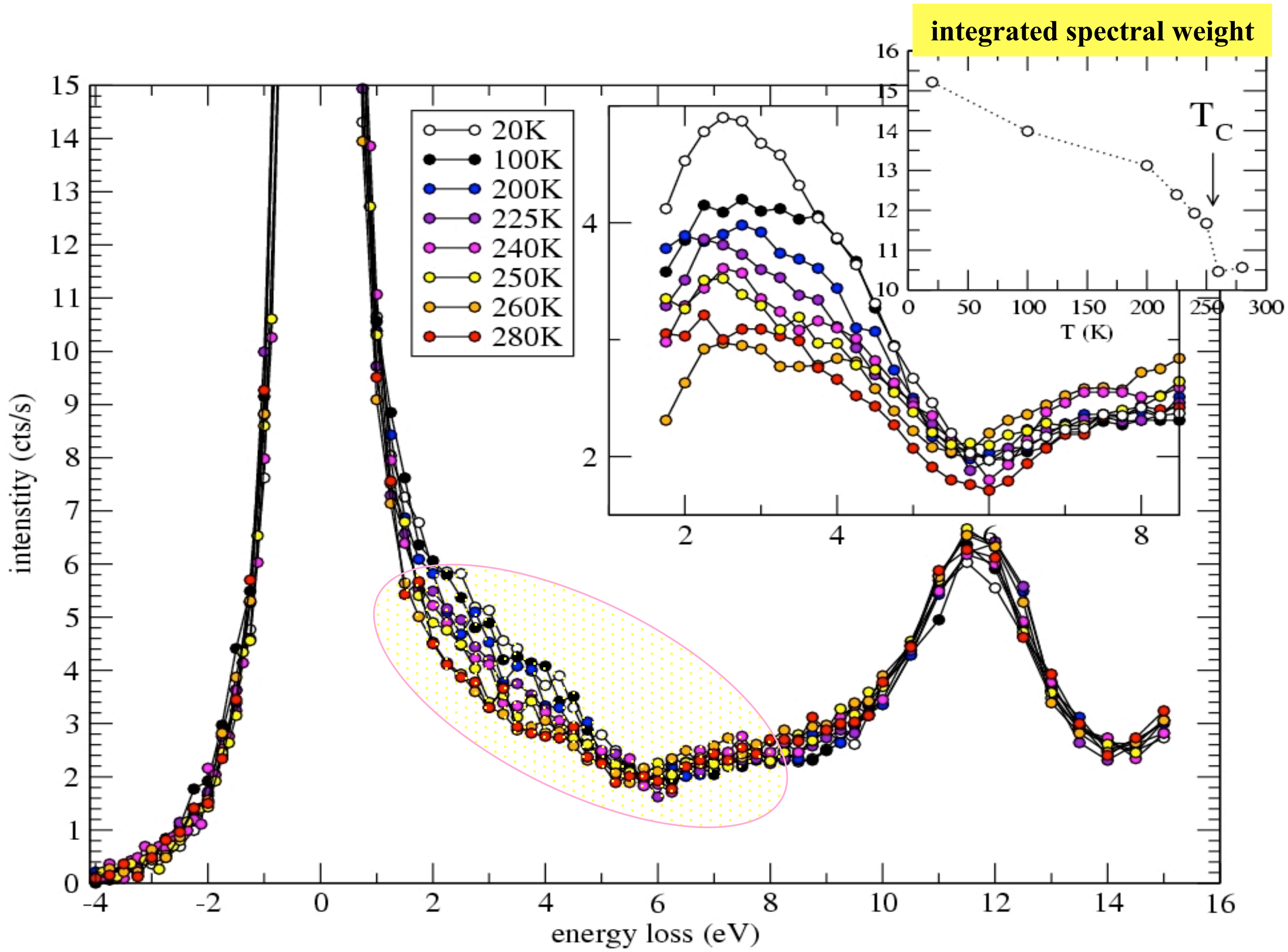
The correlation with the ferromagnetic phase transition can be better established..

The current resolution prevents any meaningful data below 1 eV.

This prevents making contact with optical measurements, apply sum rules.

Measuring the q-dependence would be very important.

Temperature Dependence in $La_{0.7}Ca_{0.3}MnO_3$



CMC-CAT data 10/20/03 S. Grenier, J.P. Hill *et al.*, unpublished.