

Bruker ARTAX μ XRF spectrometer



Famous Faustian Bargains

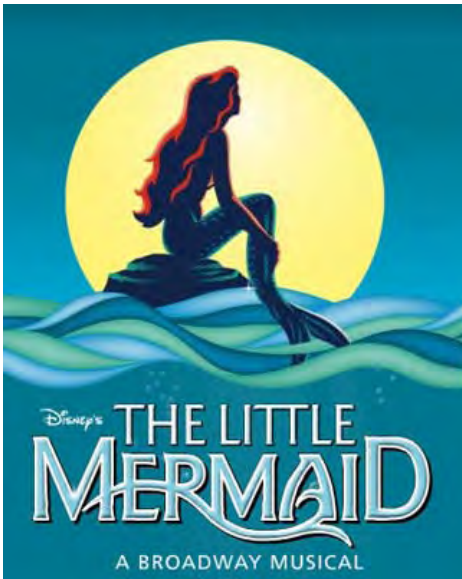
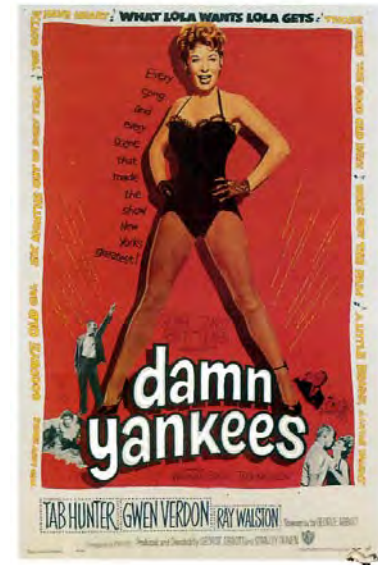


diagram of instrument

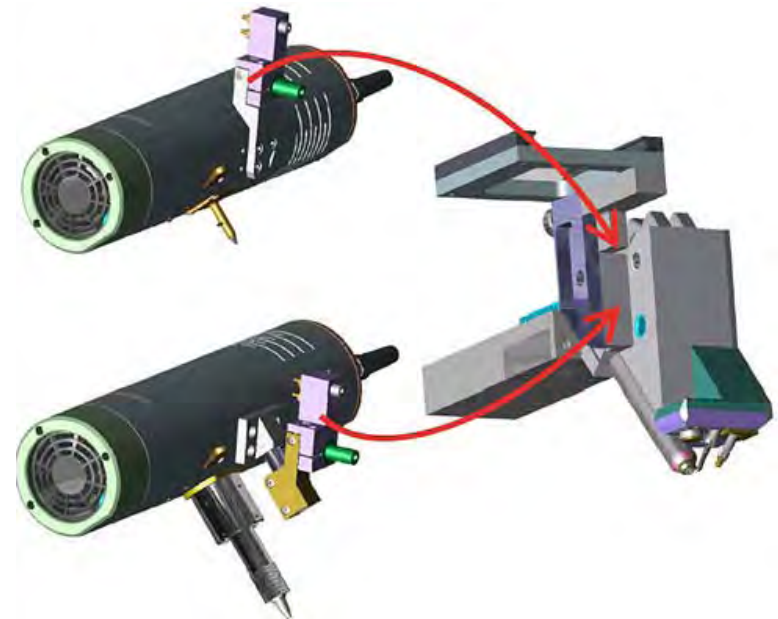
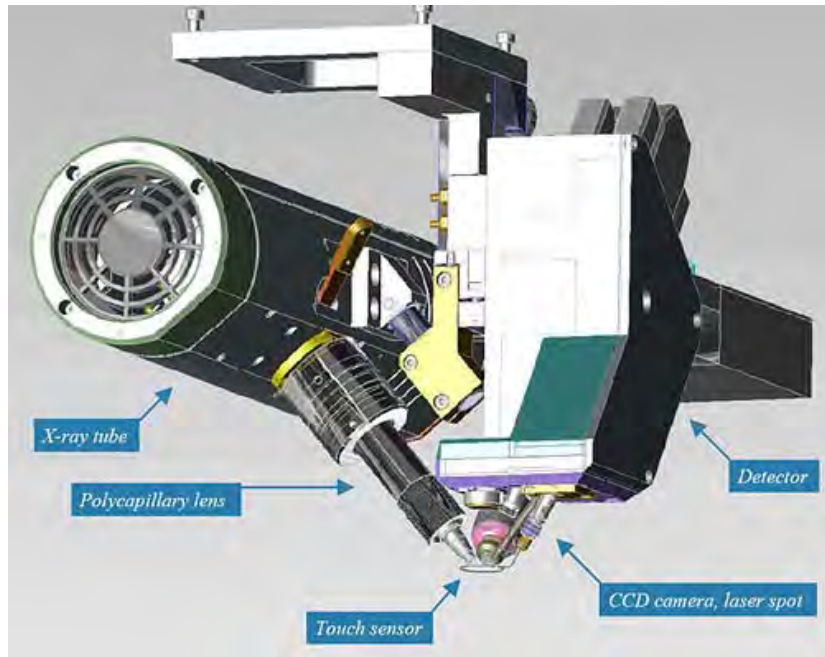


illustration of changing tubes

Tubes and spot sizes



Cr 650 μm spot
(w/collimator)

Mo 65 μm spot
(w/polycapillary lens)

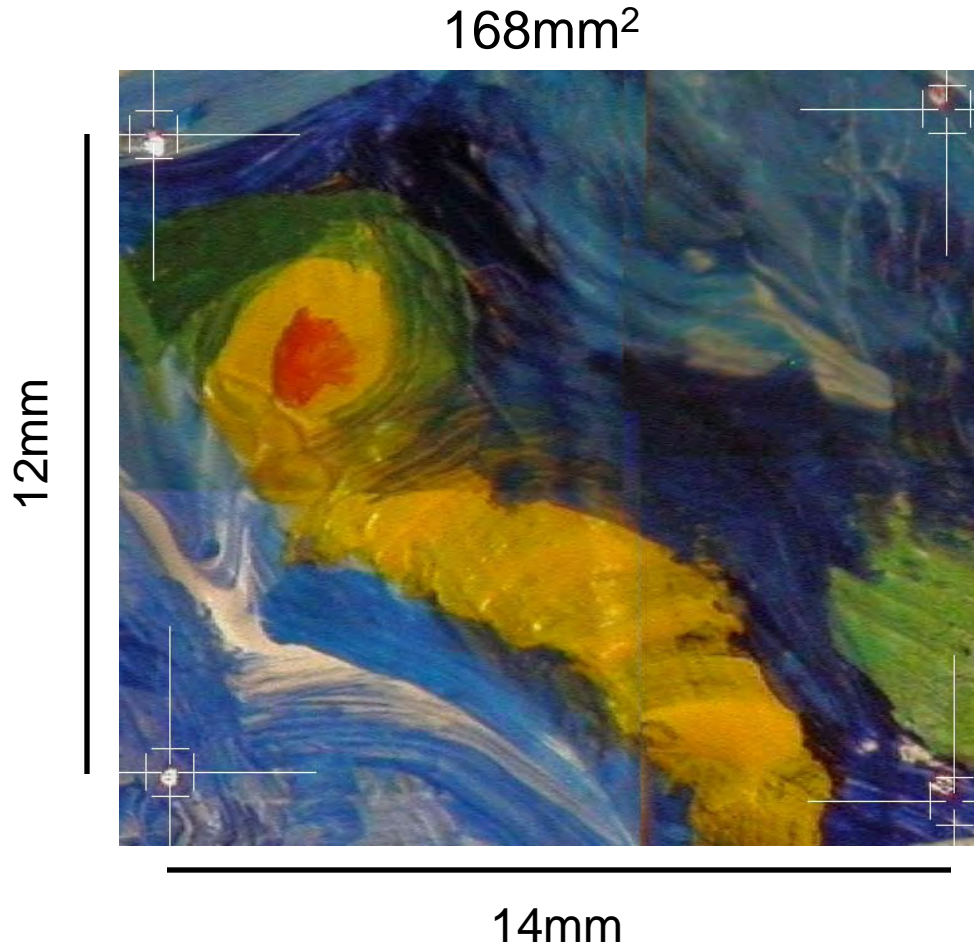
W 650 μm spot
(w/collimator)



collimators and polycapillary lens can all be removed for a 2mm spot

all tubes can be run up to 50kV & 1000 μA
minimum operating voltage = 12kV

test area mapping with the W tube (650 μm spot)



0.5mm step size \rightarrow 2 hour scan
reality: 3 hours 13 minutes

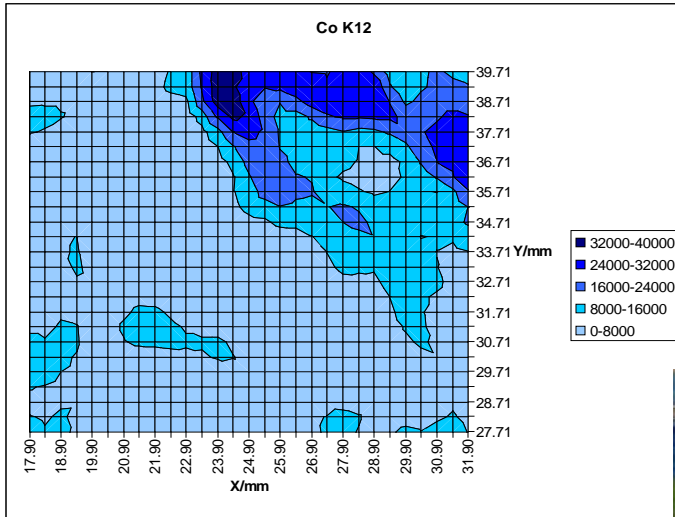
1.0mm step size \rightarrow 32.3 minutes
reality: 57 minutes

1.5mm step size \rightarrow 15 minutes
reality: 27 minutes

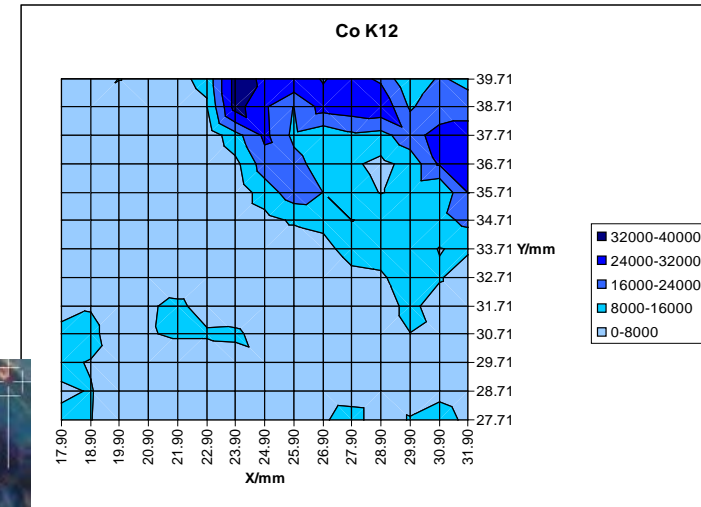
2.0mm step size \rightarrow 9.2 minutes
reality: 18 minutes

all maps run with 10 second scans

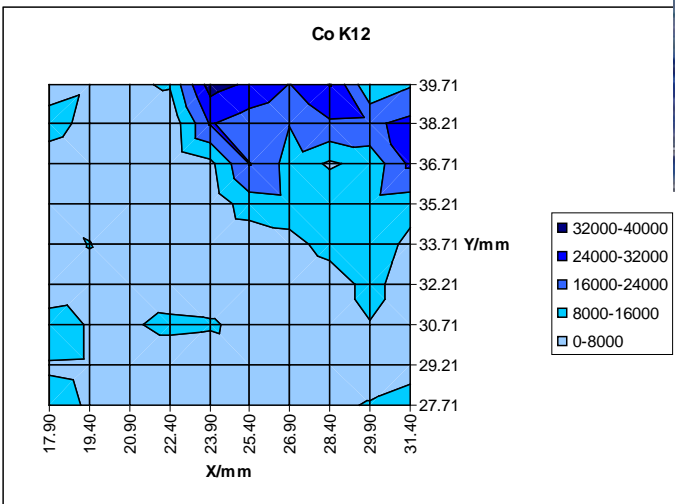
Co



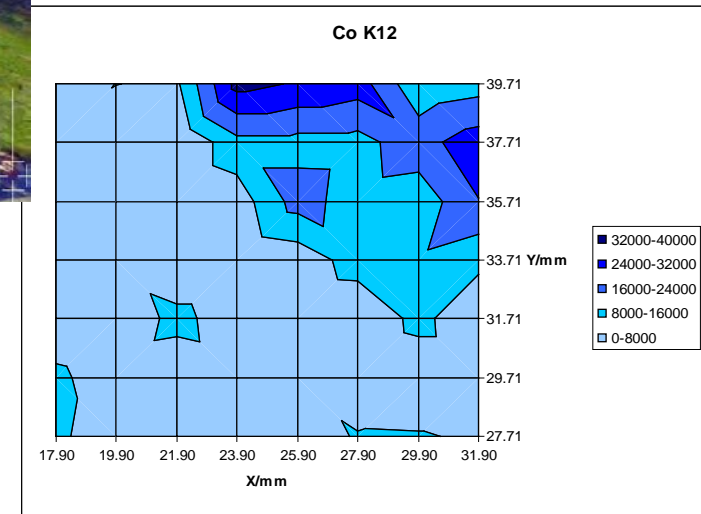
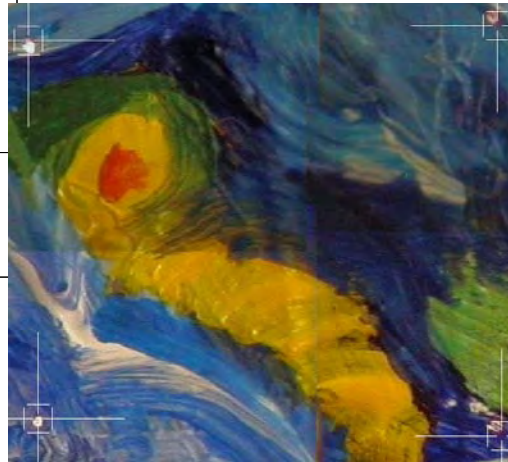
0.5 mm step size



1.0 mm step size



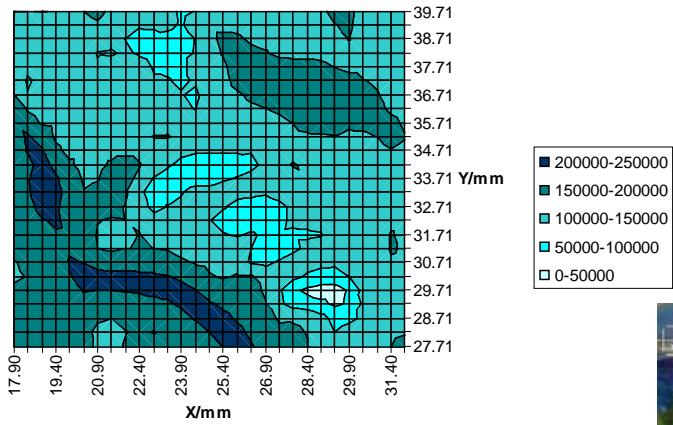
1.5 mm step size



2.0 mm step size

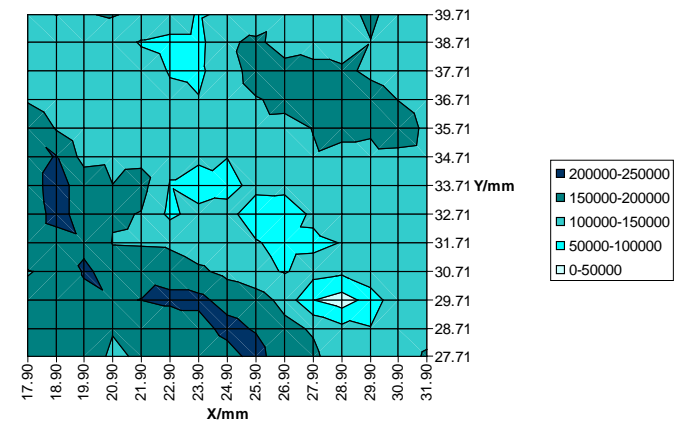
Zn

Zn K12



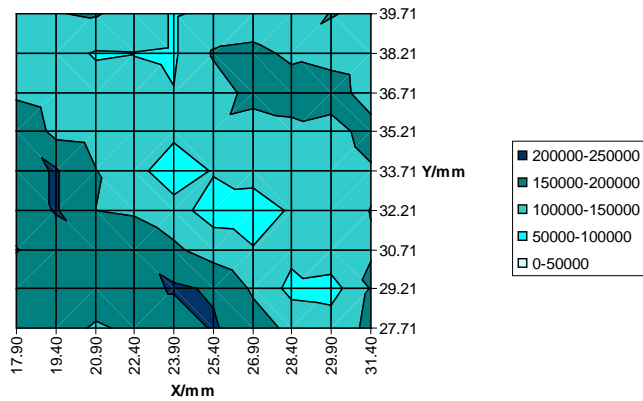
0.5 mm step size

Zn K12



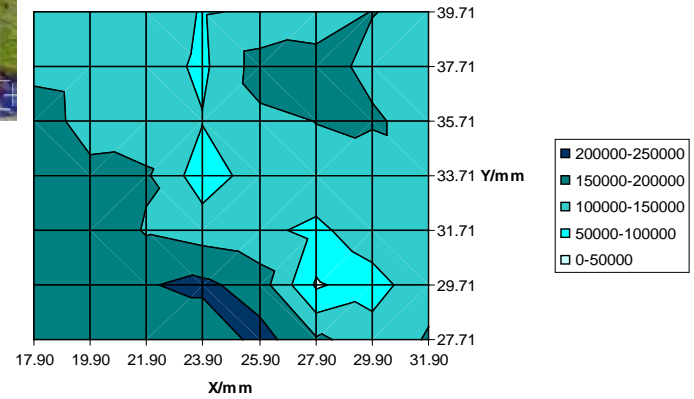
1.0 mm step size

Zn K12

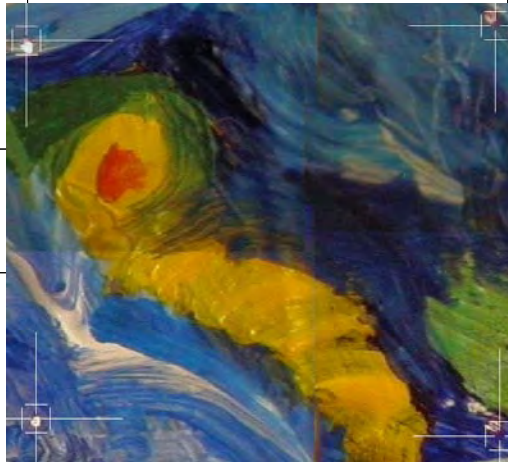


1.5 mm step size

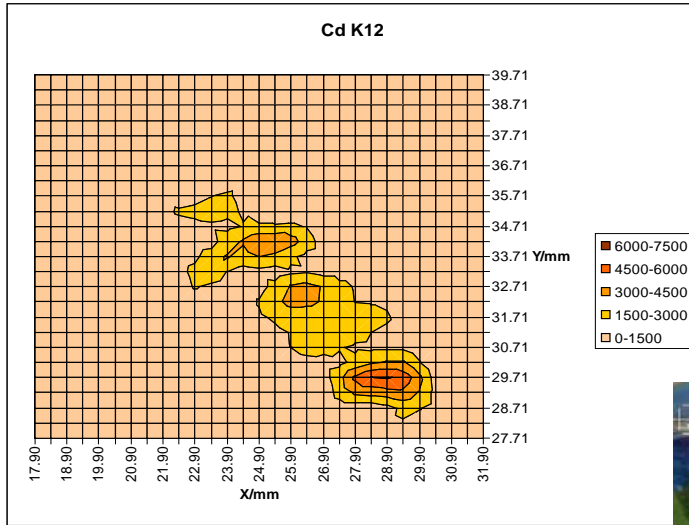
Zn K12



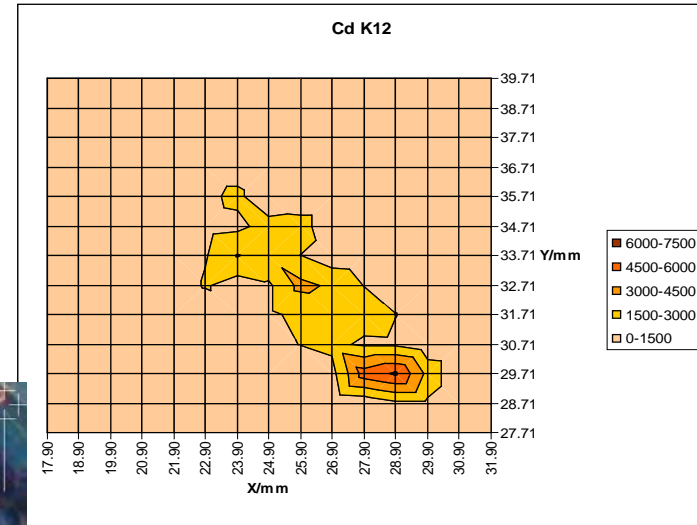
2.0 mm step size



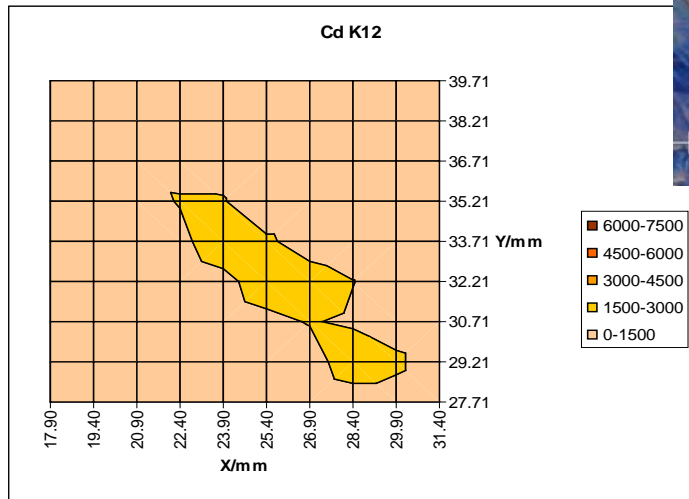
Cd K



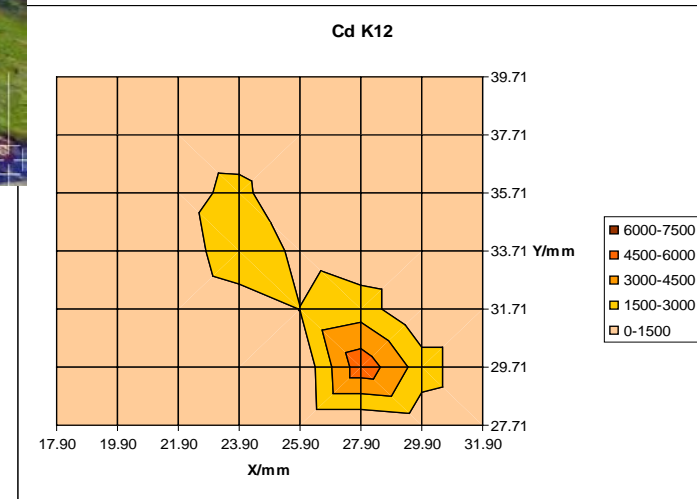
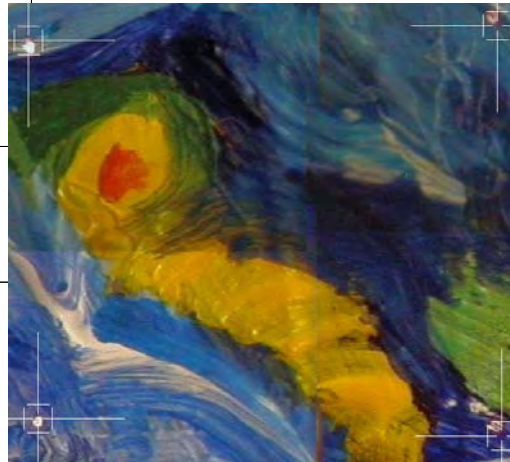
0.5 mm step size



1.0 mm step size

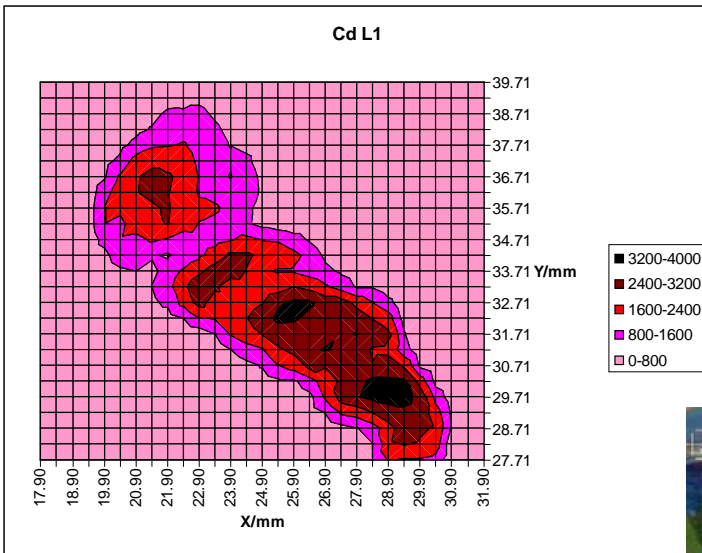


1.5 mm step size

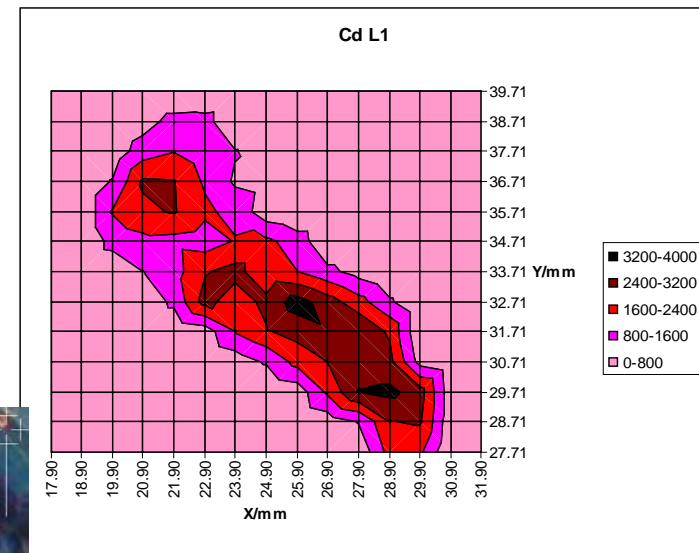


2.0 mm step size

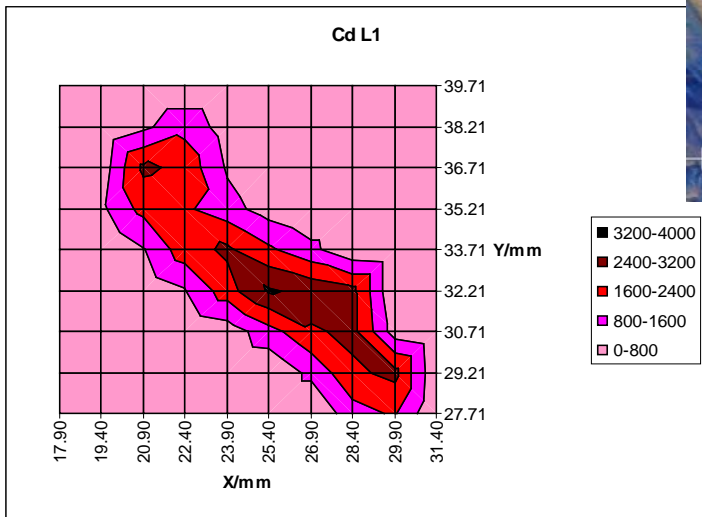
Cd L



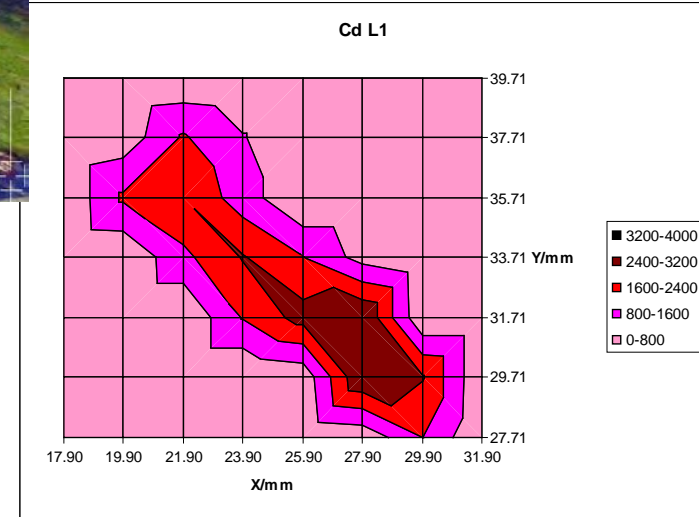
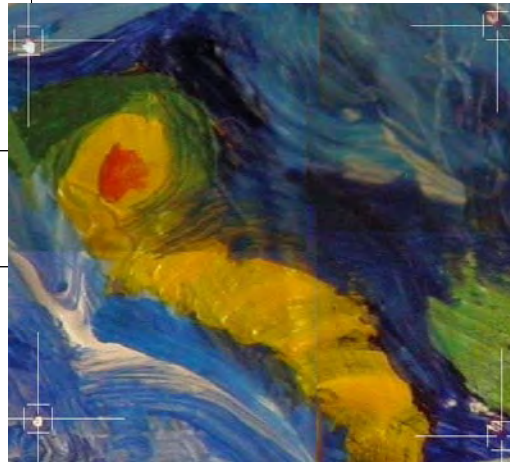
0.5 mm step size



1.0 mm step size



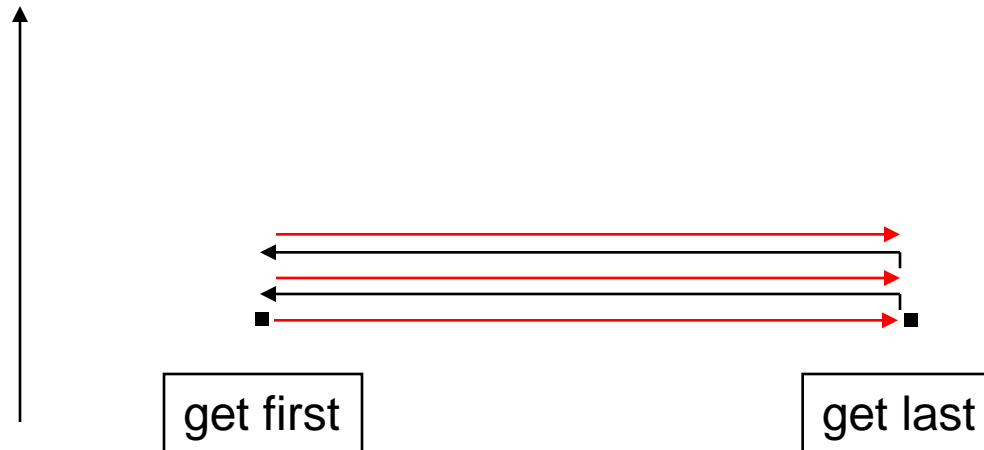
1.5 mm step size



2.0 mm step size

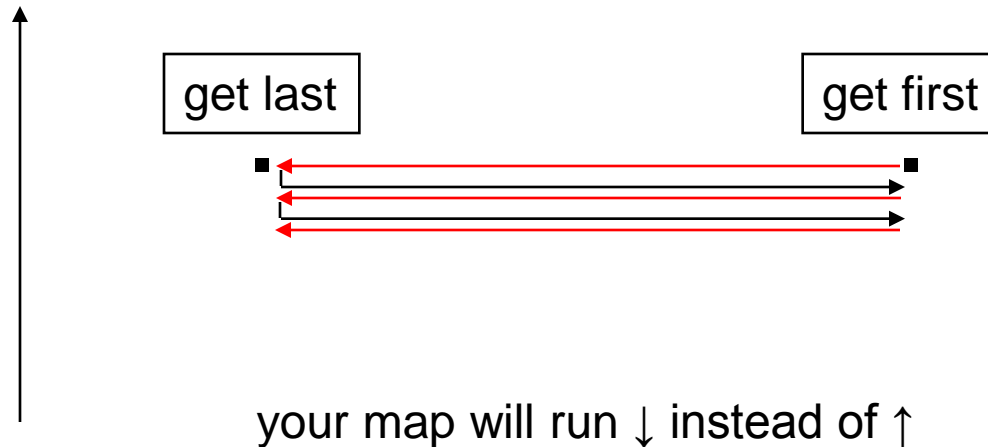
logistics of area mapping

1. choose starting and ending spots in the x-direction
2. choose total distance to be scanned in y-direction
3. start scan (acquisition shown in red, other movement in black)

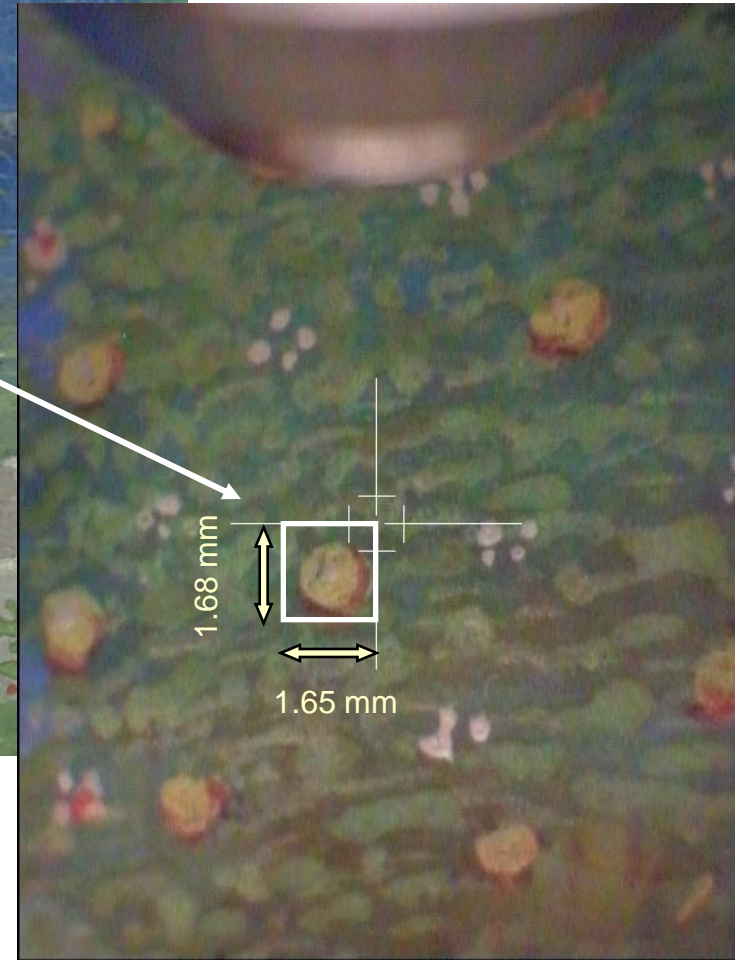
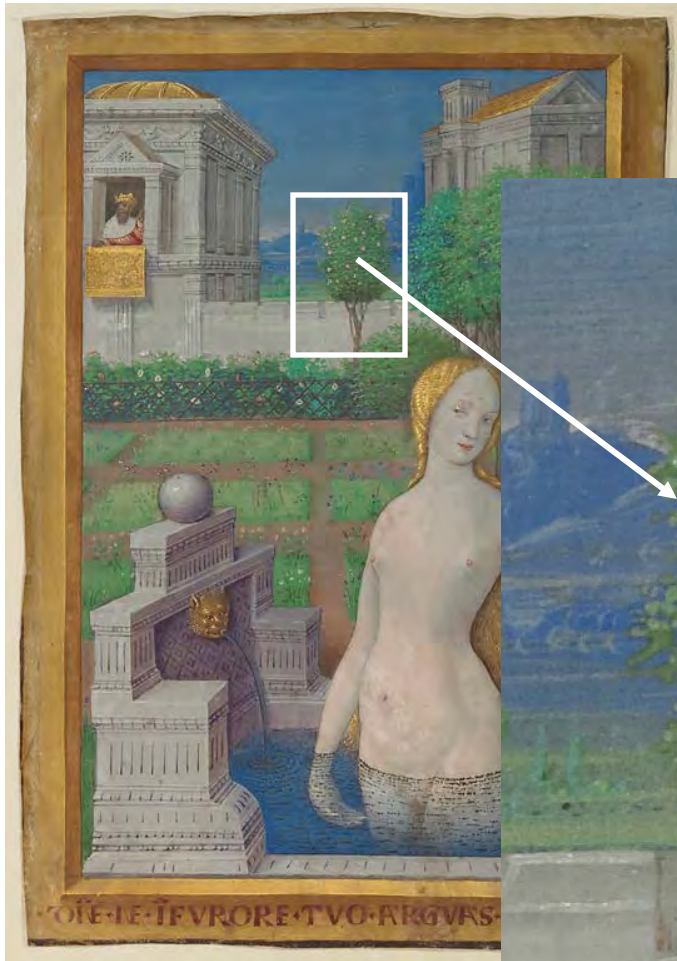


more logistics of area mapping

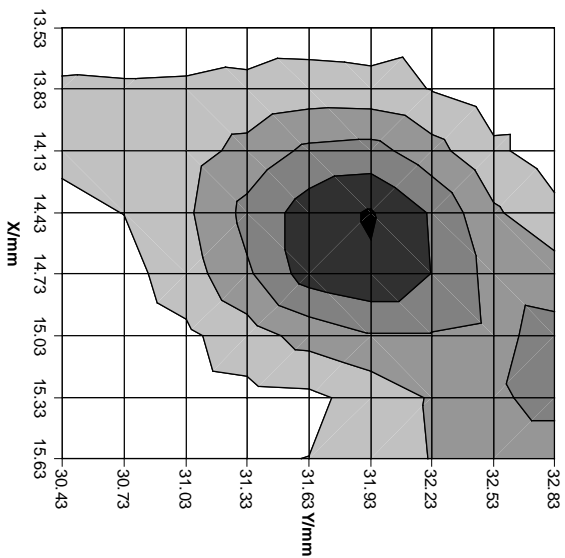
1. if you choose “get first” to the right of “get last”...
2. then choose total distance to be scanned in y-direction
3. and start your scan (acquisition shown in red, other movement in black)



Jean Bourdichon, *Bathsheba Bathing*,
Hours of Louis XII, 1498-99,
JPGM Ms 79 (2003.105)

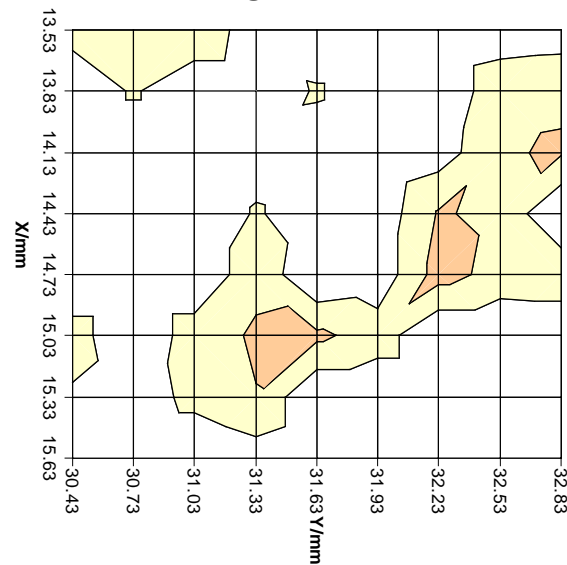


Pb L α

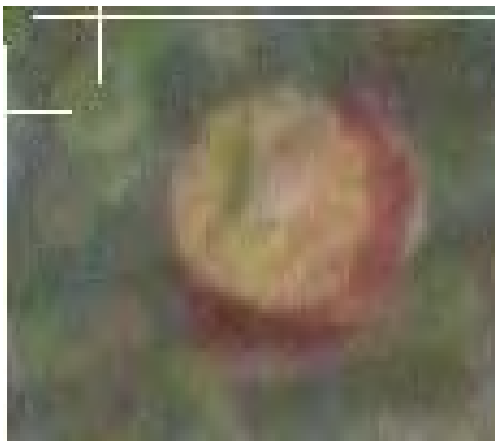
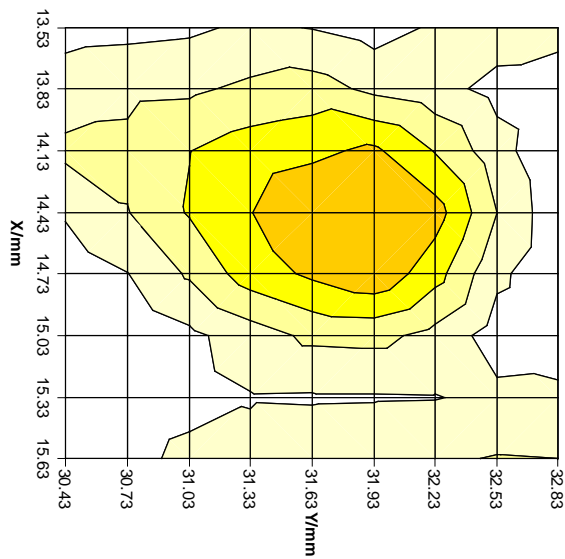


Scan area: 2.40 x 2.10 mm
Step size: 0.3 mm
Beam spot size: 650 μ m
spectra: 72, 30 sec. acq.
W tube, 40kV, 600 μ A
Time: 36 min (live time)

Hg L α

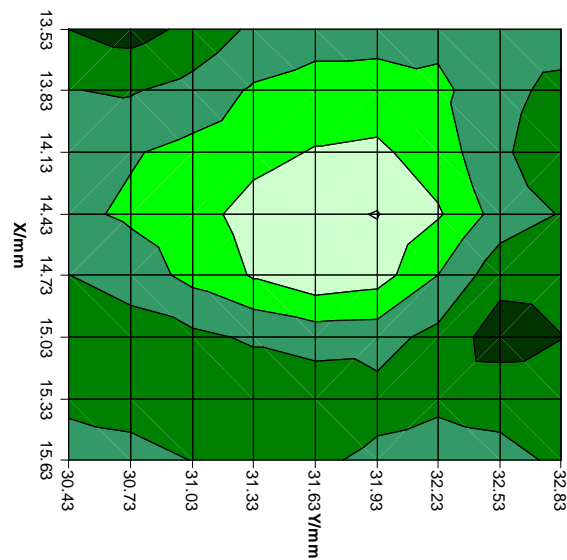


Sn L α

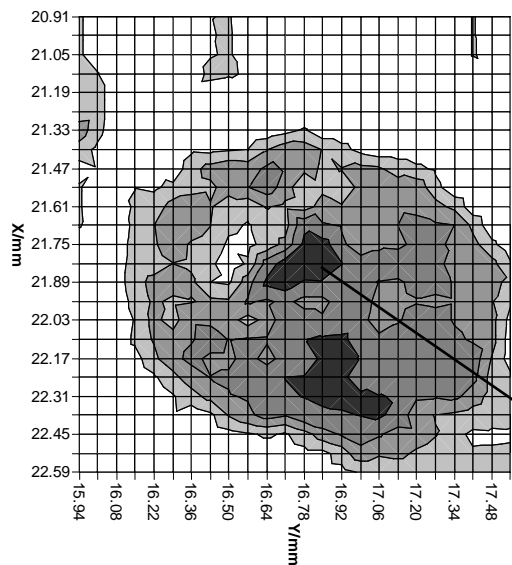


W tube
0.65 mm spot

Cu K α

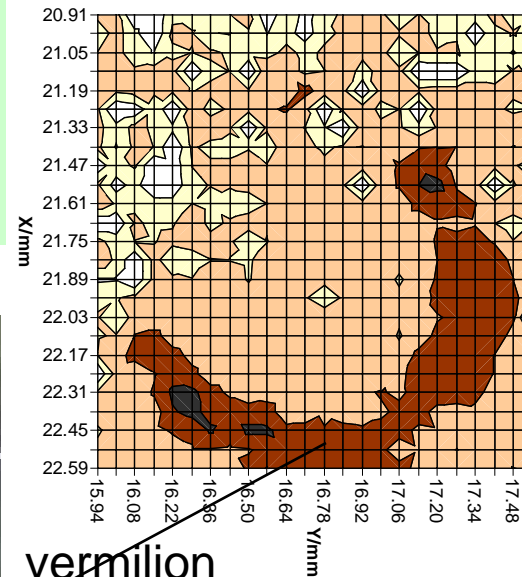


Pb L α



Scan area: 1.68 x 1.65 mm
Step size: 0.07 mm
Beam spot size: 65 μ m
spectra: 600, 20 sec. acq.
Mo tube, 40kV, 600 μ A
Time: 3 hr 20 min (live time)

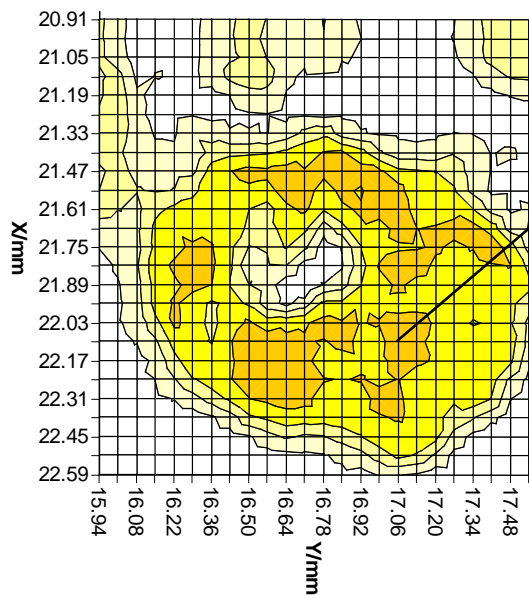
Hg L α



Lead white

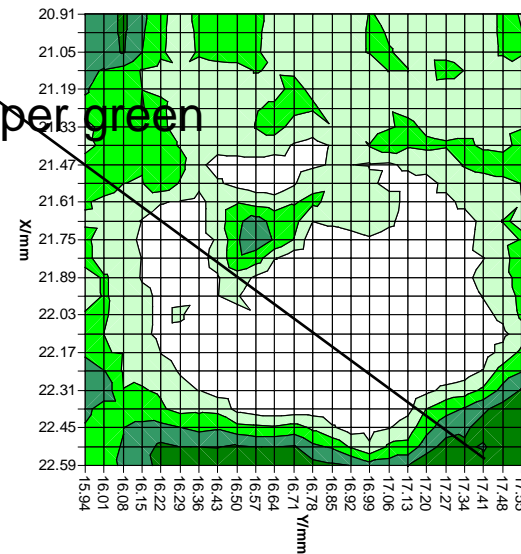
vermilion

Sn L α



Lead tin yellow

Cu K α



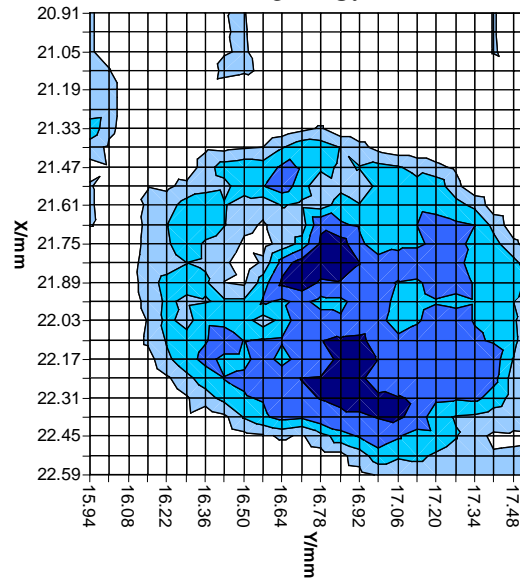
Copper green

Mo tube
0.065 mm spot

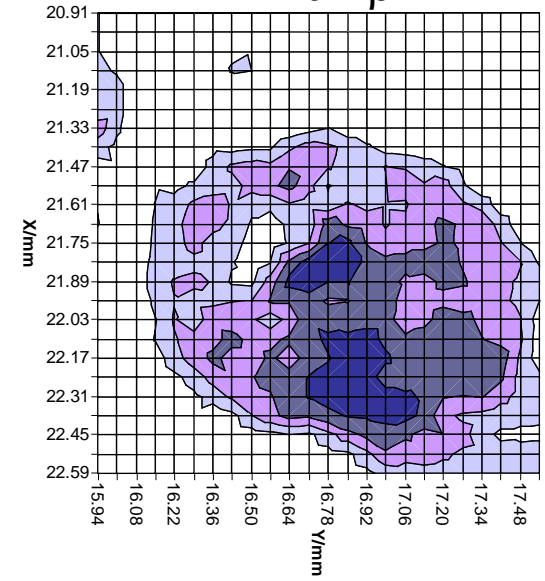
Looking at maps of individual ROIs



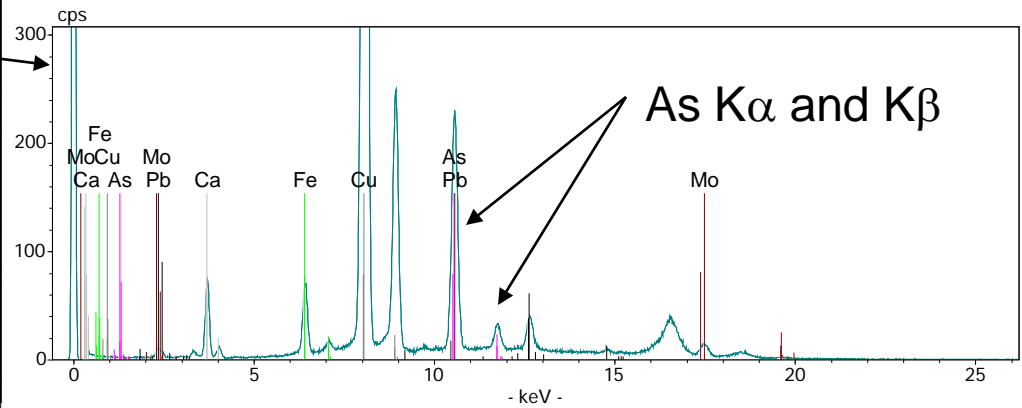
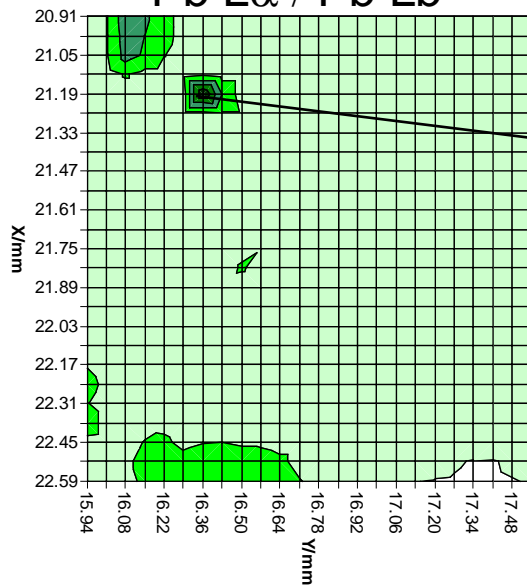
Pb L α



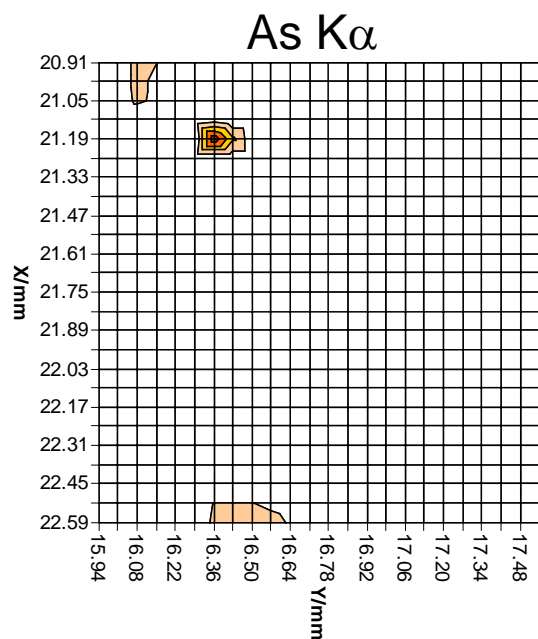
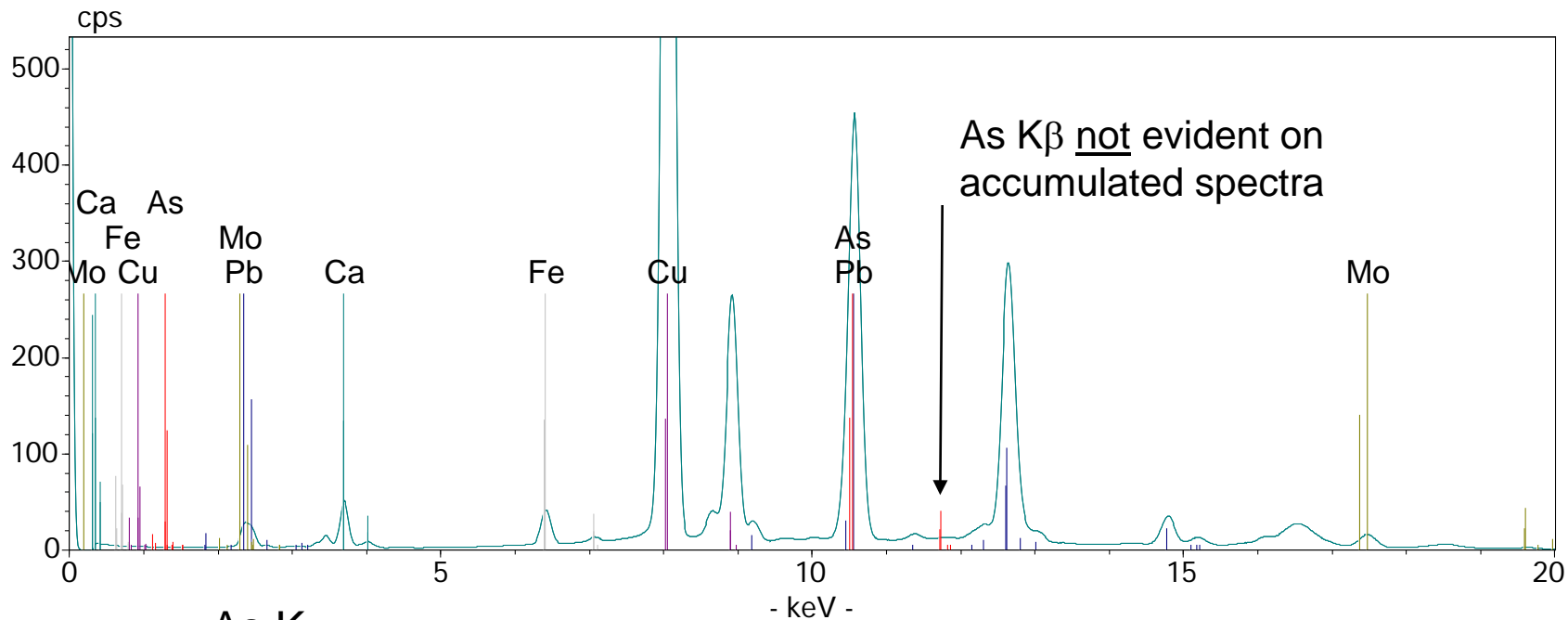
Pb L β



Pb L α / Pb L β

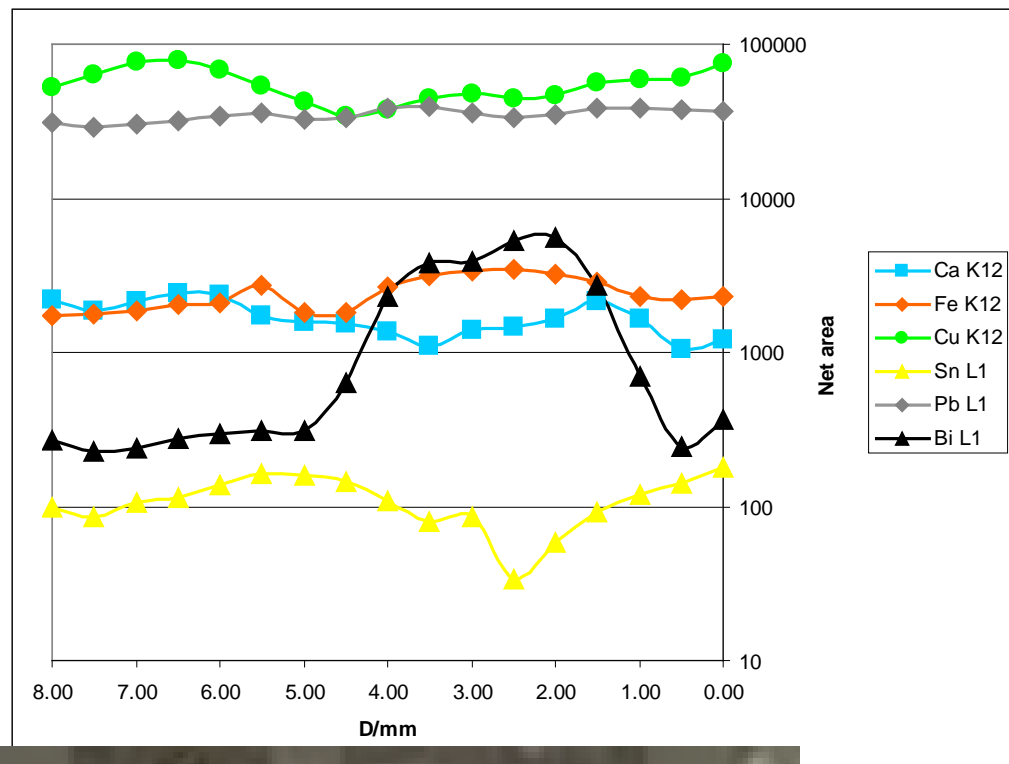
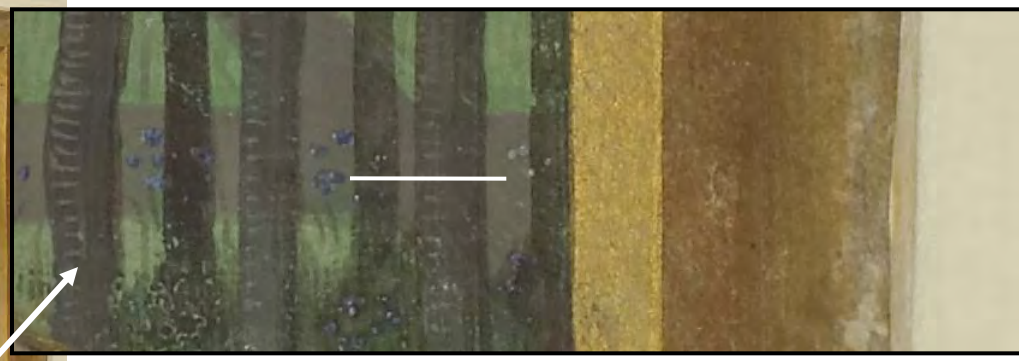
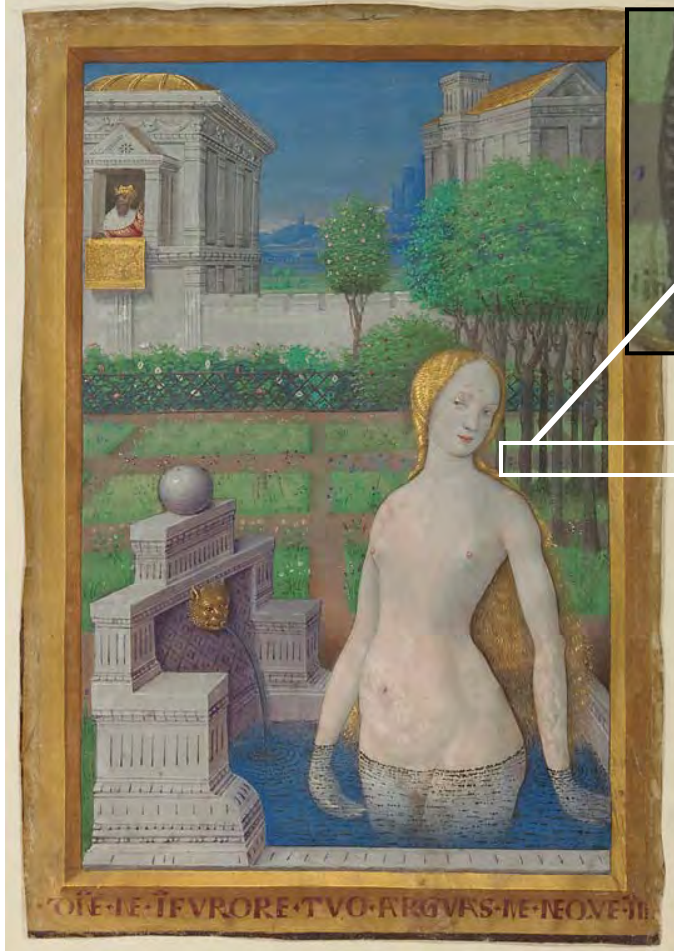


Spectrum from high L α /L β area shows As!

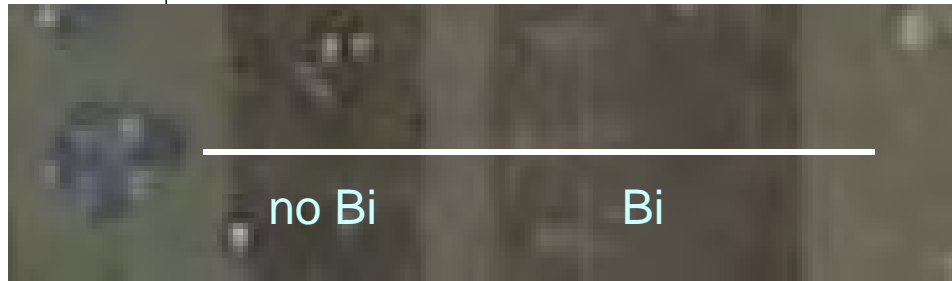


As map
generated by
manually
selecting As for
deconvolution

- Would be helpful to be able to select ROIs for mapping
- Information may be gleaned by looking at $L\alpha/L\beta$ ratios
- Best check is looking at the raw data



Line scan: 8 mm
 Step size: 0.5 mm
 Beam spot size: 0.65mm
 # spectra: 17, 30 sec. acq.
 W tube, 40kV, 600 μ A
 Time: 8.5 min (live time)



The *Laudario* of Sant'Agnese

2005.26; Ascention of Christ



Pacino di Bonaguida

2006.13.v; Martyrdom of St. Lawrence



Pacino di Bonaguida

2003.106; Pentecost



Master of the Dominican Effigies

Pacino di Bonaguida, et al.
Italian
about 1340

Analysis of flesh tones

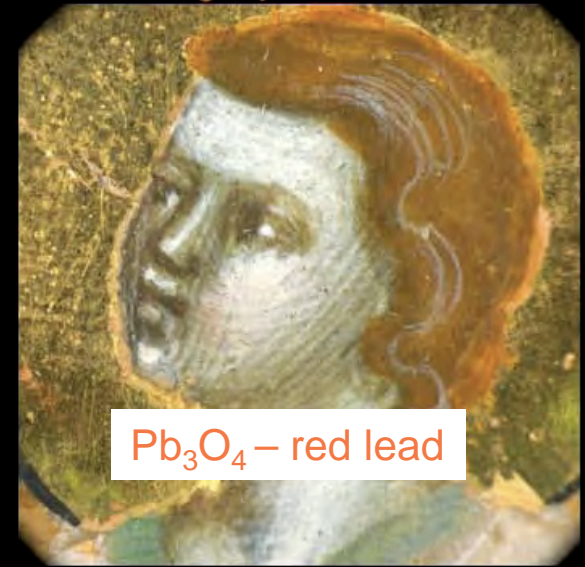


HgS – vermilion

2005.26; Pacino di Bonaguida



2006.13.v; Pacino di Bonaguida



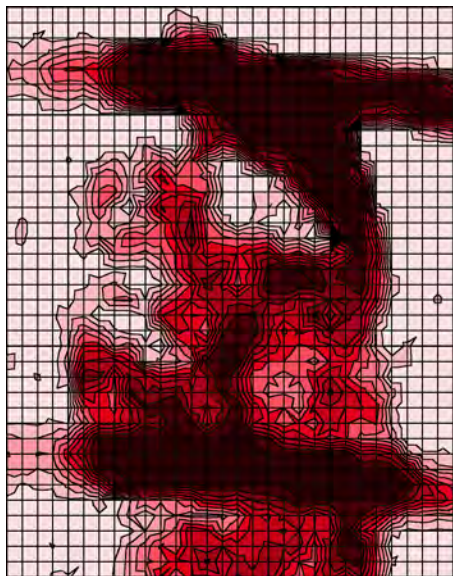
Pb₃O₄ – red lead

2003.106; Master of the Dominican Effigies



- W-tube
- 650 μm x-ray spot size
- 40 kV, 600 μA, no filters
- area maps
 - 0.35 mm step size
 - 10 sec scans
 - > 1000 scans per map

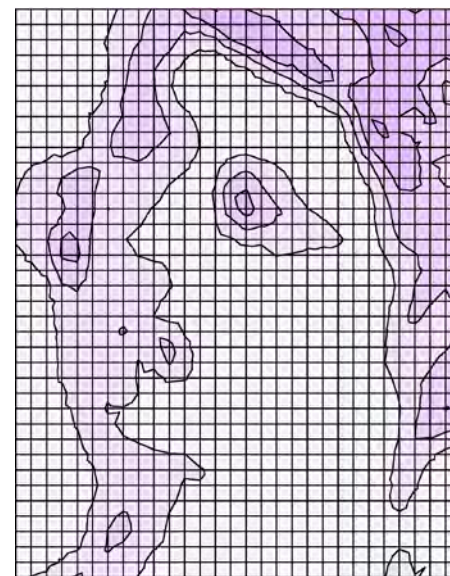
Imaging of 2006.13 (*Martyrdom of St. Lawrence*)



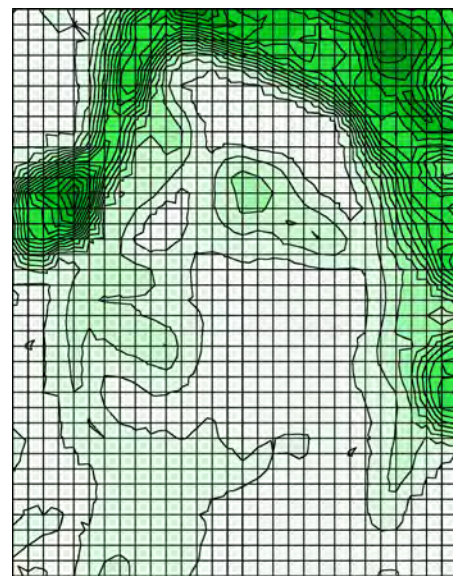
Hg L



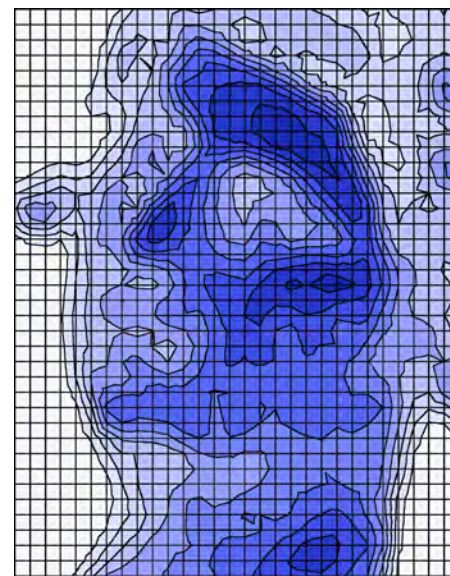
2006.13.v; Pacino di Bonaguida



Ca K

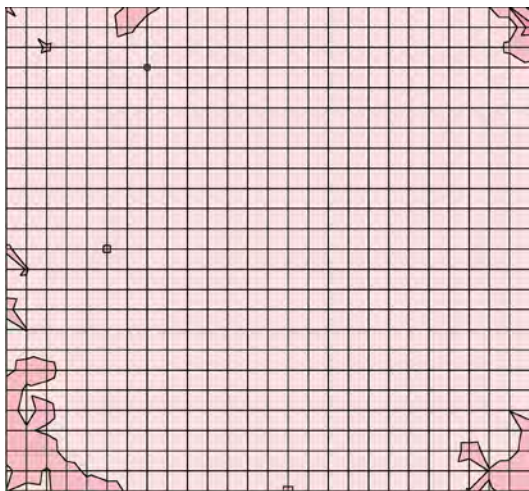


Fe K

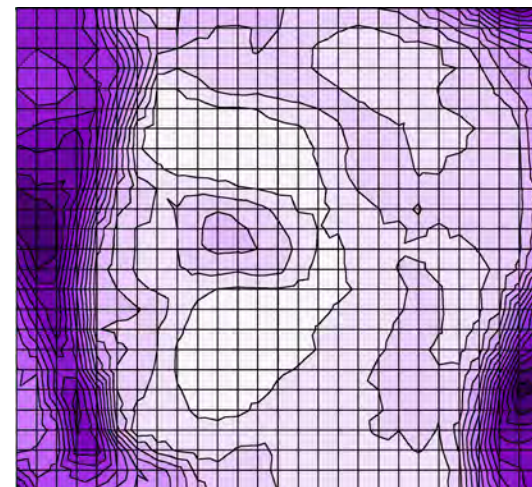


Pb L

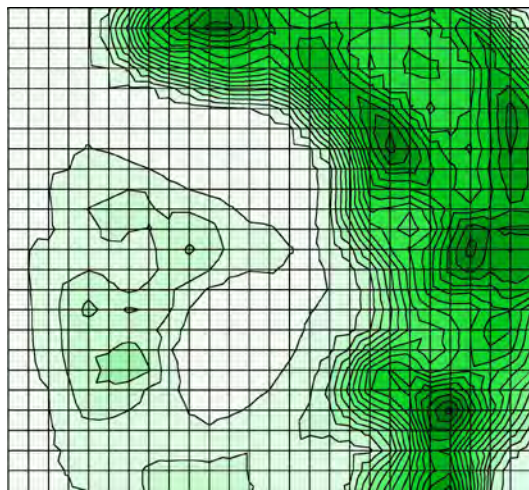
Imaging of 2006.106 (*Pentecost*)



Hg L

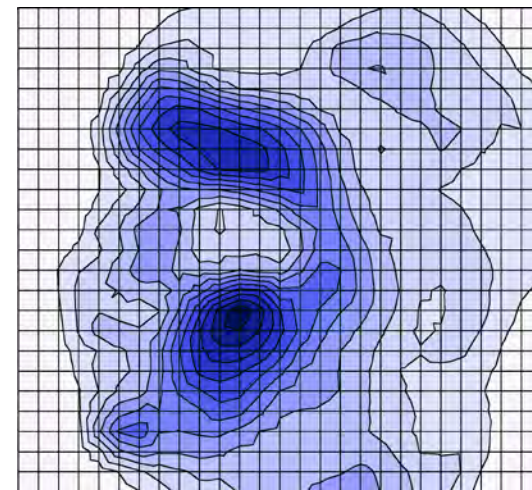


Ca K



Fe K

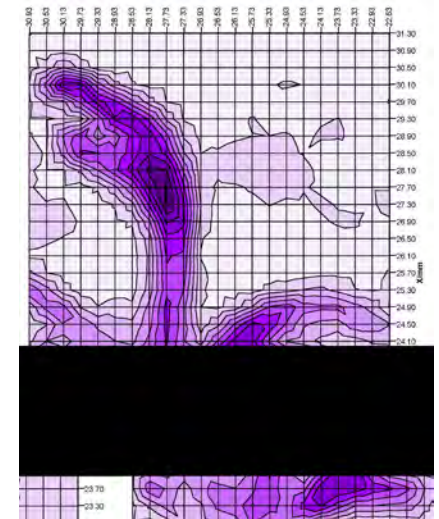
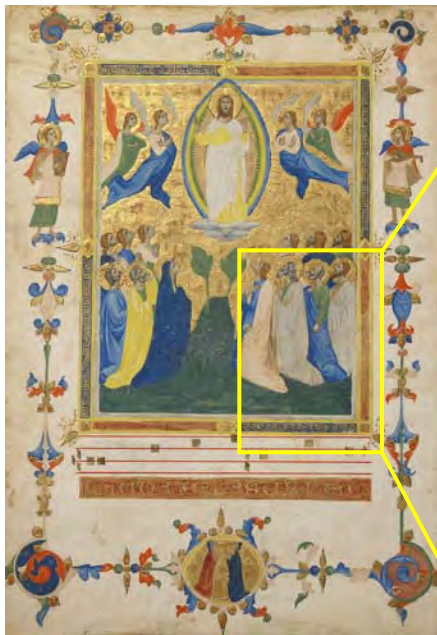
2003.106; Master of the Dominican Effigies



Pb L

Imaging of 2005.26 (*The Ascension of Christ*)

Pacino di Bonaguida



Ca K
map

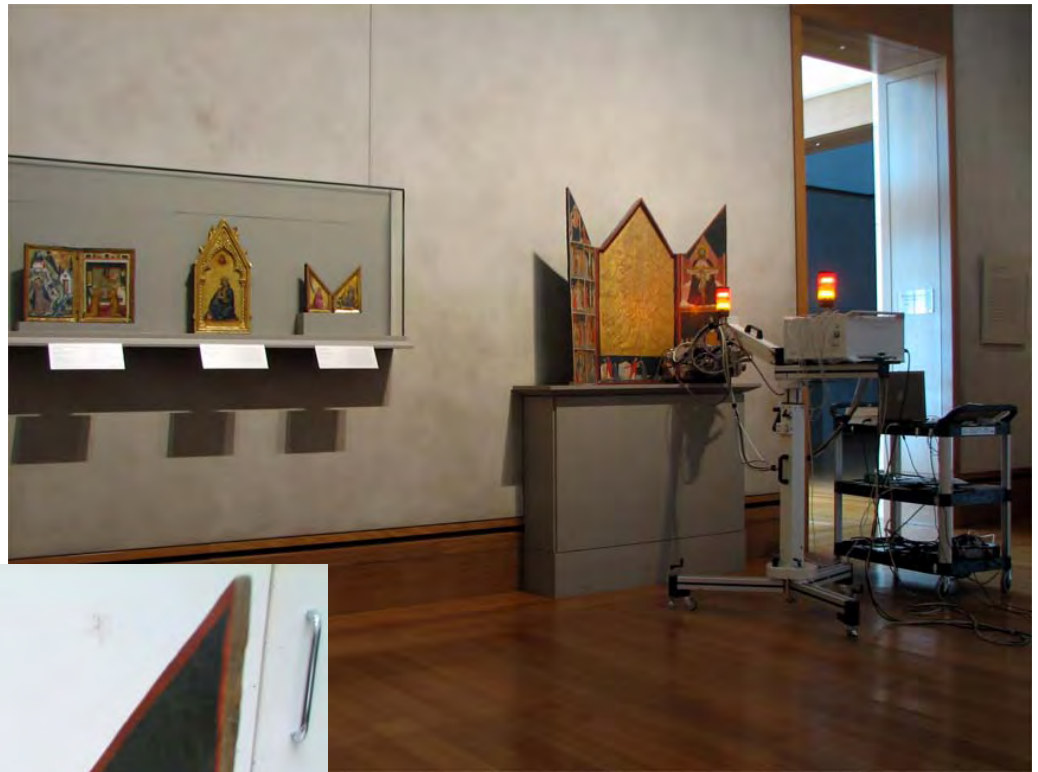
Ca substrate from faded organic lake

- Line scan to compare to area plot of little plant



Pacino's Chiarito Tabernacle

In the gallery....



In the laboratory....



Pacino di Bonaguida
Chiarito Tabernacle
Italian, about 1340s
Gilded gesso and tempera on panel
38 1/4 x 11 5/16 in.
JPGM 85.PB.311

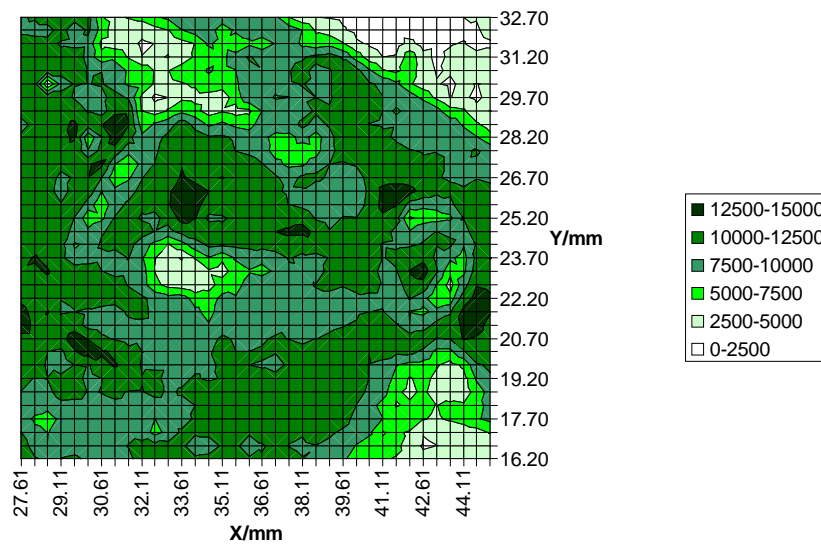
Pacino's

Chiarito Tabernacle
JPGM 85.PB.311

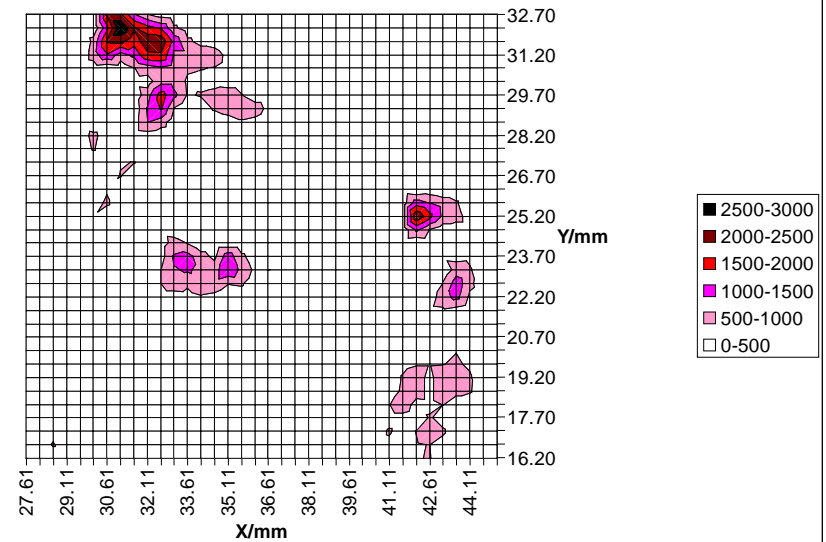


Map of Chiarito's face

Fe K12

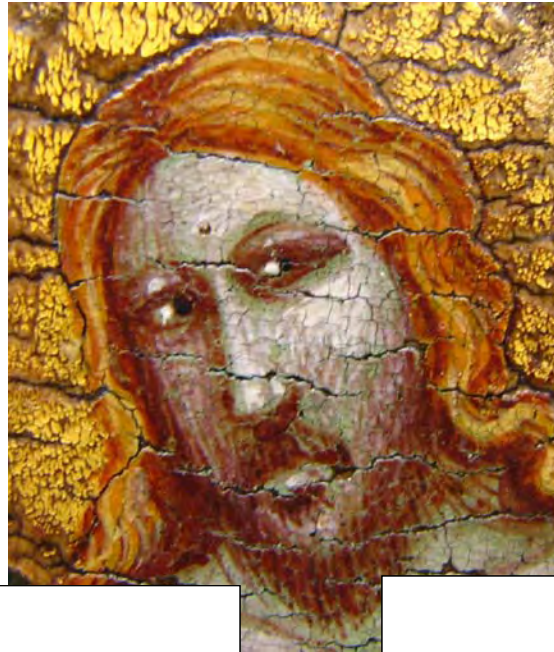


Hg L1

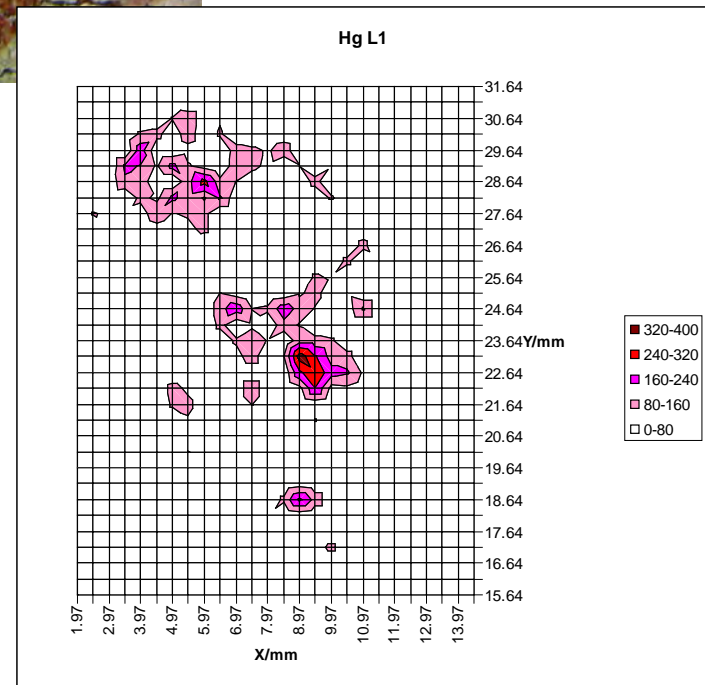
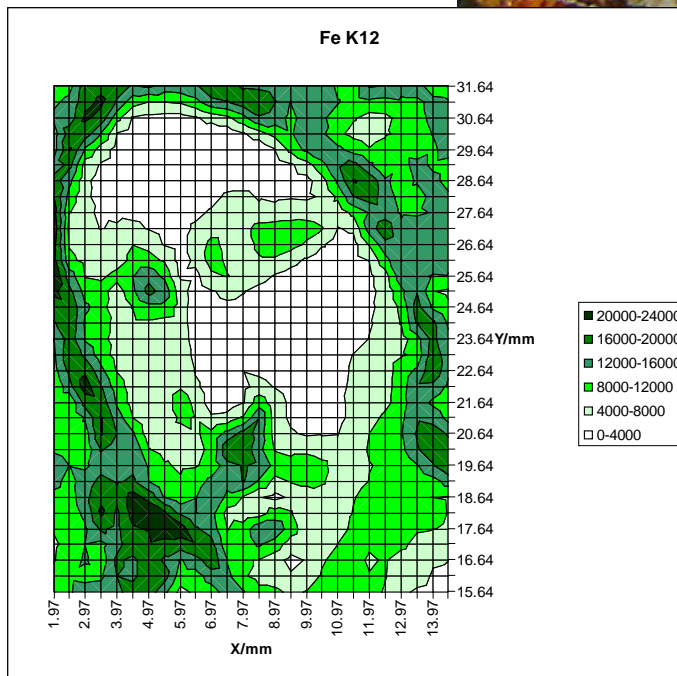


Pacino's

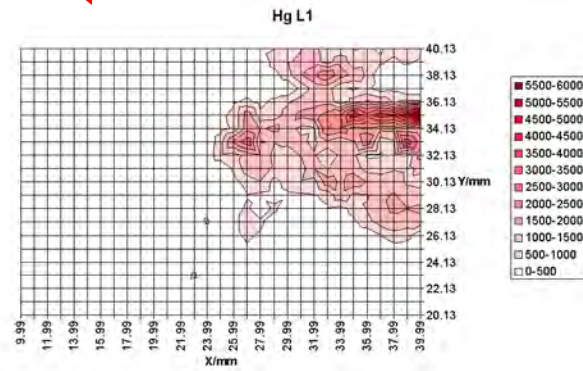
Chiarito Tabernacle
JPGM 85.PB.311



Map of Jesus's face



Rembrandt's *Old Man in Military Costume* (78.PB.246)





JPGM Accession #: 2008.41.2

Artist/Maker: P. Cipriani

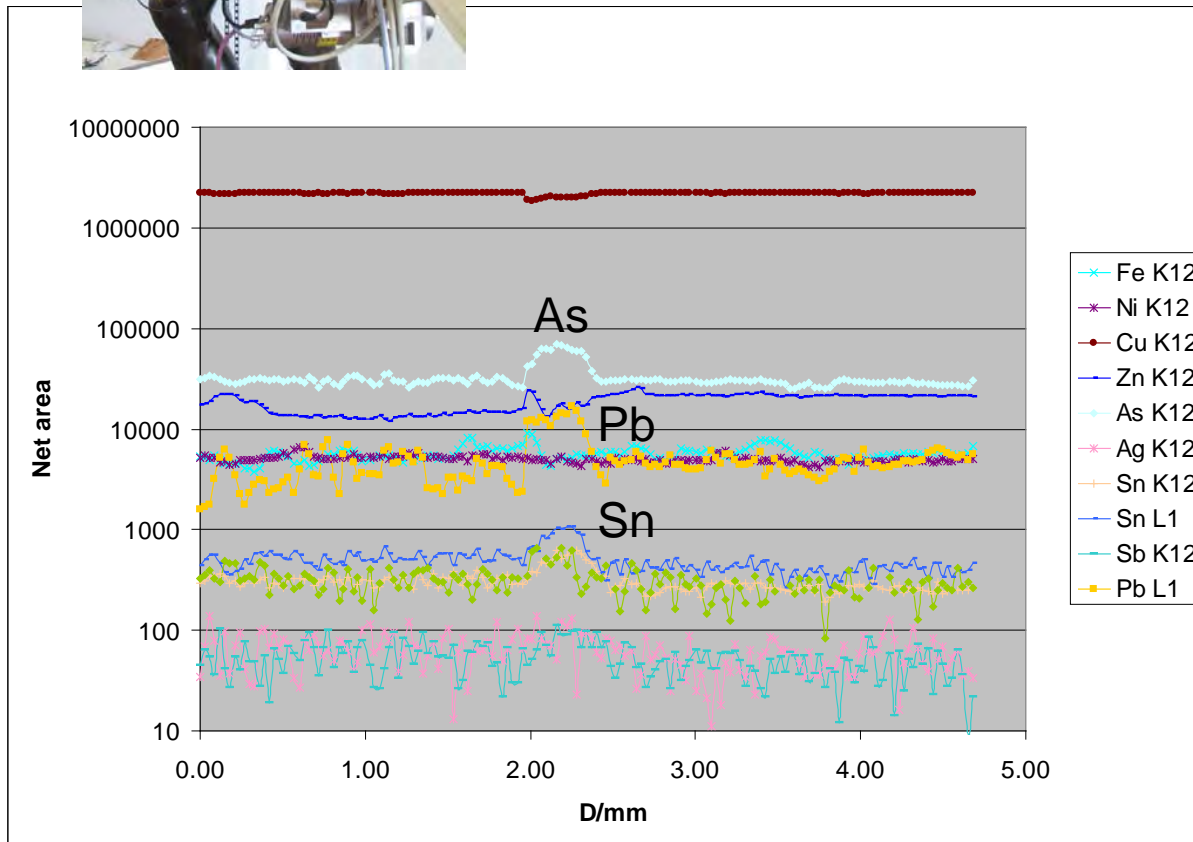
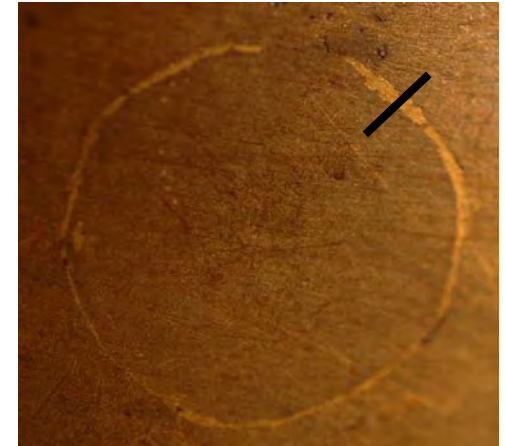
Title: Dancing Faun

Execution Date: 18th century

Dimensions: H: 143.5 cm



Line scans show increase in Pb, As and Sn across the solder line.



Parameters:
Mo tube, 50kV/200 μ A
No vacuum, No filter
45 sec scans,
0.03 mm/step
158 spectra
total distance 4.68 mm



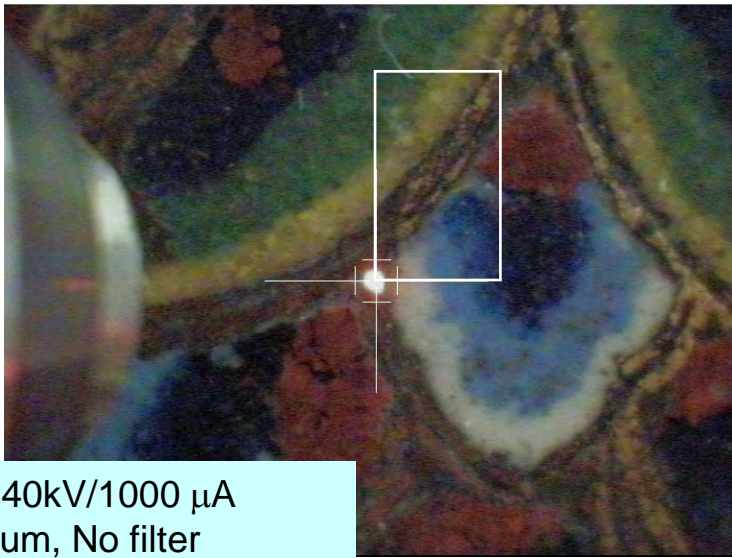
Christ in Majesty

Limoges School
French, about 1188

Copper (half relief), engraved, gilt,
champlevé enamel, colored glass

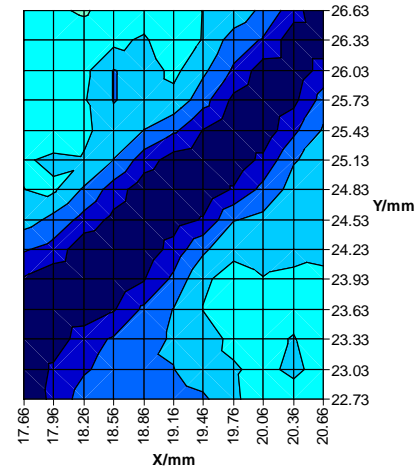
H: 17 7/8 in.

JPGM 2007.6

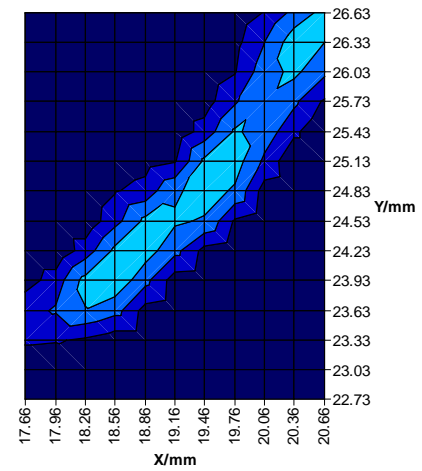


W tube, 40kV/1000 μ A
No vacuum, No filter
60 sec scans,
0.3 mm/step
154 spectra
Area mapped: 3.0 x 4.0 mm

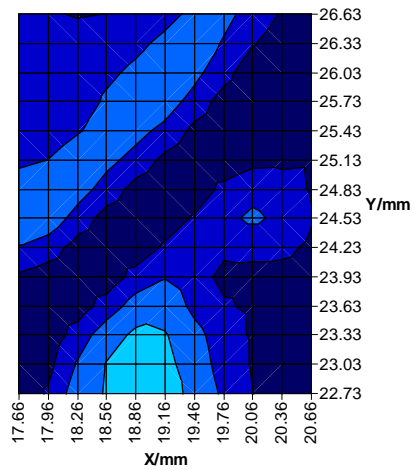
Si



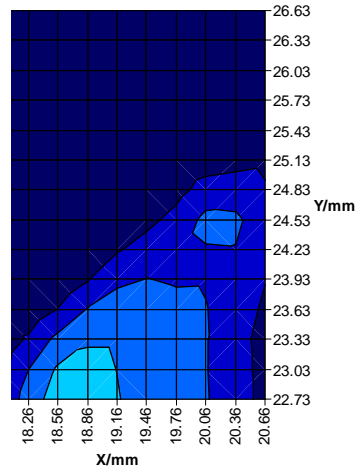
Au



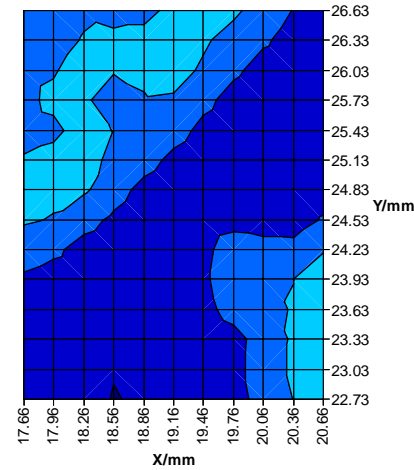
Pb



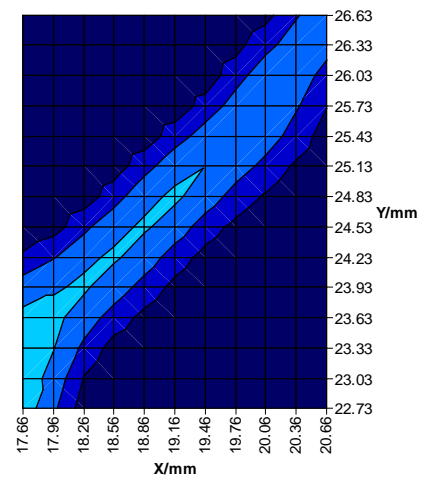
Sn



Sb



Cu



Quantitative analysis of low Z materials

Polycapillary
(65 μm spot)

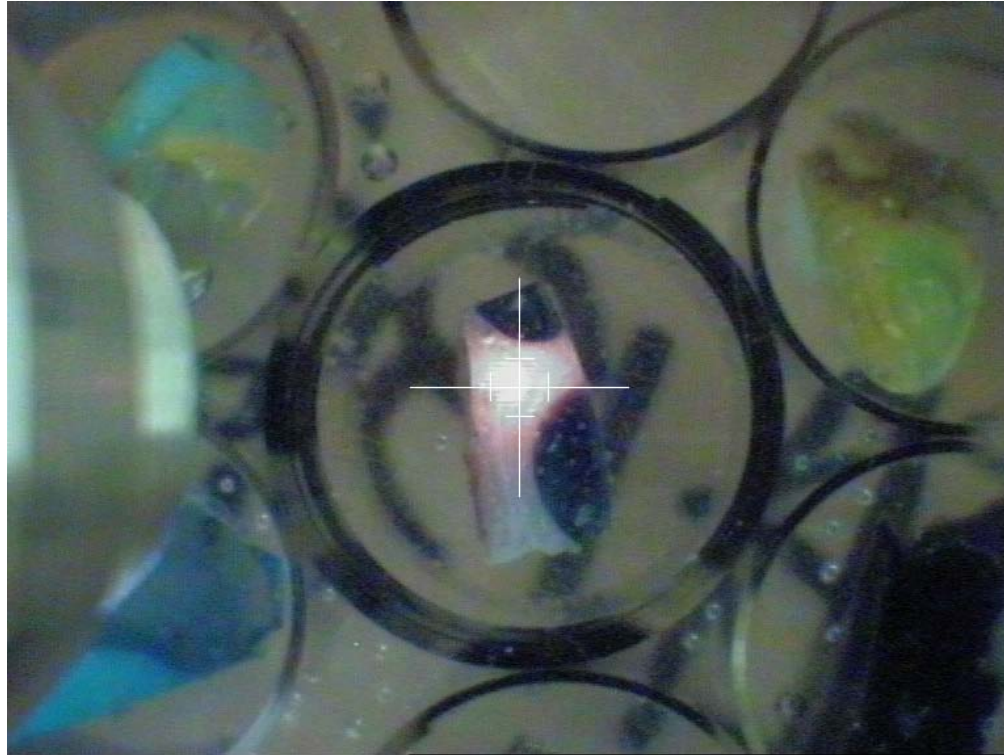


He purge
streams from
both X-ray tube
and detector

Hellenistic glass object from Black sea region

No reasonable regions available for sampling

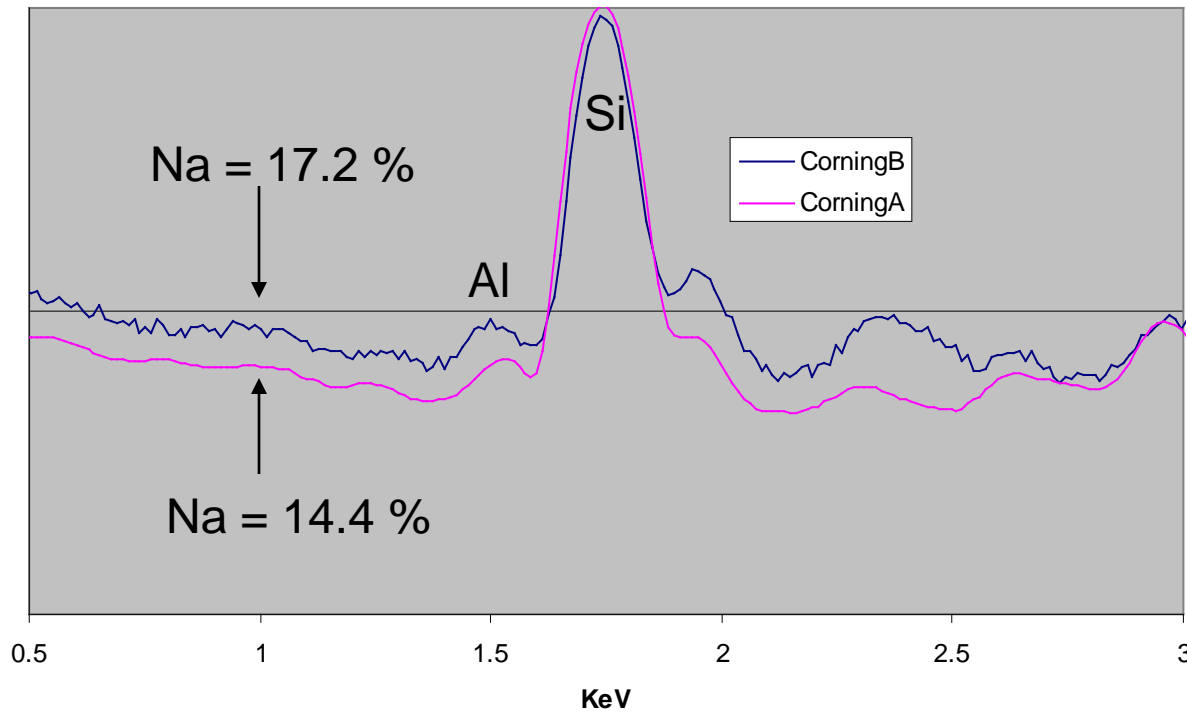
Can a reasonable analysis of glass be achieved by polycapillary XRF with He purge?



Test case: mounted and polished glass samples from Pinchnvari (black sea) already run by SEM/WDS.

Identical matrix to intact vessels that can't be sampled

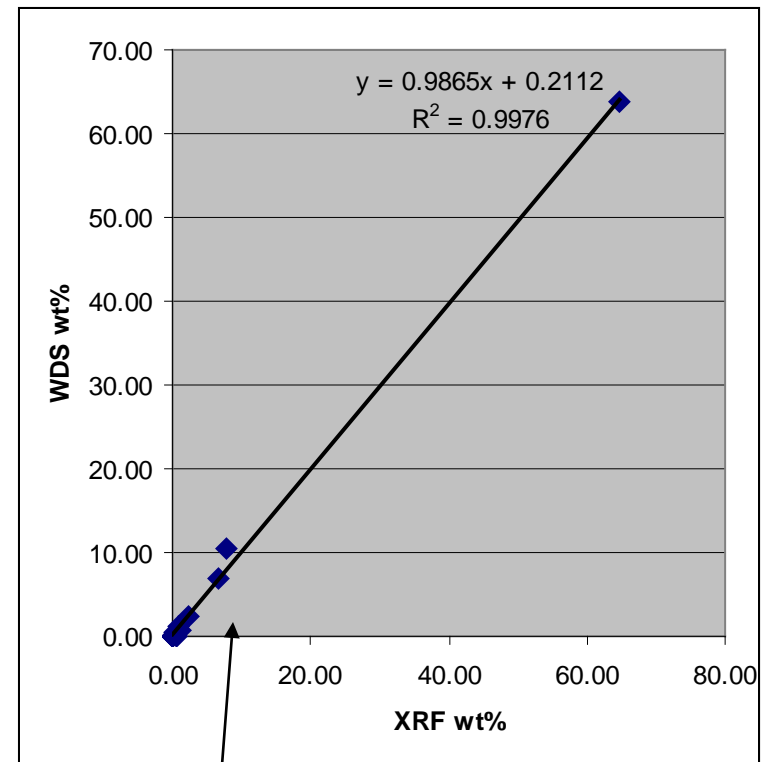
Problem: Even with He purge poor response for low Z



Can't "see" major elements below Al

Poor correspondence
in Na and Mg

	Pic16b XRF	WDS
Na ₂ O	1.86	12.44
MgO	0.01	0.44
Al ₂ O ₃	2.45	2.27
SiO ₂	64.69	63.73
K ₂ O	0.36	0.51
CaO	6.76	6.92
TiO ₂	0.06	0.06
MnO	0.02	0.03
Fe ₂ O ₃	1.14	0.79
CoO	0.01	0.00
CuO	0.02	0.03
SnO ₂	0.60	0.02
Sb ₂ O ₃	0.77	1.10
PbO	7.69	10.50



Above Mg, good linear response
between XRF wt% and WDS wt%
values!

Quantification based on empirical calibration curve

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