TESCAN

PERFORMANCE IN NANOSPACE

FYZIKA VE FIRMĚ

Martin Zadražil, 9.11.2011

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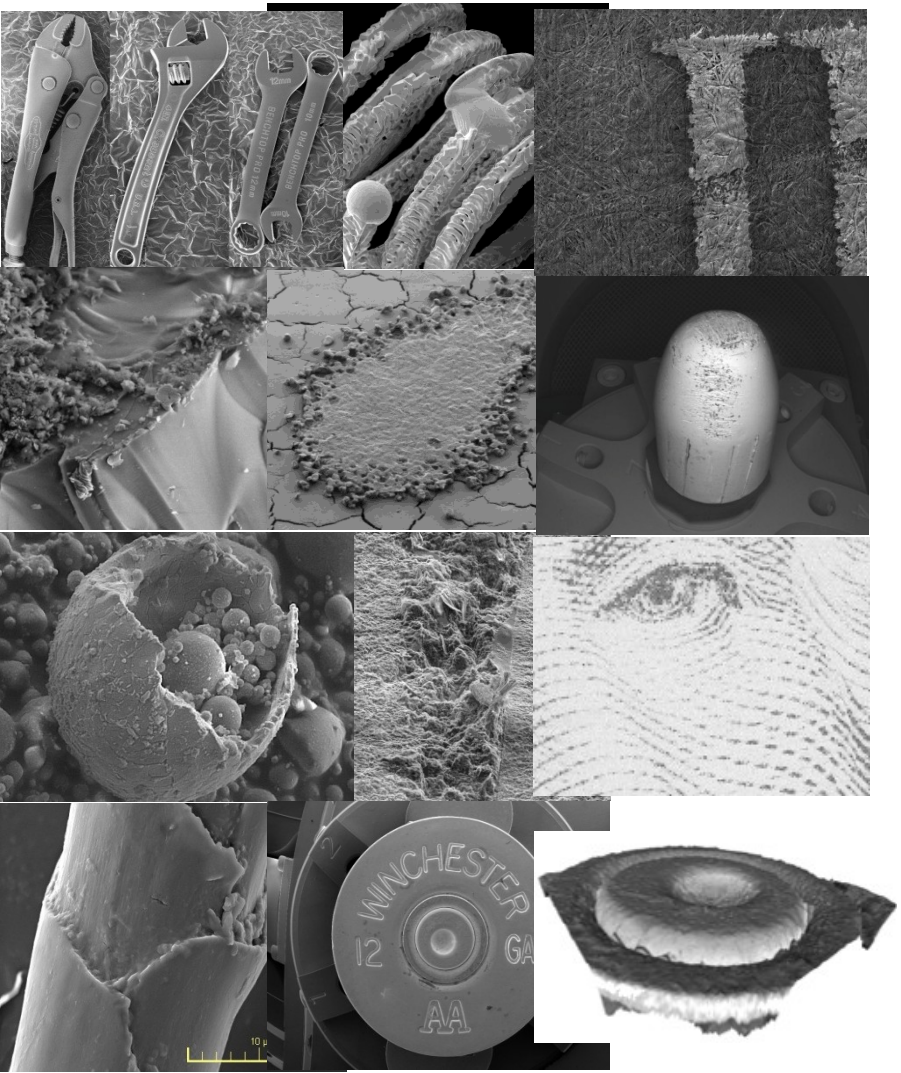
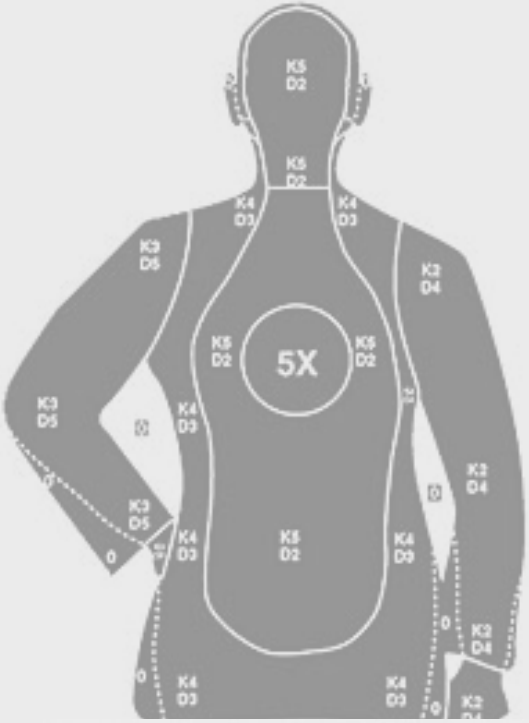


Forensic Applications in SEM :

- Gun shot residue analysis (GSR)
- Bullets and cartridge investigation
- After car crash filament and bulb investigation
- Tool marks investigation
- Analysis of hairs, textiles and papers
- Paints, prints and ink analysis
- Counterfeit signatures, bank notes
- Minerals, soils and metals analysis
- and many others...



Gunshot Residuum analysis.

- Identification of the shooter
- According GSR particles on hands/clothes
  - Typical size, shape
  - Typical composition: Pb, Sb, Ba.

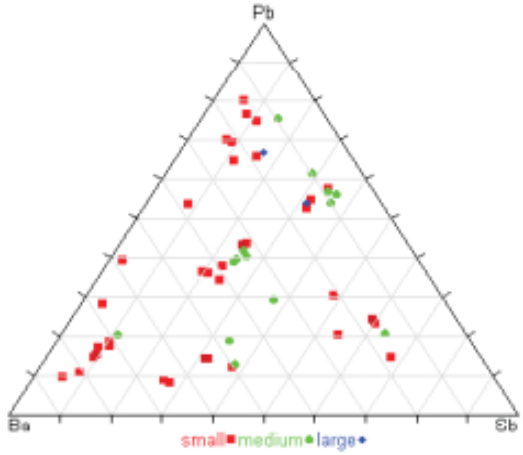
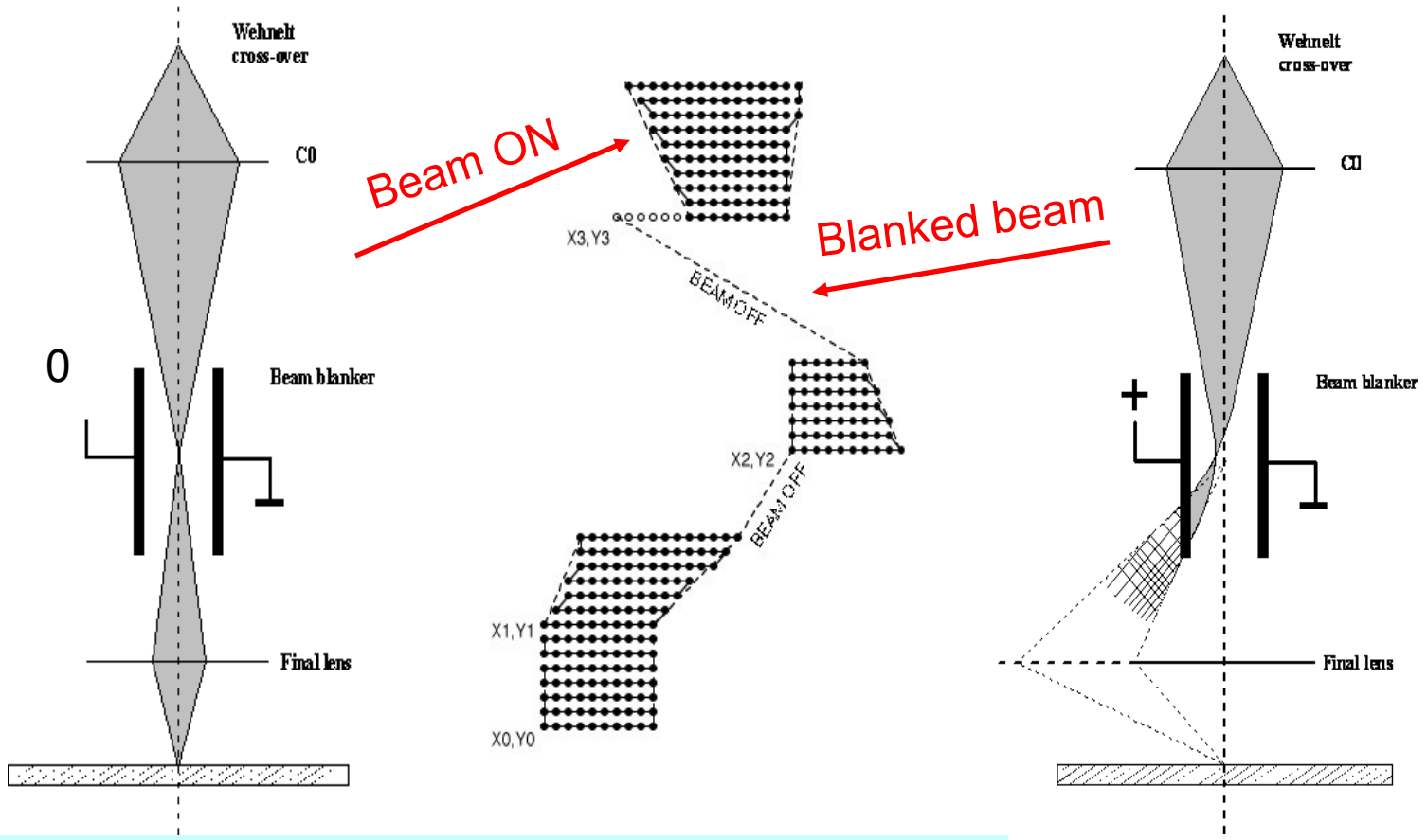
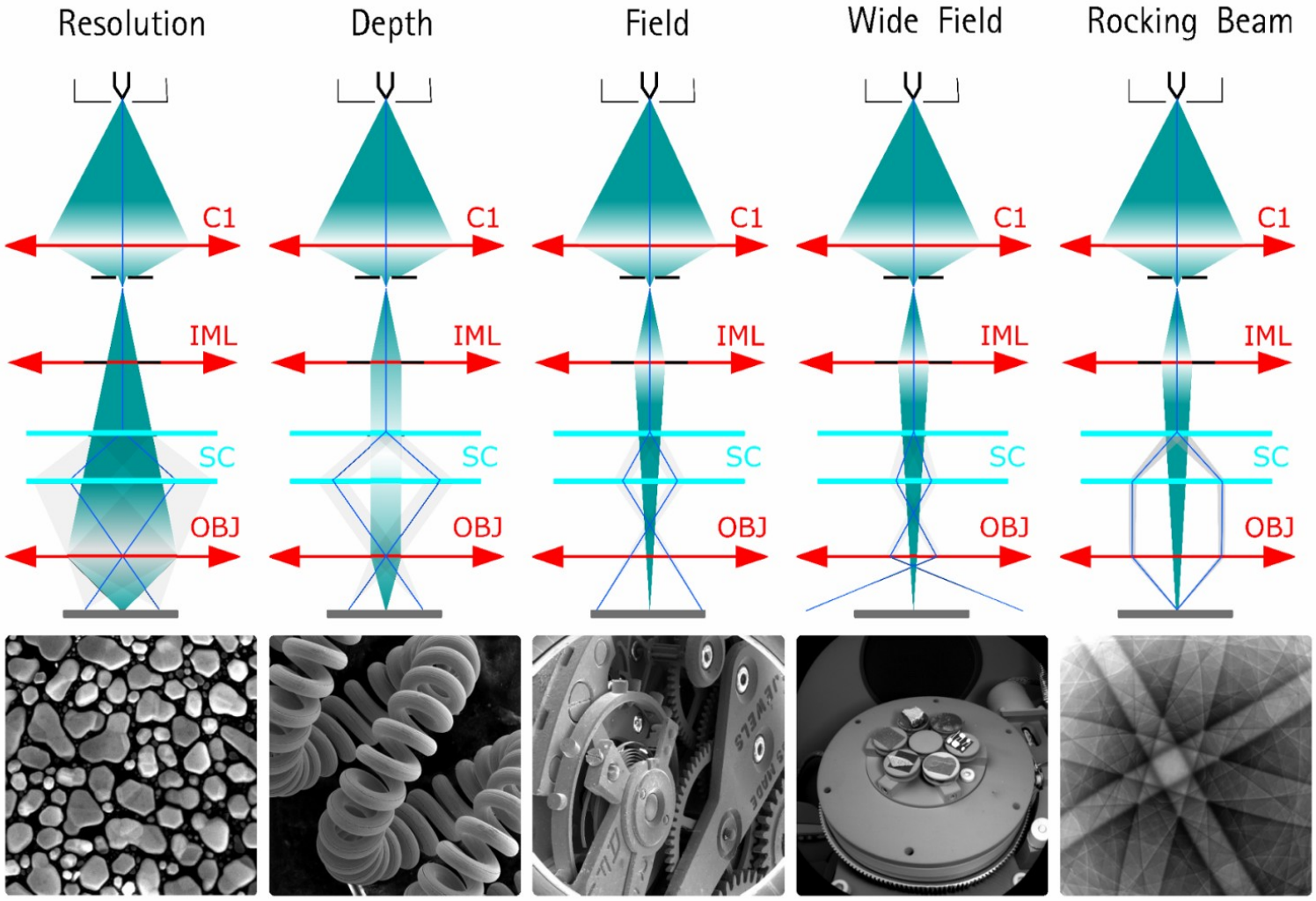


Fig. GSR Particles composition in ternary chart

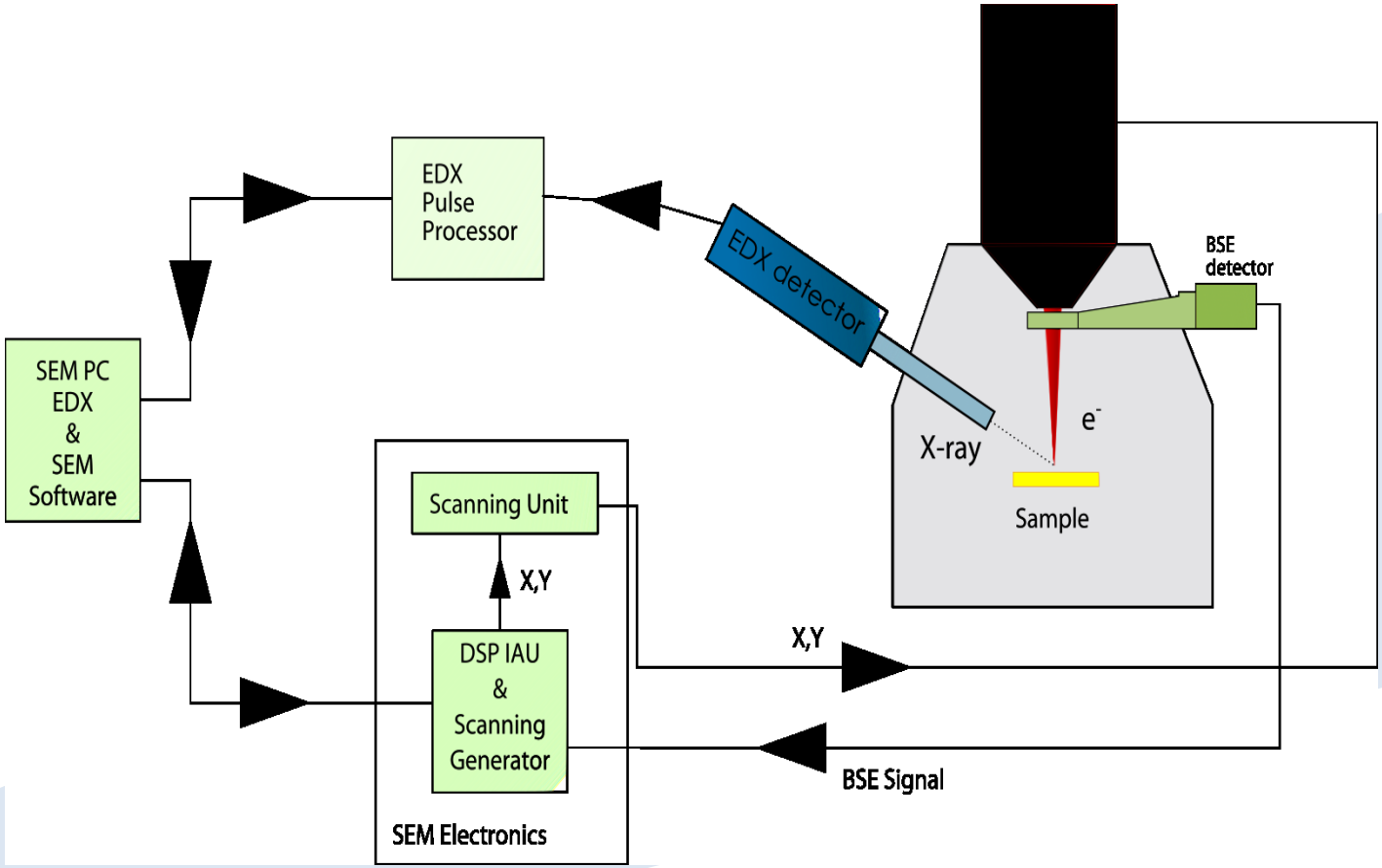
Beam interruption – Beam blanker



- Beam blanker electro-statically deflects the electron beam

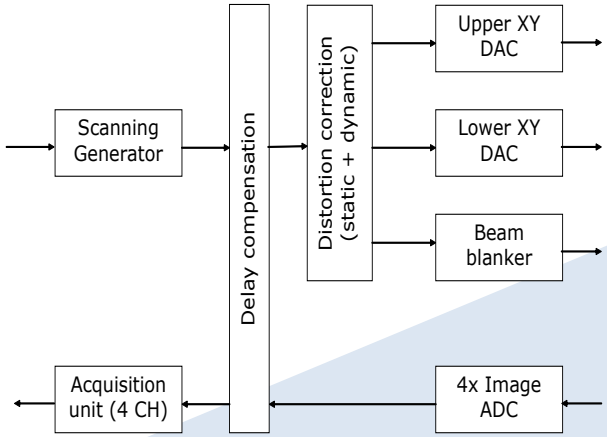

Resolution
Depth
Field
Wide Field
Rocking Beam
C1
IML
SC
OBJ

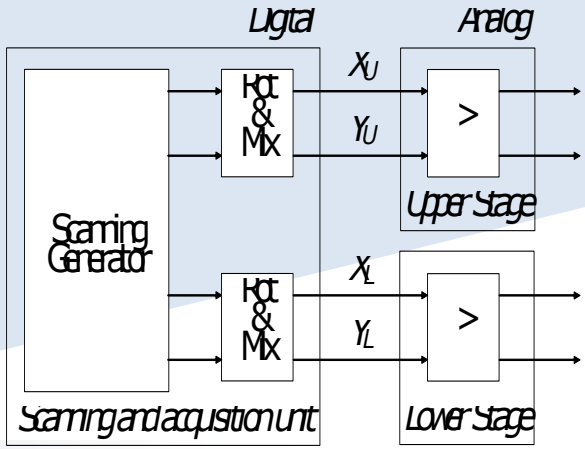
TESCAN TRACE GSR Hardware Integration



Scanning Generator

- Powerful 50 MHz internal Pattern Generator
- 2 x DAC for each stage of deflection coils (X, Y)
- 16-bit scanning ramp DACs
  (65,536 x 65,536 virtual write field)
- Variable dwell time
- Static and dynamic distortion correction
- Digital compensation of field errors
- Automatic control of electrostatic beam blanker (10 MHz)





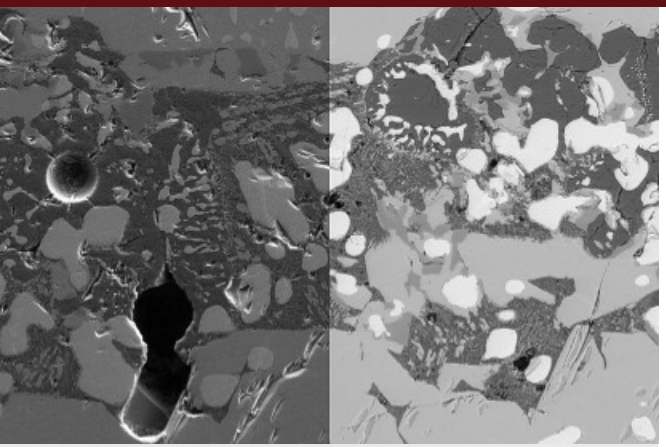


Fig. On-line SE/BSE signal mixing

Dwell/pix	1Mpix	100 fields analysis
50 us	50 s	> 1 hour
100 ns	0.2 s	< 3 min

Fast detectors save time!!

Synthetic YAG crystal

- High efficiency – low noise
- Fast response
- Unlimited lifetime
- Suitable for high vacuum

SE – Everhardt-Thornley type with YAG

Fast imaging rate (20ns/pix)

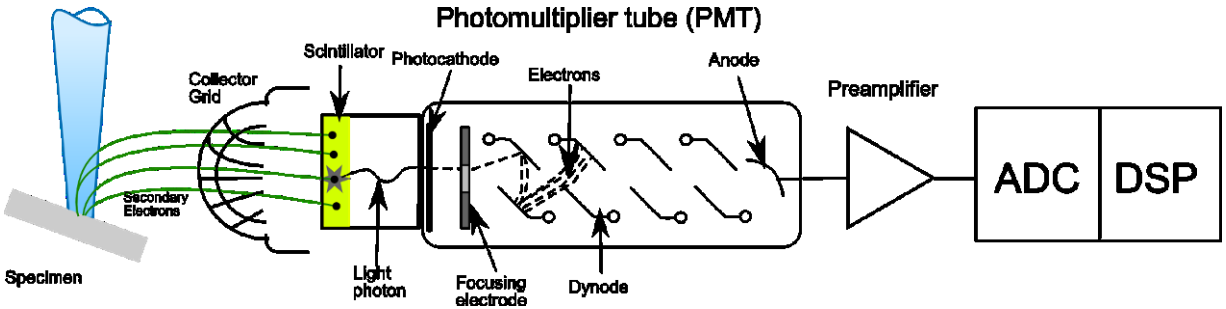


Fig. Everhart-Thornley SE Detector

Fig. Phase identification by material contrast
Used for GSR particles location

Backscattered Electron Detector

- Crucial for GSR applications
- Detection of particles containing heavy elements

Tescan R-BSE detector

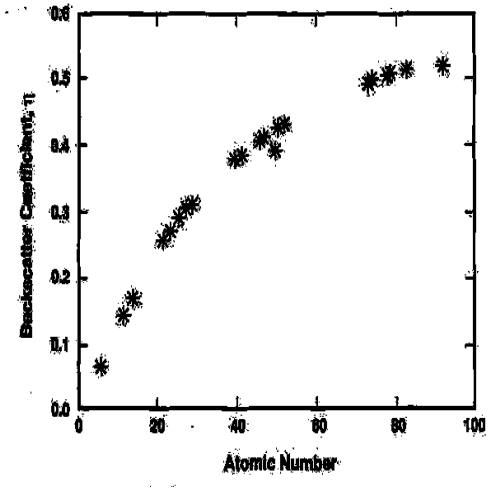


Fig. Dependecy of BSE intensity on Atomic number

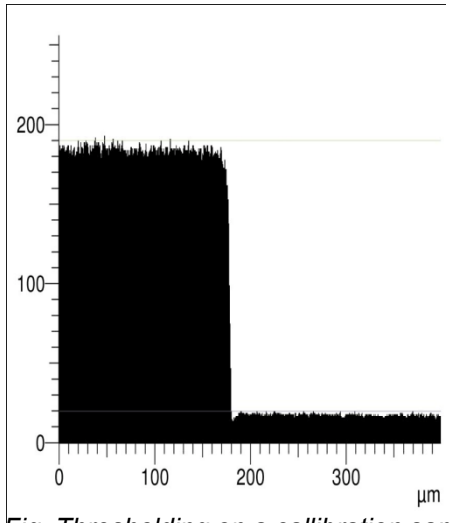


Fig. Thresholding on a callibration sample

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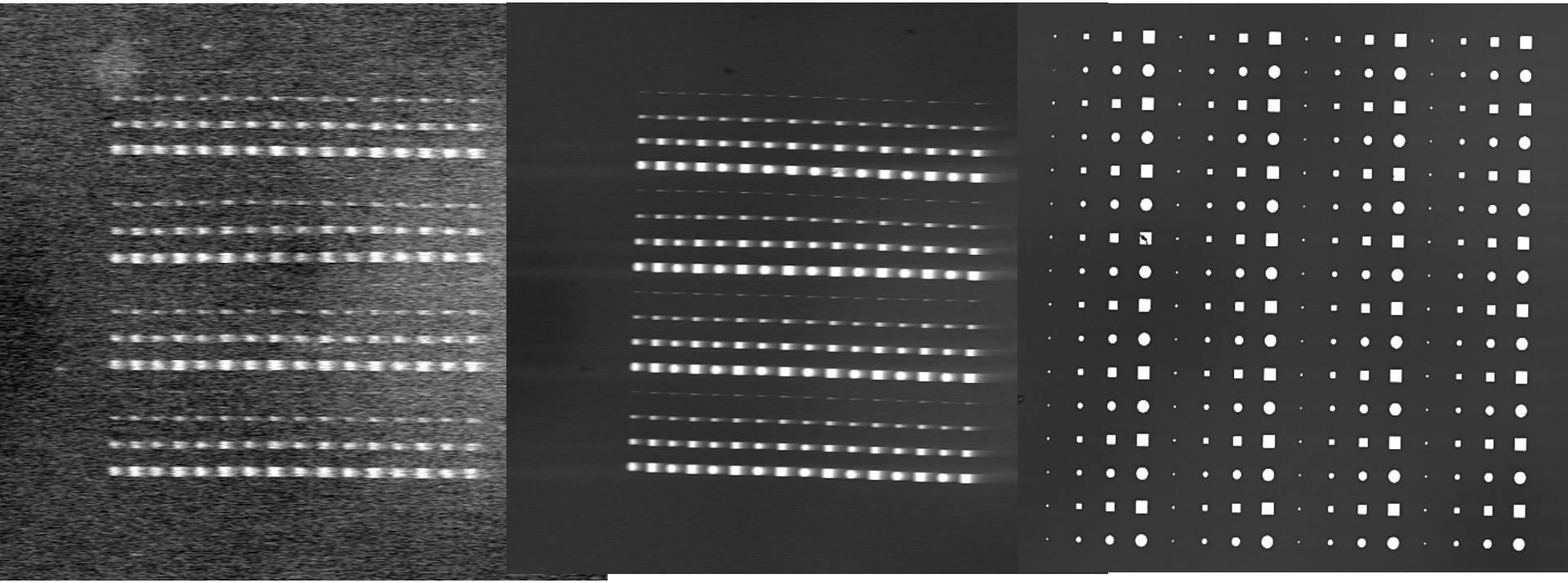
Testing sample: Gold on Si imaging standard



Low-end solid-state BSE detector
1us/ pixel

Middle-class scintillation BSE detector
500ns /pxl

Latest generation
Tescan YAG scintillation BSE
100ns /pxl

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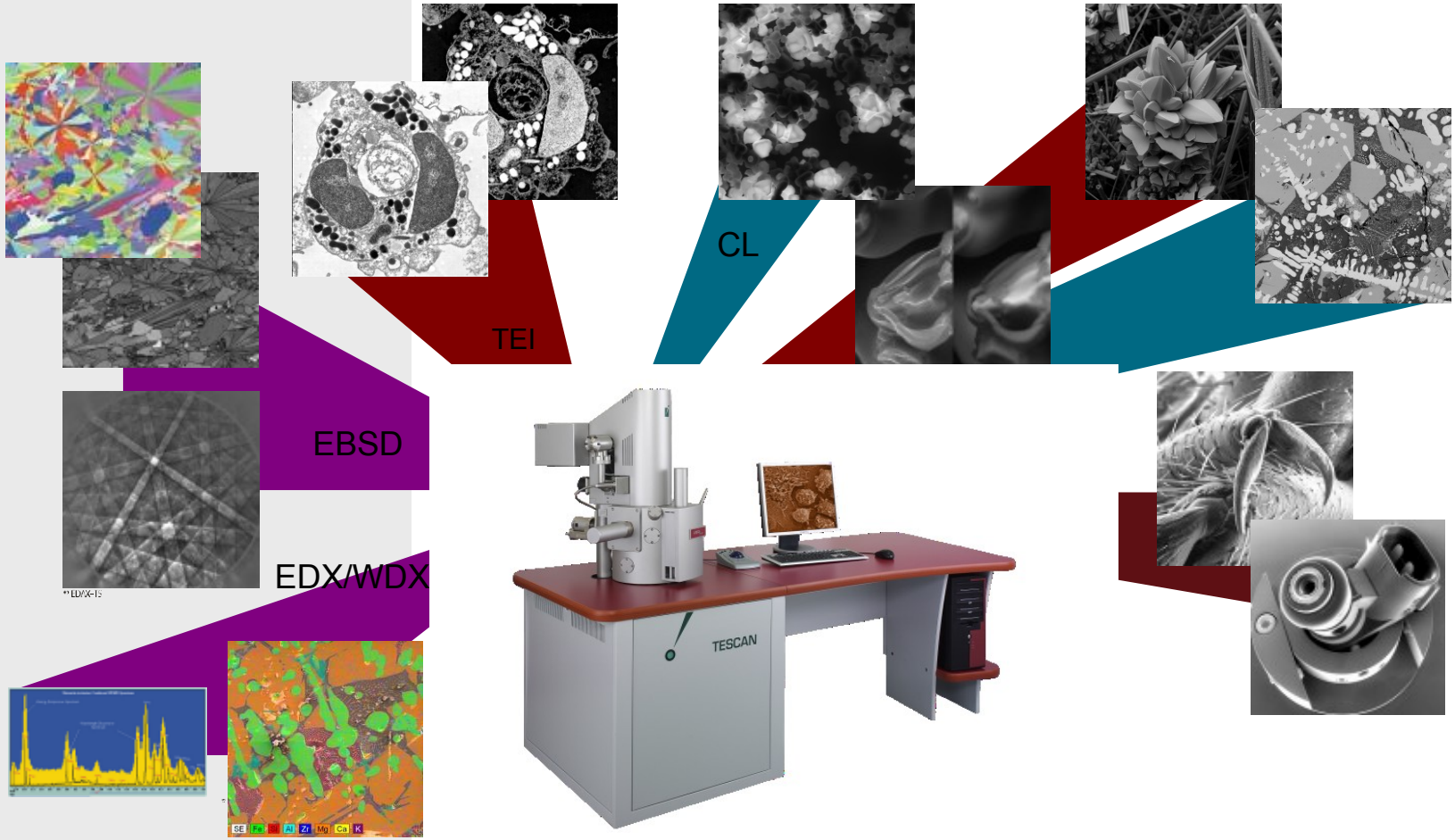

Other accessories

EBIC, Absorbed current measurement, IR chamber view camera and many other

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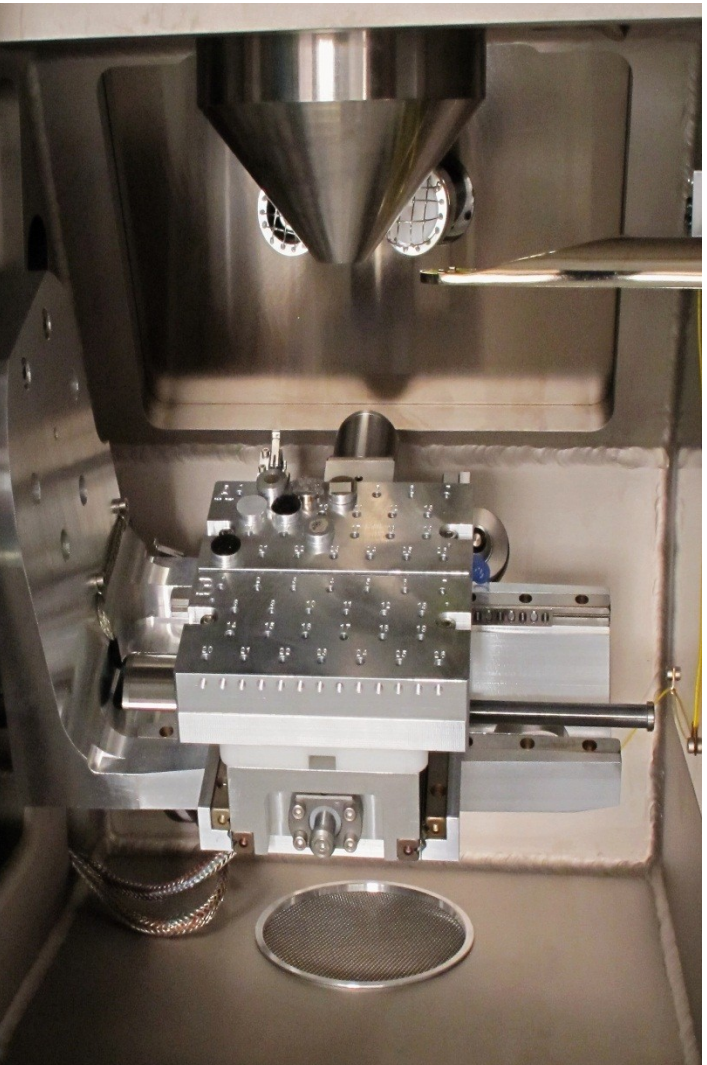
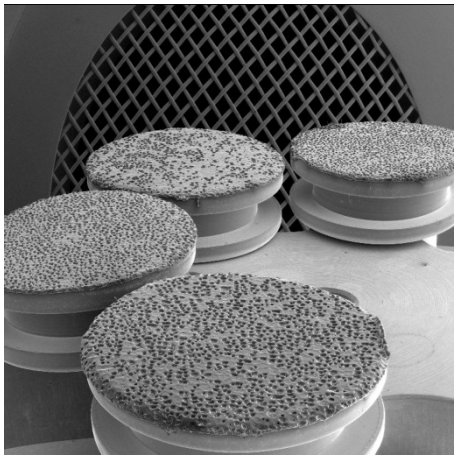
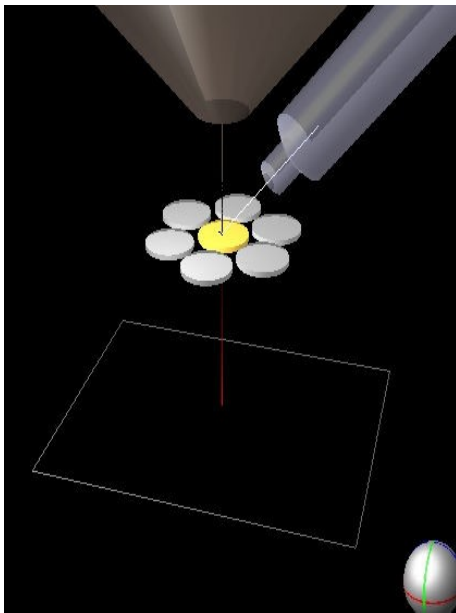


Stage movements

During GSR analysis the sample is divided into individual fields. Location and analysis of the particles is done filed-by-field using stage movements.
Positioning accuracy is critical parameter for GSR analysis.

Tescan XM Stage:
XY Range : 130 x 130 mm
Min. Step : 300 nm
Relocation accuracy: < 2um guaranteed
Speed: 5 mm/s





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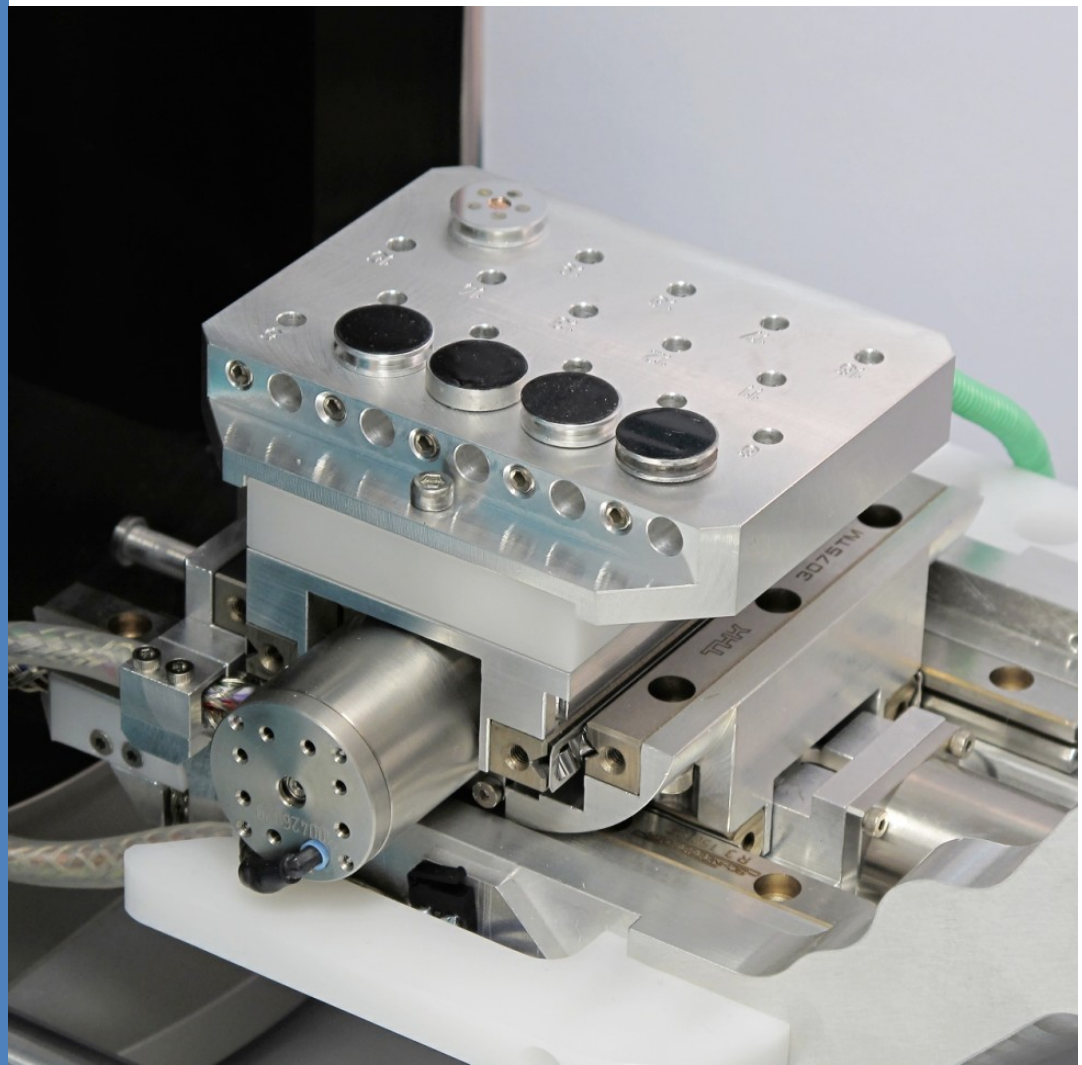


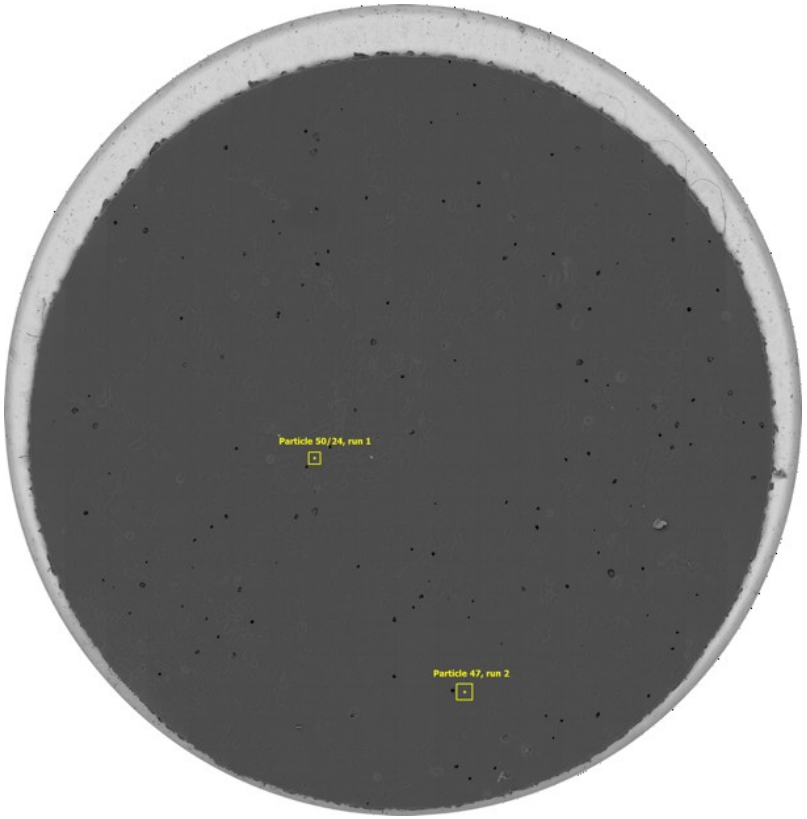
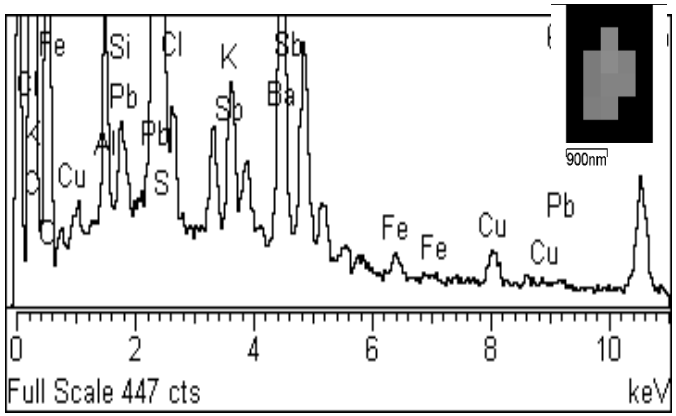
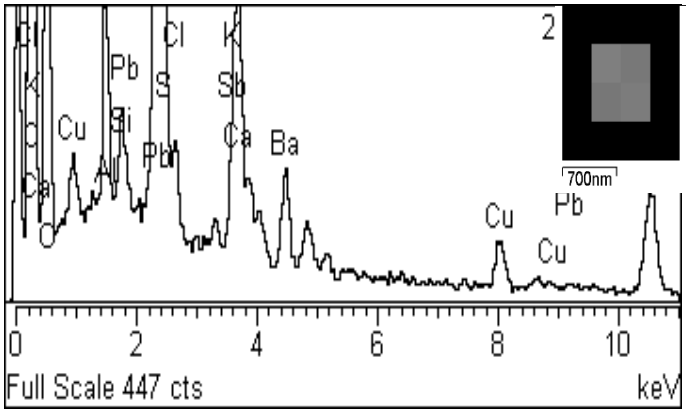


Image montage from 1048 BSE image fields with two submicron GSR particles found from totaly 48 detected particles.

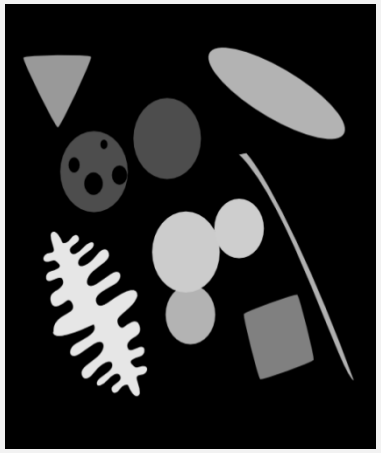


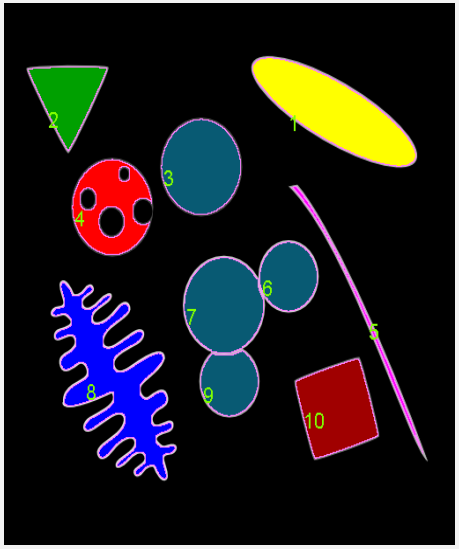


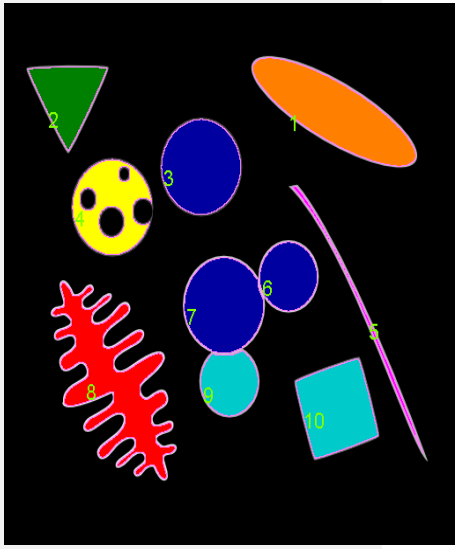
Classification by Area

Classification by Roundness

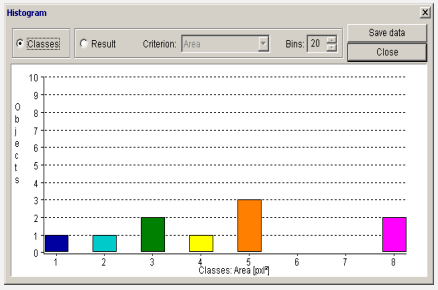
Classification by Extension (Compactness)







- **Object size and shape classification**
- **Over 40 parameters**
- **Object filtering**
- **Statistical output**



Roundness:

$R^2/(4*\pi*Area)$

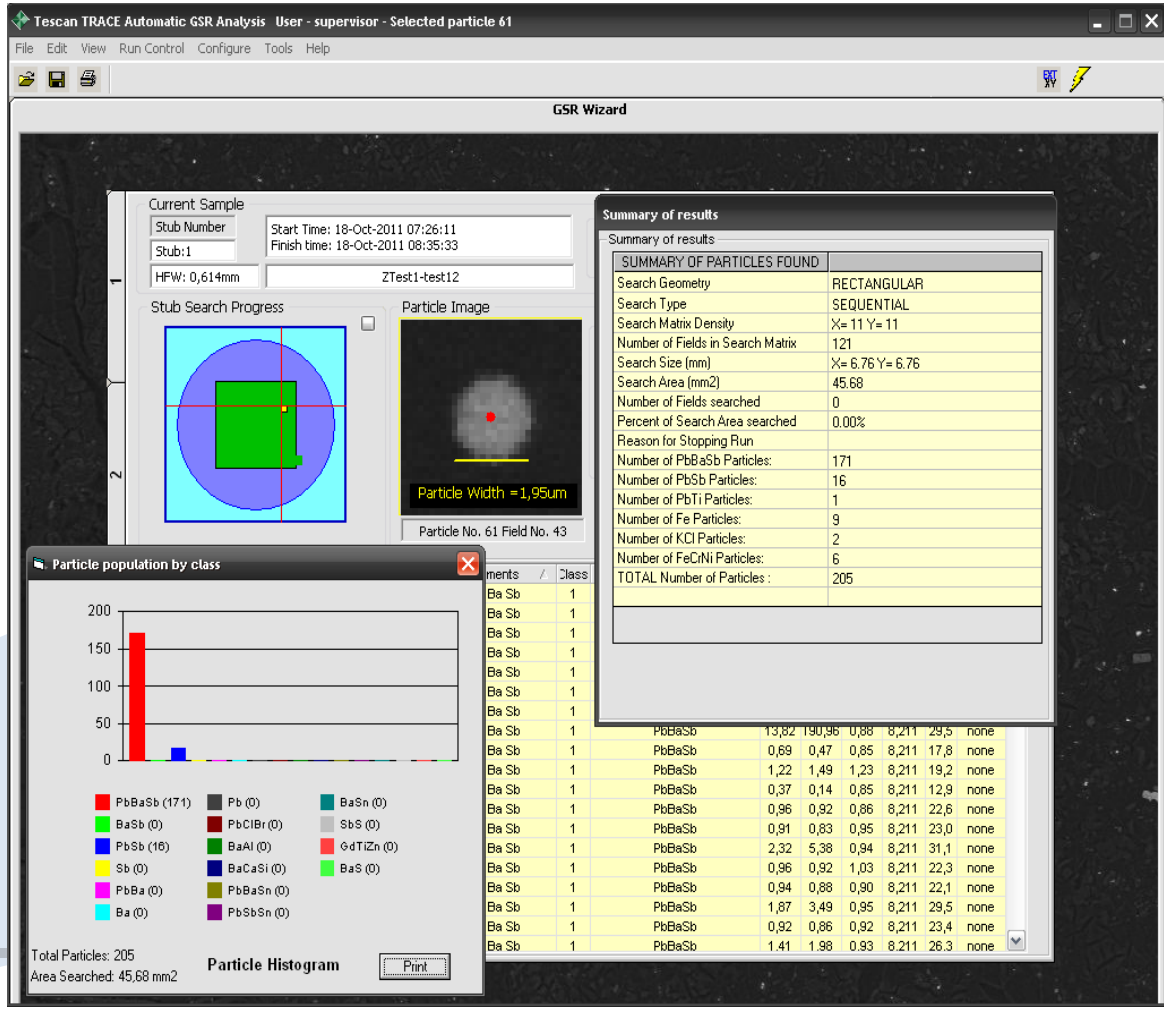
- Circle = 1
- Square = 1.3
- Triangle = 1.5
- Ellipse = 2
- Dendrite ~ 15
- Thread ~ 25

Extension:

- Circle = 0
- Square = 0.3
- Triangle = 0.5
- Ellipse = 2.5
- Dendrite ~ 4
- Thread ~ 14

TRACE GSR Results

	Plano GmbH	TESCAN, a.s.
10/15/20 µm	3	3
0,5 µm	38	36
0,7 µm	30	29
1 µm	33	32
1,5 µm	32	30
2 µm	27	27
2,5 µm	27	27
total no.	190	185



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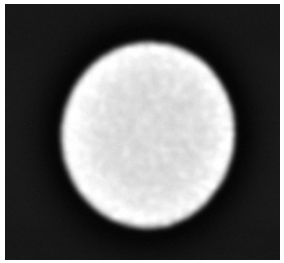

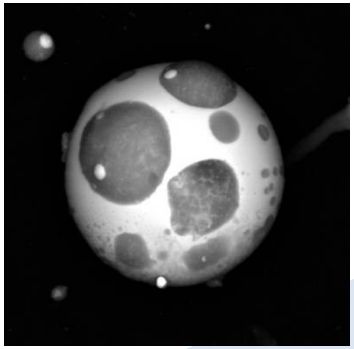

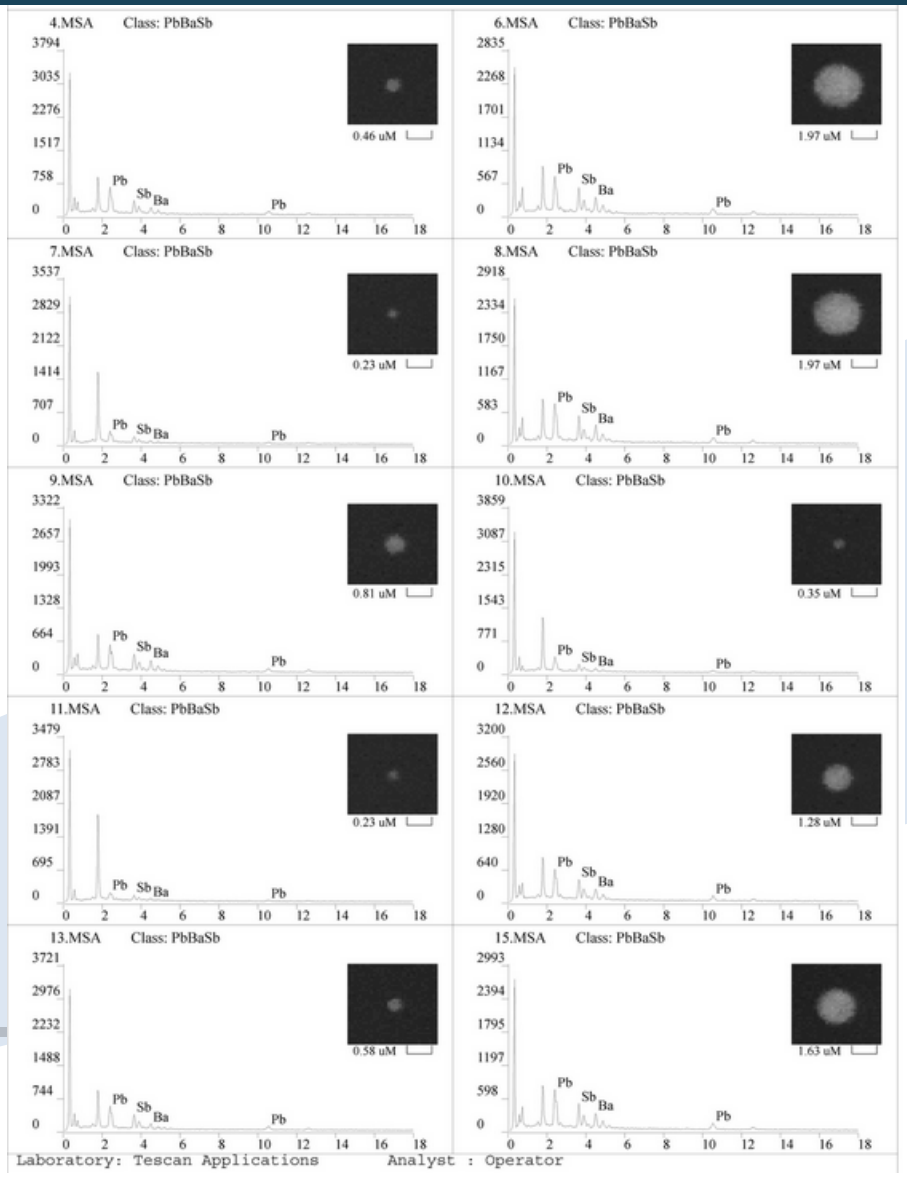

TESCAN TRACE GSR

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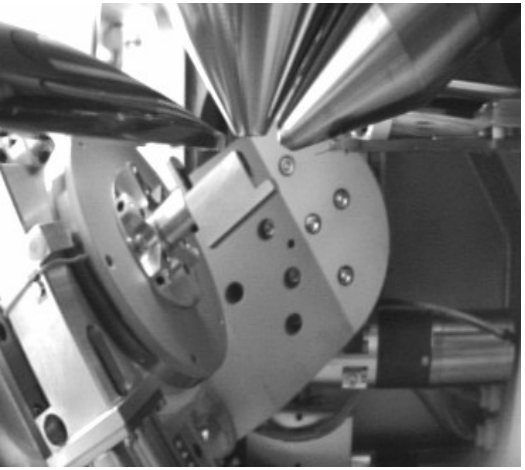
Nanotechnology Workbench

LYRA3 FEG



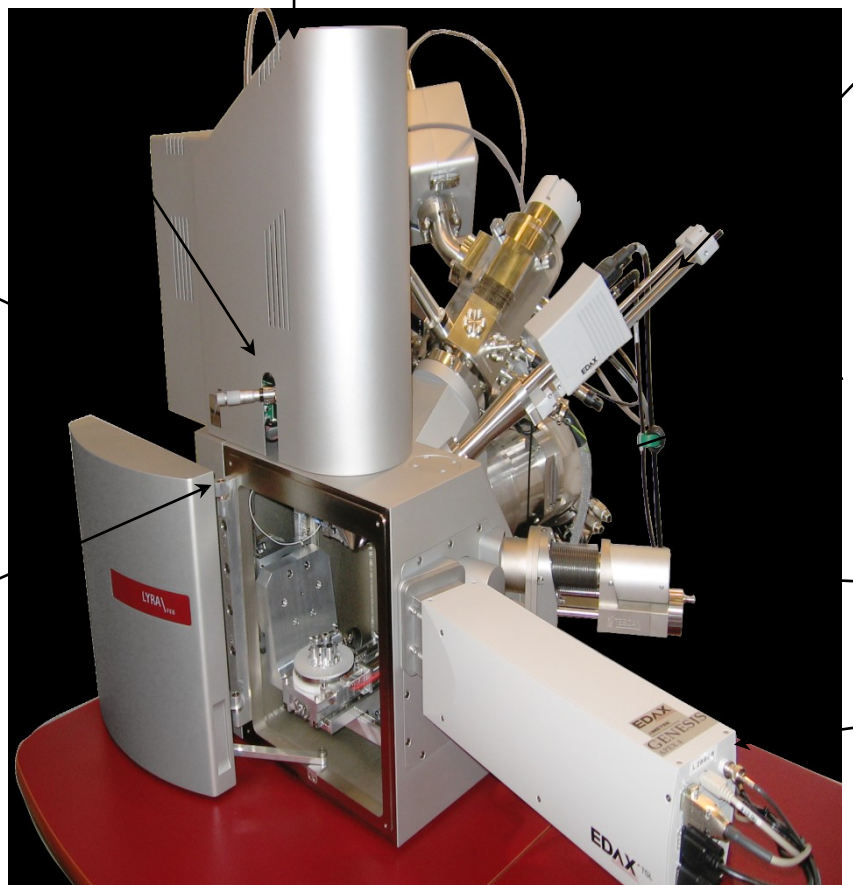


Fig. Tescan LYRA Demo as installed on EMC Aachen 2009

What's Inside?

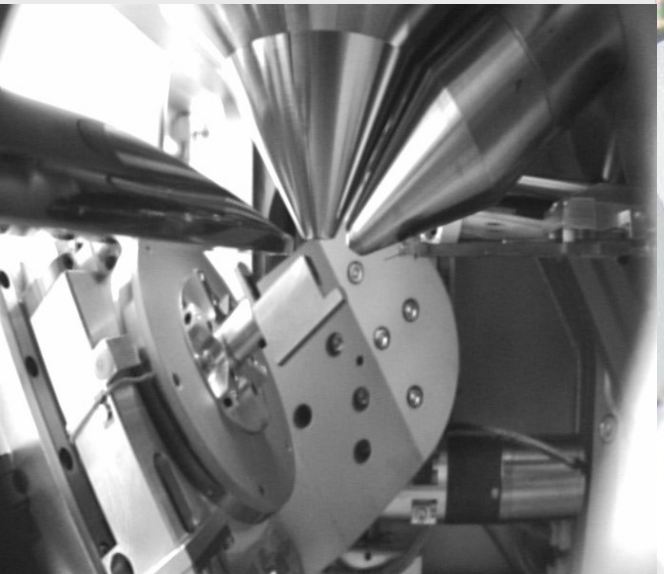
SEM objective lens

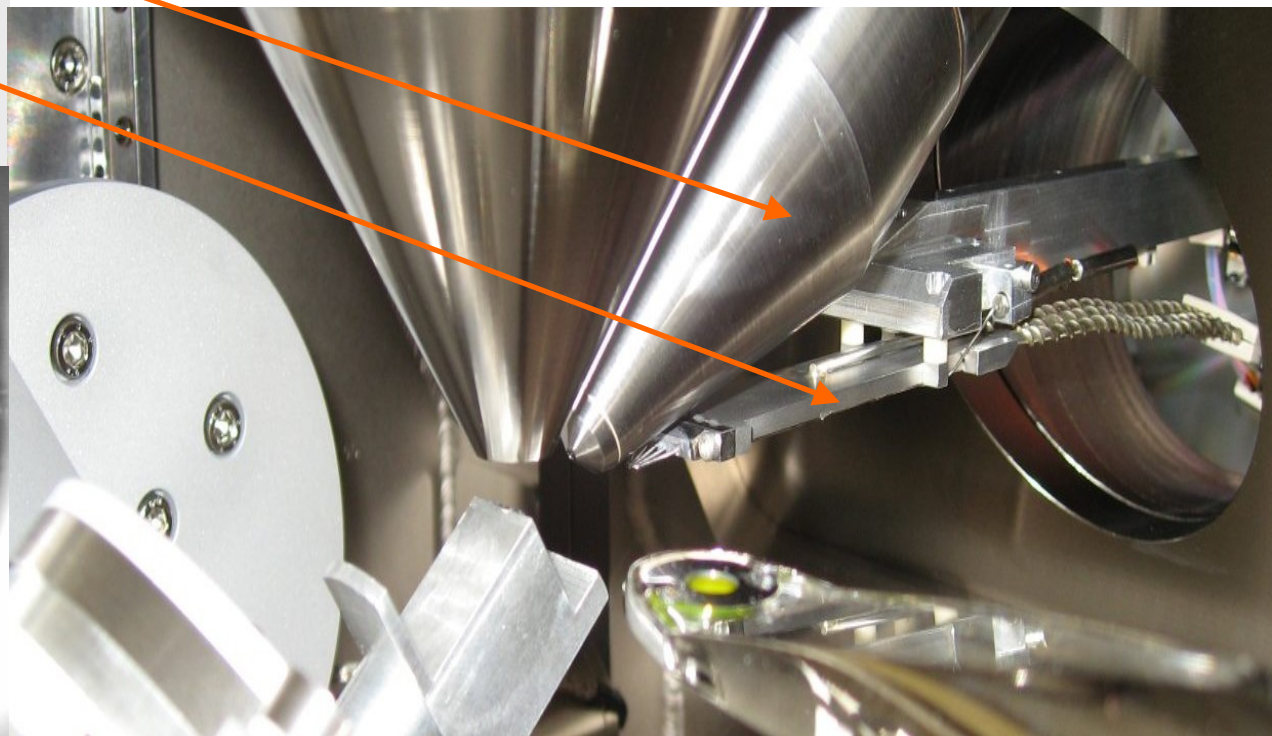
FIB column nose

GIS stage with nozzles

One Coincidence Point for All Parts

Benefit
Application





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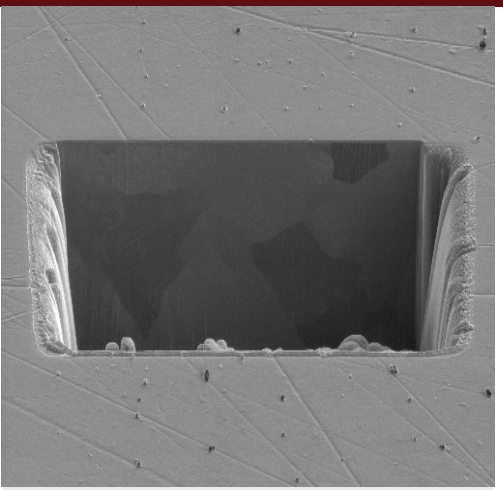
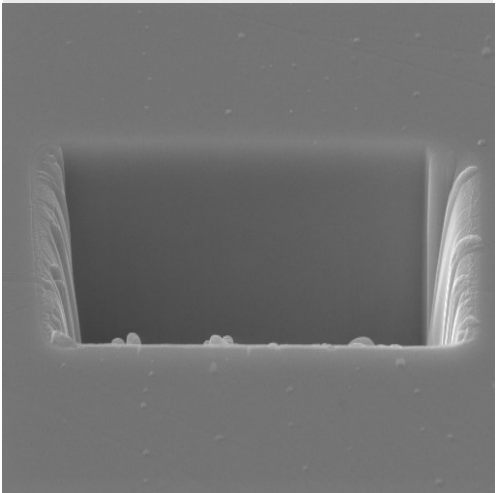
Why SEM + FIB on One System?

LYRA3 FEG



SE imaging FIB ▲, SEM▼

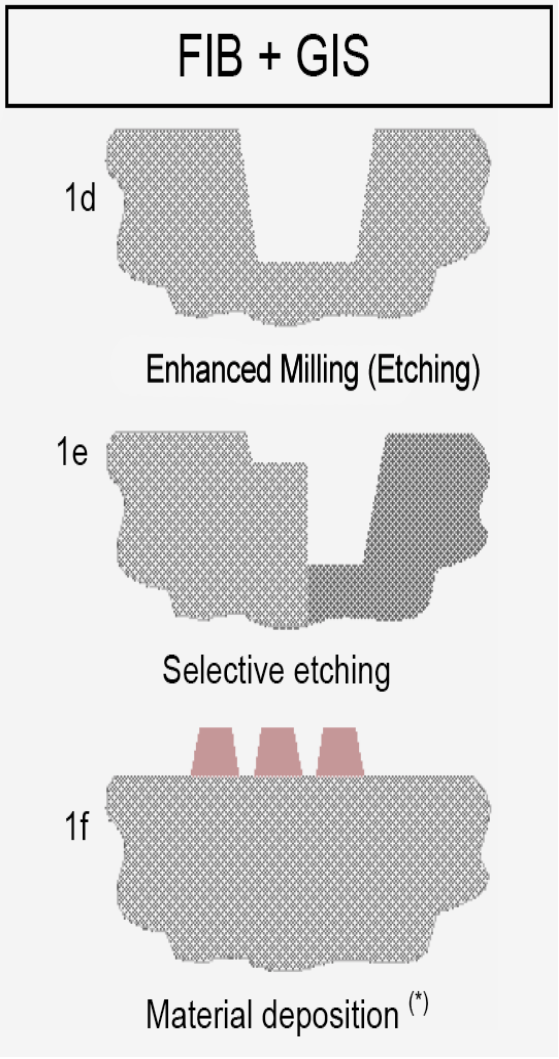


Ion Beam Imaging

- SE generated by ions
- Ion imaging resolution < 5 nm
- ✓ High surface sensitivity with ions
- ✓ High channeling effect contrast
- Ion imaging is destructive!

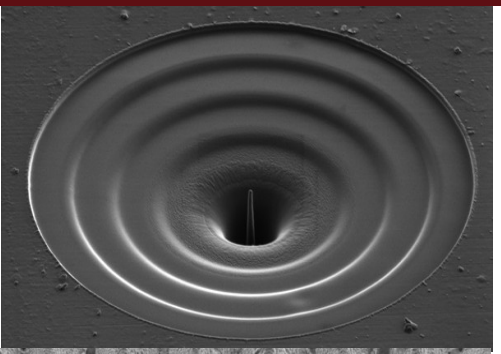
Electron Beam Imaging

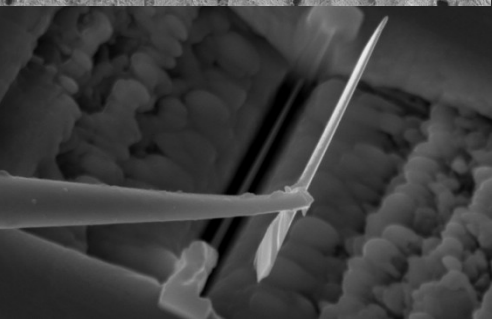
- SE generated by electrons
- High Electron Imaging Resolution
- Lower surface sensitivity especially for light elements
- ✓ Nondestructive - reason for “dual beam” systems



FIB + GIS Capabilities

- Enhanced Milling (Etching) – examples: XeF_2 enhances Si, SiO_2 and W etching by factor of 5-100 times; H_2O of PMMA and diamond 10-20 times
- Selective Milling (Etching) – combination of enhanced and reduced milling. Examples: H_2O greatly reduces etching of Al, Si and SiO_2; XeF_2 of Al.
- Material deposition – Adsorption of the precursor molecules on the surface, ion beam (or e-beam) induced dissociation of the gas molecules, deposition of the material atoms (e.g. Pt, W, C, SiO_x) .





Common SEM+FIB Applications

- Nano-structuring
- IC process inspection and failure analysis
- Nano-tomography
- Local cross-sectioning, thin film thickness measurement
- TEM sample preparation
- Biology
- Materials science
- Mineralogy
- Fossils analysis
- Forensic applications

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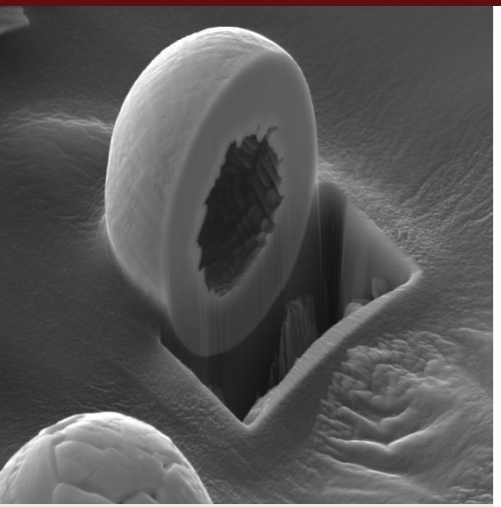
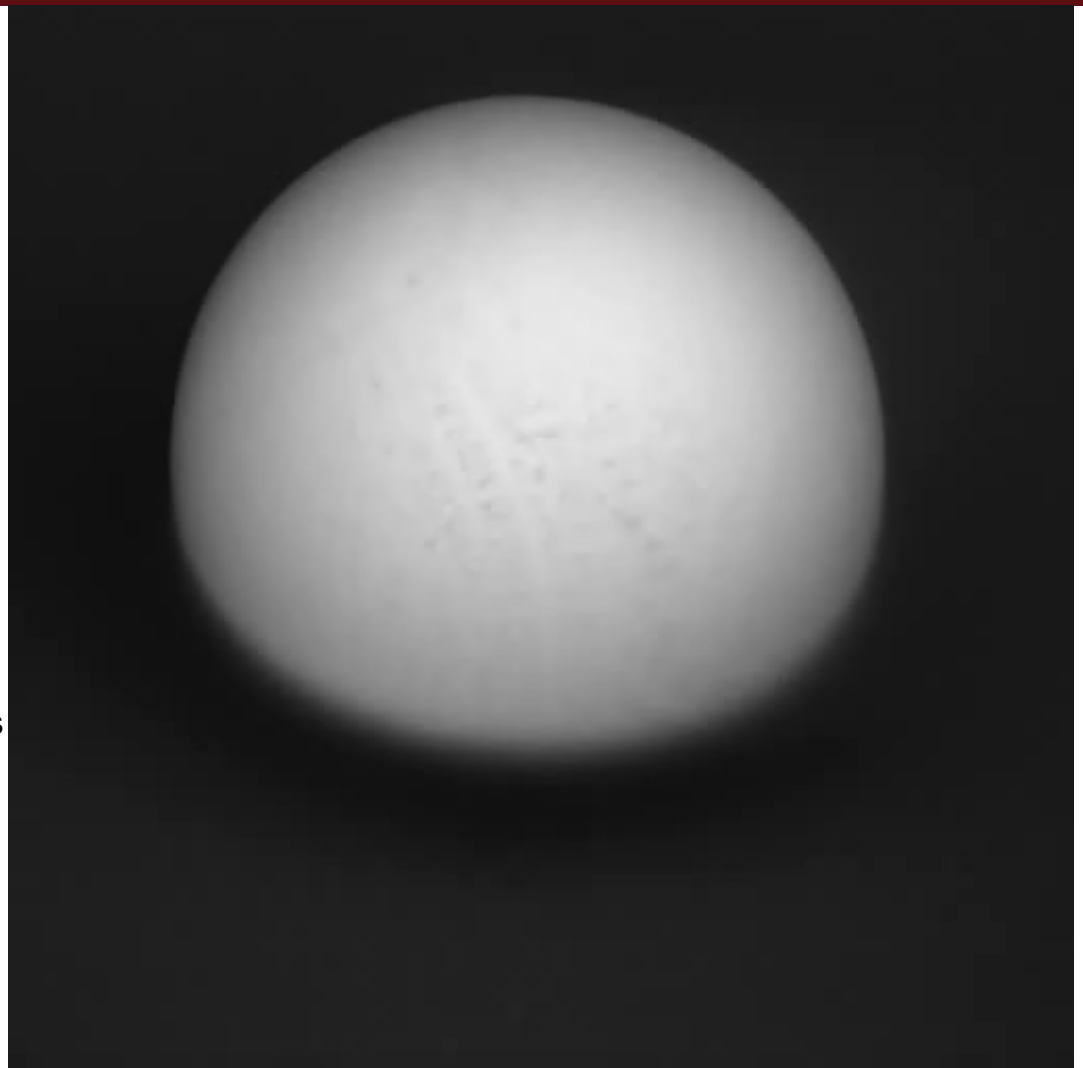
Simulteneous Imaging

LYRA3 FEG



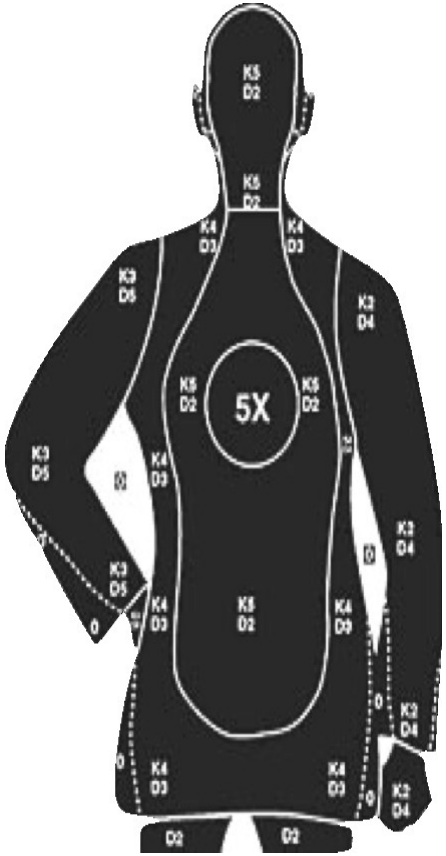


Forensic Application

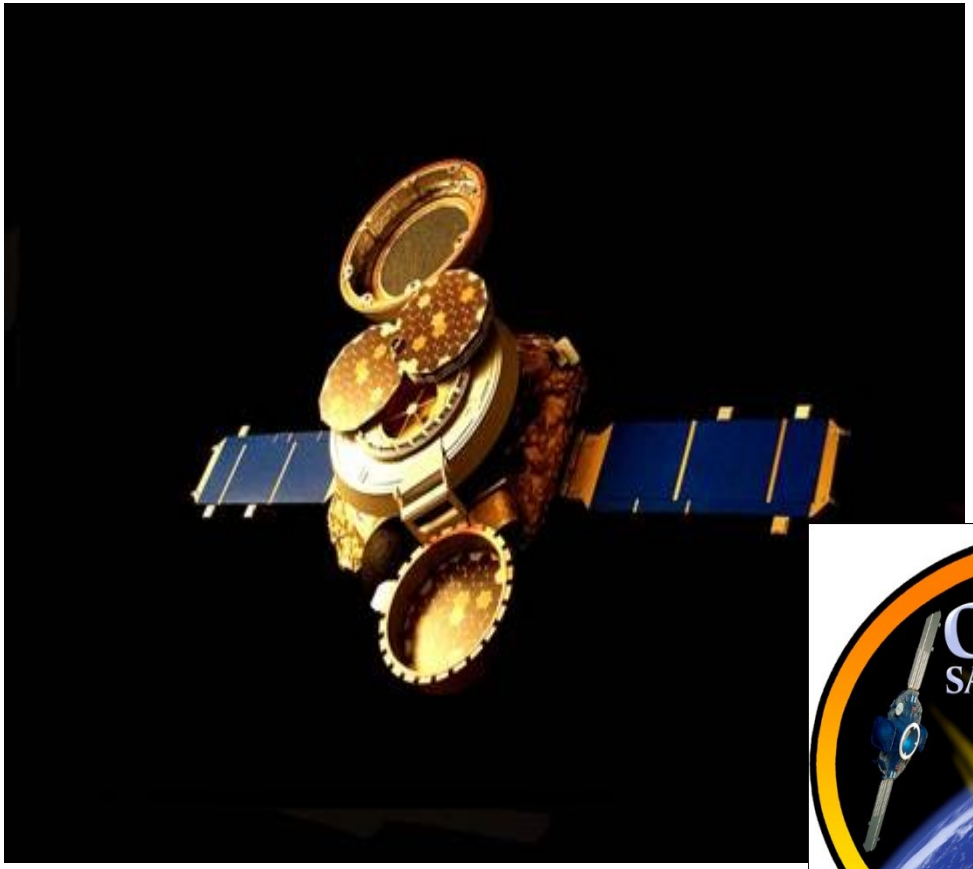
Gun Shot Residue Volume Analysis

Simultaneous imaging of the milling process.

Questions ?



Applications

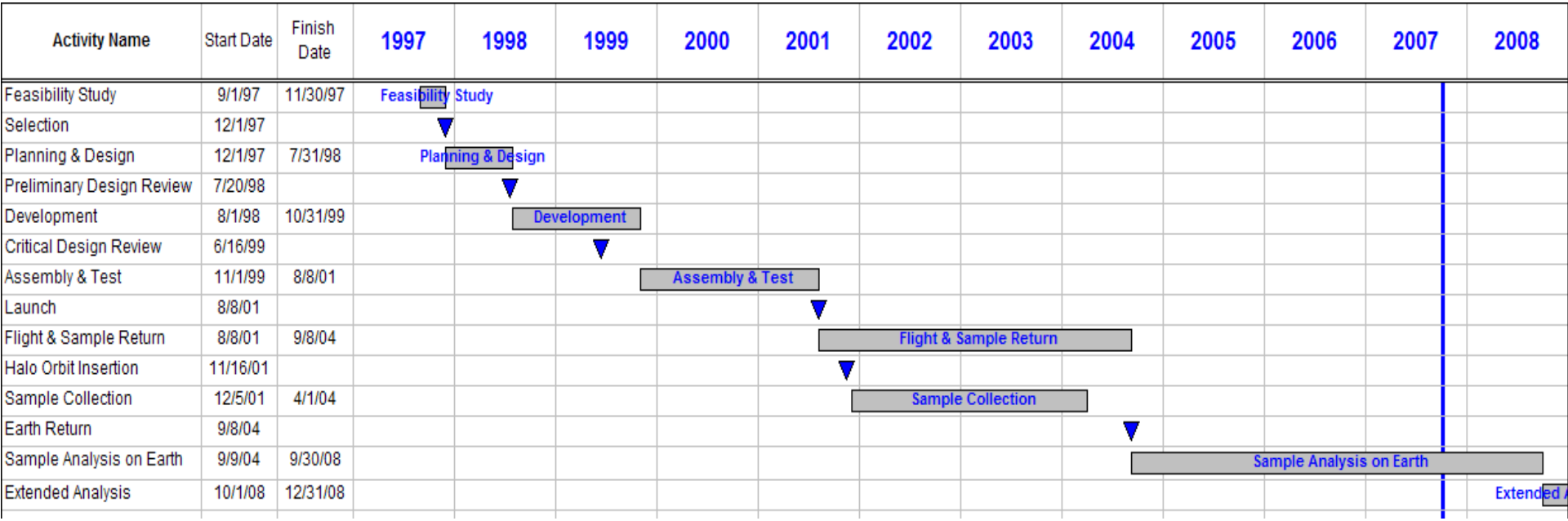


Applications

The collectors after assembly on Earth before flight

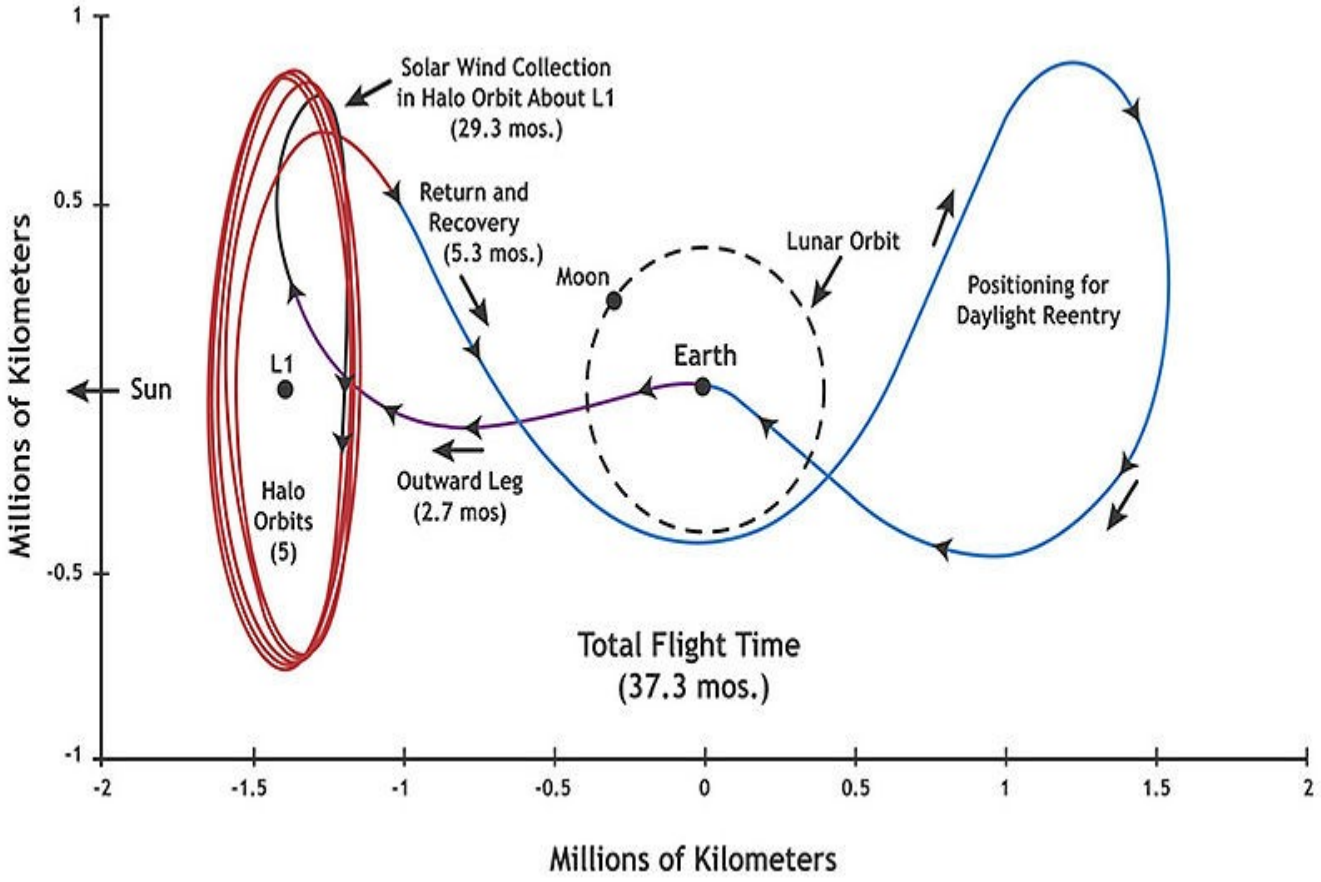
Applications

Activity Name	Start Date	Finish Date
Feasibility Study	9/1/97	11/30/97
Selection	12/1/97	
Planning & Design	12/1/97	7/31/98
Preliminary Design Review	7/20/98	
Development	8/1/98	10/31/99
Critical Design Review	6/16/99	
Assembly & Test	11/1/99	8/8/01
Launch	8/8/01	
Flight & Sample Return	8/8/01	9/8/04
Halo Orbit Insertion	11/16/01	
Sample Collection	12/5/01	4/1/04
Earth Return	9/8/04	
Sample Analysis on Earth	9/9/04	9/30/08
Extended Analysis	10/1/08	12/31/08

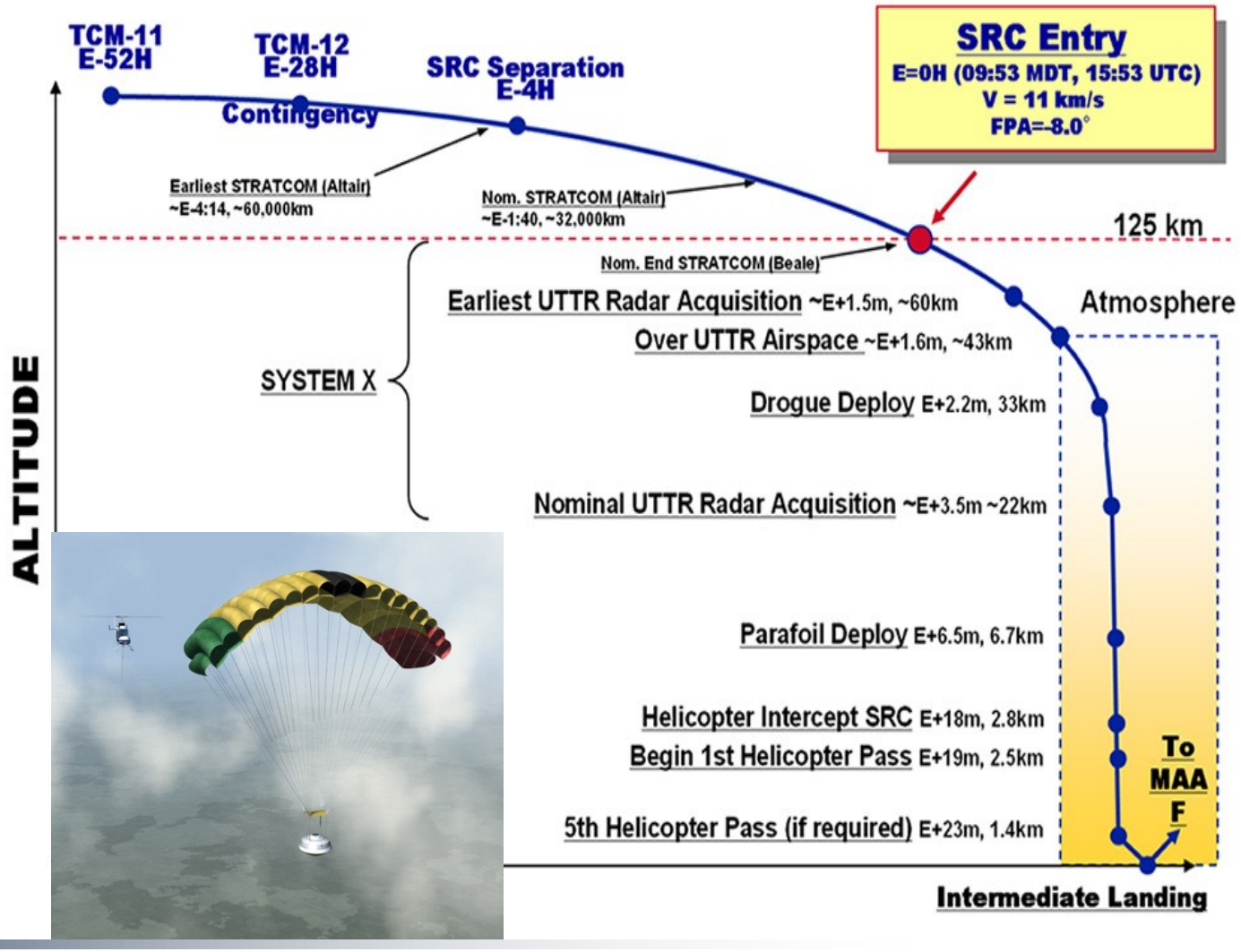


Genesis Timeline

Applications



Applications



Applications

Although the mission was a success with solar wind atoms implanted into the collectors, the return to Earth was '**non-optimal**' with the parachutes failing to open.

Applications

Gravity switch

Applications

Monument purchased and designed by Genesis team members to commemorate the return to Earth

Applications



Hundreds of collector fragments were retrieved

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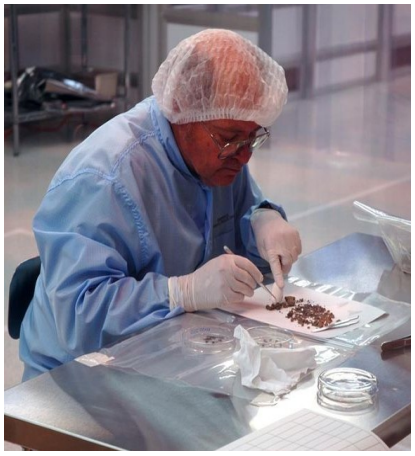
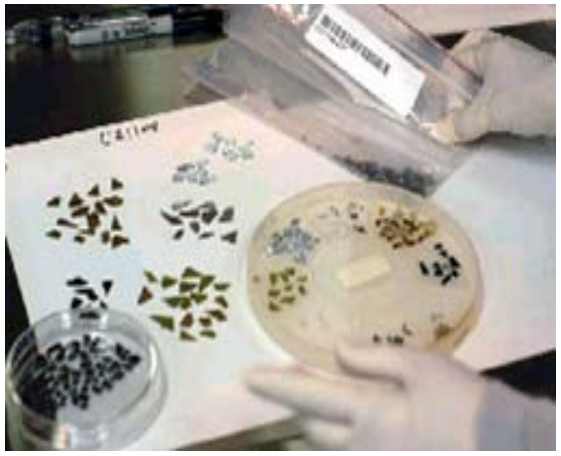
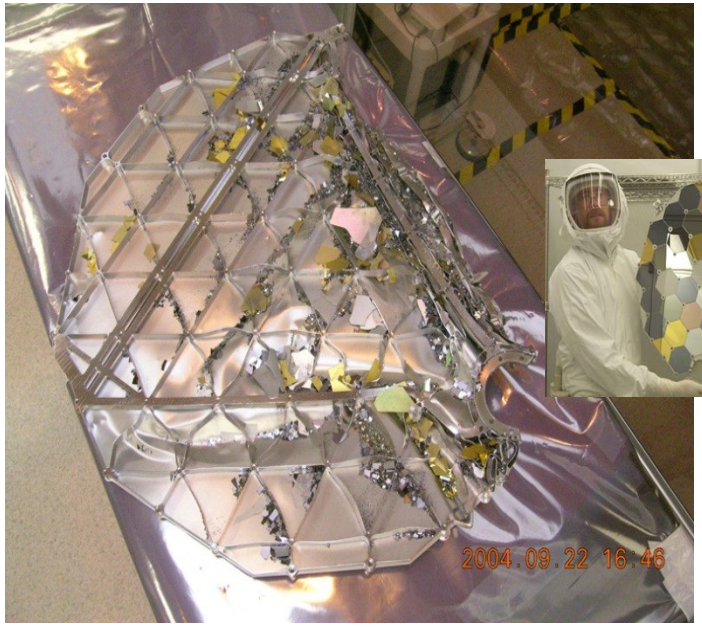
Applications







Backside of
Collector Array

Gold Foil Collector –
post landing

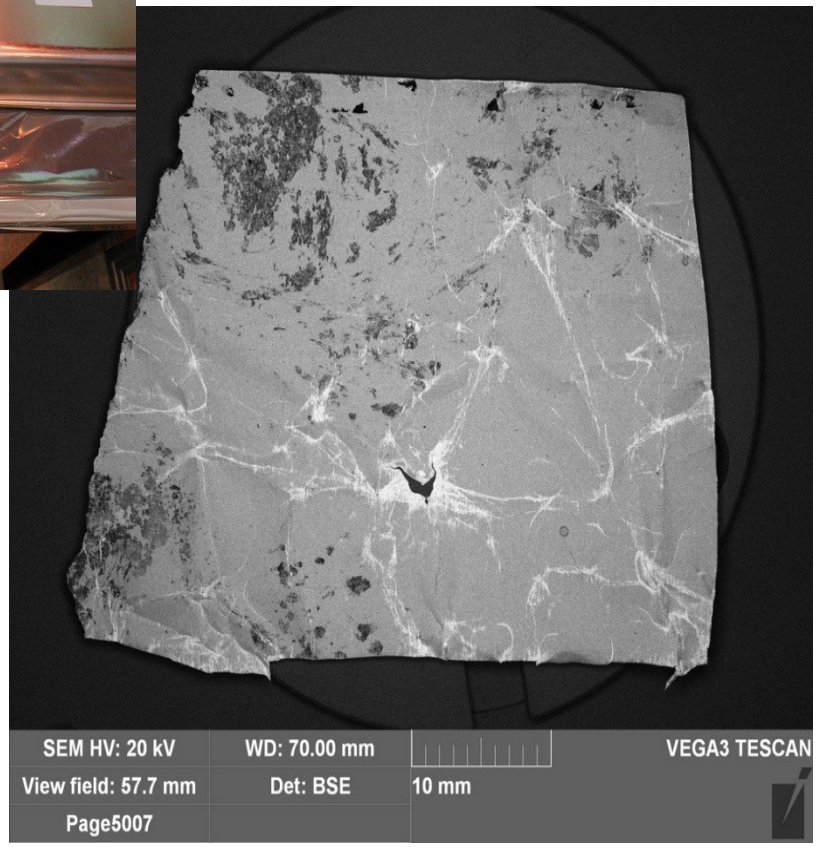
Applications

Activity Name	Start Date	Finish Date
Feasibility Study	9/1/97	11/30/97
Selection	12/1/97	
Planning & Design	12/1/97	7/31/98
Preliminary Design Review	7/20/98	
Development	8/1/98	10/31/99
Critical Design Review	6/16/99	
Assembly & Test	11/1/99	8/8/01
Launch	8/8/01	
Flight & Sample Return	8/8/01	9/8/04
Halo Orbit Insertion	11/16/01	
Sample Collection	12/5/01	4/1/04
Earth Return	9/8/04	
Sample Analysis on Earth	9/9/04	9/30/08
Extended Analysis	10/1/08	12/31/08

Genesis Timeline

Applications

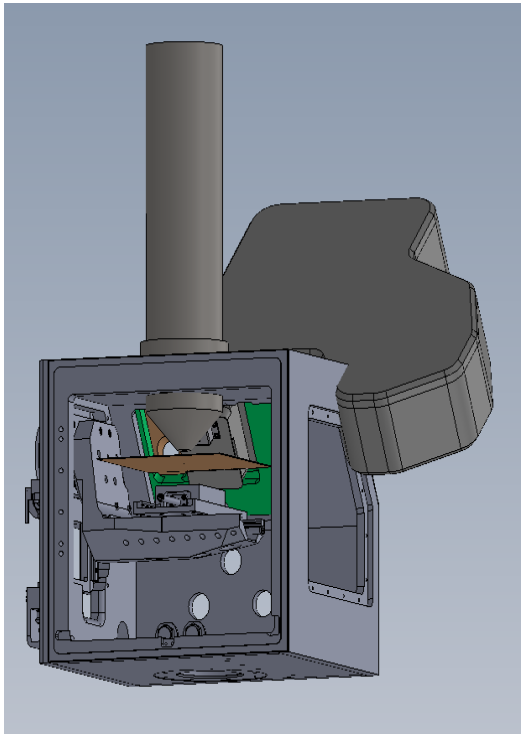
< Gold Foil Collector – post landing

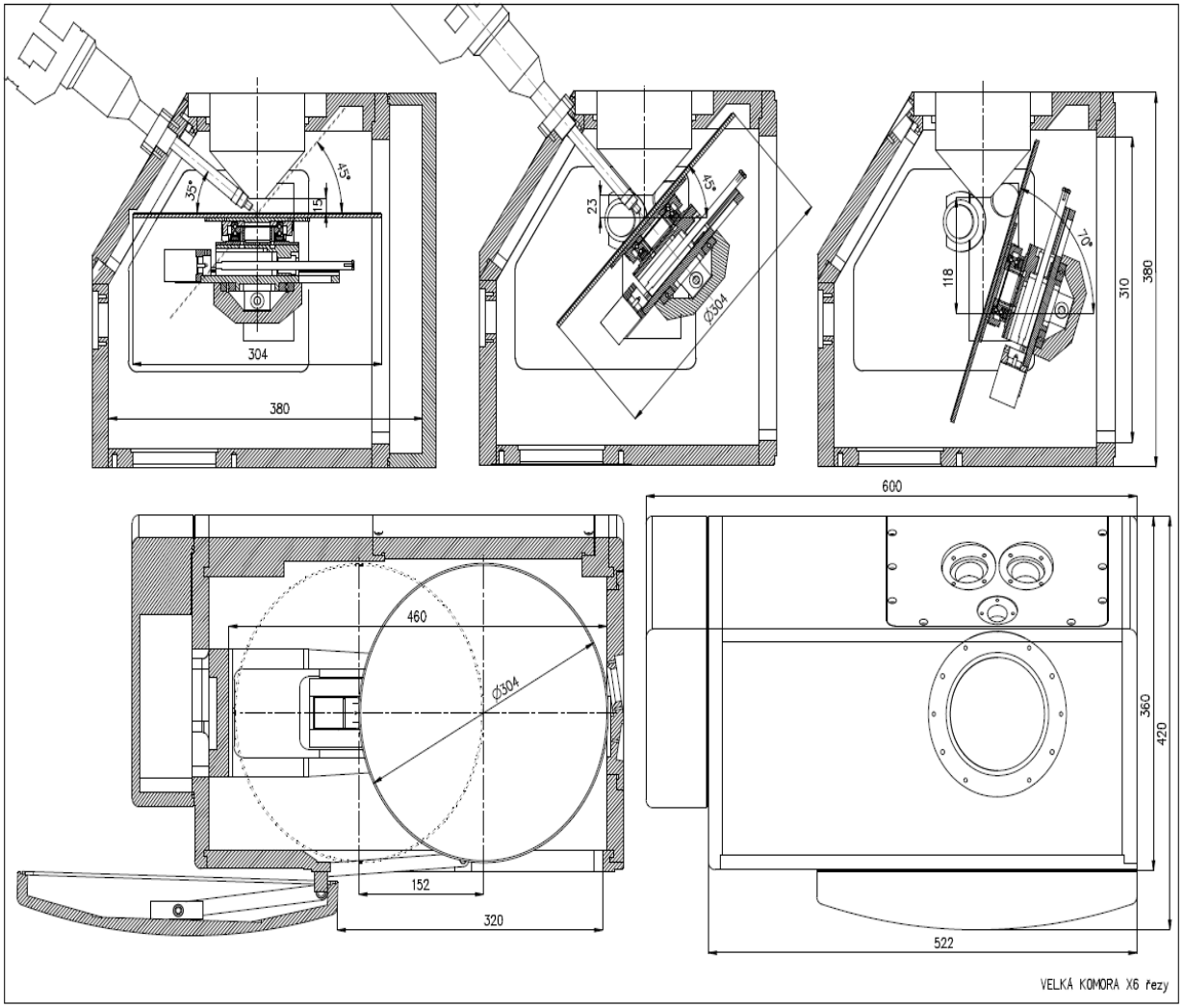


REQUIREMENT> SEM-EDS instrument with the ability to perform fast, automated detection, location and quantification of 10-µm clay-based dirt particles, molybdenum coating and platinum substrate over the entire area of minimum 16 cm x 16 cm square) crumpled Pt-Mo foils. Approximately 8000 cm2 Pt-Mo foils will be imaged in total. **Gold Foil Post-landing**

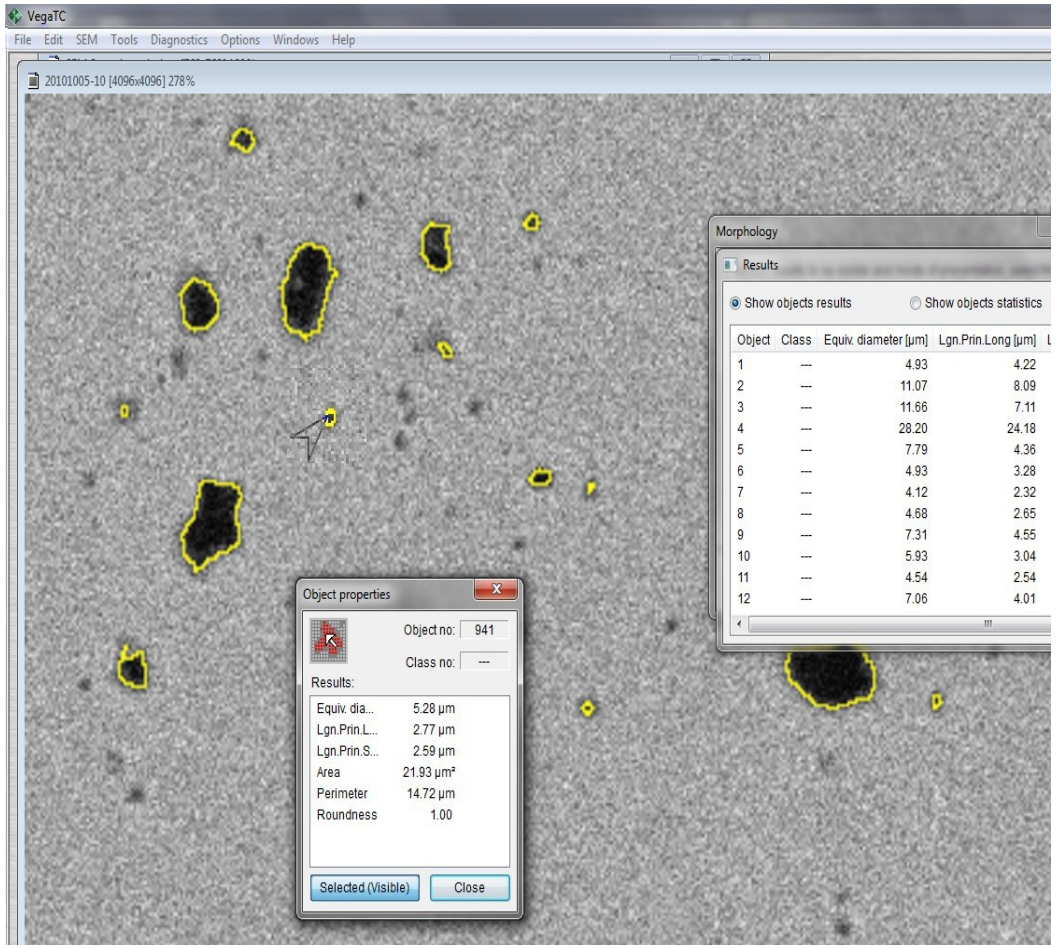
Applications

VEGA 3 XMU – X8M5





Applications



TESCAN's automated particle analysis