Response of a PADC Neutron Personal Dosemeter to HZE

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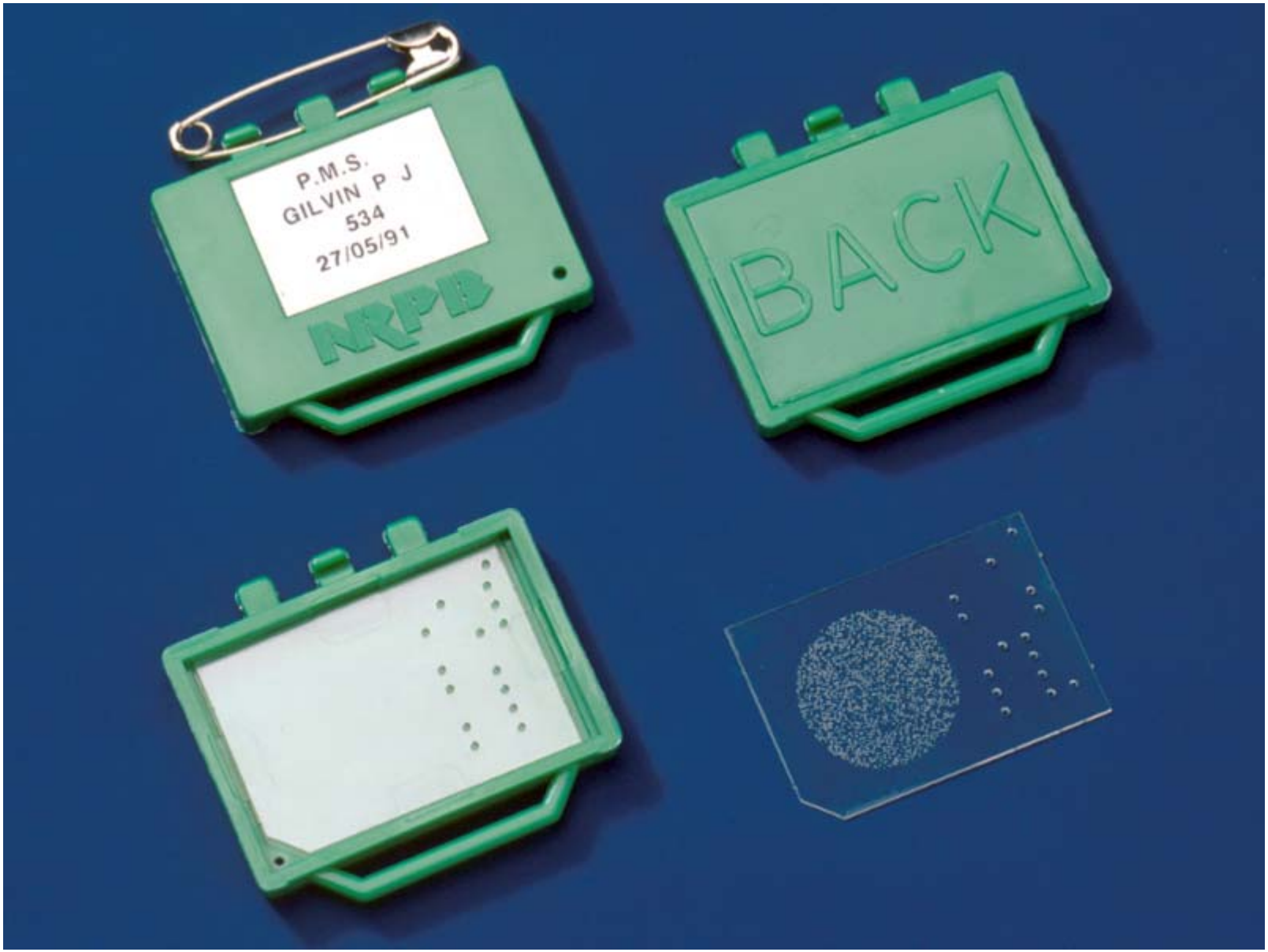
National Radiological Protection Board

The routine NRPB PADC dosemeter is electrochemically etched to measure doses from neutrons. By applying a subsequent chemical etch, heavy charged particle tracks also become visible.


P.M.S.
GILVIN P J
534
27/05/91
NRPB
BACK

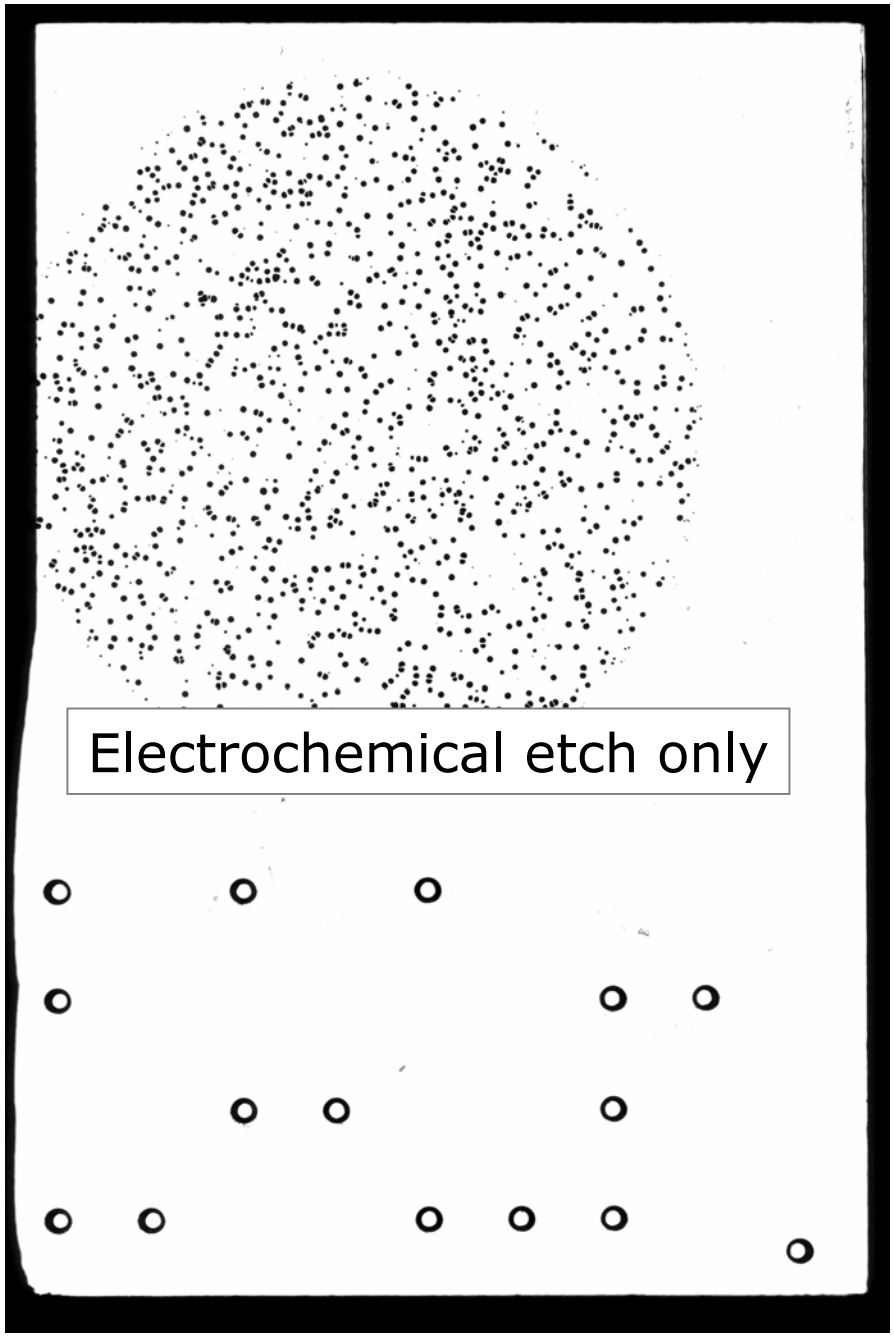
Measurements at HIMAC with the NRPB PADC Dosemeter

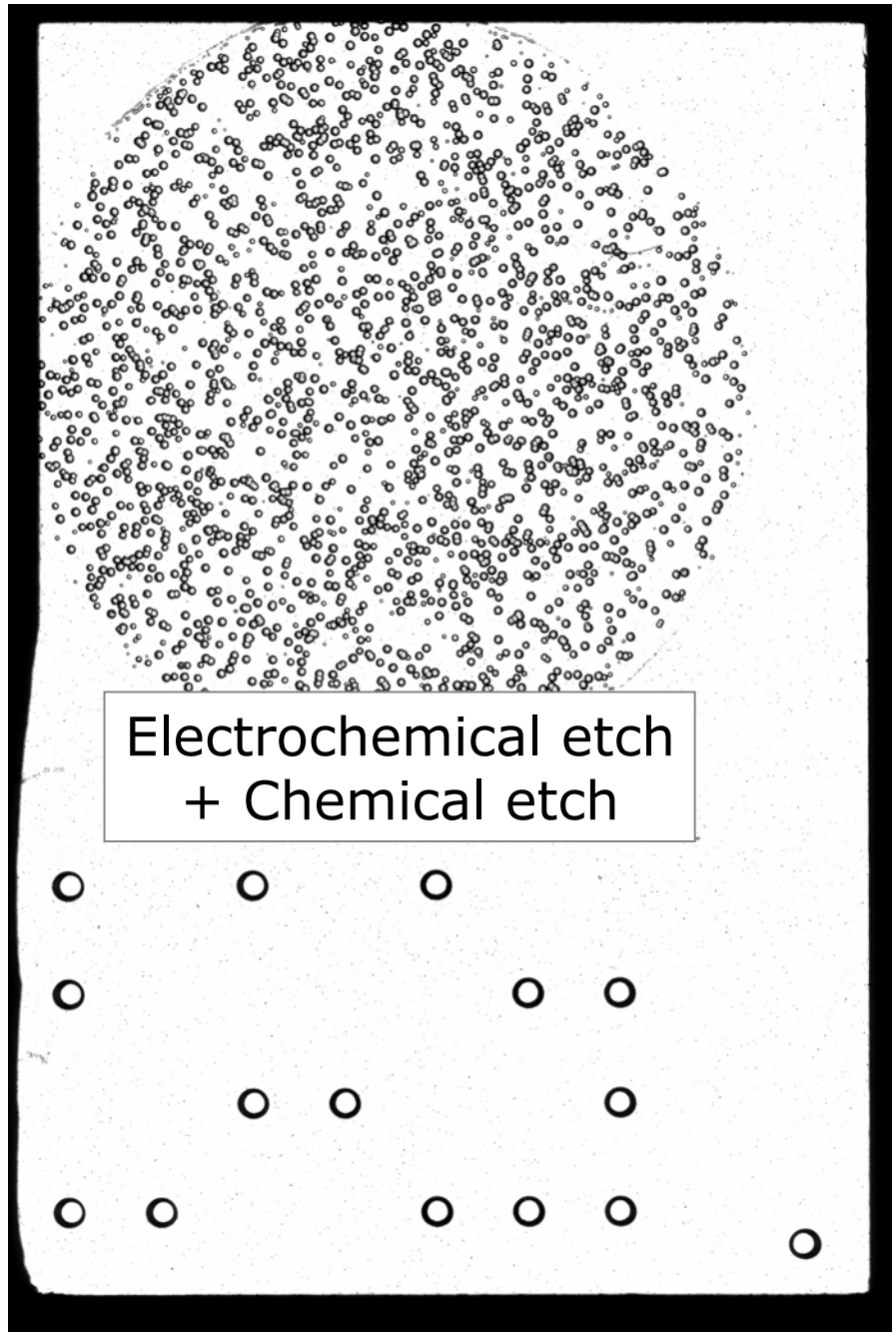
Electrochemical etch - back face

11.5 hours 20% NaOH at 40^0C followed contiguously by 8 hours 20% NaOH at 40^0C at 23.5 $kVcm^{-1}$

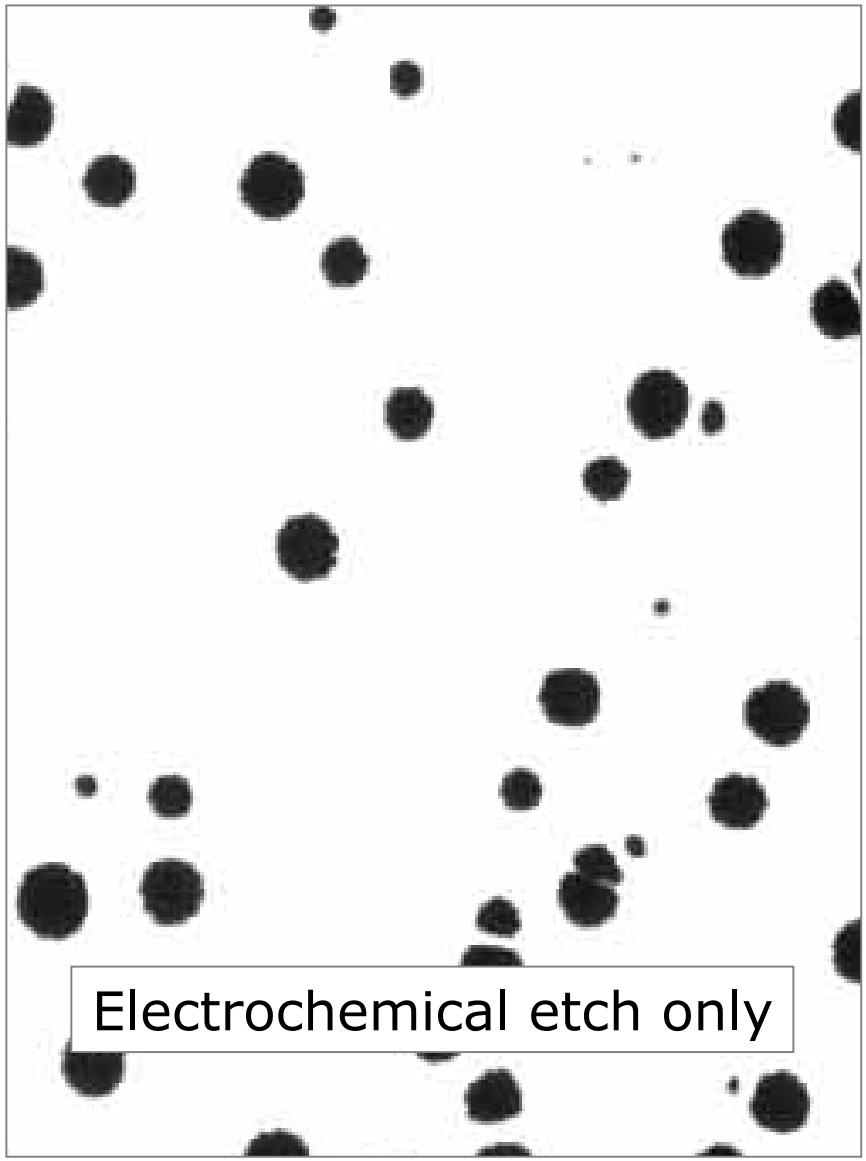
Chemical etch - both faces

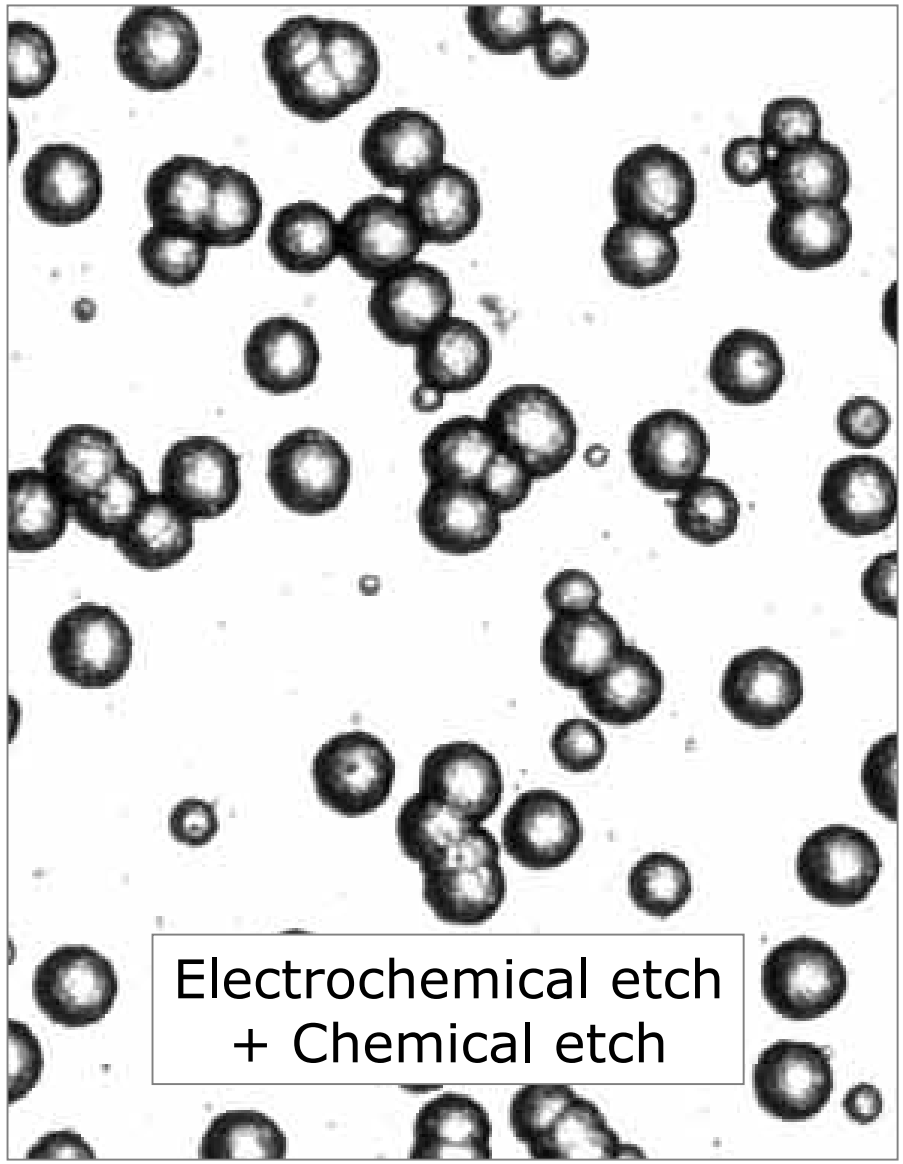
18 hours 20% NaOH at 80^0C


Electrochemical etch only


Electrochemical etch
+ Chemical etch

Comparison of Etch methods

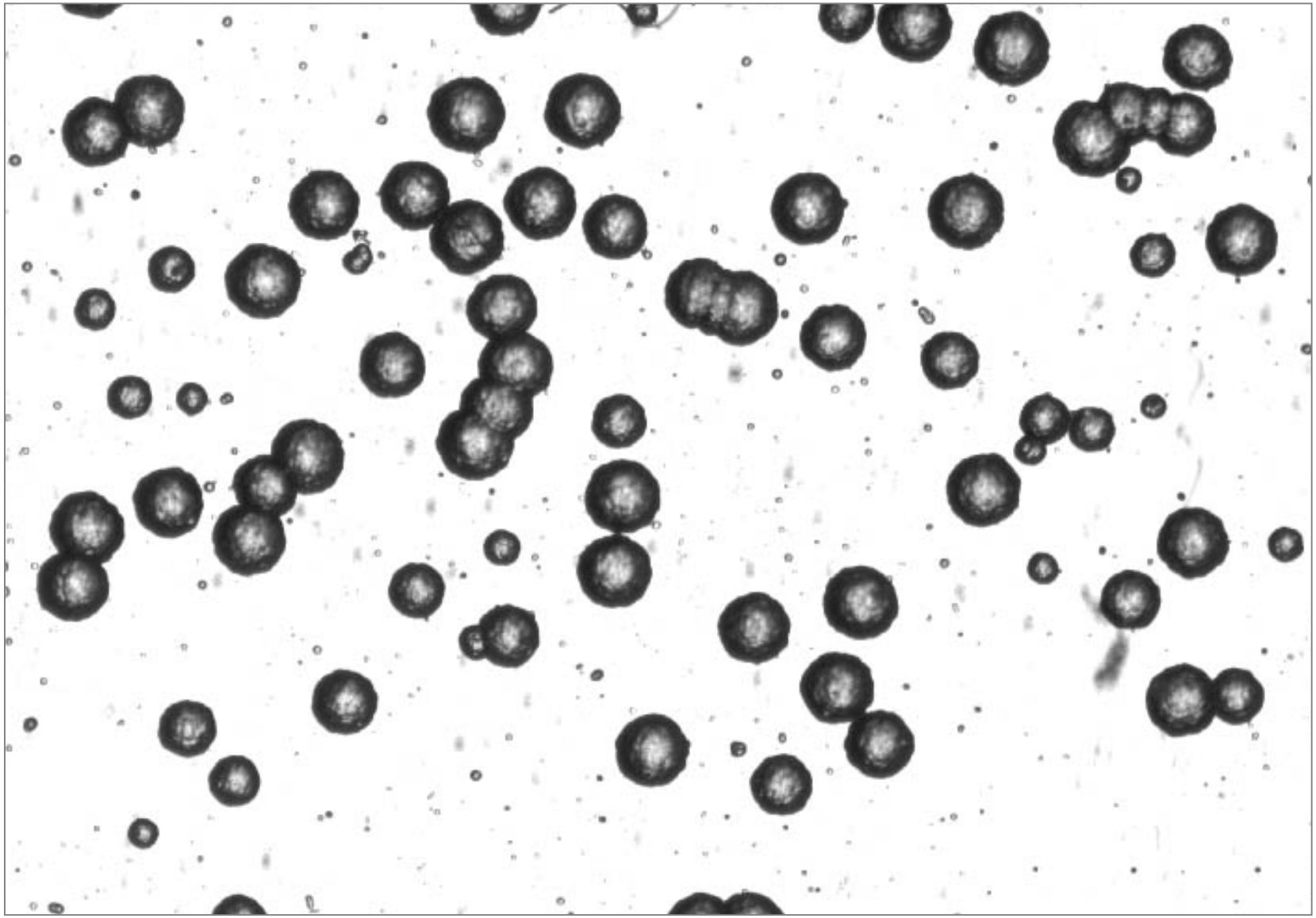




Neutrons produce short range secondaries which do not usually pass right through the detector.

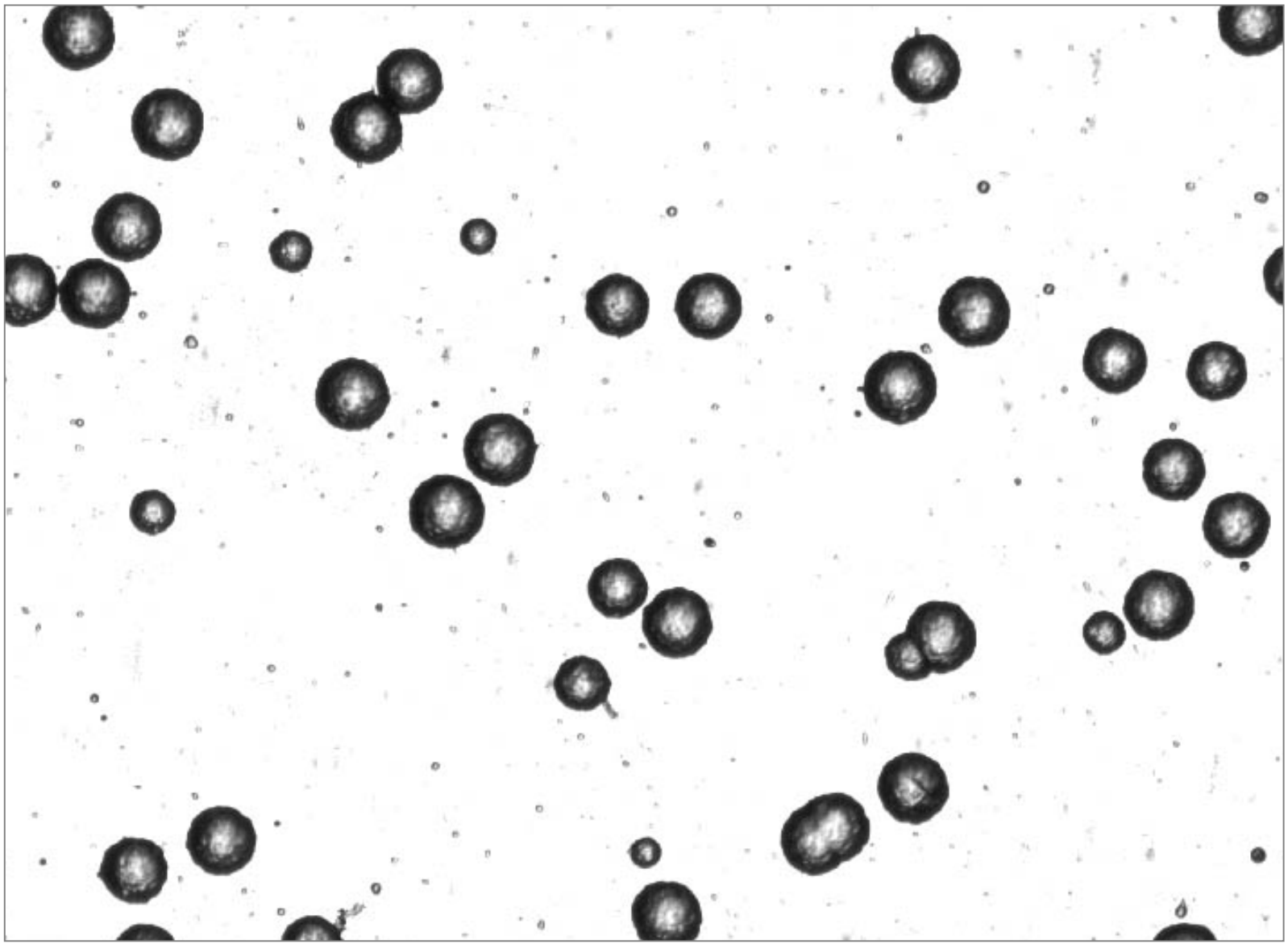
The electrochemically etched track is altered by the subsequent chemical etch so that it appears lighter and has a “bubbly” texture.

Louvain 60 MeV neutron 0º



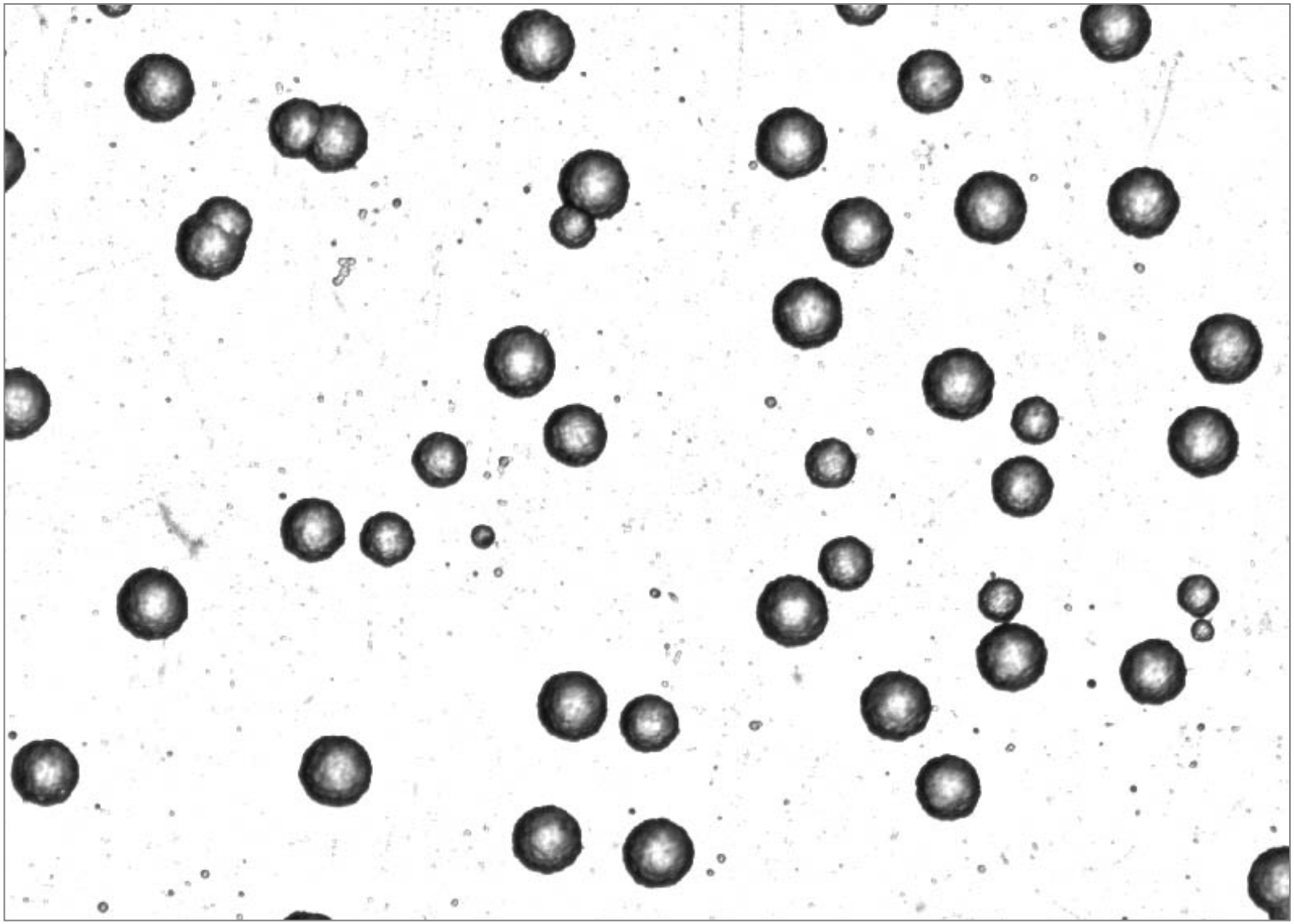
Electrochemical + Chem Etch

Louvain 60 MeV neutron 60º



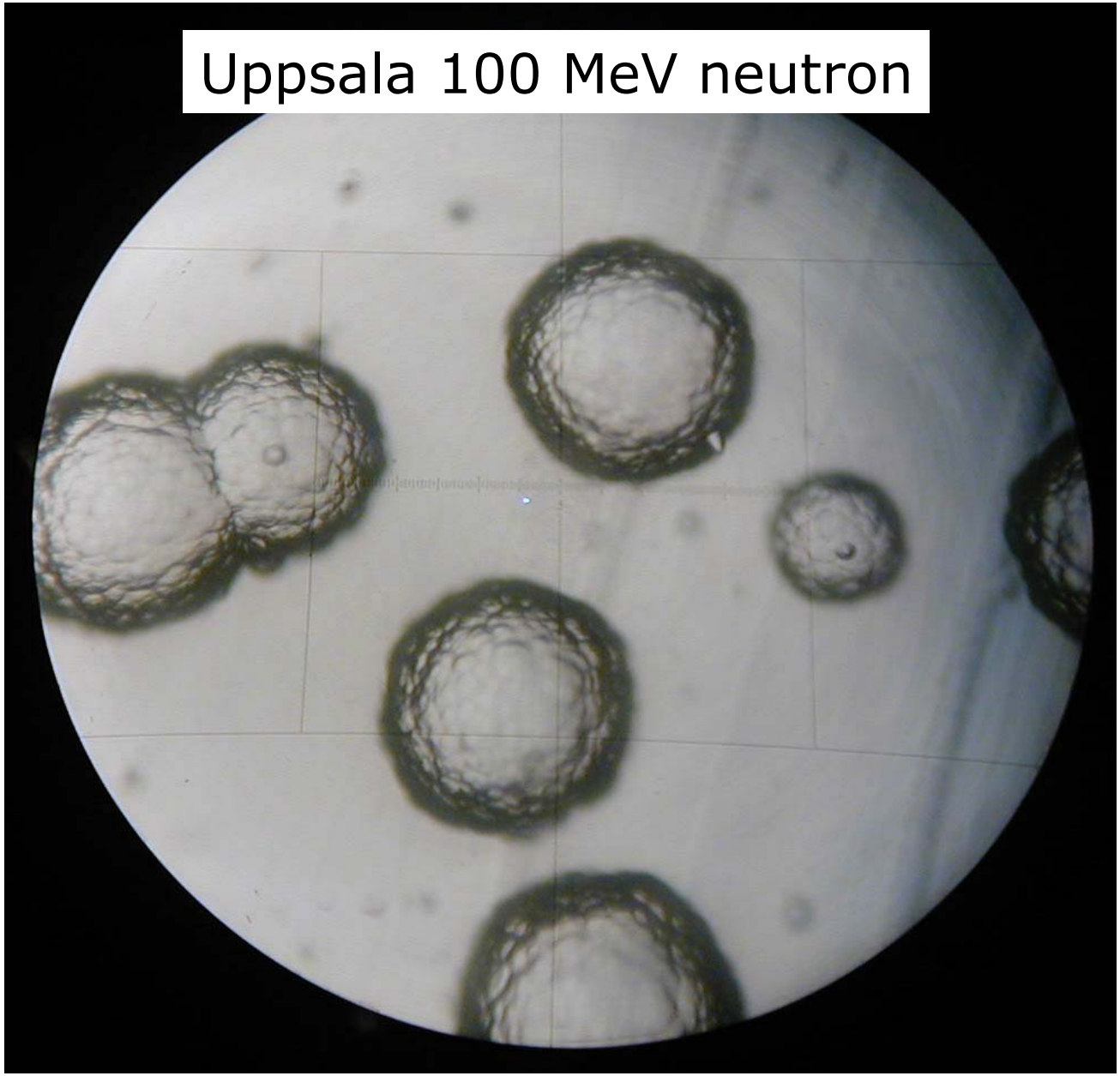
Electrochemical + Chem Etch

CERF neutrons 100 keV - 500 MeV



Electrochemical + Chem Etch

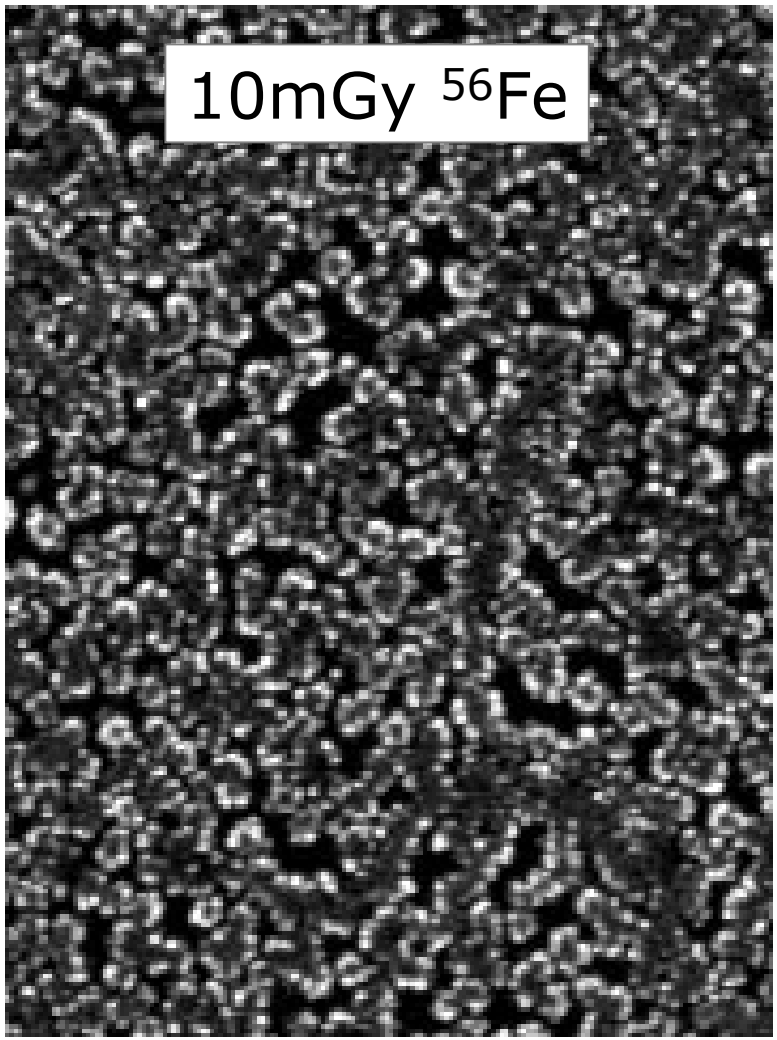
Secondary charged particles produced by very-high energy neutrons can sometimes give rise to cone shaped tracks after chemical etching

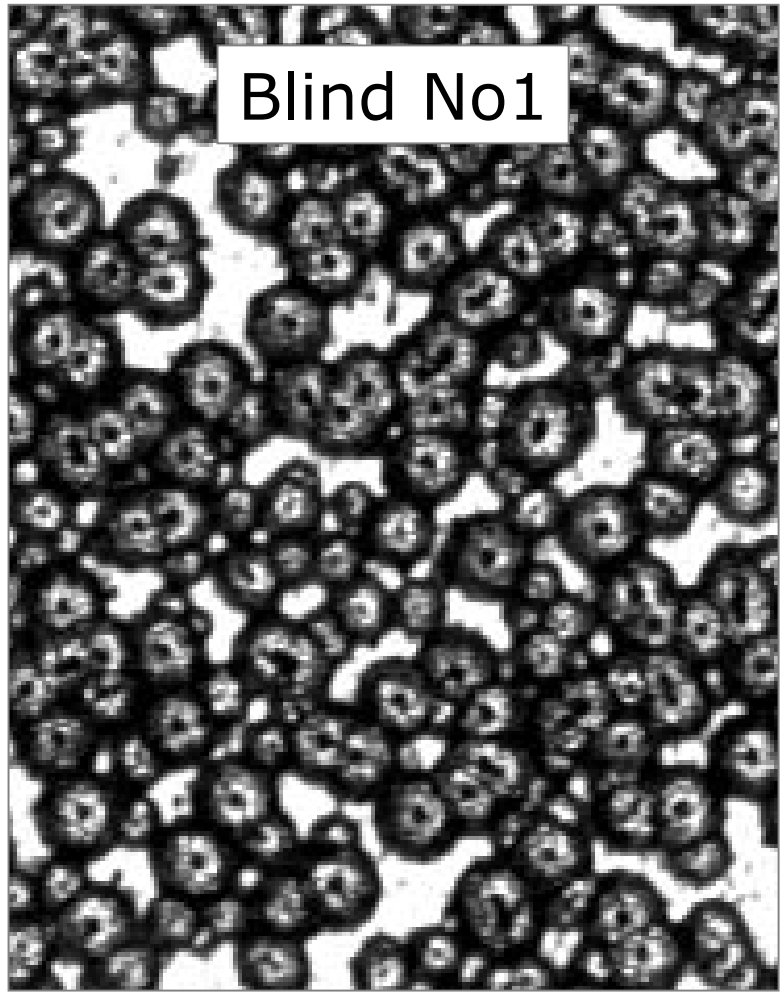

Uppsala 100 MeV neutron

ICCHIBAN Irradiations

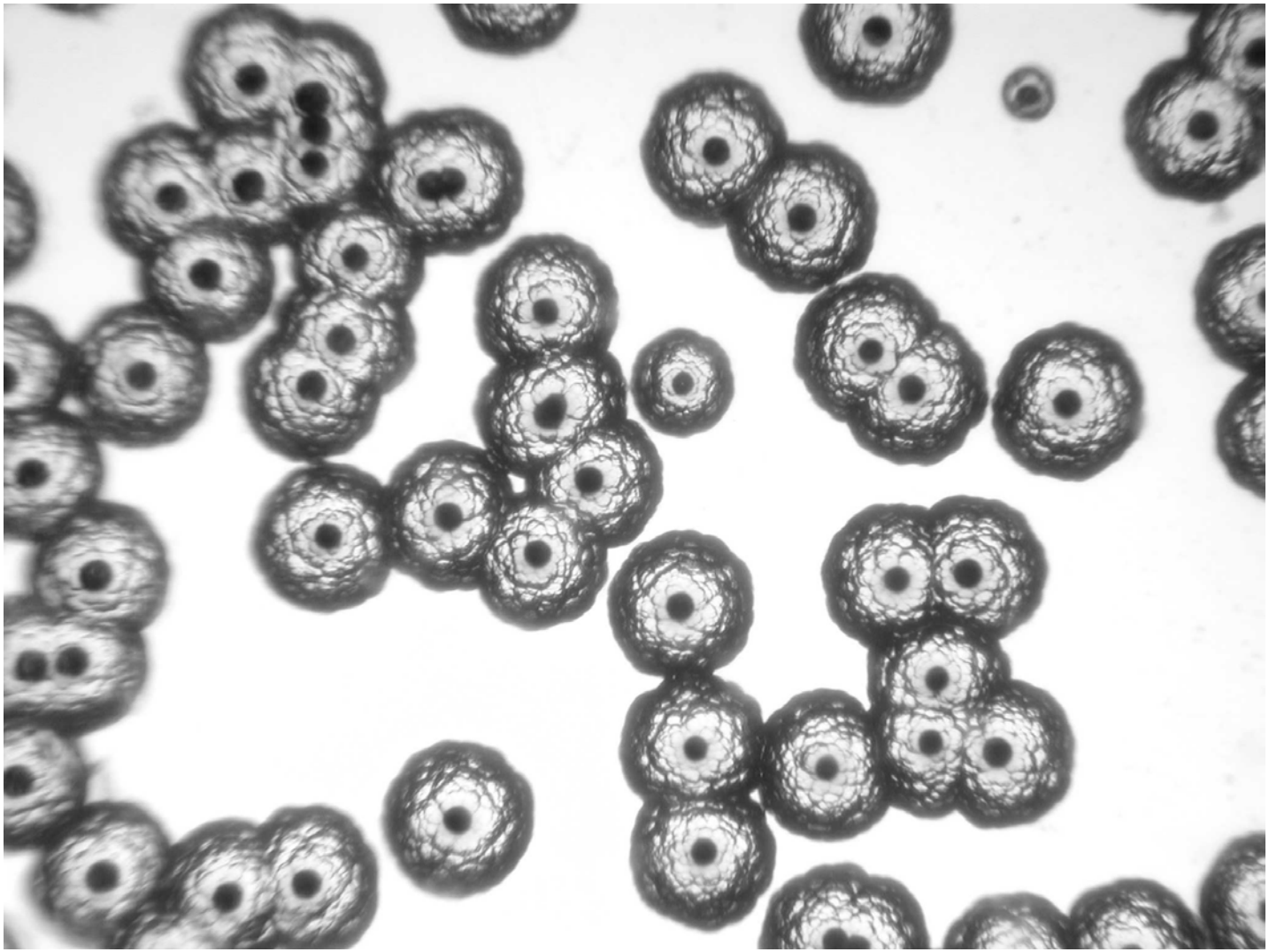
Doses for the ICCHIBAN intercomparison were very high causing saturation of the dosemeter except at the lowest dose levels. Therefore the NRPB assessed only the results from the 1mGy exposures.

Track overlap resulting in saturation

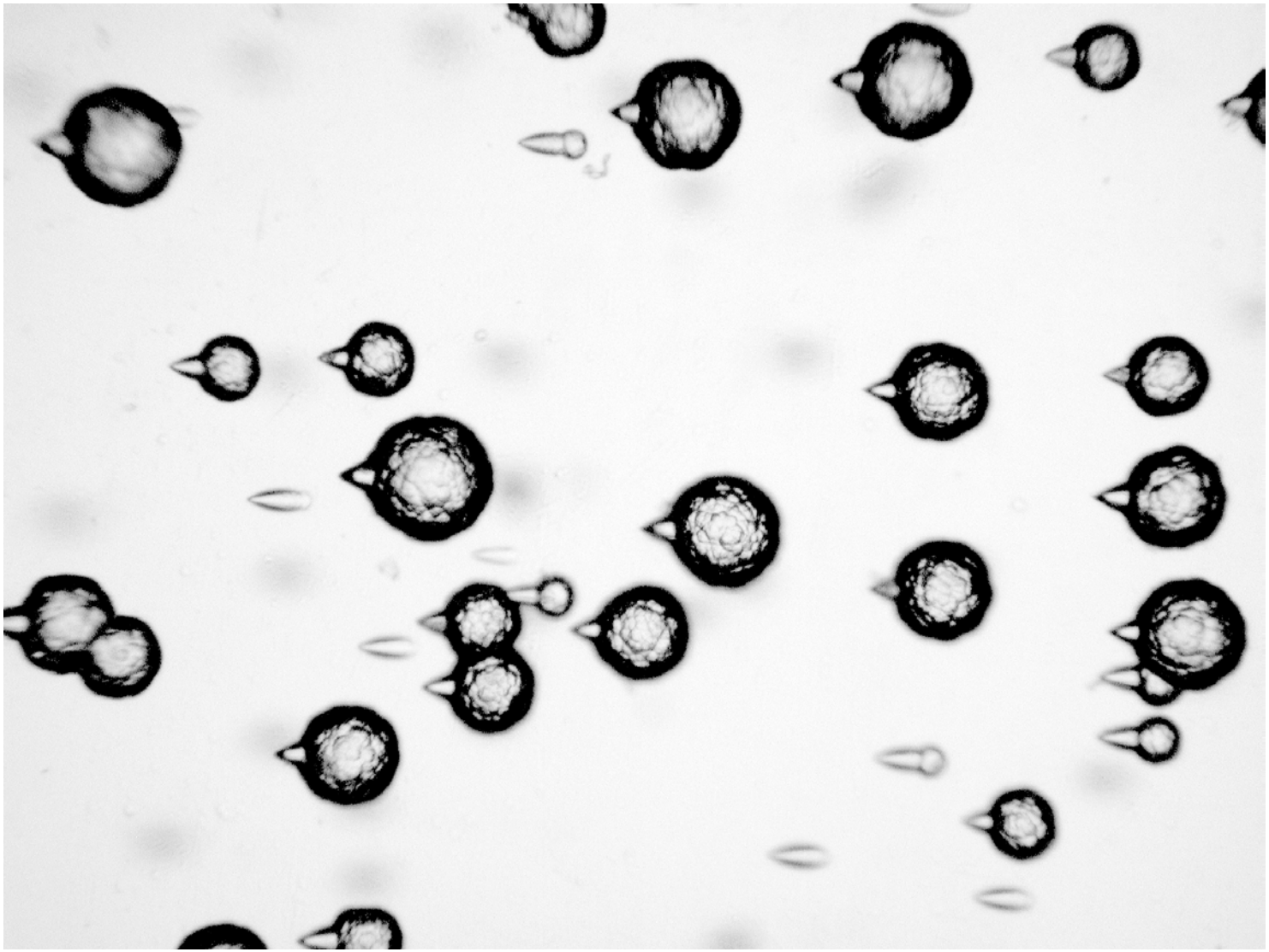




The HZE tracks which pass right through the detector are identified by their appearance which is as black spots when the particles arrive at normal incidence and as cones for all other angles. Corresponding entry and exit tracks can be seen on either side of the etched detector.



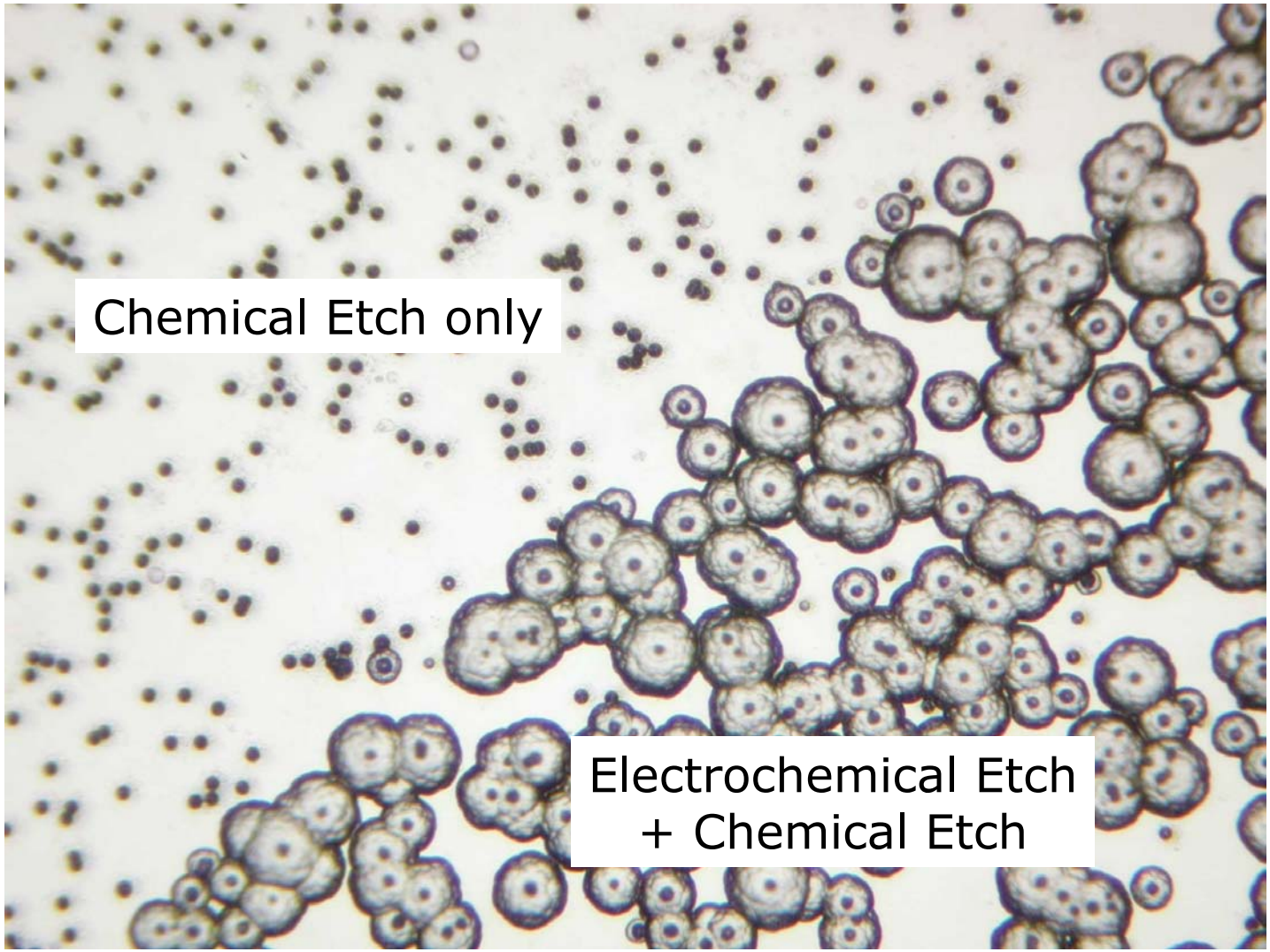
Electrochemical Etch + Chemical Etch
Particle: ^{56}Fe (1 mGy) Angle: Normal incidence



Particle: ^{56}Fe Angle: 60º to normal incidence

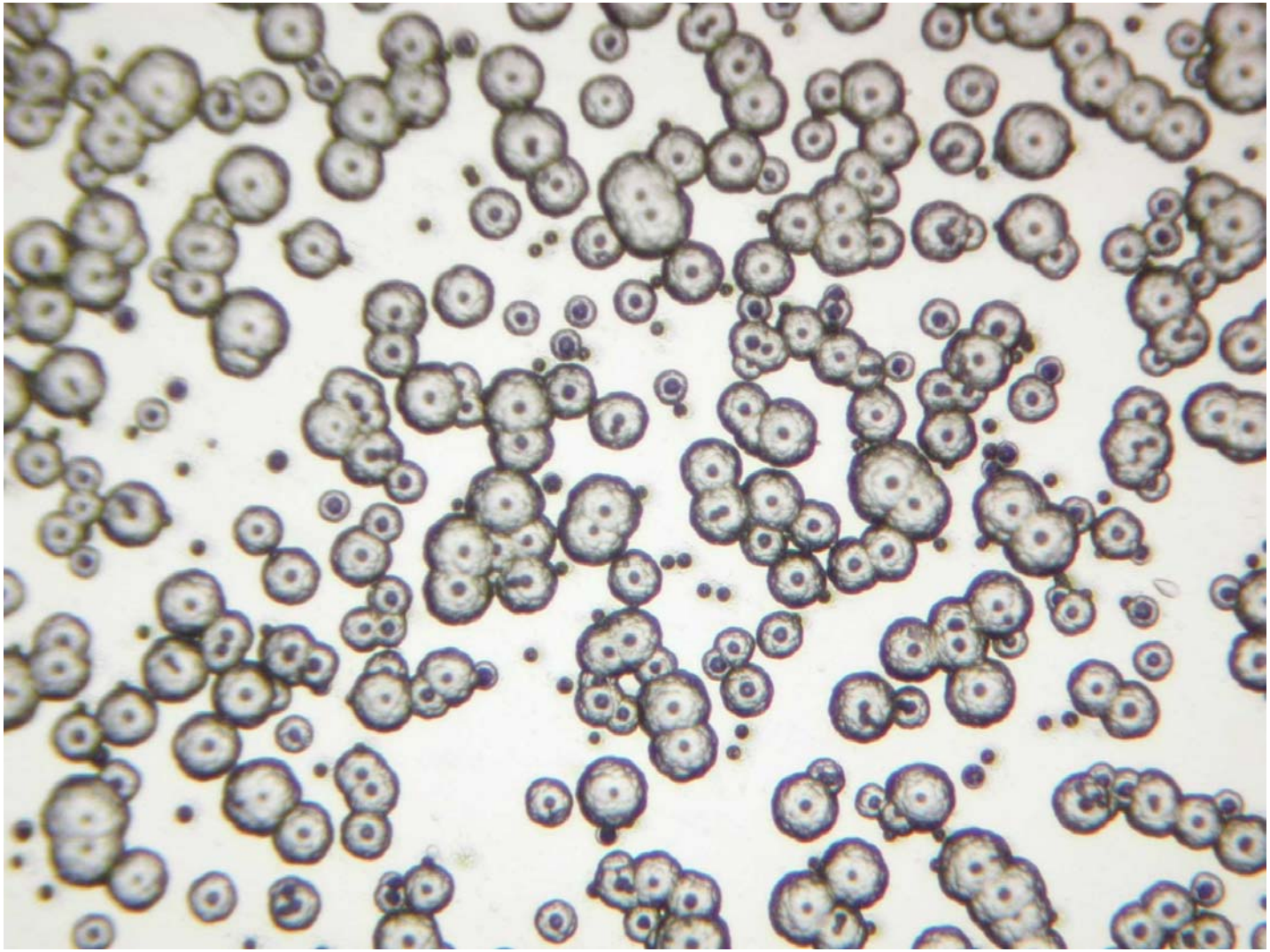
Performing a subsequent chemical etch reveals HZE tracks which would not be developed by the electrochemical etch alone. This can be clearly seen on the Si-28 normal incidence image where there are more chemically etched HZE tracks (black spots) than electrochemically etched tracks.

Carbon-12 is below the threshold for electrochemical etching; only chemical etching reveals them.



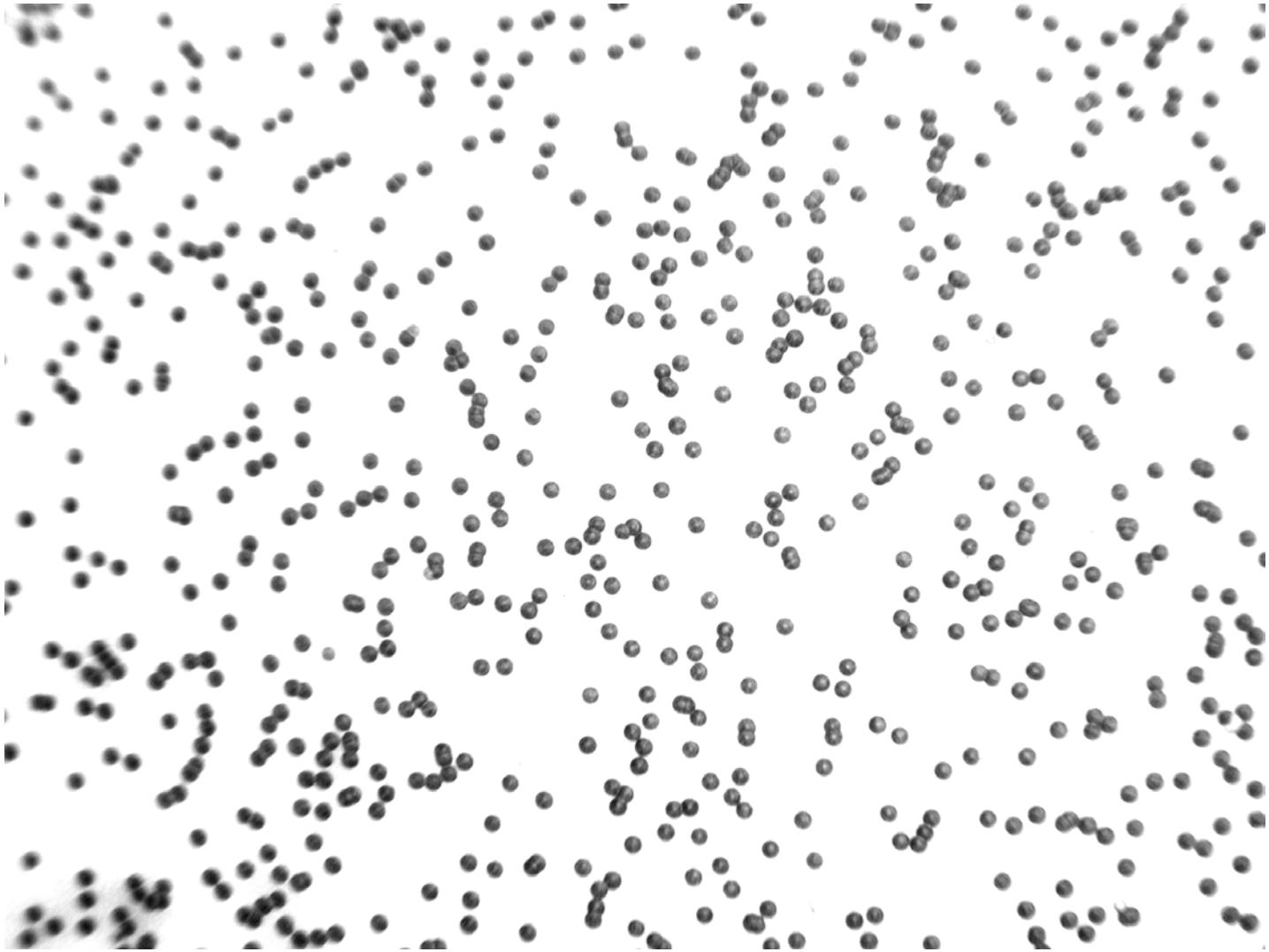
Boundary of Etch areas

Particle: ^{28}Si (1 mGy) Angle: Normal incidence



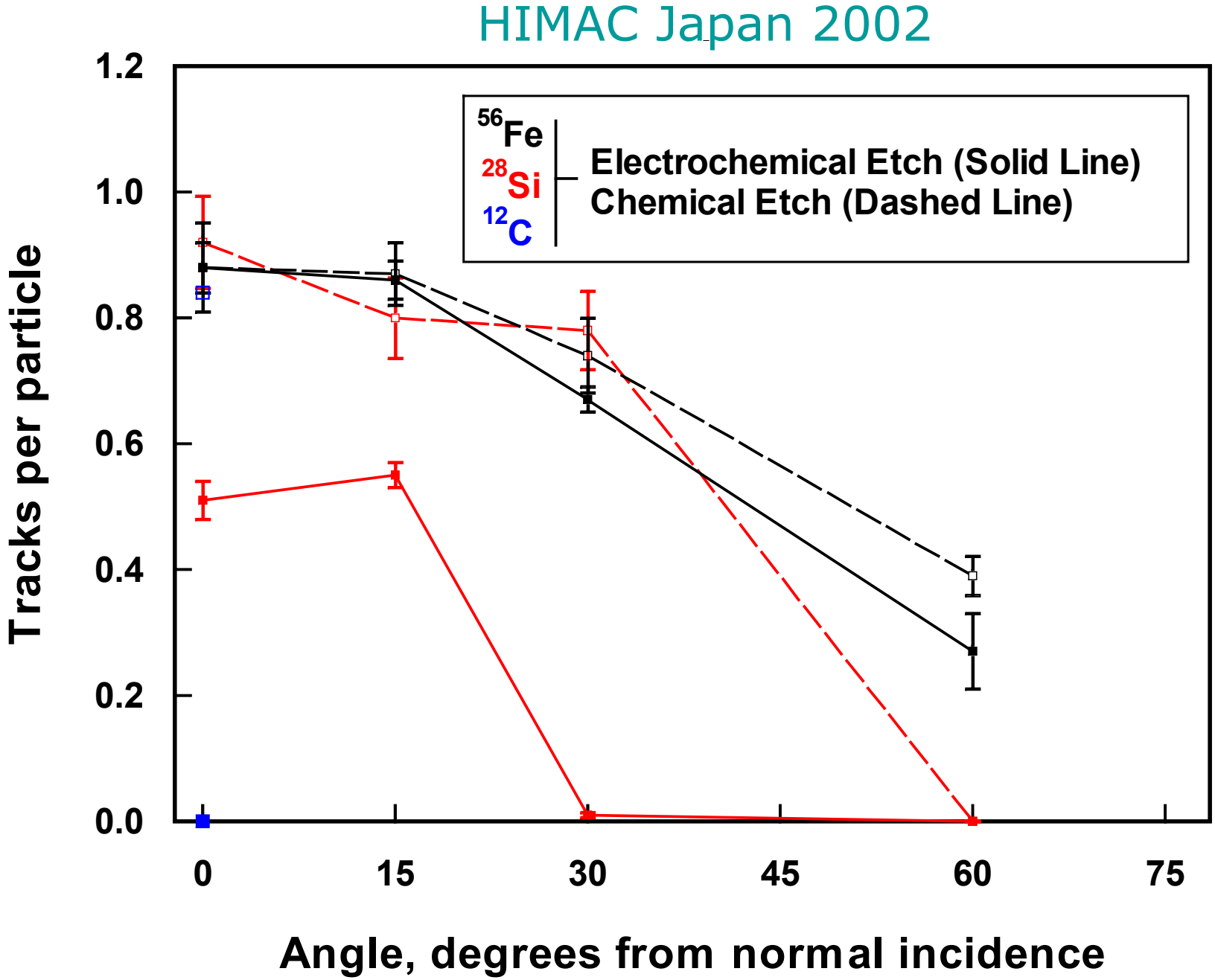
Electrochemical Etch + Chemical Etch

Particle: ^{28}Si (1 mGy) Angle: Normal incidence



Electrochemical Etch + Chemical Etch

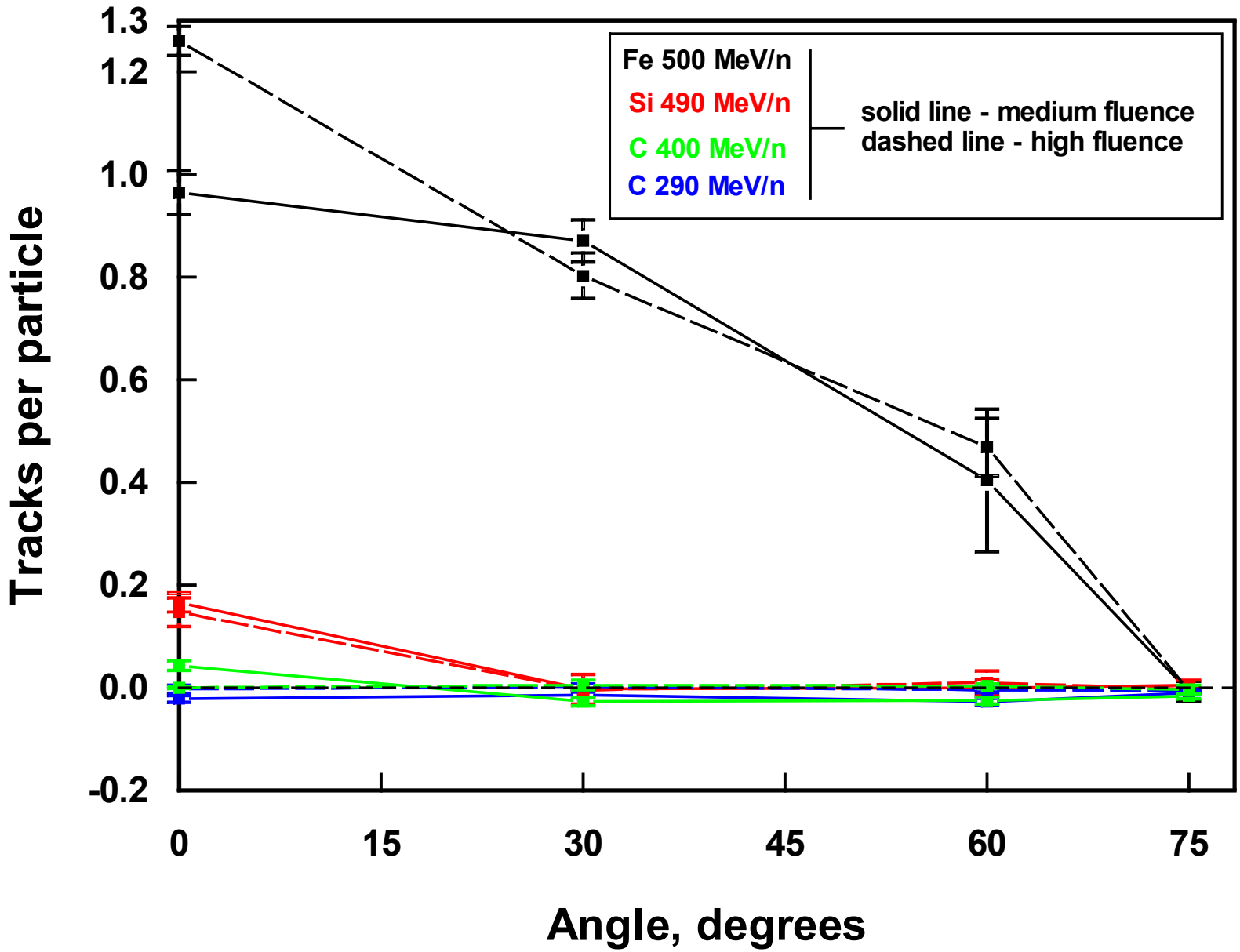
Particle: ^{12}C (1 mGy) Angle: Normal incidence


HIMAC Japan 2002
56Fe
28Si
12C
Electrochemical Etch (Solid Line)
Chemical Etch (Dashed Line)
Tracks per particle
1.2
1.0
0.8
0.6
0.4
0.2
0.0
0
15
30
45
60
75
Angle, degrees from normal incidence

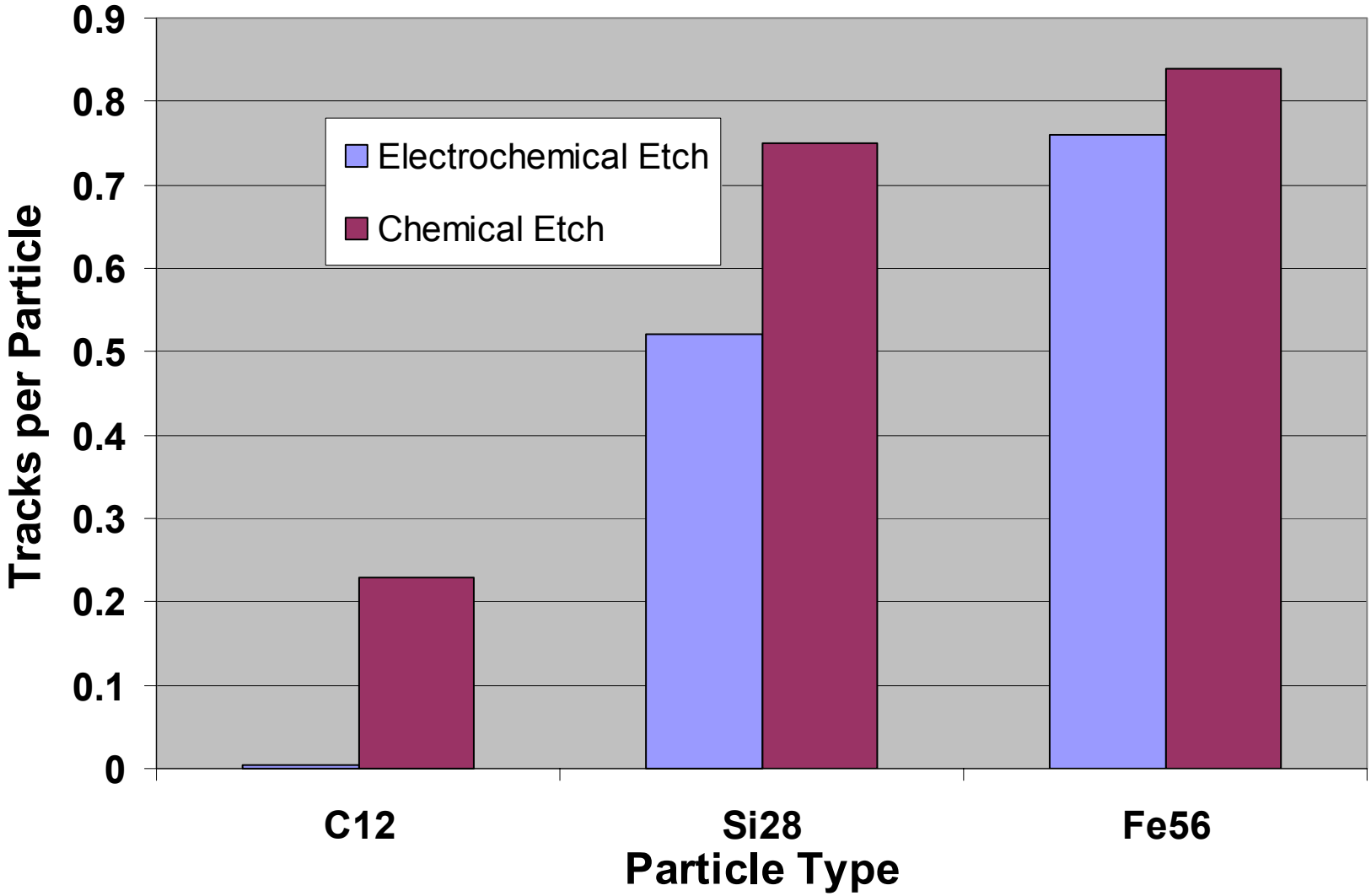
Normal Incidence 1 mGy

Particle	Quoted Ions Per 1.767 cm^2	Electrochemical etch Number of tracks	Chemical etch Number of tracks
^{12}C	98980	2	83459
^{28}Si	19840	10108	18207
^{56}Fe	5504	4947	4862

HIMAC Japan 2000



Fragmentation



Track Diameters

For neutrons using Electrochemical etch (Counted automatically with Nikon slide scanner)		50 - 200 μm
HIMAC HZE Chemical etch (Counted manually)	C-12	20 μm
	Si-28	35 μm
	Fe-56	45 μm

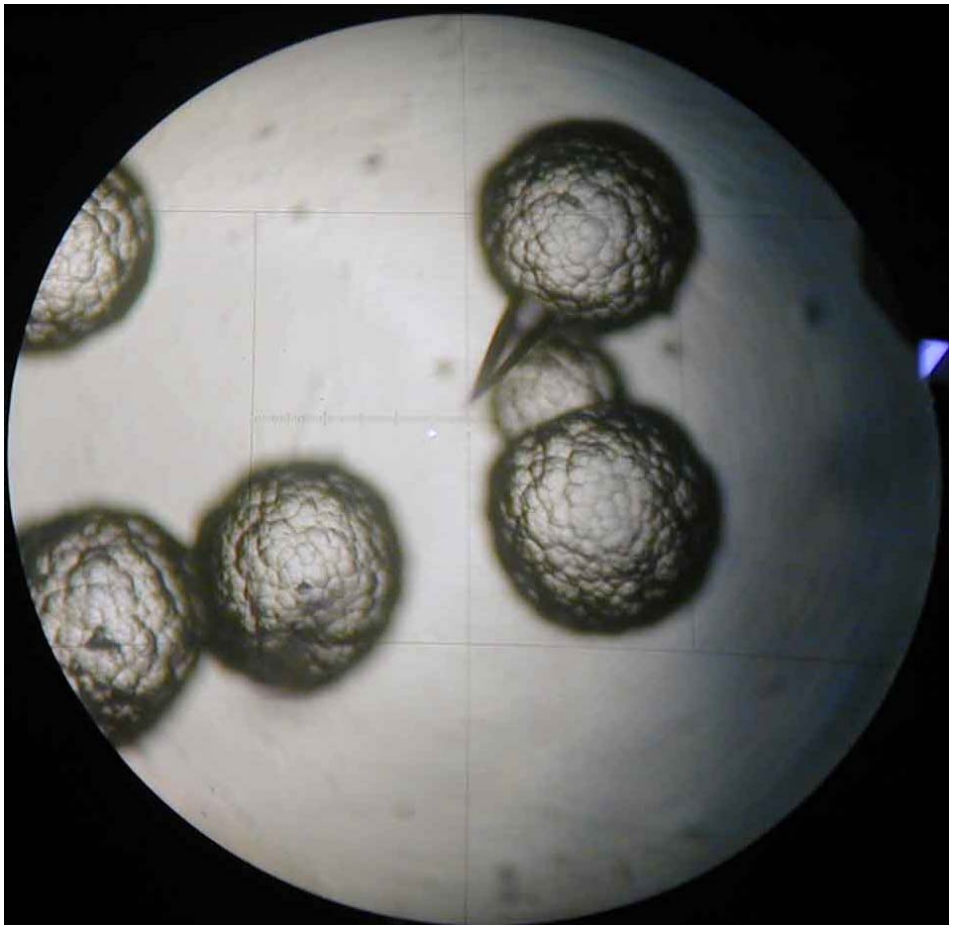
Minimum pixel size of scanner is 10 microns so chemically etched tracks can only be counted using manual techniques

NASA Shuttle Dosemeters

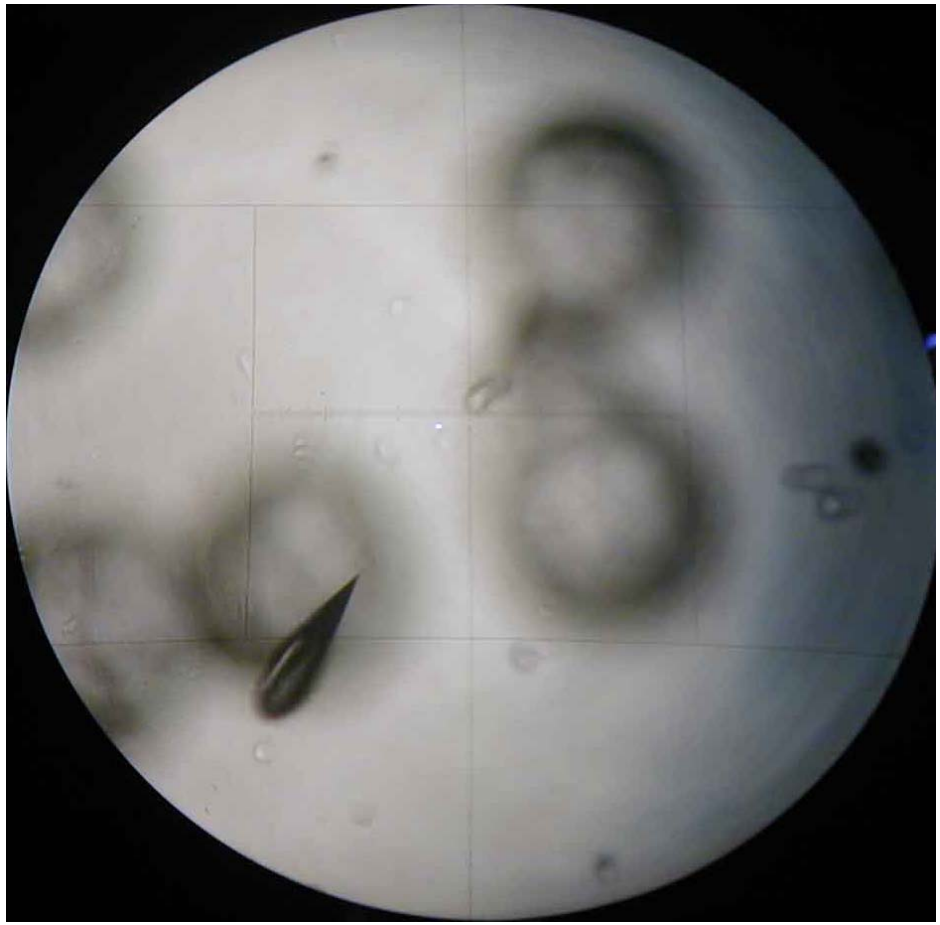
Isotropic field- At moderate to high angles of incidence the cone shaped chemically etched HZE tracks have a wide size range. Identification is based on finding corresponding entry and exit cones on the front and back faces of the dosemeter.

Proportion of tracks due to HZE component is difficult to estimate accurately as visual identification is somewhat subjective.

STS 105 - obvious HZE track

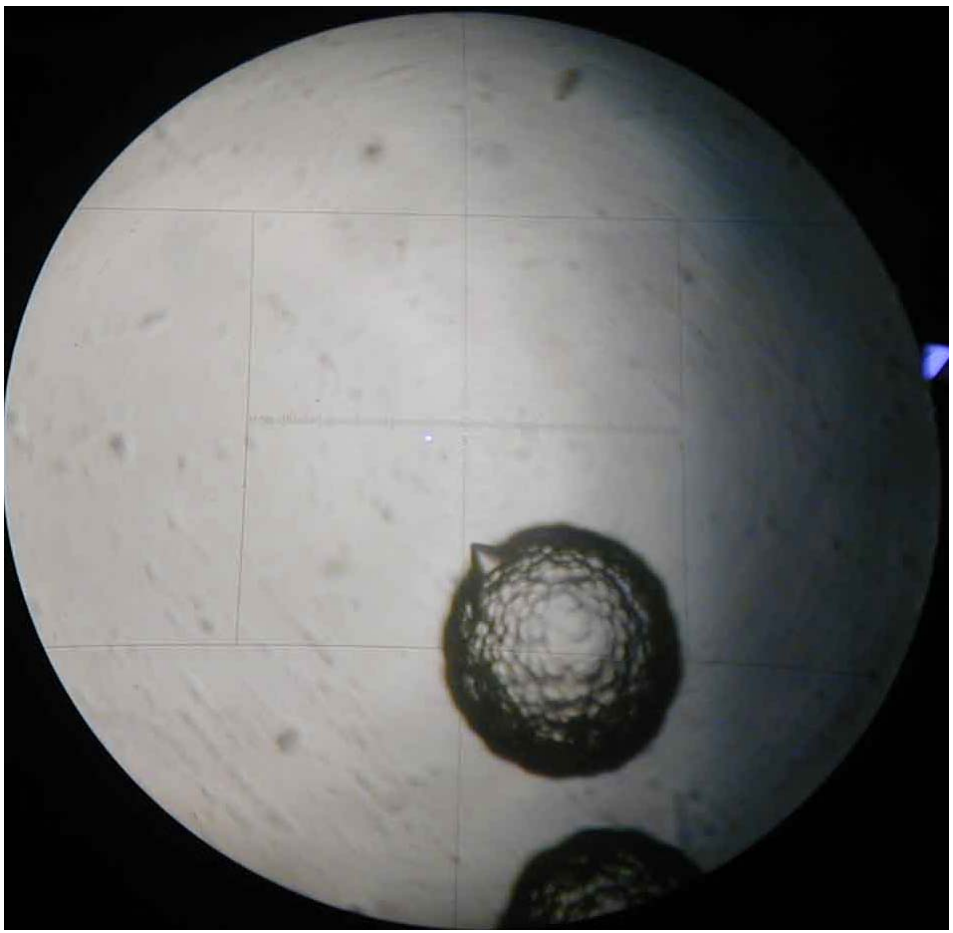


Back face



Front Face

STS 105 - typical HZE track



Back face

Front face

ACKNOWLEDGEMENTS

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