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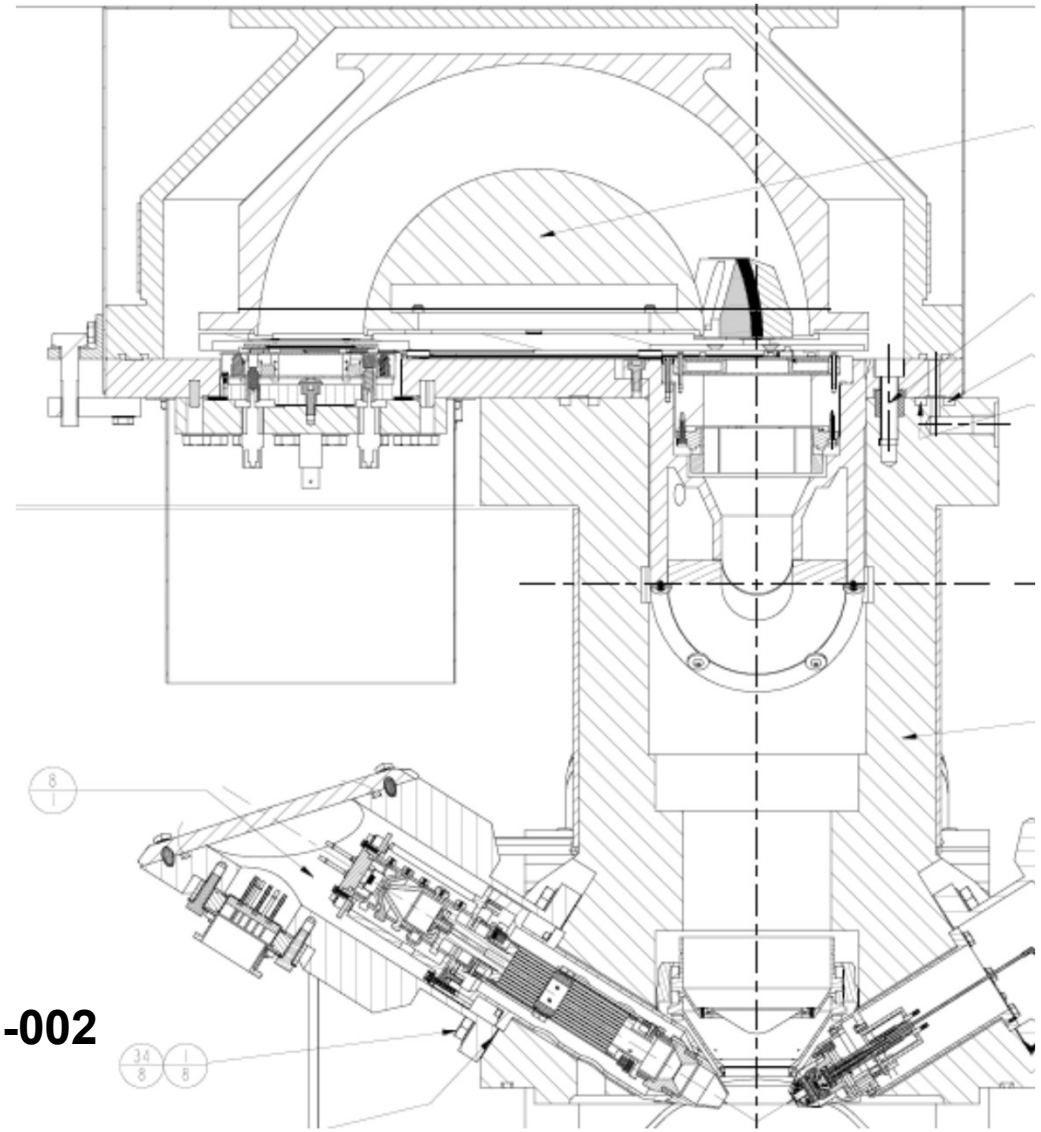
K-Alpha Lens and Analyser

Bryan Barnard

April 2007

Overview of XPS Electron Collection and Analysis



See Dwg 802-03-002

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XPS Electron Detection Optics

1. **Input Mesh Lens**
   Grabs a large solid angle of the emitted XPS electrons

2. **Quadrupole Beam Shaping Lens**
   Matches the cross section of the beam to the Analyser input slit

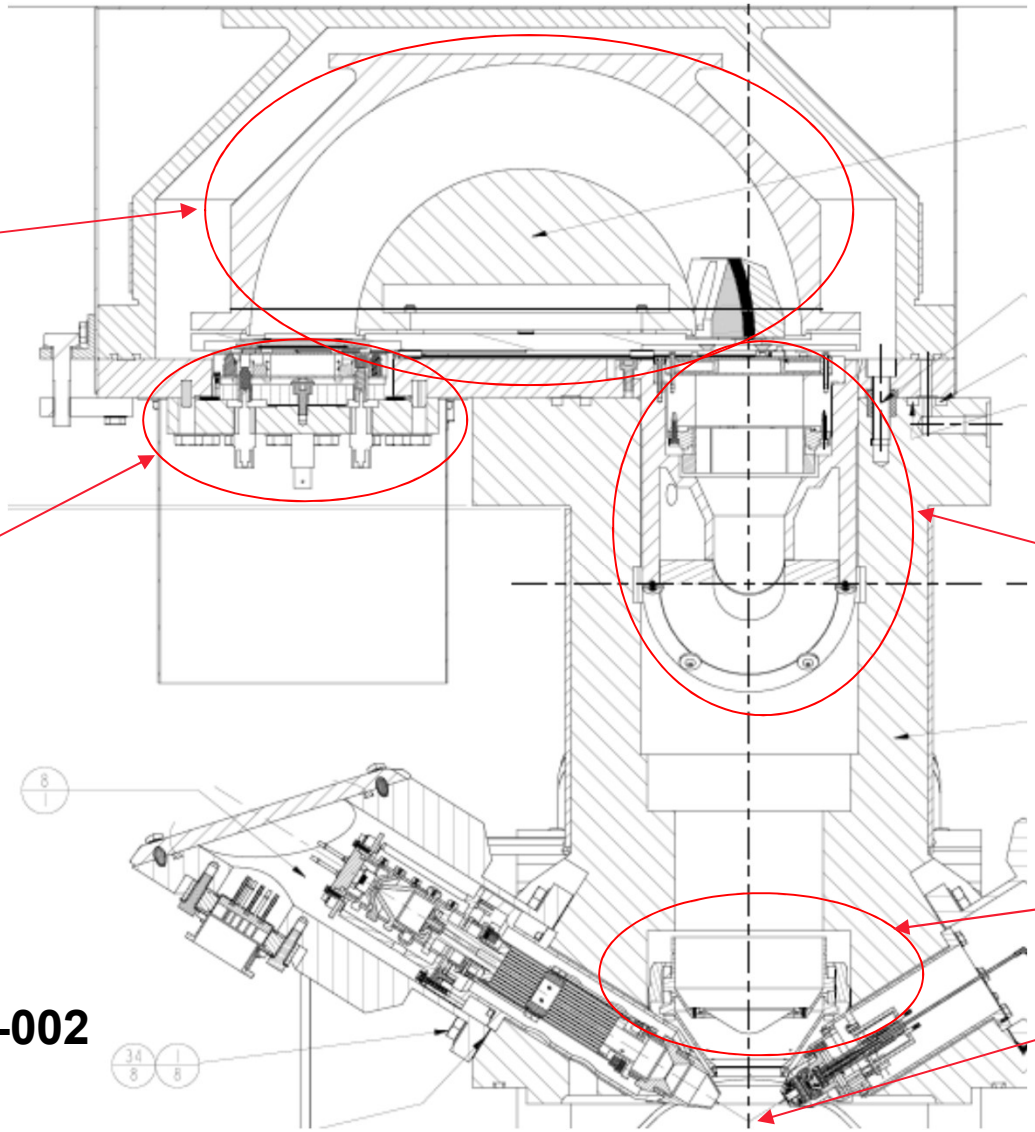
3. **Magnetic Rotator Lens**
   Matches the angular dispersion of the beam to the acceptance angles of the analyser

4. **Retardation Region**
   Allows us to programme the required analyser energy resolution

5. **Analyser**
   Provides 2D focussing and energy dispersion across the detector.

6. **Position Sensitive Detector**
   Determines energy of all detected electrons….. details to follow.

Overview of XPS Electron Collection and Analysis



Spectrometer Assembly

Detector Assembly

LQ,LM and Mirror Assembly

L1 Lens Assembly

Sample

See Dwg 802-03-002

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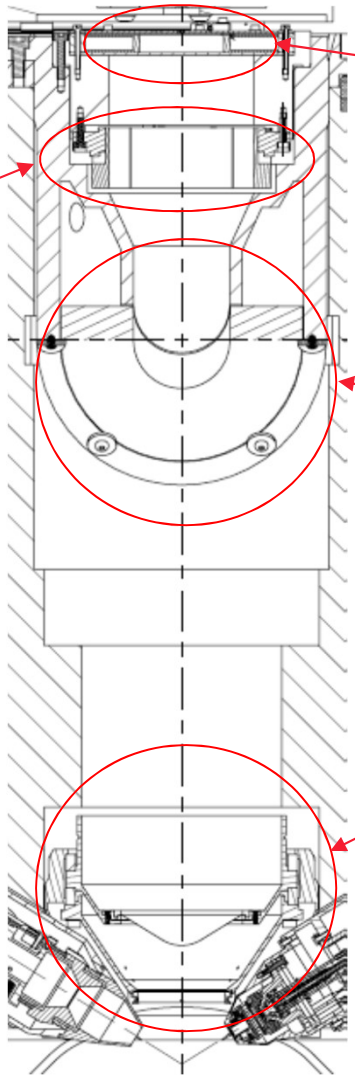
Input Lens Assembly



Magnetic Rotator

Quadrupole Lens

Mirror

Input Lens Components

Meshed Input Lens

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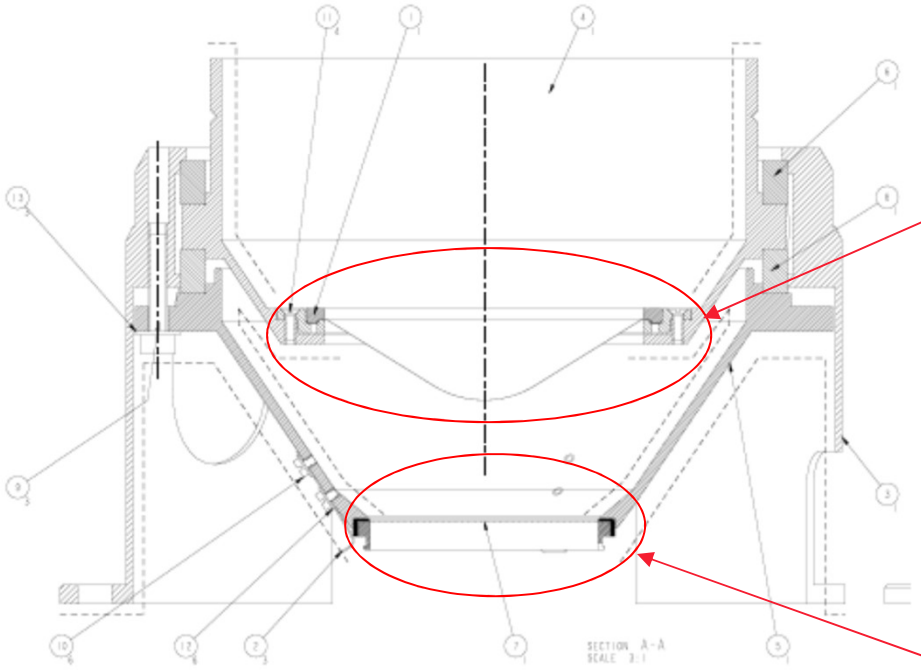
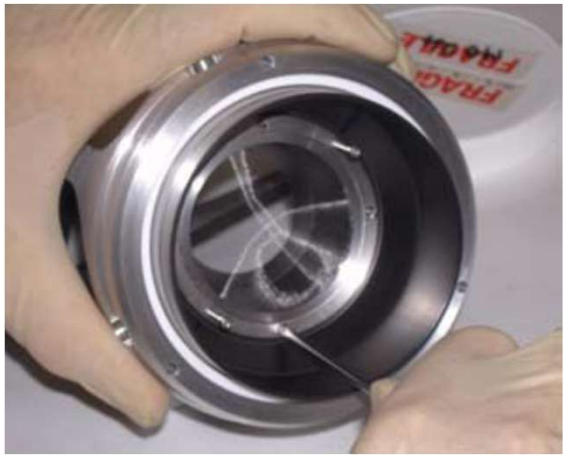
Lens 1……. Meshed input lens



Meshed Input Lens



Domed Meshed

Flat Mesh

See QAIPB007 for details

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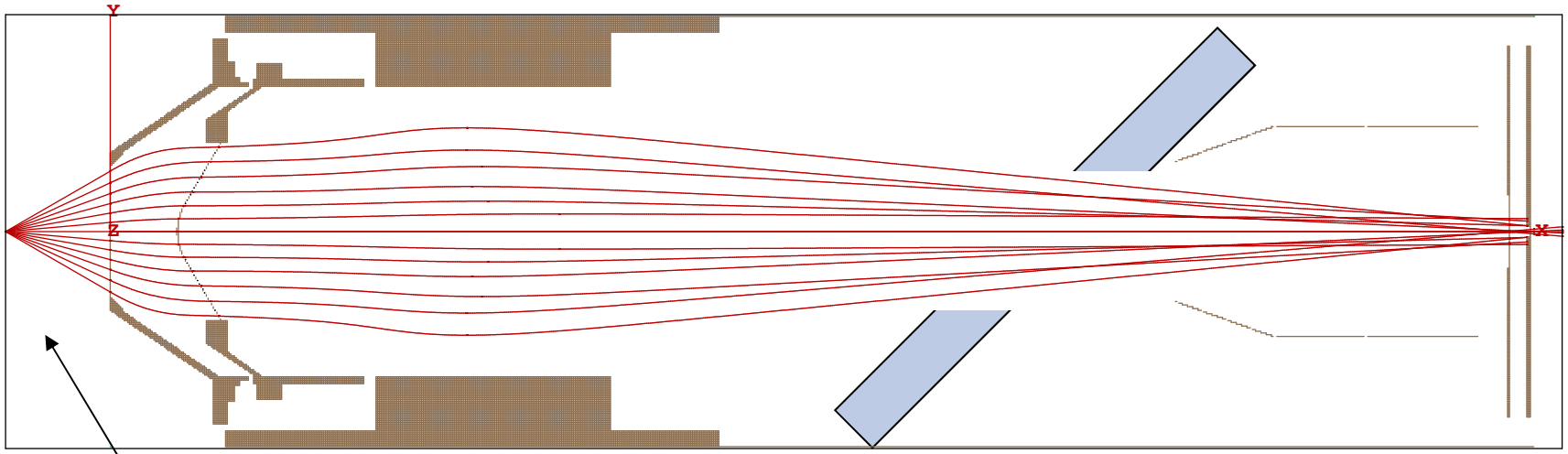
SIMION MODEL of INPUT LENS



+ -30 degree Acceptance Angle

Operation with Mesh Lens Alone

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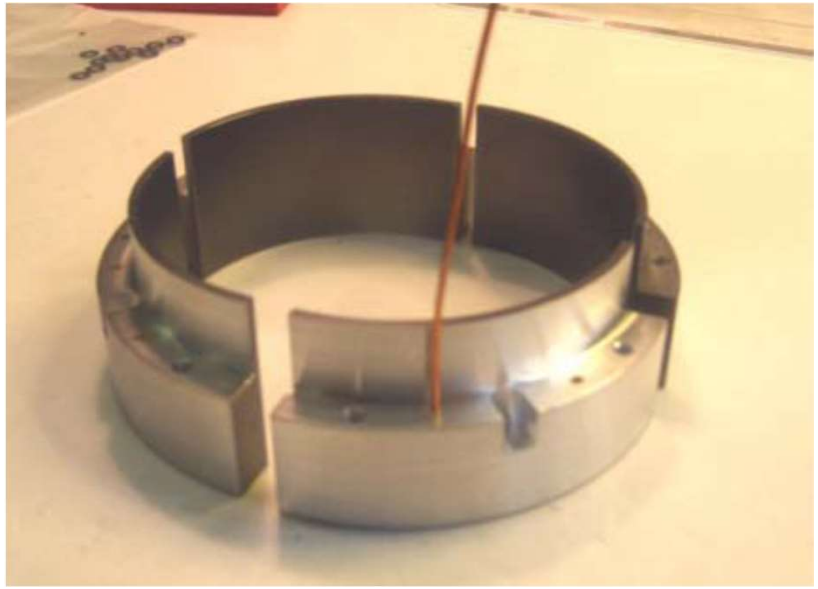
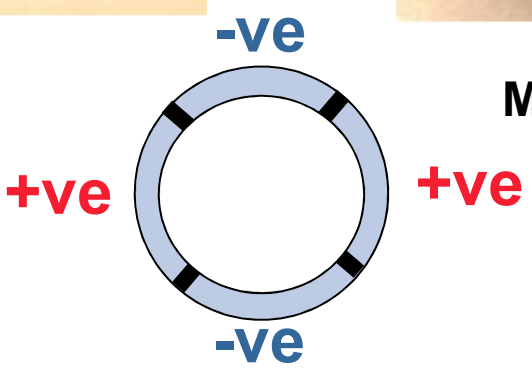
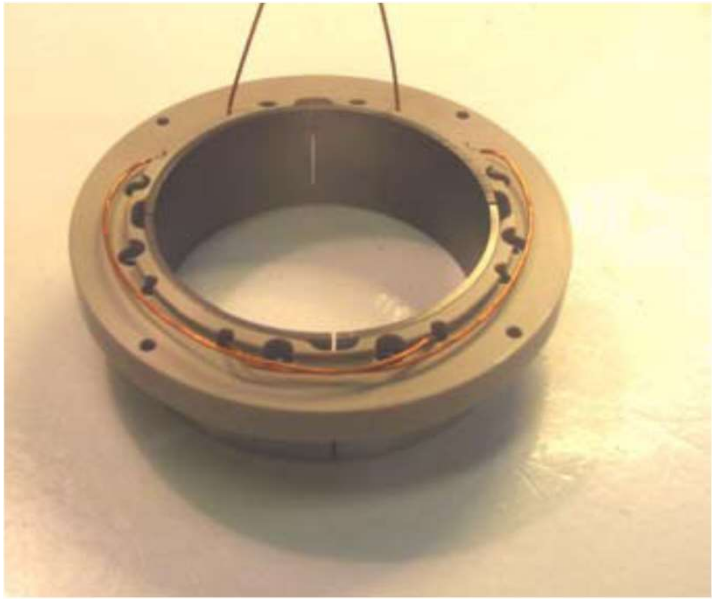
Quadrupole Lens



Four isolated elements





Mounted in PEEK spacer

See QAIPB010 for details

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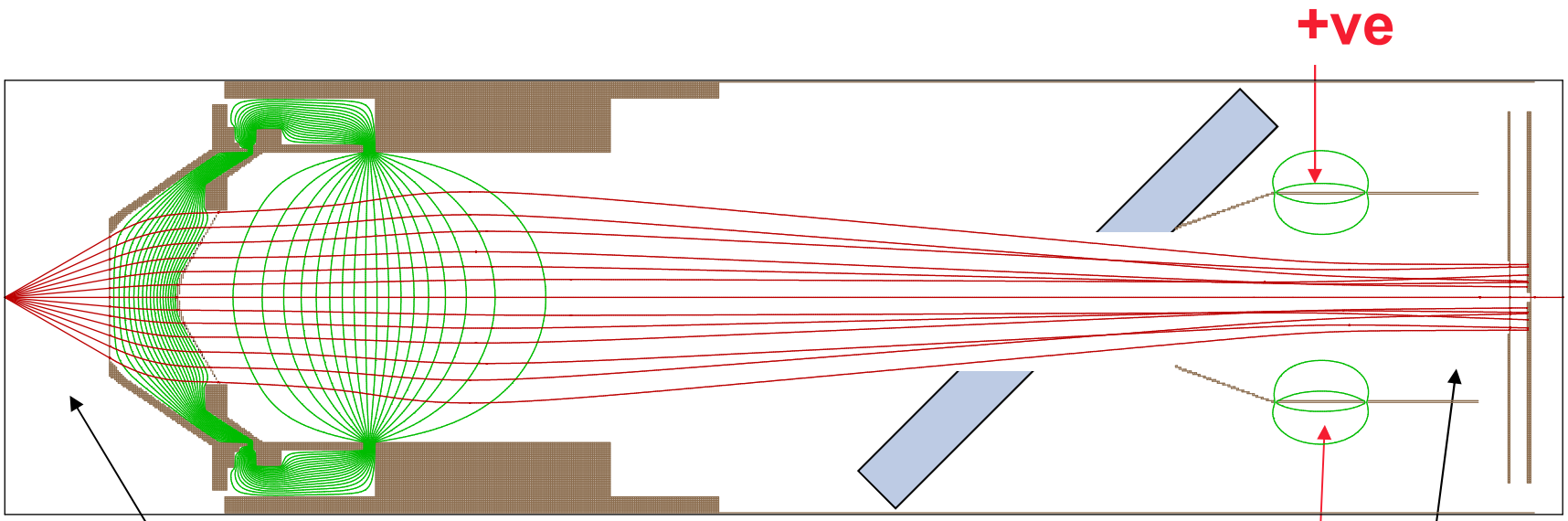
SIMION MODEL of INPUT LENS



+ -30 degree Acceptance Angle

Quadrupole produces parallel beam 25 mm wide

View in Direction of Input Slit Long Dimension

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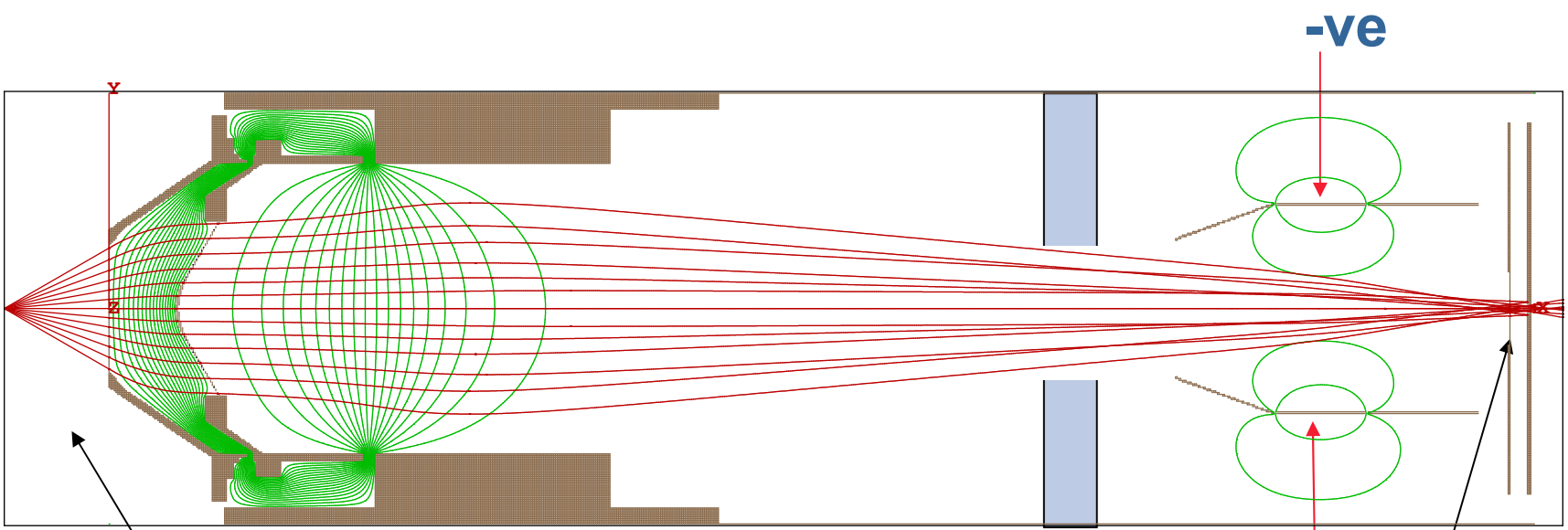
SIMION MODEL of INPUT LENS



+ -30 degree Acceptance Angle

Quadrupole produces focussed beam 2 mm wide

View in Direction of Input Slit Short Dimension

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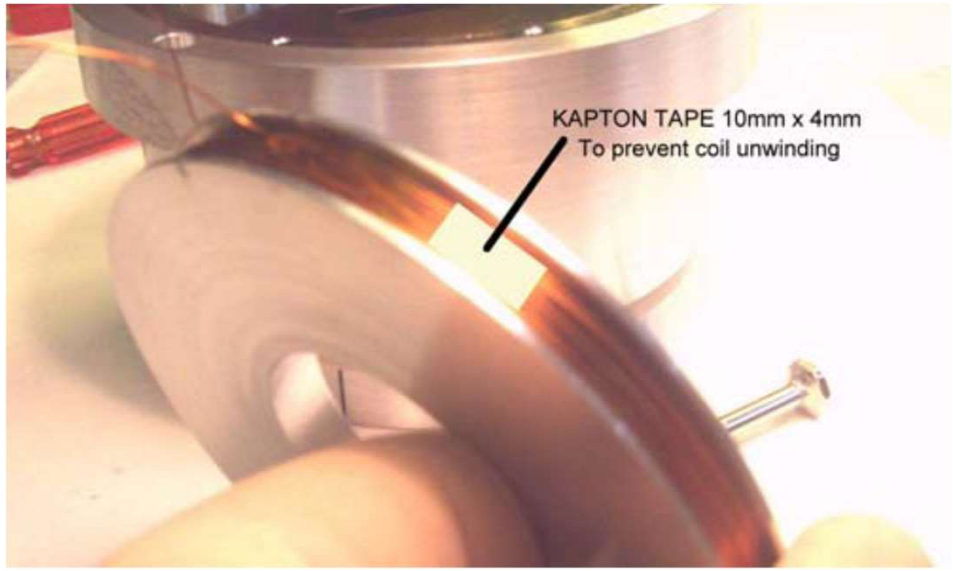
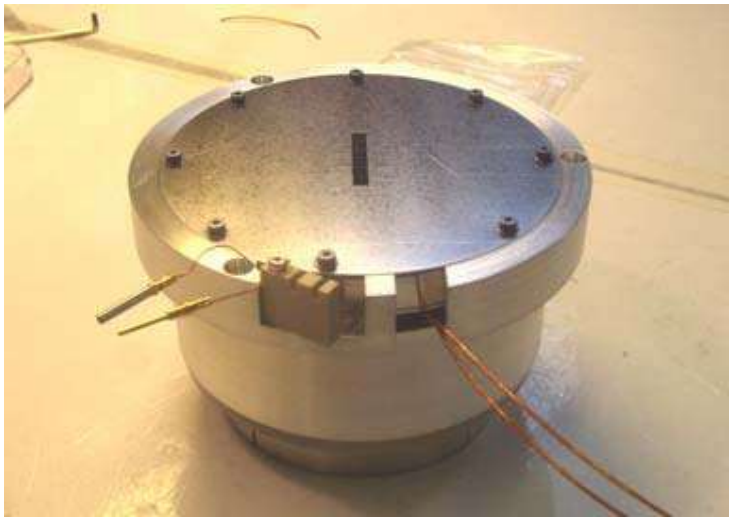
Magnetic Rotator Lens



Magnet Winding



Magnet Flux Return and End Plates

See QAIPB010 for details

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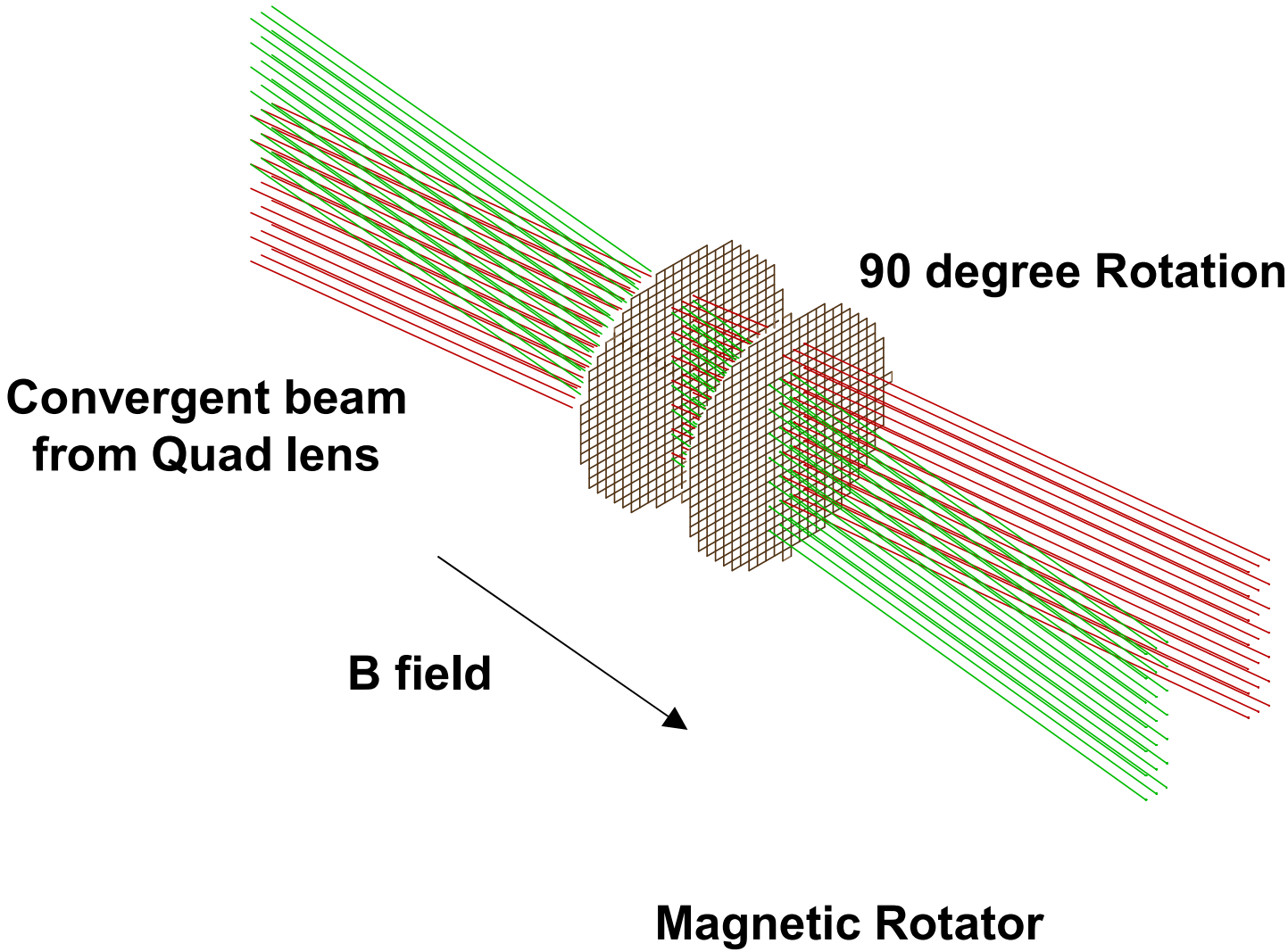
SIMION MODEL of INPUT LENS



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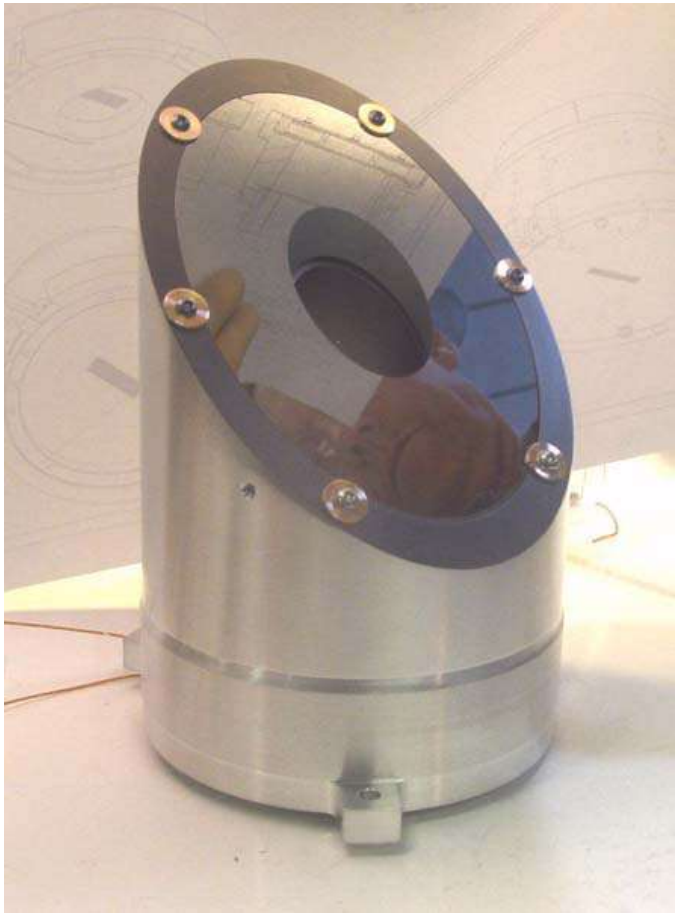
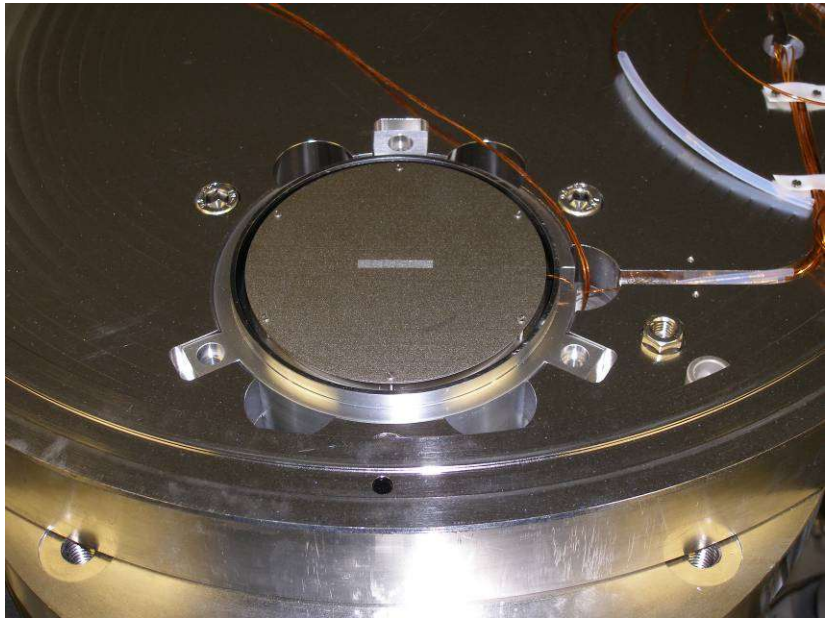
Quadrupole and Magnetic Rotator Lens with Mirror Housing



Complete Assembly of Quadrupole Lens Rotator Lens and Sample Viewing Mirror



Assembly fitted to Chamber showing exit slit from magnet

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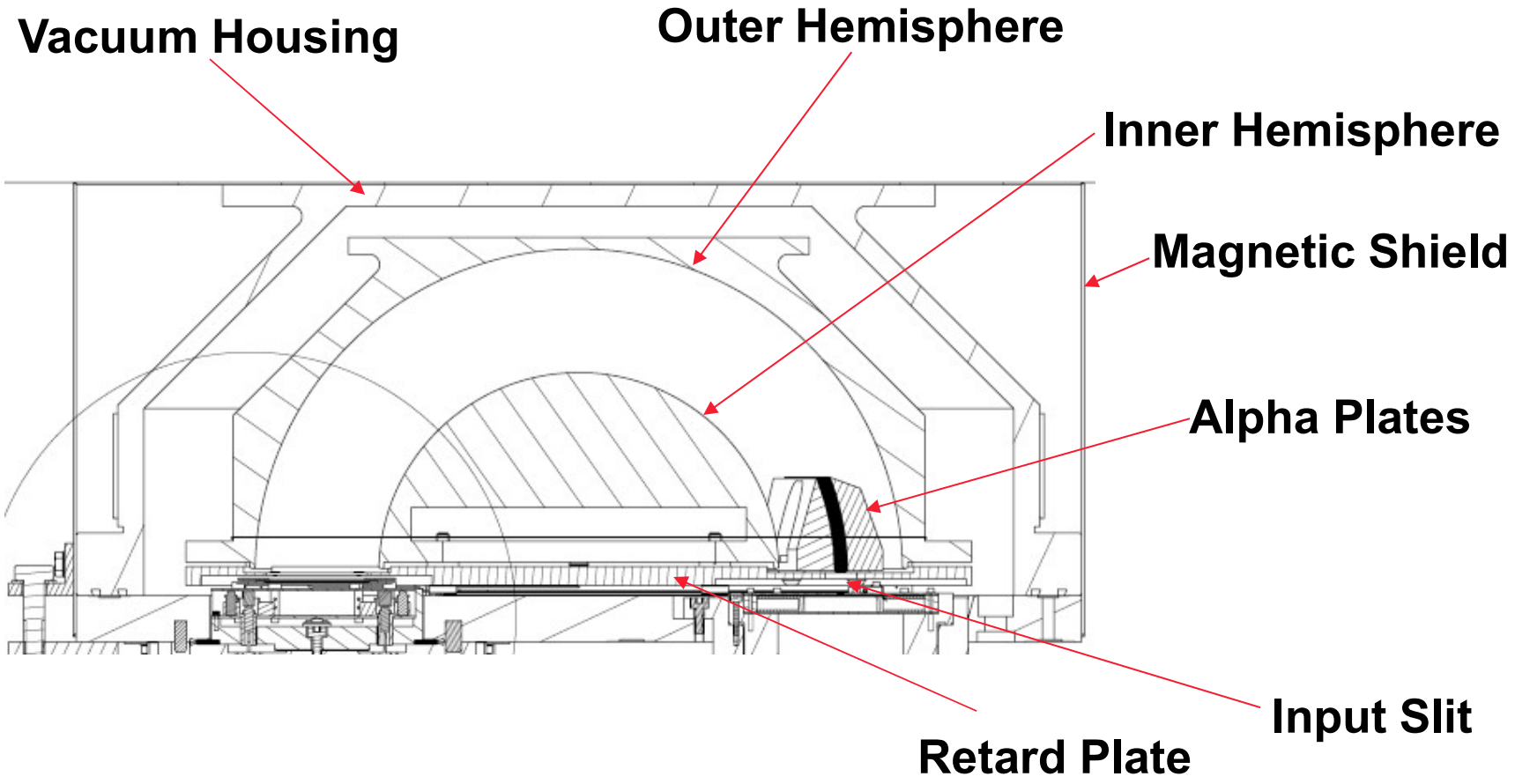
Analyser



See QAIPB009 for assembly details

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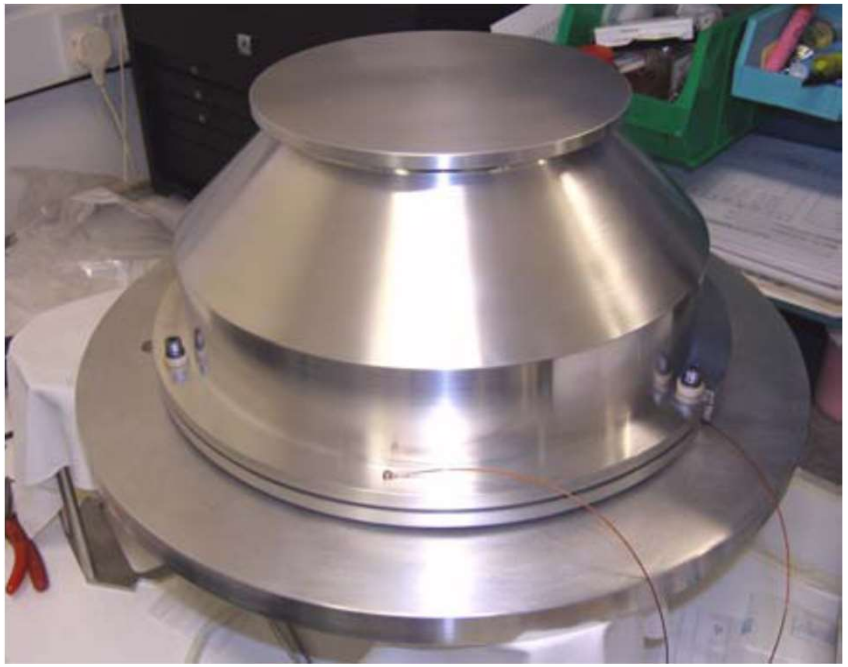
Analyser

Outer Hemisphere Removed

Showing Inner Hemisphere and Alpha plates



Outer Hemisphere Fitted

See QAIPB009 for details

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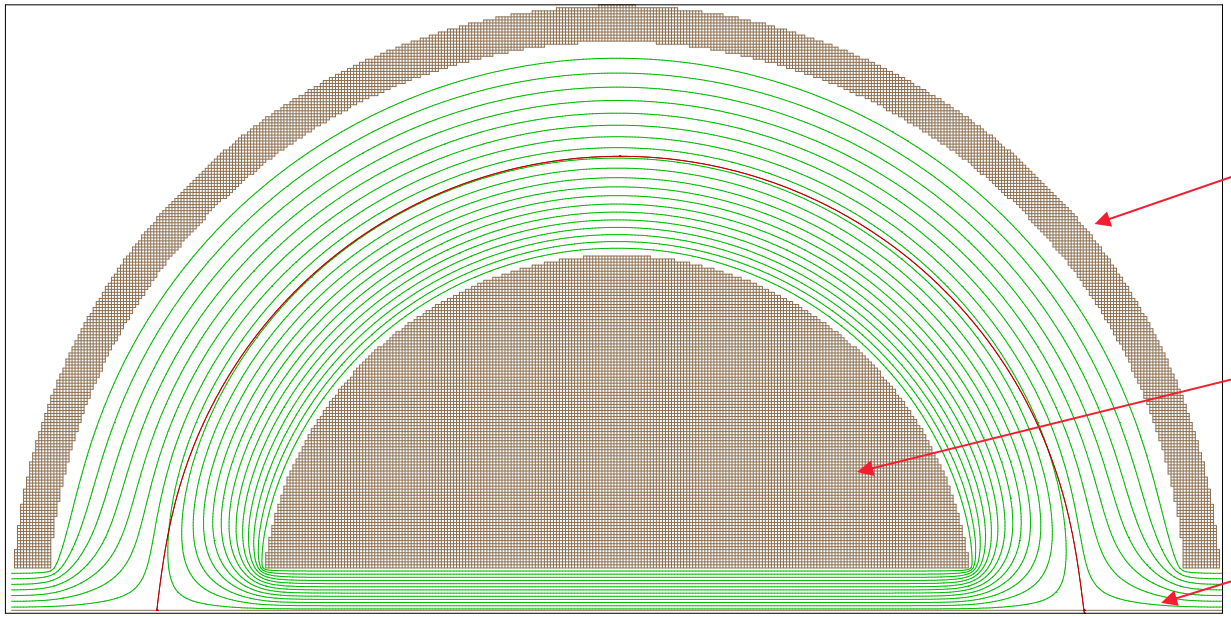
Analyser



Programming of a Hemispherical Analyser

Choose the energy (w.r.t. the base plate) of an electron which will pass around the midline. (The Pass Energy)

Calculate the +ve voltage for the inner hemisphere and the –ve voltage of the outer hemisphere to generate a perfectly spherical field.

The Voltage of the Base Plate (Retard Voltage) is generated by a resistive divider

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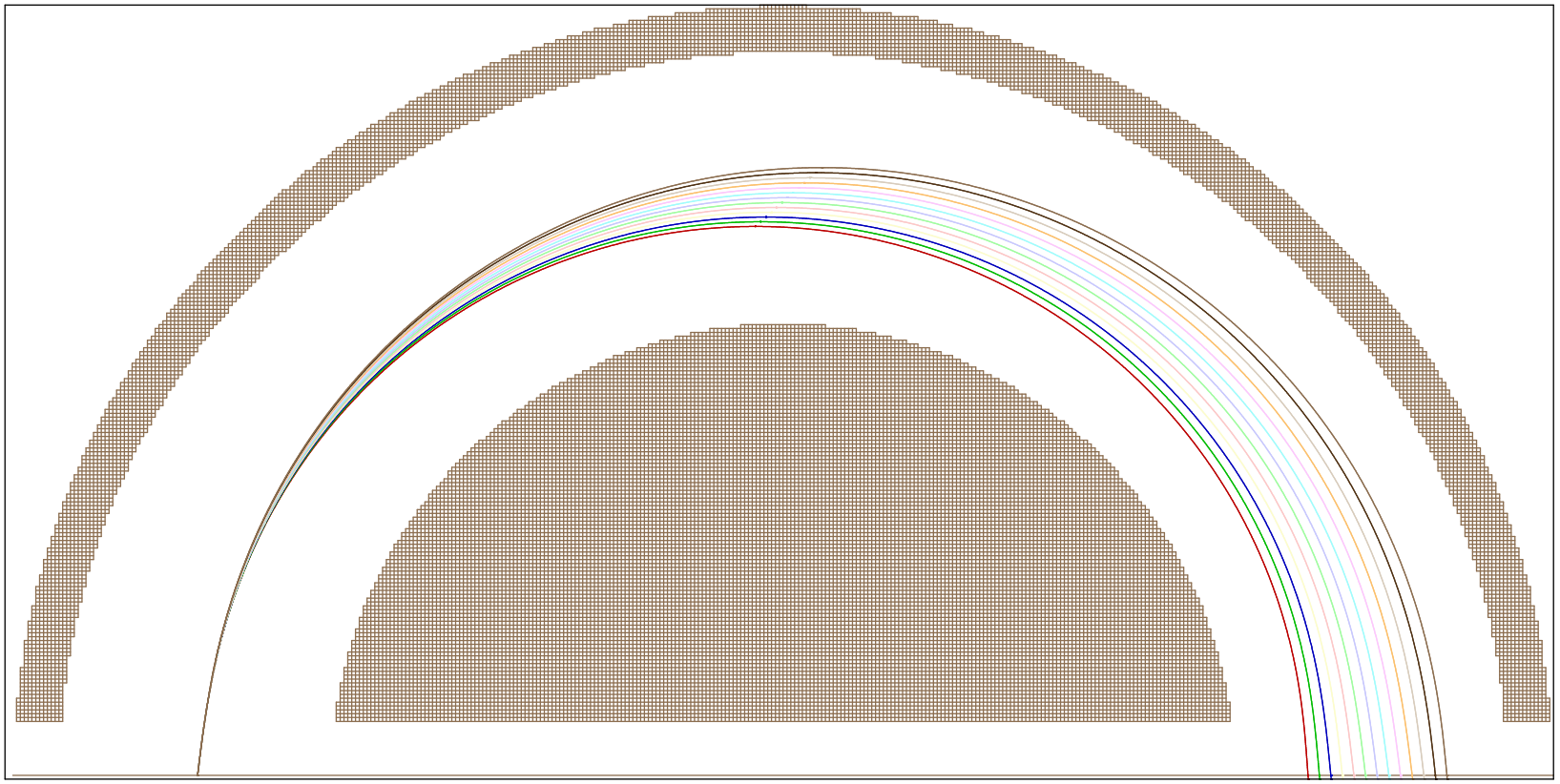
Analyser



Performance of Hemispherical Analyser as a function of Electron Energy

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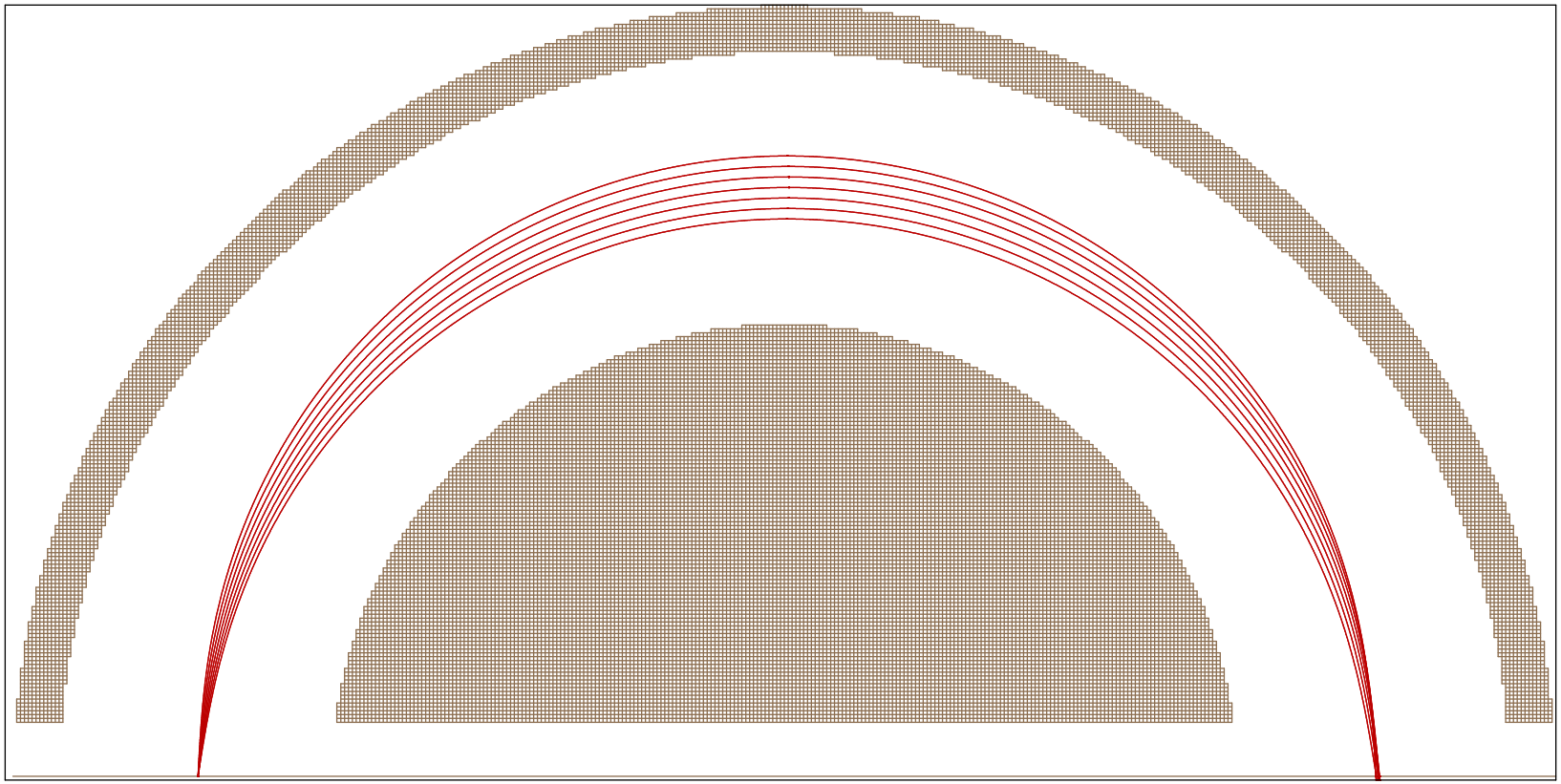
Analyser



Focusing property of Hemispherical Analyser as a function of Input Angle

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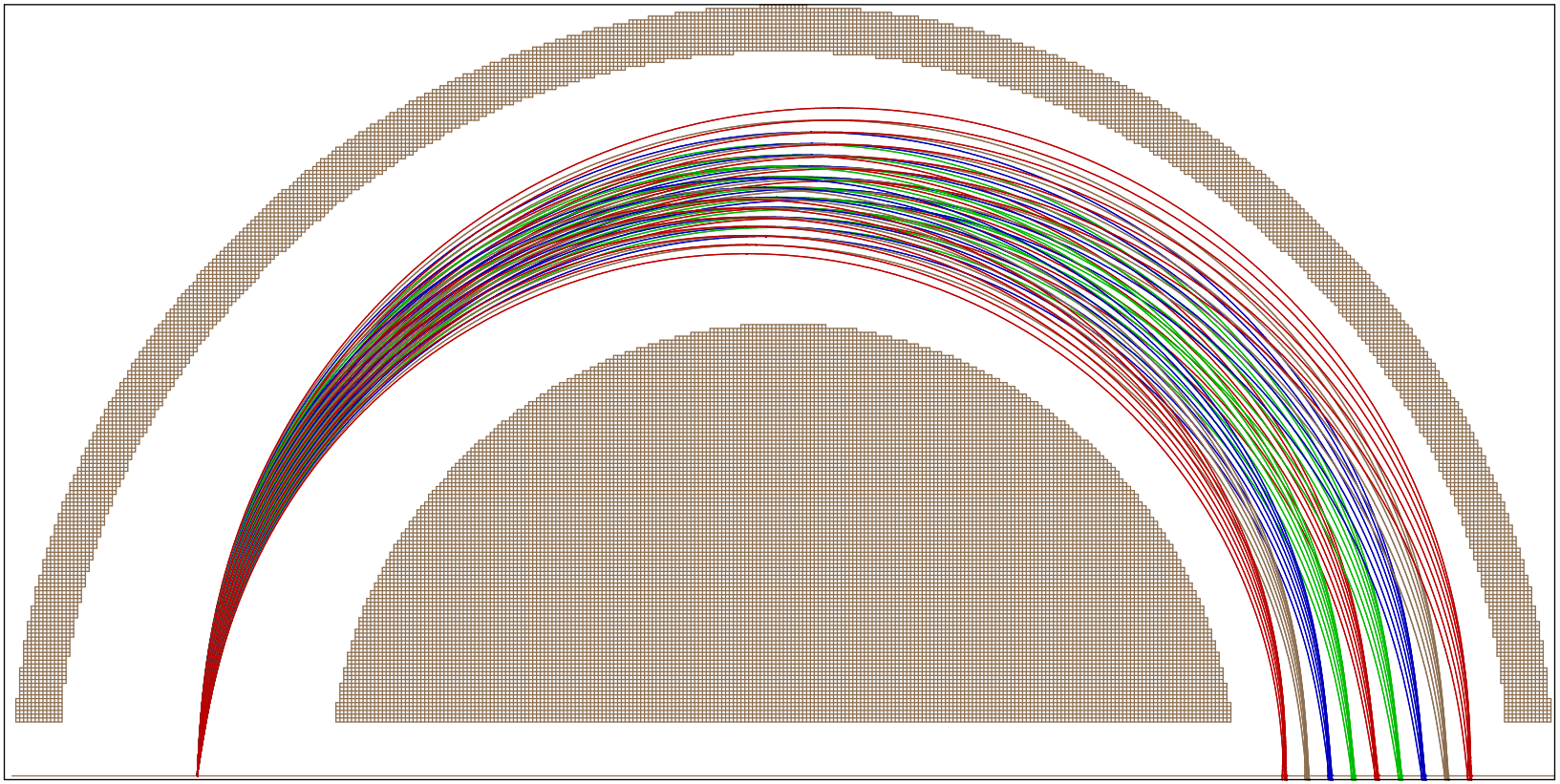
Analyser



Focusing and dispersion properties of Hemispherical Analyser

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Analyser Resolution

Energy resolution is determined by the dimensions of the analyser.

For the dimensions of the K-alpha analyser the energy resolution is 0.9 % of the programmed Pass Energy.

e.g. for a survey spectrum at 100eV Pass Energy the resolution of the spectrum will be about 1eV; largely determined by the analyser.

e.g. for a high resolution spectrum at 20eV Pass Energy the resolution will be determined almost entirely by the XPS peak width.

Retardation

Constant Analyser Pass Energy Operation (CAE)

To analyse all elements we need to acquire Electrons with energies from 200eV to 1500eV.

We would like to have the same resolution for all parts of the spectrum.

We therefore need to slow all electron down to the same energy before they enter the analyser.

This is done by “retardation” in the parallel field between the top of the Magnetic Rotator and the Base Plate of the Analyser.

To achieve this the Hemisphere Voltages are programmed to follow the Analysed energy.

Snapshot Spectrum Acquisition

Electrons with Energy equal to the Programmed Energy will hit the centre of the Detector

The width of the detector is +- 5% of the Pass Energy

We can therefore Acquire a Snapshot Spectrum with 128 data points while all Lens, Analyser and Detector Voltages are constant.

e.g. we can cover a range of 10eV at a Pass Energy of say 100eV with a resolution of 1eV.

This is most useful when we already know what elements are present

Provides fastest possible acquisition for

- **Quantification**
- **Mapping / Linescans**
- **Depth Profiling**

Scanned Spectrum Acquisition

If we wish to cover a wider energy range we need to scan the voltages.

We scan from the Start Energy to the End Energy in equal Steps and Dwell for an equal time at each Energy.

The Step Size should be a bit less than the required resolution of the data.

At each Programmed Energy the data system will acquire a Snapshot Spectrum.

The datasytem can calculate the energy of all data points in each of the snapshots.

The snapshots can then be shifted and summed to generate a single spectrum over the whole energy range.

Lens and Analyser Set Up

It's all automatic……..

- **L1 Lens Constant**
- **LQ Lens Constant**
- **LM Lens Constant**
- **Voltage Calibration / Work Function to ISO standard Peak Positions**
- **Detector Centre**
- **Detector Width**
- **Magtrim**
- **Hemisphere Constants are fixed**

All are set up at the click of a mouse…….It's easy.