ICA (ROSETTA) calibration report

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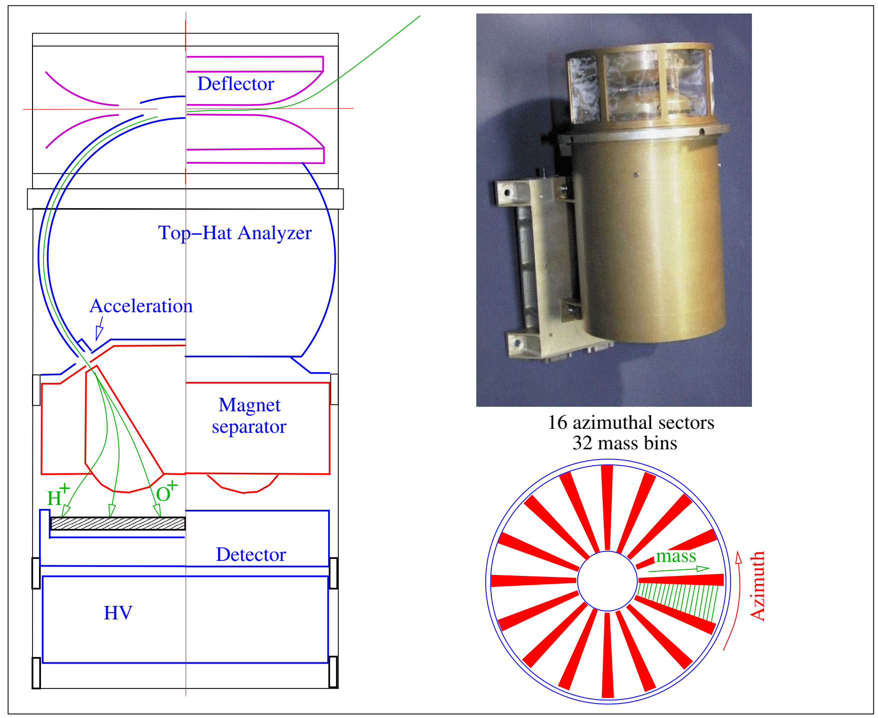
ICA is an ion energy-angular-mass spectrometer with an almost 4π field-of-view for ROSETTA mission

- electrostatic polar angle scanner
- 360° top-hat analyzer
- 16 magnet mass separation sections, positioned behind the analyzer to create 16 azimuthal sectors with mass resolution
- 2D position sensitive detector, which provides azimuthal-mass resolution

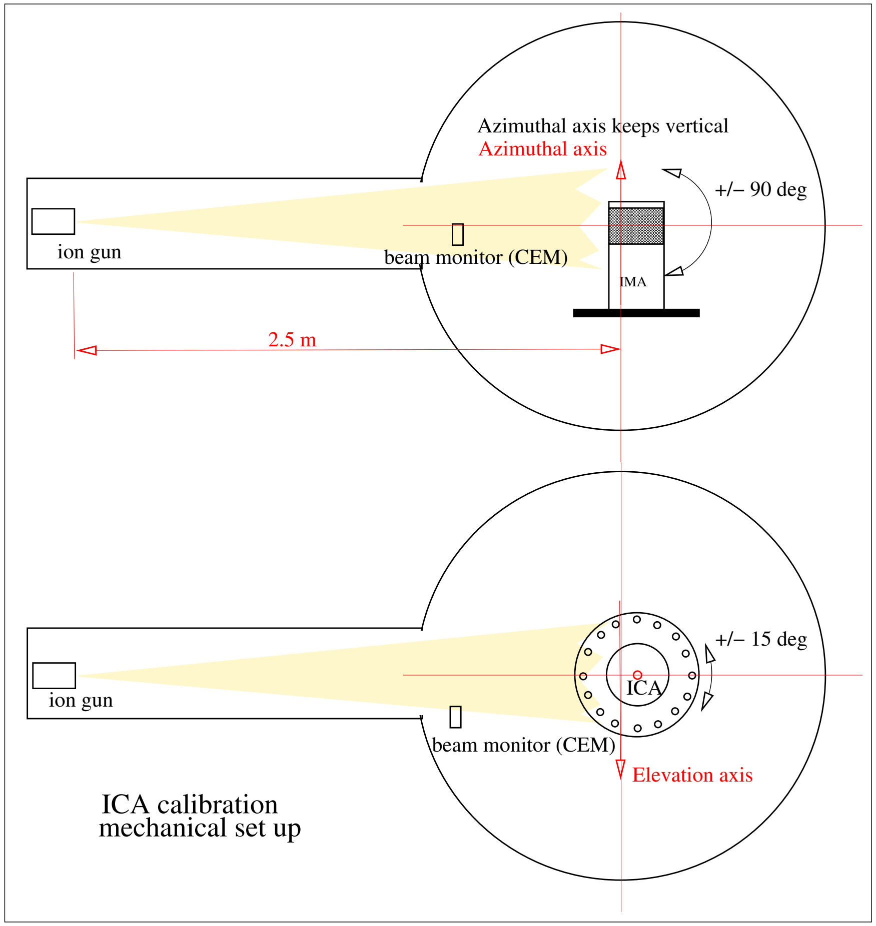


The main simplification of the ICA calibration comes from the fact, that the electrostatic scanner — the top-hat analyzer part defines relative angular - E/Q response of the instrument, while the magnet mass-analyzer defines the real geometrical factor of the sensor dependent on energy and M/Q of incident particles. This approach leads to the calibration technique as follows:

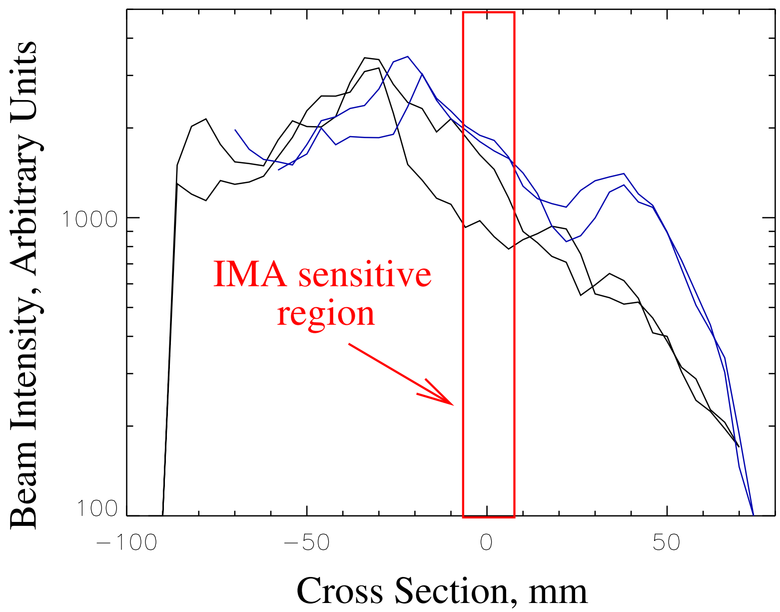
1. Relative distributed response of the detector (MCP + anode electronics) is measured.
2. E/Q - elevation response of the top-hat analyzer is measured for all possible values of the scanner voltage and for all possible azimuthal angles. This is also relative instrument response.
3. Position and shape of mass peaks is measured for a set of masses and energies of incident particles. It is made for zero elevation and azimuthal beam incident angles, and just for one sector. Calibrating position of the peak of one mass with one energy is defined for each azimuthal sector.
4. The absolute geometrical factor versus mass and energy of incoming particles is defined for one sector and for zero elevation and azimuthal angles.

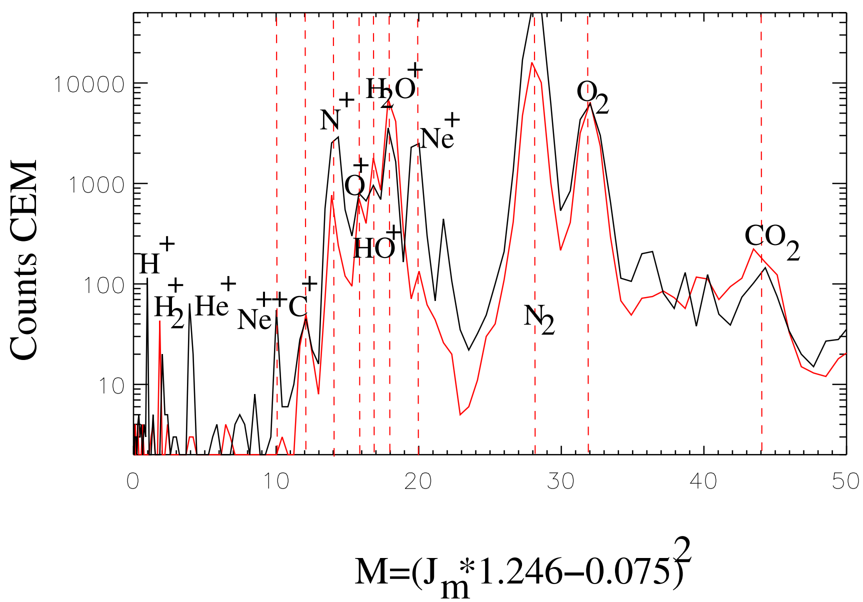
Brief description of calibration facilities: Mechanical setup

- The sensor is located at about 2.5 m from the ion source
- The center of sensor rotation is shifted from the sensor symmetry axis
- Azimuthal angle can change in the -15°—$+15^{\circ}$ range
- Elevation angle can change in the -90°—$+90^{\circ}$ range



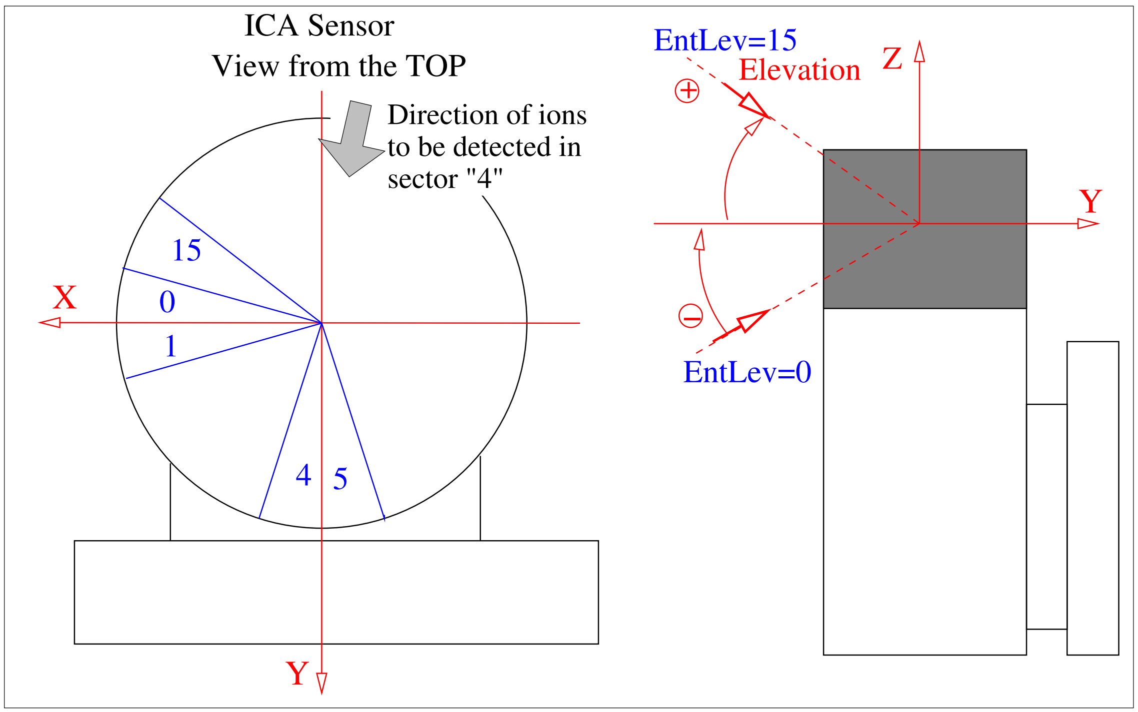
Ion gun properties



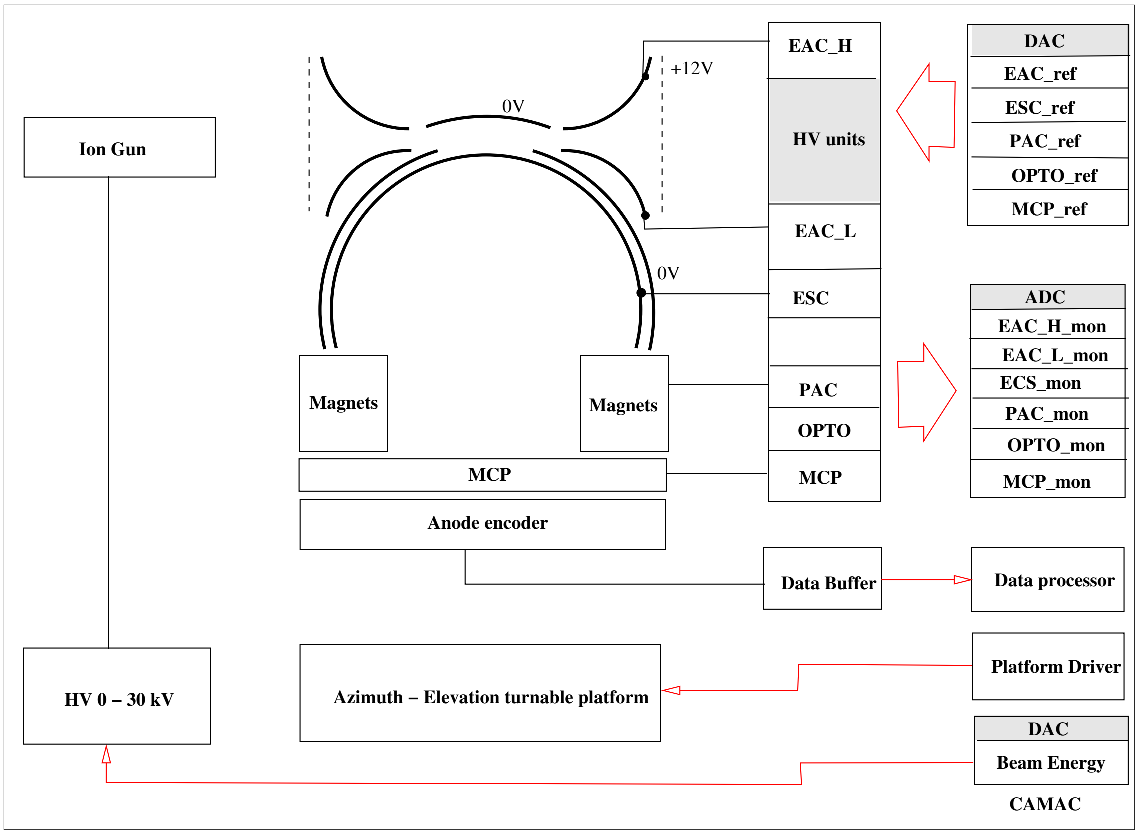


Left panel: Beam cross-section. Right panel: Ion gun—mass-spectrometer selective properties.

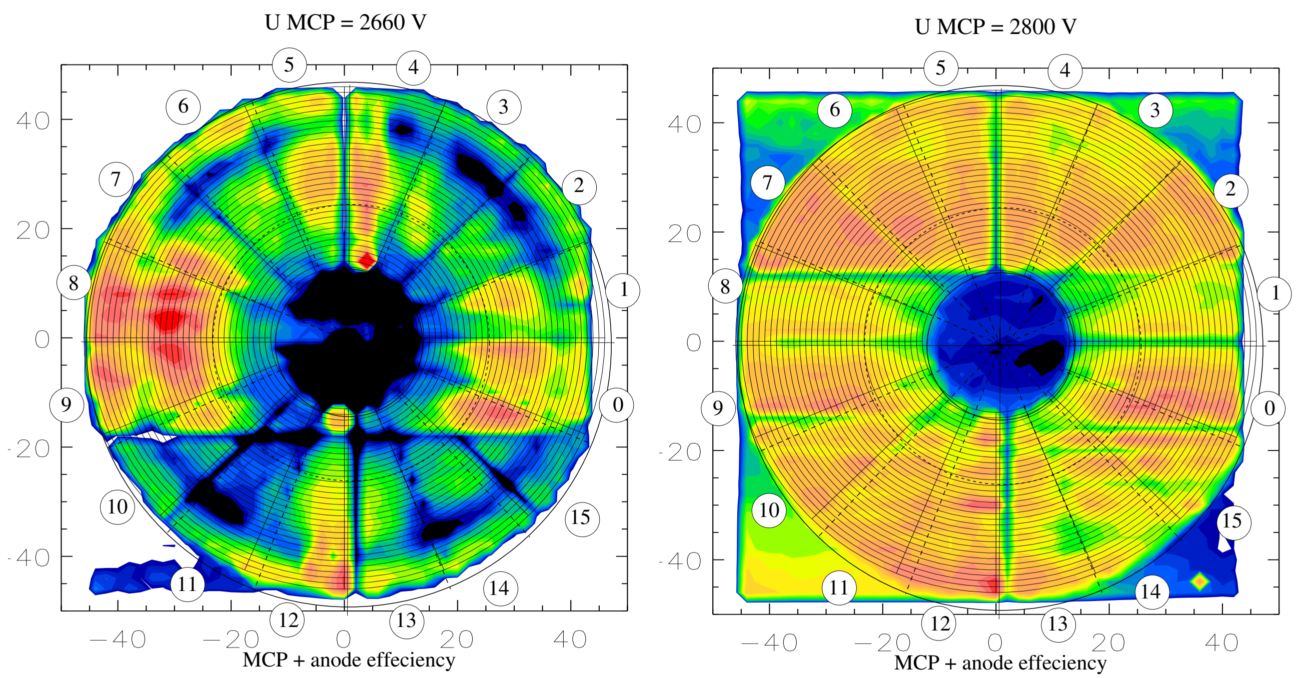
Coordinate system



Electrical setup



Distributed detector efficiency



Left panel: Distribution of anode + MCP efficiency for 2600V MCP bias. Right panel: The same for 2800V MCP bias. The horisontal variations of the count rate caused by ion beam instability.

Selected Ring/Sector response to ion beam position

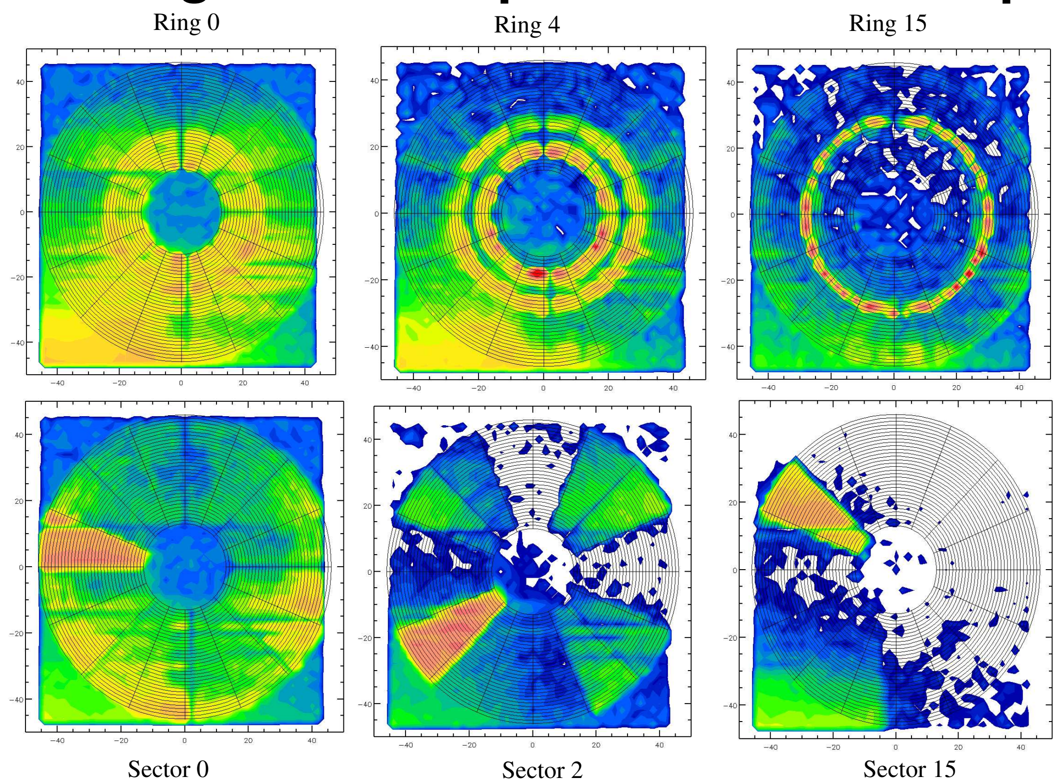
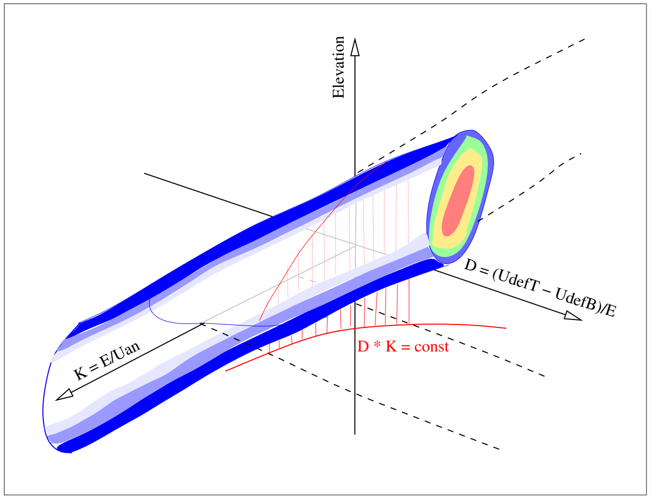
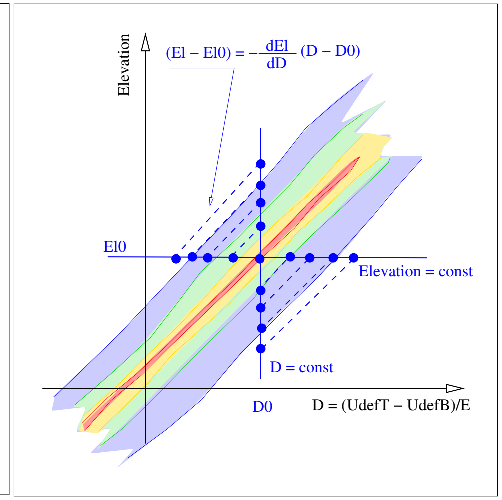


Figure shows the spatial distribution of count rate of selected sectors (low row) and selected rings (top row). Sometimes the digital cross-talk is significant. (The worst cases are shown)

Instrument response. Terms definition.





There are two invariant values which control the trajectories inside the deflector and the top-hat analyzer. Namely:

$$K = E/Uan$$

and

$$D = (UdefT - UdefB)/E$$

Here E is the incident ion energy, eV, and we use ESC_{REF}, mV as Uan. $UdefT$ and $UdefB$ are voltage of the top and bottom deflectors respectively. Actually we used EAC_{REF},mV to calculate D. If the incident azimuth is constant, the entire response of the sensor is 3-D function

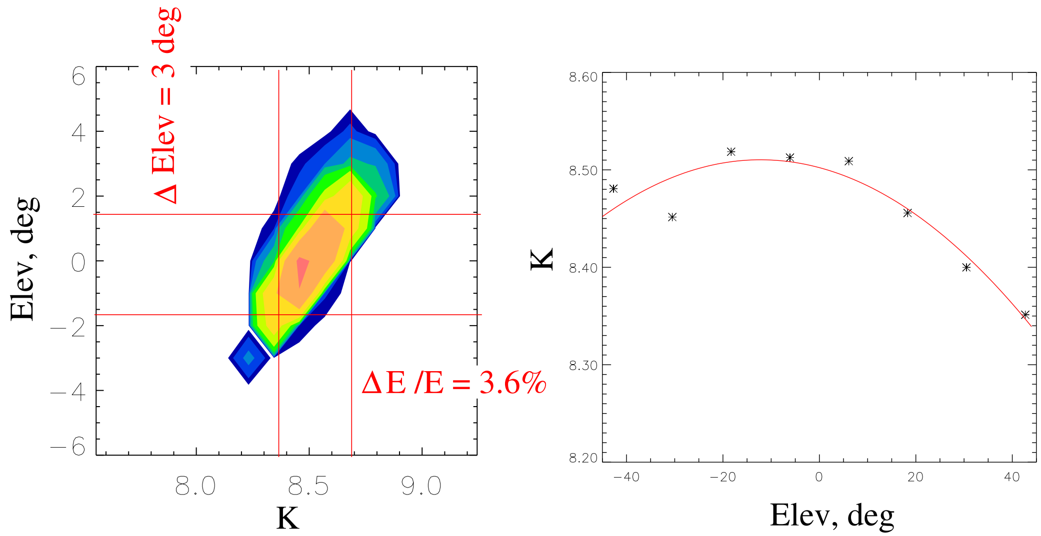
$$A = f(K, D, Elev)$$

Here A is the effective aperture of a sensor. Particular response of the instrument with fixed $Udef$ and Uan is the cross-section of the tube by plane $D \cdot K = const$.

The real elevation scan can be changed by scan in D range with re-calculation of pseudo-elevation by formula:

$$(Elev - Elev0) = -\frac{dEle}{dD}(D - D0)$$

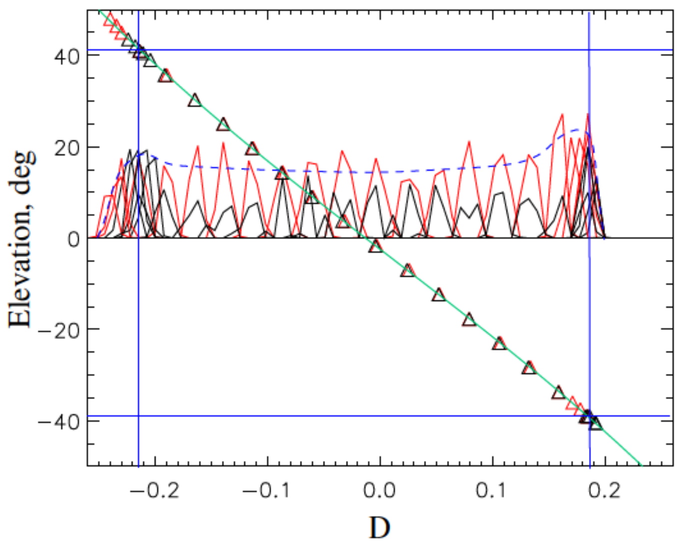
ICA Elevation and Energy response



The K_0 is a function of the elevation angle (defined by scanner) as follows:

$$K_0 = 8.50 - 1.32 \cdot 10^{-3} El - 5.42 \cdot 10^{-5} El^2$$

Electrostatic scanner properties.



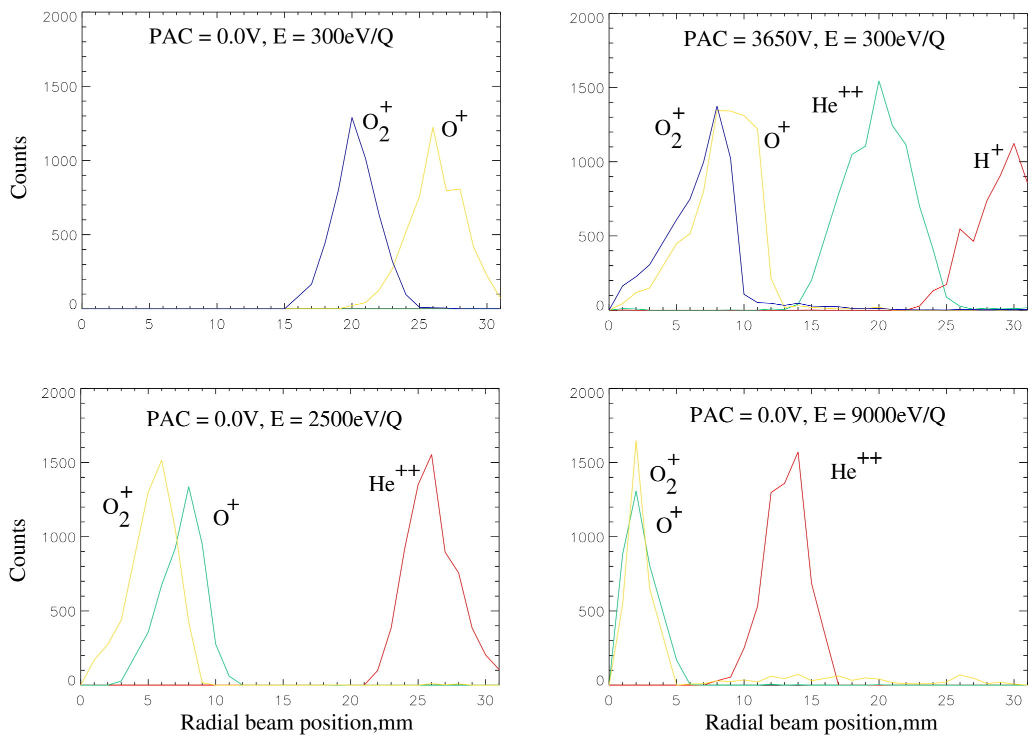
D is calculated as

$$D = \frac{EAC_{REF} \quad EAC_{REF}0}{E \quad E0}, \quad \frac{mV}{eV/charge}$$

Here $EAC_{REF}0 \quad = \quad 16.0mv$ and $E0$ = -16.0eV/charge.
Elevation versus D is as follows:

$$El = \quad 2.47 \quad 189.8D + 7.31D^2 \quad 289.2D^3, \quad deg$$

An example of mass peaks for diffrenet post acceleration level and introduction to G

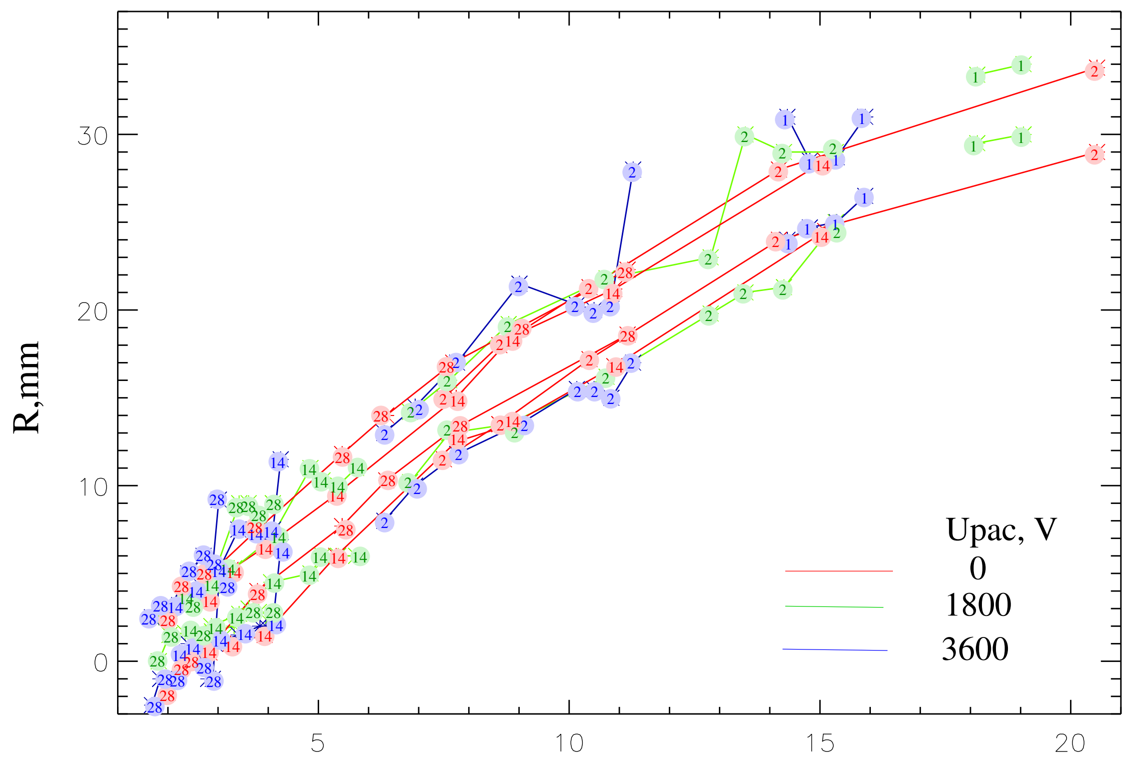


$G = const$ for the same trajectory.

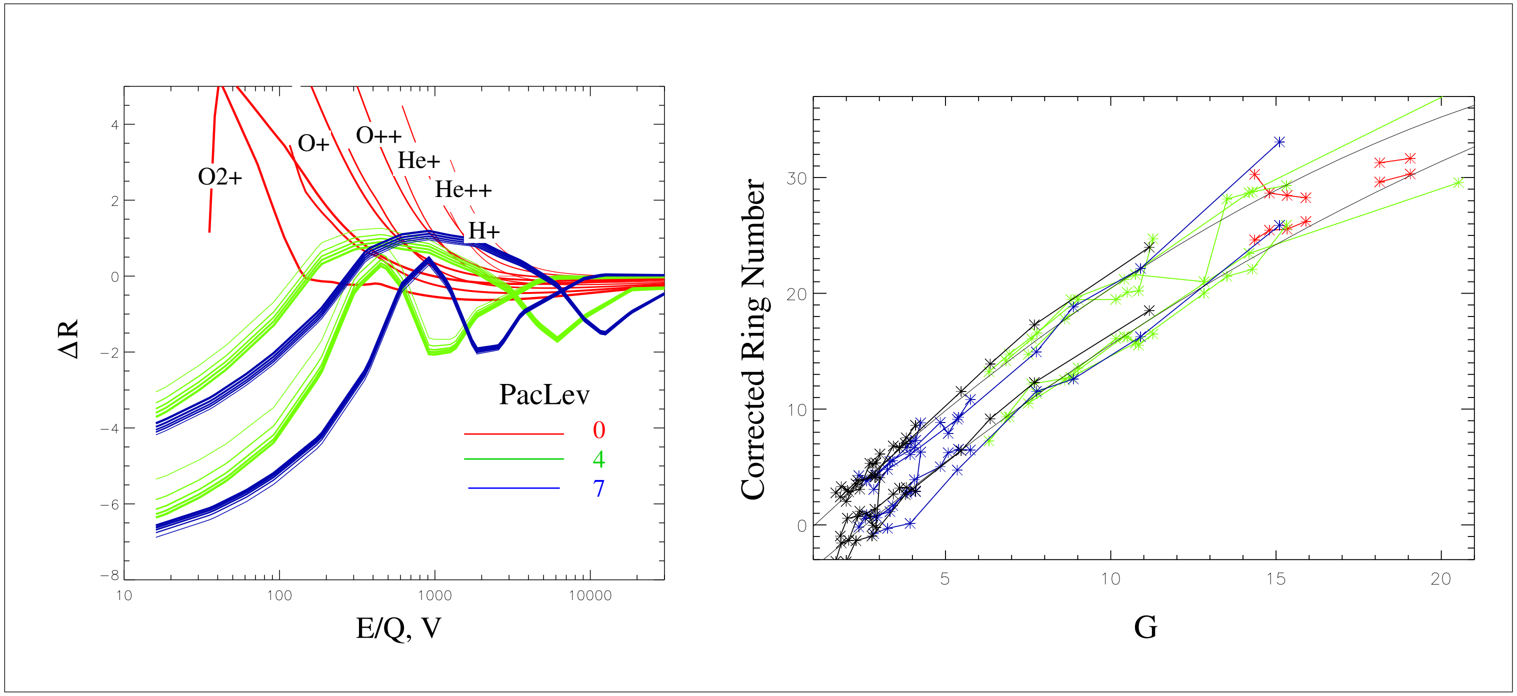
$$G = \frac{10^3}{E/Q[V] + U_{PAC}[V]) \cdot M/Q}$$

$$U_{PAC}[V] = -96.19 + 0.933 \cdot PAC_{REF}[mV]$$

The mass peak position versus G



The corrected mass peak position versus E/Q and G

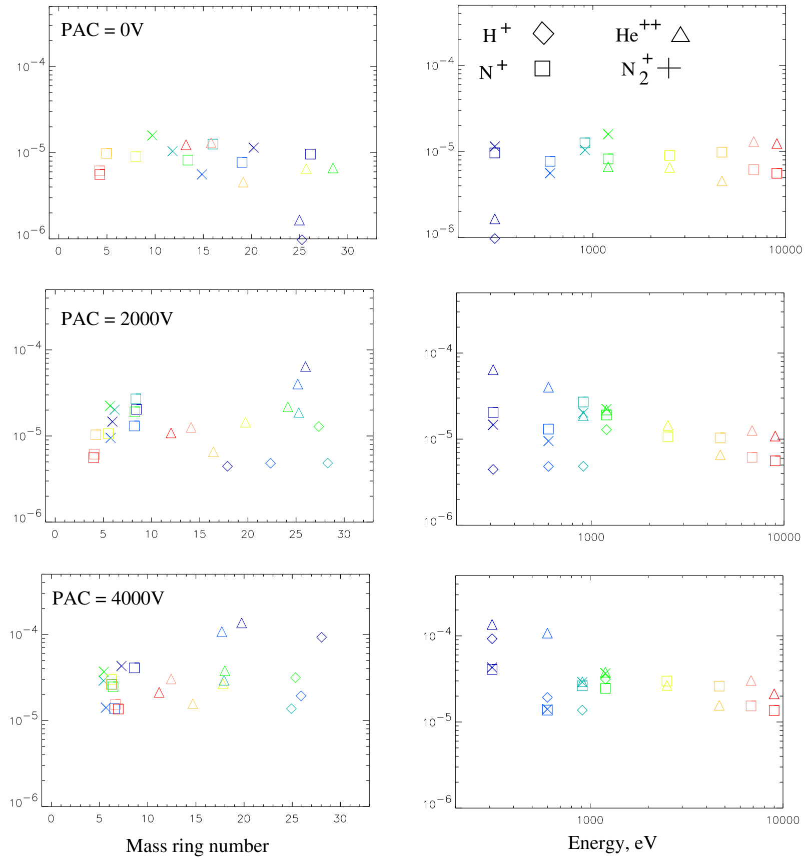


$$M0 = -6.019 + 2.52 \cdot G - 0.031 \cdot G^2 - \Delta R$$

$$M0 = -2.90 + 2.78 \cdot G - 0.043 \cdot G^2 - \Delta R$$

ΔR is calculated according to nomogramm on the right.

The absolute geometrical factor of the sensor



Color marked the energy of particles just to clarify the left column of the figure.