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# Permanent magnet ECR ion source and LEBT dipole for single-ended heavy ion ToF-ERDA facility

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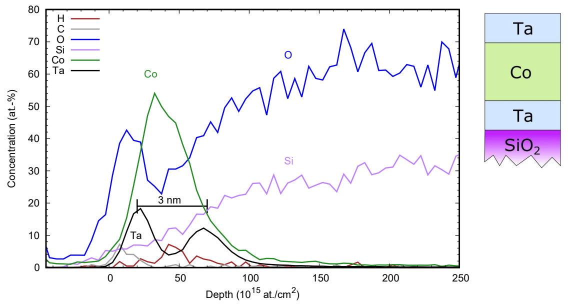
## Time-of-Flight Elastic Recoil Detection Analysis (ToF-ERDA)

is an ion beam based method revealing the elemental composition (including hydrogen) of thin film samples at different depths.

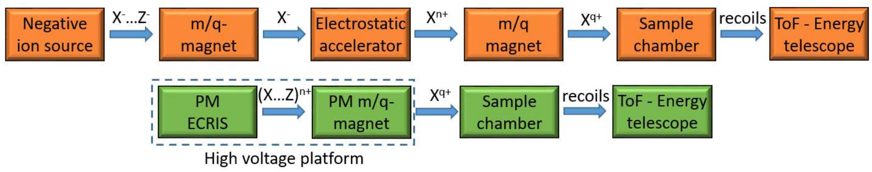



Example: metal tri-layer on silicon-oxide substrate.

Conventional ToF-ERDA facility: negative ion source and electrostatic accelerator.

**New concept: High charge state ion source on a 500 kV high voltage platform**

Simplifies the accelerator and eliminates the use of $SF_6$ (potent green house gas).




| Beam | Energy |
|---|---|
| $^{35/37}$Cl | 3 - 6 MeV |
| $^{79/81}$Br | 8 - 11 MeV |
| $^{127}$I | 9 - 16 MeV |

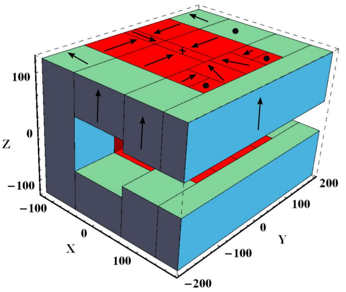
Negative ions (SNICS ion source)

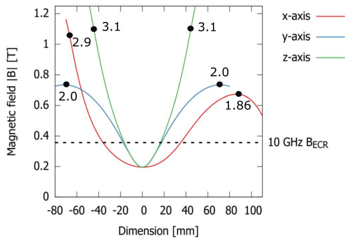
| Ion | Charge state | Energy |
|---|---|---|
| $^{40}$Ar | 6+ ... 12+ | 3 - 6 MeV |
| $^{84}$Kr | 16+ ... 22+ | 8 - 11 MeV |
| $^{136}$Xe | 18+ ... 32+ | 9 - 16 MeV |

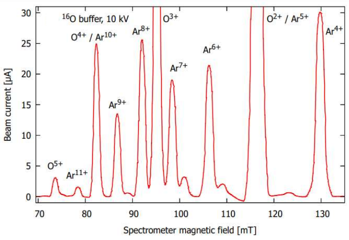
High charge state positive ions (ECR ion source)

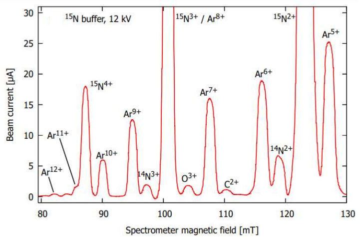
**Required ion flux: 1-10 pnA at the sample**

## 10 GHz CUBE-ECRIS – argon charge state distribution





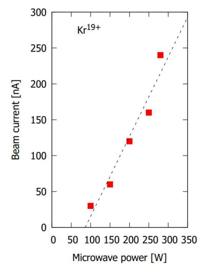

## 10 GHz CUBE-ECRIS – particle fluxes of argon, krypton and xenon

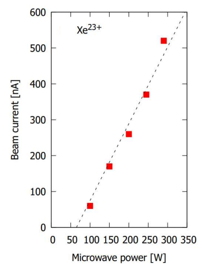
| $^{40}$Ar (3-6 MeV)* | | | $^{84}$Kr (6.5 – 9.5 MeV) | | | $^{131}$Xe or $^{136}$Xe (9 – 13.5 MeV) | | |
|---|---|---|---|---|---|---|---|---|
| Ion | $I$ [μA] | Flux [pnA] | Ion | $I$ [μA] | Flux [pnA] | Ion | $I$ [μA] | Flux [pnA] |
| $Ar^{6+}$ | 27 | 4500 | $Kr^{13+}$ | 9.5 | 730 | $Xe^{18+}$ | 6.1 | 340 |
| $Ar^{7+}$ | 24 | 3400 | $Kr^{15+}$ | 6 | 400 | $Xe^{19+}$ | 5.2 | 270 |
| $Ar^{8+}$ | 31 | 3900 | $Kr^{17+}$ | 1.8 | 110 | $Xe^{20+}$ | 3.7 | 180 |
| $Ar^{9+}$ | 16 | 1780 | $Kr^{18+}$ | 1.1 | 60 | $Xe^{21+}$ | 2.5 | 120 |
| $Ar^{10+}$ | 5.8 | 580 | $Kr^{19+}$ | 0.31 | 16 | $Xe^{23+}$ | 0.9 | 22 |
| $Ar^{11+}$ | 1.9 | 170 | | | | $Xe^{24+}$ | 0.2 | 8 |
| $Ar^{12+}$ | 0.4 | 33 | | | | $Xe^{27+}$ | 0.02 | 0.7 |

* With the planned 500 kV platform voltage

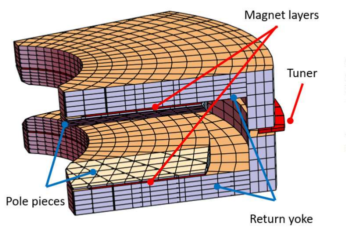
The beam currents are limited by the microwave power in 10.5-11.5 GHz frequency range and by the 50 % efficient beam transport of the slit-shaped beam.

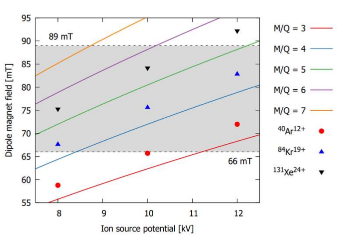
The 300 W TWT amplifier to be replaced by a 600 W solid state amplifier.

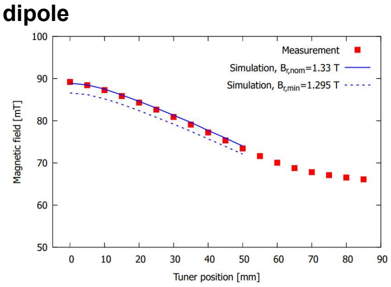


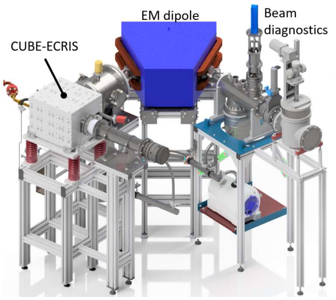



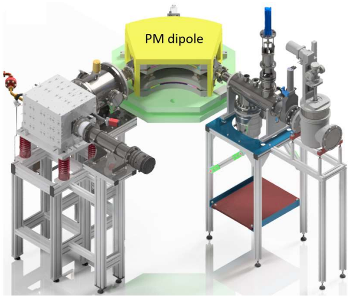

## Adjustable field permanent magnet dipole

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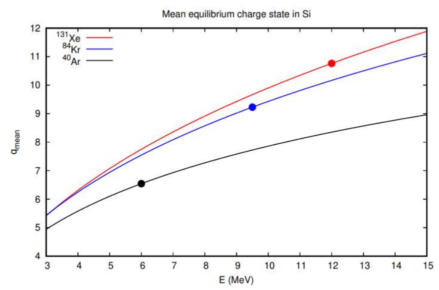
Built at STFC's Daresbury Laboratory.

To be tested at JYFL-ACCLAB.

## High charge state ion ToF-ERDA - implications on ion-matter interaction

The equilibrium charge of the ions depends on the ion velocity and target material.




Lower than the incident ion charge: must be taken into account in analysis.

Also: Release of potential energy near the surface, e.g. 2.1 keV vs. 2.7 keV / nm electronic stopping of of 6 MeV argon.

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