

# Performance of the Hybrid ECR Ion Source Development at IMP

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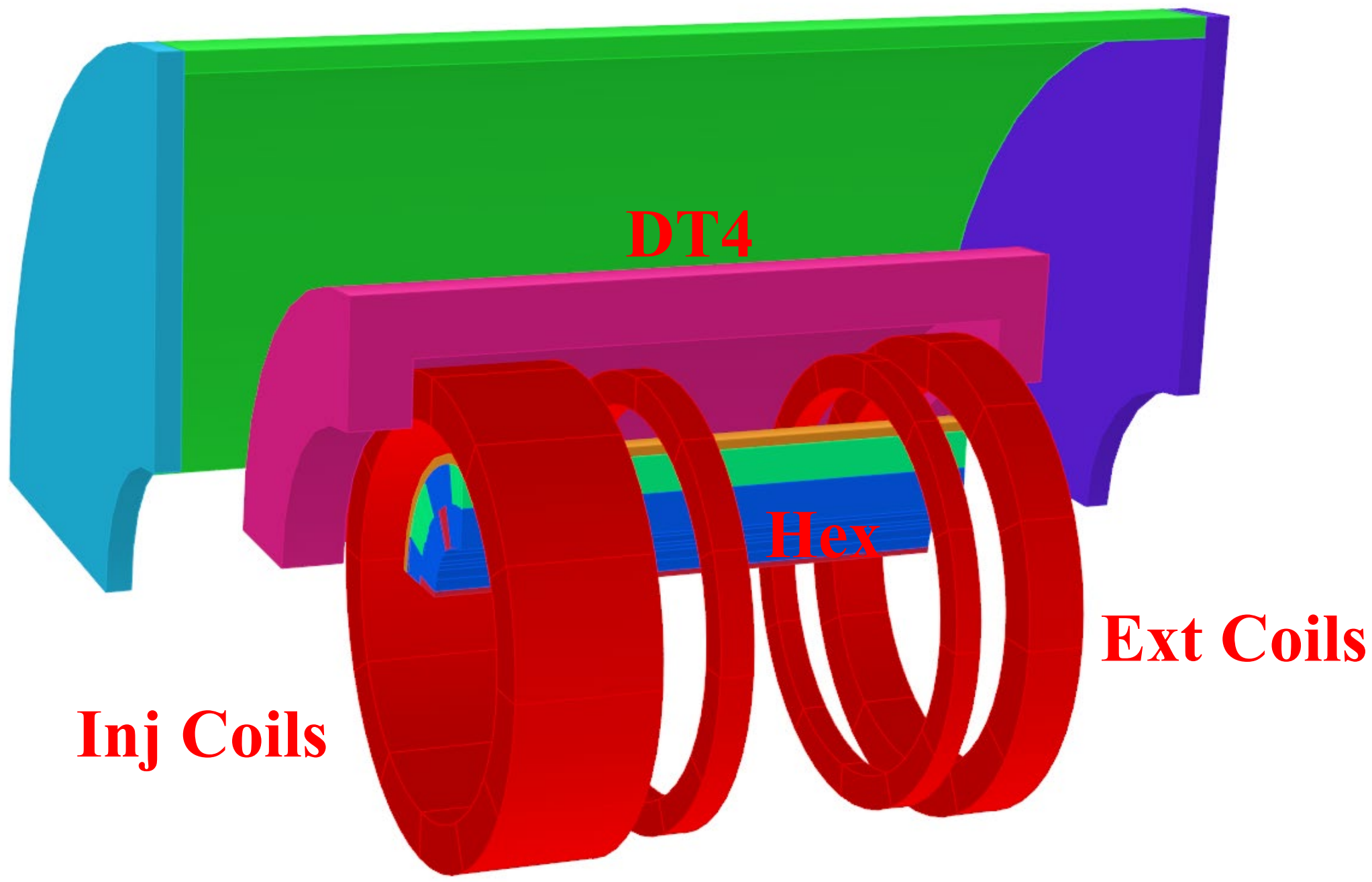
## Abstract

A Hybrid superconducting Electron Cyclotron Resonance ion source Advanced in Lanzhou (HECRAL) has been designed and constructed at the Institute of Modern Physics (IMP). The ion source was commissioned and operated at a frequency of 18 GHz with 3 kW power, approaching the performance of Superconducting Electron Cyclotron Resonance ion source with Advanced design in Lanzhou (SECRAL) operating at the same frequency.

## Design Parameters and Structure

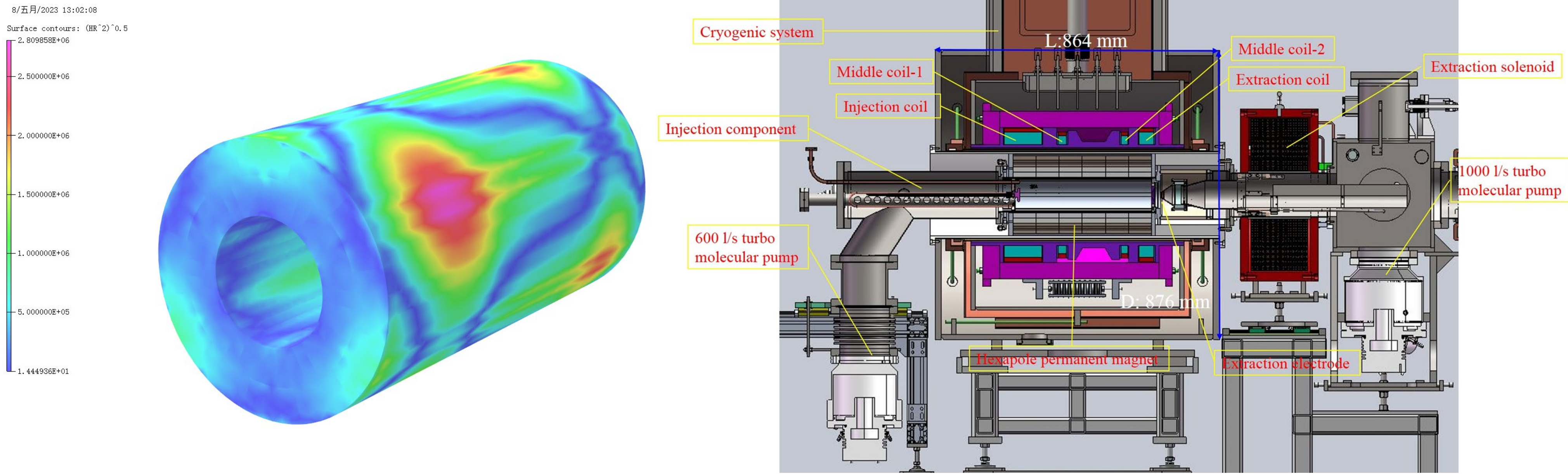
Table 1

|                    | PK-ISIS    | AISHa      | RAMSES     | DECRISS-SC | SECRAL     | HECRAL     |
|--------------------|------------|------------|------------|------------|------------|------------|
| Frequency (GHz)    | 18         | 18         | 18         | 18         | 18-28      | 18 - 24    |
| Axial Magnet       | SC-3 Coils | SC-4 Coils | SC-4 Coils | SC-4 Coils | SC-3 Coils | SC-4 Coils |
| Radial Magnet      | PM         | PM         | PM         | PM         | SC-6 Coils | PM         |
| B <sub>z</sub> (T) | 2.2/1.45   | 2.6/1.7    | 3.0/2.0    | 3.0/2.0    | 3.7/2.2    | 3.4/1.7    |
| Mirror Length (mm) | 440        | 360        | 400        | 390        | 420        | 400        |
| PC ID (mm)         | 82         | 92         | 80         | 74         | 125        | 100        |
| Br (T)             | 1.32       | 1.3        | 1.2        | 1.3        | 2.0        | 1.4        |



PM Demagnetization: H<sub>cj</sub>(36 kOe and 20 kOe)

SC Force-related: Titanium alloy support rods



## Commissioning Results and Comparison

Table 2

| Ions (eμA)                       | HECRAL-2021 | HECRAL-2022 | HECRAL-2023 | SECRAL@18GHz |
|----------------------------------|-------------|-------------|-------------|--------------|
| <sup>16</sup> O <sup>6+</sup>    | 1610        | 2116        |             | 2300         |
| O <sup>7+</sup>                  | 496         | 723         |             | 810          |
| <sup>40</sup> Ar <sup>14+</sup>  | 135         | 224         |             | 270          |
| Ar <sup>16+</sup>                | 45          | 70          |             | 73           |
| <sup>86</sup> Kr <sup>19+</sup>  | 221         | 360         |             |              |
| Kr <sup>26+</sup>                | 65          | 95          |             |              |
| <sup>129</sup> Xe <sup>26+</sup> | 274         | 430         | 350*        | 410          |
| Xe <sup>34+</sup>                | 13          | 31          |             | 21           |
| Xe <sup>35+</sup>                | 9           | 21          |             | 12           |
| <sup>209</sup> Bi <sup>29+</sup> |             |             | 184*        |              |
| Bi <sup>33+</sup>                |             |             | 120*        |              |
| <sup>238</sup> U <sup>33+</sup>  |             |             | 144*        |              |
|                                  |             |             | 88*         |              |

\* Maybe demagnetization at both ends of the hexapole permanent magnet.

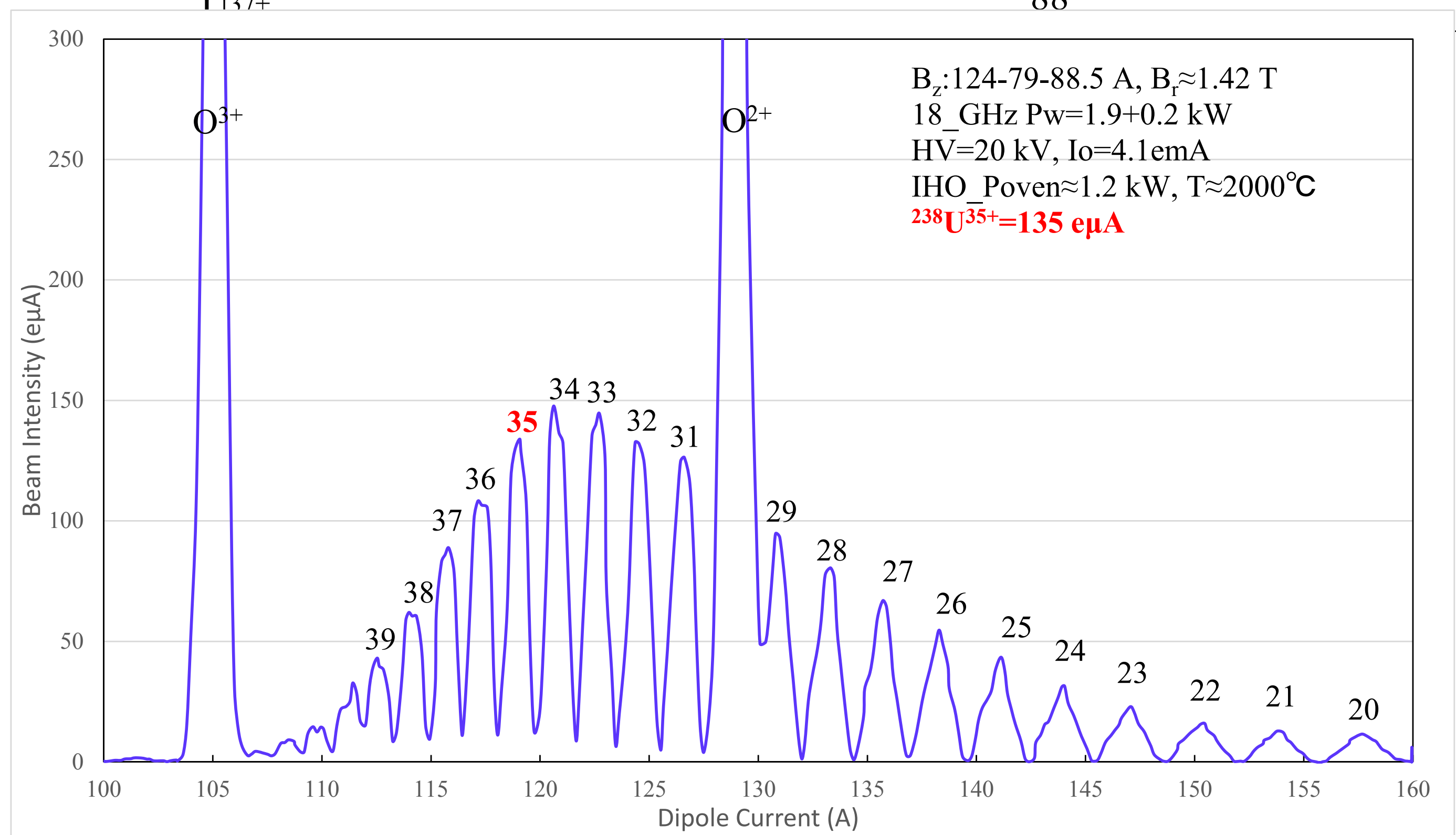
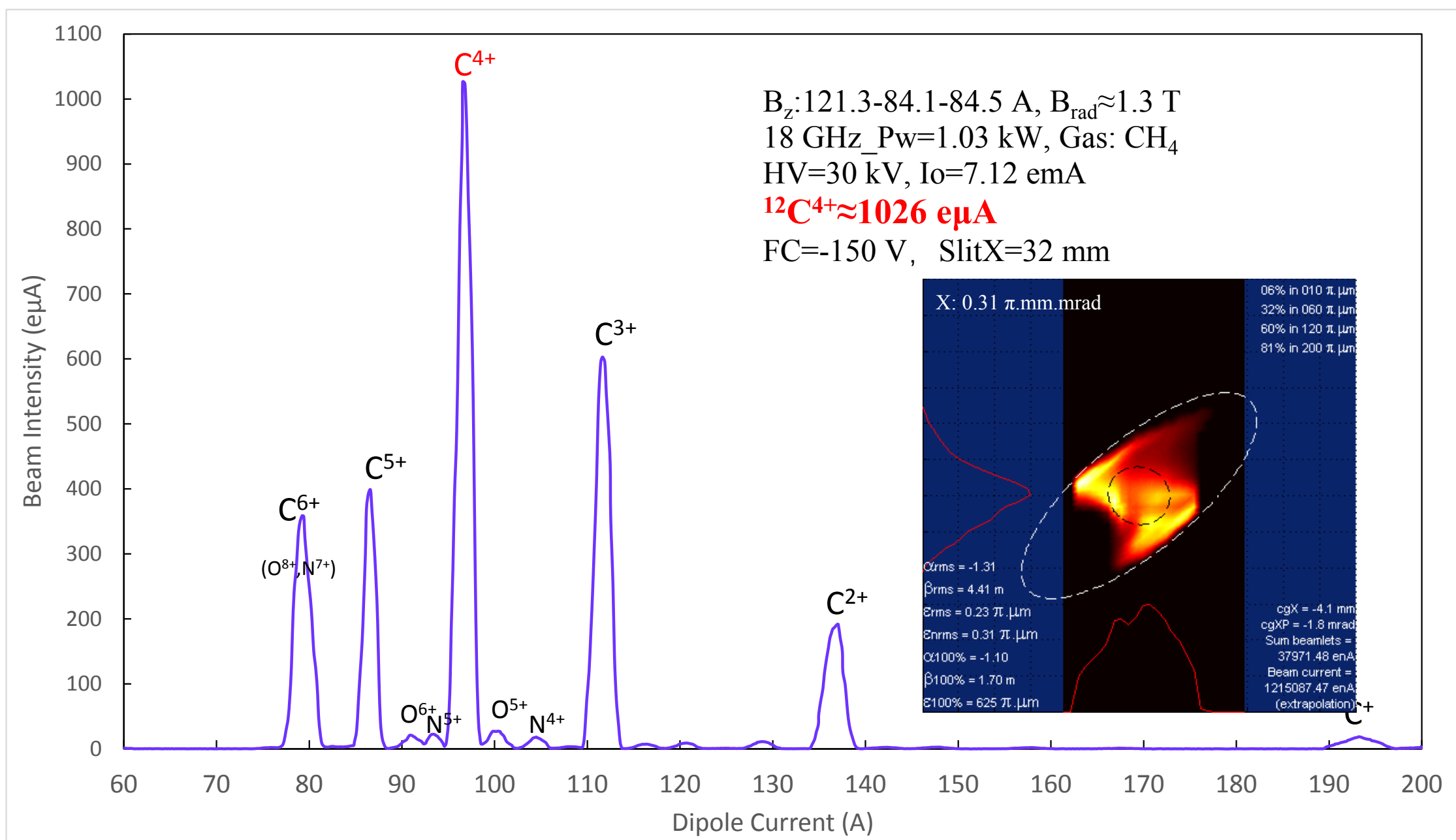


Table 3

| Ions (eμA)        | HECRAL | PK-ISIS | AISHa | RAMSES | DECRISS-SC |
|-------------------|--------|---------|-------|--------|------------|
| C <sup>4+</sup>   | 1026   |         | 520   |        |            |
| Ar <sup>12+</sup> | 543    | 200     | 140   |        | 120        |
| Ar <sup>14+</sup> | 224    | 100     | 40    |        |            |
| Kr <sup>25+</sup> | 92     |         |       | 20     |            |
| Xe <sup>26+</sup> | 430    | 100     |       |        |            |



## Conclusion and Outlook

- A High Performance Hybrid Superconducting ECR ion source HECRAL has been successfully developed at IMP.
- Developing a new Hexapole Permanent Magnet for validation of demagnetization experiments.
- Coupling microwave power up to 5 kW @18 GHz.
- Coupling multiple frequency of 18+24 GHz .