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High Performance 18 GHz ECR Ion Source Development

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ABSTRACT

At present, ECR ion sources are developing towards higher frequency, higher magnetic field technology. However, 18 GHz is the highest optimal operation microwave frequency for room temperature ECR ion sources, which can meet the needs of most of the existing heavy ion facilities. After the success of the 18 GHz ECR ion source LECR4, we developed the upgraded version source LECR5 aiming for higher beam intensity and higher charge state ions. With higher radial field, bigger plasma chamber volume, longer mirror length and flexible B_{min} field, promising results have been made at the power level of ~1.6 kW@18 GHz, for instance 81 eμA Bi^{32+} , and 22 eμA Bi^{41+}. This ion source has been recently used for the heavy ion facility SESRI (Space Environment Simulation Research Infrastructure) as the pre-injector ion source. High beam intensities and reasonable beam qualities have been demonstrated during both off-line and on-line tests. Inspired by this outcome, a hybrid 18 GHz ion source called HECRAL has been proposed aiming for the similar performance of SECRAL at 18 GHz. This paper will present the recent update of LECR5 ion source commissioning. The on-line beam test for SESRI facility will be discussed. HECRAL ion source will be also introduced.

① 18 GHz ECR Ion Source

ECR ion sources basic classification: a. RP ECRIS: Room temperature coils and Permanent magnet; b. SP ECRIS: Superconducting coils and Permanent magnet; c. PP ECRIS: All Permanent magnets; d. SS ECRIS: All Superconducting coils. 18 GHz is an optimal frequency for RP ECRIS and SP ECRIS to make a strong one with high performance and reasonable cost.

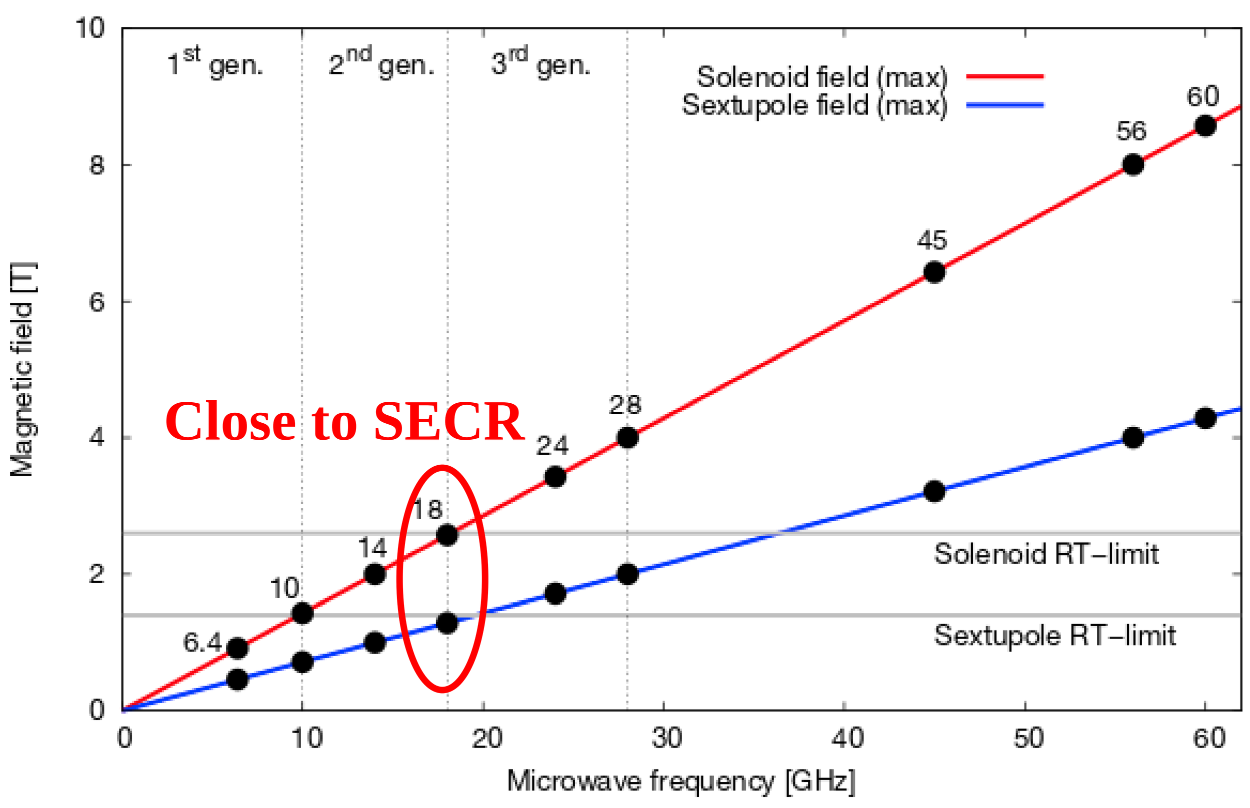


*Figure-O. Tarvainen, EPJ Web of Conferences 149, 01003(2017)

	LECR4	LECR5	GTS	HIISI	HECRAL	AISHa
	RP	RP	RP	RP	SP	SP
Parameters	IMP	IMP	CEA	JYFL	IMP	INFN
Frequency (GHz)	18	18	18	18	18 - 24	18 -21
Power (kW)	~2.0	~2.0	~2.0	~3.0	~4.0	~3.0
Axial magnetic field (T)	2.4/1.3	2.5/1.4	2.5/1.4	2.8/1.3	3.4/1.7	2.7/1.6
Middle magnetic field (T)	0.4	~0.4	~0.4	~0.4	~0.5	~0.4
Mirror length (mm)	~280	~340	300	400	420	450
Plasma chamber ID (mm)	76	80	80	100	100	92
Radial magnetic field (T)	1.0	1.2	1.2	1.4	1.4	1.3

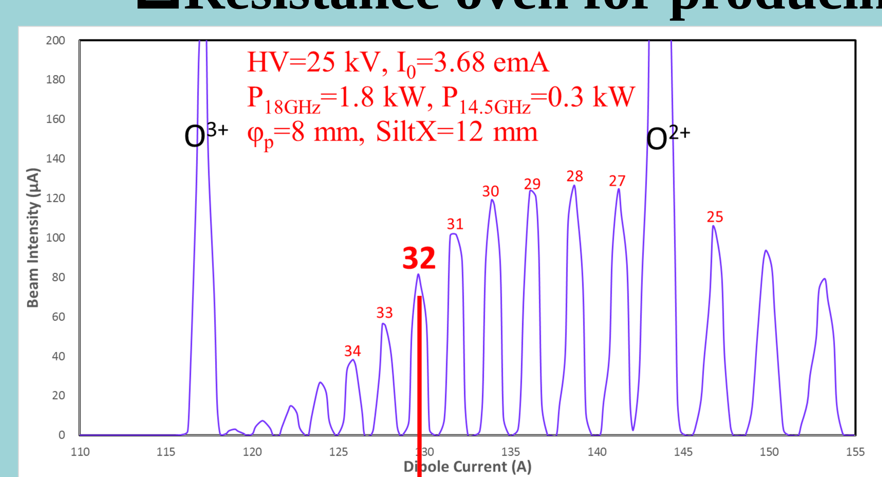
② Intensity highly charged ion beams production with LECR5

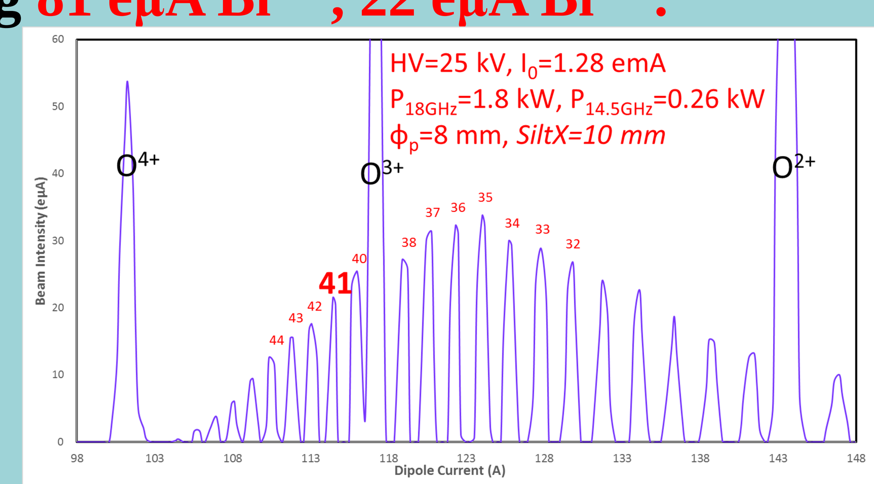
☐ **The optimal gaseous element results of single frequency commissioning meet the needs of some projects**

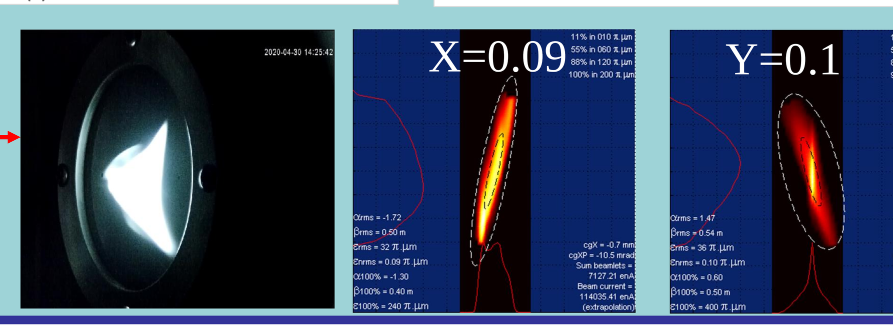
	LECR3 (eμA) 14.5 GHz	LECR4 (eμA) 18+18 GHz	LECR5 (eμA) 18 GHz	GTS (eμA) 14+18 GHz
$^{40}Ar^{12+}$	140	430	**385**	380
Ar^{14+}	30	185	121	174
Ar^{16+}	3	30	21	50
$^{86}Kr^{19+}$	-	-	169	-
Kr^{26+}	-	-	32	-
$^{129}Xe^{20+}$	160	430	**345**	310
Xe^{27+}	50	135	**145**	168
Xe^{30+}	6	43	29	60

☐ **Dual frequency 14 +18 GHz and Aluminum plasma chamber.**

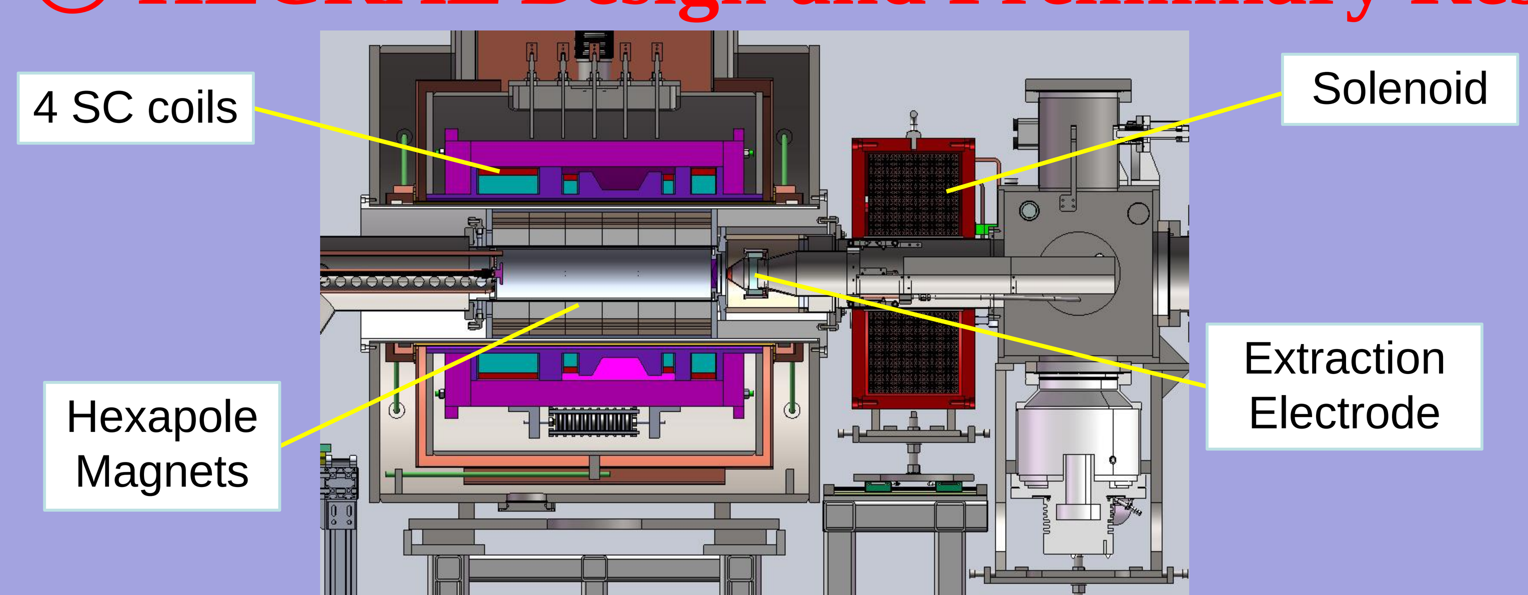
☐ **Resistance oven for producing 81 eμA Bi^{32+}, 22 eμA Bi^{41+}.**







③ HECRAL Design and Preliminary Results

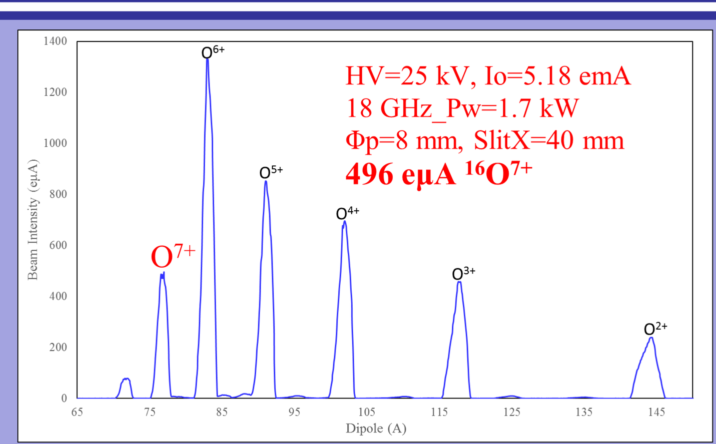


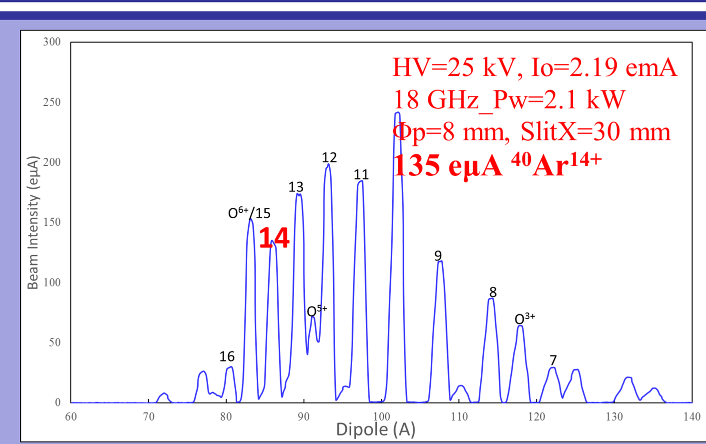
a. Superconducting Coils magnet with zero liquid helium volatilization.

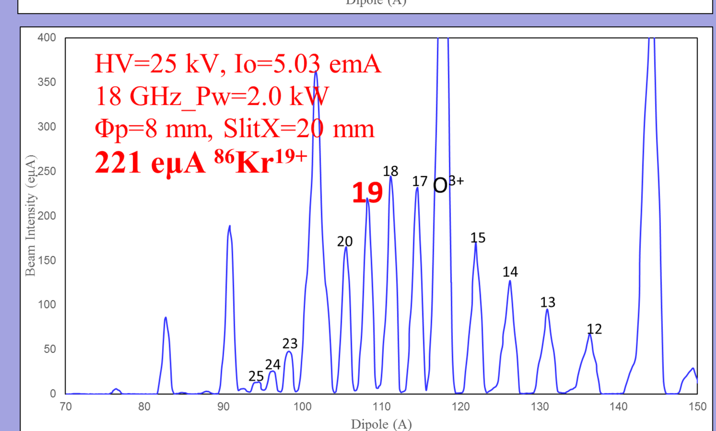
b. B_{rad} >1.4 T hexapole permanent magnet.

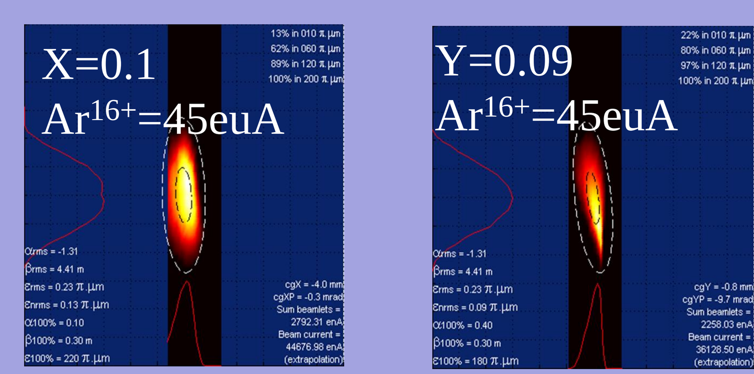
c. More convenient Commissioning and Maintenance.

d. Lower cost and Higher performance compare with others.









✓ **A high performance hybrid superconducting ECR ion source has been successfully developed in IMP.**

✓ **The commissioning results of 24 GHz and 18+24 GHz heating mode are expected on HECRAL.**