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# Recent Results and Operation at 18GHz with SECRAL

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#### Outline

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#### Review of the typical performances

#### On-line operation status

### New developments



#### The option for fully superconducting ECRIS

 $n_e \sim \omega_{rf}^2$ ,  $I \sim \omega_{rf}^2$  $B_{ecr} = \omega_{rf} m_e / q$ ,  $B_{inj} \ge 2$  Becr



**Conventional Structure** 

High B,  $\omega_{rf}$ , P<sub>rf</sub>

VENUS in Berkeley (18-28 GHz)

#### **Disadvantage:**

Very strong interaction forces;
Much longer sextupole;
Bigger source body;

**Hi** SERSE and VENUS are pioneers, MS-ECRIS, RIKEN SC-ECR, SuSi...

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SERSE in Catania (14.5-18 GHz)

Higher sextuple field;

Larger plasma chamber;

Higher rf power up to 10 kW;

**Advantage:** 





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#### **Performance review (2)**



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#### **Plasma Detection**



 Bigger ECR zone • Higher microwave frequency 18 GHz vs 14.5 GHz Better plasma confinement Higher magnetic field

Large plasma chamber

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#### SECRAL at the Axial Injection Beam Line of IMP Cyclotron (2007. 4)



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#### Preliminary emittance analysis



IMP Allison-type emittance scanner. Located after the analyzing magnet





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#### Intense <sup>129</sup>Xe ion beam for HIRFL

- The first beam: <sup>129</sup>Xe<sup>27+</sup>, extraction voltage: 22 kV,
   rf power 1.2-1.6 kW,
   Beam intensity: 140-160 eµA,
   Continuously operated for more than one month.
- Dedicated to commissioning of IMP new project HIRFL-CSR.
- $\checkmark$  SFC Xe beam increased by factor 10
- ✓ SSC Xe beam increased by factor 50
- ✓ CSRm accelerated Xe<sup>27+</sup> beam to 235 MeV/u, accumulated beam intensity up to 500 eµA (1×10<sup>8</sup> pps), the heaviest ion and the biggest beam intensity achieved for a heavy ion synchrotron with a cyclotron injector, impossible without SECRAL.



#### MMI + Ramping (<sup>129</sup>Xe<sup>27+</sup>-2.9~235MeV/u) in CSR<sub>m</sub>



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#### Intense <sup>78</sup>Kr ion beam for HIRFL



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#### **Experimental setup for mass measurement**

CSRm <sup>78</sup>Kr<sup>28+</sup> 204.7MeV/u 402.5MeV/u 403.0MeV/u 404.5MeV/u 451.1MeV/u 458.4MeV/u



#### **New Development (1)**



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#### **New Development (1)**



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#### **New Development (1)**



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#### **New Development (2)**



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#### **New Development (2)**



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## **Summary & Conclusion**

A superconducting ECR ion source SECRAL with an innovative magnet structure has been successfully built. SECRAL has reached the designed specifications and be able to operate with a nice reliability and stability;

SECRAL has been used for accelerators at IMP to produce intense stable high charge state heavy ion beams for more than one year. Many outstanding work at IMP could not be possible without the stable operation of SECRAL, such as the successful acceleration and accumulation of 235 MeV/u <sup>129</sup>Xe<sup>27+</sup>, 451 MeV/u <sup>78</sup>Kr<sup>28+</sup> and also the outstanding work of on-line nuclear mass measurement by secondary beams on CSRe. Within the maximum 2 months continuous operation, no quench or other problems occurred. Generally, ion beams are very stable and well up to the requirements of HIRFL accelerators.

 Several performance development works are under processing, such as the new aluminum plasma chamber, double frequency heating, and 24 GHz microwave driving. More results are expected in 2009.



# **THANKS 谢谢**

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