

## Status of a new 18 GHz ECRIS HIISI

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#### Space radiation environment

#### Cosmic rays

#### Solarwind particles

#### Cumulative effects

- Total Ionizing Dose (TID)
- Displacement Damage (DD)

## Single Event Effects (SEE)Single Even Upsets (SEU)

- Single Event Transients (SET)
- Destructive events

Particles trapped in magnetic field







- Induced charge: One electron-hole pair per 3.6 eV
- Electronic stopping power

dE/dx (keV/ $\mu$ m)

can be used to estimate the ionization charge in the active region



• Normalized by target density the stopping power or Linear Energy Transfer (LET) is given in units

MeV·cm<sup>2</sup>/mg





Data from SRAM-based reference SEU monitor R. Harboe-Sørensen, et. al., IEEE Trans on Nucl. Sci. 55, 3082 (2008)







In space very high energy particles penetrate through space craft and components.

In ground testing particle energy is more limited. Delidding and/or wafer thinning due to backside irradiation may be needed.







#### Jyväskylä lab



### 9.3 MeV/u cocktail









#### 16.2 MeV/u cocktail



# Xenon production on ECRIS

UNIVERSITY OF JYVÄSKYLÄ





### New 18 GHz ECRIS HIISI

Project started in 2013

Parameters from SUSI known to be work for sufficient production of Xe<sup>44+</sup>:  $B_{inj} = 2.82 \text{ T}, B_{min} = 0.46 \text{ T}, B_{ext} = 1.56 \text{ T}, B_{rad} = 1.36 \text{ T}$  $P_{RF} > 3 \text{ kW}$ 

These magnetic field values are difficult, but possible to reach with conventional normally conducting coils and permanent magnet hexapole.







### Radial field

Reaching  $B_{rad} = 1.36$  T with permanent magnets is very challenging:

- Refrigeration increases intrinsic coercivity  $\rightarrow$  high B<sub>r</sub> grades
- Remanence: 5 % increase from +20 to  $-20^{\circ}$ C.







### Axial field measurements

Measurements of field on axis match well to simulations. Maximum measured field of 2.753 T @ 0.9 mm from biased disc. Extrapolates to over 2.80 T on surface.























Measurement 1 mm from chamber (r=54.5 mm) wall shows 1.275 T average @ 20 C with current N40UH material.





#### Microwave plasma heating

400 W 11-18 GHz TWTA

2.4 kW 14 GHz Klystron

2.4 kW 18 GHz Klystron







Beam extraction from ECRIS plasma designed with IBSimu-software



Beam enters the dipole with 130 mm gap.

First focal point after the separation.





#### Magnetic stray field





#### Magnetic shielding











#### Beam results

Commissioning with beam started in May 2017

- The total plasma-on-time so far is roughly 100-200 hours
- Limited by magnetic interference to operational ion sources

#### Records with O7+:

95  $\mu A$  with 300 W 175  $\mu A$  with 600+100 W

18 GHz 250 W + 14 GHz 100 W:

O2+	30 µA	
O3+	82 µA	
O4+/C+	240 µA	
05+	210 μΑ	
O6+	250 μΑ	
07+	53 µA	
	•	



#### Overheating





### Overheating



### Overheating





## Thank you