Beam Loss Distribution and Maintenance in Super-FRS*

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For radiation protection and maintenance planning the beam losses in different sections of the Super-FRS must be estimated carefully for prediction of prompt dose as well as for activation. As it is the purpose to select only few ions out of up to 10^{12}/s the losses and where they will occur exactly can also be predicted well. However, with many different settings for less and more rare isotopes the intensities in the main separator vary a lot.

To illustrate the situation two examples are shown: Selection of ^{132}Sn produced by fission of a ^{238}U beam and ^{100}Sn from projectile fragmentation of ^{124}Xe. ^{132}Sn and many other fission fragments with similar mass and atomic number can be produced in high quantity and are difficult to separate due to the larger momentum spread of the fragments behind the target. Contrary ^{100}Sn and its neighbors on the chart of nuclides are produced much less and at higher energies they are also easier to separate.

In simulations with the Monte-Carlo code MOCADI [1] for ion transport in beamlines including matter we collected the losses for all relevant nuclides produced as a function of position along the Super-FRS (around 1000 different nuclides for ^{132}Sn and 490 for ^{100}Sn).

For prediction of levels of activation of beamline components the number of ions only is not a good criterion, the energy of the ion and mass and atomic number are also important. This was considered by comparing the number of emitted neutrons for each ion derived from a simplified scaling rule [2]. So the number of ions lost shown in Figure 1 actually refers to ^{114}Pd ions at 1300 MeV/u an ion roughly in the middle of the mass and energy distributions of all ions in the different sections of the Super-FRS. This allows defining a loss number for inserts like the target or the degraders through which ions fly through without being absorbed but lose kinetic energy.

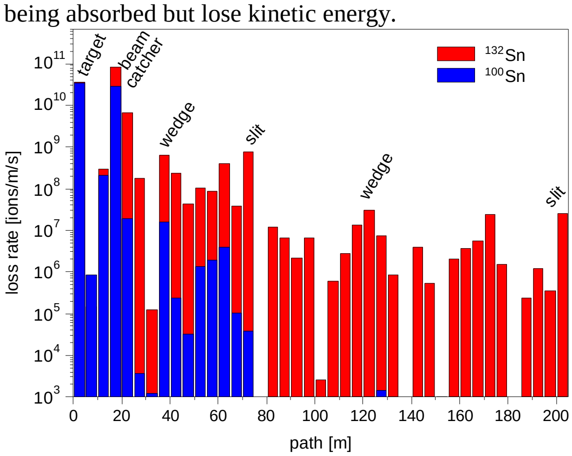

Figure 1: Number of ions lost along the path of the Super-FRS beamline per meter and second, for ^{132}Sn and ^{100}Sn settings with an initial energy of 1.5 GeV/u and an intensity of 3.3×10^{11} ions/s of ^{238}U or ^{124}Xe, respectively.

As one can see main loss points are the target and the beam catchers but also later in the system local maxima occur like the degraders or at the exit slits where a large part of the separation happens. Some ions drop out even earlier before the slits for example in the dipole regions. At the exit slit the difference between the two cases is huge. So far it cannot be foreseen how often which case will be used during operation. However, it is clear that the high intensity case is only one out of many and will therefore not run the whole operation time, but only a small fraction of it with correspondingly lower activation.

The highest activation will arise directly on the beam catchers which were already described and activation calculated in detail [3]. With the beam losses activation can now be predicted better in all parts of Super-FRS. Based on this, the frequency of planned maintenance and the likelihood of failure, four remote handling (RH) classes were defined:

- RH class 1 = components requiring regular planned replacement
- RH class 2 = components that are likely to require repair or replacement
- RH class 3 = components that are not expected to require maintenance or replacement during the lifetime of the facility but would need to be replaced remotely in case they fail
- RH class 4 = components that do not require remote handling

Classification of different parts:

Component	RH class
Target wheel	1
Beam catcher graphite	1
Drives for target and catcher	2
Pillow seals	2, 3
Wedge degrader	2, 4
Magnets near target	3
Alignment base	3
Target and catcher chambers	3
Shielding plugs	3
Devices on working platform	4
Slits	2, 4
Detectors in main separator	4

References

[1] N. Iwasa et al., NIM B 269 (2011) 752.
[2] E. Mustafin et al., NIM A 501 (2003) 553.
[3] E. Kozlova et al., NIM B 266 (2008) 4275.

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