Noble gas samples for non-proliferation applications

The achieved performance of a Penning trap-based mass separator allows a new important application, namely a laboratory production of ultra-pure samples of all xenon isotopes and isomers desired, for example, by the Comprehensive Nuclear-Test-Ban Treaty Organization (CTBTO).

Features

- Pure samples of ^{131m}Xe, ^{133m}Xe, ^{133}Xe and ^{135}Xe can be produced at the Accelerator laboratory of the University of Jyväskylä, Finland
- A Penning-trap based mass separator facility is being applied
- The same facility could be used for the production of other calibration sources as well
- Currently the production setup at Jyväskylä is being upgraded
- The upgrade includes a new MCC30/15 cyclotron
- The upgrade will provide more flexibility to the sample productions
- Currently also research related to the production of gaseous Xe samples is going on
- Contract on Xe samples between the University of Jyväskylä and the CTBTO is expected to be signed during 2012

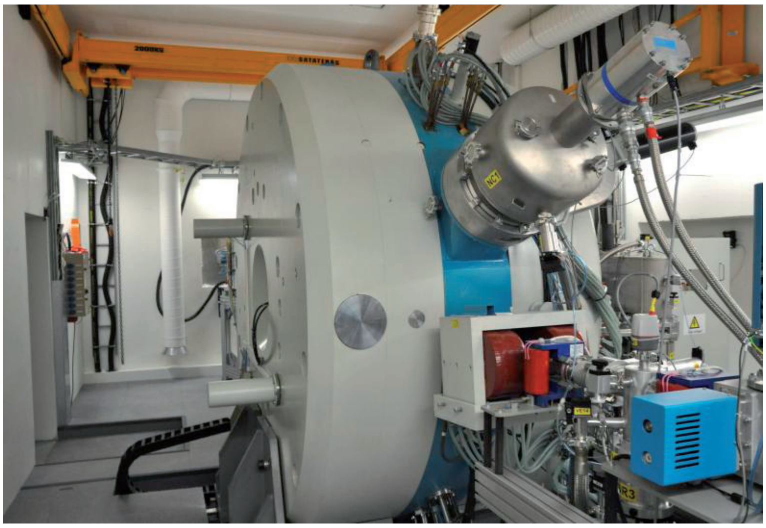

Fig. 1. Photograph of the new MCC30/15 cyclotron.

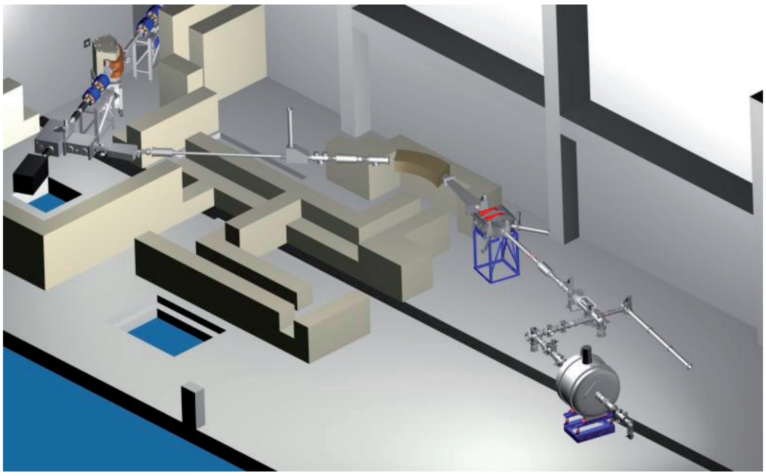

Fig. 2. CAD drawing of the new IGISOL/JYFLTRAP facility.

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Detection of nuclear weapons tests

The CTBTO has a strong technical focus. One of its main tasks is to develop an International Monitoring System (IMS) that is capable of detecting nuclear explosions occurring at any place or environment around the world at any time. Monitoring techniques include infra-sound, hydroacoustics, seismology and radionuclide methods. Upon completion, the network will contain 321 permanent monitoring stations. 80 of them will be monitoring radioactive substances in air. Particulate samples collected by these stations are first analyzed at the collection site and then sent for second counting and analysis to one of the 16 radionuclide laboratories. Figure 3 presents the global distribution of monitoring stations and radionuclide laboratories. Data provided by these stations and laboratories are transmitted via the International Data Centre located in Vienna, Austria to all States Signatories.

Fig. 3. Global distribution of monitoring stations and radionuclide laboratories.

Half of the radionuclide monitoring stations will also have the capability of detecting radioactive noble gases. This is important from the underground nuclear weapons tests detection point of view, since formed refractory elements tend to stay underground, i.e., they cannot pass through rock and soil into the atmosphere. Noble gas surveillance relies on the detection of ^{131m}Xe ($T_{1/2}$ = 11.84 d), ^{133m}Xe ($T_{1/2}$ = 2.19 d), ^{133}Xe ($T_{1/2}$ = 5.243 d) and ^{135}Xe ($T_{1/2}$ = 9.14 h) because of their significant production cross sections in fission and optimal half-lives (not too long or short). Also their relative amounts within a sample are important. Namely, activity ratios can be used to disentangle releases from nuclear power plants and weapons testing. The ^{133m}Xe/^{133}Xe ratio is a key indicator.

Xenon production process

1. Proton beam is produced with the ion source
2. The beam is accelerated with the cyclotron
3. Accelerated protons hit a U or a Th target
4. Created fission products are thermalized into a flowing He-gas
5. Charged fission products are separated from the neutral buffer gas
6. Fission products are accelerated using electric fields
7. Species with a desired mass over charge ratio are selected using a dipole magnet
8. Selected species are cooled and bunched with the RFQ-cooler
9. Final mass purification of the ion bunches is performed with a double Penning-trap device
10. Mono isotopic or isomeric ion bunches are implanted into an Al or a C foil
11. Implanted species are released from the foil to a gas bottle.

Further reading

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Technology Readiness Level 6

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