Fragment Separator
Demo instructions

Be confident when talking about the lab - you know more than they do!

Stick to the positive messages NSCL wants to convey:
- *We do world-class research (top 3 for rare isotope)*
- *We educate new nuclear scientists (#1 grad program in US)*
- *Our safety record is excellent*
- *We are good for Michigan: high-tech jobs and federal funding*
- *If you're not sure of an answer, it's OK to say "I don't know"*

Thanks for volunteering! This demo is a pretty simple way to show people how a laboratory can separate fragments in a mass spectrometer. You'll need some or all of the following equipment (provided by Zach Constan, outreach coordinator):

- Box fan
- Two plastic tubs
- Balloons
- Ball bearings

The analogy

If your visitors have already done the marble nuclei fragmentation demo, it is easy to connect this demo with the idea that fragmentation produces a variety of isotopes!

Balloons represent individual nuclei. Adding a ball bearing to a balloon can change its mass, while its radius essentially equates to charge. The fan acts as the force due to a dipole magnetic field as the balloon drops through... the balloons mass resists a change in direction with its radius increases the force imparted by moving air. Thus, this setup is analogous to a mass spectrometer like the A1900 Fragment Separator employed at NSCL. The narrow space between boxes could be the slit that allows isotopes of interest through, while others are filtered into the open box by the action of the fan "magnet".

Before the demo

Setup is fairly simple: place one box upside down and put the fan on top of it. Put the other box (opening up) about 10-12 inches away, with its longest dimension orthogonal to the first box and aligned with one side as shown above.

Note: you can control the force by adjusting the fan speed - I recommend "Medium" or "2" because low speeds don't produce enough effect and high speeds are too loud and knock the fan over.

Just before the demo, you'll want to create balloon "nuclei" of varying charge and mass:
- A small heavy balloon (contains a ball bearing) (represents a high mass, low charge nucleus)
- A small light balloon (same size as former) (represents a low mass, low charge nucleus)
- A large heavy balloon (contains a ball bearing) (represents a high mass, high charge nucleus)
- A large light balloon (same size as former) (represents a low mass, low charge nucleus)

Try different sizes and test the demo to make sure it operates as expected!

Introduce the demo:
Particle accelerator facilities can produce an incredible range of different isotopes (species/varieties of nuclei) by fragmentation (smashing). In fact, they always make far more kinds than are necessary for an experiment. The challenge to do a good experiment is then to separate (filter) the nuclei you want from everything else - thus, we need a fragment separator (essentially a mass spectrometer using dozens of magnets)!

You can think of a fragment separator like a prism, which separates white light into a rainbow of colors, only we're picking out different isotopes using magnets.

Here is a model fragment separator, but instead of filtering different isotopes/kinds of nuclei, we will separate balloons. The ones we want should end up in this space (indicate the gap between fan and box) *while the rest should be pushed into the box. Instead of magnets, we use the force of blowing air to separate them.*

Hand them the small light balloon. *Pretend this is one of the "nuclei" that we want to filter out. If you drop this balloon into the air flow from the fan, what do you think will happen to it?* Let them predict, then do it - it should end up in the box. Make several attempts if the result is not obvious! *The force of the air flow has pushed this nucleus away and filtered it out!*

Hand them the small heavy balloon. *Now pretend this is an isotope that we want to keep for an experiment* (again, indicate the gap between fan and box). *If you drop it next to the fan, where will it go?* Let them predict, then do it - it should end up in the space between fan and box. Make several attemps if the result is not obvious! *The nucleus is too heavy to be filtered out, and goes on to our experimental detector!*

Hand them the large heavy balloon. *This nucleus/isotope is as heavy as the one we want to keep, but clearly different (bigger). If you drop it next to the fan, where will it go?* Let them predict, then do it - it should end up in the box. Make several attemps if the result is not obvious! *The nucleus is heavy, but big enough that its more affected by blowing air and gets filtered out!*

Again, this is our model for demonstrating the idea - real isotopes are filtered by powerful magnets depending on their mass (weight) and charge (number of protons).

During the demo

Things you could say to visitors appear in italics

For best results, have guests drop balloons from just above the fan and slightly off center, since the center of the fan produces no air flow.

If you're having trouble with balloons deflating when they contain ball bearings, you can fix that by putting a cushion (t-shirt?) where they will land to soften the blow.

If you are getting lots of questions and have more people waiting, encourage them to take Zach's card and send email!

