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PIP: a compact recirculating accelerator for medical isotopes

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A small low-energy nsFFAG concept that uses a re-cycling beam and internal target to produce medical isotopes. It can also produce neutrons for security scanning and other purposes.

**Medical isotopes – PET and SPECT**

For making medical isotopes, for imaging or for treatment, low energy accelerators have advantages over high energy accelerators, and reactors. Isotopes can be produced locally, on demand, rather than delivered from some remote distribution centre.

Medical isotope production cross sections have respectably high peaks, but they are narrow. Medical isotopes – PET and SPECT

**Targets: thick versus thin.**

Particles lose energy in the target and regain it from the RF system. Nevertheless the emittance can become large, and the wide acceptance of an FFAG is needed.

**ERIT shows the way**

**PIP-4**

Is this a cyclotron or an nsFFAG?

At first sight this looks like a cyclotron. There are no obvious counterparts, as you expect in an FFAG. But this is deceptive. The radial field variation is enormous. The red curve in the figure shows how the magnetic field at the centre of the magnet increases from 0.07 to 1T from the inner to the outer radius. The field in sector optimisation does vary, but only by a few percent. The high gradient is characteristic of an FFAG.

The blue curve shows the field variation along the radius 30 mm off the symmetry axis. The falls, due to edge scalloping, providing the alternating gradient.

These alternating gradients provide strong focusing, making this, we would argue, an FFAG.

**PIP-14**

At first sight similar to PIP-4, PIP-14 orbits have a much higher field/no-field ratio. The radial field variation is so large that the field/no-field ratio is constant (field profiles at 0, 0.1, 0.2, 0.3 and 0.4 radians are shown).

**Conclusion**

Despite their similar appearance, PIP-14 and PIP-4 have significant differences in behaviour. This is expected as it tells us there is a lot of scope for optimisation.

More studies (including OPAL and COSY infinity) are under way.