AUGMENTED CINCH

Augmented cooperation in education and training in nuclear and radiochemistry

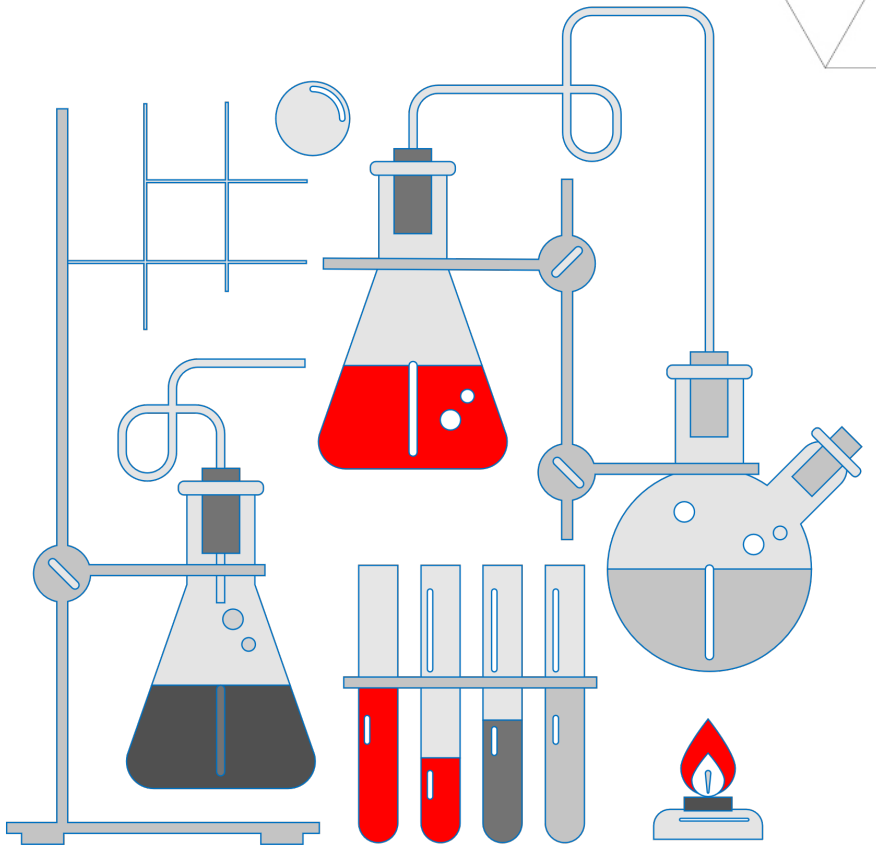
Nuclear Medicine:
Chromatography in Action

NATIONAL NUCLEAR LABORATORY

This project receives funding from the EURATOM Research and Training programme under grantagreement N° 945301 and from the Norwegian Research Council under grant agreement N° 313053.

Learning Objectives

- Recap of atomic structure and isotopes.
- Understand what is meant by radioactive decay and half-lives.
- Investigate the theory behind chromatography.
- Conduct a virtual column chromatography experiment to produce a medical radioisotope.
- Explore how radioisotopes can be used in nuclear medicine to diagnose and treat a variety of illnesses.

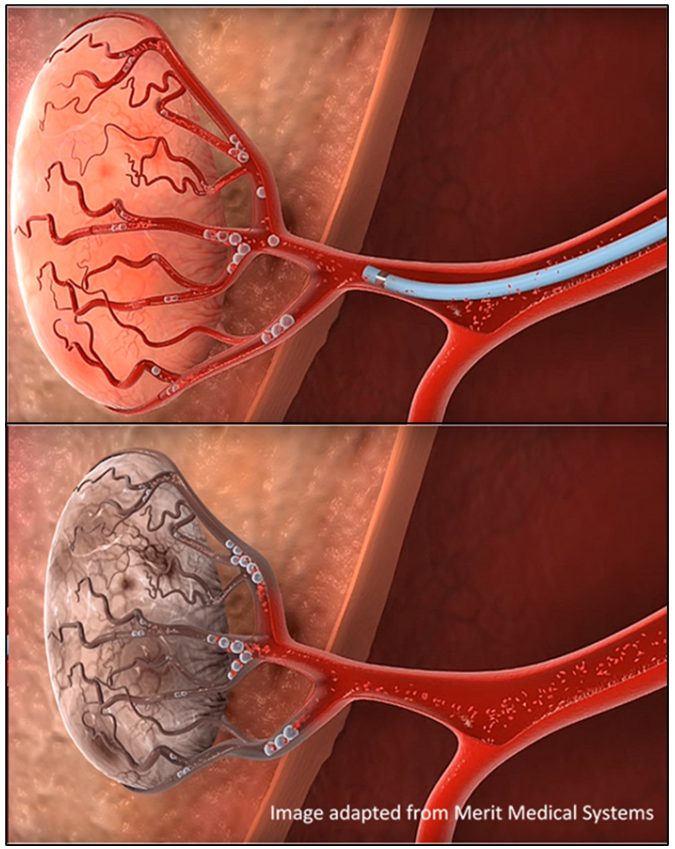


Introductory Video

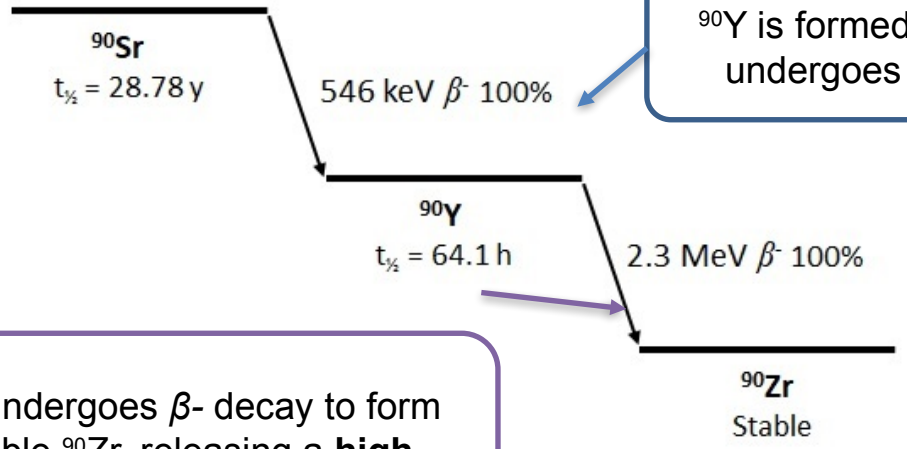
https://vimeo.com/649207531/80baf68305

Yttrium-90 (^{90}Y)

- ^{90}Y is a radioisotope that can be used to treat liver cancer using a procedure known as brachytherapy
- Microspheres filled with ^{90}Y are inserted into the liver's blood stream and become lodged in small blood vessels surrounding the cancer
- The spheres deliver a high dose of radiation to the cancer whilst cutting off the cancer's blood supply
- This targeted delivery of radiation kills the cancerous cells while minimising exposure to healthy tissue



Radioactive decay

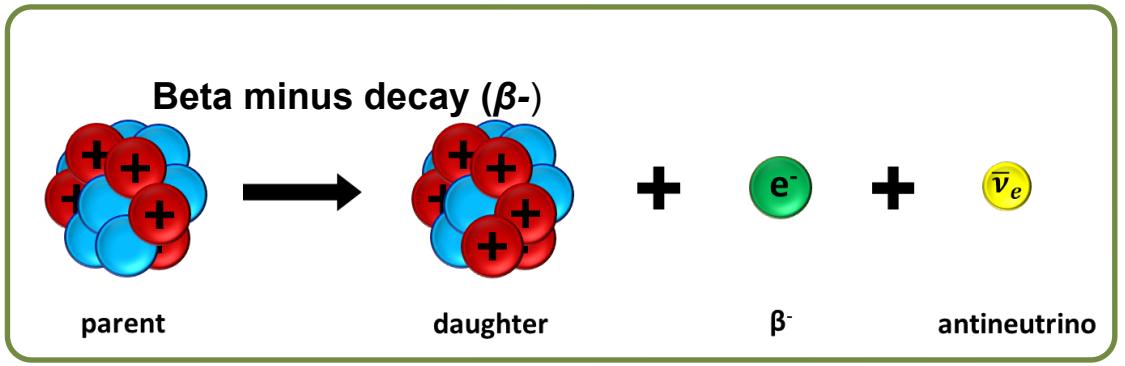


^{90}Y is formed when ^{90}Sr undergoes β- decay

$$^{90}_{38}Sr \xrightarrow[t_{½} = 29\ years]{} {}^{90}_{39}Y + e^-$$

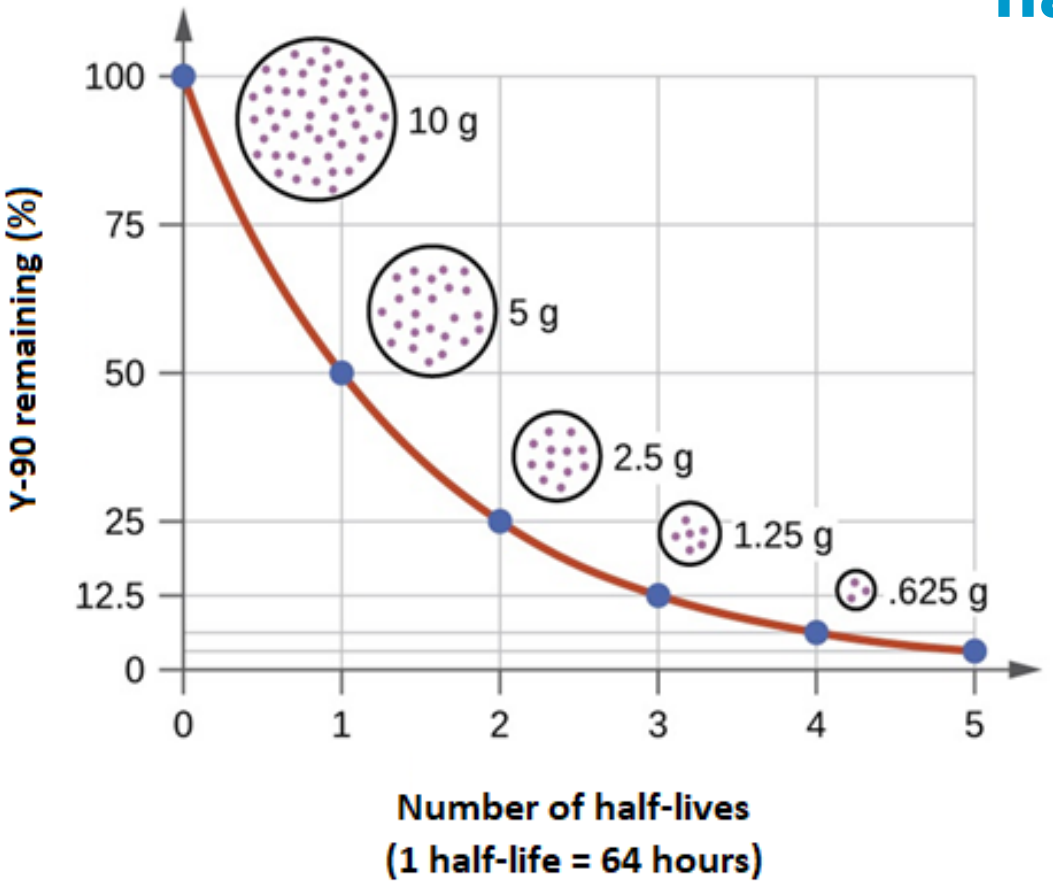
^{90}Y undergoes β- decay to form stable ^{90}Zr, releasing a **high energy** (2.3 MeV) **electron**

$$^{90}_{39}Y \xrightarrow[t_{½} = 64\ hours]{} {}^{90}_{40}Zr + e^-$$



Half-life ($t_{½}$)

“The time required for the decaying quantity to fall to one half of its initial value”



^{90}Y ($t_{½}$ = 64 hours)

- Short half-life
- Days to decay away
- Suitable for medical applications

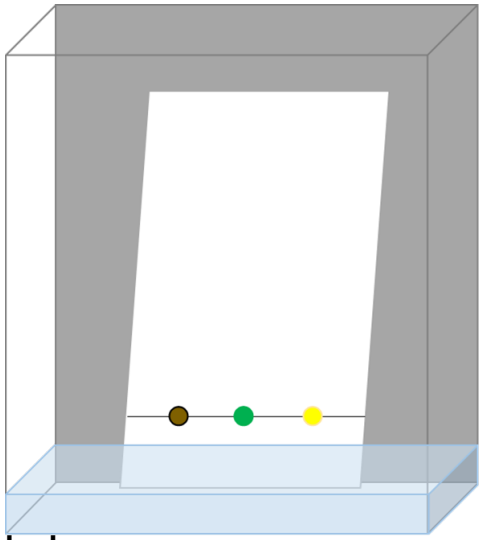
^{90}Sr ($t_{½}$ = 29 years)

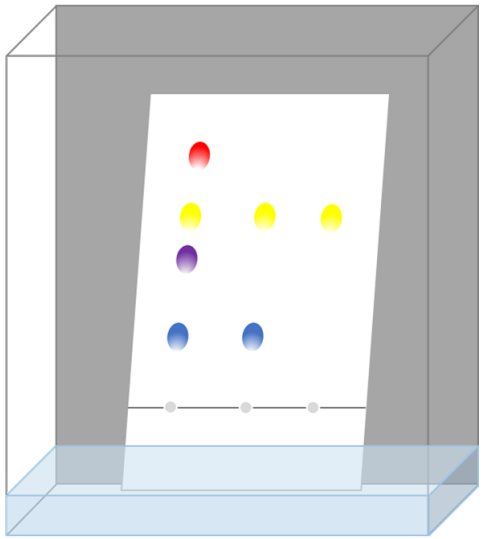
- Long half-life
- Takes years to decay away
- Accumulates in bones and leads to cancer

Chromatography

Chromatography provides an important method of **separating**, **purifying** and **identifying** components in a mixture.
Types of chromatography include:

- Thin-Layer Chromatography (TLC)
- Column Chromatography (CC)
- Gas Chromatography (GC)

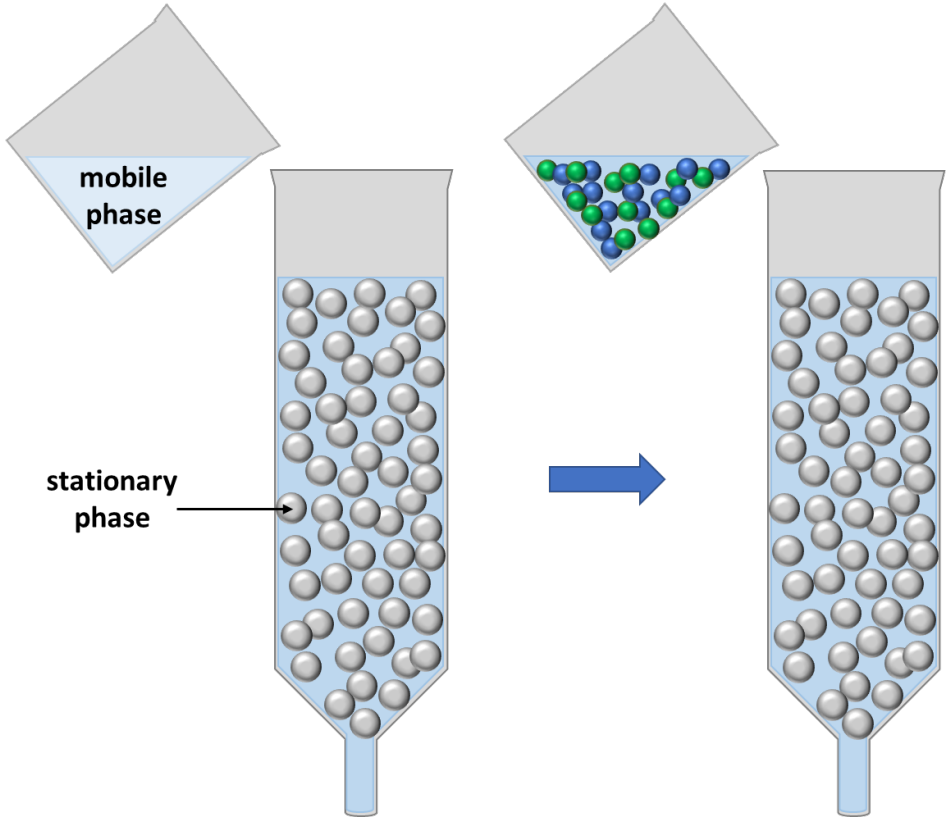




All forms of chromatography work on a similar principle.
They all have:

- A **stationary phase** (a solid, or a liquid supported on a solid) and;
- A **mobile phase** (a liquid or a gas)

Column Chromatography



❖ **Stationary phase**

Glass column packed with absorbent material (e.g. silica, ion exchange resin)

❖ **Mobile phase**

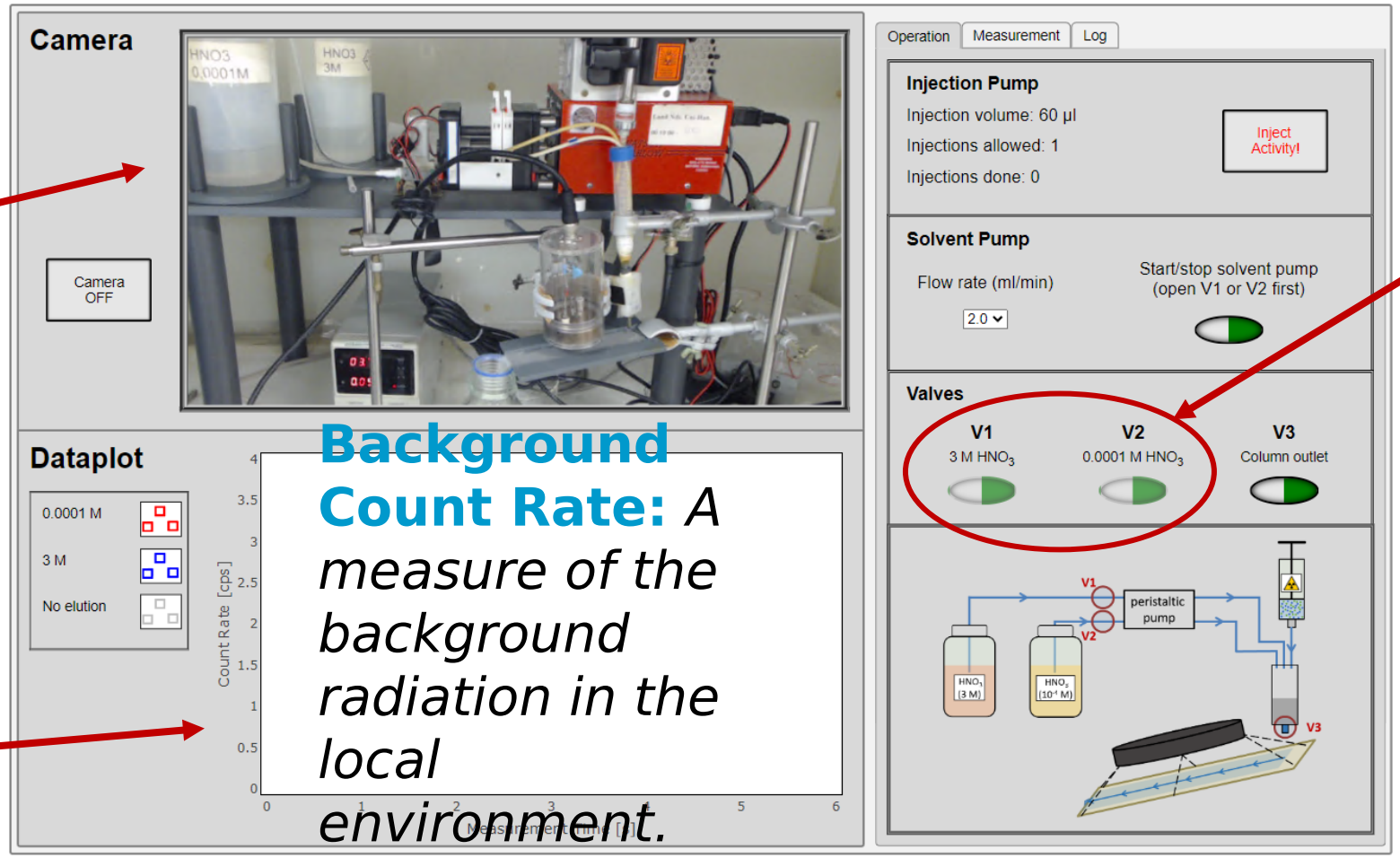
Solvent (water, acid or organic (oil))

The mobile phase flows through the stationary phase and carries the components of the mixture with it.
Each substance travels at a different rate depending on its **solubility** in the mobile phase and its **retention** by the stationary phase.

The IonLab Experiment

This camera feed shows what's happening in the lab.

Your data points will be plotted here.

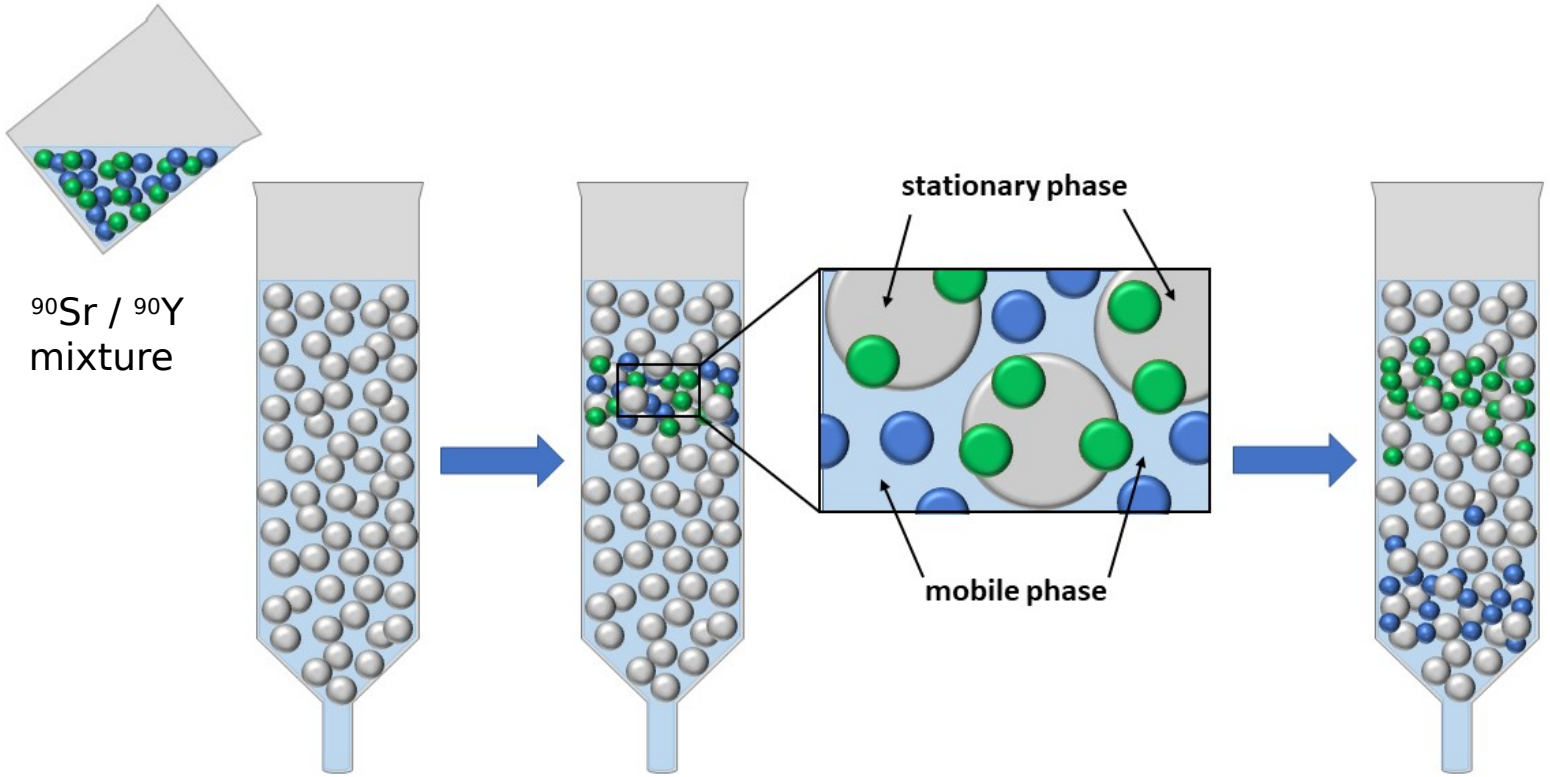


Background Count Rate: *A measure of the background radiation in the local environment.*

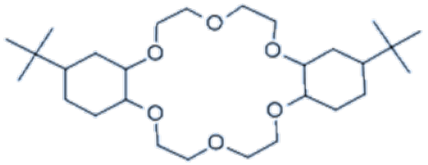
Half of you will start with solvent from Valve 1 and the rest of you will start with Valve 2. After the first peak is recorded, you will swap valves.

http://ibe.irs.uni-hannover.de/ibes/de/RoboLabs/IonLab.html

The IonLab Experiment



Crown ethers are highly selective towards certain elements based on the size of the ring

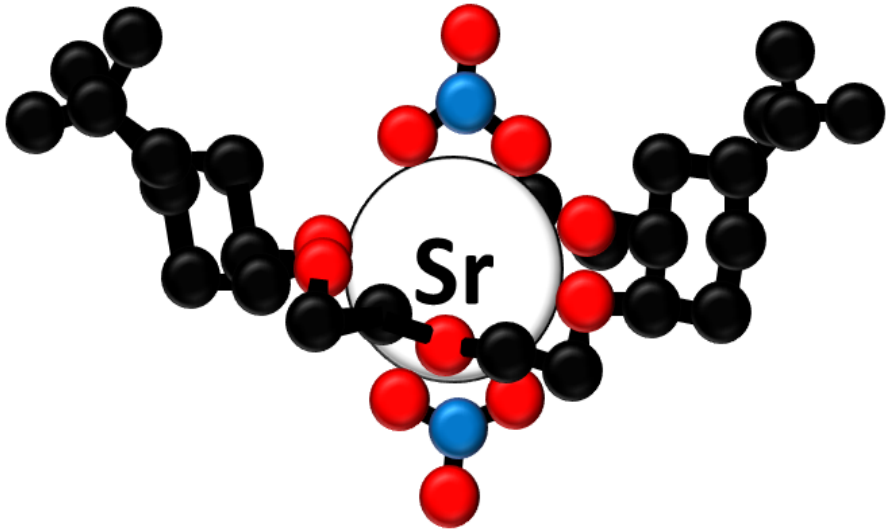


crown ether

Retention Factor (R_f)

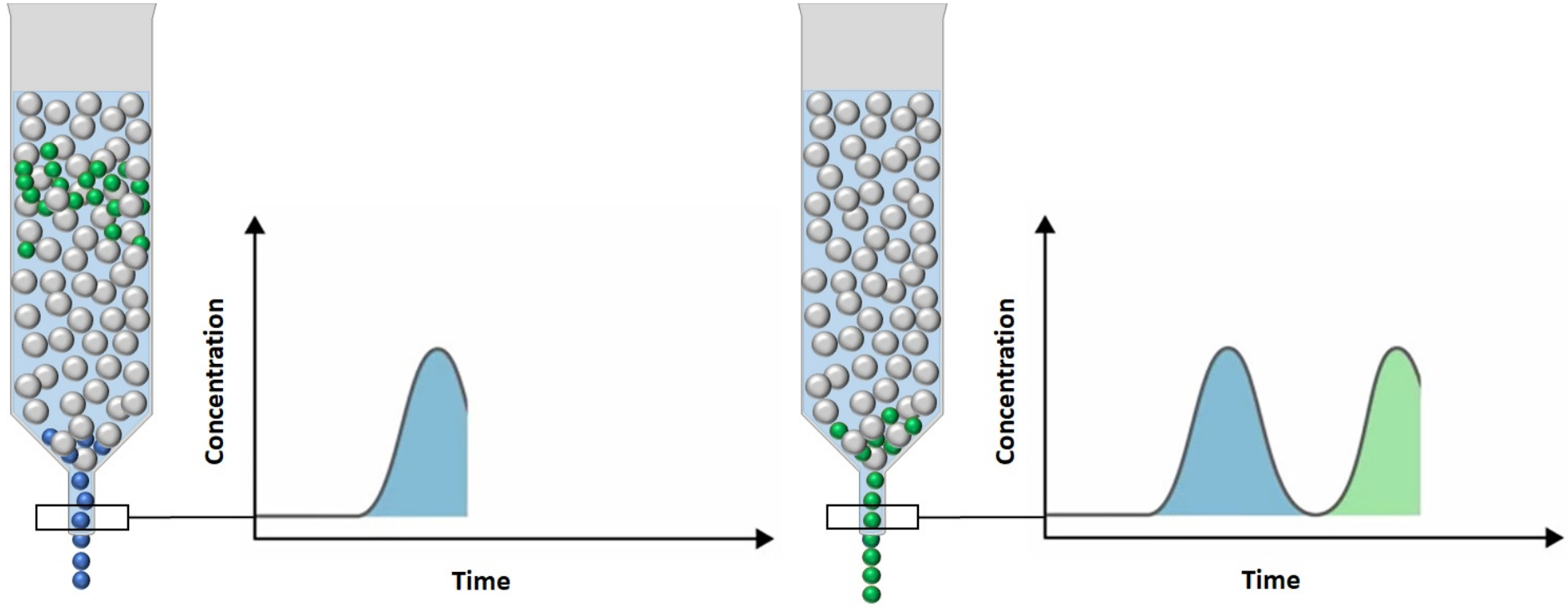
- R_f describes the migration rate of an analyte on a column
- The crown ether resin used in this experiment is highly selective towards Sr
- However, the concentration of nitric acid (HNO_3) affects the rate at with Sr passes through the column
- The crown ether can only retain Sr when there are enough nitrate ions in solution to form the stable complex shown here

Solvent	Retention Factor (R_f)	
	^{90}Sr	^{90}Y
3 M HNO_3	~70	<1
0.0001 M HNO_3	<1	<1



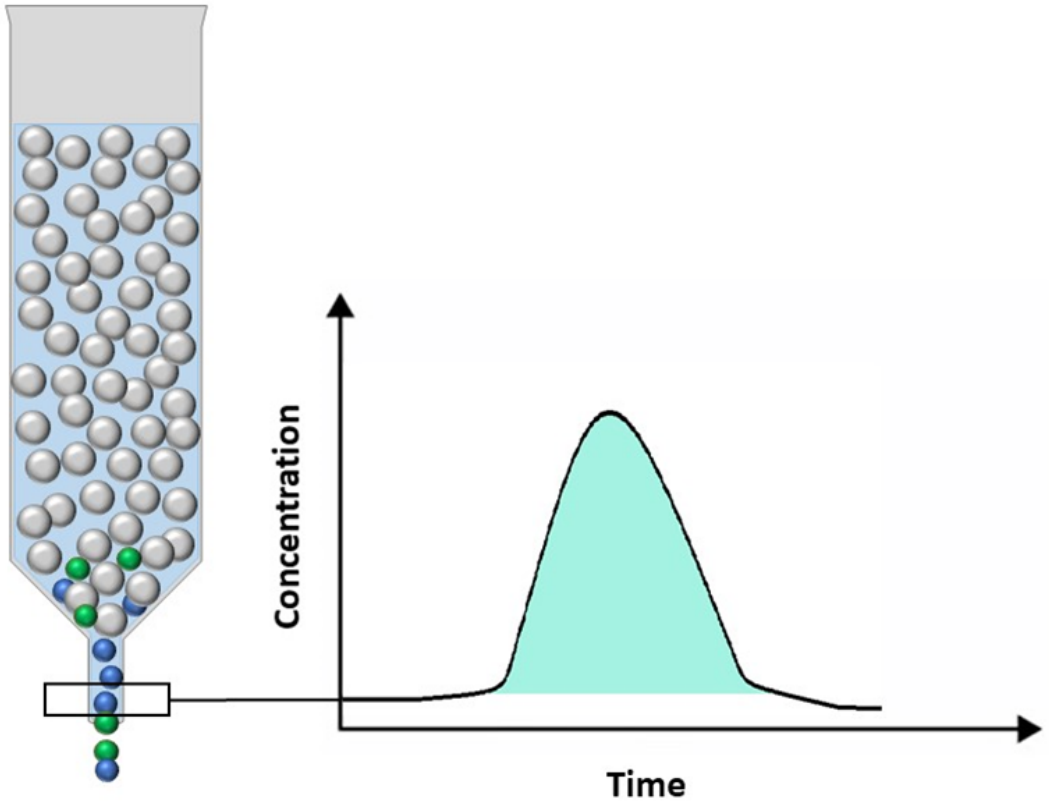
Observations

If we have a **good** separation, we should expect to see...



Observations

If we have a **poor** separation, we should expect to see...



Visit: National Nuclear Laboratory (nnl.co.uk) to learn more about the work that the UK's National Nuclear Laboratory does.

Visit:
Augmented CINCH: Augmented CINCH (cinch-project.eu)
to learn more about the A-CINCH project.

Visit: https://community.stem.org.uk/ or https://nucwik.cinch-project.eu/exercise/start to access a lesson on Pyro-Processing: Electrochemical Cells in Action.