Laboratory Safety

Dr. Tobias Flick
University of Wuppertal

EURIZON Detector School

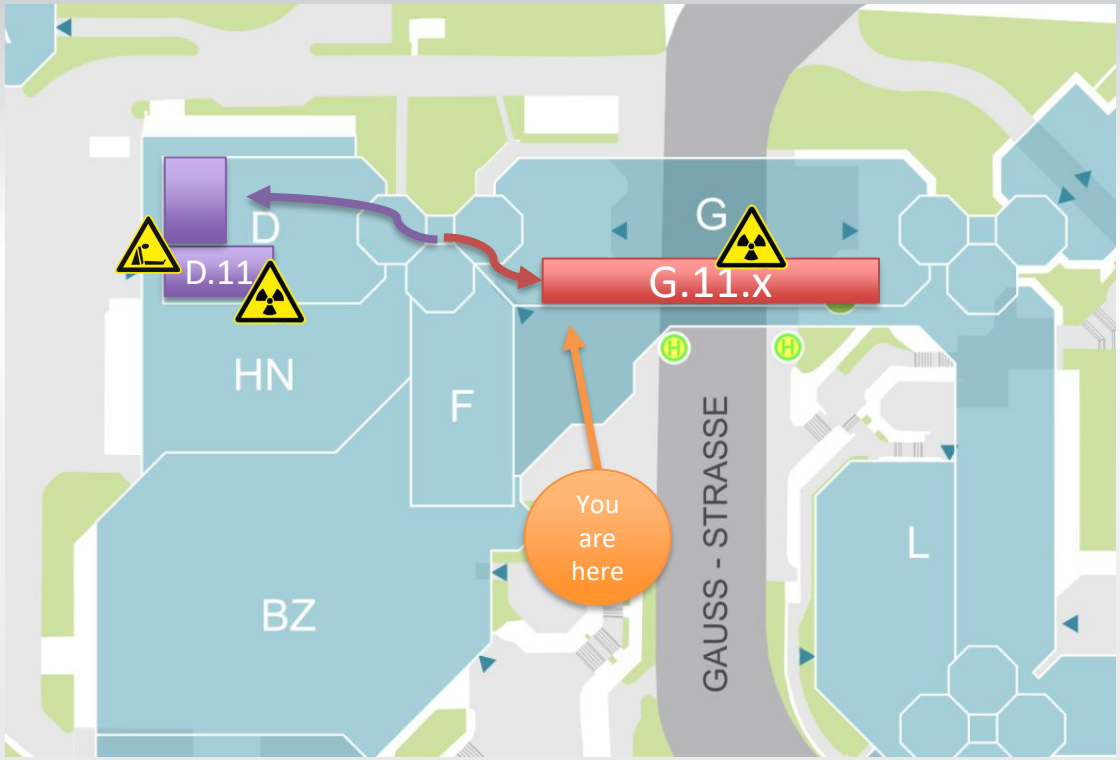
17.-28.07.2023

General Remarks

- **Welcome to Wuppertal**
- The practical part (experiments) of this school takes place in several labs of the university
- All labs belong to the physics department
- Experiments are situated in several rooms
- Working in the laboratories underlies safety rules for work in the Lab
  - *Laboratories must be designed and operated in line with the relevant regulations and the state of the art. The specific activities of insured persons in laboratories, in particular involving hazardous materials, require specific protective measures of a structural, technical, organisational or personal nature.*
- One important rule: Never work alone → Always a group of people working together

Location of Laboratories

- Location of labs for this school:
  Blg. D and G (and F for tutorials)



Nr	Title of the exercise
1	Drift tube characterisation
2	Micro-pattern gas detector, measure efficiency of mu-RWELL detector
3	Cosmo boxes
4	Microchannel plate photomultipliers (MCP-PMT) with delay-line anode
5	Silicon-photomultiplier
6	Silicon pixel detector
7	Silicon strip detector, Landau distribution
8	Do-it-yourself particle detector

Safety of Work

- **<u>Generally:</u>**
  Eating and drinking is strictly forbidden in all the labs!
- There are several sources of danger in the experiments to be aware of:
  - Electricity
  - Gases
  - Radioactive materials



- Always make sure to work in a safe environment.
- In case of danger:
  - Move away from the source of danger,
  - Warn your co-workers,
  - Inform the supervisors / Fire brigade **(Tel. 112)**.

Electricity

- **Main electrical hazards:**
  - **Electrical shock and burns from contacs with live parts**
  - **Injury from exposure to arcing (when electricity jumps from one circuit to another)**
  - **Fire from faulty electrical equipment or installations**
- Electrical current is of high danger:
  - A current of 50 mA can lead to death
- Most accidents with electricity are with “Low Voltage” (50-1000V DC or 75-1500V AC) and occur in our normal environment, like at home.
- In the lab always make sure to work safely with electrical devices:
  - Always double check electrical circuits for the correct cabling before switching on any device.
  - Never leave (potentially) powered open contacts
  - Never touch a (potentially) powered contact (cable ends etc.)
  - Disconnect the power cords once the work is done
  - Never open any electrical device (could include high voltage or lasers or any other source of danger)
  - Don’t touch spots which can be hot from electrical current (esp. solder irons ☺)

Gases

- In some of the experiment mixtures of gases are used: Ar / CO2 / CF4 or He / i-C4H10 (isubutane)
- Possible hazards:
  - All gas bottles are under pressure
  - Isubutane is highly flammable
  - C4H10, He, and Ar supress the oxygen in the room. He moves to the top and Ar and C4H10 to the bottom of the room.

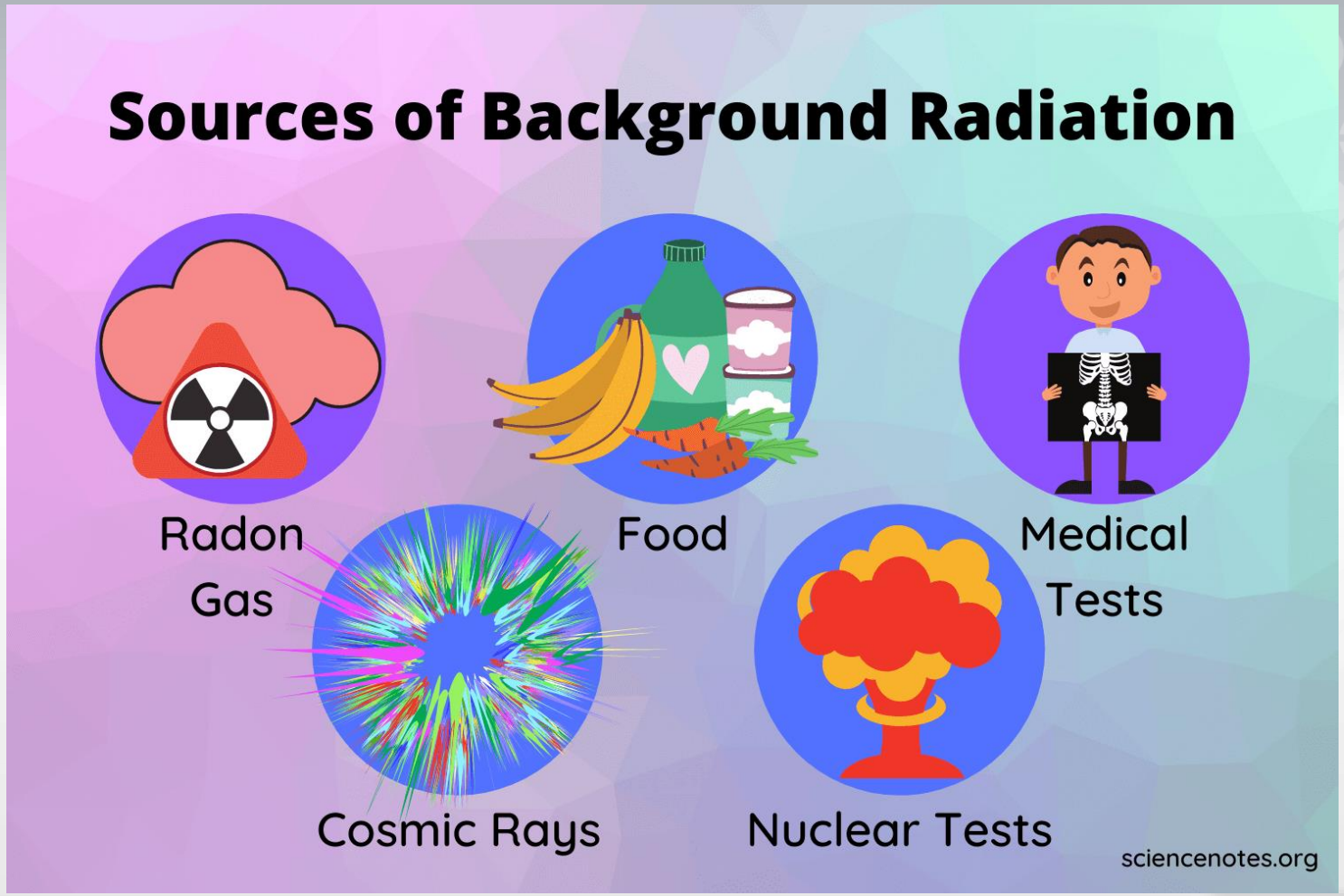
- Oxygen content of the air is normally ~21%
  - below 18% it becomes dangerous, reactions are slowed down, feeling dizzy, …
  - Below 10%: unconsciousness
  - Below 8%: death by suffocation
- **Safety measures:**
  No open fire in the room!
  Make sure of a good fresh air ventilation!

There will be oxygen level measurement devices in each of the rooms

Radiation

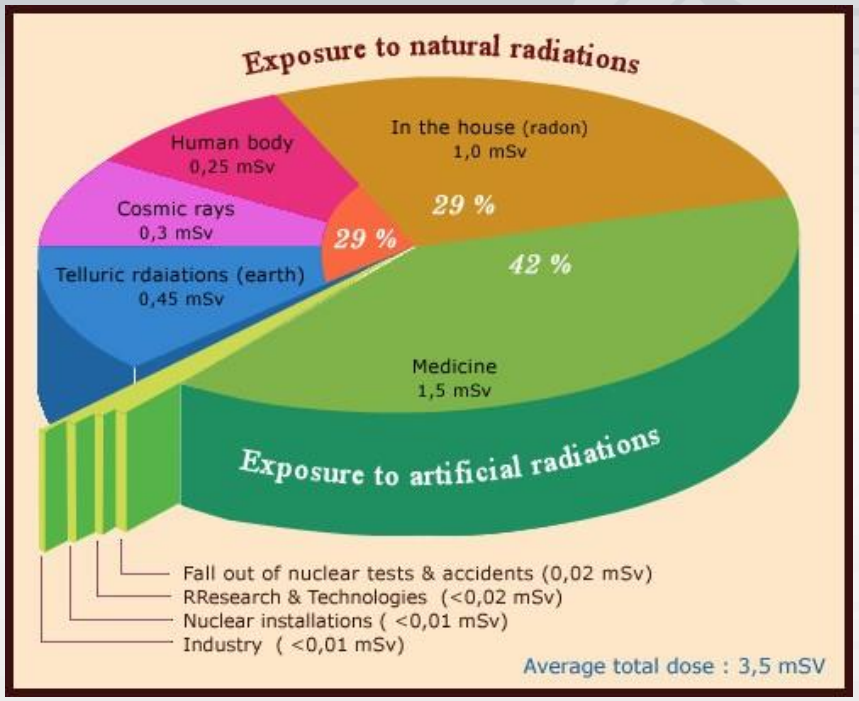
- The handling of radioactive materials is regulated by a separate law, reflecting an international radiological protection plan:
  - Strahlenschutzverordnung
- **We are obliged to supervise and instruct each person working with radioactive materials in our institute.**
- Here in a comprehensive way with a couple of sildes.

Natural background Radiation



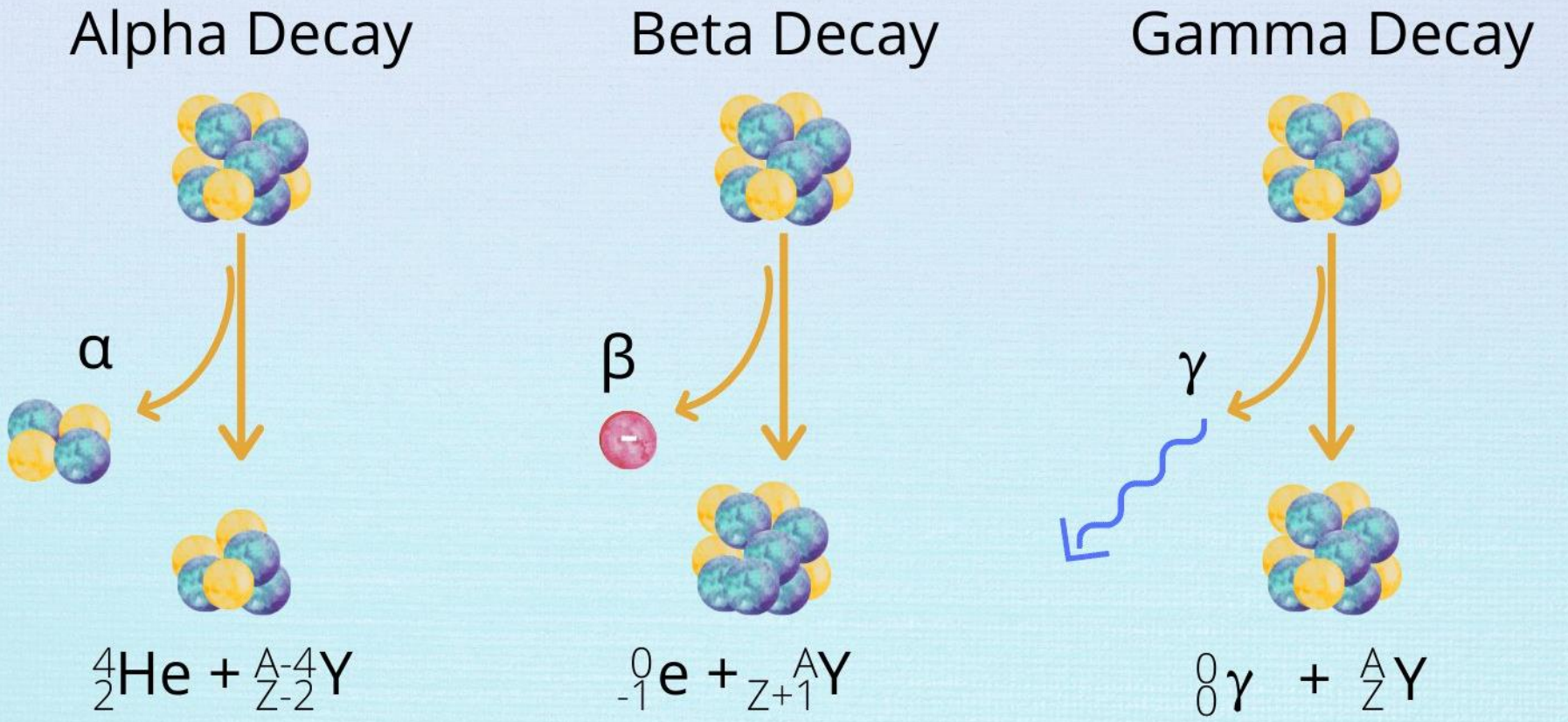
Level or natural Radiation

- In Europe the average natural radiation level is about 3.5 mSv.
- Nearly 40% is from medical radiation treatments.
- Research and technology is around 0.6% only.



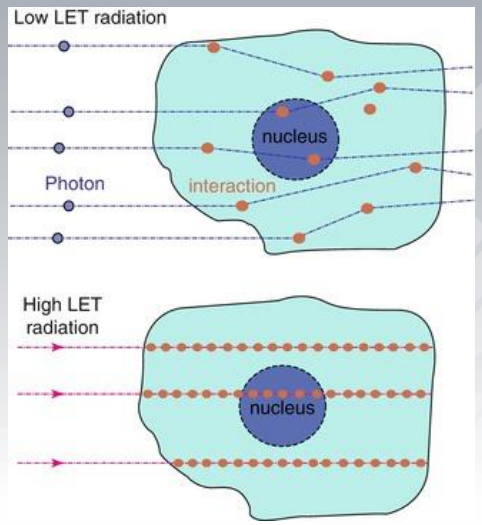
Radioactive Decays

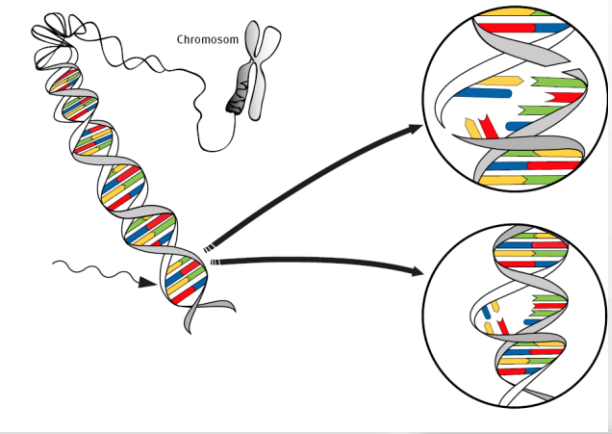
- Radioactivity is the emission of ionizing radiation from nuclear decays.



Linear Energy Transfer (LET)

- α, β and γ particles interact differently with matter.
- While α particle deposit a lot of energy within a short distance, the ionization path of β and γ particles is a lot larger.
- Danger to the DNS if there are double hits within a short distance destroying the whole information.





Several Units to “Measure” Radiation

- Activity: A in [Bq] (decays per second)
- Energy Dose: D in [J / kg = Gy] (absorbed energy per mass unit)
- Equivalent Dose: H in [J / kg = Sv] like D but weighted with a biological effectiveness factor.
- Effective Dose: E in [J / kg = Sv] = H * w_R weighted for type of radiation

Organ / Tissue	**w_T** (ICRP 103)
Gonodal	0,08
Bone marrow / large intestine / lungth / stomach / breast	0,12
Bladder / liver / gullet / thyroid	0,04
Skin / bone surface / Brain / salivary	0,01
Other organs / tissue	0,05 / 0,12

Radiation type and energy range	Radiation weighting factor, wR
Photons, all energies	1
Electrons and muons, all energies	1
Protons and charged pions	2
Alpha particles, fission fragments, heavy nuclei	20
Neutrons	a continuous function of neutron energy (see below)

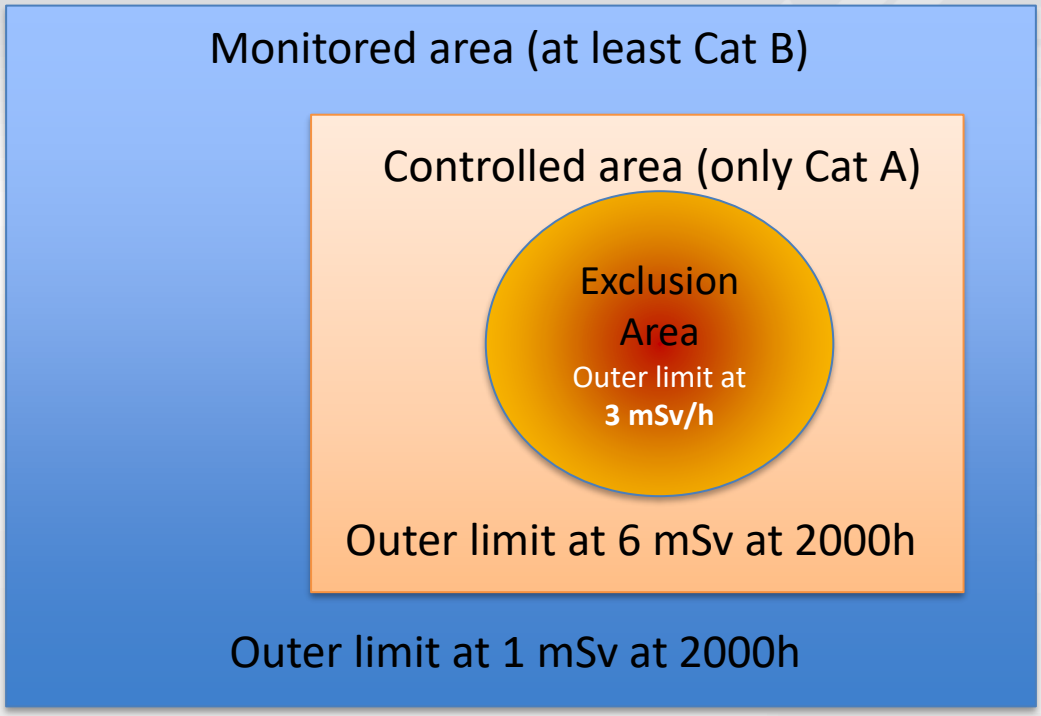
$$w_R = \begin{cases} 2.5 + 18.2e^{-[\ln(E_n)]^2/6}, & E_n < 1\ \text{MeV} \\ 5.0 + 17.0e^{-[\ln(2E_n)]^2/6}, & 1\ \text{MeV} \leqslant E_n \leqslant 50\ \text{MeV} \\ 2.5 + 3.25e^{-[\ln(0.04E_n)]^2/6}, & E_n > 50\ \text{MeV} \end{cases}$$

Regulations for Dose-Limits

- In Germany the following limits are set:
  - Hard limits:
    - Persons under the age of 18y: 1 mSv / y
    - Pregnant women (the child counts): 1 mSv / y
  - For all other persons exposed in work areas with more than 1 mSv / y:
    - Category A: > 6 mSv / y < 20 mSv / y
    - Category B: > 1 mSv / y < 6 mSv / y

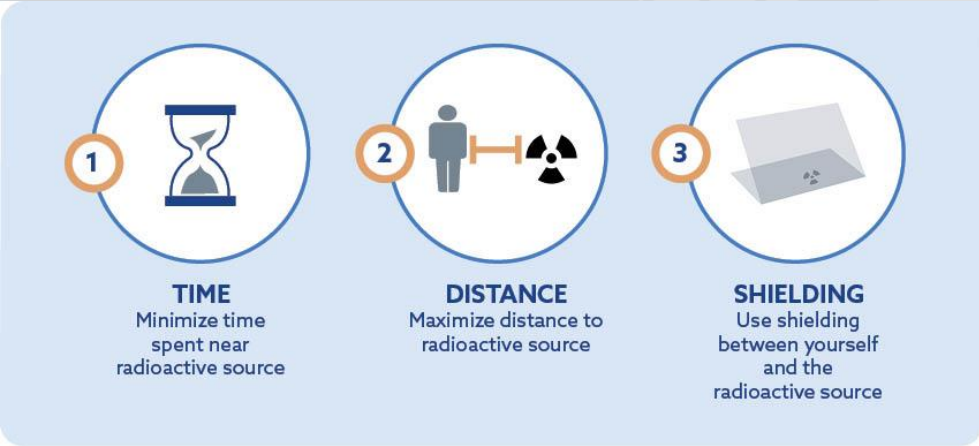
Controlled Areas

- To ensure the maximal Dose for workers, different areas in zones with radiation risk are defined.
- Areas according to the max. dose levels defined before



Basic Rule: ALARA

- ALARA: **A**s **L**ow **A**s **R**easonably **A**chievable
- In this school there is no controlled or monitored area.
- Nevertheless there are radioactive materials
  → Protect yourself!



Shielding

- Absorption is exponential: $D = D_0 e^{-\mu x}$
- For γ-radiation

Energy / MeV	D/10 (body)	D/10 (lead)
0.1	0.13 m	0.4 mm
0.5	0.24 m	14 mm
1	0.33 m	29 mm
5	0.77 m	48 mm
10	1.05 m	41 mm

- For α-radiation a piece of paper is enough
- For β-radiation a

Energy	Distance in air	Distance in body	Protection
100 keV	10 cm	0.16 mm	Wear glasses
1 MeV	4 m	4.75 mm	Aluminium protection
10 MeV	40 m	60 mm	Aluminium protection

Work safely in the Labs

- Respect the rules for the work in the labs.
- Respect the advices of the supervisors.
- Work careful and thoughtful.

- I wish you a successful and fruitful stay in Wuppertal.