

# **Balance of natural radionuclides in lignite-based power generation and consequences for the use of residues and by-products**

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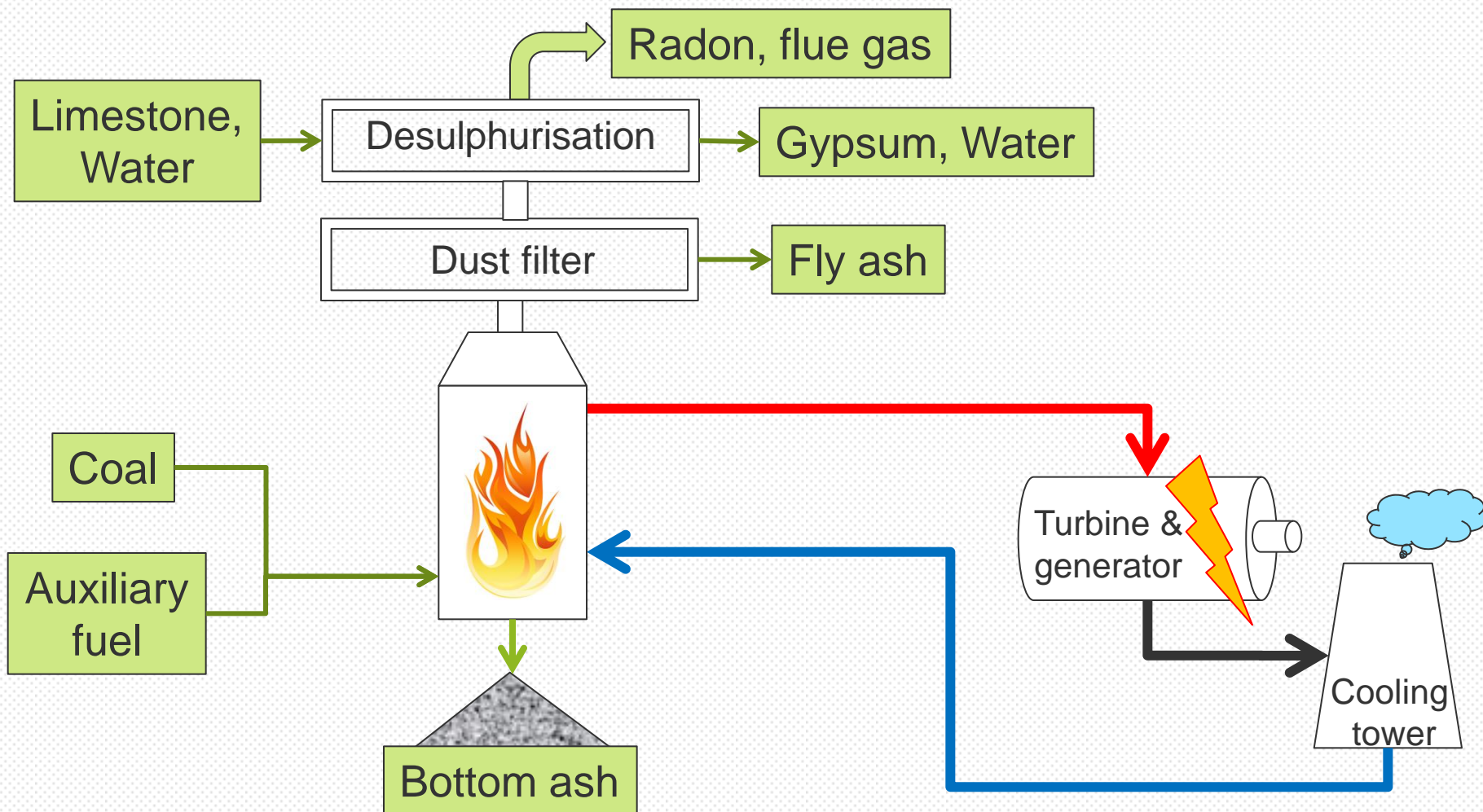
## Outline

- Radioactivity in lignite-based power generation
  - Coal, auxiliary fuel, wastes, by-products, discharges
- Systematic investigation methods: activity balance
- Use of by-products and wastes as building material
  - Public concerns vs. facts
- Conclusions

## Motivation and methodology

- Public concerns regarding natural radioactivity involved in coal (lignite) based power generation
- Close knowledge gap regarding activity transfer from lime to gypsum in desulphurisation process
- Detailed investigation of radioactivity balance
  - Complete radioactivity measurements of all inflow and outflow streams
  - Statistically representative sampling of streams with fluctuating radioactive properties

# Coal-based power generation process



## Mass flows: inputs and outputs

- Inputs

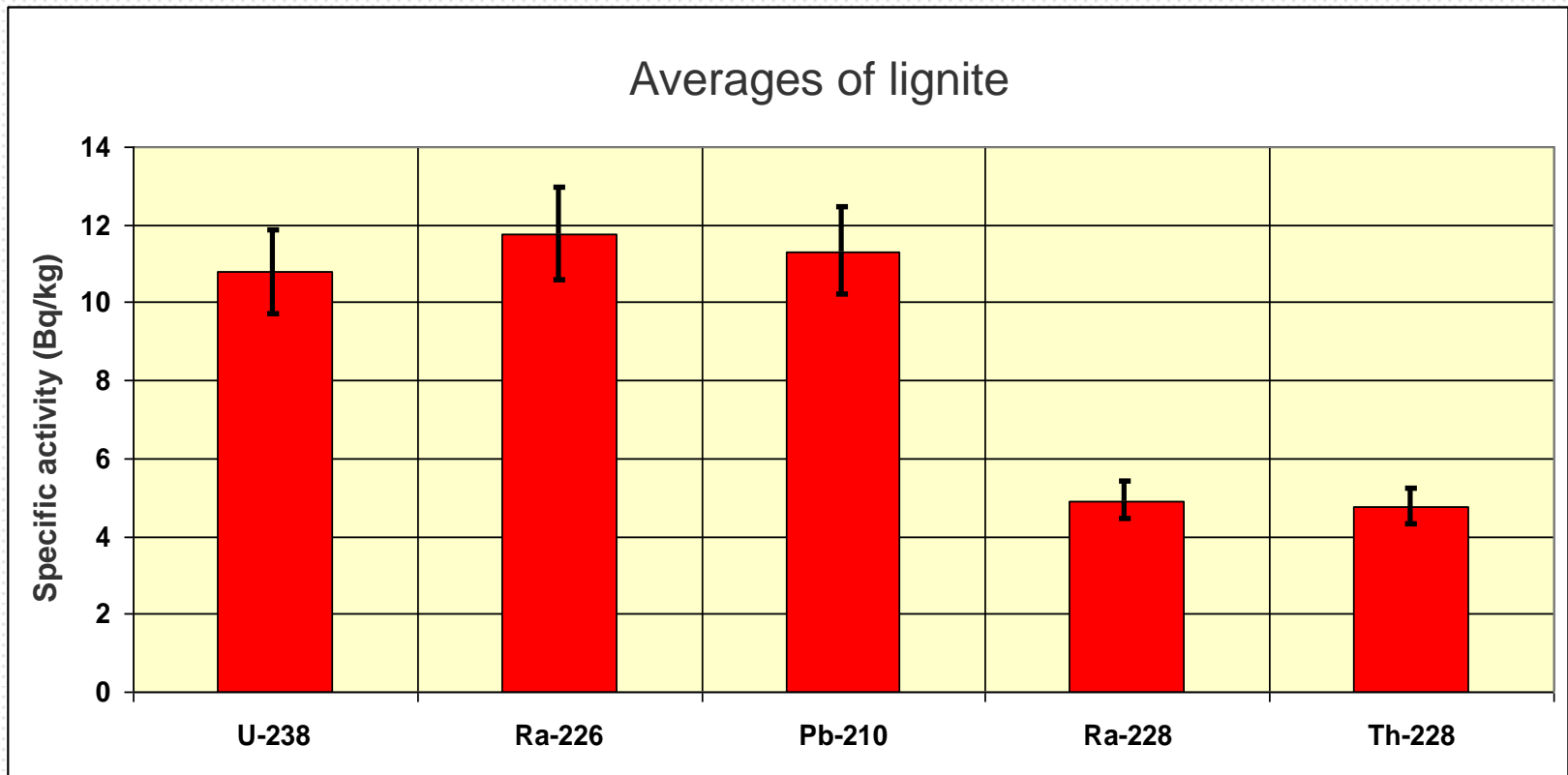
- Raw coal (lignite)
- Auxiliary fuels
- Lime/limestone
- (Water)

- Outputs

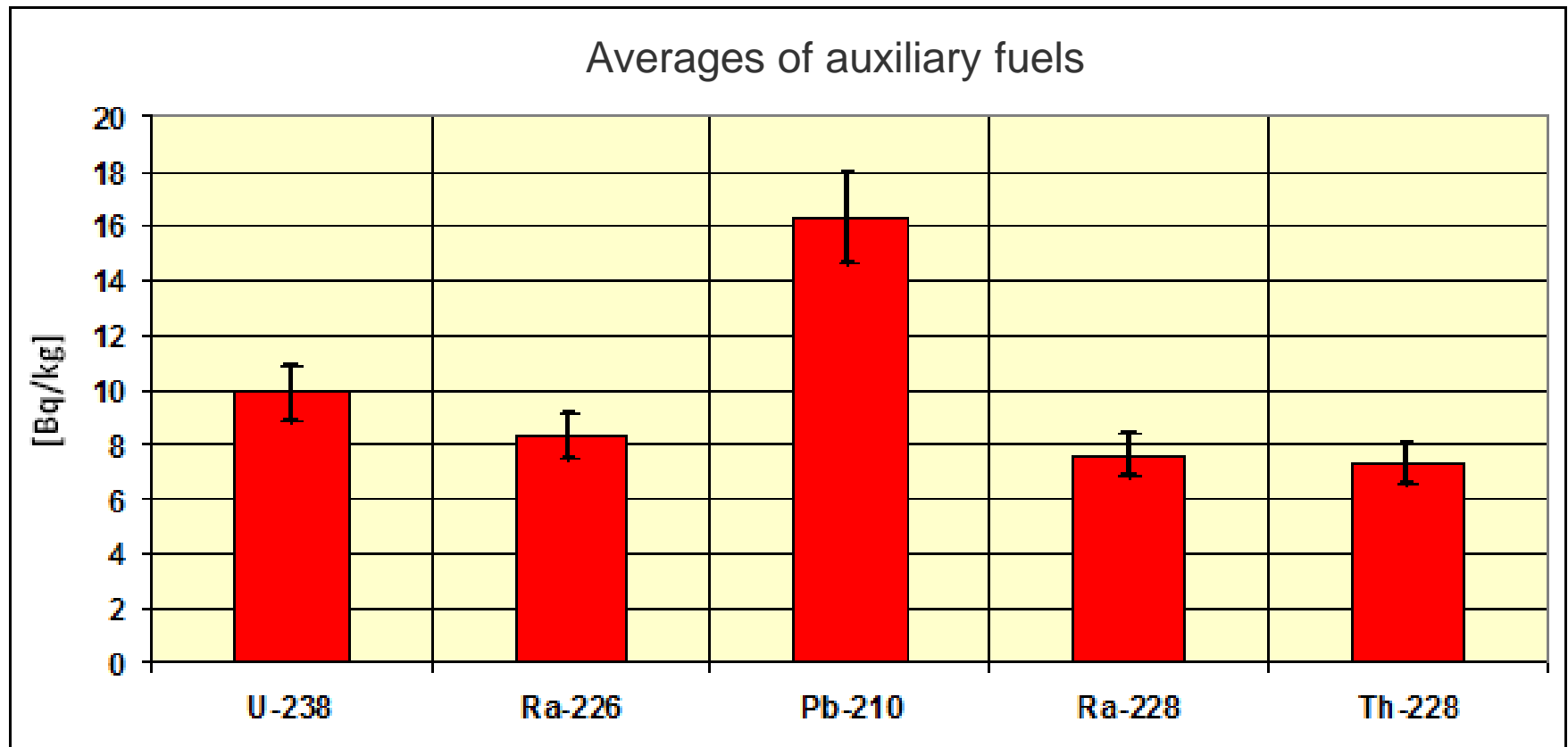
- Filter ash
- Bottom ash
- Gypsum
- Waste water
- Flue gas
- Radon

Probably for the first time detailed activity balance measurements have been carried out. Input and output measurements were measured simultaneously. Activity input and output have matched almost perfectly.

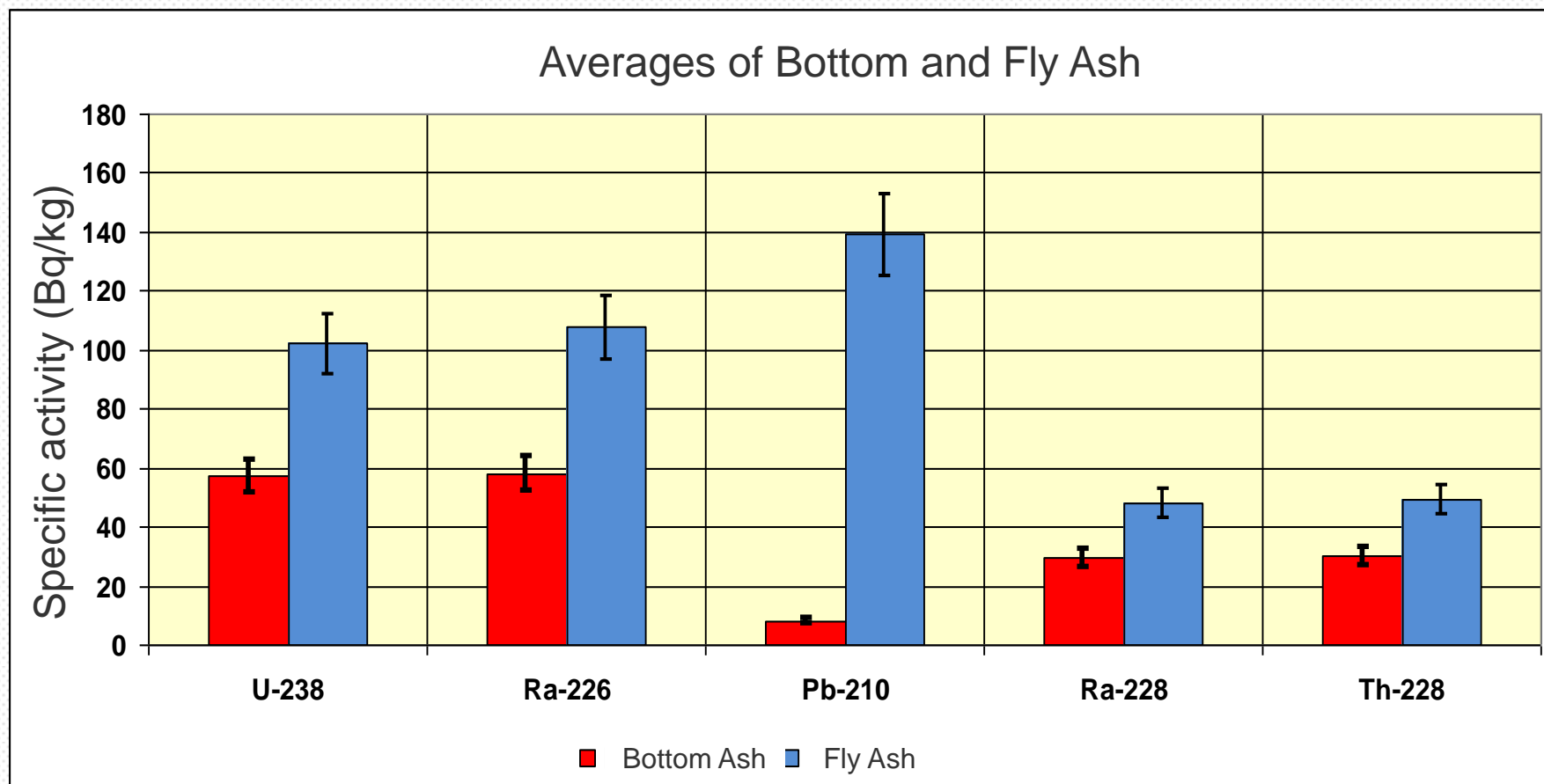
# Average activity concentration of raw lignite is rather low



# Specific activity of auxiliary fuel is in the order of 10 Bq/kg

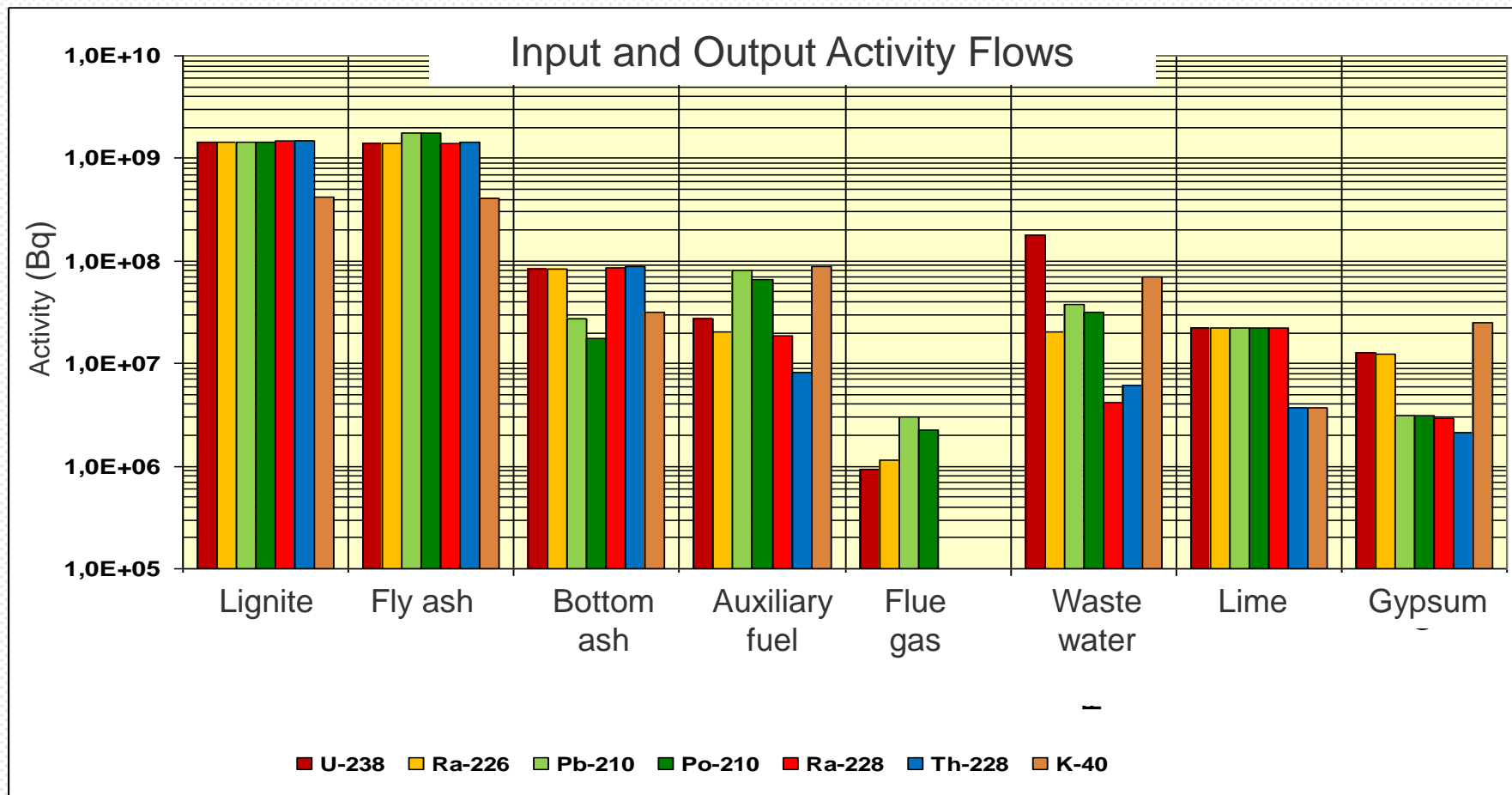


## Ashes: specific activity accumulates in bottom (x5) and fly ashes (x10, Pb: x15)





# Nuclide specific activity flows



## No transfer of radionuclides from coal/flue gas into gypsum in desulphurisation process

- Measurements have shown that all activity of the limestone (L) is transferred into gypsum (G)

$$a_L M_L = a_G M_G$$

- Note the ratio of molar weights

$$M_L / M_G = a_G / a_L = 1.72$$

- This is important for the use of gypsum as building material

## Almost perfect activity flow balance from fuels to ashes

- Measurements have also shown that the simple activity balance between coal (C), auxiliary fuel (A) and dry/bottom ashes (D, B) holds almost perfectly:

$$M_C A_C + M_A A_A = M_D A_D + M_B A_B$$

- Activity flows via flue gas and gypsum is negligible
- Most activity is transferred from fuels into dry ash (see previous slides), less into bottom ash

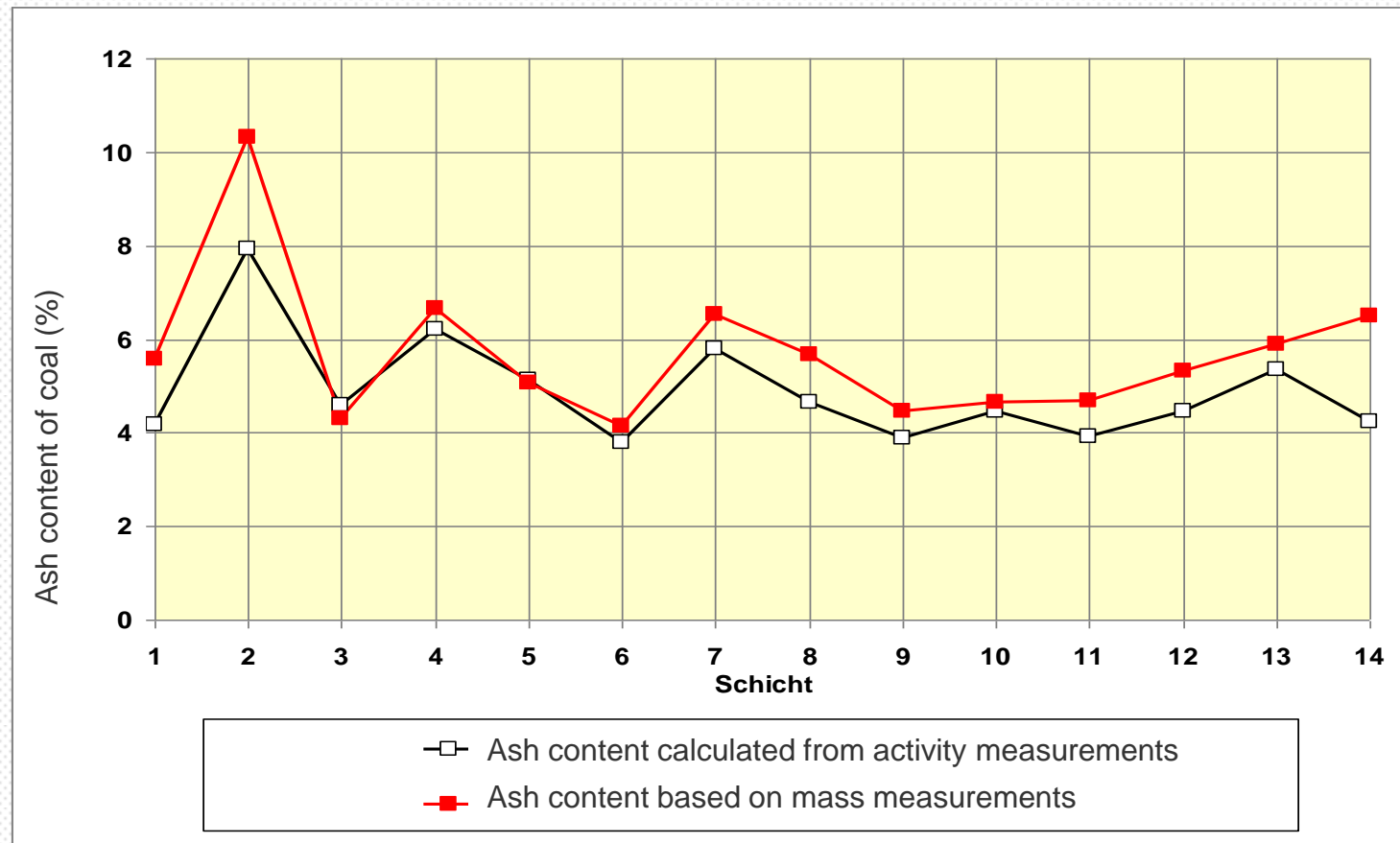
## New method to determine ash content in coal using radionuclide balance

- Usually the ash content is determined in laboratory using small amounts of coal (and ashes)
- Radionuclide analysis offers a precise alternative:

$$\frac{M_A}{M_B} \approx \frac{(1 + \alpha)A_B}{A_T + \alpha A_N}$$

- $\alpha$  is the (easy to measure) ratio of bottom/dry ash,  $A_x$  are the specific activities

# Almost perfect match of activity inputs and outputs



## Other interesting findings

- Activity release via water discharges from lignite mining and coal combustion is more than one order of magnitude lower than activity input from coal
- Radon release from lignite combustion in a power plant is lower than radon exhalation from natural soil
- See next slide

## Radon release vs. natural soil exhalation



- Release: approx. 100 GBq/a
- Natural soil exhalation of plant area (20 ha): approx. 100 GBq/a
- Building plant, suppressing natural exhalation and burning coal yields same radon exhalation as natural soil



Sources: LEAG and Google Earth



# Conclusions

- Low specific activities of raw lignite
- Accumulation of nuclides predominantly in fly ash
- Input and output activity flows match almost perfectly
- Advanced sampling to ensure representativeness is key
- Radiological concerns related to building materials, radon, dust and water releases are unfounded
- Novel method to determine ash content has been developed