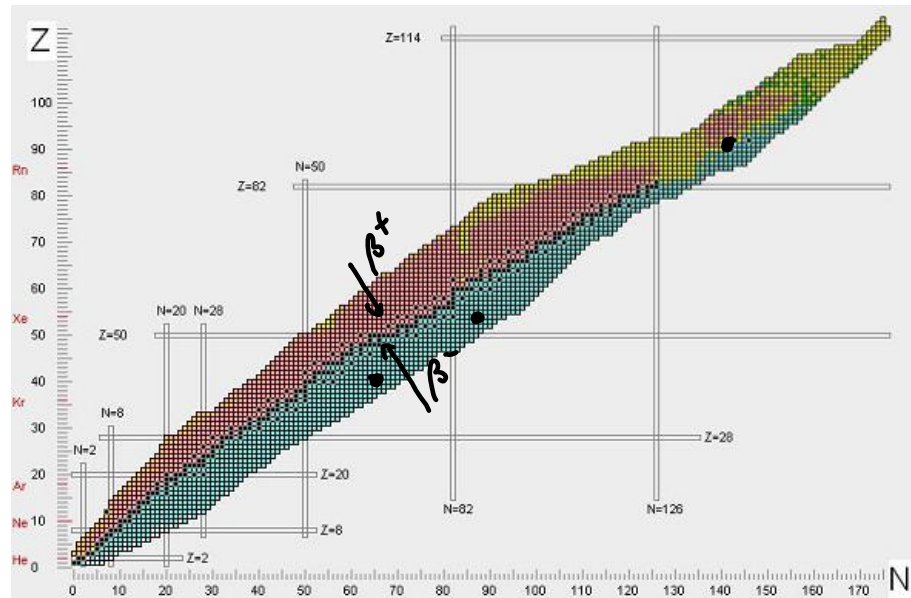


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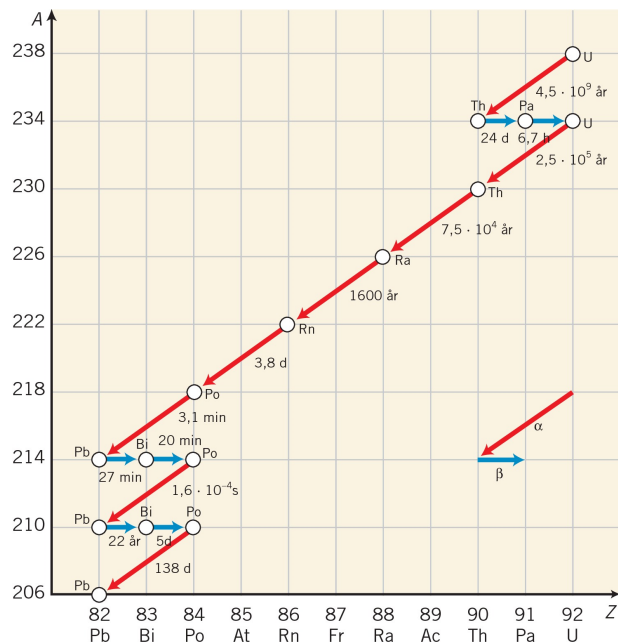
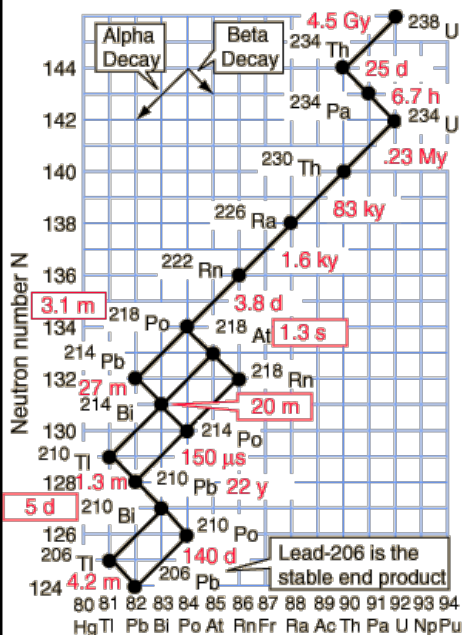


<http://www-nds.iaea.org/relnsd/vcharthtml/VChartHTML.html>

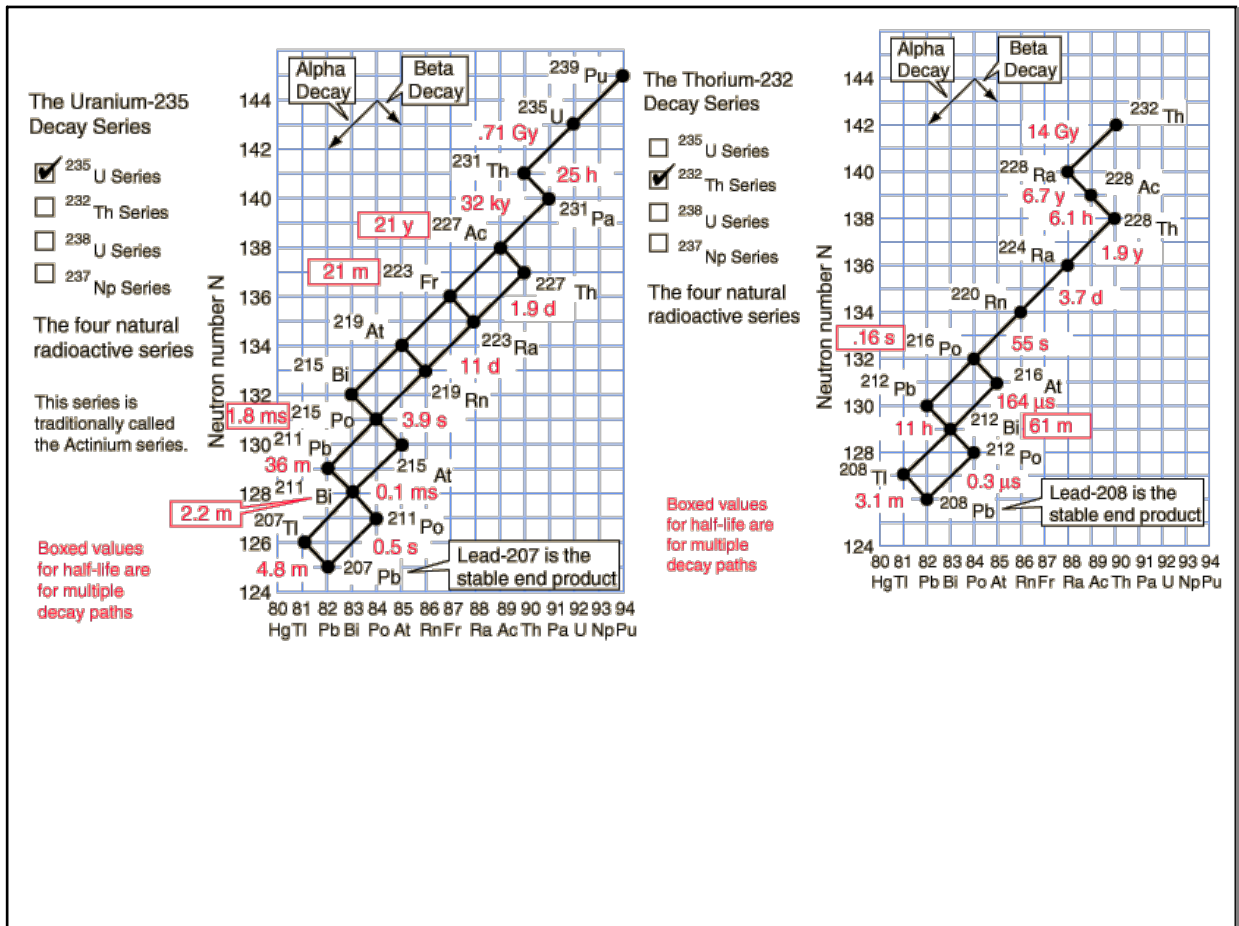


Apr 15-11:52 AM

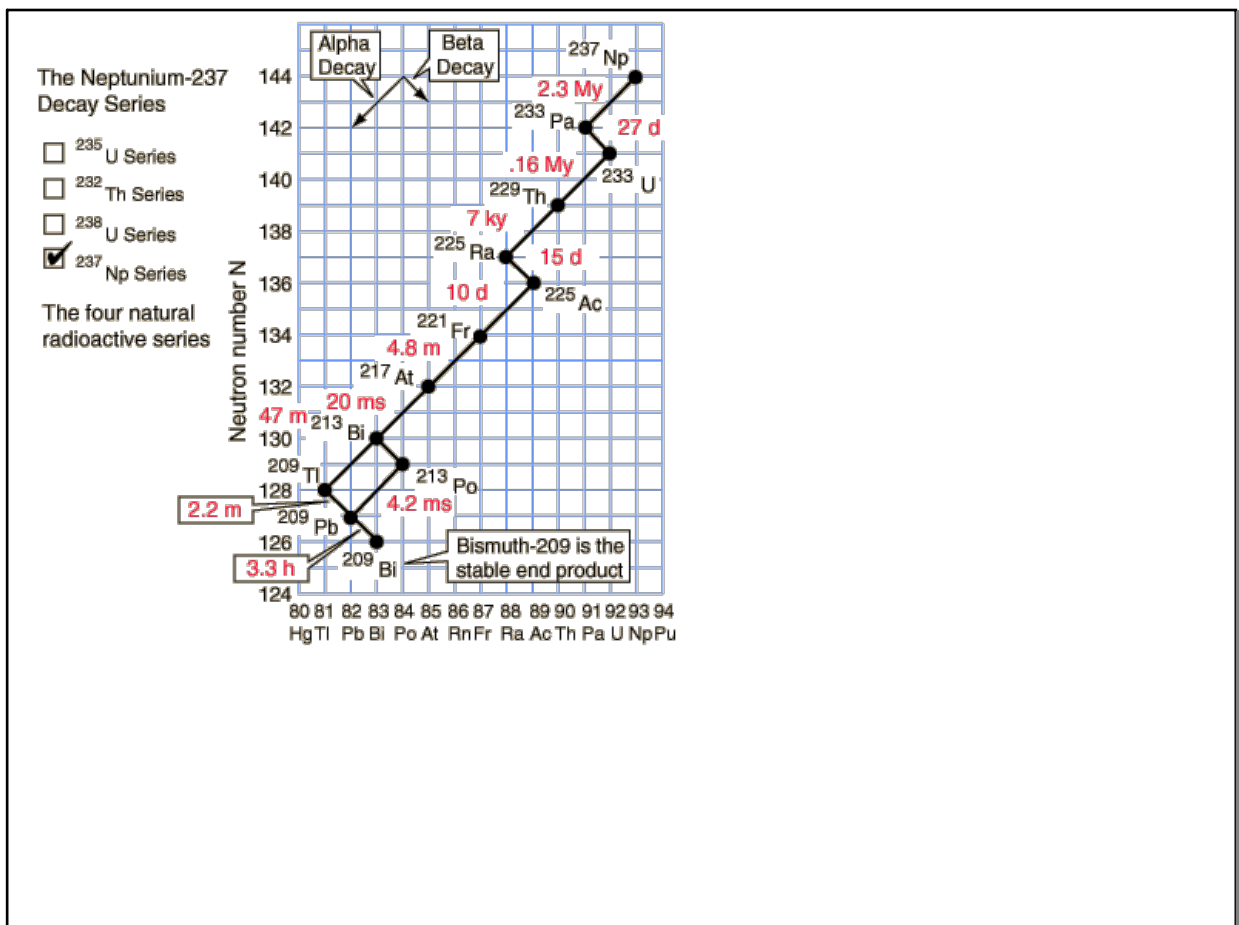
Radioaktive serier



Apr 19-9:40 AM

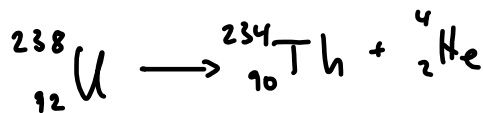


Apr 19-9:32 AM



Apr 19-10:29 AM

Massesvinn i kjernereaksjoner



$$1\text{u} = 1,66 \cdot 10^{-27} \text{kg}$$

Masser:

$${}^{238}\text{U} = 238,0508 \text{ u}$$

$${}^{234}\text{Th} = 234,0436 \text{ u}$$

$${}^4\text{He} = 4,0026 \text{ u}$$

$$238,0462 \text{ u}$$

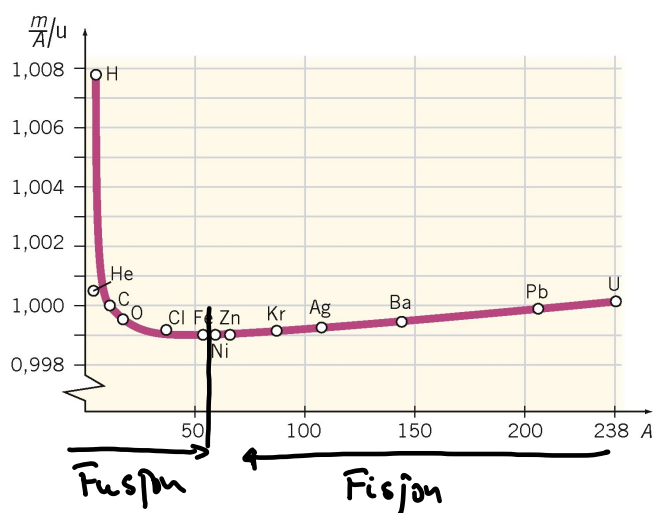
$$\Delta m = 0,00460 \text{ u}$$

$$E = mc^2$$

$$\Delta E = \Delta m c^2 = 6,87 \cdot 10^{-13} \text{ J}$$

Apr 8-2:40 PM

Fusjon og fisjon



Apr 18-1:19 PM

Fusjon

${}^1_1\text{H} + {}^1_1\text{H} \rightarrow {}^2_1\text{H} + e^+ + \nu$
 $p \rightarrow n + e^+ + \nu \quad \beta^+$

${}^2_1\text{H} + {}^1_1\text{H} \rightarrow {}^3_2\text{He} + \gamma$

$2 {}^3_2\text{He} \rightarrow {}^4_2\text{He} + 2 {}^1_1\text{H} + \gamma$

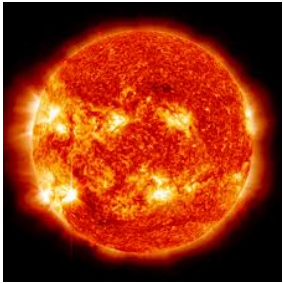
$4 {}^1_1\text{H} \rightarrow {}^4_2\text{He} + \nu + \gamma \quad \Delta m = 4 \times (1,007825 - 1,00065) \text{u}$
 $= 0,02874 \text{u}$
 $= 4,39 \cdot 10^{-29} \text{kg}$

$\frac{m}{A} : \quad {}^1_1\text{H} : 1,007825 \text{u}$
 $\quad \quad {}^4_2\text{He} : 1,00065 \text{u}$

Effekt til sola: $P = 10^{26} \text{W}$

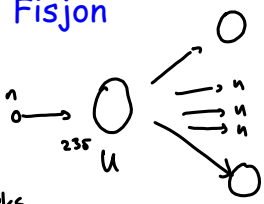
Antall He/s: $\frac{10^{26} \text{J}}{4,3 \cdot 10^{-29} \text{J}} \approx 10^{38} \text{ atomer}$
 $\sim 10^{12} \text{ kg} \sim 10^7 \text{ tonn}$

$\Delta M = 10^{38} \cdot 10^{-29} \text{kg} = 10^9 \text{ kg}$



Apr 19-10:54 AM

Fisjon



$n + {}^{235}_{92}\text{U} \rightarrow {}^{89}_{36}\text{Kr} + {}^{144}_{56}\text{Ba} + 3n$

${}^{235}_{92}\text{U} : 235,0439 \text{u}$
 ${}^{144}_{56}\text{Ba} : 143,92295 \text{u}$
 ${}^{89}_{36}\text{Kr} : 88,91763 \text{u}$
 $3n : 3,01732 \text{u}$

$\left. \begin{array}{l} 143,92295 \\ 88,91763 \\ 3,01732 \end{array} \right\} 234,8577 \text{u}$

$\Delta m = 0,1860 \text{u}$

$E = \Delta m c^2 = 0,1860 \text{u} \times 1,66 \cdot 10^{-27} \frac{\text{kg}}{\text{u}} \times (3,0 \cdot 10^8 \frac{\text{m}}{\text{s}})^2 = 2,8 \cdot 10^{-11} \text{J}$

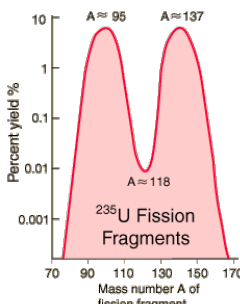
Hvor lenge kunne vi leve på 1g uran (${}^{235}\text{U}$) hvis vi kunne utnytte kjerneenergien?

$1 \text{g } {}^{235}\text{U} : \text{Antall atomer: } N = \frac{1}{235} \frac{\text{g}}{\text{mol}} \cdot 6,02 \cdot 10^{23} = 2,6 \cdot 10^{21}$

$E_{\text{totale}} = E \cdot N = 7,1 \cdot 10^{10} \text{J}$

Daglig forbruk $\approx 10000 \text{ kJ/dag} = 10^7 \text{ J/dag}$

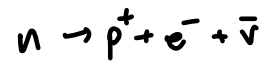
$\frac{7,1 \cdot 10^{10} \text{J}}{10^7 \text{J/dag}} \approx 20 \text{ år}$



Apr 19-10:53 AM

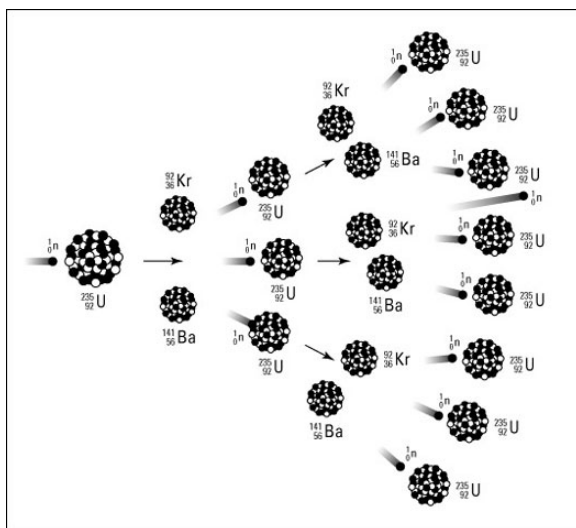
Samsnakk:

Når et uranatom fisjonerer deler det seg i to omtrent like store deler. De to delene er som oftest ustabile (radioaktive) kjerner, og vil spontant henfalle (omdannes). Kommer de til å gjøre det hovedsakelig ved å sende ut e^+ eller e^- ?



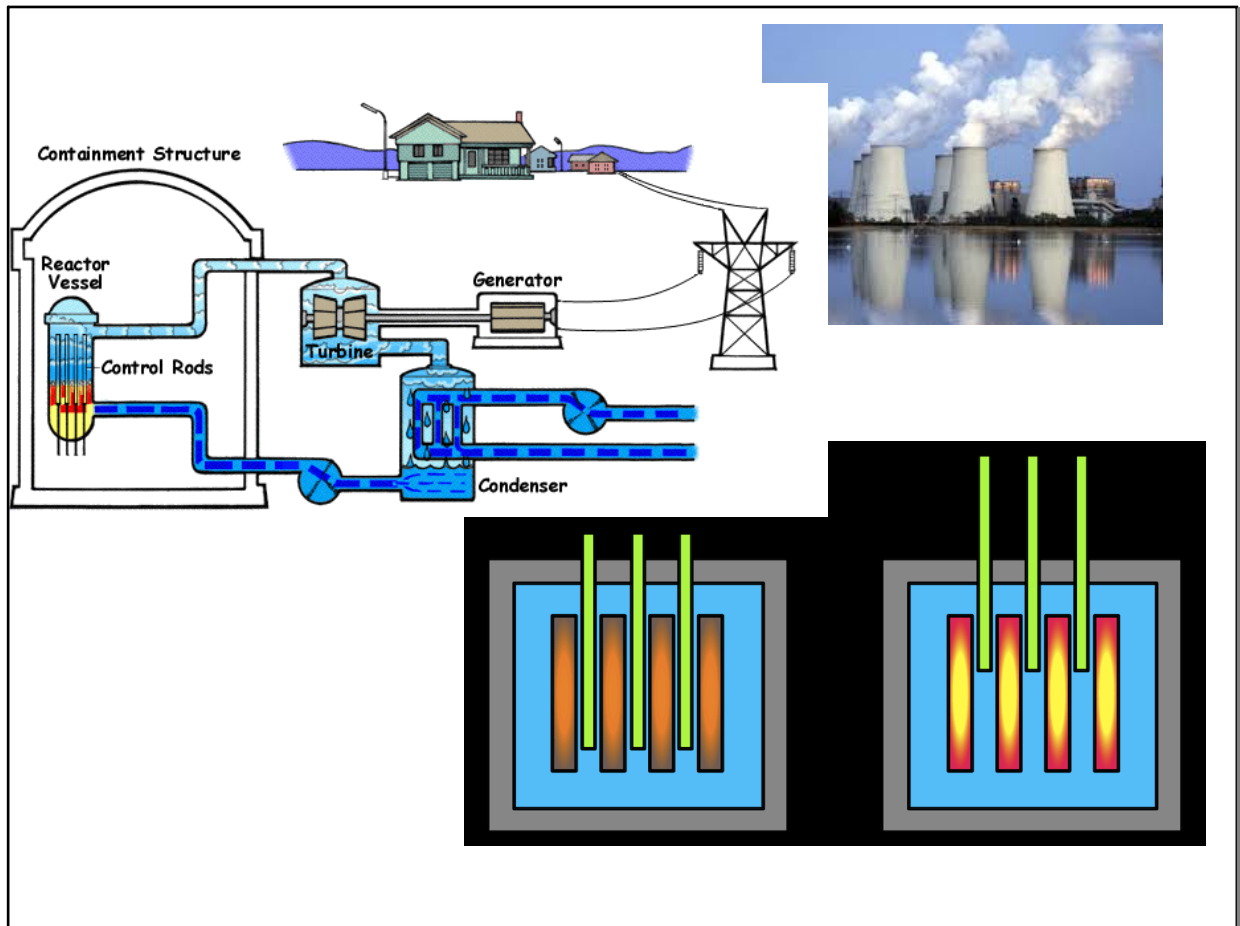
Apr 18-1:53 PM

Kjedereaksjon



Nuclide	Half Life (y)	Critical Mass (kg)	Diameter (cm)
uranium-233	159,200	15	11
uranium-235	704,000,000	52	17
neptunium-236	154,000	7	8.7
neptunium-237	2,144,000	60	18
plutonium-238	87.7	9.04-10.07	9.5-9.9
plutonium-239	24,110	10	9.9
plutonium-240	6561	40	15
plutonium-241	14.3	12	10.5
plutonium-242	375,000	75-100	19-21

Apr 19-10:58 AM



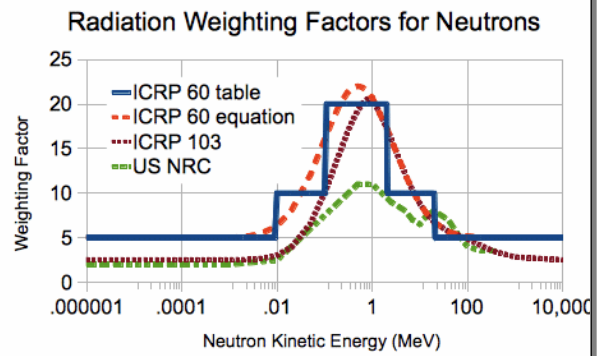
Apr 8-4:02 PM

Biologiske virkninger, stråledose

Apr 19-10:57 AM

Ekvivalent dose, vektfaktor

Røntgen, gamma, elektroner	1
Nøytroner	2-20 (avhengig av energi)
Protoner, ladde pioner	2
α -Partikler, fissionsprodukter, tunge kjerner	20



Apr 19-10:57 AM

RADIATION EFFECTS

Measurements in millisieverts (mSv). Exposure is cumulative.

HIGH RISK

- **Potentially fatal radiation sickness. Much higher risk of cancer later in life.**
- 10,000 mSv:** Fatal within days.
- 5,000 mSv:** Would kill half of those exposed within one month.
- 2,000 mSv:** Acute radiation sickness.

MODERATE RISK

- **No immediate symptoms. Increased risk of serious illness later in life.**
- 1,000 mSv:** 5% higher chance of cancer.
- 400 mSv:** Highest hourly radiation recorded at Fukushima. Four hour exposure would cause radiation sickness.
- 100 mSv:** Level at which higher risk of cancer is first noticeable

TOLERABLE LEVELS

- **No symptoms. No detectable increased risk of cancer.**
- 20 mSv:** Yearly limit for nuclear workers.
- 10 mSv:** Average dose from a full body CT scan
- 9 mSv:** Yearly dose for airline crews.
- 3 mSv:** Single mammogram
- 2 mSv:** Average yearly background radiation dose in UK
- 0.1 mSv:** Single chest x-ray

- EYES** High doses can trigger cataracts months later.
- THYROID** Hormone glands vulnerable to cancer. Radioactive iodine builds up in thyroid. Children most at risk.
- LUNGS** Vulnerable to DNA damage when radioactive material is breathed in.
- STOMACH** Vulnerable if radioactive material is swallowed.
- REPRODUCTIVE ORGANS** High doses can cause sterility.
- SKIN** High doses cause redness and burning.
- BONE MARROW** Produces red and white blood cells. Radiation can lead to leukaemia and other immune system diseases.

Apr 10-10:29 AM

Typiske stråledoser



Kosmisk stråling gir opphav til nordlys

Naturlig bakgrunnstråling: **ca 3 mSv pr år** (globalt snitt)
- stor variasjon **1 - 250 mSv pr år**
 radon (globalt snitt) *utendørs 10 Bq/m³ innendørs 46 Bq/m³ (maxverdier over 80 000)*

Tsjernobylnedfall **0,040 mSv pr år**
Flyreiser (Oslo-New York t/r) ca **0,1 mSv**
Flytte fra trehus til murhus + 0,4 mSv pr år



0,007 mSv pr time

Tannlegerøntgen **0,030 mSv pr bilde**
CT -røntgen **1-20 mSv pr bilde**
Strålebehandling (kreft) **2000 – 80 000 mSv pr behandling**



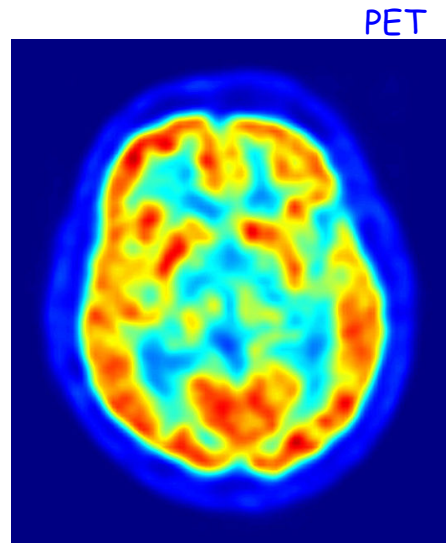
15

apr 20-09:05

En person på 70 kg spiser 200 g reinsdyrkjøtt som inneholder Cs-137. Aktiviteten når kjøttet spises er 10000 Bq/kg. Cs-137 sender ut β -partikler og γ -stråling
 Anta at den samlede absorberte energien i kroppen fra hver desintegrasjon er $3,2 \cdot 10^{-14}$ J og at den absorberte energien fordeler seg jevnt i kroppen.
 Hva er stråledosen (Gy) i løpet av 90 dager? Hva er den ekvivalente dosen (dvs i Sv) i samme tidsrom?
 Halveringstida for Cs-137 er 30 år.

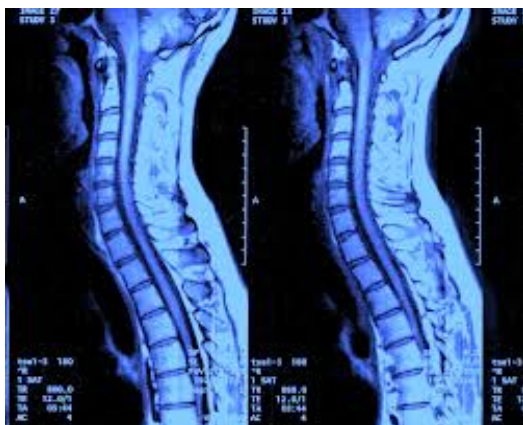
Apr 19-1:28 PM

Kjernemedisin

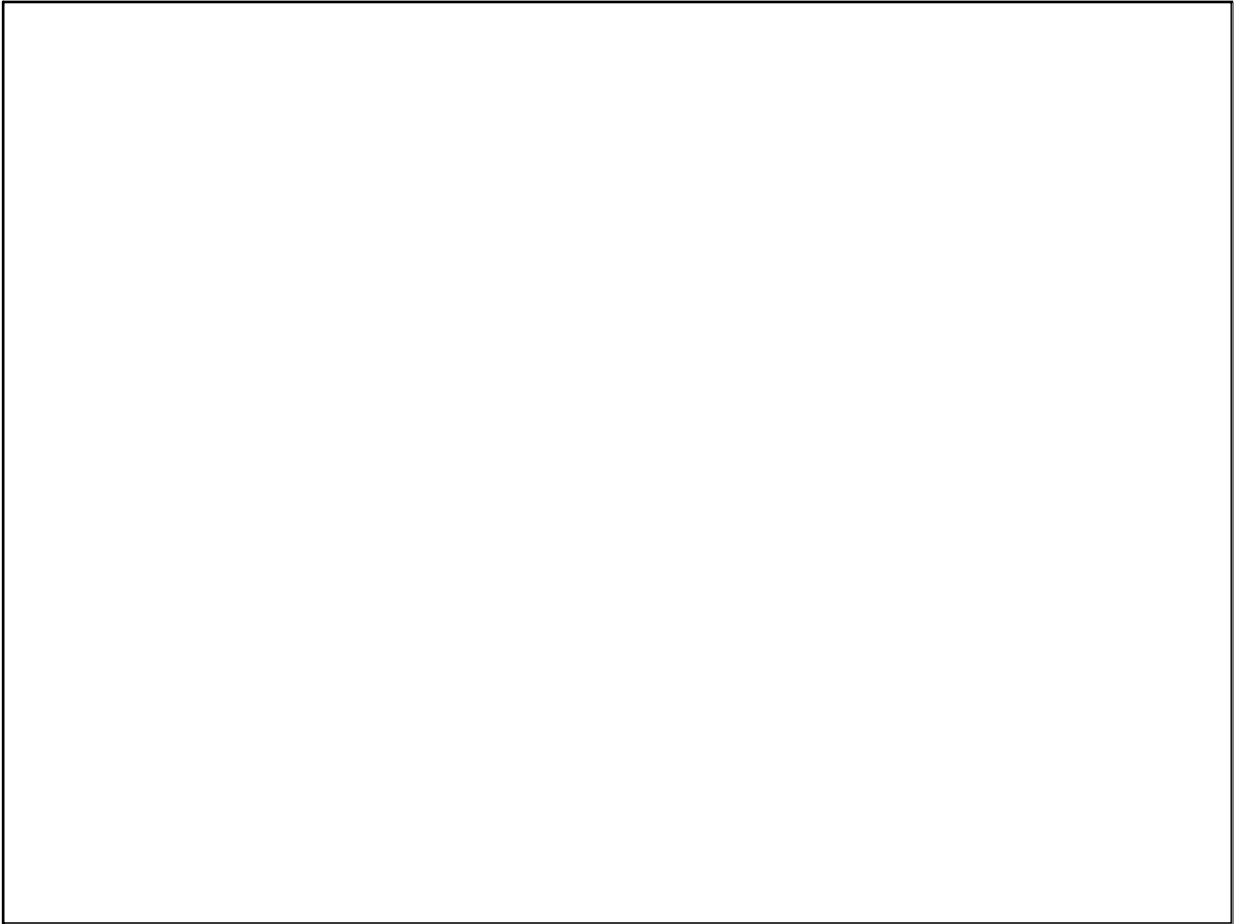


Apr 19-1:46 PM

Magnetic resonance imaging (MRI)



Apr 19-1:53 PM



Apr 4-2:02 PM