1 The Math

Okay, so here goes. We're trying to figure out some of the reactor design behind the DeLorean. First off, efficiencies. Brown needs 1.21GWe, so he actually needs

$$\frac{1.21\text{GWe}}{0.3\eta} = 4\text{GWth}$$

thermal. At 200MeV per fission, that's

$$4\text{GWth} \cdot \frac{1\text{MeV}}{1.602 \times 10^{-13}\text{MJ}} = 25.18 \times 10^{21}\text{fissions} \cdot \frac{1\text{fission}}{200\text{MeV}} = 125.88 \times 10^{18}\text{fissions}$$

Photogrammetric analysis gives us 6 seconds to fire up the flux capacitor and go, so 20.98×10^{18} fissions per second. In plutonium, that's

$$125.88 \times 10^{18}\text{fissions} \cdot \frac{239.0521634\text{g}}{N_A} = 49.968 \times 10^{-3}\text{g} = 50\text{mg}$$

of the good stuff. Back to the source document, analysis of the vial containing the plutonium shows dimensions of 150mm high and 18.6mm in diameter, using Dr. Brown's eye as a per-pixel calibration. The case is mostly empty, but there are still six full vials, which is three-tenths of a gram of plutonium. The doc is an amazing nuclear engineer. That said, if we calculate the volume of the vial as 0.0013824L, we can get that the concentration of 49 in the vials is

$$\frac{50 \times 10^{-3}\text{g}}{0.0013824\text{L}} = 36\text{g} \cdot \text{L}^{-1} \gg 10 \times 10^{-3}\text{g} \cdot \text{L}^{-1}(\text{LD50})$$

, so incredibly harmful if swallowed.

TODO:calculate exposure from vial, it's probably not much

But what we really want to know is, if the DeLorean has a reactor making 4GWth in six seconds from cold, is it even possible that Marty, Doc, or even Einstein survived their trip without radiation poisoning? Ignoring the KE of the α and fission products, we get 5.9MeV of KE per neutron, and 7.8MeV of γ per Pu fission.

For the gamma, we can get

$$142.03 \times 10^{18}\text{fissions} \cdot \frac{7.8\text{MeV}}{1\text{fission}} \cdot \frac{1.603 \times 10^{-13}\text{MJ}}{1\text{MeV}} = \frac{177.47\text{MJ}\gamma}{6\text{seconds}} = 29.58\text{MW}_\gamma$$

In neutrons, that's

$$142.03 \times 10^{18}\text{fissions} \cdot \frac{2.44\text{neutrons}}{1\text{fission}} \frac{5.9\text{MeV}}{1\text{neutron}} \cdot \frac{1.603 \times 10^{-13}\text{MJ}}{1\text{MeV}} = \frac{134.24\text{MJ}\gamma}{6\text{seconds}} = 22.37\text{MW}_n$$

But not all of that reaches the driver's seat. Further image analysis gives us that Marty McFly is sitting 43" or 1.092 meters from the core. We can also find from the earlier scene that the core is surrounded by 58mm or 2.28 inches of what we can assume is lead shielding. Michael J Fox is 5'4", 75kg, so analysis gives his upper body a surface area of 0.2652m2, and a mass absorbing the energy of 49.96kg. Here's where it gets weird. For the neutrons, is it fair to take the half-value thickness of Pb as 6.8cm and calculate

$$22.37\text{MW} \cdot \frac{0.2652\text{m}^2}{14.74\text{m}^2} \cdot \frac{5.8}{6.8} = 0.343\text{MW} = 343\text{kW}$$

and then, with a quality factor ten, get

$$10 \cdot \frac{343\text{kW}}{6\text{s}} \cdot \frac{1\text{MMF}}{50\text{kg}} = 1.9\text{Gys}^{-1} = 11.44\text{Gy}$$

? If so, Marty is a very sick boy. Am I on the right tra[redacted]