

SAFETY OF TSA'S FULL BODY SCANNERS

Starting in November of 2010 the Transportation Safety Administration(TSA)has begun using full body scans of all airline passengers using either backscatter x-ray methods or high frequency millimeter electromagnetic wave which penetrate a subjects clothing and reveal full body nude images. Since the TSA failed to adequately prepare the public for this new type of aggressive inspection of all flyers including woman and children, a large number of complaints ranging from a violation of decency laws and violation of the fourth amendment concerning unreasonable searches to the safety of the new scanning machines have appeared in the news and especially on the internet.

I want here to address just the last of these concerns, namely that of safety aspects of full body scanners. To discuss the technical aspects one needs just two basic formulas. These are -

$$\lambda \nu = c \quad \text{and} \quad E = h \nu$$

Here λ is the wavelength of the radiation being used, ν the frequency expressed in Hz, $c=3 \times 10^8$ m/s the speed of light , E the energy of the individual photons, and $h=6.626 \times 10^{-34}$ J-s is Plank's constant. If one wishes to express the energy in terms of electron-volts the conversion -

$$1eV = 1.602 \times 10^{-19} J$$

should be used.

Let's begin with the EHF electromagnetic scanners. These operate in the frequency range of 30 to 300 gigaHz and hence have the wavelength range $1\text{mm} < \lambda < 10\text{mm}$. The largest energy level reached by individual em photons will thus be just-

$$E = \frac{hc}{\lambda} = \frac{6.626 \times 10^{-34} \times 3 \times 10^8}{1.602 \times 10^{-19} \times 10^{-3}} = 1.24 \times 10^{-4} eV$$

This energy is small compared to typical atomic and molecular binding energy (Hydrogen has an ionization potential of 13.6 eV). Thus the EHF machines pose no immediate ionization health threats although prolonged exposure will cause atomic vibrations of body cells which will produce heating just as occurs in microwave cookers. I remember years ago , while a student trainee at the old National Bureau of Standards in Washington DC, that we used 2450 megahertz diathermy units (

$\lambda=12.2\text{cm}$) to excite gases at low pressure causing them to glow. I always made it a point during these experiments to insulate the waveguides used with wire mesh to avoid longer term exposure to these microwaves. The contact time for the airport machines is typically less than one minute and the heating problem should therefore be minimal.

Next let us look at the backscatter x-ray machines. Here high speed electrons driven by a voltage difference of some 40kV collide with a tungsten target located within a vacuum tube. These collisions produces a continuous spectrum of x-rays with an intensity curve peaking typically in the wavelength range $0.2\text{\AA}<\lambda<0.8\text{\AA}$. Here A stands for Angstroms with $1\text{\AA}=10^{-10}$ m. If we now consider a soft x-ray with a wavelength of 10\AA , it will still carry a photon energy of-

$$E = \frac{hc}{\lambda} = \frac{6.626 \times 10^{-34} \times 3 \times 10^8}{1.602 \times 10^{-19} \times 10^{-9}} = 1.24 \times 10^3 \text{ eV}$$

This is a large number, orders of magnitude above the requirements for atomic ionization. A direct hit of larger molecules within the human body can easily rip them apart and cause DNA damage just like a dental x-ray does. Exposure time to such radiation should be kept to an absolute minimum. In the 1930s, before people became aware of the harmful effects of x-rays, it was common practice to x-ray ones feet while wearing a new set of shoes to see how they fit. The TSA's claim that the backscatter x-ray machines are safe and are no more hazardous than flying for two minutes at 30,000 feet should be looked at with great deal of skepticism. They are comparing apples and oranges. In a plane one is partially shielded by a metal fuselage and the sun, in addition, emits most of its radiation in the visible and near infrared regions. Of particular worry for frequent flyers is that the x-rays in the backscatter machines will penetrate at least several millimeters of skin especially in those regions not covered by clothing. Of particular concern to me is what happens to the corneas of individuals subjected to frequent exposures to this ionizing radiation. Clearly cataract formation is a possible consequence. Some eye protection such as wearing opaque goggles or shielding by ones arms should be introduced.

My overall conclusion is that one should reduce ones flying frequency as much as possible until the TSA organization improves its screening procedures. If one must fly because of business, then ask to [go through the electromagnetic scanners and avoid the x-ray backscatter machines](#). The European approach to airport security seems to be far superior to the reactive approach TSA has taken against terror threats. There is no need to consider children and elderly or frequent flyers with round trip tickets as potential terrorists.