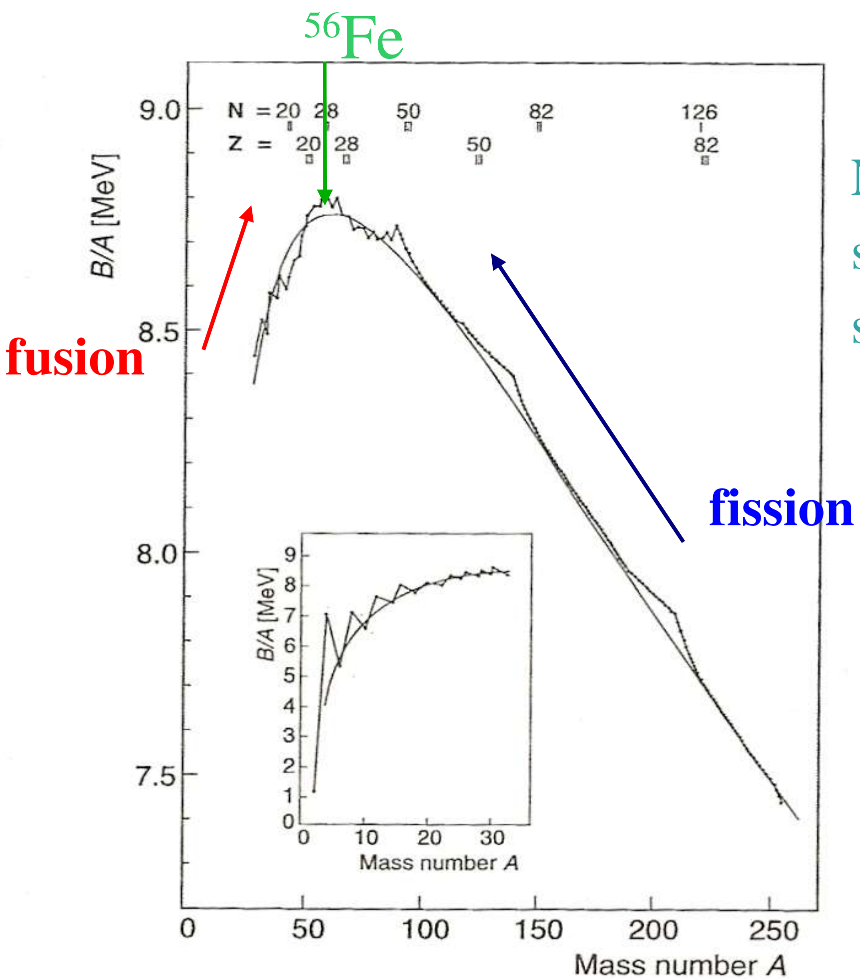
Nuclear crisis in Japan

Duncan College Panel on the Japanese Earthquake and the aftermath

Marj Corcoran April 13, 2011

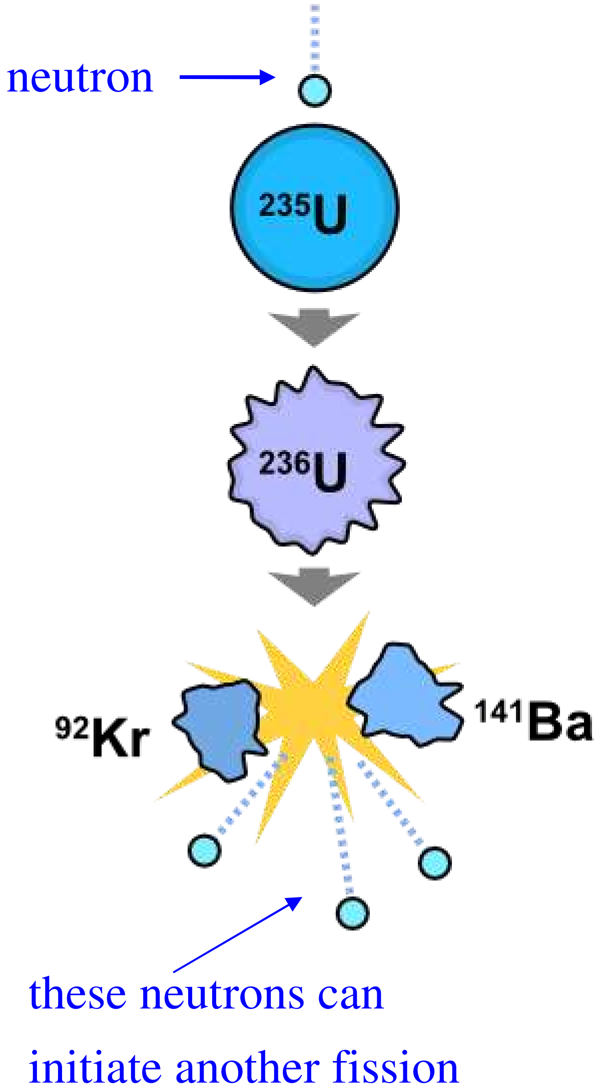
How does nuclear fission produce energy?



Nuclear fission occurs when large nuclei break into smaller ones. It produces energy because the smaller nuclei are more strongly bound

Binding energy per nucleon vs atomic number

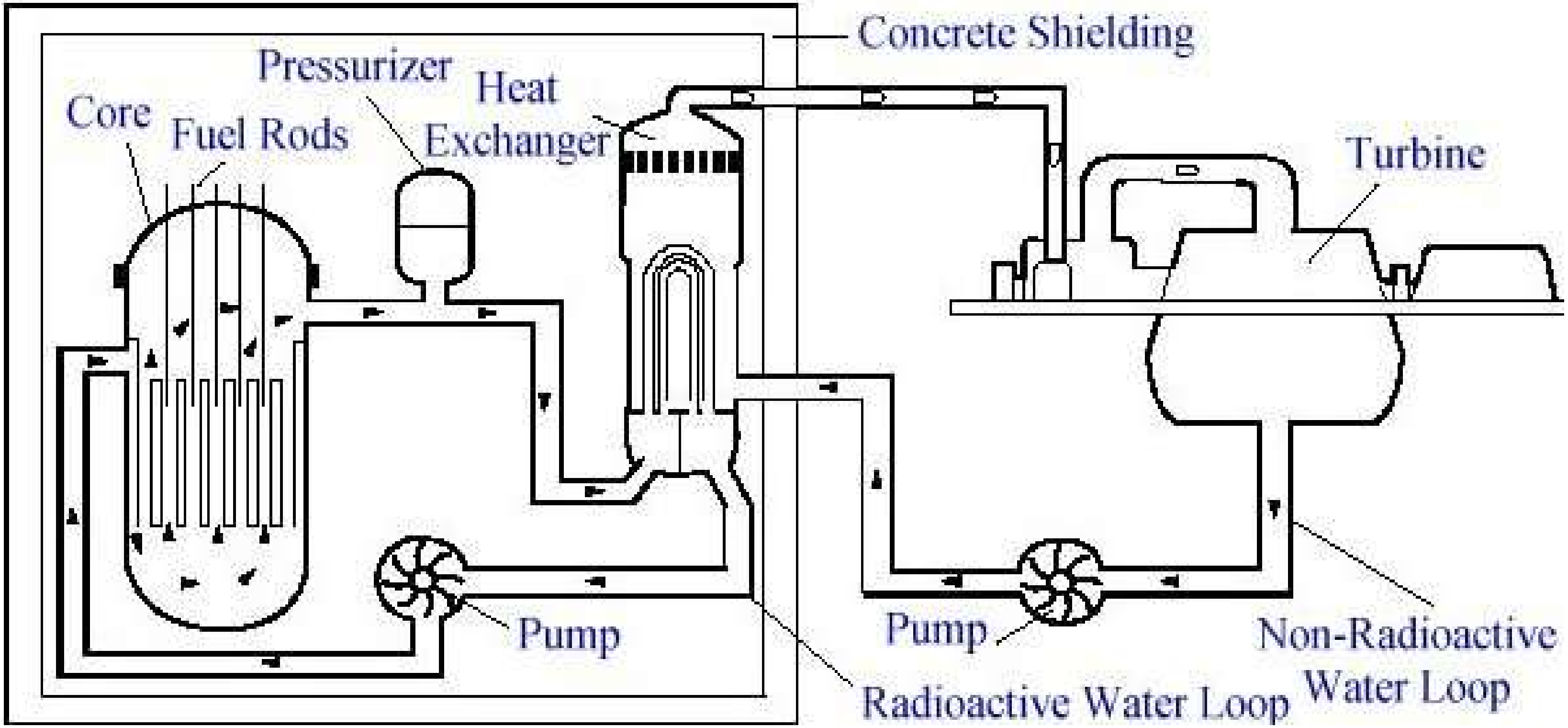
Fission reactions



Only a few nuclei, such as ^{235}U, can sustain a fission chain reaction. ^{235}U makes up 0.7% of naturally-occurring uranium.

235= number of protons + neutrons

Fission products that are often monitored are ^{131}I and ^{137}Cs, because these isotopes do not occur naturally. ^{131}I has a half-life of 8 days; ^{137}Cs has a half-life of 30 years.



Most reactors use uranium enriched in ^{235}U, enriched to about 3%.

Timeline

March 11, Earthquake hits, tsunami follows

Three of the six reactors at Fukushimi Dai-ichi were already shut down for maintenance.

The other three shut down automatically when the earthquake occurred. Cooling continued with emergency generators.

The tsunami knocked out the emergency generators and the reactors began to overheat.

The pool containing the spent fuel rods also lost cooling and overheated. The zirconium cladding on the fuel rods heated up and oxidized, producing H_2 gas, which then exploded.

To reduce pressure in the reactors, some radioactive steam was released into the atmosphere. Sea water was used to cool the reactors.

Some of the runoff from the cooling has leaked into the Pacific, and some radioactive water was deliberately released into the ocean to make room to store more highly radioactive water.

April 12, the severity of the accident was re-evaluated to be 7 rather than 5 (on a scale of 1-7).

The amount of radiation released is estimated to be 10% of that released at Chernobyl (1986)

Units

Curies or Becquerel measure the number of decays/sec.

Rad (radiation absorbed dose) or Grays measure the amount of energy absorbed in Joules/kg.

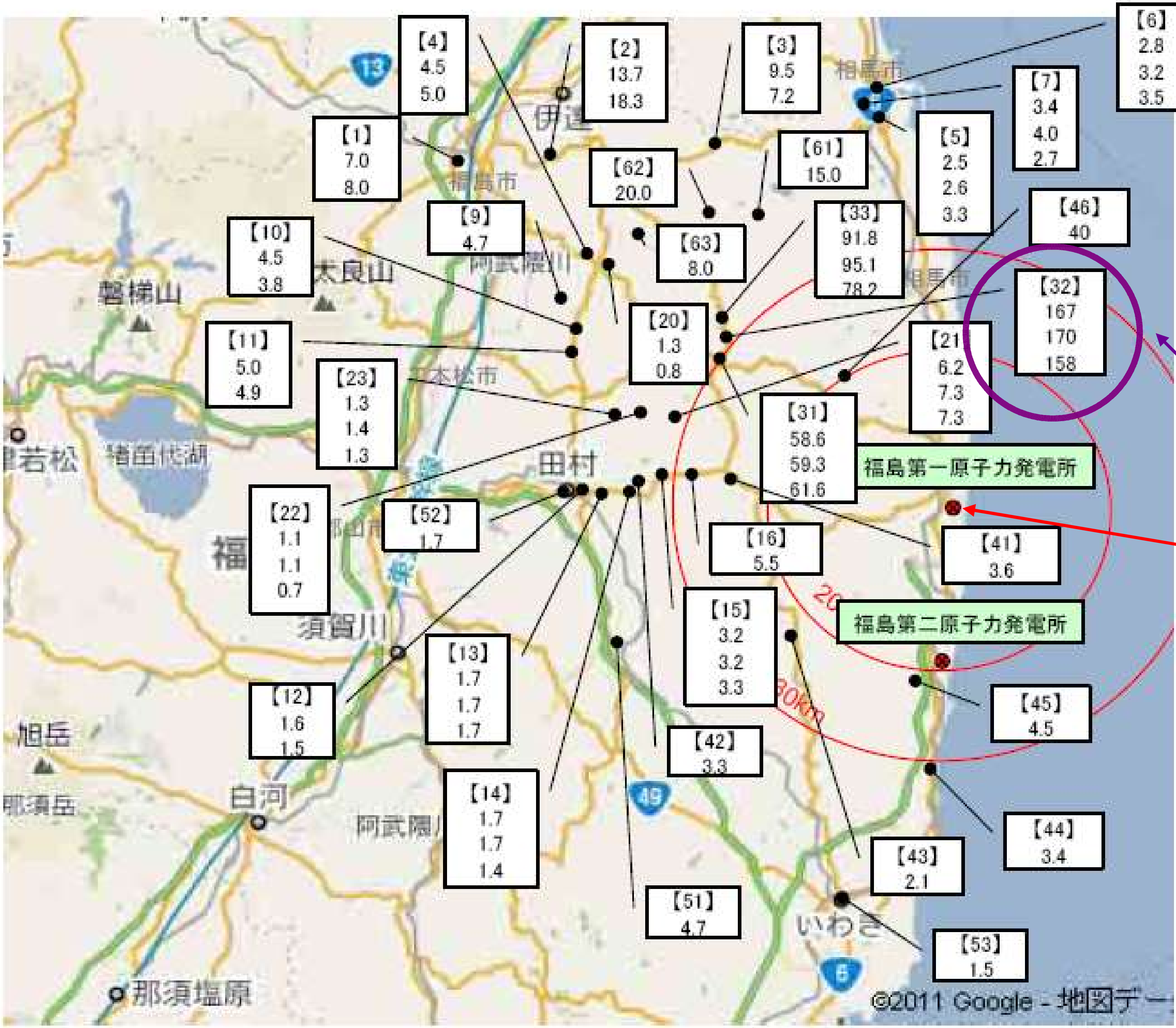
Rem or Sieverts make a correction for the biological effectiveness of different types of radiation.

For example, neutrons are much more damaging to tissue than x-rays.

1Rem=10mSv (m=milli or 1/1000)

In one year we are receive a dose of about 300mrem=3mSv from natural sources.

Readings at Monitoring Post out of Fukushima Dai-ichi NPP



Monitoring Time
March 17,
9:20~17:43

● Monitoring Post

hot spot
17mrem/hr

damaged reactors

google MEXT to get these data.

Unit : μ Sv per hour

Readings of Integrated Dose at Monitoring Post out of Fukushima Dai-ich

total dose about 3x this

Monitoring Time

- March 23th～April 4th (Monitoring Post: 7、31～34、79)
- March 23th～28th、April 3rd～4th (Monitoring Post: 71)

integrated dose =1rem

- March 25th～April 1st、April 3rd～4th (Monitoring Post: 84)
- March 31th～April 1st、April 3rd～4th (Monitoring Post: 38)
- April 1st～April 4th (Monitoring Post: 39)
- April 2nd～April 4th (Monitoring Post: 76)
- April 3th～April 4th (Monitoring Post: 80)

● Monitoring Post

(explanatory note)

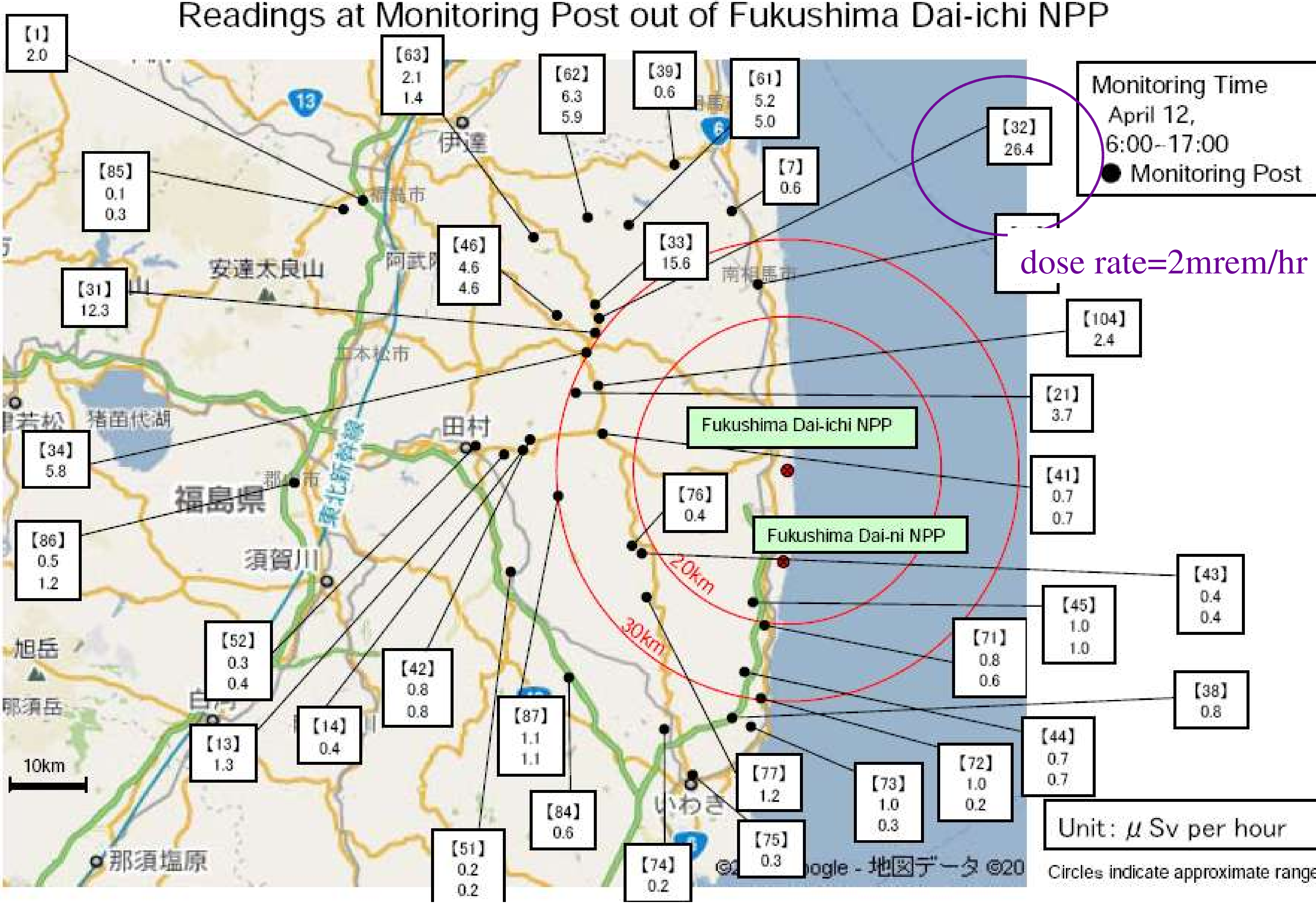
【Monitoring Post number】
Readings of Integrated Dose ※
<increment from the last monitoring>
(average dose per hour)

Readings of Integrated Dose indicate that accumulation of dose from each starting date till April 2nd, for 1 day to 10days.

Unit: μSv per hour

For comparison, the yearly allowed dose at Fermilab is 1.5 rem

Readings at Monitoring Post out of Fukushima Dai-ichi NPP



Is this level of radioactivity a danger?

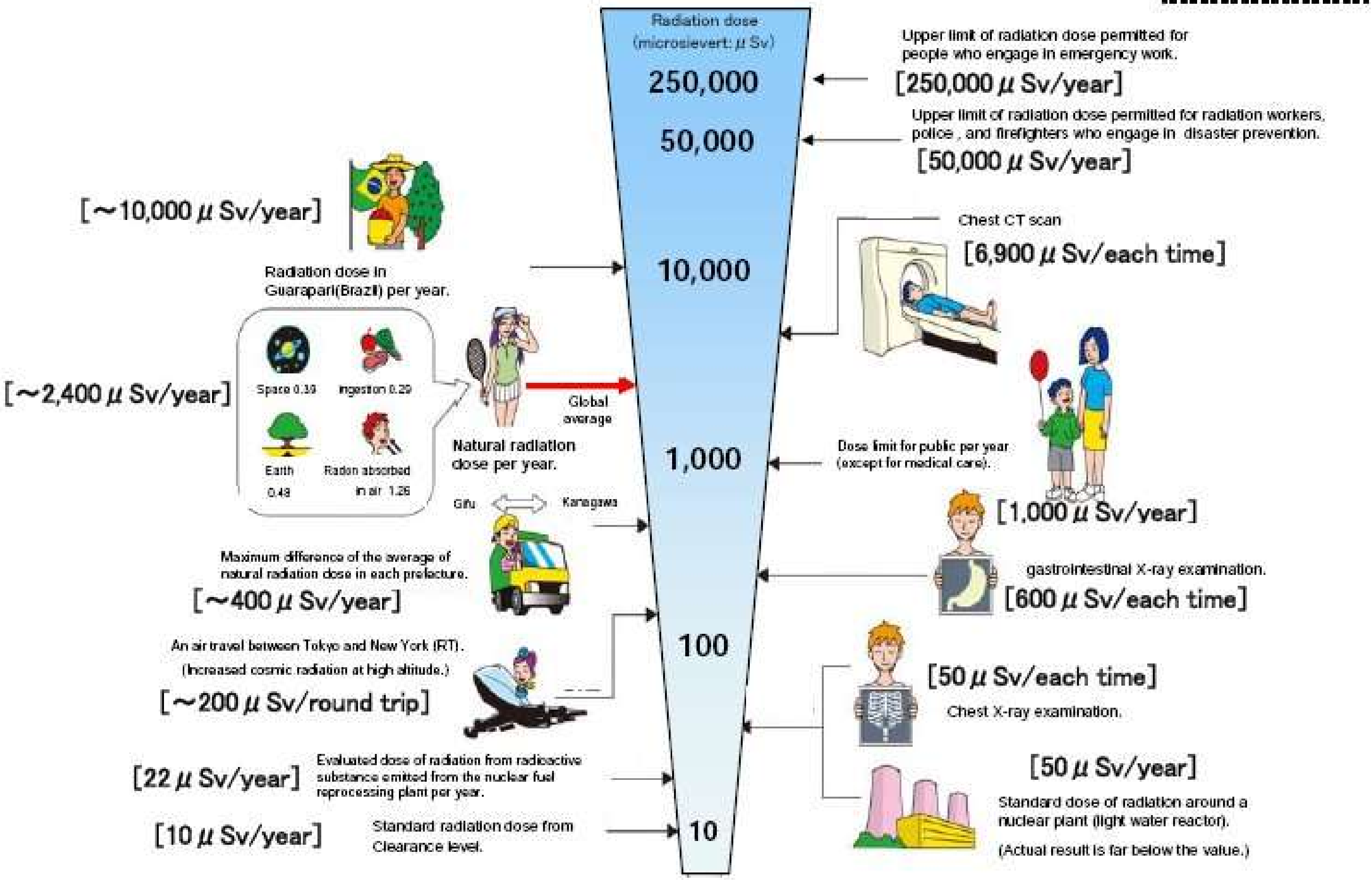
People close to but outside the evacuation region may have received an integrated dose as high as 30mSv=3rem. This is nowhere close to what will cause radiation sickness (1000mSv). But it is 10x the naturally occurring yearly dose.

Radiation exposure can induce cancers 20-30 years later. How many? For a 100mSv exposure over a short amount of time, 1% of the people will eventually develop cancer. Hard to tell what happens with smaller doses, and very hard to measure.

The trace levels of radioactivity seen in the US are no danger and well below naturally occurring radioactivity.

Radiation in Daily-life

※Unit : μ Sv



Conclusions

No one in the general public in Japan is being exposed to levels of radiation that any where near what could lead to acute radiation sickness.

But the integrated dose over a few months in some places is significantly larger than what a worker at (say) a lab like Fermilab or CERN would be exposed to in a year.

In some areas the integrated doses are large enough to induce cancers at some rate (less than 1%) 20 or 30 years from now.

The levels of radiation in the US do not pose a threat of any kind.