The significance of Xenon isotope ratios in the Fukushima catastrophe

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5th November 2011

Recently, measurements were reported for Xenon and other radionuclides in the environment of the Fukushima reactors. A copy of the handout of TEPCO press conference is available here:
http://www.tepco.co.jp/nu/fukushima-np/images/handouts_111102_01-j.pdf

It shows:

Kr-85 4.4 x 10E-1 Bq/cm3
Xe-131m 6.9 x 10E-4 Bq/cm3
Xe-133 1.4 x 10E-5 Bq/cm3
Xe-135 1.2 x 10E-5 Bq/cm3

Because nuclear fission processes create a range of radioactive products and because these nuclides have different half lives, it is possible to employ ratios of certain nuclides to show whether fission is occurring and also whether the fission is from a relatively slow controlled process or from an explosive criticality (a bomb or nuclear explosion) where the production rates are much higher. The method was employed recently to show that the Chernobyl reactor accident was caused by a nuclear explosion and not a hydrogen explosion. There is no doubt about this, the Xenon isotope ratios measured in St Petersburg shortly after the plume arrived there made it clear that there was a nuclear explosion.
Similar questions arise in the case of the Fukushima explosions, especially that in Reactor 3, and I have already explained elsewhere that I believe that a prompt criticality may have been involved there.

Here I will briefly look at the recent TEPCO figures. The ratio here of Xenon 135 to Xenon 133 can be employed. Details of these nuclides and their half lives are given in Table 1

Table 1 Xenon isotopes measured in Reactor 2 reported by TEPCO at the end of October

Nuclide	**Half Life**	**Measured activity/ cc**	**Main gamma line keV**
Xe 135	9.2h	1.2E-5	249
Xe 133	5.27d	1.4E-5	81
Xe 131m	11.8d	6.9E-4	164

Details of the activities of Xenon isotopes after their creation are given in Fig 1 where the ratios may easily be obtained. The graph in Fig 1 is obtained by plotting activity on the basis of decay half lives and was developed to show that it was possible to distinguish nuclear explosions from reactor releases.

Fig 1 The activity ratios Xe 135/Xe133 for different scenarios (From Zhang H http://belfercenter.ksg.harvard.edu/files/NKSampling_INMM07_Hui.pdf)

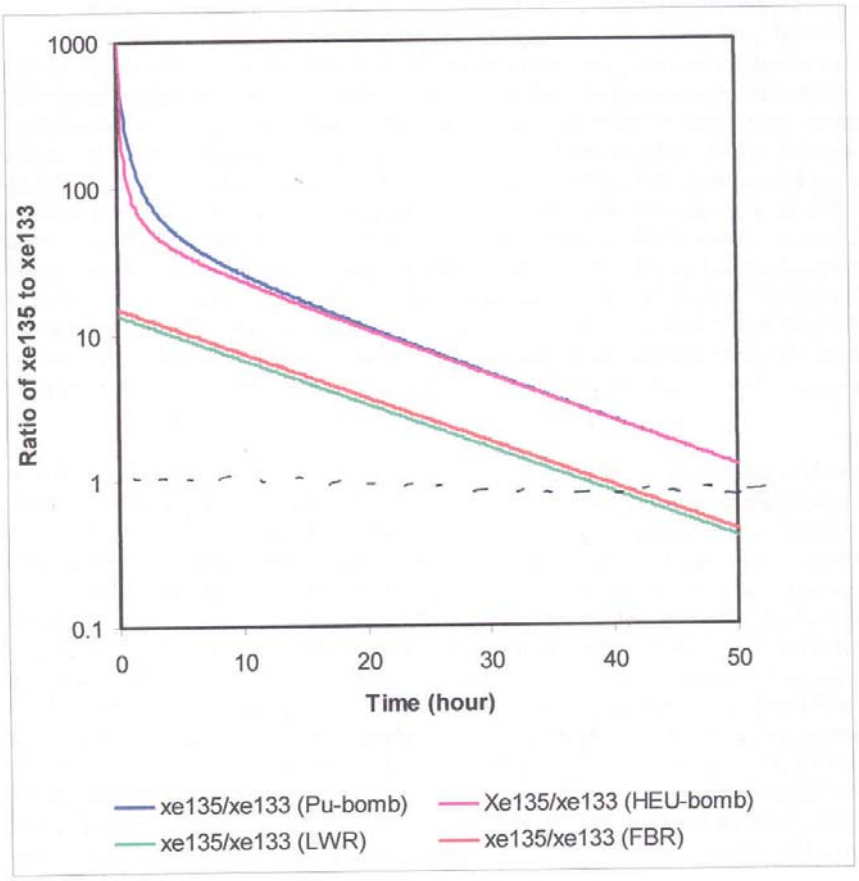

Fig.3: The activity ratio of xe-135 to xe- 133 for four cases: pu-bomb, HEU-bomb, LWR, and FBR

Conclusions

It is clear from Table1 that Xenon isotopes are fairly easy to measure using gamma spectrometry as they each have significant gamma lines.

The activity ratio of 0.85 reported by TEPCO can only result from an enriched Uranium fission having occurred about 50 hours before the samples were measured. or an explosive criticality which occurred 60 hours before the measurements. What these results confirm is that there is on-going fission occurring at the site.

The identification of prompt criticality is straightforward in samples obtained or measured within a few hours of the event.

In view of the importance of establishing the nature of the initial explosions it would be of great interest to obtain from TEPCO or any one the Xenon isotope ratios measured immediately after the catastrophe.