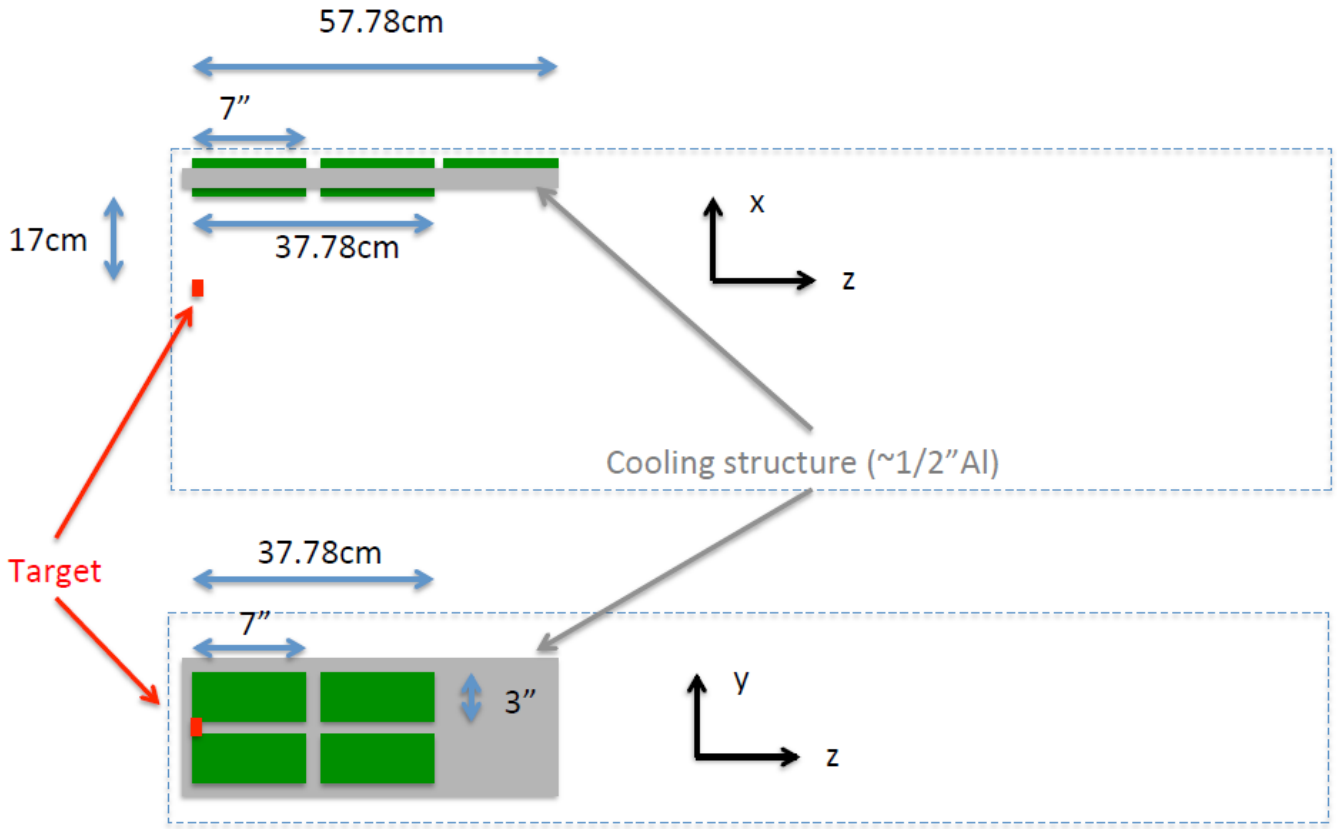
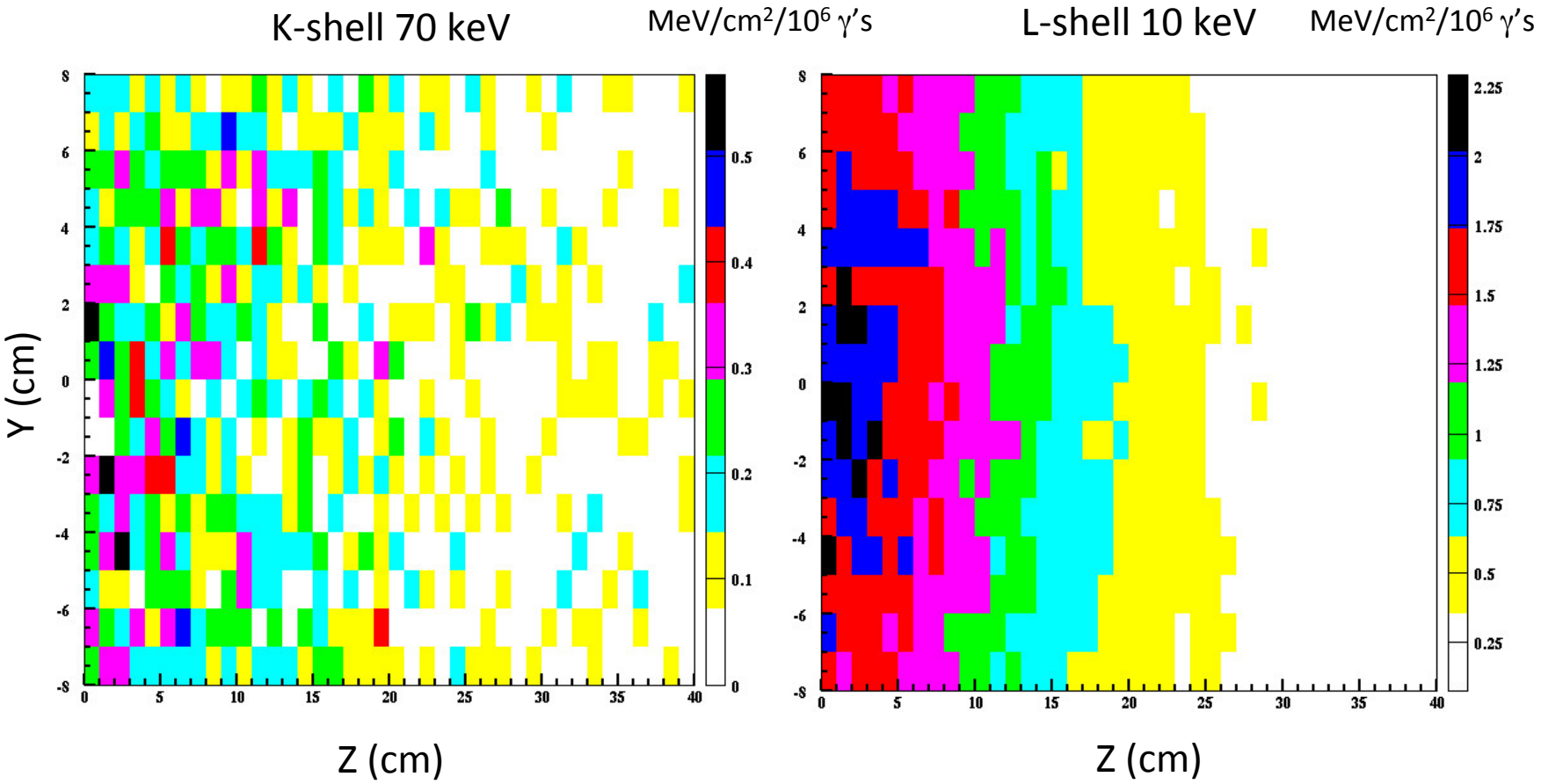
X-ray dose at FPGA

FE board positions



Energy deposition map

10^6 γ's are uniformly distributed over 4π from the target.



Dose in FPGA

	Flux/sec at target	Energy deposition from 10^6 X-rays	Dose/hour	Dose/month (100% duty cycle)
K-shell	5.3×10^9 in 4π	0.5 MeV/ $1^{cm}\times1^{cm}\times700^{\mu m}$	0.9 rad	648 rad
L-shell	8.3×10^9 in 4π	2.25 MeV/ $1^{cm}\times1^{cm}\times100^{\mu m}$	45 rad	32krad
M-shell	2.8×10^9 in 2π	1.1 MeV/$1^{cm}\times1^{cm}\times2^{\mu m}$	800 rad	576krad

Require dose <10k/year:

⇒ K-shell is ok

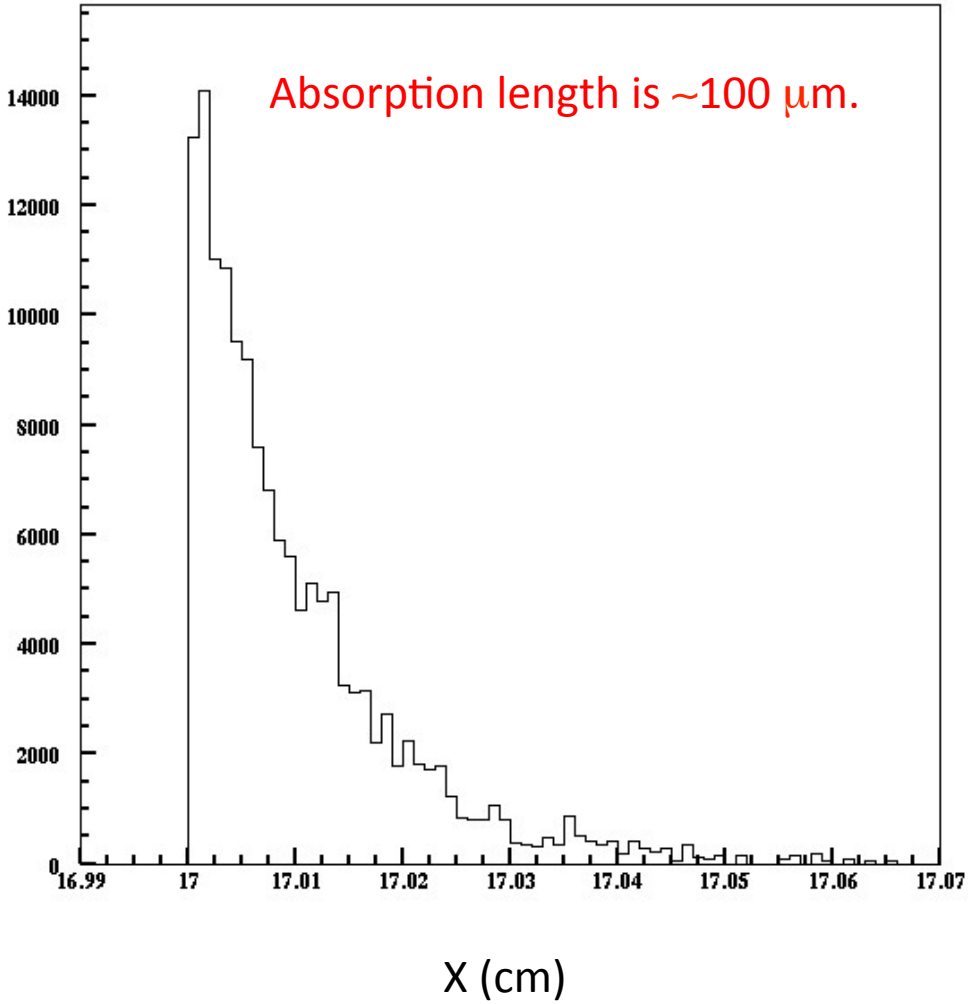
⇒ L-shell and M-shell need to be thought about.

⇒ Shielded from any Cu layer in board

⇒ Components on surface?

Energy deposition in depth

L-shell 10 keV



Silicon:
70 keV distributes energy ~uniformly in the FE board Si (and Al).
12keV will deposit 95% of the dose in first 300um of Si.
The 2keV is stopped by a few microns of Si (mu=1.54um, 99.5% in 7.7um)

Any copper layer in board will shield:
2keV (0.52um): 99.5% in 2um
10keV (5.2um): 99.5% in 25.8um
70keV (947um): 99.5% in 4.7mm

Example of shielding with a heavier element (tungsten):
2keV (0.13um): 99.5% in 0.66um
10keV (5.3um): 99.5% in 26.8um
70keV (46.3um): 99.5% in 46.3um