Summary of Activation Results

Hesham Y. Khater
Fusion Technology Institute
University of Wisconsin-Madison

NSO ENGINEERING STUDIES MEETING
May 31 – June 1, 2000
PPPL

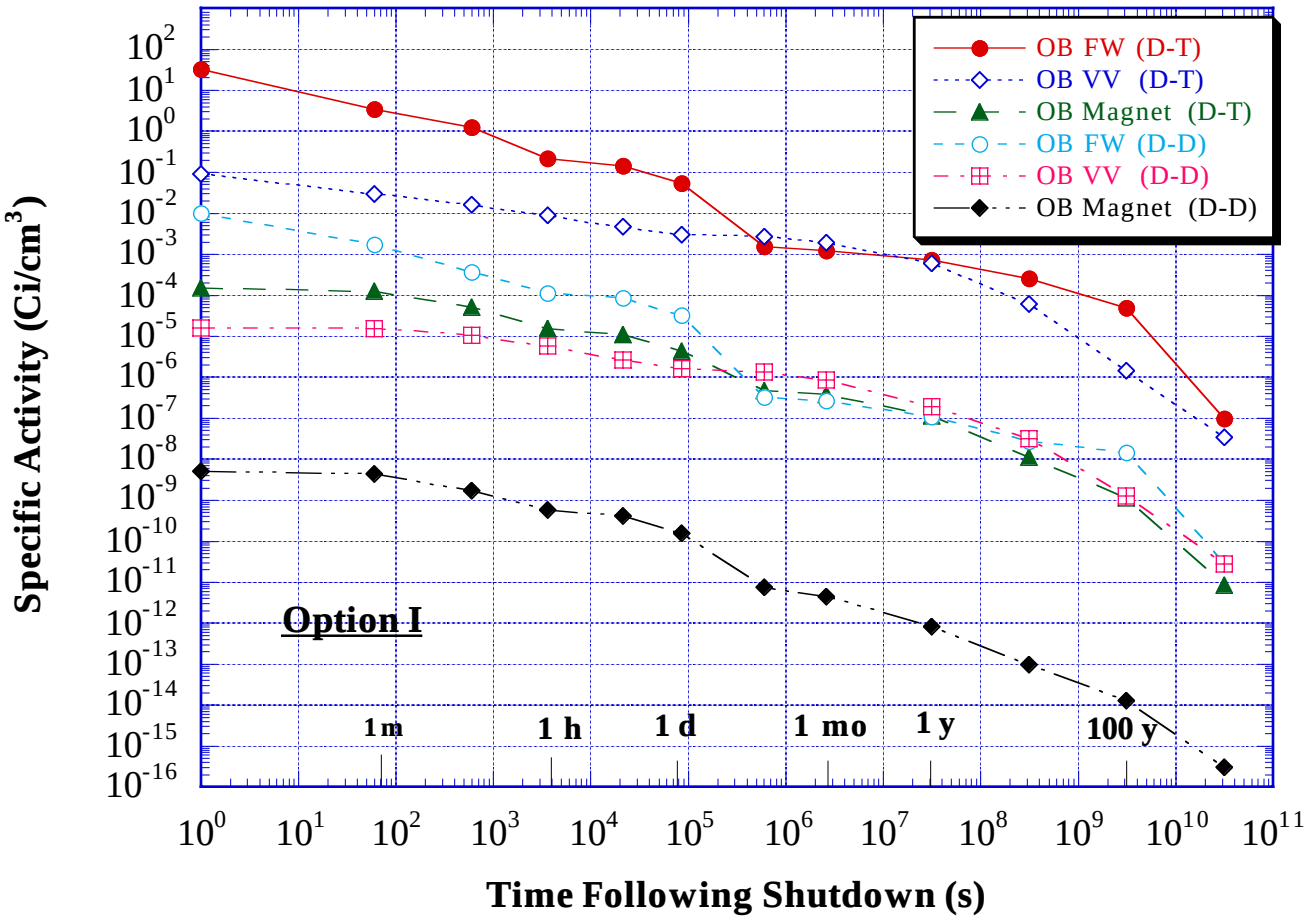
General Machine Features

University of Wisconsin

- Activation analyses are performed for the following two FW/tiles options:
  - Option 1 with passive cooling
  - Option 2 with active water cooling
- Calculations are performed for D-T pulses with 200 MW of fusion power
- An average neutron wall loading of 3 MW/m^2
- Divertor analysis assumed a peak neutron wall loading of 1.8 MW/m^2
- Four pulses per day for one FPY
- Total of 1250 pulses with a pulse burn of 20 seconds each and 3 hours between pulses
- Calculations are also performed for D-D pulses with 1 MW of fusion power
- Specific activity and decay heat values are calculated as a function of time following shutdown
- WDR for Class C waste are calculated using the 10CFR61 and Fetter waste disposal limits
- Biological dose rates were calculated at different locations following shutdown

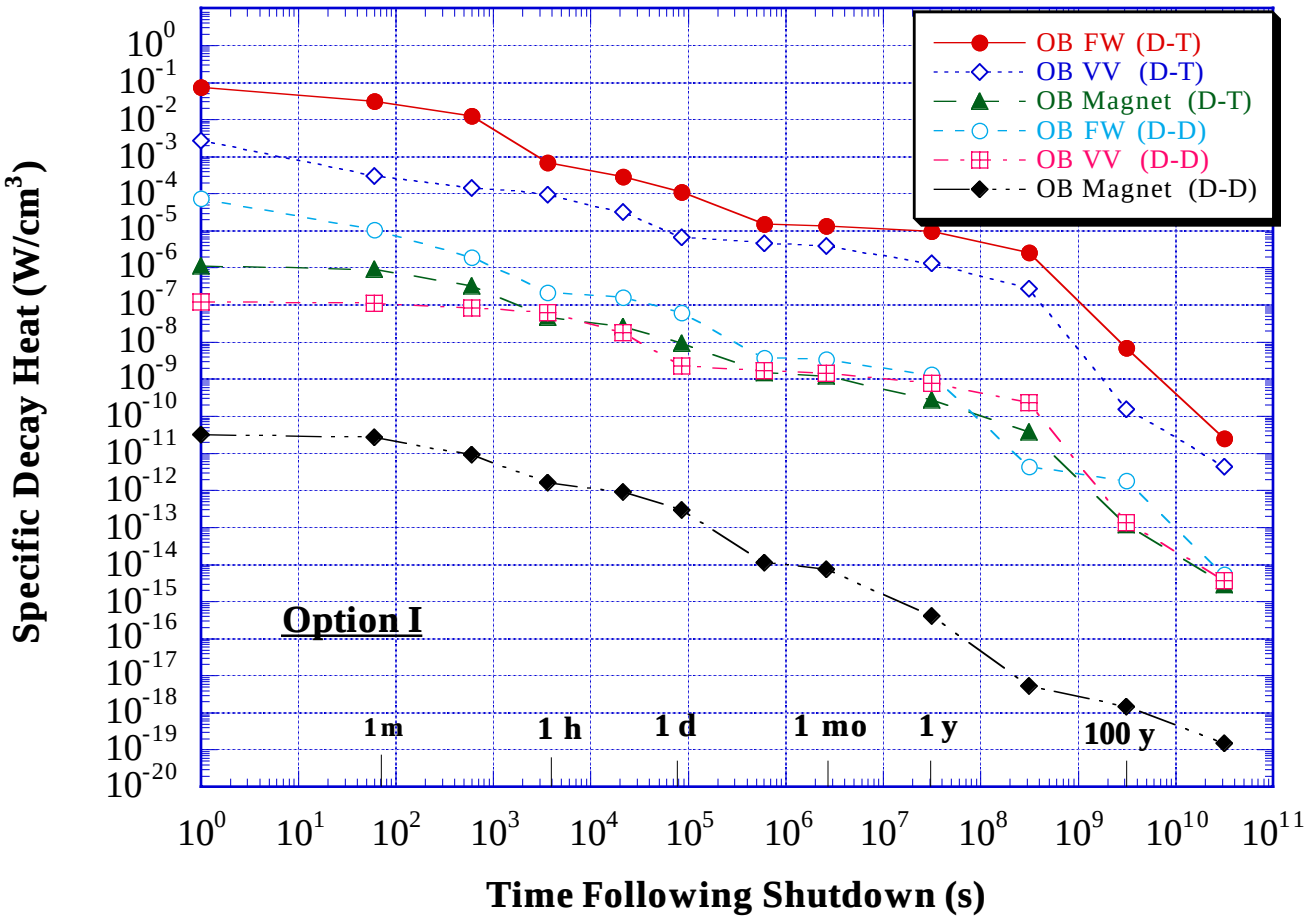
Activity Induced in the Outboard Side

University of Wisconsin



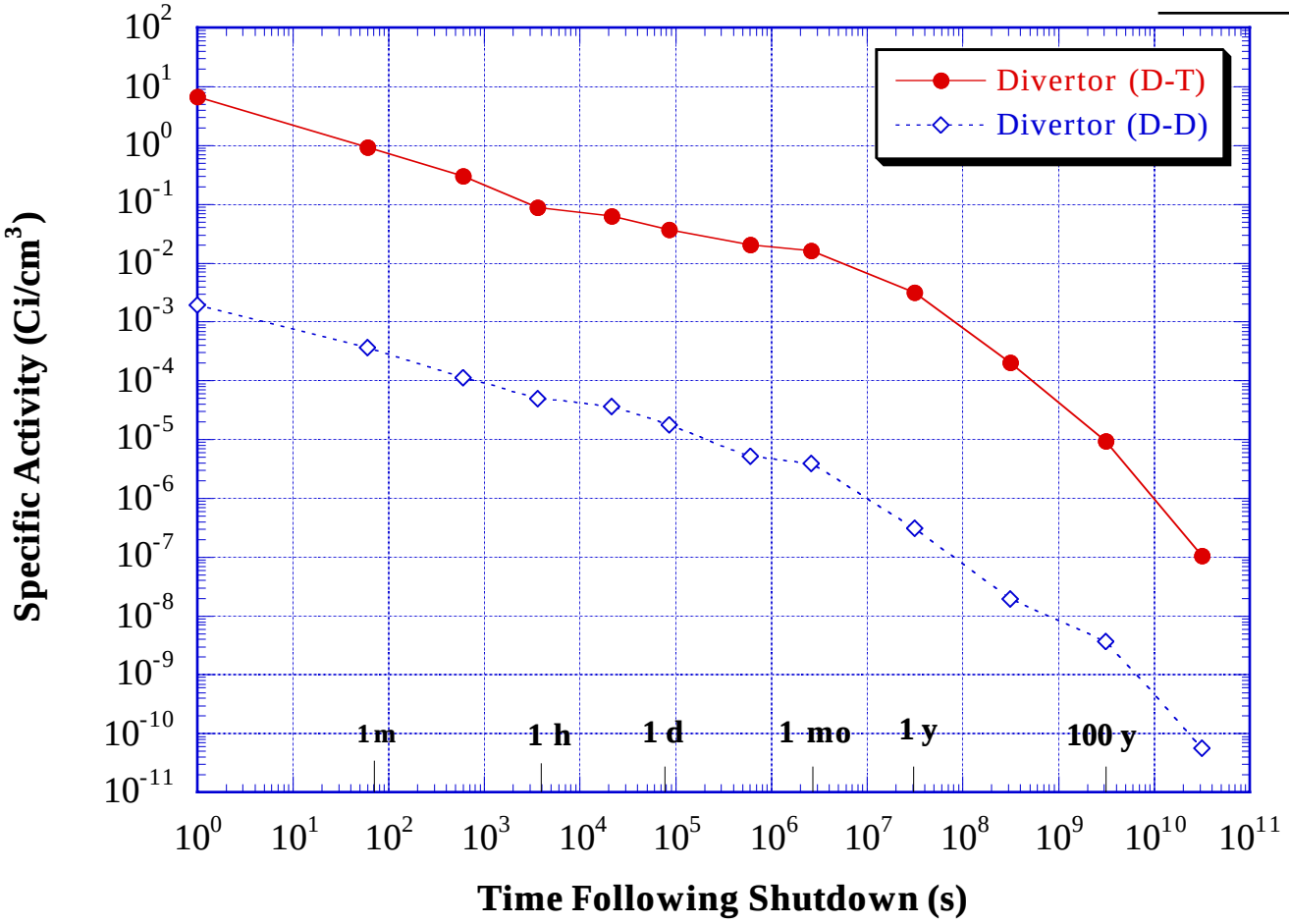
Decay Heat Induced in the Outboard Side

University of Wisconsin



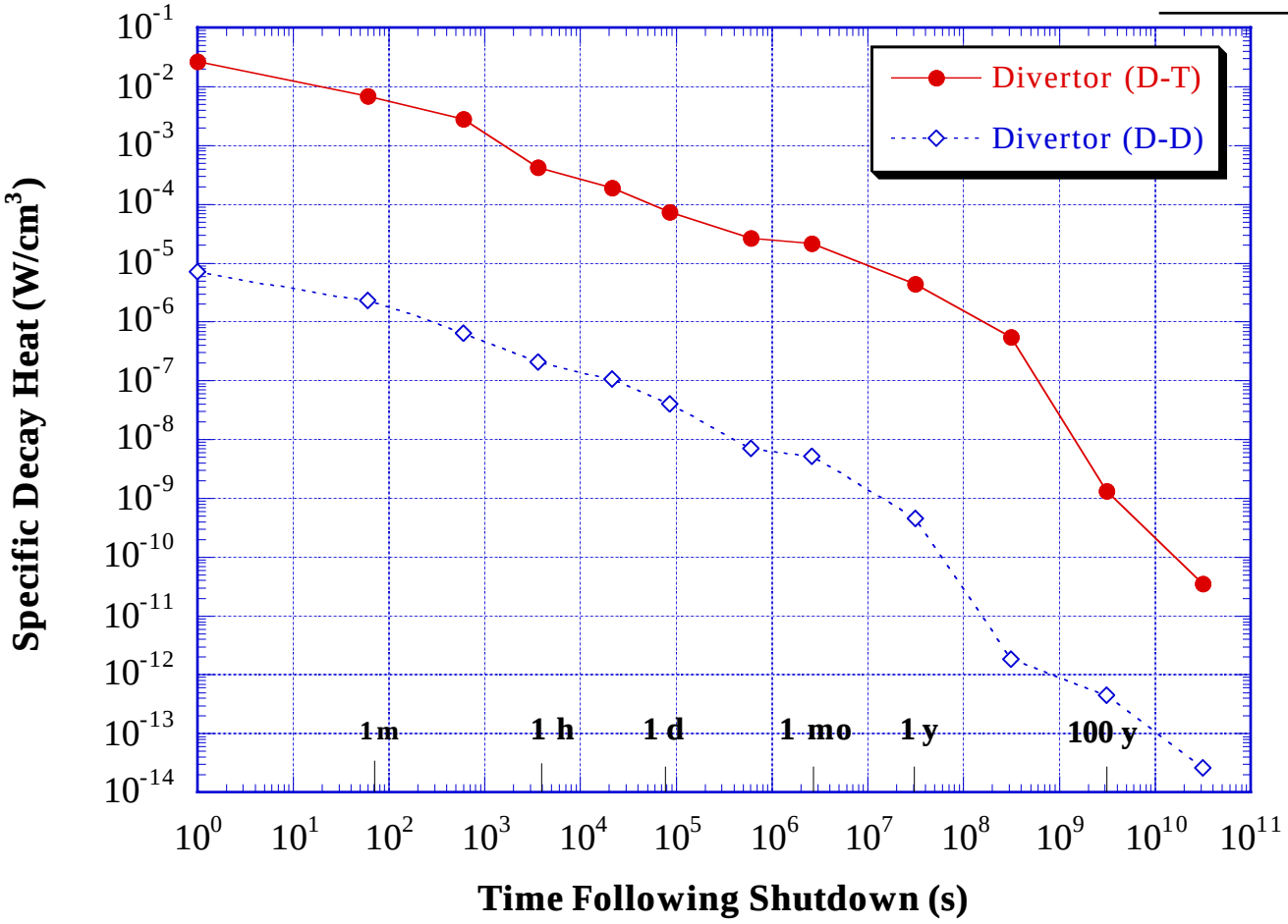
Activity Induced in the Divertor

University of Wisconsin



Decay Heat Induced in the Divertor

University of Wisconsin



Dominant Nuclides

University of Wisconsin

	Activity	Decay Heat
Short-term< 1 day		
FW	^{62}Cu, ^{64}Cu, ^{66}Cu	^{62}Cu, ^{64}Cu, ^{66}Cu
VV	^{56}Mn, ^{58}Co, ^{51}Cr	^{56}Mn, ^{58m}Co
Magnet	^{62}Cu, ^{64}Cu, ^{66}Cu	^{62}Cu, ^{64}Cu, ^{66}Cu
Divertor (W rods)	^{187}W, ^{185}W, ^{181}W	^{187}W, ^{185}W
Intermediate-term < 1 month		
FW	^{60}Co, ^{63}Ni	^{64}Cu, ^{60}Co
VV	^{55}Fe, ^{51}Cr, ^{57}Co	^{58}Co, ^{54}Mn, ^{58m}Co
Magnet	^{60}Co, ^{63}Ni	^{64}Cu, ^{60}Co
Divertor (W rods)	^{185}W, ^{181}W	^{185}W, ^{181}W
Long-term > 1 year		
FW	^{63}Ni	^{63}Ni
VV	^{63}Ni	^{60}Co, ^{63}Ni
Magnet	^{63}Ni	^{63}Ni
Divertor (W rods)	^{91}Nb, ^{63}Ni	^{94}Nb, ^{39}Ar

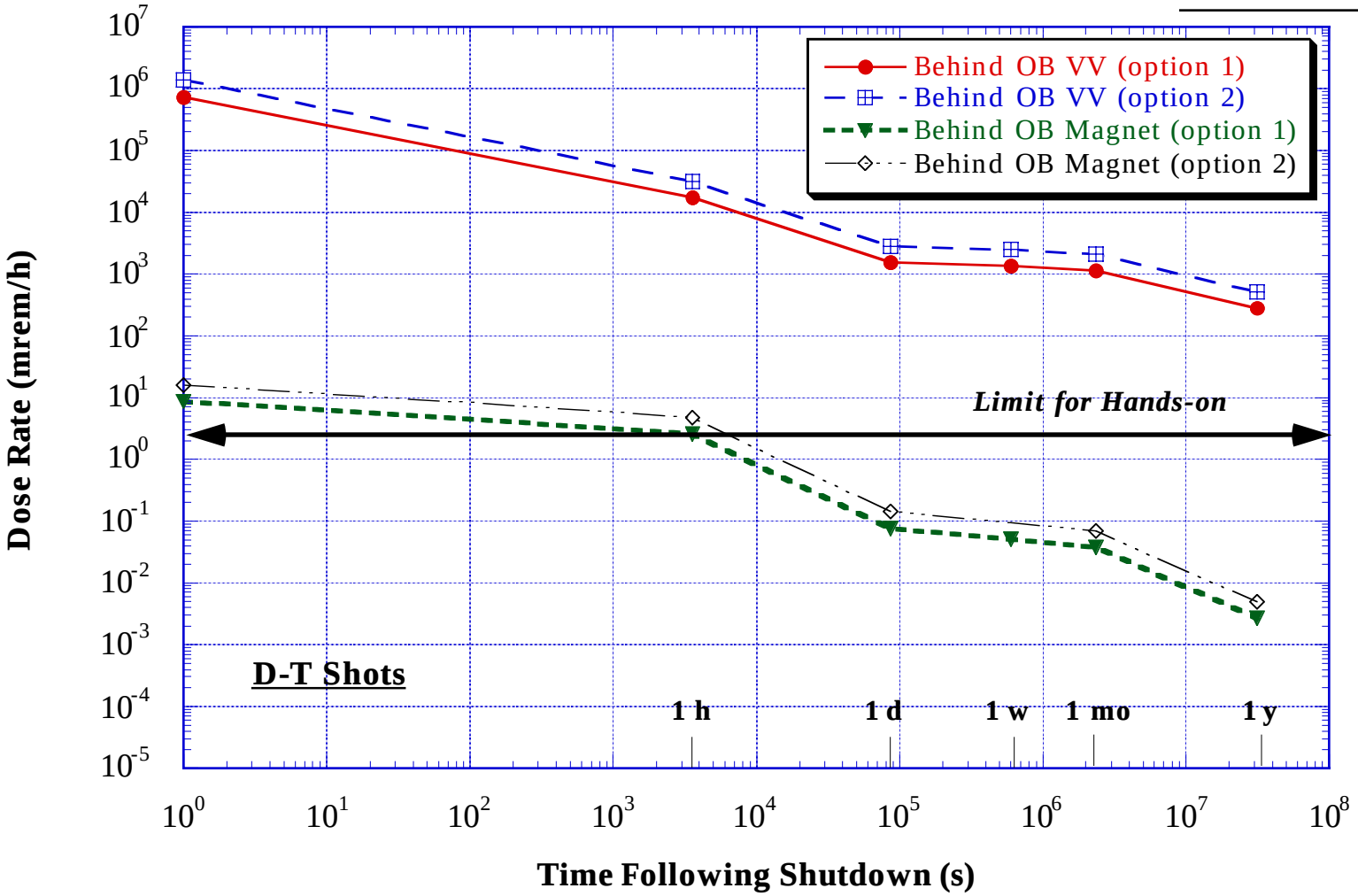
Activity and Decay Heat Values are Tolerable

University of Wisconsin

- At shutdown, the decay heat induced in the first wall is less than 0.25% of the nuclear heating generated in the FW during operation
- The ratio between the shutdown decay heat and nuclear heating in the VV during operation is on the order of 0.1%
- The activity and decay heat generated following D-D shots are more than three orders of magnitude lower than the D-T shots due to the lower fusion power and the lack of high energy neutrons
- The decay heat induced in the FW at shutdown is dominated by the two copper isotopes $^{62}Cu(T_{1/2} = 9.74$ min) and $^{66}Cu(T_{1/2} = 5.1$ min)
- The low decay heat induced in the FW at shutdown is due to the fact that the short lifetimes of ^{62}Cu and ^{66}Cu allow them to decay during the 3 hours between pulses
- The VV decay heat at shutdown is dominated by $^{52}V(T_{1/2} = 3.76$ min) and $^{56}Mn(T_{1/2} = 2.578$ hr)
- Due to the short life-time of ^{52}V, all of its radioactivity also decay between shots, resulting in a low overall radioactivity generated in the vacuum vessel at shutdown
- Activity and decay heat values at shutdown are almost fully dominated by activation during the last pulse

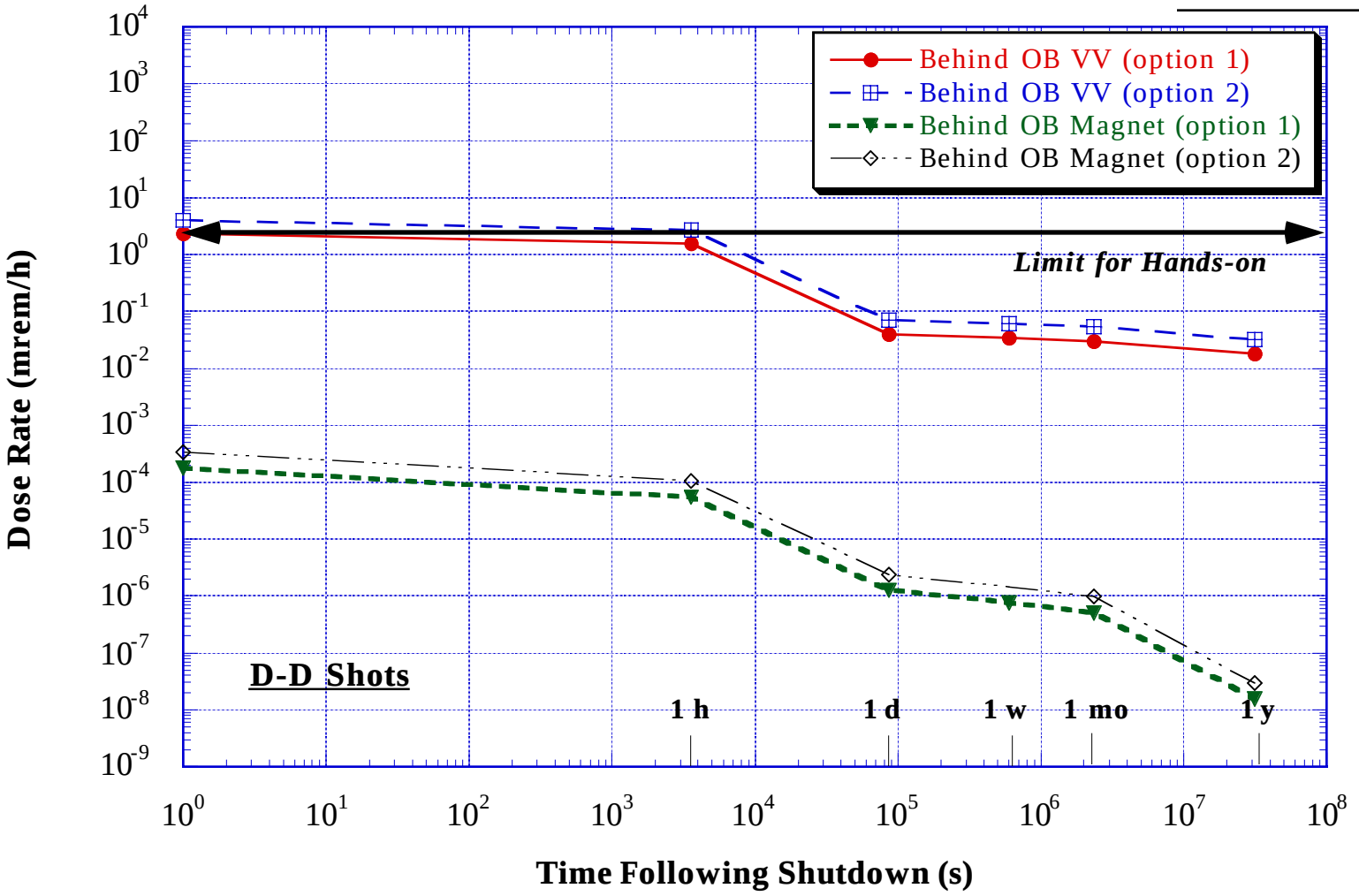
Biological Dose Rates at the Midplane as a Function of Time Following Shutdown

University of Wisconsin



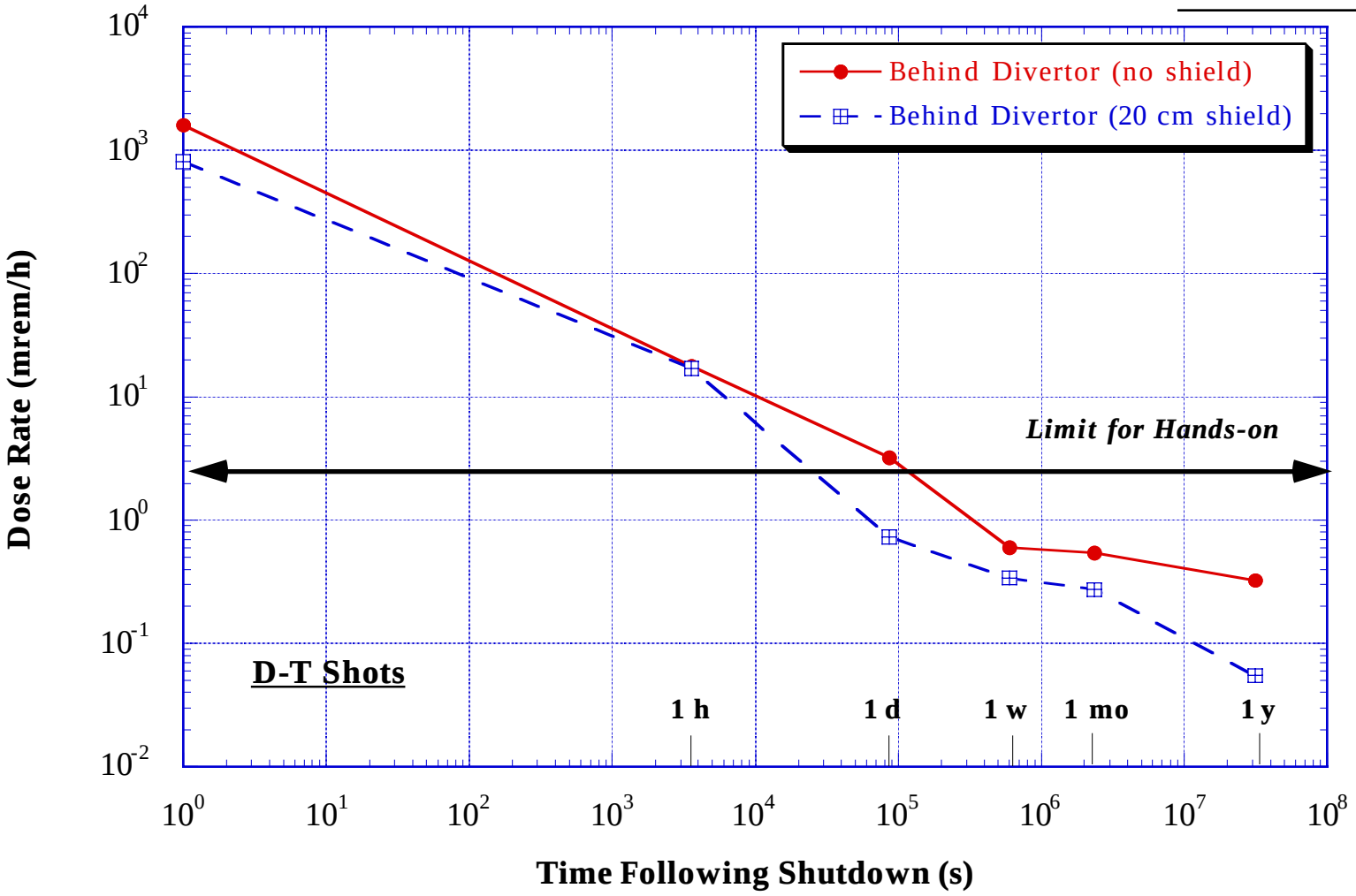
Biological Dose Rates at the Midplane as a Function of Time Following Shutdown

University of Wisconsin



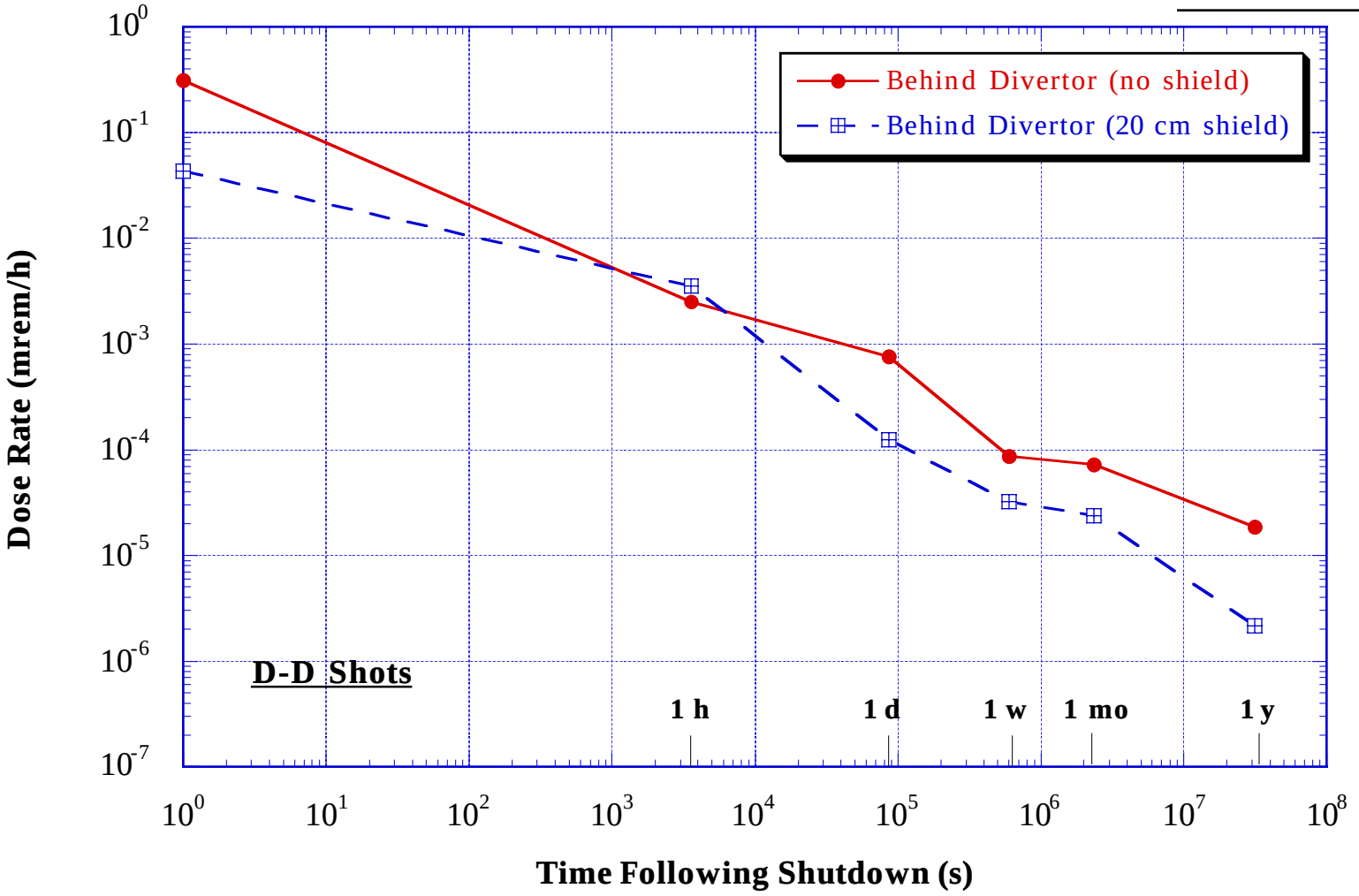
Biological Dose Rates at the Machine Top as a Function of Time Following Shutdown

University of Wisconsin



Biological Dose Rates at the Machine Top as a Function of Time Following Shutdown

University of Wisconsin



Biological Dose Rates are Moderate

University of Wisconsin

- Biological dose rates behind the vacuum vessel are high during the first year following D-T shots
- Biological dose rates behind the outboard magnet are acceptable for the two FW/tiles options
- Biological dose rates behind the vacuum vessel and magnet are acceptable following D-D shots
- The dose rates in option 2 are twice the rates in option 1
- At shutdown, the dose rates behind the magnet are caused by the $^{62m}Co(T_{1/2} = 13.9$ min) isotope
- One week following shutdown, the dose rates behind the magnet are dominated by the $^{60}Co(T_{1/2} = 5.27$ yr) isotope
- Using a 110 cm long steel plug at the midplane will stop neutron streaming through penetration and provide adequate shielding that allows for hands-on maintenance
- The dose rates caused by the ^{60}Co isotope almost increase linearly with the increase in number of pulses
- Biological dose rates behind the magnet at the top of the machine are acceptable with or without the extra POLY/CAST mix shield

Waste Disposal Ratings

University of Wisconsin

- WDR for Class C waste are calculated using the 10CFR61 and Fetter waste disposal limits
- Waste disposal ratings are given after 1 year following shutdown
- Waste disposal ratings are given for compacted wastes

Waste Disposal Ratings

University of Wisconsin

Zone	Fetter	10CFR61
IB FW	0.18 (^{108m}Ag)	1.98e-2 (^{63}Ni)
IB VV	5.67e-2 (^{94}Nb)	5.87e-2 (^{94}Nb, ^{63}Ni)
IB Magnet	2.35e-4 (^{108m}Ag)	1.15e-3 (^{63}Ni)
OB FW	0.14 (^{108m}Ag)	1.7e-2 (^{63}Ni)
OB VV	1.84e-3 (^{94}Nb)	2.44e-3 (^{94}Nb, ^{63}Ni)
OB Magnet	1.21e-6 (^{94}Nb)	1.37e-6 (^{94}Nb, ^{63}Ni)
Divertor	3.39e-2 (^{108m}Ag, ^{94}Nb)	1.33e-2 (^{94}Nb)

Conclusions

University of Wisconsin

- The specific activity and decay heat values after shutdown for the two FW/tiles options are low
- At shutdown, the decay heat induced in the first wall is less than 0.1% of the nuclear heating generated in the FW during operation
- The ratio between the shutdown decay heat and nuclear heating in the VV during operation is on the order of 0.01%
- All components would qualify for disposal as class C LLW according to both 10CFR61 and Fetter limits
- Biological dose rates behind the vacuum vessel are high during the first year following D-T shots
- Biological dose rates behind the outboard magnet are acceptable for the two FW/tiles options
- Biological dose rates behind the vacuum vessel and magnet are acceptable following D-D shots
- Biological dose rates behind the magnet at the top of the machine are acceptable with or without the extra POLY/CAST mix shield