



The simulation and measurement of the dose distribution at the TPS injection section

NSRRC

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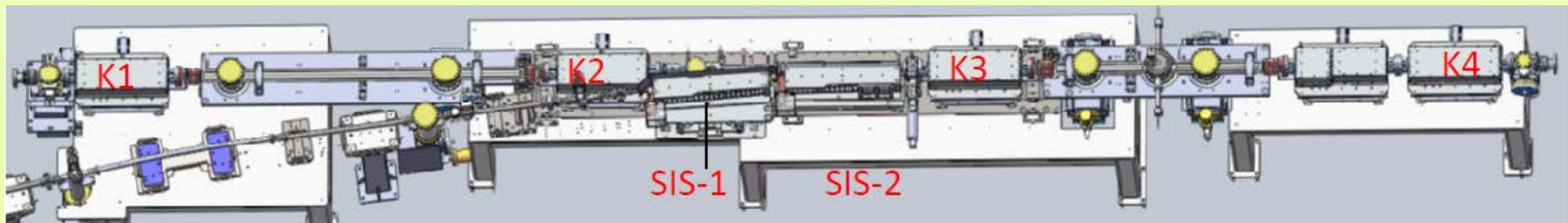
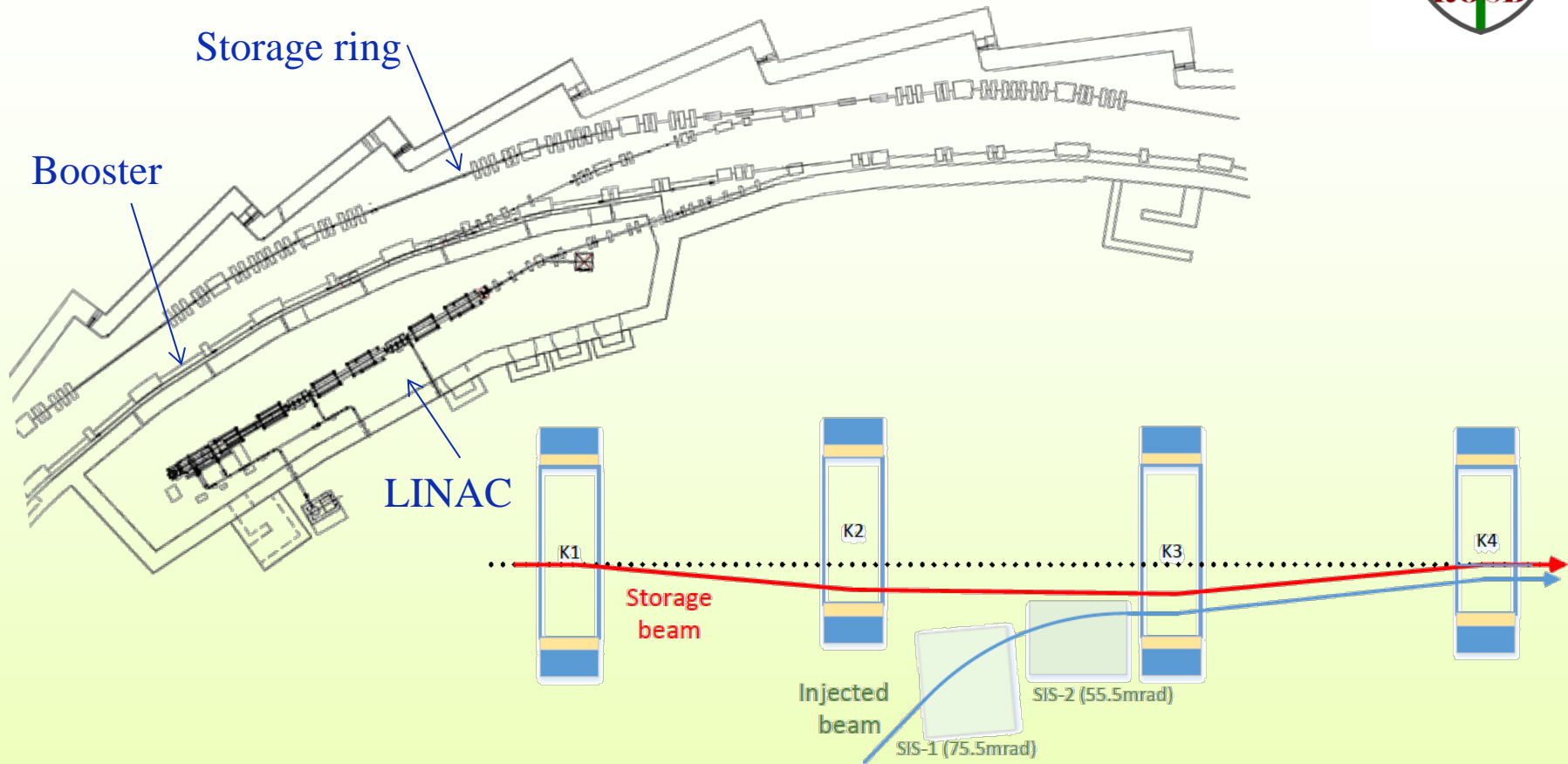
2015/6/5

outline

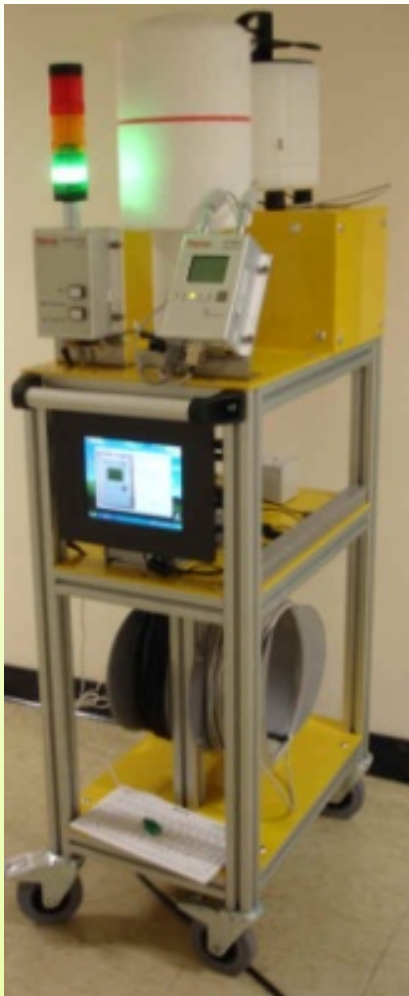


- ◆ Introduction
- ◆ Simulation and measurement of the abnormal case
– lost all electrons at the SIS-1
- ◆ Simulation and measurement for the normal injection
- ◆ summary

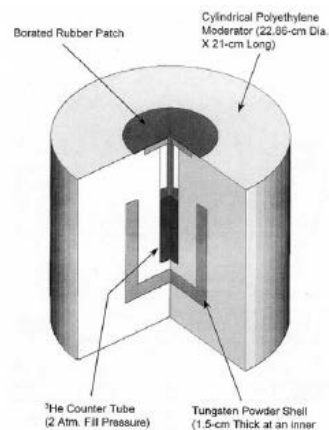
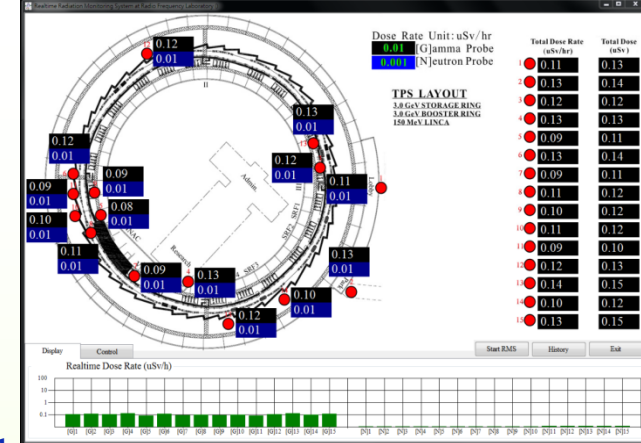
Layout of the TPS injection section



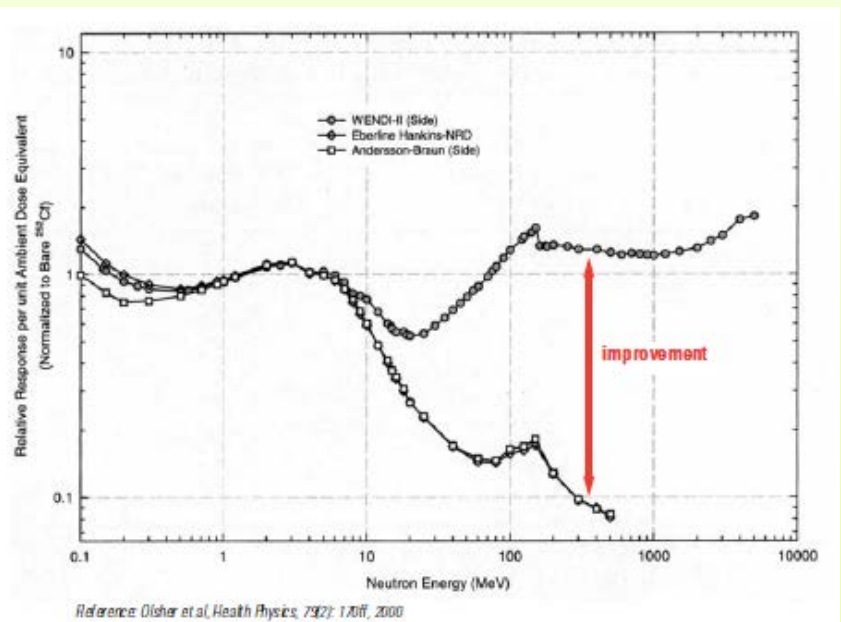
Radiation monitoring system



- $\gamma+n$ integral area monitor station
- ^3He counter wide range neutron detector, FHT 762 Wendi-2 type produced by Thermo, is used to measure neutron $H^*(10)$
- FHT 192 ionization chamber detects the gamma-ray ambient equivalent dose rate $H^*(10)$



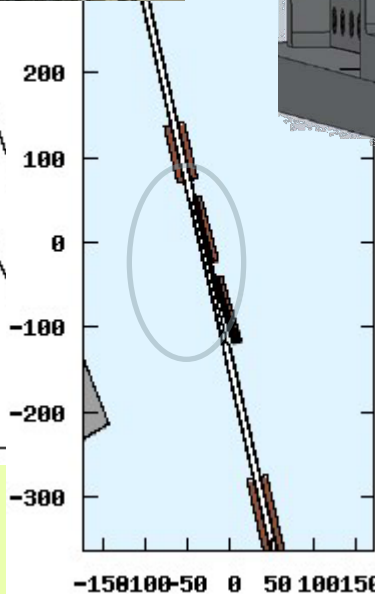
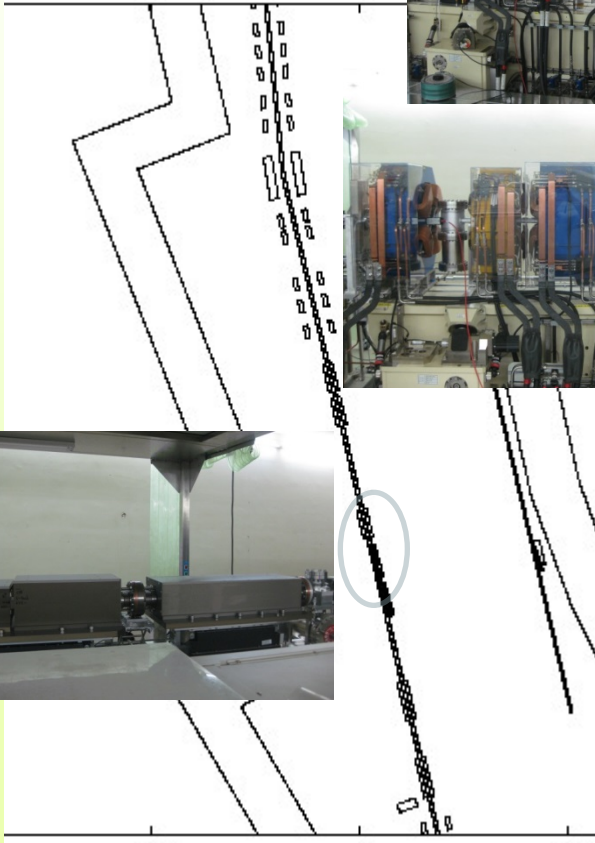
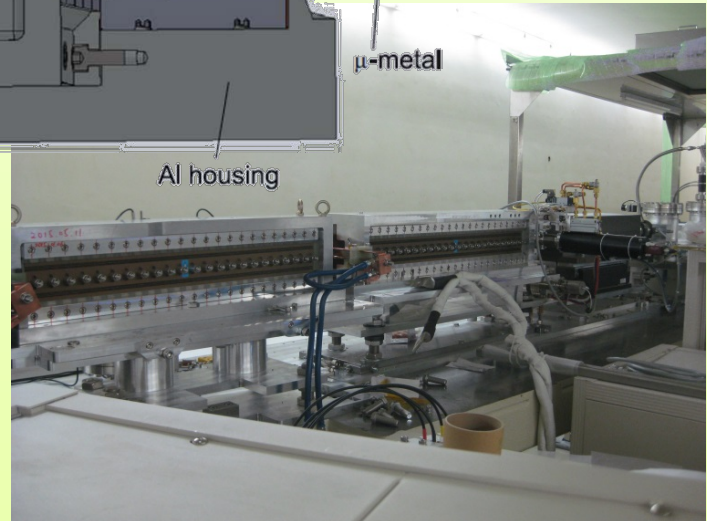
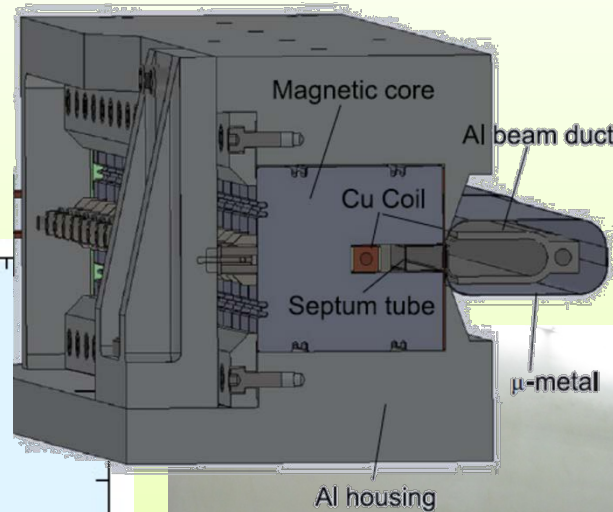
Reference: Oshar et al, Health Physics, 79(2): 170ff, 2000



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FLUKA Model

- USRBIN for dose distribution
- AMB74, Fluence-to-ambient dose conversion factors



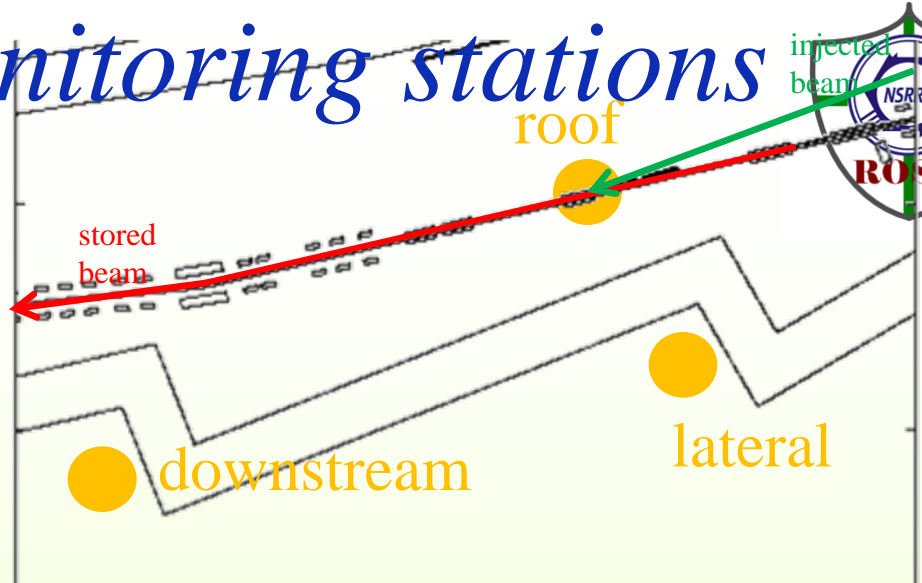
Test



- ◆ For the experiment conducted on April 1 night, LINAC output was set to be 200pC, 1Hz
- ◆ The LTB efficiency is 50%. The scraper in this section dominates the lost of the electron.
- ◆ Ramping efficiency of the booster is about 50%. Electrons lost in this part are mainly in early accelerating stage.
- ◆ The total efficiency of the BTS is about 80%. This is to divide the incremental current in ring by the charges at the last several turns in booster.
- ◆ With injection septums no fire, electrons hit the chamber inside the SIS-1 by degree-7 (with respect to the stored beam direction).

◆ In average, the electrons transferred to BTS end is

Radiation monitoring stations



Monitor station on roof

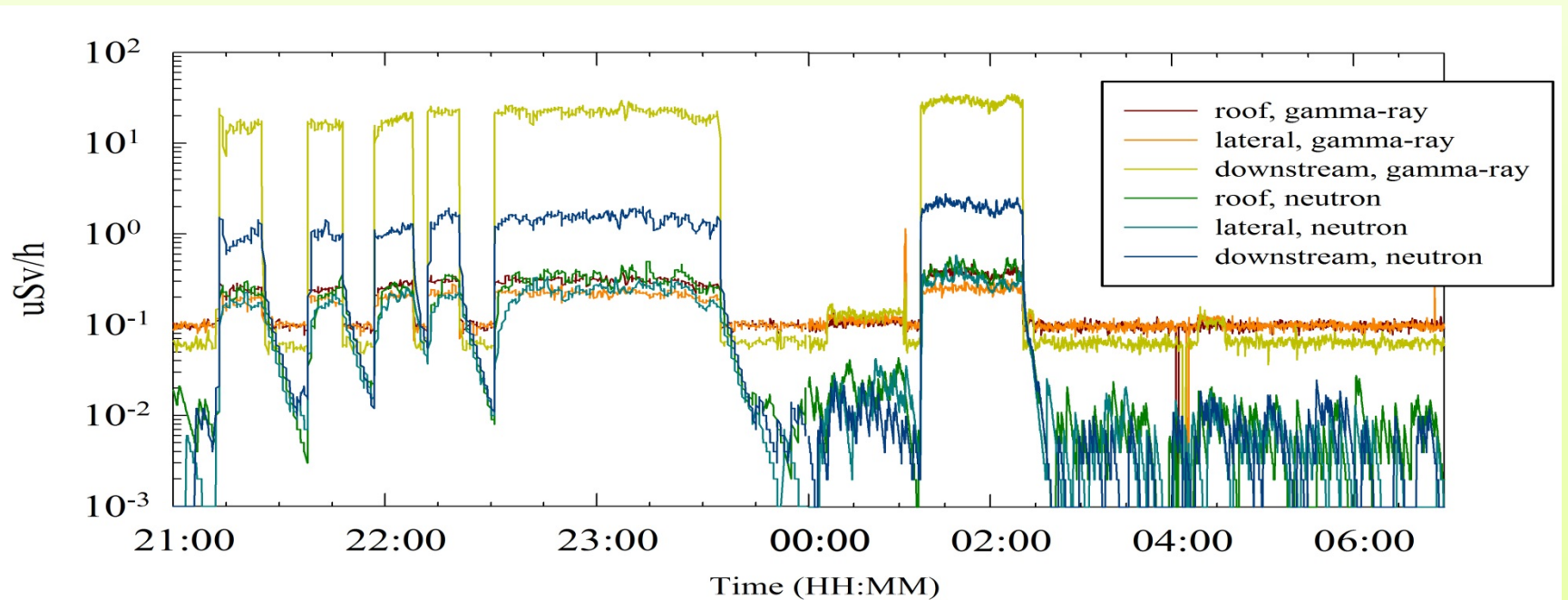


Monitor station at downstream



Monitor station outside the lateral shielding wall

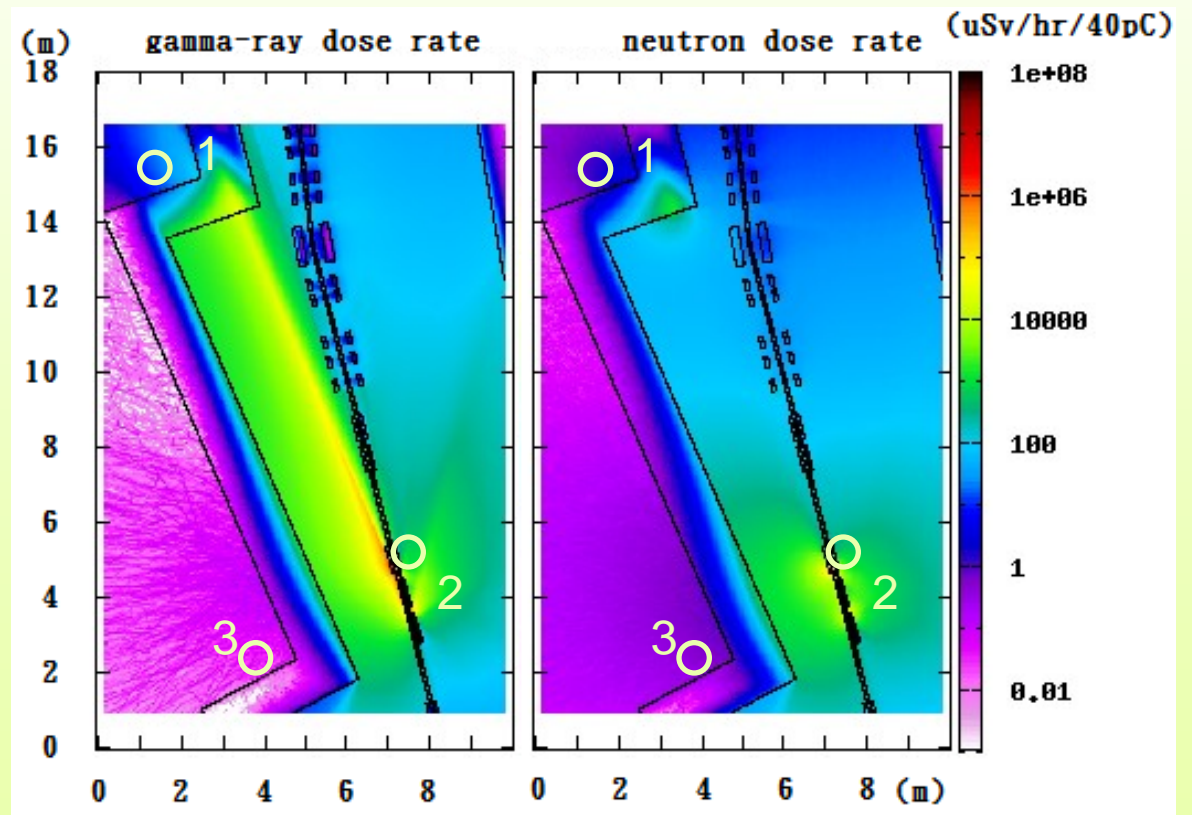
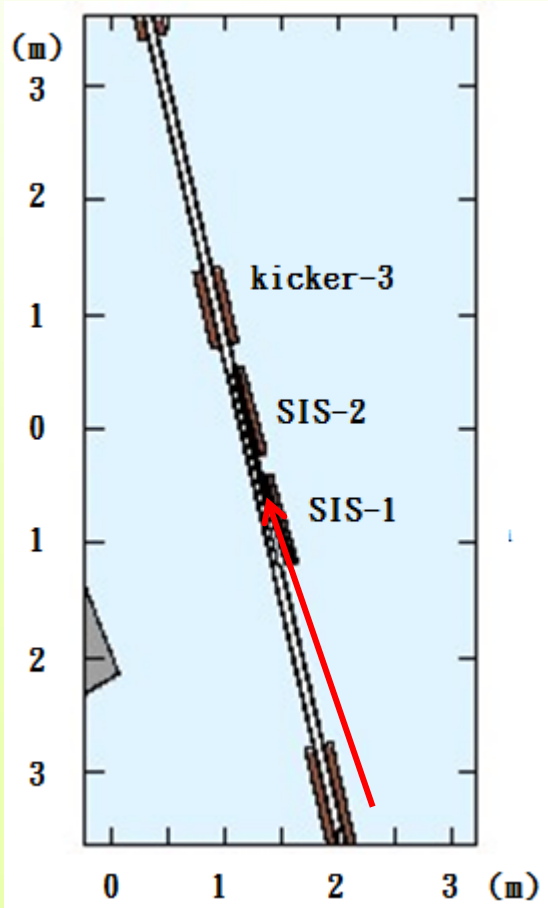
gamma-ray(uSv/h)	1st	2nd	3rd	4th	5th	6th	Average	Average-bg
Roof	0.24	0.25	0.27	0.31	0.30	0.37	0.29	0.19
Lateral	0.19	0.19	0.20	0.23	0.22	0.26	0.21	0.11
downstream	15.23	15.88	17.36	22.40	22.05	29.51	20.41	20.31
Neutron (uSv/h)	1st	2nd	3rd	4th	5th	6th	Average	Average-bg
Roof	0.22	0.18	0.22	0.27	0.32	0.39	0.27	0.27
Lateral	0.16	0.15	0.18	0.18	0.23	0.32	0.20	0.20
downstream	0.94	0.93	1.06	1.53	1.48	2.11	1.34	1.34



40pC 3.0GeV electrons lost at the end of injection septum



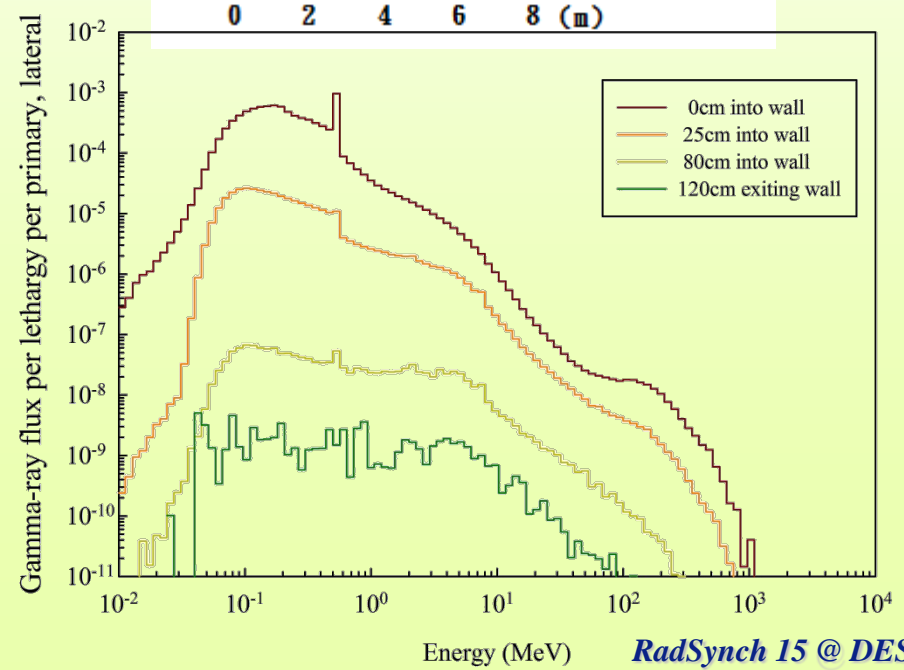
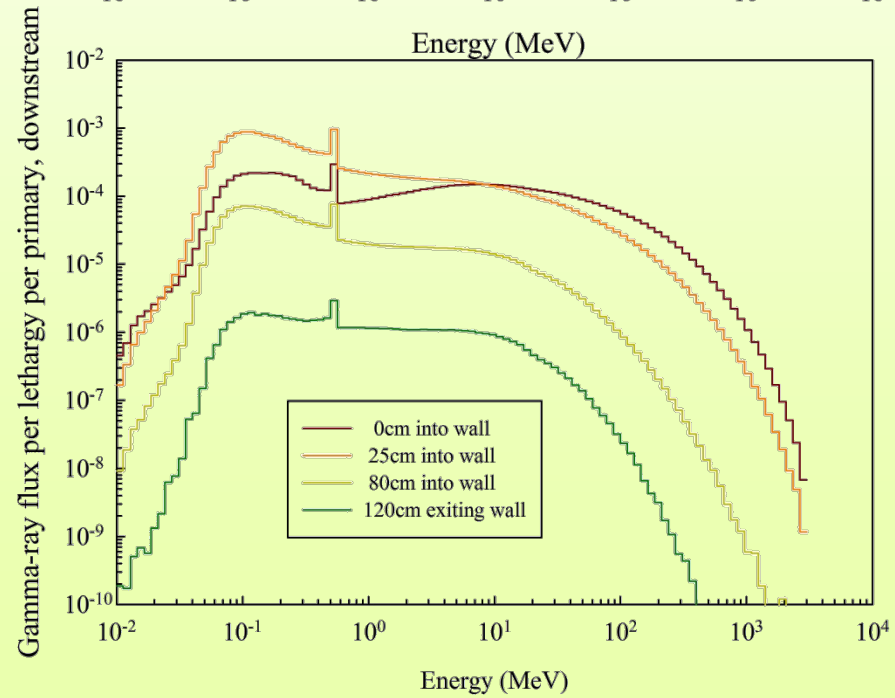
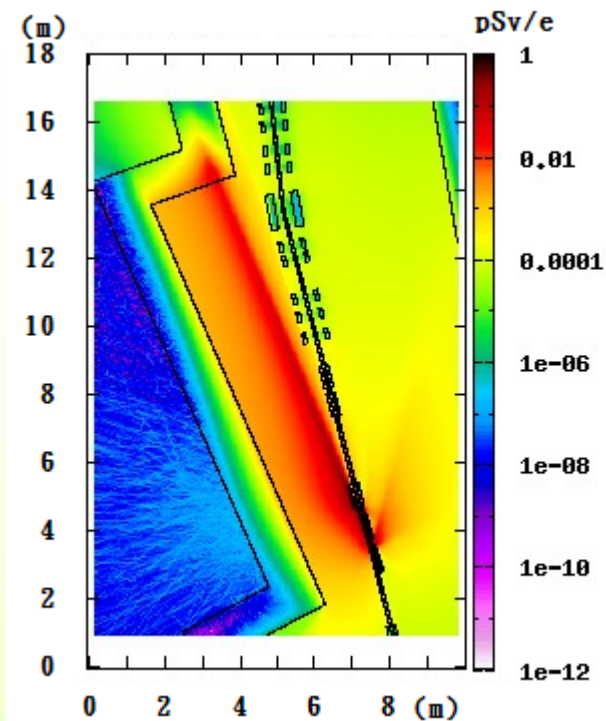
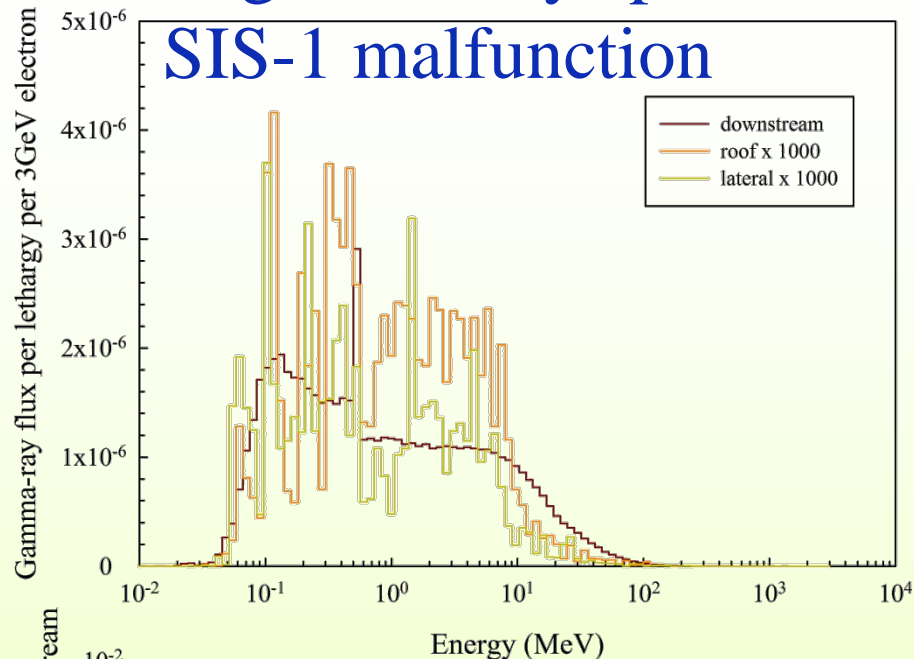
	1. Downstream			2. Roof			3. Lateral		
	Mea.	Cal.	C/M	Mea.	Cal.	C/M	Mea.	Cal.	C/M
Gamma-ray (uSv/h)	20.31	33.06±0.18%	1.63	0.19	0.05±3.80%	0.26	0.11	0.03±5.99%	0.27
Neutron (uSv/h)	1.34	2.26±0.49%	1.69	0.27	0.43±0.92%	1.59	0.20	0.46±1.34%	2.30



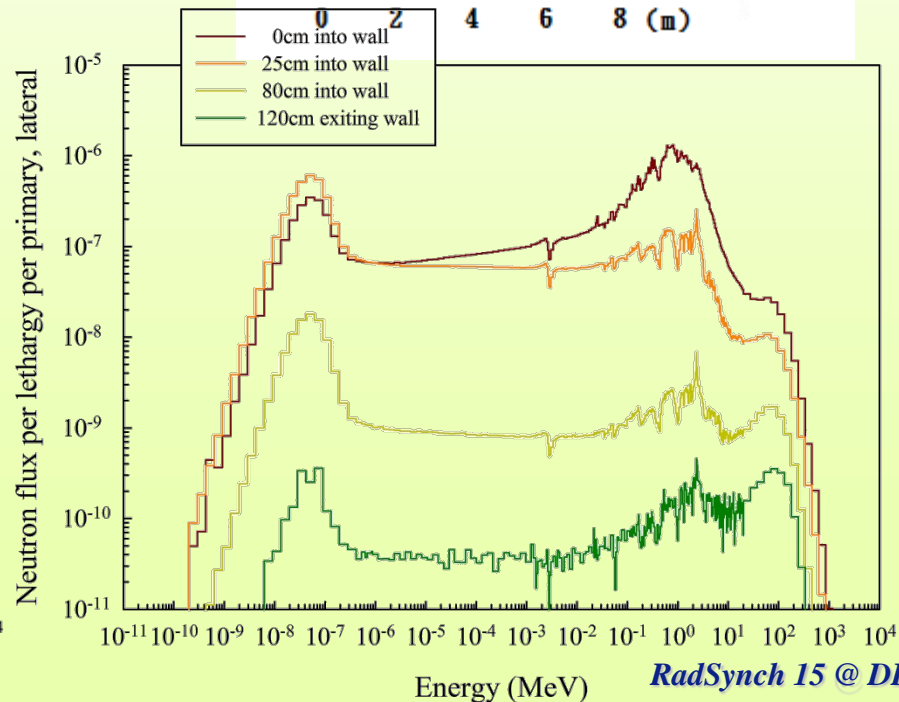
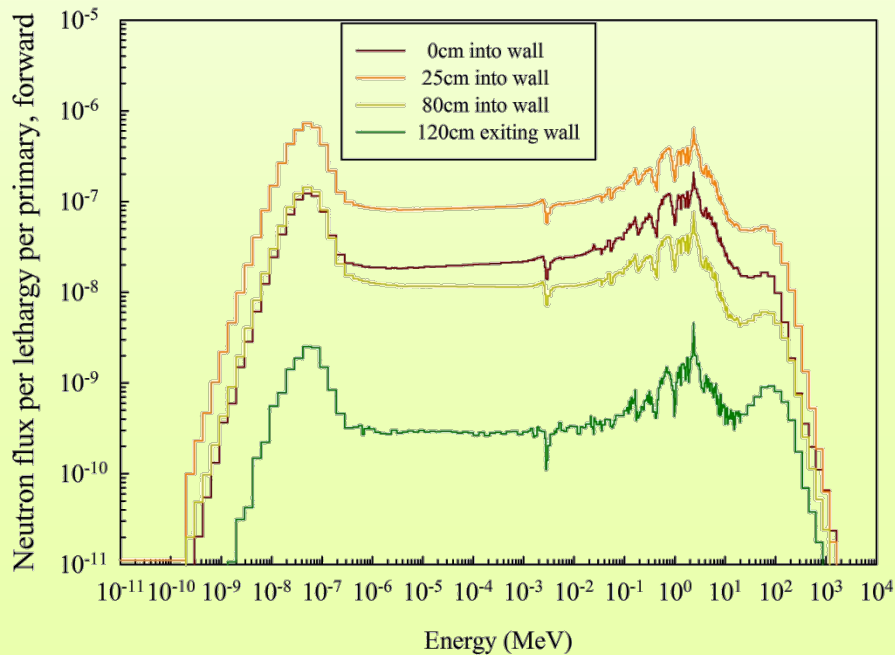
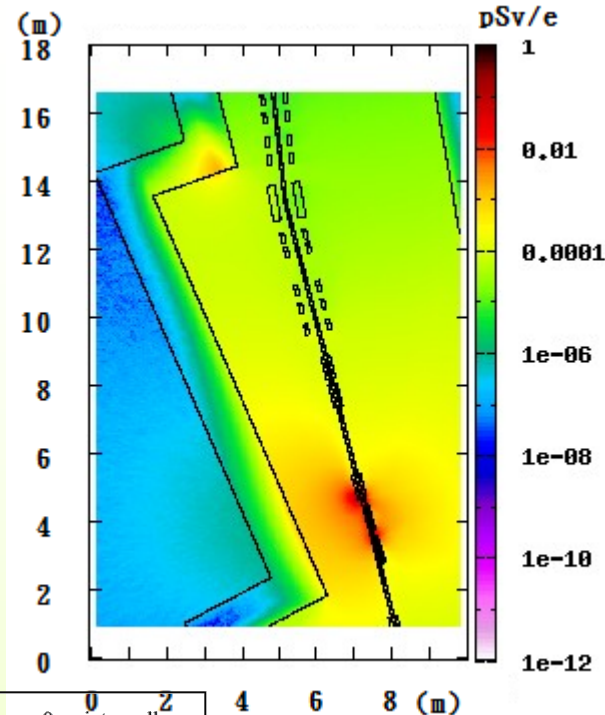
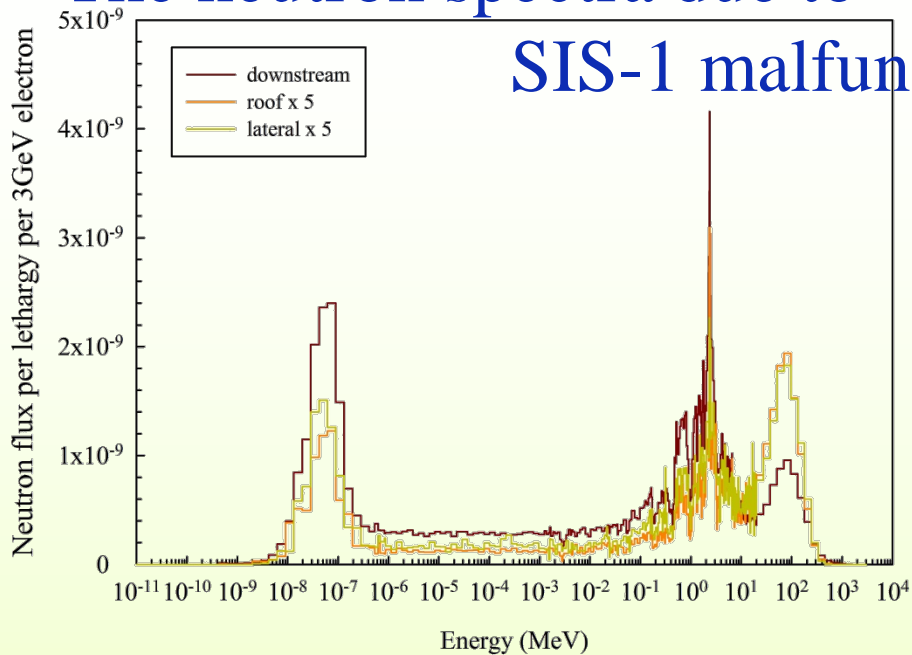
The gamma-ray spectra due to



SIS-1 malfunction

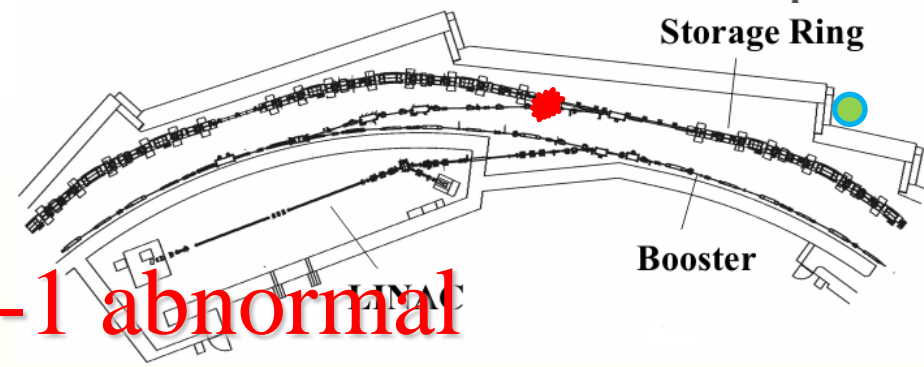


The neutron spectra due to SIS-1 malfunction



Dose rate (uSv/h) by different efficiencies

if injection failed by SIS-1 abnormal



- LINAC: 1nC, 1Hz is the general setting during the commissioning stage

location		operation	W	efficiency	W	efficiency	W	efficiency	W	efficiency
LINAC	outlet	to inj	0.15	100	0.15	100	0.15	100	0.15	100
LTB	inlet	to transfer	0.15	60	0.15	60	0.15	60+30	0.15	90
	outlet	ext/inj	0.09	95	0.09	95	0.14	95	0.14	95
Booster	inlet	ramping	1.71	60	1.71	60	2.57	60	2.57	60+30
	outlet	ext/inj	1.03	90	1.03	90+5	1.54	95	2.31	95
BTS	inlet	transfer	0.92	90	0.97	90+5	1.46	95	2.19	95
	Inj. septum	malfunction	0.83	--	0.93	--	1.39	--	2.08	--
dose rate (uSv/h) at downstream			244.76		272.71		409.07		613.61	
time (s) to trip injection			29.42		26.40		17.60		11.73	

3.0GeV electron lost for normal operation

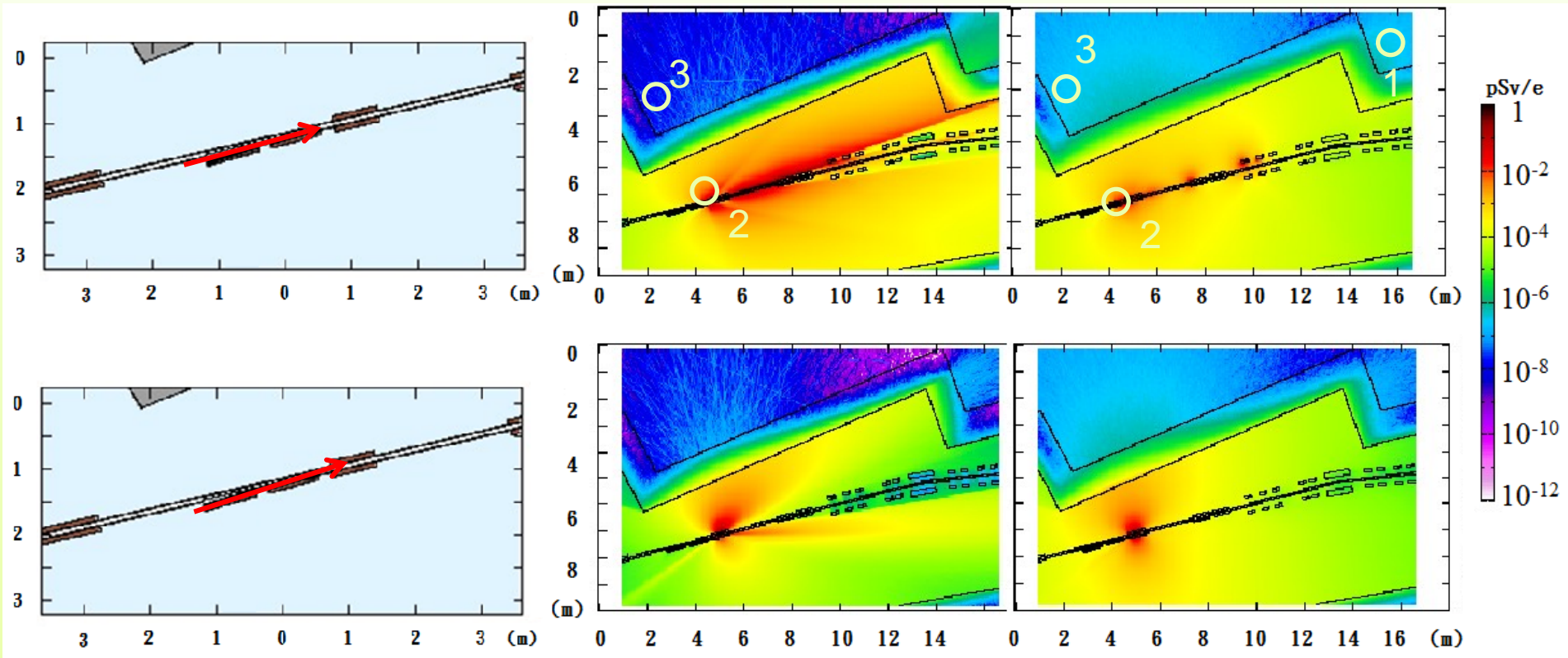


	1. Downstream				2. Roof				3. Lateral			
	Gamma-ray		Neutron		Gamma-ray		Neutron		Gamma-ray		Neutron	
	pSv/e	re(%)	pSv/e	re(%)	pSv/e	re(%)	pSv/e	re(%)	pSv/e	re(%)	pSv/e	re(%)
SIS-2	2.57E-06	0.56	4.85E-07	1.12	3.68E-08	5.66	3.77E-07	1.14	1.60E-08	7.88	3.14E-07	1.95
K3	1.00E-07	2.63	1.25E-07	1.99	3.14E-08	3.83	3.23E-07	1.08	1.83E-08	9.95	2.85E-07	1.75

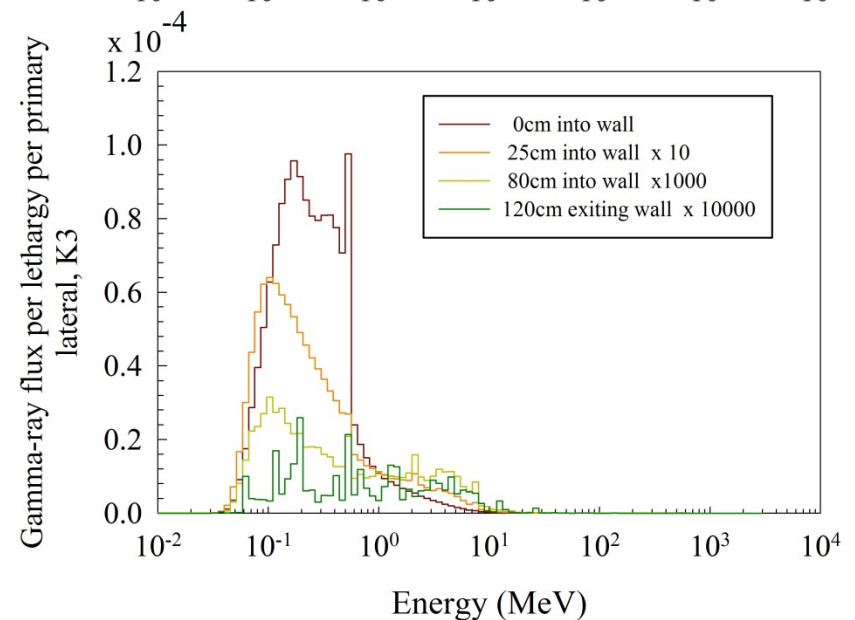
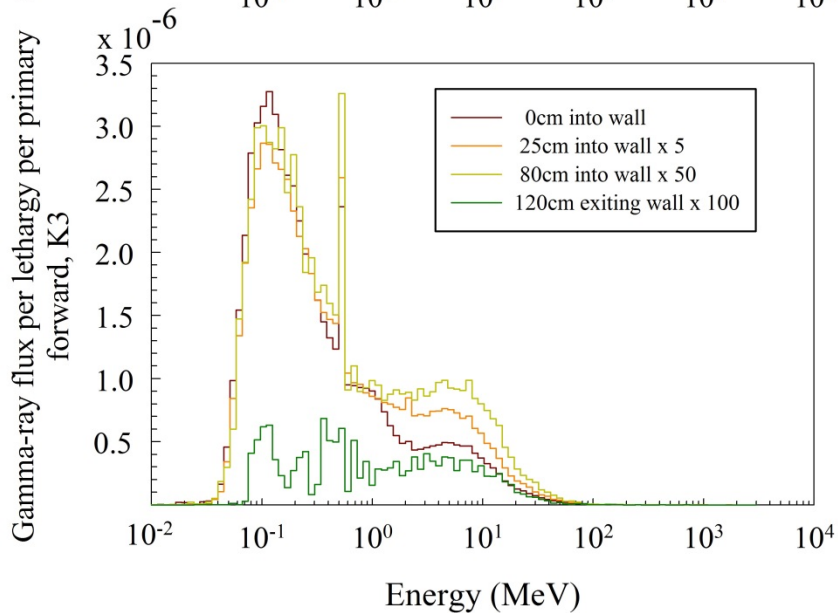
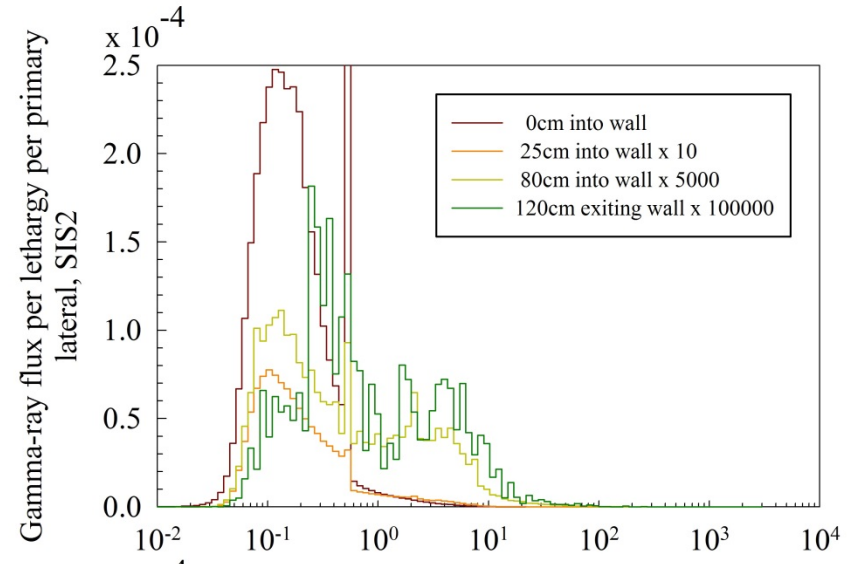
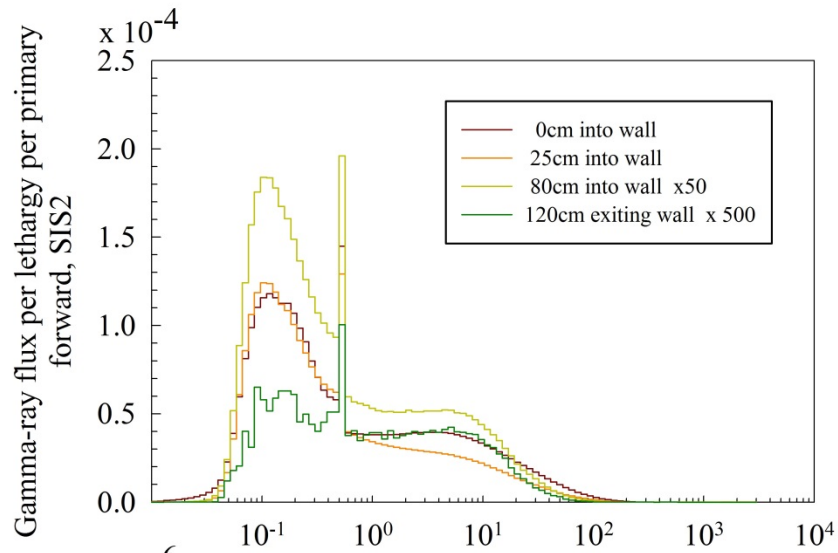
electron path

Gamma-ray dose

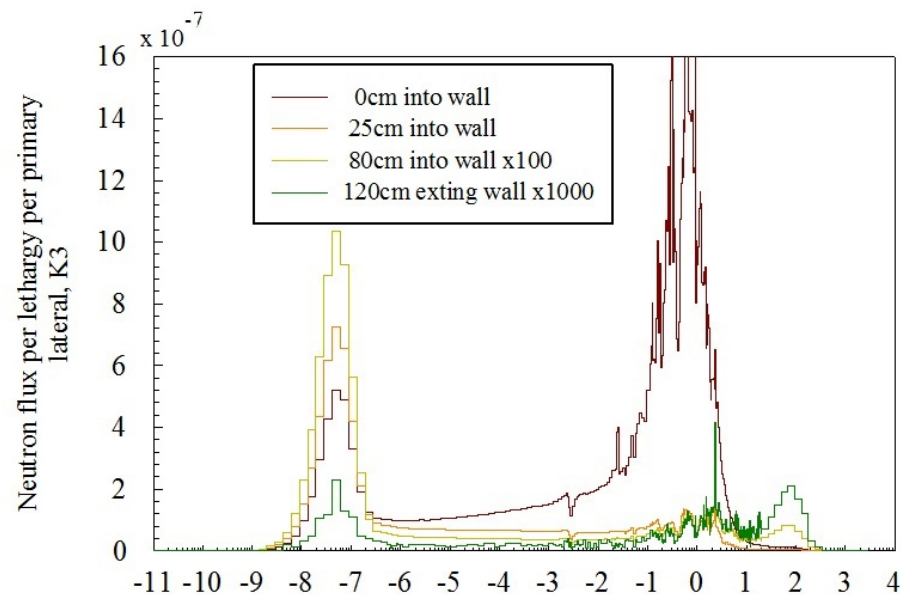
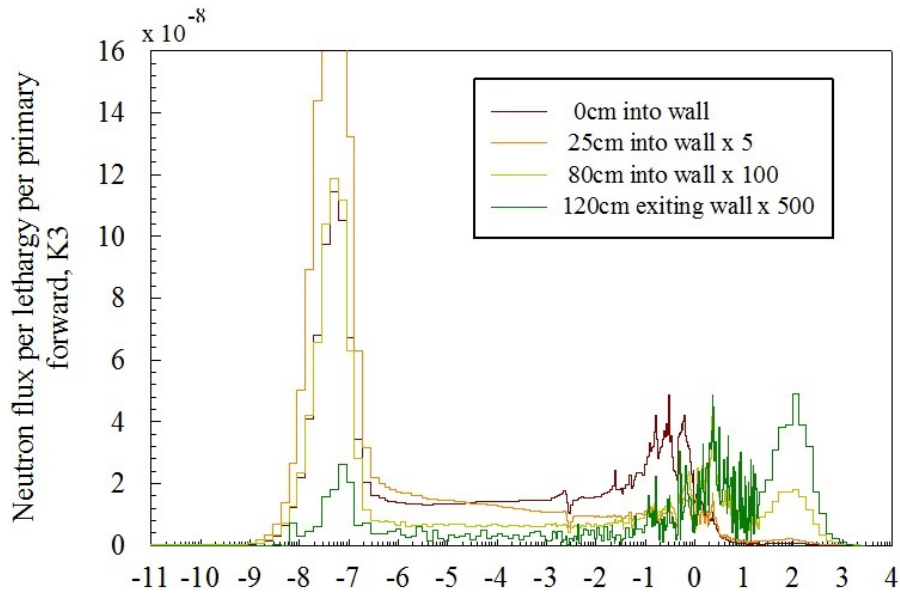
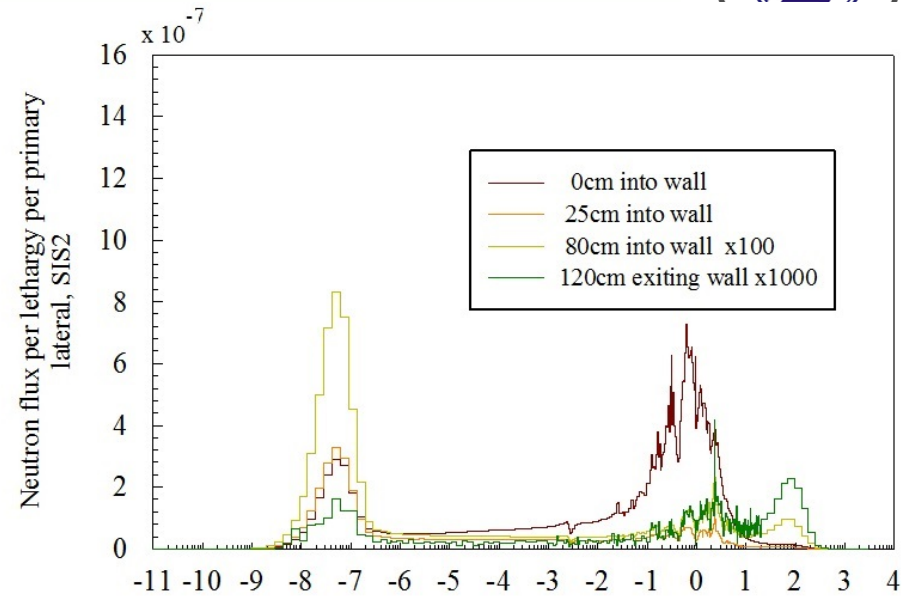
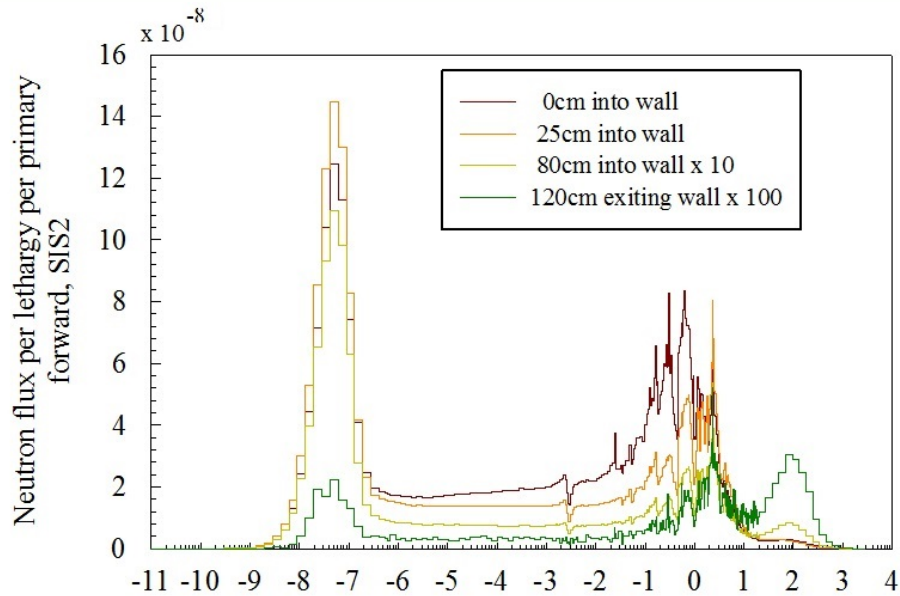
neutron dose



The gamma-ray spectra in SIS-2 and K3 scenarios



The neutron spectra in SIS-2 and K3 scenarios



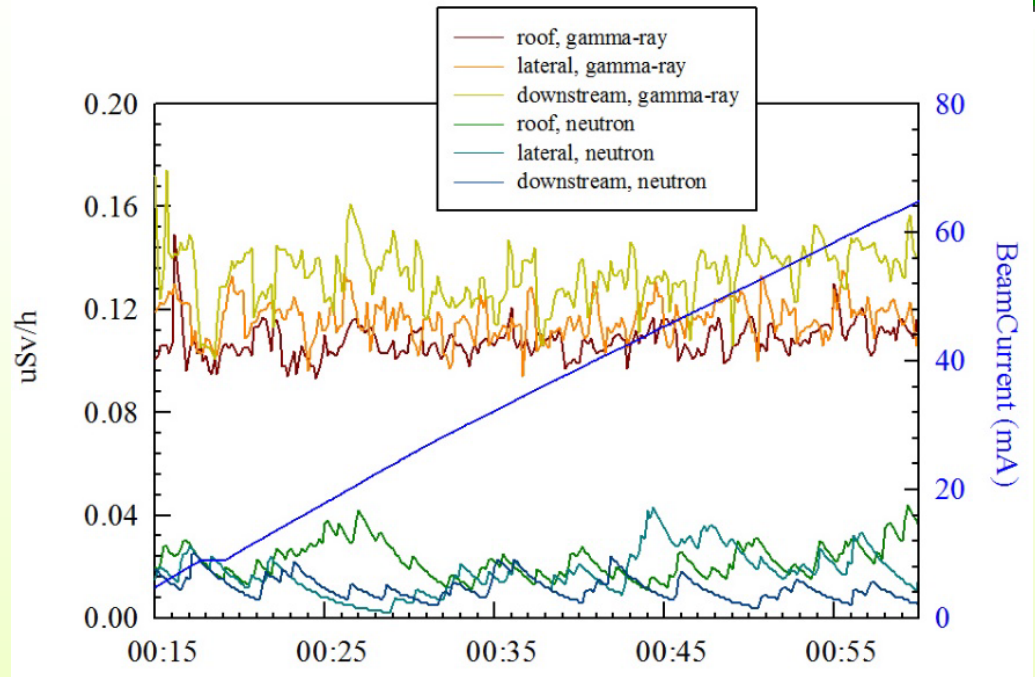
Energy (MeV, exponent only)

Energy (MeV, exponent only)



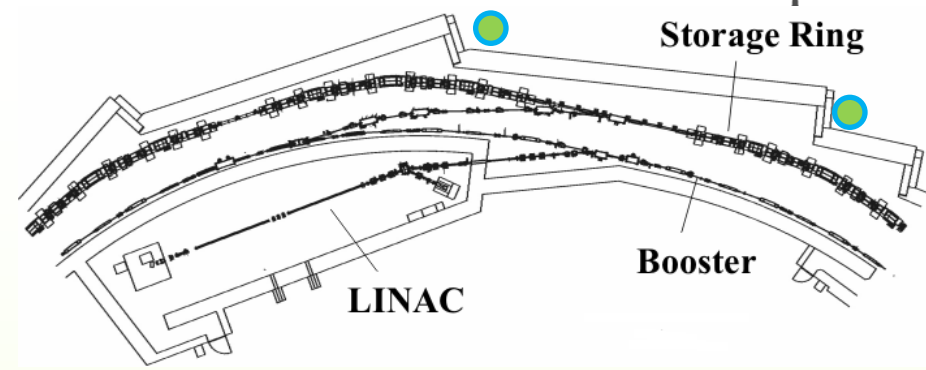
Comparison of the dose rate during normal injection

LINAC output was set to be 200pC, 1Hz		
	efficiency	W
LINAC	100%	0.03
LTB	50%	0.02
Booster ramping	50%	0.15
BTS extraction	90%	0.14
BTS transfer	95%	0.13
BTS inj	90%	0.12



	downstream			roof			lateral		
	Mea.	SIS-2	k3	Mea.	SIS-2	k3	Mea.	SIS-2	k3
\dot{D}_g (uSv/h)	0.034	0.247	0.010	0.008	0.004	0.003	0.016	0.002	0.002
\dot{D}_n (uSv/h)	0.011	0.047	0.012	0.023	0.036	0.031	0.018	0.030	0.027

Dose rate (uSv/h) by different efficiencies for normal injection



- LINAC: 1nC, 1Hz is the general setting during the commissioning stage

location		operation	W	efficiency	W	efficiency	W	efficiency	W	efficiency
LINAC	outlet	to inj	0.15	100	0.15	100	0.15	100	0.15	100
LTB	inlet	to transfer	0.15	60	0.15	60	0.15	60+30	0.15	90
	outlet	ext/inj	0.09	95	0.09	95	0.14	95	0.14	95
Booster	inlet	ramping	1.71	60	1.71	60	2.57	60	2.57	60+30
	outlet	ext/inj	1.03	90	1.03	90+5	1.54	95	2.31	95
BTS	inlet	transfer	0.92	90	0.97	90+5	1.46	95	2.19	95
	Outlet	ext/inj	0.83	95	0.93	95	1.39	95	2.08	95
Ring	Inlet	Stored	0.79	--	0.88	--	1.32	--	1.98	--
dose rate (uSv/h) at Downstream(SIS-2)/lateral(K3)			0.95 / 0.09		1.06 / 0.11		1.59 / 0.16		2.39 / 0.24	
time (min) to 100mA stored			10.94		9.82		6.55		4.37	

Summary



- ◆ The dose rate under normal operation is acceptable. The accident of the SIS failed should be prevented for the reason that it results in high dose at the accessible region.
- ◆ Neutron dose rate is a good indicator to define the electron loss position during the injection.
- ◆ To clarify the underestimation of gamma-ray dose rate at the transverse region.



Thank You !

