A study of beam loss pattern & dose distribution around the TPS LINAC during beam commissioning

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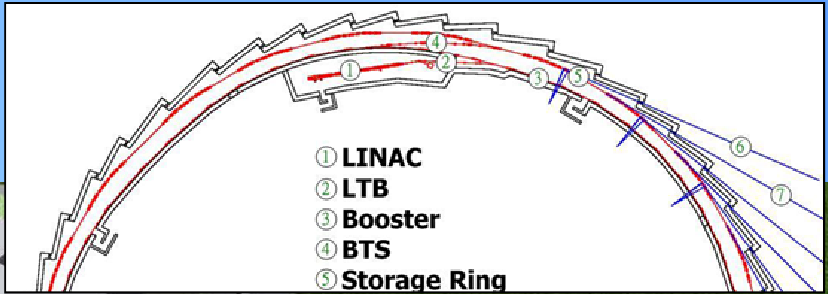
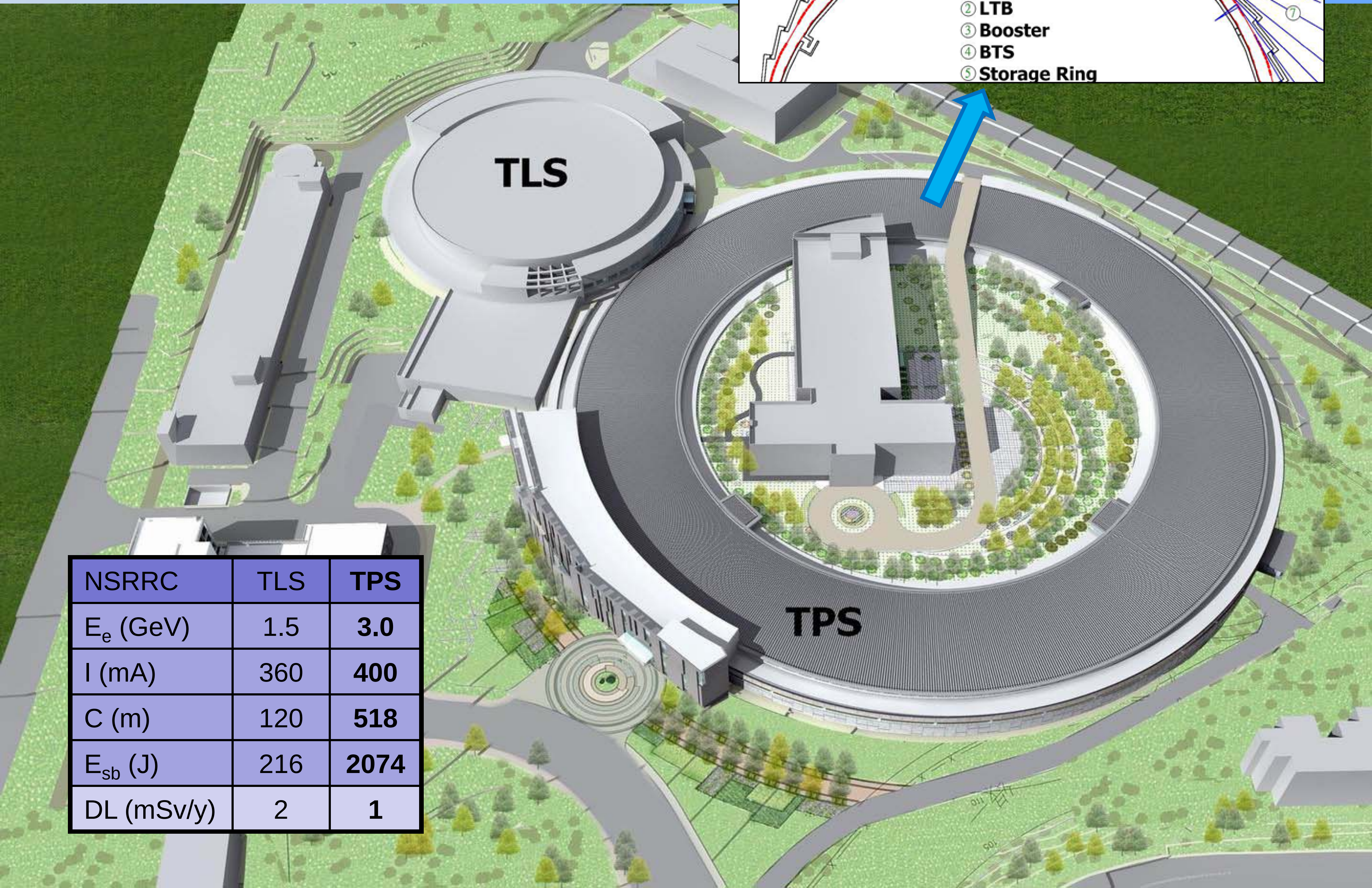
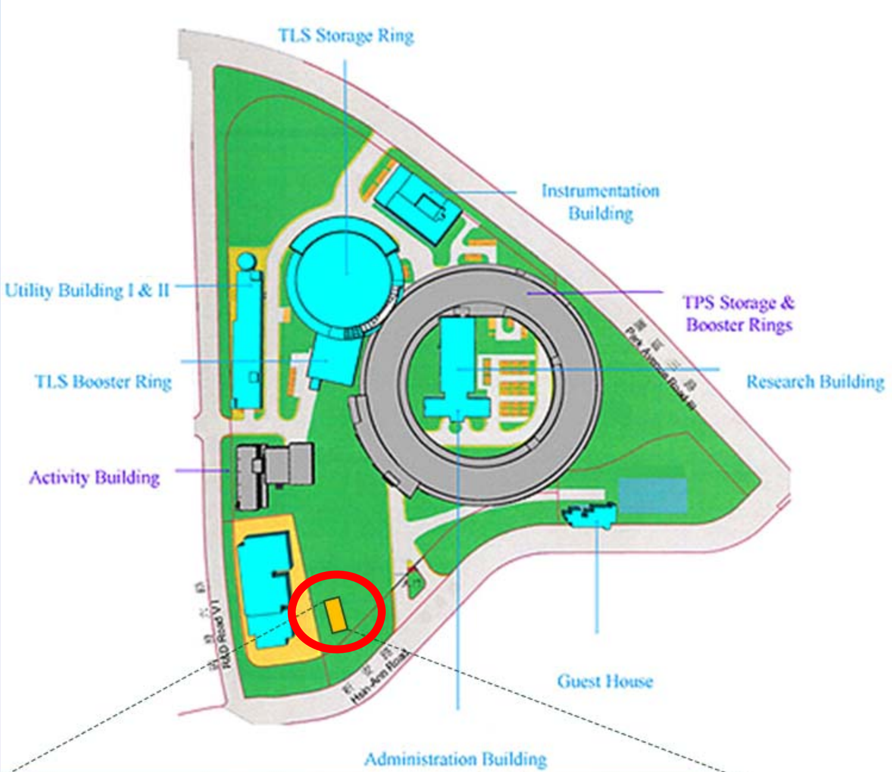
TLS & TPS in NSRRC

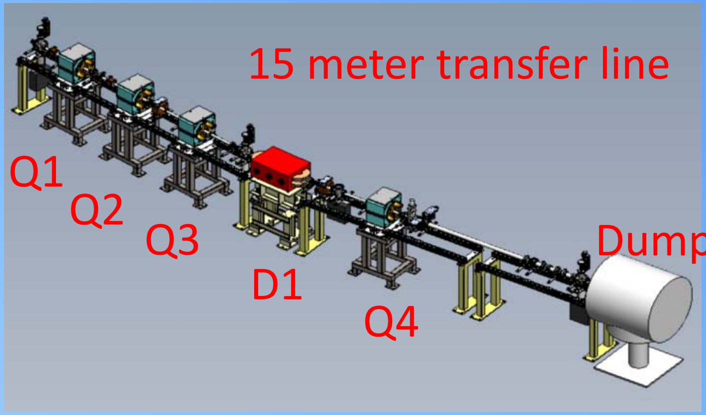


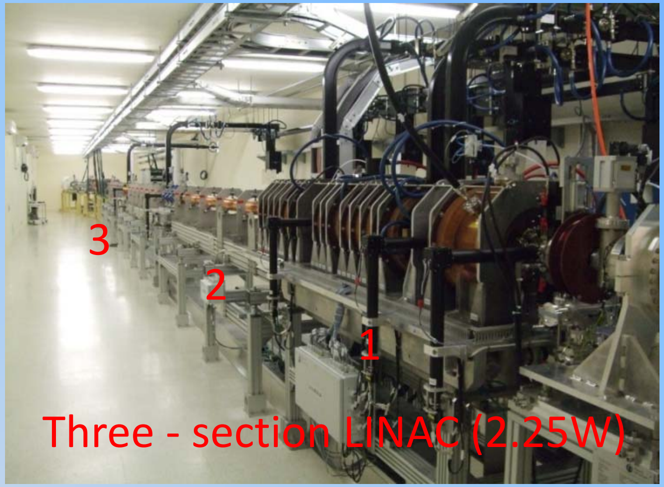


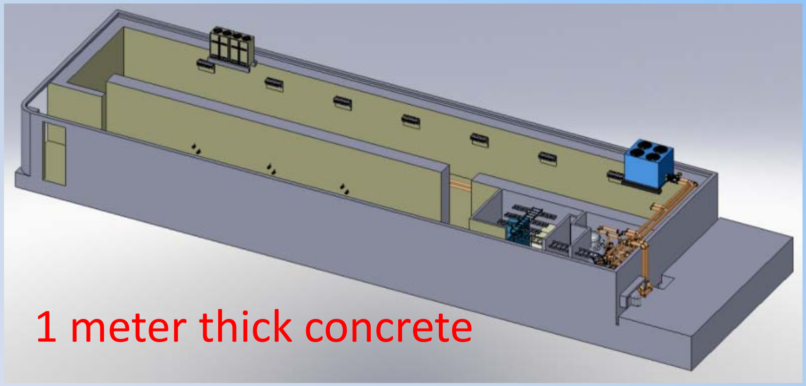
NSRRC	TLS	**TPS**
E_e (GeV)	1.5	**3.0**
I (mA)	360	**400**
C (m)	120	**518**
E_{sb} (J)	216	**2074**
DL (mSv/y)	2	**1**

TPS LINAC


TLS Storage Ring
Instrumentation Building
Utility Building I & II
TPS Storage & Booster Rings
TLS Booster Ring
Research Building
Activity Building
Guest House
Administration Building
R&D Road VI
Han-Ann Road


15 meter transfer line
Q1
Q2
Q3
D1
Q4
Dump


3
2
1
Three - section LINAC (2.25W)

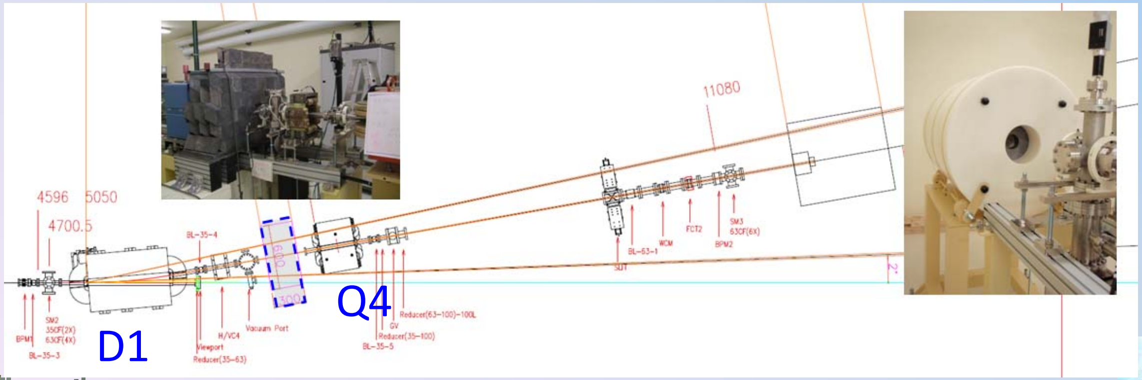

1 meter thick concrete

Radiation measurements

- A series of actions have been carried out to improve radiation safety in the area
  - Access control & beam interlock, radiation survey, local shielding
- Beam loss intensities and locations could change significantly and cause radiation safety concern
- Area monitors and survey meters used to measure radiation around the area
  - Gamma rays : VICTOREEN Model 451P
  - Neutrons : FHT 762
- Radiation survey providing useful information for beam studies

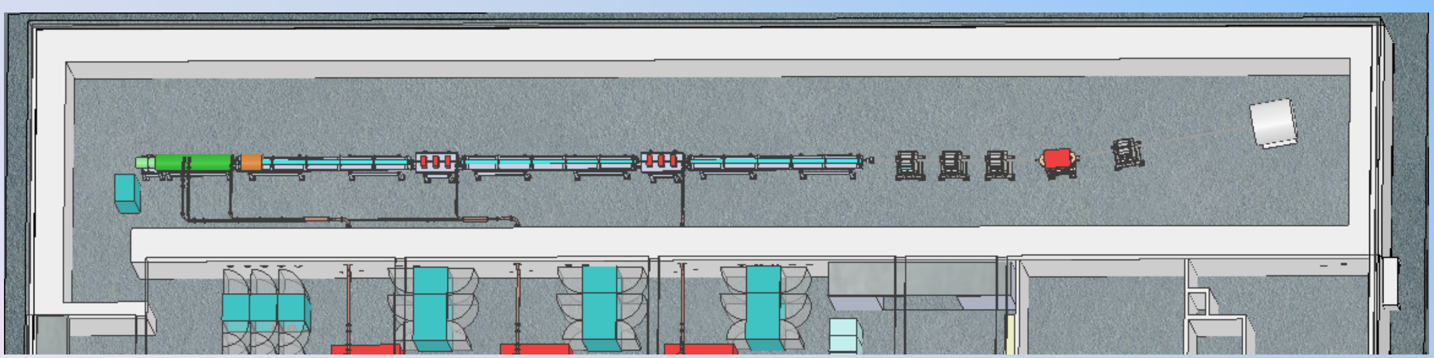
Local shielding & radiation survey

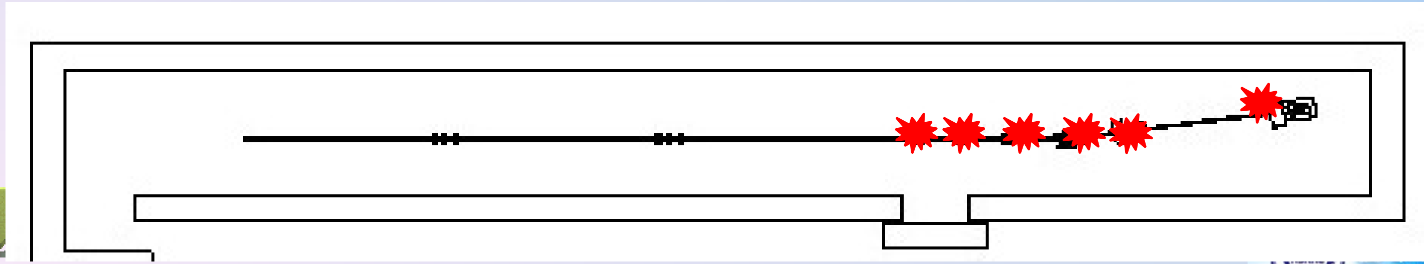
- Gamma-ray dose rates outside the downstream shielding wall could sometime reach to several mSv/h during the initial stage
- Local shielding set up between D1 and Q4
- Gamma-ray dose rates outside the downstream concrete wall are now mostly below a comfortable level about 10 μSv/h; other areas and roof are well-controlled below about 1 μSv/h (full power)



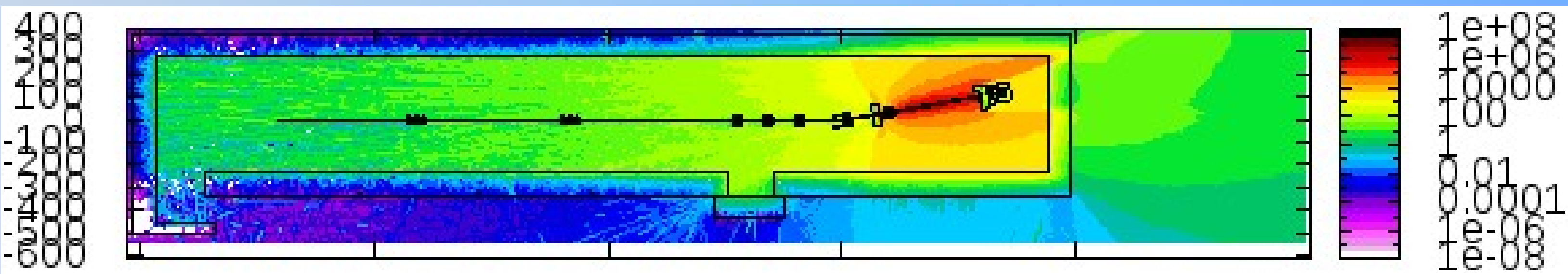
FLUKA simulations

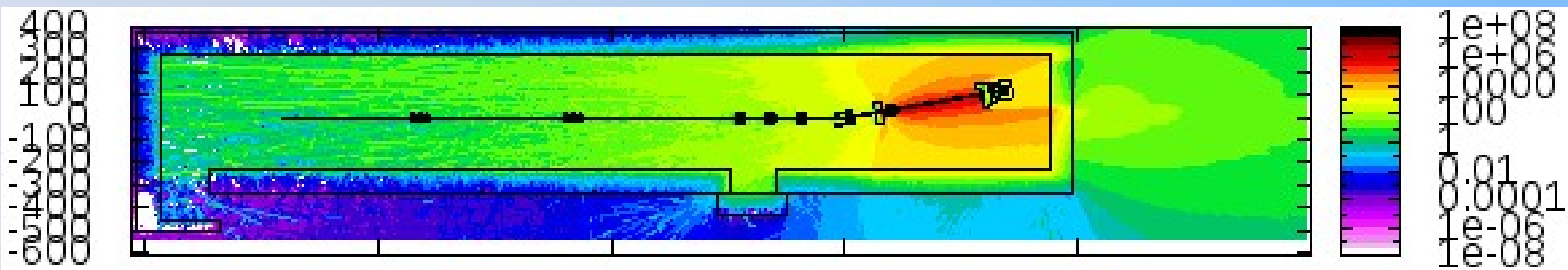
- A rather detailed geometry model was built
  - Main components, bunker structure, and local shielding
- USRBIN for dose distribution
- Fluence-to-ambient dose conversion factors
- Various beam loss locations were considered from LINAC outlet, Q1, Q2, Q3, D1, Q4, and the beam dump

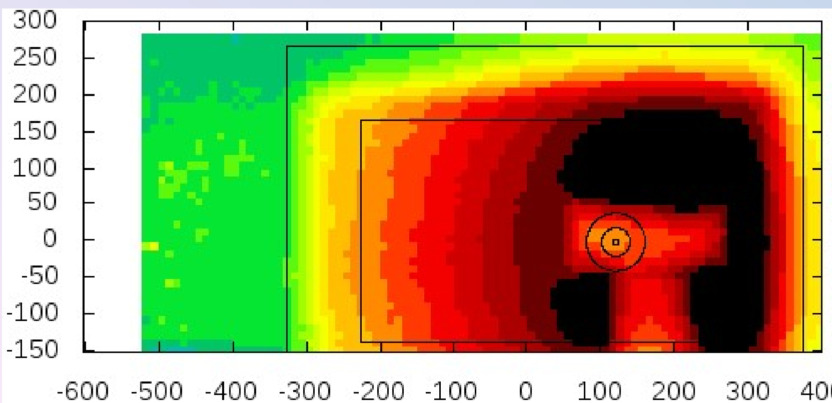


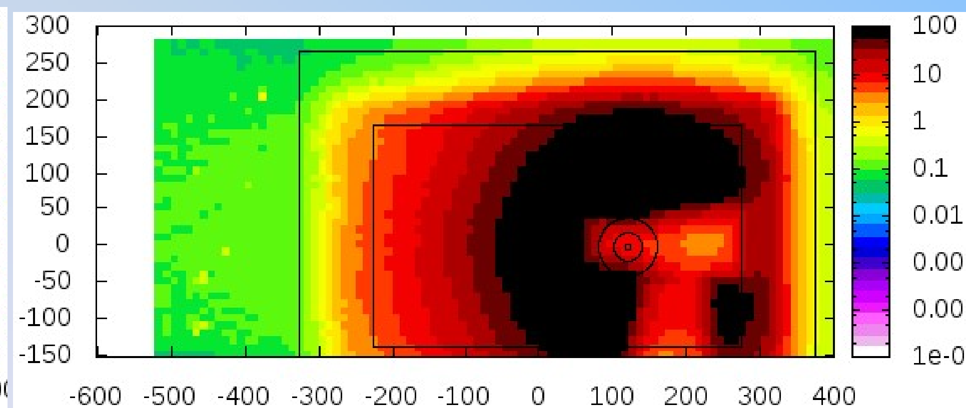


Dose maps for electron scotching pipe in opposite side



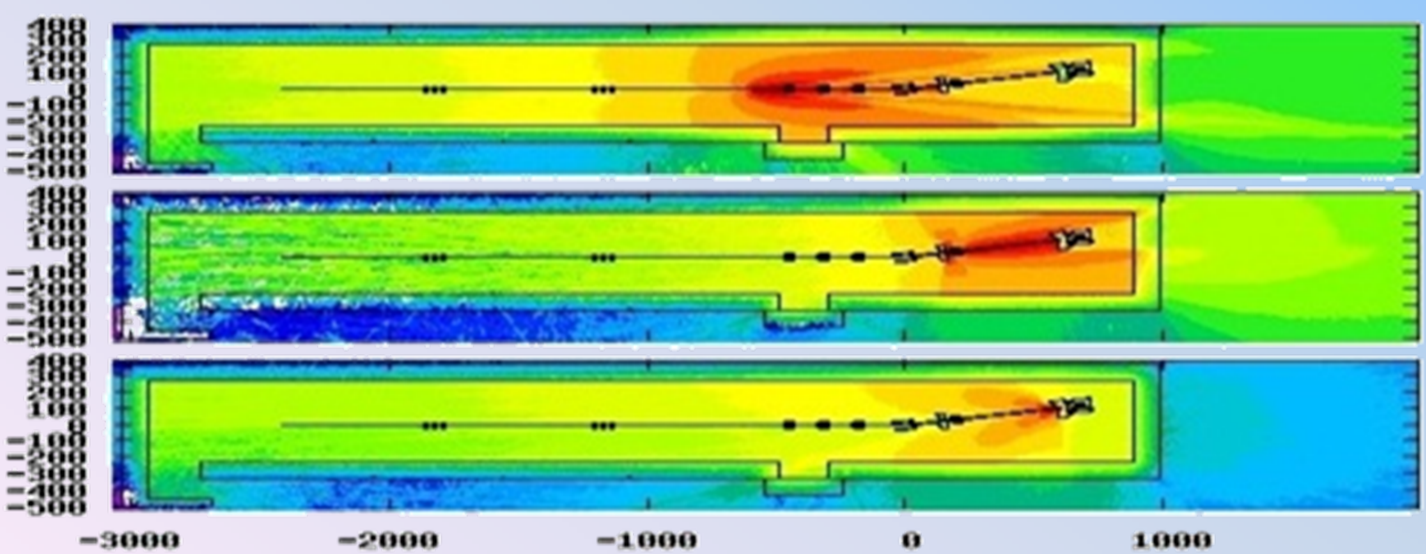


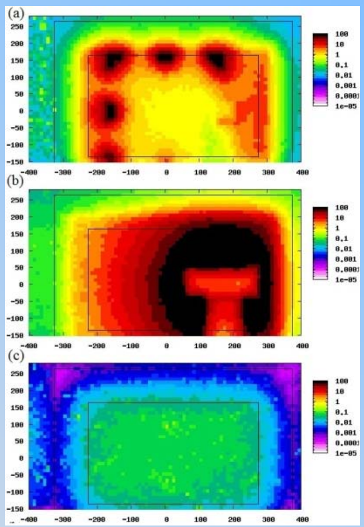




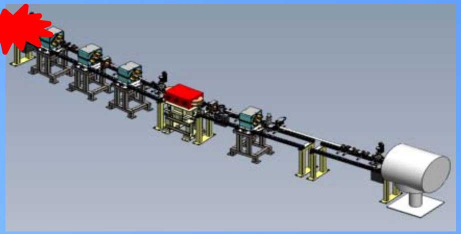
Beam loss patterns & dose distributions

- A series of beam loss scenarios with different electron loss locations along the transfer line has been systematically studied by FLUKA simulations
- The calculated results show a quantitative relationship between beam loss pattern and dose distribution in the area



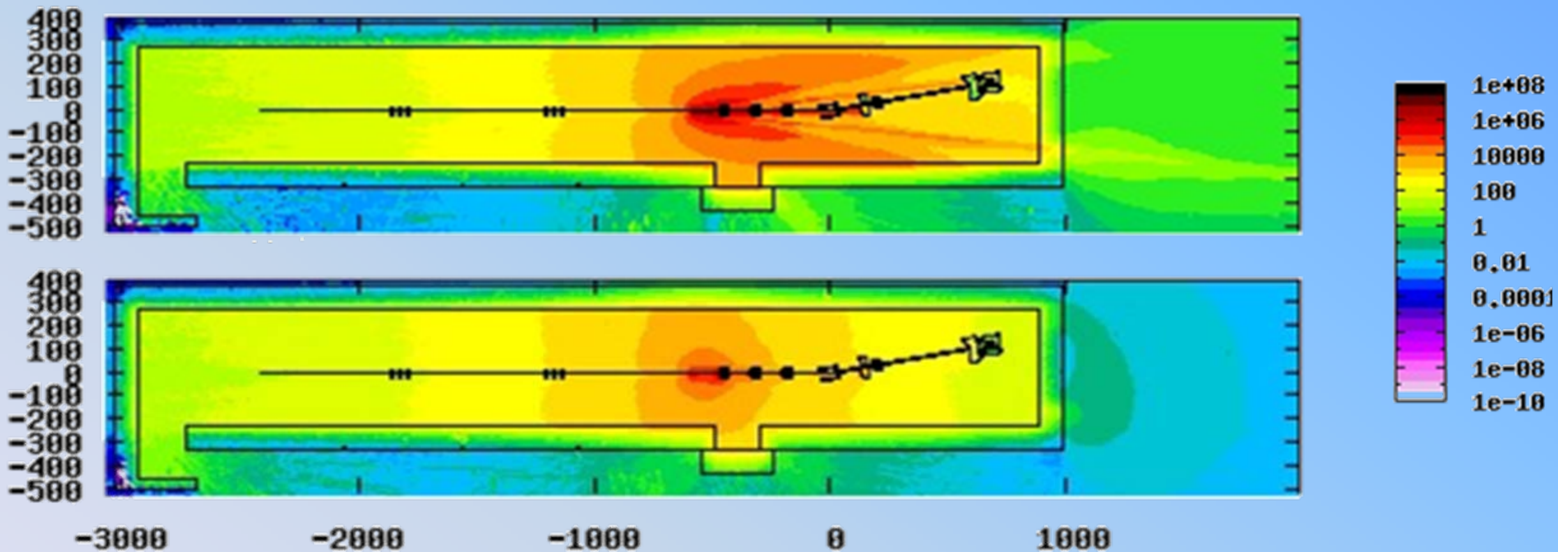


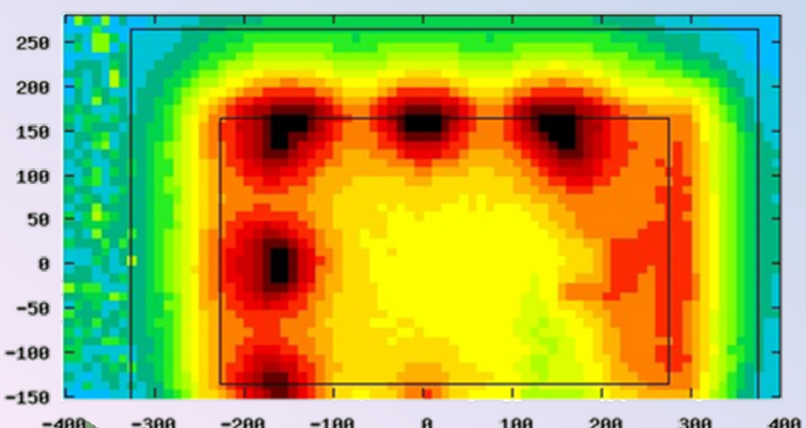
Dose rate distributions for electrons lost at the LINAC outlet



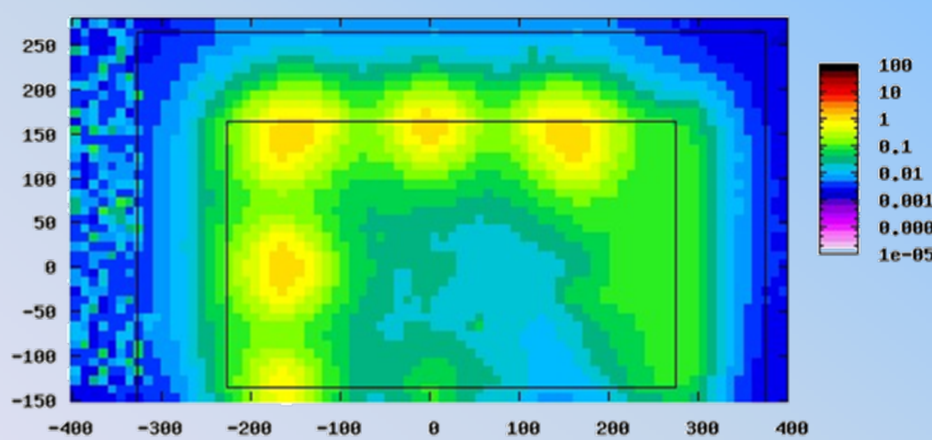
γ-ray

neutron



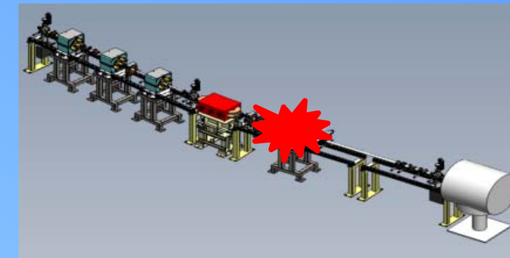


γ-ray on wall



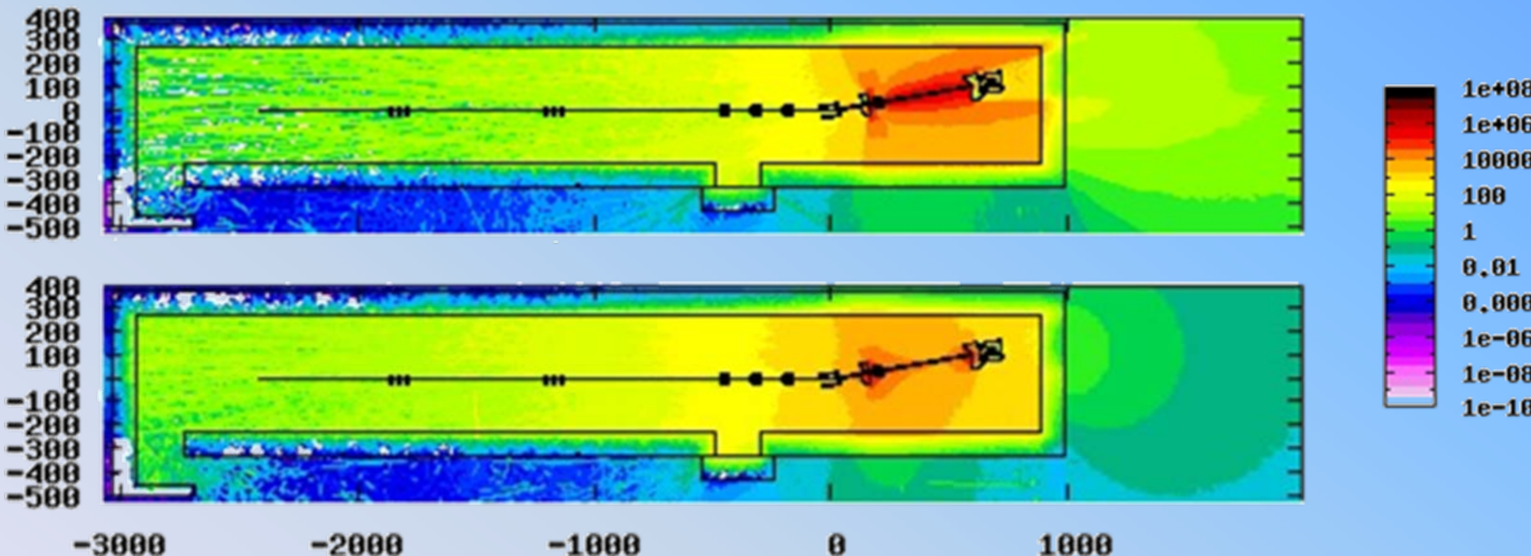
neutron on wall

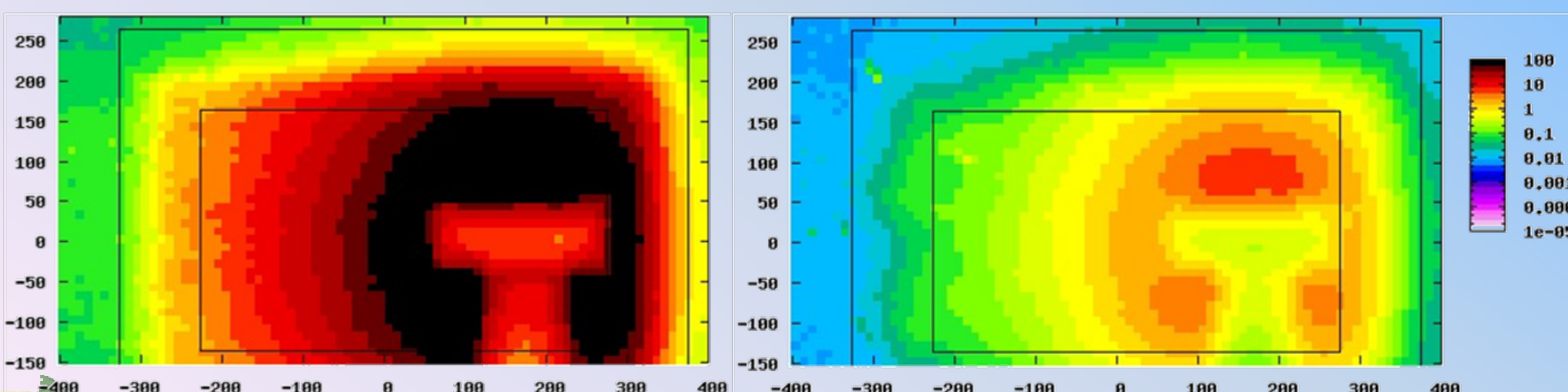
Dose rate distributions for electrons lost near the Q4



γ-ray

neutron

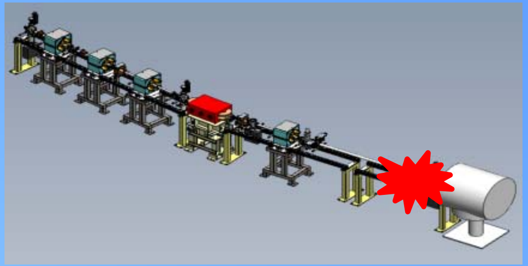




γ-ray on wall

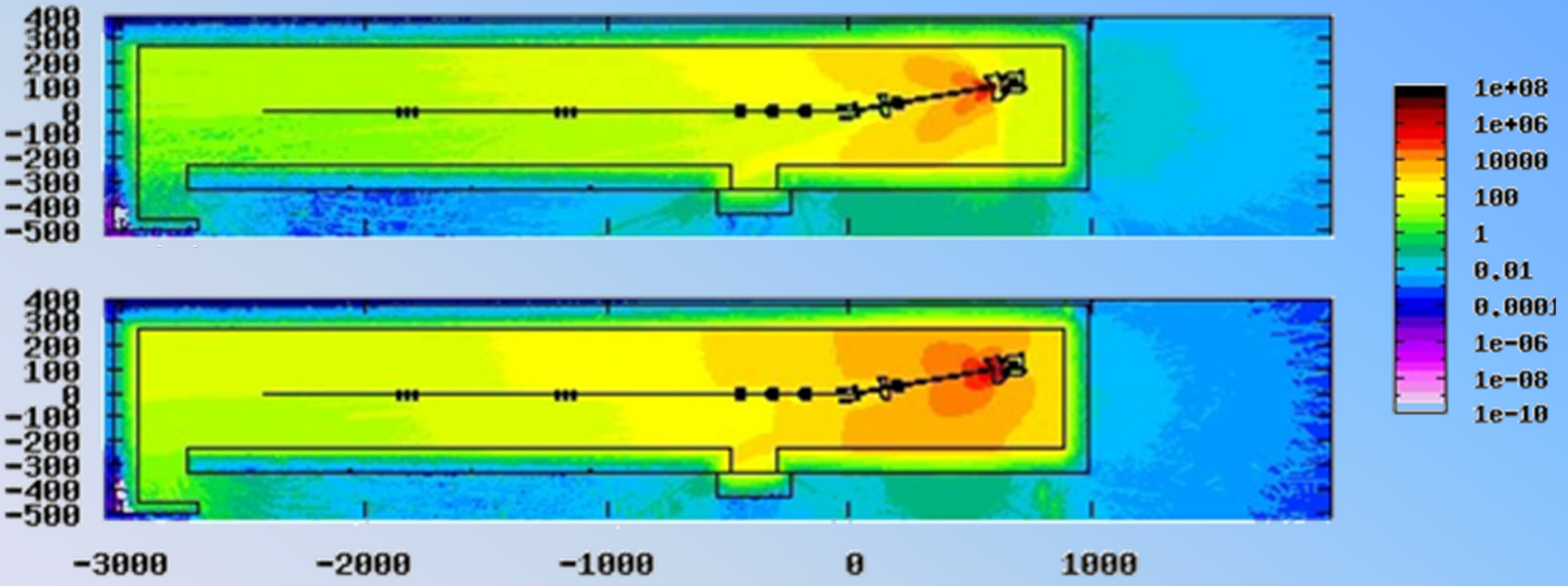
neutron on wall

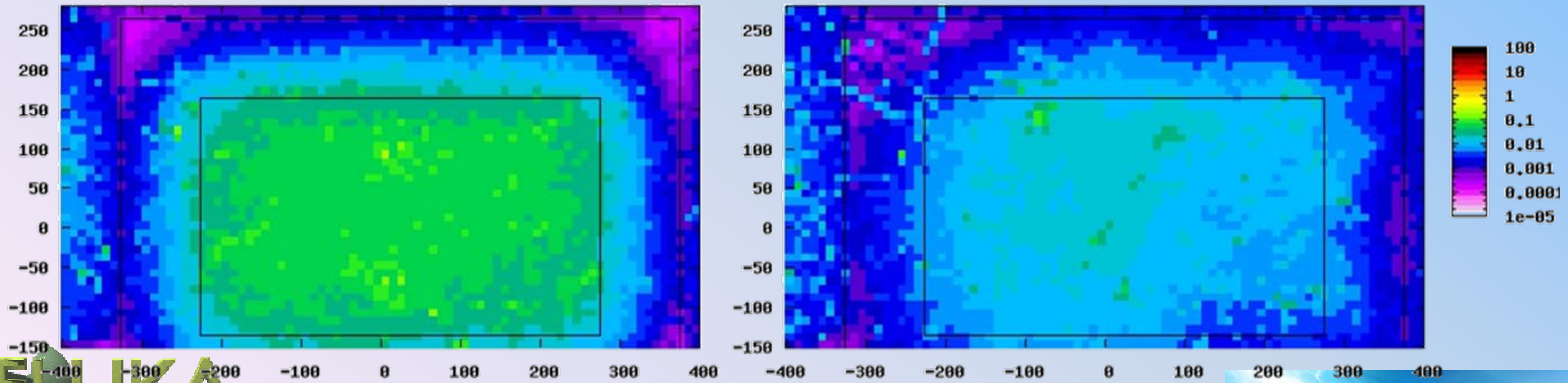
Dose rate distributions for electrons lost at beam dump



γ-ray

neutron

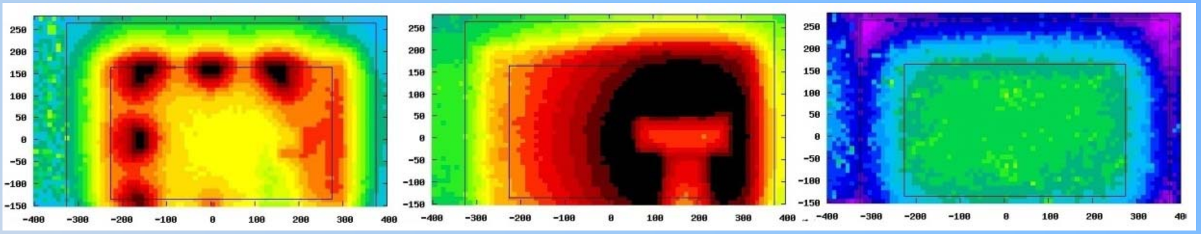




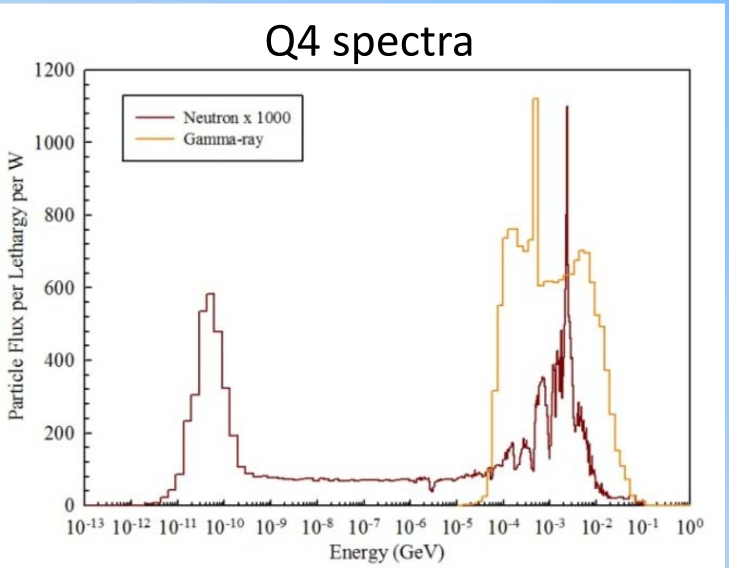
γ-ray on wall

neutron on wall

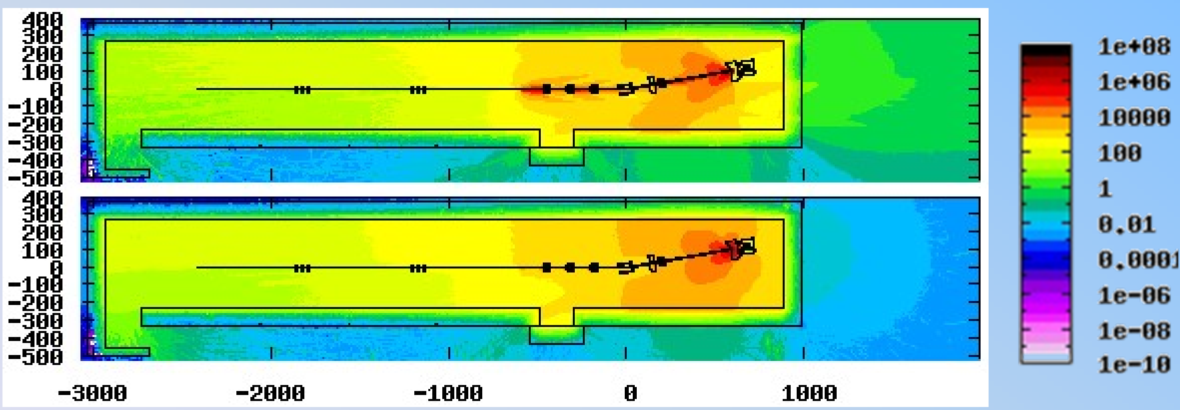
Beam loss patterns & dose distributions

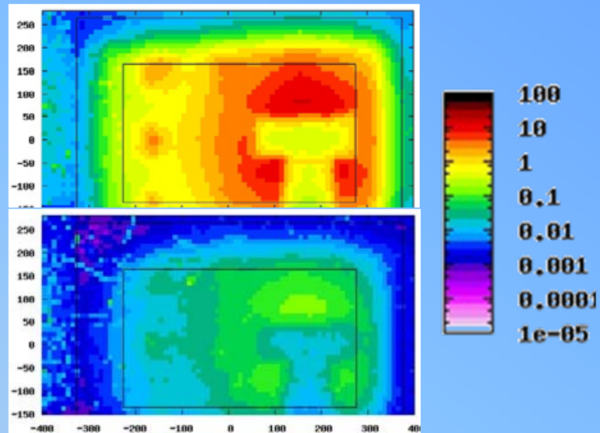


- Differences between the resultant dose distributions caused by different beam loss scenarios are evident
- These distinguishing dose response functions could be used to analyze measured results
- Beam losses near Q4 play a dominant role in the magnitude of downstream dose rates - consistent with our experience during commissioning
- Neutron and gamma-ray spectra due to electrons lost at Q4

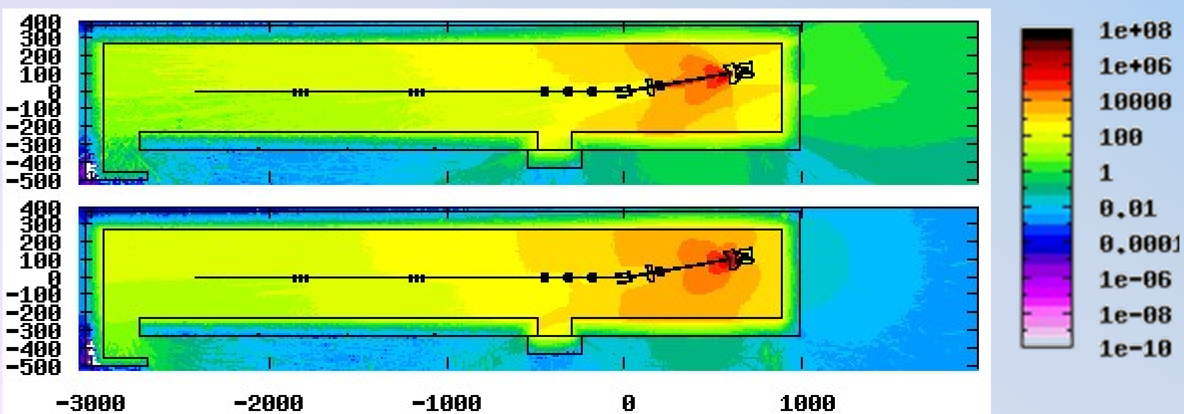


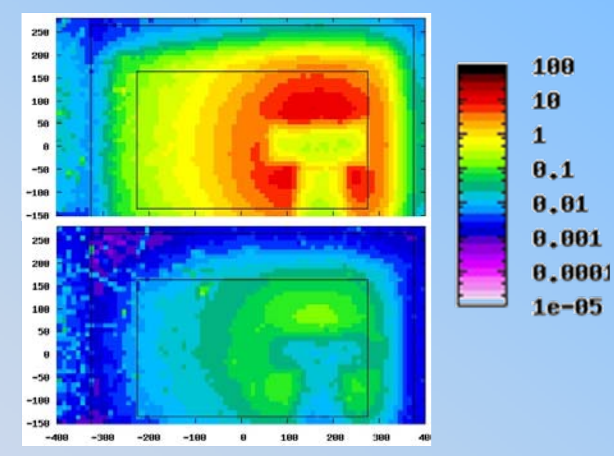
The dose distributions of some proposed beam loss scenarios





1% loss at linac outlet, 1% loss at Q2, and 2% loss at Q4





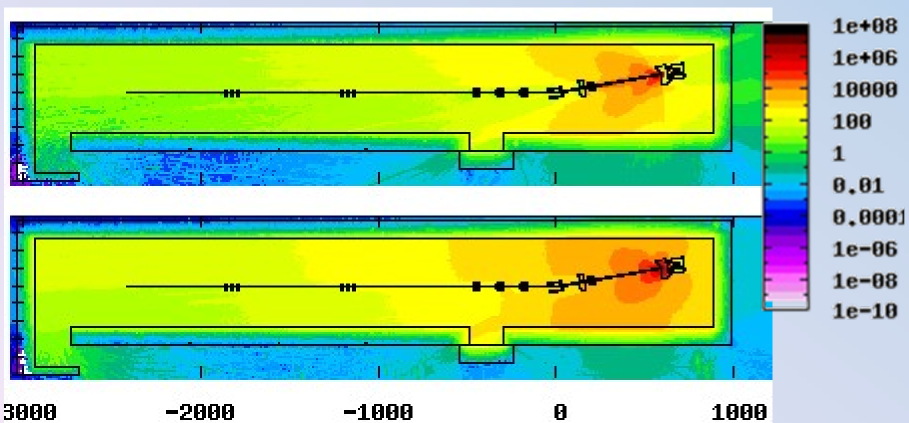
2% loss at Q4

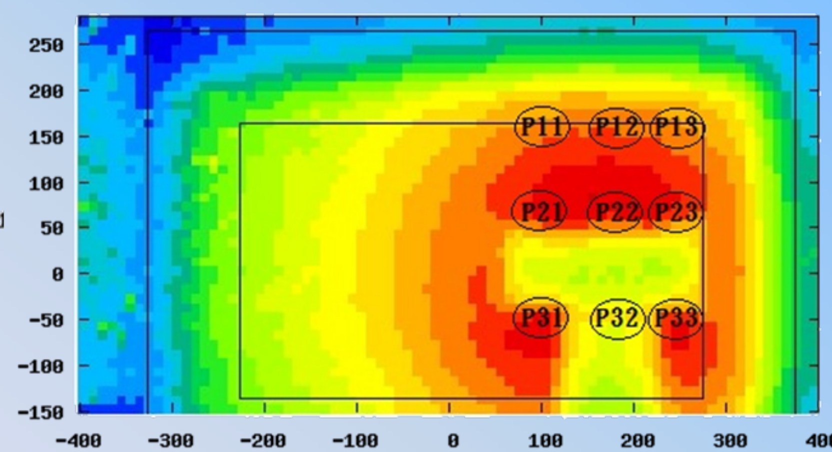
Calculations & measurements

Position	P11	P12	P13	P21	P22	P23	P31	P32	P33
1% at Q4	1.8±1.0%	2.3±3.6%	1.6±3.6%	4.1±2.0%	3.7±2.0%	2.8±2.7%	5.1±2.1%	0.3±4.6%	4.1±3.2%
2% at Q4	3.6±0.9%	4.5±3.7%	3.2±3.7%	8.0±2.0%	7.3±2.0%	5.5±2.8%	10.2±2.1%	0.5±5.2%	8.2±3.2%
3% at Q4	5.3±0.9%	6.7±3.7%	4.7±3.7%	12.0±2.0%	11.0±2.0%	8.2±2.8%	15.2±2.1%	0.7±5.4%	12.2±3.2%
Measured	2.7	5.3	4.2	2.7	8.3	7.3	11.9	0.3	8.8

low

high





- A measurement on Sep. 23, 2011 by model 451P
- Scenario : 2% at Q4 and 98% to Dump

Conclusions

- A series of simple point beam loss scenarios were used to calculate dose distributions around the LINAC area
  - Some resultant dose distributions are distinguishing with each other and can be regarded as response functions
- Dose distributions due to different beam loss scenarios are different and distinguishable, which could be used to identify possible beam loss locations
- This study has demonstrated that a reasonable beam loss pattern and a detailed dose distribution could be obtained through a synthetic analysis of the calculated response functions and on-site dose rate measurements

Thanks for your attention