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Radiation Measurements vs. Predictions for SNS LINAC Commissioning

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Outline

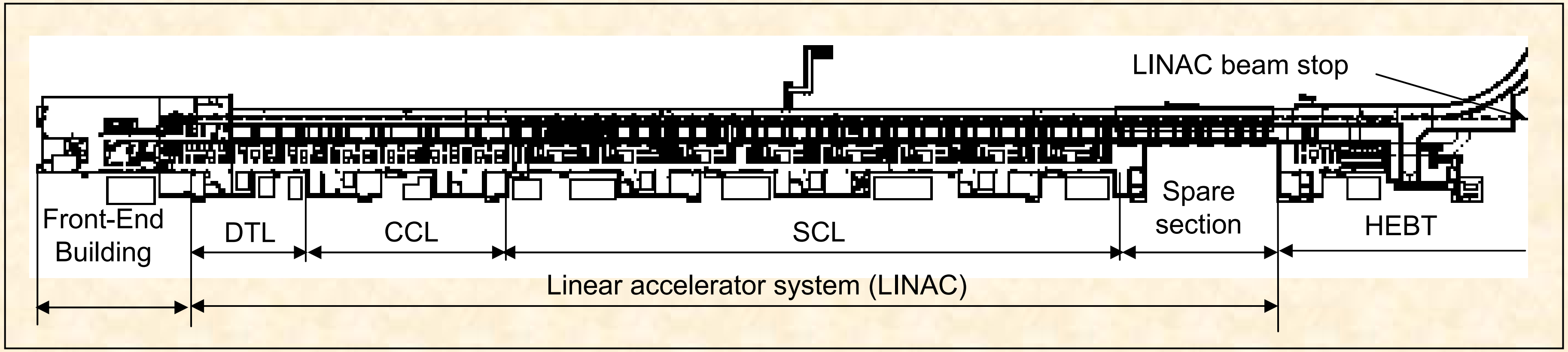
- Introduction
- General LINAC Layout
- Commissioning, schedule, parameters
- Methods and tools
- Results
- Conclusions

Introduction

- **Spallation Neutron Source (SNS) accelerator facility consists of following sections: LINAC, High Energy Beam Transfer (HEBT), Accumulator Ring and Ring to Target Beam Transfer (RTBT)**
- **High-intensity 2-mA, 1-GeV proton beam**
- **Commissioning of the accelerator system is a transition from the fabrication and installation phase to the operational phase**
- **The H^--beam power deposited in the LINAC tunnel during commissioning greatly exceed the typical operational line losses**

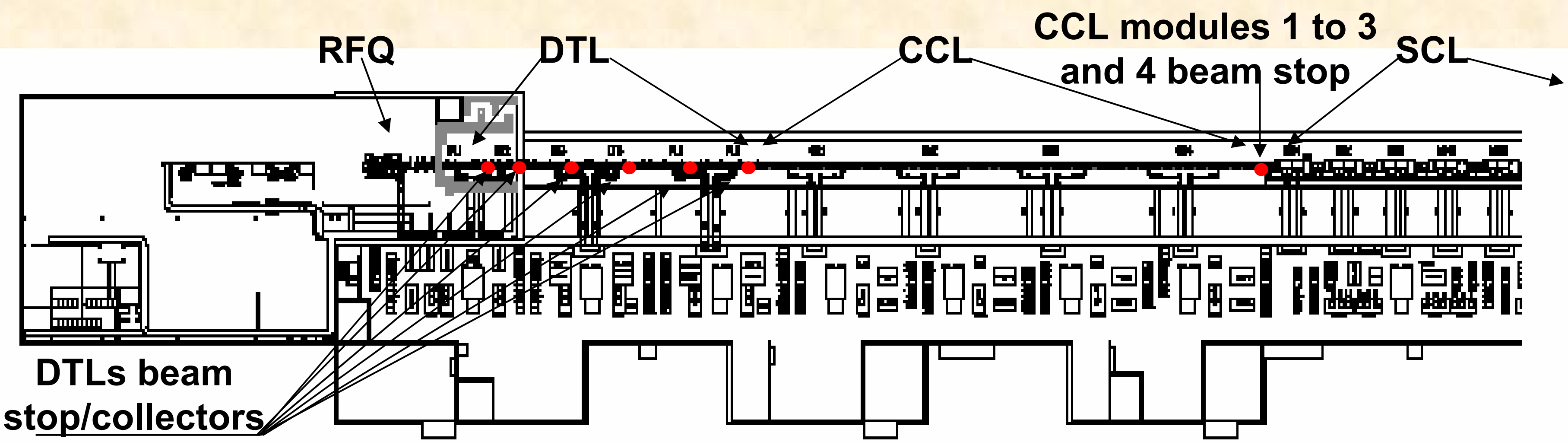
General LINAC Layout

- **In LINAC section H- beam is accelerated from 2.5 MeV up to 1 GeV**



Commissioning, schedule, parameters

Parameters	DTL tanks						CCL modules				SCL
	1	2	3	4	5	6	1	2	3	4	
Beam stop material	Nickel										
	Copper										
	Copper										
	Copper										
	Copper										
Beam energy MeV	7.5	22.3	39.8	56.6	72.5	86.8	107	132	157	157	1000
Beam power, W	16000	160	160	160	160	160	250	250	250	250	250



Methods and tools

Calculations:

- **Performed with MCNPX**
- **Using realistic 3D geometry models**

Uncertainties in calculations

- **Geometry representation in calculations**
  - **Simplification in geometry**
  - **Homogenization of some components**
- **Uncertainties in material composition**
- **Assumptions in source representations**
- **Accuracy in physics model and cross sections data**
- **Statistical errors in the code**

Methods and tools

Detectors:

- Chipmunk: Fermilab-designed neutron and gamma sensitive PPS detector
- Commersial detector unit from Far West
- Eberline RO-7: gamma sensitive
- REM500 survey meter: neutron sensitive
- Far West HPI 1030 survey meter for pulsed fields: gamma and neutron sensitive
- Remball: neutron sensitive
- TLDs

Results

DTL tank 1

Location/ Detector	Particle type	Dose rate (mrem/hr)		
		M	C	M/C
Above PE shield/TLD	neutron gamma	92 564	5 1100	18.4 0.51
Backscattering cone/TLD	neutron gamma	464 88	55 25	8.4 3.7
Detector cluster/RO-7	gamma	7	6	1.12
Detector cluster/chipmunk	neutron+ gamma	6.8	9.5	0.72
Detector cluster/ Far West	neutron+ gamma	6.4	9.5	0.72

Results

DTL tank 1 to 3

Location/ Detector	Particle type	Dose rate (mrem/hr)		
		M	C	M/C
Back-streaming cone	Neutron	1.020	0.924	1.1
	Gamma	0.248	0.180	1.4
Top of beam stop shielding	Neutron	0.832	0.650	1.28
	Gamma	0.186	0.100	1.8
Tunnel wall at beam stop level	Neutron	0.182	0.100	1.8
	Gamma	0.054	0.075	0.72

Results

DTL tank 1 to 6, CCL Modules 1 to 3
Beam stop

Location/ Detector	Particle type	Dose rate (mrem/hr)		
		M	C	M/C
On the North side of the beam stop shielding monolith, against the block wall	Neutron	88,000	98,000	0.90
	Gamma	5000	6000	0.83
On the tunnel wall directly opposite the beam stop shield monolith	Neutron	32,000	16,000	2.0
	Gamma	1000	900	1.1
Along the tunnel north wall, 20’ upstream of the beam stop	Neutron	7000	3500	2.0
	Gamma	180	130	1.4
Near the tunnel wall, next to the real time instruments	Neutron TLD	2300	900	2.2
	Neutron Far West	2000	900	2.6
	Gamma	61	31	2

Results

DTL tank 1 to 6, CCL Modules 1 to 3 FC

Location/ Detector	Particle type	Dose rate (mrem/hr)		
		M	C	M/C
On the collector side of penetration shielding	Neutron	320,000	257,000	1.3
	Gamma	11000	2420	4.6
On the penetration side of shielding	Neutron	215,000	42,000	5.1
	Gamma	5000	1082	4.6
On the North wall of the tunnel, directly opposite to the collector	Neutron	140,000	110,000	1.3
	Gamma	3200	1040	3.1
At the top of the penetration, in the center opening (RemBall)	Neutron TLD	5	11	0.5

Results

DTL tank 1 to 6, CCL Modules 1 to 4 and SCL

Detector type	Units, particles	Penetration 91		Penetration 94		Penetration 95	
		M	M/C	M	M/C	M	M/C
Albatross	(mrad/h)	1.00	0.42	4.00	0.20	15.00	0.75
Remball	(mrem/h)	2.70	0.18	19.00	0.16	15.00	0.13
Snoopy	(mrem/h)	0.40	0.03	0.70	0.01	1.70	0.01
Rem500	(mrem/h)	4.70	0.31	101.00	0.85	169.00	1.44
RO20	(mrem/h)	0.60	1.20	3.70	1.32	11.00	3.67
MicroRem	(μrem/h)	95.00	0.19	150.00	0.05	165.00	0.06
Calculations	(mrem/h) Neutrons	15.00		119.00		117.00	
	(mrad/h) Neutrons	2.40		20.00		20.00	
	(mrem/h) Gammas	0.50		2.80		3.00	

Conclusions

- Detailed predictions for radiation fields were performed and appropriate shielding was installed
- Radiation was monitored using real time radiation measurement devices and TLDs
- The measured radiation fields were analyzed and compared with transport simulations.
- TLD readings and calculations are in a good agreement, generally within a factor of two
- A large inconsistency among instrument readings was observed, and an effort is underway to understand the differences.