Development of the Dielectric Wall Accelerator

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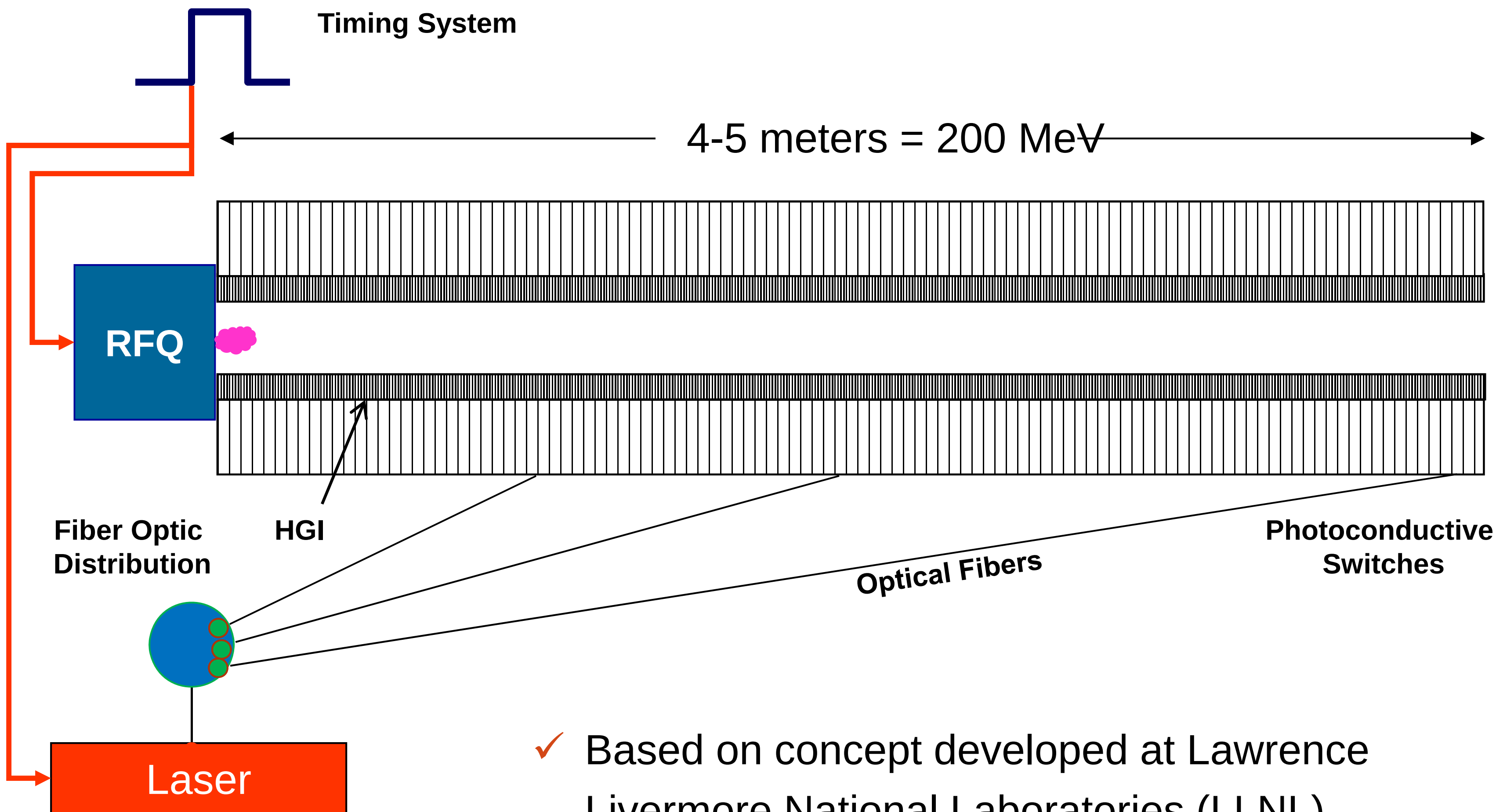
Presentation Content

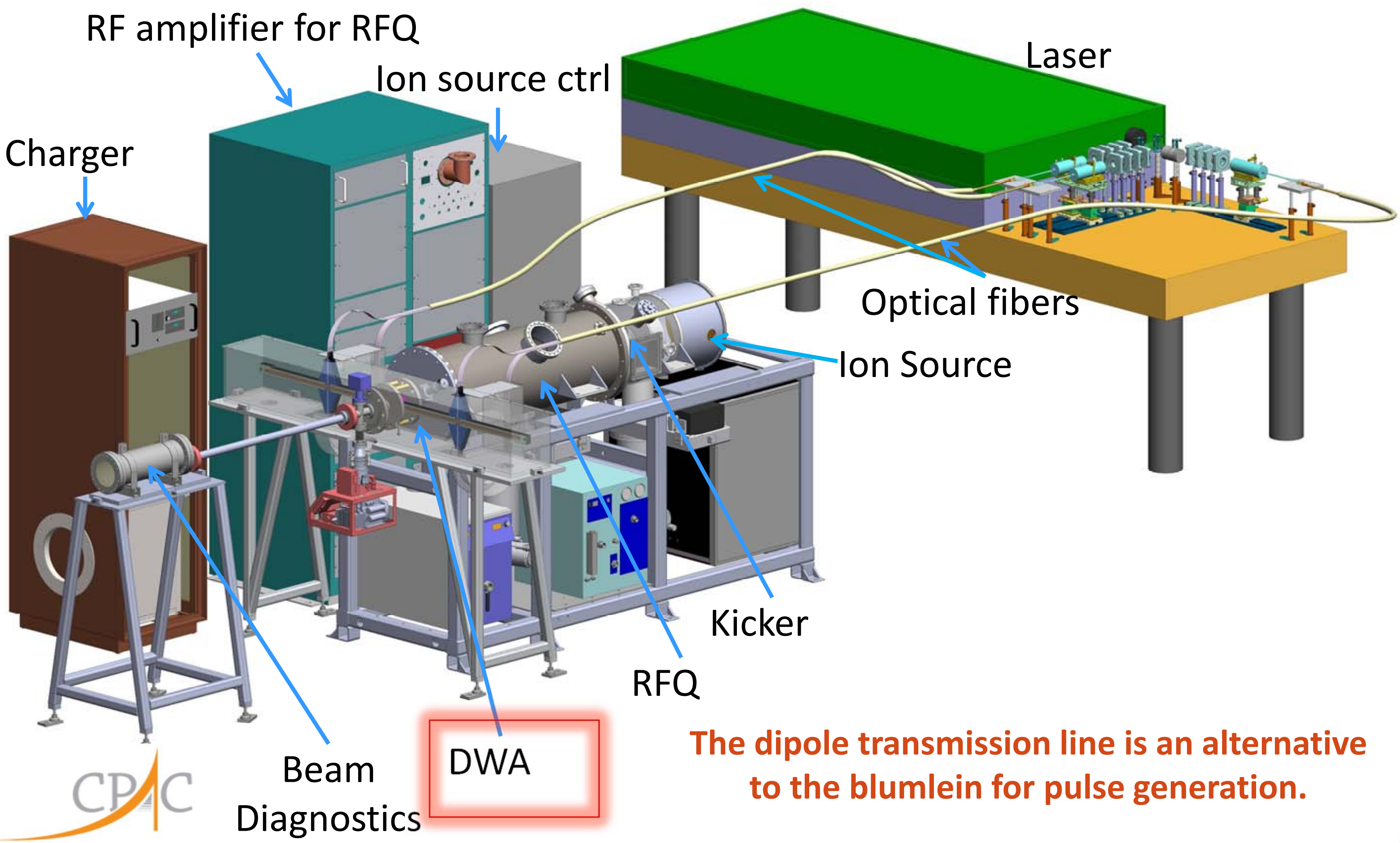
- Dielectric Wall Accelerator (DWA) introduction
- “Dipole” pulsing concept
- Single dipole model and results
- A dipole DWA system model and results
- Radiation leakage calculations
- Conclusions

Dielectric Wall Accelerator (DWA)



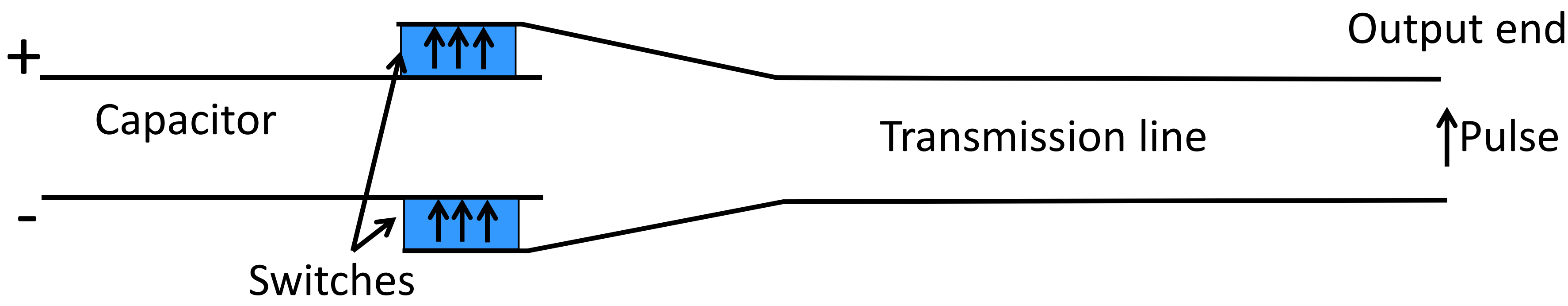
- ✓ Based on concept developed at Lawrence Livermore National Laboratories (LLNL).
- ✓ CPAC has an exclusive license to the DWA technology for all applications.

Prototype System



The dipole transmission line is an alternative to the blumlein for pulse generation.

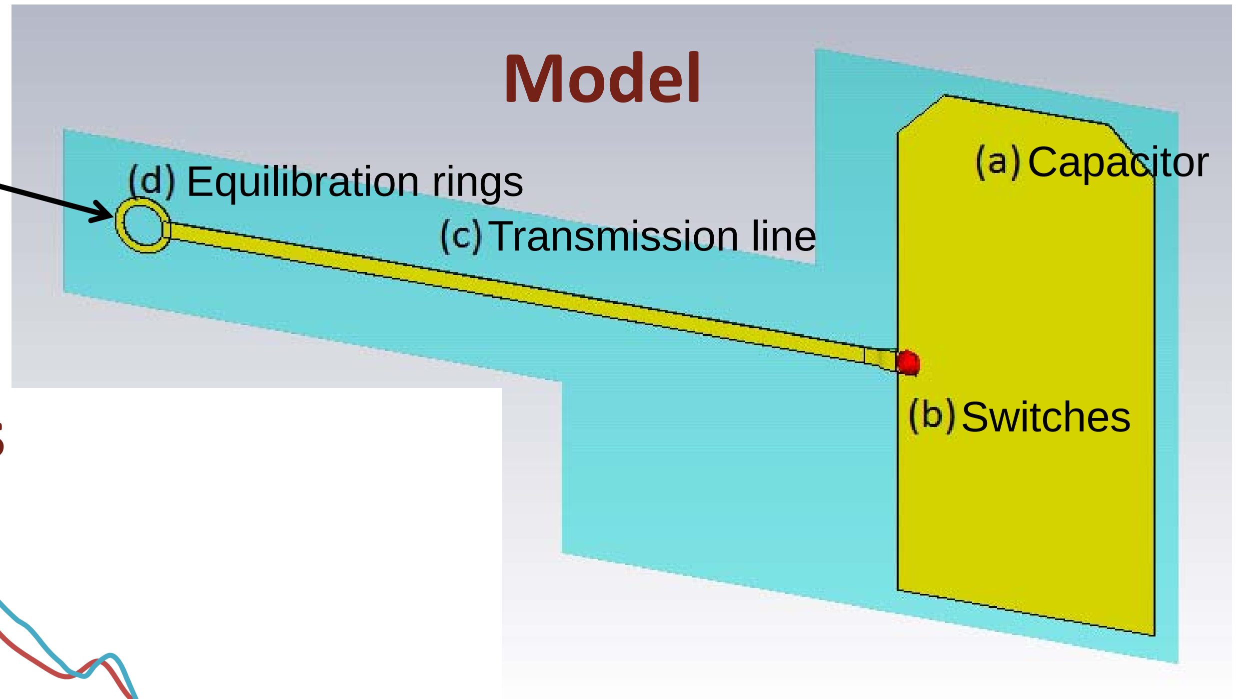
"Dipole" Pulsing Concept

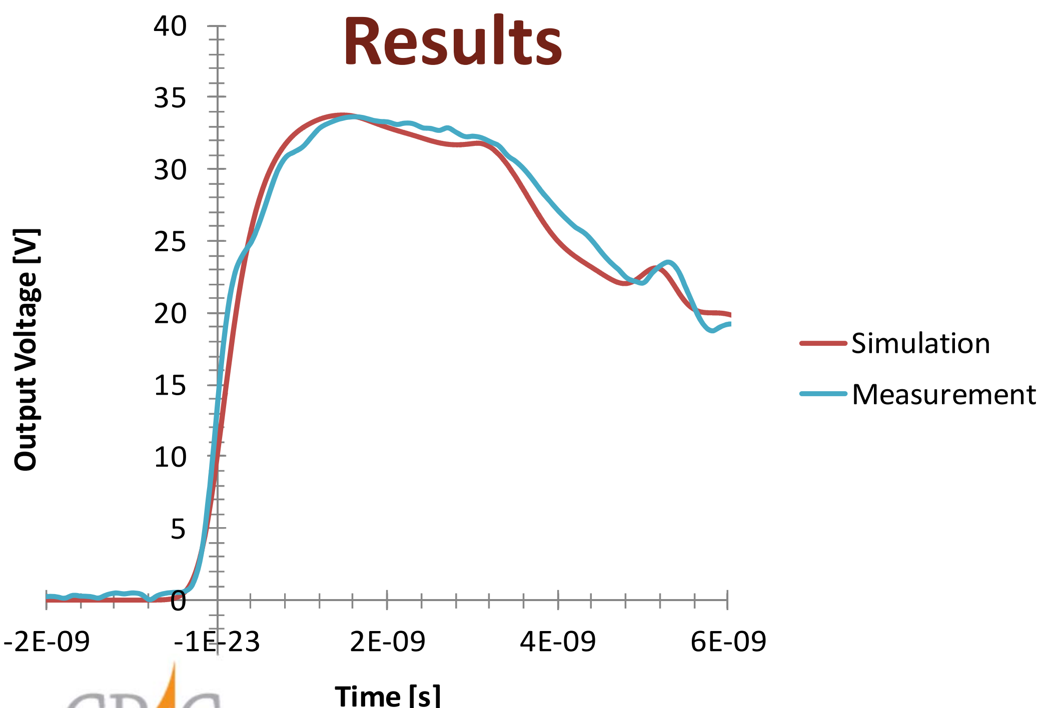


- The transmission line is connected to the capacitor through the switches.
- The capacitor is charged prior to switch closure.
- The switches closes at the same time, with the polarities of the voltages across the switches being opposite; hence, the named "dipole" concept.

Single dipole geometry

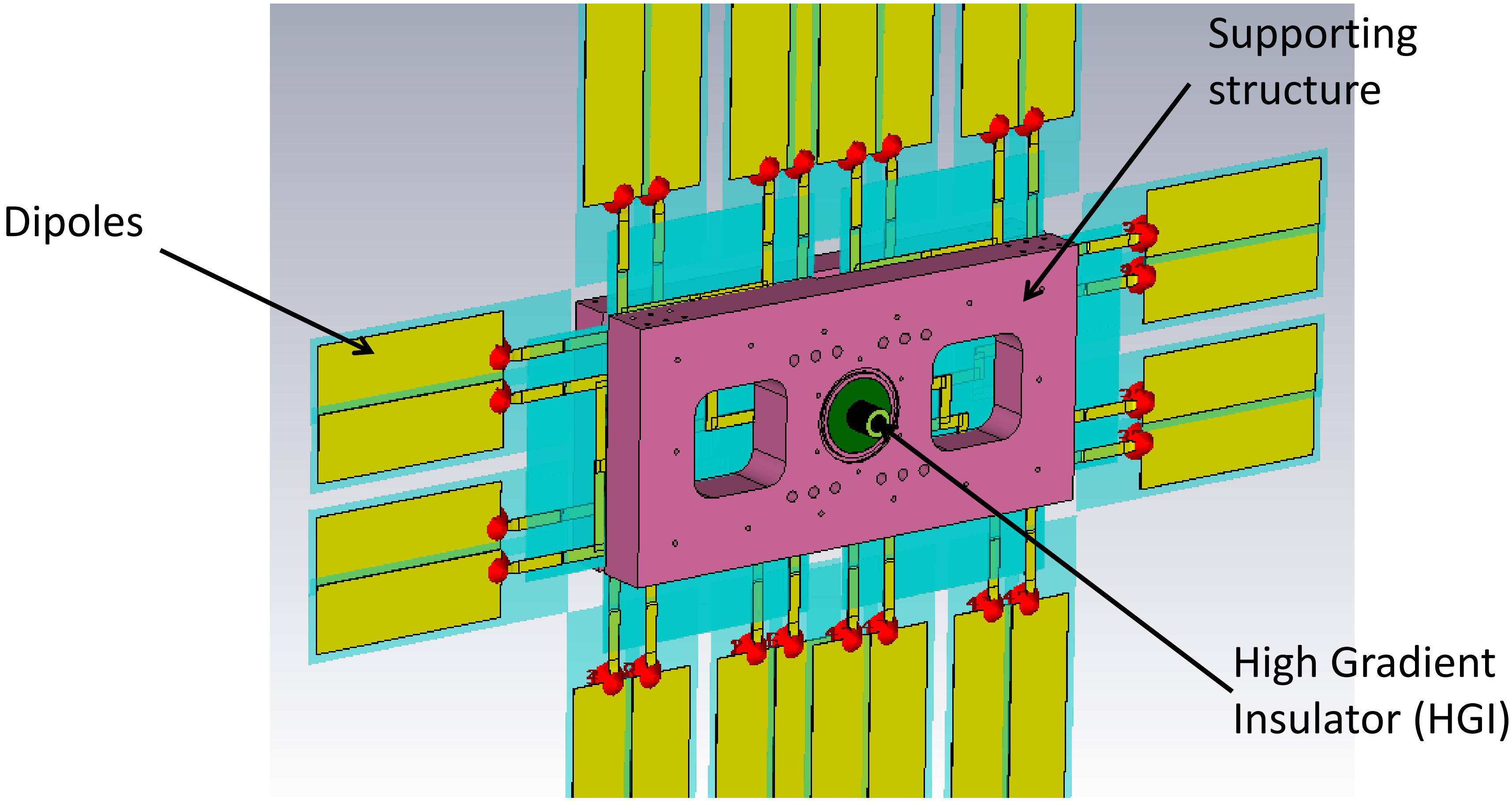
Probe connection point





Simulation agrees well with measured results in both magnitude and waveform.

Dipole DWA System



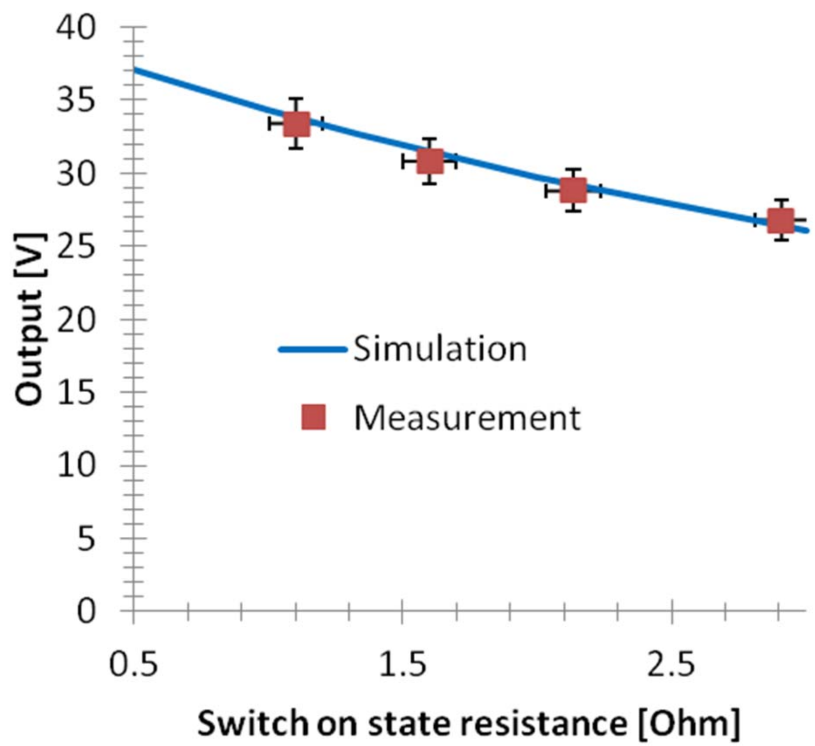
A DWA system model with 24 dipoles.

Experimental Measurements

In order to validate the model of the system, three different experimental measurements were made:

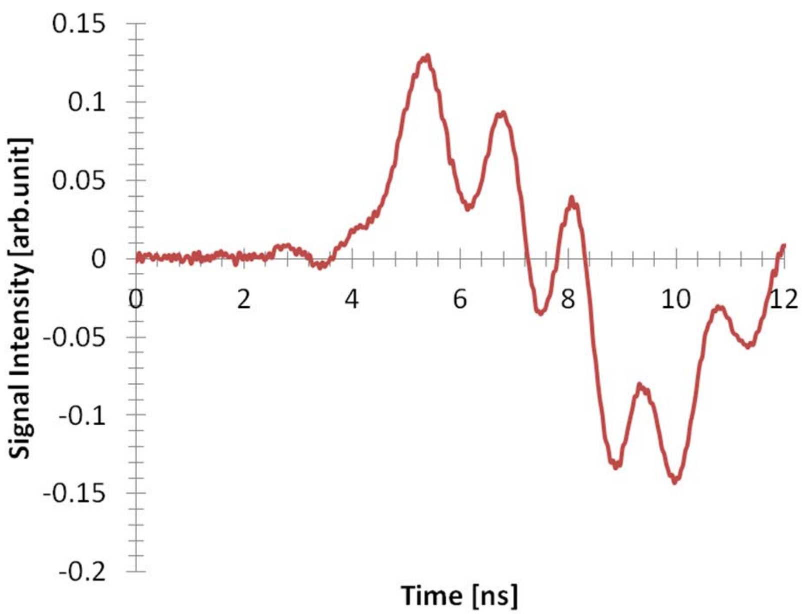
1. Measurement of output voltage of the 24 dipoles with a fast probe at low system charge voltages.
2. Fringe field measurement in the High Gradient Insulator (HGI) with a capacitive probe.
3. Proton energy measurement with Time Of Flight (TOF) at high system charge voltages.

Results: Voltage Probe

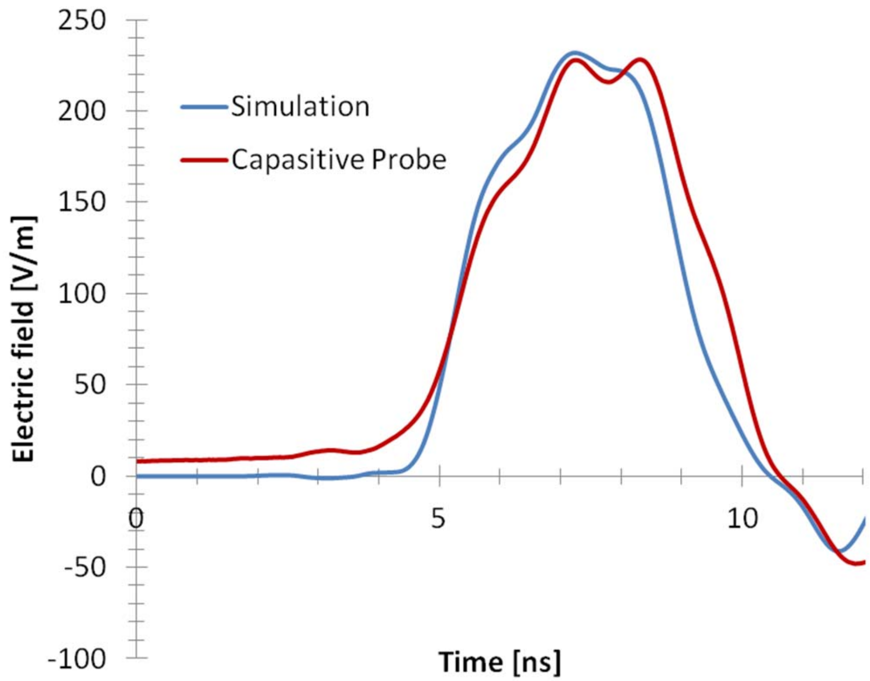


Peak values of total output voltage measured at a low system charge voltage.

Results: Capacitive Probe

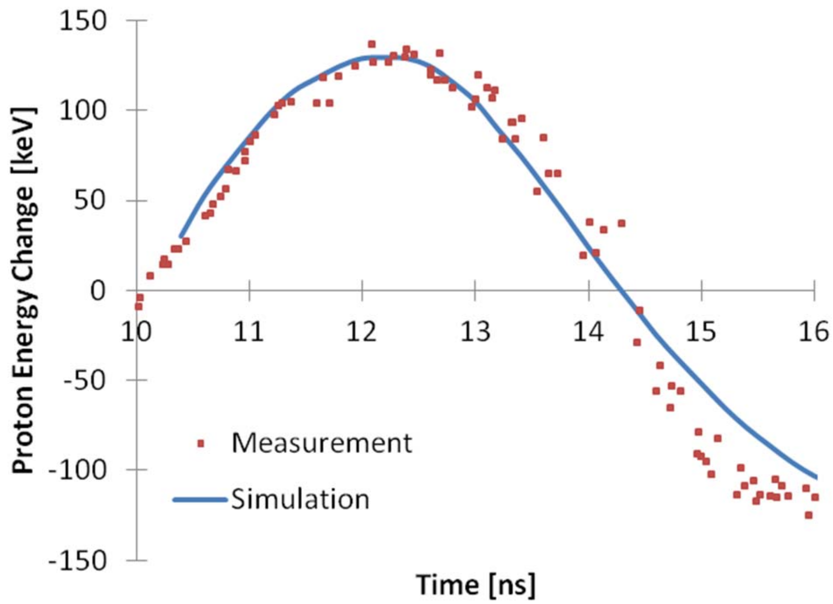


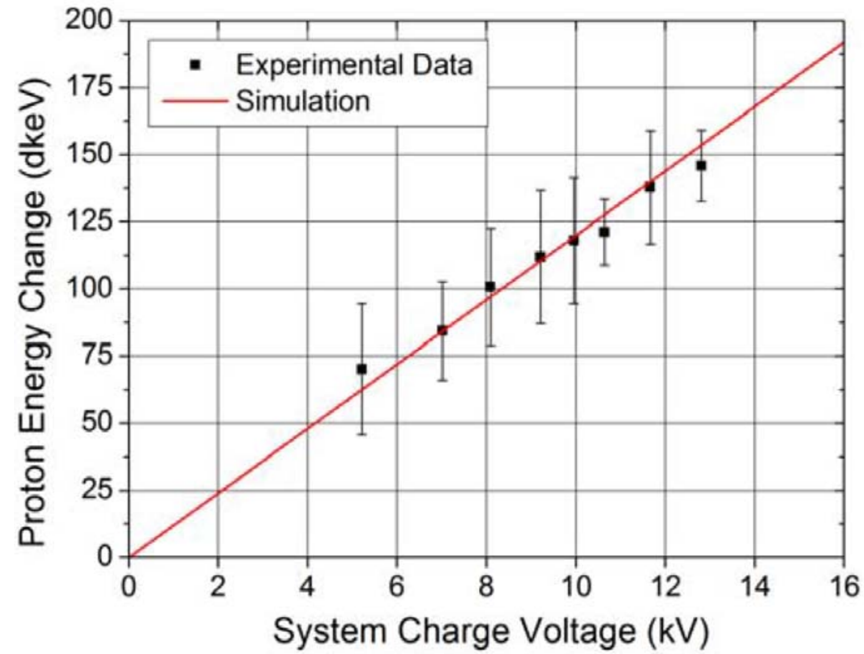
Capacitive probe raw signal.



Simulated fringe field temporal profile and integrated capacitive probe signal.

Proton Energy Gain Measurements





Proton energy change at the exit of HGI for a ~10 kV charge voltage.

Peak proton energy change for 5-13 kV capacitor charge voltage.

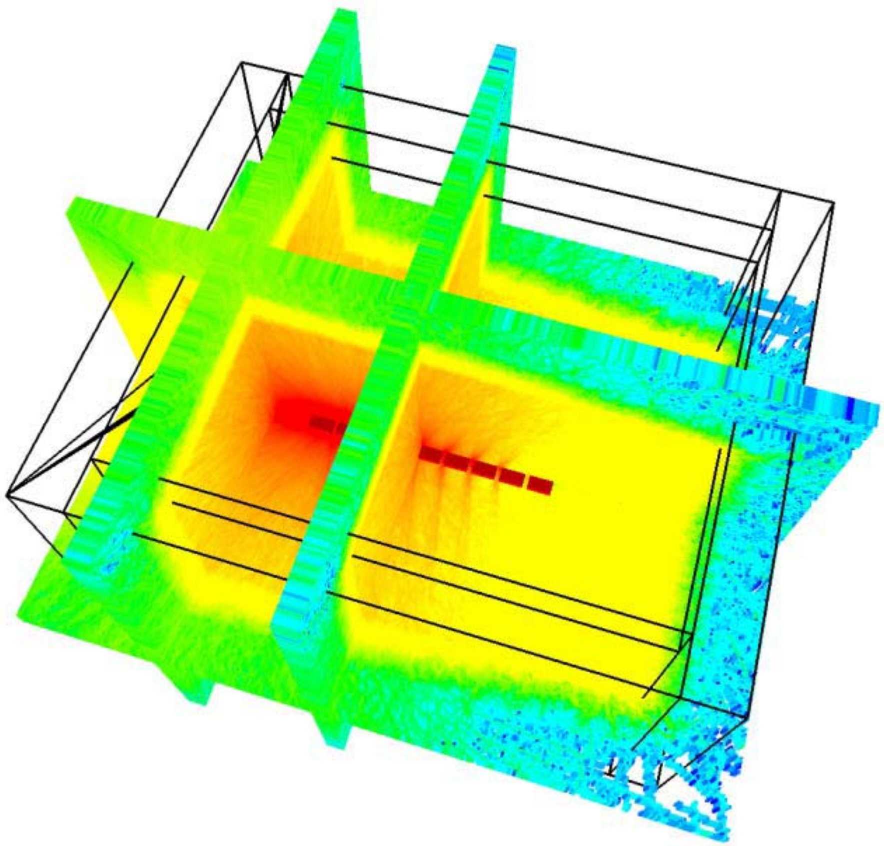
Radiation Leakage Calculations

- The Monte Carlo program MCNPX was used to simulate the radiation leakage from a 225 MeV proton DWA.
- An accelerating gradient of 50 MeV/m was assumed for these calculations.
- Radiation Limit Constraints: (2 cases considered).

	Tuning, acceptance testing, and commissioning modes	**Treatment Mode**
Workload [p/h]	1.44×10^{13}	1.92×10^{12}
Occupancy	radiation workers	public
Allowed DE [Sv/h]	2.5×10^{-5}	5.0×10^{-7}
ALARA factor	0.1	0.1
Occupancy factor	1.0	1.0
Goal DE [Sv/h]	2.6×10^{-6}	5.0×10^{-8}

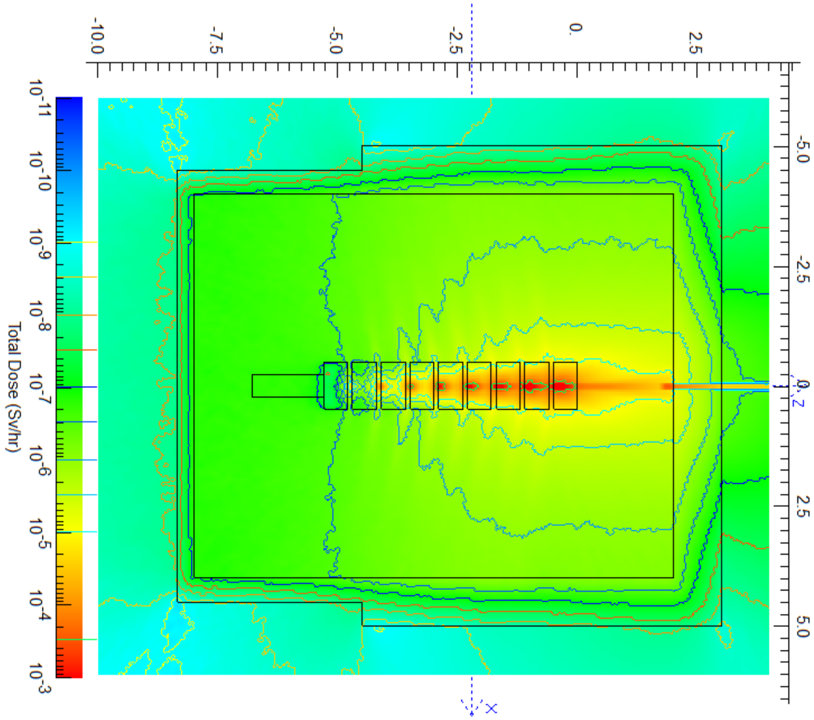
Radiation Leakage Calculation Results

Perspective view of mesh tally planes. Total Dose Equivalent (DE) from simulations is superimposed onto the mesh planes.

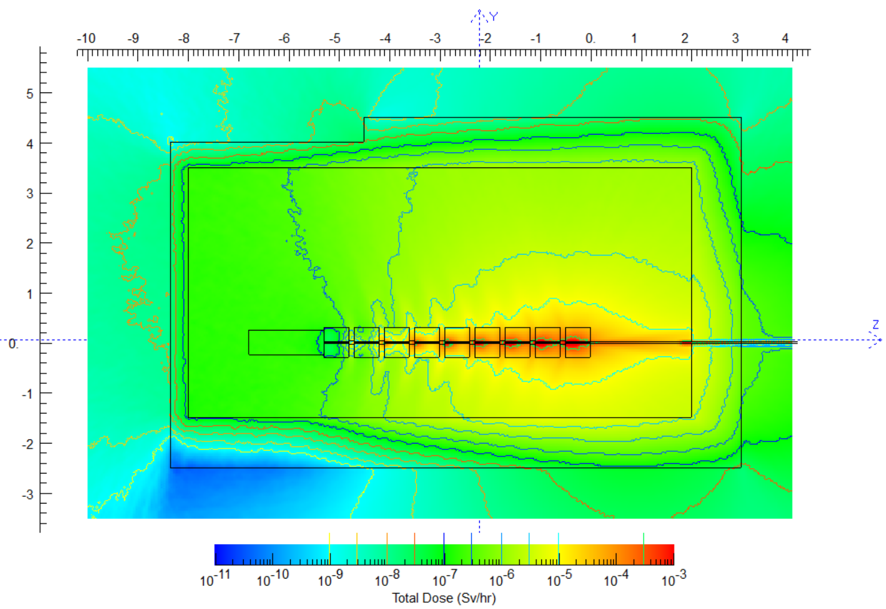


Radiation Leakage Calculation Results

Total DE in two orthogonal tally planes showing the calculated total isodose curves.



Horizontal plane through accelerator's longitudinal axis.



Vertical plane through accelerator's longitudinal axis.

Conclusions

- CPAC has developed the capability to accurately model various Dielectric Wall Accelerator configurations.
- The DWA engineering prototype system has been used as a tool to validate these simulation results.
- The dipole configuration presented will produce a DWA accelerating gradient of ~20 MeV/m at 25 kV charge voltage.
- Monte Carlo shielding calculations show that a DWA based proton therapy system will have relatively simple shielding requirements, making it a good candidate for installation in existing radiation oncology facilities.
- Work continues on the development and testing of the DWA structure at CPAC.