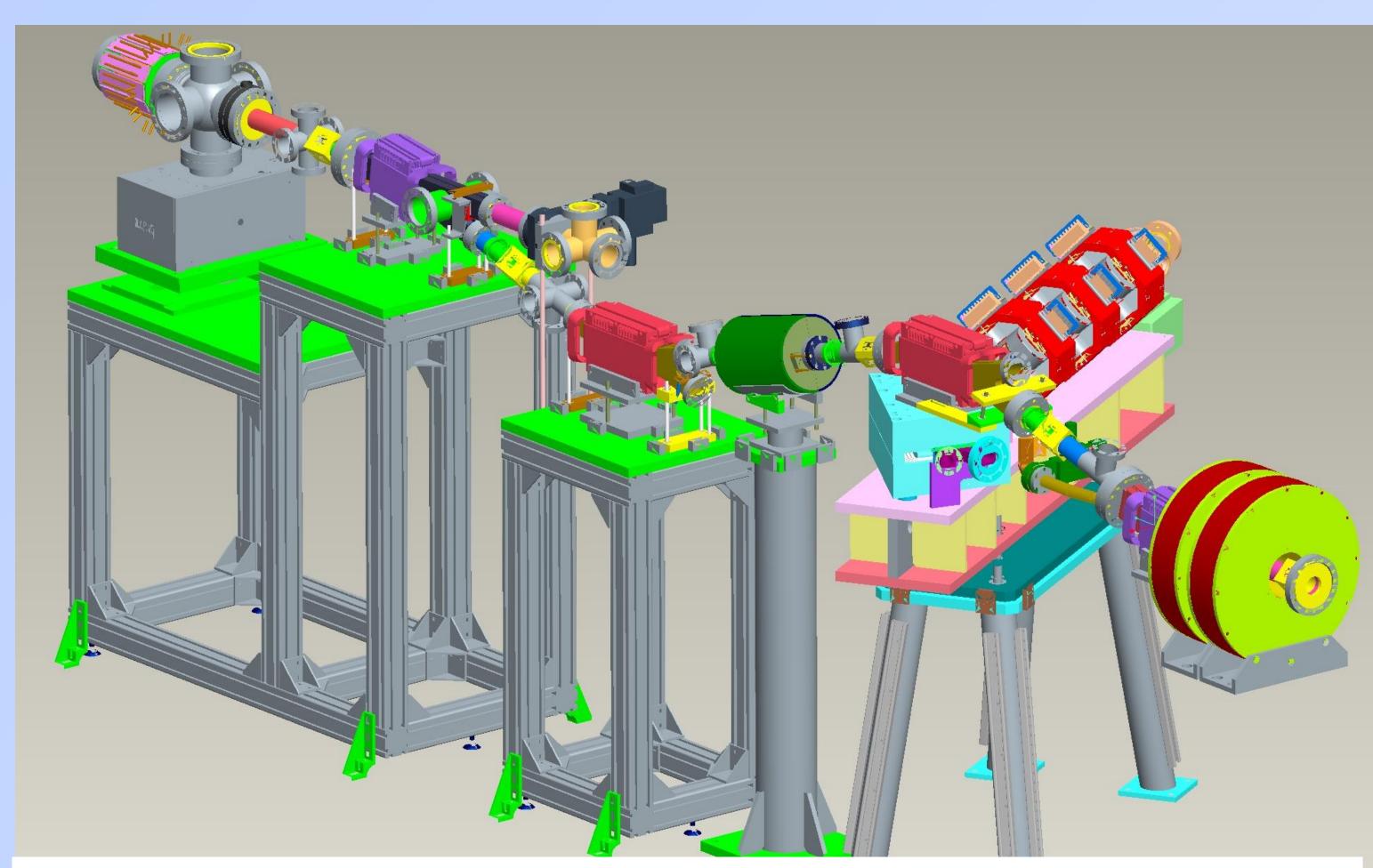
Synchronized Ramping of Magnet Power Supplies for Streamlined Operation Prerana Kankiya Brookhaven National Laboratory, New York , USA

Abstract :Synchronous ramping of an assembly of magnets is critical for operation of beam in an accelerator. Magnet currents must remain within the operational limits to avoid misalignment of electron beam. In order to comply with the design specifications of ERL and ELENS project, two different software control mechanisms have been developed. The ramp profile is automated and maintained by tracking current in all dipole magnets at ERL and superconducting solenoid magnets at ELENS. This mechanism speeds up operations and adds a level of protection. The purpose of this application is to reduce unnecessary interlocks of the personnel protection system. This paper will describe the power supply arrangement, communication mechanism and the state machine algorithm used for feedback and control. A report on operating experience will be presented.

Energy Recovery Linac Magnets



Key Software Features

- erlMagMan is a program written to co-ordinate DC ramps of several dipole, quadrupole and solenoid magnets at ERL's gun to dump beam line
- Each magnet is represented as a software object with configurable parameters such as correction angles, relationship coefficient with reference dipole magnet, maximum output current threshold

Quadrupole, Solenoid, and Precision Steering Supplies – 23 main quadrupoles, some small dipoles /solenoids. – 10 Amps, 15 Volts, 100 ppm, Bipolar, DC supplies

Electron LENS

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<u>File E</u> dit <u>V</u> iew <u>W</u> indow <u>H</u> elp <u>L</u> o	gs			
North Yellow Elens	Blue Ele	South DX Magnet 📥		
IP10 vacuum [Torr]: 1.0e-11	BLM1 dose rate [rad/h]: -0.1	sigma-e (mm): 0.75	BLM2 dose rate [rad/h]: 0.1	DX #9 vacuum [Torr]: 4.3e-10

 Output currents of each supply in the system is compared against a threshold value which is set to be at 4% of PASS system maximum. An alarm is raised at violation of this threshold

• This software is also used as underlying link between orbit correction application and magnets

Work is under progress for implementing a magnet hysteresis compensation algorithm

Dipole Magnet	Bending Angle	10	Tolerance Factor	Trim Angle	Staged Current	PS Check	Range
	deg '	Amps		mrad	Amps		_
erl-e-d3.1-mag	-15	7.23	1	0	7,230	DISABLE	ОК
erl-e-di3.2-mag	30	9.47	1.31	0	9,470	DISABLE	ОК
erl-e-di3.3-mag	-30	9.48	1.31	0	9,480	DISABLE	0K
erl-e-di3.4-mag	15	7.24	1	0	7.240	DISABLE	0K
erl-e-di5.1-mag	-30	5.69	0.79	0	5,690	DISABLE	ОК
erl-e-di5.2-mag	60	5.77	0.79	0	5.770	DISABLE	ОК
erl-e-di5.3-mag	-30	5.69	0.8	0	5,690	DISABLE	ОК
erl-e-di16.1-mag	30	5.73	0.79	0	5,730	DISABLE	ОК
		_	_				
Power Supply	Switch ON	Set Pt	Current	State Of Channel			
erl-e-d3.1-ps	<u>On</u>	3,66	3,640	0n			
erl-e-d3.2-ps	<u>On</u>	4.57	4,547	0n			
erl-e-d3.3-ps	0n	4.53	4.486	0n			
erl-e-d3.4-ps	<u> </u>	3.47	3,458	0n			
erl-e-d5.1-ps	On	2.3	2,289	0n			
erl-e-d5.3-ps	<u> </u>	0	0.001	0n			
erl-e-d5.2-ps	<u> </u>	4.57	4.547	0n			-
erl-e-d16.1-ps	0n	2.5	2.483	0n			

 Input energy is converted into magnet current for all supplies based on the relationship:

Io / (PC * PCref)

lo, Normal Bending Angle Current

PC , Momentum per particle in MeV/c

PCref, 3MeV for ERL

GSB	B-SMS current [A]: 469.8 B-FF current [A]: 470.0
652	B-SMS field [T]: 6.02 B-FF field [T]: 2.54
CS1 CST	B-GSB/CSB current [A]: 700 720 field [T]: 0.29
BY-GS1 curr	B-GS2/CS2 current [A]: 710 → 737 field [T]: 0.43 rent [A]: 850 → 854 field [T]: 0.54 BY-CS1 current[A]: 830 → 866 field [T]: 0.54
B-GSX curren Gun vacuum [Torr]: 9.0e-10 B-GSY curren	
Cathode Heater Status: Recovery Tape	PS HV Status: Recovery Tape Beam Ready : Gauges Pet Page PS Pet Page MPS Pet Page
Beam Modes and Timing O Off O Burst	Beamline Status Beam Current and Energy Modulator Constant YAG screen: Home Anode bias (kV): -0.5 -0.50 Current [mA]: 450 Do It P Value (uA V^-1. DC: 2.
 Continuous Parasitic 	Pinhole detector: Out Reflector [kV]: 3 -3.00 Beam size [mm]: 0.75 Paras: 2. Ion collector: Out Cathode heater [A]: 2.7 2.69 Beam energy [keV]: -4.978 -4.978 -4.978
TrueDC e beam current [mA]: 447	eBSD rate [Hz]: 1.6e+01 Cathode bias [kV]: -54.98 Collector [kV]: 3 - 2.98 Scale
Make Live TrueDC Burst	Gun valve: Open Modulator 1 [kV]: 4.1 4.14 MPS Status e Beam p Beam DC: 1. Collector valve: Open Modulator 2 [kV]: 3.2 3.19 OK On Off Paras: 1.

• elensWfgMan is a program to ramp four superconducting solenoids simultaneously for blue and yellow ELENS or individually. This software interfaces with The RHIC Wave Form Generator is described in detail elsewhere [1]

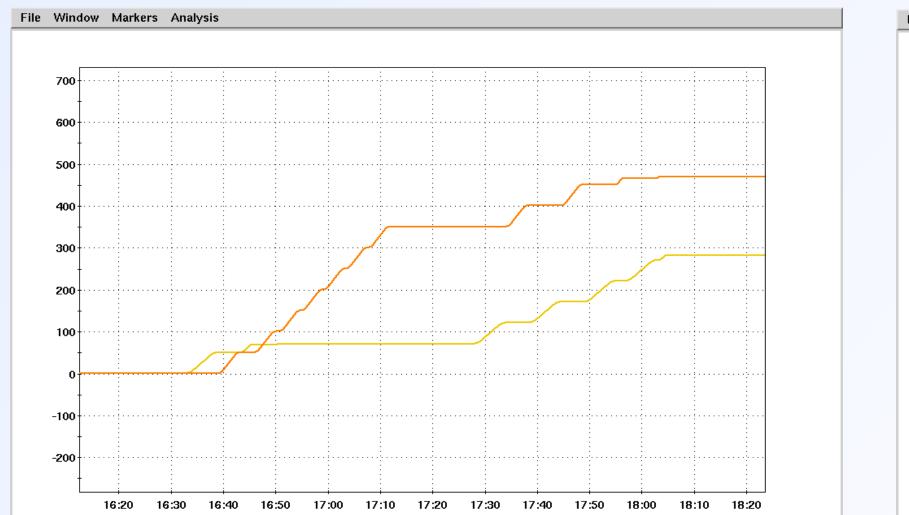
Key Software Features

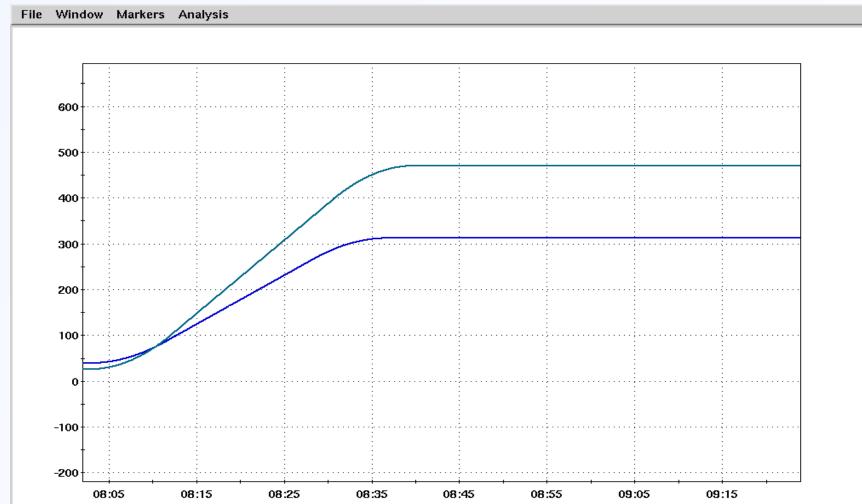
 ELENS magnet profile is broken down into various states such as IDLE, RAMP, SLOWRAMP, STOP, and RESUME

• These states are implemented in C++ in form of a state machine

Software allows easy transition between staggering ramps fig1 and smooth ramps fig2

• The user interface allows for selection of multiple magnetic fields (from Zero to Six Tesla) for the system and relevant parameters are automatically loaded from a lookup table





ICALEPCS 2015, Melbourne Australia

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Fig 1. Yellow ELENS ramp in steps of 50 amps between main and fringe solenoids.

References

1. T. Kahn, "Power Supply Waveform Generator Module Design Specification"

Fig 2. Blue ELENS ramping from 0 to 5.8 Tesla field main and fringe ramped simultaneously.