Americas

Marx Klystron Modulator Development Program

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C. Burkhart
For the Marx Project Engineering Team: C. Burkhart (Head)
R. Cassel (DFM), M. Nguyen (Prototype),
J. Olsen (Controls), P. Bellomo (ESB Installation),
P. Blum (Mechanical), A. Viceral (Lead Tech)

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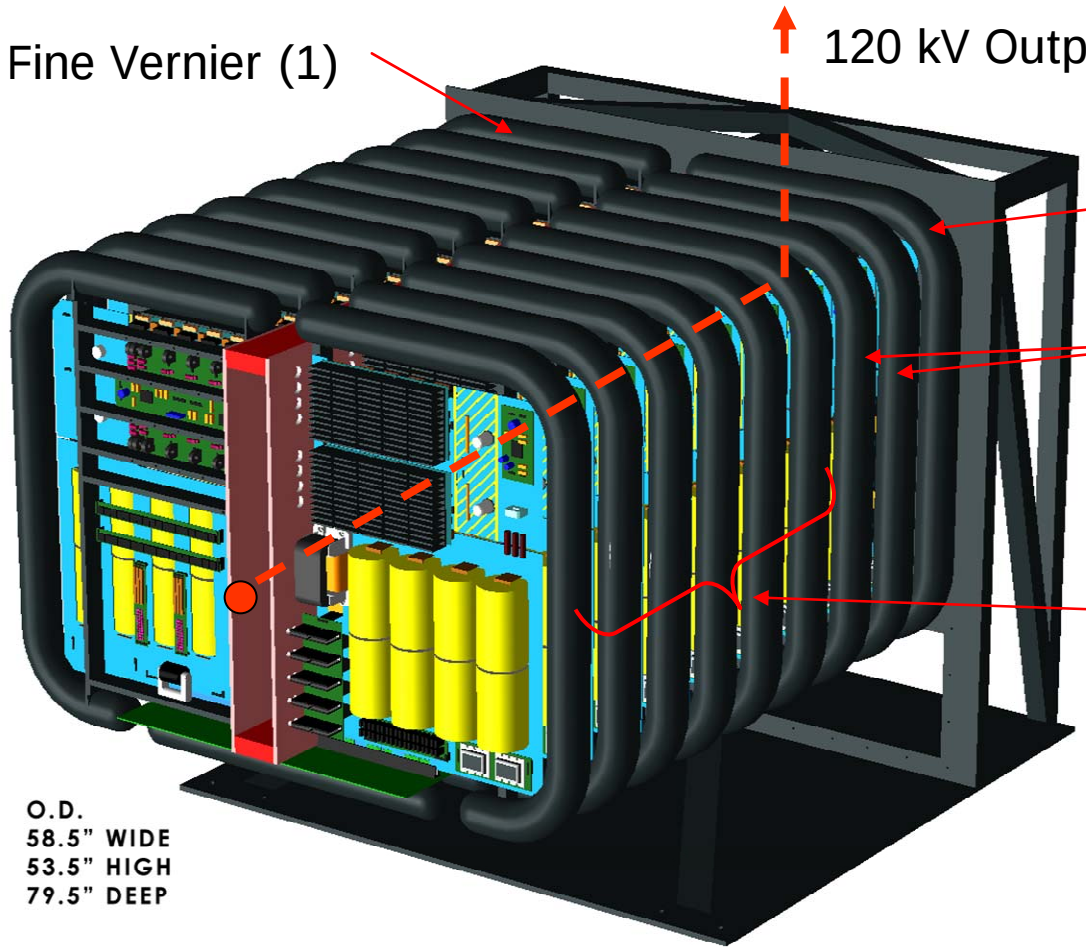
Marx Development Program

- Prototype Modulator
  - Demonstrate efficacy of Marx topology for ILC Klystron modulator application
  - Power 10 MW klystron for ESB life/performance testing
- Design For Manufacture (DFM)
  - Modify to conform to revised tunnel design
  - Improve manufacturability
  - Improve reliability/availability

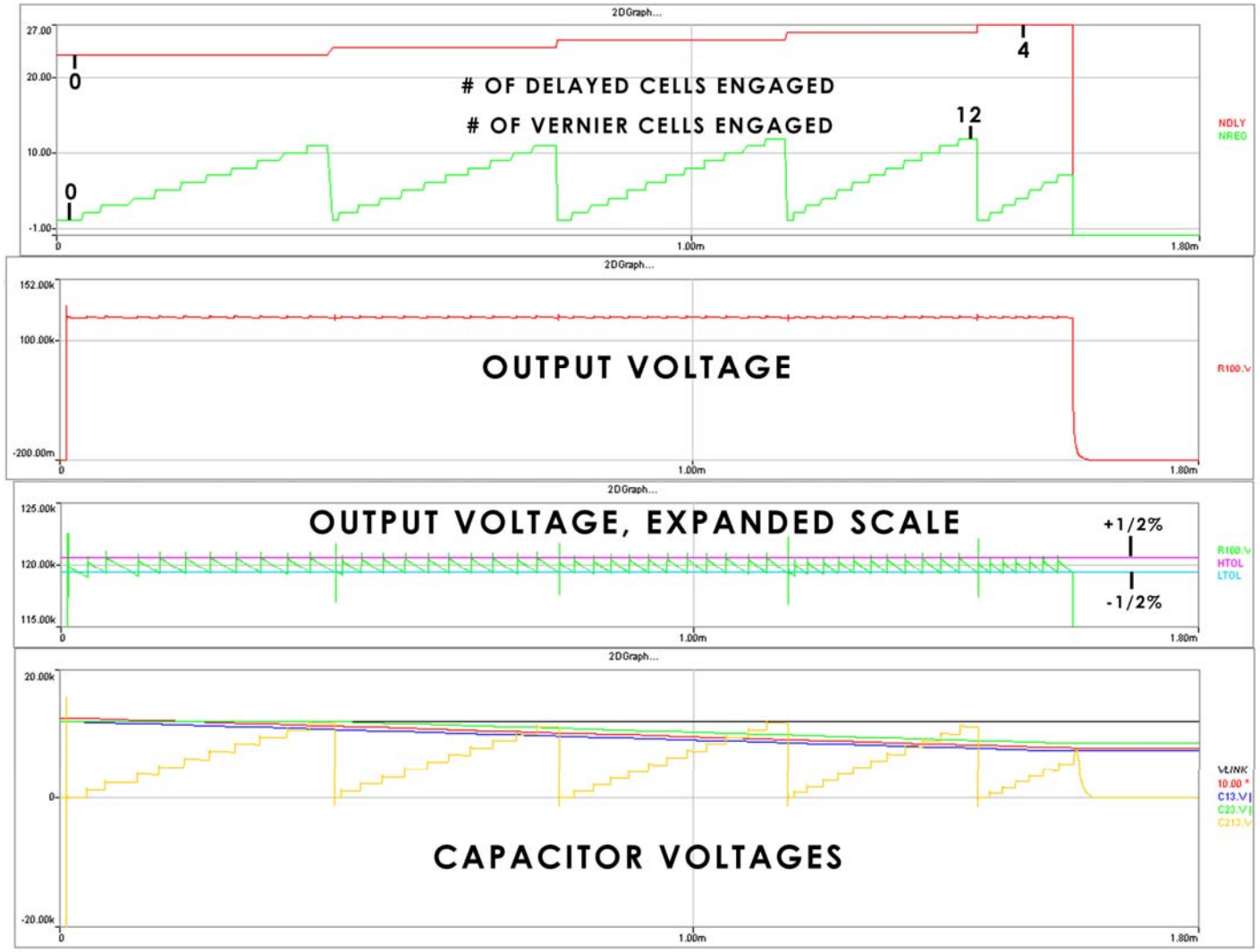
Prototype Marx Layout



DETAIL, MARX MODULATOR CORE

**Courtesy G. Leyh, SLAC*

Prototype Marx Operation



**Courtesy G. Leyh, SLAC*

2/07-10/07 Prototype Milestones

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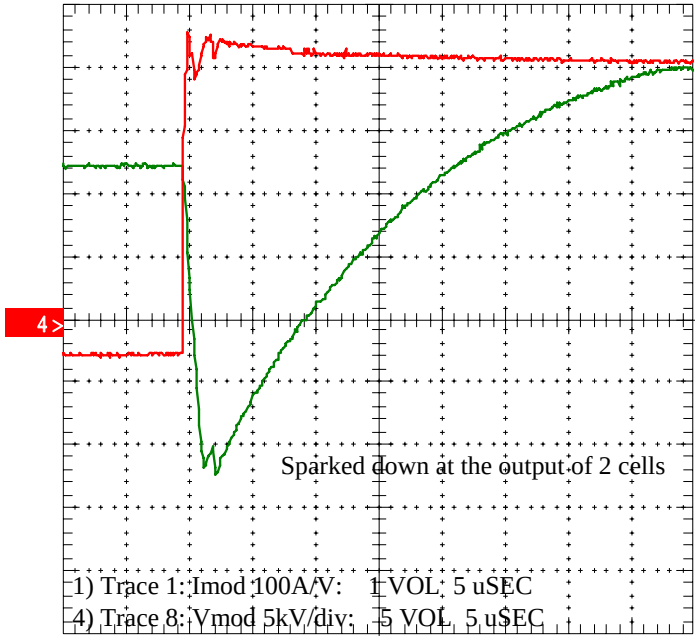
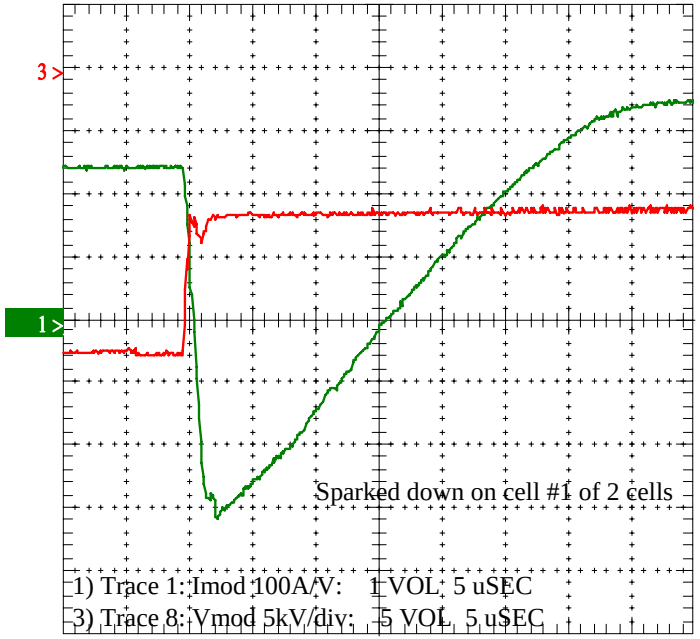
- 2/21/07 Achieved 120 kV Operation – Power & reliability limited
- 4-8/07 Reorganize development teams
  - Prototype: Nguyen, Burkhart, Cassel
  - DFM: Cassel, Burkhart, Blum
  - ESB Installation
    - Controls: Swent, Larsen, Cassel, Downing, Olsen, Chestnut, Burkhart
    - Installation: Bellomo, Swent, Corvin, Asiri, Burkhart
- 4–6/07 Prototype review
  - Analysis fault modes
  - Design improvements
- 7-8/07 Prototype Upgrades
  - Modify Marx cell components
  - Extensive single-cell testing at full operating and fault conditions
  - Initiate reassembly of Marx
- 9/07 Build up Marx in 2-cell steps
  - Extensive full power testing on 2-cell Marx under normal and fault conditions
  - Add cells: increase voltage & power
- 10/2/07 Status
  - Present configuration is 12 cells (increasing daily, fully loaded is 16 cells)
  - All rebuilds 90% complete
  - Full power source and load

2-Cell Spark-down Tests (Fault Mode)





Arc at modulator output

Arc at modulator output

Modulator voltage (5 kV/div)

Modulator current (100 A/div)

**Courtesy M. Nguyen, SLAC*

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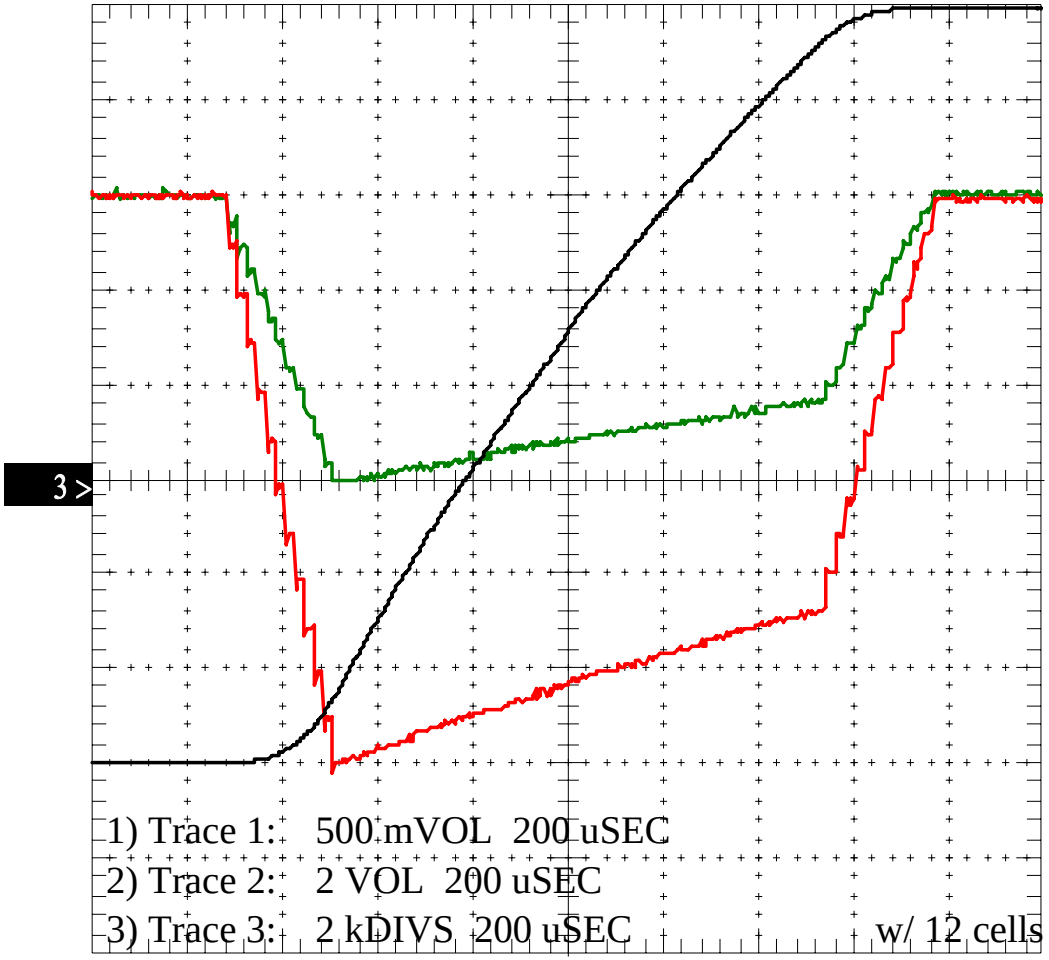
Current Operation: 12 Cells

- Voltage: 120 kV
- Current: 150 A
- Energy: 16 kJ
- 5 Hz
- 80 kW



*Courtesy M. Nguyen, SLAC

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Other Work Status

- Fine Vernier (pulse flattening)
  - Cell prototyped (undergoing revision)
  - Multi-cell testing
  - Controls firmware development
- On-cell diagnostic controller
  - Primary use: control of Marx cell
  - Incorporating sensors and firmware to evaluate cell health
- Marx enclosure, Interlocks, & Controls
  - Enclosure parts fabricated
  - Control/Interlock system topology defined
  - FPGA-based control system under development

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Design For Manufacture (DFM) Marx

- Second generation Marx design
- Motivation for modifications
  - Conform to revised tunnel design
  - Improve manufacturability
  - Improve reliability/availability

Revised Tunnel Constraints

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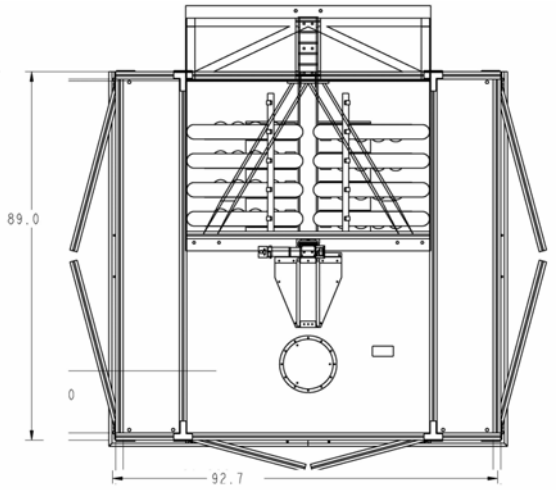
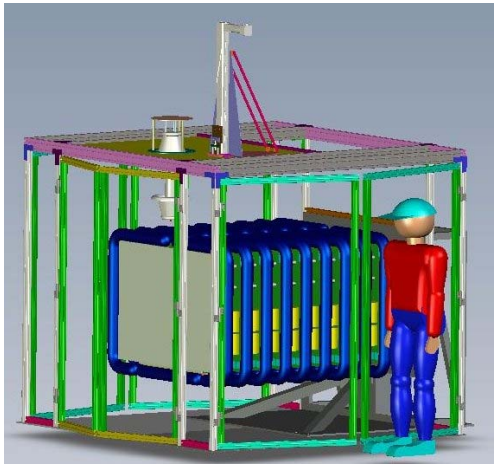
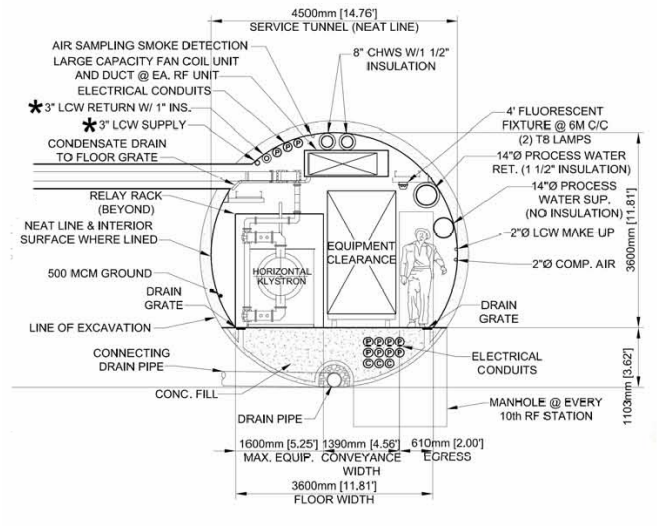
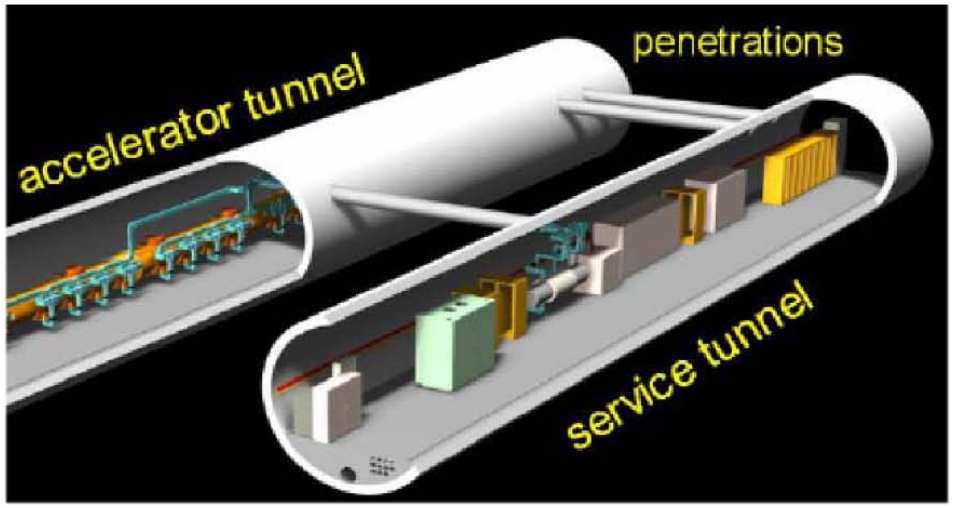
- Prototype Marx is to wide for revised ILC tunnel
- Max depth 48” (92”)
- Max height 72” (80”)
- Max length >300” (89”)









**Courtesy R. Cassel, SLAC*

Marx DFM Layout Options

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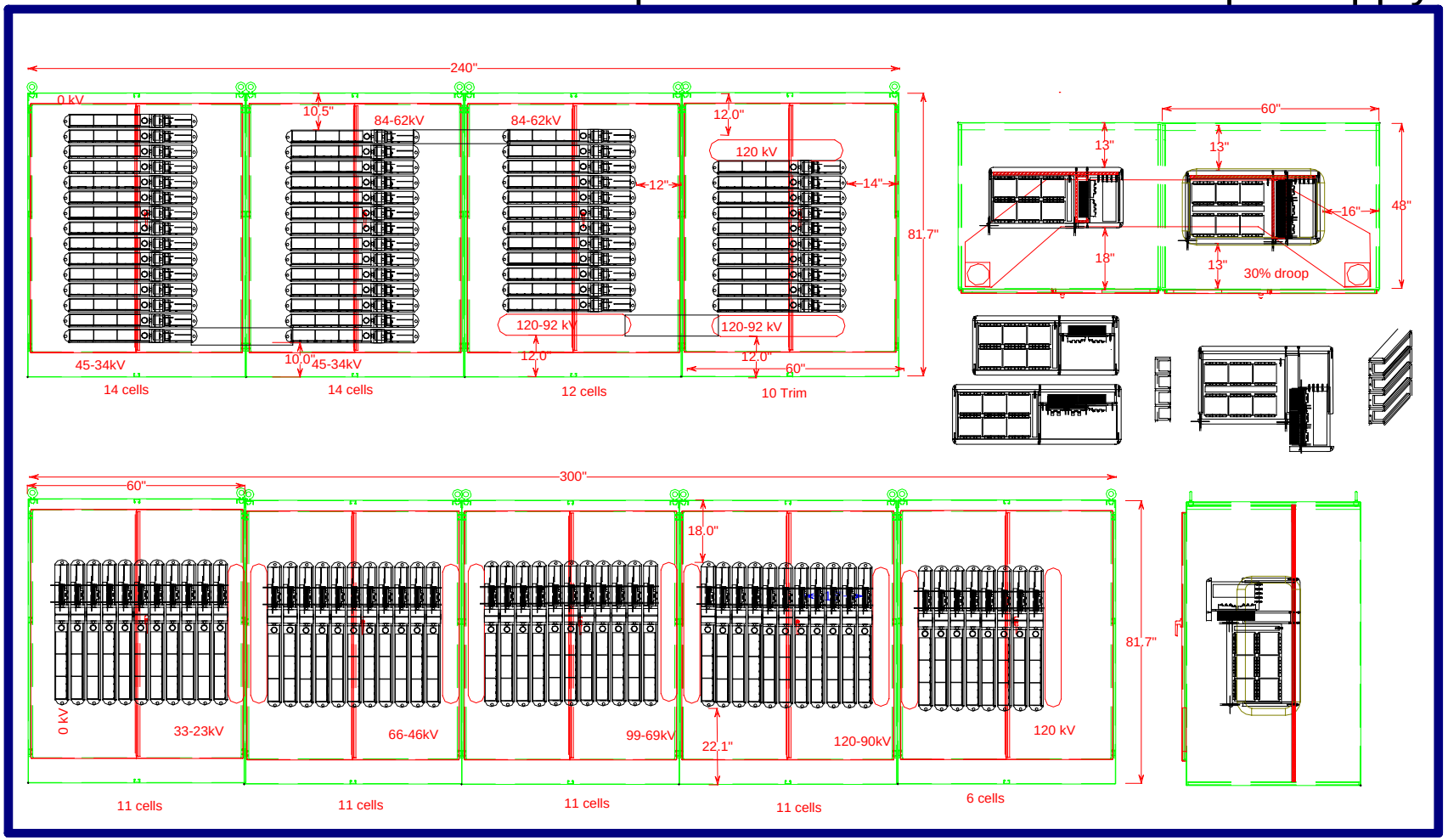
- Vertical and horizontal cell options
- 50 Cell modules per supply



**Courtesy R. Cassel, SLAC*

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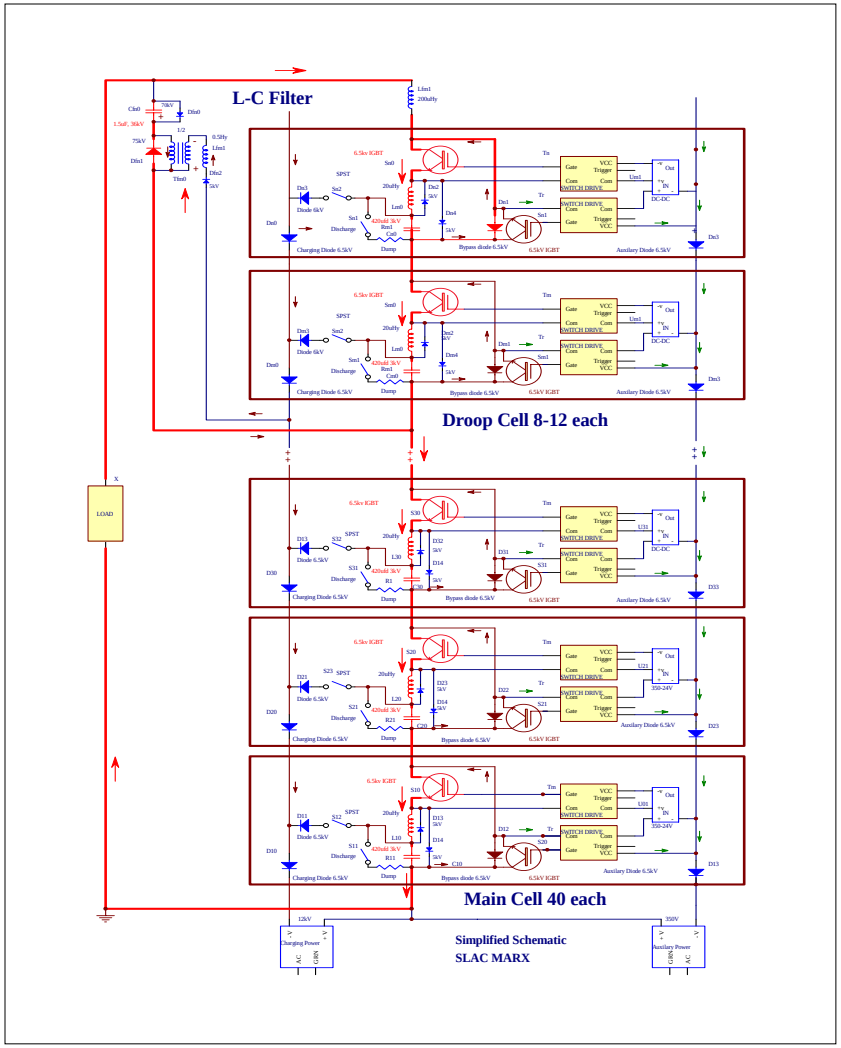
DFM Marx Modifications

- "Repackage" components into 3kV cells
  - Improved manufacturability: "industry standard" 6.5 kV, 100 A IGBT H-bridge
  - Improved reliability: reduced impact from single-point failures
  - Cells are simpler, smaller, lighter, and lower stored energy
- PWM droop compensation circuit
  - Eliminates Vernier: uses standard cells
  - Reduces pattern noise
- Capacitor Rated for 100,000 hr lifetime
  - Improved reliability

**Courtesy R. Cassel, SLAC*

DFM Marx Schematic

- Similar to Prototype
  - Same basic cell topology
  - IGBT switch elements
  - Diode isolation between cells
  - -HV charging and auxiliary power
- 40 main cell modules provide redundancy
- 8-12 droop compensation cell modules
  - Same cell design as main cells
  - L-C filter added to output



*Courtesy R. Cassel, SLAC

DFM Marx Droop Correction

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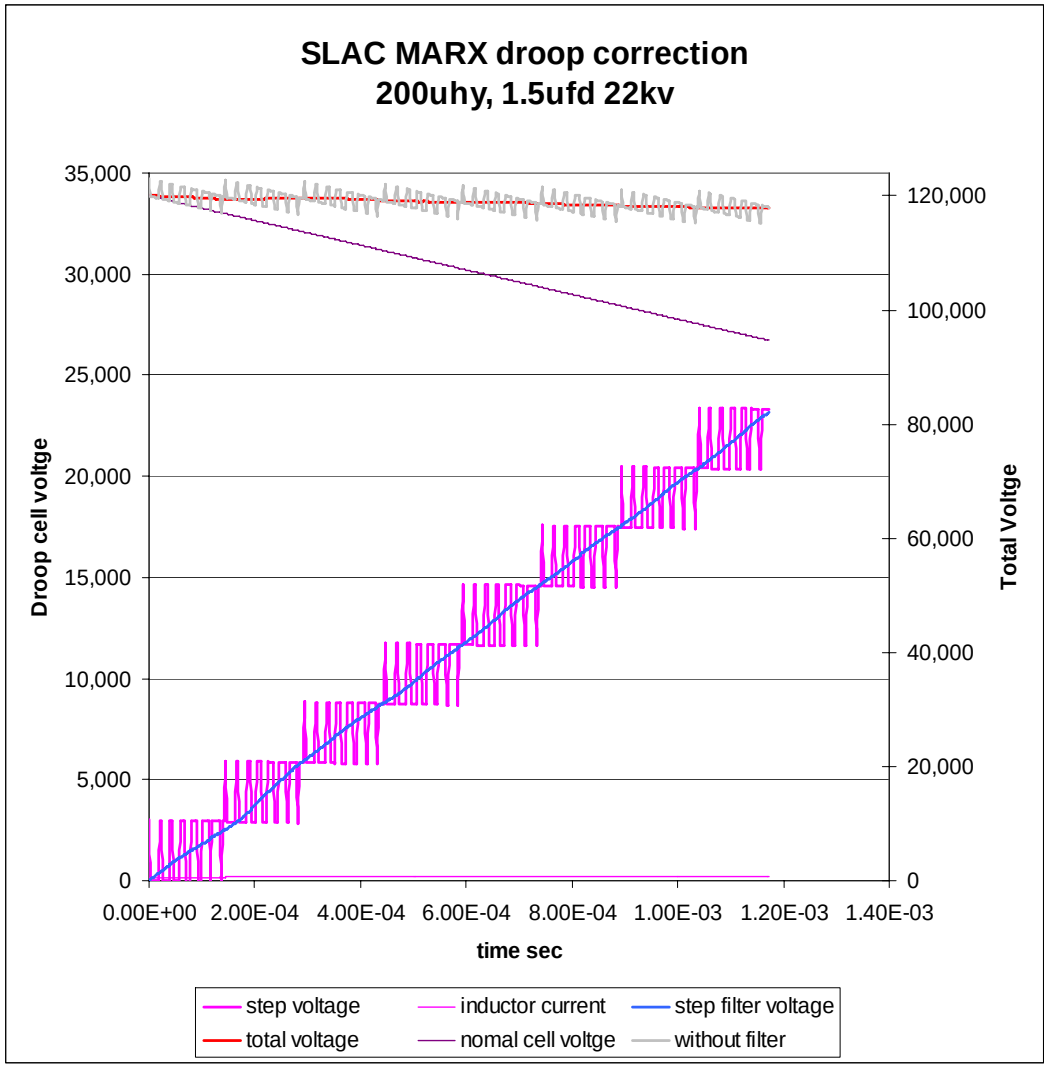
- PWM droop correction
- 8-12 standard cells: using switching buck regulator technique one section at a time



**Courtesy R. Cassel, SLAC*

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Marx Modulator Development Plan

- Prototype
  - Continue buildup to full power testing (without fine vernier)
  - Complete packaging and interlocks assembly
  - Incorporate fine vernier
  - Continue power testing
  - Move to ESB when Toshiba MBK ready (Spring 08)
- DFM
  - Continue conceptual design proposal
  - Design review
  - Detailed design, documentation
  - Build prototype as funds permit (08-09)
  - Test prototype (09)

**Courtesy R. Larsen, SLAC*