

**Director's Review of the Project X  
Cost Range Estimate:  
High Power Vector Modulators**

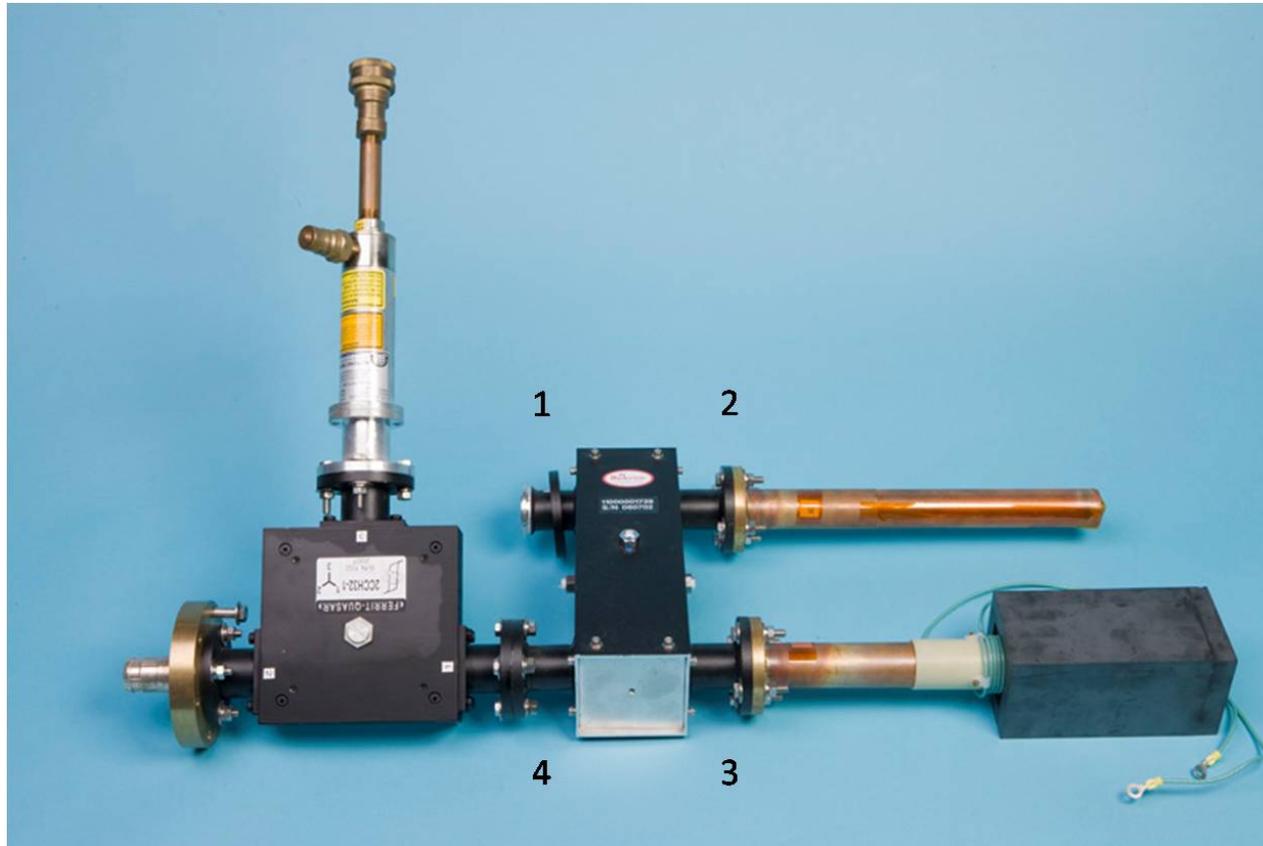
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Project X Director's Review  
March 16, 2009



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- Scope of Estimated Work
  - Boundary Conditions /Assumptions
  - Basis of Estimate
  - Technical Risks/Associated Cost Exposure
  - Potential Technical Revisions
  - Role of Outside Collaborators
  - Summary

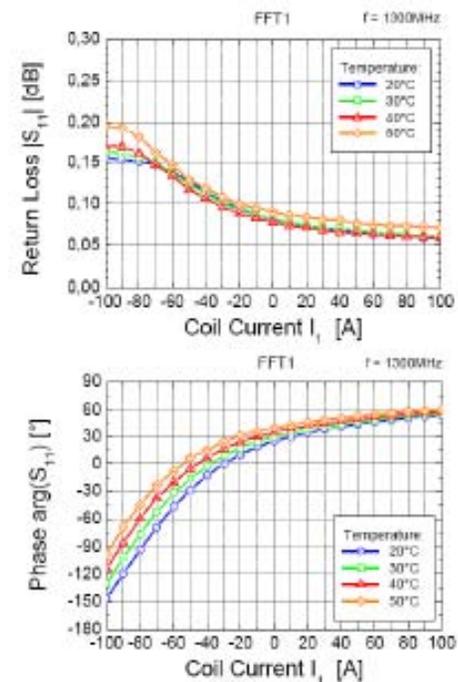
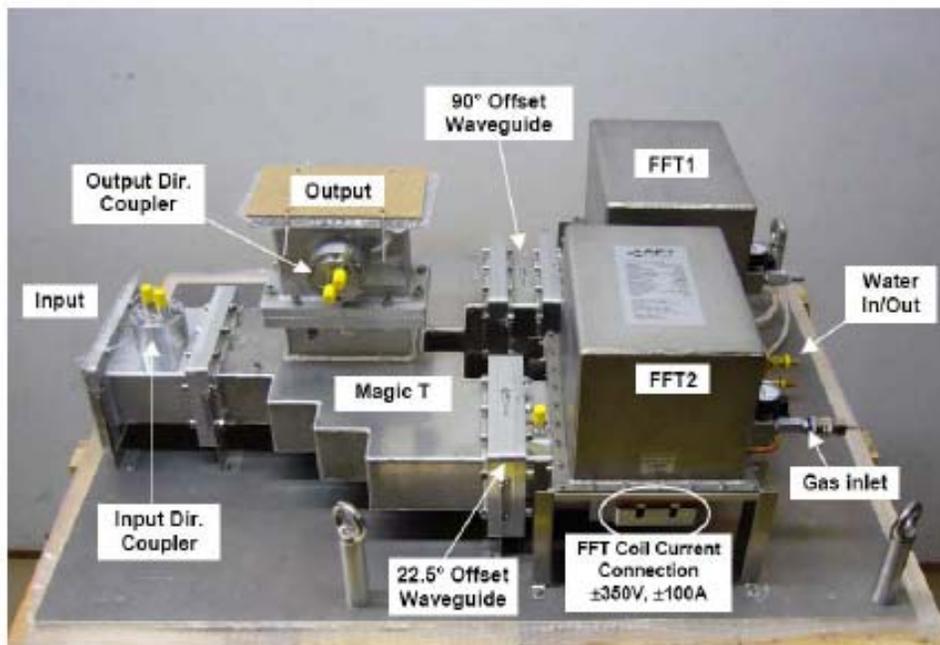


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- Description of the scope of the system corresponding to your estimate
  - 325 MHz Vector Modulators required for the entire 325 MHz Linac:
    - 32 Low Power Vector Modulators < 50 kW
    - 75 High Power Vector Modulators > 50 kW (up to 600 kW)
  - 1.3 GHz Vector Modulators required up to 2 GeV:
    - 96 High Power Vector Modulators ~ 600 kW





# Fast Amplitude and Phase Control (AFT prototype for FNAL PD)



Rated for 550 kW at 1.3 GHz and has a 30 us response time

# Boundary Conditions & Assumptions



- Primary interfaces with other systems
  - 325 MHz Vector Modulators part of HINS RF System
  - 1.3 GHz Vector Modulator will be tested at NML



- 325 MHz Vector Modulators
- Experience: Costs based on recent purchases and quotes
- Total M&S Cost \$ 6,295K
  - Low Power Vector Modulators \$ 880K
  - High Power Vector Modulators \$ 5,415K
- Total Labor
  - Mechanical Engineer 0.5FTE Years
  - Electrical Engineer 2.0FTE Years
  - Electrical Technician 1.5FTE Years
  - Mechanical Technician 2.0FTE Years
- 10% Spares \$ 630K



- 1.3 GHz Vector Modulators
- Experience: Costs based on recent prototype purchase
- Total M&S Cost \$ 8256K
- Total Labor
  - Mechanical Engineer 0.75FTE Years
  - RF Engineer 3.0FTE
  - Scientist 1.5FTE
  - Mechanical Technician 6.5FTE
  - Design Drafter 1.0FTE
- 10 % spares \$ 826K



- 325 MHz System
  - Low Power VM: good to > 75 kW
    - (R. Madrak FNAL Seminar 12/16/09)
  - High Power VM: shifters and hybrids filled with SF6 – good to > 500 kW, circulator failed, ordered a new one from industry
    - (R. Madrak FNAL Seminar 12/16/09)



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- 1.3 GHz system
    - One Vector Modulator Designed and Manufactured by AFT exists at FNAL but not tested to date
  - Description of the strategy to address these risks
    - Speed up High Power Tests at NML

# Potential Technical Revisions

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- New 325 MHz RF System based on IOT's instead of Klystrons, eliminating the need for vector modulators
- 1.3 GHz Vector Modulator based on Ferroelectrics instead Ferrites in order to reduce Response Time and Cost



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- Industry



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- Both, 325 MHz and 1.3 GHz Vector Modulators are complicated and expensive devices
  - Substantial technical and financial risks still exist
  - RF system based on 325 MHz IOT's has to carefully evaluated as a possible replacement for the present RF system
  - Alternative options of 1.3 GHz Vector Modulator (e.g. based on ferroelectrics) have to be evaluated