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# An Electro-Optic Voltage Measurement Device

## Measuring High Voltage Pulses

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# Pulsed Voltage Metrology Challenges

- Bandwidth Limitations
- Electromagnetic interference
- Inability to use standard signal averaging techniques to lower noise bandwidth

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# Promise of Electro-Optic Techniques

- Electro-optic voltage calibrator for pulsed high voltage: inherently high bandwidth and electrically isolated
- Expected uncertainty 0.5% (k=2)
- 2kV-325kV, 2.5µsec - 25µsec pulse width
- Prototype device to be installed in PSL Pulsed High Voltage Measurement System

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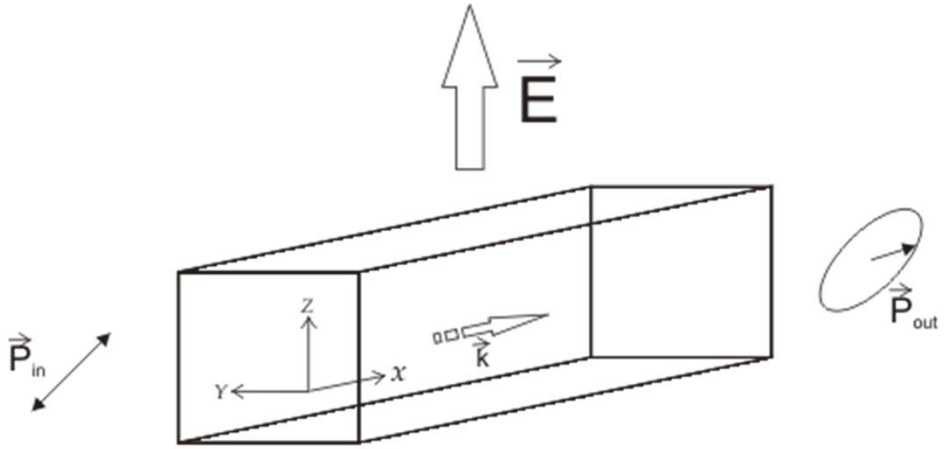
# Optical E-Field Measurements




For $LiNbO_3$:

$$\Gamma = \frac{\omega L}{2c}\left[n_{oz}^3 r_{33} - n_{oy}^3 \left(r_{13} - r_{22}\right)\right]E_z$$

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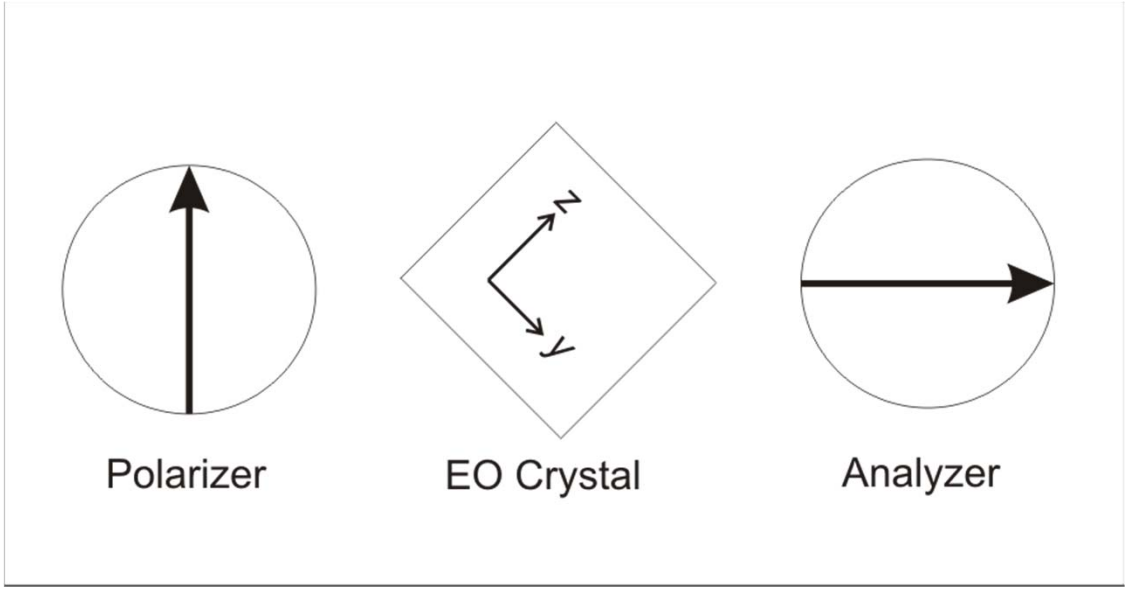
# Crystal Geometry




$$I_{out} = \frac{I_o}{2}\left[1 + \cos\left(\Gamma + \phi_{in}\right)\right]$$

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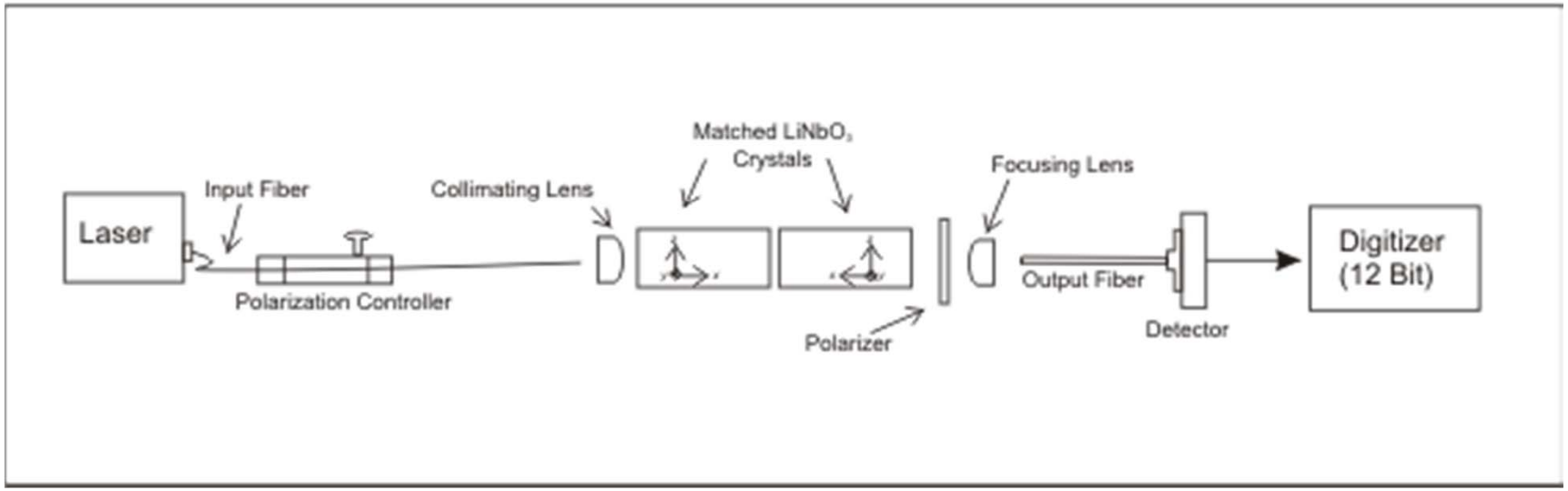
# Optical Configuration

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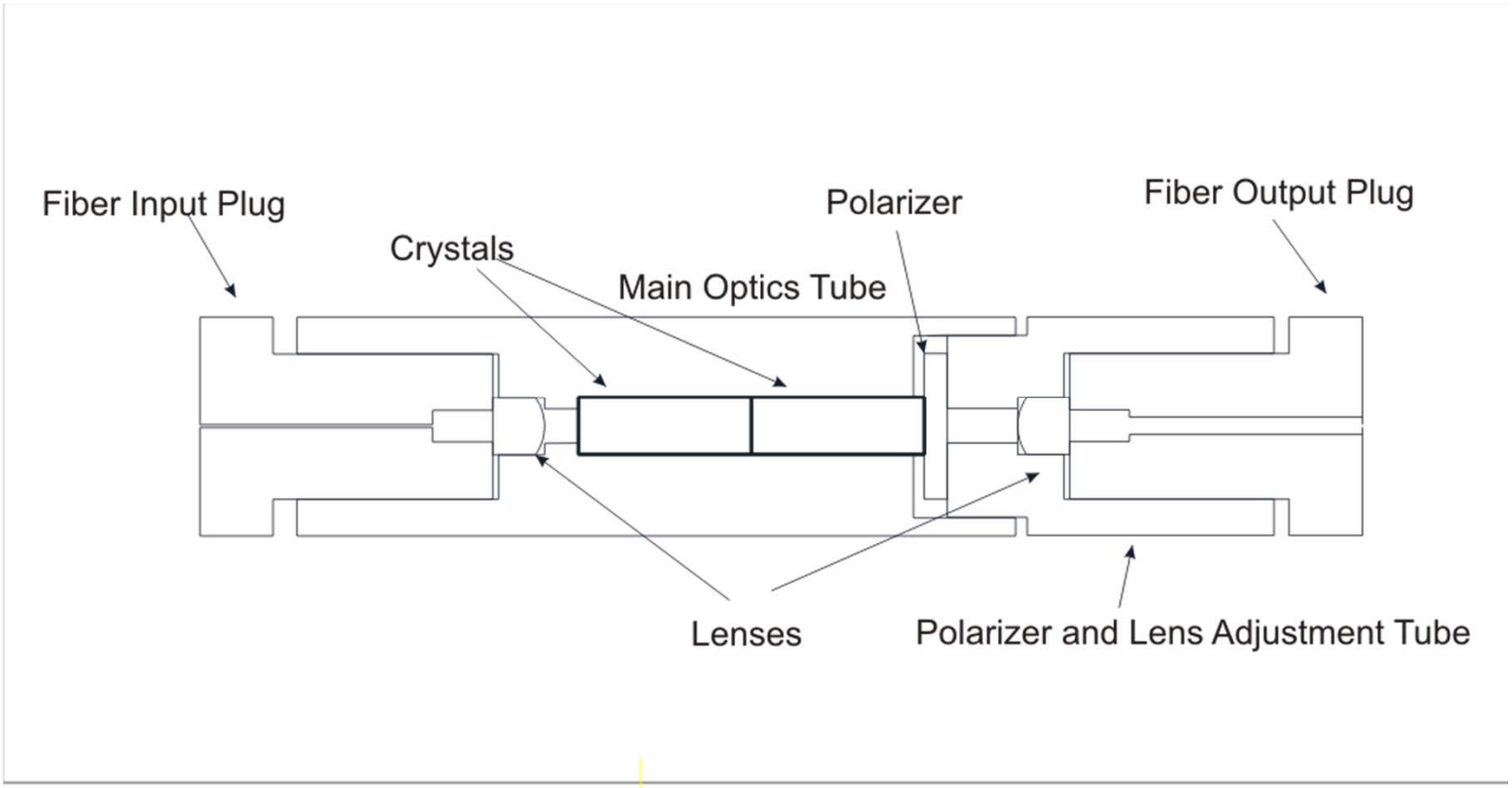
# Opto-Mechanical Design

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# PHVMS at Sandia


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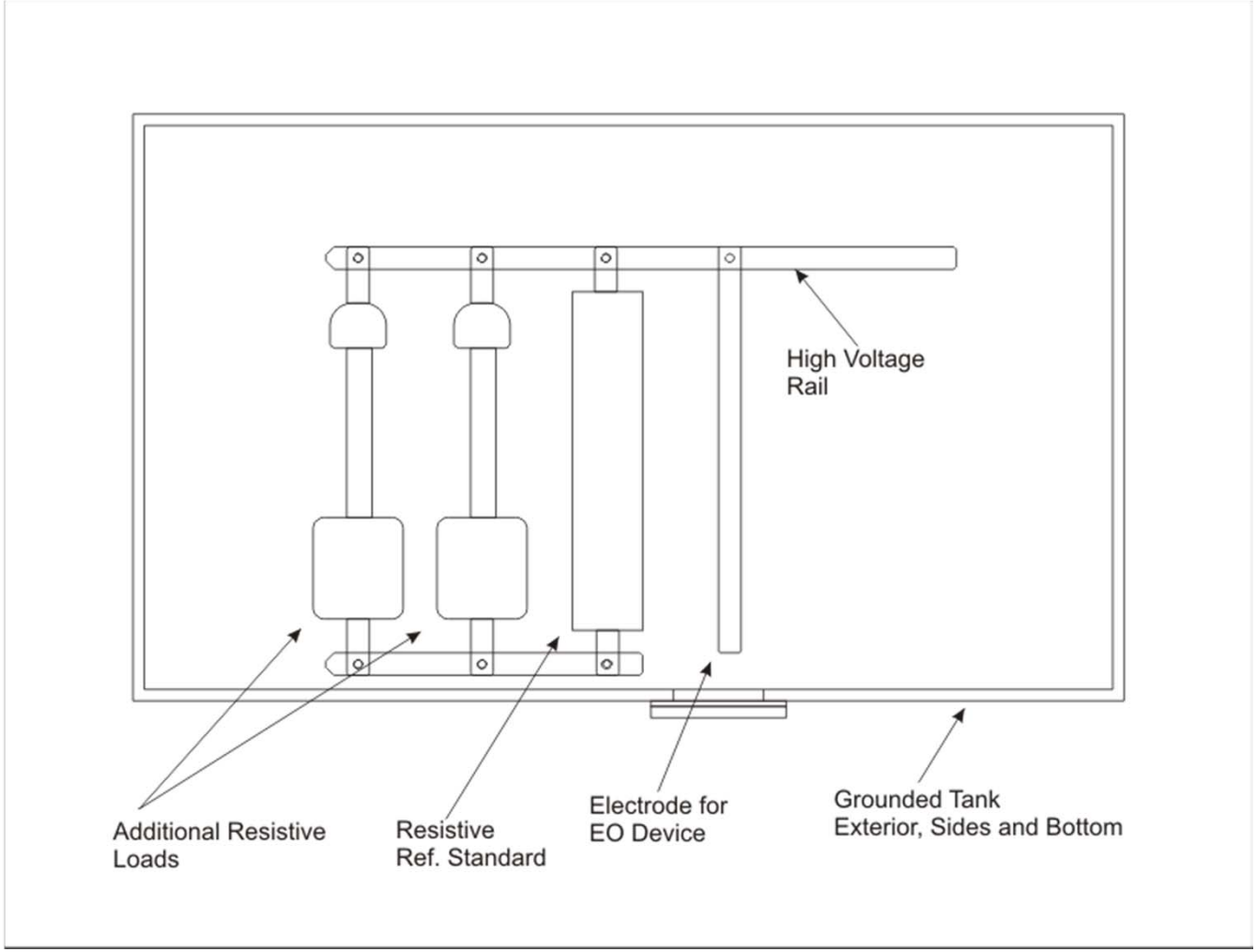
# Installation in Tank

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# Estimated Uncertainty Sources

| Source | Type A/B | Category | Approx. Mag. | Impact | Determination Method |
|---|---|---|---|---|---|
| Laser Noise | B | Statistical | 0.0001*S | Negligible | Estimated |
| Optical Scattering | B | Systematic | 0.0001*S | Negligible | Estimated |
| Detector Noise | B | Statistical | 6 mV | Significant | Manufacturers Specs. |
| Digitizer Noise | B | Statistical | 0.05-0.2%FS | Significant | Manufacturers Specs. |
| Digitizer Accuracy | B | Systematic | 0.15%FS | Most Significant | Manufacturers Specs. |
| Digitizer Resolution | B | Systematic | 0.025%FS | Negligible | Manufacturers Specs. |

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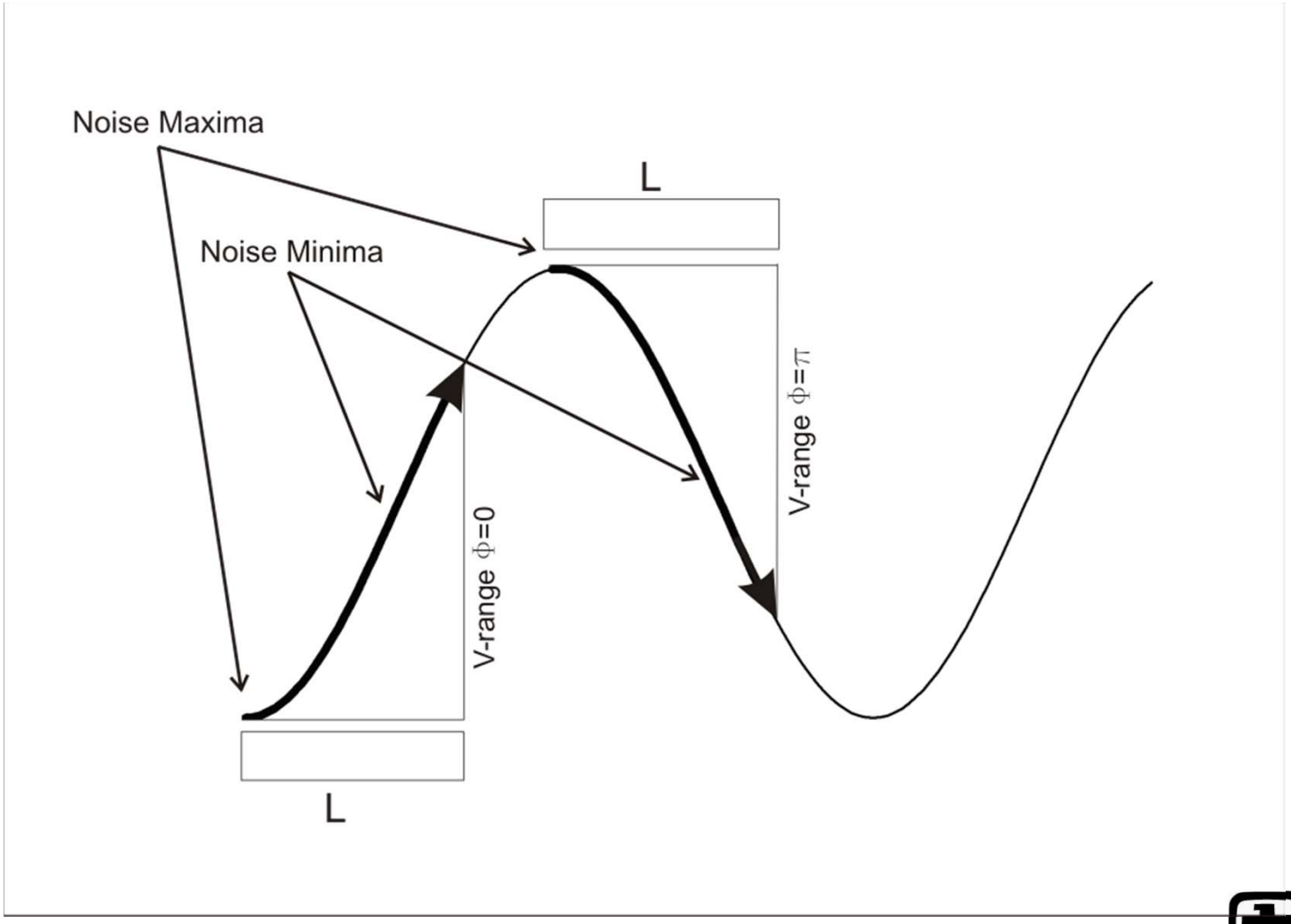
# Expected Expanded Uncertainty

| Impressed Pulsed Voltage | Induced Phase Mod (degrees, Bias=0) | Unc. (k=2) L=15mm, Bias=0, P=2mW |
|---|---|---|
| 1.00E+04 | 3 | 3.00 |
| 2.00E+04 | 7 | 0.89 |
| 3.00E+04 | 10 | 0.52 |
| 5.00E+04 | 17 | 0.27 |
| 7.50E+04 | 26 | 0.19 |
| 1.00E+05 | 34 | 0.23 |
| 1.50E+05 | 51 | 0.21 |
| 2.00E+05 | 68 | 0.13 |
| 3.00E+05 | 102 | 0.16 |
| 3.50E+05 | 119 | 0.37 |

# Adjustable Parameters

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# Summary

- In-situ electro-optic calibration device for pulsed high voltages is underway at SNL PSL.
- Expected to improve uncertainty (<0.5%) and has potential for high bandwidth measurements

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