

Time Calibration System for RF Cavity Breakdown Measurements

Juan Takase

Northwestern University

SIST INTERN Fermi National Lab

08/04/2015

Overview

- Background of Experiment
- Current need and system for calibration
- Design

BACKGROUND



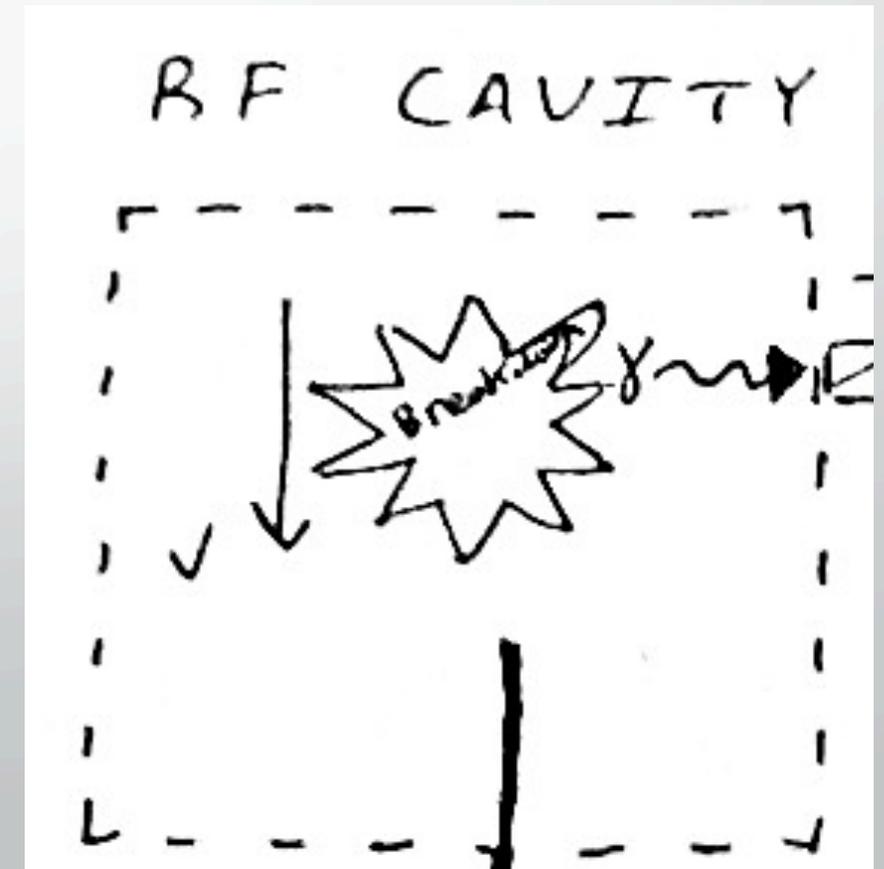
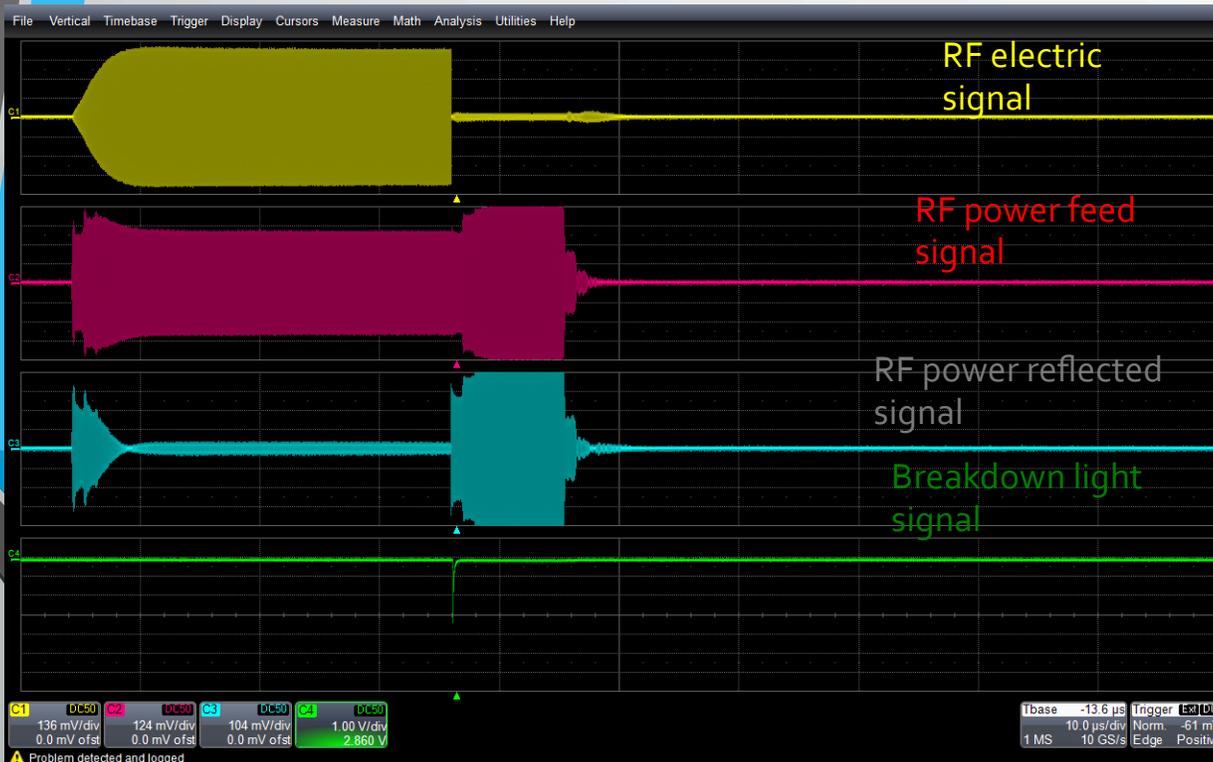
RF Cavity

- Induced electromagnetic field accelerates a charged particle as it goes through



Breakdown

- During a break down, electrons from one side of the cavity go through the space between the cavity walls to the other side.
- Releases a flash of light



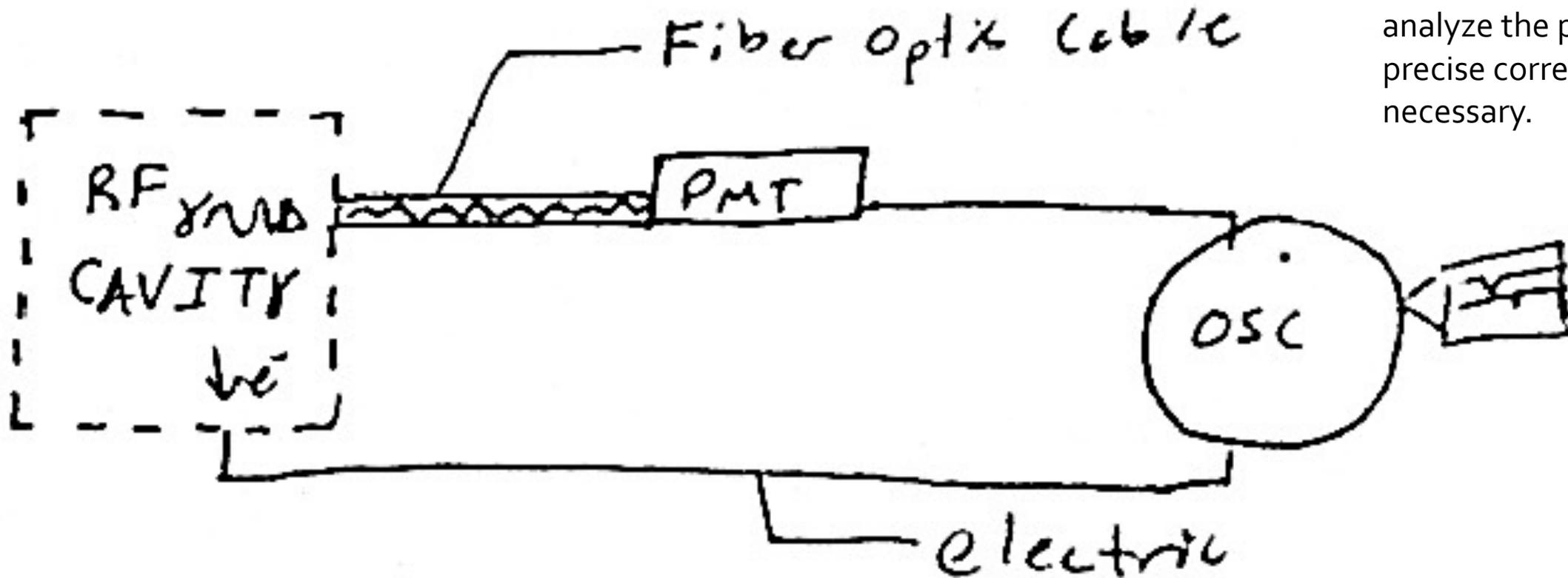
Lightning





Measurements

- Due to the different paths the data must take during measurements. The data arrive at the oscilloscope slight offset.
- This can make it difficult to analyze the physics because precise correspondence is necessary.

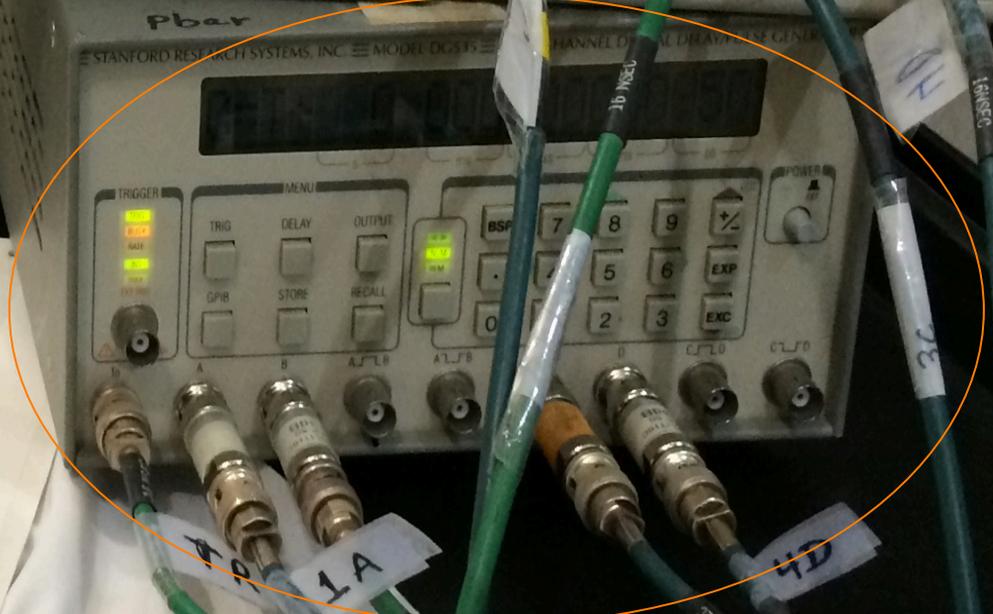
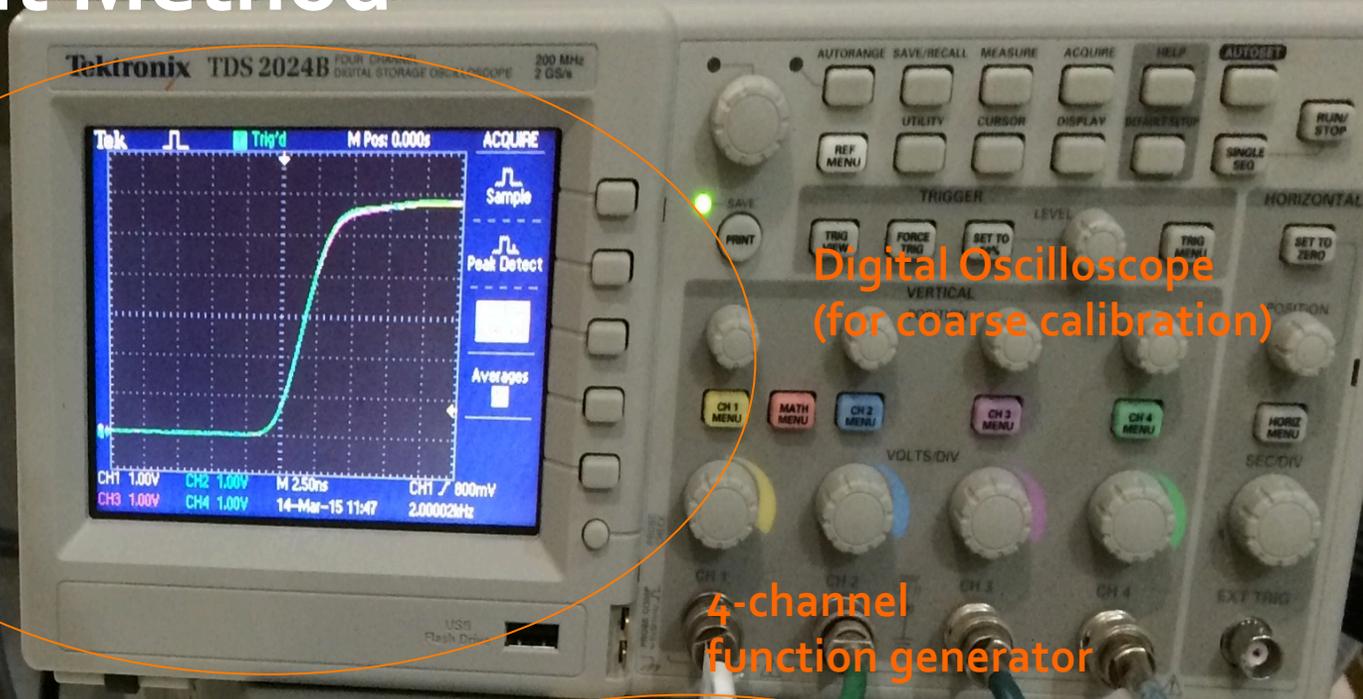


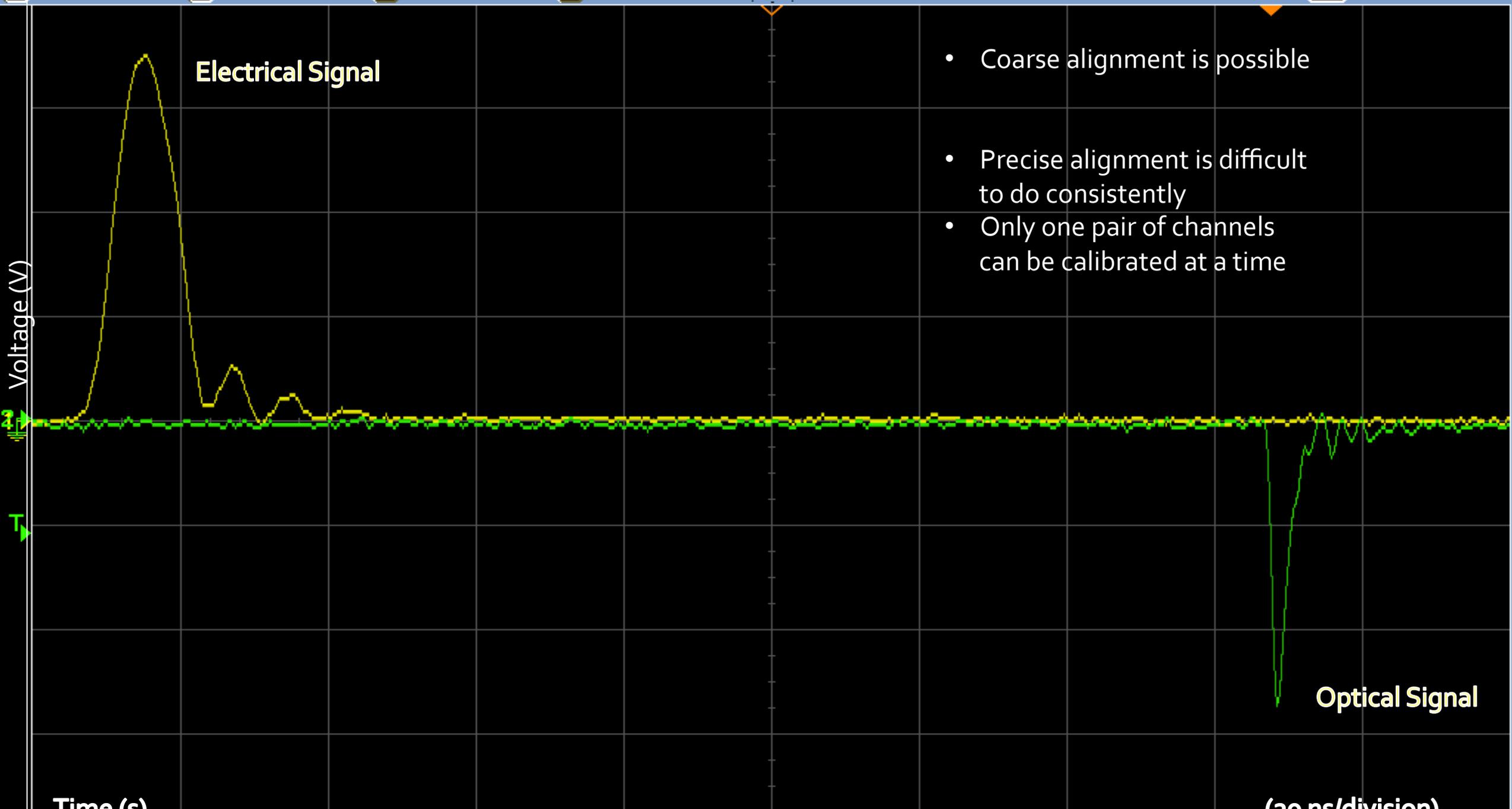
CURRENT NEED

- A time calibration system to resolve the cable arrival time delays
 - Generation of a signal into both optical and electrical tracks
 - Analyzing the difference in arrival time to resolve the arrival delay during experimental measurements.

Current Method

Current timing calibration
Laser head

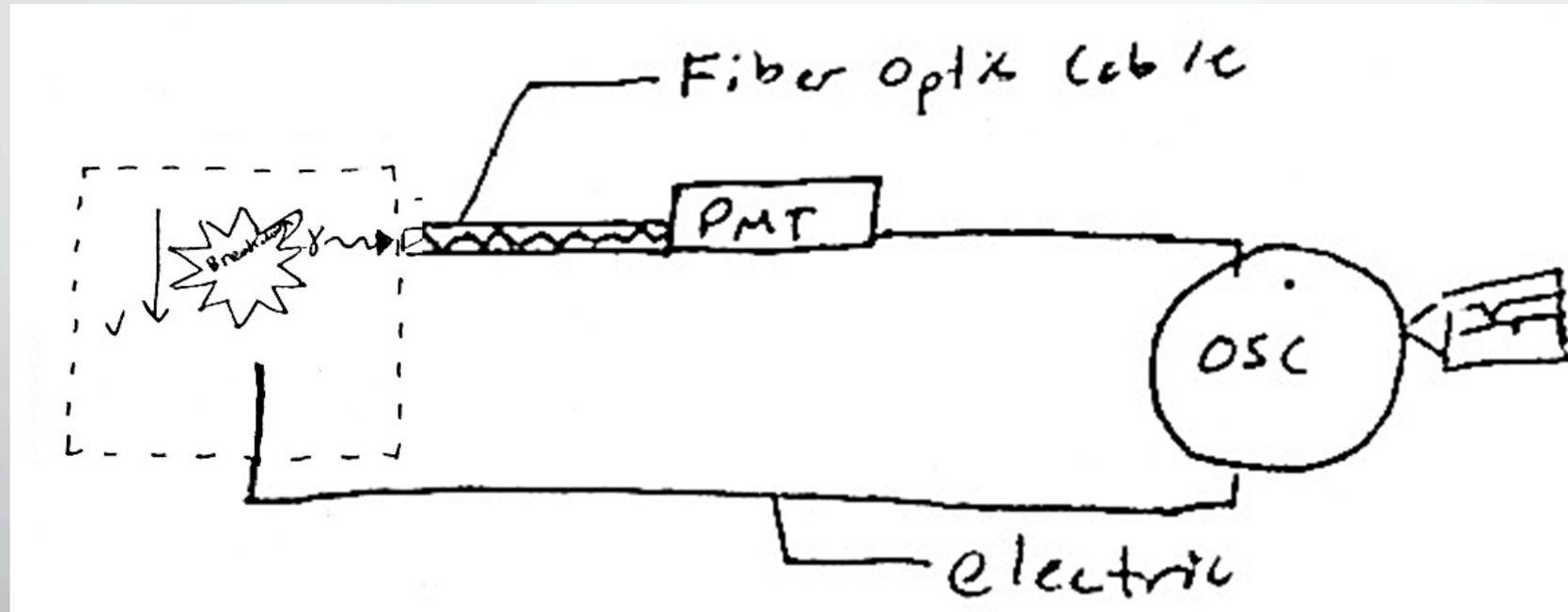




Project

- Design a system to take calibration measurements more quickly than the current method.
- Resolve this arrival time delay precisely and consistently by calculating the difference in arrival times.

DESIGN

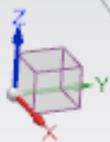


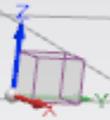
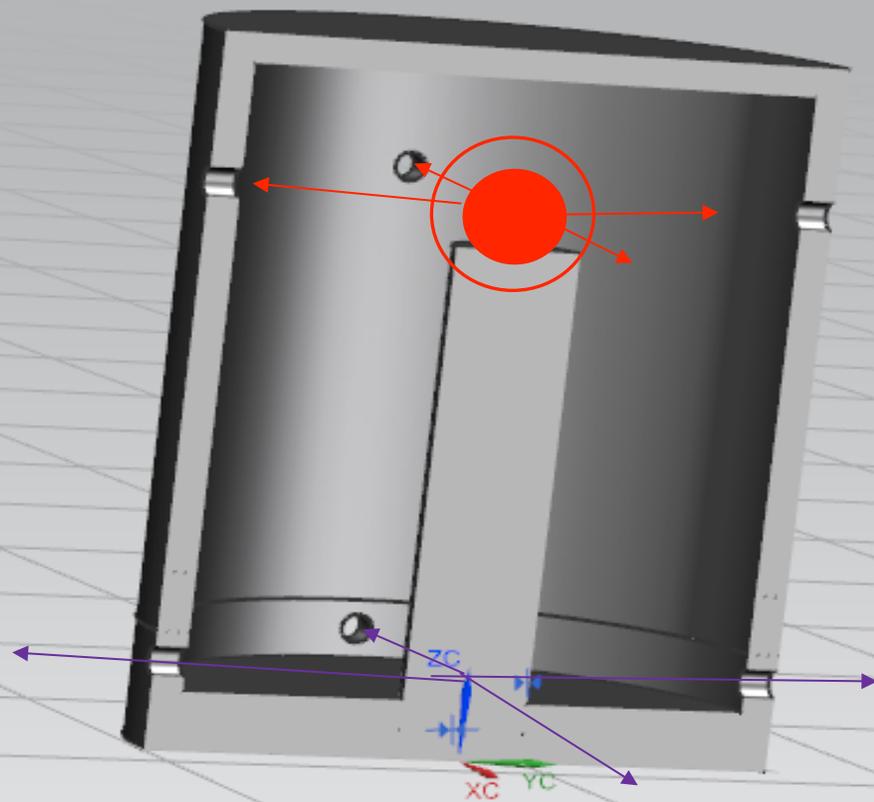


20 cm



- Multiple tracks can be calibrated at once.
- Cylindrical shape reduces asymmetrical noise





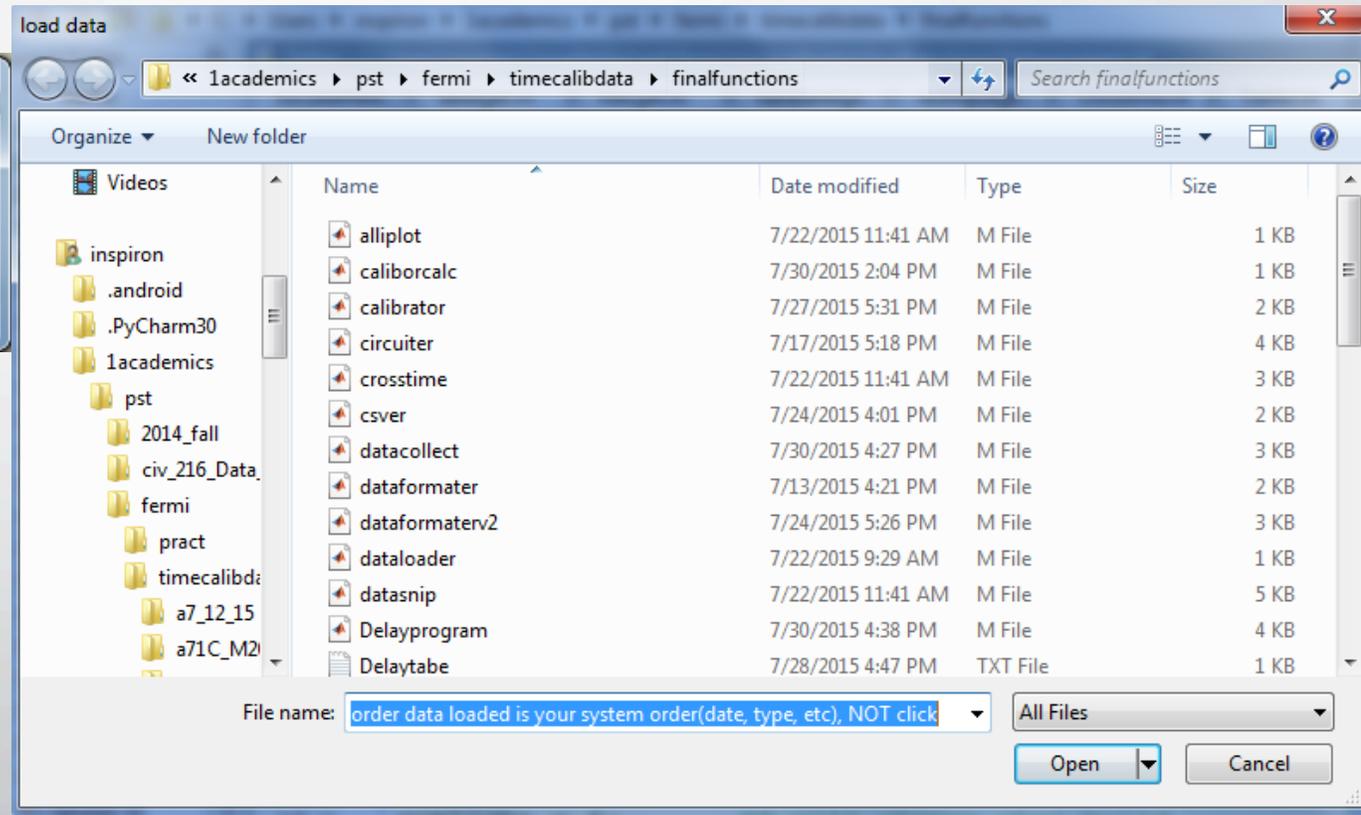
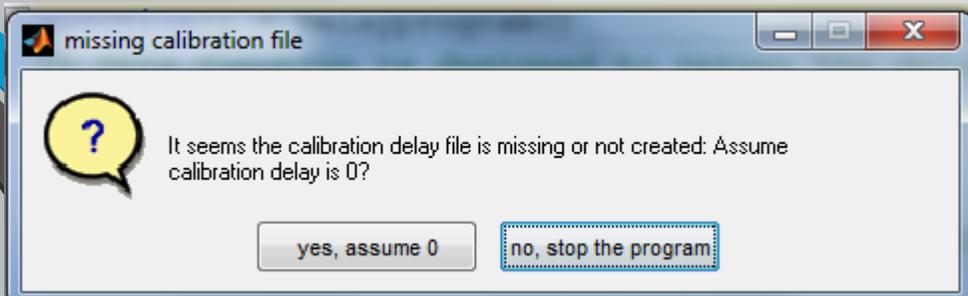
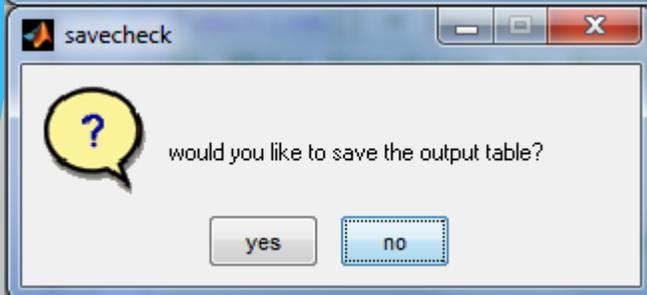
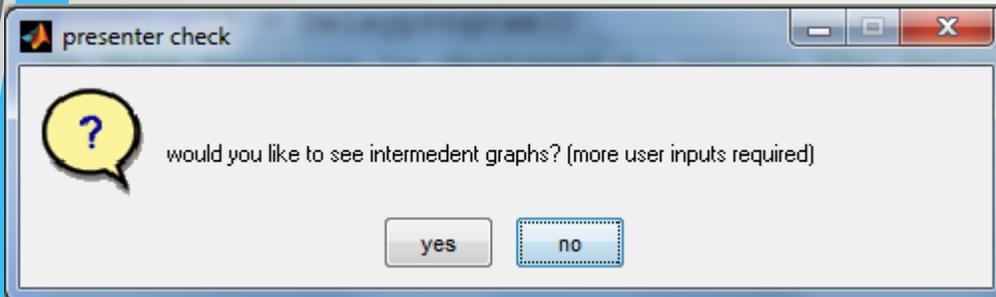
Program

- Inputs data of varying styles easily.
- Outputs of relative delays for easy interpretation.
- The user is not required to “go into the code”

Software of choice: Matlab

- Allows for a variety of loading options
- Allow for graphical displays
- Allows the use of programmable dialog boxes for data and parameter inputs

Data Input



Please select the channels of the inputted data that are light data. channels are in th...

ch(1) ch(2)

OK

Please note which hardware channels each of the data channels came from hit cancel to use default counting

ch(1)cable channel 1
5

ch(2)light channel 1
1

OK Cancel

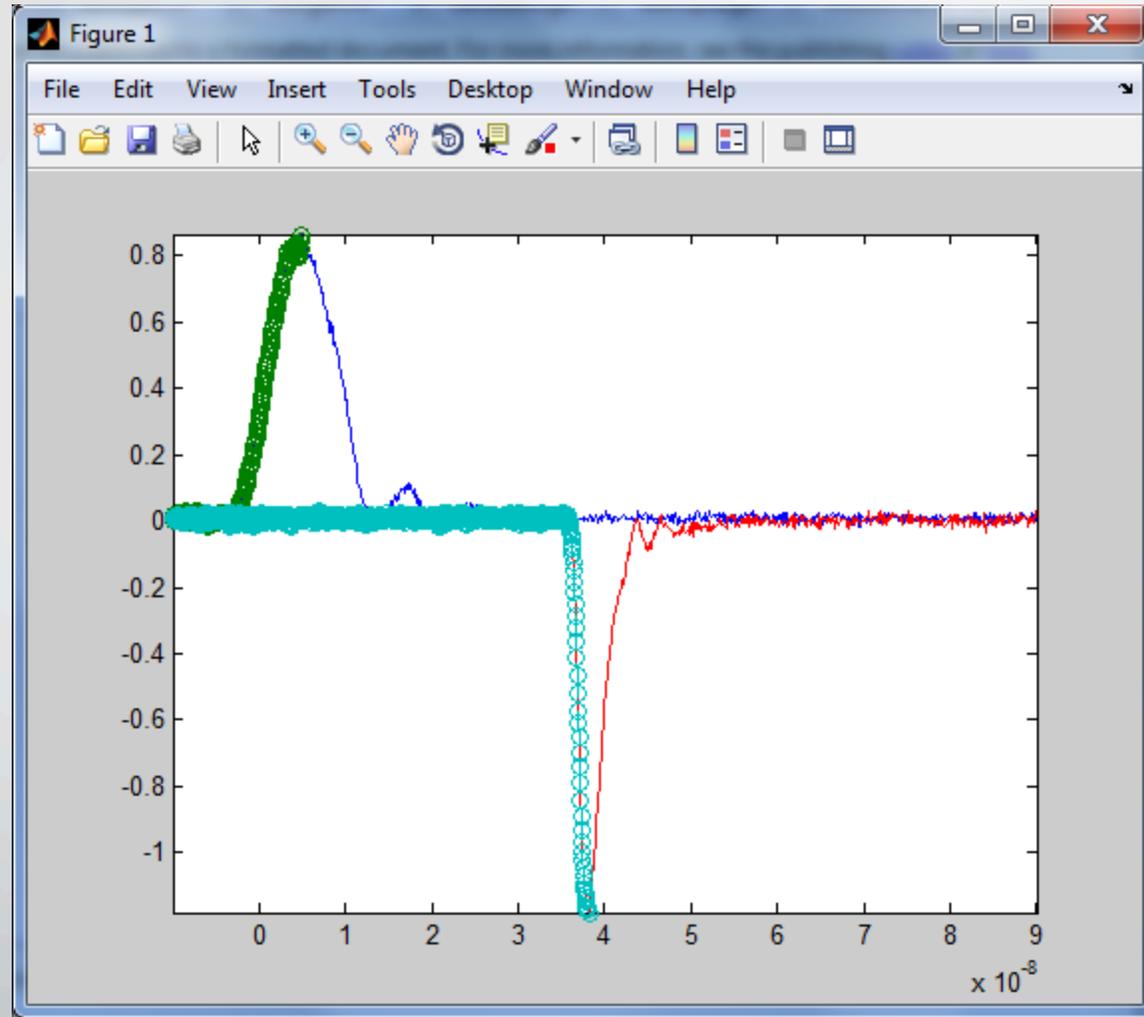
Inputs

threshold voltage of cable
7

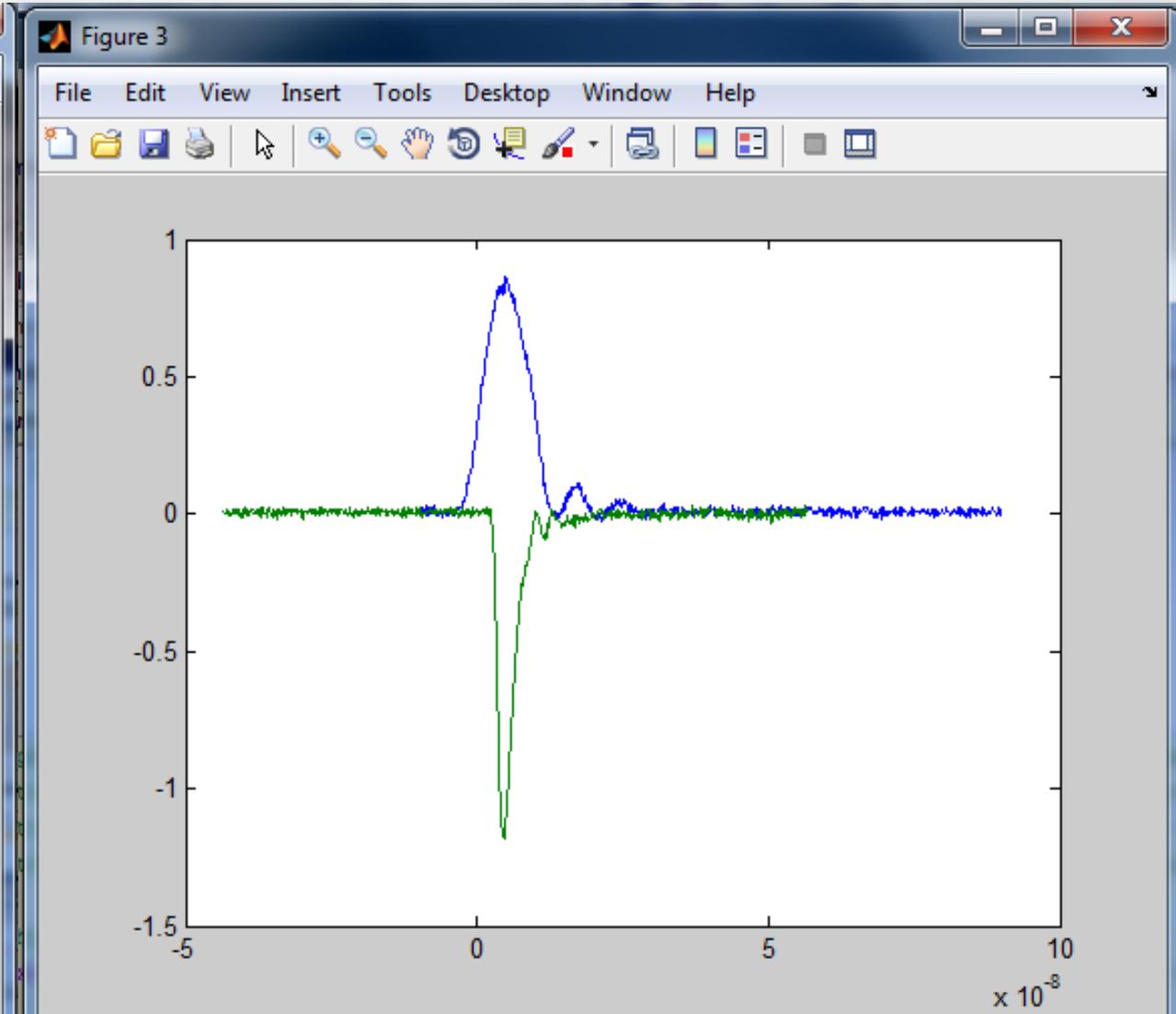
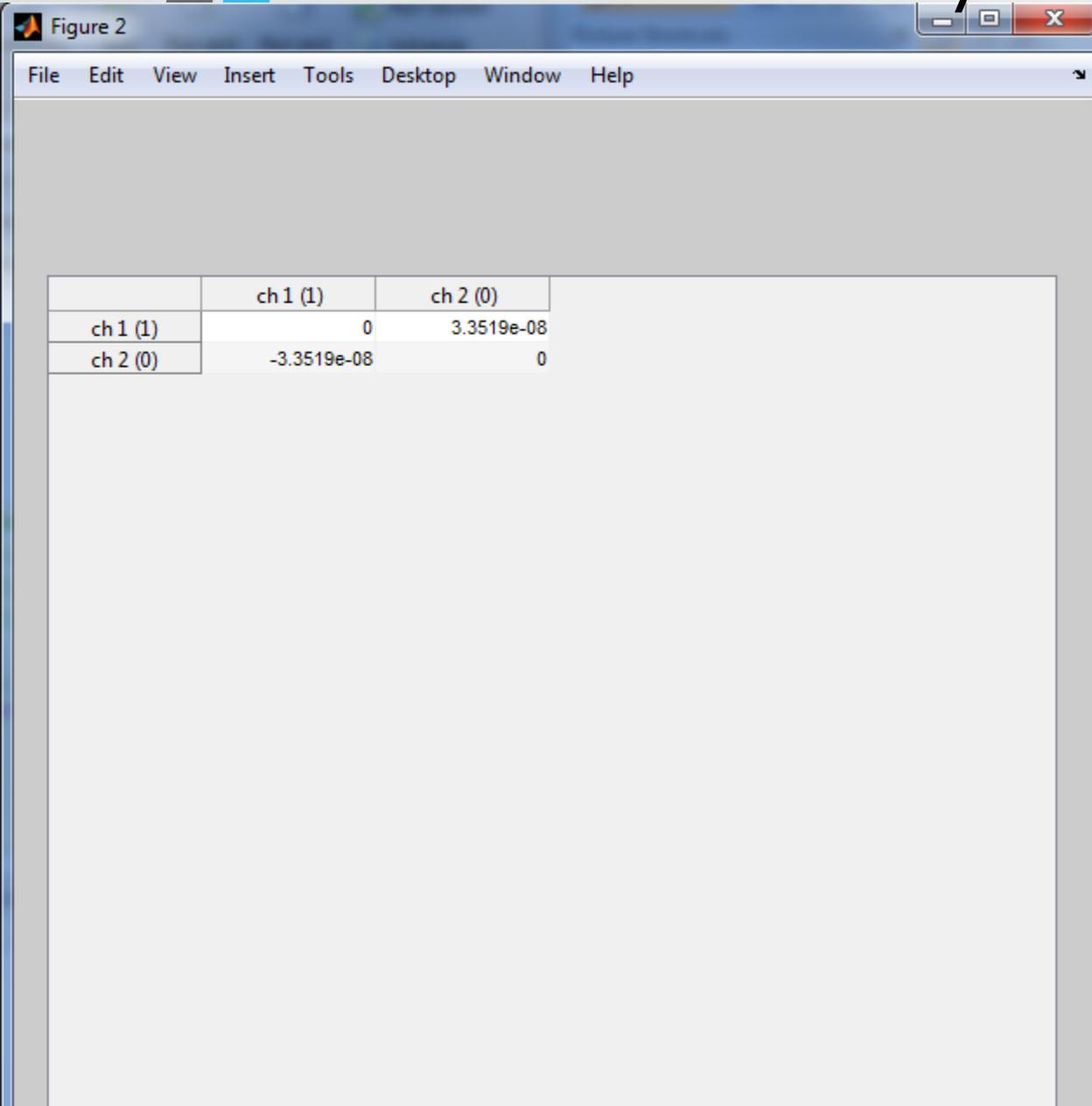
set of points for light baseline
1:150

number of standard deviations for light data to cross
5

OK Cancel



Delay Table



	ch 1 (1)	ch 2 (0)
ch 1 (1)	0	3.3519e-08
ch 2 (0)	-3.3519e-08	0

Sources of Error

- Threshold voltage deviation
 - Time cross deviation
 - Alleviated with precise inspection of LED
 - 1ns deviation
- Time cross calculation uses the average
 - Caused by noise near the crossing point.
- Temperature
 - LED has a lower threshold with rising temperature.
 - Cables of large length undergo thermal expansion, which affect measurements

	ch 1 (1)	ch 2 (0)
ch 1 (1)	0	3.3519e-08
ch 2 (0)	-3.3519e-08	0

Conclusion and Futurework

Present

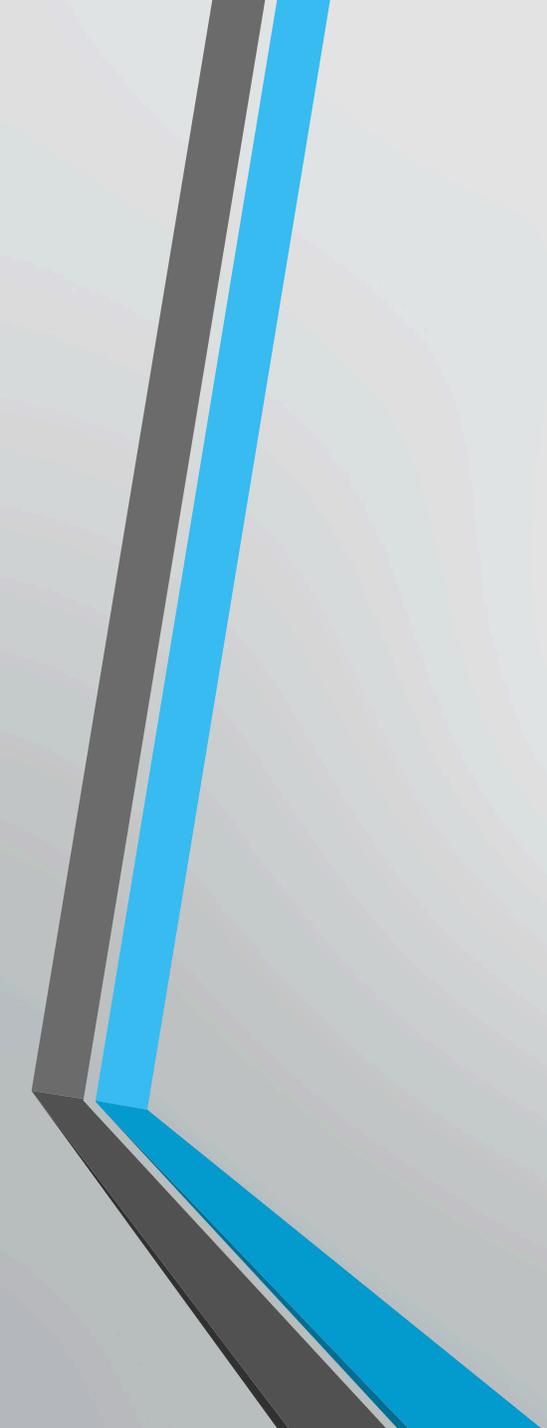
- We were able to develop a design proposal for a measurement device to collect multiple tracks of calibration data at once
- Developed a program to analyze multiple data types returning a table of delays that is easy to read.

Future

- Build device
- More efficient program (style/language)

Thanks

- Supervisor Katsuya Yonehara, and the rest of the group
- Mentor Mayling L Wong-Squires
- SIST Committee
- Fermi National Lab
- Jackie Chan



Questions?

Why Jackie Chan?



I never wanted to be the next Bruce Lee. I just wanted to be the first Jackie Chan.

(Jackie Chan)

References (pictures mainly)

- RF Cavity:
 - http://newslines.linearcollider.org/images/2010/20100617_dc_1.jpg
- Lightning
 - <http://blogs.rftdata.co.uk/photo-diary/files/2013/07/Lightning.jpg>