Muon (g-2) Calorimeter Calibration System

Carlo Ferrari

MidTerm Review, Pisa, March 4-5, 2019

Web site: risenews.df.unipi.it

European Commission

Introduction

- The main task of the laser system in the Muon experiments (both G-2 and Mu2e) is the correction of the gain drift and instability of the photodetectors (SiPM) of the calorimeters (G-2: 54 SiPMs each for 24 calorimeters, Mu2e: 900 SiPMs each for 2 calorimeters), which are a major cause of systematic error.

- The main factors that influence the SiPM gain is the temperature (gain drift); however, in the G-2 experiment, the particle splash in the early stage of the muon fill produce a gain sagging, due to high particles rate.

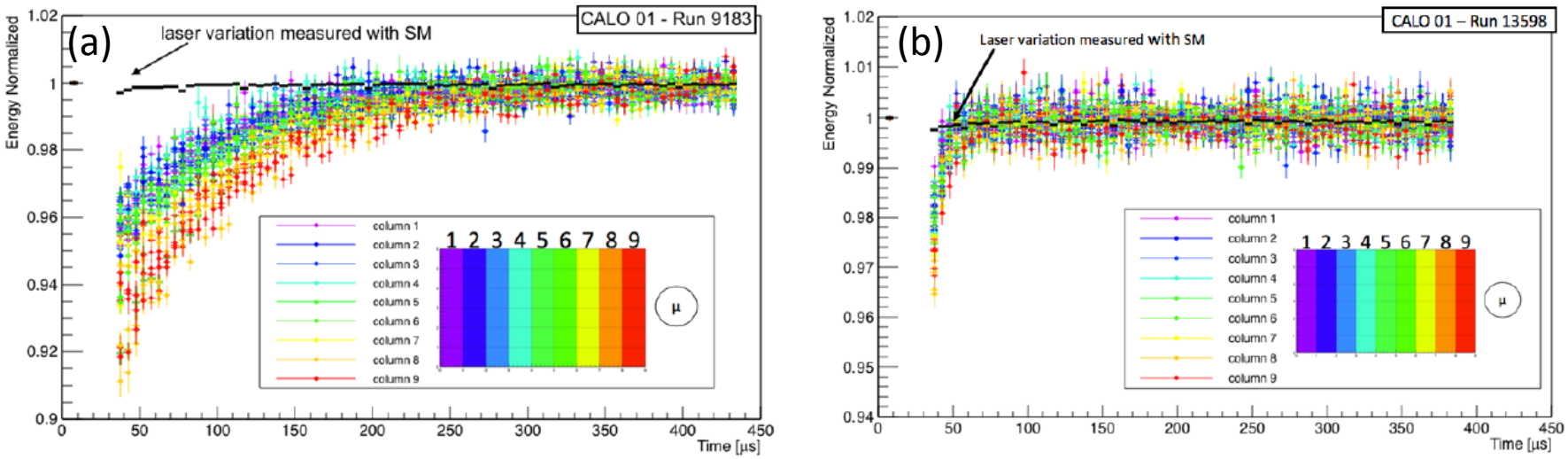
Ferrari's secondements

Secondments:

- 13th Feb 2018 – 26th Feb 2018
- 19th Jun 2018 – 13th Aug 2018

During the first secondment I worked on the reduction of gain sagging, adding capacitors near the SiPMs (embedding it in the so-called dogbox). To test the solution, a laser mode was implemented that provides a simulated splash (100 laser pulses with repetition rate of about 8 MHz) followed by probe pulses spaced temporally by 5 us. The laser pulses sent at the beginning of the fill were effective in simulating the splash.

The tests demonstrated that the added capacitors were effective in flattening the gain curve of the SiPMs and bigger capacitors (megabox) have been installed on each calorimeter.



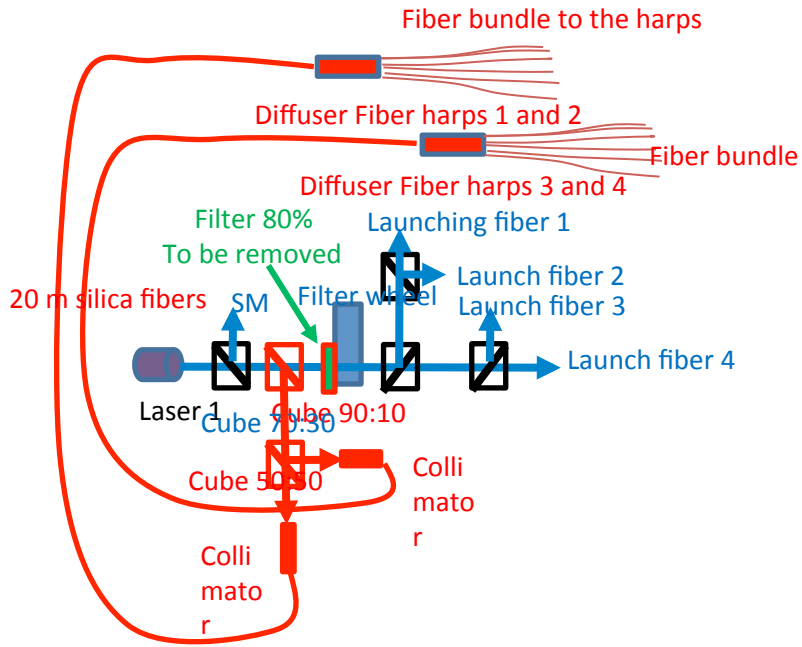
Gain function during the muon fill, for the 54 channels of calorimeter 1: (a) before (run 9183) and (b) after (run 13598) the megabox installation (thanks to Anna Driutti).

Second Ferrari's secondement

During the second secondment (19th Jun 2018 – 13th Aug 2018) I worked on the following tasks:

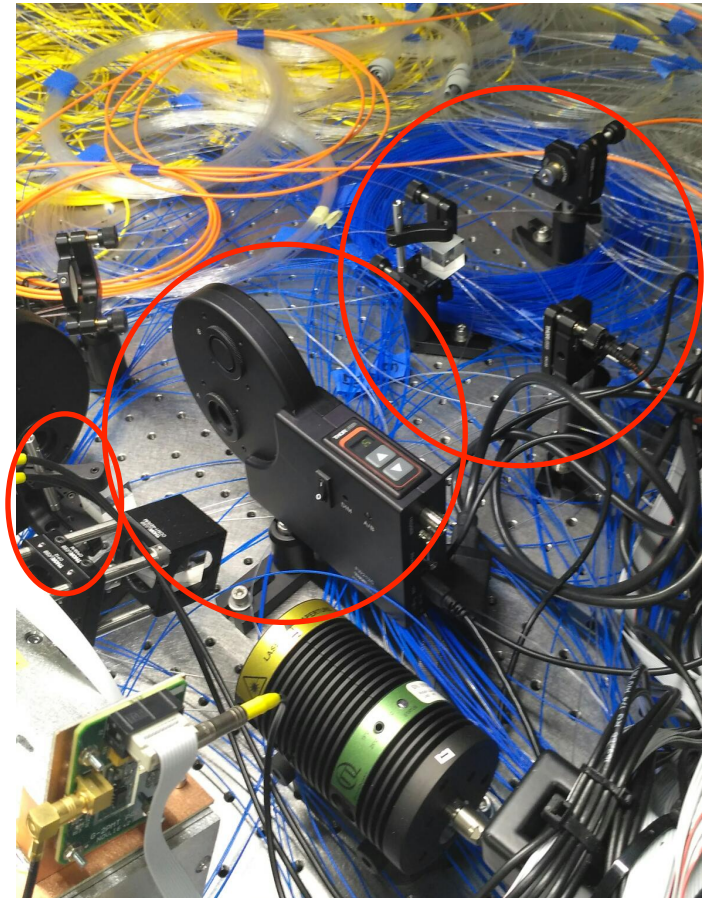
- I have done 6 shifts (8 hours each) in the control room of the G-2 experiment (June)
- I attended the Mu2e Collaboration Meeting (Jun 26th to Jun 29th, 2018)

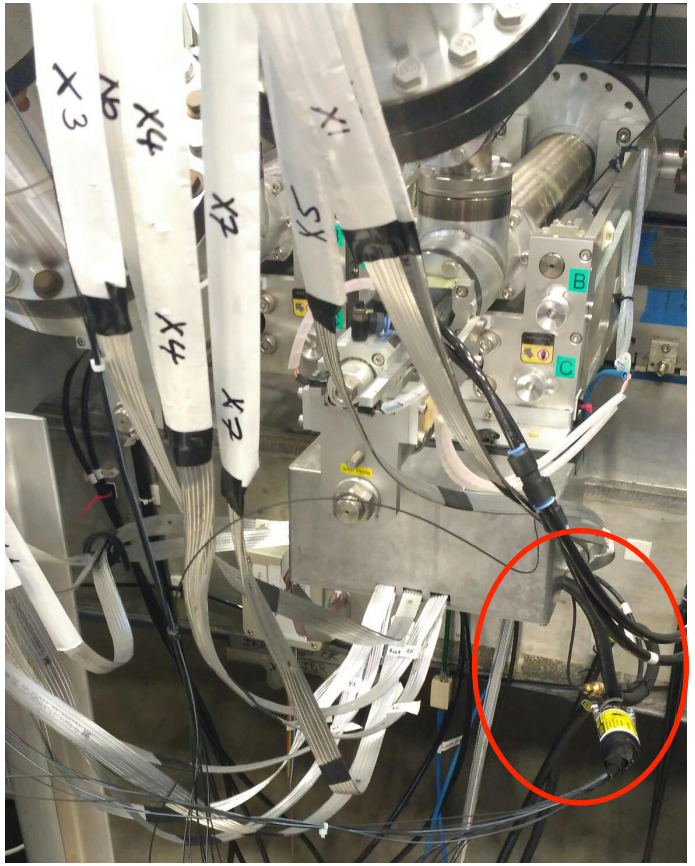
- I designed and installed optical components on the laser hut in order to provide lasers pulses to the two Fiber Harp detectors in the ring. Laser n.1 has been sampled with a 90:10 cube, the sampled beam has been splitted in two beams with a 50:50 cube, the two beams collimated into two 20 m long Silica fibers. At the end of the two fibers there are optical components in order to obtain a flat-top beam, ½" wide. At the output of each optical systems there are two fibers bundles (32 fibers each) providing the laser pulses to the SiPMs embedded in the two Fiber Harp detectors. We installed the two optical fibers, checked the transmission of the optical system. Furthermore, a filter wheel (12 filter) has been installed, in order to change the amplitude of the laser pulses.



G-2, Aug 2018: Laser pulses to the Fiber Harps

Installation of the optics in the laser hut, of two new optical fibers and two fan-out systems



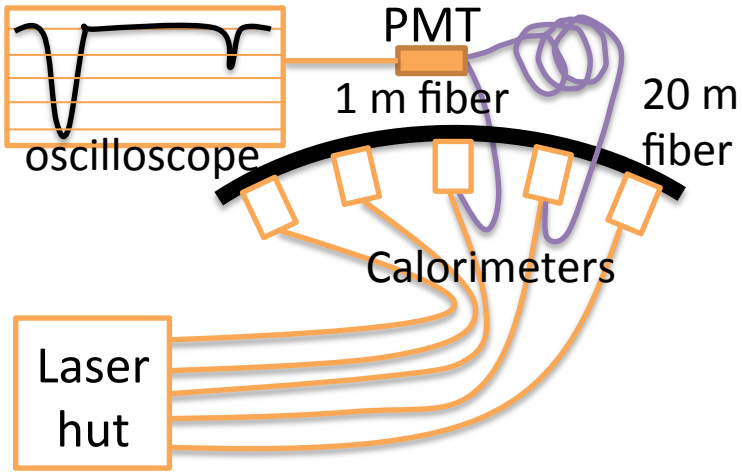


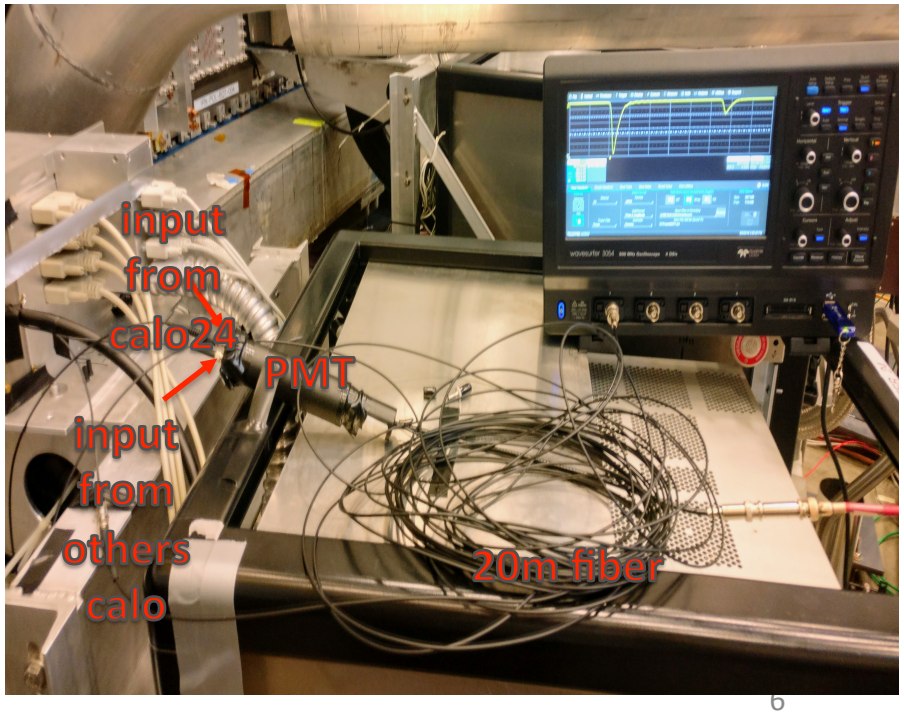
Engineered diffuser

16 fibers bundle

Second Ferrari's secondement

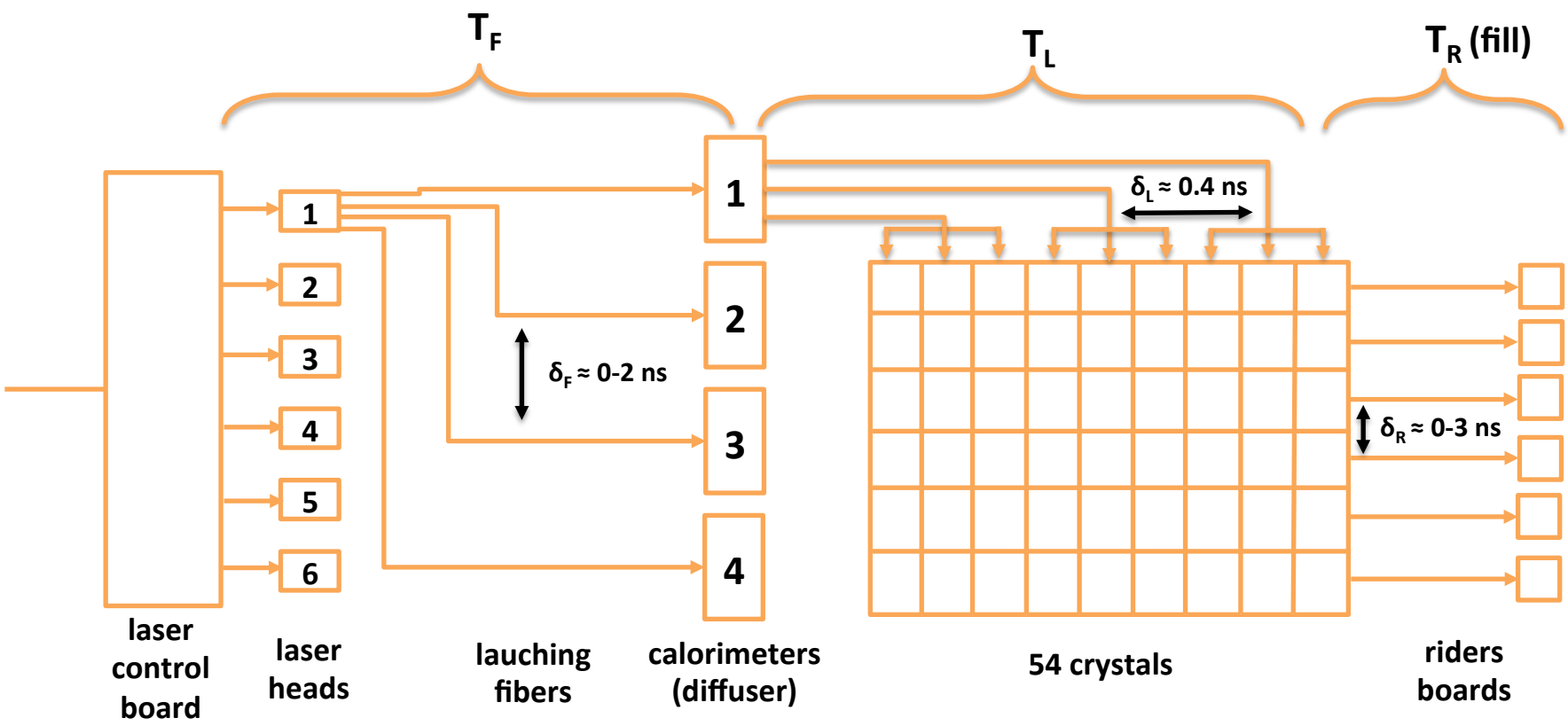
Furthermore, I proposed, designed and I have been involved in the study of the synchronisation of the laser pulses sent to the 24 calorimeters. Each launching fiber connected to the calorimeters has been disconnected and connected to a PMT along with another fiber that carries a reference signal from another calorimeter. The difference between the arrival time of the two pulses provides the time delay between the laser pulses, due to the laser heads and the length of the cables that carry the trigger signals to the control boards of the six lasers. We measured the time difference within calorimetrs with accuracy of 100 ps (well below the requested 500 ps synchronisation).



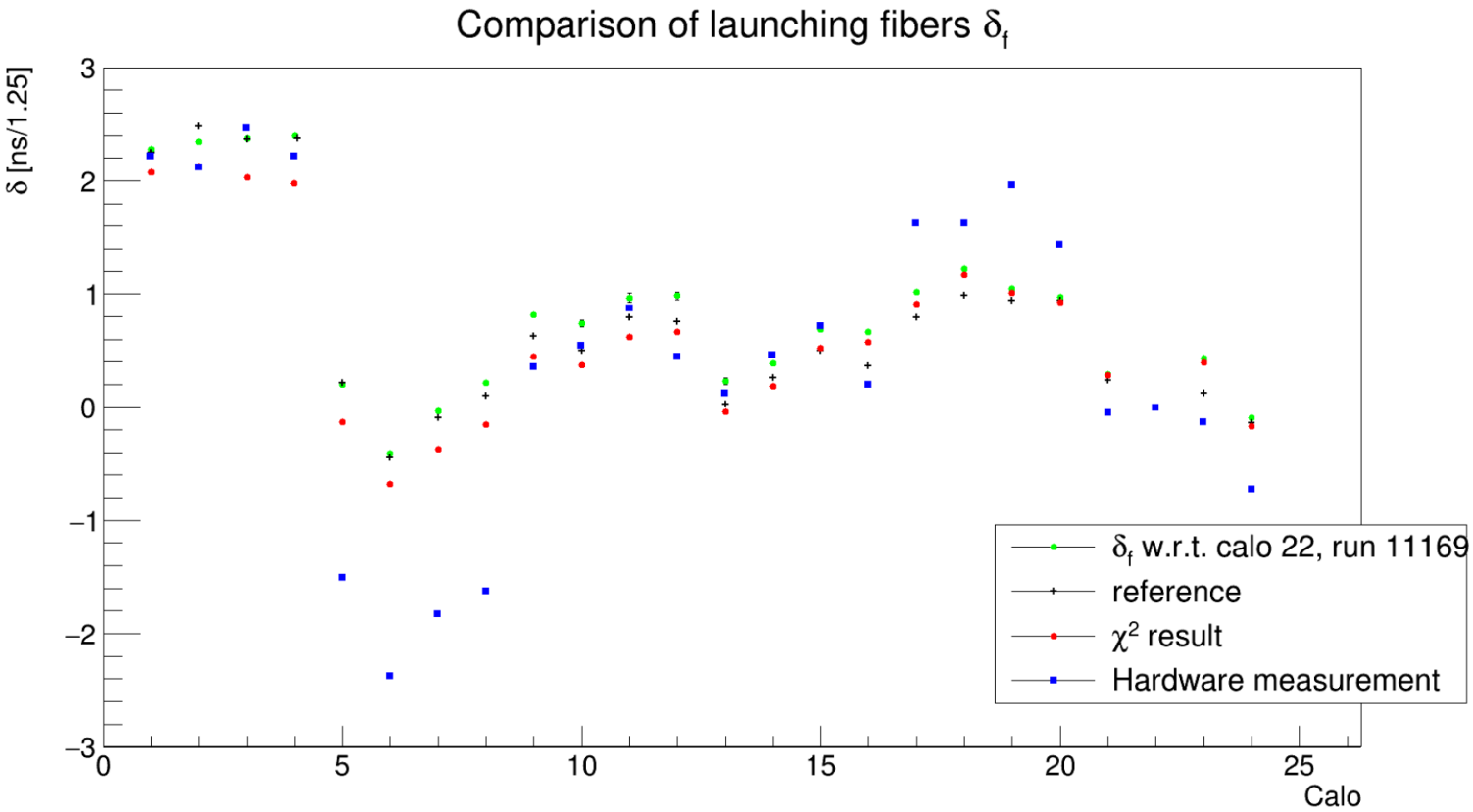


To get the hardware delay between calorimeters we send two pulses from two calorimeters through two fibers of different length.

G-2 laser pulses synchronisation



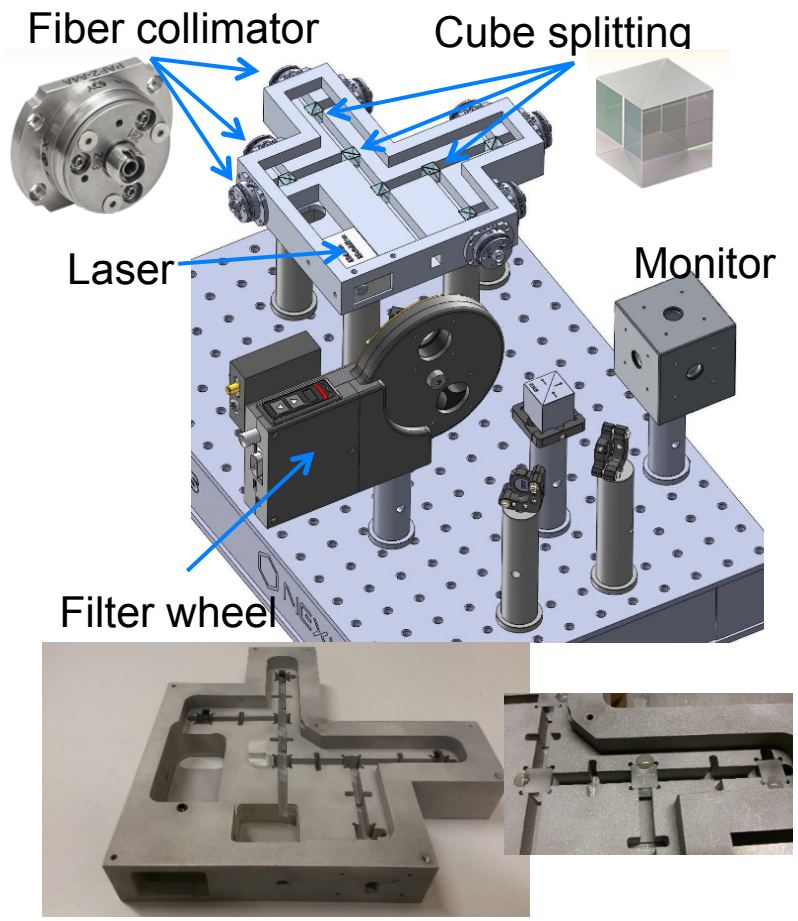
Results on G-2 hardware measurement of δ_F

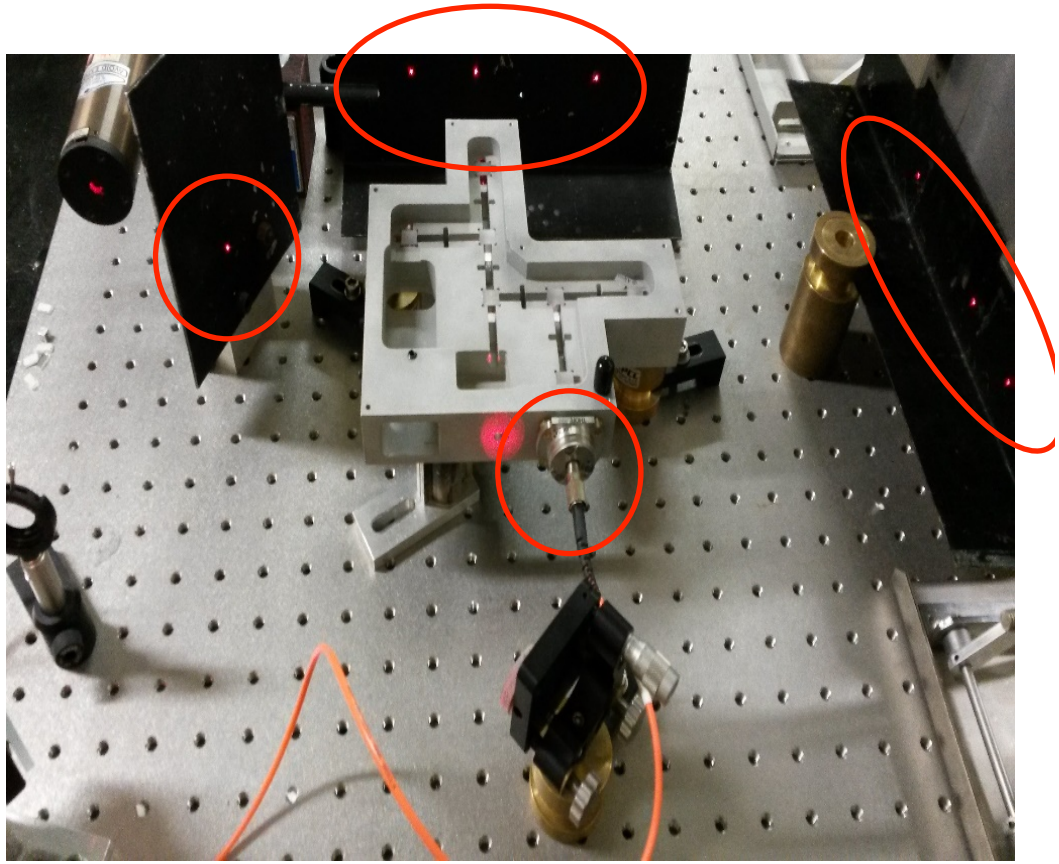


(Thanks to Paolo Girotti)

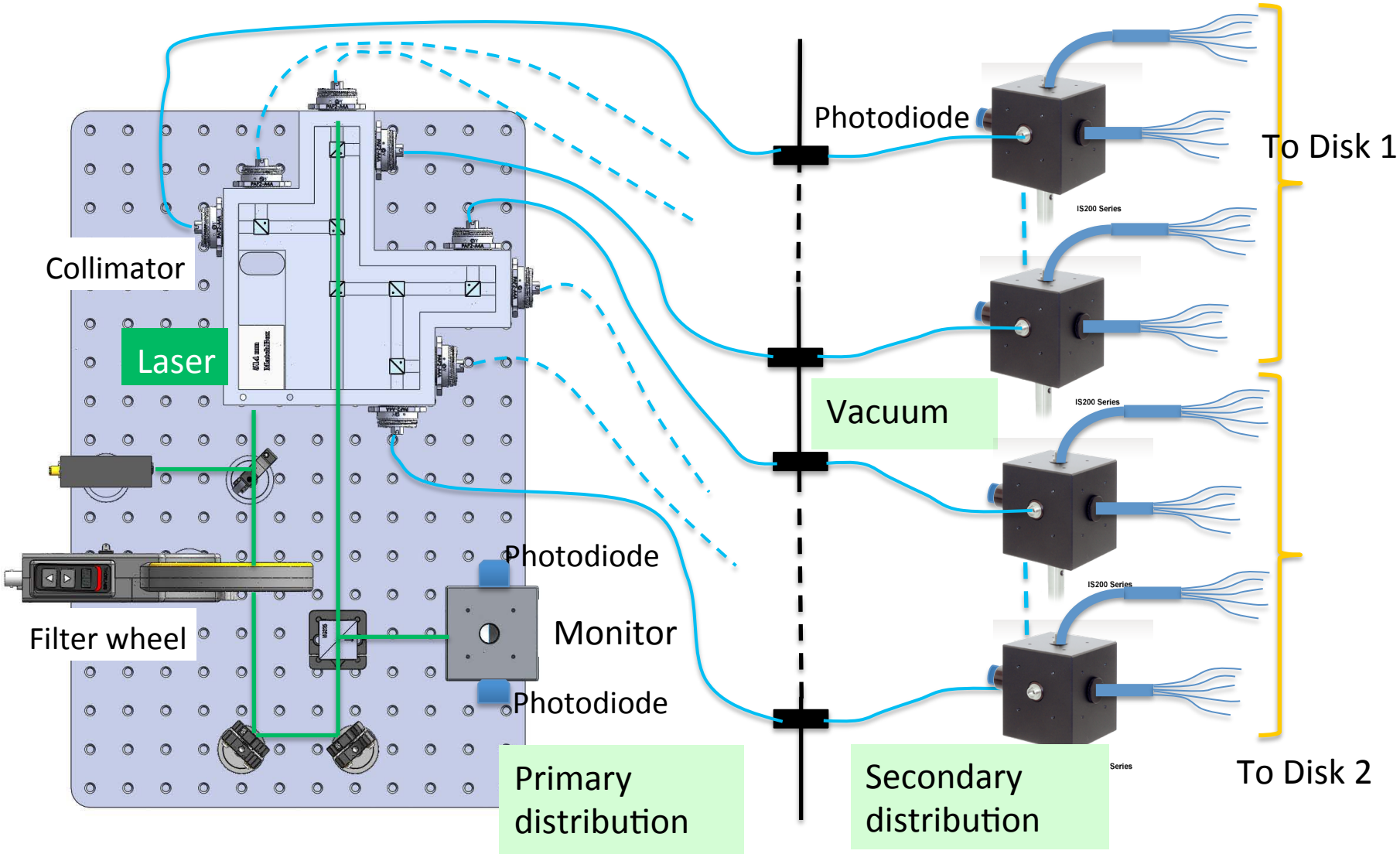
Second Ferrari's secondement

Furthermore, I made few test regarding the laser calibration system for the ***Mu2e*** experiment. The experimental setup to split the laser into 8 beams has been installed and successfully aligned in the laser room at SiDet, using 7 50:50 splitting cubes in a compact design (20 cm x 20 cm). The transmission of the system is about 8% for each beam, the uniformity of intensity is within 15%.





Mu2e Laser system scheme



The laser pulses are sent simultaneously to 1200 crytals/SiPMs located in 2 calorimeters in the vacuum chamber through 8 60 m long fibers and 8 integrating spheres. 24 fibers bundles perform the second fan-out.

Conclusions

- The G-2 laser system has been installed and is properly working

- The Mu2e laser system has been designed
- The Mu2e primary distribution system has been assembled, aligned and tested