

# The Study of Silicon Deposit and Cleaning Gas

## (Phase I)

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### Introduction

One of the ongoing aging tests at Duke is to force the silicon deposit on the wire surface and test the effectiveness of the silicon cleaning mixtures. The setup for this run is identical to the previous runs including the position and strength of  $\text{Sr}^{90}$  sources. However the ionization gas mixture is Ar- $\text{CO}_2$  (70-30), which is passed through 20 cm long 0.8 cm inner diameter copper tubing filled with Kimwipe saturated with silicon oil before entering the test module. Unfortunately after a month of running, it seems that we failed to produce silicon deposit on the wire surface. This may due to the low vapor pressure of the silicone oil, and we are about to switch to another brand with much higher vapor pressure. This report summarizes the results up to date.

### Results/Discussion

The degree of silicon deposit is checked by measuring the relative gain along the wire length, and there is no gain shift within our measurement error ( $\sim 1\%$ ) and the systematic long term drift ( $\sim 2\%$ ). During one month of running, the integrated charge around wire-joints ( $\sim 20$  cm upstream and  $\sim 10$  cm downstream of the wire-joints) varied from the highest of  $\sim 0.4$  c/cm to the lowest of  $\sim 0.2$  c/cm. The region outside the wire-joints received  $\sim 1/3$  of the dosage around wire-joints. The figures at the end of the report show the results of the gain map along the straw length.

It is not clear why there is no sign of the silicon deposit, but we can speculate the causes.

1. The evaporated silicone oil does not enter straws. The distance between the tube with silicone oil and the test module is about 60 cm and copper tubing with 0.5 cm inner diameter is used between the two. It is conceivable that the evaporated oil may be attached to the copper tubing and the inner surface of the tension and HV plates and fail to enter the straws.
2. The vapor pressure of the silicon oil used in the test may be too low. The vapor pressure is only measured at the higher temperature ranges. We extrapolated the curve to the room temperature and estimated the vapor pressure to be 0.01 to 0.001 torr, and the error could be large because there are only a few data points.

Assuming a certain vapor pressure, it is an interesting exercise to calculate the amount of silicon thickness on the wire surface if all the evaporated silicon atoms deposit on the wire surface uniformly.

$$\text{Amount of silicon entered the test module in gram} = (\text{gas flow rate in cc/min})(\text{time})(V_p/760)(\text{Silicon molar weight})/(22400) = 0.34V_p \text{ gram} \quad (\text{Eq 1})$$

gas flow rate =  $\sim 5$  cc/min,  $V_p$  = silicone oil vapor pressure in torr, time=60x24x30 (30 days of running in minutes), 22400 = volume of 1 mol of gas in cc, and I use one silicon molar weight (28 g/mol) although the evaporated silicon oil may contain more than one silicon atom.

$$\text{Amount of silicon on wire in gram} = (2\pi r)(t)(\text{length of wire})(\text{total number of wire})(\text{density}) = 0.0043t \text{ gram} \quad (\text{Eq 2})$$

$r$  is the wire radius (15 microns),  $t$  is the silicon thickness in micron, length of wire = 100 cm, total number of wire = 20, density =  $2.3 \text{ g/cm}^3$ , and I assume that the silicon deposit is uniform along the entire wire length.

Comparing (Eq 1) and (Eq 2), and for  $V_p = 0.01$  (0.001) torr, the expected thickness is  $\sim 0.8$  (0.08) micron after 30 days running time. If our estimation for the vapor pressure is off by a factor of 10, the expected thickness could be as small as 0.008 micron, which may not be enough to produce the aging effect.

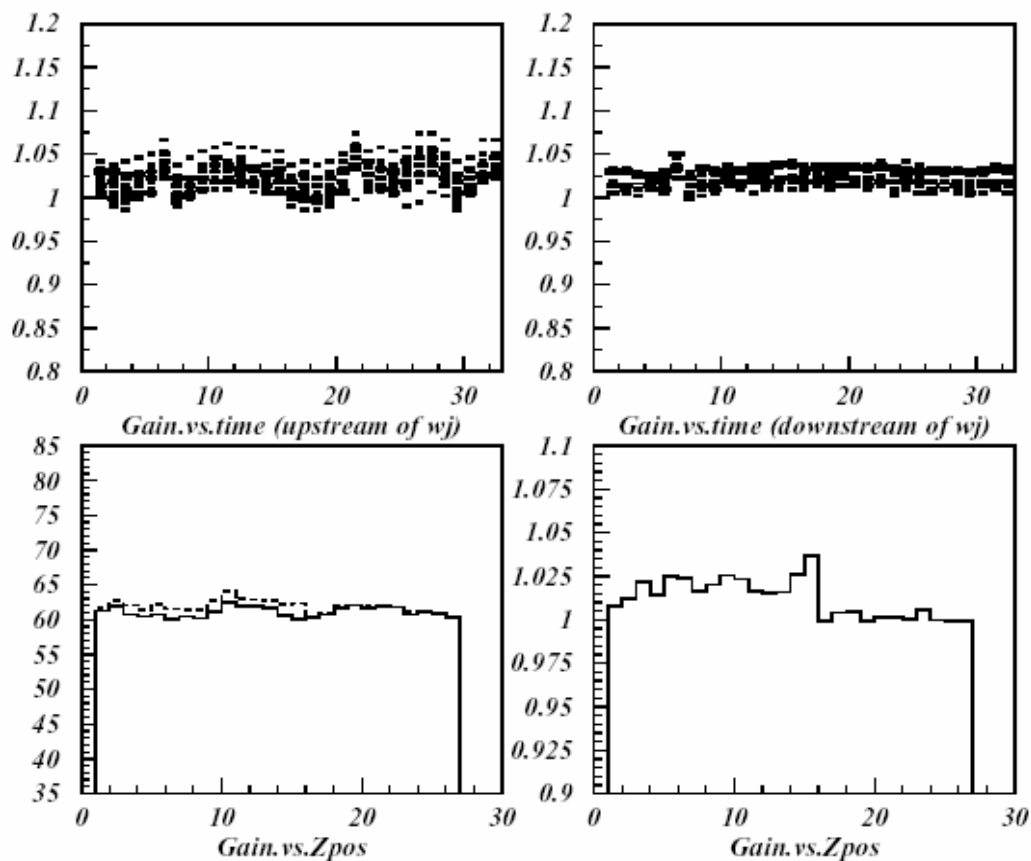
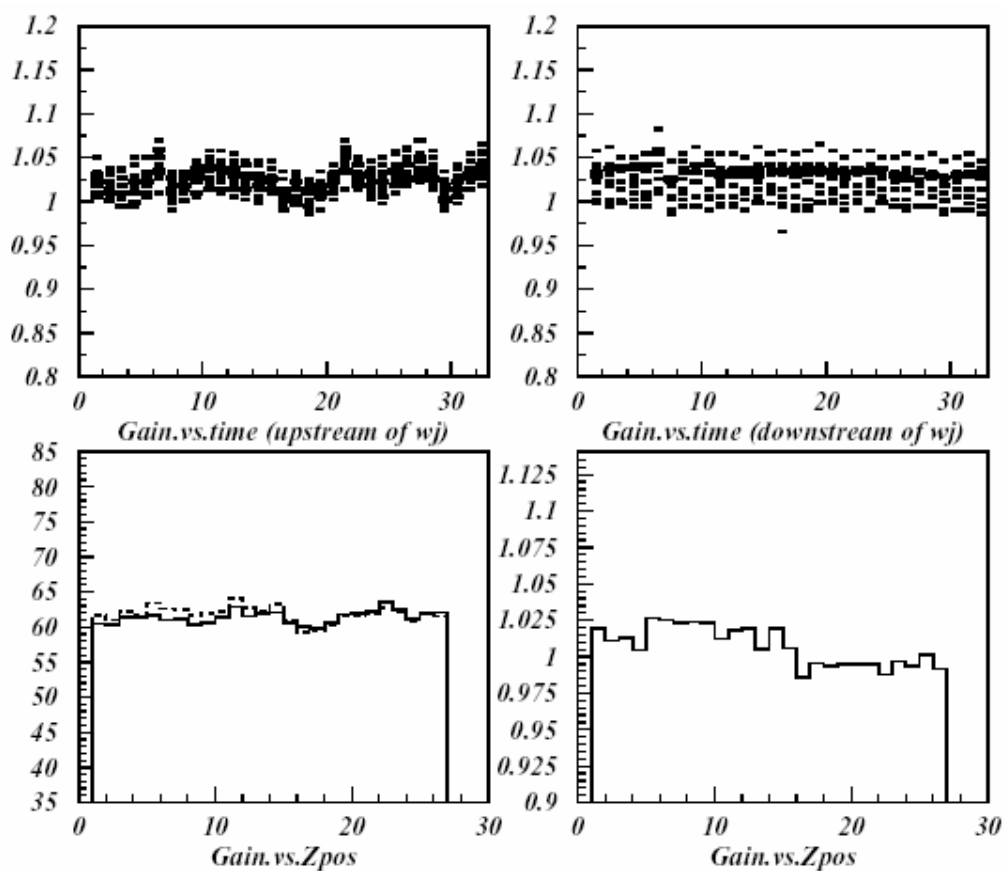
3. The moisture level in the ionization gas during the run has been around 700 ppm. Does  $\text{H}_2\text{O}$  play a role in depositing silicon? It is unlikely although there had been no systematic study.
4. The gain for the run is about 3 to 4 times of the nominal gain of 25,000. Does the gain play a role in silicon deposit? I believe that there is data and the silicon aging process still occurs at the higher gain.
5. Are there other forms of silicon which cause the aging?

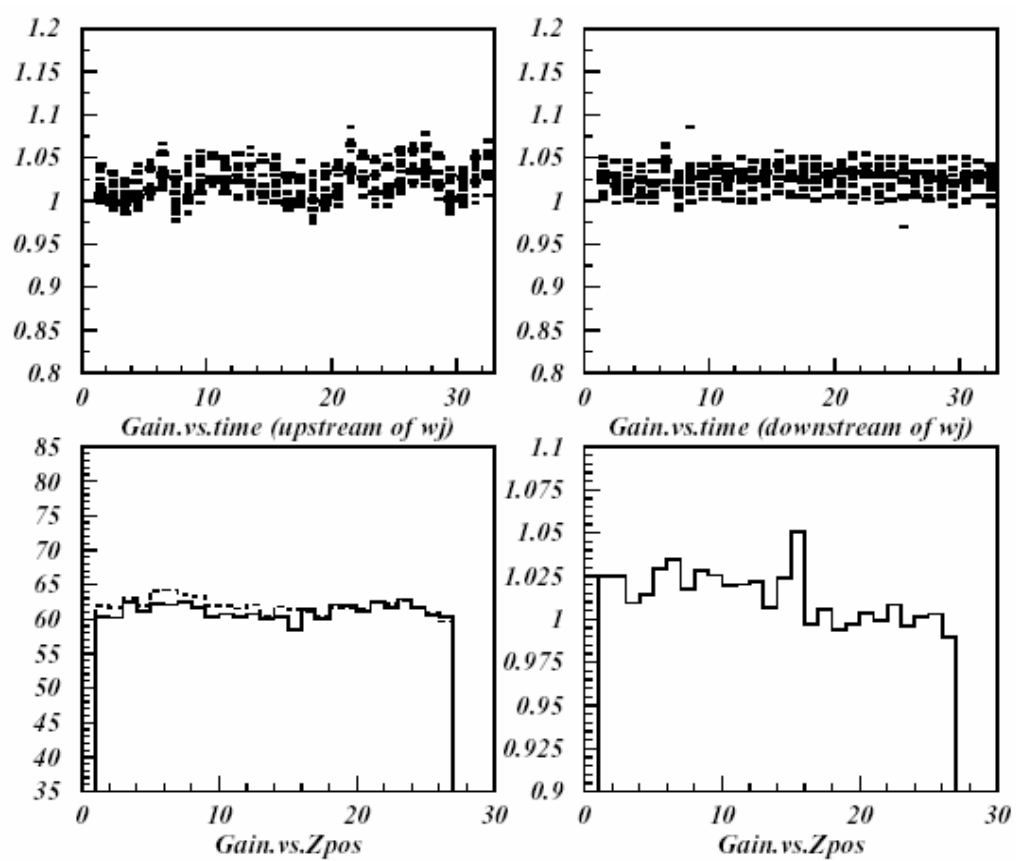
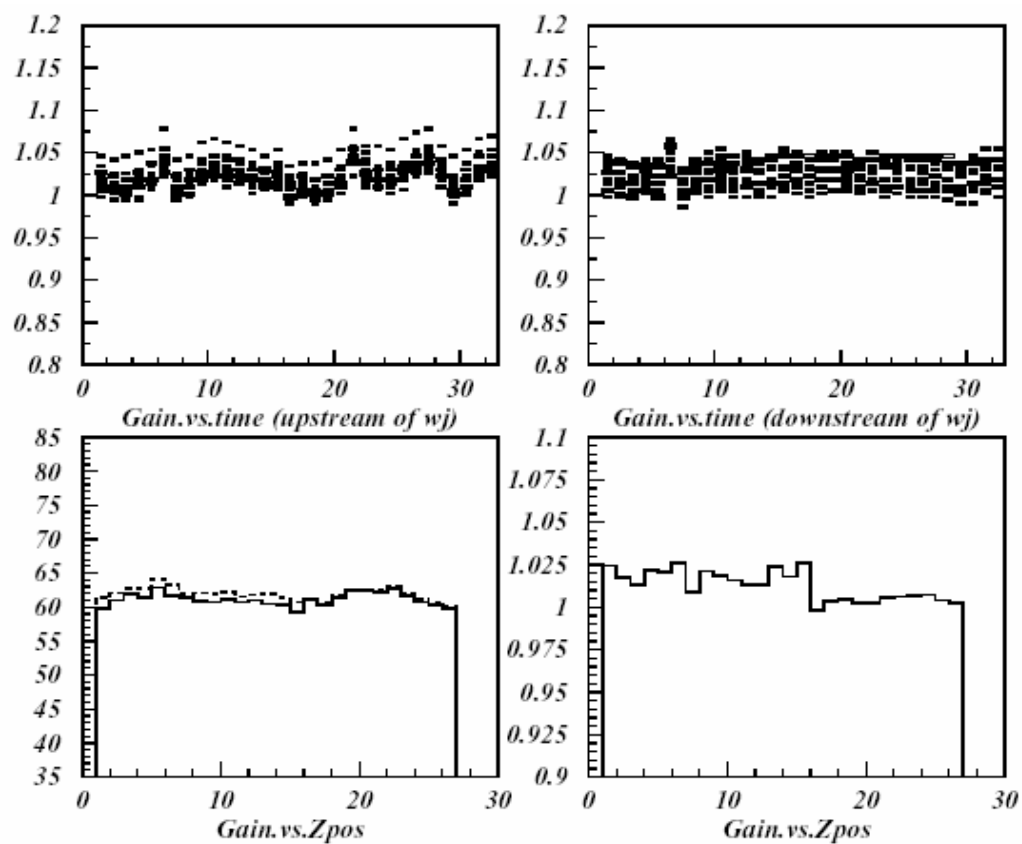
## The Next Step

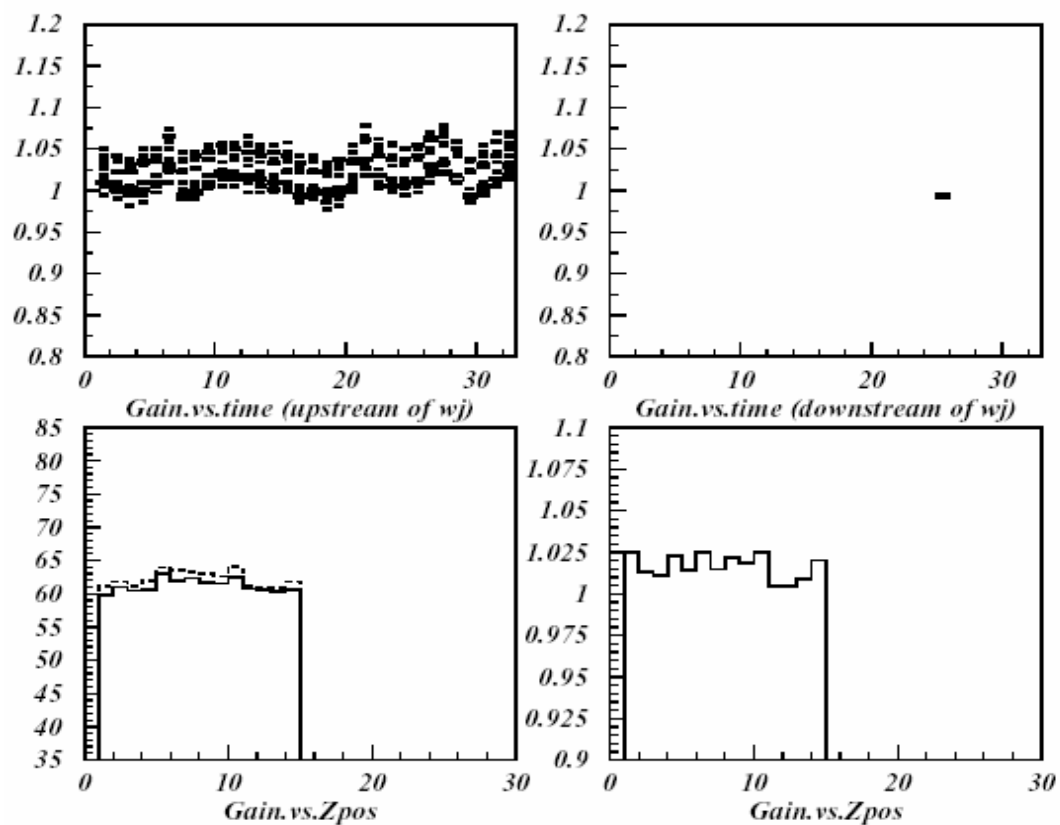
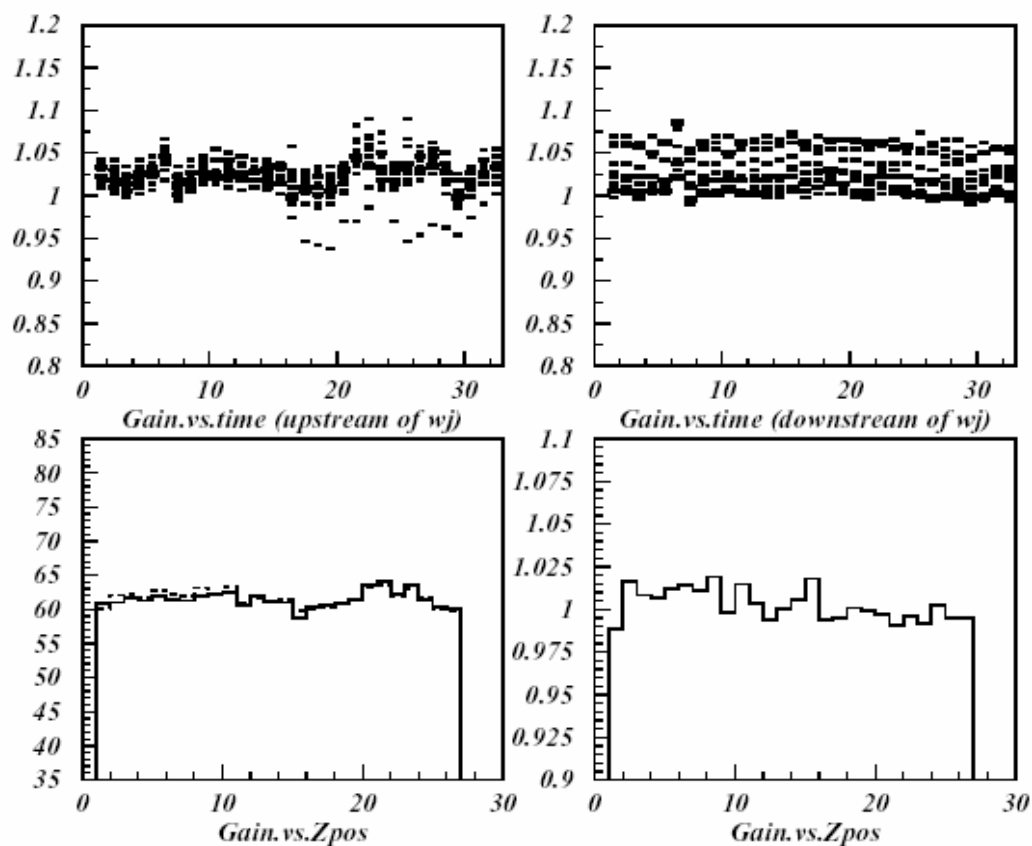
We will switch the oil with another type with much higher vapor pressure in a couple of days. The oil is designed for cleaning purpose and the vapor pressure is a few torr at the room temperature. With the vapor pressure, the thickness of the silicon deposit on the wire could be a few microns per day. We can lower the vapor pressure by cooling the oil but we will start at the room temperature.

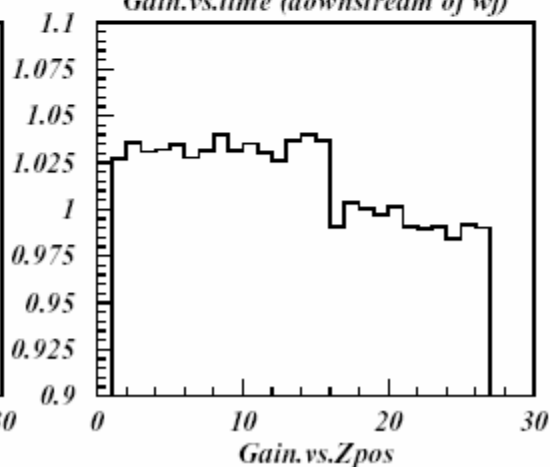
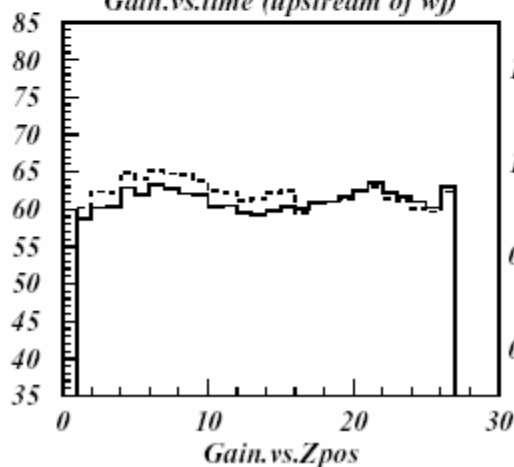
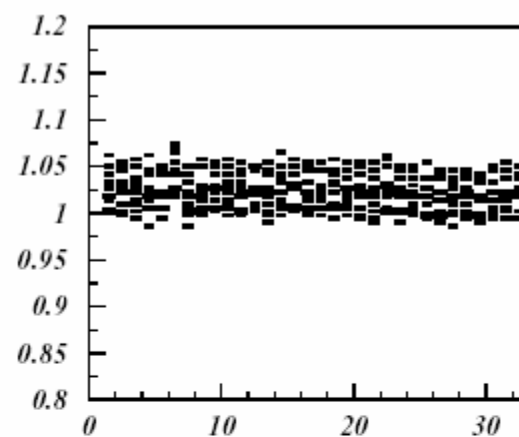
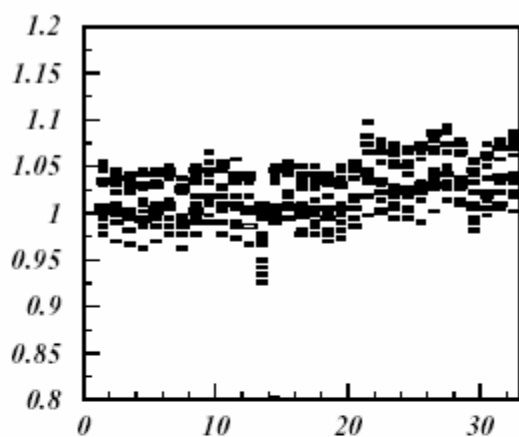
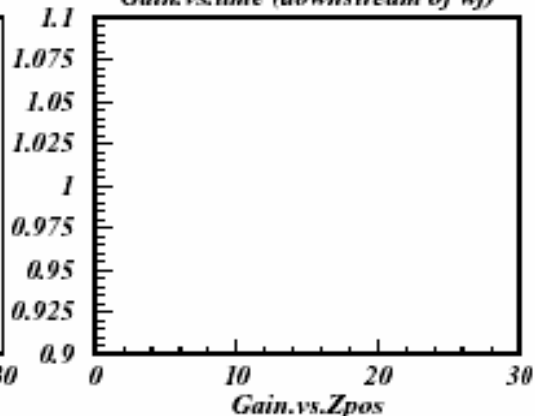
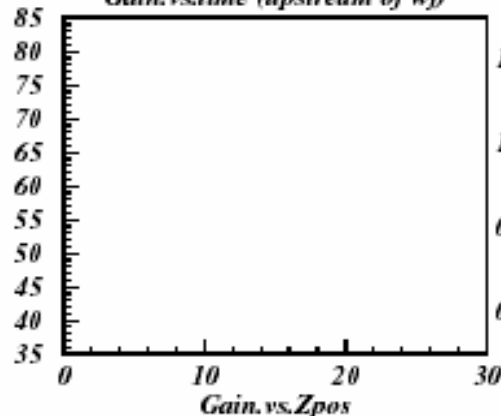
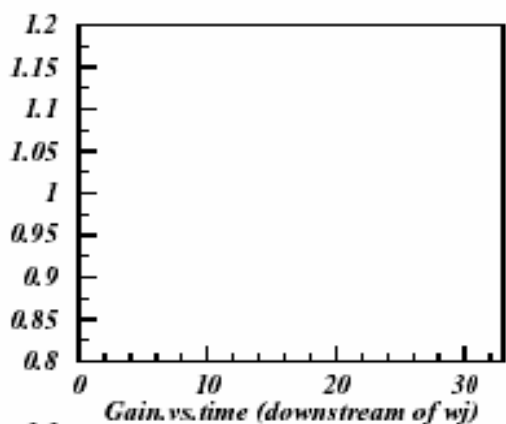
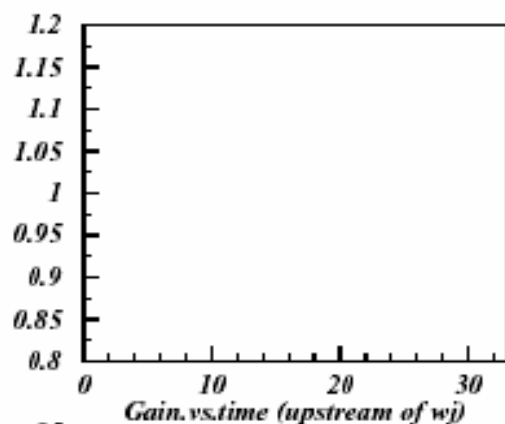
## Gain Map Figures

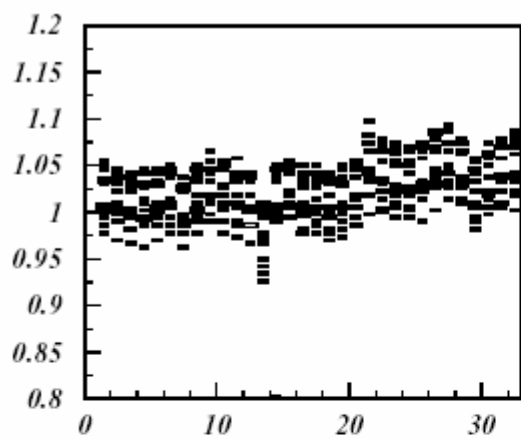
The figures below are the usual plots from the gain map. There are four plots for each straw. There are 18 straws from straw #17 to #34. The straw #34 is the reference straw. The straw #17 took the highest radiation ( $\sim 0.4 \text{ C/cm}$ ) and the dosage decreases as the straw # increases. The ones with straw # around 30 took  $\sim 0.2 \text{ C/cm}$ . The first two plots are the gain vs. time for the front and back section (one data set per day). The next plot has two curves. They are the gain map along the straw length from the beginning of the run (solid) and the latest run (dotted). The last plot is the ratio of the two previous curves. There is no obvious gain decrease in all channels.



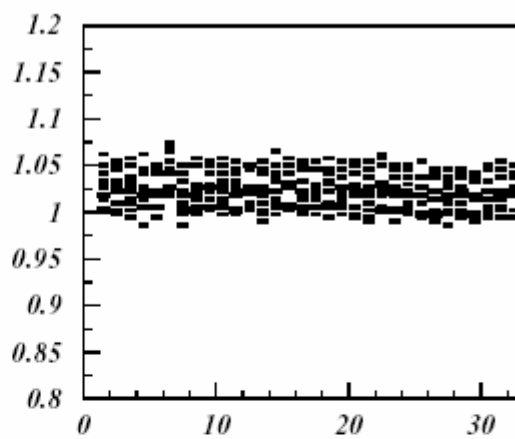




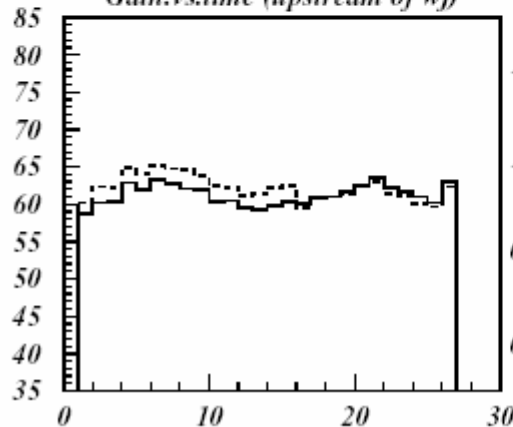




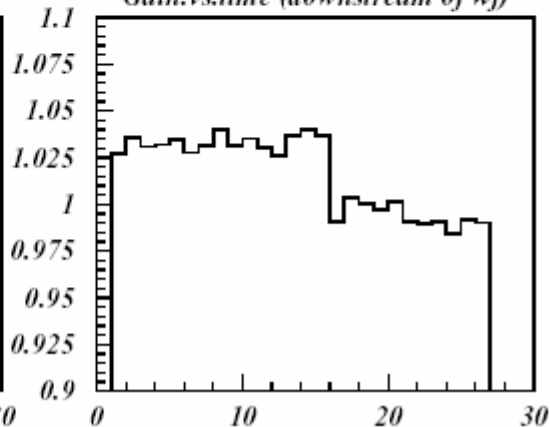
*Gain.vs.time (upstream of wj)*



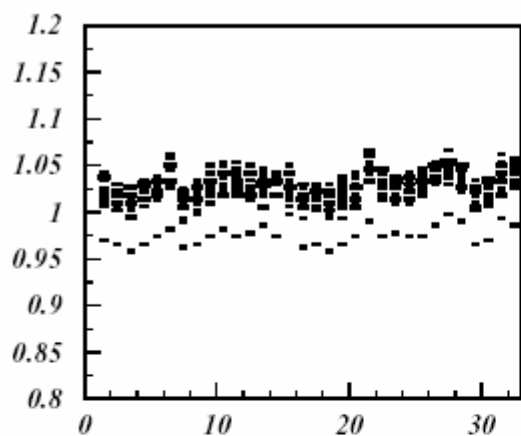
*Gain.vs.time (downstream of wj)*



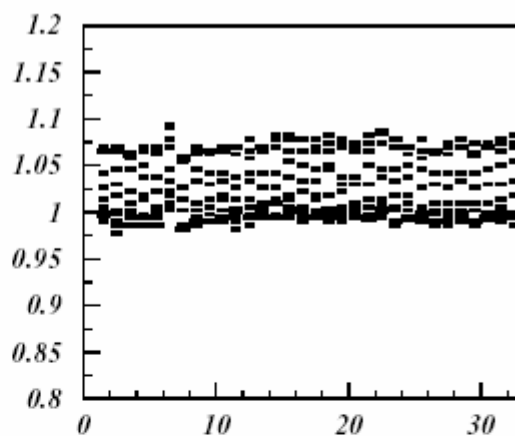
*Gain.vs.Zpos*



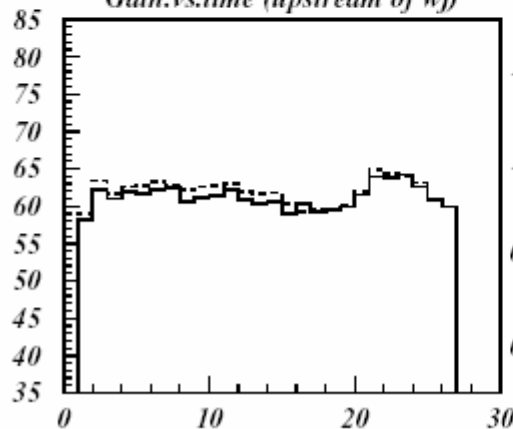
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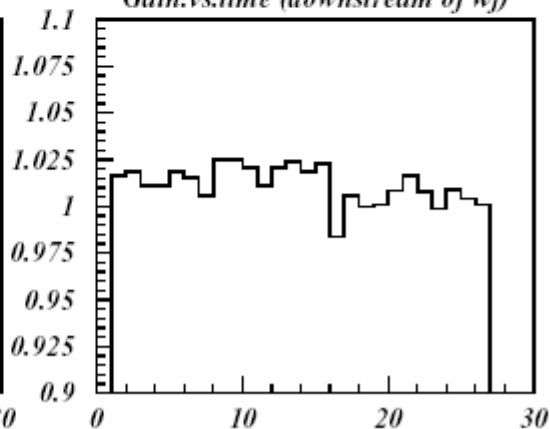
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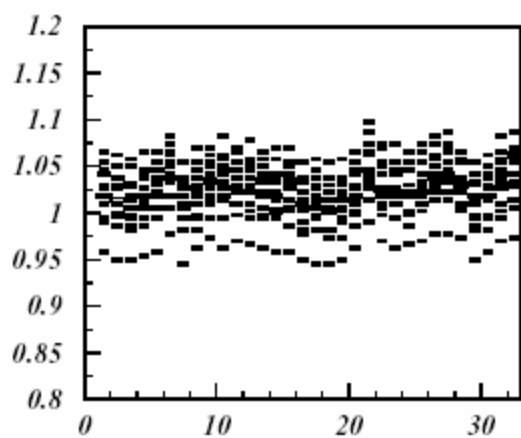
*Gain.vs.time (downstream of wj)*



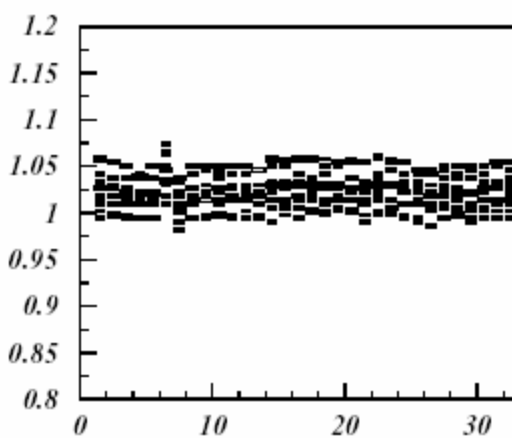
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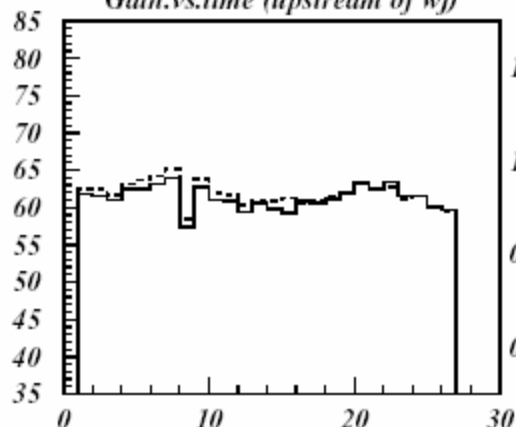
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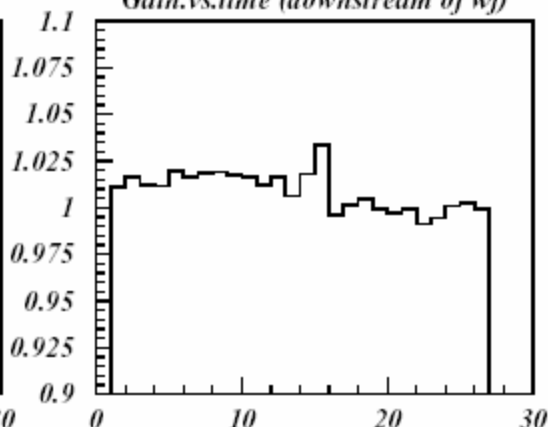
*Gain.vs.time (upstream of wj)*



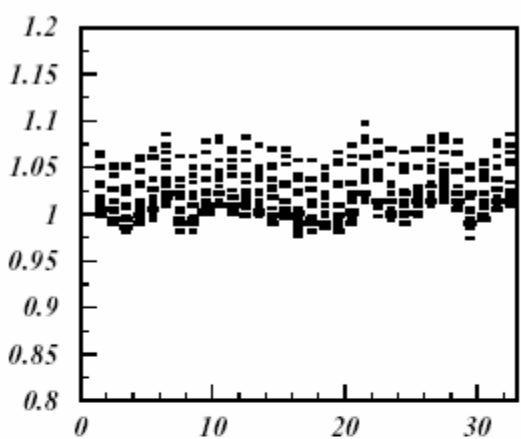
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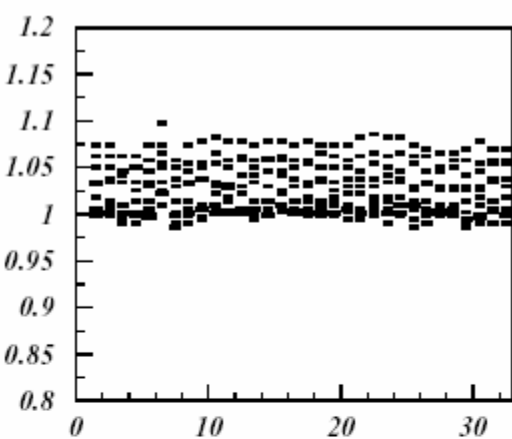
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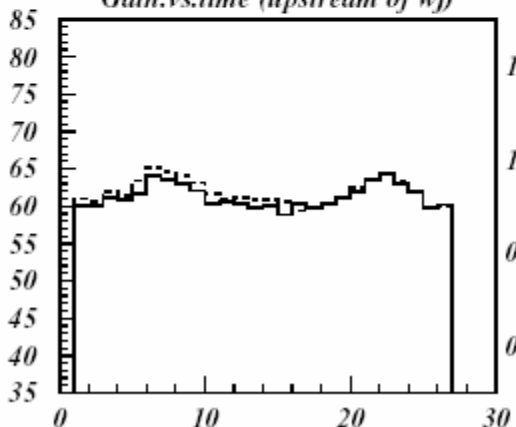
*Gain.vs.Zpos*



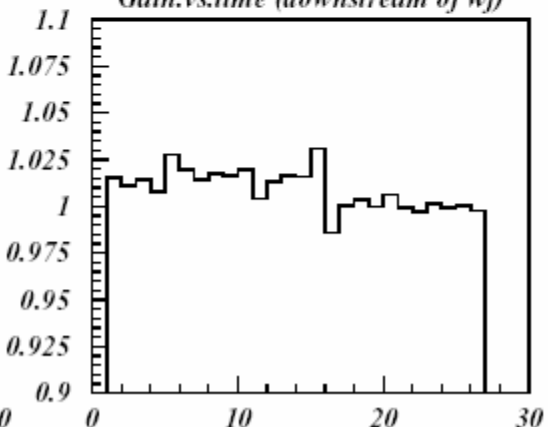
*Gain.vs.time (upstream of wj)*



*Gain.vs.time (downstream of wj)*

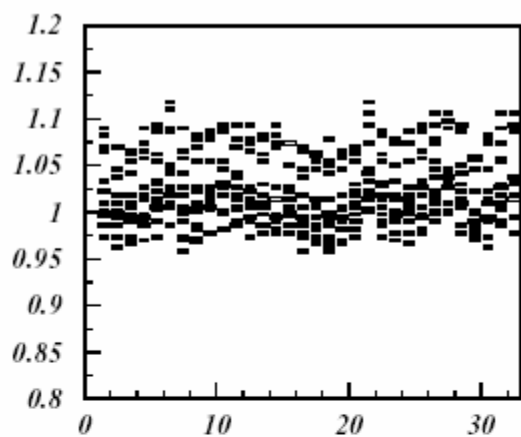


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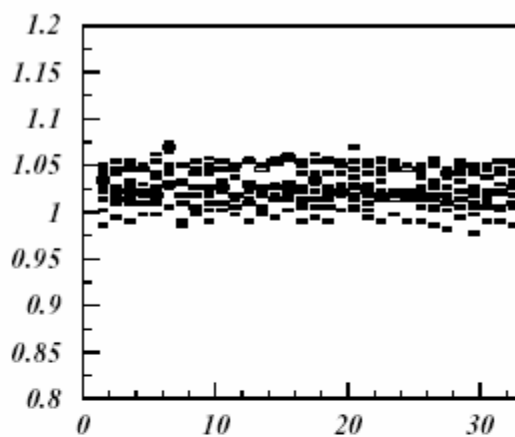


*Gain.vs.Zpos*

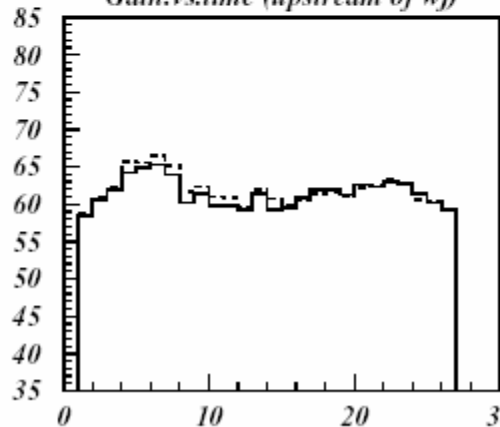




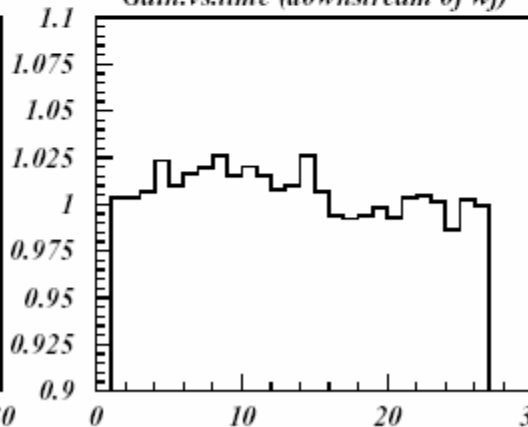
*Gain.vs.time (upstream of wj)*



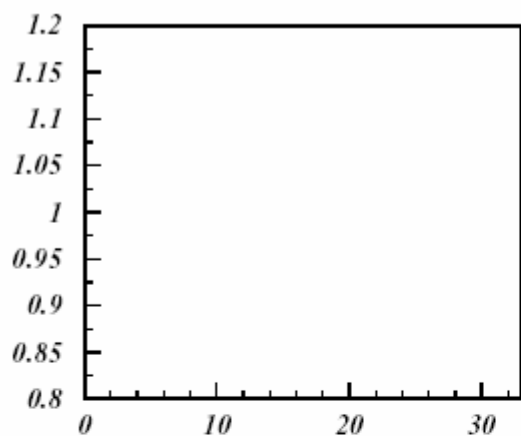
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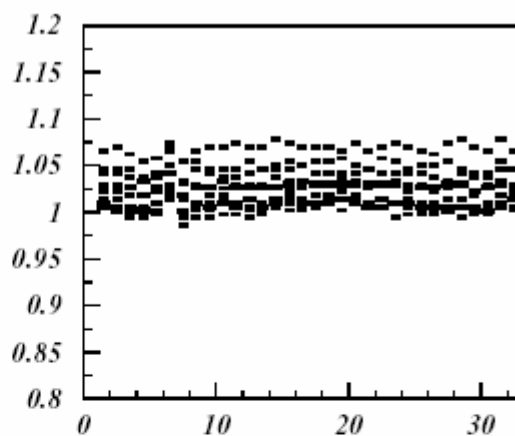
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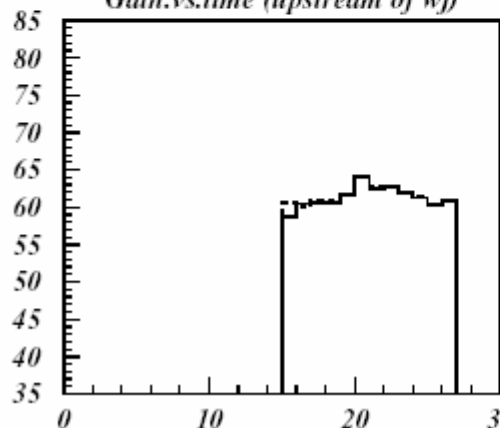
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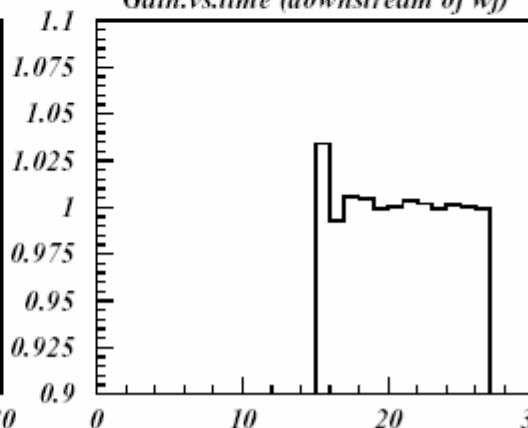
*Gain.vs.time (upstream of wj)*



*Gain.vs.time (downstream of wj)*



*Gain.vs.Zpos*



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