A Proposal for E949 Range Stack fiber based monitoring system

Alexander Kozhevnikov *, Valery Victorov †

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Abstract

This note is an addition to Technical Note #6 and describes the proposal for E949 Range Stack monitoring system, based on the fiber network with blue LED as light source for a bundle of fibers. Each bundle of 45 fibers will cover a range of sectors of Range Stack and possibly Barrel Veto and Barrel Veto Liner photomultipliers. In total it will have 40 bundles (20 on each side of the detector).

1 Introduction

One variant for RS Monitoring system described in Technical Note #6 is based on individual LEDs attached to each photomultiplier. Another solution for the RS monitoring system would be to use optical fibers, and distribute a light to each PMT through a bundle of them from a few light sources based on the same blue light emmiting diodes.

From our point of view the fiber network system with a single light source, or at least with a few light sources, monitored and kept under the same conditions should have more stable parameters. And also the cost estimation shows that this variant is less expensive.

This note builds on the work of Technical Note #6 and covers only additional problems and technical aspects of fiber network implementation for RS Monitoring.

*Email: kozh@bnl.gov

†Email: victorov@mx.ihep.su.

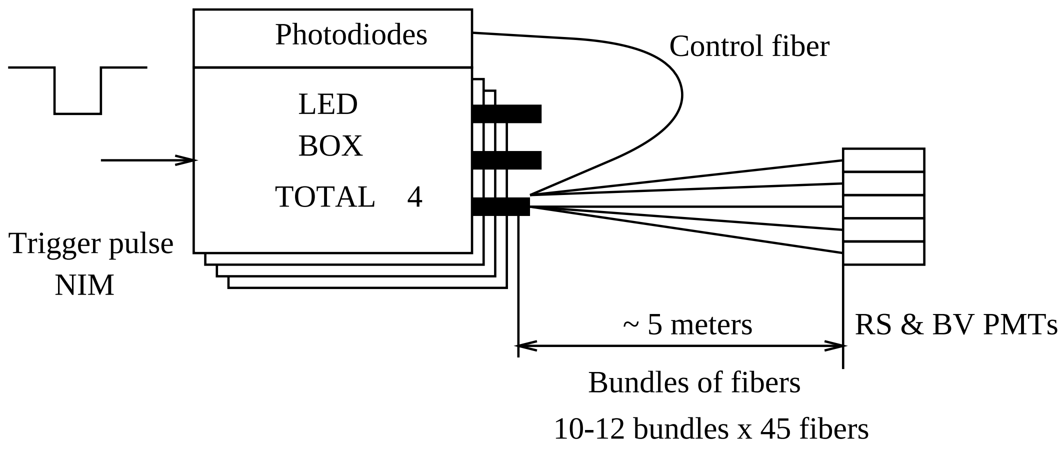

Figure 1: General layout of fiber based monitoring system.

2 System outline

The system outline is presented on Fig. 1.

Main elements are: LED box, fibers, control photodiodes and PMT region interface. Fibers are grouped into bundles. Each bundle will cover either two sectors of RS, or possibly four sectors of BV and BVL photomultipliers. The number of fibers in each bundle is 45 (40 RS + 1 control photodiode + 4 spare, or 32 BV + 8 BVL + 1 control photodiode + 4 spare). Each bundle has its own light source - Blue LED NSPB300A or NSPB320BS, as described in Technical Note #6. Each LED box will have 12 – 14 LEDs connected in series with one driver circuit. We propose to have 4 LED boxes, each will feed 10 bundles with 2 – 4 spare outputs.

The possible layout of the LED box is shown on Fig. 2. The possible layout of one fiber bundle is shown on Fig. 3.

One fiber in each bundle is a control and is connected to the photodiode to monitor stability of the light output. All photodiodes will be mounted in one separate box which will be housed in some place near the LED boxes. We propose to use well known Hamamatsu S1223-03 photodiode with temperature coefficient 0.1% per °C, which was used, for example, in the FNAL E781 experiment for similar light output monitoring.

This control scheme eliminates the need to have the temperature controlled cave for light sources and driver circuits and dramatically decreases

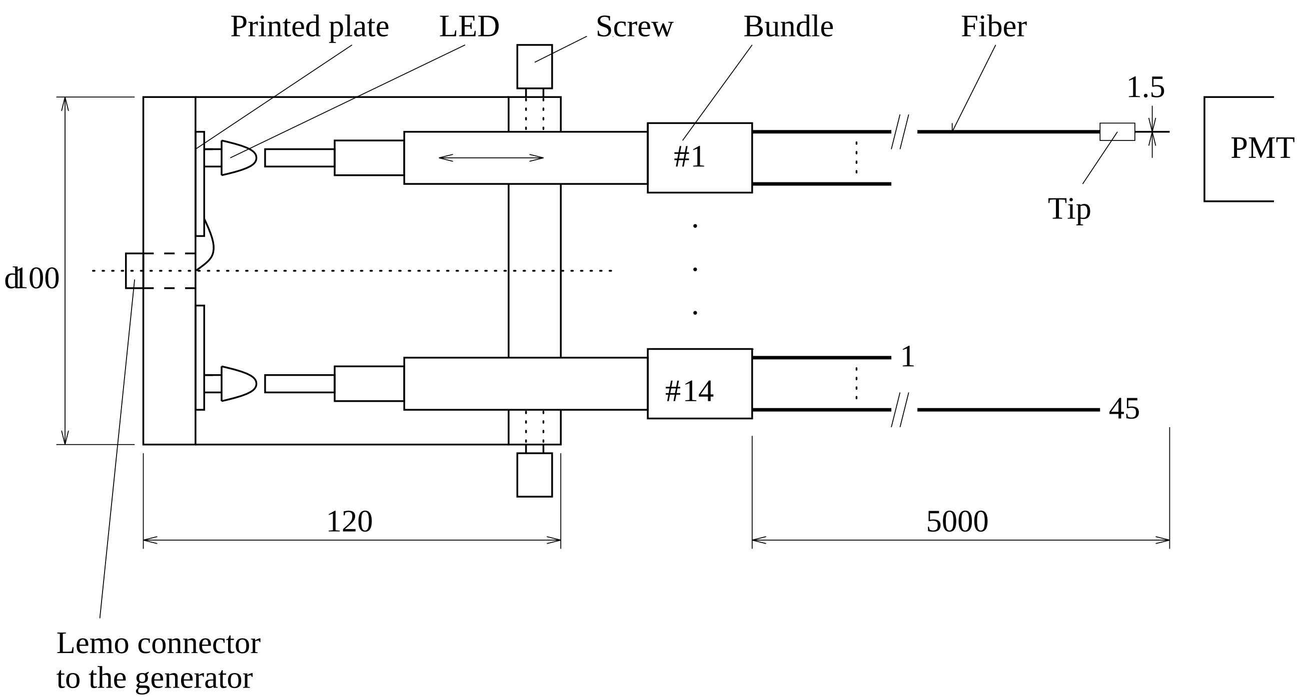

Figure 2: LED box and fiber bundles layout.

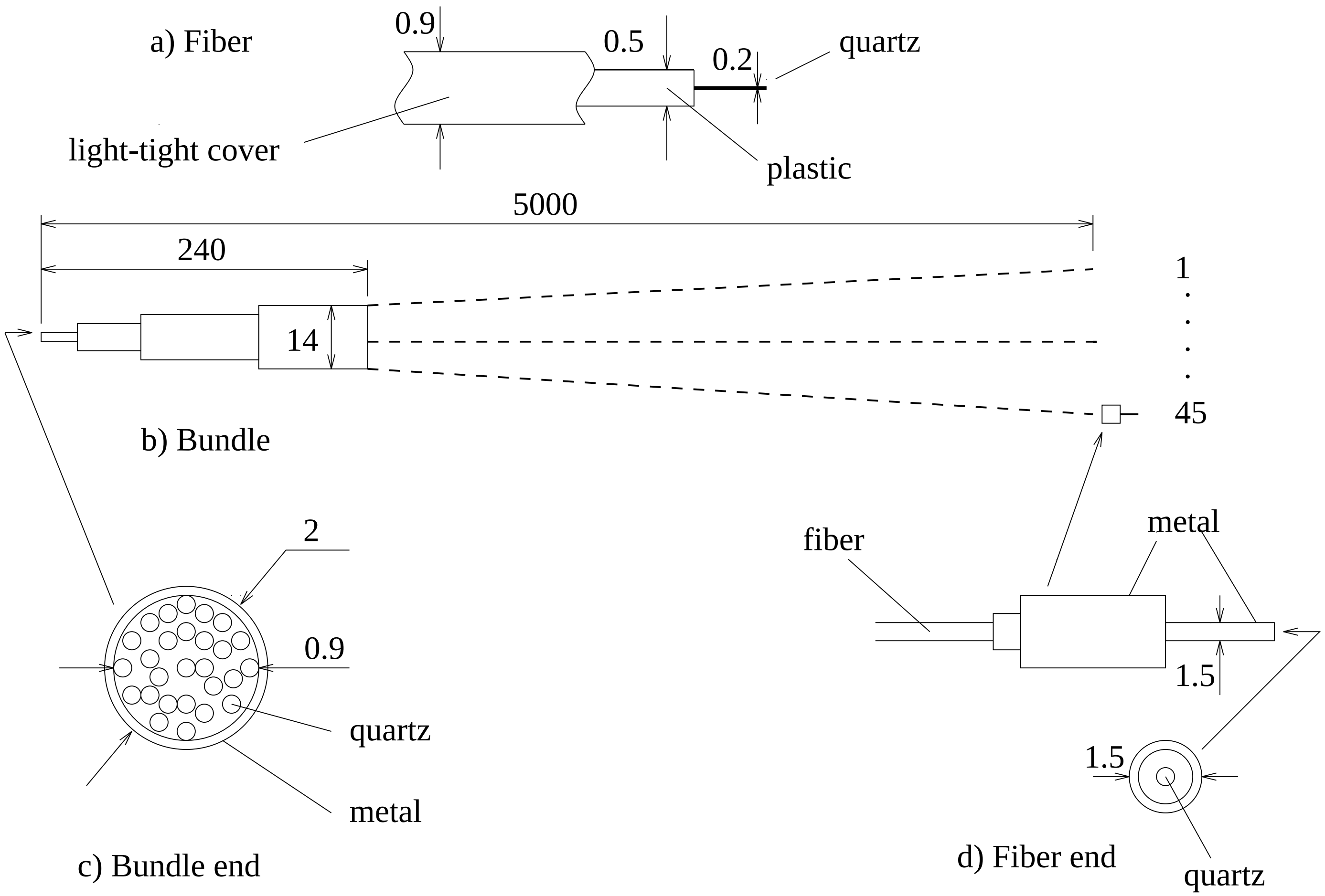

Figure 3: Fiber bundle layout.

the total cost of proposed variant of monitoring system.

For treating fiber ends we propose the following approach. The ends of fibers on the bundle end are fitted in a metal cap, then all free space is to be filled with epoxy, and after this the face of the cap with the bundle inside is to be polished to produce a good surface on fiber ends. On the other end the fiber will not have any special treatment.

Fiber type we propose to use is commercial 3M FT-200-URT with optional Hytrel outer coating. Specs for this fiber are:

- core diameter - 200 microns (0,2 mm),
- outer buffer diameter - 500 microns (0,5 mm),
- minimum bend diameter - 20 mm short term/40 mm long term,
- outer diameter with coating - 900 microns (0,9 mm).

2.1 PMT connection options

There are at least 3 options how to connect fiber with PMT. The simple drawings for each option are shown on Fig. 4, 5, 6 respectively.

2.1.1 Option A:

The fiber is inserted into the Mu-shield via special bent piece of plastic pipe through a hole in the shield. The pipe is fixed with special washer and nut to position the fiber end in the right direction. The hole position is unique for each shield. This option will be hard to install because of very tiny space between Mu-shields.

2.1.2 Option B:

There is a 1/8" gap between PMT and Mu-shield. Now this gap is filled with mylar sheet wrapped around the PMT. And fiber can be inserted through this gap. Either through the slit in existing mylar wrapping, or this wrapping could be replaced with soft foam spacers leaving the room for fiber installation. The fiber is bent by special fixture, so the fiber end is facing the PMT window. This bending piece of plastic can be mounted either on the Mu-shield as shown on the figure, or just taped to the PMT cylinder sides so it is touching the cookie. So depending on the mounting, fiber will be installed either together with the Mu-shield, or with the phototube.

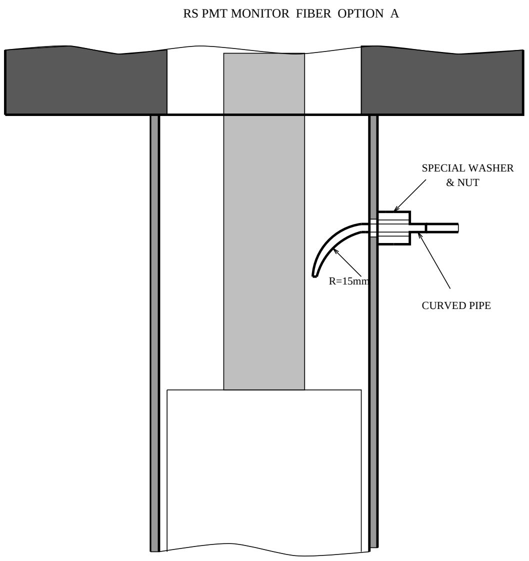

Figure 4: Option A for installing the fiber to the PMT region.

2.1.3 Option C:

This one was proposed by E. Garber and advocated by Jim Frank. The fibers or LED wires either are attached to the light guides, and are going in together with them through the jig-saw structure as it is shown on the Fig. 6, or are routed through a separate 1 mm hole drilled in the jig-saw pieces near the light guide entry. And then they are routed out together with RSSC cables. This option looks like the easiest one.

3 Preliminary test results

To estimate the proposed system behavior some simple tests were made with a fabricated bundle of 35 fibers. The fiber used for this test bundle was very similar to the proposed type with a quartz core of 200 microns (0.2 mm) in diameter. But the bundle length was 2.5 meters instead of 5 meters as in proposed design.

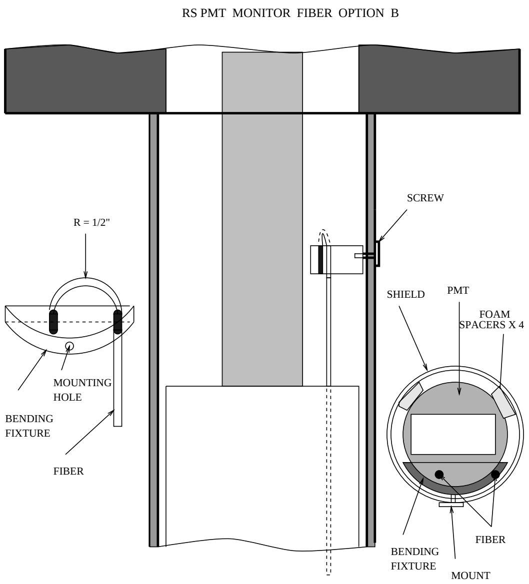

Figure 5: Option B for installing the fiber to the PMT region.

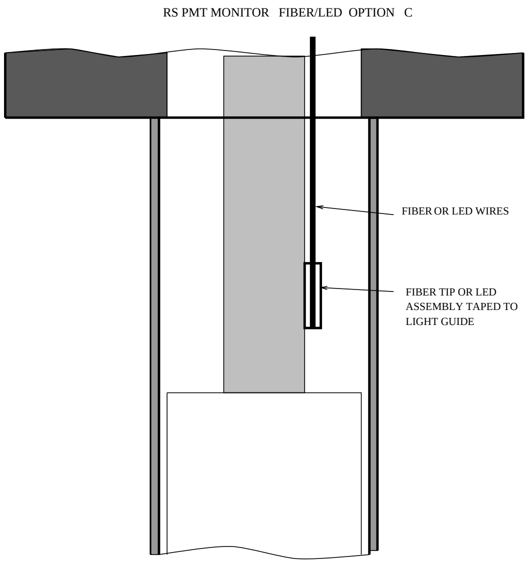

Figure 6: Option C for installing the fiber to the PMT region.

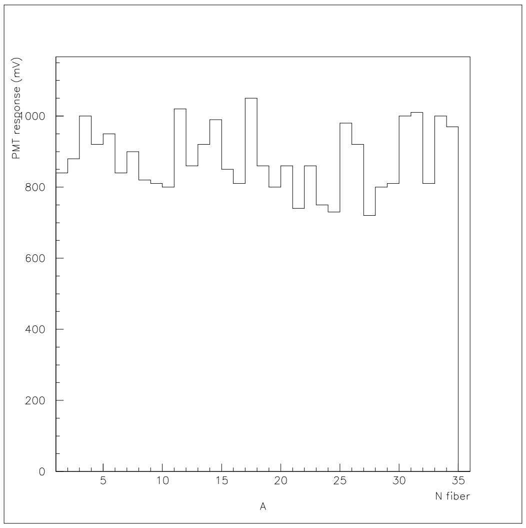

Figure 7: Light amplitude from fiber to fiber in bundle of 35 fibers.

3.1 Light uniformity test

Light uniformity test with blue LED NSPB300A was done to estimate the difference in light yield between fibers in the bundle with geometry very similar to a real system. An instrumental generator was used to fire the LED with impulse parameters: amplitude +2V and duration 30ns. Output PMT signal was 100ns in the base and FWHM 30ns. The amplitude profile from fiber to fiber is shown on Fig. 7. The corresponding distribution is shown on Fig. 8.

One fiber in this bundle was not working and was excluded from distribution on Fig. 8. The PMT response in millivolts shown on this figures corresponds to the number of photoelectrons by approximately 1 mV equals 1.5 p.E. The distribution shows mean value of 879 mV with RMS of 91 mV, which means a rather good uniformity in the bundle of proposed geometry.

3.2 Light intensity

The following dependence of light intensity was measured for the same conditions as in previous test with one selected fiber. The result is shown on Fig. 9. Here on X axis is pulse amplitude applied to the LED, on Y axis is the PMT response in thousands of photoelectrons. The result shows that

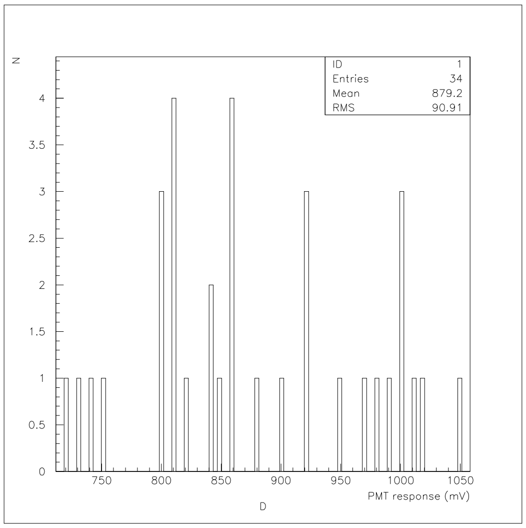

Figure 8: Light distribution in bundle of 35 fibers.

system is easily adjustable to produce a required light intensity.

3.3 Stability test

Simple stability test was also performed with NSPB300A LED and one selected fiber 2.5 m long. For 48 hours LED worked with 50Hz frequency and 45ns generator pulse width.

Start point on March 21 at 12:30: T = 21 °C; PMT response A = 1865 ADC counts (930pC); N p.e.=1415.

End point on March 23 at 12:30: T=23 °C; PMT response A = 1873 ADC counts; N p.e.=1414.

This is a some result but more stability tests are needed.

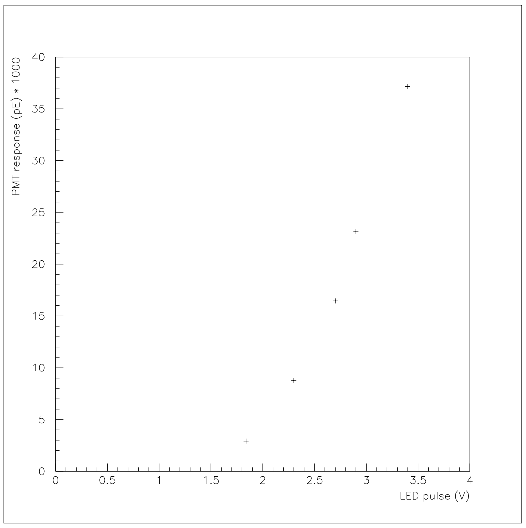

Figure 9: Light intensity vs pulse amplitude.

4 What more need to be done

There are some things which need to be completed:

- Fiber samples tests to make and verify fiber selection;
- More detailed and long stability test;
- A prototype with a real fiber and PMT entry mechanics;
- Photodiode sample tests;
- LED driver development and tests.

5 Estimated Time Schedule

Preliminary timetable is shown on Fig. 10. The only time critical path item for this system is the fabrication and testing of fiber bundles itself. This task has to be finished before the detector closing will start (September 2000). We estimate this time, including 1.5 month for fibers shipment and additional tests, to be about 4 – 5 months. So, starting in April all bundles should be finished in August. This job will be done at BNL.

Another but less critical item is bending fixtures. The production of them can be done in 3 – 4 months in BNL. The fabrication of LED boxes

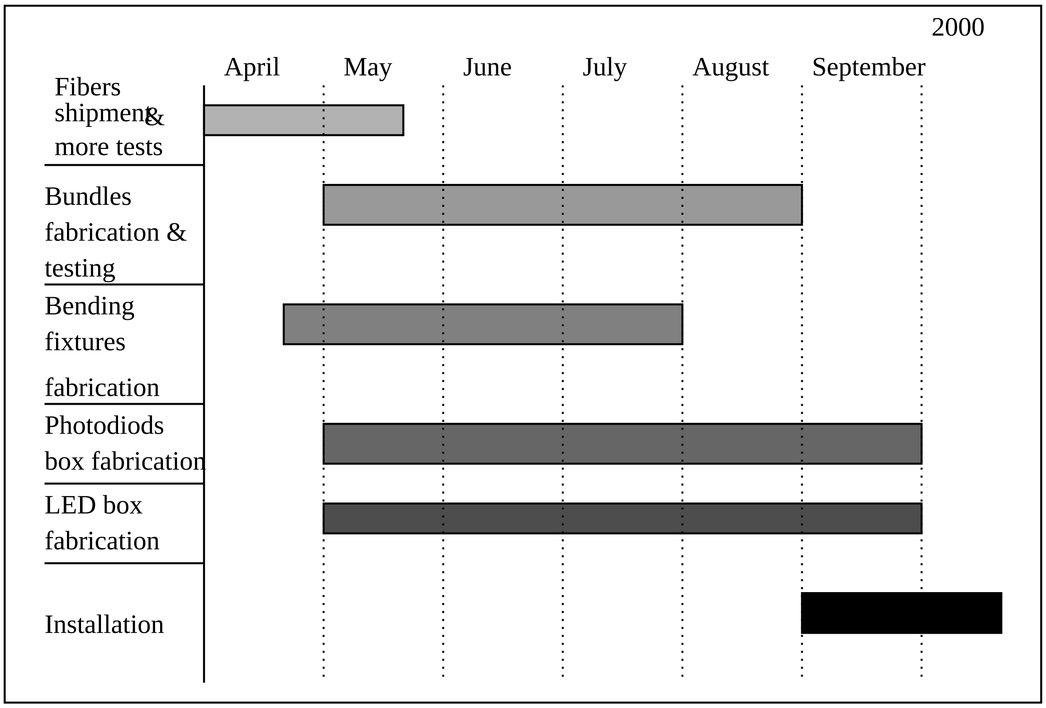

Figure 10: Preliminary Time Schedule.

and photodiodes box can be done in IHEP in parallel. The time scale to finish them is about 3 – 5 months.

6 Cost estimation

Preliminary cost estimation:

• Fibers ($10 per channel for 1800 channels)	$18000;
• LED boxes ($500 per box for 4 boxes)	$2000;
• Fiber ends treating kit	$500;
• Photodiodes with box	$1000;
• Bending fixtures for Option A or B ($3 per channel)	$3000;
TOTAL:	$24500

7 Conclusions

We propose to use a fiber based network variant for RS PMT Monitoring system. This variant could also be used for monitoring BV and BVL photomultipliers simultaneously with RS. Light source for this system is the same as for individual LEDs based variant. Expected stability and cost of this variant are better. The main disadvantage of it is more complicated installation of RS PMTs.

Proposed fiber based variant of RS Monitoring system, although not finally optimized and tested, looks to be a good solution for E949 experiment.