RTD System Design and Setup Procedure

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1 Introduction

For the Hall A laser-driven polarized ^3He target experiments, it's very important to have a precise knowledge of the oven temperature, the temperature distribution of the pumping cell, target cell and reference cell, since both the Rubidium gas saturation pressure(and thus density) and the ^3He target density in the pumping cell and target cell are dependent on the temperature, which in turn determine the achievable target polarization in the target cell.

We will use eleven RTDs to measure the temperature in the oven and along the three glass cells, as will be descibed in the following.

2 General Considerations for RTD System

The conceptual design of the RTD system is shown in Figure 1. The RTD system is composed of three components: RTD sensors, connectors, and wiring. We shall consider them in detail separately.

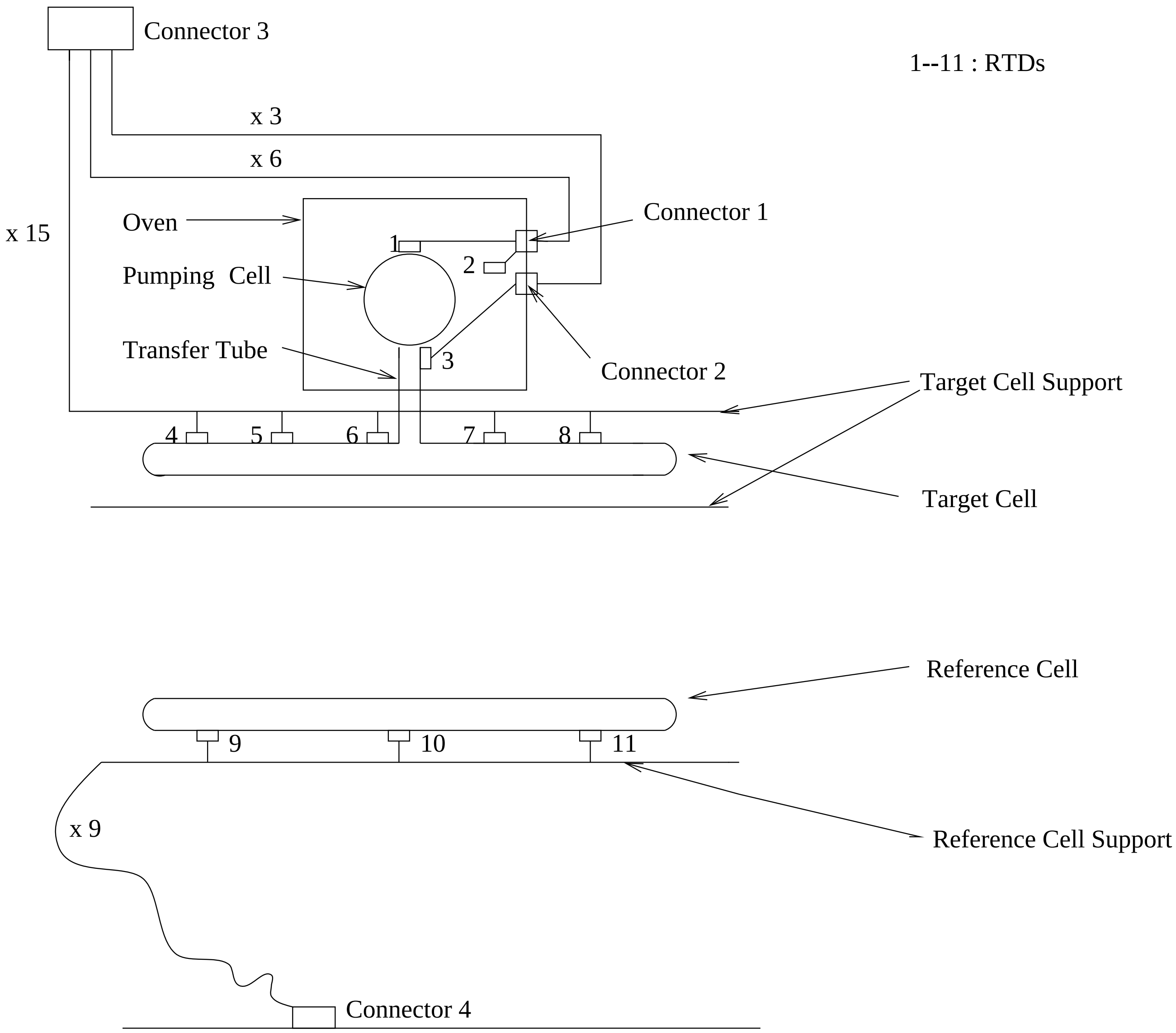

Figure 1: RTD System Design

2.1 RTD Sensors

RTD is a very sensitive detector for temperature ranging from 0^0 C to 600^0 C. It's made of a certain material whose electrical resistance is very sensitive to the environmental temperature. Thus, if we apply a constant current to the RTD, the voltage signal from it will give us the precise value of temperature, given the calibration formular.

We shall need three RTDs in the oven. One of the RTDs will serve for the temperature readout of the hot air and the other two for the readout of the pumping cell. We also need five RTDs on the upper surface of target cell and three others on the lower surface of reference cell to map the temperature distribution along the two glass cells. We will label them from 1 to 11, as shown in Figure 1.

Each RTD has two ends(for current in and current out), but we will solder three copper wires to it to compensate for the non-zero resistance of the transport wires. We will label the two copper wires soldered to the same RTD end as E and F, the other one as A, as shown in Figure 2. Thus, for each wire we can assign a unique label such as 4E, which is very important since we do not want to mix the thirty-three wires in the setup process.

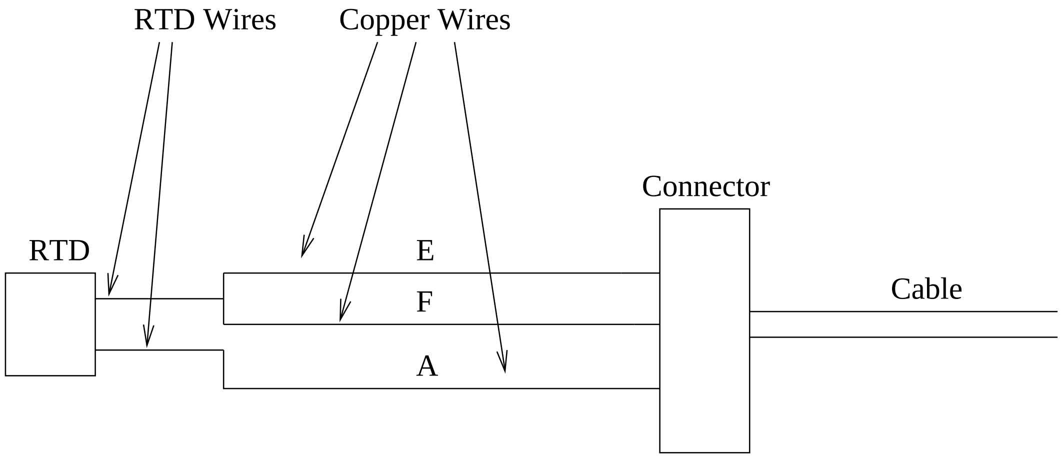

Figure 2: RTD sensor

2.2 Connectors

The copper wires we connect to RTDs are very thin(gauge 26) and fragile, and therefore they are not very good for long distance signal transmission. Instead, we use four connectors to send out the RTD signal, as shown in Figure 1. The structure of the connector is shown in Figure 3. It is composed of two parts, the receptacle and the plug.

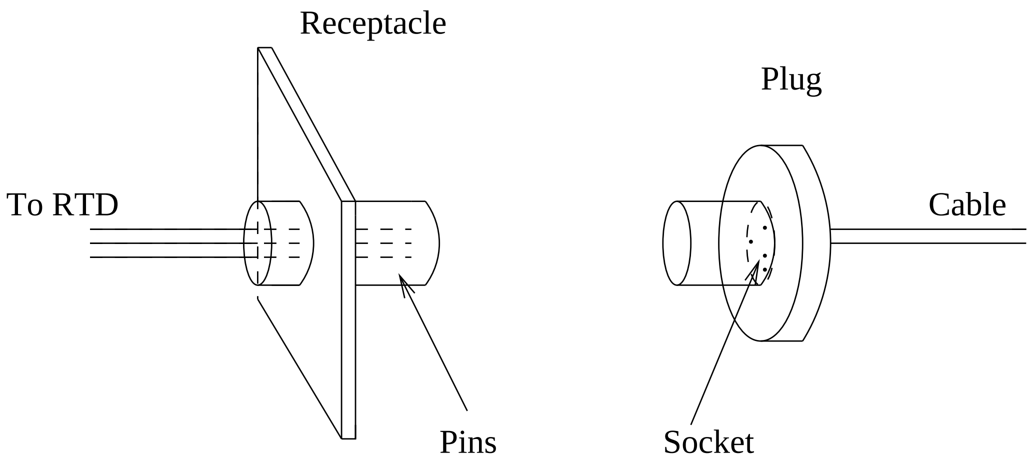

Figure 3: Connector

Two holes were made specifically to hold connectors 1 and 2 in one side of the oven. They are both 6-contact connectors. Three contacts of connector 1 will be used for RTD 1, which will be taped on the top of the pumping cell, the other three will be used for RTD 2, which hangs inside the oven. Three contacts of connector 2 will be used for RTD 3, which is taped on the upper neck of the transfer tube. The other three may be used in the future for the detection of possible explosion of the target cell. These two connectors are required to be non-magnetic, since otherwise it would have an negative effect on both the magnitude and direction of the target polarization, and would be harmful for NMR and EPR measurement.

In the experiment the target cell and the oven are fixed in the target ladder, but the reference cell is only screwed into the ladder, and can be dissembled from it if necessary. This design is for the following reason: During the experiment, there is a chance for the target cell to break. In case of this happened, we would have to take it out, and it's a bad practice if we move all the cells out. In consideration of this, the fifteen copper wires coming out from the RTDs on the target cell and the nine wires coming out from connectors 1 and 2 will go up to a 32-contact connector fixed in the upper part of the target ladder. The nine wires from the reference cell will instead go down to a 15-contact connector fixed in the bottom of the target enclosure.

2.3 RTD Wiring Path

We have descibed a lot about the RTD wiring in the above two subsections. Here we only add some important notices.

We should be very careful with the path of the copper wires, since we don't want them to be in the way of the laser beam, the incident electron beam and the scattered electrons. The wires from the RTDs on the surface of target cell should go along the target cell support—we may use tape or glue to fix them onto the support so that they will not hang around. The same is true for the reference cell. But there is another sutlety here. Since the reference cell will move with the ladder during the experiment, yet the connector for it is fixed in the bottom of target enclosure, we should use wires which is long enough and goes loosely but neatly from the reference cell down to the connector, so that they will not create a hazard when we move the target ladder. We will have to find some tape or glue that is both radiation-resistive and high temperature-resistive.

3 Setup Procedure

Extreme care should be taken both in mounting RTDs onto the cell surfaces and in wiring. And it's very important to obey the prescriped procedure.

3.1 Preparation

When the new design of the target ladder is ready, we will measure all the necessary wiring distances from RTDs to connectors, connectors to connectors, etc. and decide the appropriate length of each of the thirty-three copper wires. We will then carefully label the wires and solder them to the RTDs(The RTD end wire is easy to break, so be careful). The next step is to feed the wires through the four connectors according to Figure 1. We will descibe the following work in two subsysterms for convenience.

3.2 Reference Cell Subsystem

We should first finish the connection for the reference cell subsystem, since it is dangeous to work in the presence of the target cell(We will have to wear hearing protection and head protection when working in the presence of the target cell.)

Tape or glue the nine wires (with RTDs at one end and connector 4 at the other) for the three reference cell RTDs onto the lower support for the reference cell. Fix connector 4 in the bottom of the target enclosure. Make the wiring down to connector 4 neat and smooth. Put the reference cell in the support and tape or glue the RTDs onto the lower surface of the cell.

3.3 Oven and Target Cell Subsystem

Use tape or glue to fix the fifteen wires(with RTDs at one end and connector 3 at the other) for the five target cell RTDs onto the upper cell support. Open and take out the side of oven with two holes, fix the receptacle part of connector 1 and connector 2(now with the RTD at one end) into the holes. The RTDs should be positioned in such a way so that it can be very easily taped or glued to the cells later.

Move the target cell together with the pumping cell into the target ladder(Pumping cell inside the oven) carefully, since the target cell is fragile. Glue or tape the five target cell RTDs onto the upper target cell surface. Glue or tape one of the two RTDs for the pumping cell on the top of the pumping cell, another one on the upper neck of the transfer tube. Close the oven side, connect the plug part of connector 1 and 2 to the receptacle part, fix connector 3 in the upper target ladder. Close the target enclosure. Relax after all the sweating.

4 Corrections

Since the finish of this report, there is some improvement in the new target ladder design. Among others, we want to have a perfect alignment of the target cell with the beam line. We will draw a line both along the target cell upper surface and the cell support and use these lines to do the alignment. We also want the cell and the support to be as close as possible(maybe 1mm). This creates an additional hazard to the RTD system design, because we can not place the RTDs on the top of the target cell, as originally planned. Instead, we will have to move them a little bit downstream. But as pointed out before, we shouln't allow them to be in the way of the scattered electrons. After some sultle consideration, about which Jianping is the best person to consult, we find we must place the RTDs within about 60^0 degree with respect to the verticle plane through the cell center, as shown in the following figure.

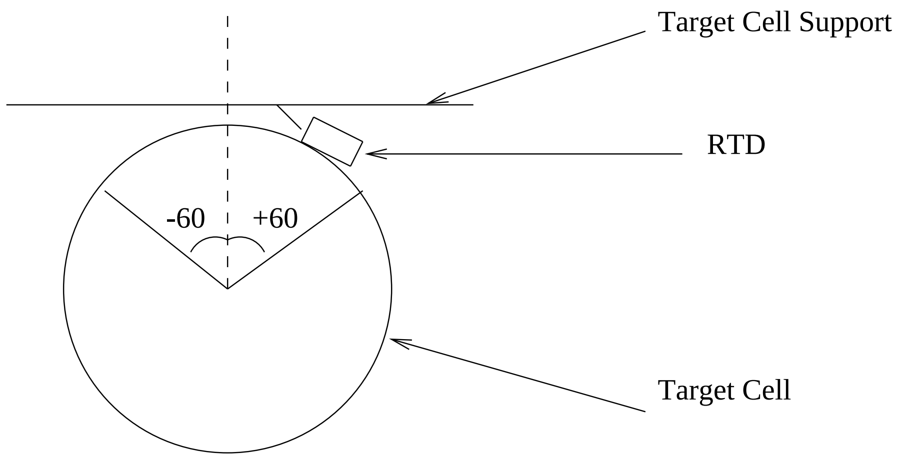

Figure 4: Target Cell RTD Positioning

It's necessary both to put the RTDs within this range and to stick them firmly to the fragile and explosive cell, this is not a trivial work, and those who will perform it should be very careful and thoughtful. Good luck with them.

The same is with reference cell.

5 Acknowledgement

We would like to thank Dr. Jianping Chen, Dr. Haiyan Gao and Dr. Zein-Eddine Meziani for their many suggestions and valuable advice. Feng would like to express his great appreciation to little Enka, not only for her help and ingenuous advice all the time, but also for the numerous fun shared with her in all these passing days. She is just like a lovely lule in the morning's sunshine, always fragnant and always pleasant ...