DRAFT Plan for the PHENIX FVTX Wedge Assembly
David Winter, Columbia University

Scope

The task of the FVTX wedge assembly is to receive the backplanes, high-density interconnects (HDIs), sensors, and other surface mount devices (SMDs); assemble wedge units; and ship to the cage assembly facility for final installation. The scope of this task includes development and execution of the assembly procedure, the appropriate research and development of the adhesives and their application, identification of vendors for wire bonding and surface mounting, and testing of the wedge units before shipping.

Deliverables

The units to be delivered consist of two types of wedges: large and small. The large wedges will be part of the six outer stations while the small wedges will be used to construct the two inner stations. Each wedge (large or small) covers 15 degrees in azimuth (physical size) with 7.5 degrees of sensitive area. Each of the eight stations will be comprised of 48 wedges. Thus the total number of deliverables will be:

1. 313 Large Wedges (288 required for operation plus 25 spares)
2. 104 Small Wedges (96 required for operation plus 8 spares)

Important Dates

Based on the WBS, the dates for items critical to the wedge assembly are:

1. Fabrication of backplanes – 3/12/09 to 4/8/09
2. Procure HDI – 1/2/09 to 3/12/09
3. Procure Wedge Assembly Jigs – 4/23/09 to 6/3/09
4. Procure and Test sensors – 10/1/08 to 5/5/09
5. FNAL testing of production run of FPHX – 3/25/09 to 6/16/09
6. Endcap assembly – 2/10/10 to 5/4/11

Thus production of wedges will take place during the period of roughly 6/09 to 2/10. At an assembly rate of three per day, this works out to be approximately 30 weeks of production (assuming one eight hour shift per day and five days per week). This fits into the schedule with approximately two weeks of contingency. The goal of three per day is intended to be an average rate, and will be achieved by pipelining the stages of assembly. In addition, we will prepare more than one site for production and operate them if necessary.

Technical Issues

The primary technical issues to be addressed are:

1. Storage and transportation of sensitive components
2. Design and construction of assembly jigs and holder/transfer jigs
3. Proper procedure (order) for assembly
4. Choice of adhesives and their application process
5. QA testing of the assemblies
6. Alignment/metrology of the finished units

The FVTX collaboration has extensive experience in these areas from previous projects, as well as current projects, eg. the barrel vertex detector (VTX) under construction.

Storage and Transportation

Silicon sensors (and to a lesser degree other dies) are very sensitive to humidity and dust. Facilities dealing with the components will require storage containers (such as enclosed shelving units) flushed with dry N_2, or an equivalent desiccating enclosure. The preferred containers for individual sensors will be gel-packs. The same dry enclosures will be used for storage of finished units awaiting transportation to the cage assembly facility.

Individual storage holders for the wedges will be procured, preferably COTS units. Any required customizations will be developed jointly with the cage assembly and installation team. The holders will be extensively labeled to allow for tracking the units through the various steps of assembly, minimizing or eliminating the need to touch them as part of the documentation process. The holders will also be required to be easily stackable to ensure their contents safety while stored in the enclosures at the clean facilities. The same holders will be used for transportation to the cage assembly facility.

Assembly Plan

The proposed plan for assembling a single unit is the following:

1. Bond HDI to backplane
2. Bond sensor to HDI
3. Solder filter components and bias resistors to HDI
4. Bond FPHX readout chips to HDI
5. Wire bond FPHX output pads to HDI
6. Wire bond sensor output pads to FPHX input pads
7. Inspect and test assembly
8. Encapsulate wire bonds

Wherever possible, these steps will be performed by vendor(s) who have been strictly qualified by the FVTX collaboration, and will be closely supervised by members of the FVTX collaboration. It is expected that bonding of the HDI to backplane and sensor to HDI will be performed in-house, and aided by the use of precision-drilled holes as well as assembly jigs. The baseline procedure will be adapted as needed to take into account constraints of the available vendors' capabilities as well as maintaining an optimal cost/benefit ratio.

Adhesives

Adhesive bonds must have

1. Adequate strength
2. Good aging characteristics
3. Relevant materials compatibility
4. Reproducible application characteristics
5. Sufficient rigidity under bond pads
6. Adequate thermal or electrical conduction characteristics where required
   a) Backplane to HDI: electrically non-conducting
   b) Sensor to HDI: electrically conducting
   c) Both: thermally conductive
   d) FPHX: TBD as per spec from FNAL designer's recommendations
7. Retention of thermal and electrical characteristic when subject to thermal cycling

Work will be done in accordance with OSHA/Industrial Safety and Hygiene requirements.

An example of a commonly used (CMS, ATLAS, VTX, etc) electrically non-conductive is Araldite-2011.

We will evaluate various products in close consultation with Hytec, because the company has experience and expertise with these products. If we choose to work with epoxies, we may have to evacuate the mix to get rid of bubble formation. It is very likely that we would use an automated glue dispenser in order to achieve a reproducible epoxy bead pattern. For example, the VTX assembly has developed a procedure for the stripixel ladders that uses a syringe on a robotic xyz stage

The gluing procedures and testing will be performed using dummy components, eg. glass and aluminum mockups of the components. Use of mockups will allow for development of the gluing techniques as well as the overall assembly process.

QA Procedures and Testing

It is expected that QA will have been performed on the individual components being assembled into the wedge prior to receipt. This means the FPHX chips will have been probe tested, the HDIs have been electrically tested, and the sensors have been probe tested and characterized

Once a unit has been assembled, it will be visually inspected and tested. A "mini-DAQ" will be required to test and verify the ability to communicate with the control channels of all readout chips as well as read data from them. Tests will include the following:

1. Power up to verify low voltage and bias channels are operational
2. Download of configuration to the FPHX chips
3. Read back of configuration from the FPHX chips
4. Threshold and noise measurements of the FPHX chips

5. Injection of test pulses and test patterns.
6. Readout of strips in response to laser diodes and/or radioactive sources

All of the above test procedures have been developed and applied to the closely-related LDRD project. The institutional knowledge being developed is based on the FPHX progenitor, the FPIX, and it is expected that the lessons learned in the process will be directly applicable to testing the FPHX-based wedges.

Dark boxes will be required for testing purposes. The boxes need only be as large enough to hold one unit and an LED. Whether these boxes will be designed to allow source testing will be contingent upon the availability and types of sources to be used.

Additionally we will want to perform thermal cycling tests on the samples of the assembled units to ensure there are no failed wire bonds or solder joints. Based on the experiences of ATLAS members at Nevis, a baseline thermal cycling plan would proceed as follows:

1. Temperature cycle of approximately 100 min at a high set point, followed by 20 min at a low set point
2. Rate of temperature change covering the temp range in approximately 5 minutes.
3. Number of cycles = 4
4. During the thermal cycling test, the wedge would be powered, clocked, downloaded, pulsed, and read out, in order to fully exercise the components.
5. Total duration: approximately 8 hours

Each unit will be required to undergo thermal cycling tests. The parameters of the test will be developed during development of overall QA procedures. Nevis has an oven facility available, though its use will require an agreement be worked out with the ATLAS group. The thermal testing plan will be further developed in conjunction with the mechanical integration liaisons as well as Hytec.

Alignment/Metrology

The internal position tolerance for the wedge assemblies within the cage is 25 microns. Accurate alignment of the HDI to the backplane will be achieved through the use of precision drilled holes and pins. Alignment of the sensor to the HDI will be achieved via precision assembly fixtures (jigs). Well-defined points will be identified (and marked if necessary) so that the position of the wedge can be measured subsequent to its installation in the cage. This surveying will be done at the cage assembly facility.

Facility Requirements

A summary of the minimum requirements for the facility(ies) where wedge assembly will take place is:

6. Clean room or tent at the level of Class 10000
7. Enough room and table space to accommodate 3-4 workers
8. Shelving enclosures with dry N_2 flow or desiccators
9. Gluing machine for liquid adhesives and clamping fixtures for dry adhesives
10. Assembly jigs
11. Dry boxes for QA and testing of individual units
12. mini-DAQ for testing of individual units
13. Storage holders for individual units

The primary assembly facility will be Nevis laboratories, which has approximately 300 sq. ft of clean room space with a dedicated HVAC system, backed by extensive equipment resources at Nevis. Facilities have also been identified at UNM, as well as possible sites at LANL and BNL, which will be used to ensure wedge production take place in a timely manner.

Workforce and Management

Nevis will provide the oversight and management of the activities surrounding the wedge assembly. The facility at Nevis has the space for 3-4 people to work on assembly simultaneously. It is assumed that wedge production will proceed at an average rate of three wedges per day, using five eight-hour shifts per week as the baseline. The schedule represents approximately 140 person-days over the course of the construction phase. The manpower resources will be shared as much as feasible between the wedge and cage assembly operations, given that these activities are so closely related.