	Pixel Local Supports FDR		
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Pixel Local Support Interface Document

Abstract

This document describes the interfaces and controlled parameters necessary to finalize Local Support Design

Prepared by:	*Checked by:*	*Approved by:*
E. Anderssen **S. Cuneo**		

Distribution List

History of Changes

Rev. No.	*Date*	*Pages*	*Description of changes*
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1 Overview

This document will cover the interfaces of the Pixel Local supports. We describe what is and is not a local support and then describe the qualities that the boundaries must posses such that the local support design need not change in response. As such the document will contain, information also found in the various requirement documents for the bounding systems.

The interfaces for the local supports are broken into three sections. The first covers common interfaces and definitions. A section on Staves and Sector interfaces follows.

2 Description of Local Supports

The functional definitions of the local supports are given below. The sections on the staves and the sectors describe the local environment, and what is and is not included in the local support, providing a starting point for the definition of interfaces

2.1 General

Local Supports are integrated support and cooling structures for Pixel Modules. They take the form of Staves and Sectors for use in the Barrel and Forward regions respectively. Specific interfaces vary in the two regions, with some common system-level interfaces.

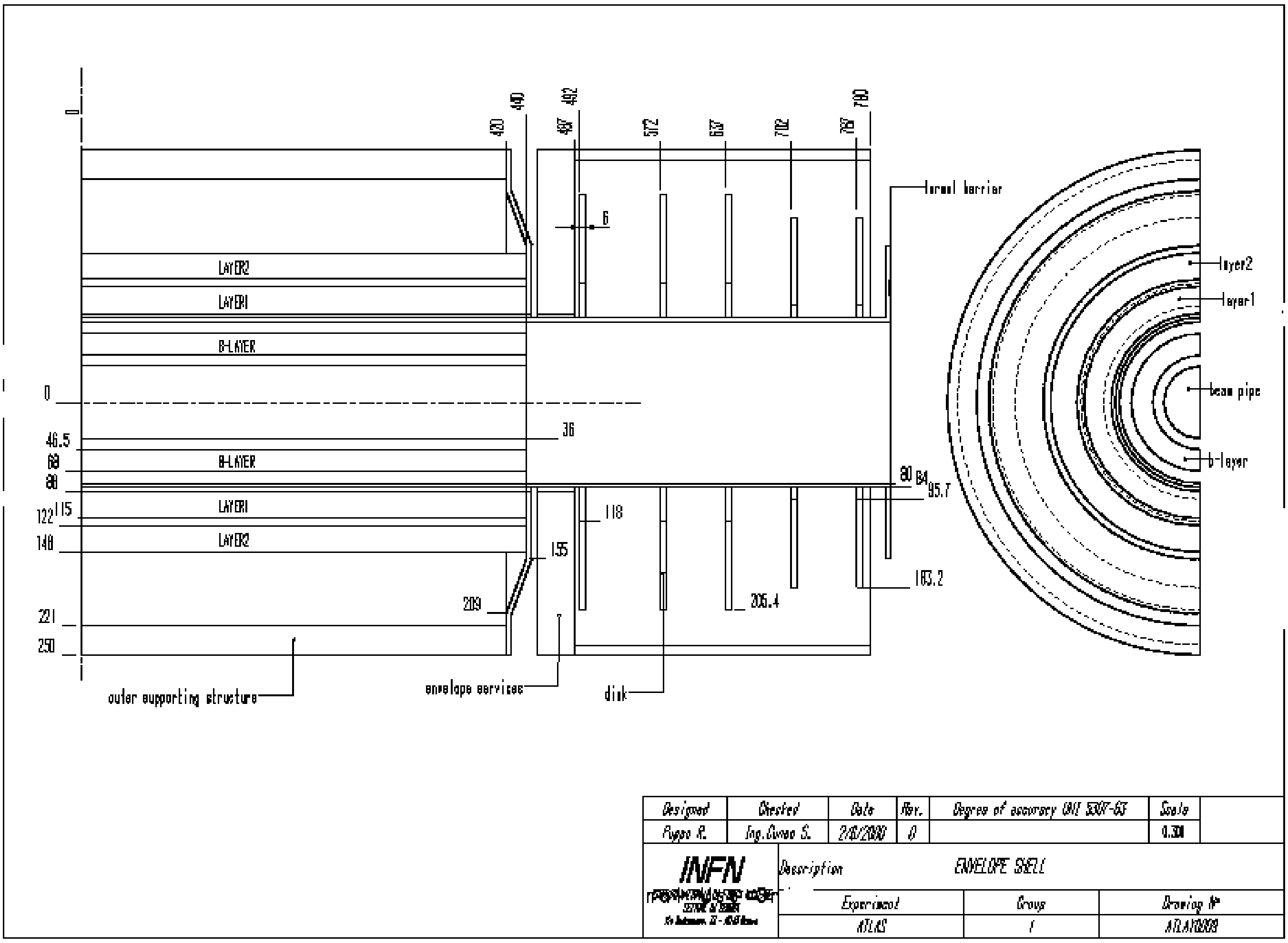

Figure 1 Envelope dimensions of Local supports and neighboring structures

2.2 Stave

As is not much meaningful to consider, from the point of view of the interfaces with other systems and/or structures, a stand-alone stave, in the following we'll consider the interfaces of the bi-stave subassembly. The pixel barrel layers, composed of staves on shell supporting structures with the relevant services, will feature the envelopes as in the figure below.

For more details, see Atlas Pixel Local Support Overview (done by M. Olcese) and Stave Design Status.

2.3 Sector

The Sector provides support and cooling for 6 modules—3 per face. There are two sector types: the first is intended for 11-Sector Disks, the other for 9-Sector Disks. Interfaces for both sector types are common in nature, but with specific modifications respective to the differing geometry. (Illustrations here will predominantly show the 11-Sector Disk type.)

Sectors are mounted to Disk Rings by way of a 3-point rigidly bolted through-hole mount. Mounting pads for this mount are included on the sector, and abut pads on the Disk-Ring. These pads also provide clearance for the electrical services.

Modules are attached to the facings of the sectors with thermally conductive material and tacked in place. Module services are attached and terminated to the module, but supported by the sector facing. On the Ringside facing, the module services pass between the ring and the sector.

Cooling Services terminate to the Sector Cooling Tube, which runs between both facings, presenting ends at the sector outer-radius for inlet and outlet termination. The termination and strain-relief for the cooling interface is included as part of the sector.

3 Common Interfaces

3.1 Environmental Conditions

These values are not meant to drive the design, they are extracted from a higher level document describing the Pixel detector local environment. They are summarized here for convenience. It is assumed that if anything listed below changes significantly, the design requirements and performance should be reviewed to assess the impact.

3.1.1 Gas

It is currently foreseen to use Nitrogen for the environmental Gas. All structures must be compatible with Nitrogen in an irradiated environment.

3.1.2 Pressure

Gas pressure will be controlled to within a few tens of millibars of Atmospheric pressure—no special pressure environment exists exterior to the local supports

3.1.3 Temperature

Ambient temperature of the environmental gas is delivered at –7 °C, but not controlled to any level inside the volume. It is intended that little to no thermal exchange will occur between the environmental gas and the local supports. All cooling power for the Pixel Modules will be provided by the local supports.

3.1.4 Radiation

The Maximum radiation environment within the Pixel detector occurs on the B-Layer, however this is a replaceable structure. Layer 1 and the inner radii of the Disk structures must withstand 30Mrad ionizing radiation, and 10^{15} Neutron/cm^2. The requirements for radiation hardness of the structures are based on the above number, with some safety factor i.e. yielding 50MRad.

3.2 Cooling System Interface

The same cooling system will be used for both disks and staves, with appropriate adjustment of inlet and exhaust tube diameters. The limiting operating conditions are presented here.

3.2.1 Physical Interface

Covered in Stave/Sector physical interfaces.

3.2.2 Coolant

The Pixel detector will use the same coolant as the SCT to minimize overhead involved in system development. The coolant used will be C_3F_8

3.2.3 Temperature Range

Minimum temperature allowable is –35 °C. This is a no-power condition with cooling system running. It is foreseen during startup conditions. Operating temperature is a function of module power and cooling system parameters and is not covered here.

3.2.4 Pressure Range

Maximum pressure that is allowed in the cooling system during failure conditions is 8bar absolute. Local supports are designed to be acceptably stable up to 4bar absolute operating pressure.

3.3 Electrical interface

The grounding and shielding system is not defined, however it is clear that the local supports are electrically conductive and may be coupled to the modules they support. To the extent that the local supports are involved in the grounding and shielding scheme, an interface to that system is defined.

3.3.1 Grounding

It is intended that the local support float relative to it's respective mounting structure, e.g. Barrel Shells, and Disk Rings. The local supports must also be isolated from both the modules and the cooling system (inlet/outlet piping). Provisions will be made to tie each individual local support (single stave/sector) separately to a known potential.

This scheme relies on the making of an electrical connection to all pieces of Carbon-Carbon used in a local support structure.

3.3.2 Conductive Particles

Some means will be used to guarantee that no conductive particles are released from the Carbon-Carbon, either through impregnation or sealing of all carbon-carbon used in the local supports.

3.4 Module Interface

The interface itself is between the front-end chip substrate side on the Module and a flat surface provided by the local support. The Accuracy of these interfaces is covered in the Requirements document for the Local Supports. Special requirements on the modulus of the adhesive, and the thickness of the adhesive layer will be covered here.

3.4.1 Physical

The primary physical interface of the module to the local support structures is an adhesive layer. The final module attachment scheme has yet to be worked out, however it will consist of an adhesive layer of specified modulus and a series of UV tacks designed to hold the module against creep and delaminating forces. The location of these tacks, as currently understood will be addressed in the specific sections on the Stave and the Sector.

The Flatness of the Local support interface is covered in the specific sections on the Stave and the Sector. Module flatness is non-critical to this interface, as the forces to flatten are low.

The shape of the module and the size of the active area can affect layout and thus the shape of the local supports. All driving dimensions on the module are captured in the Module Envelope drawing (####), with relevant values listed in the specific sections on the Staves and the Sectors.

3.4.2 Electrical

The modules will float relative to the local supports by way of the adhesive layer used to attach them.

3.4.2.1 Controlled Parameters

Module Adhesive: Non-conducting

3.4.3 Thermal

The module power dissipation is the primary heat load of the detector. Each module dissipates 8.25W, except the B-Layer modules, which dissipate 10.3W each. Both of these values are worst case estimates at end of detector life, however they are not based on measurements of actual modules. The local supports are designed to extract this heat and keep the temperature of the silicon sensor at or below –6C. The hydraulic diameter of the cooling channels integrated into the local supports and the exhaust tubes attached to them hinges on this power dissipation budget with very little margin.

The power estimates are based on the sum of contributions including Sensor leakage current, FE electronics, and Module Pigtail. The Pigtail contribution can locally exceed the specified parameter as long as the average value of all modules and pigtails on a given local support structure is below the controlled power dissipation.

The ΔT across the thermal adhesive is budgeted at 2C. Contributions to this budget include surface effects and voids, but is dominated by the layer thickness. Local variations in the local support flatness are sized relative to this value.

3.4.3.1 Controlled Parameters

Module Power Dissipation: 8.25W including Pigtail

B-Layer Module Power Dissipation: 10.3W including Pigtail

Module Adhesive Layer Thickness: $\leq 100\mu$

3.5 Services

Physical interfaces will be dealt with in Stave/Sector specific sections. This section is intended to describe common attributes of the services on both local support structures

3.5.1 Cables

Modules are serviced electrically by Pigtails, which terminate to the module on one end, and the first cable run on the other. The Pigtail is terminated to the module and supported for part of its length by strain relief structures attached to the local support structures. The strain relief structures are as yet not designed, but space reserved will be indicated for their mounting in the specific sections on Stave/Sector.

The Far end of the Pigtail is not supported by the local support structure. It will be strain relieved to features built into the intermediate support structures (Barrel-Shells/Disk-Rings).

3.5.2 Fiber-Optic

Signal and Fast control are brought in on fiberoptics. These are integrated into the pigtail, and have no specific interface to the local support

3.5.3 Cooling

Cooling pipes terminate to Stave and Sector Pairs, with a series connection between paired local supports. These terminations will be covered in Stave/Sector sections more directly.

Cooling Service Runs along the forward frame are strain-relieved to the Global Support Frame close to the local supports to minimize CTE induced strains. These will be covered in the sections on the Stave and the Sector cooling terminations.

Electrical Breaks in the cooling tube close to the local supports are necessary for the grounding and shielding rules.

4 Stave Specific

4.1 Module

See Local Requirements and Local Supports Overview documents (done by M. Olcese).

4.2 Support Points

Staves are mounted to common supports by means of screws and dowel pins, then forming subassemblies called "bi-staves". These last, on their turn, are mounted to shell supporting structure by means of screws. Purpose-shaped rings, integral with the shell structure, will feature precisely machined grooves that should allow the accurate location of the bi-stave on φ. The mating surface between the above-mentioned rings and the stave supports is the interface between the bi-stave and the supporting structure. More details can be found in the Stave Design Status document.

4.3 Cooling Termination

The cooling pipe are clamped and glued to PEEK terminations, protruding outside the staves. Such terminations are glued inside the cooling channel when the omega profile is bonded to the TMT. Their geometry allows the U-bend pipe that connects two staves in series, as well as the exhaust pipe, to be clamped and glued outside their diameter, while the capillary termination can be glued inside. As both U-bend and exhaust pipe will be components of the bi-stave assembly, the interfaces with the cooling circuit will be the stave termination where the capillary end will have to be glued in and the hydraulic connector at the end of the exhaust pipe.

4.4 Service supports

The exhaust cooling pipes will be strain-relieved to an intermediate ring, placed in between the pipes themselves and the shell support structure. The pipe saddles on such a ring will be the interface between the bi-stave exhaust pipes and the shell support structure.

The electric connections ("pigtails") are supposed to have an envelope section of 3x7 mm; their strain-relief is foreseen on the end cone, where the electrical connector will be glued/screwed on: then the end cone is the first interface the electrical and optical services will find after the modules on the staves.

5 Sector Specific

5.1 Module

5.1.1 Placement

Placement tolerances are covered in the Local Supports Requirements Document ATL-IP-EP-0005.

Coordinate system used for Module placement is described in Section on Support points below

5.1.2 Module Envelope and Layout

The layout of the sectors follows directly from the placement of the modules in the detector layout. In the Disk region, the primary driving parameter in the layout is the physical width of the module. This is due to module to module clearance near the inner radius on a given face, which is nominally 1mm. Changes in module width map to changes in Sector Radius to maintain the given nominal clearance of 1mm.

Module height (not thickness) is used in the layout to get the nominal inner radii of ring as shown in figure 2, but the dimensions are not critical to the millimeter level. Changes in module height which affect coverage do not affect the sector directly, this essentially only changes the disk position in the frame

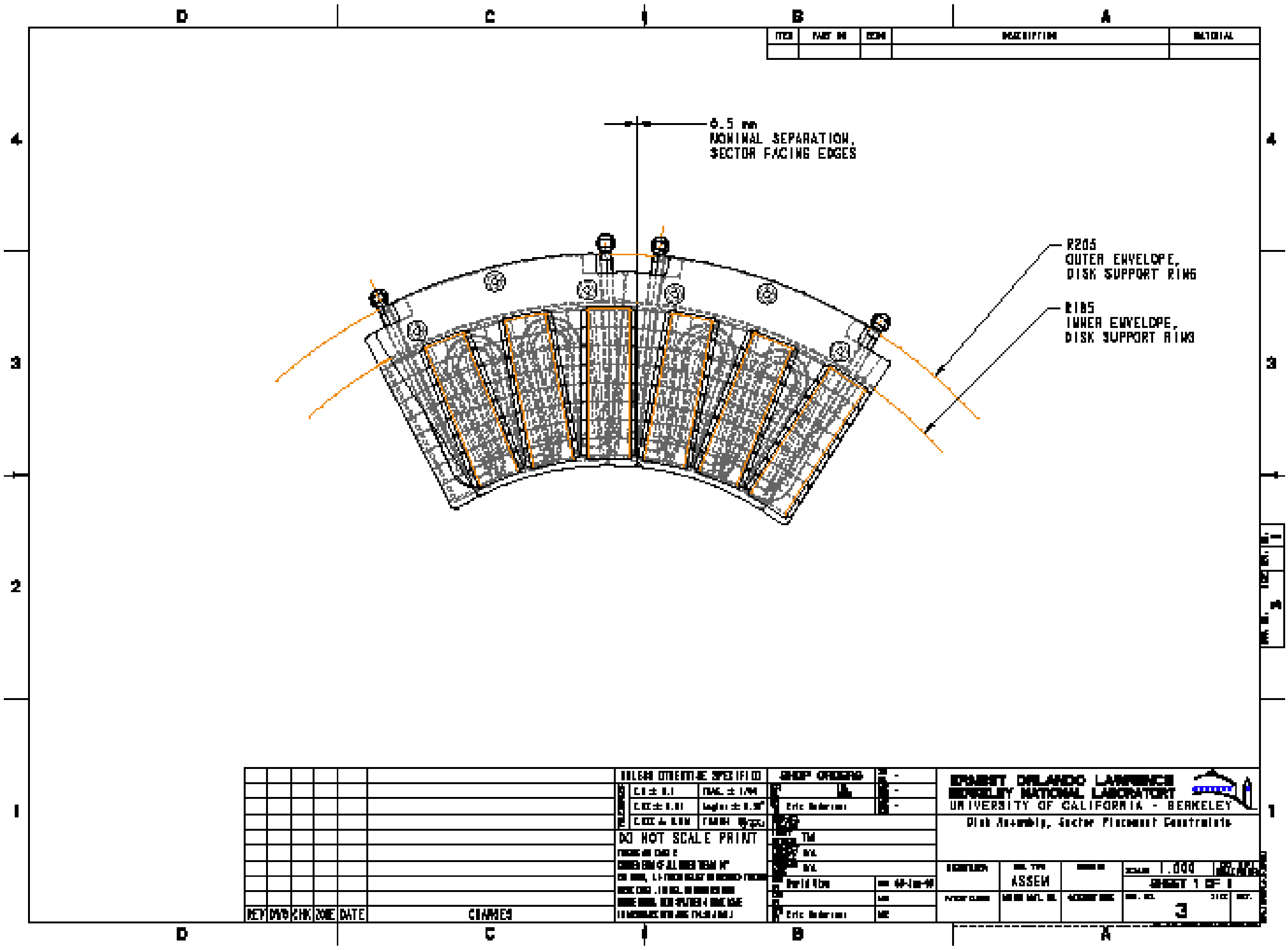

Figure 2 Sector Assembled Layout showing Sector to Sector clearance and Ring envelope dimensions

The nominal clearance used in the layout of modules (1mm) is deemed sufficient to contain all module placement errors and tooling clearance. Module placement errors do not affect Sector Layout.

5.1.2.1 *Controlled Parameters:*

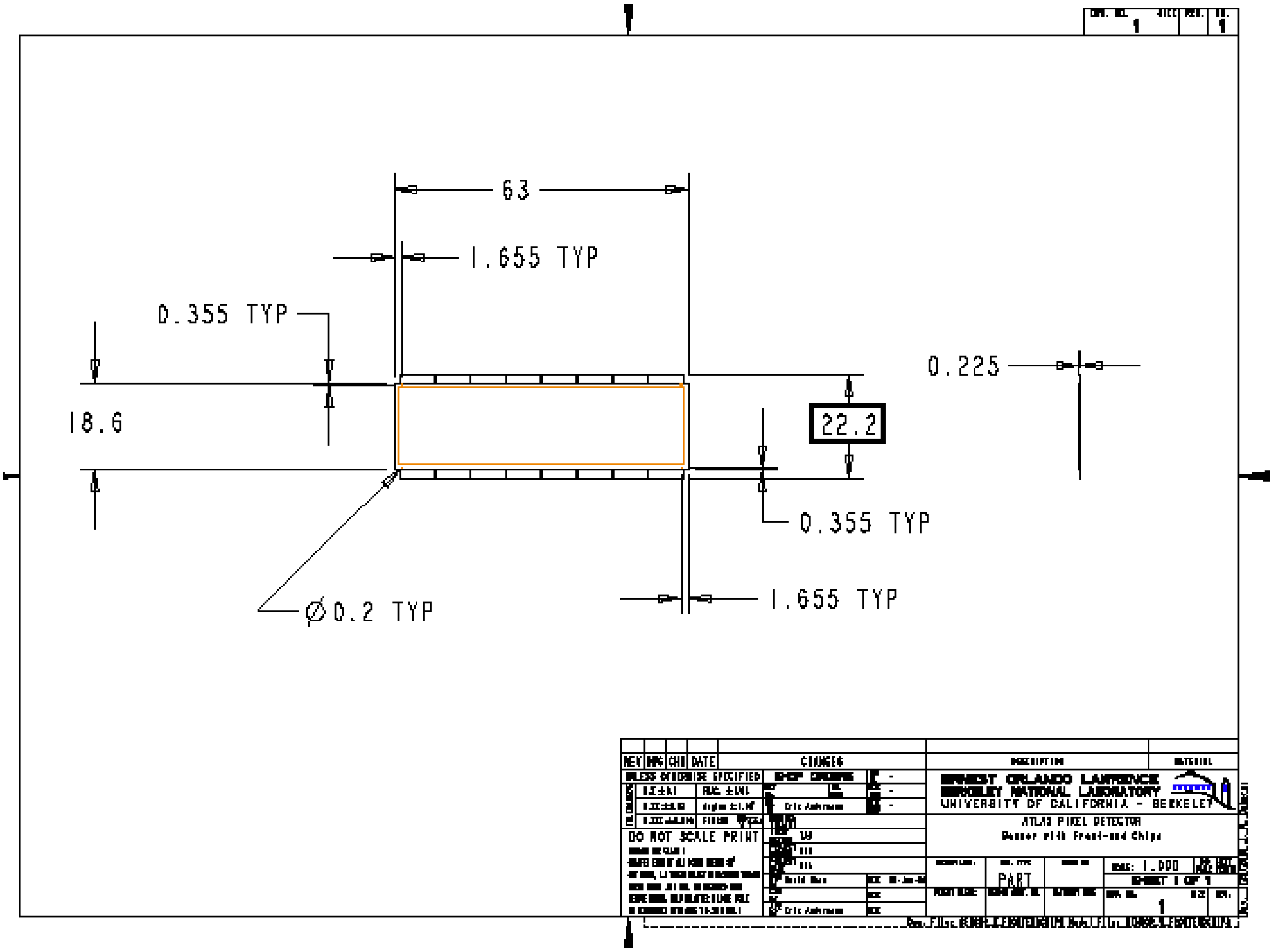

Figure 3 Module footprint showing controlled dimension of 22.2mm in Box

Module Width over FE-Chips: 22.2mm

5.1.3 Module Adhesive Layer

The Module is attached to the Sector via a layer of thermally conductive adhesive and UV cured tacks. A template that is placed on the sector facing and used to screen on the adhesive controls this layer. The Module to Sector interface is therefore this adhesive layer and tacks. Critical requirements are the thickness of the adhesive layer and the quality of the thermal contact. Local flatness of the sector facing can affect the adhesive layer thickness, and thermal resistance can be degraded through introduction of foreign substances.

Tacking of the module via UV adhesive buttons is necessary to prevent substrate delamination, and creep (thermal adhesive has very low modulus). The locations of these button is not rigorously defined, however space and access is reserved at the module corners—leaving open options to tack either the sensor, FE Chip or Hybrid.

Disk sectors have no special requirements on the modulus of the adhesive chosen, but have only tested adhesives <1000Mpa after 50Mrad.

5.1.3.1 *Controlled Parameters*

Facing local Flatness: <75µm

Facing Impregnation/Coating: <25µm

Tack Locations: TBD—area is clear around entire periphery of module

Adhesive Modulus: <1000Mpa after 50Mrad

5.2 Support Points (Sector-to-Ring)

Sectors mount to disk rings mechanically, using a pseudo-kinematic support scheme. For all disks, excepting disk 1 (closest to IP), the sectors mount on the side away from the IP. The only difference in sectors is the tube orientation on assembly. The mechanical interface remains the same.

5.2.1 Mount Points Geometry

The geometry differs for the 9 and 11-Sector Disks. All tolerancing and schema are the shared between the two sectors. See section below regarding the Disk 1 option.

In Figure 2, the inner and outer radii of the Disk 1-3 rings are shown. This is related to the module positions, however the nominal radial extent of the disk rings is 20mm. 9-Sector rings and sectors are not shown in detail in this document, but will be in future revisions. The Physical dimension of mount point location is determined by bond fixture, and should coincide with the hole locations on the mount ring. The mount ring is not yet designed; the holes placed in the ring will be consistent with the dimensions in figure 4, with pilot hole coinciding with datums C and B of the Sector. 11 sets of holes will be placed in the ring with tolerances appropriate for the mounting scheme, which is currently undecided, but baselined as 3-tight fitting pins in accurate holes. Tolerances across the set are better than H7 for 3mm nominal (12μm). Clocking of the holes on the ring are controlled only to the level that the sectors do not collide, however it is reasonable to apply the same tolerance on their

5.2.1.1 Controlled Parameters:

Hole Locations on Ring: Ref Drawing of Ring (TBD)

Tolerances of position of hole sets: 12μm← assumes rigid non-kinematic mounts

5.2.2 Coordinate Systems

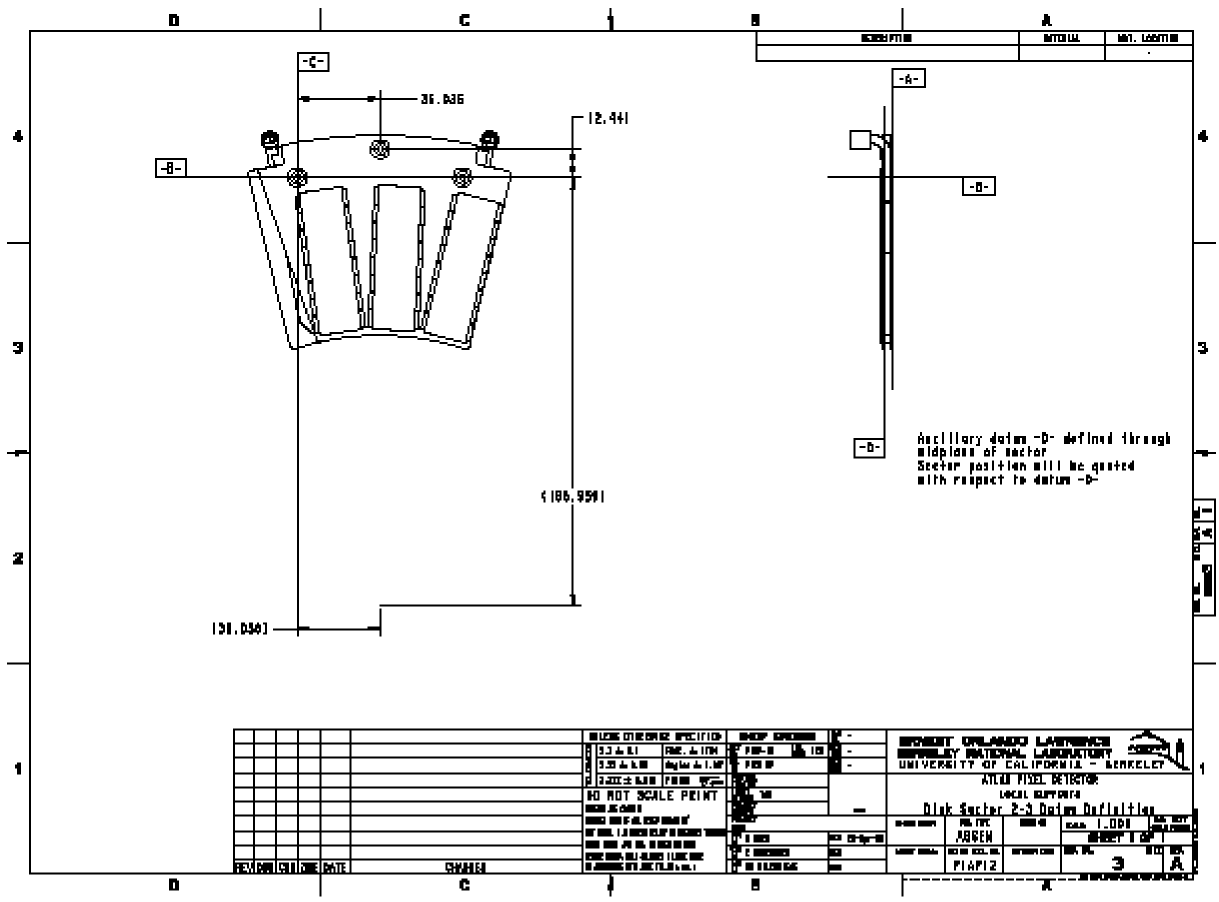

Figure 4 Sector Datums are defined through the mount points for ease of QA and physical Survey

Disk Sector Datums are tied to physically measurable features as illustrated in figure 4—dimensions are specific to the 11-sector. The Auxiliary datum –D- is defined for ease of comparison to physics layouts, which quote sector position from sector midplane.

5.2.3 Disk 1 option

Disk one differs from disks 2 and 3 in that the sectors are mounted on the IP side of the Ring. This changes only the direction that the tubing is installed, not the mounting scheme, points or datums. No special consideration is necessary for the sectors on Disk 1. What is necessary to note is only that the relation of the disk 1 coordinate system is mirrored with respect to the Pixel global coordinate system.

5.2.4 Mount Point Hardware

The mounting hardware is likely to consist of metal pins, nuts and washers, so the mount pads on the Disk Ring must be non-conducting, and or electrically isolated from the structure of the Disk Ring. The current plan is to fabricate them from PEEK

The Mount pads must allow for module electrical services to pass underneath

The mount scheme documented here is rigid, non-kinematic mounting—the pins are tight fitting and nutted, relying on good match between sector and ring hole locations.

5.2.4.1 Controlled Parameters

Ring mount pad Material:	PEEK
Ring Mount Pad Thickness:	>0.5mm
Inner Mount Pad Hole diameter:	3.175mm +0.010/-0 (H7)
Tight-Pin, and Diamond-Pin major diameter:	3.175mm +0/-0.006 (h6)
Outer Mount Pad Hole diameter:	3.175mm +0.025/-0 (H9)
Loose-Pin diameter:	3.175mm –0.020/-0.045 (d9)

5.3 Cooling Termination

The Termination of the sector to a cooling plant is accomplished via a square to round transition piece glued to the end of the rectangular sector cooling tube. The termination must be compatible with both evaporative and Monophase-cooling connections so that the QA equipment at LBNL could remain liquid based. They must also provide a round external surface, which can be sealed to in a non-permanent manner. The Adaption of the termination to evaporative can be a permanent one, near to final integration of fully qualified sectors into a final structures

5.3.1 Cooling Tube End Termination and Strain Relief

The Strain relief is internal to the sector and prevents the tube from being torn from the sector by external forces—it has no external interfaces.

The Sector tube termination is a Square to Round termination which bonds to both the end of the sector tube and also provides a round bonding surface for either a capillary spud or an exhaust tube. The termination piece also provides a round exterior interface allowing a temporary seal to be made for QA. The parameters which must be controlled are the sector tubing dimensions, and the exhaust tube dimensions (covered later). The Sector tube dimensions are an internal interface and not considered here.

5.3.2 Exhaust Tube Termination

The Exhaust tube will be glued into the tube termination using Hysol EA9396 adhesive—the same adhesive used to assemble the sector. The diameter of the Exhaust tube is sized for evaporative cooling and the local power budget. The module power budget is controlled elsewhere in this document, but this obviously depends on it. The prototype sectors and terminations have been sized for ¼-inch tubing, but can easily be adapted for the 4mm tubing which is the current baseline exhaust tube diameter. The controlled dimension will remain 6.35mm until we move to the production sectors where 4mm will be adopted.

5.3.2.1 Controlled Parameters:

Exhaust tube Outside Diameter:	6.35mm

5.3.3 Capillary Termination

The square to round tube terminations are designed to terminate exhaust tubes—the capillary will be adapted with a bushing which spans the difference between exhaust tube OD and capillary OD.

5.3.4 Series Connection

The series connection must respect the forces requirement and has the same interface as the exhaust tube

5.4 Services Support and Routing

5.4.1 Pigtail Envelope

The width and length allowed for a tab on the module and termination to the pigtail are documented in figure 5. The overall thickness of the Pigtail and termination must not exceed 1mm as the clearance between sector and ring facings is nominally 1.15mm.

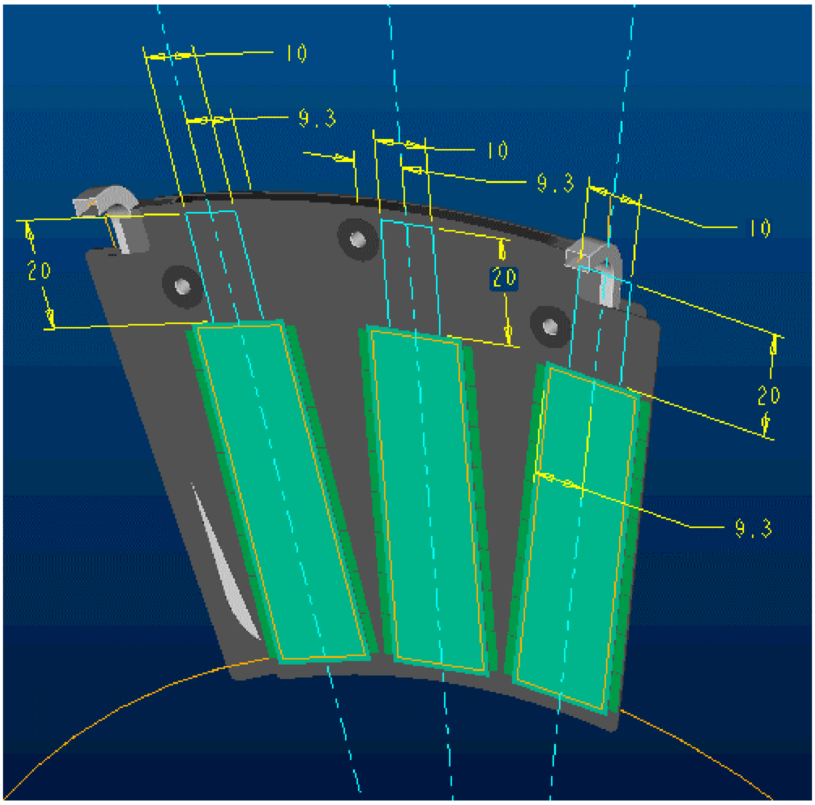

Figure 5 Pigtail and Module Tab Stay in regions

5.4.1.1 Controlled Parameters

Tab Width:	10mm
Pigtail Width:	10mm
Tab Length:	20mm
Connection Thickness:	1mm

5.4.2 Strain-Relief

Strain relief of the pigtail is trivial, the connection on the opposite end from the module is supported by the global support frame. Locally, the pigtail and module tab may be glued to the sector facing. There is ample space for this, excepting the neighborhood around mound tabs