
PLR Manufacturing Options

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31 October 2024

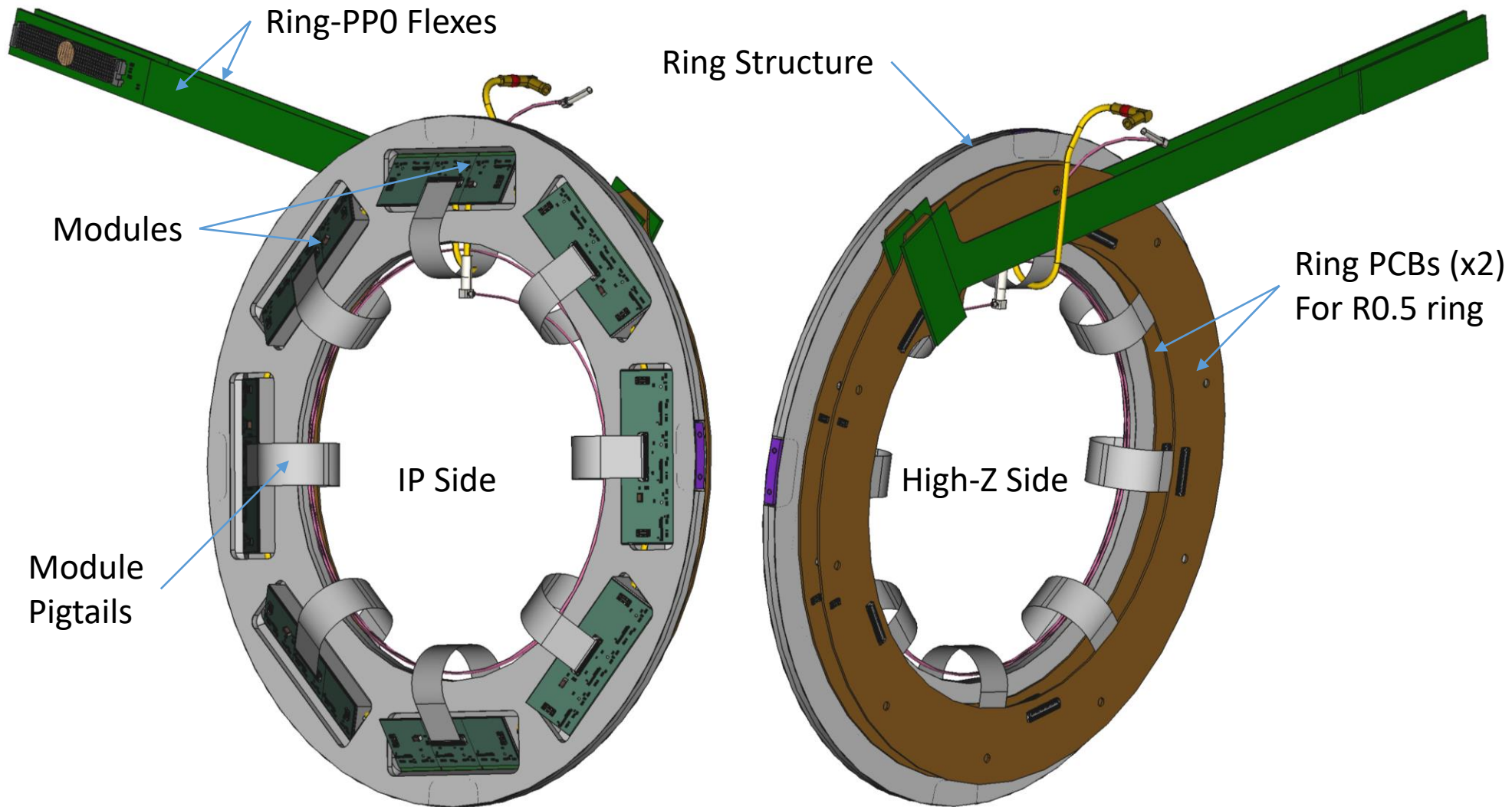
Background

- PLR was originally costed as an extension to the US project
 - This was deemed too costly or undesirable for various reasons
- CERN has potentially taken up the role of coordinating the project, alleviating the US of direct financial responsibility
- However, as the PLR is based on US-supplied underlying components, there is an intrinsic US contribution
- This attempts to outline the ways in which those components could be supplied, and what impact that would imply on the US-side

Overview

- PLR Ring is based on a standard Quad Ring
 - Maintains pipe shape
 - Maintains overall dimensions
 - Maintains basic machining
 - Only addition is additional machining (during same setups) and bonding on “Module Wedges”
- PLR Services are based on standard pixel inner system services
 - PPO and Type 1 Services bundle
 - Ring PCBs
 - Ring to PPO flexes
 - Module pigtails
 - With the exception of module pigtails, all parts are standard
- Thermal performance is dependent on several factors
 - Wedge angle, Facesheet-pipe distance, Lateral wedge position (i.e. radius since pipe radius is fixed), Ring thickness
 - We have defined the optimum value for all of these factors, given manufacturing concerns and performance
 - We have confirmed thermal performance in FEA with some reasonable assumptions, but this is an initial design, and would benefit from additional engineering

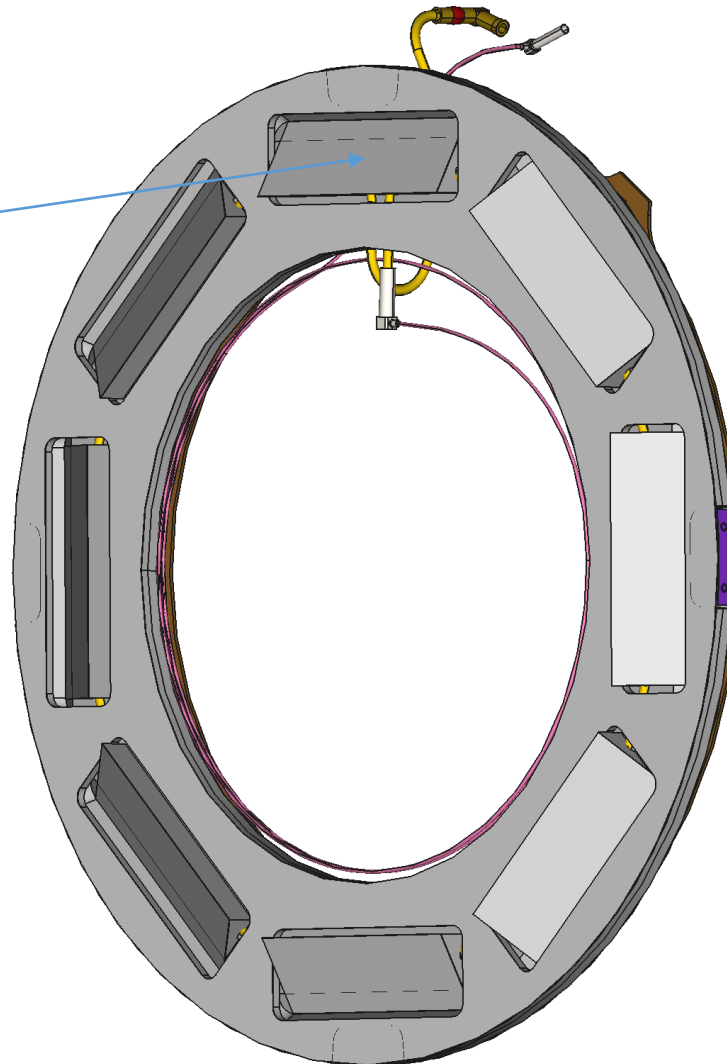
PLR Ring Assembly



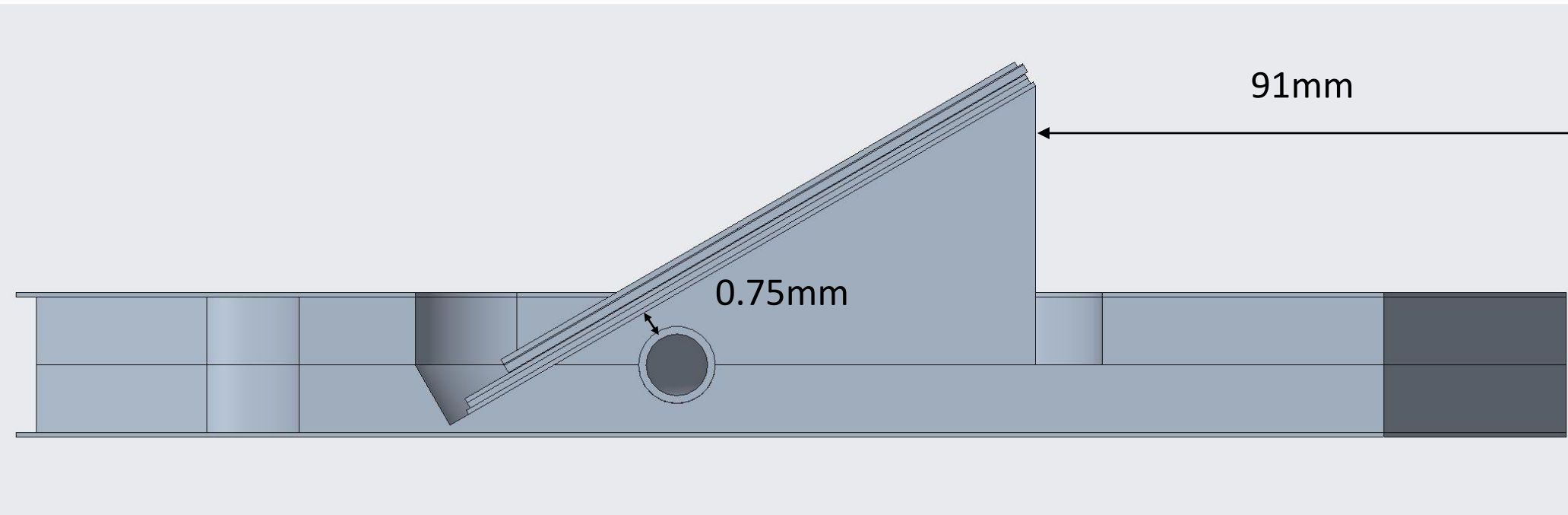
PLR Ring Structure

Module “Wedges”
Are the characteristic
Element of this design

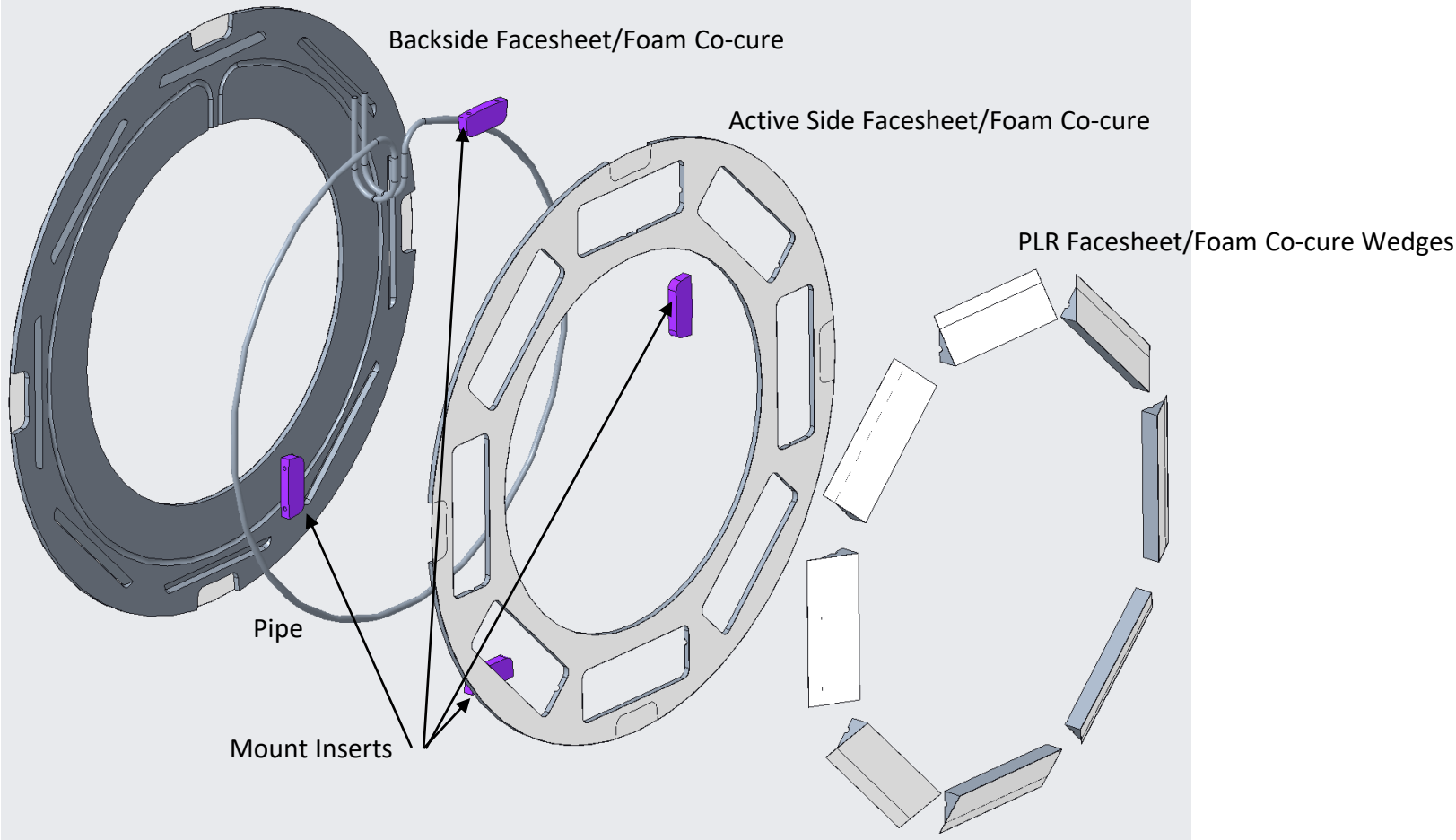
In all other ways the
Ring is a standard R1 Ring



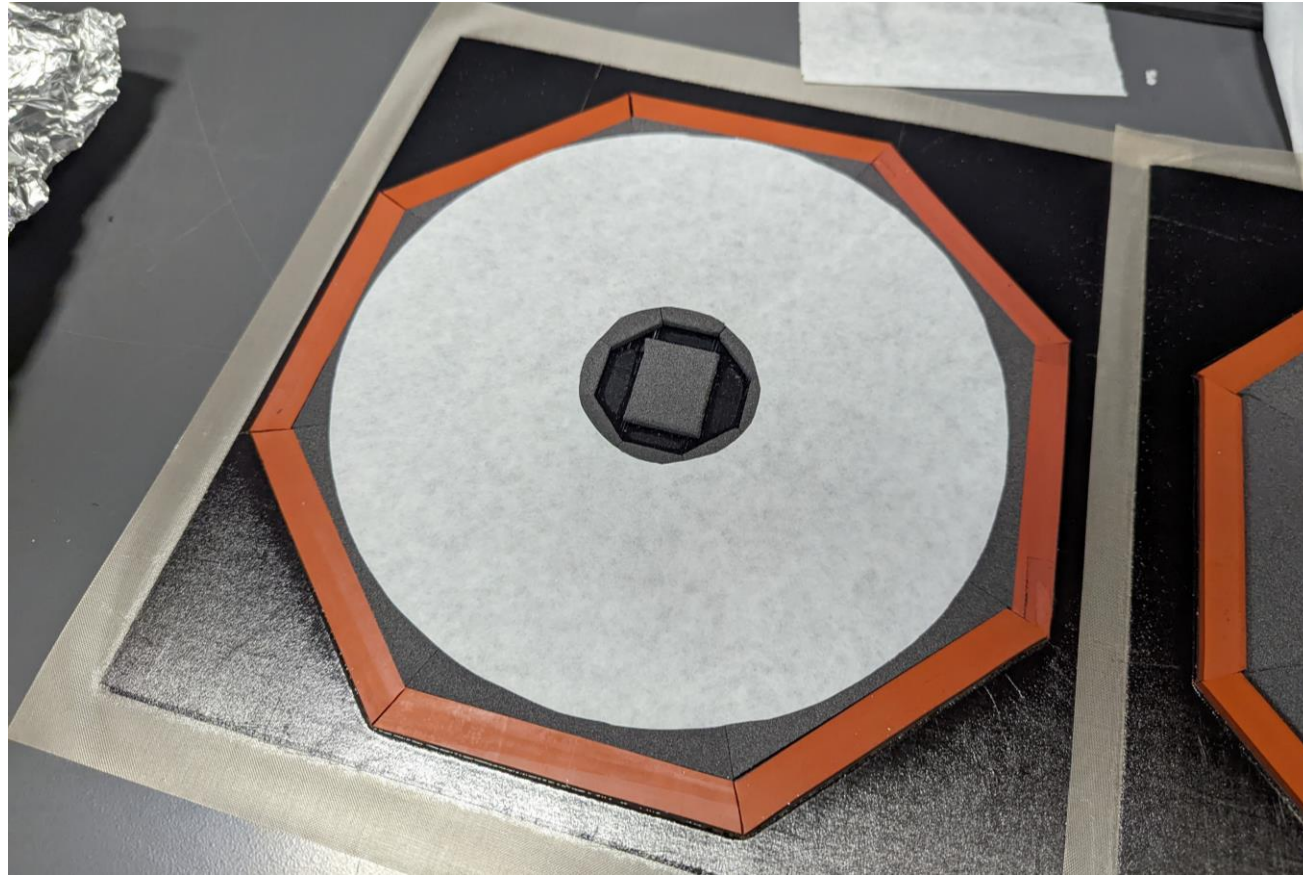
Ring Cross Section



Exploded Assembly

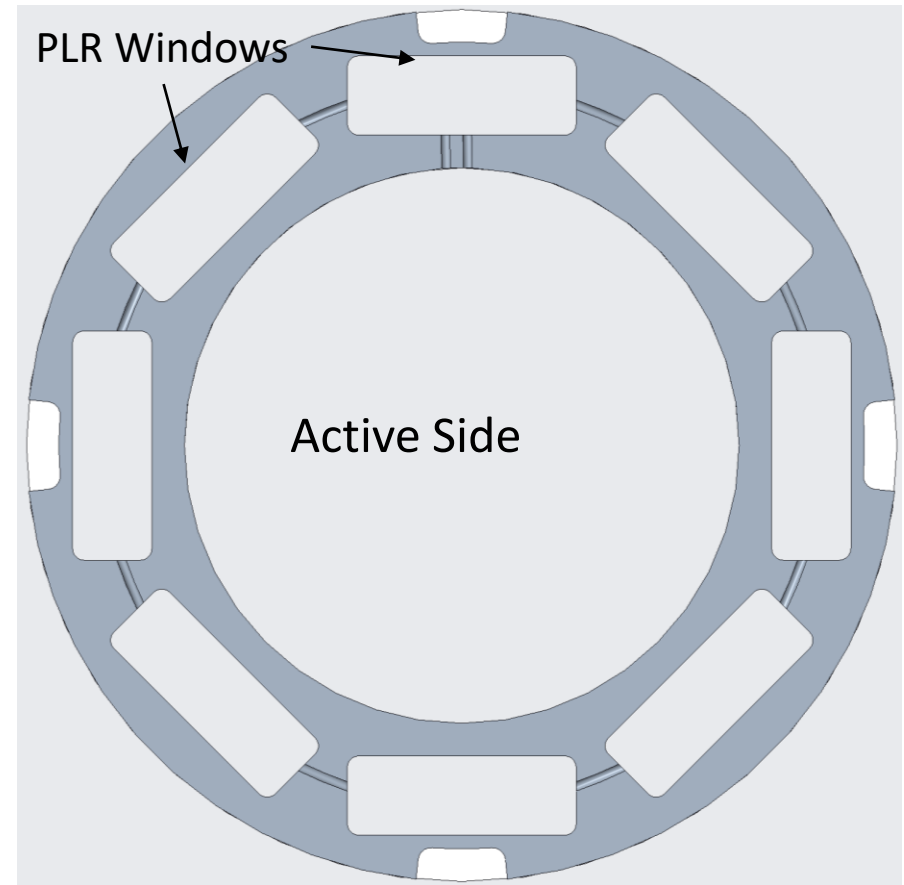
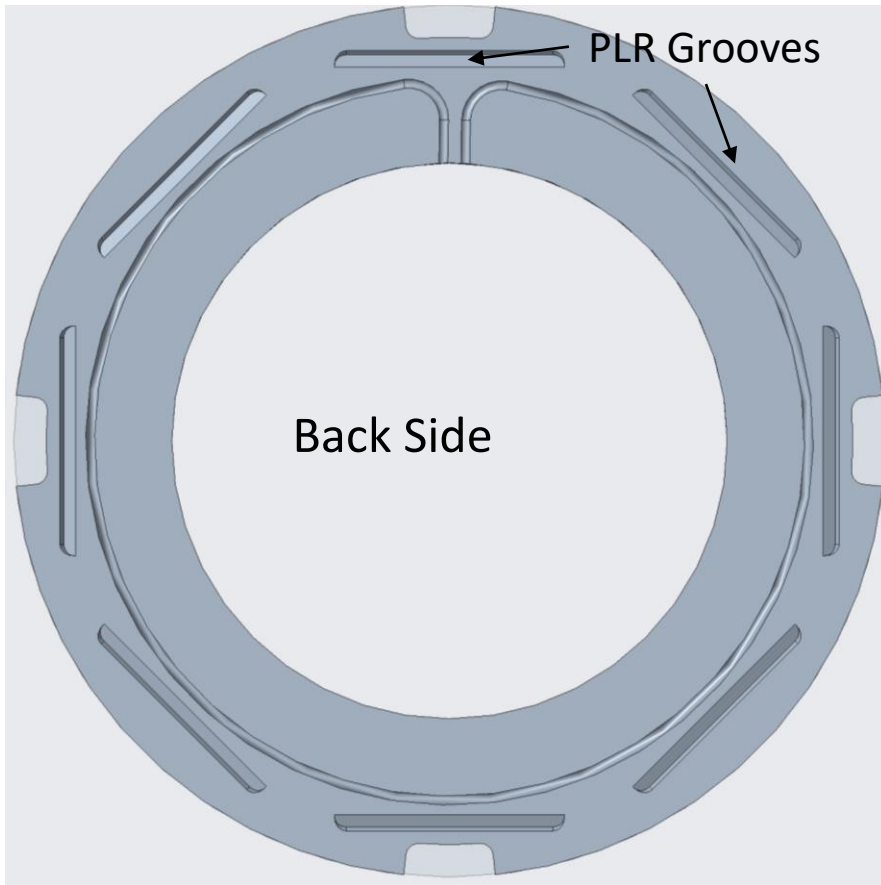


Step #1 Make Regular Quad Ring Blanks



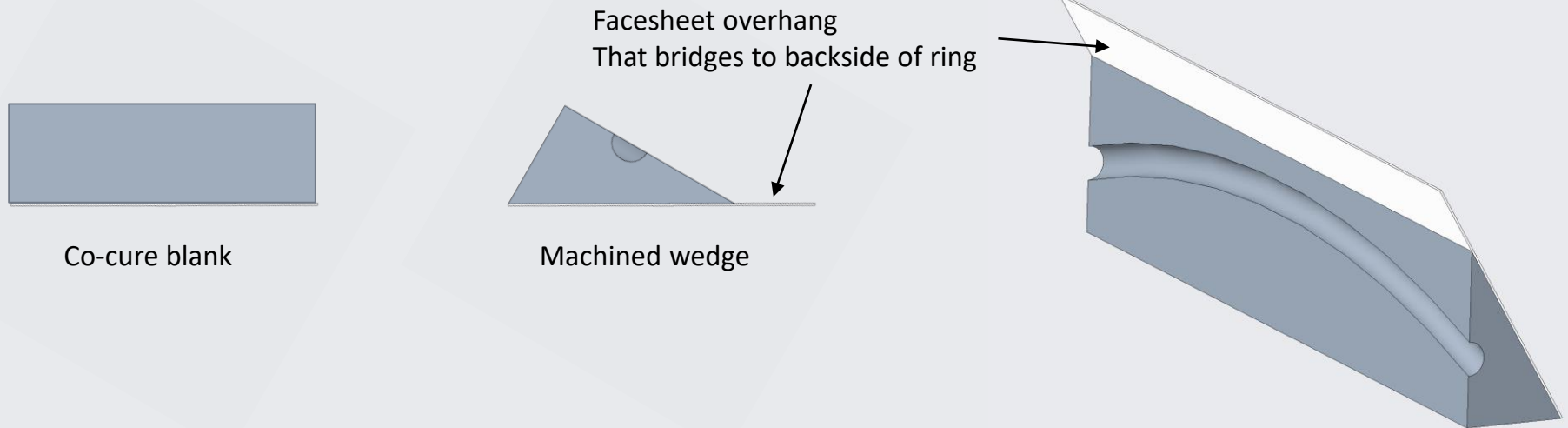
LBL would supply the raw material, outside vendor would create the blank co-cures. (likely vendor Purdue, who is already in possession of the necessary CF pre-preg for IS uses, but foam would need to be supplied).

Step #2 Machine PLR Features



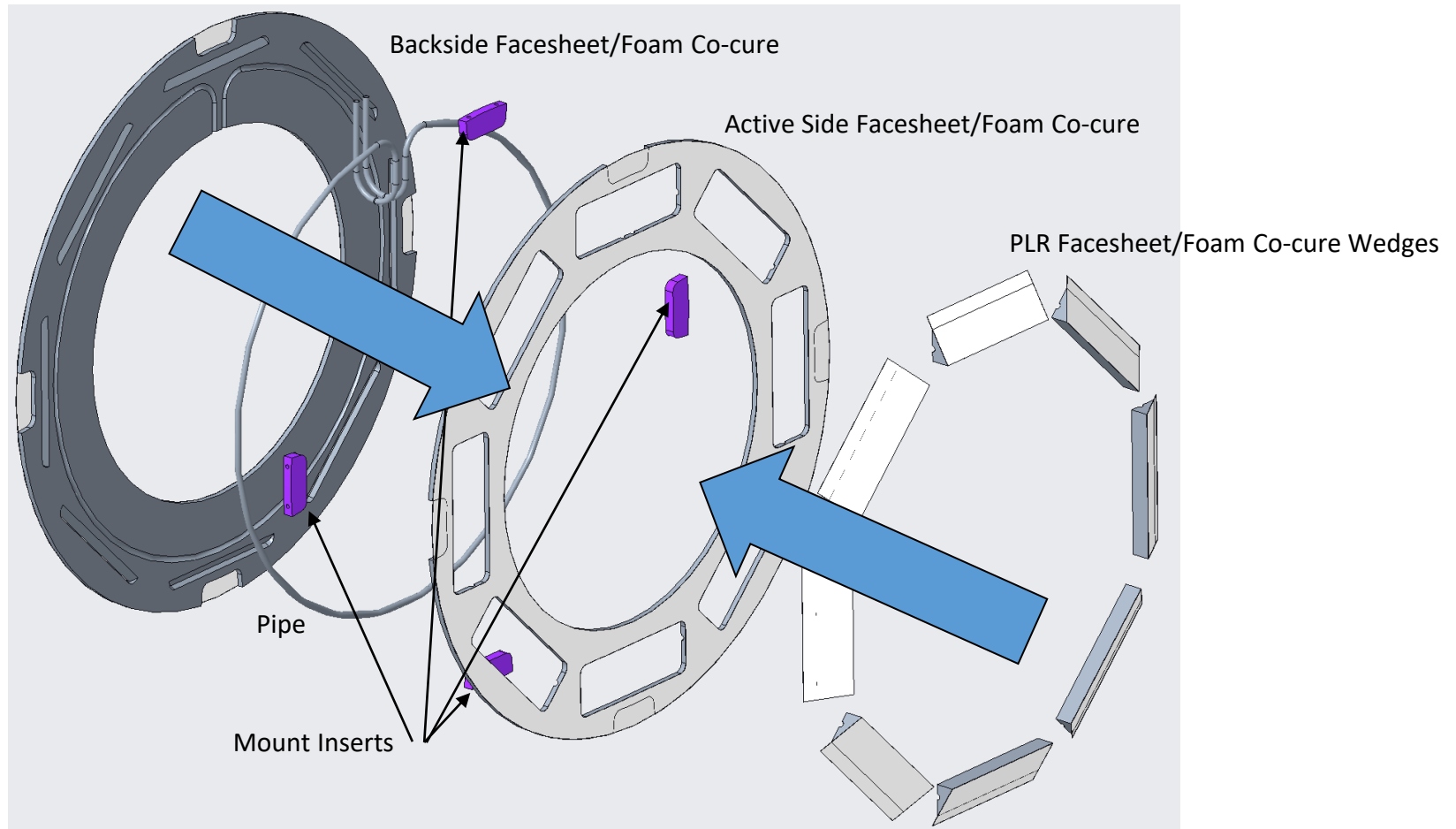
This step would be done by an outside vendor, potentially using LBNL Tooling (on loan) for holding the ring in the machine. (likely vendor Purdue)

Step #3 Wedge Fabrication and Machining



This step would be done by the outside vendor, from co-cure to machining. The amount of material is infinitesimal, and Purdue will already possess the required carbon due to other activities. Foam would need to be supplied. (Likely vendor Purdue).

Assembly – all in one bonding operation



This step would be done by an outside vendor, potentially using LBNL Tooling (on loan) for holding the ring during bonding. (likely vendor Purdue)

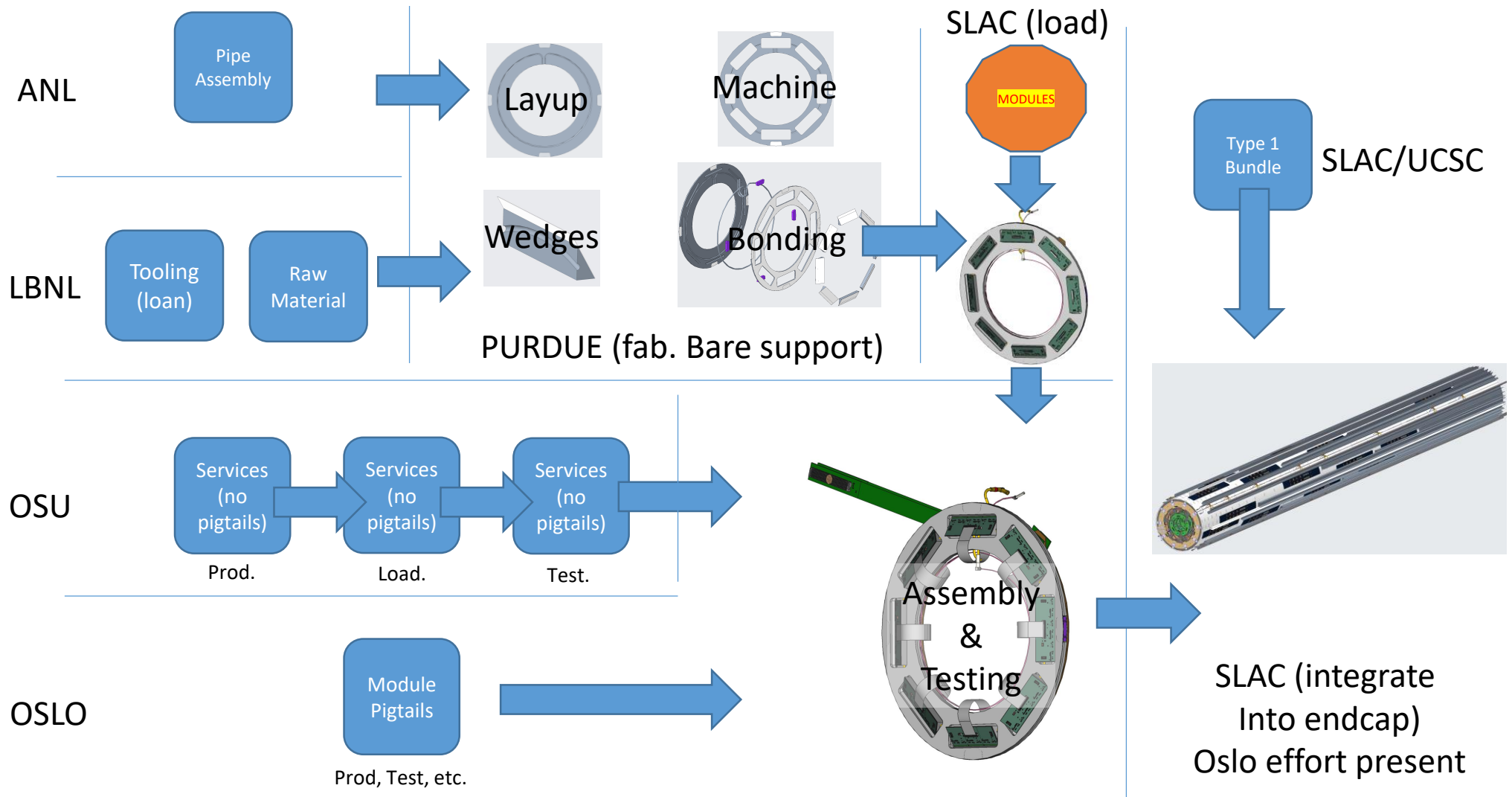
Services

- PLR Services are based on standard pixel inner system services
 - PPO and Type 1 Services bundle
 - Ring PCBs (R0.5)
 - Ring to PPO flexes
 - Module pigtails
 - With the exception of module pigtails, all parts are standard, though there are some questions
- PPO and Type 1 Services bundle
 - PPO and bundle would be standard, might need something unique for opto-terminations
 - In any case, every bundle in the inner system is unique, so this would be a unique bundle, but probably only in length
- Since 8 modules at 45 degree intervals are being connected to 2x R0.5 rings with connectors at 72 degree intervals, the module pigtails will be unique
 - Current plan is to have Oslo design and build these flexes

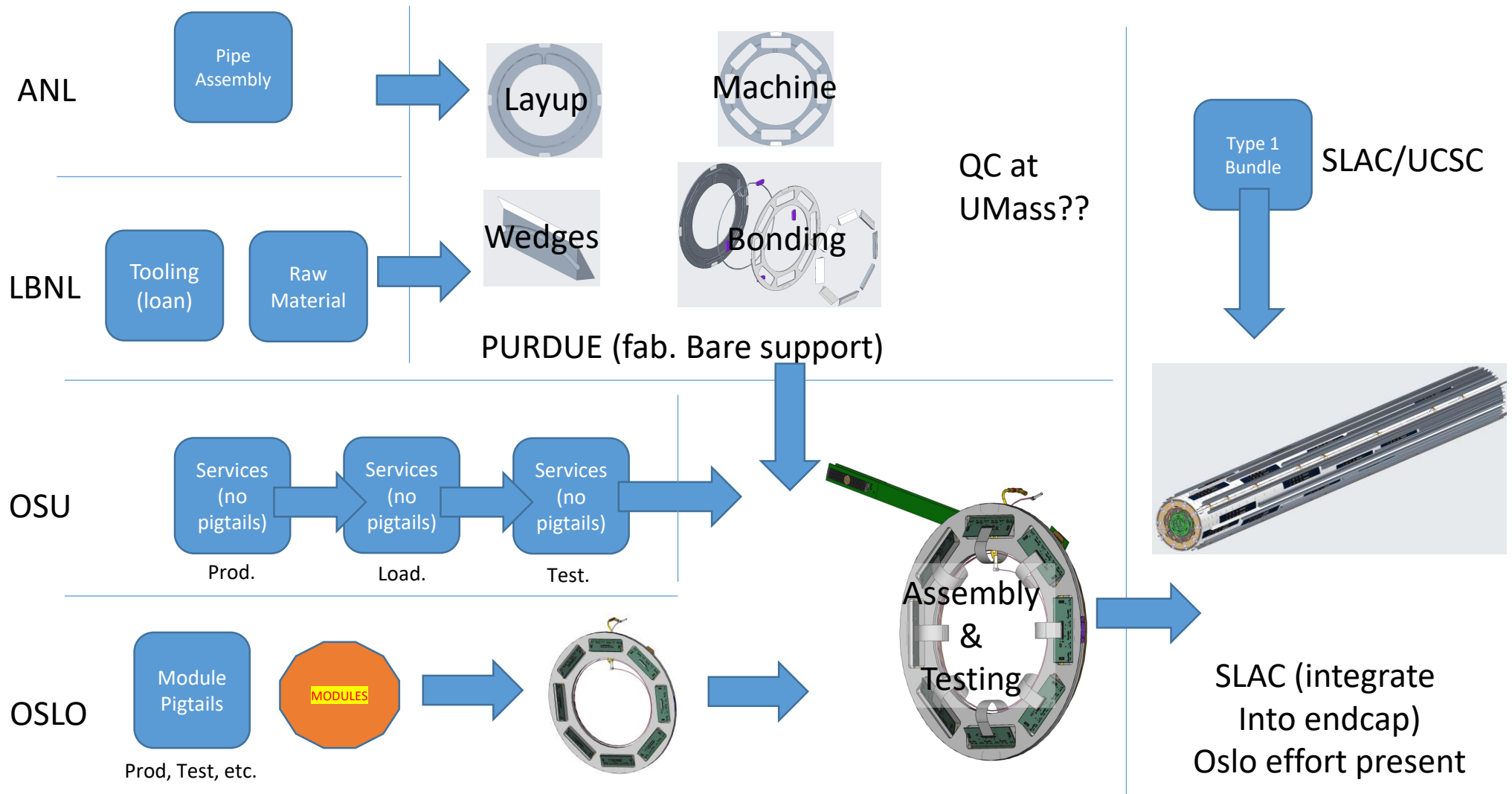
Services Production

- With the exception of module pigtails, all services require production and dedicated testing, currently being performed by OSU
- There is no sense in splitting the PLR pieces out of this process, since it would require the development of additional testing equipment and protocols in Norway, for a very small number of parts
- In addition, Ring PCBs require loading with components, so this should also remain in the routine US production path
- On the other hand, the pigtails will be entirely *outside* of the US production scope

Workflow – Option 1



Workflow – Option 2



Delivery Scope

| Unit | Production (Overall IS w/o PLR) | PLR Prototype /Preproduction | PLR Production | PLR Total | % of Overall Production |
|--------------------------|------------------------------------|---------------------------------|-------------------|--------------|----------------------------|
| Ring Structure | 58 | 2 | 2 | 4 | 6% |
| Intermediate Ring PCB | 12 | 2 | 4 | 6 | 33% |
| Ring to PPO Flex | 208 | 2 | 4 | 6 | 3% |
| PPO+Type 1 Bundle | 112 | 1 | 2 | 3 | 3% |
| Module pigtails | 0 | 8 | 16 | 24 | NA |
| Modules | 96 | 8 | 16 | 24 | 20% |

Summary

- This production plan limits US exposure and scope while still allowing the use of US-developed core technologies (critical to the success and minimized cost of the PLR)
- While the US is still responsible for manufacturing multiple PLR components, they are all simply +X additions to existing batches (where X is 2-4 pieces)
- The one exception is in the Type 1 bundle, which must be a custom length, and the module pigtails
 - Type 1 bundle lengths are all unique, so this is not such an onerous addition
 - Module pigtails will be entirely managed by Norway
- All mechanics to be done by Purdue, which is perfectly qualified to do this work. The only delivery from LBNL is material – CFRP and carbon foam. Cost is incremental, no changes in delivery scope for these materials are needed.
- Integration at SLAC could be aided by the presence of international collaborators onsite (Norway, CERN, etc.), though there will still be a limited need for US technician effort
- Loading could potentially be performed by Purdue under Work for Others