High-density High-speed Service Infrastructure for ATLAS ITk Pixel Detectors

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Introduction

➢ LHC will undergo "Long Shutdown 3" in 2025
  ➢ LHC with be upgraded to HL-LHC
  ➢ Increase to 200 collisions per bunch crossing

➢ ATLAS detector will be upgraded

➢ ATLAS Inner Detector will become the Inner Tracker (ITk)
  ➢ Pixel Detector and Semiconductor Tracker will be upgrade
  ➢ The Transition Radiation Tracker will be removed

➢ Type-0 services for upgraded Pixel Detector are densely routed
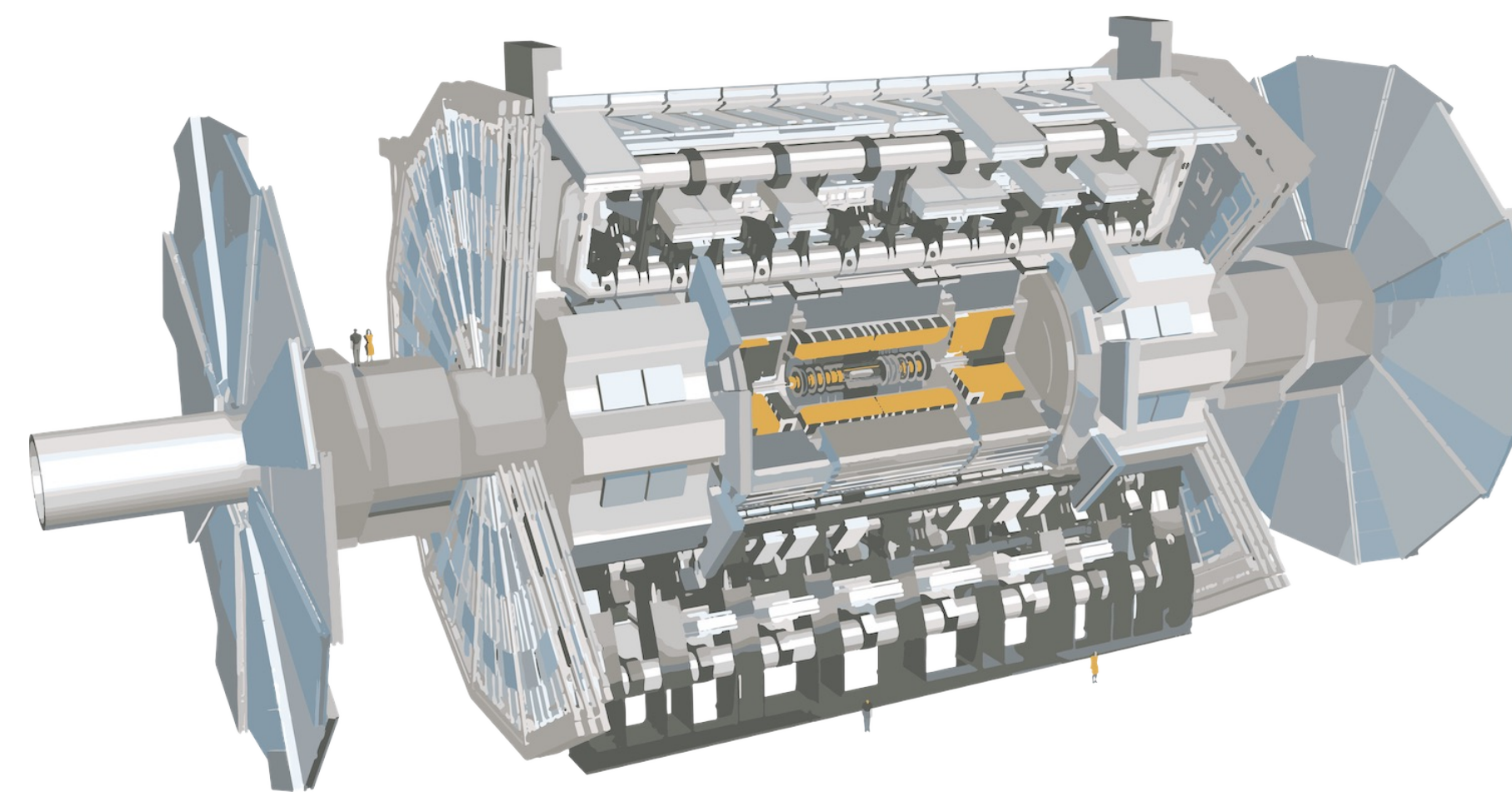 ➢ Type-0 services connect pixel modules to rest of the readout

Figure 1: Image of the current ATLAS detector

Figure 2: Schematic Pixel Detector readout

ITk Pixel Detector Layout

➢ The pixel detector is the 5 inner-most layers of the ITk

➢ Broken into 4 different sections
  ➢ Inner System: 2 inner layers (low r)
  ➢ Outer System: 3 outer layers (high r)
  ➢ Barrel: Low Z (horizontal lines)
  ➢ Endcap: High Z (vertical lines)

➢ Endcap Services have 3 components
  ➢ Data pigtails: Connects directly to modules
  ➢ Rigid Ring: Connects to multiple data pigtails
  ➢ Type-0 to PP0: Connects Rigid Ring to PP0

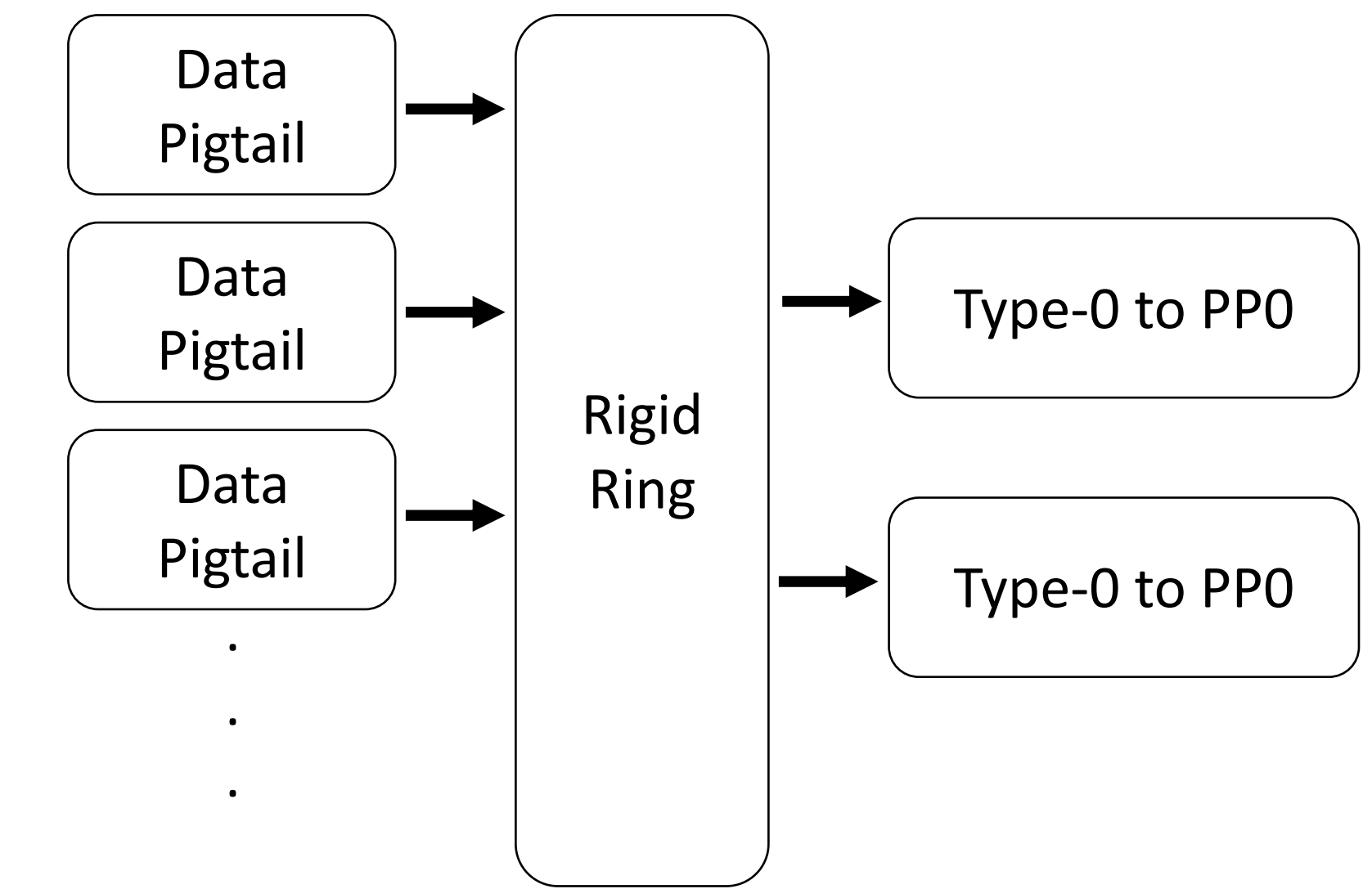➢ Type-0 to PP0 has the highest density of traces
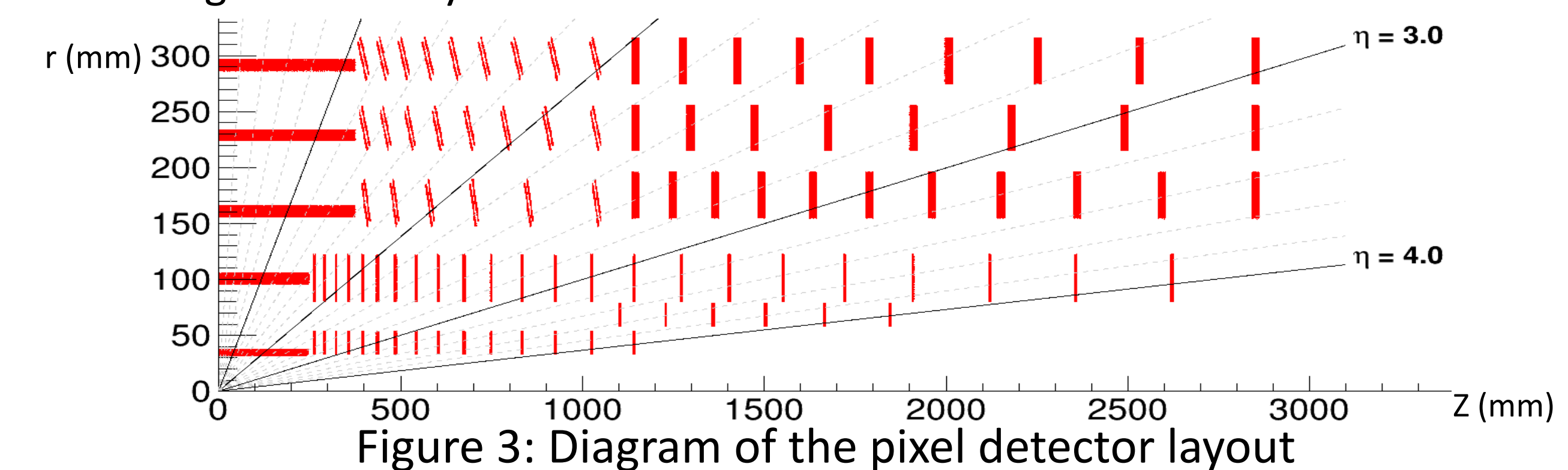

Figure 4: Schematic of the endcap services

Figure 3: Diagram of the pixel detector layout

Type-0 to PP0 Requirements

➢ 52 data traces per connector
  ➢ Coplanar differential pairs
  ➢ Differential impedance of 100 Ω

➢ Low voltage supply lines
  ➢ 4 different channels
  ➢ Return is AC coupled to ground
  ➢ Less than 1W of power dissipation

➢ High voltage supply lines
  ➢ 5 supply channels
  ➢ 5 return channels

➢ Module monitoring
  ➢ Power and command

➢ Interlock sensing

➢ Low power enable

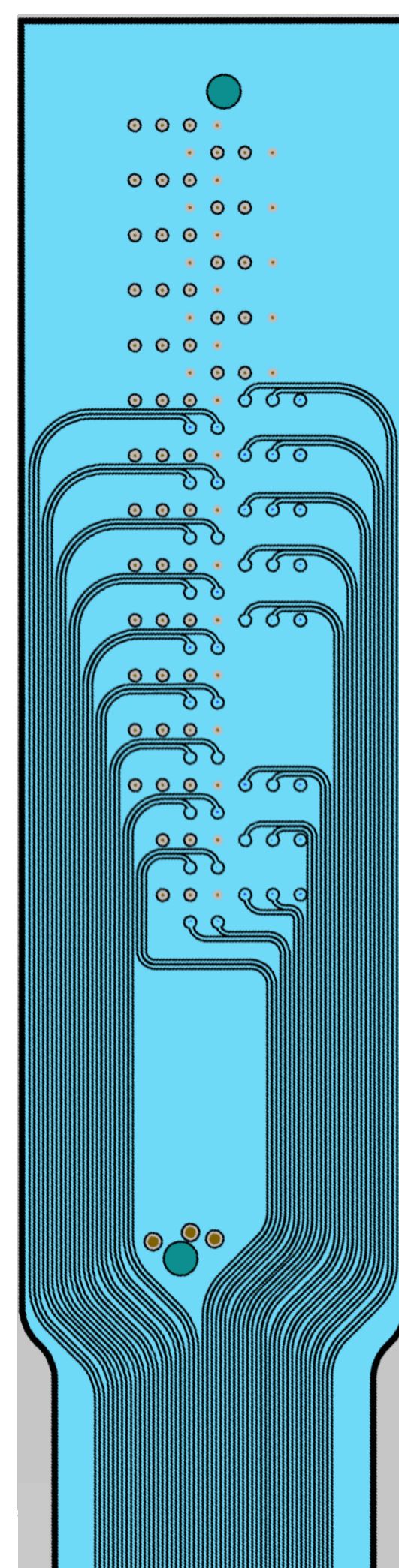➢ Restricted to 18 mm width at the PP0 side

Figure 4:Cutout showing routing

Testing

➢ Each board will be tested before being sent for assembly

➢ Connectivity
  ➢ Check if any of the traces are broken in the board

➢ High Voltage
  ➢ Test the high voltage limits

➢ S-parameters
  ➢ Measures impedance matching and signal loss

➢ Eye diagrams
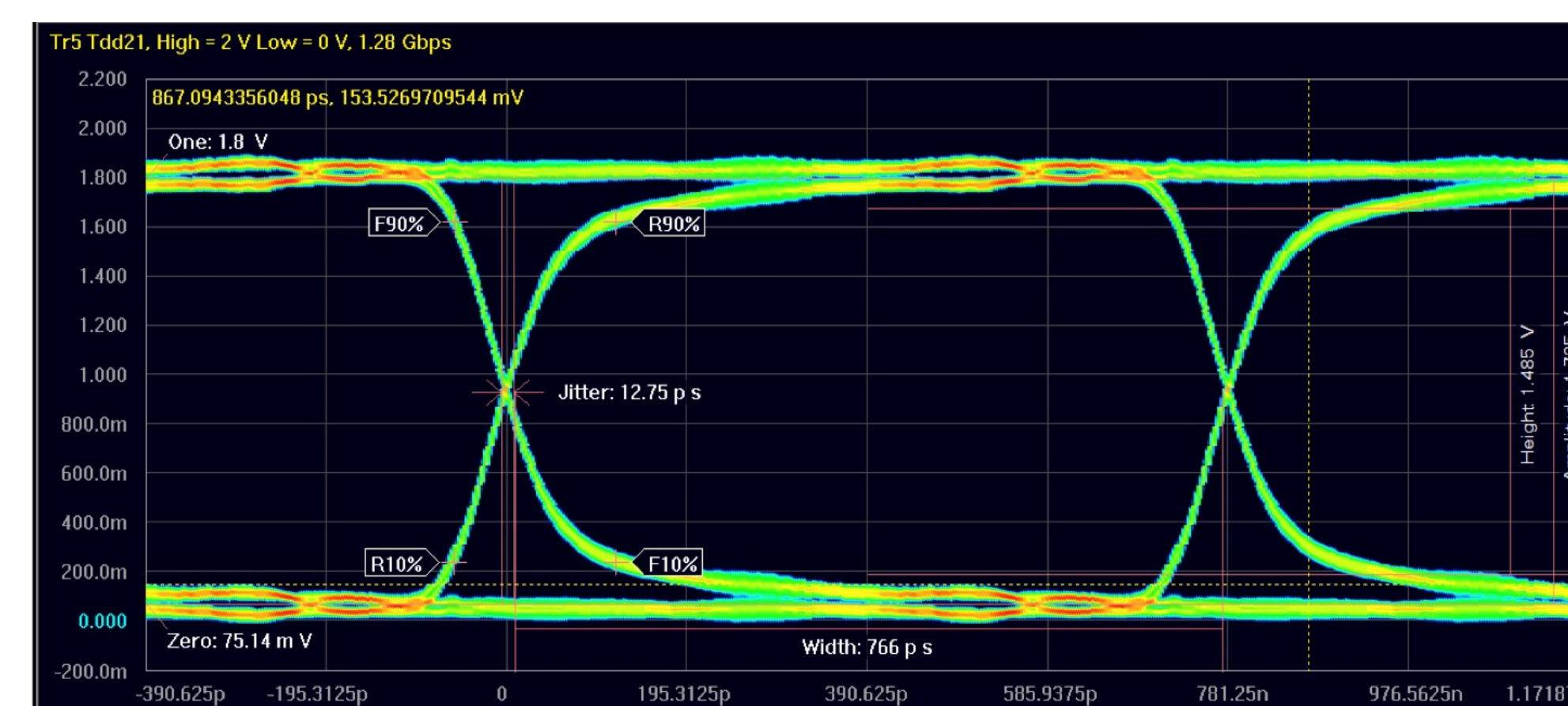 ➢ Shows the variation in signal at the readout

Figure 5: Eye diagram of a Type-0 to PP0 prototype

Conclusions

➢ Type-0 services for the upgraded Pixel Detector are densely routed
  ➢ Cables that connect the pixel modules to the rest of the readout

➢ There are several components that need to be manufactured

➢ Test the signal integrity of each board
  ➢ Connectivity
  ➢ High Voltage
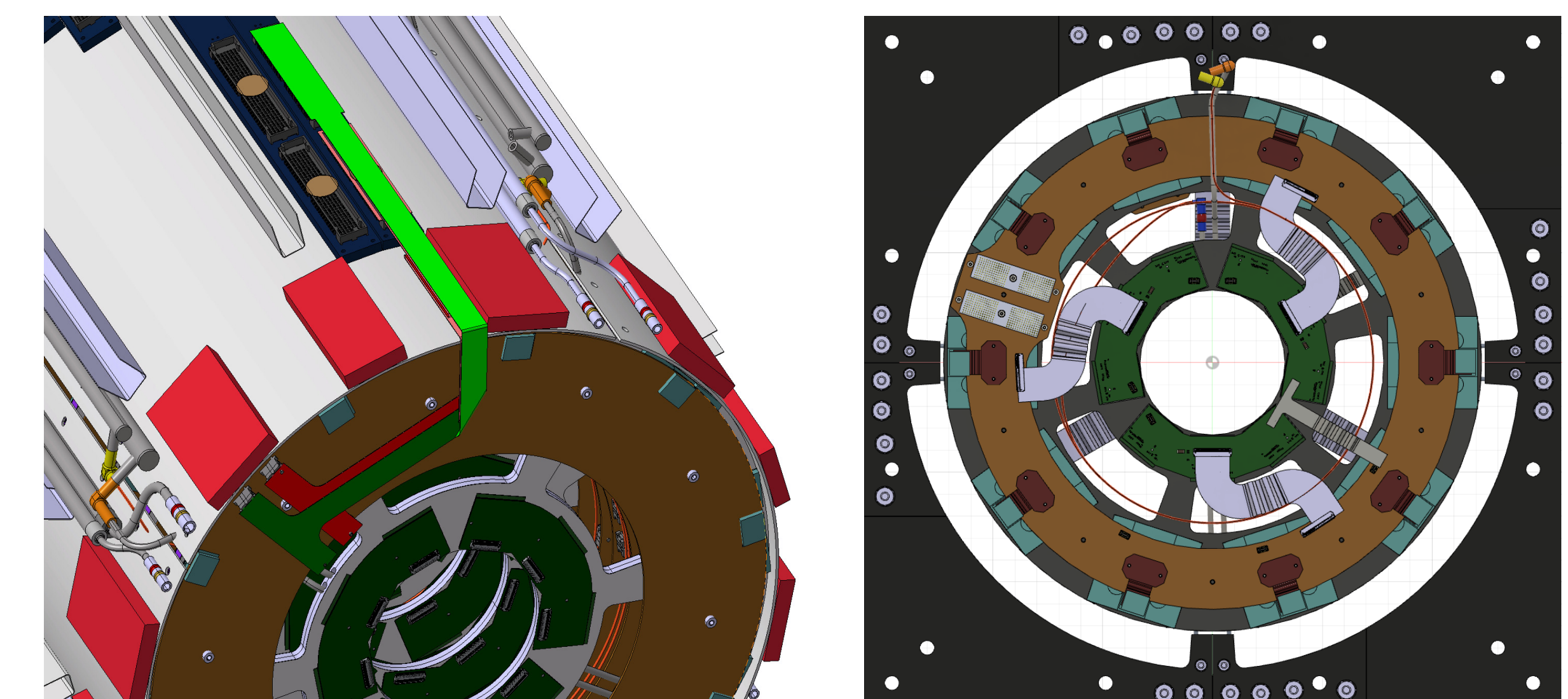 ➢ S-parameters
  ➢ Eye diagrams

Figure 6: Imagine of the connected Type-0 to PP0 (left) and the connected data pigtails (right)