Preliminary Feasibility Study of a Photodetector with 10 Picosecond Time Resolution for a Fast-Timing Subsystem in the ATLAS Detector at the LHC

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Motivation and Introduction

When the LHC upgrades in the 2020's, the number of collisions per bunch crossing will be large. Near parallel to the beam, fast timing can be used to distinguish collisions by measuring differences in arrival times from different locations.

Large-Area Picosecond Photodetectors (LAPPD's) are a developing detector technology that are intended to have a large area and fast timing. They are an excellent candidate for fast timing at the LHC.

To handle the large particle fluxes, the detector needs to be pixelated with pixels sufficiently small such that each pixel has a small number of hits per bunch crossing. This can be accomplished in LAPPD's with the "Inside-Out" configuration, diagrammed below.

In the ATLAS collaboration, the High Granularity Timing Detector (HGTD) project is attempting to put fast-timing in this region. Assuming this project, I computed the necessary pixel sizes with a Pythia simulation. The results are shown in the table.

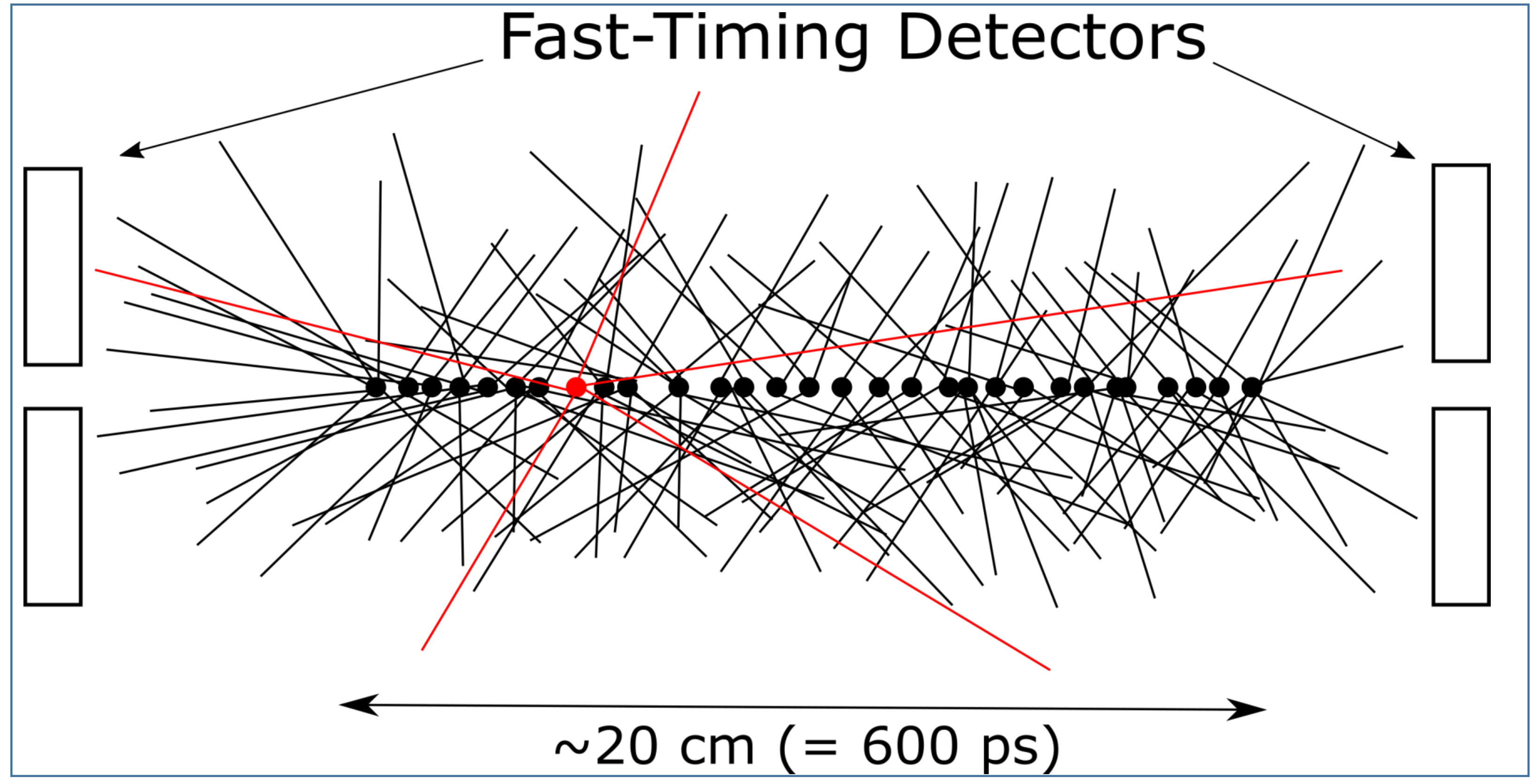

Figure 1: A cartoon of single bunch crossing in ATLAS.

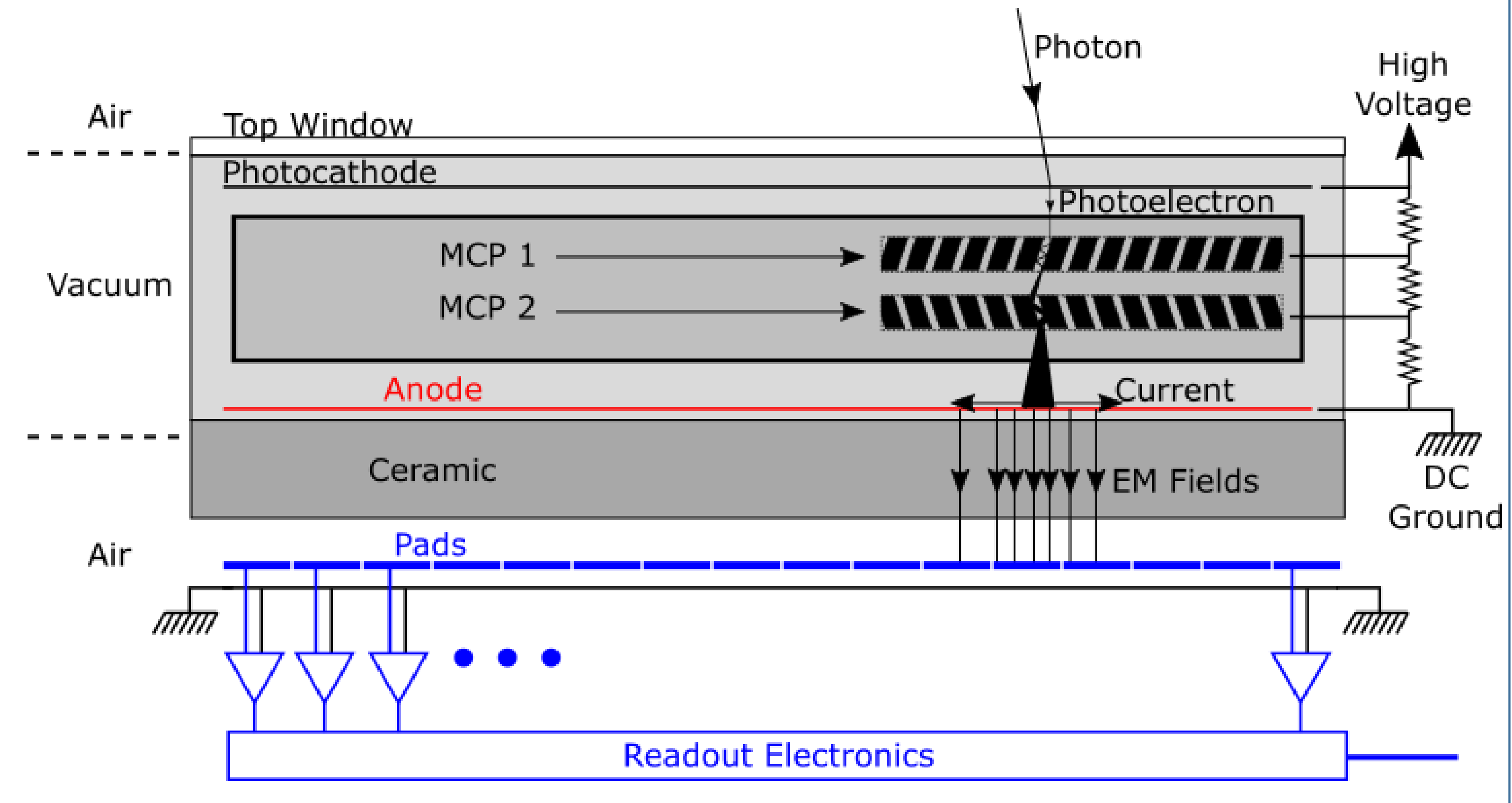

Figure 2: A schematic of an inside-out LAPPD.

	0.1 Occupancy		0.01 Occupancy	
Rapidity Region	Pad Size (mm)	Channels	Pade Size (mm)	Channels
$2.4 < \eta < 3.0$	8.3	1.3×10^4	2.3	1.8×10^5
$3.0 < \eta < 3.7$	4.7	1.2×10^4	1.5	1.7×10^5
$3.7 < \eta < 4.3$	2.5	1.1×10^4	0.8	1.2×10^5

Setup

As a model for an inside-out LAPPD, we placed a similar photodetector coupled to a 10 nm, grounded layer of Nickel Chromium deposited onto a ceramic plate. Beneath this I placed a printed circuit board with different sized pads, each connected to an SMA readout. A pulsed 405 nm laser was fed through a fiber optic attached to a motorized stage that allowed for position adjustments. This setup is shown in Figure 3.

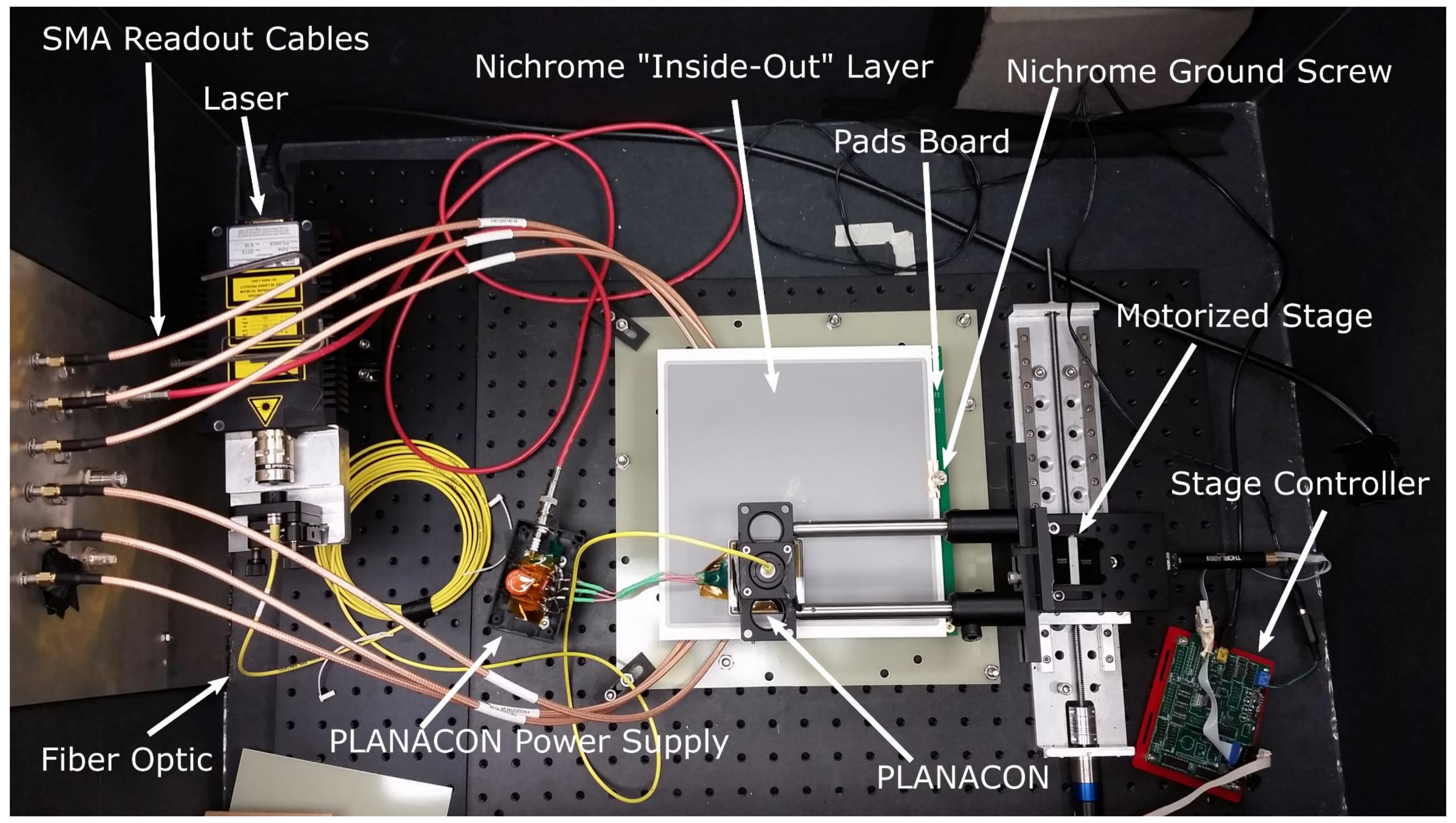

Figure 3: The experimental setup used to test the inside-out pads.

Results

The average pulse shape of the response of the pads is shown in Figure 4. The pad over which the laser is centered clearly has the strongest signal, with a smaller signal in adjacent pads. Thus the pads have effectively pixelated the LAPPD.

The rise-time distribution is shown in Figure 5. Given the systematic errors present, there is not a significant difference in average rise time between the two configurations. This shows that the inside-out configuration should not slow the fast-timing, even with large capacitances.

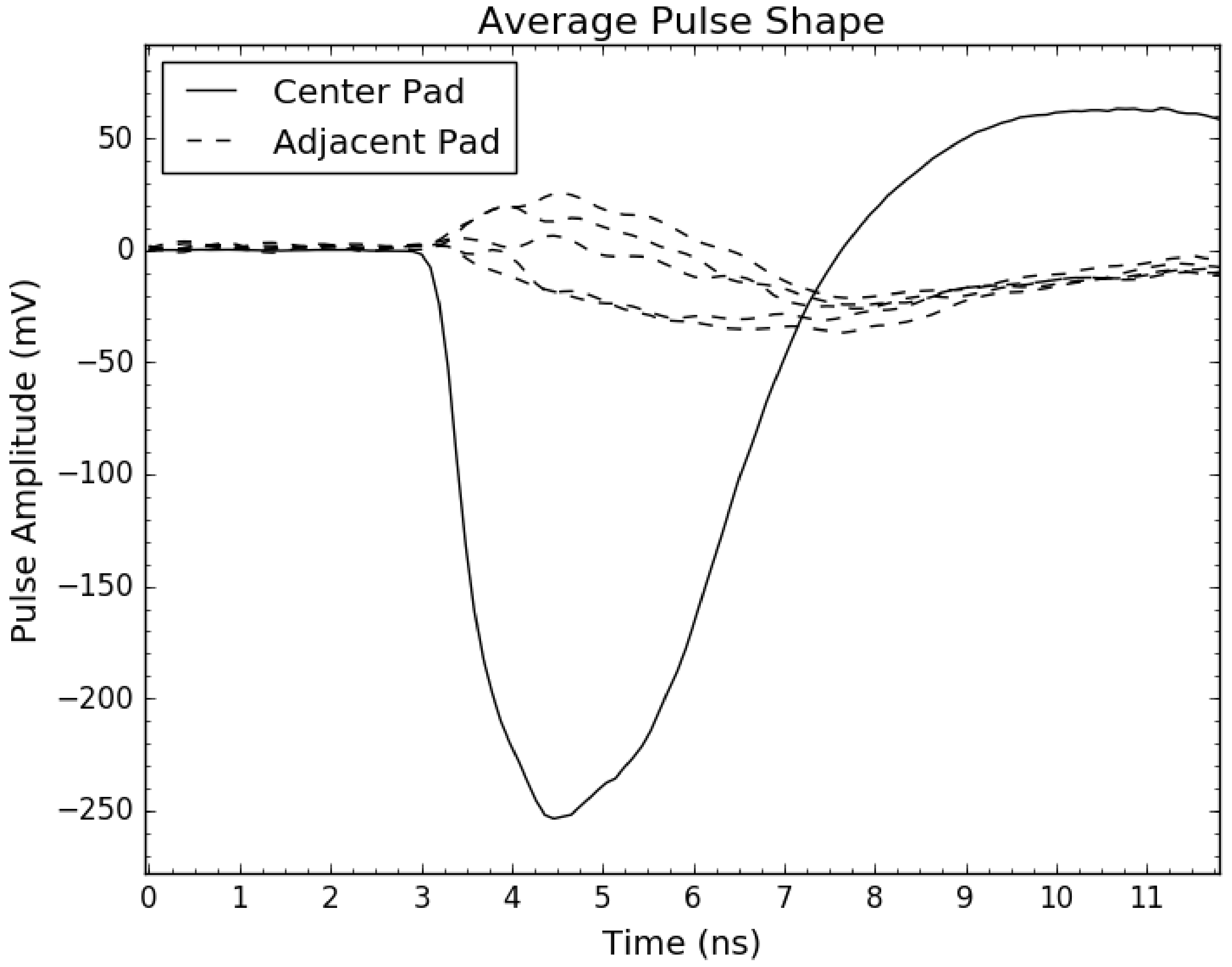

Figure 4: The average inside-out pulse shape with pads.

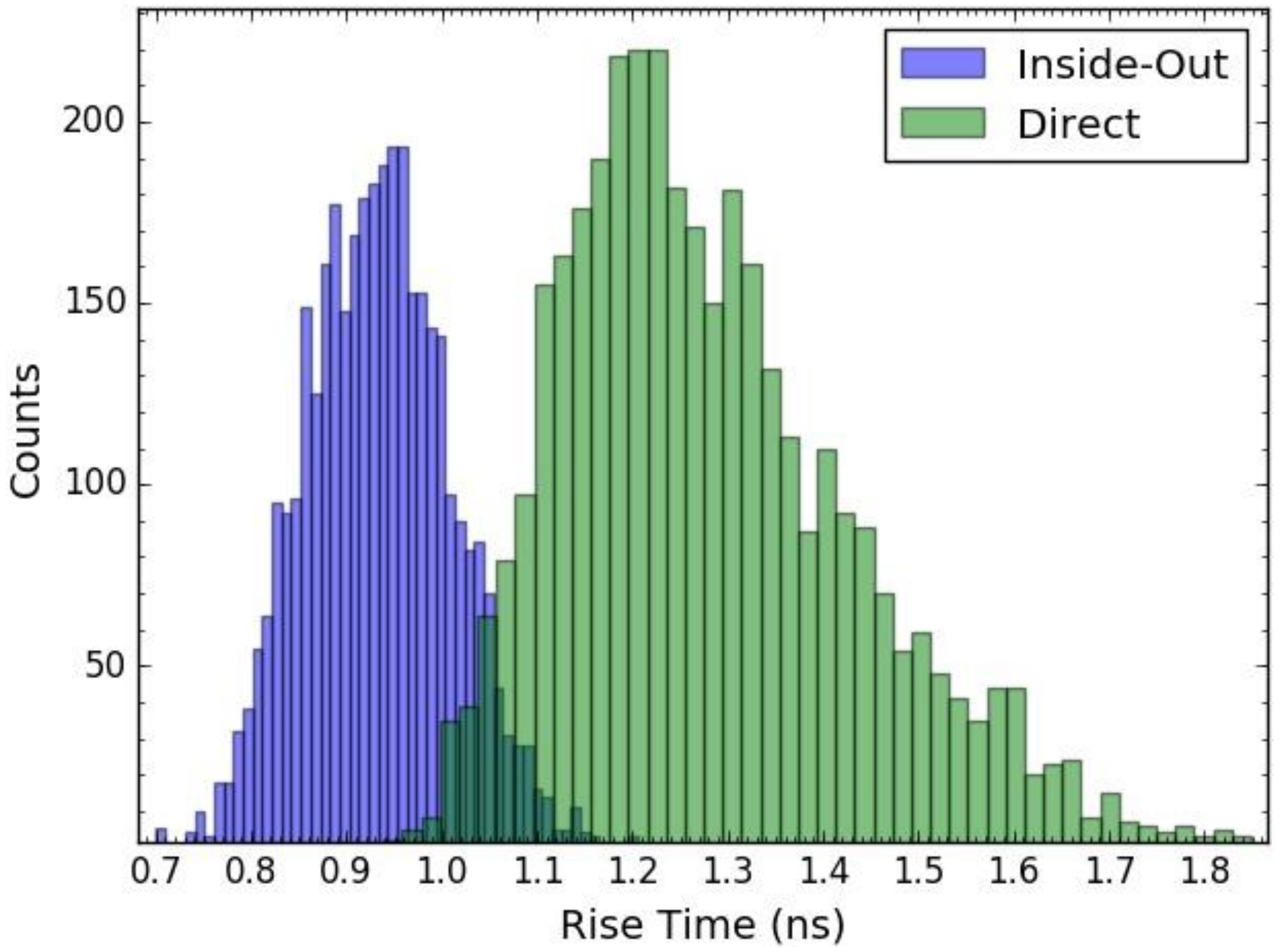

Figure 5: The distribution of rise times in an inside-out and direct setup.

Conclusions

As of yet, there seem to be no fundamental limitations to using inside-out LAPPD's in ATLAS. However, more testing remains, such as testing smaller pad sizes.