Input Mezzanine Card for the Fast Tracker at ATLAS
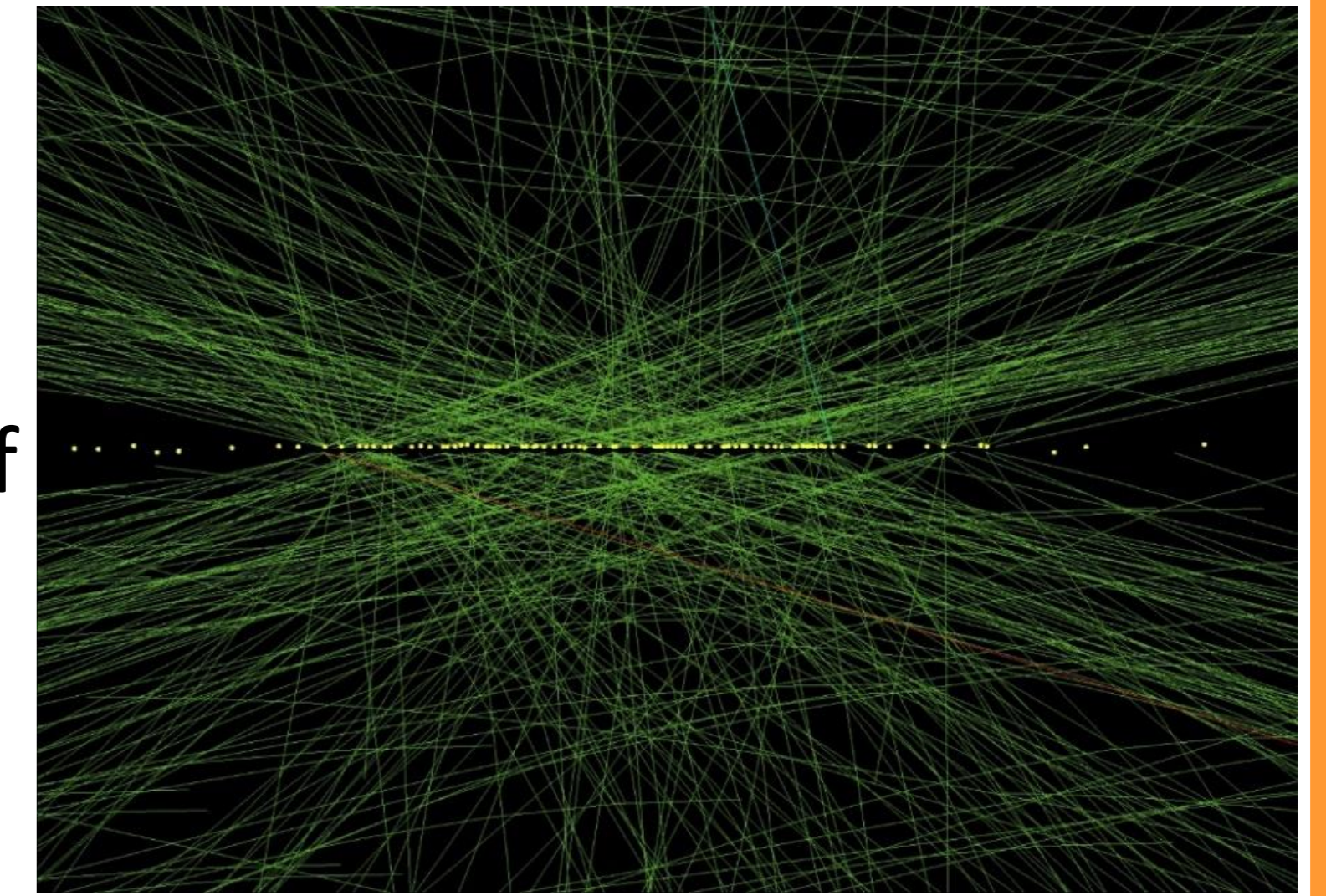
Tomoya Iizawa, Waseda University
on behalf of the ATLAS Collaboration

FTK TDR [http://cds.cern.ch/record/1552953/files/ATLAS-TDR-021.pdf]
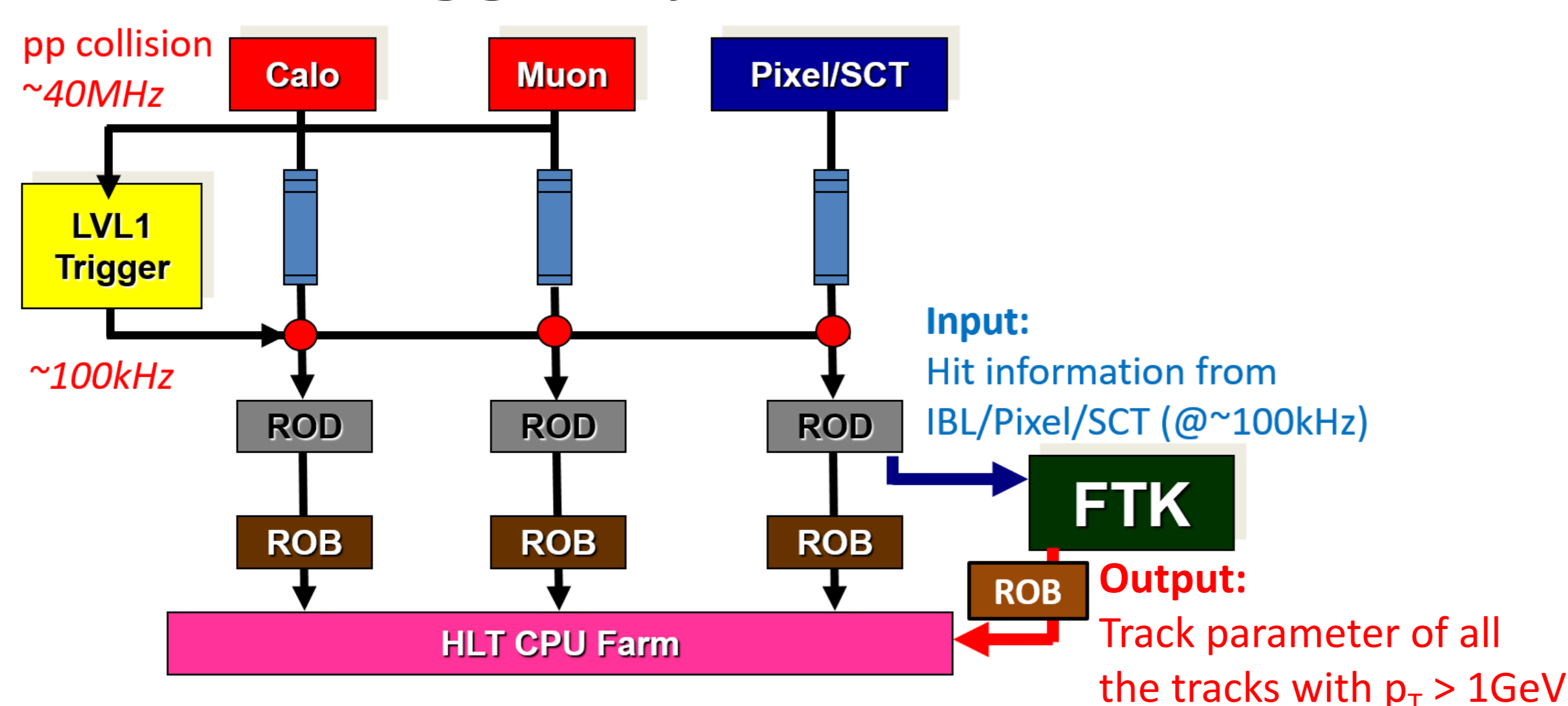
Waseda University

What is the Fast Tracker?

➢ Motivation

✓ In LHC Run 2/3 (2015 - 2022) up to 80 overlapping pp collisions per bunch crossing are expected. Tracking information is important to separate the primary vertex from the pile-up.
  → Tracking at trigger level will become more difficult and time consuming, due to the large number of possible combinations of hits forming tracks.

➡ **A solution : Fast Tracker (FTK) !**

✓ FTK is one of the ATLAS upgrades being developed and integrated. It is a highly-parallel hardware system that reconstructs tracks in real-time.

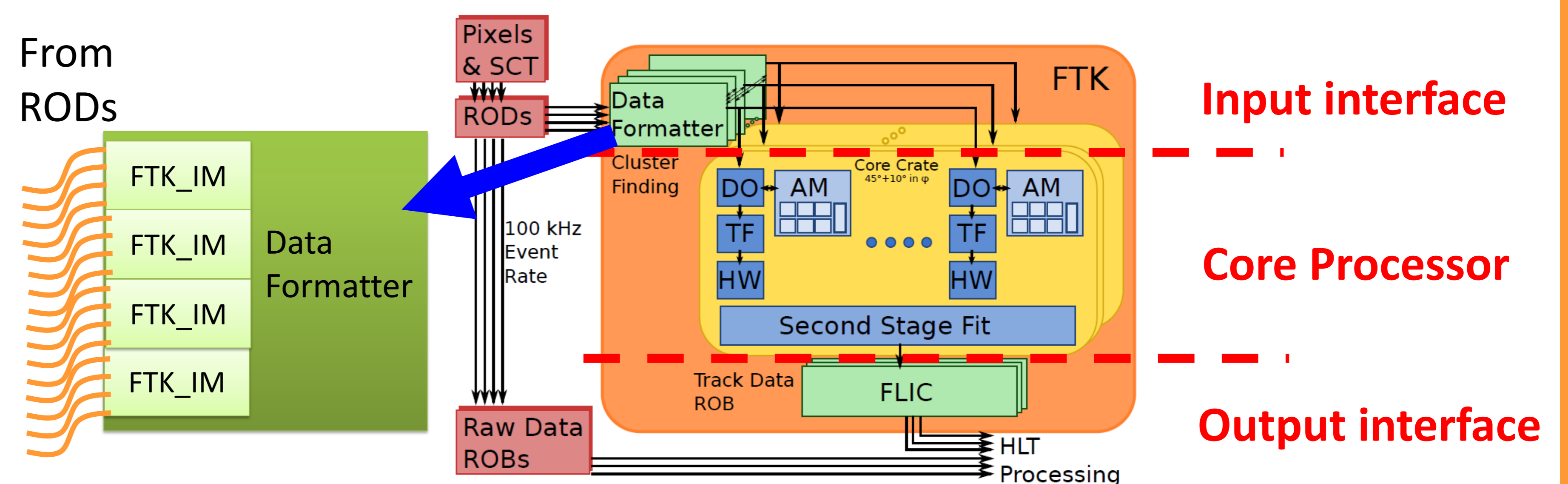Tracks in ~80 pile-up

➢ ATLAS trigger system and FTK

Input:
Hit information from
IBL/Pixel/SCT (@~100kHz)

Output:
Track parameter of all
the tracks with $p_T > 1$GeV

✓ 2 stages of trigger, the Level-1 and the High Level Trigger(HLT).
✓ FTK will be inserted between the two, reconstructing tracks for all events that pass Level-1 and sending them to the HLT.

➢ Functional Overview

Input interface

Core Processor

Output interface

✓ FTK consists of several electrical circuit boards controlled by FPGAs.
✓ **FTK Input Mezzanine (FTK_IM) is the first board of the system's input interface.**
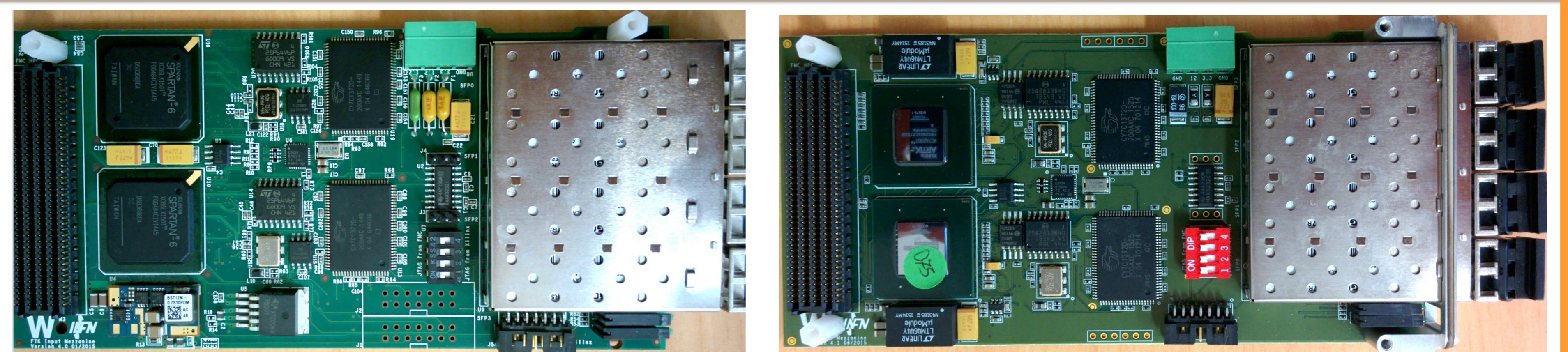
Input of the FTK

➢ ATLAS inner detector

SCT

IBL/Pixel
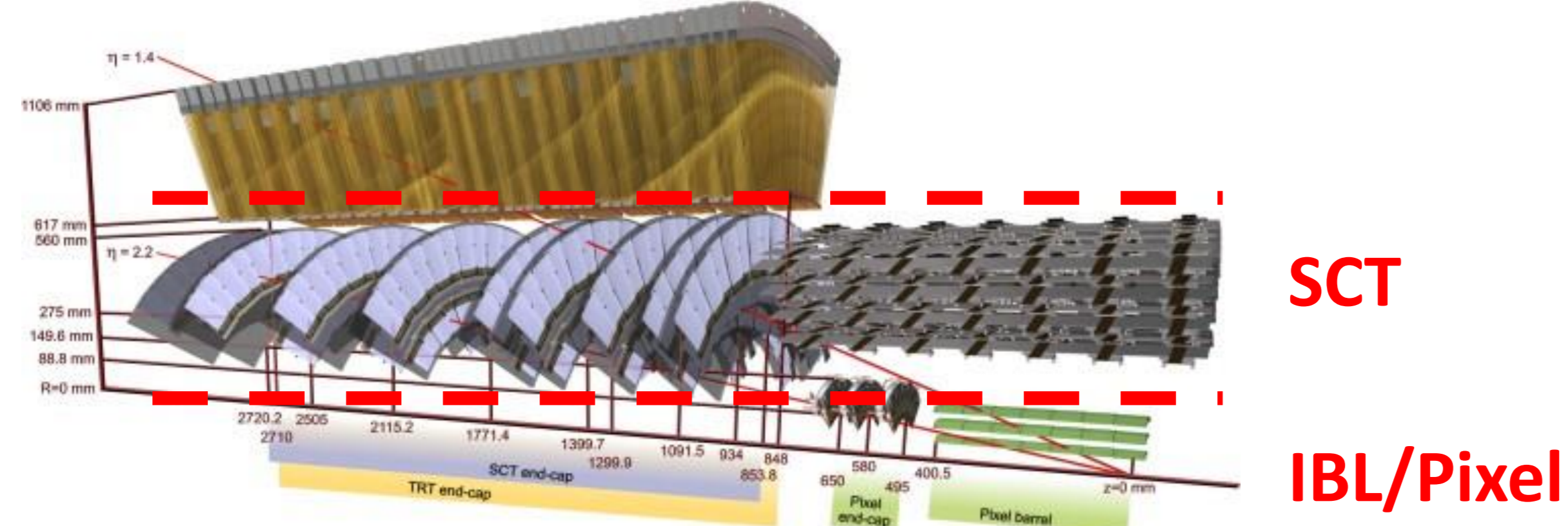
✓ Measures the **position** and the **momentum**.

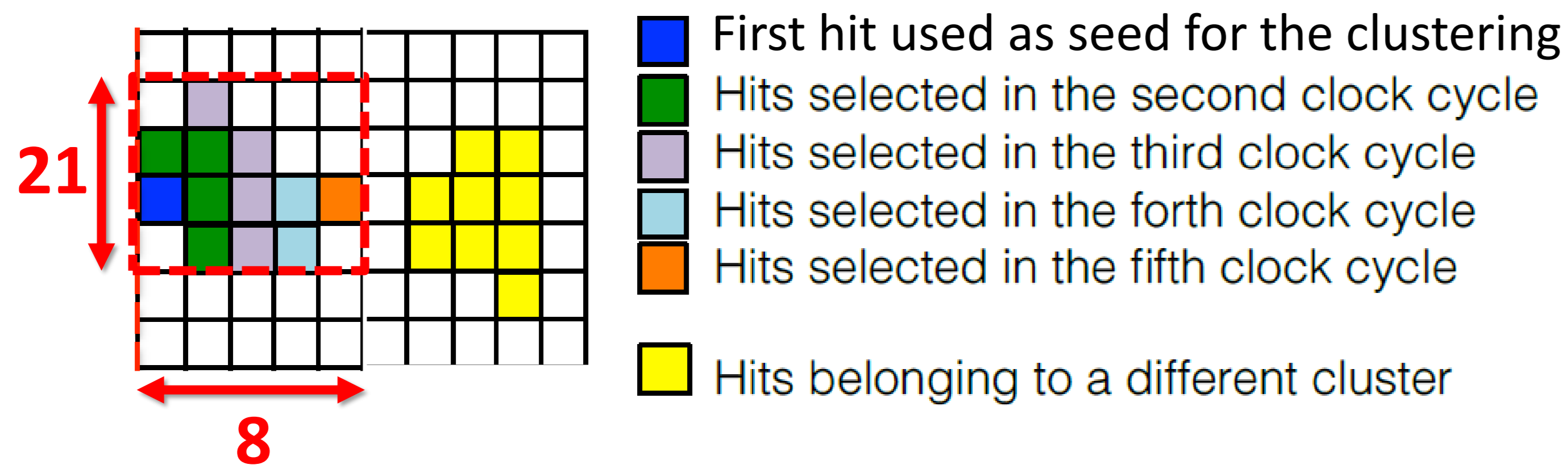|	#layers	Readout	size/unit	#channels
IBL	1	2-dim.	50μm x 250μm	12M
Pixel	3	2-dim.	50μm x 400μm	80.4M
SCT	8	1-dim.	80μm	6.3M

FTK Input Mezzanine

w/ Spartan-6(XC6SLX150T) FPGAs   w/ Artix-7(XC7A200T) FPGAs

✓ FTK_IM **receives hit data** from IBL/Pixel/SCT, **performs clustering** to reduce data size, and **forwards the data** to its mother board (the Data Formatter).

➢ **Characteristics**

✓ 2 FPGAs/board
✓ 12 layer board
✓ FMC connection to mother board
  - LVDS parallel bus, I2C for control
  - GTP (3.1Gb/s @ Max)
✓ 4x SFP each 2.0 Gb/s
✓ SRAM
✓ 200 MHz DDR output

FTK_IM Main Function: Hit Clustering

21

8

■ First hit used as seed for the clustering
■ Hits selected in the second clock cycle
■ Hits selected in the third clock cycle
■ Hits selected in the forth clock cycle
■ Hits selected in the fifth clock cycle
■ Hits belonging to a different cluster

Clustering: Determine the cluster center and the cluster size.
Challenge: Perform 2D cluster finding in real-time.
→ **Parallel processing utilizing a sliding window algorithm**
1. Define a cluster window around the first hit. (8x21)
2. Load the hits within the window.
3. Select the neighboring hits until there is no neighboring hit.

reference: [doi: 10.1109/TNS.2014.2364183]

Development Status
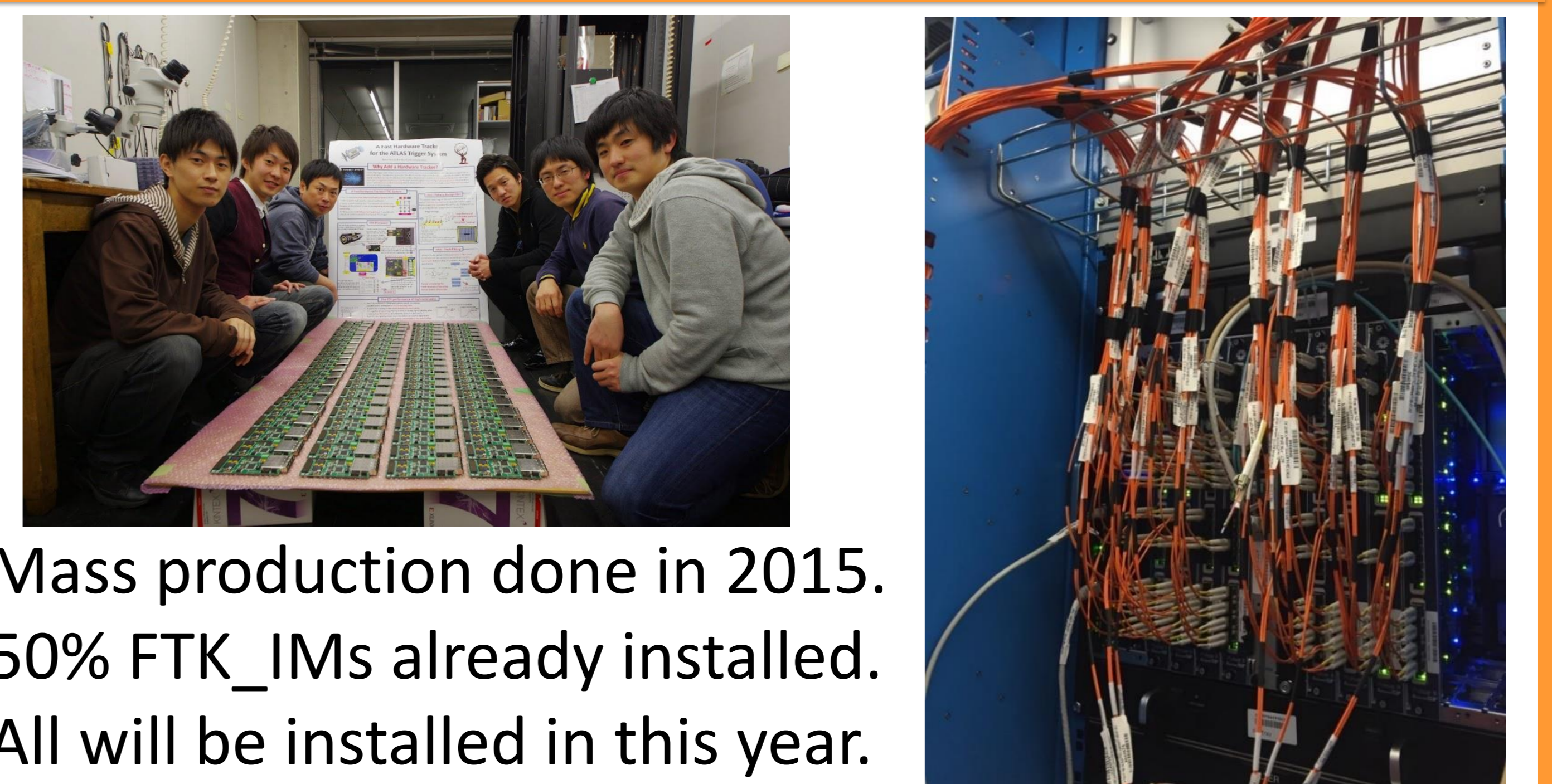
✓ Mass production done in 2015.
✓ 50% FTK_IMs already installed. All will be installed in this year.
✓ Pixel/SCT clustering are tested with real data and almost validated. IBL clustering is being tested with simulation data.

FTK_IM is the input data reduction stage that enables huge data processing.