The High-Granularity Timing Detector module flex design and simulation for the ATLAS Phase-II Upgrade

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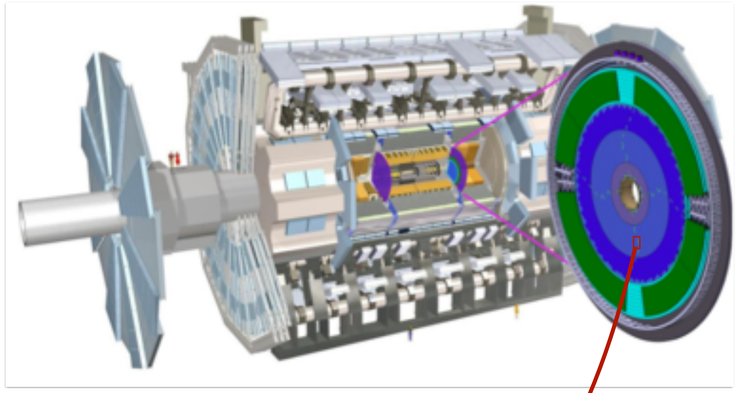
Introduction

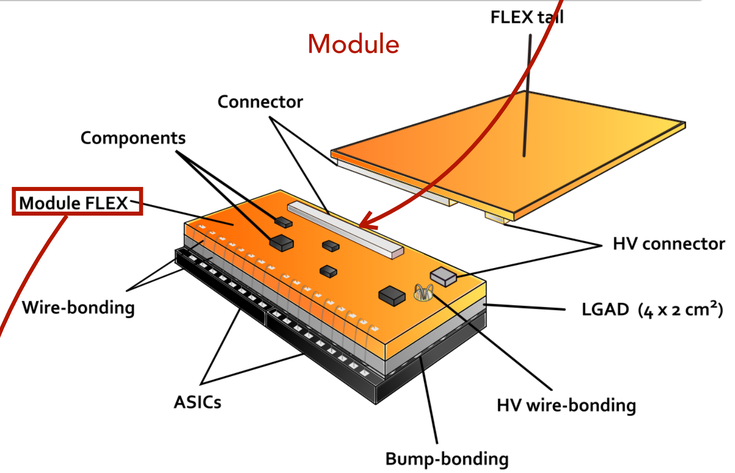
- Module flex
  - A flexible printed circuit board with multiple layers
  - The module flex provide
    - analog and digital power for the ASIC chips, including the necessary filtering and reference voltages
    - routing and filtering of the sensor High Voltage bias
    - connection, distribution and DC coupling of the up/downlink data signals
    - housing of the NTC for the interlock system
  - Module flex plays a key role in module assembly
  - IHEP will undertake ~4000 module assembly, of which

    module flex is completely designed and produced by IHEP

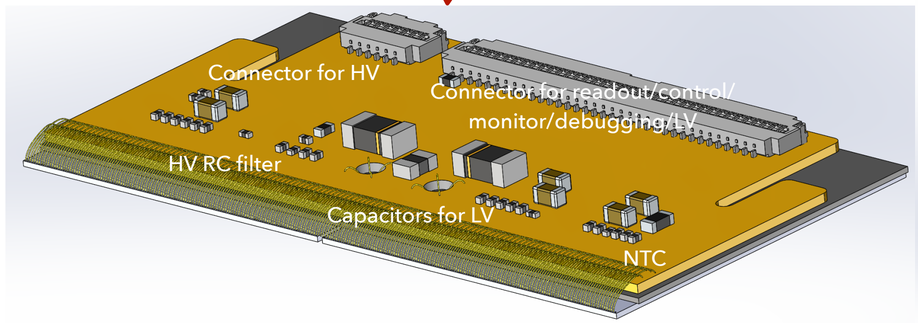
The High-Granularity Timing Detector(HGTD)

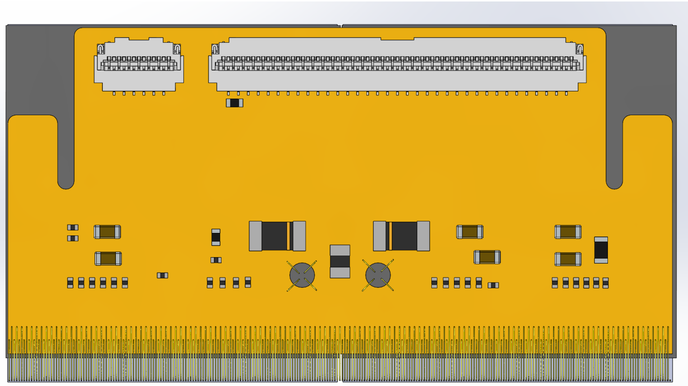


Active area: 6.4m²
~ 8000 module



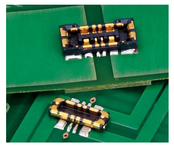
Module flex 3D model

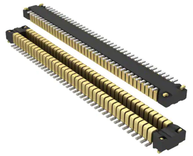


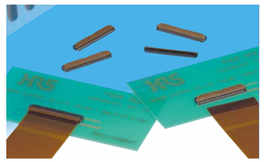


Design

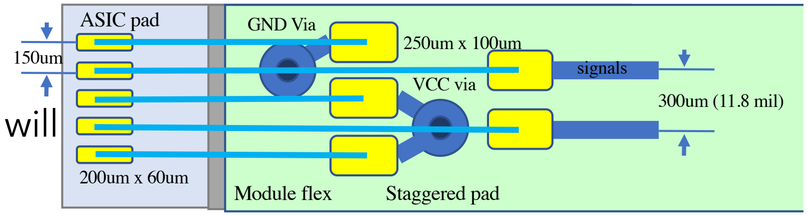
- Components selection
  - Connectors for HV, Capacitors

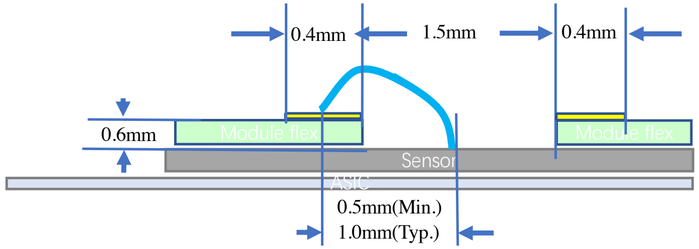






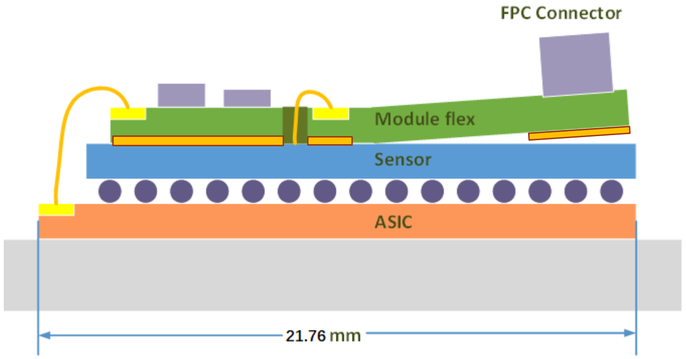
- Wire bonding design
  - ASIC signals, low voltage, bias voltage for the sensor will be connected to the module flex by wire bonding

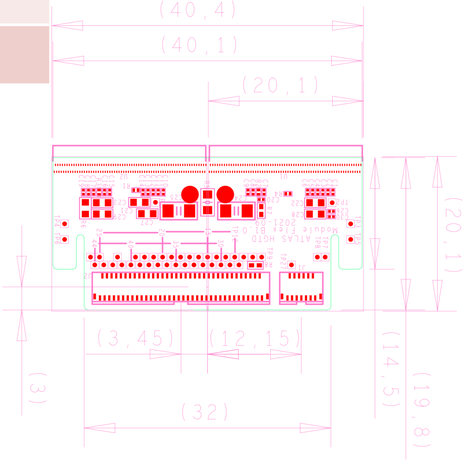




- PCB design
  - Stack-up construction
    - 6 layers flexible circuit boards
    - Three different stack-up are designed
  - Thickness
    - 6 layers flexible circuit boards 0.54 ± 0.08 mm including 0.1 mm stiffener under the connector
  - Impedance control
    - Single impedance: 50 ± 10% Ohm
    - Differential pair impedance: 100 ± 10% Ohm

Layer Name	Option A	Option B	Option C (one ground)
Top	HV Power and HV Ground, Signal lines	HV Power and HV Ground, Signal lines	HV Power and HV Ground, Signal lines
L2	Digital Ground (Plane)	Analog Ground (Plane)	Ground (Plane)
L3	Digital Power (Plane)	Digital Power & Digital Ground (Wires), Analog Power (Wires)	Digital Power (Plane)
L4	Analog Power (Plane)	Digital Power & Digital Ground (Wires), Analog Power (Wires)	Analog Power (Plane)
L5	HV Power and HV Ground, Signal lines	HV Power and HV Ground, Signal lines	HV Power and HV Ground, Signal lines
Bottom	Analog Ground (Plane)	Analog Ground (Plane)	Ground (Plane)



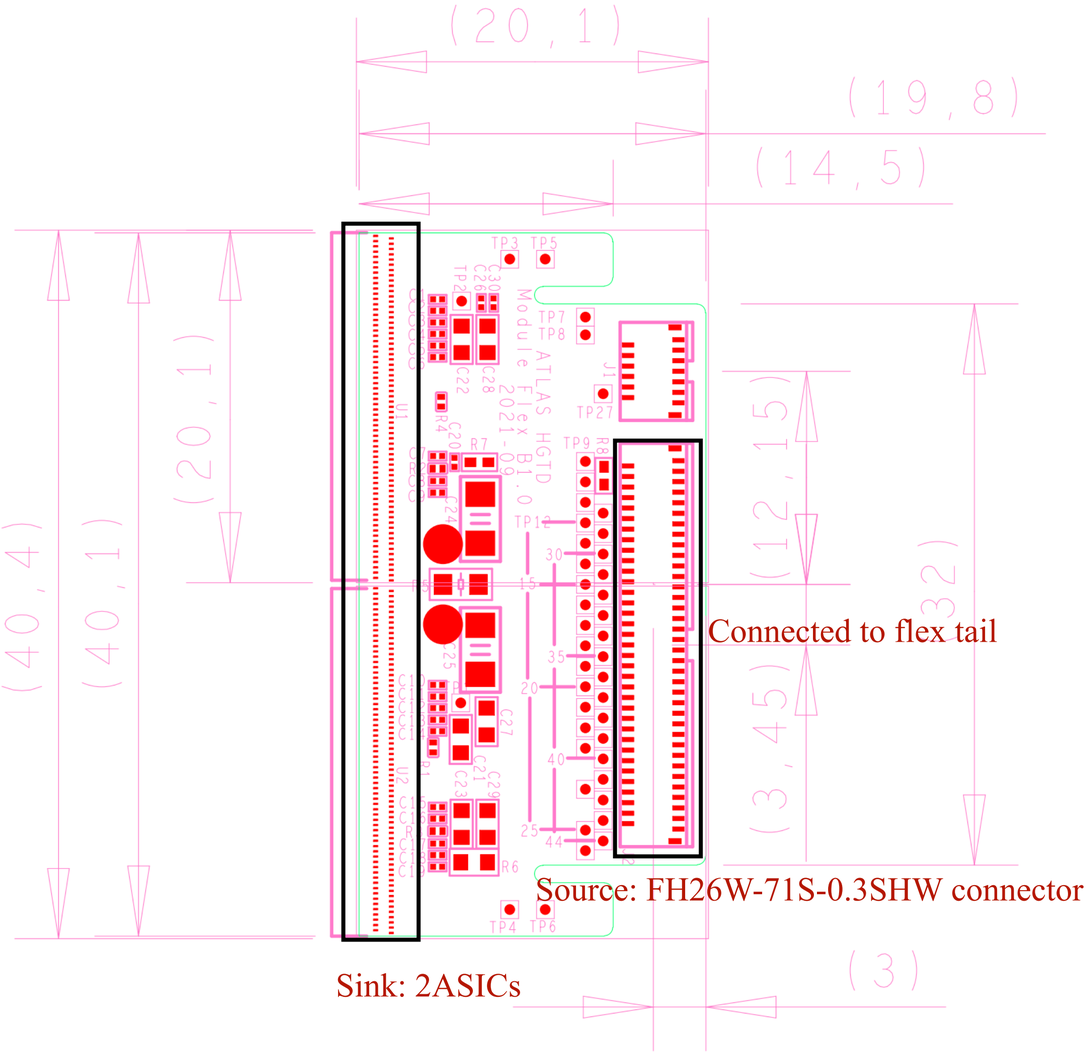


Voltage Drop Simulation

- Simulation configuration
  - SoftWare: Cadence 16.6 Allegro PCB SI GXL
  - Source (Connectors or Components provide current)
    - FH26W-71S-0.3SHW connectors (connected to flex tail)
  - Sink (Components need power supply)
    - 2 ASICs
  - Current and Voltage distribution
    - Analog: 0.42A x 2 for all pad, 1.2V for every pad
    - Digital: 0.58A x 2 for all pad, 1.2V for every pad
- Simulation Results

IR Drop Simulations For Module Flex						
Plane	Option A		Option B		Option C	
	$Voltage_{max}$ [mV]	$Voltage_{max}$ [mV/cm]	$Voltage_{max}$ [mV]	$Voltage_{max}$ [mV/cm]	$Voltage_{max}$ [mV]	$Voltage_{max}$ [mV/cm]
Power digital	1.94	0.96	19.71	9.80	1.94	0.96
Power analog	1.17	0.58	11.42	5.68	1.18	0.59
Ground digital	2.01	1.00	7.91	3.93	1.92	0.96
Ground analog	1.61	0.80	1.21	0.61		

- The voltage drop simulation results are reasonable



Summary and Future Directions

- The module flex for HGTD has been completed.
- The company is producing 3 types of module flex, 200 each of PCB Stack-up
- The Voltage drop simulation has been done for 3 different stack-up module flex.
- After the module flex production is completed, it will be tested.