

HGTD Production Database

Song-Ming Wang¹, Salah-Eddine Dahbi,¹ [Yun-Ju Lu](#)¹, Pai-hsien Jennifer Hsu²

¹Academia Sinica

²National Tsing Hua University

On behalf of TW ATLAS HGTD team

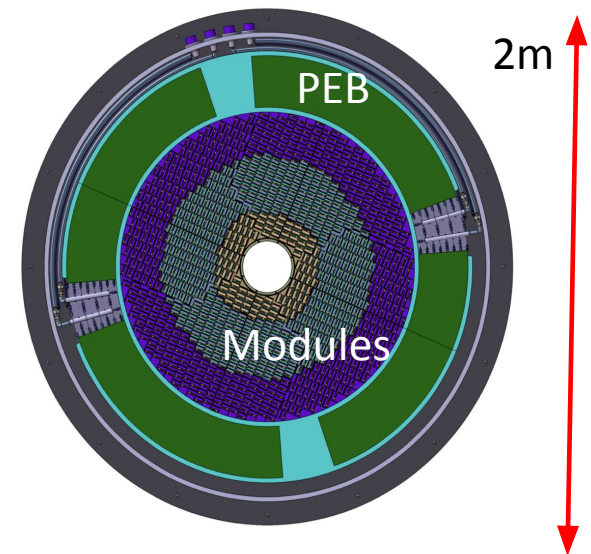
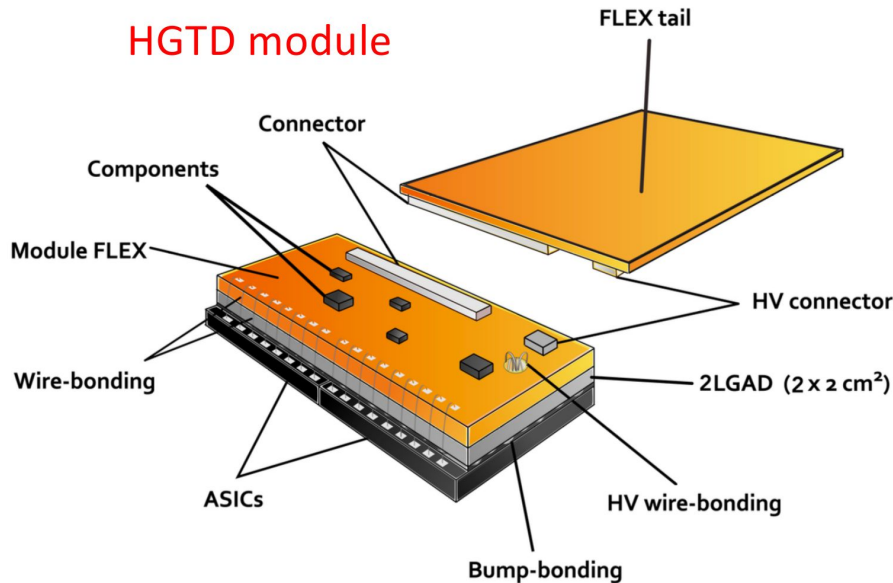
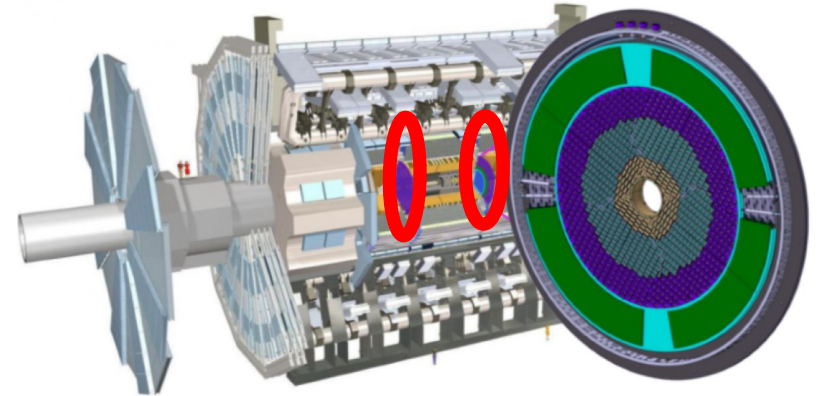
22th Nov, 2024

2024 TIDC



High Granularity Timing Detector(HGTD)

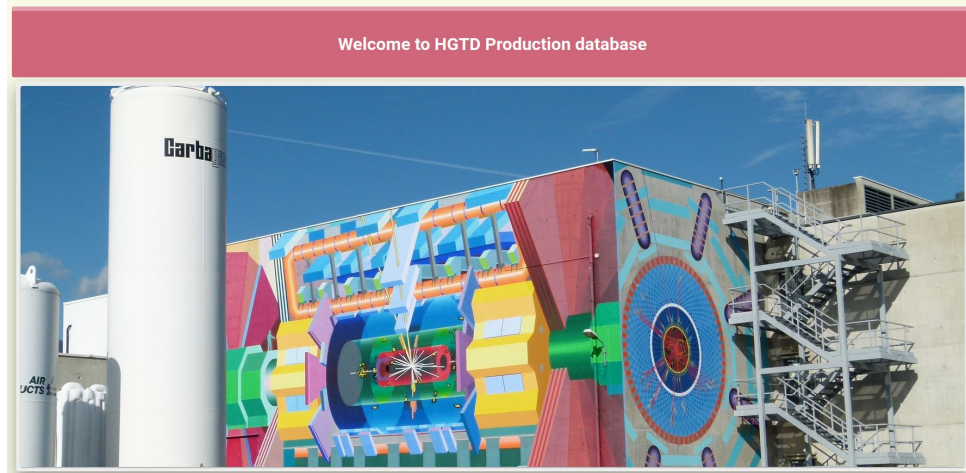
- ATLAS Phase-II upgrade
- HGTD is being designed for operation with average pile-up = 200 and a total integrated luminosity of 4000 fb^{-1}
- Time resolution
 - 30-50 ps/per track
 - 35-70 ps/per hit



HGTD production database

- **Solution to handle the HGTD production of 8032 modules**
 - Production history and quality control
 - Measurement results
 - Assembly information
- **New version started in summer 2023**
 - Fully migrated from MySQL to Oracle
 - Generic database designed
- **New features developed since TIDC 2023**
 - Add measurement tables and shipment tables
 - Option to batch upload information for components
 - Add database monitoring :
 - JSON endpoints to link with Grafana APIs to view data in Grafana web interface
 - Unify serial number definition of different components
 - Store component images in database

HGTD production database



- Admin
 - Define institutes, locations, component types, component attributes, relationship between component types
- Parts information
 - Registration of components and attributes
- Detector Assembly
 - Define hierarchy of relationship between components
- **NEW** Shipment information
- **NEW** Measurements
- **NEW** Grafana Monitoring

Key Feature : Generic component registration



➤ Users with administration rights to create/define new items

2. User adds parts

- Institutes, manufacturers/vendors locations
- Add new component types
- Add attributes

1. Admin define basic info and attributes

Add Location

Location Name
IFAE

Institute Name
IFAE (2241)

Add Attributes

Attribute Name
weight

KoP Name
Module (1005)

Add Parts

Barcode

Serial #
99WM0121000007

Version
0

Name Label

KindOfParts
Module (1005)

Location
IFAE (1)

Manufacturer
IFAE (1003)

Comments / description
3rd ALTI3 glued by hand

3. User views basic information

Parts List

KindOfParts: Module (1005)

SEARCH

ADVANCE FILTERS EXPORT TO CSV

| Part ID | Serial # | Barcode | Version | Name Label | KindOfPart | Manufacturer | Comments | User | Action |
|---------|----------------|---------|---------|-----------------------------|------------|--------------|--|-----------------|-------------|
| 2565 | 20WMO121000001 | | Ver 0 | M101 Tests ALTIROC3 | Module | IFAE | First ALTIROC3 module glued by hand. Thick sensors | ATLAS_HGTD_PROD | view/update |
| 2583 | 20WMO121000002 | | Ver 0 | M102 Tests ALTIROC3 | Module | IFAE | Early ALTIROC3 module glued by hand. Thick sensors | ATLAS_HGTD_PROD | view/update |
| 2584 | 20WMO121000003 | | Ver 0 | M103 Tests of ALTIROC3 | Module | IFAE | 3rd ALTI3 glued by hand. Broken when handling! | ATLAS_HGTD_PROD | view/update |
| 2601 | 20WMO121000004 | | Ver 0 | M104 ALTI3 Module for Tests | Module | IFAE | ALTI3 glued by hand, 300um edge | ATLAS_HGTD_PROD | view/update |

Key Feature : Generic relationship

List of basic info, attributes and relations of a module and a hybrid

Module

Parts Detail

Kind of Part Module

Part # 2643

Location IFAE

Manufacturer IFAE

Serial # 99WMO121000007

Barcode #

Batch #

User

Version # Ver 0

Name Label M103 Tests of ALTIROC3

Installed Date

Production Date

Comments 3rd ALTI3 glued by hand. Broken when handling!

Attributes

| ATTRIBUTE NAME | ATTRIBUTE VALUE | ACTION |
|----------------------|-----------------------------|--------|
| delta_F_C_0 (mm) | 2.446 | |
| delta_F_C_1 (mm) | 2.46 | |
| gap (um) | 94.4 | |
| glue (mg) | 19.8 | |
| length (mm) | 41.131 | |
| rot_0 (deg) | 0.071 | |
| rot_1 (deg) | 0.067 | |
| weight (g) | 3.084 | |
| width (mm) | 21.748 | |
| wire_bond_inspection | HV wires unavailable (glue) | |
| wire_bond_pull (gf) | 7.81 | |

Parent Component

| SERIAL # | KINDOFPART | ACTION |
|----------------|------------|--------|
| 99WHY120000003 | Hybrid | |
| 99WHY120000004 | Hybrid | |

Child Component

| SERIAL # | KINDOFPART | ACTION |
|----------------|------------|--------|
| 99WMO121000007 | Module | |

Hybrid

Parts Detail

Kind of Part Hybrid

Part # 2623

Location IFAE

Manufacturer IFAE

Serial # 99WHY120000003

Barcode #

Batch # 23

User

Version # ALTIROC3

Name Label ALTIROC3 Hybrid

Installed Date 2024-02-02T11:23:10Z

Production Date 2024-01-09T01:01:08Z

Comments PWchip bumps, IME-V3 W25 9, 5

Attributes

| ATTRIBUTE NAME | ATTRIBUTE VALUE | ACTION |
|-----------------------------------|-----------------|--------|
| UBM | AMTec | |
| charge_collection (uA) | 0.01 | |
| disconnected_bumps | 0 | |
| inspection | good | |
| side_of_module (L=left / R=right) | R | |

Parent Component

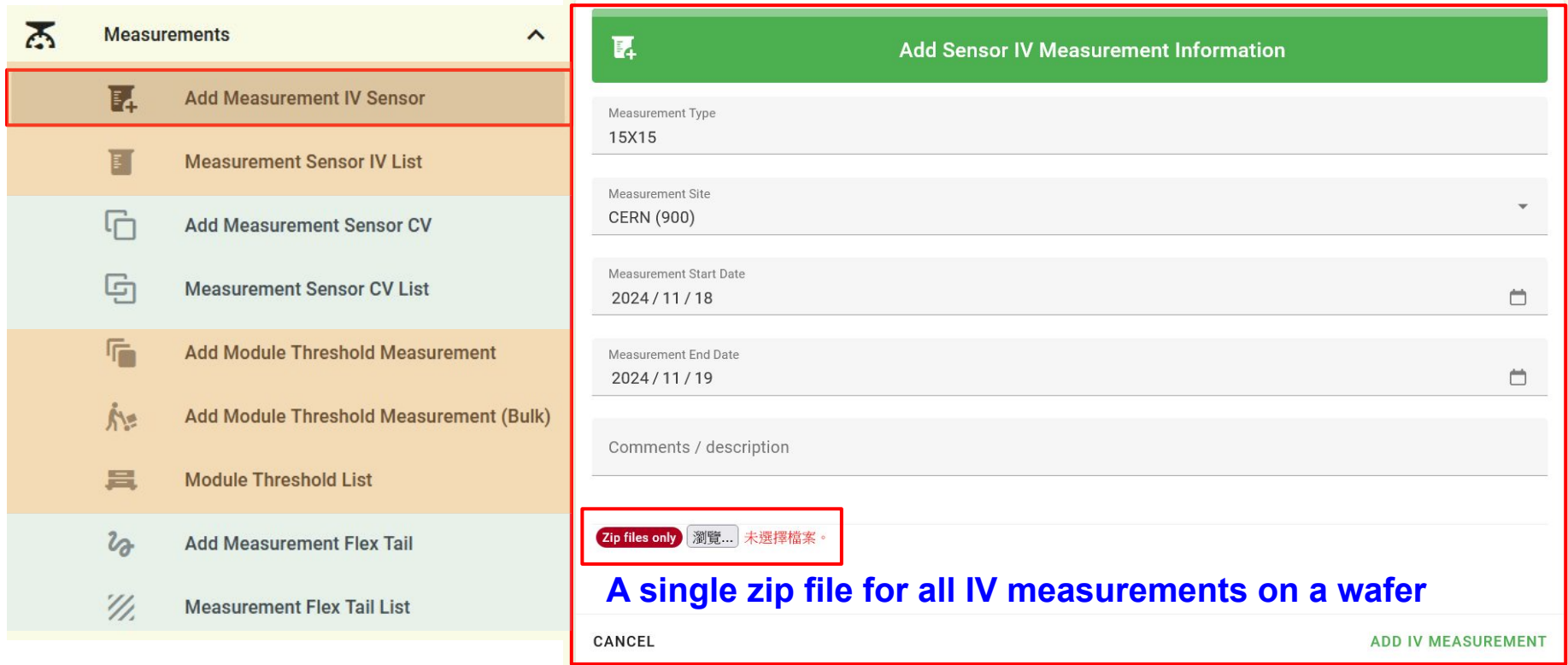
| SERIAL # | KINDOFPART | ACTION |
|----------------|------------|--------|
| 99WMO121000007 | Module | |

Child Component

| SERIAL # | KINDOFPART | ACTION |
|----------------|------------|--------|
| 99WHY120000003 | Hybrid | |

New Feature : Measurement tables

- Sensor : IV and CV measurements
- Module : thresScan, vthcScan, chargedScan, bump connection
- Flex tail (developing) : thickness, voltage drops...



The screenshot shows the 'Measurements' menu on the left with the following options:

- Add Measurement IV Sensor
- Measurement Sensor IV List
- Add Measurement Sensor CV
- Measurement Sensor CV List
- Add Module Threshold Measurement
- Add Module Threshold Measurement (Bulk)
- Module Threshold List
- Add Measurement Flex Tail
- Measurement Flex Tail List

The 'Add Sensor IV Measurement Information' dialog box contains the following fields:

- Measurement Type: 15X15
- Measurement Site: CERN (900)
- Measurement Start Date: 2024 / 11 / 18
- Measurement End Date: 2024 / 11 / 19
- Comments / description

A file selection dialog is open, showing a 'Zip files only' filter and a '浏览...' button. Below the dialog, the text reads: **A single zip file for all IV measurements on a wafer**. At the bottom of the dialog are 'CANCEL' and 'ADD IV MEASUREMENT' buttons.

IV measurement done on pixel
 A sensor contains : 15*15 pixel
 A wafer contain 52 sensors
 Total 52*15*15=11700 IV files in a Zip file

New Feature : Measurement tables



IV measurements of a pixel

```
{
  "V": [
    [5,10,15,20,25,30,35,40,45,50,55,60,65,70,75,80,85,90,95,100,105,110,115,120,125,130,135,140,145,150,155,160,165,170,175,180,185,190,195,200,205,210,215,220,225,230,235,240,245,250],
    [7.05e-08,6.81e-08,6.81e-08,1.302e-07,1.729e-07,2.009e-07,2.125e-07,2.18e-07,2.233e-07,2.201e-07,2.216e-07,2.222e-07,2.184e-07,2.201e-07,2.188e-07,2.2e-07,2.163e-07,2.158e-07,2.127e-07,2.149e-07,2.111e-07,2.134e-07,2.126e-07,2.143e-07,2.132e-07,2.101e-07,2.073e-07,2.112e-07,2.099e-07,2.156e-07,2.121e-07,2.128e-07,2.115e-07,2.145e-07,2.208e-07,2.389e-07,2.424e-07,2.954e-07,5.762e-07,4.3787e-06,5.0668e-06,4.9126e-06,4.8623e-06,5.0348e-06,4.8944e-06,5.0103e-06,4.8796e-06,4.8293e-06,4.9456e-06,4.8768e-06]]
  ]
}
```

CLOSE DIALOG

Serial Number: 20WS1002001625 |
 Measurement Type: 15x15 |
 Run Number: 9903 |
 Pad Location:

leave Pad Loc empty to select all values

SEARCH

225 IV measurements of a single sensor

COLUMN FILTERS EXPORT TO CSV

| SERIAL NUMBER | RUN NUMBER | Measurement TYPE | Measurement Start Time | Measurement End Time | PAD_LOCATION ↑ | GUARD_RING | IV_GUARD_RING | IV_PAD | Action |
|----------------|------------|------------------|------------------------|----------------------|----------------|------------|-----------------|-------------|--------|
| 20WS1002001625 | 9903 | 15x15 | 2023-10-24T00:00:00Z | 2023-10-24T00:00:00Z | 1 | | OPEN GUARD RING | OPEN IV PAD | |
| 20WS1002001625 | 9903 | 15x15 | 2023-10-24T00:00:00Z | 2023-10-24T00:00:00Z | 2 | | OPEN GUARD RING | OPEN IV PAD | |
| 20WS1002001625 | 9903 | 15x15 | 2023-10-24T00:00:00Z | 2023-10-24T00:00:00Z | 3 | | OPEN GUARD RING | OPEN IV PAD | |
| 20WS1002001625 | 9903 | 15x15 | 2023-10-24T00:00:00Z | 2023-10-24T00:00:00Z | 4 | | OPEN GUARD RING | OPEN IV PAD | |
| 20WS1002001625 | 9903 | 15x15 | 2023-10-24T00:00:00Z | 2023-10-24T00:00:00Z | 5 | | OPEN GUARD RING | OPEN IV PAD | |
| 20WS1002001625 | 9903 | 15x15 | 2023-10-24T00:00:00Z | 2023-10-24T00:00:00Z | 6 | | OPEN GUARD RING | OPEN IV PAD | |
| 20WS1002001625 | 9903 | 15x15 | 2023-10-24T00:00:00Z | 2023-10-24T00:00:00Z | 7 | | OPEN GUARD RING | OPEN IV PAD | |
| 20WS1002001625 | 9903 | 15x15 | 2023-10-24T00:00:00Z | 2023-10-24T00:00:00Z | 8 | | OPEN GUARD RING | OPEN IV PAD | |
| 20WS1002001625 | 9903 | 15x15 | 2023-10-24T00:00:00Z | 2023-10-24T00:00:00Z | 9 | | OPEN GUARD RING | OPEN IV PAD | |
| 20WS1002001625 | 9903 | 15x15 | 2023-10-24T00:00:00Z | 2023-10-24T00:00:00Z | 10 | | OPEN GUARD RING | OPEN IV PAD | |

New Feature : Shipment tables

1. Fetch component info from database

Search Filter

Kind of Parts: Wafer (1001) | Location: Taipei (1001)

Record Insertion User: | Serial Number:

Manufacturer: Academia Sinica (1001)

FETCH INFORMATION

Select All

CHECK SELECTED ITEMS

| part_id | serial_number | version | name_label | comment_description | action |
|---------|---------------|---------|------------|---------------------|-------------------------------------|
| 2470 | WF1247 | | | Comment | <input checked="" type="checkbox"/> |
| 2474 | WF125 | | | Comment | <input checked="" type="checkbox"/> |
| 2475 | WF126 | | | Comment | <input type="checkbox"/> |
| 1400 | 1234213 | V-12345 | name label | Comment comments | <input type="checkbox"/> |

Add Shipment Information

Shipment Company Name: DHL (1) | Shipment Date: 2024 / 11 / 18

EDH Link: | Tracking #:

Location To: CERN (900) | Location From: Taipei (1001)

Status: Created | Shipment Reception Date: 2024 / 11 / 20

From Contact: | From Contact Email:

To Contact: | To Contact Email:

RESET **SUBMIT**

3. Fill shipment information and submit

2. Select components to ship

New Feature : Shipment tables

- User creates a the shipment item
- User can check status of a shipment and what are components shipped
- User can also update the status of a shipment

| Shipment Information | | | | |
|----------------------|------------|----------|----------|----------------------|
| Shipment ID | Tracking # | Status | EDH Link | Shipment Date |
| 1103 | 344 | Created | | 2024-08-20T00:00:00Z |
| 1041 | 123 | Received | | 2024-08-21T00:00:00Z |
| 1083 | 456 | Received | | 2024-08-20T00:00:00Z |
| 1121 | 112233 | Received | | 2024-09-24T00:00:00Z |
| 123 | TR#123 | Shipped | | 2024-08-19T00:00:00Z |
| 1141 | DHL1234567 | Received | | 2024-09-25T00:00:00Z |
| 1101 | 223 | Shipped | | 2024-08-19T00:00:00Z |
| 1061 | 123456 | Shipped | | 2024-08-22T00:00:00Z |

| Shipment Parts Attached | |
|-------------------------|--|
| Serial No | Comments |
| 20WMO121000017 | IPre, AltI3 NCAP bumps, glued hand, rfw |
| 20WMO121000018 | IPre, AltI3 NCAP bumps, glued hand |
| 20WMO121000019 | IPre, AltI3 NCAP bumps, glued hand |
| 20WMO121000020 | IPre, NCAP hybrids, glued hand |
| 20WMO121000021 | IPre, NCAP hybrids, glued jigs Wrong |
| 20WMO121000022 | IPre, AltI3 NCAP bumps, glued hand |
| 20WMO321000007 | Thick module ALTIROC3 IJCLab |
| 20WMO111000009 | |
| 99WMO121000006 | 3rd ALTI3 glued by hand. Broken when handling! |
| 99WMO121000001 | 3rd ALTI3 glued by hand. Broken when handling! |

Items per page: 10 1-10 of 94

New Feature : batch upload

Both parts and relations can be batch uploaded via CSV file

- Hybrid parts CSV file**

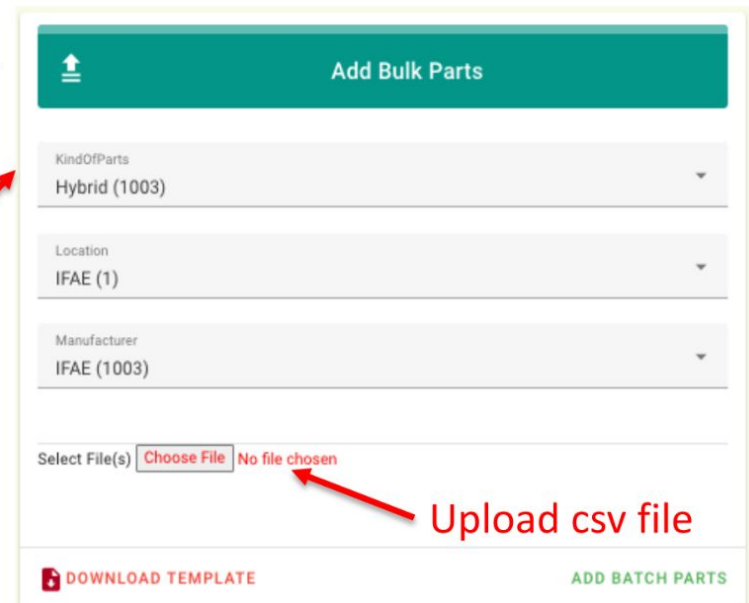
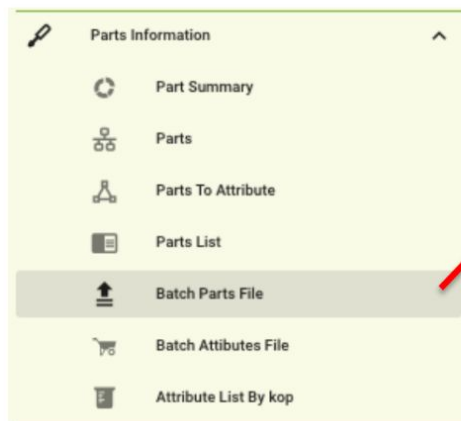
```
serial_number,batch_number,version,name_label,installed_date,production_date,comment_description
99WHY120000003,23,ALTIROC3,ALTIROC3 Hybrid,2024-02-02 11:23:10,2024-01-09 01:01:08,"PWchip bumps, IME-V3 W25 9, 500um edge, thin"
99WHY120000004,23,ALTIROC3,ALTIROC3 Hybrid,2024-02-02 14:47:28,2024-01-10 14:33:10,"PWchip bumps, IME-V3 W25 9, 500um edge, thin"
```

- Module parts template CSV file**

```
serial_number,version,name_label,comment_description
99WMO121000006,"Ver 0","M103 Tests of ALTIROC3","3rd ALTI3 glued by hand. Broken when handling!"
99WMO121000007,"Ver 0","M103 Tests of ALTIROC3","3rd ALTI3 glued by hand. Broken when handling!"
```

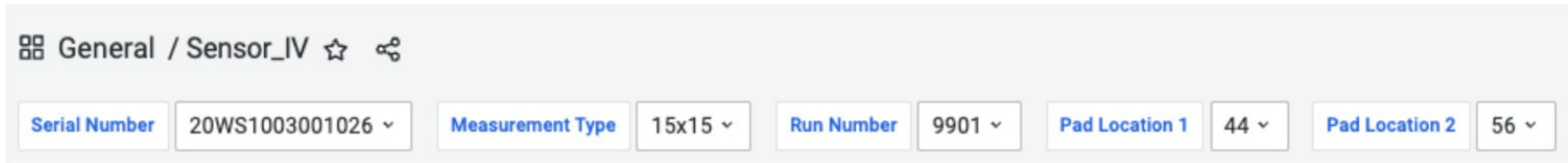
- Relationship between hybrid and module CSV file**

```
parent_kind_of_part,parent_serial_number,child_kind_of_part,child_serial_number
Module,99WMO121000007,Hybrid,99WHY120000003
Module,99WMO121000007,Hybrid,99WHY120000004
```

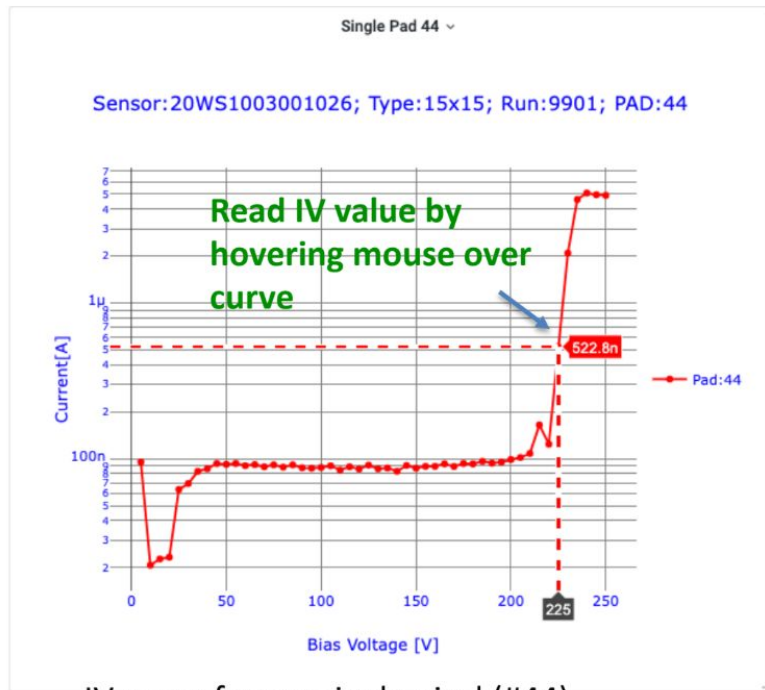


New Feature : Monitoring

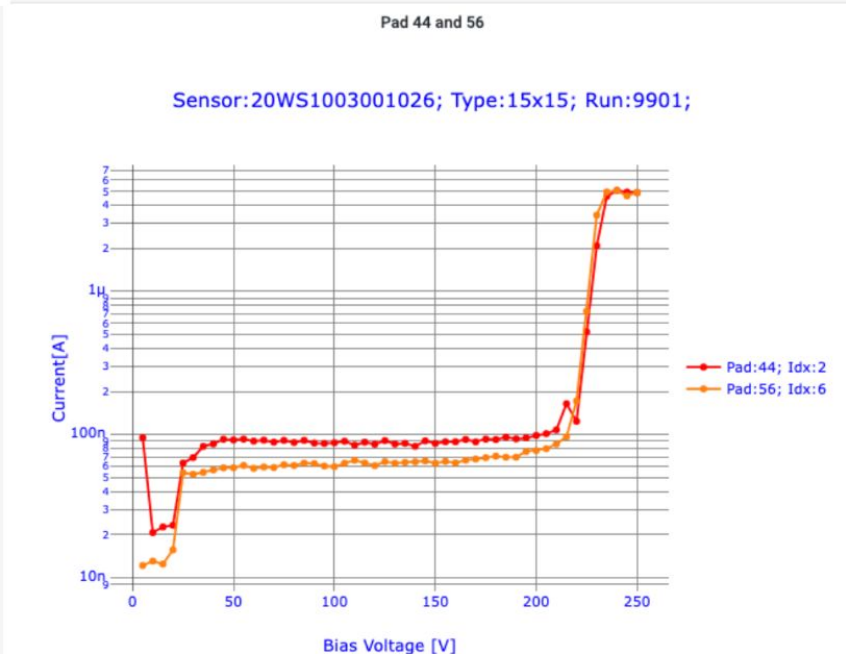
- JSON endpoints to Grafana interface for data visualization
 - Sensor IV measurements
 - Module threshold measurements



- User identify the IV measurement via several selection parameters



IV curve from a single pixel (#44)

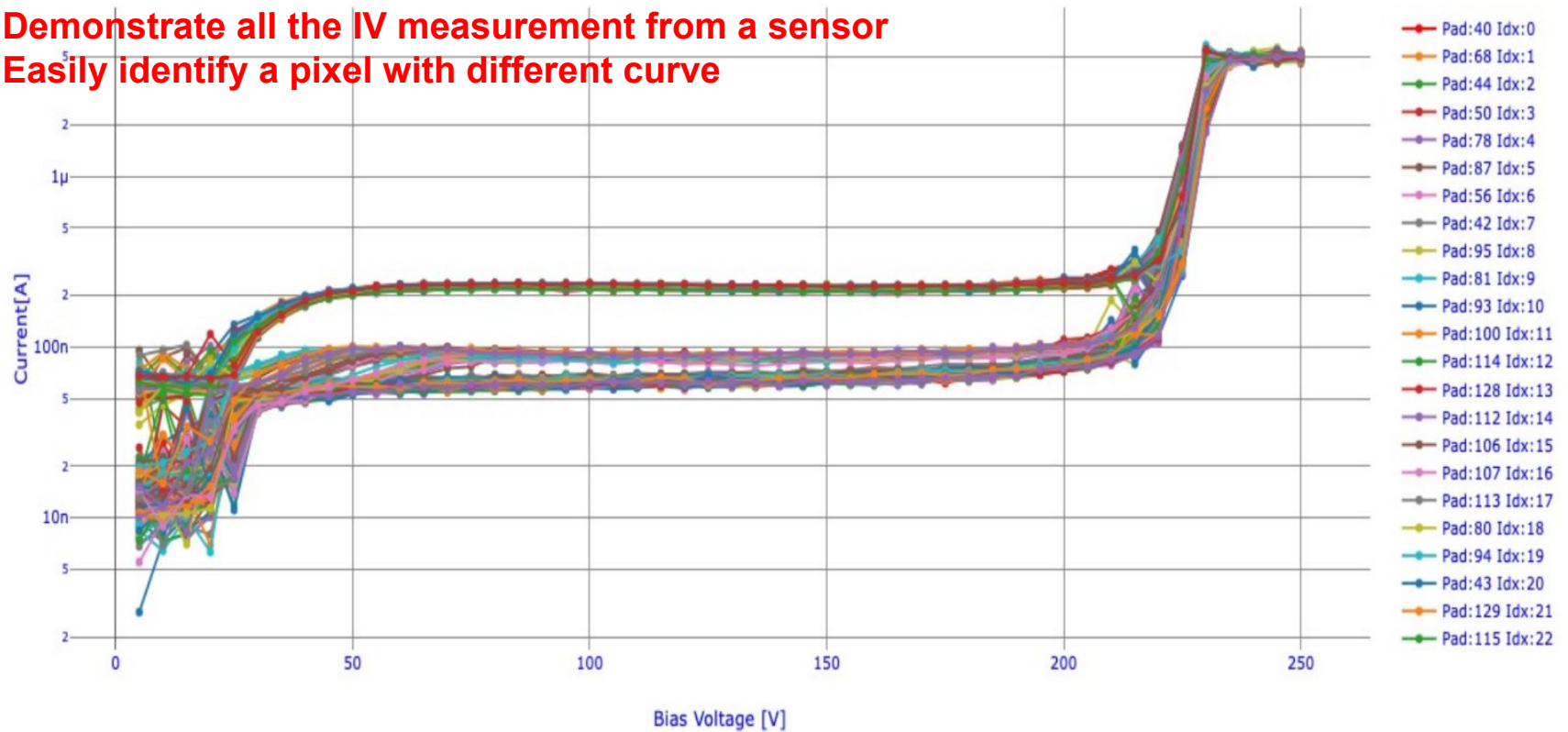


Compare IV curves from pixel #44 and #56

New Feature : Monitoring

Sensor:20WS1003001026; Type:15x15; Run:9901;

Demonstrate all the IV measurement from a sensor
Easily identify a pixel with different curve



New Feature : Monitoring

thresScan measurement for module (SN=20WMO121000001)

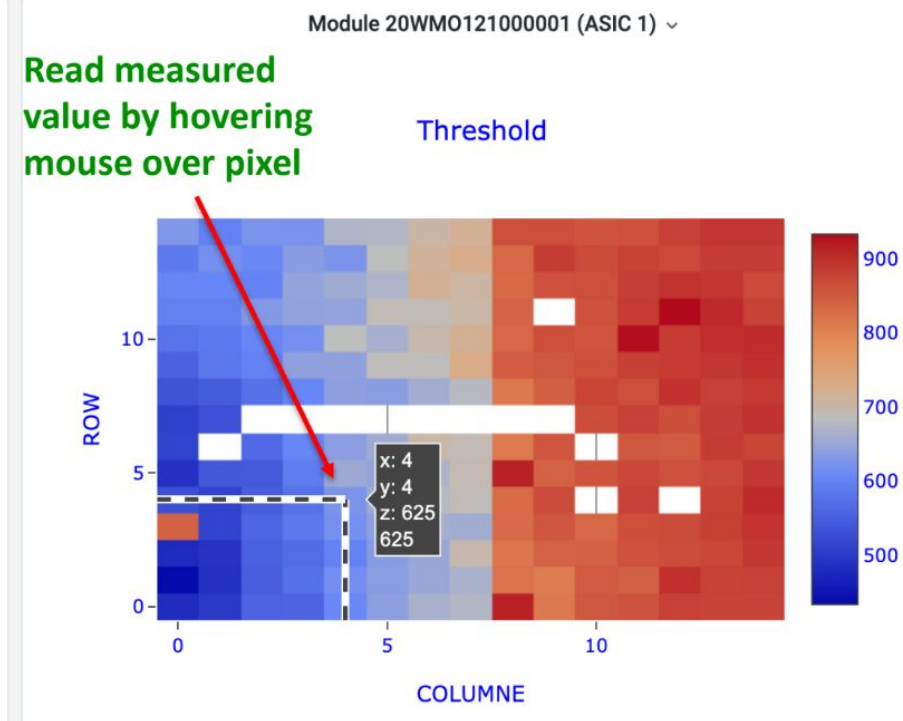
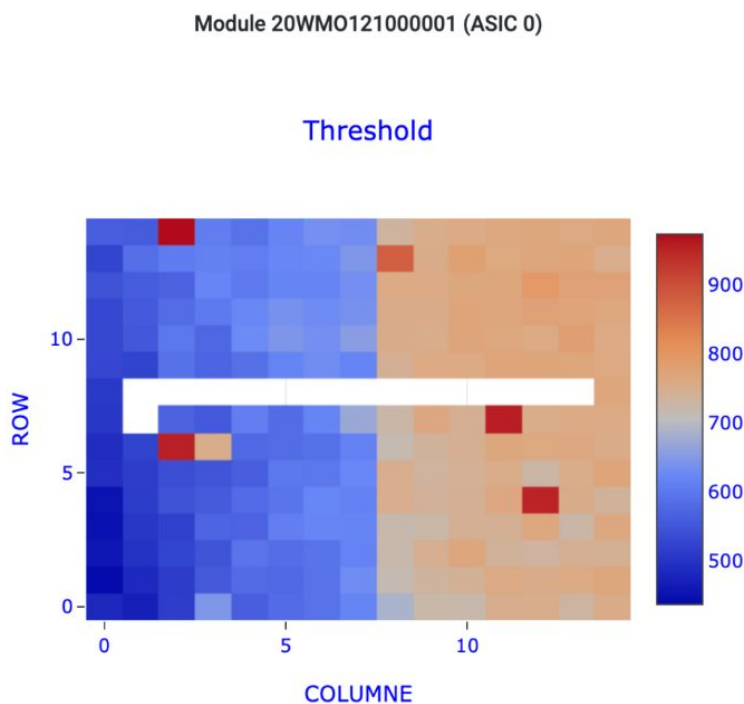
ASIC 0 (left)

ASIC1 (right)

☰ General / Module ☆ 🔗

Serial Number 20WMO121000001 ▾ Run Type Module Threshold ▾ Run Number 1 ▾

- User identify the threshold measurement via several selection parameters



Summary

- New Oracle HGTD Production Database is setup and running at CERN
- All major components are defined in DB
 - Wafer and Sensor, ASIC, Hybrid, Module Flex, Module, Flex Tail, Support Unit/ Detector Unit defined
 - PEB to be added
- Measurements results are stored for sensors and modules.
 - Visualize with Grafana monitoring
 - Storing flex tail measurements

| KindofParts List | | | | |
|------------------|----------------|--|---------------|--------|
| Type to Search | | ADVANCE FILTERS | EXPORT TO CSV | |
| KoP ID ↑ | Display Name | Comments | User | Action |
| 1000 | Sensor | sensor | mrao | |
| 1001 | Wafer | sensor wafer | mrao | |
| 1002 | ASIC | asic | mrao | |
| 1003 | Hybrid | Consists of a sensor bump bonded to an asic | mrao | |
| 1004 | Module_flex | module flex | mrao | |
| 1005 | Module | Assembled from 2 hybrids and a module flex | mrao | |
| 2020 | wafer_assembly | wafer comments | mrao | |
| 2405 | glue | gluing used to attach hybrids to module_flex | mrao | |
| 2407 | Detector Unit | modules loaded on support units | mrao | |
| 2408 | Support Unit | Support Unit | mrao | |

Ongoing tasks

- More than 3k parts now registered in the database
 - Sensor and wafer group utilized the HGTD production DB and provided feedback
- Synchronize format for upload CSV/ZIP files
- Weekly meeting with component groups to receive feedback
- Prepare for HGTD pre-production (Jan 2025)

| KindOfParts Summary | | |
|---------------------|--------|-------|
| SR# | NAME | TOTAL |
| 1 | Sensor | 2768 |
| 2 | Hybrid | 219 |
| 3 | Wafer | 135 |
| 4 | Module | 95 |

| Manufacturer Summary | | |
|----------------------|-----------------|-------|
| SR# | NAME | TOTAL |
| 1 | USTC-IME | 1536 |
| 2 | IHEP-IME | 1349 |
| 3 | IHEP | 176 |
| 4 | IFAE | 168 |
| 5 | Academia Sinica | 18 |
| 6 | NCP | 15 |
| 7 | IJCLab | 14 |
| 8 | TSMC | 5 |
| 9 | Germany | 4 |

| Location Summary | | |
|------------------|------------|-------|
| SR# | NAME | TOTAL |
| 1 | USTC | 1059 |
| 2 | IHEP-IME | 1059 |
| 3 | IHEP | 930 |
| 4 | IFAE | 163 |
| 5 | CERN | 35 |
| 6 | IJCLab | 15 |
| 7 | Taipei | 9 |
| 8 | CERN-ATLAS | 7 |

Thank you !

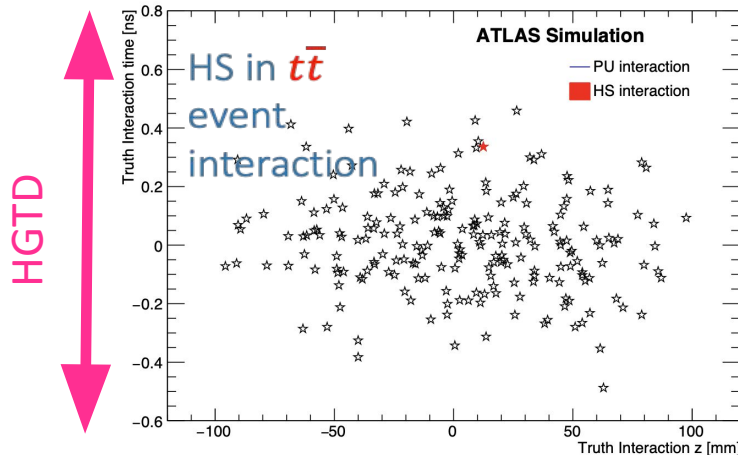
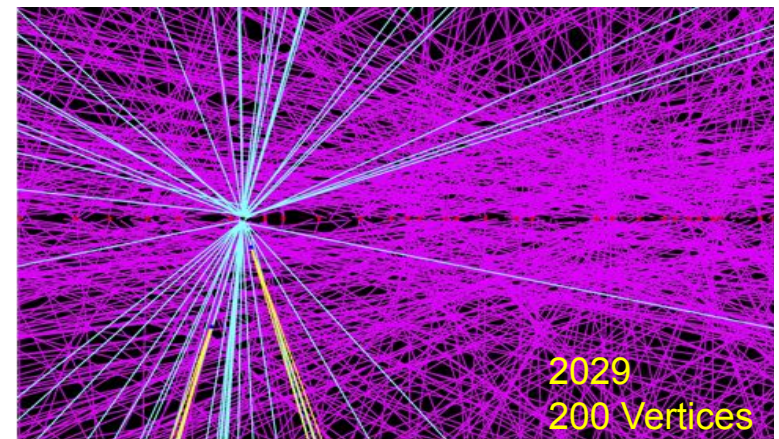
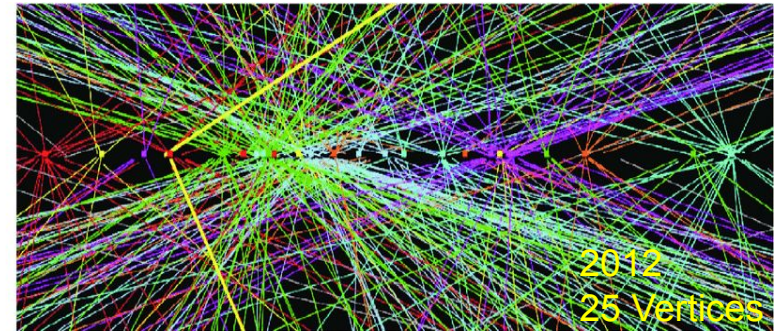
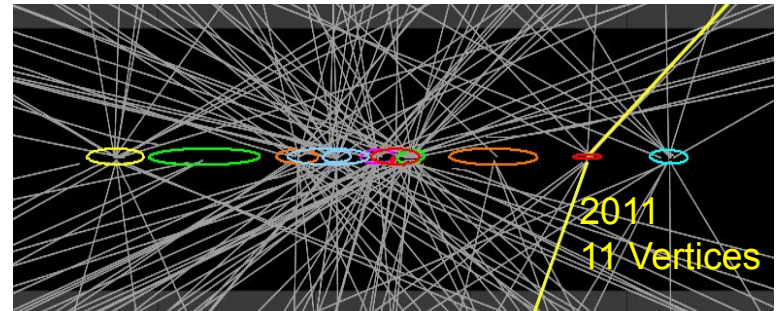


鄭自妍-烏石港天空之鏡

Back up

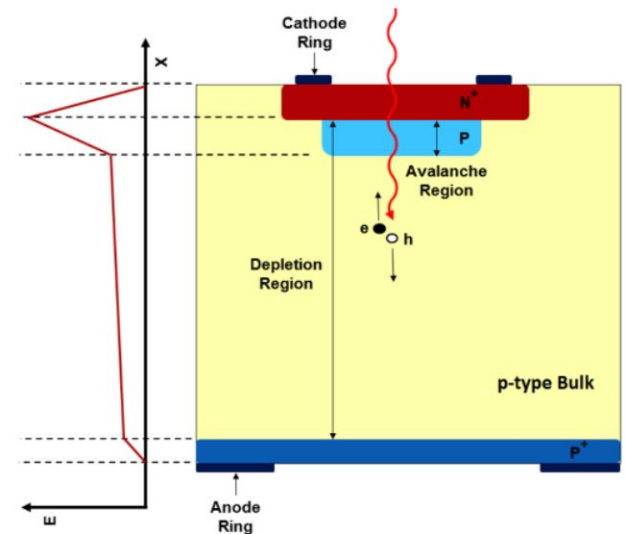
High Luminosity (HL)-LHC program

- Key numbers :
 - Instantaneous luminosity $7.5 \times 10^{34} \text{ cm}^{-2} \text{ s}^{-1}$ (~ 5 times Run 2)
 - Pile-up density (μ) 200 in bc of 25 ns
 - Interaction Density 1.8 vertices/mm
- Challenges
 - Primary vertex reconstruction
 - Detector radiation hardness
- High Granularity Timing Detector (HGTD) provides an extra dimension (time) to separate the individual interactions



Low Gain Avalanche Diode: Sensors

- LGAD sensors are an advanced type of silicon photodetector that harness the avalanche multiplication effect to amplify signals
- LGAD sensors operate in a low gain mode, ensuring linearity and reducing excess noise
- LGAD specifics for HGTD
 - ▶ 50 μm thick
 - Compromise between Landau fluctuations contributing to the time resolution etc
 - ▶ Pad size $1.3 \times 1.3 \text{ mm}^2$
 - Compromise between rise time, capacitance, occupancy
 - ▶ Signal level: 10 fC (w/20 gain) before and 4 fC (w/8 gain) after irradiation

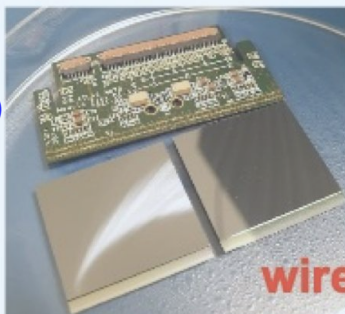


HGTD module assembly

1

Module FLEX (flexible PCB)

2 Hybrid (LGAD + ASIC)

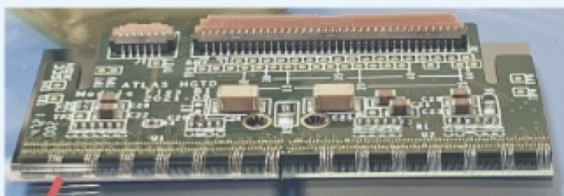


Module

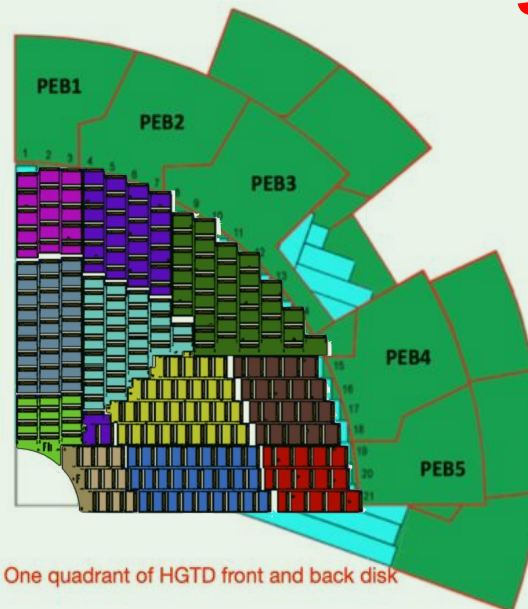
(8034 modules per disc)

glue+
wire-bonds

Assembled module

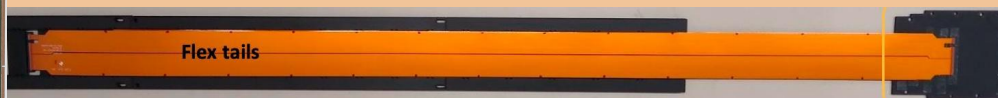
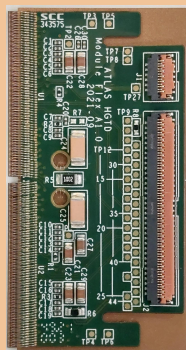


3



One quadrant of HGTD front and back disk

2



Flex tails

PEB
(peripheral
electronics)

HGTD Production Database

- Production database to monitor and record HGTD construction
 - Large amount of different components
 - Production history and quality control
 - Measurements
 - Relationship of components(assembly)
- Characteristic of the database
 - A flexible and generic database design for components registration, attributes and module assembly.
 - Provision of shipment and handling
 - Custom tables for measurements and quality control data.

Measurements

- Leakage current, breakdown voltage of the LGAD sensors, timing calibration of the ASICs
- Component metrology (e.g. length, width, thickness...)
- Component images

Components to be registered

- sensor wafer, sensor
- ASIC (front end readout chip)
- Hybrid
- module flex
- Module
- flex tail
- support unit
- detector unit
- peripheral electrics board (PEB)

HGTD Production Database



- Oracle database hosted at CERN
- Web Applications
 - Frontend Application
 - VueJS based application that provides interface for the client to interact with the database.
 - Calls backend APIs provided by backend application.
 - Used for components registration, data uploading, module assembly and other relevant tasks.
 - Backend Application
 - Developed in Django REST Framework.
 - Provides APIs to frontend application and interacts directly with the database
 - Monitoring Application
 - Provides JSON endpoints to Grafana interface for data visualization.

HDTD modules

- Each module consists of two bump-bonded LGAD sensor+ASIC readout chip combinations, glued and wire-bonded to a module flex
- Module = 2 Hybrid (LGAD + ASIC) + Module FLEX (flexible PCB)
- Flexible PCB connect to peripheral electronics(PEB) through FLEX tail

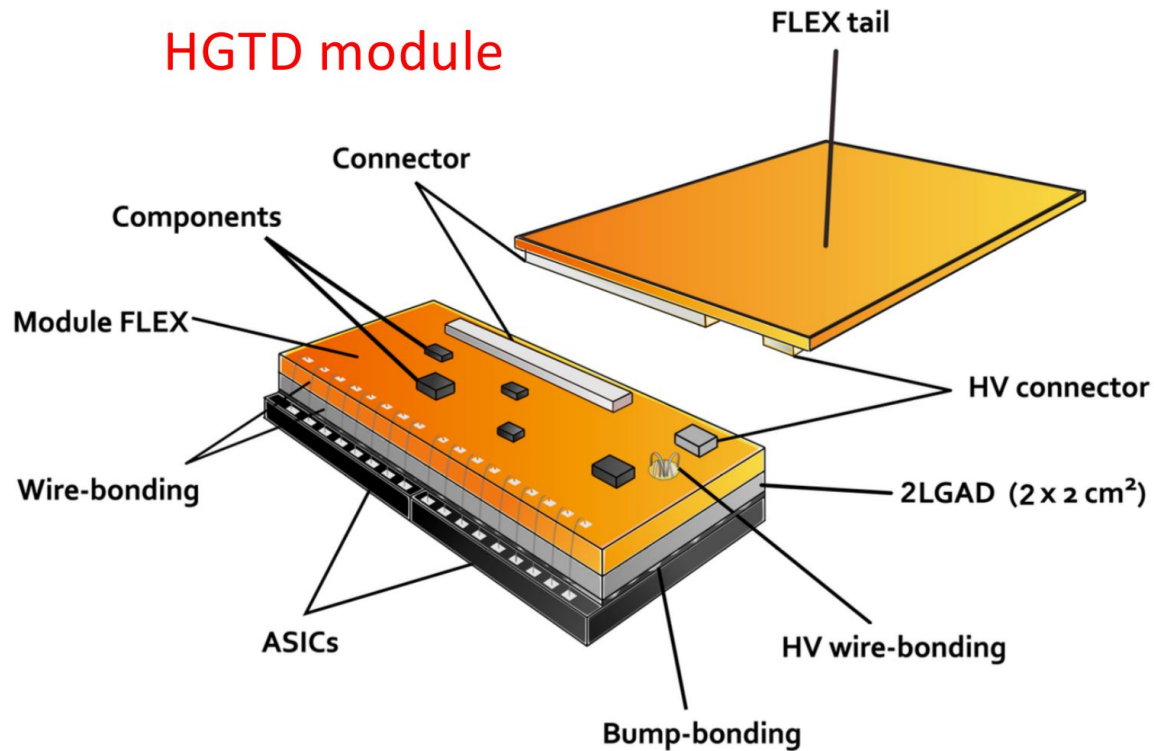
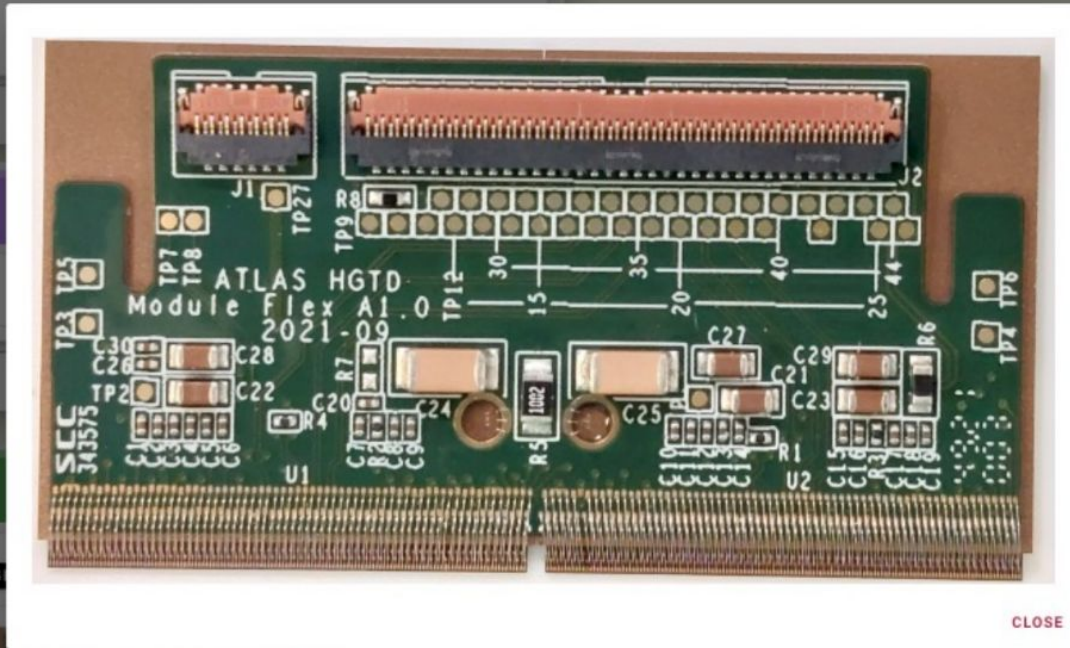


Image upload (assembled module)



image_module_20WMD11000006_1.jpg

Choose File No file chosen

UPLOAD IMAGE

SHOW IMAGE DELETE IMAGE