HGTD Production Database

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On behalf of TW ATLAS HGTD team

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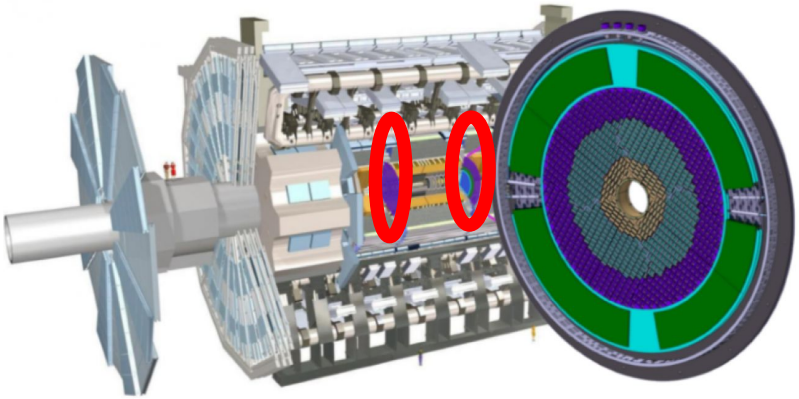
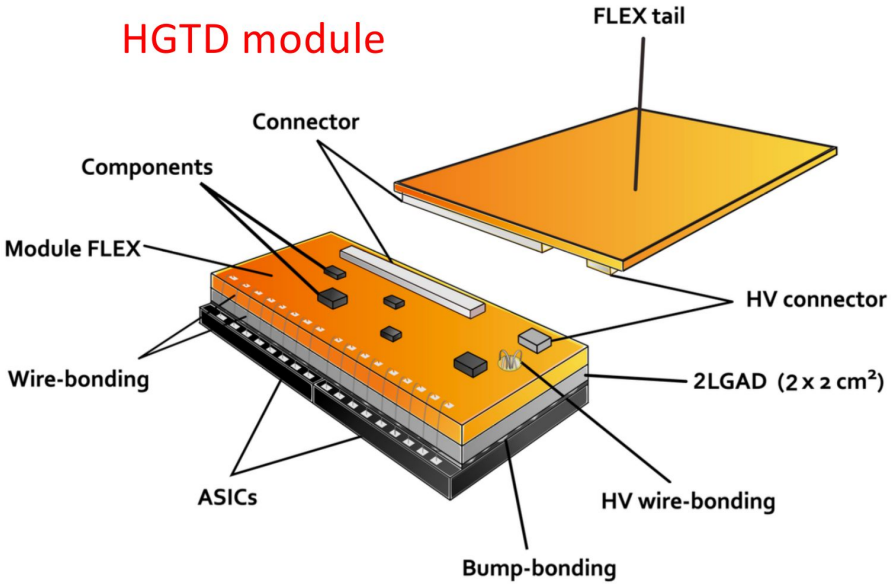
2024 TIDC

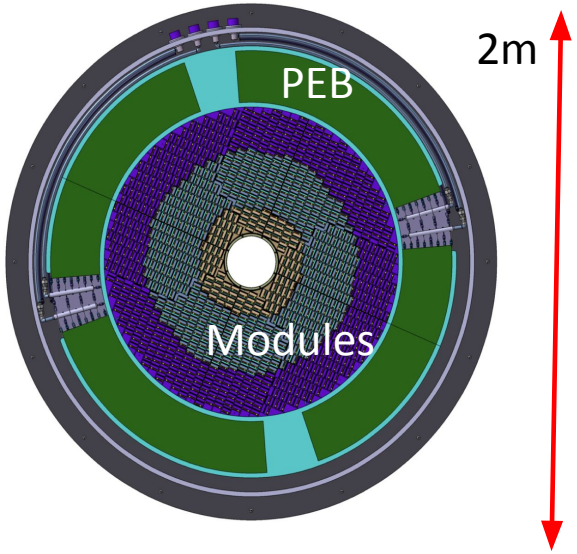
High Granularity Timing Detector(HGTD)

- 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 module





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

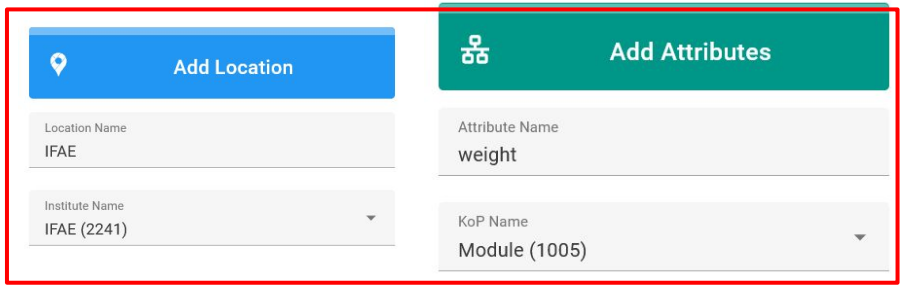
HGTD production database

- 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

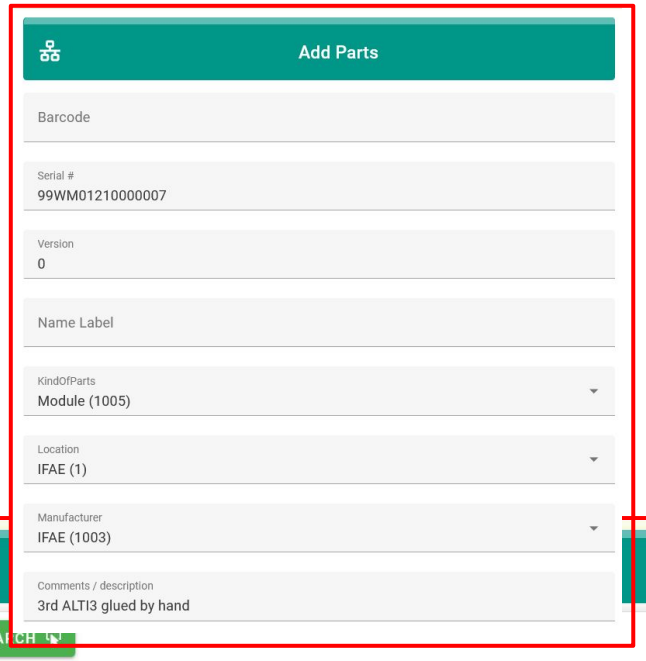
Key Feature : Generic component registration

- Users with administration rights to create/define new items
  - Institutes, manufacturers/vendors locations
  - Add new component types
  - Add attributes

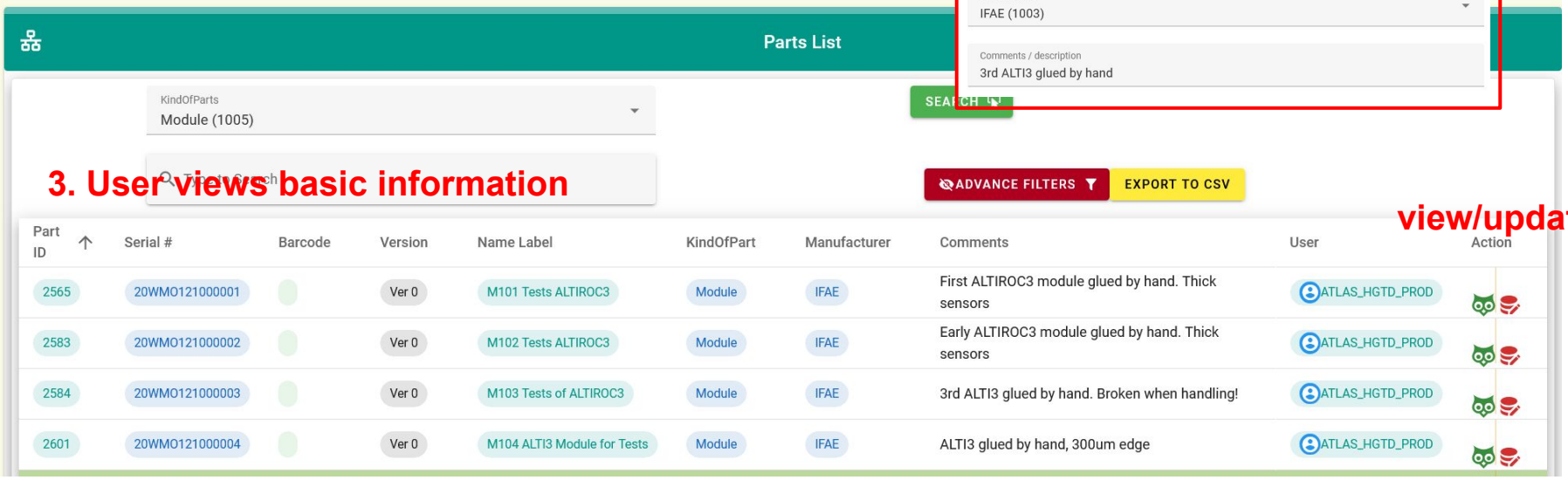
1. Admin define basic info and attributes



2. User adds parts



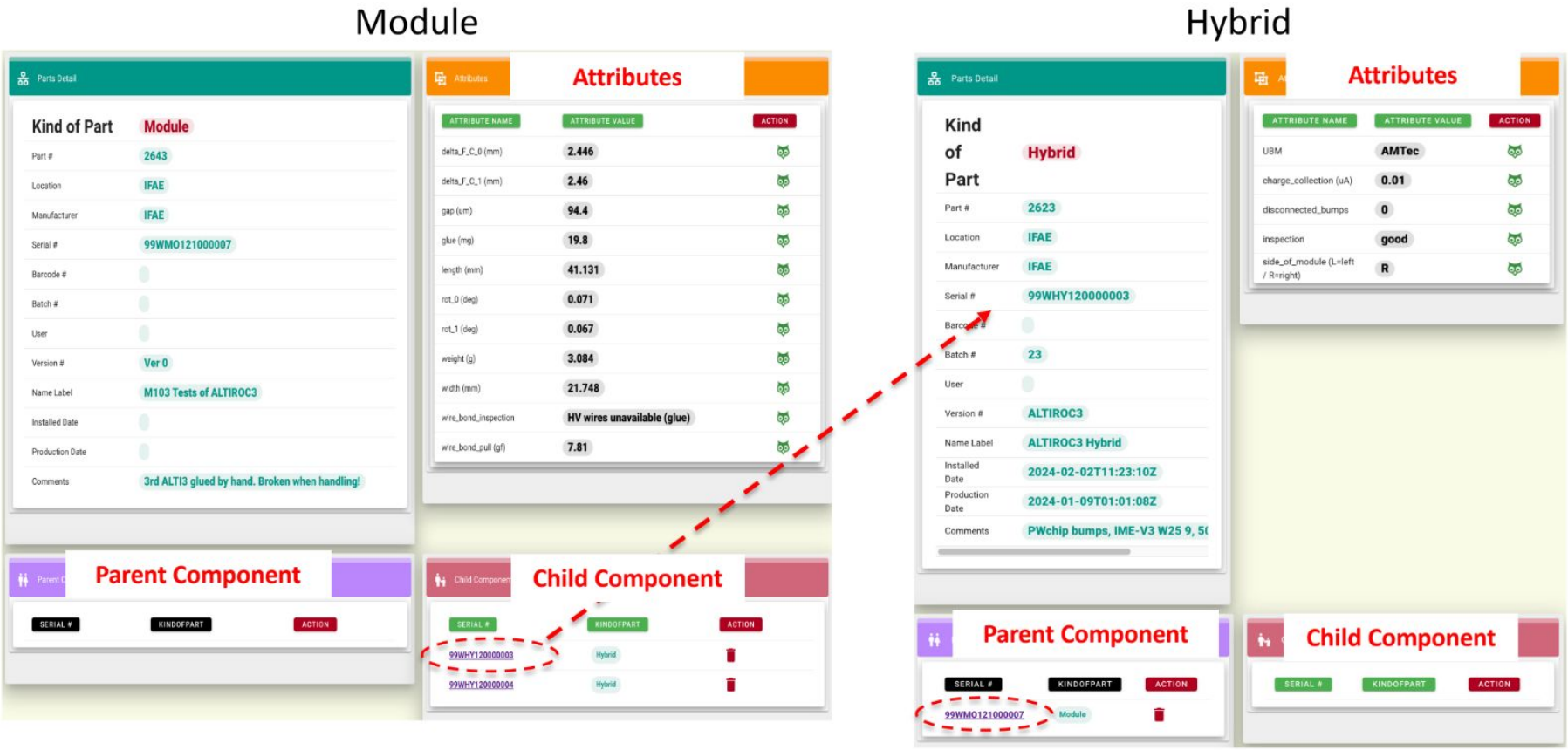
3. User views basic information



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	
2583	20WMO121000002		Ver 0	M102 Tests ALTIROC3	Module	IFAE	Early ALTIROC3 module glued by hand. Thick sensors	ATLAS_HGTD_PROD	
2584	20WMO121000003		Ver 0	M103 Tests of ALTIROC3	Module	IFAE	3rd ALTI3 glued by hand. Broken when handling!	ATLAS_HGTD_PROD	
2601	20WMO121000004		Ver 0	M104 ALTI3 Module for Tests	Module	IFAE	ALTI3 glued by hand, 300um edge	ATLAS_HGTD_PROD	

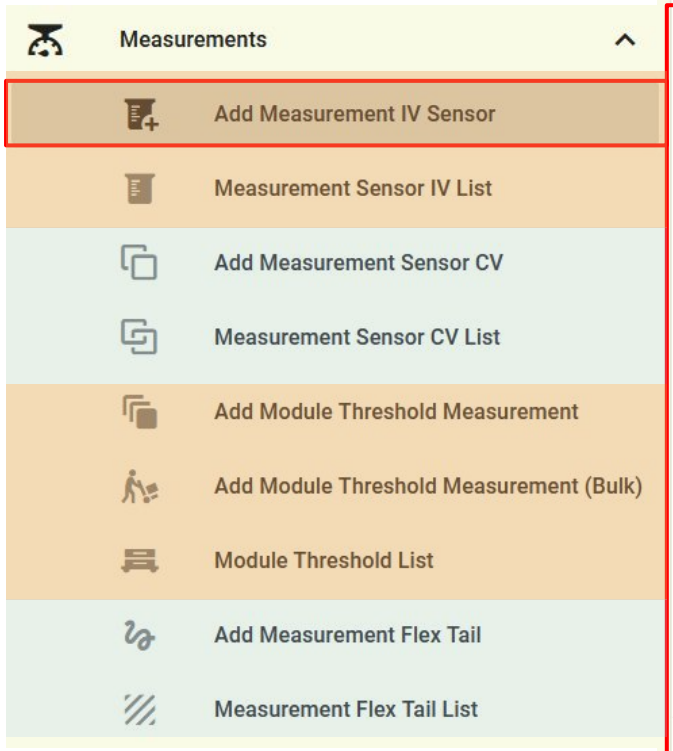
Key Feature : Generic relationship

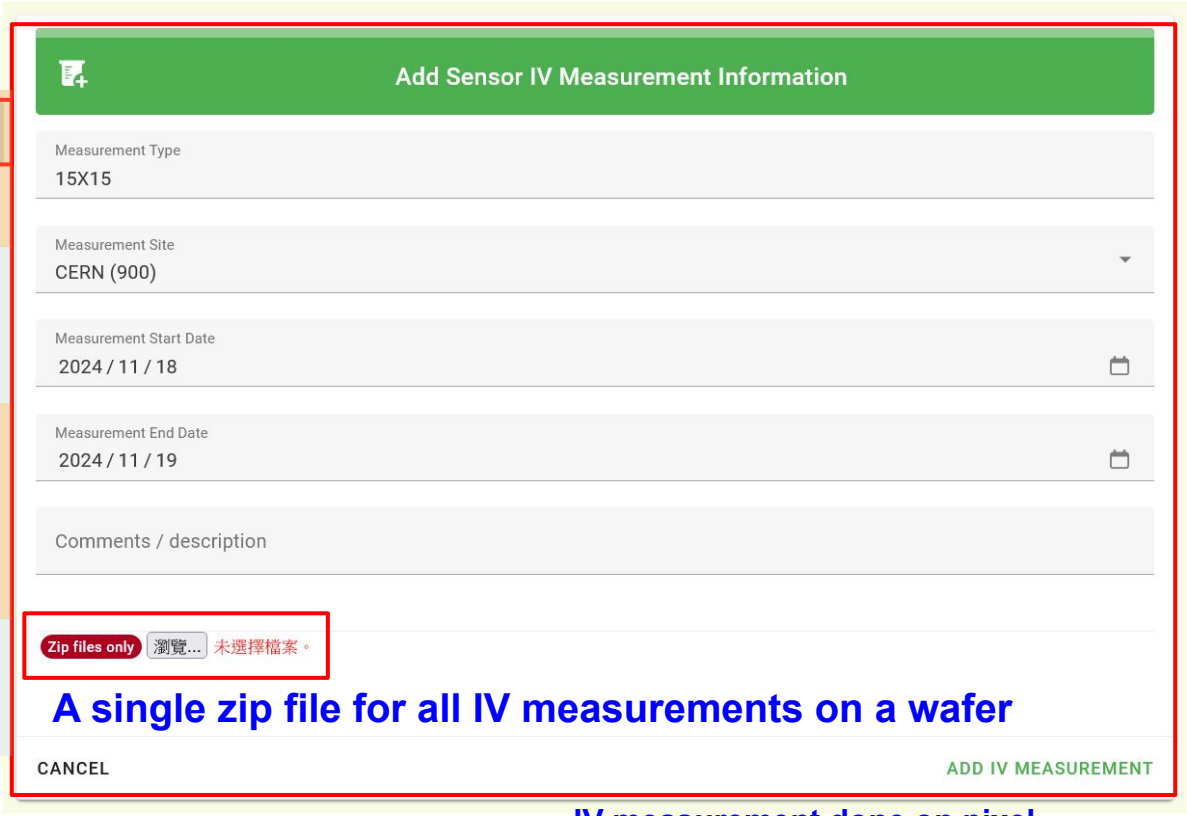
List of basic info, attributes and relations of a module and a hybrid



New Feature : Measurement tables

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





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"],"I":["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","4.9944e-06","5.0103e-06","4.9796e-06","4.8293e-06","4.9456e-06","4.9768e-06"]}

CLOSE DIALOG

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

leave Pad Loc empty to select all values

SEARCH

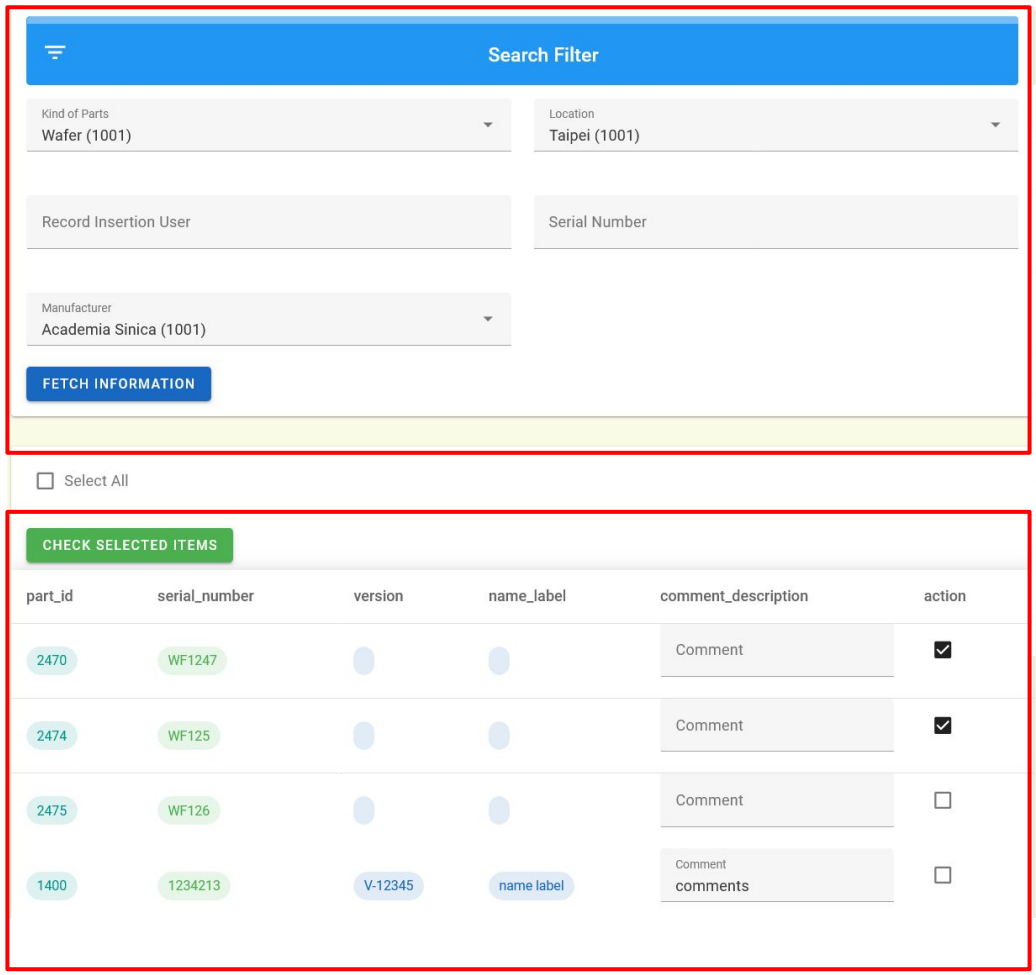
225 IV measurements of a single sensor

COLUMN FILTERS | EXPORT TO CSV

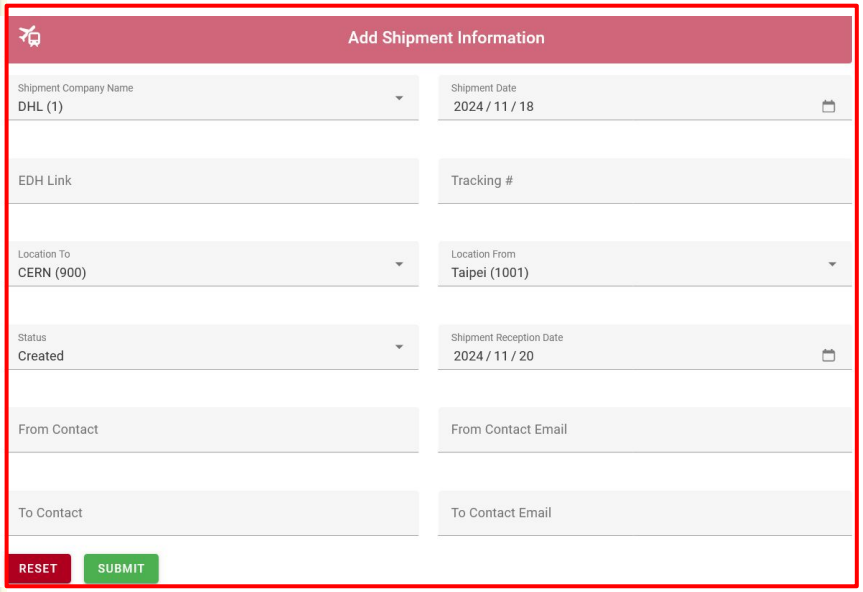
SERIAL NUMBER	RUN NUMBER	Measurement TYPE	Measurement Start Time	Measurement End Time	PAD_LOCATION	GUARD_RING	IV_GUARD_RING	IV_PAD	Action
20WS1002001625	9903	15x15	2023-10-24T00:00:00Z	2023-10-24T00:00:00Z	1		OPEN GUARD RING	OPEN IV PAD	
20WS1002001625	9903	15x15	2023-10-24T00:00:00Z	2023-10-24T00:00:00Z	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



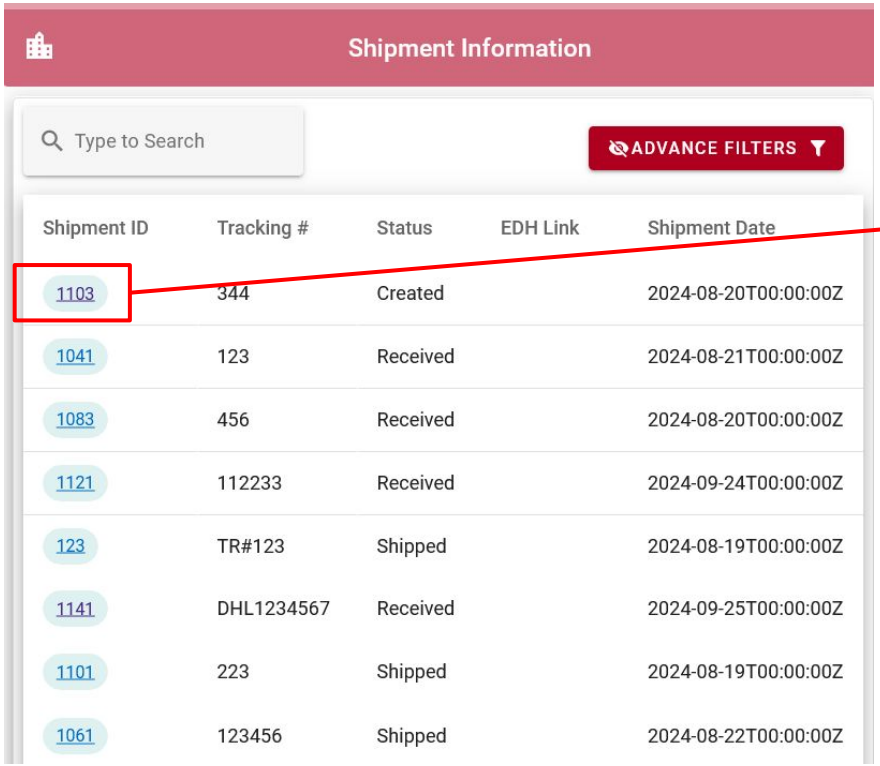
2. Select components to ship

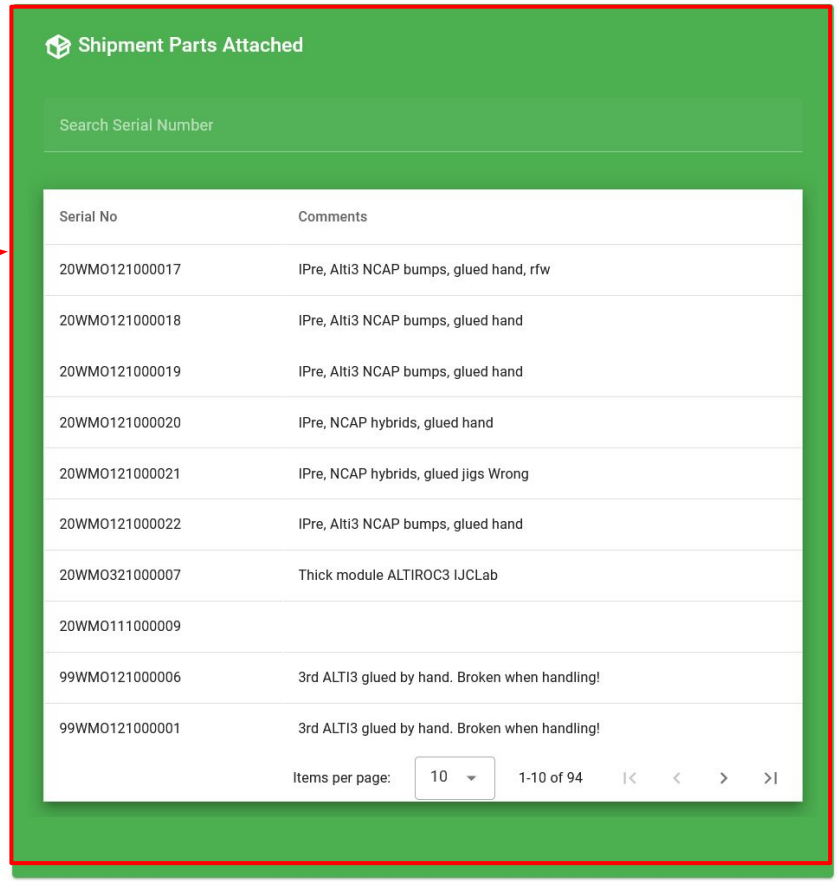


3. Fill shipment information and submit

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





New Feature : batch upload

Both parts and relations can be batch uploaded via CSV file

- **Hybrid parts CSV file**

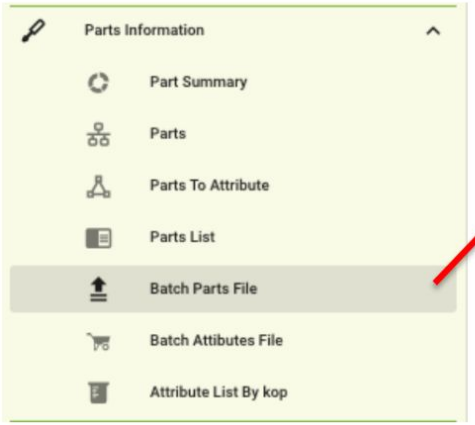
serial_number,batch_number,version,name_label,installed_date,production_date,comment_description
99WHY120000003,23,ALTIROC3,ALTIROC3 Hybrid,2024-02-02 11:23:10,2024-01-09 01:01:08,"PWchip bumps, IME-V3 W25 9, 500um edge, thin”
99WHY120000004,23,ALTIROC3,ALTIROC3 Hybrid,2024-02-02 14:47:28,2024-01-10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

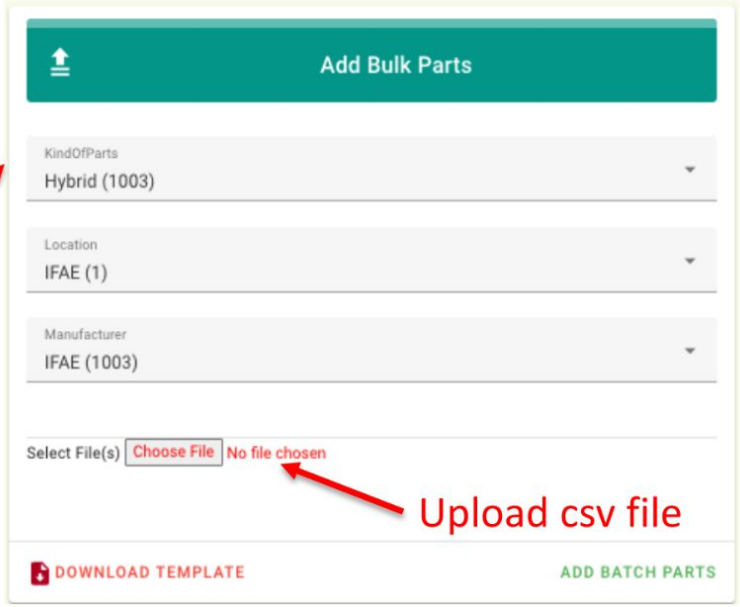
- **Module parts template CSV file**

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**

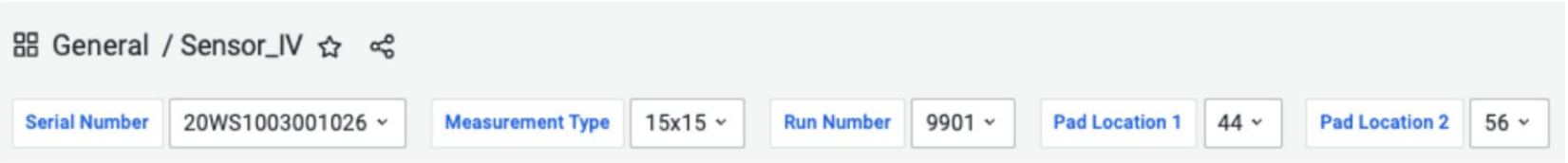
parent_kind_of_part,parent_serial_number,child_kind_of_part,child_serial_number
Module,99WMO121000007,Hybrid,99WHY120000003
Module,99WMO121000007,Hybrid,99WHY120000004



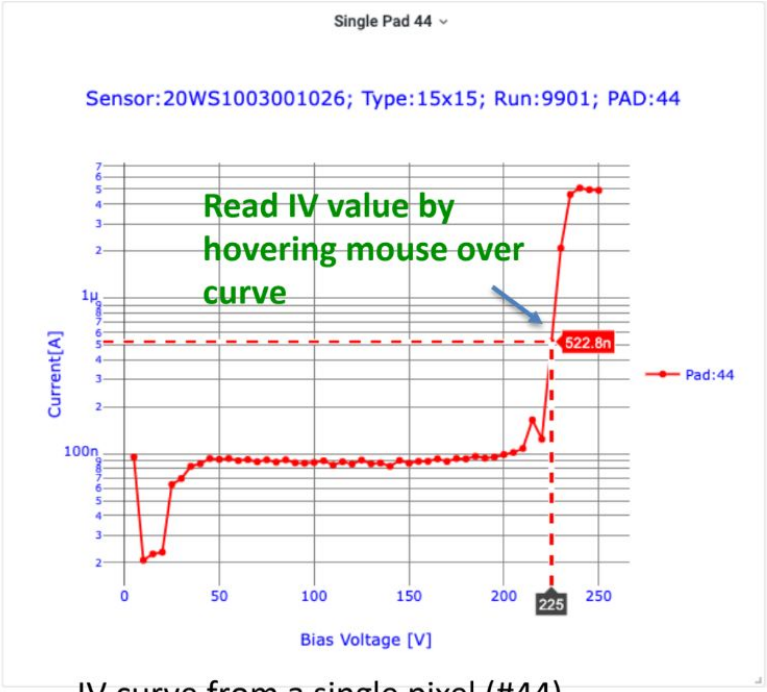


New Feature : Monitoring

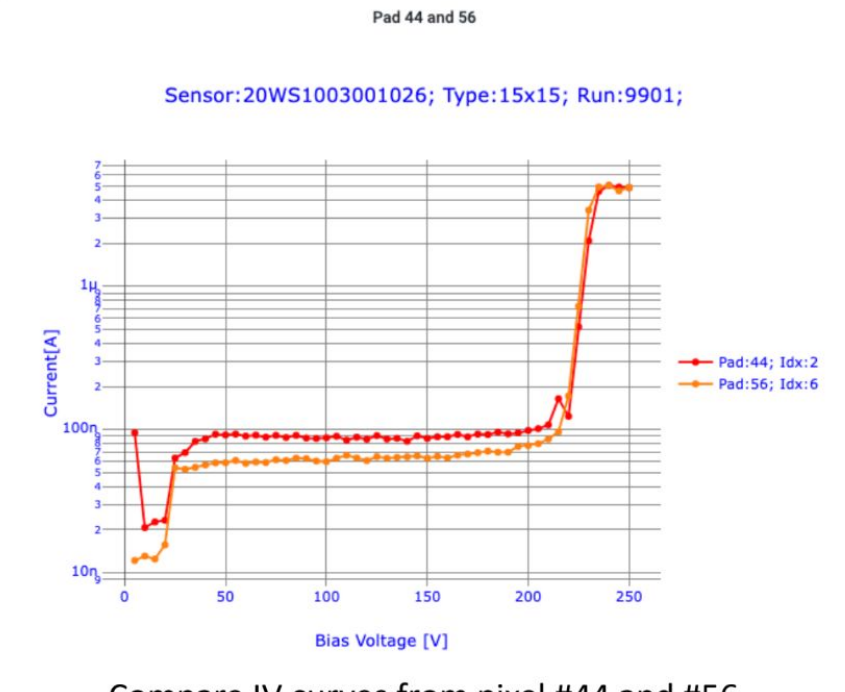
- JSON endpoints to Grafana interface for data visualization
  - Sensor IV measurements
  - Module threshold measurements



- User identify the IV measurement via several selection parameters



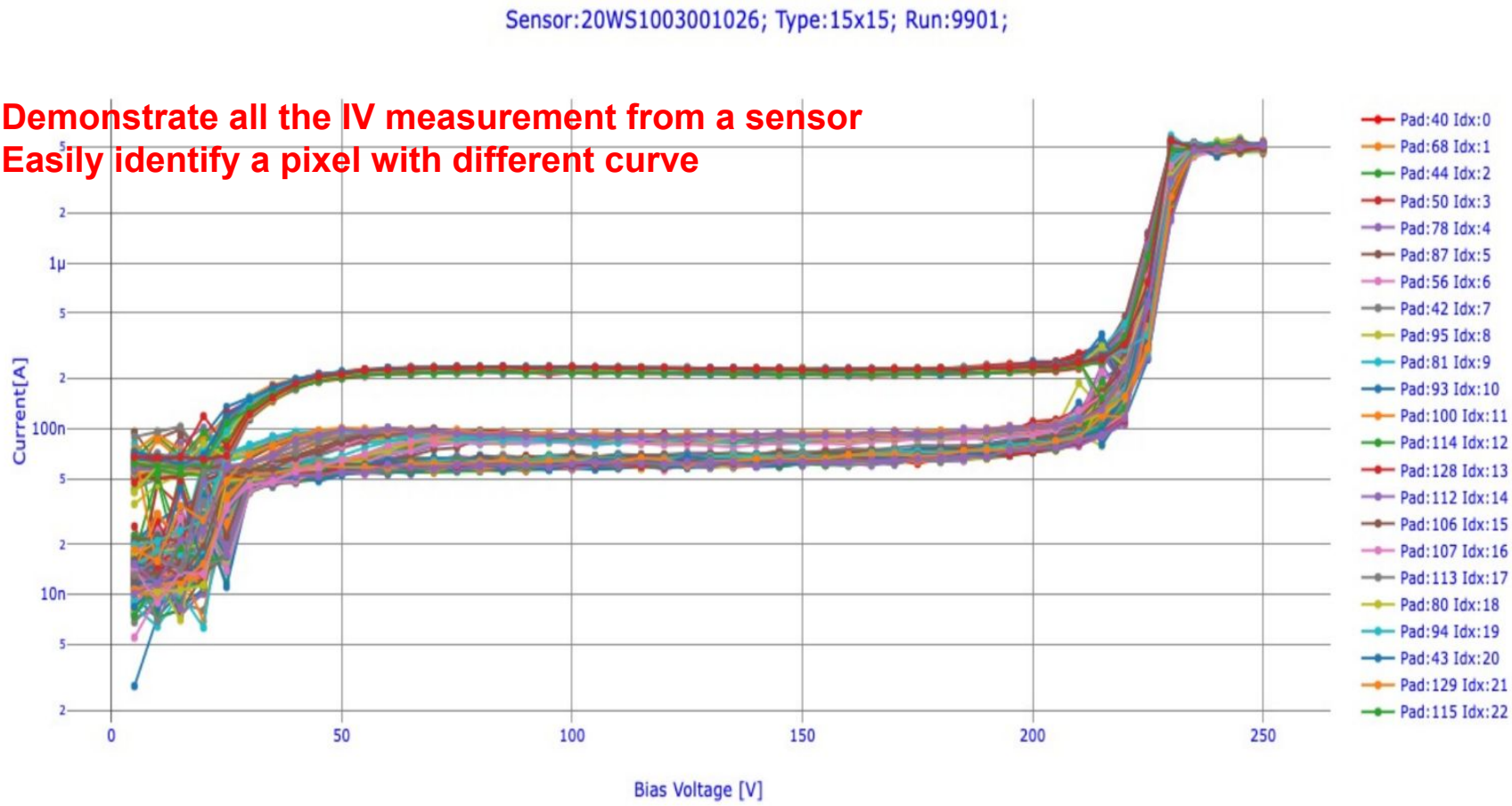
IV curve from a single pixel (#44)



Compare IV curves from pixel #44 and #56

New Feature : Monitoring

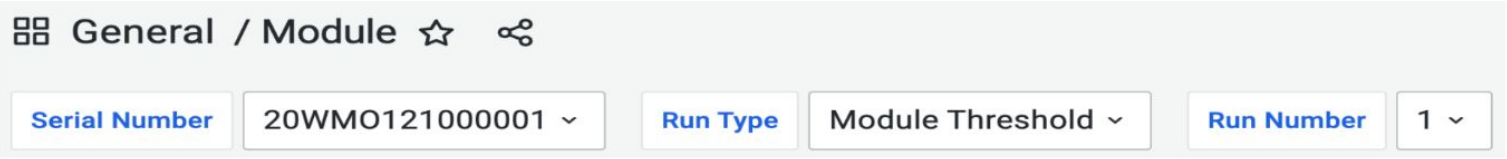
Demonstrate all the IV measurement from a sensor
Easily identify a pixel with different curve



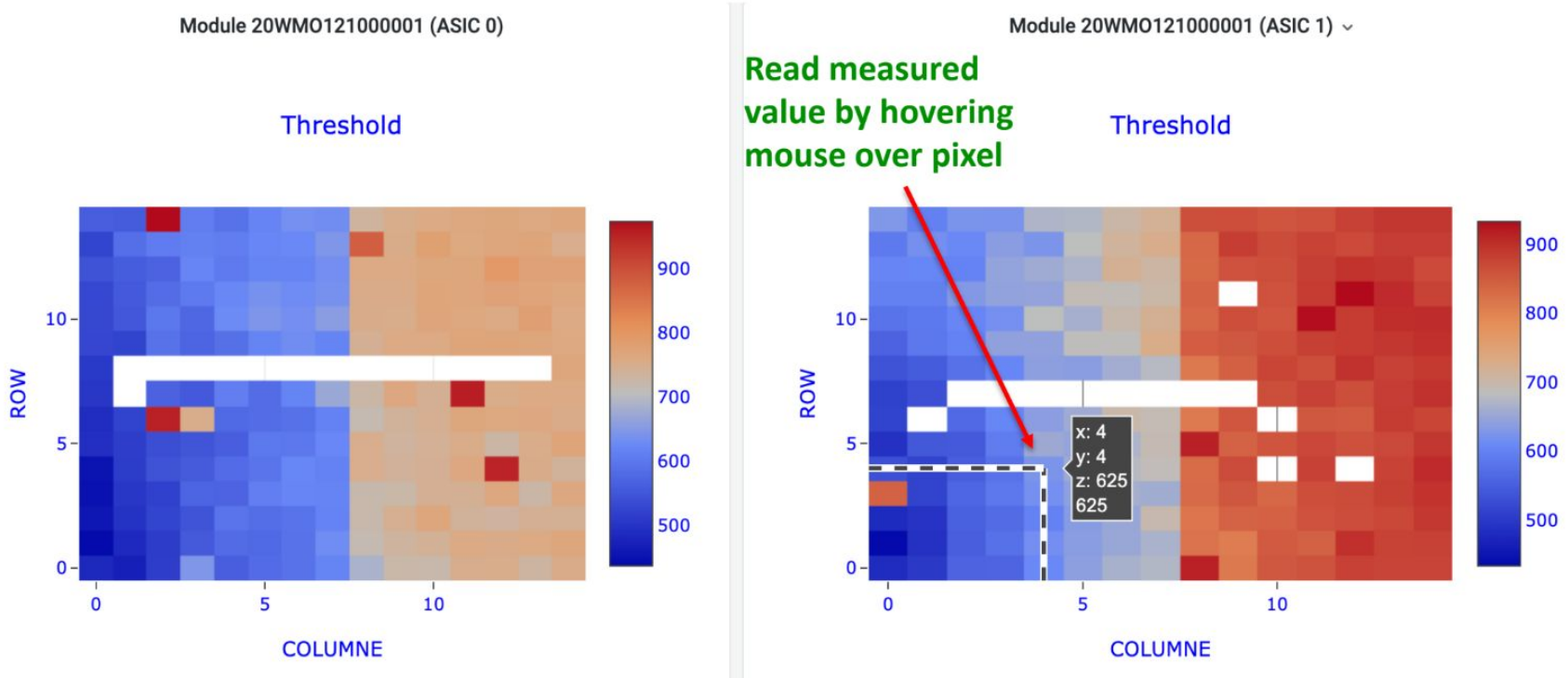
New Feature : Monitoring

thresScan measurement for module (SN=20WMO121000001)

ASIC 0 (left) **ASIC1 (right)**

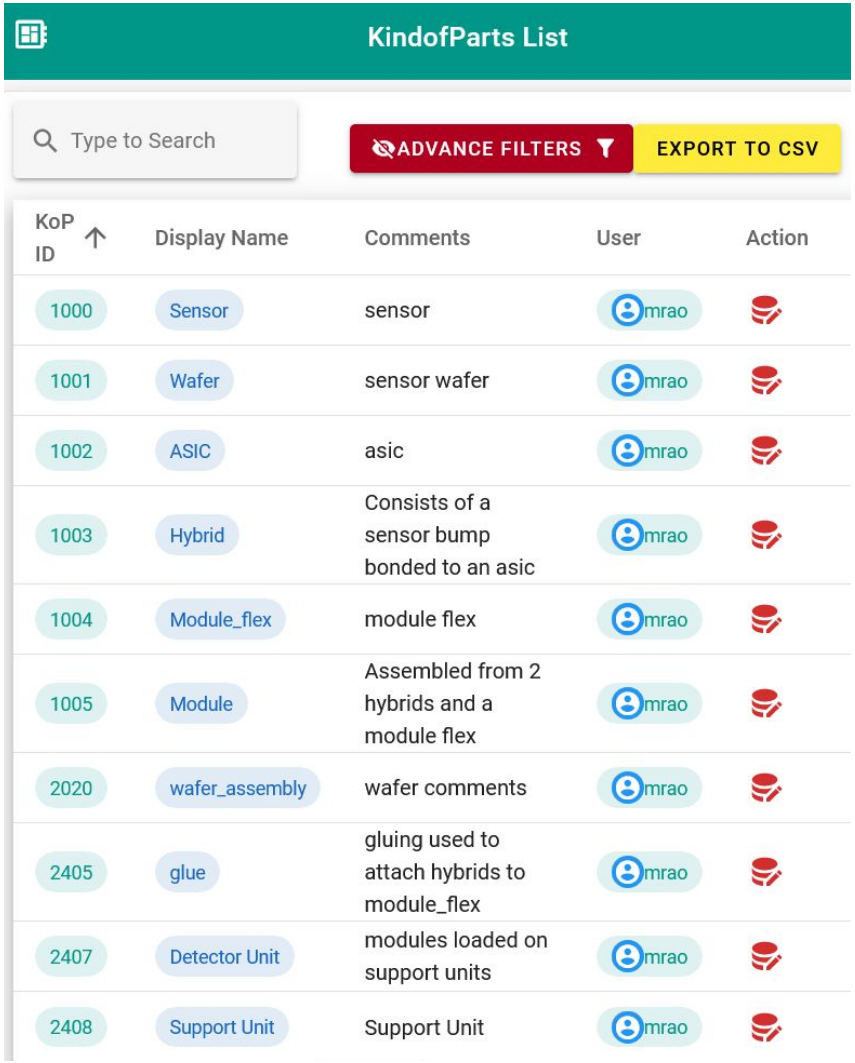


- User identify the threshold measurement via several selection parameters



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



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

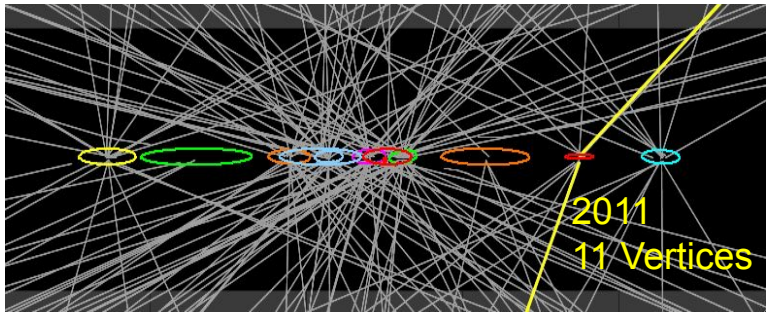
SR#	NAME	TOTAL
1	USTC	1059
2	IHEP-IME	1059
3	IHEP	930
4	IFAE	163
5	CERN	35
6	IJCLab	15
7	Taipei	9
8	CERN-ATLAS	7

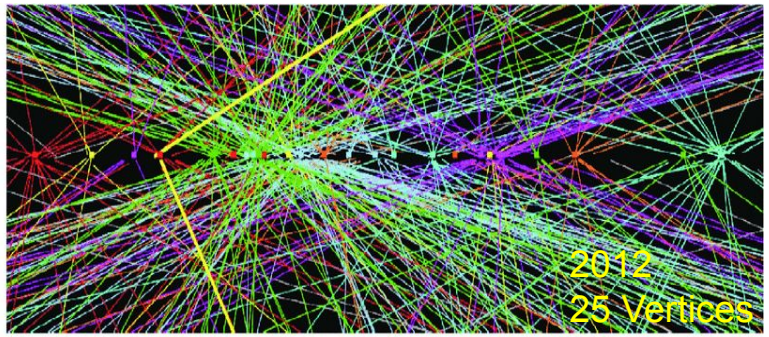
Thank you ！

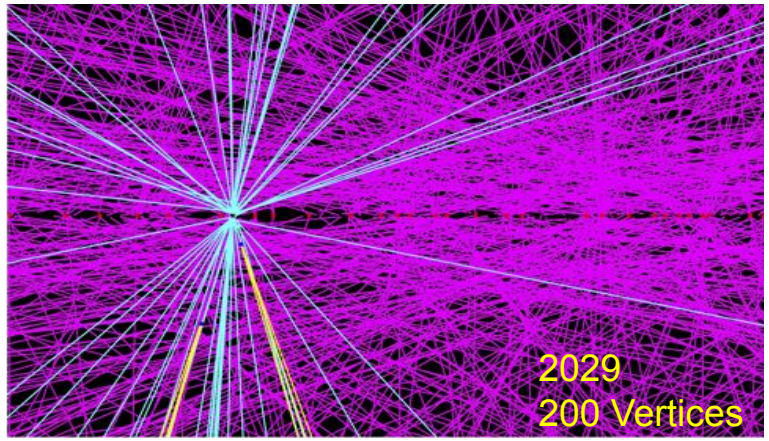
Back up

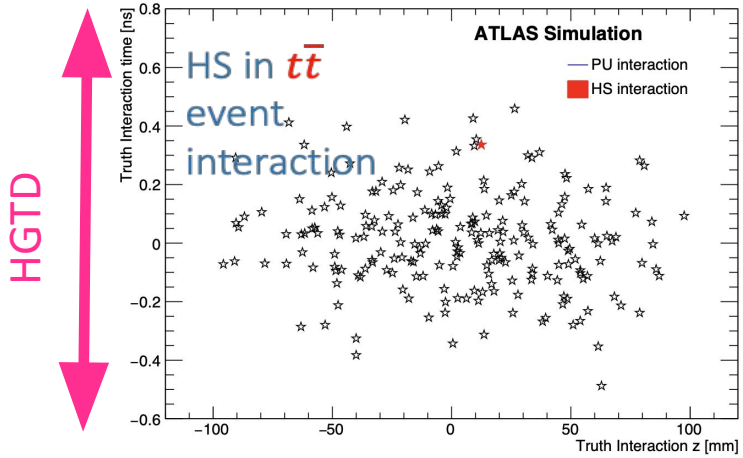
High Luminosity (HL)-LHC program

- Key numbers :
  - Instantaneous luminosity 7.5x1034 $cm^{-2}s^{-1}$ (~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



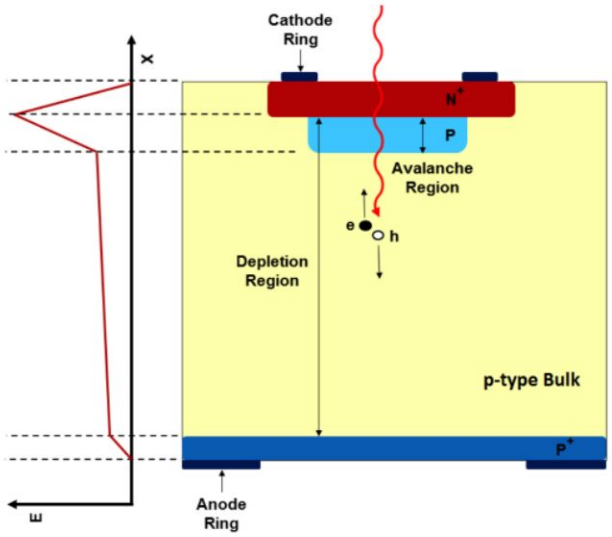






Low Gain Avalanche Diode: Sensors

- 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 size1.3 ×1.3 mm^2
    - Compromise between rise time, capacitance, occupancy
  - Signal level: 10 fC (w/20 gain) before and 4 fC (w/8 gain) after irradiation

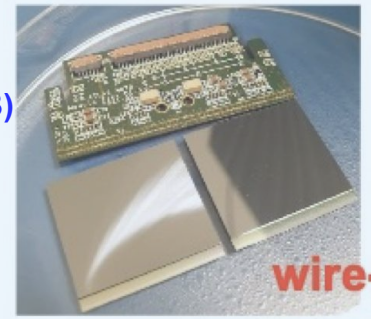


HGTD module assembly

1

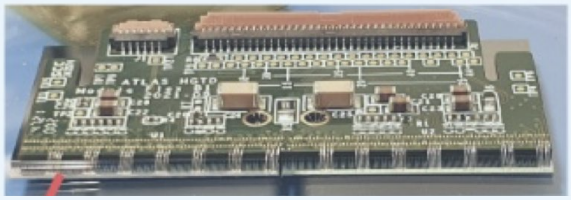
Module FLEX (flexible PCB)

2 Hybrid (LGAD + ASIC)



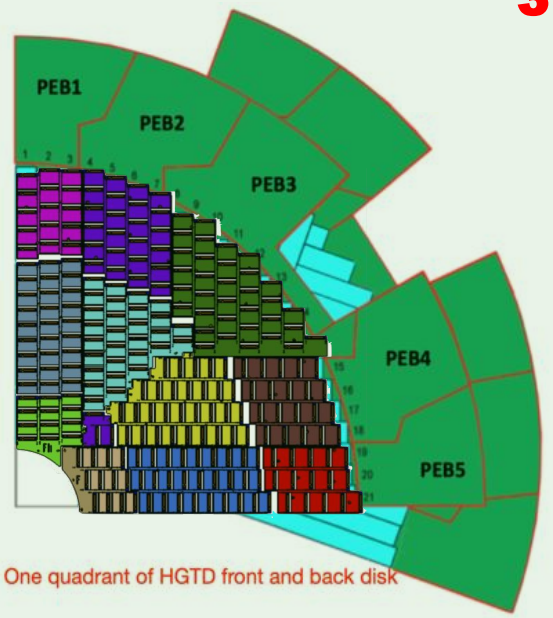
Module
(8034 modules per disc)

glue+
wire-bonds



Assembled module

3



One quadrant of HGTD front and back disk

2

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

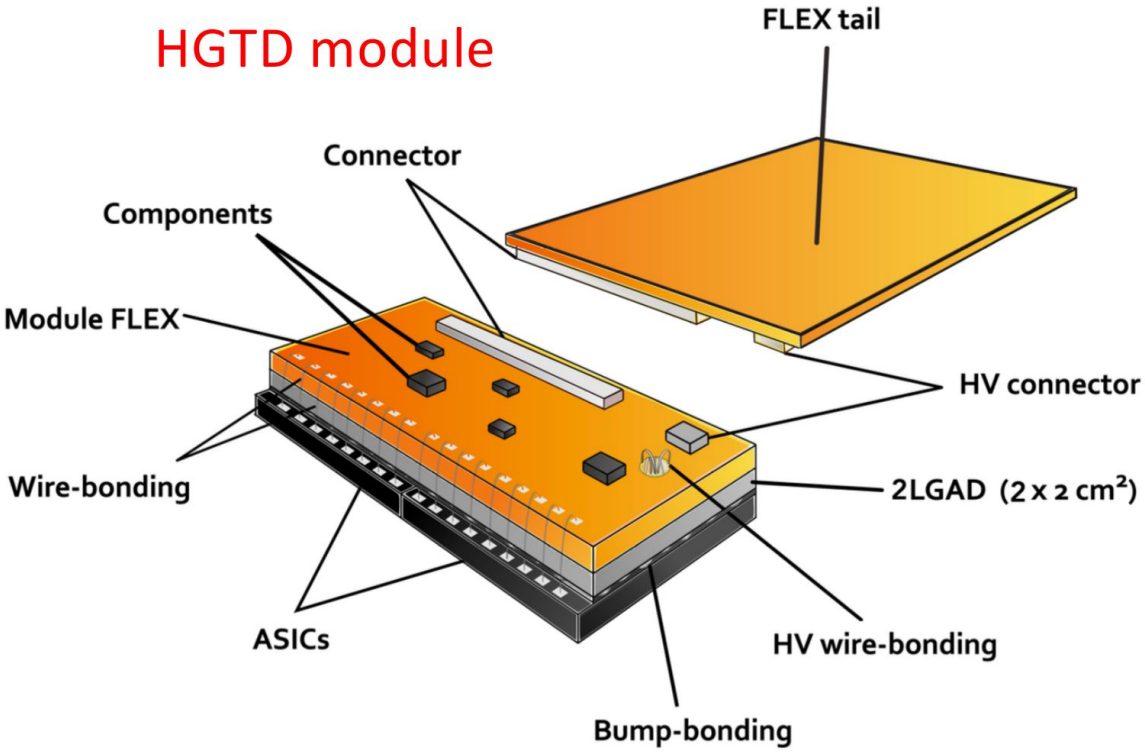


Image upload (assembled module)