

u<sup>b</sup>

UNIVERSITÄT  
BERN

AEC  
ALBERT EINSTEIN CENTER  
FOR FUNDAMENTAL PHYSICS

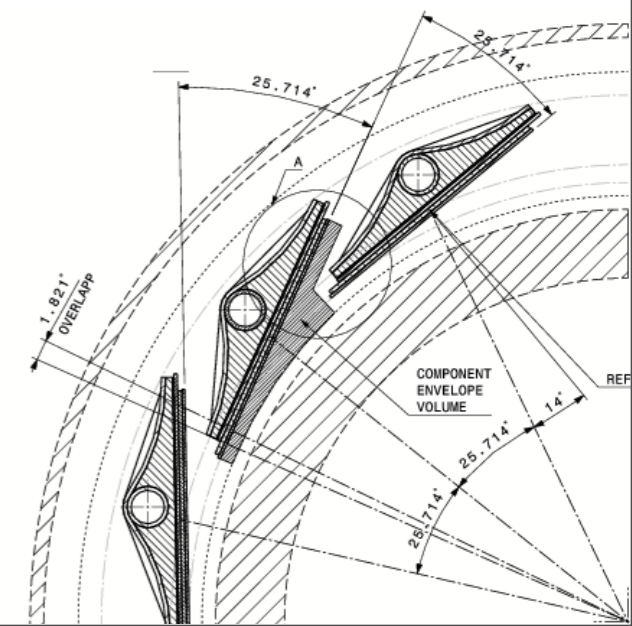


# IBL Module Quality Check

*triboung*

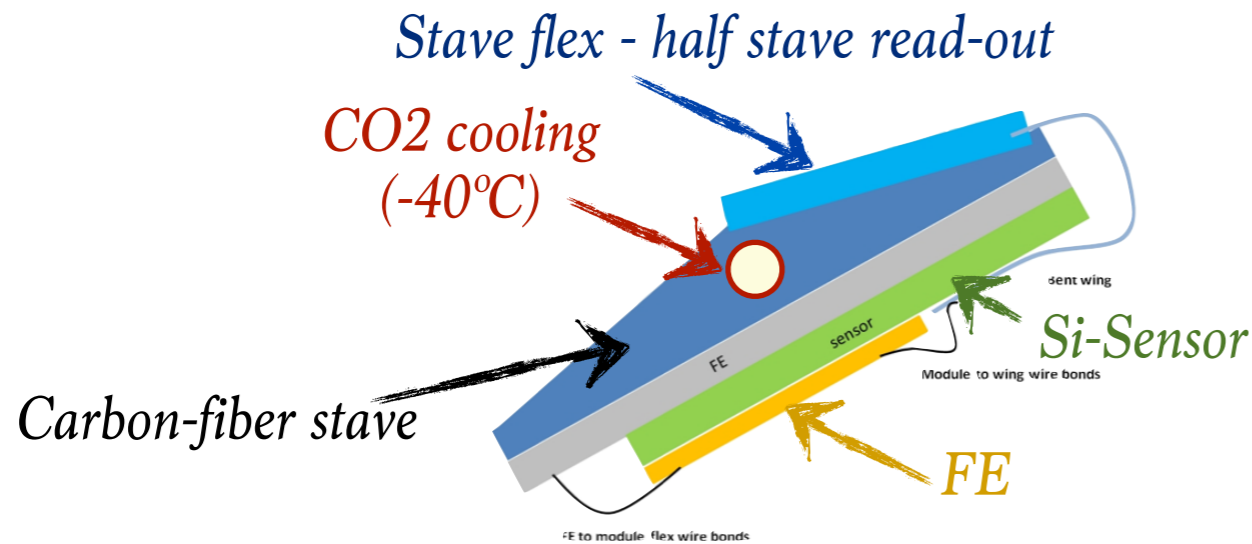
SPS Annual Meeting - 1 July 2014  
Stefania Stucci - Universität Bern

- The IBL Project
- Module Reception Test and Stave Test

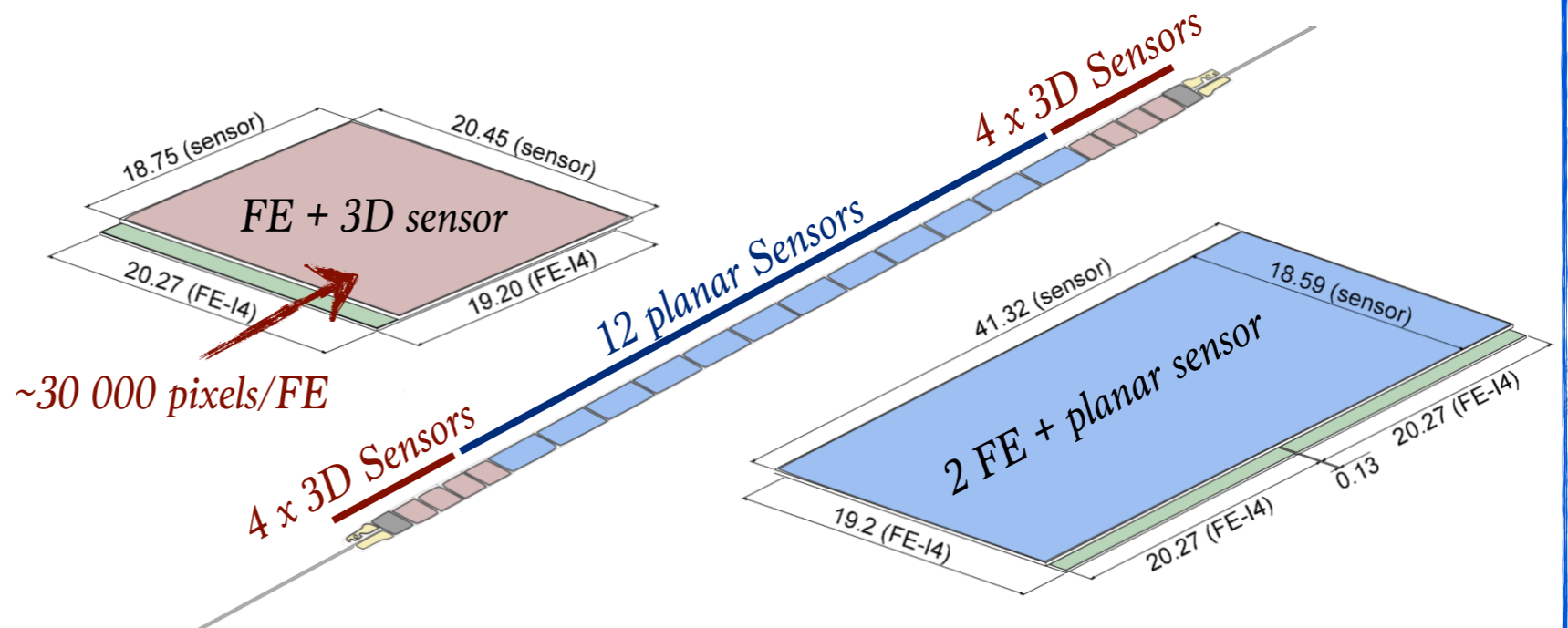


# IBL Mechanical Design

- Average radius of 34mm with a 9mm envelope
- Pixel size ( $\varphi, z$ ): 50,250  $\mu\text{m}$
- 1.9%  $X_0$
- $|\eta| < 2.5$
- Hermeticity ensured with an overlap of 1.8° between staves
- 250Mrad TIF and  $5 \cdot 10^{15} \text{ n}_{\text{eq}} \text{cm}^{-2}$  NIEL

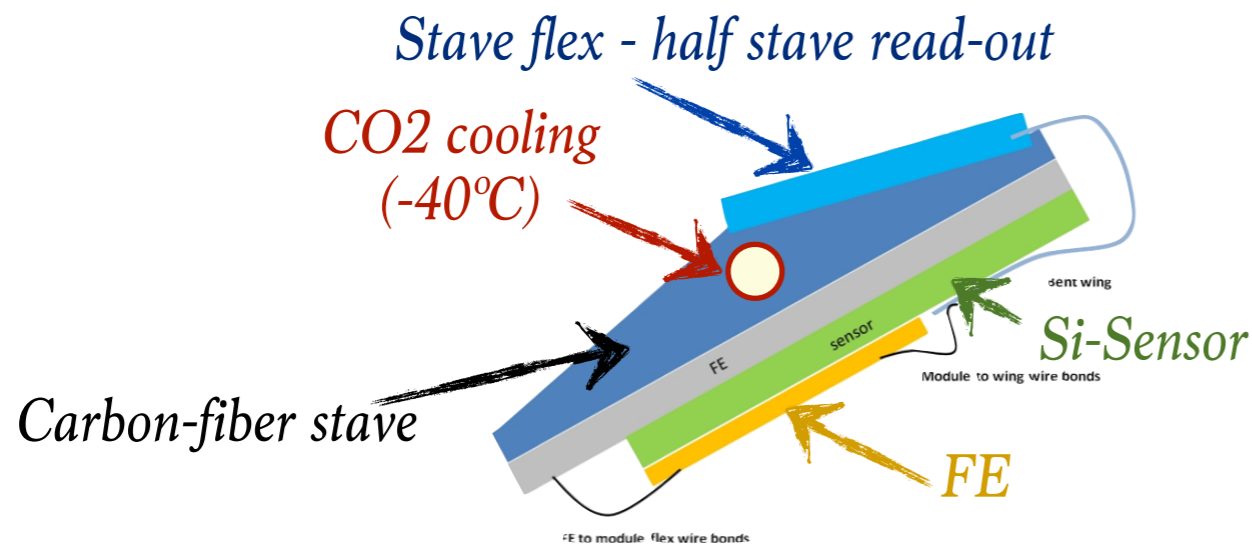


- Composed of 14 staves
- 2 Sensor Technologies: Planar, 3D
- New FEI4 - 32 chips per stave - 448 in total

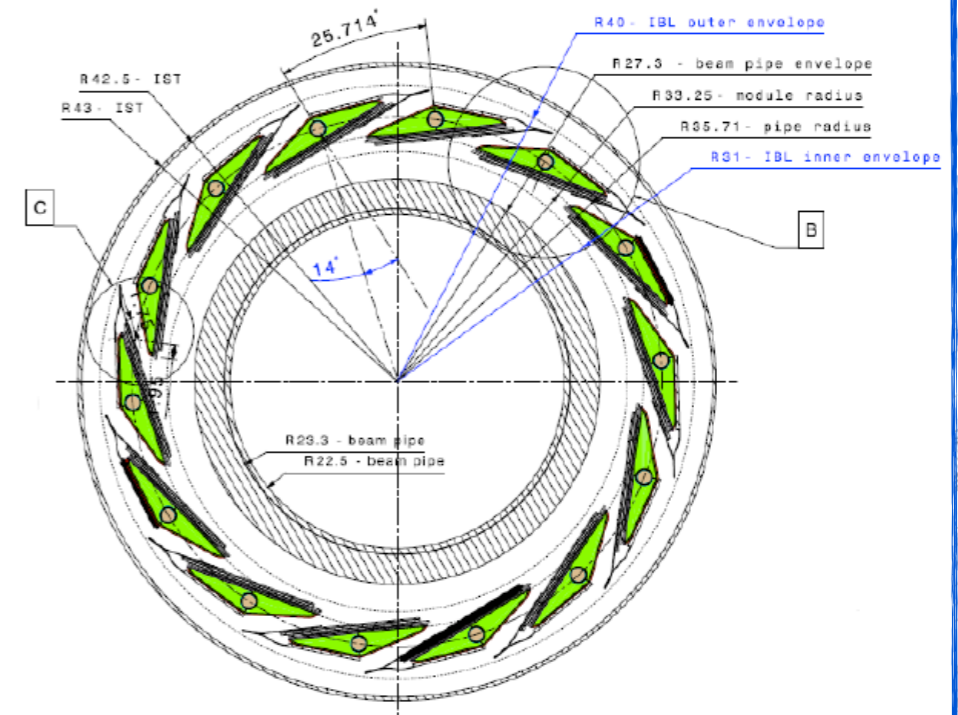
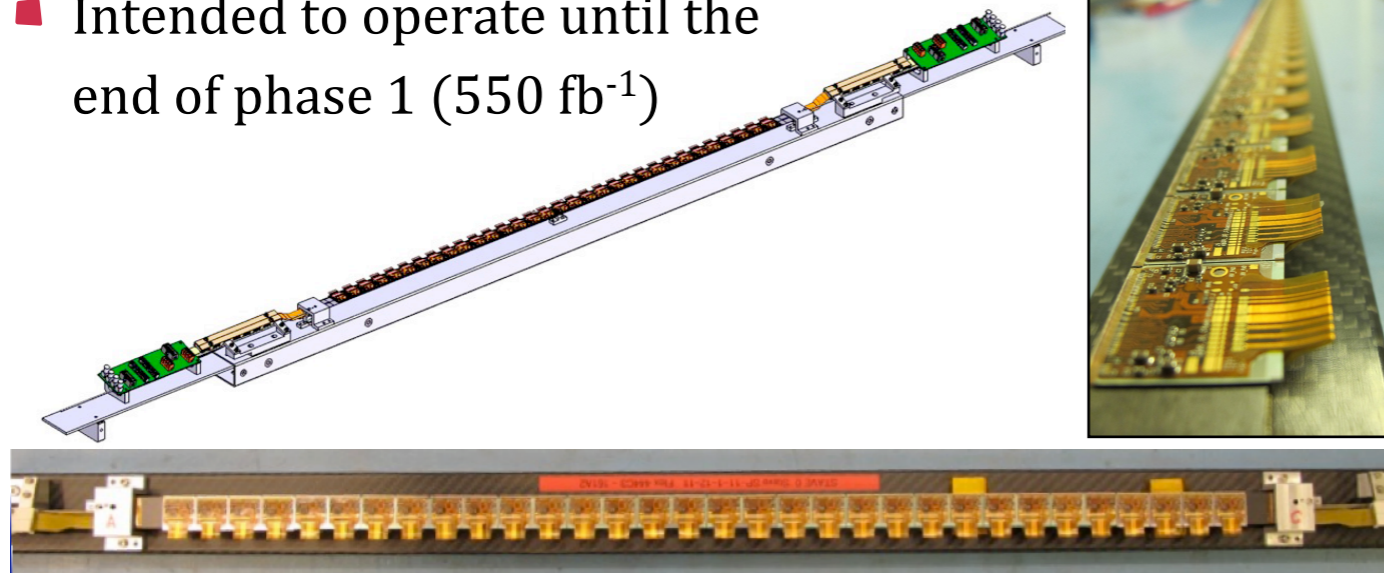


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- Installation completed in the 2013-2014 shutdown
- Intended to operate until the end of phase 1 ( $550 \text{ fb}^{-1}$ )







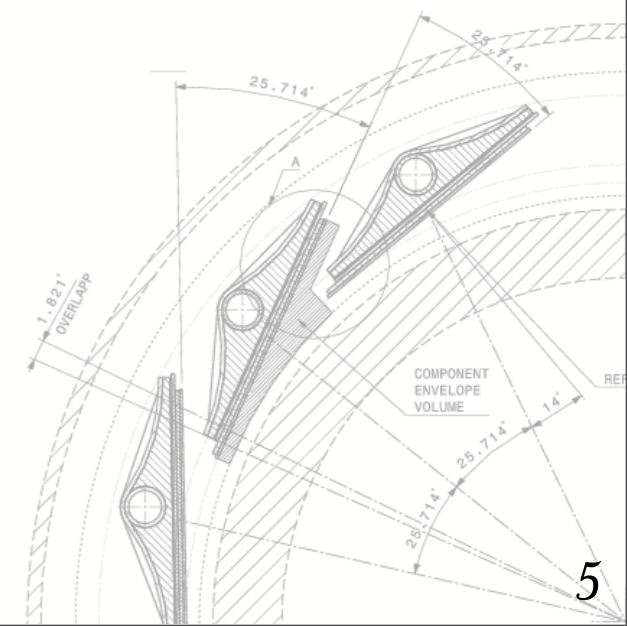


# Module Reception Test

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Aim to check the functionality of modules after the shipment from the production sites to the loading site. The procedure consists of:

- Optical Inspection
- Electrical Qualification



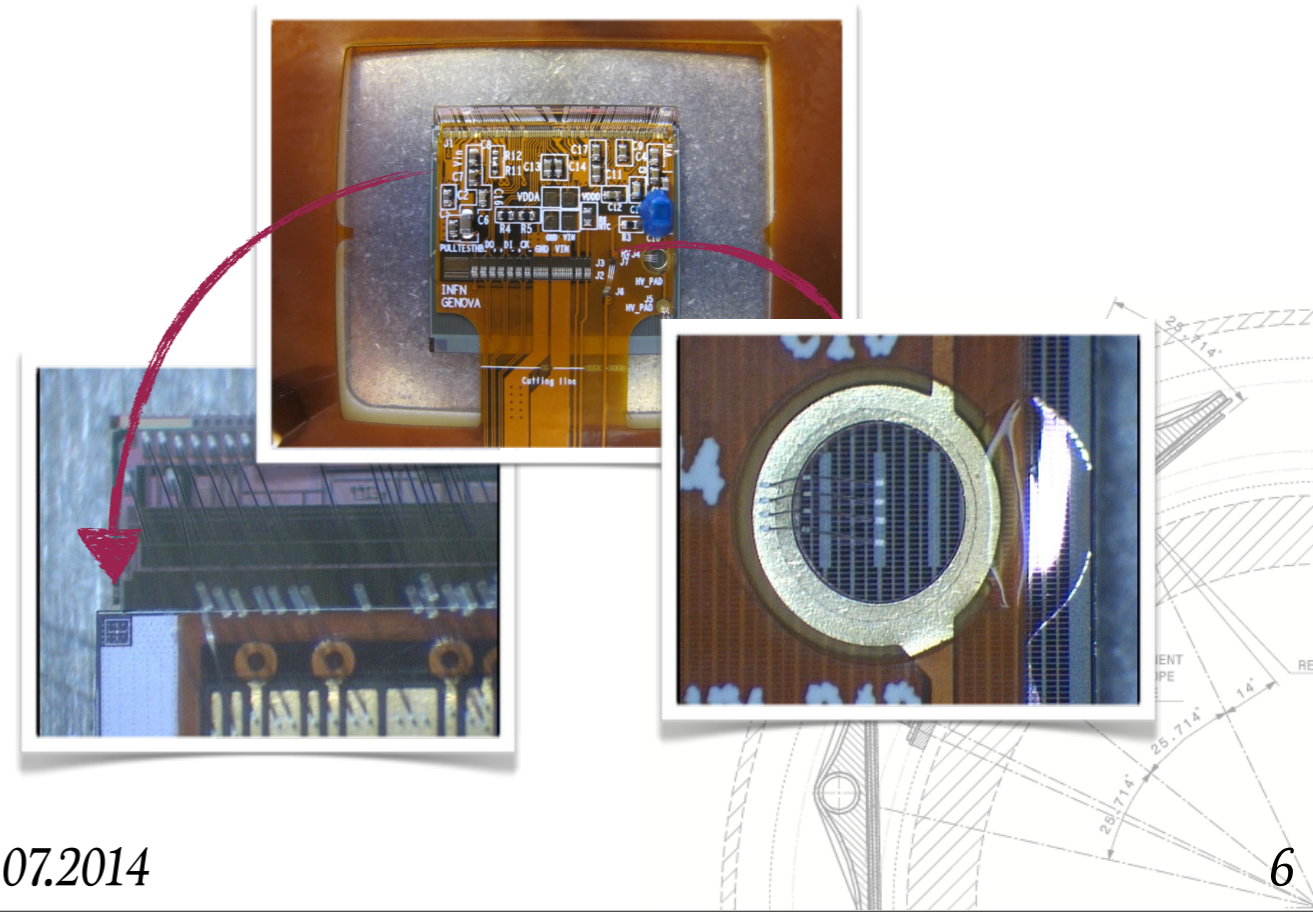
# Module Reception Test: Optical Inspection

Aim to check the functionality of modules after the shipment from the production sites to the loading site. The procedure consists of:

- Optical Inspection
- Electrical Qualification
- ▶ Modules Integrity
- ▶ Particular attention to: wire bondings, fiducial marks, HV pads
- ▶ High resolution pictures saved for reference

*Microscope+Digital Camera*

*Extra Microscope*



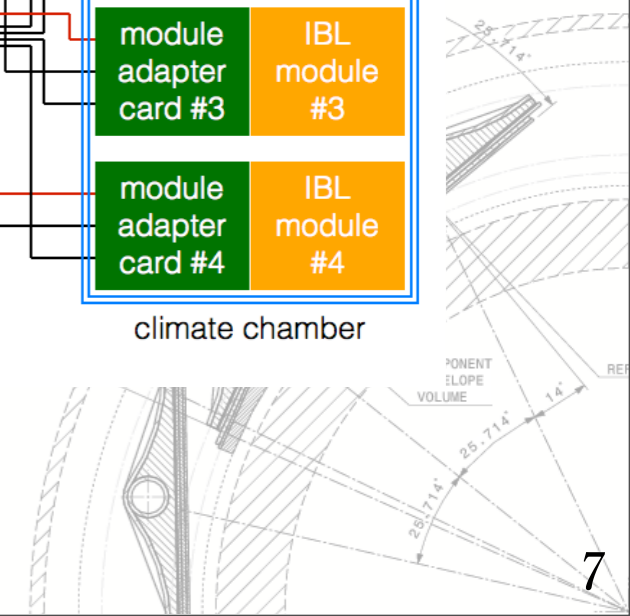
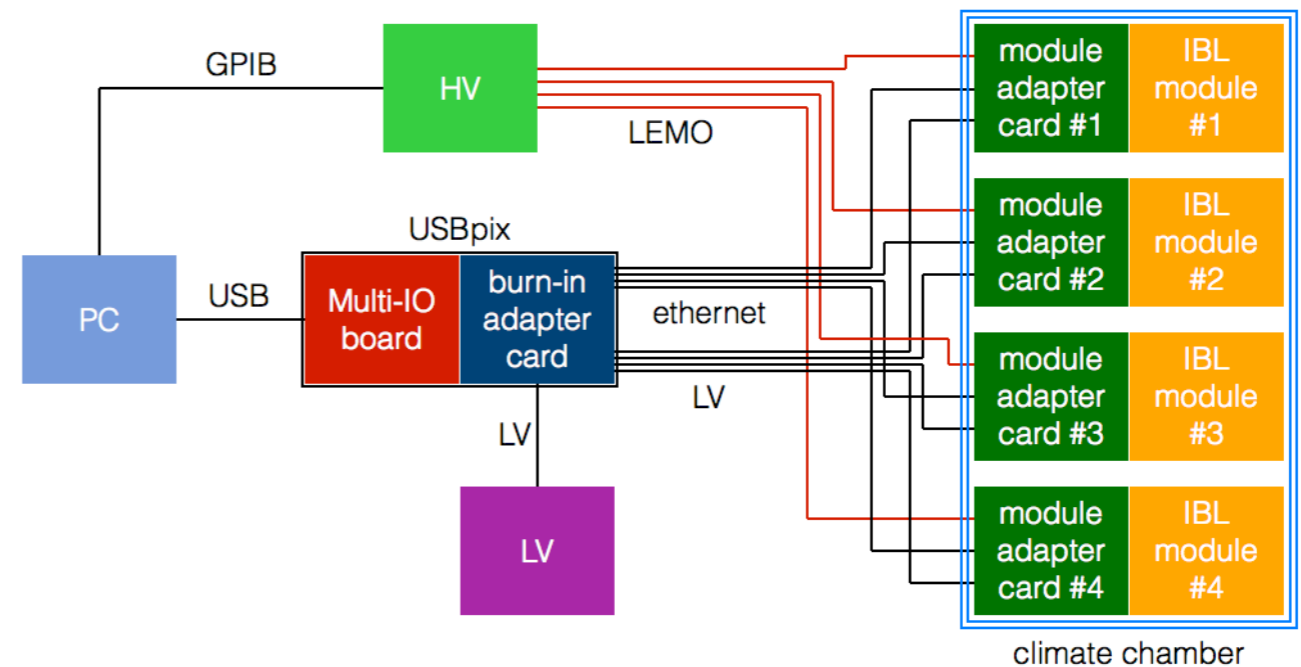
# Module Reception Test: Electrical Test

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- Optical Inspection
- Electrical Qualification
  - ▶ I-V Curve (FE on/off)
  - ▶ FE operation-tests (HV on/off)

Two alternative Readout System :

- ▶ USBpix (Bonn)
- ▶ RCE (SLAC)





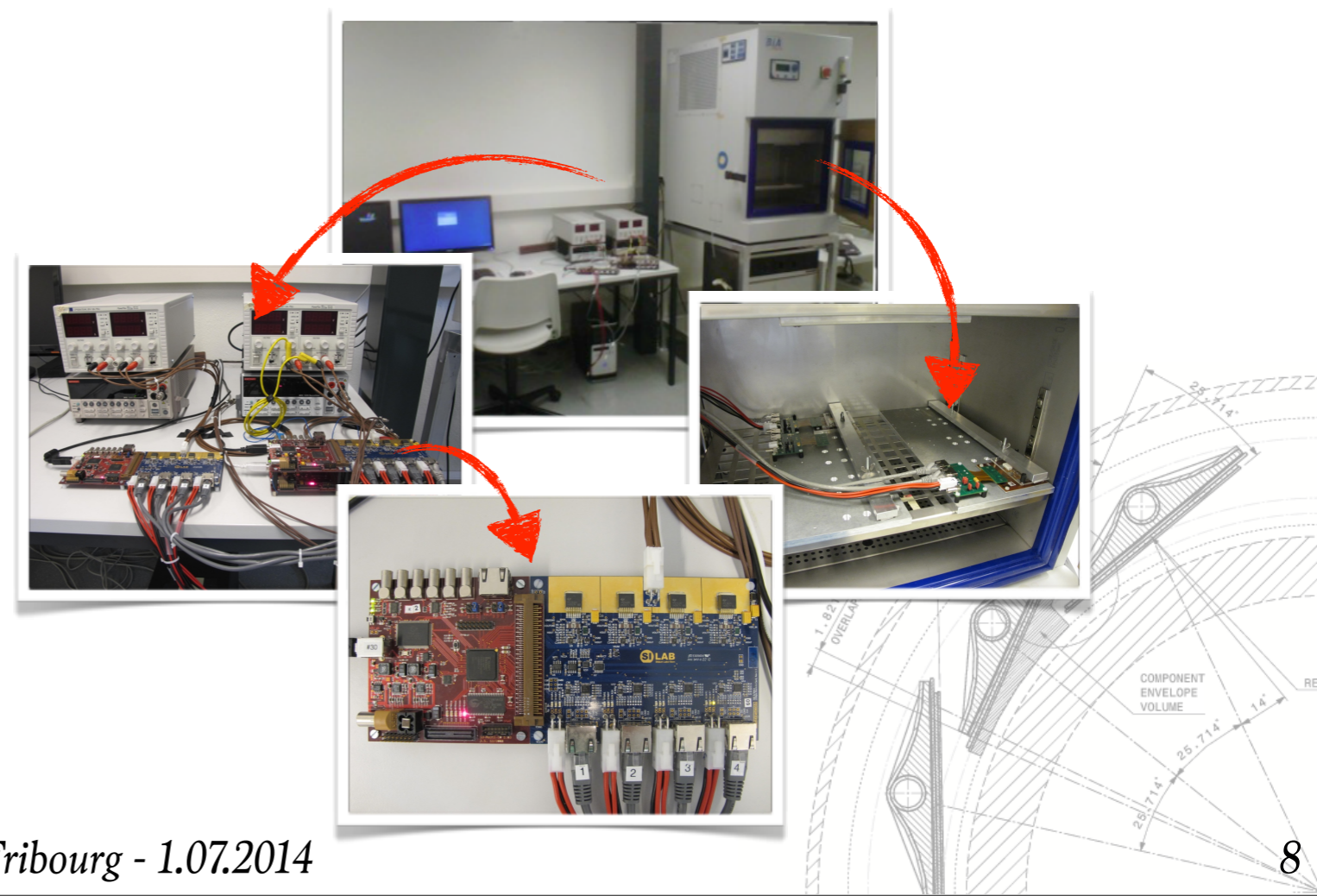
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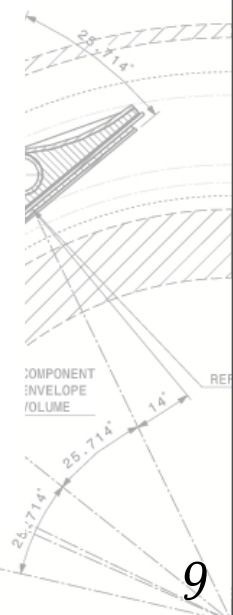
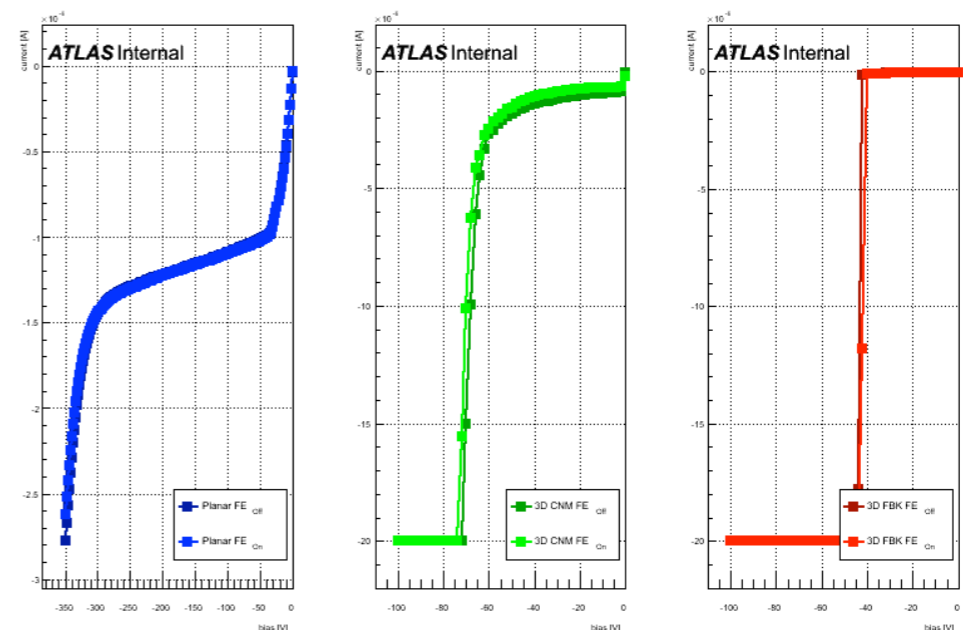
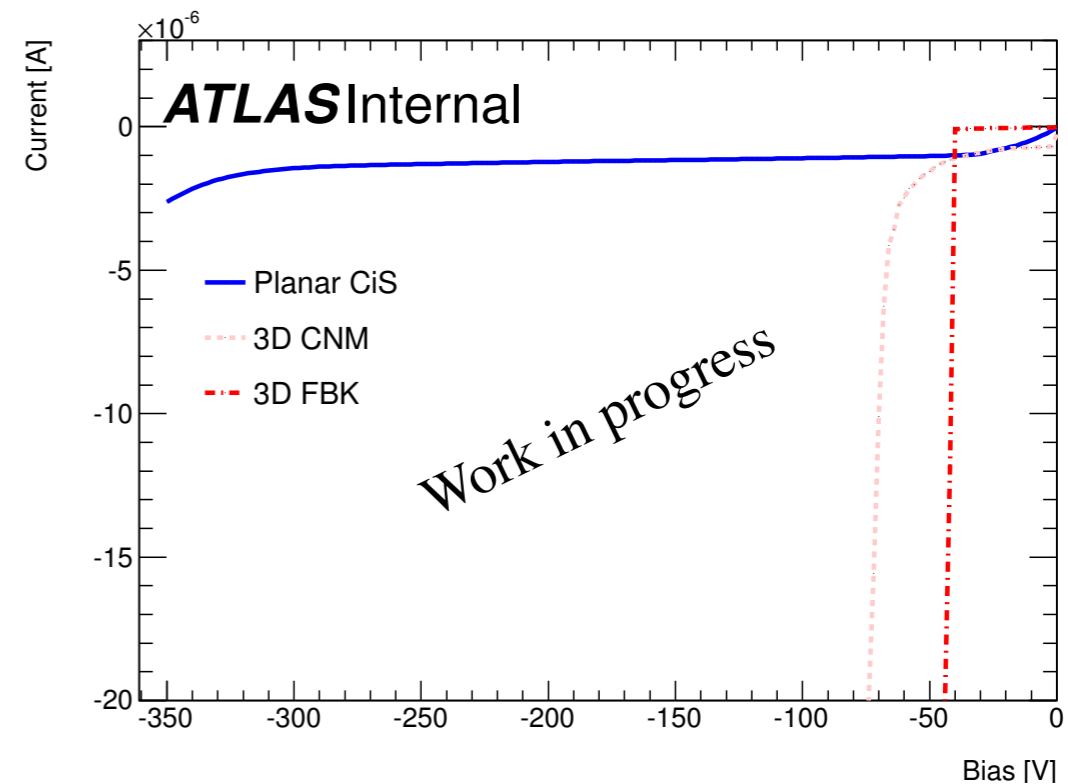
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- ▶ USBPix (Bonn)
- ▶ RCE (SLAC)



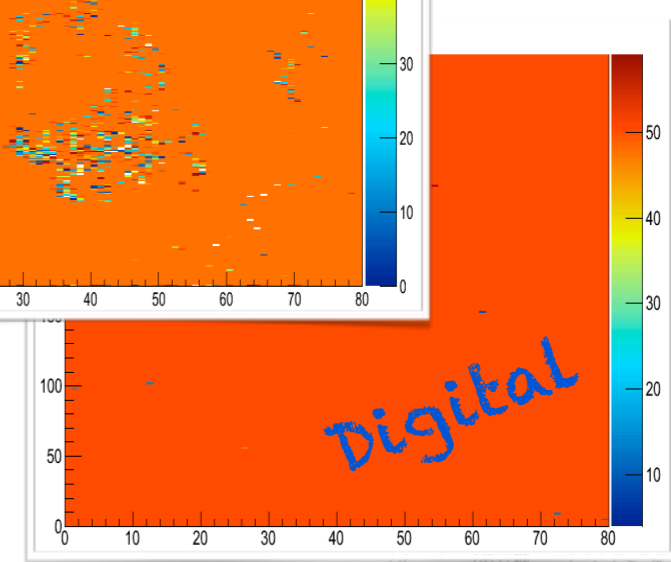
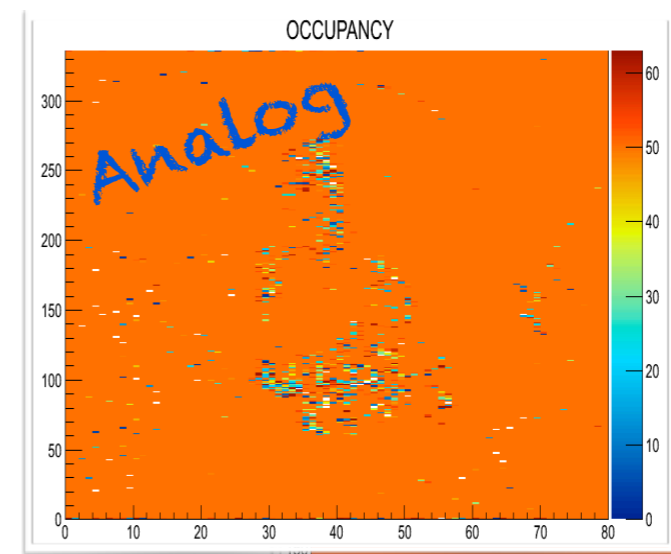
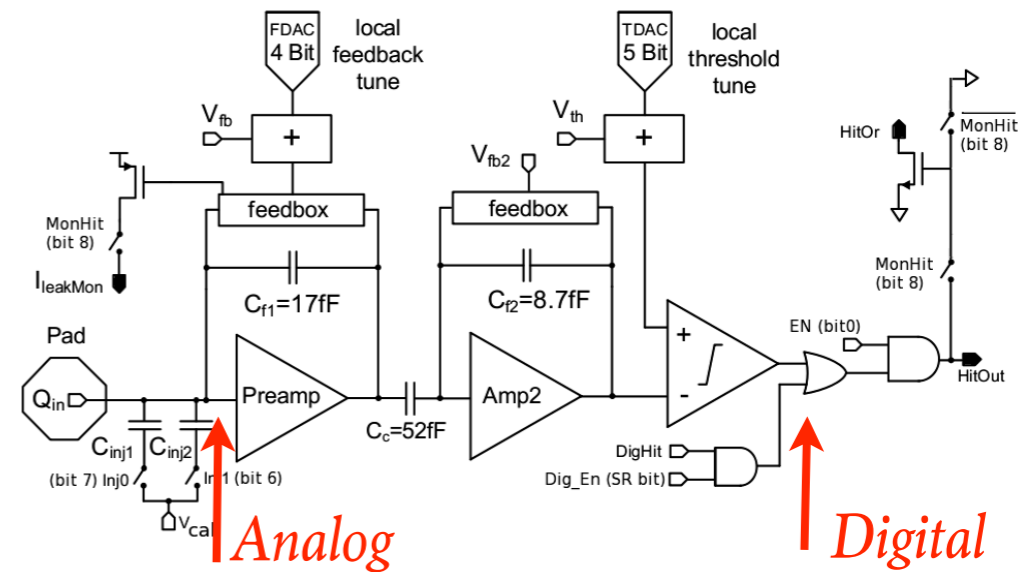
# Module Reception Test: I-V Scan

- Check for sensor damages
- Measurement of the I-V curve with FE on/off
- Different for 3D and Planar sensors
- Expected leakage current @ operational voltage:  $2\mu\text{A}$
- Expected breakdown:  $>120\text{V}$  for Planar,  $>35\text{V}$  for 3D



# Module Reception Test: Digital and Analog Scan

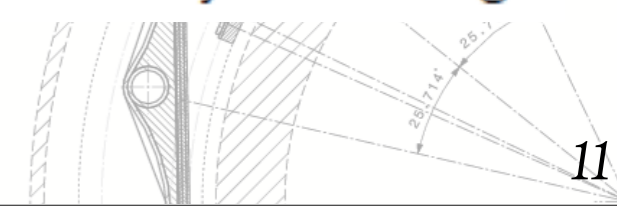
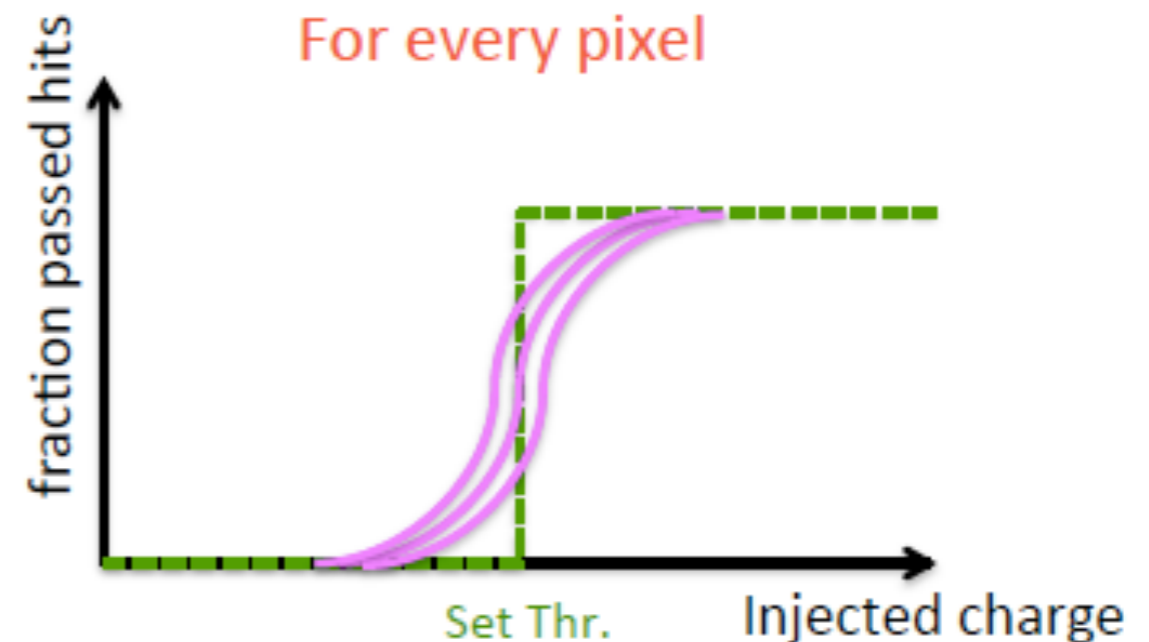
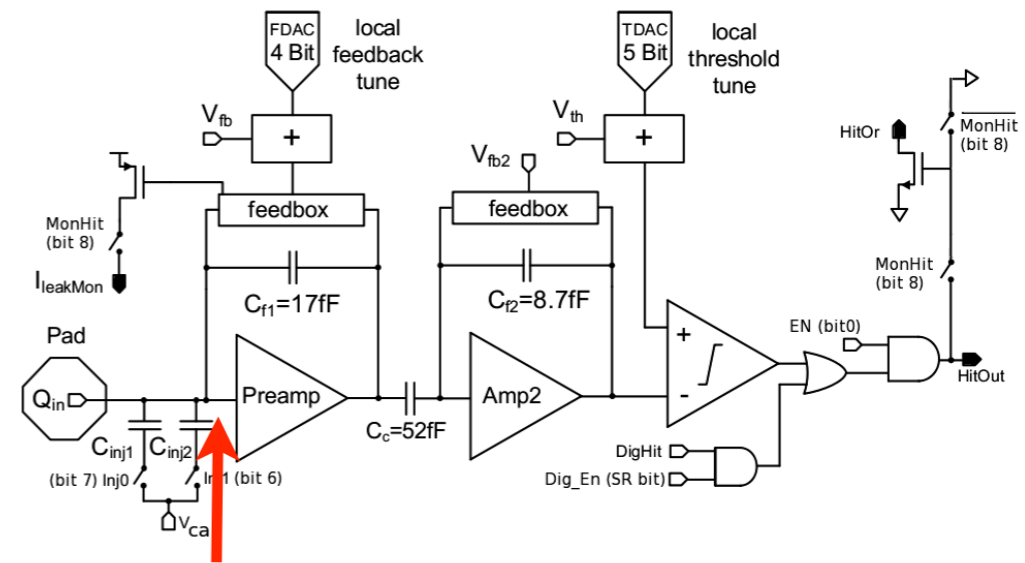
- Test the readout chain and detect the defective channels
- Injection of a large test charge to each pixel. The result is a map with the occupancy of each pixel
- To disentangle errors between the analog and digital readout chains a digital test can be used





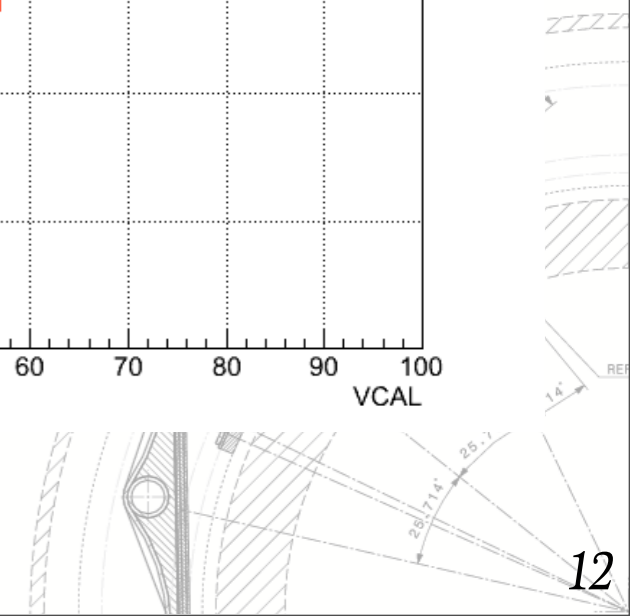
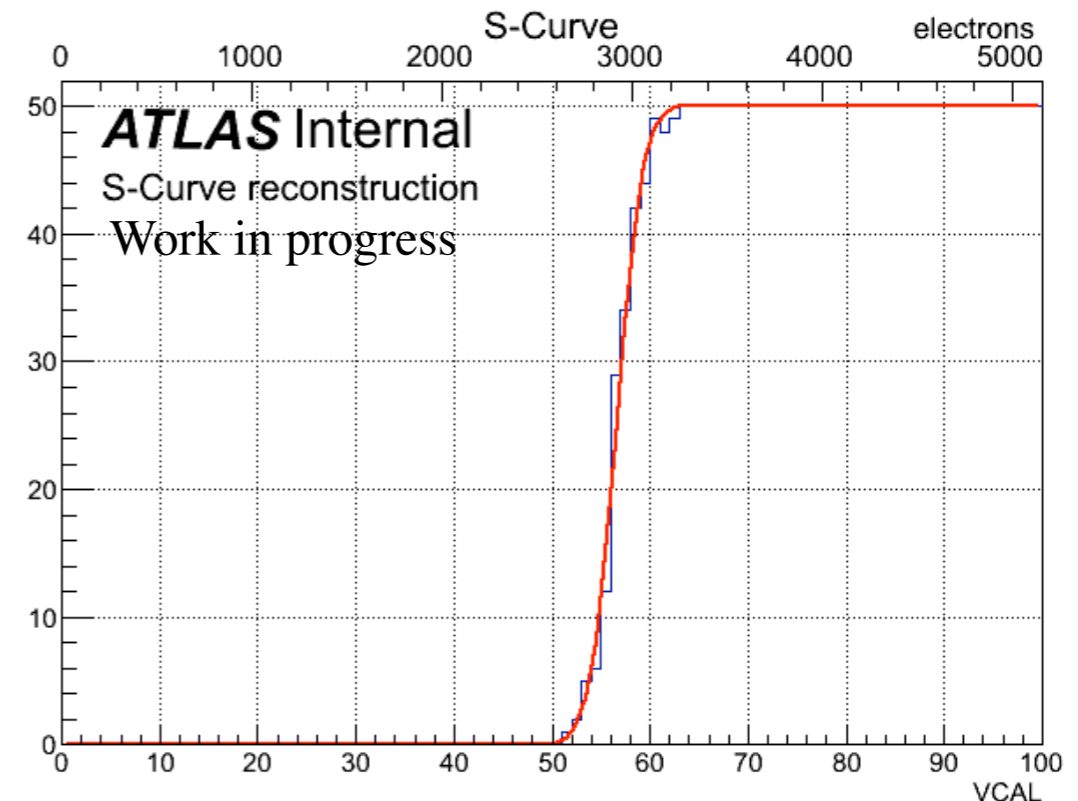
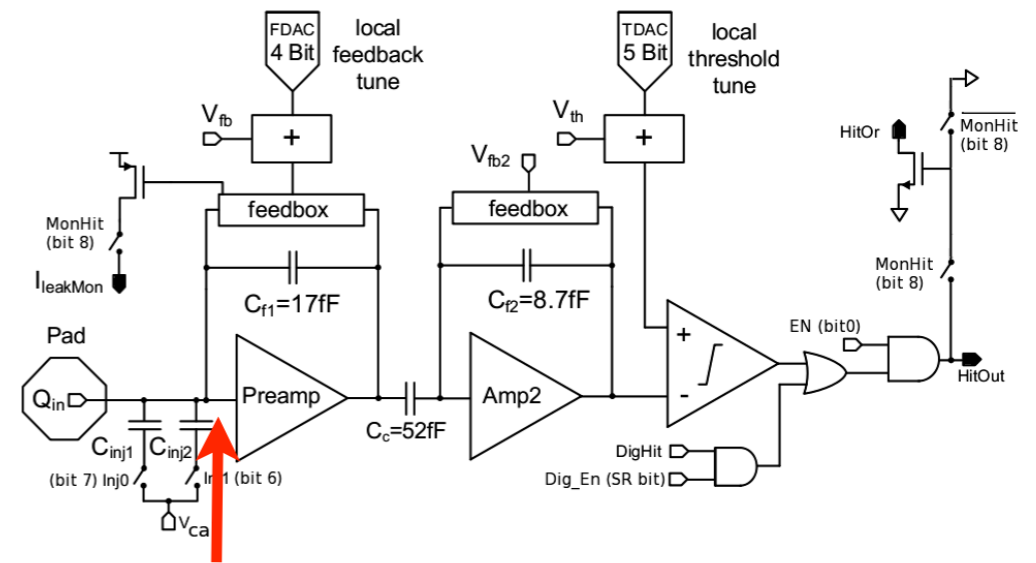
# Module Reception Test: Threshold Scan

- Measurement of the threshold and noise (ENC) of each pixel
- A certain number of pulses is generated for different values of the injected charge
- The fraction of hits as a function of the injected charge is the convolution of a step function (ideal case) and a gaussian (noise)
- If there's no difference in noise between HV off and HV on, the bump pixel is not properly connected



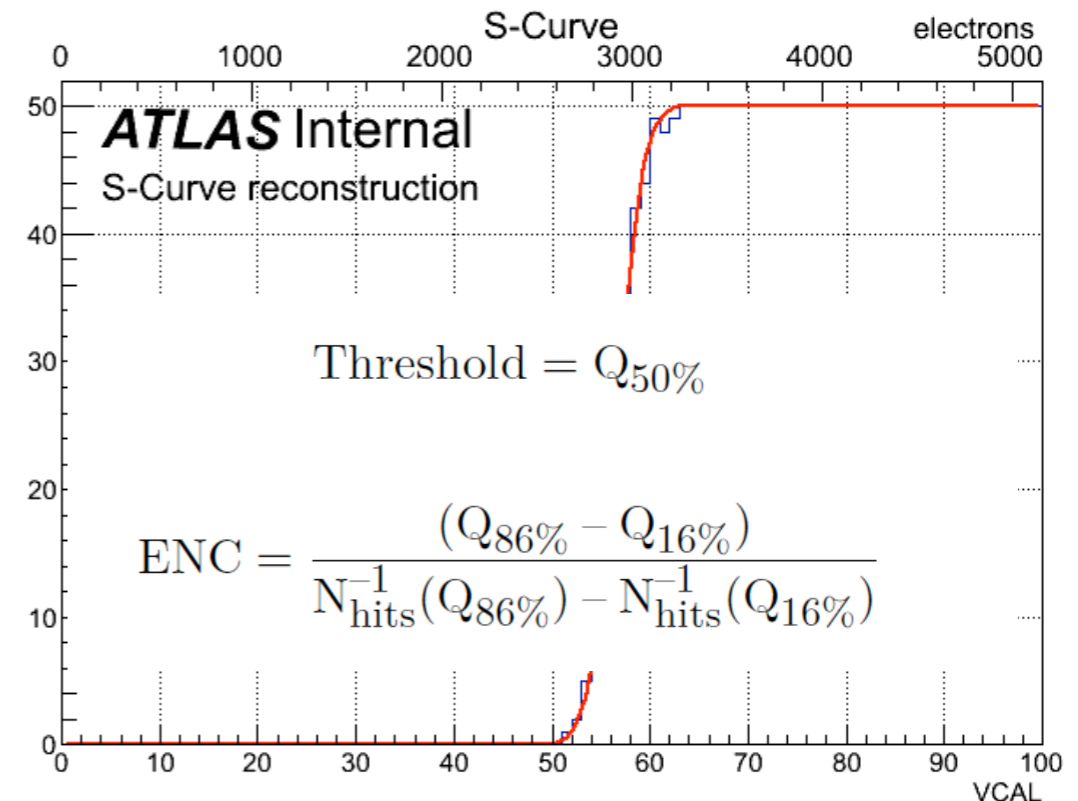
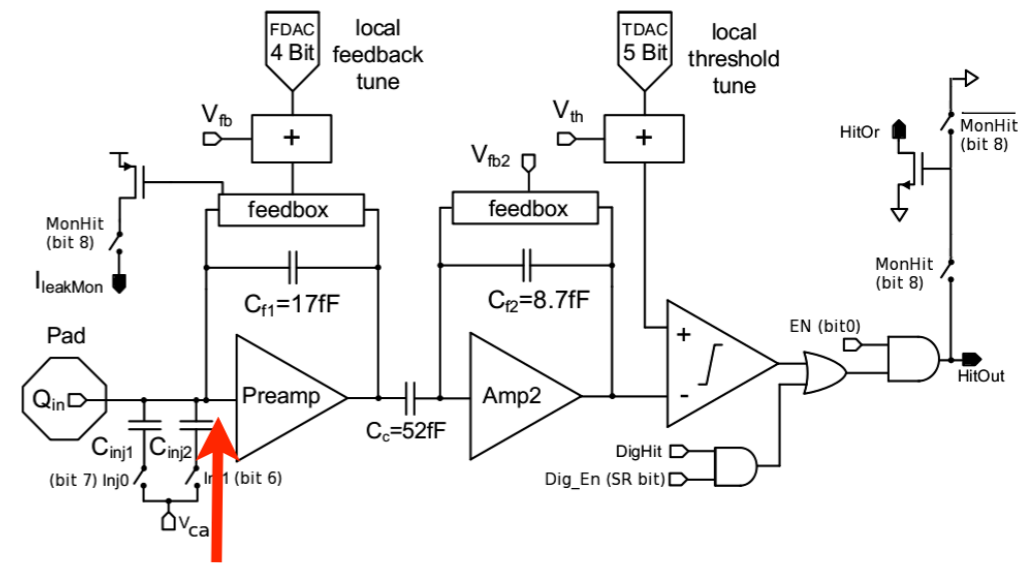
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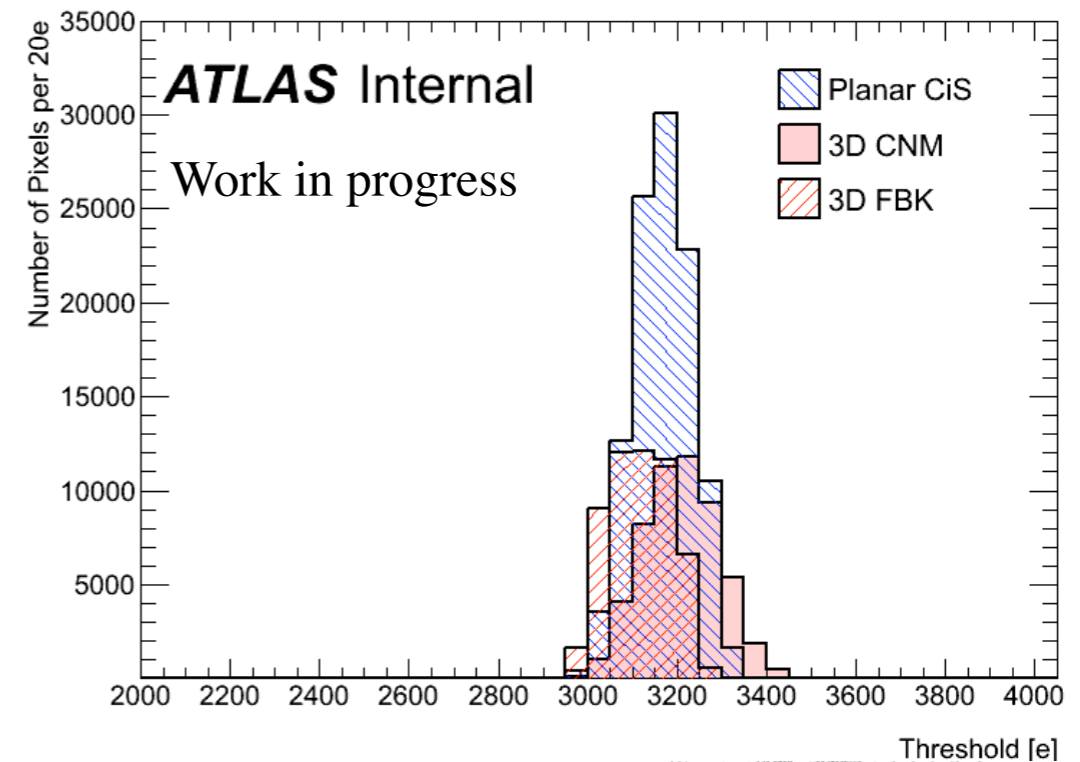
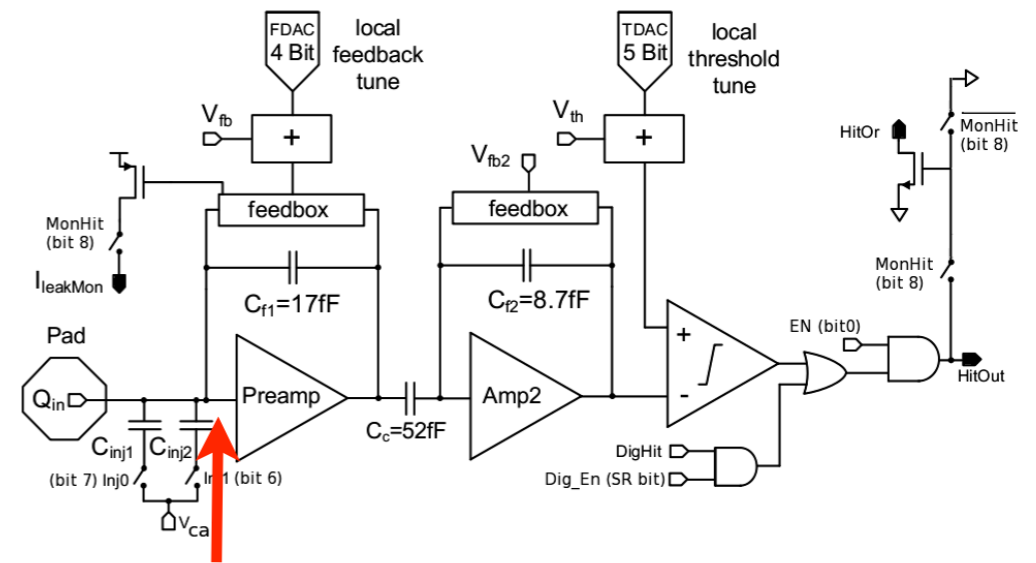
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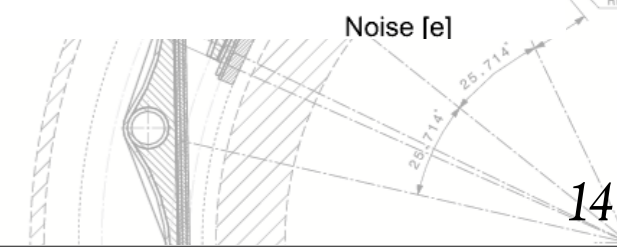
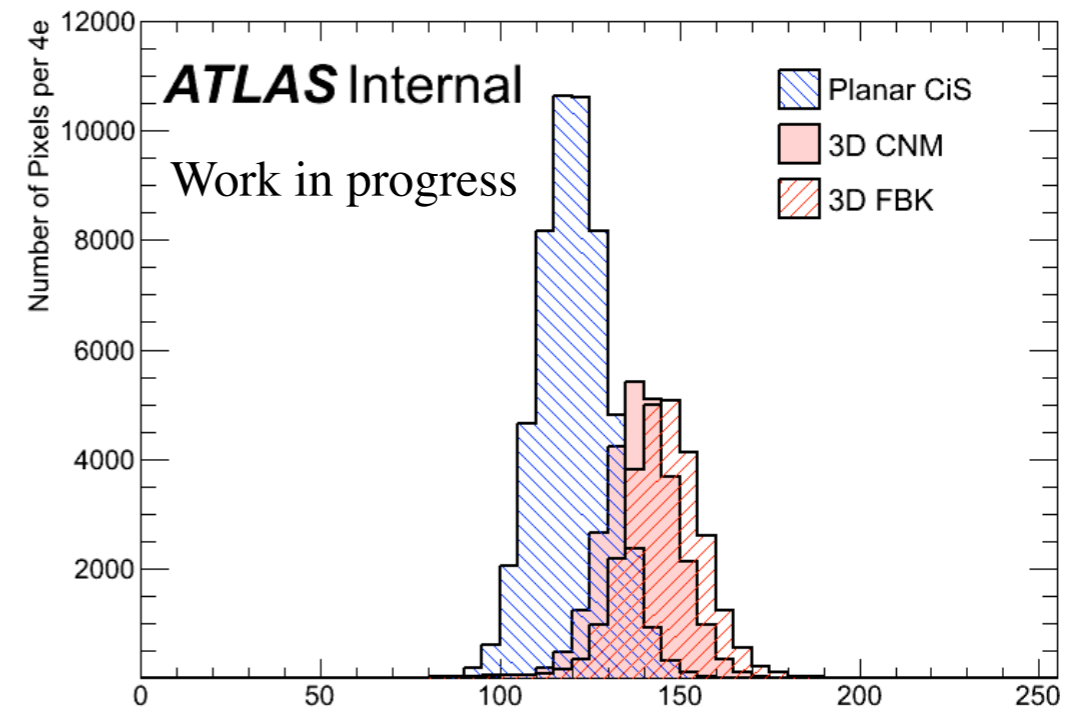
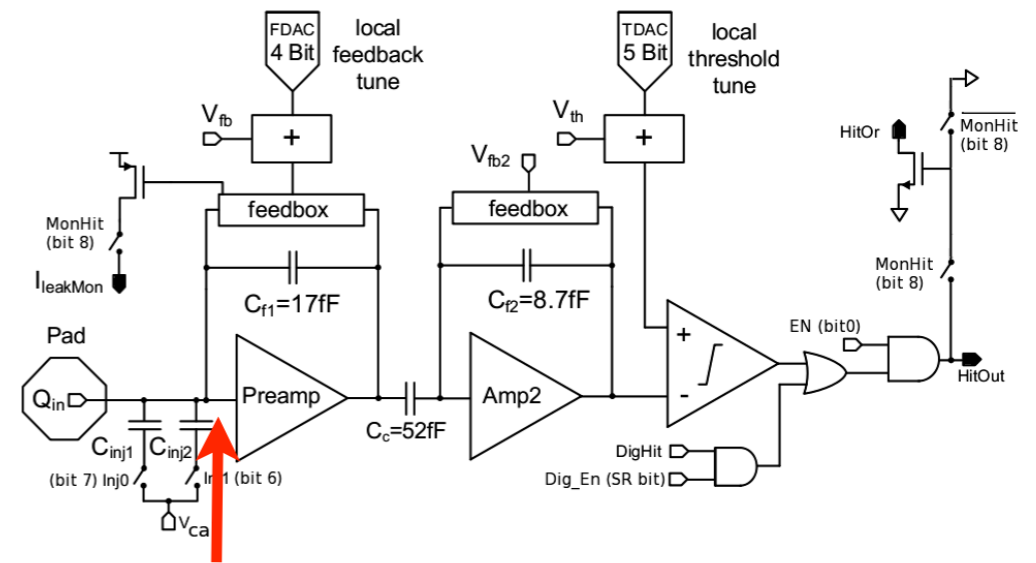
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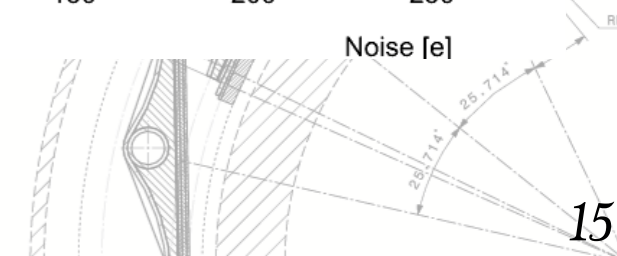
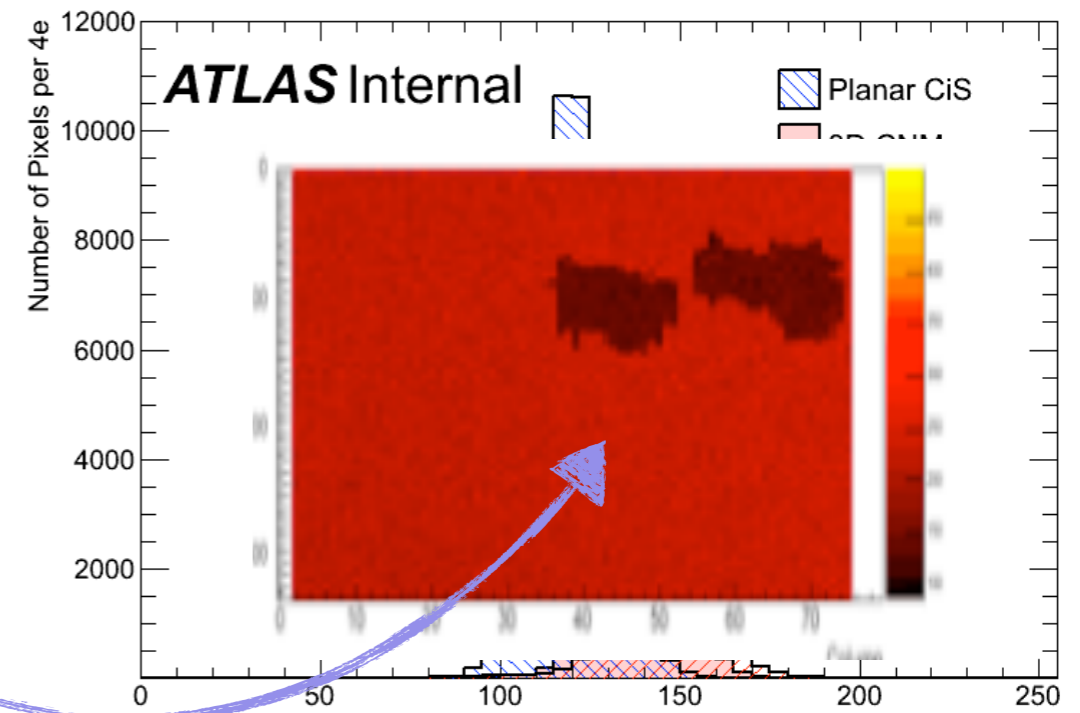
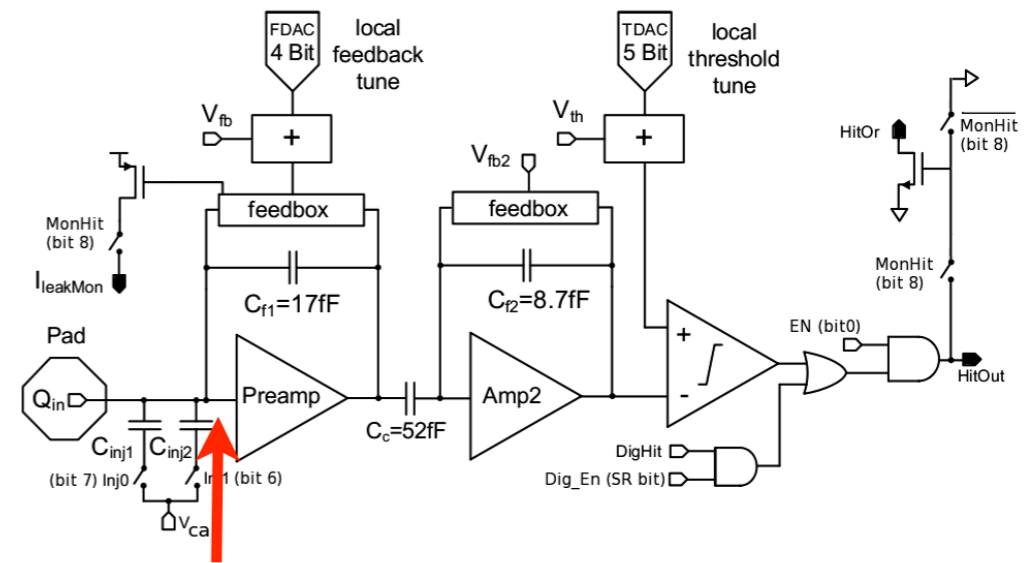
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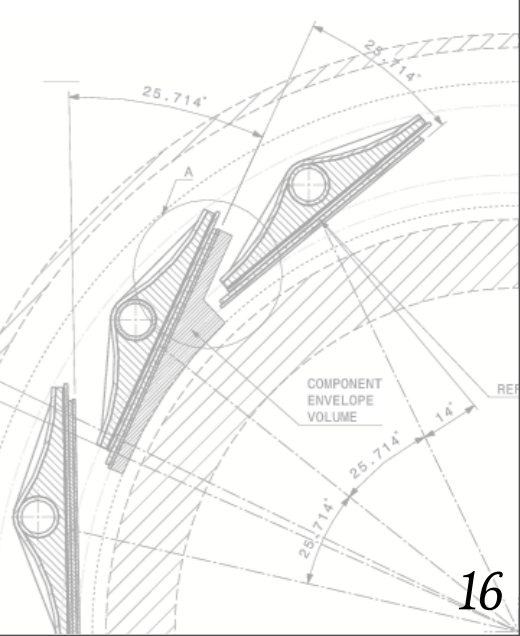
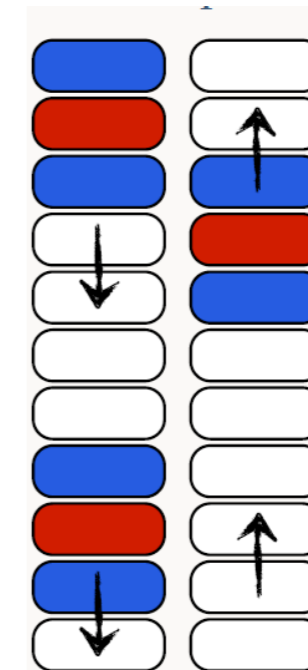
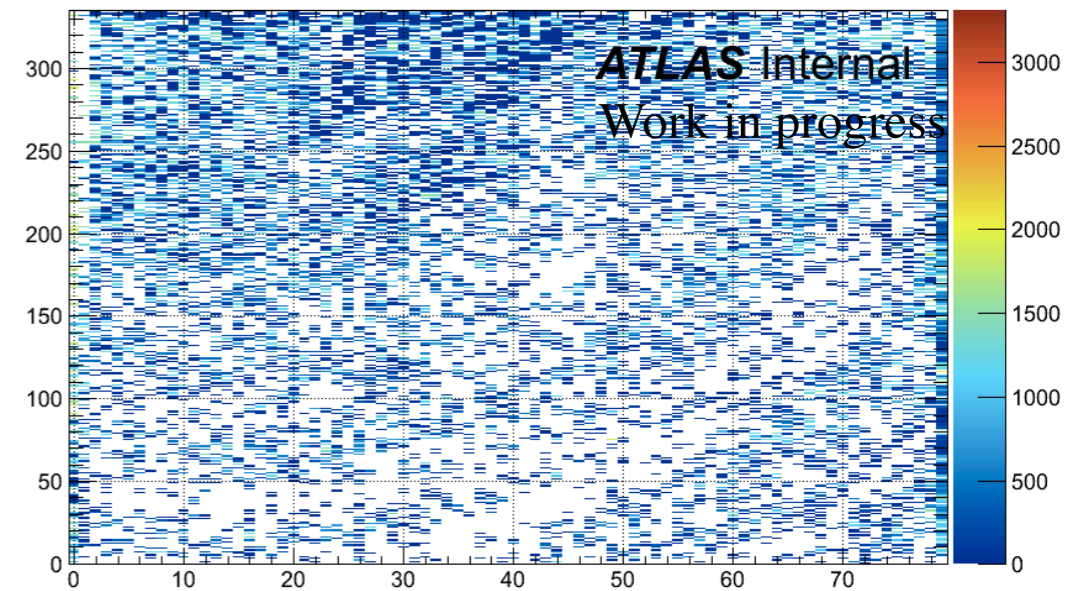
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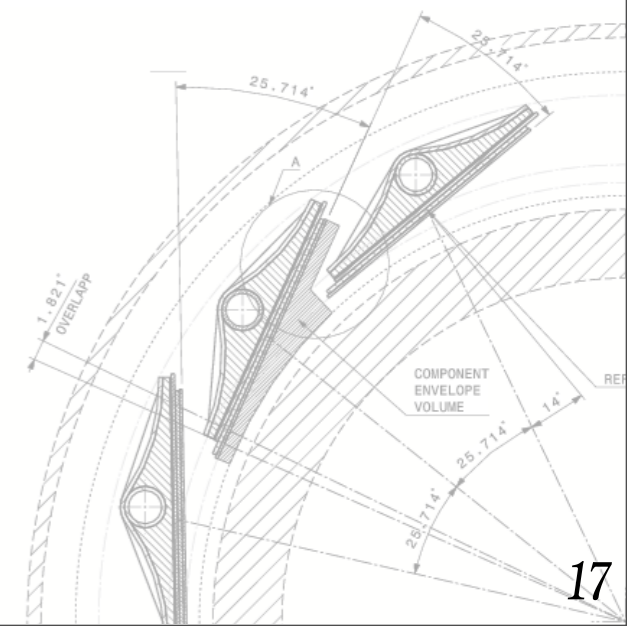
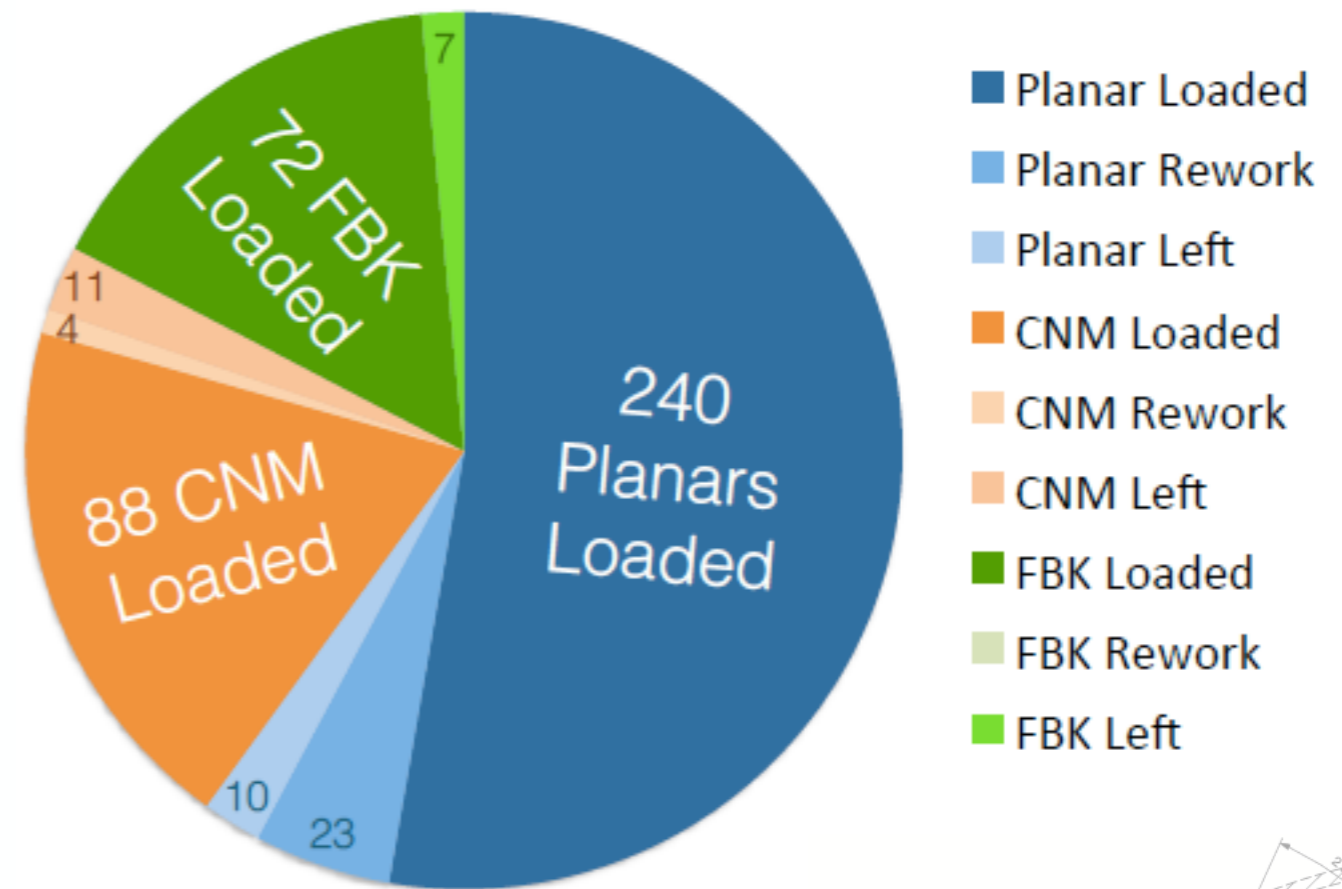
# Module Reception Test: Crosstalk Scan

- Coupling between pixels can result in a hit detected in a neighboring pixel.
- The charge is injected in two over next pixel size, while only the pixel in between is enable for readout
- Can be caused by shorted bumps



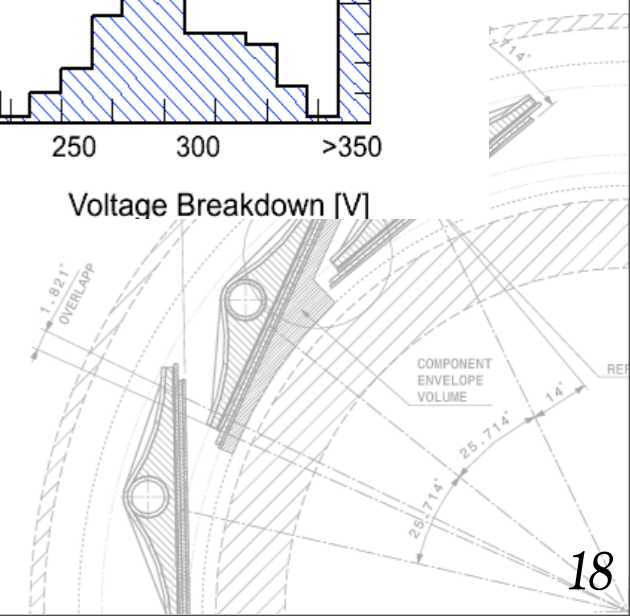
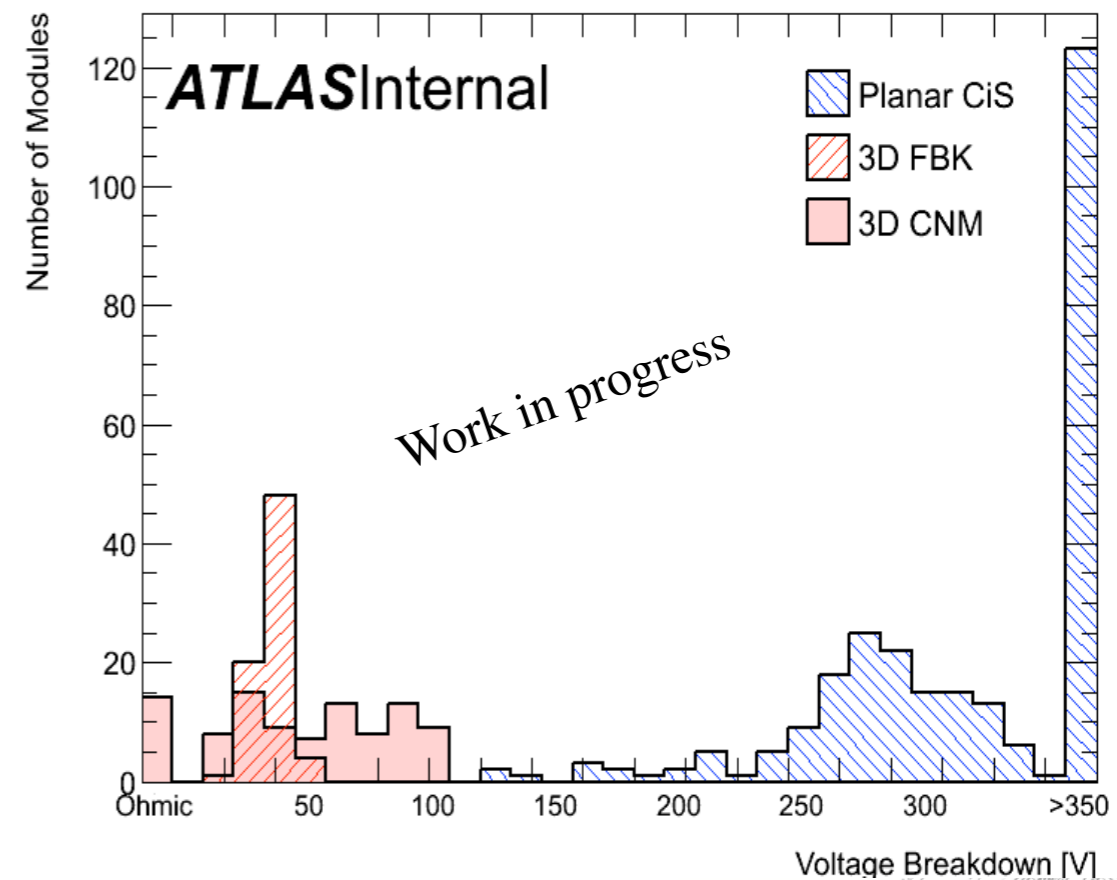
# Results: Module Reception Test

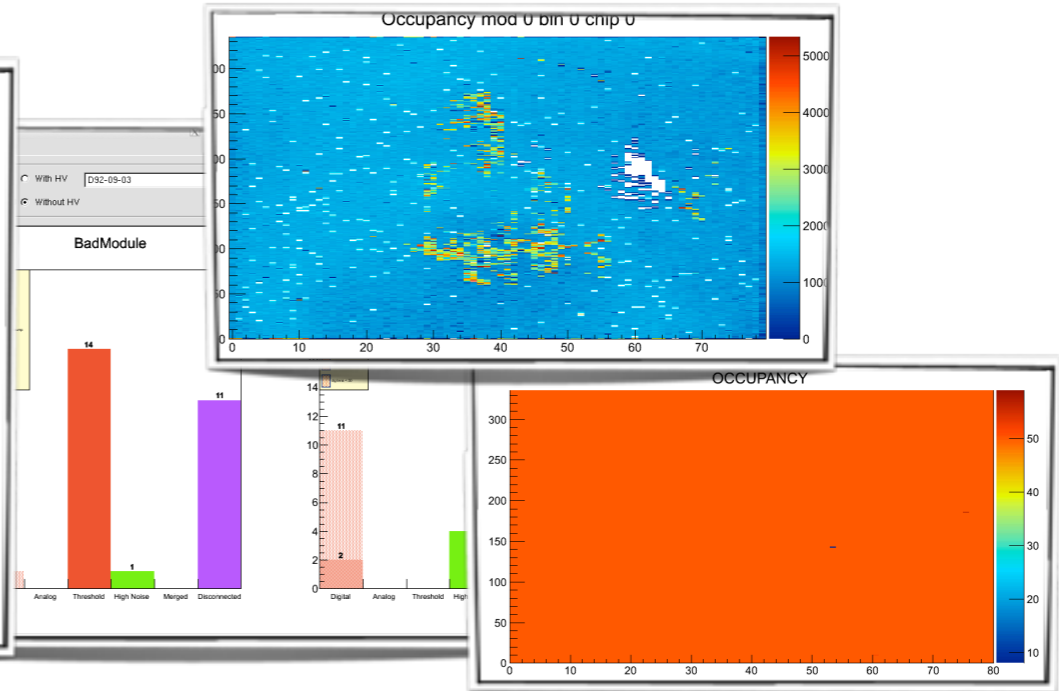
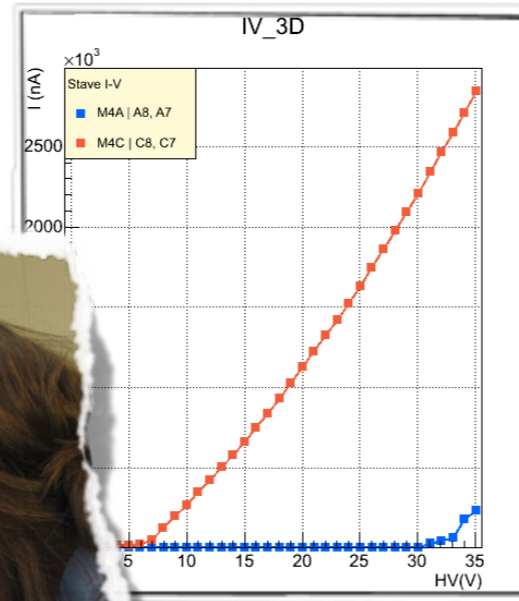
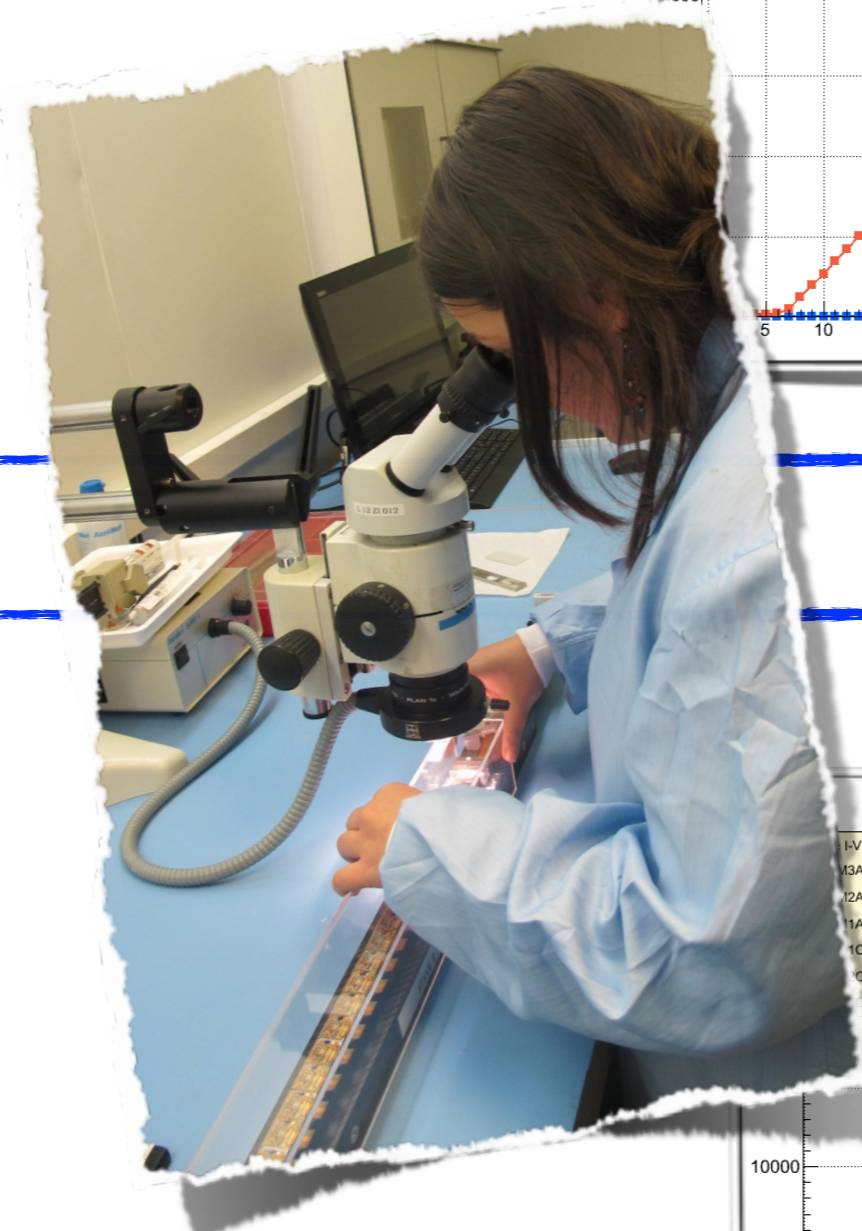
- 455 modules tested: 273 Planar + 103 CNM + 79 FBK
- No modules rejected at the optical inspection stage
- Less than 10 modules have been rejected due to functional issues
- Lowering in the BD value observed for few modules: a penalty was added to the initial ranking



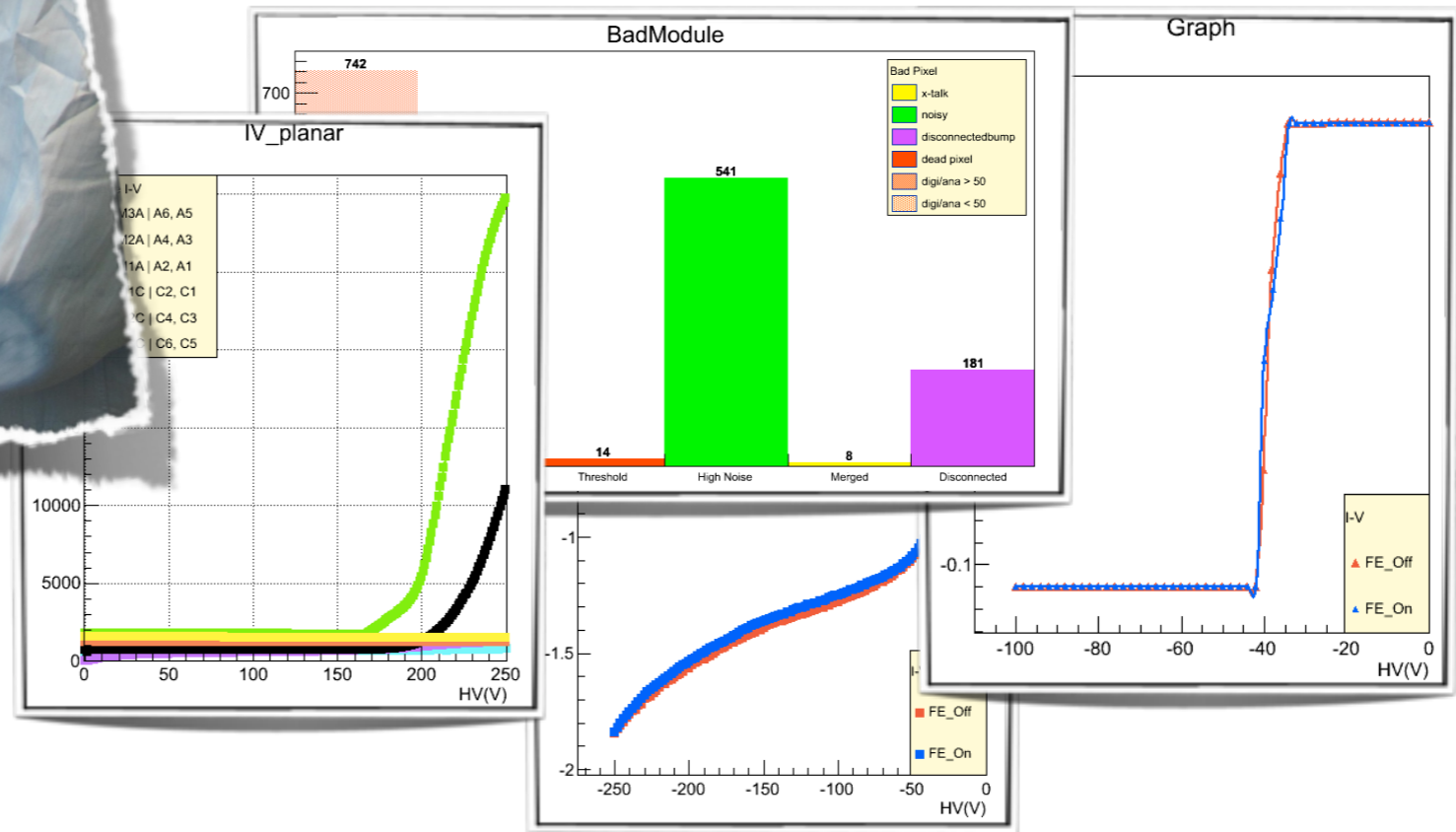
# Results: Module Reception Test

- The minimum BD value for planar sensors is 130V
- The 95% of planar sensors have BD values greater than 200V
- FBK sensors has BD mean value of 42.5V
- CNM sensors present a flat distribution between 20V and 105V
- 14 CNM module present a resistive behavior



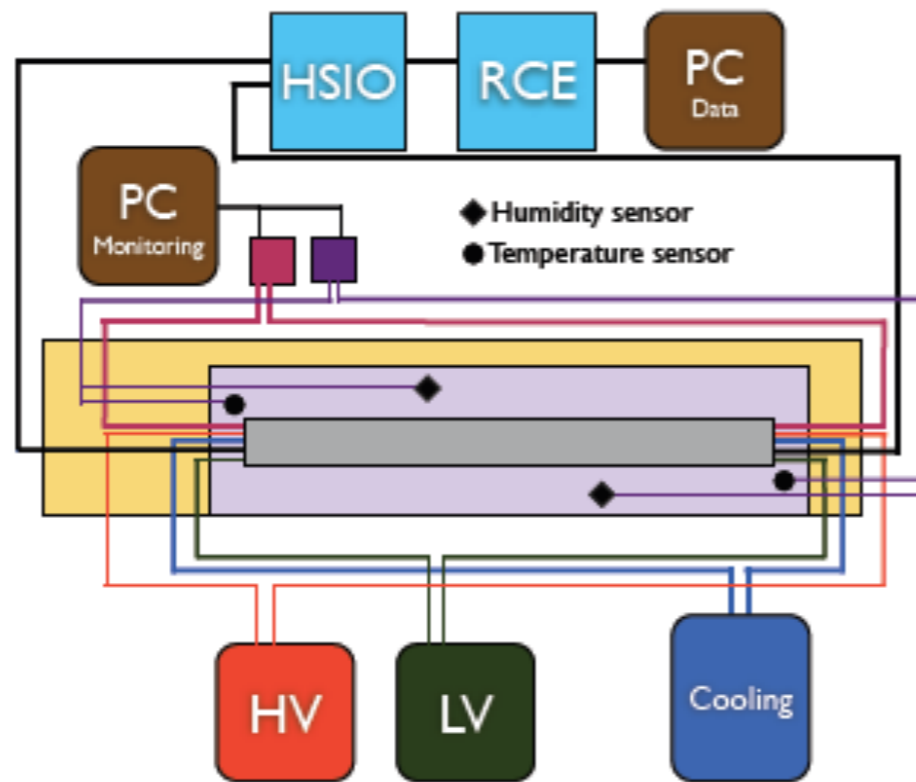


# Stave QC

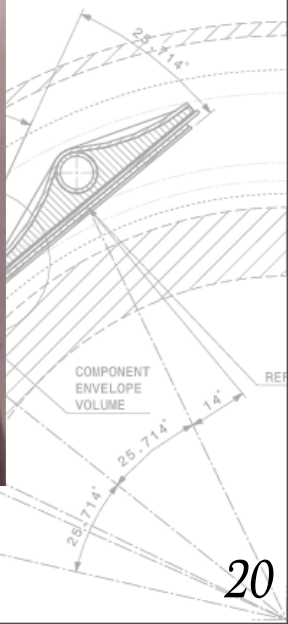
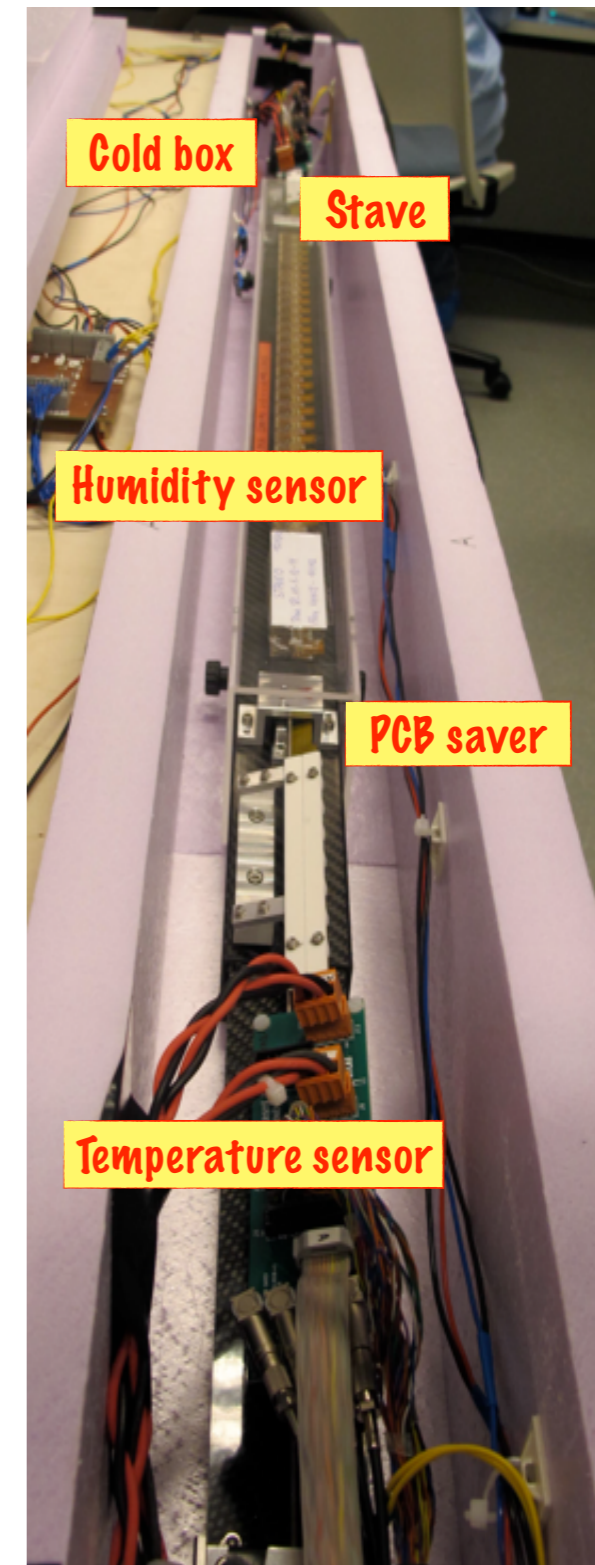




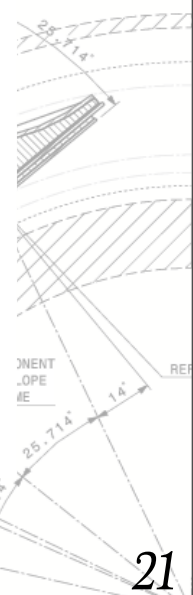
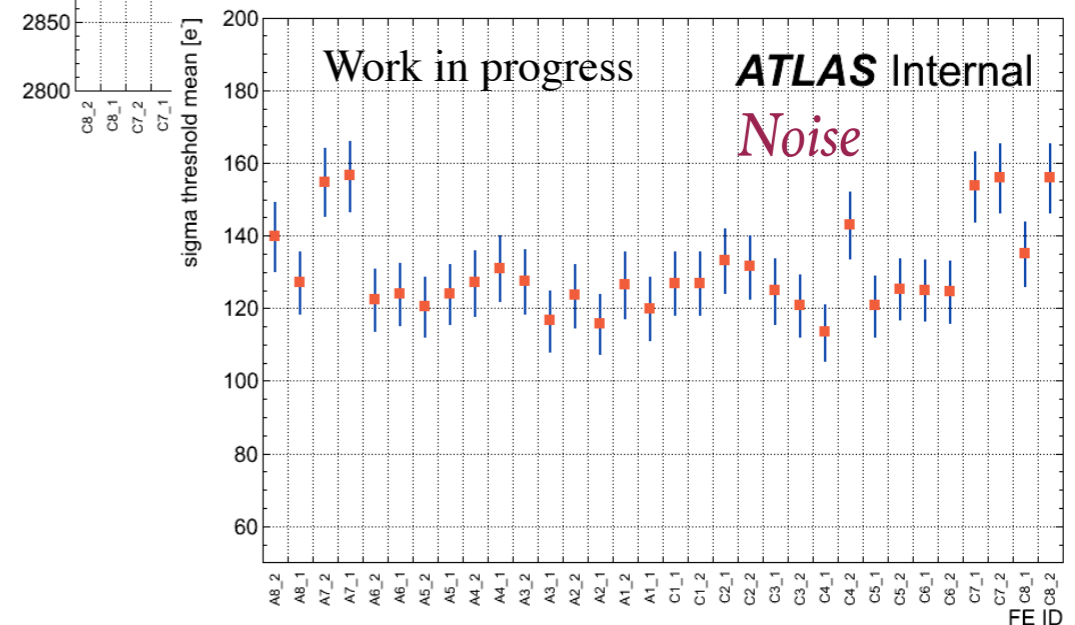
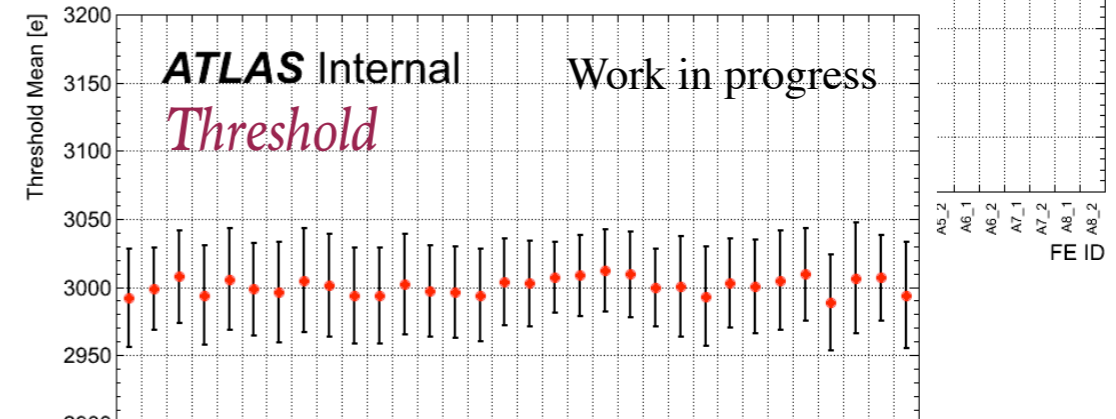
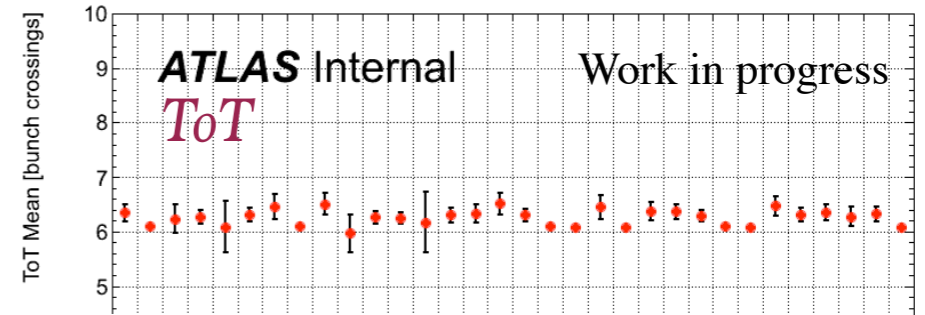
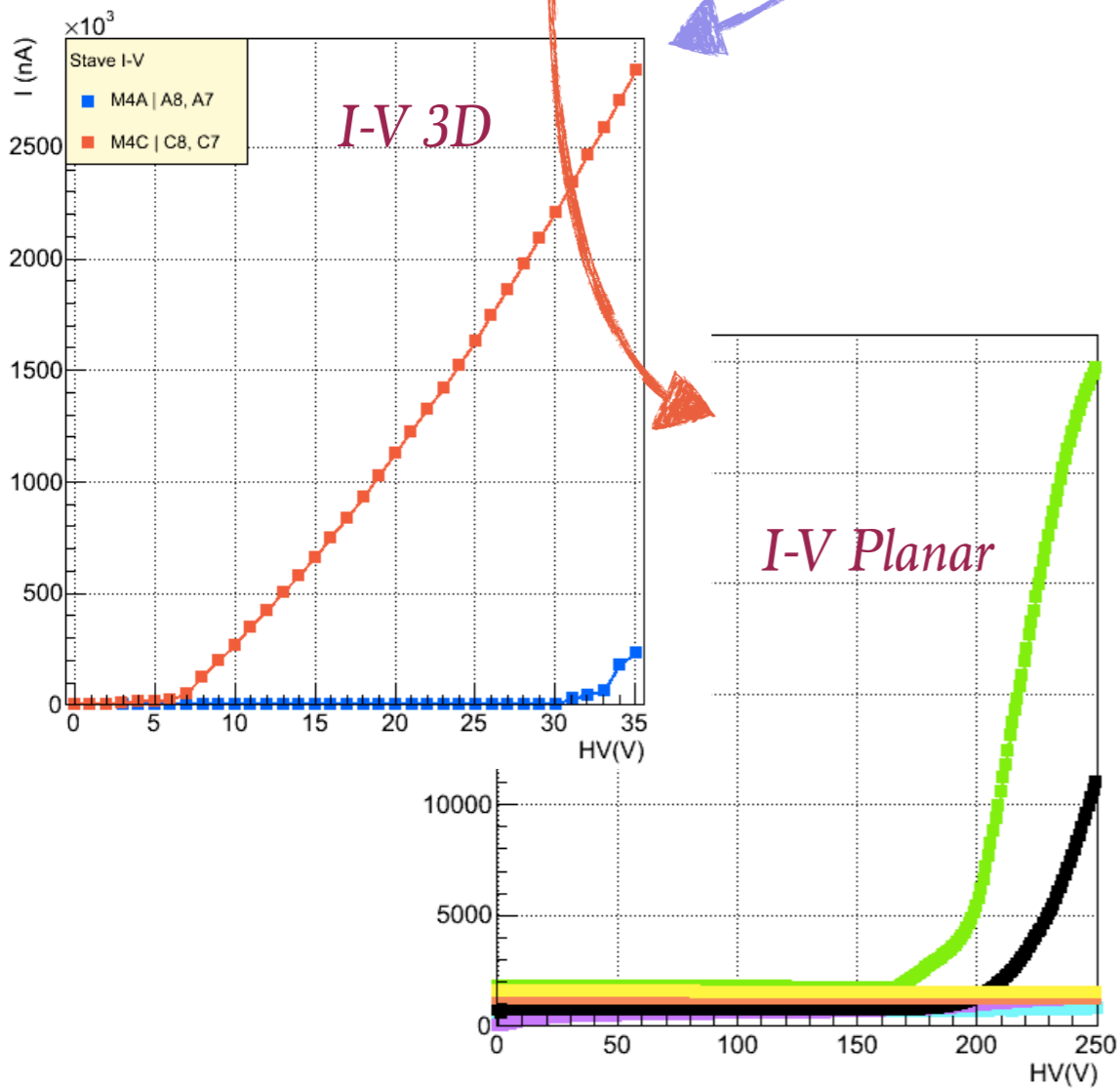
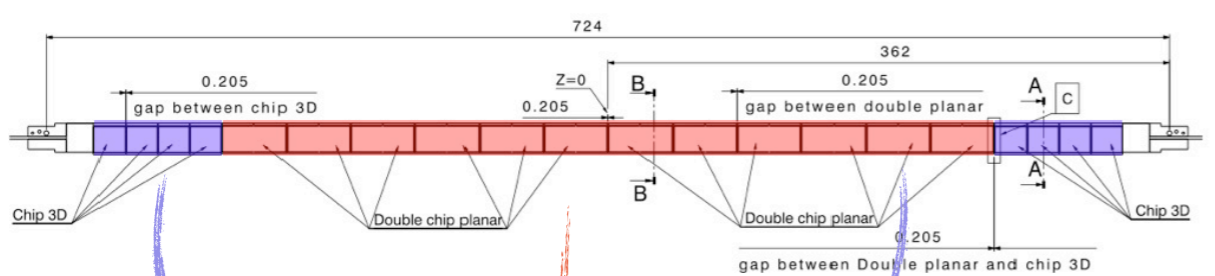
# Stave Tests Setup



- Thermal Cycling
- Optical Inspection
- Electrical Test (LV, HV)
- Sensor Crosscheck (IV)
- Individual Module and Global Stave Response

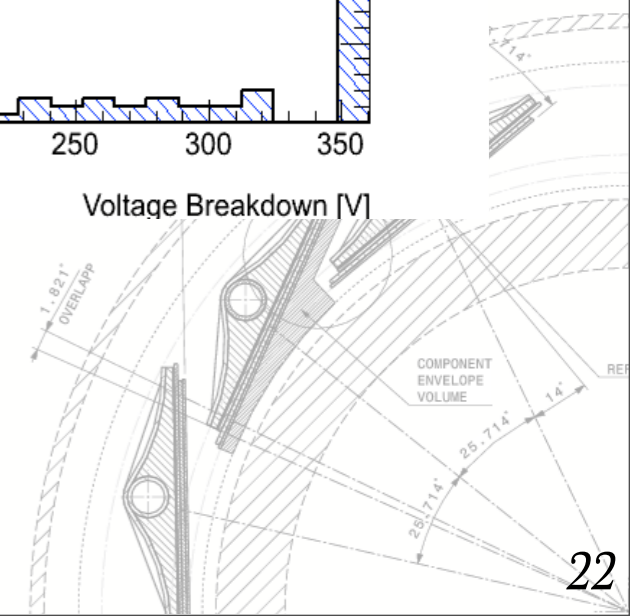
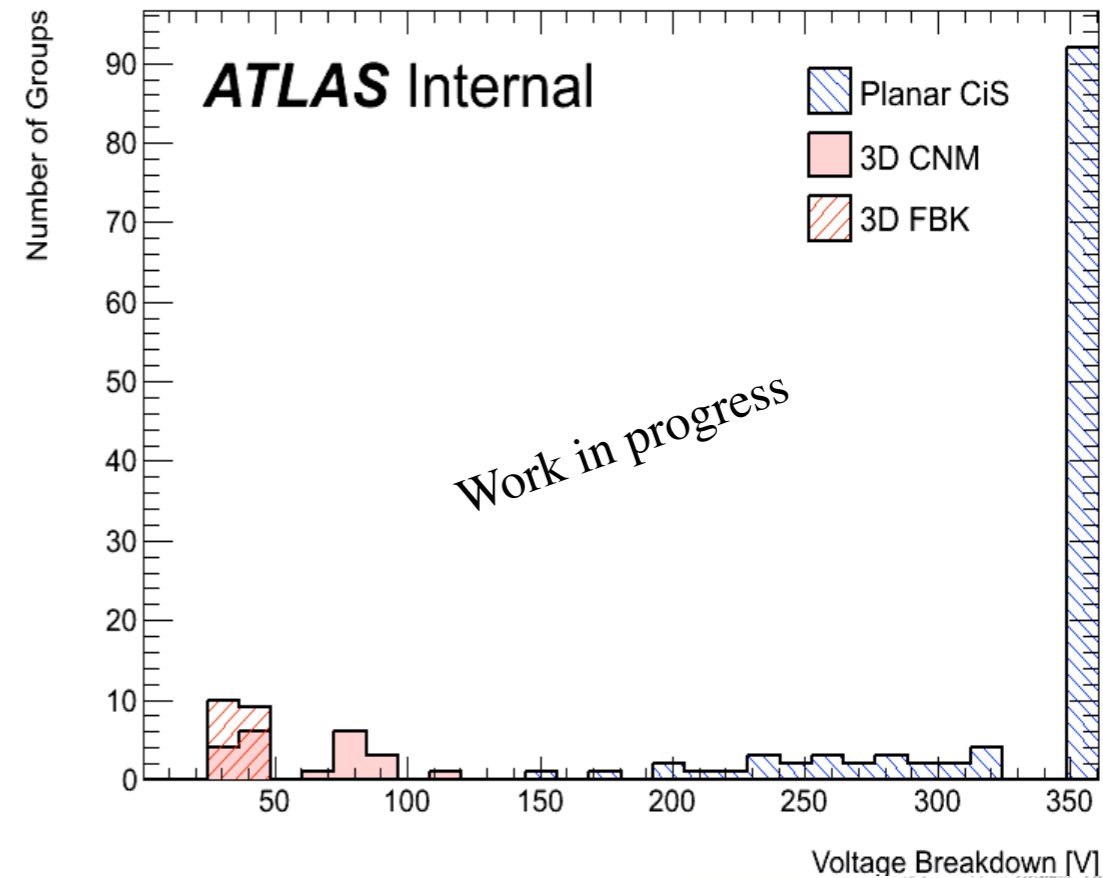


# Stave Electrical Test



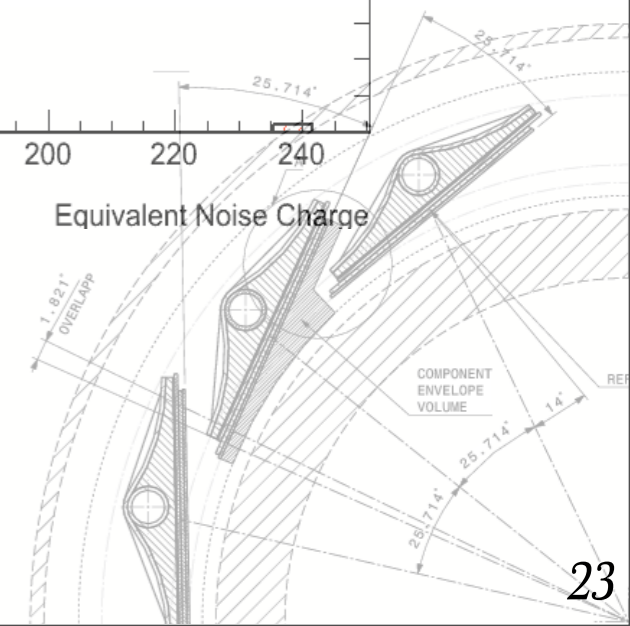
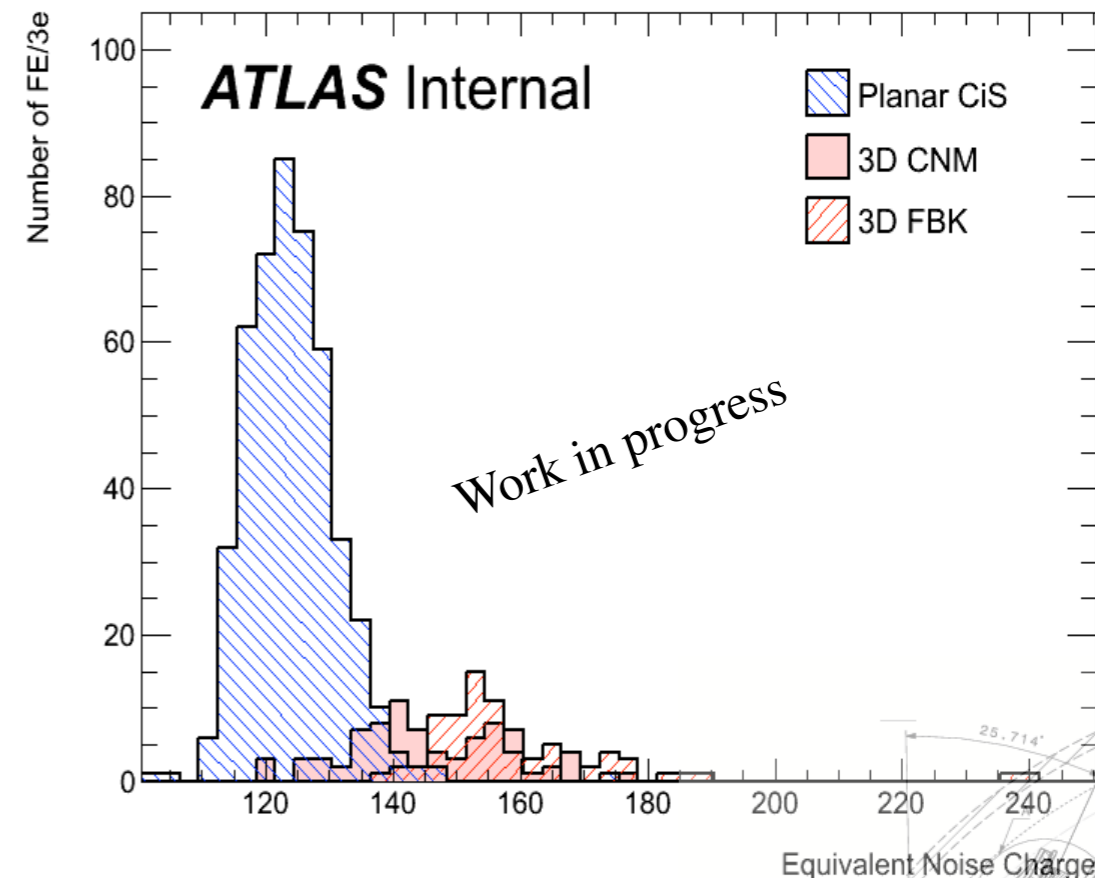
# Results: Stave QC

- I-V performances coherent with the module reception tests
- ENC mean value for planar sensors around 130e. Slightly higher for 3D sensor due to the larger coupling pixel capacitance
- Noise value not affected by the loading procedure
- Less than 1‰ bad pixels per stave



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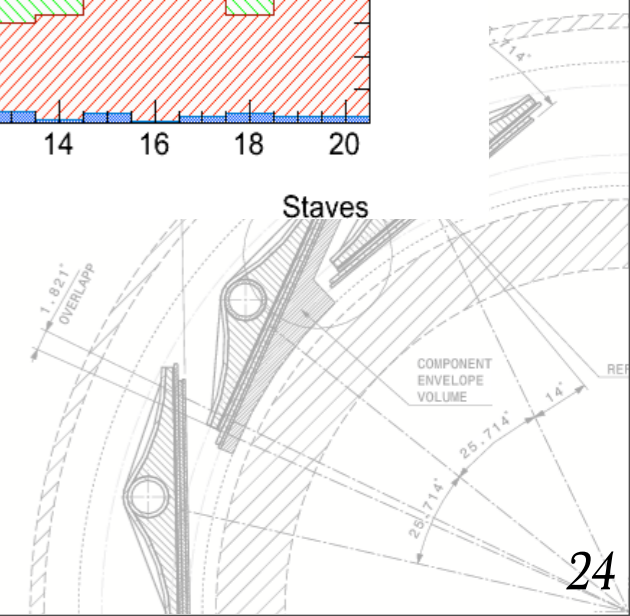
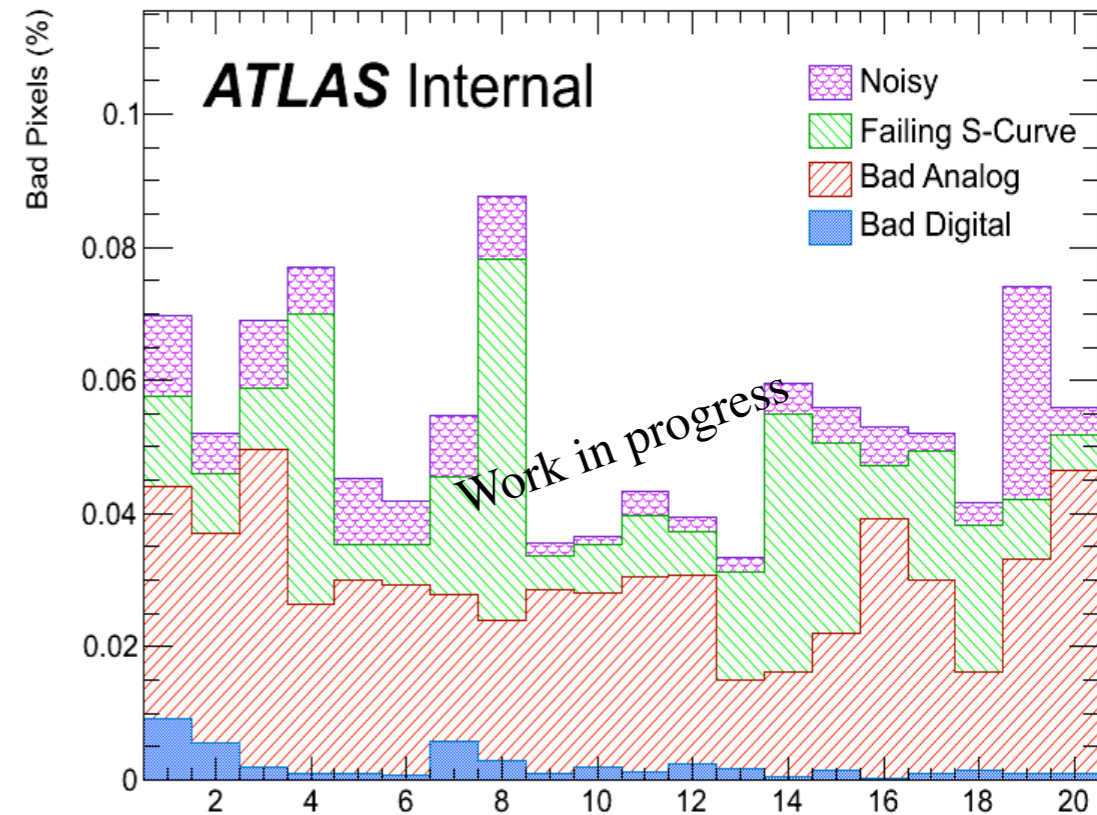
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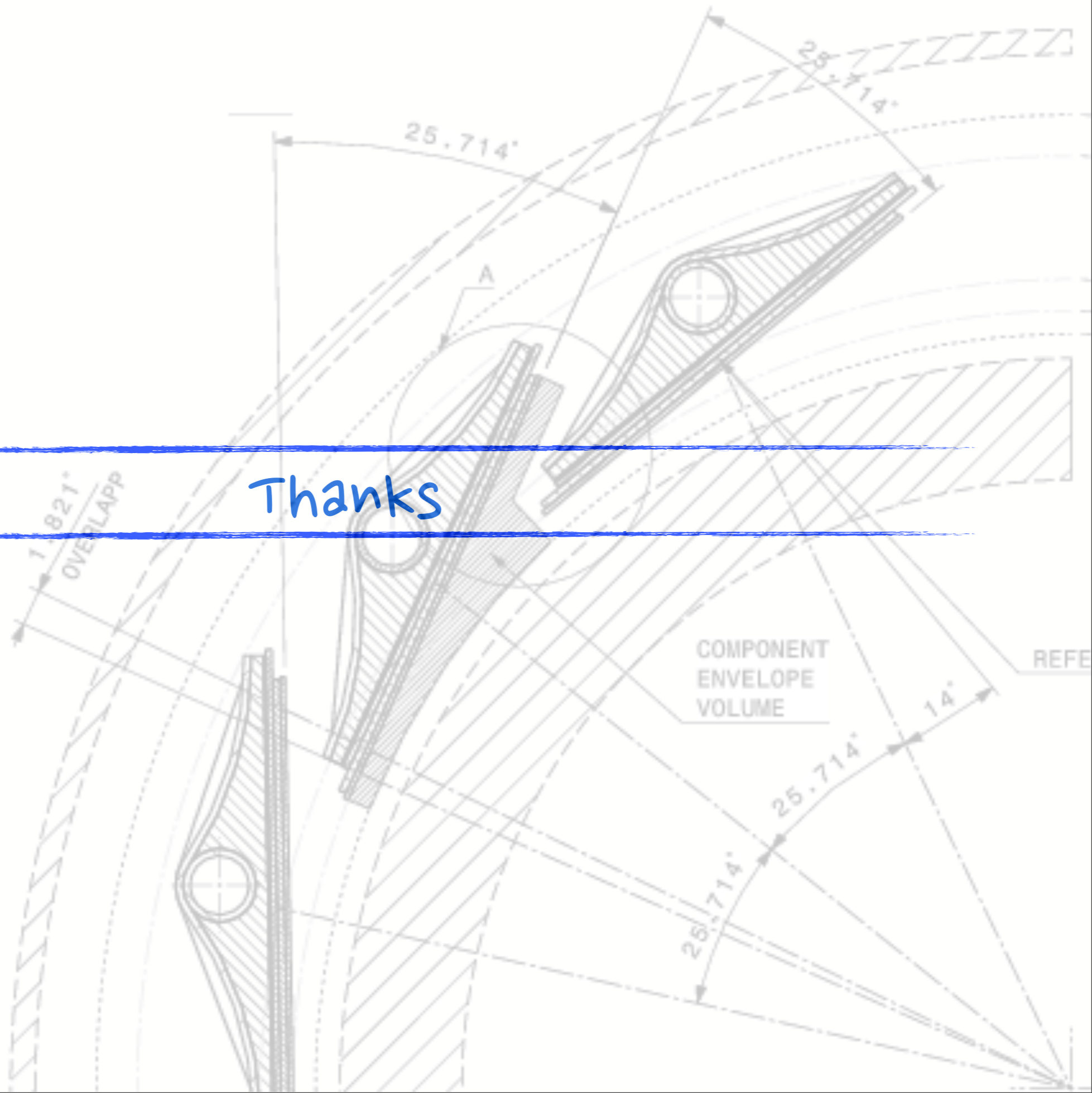


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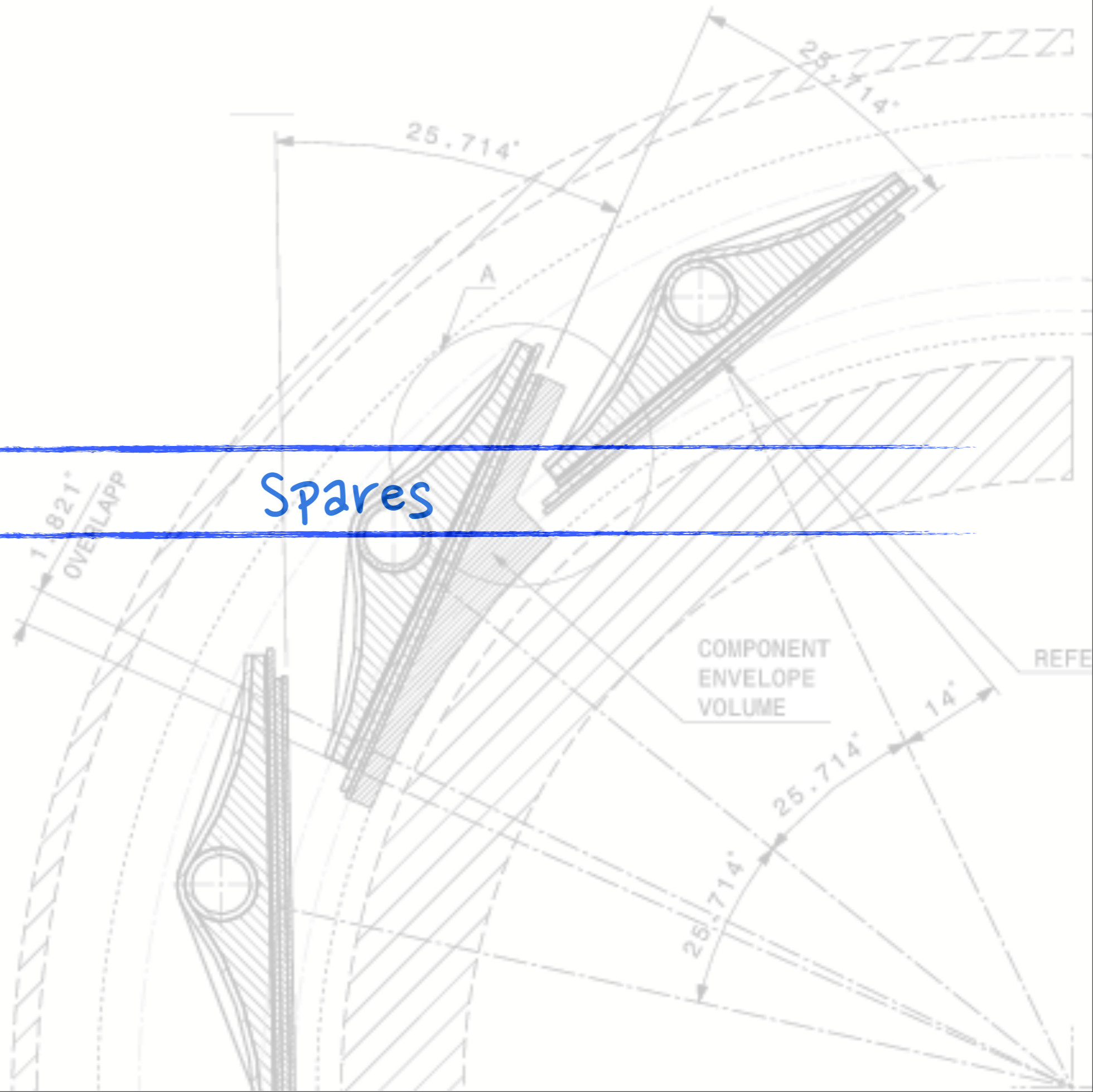
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Thanks



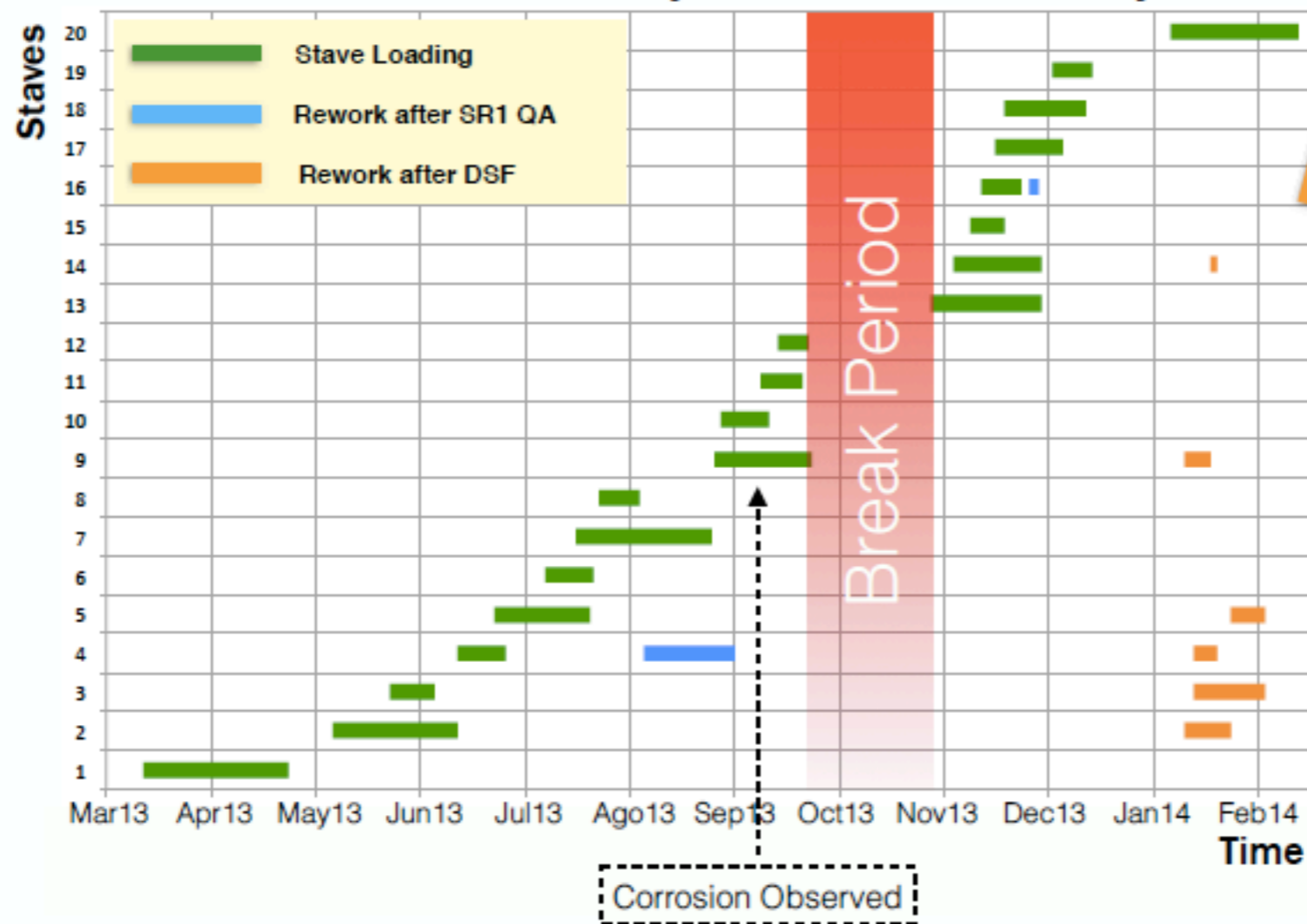
# Spares



# Stave Loading

- Production started in March 2013 and finished in February 2014
- 2 main production parts
  - Mar.13 - Oct.13: before observation of corrosion
    - 12 staves built
  - Oct.13 - Feb.14: after observation of corrosion
    - no more Thermal Cycle, 8 staves loaded + rework after DSF

## Workflow of the activity in Geneva Laboratory

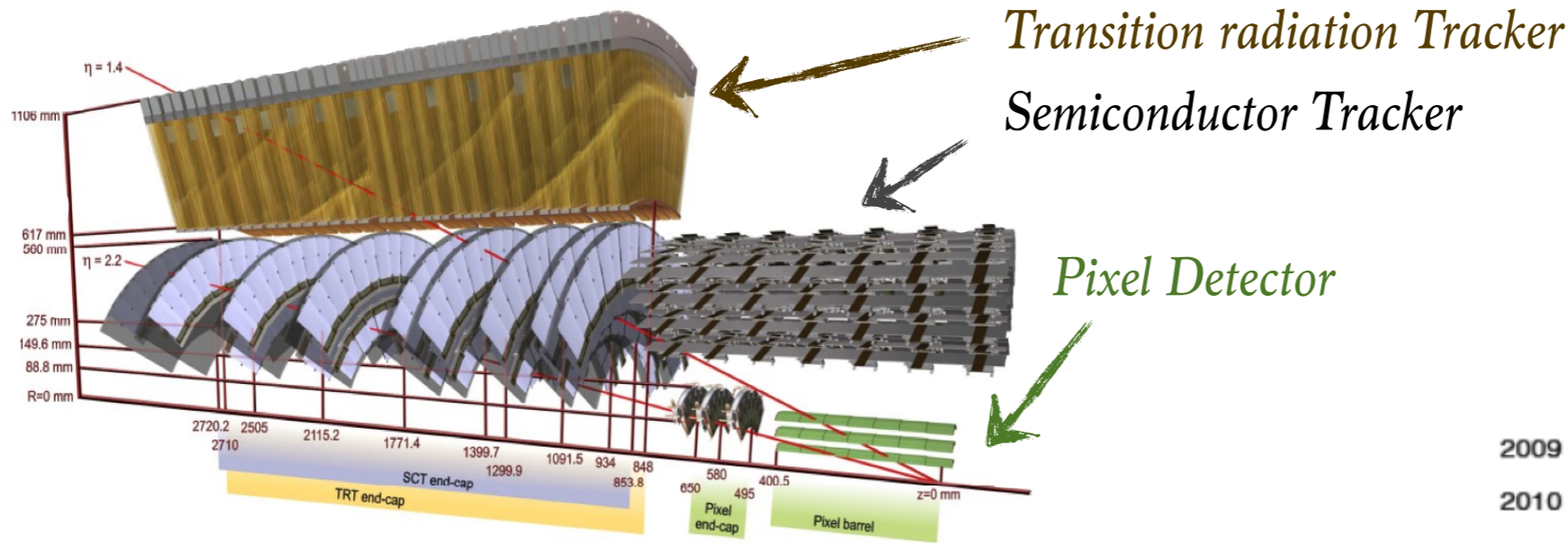


Average: 16  
working days  
per stave



# Atlas Inner Detector and LHC Program

<https://www.youtube.com/watch?v=LGAlY8wfhC4>



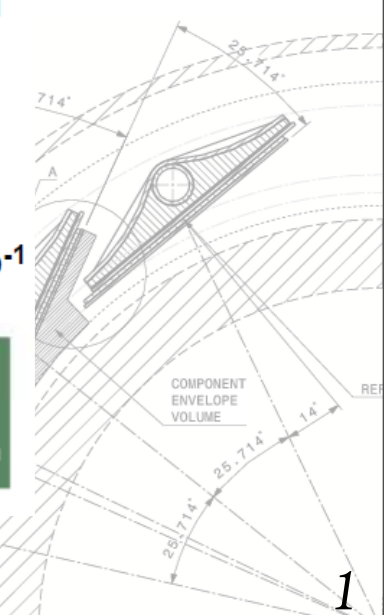
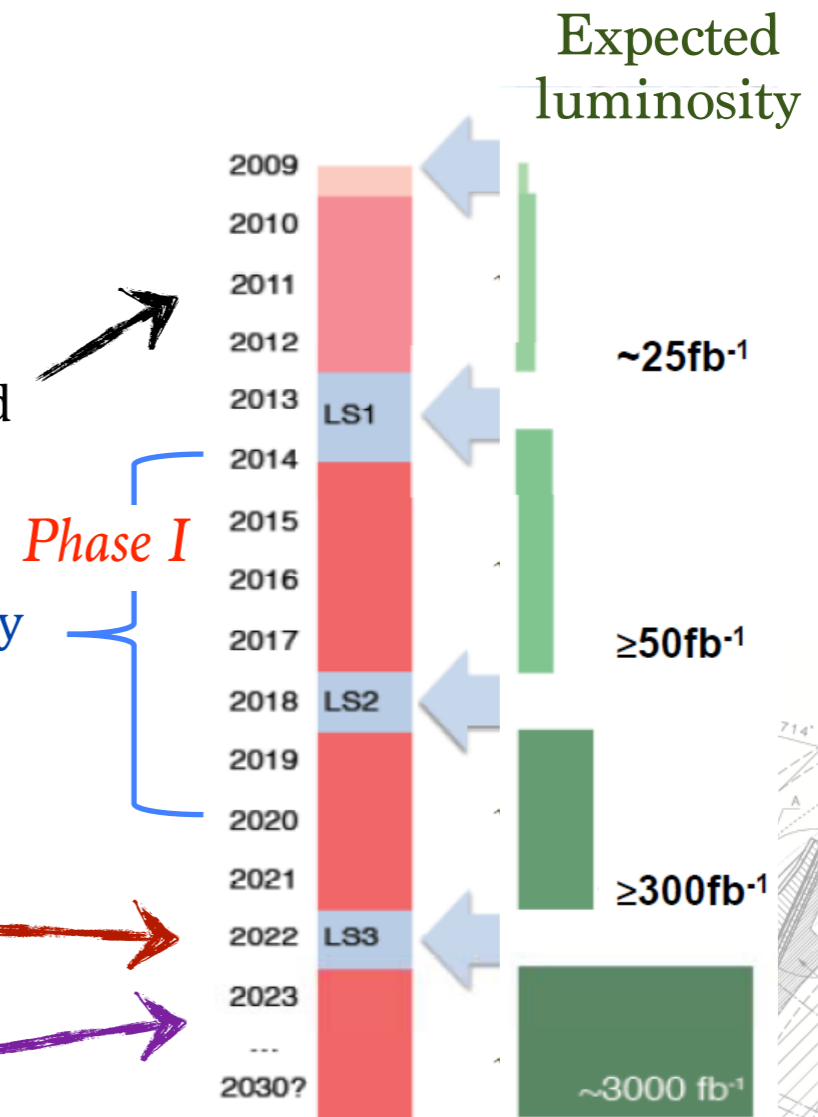
Operating since 2009 with an integrated luminosity  $\leq 30 \text{ fb}^{-1}$

LHC upgrade: higher Luminosity and Energy  
14 TeV &  $2.10^{34} \text{ cm}^{-2}\text{s}^{-1}$

More than  $300 \text{ fb}^{-1}$  and 8-12 years of time life +  
Luminosity effects

HL LHC

Complete new ATLAS tracker pixels and strip detectors

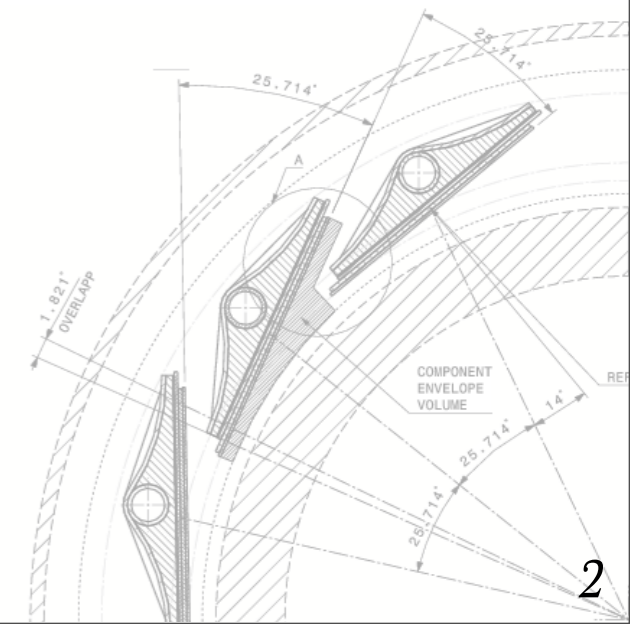
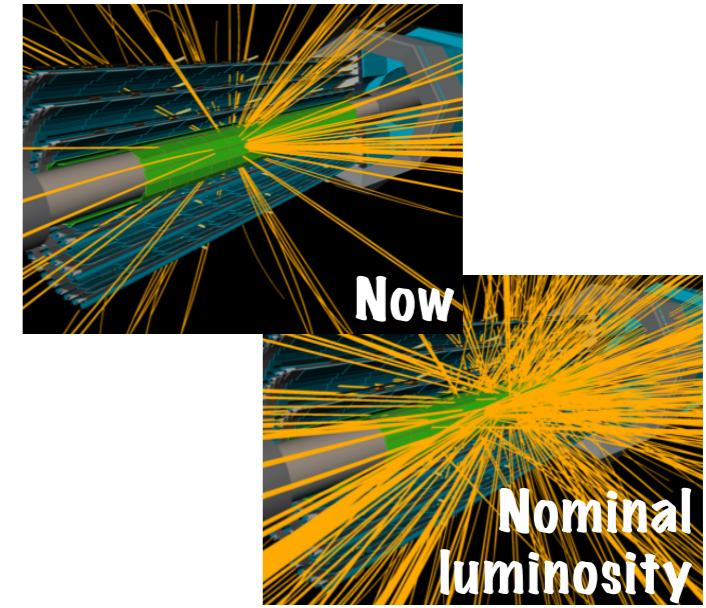
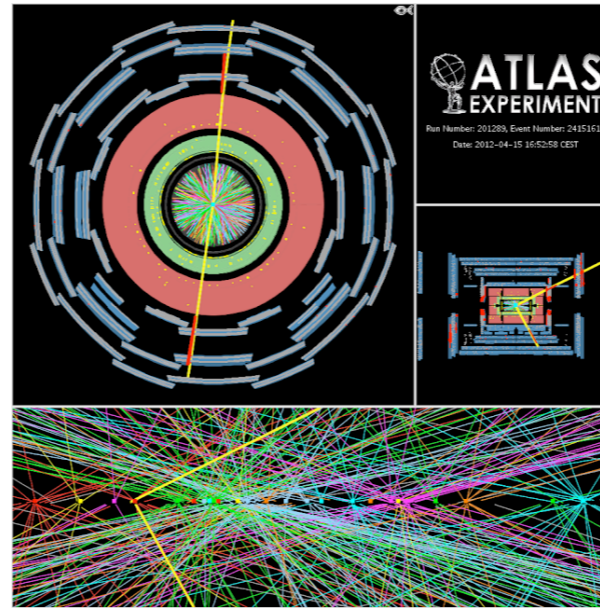


# Corrected Isolation Upgrade

UPGRADE THE CURRENT PIXEL DETECTOR WITH A NEW 4<sup>th</sup> INNER LAYER WITH FINER SEGMENTATION: IBL

## Motivation:

- Luminosity Effects
- Tracking Robustness
- Tracking Precision



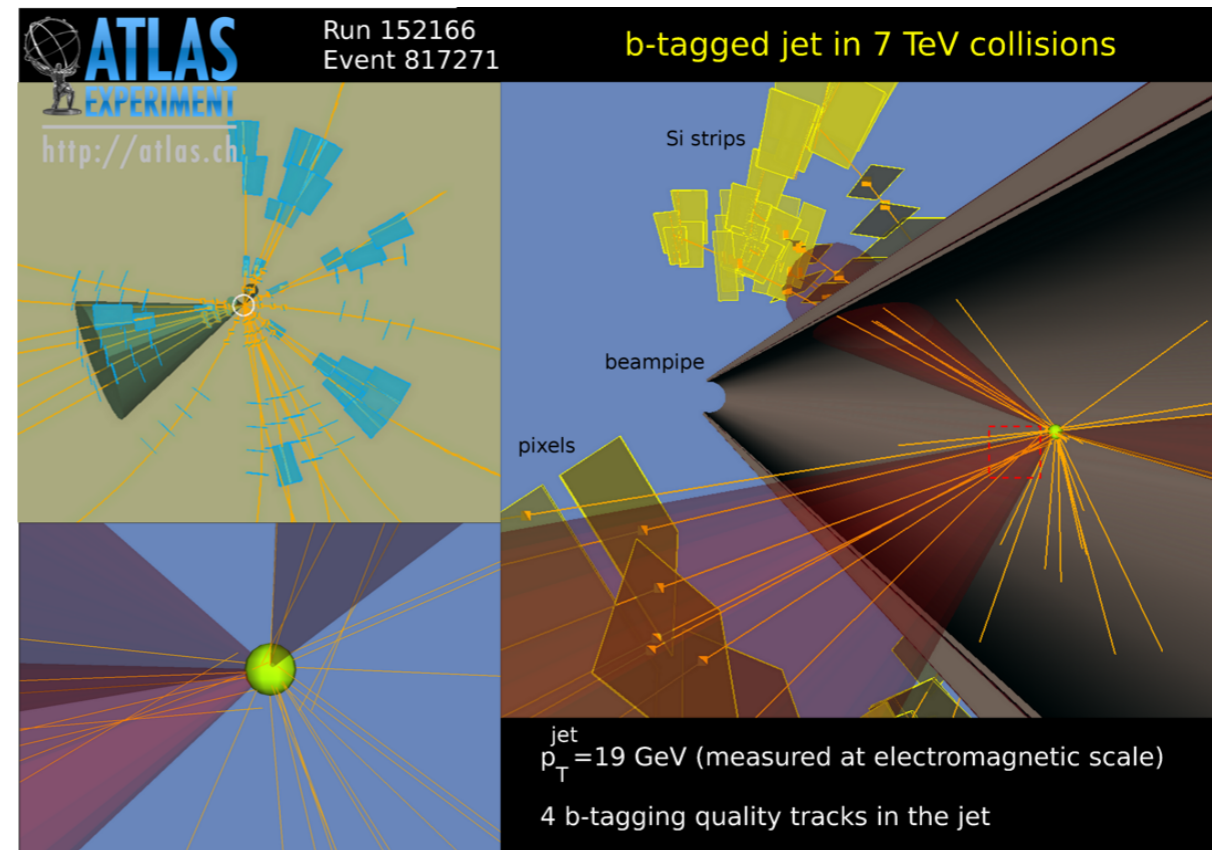
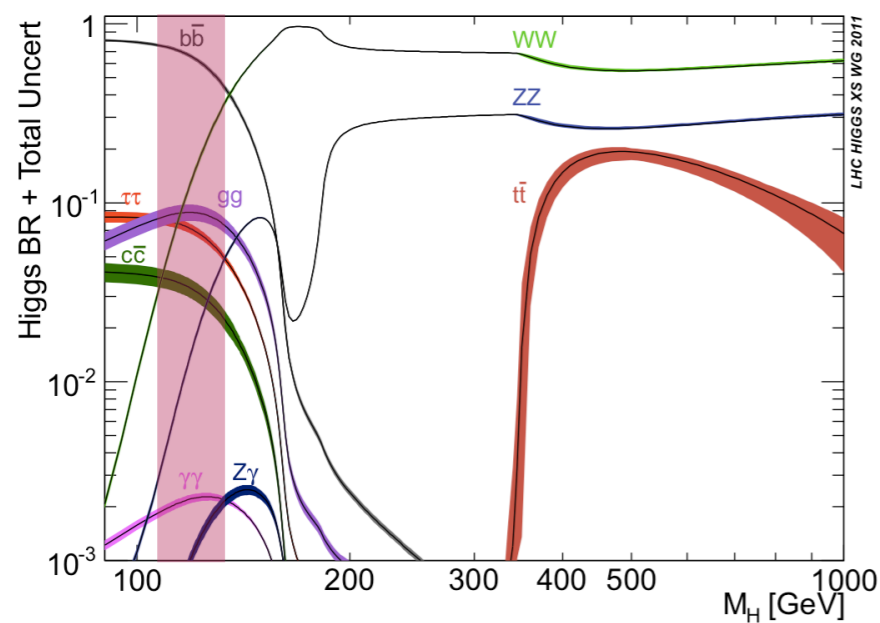
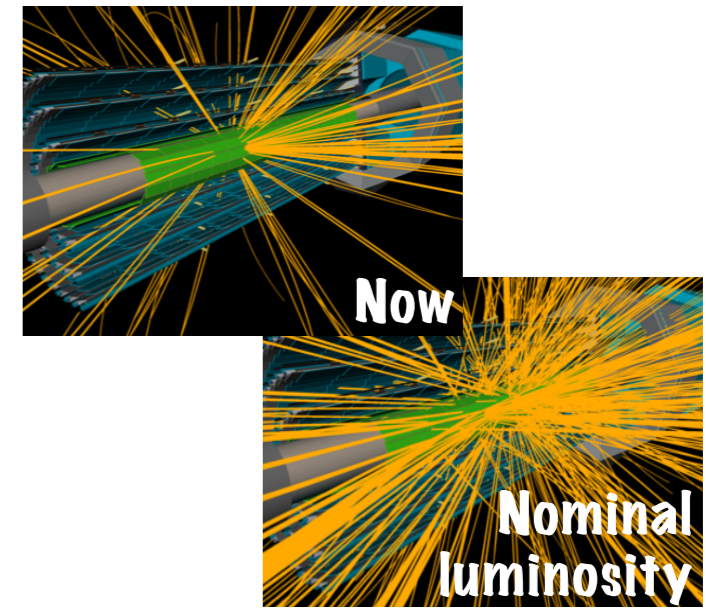
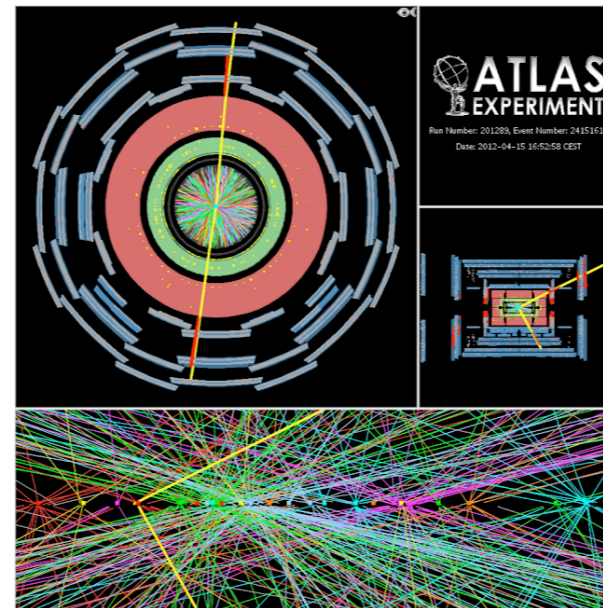


# IBL in Atlas

UPGRADE THE CURRENT PIXEL DETECTOR WITH A NEW 4<sup>th</sup> INNER LAYER WITH FINER SEGMENTATION: IBL

## Motivation:

- Luminosity Effects
- Tracking Robustness
- Tracking Precision



# Module Reception Test

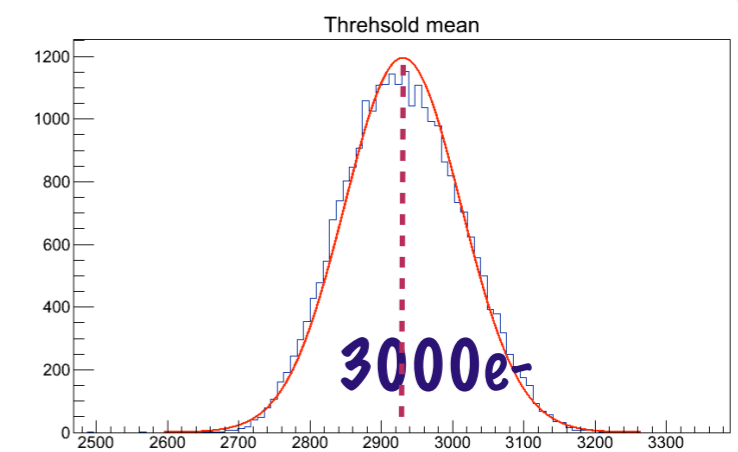
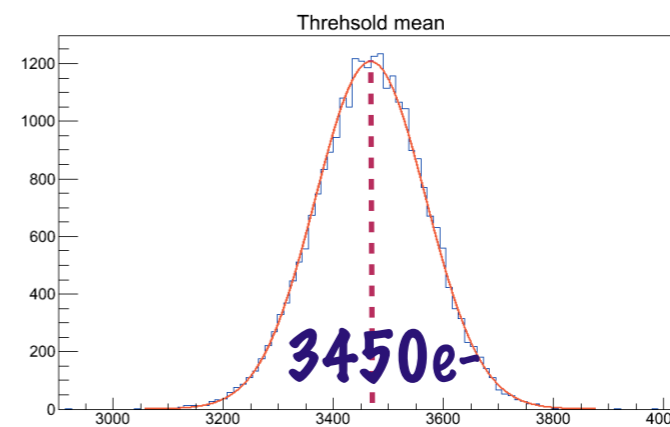
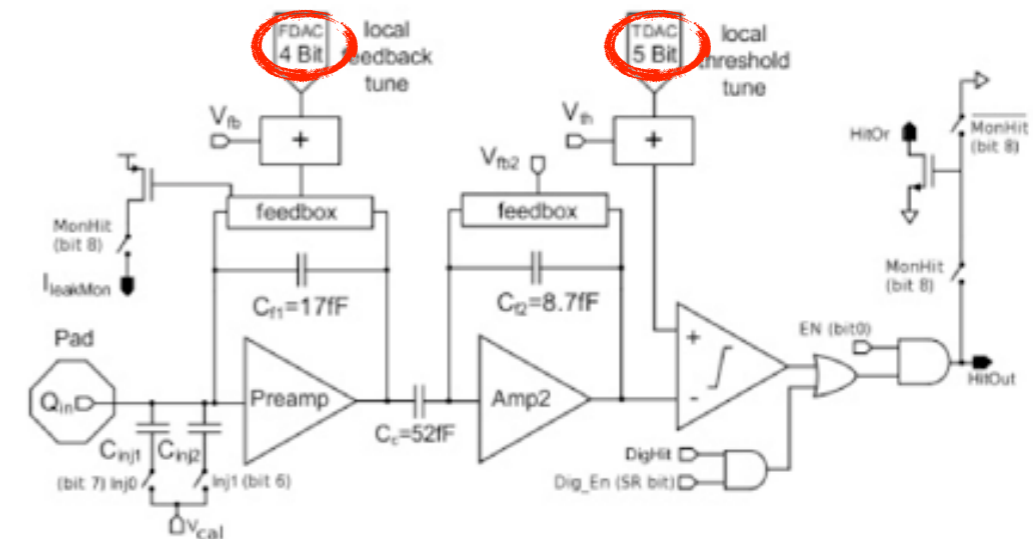
## Threshold Tuning

**Purpose:** Set a uniform threshold along the module close to the target threshold of 3000 e-

**Description:**

- Threshold needs to be globally adjusted for each FE to the target threshold (GDAC)
  - Two algorithms in USBPix:
    - ➔ Fast one: inject the target charge and use a binary search to adjust GDAC to a average occupancy of 50%
    - ➔ Slow one: performs full threshold scans for several GDAC settings and extrapolate the GDAC value close to the target threshold
- Pixel Tuning (TDAC, FDAC): process similar to the global one. Again there are two algorithms: fast and slow ones

The threshold tuning is affected by the ToT tuning. The TDAC will be repeated to re-tune the thresholds after the performing the ToT tuning





# Module Reception Test

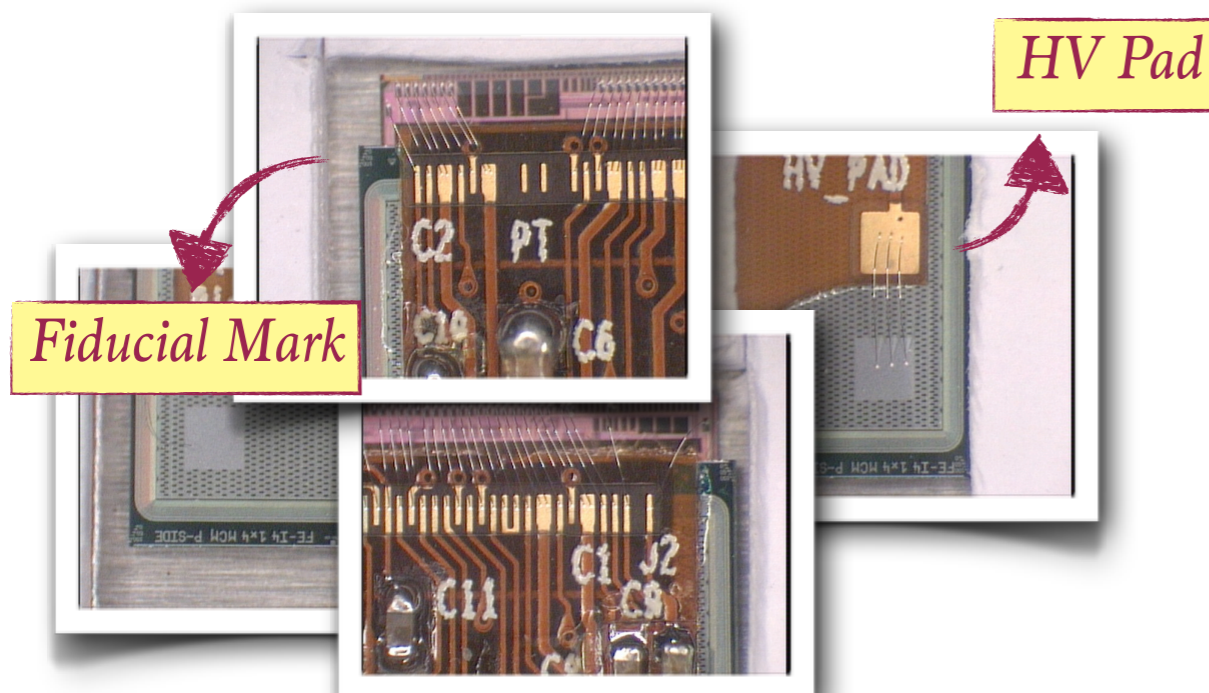
The module RT aims to check the functionality of modules after the shipment from the production sites (U. Bonn and INFN-Genova) to the loading site (U. Geneva).

## Optical Inspection

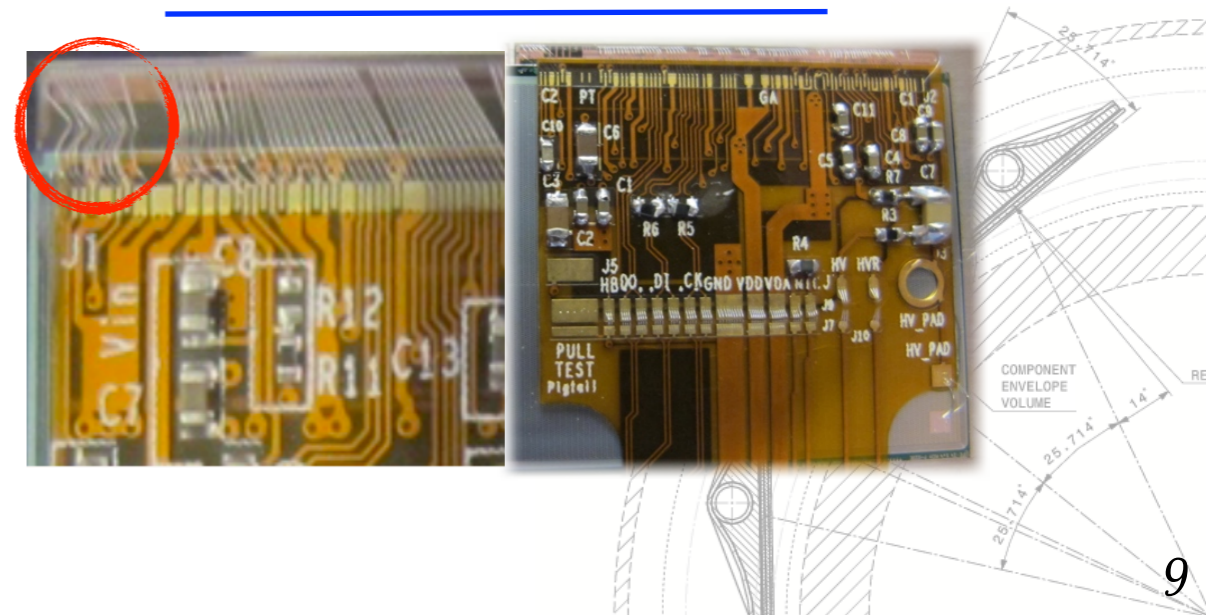
- General high resolution picture and inspection
- Microscope inspection and pictures taken of critical regions and defects if observed
  - Fiducial Marks, Wire-bonding pads (on module-flex and FE sides), bonded wires, wire bonding feet and module flex contamination

Microscope+Digital Camera

Extra Microscope

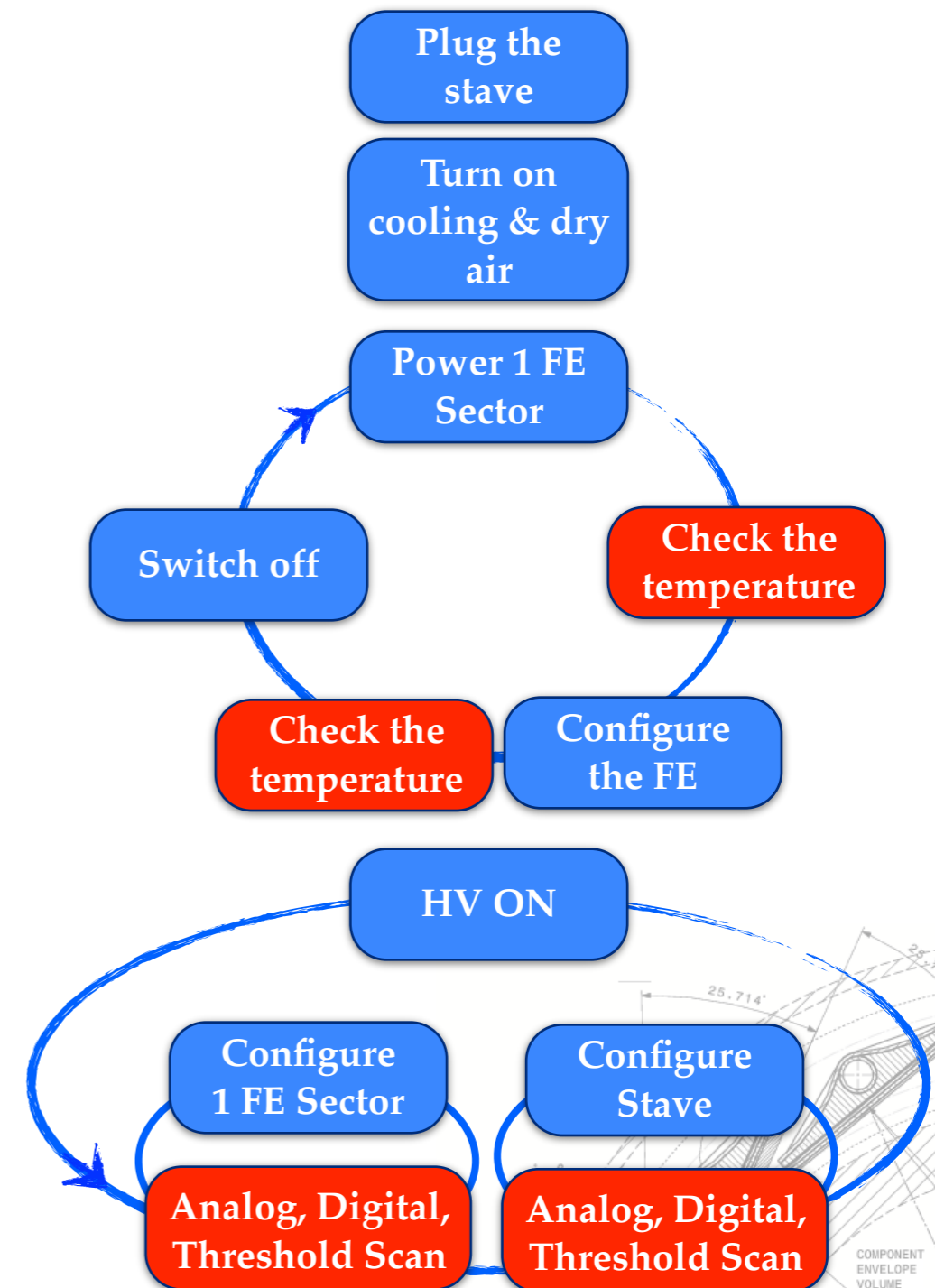


## Mechanical Classification



# Stave Electrical Test

- *Connectivity & Powering tests*
- *Temperature & Humidity check*
- *FE operation-tests (individually, sector by sector, stave)*
- *HV (on/off): Digital & Analog tests, Threshold*
- *IV*





...now let's "tAste" a stave in a  
different way!!!

