FEMB Post-Assembly Processing –Serial Number Recognition & Checkout Testing

Version	Date	Author	Notes
v1.0	2025-05-05	K. Flores, L. Ke, S. Gao, V. Tishchenko	Initial draft for internal review

Contents

1 Introduction

These instructions will guide the reader through the FEMB Post-Assembly processing using the Post-Assembly Visual Inspection & Checkout setups located in room 1-216 (see Figure 1).**We recommend the testers to read this document entirely before they start using the setups.**

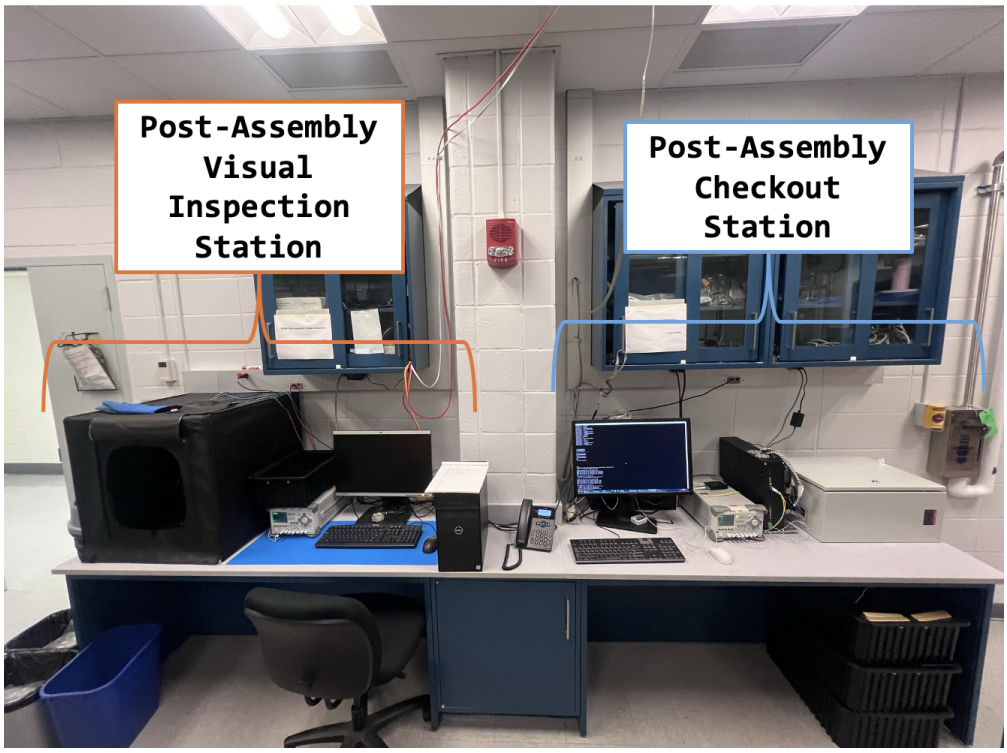


Figure 1: FEMB Post-Assembly Visual Inspection and Checkout stations located in room 1-216.

The **Post-Assembly FEMB Visual Inspection Setup** has been designed to take high-resolution pictures of FEMBs and WIBs for quality control (QC) procedures. We will focus on FEMBs for the purpose of this manual, but the process for WIBs should be identical. The FEMB picture-taking process is powered by the VimbaX software suite. VimbaX is a robust and flexible Allied Vision camera control framework that integrates very nicely with Python, which makes it ideal for our application. Such application allows you to capture multiple pairs (FRONT and BACK) of FEMB/WIB images with minimal input—simply press the `ENTER` key to save a picture! These pictures will then be processed to retrieve the serial numbers of the chips and the boards using a very sophisticated set of tools for Optical Character Recognition (OCR). This information will then be used to create the FEMB's records in DUNE's Hardware Database.

The **Post-Assembly FEMB Checkout Setup** will run a quick checkout test to verify the basic functionality of the FEMBs before sending them to be assembled in a CE Box. This initial checkout test is designed to be fast and automated, identifying any major issues before more detailed characterization is performed. These are the main aspects checked:

- **Register Scan:** Verifies that all configuration registers on the FEMB are accessible and return expected default values.

- **Power Scan:** Measures and logs voltage and current values for each power rail and makes sure that all rails are within specifications.
- **Pedestal and RMS Calculation:** Records the baseline (pedestal) and noise (RMS) levels to try to identify excessive noise or offsets that may indicate hardware issues.
- **Single-Ended On Pulse:** Injects a known signal through the single-ended test input path to check the functionality of the analog signal chain, to validate signal detection and linearity.
- **Power Rail and Scan:** Repeats power rail measurements after signal injection to detect any dynamic instabilities or excessive current draw due to active circuitry.
- **Differential Pulse:** Sends a test pulse through the differential input to assess differential signal handling and common-mode noise rejection.
- **Power Rail and Scan:** Conducts a final power rail check following the differential pulse test to ensure no degradation or abnormal behavior in power consumption.
- **Monitoring Path:** Confirms monitoring systems are operational and accurate.
- **Backup Power Rail:** Verifies the presence and correctness of backup or redundant power rails if applicable, to make sure that the FEMB can maintain operation under fallback power scenarios.

The tester will perform these two processes in the FEMBs (Figure 2):

1. FEMB Scan

   Capture Front/Back Pictures of FEMB

   Serial Number Recognition

   Hardwdare Database record creation

2. Checkout Test

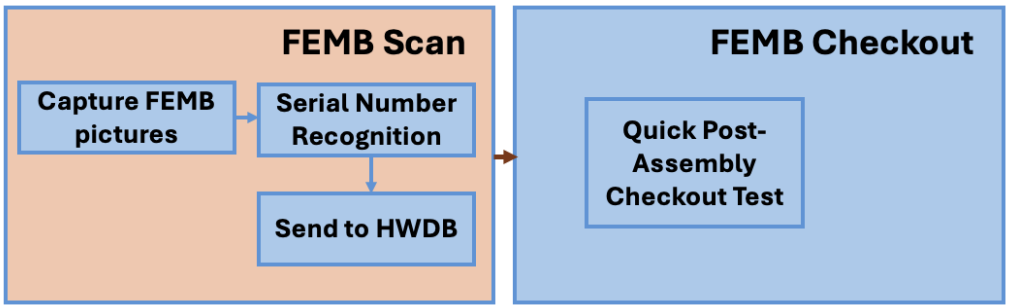


Figure 2: FEMB Post-Assembly Processing.

2 List of Equipment

2.1 FEMB Post-Assembly Visual Inspection Setup

Please, refer to Table 1 for a detailed list of equipment needed to operate the QC Camera Setup. These items are illustrated in Figure 3.

Code	Name	Notes
101	Allied Vision Alvium G1-1240c Camera	
102	Custom Stand	
103	Ground Cable	
104	Ethernet Cable	
105	Power Cable	
106	Camera Booth	
107	12V / 6A Power Supply	
108	Polarized LED Ring Lamp	
109	Desktop	with VimbaX SDK

Table 1: List of the Post-Assembly FEMB Visual Inspection Setup components and their corresponding codes.

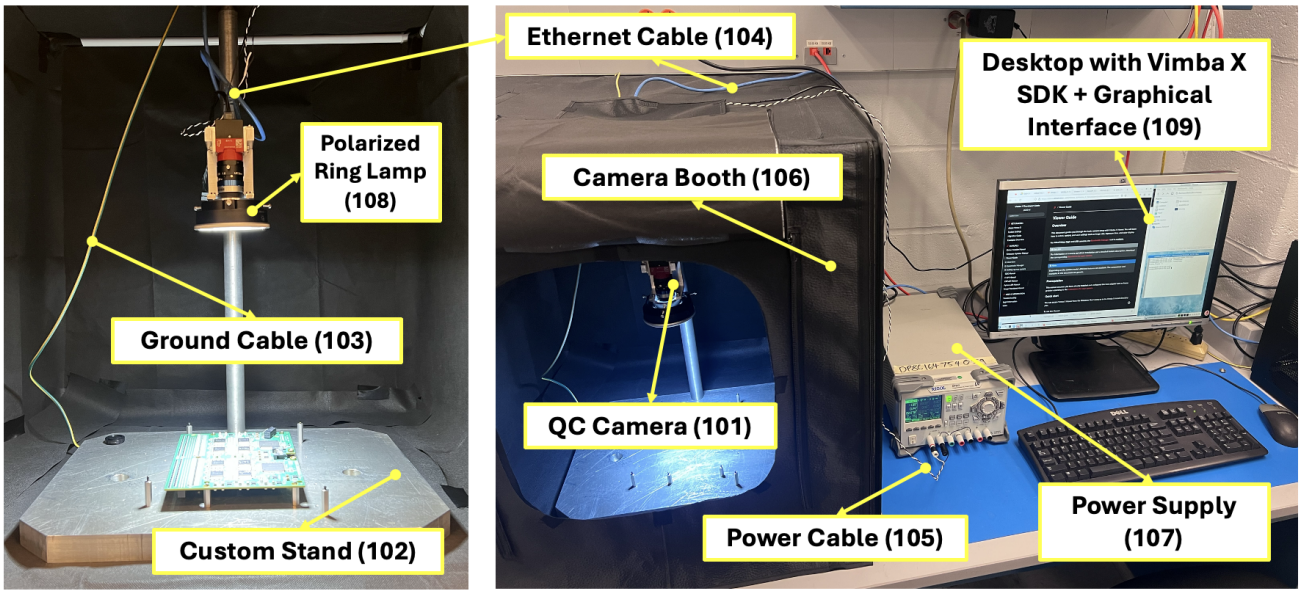


Figure 3: Equipment needed to operate the Post-Assembly FEMB Visual Inspection Setup.

2.2 FEMB Post-Assembly Checkout Setup

Please, refer to Table 2 for a detailed list of equipment needed to operate the QC Camera Setup. These items are illustrated in Figure 4.

Code	Name	Notes
201	WIB Box	
202	12V / 6A Power Supply	
203	Checkout Box	
204	Fiber to RJ45 Converter	
205	WIB Power Cable	
206	Ethernet Cable	
207	Fiber Cable	
208	FEMB Cables	
209	Desktop	With updated version of checkout script

Table 2: List of the Post-Assembly FEMB Checkout Setup components and their corresponding codes.

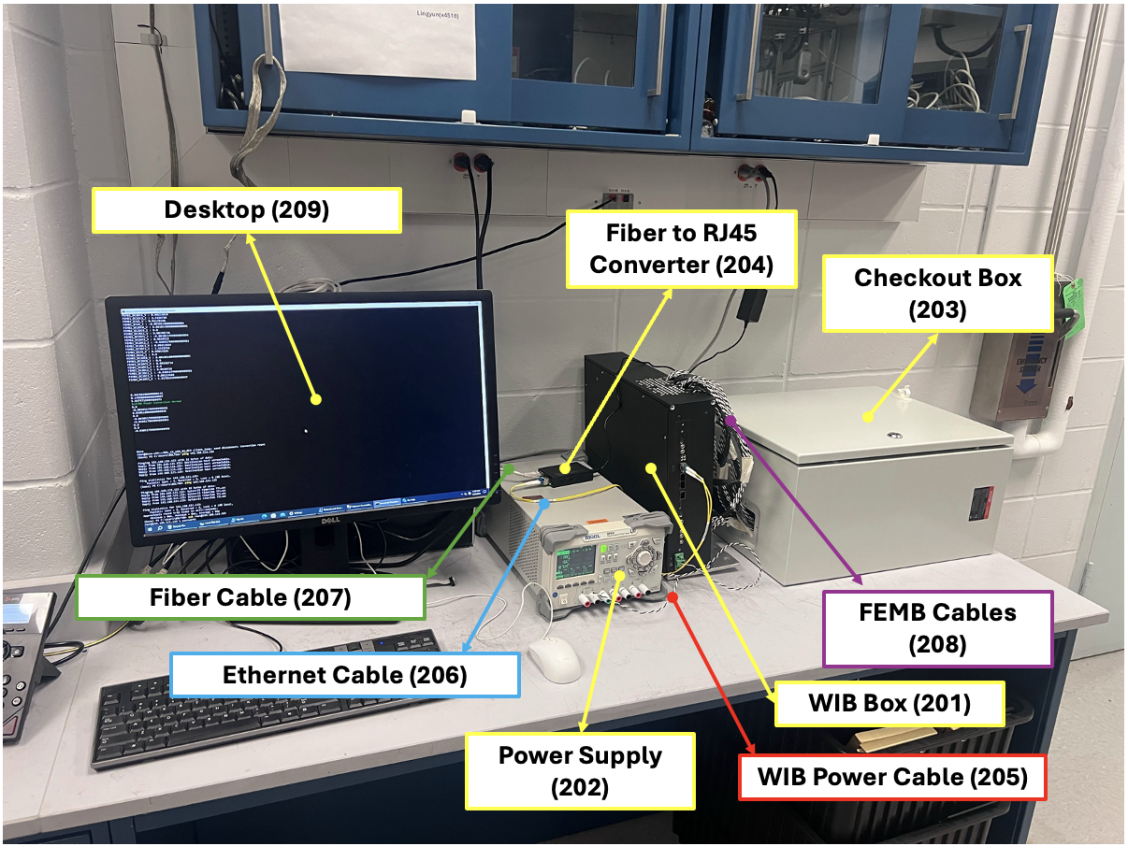


Figure 4: Equipment needed to operate the Post-Assembly FEMB Checkout.

3 Post-Assembly FEMB Visual Inspection Procedure

The overall procedure is illustrated in Figure 5.

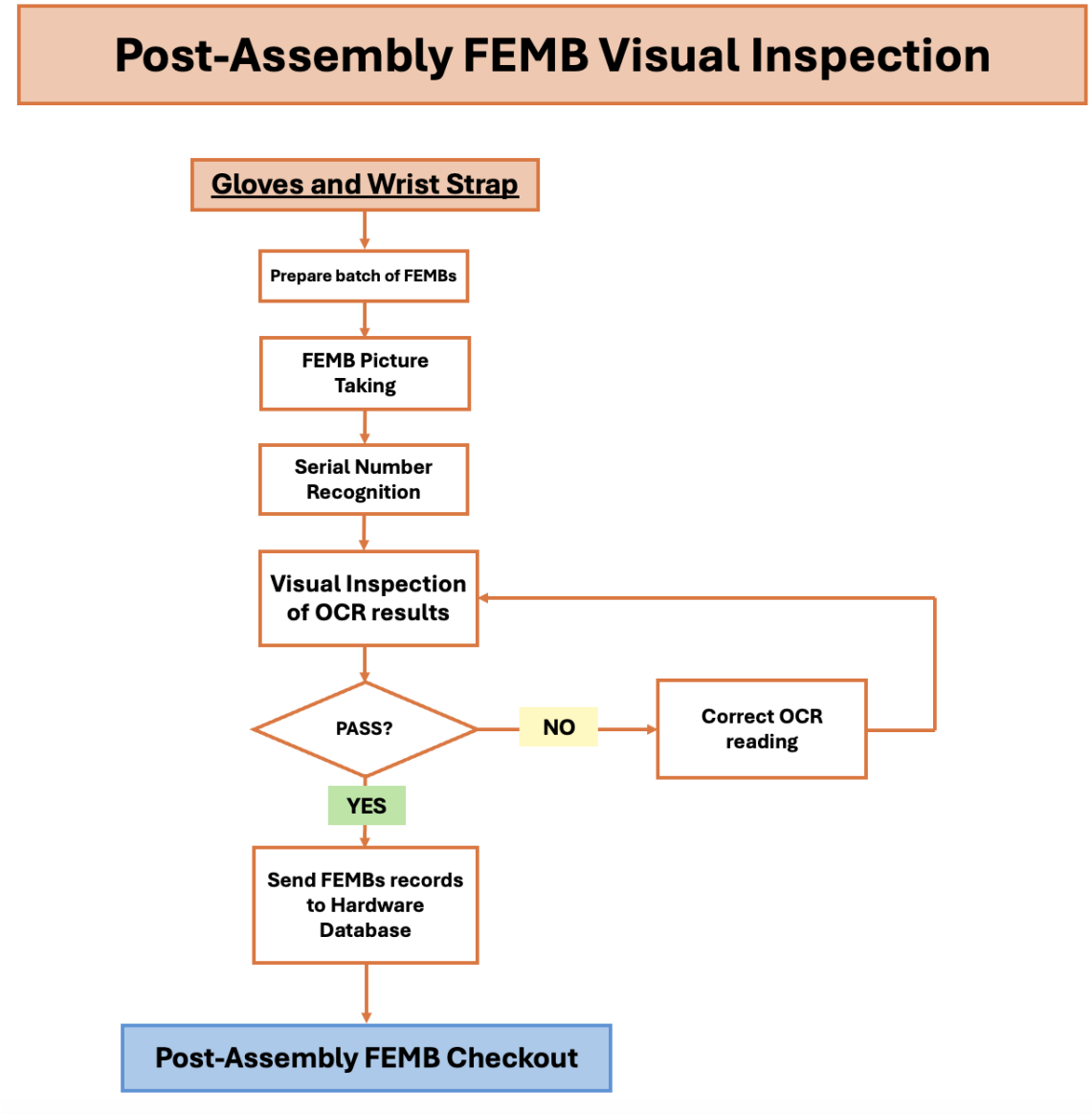


Figure 5: Post-Assembly FEMB Visual Inspection workflow.

Sections 3.1 to 3.4 contain a detailed explanation of the steps that the tester needs to follow to perform this procedure.

3.1 Capturing Pictures

Follow these steps to begin taking pictures:

1) **Turn on the power supply:** Press the button indicated in Figure 6.

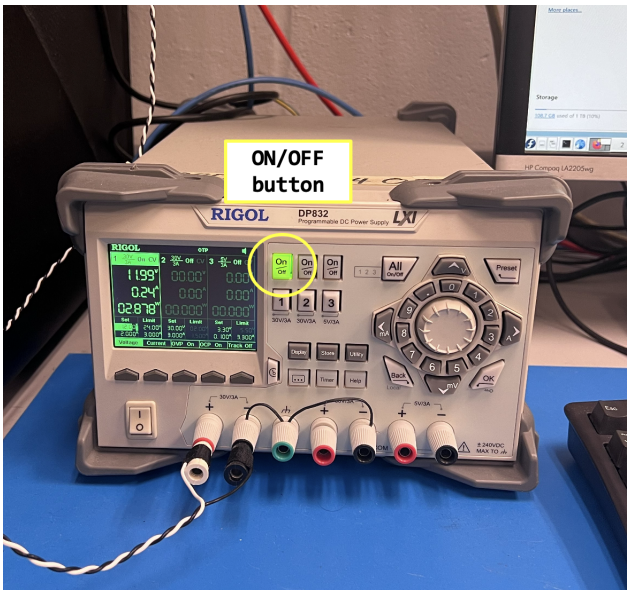


Figure 6: Power supply ON/OFF button.

2) **Turn on the Polarized LED Ring Lamp:** Carefully press the lamp's ON/OFF button. Make sure **not** to rotate the polarizer when you press its ON/OFF button, as it is already set at the correct angle for optimal picture-taking (see Figure 7).

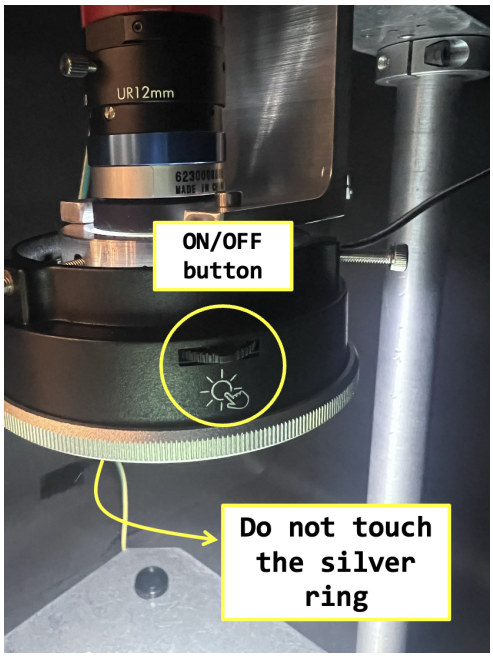


Figure 7: LED Polarizer Light ON/OFF button.

3) **Make sure you are wearing a grounding wrist strap:** This is to avoid any potential damage to our sensitive (and expensive) electronics. **Do not handle any boards without grounding yourself first!**

4) **Place the FEMB:** Ensure boards are kept safe and ready for quick handling. Securely place the first board facing up (FRONT) using the holding screws on the base, as shown in Figure 8.

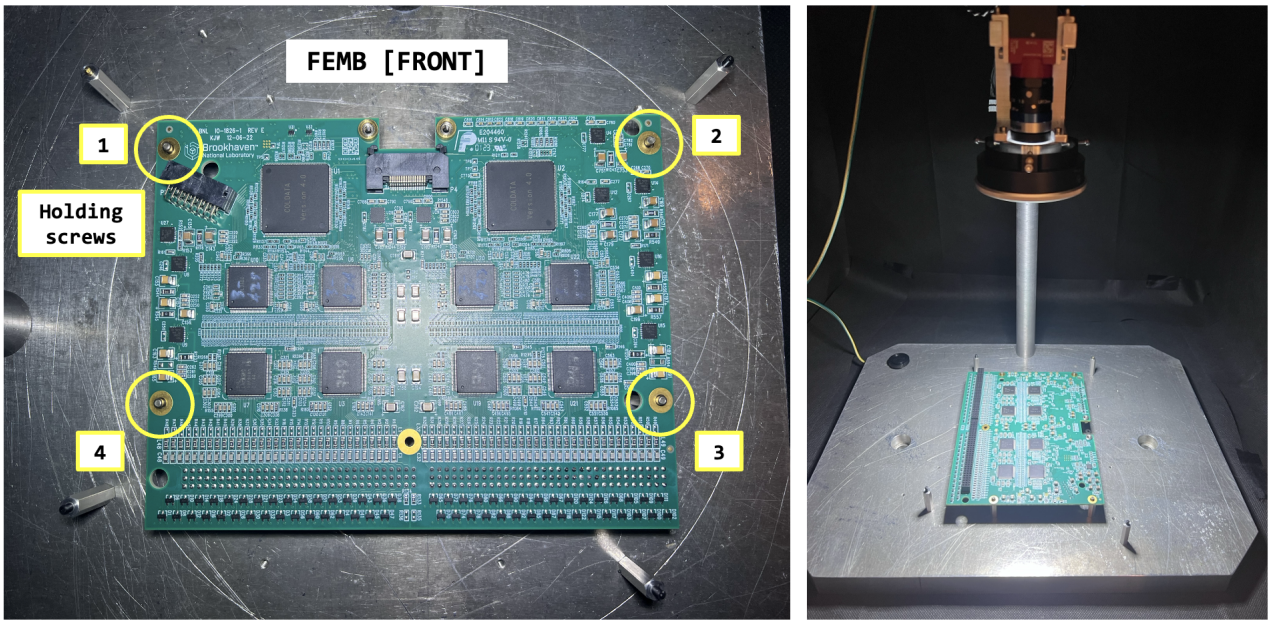


Figure 8: An FEMB placed on the base, ready to have its picture taken.

Don't forget to shut the booth's curtain in between pictures!

Figure 9: Shutting the booth's curtain before taking a picture.

5) **In the computer, open a terminal (`Ctrl+Alt+T`) and navigate to the application directory:**

```
$ cd coldelec/Documents/FEMB_SN_recognition
```

6) **Run the application:**

```
$ python3 capture_pictures_FEMB.py
```

7) **Follow the application instructions:** From now on, you'll be taking pairs of pictures (two pictures per FEMB–one from the FRONT and one from the BACK). Keep these tips in mind:

- The **`Batch_ID`** variable is an integer number to help organize our pictures (Figure 10). You only need to input it once per batch of FEMBs. The new `Batch_ID` for a given batch must be the next integer after the last batch of pictures you processed, so take note of which batch you processed last!

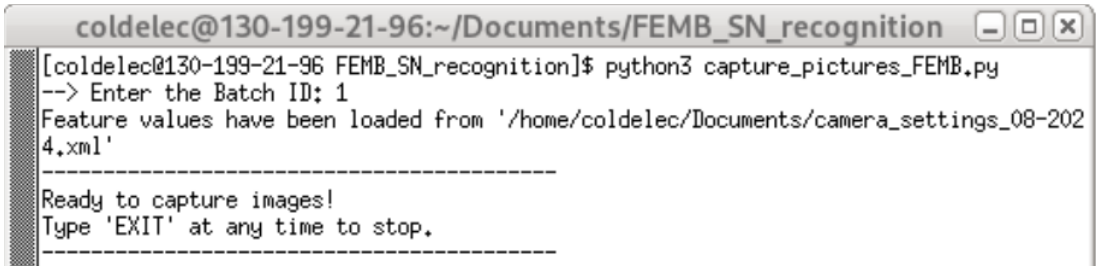


Figure 10: Inputting Batch ID = 1 in the application.

- You will be taking lots of pictures, so please take your time with each FEMB to ensure you **flip the FEMB board before taking the BACK picture**. This is crucial to ensure a good record-keeping of our boards.
- All captured images are saved in the `images` directory. The folders are named based on the `Batch_ID` you provide every time you start running the application (see Figure 11).

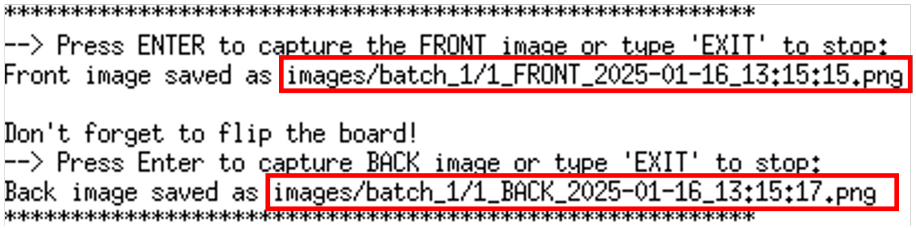


Figure 11: The application showing where each picture is saved.

- If you need to **retake a picture**, exit the application, delete the old pair of images, and rerun (`python3 capture_pictures_FEMB.py`) to take both FRONT and BACK pictures again.
- For any issues with the application, feel free to contact Karla Flores via email (`ktellezgi@bnl.gov`), or stop by her office (3-211).

3.2 Serial Number Recognition

After taking pictures, we need to identify all the FEMB components (chip types and serial numbers) so we can send them to DUNE's Hardware Database (HWDB) to keep them in the records for future use. We do this by running the recently-taken pictures through an OCR software based on Artificial Intelligence (AI). This piece of software will read the serial numbers (SN) of the FEMB and all its chips and will output two text files per board (one for the *front* side and one for the *back* side).

Follow these steps to perform the SN recognition:

1) **Open a new terminal (`Ctrl+Alt+T`) and navigate to the application directory:**

```
$ cd coldelec/Documents/FEMB_SN_recognition
```

Make sure that all the batches of pictures you want to process exist in the `images` directory (Figure 12).

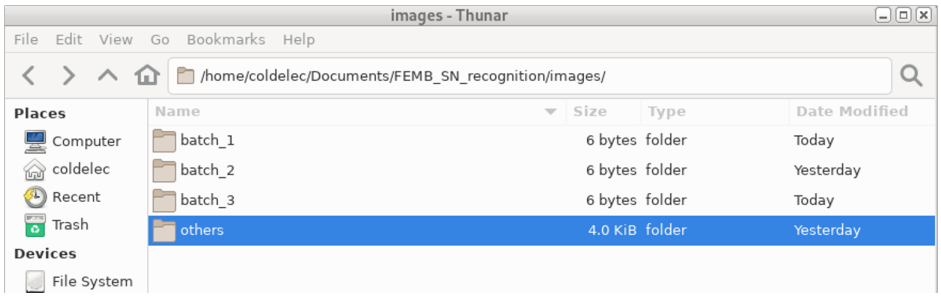


Figure 12: Three batches of pictures waiting to be analyzed for OCR.

2) **Does the FEMB have a QR code or a Density Matrix?** The FEMB serial number comes from reading its QR code (or Density Matrix (DM), in some cases). Make sure you identify what type of code the FEMB has (Figure 13). If necessary, modify the type of code the application reads by opening the `sn_recognition_qc_camera.py` file, and changing line 112. Don't forget to save before closing the file!

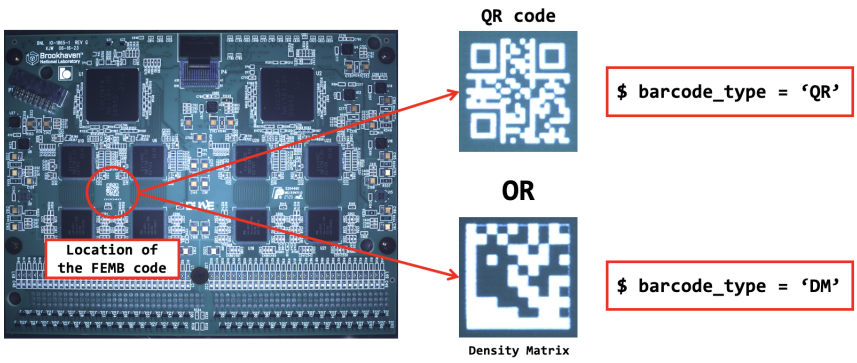


Figure 13: Inspect the FEMB to see if it has a QR code or a Density Matrix and modify the code accordingly.

3) Run the application

```
$ python3 sn_recognition_qc_camera.py
```

This will process all the batches inside the `images` directory. **If there are any batches that you don't wish to process, make sure to move them to the `others` folder before running the application.**

4) Wait patiently: the application might take a few minutes to run, depending on how many batches and how many boards is processing. You can see the results of the OCR live in the terminal as the application runs, as shown in Figure 14. Make sure to pay attention to these readings to detect any potential errors.

Figure 14: The SN-recognition application running and showing its output.

5) Make sure the results are being saved: the results of the OCR for each batch are saved in the `results` directory. If you open the corresponding batch directory (`batch_X`, with `X` being the batch number), you will find a set of subdirectories that contain the OCR results of each FEMB, named after each FEMB Serial Number.

3.3 Visual Inspection of the OCR Results

Once you have processed a batch (or more), it's important to perform a careful visual inspection of the results. The goal is to make sure that the serial numbers and batch numbers on each chip have been accurately recognized by our SN-recognition application.

To make the inspection process efficient and reliable, keep the following key points in mind:

1. **What are we looking for?** Figure 15 shows the most critical parts of the text on each chip. These elements **must** be correctly recognized by the OCR tool and **cannot** be wrong. The primary goal of the visual inspection is to verify that the extracted text matches exactly with what appears on the chips.

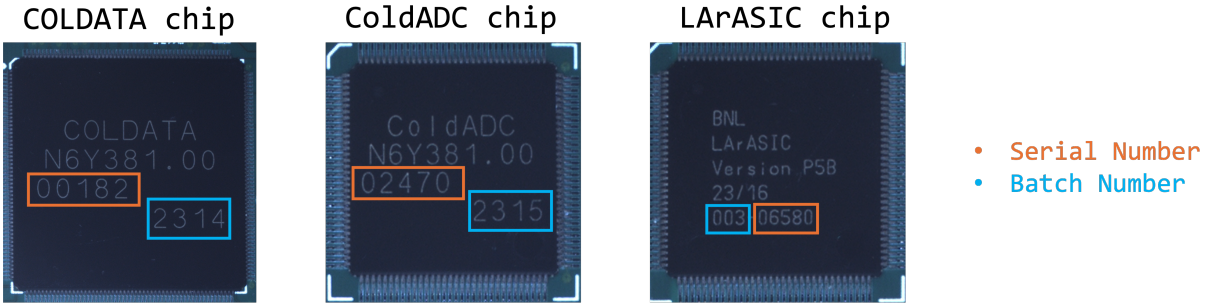
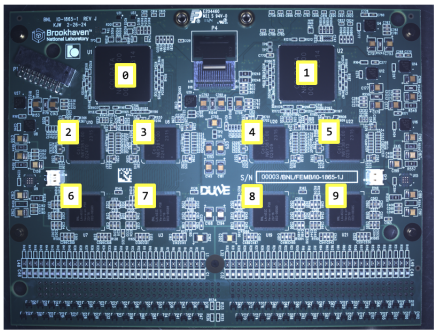


Figure 15: Serial numbers and batch numbers on individual chips. These are the most critical elements to be read by our application.

2. **Understand the Chip Naming Convention.** In the code, chips are labeled from 0 to $N-1$, where N represents the total number of chips on each side of the FEMB. Figure 16 provides tables that illustrate the mapping between these numerical labels and the physical chip locations on the FEMB.

FRONT of FEMB

Name in the code	Actual chip
Chip 0	COLDATA
Chip 1	COLDATA
Chip 2	ColdADC
Chip 3	ColdADC
Chip 4	ColdADC
Chip 5	ColdADC
Chip 6	LArASIC
Chip 7	LArASIC
Chip 8	LArASIC
Chip 9	LArASIC



BACK of FEMB

Name in the code	Actual chip
Chip 0	ColdADC
Chip 1	ColdADC
Chip 2	ColdADC
Chip 3	ColdADC
Chip 4	LArASIC
Chip 5	LArASIC
Chip 6	LArASIC
Chip 7	LArASIC

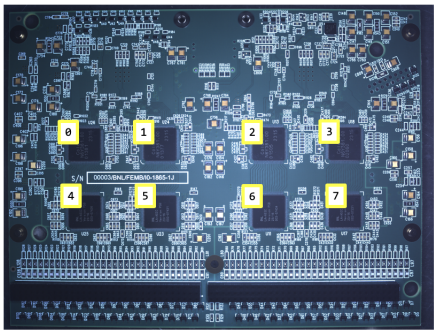


Figure 16: Mapping between chip label and chip location on both sides of an FEMB.

3. **How to Perform the Visual Inspection?**

   Inspect individual FEMBs. Navigate to the corresponding `batch_X` folder and open a specific FEMB directory. Inside, you will find multiple `.png` files, each containing a cropped image of a chip. Additionally, there will be two `.txt` files—one for the **front** and one for the **back** of the FEMB.

   Figure 17 shows an example of `front_results.txt` for an FEMB with serial number `00003`. Your task is to open each chip image and compare its text with the corresponding OCR result in the `.txt` file. Ensure that both the batch number and serial number (Figure 15) are correctly recognized.

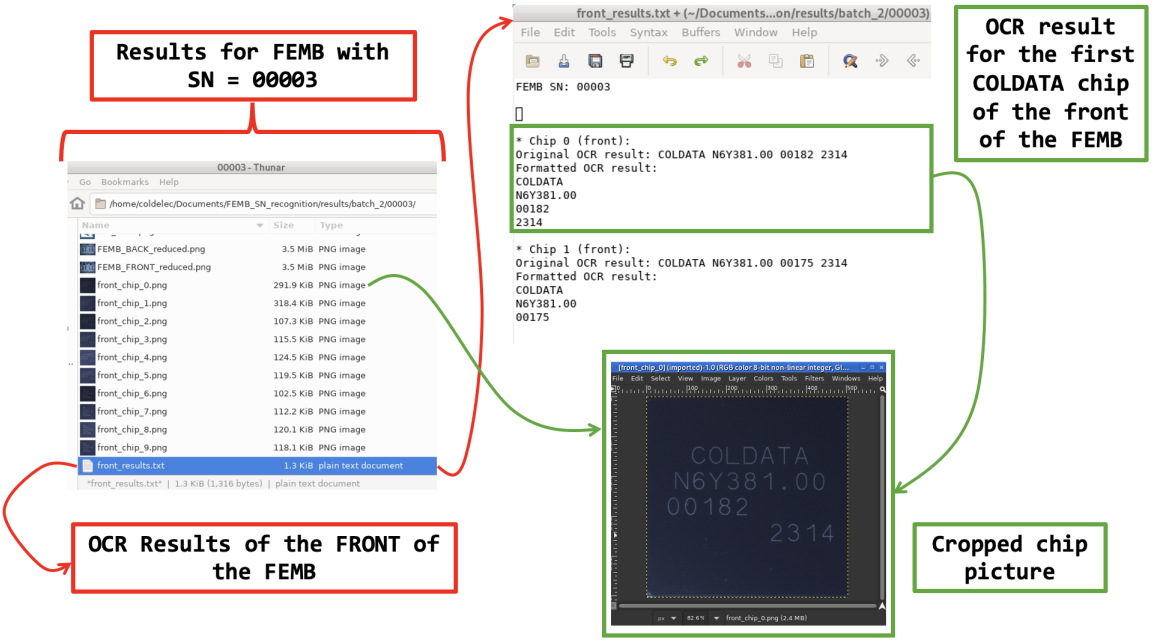


Figure 17: Running a quick visual inspection of the OCR result for Chip 0, front.

4. **If you find errors in any chip SN reading, modify the corresponding `.txt` file and save it.**

5. **SN-recognition Application available in GitHub:**

   `https://github.com/KARLATGF/DUNE-sn-rec`

3.4 Sending Records to DUNE's Hardware Database

After you are done processing a batch of FEMBs, and you have ran a visual inspection of the results, you must create each FEMB's records in DUNE's HWDB. For this, follow the next steps:

1. If this is the first time you are uploading data to HWDB, or if you ran out of tokens, follow the instructions in the following link to obtain your JWT (JASON Web Token) tokens:

   `https://dune.github.io/computing-HWDB/setup.html`

   After you execute

   ```
   $ htgettoken --vaultserver=htvaultprod.fnal.gov --issuer=fermilab
   ```

   you will see some info printed in the terminal. Keep note of the place where your tokens are stored, for instance

   ```
   $ Storing bearer token in /run/user/1000/bt_u1000
   ```

2. You will need to define the `CURL` and `APIPATH` variables. To define `CURL`, type the following in the terminal (make sure you use the correct directory, obtained from the previous step):

   ```
   $ alias CURL='curl -s --header "Authorization: Bearer $(cat /run/user/1000/bt_u1000)"'
   ```

   To define `APIPATH`, type

   ```
   $ export APIPATH='https://dbwebapi2.fnal.gov:8443/cdbdev/api/v1'
   ```

3. Then, open a new terminal in the current directory (`coldelec/Documents/FEMB_SN_recognition`) and run the script to generate the corresponding `.txt` files for the batch:

   ```
   $ python3 produce_txt_json.py
   ```

   The script will first ask you which batch you wish to process (Figure 18). Once you type the batch number and hit *Enter*, the script will generate a `femb_parts.txt` file in every FEMB directory, which contains the serial numbers of the FEMB itself, and its chips.

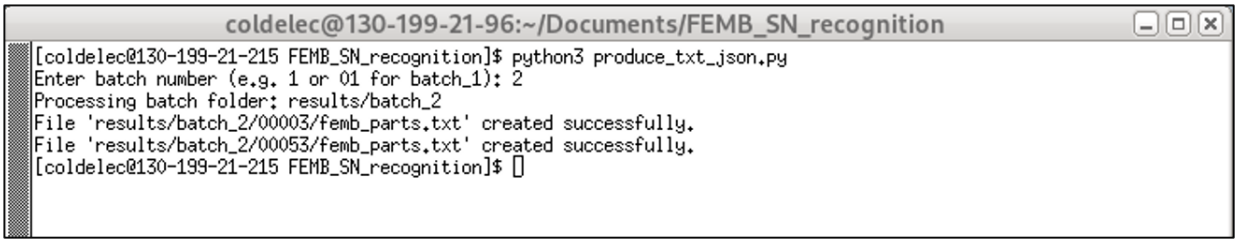


Figure 18: Running the script `produce_txt_json.txt` to produce the files needed to send records to HWDB.

4. As a final visual test, which could be optional, you could open each of these `femb_parts.txt` and make sure that the information in there matches each of the chips (Figure 19).

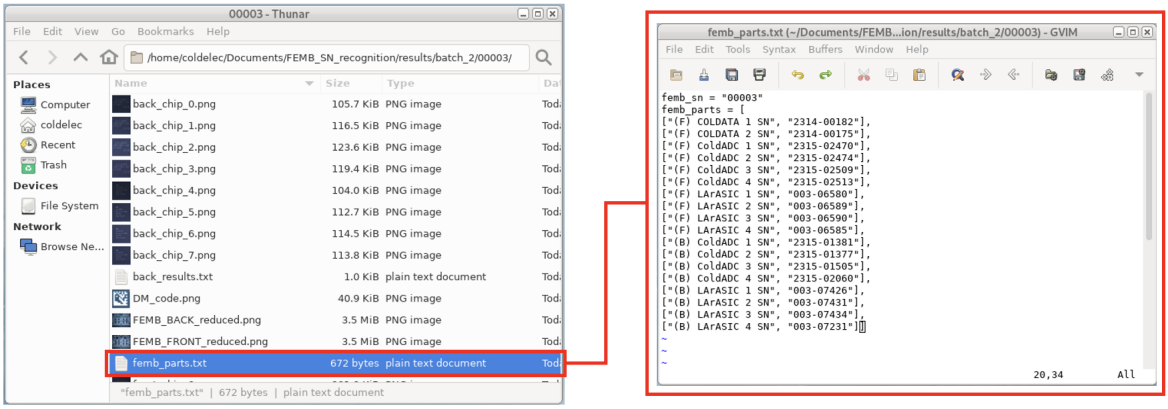


Figure 19: Checking the `femb_parts.txt` file one last time before sending the records to HWDB.

5. Next, open a new terminal and go to the HWDB directory:

```
$ cd coldelec/Documents/FEMB_SN_recognition/HWDB
```

6. Open the file `dune_ce_hwdb.py` and make sure that the `curl_command` variable includes your information:

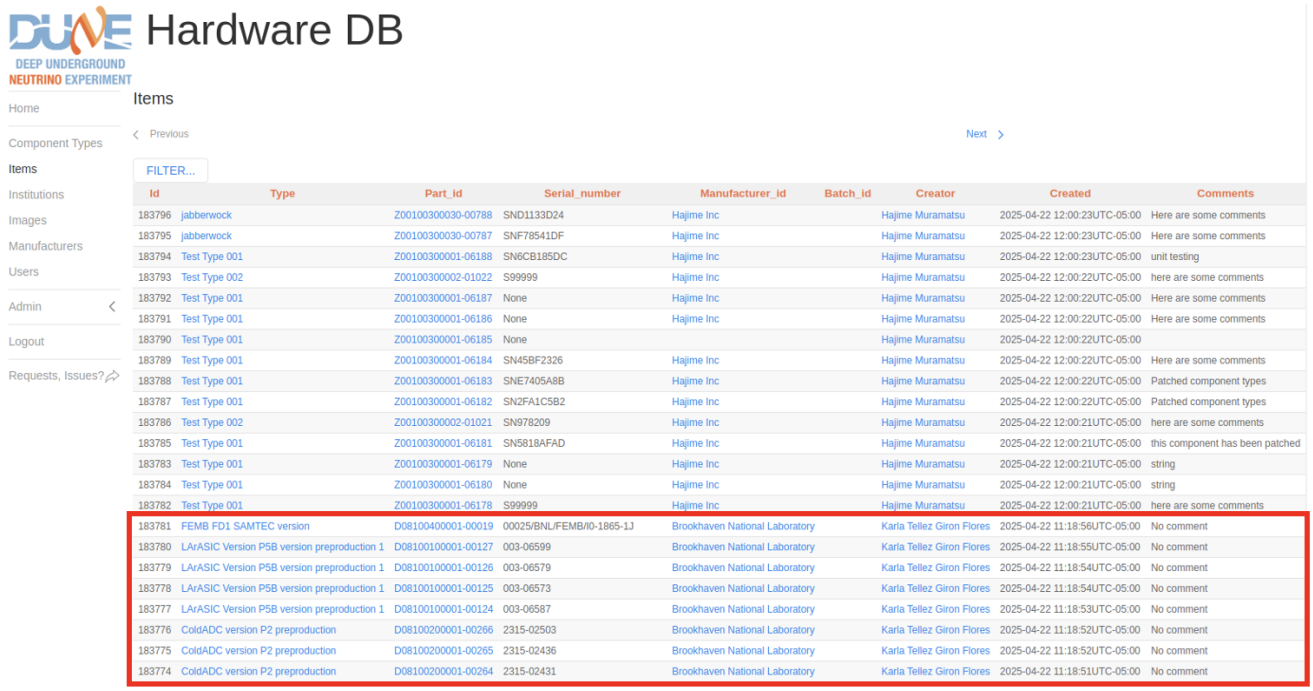
```
curl_command = 'curl -s --header "Authorization: Bearer $(cat /run/user/1000/bt_u1000)"'
```

7. After you save any changes on `dune_ce_hwdb.py`, run the following script:

```
$ python3 submit_FEMBs.py
```

This script will create each FEMB record in the HWDB, including each of its chips. This could take a few minutes to execute, depending on how many FEMBs per batch exist.

8. To check if the records were created, you can log into `https://dbweb9.fnal.gov:8443/cdbdev/` and search for *FEMB* under *Items*. Figure 20 shows a freshly-uploaded FEMB and its components (COLDATA, ColdADC and LArASIC chips).



Id	Type	Part_id	Serial_number	Manufacturer_id	Batch_id	Creator	Created	Comments
183796	jabberwock	Z00100300030-00788	SND1133D24	Hajime Inc		Hajime Muramatsu	2025-04-22 12:00:23UTC-05:00	Here are some comments
183795	jabberwock	Z00100300030-00787	SNF78541DF	Hajime Inc		Hajime Muramatsu	2025-04-22 12:00:23UTC-05:00	Here are some comments
183794	Test Type 001	Z00100300001-06188	SN6CB185DC	Hajime Inc		Hajime Muramatsu	2025-04-22 12:00:23UTC-05:00	unit testing
183793	Test Type 002	Z00100300002-01022	S99999	Hajime Inc		Hajime Muramatsu	2025-04-22 12:00:22UTC-05:00	here are some comments
183792	Test Type 001	Z00100300001-06187	None	Hajime Inc		Hajime Muramatsu	2025-04-22 12:00:22UTC-05:00	Here are some comments
183791	Test Type 001	Z00100300001-06186	None	Hajime Inc		Hajime Muramatsu	2025-04-22 12:00:22UTC-05:00	Here are some comments
183790	Test Type 001	Z00100300001-06185	None			Hajime Muramatsu	2025-04-22 12:00:22UTC-05:00	
183789	Test Type 001	Z00100300001-06184	SN45BF2326	Hajime Inc		Hajime Muramatsu	2025-04-22 12:00:22UTC-05:00	Here are some comments
183788	Test Type 001	Z00100300001-06183	SNE7405A8B	Hajime Inc		Hajime Muramatsu	2025-04-22 12:00:22UTC-05:00	Patched component types
183787	Test Type 001	Z00100300001-06182	SN2FA1C5B2	Hajime Inc		Hajime Muramatsu	2025-04-22 12:00:22UTC-05:00	Patched component types
183786	Test Type 002	Z00100300002-01021	SN978209	Hajime Inc		Hajime Muramatsu	2025-04-22 12:00:21UTC-05:00	here are some comments
183785	Test Type 001	Z00100300001-06181	SN5818AFAD	Hajime Inc		Hajime Muramatsu	2025-04-22 12:00:21UTC-05:00	this component has been patched
183783	Test Type 001	Z00100300001-06179	None	Hajime Inc		Hajime Muramatsu	2025-04-22 12:00:21UTC-05:00	string
183784	Test Type 001	Z00100300001-06180	None	Hajime Inc		Hajime Muramatsu	2025-04-22 12:00:21UTC-05:00	string
183782	Test Type 001	Z00100300001-06178	S99999	Hajime Inc		Hajime Muramatsu	2025-04-22 12:00:21UTC-05:00	here are some comments
183781	FEMB FD1 SAMTEC version	D08100400001-00019	00025/BNL/FEMB/I0-1865-1J	Brookhaven National Laboratory		Karla Tellez Giron Flores	2025-04-22 11:18:56UTC-05:00	No comment
183780	LArASIC Version P5B version preproduction 1	D08100100001-00127	003-06599	Brookhaven National Laboratory		Karla Tellez Giron Flores	2025-04-22 11:18:55UTC-05:00	No comment
183779	LArASIC Version P5B version preproduction 1	D08100100001-00126	003-06579	Brookhaven National Laboratory		Karla Tellez Giron Flores	2025-04-22 11:18:54UTC-05:00	No comment
183778	LArASIC Version P5B version preproduction 1	D08100100001-00125	003-06573	Brookhaven National Laboratory		Karla Tellez Giron Flores	2025-04-22 11:18:54UTC-05:00	No comment
183777	LArASIC Version P5B version preproduction 1	D08100100001-00124	003-06587	Brookhaven National Laboratory		Karla Tellez Giron Flores	2025-04-22 11:18:53UTC-05:00	No comment
183776	ColdADC version P2 preproduction	D08100200001-00266	2315-02503	Brookhaven National Laboratory		Karla Tellez Giron Flores	2025-04-22 11:18:52UTC-05:00	No comment
183775	ColdADC version P2 preproduction	D08100200001-00265	2315-02436	Brookhaven National Laboratory		Karla Tellez Giron Flores	2025-04-22 11:18:52UTC-05:00	No comment
183774	ColdADC version P2 preproduction	D08100200001-00264	2315-02431	Brookhaven National Laboratory		Karla Tellez Giron Flores	2025-04-22 11:18:51UTC-05:00	No comment

Figure 20: An FEMB that has been uploaded to the HWDB.

4 Post-Assembly FEMB Checkout Test Procedure

This process should be carried out immediately after the FEMBs have undergone the SN-recognition process. The user can checkout-test up to four FEMBs simultaneously. Ideally, the user will process a batch of $4N$ FEMBs for SN-recognition and then proceed directly with the checkout test. The procedure is illustrated in Figure 21.

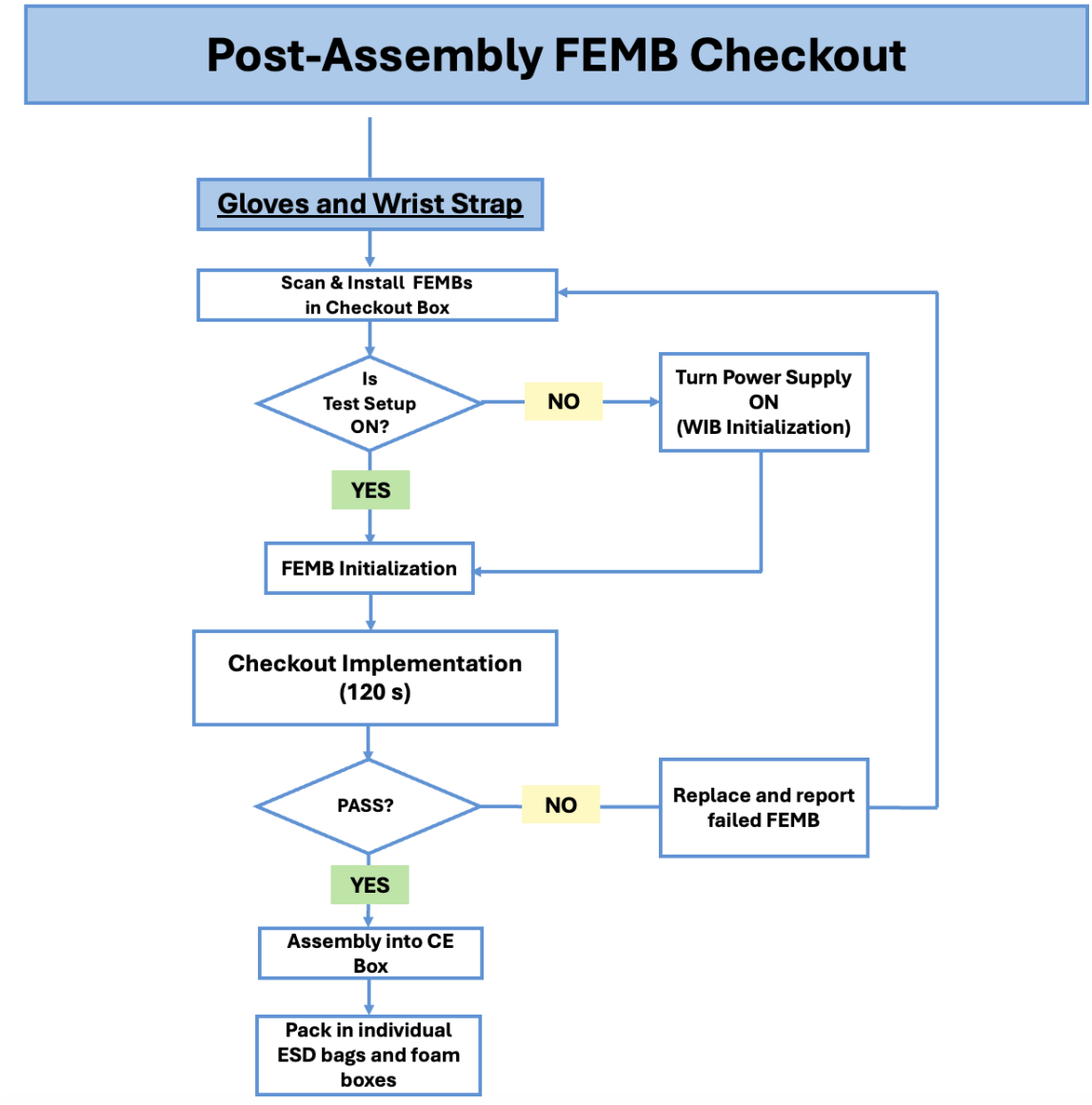


Figure 21: Post-Assembly FEMB Checkout Test workflow.

Important: Always wear an ESD wrist strap and anti-static gloves when handling FEMBs.

1. Open the lid of the checkout test box (203).
2. Take one FEMB and connect both the data and power cables (208).
3. Carefully place the FEMB inside the checkout test box, using one of the available slots (Figure 22).

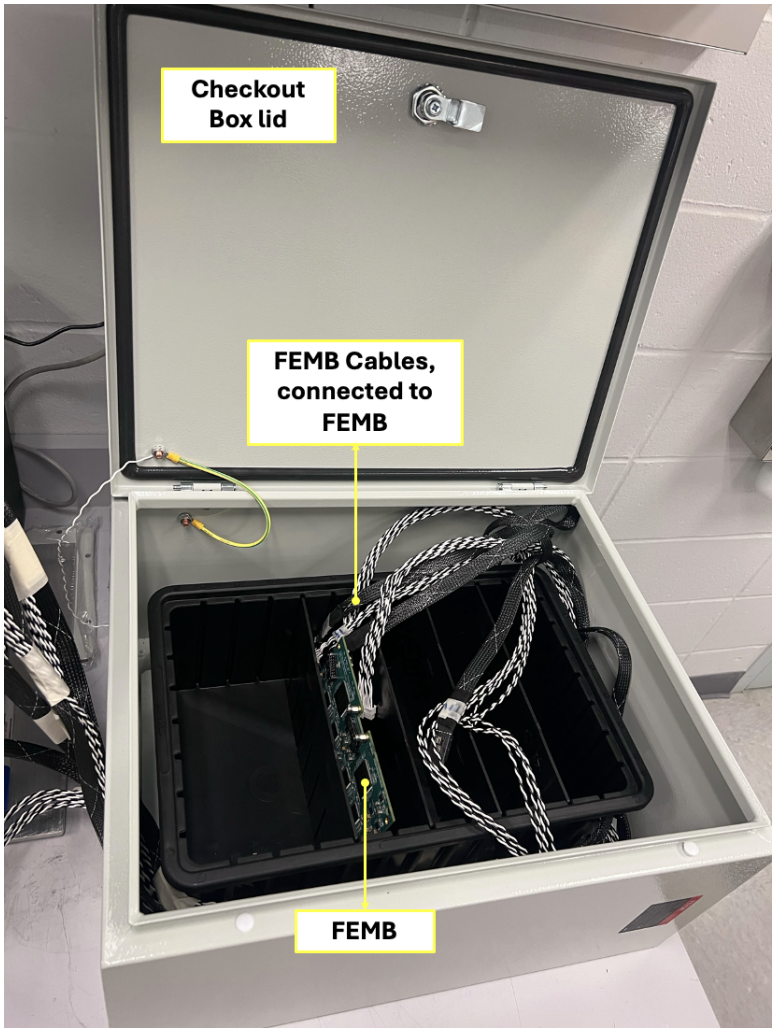


Figure 22: Placing an FEMB inside a slot in the checkout box.

4. Repeat steps 2 and 3 for three additional FEMBs (for a total of four FEMBs).
5. Close the lid of the checkout test box.
6. Verify that the power supply unit (202) is turned on. If it is off, power it on.
7. Wait approximately 30 seconds to allow the system to stabilize.
8. **(Optional)** Open a terminal and ping the WIB to confirm it is powered on and communicating correctly.
9. Open a terminal and navigate to the directory containing the checkout script `FEMB_CHK.py`. Run the script:

```
$ python FEMB_CHK.py
```

10. Follow the instructions displayed by the script:

    (a) Enter your name when prompted.

    (b) Scan the FEMB QR or Data Matrix codes using the scanner (see Appendix A to learn how to do this). If a scanner is unavailable, the codes can be entered manually.

    (c) Press `Enter` to begin the checkout test.

11. The test will start automatically and take approximately three minutes. A summary of the results will be displayed in the terminal (Figure 23).

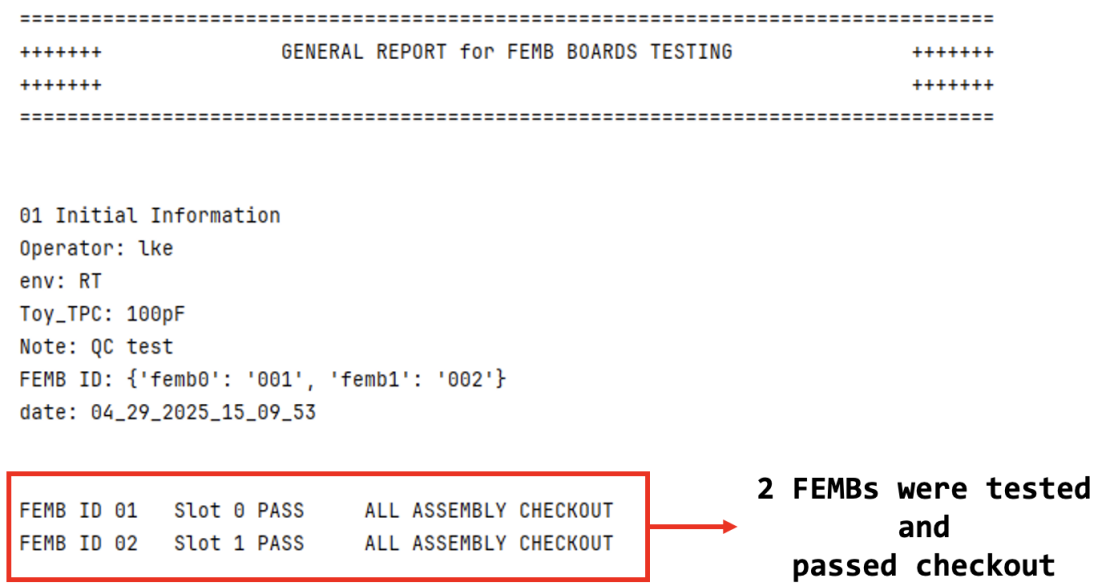


Figure 23: An example of the results of a checkout test ran with two FEMBs.

12. If the test fails for any FEMB:

    - Record its identifier.
    - Carefully place the FEMB aside in a safe spot.
    - Report the issue to Lingyun or Shanshan.

13. For FEMBs that pass, pack each one in its individual ESD bag and place them in a safe location.

14. Repeat this procedure for the remaining FEMBs in the current $4N$ batch.

A Using a scanner to scan FEMB codes

1. Refer to Figure 24 to locate the code (either QR or DM) on the FEMB.

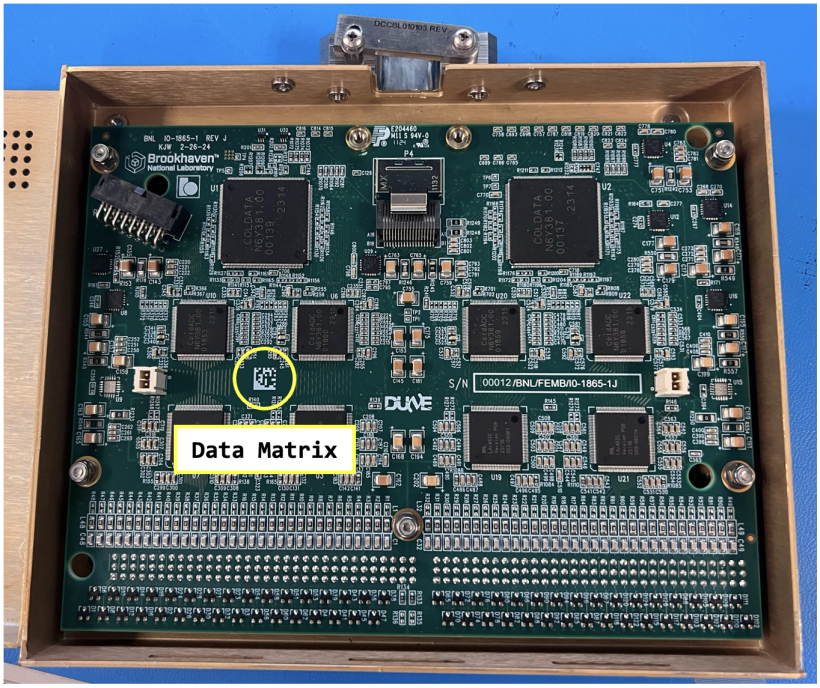


Figure 24: An FEMB inside a CE Box. Its Data Matrix is enclosed in a circle.

2. Find the Code Scanner and ensure its Bluetooth dongle is plugged into the PC. Next, power on the scanner by pressing the trigger. The scanner is ready for use when the blue light illuminates and it emits a series of *beeps* (Figure 25).

Figure 25: Bluetooth dongle connected to the PC (left). Code Scanner is ready to use (right).

3. Scan the FEMBs QR/DM code (Figure 26). When a code is scanned, you will hear a *beep*, followed by the displaying of the contents of the code on the terminal.

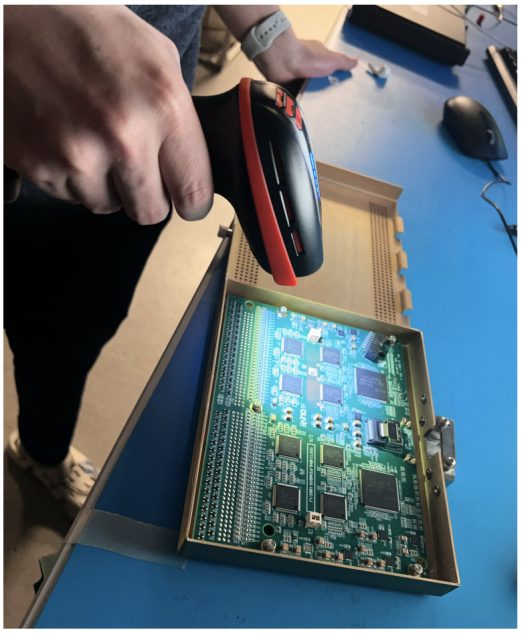


Figure 26: Scanning an FEMB's DM code.

4. Review the information on the terminal and follow the instructions. You have the option to modify the info if there is anything wrong, as well as the option to proceed with the testing if everything looks correct.