

# Baby-MOSS Studies Beam Test @ UC Davis

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### Outlines

- Beam Test Setups
- Beam Test Procedure
- Studies on Threshold (THR) Scan
- Preliminary Reults
  - FHR vs Dose
  - THR vs Dose
- Summary & Outlooks



# Beam Test Setup @ UC Davis





- **People:** Zhenyu Ye, Yu Hu, Shujie Li, Austin Raymer
- Target Does: 1 Mrad (Si)
  - Planed Boards: 2 boards @ room Temperature
    - Board-D (tested @ Fermi Lab)
    - Board-B
- Beam E (MeV): 64.0
- Test with Old & New Framework

\*60 MeV protons with intensity:

- 10<sup>10</sup> cm<sup>-2</sup>s<sup>-1</sup> in ~730s
- 10<sup>9</sup> cm<sup>-2</sup>s<sup>-1</sup> ~ 1h



# **Beam Test Procedure**





# Irradiation Log from UC Davis

**Board-D** 

**Board-B** 

						~~~~~				
Run	Time	Run Time (s)	Mean Current (A)	Std Dev (A)	Incr Dose (rad)	Acc Dose (rad)	Incr Fluence $(p/cm^2)$	Acc Fluence $(p/cm^2)$	Avg Dose Rate (rad/s)	Beam Profil
Run #1	13:59:38	603.311	9.961E-09	1.325E-09	1.002E+05	1.002E+05	7.502E+11	7.502E+11	1.660E+02	0 - 0.5 cm
BaybyMoss-D					9.966E+04	9.966E+04	7.464E+11	7.464E+11	1.652E+02	0.5 - 1.5 cm
0			5		9.766E+04	9.766E+04	7.314E+11	7.314E+11	1.619E+02	1.5 - 2.5 cm
Run #2	15:10:43	636.162	9.454E-09	2.093E-09	1.002E+05	2.004E+05	7.507E+11	1.501E+12	1.576E+02	0 - 0.5 cm
BaybyMoss-D					9.974E+04	1.994E+05	7.470E+11	1.493E+12	1.568E+02	0.5 - 1.5 cm
					9.773E+04	1.954E+05	7.314E+11	1.462E+12	1.619E+02	1.5 - 2.5 cm
Run #3	16:07:07	1874.594	9.604E-09	1.799E-09	3.001E+05	5.001E+05	2.247E+12	3.745E+12	1.601E+02	0 - 0.5 cm
BaybyMoss-D	1			2	2.986E+05	4.976E+05	2.236E+12	3.727E+12	1.593E+02	0.5 - 1.5 cm
					2.926E+05	4.876E+05	2.191E+12	3.652E+12	1.561E+02	1.5 - 2.5 cm
Run #4	17:39:30	1304.753	2.300E-08	3.950E-09	5.002E+05	1.000E+06	3.746E+12	7.491E+12	3.834E+02	0 - 0.5 cm
BaybyMoss-D					4.977E+05	9.952E+05	3.728E+12	7.454E+12	3.815E+02	0.5 - 1.5 cm
					4.877E+05	9.752E+05	3.653E+12	7.304E+12	3.738E+02	1.5 - 2.5 cm
Run #5	19:45:40	513.371	2.342E-08	3.216E-09	2.004E+05	2.004E+05	1.501E+12	1.501E+12	3.904E+02	0 - 0.5 cm
BaybyMoss-B					1.994E+05	1.994E+05	1.494E+12	1.494E+12	3.884E+02	0.5 - 1.5 cm
					1.954E+05	1.954E+05	1.462E+12	1.462E+12	3.619E+02	1.5 - 2.5 cm
Run #6	20:28:31	999.022	2.301E-08	5.619E-09	3.831E+05	5.831E+05	2.869E+12	4.367E+12	3.835E+02	0 - 0.5 cm
BaybyMoss-B					3.812E+05	5.802E+05	2.855E+12	4.345E+12	3.816E+02	0.5 - 1.5 cm
2-240 - 220					3.735E+05	5.685E+05	2.798E+12	4.258E+12	3.739E+02	1.5 - 2.5 cm
Run #7	20:49:58	1049.252	2.387E-08	3.677E-09	4.174E+05	1.000E+06	3.126E+12	7.492E+12	3.978E+02	0 - 0.5 cm
BaybyMoss-B					4.153E+05	9.954E+05	3.110E+12	7.455E+12	3.958E+02	0.5 - 1.5 cm
					4 060E 105	0.754E.05	2 0485 12	7 205E 12	2 8785.02	15 25 am

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# Studies on Threshold (THR) Scan

What is threshold scan?

In my language, THR is sending N pulses (n\_injection) with a certain voltage (Vpulseh) to each pixel, and check the response. Scan the Vpulseh in a given range.



# Example of the THR Scan (before irradiation)



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#### Example of the THR Scan (before irradiation)



### THR vs Vcasb



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#### THR vs Vcasb after Irradiation



Still working on the 1Mrad THR data



### Mask on Hot Pixels

Pixels have abnormally high level of activity - fire too often : >1% events



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# FHR w. Hot Pixel Mask - Vcasb=100



Hot Pixel Defination: 100krad, Vcasb=100; fire >1% events



# FHR w. Hot Pixel Mask - Vcasb=112



- No clear peak structure is observed at large N
- With different Vcasb, the masked pixels will be different

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#### FHR vs Vcasb w. Dose



Still analyzing the FHR after irradiation; More checks are needed



# FHR vs THR w. Dose



Still analyzing the FHR after irradiation; More checks are needed



# Summary & Outlook

#### Summary

- We tested board-D and board-B during the beam test @ UC Davis, each board is exposed for1Mrad
- We studied the THR dependence after Irradiation for board-D
- We showed the very preliminary FHR for board-D after irradiation

#### Outlook

- Studies on THR vs Temperature (before & after irradiation)
- More checks on FHR w. different hotpixel mask & dependence on THR
- Studies on the Full Scan (other than FHR & THR)
- Results comparison between the Old & New Framework



# Backups

# Cyclotron @ UC Davis

Table 1. Beam Parameters			
Particle	Max Energy MeV	Max Current in uA	Max Flux protons/(cm2-sec)
Protons ( <sup>1</sup> H)	67.5	0.100	1.6 X 10 <sup>10</sup>
Deuterons ( <sup>2</sup> H)	45	0.100	1.6 X 10 <sup>10</sup>
Alphas ( <sup>4</sup> He)	90	0.100	8X 10 <sup>9</sup>
Helion ( <sup>3</sup> He)	130	0.100	8X 10 <sup>9</sup>



#### Proposal:

 TID of 1 Mrad (Si) can be accumulated with 60 MeV protons with 10<sup>10</sup> cm<sup>-2</sup>s<sup>-1</sup> intensity in ~730s

1 Mrad/(8.55 MeV cm<sup>2</sup> g<sup>-1</sup> \* 10<sup>10</sup> cm<sup>-2</sup>s<sup>-1</sup>) ~ 730s

 Displacement damaged in Si with fluence of 10<sup>13</sup> 1 MeV equivalent neutron/cm<sup>2</sup> can be accumulatd with 60 MeV protons with 10<sup>10</sup> cm<sup>-2</sup>s<sup>-1</sup> intensity in ~620s

 $10^{13} \text{ cm}^{-2} / 1.6*10^{10} \text{ cm}^{-2}\text{s}^{-1} \sim 620 \text{s}$ 

Expose the Baby-MOSS chip for 11~15 mins with 60 MeV protons



# Cyclotron @ UC Davis





Figure 1. Radial distribution of fluence factors for the 63.3 MeV proton beam

- Scheduled time: 2025.01.21
- The beam intensity varies < 5% within 3 cm



# Plans for the beam test @ UC Davis



- Controller to adjust the XY position with remote control available
- Two real-time cameras to monitor
- Beam dose monitor/counter
- Different shapes of beam filter/cover, size/shape adjustable



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# Plans for the beam test @ UC Davis



Scheduled 8 hours beam time for testing:

- Goal: Chip expose test under different times/dose
- During the beam test:
  - 1 babyMOSS (expose) + 1set of readout board (shielded);
  - Constantly running FHR tests all the time in the background

#### After the beam test:

Compare the FHR before and after the expose

- FHR at different Vcasb with different temperature
- Prepare for the beam tests:
  - Finish the threshold scan under different temperature;



## **Babymoss - from ALICE ITS report**



3.30; page 46, Fig. 3.33

Figure 3.27: Photograph of the MOSS test system.

MOSS

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# Testing configureations @ LBL

#### Configure w. DAC units:





Figure 3.40: Simplified schematic of the pixel front-end amplifier and discrimination sections.

#### For the threshold scan:

VPULSEH = 0 to 70 STEP = 1 N-Injection = 25 Strobe-Length = 100

#### Tests:

- Vcasb scan
- Temperature scan
- Threshold scan

#### W21D4 S3 CHIP3 W20E1 S2 CHIP1 W20E1 S2 CHIP3





# W20E1 S2 CHIP1 @ Room Temperature



#### Layer-over comparison with ALICE tests





#### small design differences in each region

	Region 0	Region 1	Region 2	Region 3
ТОР	Standard	Larger input transistor (M1)	Larger discriminator input transistor (M11)	Larger common-source transistor (M2)
воттом	Standard	Standard	Standard	Slightly different layout

- Good consistence for Region-0,1,3
- Some differences for Region-2

Individual differences?



### Temperature test with climatic chamber



- Temperature studies with both climatic chamber & cooling unit @ 5°C, 15°C, 25°C, 35°C, 45°C
- The loop with a cooling unit is built for the future beam test with controlled temperature



# FHR vs V<sub>casb</sub> @ different T



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# Summary

- We preseted the testing plan for the beam test @ UC Davis
  - Expose the Baby-MOSS chip for 11~15 mins with 60 MeV protons
  - Constantly running FHR tests all the time in the background
  - Compare the FHR at different Vcasb with different temperature before and after the expose
- We studied the baby-MOSS with different Vcasb and Temperature

![](_page_27_Picture_6.jpeg)

#### Where are the hot pixels?

![](_page_28_Figure_1.jpeg)

- 2D hit map are very random, so shown a Psedo-index vs FHR (eg. Index = X\*256+Y)
- Some of the pixels are fired every time, which should be masked out
- Most of the pixels are random fired

![](_page_28_Picture_5.jpeg)

# FHR vs Pixel Index @ 25 C

![](_page_29_Figure_1.jpeg)

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- In total: TOP: 256x256=65536 Pixels; BOT: 320x320=102400 Pixels
- Reorder all the Psedo-index form high to low, and plot it vs FHR

# FHR vs Pixel Index @ different T

![](_page_30_Figure_1.jpeg)

![](_page_30_Picture_2.jpeg)

# FHR vs Number of Masked Pixels

![](_page_31_Figure_1.jpeg)

• FHR as a function of number of masked Pixels

![](_page_31_Picture_3.jpeg)

### **Temperature calibration**

![](_page_32_Figure_1.jpeg)

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30 35

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50

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# **Cooling loop layout**

![](_page_33_Figure_1.jpeg)

# Testing system @ L268

#### Board-A

![](_page_34_Picture_2.jpeg)

![](_page_34_Picture_3.jpeg)

![](_page_34_Picture_4.jpeg)

![](_page_34_Picture_5.jpeg)

![](_page_34_Picture_6.jpeg)

# Compare with the tests using climatic chamber

![](_page_35_Figure_1.jpeg)

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- FHR are consistent with the tests using climatic chamber
- Slightly higher FHR for TOP-0 and BOT-1 with our cooling unit
  - Light? Will check with a dark tape covered

# Slow control for the cooling unit

![](_page_36_Figure_1.jpeg)

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# Heating/Cooling efficiency

Chiller Temp (°C)	Thermistor Readout (Arb.)	Thermistor Readout (°C)
5	576	9.6
50	1344	45.2

- Under the current configuration, we could reach 10~45 °C within 10 mins.
- We expect a longer time & narrower range once using a longer tube - will test before beam test

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![](_page_37_Figure_4.jpeg)

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