SiBT status for run 2025

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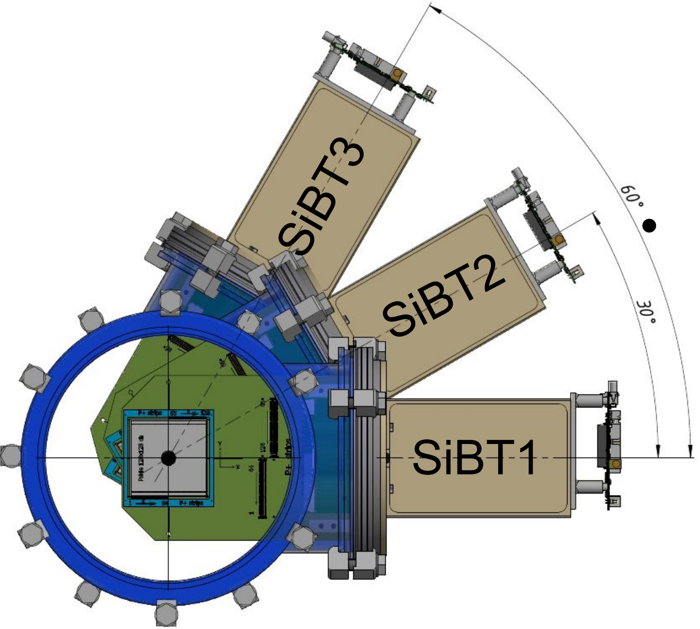
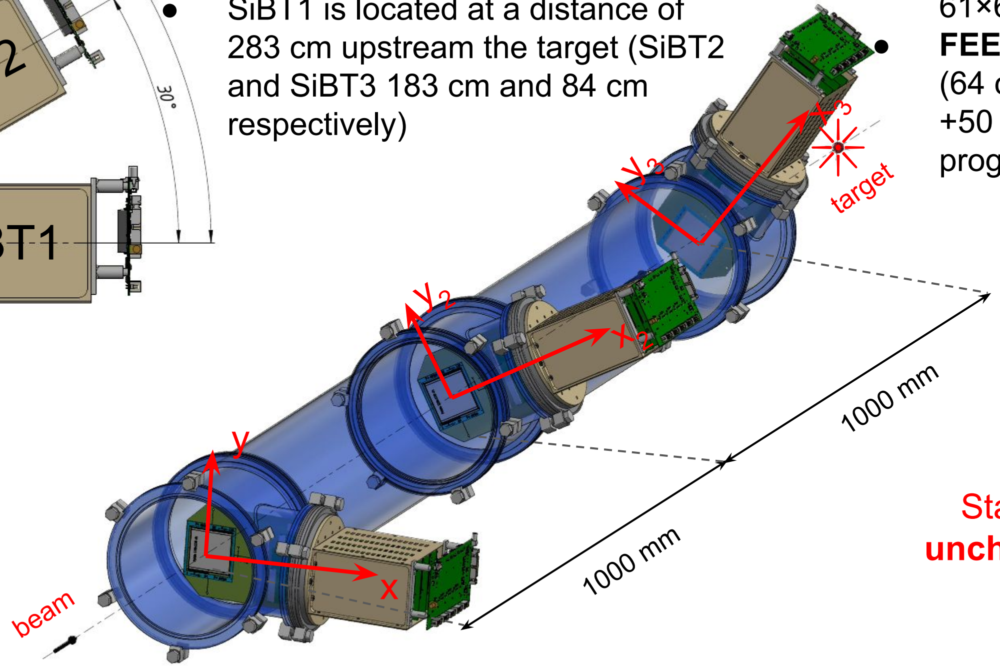
4-5 March 2025

Silicon Beam Tracker

- SiBT1 is positioned inside the beam pipe such that the strips are aligned along the X and Y axes whereas the plates of the SiBT2 and SiBT3 detectors are rotated azimuthally by 30° and 60° respectively;
- SiBT1 is located at a distance of 283 cm upstream the target (SiBT2 and SiBT3 183 cm and 84 cm respectively)

- **Physical purpose**: determination of the reaction plane, *refinement of the vertex definition*, beam profilometry
- **detector:** DSSD, 128×128 strips, pitch p+ / n+ strips 470 μm, thickness 175 μm, active area 61×61 mm^2
- **FEE**: based on VATA64HDR16.2 (64 ch, dynamic range: -20 pC ÷ +50 pC; 50, 100, 150, 300 ns programmable shaping time)





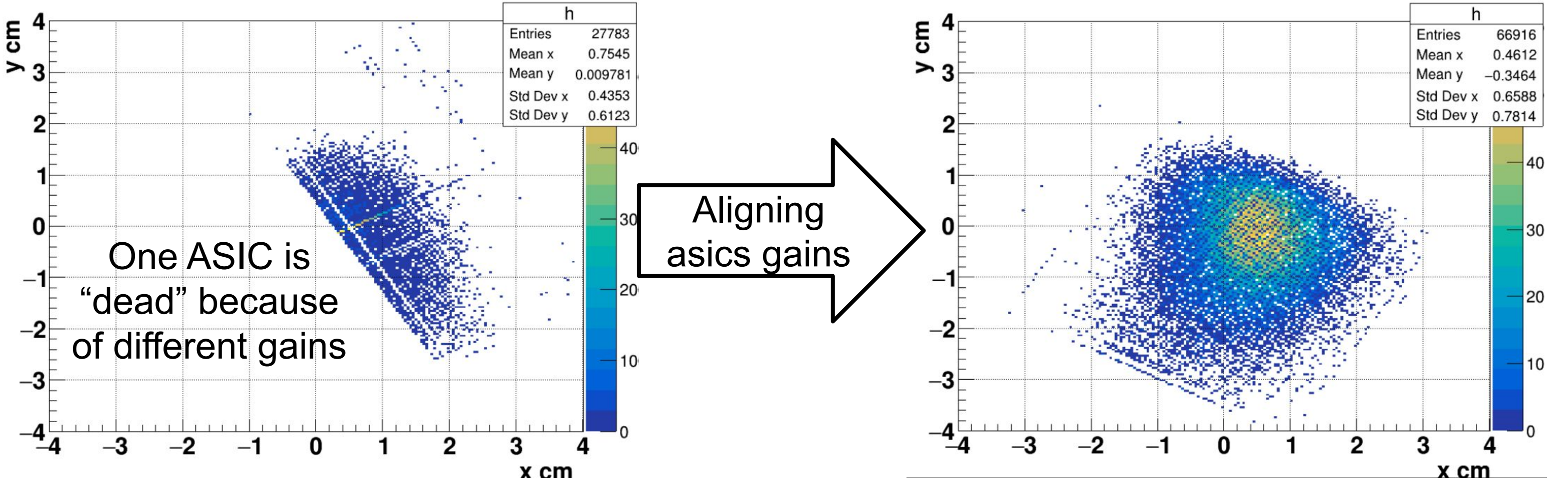
Station locations are **unchanged** compared to run 22-23

Setting the gain of SiBT ASICs

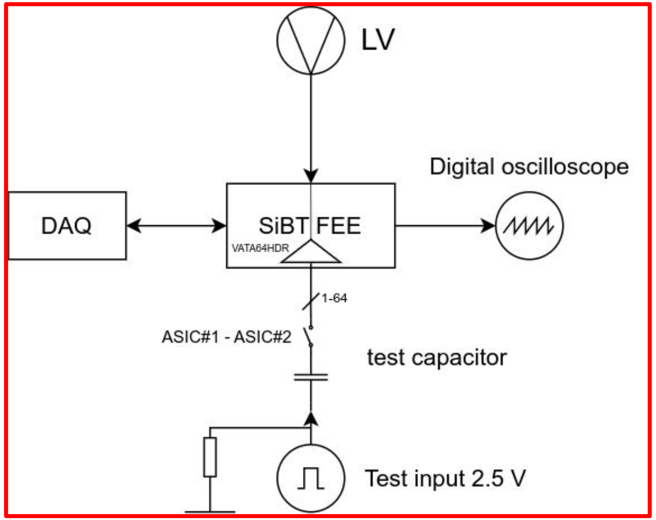
During the Xe run, the FEE gains of the SiBT chips were not tuned to signals on the order of 10.9 pC (the energy loss of Xe with energy of 3.8 GeV/n is about 245.5 MeV). Because of this, some of the signals (and hits) were lost. It is necessary to adjust the ASIC gain in the case of an input signal of the order of 10 pC.

Gains of chips with large dynamic range for input signals corresponding to Xe energy loss in silicon were adjusted, and then testing was done.

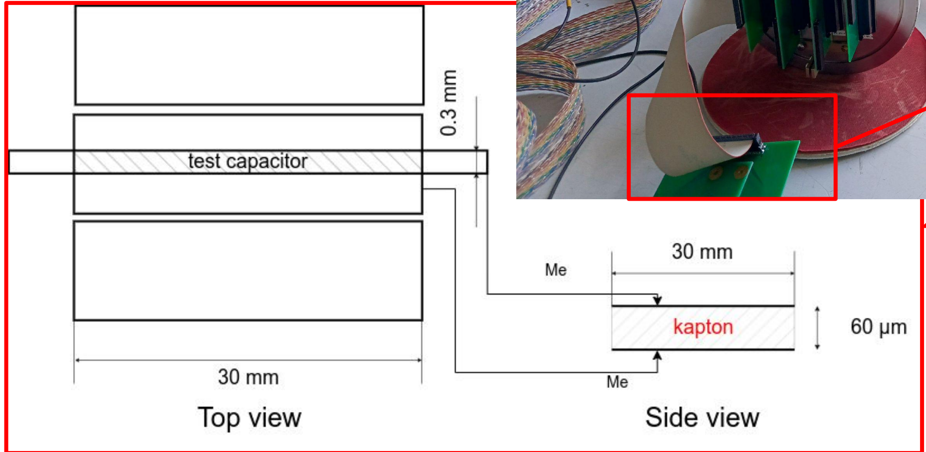
Due to the huge amplitude of the input signal, it is not possible to perform tests with the source, so FEE testing was performed with a test signal applied to the input test capacitance.

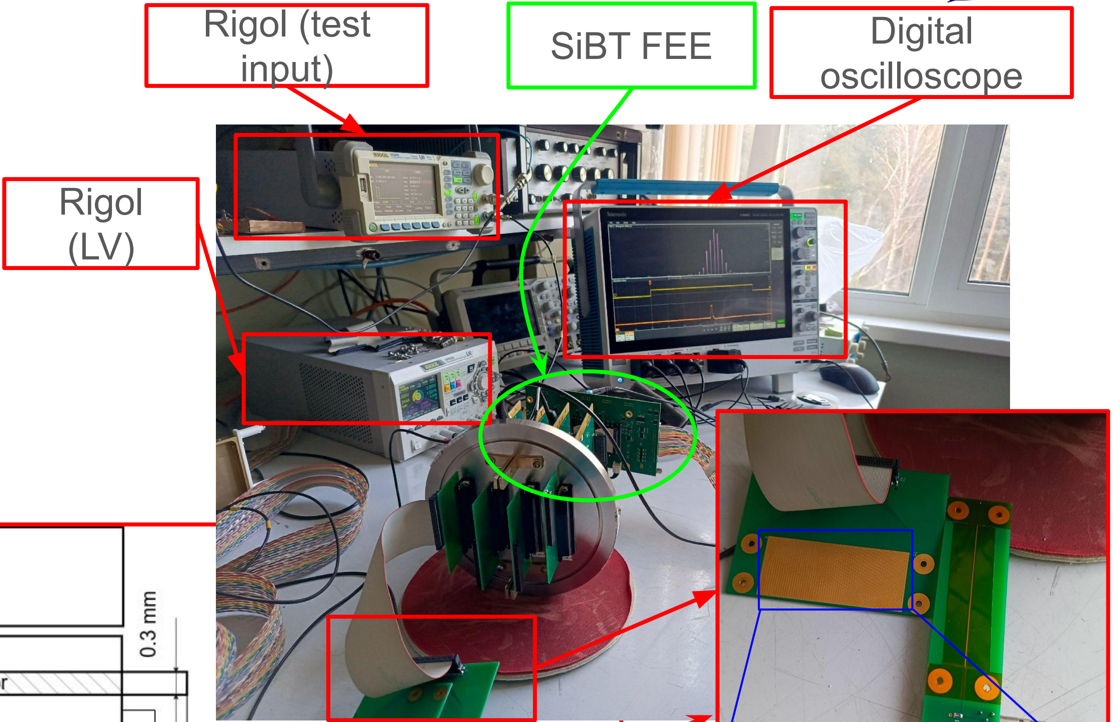


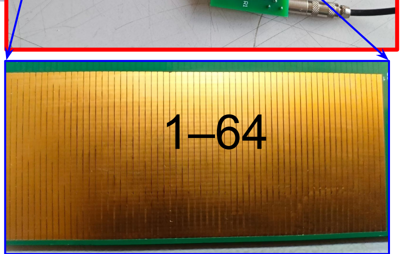
Test bench



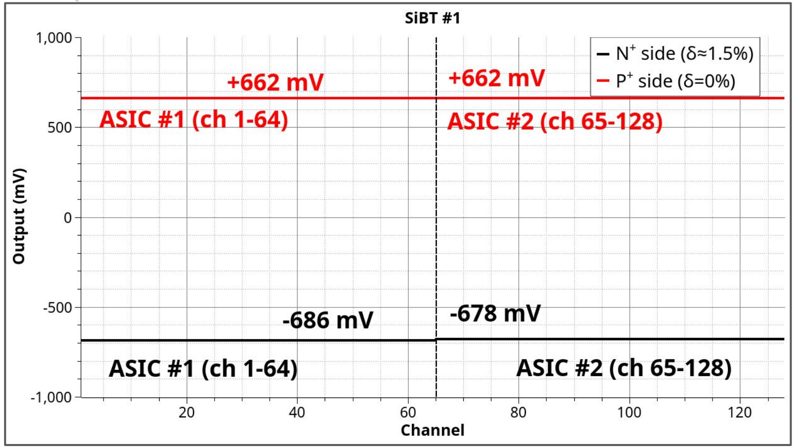
To test the FEE of SiBTs, a **2.5 V** signal was applied through a test capacitance into one of the channels of each chip. The test capacitance is formed by the intersection of two conductive lamellae, between which there is a layer of kapton (60 μm)

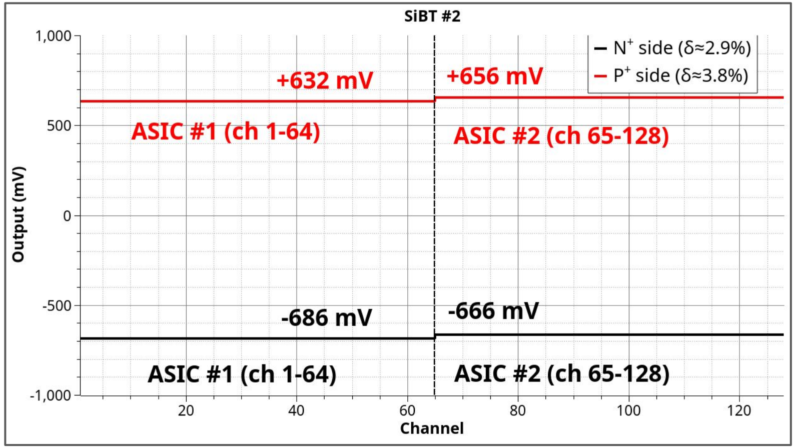






Test results



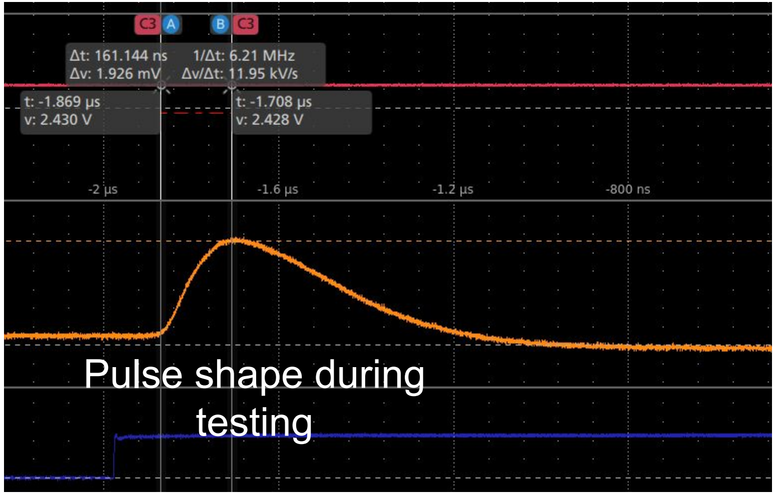


$$C = \frac{\epsilon \cdot \epsilon_0 \cdot S}{d}$$

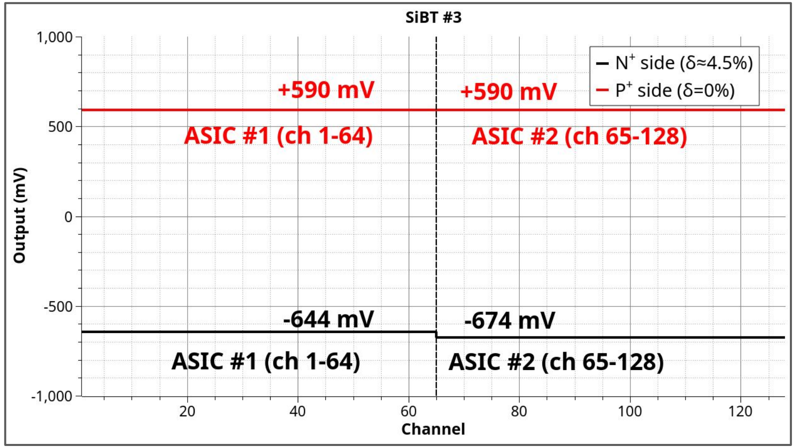
$$q = C \cdot U$$

- ε=3.4
- $\varepsilon_0 = 8.854 \cdot 10^{-12}$ F/m
- $S = 9 \cdot 10^{-6}$ m^2
- d≈60 µm
- U=2.5 V

C≈4.5 pF; **q≈11.2 pC**



Pulse shape during testing



ΔE_{Xe} ≈245.5 MeV (GEANT4)
Consequently, the charge released in the detector from the xenon passage is approximately **10.9 pC**

Working in follow-up BM@N runs

Based on the measured main parameters (I_{strip}, P, U_{fd}) of the detectors damaged by ^{124}Xe(3.8 AGeV) nuclei for the 2022-2023 run, we can make a prediction for the remaining resource at the SiBT DSSD detectors for future BM@N runs and for different ion types, but with the same integral per run **N ≈ 4.44×10^{10}**:

- ^{124}Xe(3.8 AGeV): **10 runs** ($N_{Xe} \approx 4.44\times10^{11}$), $I_{strip(max)}$ = 2 μA, I_{det} = 65 μA;
- ^{197}Au(3.8 AGeV): **5 runs**, $I_{strip(max)}$ = 2 μA;
- ^{209}Bi(3.8 AGeV): **4 runs**, $I_{strip(max)}$= 2 μA .

Real data on detector damage by ^{197}Au and ^{209}Bi ions will be obtained only after the first run with these ions.

Particle	Energy	ΔE, MeV/175 μm Si	NIEL, MeV×cm^2/g	Hardness factor/Si
^{209}Bi	3.9 AGeV	476,9	1,0736	671
^{197}Au		431,9	0,9749	609
^{124}Xe		245,5	0,46	276
^{84}Kr		89,69	0,1568	98
^{40}Ar		22,43	0,0496	31
^{12}C		2,52	0,006	3,75
p	1 GeV	0,073	0,00136	0,85
n	1 MeV	1	0,0016	1

Conclusions

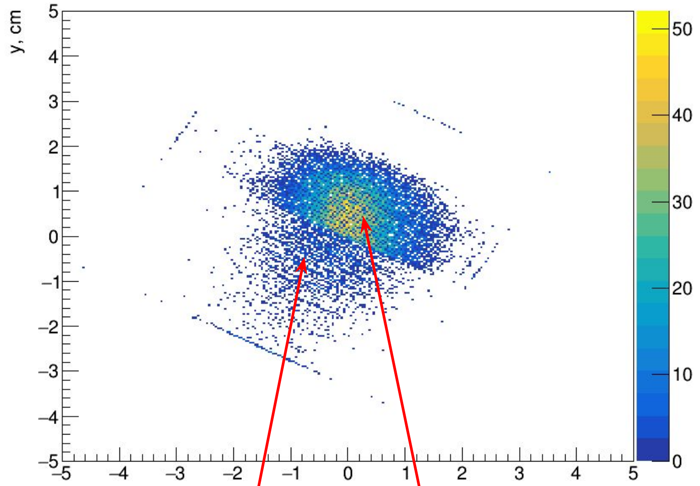
- The FEE SiBTs were tested using a test signal corresponding to the charge released when passing ^{124}Xe through the detector.The FEE gains were set to optimal values
- A prediction (based on the measured main parameters of the detectors damaged by ^{124}Xe(3.8 AGeV)) is made for the remaining resource of DSSD detectors SiBT for future BM@N runs:
  - ^{124}Xe(3.8 AGeV): **10 runs** ($N_{Xe} \approx 4.44\times10^{11}$), $I_{strip(max)}$ = 2 μA, I_{det} = 65 μA;
  - ^{197}Au(3.8 AGeV): **5 runs**, $I_{strip(max)}$ = 2 μA;
  - ^{209}Bi(3.8 AGeV): **4 runs**, $I_{strip(max)}$ = 2 μA .
- SiBT will be placed to BM@N experimental hall after finish all necessary tests (tests with α-source).

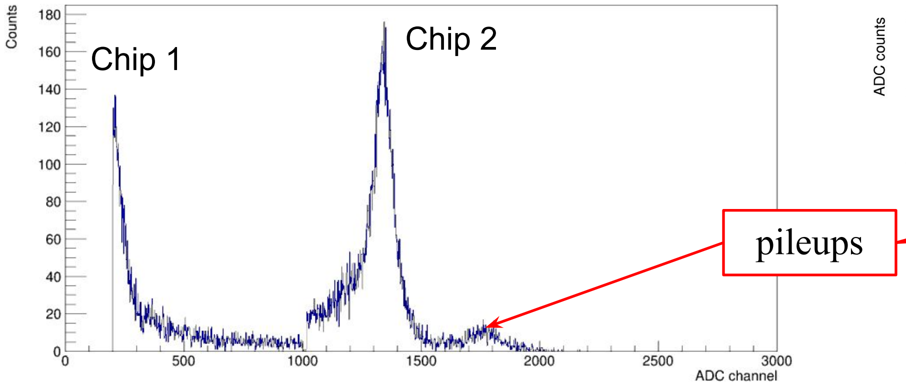
BACKUP

SiBT FEE during Xe-run

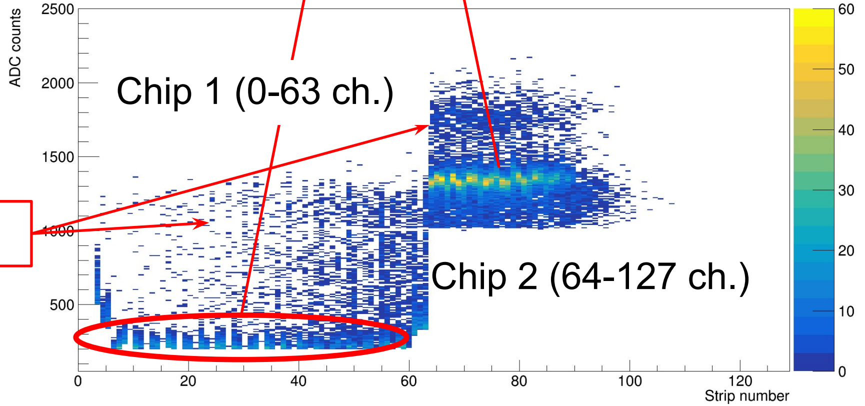
This slide shows SiBT FEE operation in XE-run on example of SiBT #2 (run 8387, 1.02.2023). The gains of FEE-chips on n+ side were not tuned for signals on the order of 10.9 pC (energy losses of Xe with energy 3.8 GeV/n are 245.5 MeV). Because of this signals from one of FEE-chips were below th threshold and were not written (in this case – chip 1 (channels 0 – 63)

Hit plot SiBT #2





Amplitude distribution (SiBT #2 n+ side)



Channel distribution of amplitudes (SiBT #2 n+ side)

SiBT #1 FEE boards

Position	Input signal, pC	peaking time, ns	Amp, mV
Board1 P^+ 1-64, Gain=2.05	1	150	71
	4	170	240
	8	186	481
	10	264	572
Board2 P^+ 65-128, Gain=2.05	1	166	69
	4	166	224
	8	189	463
	10	264	536
Board3 N^+ 65-128, Gain=4.5	-1	194	
	-4	207	-255
	-8	242	-464
	-10	267	-574
Board4 N^+ 1-64, Gain=4.5	-1	170	-63
	-4	211	-276
	-8	243	-503
	-10	261	-614

SiBT #2 FEE boards

Position	Input signal, pC	peaking time, ns	Amp, mV
Board1 P^+ 1-64, Gain=2.46	1	165	69
	4	169	234
	8	180	471
	10	265	558
Board2 P^+ 65-128, Gain=2.05	1	162	74
	4	167	240
	8	182	489
	10	264	579
Board3 N^+ 65-128, Gain=4.5	-1	181	-63
	-4	217	-276
	-8	244	-492
	-10	264	-602
Board4 N^+ 1-64, Gain=4.5	-1	181	-50
	-4	222	-261
	-8	242	-459
	-10	263	-577

SiBT #3 FEE boards

Position	Input signal, pC	peaking time, ns	Amp, mV
Board1 P^+ 1-64, Gain=2.05	1	168	79
	4	173	271
	8	186	561
	10	271	641
Board2 P^+ 65-128, Gain=2.05	1	149	70
	4	161	241
	8	190	489
	10	274	561
Board3 N^+ 65-128, Gain=4.5	-1	180	-65
	-4	212	-274
	-8	250	-500
	-10	273	-616
Board4 N^+ 1-64, Gain=4.5	-1	177	-60
	-4	205	-266
	-8	239	-472
	-10	267	-578