







Lead tungsten calorimetry for the Electron-Ion Collider:

first beam test results

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The EIC facility at BNL (NY, U.S.A.)



- ➤ CME: ~ 20–140 GeV
- ➤ Luminosity: ~ 10³³⁻³⁴ cm⁻²s⁻¹

EIC detector milestones

- Dec 2021: Detector design
- Currently: Detector R&D
- End 2025: TDR completed (CD-3), start of construction
- > 2030: Detector commissioning
- > 2031: Pre-ops
- 2034: Start of physics program (CD-4)



2 detector interaction points capability in the design



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Backward ECal in ePIC (EIC detector)

- ~3000 PWO crystals
- SiPM readout
- Cooling
- LED monitoring

Requirements:

- Energy resolution: $2\%/\sqrt{E} + (1-3)\%$ \geq
- Pion suppression: 1:10⁴
- Minimum detection energy: > 50 MeV \succ

Technology choice: PWO crystals (2x2 cm²) with high density SiPM (16 3x3 mm² or 4 6x6 mm² per crystal)

High resolution in the forward region (endcap) can only be achieved with homogeneous materials, such as crystals

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ECal



5x5 PWO prototype with 16 SiPMs per crystal

- > 25 PWO crystals from CRYTUR
- SiPM readout
- Cooling and temp control



SiPMs: Hamamatsu S14160-3015PS (3x3 mm²; 15µm pixel size)



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Setup at T24 in DESY test beam facility



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- > 1 5 GeV electron beam through a 2x2 mm² collimator
- Triggered by 2 scintillators
- Typical DAQ rates: ~50-100 Hz
- Prototype on a X-Y table with 0.1 mm position accuracy

19/06/2025

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 \triangleright

+ preamp board & CAEN V1725S 14-bit 250MS/s digitizers

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Readout options tested



Each SiPM individually

530 pF per channel

400 channels

- SiPMs grouped by 4 \geq in a crystal
- 100 channels
- 2120 pF per channel \geq

+ Readout with H2GCROC3b chip

- All 16 SiPM in a crystal \succ read in parallel
- 25 channels \geq

ePIC Backward ECal Test Beam

8480 pF per channel \geq

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	84.5				
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-0	11.1.0		M1.9		
-0	SPACE	983.54		200,00	
-24.8	14	-64 -14			

- All 16 SiPM in a crystal \succ read in parallel
- 25 channels \triangleright
- 8480 pF per channel \geq











ADC vs TOT



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Energy measurement by a combination of a:

- > 10-bit ADC (for small signals) and a
- 12-bit TDC (for large signals) \succ







SiPM signal shapes

- HGCROC can sample the signal at 40 MHz (every 25 ns)
- We can scan the phase between the trigger and the sampling clock for finer time resolution



Figure 22: Waveform measured in a phase scan for each of the different daughther boards: all independent (left), 4×4 (center) and all parallel (right). The value of Rf is 1100 (6.7 KOhm). The current conveyor gain is 0.3 (left), 0.1 (center) and 0.05 (right).

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Waveform fits

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Energy scan: ADC and TOT



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 ADC is linear before saturation

 TOT needs correction for non-linearity





Sample event at 5 GeV

Event display (energy per crystal in GeV)

⁵ 4.5 0.02	0.05	0.05	0.04	0.11	
⁴ 3.5 0.02	0.05	0.25	0.11	0.01	- 1
³ 2.5 0.02	0.18	4.62	0.20	0.07	
² 1.5 0.04	0.12	0.21	0.11	0.06	10
0.5 0.00	0.02	0.02	0.20	0.03	- 10

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=0.0,t=-21,B=32	A=0.0,1=12,B=46	A=0.0,t=15,B=15	A=0.0,t=0,B=44
-0.0,1-4,B-32	A=-0.0,1=-2,B=31	A=0.0,5=1,B=36	A=0.0,5=-13,B=43
=0.0,t=-2,B=26	A=0.0,t=-16,B=65	A=inf,t=-1,B=63	A=0.0,t=10,B=43
4=0.0,t=4,B=48	A=0.0,t=-13,B=29	A=0.0,1=-1,B=42	A=0.0,t=-17,B=48

0.0,1=-26,B=50	A=0.1,1=12,B=33	A=0.0,t=18,B=47	A=0.0,1=4,B=52
-0.0,11,B-28	A=-0.0,1=-23,B=44	A=0.0,t=17,B=51	A=0.0,t=-1,B=47
4=0.0,1=-1,B=23	A=0.0,t=18,B=37	A=0.0,1=17,B=49	A=-0.0,1=-6,B=46
4=0.0,t=15,B=34	A=0.0,t=16,B=65	A=0.0,t=15,B=40	A=0.0,t=15,B=79

-0.0,1=15,B=95	A=0.0,1=18,B=37	A=0.0,t=14,B=35	A=0.0,5=18,B=27
=0.0,t=17,B=49	A=0.0,1=18,B=40	A=0.0,1=14,8=41	A=0.0,t=17,B=37
-0.0,t=14,B=39	A=0.0,1=14,B=47	A=0.0,t=15,B=30	A=0.0,t=17,B=32
4=0.0,t=18,B=37	A=0.0,t=18,B=63	A=0.0,t=17,B=31	A=0.0,t=-24,B=28

A=0.0,t=13,B=80	A=0.0,t=11,B=49	A=0.0,t=4,B=50
A=0.0,1=1,B=39	A=0.0,t=15,B=48	A=0.0,t=16,B=70
A=0.1,1=4,B=65	A=0.1,t=10,B=49	A=0.0,t=-5,B=58
A=0.0,t=18,B=88	A=0.0,t=11,B=64	A=0.0,t=14,B=55
	A=0.0,1=13,B=80 A=0.0,1=1,B=33 A=0.1,1=4,B=05 A=0.0,1=18,B=88	A=0.0,1=13,B=80 A=0.0,1=1,B=39 A=0.0,1=1,B=39 A=0.0,1=13,B=48 A=0.0,1=10,B=49 A=0.0,1=11,B=64

0.0,1=-21,B=35	A=-0.0,1=-17,B=34	A=-0.0,t=-12,B=26	A=-0.0,1=-23,B=28
=0.0,1=27,B=38	A=0.0,1=12,B=34	A=0.0,t=9,B=27	A=-0.0,t=-20,B=15
=0.0,1=16,B=33	A=0.0,1=23,B=64	A=0.0,t=8,B=80	A=-0.0,1=24,B=24
A=-0.0,t=-1,B=29	A=-0.0,1=-6,B=30	A=-0.0,t=-5,B=29	A=0.0,t=-1,B=21

A=0.0,t=19,B=33	A=0.1,t=11,B=59	A=0.0,1=3,B=92
A=0.0,1=17,B=53	A-0.0,t=16,B=61	A=0.0,1=-1,B=60
A=0.1,1=4,B=63	A=0.0,t=-7,B=71	A=0.1,t=16,B=71
A=0.1,1=3,B=53	A=0.0,1=8,B=61	A=0.1,t=-7,B=75
	A=0.0,1=19,B=53 A=0.0,1=17,B=53 A=0.1,1=4,B=63 A=0.1,1=3,B=53	A=0.0,1=19,8=33 A=0.1,1=11,8=59 A=0.0,1=17,8=53 A=0.0,1=16,8=61 A=0.1,1=4,8=63 A=0.0,1=7,8=71 A=0.1,1=3,8=53 A=0.0,1=8,8=61

-0.0,1=23,B=57	A=0.0,t=23,B=49	A=0.1,5=18,B=62	A=0.1,1=16,B=69
=0.0,1=24,B=39	A=0.0,1=27,B=72	A=0.0,5=23,B=50	A=0.1,1=18,B=53
4=0.0,1=24,B=36	A=0.0,1=20,B=73	A=0.0,t=22,B=46	A=0.1,1=17,B=54
_			\sim
-0.0,1=21,B=44	A=0.0,1=22,B=47	A=0.0,t=15,B=54	A=0.1,t=8,B=49

9=0.2,1=23,B=8	A=0.2,1=19,B=90	A=0.2,t=17,B=53	A=0.2,1=21,B=49
-0.2,1=6,B=31	A=0.2,1=9,B=43	A=0.1,t=21,B=32	A=0.2,1=16,B=56
s=0.2,1=7,B=29	A=0.2,1=20,B=31	A=0.2,t=21,B=54	A=0.2,1=20,B=49
9=0.2,1=8,B=36	A=0.2,t=19,B=50	A=0.2,1=19,B=45	A=0.2,t=19,B=45

-0.1,t=3,B=56	A=0.1,1=8,B=39	A=0.1,t=8,B=48	A=0.1,1=4,B=42
~	~	~	~
-0.1,t=8,B=114	A=0.1,1=11,B=57	A=0.1,t=0,B=50	A=0.1,1=9,B=44
	<u>`~</u>	\sim	~
=0.1,t=3,B=47	A=0.1,1=12,B=47	A=0.2,t=1,B=50	A=0.1,t=8,B=78
~	<u> </u>	\sim	~~
=0.1,t=9,B=47	A=0.1,1=8,B=44	A=0.1,t=11,B=58	A=0.1,t=4,B=77
		-	

=0.0,1=-11,B=45	A=0.0,1=-23,B=45	A=0.0,t=-23,B=37	A=0.0,1=-24,B=28
=0.0,t=-20,B=43	A=0.0,t=-21,B=40	A=0.1,t=-17,B=37	A=0.0,1=-22,B=32
=0.0,t=-11,B=46	A=0.0,1=-13,B=38	A=0.0,1=-25,B=23	A=0.0,t=-24,B=25
a=0.0,t=-24,B=39	A=0.0,1=-22,B=39	A=0.0,1=-28,B=40	A=0.0,t=-0,B=23

=0.1,t=-1,B=52	A=0.0,t=9,B=61	A=0.0,t=8,B=60	A=0.0,1=7,B=51
-0.0,11,B-52	A=0.1,t=1,B=45	A=0.1,t=-1,B=06	A=0.0,1=7,B=57
4=0.1,t=5,B=54	A=0.1,t=16,B=50	A=0.0,t=0,B=49	A=0.0,t=-1,B=56
A=0.1,1=-4,B=47	A=0.0,t=-0,B=47	A=0.0,t=-0,B=85	A=0.0,1=6,B=54
~			

A=0.3,1=5,B=41	A=0.3,1=2,B=43	A-0.2,1-6,B-75	A-0.2,1-8,B-64
A=0.2,1=3,B=44	A-0.3,t=1,B=110	A=0.2,1=9,B=66	A=-0.0,1=-1,8=44
4-0.2,1=16,B=40	A=0.2,t=16,B=45	A=0.3,t=6,B=58	A=0.3,1=-0,B=59



A=0.2,1=8,B=56	A=0.2,t=6,B=82	A-0.2,1-19,B-59	A-0.3,1-2,B-54
0.0,1=-14,B=65	A=0.2,1=5,B=58	A=0.2,1=16,B=80	A=0.2,1=7,B=52
A=0.2,1=4,B=95	A=0.3,t=0,B=79	A=0.2,1=3,B=57	A=0.2,1=20,B=51
=0.2,t=6,B=63	A=0.2,1=2,B=52	A=0.2,1=3,B=87	A=0.2,1=18,B=45

b=0.0,i=11,B=51 A=0.0,i=29,B=62 A=0.0,i=-5,B=47 A=0.0,i=-13,B=39 b=0.0,i=-1,B=55 A=0.0,i=-6,B=59 A=0.0,i=-13,B=46 A=0.0,i=19,B=42 b=0.0,i=6,B=133 A=0.0,i=16,B=48 A=0.0,i=-10,B=45 A=0.0,i=18,B=39	4=0.0,t=9,B=51	A=0.0,1=-2,B=56	A-0.0,t=16,B=45	A=0.0,1=-11,B=35
A=0.0,1=-1,B=55 A=0.0,1=-16,B=48 A=0.0,1=-10,B=45 A=0.0,1=18,B=32	4-0.0,t-11,B-51	A=0.0,1=29,8=62	A=0.0,1=-5,B=47	A=0.0,1=-13,B=39
A=0.0,1=6,B=133 A=0.0,1=16,B=48 A=0.0,1=-10,B=45 A=0.0,1=18,B=31	-0.0,t1,B=55	A=0.0,t=-8,B=59	A=0.0,t=-13,B=46	A=0.0,1=19,B=42
	A=0.0,t=6,B=133	A=0.0,t=16,B=48	A=0.0,t=-10,B=45	A=0.0,t=18,B=39

	A=0.0,t=-27,B=16	A=0.1,1=-4,B=13	A=0.1,1=13,B=40
		<u> </u>	-
=0.0,1=-4,8=2	A=0.0,t=17,B=2	A=0.1,1=-3,B=23	A=0.0,1=13,B=54
4=0.0,t=16,B=1	A=0.0,t=20,B=4	A=0.0,1=9,B=61	A=-0.0,1=-21,B=15
	an Armen		
0.0,t=-34,B=26	A=0.1,t=-4,B=22	A=0.1,t=-4,B=6	A=0.0,1=19,B=17

+0.1,t=16,B=42	A=0.1,t=16,B=51	A=0.1,1=19,B=58	A=0.1,1=18,B=25
5	\sim	\sim	
-0.1,t=18,B=48	A=0.1,t=7,B=50	A=0.1,1=9,B=46	A=0.1,1=17,B=35
\sim	~	~	
4=0.1,t=1,B=48	A=0.1,t=9,B=78	A=0.1,1=8,B=58	A=0.1,1=15,8=38
<u> </u>	\sim	~	
A=0.1,t=3,B=54	A=0.1,1=19,B=46	A=0.1,t=20,B=47	A=0.1,t=20,B=31
A=0.1,t=3,B=54	A=0.1,1=19,B=46	A=0.1,t=20,B=47	A=0.1,t=20,B=31

=0.2,1=17,B=46	A=0.2,1=16,B=78	A=0.2,1=9,B=39	A=0.2,1=3,B=31
-0.3,1=16,B=44	A=0.2,1=16,B=37	A=0.2,1=14,B=30	A=0.2,1=7,B=30
=0.3,t=15,B=36	A=0.2,t=18,B=35	A=0.2,1=15,B=40	A=0.2,1=6,B=33
\$=0.2,t=18,B=48	A=0.2,1=17,B=35	A=0.2,1=8,B=39	A=0.2,t=2,B=38

+0.1,t=9,B=55	A=0.1,1=8,B=54	A=0.1,t=4,B=60	A=0.1,1=14,B=51
-0.1,t=1,B=80	A=0.2,1=0,B=47	A=0.1,1=8,B=54	A=0.1,1=4,B=56
N=0.1,t=13,B=49	A=0.1,1=0,B=58	A=0.1,t=4,B=90	A=0.1,t=11,B=48
A=0.1,t=12,B=52	A=0.1,1=12,B=55	A=0.1,t=5,B=50	A=0.1,t=0,B=46

N=-0.2,1=-22,B=54	A=0.3,1=10,B=22	A=0.3,1=11,B=22	A+0.2,1+9,8+43
N=-0.1 p=-22,B=56	A=0.4,t=10,B=31	A=0.3,1=10,B=27	A=0.2,1=11,B=18
N=-0.2.0=-22,B=62	A=-0.2,1=-22,B=48	A=0.3,1=10,B=33	A=0.4,1=11,B=21
4=0.0,1=22,B=21	A=0.3,1=10,B=29	A=0.3,1=10,B=27	A=-0.0,1=-1,B=21

4=0.1,1=8,B=43	A=0.1,t=6,B=51	A=0.1,t=10,B=31	A=0.1,t=10,B=17
4-0.1,3-11,B-37	A=0.4,t=13,B=10	A=0.1,1=13,8=5	A=0.1,t=7,B=22
A=0.1,t=6,B=44	A=0.1,t=16,B=39	A=0.2,1=-14,B=5	A=0.0,t=10,B=22
A=0.1,t=6,B=45	A=0.0,t=11,B=44	A=0.1,t=13,B=26	A=0.1,1=12,B=17

4=-0.0,t=-29,B=55	A=-0.0,t=-28,B=74	A=-0.0,1=-31,B=36	A=0.0,1=21,B=46
the second s	_		
-0.0,t=18,B=55	A=-0.0,t=-114,B=50	A=-0.0,1=-3,B=44	A=-0.0,1=-37,B=30
_			_
-0.0,t=-26,B=54	A=-0.0,t=-9,B=48	A=-0.0,1=-25,B=44	A=-0.0,1=-6,B=37
A=0.0,t=21,B=58	A=0.0,t=17,B=41	A=-0.0,t=-6,B=36	A=-0.0,t=-2,B=31

4-0.1,2-13,8-43	A=0.1,t=12,B=28	A=0.1,1=7,B=29	A=0.1,t=10,B=32
-0.1,5-10,B-34	A-0.1,t-11,B-39	A=0.1,1=9,B=28	A=0.1,1=10,B=34
4-0.1,1-10,8-29	A=0.1,t=9,B=49	A=0.1,1=16,B=31	A=0.1,1=11,B=31
4=0.1,t=16,B=34	A=0.1,t=10,B=35	A=0.1,t=12,B=35	A=0.0,1=4,B=32

4-0.1,s-14,B-67	A=0.1,t=12,B=78	A=0.1,1=14,8=75	A=0.0,1=16,B=58
-0.1,s=10,B=34	A=0.1,1=11,8=41	A=0.1,1=12,B=85	A=0.0,1=13,B=54
4=0.1,t=12,B=42	A=0.1,5=16,B=34	A=0.1,t=12,B=38	A=0.1,t=13,B=50
=0.1,t=13,B=36	A=0.1,t=9,B=69	A=0.1,t=16,B=50	A=0.1,1=9,B=50

A=0.0,t=1,B=60	A=0.0,1=13,B=62	A=0.0,1=15,B=52	A=0.0,1=16,B=53
4=0.0,t=-1,B=30	A=0.0,1=17,B=41	A=0.0,1=4,B=51	A=0.0,1=12,B=84
4=0.0,t=12,B=30	A=0.0,t=18,B=43	A=0.0,1=16,B=45	A=0.0,1=18,B=69
A=0.0,t=15,B=31	A=0.0,t=5,B=61	A=0.0,t=18,B=76	A=0.0,1=21,B=52

ľ	-3.6,9-3 B-50	-3.5,9 8-57	4=0.2,t=17,B=46
1	-3.9,0-57	-3.8,12 -00	5-0.3,1-16,B-44
1	-3.6.9 B-42	*3.4,1** (B=51	-0.3,t=15,B=36
8=87	=3.4,1=- B=65	-3.3,138-90	A=0.2,1=18,B=48



Another event at 5 GeV

Event display (energy per crystal in GeV)



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*-0.0,t=-1,D=34	A=0.0,1=-2,0=49	A=0.0,1=-14,8=12	A=-0.0,=-20,0=44
-0.0,1-22,8-34	A-0.03-21,8-34	A=0.0,1=14,B=35	A=-0.0,t=-20,0=43
-0.03-18,8-27	A-0.031,B-66	Aninf,t=-1,B=63	A0.0,:=23,8-44
4=0.0,1=-13,B=46	A-0.0,t-19,B-30	A=0.0,1=-8,8=-64	A=0.0,t=-1,B=49

-0.0,1-10,0-49	A-0.0,1-16,8-33	A=-0.0,t=-24,0=48	A=0.0,1=1,0=55
-0.0,1-13,8-24	A=0.1,1=13,8=37	A=0.0,1=1,B=47	A=0.0,1=19,0=44
-0.13-18,8-25	A-0.13-13,8-37	A=0.0,1=22,0=46	A=0.0,1=13,0=43
-0.0,1-13,8-30	A-0.0,t-1,B-63	A=0.0,1=18,B=42	A-0.0,1-14,8-79

-0.0,1-21,0-95	A-0.0,1-12,0-34	A=0.0,t=17,B=33	A=0.0,1=22,0=24
-0.03-14,8-52	A-0.0,1-1,0-39	A=-0.0,t=-21,0=39	A=0.0,1=16,0=30
-0.0,3-22,B-102	A-0.0,1-20,0-47	A=-0.0,t=-2,0=28	A-0.0,1-28,D-28
-0.0,2-1,8-39	A-0.0,t=24,B=59	A=0.0,1=14,B=30	A=0.0,1=24,B=27

=0.0,t=-0,B=56	A-0.0,1-0,8-01	A=0.0,t=19,B=52	A=-0.0,t=-28,0=57
-0.03-14,B-52	A-0.0,1-7,8-42	A=0.0,1=19,B=49	A=0.0,1=13,0=70
1-0.0,1-1,8-45	A-0.0,1-29,0-68	A=0.0,1=-14,0=50	A=-0.0,t=-19,0=57
-0.0,:-1,8-43	A=0.0,t=25,B=90	A=0.0,1=4,B=64	A=0.0,t=10,B=59

-0.0,1-13,8-32	A=0.0,1=-18,B=32	A=-0.0,t=-24,0=26	A=-0.0,t=-20,0=30
-0.0,1-25,8-39	A-0.03-11,0-34	A=0.0,1=16,B=30	A=-0.0,1=-0,0=15
-0.0,1-28,8-32	A-0.03-13,8-64	A=-0.0,t=-17,0=02	A=0.0,1=-6,D=22
-0.0,t-21,B-33	A-0.0,t-14,B-28	A=0.0,1=-20,B=28	A-0.0,1-28,B-20

-0.0,t1,D-15	A=0.0,1=-3,B=34	A=0.0,1=-23,D=64	A=0.0,t=-28,B=95
-0.0,1-4,0-47	A=-0.0,1=23,B=56	A0.0,1-21,0-65	A=-0.0,1=-1,0=64
-0.0,130, 0- 47	A=0.0,1=-32,B=67	A=-0.0,t=23,D=74	A=0.0,1=10,0=75
A=-0.0,t=27,B=52	A=0.0,1=17,8=57	A=0.0,t=-35,B=65	A=0.0,t=-29,B=7

e-0.0,t=-14,0=57	A-0.0,1-20,B-51	A-0.0,1-22, B-63	A=0.1,1=13,0=67
-0.0,1-21,0-39	A-0.0,1-16,0-71	A=0.0,1=16,0=47	A=-0.0,1=-10,0=54
=0.1,3=20,B=35	A-0.0,1-20,8-73	A=0.0,1=24,B=45	A=-0.0,t=-14,B=52
-0.0,t16,B-45	A-0.0,1-25,B-47	A-0.0,1-16,B-57	A-0.0,1-14,B-51

-0.2,9-16,8-34	A-62,1-21,D-86	A=0.1,0=21,0=49	A=0.1,1=22,0=43
-8.2,9-13,8-25	A=0.2,1=16,0=40	A=0.1,3=17,B=37	A=0.1,1=21,0=50
4-8.2,9-14,8-25	A=0.2,1=16,0=34	A=0.2,1=22,0=47	A=0.2,1=21,8=41
-0.2,t-17,B-35	A-0.2,1-23,B-23	A-0.1,1-22,B-35	A-0.1,0-23,8-22

-0.1,1-14,B-56	A=0.1,1=13, B=42	A=0.1,1=17,B=50	A=0.1,1=14,8=45
			5
=0.1,0=17,0=117	A=0.0,1=21,D=60	A=0.1,1=16,D=52	A=0.1,1=19,0=48
-0.1,0-11,D-50	A=0.1,1=13,0=49	A=0.1,1=10,D=53	A-0.1,1-18,8-77
-0.1,t=10,B=48	A=0.1,t=1,B=47	A=0.1,t=19,B=59	A=0.1,t=14,B=79

-0.0,1=4,B=42	A=-0.0,t=-172,0=42	A=0.0,1=-3,D=36	A=0.0,1=-13,B=28
=0.0,2=-13,B=44	A-0.0,1-18,0-38	A-0.0,1-4,B-37	A=0.0,1=-13,B=29
-0.0,13, 0 -46	A-0.0,1-1,8-36	A=0.0,1=-11,B=22	A=0.0,t=-12,B=23
-0.0,11,B-37	A-0.0,1-15,8-36	A=0.0,1=14,B=37	A=0.0,1=15,B=24

A=-0.0,1=29,B=55	A=0.0,1=6,B=67	A=0.0,t=-21,0=59	A=0.0,1=-1,B=55
-0.0,t30,B-56	A=0.0,t=20,D=49	A=0.0/=-23,0=99	A=-0.0,t=-1,D=59
=0.0,1=-1,B=59	A=0.0,1=-24,0=54	A=0.0,2=-19,0=54	A=0.0,1=-23,D=54
k=0.0,t=-1,B=53	A=0.0,1=-22,B=51	A=0.0,1=-26,B=89	A=0.0,1=-25,8=53

A=0.2,1=12,ID=40	A=0.2,1=15,0=46	A-0.3,1-7,0-71	A-0.2,1-14,B-63
-0.2,1=0,0=42	A-0.2,t=10,B=110	A=0.2,1=10,D=64	A=-0.0,1=-1,0=43
A=0.2,1=16,B=39	A-0.3,t=14,0=43	A=0.2,1=3,0=56	A=0.2,1=10,B=56



x-0.3,5-7,0-56	A=0.2,1=15,0=03	A=0.2,1=19,D=56	A-02,H0,B-54
4-0.1,1-6,0-60	A=0.2,1=12,0=56	A-0.2,1-14,0-00	A=0.2,1=10,B=55
k-0.1,1-16,D-93	A-9.23-7,B-77	A=0.1,t=16,D=56	A=0.2,1=20,0=51
-0.23-0,8-63	A-0.2,1-6,8-49	A-0.2,1-12,B-86	A-0.2,1-18,8-46

4=0.0,t=21,B=49	A=0.0,t=10,D=57	A=0.0,2=0,0=43	A=-0.0,t=-1,D=37
k=-0.0,t=-28,B=50	A=0.0,t=-1,0=67	A=-0.0,t=-27,B=60	A=0.0,1=22,B=40
N=0.0,1=10,D=54	A=0.0,t=10,D=50	A=0.0,t=18,B=47	A=0.0,1=0,0=40
A=0.0,t=-3,B=134	A=-0.0,1=28,B=48	A-0.0,1-6,8-46	A=0.0,53,8-40

	A=0.0,==19,B=24	A-0.13-1,8-28	A-0.13-1,8-41
-0.0,1-15,8-5	A=0.1,3=10,D=6	A-0.1;1-1;8-22	A-0.1,1-7,8-59
-0.0,/-17,8-2	A=0.0,2=16,B=34	A=0.0,1=12,0=58	A=0.0,3=21,8=19
-0.1,1-21,8-22	A-0.0,116,B-14	A-0.1,1-11,B-16	A0.1,1-18,8-22

4-0.1,t-9,D-46	A=0.1,1-20,0-50	A=0.1,1=10,0=60	A=0.1,1=17,8=27
5	\sim	_	
-0.0,1-21,0-52	A=0.1,1=10,0=48	A=0.1,1=17,8=47	A=0.1,1=21,8=35
	~	~	
A-0.1.0-16.0-48	A-0.1.0-75	A-0.11-0.0-59	A=0.1 (= 17.0=36
\sim		\langle	-
A=0.1,1=7,B=58	A=0.1,1=18,B=49	A=0.1,t=19,B=48	A=0.1,t=18,B=28
-			

-042-13,0-44	A-03,0-14,0-76	A-0.43-6.8-39	A-0.3,=1,0-32
A-9.4,5=15,B=42	A-6.4,9-14,B-35	A-0.43-8,8-32	A-0.43=7,B-28
4-9.4.1-16,D-33	A-6.4,9-14,B-37	A-0.43-12,0-40	A-0.43-6.B-35
1-0.4 (-14,B-47	A-0.41-14,B-35	A-0.4,1-7,B-38	A-0.4,0-36

-0.1,1-13,8-56	A=0.1,3=10,B=57	A-0.1,1-14,8-61	A=0.1,3=18,8=55
=0.1,t=16,B=03	A=0.1,2=10,B=49	A=0.0,1=25,8=59	A=0.1,3=12,8=59
+0.1,t=14,B=51	A=0.1,3=15,B=60	A-0.13-4,8-89	A=0.1,3=17,8=50
-0.1,3-10,8-55	A=0.1,t=18,B=58	A-0.1,t-16,B-54	A=0.1,t=18,B=49



4=-0.0,1=24, 0 =49	A=-0.0,1=22,8=53	A=-0.0,t=27,B=36	A=-0.0,t=7,D=23
0.0,1=25,0=42	A0.03-26,8-63	A-0.2,1-2,D-16	A0.0/-20,0-24
-0.0j24,B-45	A=0.0,1-4,0-41	A=0.2,1=-12,B=14	A=-0.0,t=21,B=24
4-0.0,t-13,B-48	A=-0.0,1=25,B=51	A0.0,1-29,8-30	A-0.0,141,8-19

-0.0,1-22,8-57	A=0.1,t=13,8=71	A=0.0,t=10,B=36	A=0.0,1=14,B=47
-0.0,1-22,8-56	A=0.1,1=13,8=50	A=0.1,0=0,B=42	A=0.0,t=-1,B=31
v=0.0,t=-3,B=52	A=0.0,1=10,0=40	A-0.1,1-11,0-43	A=0.0,1=17, B=35
\$=0.0,t=5,B=57	A=0.0,t=21,B=44	A=0.0,1=17,B=32	A=0.0,t=13,B=28

-0.0,1=21, B =47	A=0.0,1=-4,0=34	A=-0.0,1=21,0=36	A-0.0,t-0,B-37
0.0,1=29, D =35	A=0.0,t=-17,0=45	A=-0.0,1=29,0=32	A-0.0,t-1,B-37
4=-0.0,1=20,B=37	A=0.0,t=-1,0=55	A=-0.0,t=32,0=33	A=0.0,t=-1,B=34
\$=-0.0,t=-2,B=42	A=-0.0,1=25,B=42	A=-0.0,t=26,B=40	A=-0.0,t=-1,B=37

0.0,11,B-69	A=0.0,=-1,0=75	A=-0.0,t=16,D=79	A=0.0,1=-14,0=50
-0.0,t22,B-35	A=-0.0,1=23,0=44	A=0.0,1=241,0=05	A=0.0,t=-17,D=53
v=0.0,t=-25,D=48	A=-0.0,t=-2,B=36	A=0.0,1=-13,8=37	A=-0.0,t=29,D=52
0.0,1-30,B-38	A=-0.0,1=20,B=70	A0.0,1-25,8-53	A=0.0,1=-17,B=53

0.0.1/-16,0-31 A=-0.0.2/-5,0-46 A=-0.0.2/-0,0-61 A=-0.0.2/-1,0-66 A=0.0.1/-17,0-31 A=-0.0.1/-27,0-61 A=-0.0.1/-27,0-76 A=-0.0.1/-20,0-51 A=0.0.2/-18,0-37 A=-0.0.1/-7,0-61 A=-0.0.1/-27,0-76 A=-0.0.1/-20,0-51	-0.0,1-13,8-57	A=0.0,1-17,0-61	A=0.0,1=-24,B=51	A0.0,t=2,B=51
A=0.0,1=17,B=31 A=0.0,1=7,B=61 A=0.0,1=27,B=76 A=0.0,1=20,B=51 A=0.0,1=27,B=76 A=0.0,1=20,B=51	-0.0,1-16,8-01	A-0.0,1-5,0-46	A=0.0,1=-0,0=54	A=0.0,1=11,B=06
A=0.0;=18,B=37 A=0.0;=7,B=61 A=0.0;=27,B=76 A=0.0;=20,B=51	-0.0,t=17,B=01	A=0.0,1=21,0=43	A=0.0,1=-0,8=47	A=0.0,t=1,0=68
	-0.0,t=18,B=37	A-0.0,1-7,B-61	A=0.0,1=27,B=76	A=0.0,1=20,8=51

f ^e	-242-13,0-64	A-0.3,0-14,0-76	A-0.43-6.8-39	Ĺ
r L	-9.42-15,0-42	A-0.4,0-14,0-35	A-0.4)-8,B-32	ĺ
f"	 4-9.4.2-16,B-33	A-8.4,0-14,B-37	A-0.43-13,0-40	ĺ
Æ	 1-0.43-14.B-47	A-0.41-14,B-35	A-0.4,1-7,8-38	Ĺ

N	\leq	\sim	<
and the second	-9.42-15,0-42	A-6.4,0-14,D-35	A=0.43=8,B=32
No. of Street, or other	 4-9.4.2-16,B-33	A-8.4,0-14,B-37	A-0.43-13,0-40
and the second second	-0.40-14.8-47	A-0.41-14,B-35	A-0.4,1-7,B-38



5 GeV run



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6.2% energy resolution

Still far from goal: ~2%



Large low energy background observed







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Grounding issue in to HGCROC boards

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Initial Scheme (cf p.5)

No GND connection of the flat cable connectors pins (floating shields)

=> The amplitude of the spikes significantly varies when moving the cable. Here, "best" case (~33mV pp)











Grounding issue in to HGCROC boards: fixed







After shield pins soldering



Noticeable reduction of the spikes amplitude (~10mV pp)

Conclusion: soldering the 2 GND pins on each connector recommended (if not already done)!





Stability of the bias voltage supply



With a different power supply with a 'High Capacitance Mode'

- A large oscillation in the power supply is observed when SiPMs are connected (400 mV peak-to-peak, ~37kHz)
- This affects all SiPMs, as the power supply is common

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Analysis still ongoing

- Channel-by-channel ref shapes
- Better calibration of individual channels
- Mask (and correct for) bad/dead channels
- Investigation on different sources of background and fluctuations (Power supply, HGCROC boards, light leaks...)
- Upcoming 2nd campaign at DESY this improved setup with improved setup (better PS, better grounding, improved trigger)

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