US CALET Simulation Status Report

John Krizmanic for the US CALET simulation group:
GSFC: JFK, Yosui Akaike, Nick Cannady, Alex Moiseev
LSU: Anthony Ficklin, Greg Guzik
WUSTL: Brian Rauch

1. GSFC Simulations (UnifiedOutput uploaded to Waseda Archive):
   a. 320 cores dedicated to CALET on GSFC ADAPT cloud
   b. 1 Family of ^{4}He
      i. *Configuration*: Cosmos8.035, Epics9.26, CALETrev22.
      ii. 0.2GeV – 20 TeV: E^{-1} spectrum; 10^{7} events/decade
      iii. 20 TeV – 1 PeV: $E^{-2.5}$ spectrum; 28,900,000 events
   c. Heavy nuclei runs to 1 PeV: *Configuration*: Cosmos8.01, Epics9.21, CALETrev22.
   d. Pair production/screening bug fixed in Epics9.26
   e. Runs to assess incorporation of direct $e^{\pm}$ pair production in Epics9.28
2. LSU Simulations (UnifiedOutput uploaded to Waseda Archive):
   a. Received 2e6 SU allocation (July 2019)
   b. Anthony Ficklin developed efficient batch submission process for highest energy runs, SUs no longer wasted due to being tied to the longest runtime process within a group.
   c. Cosmos8.038, Epics9.27 (Rev22)
   d. 1.5 families of ^{4}He + others.
   e. Saving 50k SUs for UH runs once Epics9.28 direct electron modeling validated.

LSU Simulation Run Listing

Particle	Energy	Spectrum	Theta	Throwing Geometry	# of Events
He^4	0.2 – 2 GeV	-1	90*	Isotropic (Downgoing)	150,000,000
He^4	2 – 20 GeV	-1	90*	Isotropic (Downgoing)	150,000,000
He^4	20 – 200 GeV	-1	90*	Isotropic (Downgoing)	150,000,000
He^4	200 – 2000 GeV	-1	90*	Isotropic (Downgoing)	150,000,000
He^4	2 – 20 TeV	-1	90*	Isotropic (Downgoing)	150,000,000
He^4	20 – 1000 TeV	-2.5	90*	Isotropic (Downgoing)	43,350,000
Gamma	.1 – 1 GeV	-1	90	Isotropic (Upper)	320,000,000
Gamma	1 – 10 GeV	-1	90	Isotropic (Upper)	320,000,000
Gamma	10 – 100 GeV	-1	90	Isotropic (Upper)	320,000,000
Gamma	100 – 1000 GeV	-1	90	Isotropic (Upper)	320,000,000
e-	.1 – 1 GeV	-1	180	Isotropic (Full)	64,000,000
e-	1 – 10 GeV	-1	180	Isotropic (Full)	64,000,000
e-	10 – 100 GeV	-1	180	Isotropic (Full)	64,000,000
e-	100 – 1000 GeV	-1	180	Isotropic (Full)	64,000,000
e-	.2 – 2 GeV	-1	90*	Isotropic (Downgoing)	320,000,000
e-	2 – 20 GeV	-1	90*	Isotropic (Downgoing)	320,000,000
e-	20 – 200 GeV	-1	90*	Isotropic (Downgoing)	320,000,000
e-	200 – 2000 GeV	-1	90*	Isotropic (Downgoing)	263,596,283
ATMNC**	2 – 50 TeV	**	**	**	201,691,728

Isotropic (Upper) – Particles thrown isotropically for the upper half of the sphere.

Isotropic (Full) – Particles thrown isotropically from the full sphere.

Isotropic(Downward Going) – Particles thrown from the full sphere, but events with upward trajectories are discarded.

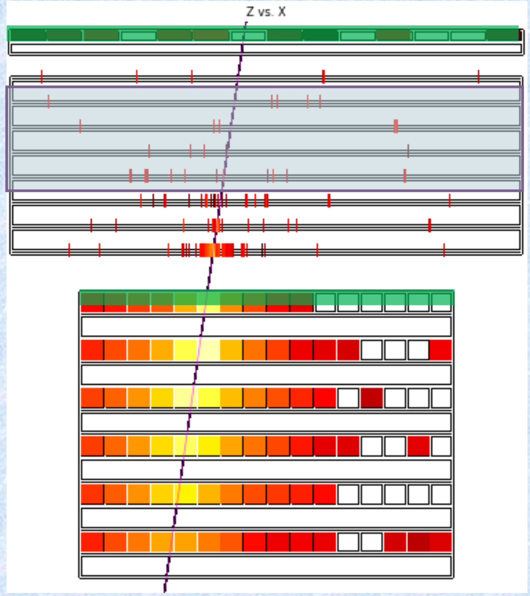
* Produced using the unique downgoing sepicsfile and ephook configuration files.
** ATMNC spectra consisting of helium, gamma, and proton primaries with unique configuration files defined by ATMNC3: see *CALET Calibration on ISS Orbit Using Cosmic Rays*: TAE NIITA AND THE CALET COLLABORATION : icrc2013-0435.pdf

GSFC Simulation partial Run Listing

Focus on heavy nuclei: Yosui Akaike
Also validating Cosmos/Epics upgrades: Yosui Akaike

CALET_rev22_C8.01EP9.21	Z3A6_1~10TeV_dpmjet3_El_hin	22	V5.2	v8.01	v9.21	6Li	1TeV	10TeV	-1	200,000	200	1,000	dpmjet3	El_hin	top2bot2
CALET_rev22_C8.01EP9.21	Z3A7_1~10TeV_dpmjet3_El_hin	22	V5.2	v8.01	v9.21	7Li	1TeV	10TeV	-1	200,000	200	1,000	dpmjet3	El_hin	top2bot2
CALET_rev22_C8.01EP9.21	Z4A7_1~10TeV_dpmjet3_El_hin	22	V5.2	v8.01	v9.21	7Be	1TeV	10TeV	-1	200,000	200	1,000	dpmjet3	El_hin	top2bot2
CALET_rev22_C8.01EP9.21	Z4A9_1~10TeV_dpmjet3_El_hin	22	V5.2	v8.01	v9.21	9Be	1TeV	10TeV	-1	200,000	200	1,000	dpmjet3	El_hin	top2bot2
CALET_rev22_C8.01EP9.21	Z5A10_1~10TeV_dpmjet3_El_hin	22	V5.2	v8.01	v9.21	10B	1TeV	10TeV	-1	400,000	200	2,000	dpmjet3	El_hin	top2bot2
CALET_rev22_C8.01EP9.21	Z5A11_1~10TeV_dpmjet3_El_hin	22	V5.2	v8.01	v9.21	11B	1TeV	10TeV	-1	400,000	200	2,000	dpmjet3	El_hin	top2bot2
CALET_rev22_C8.01EP9.21	Z6A12_1~10TeV_dpmjet3_El_hin	22	V5.2	v8.01	v9.21	12C	1TeV	10TeV	-1	400,000	200	2,000	dpmjet3	El_hin	top2bot2
CALET_rev22_C8.01EP9.21	Z7A14_1~10TeV_dpmjet3_El_hin	22	V5.2	v8.01	v9.21	14N	1TeV	10TeV	-1	200,000	200	1,000	dpmjet3	El_hin	top2bot2
CALET_rev22_C8.01EP9.21	Z7A15_1~10TeV_dpmjet3_El_hin	22	V5.2	v8.01	v9.21	15N	1TeV	10TeV	-1	200,000	200	1,000	dpmjet3	El_hin	top2bot2
CALET_rev22_C8.01EP9.21	Z8A16_1~10TeV_dpmjet3_El_hin	22	V5.2	v8.01	v9.21	16O	1TeV	10TeV	-1	400,000	200	2,000	dpmjet3	El_hin	top2bot2
CALET_rev22_C8.01EP9.21	Z9A19_1~10TeV_dpmjet3_El_hin	22	V5.2	v8.01	v9.21	19F	1TeV	10TeV	-1	200,000	200	1,000	dpmjet3	El_hin	top2bot2
CALET_rev22_C8.01EP9.21	Z10A20_1~10TeV_dpmjet3_El_hin	22	V5.2	v8.01	v9.21	20Ne	1TeV	10TeV	-1	200,000	200	1,000	dpmjet3	El_hin	top2bot2
CALET_rev22_C8.01EP9.21	Z10A22_1~10TeV_dpmjet3_El_hin	22	V5.2	v8.01	v9.21	22Ne	1TeV	10TeV	-1	200,000	200	1,000	dpmjet3	El_hin	top2bot2
CALET_rev22_C8.01EP9.21	Z11A23_1~10TeV_dpmjet3_El_hin	22	V5.2	v8.01	v9.21	23Na	1TeV	10TeV	-1	200,000	200	1,000	dpmjet3	El_hin	top2bot2
CALET_rev22_C8.01EP9.21	Z12A24_1~10TeV_dpmjet3_El_hin	22	V5.2	v8.01	v9.21	24Mg	1TeV	10TeV	-1	200,000	200	1,000	dpmjet3	El_hin	top2bot2
CALET_rev22_C8.01EP9.21	Z13A27_1~10TeV_dpmjet3_El_hin	22	V5.2	v8.01	v9.21	27Al	1TeV	10TeV	-1	200,000	200	1,000	dpmjet3	El_hin	top2bot2
CALET_rev22_C8.01EP9.21	Z14A28_1~10TeV_dpmjet3_El_hin	22	V5.2	v8.01	v9.21	28Si	1TeV	10TeV	-1	200,000	200	1,000	dpmjet3	El_hin	top2bot2
CALET_rev22_C8.01EP9.21	Z15A31_1~10TeV_dpmjet3_El_hin	22	V5.2	v8.01	v9.21	31P	1TeV	10TeV	-1	200,000	200	1,000	dpmjet3	El_hin	top2bot2
CALET_rev22_C8.01EP9.21	Z16A32_1~10TeV_dpmjet3_El_hin	22	V5.2	v8.01	v9.21	32S	1TeV	10TeV	-1	200,000	200	1,000	dpmjet3	El_hin	top2bot2
CALET_rev22_C8.01EP9.21	Z17A35_1~10TeV_dpmjet3_El_hin	22	V5.2	v8.01	v9.21	35Cl	1TeV	10TeV	-1	200,000	200	1,000	dpmjet3	El_hin	top2bot2
CALET_rev22_C8.01EP9.21	Z18A36_1~10TeV_dpmjet3_El_hin	22	V5.2	v8.01	v9.21	36Ar	1TeV	10TeV	-1	200,000	200	1,000	dpmjet3	El_hin	top2bot2
CALET_rev22_C8.01EP9.21	Z18A38_1~10TeV_dpmjet3_El_hin	22	V5.2	v8.01	v9.21	38Ar	1TeV	10TeV	-1	200,000	200	1,000	dpmjet3	El_hin	top2bot2
CALET_rev22_C8.01EP9.21	Z19A39_1~10TeV_dpmjet3_El_hin	22	V5.2	v8.01	v9.21	39K	1TeV	10TeV	-1	200,000	200	1,000	dpmjet3	El_hin	top2bot2
CALET_rev22_C8.01EP9.21	Z20A40_1~10TeV_dpmjet3_El_hin	22	V5.2	v8.01	v9.21	40Ca	1TeV	10TeV	-1	200,000	200	1,000	dpmjet3	El_hin	top2bot2
CALET_rev22_C8.01EP9.21	Z20A44_1~10TeV_dpmjet3_El_hin	22	V5.2	v8.01	v9.21	44Ca	1TeV	10TeV	-1	200,000	200	1,000	dpmjet3	El_hin	top2bot2
CALET_rev22_C8.01EP9.21	Z21A45_1~10TeV_dpmjet3_El_hin	22	V5.2	v8.01	v9.21	45Sc	1TeV	10TeV	-1	200,000	200	1,000	dpmjet3	El_hin	top2bot2
CALET_rev22_C8.01EP9.21	Z22A47_1~10TeV_dpmjet3_El_hin	22	V5.2	v8.01	v9.21	47Ti	1TeV	10TeV	-1	200,000	200	1,000	dpmjet3	El_hin	top2bot2
CALET_rev22_C8.01EP9.21	Z23A49_1~10TeV_dpmjet3_El_hin	22	V5.2	v8.01	v9.21	49V	1TeV	10TeV	-1	200,000	200	1,000	dpmjet3	El_hin	top2bot2
CALET_rev22_C8.01EP9.21	Z24A52_1~10TeV_dpmjet3_El_hin	22	V5.2	v8.01	v9.21	52Cr	1TeV	10TeV	-1	200,000	200	1,000	dpmjet3	El_hin	top2bot2
CALET_rev22_C8.01EP9.21	Z25A53_1~10TeV_dpmjet3_El_hin	22	V5.2	v8.01	v9.21	53Mn	1TeV	10TeV	-1	200,000	200	1,000	dpmjet3	El_hin	top2bot2
CALET_rev22_C8.01EP9.21	Z26A56_1~10TeV_dpmjet3_El_hin	22	V5.2	v8.01	v9.21	56Fe	1TeV	10TeV	-1	200,000	200	1,000	dpmjet3	El_hin	top2bot2
CALET_rev22_C8.01EP9.21	Z27A59_1~10TeV_dpmjet3_El_hin	22	V5.2	v8.01	v9.21	59Co	1TeV	10TeV	-1	200,000	200	1,000	dpmjet3	El_hin	top2bot2
CALET_rev22_C8.01EP9.21	Z28A58_1~10TeV_dpmjet3_El_hin	22	V5.2	v8.01	v9.21	58Ni	1TeV	10TeV	-1	200,000	200	1,000	dpmjet3	El_hin	top2bot2

Pair production/electron screening bug fix validation: Nick Cannady



Photon selection requires

1. **Geometry E: top of CHD, top of TASC**
2. 2 < Np < 8

Efficiency of the Np selection is the fraction of in-geometry events pair producing

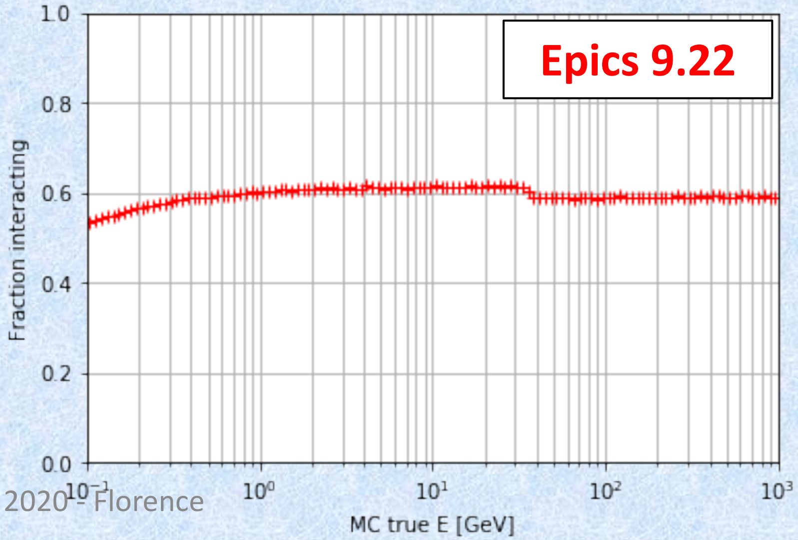
- below IMC 1 (Np < 8)
- above IMC 6 (Np > 2)

Used UnifiedOutput EPICS photon data from 100 MeV – 1 TeV to evaluate efficiency

Event satisfied geometry E (passes green shaded regions above)

Event has pair production in fiducial region of IMC (blue shaded region above)

Previously EPICS showed a sharp decrease at ~35 GeV



Pair production/electron screening bug fix validation: Nick Cannady

KK reported this fixed in a subsequent version of Epics. Current production runs from HPC resources at LSU confirm with high statistics that the change in efficiency has disappeared.

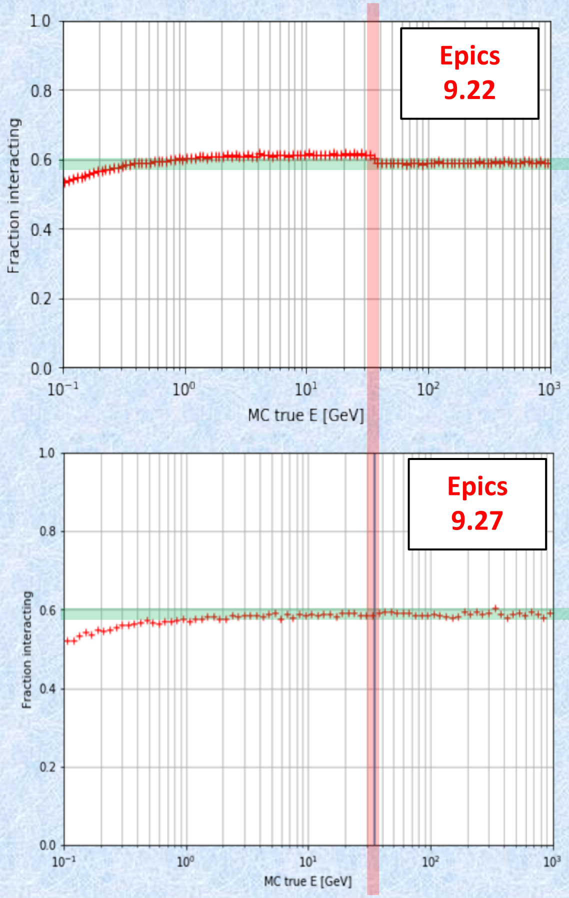
The efficiency is now smooth and shows that we had slightly overestimated the tracking efficiency below 35 GeV.

NC had also found that CC Track efficiency exceeded the number of ”good” starting at ~35 GeV.

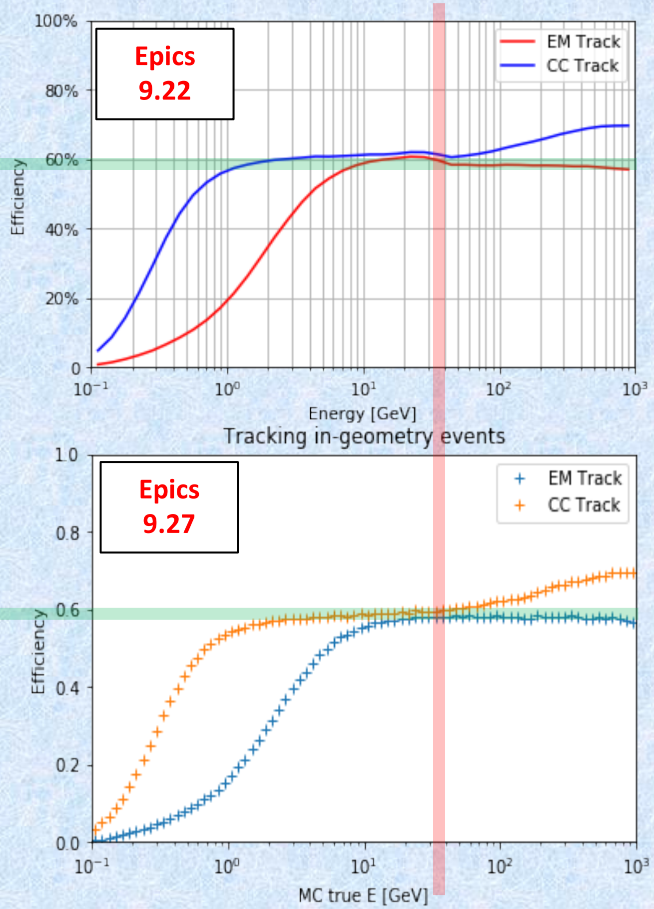
Unfortunately, this feature is still present and means there are spurious CC Track events at >10 GeV

But using CC Track for ≤ 10 GeV, EM Track > 10 GeV

EM Track efficiency is now featureless above ~10 GeV



UO: Efficiency of in-geo photon to interact in fiducial region

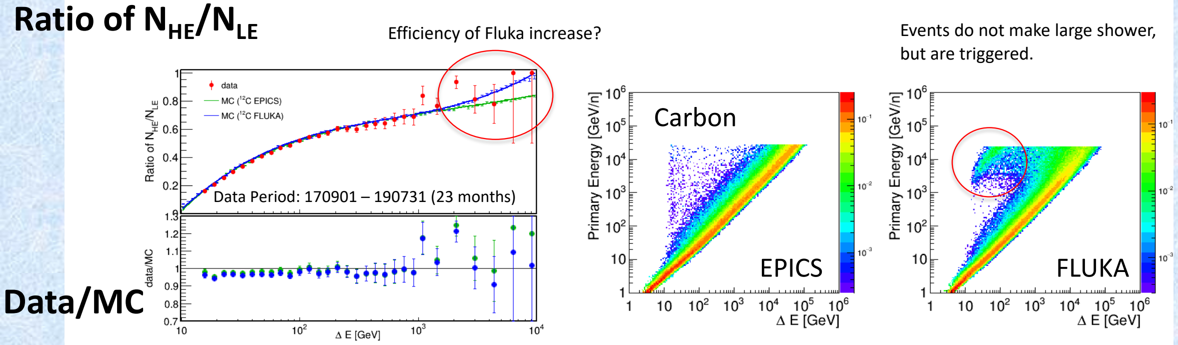


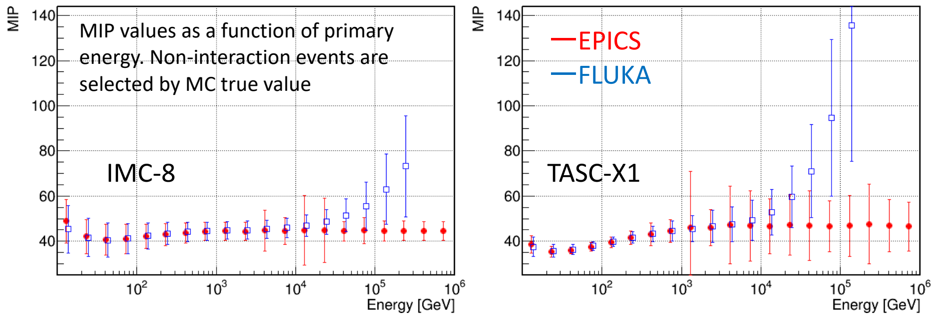
DST: Efficiency of in-geo photon to be tracked with 2 < Np < 8

Issue with direct e± pair production (2-γ process) in Epics: Yosui Akaike

See Paulo Maestro's presentation: ***Results of carbon and oxygen analysis***

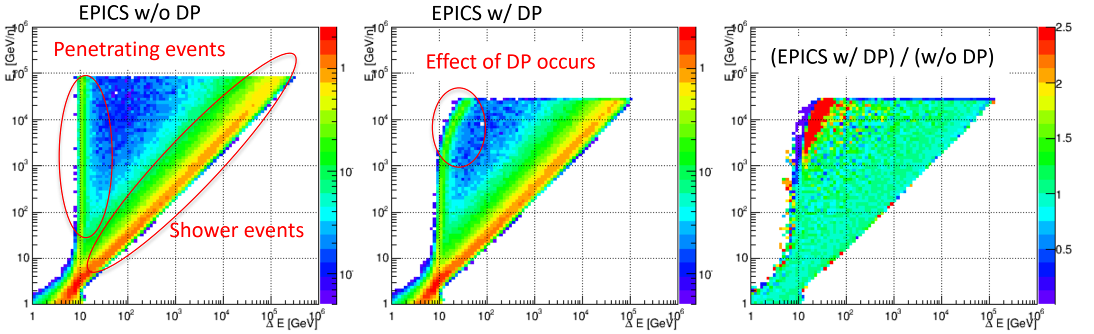
Difference of EPICS and FLUKA



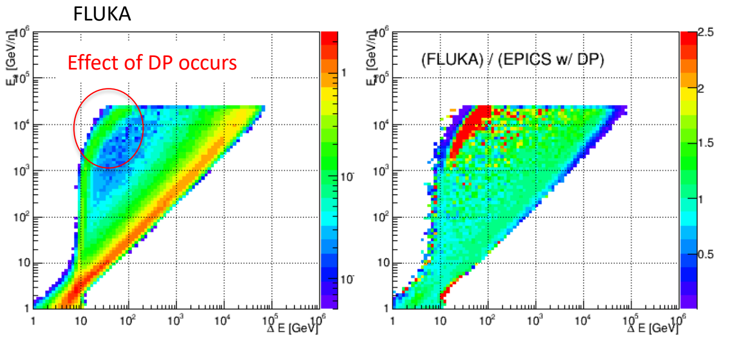


2

Primary energy vs observed energy in TASC



- Carbon
- LE trigger
  (all events)



5

Discussion Topics

1. US group still has significant simulation capacity
   - If needed, can accommodate based on input from Collaboration
2. UH runs scheduled once Epics9.28 validated:
   - ^{26}Fe, ^{28}Ni, ^{30}Zn, ^{31}Ga, ^{32}Ge and ^{34}Se
   - 500 MeV/n -> 10 GeV/n, E^{-1} spectrum
     - 500 MeV/n -> 1 GeV/n: 1e7 events/primary
     - 1 GeV/n -> 10 GeV/n: 1e7 events/primary
     - Isotropic(Downward Going) – Particles thrown from the full sphere, but events with upward trajectories are discarded.
3. LSU to put in new for SuperComputing allocation request:
   a. Additional runs of electrons: 200 GeV to 2 TeV (previous set ~80% complete)
   b. Photons 1 – 10 TeV (Asaoka-san request)
   c. Electrons: 2 to 20 TeV (Asaoka-san request)
4. GSFC to run simulations as needed:
   a. Run heavy nuclei using Epics9.28 once direct electron modeling validated