Trigger Simulation at IHEP

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2021.02.22

outline

- trigger acceptance comparison study
  - inconsistency results found since Xi'an workshop
    - between CIEMAT and IHEP
  - needs cross check by baseline geometry, baseline trigger definition
- CSS geometry related
  - blocked geometrical acceptance
  - update of trigger rate by considering
    - events below horizontal plane
    - secondary particles due to passive material around the payload

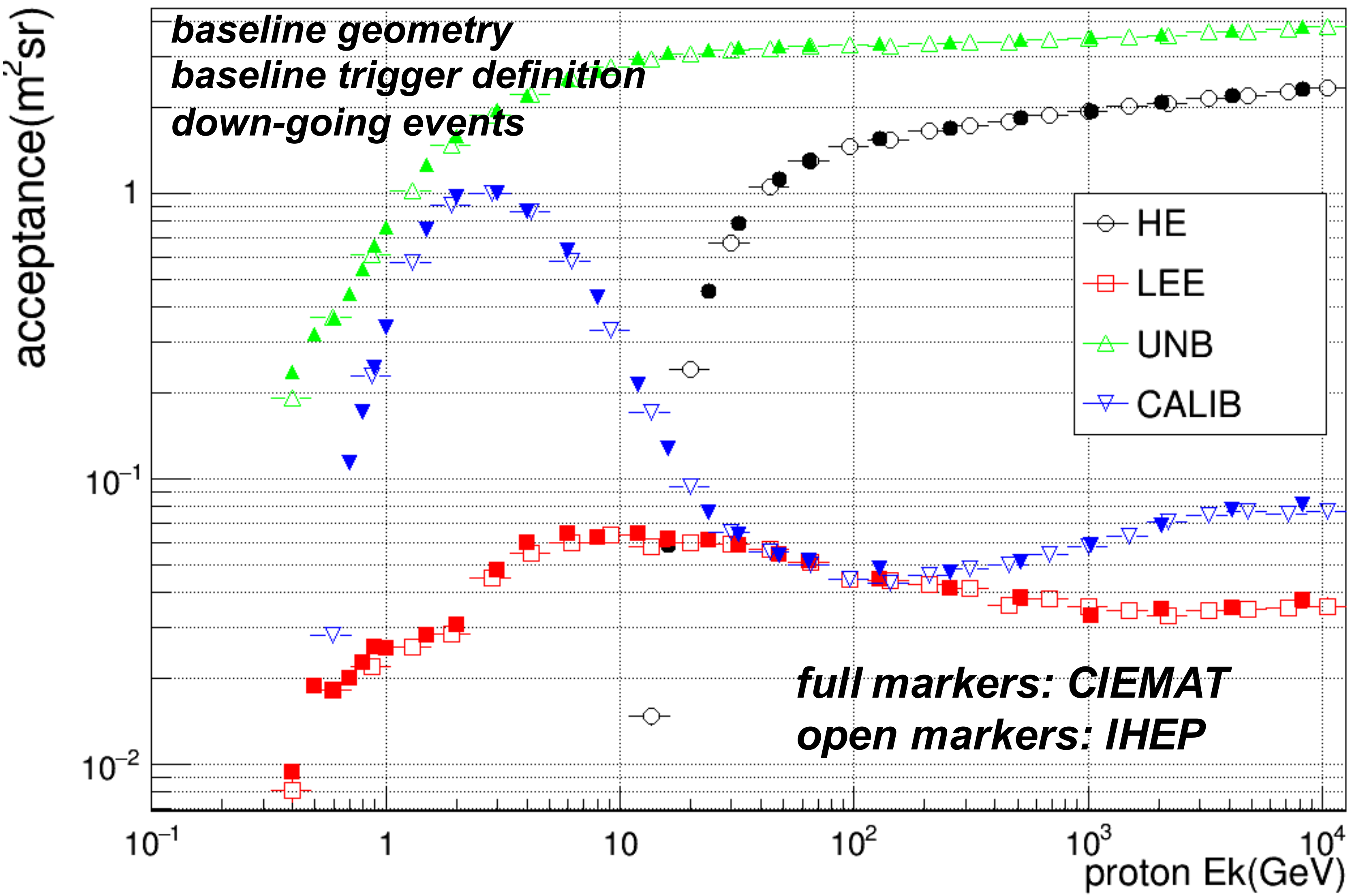
HERD baseline trigger definition (in GeV)

- high Energy (HE)
  - energy_in_core > 10
- low Energy Electron (LEE)
  - (energy_in_RAM_shell > 0.35 AND energy_in_core < 0.06) OR (energy_in_RAM_shell > 1 AND energy_in_core < 0.6)
  - Low Energy Gamma (LEG)
  - energy_in_TOP_shell > 0.35 AND energy_in_ANY_PSD_side < 0.001
- unbiased (UNB)
  - energy_in_ANY_shell > 0.35 with pre-scale
- global (GLOBAL) :
  - HE3 || LEG || LEE || UNB/1000
- standalone calibration (CALIB)
  - 0.1 < SUM_of_energy_in_all_shells < 0.8 AND energy_in_core > 0.5

trigger rate comparison

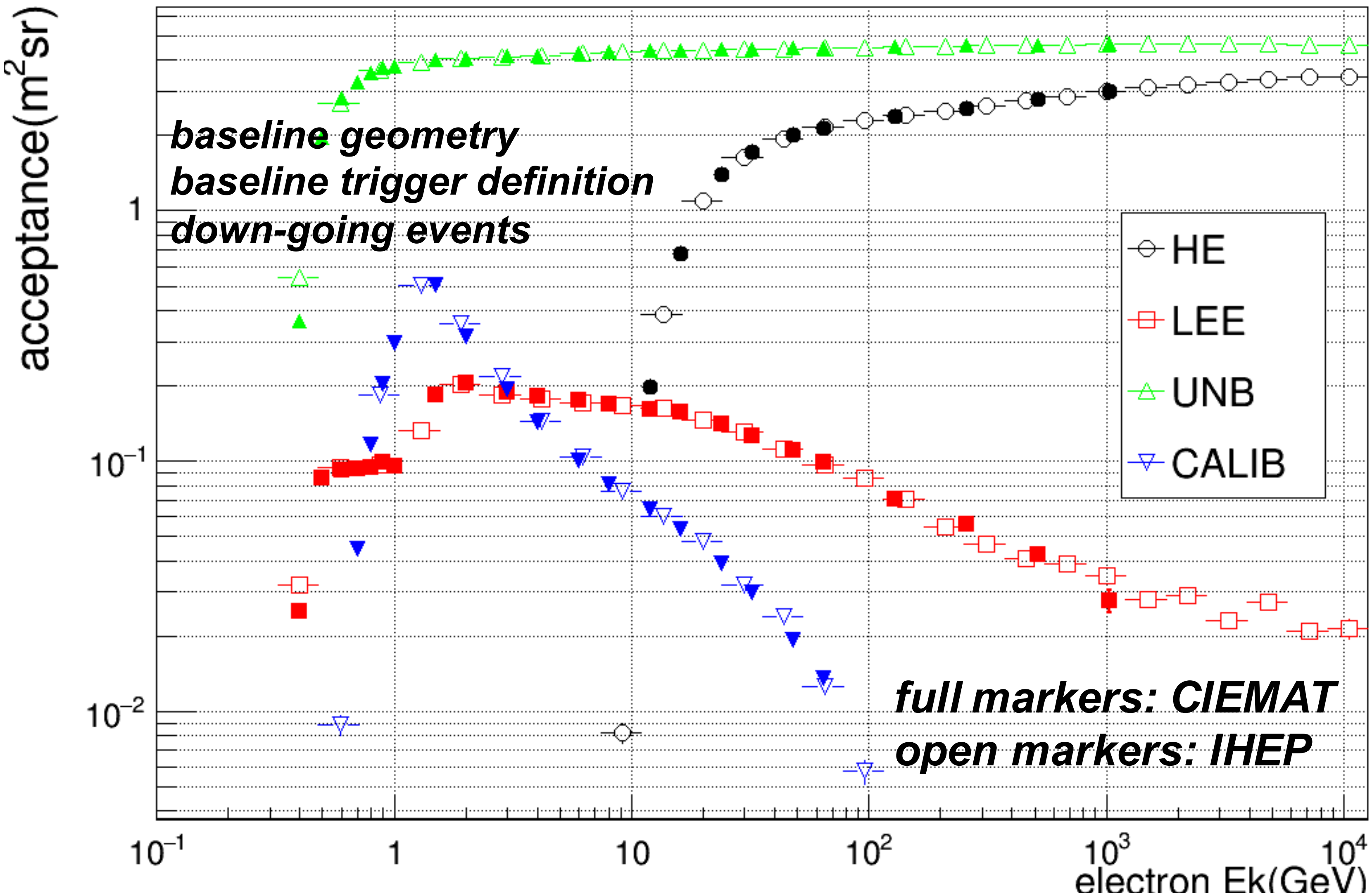
- separate trigger acceptance from particle fluxes
  - compare trigger acceptance firstly
- common particle fluxes SES package as input to evaluate further trigger rate

trigger acceptance comparison for protons



in general the results agree well in each channel beside LEG, and the inconsistency was found due to payload geometry

trigger acceptance comparison for electrons



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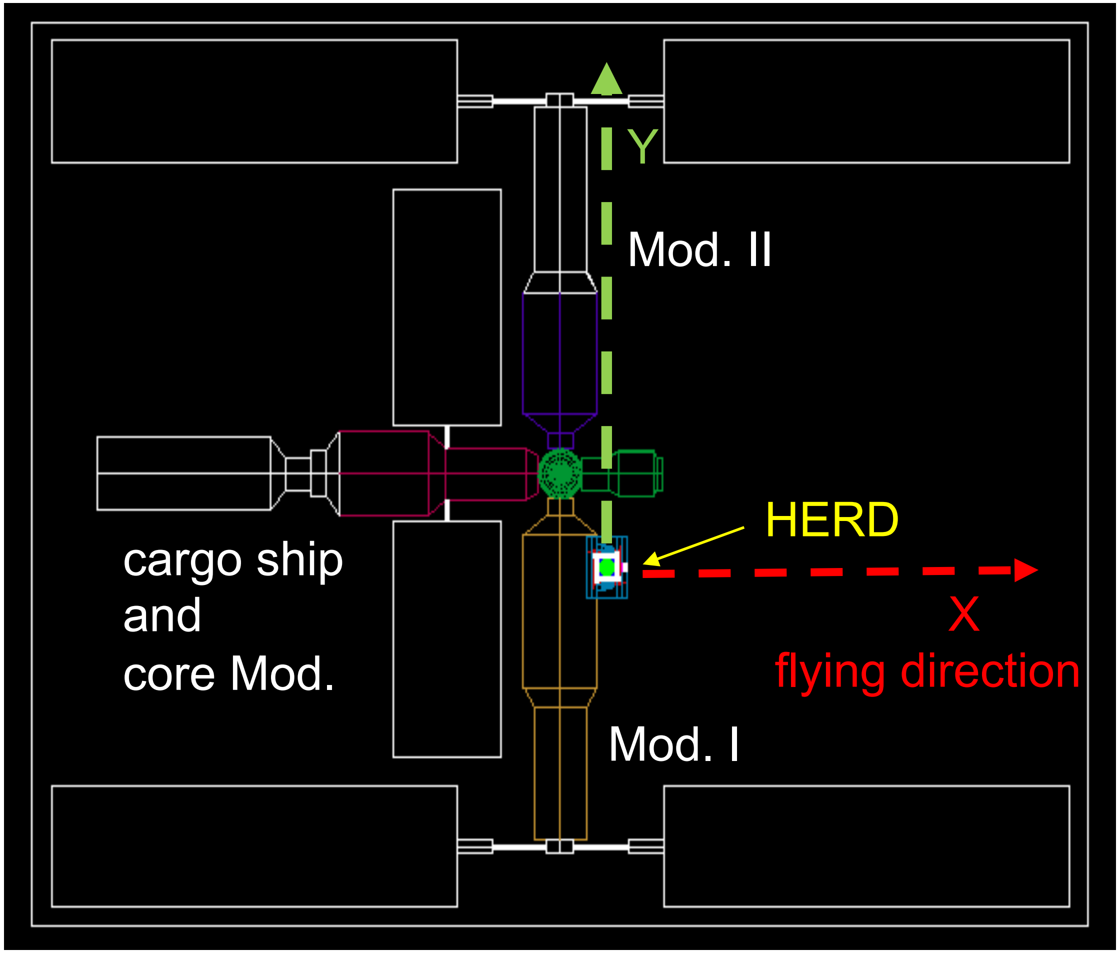
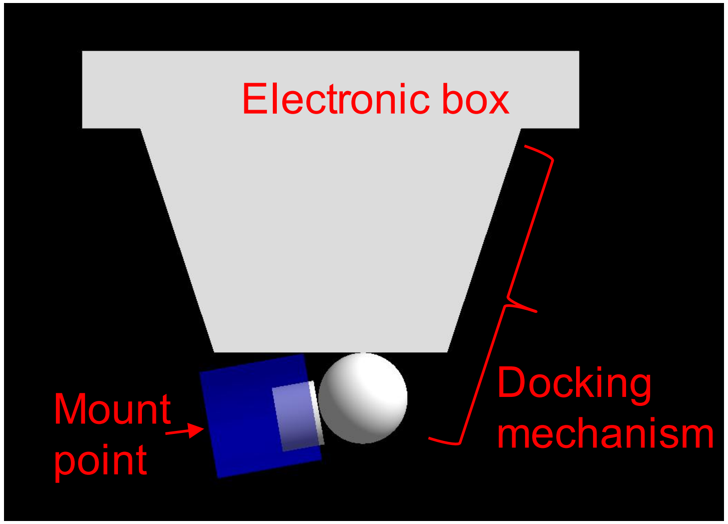
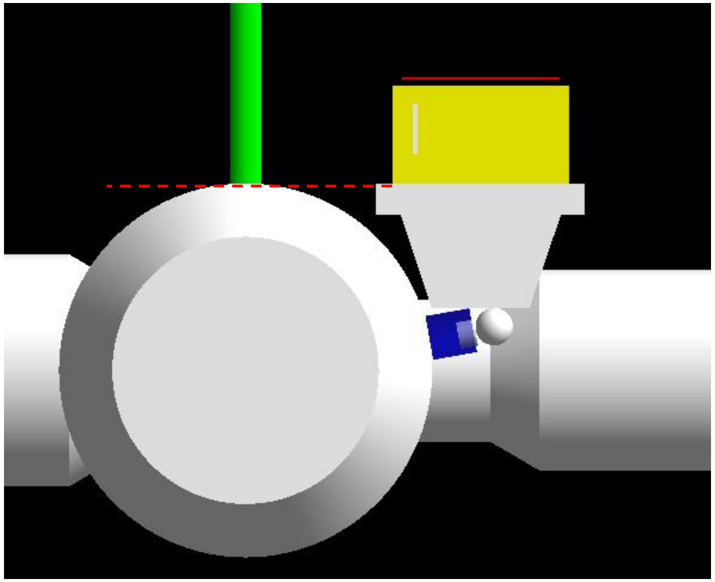
CSS part

CSS geometry in MC







key parameters of CSS

- general
  - dimension: 45.5 m * 37 m * 4.5 m (length*width*height)
  - weight: 62 tons totally (launched weight)
    - basically 20 tons for each module
  - cabin material: Aluminum, Kevlar
- solar panels
  - 4 of them mounted at the rear side of M.1 and M. 2 (11.5 m*3 m)
  - 2 of them mounted at the middle part of M. core (3 m * 5.8 m)
  - material: mainly composed of Kapton
  - trajectory
    - panels on the same cabin share common revolution velocity
    - no revolution for those on M. core.
    - 6 spin parameters and 2 revolution parameters, independently

particle source and trigger definition

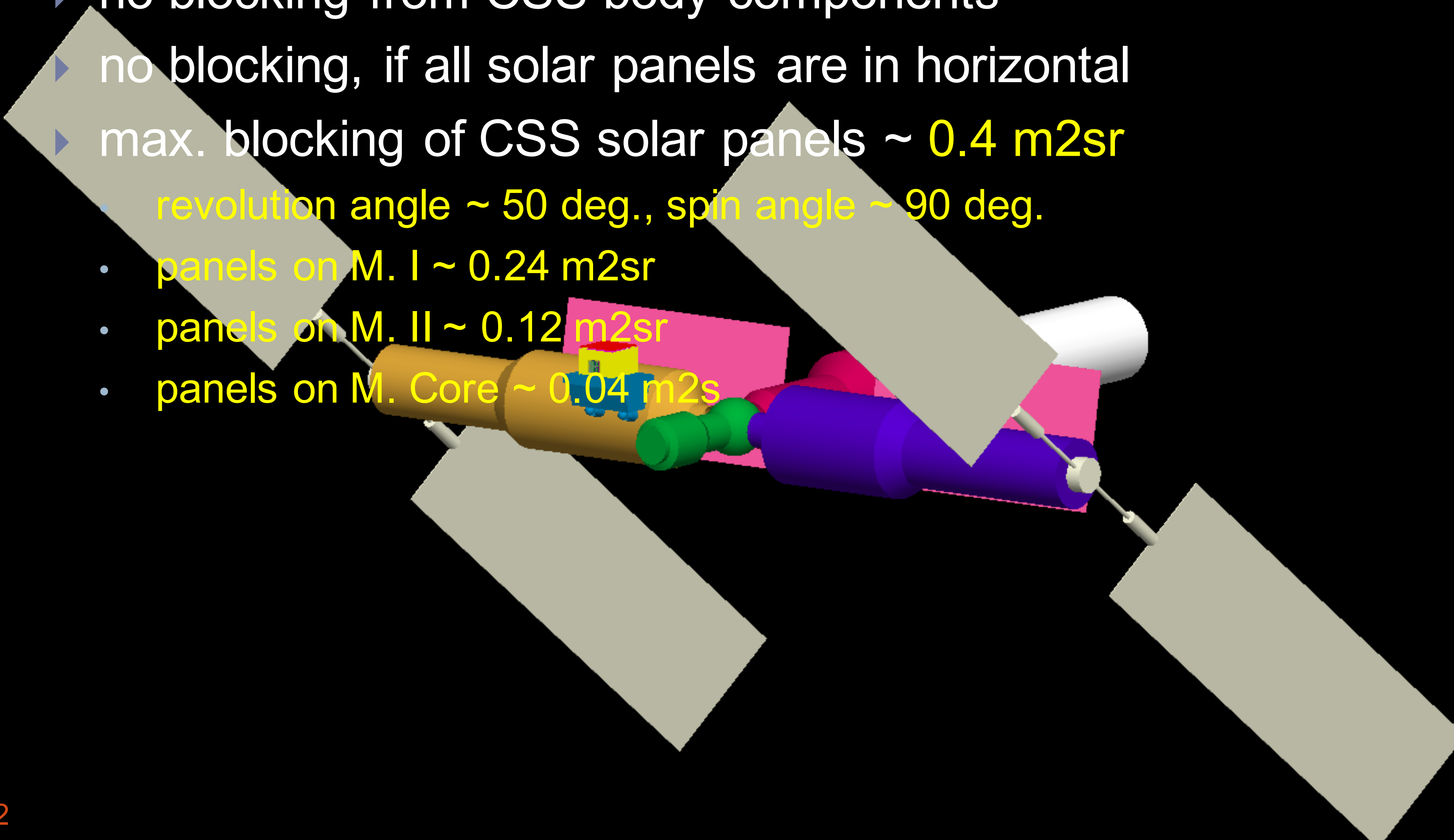
- source:
  - 45 m surface sphere, 4*pi, focusing to 3m sphere to enhance simulation efficiency
  - geantino, geometric acceptance study
  - protons, electrons, 500 MeV -5 TeV, power law
- CSS geometry
- HERD baseline geometry
- trigger definition optimized:
  - HE optimized, Etot > 15 GeV
    - easier to evaluate trigger efficiency at higher energies

geometrical blocking study

- particles pass CSS volume firstly will be tagged as invalid events
  - primary or secondary confusion
  - charge confusion due to fragmentation
  - should be removed from reconstruction procedure
- geometric acceptance study with geantino, and blocked acceptance defined as
  - valid CALO hit and valid CSS hit
  - events will be tagged as CSS body hit, if the body and panels are both passed through
  - if more than one CSS body volume passed through, the closest one to HERD as the blocking volume

blocking of upper half sphere down-going events

- CALO geometric factor ~ 4.37 m2sr
- no blocking from CSS body components
- no blocking, if all solar panels are in horizontal
- max. blocking of CSS solar panels ~ 0.4 m2sr
  - revolution angle ~ 50 deg., spin angle ~ 90 deg.
  - panels on M. I ~ 0.24 m2sr
  - panels on M. II ~ 0.12 m2sr
  - panels on M. Core ~ 0.04 m2s



blocking of up-going events

- up going events in full sphere surface, CALO GF ~ 4.38 m2sr (without earth blocking)
- only considering CSS body blocking
  - solar panels in horizontal

	down-going (m2sr)	up-going (m2sr)
CALO G. F.	4.37	4.38
equ. box (electronic box+ docking mech.) blocked	0	3.03
M.I blocked	0	0.30
sum of other body blocked	0	0.15
remain unblocked	4.37	0.90

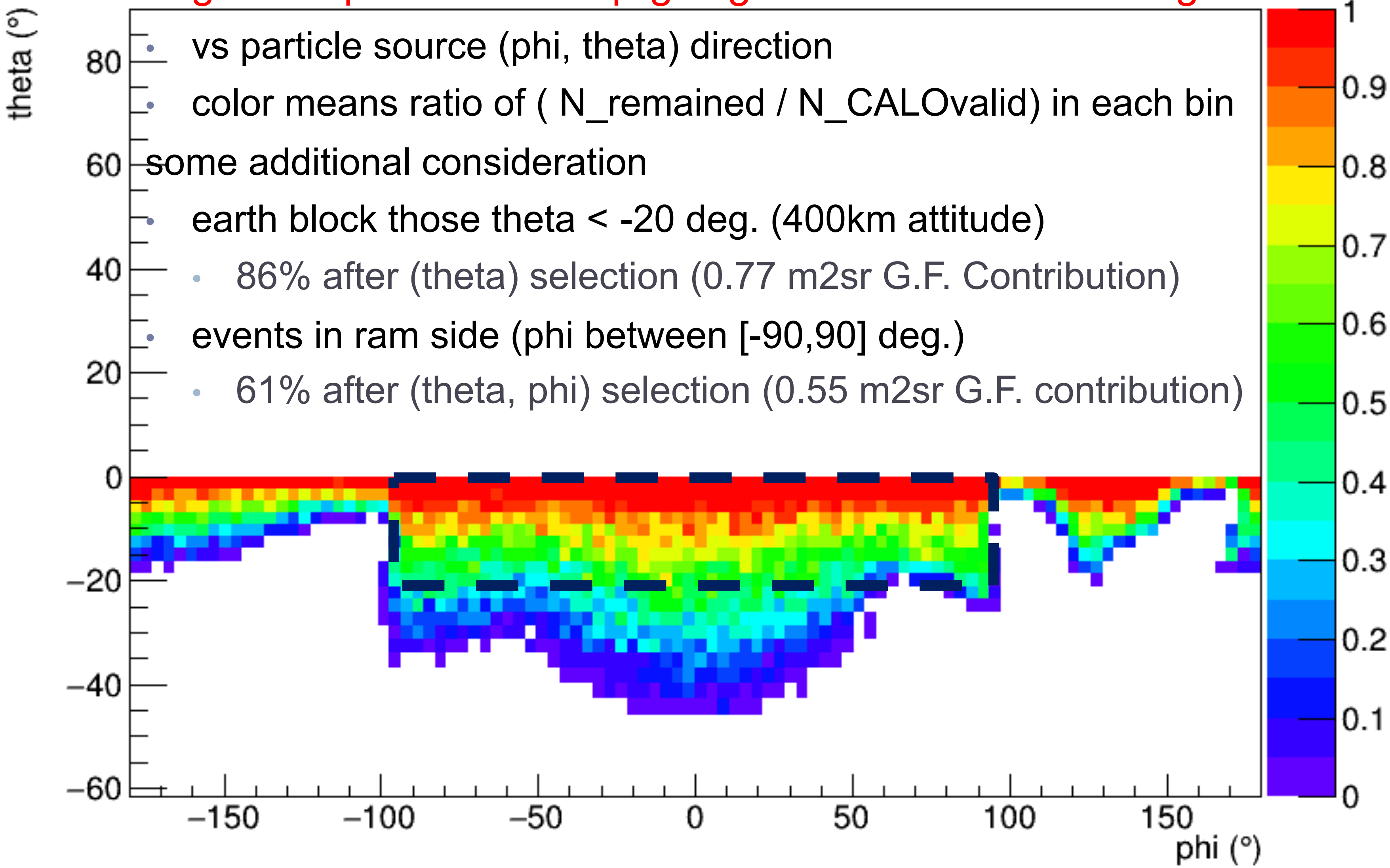
remain unblocked

angular dependence of up-going events without blocking

- vs particle source (phi, theta) direction
- color means ratio of (N_remained / N_CALOvalid) in each bin

some additional consideration

- earth block those theta < -20 deg. (400km attitude)
    - 86% after (theta) selection (0.77 m2sr G.F. Contribution)
- events in ram side (phi between [-90,90] deg.)
    - 61% after (theta, phi) selection (0.55 m2sr G.F. contribution)



update study of the trigger acceptance and rates

- adopt CSS geometry and different cabin material and equipment box geometry for robust consideration
  - same total weight constrains (~ 62 tons)
    - cabin composed of Al, C, KEVLAR(KVL), respectively
  - same equipment box weight constrains (0.3 tons)
    - low density solid(0.04 g/cm3, Al)
    - or shell structure(2.7 g/cm3, Al)
  - solar panels in horizontal

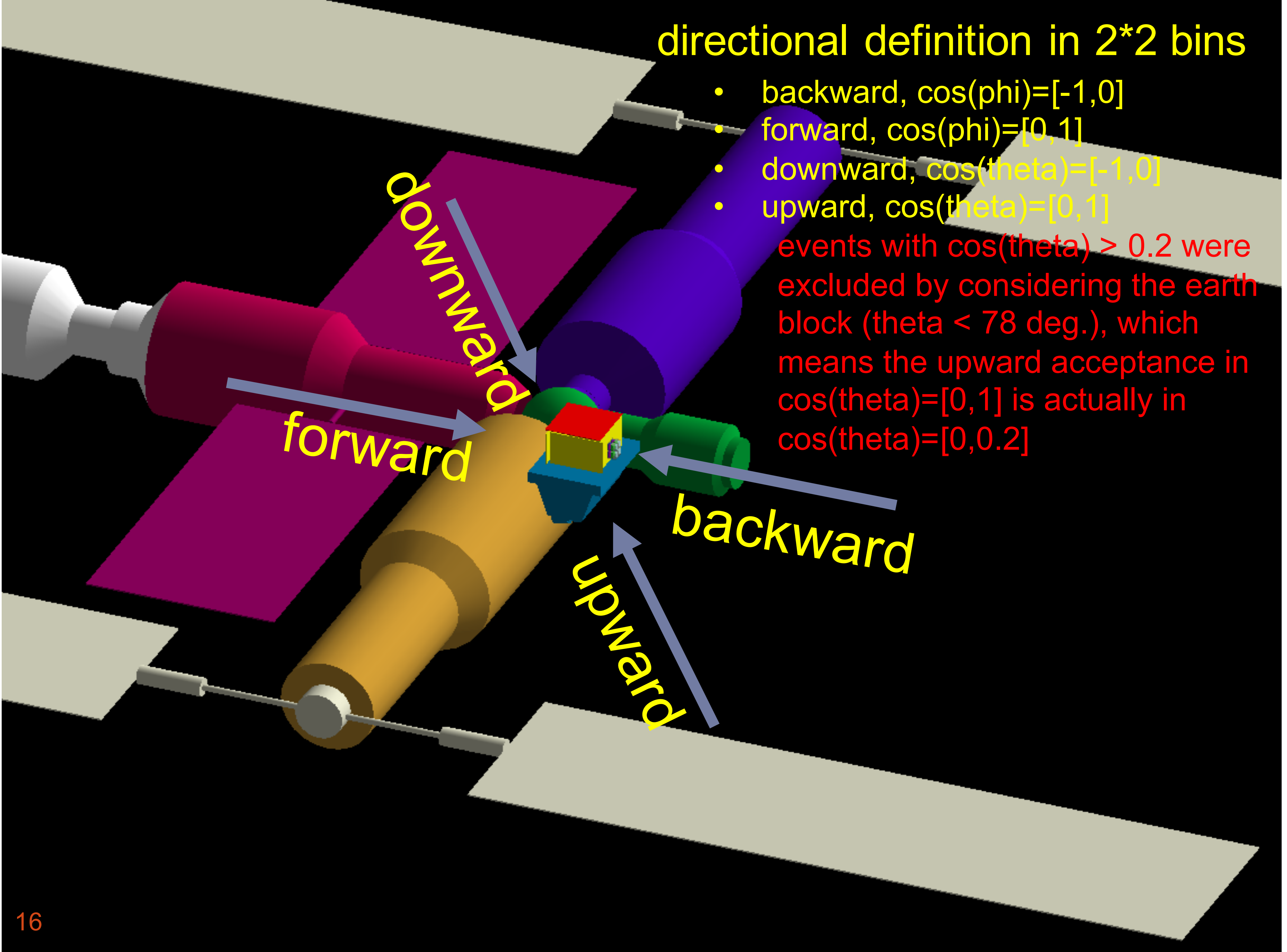
	Aluminum(2.7 g/cm3) ave. cabin wall(mm)	Carbon (2 g/cm3) ave. cabin wall(mm)	KEVLAR(1.4 g/cm3) ave. cabin wall(mm)
Core + Node Mod. (21 tons)	53	73	102
Mod. I (20 tons)	38	53	74
Mod. II (20 tons)	40	54	76

- trigger acceptance and rates, additional contribution other than down-going events
  - by those secondary particles from the passive material around HERD
  - by directly the upward events

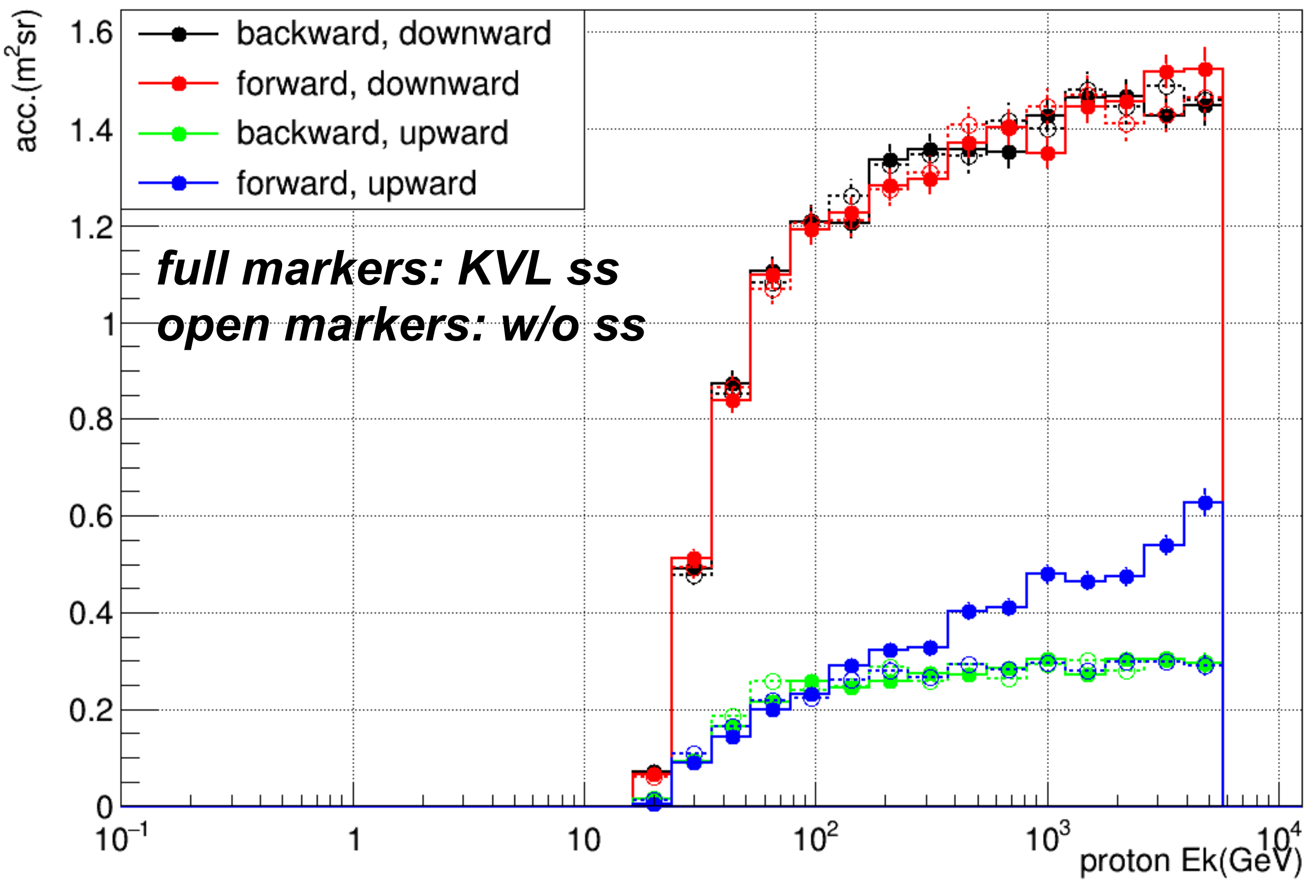
directional definition in 2*2 bins

- backward, cos(phi)=[-1,0]
- forward, cos(phi)=[0,1]
- downward, cos(theta)=[-1,0]
- upward, cos(theta)=[0,1]

events with cos(theta) > 0.2 were excluded by considering the earth block (theta < 78 deg.), which means the upward acceptance in cos(theta)=[0,1] is actually in cos(theta)=[0,0.2]

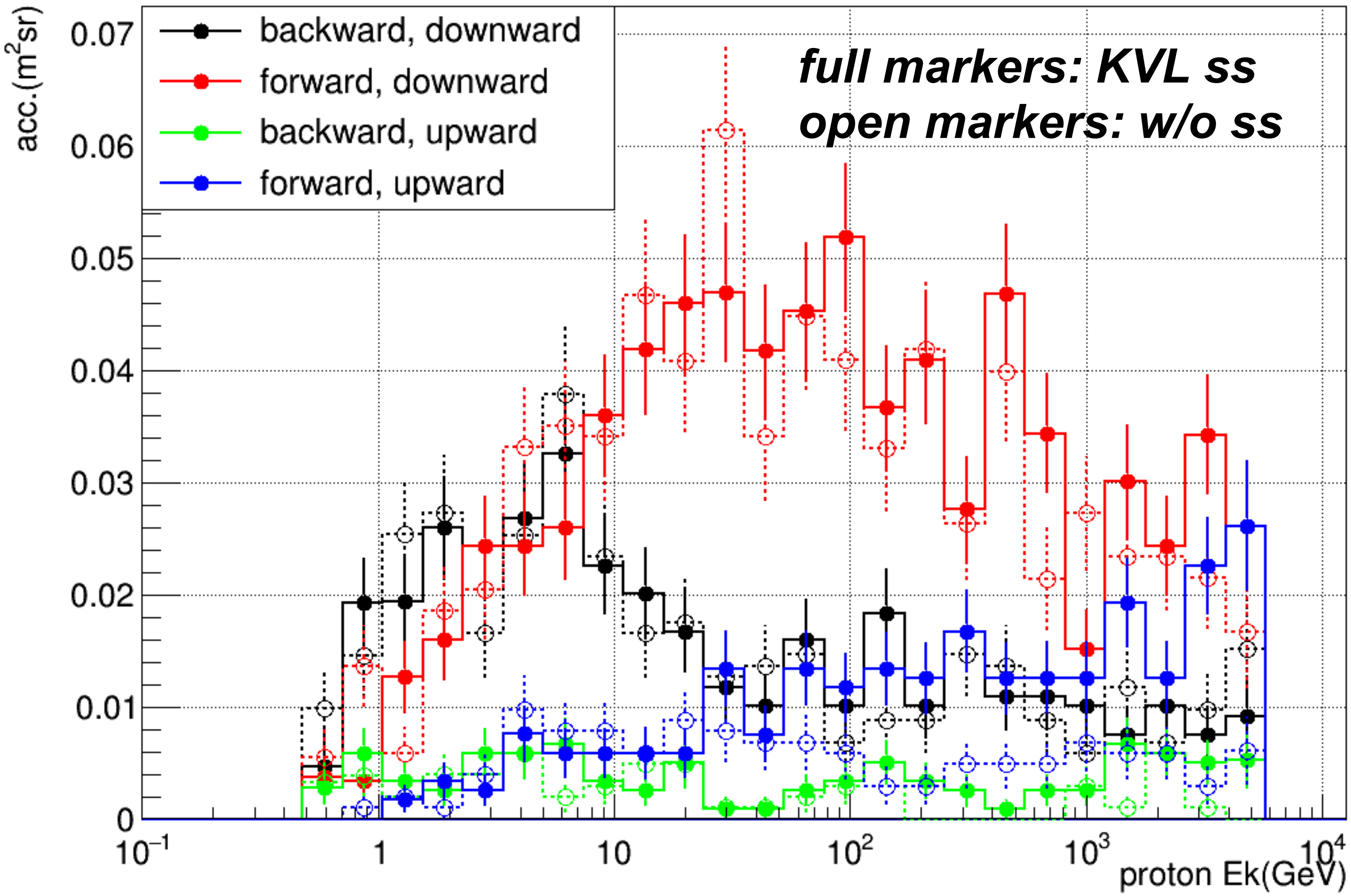


directional trigger acceptance in HE



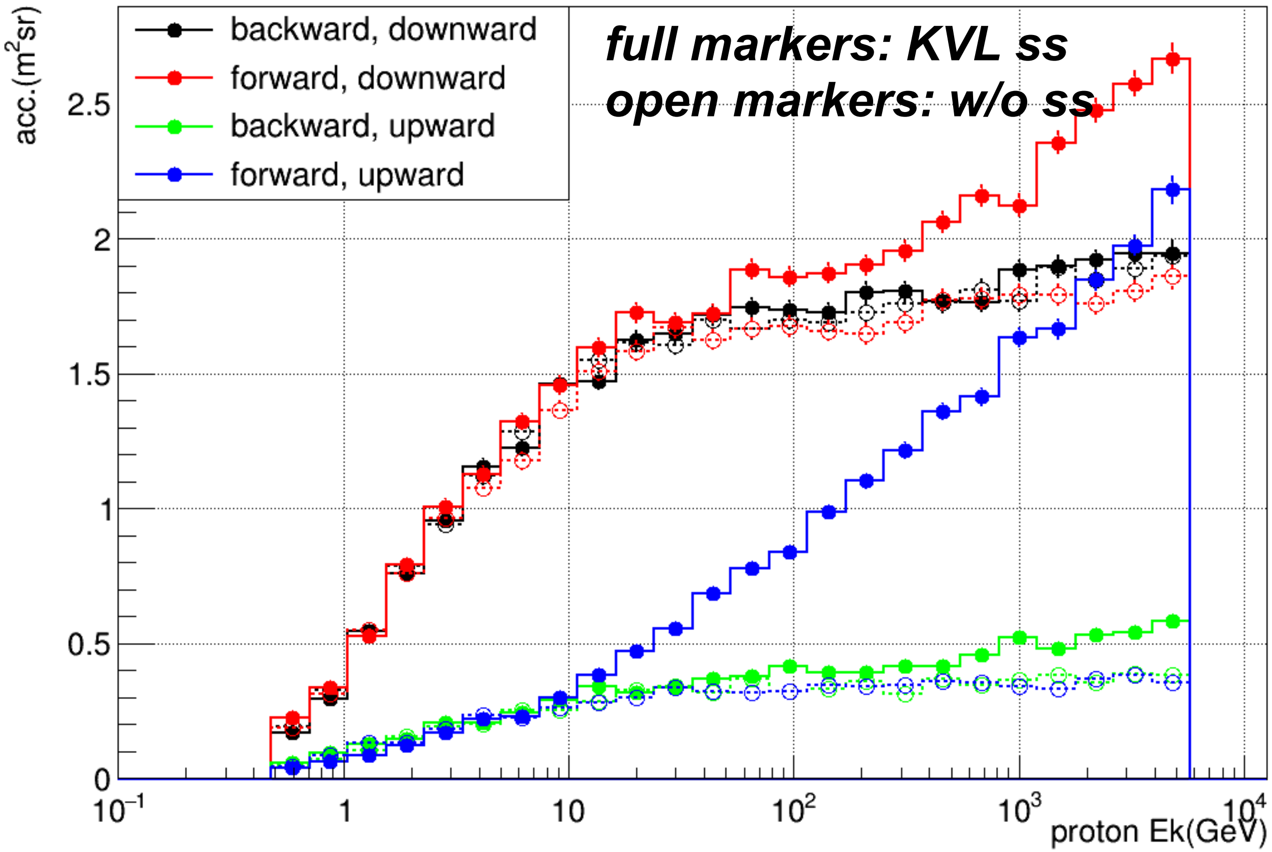
- *upward* less than *downward* due to earth block
- none contributions from secondaries except *(forward, upward),* since a high energy response is required
- *(backward, upward)* contributions by primaries free of blocking ~ 0.2 m2sr
- for the worst case in *(forward, upward)*, at higher energies with higher probability of secondary produced in cabins beyond HE threshold

directional trigger acceptance in LEE



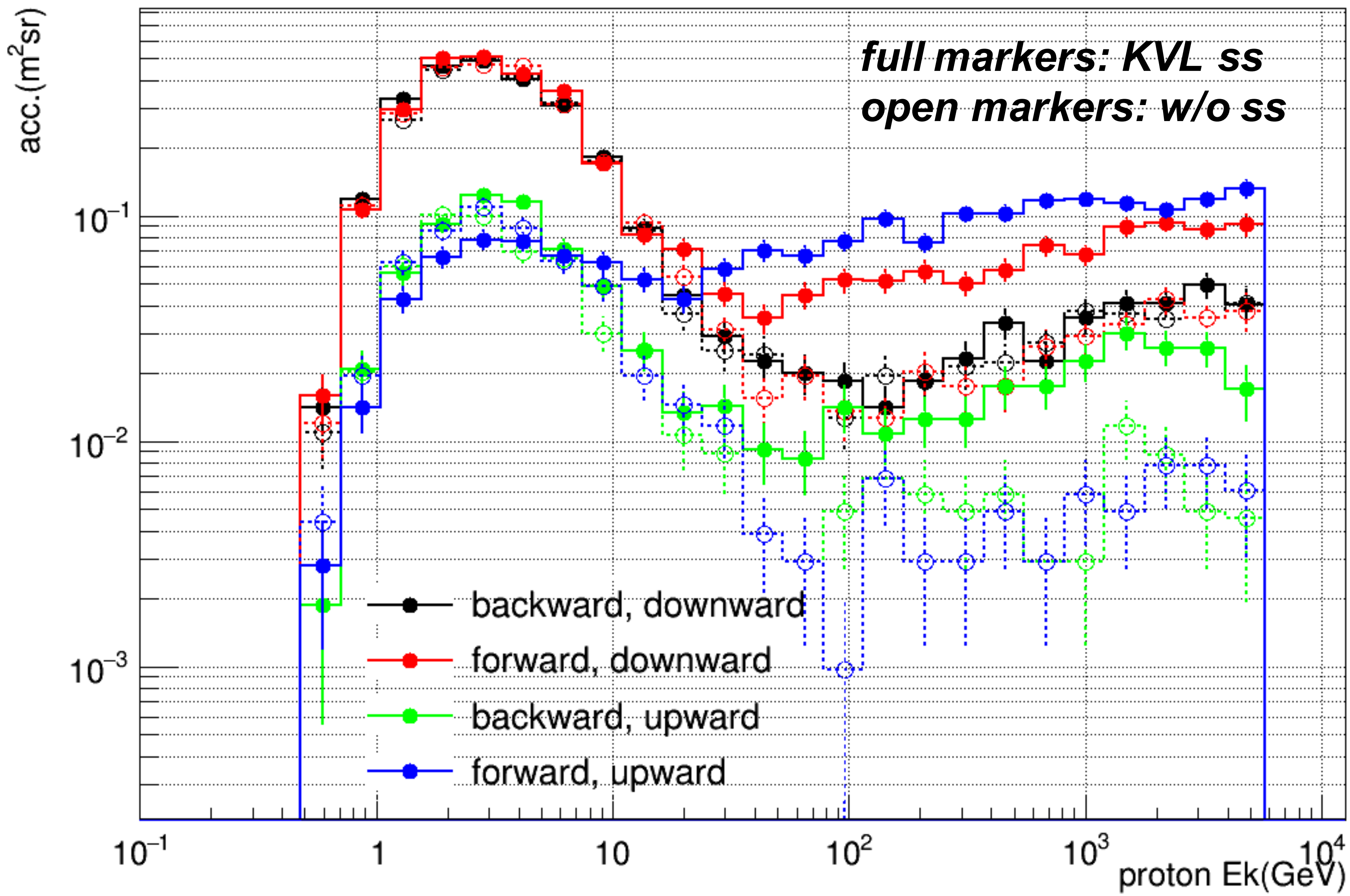
- *forward* more than *backward* due to non-uniformity of trigger region in phi
- none contributions from secondaries, except *(forward, upward),*
- *(backward, upward)* contributions by primaries free of blocking ~ 10% of the *(backward, downward)* acceptance
- for the worst case in *(forward, upward),* at higher energies with higher probability of secondary produced in cabins beyond LEE threshold

directional trigger acceptance in UNB

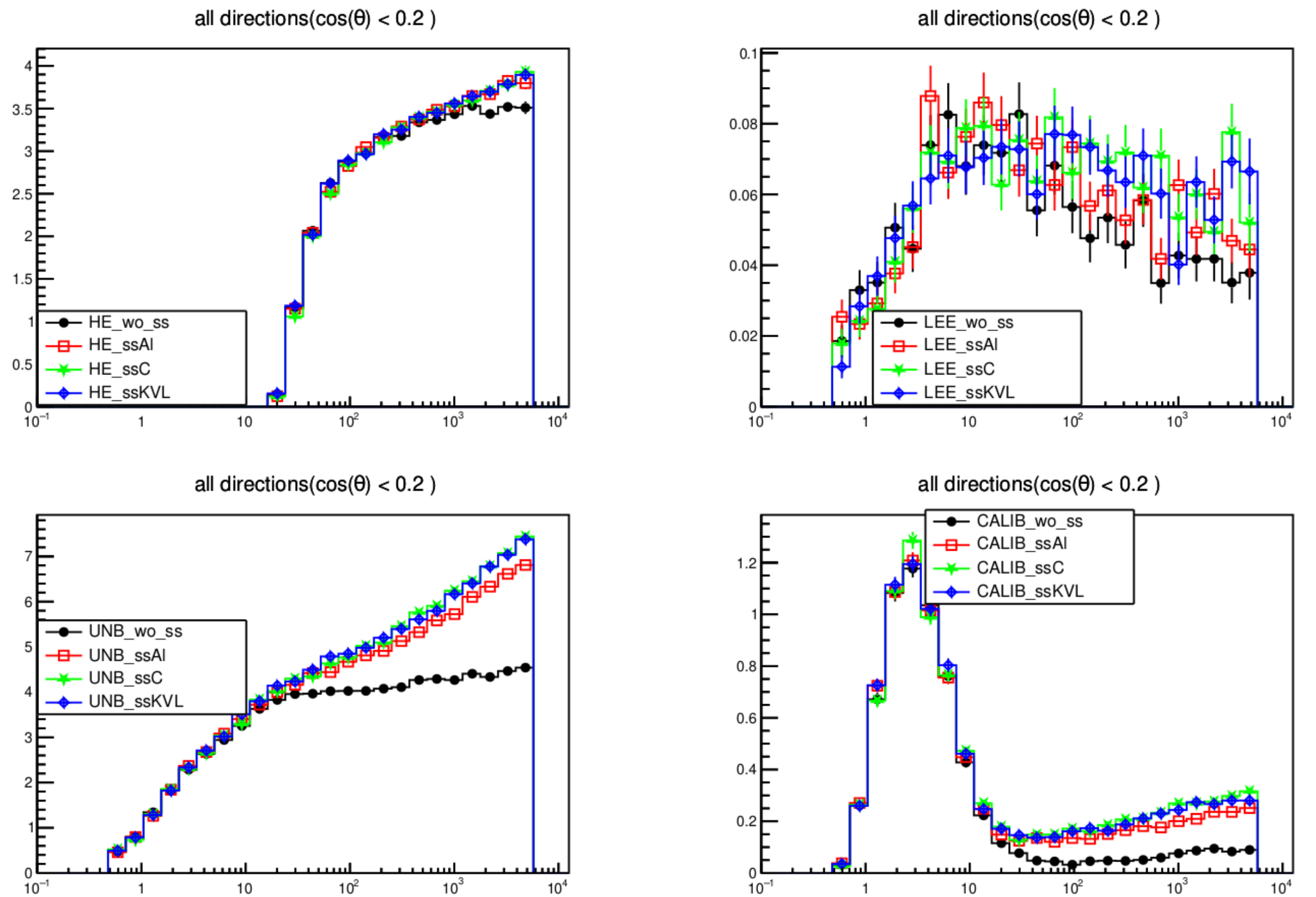


- a very low energy threshold of either shells
- contribution of secondaries is clear (>10GeV) in three directional bins except *(backward, downward)*
- *(forward, downward),* secondaries are "shower backsplahsed ones" due to CSS cabins at higher energies (>100GeV)
- *upward* comparison in *backward* and *forward* direction, the increased ratio is fraction of passive material related

directional trigger acceptance in CALIB



sum of all directions for trigger acceptance



- HE, additional acceptance contribution from secondaris for energies > 300 GeV
- LEE,UNB and CALIB, contribution from secondaris for energies > 20 GeV
- and in the same weight constrain, the station composed of Kevlar cabin will contribution more than the Aluminum case

trigger rate comparison

trigger rate of each channel based on particle fluxes from SES v4,
by considering the directional cutoff and directional acceptance

particles	directional selection	space staion config.	average trigger rate(Hz)			
			HE(Etot>15GeV)	LEE(RAM shell)	UNB	CALIB
proton	down-going (cos(theta)<0)	w/o ss	50	24	1018	228
		ss Al	49	24	1034	231
		ss KVL	51	22	1046	232
	extension to cos(theta<0.2)	w/o ss	60	27	1213	274
		ss Al	59	28	1255	276
		ss KVL	61	26	1272	280
electron	down-going (cos(theta)<0)	w/o ss	1	5	124	7
		ss Al	1	5	124	8
		ss KVL	1	5	124	8
	extension to cos(theta<0.2)	w/o ss	2	6	144	10
		ss Al	2	6	144	10
		ss KVL	2	6	145	10

- compared between down-going and extension case
  - 15% ~ 20% increase of trigger rate by primary particles below horizontal plane
- compared between with or w/o CSS case
  - by considering particle flux decrease by power law
  - limited increase of trigger rate in all channels by those secondary particles

summary

- good agreement of trigger acceptance between CIEMAT and IHEP by using the baseline geometry
- latest CSS geometry was successfully adopted in trigger simulation
  - max. blocking of CSS solar panels ~ 0.4 m2sr
  - ~ 0.55 m2sr additional G.F. contribution by *upward backward* events. compared with down-going events acceptance, 10% increasing for high energy particles
  - 15%~20% increasing of trigger rate
    - mostly by *upward* events
    - contribution from secondaries due to passive material around the payload is negligible