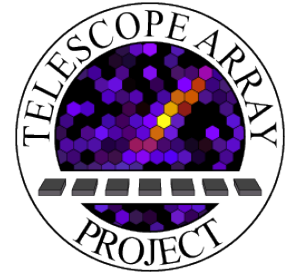


宇宙線望遠鏡による 極高エネルギー宇宙線の研究



多米田裕一郎 (大阪電通大・工)
for the Telescope Array collaboration

Telescope Array

ファイル(F) 表示(V) 追加(A) ツール(T) ヘルプ(H)

Telescope Array Project, ユタ州

テレスコープアレイ実験

テレスコープアレイ実験またはテレスコープアレイ計画とは、超高エネルギー宇宙線を高精度で検出するための実験計画のことである。アメリカ合衆国ユタ州ミラード郡の700km²の範囲に507台のシンチレーション検出器を設置、その周囲3箇所に大気蛍光を検出するための反射望遠鏡が計38基ずつ設置された。

ウィキペディア

テレスコープアレイ実験 Utah, アメリカ合衆国

telescopearray.org

+1 801-581-6628

場所
ミラード, ユタ州

標高
1,400 m (4,600 フィート)

プロジェクトに保存

北半球最大の宇宙線観測実験
Delta, Utah, USA. ~1,400 m a.s.l.
Collaborators from HiRes, AGASA and other institutes

Google 100% データの帰属表示

1,000 km カメラ: 11,898 km 36°26'02"N 76°39'10"W

Telescope Array collaboration

119 collaborators from 30 institutes in 9 countries and regions

R.U. Abbasi (1), T. Abu-Zayyad (1,2), M. Allen (2), J.W. Belz (2), D.R. Bergman (2), I. Buckland (2), W. Campbell (2), B.G. Cheon (3), K. Endo (4), A. Fedynitch (5,6), T. Fujii (4,7), K. Fujisue (5,6), K. Fujita (5), M. Fukushima (5), G. Furlich (2), Z. Gerber (2), N. Globus (8), W. Hanlon (2), N. Hayashida (9), H. He (8), K. Hibino (9), R. Higuchi (8), D. Ikeda (9), T. Ishii (10), D. Ivanov (2), S. Jeong (11), C.C.H. Jui (2), K. Kadota (12), F. Kakimoto (9), O. Kalashev (13), K. Kasahara (14), Y. Kawachi (4), K. Kawata (5), I. Kharuk (13), E. Kido (8), H.B. Kim (3), J.H. Kim (2), J.H. Kim (2), S.W. Kim (11), R. Kobo (4), I. Komae (4), K. Komatsu (15), K. Komori (16), C. Koyama (5), M. Kudenko (13), M. Kuroiwa (15), Y. Kusumori (16), M. Kuznetsov (13,17), Y.J. Kwon (18), K.H. Lee (3), M.J. Lee (11), B. Lubsandorzhev (13), J.P. Lundquist (2,19), A. Matsuzawa (15), J.A. Matthews (2), J.N. Matthews (2), K. Mizuno (15), M. Mori (16), M. Murakami (16), S. Nagataki (8), M. Nakahara (4), T. Nakamura (20), T. Nakayama (15), Y. Nakayama (16), T. Nonaka (5), S. Ogio (5), H. Ohoka (5), N. Okazaki (5), M. Onishi (5), A. Oshima (21), H. Oshima (5), S. Ozawa (22), I.H. Park (11), K.Y. Park (3), M. Potts (2), M. Przybylak (23), M.S. Pshirkov (13,24), J. Remington (2), C. Rott (2,11), G.I. Rubtsov (13), D. Ryu (25), H. Sagawa (5), N. Sakaki (5), R. Sakamoto (16), T. Sako (5), N. Sakurai (5), S. Sakurai (4), D. Sato (15), S. Sato (16), K. Sekino (5), T. Shibata (5), J. Shikita (4), H. Shimodaira (5), B.K. Shin (25), H.S. Shin (4,7), K. Shinozaki (26), J.D. Smith (2), P. Sokolsky (2), B.T. Stokes (2), T.A. Stroman (2), Y. Takagi (16), K. Takahashi (5), M. Takeda (5), R. Takeishi (5), A. Taketa (27), M. Takita (5), Y. Tameda (16), K. Tanaka (28), M. Tanaka (29), S.B. Thomas (2), G.B. Thomson (2), P. Tinyakov (13,17), I. Tkachev (13), T. Tomida (15), S. Troitsky (13), Y. Tsunesada (4,7), S. Udo (9), F. Urban (30), I.A. Vaiman (13), M. Vrábel (26), D. Warren (8), K. Yamazaki (21), Y. Zhezher (5,13), Z. Zundel (2), and J. Zvirzdin (2)

(1) Department of Physics, Loyola University Chicago, Chicago, Illinois 60660, USA, (2) High Energy Astrophysics Institute and Department of Physics and Astronomy, University of Utah, Salt Lake City, Utah 84112-0830, USA, (3) Department of Physics and The Research Institute of Natural Science, Hanyang University, Seongdong-gu, Seoul 426-791, Korea, (4) Graduate School of Science, Osaka Metropolitan University, Sugimoto, Sumiyoshi, Osaka 558-8585, Japan, (5) Institute for Cosmic Ray Research, University of Tokyo, Kashiwa, Chiba 277-8582, Japan, (6) Institute of Physics, Academia Sinica, Taipei City 115201, Taiwan, (7) Nambu Yoichiro Institute of Theoretical and Experimental Physics, Osaka Metropolitan University, Sugimoto, Sumiyoshi, Osaka 558-8585, Japan, (8) Astrophysical Big Bang Laboratory, RIKEN, Wako, Saitama 351-0198, Japan, (9) Faculty of Engineering, Kanagawa University, Yokohama, Kanagawa 221-8686, Japan, (10) Interdisciplinary Graduate School of Medicine and Engineering, University of Yamanashi, Kofu, Yamanashi 400-8511, Japan, (11) Department of Physics, Sungkyunkwan University, Jang-an-gu, Suwon 16419, Korea, (12) Department of Physics, Tokyo City University, Setagaya-ku, Tokyo 158-8557, Japan, (13) Institute for Nuclear Research of the Russian Academy of Sciences, Moscow 117312, Russia, (14) Faculty of Systems Engineering and Science, Shibaura Institute of Technology, Minato-ku, Tokyo 337-8570, Japan, (15) Academic Assembly School of Science and Technology Institute of Engineering, Shinshu University, Nagano, Nagano 380-8554, Japan, (16) Graduate School of Engineering, Osaka Electro-Communication University, Neyagawa-shi, Osaka 572-8530, Japan, (17) Service de Physique Théorique, Université Libre de Bruxelles, Brussels 1050, Belgium, (18) Department of Physics, Yonsei University, Seodaemun-gu, Seoul 120-749, Korea, (19) Center for Astrophysics and Cosmology, University of Nova Gorica, Nova Gorica 5297, Slovenia, (20) Faculty of Science, Kochi University, Kochi, Kochi 780-8520, Japan, (21) College of Science and Engineering, Chubu University, Kasugai, Aichi 487-8501, Japan, (22) Quantum ICT Advanced Development Center, National Institute for Information and Communications Technology, Koganei, Tokyo 184-8795, Japan, (23) Doctoral School of Exact and Natural Sciences, University of Łódź, Łódź, Łódź 90-237, Poland, (24) Sternberg Astronomical Institute, Moscow M.V. Lomonosov State University, Moscow 119991, Russia, (25) Department of Physics, School of Natural Sciences, Ulsan National Institute of Science and Technology, UNIST-gil, Ulsan 689-798, Korea, (26) Astrophysics Division, National Centre for Nuclear Research, Warsaw 02-093, Poland, (27) Earthquake Research Institute, University of Tokyo, Bunkyo-ku, Tokyo 277-8582, Japan, (28) Graduate School of Information Sciences, Hiroshima City University, Hiroshima, Hiroshima 731-3194, Japan, (29) Institute of Particle and Nuclear Studies, KEK, Tsukuba, Ibaraki 305-0801, Japan, (30) CEICO, Institute of Physics, Czech Academy of Sciences, Prague 182 21, Czech Republic

TA実験関連 共同利用費まとめ

単位：千円

整理番号	代表者	研究課題	研究費	旅費	計
F1	荻尾 彰一	宇宙線望遠鏡による極高エネルギー宇宙線の研究	0	1,000	1,000
F2	有働 慈治	TA実験サイトにおける大気透明度測定法の研究・開発	0	300	300
F3	荻尾 彰一	TALEハイブリッド実験による10の17乗eV領域宇宙線の研究	0	452	452
F4	富田 孝幸	ドローンに搭載された標準光源による大気蛍光望遠鏡の光学特性の評価	0	200	200
F5	山崎 勝也	大気蛍光望遠鏡の自動観測を目指した夜間雲量測定用CCDカメラの開発と解析	0	300	300
F6	藤井 俊博	TA実験サイトでの新型大気蛍光望遠鏡による極高エネルギー宇宙線観測	0	200	200
F7	多米田 裕一郎	次世代の超高エネルギー宇宙線観測のためのフレネルレンズ型大気蛍光望遠鏡の開発研究	200	300	500
F24	富田 孝幸	「コズミック・レイ」を一般語にしよう計画（ヴァーチャルリアリティー技術の応用）	0	0	0
F25	木戸 英治	TAx4実験用地表検出器拡張のためのデータ収集システムの開発	0	300	300
F26	樋口 諒	銀河磁場モデル・質量組成モデルに基づく最高エネルギー宇宙線起源探査	0	40	40
F27	竹田 成宏	宇宙線観測におけるオープンデータにむけたシステム構築の検討	200	0	200

全11件、合計3,492千円

ご支援ありがとうございます。今後ともよろしく願いいたします。

Journal articles

1. “Mass composition of ultrahigh energy cosmic rays from distribution of their arrival directions with the Telescope Array”, Telescope Array Collaboration, Phys. Rev. D 110 (2024) 022006
2. “Isotropy of Cosmic Rays beyond 10^{20} eV Favors Their Heavy Mass Composition”, Telescope Array Collaboration, Phys. Rev. Lett. 133 (2024) 041001
3. “Intermediate Fluence Downward Terrestrial Gamma Ray Flashes as Observed by the Telescope Array Surface Detector”, Telescope Array Collaboration, Journal of Geophysical Research: Atmospheres, Volume129, Issue24 (2024) e2024JD041260
4. “First Time-Resolved Leader Spectra Associated With a Downward Terrestrial Gamma-Ray Flash Detected at the Telescope Array Surface Detector”, Journal of Geophysical Research: Atmospheres, Volume129, Issue24 (2024) e2024JD041720

Presentation

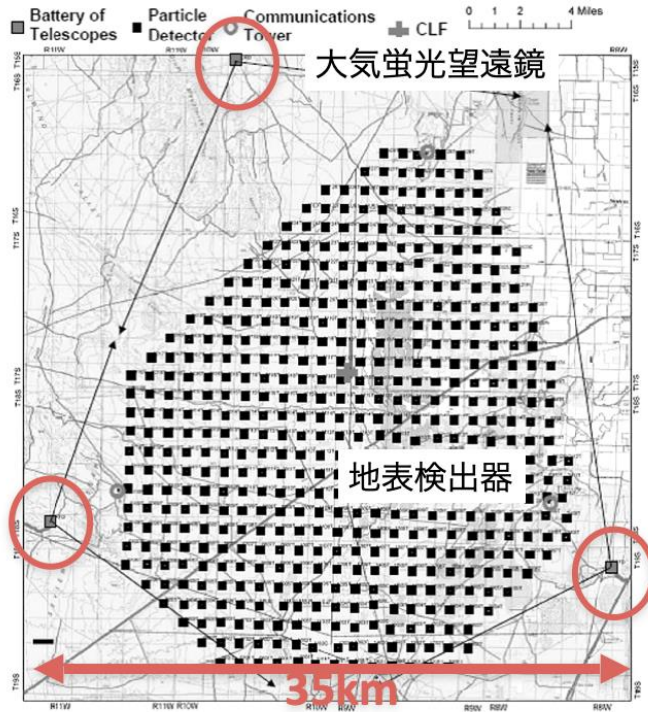
1. Calibration of the TA Fluorescence Detectors and Systematic Uncertainties in UHECR Analysis, T. Tomida, UHECR2024 (2024) Argentina
2. Correlation studies on UHECR arrival direction and source candidates, with a convolution of magnetic field and mass composition, R. Higuchi, UHECR2024 (2024) Argentina
3. Cosmic Ray Composition Measurement between 3PeV to 30PeV with the TALE Hybrid Detector, K. Fujita, UHECR2024 (2024) Argentina
4. Depth of maximum of air-shower profiles: testing the compatibility of the measurements at the Pierre Auger Observatory and the Telescope Array, A. Yushkov, UHECR2024 (2024) Argentina
5. Development of an analysis method for neutrino-induced air showers with the Telescope Array surface detectors, K. Takahashi, UHECR2024 (2024) Argentina
6. Evaluation of the Telescope Array Surface Detector’s Energy Reconstruction Performance using a Deep Neural Network and Hybrid Data, A. Proskin, UHECR2024 (2024) Argentina
7. Measurement of cosmic rays with energies down to the PeV region using the TALE-infill SD array, Y. Kawachi, UHECR2024 (2024) Argentina
8. Measurement of cosmic-ray energy spectrum with the TALE detector in hybrid mode, H. Oshima, UHECR2024 (2024) Argentina
9. Search for magnetic deflection multiplets in the observed data by the Telescope Array surface detectors, E. Kido, UHECR2024 (2024) Argentina
10. Search for ultra-high energy photons using the Telescope Array Surface Detector array, G. Rubtsov, UHECR2024 (2024) Argentina
11. TA SD energy spectrum analysis, J.H. Kim, UHECR2024 (2024) Argentina
12. TA SD medium-scale anisotropy analysis, J.H. Kim, UHECR2024 (2024) Argentina
13. Telescope Array anisotropy summary, M. Kuznetsov, UHECR2024 (2024) Argentina
14. Tests of anomalous correlations between ultra-high-energy cosmic rays and BL Lac type objects with the Telescope Array data, S. Troitsky, UHECR2024 (2024) Argentina
15. The fractional analysis of mass composition measured by the Telescope Array FADC fluorescence detectors in hybrid mode, J.H. Kim, UHECR2024 (2024) Argentina
16. Update on full-sky searches for large- and medium-scale anisotropies in the UHECR flux using the Pierre Auger Observatory and the Telescope Array, M. Bianciotto, UHECR2024 (2024) Argentina
17. Analysis of Inclined Air Shower Events Observed by the TAx4 SD, C. Koyama, UHECR2024 (2024) Argentina
18. Latest updates and results from the Fluorescence detector Array of Single-pixel Telescopes (FAST), F. Bradfield, UHECR2024 (2024) Argentina
19. Progress in the development of the observation system for the CRAFT project, Y. Tameda, UHECR2024 (2024) Argentina

ほか15件

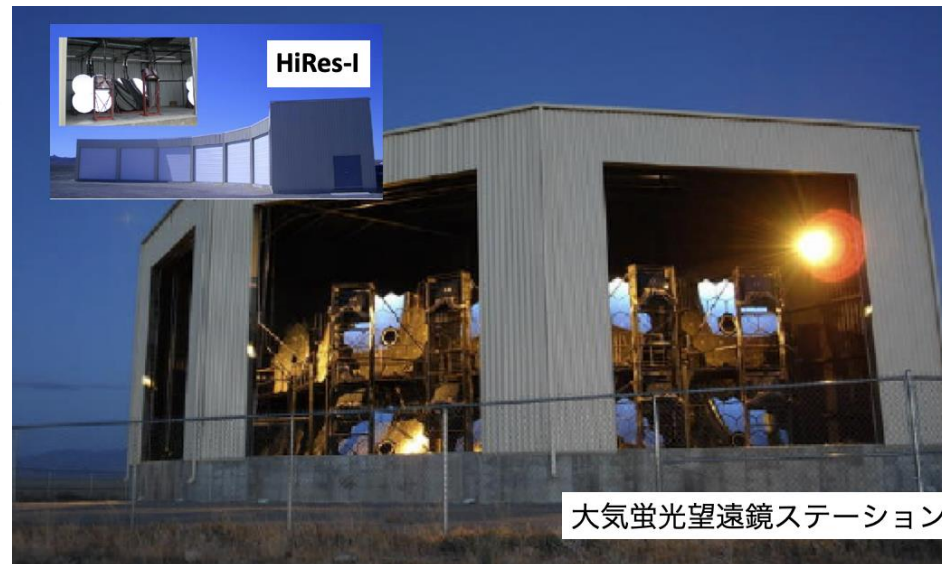
国内発表：24件

学位論文：博士論文 2件、修士論文 6件、学士論文 17件 (2023年度)

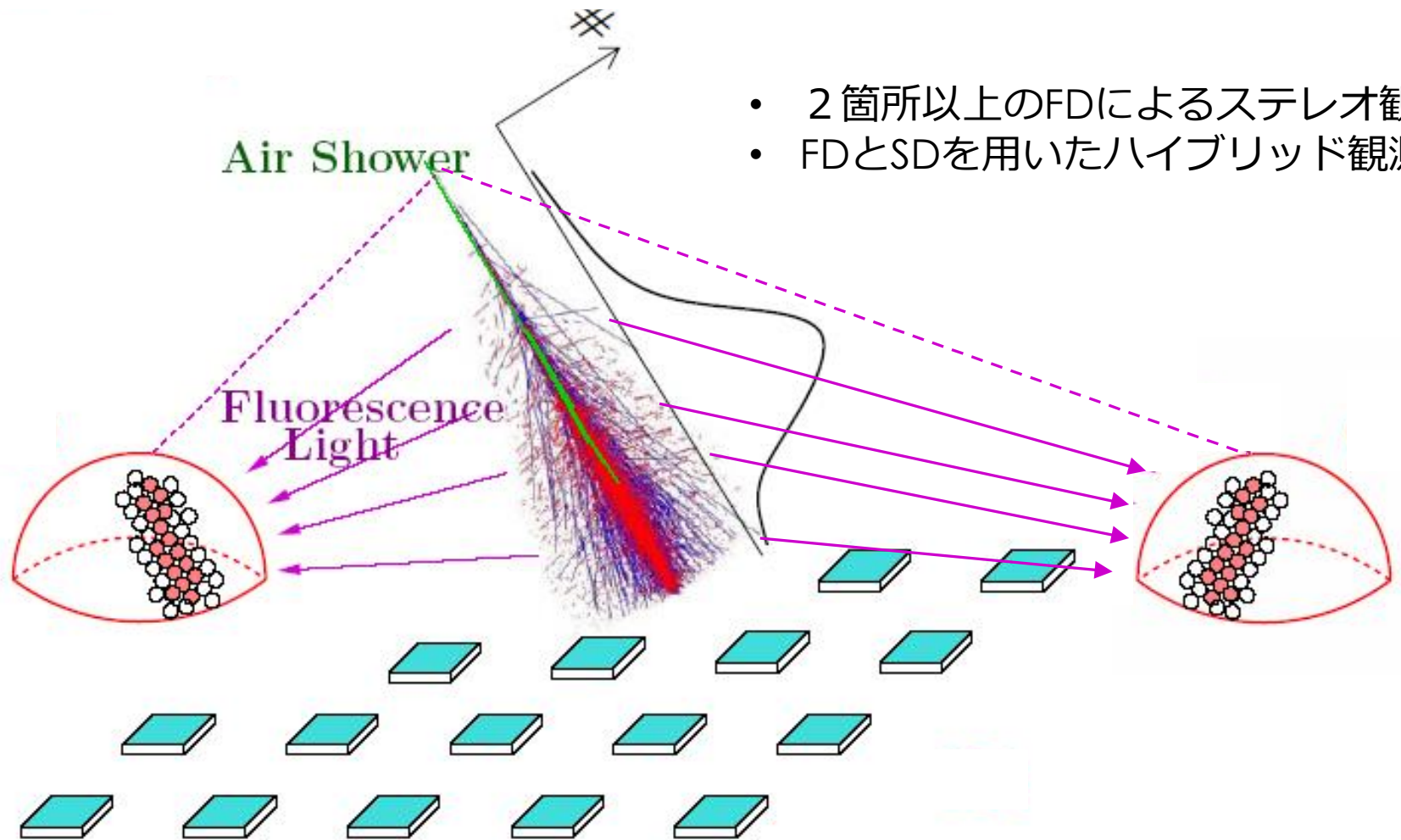
TA実験



- 米国ユタ州ミラード郡南西部砂漠地帯
- 大気蛍光望遠鏡ステーション 3カ所
 - 北サイトはHiRes-Iから移設
- 地表検出器 507台
 - 1.2 km間隔、約700 km²
- 2007年11月よりステレオ観測開始
- 2008年3月よりハイブリッド観測開始

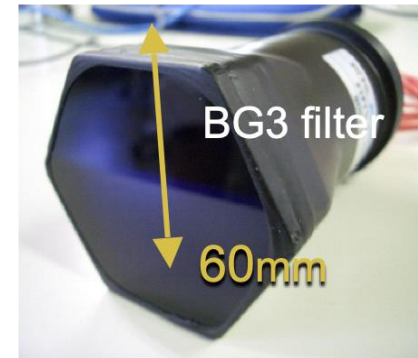
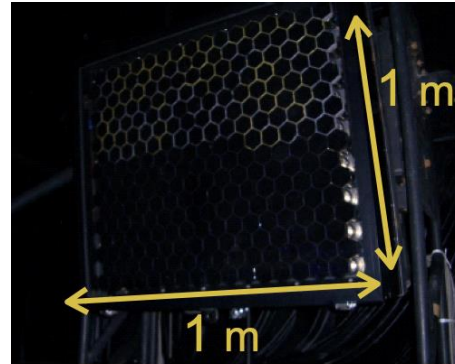
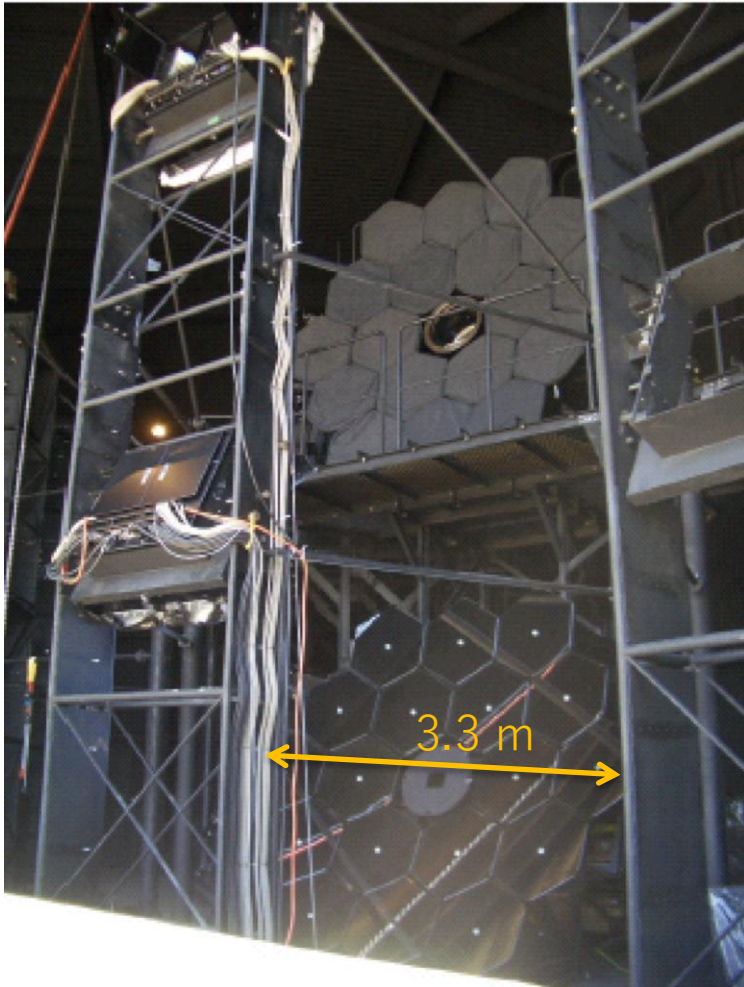


空気シャワー観測手法



- 2箇所以上のFDによるステレオ観測
- FDとSDを用いたハイブリッド観測

大気蛍光望遠鏡 (Fluorescence Detector, FD)



PMTカメラ

HAMAMATSU R9508 x 256

Hexagonal bialkali photocathode

Borosilicate glass window, 8dynodes

Q.E. : 30% (350nm),

Gain : 8.0×10^4 (800V)

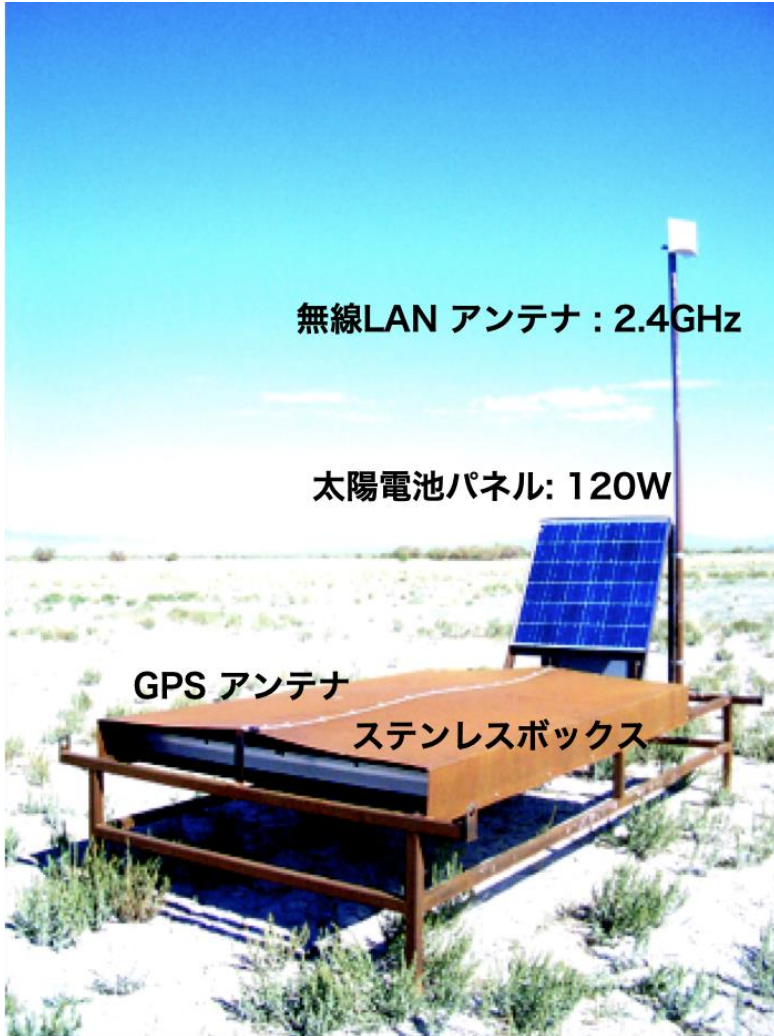
視野 : PMT $1.1^\circ \times 1.0^\circ$, Camera $18^\circ \times 15.6^\circ$

球面反射鏡

口径 : ~3.3 m (18枚から成る合成鏡)

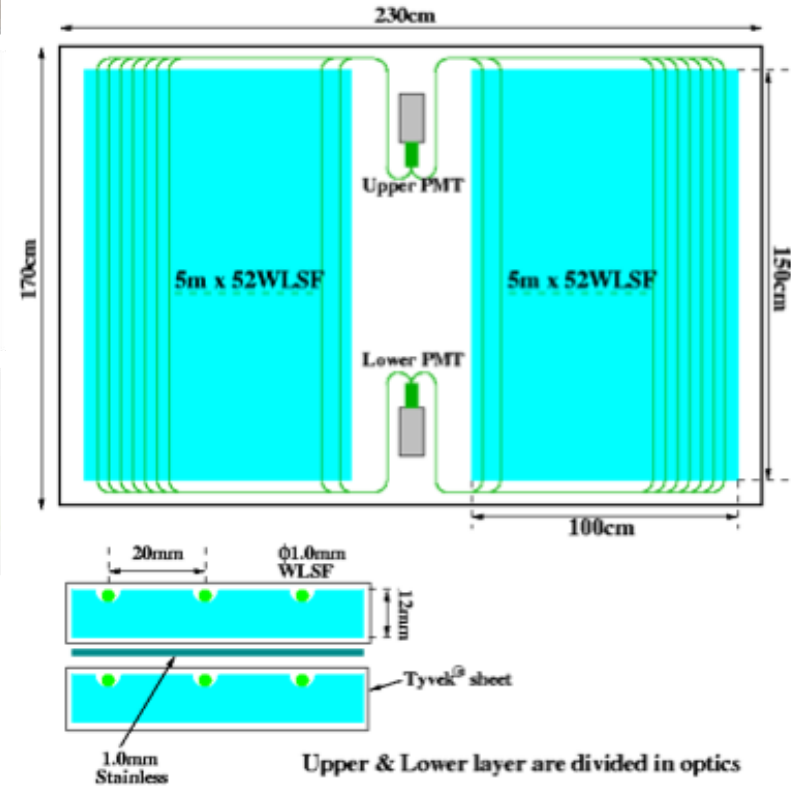
曲率半径 : 6067 mm

地表検出器 (Surface Detector, SD)

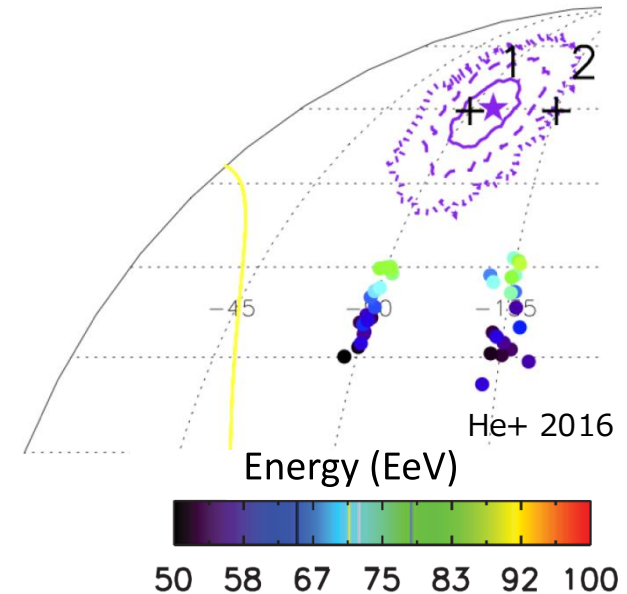
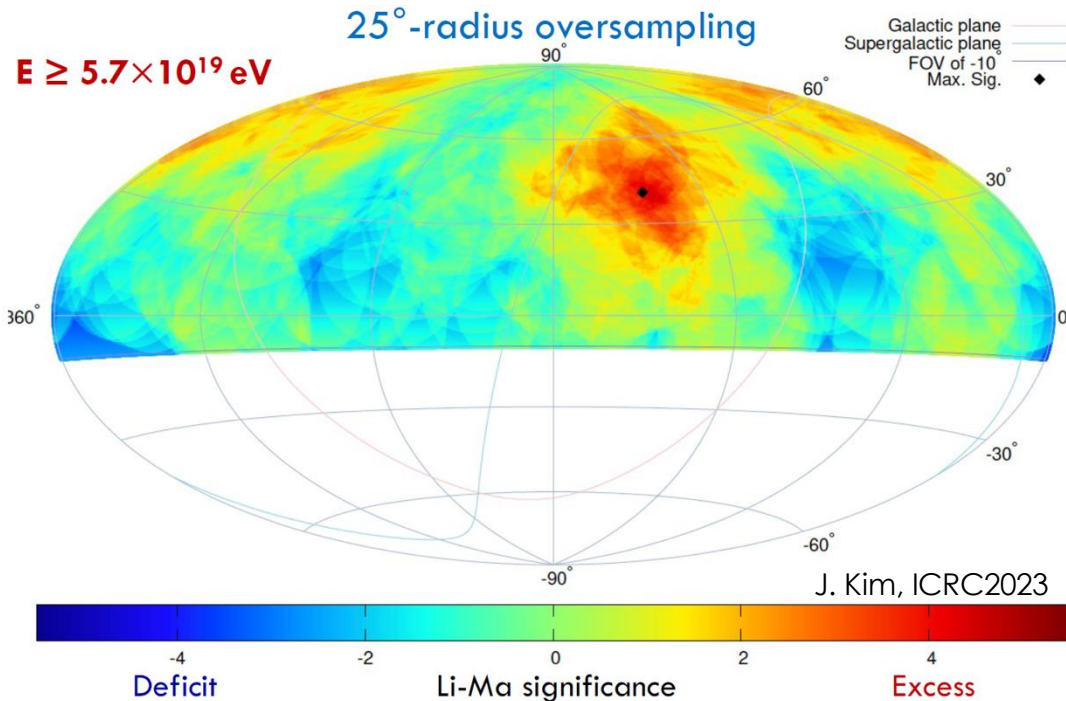


FADC 12bit 50MHz
GPS
LAN-MODEM
Battery

シンチレータ : $3\text{m}^2 \times 1.2\text{cm} \times 2\text{層}$
波長シフトファイバ : $\phi 1.0\text{mm}$ 2cm spacing
光電子増倍管 : Electrontubes 9124SA $\times 2$



TASD : ホットスポット の起源天体探索



- Evidence of anisotropy in the arrival directions is showing up at above several tens of EeV.
- Correlation studies of arrival directions with astrophysical objects considering random and regular magnetic field models were conducted to search for UHECR sources.
- There is considerable ambiguity in magnetic deflections of UHECRs in galactic and extragalactic magnetic field models.
- Magnetic deflection ``multiplet''.
- Deflection angle (δ_{reg} and δ_{rms}) from the source direction $\propto 1/E$ (single nuclear charge is assumed)
- Search for the magnetic deflection multiplet.

Regular component

$$\delta_{\text{reg}} = A_1 \times \frac{100 \text{ EeV}}{E}$$

Random component

$$\delta_{\text{rms}} = A_2 \times \frac{100 \text{ EeV}}{E}$$

TASD : ホットスポット の起源天体探索

Event selection (same as the TA hotspot analysis):

- $E > 57$ EeV
- Zenith angle < 55 deg.
- No. of SDs > 4 used for the event reconstruction
- Angular uncertainty of the geometry fit < 10 deg.
- > 0.2 secs from nearby lightning strikes

Data: 217 SD events (15 years TA SD data)

6 free fitting parameters

β : direction of the regular deflection (north pole: 0°)

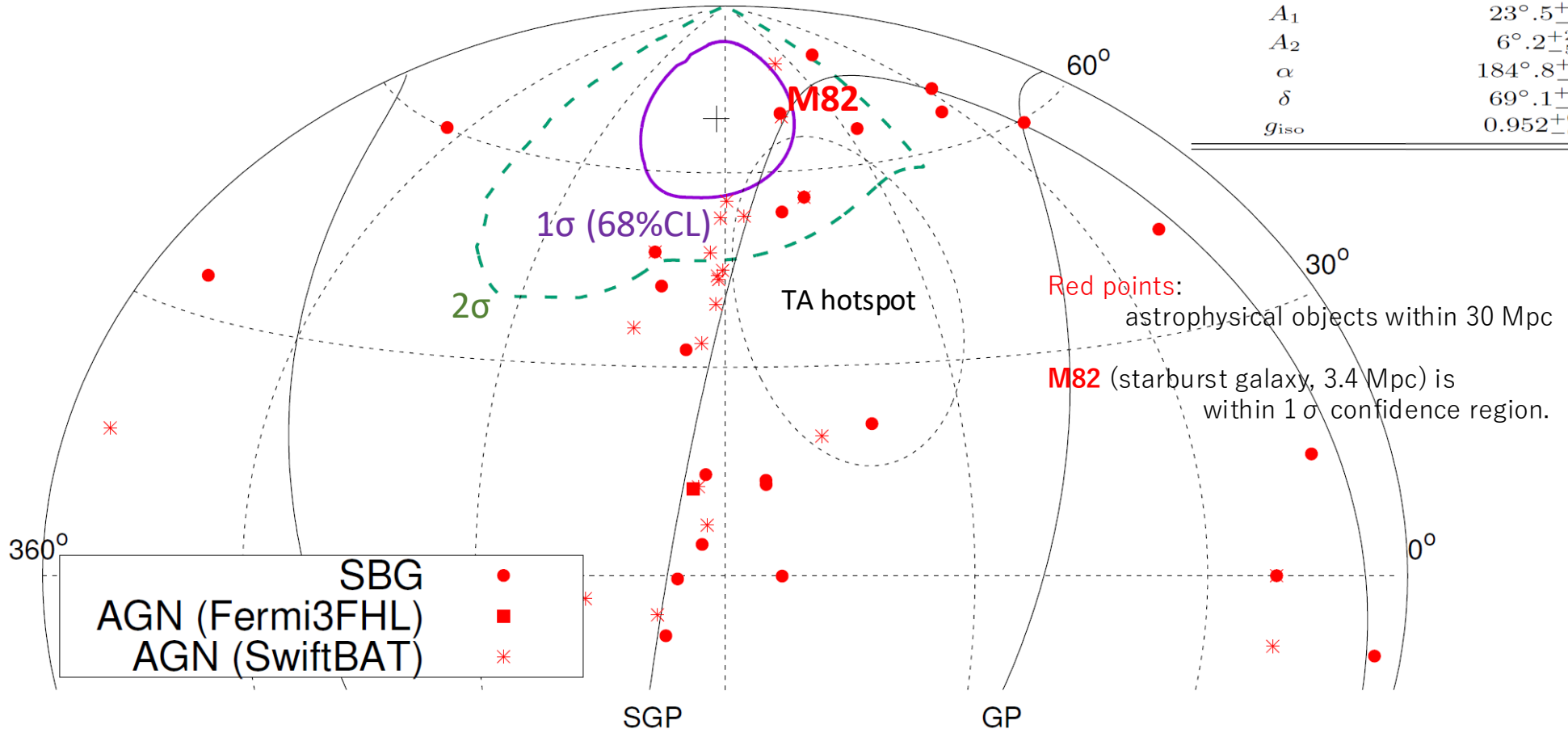
A_1 : regular deflection at 100 EeV (degrees)

A_2 : Gaussian σ at 100 EeV (degrees)

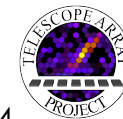
α and δ : right ascension and declination of the source

g_{iso} : fraction of isotropy background

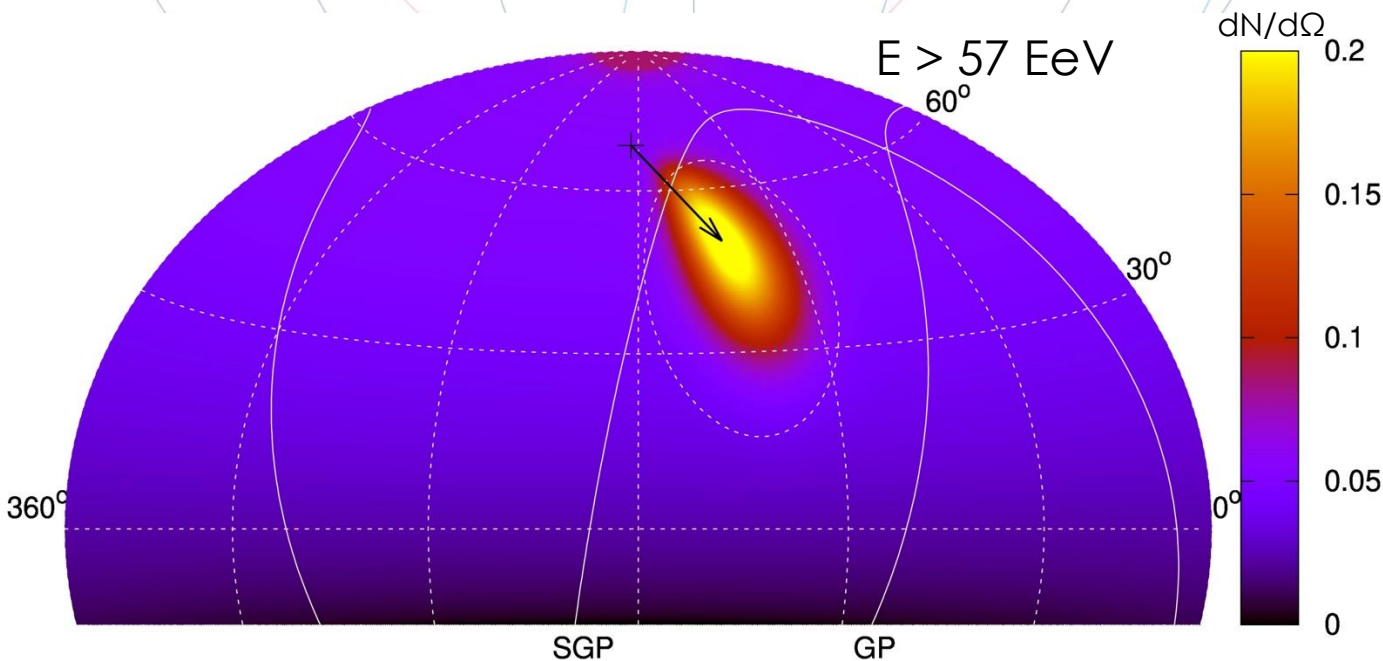
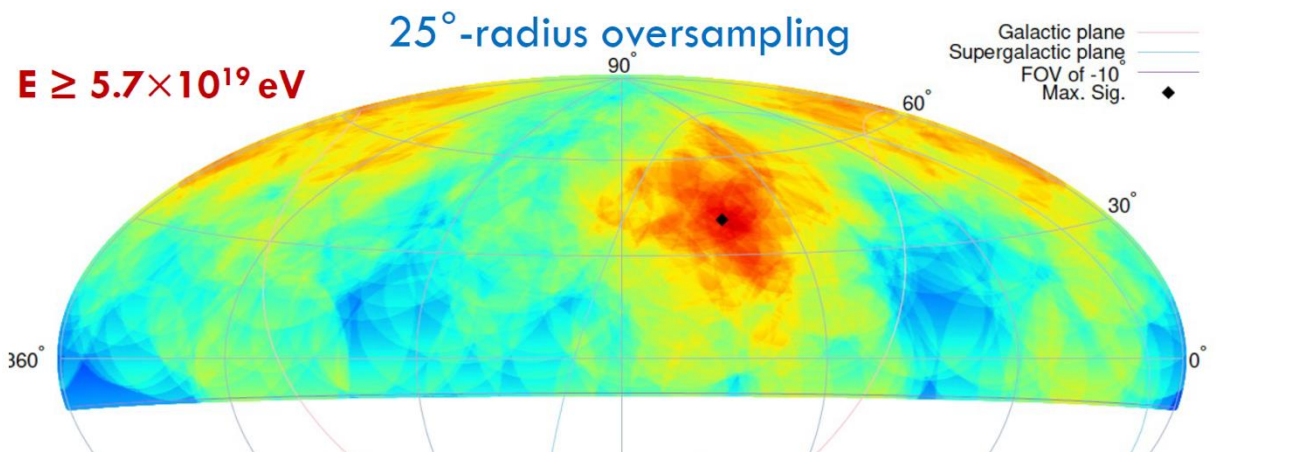
Fit parameter	Best-fit value
β	$116^\circ.4^{+47^\circ.3}_{-34^\circ.4}$
A_1	$23^\circ.5^{+7^\circ.7}_{-8^\circ.0}$
A_2	$6^\circ.2^{+2^\circ.2}_{-5^\circ.0}$
α	$184^\circ.8^{+25^\circ.1}_{-27^\circ.8}$
δ	$69^\circ.1^{+8^\circ.8}_{-8^\circ.6}$
g_{iso}	$0.952^{+0.016}_{-0.018}$



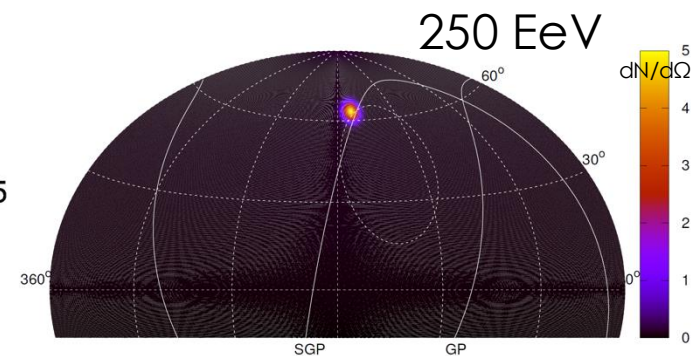
TASD : ホットスポット の起源天体探索



E. Kido, UHECR2024



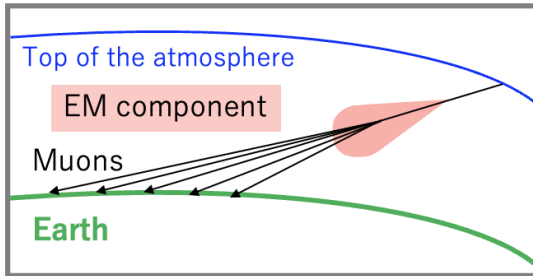
Single source + isotropy model
with best-fit parameters



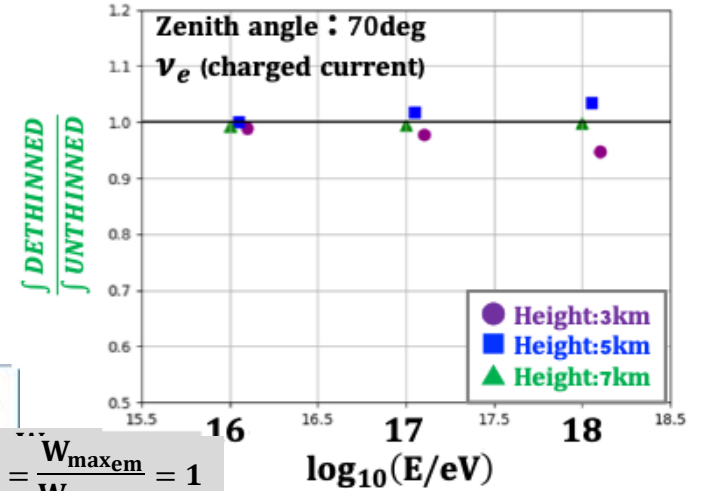
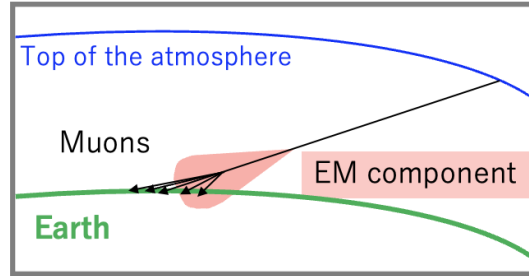
TA SDの大天頂角データからニュートリノシャワーを探索する

- ・ニュートリノが大気と反応しやすい
- ・BGとなるハドロンシャワーとの弁別がしやすい

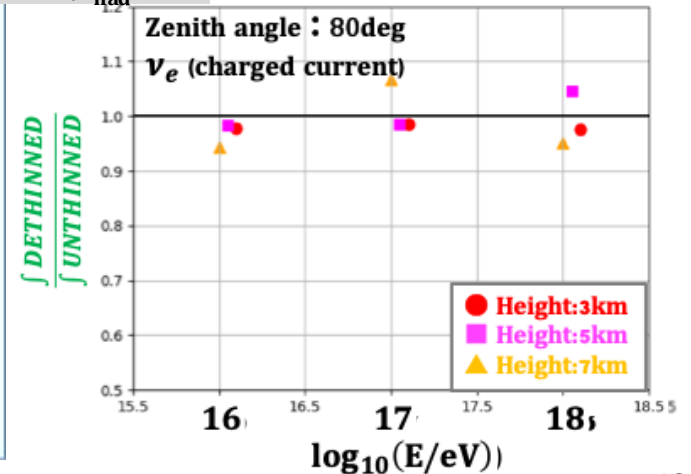
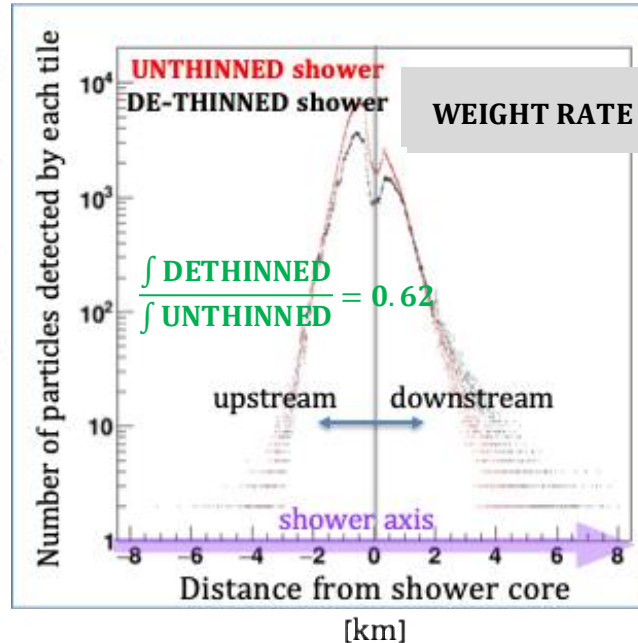
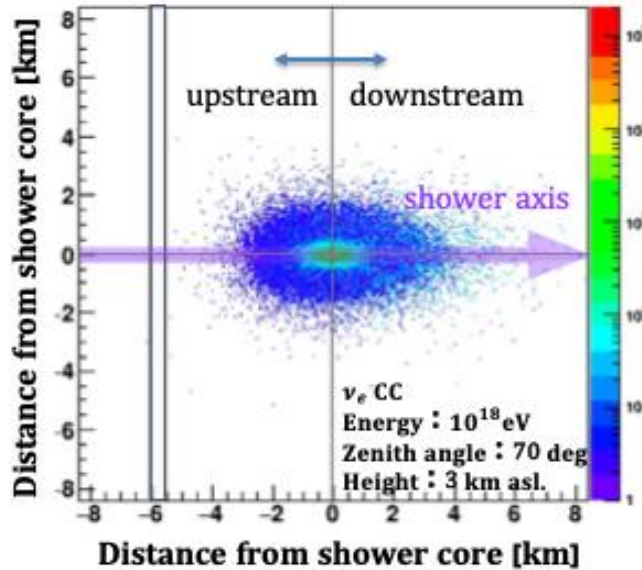
Proton inclined shower



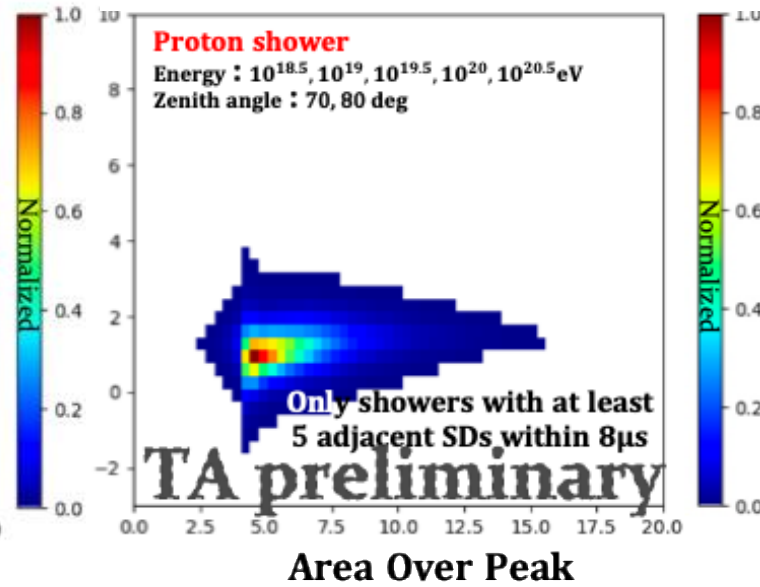
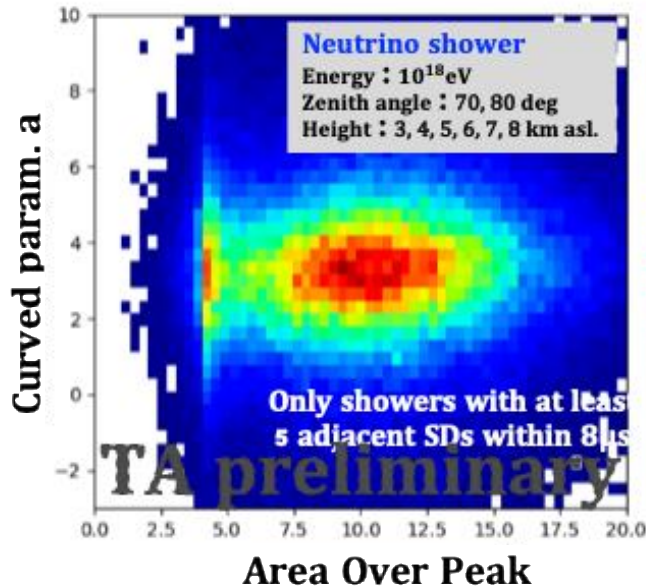
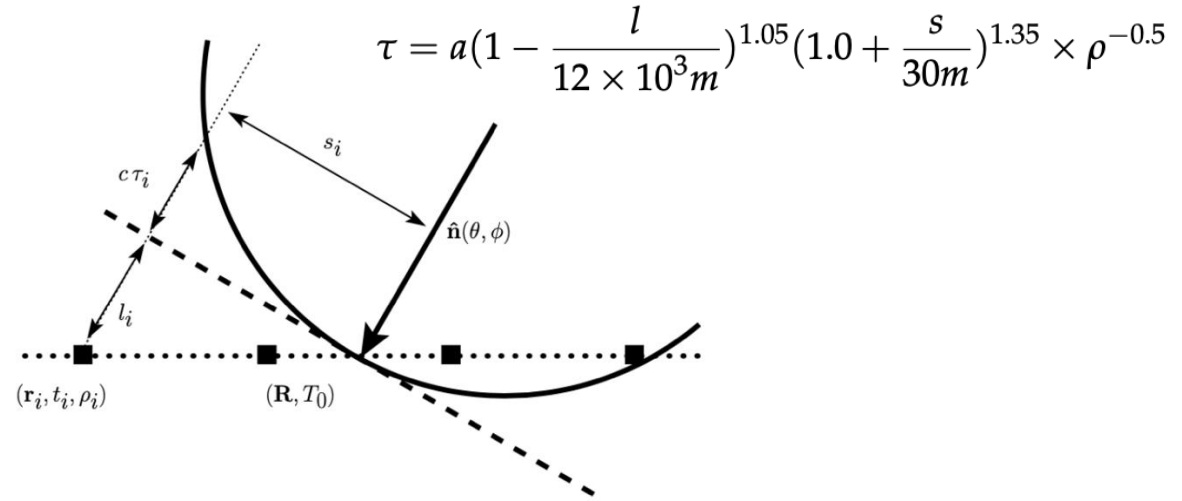
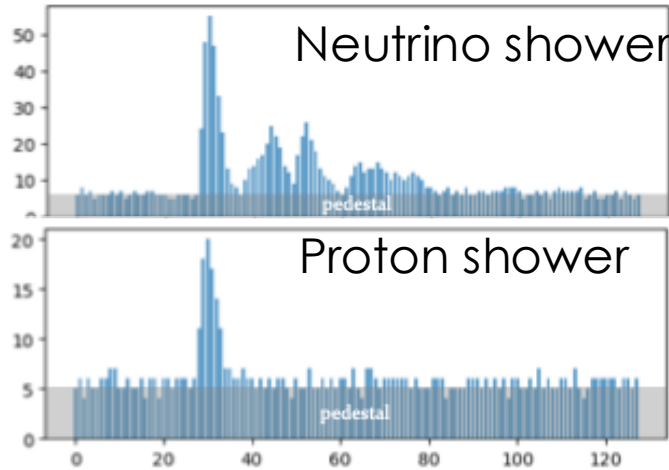
Neutrino inclined shower



ThinningとDe-thinningの比較



ニュートリノ事象弁別に2パラメータ：Area-over-Peak(AoP), 曲率パラメータ a



ニュートリノの
AoPと曲率パラメータ a
は大きい傾向
弁別に有用

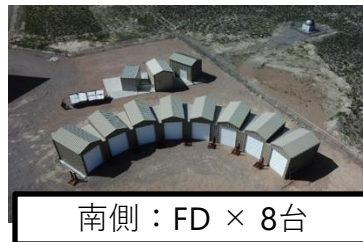
TAx4実験

TA実験含めて観測面積を4倍にし、TA実験の捉えた最高エネルギー宇宙線の異方性の兆候 (TA Hotspotなど) を確認し、起源を解明する

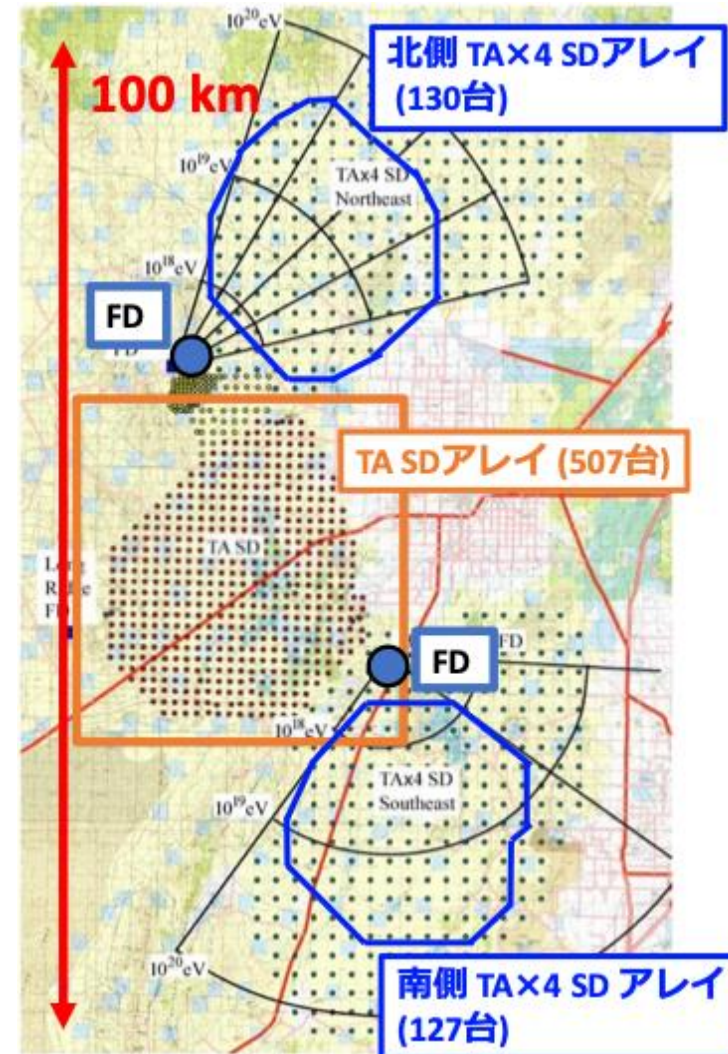
- 2019年に最終目標の半分を拡張
観測面積: $700 \text{ km}^2 + 1000 \text{ km}^2$
- TA×4実験は特に $E > 5.7 \times 10^{19} \text{ eV}$ の統計数増加を目指す
TA SD アレイ: 1.2 km, ~100% efficiency @ $E \geq 10^{18.8} \text{ eV}$
TA×4 SD アレイ: 2.08 km, ~100% efficiency @ $E \geq 10^{20} \text{ eV}$
- TA×4 FD ステーション (2ヶ所, 新規設置)
北側FD: 2019年6月から定常観測
南側FD: 2020年9月から定常観測



北側: FD × 4台

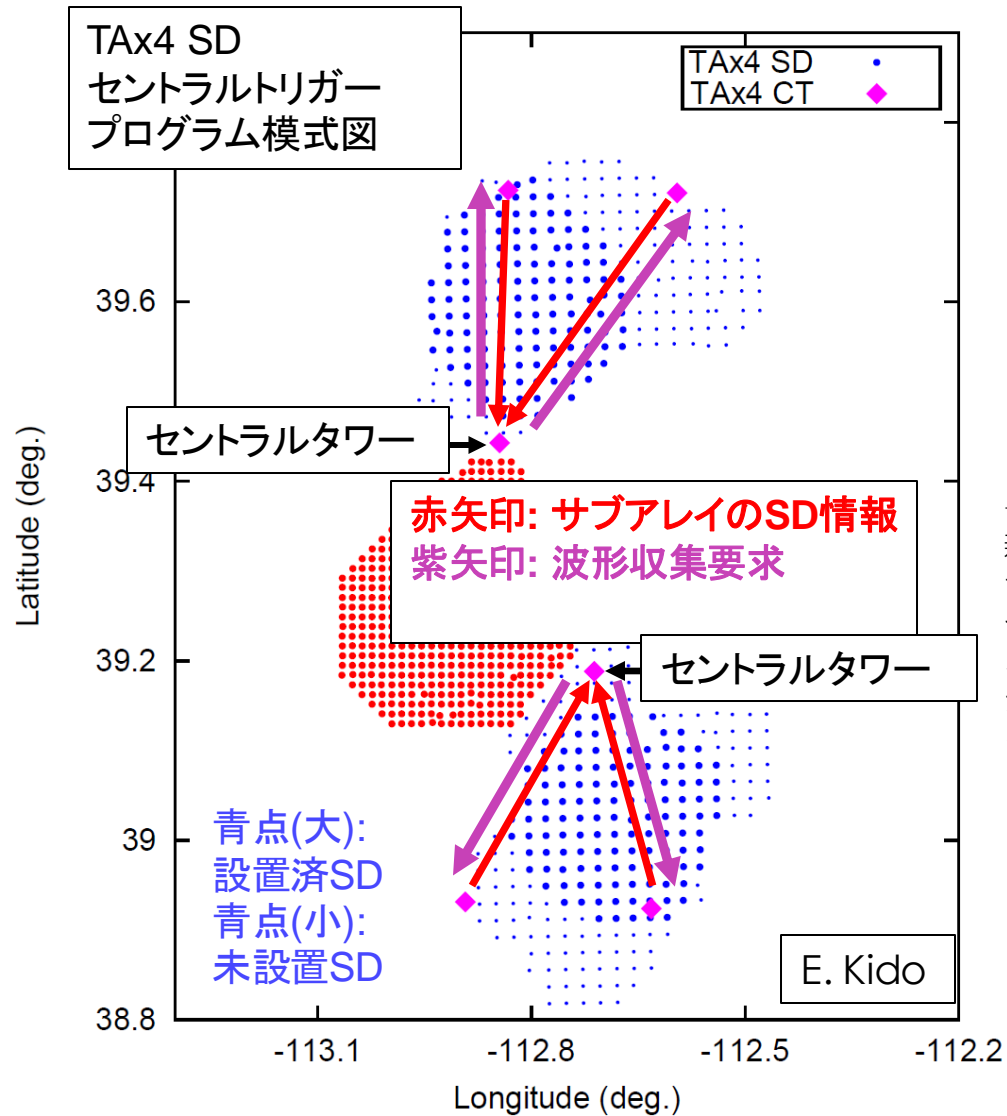


南側: FD × 8台



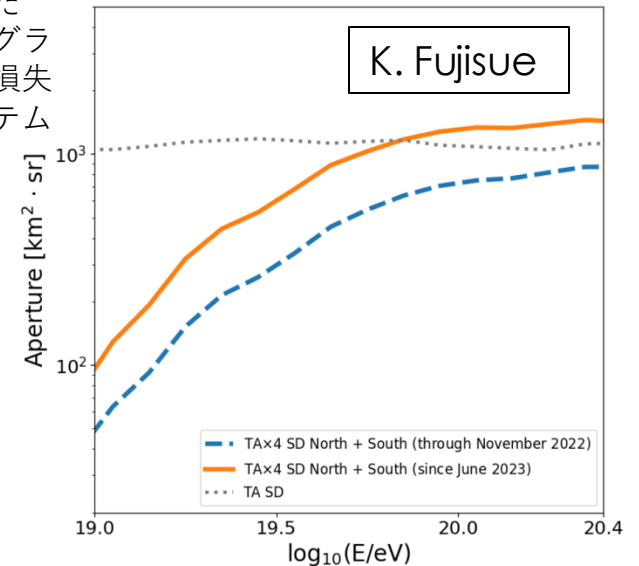
TAx4実験用地表検出器(SD)拡張のためのデータ収集システムの開発

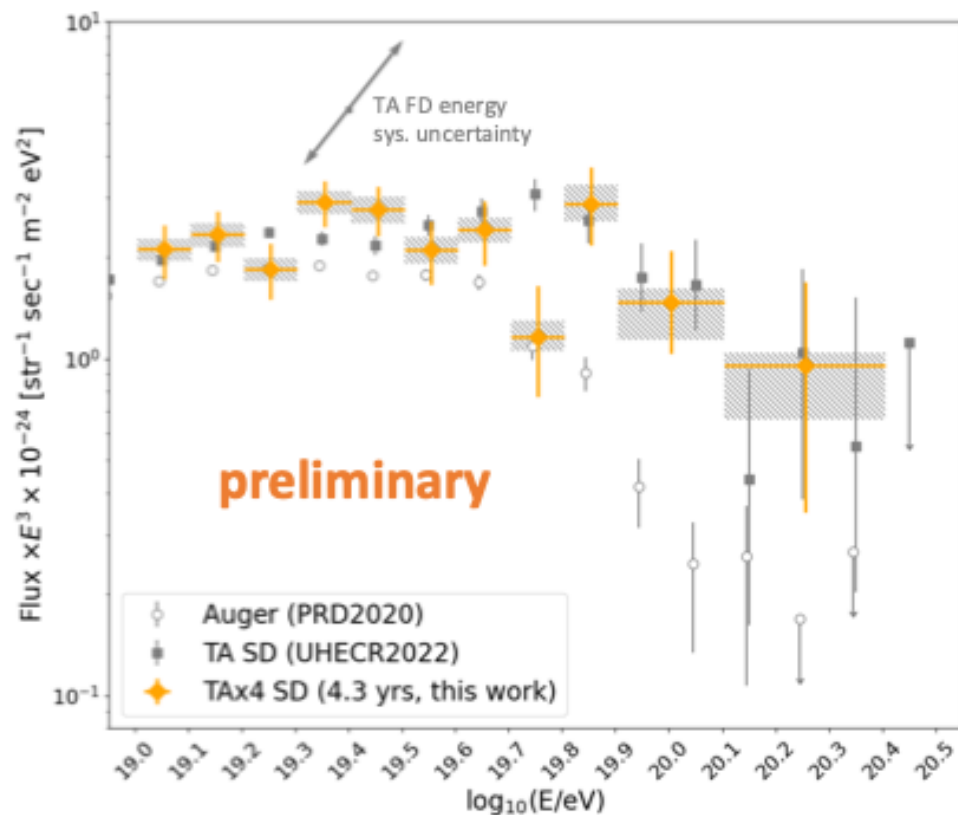
F25: 木戸



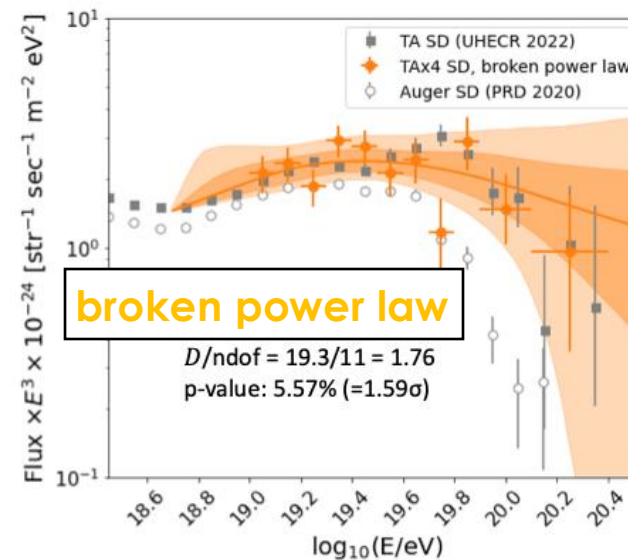
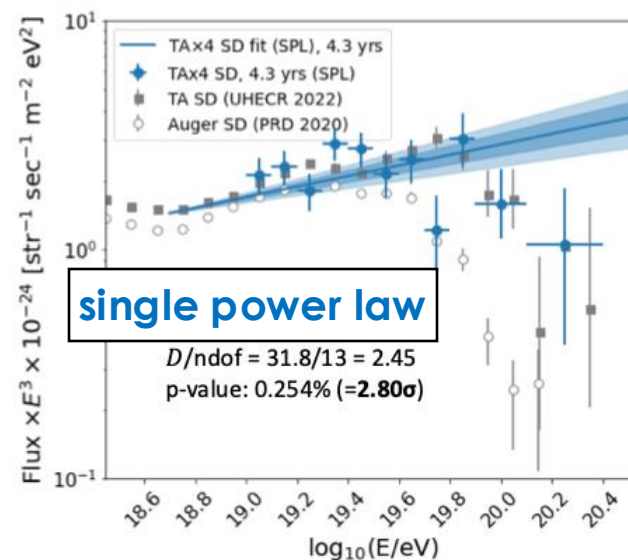
- 最もSDの多い(69 SD)サブアレイでは、データ収集システムの限界のためSDを追加できない。
- 全てのデータをセントラルタワーに集めてトリガー判定をする、**セントラルトリガープログラム**を開発。2022年11月から安定稼働。
- MCシミュレーションから、アパーチャーがセントラルトリガー導入以前の約1.5倍になっていて、想定通りになっていることを確認。
- セントラルトリガー導入後のデータとシミュレーションの一致も確認

→ 今後SDを追加する際は、新たなサブアレイを追加し、サブアレイ間で、作成したセントラルトリガープログラムを走らせ、全体として損失が小さいデータ収集システムを実現する。



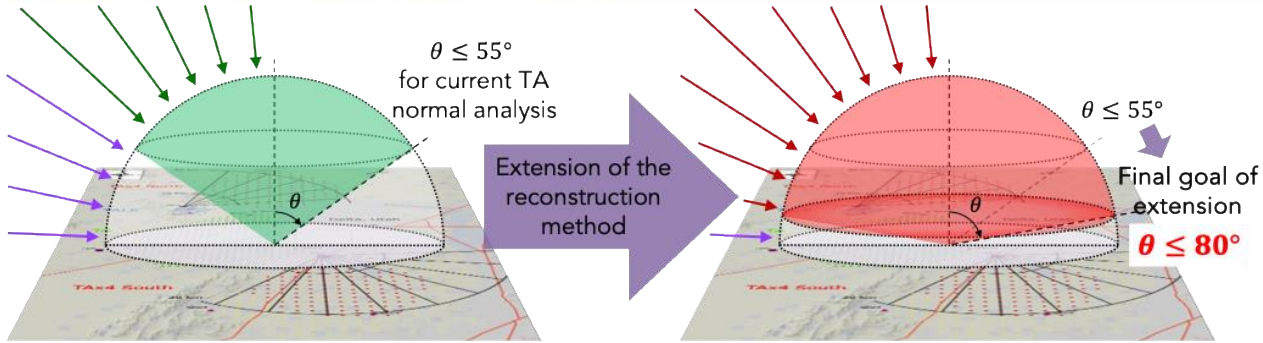


TAx4SDでカットオフを検証
Broken power law model がより観測に一致



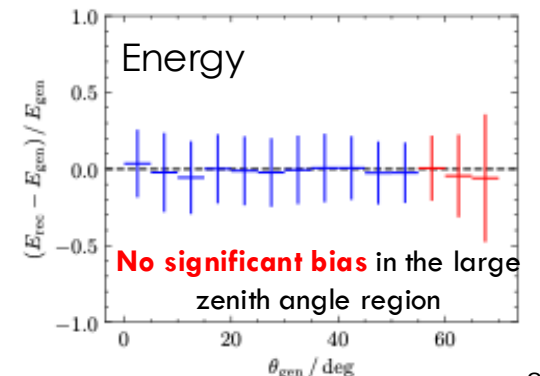
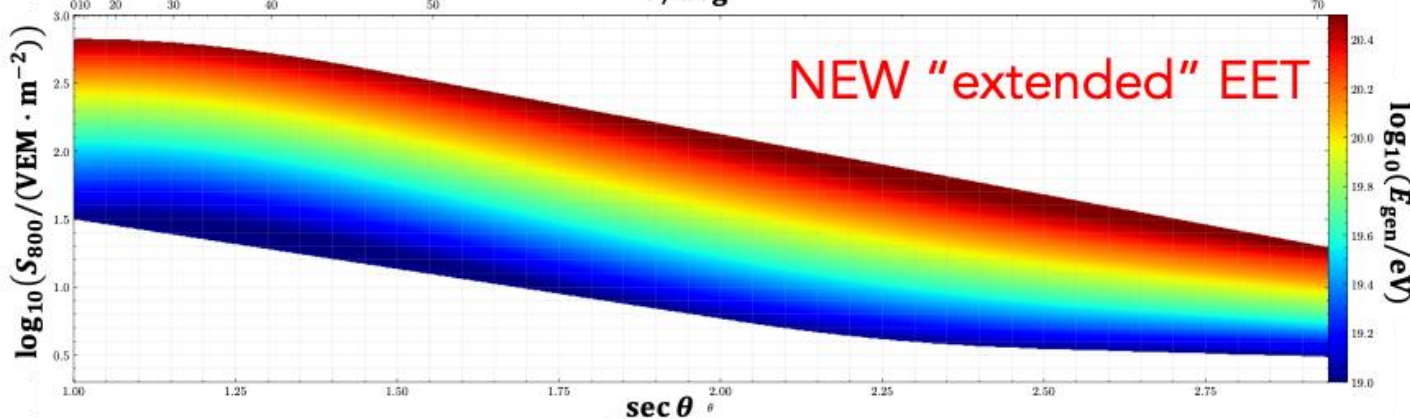
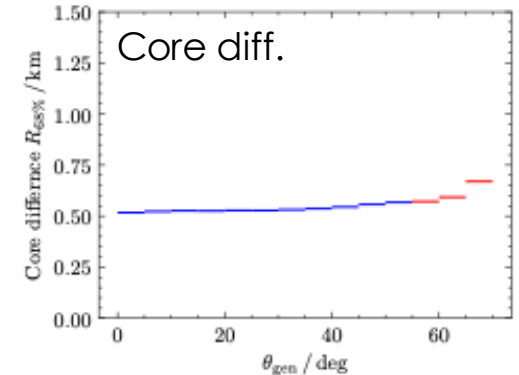
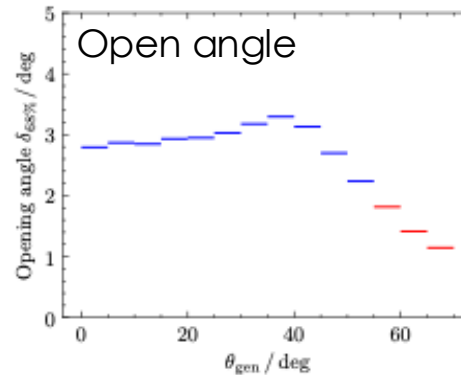
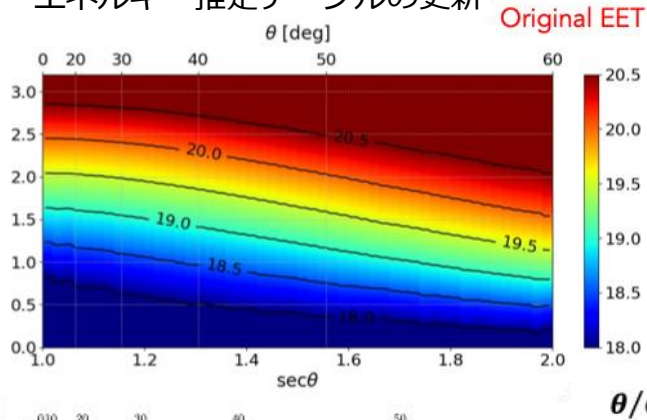
大天頂角空気シャワー再構成 TA×4

C. Koyama, UHECR2024

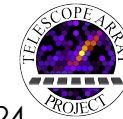


If extended from 55° to 80° ,
 $\sim 1.5 \times$ aperture for TA $\times 4 \rightarrow \sim 6 \times$ of TA
 We can apply to **past data** as well \Rightarrow
 TA $\times 4$ 4yr $\rightarrow \sim$ TA $\times 4$ 6yr equiv.
 If we apply to **TA SD** data, \Rightarrow
 TA 15.5yr $\rightarrow \sim$ TA 23yr equivalent

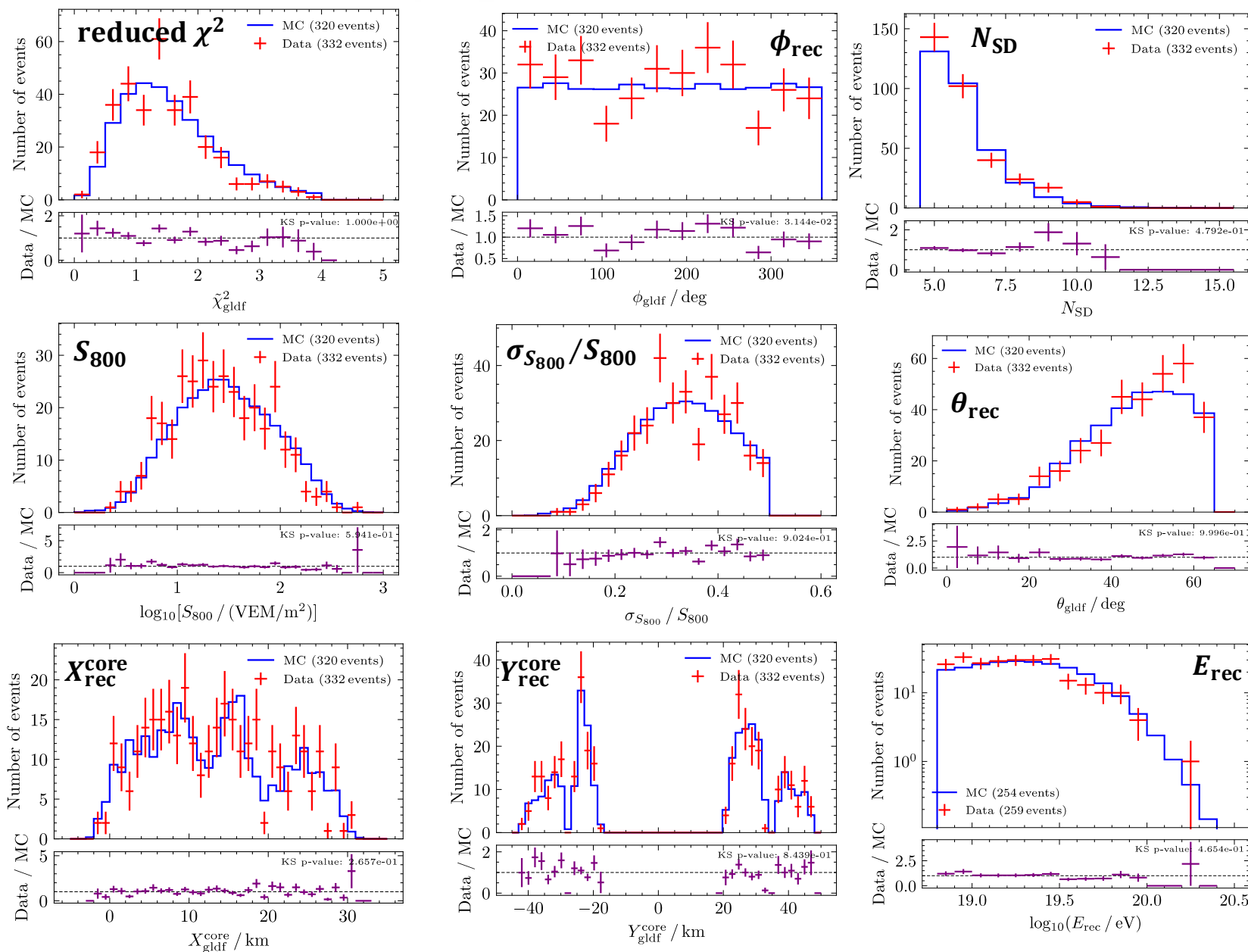
エネルギー推定テーブルの更新



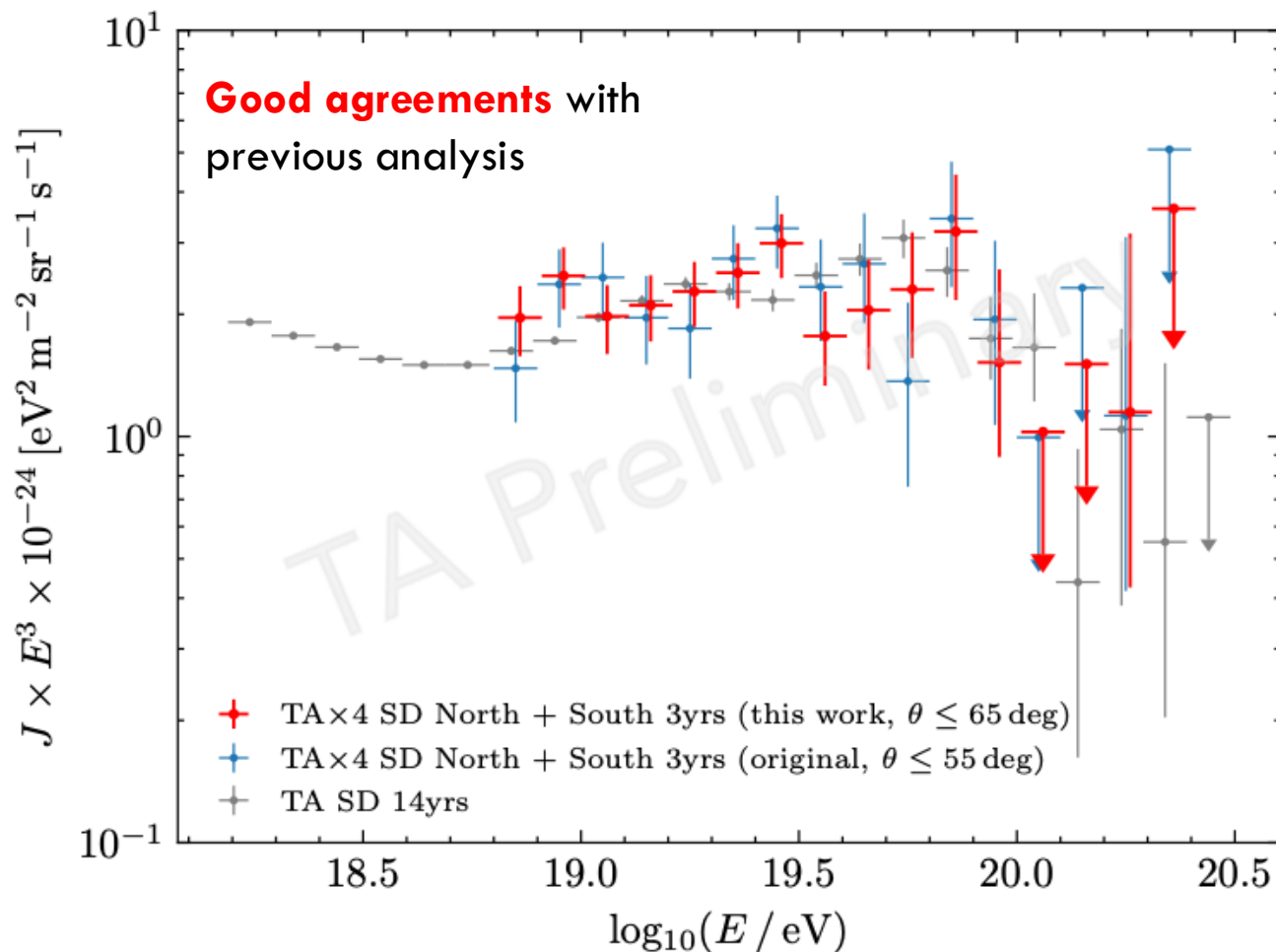
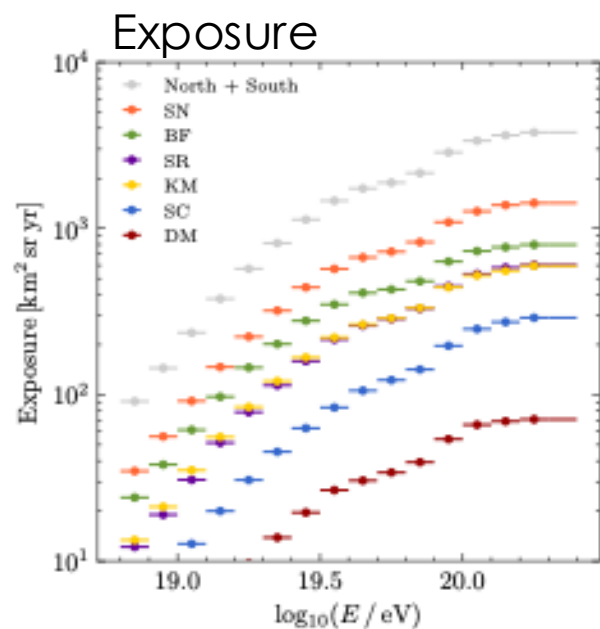
大天頂角空気シャワー再構成 TAx4



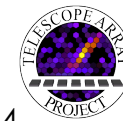
C. Koyama, UHECR2024



エネルギースペクトル (Period : Oct. 2019 – Oct. 2022)



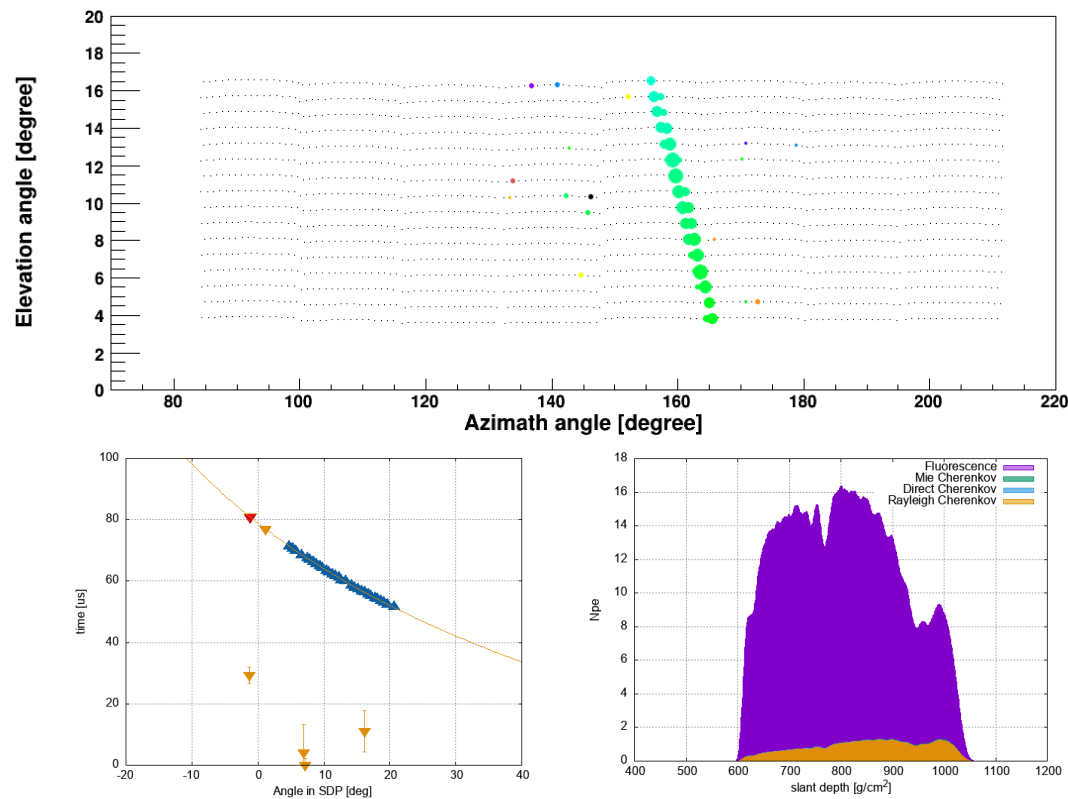
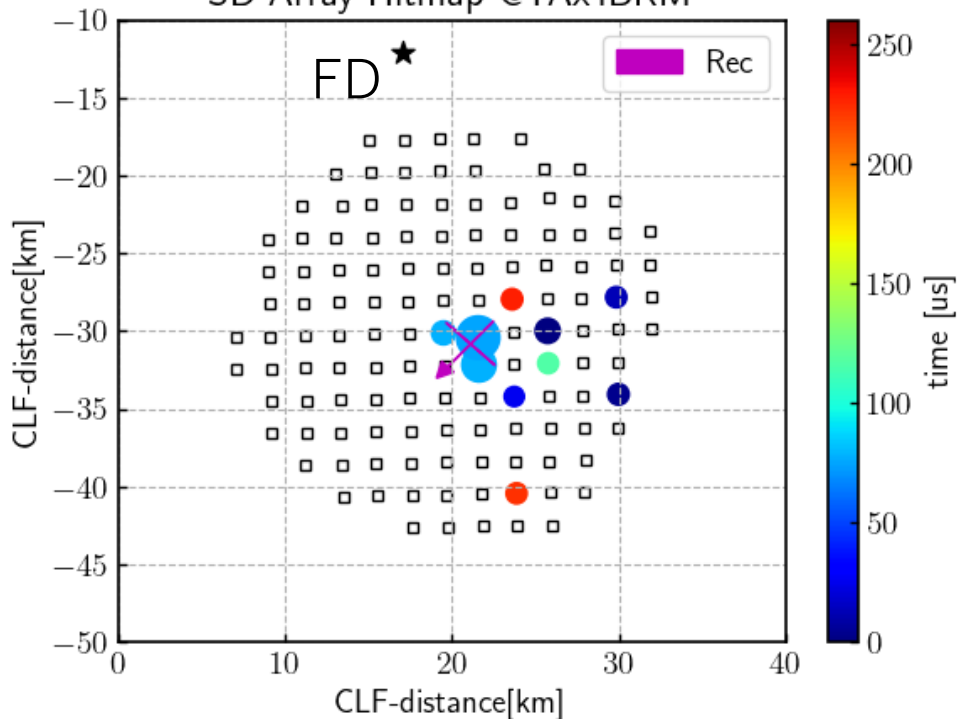
TAx4 Hybrid Xmax



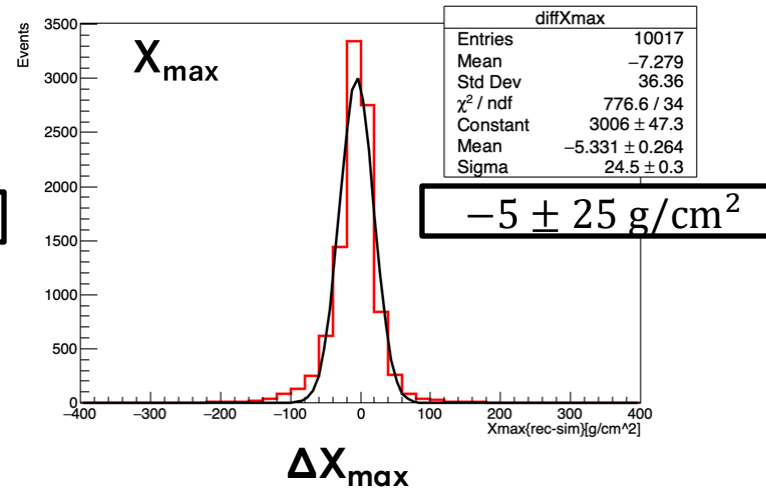
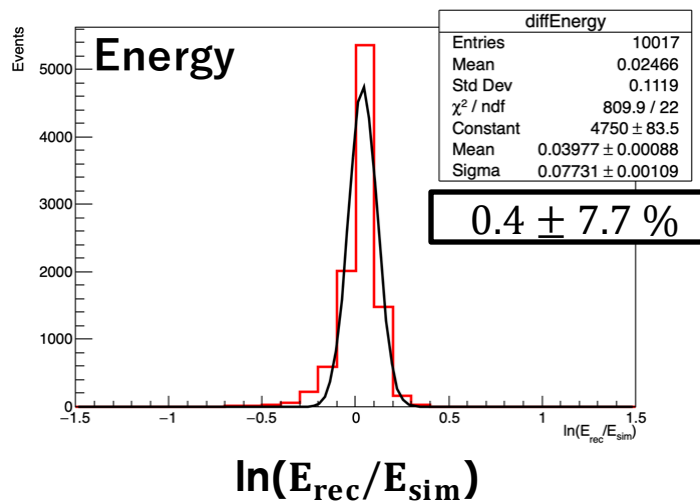
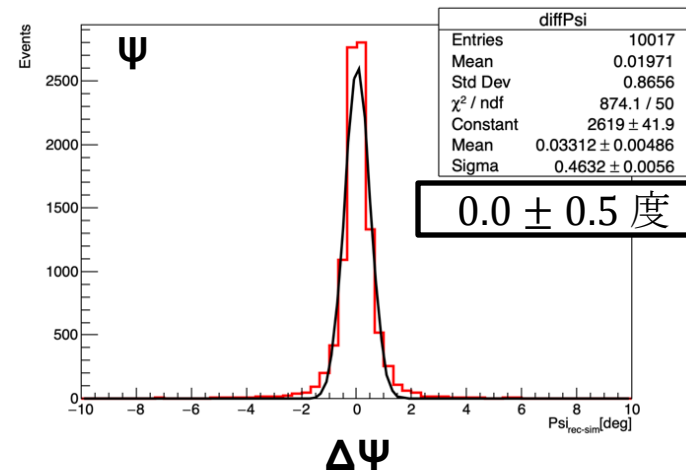
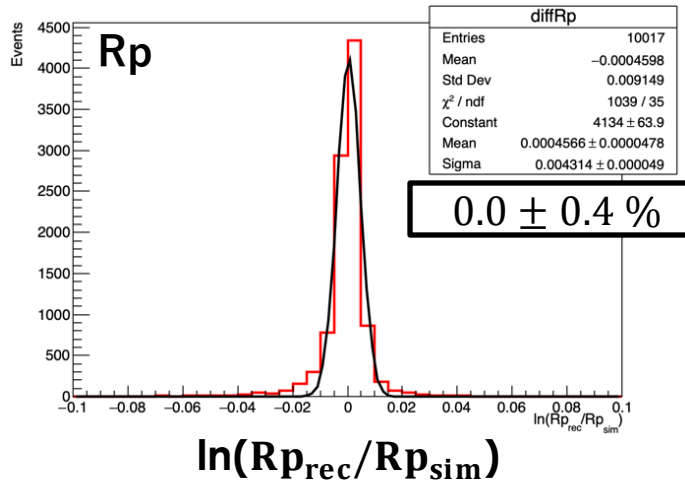
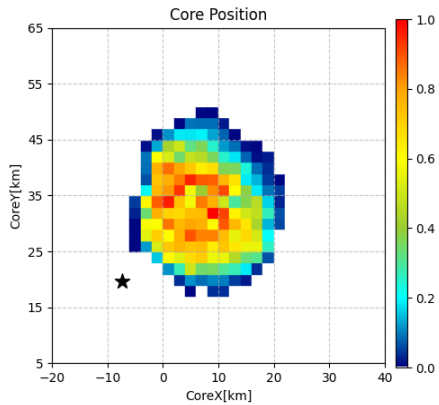
楠森, JPS2024

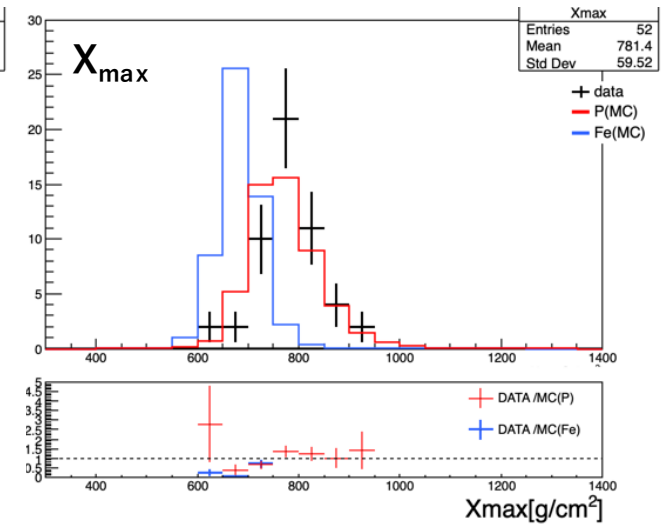
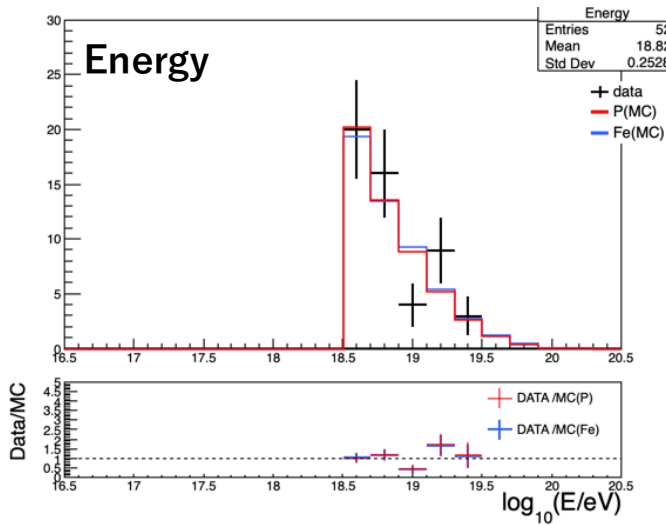
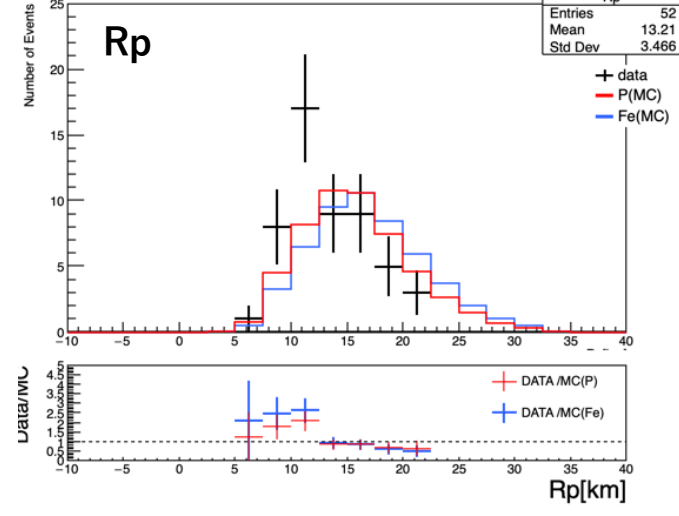
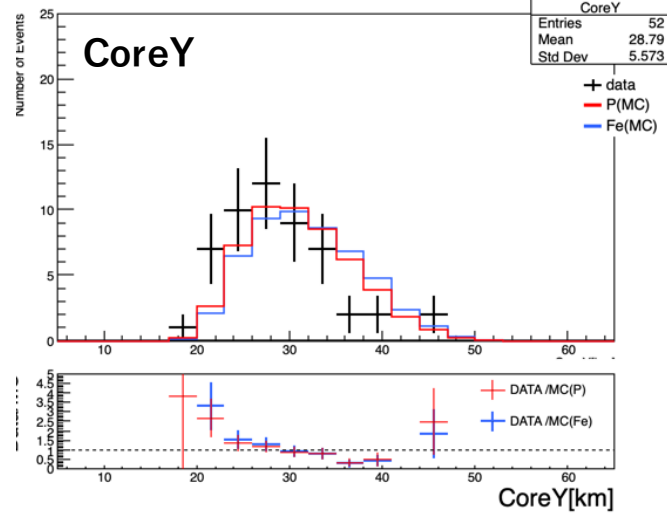
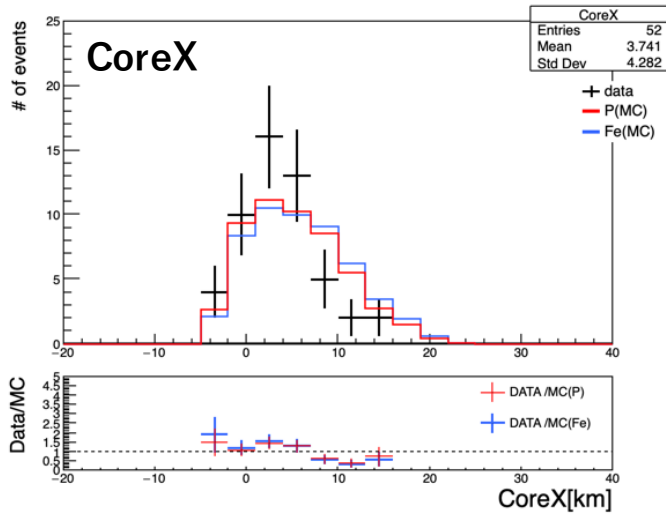
2022/03/01 10:18:05.4417793

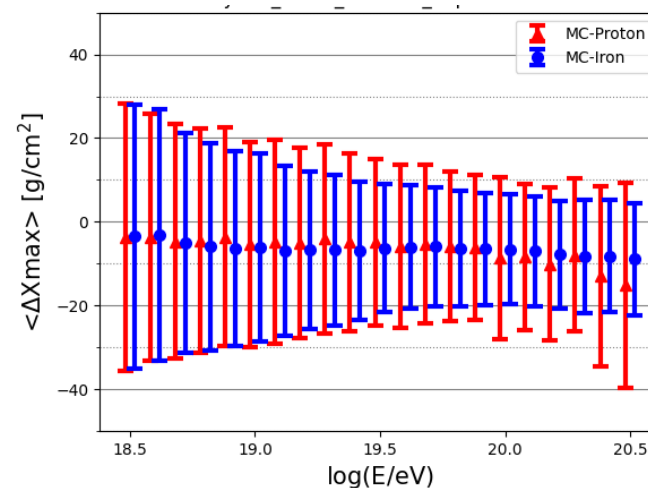
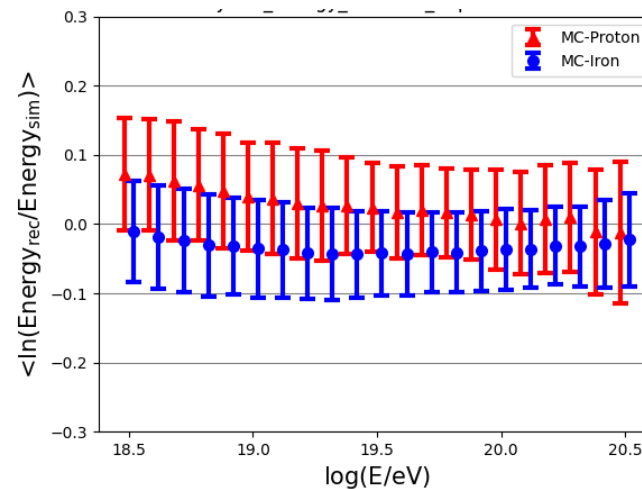
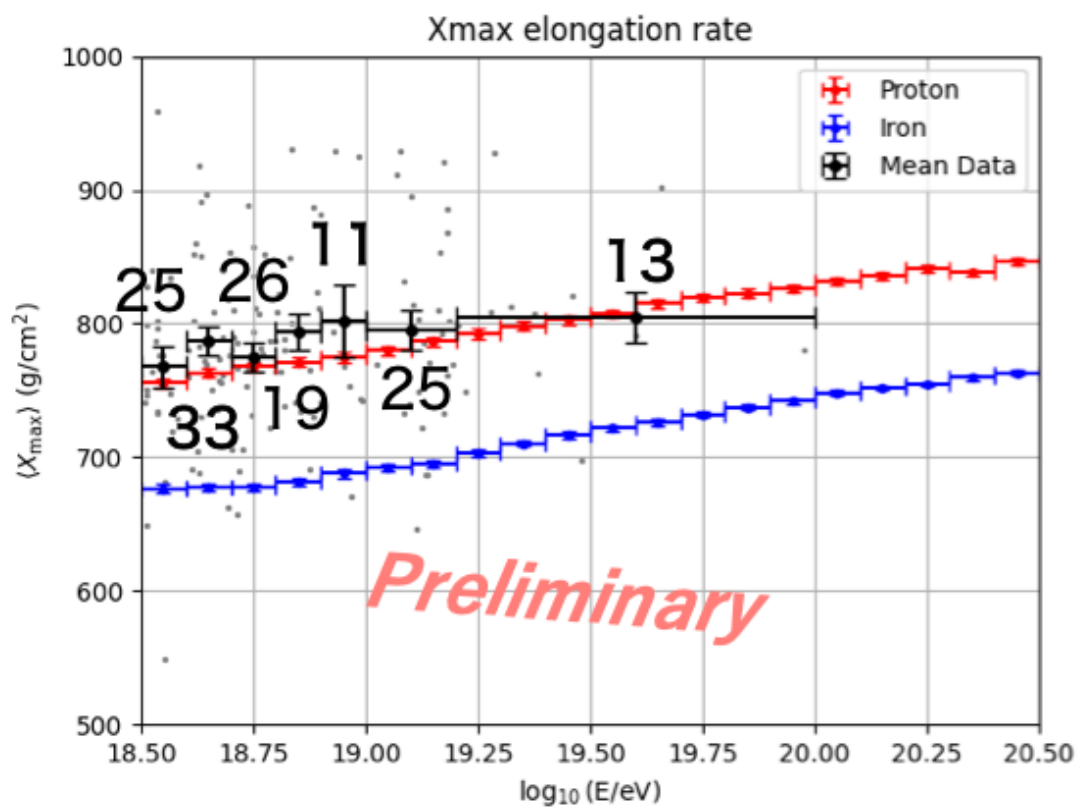
SD Array Hitmap @TAX4BRM



Zenith [deg]	Azimuth [deg]	CoreX [km]	CoreY [km]	X _{max} [g/cm ²]	Energy [E/eV]
41.448	40.033	21.112	-30.835	921.529	19.173







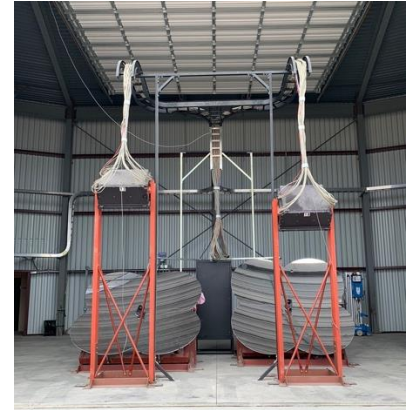
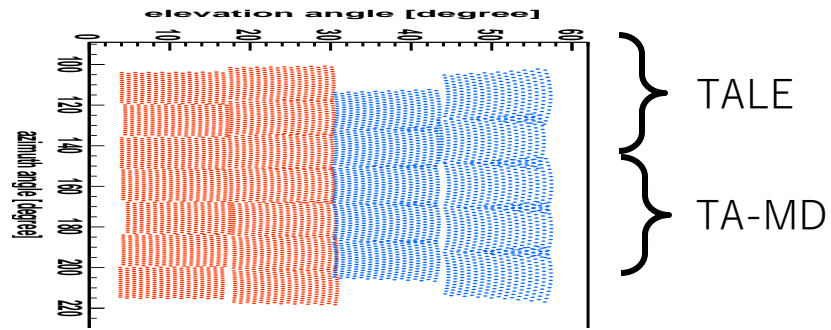
Telescope Array Low-energy Extension (TALE)

Upgrade TA hybrid detector sensitivity down to PeV range → **TALE**

F3: 萩尾



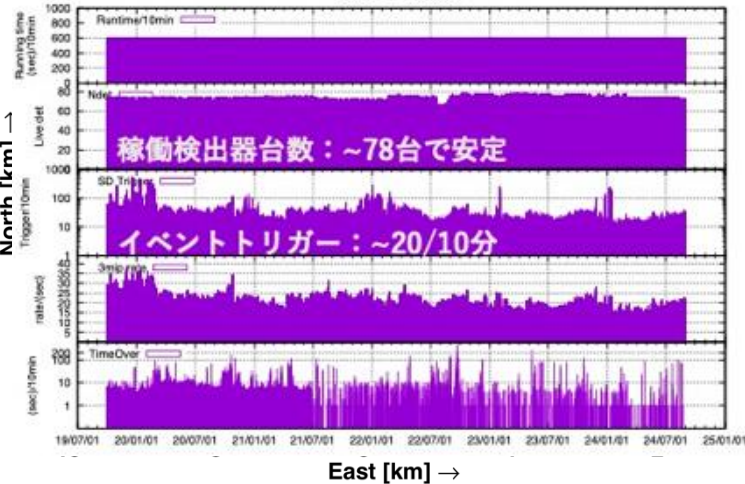
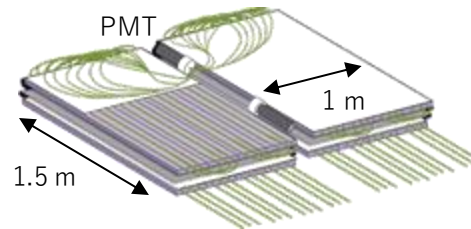
10 High-elevation telescopes (31° - 59°)
 256pixel, 8bit 10MHz FADC readout
 Started observation since 2013



2nd TALE SDアレイの稼働状況

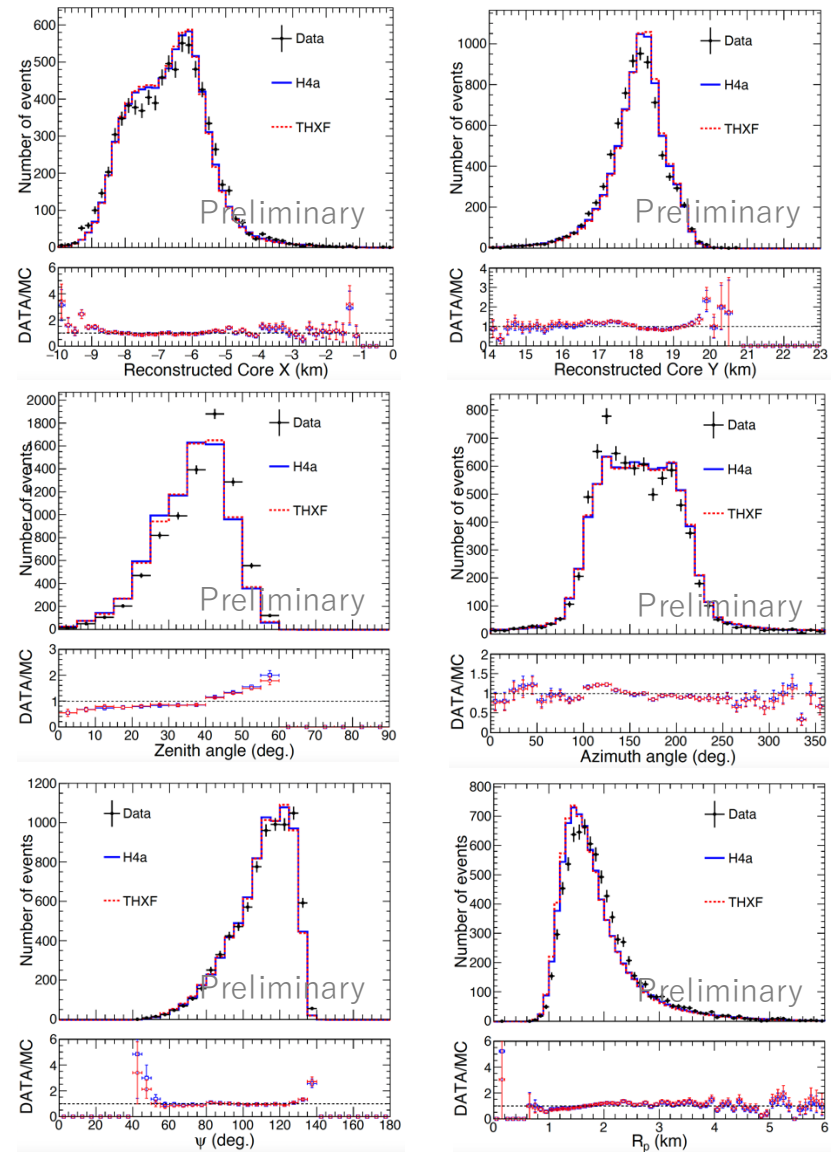
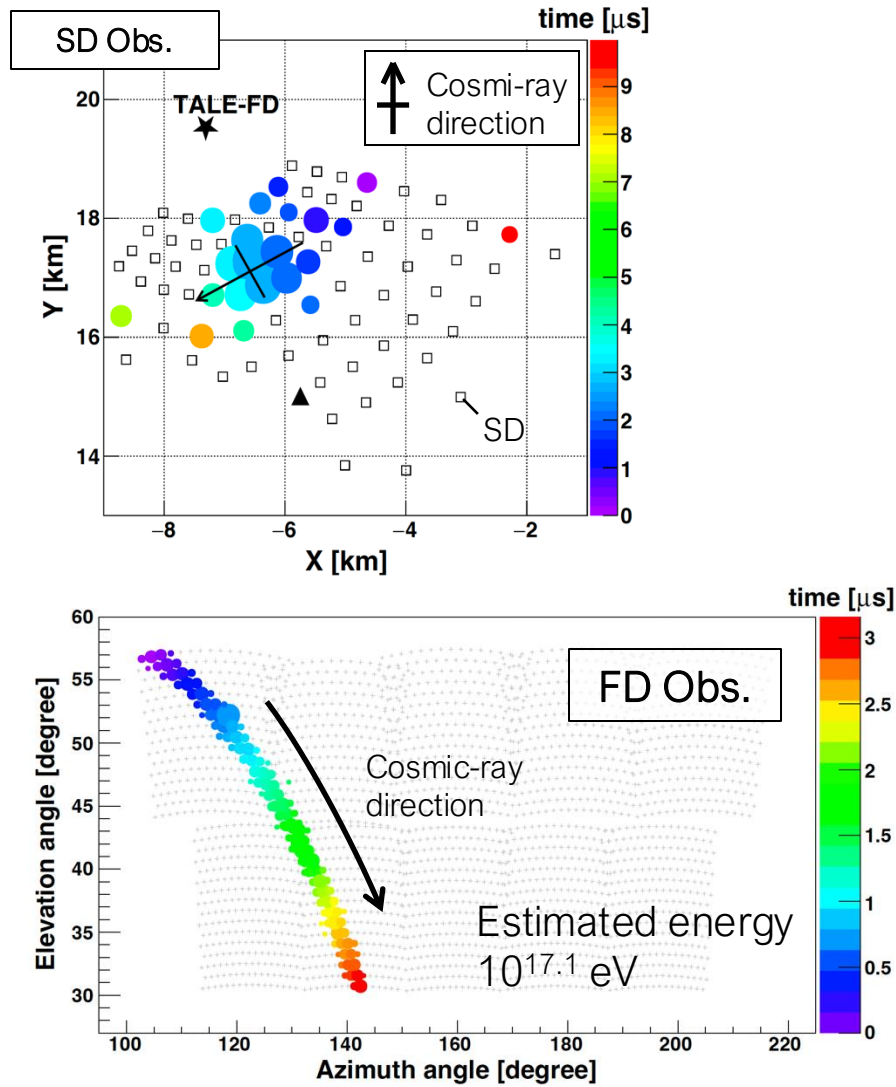
SD array

40SDs with 400m, 40SDs with 600m
 2 layers Scintillation counter, 3m²
 Started observation since 2017



TALE Hybrid : Event display and Data/MC

H. Oshima, UHECR2024



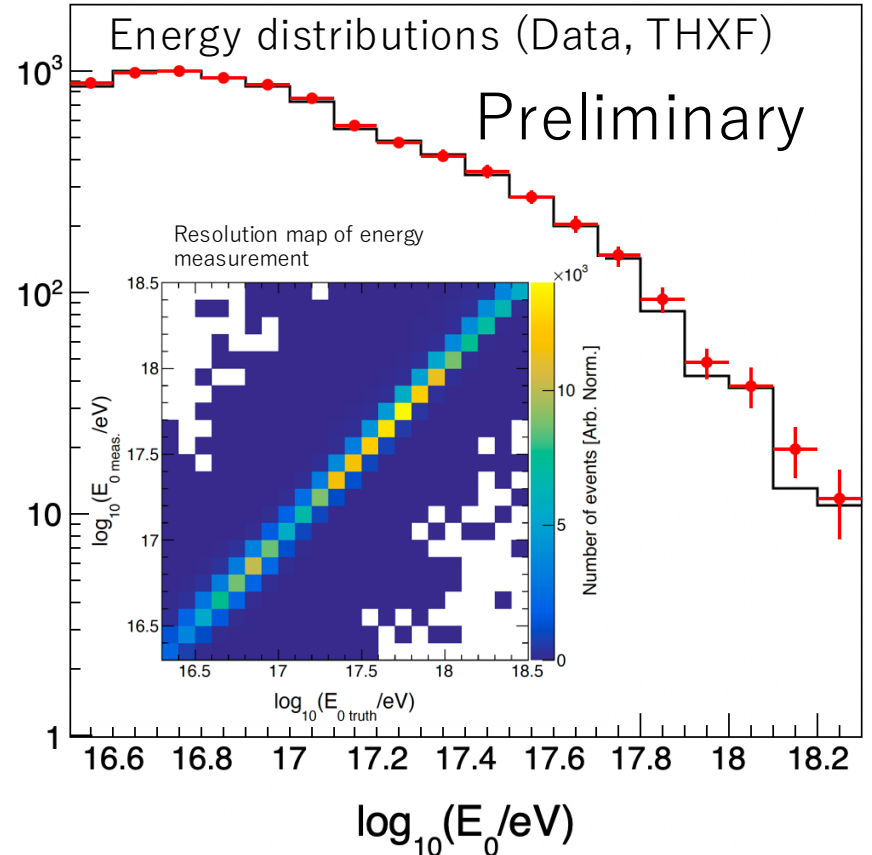
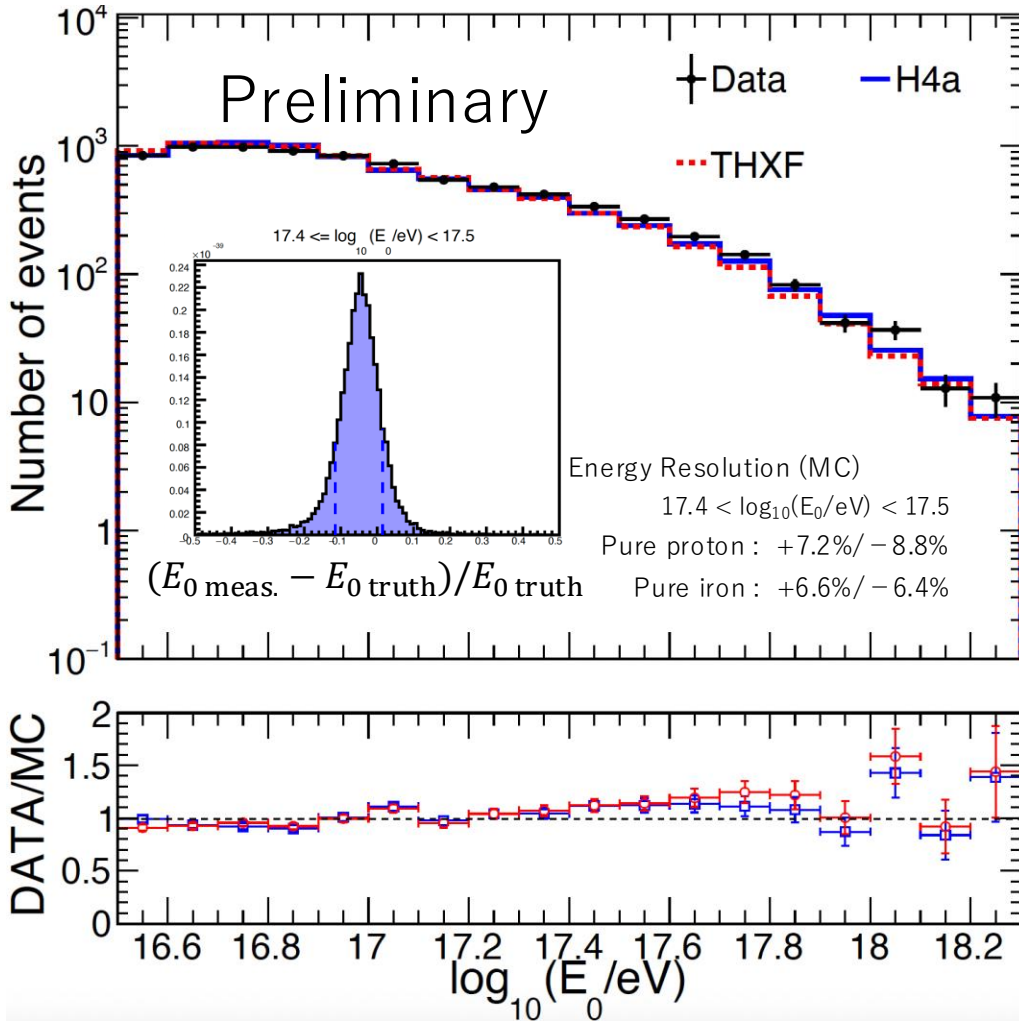
Iterative D'Agostini unfolding

Unfolded spectrum

Smearing matrix

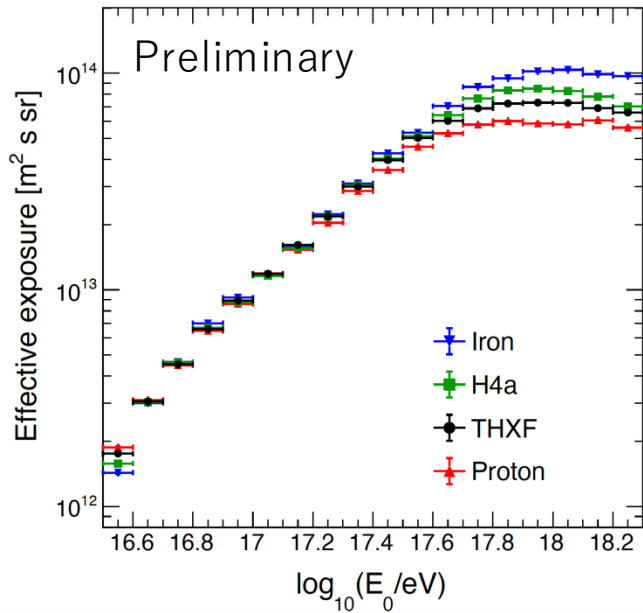
$$C'_i = \sum_{j=1}^{N_m} U_{ij} E_j^{\text{data}}$$

Number of events in measured bin j

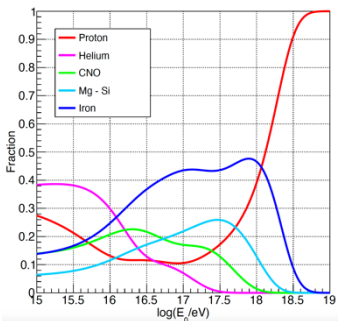




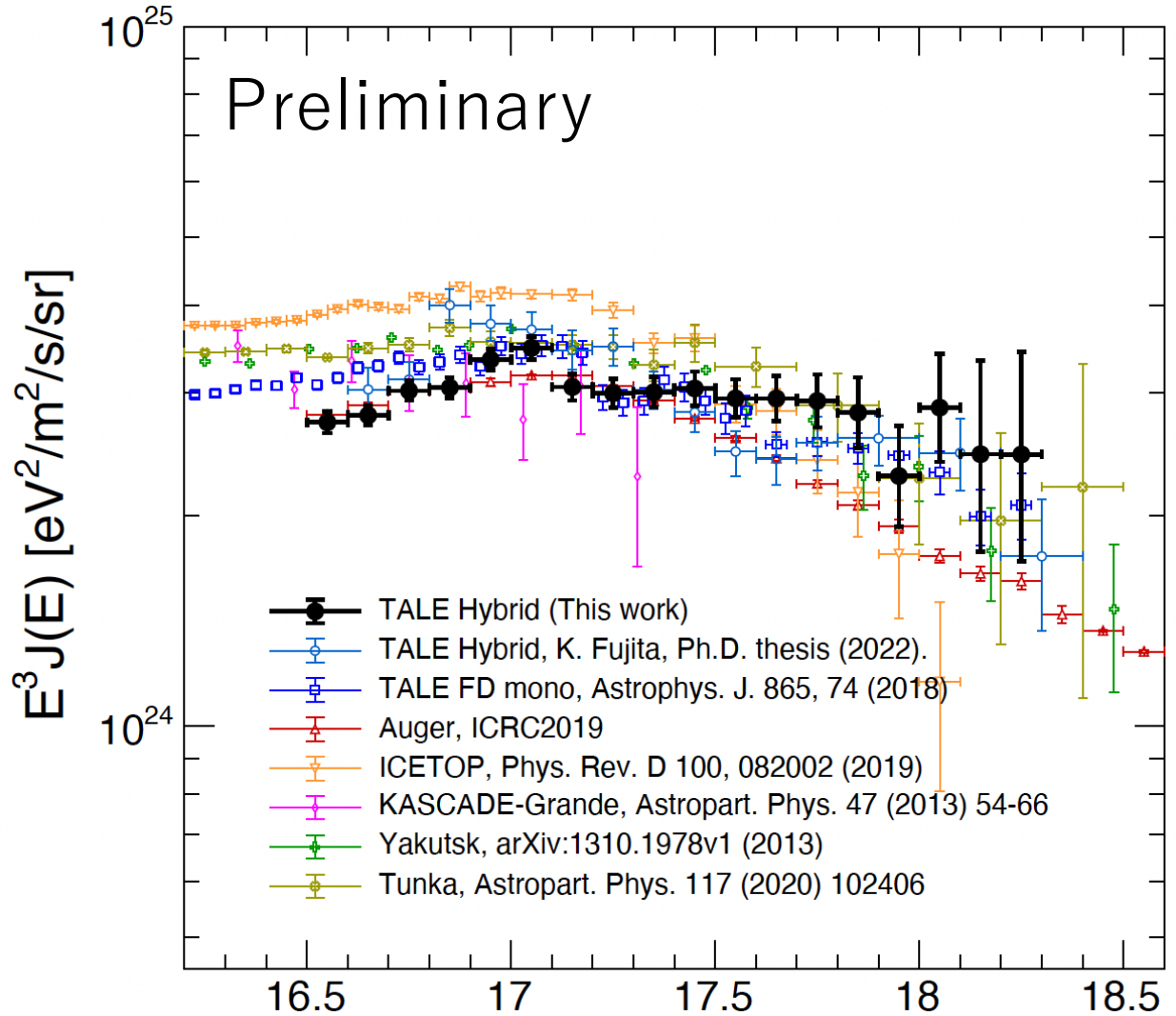
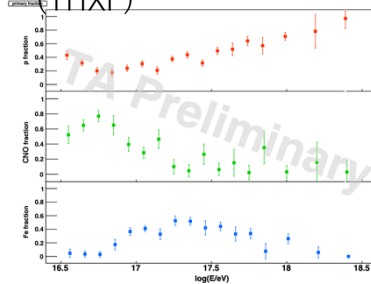
Effective Exposure



H4a model



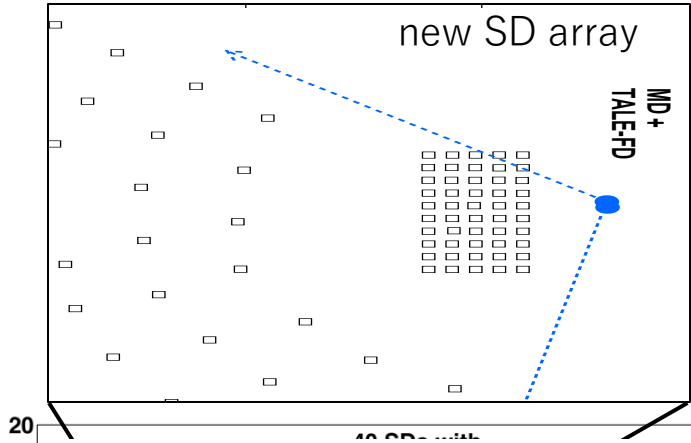
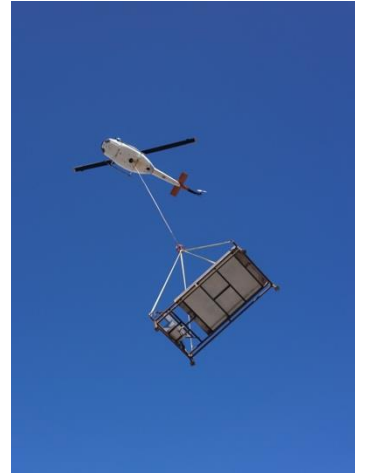
TALE Hybrid X_{max} Fitting (THXF)



TALE infill

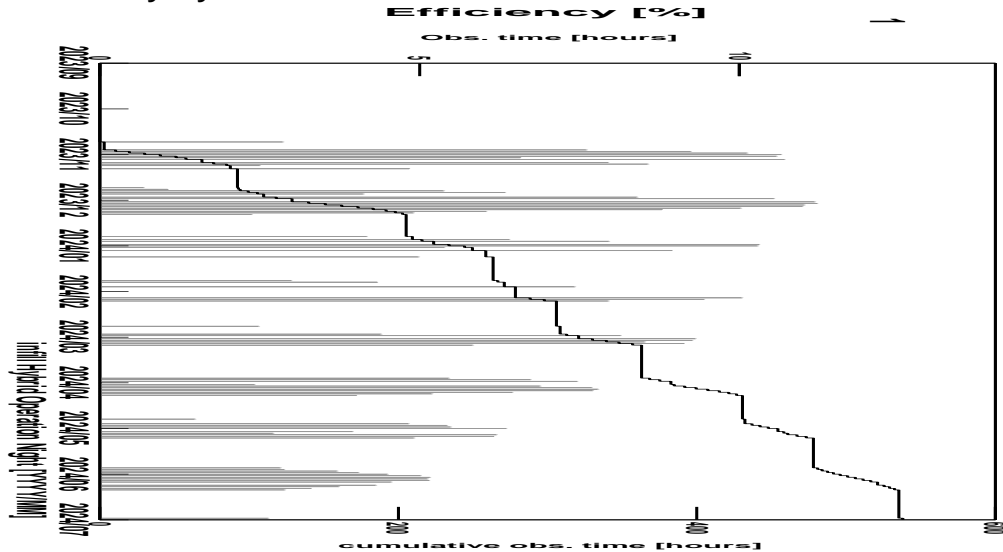
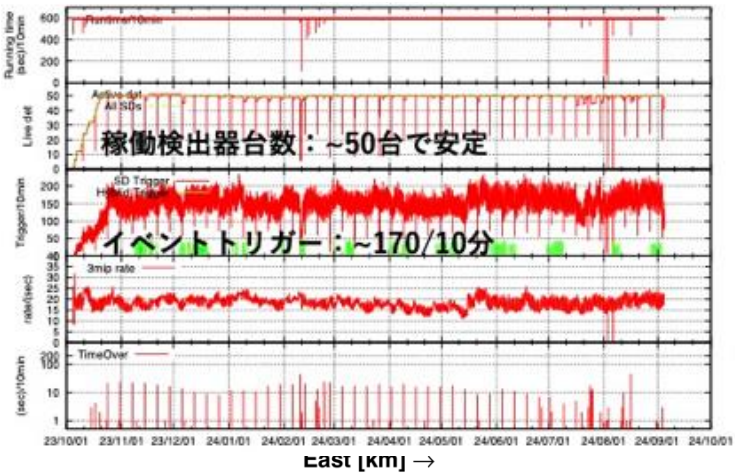
Upgrade TA hybrid detector sensitivity down to PeV range → **TALE**

F3: 狹尾



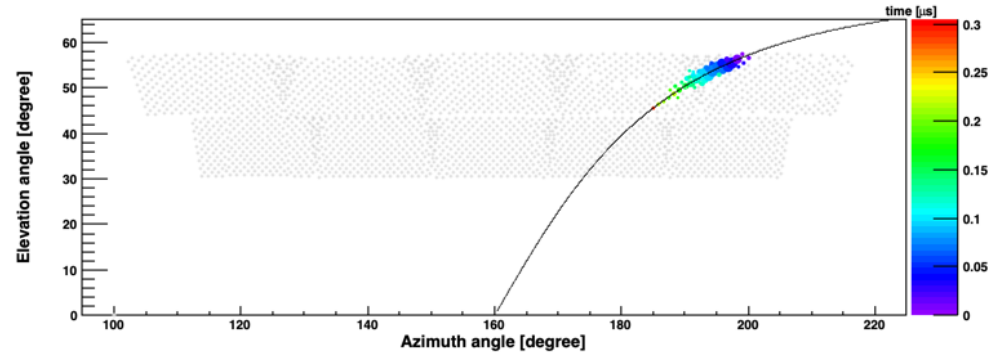
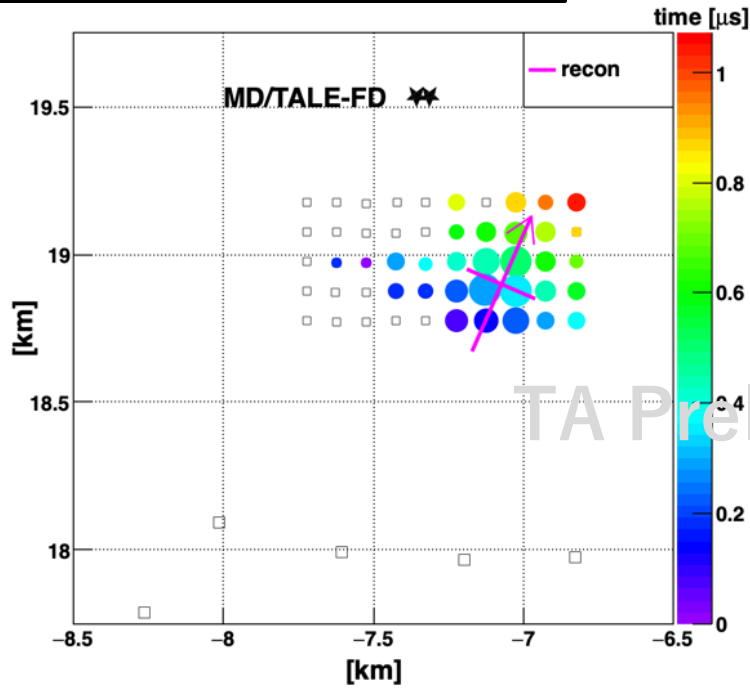
- Further dense SD array
 - **50SDs** with **100m** spacing
 - 2 layers Scintillation counter
 - trigger condition:
5 adjacent SDs hit within $3\mu\text{s}$
 - Started observation since Nov. 2023
 - duty cycle: > 98%

TALE-infill SDアレイの稼働状況

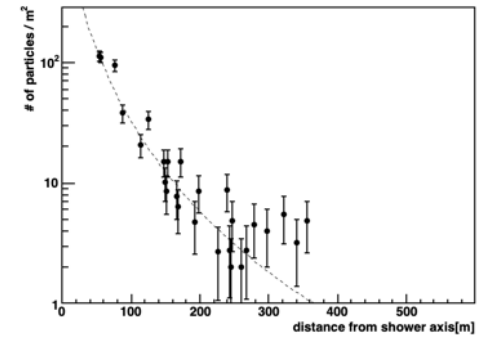
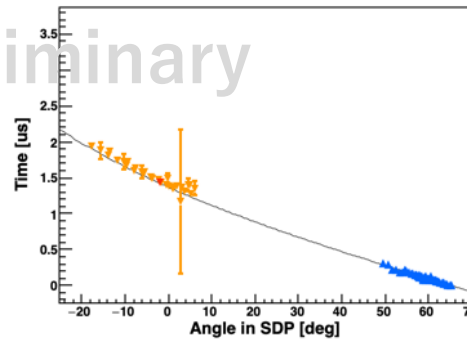


infill Hybrid Operation time

Observed event, 20231215 02:20:36



TA Preliminary

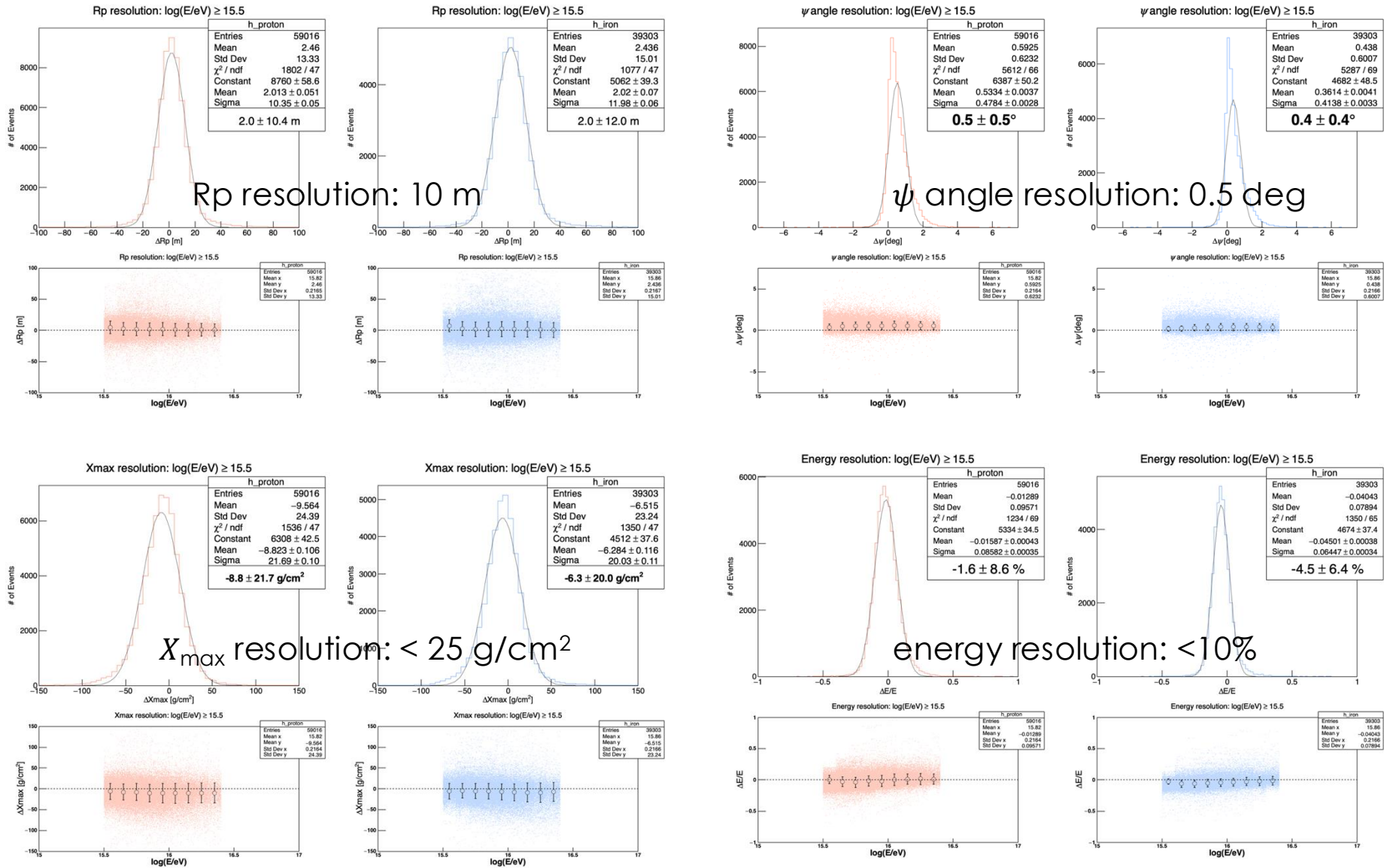


Result.	θ [deg]	ϕ [deg]	R_p [km]	ψ [deg]	coreX[km]	coreY[km]	X_{max} [g/cm ²]	log(E/eV)
Hybrid	31.1	66.8	0.63	112.3	-6.99	18.89	586	16.04
SD	30.7	65.0	-	-	-7.07	18.91	-	16.01

TALE infill Hybrid :Reconstruction resolution

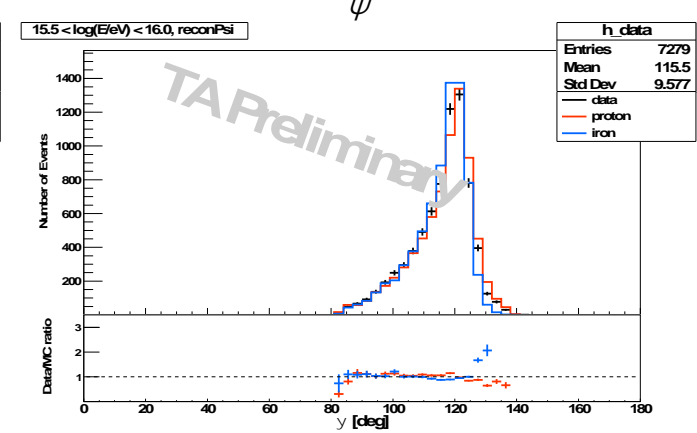
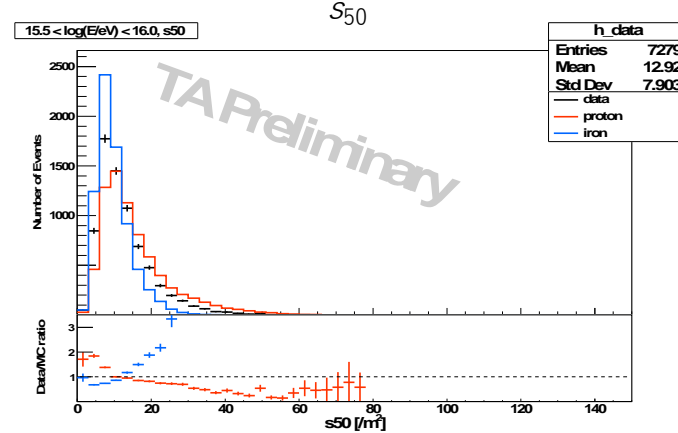
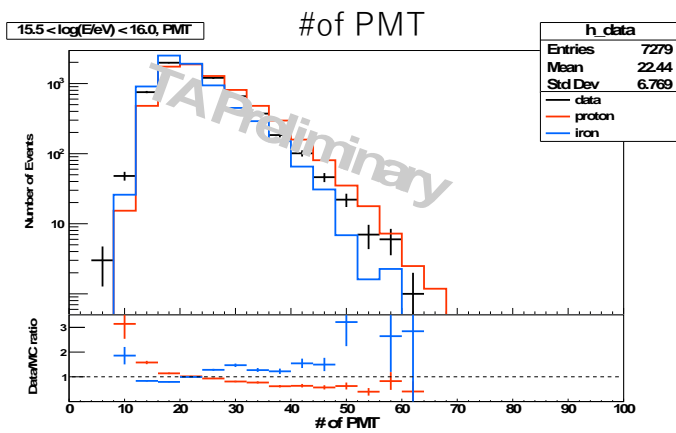
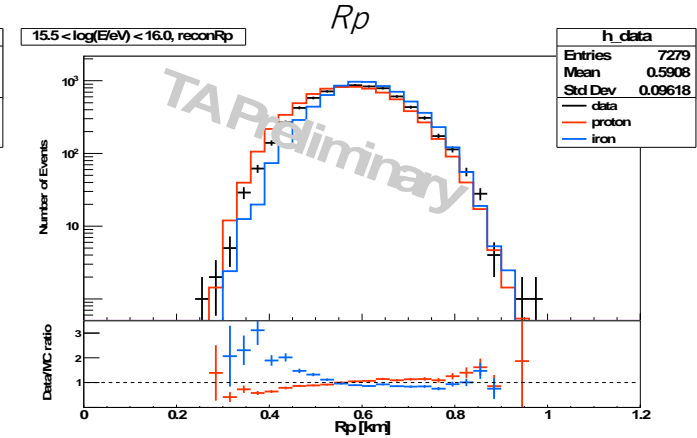
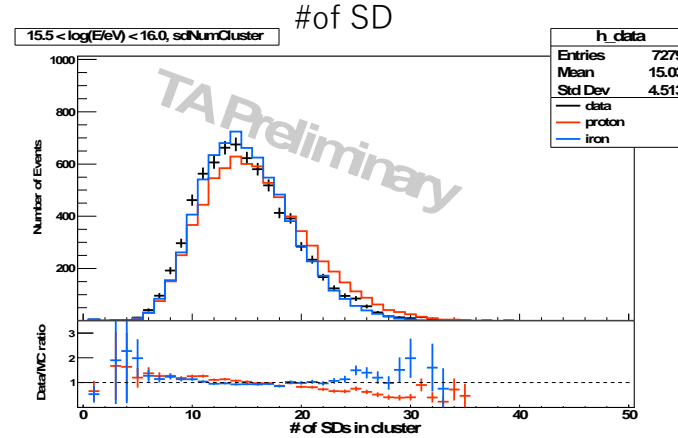
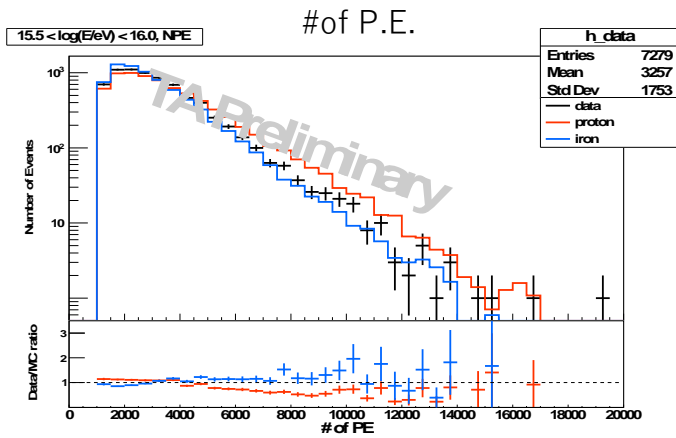


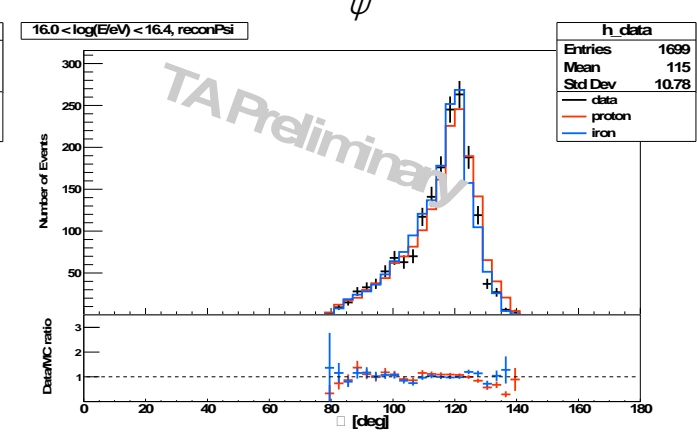
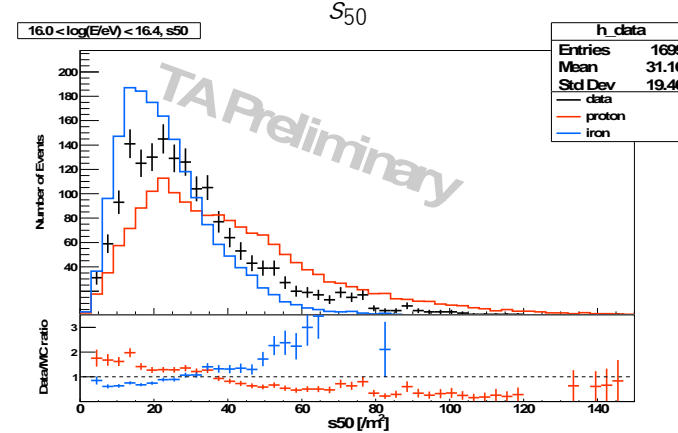
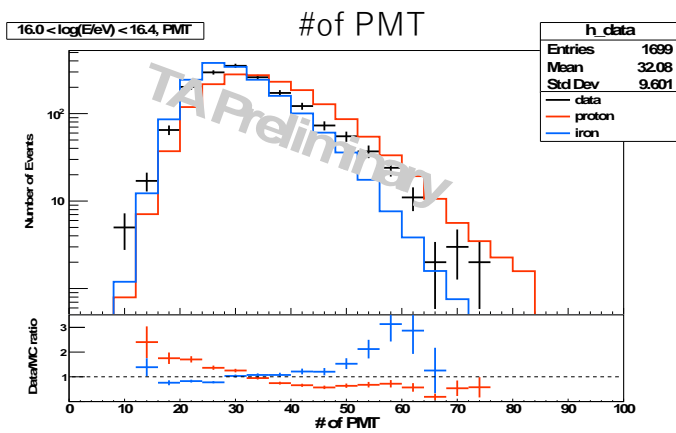
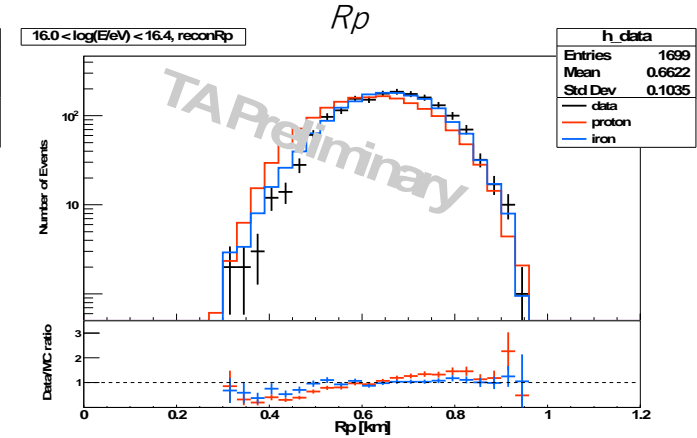
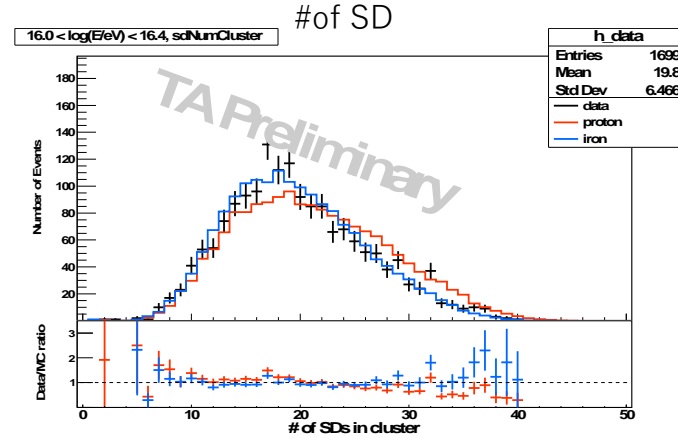
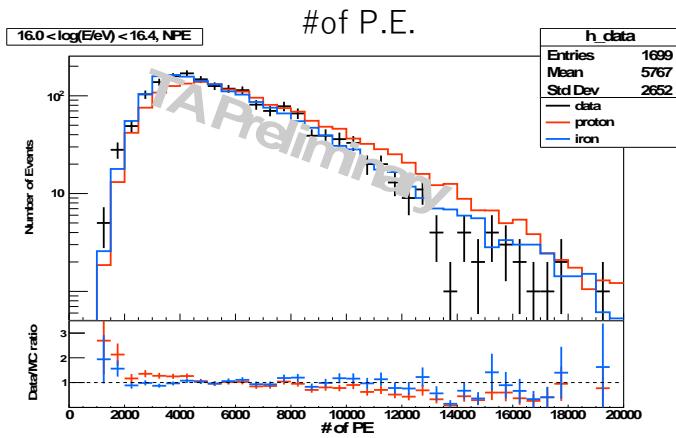
K. Fujita, UHECR2024



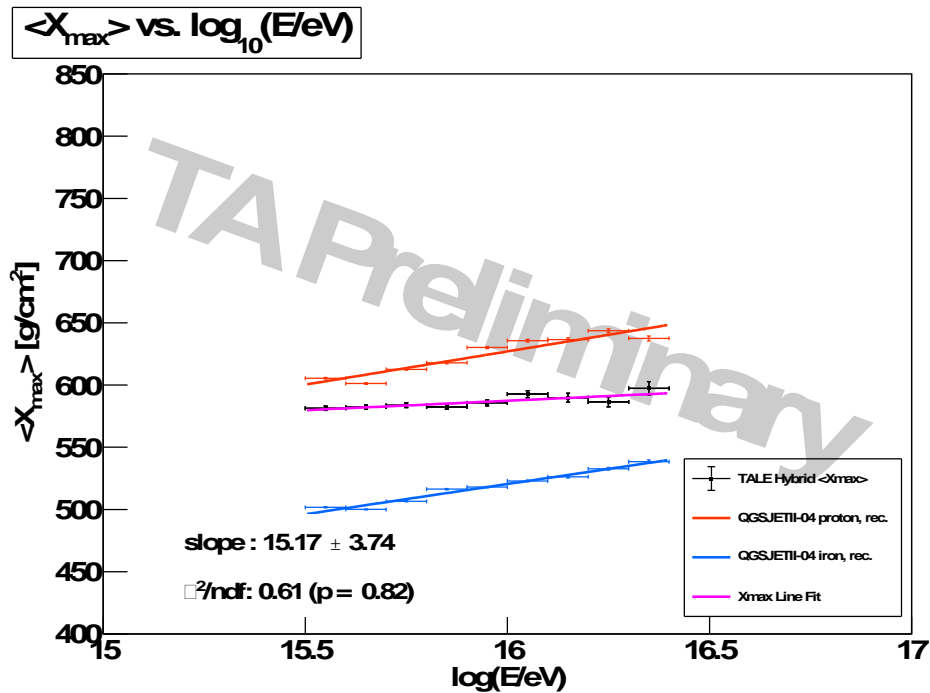
TALE infill Hybrid : Data/MC @ $10^{15.5} - 10^{16.0}$ eV

K. Fujita, UHECR2024

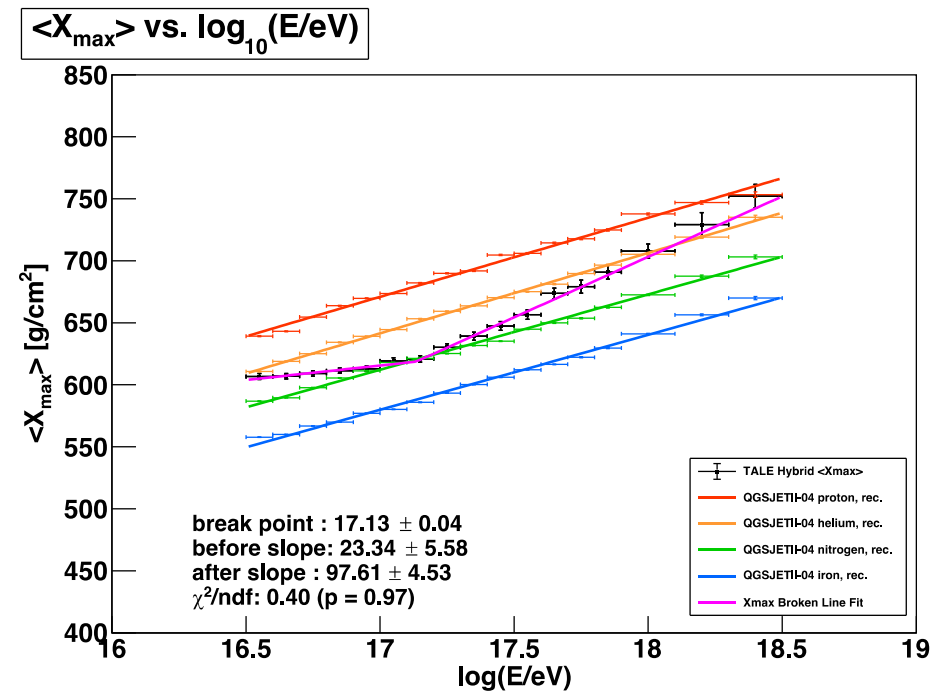




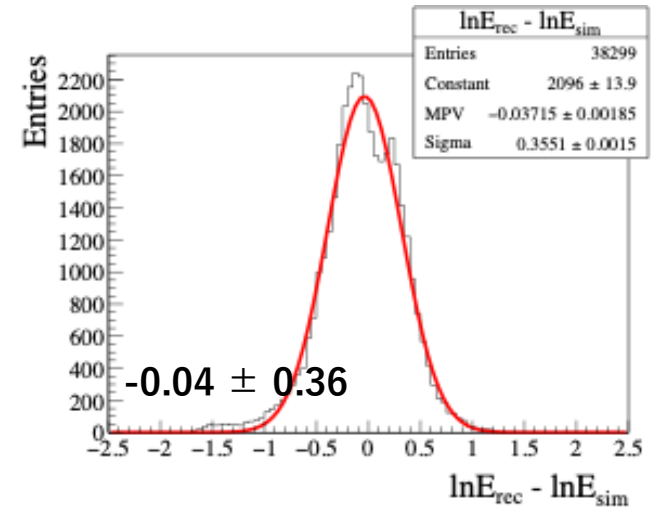
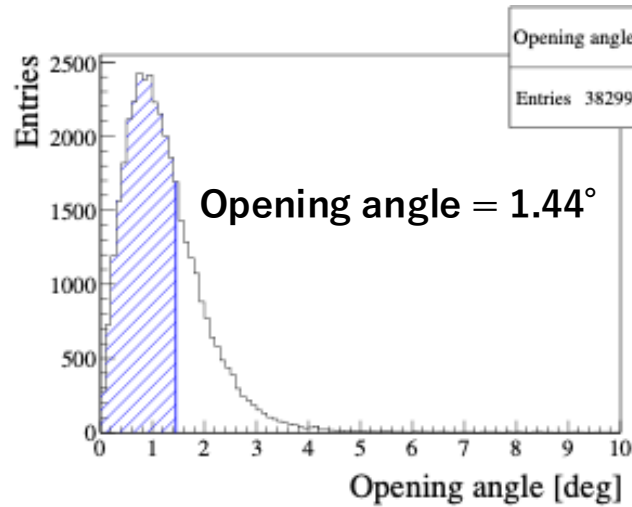
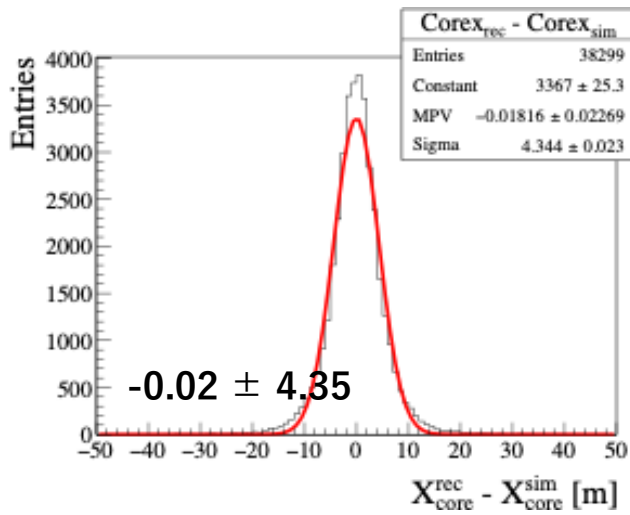
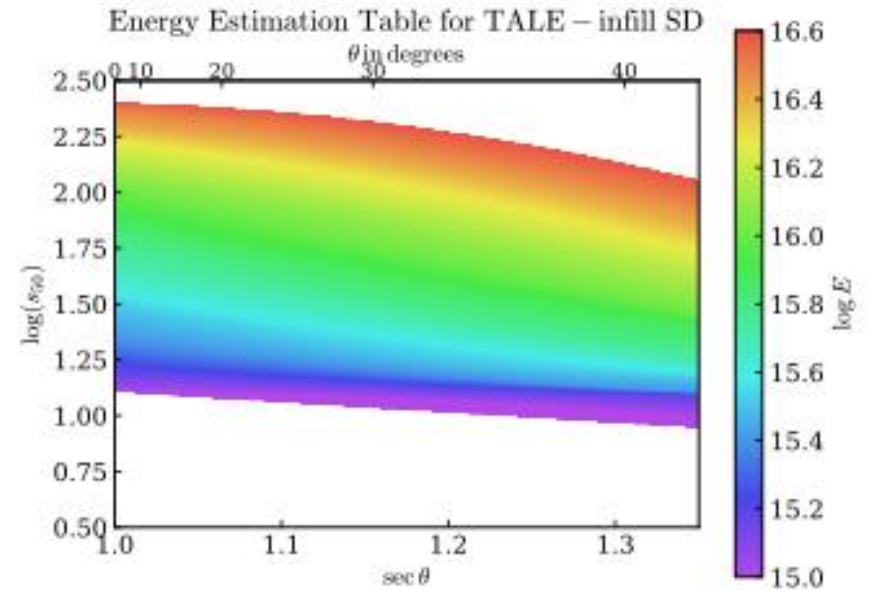
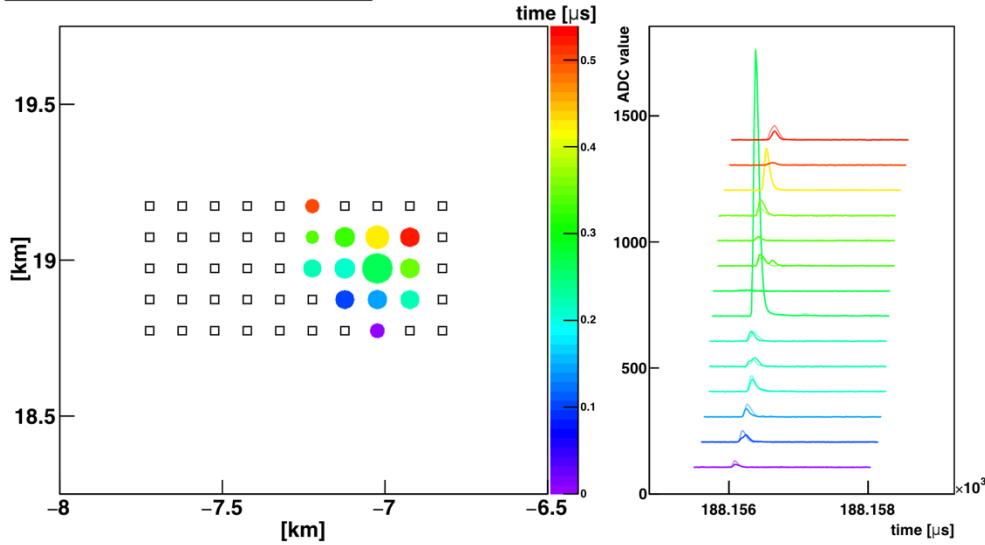
TALE FD + new SD array hybrid measurement

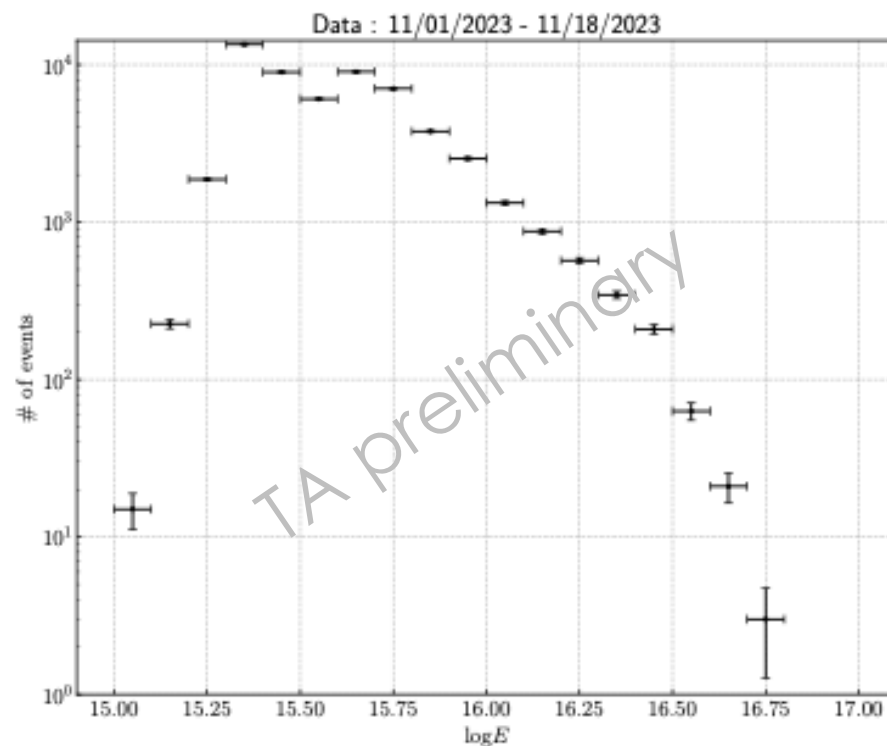
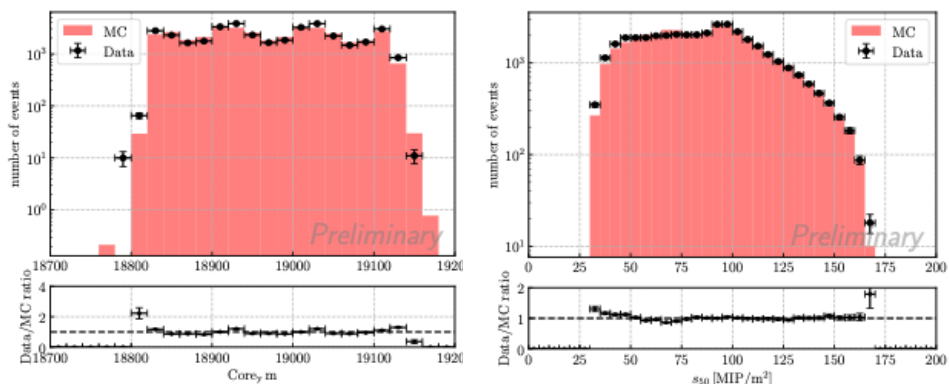
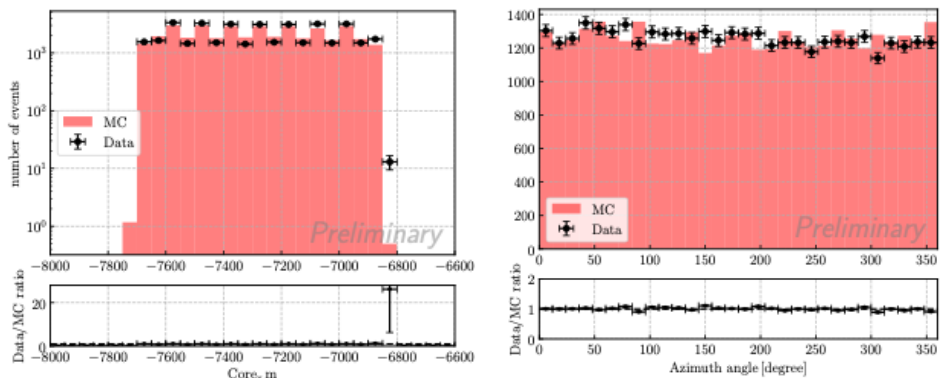
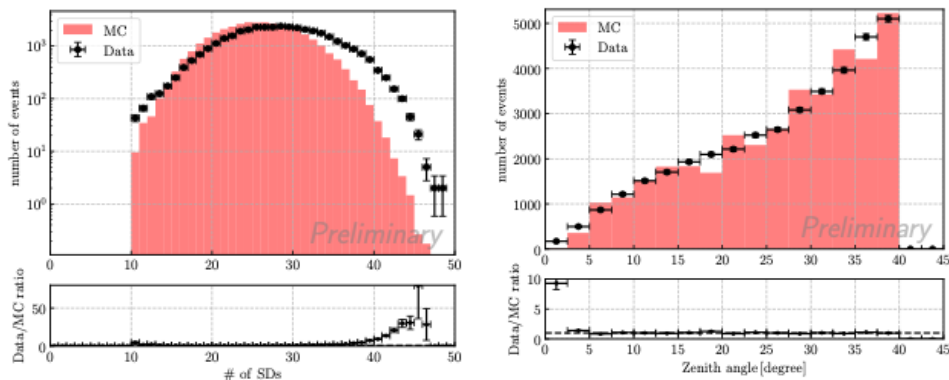


TALE FD + TALE SD array hybrid measurement



2023/10/11 00:01:50.188156





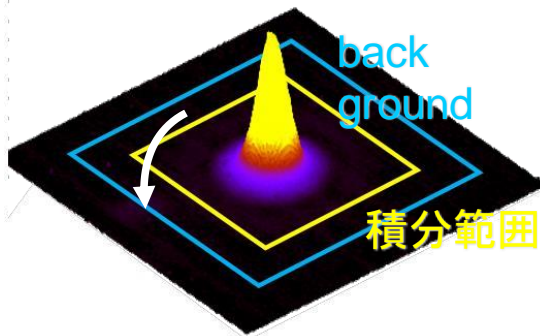
TALE-infill SDアレイによる2023年11月1日から2024年6月28日までの約40,000イベントのデータ解析で得られたイベントのエネルギー分布

TALE-infill SDアレイによる2023年11月1日から2024年6月28日までの約40,000イベントのデータ解析で得られたシャワーパラメーターのデータ/MC比較（不一致も見られる。調査中）

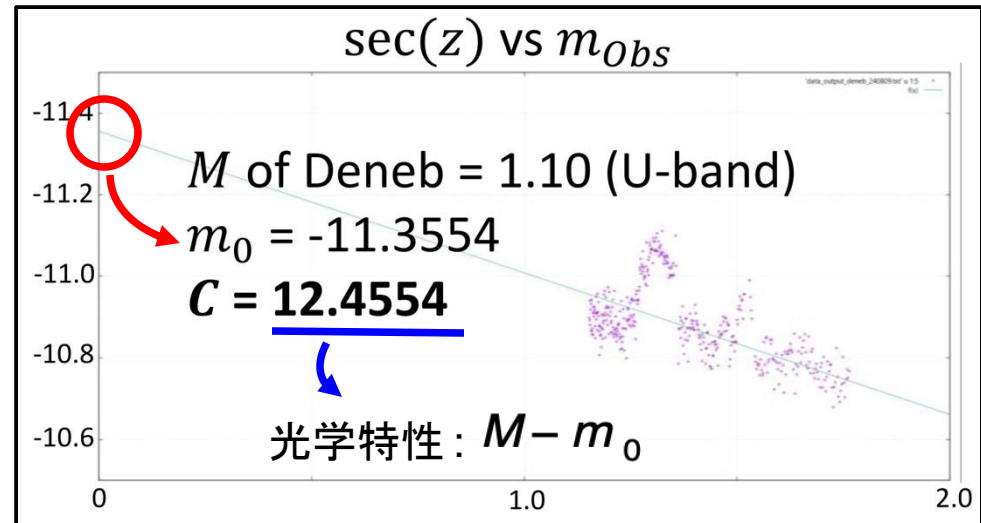
TA実験サイトにおける大気透明度測定法の研究・開発

F2: 有働

- ・ 恒星光度の追尾測定による大気状態変化の測定
 - ・ 冷却CCDで撮影、光度の時間変化を追う
 - 画像データ → 器械等級を計算 m_{obs}
 - 天頂角依存性 → 大気圏外等級 m_0
 - ・ 2024/08/05-11 明野観測所
 - 改善点 (↔ 2022/08 ユタでの観測)
 - 露光時間 0.01s → 20s
 - 紫外線透過フィルター使用
 - 開口測光



本来は円形?
今回はとりあえず正方形で

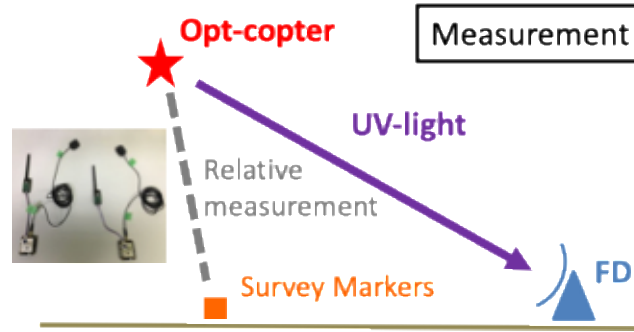
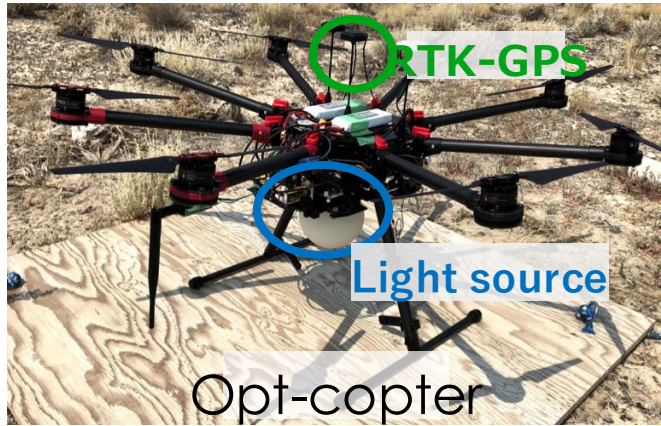


ドローンに搭載された標準光源による 大気蛍光望遠鏡の光学特性の評価



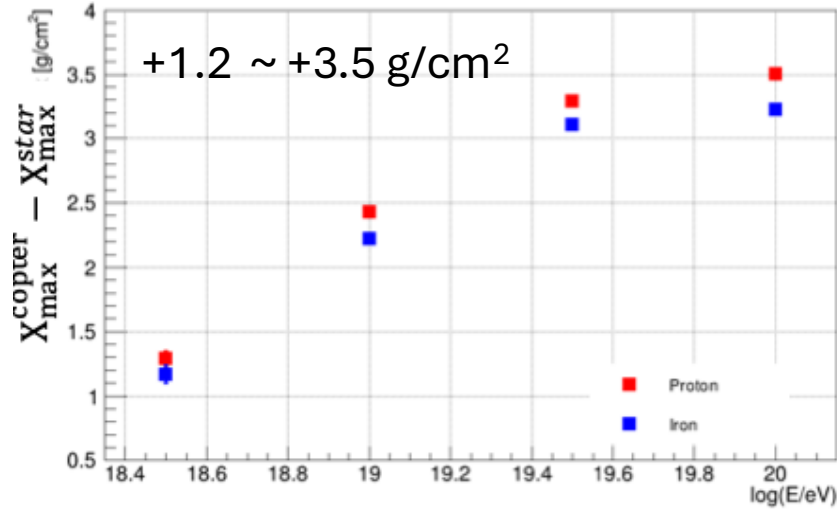
T. Tomida, D. Sato, UHECR2024

F4: 富田

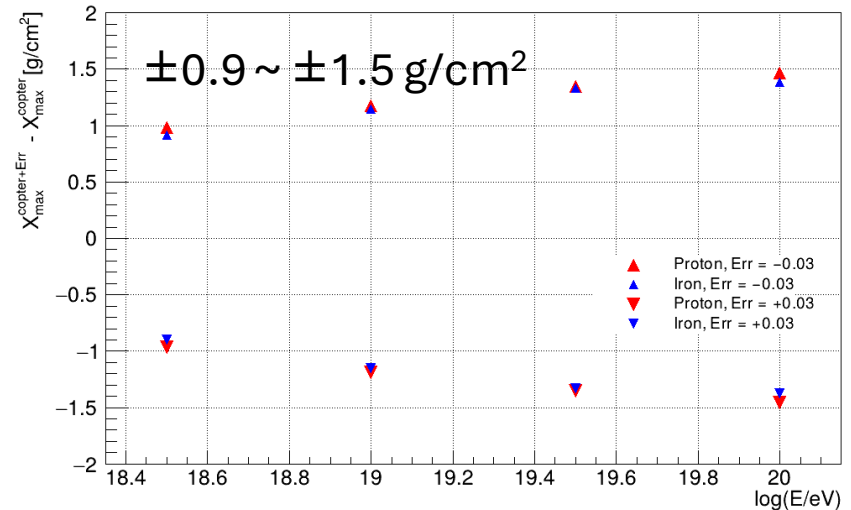


	FD00	FD01	FD02	FD03	FD04	FD05	FD06	FD07	FD08	FD09	FD10	FD11
Δ Azimuth [deg.]	0.05	0.00	0.04	0.04	0.04	0.02	0.01	-0.04	0.01	-0.05	-0.02	0.01
Δ Elevation [deg.]	0.11	-0.04	0.02	-0.03	-0.04	-0.12	-0.05	-0.14	-0.12	-0.19	-0.14	-0.15

星解析とドローンにより得られた視野方向の X_{max} に与える影響

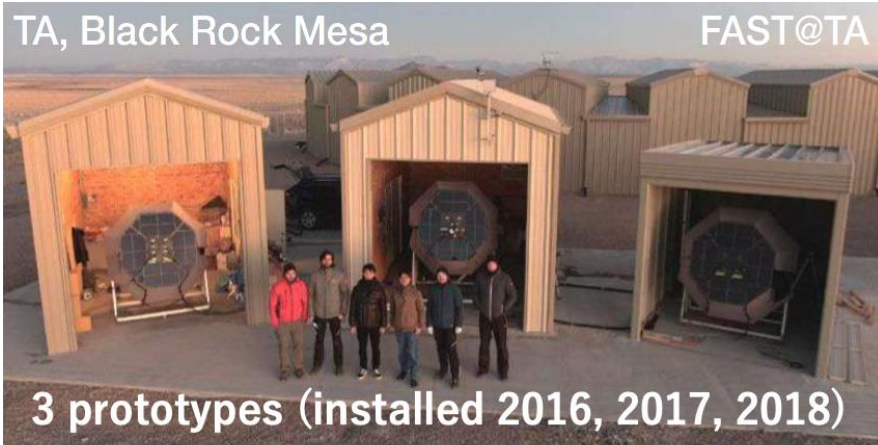


ドローンにより得られた視野方向の精度 ($\pm 0.03^\circ$) による X_{max} の系統誤差

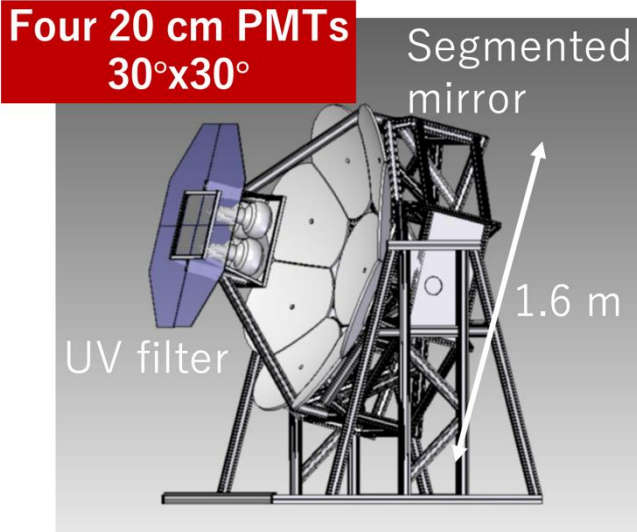
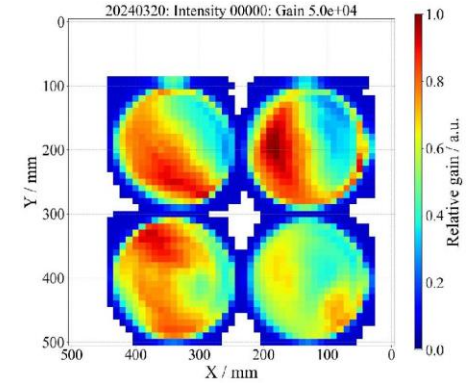
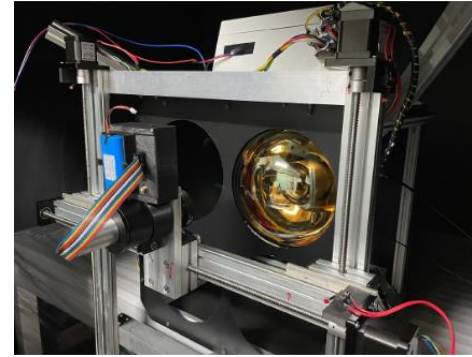


TA実験サイトでの新型大気蛍光望遠鏡による極高エネルギー宇宙線観測

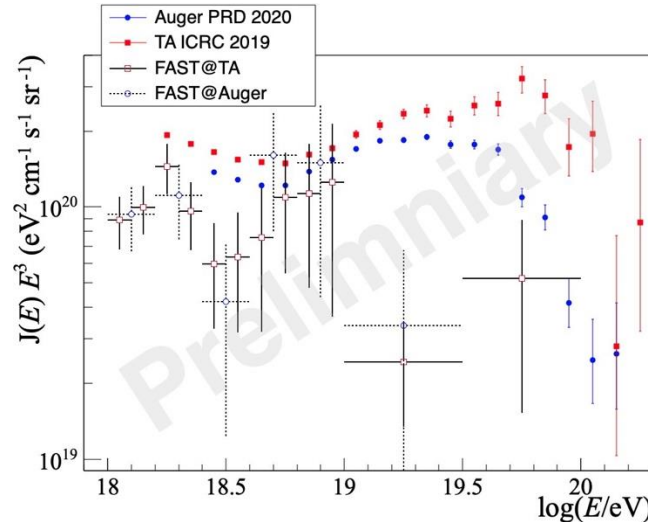
F6: 藤井



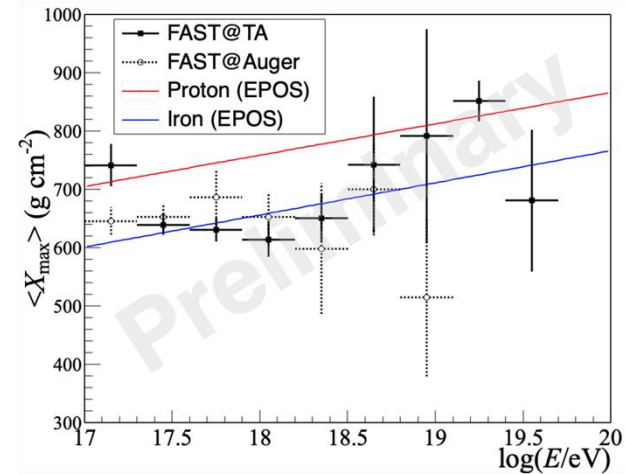
On-site PMT non-uniformity measurements in March 2024



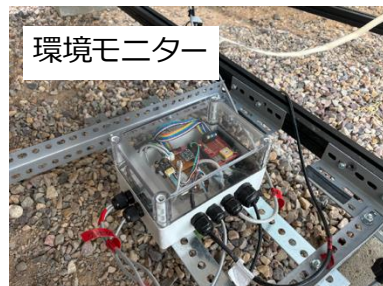
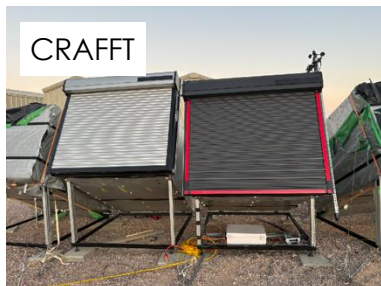
First results of energy spectrum and mass composition



F. Bradfield, UHECR 2024



F7: 多米田



- 完全自動観測のための試験を実施 (2024年8, 9月)
- 環境モニターを設置し、常時監視
- シャッターの状態を取得し自動制御
- 自律トリガーにより試験観測(Any 2 w/ Cosmo-z)
- HV, Ampなどのエレクトロニクスの開発

モニター画面

CRAFT monitor (2024/11/10 23:40:00)

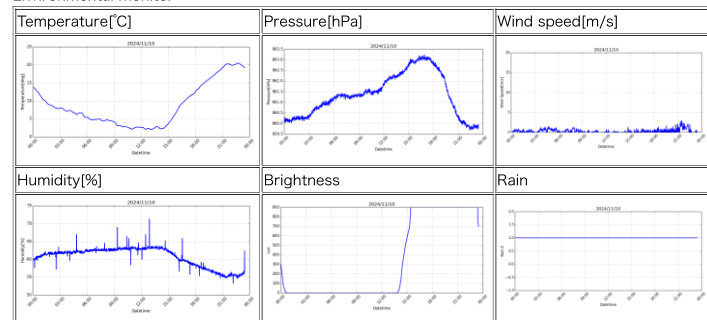
Recorded date	Recorded Time	Timezone
2024/11/10	23:36:22	UTC

Observation start	Observation end	Status
07:45:41	12:38:11	NG

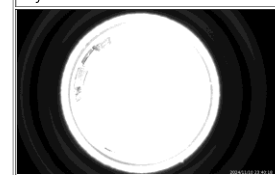
Temperature	Pressure	Wind speed	Brightness	Rain	Shutter
18.93 °C	859.908 hPa	0.04 m/s	BRIGHT	OK	CLOSE



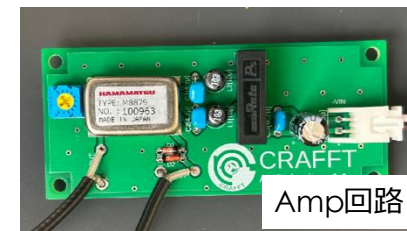
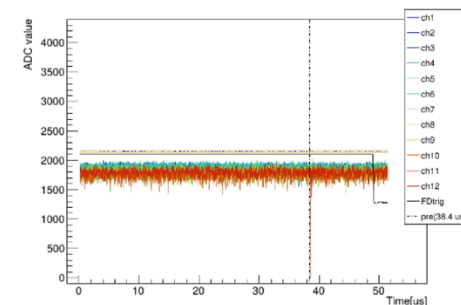
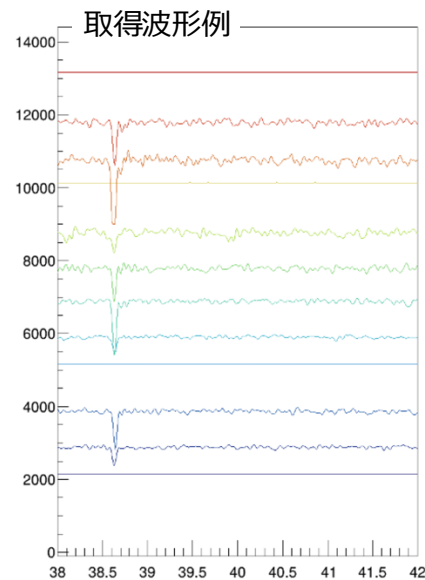
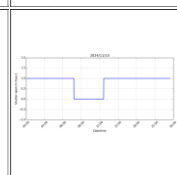
Environmental monitor



Sky Monitor



Shutter status



大気蛍光望遠鏡の自動観測を目指した夜間雲量測定用CCDカメラの開発と解析

F5: 山崎

- これまでTAサイトで使用していたカメラ類が入手困難
 - 後継として、より廉価かつ入手性の高いカメラとサーバー組み合わせを検討ハウジングも新たに作成した。



CMOSカメラ

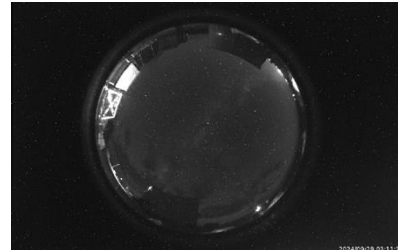
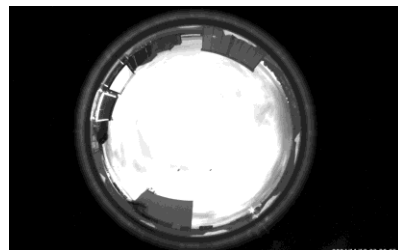


Raspberry Pi

・全体費用が～50万円 → ～10万円にコストダウン



- CRAFFT 望遠鏡に併設
 - 望遠鏡自律運用のための試験運用を開始した。長期運用による安定性の試験と、取得したデータの解析を進める。



まとめ

- TA SD
 - ホットスポット解析
 - ニュートリノ事象探索
- TAx4
 - アレイ拡張のためのトリガー開発
 - 最高エネルギー領域のエネルギースペクトル
 - 大天頂角事象解析
 - ハイブリッドXmax解析
- TALE
 - ハイブリッド解析によるエネルギースペクトル
- TALE infill
 - ハイブリッド解析による質量組成
 - SD解析
- その他
 - 新しい大気透明度測定手法
 - ドローンを用いたTAFD視野方向較正
 - 次世代観測装置の開発研究のプラットフォーム
 - FAST、CRAFT