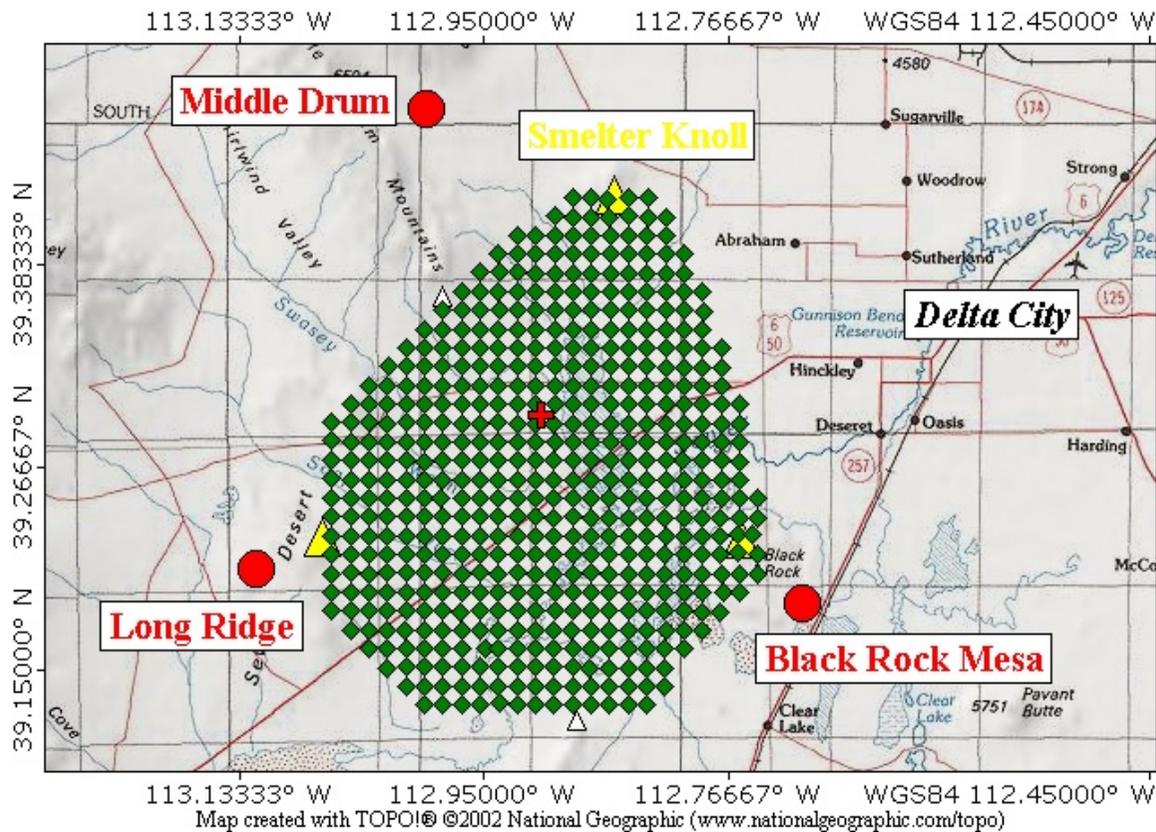


# テレスコープアレイ実験

## The TA Collaboration ( 竹田 成宏 . 宇宙線研究所 )



## < TA 関連の共同利用研究課題 >

整理 番号	研究代表者	研究課題	配分額 (単位：千円)			執行済額 (12/14 まで)		
			研究費	旅費	合計	研究費	旅費	合計
D-02	荻尾 彰一	宇宙線望遠鏡実験用地表検出器の 製作と性能試験	0	240	240	0	128	128
D-03	常定 芳基	大気蛍光望遠鏡におけるハイブリ ッドトリガの開発	120	120	240	120	120	240
G-05	芝田 達伸	小型電子加速器による空気シャ ワーエネルギーの絶対較正の研究	710	900	1,610	180	252	432
G-14	千川 道幸	絶対光量測定による新型大気モニ タ装置の開発	800	500	1,300	149	1,151	1,300
G-27	佐川 宏行	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	0	1,000	1,000
合計			1,630	2,760	4,390	449	2,651	3,099

- 今年度も Telescope Array 実験の観測・運用・研究にご支援いただき  
ありがとうございました
- 来年度も よろしくお願い致します

# < The TA Collaboration >



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<sup>22</sup> Chungnam National University, Daejeon 305-764, Korea

<sup>23</sup> University Libre de Bruxelles, Brussels, Belgium

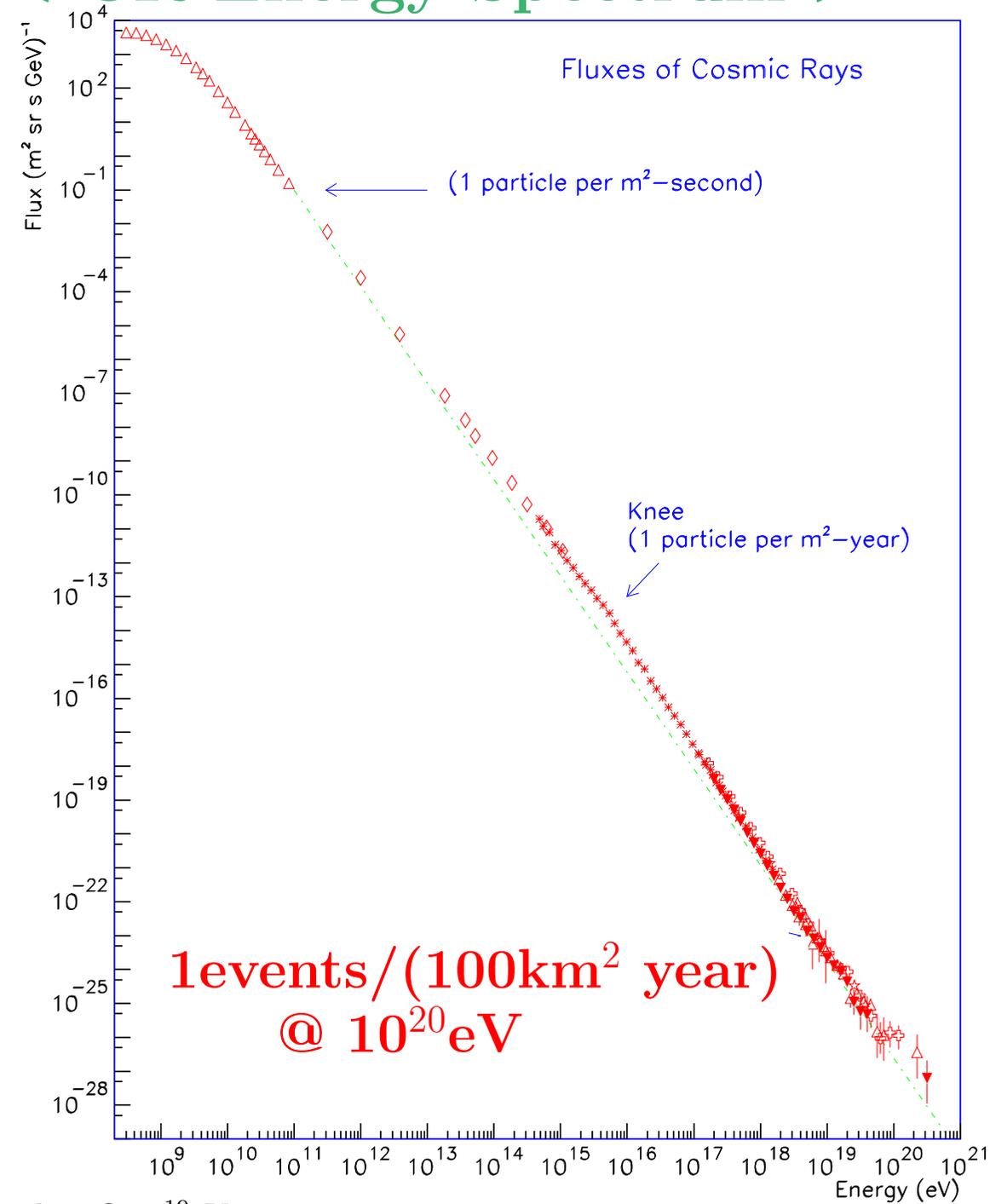
<sup>24</sup> Kochi University, Kochi 780-8520, Japan

<sup>25</sup> Hiroshima City University, Hiroshima 731-3194, Japan

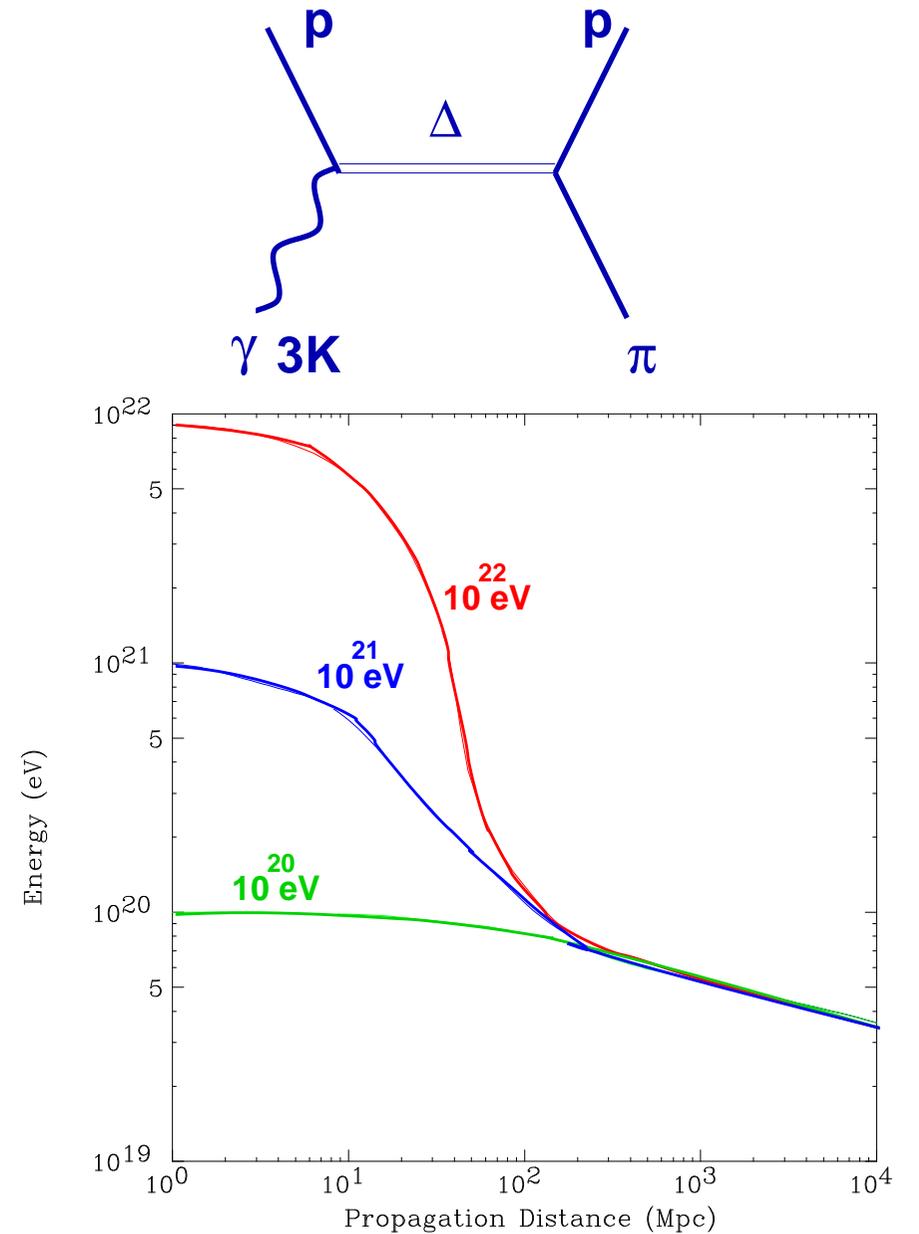
<sup>26</sup> National Institute of Radiological Sciences, Chiba 263-8555, Japan

<sup>27</sup> Ehime University, Ehime 790-8577, Japan

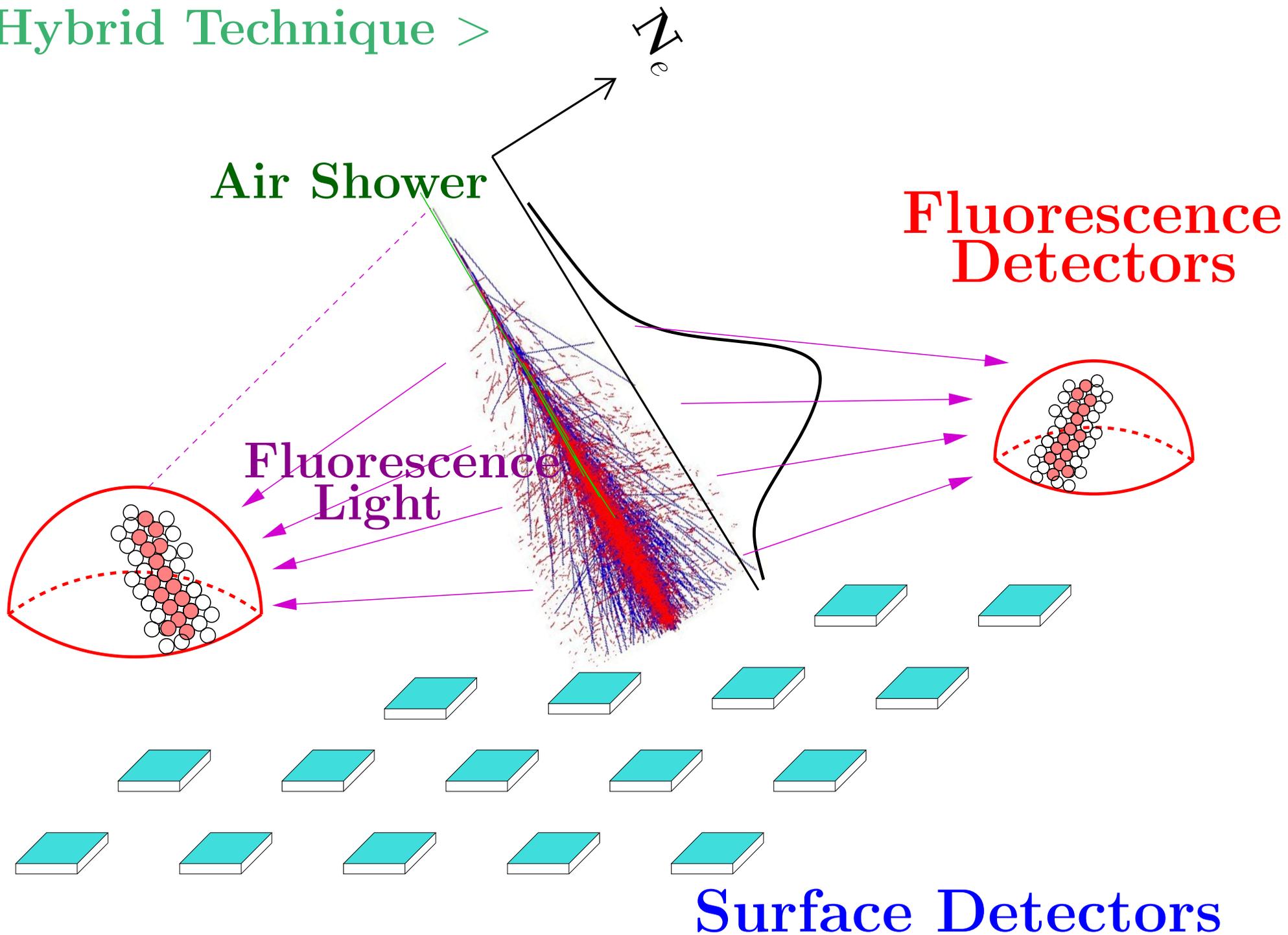
# < CR Energy Spectrum >



# < GZK Effect >

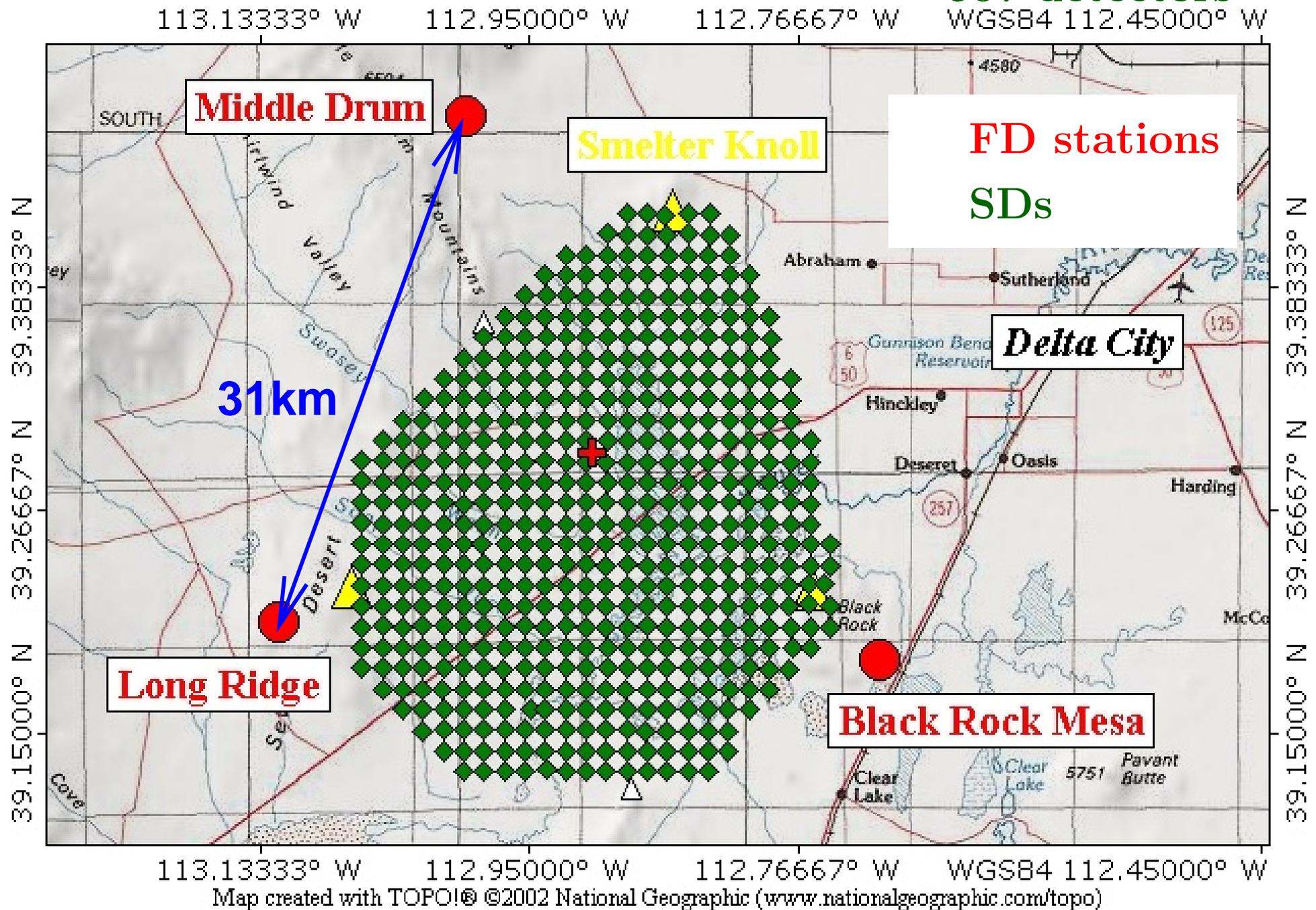


# < Hybrid Technique >



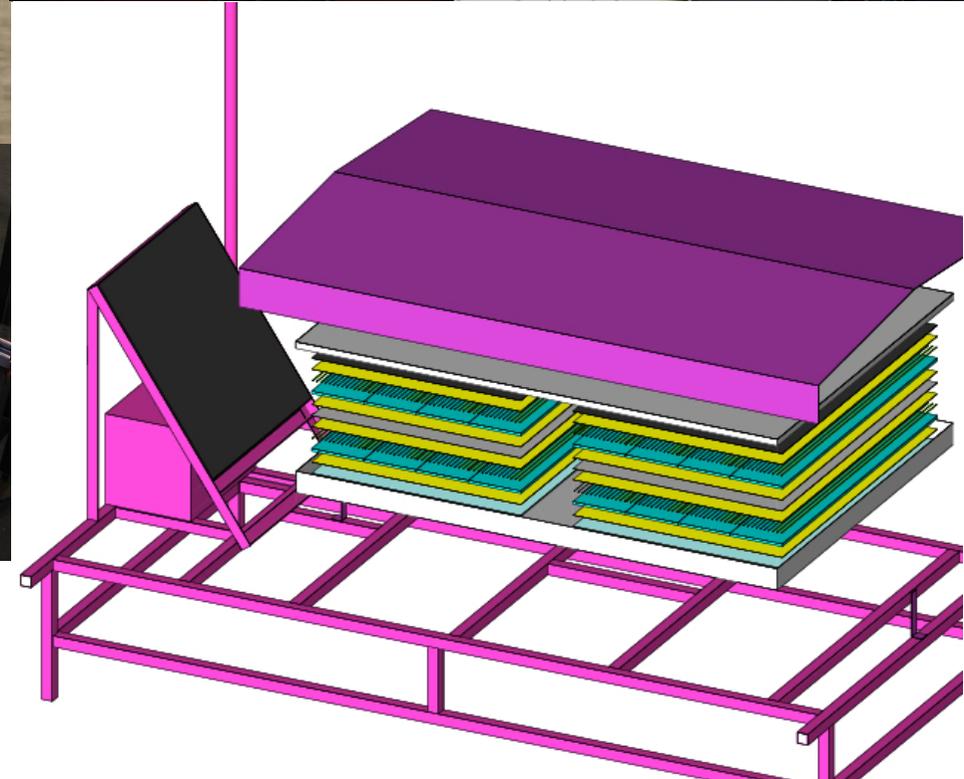
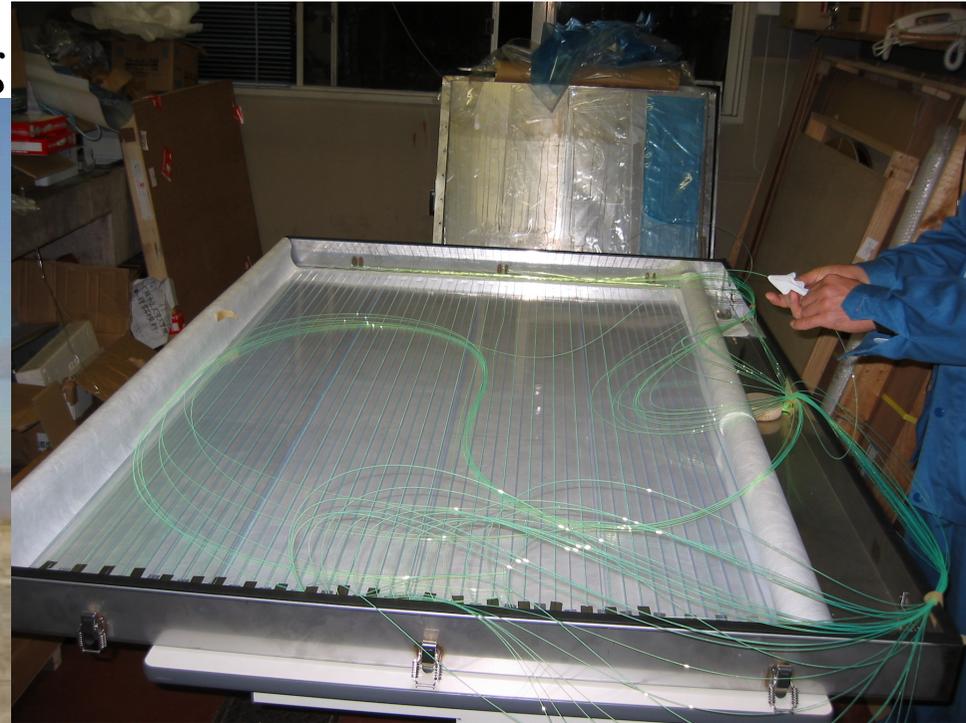
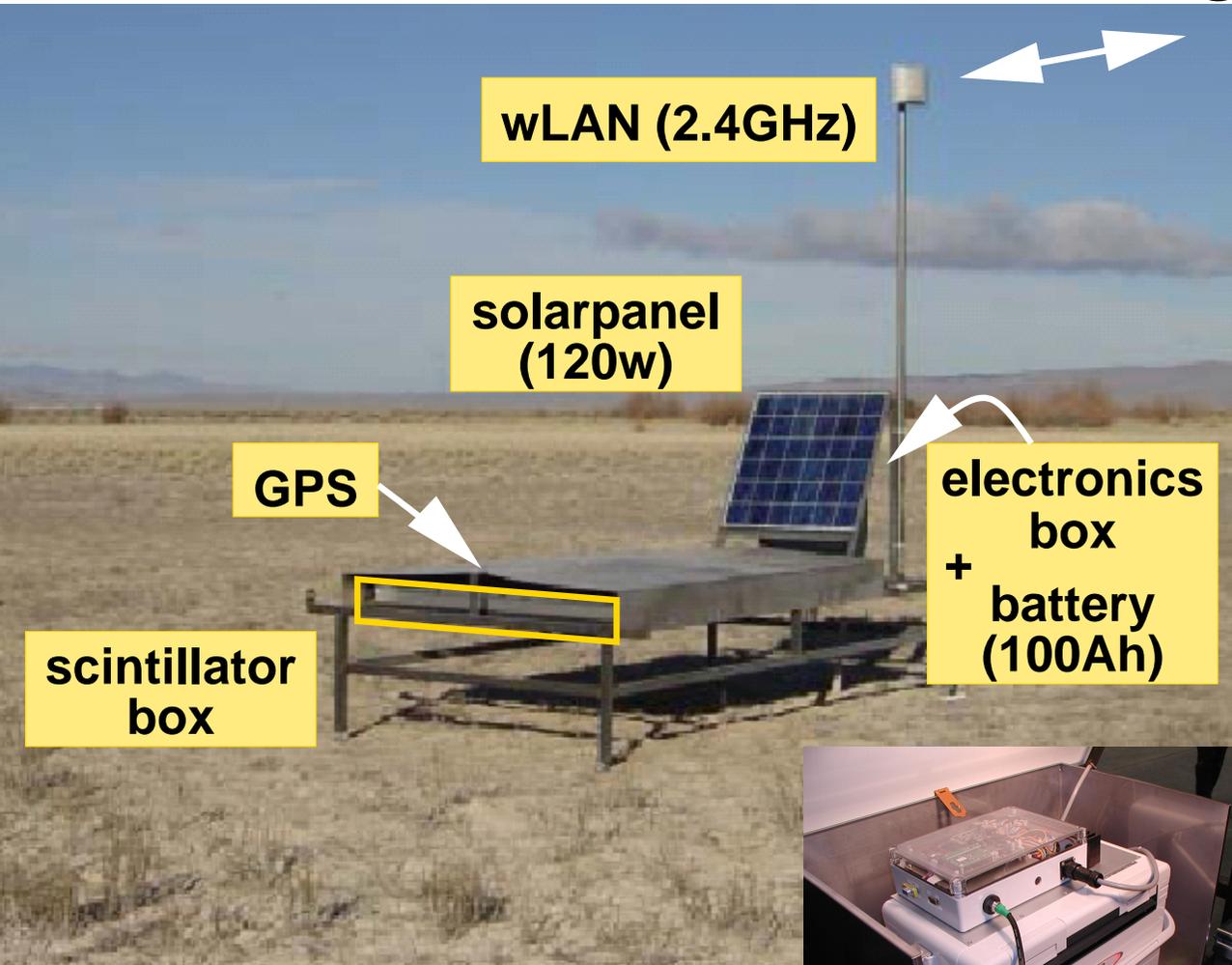
# < Detector Arrangement >

3.0m<sup>2</sup>, 1.2km grid  
507 detectors



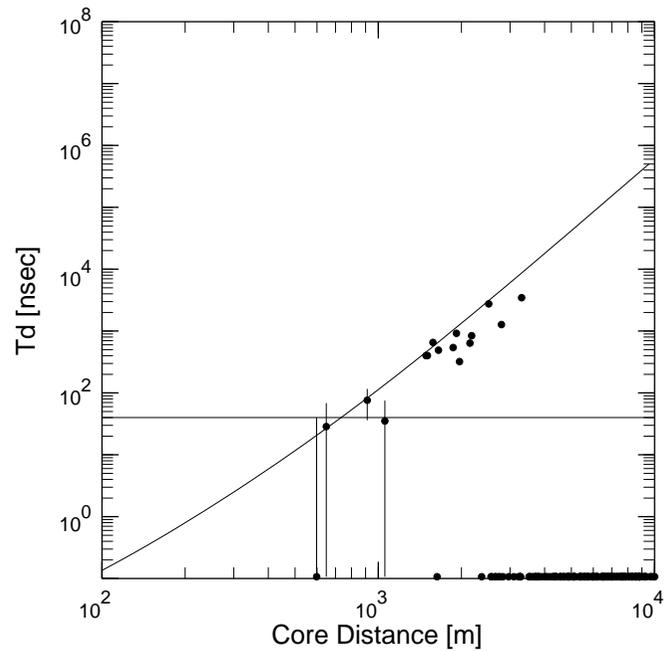
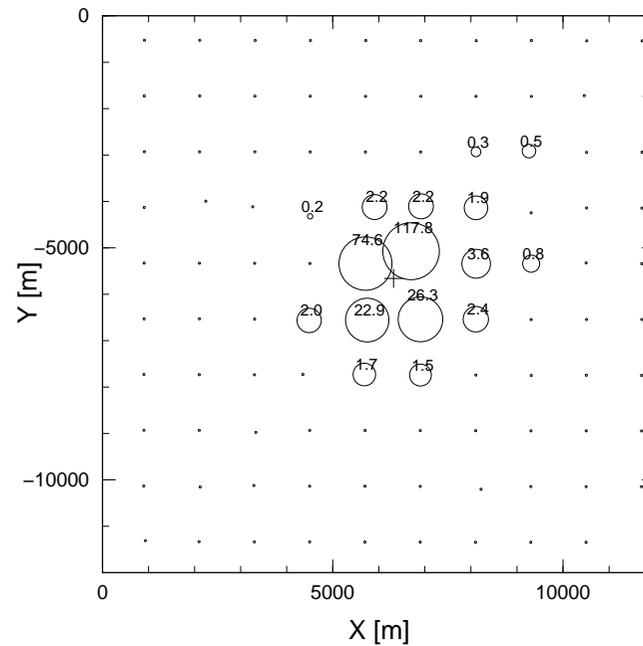
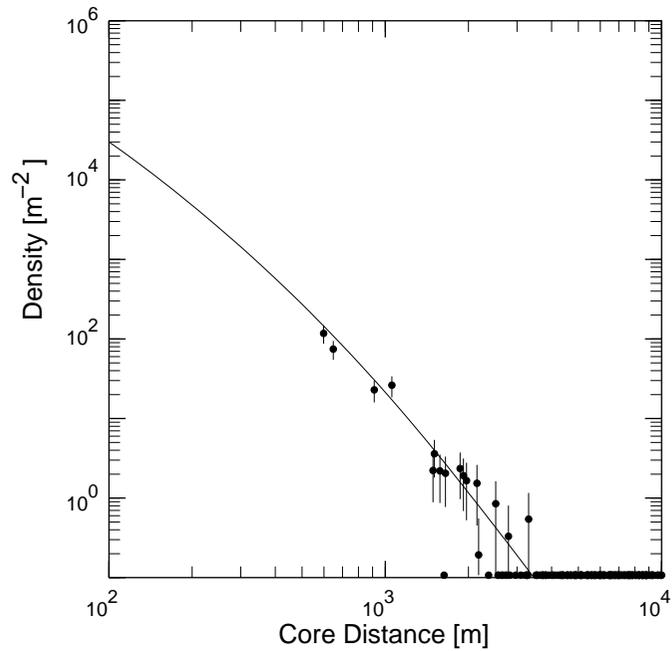
# < Surface Detector >

~200kg

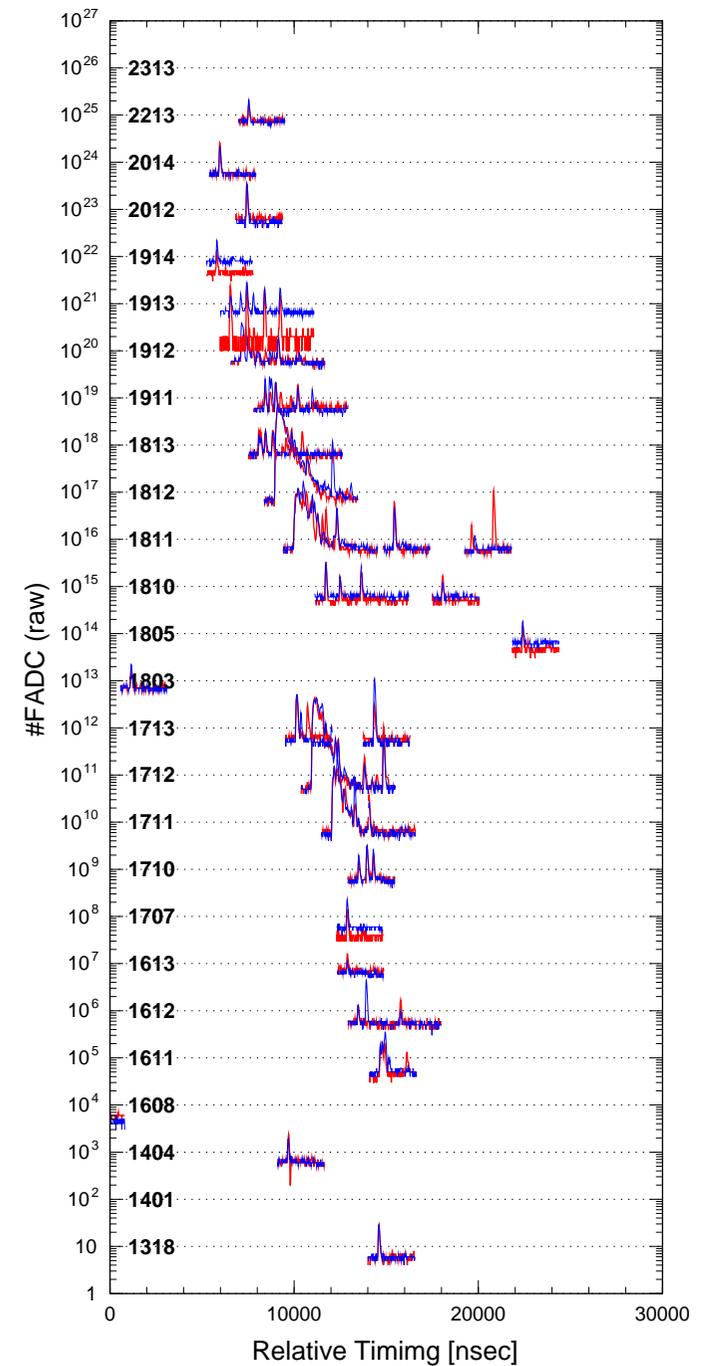


- WLSF: 1.0mm $\phi$   
(2cm separation)
- PMTs: ET 9123SA  $\times$  2
- 3m<sup>2</sup> (12mm  $\times$  2 layers)

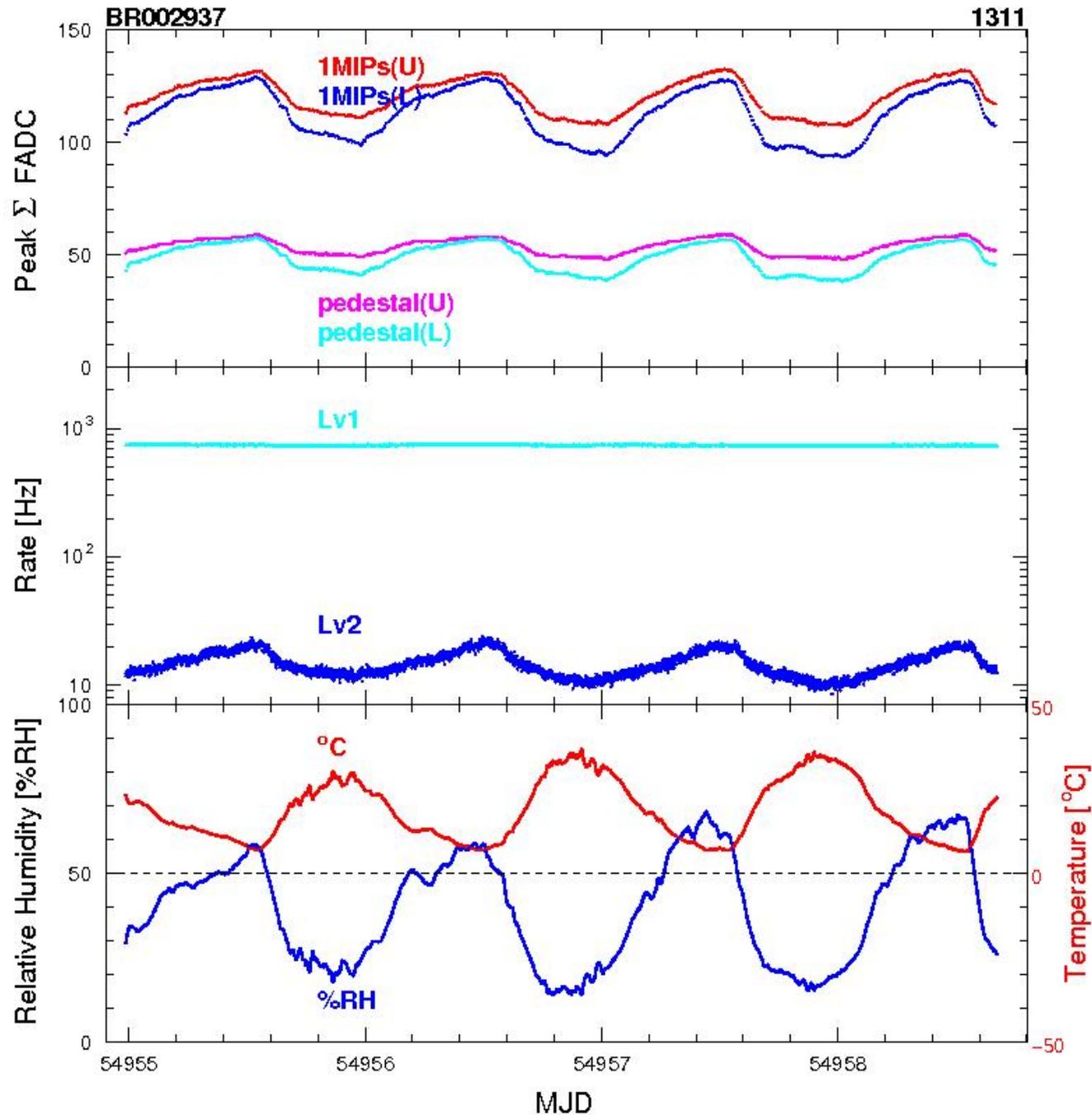
# < SD Event Example >



RUN(50141)      EVENT(2182)  
 DATE(080531)    TIME(050737)

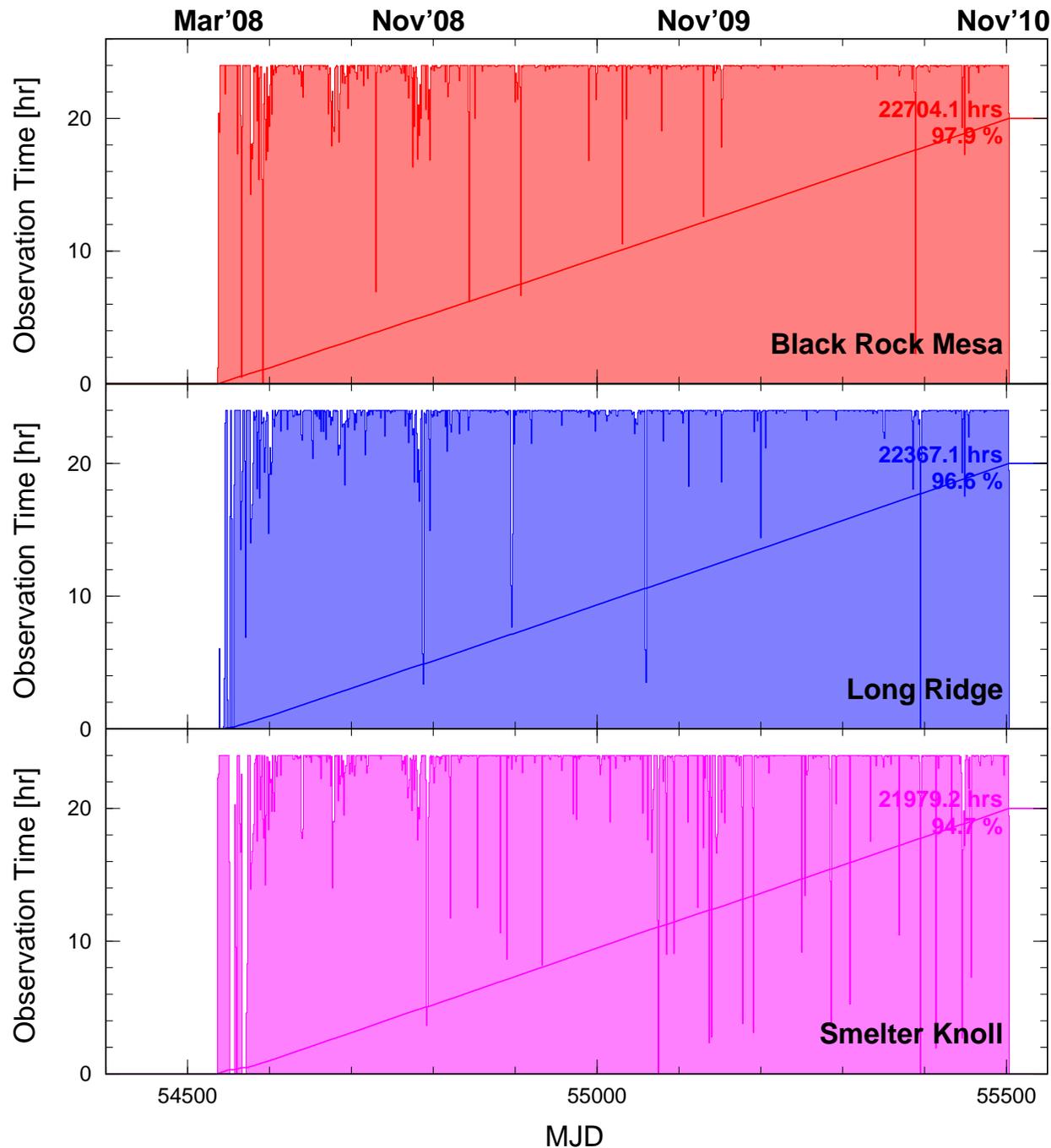


# < SD Monitor >



- 1 MIPs peak position
- pedestal position
- Level-1 trigger rate  $\simeq 700\text{Hz}$
- Level-2 trigger rate  $\simeq 20\text{Hz}$
- Temperature & Humidity in SD box
- Status:
  - solar panel
  - battery
  - GPS antenna
  - internal clock

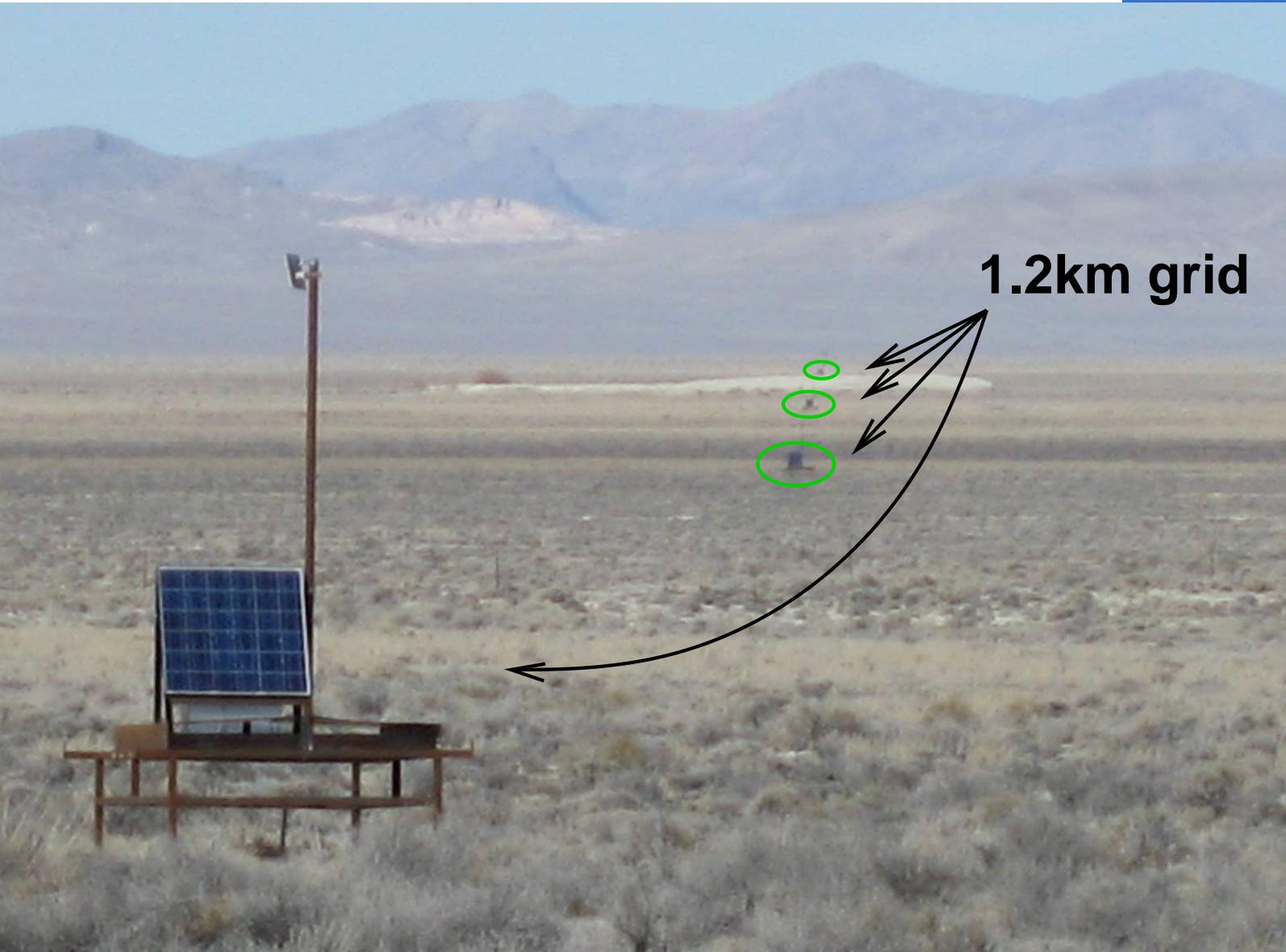
# < SD Observation Status >



- operation in stable  
     $\gtrsim 95\%$   
     $\gtrsim 22\text{k hours}$
- wLAN interference  
    in early stage
- thunder storms  
    in summer
- maintenance access  
    in autumn
- low temperature &  
    snow in winter

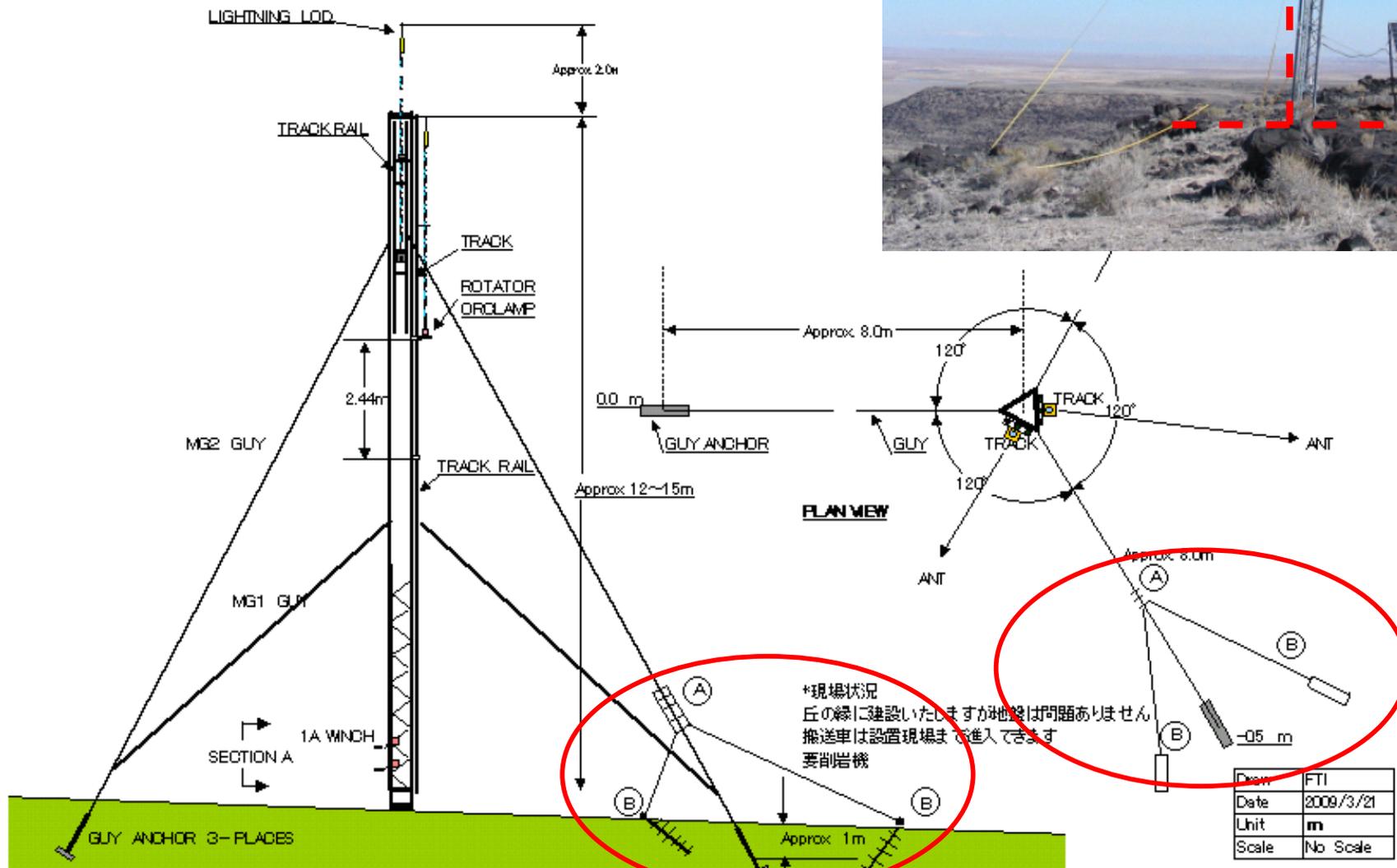
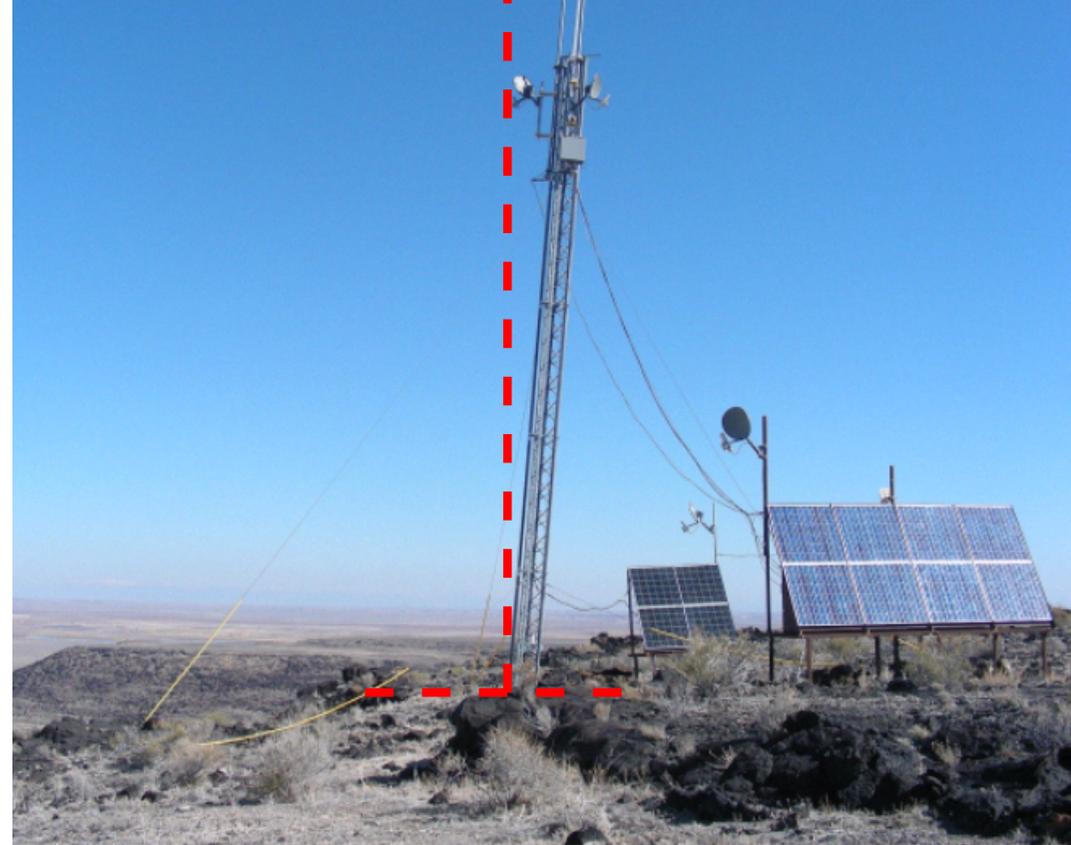
## < SD Maintenance >

- BLM restriction for Apr – Sep
- Deployment: Oct'06 – Mar'07
- Maintenance: Oct'07, Nov'08, '09, '10



# < Tower Reinforcement >

- $\geq 30\text{m/s}$  wind in winter
- Additional wiring in Jan'10



# < FD Station @ Black Rock Mesa >

Azm:  $18^\circ \times 6 = 108^\circ$

Elv:  $3^\circ \sim 18^\circ$  (Upper)

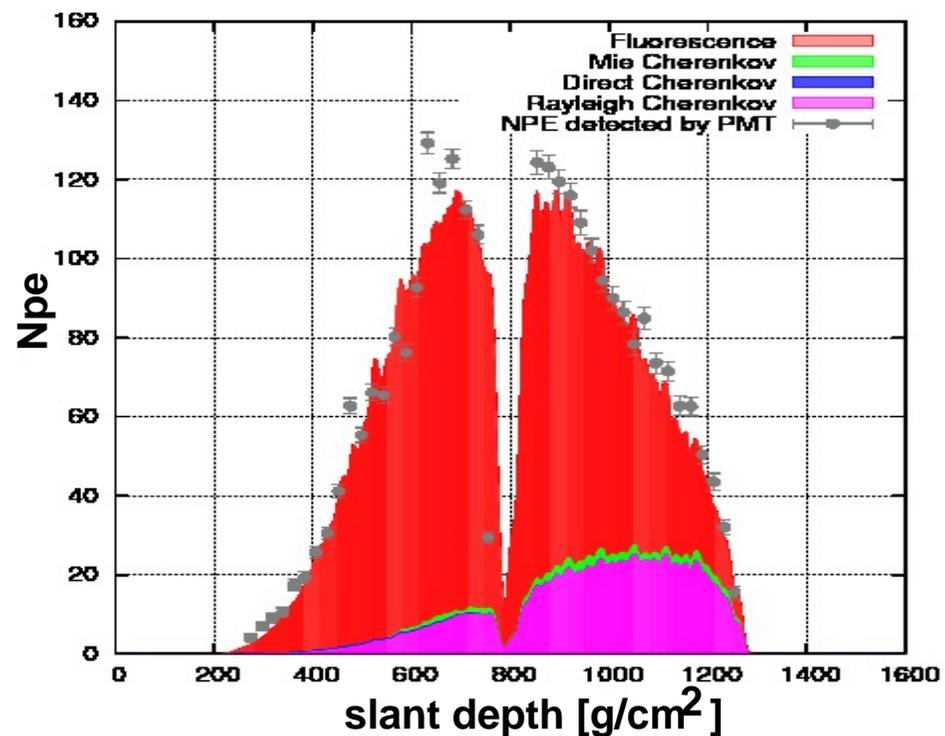
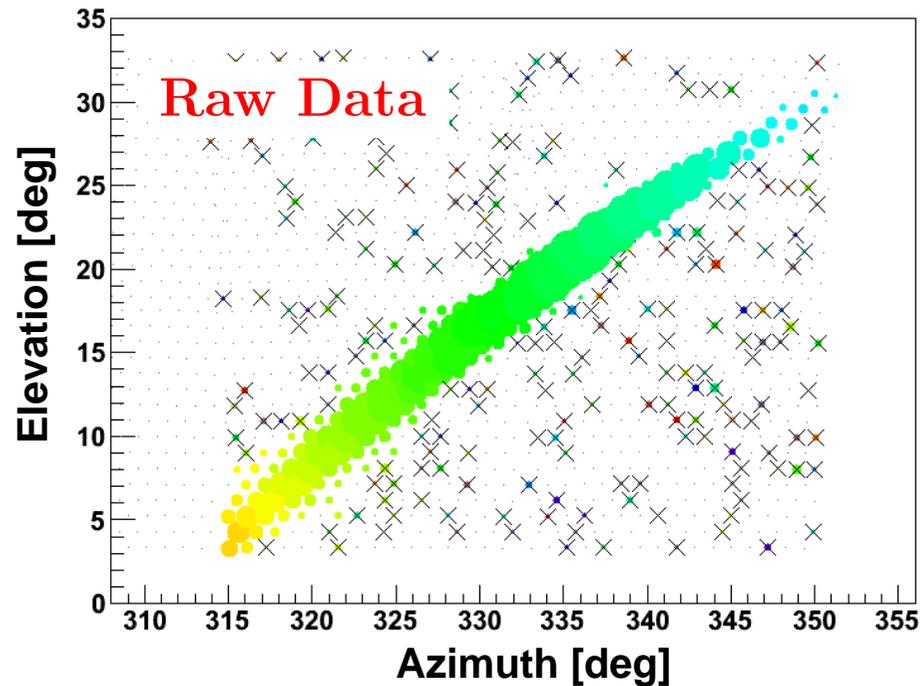
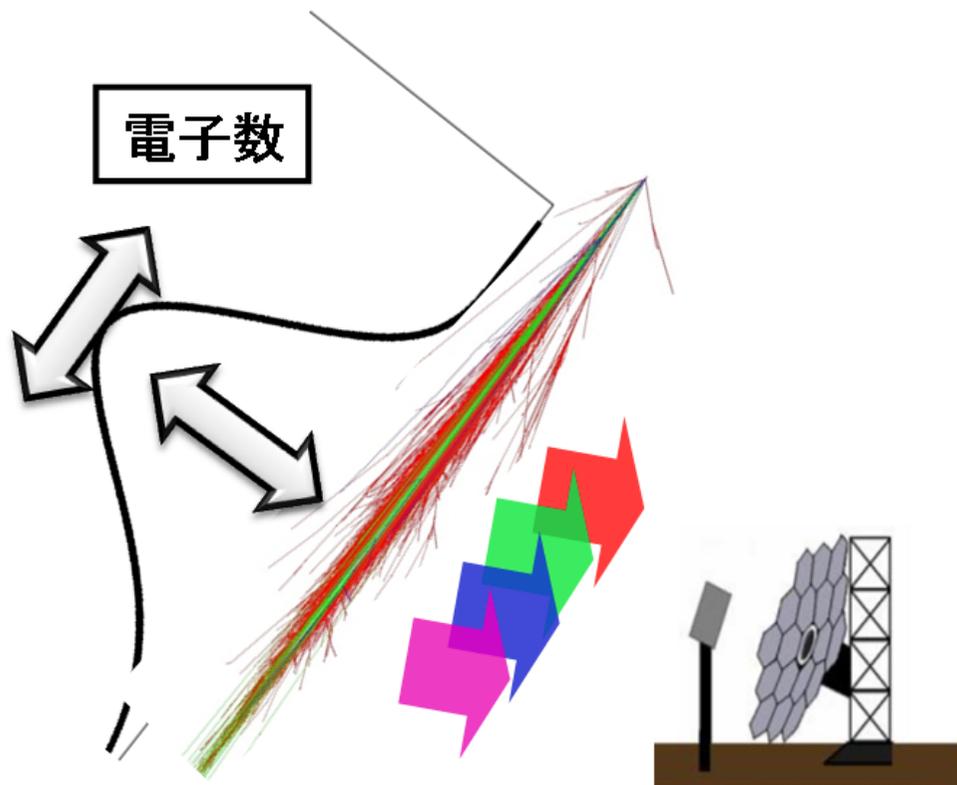
$17.7^\circ \sim 33^\circ$  (Lower)



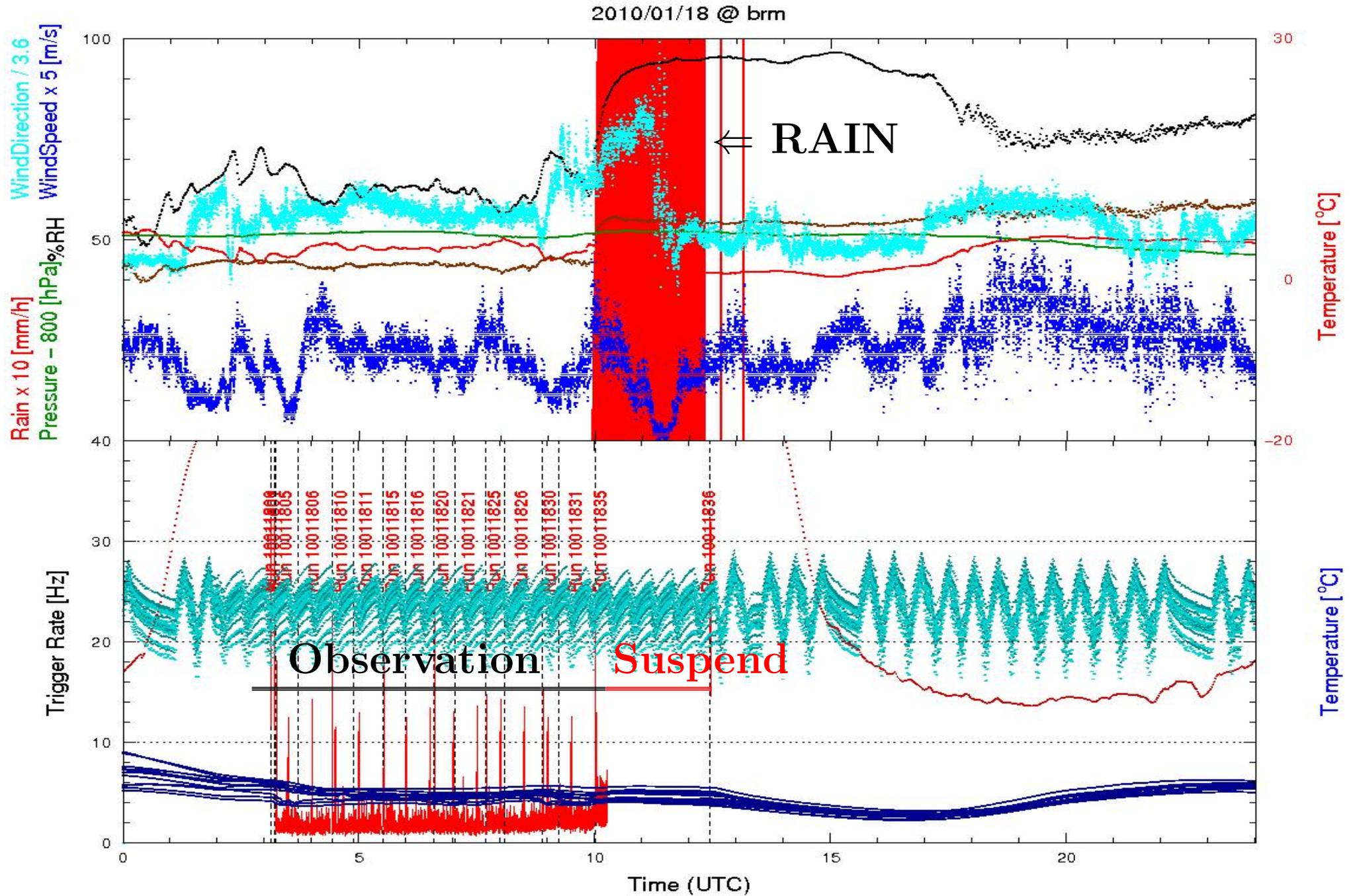
# < FD Event Exsample >

- Event-reconstruction with a set of 'simulated' events including
  - shower profile
  - atmonsphere
  - detector performance

↑ Inverse Monte Carlo method

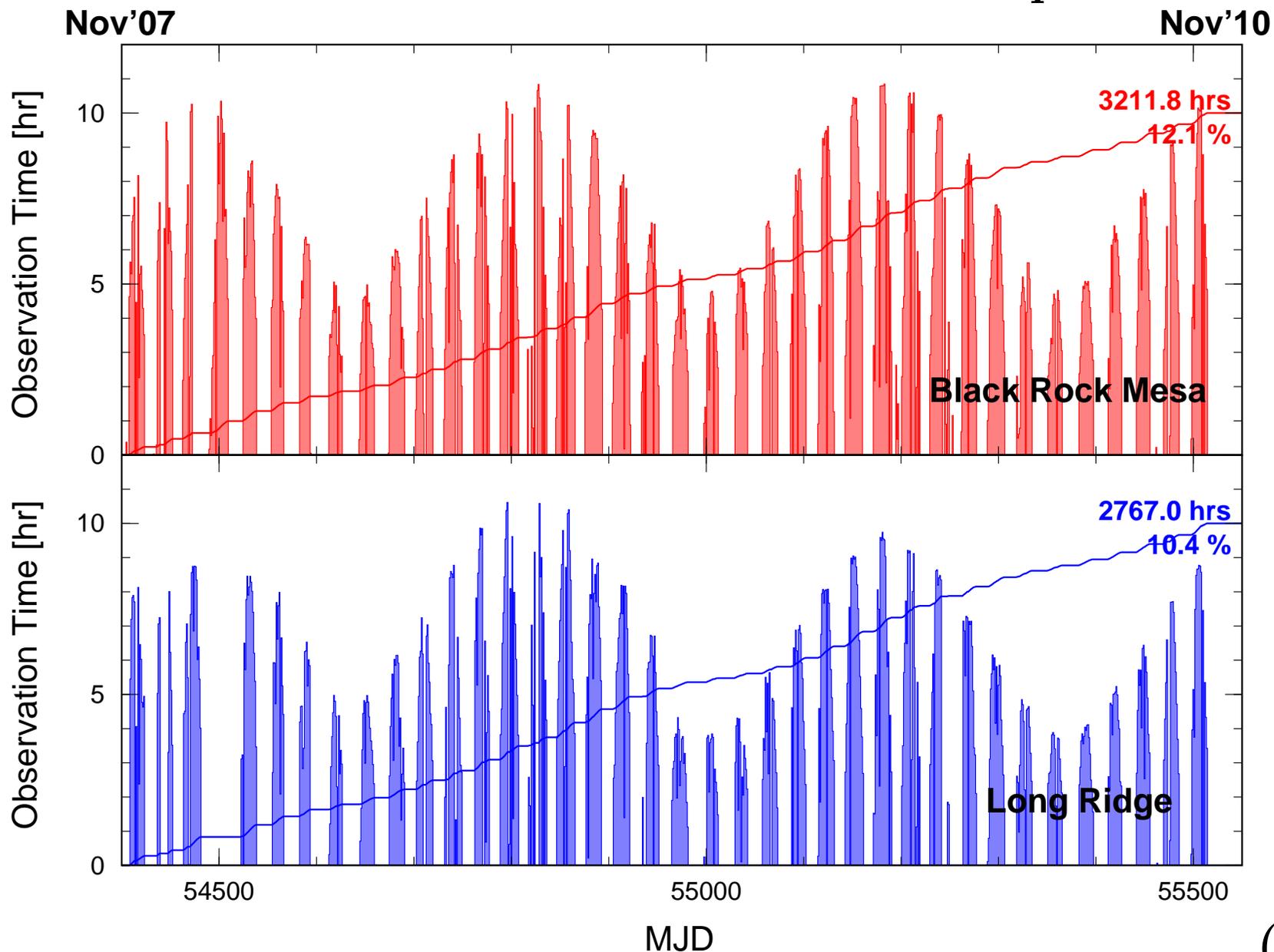


# < FD Environmental Monitor >



# < FD Observation Status >

● Full operation since Nov '07



●  $\gtrsim$  3.2k hrs

●  $\gtrsim$  2.7k hrs

(Duty:  $\sim$  10%)

● Long Ridge remote operation since May '09

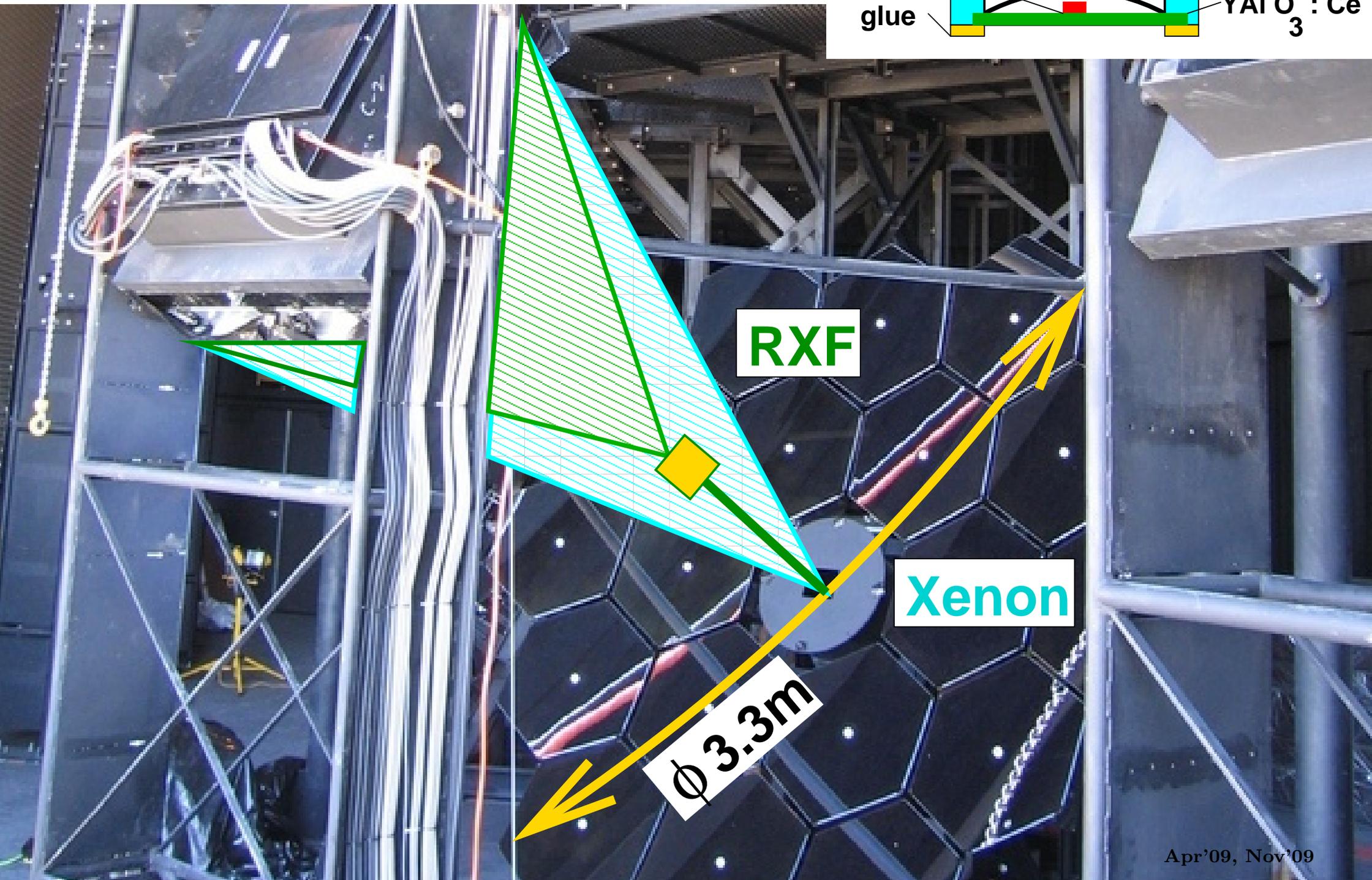
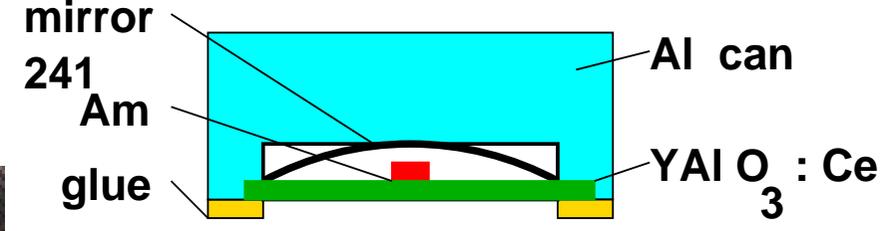
## < FD Maintenance >

- Downspout and wall was broken with  $\approx 12\text{m/s}$  wind
- Generators were replaced ( $\approx 20\text{k}$  hours operation)

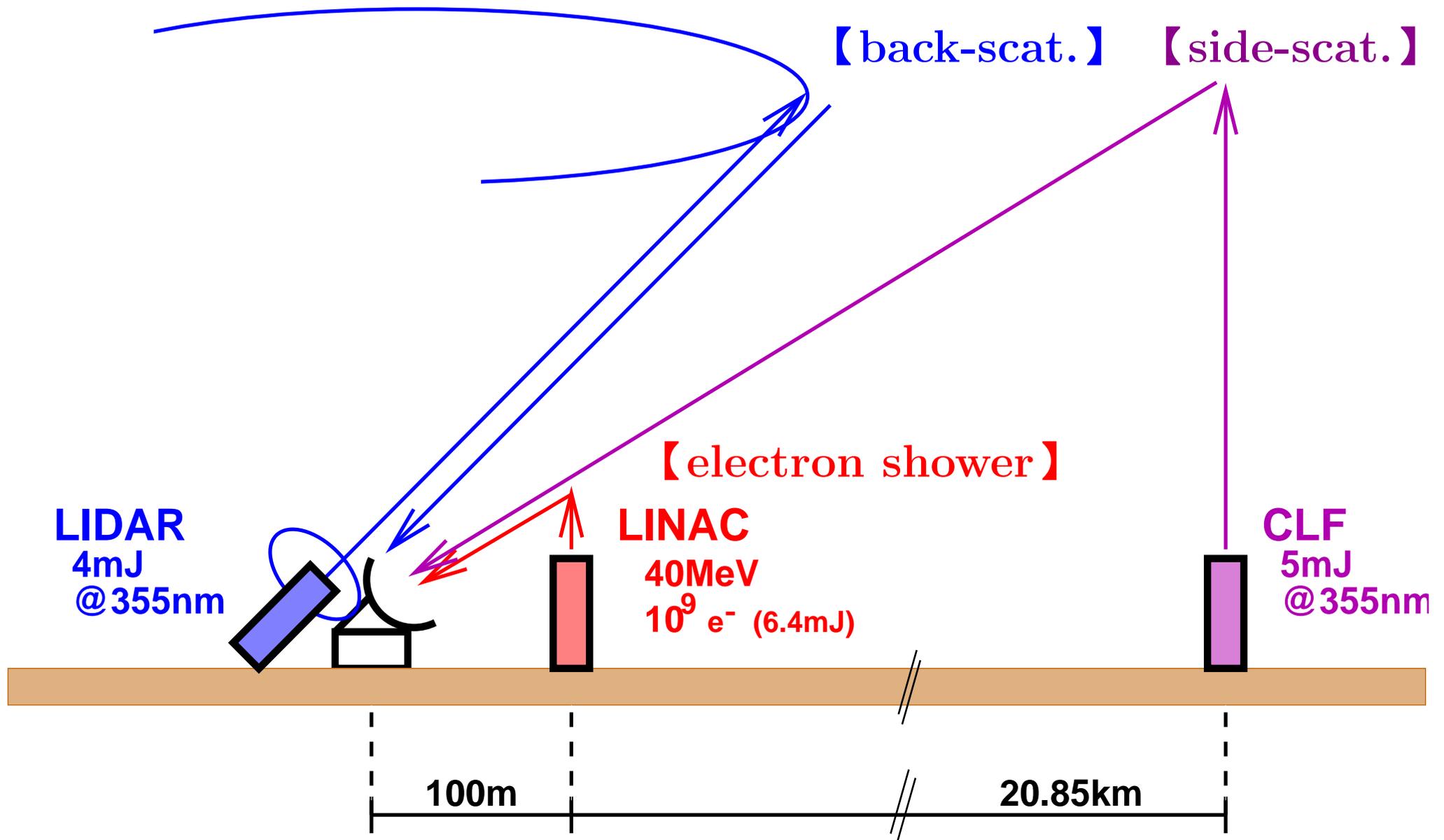


2009.10.28 18:13

# < FD Calibration >



# < Atmospheric Monitor (LIDAR, CLF) & LINAC >

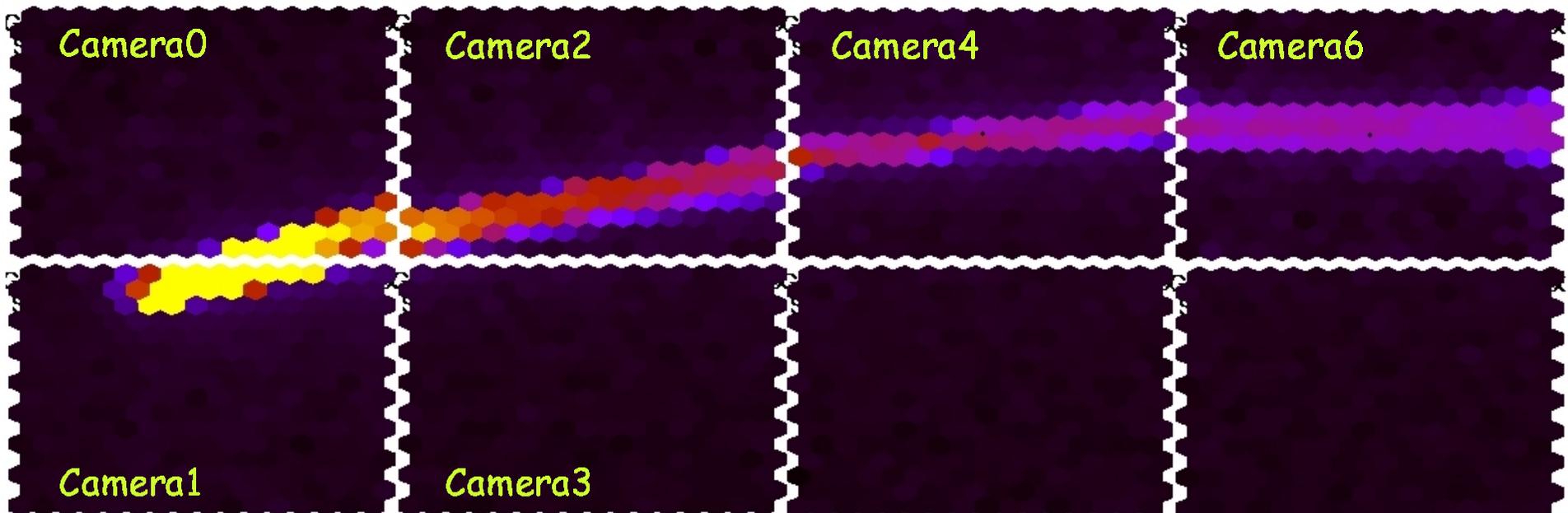


# < LIDAR system >

- Operating at Black Rock Mesa



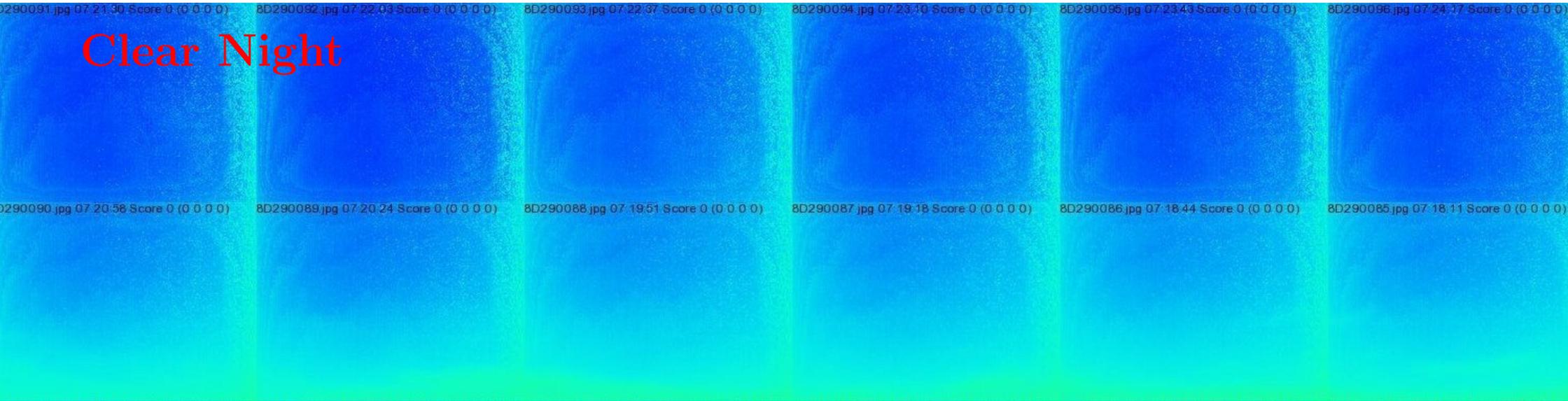
Mirror :  
30cm $\phi$   
Nd YAG :  
355nm  
4mJ(max)



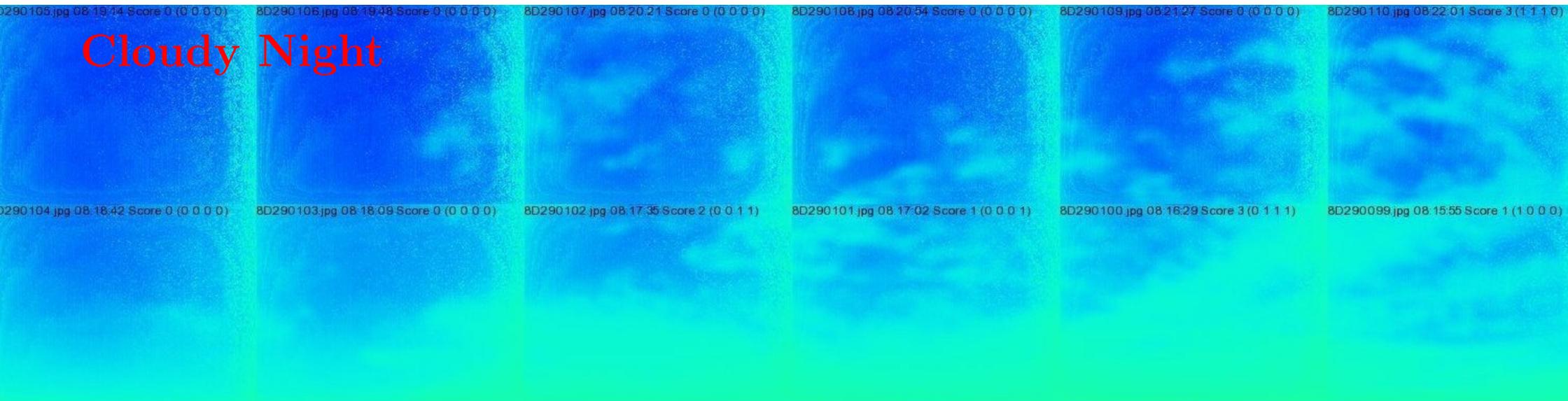
# < Cloud Monitoring >

- IR camera ...  $8\mu\text{m}$ – $14\mu\text{m}$  ( $-20^{\circ}\text{C}$ – $300^{\circ}\text{C}$ )
- Confirm WEAT code (Eye Scan)

Clear Night



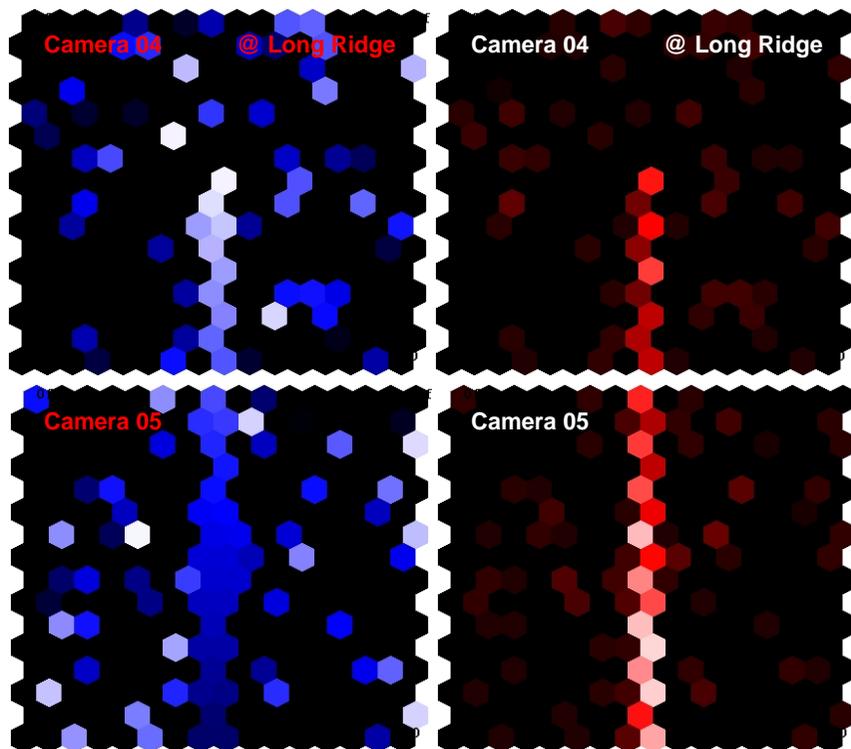
Cloudy Night



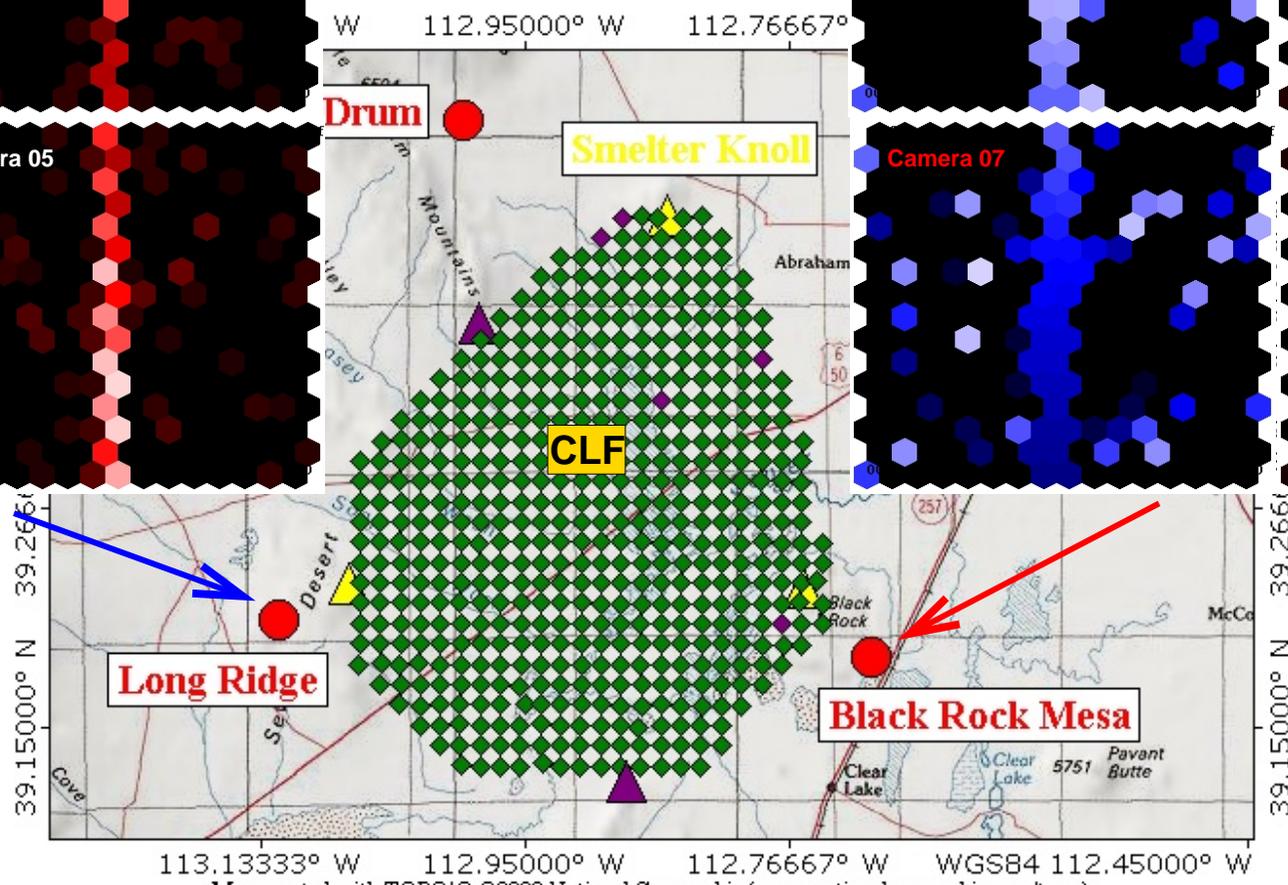
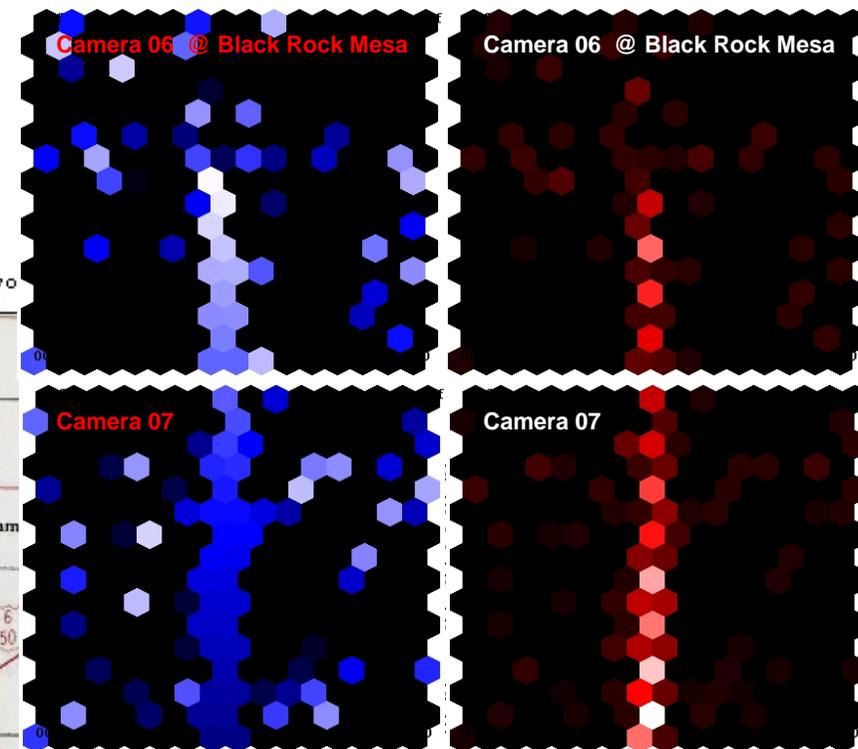
# < Central Laser Facility >

- Standard Light for three FD stations)
- Steerable Nd:YAG laser 355nm 5mJ

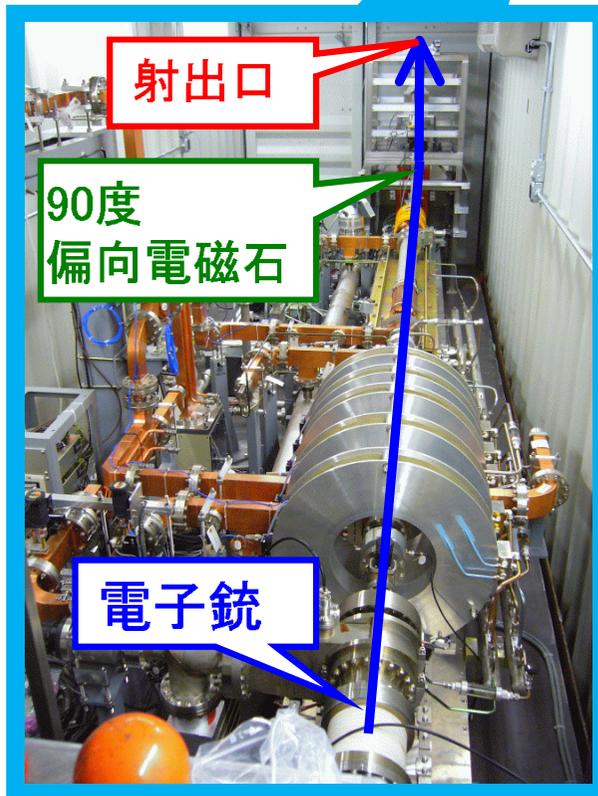
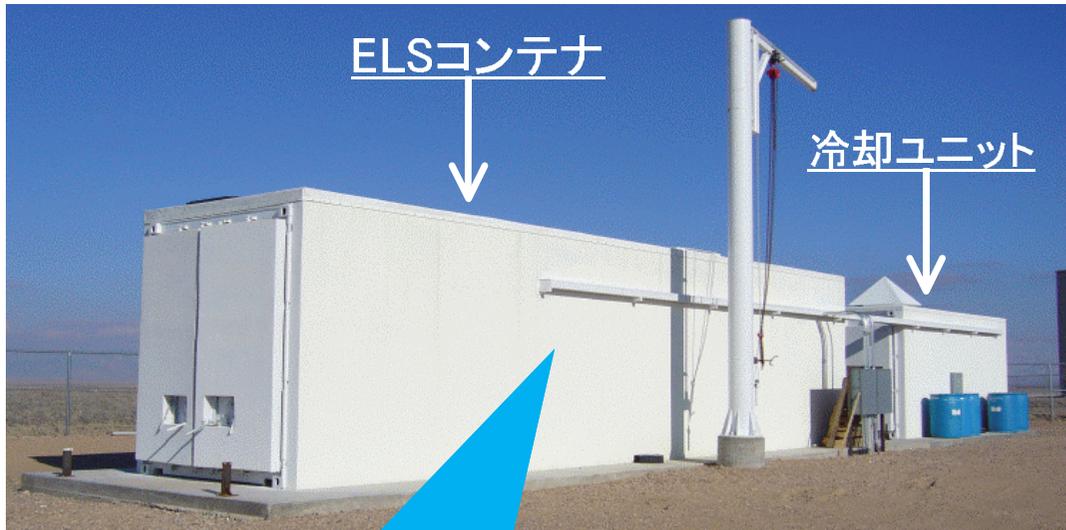
## Long Ridge



## Black Rock Mesa



# < TA-LINAC (ELS) >



## ● Specification

- Energy 40MeV ( $\Delta E/E \leq 1\%$ )
- Charge  $10^9 e^- / \text{pulse}$  ( $\pm 6\%$ )
- Beam Width 1  $\mu\text{sec}$

## ● Transfer troubles

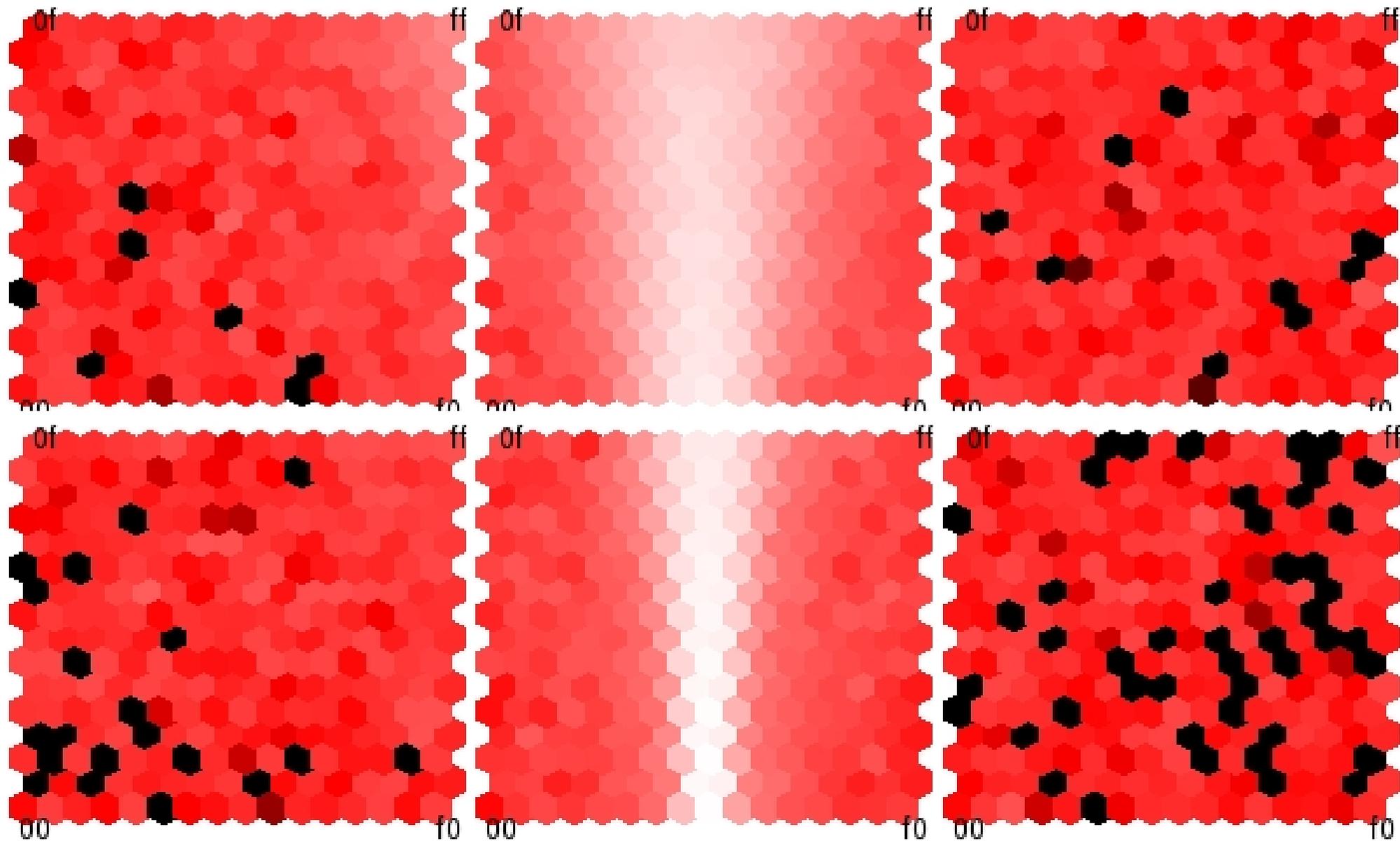
- Klystron broken replaced
- Vacuum leak fixed
- Operation application approved

## ● First shooting

- Sep '10

# < ELS Event (charge map) >

• 2010/09/04 04:01UTC



41.4MeV , 40-140pC/pulse , 0.5Hz

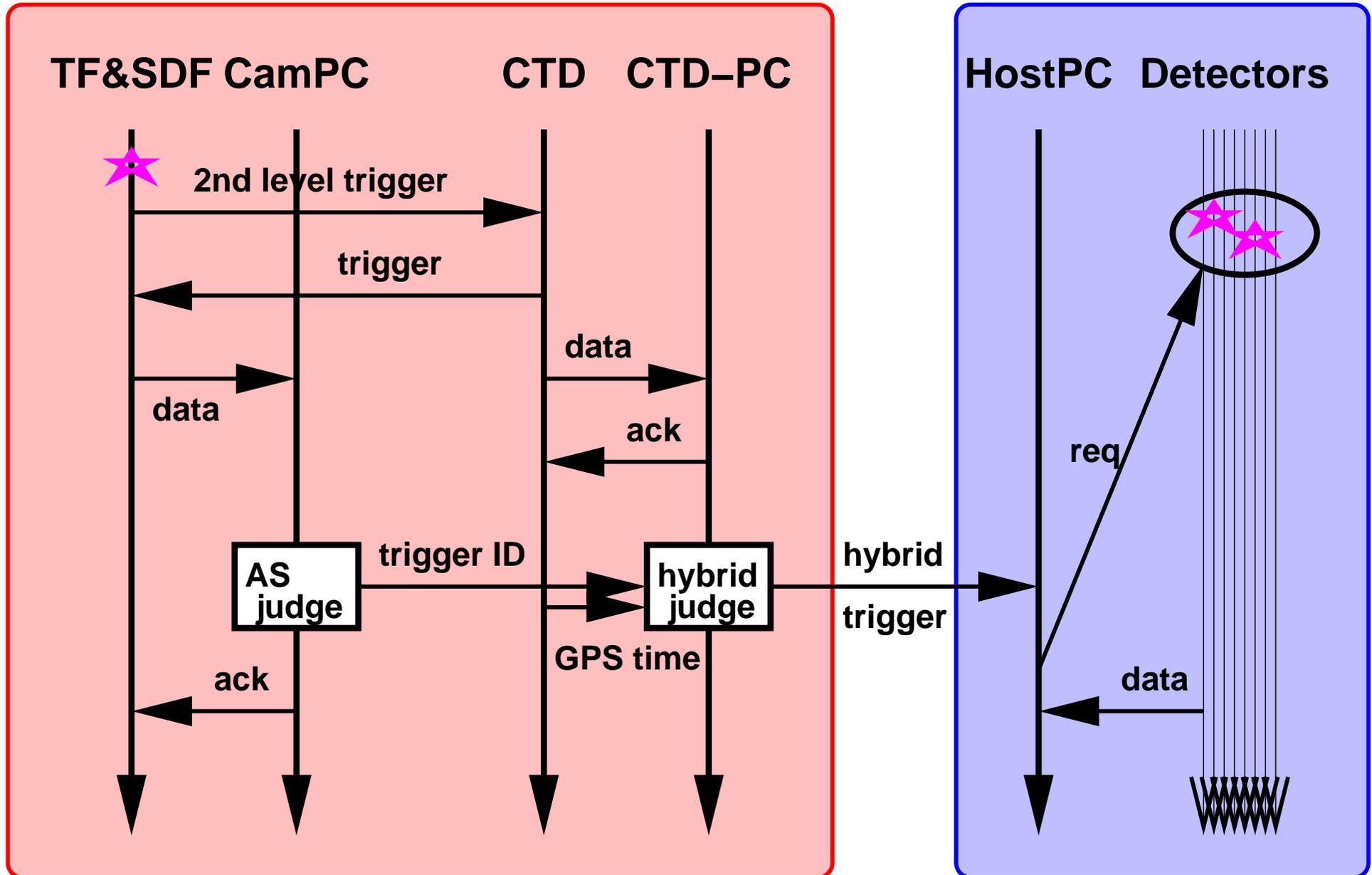
# < Hybrid-trigger Starts >

Oct.'10 ~

- Improve FD Low Energy Reconstruction with SD data

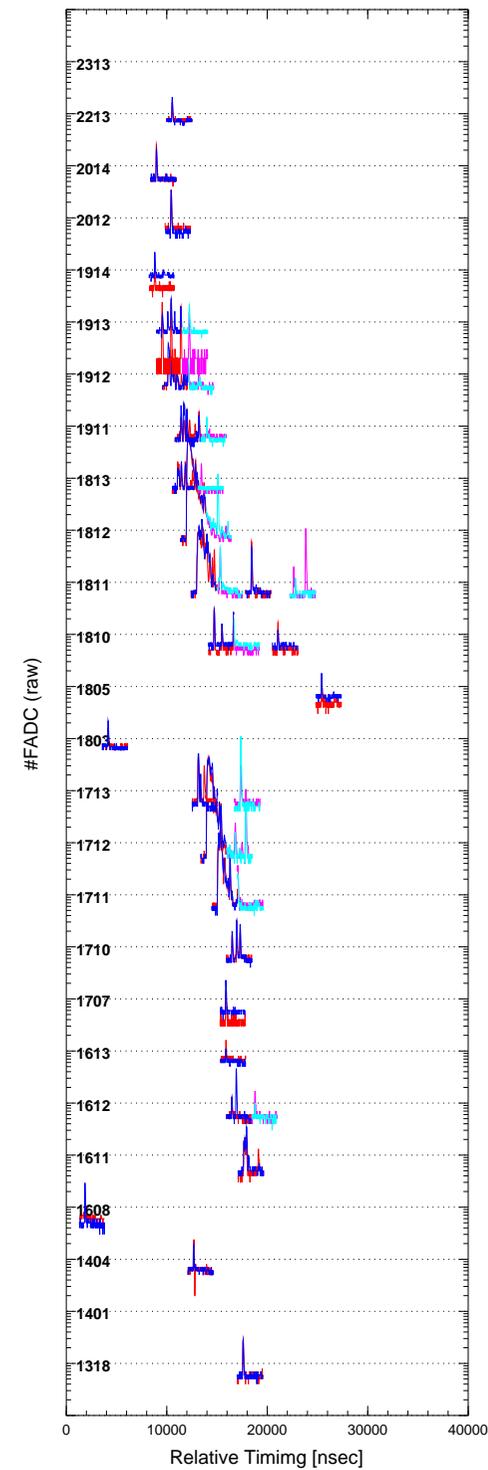
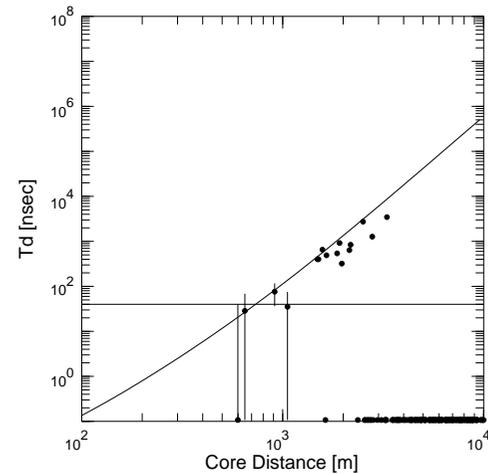
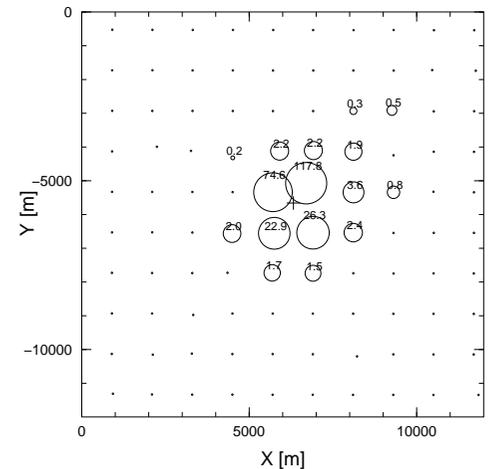
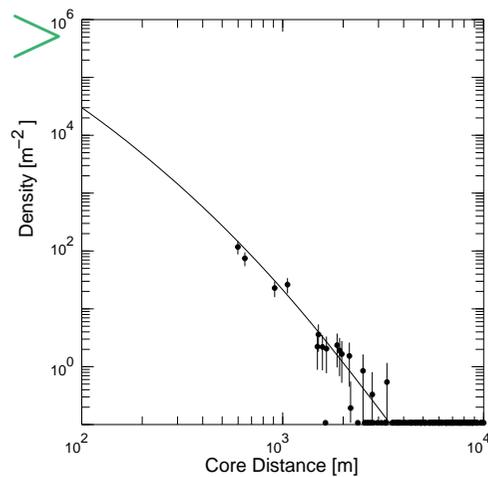
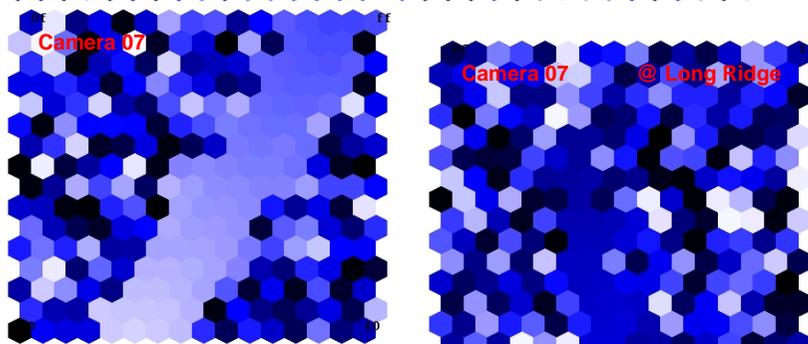
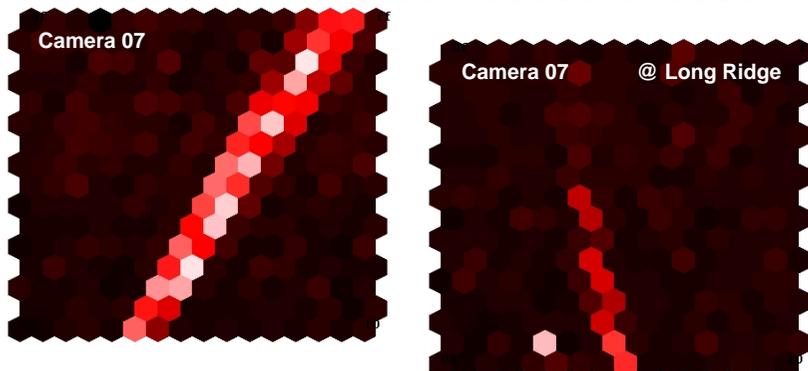
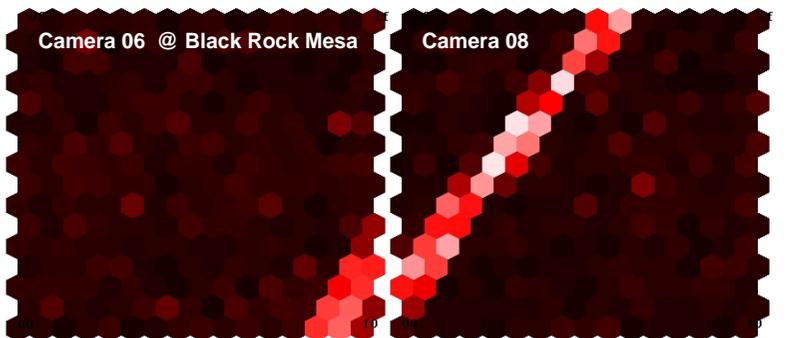
**FD**

**SD**

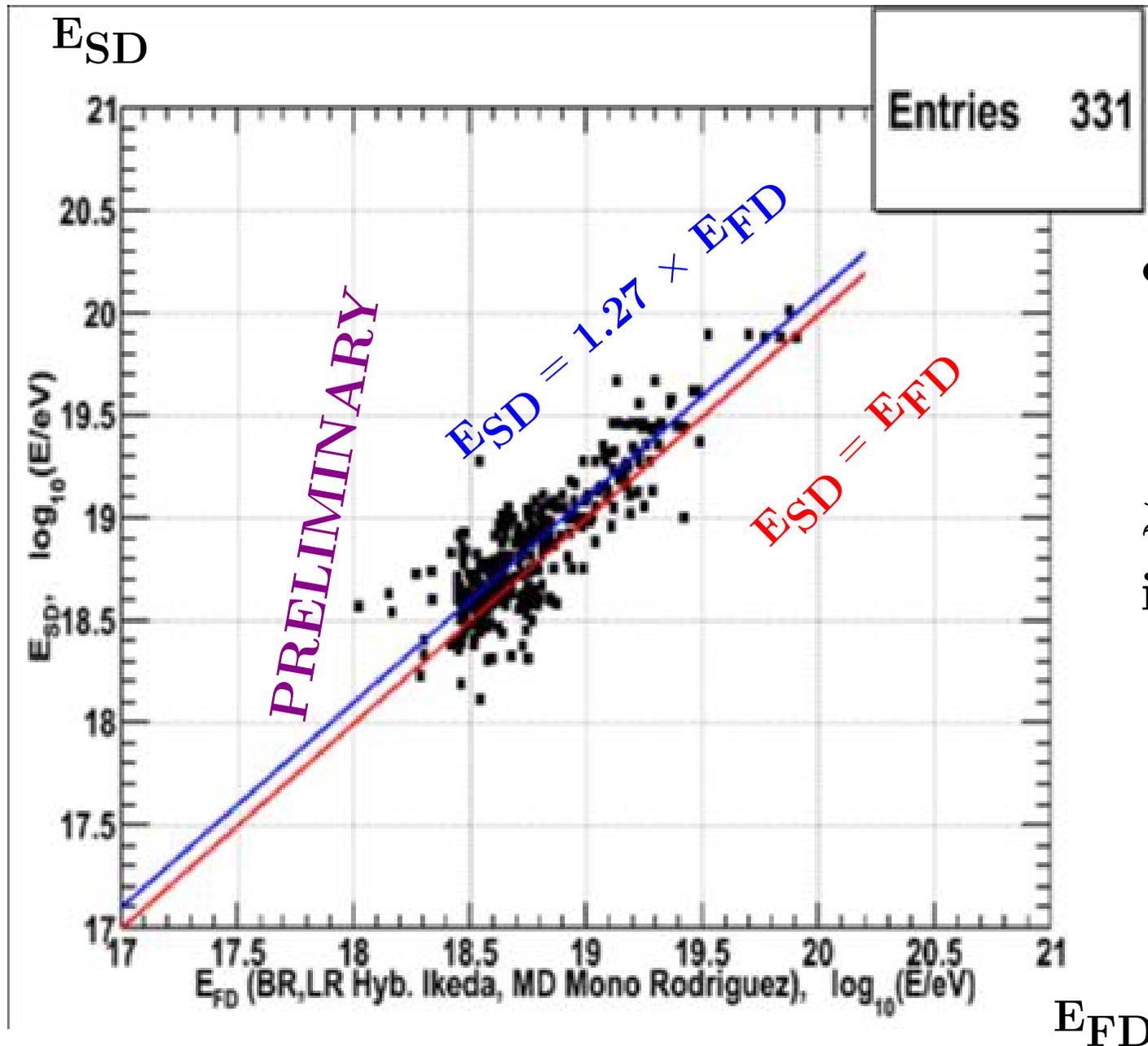


# < Hybrid- & Stereo- Event >

● 2008/05/31 05:07 UTC



# < FD-SD Energy Comparison >



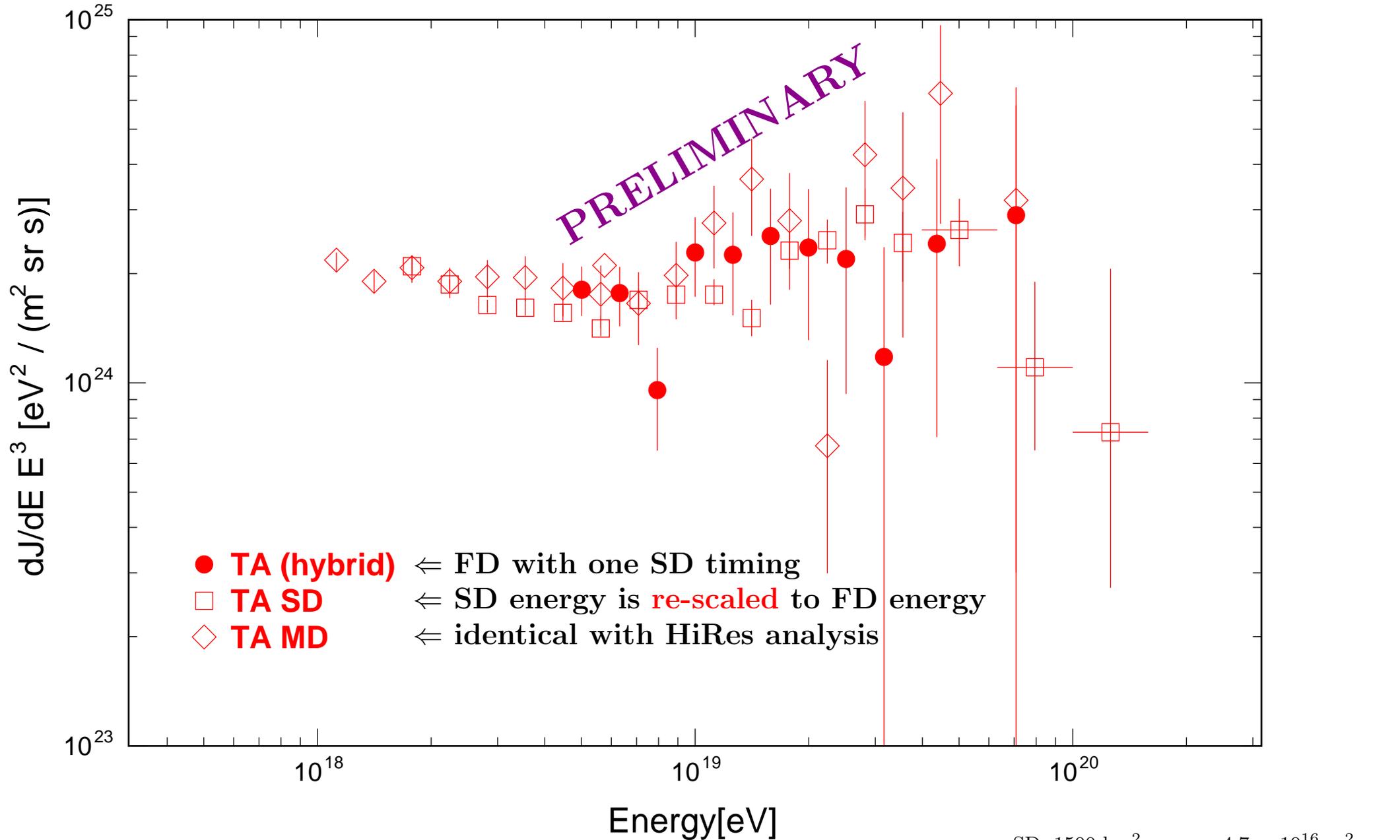
- SD energy is reduced by  $1/1.27$



$\approx E_{\text{HiRes}} / E_{\text{AGASA}}$   
in "unified" spectrum

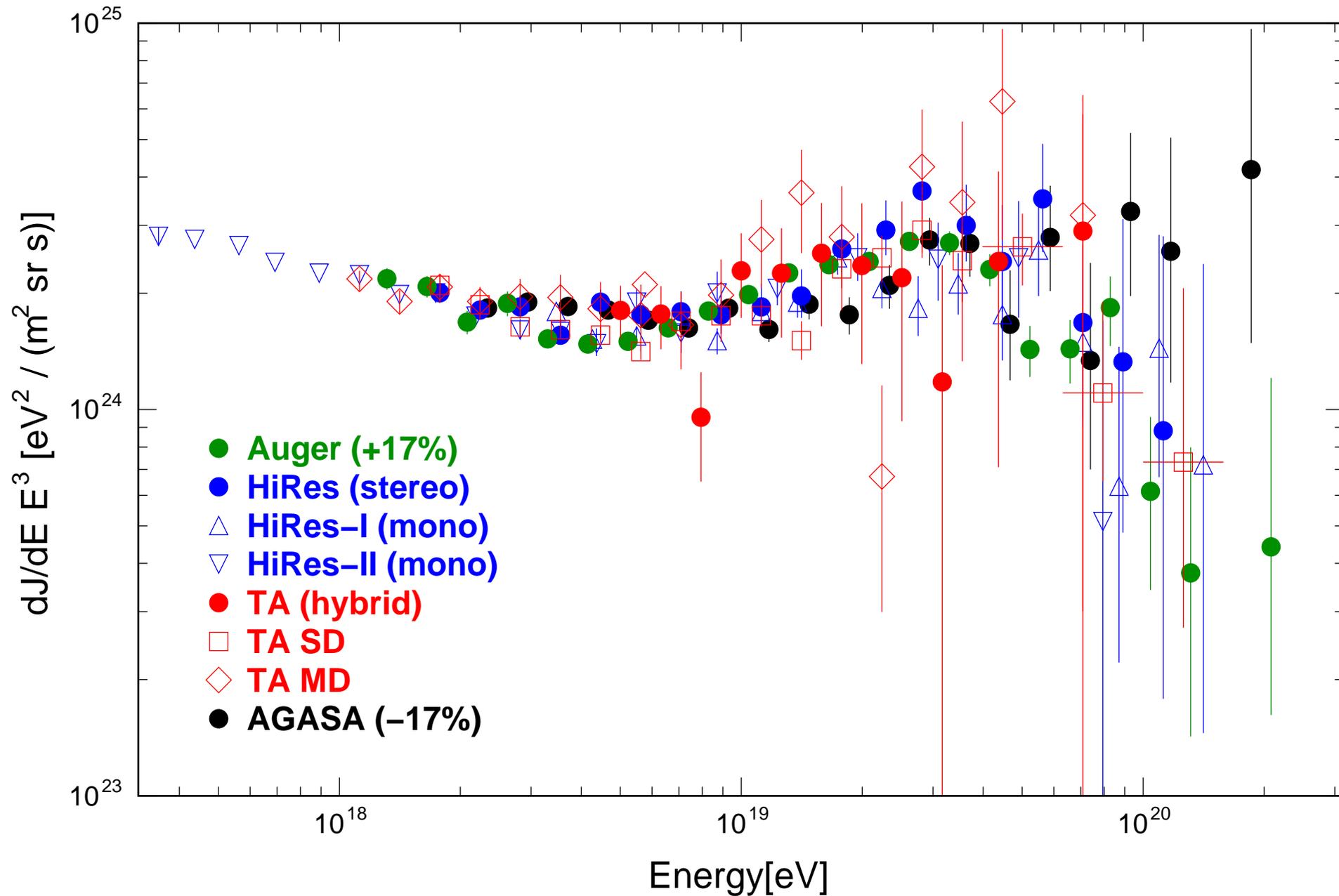
# < Preliminary Energy Spectrum >

- FD-MD, FD-hybrid, SD spectra are consistent with each other.



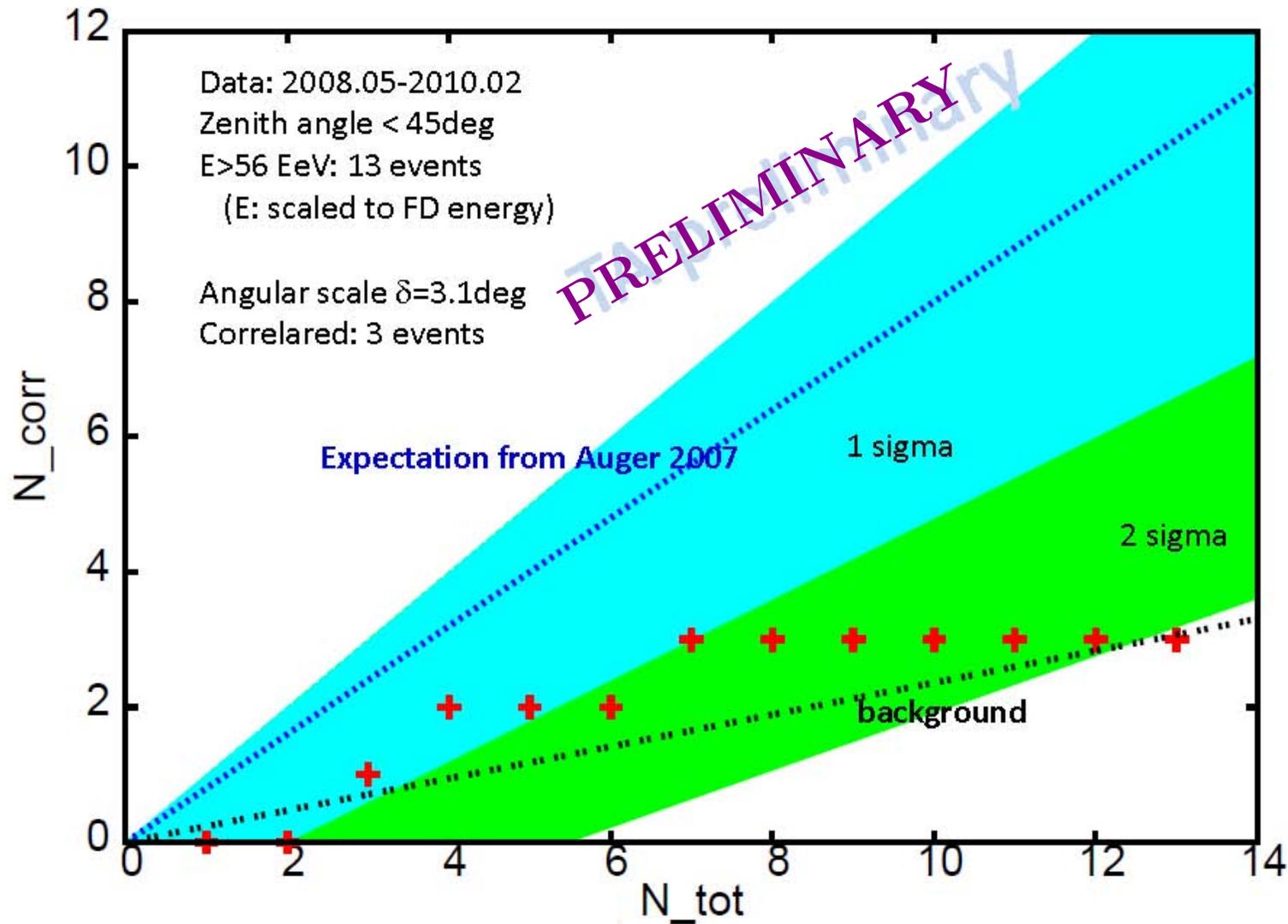
# < Unified? Energy Spectrum >

- roughly normalized at  $10^{19}$  eV



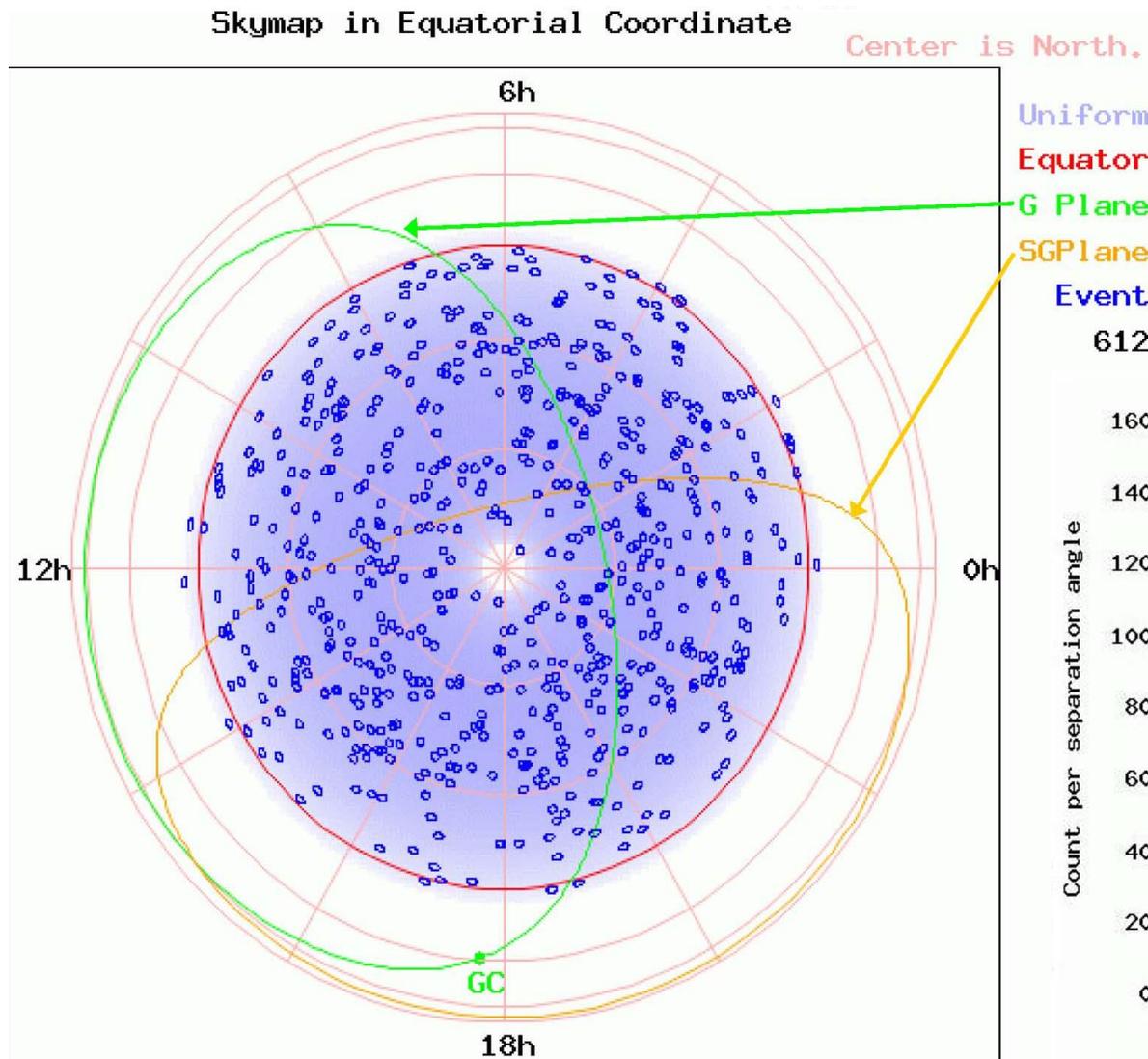
# < AGN correlation >

$E \geq 56 \text{ EeV}$



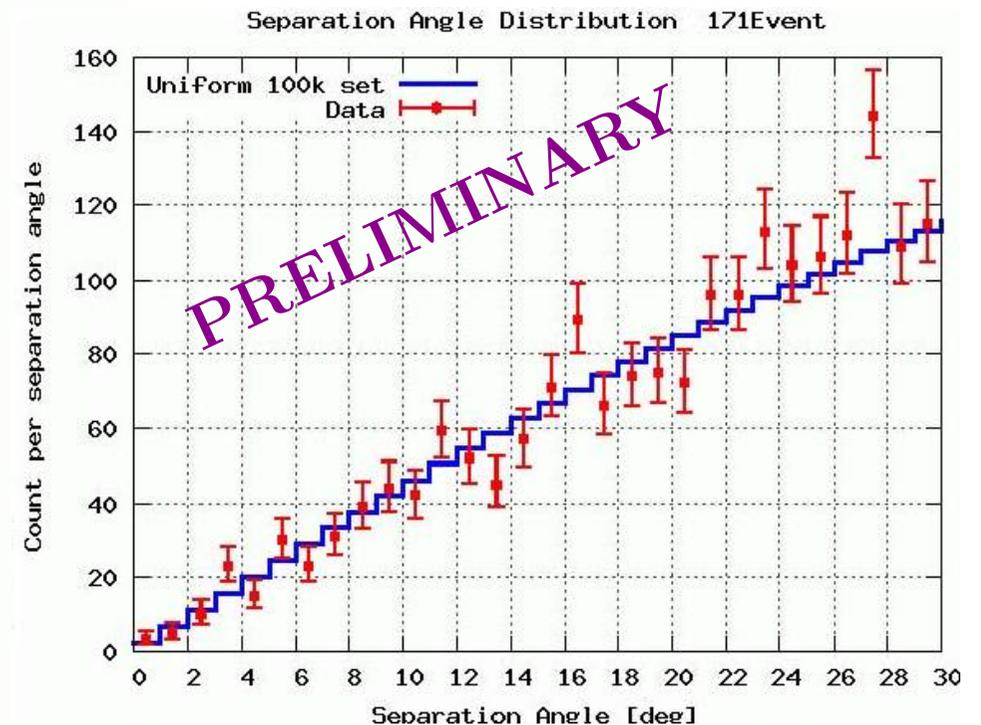
⇒ Consistent with "background" level  
( re-scaled SD energies )

# < Clusters (self correlation) >



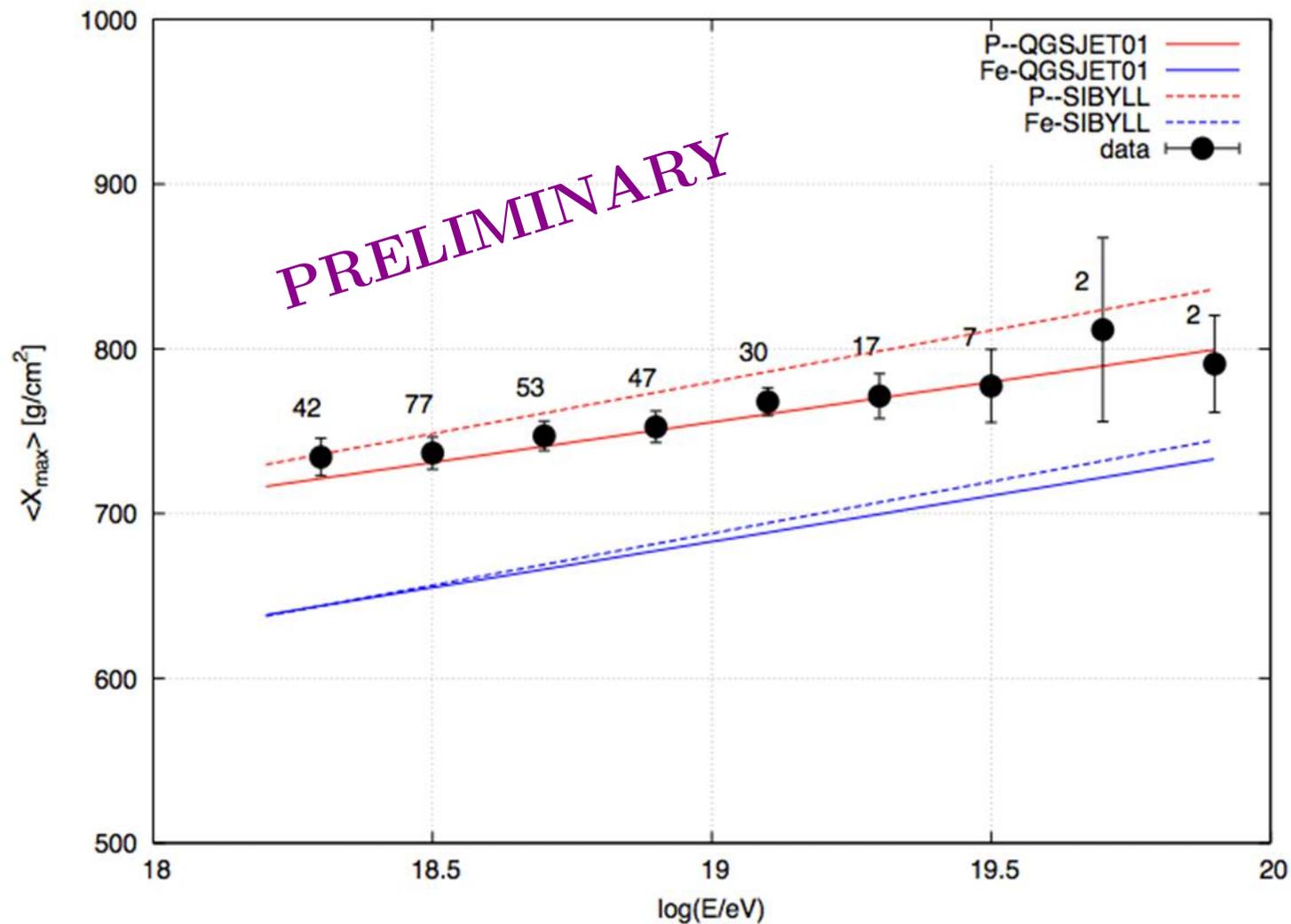
$$\Leftarrow E \geq 1 \times 10^{19} \text{eV}$$

$$\Downarrow E \geq 2 \times 10^{19} \text{eV}$$



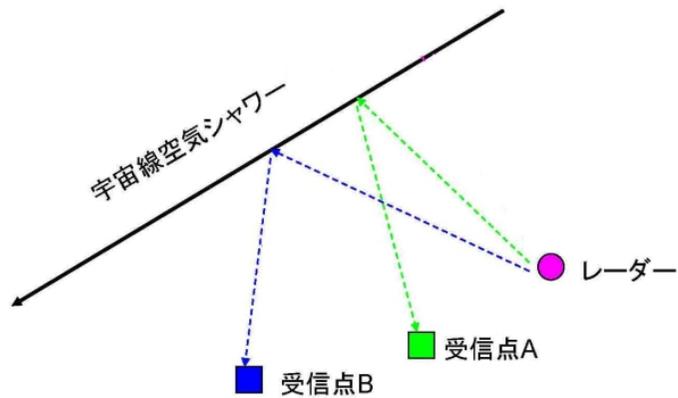
⇒ Consistent with **uniform distribution**  
( re-scaled SD energies )

# < $X_{max}$ distribution >



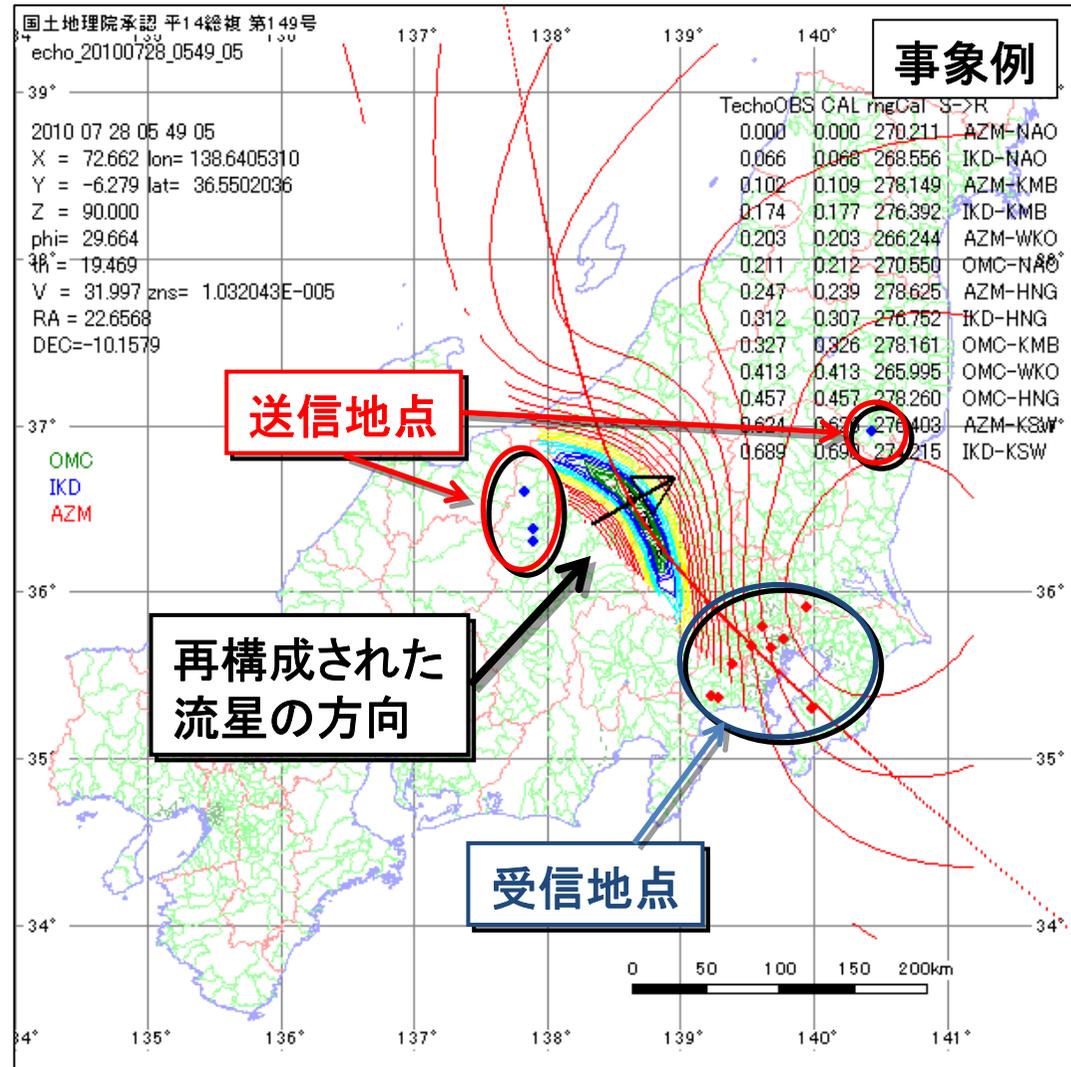
⇒ Consistent with **Proton primary**  
( Energy and  $X_{max}$  are **reconstructed** value. )

# 電波エコーによる空気シャワー観測



多地点同時流星観測プロジェクトに本年から柏も参加  
送信: 4ヶ所、受信: 9ヶ所

- 50MHz帯の電波を送信し、空気シャワー通過後に形成される電子柱における反射を受信
- 本手法は流星観測にて確立済
- 反射条件を満たした受信器のみ受信できる
- 多地点受信で、
  - シャワー軸の再構成
  - 空気シャワー縦発達の観測
- 多地点送信で実効観測点数の増加



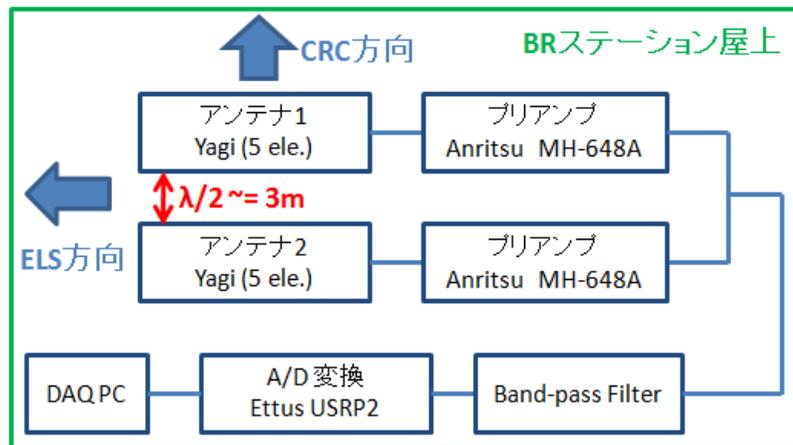
# ELSによる手法の確立

TA実験のELSで形成された疑似空気シャワーを用いて本観測手法を確立する

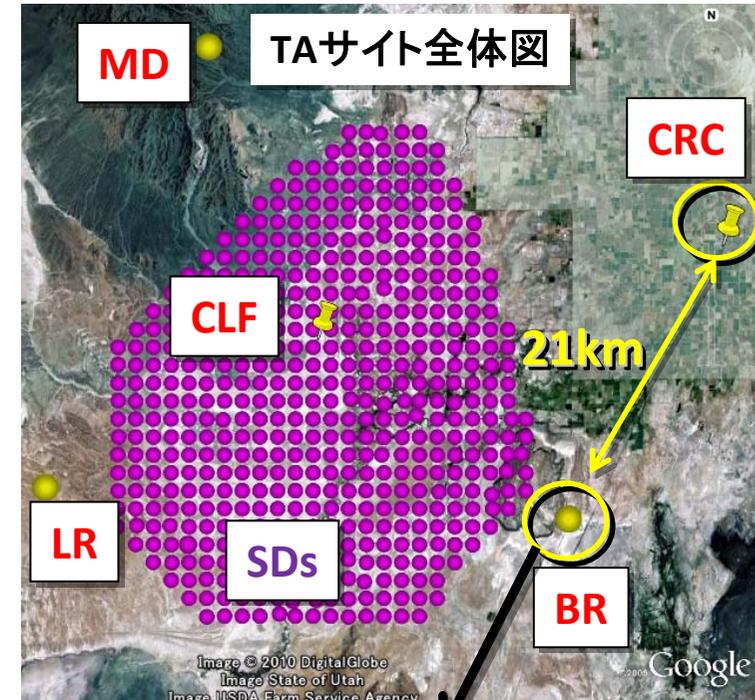
送信器: 米国TV局(旧アナログ2ch)で使用された、出力2kW, 20kWの二つの送信器

受信器: 5エレメント八木アンテナ×2(設計済)

- CRCに送信器を設置し、21km離れたBRステーションにてELSからのエコーを測定
- CRC-BR間とELS-BR間の角度が90度であることを利用して、送信波の直接受信量を減少させる。



15分の測定で、S/N比30でELSシャワーを観測



## < TA Status Summary & Schedule >

- DAQ systems have fully operated since March 2008, and they work in stable.
- DAQ systems were further improved for
  - ELS (TA-LINAC) shooting
  - FD-SD hybrid trigger
- Physics analyses are still "preliminary", but preparing to be published on Journals :
  - Energy Spectrum, Composition, Anisotropy, Comparison between FD and SD

THE SYMPOSIUM ON  
"THE RECENT PROGRESS  
OF ULTRA-HIGH ENERGY  
COSMIC RAY OBSERVATION"

UHECR  
2010

Nagoya Congress Center, Nagoya, JAPAN

Dec.10(Fri)-12(Sun),2010

web site : <http://uhecr2010.icrr.u-tokyo.ac.jp/>

contact : [uhecr2010@icrr.u-tokyo.ac.jp](mailto:uhecr2010@icrr.u-tokyo.ac.jp)

New generation experiments of UHECRs; Pierre Auger Observatory in Argentina and Telescope Array in Utah, USA, have been collecting a large number of event samples. Precision calibrations obtained by LHCf, AIRFLY, FLASH, ELS and others are contributing to a rapid understanding of the air shower phenomena at extremely high energy.

In the symposium, we review existing and emerging results on the energy spectrum, particle composition and the anisotropy, and discuss its implications to the physics of UHECRs.

- Nagoya Congress Center
- Dec.10(Fri) - Dec.12(Sun), 2010

<http://uhecr2010.icrr.u-tokyo.ac.jp/>

- Recent highlights on UHECR  
+ panel discussions

- energy spectrum
- arrival directions
- composition
- energy scale
- interaction models
- future directions

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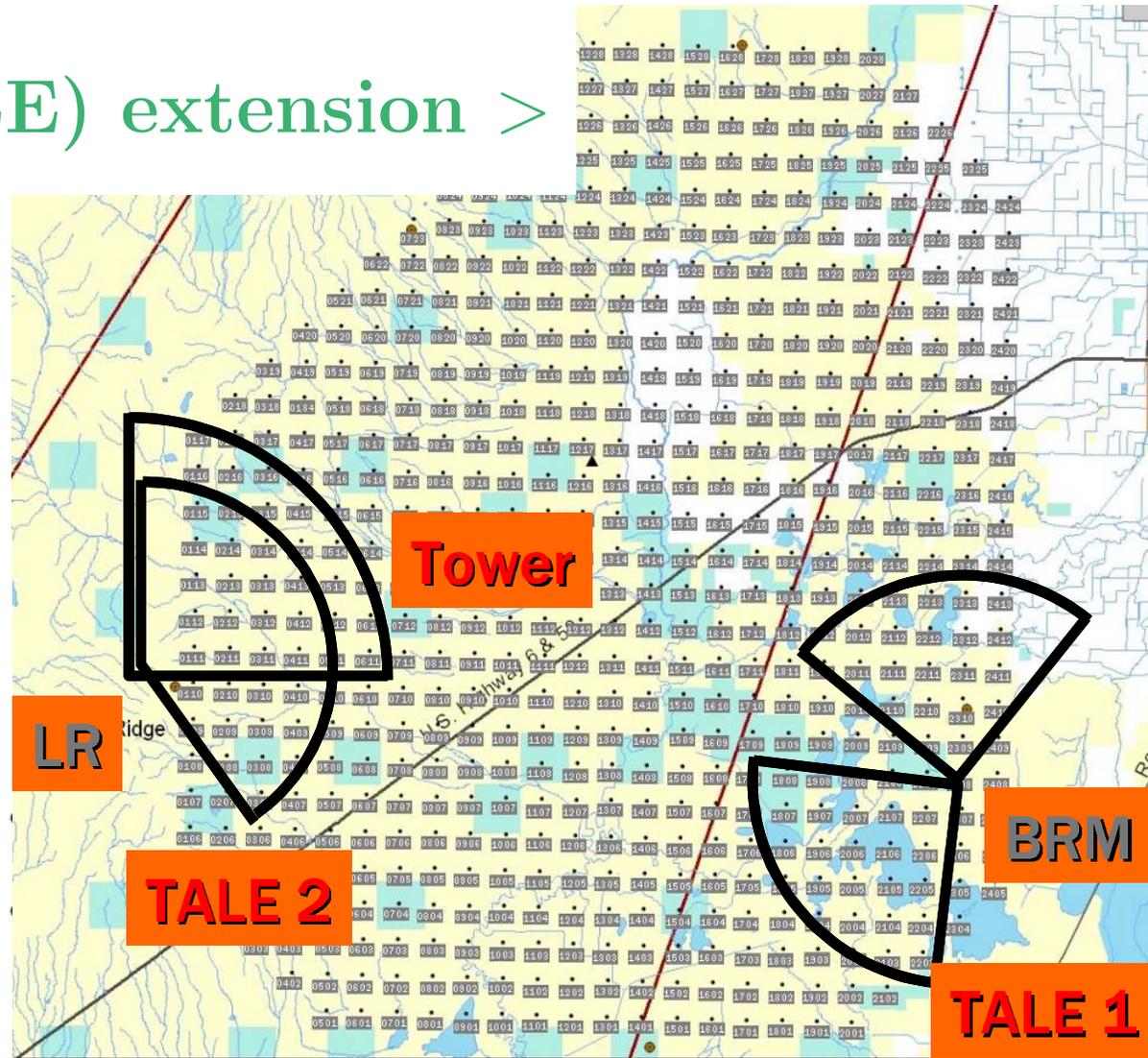
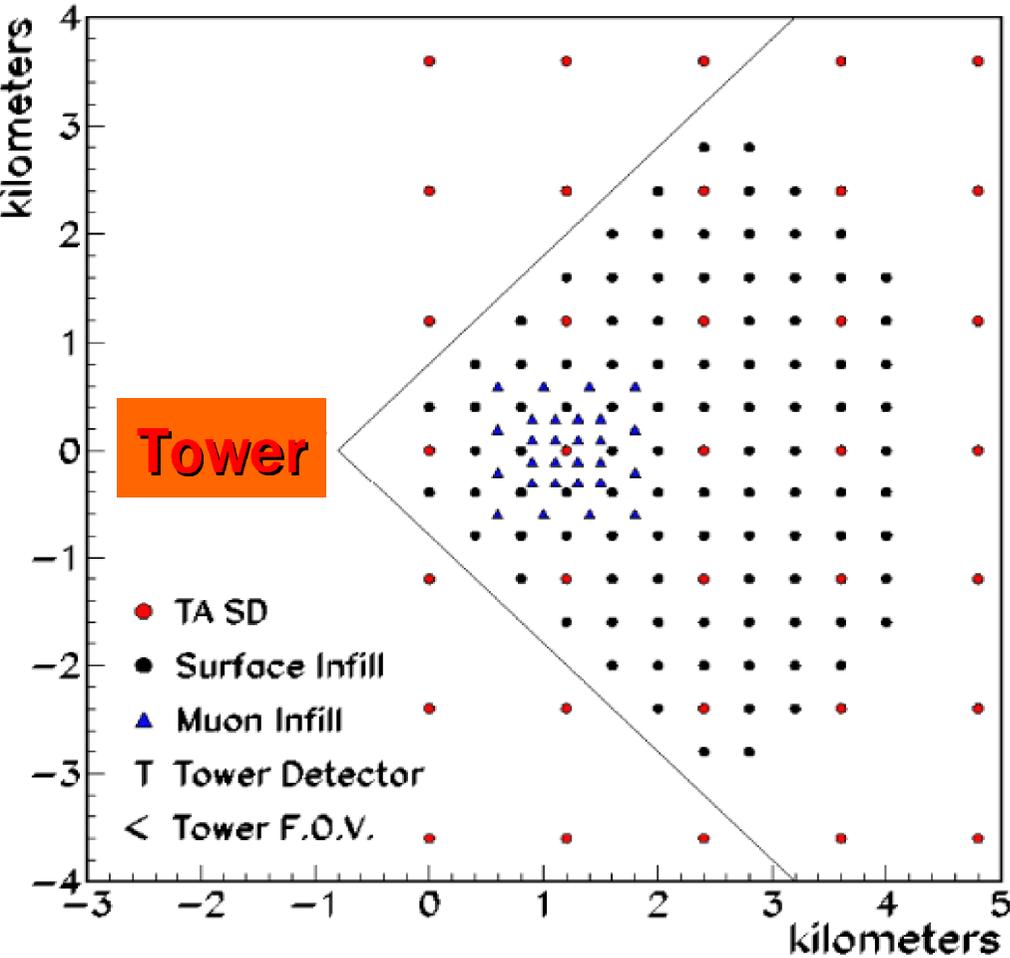
Supported by

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- Nagoya University GCOE program "Quest for Fundamental Principles in the Universe"
- Osaka City University GCOE program "Research and Education linked by Einstein's Physics"
- Tokyo Institute of Technology GCOE program "Nanoscience and Quantum Physics"

# < TA Low Energy (TALE) extension >

- Future plan  
Target:  $10^{16.5} \text{eV} - 10^{19} \text{eV}$

↓ SD infill array



↑ near the current FD stations