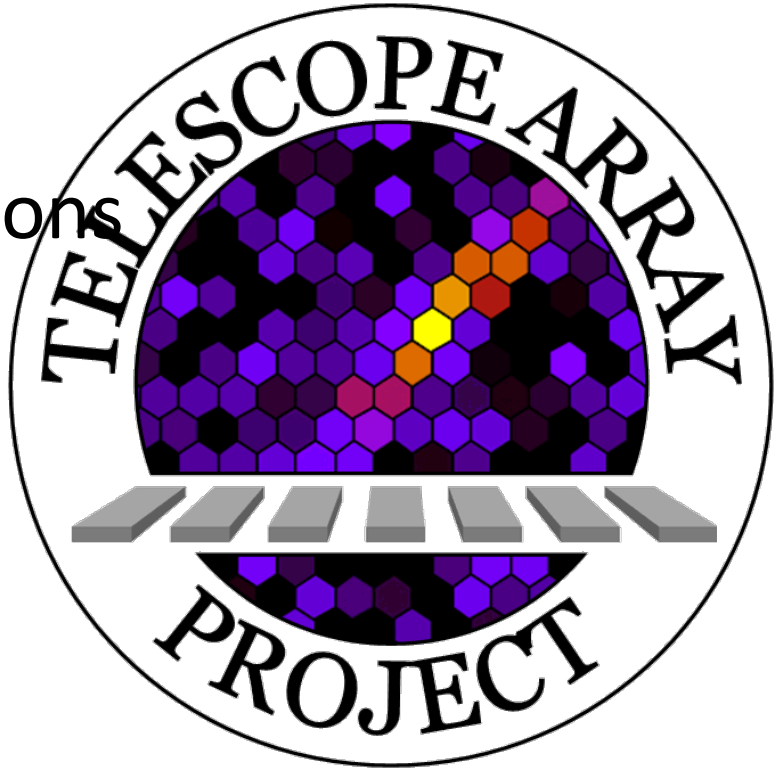
Future plans of the Telescope Array experiment

Shoichi Ogio (Osaka City University)

Future plans of the Telescope Array experiment

- Three future plans
- One is ongoing project....
- Personal idea included

..... as a beginning of discussions



Future plans of the Telescope Array experiment

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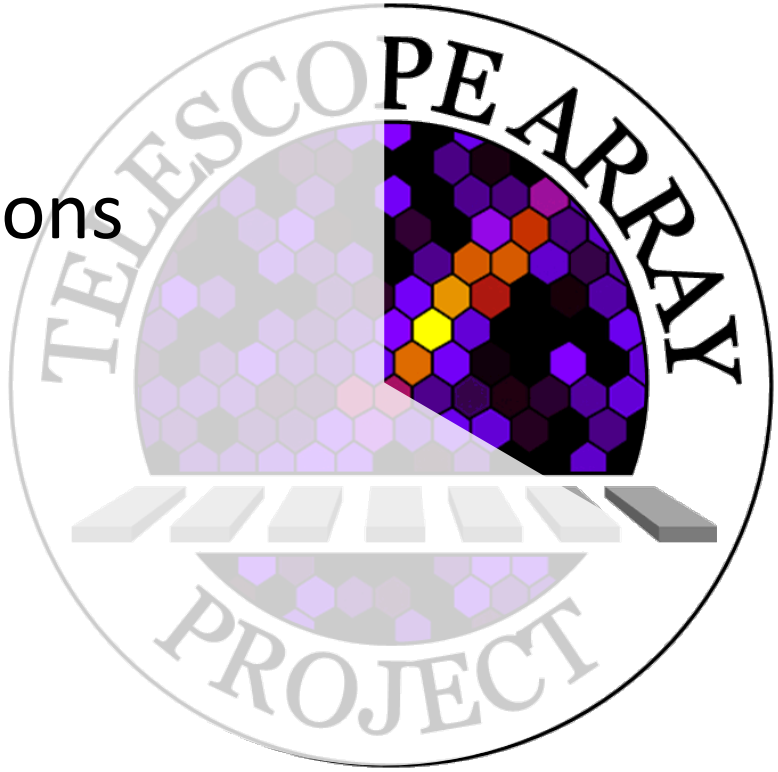
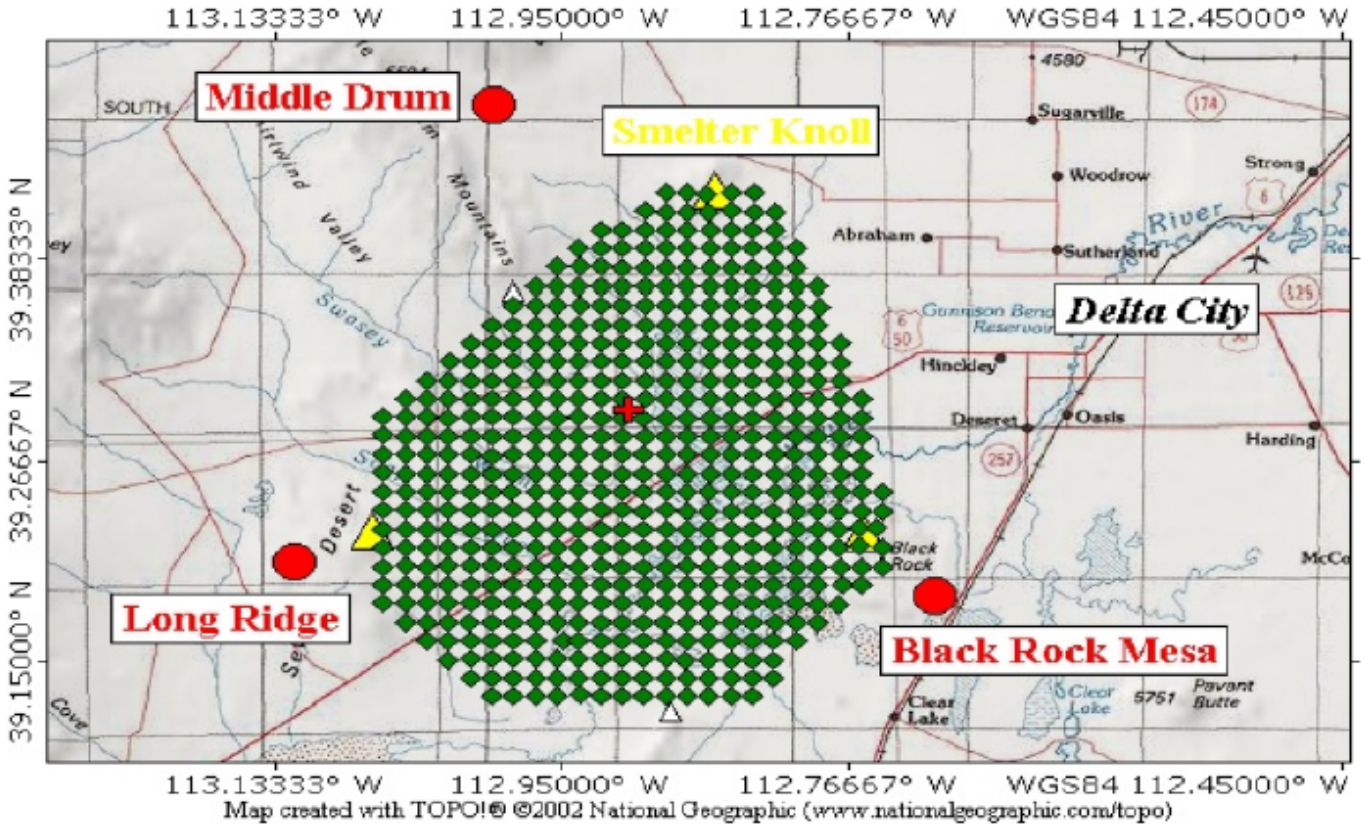


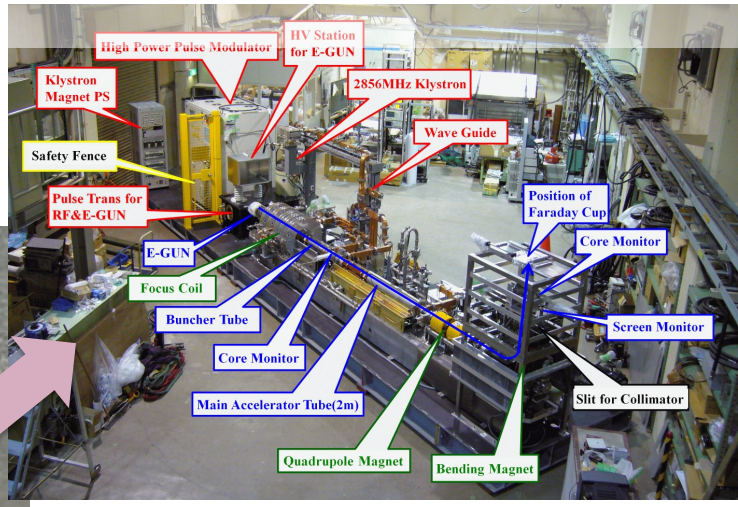
Two out of thee plans are
not fully approved
by the TA collaboration

TELESCOPE ARRAY HYBRID DETECTOR

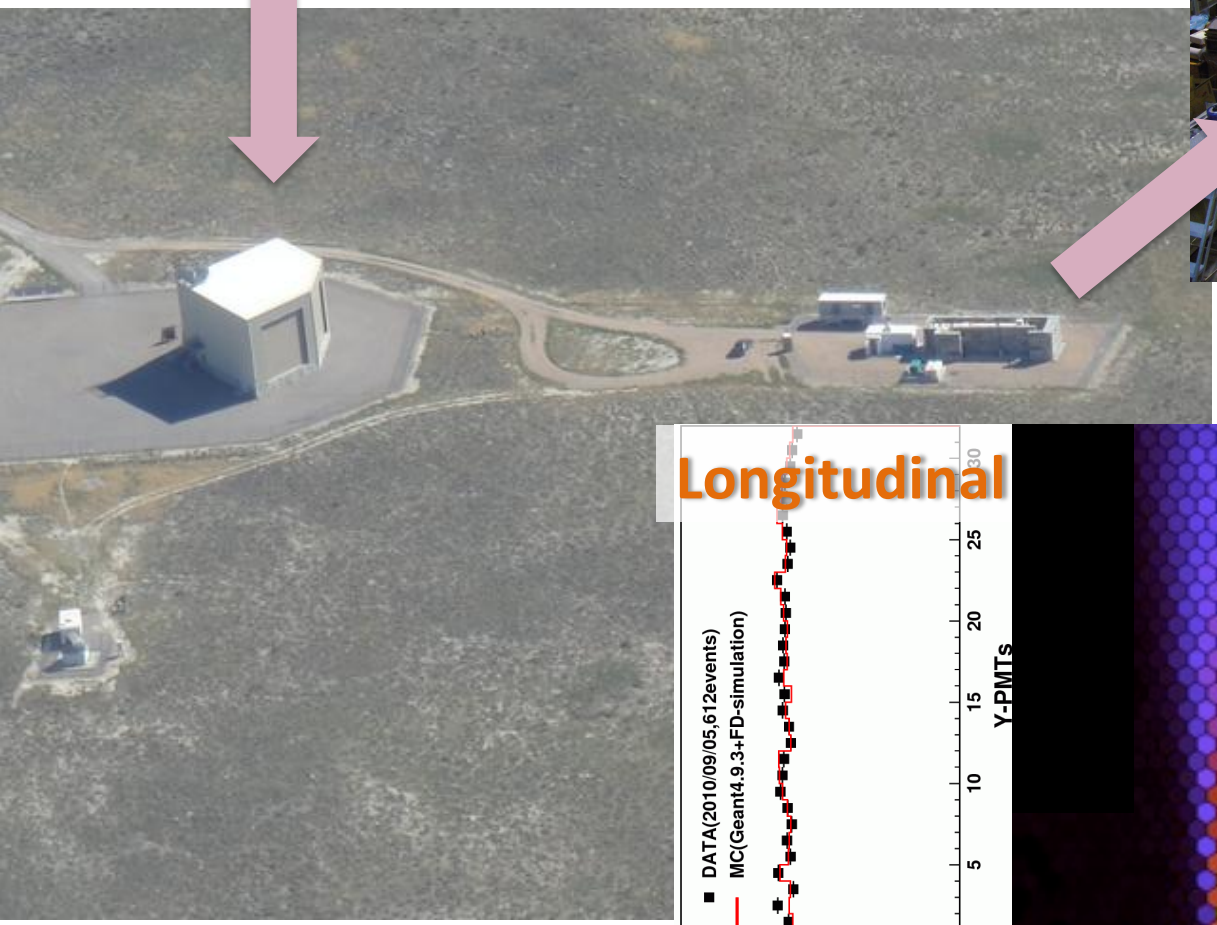


- 507 scintillator detector covering 680 km^2
- 3 fluorescence detector stations, 38 telescopes
- Full operation since March 2008
- SD array relative size TA ~ AGASA x 7 ~ Auger / 4

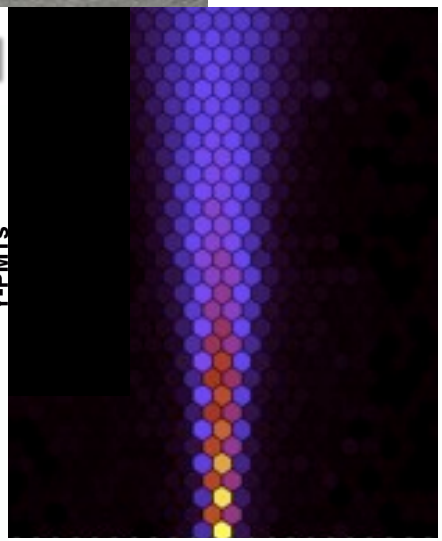
ELS(Electron Light Source)



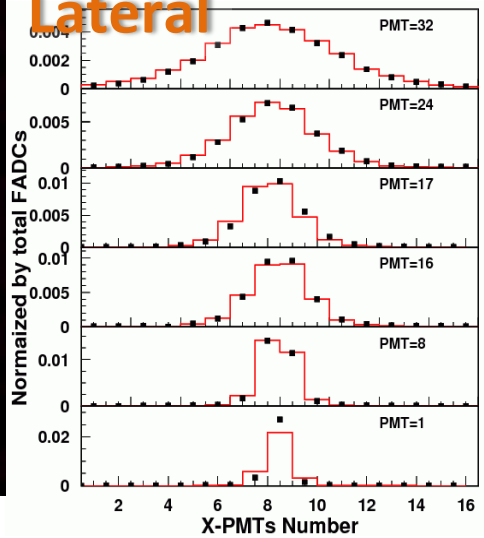
Shot: Sep. 5, 2010, 4:30UTC
Energy: 41.1 MeV



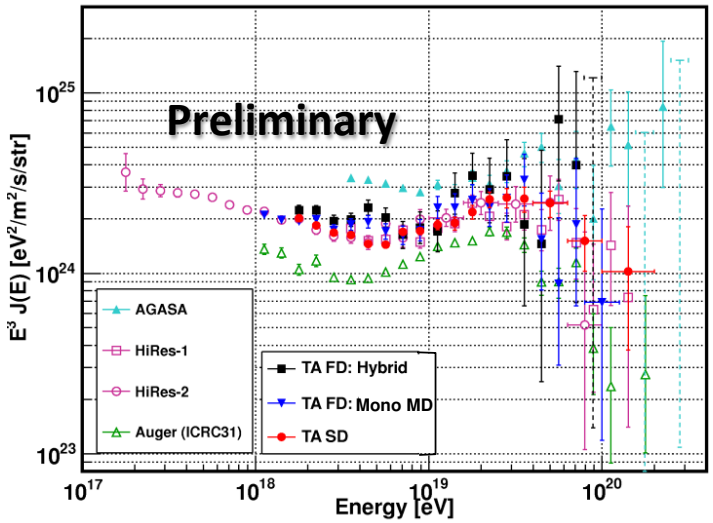
Longitudinal



Lateral



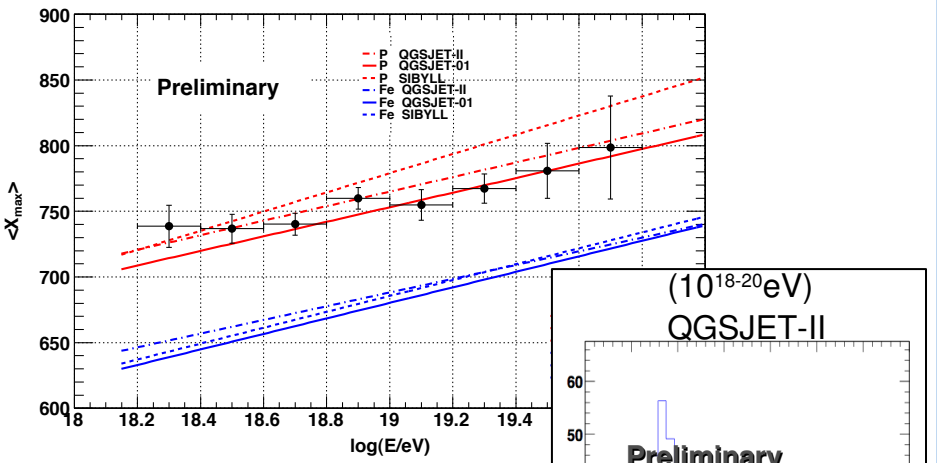
Summary of the results from TA



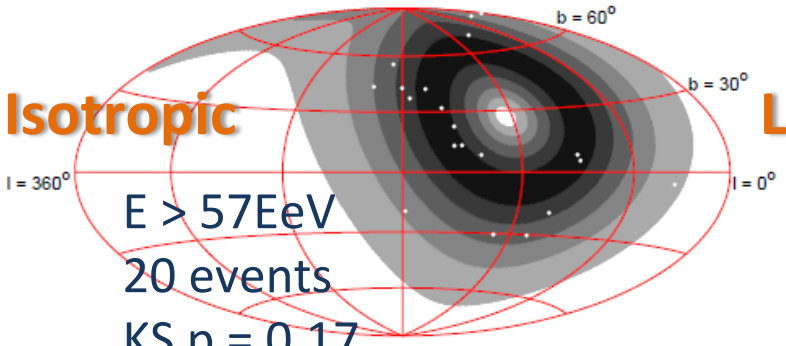
Sharp cutoff @ $\log_{10}E \sim 19.8$

Preliminary results are .....

consistent with GZK feature



Xmax are consistent with "purely 1ry proton"

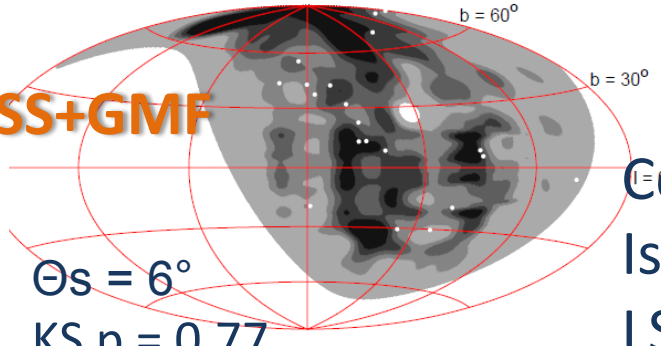


Isotropic

E > 57EeV

20 events

KS p = 0.17



LSS+GMF

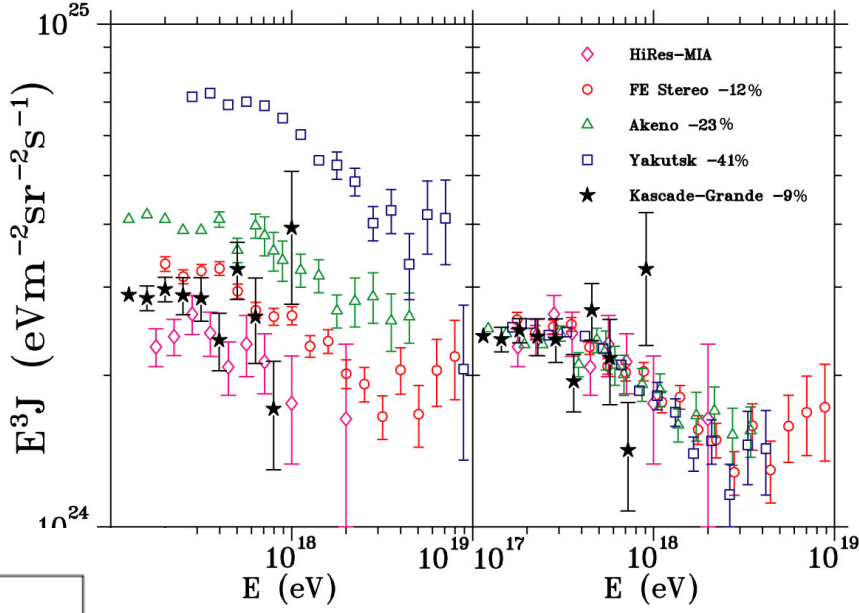
Θs = 6°

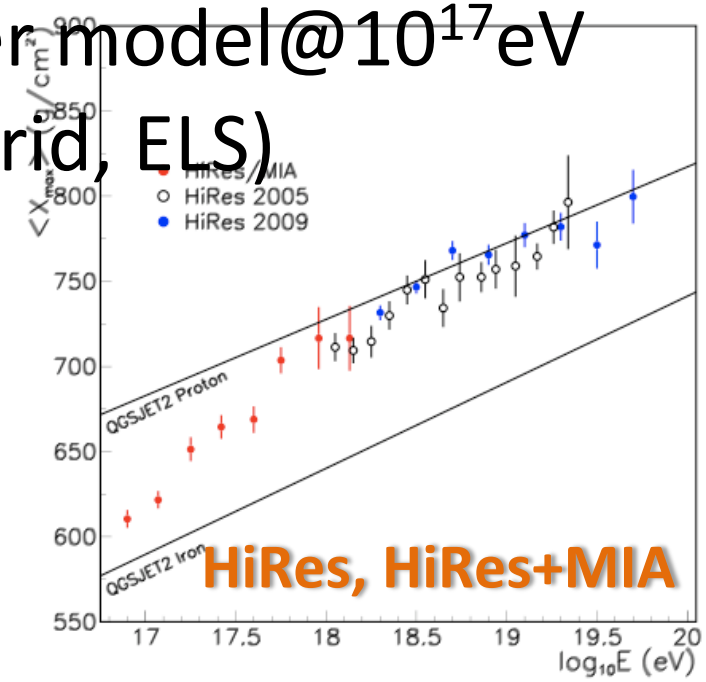
KS p = 0.77

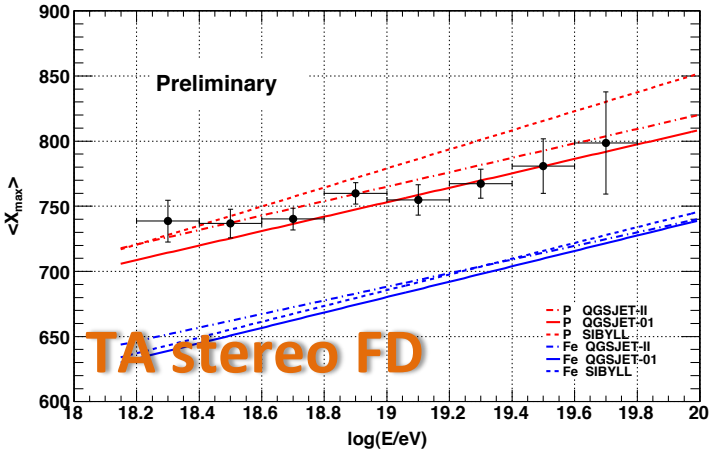
Compatible with Isotropic & LSS+GMF

Future Plan 1: TA Low Energy Extension

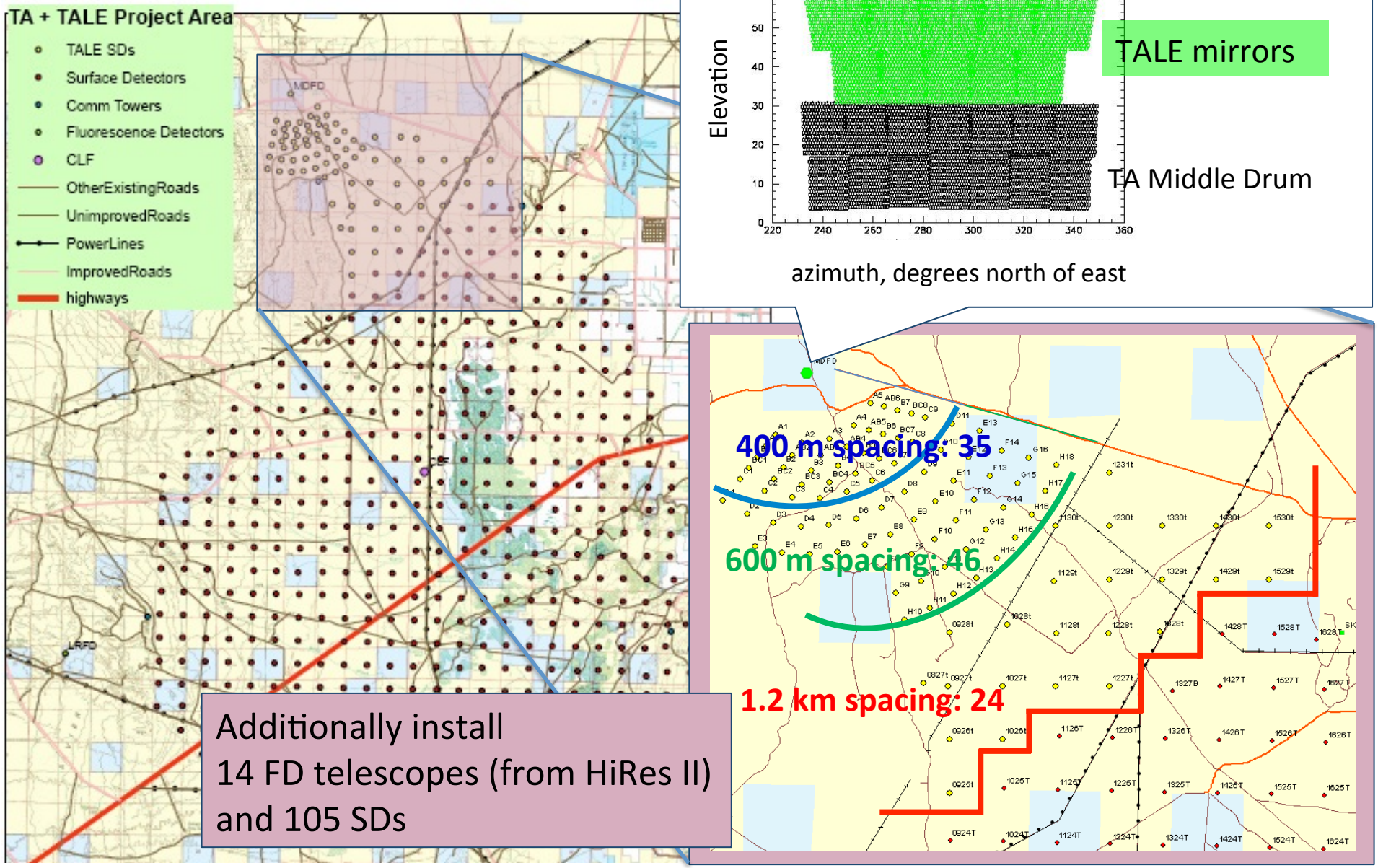
- Galactic-to-Extragalactic transition
- iron knee
- second knee
- Air shower model@10^{17}eV (LHC, Hybrid, ELS)







TA Low Energy Extension (TALE)



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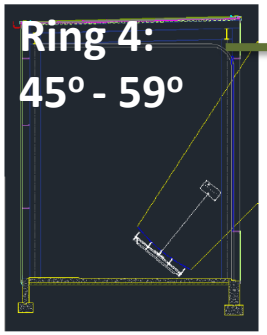
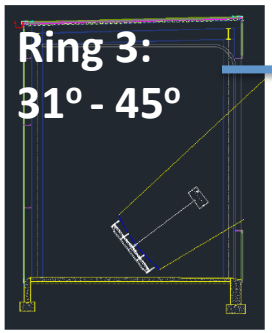
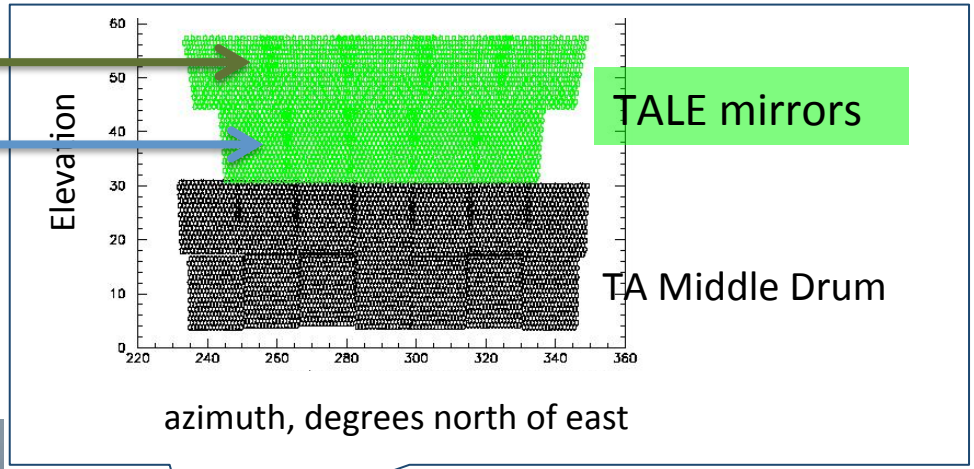
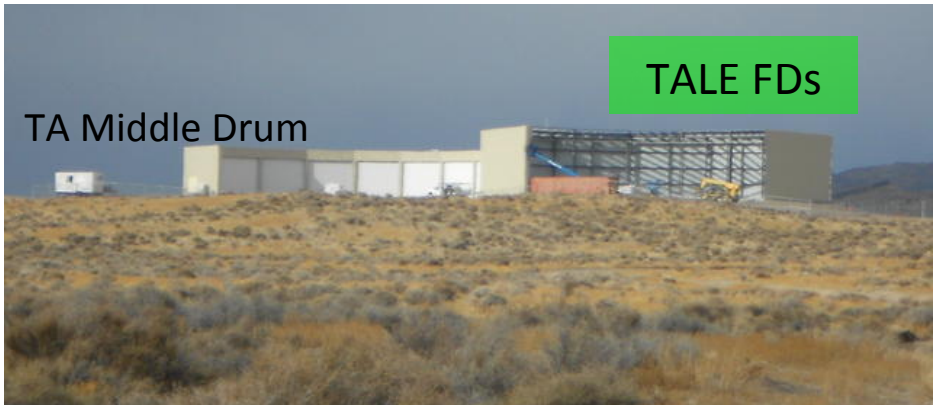
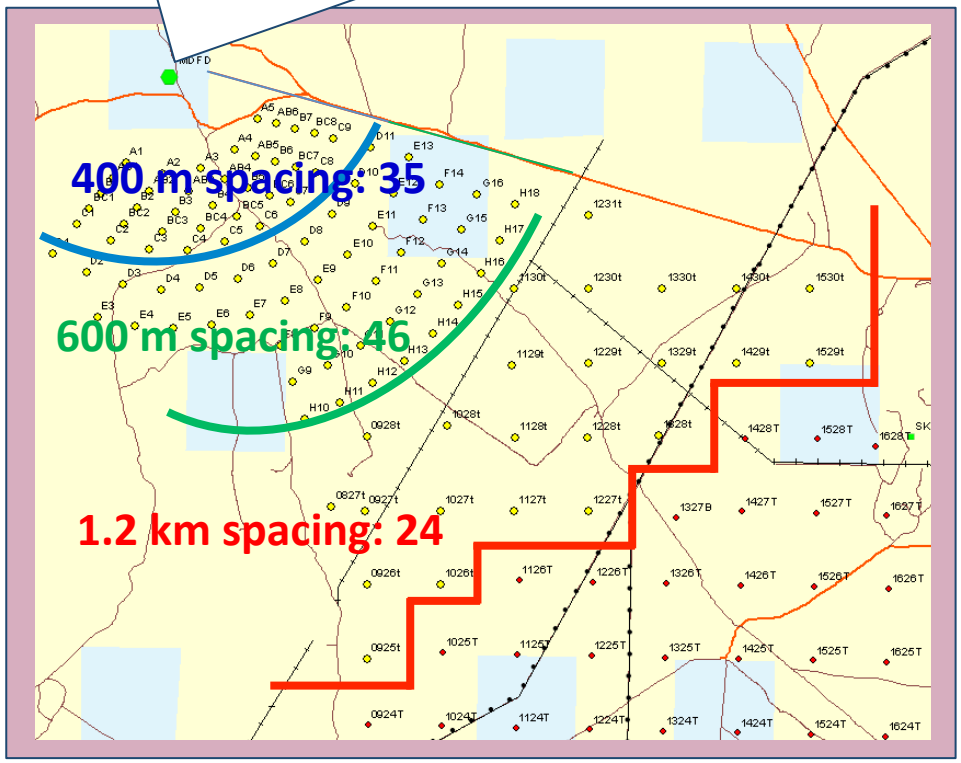




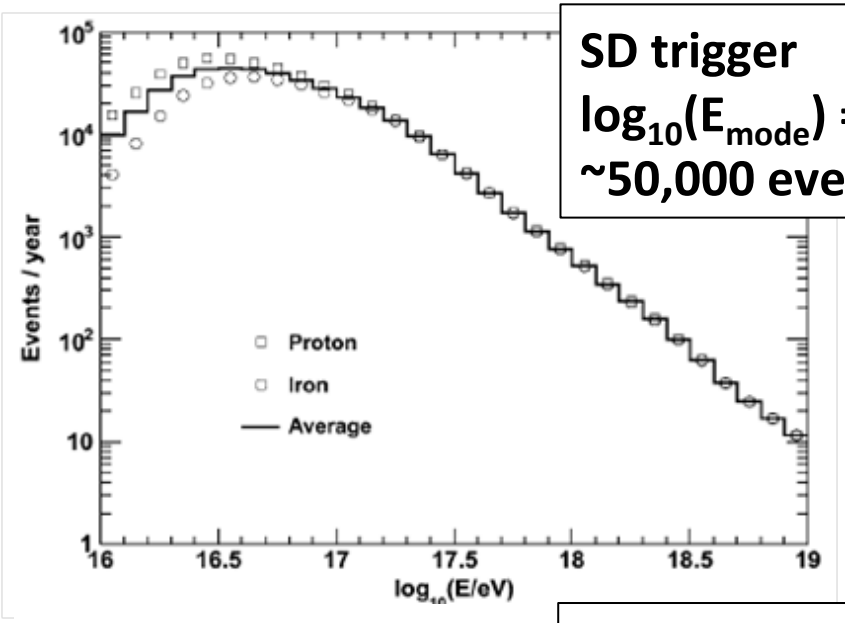




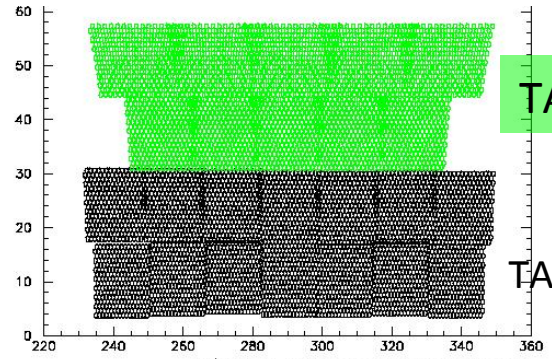
Same design/specifications as TA SD



Specifications of TALE

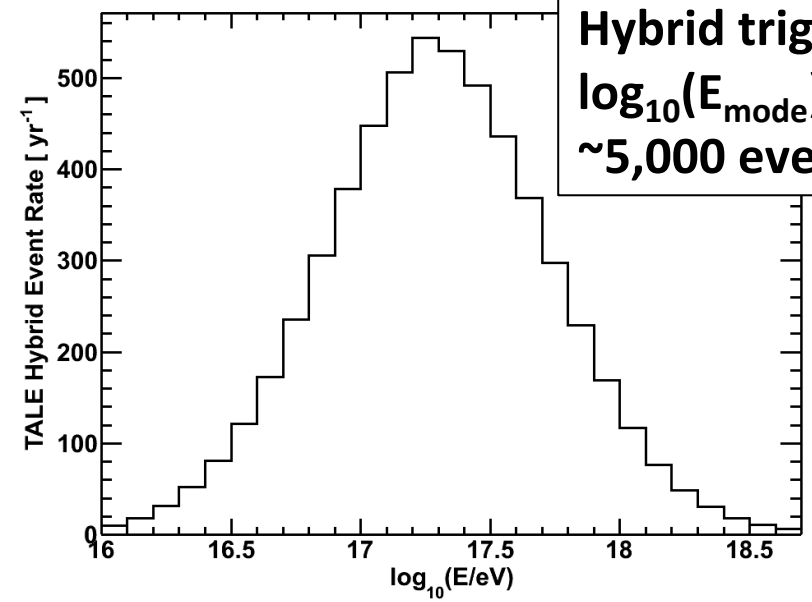


SD trigger
$\log_{10}(E_{mode}) = 16.5$
~50,000 events/yr

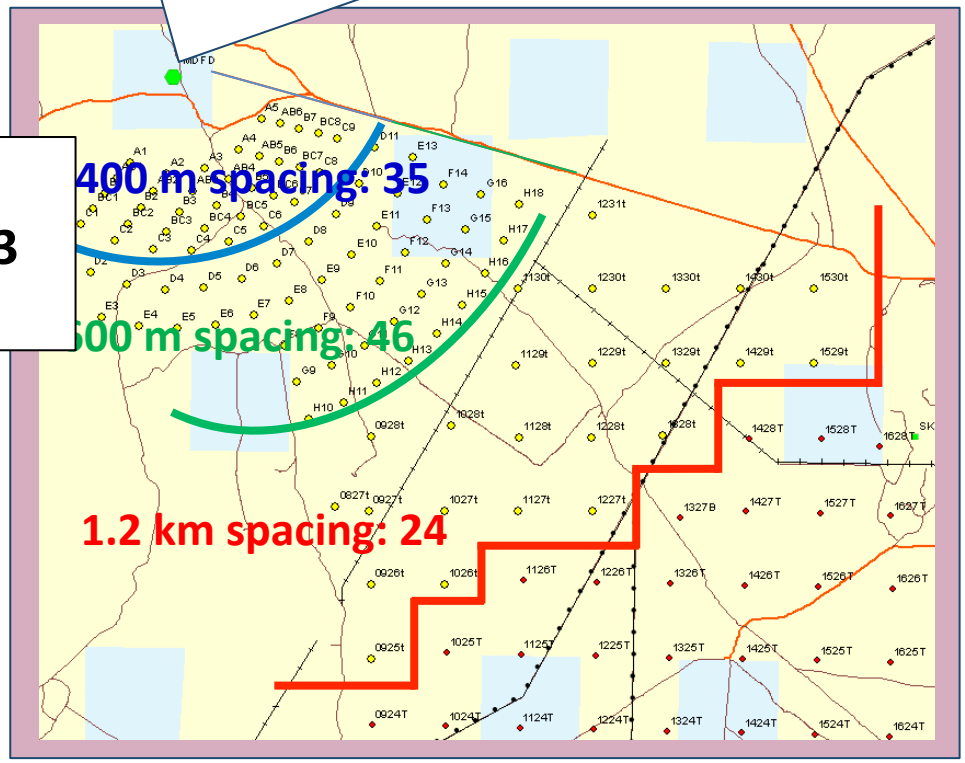


TALE mirrors

TA Middle Drum

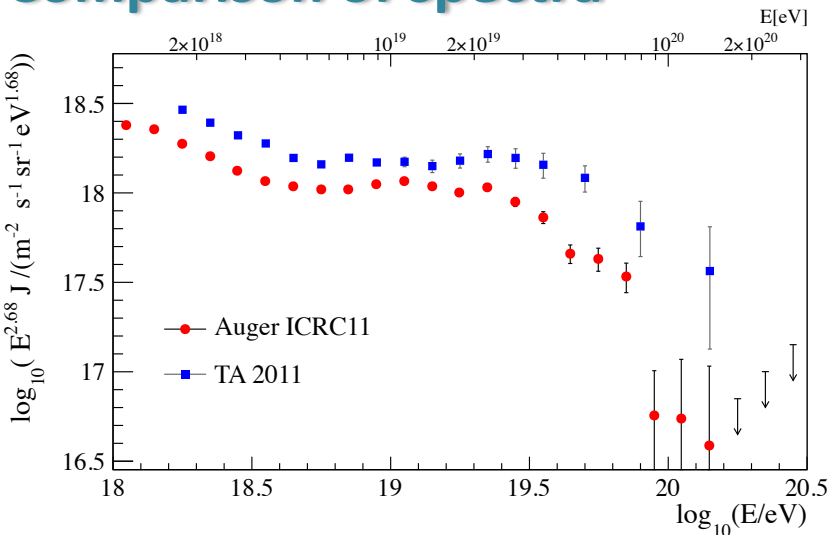


Hybrid trigger
$\log_{10}(E_{mode}) = 17.3$
~5,000 events/yr



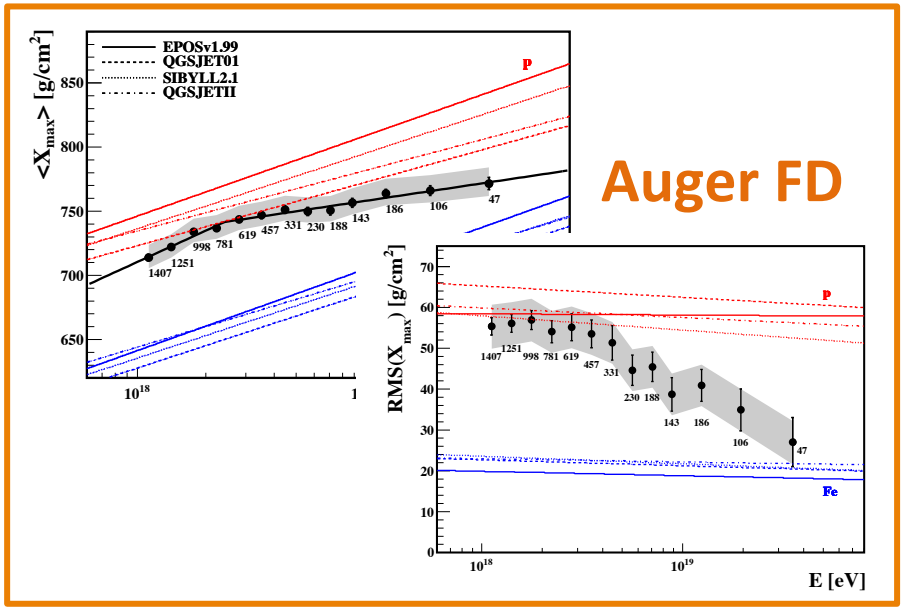
To Solve the discrepancy...

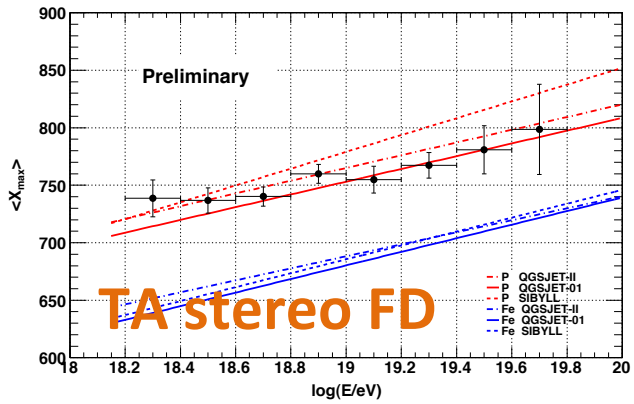
Comparison of spectra



The working groups were organized and will continue to make effort to solve these problems. Not only exchanging data/exchanging calibration devices, etc...., but also I would like to propose **exchanging experimental equipment themselves** between TA and Auger.

Comparison of longitudinal EAS development

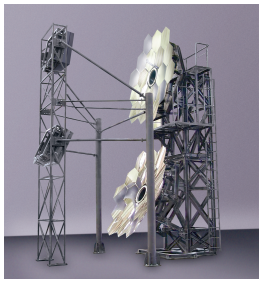




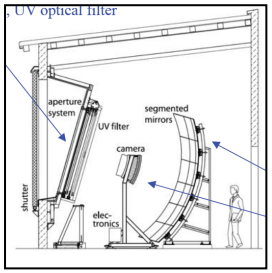
Future Plan 2: Exchange FDs / SDs

- 2 TA FD ⇔ 1 Auger FD
  (FOV ~ 20° - 30°)

estimated cost ~ $1M



⇔



- 1 TA station + 100 TA SDs ⇔ 1 Auger station + 100 Auger SDs

estimated cost ~ $10M
(for TA < $5M)

What we know about UHECRs ?

Telescope Array's observations suggests that

- (Spectrum) Sharp cut off @ the highest energy
- (Composition) purely protons @ E >10^{18}eV

Preliminary

⇒ **GZK mechanism**

Discrepancy must be solved near future, I hope..

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What we don't know about UHECRs ?

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What we don't know about UHECRs ?

Origin of UHECRs

(Sources, Acceleration mechanism, propagation...)

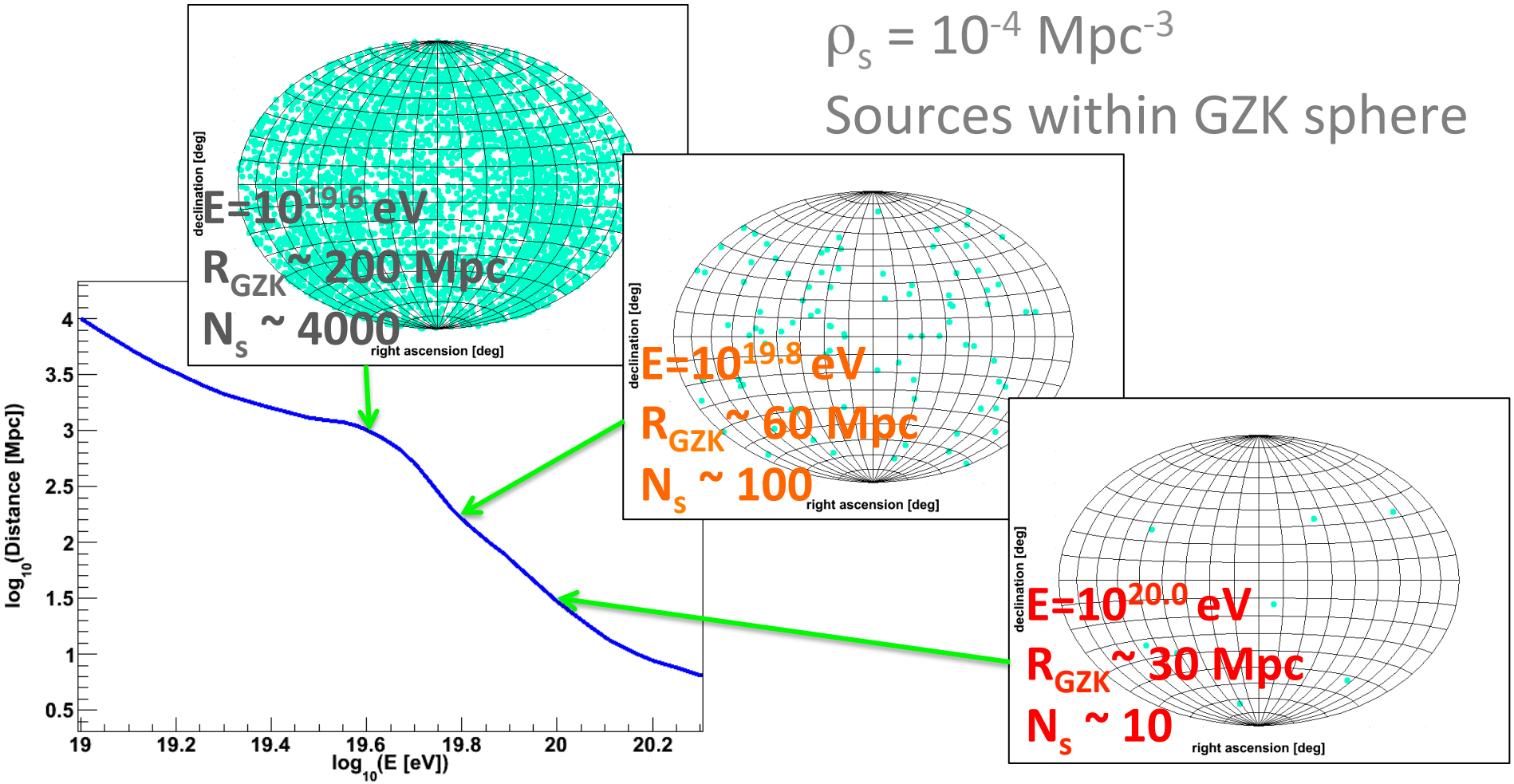
In order to identify point sources...

Observations should be concentrated on

the highest energy = To limit the number of sources

$\rho_s = 10^{-4}$ Mpc^{-3}

Sources within GZK sphere

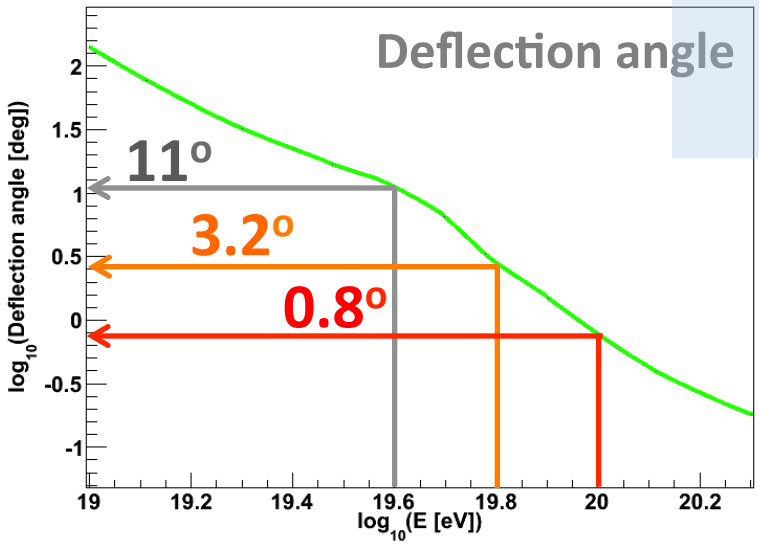


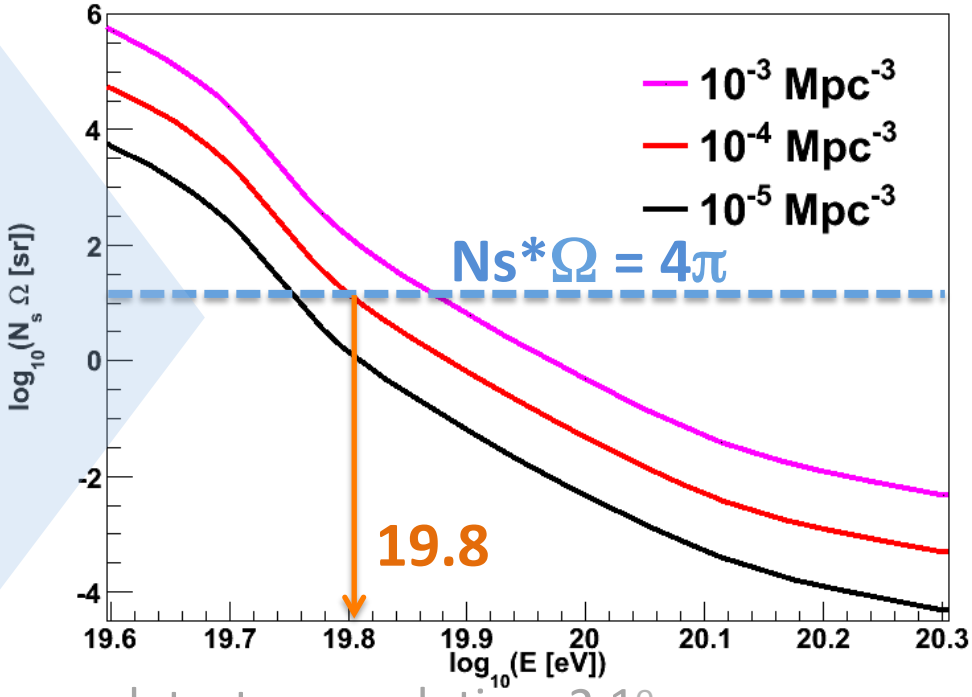
In order to identify point sources...

To resolve sources, Ns x Ω(source resolution) < 4π

then, we should set ... **$\log_{10}E_{th}$ = 19.8 - 19.9**

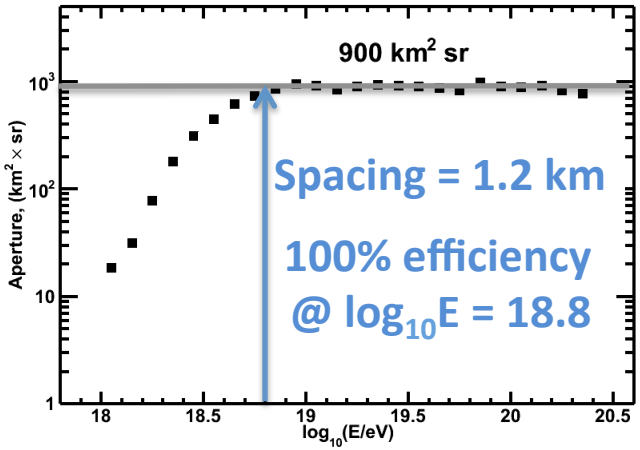
($\log_{10}$E)	(Ns)
19.6	~4000
19.8	~100
20.0	~10



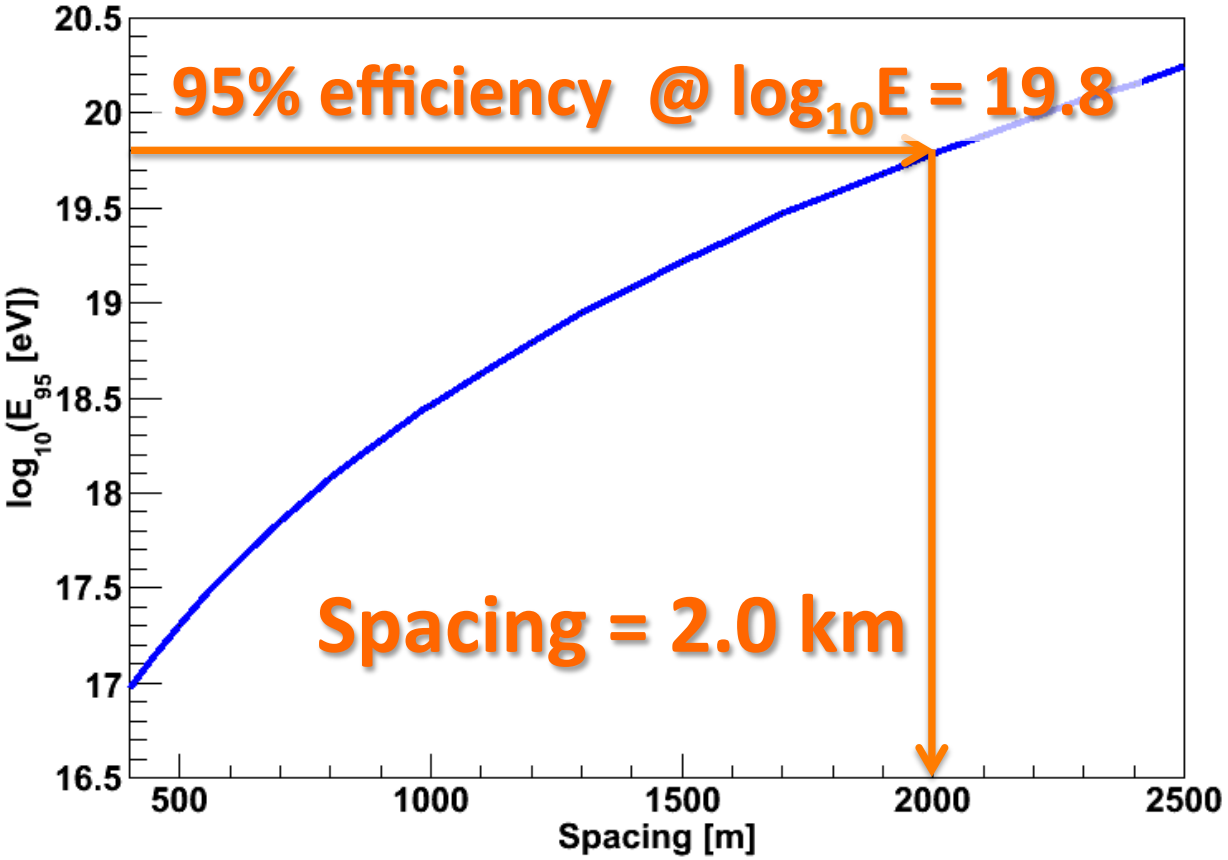


detector resolution, 2.1°, included

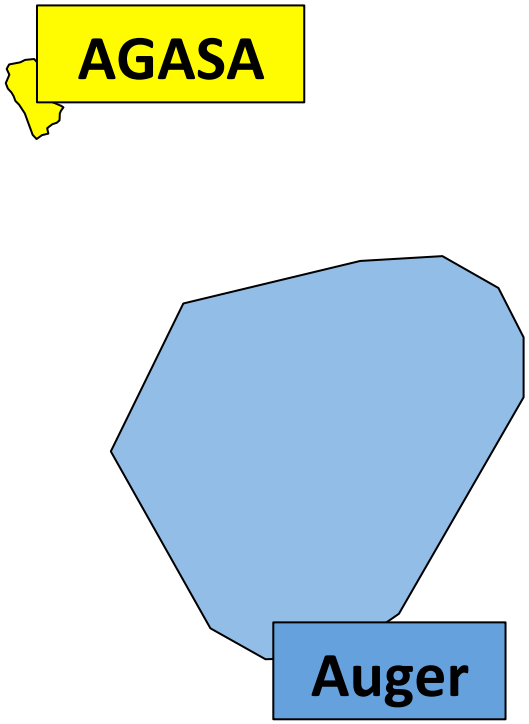
Optimized detector spacing

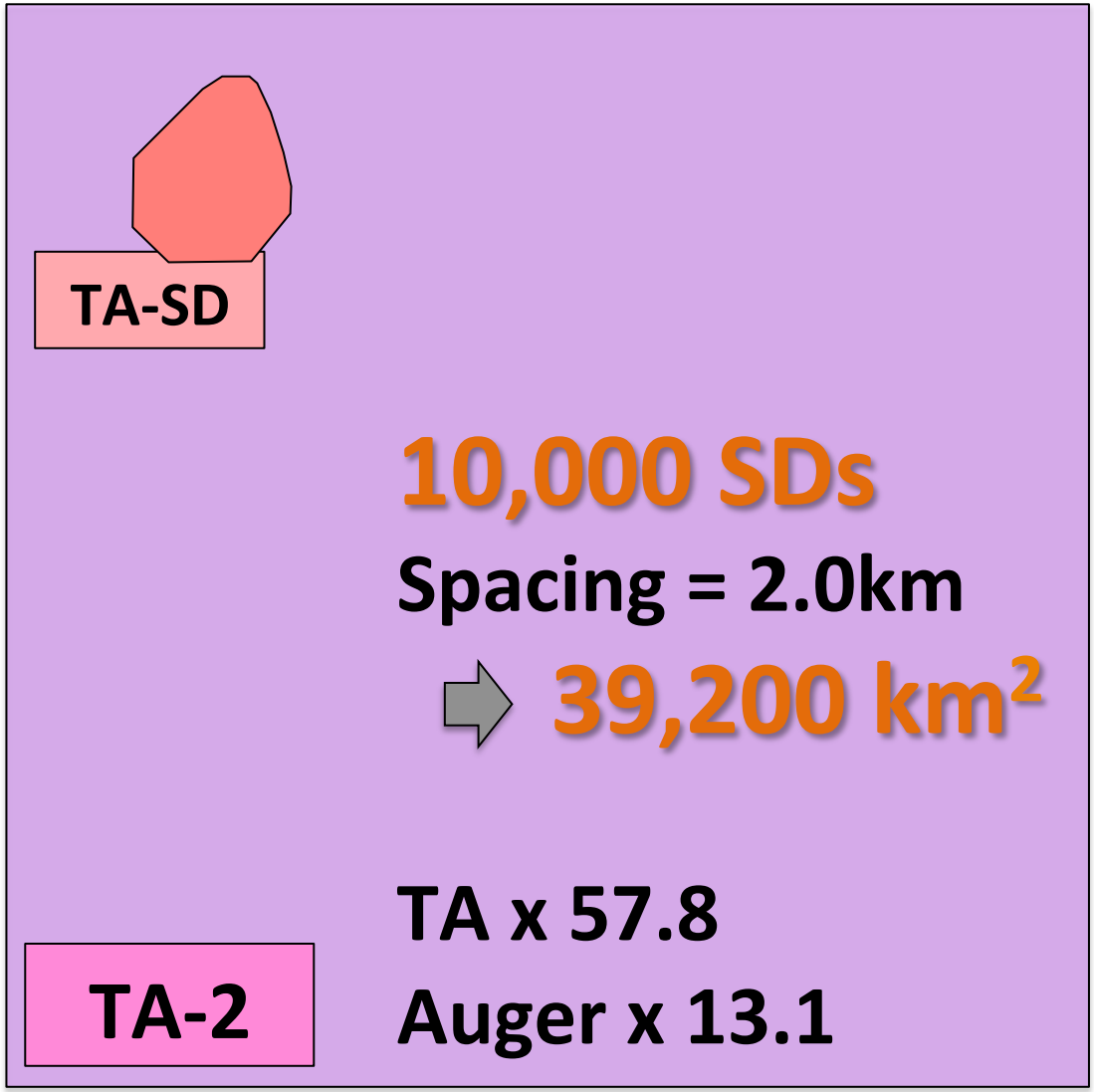


TA SD array

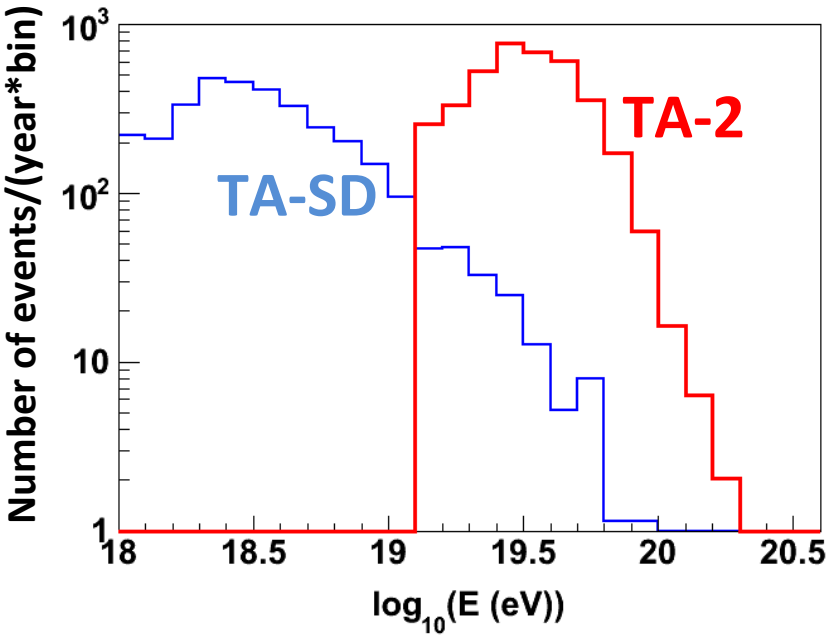


Future Plan 3: Huge air shower array

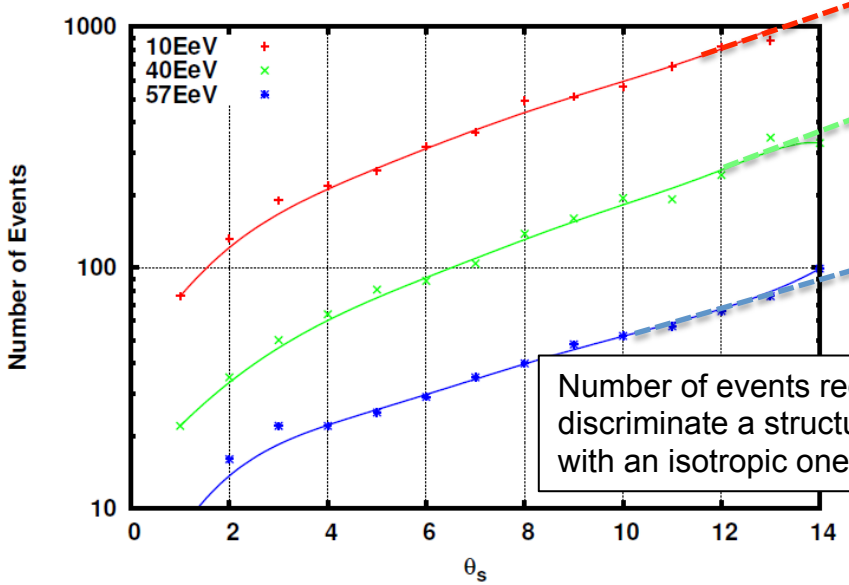




Expected results



	[events/yr]
$\log_{10}E > 19.8$	257.9
$\log_{10}E > 19.9$	84.7
$\log_{10}E > 20.0$	25.6
(* E > 57 EeV	434.5)



Number of events required to discriminate a structure model with an isotropic one (95% C.L.)

10EeV 3788 /yr

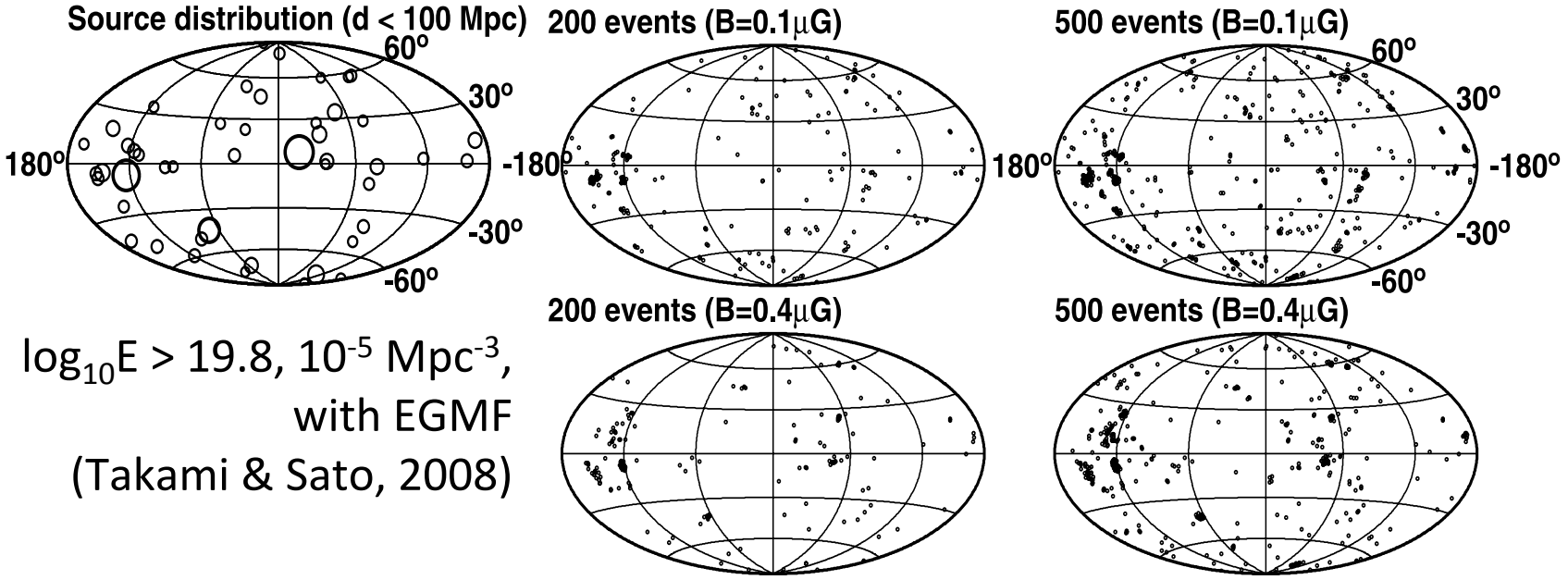
40EeV 1218 /yr

57EeV 434.5 /yr

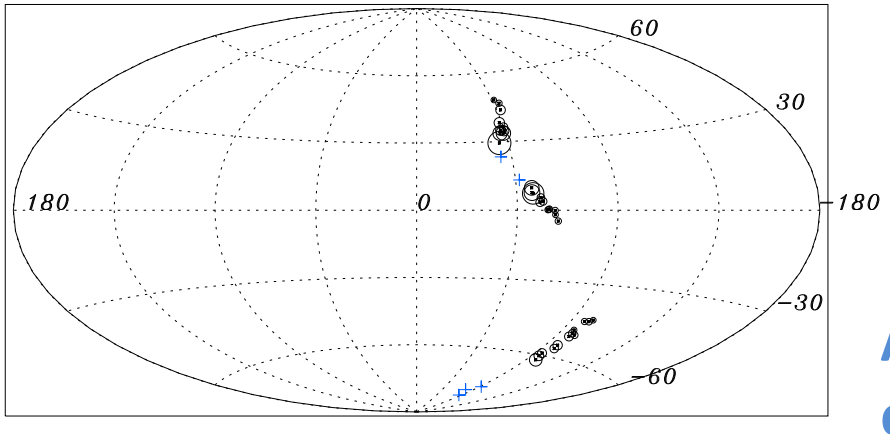
smearing = 20°

Even if smearing angle ~ 20°, isotropic ⇔ LSS can be discriminated w 95 % CL

Source Identification



$\log_{10}E > 19.8$, 10^{-5} Mpc^{-3}, with EGMF (Takami & Sato, 2008)



Energy-position correlated multiplet will be helpful (Golup for the Auger collaboration, 2011)

Angular and energy resolutions are essentially important for source identifications and EG/GMF studies.

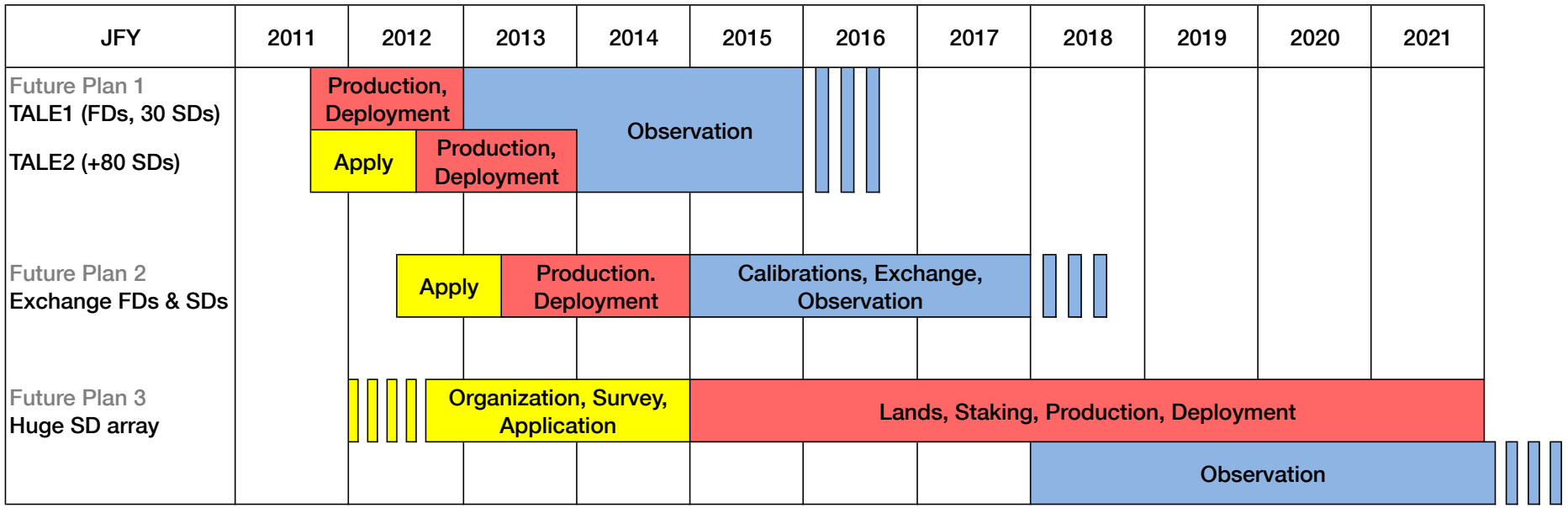
Cost and Schedule

- 10,000 SDs, Spacing = 2.0km
- total coverage 39,200 km^2

  (TA x 57.8, Auger x 13.1)
- ($10,000 per SD) x 10,000 SDs = **$100M**

  *Including the deployment cost

  **Expected 10% cost-down from TA-SD



Summary (1)

- Future Plan 3: Huge air shower array
  - Concentrate on the highest energies
    - Set 95% efficiency @$\log_{10}E = 19.8 – 19.9$
  - $40{,}000\text{km}^2$ => 10 sources and 25 events for $E > 10^{20}$ eV
  - Need good angular and good energy resolution
  - Need study for design optimization
    - Scintillator, water tank or other type ?
    - Size, spacing
    - **Sensitivity for neutrinos and for composition?**

Summary (2)

- Future Plan 1: TA Low energy Extension (TALE)
  - Ongoing project
  - 14 FDs + 35 SDs systems will start working early 2013

- Future Plan 2: Exchange FDs + SDs
  - Check systematics: real same CR events, same CLF, same ELS beams, event by event bases.
  - Solve discrepancies in energy scale and Xmax
  - Critically important step for further extension of UHECR research