Tibet AS+MD+YAC Project

AS=Air Shower array
MD=Muon Detector array
YAC=Yangbajing Air shower Core detector

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2010年9月17日

日本側ホスト: ICRR　　中国側ホスト: IHEP

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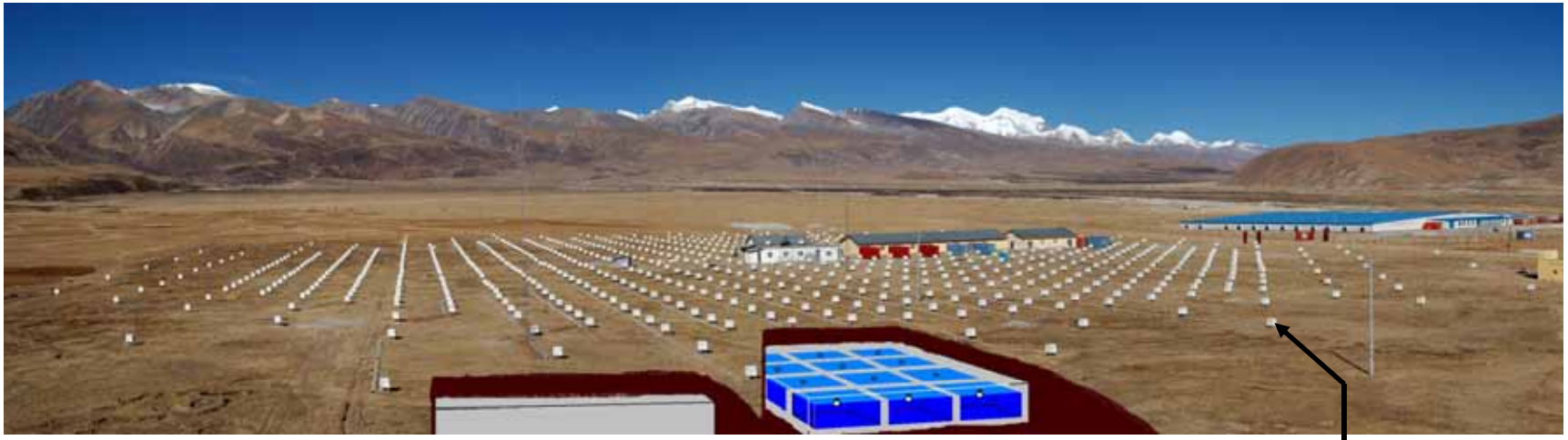
羊八井　宇宙線観測所

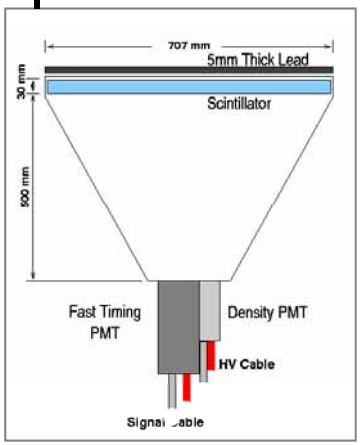
中国　チベット自治区　羊八井 (ヤンパーチン)

90˚ 522**E**,　30˚ 102**N**,　**標高**4,300 m (606g/cm^2)

チベット空気シャワー観測装置 (Tibet AS)



水チェレンコフミューオン観測装置 (イメージ) ↑



- 中国チベット (90.522°E, 30.102°N) 標高4300 m

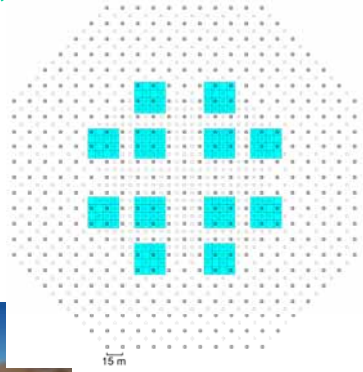
シンチレーション検出器数	0.5 m^2 x 789
空気シャワー有効面積	~37,000 m^2 → 83,000 m^2
最頻エネルギー	~3 TeV
角度分解能	~0.2 @100 TeV
エネルギー分解能	~40% @100TeV
視野	~2 sr

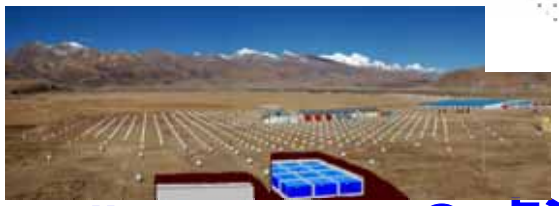
→空気シャワー中の電磁成分($e^{+/-}$,γ)を主に観測し
一次宇宙線エネルギー、方向、空気シャワーのコア位置などを測定

Tibet AS(~8.3万m^2)
+MD(384ch, ~$10^4 m^2$)

100TeV領域γ–>

宇宙線起源と加速





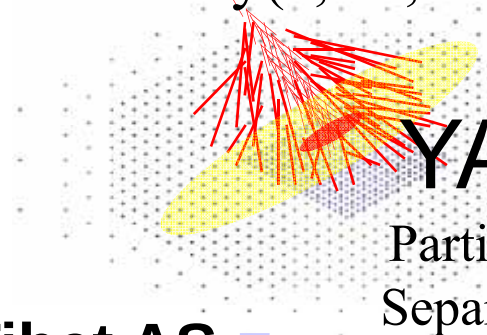
Tibet AS+YAC(0.2~5千m^2)

Knee of p, He, Fe

Cosmic ray(P,He,Fe…)

->加速限界のZ依存性

->SNR加速の証拠



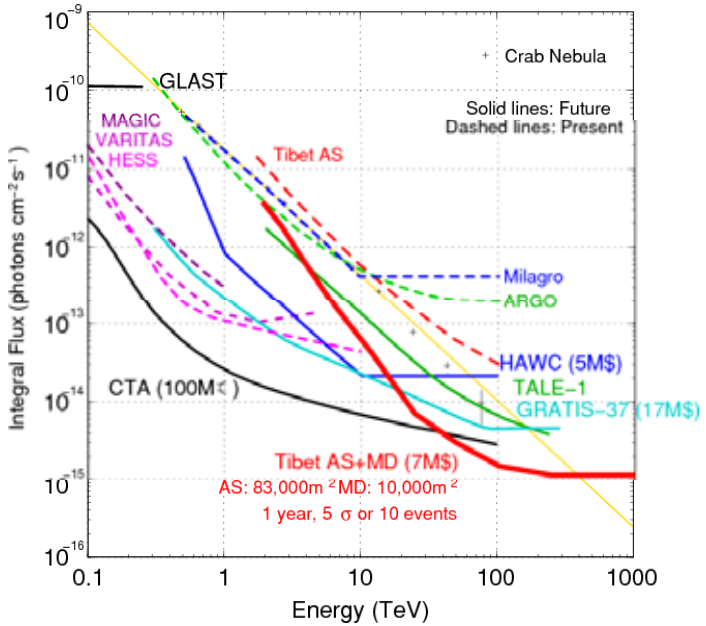
YAC

Particle density & spread

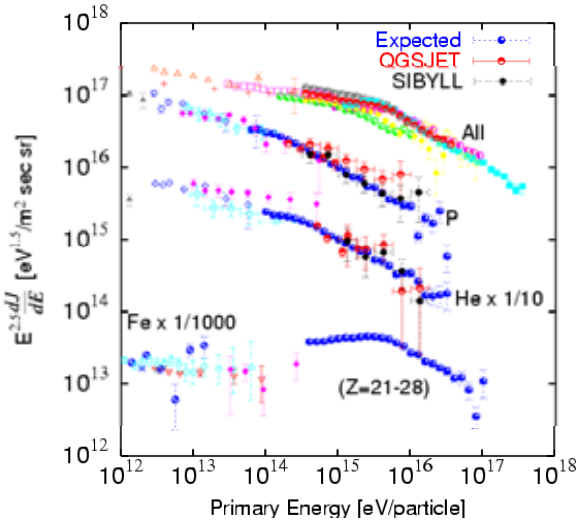
Separation of particles

Tibet AS: Energy and direction of air shower

Tibet AS + MDのγ点源に対する感度



青が期待値



Why in Tibet?

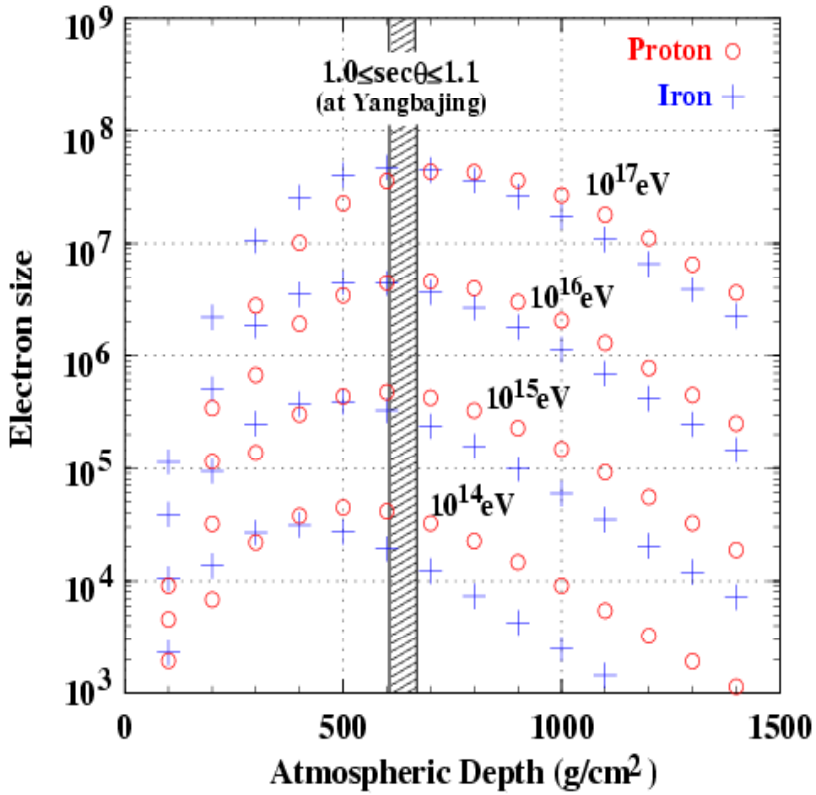
1.100TeV領域宇宙ガンマ線

->大気中で減衰

->Sea Levelに到達しない。

2. Knee領域宇宙線

->エネルギー決定精度の原子核依存性が少ない。



次期計画概要： 総額10.5億円-> 大型科研費もしくは概算要求？

1．Tibet Muon Detector arrayの建設 ~ 10000m^2 6 億円

2. Tibet Air Shower Arrayの拡張 1.5億円

37000m^2->83000m^2 (+292台)

Tibet AS + MD -> 100 TeV γ astronomy (point & diffuse sources, acceleration limits, origin of cosmic rays)

3. Yangbajing Air shower Core Detector phase I の建設 0.5億円

Tibet AS+ YAC-I (160m^2,100台) -> Proton & Helium knee

4. Yangbajing Air shower Core Detector phase IIの建設 2.5億円

Tibet AS+ YAC-I I(5000m^2,400台) -> Fe knee

次期計画の年次計画： 合計6年間

1年目：YAC-I & MD約半分の建設と観測

2年目：MD残り約半分の建設と観測

3年目：Tibet AS拡張&YAC-II建設&と観測

4年目：観測

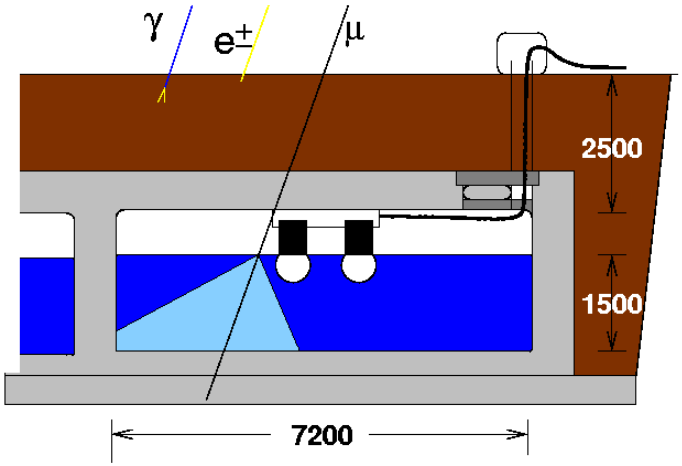
5年目：観測

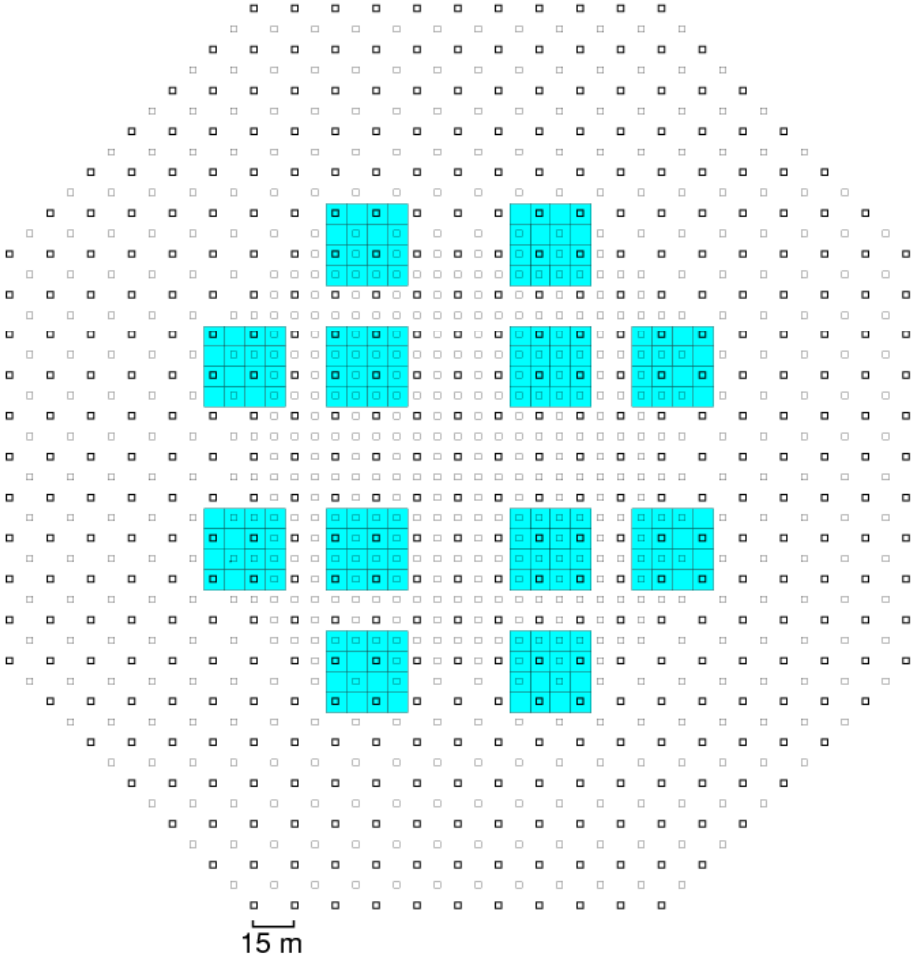
6年目：観測

チベット水チェレンコフミューオン観測装置 (Tibet MD)

地下 2.5m (物質厚 ~515g/cm^2~19X_0)
7.2m×7.2m×水深1.5m　水槽　192台
20”ΦPMT　2本 (HAMAMATSU R3600)
水槽材質：
コンクリート
白色エポキシ樹脂塗装

合計　～10,000m^2

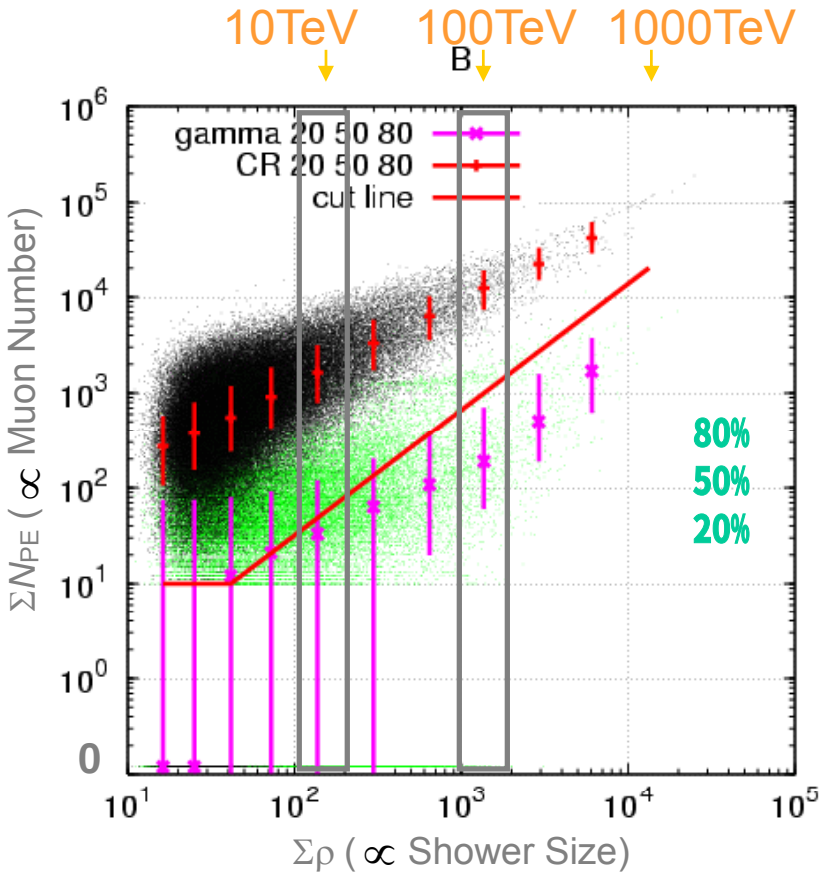


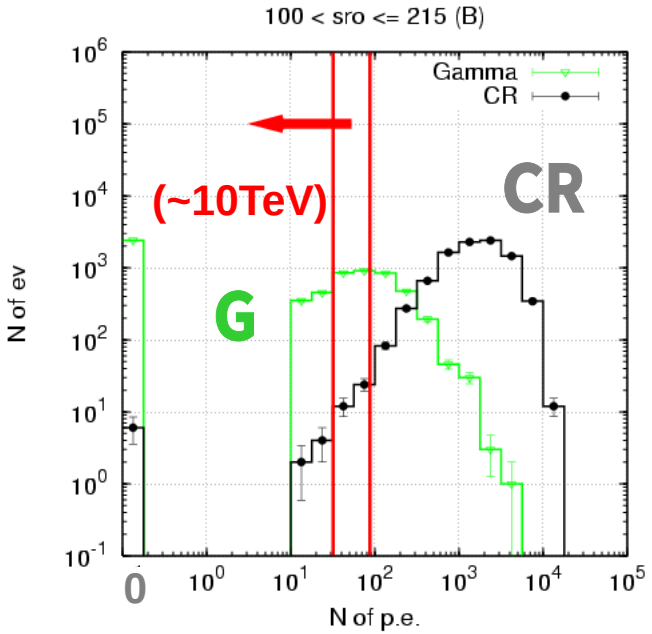


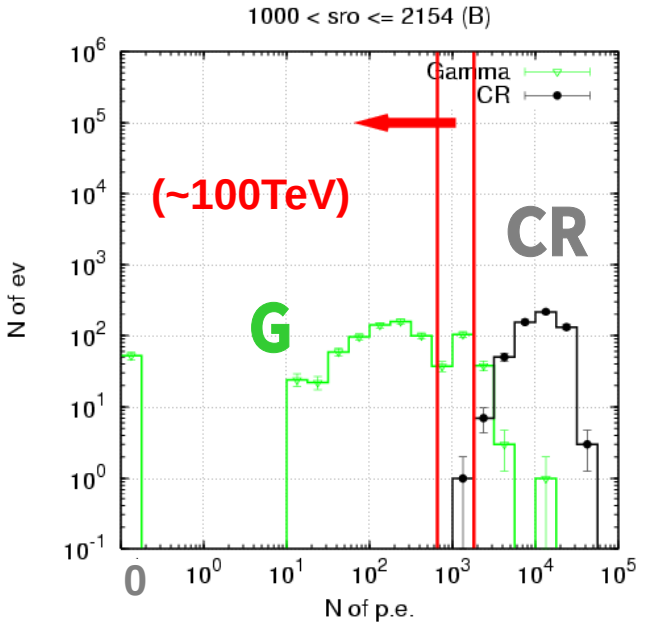
→空気シャワー中のミューオン数を測定し、ガンマ線／核子選別

ミューオン数ＶＳシャワーサイズ　(シミュレーション)

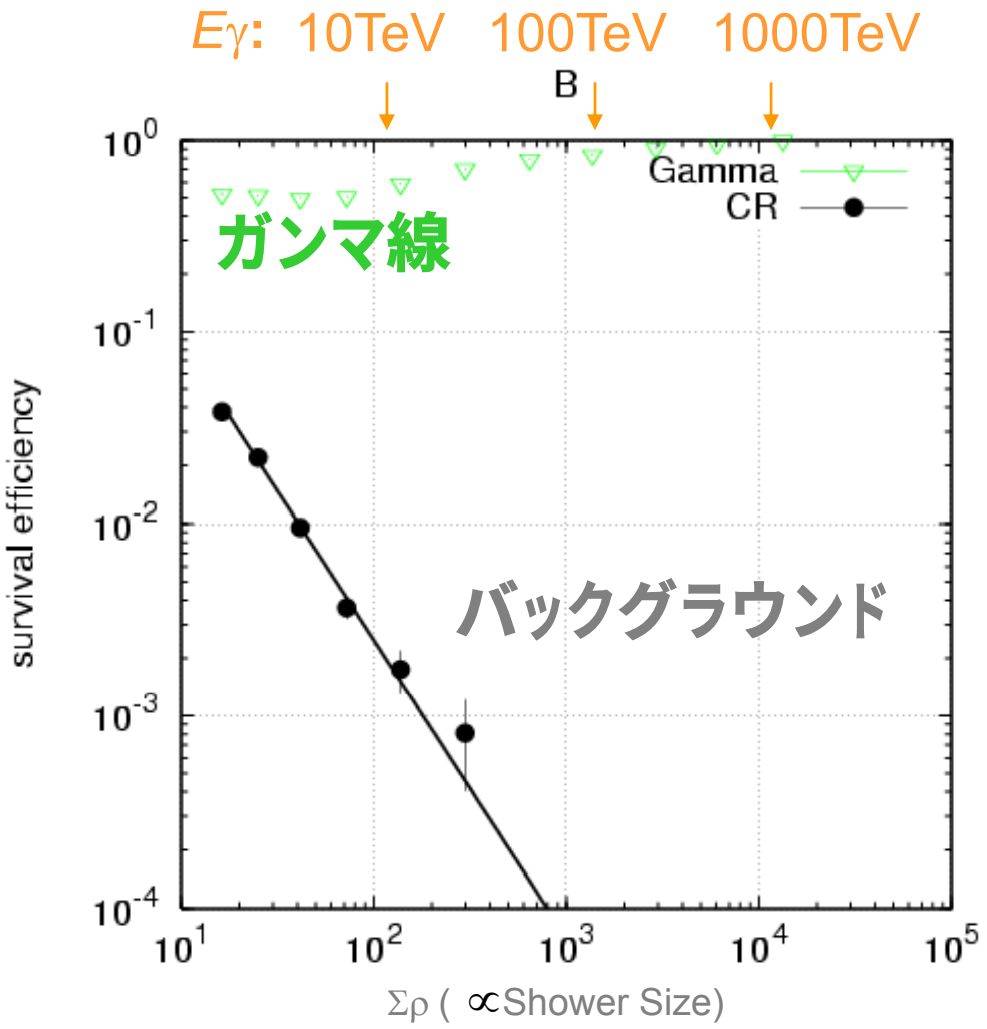
Σ ρ : シンチレータ検出器で観測した粒子密度の和
　　∝シャワーサイズ
Σ N_{PE}: ミューオン検出器で観測した光電子数の和
　　∝ミューオン数
　　(ＭＤ検出器の閾値　N_{PE} >10 光電子)







カット後の生存率　(シミュレーション)



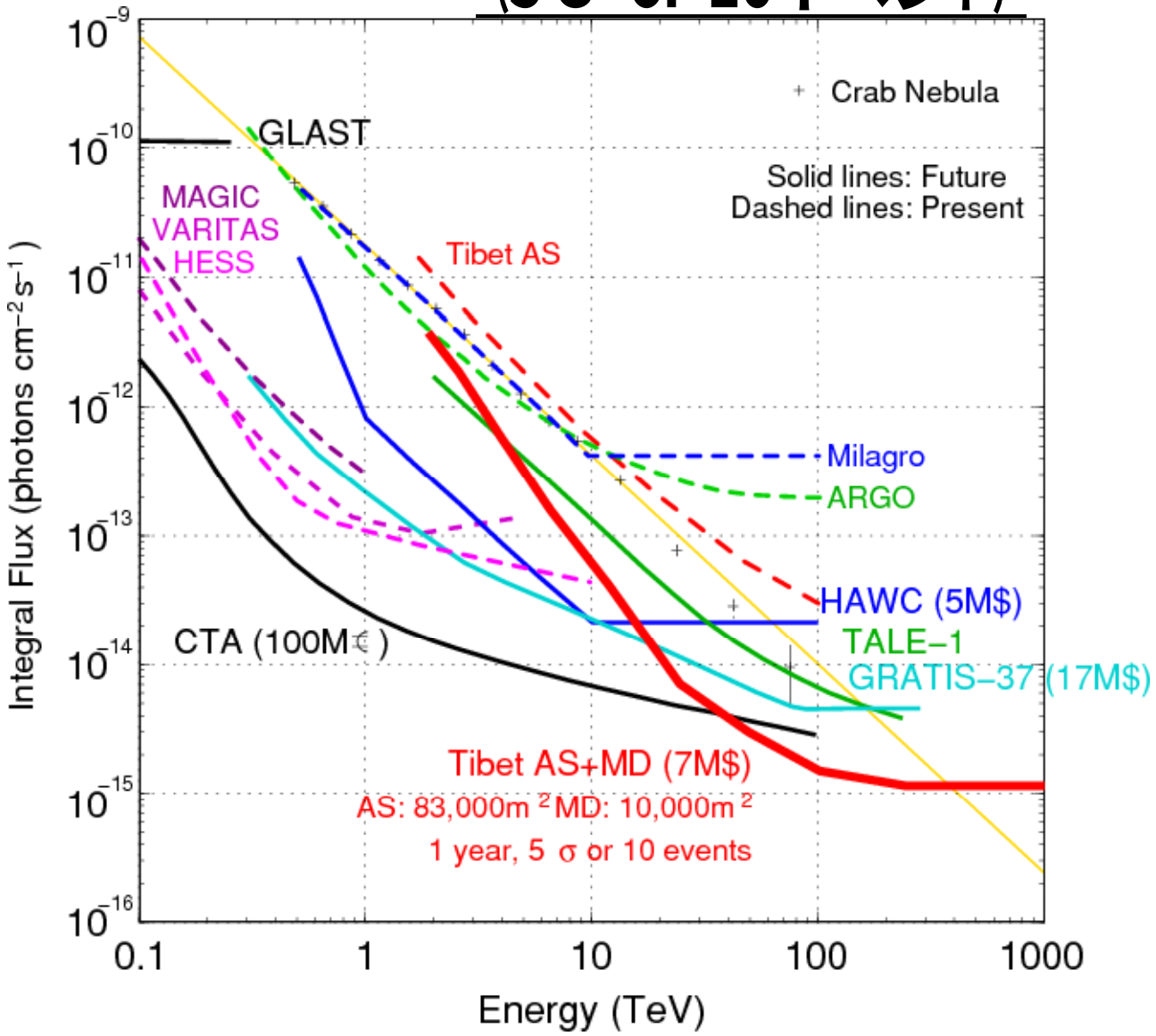
10TeV:
カットΣN_{PE}=~50
バックグラウンド:　~99.8%　除去
ガンマ線:　~65%　生存
ガンマ線感度:　~10倍　感度UP！

100TeV:
カットΣN_{PE}=~1000
バックグラウンド:　~99.99% 除去
ガンマ線:　~95% 生存
ガンマ線感度: バックグラウンドフリー!

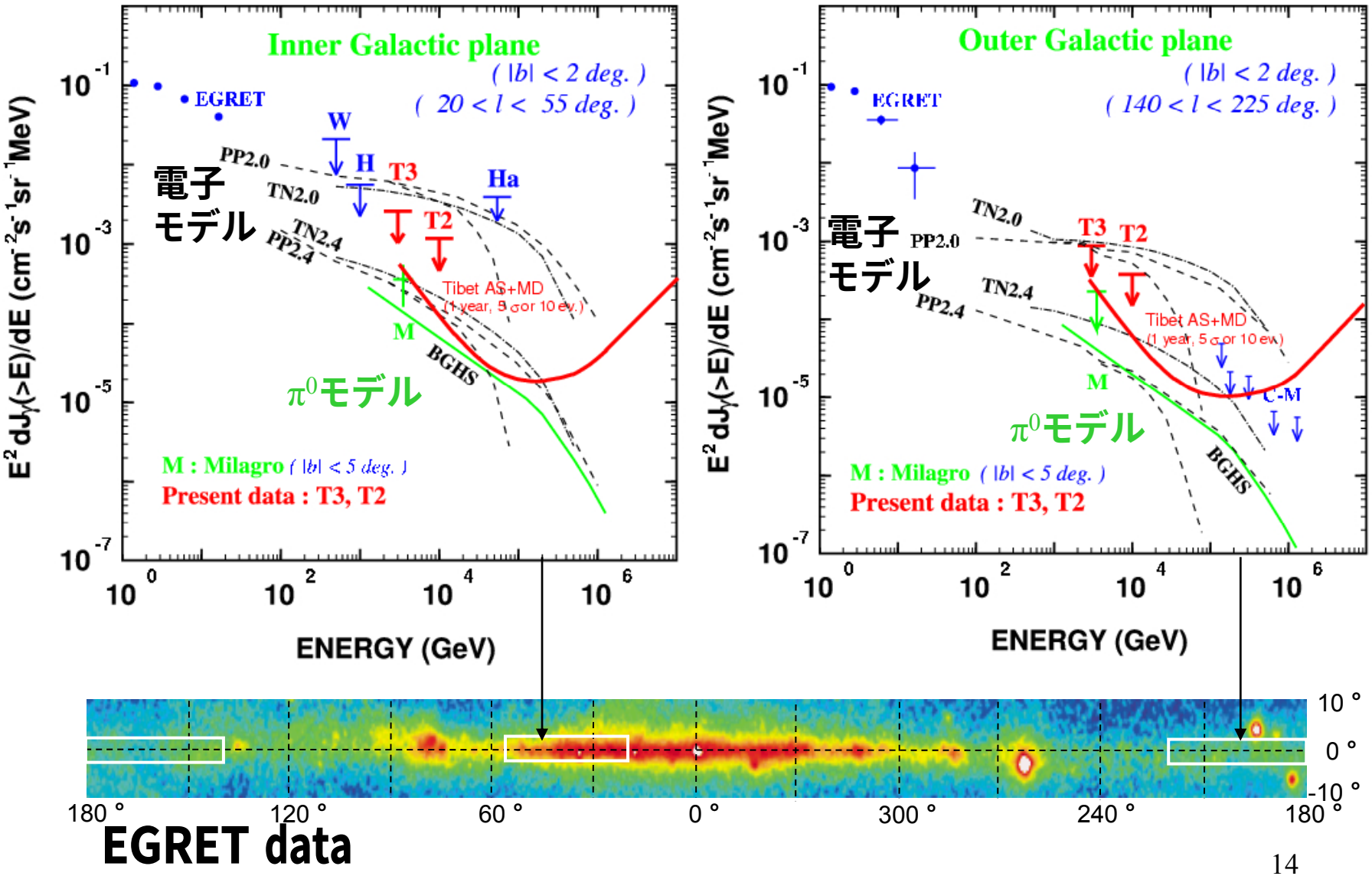
1000TeV:
カットΣN_{PE}=~20000
バックグラウンド:　>>~99.99%　除去
ガンマ線:　~99% 生存
ガンマ線感度: バックグラウンドフリー!

	Tibet AS+MD >~100 TeV	HESS >~TeV
Location	30N-90E	23S-16E
FOV	~2 sr	~0.02 sr
Duty cycle	~90%	~10%
θResolution	~0.2 °	~0.1 °
E Resolution	~40%	~20%
Background Rejection	~99.99%	~99%
S/N Ratio (RX J1713)	S/N = 80ev / 0.5ev (1yr in 0.6° radius, >100TeV)	S/N = 2500ev / 2000ev (50hrs in 0.6° radius, >1TeV)
	S/N = 200 / 5 (1yr in 0.6° radius, >40TeV)	S/N = 20 / 20 (50hrs in 0.6° radius, >40TeV)

Comparison with other experiments or future plans
(5σ or 10イベント)



銀河面からのDiffuseガンマ線



まとめ

チベットMD計画

～83000 m^2 チベット空気シャワー観測装置+
～10000 m^2　水チェレンコフミューオン観測装置
→100TeV領域(10-1000TeV)ガンマ線の観測（宇宙線加速限界と拡散γ線）

シミュレーションによる予想感度

F(>100(20)TeV) ～10^{-15} cm^{-2} s^{-1} ～10 (5) % Crabs
→従来より1桁以上ガンマ線に対する感度が改善
>10-20TeV で>HESS, >30-40TeVで>CTA

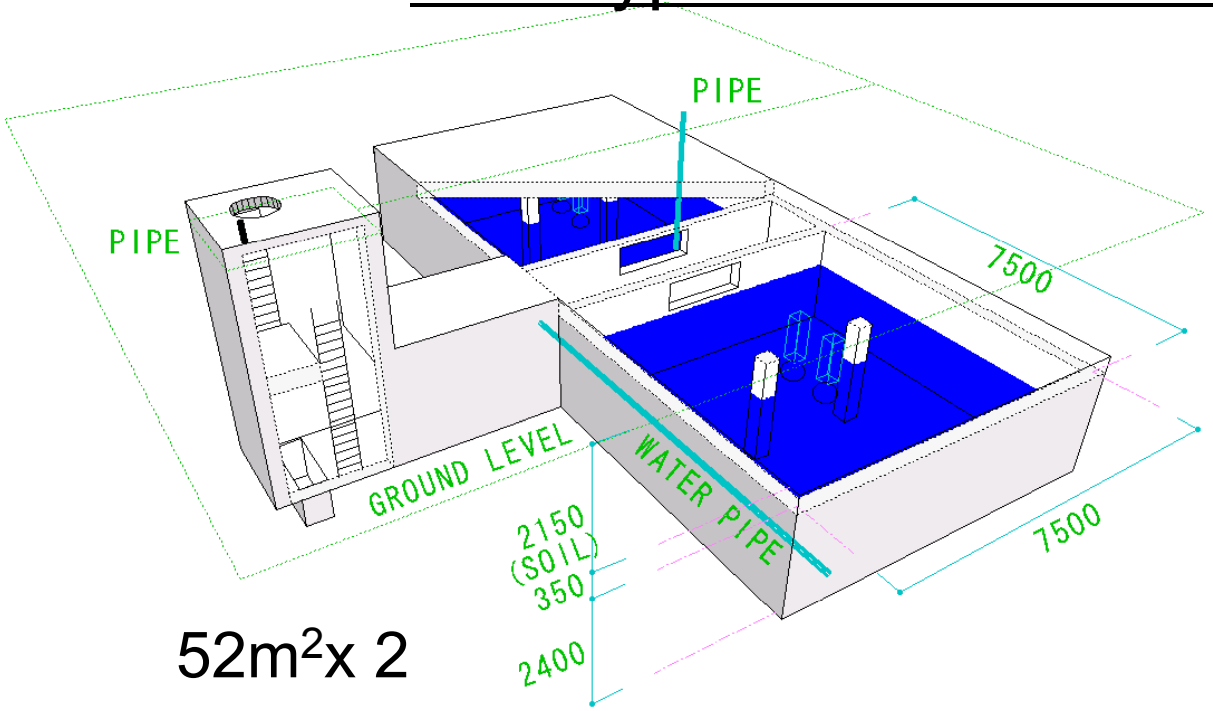
北天100TeV領域のガンマ線候補天体:

観測可能天体　： Diffuse γ from Milky way,
(1 year) Crab, TeV J2032+4130,
MGRO J2019+37, MGRO J1908+06, MGRO J2031+41
HESS J1837-069, Mrk 421

面白そう　： Cas A, M87, HESS J1834-089, HESS J0632+058
(Several years) Mrk 501, LS I +61 303, IC443, Extragalactic Diffuse γ???

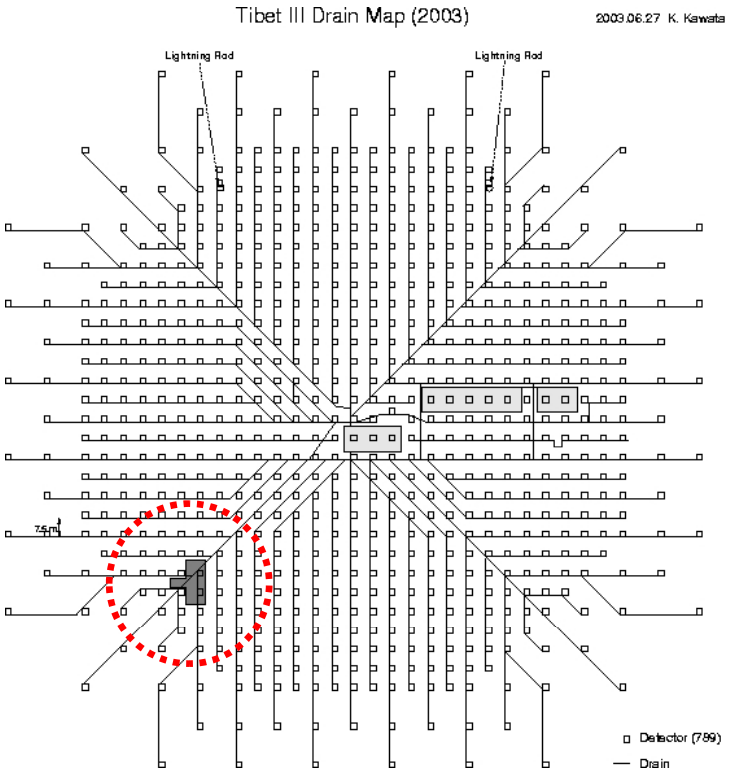
予想未知天体数　：　数個-10個位!?

Prototype Muon Detector in Tibet



52m^{2}x 2

Construction from
Sep. 2007
Data taking from
Dec. 2007



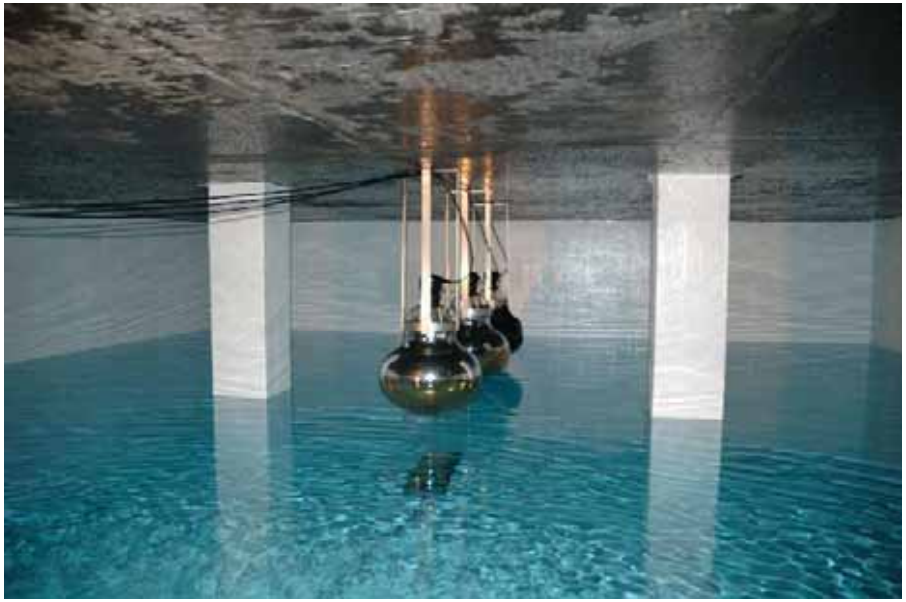
- Construction feasibility in Tibet ?
- MC simulation OK?
- γ observation above multi 100 TeV

16 November, 2007 Prototype Muon Detector

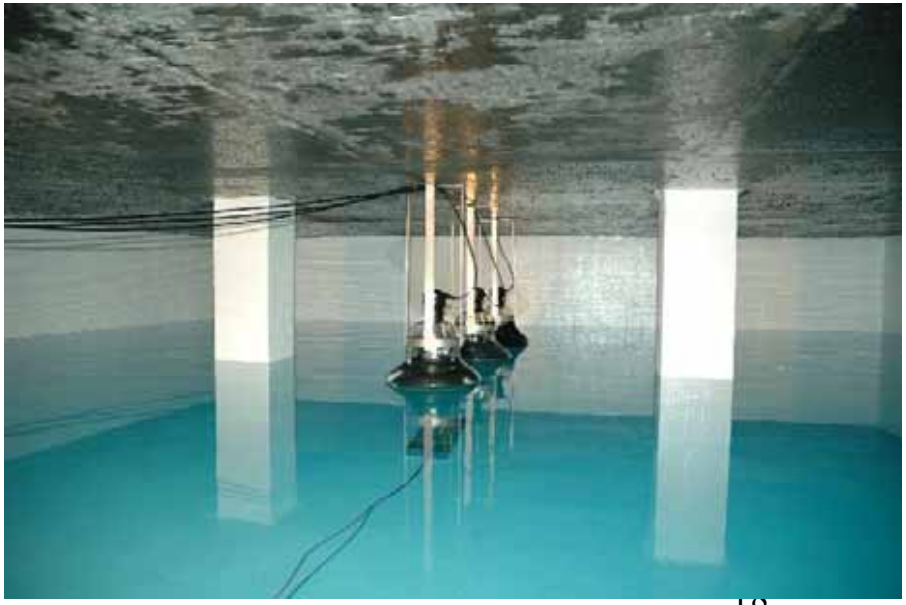
Interior decorations

Pool(1): white epoxy resin (high cost)

Pool(2):cheap waterproofing + Tyvek (low cost)



Pouring very clear well-water

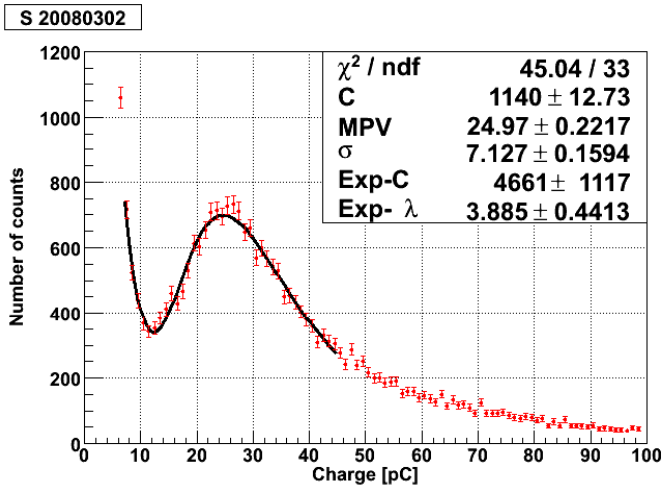


Filled up water 1.5 m in depth

Data Analysis

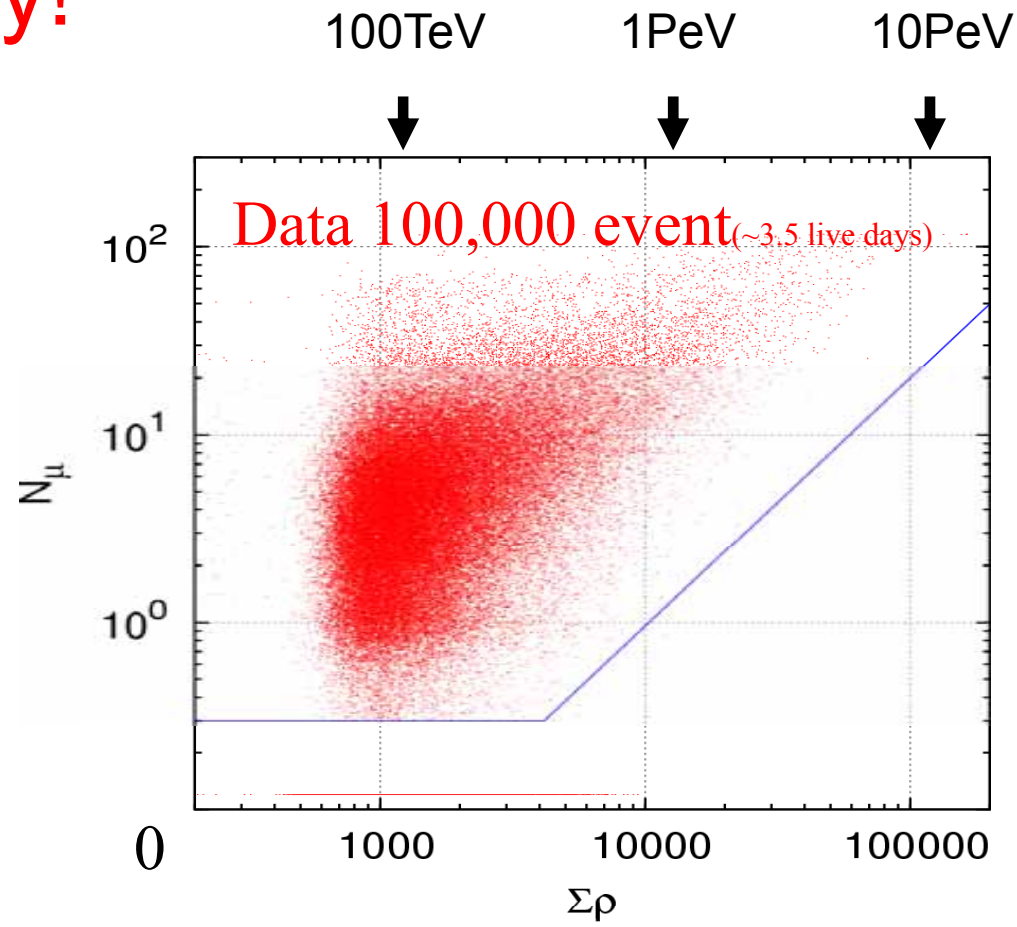
Very Preliminary!

Single Muon Peak



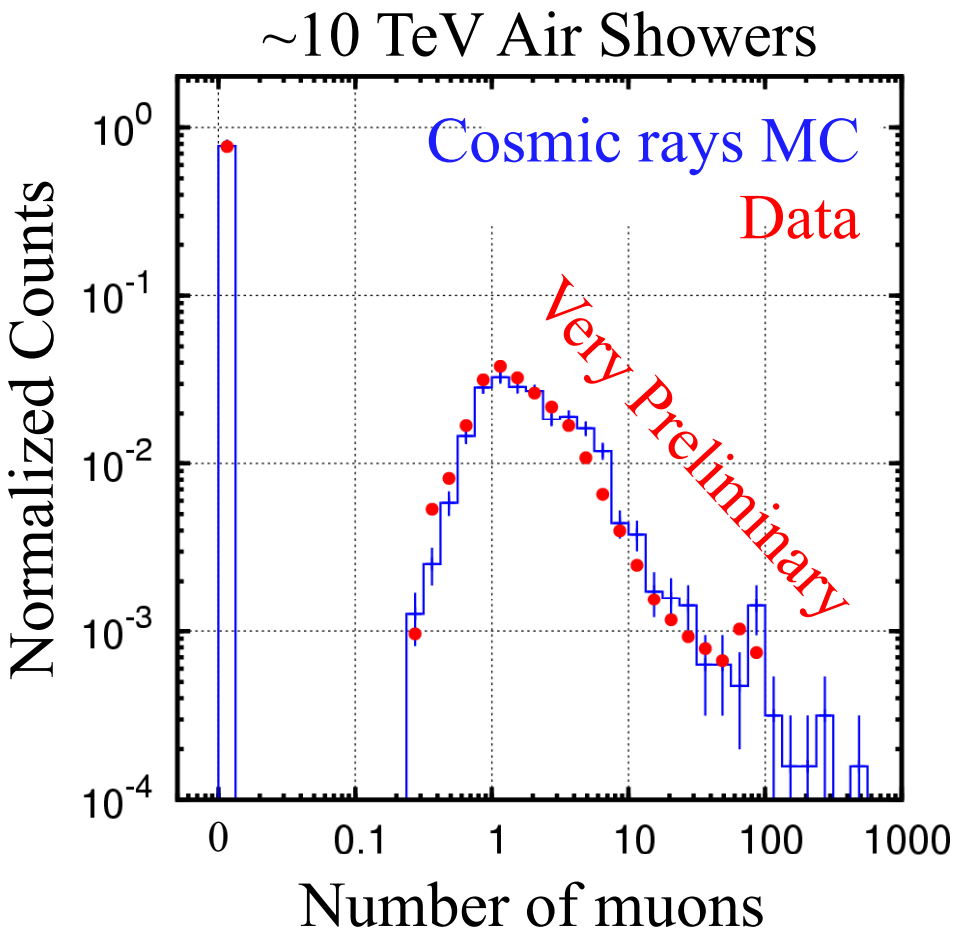
Air Shower Size v.s. Nμ

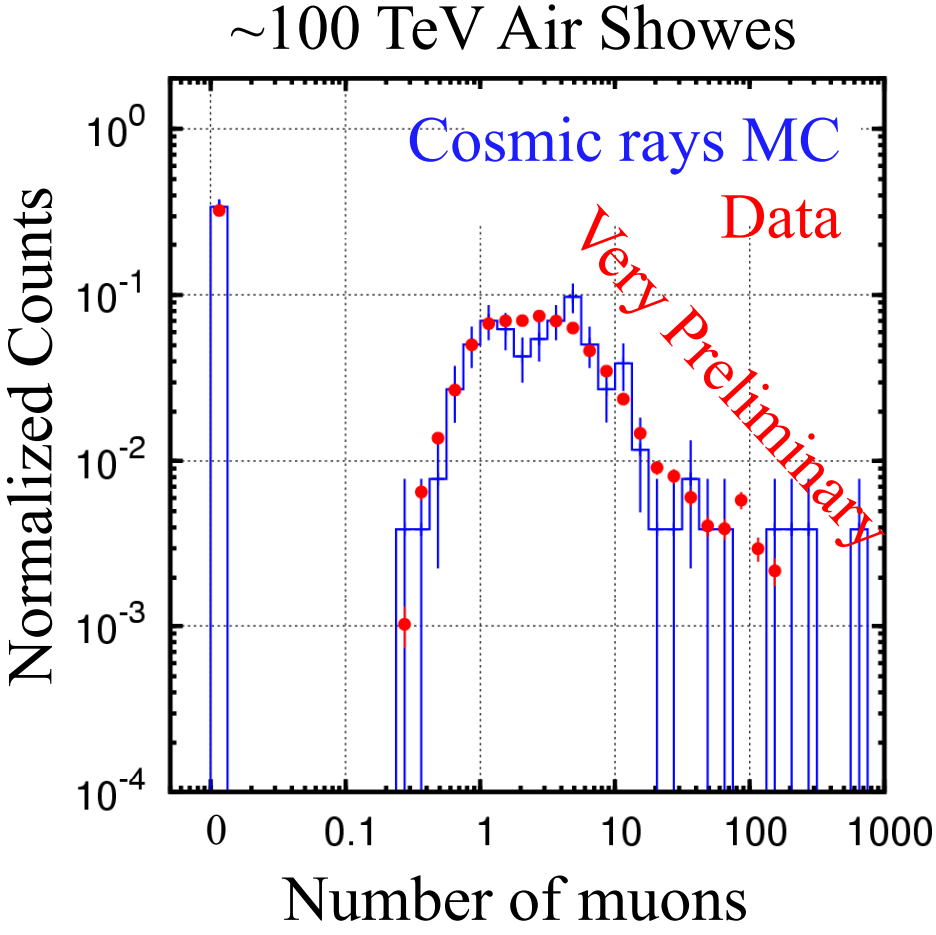
Low-energy events are cut (Eth = ~ 50 TeV)



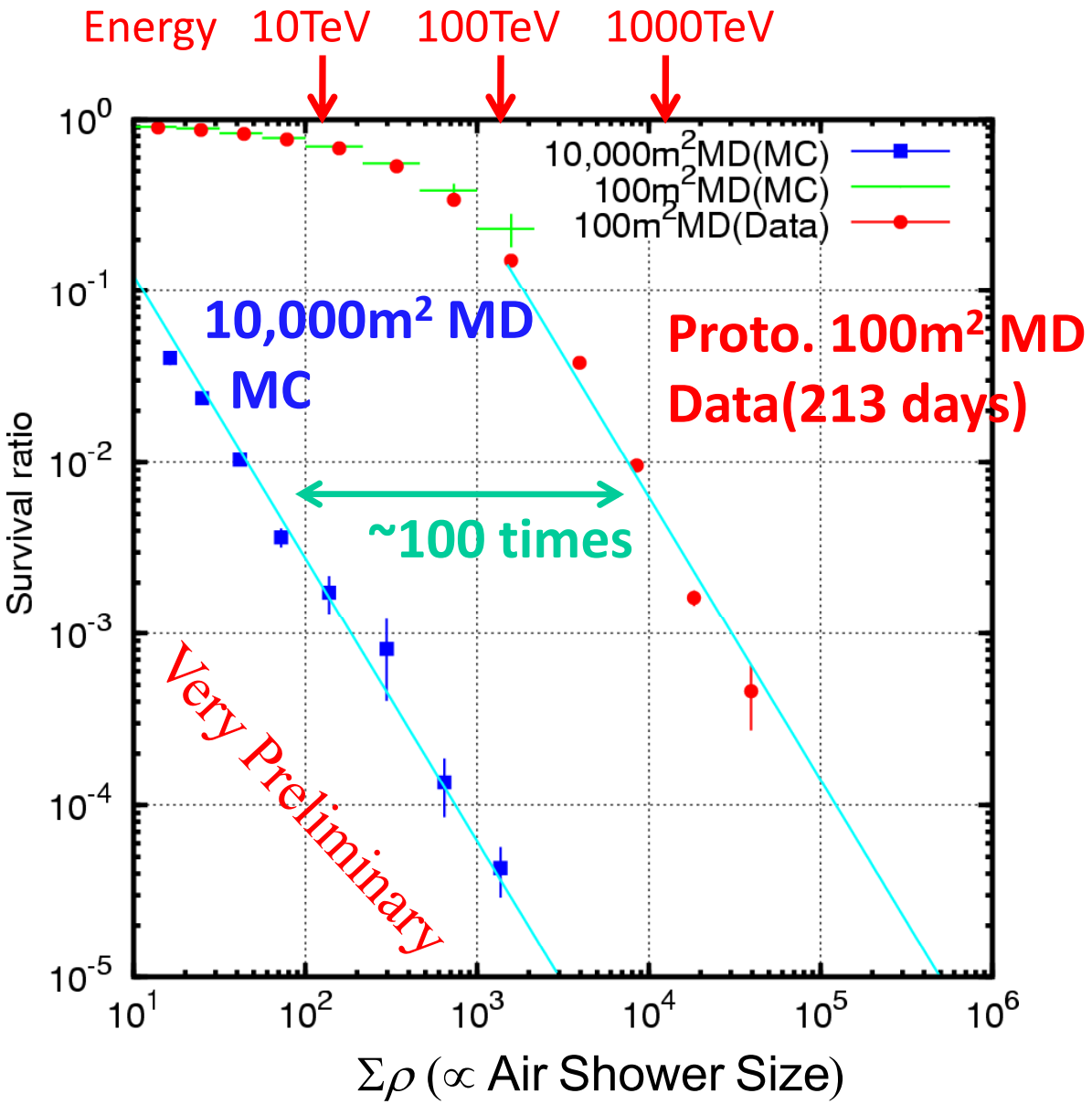
Σρ (∝ Air Shower Size)

Number of muons

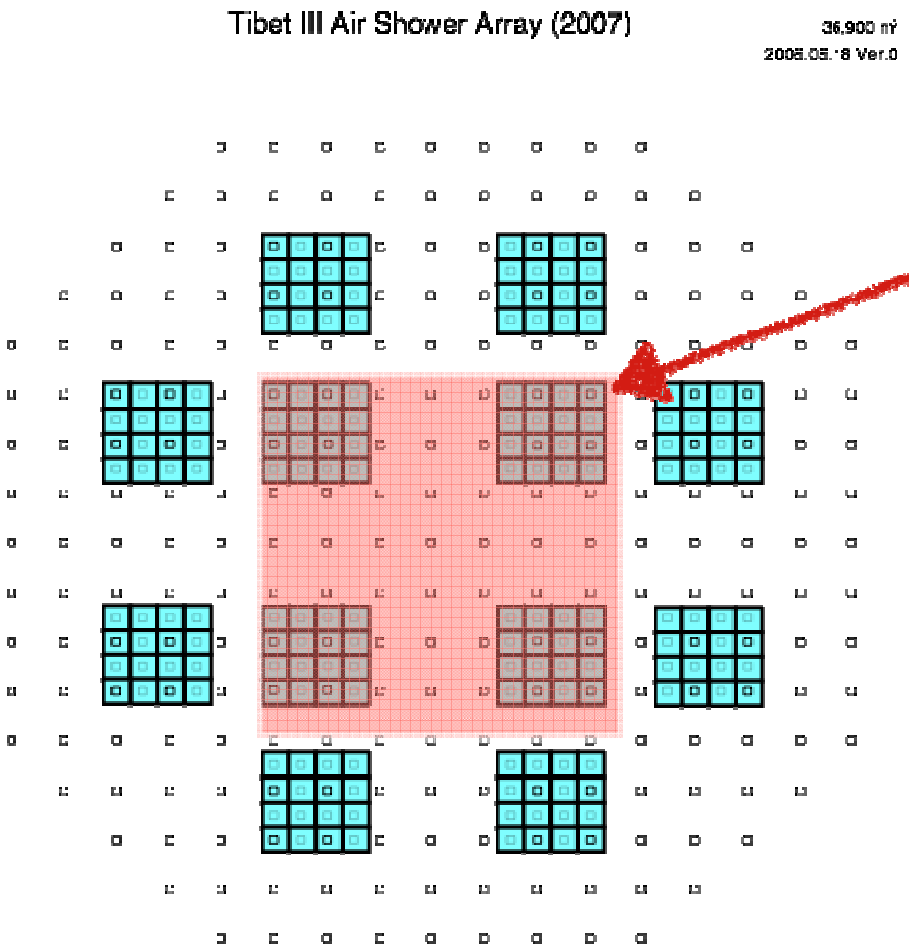




Cosmic Ray (Nucleus) Survival Ratio



2010 Tibet Muon Detector (MD)



2010年建設中…

4プール＝64セル

～3300m^2

7月13日　着工

・・・

11月20日　竣工予定

現在の状況 (9/9時点)

北西プール　壁の配筋

北東プール　壁の型枠組立

南西プール　捨てコン打設

南東プール　床の配筋

YAC I
(Dense version)　(0.5億円)

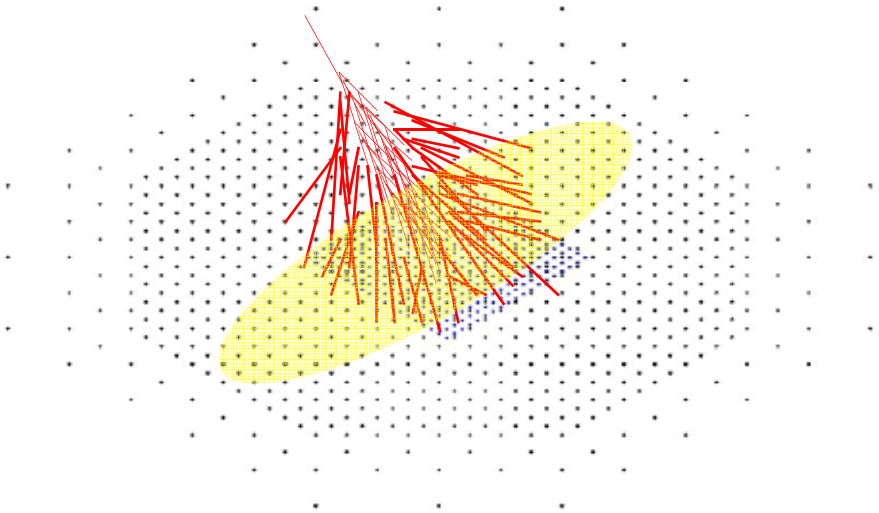
YAC I detector consists of 100 burst detectors with 1.5m spacing between detectors.

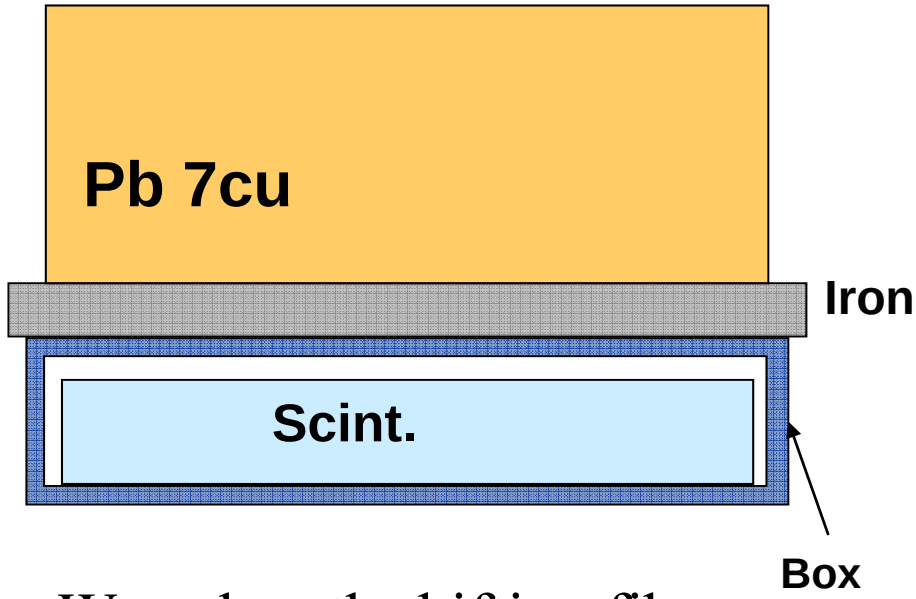
Total area of the array is 160 m^2 located near the center of Tibet III AS array.

It is designed to measure proton and helium spectra in the knee region. **Expected number of protons (>100TeV) and helium (>200TeV) using HD model are 2300 and 800 per one year, respectively.**

Design of YAC-I

40cm x 50cm, 100 channels S=160m^2

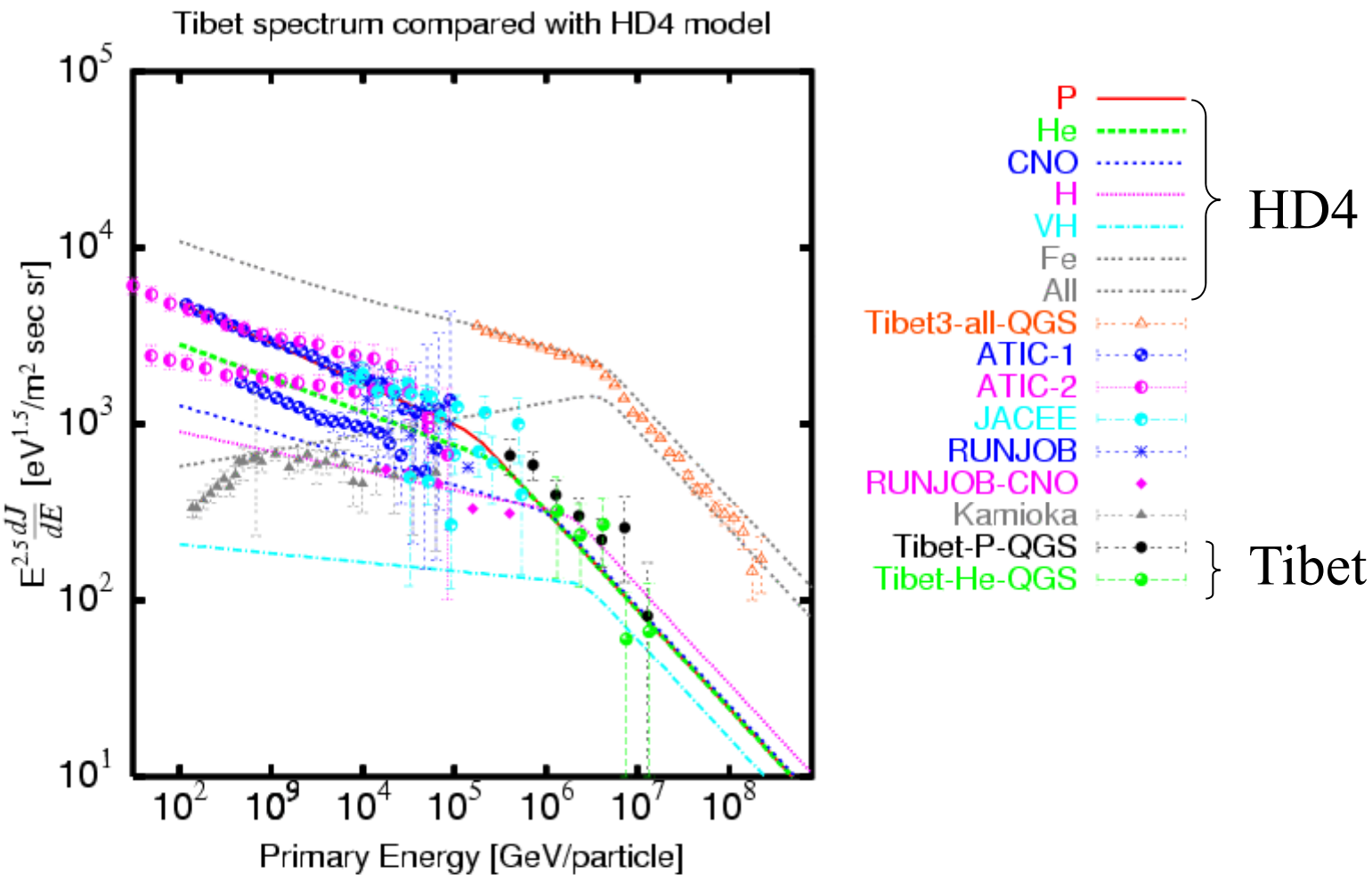




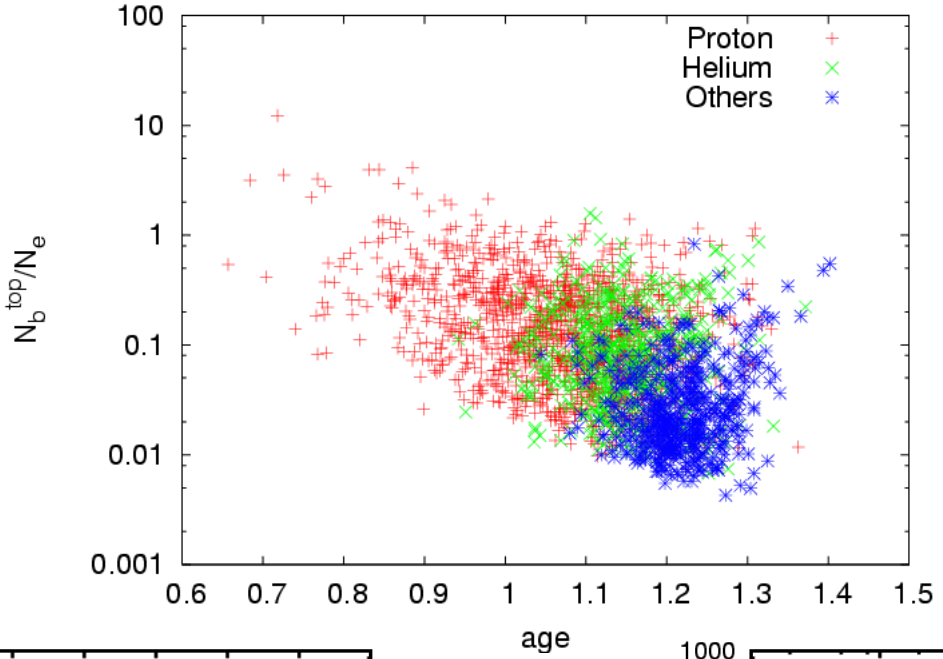
1.5m spacing 100ch
N_b>100**電子数**,
any 1 (>30GeV)

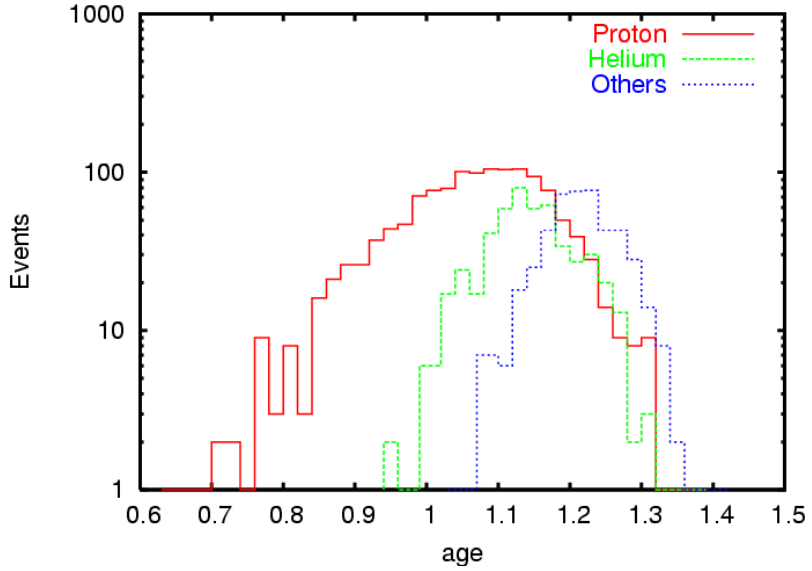
Wave length shifting fiber
+ 2 PMTs
(Low gain & High gain)
$10^2<N_b<10^6$

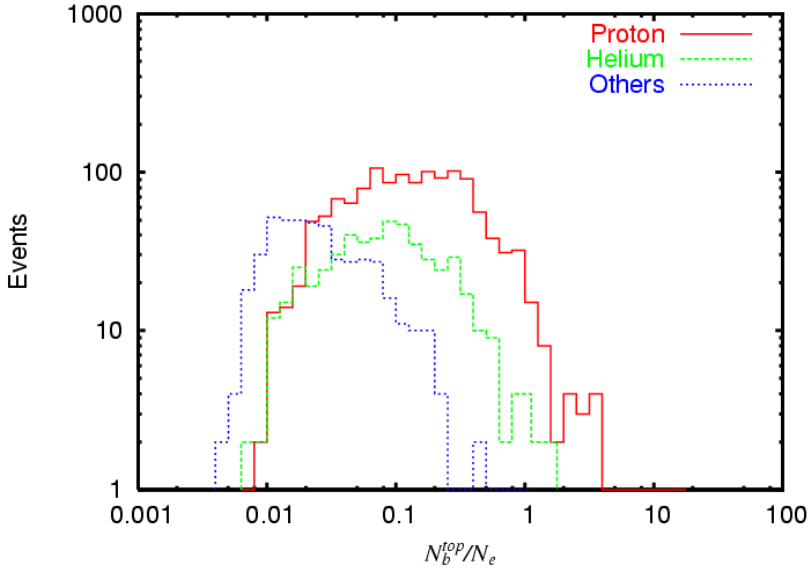
Tibet All, P, He spectrum

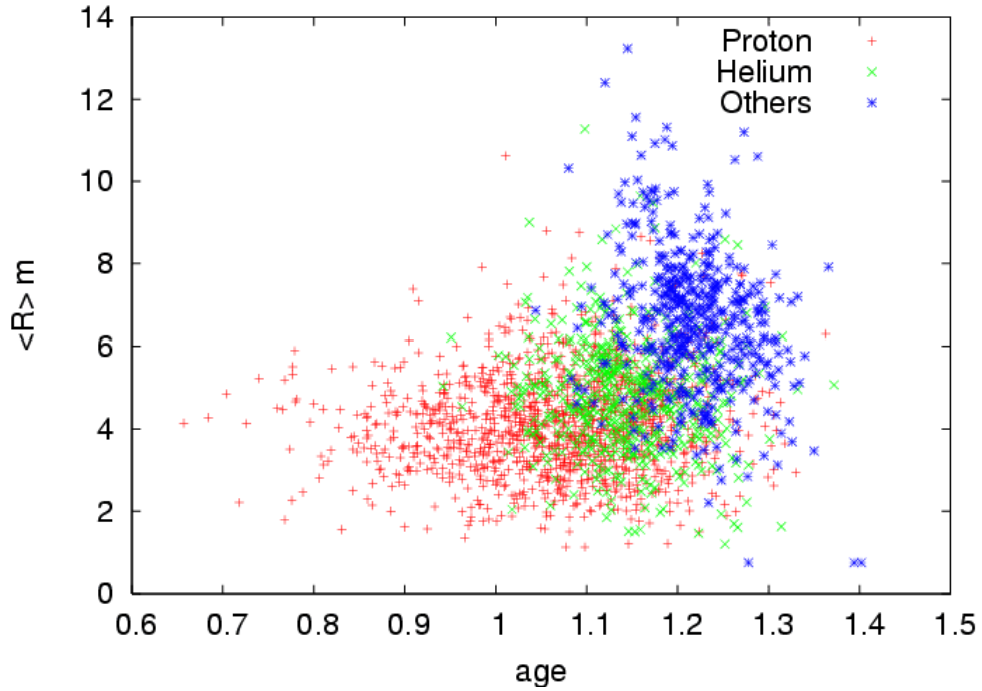


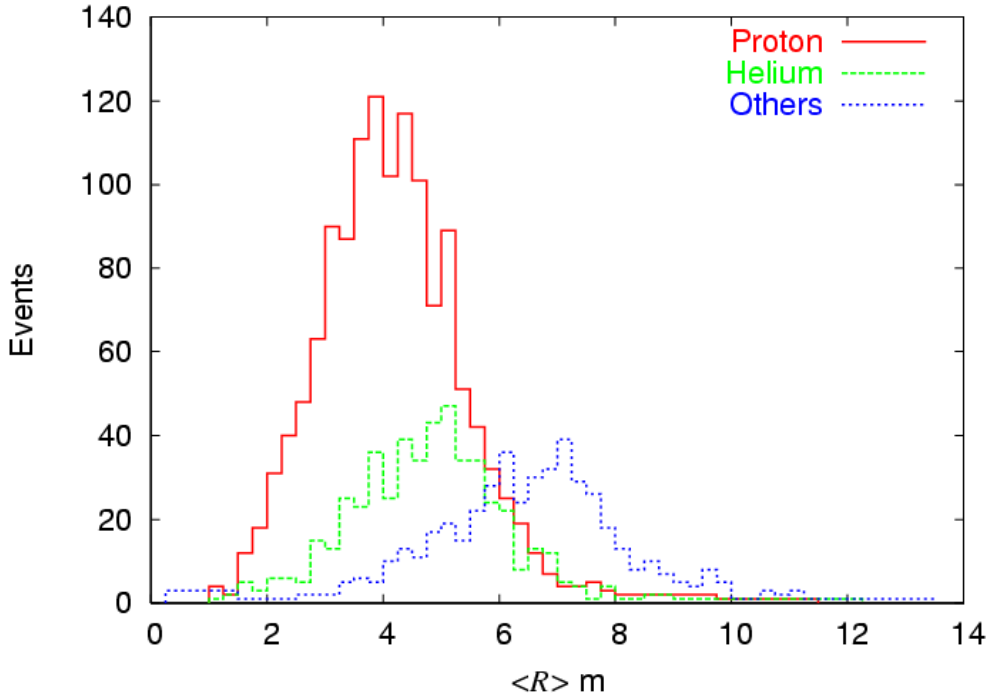
Features of YAC observables





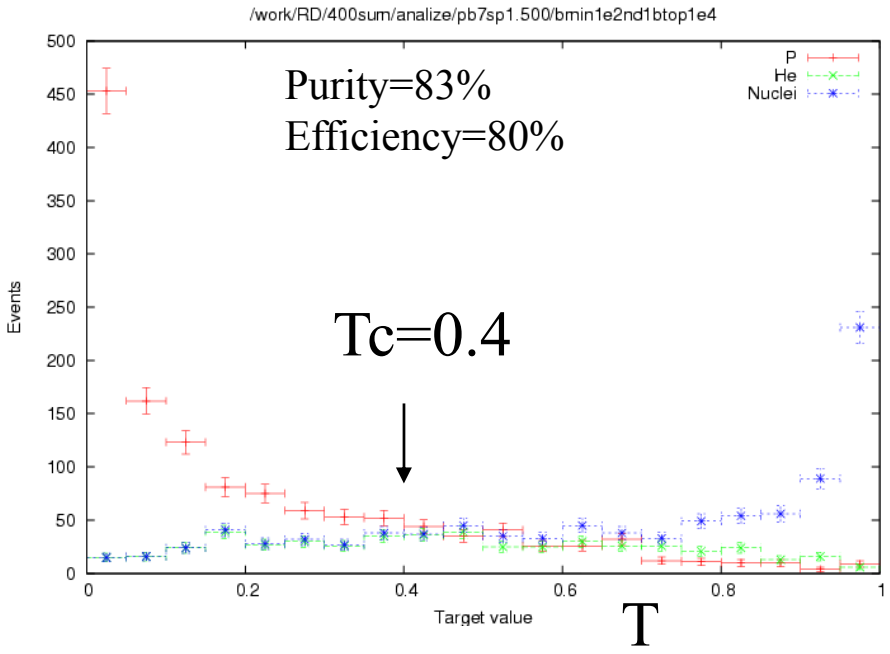



Proton
Helium
Others
<R> m
age
0
2
4
6
8
10
12
14
0.6
0.7
0.8
0.9
1
1.1
1.2
1.3
1.4
1.5


Proton
Helium
Others
Events
<R> m
0
20
40
60
80
100
120
140
0
2
4
6
8
10
12
14

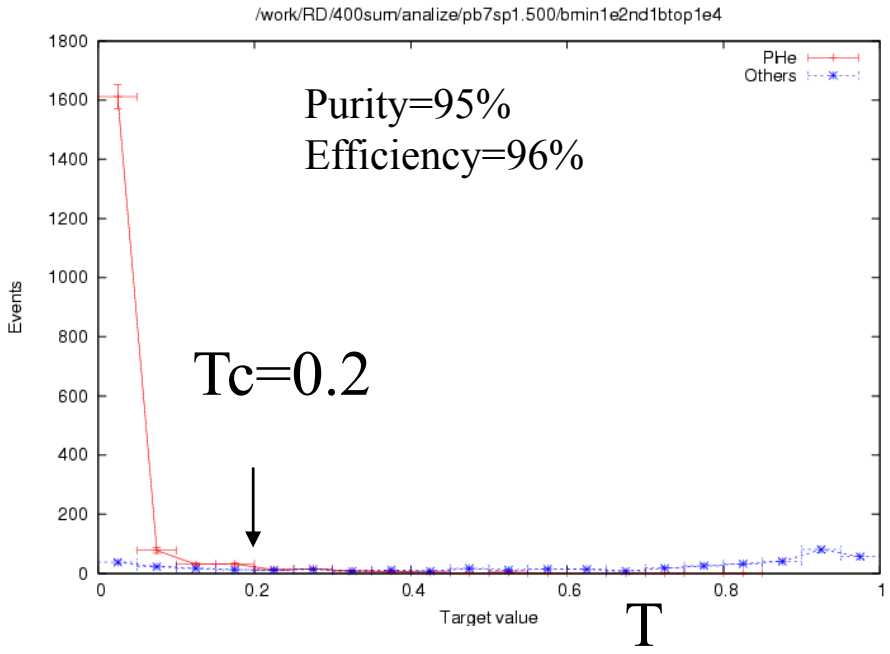
ANN output

Proton separation



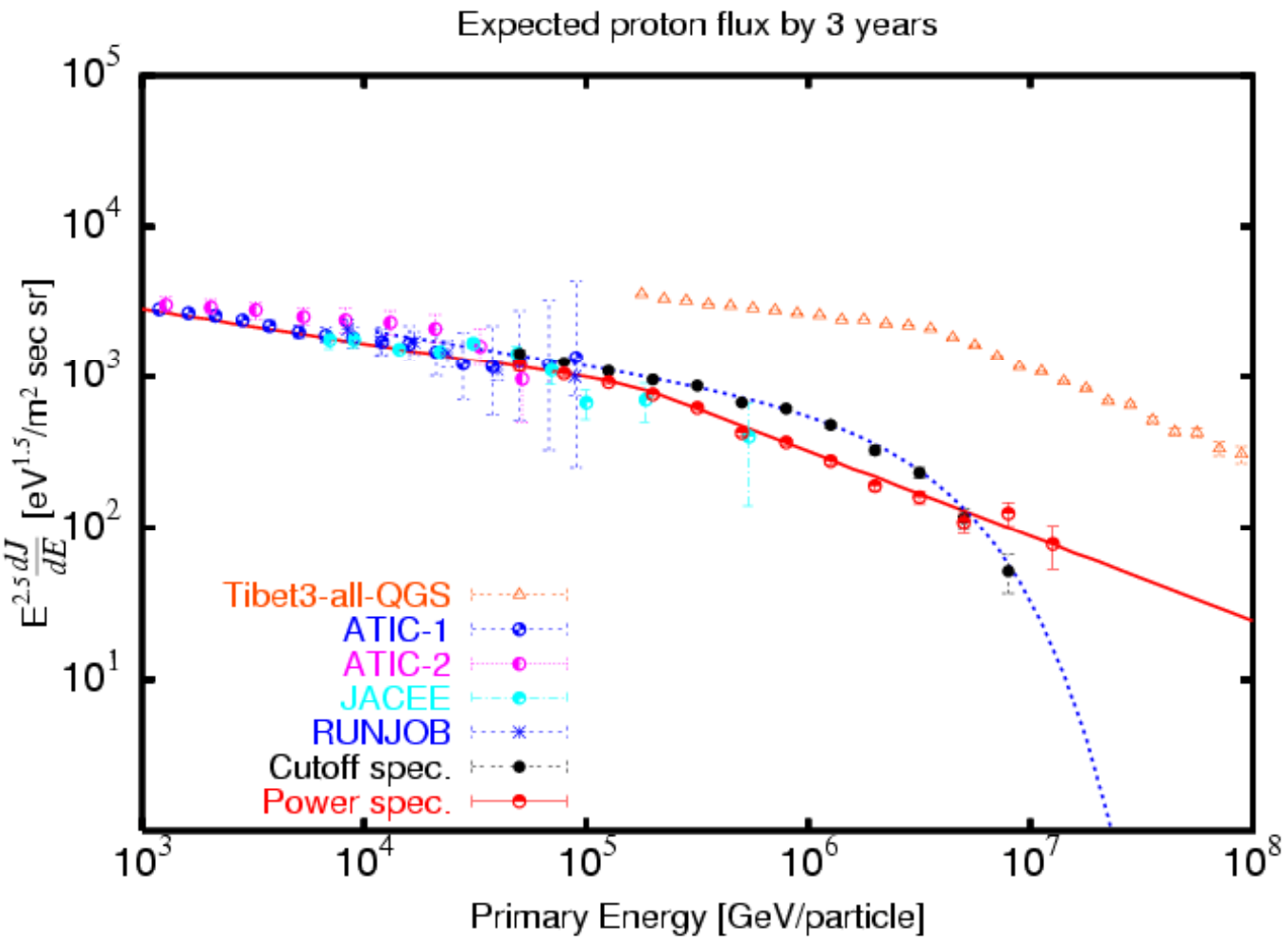
Contamination is exclusively by helium nuclei.
The fraction of helium events missidentified as protons is about 40% of helium events by Tc=0.4.

P+He separation

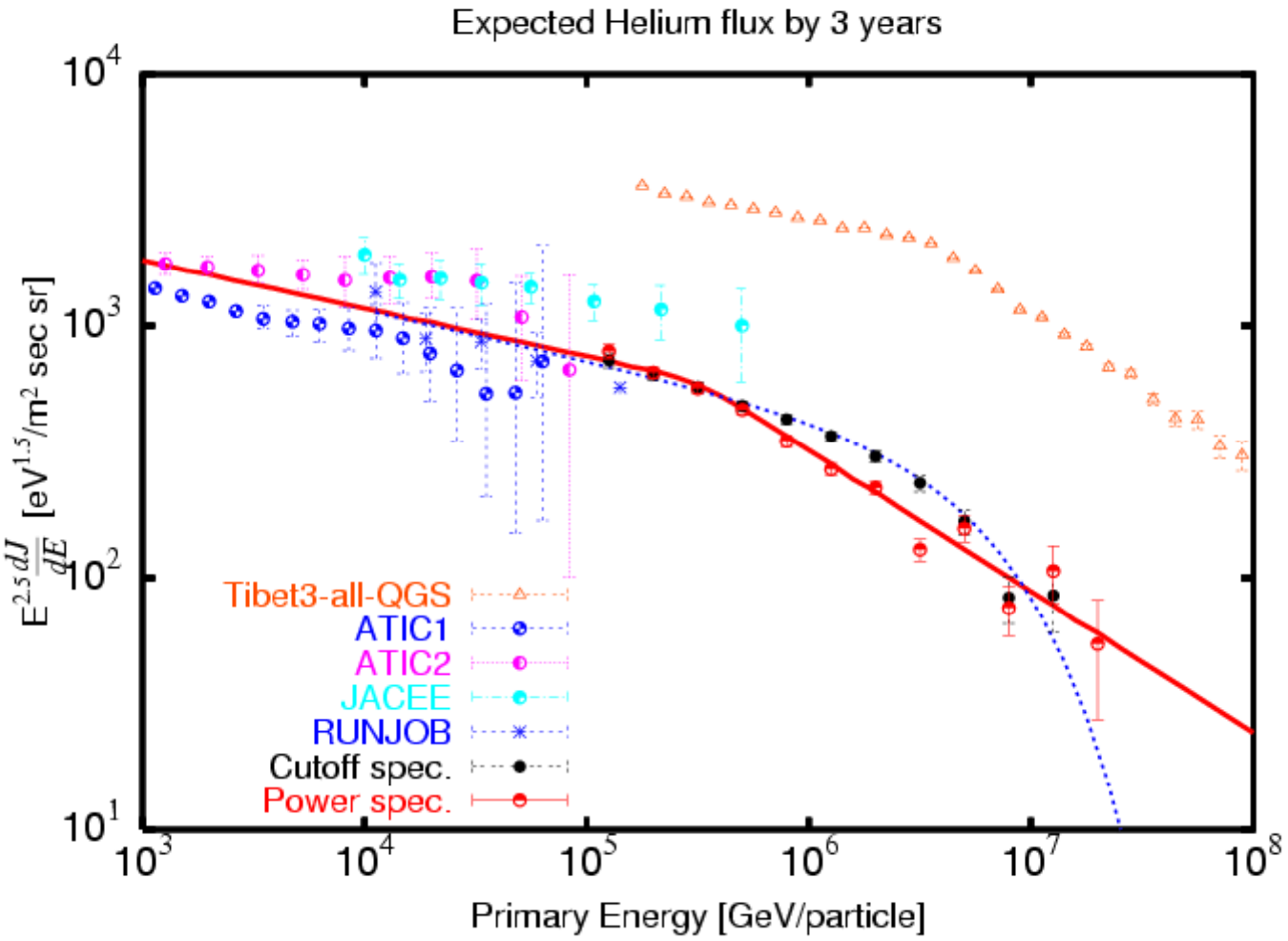


20% of heavier nuclei than helium contaminates to P+He region.

Expected proton spectrum (YAC-I)



Expected He Spectrum (YAC-I)



YAC II
(Wide version)　2.5**億円**

YAC II detector consists of 400 burst detectors with 3.75m spacing between detectors.

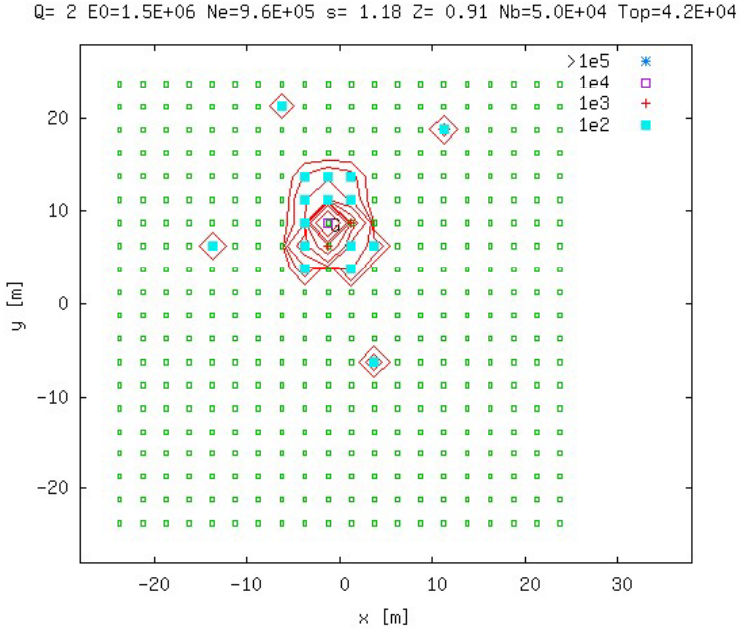
Total area of the array is 5000 m^2 located near the center of Tibet III AS array.

It is designed to measure iron group spectra in the knee region. **Expected number of irons (>1000TeV) using HD model is 4400 per one year.**

Design of YAC

40cm x 50cm, 20x20 channels

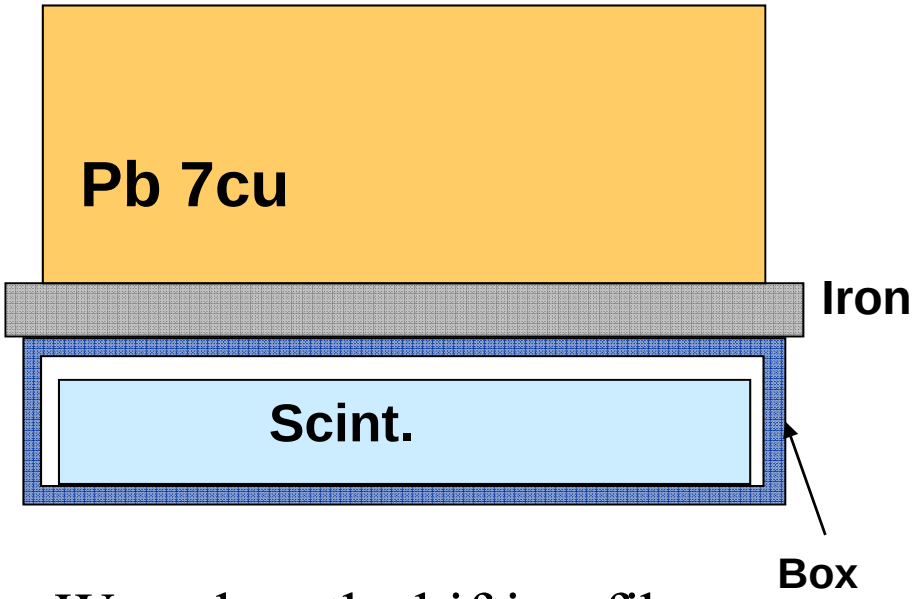
$S=5000m^2$



3.75m spacing 400ch

N_b>100, any 5

(>30GeV)



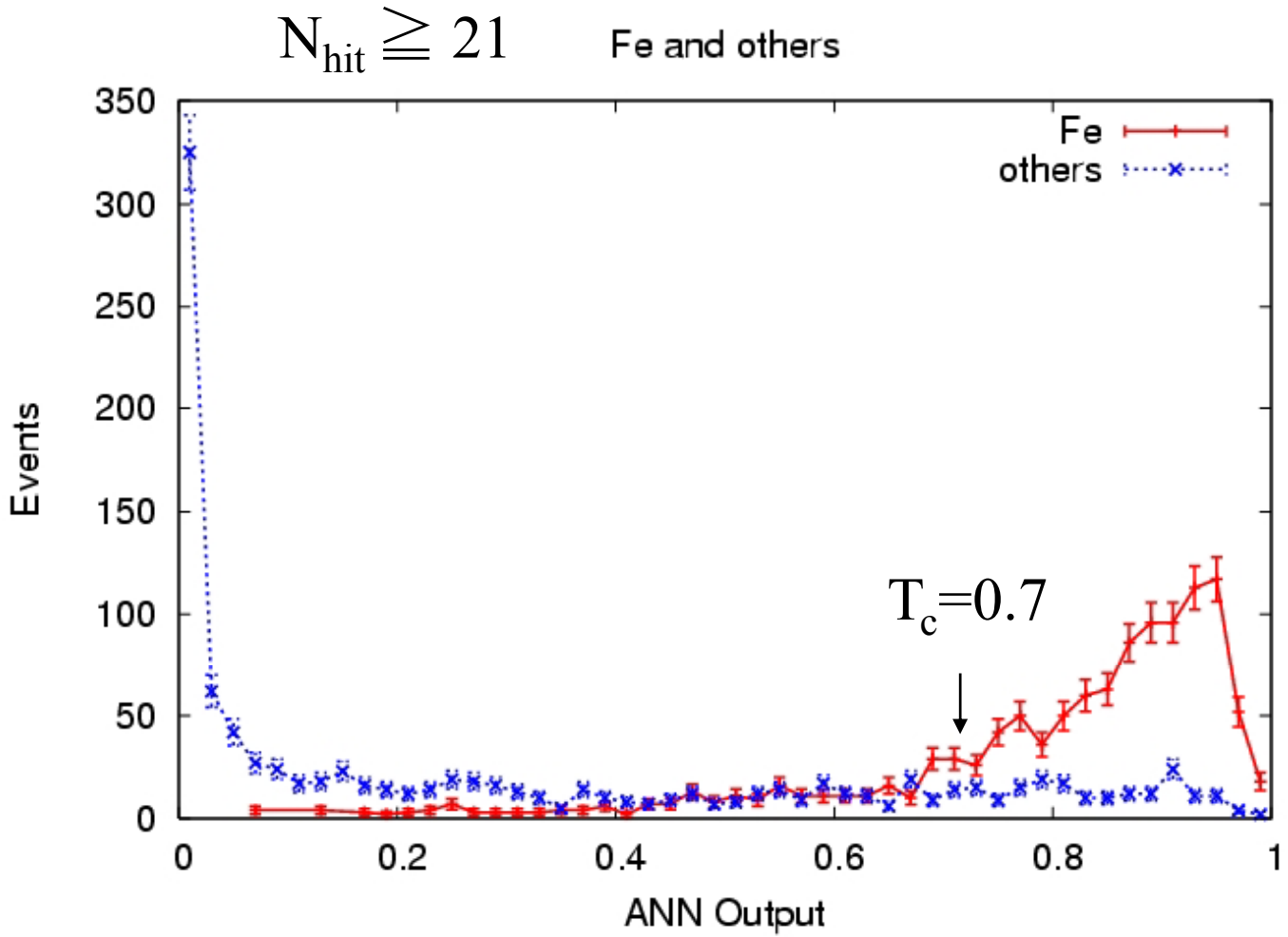
Wave length shifting fiber

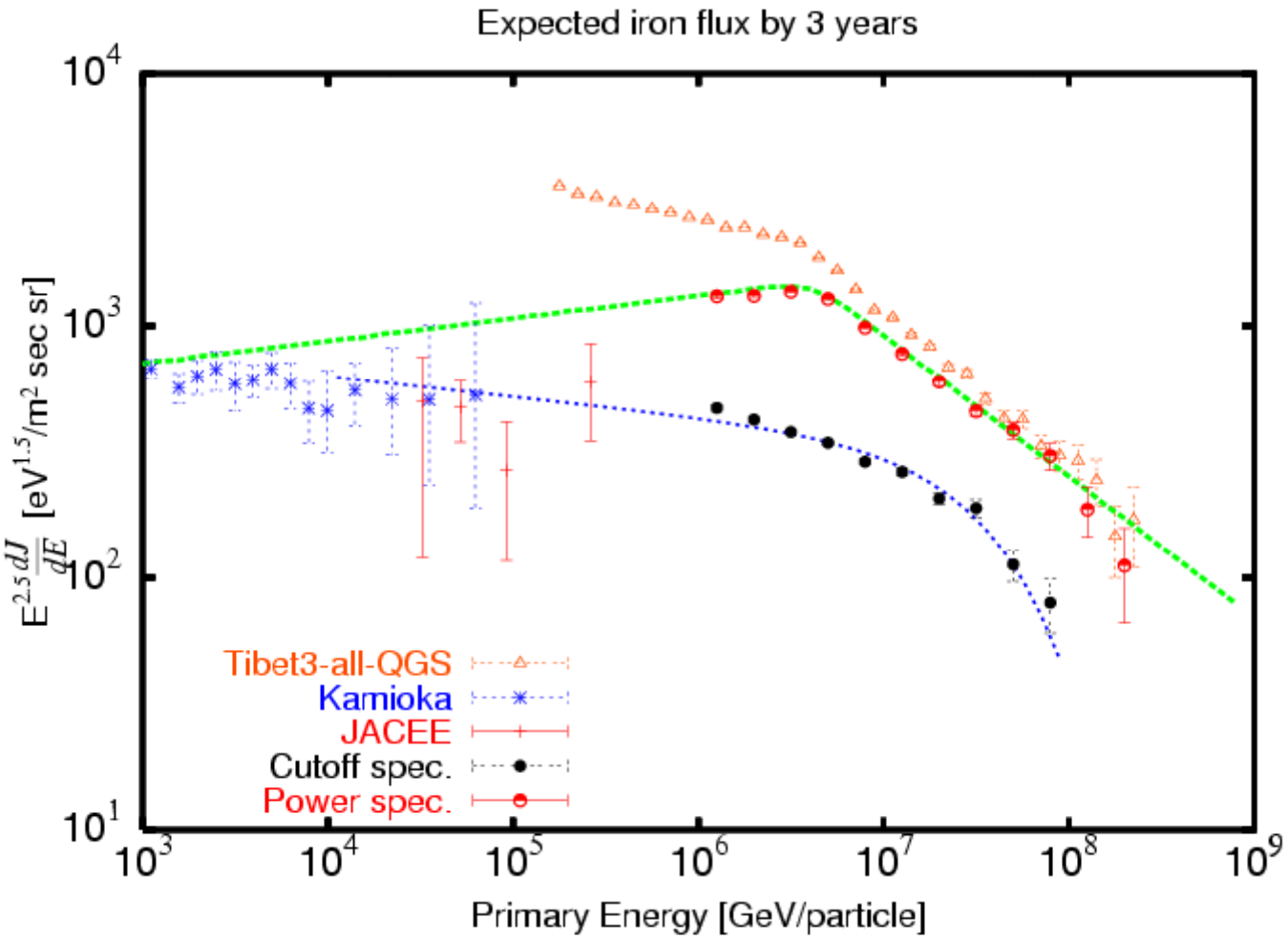
+ 2 PMTs

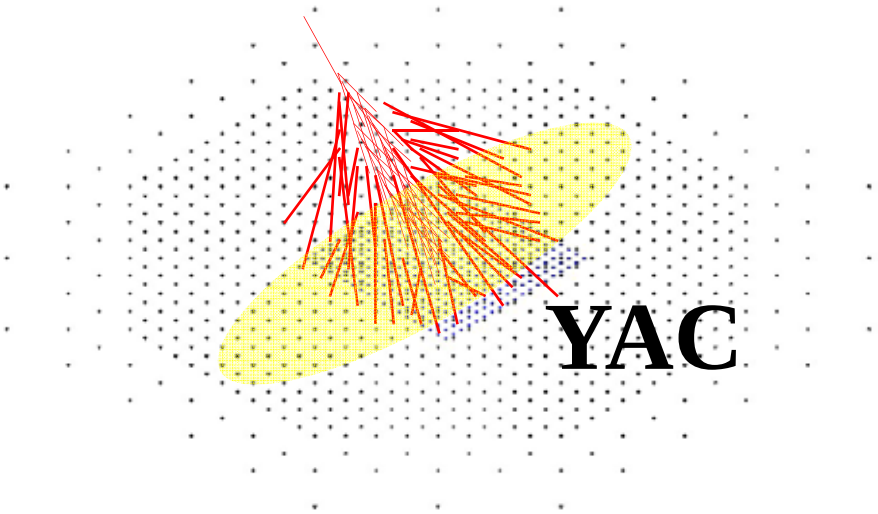
(Low gain & High gain)

$10^2<N_b<10^6$

Separation of Fe by YAC II



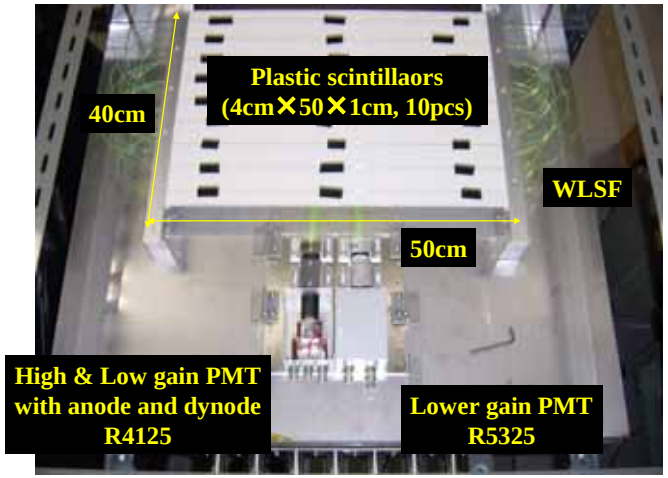

Expected iron flux by 3 years
10^4
10^3
10^2
10^1
$E^{2.5}\frac{dJ}{dE}$ [eV$^{1.5}$/m^2 sec sr]
Tibet3-all-QGS
Kamioka
JACEE
Cutoff spec.
Power spec.
10^3
10^4
10^5
10^6
10^7
10^8
10^9
Primary Energy [GeV/particle]

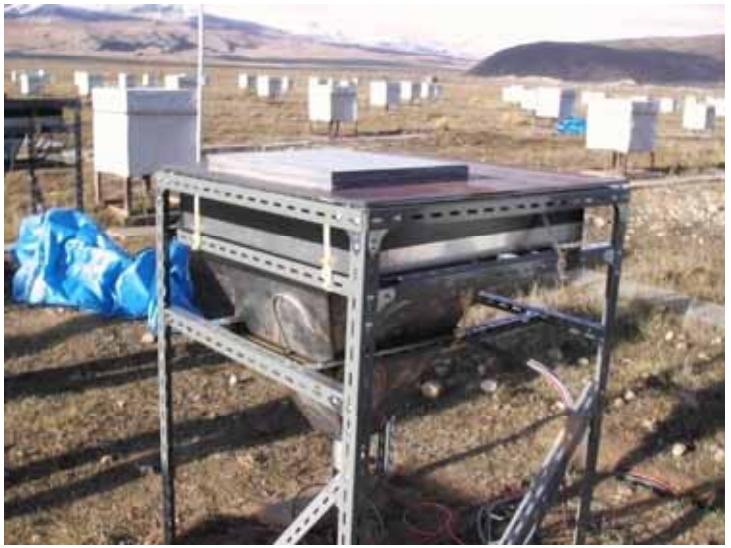


Tibet AS γ

Proto-type YAC Detector

Prototype of YAC
(Yangbajing Air shower Core detector)





- R&D DONE for MD&YAC
- ~1/3 full MD under construction &
- YAC-I construction will start soon.

We are READY , TRYING to get fully funded!

End