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#0903 A Linear Accelerator for FD calibration

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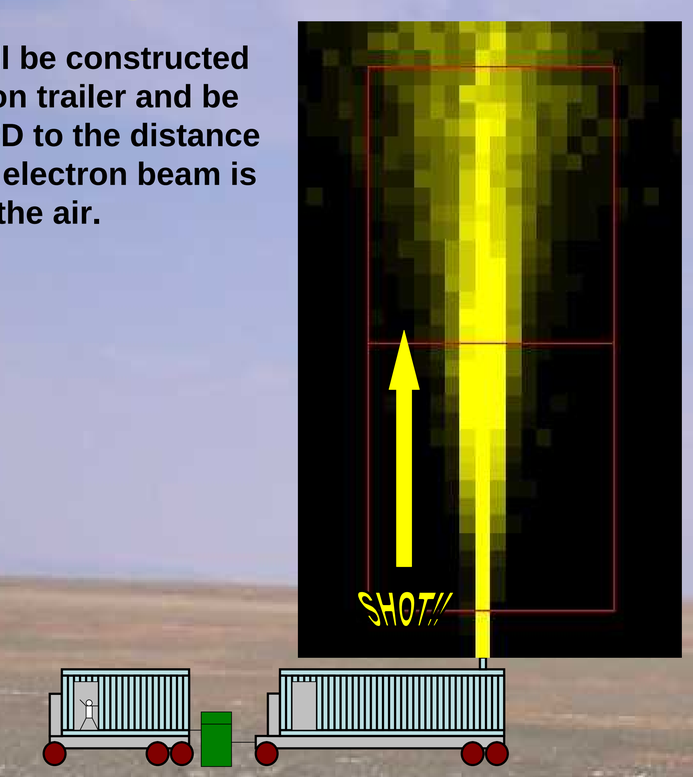
Outline

The Telescope Array project (TA) is one of the large scale experiment which observes extremely high energy cosmic ray. Fluorescence Detector (FD) observes ultraviolet photons emitted from nitrogen molecule in the air excited with electrons in air shower. Since the total number of generated fluorescence photons is in proportion with energy of mother electron, the energy of primary particle can be calculated from number of photons. However the reconstructed energy of primary particle has large uncertainties. We estimated that of TA FD is ~23%. It is impossible to calibrate between energy of cosmic ray and number of detected photons directly, because we don't know the true energy of that. We can expect that the calibration by using accelerator beam is useful for absolute energy calibration of FD. We are developing a Linear accelerator at KEK in Japan. We call the Linac as "TA-LINAC".

TA-LINAC System

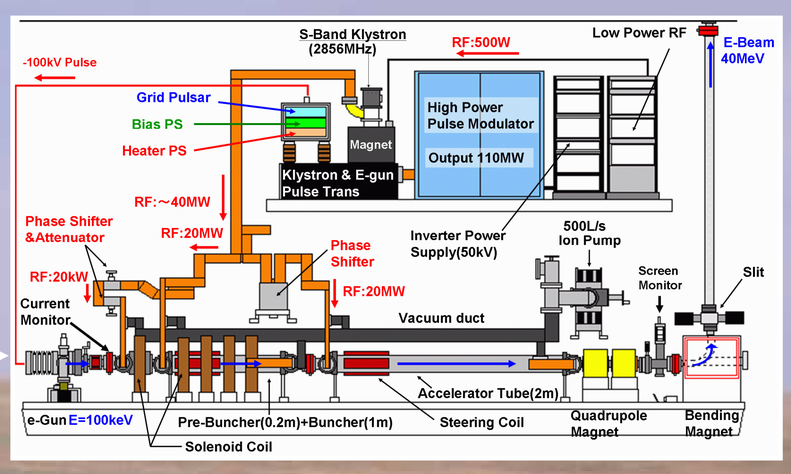
TA-LINAC will be constructed in container on trailer and be set up from FD to the distance of 100m. The electron beam is injected into the air.



Specification of TA-LINAC

Particle	electron
Maximum Energy	40MeV
Beam Power	6.4mJ/pulse
Pulse width	1μsec
Frequency	1Hz

TA-LINAC is base on S-band RF acceleration system. Almost all of components except high power pulse modulator are the removal equipments to KEKB at the up-grade. The high power pulse modulator was developed for C-band Linear Collider system at KEK.



Main Components and Specification

Electron Gun	-100kV Pulse
Pre-buncer	2MV/m
Buncher	17MV/m
2m Accelerator Tube	18MV/m
Bending Magnet	0.67T(40MeV case)
Collimator	Tantalum thickness=50mm
High power pulse Modulator	100MW
High power Klystron	40MW (2856MHz)

Monitor ... Core Monitor ×4 + Screen Monitor ×1 + Faraday Cup ×1

We will use two container. The beam line and RF system will be set in the main container(40feet). The cooling system and control room will be set in sub container(20feet).

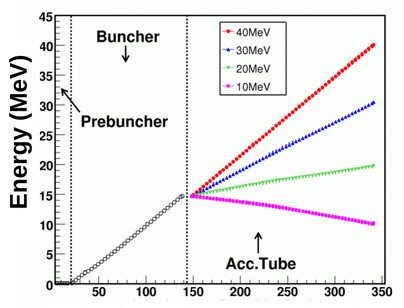
Cooling System

Cooling Power	20kW
Flowing quantity	110L/min
Volume of water	500~600L

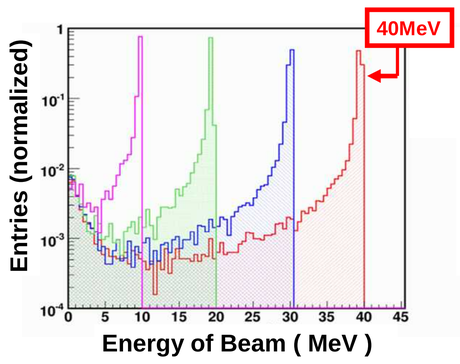
This cooling system is a unit for using in the desert. Total calorific value of the load in Linac system was estimated as 8.4kW.

Simulation of Beam Dynamics and Air Shower detected by FD

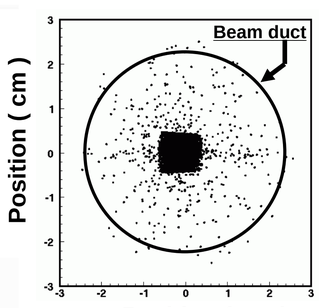
We studied the performance of electron beam dynamics, air shower generated by 40MeV electron, and FD response by using PARMELA(Phase And Radial Motion in Electron Linear Accelerator) and GEANT4.8.



Beam Accelerating



Energy Distribution of Output Beam

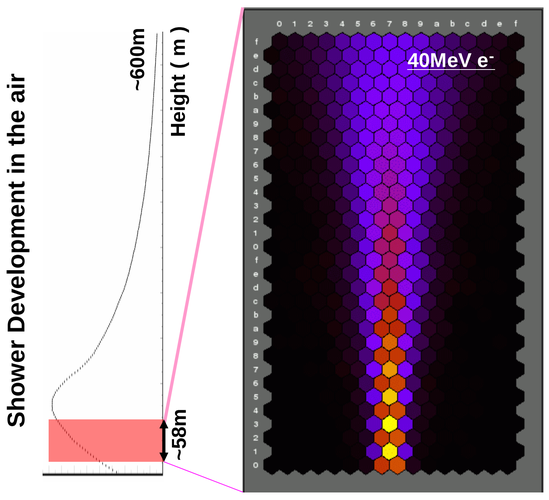


Size of 40MeV Beam

Best RF Parameters

Input RF into Pre-buncher	6.4kW / any phase
Input RF into Buncher	14.9MW / 150 deg (relative angle from pre-buncher)
Input RF into 2m Accelerator Tube	15.0MW / 130 deg (relative angle from pre-buncher, 40MeV case)

Total RF power 30MW



Detected Photons by FD cameras

Air shower max $0.35X_0$

Number of Detected Photons by two cameras 7.7×10^5

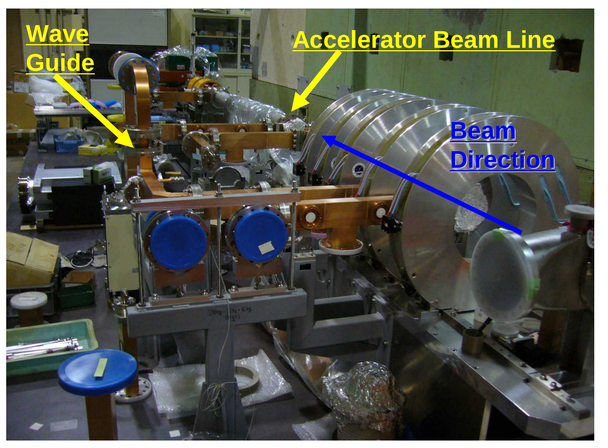
(Maximum photons/PMT 1.6×10^5)

Estimated ADC counts ~ 8000 counts/100ns

(No Geomagnetic field)

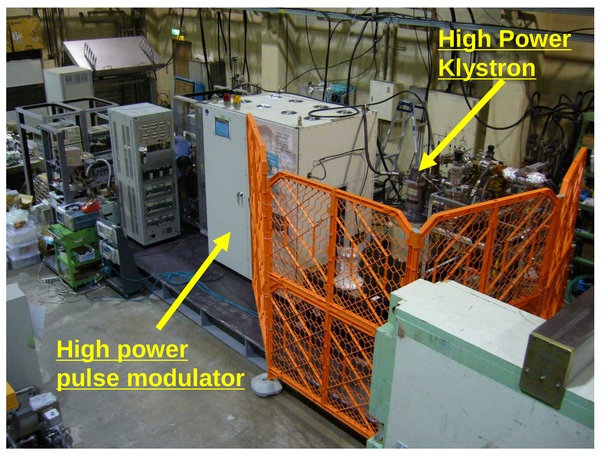
Systematic error of detected photons was estimated by using these simulations. We considered the error of photon yield, weather conditions, the error of detector parameters. The uncertainty of detected photons from the error of detector parameters were ~5%, and from the error of photon yield are ~8%. Above all, we can expect that the total systematic error is modified from 23% to ~17%.

Status of development of TA-LINAC at KEK



Beam Line of TA-LINAC (be token in June.29)

The construction was started from Jan.2007, and will be completed in this summer. Total weight included base was estimated as 20 ton. We plan to beam test in KEK. At this test, we will confirm the accuracy of output beam energy and measure the beam current by a Faraday cup. After beam test in KEK, we will export TA-LINAC to Utah, US, and will start beam operation in this winter.



S-Band Klystron Test stand (Left) and Input Pulse and Out put RF pulse (Right)

In June.28-29, we held the RF test with a high power pulse modulator and a high power klystron. We used 50kV DC power supply for charging into High power modulator. The maximum output power from modulator was 100MW. We could measure 40MW RF pulse with 100MW input. The RF pulse width was 2.5μs. We could confirm that this RF system has enough specification for using TA-LINAC.