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CAET Mission on the ISS

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ABSTRACT

We are developing the CALorimetric Electron Telescope, CALET, mission for the Japanese Experiment Module Exposed Facility, JEM-EF, of the International Space Station. Major scientific objectives are to search for the nearby cosmic ray sources and dark matter by carrying out a precise measurement of the electrons in 1 GeV - 20 TeV and gamma rays in 20 MeV - several 10 TeV. CALET has a unique capability to observe electrons and gamma rays over 1 TeV since the hadron rejection power can be larger than 10^5 and the energy resolution better than a few % over 100 GeV. The detector consists of an imaging calorimeter with scintillating fibers and tungsten plates and a total absorption calorimeter with BGO scintillators. CALET has also a capability to measure cosmic ray H, He and heavy ions up to 1000 TeV. It also will have a function to monitor solar activity and gamma ray transients. The phase A study has started on a schedule of launch in 2013 by H-II Transfer Vehicle (HTV) for 5 year observation.

Keywords: cosmic ray, dark matter, diffuse gamma ray, gamma ray burst, solar modulation, ISS, high energy, calorimeter

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1. INTRODUCTION

CALET (CALrimetric Electron Telescope) is an international program for the International Space Station (ISS) that will search for signatures of Dark Mater and provide the highest energy direct measurements of the cosmic ray electron spectrum in order to observe discrete sources of high energy particle acceleration in our local region of the Galaxy. CALET will address many of the outstanding questions including (1) the nature of the sources of high energy particles and photons, through the high energy spectrum, (2) the details of particle transportation in the Galaxy, and (3) signatures of dark matter, in either the high energy electrons or gamma ray spectrum. It will also be capable of monitoring gamma ray transients and solar modulation.

The unique feature of CALET is its thick, fully active calorimeter that allows well into the TeV energy region with excellent energy resolution, coupled with a fine imaging upper calorimeter to accurately identify the starting point of electromagnetic showers. It is in the TeV region that we anticipate being able to observe, for first time, an unambiguous signature of energetic particles (electrons) accelerated in specific sources in our local region of the Galaxy and then propagating to Earth. These observations will provide unprecedented detail on the operation of 'Cosmic Accelerators'. Morevoer, some theories predict that potential dark matter particles (Kaluza-Klein particles from extra-dimension theories, or neutralinos predicted by supersymmetric theories) may have masses in the hundreds of GeV to TeV range. The characteristic signatures of such particles in both the electron and gamma ray spectra can only be observed at the high energies reached by CALET. Finding a dark matter signature would be a fantastic discovery. Even non-observation is important for the ubiquitous dark matter. While optimized for electron observations, CALET will of necessity also separate hadrons from electrons. The hadronic data provide another channel through which the details of particle acceleration in supernova remnants or other sources will be investigated. Combining, for the first time, high energy, high resolution measurements of electrons, protons, helium, and high-Z particles provides a new tool to investigate cosmic accelerators in the high energy universe.

CALET is a Japanese led international mission proposed as part of the utilization plan for the ISS[1]. CALET will be launched by an H2 rocket utilizing the Japanese developed HTV (H-IIB Transfer Vehicle). The instrument will be robotically emplaced upon the Exposure Facility attached to the Japanese Experiment Module (JEM-EF, as shown in Figure 1) using the attach point that accommodates zenith-viewing payloads. CALET is a calorimeter-based experiment which will have excellent separation between hadrons and electrons and between charged particles and gamma rays. It will provide unparalleled energy resolution and broad sky coverage to probe the High Energy Universe. The Japanese Space Agency (JAXA) has approved CALET for a phase A/B study in 2008-2009, leading to a 2013 projected launch.

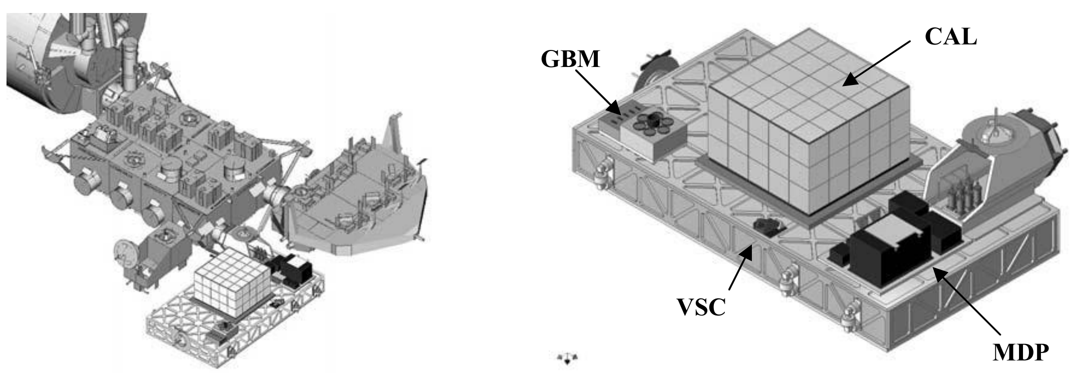

Fig. 1. Overview of the CALET instrument on the JEM/EF (left) and the CALET's components (right). See §3.3 for detail. .

2. HIGH ENERGY ASTROPHYSICS FROM CALET

It has become increasingly clear in recent years that major changes in, and the evolution of, our own and other galaxies are intrinsically linked to high energy phenomena – e.g., Supernova explosion, Black Hole accretion, Active Galactic

Nuclei (AGN) jets, etc.- and that these involve the acceleration of charge particles, often to extreme energies. The release of these high energy particles fuels the galactic cosmic radiation, while the interactions of the energetic particles produce X ray and gamma radiation through synchrotron, inverse Compton, and neutral pion decay processes. CALET will provide another important window on the High Energy Universe by observing high energy electrons, hadrons, diffuse gamma rays up to the highest energy region observed in space.

2.1 High energy electrons

Supernova explosions are generally accepted as the only sources capable of supplying the energy required to accelerate the majority of Galactic cosmic rays. Evidence that particle acceleration to multi-TeV energyis is taking place in super nova remnant (SNR) is provided by electron synchrotron and gamma ray emission measurements. Several SNR, e.g. RXJ 1713-3946 [2] have been observed by air Cerenkov arrays and show an energy spectrum most easily explained as neutral pion decay, but these remains the possibility that these gamma rays could be of inverse Compton origin. Although the photon evidence for particle acceleration in SNR is clear, there is no direct evidence that the accelerate particles escape the source region. CALET is uniquely able to address this question by investigating nearby SNR sources via very high energy electrons.

Electrons provide a singularly sensitive probe of nearby high energy cosmic accelerators. Since high energy electrons lose their energy in proportion to square of the energy, by synchrotron radiation and inverse-Compton scattering. As a result, the highest energy electrons (in the TeV region) that we see very likely originate from sources at a distance less than ~1 kpc from the Solar System and younger than ~ 10^5 years. Prime candidates are the Vela , Monogem and Cygnus Loop remnants, but other possible SNR include G65.3, HB21, Geminga, S147, Loo1 , SN185, and of course unidentified sources. Thus, the high energy electron spectrum should exhibit structure [3] and very likely anisotropy [4,5] This, plus the certainty that electrons are accelerated to multi-TeV of identifying individual cosmic accelerators and determining the diffusion coefficient.

Kobayashi et al. [6] calculated the possible contribution to the observed Galactic cosmic ray electron spectrum from both distant and possible nearby sources. For a particular choice of model parameters, Fig.2 shows the calculated electron spectrum compared to a compilation of previous electron measurements. The possible contributions of Vela, Monogem, and the Cygnus Loop are shown as examples. Adding these three sources to the "distant component" give the upper curve with the anticipated CALET measurements superposed. The expected source signature is at high energies, above the range of any other experiment. Investigating such structure in detail and directly observing, for the first time, a source or electron acceleration at very high energies is only possible with CALET.

At very high energies, significant anisotropy in the electron arrival directions is expected due to the local source. Since CALET will accurately determine the event trajectory, the electron arrival direction will be know to better than 0.5 degrees in both zenith and azimuth. Combines with the Visual Sky Tracker and ISS ephemeris, the arrival direction can be mapped onto the sky. The anticipated anisotropy measurement is illustrated in Fig. 3 for the case in which Vela is a source of high energy electrons.

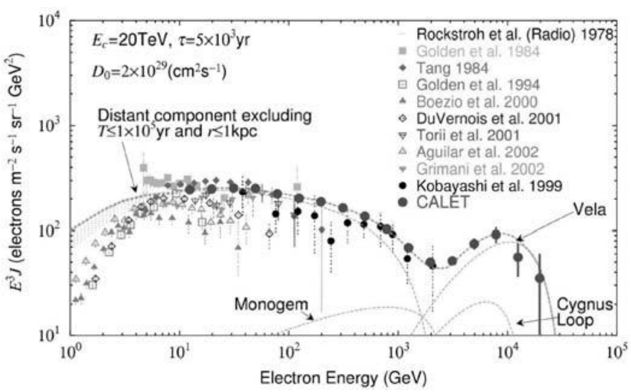

Fig. 2. Calculated electron spectrum compared with present data and the expected spectrum by the CALET observation.

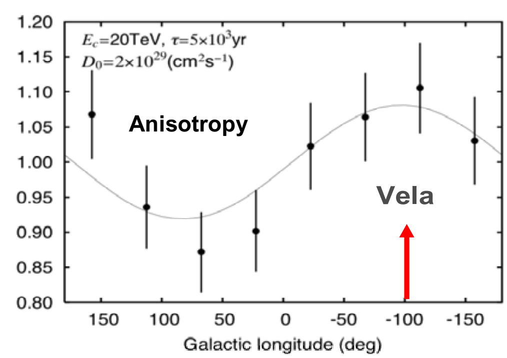

Fig. 3. Anticipated anisotropy from Vela. in the TeV region.

One of the most important parameters describing particle transport is the diffusion coefficient *D*, whose value in the solar neighborhood is uncertain to within a factor of 3-5. The diffusion coefficient is energy dependent [6] but never measured. If a nearby source such as Vela can be observed and identified by CALET, the value of *D* at high energies can be inferred. Even if such nearby sources are not seen, the shape of the high energy electron spectrum can constrain the cosmic ray diffusion coefficient.

2.2 High energy hadrons

High energy hadron spectra are important complements to the information derived from electron observations. Measurements of the cosmic ray H, He and higher Z energy spectra, including important secondary elecments (e.g. B), have been pushed to every higher energy through Long Duration Balloon experiments, but these are reaching a practical limit in energy. While particle acceleration associated with supernova remnant shocks appears to be the best explanation for how galactic cosmic rays below the "knee" achieve their high energies, the energy spectrum signatures that would provide strong support for this SNR model (i.e. charge dependent high energy spectral cutoffs) have yet to be observed, There is still no proof that SNR do, in fact, accelerate hadrons. Extending direct measurements is only possible with the long exposure of a space experiment. CALET will also make a unique contribution in hadron observation. Although optimized for electrons and gamma rays, CALET will measure protons and heavier nuclei with good sensitivity and energy resolution. A CALET exposure on JEM-EF will extend the spectral measurements by nearly an order of magnitude in energy and provide high precision data to define spectral shapes/changes that are anticipated from acceleration and propagation models [7,8] . Figure 4 presents the data that CALET can provide to extend the H and He spectrum and the B/C ratio.

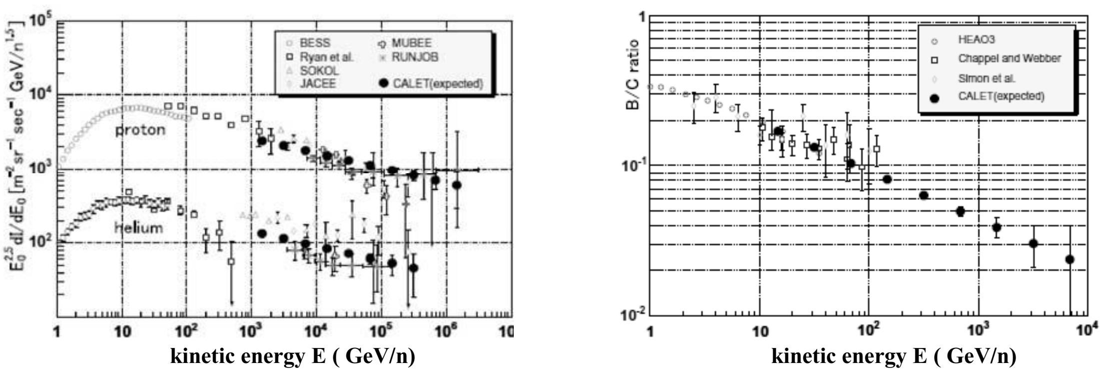

Fig. 4 H and He spectrum (left) and B/C ratio (right) anticipated by the CALET observation and the present data.

2.3 Dark matter

Over the last several decades, experimental and theoretical work has essentially eliminated all known particles as dark matter candidates leaving only a few exotic species as possible [9]. Such candidates include Weakly Interacting Massive Particles, such as neutralinos, which annihilate and produce gamma rays and positrons as a signature. Another possibility[10] is the Kaluza-Klein (KK) particles resulting from theories involving compactified extra dimensions. CALET will conduct a sensitive search for signatures of these dark mater candidates in both the electron and gamma ray spectra. The predicted signature are dependent on models with many parameters and even a non-observation by CALET will effectively constrain these parameters or eliminate some theories.

Like neutrarinos, KK particles can annihilate and produce an excess of both positrons and negatrons observable at Earth. Unlike neutralinos, however, direct annihilation of KK partilces to e, μ , τ is not suppressed and consequently the KK electron signal is enhanced relative to that from neutralinos. Also, since this is a direct annihilation, it results in the appearance of monoenergetic electrons and positrons which would create a specific, easily recognizable spectral feature. Figure 5 shows just the predicted positron signal for possible KK particle masses with estimated background flux of secondaly particles from interactions of cosmic rays with interstellar material. A significant feature shown in Fig. 5 is the sharp cutoff at about the KK mass which could produce a detectable feature in the electron spectrum. This is illustrated in Fig. 5 showing simulated CALET observations of annihilations from a KK model with a 300 GeV KK peak superimposed on an all-electron power law spectrum[11]. The cutoff at KK mass gives a clear feature, although it is not as sharp in the all-electron spectrum as for the positrons alone.

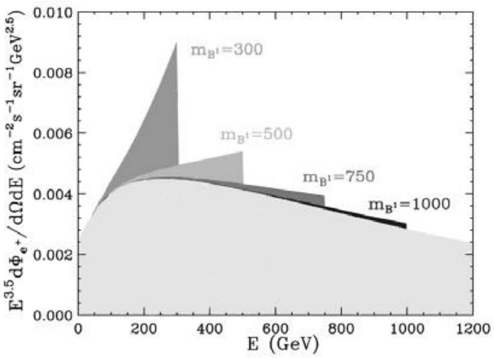

Fig. 5 Predicted positron signal from annihilation of Kaluza-Klein dark matter candidate particles. From Cheng, Feng and Matchev (2002)[10].

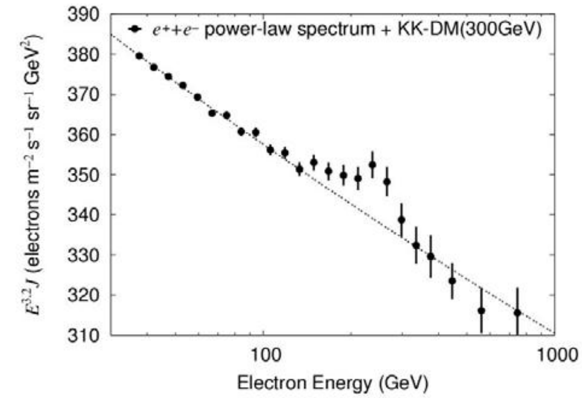

Fig. 6 Simulated energy spectrum of $e^{+}+e^{-}$ with Kaluza-Klein dark matter annihilatin for 300 GeV mass. The background with power law spectrum is including using present data.

There are hints of a possible dark mater annihilation in recent balloon data, giving increased impetus to the CALET mission. Figure 7 shows a compilation of electron spectrum measurements above a few GeV from balloon experiments compared to predictions of the electron flux from a calculation by Kobayashi et al. The curve below 10 GeV is the calculated interstellar spectrum while the observed data presents the effect of solar modulation. The current electron measurements generally follow the calculated curve except in the region around 500-600 GeV where recent experiments report a slight excess. Such a feature could be the result of a nearby source or could be a signature of dark matter annihilation. Higher precision and higher statistics measurements are required to understand this intriguing energy range. CALET, above the Earth's atmosphere and with its excellent energy resolution, will be able to investigate this feature in detail. CALET's tracking capability and ability to measure anisotropy will enable it to distinguish between a nearby source versus dark matter explanation for such a feature in the spectrum.

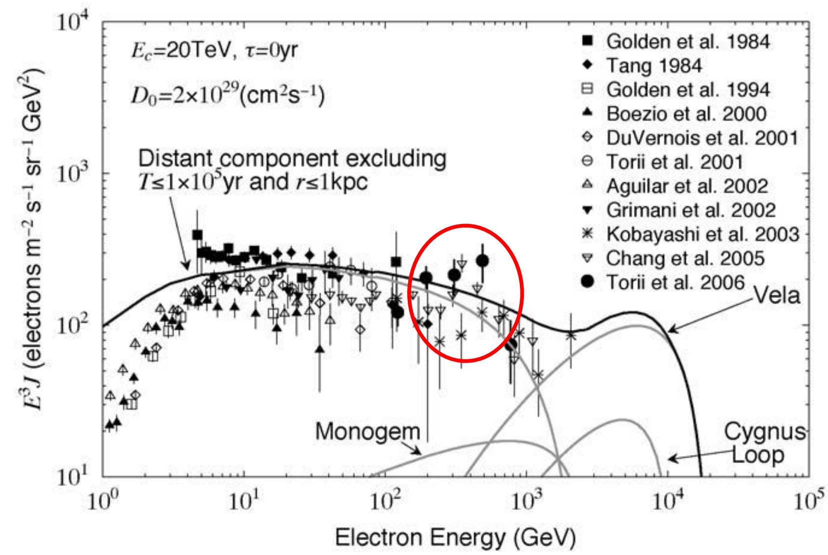

Fig. 7 Compilation of electron spectrum measurements above a few GeV compared to prediction by calculation. A slight excess is observed in the region around 500-600 GeV (denoted by circle) from two observations (Torii et al. [12] and Chang et al.[13]) . Combined significance of the excess from the power law spectrum is nearly 5 σ .

If neutralinos are the dark matter particles, they are most readily seen as a line in the high energy gamma ray spectrum. If the neutralinos mass is below several hundreds GeV, such a line will surely be observed by GLAST. However, the superior energy resolution of CALET will enable better line-shape analysis of the detected line. Figure 8 shows a comparison of the simulate GLAST and CALET measurements of a possible gamma ray line at 78 GeV from neturalino annihilation [14]. The significance in terms of detected photons is better for GLAST, but the line-shape is better defined by CALET. For dark matter candidate with massed above several hundred GeV, CALET will provide the best possibility of detection. Figure 9 shows the anticipated signature in CALET for a neutralino of mass 690 GeV according to one model of the clumpy distribution [11]. The importance of CALET's excellent energy resolution for detecting and interpreting such a line is evident. Depending on the distribution of the dark matter, the flux could be an order of magnitude higher or lower than the model shown or , because of annihilations at increasing redshift, could result in a continuum with a cutoff at the neutralino mass. Even a non-observation by CALET would help constrain these models.

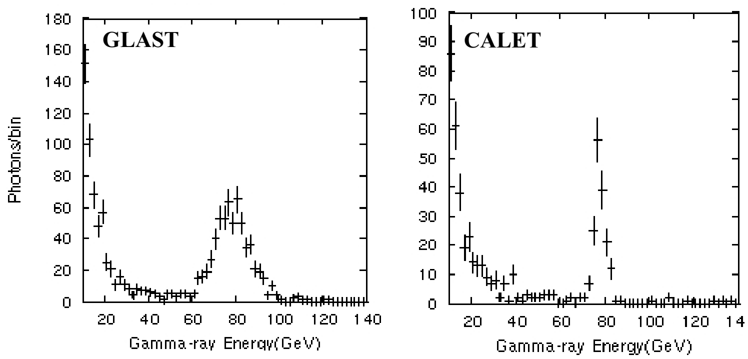

Fig. 8 Expected line profiles for neutralino decay. CALET will provide much better resolution than GLAST of neutralino decay lines in the diffuse gamma ray spectrum.

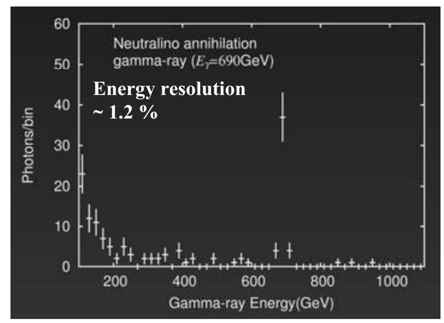

Fig. 9 Anticipated signature in CALET for a neutralino of mass 690 GeV.

2.4 Gamma ray sources

Up to 300 GeV, the CALET gamma ray sensitivity is lower than that of GLAST. CALET's thicker calorimeter, however, extends the observable energy range to higher energy. Since CALET has a large field of view (~2 sr) and a wide effective area (~5000 cm^2 > 10GeV) for gamma rays , it can observe the whole sky without any attitude control. As a result, CALET will obtain ~70 % coverage of the sky in a day, all sky coverage in 20days, and typical exposure of 50 days for individual sources. This makes CALET a valuable complement to GLAST and may make it possible to extend much of the GLAST measurement program after the end of the GLAST prime mission.

CALET's excellent proton rejection will make it an exceptional instrument for studying the diffuse high energy gamma ray background at energies above the upper limit of GLAST. The extended energy coverage for the diffuse extragalactic background (EBL) should enable major progress in understanding the EBL. Moreover, the energy resolution will make CALET uniquely capable of searching for sharp lines in the high energy diffuse spectrum. For the galactic background, the CLAET gamma ray sensitivity to 1 TeV should allow a potential cutoff up to approximately 100 TeV to be investigated [15].

Observation of sources will not be a primary objective for CALET. However, data on strong sources (in particular, transients) will be available for analysis. CALET will follow GLAST into space by 5-6 years. In that period, the gamma ray source catalogue will be expanded many-fold by GLAST and the new Cerenkov telescopes. If one or more sources has a major outburst, CALET will measure variability and energy spectrum changes as a function of time. Moreover, CALET will complement GLAST's measurement of the high energy cutoffs of AGN spectra as function of redshift due to attenuation on the extragalactic light.

2.5 Gamma ray bursts

CALET's $LaBr_3$ and BGO scintillators will extend the GRB studies being performed by other experiments (e.g. Swift and GLAST) and will provide added exposure when other detectors are not available or are viewing in other directions. Moreover, the CALET main telescope has limited sensitivity - with low resolution- down to about 20 MeV, so that higher energy photons associated with a burst event can be recorded over the entire CALET energy range. Extending

GRB measurements through much of the next decade will be useful as new GRB capabilities come on-line, fore example the gravitational wave measurements due to become operational in 2013. LIGO, with its non-detection of the short burst GRB070201 from the direction of the nearby galaxy M31, appear to have ruled out the possibility of this burst originating in a merger of neutron stars or black holes[16]. Further fortuitous "multi-messenger" observations (or non-observations) of such rare events will help answer open science questions, and the likelihood of such simultaneous observations can be significantly enhances with multiple complementary detectors flying either at the same time or for a longer period of time.

2.6 Solar modulation

As shown in Fig.7, the effects of solar modulation extend up to 10-20 GeV for electrons. With the high statisrics data from CLAET, including measurements below 10 GeV, the evolution of the electron spectrum as a function of time can be recorded in detail. These data can be used validate models for the transport of electrons into and within Heliosphere.

3. THE CALET INSTRUMENT

To effectively address these scientific issues, a large exposure detector, sensitive to > 100 GeV electrons, protons and heavy ions, is needed. CALET, currently undergoing concept design in Japan, is expected to satisfy these requirements. CALET is optimized to provide a precise measurement of the cosmic ray energy spectrum of electrons up to greater than 10 TeV, of protons, helium and other heavy ions up to several hundred TeV as well as complementary diffuse gamma ray spectrum measurement up to several 10 TeV. At these energies, particle measurement is best accomplished by using ionization calorimeter and, based upon our experience with the development and flight of the BETS imaging calorimeter[12] and the ATIC calorimeter[17].

3.1 Detector Concept

A schematic of the CALET detector concept is shown in Fig.10. The detector consists of a single particle telescope that operates in event-by-event mode. It is composed of four subcomponents that collectively provide event identification and background suppression. The instrument is composed of two major subsystems: the Imaging Calorimeter (IMC) and the Total Absorption Calorimeter (TASC) plus two additional subsystems: Silicon Detector Array (SIA) and Scintillator Anti-Coincidence System (SACS). The total weight of detector will be 1450 kg with the absorber thickness of 31 radiation lengths (X_0) and 1.7 proton interaction lengths (λ), and the effective geomagnetic factor for high energy electrons is 0.7 m^2 sr. A concept instrument design for CALET is shown in Fig.11.

The particle or gamma ray first passes through the SACS, which separates charged particles from gamma rays, and the through the SIA which identify He and heavier nuclei. The event then passes into the IMC where the event is tracked to determine the point at which cascade is initiated. The shower then develops in the fully active TASC. The energy

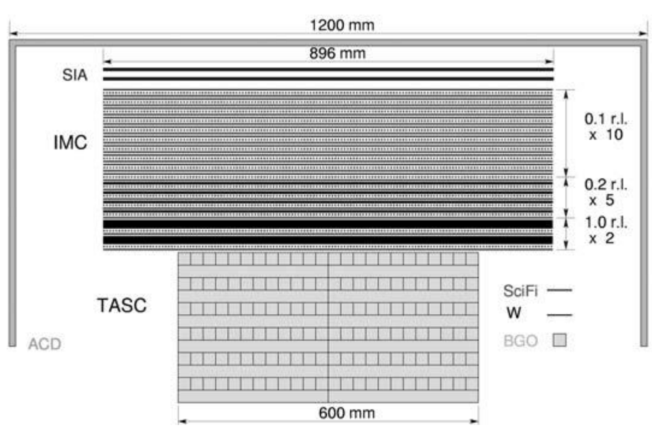

Fig. 10 A schematic side view of the CALET detector concept. See text for acronym of the detector components.

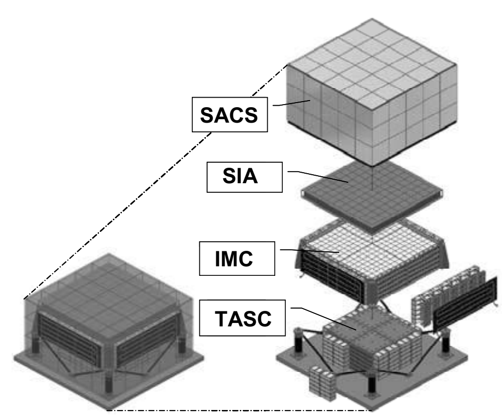

Fig. 11 A concept instrument design for the main calorimeter of CALET.

deposited in the TASC is a measure of the incident particle energy. Proton are separated from electrons and gammas by shower shape analysis in the IMC and the TASC, and electrons are separated from gammas by use of the SACS. CALET's unique feature compared to other instruments is its combination of fine imaging and very thick fully active calorimeter, developed for accelerator experiments and on balloons but never before flown on a space mission. The provides unparalleled energy resolution and access to the TeV energy domain.

The IMC consists of 17 layers of tungsten plates each separated by 2 layers of 1 mm square cross section scintillating fiber (SciFi) belts arranged in the x and y direction and is capped by an additional x,y SciFi layer pair. The dimensions of the IMC are about 90cm by 90cm. While the total thickness of the IMC is 4 X_0 , about 0.13 λ . The first 10 tungsten – SciFi layers sample the particle at 0.1 X_0 , followed by 5 layers that are 0.2 X_0 thick and finally 2 layers that are 1 X_0 deep. This provides the precise measurement to 1) separate the incident particles, 2) precisely determine the starting point for the shower, and 3) determine the incident particle trajectory. The readout for the SciFi layers consist of multi-anode phtomultiplier tubues (MA-PMT), such as the Hamamatsu R5900 [18]. Each R5900 MA-PMT has 64 anodes and, consequently , about 16 MA-PMTs will be needed to read each belt. The front-end electronics for the IMC will be based upon high density ASIC such as 32 channel Viking (VA32HDR14) chip [19]. Two chips are used to read out 64 channels of one MA-PMT. The power consumption is measured and it turn out to be 420 mW for 64 channels. Then the total power consumption of the FEC is nearly 200 W for the read-out of all of SciFi. We have also confirmed that the dynamic range of the FEC reaches to 3000 MIP (minimum ionizing particle) , and input range of ASIC matches to the output charge of the MA-PMT.

The TASC measures the development of the electromagnetic shower to 1) determine the total energy of the incident particle and 2) to separate electrons and gamma rays from hadrons. The TASC is composed of 12 layers of Bismuth Germanate (BGO) "logs" where each log has dimensions of 2.5 cm $\times$2.5 cm $\times$ 30 cm. The logs are wrapped on five sides for optical isolation and, for each layer, are assembled next to each other in two rows with the unwrapped face outward. The photodiode (PD) are then attached to the unwrapped log faces. There are 48 such logs in each layer. Alternate layers are orientated 90 degrees to each other to provide an x,y coordinate for tracking the shower core. Finally, the PD readout electronics (PreAMP+AMP) boxes are assembled on each face of the TASC. The total area of the TASC is about 0.36 m^2 and the vertical thickness is about 27 X_0 and 1.4 λ . It is anticipated that each BGO log will be read by a multi-photodiode and laboratory tests have confirmed that such a system is capable of detecting 0.5 MIP and currently underway to develop electronics with a very high dynamic range to 10^7 MIP[20].

On top of the IMC is a double layer, pixellated Si detector array, combining ~6400 pixels per layer[21]. Schematic view of SIA is presented in Fig. Each pixel is 1.125 cm $\times$ 1.125 cm and is made from 500 micron thick silicon. The SIA is designed to provide incident particle identification and superior charge resolution (0.1e for H to 0.35e for Fe). Surrounding the entire detector component is a segmented scintillator array, the SACS, to provide anti-coincidence protection for low energy gamma ray measurements. The SACS will consist of an array overlapping plastic scintillator tiles read out by photomultiplier tubes (PMTs).

Finally, a separate Gamma ray Burst Monitor (GBM) will consist of six 4'' diameter x 0.5" thick $LaBr_3$ and a 5" diameter x 3" thick BGO scintillator designed to detect 150 GRBs per year over the energy range 7 keV-20 MeV[22].

Fig. 12 A schematic view of Silicon Pixel Array.

3.2 Expected Detector Performance

CALET was designed specifically for precise measurements of the cosmic ray electron energy spectrum over the range 1 GeV to 20 TeV. A necessary requirement , therefore, is to be able to efficiently identify high energy electrons among the "sea" of background cosmic ray hadron events. The imaging calorimeter exploits two principal differences between proton and electron/gamma ray showers to satisfy the requirement. First, proton induced showers are longitudinally wider than electron showers due to the spread of secondary particles in nuclear interactions. The SciFi belt in the IMC are used to determine the shower width r.m.s as the shower develops. Second, an electron induced shower will start and die off earlier than a proton cascade as only a fraction of the hadron total energy (~40 %) is deposited in the calorimeter. The CALET electron identification method is illustrated in Fig. 13 for the bottom BGO layer in the TASC where the electron shower is almost complete, but the proton shower is still building up. In the figure, the simulated proton and electron data is plotted as the fraction of the total shower. The curved line separates the electron events from the proton events. As shown in the figure, for 10^6 only 9 would be identified as electrons. This is, however, for only one TASC layer and for layers near the top, electrons and protons would have comparable energy fractions, but be widely separated in shower lateral spread. Combining the particle identification results from each CALET layer yields an electron detection efficiency above 95 % and a proton rejection factor of 1 in 5×10^5 as described in Chang et sl. [23]. Figure 14 shows the relation ship between the measured electron flux, the cosmic ray proton spectrum (top most curve) and proton rejection factors of 1 in 10^5 and 5 x 10^5 (bottom most dotted curves). With the expected proton rejection factor, CALET will provide accurate measurements of the energy spectrum above 1 TeV whether individual sources such Vela are evident or not.

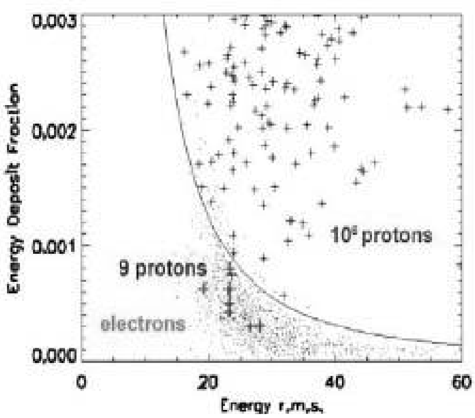

Fig. 13 Electron identification technique using simulated data.

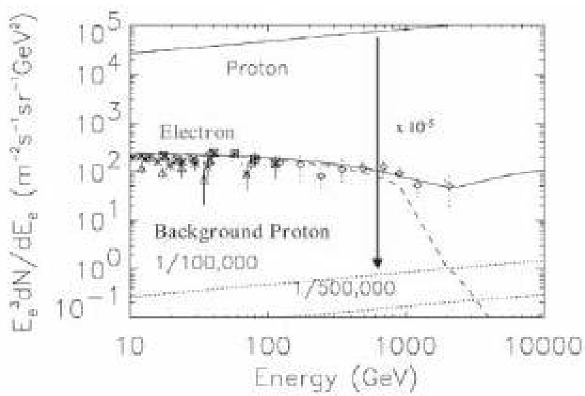

Fig. 14 Expected proton rejection power.

A model of the CALET instrument was exposed to electron and proton beams at the CERN-SPS accelerator, and these experimental data were used to validate the simulation calculations. CALET will have an electron detection efficiency above 95 % and a proton rejection factor of 1 in 10^5. Figure shows the relationship between the measured electron flux, the cosmic ray proton spectrum (top most curve) and proton rejection factor of 1 in 10^5 and 1 in 5×10^5 (bottom dotted curves). By the beam test, the angle resolution of electron shower axis and the positional resolution of incident electrons are observed to be 0.1 degrees and 0.2 mm with the IMC, respectively. The capability to find the precise position of incident particle is very effective to resolve the incident particle from the back-scattered particles for particle identification. The expected performance obtained by the simulation calculations with the beam tests is discussed in Kasahara el al.[24]. Moreover, a proto-type detector of CALET ,with an effective area of ~ 20 cm^2 sr, as been constructed for the balloon experiment . By the observation, we have successfully demonstrated the detector could work well and observed the electron spectrum from 1 GeV - a few10 GeV [25].

3.3 CALET on the Orbit

The CALET will be launched by a Japanese carrier, HII Transfer Vehicle (HTV), and attached to the EFU #9, which is capable to maintain a heavy payload up to 2,000 kg in mass and has a wider field of view, 45 degrees. Figure 1 shows a schematic view of the CALET payload on ISS/JEM. The main structure of CALET is designed by adopting an interface structure of a usual exposed facility. The structure, therefore, includes a pallet to sustain the detector, which is used both for launching by HTV and for attaching to JEM. The structure was optimized to meet the requirements from the ISS for the vibration condition. A gamma ray burst monitor (GBM) composed of the hard X ray monitor (HXM) and the soft gamma ray monitor (SGM) , a support sensor composed of the visual sky camera (SVC) and the GPS receiver (GPSR) will be arranged on the pallet . The mission data processor (MDP) for data acquisition will be allocated

Also, the heat condition was analyzed in several phases of the experiment. CALET will use the Active Thermal Control System (ATCS) by the fluid interface, which is adopted in ISS as a standard equipment. Preliminary thermal analysis in orbital visiting phase gives the temperature of + 30 ℃ after circulating the system in which the input temperature of fluid is + 20 ℃. Since the maximum temperature gradient between the fluid and the instrument will not be larger than 10℃, the temperature of the instrument will be less than + 40 ℃. By a structural analysis, it is proven that the 1st mode eigen value of the structure is ~3Hz on JEM-EF, which satisfy the stiffness requirement: >2Hz.

4. SUMMARY AND FUTURE PROSPECTS

The CALET mission is proposed to perform observations of electrons, gamma rays, and H, He and heavy particles at the high energy frontiers. Nearby sources of electrons will be directly identified by observing the energy spectrum and the anisotropy in the TeV region. Signatures of the dark matter candidates will be searched within a sensitivity expected by theories in both the electron and gamma ray spectra. The hadoron observation will reaveal the origin of "knee" and the mechanism of transportation in the Galaxy. Moreover, CALET will be useful for monitoring the gamma ray transients and solar modulation. The CALET projected has been approved as a phase A study and the major key technology has been successfully developed. The performance of detector was tested by accelerator beams, and the proto type detector was flown to demonstrate the performance for the electron observation. Following the application of our proposal to the next phase to JAXA, we expect to begin operations on the ISS/JEM around 2013 for mission life of 3-5 years.

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