60 周 年 記 念

東 京 大 学 宇 宙 線 研 究 所

乗 鞍 観 測 所

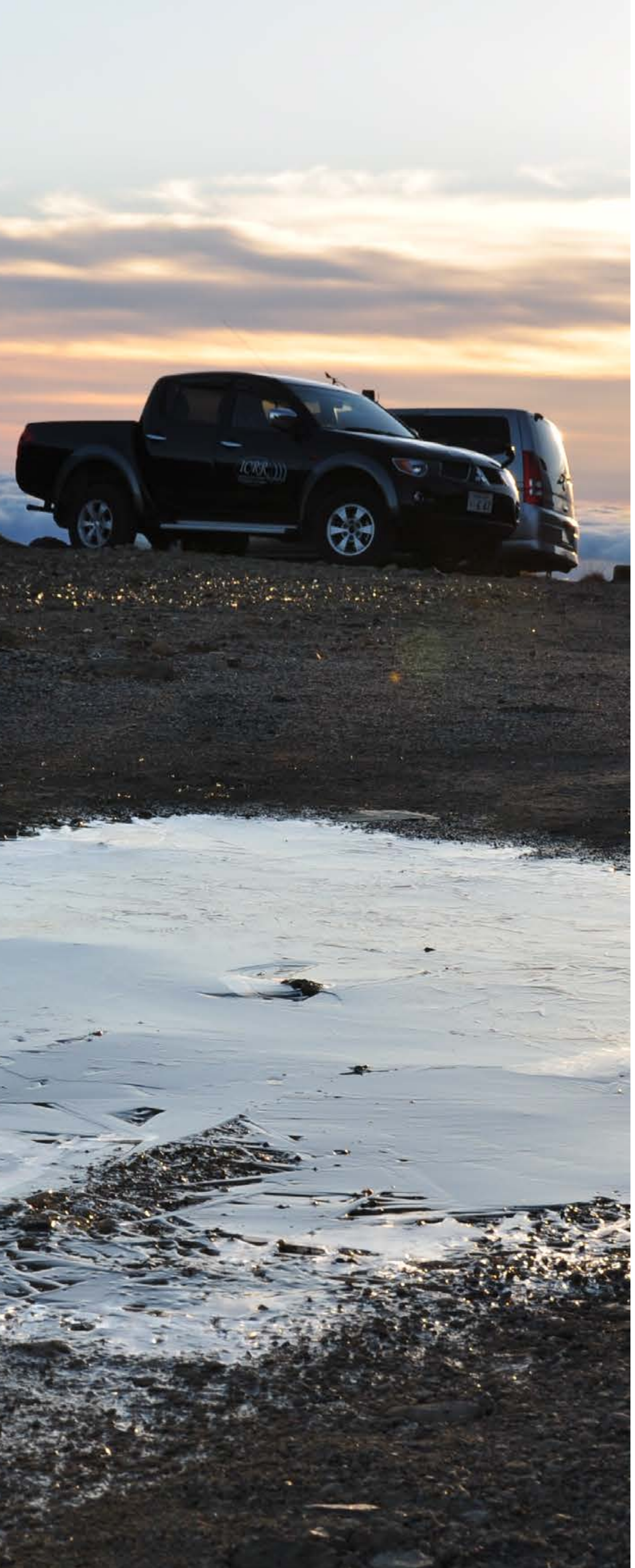
平成２５年８月２３日

60th Anniversary
Commemorative Edition

Norikura Observatory

Institute for Cosmic Ray Research
(ICRR)
The University of Tokyo

August 23, 2013



平成２５年８月２３日

東京大学宇宙線研究所

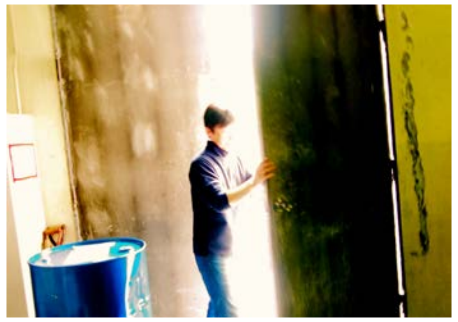
〒277-8582
千葉県柏市柏の葉５－１－５
TEL：04-7136-5148（広報担当）
FAX：04-7136-3115

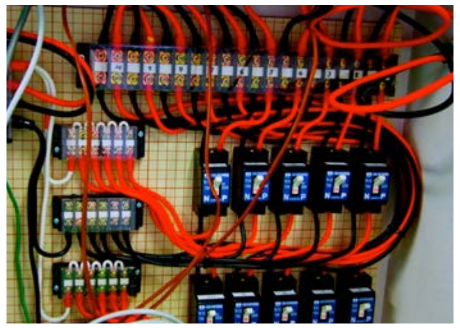
編　集

瀧　田　　正　人
下　平　　英　明
石　塚　　秀　喜
（デザイン 林田　美里）

乗鞍観測所６０周年記念

contents





乗鞍観測所
60周年を記念して

宇宙線研究所長ご挨拶

東京大学宇宙線研究所長
梶田　隆章

乗鞍岳に東京大学宇宙線観測所、現乗鞍観測所、が設置されて、今年で60年になります。宇宙線観測所10周年を記念した当時の野中到所長の文書では「宇宙は天与の加速器であって天空の彼方から宇宙線として高エネルギー粒子が貧富の差別なく地上に降りそそいでくるので、測定装置さえ用意すれば余り金をかけずに素粒子研究ができる。これが本観測所設立の出発点であったと思う。」と書かれています。このように終戦後まもなく日本の復興の最中に、宇宙線を利用して素粒子物理学研究を行おうという情熱が全国で高揚し、全国初の実験系の全国共同利用研究機関として、乗鞍観測所が設置されたと聞いています。

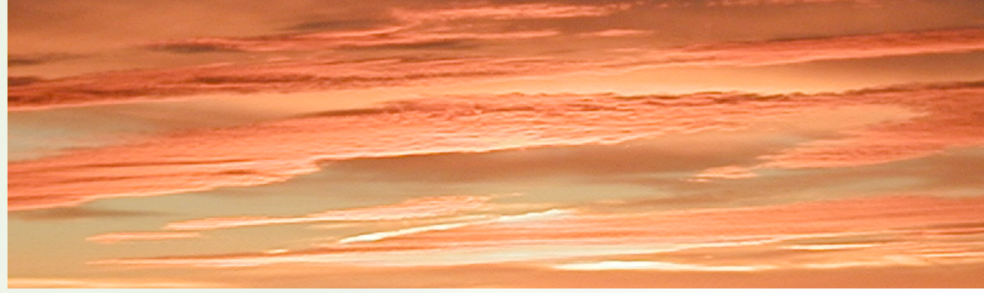
乗鞍観測所の数々の成果を通して日本の宇宙線研究は大きく発展し、1976年に乗鞍観測所と当時の原子核研究所の一部、また新たな部門も加わって宇宙線研究所が設立されました。宇宙線研究はその後も大きく発展し、例えば現在の宇宙線研究所では、ニュートリノ研究などを行っているスーパーカミオカンデ(Super-Kamiokande)実験をはじめ、最高エネルギー宇宙線の研究を行うアメリカ・ユタ州のテレスコプ・アレイ(Telescope Array, TA)実験、銀河宇宙線の精密観測を行う中国・チベットのチベットAS-ガンマ(Tibet AS-γ)実験、宇宙のダーク・マターの探索を行うエックスマス(XMASS)実験などがおこなわれ、また中性子星やブラックホールなどの天体起源の重力波の観測をめざした大型低温重力波望遠鏡(KAGRA)の建設が進んでいます。更には今後の研究として次世代の超高エネルギーガンマ線天文学や、ニュートリノ研究など様々な可能性が検討されています。

乗鞍観測所が、これらの日本の宇宙線研究の発展や現在の宇宙線研究所の基礎を作り、今日まで活動を続けて来られたのは、文部科学省・東京大学をはじめ関係各所の御支援、鈴蘭をはじめ岐阜県・長野県の地元の皆様の御理解、旧国立天文台乗鞍コロナ観測所の御協力、また、もちろん全国の宇宙線研究者の皆様の御活躍と御協力のお陰です。この場をお借りして、深く御礼申し上げます。それとともに乗鞍観測所を出発点とする日本の宇宙線研究と宇宙線研究所の更なる発展にも御指導・御協力のほどあわせてお願い申し上げます。

平成25年 8月 23日
東京大学宇宙線研究所長　梶田 隆章

剣ケ峰へ向かう山道から望む

歴代観測所長




平田　森三


菊池　正士


野中　到


菅　浩一


三宅　三郎


近藤　一郎


湯田　利典


福島　正己


瀧田　正人

沿革

乗鞍における宇宙線研究の始まりは昭和24年に大阪市立大学が畳平で行った実験である。翌25年には大阪市立大学、名古屋大学、神戸大学、理化学研究所の4機関が朝日新聞学術奨励金を受けて室堂ヶ原の現在の場所に通称「朝日の小屋」を建設し、宇宙線の研究にさらに弾みをつけた。昭和27年には全国の宇宙線研究者の強い要望により、東京大学に宇宙線観測所が附置されることが決まった。翌28年、矢内原総長を会長に、朝永振一郎東京教育大学教授等13名の委員から構成された宇宙線観測所設立準備委員会がつくられ、同年8月初めての全国の大学の共同利用のための研究機関として東京大学宇宙線観測所（初代所長は平田森三東大教授）が正式に発足した。この観測所は施設の共同利用を目的としているため固有の研究部門を持たないが、共通の施設の管理、維持のために技術職員が採用された。発足当初の乗鞍の施設・設備は研究管理棟本館、発電装置、重油タンク、暖房・給水、霧箱用電磁石等であり、世界的に見ても第一級の観測所となった。昭和41年には雪上車が導入され、冬の上下山も容易にできるようになった。昭和51年には東京大学原子核研究所宇宙線部を併合と拡充改組により、それまでの観測所は6部門1施設からなる東京大学宇宙線研究所として生まれ変わり、乗鞍観測所はその附属施設となった。そして、東京大学は平成16年度に国立大学から国立大学法人東京大学へと転換された。国立大学法人化に合わせて、平成16年より乗鞍観測所の冬期自動運転化試行が始まった。冬期自動運転中も連続運転している観測装置を維持するために、2.4GHz帯長距離無線LANシステム（乗鞍観測所⇔信州大学間42kmで11Mbpsの速度）の導入、その無線LANシステムを維持するための太陽光発電システムの導入を行った。また、観測所維持費を削減するために、保有発電装置の可搬型発電機（125KVAを2台）への更新、保有地下重油タンクの廃棄・新式地下重油タンクの導入、保有地下灯油タンクの撤去、雪上車・スノーモービルの廃棄等を行った。さらに、2.4GHzの長距離無線LANシステムが電波干渉と推定される原因で動作不安定になってきたために、平成24年には無線免許の必要な5GHz帯長距離無線LANシステムに更新した。当初はいろいろなトラブルが多かった冬期自動運転化だが、現在は順調である。

観測所が発足した当時は宇宙線研究の主流は超高エネルギー領域での素粒子・核反応であり、これに関連した重要な研究が幾つか行われた。当時、高エネルギー宇宙線と原子核の反応による粒子の多重発生が核子同士の一回の衝突で起こるのか、原子核内の核子との何回かの衝突によって起こるのかが大問題となっていた。三宅（大阪市大）等はこの問題に決着をつけるため、数百気圧に耐える高圧水素霧箱を作り、核子同士の一回の衝突でも粒子の多重発生が起こることを世界で初めて示した。昭和32年には空気シャワー観測装置（大阪市大）が設置され、空気シャワーの発達が詳細に調べられ、のちの空気シャワー研究の基礎を作った。昭和35年には世界最大の霧箱が完成し、空気シャワーコアの研究から、超高エネルギー領域では大きな横運動量をもった粒子がかなりの頻度で発生していることが示された。昭和47年には総面積50m^2の大型スパークチェンバー（甲南大、神戸大、高知大他）を設置し、空気シャワーコアのさらに詳しい研究を始めた。また、昭和33年頃には大型のエマルションチェンバーによる核反応観測実験（東大核研、早大他）がここで行われた。ここでX線フィルムが初めて併用され、また原子核乾板長期露出のための技術改良がくわえられ、大気中でのジェット現象が数多く観測された。後の富士山（3750m）、ボリビア国チャカルタヤ山（5200m）、チベットのカンパラ山（5500m）及び羊八井高原(4300m)等その後の高山における100m^2級を超える超大型エマルションチェンバー実験の基礎はここ乗鞍での実験によってほぼ確立された。他に、1〜2年の短期間の実験や装置のテスト実験も頻繁に行われている。たとえば、クォークの探索実験（大阪市大）、世界で初めての広間隙放電箱によるジェットシャワーの観測（名大）、大統一理論で予想される超重粒子のCR39を用いた探索（東大、早大）、宇宙天体からの超高エネルギーガンマ線を探索する実験、超伝導スペクトロメーターを用いた宇宙線（陽子・反陽子・ミューオン）精密観測実験（東大理）等の実験がある。

昭和44年には中間子強度高精度測定設備（名大）が完成し、銀河系、太陽惑星間空間における宇宙線変動と磁場や太陽活動との関係を調べる研究が始まった。理化学研究所による中性子モニターも昭和35年頃から連続的に稼働し、中性子強度の汎世界分布の一環として貴重なデータを提供している。また、太陽宇宙線について特筆すべき成果が得られた。太陽活動が非常に活発な時期の平成元年9月29日に、乗鞍観測所はこれら中間子強度高精度観測装置及び中性子モニターは太陽フレアーにともなう宇宙線強度の異常増加を30年ぶりに観測した。これは太陽フレアーで10数GeVまで非常に短時間に加速できることを示している。平成2年には到来方向が分かる太陽中性子観測装置（名大）も設置された。この装置を含む3つの観測装置が平成3年6月4日に太陽からの数百MeVの中性子を各々独立に観測した。これは、9年前のスイス・ユングフラウの観

背景：ハクサンイチゲの実

日の出と雲海

測に続いて史上2番目であり、フレアーに伴う粒子の瞬時加速についての貴重なデータとなっている。これらの観測が成功したことによって、中性子の到来方向だけでなくエネルギーも測定できる中性子望遠鏡で、爆発の継続時間を正確に決めようとの機運が高まり、$64m^2$の大型太陽中性子望遠鏡（名大STE研）が平成8年に完成した。他にも、平成9年には太陽表面爆発で発生した磁気雲の様子を2次元的に観測（宇宙天気予報）するミュー粒子望遠鏡が設置された。それらの観測装置は太陽活動期での激しい爆発現象を待ち構えているが、これまでの所、乗鞍観測所天頂方向での大きな爆発は発生していない。

　また、平成16年には雷電場計と粒子検出装置を用いて、雷雲中の2次宇宙線ミューオン加速と解釈できる証拠（名古屋大STE研）が乗鞍で得られた。さらに、平成20年から22年にかけて雷光モニター・雷電位計及びNaIシンチレーター・薄いプラスチックシンチレーター粒子検出器を用いて、雷雲中で加速されたMeV領域ガンマ線及び電子の長時間（数秒から数分）バーストを世界で初めて同時観測（理研）した。これは最近の特筆すべき研究成果である。

　また最近では、温暖化・酸性雨などが高山の植生に及ぼす影響の調査、宇宙放射線に対する物質耐性の研究、分光光度計を利用した大気中のオゾン・紫外線の測定、雷鳥の雛のケージ飼育など、地球環境に関する研究が盛んになった。2次宇宙線中性子強度の高度依存性測定、宇宙線観測用望遠鏡の性能試験など、高い標高や暗い夜間を利用した試験観測も行われている。近年の乗鞍観測所は、その特徴を生かして、多様な分野の研究者によって多目的に利用されている。

　今年8月、観測所は創立60周年を迎えた。人間で例えれば還暦である。観測所の老朽化も進み、設備・建物や道路等の維持管理にも費用・手間がかかるようになった。観測所発足当時の職員の方は既に退職され、観測所の維持・運営も新しい世代の方々に引き継がれている。加えて平成16年度に東京大学は国立大学から国立大学法人へと転換された。乗鞍観測所は冬期自動運転化、長距離無線LANの導入、設備の更新等により、現有の人員・予算範囲で共同利用研究をサポートする体制を確立することができた。しかし、激動の時代を乗り越えて、新しい時代に相応しい乗鞍観測所を真剣に考える時期に来ていることにも異論はなかろう。

東京大学宇宙線研究所附属乗鞍観測所長　瀧田 正人

50周年後の10年間

最近10年の歩み

2003年10月

可搬型ディーゼル発電機4号機を導入

冬期自動運転に備え、可搬型のディーゼル発電機(125kVA)が導入されました。エンジン音が静かになり、発電機室内で会話ができるようになりました。冷却水もラジエーターが装備されているので、大がかりな冷却設備は不要となり、メンテナンスコストも大幅に下がりました。

乗鞍観測所

信州大学　松本キャンパス

2003年9月

2.4ギガヘルツ帯長距離無線LANの設備を導入

乗鞍観測所から信州大学・松本キャンパス間42Kmを結ぶ11Mbps長距離無線LAN導入。快適なネットワーク環境が得られるようになりました。

背景：コマクサ

2004年4月

国立大学の法人化

太陽光発電の設備　―　冬

太陽電池パネルは壁面に垂直に設置され、雪で埋もれることはありません。周囲にある積雪が太陽光を反射し太陽電池パネルへ光を集めてくれます。そのため夏季より冬季３月の方が発電量は多くなります。


夏の観測所


観測所の夕暮れ


冬の観測所


壁に垂直に設置されたソーラーパネル

2004年

太陽光発電設備の完成

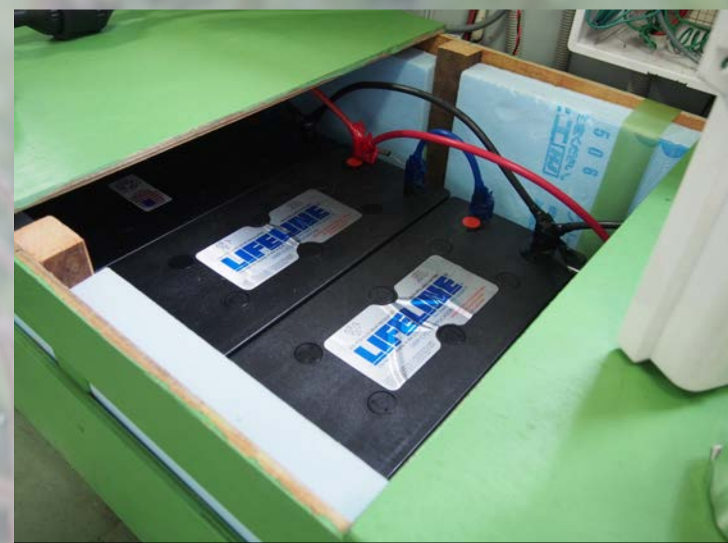
冬期自動運転中の共同利用者へのサポートとして、太陽光発電によりネットワーク設備へ電力を供給します。データ収集が滞らないように無人での24時間運転を目指し稼働を開始しました。 発電出力は900W、供給電力は常時50Wです。

2004年

冬期自動運転の開始

2003年までは冬期も研究者やスタッフが常駐し、設備の管理を行っていました。冬期常駐に必要な管理スタッフの確保が難しくなったため、冬期の遠隔での運転の必要性が高まりました。共同利用者による観測装置の省電力化も実現し、太陽電池での運用が可能になったことで、冬期自動運転が実現しました。


太陽電池接続ボックス



蓄電池

冬期自動運転の準備作業を終えて観測所スタッフ全員で記念撮影。

後列左から、横山、山本、上松、吉田
前列左から、下平、石塚、牛丸、村上

冬　期　自　動　運　転

2004年11月

冬期自動運転の試行開始

冬期自動運転の準備作業

初めての冬期自動運転。各設備は乾燥剤を入れて出来るだけ密閉し、ブルーシートで覆って冬に備えました。

雪上車

1996年から冬期登下山に活躍した雪上車。写真は３代目となる最後の雪上車です。雪上車の走行コースを作る除雪作業が大変でした。しかし、悪天候でも職員の交替ができたのは雪上車のおかげです。

後列左から、下平、横山、上松、村上
前列左から、牛丸、山本、石塚、吉田

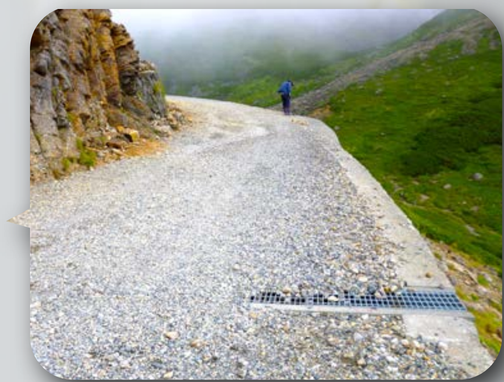
スノーモービル

春先など安定した雪面では機動力を発揮したスノーモービル。
新雪は少し苦手でした。

氷雪や外部からの侵入者を防ぐために本館北側の窓を厚いパネルで覆いました。

撤　去　と　設　置

2004年9月
専用道路の横断溝を設置



大雨による土砂の流失で路面が荒れ、車両の通行に支障をきたすことがありましたが、専用道路入口から乗鞍コロナ観測所分岐点までの間に横断溝を14か所増設しました。路面の荒れが抑えられて安全に通行できるようになりました。

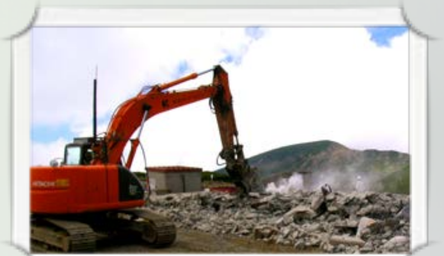
雪上車車庫の前室を撤去

2005年
可搬型ディーゼル発電機 ５号機の導入

2003年10月導入の発電機と同型（125kVA)の発電機が導入され、並列運転が可能になったおかげで、無停電で電力供給できるようになりました。自動切換の装備がなく手動切換のため、電球の点滅を見ながら行う昔ながらの操作です。

2005年6月
雪上車車庫の前室を撤去

除雪作業を軽減する目的で建てられた雪上車車庫前室。雪上車が利用されない今はその役割を終え、スタッフ総出で取り壊しを行いました。



2006年6月

110キロリットル重油地下タンクの解体および撤去

発電機用燃料の重油を貯蔵した11万リットル地下タンク。冬期自動運転により大きなタンクが必要なくなったために廃止・撤去しました。

2006年

10キロリットル重油地下タンクの新設

11万リットル重油地下タンクが撤去されて、１万リットルの重油地下タンクが新設されました。最新型の地下タンクになり、漏洩事故防止の対策も万全な設備体制となりました。

2007年10月

58キロリットル重油地下タンクの解体および撤去

発電機用燃料の重油を貯蔵した５万８千リットルの地下タンク。11万リットルタンクと合わせて16万８千リットル貯蔵可能となっていましたが、このタンクも役目を終え、廃止・撤去しました。現在、重油地下タンクは新設した1万リットル地下タンクひとつとなりました。

2007年10月

灯油地下タンクの解体および撤去

暖房機用燃料の白灯油を貯蔵した７万９千リットル地下タンク。冬期の運用が無くなった事により廃止・撤去しました。
夏期は現在も小型屋内タンクを用いて灯油暖房機を使用していますが、電気暖房機を併用し白灯油の消費を減らす努力をしています。

2008年2月

三菱トライトン納車

乗鞍観測所の所用車は、代々トヨタ・ランドクルーザーでしたが、更新時に荷台があるピックアップトラックにしました。乗り心地がよく、荷物の運搬も便利になりました。

新しく設置された重油地下タンク

三菱トライトン

2010年8月

濱田総長のご視察

東京大学 濱田純一総長は乗鞍観測所をご訪問され、観測所施設や共同利用施設などをご視察されました。

左から：梶田研究所長、濱田総長、瀧田観測所長、山本技術職員

2011年8月

女性専用シャワー室の完成

女性職員が着任したことにより、女性専用のシャワー室とトイレができました。

2012年7月

5ギガヘルツの長距離無線へLAN設備の拡張

2003年に導入した2.4ギガヘルツ帯の長距離無線LAN設備は、順調に稼働していましたが、周囲の無線LANの普及などによる電波干渉と思われる通信障害が発生し、通信状態が不安定になりました。
通信状態の改善のため、５ギガヘルツ帯の長距離無線LAN設備へ変更。5ギガヘルツ帯の利用には、無線局開設および免許が必要になります。変更後は安定して利用できるようになりました。

↑黒い半球がアンテナで、白いボックスに本体（SINELINK5G 高速無線レピータ装置）が収納されています。

スチールシャッター（窓上部）

至現在

2012年9月

本館北側の窓にシャッターを取り付け

今まで厚く重たい木板で窓を保護していましたが、積雪の少ない北側にはスチールシャッターを取り付けました。これで冬期自動運転の準備作業が楽になりました。

朝日の小屋

建設から63年の歳月が経ち
老朽化が進んでいる朝日の小屋。
建屋内に入ると造りの
しっかりしているのに驚かされる。
狭い部屋には研究者が
寝泊まりしたのであろう
ベッドが置かれている。
明日の宇宙線研究を
夢見ていたのだろうか。
高山と言う過酷な環境の中で
観測装置を設置し、
研究に没頭していた光景が偲ばれる。

昭和25年（1950年）に建設され日本の宇宙線共同研究の発祥の地となり、我が国初の全国共同利用研究所である東京大学宇宙線観測所の設立へとつながりました。その後、宇宙線観測所は東京大学宇宙線研究所へと発展しました。朝日の小屋は現在、東京大学宇宙線研究所附属乗鞍観測所の一部となっています。

今日の乗鞍観測所

牛丸　司

観測所への中継施設として重要な役割を果たしている鈴蘭連絡所。昔は冬山に登るためのスキー装備などの登山準備を行った、乗鞍の利用者や職員には欠かせない施設でした。

石塚　秀喜

冬期自動運転に欠かせなくなりつつある太陽光発電、小さな電力ですが冬期きびしい天候の中その小さな電力は大きな力として発揮してくれます。

スタッフの日常

現在は通常2名で勤務を行っています。滞在期間はそれぞれ１週間と短期に。 1週間の勤務が終わり次の勤務チームが到着すると、交代引継の打ち合わせを行います。

食事は自炊に変わりました。滞在期間中に必要な食糧を調達してから乗鞍入りします。その日の当番が台所に立ち、バランスのとれたメニューを考えて腕をふるいます。夕食時には全員食卓について、日々の話題に花をさかせます。

下平　英明

2005年まで観測所の電力を支えた発電機。高地での使用や燃費を考慮した乗鞍仕様のエンジンに、自動並列運転など機能が充実した発電設備でした。

岡崎　奈緒

乗鞍に新しいメンバーも加わりました。「乗鞍２年目です。乗鞍の美味しい空気をすっていろんなことを学び吸収していきたいです。」

上松　義昭

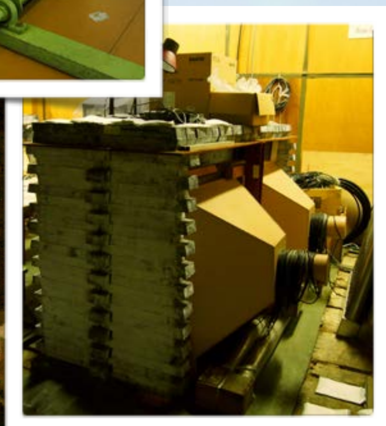
観測所開所と同時に乗鞍山頂噴火口（権現池）から生活揚水を取り入れています。権現池⇔観測所間の約１キロメートルの距離にポリパイプを使用し、水を引きます。中間のジョイント部でエアー抜き作業を行ってます。

東谷　千比呂

晴天の朝は必ずご来光を拝みに剣ケ峰へ散歩するスタッフもいます。

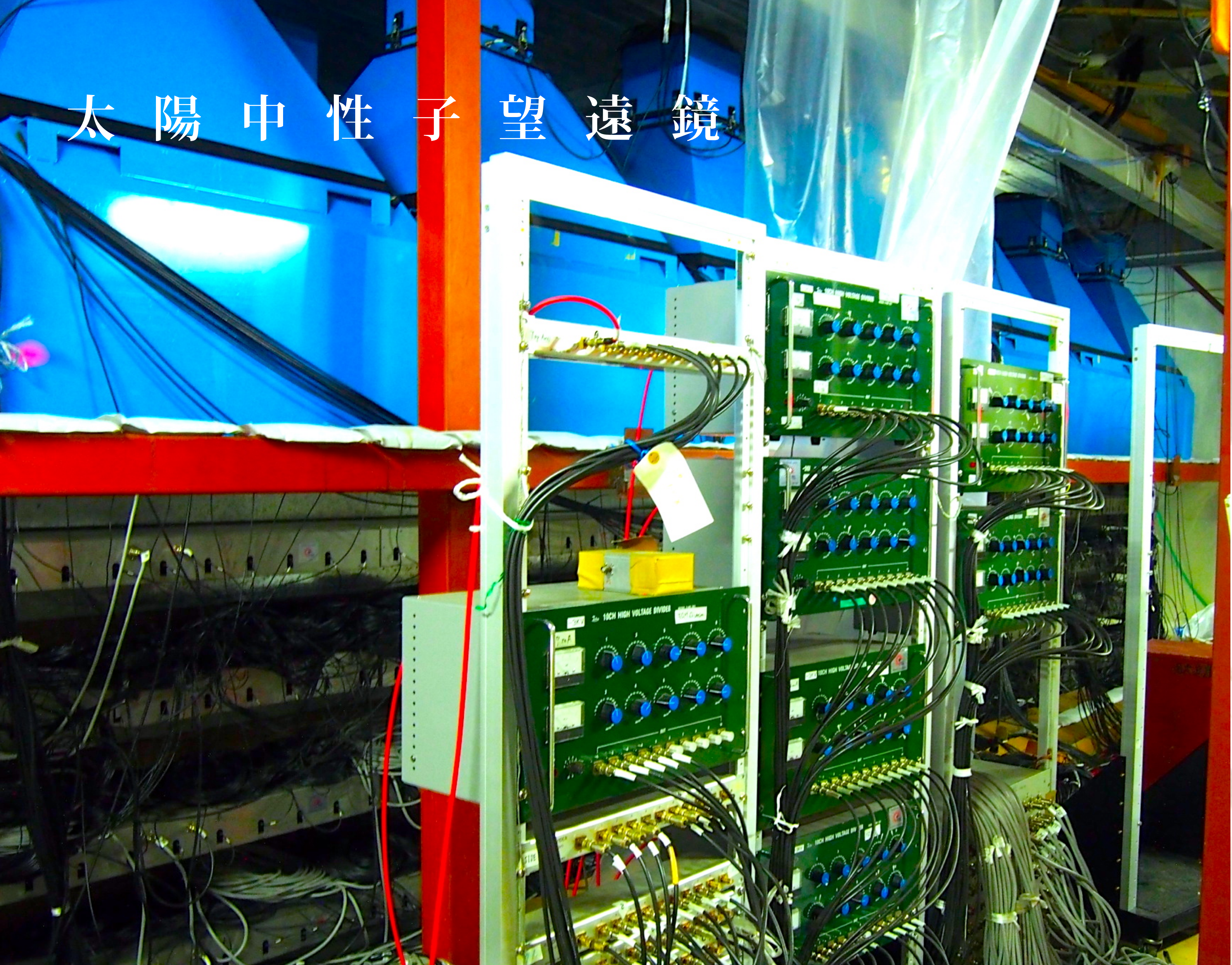
共　同　利　用　研　究

乗鞍観測所共同利用　研究課題一覧



	研究課題	研究代表者機関名・代表者名	研究実施年度													
			2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
1	新方式による太陽中性子の観測	名古屋大学・村木　綏／松原　豊	○	○	○	○	○	○	○							
2	第24太陽活動期における太陽中性子の観測	名古屋大学・松原　豊								○	○	○	○	○	○	○
3	乗鞍岳における空気シャワーの連続観測及びミューオン強度の高精度測定	愛知淑徳大学・安野志津子	○	○	○	○	○	○								
4	乗鞍岳に於けるミューオンの精密観測	名古屋大学／名古屋女子大・藤本和彦	○	○	○											
5	乗鞍山上での大広域空気シャワーの観測	高知大学・大盛　信晴	○	○	○											
6	ニュートリノ現象の計算及び乗鞍環境ガンマ線データーの解析	山梨学院大学・三井　清美	○													
7	太陽フレアと高エネルギー粒子加速	国立天文台・櫻井　隆	○	○												
8	乗鞍岳における大気中エアロゾルの除去機構の研究　非人為的影響域における大気中エアロゾルの動態とキャラクタリゼーション	静岡大学・鈴木　款	○	○												
9	乗鞍岳におけるオゾン・水蒸気・Rnをトレーサーにした成層圏／対流圏物質輸送と大気エアロゾルに関する研究	名古屋大学・岩坂　泰信	○	○	○	○	○									
10	高山植物の生理生態的機能と環境形成作用	東邦大学・丸田恵美子	○	○	○	○	○	○	○	○	○	○	○	○		
11	乗鞍岳・森林限界におけるオオシラビソ林の動態	東邦大学・丸田恵美子													○	○
12	中緯度山岳地域における気候変動に対する地生態の応答	東京大学・大森　博雄		○	○											
13	乗鞍岳における大気及び霧水中の化学組成の変化に関する研究調査	静岡大学・鈴木　款			○											
14	乗鞍岳におけるミューオン強度の精密観測	信州大学・宗像　一起				○	○	○	○	○	○	○	○	○	○	○
15	乗鞍岳における大気・降水中の生物起源粒子及び人為起源粒子の挙動に関する調査研究	静岡大学・鈴木　款				○										
16	乗鞍岳における大気・降水中の生物起源粒子の挙動に関する調査研究	静岡大学・鈴木　款					○									
17	ポリイミドフィルムの宇宙線に対する耐性の研究	神奈川大学・立山　暢人					○	○	○	○	○	○				
18	Micro Segment Chamberを用いた乗鞍高度における反陽子の観測	名古屋大学・星野　香					○									
19	雷雲中における放射線強度変動に関する研究	核燃料サイクル開発機構／日本原子力研究開発機構・鳥居　建男					○	○		○						
20	地球気候変動に対する地生態系の応答	東京大学・大森　博雄					○									
21	高山における大気発光現象と雲による反射、散乱の測定	理化学研究所／青山学院大学・榊　直人					○	○			○	○	○	○		
22	高山における連続微気圧観測	東京大学・綱田　昏吾					○	○	○	○	○	○				
23	乗鞍岳における雲とエアロゾルの相互作用の研究	名古屋大学・柴田　隆								○						
24	最高エネルギー太陽宇宙線の観測的研究	甲南大学・村木　綏									○	○	○			
25	雷や雷雲からのX線・γ線を利用しての雷場による粒子加速の検証	理化学研究所・土屋　晴文									○	○	○			
26	積雪傾度に従った高山植物の群落構造と葉特性の適応戦略	東北大学・彦坂　幸毅									○					
27	無人観測用自然エネルギー電源装置の乗鞍岳における環境試験	国立極地研究所・山岸　久雄									○					
28	乗鞍岳におけるブリューワー分光高度計を使用したオゾン・紫外線の観測	気象庁・伊藤　真人										○	○	○	○	○
29	乗鞍岳の高山帯の植物調査	信州大学・高橋　耕一											○			
30	二次宇宙線中性子の高度依存線量評価	放射線医学総合研究所・保田　浩志／矢島　千秋												○	○	○
31	雷活動に起因する高エネルギー放射線発生と宇宙線の関係	東京学芸大学・鴨川　仁													○	
32	ライチョウの域内保全　-孵化後の雛１ヶ月間ケージ飼育による保護手法の確立-	信州大学・中村　浩志													○	○
33	乗鞍高度における宇宙線生成核種濃度の短時間変動の観測	山形大学・櫻井　敬久														○
34	乗鞍岳における高山植生調査	信州大学・高橋　耕一														○
35	エマルション望遠鏡のガンマ線に対する応答の評価	神戸大学・青木　茂樹														○

太陽中性子望遠鏡



名古屋大学

面積は64m²。
世界7箇所に設置された
太陽中性子望遠鏡の中で
最大を誇ります。

越冬を待つ中性子データ収集システム

平成16年からは、太陽電池パネルによる自然エネルギーを利用して、データ収集に必要な電力を供給しています。太陽中性子望遠鏡の設置された建物の南側に、40枚のパネルが取り付けられています。

平成21年度冬期前に設置した風力発電機

信　州　大　学

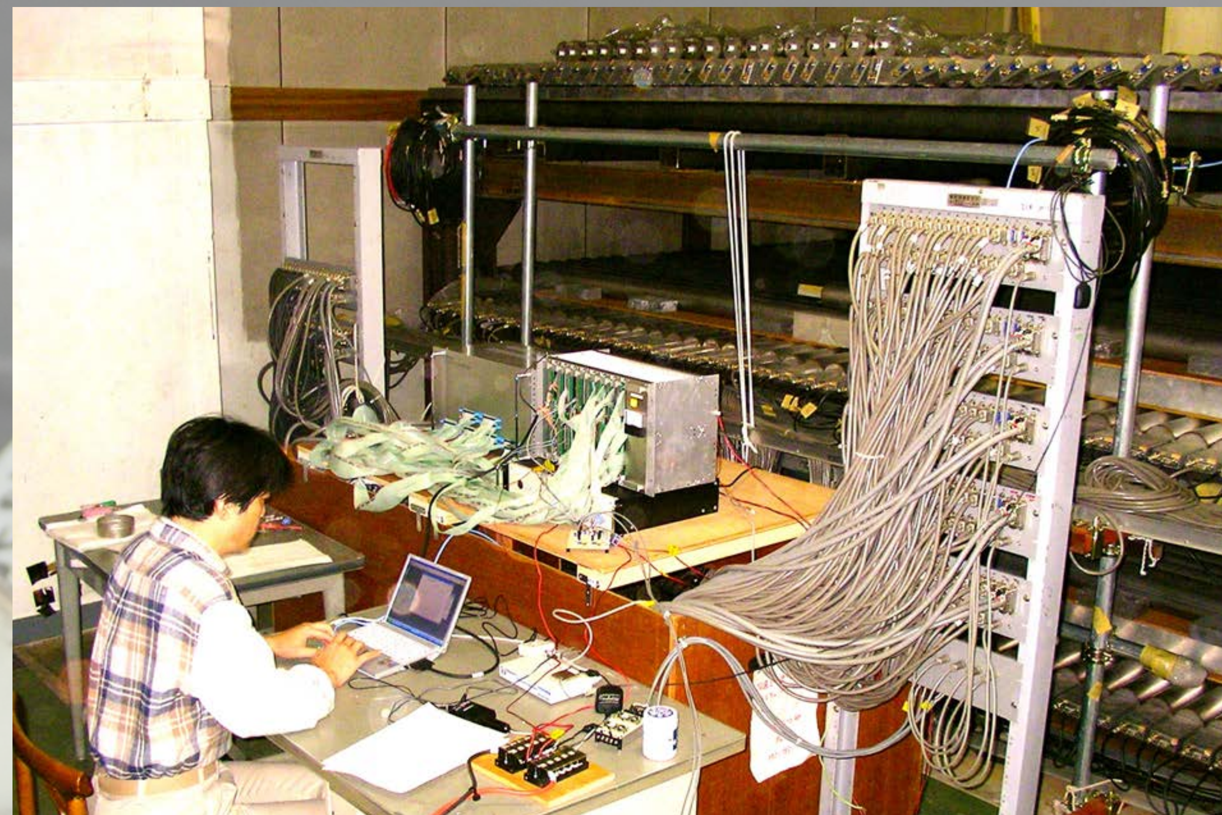
多　方　向　ミ　ュ　ー　オ　ン　計

太陽面爆発等に伴う宇宙嵐は、地上で観測される宇宙線異方性（宇宙線の風）もはげしく変化させます。中でも「宇宙線前兆現象」と呼ばれる変動は、宇宙線観測による「宇宙天気予報」の可能性を示唆するものとして注目されています。

乗鞍の多方向ミューオン計は、この「宇宙線前兆現象」の観測に必要な検出器の条件を調べることを目的として設置されました。入射方向の分解能を上げても十分な統計精度が得られるよう、高山での観測が必要です。

- ✦ 乗鞍多方向ミューオン計10cm径・5m長の比例計数管を井桁状4層積み上げている。
- ✦ 有効検出面積は約25m^2、鉛直入射ミューオンの計数率は約10万c/h。
- ✦ 観測はノートPCで自動制御され、データはネットワーク経由で毎時自動的に信大へ転送される。
- ✦ システム全体の消費電力は約45W。

信州大理・宇宙線グループは、世界4か所に設置された多方向ミューオン計からなるGMDN（Global Muon Detector Network）を用いて、宇宙線異方性の連続観測を行っています。目的は宇宙線観測による宇宙天気研究です。



バッテリーバンク

太陽光発電システム

太陽電池パネル12枚からなる

NORIKURA OBSERVATORY SCIENTIFIC ACTIVITY REPORT

EXTERNAL REVIEW 2006

1999 - 2005

INTRODUCTION

Norikura Observatory (36.10°N and 137.55°E) was founded in 1953 and attached to ICRR in 1976. It is located at 2,770 m above sea level, and is the highest altitude manned laboratory in Japan. Experimental facilities of the laboratory are made available to all the qualified scientists in the field of cosmic ray research and associated subjects. The AC electric power is generated by the dynamo and supplied throughout the observatory. In 1996, two dynamos of 70 KVA each were replaced with the new ones. The observatory can be accessed easily by car and public bus in summer (July-September). The 50th anniversary of Norikura Observatory was celebrated in 2003.

The feasibility of the automatic operation of Norikura Observatory during winter period has been tested since winter 2004 in order to study the possibilities to reduce maintenance and labor costs without seriously damaging to the use of researches. A long-distance (~40km) wireless LAN system (11M bps) was set up in 2003. Two new

Fig. 1. Norikura Observatory.

easy-to-handle and easy-to-maintain dynamos of 125 KVA each were installed in 2003 and 2005 as well. The unmanned operation of Norikura Observatory was successful in the first winter, during which the battery backed-up solar panels and/or wind power generators kept supplying the electricity to the wireless LAN and on-going cosmic-ray experiments.

Present major scientific interests of the laboratory is focused on the modulation of high energy cosmic rays in the interplanetary space associated with the solar activity and the generation of energetic particles by the solar flares, both of which require long-term monitoring. This research has been carried out by the group of universities, where ICRR provides them with laboratory facility. A part of the facility has been open for the environmental study at high altitude such as the aerosol removal mechanism in the atmosphere or for the botanical study of the high altitude environment.

COSMIC RAY PHYSICS

For the modulation study [2], two small experiments have been operated continuously for a long time. One is a neutron monitor operated to study the correlation of solar activity and the cosmic ray flux. The other is a high counting muon telescope consisting of 36 m^2 scintillation counters to study the time variation of cosmic rays with energies of 10–100 TeV over 20 years. The neutron monitor data are open to researchers worldwide as a world observation network point (WDC). The 5 years from 2000 corresponded to the solar maximum (2000) to a declining phase in the solar cycle 23. The sun spot number in 2004 is approximately one fourth of the those at maximum. Nonetheless, there occurred active cosmic-ray phenomena associated with Coronal Mass Ejection (CME). As regards solar cosmic rays, although many ground level enhancement (GLE) phenomena took place every year, such GLEs were observed only by neutron monitors in Japan, as the maximum cosmic-ray energy was several GeV in the GLEs and the magnetic rigidity cutoff in Japan is approximately 10 GeV for charged particles initiating secondary muons. The sunspot numbers in the solar cycle 23 was smaller than those in the previous cycle 22, indicating less solar activities of cycle 23. Although the GLEs above 10 GeV were not observed in cycle 23, the total number of GLEs were greater in cycle 23 than in cycle 22. This suggests that the charged particle acceleration associated with CME was less frequent in the cycle 23 than in the cycle 22. On the other hand, Forbush decreases in galactic cosmic rays caused by CME in the Sun were observed frequently in cycle 23, though the solar activities have been in a declining phase since 2000. The worldwide observation of Forbush decreases may contribute significantly to space weather study.

In addition, space weather observation is actively made by a 25 m^2 muon hodoscope at Norikura Observatory [1, 2, 3, 4, 5, 6, 7, 8]. A loss cone anisotropy is observed by a ground-based muon hodoscope in operation at Norikura Observatory in Japan for 7 hours preceding the arrival of an interplanetary shock at Earth on October 28, 2003. Best fitting a model to the observed anisotropy suggests that the loss cone in this event has a rather broad pitch-angle distribution with a half-width about 50° from the interplanetary magnetic field (IMF). According to numerical simulations of high energy particle transport across the shock, this implies that the shock is a "quasi-parallel" shock in which the angle between the magnetic field and the shock normal is only 6°. It is also suggested that the leadtime of this precursor is almost independent of the rigidity and about 4 hour at both 30 GV for muon detectors and 10 GV for neutron monitors (see paper [7]).

The Sun is the nearest site to the Earth capable of accelerating particles up to high energies. When the Sun becomes active, flares are frequently observed on its surface. The flare accelerates the proton and ion to high energy and they are detected on the Earth soon after the flare. Among the particles generated by the flare, high energy neutrons provide the most direct information about the acceleration mechanism as they come straight from the flare position to the Earth without deflected by the magnetic field.

In 1990, Nagoya group constructed a solar neutron telescope consisting of scintillators and lead plates, which measures the kinetic energy of incoming neutrons up to several hundred MeV. This telescope observed high energy neutrons associated with a large flare occurred on the 4th of June, 1991. The same event was simultaneously detected by the neutron monitor and the high counting muon telescope of Norikura Observatory. This is the most clear observation of solar neutrons at the ground level in almost ten years since the first observation at Jungfraujoch in 1982.

Fig. 2. New Solar-Neutron Telescope of Nagoya Group.

A new type of the large solar neutron telescope (64 m^2 sensitive area) was constructed by Nagoya group in 1996. It consists of scintillators, proportional counters and wood absorbers piled up alternately. This takes a pivotal role among a worldwide network of ground based solar neutron telescopes of the same type in Yangbajing in Tibet, Aragatz in Armenia, Gornergrat in Switzerland, Chacaltaya in Bolivia and Mauna Kea in Hawaii. The Sun is being watched for 24 hours using this network.

The Sun reached the maximum activity in 2000 and the active phase continued for the next few years. All the telescopes in Norikura Observatory, neutron telescope, neutron monitor, muon telescope and muon hodoscope, have been operated almost continuously through the solar cycle 23 in order to obtain comprehensive information on the solar flare phenomena. Important hints for understanding the mechanism of cosmic-ray acceleration near the solar surface will be obtained by these measurements, especially by energy spectra measured by the timing information of arriving neutrons and muons.

Furthermore, the relation between the electric fields induced by thunderclouds is studied recently[10]. The electric fields with thunderclouds change the intensity of secondary cosmic rays observed on the ground. This effect has been investigated using several detectors located at Norikura Observatory where excesses of 1 % and more of the average counting rate are observed when the observatory is covered with thunderclouds. A frequency analysis of the time series of days with such excesses for the period 26 October 1990 to 15 January shows the expected summer maximum in the rate of occurrence and, surprisingly, a 26-day variation. An electric field mill was installed to help determine the relationship between the intensity variations and the strength and direction of the field near the detector system: the excess is usually observed when a negative electric field (accelerating negative charges downward) greater than 10 kV/m is present in the atmosphere above the observatory. Based on Monte Carlo simulations, it is predicted that excess counting rates measured without charge discrimination will be expected as a consequence of the excess of positive muons among the secondary cosmic rays.

In addition to the long-term cosmic-ray observations mentioned above, various kinds of short-dated experiments are carried out every year taking an advantage of the high altitude of the observatory. A few examples include a search for super heavy particles with plastic plates, a precise measurement of atmospheric gamma rays and muons, collection of cosmic dusts contained in the snow and the performance study of the balloon borne cosmic ray experiments.

ENVIRONMENTAL STUDY

One of the interesting topics is atmospheric environment especially relating with atmospheric aerosol particles and water soluble gases. Because of its height, AC power supply, accommodation facility, and accessibility of cargos, the cosmic ray observatory at Mt. Norikura provides a very unique opportunity for atmospheric observation, especially for free-tropospheric conditions. (The atmosphere lower than a few kilometer is highly affected by the ground. This height level is named as 'atmospheric boundary layer'. The height of the boundary layer is about 4 km in daytime and about 2 km in nighttime around Norikura area. The atmosphere higher than this atmospheric boundary layer is called 'free troposphere'.) Originally, atmospheric observation at the cosmic ray observatory was initiated to study cosmogenic radionuclides with Prof. Suzuki at Shizuoka University. During early stage of the research at Mt. Norikura, a local effect of air contamination was recognized. To reduce air contamination from diesel exhausts and other activities around the observatory, an atmospheric observation hut (6 m^2) was installed at the west end (windward) of the observatory in September 1999. From year 2000, continuous monitoring (mostly mid-May to mid-October) of meteorology was started, number-size distribution of aerosols, dew point, aerosol chemical composition, ozone and radon concentrations, and column amount of aerosols from sky radiometer and ceilometer. Monitoring of ozone and radon concentrations was extended during 2 winters from 2001 to 2003. During summer season, also collected were rain, fog, water-condensed aerosol samples. These samples combined with other parameters were used in several thesis (master) works and provided useful information about future seeds of hygroscopic study of aerosols. During the past 5 years, the following results [11, 12, 13] were obtained at Mt. Norikura.

(1) Polluted air pumping effects over central Japanese Alps in summer

Under the clear sky conditions in summer, polluted air from mountain valley area is lifted up about 4km of altitude (1km above the mountain top) over Mt. Norikura. The height of observatory is within the atmospheric boundary layer in the daytime, and is out of (higher than) the atmospheric boundary layer in nighttime. The ratio of aerosol volume concentration for daytime (polluted valley wind) to nighttime (clean free-tropospheric) conditions was about 10. The air pumping effects over central Japanese Alps carry about 10 time higher concentration of aerosols to the free-troposphere over Japan in summer. Under the high-pressure system centered over the northwest Pacific in typical summer condition, backward air trajectories were originated from the northwest Pacific to Mt. Norikura and forward trajectories returned to the north Pacific with some deviations to east Russia and the Kurile Islands. The air pumping effects over mountain area provide a strong pollution source mechanism to the free-troposphere over the western Pacific region including East Asia.

(2) Seasonal variation of aerosol chemistry in free troposphere

An automated aerosol sampler was installed at the site in September 2000 to obtain seasonal aerosol samples. The sampler collected aerosols from mid-May to mid-October in 2001 and 2002. Results of its analysis showed seasonal changes in major and minor constituents of aerosols associating with changes of dominant air mass type over Japan.

(3) Vertical profiles of aerosols and clouds near the top of the atmospheric boundary layer

Ceilometer (lidar with small output energy) was installed in summer 2002, and was operated in 4 summer seasons. The aerosol and cloud profiles near the top of the atmospheric boundary layer have been observed. Some events of Asian dust, and of smoke from Siberian forest fire at lower free troposphere have been detected.

BOTANICAL STUDY

It is predicted that ecosystems in high-latitudes and alpine regions are sensitive to global climatic warming. The significant increasing trends in air temperature are found in the Hida Mountains, where Mt. Norikura is located. Thus, effects of climatic change caused by global warming on alpine ecosystems must be urgently studied in the alpine region of central Japan. The Hida Mountains, strongly influenced by cold-air masses from Siberia in winter, receive some of the heaviest snowfall in the world. Due to heavy snowfall, dynamics of alpine ecosystems may be peculiar to the Hida Mountains. However, few studies have been made because of difficulty in approach to the alpine study site. The inter-university research program of ICRR, gave an opportunity to make an intensive study all year around in the alpine region on Mt. Norikura [14, 15].

(1) Tree line dynamics

The tree form of evergreen sub-alpine fir (Abies mariesii) is studied at the upper distribution limit (2500m above sea level) on Mt. Norikura. Leader stems degenerate above the maximum snowpack line (3-4m high) , whereas branches below the snowpack line grow densely. In winter, leaves above snowpack line were severely damaged by environmental stresses, such as abrasion by windblown snow particles, desiccation, photo inhibition. Longevity of leaves was shortened to 4-5 years due to high mortality rate in winter. In contrast, leaves below snowpack line were protected from environmental stresses and their longevity was 11 years. As a result, biomass below the snowpack line takes more than 80 with climate change should have unfavorable effects on tree line Abies mariesii.

(2) Alpine region

Pinus pumila, an alpine prostrated pine, is dominant in the alpine regions (2500~3000m above sea level). At wind-protected sites, Pinus pumila grows vigorously with the tree height of 1-2m. They were beried in snowpack throughout the winter. At the wind-exposed ridge, growth is suppressed with the tree height of 0.2-0.5m. Throughout the winter, the surface of the pine community was exposed due to strong wind at the ridge. Leeward leaves were sound, because pine stems with high elasticity were prostrated and buried in snow. Thus, alpine pine can catch and accumulate snow to protect itself. This feature may be advantageous to alpine trees in comparison with sub-alpine trees (Abies mariesii). On the other hand, at the windward side (western), cuticular layer covering epidermal cells of leaf was abraded probably due to wind-blown snow and ice particles. By spring, abraded leaves at the windward side were dead caused by desiccation and photoinhibition. Even Pinus pumila community could reduce its habitat in small snowfall condition caused by global warming. Impact of global warming due to so-called greenhouse gases like CO_2, CH_4 and others on vegetation ecology is among the most serious environmental issues. To investigate how plants response to global warming, an experiment of greenhouse effect on vegetation has been continued at a high mountain, Mt. Norikura (3,025 m a.s.l.), central Japan, since 1997. Five open-top chambers which are small greenhouses with a size of maximum open-top diameter, the maximum basal diameter and the height of the chamber were 47 cm, 85 cm and 30 cm, respectively, were set over alpine plant communities consisting of small woody plants and herbaceous vegetation. At places inside and outside of the chambers, seasonal changes in vegetation growth and phenology were observed every month. Using automatic data-recorders, some climate elements such as air and ground temperatures, humidity and rainfall have been observed every hour. Some results through the experiment were quite remarkable. Due to the temperature enhancement of about 0.8°C for air temperature and about 0.3°C for ground temperature, plant growth rates and phenological changes showed notable differences between inside and outside of the chambers. The responses to warming, however, were different by different plant species. The results suggest [16, 17] that dominant species in plant community should be replaced by the species with a high physiological response to warming and with a growing form extending tree crown.

REFERENCES

[1] "Precursors of geomagnetic storms observed by the muon detector networ", K. Munakata, J. W. Bieber, S. Yasue, C. Kato, M. Koyama, S. Akahane, K. Fujimoto, Z. Fujii, J. E. Humble, and M. L. Duldig, J. Geophys. Res., Vol. 105, No. A12, pp. 27, 457-27,468 (2000).

[2] "Solar cycle variations of modulation parameters of galactic cosmic- rays in the heliospher", K. Munakata, H. Miyasaka, I. Sakurai, S. Yasue, C. Kato, S. Akahane, M. Koyama, D. L. Hall, Z. Fujii, K. Fujimoto, S. Sakakibara, J. E. Humble, and M. L. Duldig, Adv. Space Res., Vol. 29, No. 10, pp. 1527-1532 (2002).

[3] "A 1.7 year quasi-periodicity in cosmic ray intensity variation observed in the outer heliosphere", C. Kato, K. Munakata, S. Yasue, K. Inoue, and F. B. McDonald, J. Geophys. Res., Vol. 18, No. A10, p.1367, doi: 10.1029/2003JA009897 (2003).

[4] "Exploration of the heliosphere by cosmic rays", K. Munakata, published as the chapter 2 of Advances in Solar-Terrestrial Physics, pp.101-116, edited by H. Oya, published by TERRAPUB, Tokyo (2004).

[5] "Cosmic-ray modulation in the heliosphere: global and near-earth measurements and modeling", K. Munakata, Rapporteur paper in 28th International Cosmic Ray Conference, Vol.8, edited by T. Kajita et al., pp. 251-276, Univ. Acad. Press, Tokyo (2004).

[6] "Geometry of an interplanetary CME on October 29, 2003 deduced from cosmic rays", T. Kuwabara, K. Munakata, S. Yasue, C. Kato, S. Akahane, M. Koyama, J. W. Bieber, P. Evenson, R. Pyle, Z. Fujii, M. Tokumaru, M. Kojima, K. Marubashi, M. L. Duldig, J.

E. Humble, M. Silva, N. Trivedi, W. Gonzalez and N. J. Schuch, Geophys. Res. Lett., Vol.31, L19803, doi: 10.1029/2004GL020803 (2004).
[7] “A “loss-cone” precursor of an approaching shock observed by a cosmic-ray muon hodoscope on October 28, 2003”, K. Munakata, T. Kuwabara, S. Yasue, C. Kato, S. Akahane, M. Koyama, Y. Ohashi, A. Okada, T. Aoki, H. Kojima and J. W. Bieber, Geophys. Res. Lett., Vol. 32, L03S04, doi: 10.1029/2004GL021469, 2005.
[8] “CME-geometry and cosmic-ray anisotropy observed by a prototype muon detector network”, K. Munakata, T. Kuwabara, J. W. Bieber, P. Evenson, R. Pyle, S. Yasue, C. Kato, Z. Fujii, M. L. Duldig, J. E. Humble, M. R. Silva, N. B. Trivedi, W. D. Gonzalez and N. J. Schuch, Adv. Space Res., doi:10.1016/j.asr. 2003.05.064, 2005, in press.
[9] “Acceleration below Thunder Clouds at Mount Norikura”, by the Tibet hybrid experiment”, Y. Muraki et al., Proceedings in the 28th International Cosmic Ray Conference, (31 July - 7 August 2003, Tsukuba, Japan), Vol.7, pp 4177-4180.
[10] “Effects of atmospheric electric fields on cosmic rays”, Y. Muraki et al., Phys. Rev. D, 69, 123010–1-13 (2004).
[11] K. Osada, M. Kido, C. Nishita, K. Matsunaga, Y. Iwasaka, M. Nagatani, H. Nakada, Changes in ionic constituents of free tropospheric aerosol particles obtained at Mt. Norikura (2770 m a. s. l.), central Japan, during the Shurin period in 2000, Atmos. Environ., 36, 5469-5477, 2002.
[12] “Atmospheric diffusion process based on time change of 222Rn vertical profile”, K. Yoshioka, Journal of Aerosol Research, Japan, 17, 267- 275, 2002 (in Japanese).
[13] “Free-tropospheric aerosols based on airplane and mountain observations”, K. Osada, Journal of Aerosol Research, Japan, 15, 335-342, 2000 (in Japanese).
[14] “Diurnal changes in needle gas exchange in alpine Pinus pumila during snow-melting and summer seasons”, A. Ishida, T. Nakano, S. Sekikawa, E. Maruta, T. Masuzawa, Ecological Research 16, 107-116 (2001).
[15] “Effects of high light and low temperature during harsh winter on needle photodamage of Abies Mariesii growing at the forest limit on Mt. Norikura in Central Japan”, J. Yamazaki, A. Ohashi, Y. Hashimoto, E. Negishi, S. Kumagai, T. Kubo, T. Oikawa, E. Maruta, Plant Science 165, 257-264 (2003).
[16] “Chemistry of surface water at a volcanic summit area, Norikura, central Japan: Multivariate statistical approach”, K. Anazawa and H. Ohmori, Chemosphere, 45, 807-816 (2001).
[17] “Experimental research on vegetation response to artificial warming on a mid-latitude high mountain, central Japan”, H. Ohmori, J.H. Iguchi, T. Ohta, A. Terazono and K. Hikita, Geogr. Rev. Japan, 77, 301-320 (2004).

INTRODUCTION

Norikura Observatory (36.10°N and 137.55°E) was founded in 1953 and attached to ICRR in 1976. It is located at 2,770 m above sea level, and is the highest altitude manned laboratory in Japan (Fig. 1). Experimental facilities of the laboratory are made available to all the qualified scientists in the field of cosmic ray research and associated subjects. The AC electric power is generated by the dynamo and supplied throughout the observatory. The observatory can be accessed easily by car and public bus in summer (July-September). The 50th anniversary of Norikura Observatory was celebrated in 2003.

Fig. 1. Norikura Observatory.

Norikura Observatory gave manned operation to the observations by the qualified scientists all the year until the year 2003. However, the feasibility of the automatic operation of Norikura Observatory during winter period has been tested since winter 2004 in order to study the possibilities to reduce maintenance and labor costs without causing serious inconveniences for the researches. A long distance (~40km) wireless LAN system (11M bps) was set up in 2003. Two new easy-to-handle and easy-to-maintain dynamos of 125 KVA each, as shown in Fig. 2 were installed in 2003 and 2005 as well. The unmanned operation of Norikura Observatory has been mostly successful in winter, during which the battery backed-up solar panels and/or wind power generators kept supplying the electricity to the wireless LAN and on-going cosmic-ray experiments.

Present major scientific interests of the laboratory is focused on the modulation of high energy cosmic rays in

Fig. 2. A dynamo of 125KV.

the interplanetary space associated with the solar activity and the generation of energetic particles by the solar flares, both of which require long-term observation. This research has been carried out by the group of user universities, where ICRR provides them with laboratory facility. A part of the facility has been open for the environmental study at high altitude such as aerosol-related mechanism in the atmosphere, observation of total ozone and UV solar radiation, for botanical study in the high-altitude environment, etc..

COSMIC RAY PHYSICS

Space weather observation [represented by Kazuoki Munakata, Shinshu University]

Space weather observation is actively made by a 25 m^2 muon hodoscope at Norikura Observatory [1, 2, 3, 4, 5, 6, 7, 8, 9].

The anisotropy observed with the global muon detector network (GMDN) provides us with a unique information of the spatial gradient of the GCR density which reflects the large-scale magnetic structure in the heliosphere. The solar cycle variation of the gradient gives an important information on the GCR transport in the heliosphere, while the short-term variation of the gradient enables us to deduce the large-scale geometry of the magnetic flux rope and the interplanetary coronal mass ejection (ICME). Real-time monitoring of the precursory anisotropy which has often been observed at the Earth preceding the arrival of the ICME accompanied by a strong shock may provide us with useful tools for forecasting the space weather with a long lead time. By using a selfsupporting power system utilizing the solar panels and batteries, we keep a 25 m^2 muon hodoscope running at the Norikura Observatory as an important component detector of the GMDN. The total power consumption of this detector has been suppressed as low as 36 Watt by replacing all amplifier boards with those using CMOS ICs and by introducing a new recording system using the FPGA. This new system, in which the observation has been automatically carried out by a PC connected with the Internet, also enabled us to monitor the data on the real-time basis for the space weather study.

Solar neutron observation [represented by Yutaka Matsubara, Nagoya University]

Observation of solar neutron has been conducted at the Norikura Observatory since 1990. Neutron is used to clarify the acceleration mechanism of high energy particles in association with solar flares, because the neutron is not reflected by the interplanetary magnetic field. The 64m^2 solar neutron telescope was constructed in 1996, which is one of 7 solar neutron telescopes deployed at different longitudes to make up a network of 24 hour observation of solar neutrons[10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22]. The Norikura 64m^2 solar neutron telescope has been operated by solar batteries and wind power generators since 2004.

This collaborative work has started since fiscal 2007 succeeding to the previous project titled 'Observation of solar neutrons by using a new method'. Although solar cycle 24 has started since 2008, the solar activity has continued to be inactive, and no new solar neutron event has been detected by the network since 2006. The last solar neutron event was on September 7, 2005. This event is unique because it indicates ions were accelerated or trapped at the acceleration region longer than electrons. The summary of 11 solar neutron events detected until 2005 shows that it may not be probable that a very efficient acceleration such as the shock acceleration works for ions at solar flares. This is given by deriving the energy spectrum of neutrons at the solar surface for each solar neutron event with a power law. Power law indices obtained span from 3 to 7. The energy spectrum of the original ions is softer than that of neutron. Therefore an efficient acceleration has not been detected by the observation of solar neutrons so far. This work continues in solar cycle 24 to accumulate more events to obtain definite results related with particle acceleration at the solar surface.

New neutron telescope [represented by Yasushi Muraki, Konan University]

Another effort aiming at observation of highest energy solar cosmic rays started at the Norikura Observatory. The Sun is an accelerator of protons and electrons in the universe. In association with large solar flares, protons and electrons are accelerated into high energies. It is known that protons are accelerated over 50 GeV in the largest solar flares[23]. These high energy particles produce the Ground Level Enhancement (GLE). In order to understand the acceleration mechanism of protons, we have prepared several solar neutron telescopes at the high altitude laboratories in the world. They are located at Gornergrat (3,135m), Mt. Aragats in Armenia (3,200m), Tibet (4,200m), Mauna- Kea in Hawaii (4,200m), Mt. Chacaltaya in Bolivia (5,250m), and at Mt. Sierra Negra in Mexico (4,900m). We have constructed a solar neutron telescopes at Norikura Observatory (2,770m) in 1990 and operated it until 2004[24]. However due to the lack of power supply during the winter time since 2005, the first solar neutron telescope (36 m^2) has not been operated. From 2008 to 2009, we have decided to make a new solar neutron telescope to utilize the large amount of the plastic scintillator (0.5m^3), as shown in Fig. 3, left at the observatory.

The new solar neutron telescope with use of the recycled plastic scintillator consists of main target where neutrons are converted into protons and of the anti-counters surrounding the target. The signals of neutrons converted into protons are observed by using one photomultiplier from bottom side to reduce the electric power. Furthermore a lead plate with the thickness of 1cm is located over the target and the lead plate is sandwiched by

Fig. 3. 0.5-m^2 plastic scintillation counter for a new neutron telescope.

two layers of the plastic scintillator to identify gamma-rays from neutrons. The new solar neutron telescope has a function to reject charged particles with an efficiency of 90%. Therefore the new solar neutron telescope has capability of 1/3 of the 64m^2 large solar neutron telescope located at the same place. We are waiting large solar flares over our detectors.

Particle production and acceleration mechanism in thunder clouds [represented by Harufumi Tsuchiya, Riken]

High-energy radiations from thunderstorms have been observed by flight measurement, high mountain observations and ground-based measurement. There are two types of those radiations associated with thunderstorms. One is short-duration radiations with duration of 1 ms or less. The other is long-duration emissions lasting for a few seconds to a few minutes, or a few tens of minutes on rare occasions. It is believed that both emissions originate from electrons accelerated in strong electric fields formed in lightning and thunder clouds. However, compared with the former, the latter has remained less understood due to lack of a large sample of observations.

To investigate production mechanism of long duration emissions and the relevant electron acceleration, we installed at Norikura Cosmic-ray Observatory a radiation detection system and environmental sensors to measure light and electric fields during 2008-2010. The radiation system consists of a spherical NaI scintillator and a thin plastic scintillator that is placed just above the NaI counter. During the period, the system detected one long duration bursts as well as five short-duration events.

Figure 4 shows the long-duration event observed during thunderstorms on 2008 September 20[25]. The event lasted for 90 sec. Figure 4(Bottom) represents an observed photon spectrum extending from 10 keV to 10 MeV. This indicates that electrons can be accelerated to at least 10 MeV in a quasi-stable thundercloud electric field. In addition, we compared the observed spectrum with model ones, and concluded that a gamma-ray source is located 60m -130m (at 90% confidence level) apart from our detector. Given these results, the observed emission was found to consist of not only gamma rays but also electrons. This was the first simultaneous observation of gamma rays and electrons in long duration bursts.

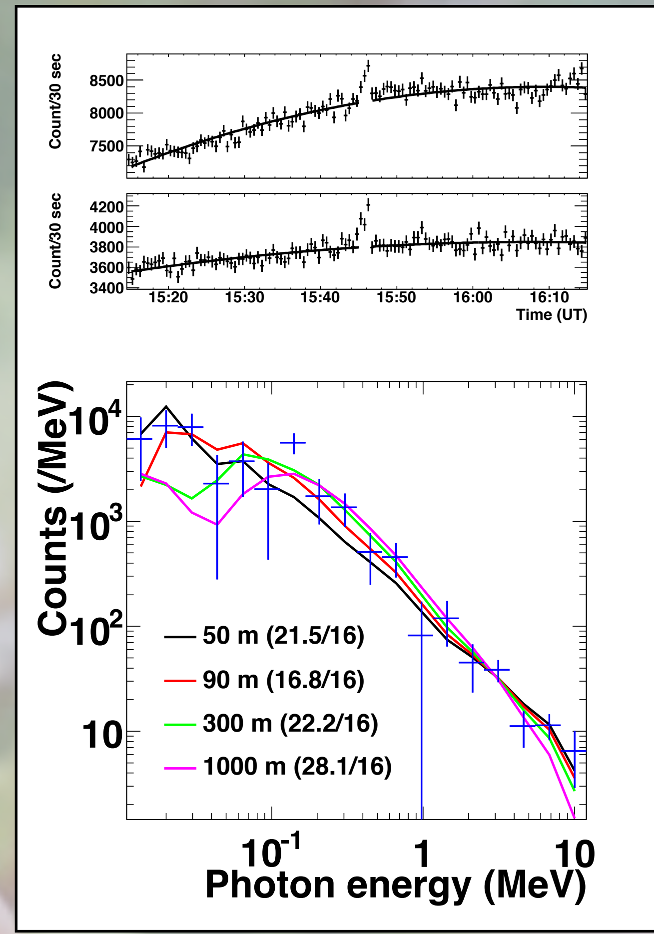


Fig. 4. (Top) Count rates per 30 sec observed by the >10 keV NaI scintillator and (Middle) by the > 100 keV plastic one. (Bottom) The photon spectrum observed by the NaI scintillator.

Study of air fluorescence [represented by Naoto Sakaki, Aoyamagakuin University]

Observation of night sky background is carried out at Mt. Norikura for basic study of ultra high energy cosmic-ray physics.

The JEM-EUSO mission is going on in order to study ultra high energy cosmic rays (UHECRs), especially above 10^{20}eV. A 2.5m telescope with 60° FoV will be attached to the International Space Station in 2017 and detect fluorescence in near UV band from extensive air showers induced by UHE-CRs. Observation of UHECRs from a satellite orbit has not been done yet, so that the knowledge of background light intensity is important to realize the observation. We have measured it from a balloon altitude, but the opportunity is limited. We started the background measurement at Mt. Norikura. Two 1 inch multi-anode photomultipliers (MAPMTs) developed for EUSO was used with UV filters. The center wavelengths of the filters were 337, 350, 358, 370, 380, 391, 400nm with 10nm band width. In addition BG3 filter was used to

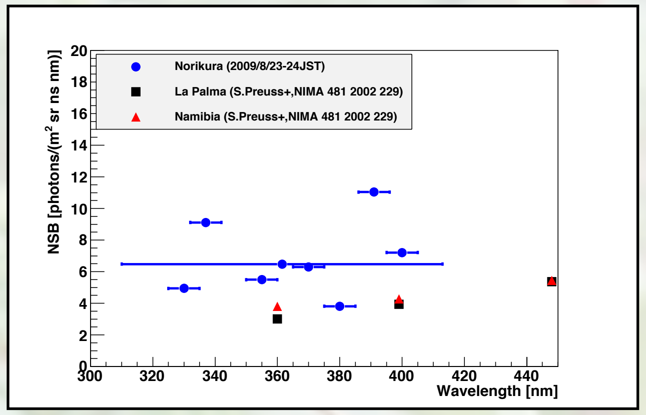


Fig. 5. Spectrum of night sky background measured at Mt. Norikura compared with those at La Palma and Namibia.

detect light in wider range from 330nm to 430nm. The MAPMTs were collimated to 7° FoV. The data was taken with the photon counting method.

We have observed several nights for three years. The intensity at zenith was almost constant at 600-800 photons/ns sr m^2 for BG3 filter. The spectral intensity was about 1.5-2 times larger than those measured at La Palma and Namibia. The estimated portion of star light and zodiacal light was ~30% and artificial light and night glow at upper atmosphere may be the main components at Mt. Norikura. Night sky background measured at Mt. Norikura is shown in Fig. 5.

ENVIRONMENTAL STUDY

Atmospheric aerosol particles and water soluble gases [represented by Takashi Shibata, Nagoya University]

One of the interesting topics is atmospheric environment especially relating with atmospheric aerosol particles and water soluble gases. The cosmic ray observatory at Mt. Norikura provides us very unique opportunity for the observations of atmosphere at free-tropospheric conditions with its high altitude, AC power supply at the site, accommodation facility, and easy accessibility. From year 2000 to 2007, we conducted continuous monitoring (mostly mid-May to mid-October) of meteorological parameters, number-size distribution of aerosols, aerosol chemical composition, ozone and radon concentrations, and column amount of aerosols from sky radiometer and ceilometers. We also collected rain, fog, water-condensed aerosol samples. These samples combined with other observed parameters were used in publications [26, 27, 28] in the following subjects:

(1) Polluted air pumping effects over central Japanese Alps in summer
(2) Seasonal variation of aerosol chemistry in free troposphere
(3) Vertical profiles of aerosols and clouds near the top of the atmospheric boundary layer.

Ceilometer (lidar with small output energy) was installed in summer 2002, and was operated in 6 summer seasons. The aerosol and cloud profiles near the top of the atmospheric boundary layer have been observed. Some events of Asian dust were detected.

Observations of total ozone and UV solar radiation with Brewer spectrophotometer [represented by Mahito Ito, Japan Meteorological Agency] Observations of total ozone and UV solar radiation with Brewer spectrophotometer on the Norikura mountains are made[29, 30, 31].

Aerological Observatory started this research as a joint project with the ICRR. Purpose of this study is based on the concept of developing Regional Brewer Calibration Centre in Asia and study of total ozone, total sulfur oxide and global/diffuse UV included solar radiation on the high mountains. Observation results by using Brewer spectrophotometers and other instruments for the observation period of three summer seasons of recent three years between 2009 to 2011 are summarized as follows;
(1) Daily means of ds (direct-sun-observation) O3 (total ozone) at Norikura for the observation periods were approx. 280 to 290 milli-atm-cm (i.e., total integrated amount of ozone above the observation site being 2.8mm to 2.9mm at 1 atm) and were running on the lower values of approx. -3 to -6% compared to the value at Tsukuba (36.06 N, 140.13 E, 39 m a.s.l.) at almost same latitude. Day-today variations at Norikura were also small against Tsukuba. On the other hand, daily mean of ds SO_2 (total sulfur oxide) values were not recognized at Norikura.
(2) Absolute calibration of Brewers for ds O_3 and ds SO_2 observations could be carried out at Norikura in the clear day within the zenith-angle range from 7.928 (maximum) to 1.028 (minimum) in unit of air mass at Norikura, where one air mass unit is defined to be the distance traversed in the atmosphere by solar light perpendicular to the ground. O_3 and SO_2 Extra-Terrestrial Coefficients (=ETC), i.e., instrumental coefficients of Brewers could be produced as about 10 samples. As an example of the calibration in 2011, the average of O_3 ETC of Brewers was identical within 1% to the currently used coefficient.
(3) In comparison to the data acquired at Tsukuba, the average of daily total GL_{UV} (global UV = all-sky UV integrated above the horizon) at Norikura measured in the wavelength range CIE (corresponding to the Erythema UV region defined by a committee "Commission Internationale de L'Éclairage") for the observation periods indicated the intensities of approx. +23 % in 2009 to -6 % in 2011. The low intensity in 2011 was due to the bad weather on the Norikura Mountain. In the case of clear days, the GLUV at Norikura indicated high intensities of approx. +35 to +52 % against the values at Tsukuba. On the other hand, the GL_{UV} increased in the short wavelength range at Norikura against the average at Tsukuba. The altitudinal increasing rate of GL_{UV} in the clear day indicated the calculated amounts of approx. +13 to +18 % per 1,000 m.

This joint project had been clarifying the low total O_3, high UV in clear day, low turbidity and etc. at Norikura against the value at Tsukuba. Those environmental conditions are useful for the inter comparison and the absolute calibrations with Brewers. The continuous observations with Brewers and other instrument are very important for the clarification of the seasonal variation and the coefficient trends.

Effect of snow cover on pine shrub Pinus pumila in the alpine region [represented by Emiko Maruta, Toho University]

High mountainous habit is one of the most severe habits for plant life and sometimes dwarf shrubs cannot survive. In the alpine regions of Japan, the dwarf shrub Pinus pumila (Japanese name : Haimatsu) forms communities together with small alpine plants, whereas dwarf shrubs occur only in the transition zone between the alpine region and the subalpine forest in Europe and North America. This characteristic of alpine vegetation is considered to be owing to winter heavy snow in the alpine regions of Japan. The purpose of this study is to elucidate how snow cover protects Haimatsu from winter environmental stresses in the alpine region of Mt. Norikura[32, 33].

REFERENCES

[1] K.Munakata, S. Yasue, C. Kato, J. Kota,M. Tokumaru,M. Kojima, A. A. Darwish, T. Kuwabara and J. W. Bieber, "On the cross-field diffusion of galactic cosmic rays into the magnetic flux rope of a CME", Advances in Geosciences, 2, 115-124, eds. W. H. Ip and M. Duldig (World Scientific Publishing Co., USA), (2006).
[2] T. Kuwabara, J. W. Bieber, J. Clem, P. Evenson, R. Pyle, K. Munakata, S. Yasue, C. Kato, S. Akahane, M. Koyama, Z. Fujii, M. L. Duldig, J. E. Humble, M. R. Silva, N. B. Trivedi, W. D. Gonzalez and N. J. Schuch, "Real-time cosmic ray monitoring system for space weather", Space Weather, 4, S08001-1 10, (2006).
[3] M. R. Da Silva, A. Dal Lago, E. Echer, A. de Lucas, W. D. Gonzalez, N. J. Schuch, K. Munakata, L. E. A. Vieira, and F. L. Guarnieri, "Muon and neutron observations in connection with the corotating interaction regions", Adv. Space Res., 40, pp348-352, (2007).
[4] Y. Okazaki, A. Fushishita, T. Narumi, C. Kato, S. Yasue, T. Kuwabara, J. W. Bieber, P. Evenson, M. R. Da Silva, A. Dal Lago, N. J. Schuch, Z. Fujii, M. L. Duldig, J. E. Humble, I. Sabbah, J. Kta and K.Munakata, "Drift effects and the cosmic ray density gradient in a solar rotation period: First observation with the Global Muon Detector Network (GMDN)", Astrophys. J., 681, 693-707, (2008).
[5] T. Kuwabara, J. W. Bieber, P. Evenson, K. Munakata, S. Yasue, C. Kato, A. Fushishita, M. Tokumaru,M. L. Duldig, J. E. Humble, M. R. Silva, A. Dal Lago, and N. J. Schuch, "Determination of ICME Geometry and Orientation from Ground Based Observations of Galactic Cosmic Rays", J. Geophys. Res., 114, A05109-1 10, doi:10.1029/2008JA013717, (2009).
[6] A. Fushishita, T. Kuwabara, C. Kato, S. Yasue, J. W. Bieber, P. Evenson, M. R. Da Silva, A. Dal Lago, N. J. Schuch, M. Tokumaru, M. L. Duldig, J. E. Humble, I. Sabbah, H. K. Al Jassar, M. M. Sharma, and K. Munakata, "Precursors of the Forbush Decrease on 2006 December 14 observed with the GlobalMuon Detector Network (GMDN)", Astrophys. J., 715, 1239-1247, (2010).
[7] A. Fushishita, Y. Okazaki, T. Narumi, C. Kato, S. Yasue, T. Kuwabara, J. W. Bieber, P. Evenson, M. R. Da Silva, A. Dal Lago, N. J. Schuch, M. Tokumaru, M. L. Duldig, J. E. Humble, I. Sabbah, J. Kta, and K. Munakata, "Drift effects and the average features of cosmic ray density gradient in CIRs during successive two solar minimum periods", Advances in Geosciences, eds. W. H. Ip and M. Duldig (World Scientific Publishing Co., USA), 21, 199-210, (2010).
[8] M. Tokumaru, M. Kojima, K. Fujiki, K. Munakata, T. Kuwabara and K. Marubashi, "Relation between loop-shaped interplanetary disturbances and the magnetic flux rope", Advances in Geosciences, eds. W. H. Ip and M. Duldig (World Scientific Publishing Co., USA), 21, 21-32, (2010).
[9] M. Rockenbach, A. Dal Lago, W. D. Gonzalez, K. Munakata, C. Kato, T. Kuwabara, J. W. Bieber, N. J. Schuch, M. L. Duldig, J. E. Humble, H. K. Al Jassar, M. M. Sharma, and I. Sabbah, "Geomagnetic Storm's Precursors Observed from 2001 to 2007 with the Global Muon Detector Network (GMDN)", Geophys. Res. Lett., 38, L16108-1 4, doi: 10.1029/2011GL048556, (2011).
[10] "Solar neutron events of October–November 2003", Watanabe, K. et al., Astrophys. J., 636, 1135–1144, 2006.

[11] “Solar neutron events in association with large solar flares in November 2003”, Watanabe, K. et al., Adv. Space Res., 38, 425–430, 2006.
[12] “Long-lived solar neutron emission in comparison with electronproduced radiation in the 2005 September 7 solar flare”, Sako, T. et al., Astrophys. J., 651, L69–L72, 2006.
[13] “Highly significant detection of solar neutrons on 2005 September 7”, Watanabe, K. et al., Adv. Space Res., 39, 1462–1466, 2007.
[14] “A solar neutron telescope in Tibet and its capability examined by the 1998 November 28th event”, Muraki, Y. et al., Astroparticle Phys., 28, 119–131, 2007.
[15] “Simultaneous detection of high-energy solar neutrons and protons at Chacaltaya observatory on April 15, 2001”, Muraki, Y. et al., in Proc. 30th Int. Cosmic Ray Conf, Merida, 1, 25–28, 2007.
[16] “Search for solar neutrons associated with series of X-class flares during the declining period of solar cycle 23”, Matsubara, Y. et al., in Proc. 30th Int. Cosmic Ray Conf, Merida, 1, 29–32, 2007.
[17] “Ion acceleration and neutral emission mechanisms for 2005 September 7 flare”,Watanabe, K. et al., in Proc. 30th Int. Cosmic Ray Conf,Merida, 1, 45–48, 2007.
[18] “Energy spectrum for the solar neutron event of September 7 2005, derived from the SNT at Sierra Negra”, Gonzalez, L. X. et al., in Proc. 30th Int. Cosmic Ray Conf, Merida, 1, 57–60, 2007.
[19] “Status of the world-wide network of solar neutron telescopes in solar cycle 24”, Matsubara, Y. et al., in Proc. 31st Int. Cosmic Ray Conf, Lodz, 1, On Conference home page, 2009.
[20] “Detection of high-energy solar neutrons and protons by ground level detectors on April 15, 2001”, Muraki, Y. et al., Astropart. Phys., 29, 229–242, 2008.
[21] “Solar neutron events as a tool to study particle acceleration at the Sun”, Valdes-Galicia, J. F. et al., Adv. Space Res., 43, 565–572, 2009.
[22] “Physics of ion acceleration in the solar flare on 2005 September 7 determines g -ray and neutron production”, Watanabe, K. et al., Adv. Space Res., 44, 789–793, 2009.
[23] “Observation of solar neutrons associated with the large flare on 1991 June 4”, Muraki, Y. et al., ApJ, 400, L75-L78 , 1992.
[24] “Detection of high-energy solar neutrons and protons by ground level detectors on April 15, 2001”, Muraki, Y. et al., Astropart. Phys., 29,
[25] “Observation of an energetic radiation burst from mountain-top thunder clouds”, H. Tsuchiya et al., Phys. Rev. Lett. 102, 255003 (2009), Citation Index: 13.
[26] “Nucleation mode particles in up-slope valley winds at Mt. Norikura, Japan: implications for the vertical extent of new particle formation events in the lower troposphere”, Nishita, C., K. Osada, K.Matsunaga, Y. Iwasaka, J. Geophys. Res., 113, D06202, doi: 10.1029/2007JD009302, 2008.
[27] “Temporal variation of water-soluble ions of free tropospheric aerosol particles over central Japan”, Osada, K., Kido, M., Nishita, C., Matsunaga, K., Iwasaka, Y., Nagatani, M., Nakada, H., Tellus, 59B, 742-754, 2007.
[28] “Number-size distributions of free tropospheric aerosol particles at Mt. Norikura, Japan: effects of precipitation and air-mass transportation pathways”, Nishita, C., K. Osada, K. Matsunaga, Y. Iwasaka, J. Geophys. Res., 112, doi:10.1029/2006JD007969, 2007.
[29] “Observations of total ozone and UV solar radiation with Brewer spectrophotometers on the Norikura mountains in 2009.”, Ito, M.,M. Takano, H. Oguri, M. Takita, H. Shimodaira and H. Ishitsuka, Jour. of the Aerological Observatory, 69, 41-54 2011.
[30] “Observations of total ozone and UV solar radiation with Brewer spectrophotometers on the Norikura mountains, Northern Japanese Alps, from 2009.”, Ito, M., S. Shimizu, Y. Noto, T. Shimamura, M. Takano, M. Takita, H. Shimodaira and H. Ishitsuka, The 13th WMO Biennial Brewer Workshop, Beijing, China in 2011, 2011.
[31] “Total ozone and UV solar radiation with Brewer spectrophotometers at Norikura of Northern Japanese Alps, in recent three years.”, Ito, M., S. Shimizu, Y. Noto, T. Shimamura, M. Takita, H. Shimodaira and H. Ishitsuka, Jour. of the Aerological Observatory, 70, in contribution.
[32] “Needle browning and death in Pinus pumila in the alpine region of centralJapan were not related to mechanical damage of cuticle and cuticle thickness.”, Nakamoto A., Ikeda T., Maruta E., Can. J. For. Res. 42, 167-178 (2012).
[33] “Needle traits of an evergreen, coniferous shrub growing at wind exposed and protected sites in a mountain region: does Pinus pumila produce needles with greater mass per area under wind-stress conditions?”, Nagano S., Nakano T., Hikosaka K and Maruta E., Plant Biology 11(Suppl.1), 94-100, (2009).


乗鞍の紅葉

乗鞍観測所

〒506-2100
岐阜県高山市丹生川町乗鞍岳
TEL： 090-7721-5674　090-7408-6224

地理的位置：北緯36度6分、東経137度33分
標高：2,770m（平均気圧720hPa）
設備：自家発電機　交流125KVA2基

鈴蘭連絡所

〒390-1513
長野県松本市安曇4306-6
TEL：0263-93-2211
FAX：0263-93-2213