Solar Energetic Particles (SEP), Solar Modulation and Space Radiation: New Opportunities in the AMS-02 Era #2

Report of Contributions

https://indico.cern.ch/e/586603

Contribution ID: **1** Type: **not specified**

Evaluation of galactic cosmic rays (GCR) models using AMS2 and PAMELA measurements

Wednesday, 26 April 2017 10:00 (30 minutes)

Traditionally, Galactic Cosmic Rays (GCR) models are used as a boundary condition input to the deterministic or stochastic (e.g. Monte Carlo) based radiation transport codes with the goal of extracting
dosimetric quantities of interest such as dose, dose equivalent, effective dose, etc. at a desired target
point within the spacecraft. To compute the dosimetric quantities of interest, the geometry and mass
property of the spacecraft which represent the structure and detector are defined through a ray-tracing
process. The transported fluxes are then used to interpolate on the ray-traces at different depths of
materials to complete the computation.
In this talk, three widely used free space GCR models are evaluated against measurements by the Alpha Magnetic Spectrometer 2 (AMS2) and the Payload for Antimatter Matter Exploration and Lightnuclei
Astrophysics (PAMELA) detectors. The AMS2 is mounted on the main truss of the International Space Station (ISS), while PAMELA is mounted on the exterior of the Russian Resurs DK1 satellite. For the
three GCR models particular emphasis is put on energy region where GCR peaks (i.e. Ek < 3 GeV) to
evaluate the discrepancies between the models and the AMS2/PAMELA measurements.

Primary authors: Dr BADAVI, Francis (Old Dominion University); MERTENS, Christopher J. (NASA Langley Research Center); SLABA, Tony C. (NASA Langley Research Center)

Presenter: Dr BADAVI, Francis (Old Dominion University)

Session Classification: Early Wednesday Morning

Contribution ID: **2** Type: **not specified**

Implementation of Two Galactic Cosmic Rays Cutoff Rigidity Models

Wednesday, 26 April 2017 10:45 (30 minutes)

Within the Earth geomagnetic field, the computation of Galactic Cosmic Rays (GCR) cutoff rigidity is a necessary step in modulating the magnitude of free space GCR ions that reach Low Earth Orbit (LEO). Traditionally, the cutoff rigidity calculation has been carried out using a computationally efficient approximation named Stormer which models the Earth geomagnetic field as a simple dipole. However, for a geodetic point in space defined by the triplet (longitude, latitude, altitude), the Stormer model is limited in that it can only estimate the cutoff rigidity within a narrow field of view known as the allowed cone. That is, it cannot account for the complicated motion of an ion in directions outside this cone.
A second approach, based on following the trajectory of an ion within the geomagnetic field, attempts to trace out the complicated ion specific trajectory in all directions by solving the three dimensional Newton equation of motion in spherical coordinates. This approach inherently carries all the needed physical details of an ion cutoff rigidity during its motion in the magnetic field. However, it suffers from slow computational time as the numerical integration process involves keeping track of complicated trajectories near the cutoff rigidity, and many numerical trajectories are needed to be traced in order to find the proper cutoff.
In this talk, the trajectory tracing methodology is visited for a target point within the US-Lab module of the International Space Station (ISS). At this target point, dosimetric quantities are computed at several selected ISS orbital positions to assess the computational accuracy and efficiency of the trajectory tracing versus Stormer for cutoff rigidity calculation. These calculations, inherently carry information on the computational time to perform trajectory tracing, ion transport, and interpolation on the realistic precomputed ISS geometry (i.e. mass model). Therefore, it provides a realistic assessment of the amount of time it takes to perform an end-to-end calculation which is of primary interest to the ISS radiation assessment operations.

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Presenter: BADAVI, Francis (Nasa)

Session Classification: Late Wednesday Morning

Contribution ID: **3** Type: **not specified**

Variability of the energetic particle population in the Earth's magnetosphere as a result of geomagnetic disturbances

Tuesday, 25 April 2017 14:50 (25 minutes)

The Earth's energetic particle environment consists of several components of the ionizing radiation: galactic cosmic rays (GCRs), solar energetic particles (SEP), and particles populating two radiation belts. Of those, it is SEPs and GCRs that are critical for evaluating the safety of space operations performed in the LEO altitude range.

According to the current paradigm, GCRs are produced by diffusive shock acceleration in supernova remnants (e.g., Blandford & Eichler 1987) from which they diffuse to fill the whole galaxy. The composition of GCRs is dominated by H⁺ and He²⁺ (e.g., Simpson 1983; Mewaldt 1994). In order to be observed at the Earth, these charged particles have to penetrate the electromagnetic fields of the heliosphere, which is a region around the Sun extended further than 100 AU, and dominated by the solar-wind plasma and by the interplanetary magnetic field (IMF). SEPs are energetic particles ejected by the Sun in events that are correlated with coronal mass ejections (CMEs) and solar flares (e.g., Reames 1999).

GCR and SEP particles with energies below 100 MeV/n are effectively shielded by the Earth's magnetosphere (Badavi et al. 2011; Vainio et al. 2008; Badhwar 1997). Transmission of these particles is usually described in terms of the cutoff rigidity. Since the cutoff rigidity depends on the geomagnetic field, a perturbation of the magnetosphere during an active time can result in a variability of the cutoff.

In this presentation we will address fundamental questions of the variability of the geospace radiation environment due to GCRs and SEPs in response to that of the Earth's magnetosphere. That will be done by modeling of propagation of SEPs and GCRs in the magnetosphere using our Adaptive Mesh Particle Simulator (AMPS), which is a global Monte Carlo particle code describing dynamics of the relativistic particles affected by the geomagnetic field. We will present results of our calculations of fluxes and energy spectra of SEPs and GCRs in the altitude range starting from GEO, and going down to LEO during quiet and active solar conditions.

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Presenter: TENISHEV, Valeriy (University of Michigan)

Session Classification: Early Tuesday Afternoon

Contribution ID: **4** Type: **not specified**

Solar Wind-Driven Enhancements and Losses of Radiation Belt Particles: Van Allen Probes Observations

Monday, 24 April 2017 09:00 (30 minutes)

The dual-spacecraft Van Allen Probes mission has provided a new window into megaelectron Volt (MeV) particle dynamics in the Earth's radiation belts. Observations (up to E ˜10 MeV) show clearly the behavior of the outer electron radiation belt at different time scales: months-long periods of gradual inward radial diffusive transport and weak loss being punctuated by dramatic flux changes driven by strong solar wind transient events. Analysis of multi-MeV electron flux and phase space density (PSD) changes during key intervals from March 2012 into 2017 are presented in the context of the first several years of Van Allen Probes operation. These key periods demonstrate the classic signatures both of inward radial diffusive energization as well as abrupt localized acceleration deep within the outer Van Allen zone (L ˜4.0±0.5). Such results reveal graphically that both "competing" mechanisms of multi-MeV electron energization are at play in the radiation belts, often acting almost concurrently or at least in very rapid succession. They also show in remarkable ways how the coldest plasmas in the magnetosphere intimately control the most highly energetic particles.

Primary author: Dr DANIEL N., Baker (Director and Distinguished Professor Laboratory for Atmospheric and Space Physics, University of Colorado, Boulder, CO, USA.)

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Session Classification: Early Monday Morning

Contribution ID: **5** Type: **not specified**

Welcome

Session Classification: Early Monday Morning

Contribution ID: **6** Type: **not specified**

Welcome

Welcome from Veronica Bindi

Session Classification: Early Monday Morning

Contribution ID: **7** Type: **not specified**

Solar Energetic Particle Events with Protons above 500 MeV between 1995 and 2015 Measured with SOHO/EPHIN

Tuesday, 25 April 2017 16:50 (25 minutes)

The Sun is an effective particle accelerator producing solar energetic particle (SEP) events during which particles up to several GeVs can be observed. Those events observed at Earth with the neutron monitor network are called ground level enhancements (GLEs). In this work, SEP events with protons accelerated to above 500 MeV have been identified using data from the Electron Proton Helium Instrument (EPHIN) aboard the Solar and Heliospheric Observatory (SOHO) between 1995 and 2015. The compliled list of 42 SEP events is discussed based on the fitted spectral slopes and absolute intensities with special emphasis on whether or not an event has been observed as GLE. Furthermore, a correlation between the derived intensity at 500 MeV and the observed increase in neutron monitor count rate has been found
for a subset of events.

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Presenter: KÜHL, Patrick (University of Kiel)

Session Classification: Late Tuesday Afternoon

Contribution ID: **8** Type: **not specified**

Solar modulation in a very quiet heliosphere

Monday, 24 April 2017 15:15 (25 minutes)

Solar activity was at its lowest level since the beginning of the space exploration era from 2006 to 2009. During this period, the PAMELA space experiment observed spectra for galactic protons and electrons down to 70 MV and 400 MV, respectively, during what is called an A < 0 solar magnetic polarity cycle. This provides the opportunity to study charge-sign-dependent modulation under very quiet heliospheric conditions. Drift theory for the solar modulation of cosmic rays predicts that the intensity of protons at the Earth is expected to show a different rate of recovery towards solar minimum when compared to electrons during A < 0 cycles. The solutions of a comprehensive three-dimensional drift model are compared to PAMELA spectra to authenticate the modelling approach and then it is used to make predictions of how cosmic rays are differently modulated. Computations are done down to 1 MeV for the mentioned period and are based on new very local interstellar spectra.

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Presenter: Prof. POTGIETER, Marius (North-West University)

Session Classification: Early Monday Afternoon

Contribution ID: **9** Type: **not specified**

An investigation of Forbush decrease events based on a time-dependent cosmic ray SDE transport model

Monday, 24 April 2017 16:00 (25 minutes)

A three-dimensional (3D) diffusion-barrier-type model is constructed for producing Forbush decreases (Fds) in the heliosphere. It is based on reduced diffusion inside these barriers, which is incorporated into a Stochastic Differential Equation (SDE) based time-dependent, cosmic ray transport model. This 3D numerical model for simulating Fds is built for and applied to a period of relatively quiet solar activity. We find the following results: (1) Both the latitudinal and longitudinal extent of the barrier have relatively less effects on Fd profiles than its radial extent and the level of decreased diffusion inside the disturbance. (2) The magnitude of a Fd overall decreases with heliocentric radial distance, and it exhibits additionally an oscillating pattern as radial distance increases, which coincides well with the wavy profile of the heliospheric current sheet (HCS). (3) The rotational motion of this HCS causes the relative location from the observation point to the HCS to vary, so that a periodic pattern appears in the cosmic ray intensity at the observing location. Correspondingly, the magnitude and recovery time of Fds change so that the recovering part of the Fd profile contains clear 12-13 day oscillations. Additionally, since the PAMELA and AMS-02 missions have observed Fds in the cosmic ray electron intensity, it is worthwhile to develop a dedicated numerical model for electron Fds. This is done using a new local interstellar spectrum for galactic electrons, and utilizing a different diffusion model for electrons than for protons. Because of the difference in charge and mass, this model enables us to study how protons and electrons behave differently during a single Fd event. These differences, caused by what is assumed for particle drift and diffusion theory, can now be valuated with the help of the mentioned precise observational data.

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Session Classification: Late Monday Afternoon

Contribution ID: **10** Type: **not specified**

Characteristics of 29 Sustained-Emission >100 MeV Gamma-Ray Events Associated with Impulsive Solar Flares

Wednesday, 26 April 2017 14:00 (25 minutes)

We detail the characteristics of 29 sustained-emission >100 MeV solar gamma-ray events observed by Fermi that are distinct from the associated impulsive flares. The >100 MeV gamma-ray emission is well fit by pion-decay spectra produced by >300 MeV protons following a power-law spectrum, or one that rolls over at high energy, and is inconsistent with bremsstrahlung from primary electrons. Sustained gamma-ray emission results: 1) temporal characteristics – onset times from CME launch to 80 min later, durations from 4 min to 20 hr that are correlated with >100 MeV SEP durations, neither due to tail of the impulsive flare nor post-flare episodic emission; 2) proton characteristics—spectra soften >100 MeV to a mean power-law index −4.5 > 300 MeV, evidence that spectra of long-duration events soften in time and that short-duration spectra harden in time, proton number >10 times that in the impulsive flare and 10-2 times that in accompanying SEP; 3) location: neither just from active region nor globally from Sun, but can extend tens of degrees from the AR; 4) associations: all with impulsive flare HXRs >100 keV and all but two with CMEs, bremsstrahlung from MeV electrons observed along with sustained gamma rays from a behind-the-limb flare. The sustained gamma-ray emission is likely produced by CME shock acceleration, common to that producing the associated SEPs, of a seed population that includes sub-MeV flare particles onto magnetic field lines returning to the Sun.

Primary author: SHARE, Gerald

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Presenter: SHARE, Gerald

Session Classification: Early Wednesday Afternoon

Contribution ID: **11** Type: **not specified**

The STEREO Electron Spikes and the Interplanetary Magnetic Field

Monday, 24 April 2017 10:00 (30 minutes)

Klassen, etal discussed observations of a spike event of 55-65 keV electrons which occurred very nearly simultaneously at STEREO A and STEREO B, which at the time were separated in longitude by 38 degrees. The authors associated the spikes with a flare at the Sun near the footpoint of the nominal Archimedean spiral magnetic field line passing through STEREO A. The spike at STEREO A was delayed by 2.2 minutes from that at STEREOB. We discuss the observations in terms of a model in which the electrons, accelerated at the flare, propagate without significant scattering along magnetic field lines which separate or diverge as a function of radial distance from the Sun. The near simultaneity of the spikes at the two spacecraft is a natural consequence of this model. We interpret the divergence of the magnetic field lines as a consequence of field-line random walk and flux-tube expansion. We show that the field-line random walk in the absence of flux-tube expansion produces an rms spread of field lines significantly less than that which is required to produce to observed divergence. We find that observations of the solar wind and its source region at the time of the event can account for the observations in terms of propagation along interplanetary magnetic field-lines.

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Co-author: Dr SHEELEY, Neil (NRL)

Presenter: Dr JOKIPII, Jack (University of Arizona)

Session Classification: Early Monday Morning

Contribution ID: **12** Type: **not specified**

Review of Diffusive Shock Acceleration modeling of Solar Energetic Particle Events

Wednesday, 26 April 2017 08:30 (30 minutes)

An overview of the theoretical modeling of acceleration of solar energetic particles at interplanetary shocks will be presented. The basic tenets of diffusive shock acceleration will be discussed in the framework of particle acceleration at coronal mass ejection-driven shocks using the Particle Acceleration Throughout the Heliosphere (PATH) code. The original PATH code was restricted to a single spatial direction. Recently, Hu et al., 2017 have extended the PATH model to study particle acceleration at 2D CME-driven shocks and the subsequent 2D transport. The new model and code, now called iPATH, follows the propagation of a CME and the shock it drives in the ecliptic plane from 20 solar radii to 2 AU. Particle acceleration at the shock now depends on both the parallel and perpendicular diffusion coefficients and therefore depends on the shock-obliquity as it propagates from the Sun. We discuss the extension of the basic physics introduced in the original Zank et al., 2000 model two spatial dimensions. Basic properties of modeled time intensity profiles and particle spectra as well as particle pitch angle distributions are shown for two example CME shocks.

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Presenter: Prof. ZANK, Gary (University of Alabama in Huntsville)

Session Classification: Early Wednesday Morning

Contribution ID: **13** Type: **not specified**

Long Duration Gamma-Ray Flares & Solar Energetic Particles —Is there a Connection?

Little is known still about the origin of the high-energy and sustained emission from Long Duration Gamma-Ray Flares (LDGRFs), identified with Compton Gamma-Ray Observatory (CGRO), the Solar Maximum Mission (SMM), and now Fermi. Though Fermi/LAT has identified dozens of flares with LDGRF emission, the nature of this emission has been a challenge to explain both due to the extreme energies and long durations. The highest energy emission has generally been attributed to pion production from the interaction of high-energy protons with the ambient matter, suggesting that particle acceleration occurs over large volumes extending high in the corona, either from stochastic acceleration within large coronal loops or from back precipitation from CME-driven shocks. It is possible to test these models by making direct comparisons between the accelerated ion population at the flare derived from the observations of Fermi/LAT with PAMELA measurements of solar energetic particles in the energy range corresponding to the pion-related emission observed with Fermi. For nearly a dozen SEP events, we compare the two populations (SEPs in space and the interacting population at the Sun) and discuss the implications in terms of particle acceleration and transport models.

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Presenter: DE NOLFO, Georgia (NASA/Goddard Space Flight Center)

Contribution ID: **14** Type: **not specified**

Understanding Short-Term Modulation of Cosmic Rays

Monday, 24 April 2017 11:45 (30 minutes)

Short-term (few-day duration) modulations of the galactic cosmic ray intensity have been observed for many decades by ground-based instruments and spacecraft, and are associated with structures in the heliosphere, in particular, interplanetary coronal mass ejections (including magnetic clouds) and co-rotating interaction regions. For all of the observations, there is still no consensus on the physical cause(s) of these events which may include processes that involve changes in solar wind velocity, magnetic field strength, and turbulence. We will discuss how new data from PAMELA, which can measure modulation effects over a wide range in rigidity, may help resolve the relative importance of these various processes in CIR-associated modulations.

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Presenter: CHRISTIAN, Eric (NASA/GSFC)

Session Classification: Late Monday Morning

Contribution ID: **15** Type: **not specified**

Solar Energetic Particle Spectra Measured with PAMELA

Monday, 24 April 2017 11:15 (30 minutes)

We present updated event integrated spectra from several SEP events occurring from 2006 to 2014 in the energy range starting at 80 MeV and extending well above the neutron monitor threshold. The PAMELA instrument is in a high inclination, low Earth orbit and has access to SEPs when at high geographic latitudes. This means that the spectra have been assembled from regularly spaced measurements with gaps during the course of the event. Furthermore, the field of view of PAMELA is small and during the high latitude passes it scans a wide range of asymptotic directions as the spacecraft moves. Correcting for data gaps and solid angle effects, we have compiled event-integrated intensity spectra that typically exhibit power law shapes in energy with an exponential roll over. The events analyzed include two, maybe three, GLEs. In those cases the roll over energy lies above the neutron monitor threshold (˜1 GV) while the others are lower. We see no qualitative difference between the spectra of GLE vs. non-GLE events. One event has been studied where we separately examined the spectra during the impulsive and gradual phases of the GLE. Those results will be compared to those of the event integrated data.

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Presenter: RYAN, James (Space Science Center, University of New Hampshire, Durham, NH, United States)

Session Classification: Late Monday Morning

Contribution ID: **16** Type: **not specified**

Why are there so few solar proton events in Solar Cycle 24?

Wednesday, 26 April 2017 09:00 (30 minutes)

There have been significantly fewer large solar proton events (SPEs) in the current solar cycle (solar cycle 24) compared to the previous one. Solar proton events occur when the flux of solar-energetic particles with energies greater than 10 MeV exceeds 10 protons/(cm2 s sr) and are reported by NOAA/GOES. Such events are usually associated with shock waves driven by fast coronal mass ejections (CMEs). Using a model combining observations of CMEs and diffusive shock acceleration of energetic protons at interplanetary shocks, we determine the total integrated flux of SPEs at Earth throughout the past two solar cycles. We compare with NOAA/GOES observations of SPEs during this period. We find that the dearth of large SPEs in the current solar cycle is caused partly by there being fewer fast CMEs, and partly because the inferred diffusion coefficients of energetic particles moving in the turbulent interplanetary magnetic field is larger in solar cycle 24. This causes the particles to be accelerated more slowly; and during the time over which shocks move from the Sun to 1 AU, the slower acceleration rate results in a lower intensity of high-energy particles. The cause of the larger diffusion coefficient is the result of a significantly weaker interplanetary magnetic field magnitude this solar cycle, compared to the previous one.

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Presenter: GIACALONE, Joe (University of Arizona)

Session Classification: Early Wednesday Morning

Contribution ID: **17** Type: **not specified**

Fermi Large Area Telescope observations of high-energy gamma-ray emission from Solar Flares

Wednesday, 26 April 2017 11:45 (30 minutes)

The Fermi Large Area Telescope (LAT) observations of the active Sun provide the largest sample of detected solar flares with emission greater than 30 MeV to date. These include detections of impulsive and sustained emission, extending up to ˜20 hours in the case of the 2012 March 7 X-class flares. These high-energy flares are coincident with GOES X-ray flares of X, M and C classes as well as very fast Coronal Mass Ejections (CME). We will present results from the First Fermi-LAT solar flare catalog covering the majority of Solar Cycle 24 including correlation studies with the associated Solar Energetic Particles (SEP) and CMEs.

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Presenter: Dr PESCE-ROLLINS, Melissa (INFN-Pisa)

Session Classification: Late Wednesday Morning

Contribution ID: **18** Type: **not specified**

Current Issues in the Acceleration and Transport of Solar Energetic Particles

Monday, 24 April 2017 09:30 (30 minutes)

This presentation addresses the theory of shock acceleration as applied to gradual events (the large temporally-extended high-energy events responsible for inclement weather in space), including the basic elements of first-order Fermi and shock drift acceleration at CME-driven shocks, wave excitation (which enhances the efficiency of shock acceleration), the effect of shock obliquity, the nature of injection, and the escape of particles upstream of the shock. The spatial morphology and energy spectra of the events also depend crucially on their transport in the solar wind. Specific topics will be emphasized including the ubiquitous double-power-law fluence spectra, characteristic power-law spectral indices, wave excitation by SEPs throughout the solar wind, the high-energy rollover due to escape of accelerating particles from the ion foreshock, and the spatial distribution of the SEPs throughout the heliosphere with a "reservoir"in the inner heliosphere. Reference to the "pump mechanism"(Fisk and Gloeckler, 2014) as an alternative acceleration mechanism for these events will also be made.

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Presenter: Prof. LEE, Martin (University of New Hampshire)

Session Classification: Early Monday Morning

Contribution ID: **19** Type: **not specified**

Probabilistic Modeling of the Space Radiation Environment

Tuesday, 25 April 2017 14:00 (25 minutes)

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Design and planning for space missions must account for possible solar energetic particle events (SEPEs) during these missions. Missions account for SEPEs by designing or planning to the worst operating reference environment. It is important to choose a mission-specific environment to avoid expensive over-design of the satellite.

This discussion focuses on two new probabilistic models for choosing the design reference environment of a mission. First probabilistic model is a peak mission flux model used for mission durations ranging from 10's of minutes to several years. Second model is a SEPE episode-integrated fluence model used for mission durations ranging from a few weeks to several years. Both models use a new data set of SEPEs that utilizes a much lower threshold for SEPE identification.

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Presenter: Mr ROBINSON, Zachary (Fifth Gait Technologies, Inc.)

Session Classification: Early Tuesday Afternoon

Contribution ID: **20** Type: **not specified**

Focused Transport of Solar Energetic Particles in the Interplanetary Space and the Formation of the Anisotropic Beam-like Distribution of Particles in the Onset Phase of Large Gradual Events

In the onset phase of large gradual solar energetic particle (SEP) events, the first particles of a given rigidity to arrive at Earth are accelerated in the low corona, focused into a narrow cone of pitch angles by the diverging magnetic field, and transported from near the Sun to 1 AU with minimal scattering. The effects of focused transport on the evolution of the beam-like SEPs are investigated analytically. The model assumes for simplicity constant focusing length and constant pitch angle diffusion coefficient for SEPs at small pitch angles. Cross-field transport is neglected. The analytical approximation provides a reasonable representation of the spatial and pitch angle distribution of the beam-like SEPs. Assuming an instantaneous injection of SEPs near the Sun, the model naturally reproduces several features of the SEP onset profiles observed at 1AU including the spike-like time-intensity profiles with rapid rising and declining edges, the highly anisotropic nature characterized by a Gaussian pitch-angle distribution with a width that increases with time, and the similar shape but dispersed onset times of the time-intensity profiles due to the late arrival of SEPs of lower rigidities. The dependence of some observable features on the magnetic path length (Lp) between SEP injection and observation is examined analytically. The model predicts a peak intensity in the anisotropic phase with a rise-time (Tr) from event onset that approximately satisfies Tr~Lp^(-2) and a width (Epsilon) of the Gaussian pitch-angle distribution at the peak that approximately satisfies Epsilon~Lp^(-1/2). Assuming that the SEPs that are observed after the beam-like structure in a large SEP event are nearly isotropic and governed by diffusive transport in interplanetary space, we perform an illustrative calculation to demonstrate the possible origin of the isotropic phase following the anisotropic onset as a natural result of interplanetary transport of SEPs.

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Presenter: LI, Gen

Contribution ID: **21** Type: **not specified**

COMPARING SPACE RADIATION GCR MODELS WITH AMS DATA

Wednesday, 26 April 2017 11:15 (30 minutes)

The Alpha Magnetic Spectrometer (AMS) onboard the International Space Station has recently made high precision measurements of the hydrogen and helium spectra from an energy of several hundred MeV/n up to the very high energy TeV/n region. Recent studies of space radiation transport through realistic spacecraft shielding scenarios have emphasized the importance of high energy hydrogen and helium contributions to the radiation effective dose received by astronauts on deep space missions. The recent AMS measurements are therefore relevant to space radiation studies. A variety of galactic cosmic ray (GCR) models currently being used for space radiation studies are compared to the AMS data.

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Presenter: NORBURY, John (NASA)

Session Classification: Late Wednesday Morning

Contribution ID: **22** Type: **not specified**

Methodology of Real-Time Space Radiation Dose Estimates Using Onboard Vehicle Dosimeters

Tuesday, 25 April 2017 14:25 (25 minutes)

Radiation exposure from solar energetic particle (SEP) events becomes a much greater concern as human exploration extends beyond low Earth orbit (LEO) and the protective environment of Earth's magnetic field. Free space SEP events have an increased impact on mission planning and operations, as countermeasures may be necessary to avoid exceeding astronaut permissible exposure limits (PELs) and acute radiation syndrome (ARS). Operational analysis tools are needed to assess acute radiation effects during SEP events in order to determine courses of action during the mission. A methodology has been developed to meet this need, which utilizes onboard vehicle dosimeter measurements to estimate dose quantities at astronaut crew locations. The estimated dose quantities provide the necessary inputs to acute biological response models that predict radiation induced performance decrement (RIPD) and other acute radiation effects. The active dosimeter-based crew dose estimate methodology is presented here, which will be tested on Exploration Mission 1 (or EM-1) of the Orion spacecraft.

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Presenter: Dr MERTENS, Christopher (NASA Langley Research Center)

Session Classification: Early Tuesday Afternoon

Contribution ID: **23** Type: **not specified**

A Predictive and Analytic Model for Solar Modulation

Tuesday, 25 April 2017 16:00 (25 minutes)

Significant uncertainties in solar modulation inhibit our ability to understand the physics of interstellar cosmic-ray injection and propagation. The effect of solar modulation on the propagation of cosmic-rays from the heliopause to the Earth is extremely complex, requiring the careful treatment of diffusion, particle drift, convection and adiabatic energy losses. Particle propagation codes are becoming increasingly sophisticated to meet these challenges. However, they require significant processing power and are not well suited to scans covering the large parameter space of cosmic-ray propagation. Models seeking to constrain cosmic-ray propagation parameters have instead utilized the force-field approximation, where the effect of solar modulation is treated as a simple, charge-dependent potential which cosmic-rays must climb before reaching the Earth. However, the magnitude and time-dependence of this potential is unconstrained, significantly increasing the number of degrees of freedom in the parameter space scan.

In this talk, I will discuss an intermediate option, based on a physically motivated correlation between heliospheric propagation parameters and solar observables. This allows us to construct a time-, charge-, and rigidity-dependent model for the solar potential that is analytic, and can be quickly applied to a wide parameter space of particle propagation models. Moreover, this model is predictive, as the only inputs relate to observable solar parameters such as the strength of the solar magnetic field at Earth, and the tilt of the heliospheric current sheet. Thus, this model significantly reduces the systematic uncertainty in models of interstellar cosmic-ray propagation. Finally I will discuss the implications of these models for our understanding of the rising cosmic-ray positron fraction, as well as an intriguing hardening in the antiproton spectrum recently observed by AMS-02.

Primary authors: LINDEN, Tim; CHOLIS, Ilias (Fermi National Accelerator Laboratory); HOOPER, dan

Presenter: LINDEN, Tim

Session Classification: Late Tuesday Afternoon

Contribution ID: **24** Type: **not specified**

Neutron monitors for solar modulation studies: phi time series

Wednesday, 26 April 2017 15:15 (25 minutes)

The level of solar modulation phi at different times (related to the solar activity) is a central question of solar and galactic cosmic-ray physics. We detail a procedure to obtain a reference time series from neutron monitor data. We obtain an unbiased and accurate reconstruction at a precision of 10%. Reconstructed time series from the 50's are compared to the previous time-series of Usoskin et al., and to phi values extracted from direct CR flux experiments. An on-line application is available at http://lpsc.in2p3.fr/crdb to retrieve phi values from any period.

Primary author: Mr MAURIN, David Alain (Centre National de la Recherche Scientifique (FR))

Presenter: Mr MAURIN, David Alain (Centre National de la Recherche Scientifique (FR))

Session Classification: Early Wednesday Afternoon

Contribution ID: **25** Type: **not specified**

EPAMELA observations of solar modulation effects in cosmic ray protons and helium nuclei

Monday, 24 April 2017 14:00 (25 minutes)

The satellite-borne experiment PAMELA (A Payload for Antimatter-Matter Exploration and Light-nuclei Astrophysics) has been continuously collecting data since June 15th of 2006, when it was launched from the Baikonur cosmodrome. Its main scientific goal is the detection of the charged component of the cosmic radiation over a wide energy range and with high precision. The apparatus design is well suited for the particle and antiparticle identification and optimized for searching antimatter. Moreover, thanks to the satellite quasi-polar orbit, a low rigidity threshold of about 400 MV for protons and about 800 MV/n for Helium is achieved. This makes the instrument also well suited for the investigation of phenomena related to galactic cosmic ray modulation by the Sun in the inner heliosphere. We present hereby data for light hadrons, namely protons and Helium nuclei, collected between 2006 and 2015, during both the 23rd and 24th solar cycles. The time and rigidity dependence of galactic cosmic ray intensities are presented.

Primary authors: MARTUCCI, Matteo (INFN-Laboratori Nazionali di Frascati); BOEZIO, Mirko (Universita e INFN (IT)); DI FELICE, Valeria (Italian Space Agency ASI); MUNINI, Riccardo (INFN - Universita Studi Trieste); POTGIETER, Marius (North West University, South Africa); Mr RAATH, Jan-Louis (North-West University); MARCELLI, Nadir (University of Roma Tor Vergata)

Presenter: MARTUCCI, Matteo (INFN-Laboratori Nazionali di Frascati)

Session Classification: Early Monday Afternoon

Contribution ID: **26** Type: **not specified**

What Governs the Longitudinal Spread of Solar Energetic Particles?

Monday, 24 April 2017 10:45 (30 minutes)

The launch of the STEREO spacecraft has ushered in a new era of studying solar energetic particle (SEP) events from multiple vantage points simultaneously. Surprising results, such as 3He-rich SEP events extending over 100 degrees in longitude and 25 MeV protons being detected over 360 degrees within 30 minutes of the start of an SEP event, have challenged our understanding of the transport of SEPs through the inner heliosphere. In an effort to study the roles energy and rigidity play in the longitudinal spread of SEPs, we have examined >40 multi-spacecraft events with measureable 10 MeV/nuc oxygen intensities. We fit the observed fluences of H, He, O, and Fe as a function of the spacecraft magnetic footpoint separation from the solar source to obtain centers and widths of the distributions. We find no substantial organization with the elements' charge-to-mass ratios, but some dependence on particle energy. These results will be discussed along with their implications for the dominant mechanism(s) for the longitudinal distribution of SEPs.

Primary authors: COHEN, C. M. S. (Caltech); MASON, G.M. (JHUAPL); MEWALDT, R.A. (Caltech)

Presenter: COHEN, C. M. S. (Caltech)

Session Classification: Late Monday Morning

Contribution ID: **27** Type: **not specified**

How Electron Beams Drives Cyclic Langmuir Collapse and Coherent Radio Emission

Wednesday, 26 April 2017 14:25 (25 minutes)

Electron beams accelerated by solar flares and nanoflares are believed to be responsible for several types of solar radio bursts observed in the corona and interplanetary medium, including flare-associated coronal Type U and J and interplanetary Type III radio bursts, and nanoflare-associated weak coronal type III bursts. The characteristic of these radio bursts is their frequency is consistent with the local electron plasma frequency. However, how electron two-stream instability driven by electron beams produces coherent emission with a duration of several orders of magnitude longer than the linear saturation time is a long-standing puzzle. Recently Che, Goldstein,Diamond and Sagdeev proposed that continuous plasma coherent emission is maintained by repetitive Langmuir collapse. The study of coherent radio emission provides a powerful tool to probe the plasma environment of solar corona and the mechanism of acceleration and energetic particle propagation.I will present this mechanism and the new features that can be observed by spacecrafts and ground based telescope.

Primary author: Dr CHE, Haihong (UMCP/GSFC)

Co-authors: Prof. DIAMOND, Patrick; Prof. SAGDEEV, Roald (UMCP); Dr GOLDSTEIN, Melvyn

Presenter: Dr CHE, Haihong (UMCP/GSFC)

Session Classification: Early Wednesday Afternoon

Contribution ID: **28** Type: **not specified**

Observations of solar particle events with the PAMELA mission

Monday, 24 April 2017 14:50 (25 minutes)

The PAMELA satellite experiment, in low Earth orbit since June 2006, is providing comprehensive observations of the Solar Energetic Particle (SEP) events between solar cycles 23 and 24. Its unique capabilities include the possibility of accurately measuring the SEP energetic spectra in a large interval (>80 MeV), encompassing the low energy data by other space-based instruments and the Ground Level Enhancement (GLE) data by the worldwide network of neutron monitors. Furthermore, PAMELA is able to measure the flux angular distribution and thus investigate possible anisotropies. The analysis is supported by back-tracing techniques based on a realistic modeling of the terrestrial magnetosphere, which enables to reconstruct the asymptotic pitch-angle distribution of SEPs with respect to the local interplanetary magnetic field. PAMELA results significantly enhance the characterization of SEP fluxes in the near-Earth space, constraining the scenarios for particle acceleration and transport mechanisms.

Primary authors: Dr BRUNO, Alessandro (INFN sezione di Bari); Dr BOEZIO, Mirko (INFN sezione di Trieste); CHRISTIAN, Eric R. (NASA/GSFC); DE NOLFO, Georgia A. (NASA/GSFC); MARTUCCI, Matteo (Università di Roma Tor Vergata); RYAN, James M. (Space Science Center, University of New Hampshire, Durham, NH, United States)

Presenter: Dr BRUNO, Alessandro (INFN sezione di Bari)

Session Classification: Early Monday Afternoon

Contribution ID: **29** Type: **not specified**

Is There a Relationship Between Asymmetries in Solar Particle Events, Dimming Regions and CME propagation directions?

Studies of the longitudinal distribution of solar energetic particles generally use the location of the related solar flare as a reference longitude. In particular, particle intensities are typically found to fall off with increasing "connection angle"–the longitudinal separation between the flare and the footpoint of the field line passing the observing spacecraft –and are often fitted by Gaussians in connection angle. Although the peak of the Gaussian is often close to zero connection angle, i.e., on field lines connecting close to the flare longitude, some ˜25 MeV proton events observed by both STEREO spacecraft and at the Earth show clear asymmetries, either to the east or west, relative to the flare longitude, in their early stages. There are various possible reasons for such asymmetries, one being that the flare longitude may not represent the expansion direction of the coronal mass ejection and associated shock, which may accelerate the particles. We examine this possible cause for the asymmetry by comparing the longitudinal offsets relative to the flare of the connection angle of the SEP peak, the centroid of the dimming region below the related CME, and the CME propagation direction inferred using a compound geometric model which fits an ellipsoid shape to multi-spacecraft observations of the shock front, for ˜40 "three-spacecraft"proton events.

Primary authors: RICHARDSON, Ian (University of Maryland); THOMPSON, Barbara (NASA/GSFC); KWON, Ryun-Young (Applied Physics Laboratory/George Mason University); VON ROSENVINGE, Tycho

Presenter: RICHARDSON, Ian (University of Maryland)

Contribution ID: **30** Type: **not specified**

Charge-sign dependent solar modulation as observed by the PAMELA experiment

Monday, 24 April 2017 14:25 (25 minutes)

The satellite-borne PAMELA experiment was launched on the 15th June 2006 from the Baikonur cosmodrome. Till January 2016 PAMELA has detected the charged component of cosmic-rays over a wide energy range measuring both particles and antiparticles. In particular, as a result of its highly inclined orbit, the instrument samples low geomagnetic cut-off regions and can explore in detail the low energy range of the galactic cosmic ray spectrum, where heliospheric effects are relevant. During about ten years of observation, solar modulation of positively and negatively charged particles has been observed under different solar activity conditions: from the whole A<0 solar minimum of cycle 23/24, through the polarity reversal of the heliospheric magnetic field, to the solar maximum of solar cycle 24. Observations of time-dependent electron and positron spectra will be presented. The study of their different response to the solar activity variations can provide useful information about the charge-sign dependent effects.

Primary authors: Dr MUNINI, Riccardo (INFN - Universita Studi Trieste); BOEZIO, Mirko (INFN, Trieste (IT)); DI FELICE, Valeria (Italian Space Agency ASI); POTGIETER, Marius (North West University, South Africa); Mr RAATH, Jan-Louis (North-West University)

Co-author: PAMELA COLLABORATION

Presenter: Dr MUNINI, Riccardo (INFN - Universita Studi Trieste)

Session Classification: Early Monday Afternoon

Contribution ID: **31** Type: **not specified**

Cosmic Ray Modulation Observed by the Princess Sirindhorn Neutron Monitor at High Rigidity Cutoff

Wednesday, 26 April 2017 16:00 (25 minutes)

Neutron monitors (NMs) are the premier instruments for precisely tracking time variations in the Galactic cosmic ray (GCR) flux at the GV-range. The worldwide NM network has provided continuous measurements of the solar induced variations of the GCR flux impinging Earth and the data cover about six 11-year solar cycles. The recent rise of space exploration, with PAMELA and AMS-02 spacecraft, brings new energy sensitive measurements of GCR fluxes. Moreover since late 2007, the range of sensitivity of the worldwide NM network has been increased with the installation of the Princess Sirindhorn Neutron Monitor (PSNM), at the summit of Doi Inthanon, Thailand. PSNM records the GCR flux with the world's highest vertical rigidity cutoff for a fixed station, 16.8 GV. PSNM data now cover the last solar minimum and maximum, and the last solar magnetic polarity reversal. This gives us the opportunity to study the solar modulation and its polarity dependence at such high rigidity for the first time. We present here the observations of PSNM. We compare measurements with those from NMs located at low rigidity cutoff. The solar modulations at high and low rigidity cutoff are linearly related during the periods of low solar activity. The observed dependence on the solar magnetic polarity is in agreement with previous measurements and is not predicted by the force field model. Observations are consistent with a crossover in spectra measured around the polarity reversal. During the negative polarity, the solar modulation is partially but not fully explained by the tilt angle as expected by the drift explanation.

Primary authors: Dr MANGEARD, Pierre-Simon (University of Delaware); CLEM, John (University of Delaware); EVENSON, Paul (University of Delaware); PYLE, Roger (Pyle Consulting Group, Inc.); MITTHUMSIRI, Warit; RUFFOLO, David (Mahidol University); SAIZ, Alejandro (Mahidol University); Dr NUTARO, Tanin (Ubon Ratchathani University)

Presenter: Dr MANGEARD, Pierre-Simon (University of Delaware)

Session Classification: Late Wednesday Afternoon

Contribution ID: **32** Type: **not specified**

Dosimetry for a Deep-Space (Mars) Mission using Recent Measurements from RAD on the Mars Science Laboratory

Tuesday, 25 April 2017 09:00 (30 minutes)

The space radiation environment is one of the outstanding challenges of a manned deep-space mission to Mars. To improve our understanding and take us one step closer to enabling a human Mars to mission, the Radiation Assessment Detector (RAD) on the Mars Science Laboratory (MSL) has been characterizing the radiation environment, both during cruise and on the surface of Mars for the past 4 years.

Perhaps the most significant difference between space radiation and radiation exposures from terrestrial exposures is that space radiation includes a significant component of heavy ions from Galactic Cosmic Rays (GCRs). Acute exposures from Solar Energetic Particles (SEPs) are possible during and around solar maximum, but the energies from SEPs are generally lower and more easily shielded. Thus the greater concern for long duration deep-space missions is the GCR exposure.

In this presentation, I will review the MSL RAD observations and discuss current approaches to radiation risk estimation used by NASA and other space agencies.

Primary authors: HASSLER, Donald M. (Southwest Research Institute); ZEITLIN, Cary (Southwest Research Institute); WIMMER-SCHWEINGRUBER, Robert F. (Southwest Research Institute); MSL RAD SCIENCE TEAM

Presenter: HASSLER, Donald M. (Southwest Research Institute)

Session Classification: Early Tuesday Morning

Contribution ID: **33** Type: **not specified**

Neutron-Decay Protons from Solar Flares as Seed Particles for CME-Shock Acceleration in the Inner Heliosphere

The protons in large solar energetic particle events are accelerated in the inner heliosphere by fast shocks produced by coronal mass ejections. Unless there are other sources, the protons these shocks act upon would be the solar wind. The efficiency of the acceleration depends on the kinetic energy of the protons. For 1 - 2 thousand km/s shocks, the most effective proton energies would be 10 - 50 keV; i.e, within the suprathermal tail component of the solar wind. We investigate one possible additional source of such protons: those resulting from the decay of solar-flare-produced neutrons that escape from the Sun into the low corona. The neutrons are produced by interactions of flare-accelerated ions with the solar atmosphere. We discuss the production of low-energy neutrons in flares and their decay along a Parker-spiral field line near the Sun. We find that, even when the flaring conditions are optimal, the 10 - 50 keV neutron-decay proton density produced by even a very large solar flare would amount to less than 1% of that of the 10 - 50 keV solar-wind suprathermal tail. We discuss the implication for a seed particle source of more-frequent, small flares.

Primary authors: Dr MURPHY, Ronald (Naval Research Laboratory); Dr KO, Yuan-Kuen (Naval Research Laboratory); Dr NG, Chee (Retired, GMU); Dr TYLKA, Allan (Emeritus, NASA/GSFC)

Presenter: Dr MURPHY, Ronald (Naval Research Laboratory)

Session Classification: Late Monday Afternoon

Contribution ID: **34** Type: **not specified**

The GeV-TeV Sun

Tuesday, 25 April 2017 15:15 (25 minutes)

The Sun does not shine at GeV-TeV energies on its own power, but because Galactic cosmic rays (CR) interact with its matter and light. By observing and modeling these interactions in and near the Sun, one may learn about CR propagation in the inner heliosphere and in the solar atmosphere. In this talk, I will present observations and a set of ongoing calculations that sharpen our understanding of how the Sun interacts with CR. From data taken with Fermi-LAT, I will show that the Sun is a luminous source of gamma rays up to at least 100 GeV, with time variability up to at least 10 GeV that anti-correlates with the solar activity cycle. I will show how this result compares with theoretical models (spoiler alert: badly), and show how observations from ground-based gamma-ray telescopes (HAWC, LHAASO) can tighten constraints on the most uncertain parts of the theory calculation related to CR propagation. I will show that neutrinos from the same CR-Sun interactions are a complementary probe of CR propagation, and highlight the prospects for IceCube and future neutrino experiments to detect this exciting new astrophysical signal.

Primary author: Prof. PETER, Annika (The Ohio State University)

Co-authors: Mr NG, Kenny (Weizmann Institute); Prof. BEACOM, John (The Ohio State University); Mr ZHOU, Bei (The Ohio State University); Prof. ROTT, Carsten (Sungkyunkwan University); Dr TANG, Qingwen (The Ohio State University)

Presenter: Prof. PETER, Annika (The Ohio State University)

Session Classification: Early Tuesday Afternoon

Contribution ID: **35** Type: **not specified**

Global Energetics of Solar Particle Events

In a solar event, energy is released in many forms such flare emissions (X-rays, gamma-rays radio, thermal), kinetic and potential energy in coronal mass ejections and other mass motions, and energetic particles. The global energetics of 38 large solar events were discussed by Emslie et al. (2012; doi: 10.1088/0004-637X/759/1/71). However, additional insight may be obtained by incorporating multi-point observations from STEREO, and improved solar observations from SDO, motivations for a new study of global energetics focusing on 398 M and X class flares in June, 2010 to January, 2014 (Aschwanden et al., 2017; doi: 10.3847/1538-4357/836/1/17). We discuss efforts to estimate the global energy content of the solar energetic particles (protons, heavy ions and electrons), if detected, associated with these flares for this study, focusing on the subset of particle events observed at both STEREO spacecraft and near the Earth. For these events, we estimate that the SEP total energy is a few percent of the energy of the associated coronal mass ejection.

Primary authors: Dr RICHARDSON, Ian (University of Maryland); MEWALDT, Richard (Caltech); COHEN, Christina (Caltech); DESAI, Mihir (SwRI); LARIO, david (JHU/APL); MASON, Glenn (JHU/APL); HO, George (JHU/APL)

Presenter: Dr RICHARDSON, Ian (University of Maryland)

Contribution ID: **36** Type: **not specified**

Response Functions of South Pole Neutron Monitors

Wednesday, 26 April 2017 14:50 (25 minutes)

The South Pole is an ideal location for the detecting solar energetic particles because of its low geomagnetic cutoff and high altitude. Neutron Monitors have operated at the South Pole for many decades, and they are able to distinguish between Solar and Galactic cosmic ray variations. They are excellent devices for observing space weather. Physicists at the University of Wisconsin-River Falls, a small undergraduate, liberal arts university, recently assumed a leadership role in the operation and maintenance of the South Pole monitors. To undertake a complementary analysis of neutron monitor data with data from other cosmic ray experiments at the South Pole, an updated Monte Carlo simulation is needed, one that includes not only the monitors, but which also includes the environment like snow cover and buildings. We have written a new simulation using Fluka, which includes the monitors and some of the structures at the Pole. We present the first results for the response functions of the South Pole neutron monitors from the new simulation.

Primary authors: Dr SEUNARINE, Suruj (University of Wisconsin-River Falls); Mr AHLSWEDE, Mitchell (University of Wisconsin-River Falls); Dr NUNTIYAKUL, Waraporn (Chandrakasem Rajabhat University, Thailand); Prof. MADSEN, James (University of Wisconsin-River Falls)

Presenter: Dr SEUNARINE, Suruj (University of Wisconsin-River Falls)

Session Classification: Early Wednesday Afternoon

Contribution ID: **37** Type: **not specified**

Solar Particle Event Protection Requirements for Exploration Habitats

Tuesday, 25 April 2017 09:45 (30 minutes)

Under the Next Space Technologies for Exploration Partnerships (NextSTEP), NASA is collaborating with six companies to design, develop, and test habitat concepts for human missions beyond low Earth orbit. A method for protecting astronauts from the harmful effects of Solar Particle Events (SPEs) must be incorporated into these habitats. This radiation protection may take the form of a heavily shielded area within the habitat in which the astronauts can wait out a storm, a deployable shelter that can be set-up when a solar storm begins, or a shielding garment that can be donned at the onset of a storm. In anticipation of the NextSTEP design efforts, a set of SPE protection requirements has been developed and is currently being vetted. These new requirements include an exposure limit and a design basis SPE spectrum to be used in evaluating astronaut exposure. The proposed requirements will be presented and the relationship of these requirements to existing Permissible Exposure Limits (PELs) will be discussed.

Primary authors: CLOWDSLEY, Martha (NASA Langley Research Center); SEMONES, Edward (NASA)

Presenter: CLOWDSLEY, Martha (NASA Langley Research Center)

Session Classification: Early Tuesday Morning

Contribution ID: **38** Type: **not specified**

Ion Acceleration via Magnetic Reconnection

Monday, 24 April 2017 16:50 (25 minutes)

Magnetic reconnection is an important driver of energetic particles in a variety of astrophysical phenomena, and may play a key role role in pre-heating and accelerating Solar Energetic Particles during events. Recently, we developed a guiding-center model that successfully described the fundamental electron energization mechanisms that operate during reconnection. The most efficient mechanism was a first-order Fermi process driven by field-line contraction inside magnetic islands.

We present an extension of this model to treat proton energization. The out-of-plane 'guide field' plays an important role, controlling the energization efficiency of Fermi-type acceleration relative to heating via parallel electric fields. We examine the roles of parallel electric fields and a 'slingshot' mechanism in pre-heating ions. We discuss limitations of the model, which does not capture non-adiabatic processes such as ion pick-up in the reconnection exhaust.

Primary author: Dr DAHLIN, Joel (NASA GSFC)

Co-authors: Prof. DRAKE, James (University of Maryland); Dr SWISDAK, Marc (University of Maryland)

Presenter: Dr DAHLIN, Joel (NASA GSFC)

Session Classification: Late Monday Afternoon

Contribution ID: **39** Type: **not specified**

High-energy Particle Acceleration at Coronal Shocks: the Effect of Large-scale Streamer-like Magnetic Field Structures

Monday, 24 April 2017 16:25 (25 minutes)

Large gradual solar energetic particle (SEP) events are of particular importance because of their hazardous threats to astronauts and equipment in space. Although there are compelling observational evidence supporting the scenario of particle acceleration at strong shocks driven by coronal mass ejections, it is not clear how those high-energy particles are accelerated and what the determining factors are in producing extremely large events. Recent observations have shown that in extreme large SEP events the CME-shocks develop and accelerate particles at heights very close to the Sun (<3 solar radii). Motivated by this, we present an SEP acceleration study including the process that a strong shock propagates through a streamer-like magnetic field in the low corona region. Particle acceleration is modeled by numerically solving the Parker transport equation with both spatial diffusion along and across the magnetic field. We show that particles can be sufficiently accelerated to up to a few hundred MeV within a few solar radii. In the streamer-like field case, particles are more efficiently accelerated compared to the case with a simple radial magnetic field. This suggests that the coronal magnetic field configuration is an important factor for producing large SEP events. We also discuss the distribution of particles as they propagate in the shock region with changing magnetic field geometry at the shock front, which may offer predictions of energetic particles that Solar Probe Plus can test.

Primary authors: Dr GUO, Fan (Los Alamos National Laboratory); KONG, Xiangliang (Shandong University); GIACALONE, Joe (University of Arizona); LI, Hui (Los Alamos National Laboratory)

Presenter: Dr GUO, Fan (Los Alamos National Laboratory)

Session Classification: Late Monday Afternoon

Contribution ID: **40** Type: **not specified**

Solar Energetic Particle Events Observed at Widely Separate Heliographic Longitudes

Wednesday, 26 April 2017 09:30 (30 minutes)

During solar cycle 24, thanks largely to the Solar Terrestrial Relations Observatory (STEREO), many solar energetic particle (SEP) events have been observed at widely separate heliographic longitudes, even including impulsive events. The particle intensity profiles sometimes show rather quick onsets after the solar event even if the measurements are made at a longitude generally considered to be poorly connected to the source region. Furthermore, we seldom find more than one eruption that could account for the observations of particles at separate locations. It is found that many of these wide-longitude SEP events accompany wave-like, large-scale coronal propagating fronts in Extreme-ultraviolet (EUV) images, usually referred to as EUV waves. They may represent the lower part of coronal shock waves at the coronal base, which are driven by fast coronal mass ejections (CMEs). In recent years, sophisticated geometrical models have been developed that integrate EUV waves into coronal shocks in 3D. Using such models, it has been shown that the estimated SEP release time is consistent with the time when the CME-driven shock wave comes into contact with the field line that is connected to the observer. However, many wide-longitude SEP events, observed at more than one heliographic longitude, do not appear to be explained in this scheme. In particular, we may need cross field diffusion when the SEP onset is slow and late. We discuss the uncertainties in interpreting existing data that prevent us from clearly understanding the temporal and spatial behaviors of SEP events during the onset phase.

Primary author: NITTA, Nariaki (Lockheed Martin Advanced Technology Cente)

Co-authors: JIAN, Lan (University of Maryland, NASA/GSFC); GÓMEZ-HERRERO, Raúl (University of Alcalá)

Presenter: NITTA, Nariaki (Lockheed Martin Advanced Technology Cente)

Session Classification: Early Wednesday Morning

Contribution ID: **41** Type: **not specified**

Introduction

Monday, 24 April 2017 08:45 (15 minutes)

Introduction to the workshop from Veronica Bindi

Session Classification: Early Monday Morning

Contribution ID: **42** Type: **not specified**

Human Space Exploration

Tuesday, 25 April 2017 08:30 (30 minutes)

by William H. Gerstenmaier

Session Classification: Early Tuesday Morning

Contribution ID: **43** Type: **not specified**

Edward Semones

Tuesday, 25 April 2017 09:30 (15 minutes)

Session Classification: Early Tuesday Morning

Contribution ID: **44** Type: **not specified**

The Influence of short timescale solar activity on the proton flux measured by AMS: Solar Energetic Particles and Furbush Decreases

Primary author: WHITMAN, Katie (University of Hawaii at Manoa)

Presenter: WHITMAN, Katie (University of Hawaii at Manoa)

Session Classification: Late Tuesday Morning

Contribution ID: **45** Type: **not specified**

Solar Energetic Particles Measured by AMS

Solar energetic particles (SEPs) with energies of about a few hundred MeV and above are not well studied. AMS was installed on the ISS on May 19, 2011, during the ascending phase of the solar cycle; it will take measurements until the end of ISS operations, covering solar cycle 24 and beyond. It is the largest experiment capable of studying these particles directly. In its first five years of operation, AMS has measured numerous SEP events associated with M-and X-class flares with associated fast coronal mass ejections. These observations, with high particle statistics and resolution, can be used to constrain models of SEP acceleration and propagation. Selected SEP events measured by AMS will be presented.

Primary author: POPKOW, Alexis (University of Hawaii at Manoa)

Co-authors: LIGHT, Christopher (University of Hawaii at Manoa); CORTI, Claudio (University of Hawai'i at Manoa (US)); CONSOLANDI, Cristina (University of Hawai'i at Manoa (US)); WHITMAN, Kathryn (University of Hawai'i at Manoa (US)); PALERMO, Matteo (University of Hawai'i at Manoa (US)); BINDI, Veronica (University of Hawai'i at Manoa (US))

Presenter: POPKOW, Alexis (University of Hawaii at Manoa)

Contribution ID: **46** Type: **not specified**

Numerical Simulation of Cosmic Ray Protons Over Time Measured by AMS-02

Tuesday, 25 April 2017 16:25 (25 minutes)

The AMS-02 experiment on board the International Space Station measured with unprecedented accuracy the time variation of the cosmic ray proton and helium flux between May 2011 and May 2016 in the rigidity range from 1 to 100 GV. A comprehensive 3D steady-state numerical model is used to solve the Parker's transport equation and to reproduce the monthly fluxes observed by AMS-02. The limitations of this approach in describing the heliosphere during the maximum of solar activity are discussed.

Primary author: CORTI, Claudio (University of Hawai'i at Manoa (US))

Co-authors: BINDI, Veronica (University of Hawai'i at Manoa (US)); CONSOLANDI, Cristina (University of Hawai'i at Manoa (US)); Mr LIGHT, Christopher (University of Hawaii at Manoa); Dr PALERMO, Matteo (University of Hawaii at Manoa); Dr POPKOW, Alexis (University of Hawaii at Manoa); WHITMAN, Kathryn (University of Hawai'i at Manoa (US))

Presenter: CORTI, Claudio (University of Hawai'i at Manoa (US))

Session Classification: Late Tuesday Afternoon

Contribution ID: **47** Type: **not specified**

Open Discussion

Wednesday, 26 April 2017 16:25 (50 minutes)

Open Discussion & Meeting Adjourned

Session Classification: Late Wednesday Afternoon

Contribution ID: **48** Type: **not specified**

Forbush decreases measured by the Alpha Magnetic Spectrometer on the International Space Station

The Alpha Magnetic Spectrometer (AMS) was installed on the International Space Station in May 2011. During the first 5 years of operations, AMS observed several fast depletions of the galactic cosmic ray (GCR) flux followed by a recovery period. These phenomena are called Forbush decreases (FDs) and are temporary decreases in GCR flux due to heliospheric disturbances. Thanks to its large acceptance and particle detection capabilities, AMS precisely measures the time evolution of FDs at different rigidities and for different particle species. Data of this kind is completely new to the study of Forbush decreases.

Primary author: LIGHT, Christopher (University of Hawaii)

Co-authors: BINDI, Veronica (University of Hawai'i at Manoa (US)); CONSOLANDI, Cristina (University of Hawai'i at Manoa (US)); CORTI, Claudio (University of Hawai'i at Manoa (US)); Dr PALERMO, Matteo (University of Hawaii); Dr POPKOW, Alexis (University of Hawaii); WHITMAN, Kathryn (University of Hawai'i at Manoa (US))

Presenter: LIGHT, Christopher (University of Hawaii)

Contribution ID: **49** Type: **not specified**

Solar Modulation Effect and Short Term Solar Activity with AMS

Tuesday, 25 April 2017 11:15 (30 minutes)

The Alpha Magnetic Spectrometer (AMS), on the International Space Station (ISS) since May 2011, has acquired the largest number of particles ever measured in space by a single experiment, performing the most precise measurement of galactic cosmic rays (GCR) to-date. For the first time we present the detailed time variation of multiple particle species fluxes measured in the first five years of operations, during the ascending phase of solar cycle 24 and reversal of the Sun's magnetic field polarity (from negative A < 0 to positive A > 0).
For all particles, the high energy spectrum remains stable versus time, while the low-energy range is strongly modulated by the solar activity that recently reached its maximum.
In addition, the detailed fluxes behavior show sub-structures immersed in the long term modulation which are related to the strongest solar events, i.e. coronal mass ejections and Forbush decreases. Modulation charge sign effects and multiple particle comparison will be shown. Solar energetic particle fluxes related the some of the strongest solar events of solar cycle 24 will be also presented.

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Session Classification: Late Tuesday Morning

Contribution ID: **50** Type: **not specified**

The influence of short timescale solar activity on the proton flux measured by AMS: Solar energetic particles and Forbush decreases

Tuesday, 25 April 2017 11:45 (30 minutes)

During the first 5 years of operations on board of the International Space Station, from May 2011 to May 2016, AMS has detected many short-term increases in the proton flux due to solar energetic particle (SEP) events and many sudden suppressions of the galactic cosmic ray (GCR) flux, called Forbush decreases (FD). AMS is able to measure the most energetic SEPs and has observed 27 SEP events associated with M- and X-class flares and fast coronal mass ejections (CME) with rigidities near to and above 1 GV. FDs associated with interplanetary CMEs and corotating interaction regions are observed and AMS can study their behavior with rigidity. Selected examples of each type of event will be presented.

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Session Classification: Late Tuesday Morning

Contribution ID: **51** Type: **not specified**

The latest results from the AMS experiment of the International Space Station

Tuesday, 25 April 2017 10:45 (30 minutes)

The Alpha Magnetic Spectrometer (AMS) is a general-purpose high-energy particle physics detector. It was installed on the International Space Station (ISS) in May 2011 to conduct a unique long-duration mission of fundamental physics research in space. AMS has acquired the largest number of particles ever measured in space by a single experiment, performing the most precise measurement of galactic cosmic rays (GCR) to-date. An overview of the latest results from AMS will be presented.

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Contribution ID: **52** Type: **not specified**

Solar Modulation of the Local Interstellar Spectrum with Voyager 1, AMS-02, PAMELA and BESS

In recent years, the increasing precision of direct cosmic rays measurements opened the door to high-sensitivity indirect searches of dark matter and to more accurate predictions for radiation doses received by astronauts and electronics in space. The key ingredients in the study of these phenomena are the knowledge of the local interstellar spectrum (LIS) of galactic cosmic rays and the understanding of how the solar modulation affects the LIS inside the heliosphere.
Voyager 1, AMS-02, PAMELA and BESS measurements of proton and helium fluxes provide valuable information, allowing us to shed light on the shape of the LIS and the details of the solar modulation during solar cycles 22-24.
A new parametrization of the LIS is presented, based on the latest data from Voyager 1 and AMS-02. Using the framework of the force-field approximation, the solar modulation parameter is extracted from the time-dependent fluxes measured by PAMELA and BESS. A modified version of the force-field approximation with a rigidity-dependent modulation parameter is introduced, yielding better fits than the force-field approximation. The results are compared with the modulation parameter inferred by neutron monitors.

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