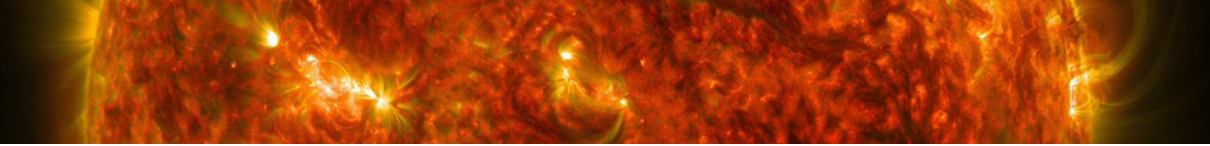

Rapporteur talk: Solar and Heliospheric (SH) Physics

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ICRC, virtual via Berlin, 2021

NWU®

Introduction

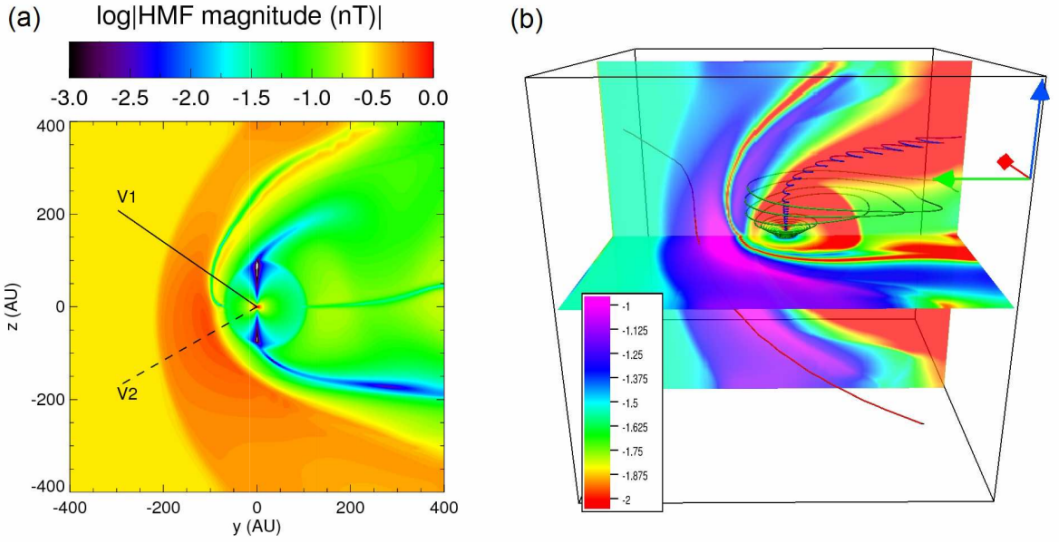
– SH contributions consisted of 2 review talks, 3 highlight talks, and 118 contributions over the forum and different discussion sessions.

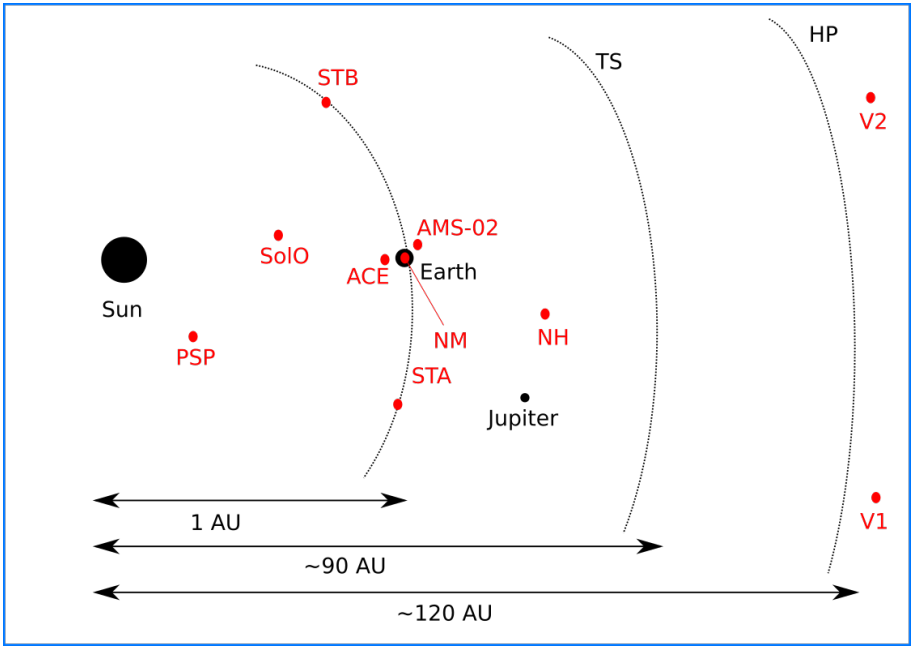
– I hope I do these excellent presentations justice and apologize for not being able to showcase all the work!

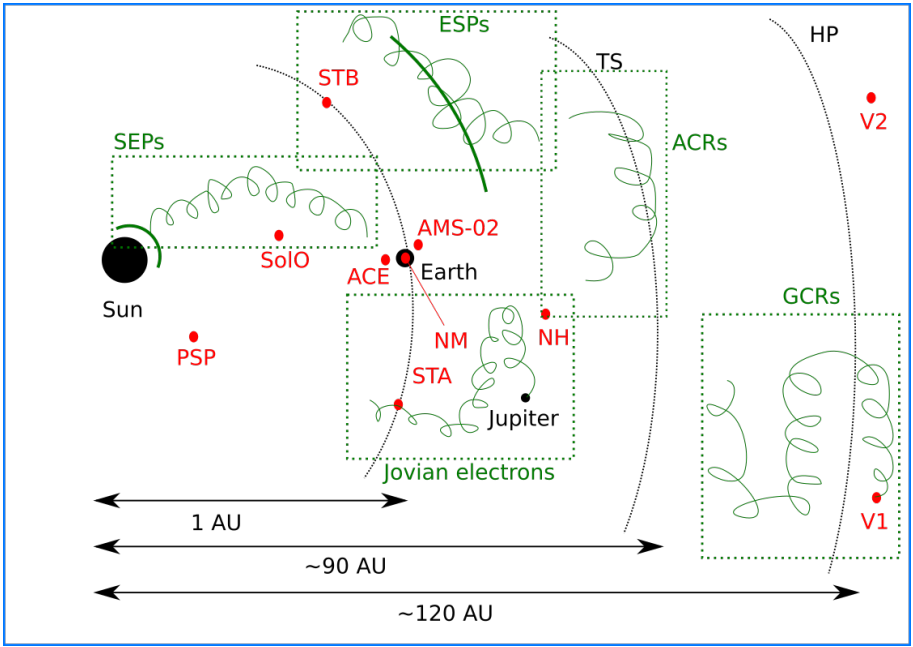
– In this talk I will NOT discuss any of the plenary presentations, but focus on contributions, and especially dicussion sessions.

– But first, an overview of the heliosphere....

MHD simulation of the heliosphere (Strauss et al., 2012).




HP
TS
STB
V2
AMS-02
SolO
ACE
Earth
Sun
NM
NH
PSP
STA
Jupiter
V1
1 AU
~90 AU
~120 AU


ESPs
STB
TS
HP
V2
SEPs
ACRs
AMS-02
SolO
ACE
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Sun
GCRs
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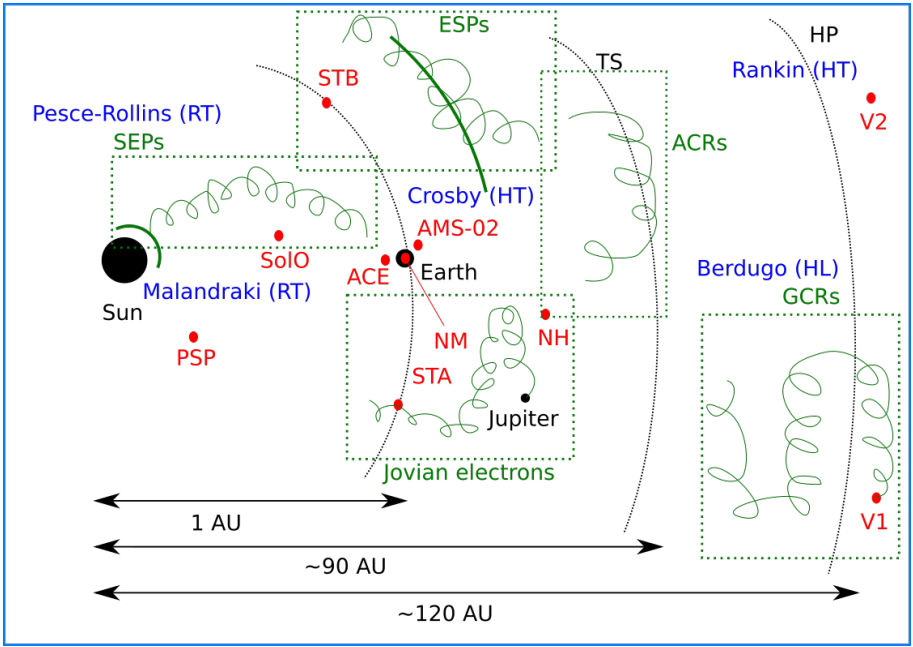
Jupiter
Jovian electrons
1 AU
~90 AU
V1
~120 AU


ESPs
STB
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HP
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ACRs
Crosby (HT)
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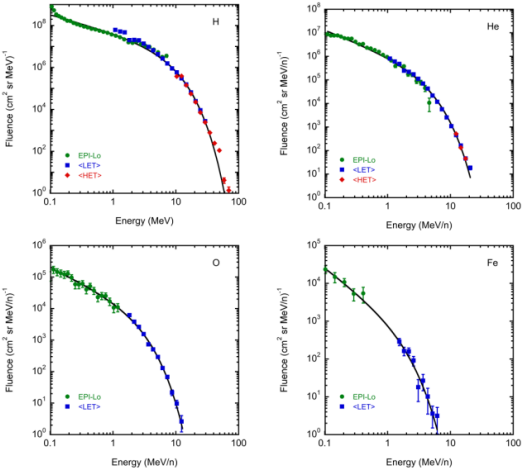
Earth
Berdugo (HL)
GCRs
Malandraki (RT)
Sun
NM
NH
PSP
STA
Jupiter
Jovian electrons
V1
1 AU
~90 AU
~120 AU

Discussion session #19: SEP acceleration and transport

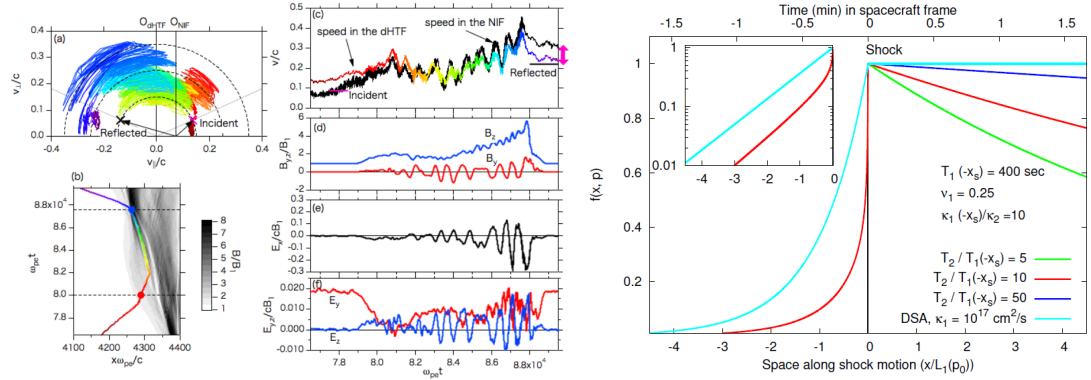
Conveners: Silvia Dalla & Eric Christian

New data from new missions!



Data presented by Cohen [816].

Acceleration of energetic particles: What processes are involved?



Figures from Otsuka [744; left] and Fraschetti [1293; right].

Candidates are magnetic reconnection in solar flares and shock acceleration by coronal mass ejection driven shocks. Relative role of each process is still debate – this may depend on each event and may be masked by transport effects.

Transport of energetic particles: What processes are involved?

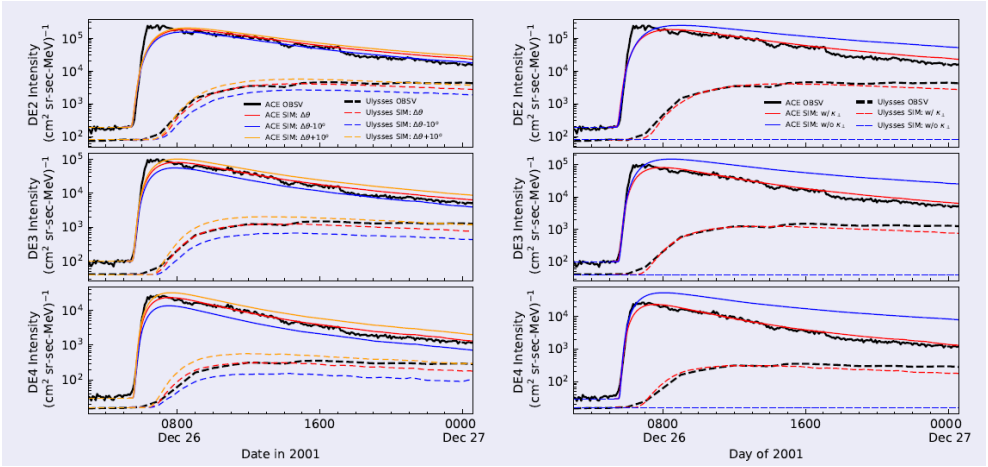


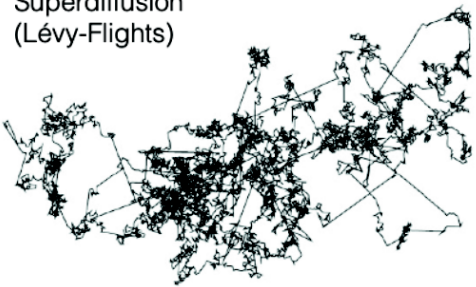
Figure from Lian [945].

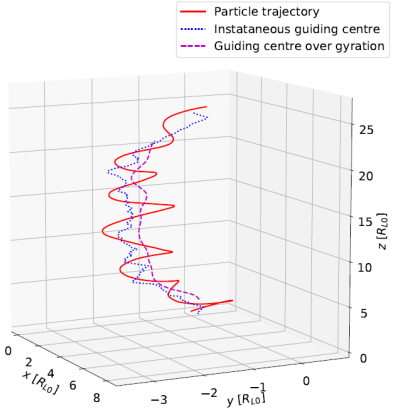
Magnetic turbulence leads to scattering along and perpendicular to the mean field. A major uncertainty is the level to which perpendicular diffusion contributes...

Also some discussions on the micro-physics of the transport processes...

Subdiffusion
(extended
waiting times)

Superdiffusion
(Lévy-Flights)





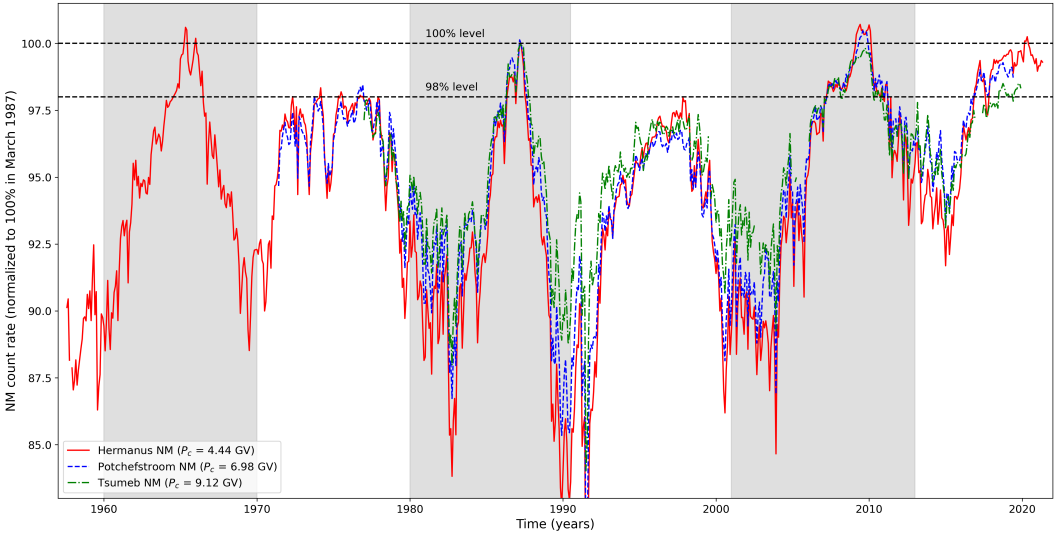
Now with composite 20% slab and 80% 2D turbulence

Figures from Effenberger [557; left] and van den Berg [340; right].

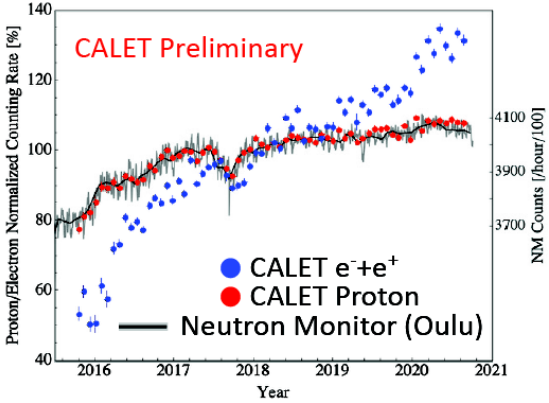
Discussion session #20: GCR long-term modulation

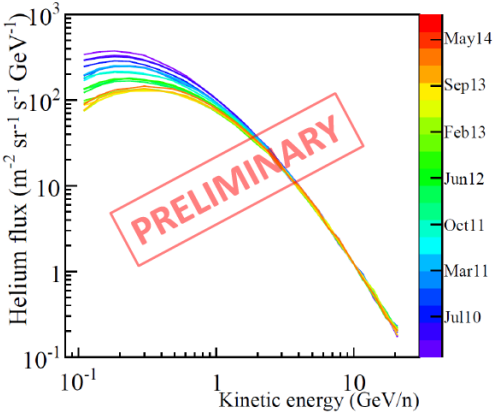
Conveners: Nicola Tomassetti & Konstantin Herbst

Neutron monitor count rates spanning 70 years and 6 solar cycles. Was the last two cycles different? How does the quiet Sun influence particle propagation?

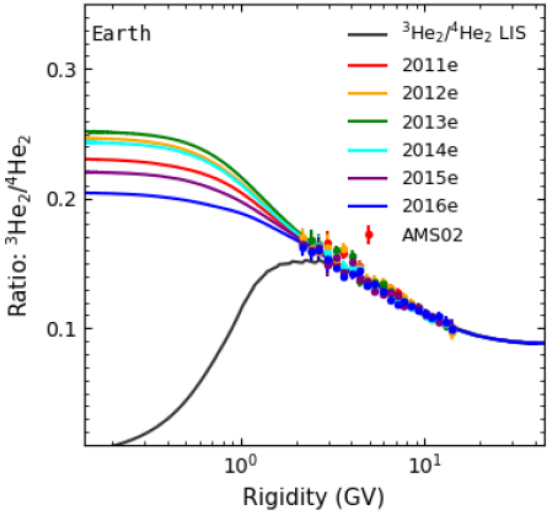


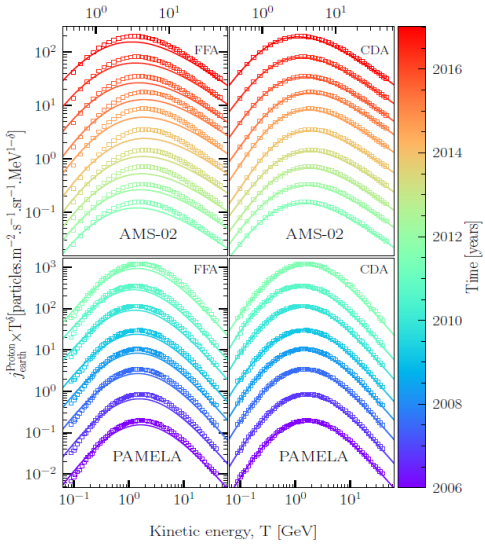
New data from newer instruments: Charge-sign dependent modulation (Miyake [332; left]) and Helium spectra from solar minimum to maximim (Marcelli [626; right]).





Data reproduced with models of varying complexity: Numerical drift model from Ngobeni [262; left] and analytical approximations by Mosotho [318; right].

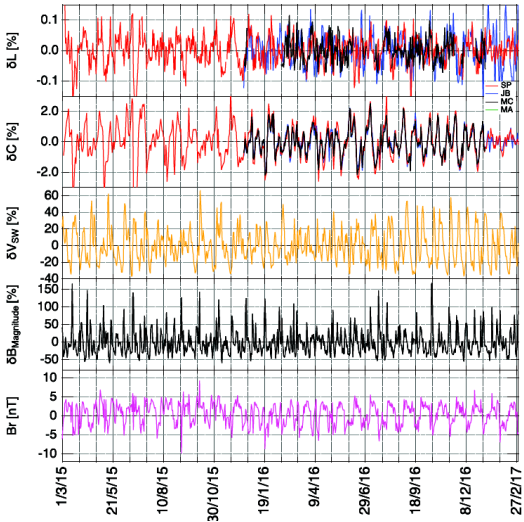


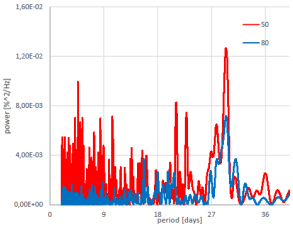


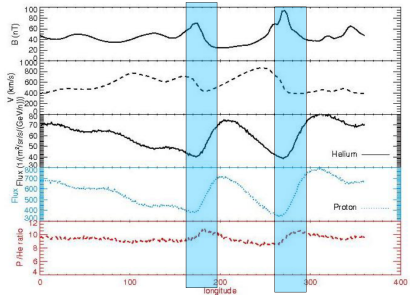
Discussion session #21: Short-term modulation

Conveners: Agnieszka Gil & Bernd Heber

Recurrent 27 day variations cause by co-rotating interacting regions.

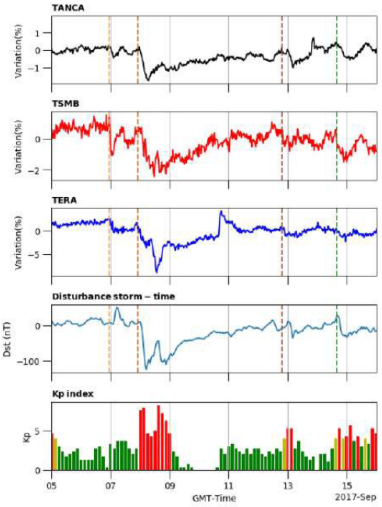


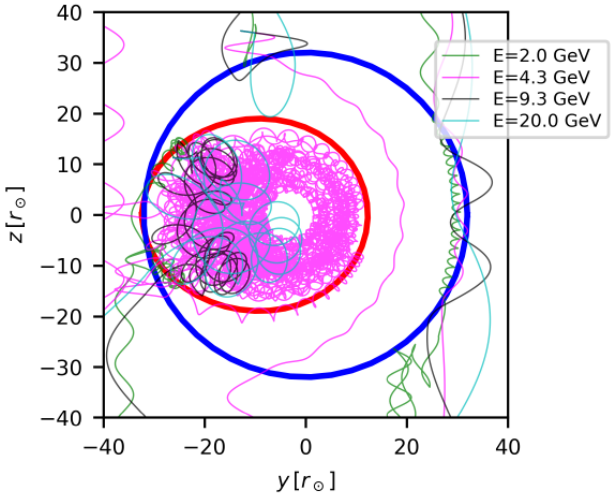




Data from Muangha [670], Modzelewska [361], and simulations from Luo [1080].

Transient variations due to coronal mass ejections; Forbush decreases. Data from De Aguiar [236] and simulations from Laitinen [1322].





Discussion session #22: Atmospheric effects on CRs

Conveners: Ilya Usoskin & Konstantin Herbst

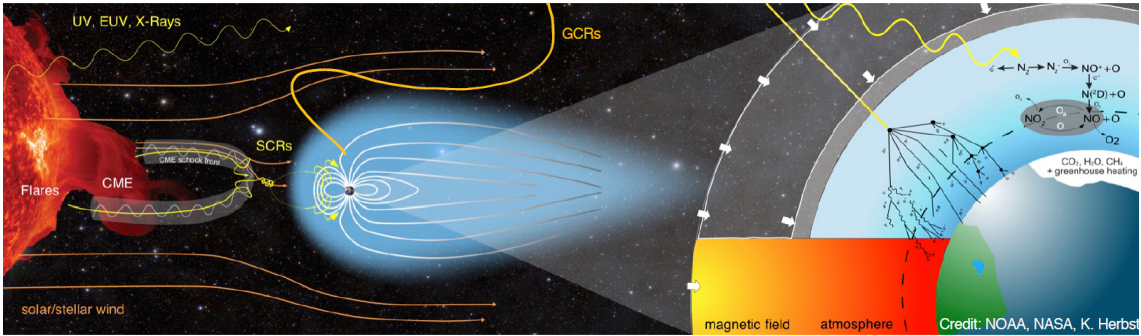


Figure from Rodgers-Lee [75].

[Alejandro Saiz] Earth's magnetosphere and atmosphere is part of any ground based detector. As such, they should be sufficiently characterized....

Also: Implications for exo-planet habitability, atmospheric chemistry, atmospheric radiation (dosimetry), etc...

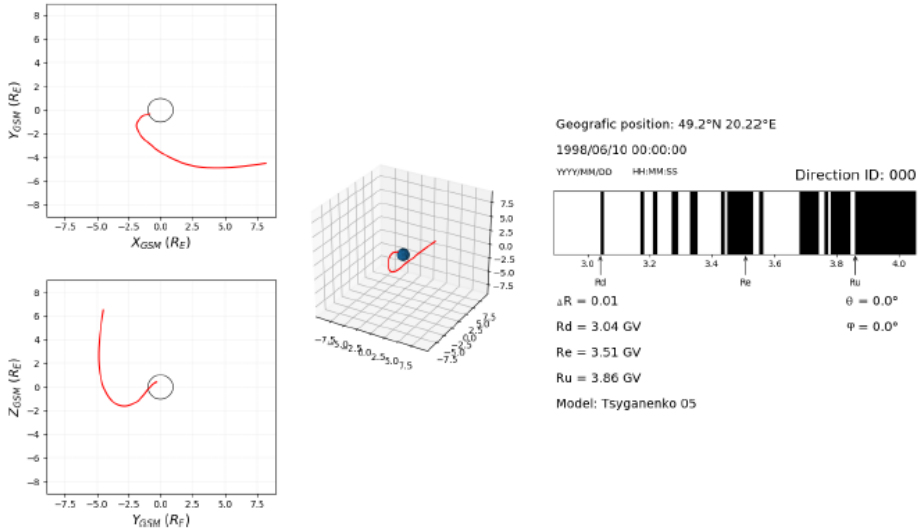


Figure from Gecášek [242] illustrating their new online tool `https://cor.crmodels.org/` .

For ground-based instruments, the atmosphere serves as a converter level, converting primary CRs into e.g. muons, neutrons, ... Meterological corrections (barometric, temperature, water vapour content, ...) are therefore very important for instruments.

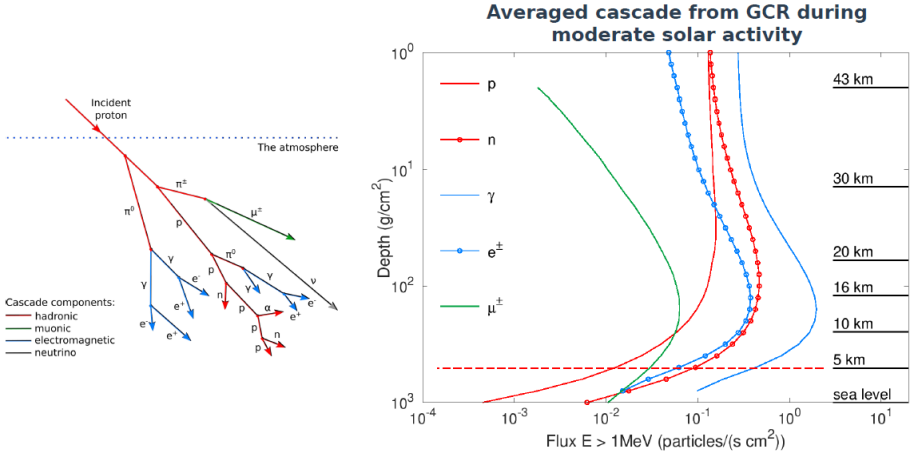
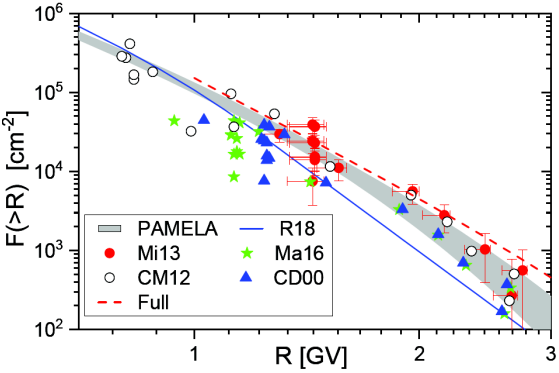


Figure from Poluianov [59].

Discussion session #23: Solar events observed on/near Earth

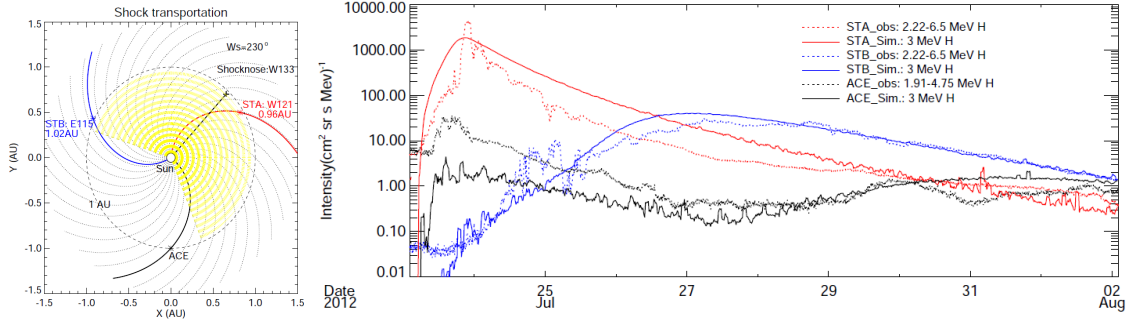
Conveners: Alexander Mishev & Gang Qin

Combining space-based SEP measurements (e.g. PAMELA, AMS-02, ...) with that inferred from NMs on ground-level.



Figures from Koldobskiy [363].

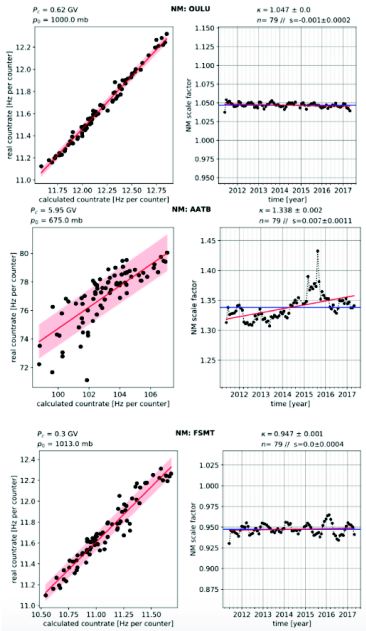
We also have spatially seperated measurements allowing us to test particle transport/diffusion theories...



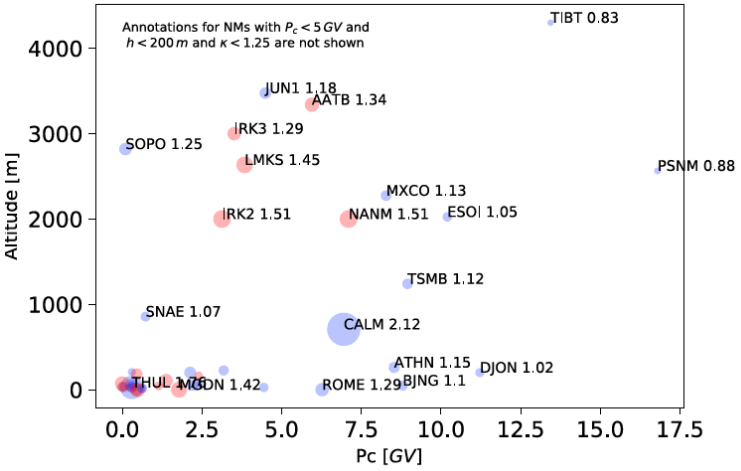
Figures from Qi [798].

Discussion session #24: Ground-based measurements of low-energy GCRs

Conveners: David Ruffolo & Toshiyuki Nonaka

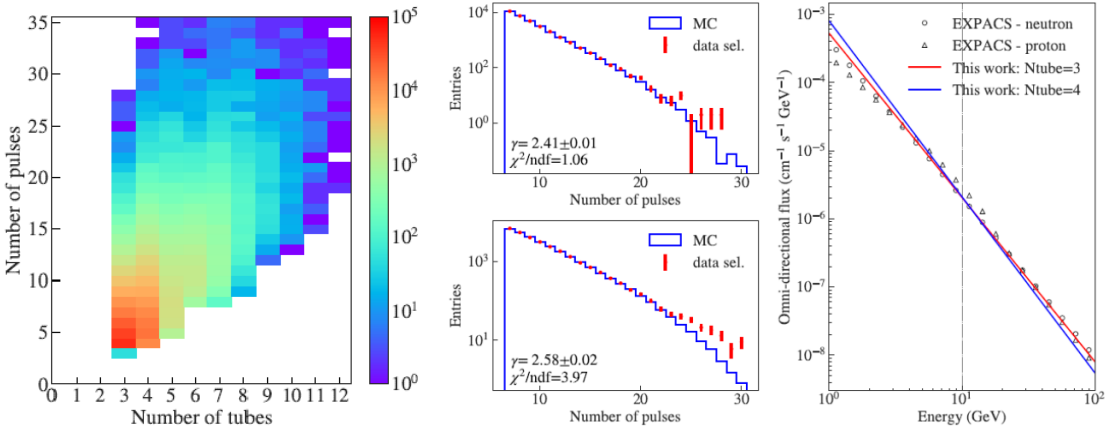


Correct combination of the world-wide NM network requires inter-callibration.



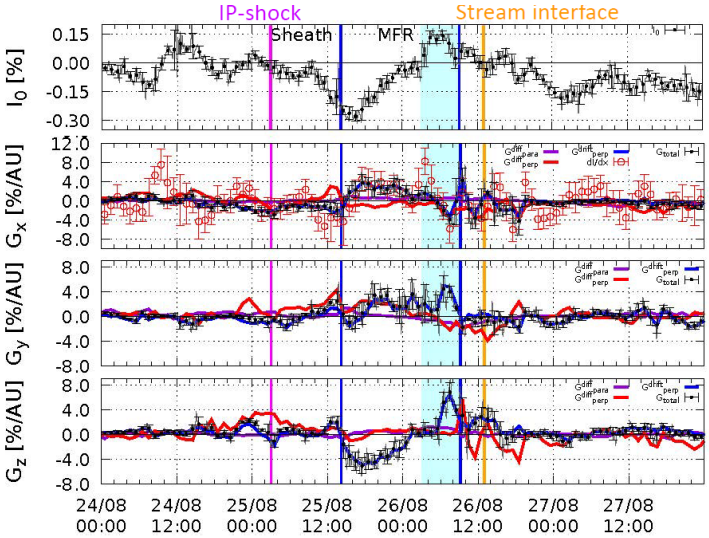
Figures from Koldobskiy [364].

Or energy spectra may be obtained from a single monitor....



Figures from Evenson [169].

Combined global muon telscope network allows precision measurements of 60GV CRs.

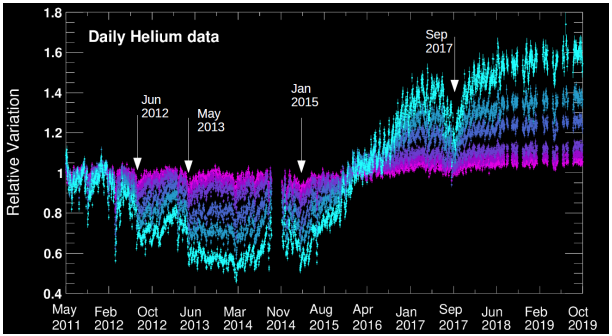


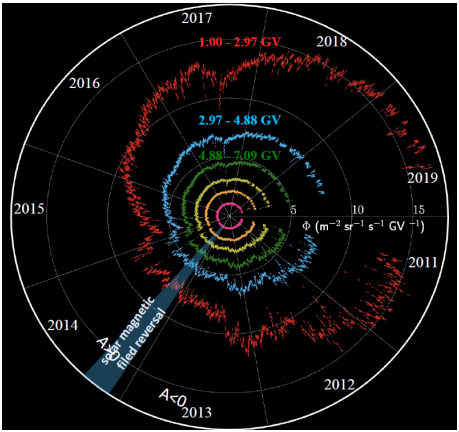
Taken from Munakata [114].

Presenter forum

Only a small selection discussed here, unfortunately...

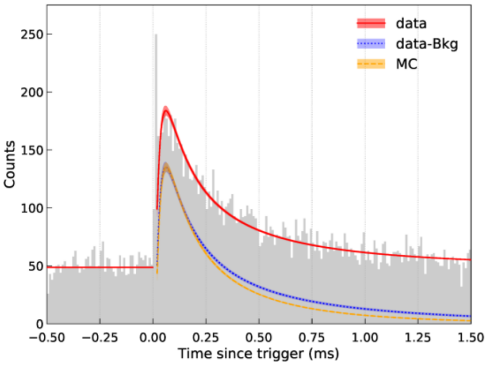
High resolution, long-term data from AMS-02 to test GCR transport theories...

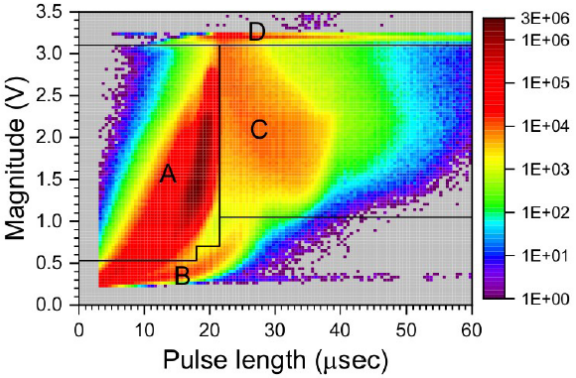




Figures from Consolandi [1139; left] and Xu [1211; right].

New science with (old) neutron monitors....





Figures from Chaiwongkhot [430; left] and Poluianov [57; right].

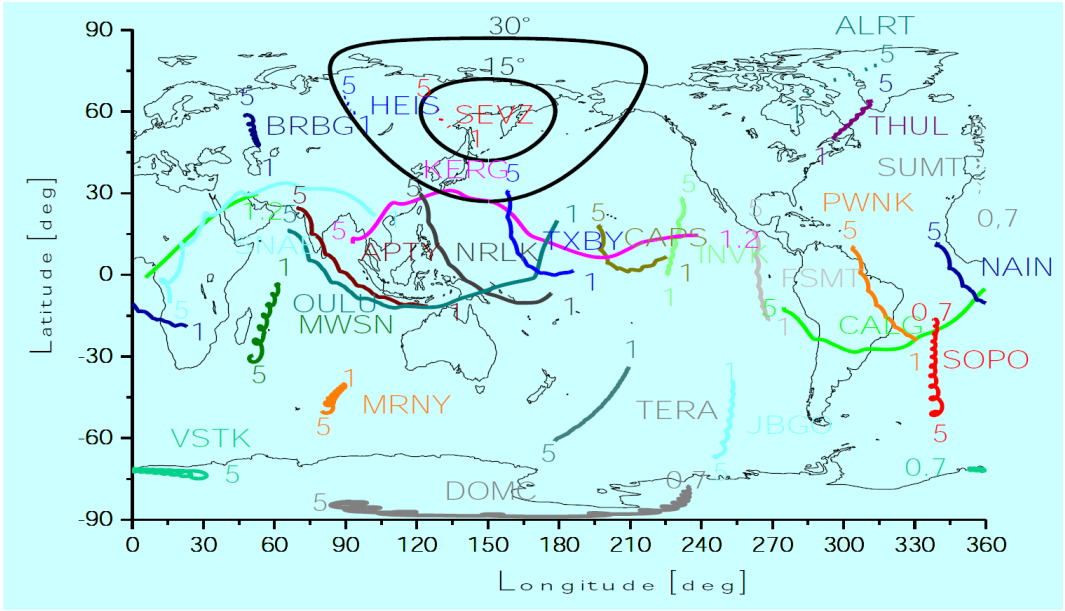
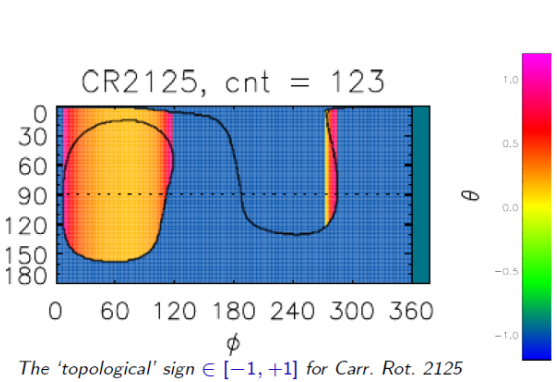
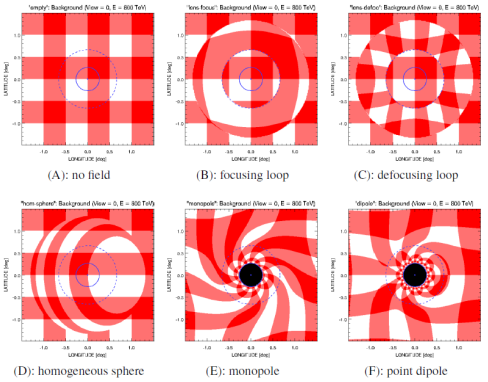


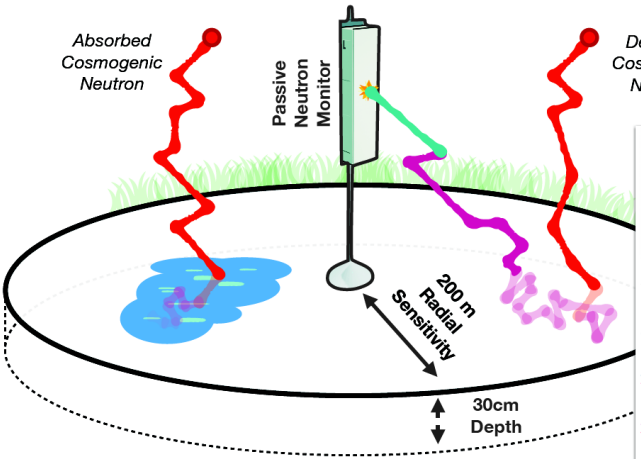
Figure from Mishev [49].

A reminder that heliospheric processes are driven by the Sun and it's interplanetary extension...





Figures from Fichtner [704; left] and Kleimann [181; right].

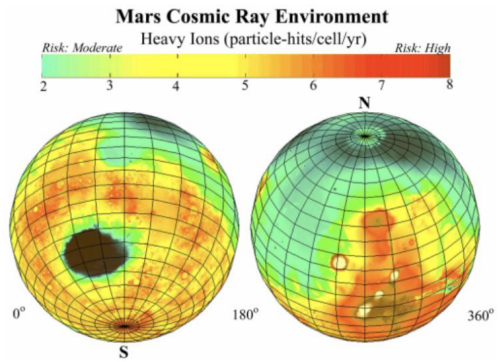


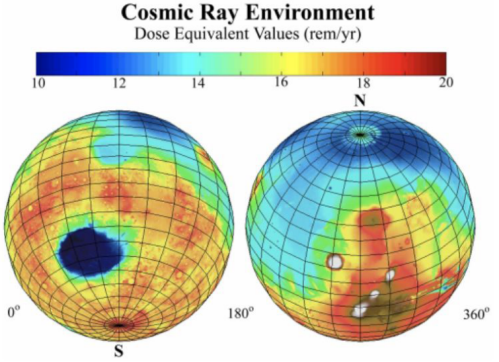
$$VWC = \left(\frac{0.0869}{f_p f_c \frac{N}{N_0} - 0.1236} - 0.1236 \right)$$

N - Measured Neutron Counting Rate
(hourly integrations)
N_0 - Dry Counting Rate
(Max detector rate estimated from field calibration)
f_p - Local environmental conditions correction
(derived from pressure, temperature, humidity)
f_c - High energy cosmic ray intensity correction
(derived from Jungfraujoch neutron monitor database)

Figure from Stowell [584].

Estimated Radiation Dose from GCRs





The absorbed radiation dose during a round trip to Mars for a Hohmann transfer would be between **906 mSv - 1, 554 mSv**, whereas the absorbed radiation dose during the stay on Mars would be between **97 mSv - 115 mSv**.

Figure from Bloshenko [60].

Summary

It's a really good time to be in SH CR studies; plenty of data available:

- We have good measurements of GCR inside and outside of the heliosphere.
- We have accurate CR measurements on ground-level and near Earth, allowing detailed reconstructions.
- We have spacecraft exploring the innermost regions of the heliosphere.

We're exiting a very quiet solar mimimum condition with record-setting GCR intensities at Earth $\Rightarrow$ it's the perfect time to study GCR modulation!

We're looking forward to increasing solar activity $\Rightarrow$ transient events can be studies in unprecedented detail!

As mentioned in one of the talks [Nicola Tomassetti?]: "This the golden age of heliospheric CR studies."

– Thank you –