Status update on proton and helium daily fluxes

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On behalf of
INFN Milano Bicocca group

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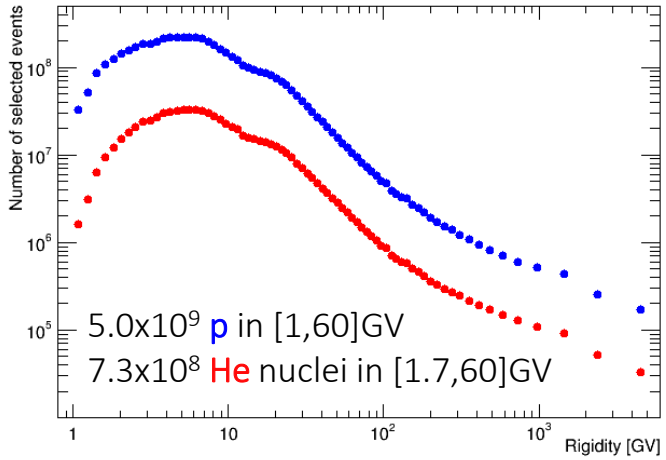
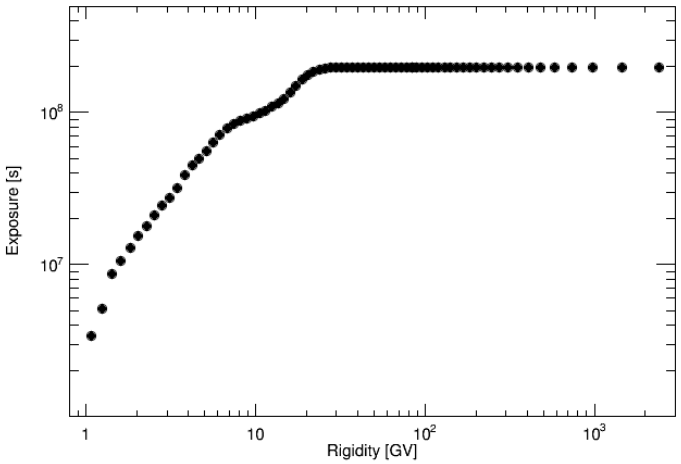
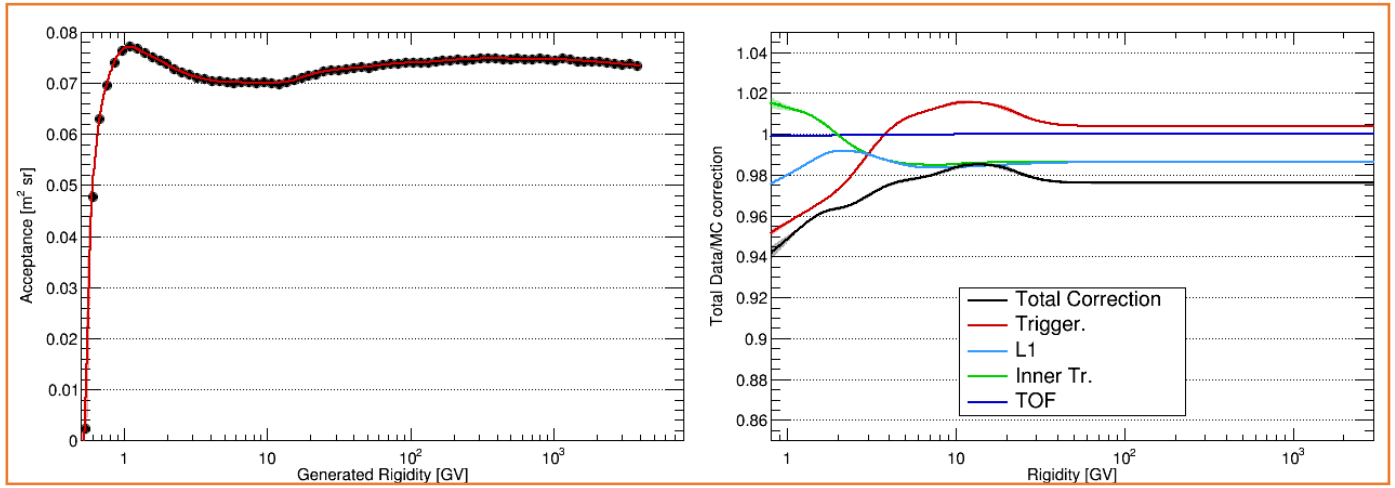
Flux measurement

We are currently involved in the geomagnetic rigidity cut-off optimization *(see D. Grandi presentation)* and estimation of its systematic error.



$$\Phi(R) = \frac{N(R)}{T(R)\,\Delta R\,A_{eff}(R)\,\delta(R)}$$

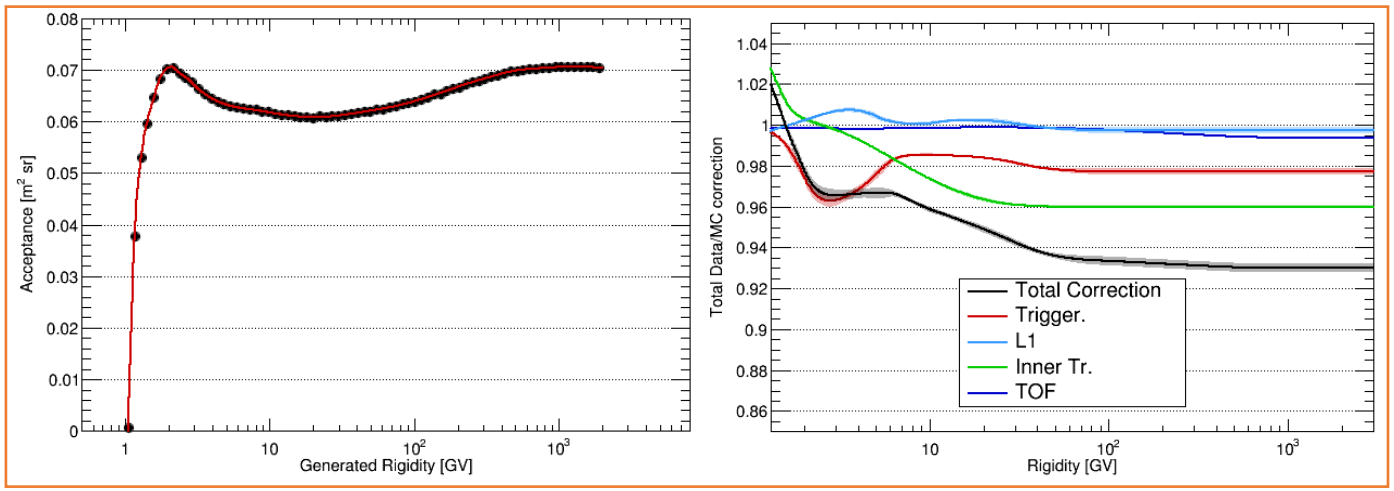




Proton

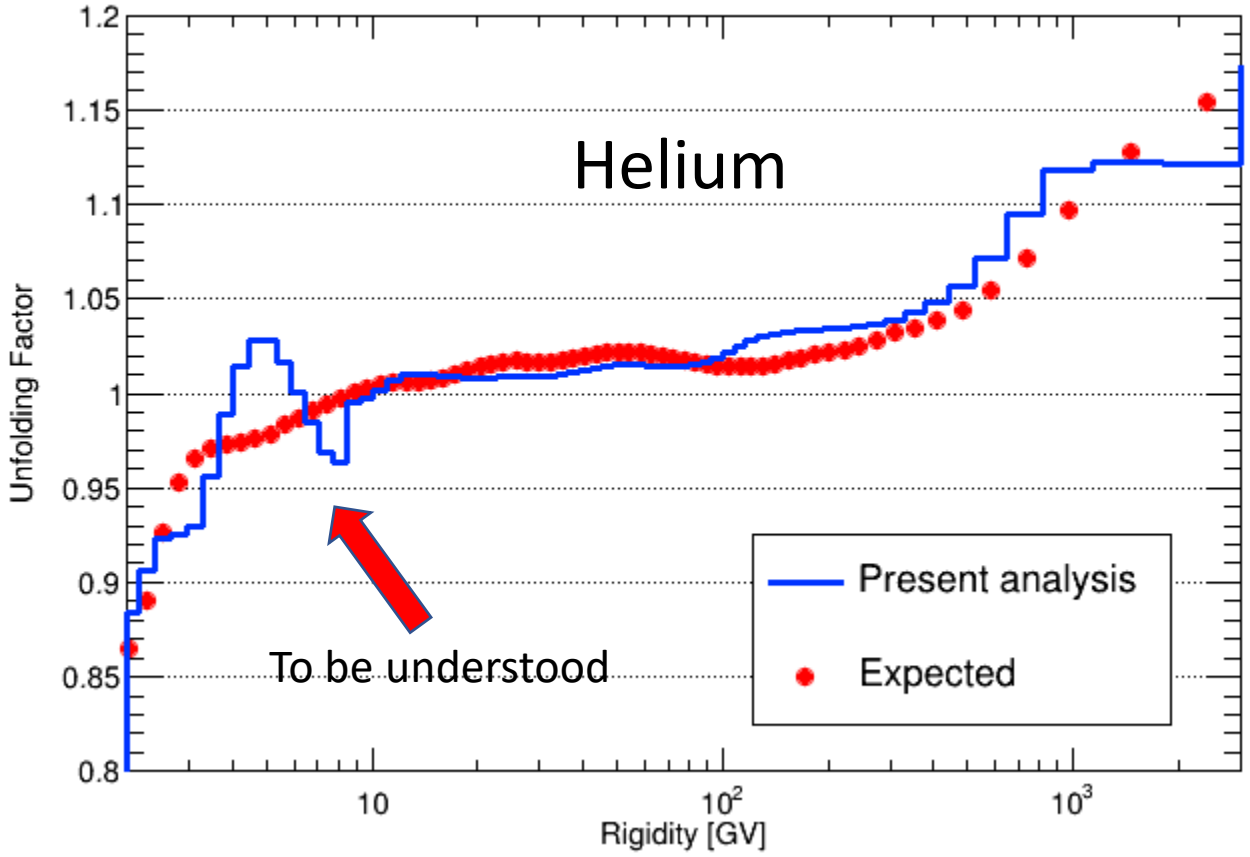
Inner Tracker + L1 geometry

Helium



Full period: unfolding factor

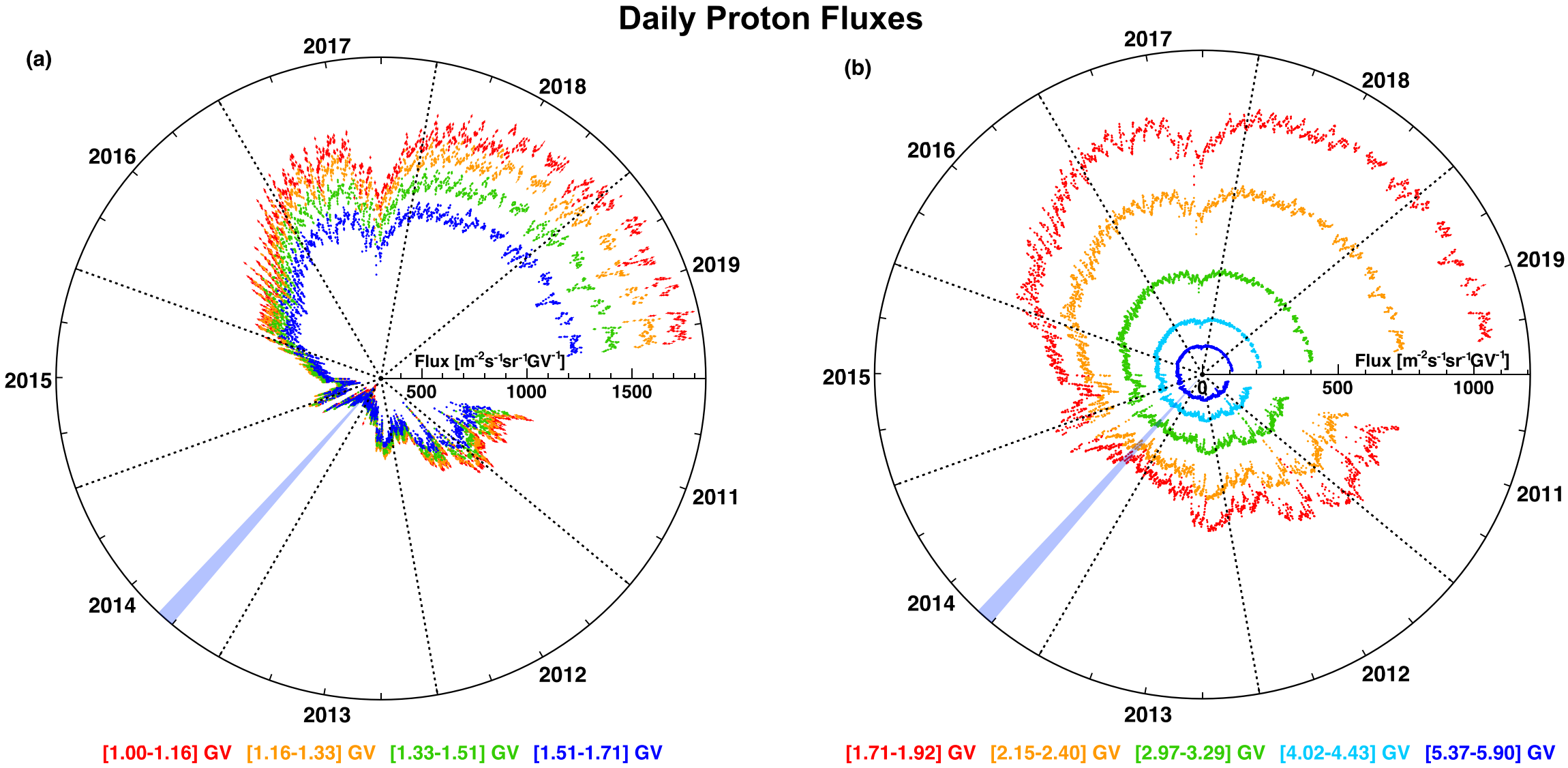
Forward Unfolding: work in progress…



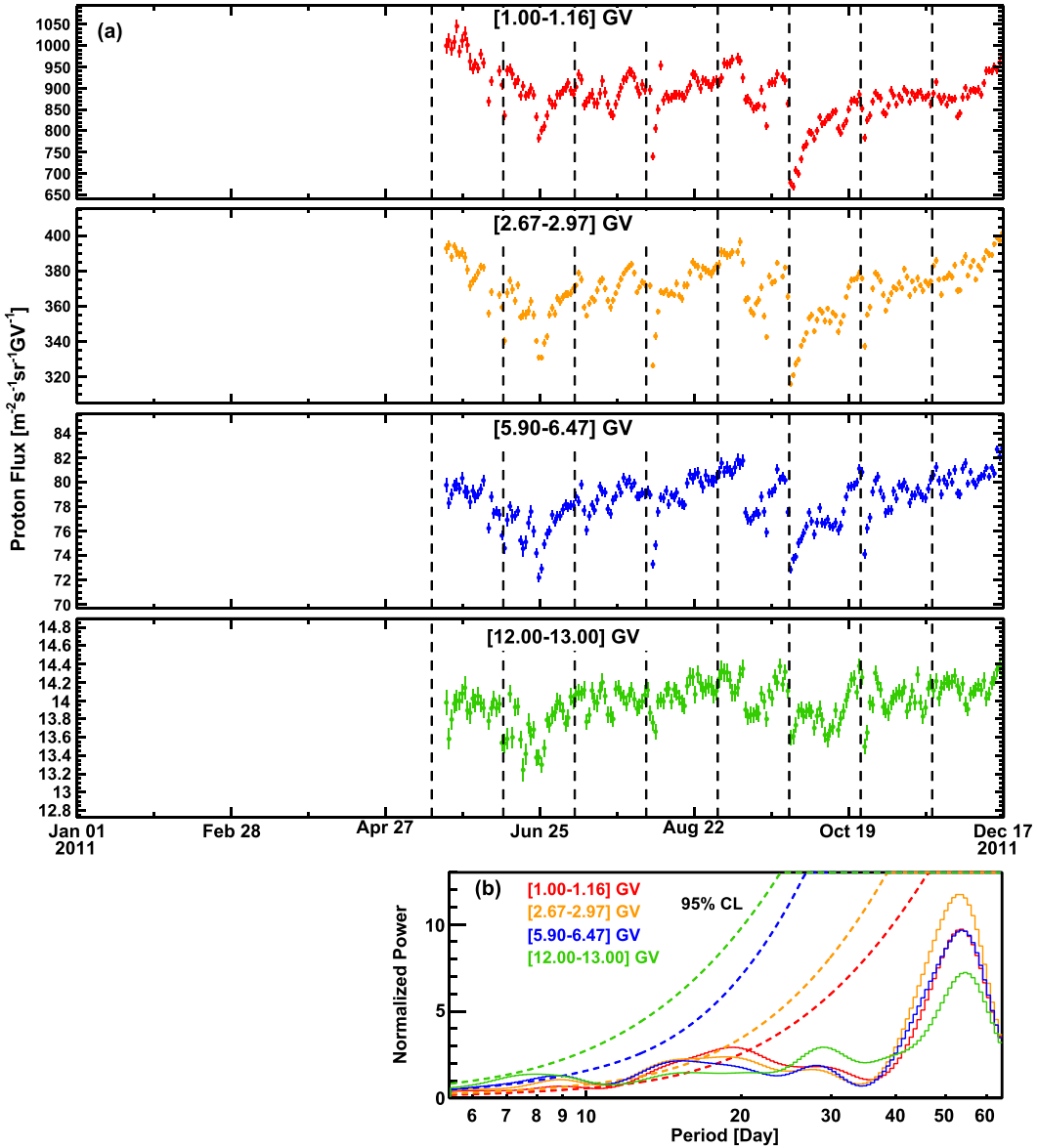
Current status of proton and helium daily flux measurement

The groups currently working on this topic are MIT, University of Hawaii, MIB

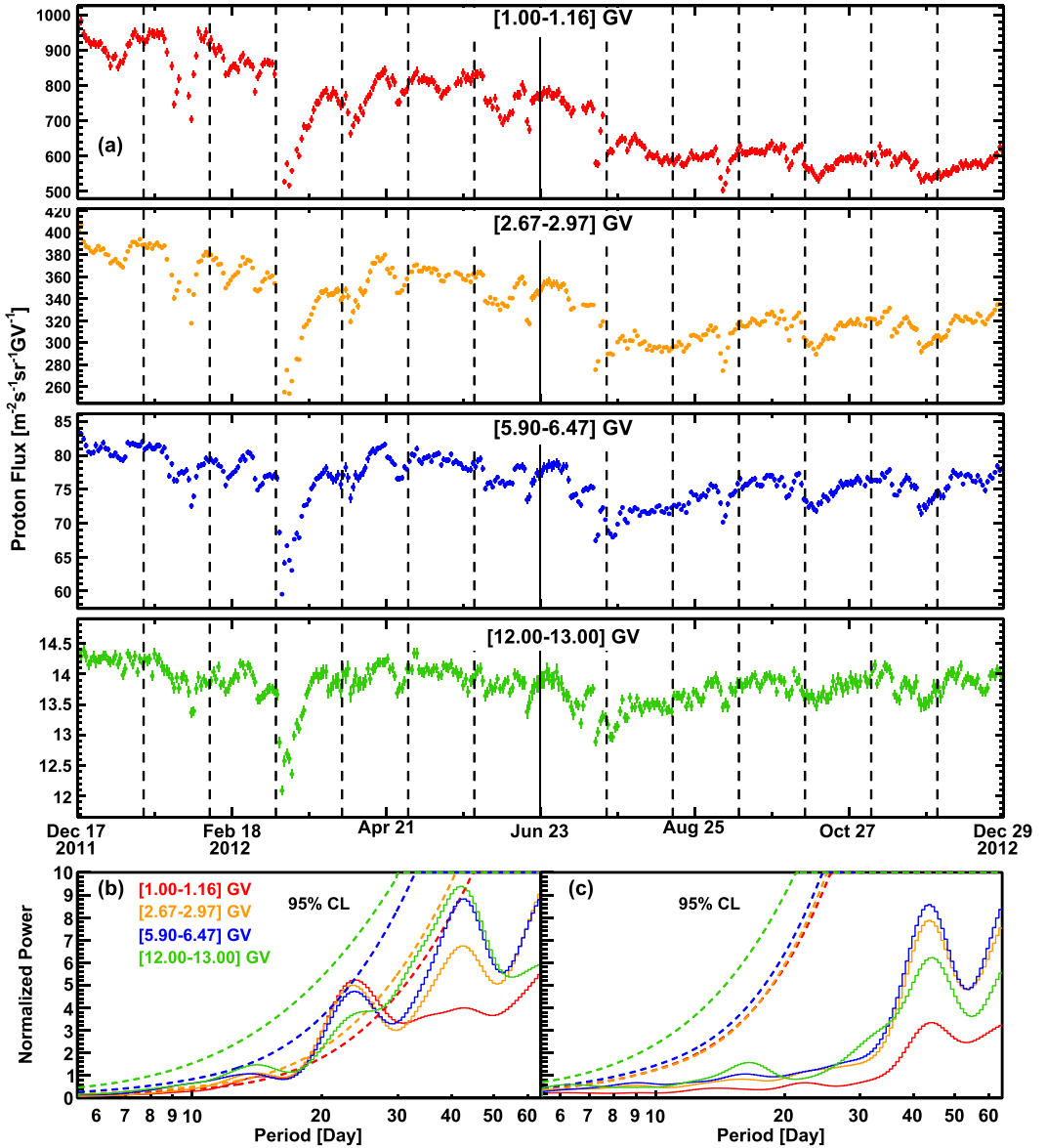
Daily proton flux: long term variation



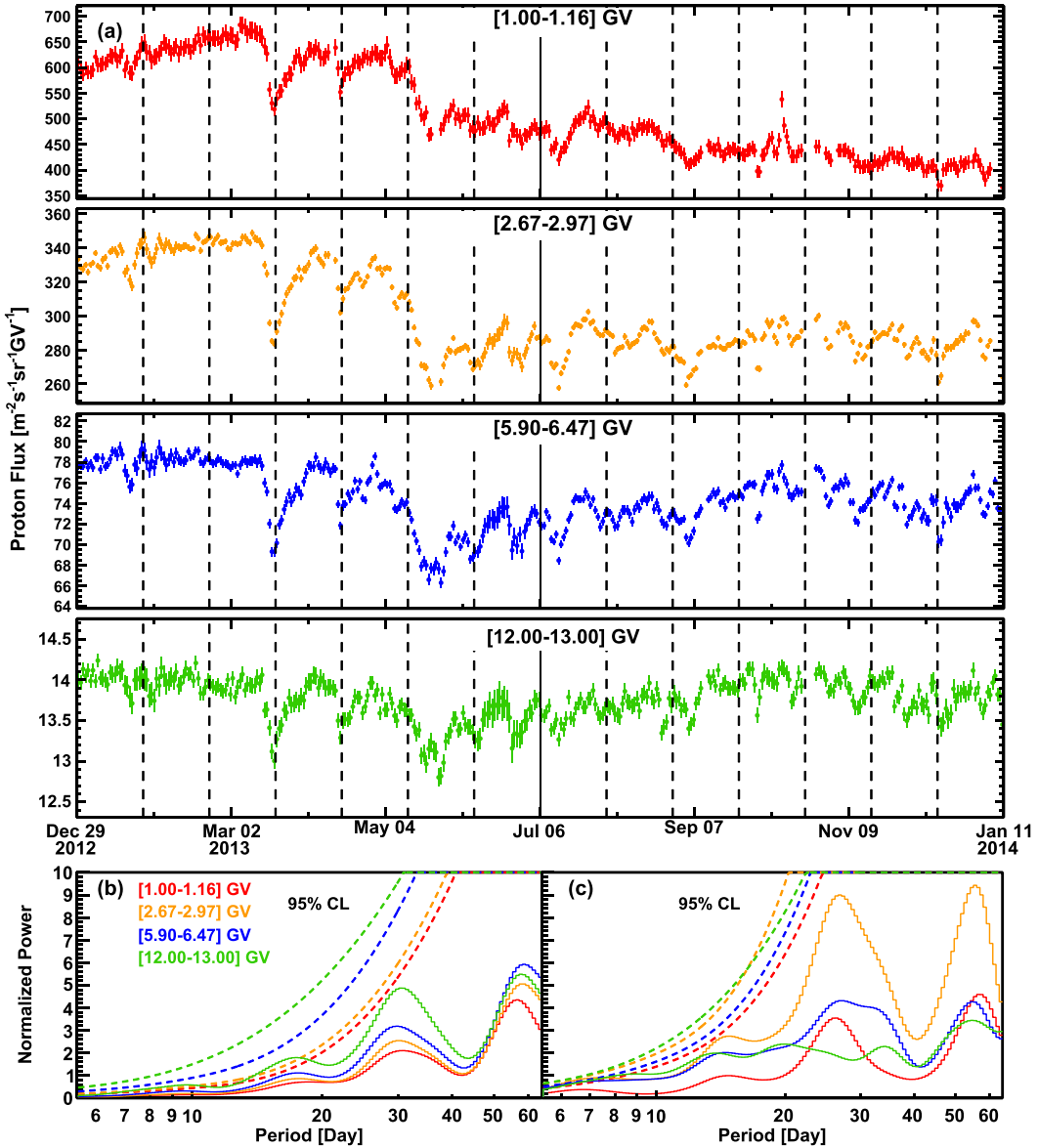
2011


(a)
[1.00-1.16] GV
[2.67-2.97] GV
[5.90-6.47] GV
[12.00-13.00] GV
Proton Flux [m^{-2}s^{-1}sr^{-1}GV^{-1}]
Jan 01 2011
Feb 28
Apr 27
Jun 25
Aug 22
Oct 19
Dec 17 2011
(b)
95% CL
Normalized Power
Period [Day]

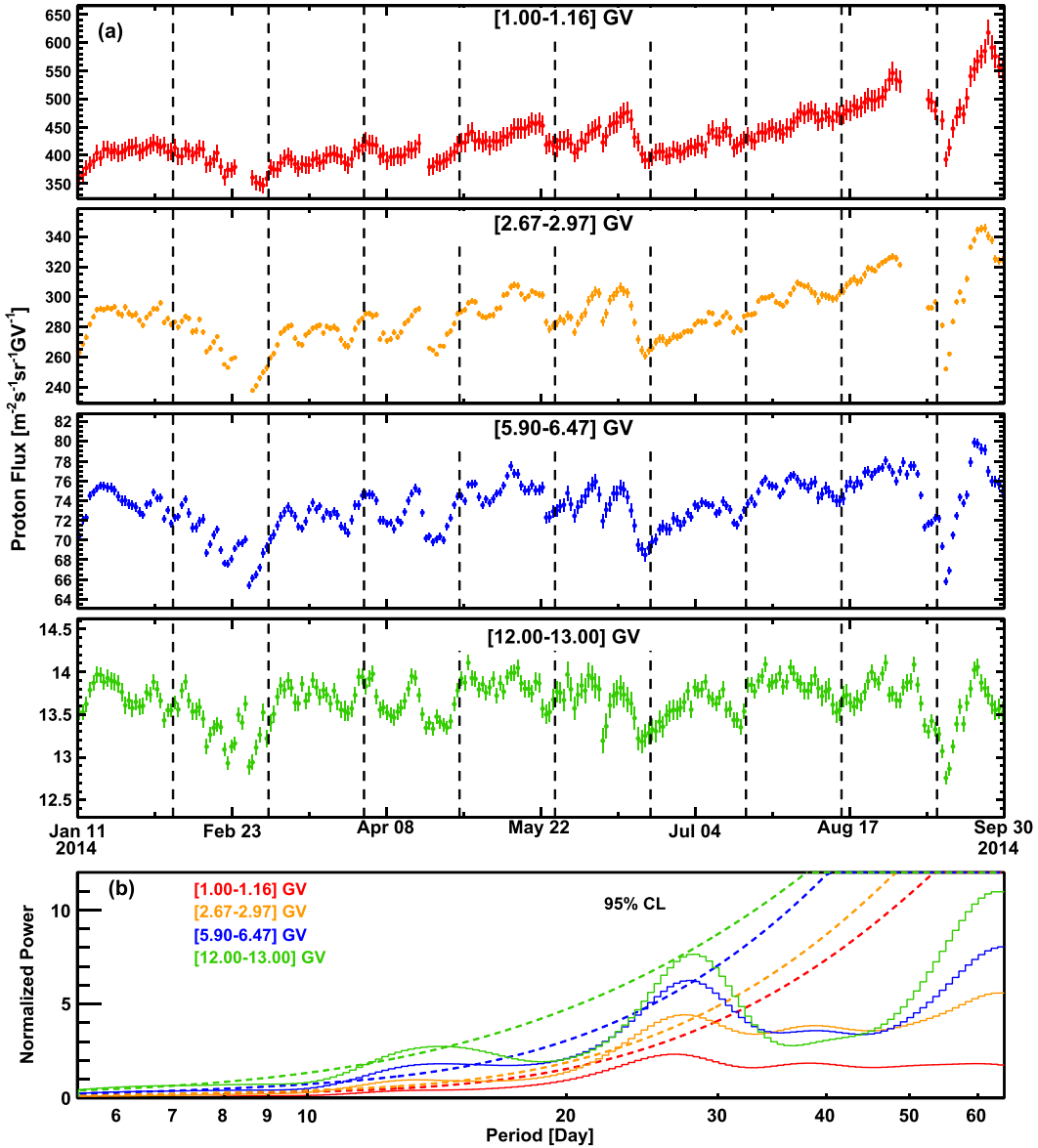
2012


(a)
[1.00-1.16] GV
[2.67-2.97] GV
[5.90-6.47] GV
[12.00-13.00] GV
Proton Flux [m^{-2}s^{-1}sr^{-1}GV^{-1}]
Dec 17 2011
Feb 18 2012
Apr 21
Jun 23
Aug 25
Oct 27
Dec 29 2012
(b)
(c)
95% CL
Normalized Power
Period [Day]

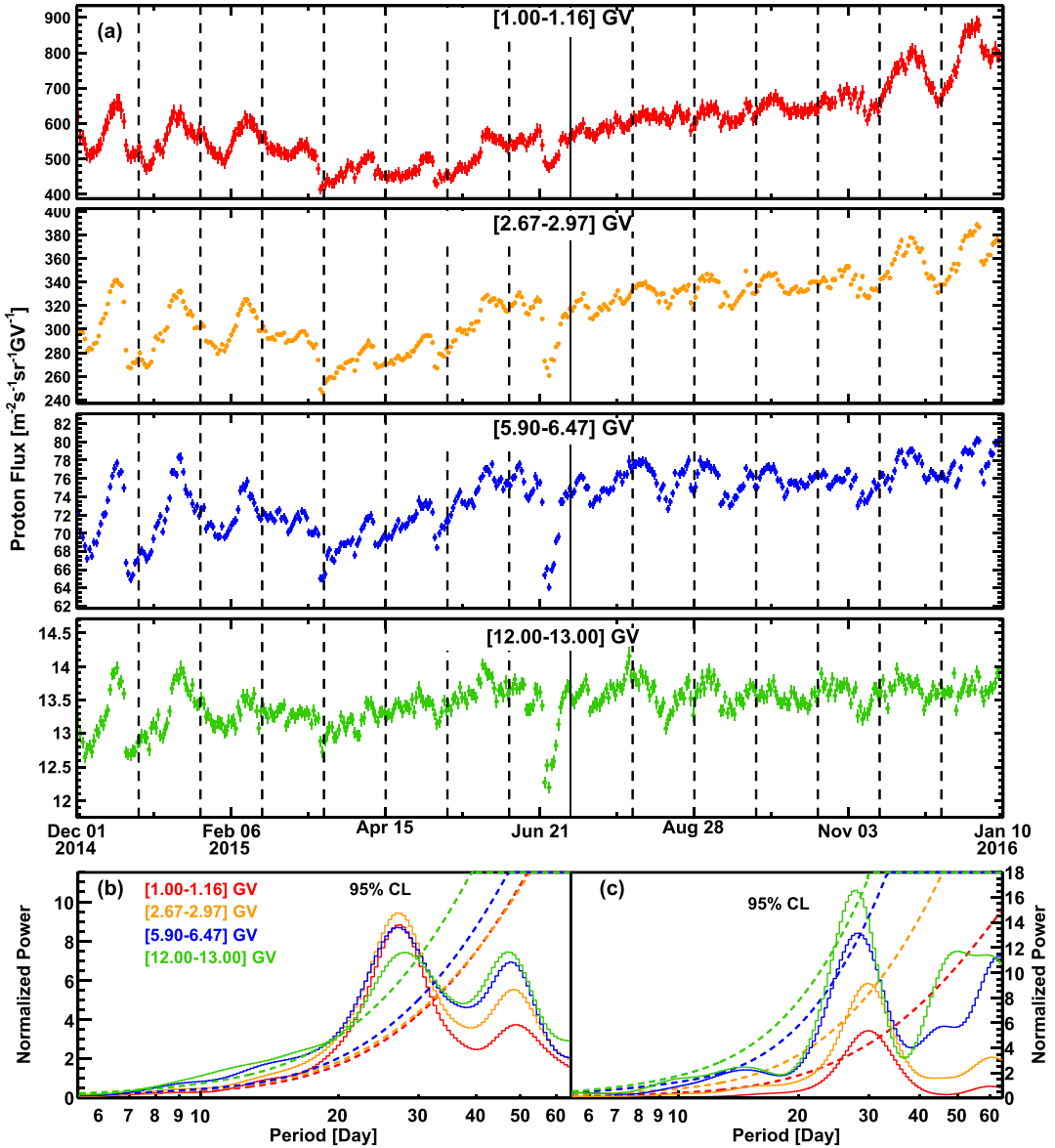
2013


(a)
[1.00-1.16] GV
[2.67-2.97] GV
[5.90-6.47] GV
[12.00-13.00] GV
Proton Flux [m^{-2}s^{-1}sr^{-1}GV^{-1}]
Dec 29 2012
Mar 02 2013
May 04
Jul 06
Sep 07
Nov 09
Jan 11 2014
(b)
95% CL
(c)
95% CL
Normalized Power
Period [Day]

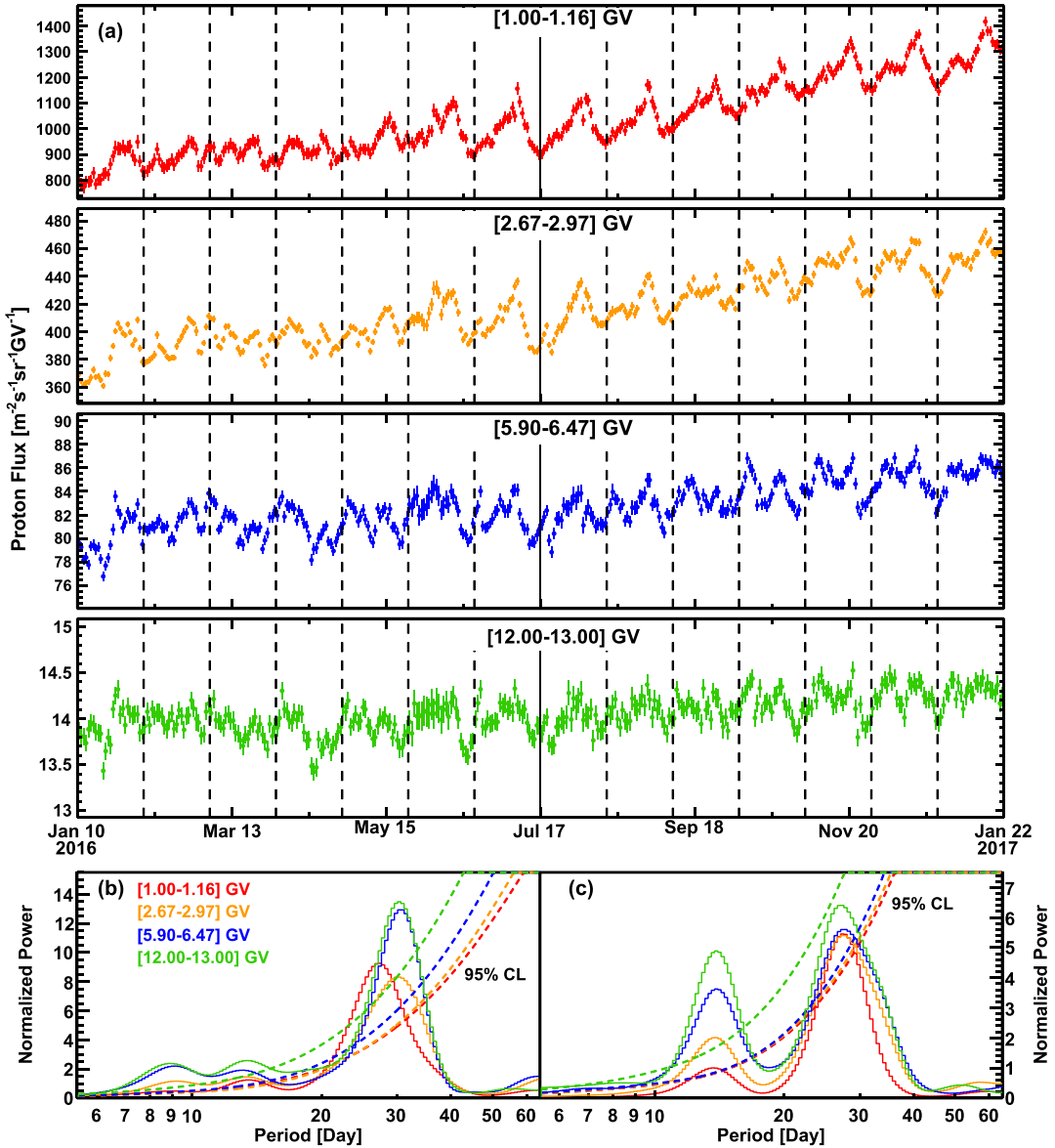
2014


(a)
[1.00-1.16] GV
[2.67-2.97] GV
[5.90-6.47] GV
[12.00-13.00] GV
Proton Flux [m^{-2}s^{-1}sr^{-1}GV^{-1}]
Jan 11 2014
Feb 23
Apr 08
May 22
Jul 04
Aug 17
Sep 30 2014
(b)
95% CL
Normalized Power
Period [Day]

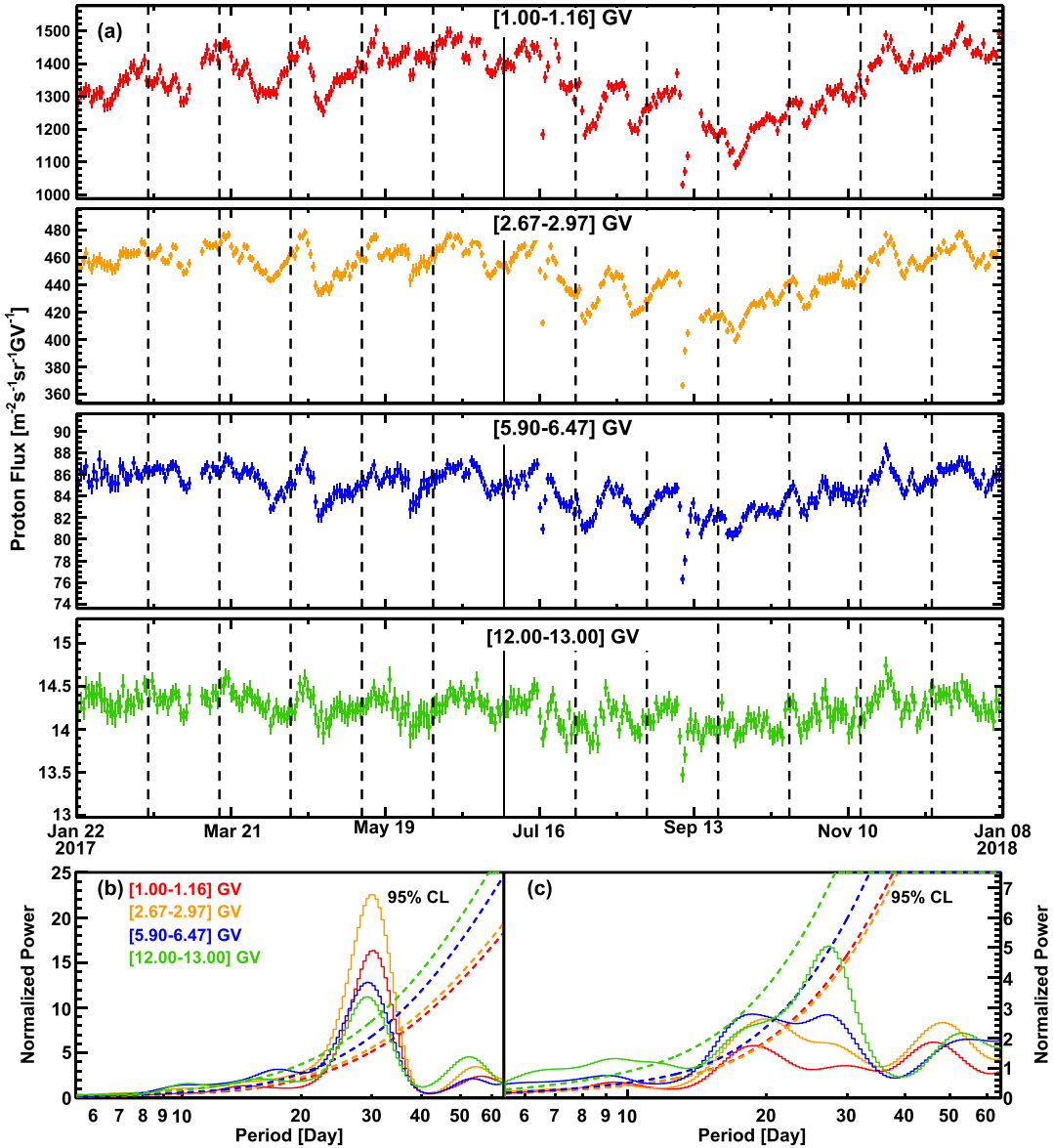
2015


(a)
[1.00-1.16] GV
[2.67-2.97] GV
[5.90-6.47] GV
[12.00-13.00] GV
Proton Flux [m^{-2}s^{-1}sr^{-1}GV^{-1}]
Dec 01 2014
Feb 06 2015
Apr 15
Jun 21
Aug 28
Nov 03
Jan 10 2016
(b)
95% CL
(c)
Normalized Power
Period [Day]

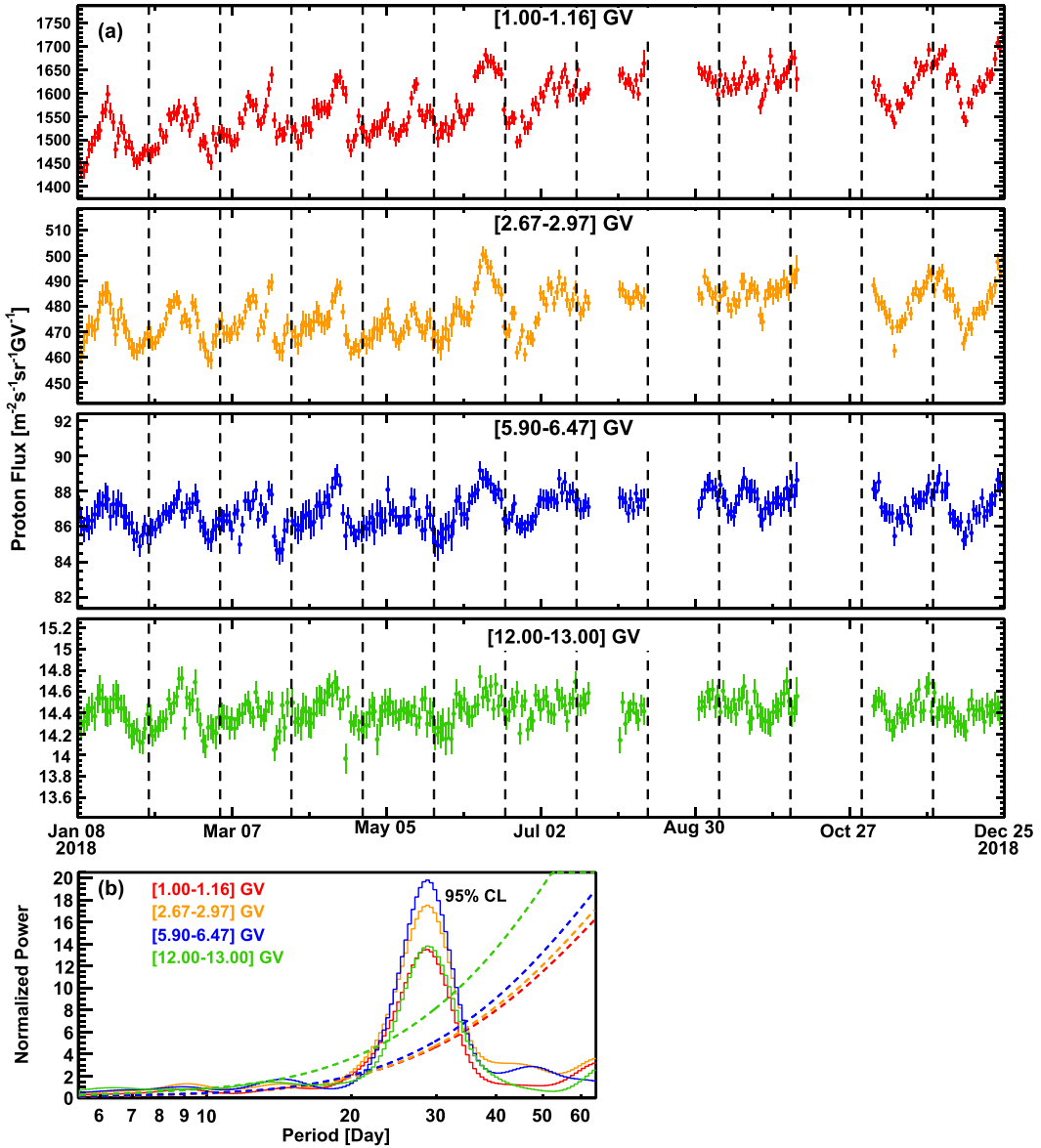
2016


(a)
[1.00-1.16] GV
[2.67-2.97] GV
[5.90-6.47] GV
[12.00-13.00] GV
Proton Flux [m^{-2}s^{-1}sr^{-1}GV^{-1}]
Jan 10 2016
Mar 13
May 15
Jul 17
Sep 18
Nov 20
Jan 22 2017
(b)
95% CL
(c)
Normalized Power
Period [Day]

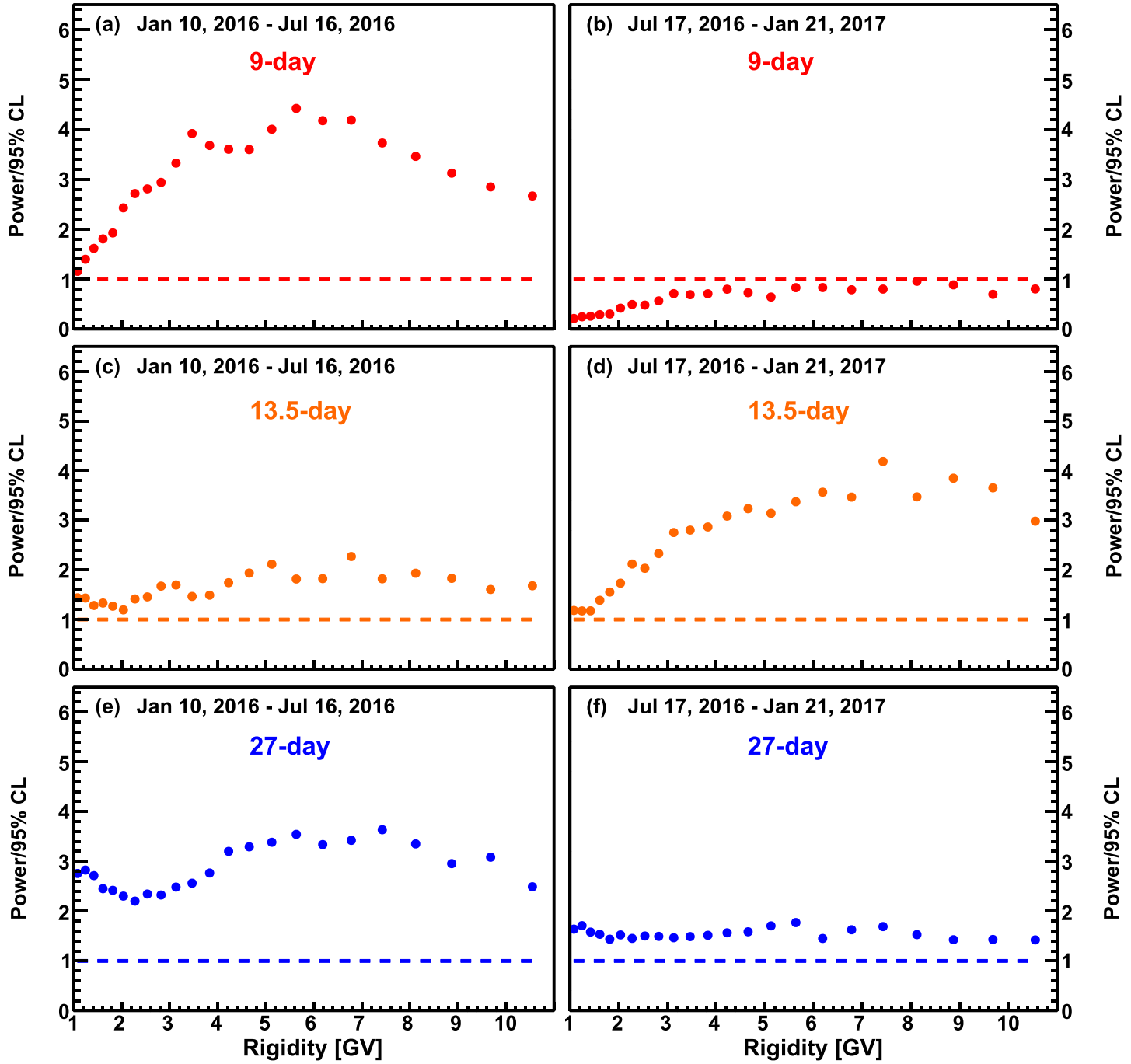
2017


(a)
[1.00-1.16] GV
[2.67-2.97] GV
[5.90-6.47] GV
[12.00-13.00] GV
Proton Flux [m^{-2}s^{-1}sr^{-1}GV^{-1}]
Jan 22 2017
Mar 21
May 19
Jul 16
Sep 13
Nov 10
Jan 08 2018
(b) [1.00-1.16] GV
[2.67-2.97] GV
[5.90-6.47] GV
[12.00-13.00] GV
95% CL
(c)
95% CL
Normalized Power
Period [Day]

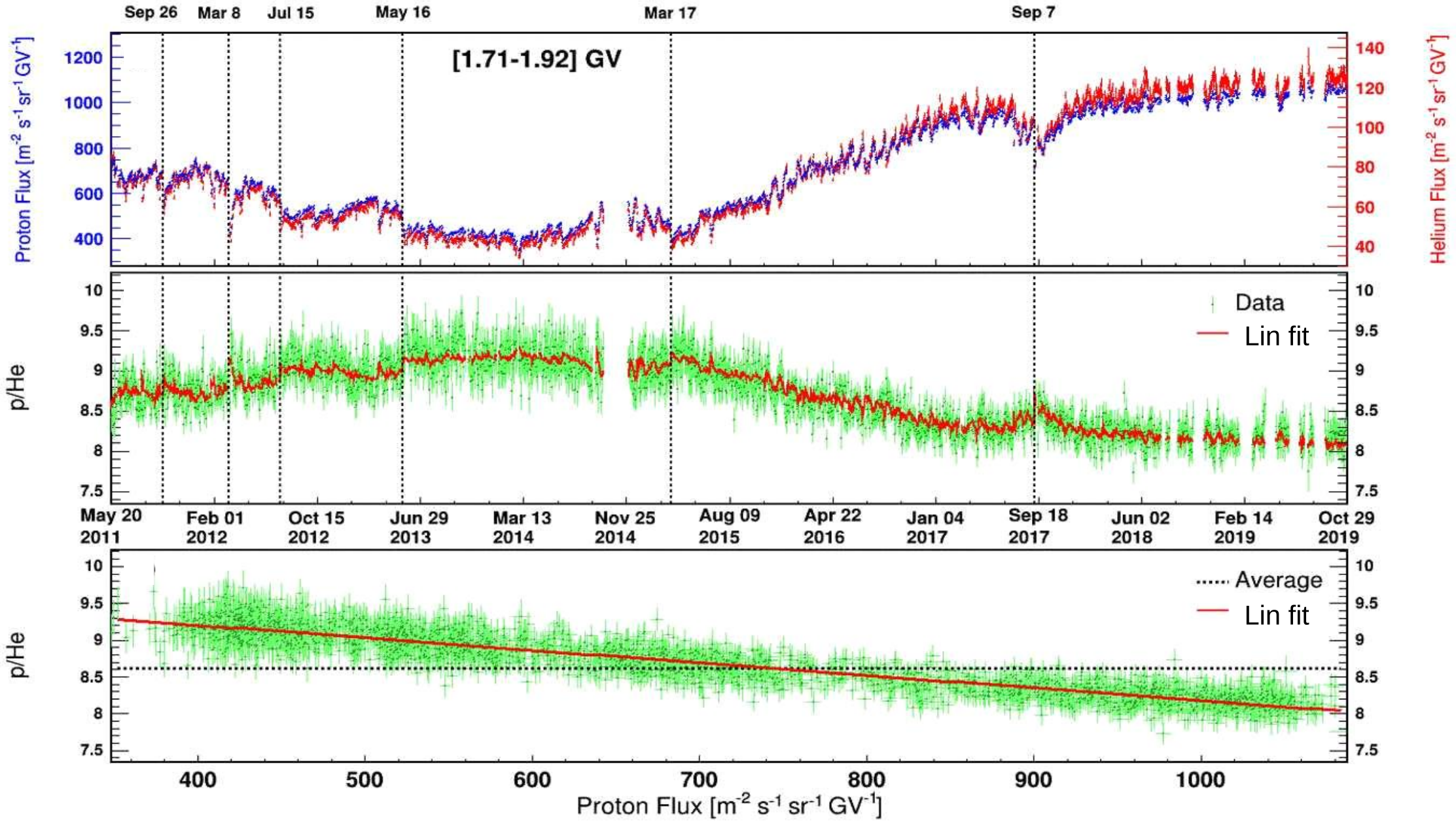
2018


(a)
[1.00-1.16] GV
[2.67-2.97] GV
[5.90-6.47] GV
[12.00-13.00] GV
Proton Flux [m^{-2}s^{-1}sr^{-1}GV^{-1}]
Jan 08 2018
Mar 07
May 05
Jul 02
Aug 30
Oct 27
Dec 25 2018
(b) [1.00-1.16] GV
[2.67-2.97] GV
[5.90-6.47] GV
[12.00-13.00] GV
95% CL
Normalized Power
Period [Day]

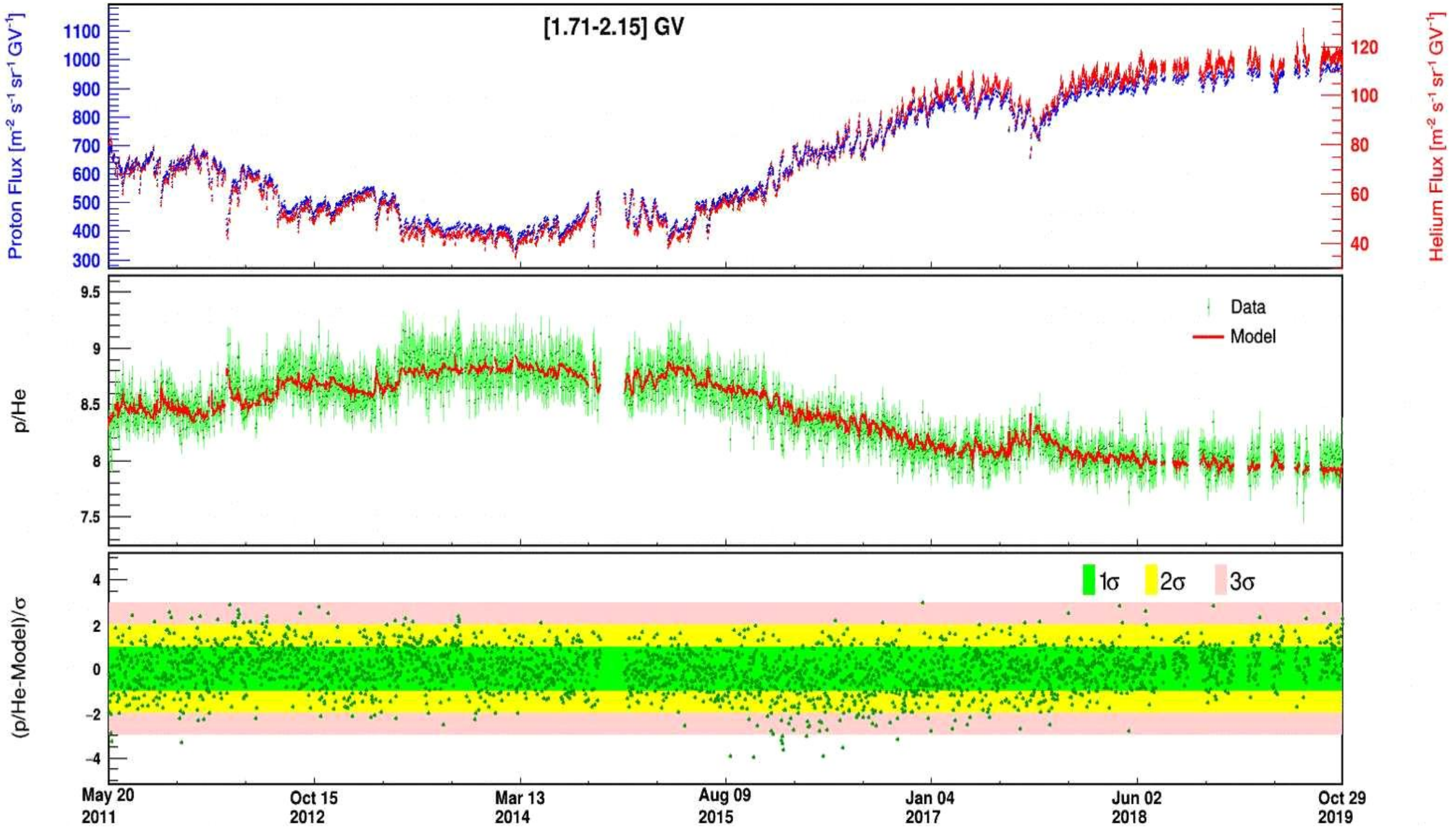
For the first time, rigidity dependence of 27-day, 13.5-day, and 9-day periodicities are measured up to tens of GV.



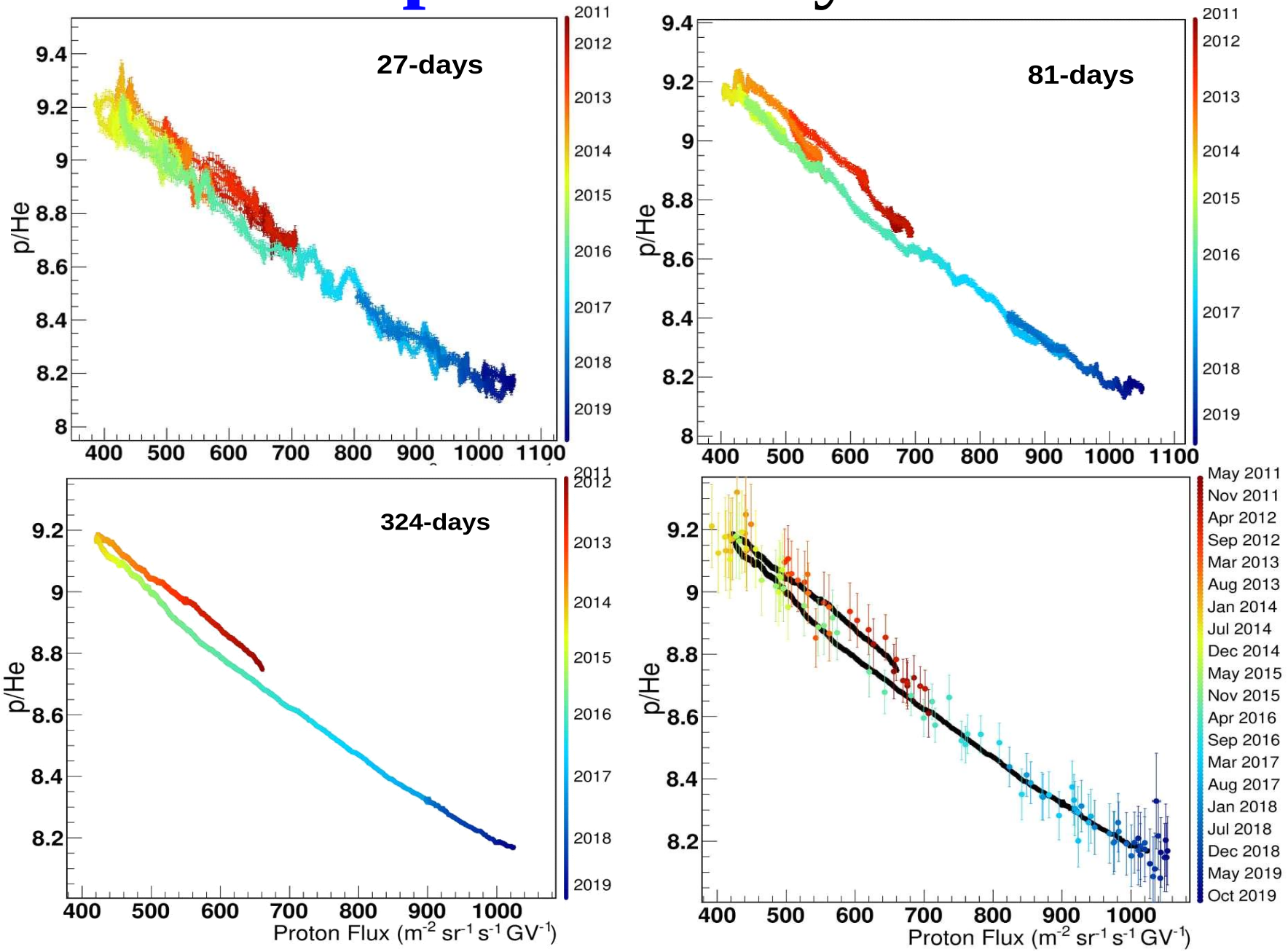
p & He daily fluxes: flux ratio



p & He daily fluxes: flux ratio



p & He daily fluxes: flux ratio



[1.71-1.92]GV

The average is done every N days with a sliding window of 1 day.

p/He vs. p-flux **hysteresis cycle** is evident when averaging data in time.

Daily flux papers

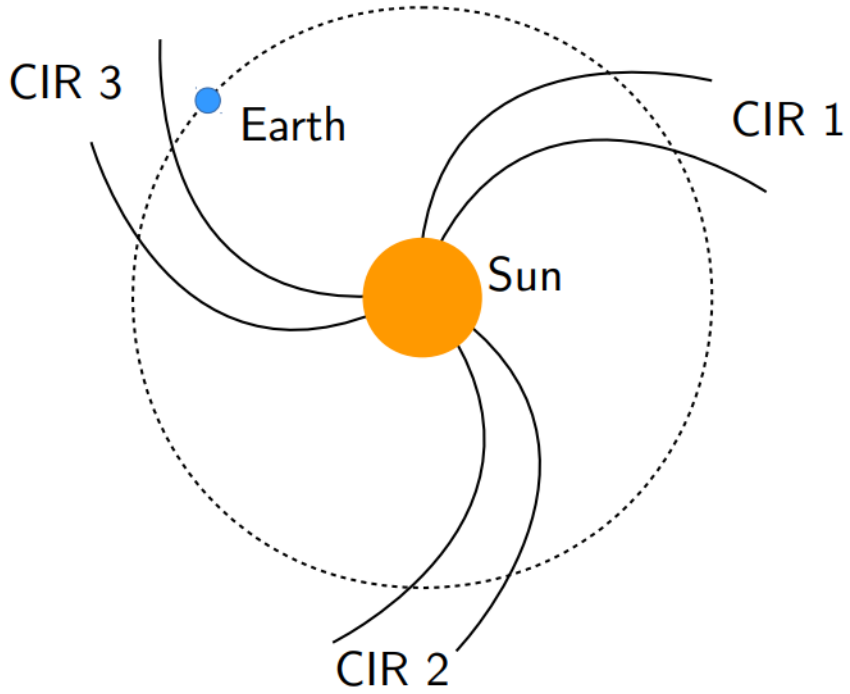
1. **Daily proton flux**
   - Focused on the time and rigidity dependence of short-term (less than a month) periodicities.
   - *AMS unique contribution*: first measurement of rigidity dependence of periodicities up to tens of GV.
2. **Daily helium flux**
   - Focused on the differences in heliospheric propagation between p & He for both short-term and long-term scales.
   - *AMS unique contribution*: first measurement of both p & He above 1.7 GV for an extended period of time.

1. Daily proton paper

Recurrent variations with a period of 27 days and shorter periods (e.g. 13.5 and 9 days) are related to the passage of Corotating Interaction Regions originated from one or more (equatorial) **Coronal Holes** on the surface of the Sun.

The origin of the periodicities can be understood with **solar wind data** and Sun images.

- AMS measures **the rigidity dependence of the periodicities**, providing previously unavailable data for modelers to investigate the effect of CIRs at different energies and different times.



2. Daily helium paper

- **Long term** behaviour of solar modulation is related to **global** properties of the heliosphere, related to the magnetic field and solar wind configuration in the whole heliosphere;
- **Short term** behaviour of the solar modulation is related to the magnetic field and solar wind configuration in **local** (close to Earth) solar wind structures, like coronal mass ejections and corotating interaction regions.

- p/He flux ratio behaviour at different time scale can be used to probe the difference between **global** and **local** processes.

Summary

- MIB analysis efforts for daily p&He fluxes:
  - Implementation of the forward unfolding correction is on-going
  - Geomagnetic rigidity cut-off optimization and estimation of its systematic error

Proton and helium fluxes show fine structures related to the solar activity:

- Structures with measured periodicity of 27-, 13.5- and 9-days are clearly seen during the descending phase to solar minimum. These structures show features varying with rigidity and time.
  - **Daily proton flux paper (currently discussed at 14:00 o'clock meetings):**
- Below 7 GV the p/He flux ratio has a long-term variation and multiple short-term structures in coincidence with periods of strong flux suppression were observed.
  - **Daily helium flux paper:**