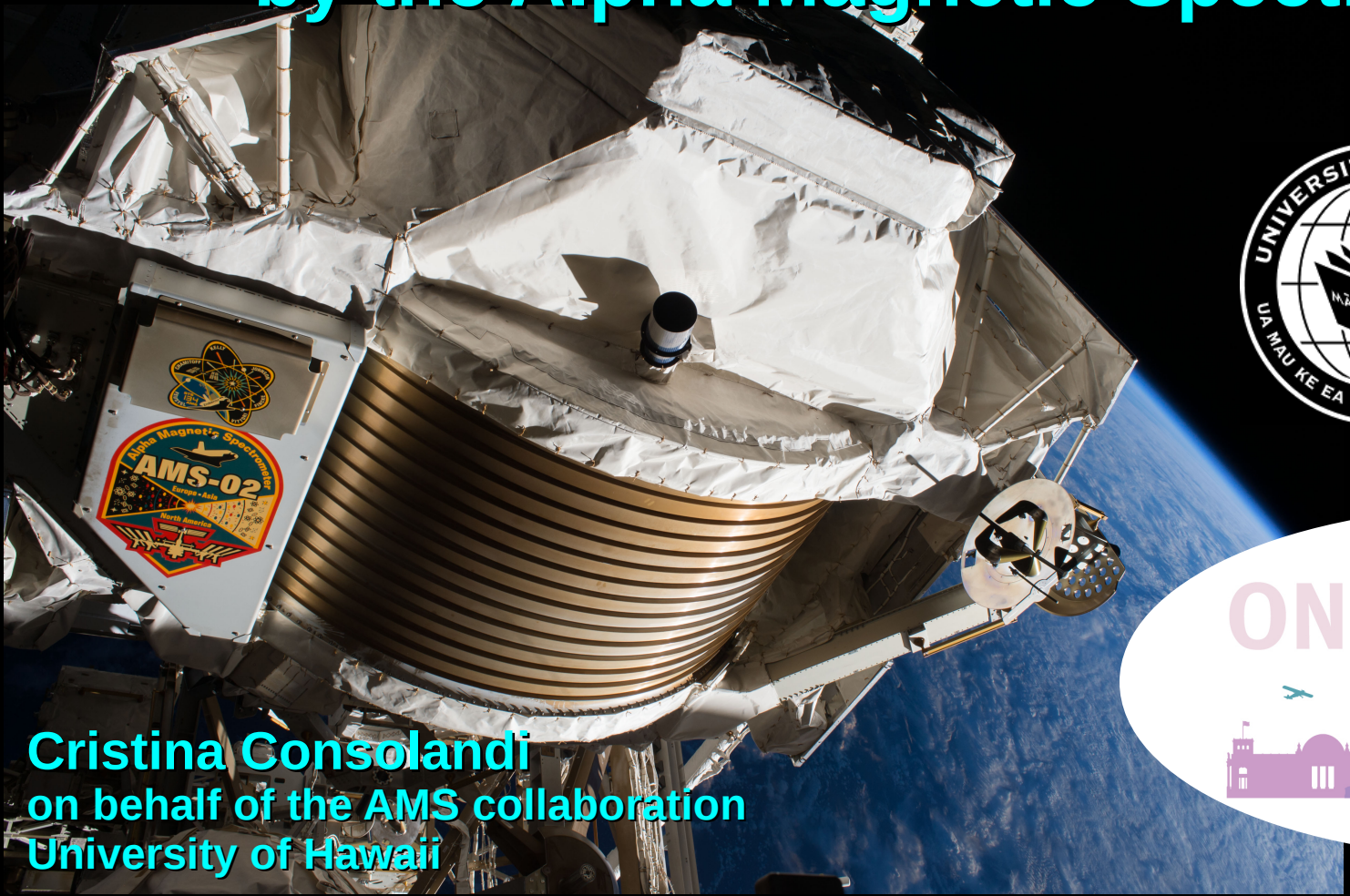
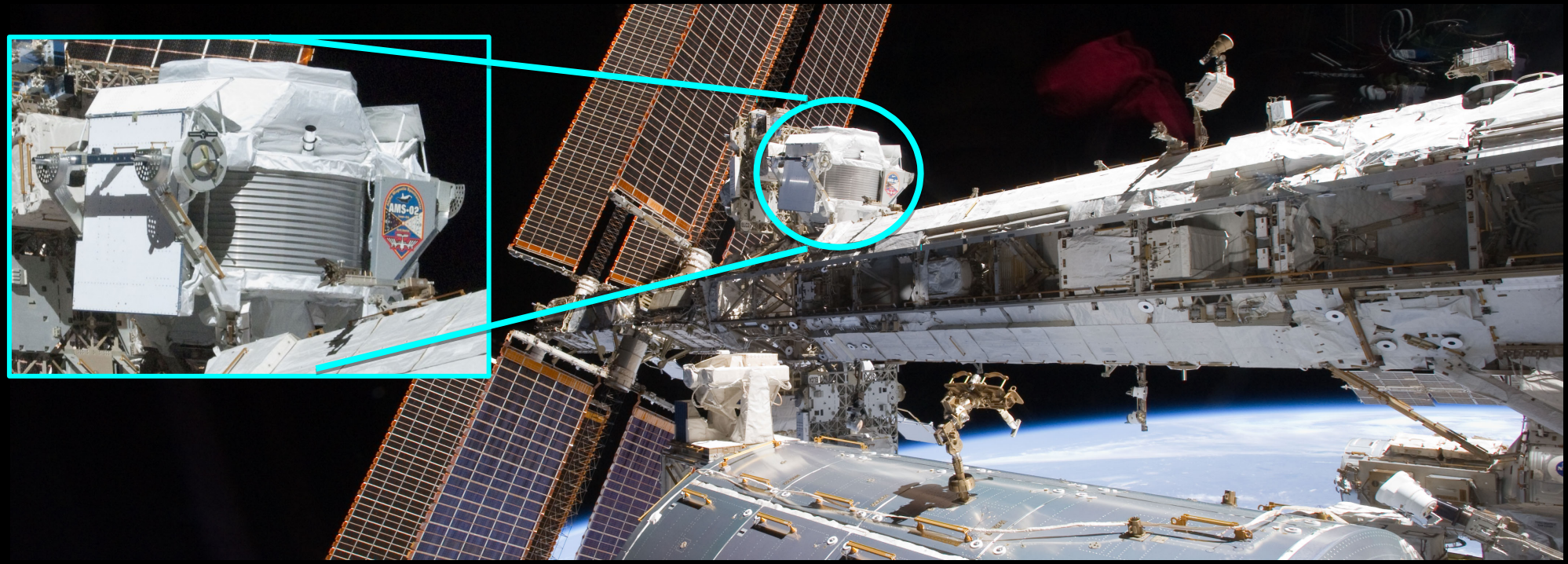
Precision Measurement of Daily Helium Fluxes by the Alpha Magnetic Spectrometer



Cristina Consolandi
on behalf of the AMS collaboration
University of Hawaii

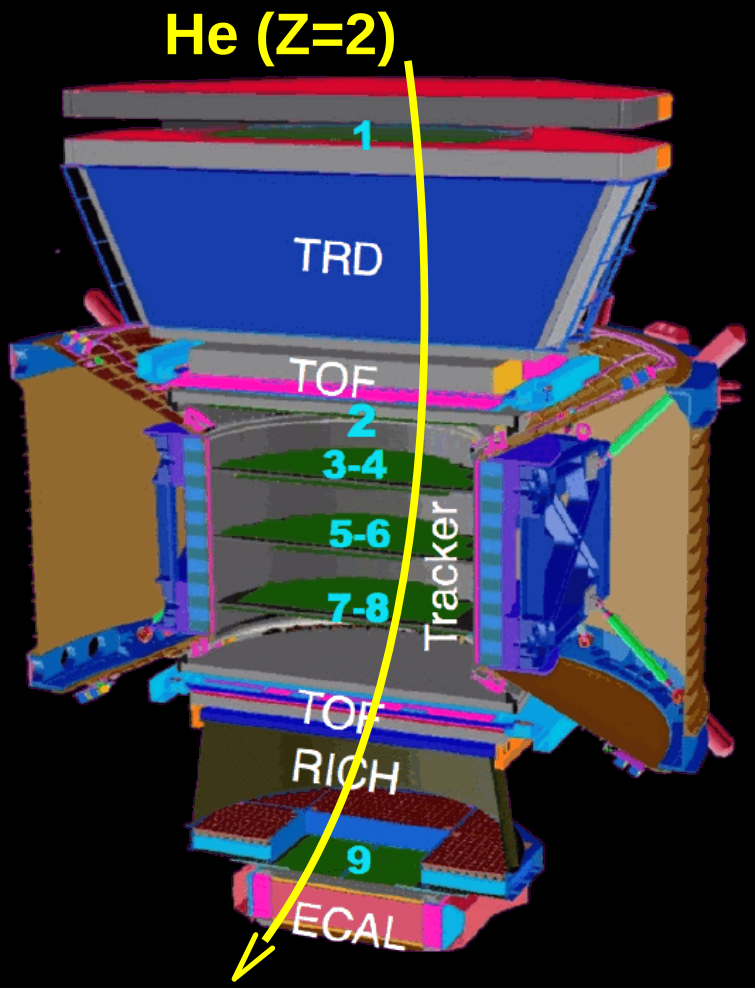
ONLINE ICRC 2021
THE ASTROPARTICLE PHYSICS CONFERENCE
Berlin | Germany
37th International Cosmic Ray Conference
12–23 July 2021

Alpha Magnetic Spectrometer
on the International Space Station since May 2011



Over 180 billion charged particles have been measured

AMS Particle Detector



Transition Radiation Detector
- e+ e- identification

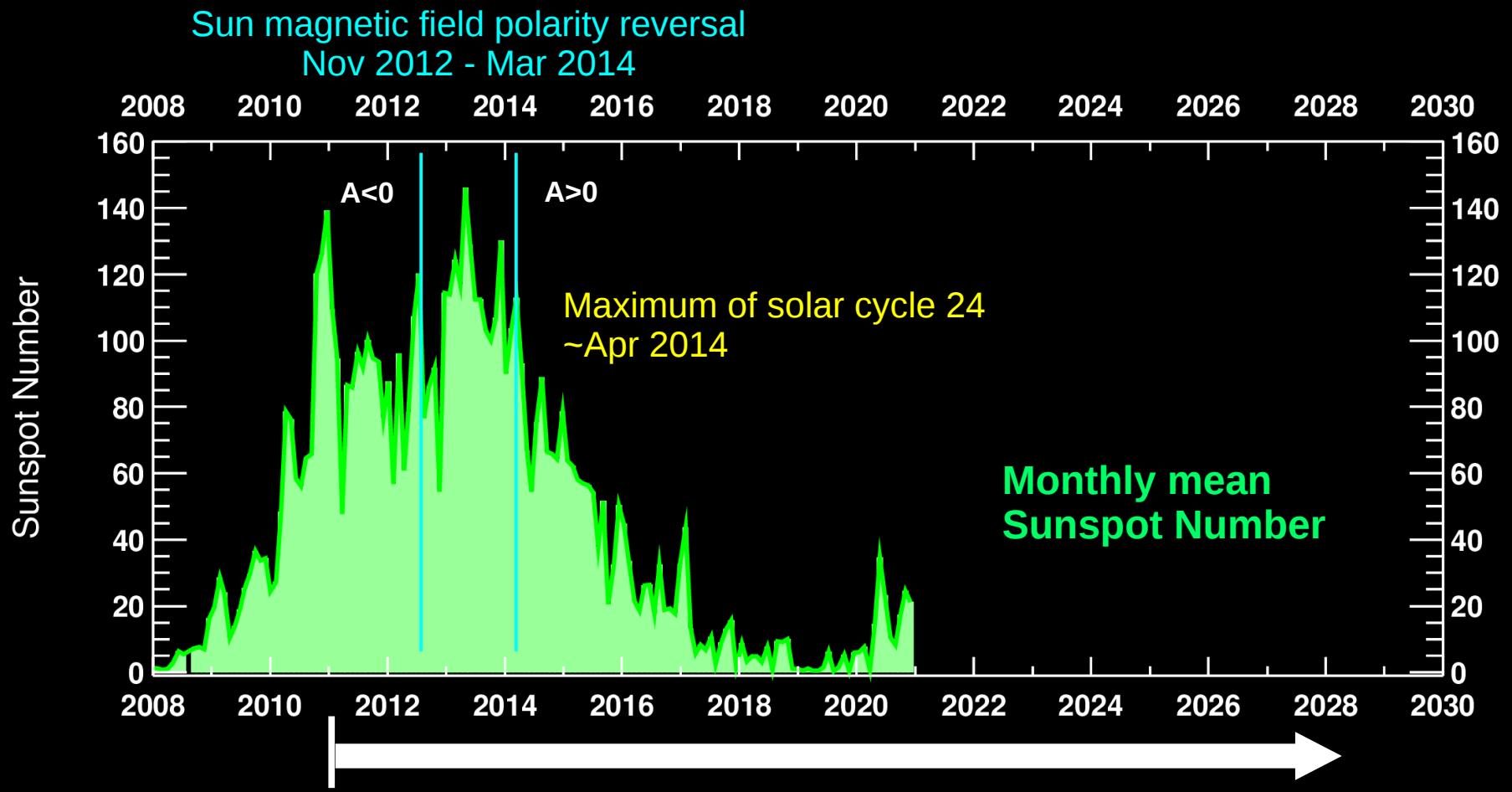
Time-of-Flight counter
- Trigger
- Velocity
- Charge
- Particle flight direction

Silicon Tracker + Magnet
- Rigidity
- Charge & sign

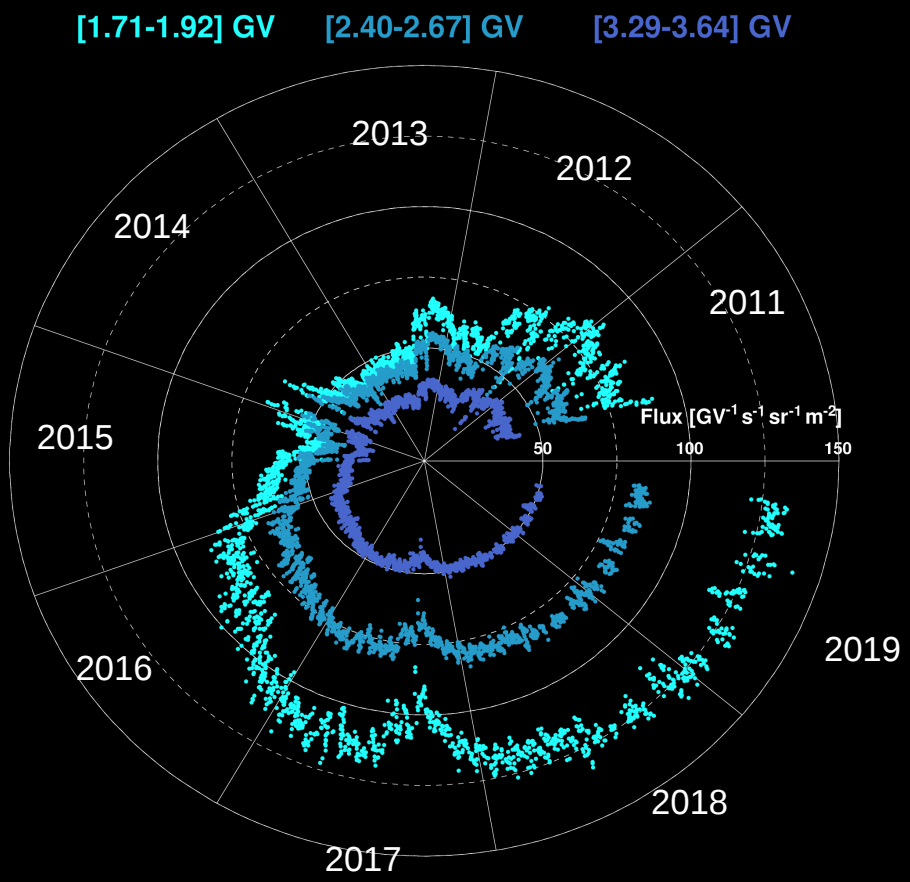
Ring Imaging Cherenkov detector
- Velocity
- Charge

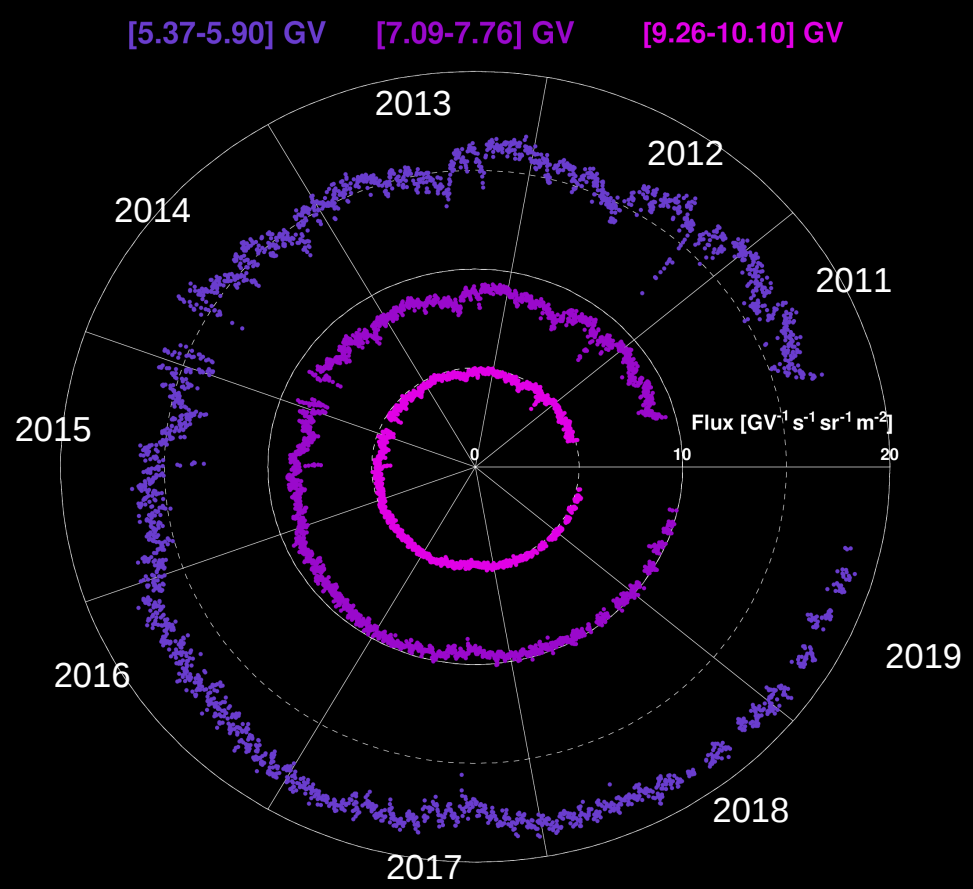
Electromagnetic Calorimeter
- e+ e- identification
- e+ e- Energy

AMS Period of Observation



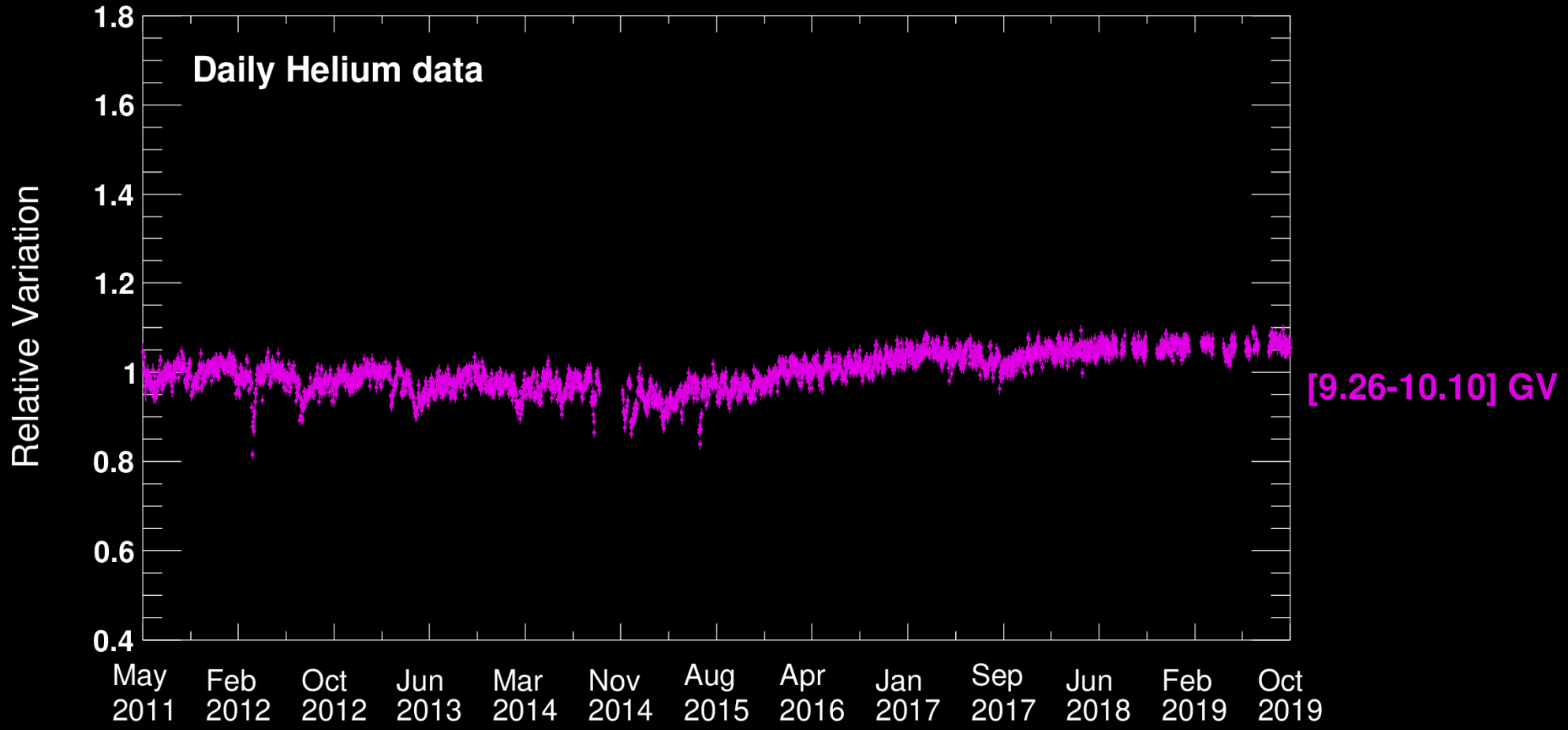
Daily Helium Fluxes: May 20, 2011 - Oct 29, 2019





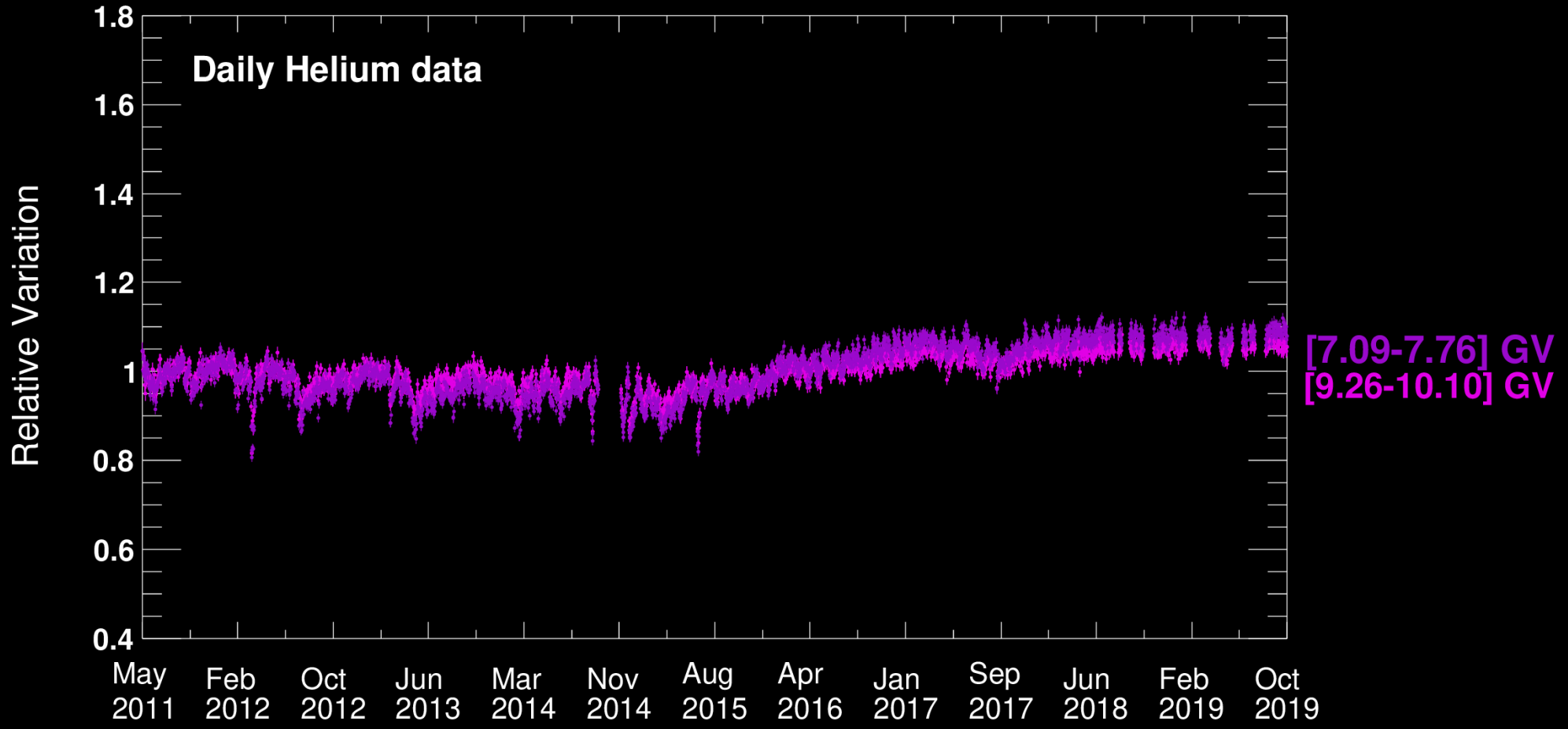
Preliminary data, refer to upcoming AMS publication

Daily Helium Fluxes Relative Variation



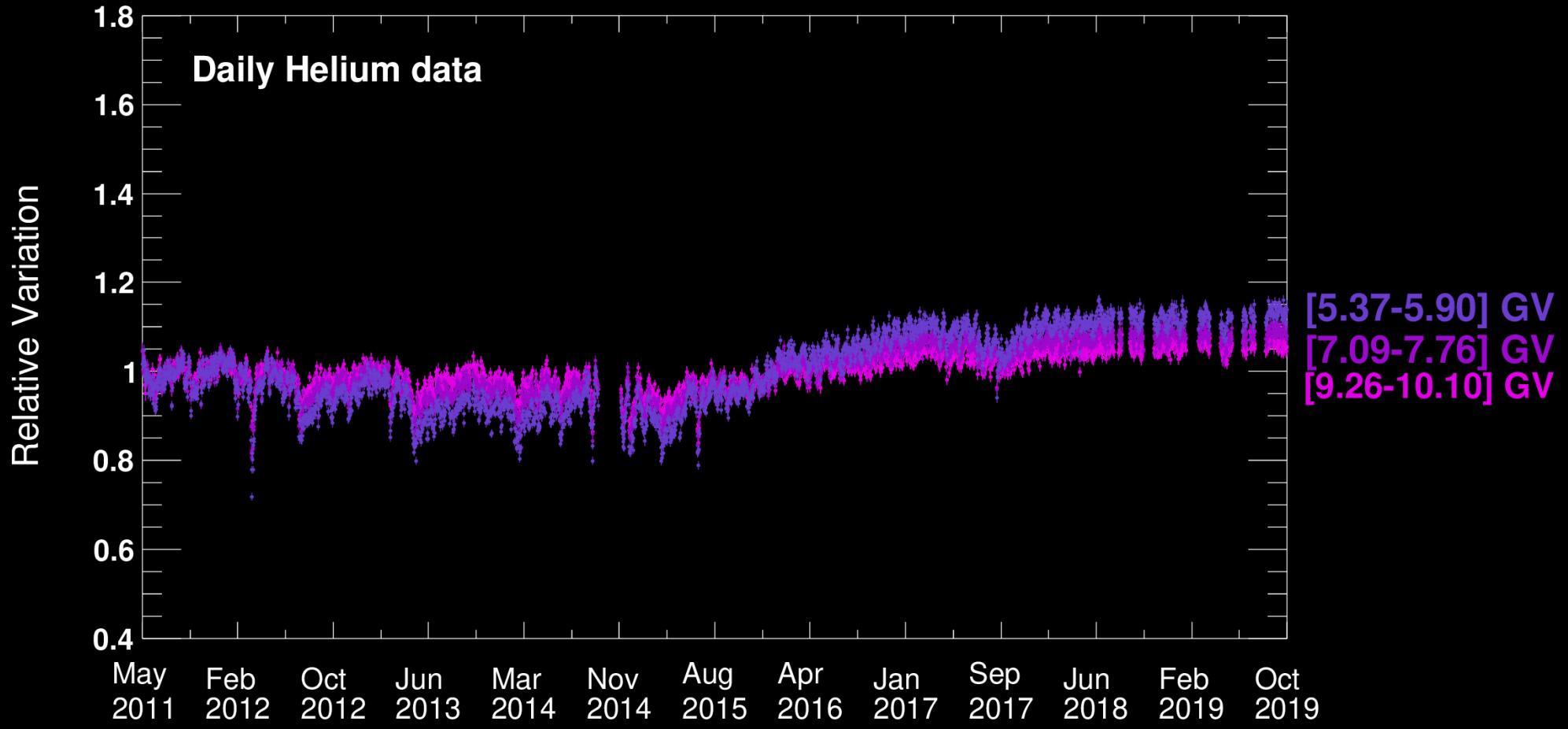
Preliminary data, refer to upcoming AMS publication

Daily Helium Fluxes Relative Variation



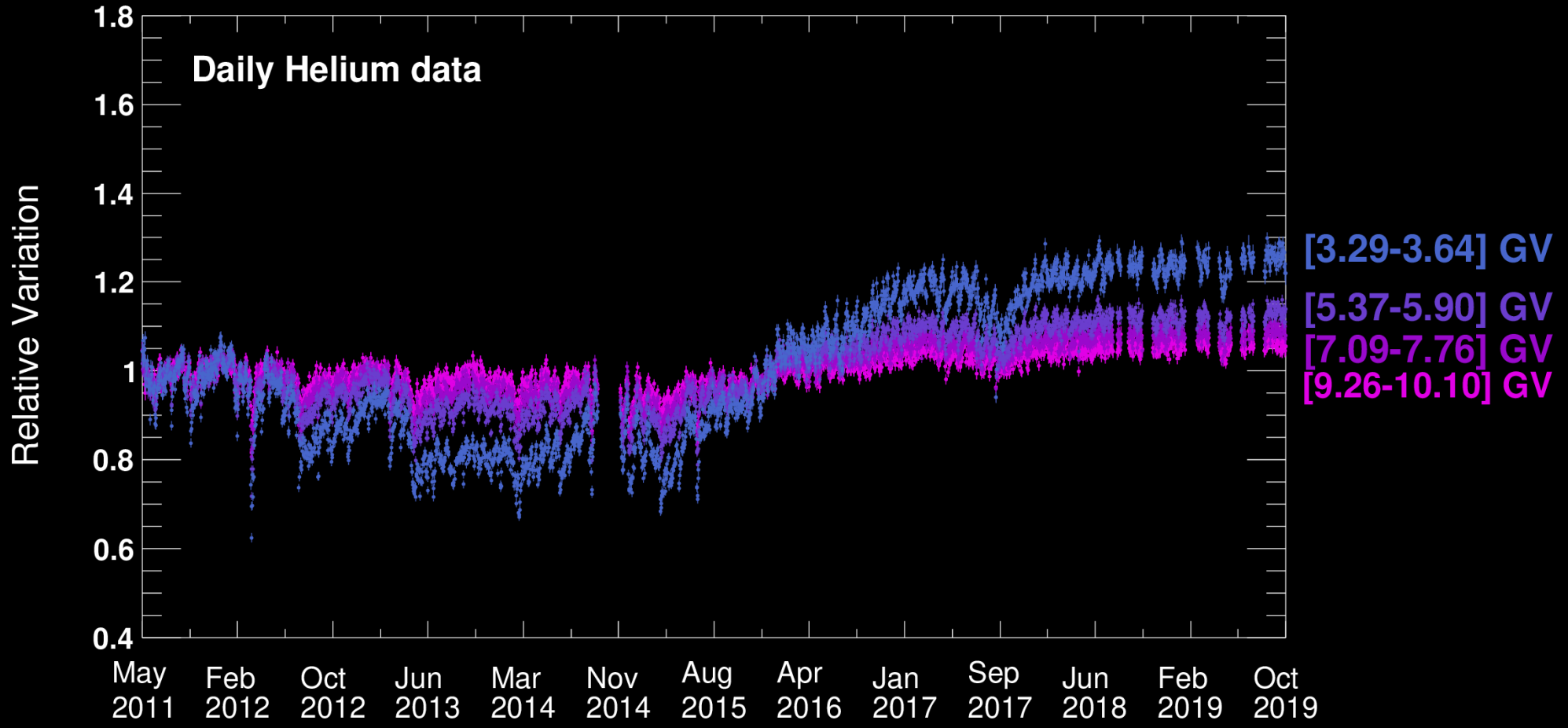
Preliminary data, refer to upcoming AMS publication

Daily Helium Fluxes Relative Variation



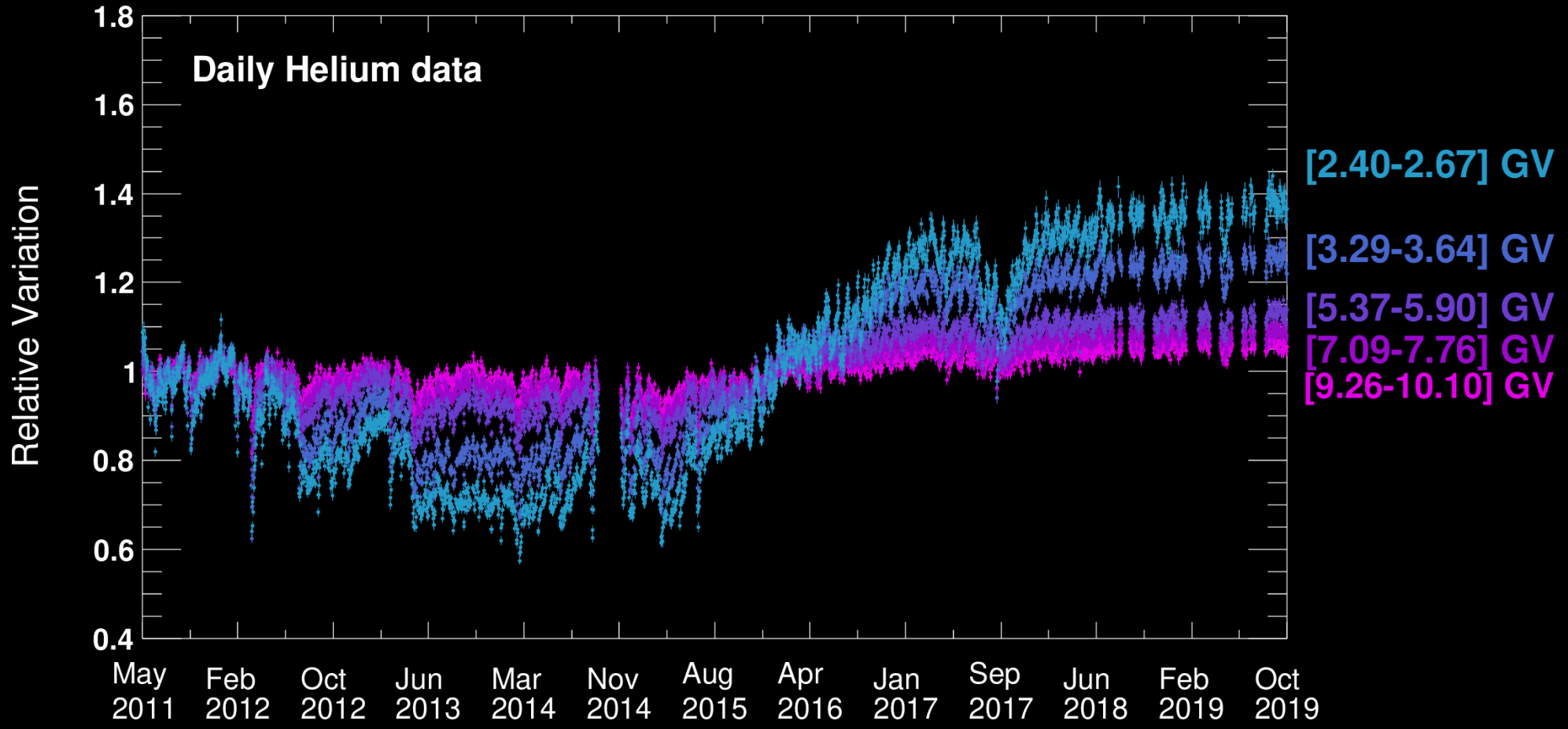
Preliminary data, refer to upcoming AMS publication

Daily Helium Fluxes Relative Variation



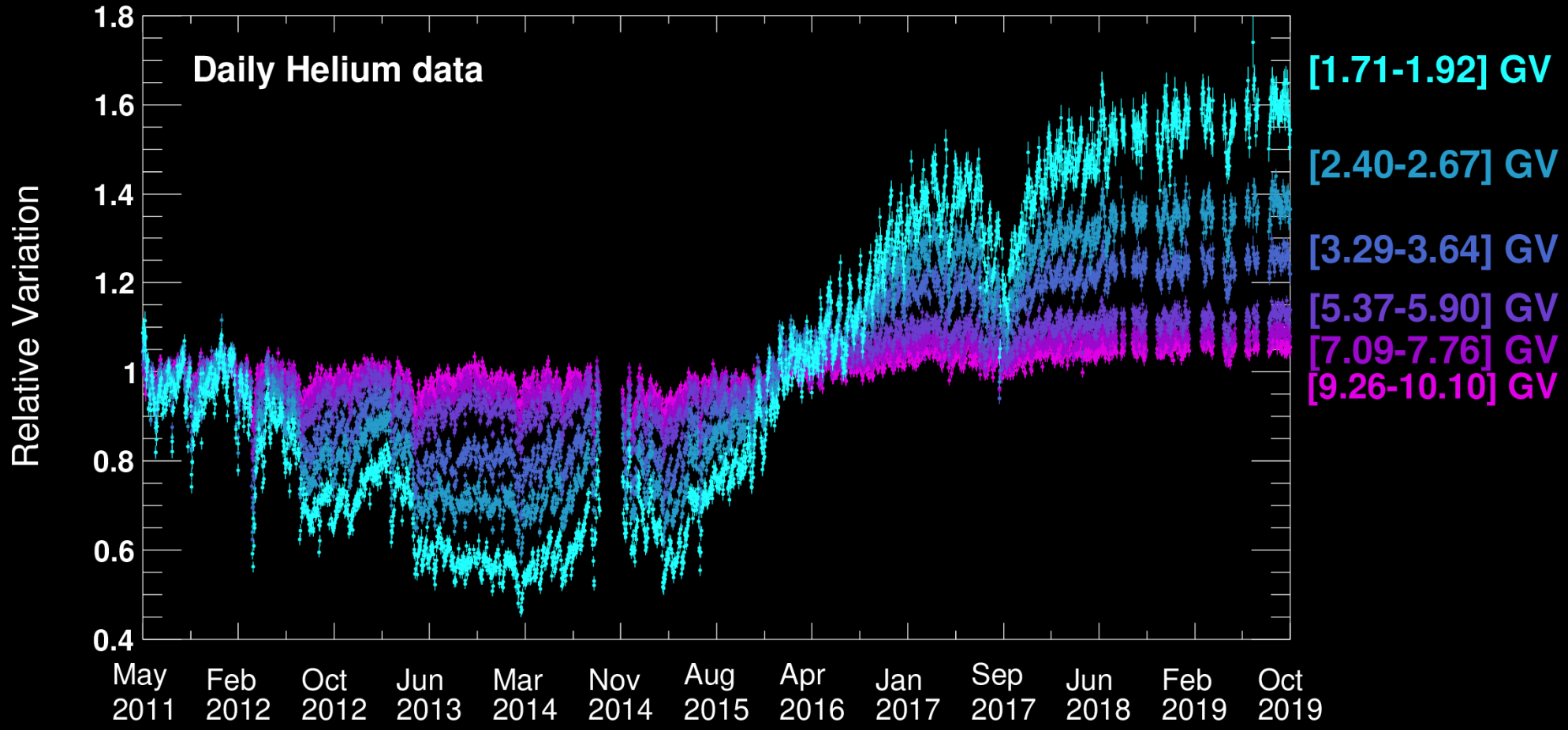
Preliminary data, refer to upcoming AMS publication

Daily Helium Fluxes Relative Variation



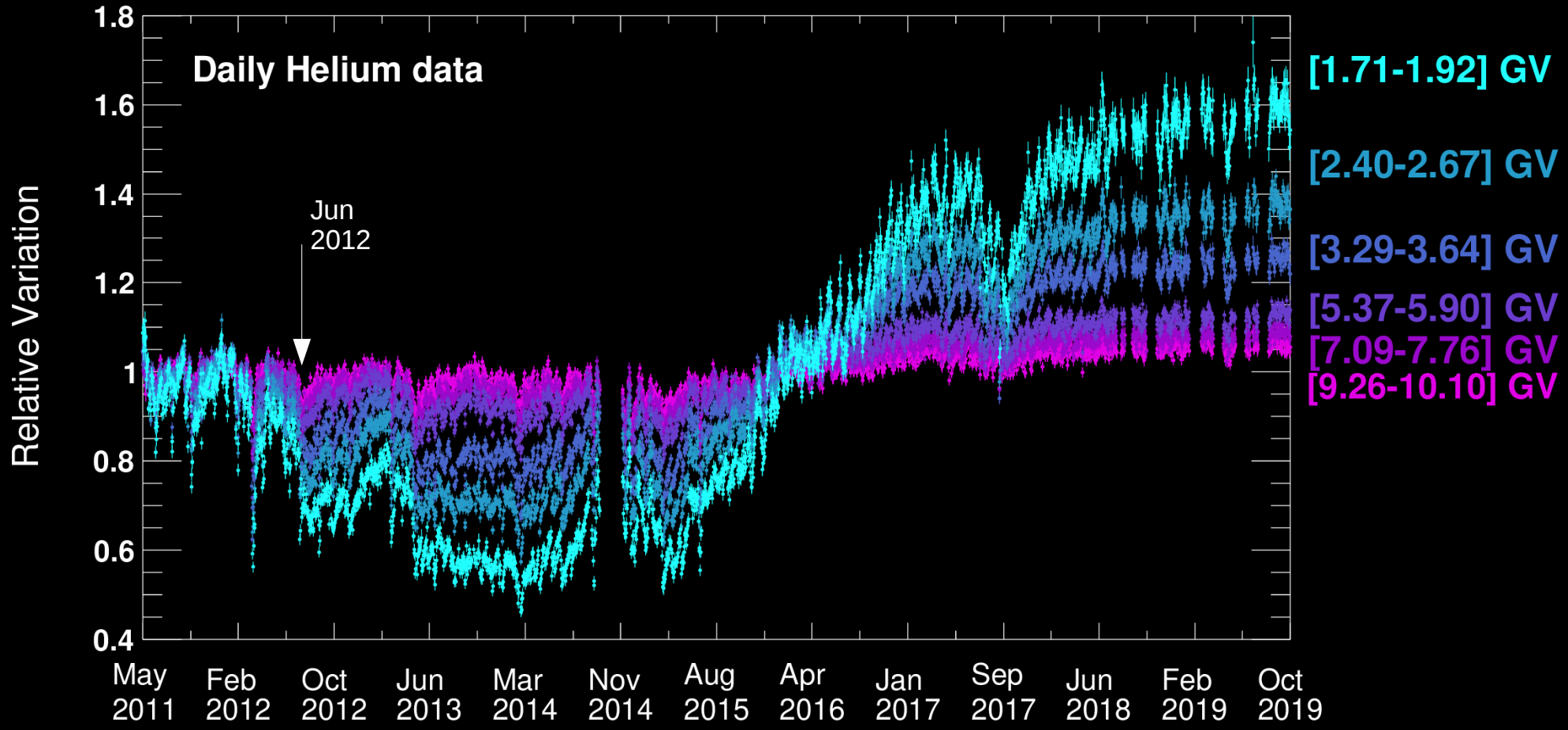
Preliminary data, refer to upcoming AMS publication

Daily Helium Fluxes Relative Variation



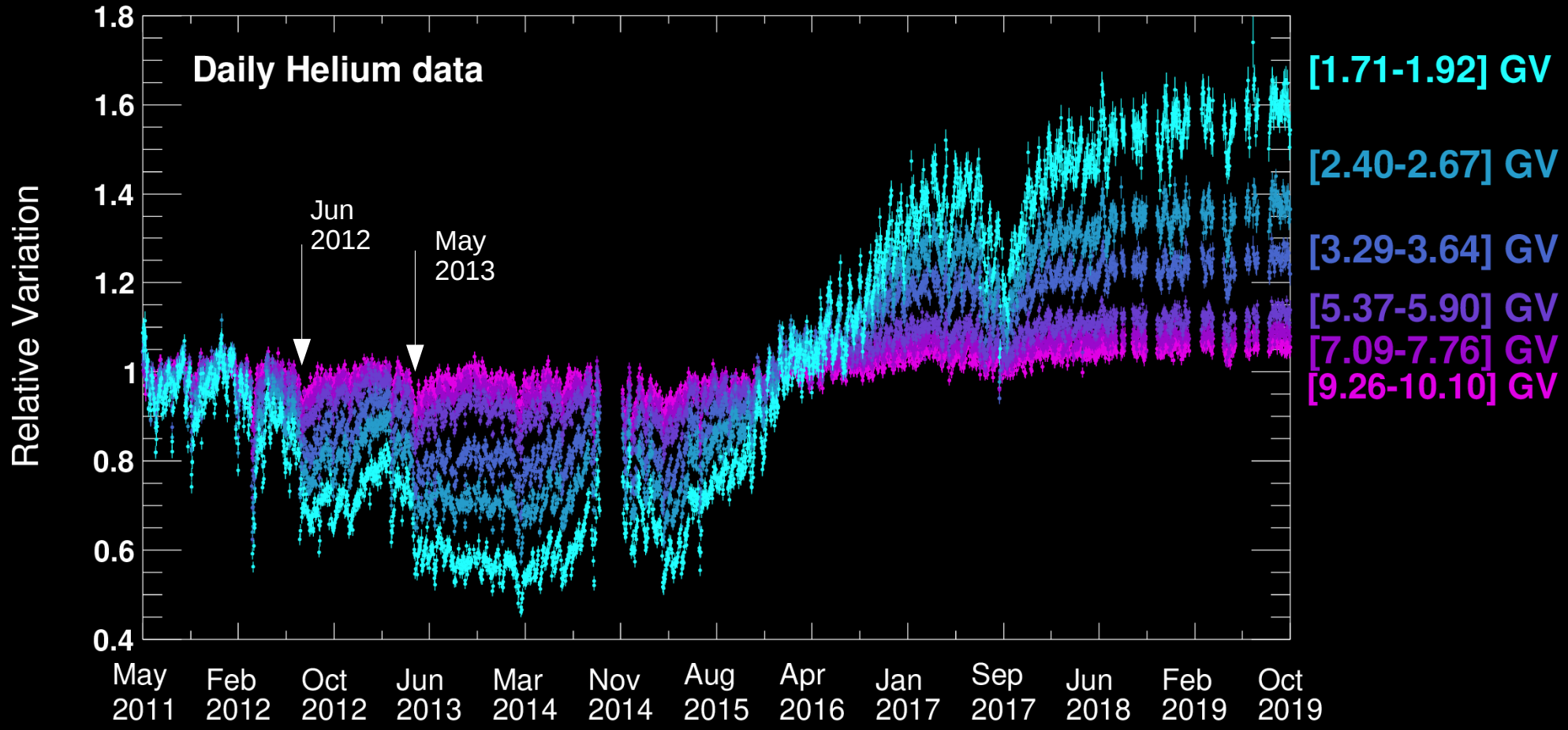
Preliminary data, refer to upcoming AMS publication

Daily Helium Fluxes Relative Variation



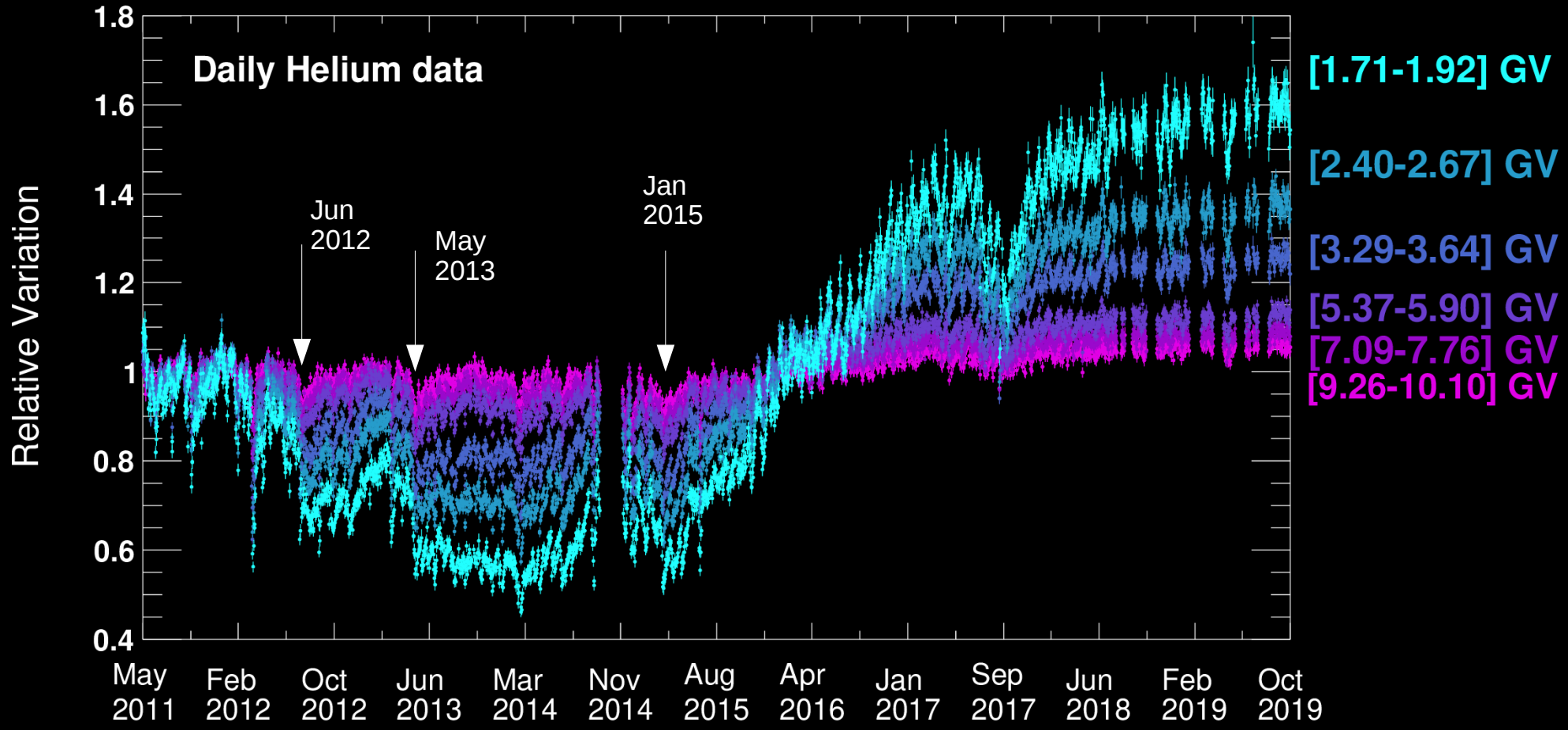
Preliminary data, refer to upcoming AMS publication

Daily Helium Fluxes Relative Variation



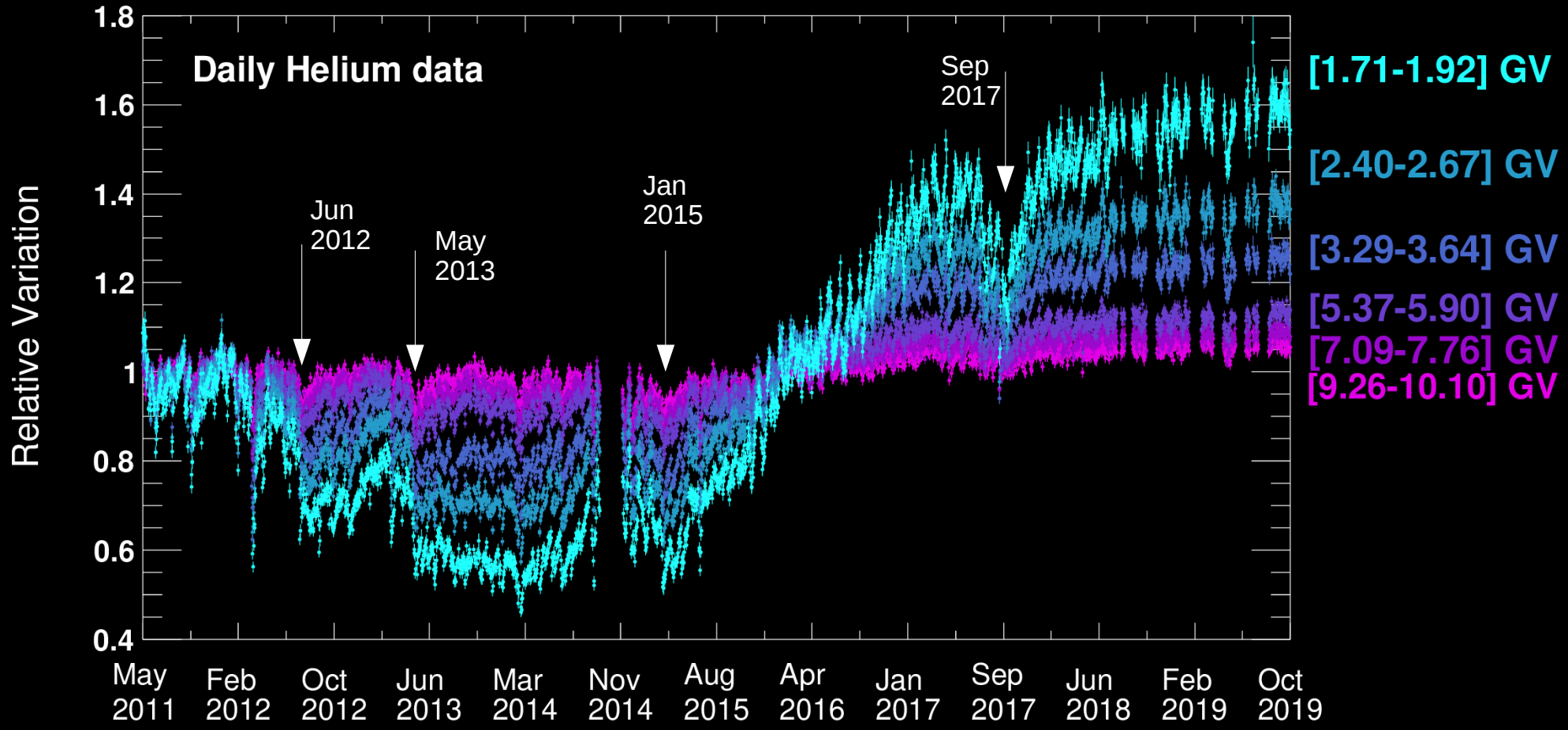
Preliminary data, refer to upcoming AMS publication

Daily Helium Fluxes Relative Variation



Preliminary data, refer to upcoming AMS publication

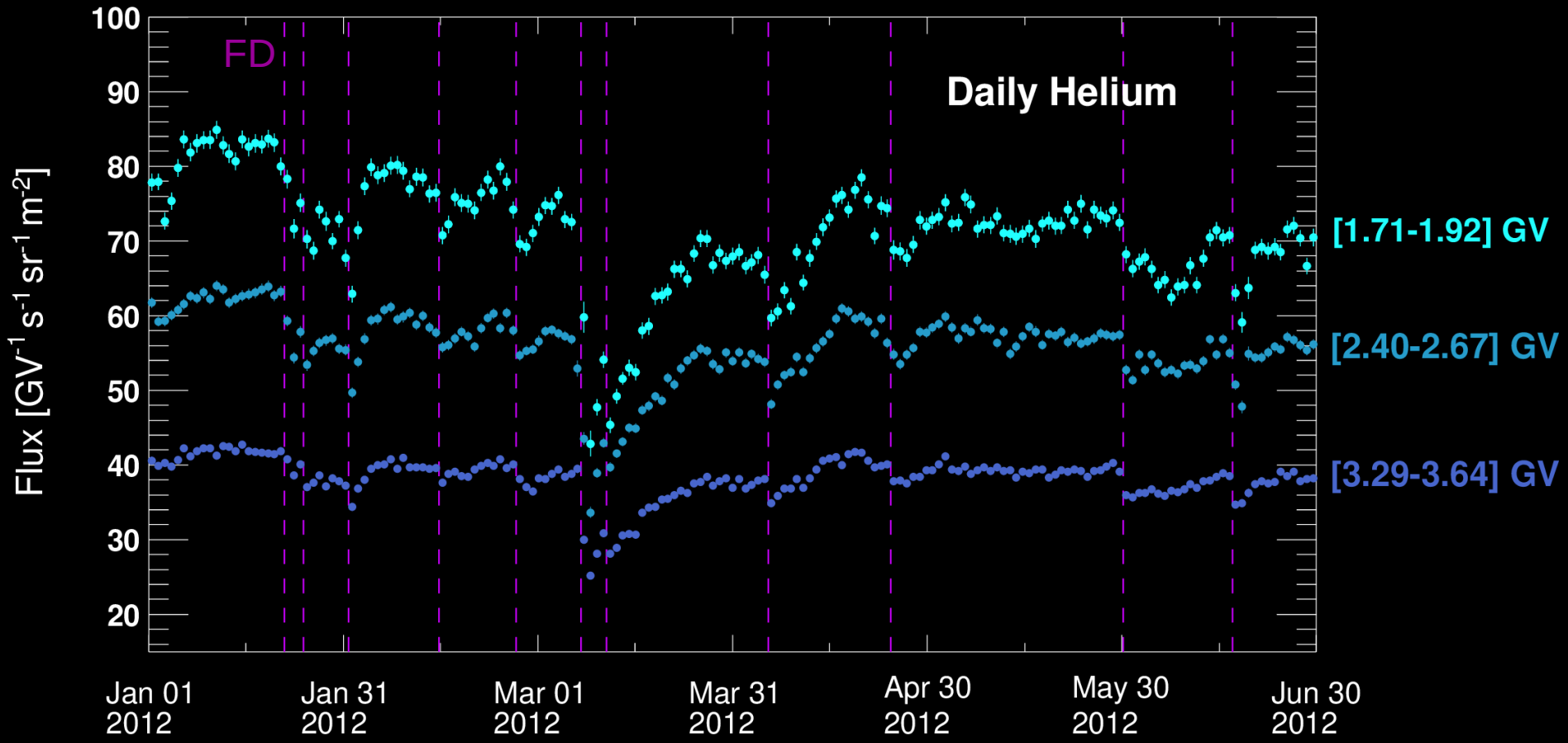
Daily Helium Fluxes Relative Variation



Preliminary data, refer to upcoming AMS publication

Helium Forbush Decreases

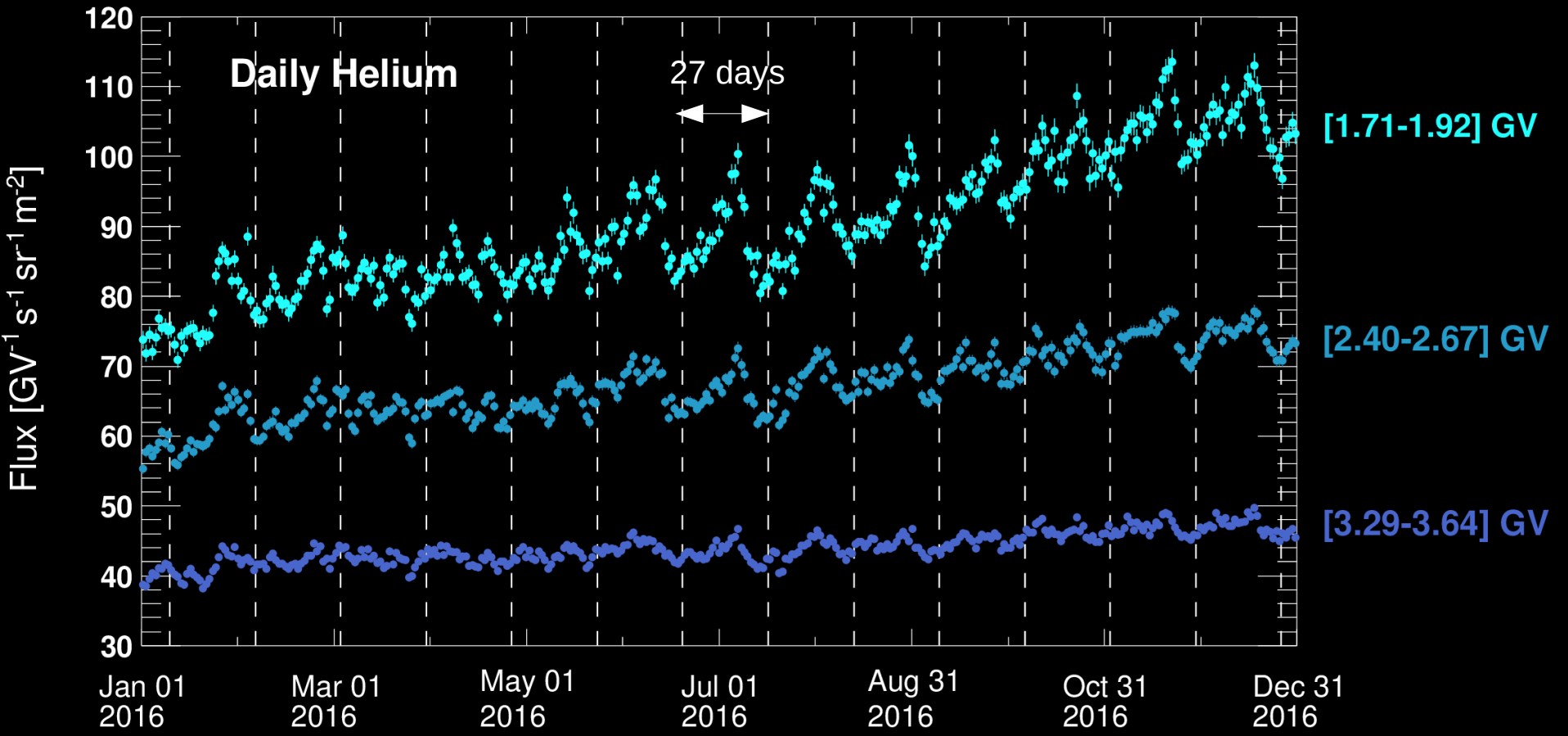
Over 100 Forbush decrease events were observed.



Preliminary data, refer to upcoming AMS publication

Daily Helium Periodicities

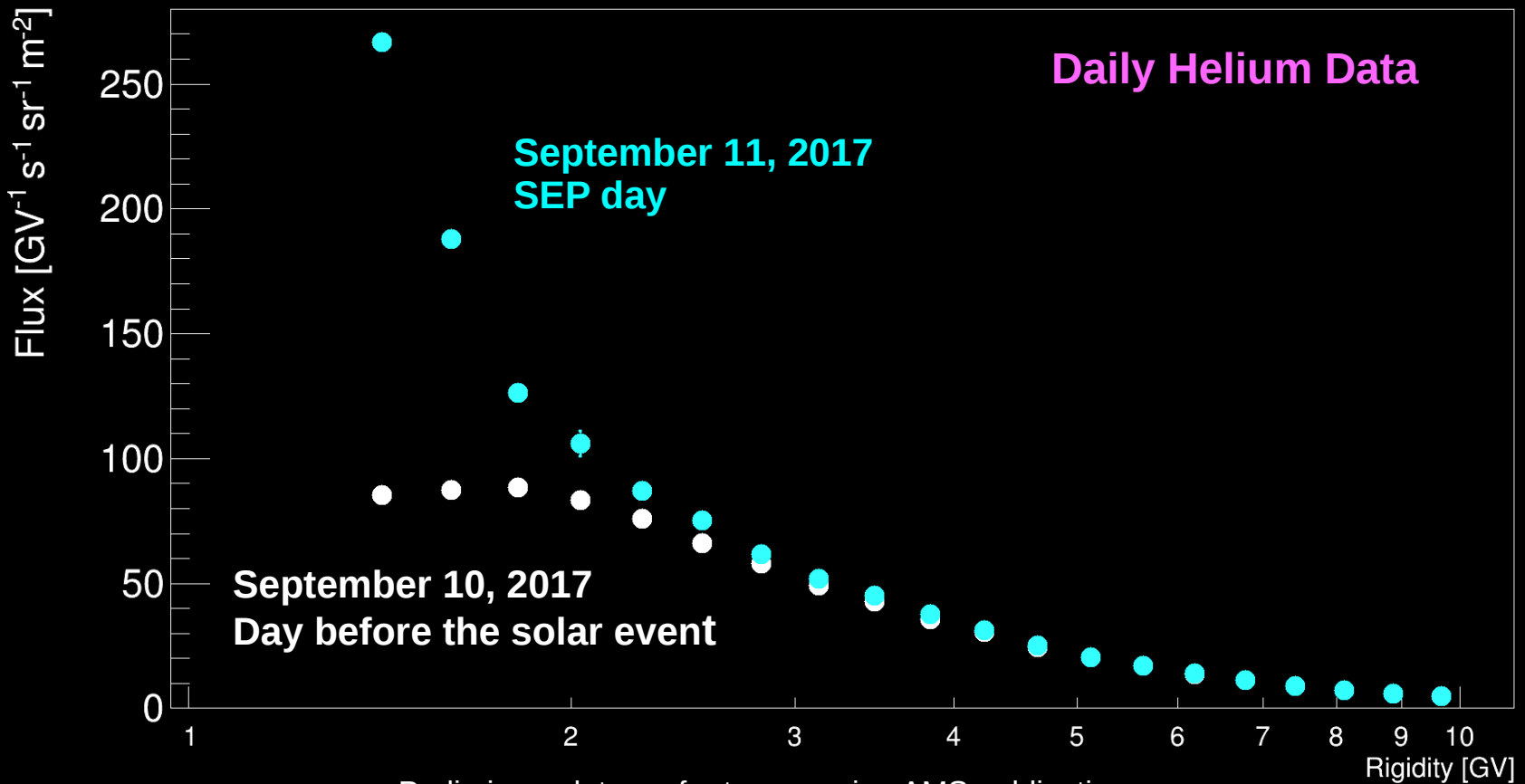
#749 Y. Jia: Precision Measurement of Periodicities in the Daily Proton Fluxes with AMS



Preliminary data, refer to upcoming AMS publication

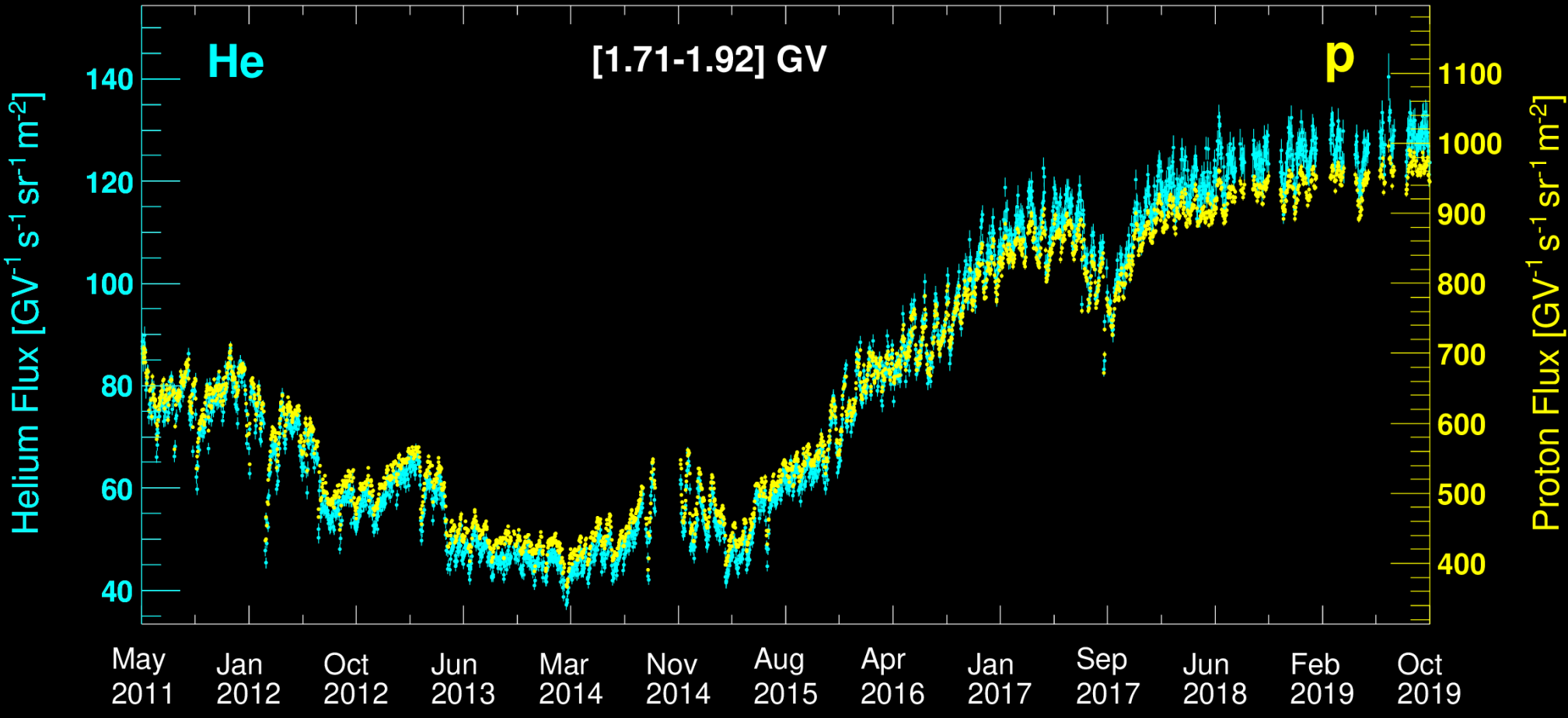
Helium Solar Energetic Particles

#1003 C. Light: Solar Energetic Particles measured by AMS during solar cycle 24



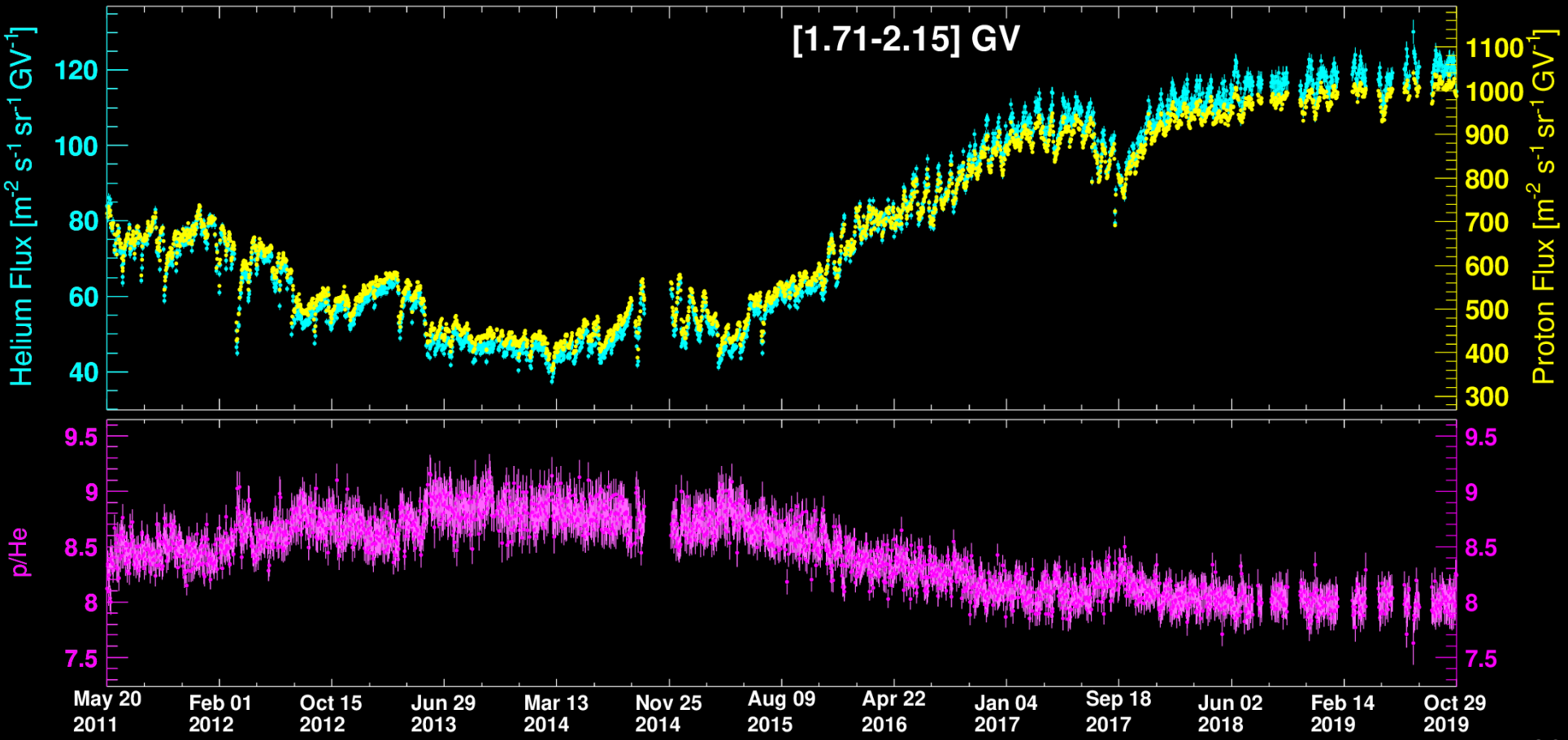
Preliminary data, refer to upcoming AMS publication

Daily Helium and Proton Flux Comparison



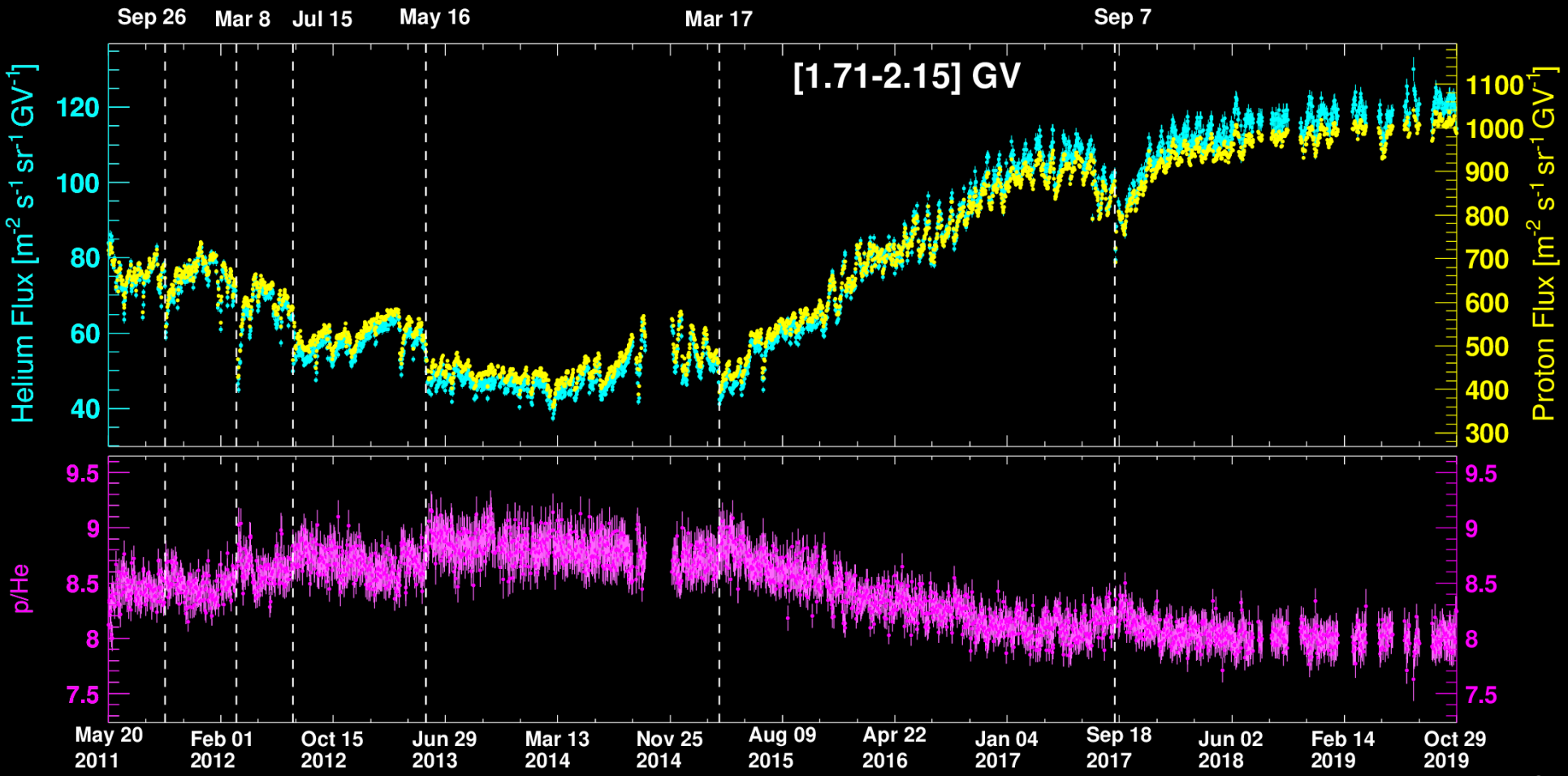
Preliminary data, refer to upcoming AMS publication

Daily p/He Flux Ratio



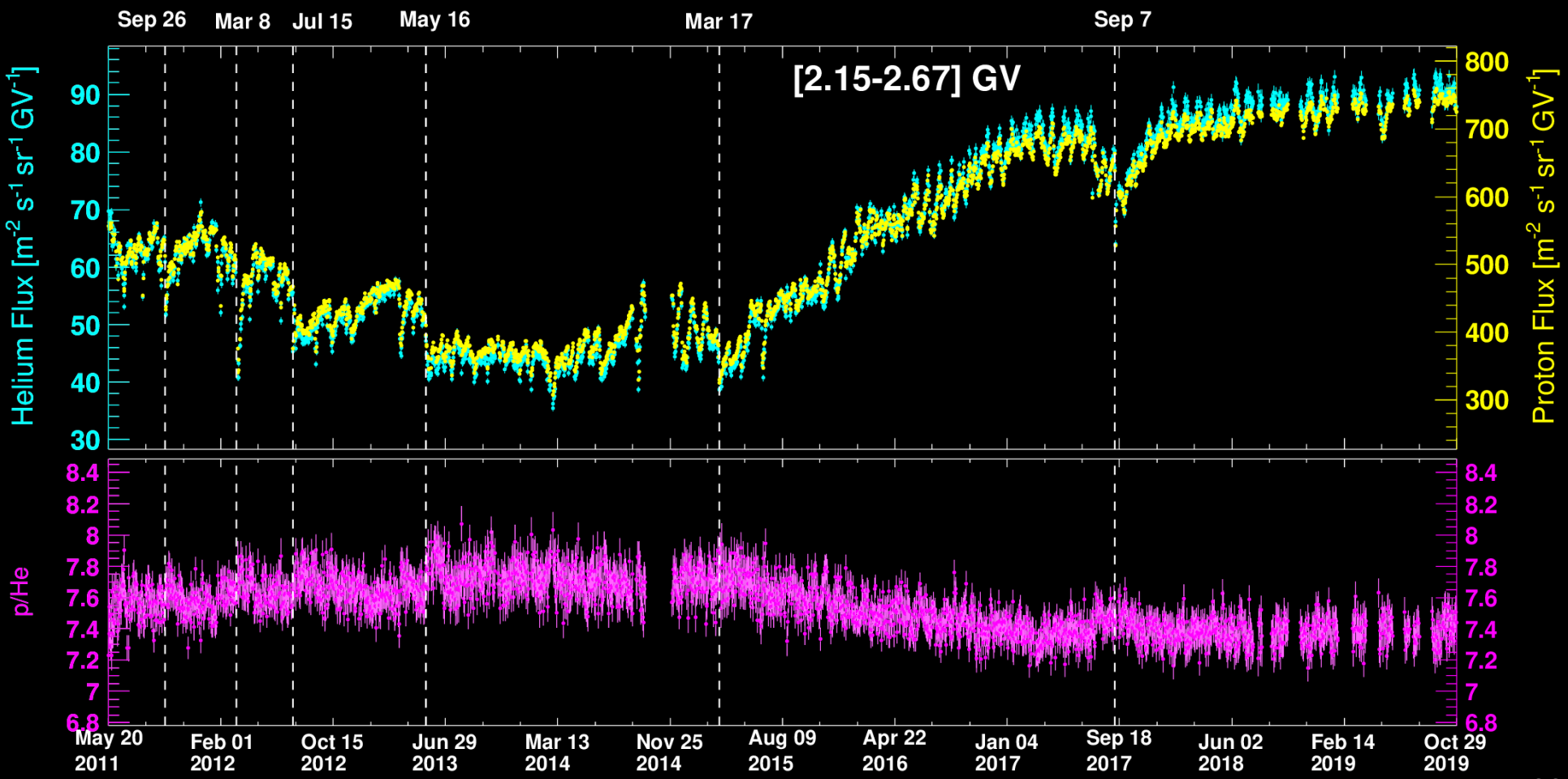
Preliminary data, refer to upcoming AMS publication

Daily p/He Flux Ratio



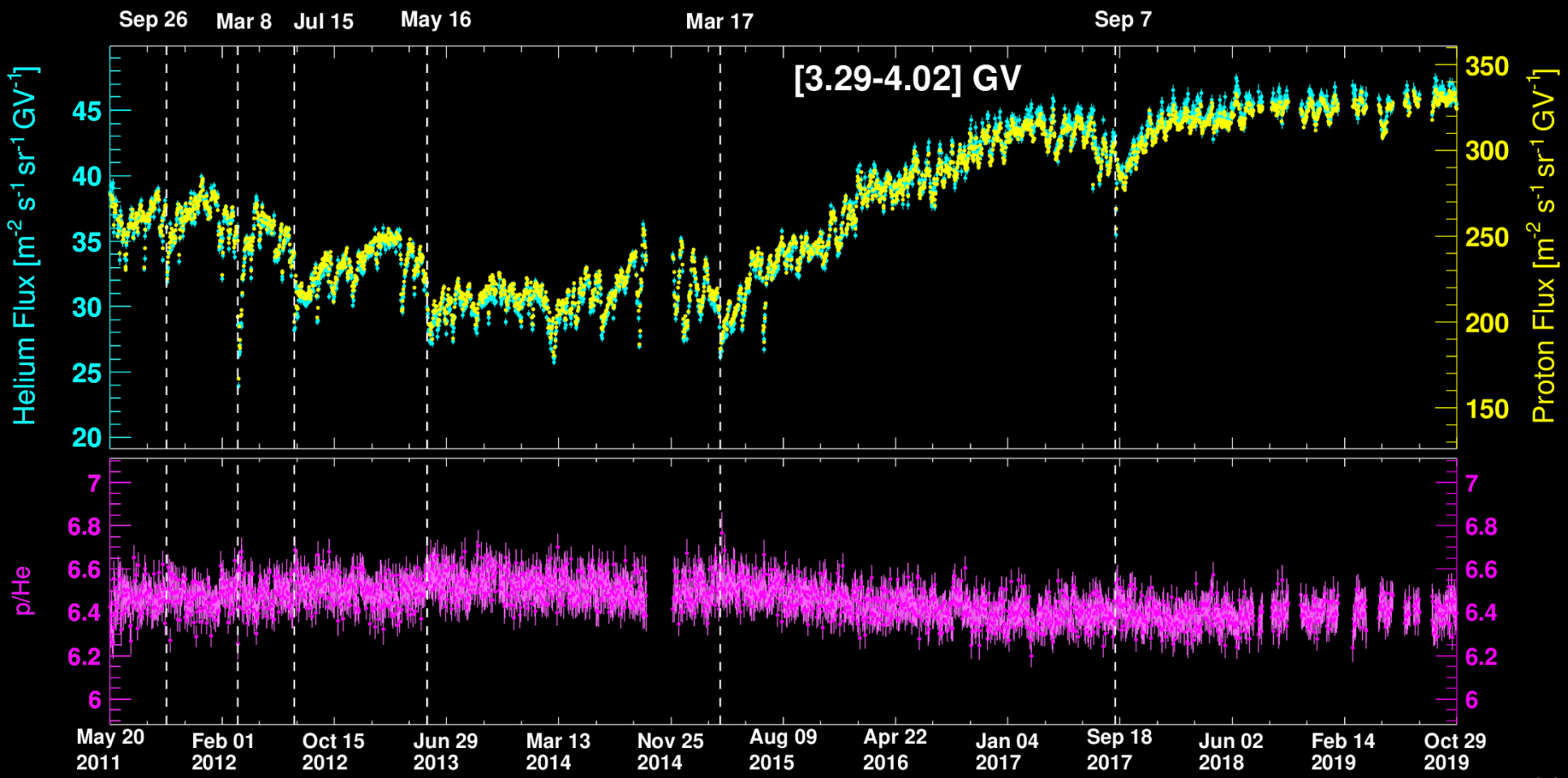
Preliminary data, refer to upcoming AMS publication

Daily p/He Flux Ratio



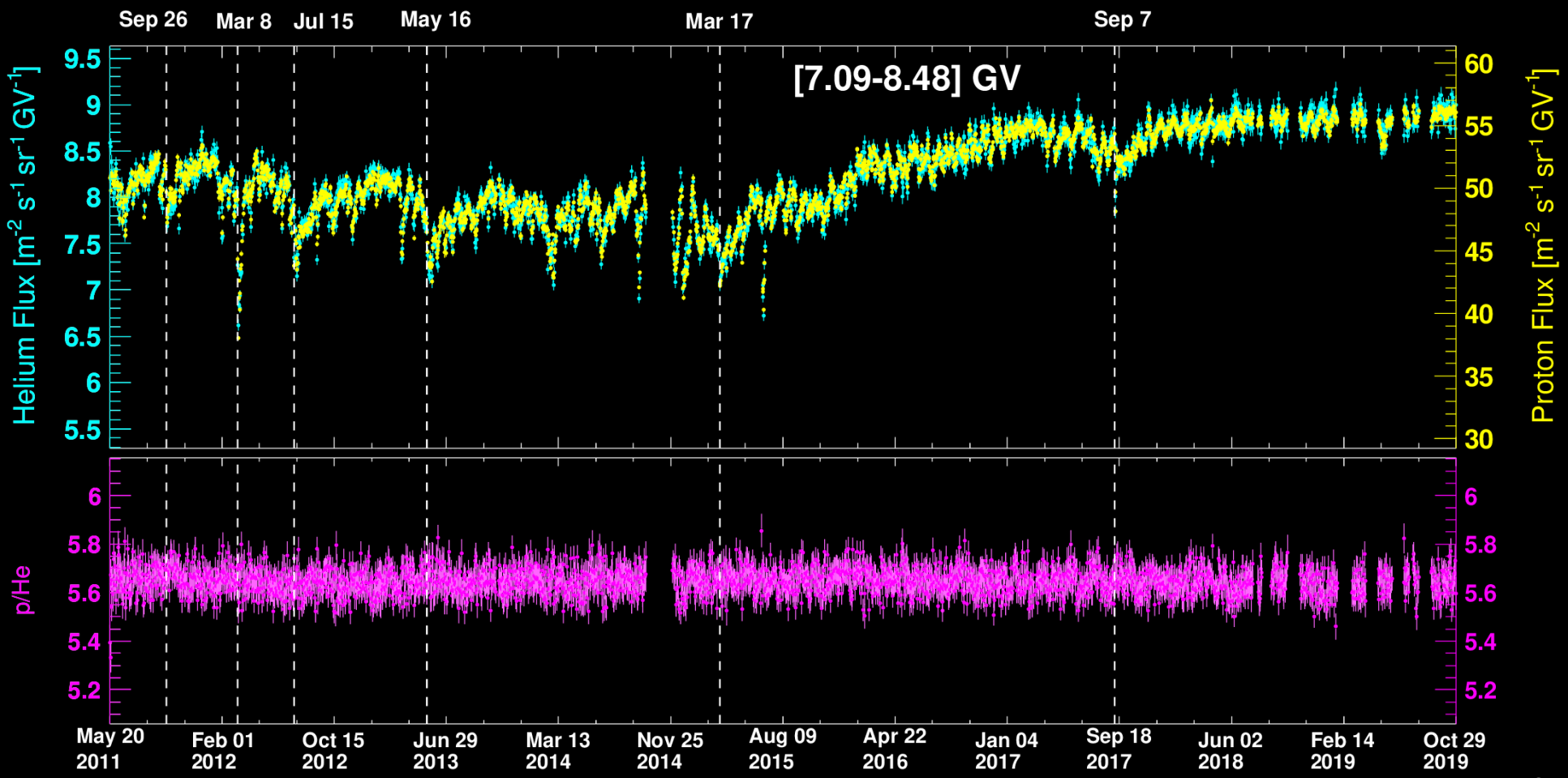
Preliminary data, refer to upcoming AMS publication

Daily p/He Flux Ratio



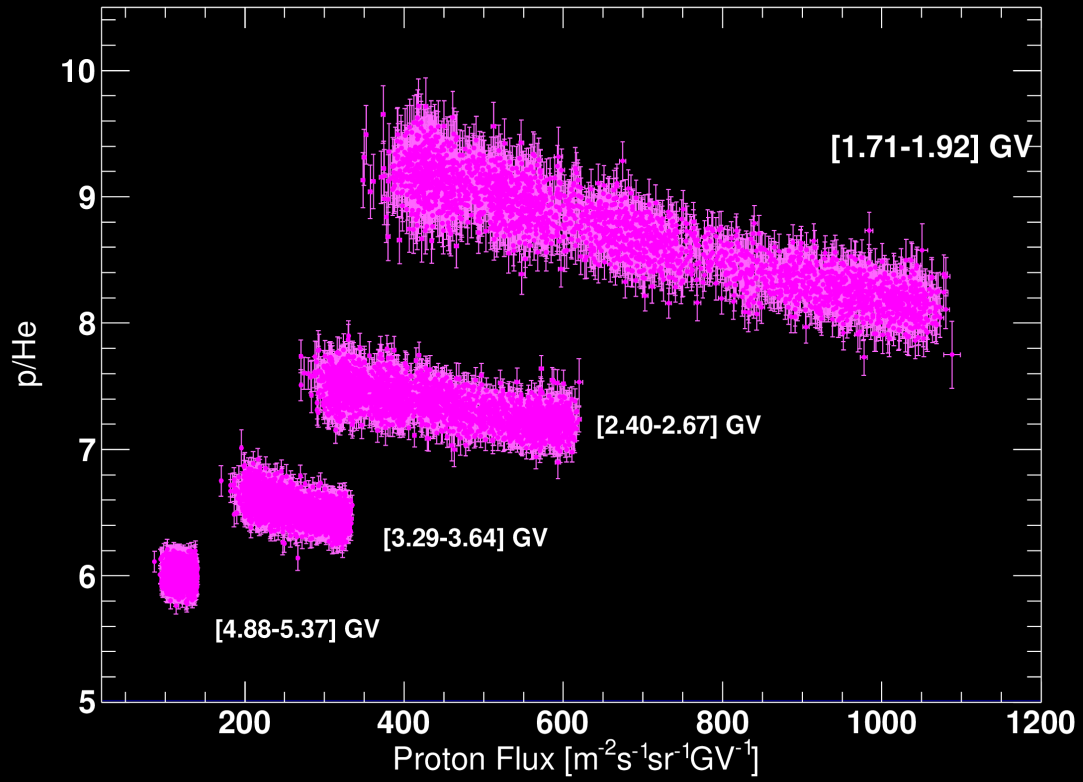
Preliminary data, refer to upcoming AMS publication

Daily p/He Flux Ratio



Preliminary data, refer to upcoming AMS publication

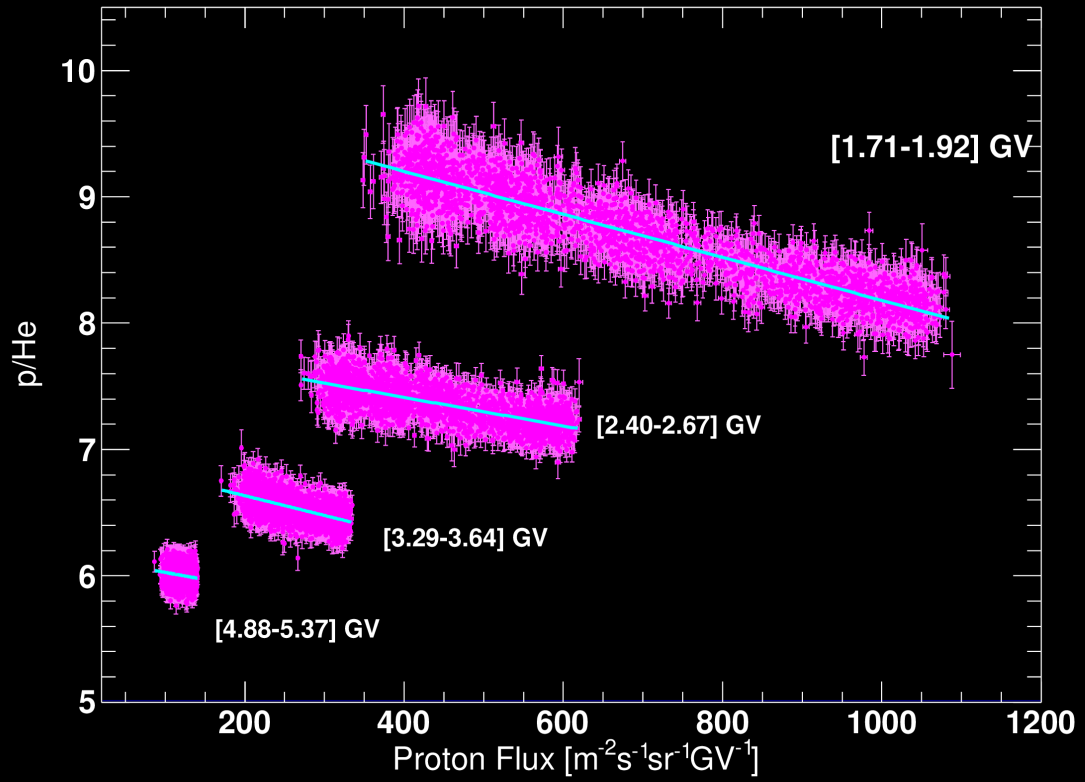
Daily p/He Flux Ratio
Anticorrelation with the Absolute Flux

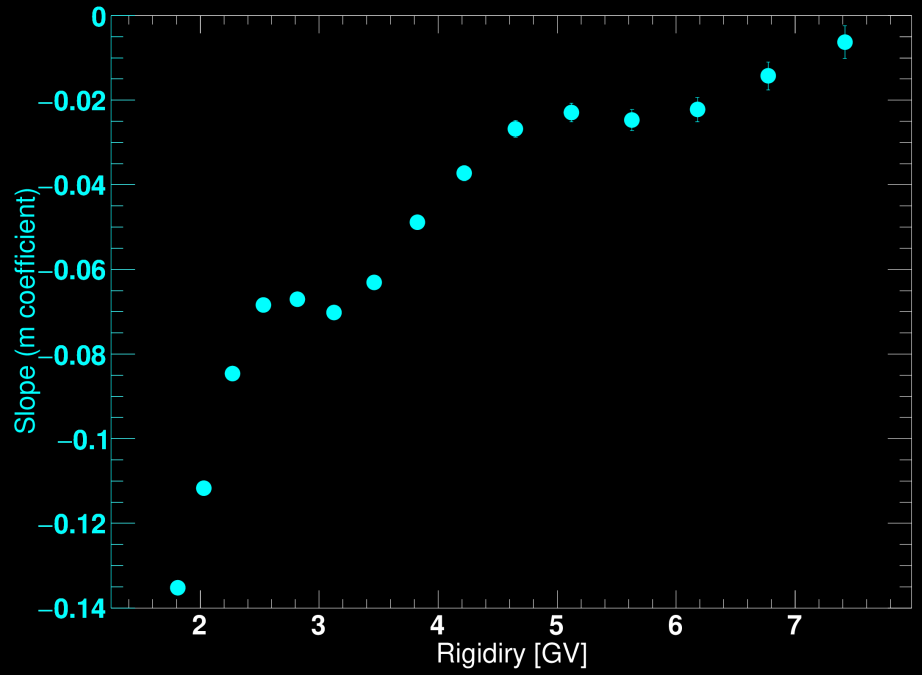


Preliminary data, refer to upcoming AMS publication

Daily p/He Flux Ratio
Anticorrelation with the Absolute Flux

$$\frac{p/He}{\langle p/He \rangle} - 1 = m\left(\frac{p}{\langle p \rangle} - 1\right)$$





Preliminary data, refer to upcoming AMS publication

Propagation of GCR in Heliosphere - Parker Equation

$$\frac{\partial f}{\partial t} = \underbrace{-\vec{V}_{SW}\cdot\vec{\nabla} f}_{\text{Solar wind convection}} \underbrace{-\vec{V}_{D}\cdot\vec{\nabla} f}_{\text{Particle drifts}} + \underbrace{\vec{\nabla}\cdot(K\cdot\vec{\nabla} f)}_{\text{Particle diffusion}} + \underbrace{\frac{1}{3}\vec{\nabla}\cdot\vec{V}_{SW}\frac{\partial f}{\partial \ln R}}_{\text{Adiabatic energy changes}}$$

- Particle drifts due to heliospheric magnetic field gradients, curvatures and heliospheric current sheet.
- K = diffusion tensor, due to scattering on magnetic irregularities
- Adiabatic energy losses/gains due to expansion/compression of solar wind, proportional to spectral index.

Hypotheses for p/He time dependent behavior

$$\frac{\partial f}{\partial t} = \underbrace{-\vec{V}_{SW}\cdot\vec{\nabla} f}_{\text{Solar wind convection}} \underbrace{-\vec{V}_{D}\cdot\vec{\nabla} f}_{\text{Particle drifts}} + \underbrace{\vec{\nabla}\cdot(K\cdot\vec{\nabla} f)}_{\text{Particle diffusion}} + \underbrace{\frac{1}{3}\vec{\nabla}\cdot\vec{V}_{SW}\frac{\partial f}{\partial \ln R}}_{\text{Adiabatic energy changes}}$$

1) Velocity dependence of the diffusion coefficient: $k(r,R) = \beta k_1(r) k_2(R)$
Even if k_2 is the same for all nuclei, the beta multiplying it will change the divergence of the diffusive flux term in the Parker equation for nuclei with different A/Z.
A/Z(p) = 1; A/Z(^{3}He) = 3/2; A/Z(^{4}He) = 2

2) Difference in the LIS shape: the adiabatic energy change term in the Parker equation depends on the spectral index, so if two nuclei have the same A/Z, but different spectral index, the last term will be different.

Summary

1) The AMS **daily Helium** flux measurement from **May 20, 2011 to Oct 29, 2019** was presented.

2) The daily Helium flux shows **multiple time variations** : Forbush decreases, 27-day periodicities, SEP.

3) During the maximum of solar cycle 24, **the helium flux was more suppressed than the proton flux.**

4) **p/He** flux ratio has a **long-term variation** seen in 8.5 years

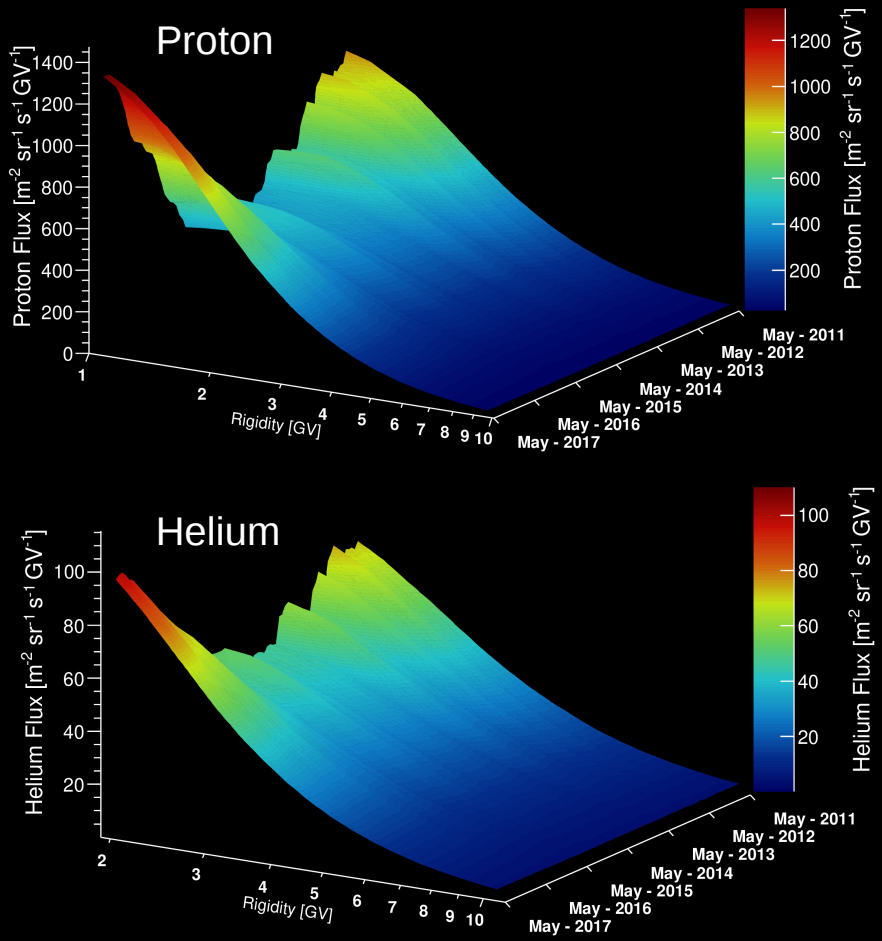
5) The daily **p/He** ratio shows **sub-structures** in the **short-term variation** in coincidence with periods where the p and He fluxes has strong flux suppression.

6) A strong **anticorrelation** exists between the **p/He flux ratio and the p flux** at low rigidities.

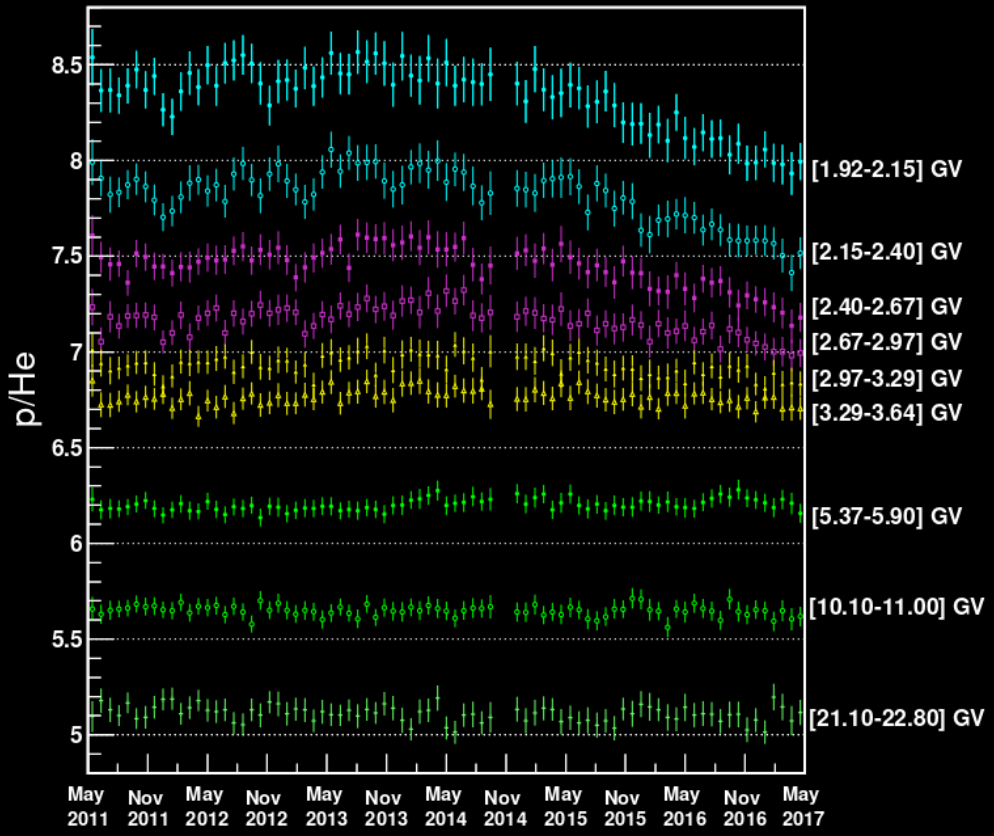
Backup

Previous Measurements: Monthly p and He Fluxes

PRL 121, 051101 (2018)



#1009 M. Palermo Monthly p, He, C, and O



Previous Measurements: ^{3}He and ^{4}He Time Variation

PRL 123, 181102 (2019)

#320 F. Giovacchini He isotopes