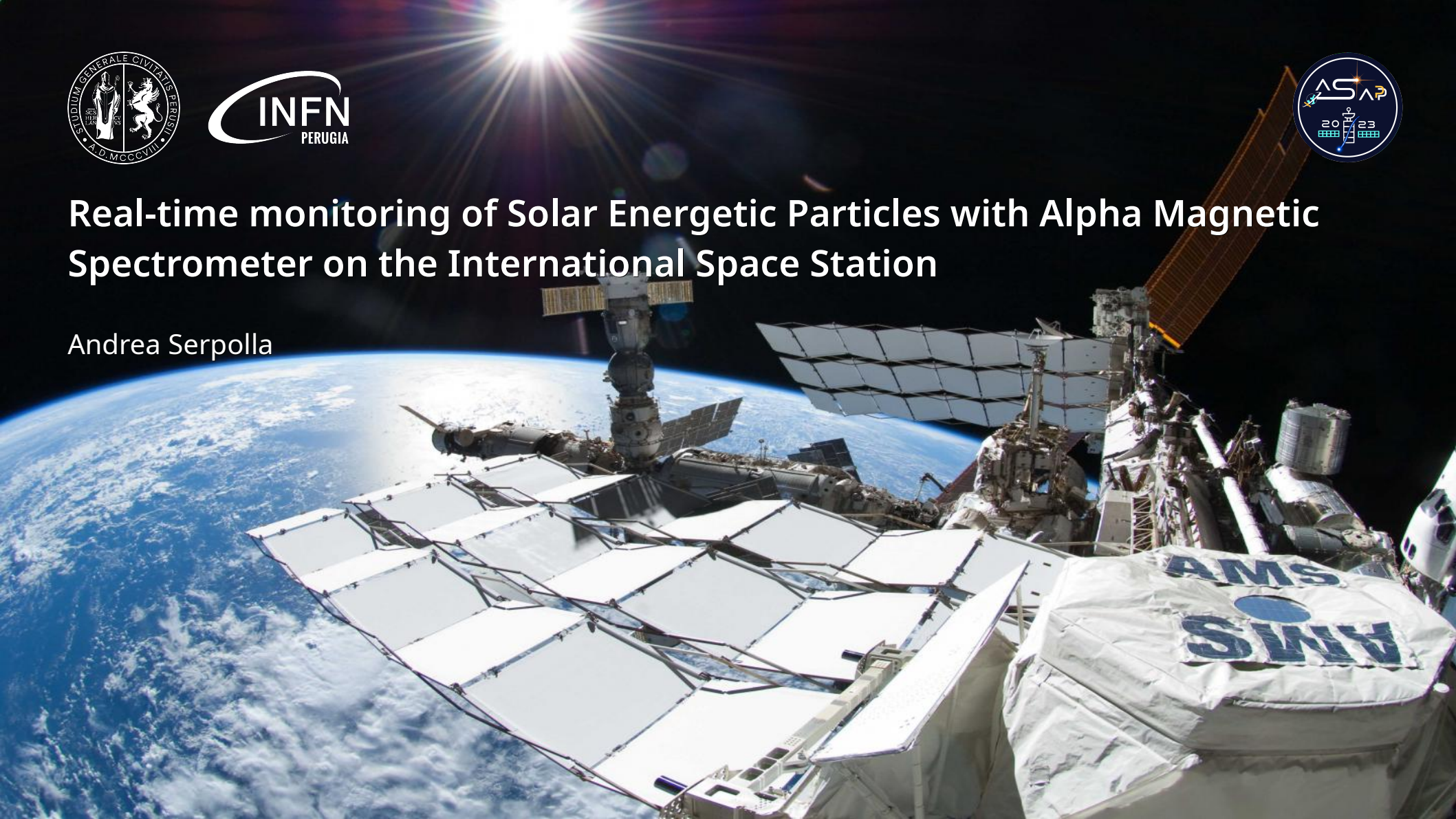
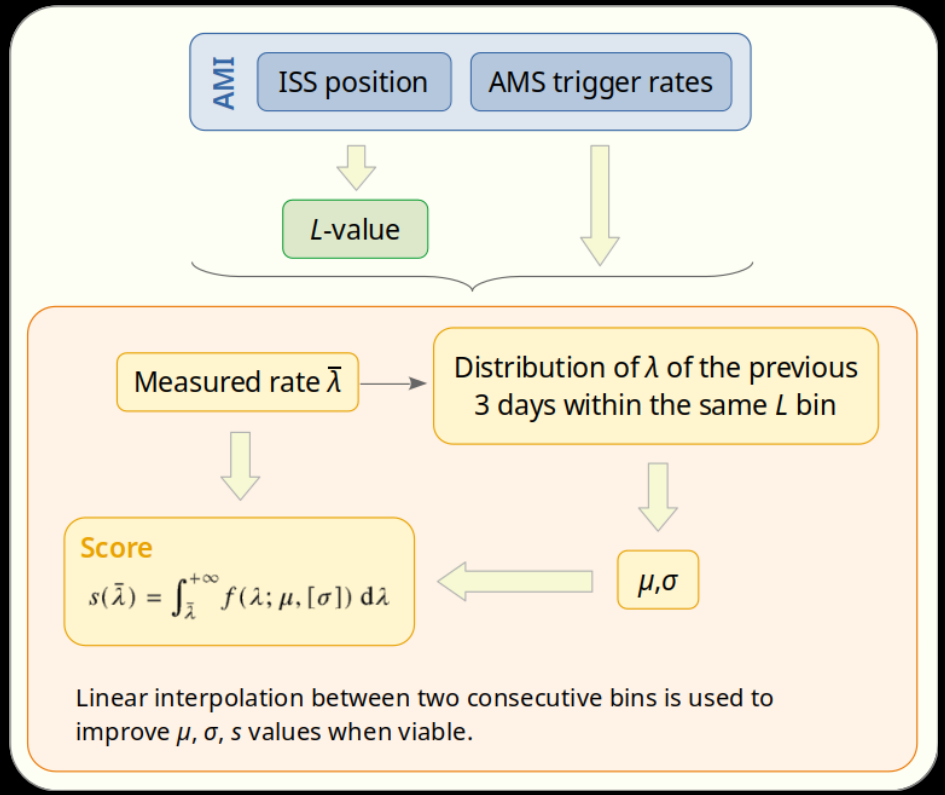
Real-time monitoring of Solar Energetic Particles with Alpha Magnetic Spectrometer on the International Space Station

Andrea Serpolla

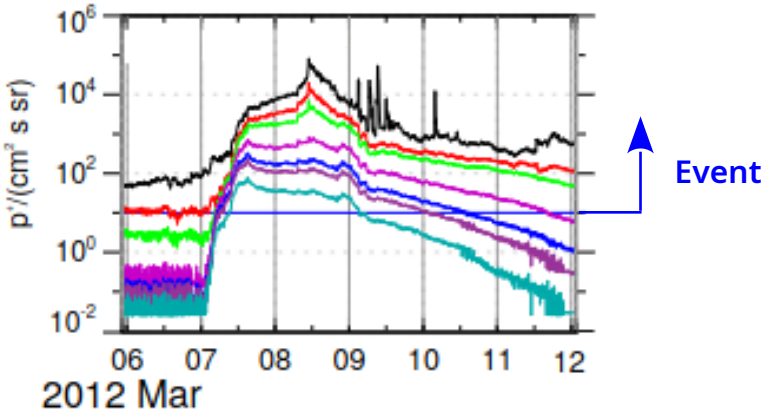


Detection algorithm



- The algorithm relies on **AMS Monitoring Interface (AMI)**.
- McIlwain's ***L*-parameter** is used to separate data taken under **different conditions**.
- **SEP events** produce increments in AMS trigger rates, lowering the **score towards 0**.

A SEP event

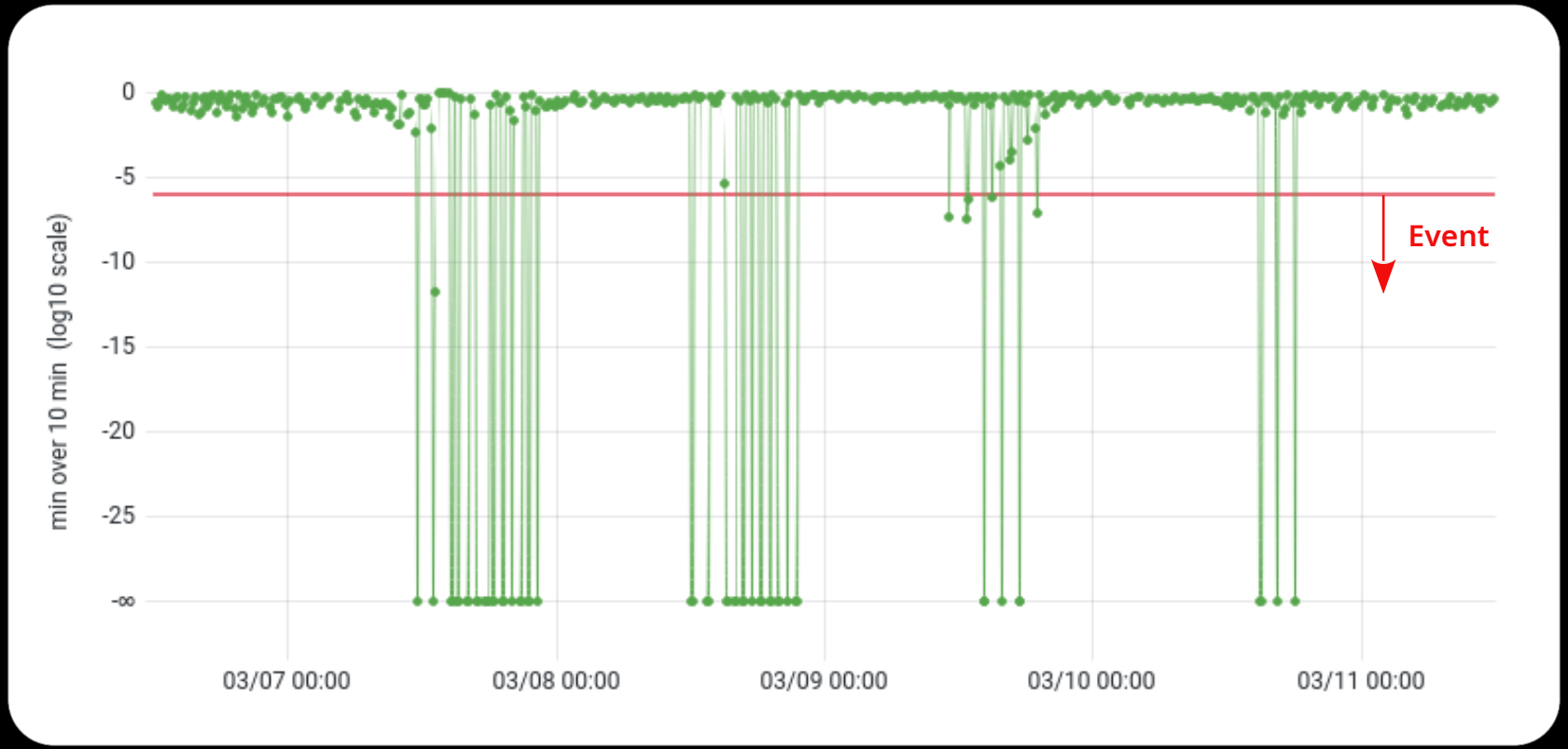


Proton fluxes from GOES-13

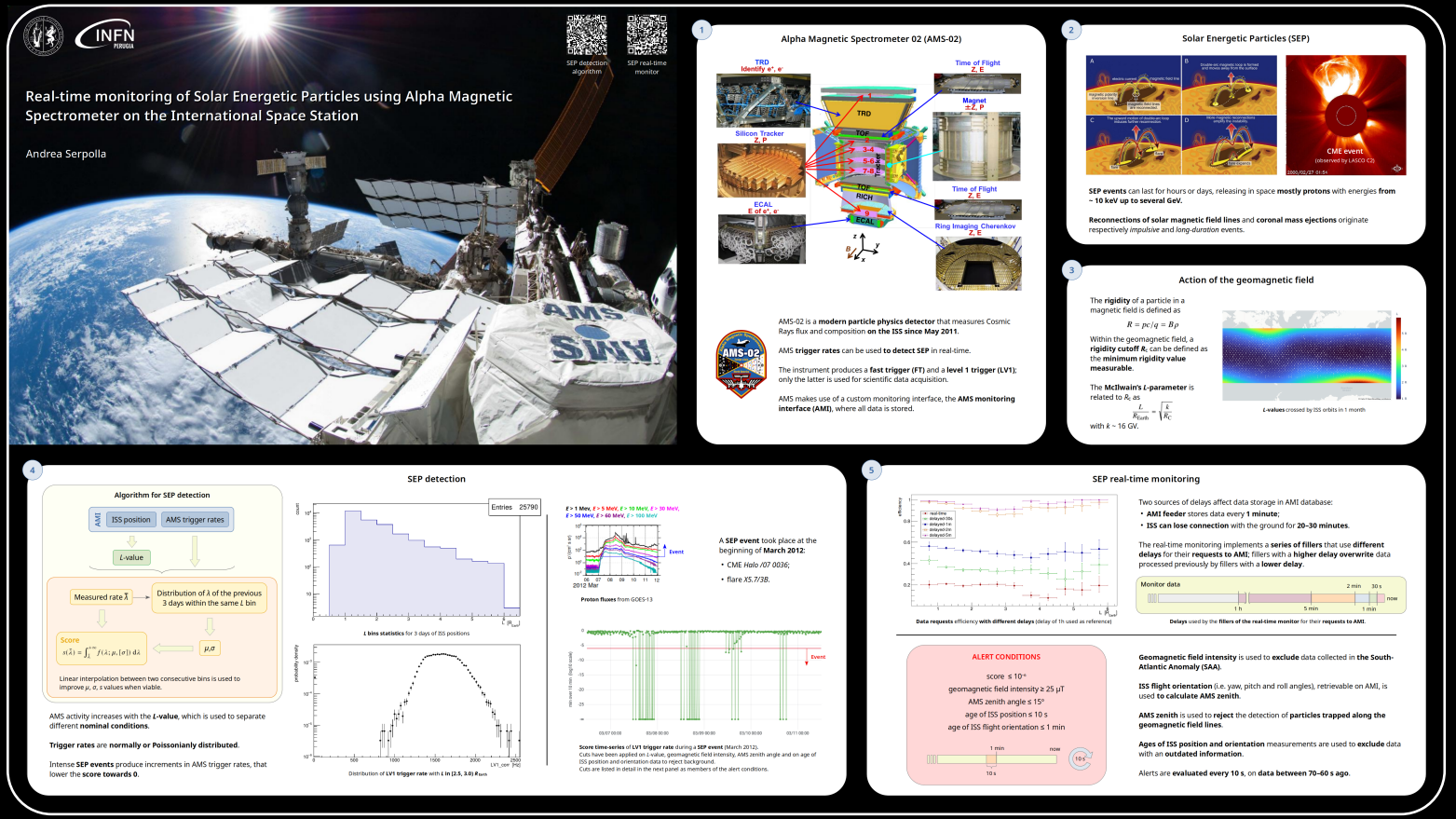
A **SEP event** took place at the beginning of **March 2012**:

- CME *Halo /07 0036*;
- flare *X5.7/3B*.

A SEP event


0
-5
-10
-15
-20
-25
-∞
min over 10 min (log10 scale)
Event
03/07 00:00
03/08 00:00
03/09 00:00
03/10 00:00
03/11 00:00

The poster


INFN PERUGIA
SEP detection algorithm
SEP real-time monitor
Real-time monitoring of Solar Energetic Particles using Alpha Magnetic Spectrometer on the International Space Station
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1
Alpha Magnetic Spectrometer 02 (AMS-02)
TRD
Identify e+, e-
Time of Flight
Z, E
Silicon Tracker
Z, P
Magnet
±Z, P
ECAL
E of e+, e-
Time of Flight
Z, E
Ring Imaging Cherenkov
Z, E
AMS-02 is a modern particle physics detector that measures Cosmic Rays flux and composition on the ISS since May 2011.
AMS trigger rates can be used to detect SEP in real-time.
The instrument produces a fast trigger (FT) and a level 1 trigger (LV1); only the latter is used for scientific data acquisition.
AMS makes use of a custom monitoring interface, the AMS monitoring interface (AMI), where all data is stored.
2
Solar Energetic Particles (SEP)
CME event
(observed by LASCO C2)
SEP events can last for hours or days, releasing in space mostly protons with energies from ~ 10 keV up to several GeV.
Reconnections of solar magnetic field lines and coronal mass ejections originate respectively impulsive and long-duration events.
3
Action of the geomagnetic field
The rigidity of a particle in a magnetic field is defined as
$R = pc/q = B\rho$
Within the geomagnetic field, a rigidity cutoff R_c can be defined as the minimum rigidity value measurable.
The McIlwain's L-parameter is related to R_c as
$\frac{L}{R_{Earth}} = \sqrt{\frac{k}{R_c}}$
with k ~ 16 GV.
L-values crossed by ISS orbits in 1 month
4
Algorithm for SEP detection
AMI
ISS position
AMS trigger rates
L-value
Measured rate
Distribution of λ of the previous 3 days within the same L bin
Score
Linear interpolation between two consecutive bins is used to improve μ, σ, s values when viable.
AMS activity increases with the L-value, which is used to separate different nominal conditions.
Trigger rates are normally or Poissonianly distributed.
Intense SEP events produce increments in AMS trigger rates, that lower the score towards 0.
SEP detection
Entries 25790
L bins statistics for 3 days of ISS positions
Distribution of LV1 trigger rate with L in [2.5, 3.0] R_Earth
Proton fluxes from GOES-13
A SEP event took place at the beginning of March 2012:
CME Halo /07 0036;
flare X5.7/3B.
Score time-series of LV1 trigger rate during a SEP event (March 2012).
Cuts have been applied on L-value, geomagnetic field intensity, AMS zenith angle and on age of ISS position and orientation data to reject background.
Cuts are listed in detail in the next panel as members of the alert conditions.
5
SEP real-time monitoring
Data requests efficiency with different delays (delay of 1h used as reference)
Two sources of delays affect data storage in AMI database:
AMI feeder stores data every 1 minute;
ISS can lose connection with the ground for 20–30 minutes.
The real-time monitoring implements a series of fillers that use different delays for their requests to AMI; fillers with a higher delay overwrite data processed previously by fillers with a lower delay.
Monitor data
Delays used by the fillers of the real-time monitor for their requests to AMI.
ALERT CONDITIONS
score ≤ 10⁻⁴
geomagnetic field intensity ≥ 25 μT
AMS zenith angle ≤ 15°
age of ISS position ≤ 10 s
age of ISS flight orientation ≤ 1 min
Geomagnetic field intensity is used to exclude data collected in the South-Atlantic Anomaly (SAA).
ISS flight orientation (i.e. yaw, pitch and roll angles), retrievable on AMI, is used to calculate AMS zenith.
AMS zenith is used to reject the detection of particles trapped along the geomagnetic field lines.
Ages of ISS position and orientation measurements are used to exclude data with an outdated information.
Alerts are evaluated every 10 s, on data between 70–60 s ago.