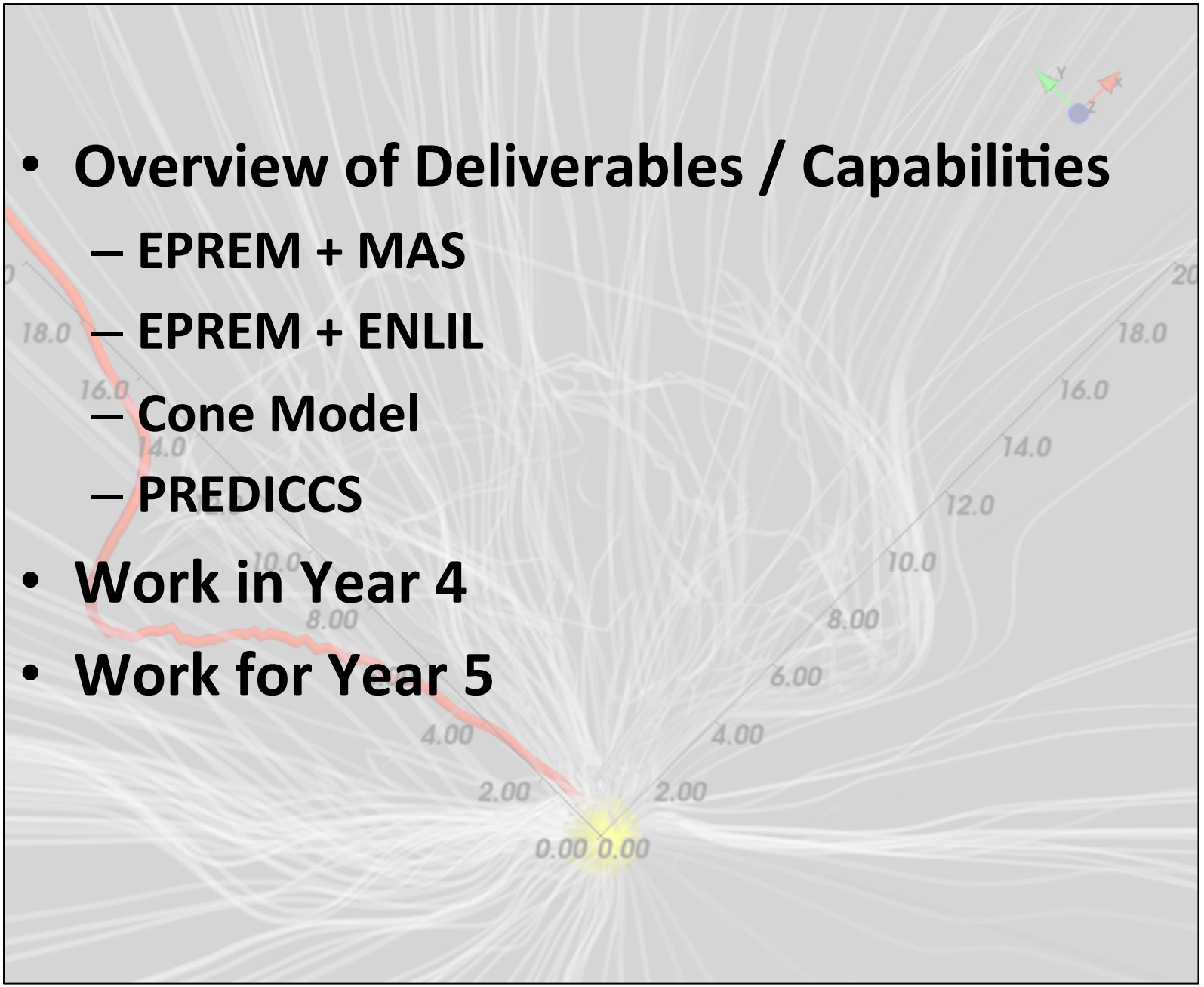
C-SWEPA Tools and Methodology

Matthew Gorby

LWS TIM 2017

University of New Hampshire



- **Overview of Deliverables / Capabilities**
  - **EPREM + MAS**
  - **EPREM + ENLIL**
  - **Cone Model**
  - **PREDICCS**
- **Work in Year 4**
- **Work for Year 5**

MAS (Description and CME Initiation)

MAS is a 3D coronal MHD model and a part of CORHEL, a coupled set of models and tools for quantitatively modeling the ambient solar corona and solar wind.

$\vec{V}$, $\vec{B}$, ρ and Δt are specified on a spherical grid of resolution $250 \times 300 \times 261$ in $r \times \theta \times \phi$ at a cadence of ˜30 seconds early in the CME eruption, at ˜3 seconds during the main phase, and then to ˜300 seconds while the CME propagates out past 20 solar radii.

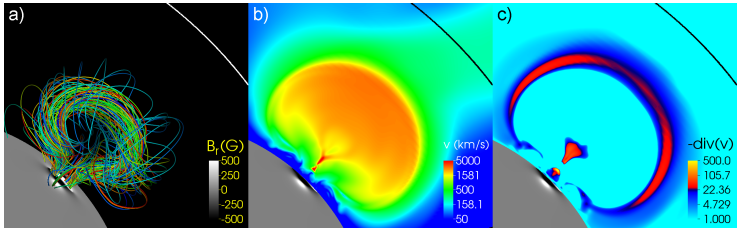
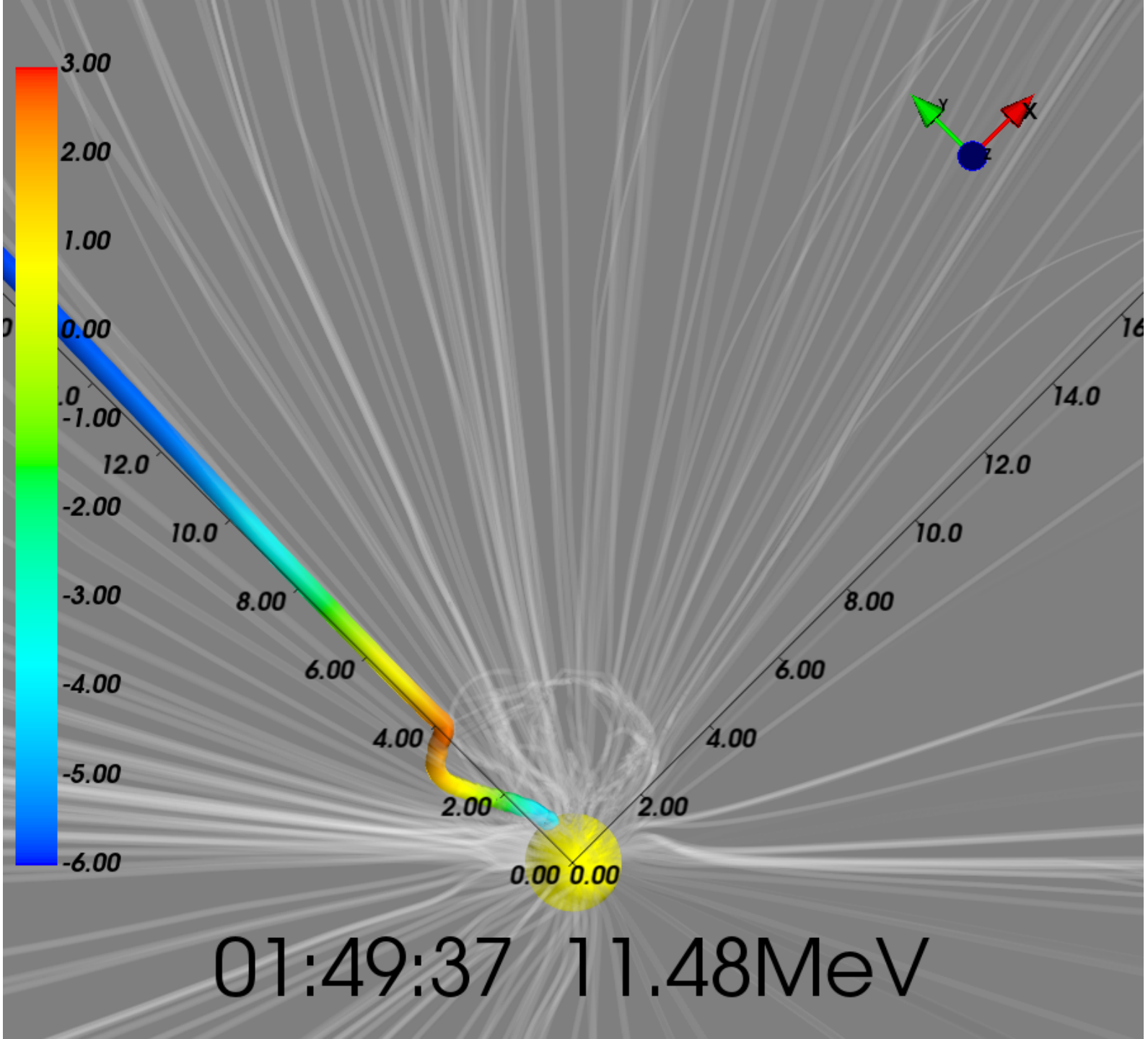


Figure: (a) the magnetic field lines of the flux rope superimposed on the radial magnetic field in grayscale at the solar surface; (b) the outward speed of the plasma; (c) the negative divergence of the plasma velocity, which highlights regions of strong compression. The curved line in the top right corners of each panel indicates the height of two solar radii.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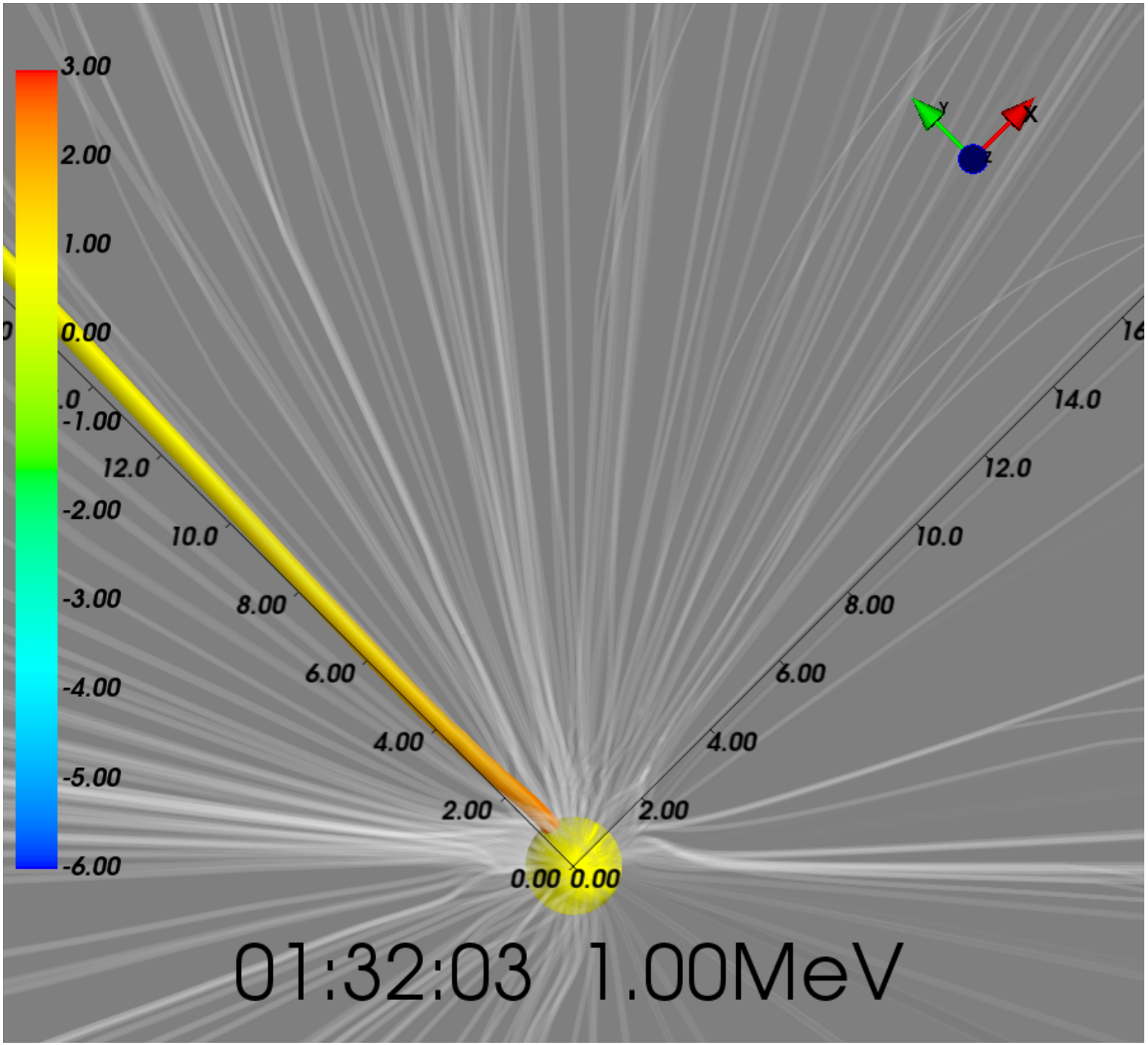
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MAS (+ EPREM)

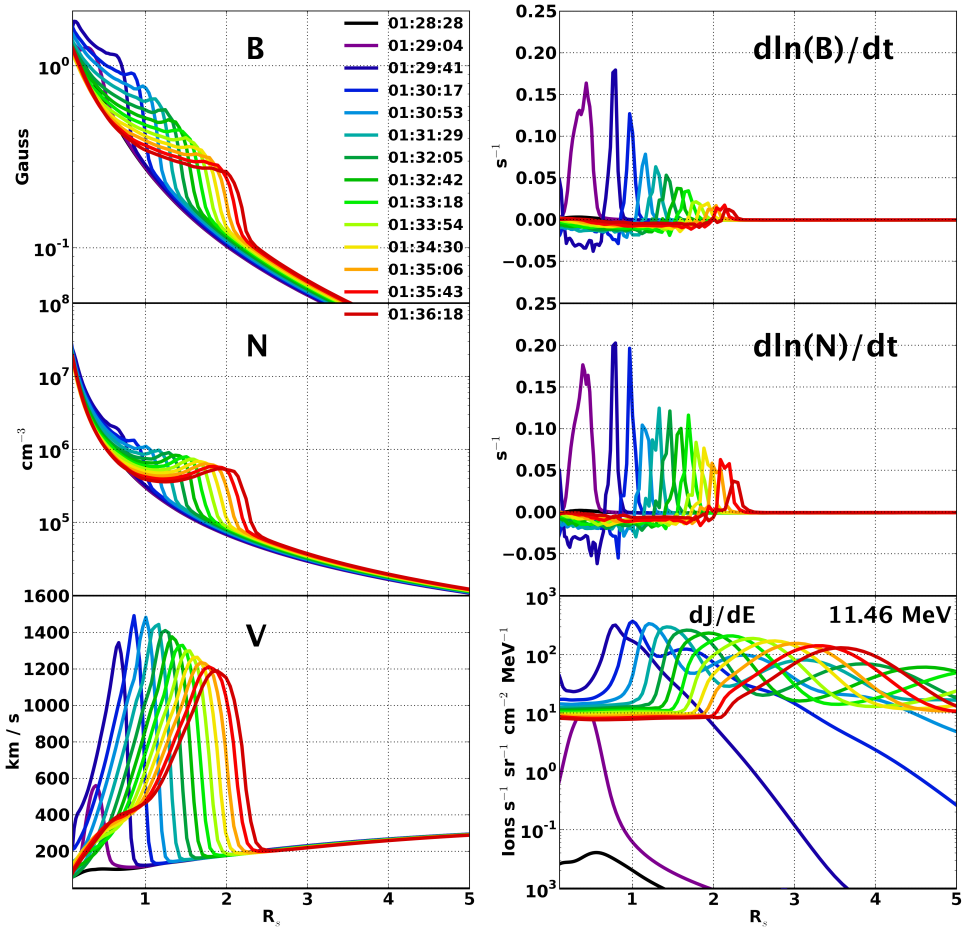


Figure: The colored lines are simulation time steps (HR:MIN:SEC) and all x-axes are in distance along the stream in solar radii. *(left panel)* B magnetic field magnitude, N number density, V bulk flow speed; *(right panel)* $dln(B)/dt$ change in the natural log of magnetic field magnitude w/ time, $dln(N)/dt$ change in the natural log of density w/ time, dJ/dE differential energy at 11.46 MeV.

MAS (+ EPREM) Bastille Day Event

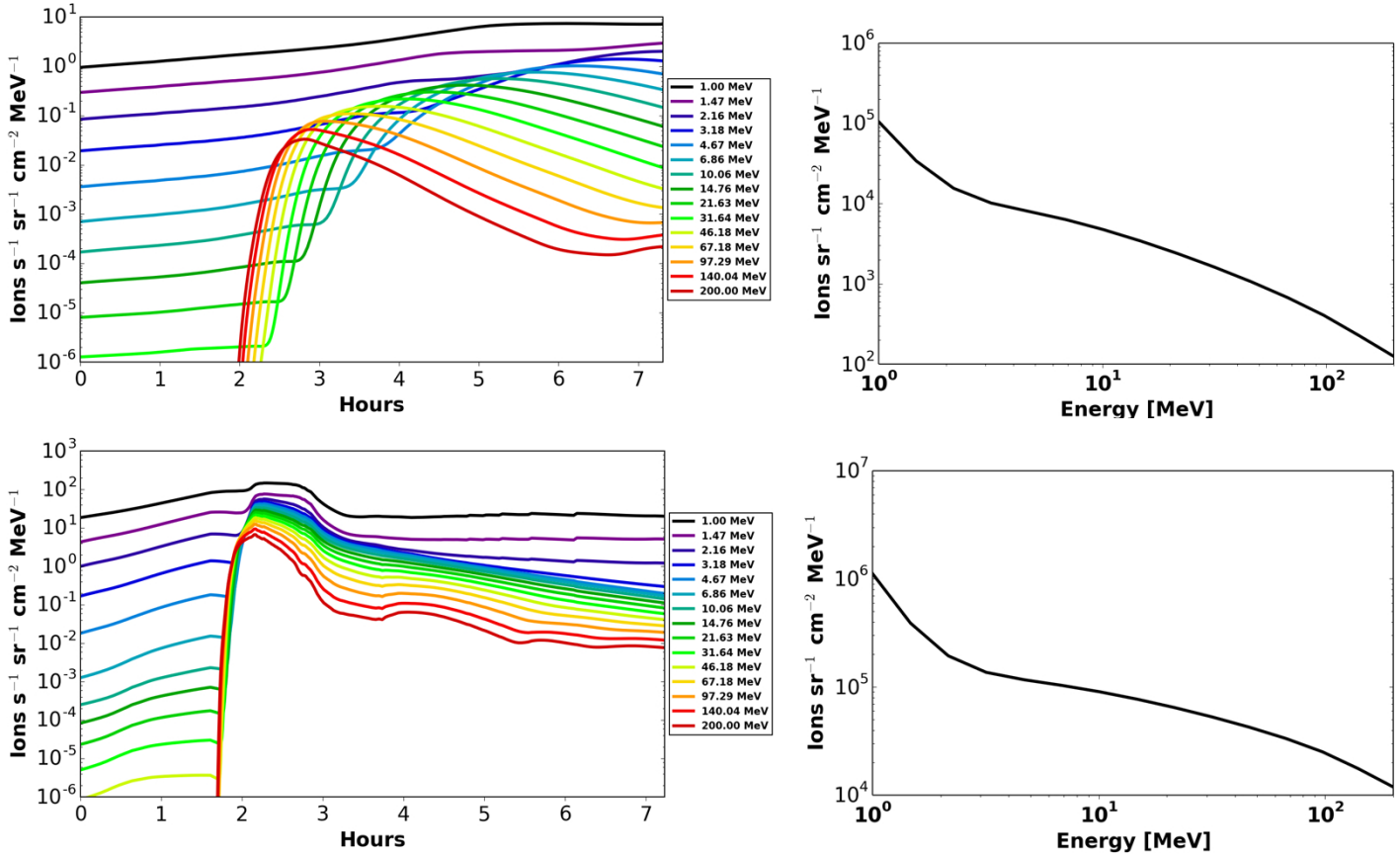


Figure: *(top left)* Flux at Earth Observer; *(top right)* Fluence at Earth Observer; *(bottom left)* Flux at 0.05 AU *(bottom right)* Fluence at 0.05 AU.

Enlil (Description)

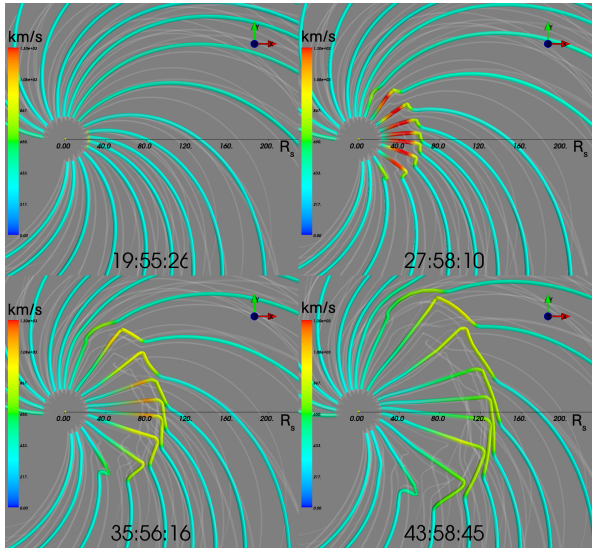


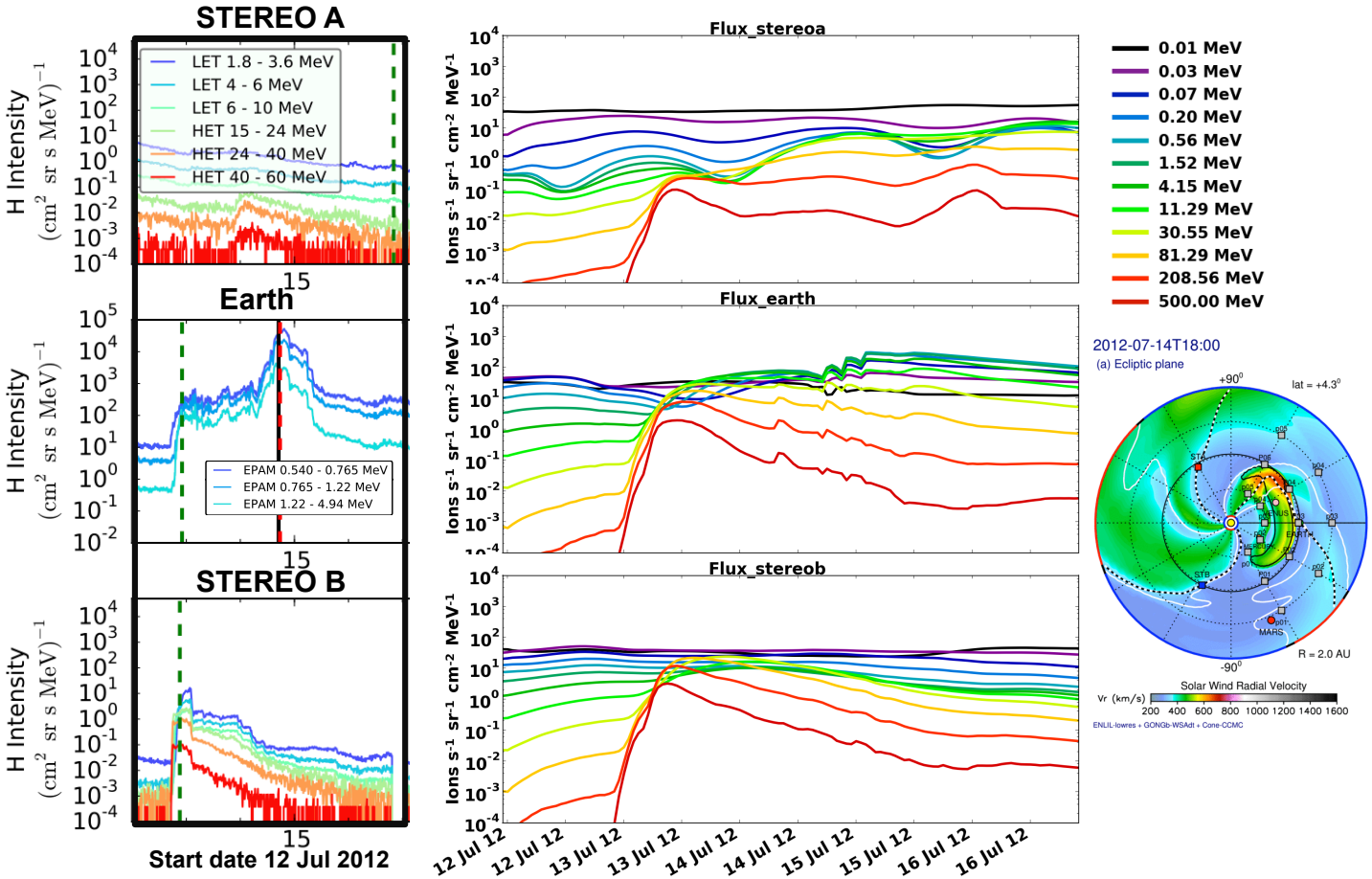
Figure: EPREM domain advancing in time using Enlil field values, for the 12 July 2012 event. Only the ecliptic streams are colored by the solar wind speed.

Enlil is a time-dependent 3D MHD model of the heliosphere. It solves equations for plasma mass, momentum and energy density, and magnetic field, using a Flux-Corrected-Transport (FCT) algorithm.

Observers may be fed into EPREM via Enlil .evo files, allowing comparison of field values and particle distributions to observations. Additionally, synthetic observers may be specified anywhere in the domain, giving the ability to probe latitudinal and longitudinal variations. Results for the 12 July 2012 Event are presented below.

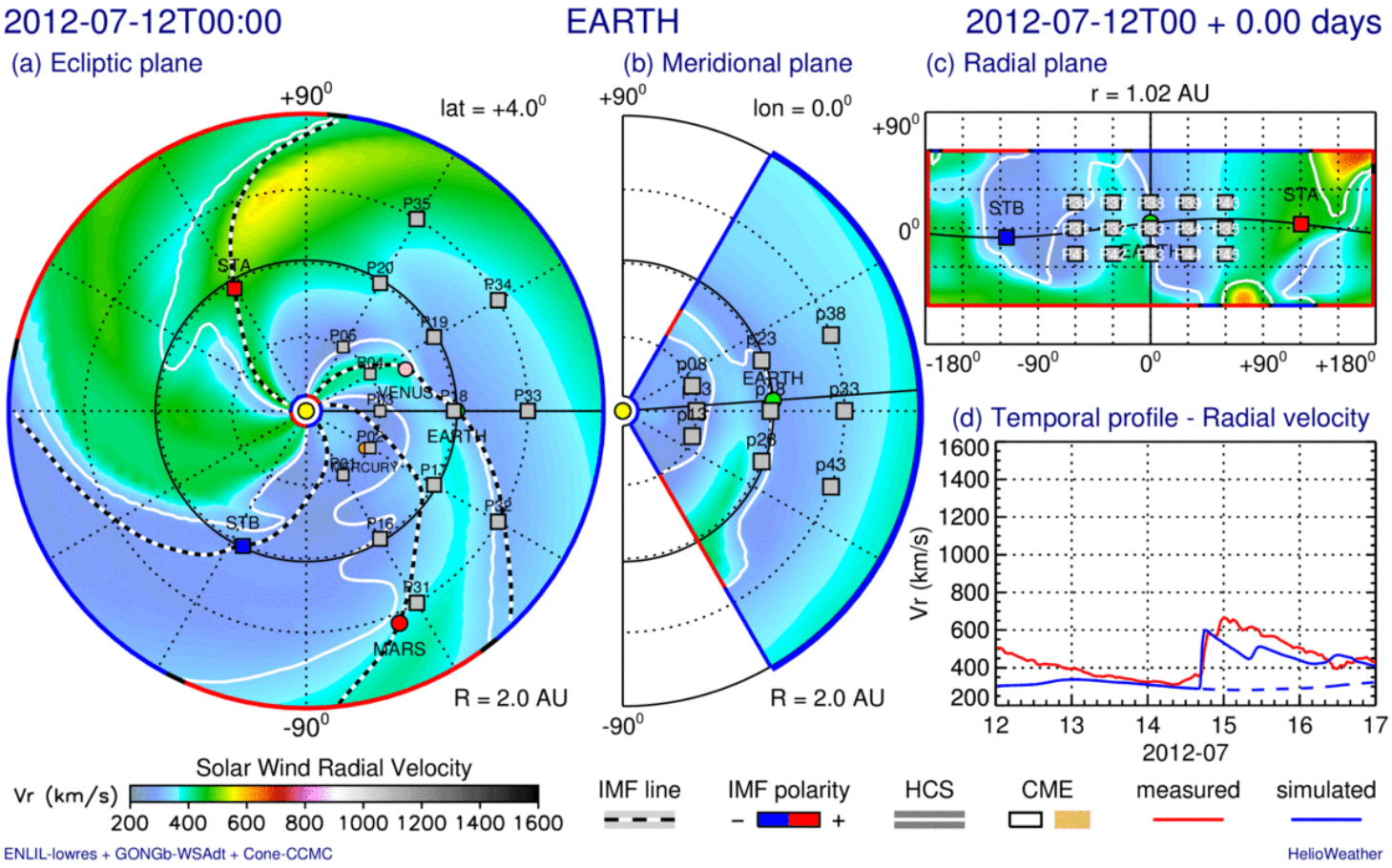
Enlil (+ EPREM)

12 July 2012 CME
Preliminary ENLIL+EPREM results



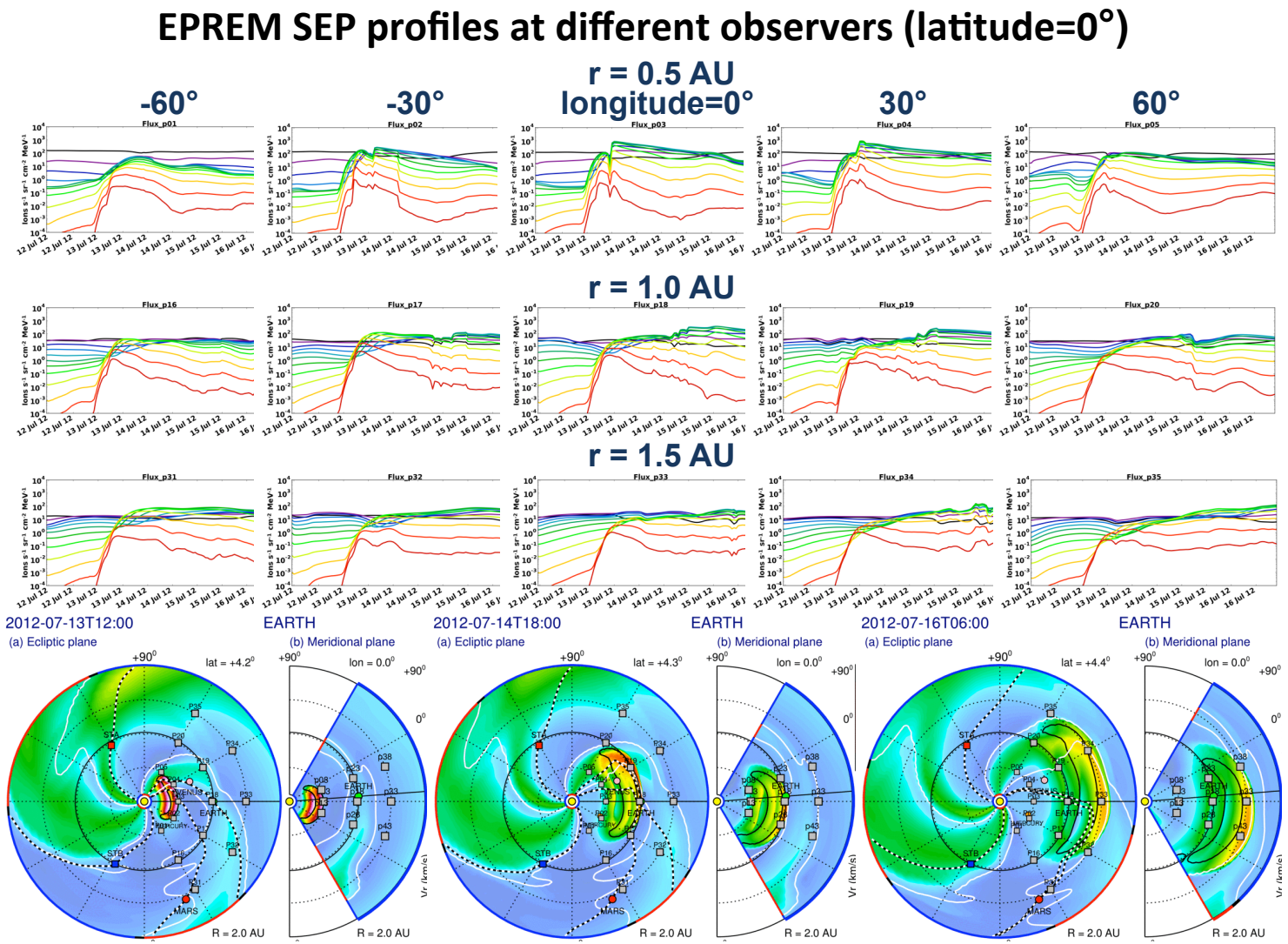
Enlil (+ EPREM)

Position hypothetical satellites throughout ENLIL domain



12 July 2012 CME WSA-ENLIL+Cone velocity contour plot

Enlil (+ EPREM)


EPREM SEP profiles at different observers (latitude=0°)
r = 0.5 AU
longitude=0°
-60°
-30°
30°
60°
r = 1.0 AU
r = 1.5 AU
2012-07-13T12:00
EARTH
(a) Ecliptic plane
(b) Meridional plane
2012-07-14T18:00
EARTH
(a) Ecliptic plane
(b) Meridional plane
2012-07-16T06:00
EARTH
(a) Ecliptic plane
(b) Meridional plane
R = 2.0 AU

EPREM (Cone CME)

The run
was initiated with a constant solar wind solution of 400 km/s and allowed to come to equilibrium. The shock profile to the right then propagated out from the inner boundary at 1800 km/s. The discontinuity is assumed to be a shock and the shock solver was applied everywhere $dlnN/dlnr > -1.9$.

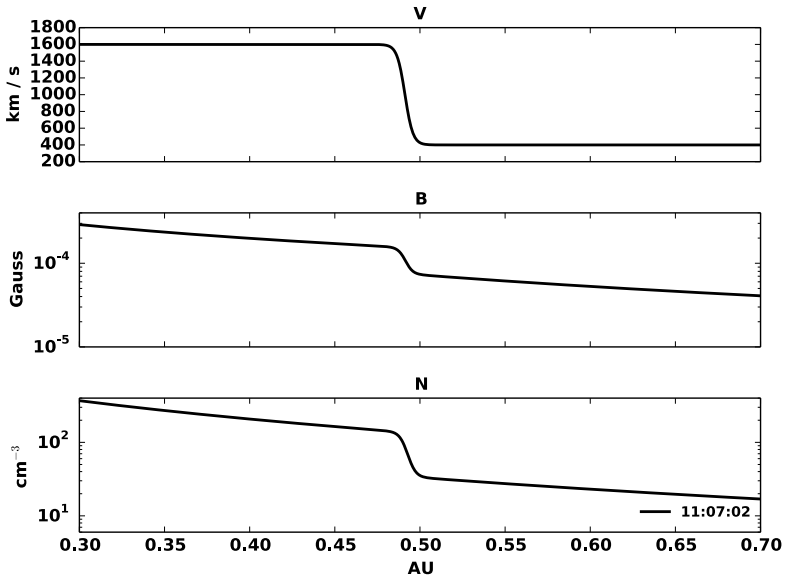


Figure: Solar wind speed, magnetic field strength, and density profile for the shock as it passes by 0.5AU

Flux and Fluence

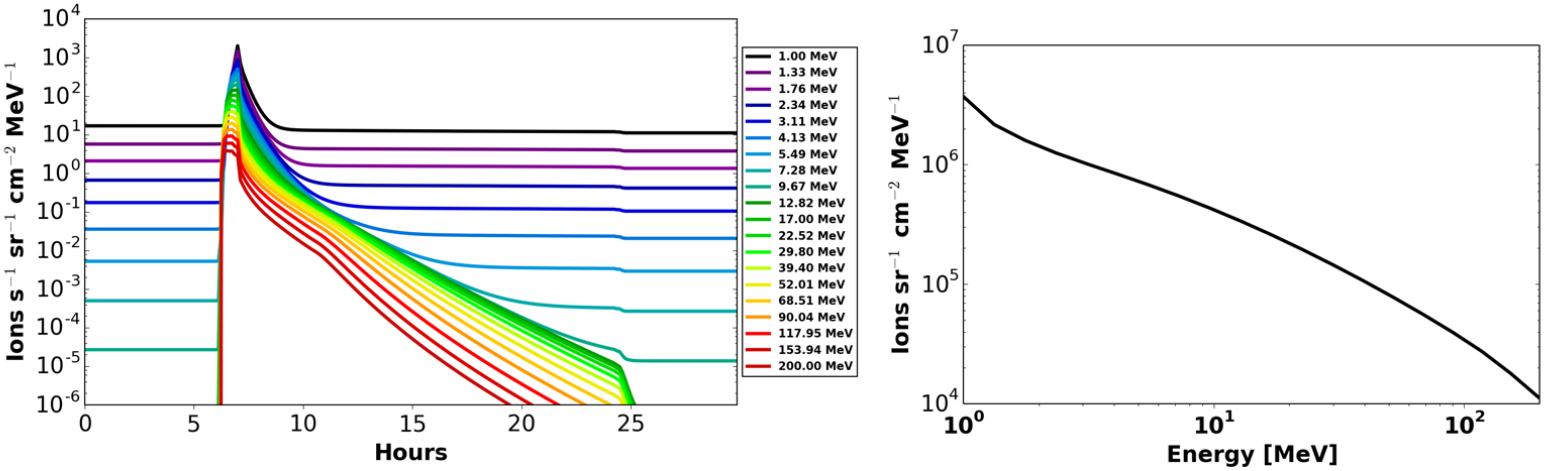
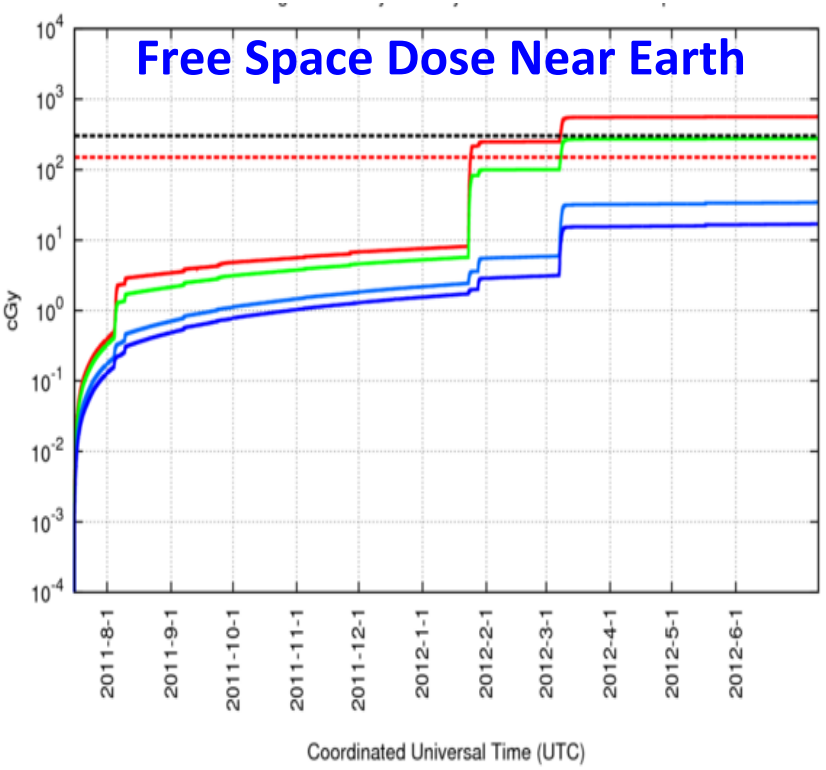
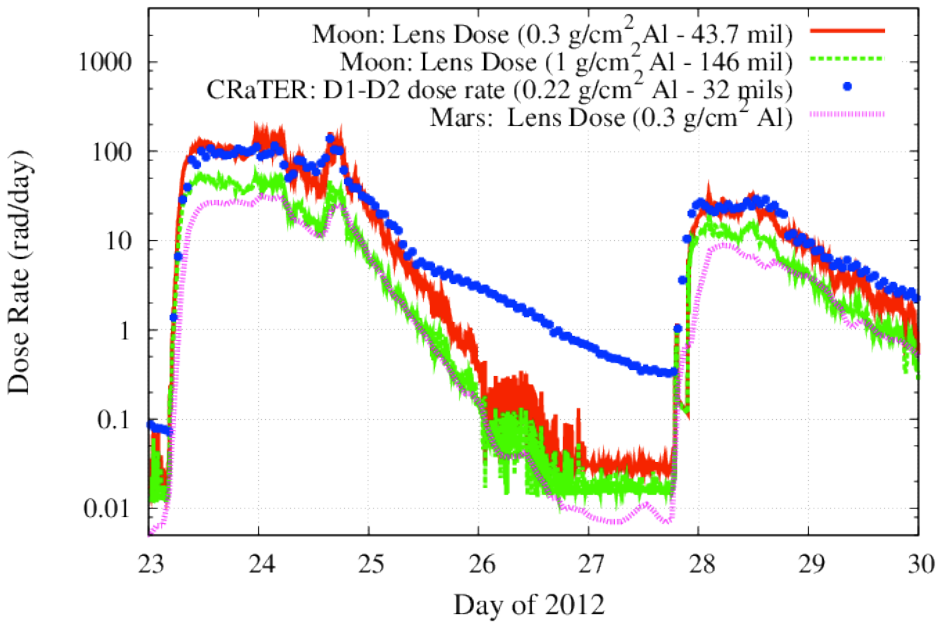


Figure: MFP of 1AU at 1AU and 1GV. *(left)* Flux at 0.05 AU *(right)* Fluence at 0.05 AU

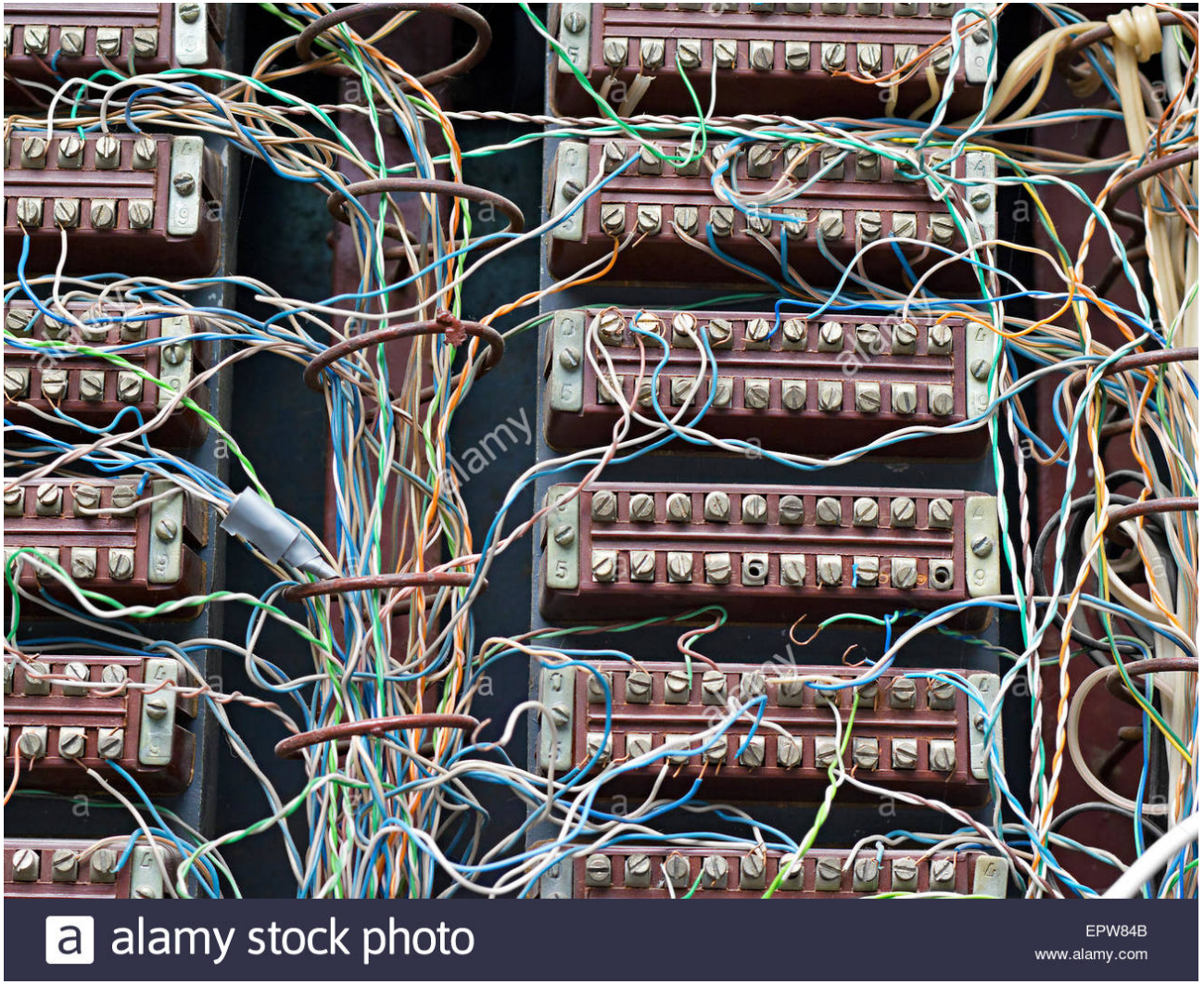
PREDICCS

PREDICCS integrates a host of near-real-time measurements being made by satellites currently in space with numerical models (e.g., EMMREM; Schwadron et al., 2010) to determine radiation doses and dose equivalents that characterize biological impacts, and energetic particle propagation codes that can accurately project radiation levels through the inner solar system and out to Mars. PREDICCS provides updates of the radiation environment on an hourly basis and archives the data weekly, monthly, and yearly to provide a clear historical record of the space radiation environment.





“The real problem is that programmers have spent far too much time worrying about efficiency in the wrong places and at the wrong times; premature optimization is the root of all evil (or at least most of it) in programming.”
- Donald Knuth



Year 4:

- Dependency Repository and Installation Script
- Suite of Tests: Cone, CSWS, Coupling, etc.
- Parallelized I/O
- Refactored Data Structures for Efficiency
- Replaced Legacy Dependencies

Year 5:

- Work with Leila Mays at the CCMC to complete the runs-on-request process for EPREM+Enlil and Cone Model.
- Removal of all legacy compile-time configurations.
- Documentation, much of which is completed with the meta-data input at the CCMC.
- Re-Implement the C-SPICE module.
- Compare the results from the 12 July 2012 event.
- Visualization tools with PSI.