Transitioning AWSoM-R, EEGGL and M-FLAMPA to the CCMC

Igor V. Sokolov, University of Michigan, on behalf of
the SWMF Team and CCMC team

9th CCMC User Workshop College Park, MD , April 24 2018

The First-Principles Model of CME Magnetic Structure and Evolution is Available to the World
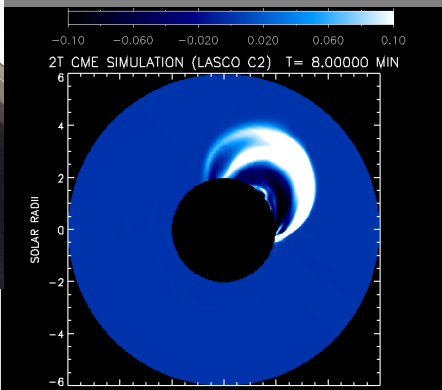
StereoCAT CME Analysis Tool

EEGGL Eruption Event Generator by Gibson & Low
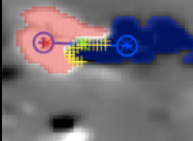**(delivered as a package)**

SWMF AWSoM-R

Global MHD simulations of CME plasma and magnetic structure eruption and propagation through space
24 user simulations executed since Nov 2016

NSO/GONG Magnetogram - processed for SWMF input

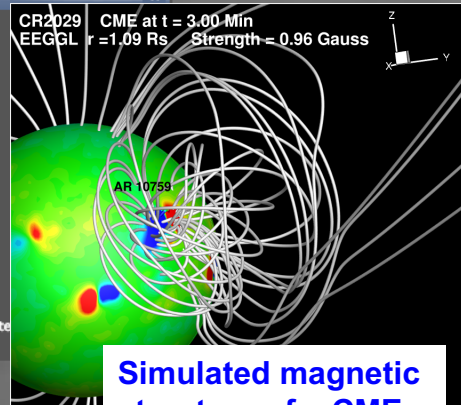2T CME SIMULATION (LASCO C2) T= 8.00000 MIN

Recommended Parameters

GL Flux Rope Parameters
Longitude: 130.50°
Latitude: 14.50°
Orientation: 358.72°
Radius[Rs]:   1.58
Bstrength[Gs]:   -0.02

Grid Refinement Parameters
R_Start[Rs]:   1.15
Longitude_Start: 67.30°
Latitude_Start: -17.10°
R_End[Rs]:   22.00
Longitude_End: 193.70°
Latitude_End: 46.10°

Request SWMF Run Using Parameters

CR2029   CME at t = 3.00 Min
EEGGL r =1.09 Rs   Strength = 0.96 Gauss

AR 10759

Simulated synthetic images as seen from SOHO or STEREO

Simulated magnetic structure of a CME

SWMF Team: Igor Sokolov, Meng Jin (UMich)   CCMC: R. Mullinix, A. Taktakishvili

# DONKI

StereoCAT

StereoCAT

MHD Simulation. CME Simulation

Initiating CME simulation with Eruptive Event Generator using Gibson-Low flux rope (EEGGL)
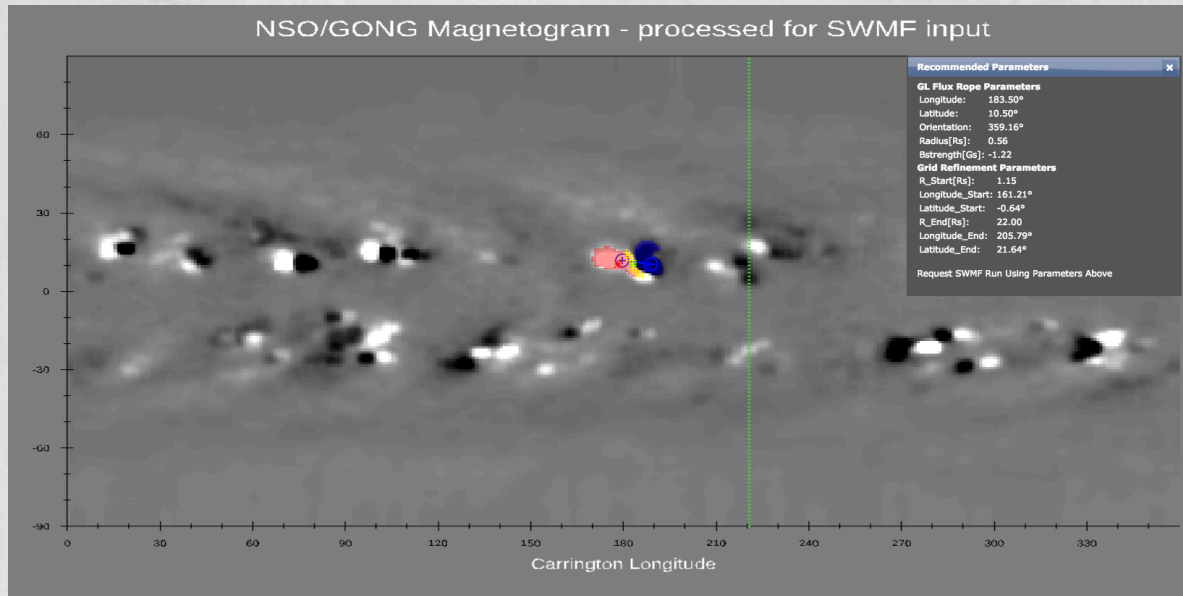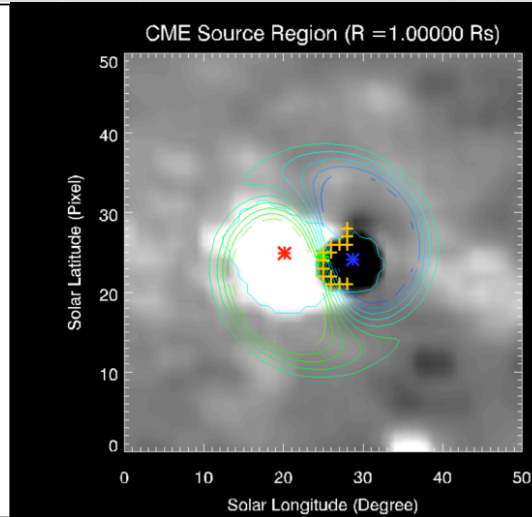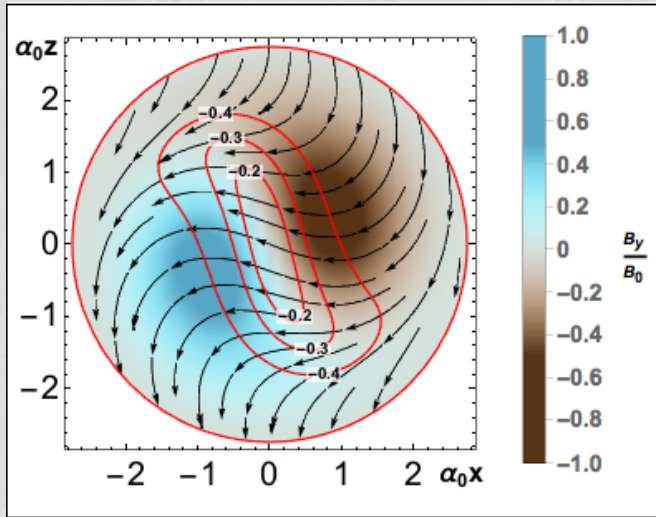
MHD Simulation. CME Simulation

- To initiate CME in simulation - impose Gibson-Low (GL) flux rope
- Apply stretching transformation (Gibson and Low 1998, Shiota and Kataoka 2016)
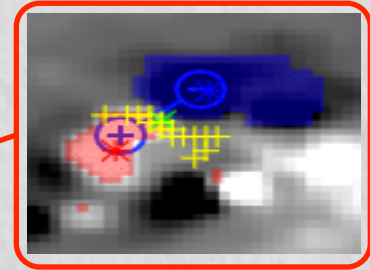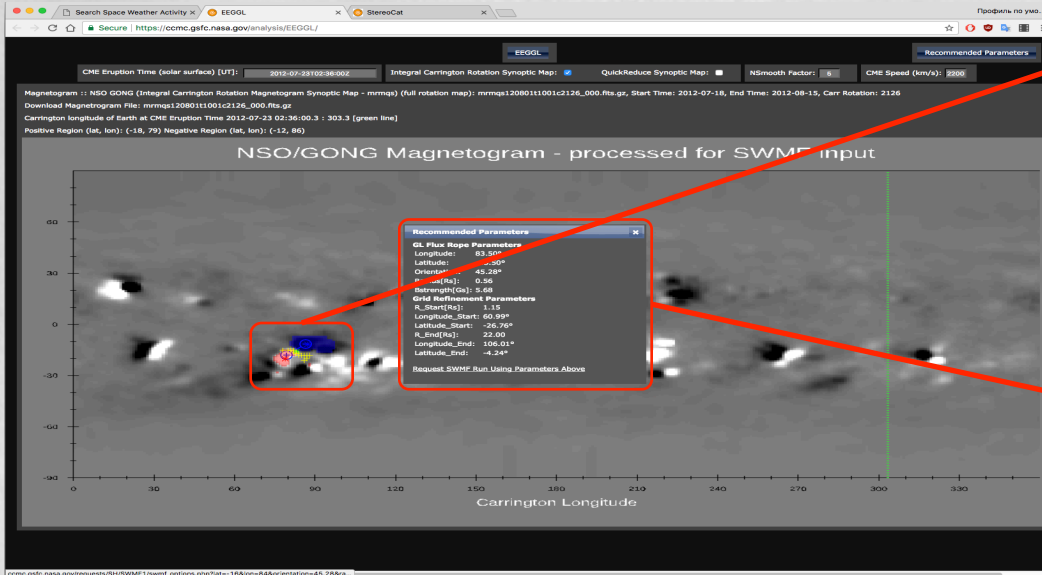- Described in the commentary by Borovikov et al JGR (2017)
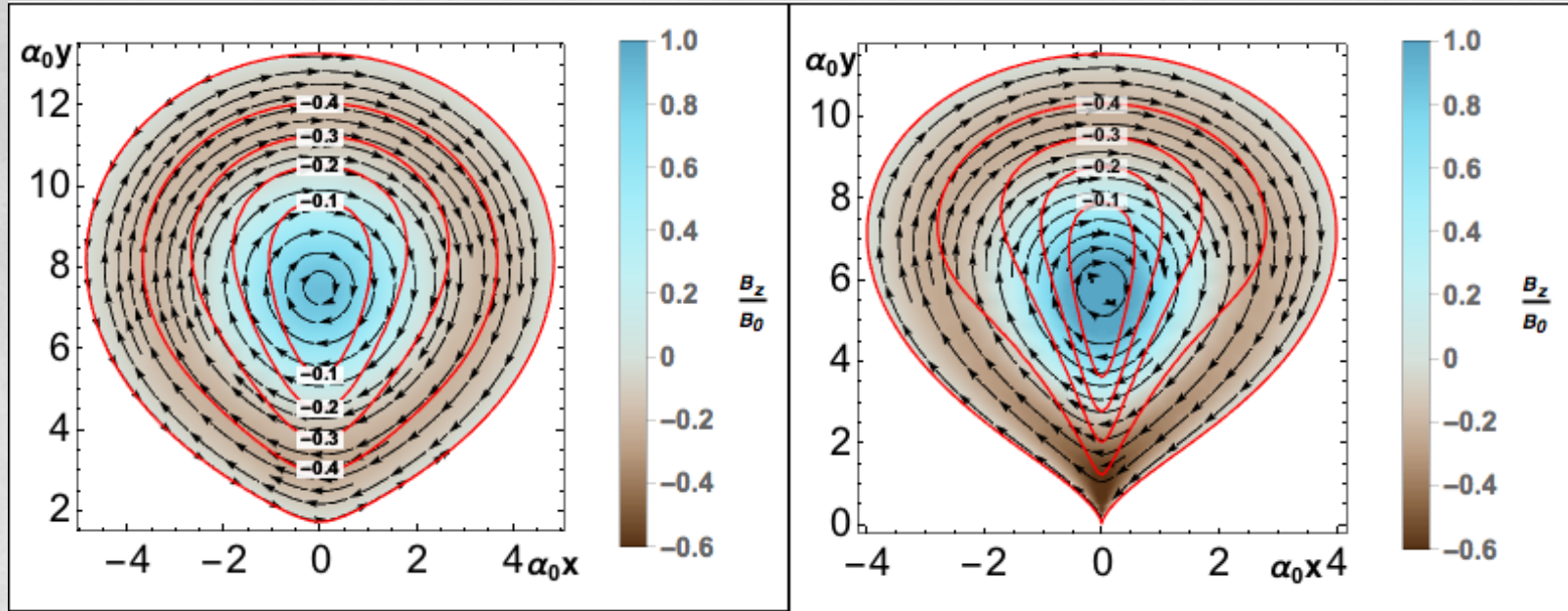
MHD Simulation. CME Simulation

Initiating CME simulation with EEGGL
• Based on magnetogram (boundary condition),
  parameters of GL flux rope are computed

EEGGL

CME Visualization
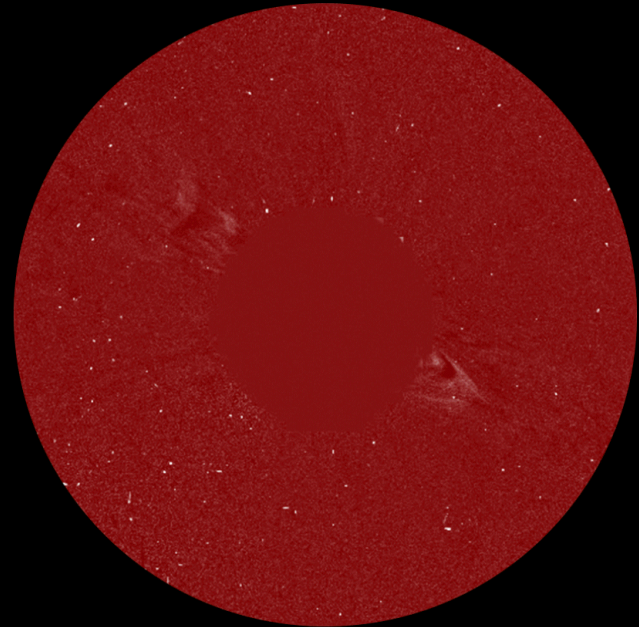
New Model   Satellite Observations

Towards coupled heliosphere and SEP models

CCMC is making steps towards offering a system to run SEP models driven by a variety of heliospheric models.

Developed and painted by M.Kuznetsova

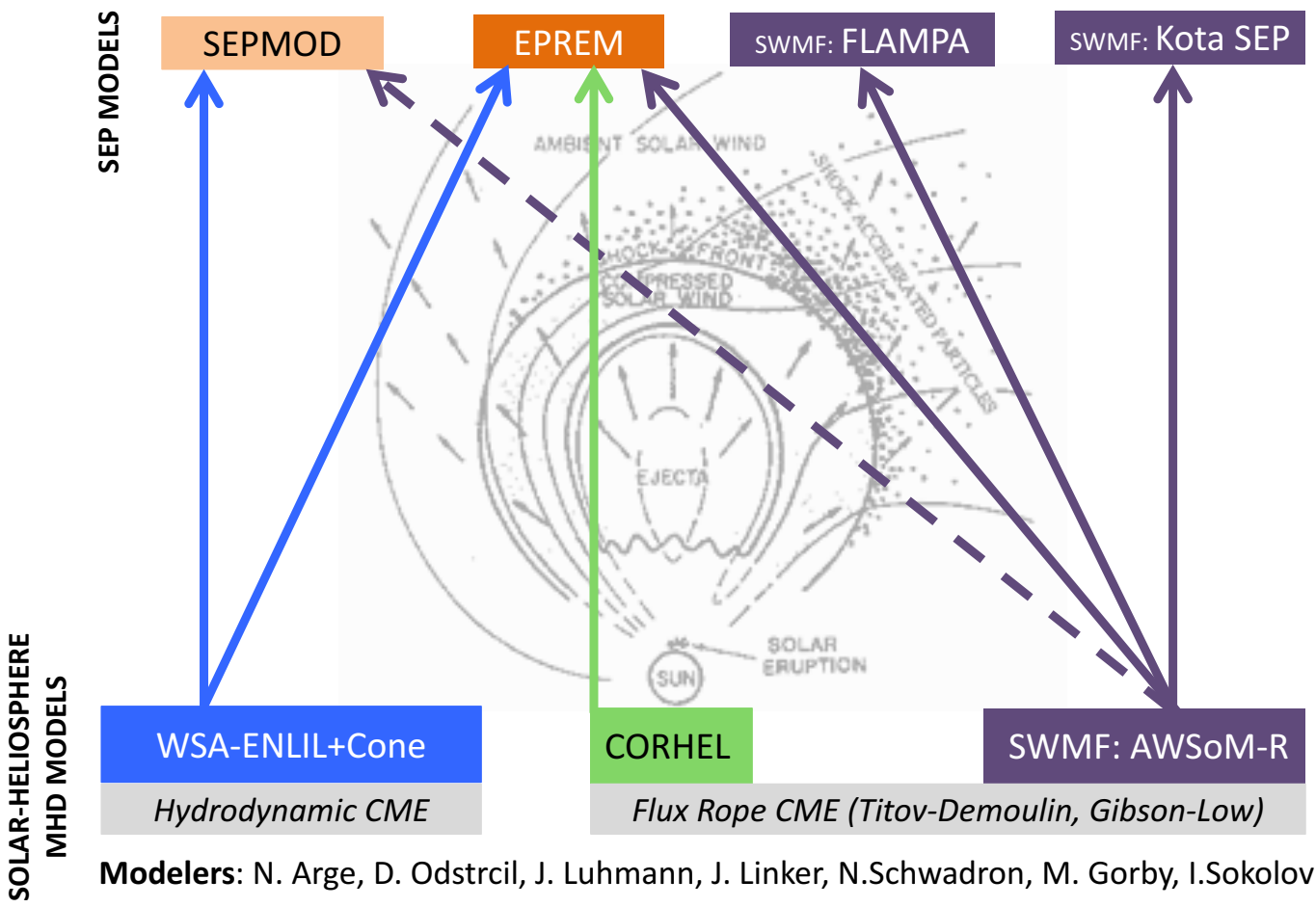**SEP MODELS**

SEPMOD   EPREM   SWMF: FLAMPA   SWMF: Kota SEP

AMBIENT SOLAR WIND
SHOCK ACCELERATED PARTICLES
SHOCK FRONT
COMPRESSED SOLAR WIND
EJECTA
SOLAR ERUPTION
SUN

SOLAR-HELIOSPHERE MHD MODELS

WSA-ENLIL+Cone   CORHEL   SWMF: AWSoM-R

Hydrodynamic CME   *Flux Rope CME (Titov-Demoulin, Gibson-Low)*

Modelers: N. Arge, D. Odstrcil, J. Luhmann, J. Linker, N.Schwadron, M. Gorby, I.Sokolov
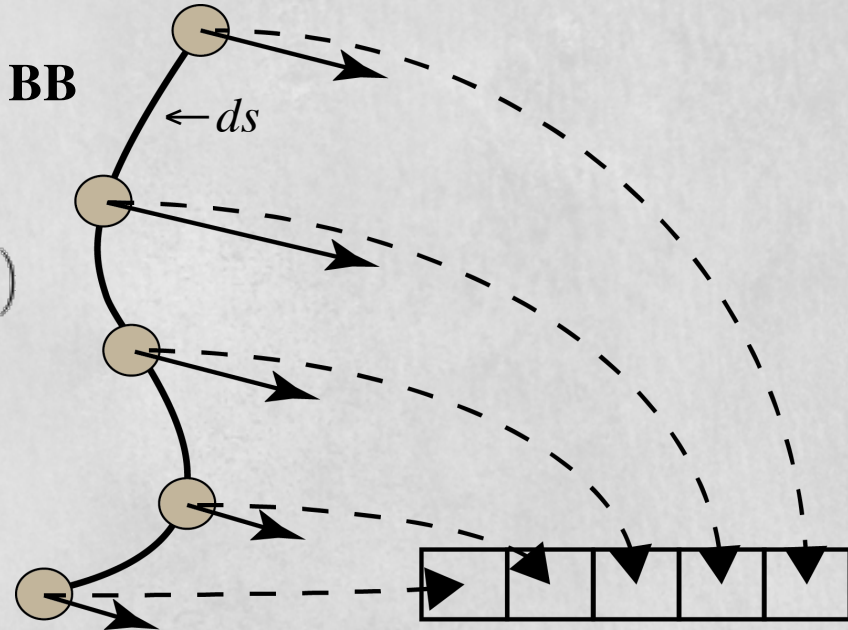
Field-Line-Advection Model for Particle Acceleration (FLAMPA)

Parker equation or the focused transport equation may be expressed in the Lagrangian coordinates (Sokolov et al 2004, Kota et al 2005)

$$\frac{\partial f}{\partial t} + \mathbf{u} \cdot \nabla f - \frac{1}{3}(\nabla \cdot \mathbf{u}) \frac{\partial f}{\partial \log p} = \nabla \cdot (\kappa \cdot \nabla f), \quad \kappa \propto \mathbf{BB}$$

$$\frac{Df}{Dt} + \frac{1}{3} \frac{D \ln \rho}{Dt} \frac{\partial f}{\partial \ln p} = B \frac{\partial}{\partial s} \left(\frac{\varkappa}{B} \frac{\partial f}{\partial s} \right)$$
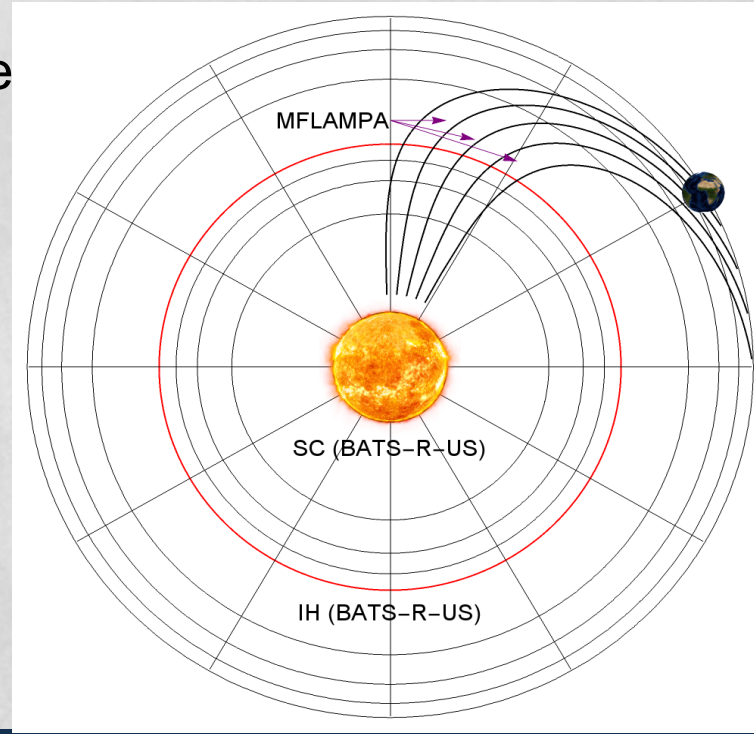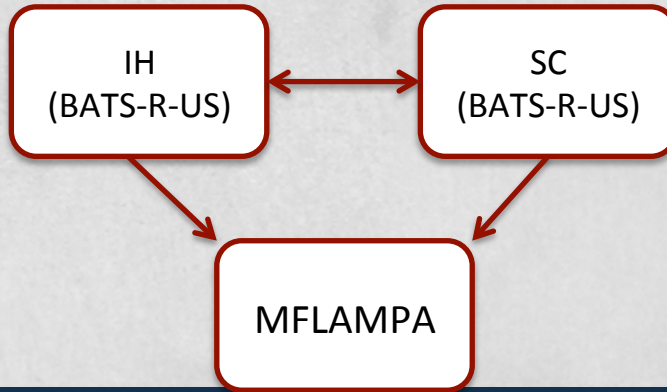
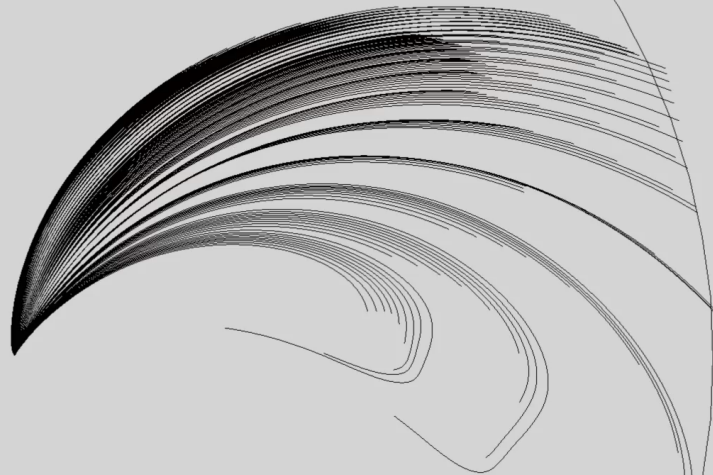Reduction to single spatial dimension transforms spatially 3-D problem to multitude of spatially 1-D problems
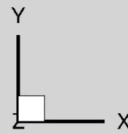
$\leftarrow ds$

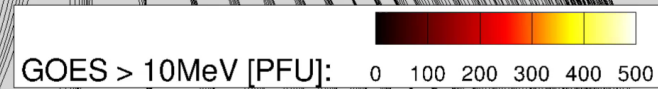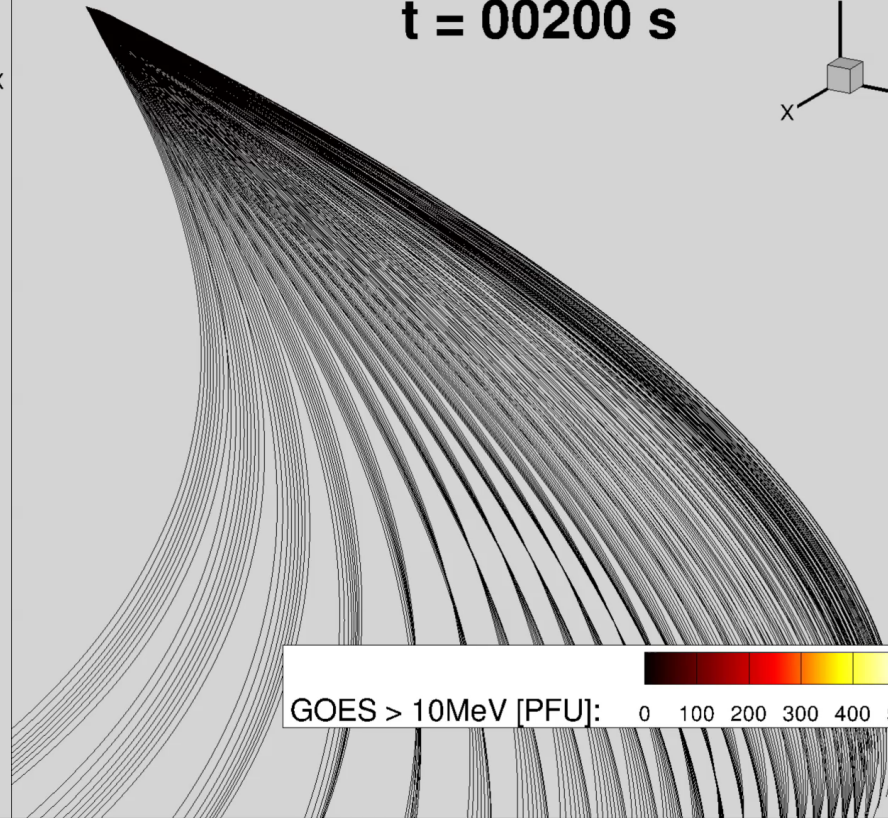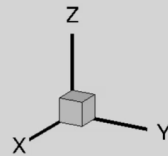# Technology with Many Field Lines. Design

A forecasting framework:

- Model of Solar Corona and Inner Heliosphere
  - Block-Adaptive-Tree-Solar-wind-Roe-type-Upwind-Scheme (BATS-R-US)
- Kinetic particle model
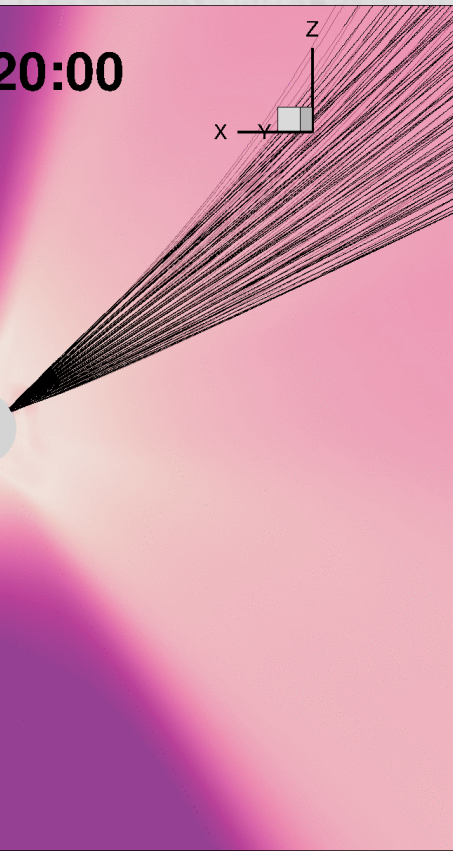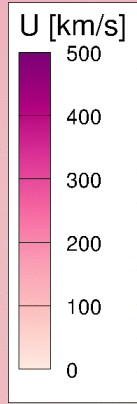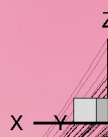 - Multi-Field-Line Advection Model of Particle Acceleration (M-FLAMPA)

t = 00200 s

t = 00200 s

GOES > 10MeV [PFU]: 0 100 200 300 400 500

GOES > 10MeV [PFU]: 0 100 200 300 400 500

T=0000:20:00