Understanding solar eruptions: an observational perspective on space weather

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Solar-C; 2013/11/11; Takayama, Japan

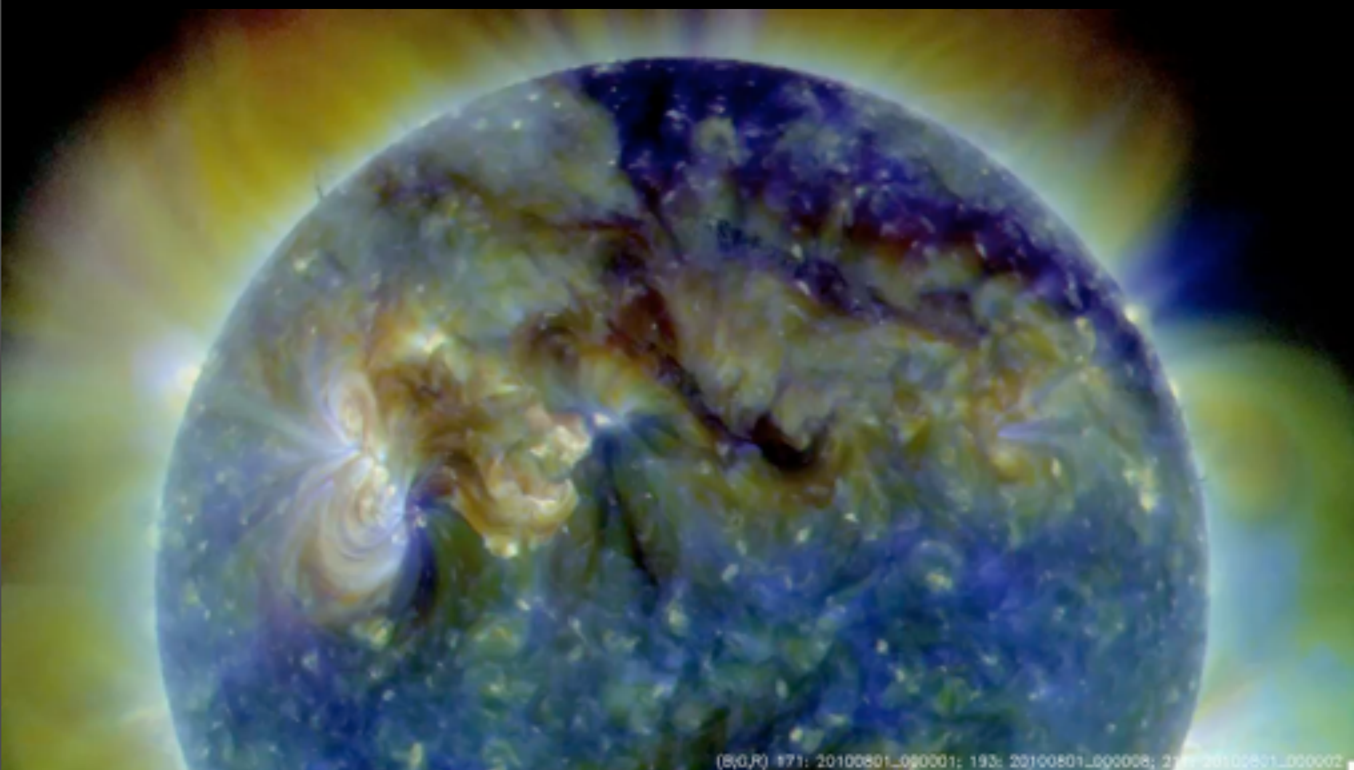
Space weather user objectives:

- For space assets (energetic-particle impacts on S/C and astronauts) and for radio communications (including navigation and timing):
  - forecast with at least 24-h lead time when an eruption of specified magnitude will go off, and what the associated energetic particles populations and shocks will be that propagate earthward.
- For long ground-based conductors, including electric power grids:
  - forecast with at least 24-h lead time what the magnetic properties are of the field erupting into the heliosphere towards Earth-Sun L1 [because L1 is far too close].

In solar-physics terms:

- Objectives: 24h ahead of time,
  - forecast the timing and magnitude of flares and eruptive events,
  - specify the field geometry of the erupting rope and of the overlying field, and
  - predict pathways and population properties of energetic particles.
- Needs: understanding of the injection, storage, and release of energy into active-region coronae, and their surrounding fields.
- Data: active-region details [Solar-C] and global-Sun field [e.g., SDO, STEREO, SoHO, to drive coronal-heliospheric model].

2010/08/01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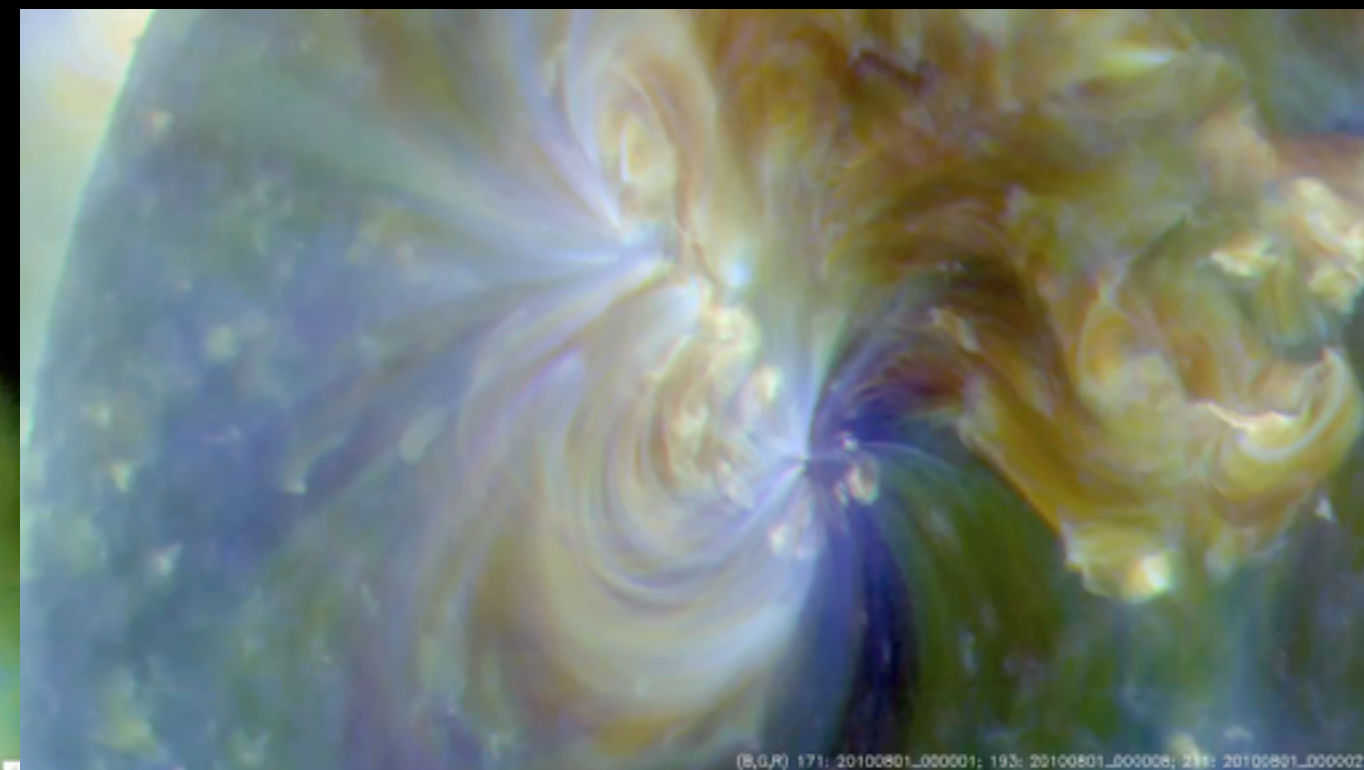
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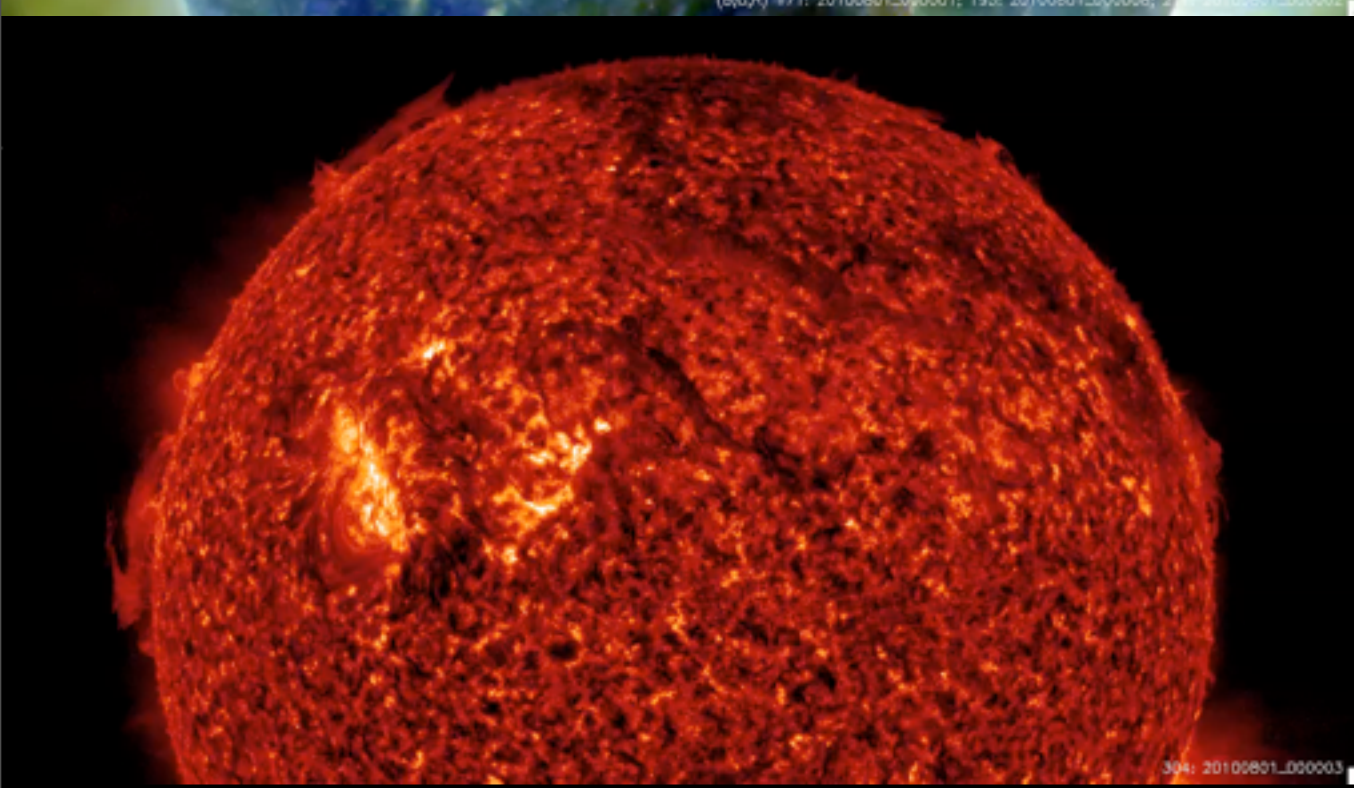
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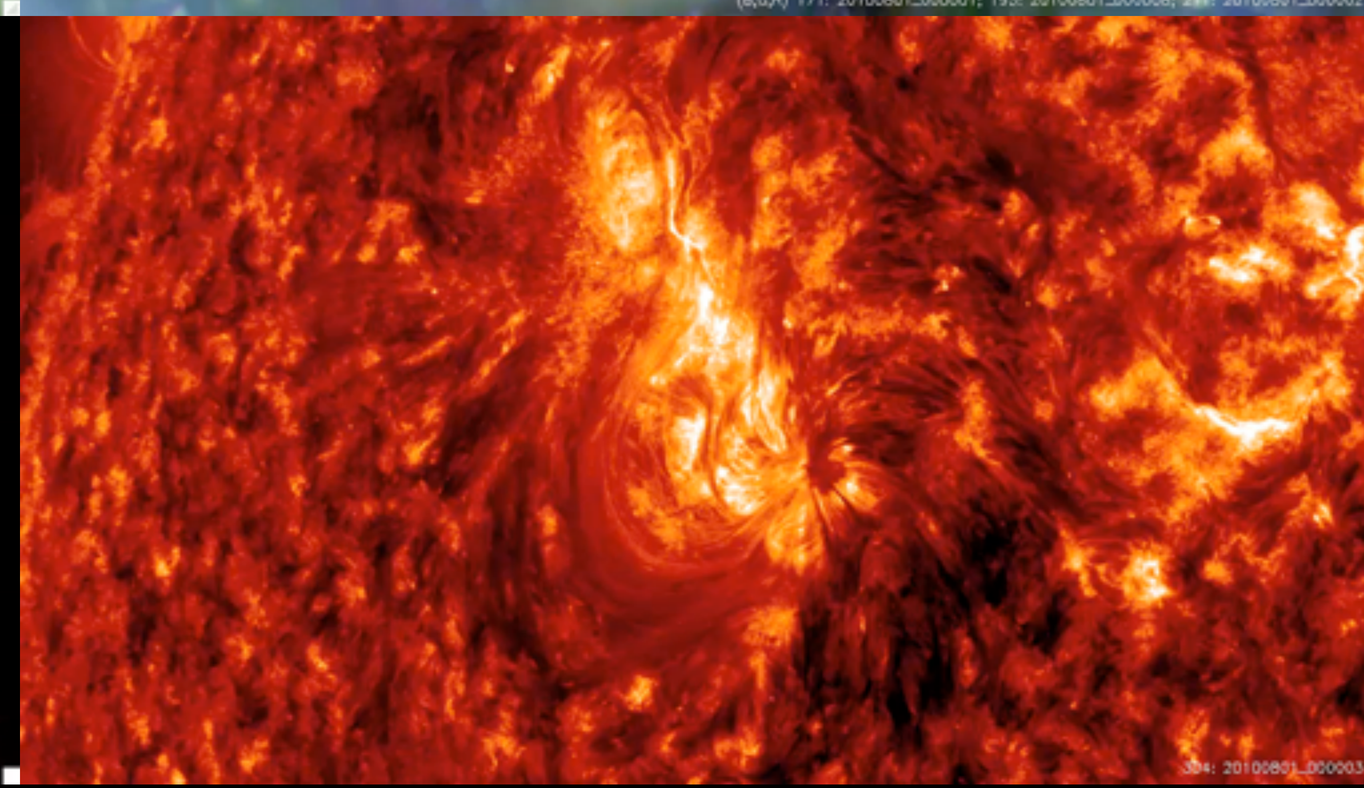
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Destabilizing B

Energy buildup/storage

Energy conversion/release

Field configuration reaches non-equilibrium state

How much?
When?
In what form?

Destabilizing B

Need to understand:

* energy released in flares (down to QS microflaring of 10^{24} ergs): O(0.5x total atmospheric losses).
* energy released in flares from C1 upward: 1% of total radiated energy.
* Why so little for larger events?
* Power laws link small and large. Are all events "similar" and thus to be understood together?

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Need to understand:
energy partitioning over
* spectral irradiance,
* bulk kinetic (CME),
* energetic particles (reconnection & shock)

and geometry of the erupting and overlying field and their interactions

Destabilizing B

Flux/rope emergence

Modified shear

Modified 'external' field

Field configuration reaches non-equilibrium state

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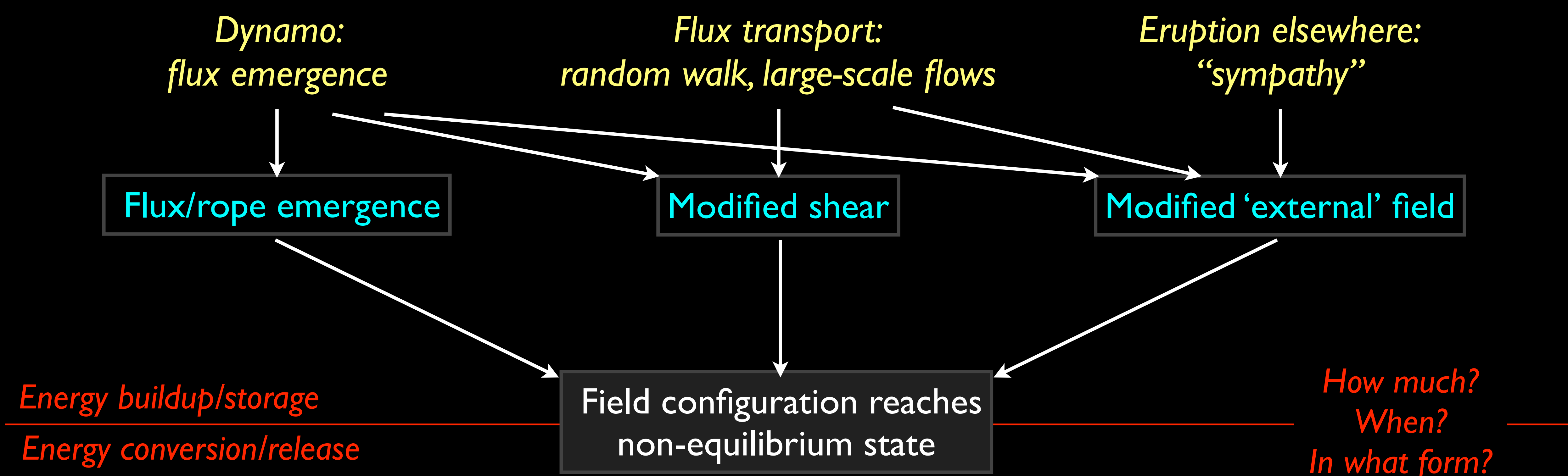
Destabilizing B



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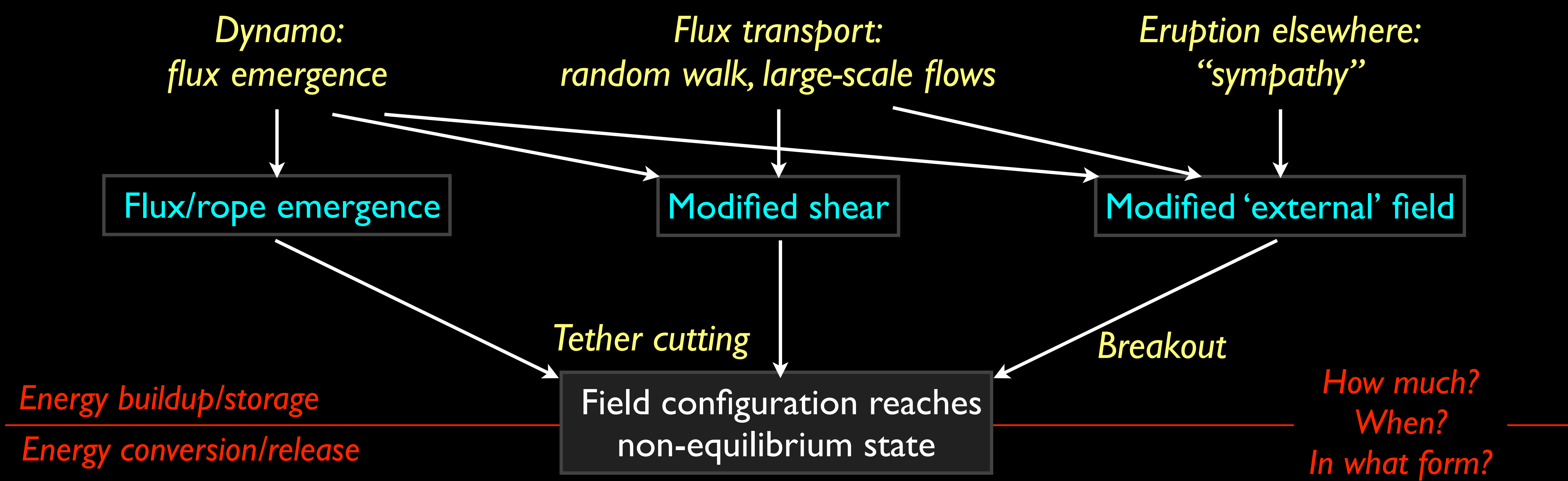

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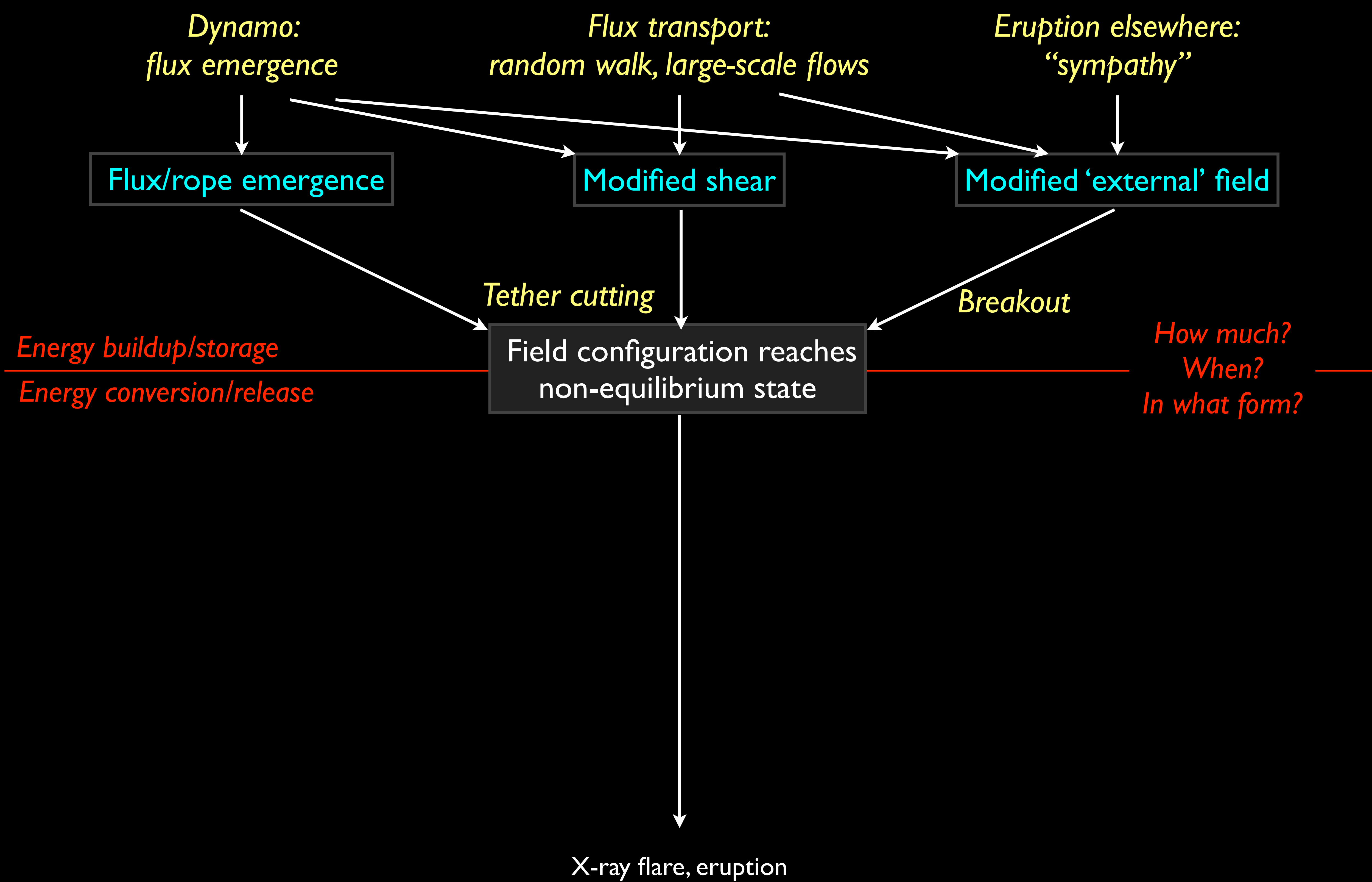

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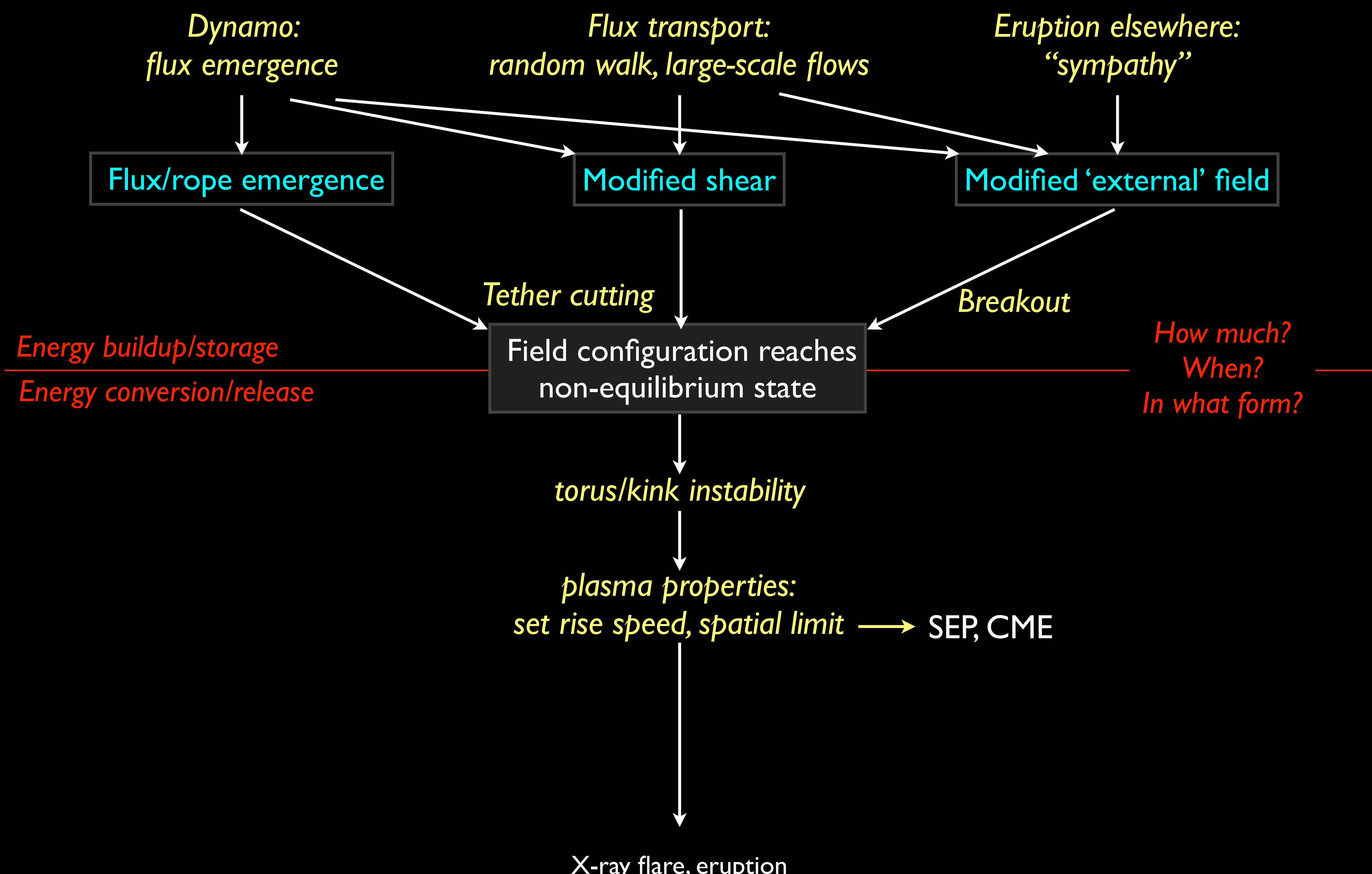

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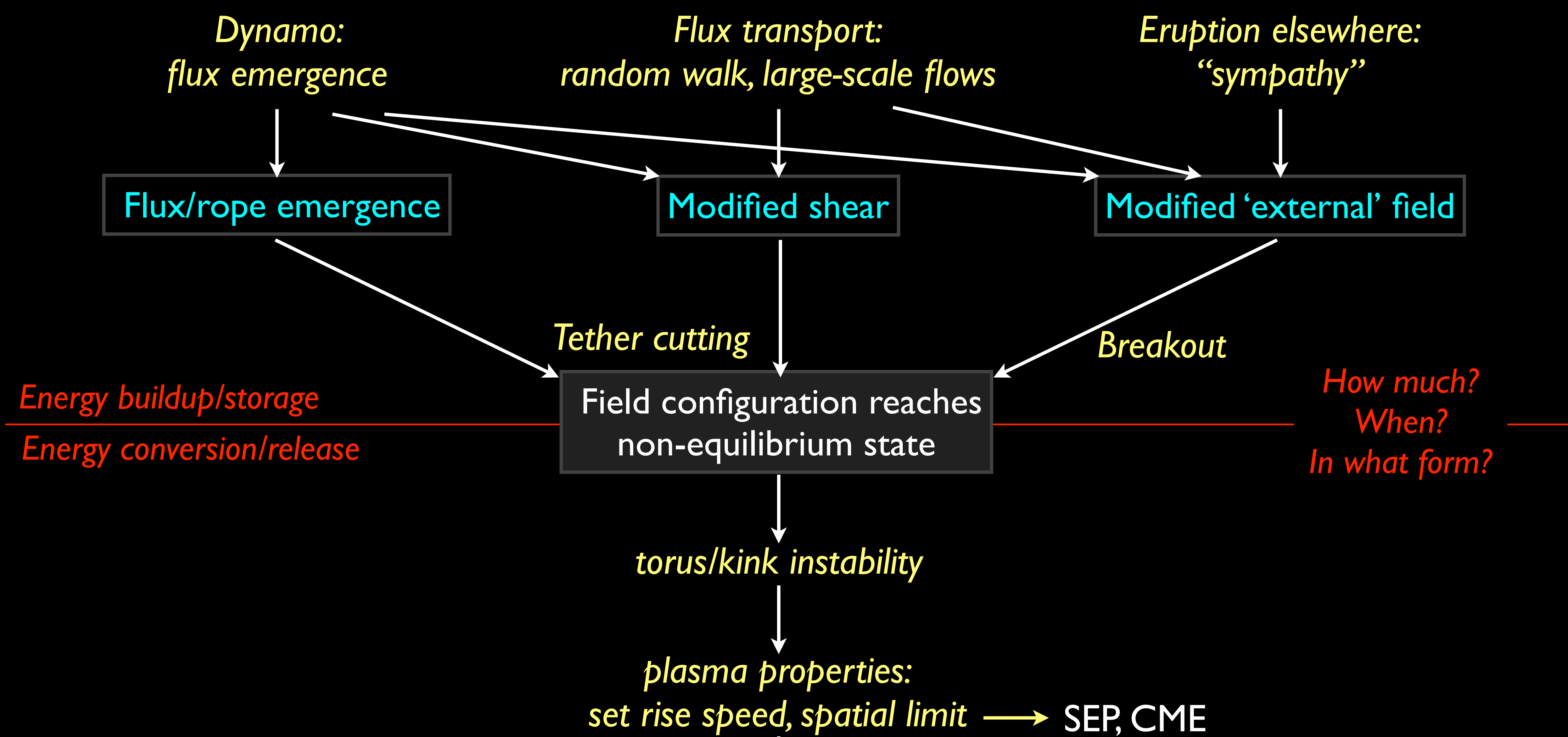
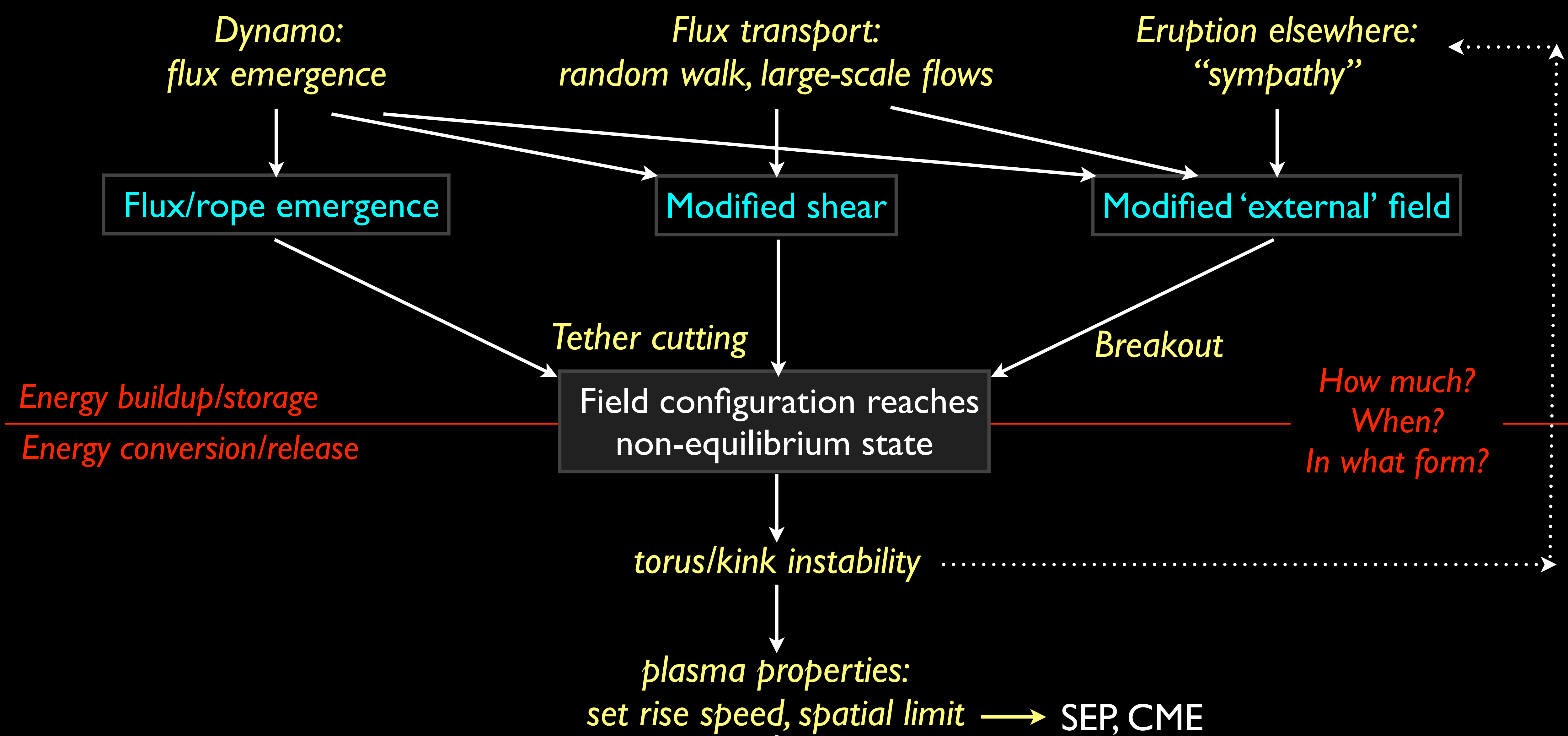


	"Small" scale	"Large scale"
"Weak" field	Fibril eruption / EUV microflare	QS filament eruption, EUV signature
"Strong" field	X-ray flare, eruption	**?

Destabilizing B



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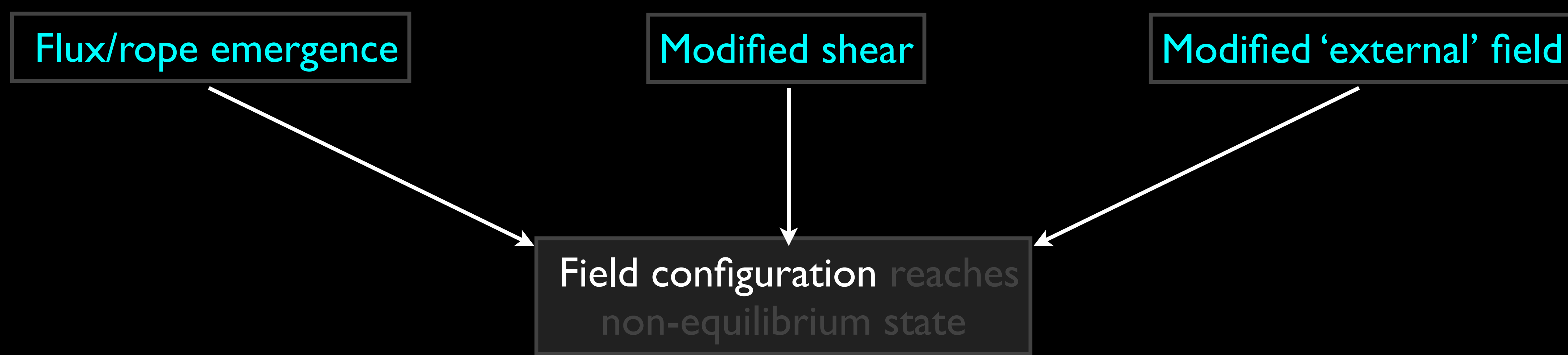

Destabilizing B

Continuous, high-res. observing

Photosphere/chromosphere

Chromosphere/corona

Large f.o.v. X/EUV context

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Assimilation-driven model field

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Solar-C

with context observations by

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SDO/STEREO

supported by assimilative

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models (NLFFF, magnetofrictional, MHD)

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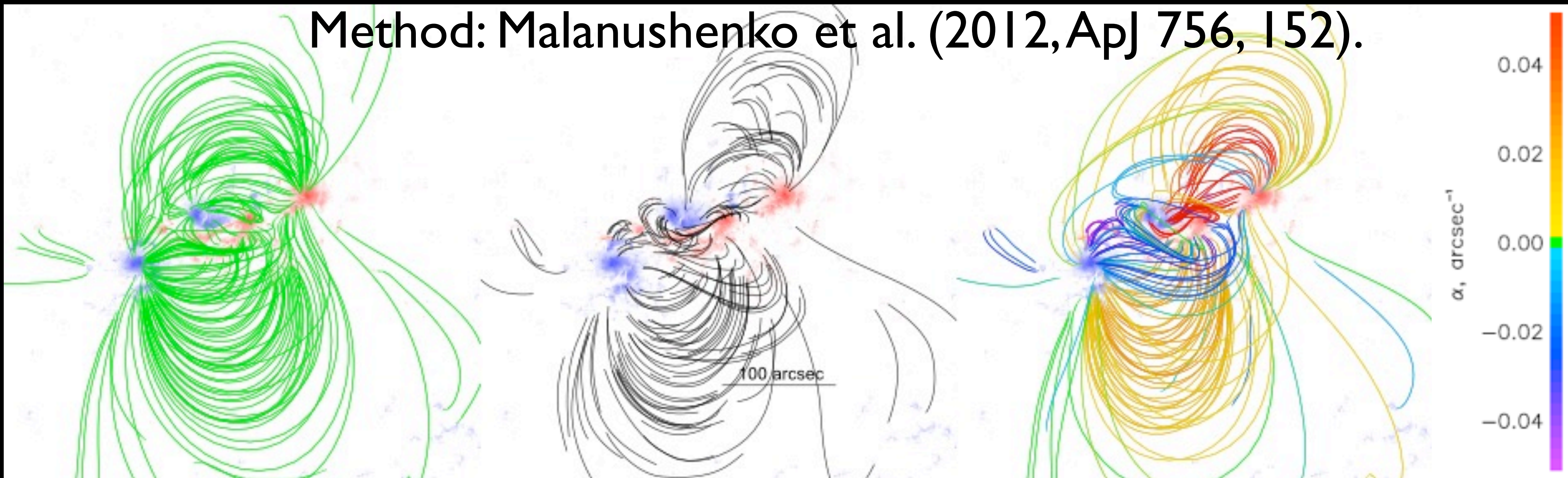
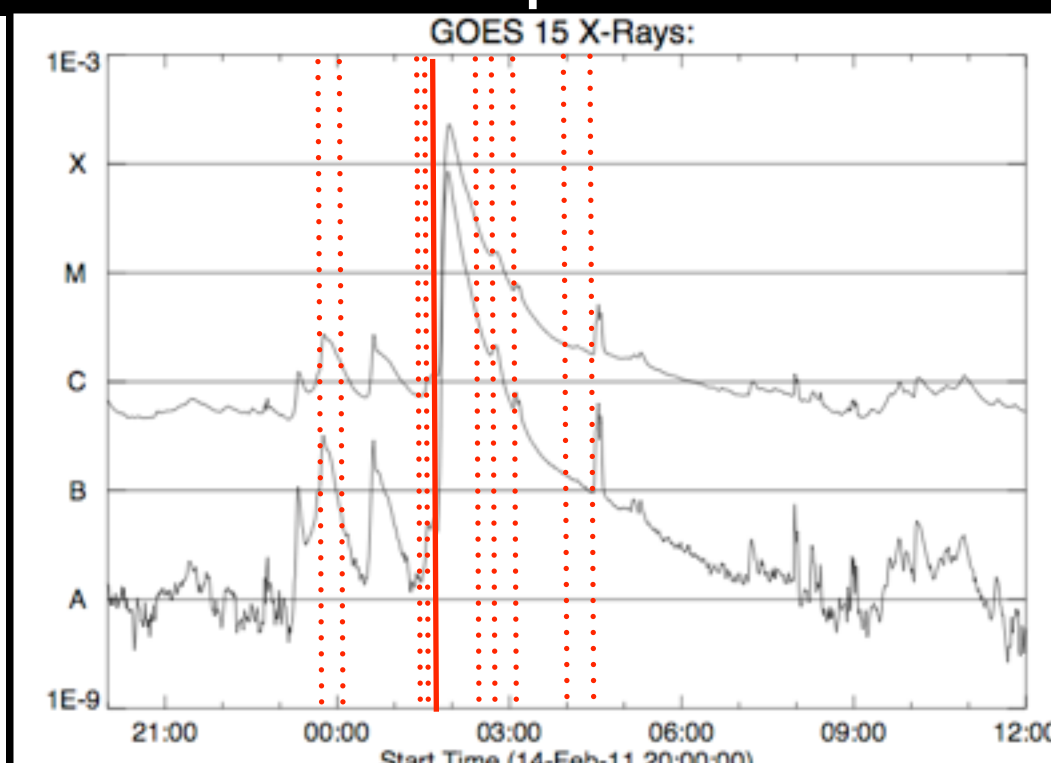
2011/02/15 01:40 UT

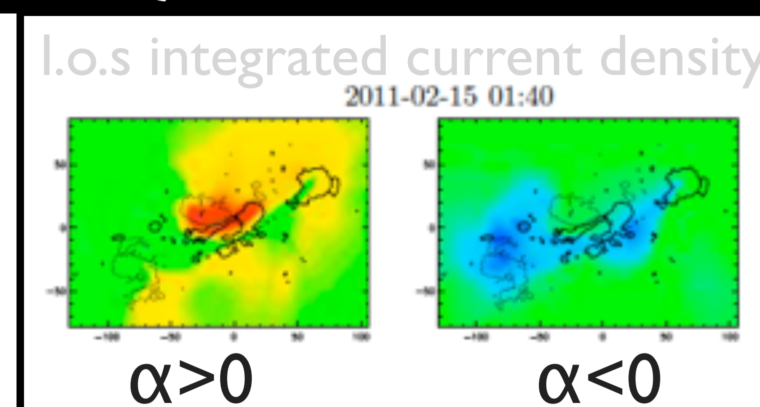
Method: Malanushenko et al. (2012, ApJ 756, 152).

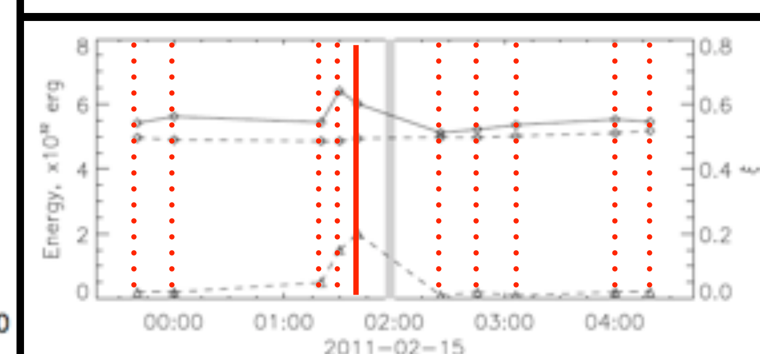


Potential field | Traced loops | Best-fit QGR-NLFFF

2011-02-...	E_P $\times 10^{32}$ erg	E_F $\times 10^{32}$ erg	E_{tot} $\times 10^{32}$ erg
14 23:40	4.97	0.45	5.43
15 00:00	4.90	0.72	5.62
15 01:20	4.86	0.58	5.44
15 01:30	4.86	1.55	6.41
15 01:40	4.94	1.07	6.01
15 02:25	4.98	0.14	5.11
15 02:45	4.97	0.25	5.23
15 03:06	5.02	0.34	5.35
15 04:00	5.11	0.42	5.53
15 04:19	5.18	0.28	5.45







2011/02/15 02:25 UT

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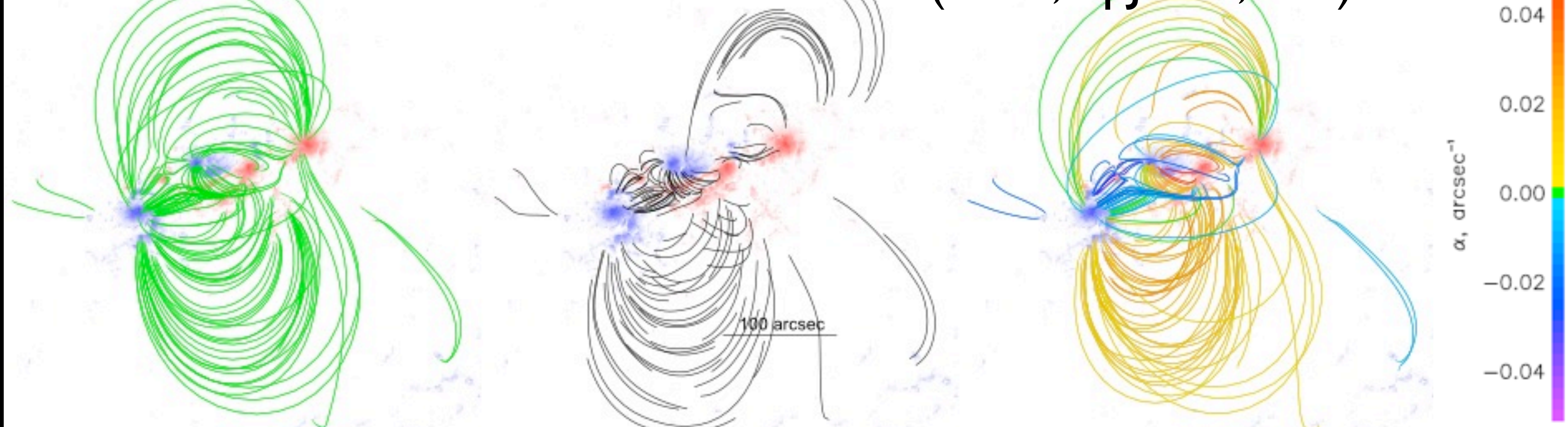

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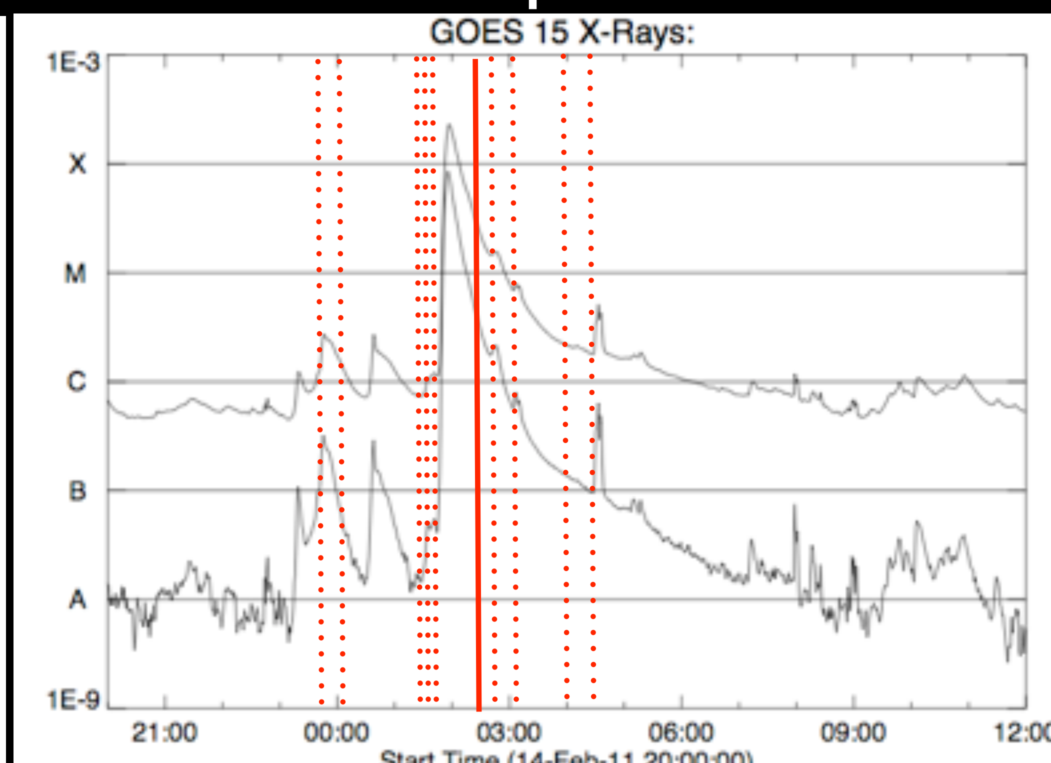

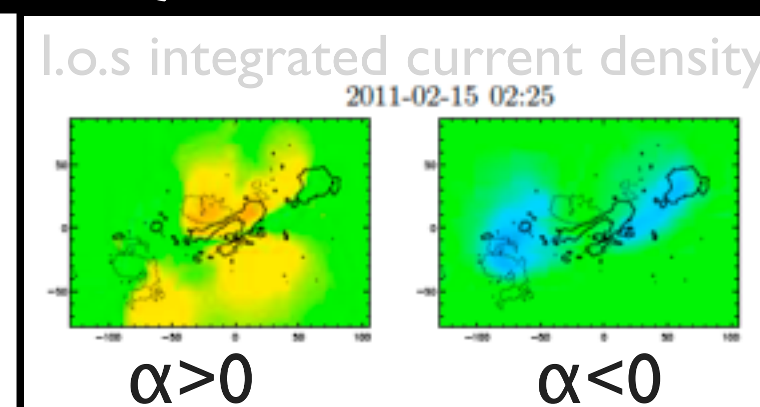

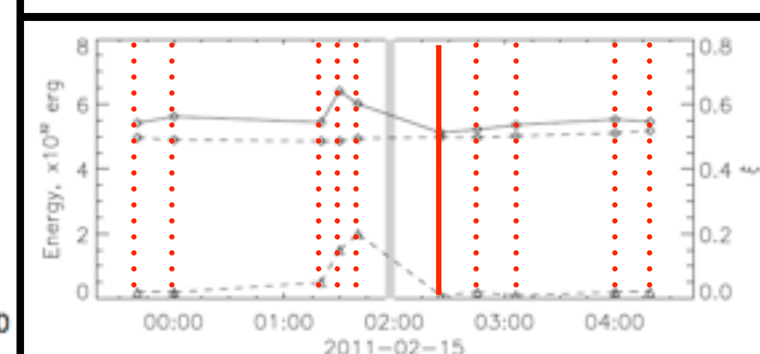

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Forecasting space weather

Continuous, high-res. observing

Photosphere/chromosphere

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