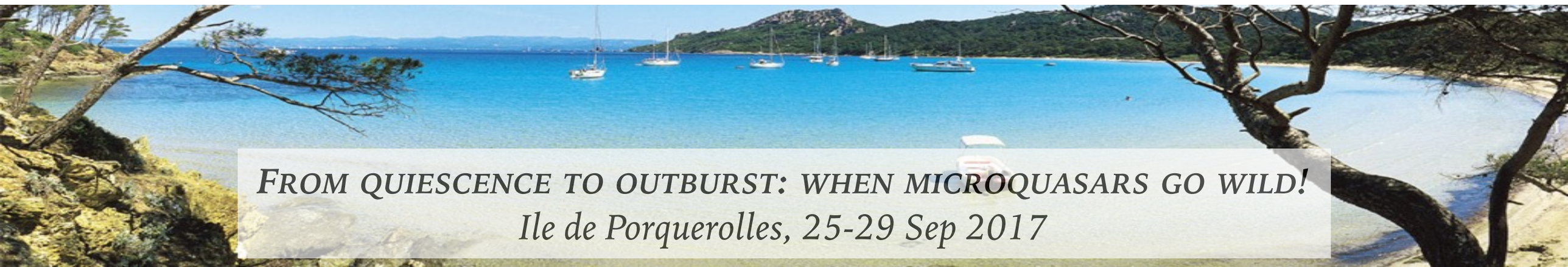
SELF-SIMILAR SEMI-ANALYTICAL RMHD(+G) JET MODEL:

first step towards a more comprehensive jet modelling for data fitting

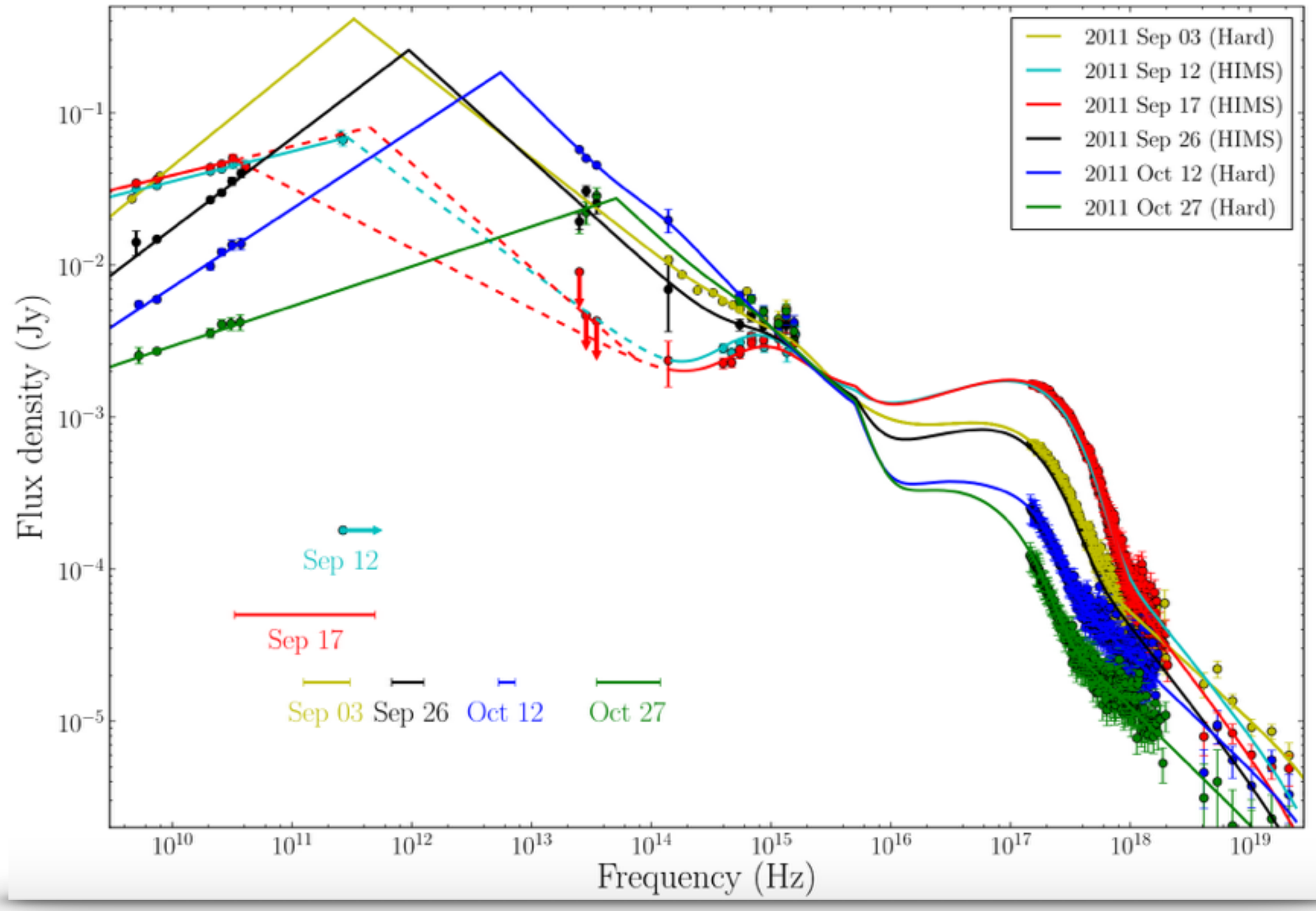
Chiara Ceccobello

Y. Cavecchi, M.H.M. Heemskerk, S. Markoff, P. Polko, D. Meier

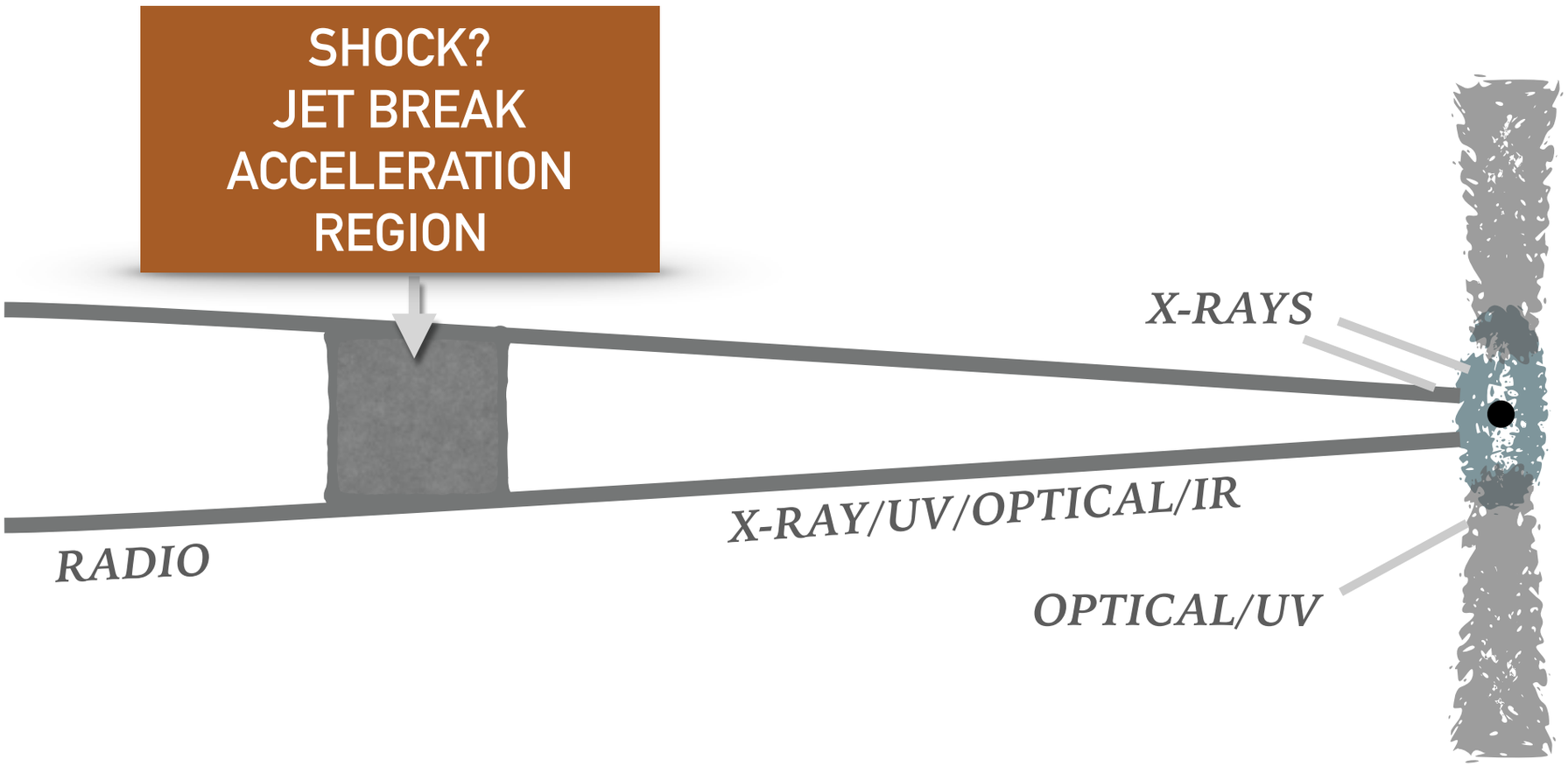


FROM QUIESCENCE TO OUTBURST: WHEN MICROQUASARS GO WILD!
Ile de Porquerolles, 25-29 Sep 2017

MAXI J1836-194 *Russell et al. 2014*

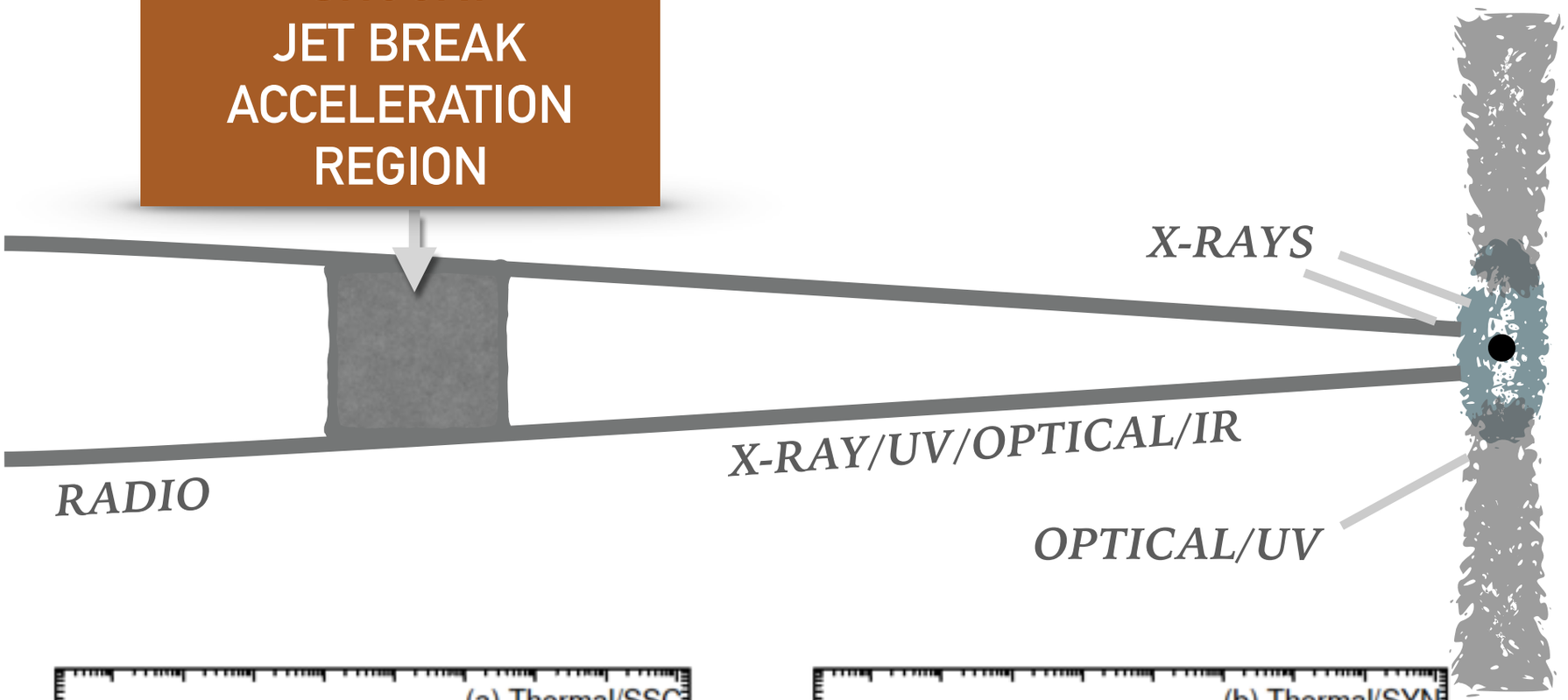


MOTIVATION



Romero+2003,
Markoff+2005,
Yuan+2005,
Belmont+2008,
Zdziarski+2012,2014,
Pepe+2015, …

SHOCK?
JET BREAK
ACCELERATION
REGION



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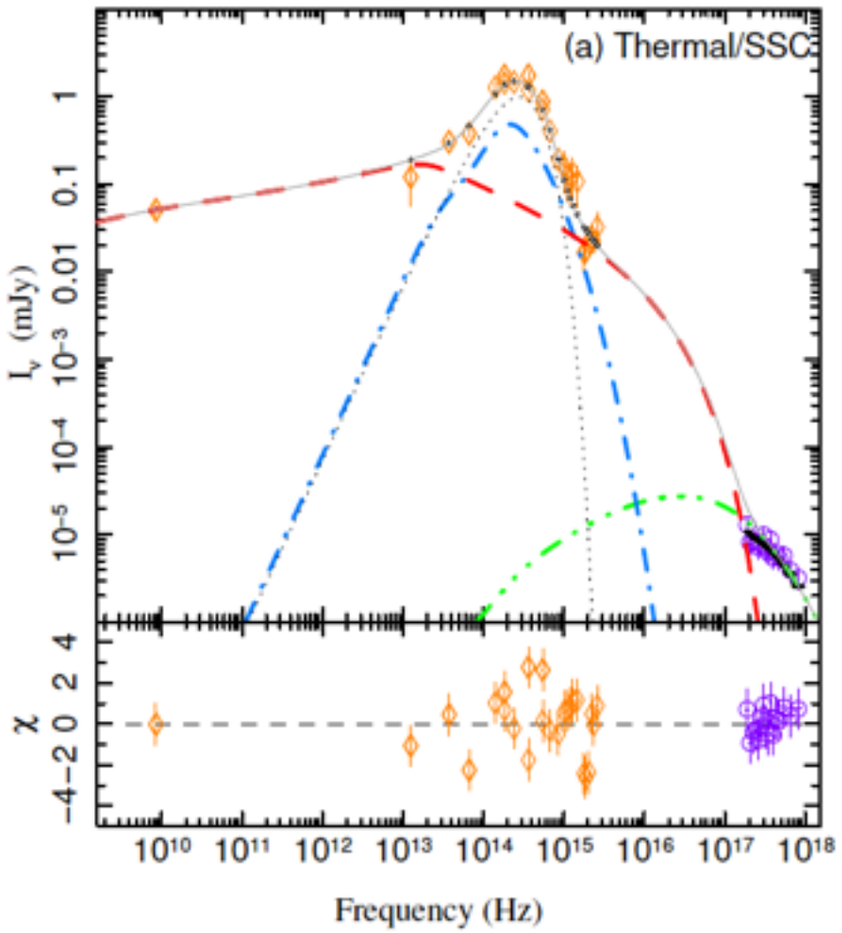
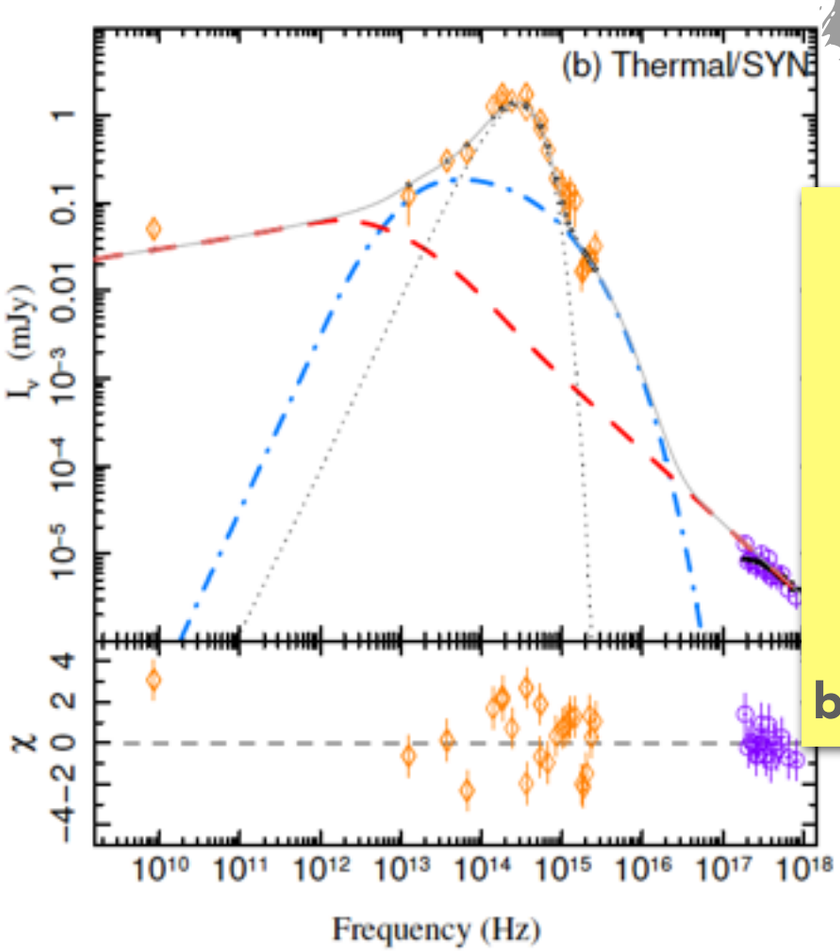




Connors et al. 2017

…but even with more sophisticated radiation modelling, we still have major issues with

DEGENERACY

between classes of models!

MOTIVATION

SHOCK?
JET BREAK
ACCELERATION
REGION

Romero+2003,
Markoff+2005,
005,
+2008,
+2012,2014,
015, …

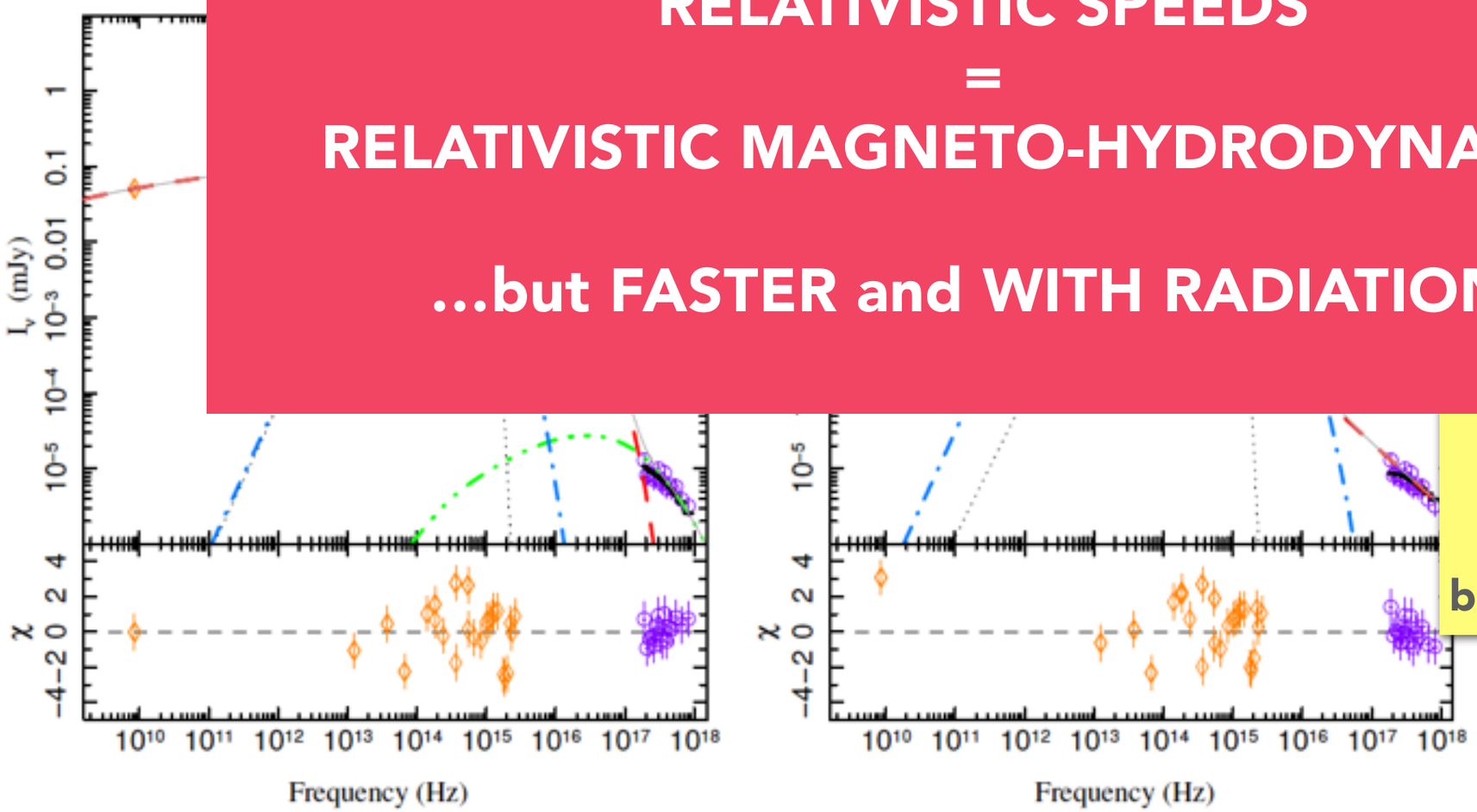
WE NEED TO HAVE AN ADEQUATE TREATMENT OF THE **DYNAMICS AND MORPHOLOGY OF JETS,** INCLUDING **MAGNETIC FIELDS, GRAVITY AND RELATIVISTIC SPEEDS**

=

RELATIVISTIC MAGNETO-HYDRODYNAMICS

…but FASTER and WITH RADIATION!

with more
d radiation
ling,
have
major issues with
DEGENERACY
between classes of models!



Connors et al. 2017

MOTIVATION

AIM 1:

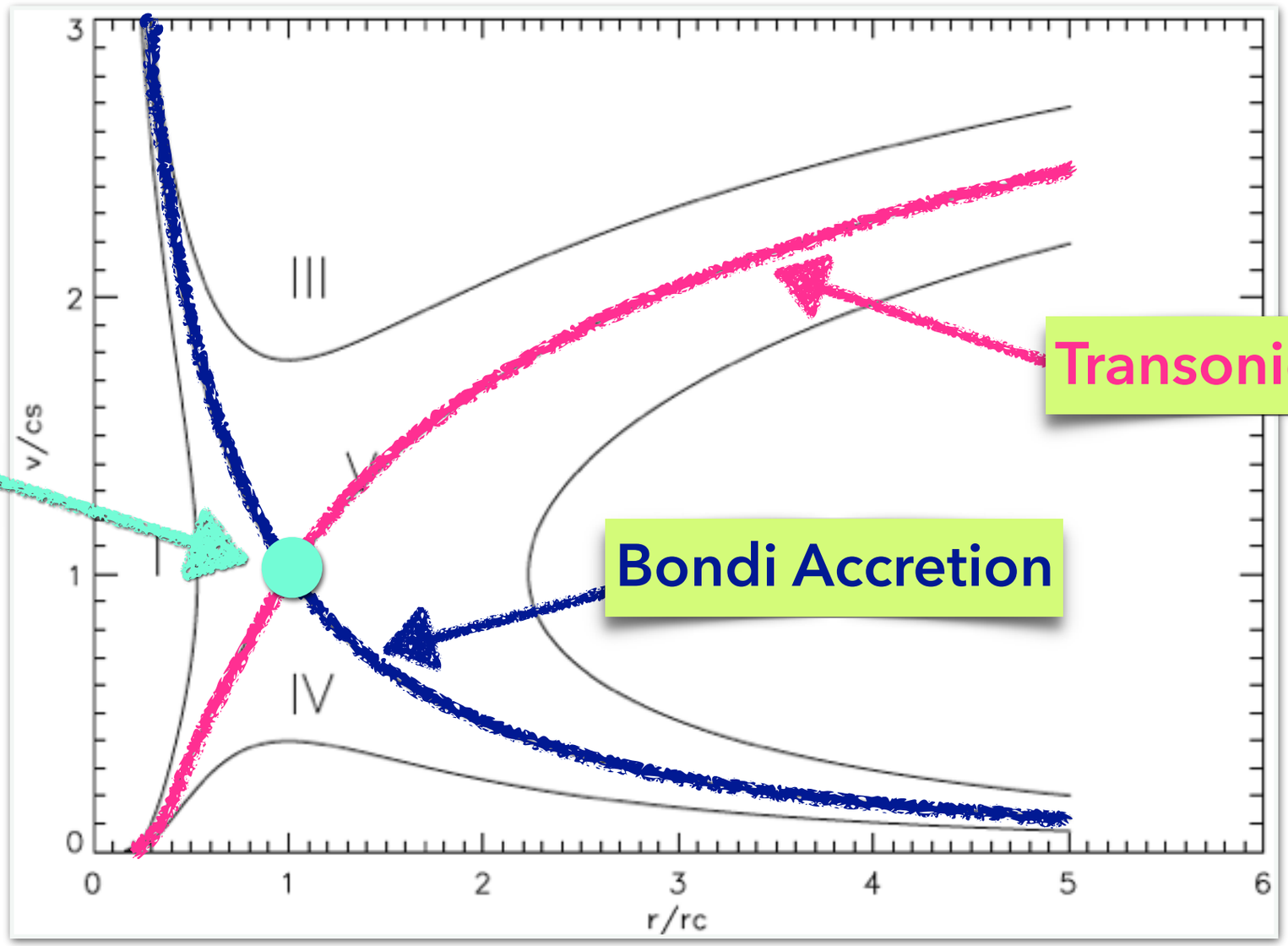
we want to describe

- a *relativistic, hot, accelerating flow*
- embedded in a **MAGNETIC FIELD**
- close to a BH (non-negligible **GRAVITY**)

Parker

HD wind:

1 singular point



THEORY

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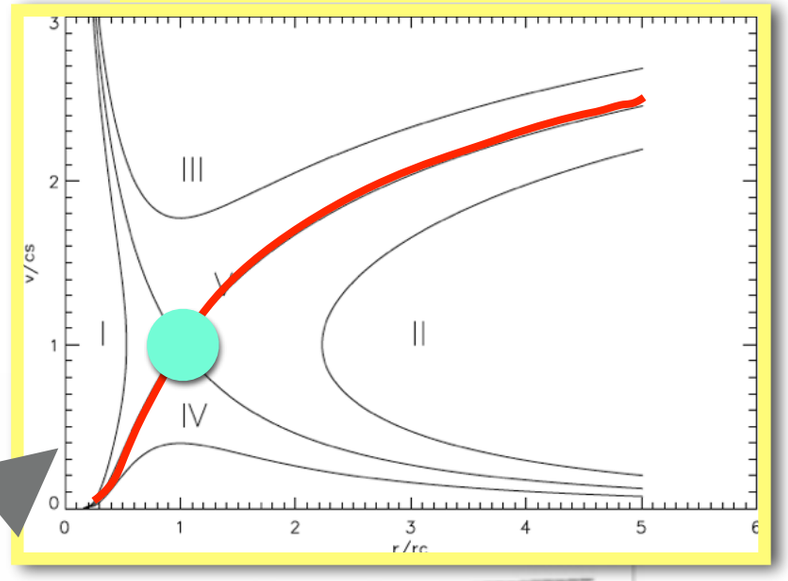
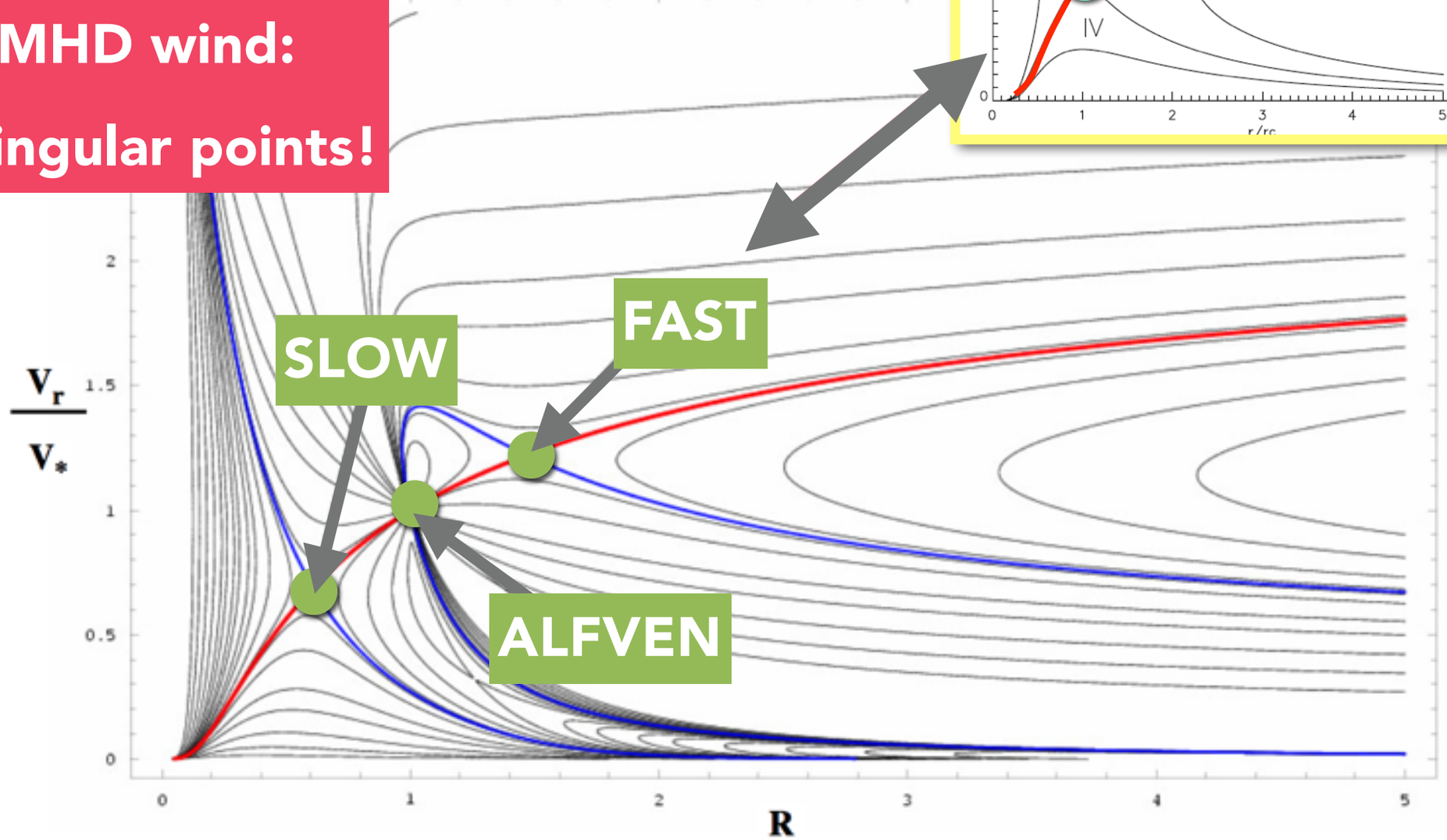


Weber & Davis

MHD wind:

3 singular points!



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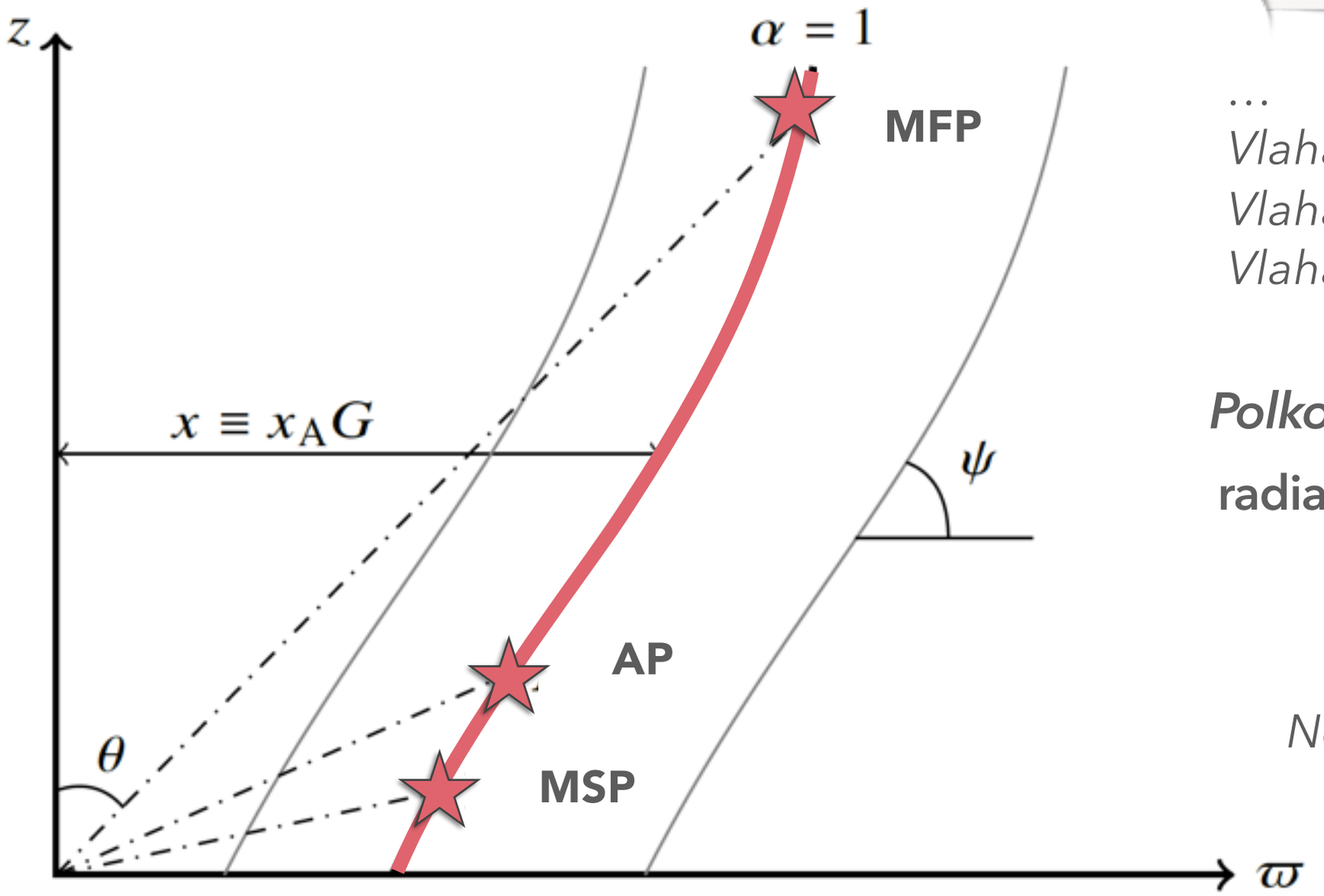
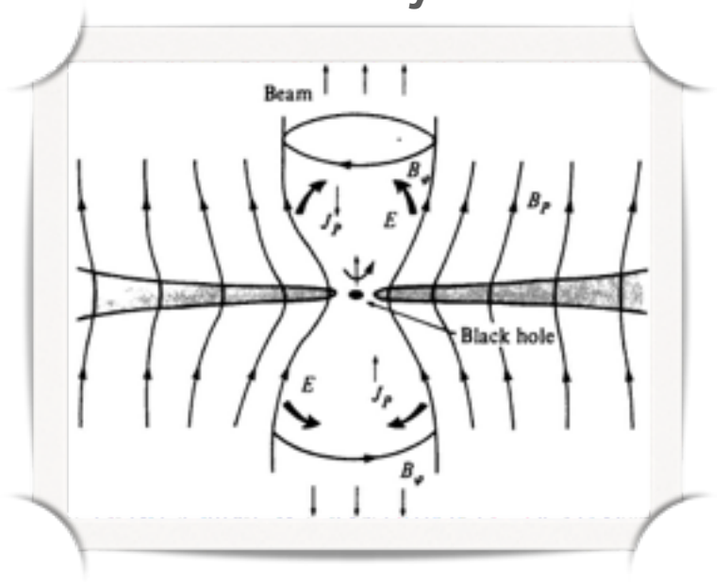


Blandford & Payne 1982



…

Vlahakis & Tsinganos 1998, Vlahakis et al 2000, Vlahakis & Königl 2003, …

Polko, Meier, Markoff (2014)

radial self-similar RMHD JET

with gravity

Not a global solution!

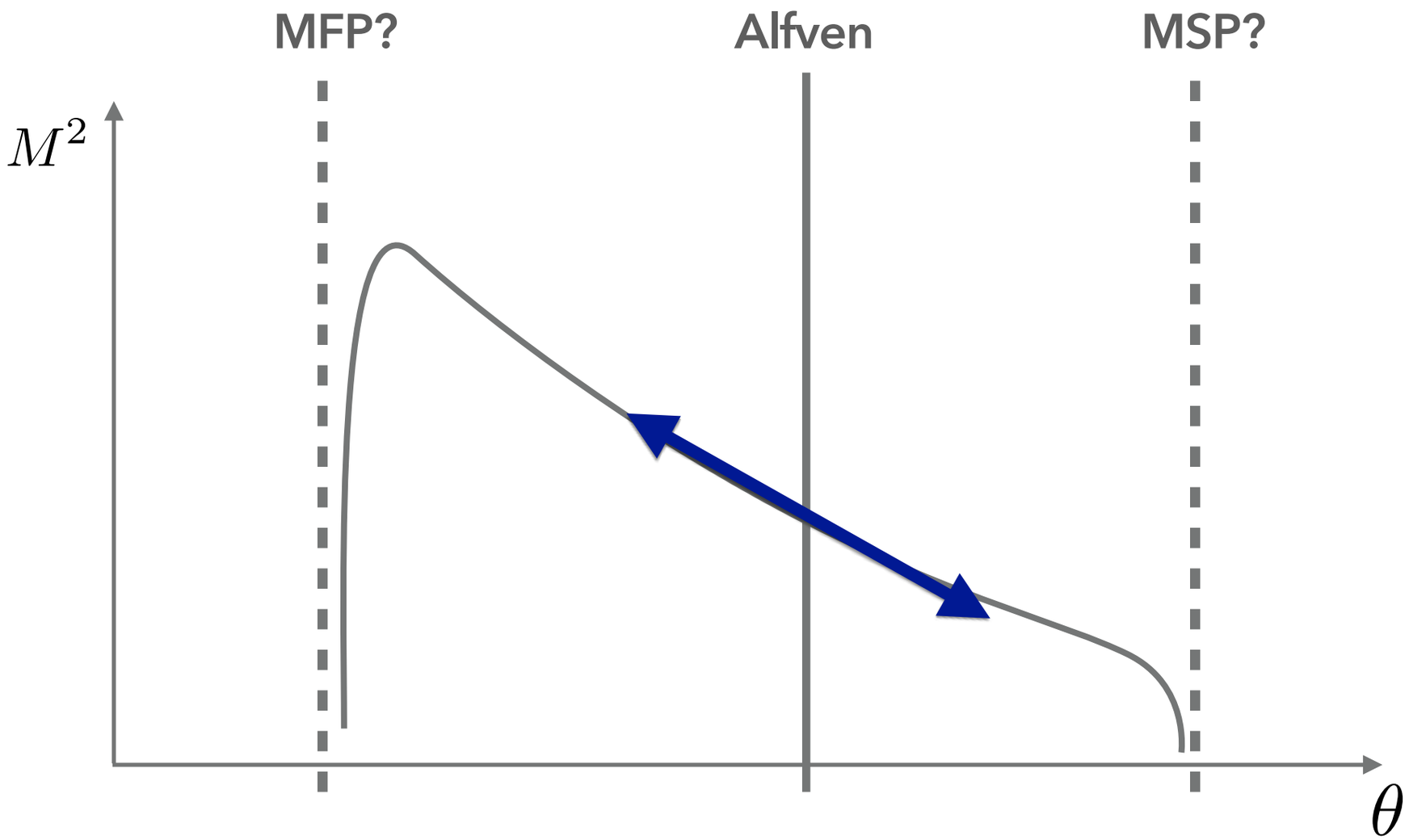
THEORY

AIM 1:

we want to describe

- a *relativistic, hot, accelerating flow*
- embedded in a **MAGNETIC FIELD**
- close to a BH (non-negligible **GRAVITY**)

OLD APPROACH:
integrating *TOWARDS* the singularities



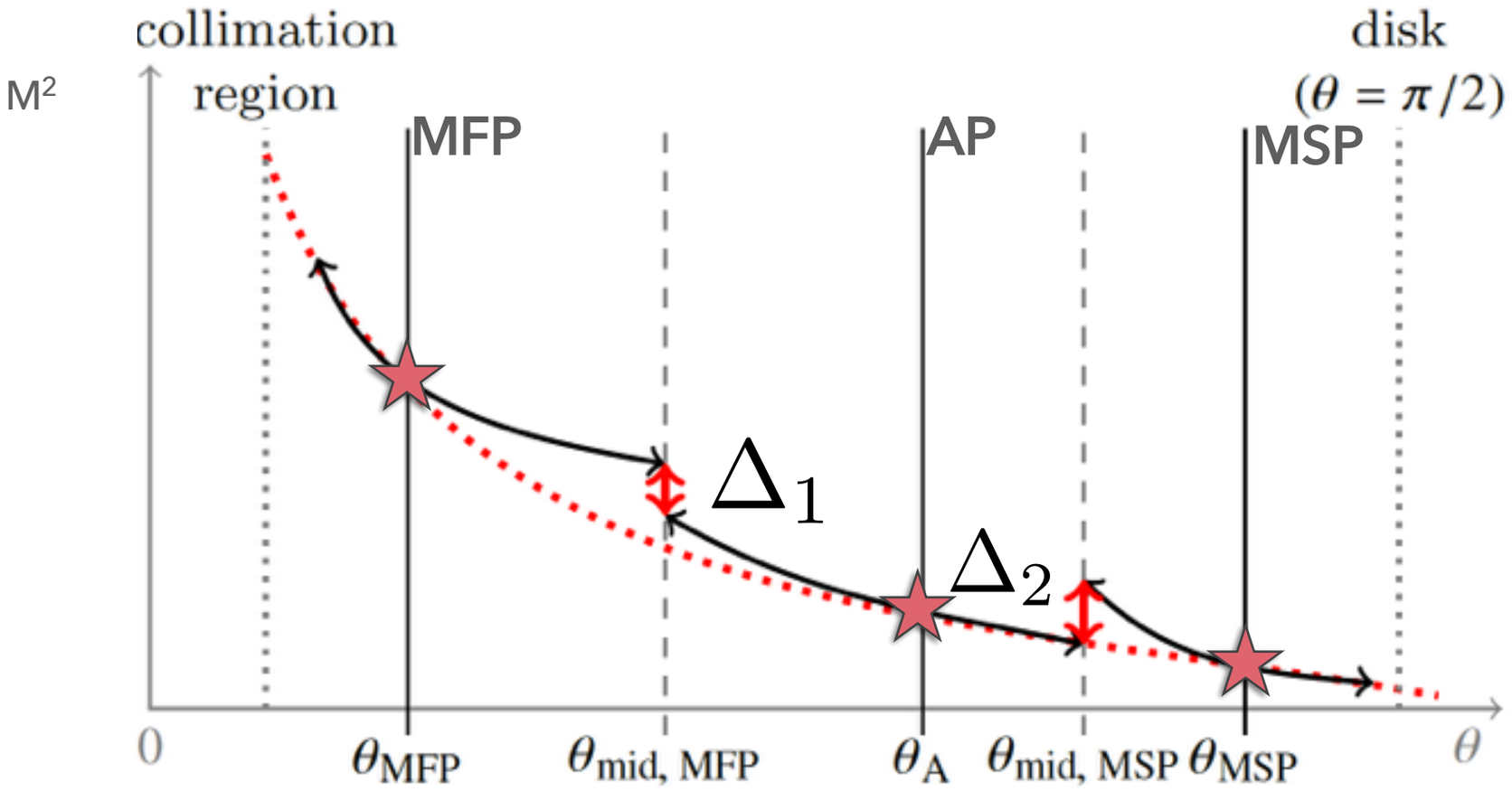
METHOD

AIM 1:

we want to describe

- a *relativistic, hot, accelerating flow*
- embedded in a **MAGNETIC FIELD**
- close to a BH (non-negligible **GRAVITY**)

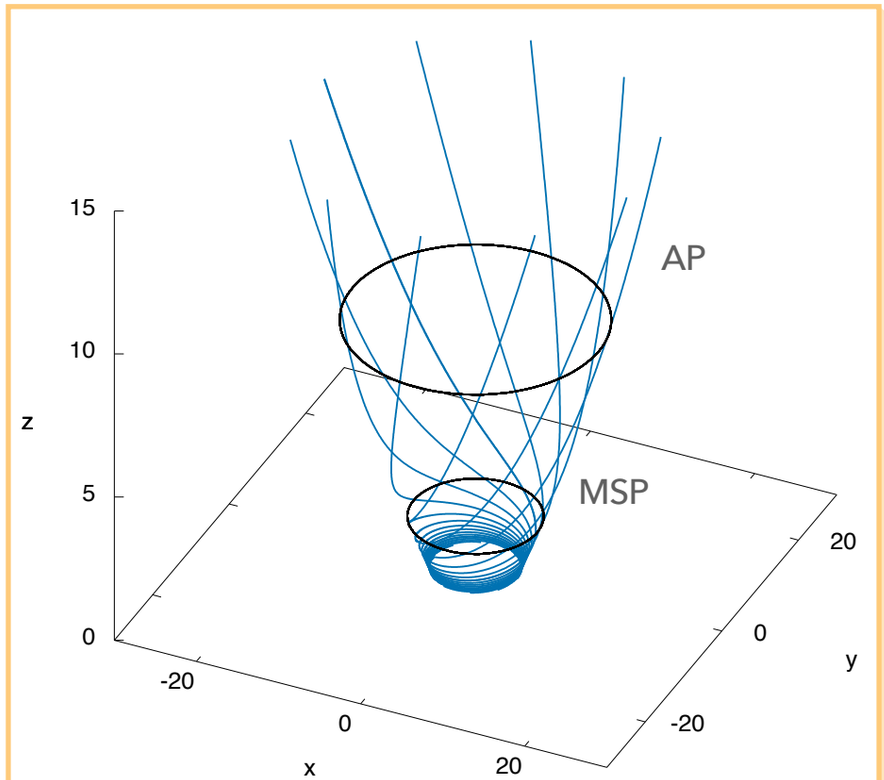
NEW APPROACH:
integrating *AWAY* from the singularities

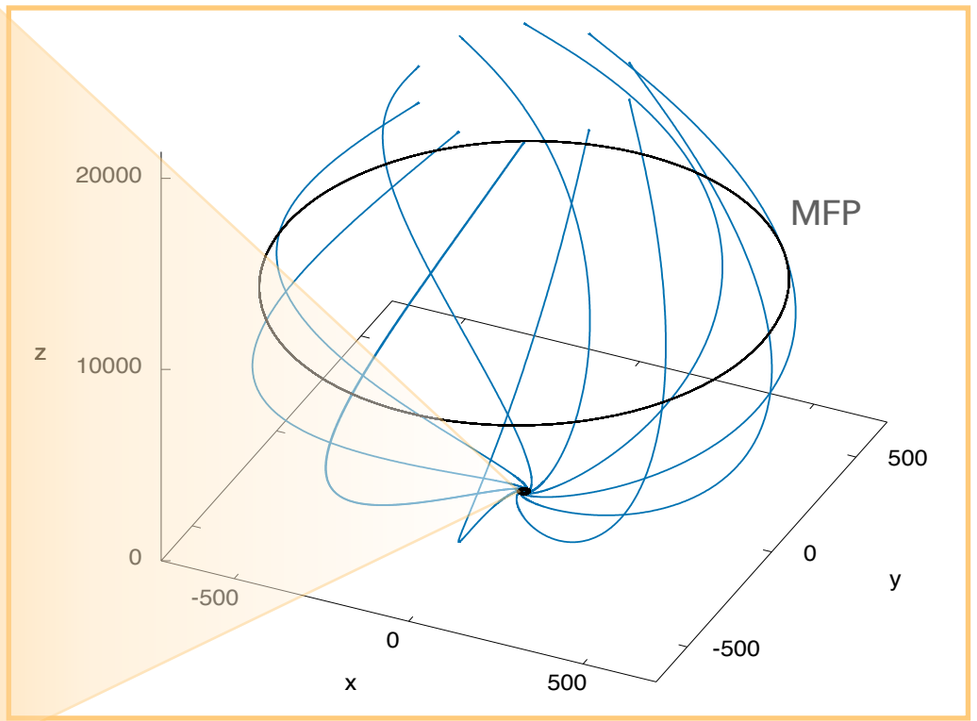


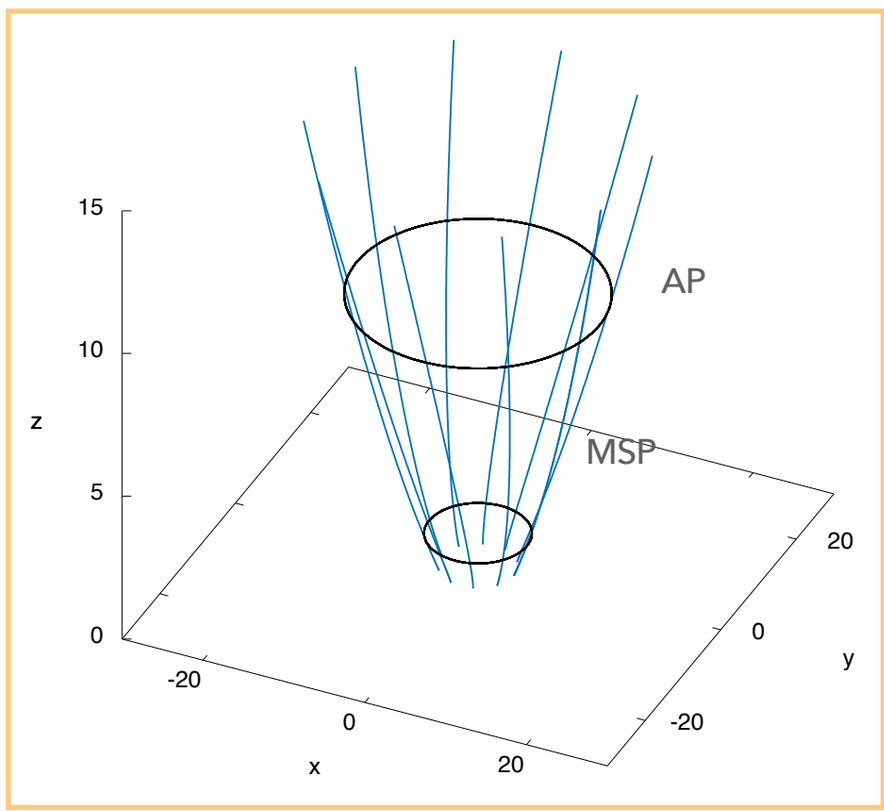
METHOD

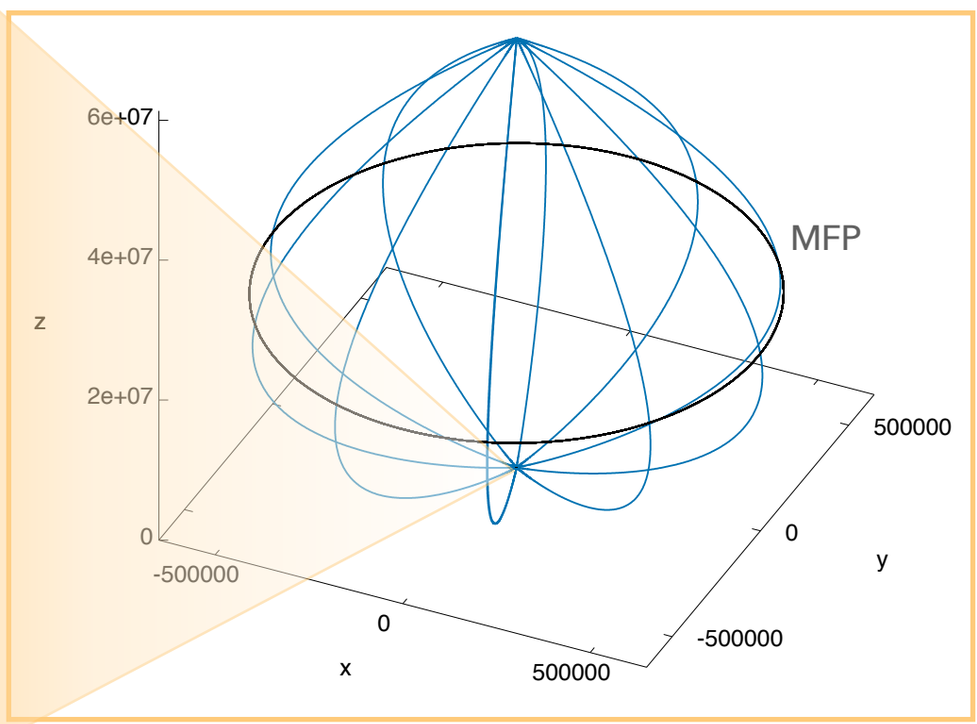
MAGNETIC FIELD MORPHOLOGIES

Streamlines examples





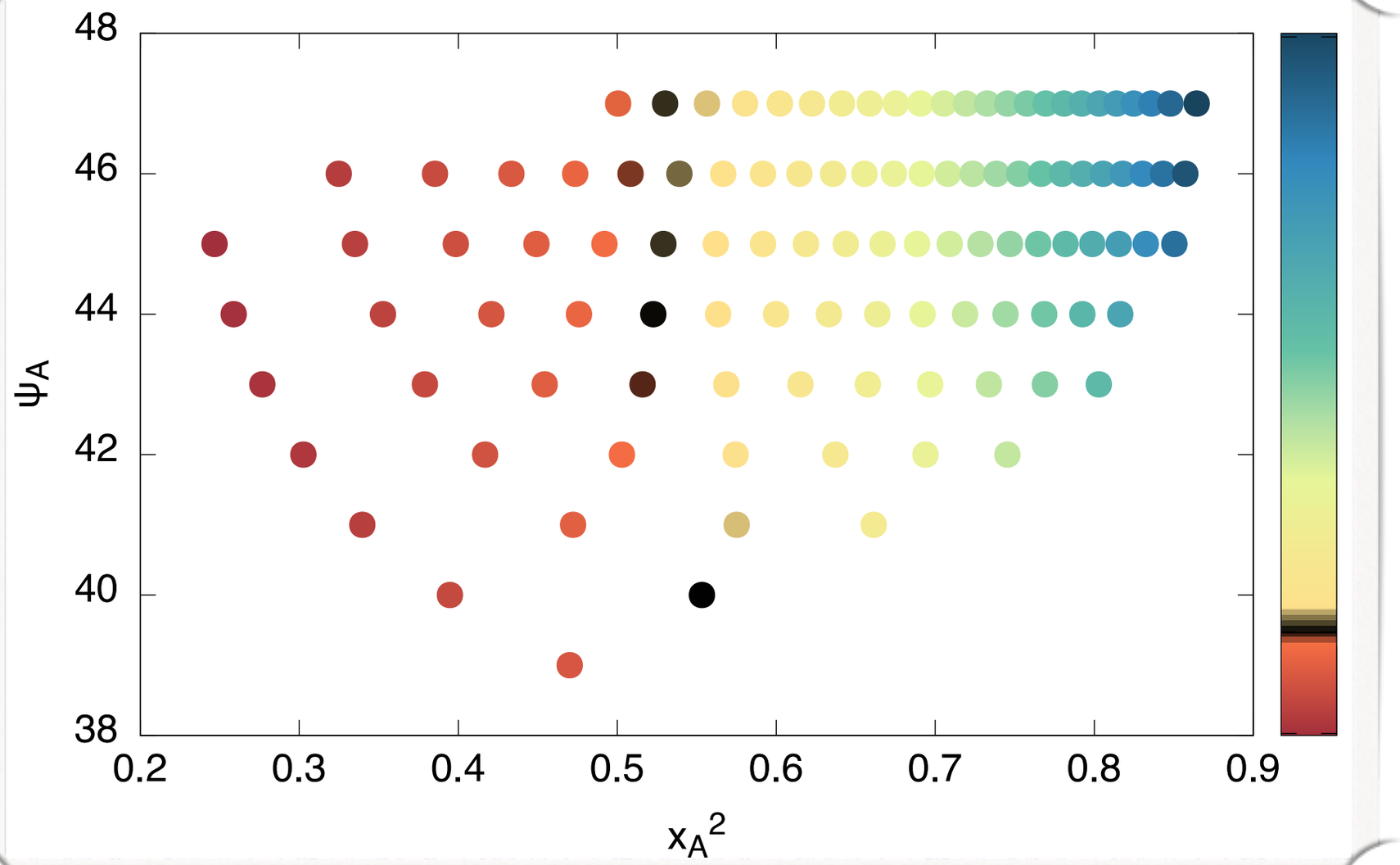




GEOMETRY

PARTITION OF ENERGY AT THE BASE (MSP) OF THE JET

TOT ENERGY = **THERMAL** + **MAGNETIC** + **KINETIC**



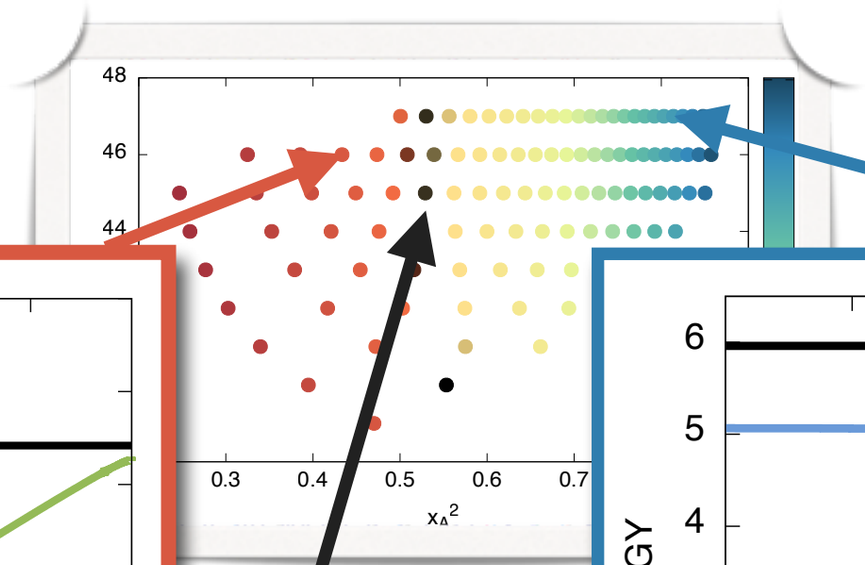
MAGNETICALLY DOMINATED @ MSP

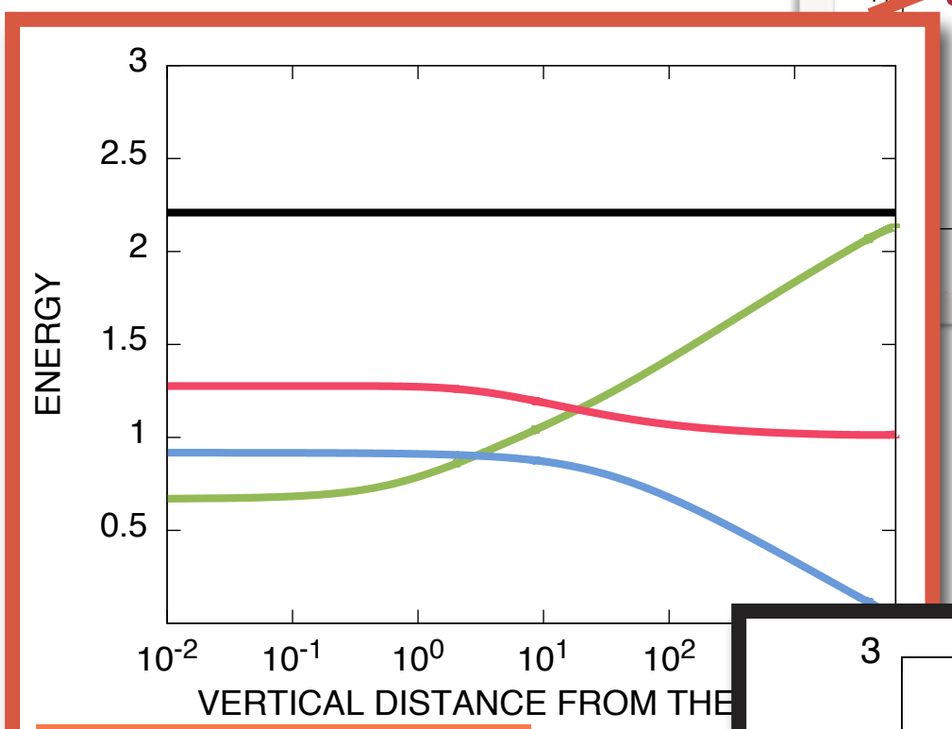
EQUIPARTITION @ MSP

THERMALLY DOMINATED @ MSP

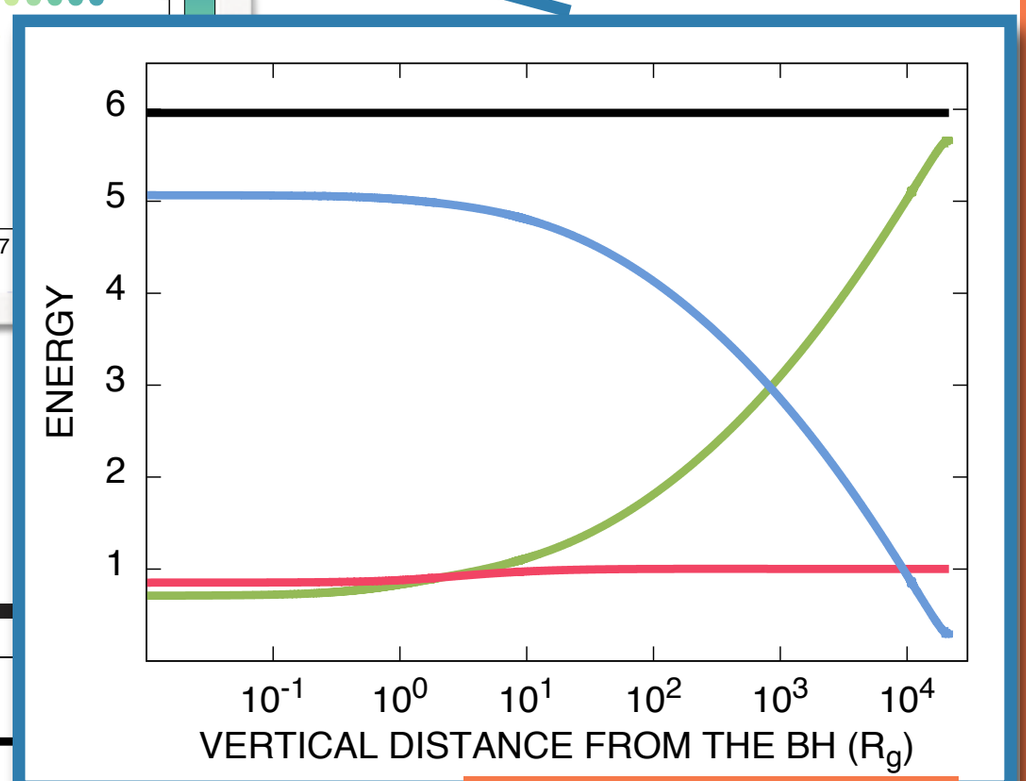
DYNAMICS

TOT ENERGY = **THERMAL** + **MAGNETIC** + **KINETIC**

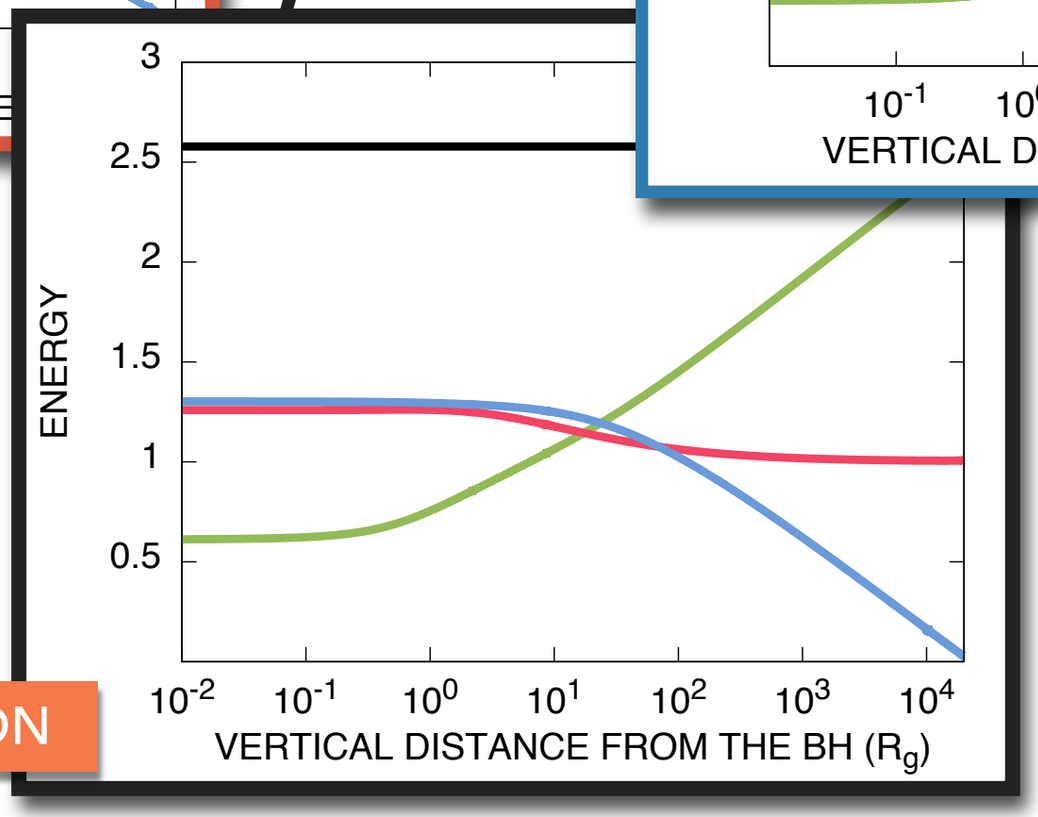




THERMALLY DOMINATED



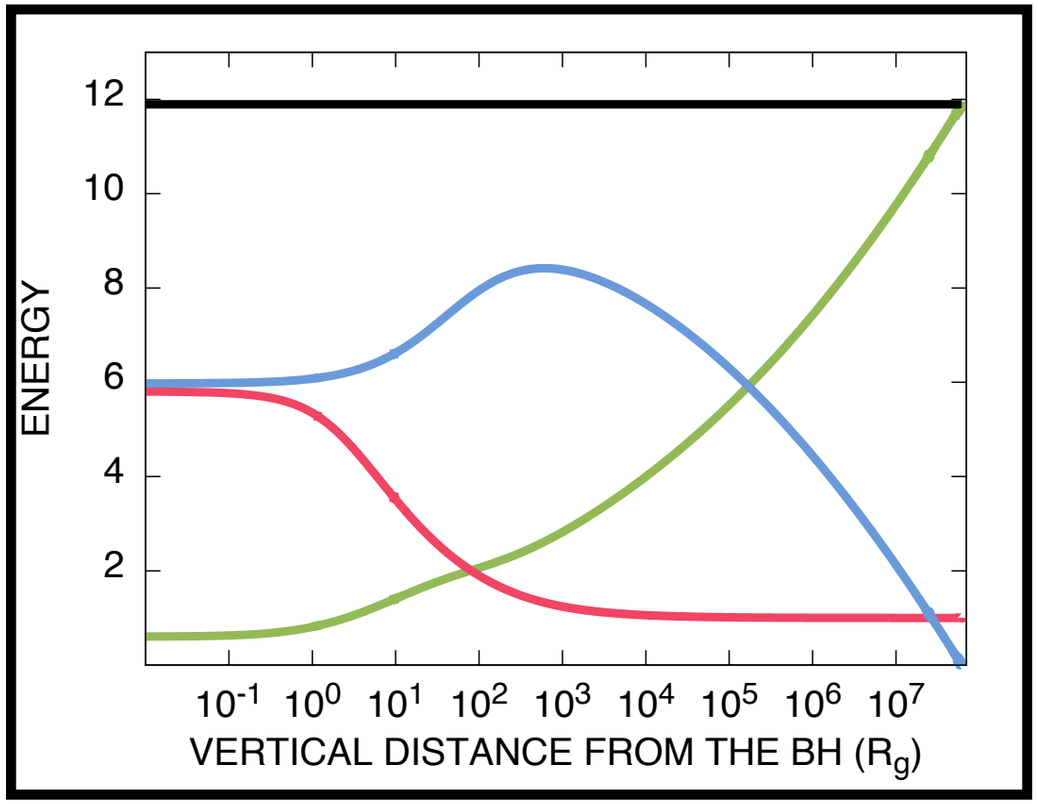
MAGNETICALLY DOMINATED

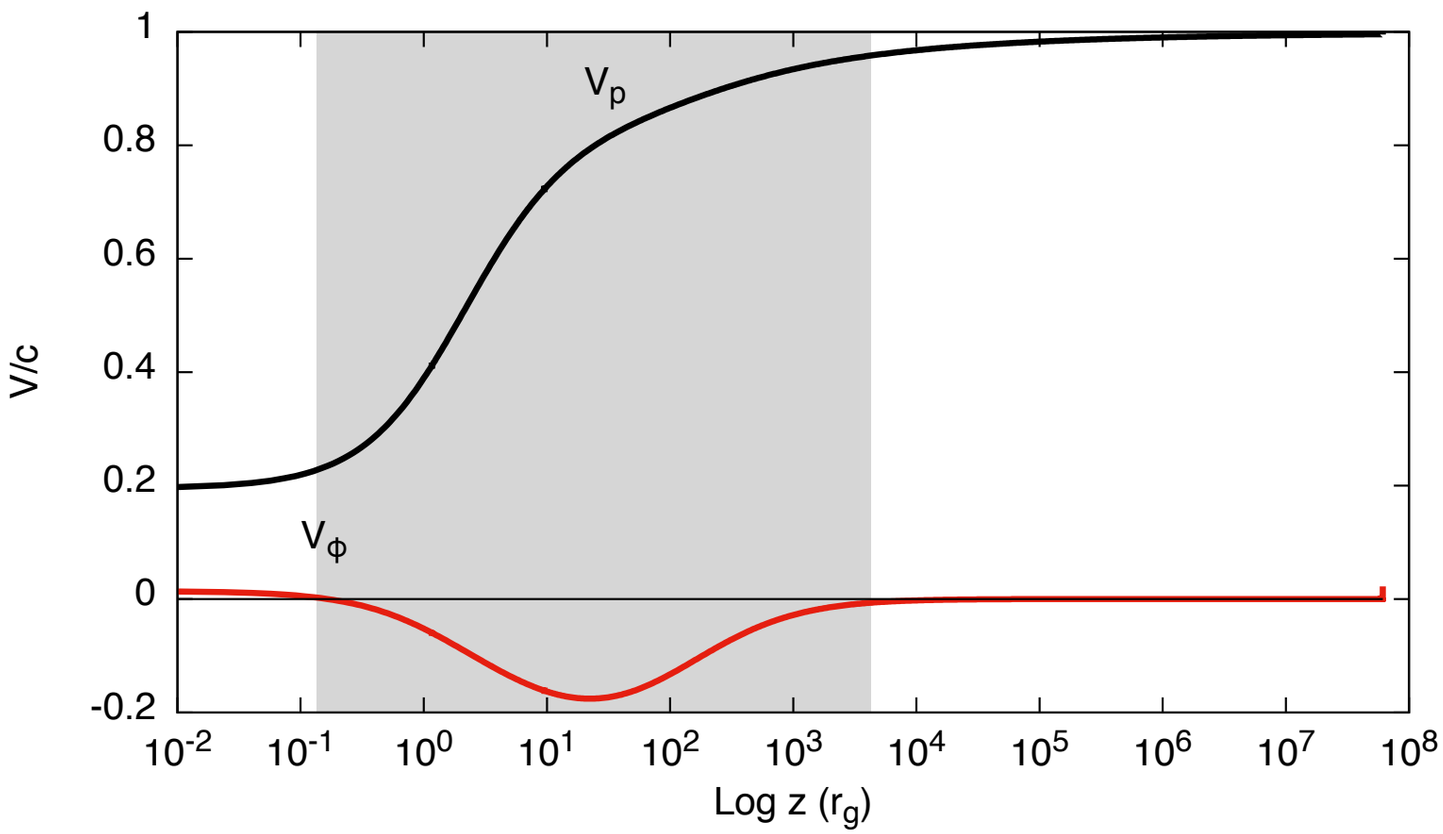


EQUIPARTITION

DYNAMICS

TOT ENERGY = **THERMAL** + **MAGNETIC** + **KINETIC**





HOT, MAGNETIZED, COUNTER-ROTATING JETS!

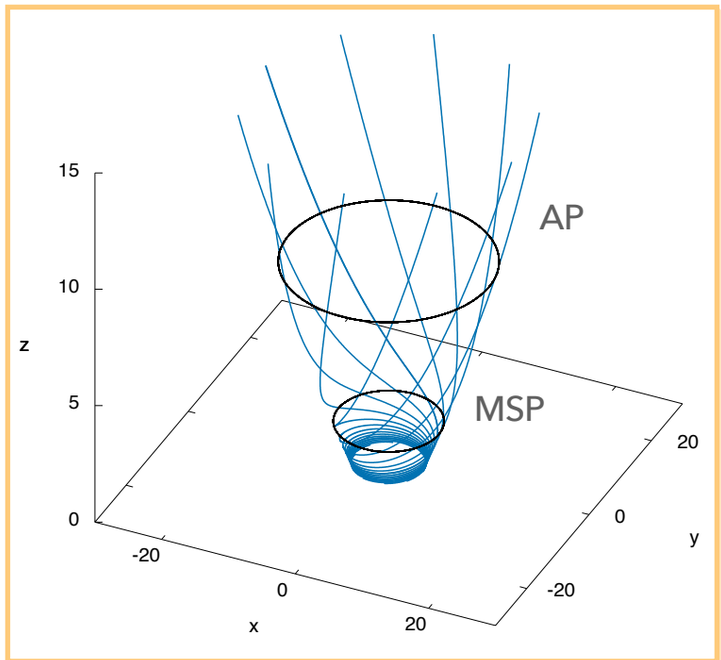
in simulations:
Komissarov+2009, Sauty+2012, Cayatte+2014 Staff+2015

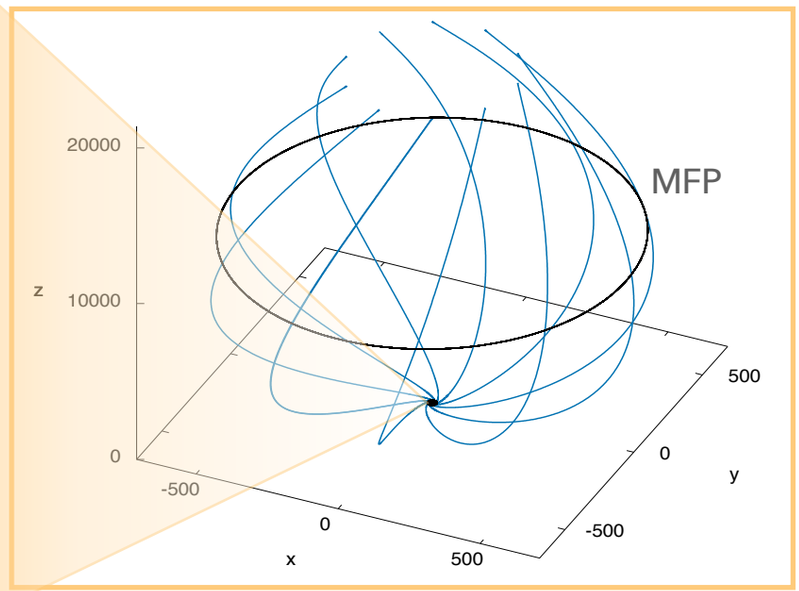
in observations of YSOs(?):
Coffey+2004, Cabrit+2006, Louvet+2016

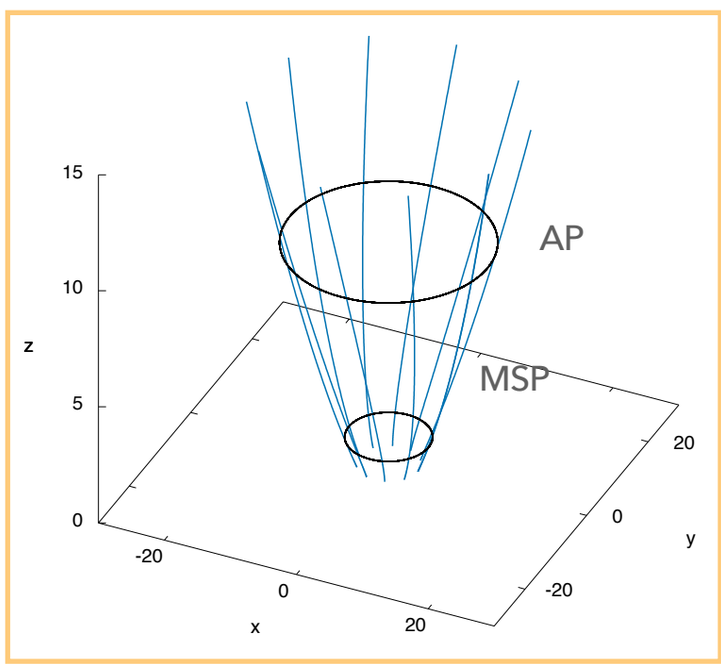
DYNAMICS

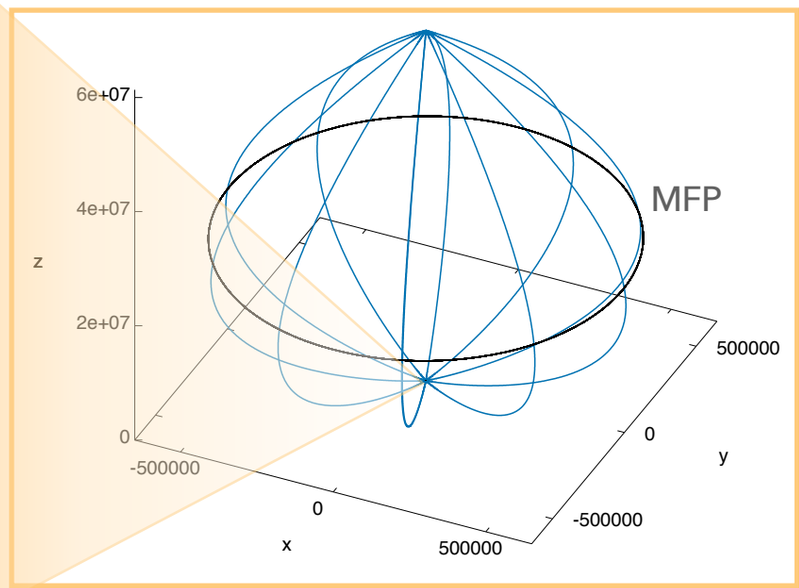
What if…

MFP







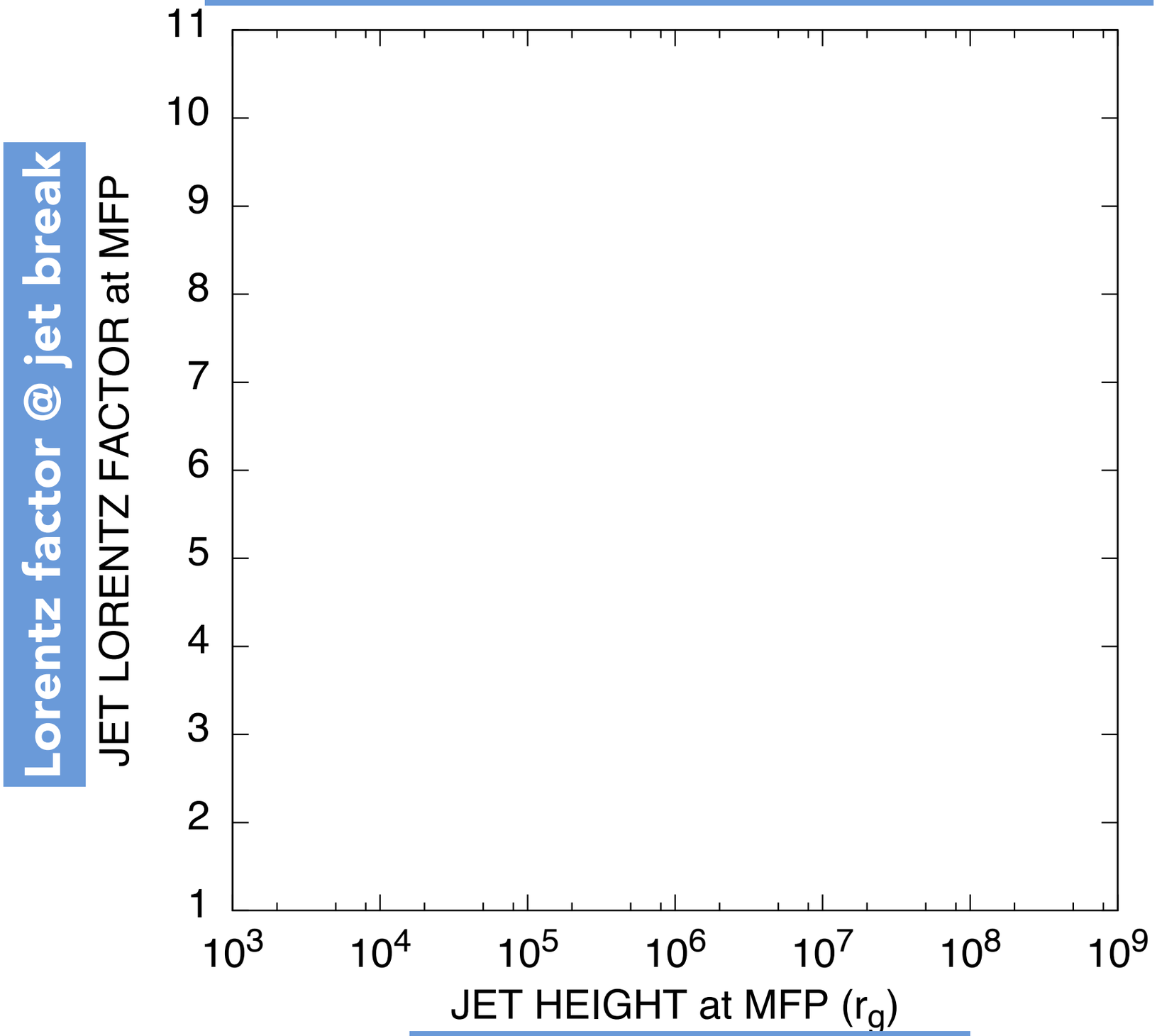


MSP and AP

MOTIVATION

AIM 2:
A LARGE and **DENSE** collection of solutions to fit data

If **MFP = recollimation shock = jet break**

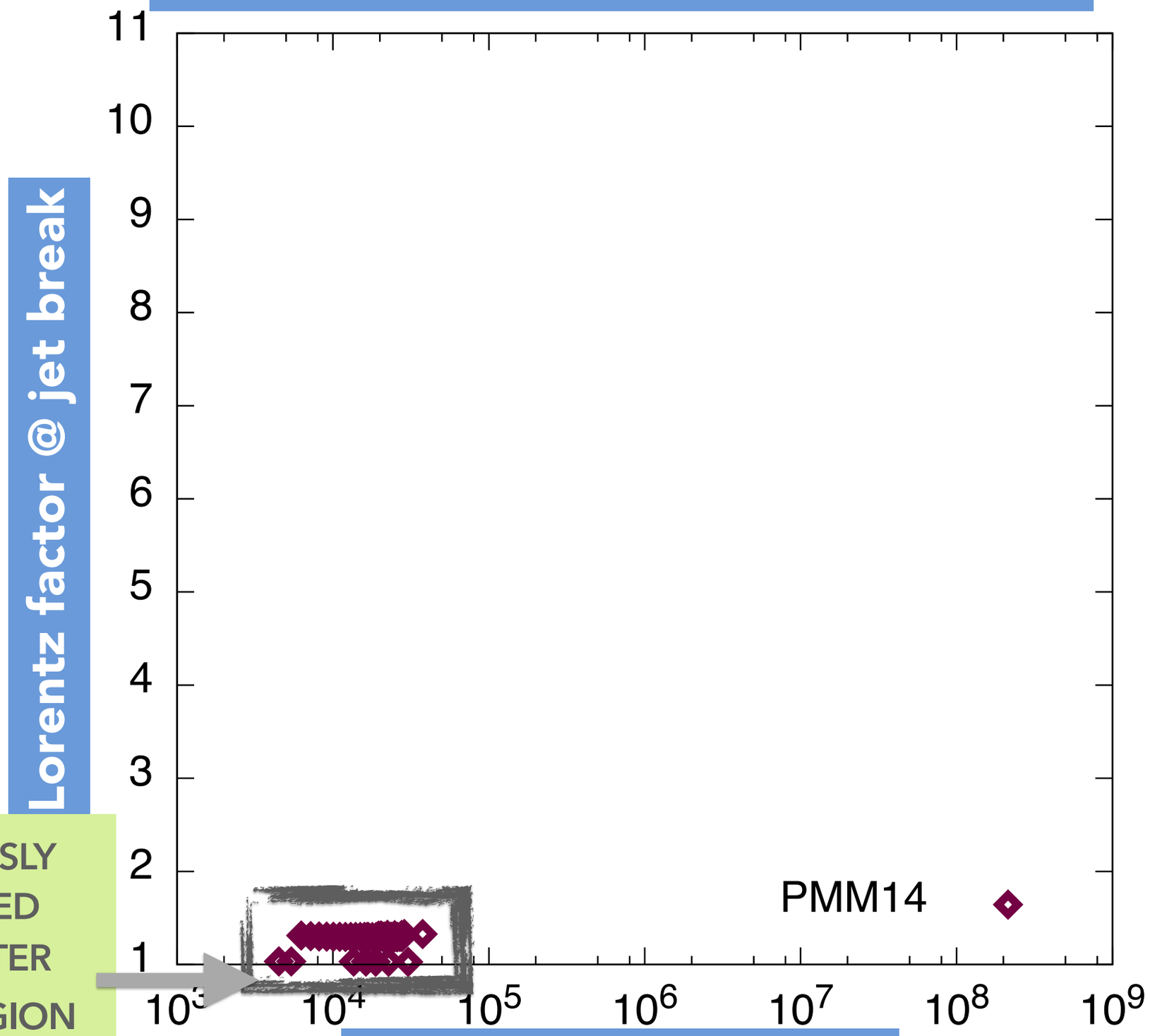


height of the jet break

RESULTS

AIM 2:
A LARGE and **DENSE** collection of solutions to fit data

If **MFP = recollimation shock = jet break**



PREVIOUSLY EXPLORED PARAMETER SPACE REGION (POLKO ET AL. 2014)

RESULTS

AIM 2:
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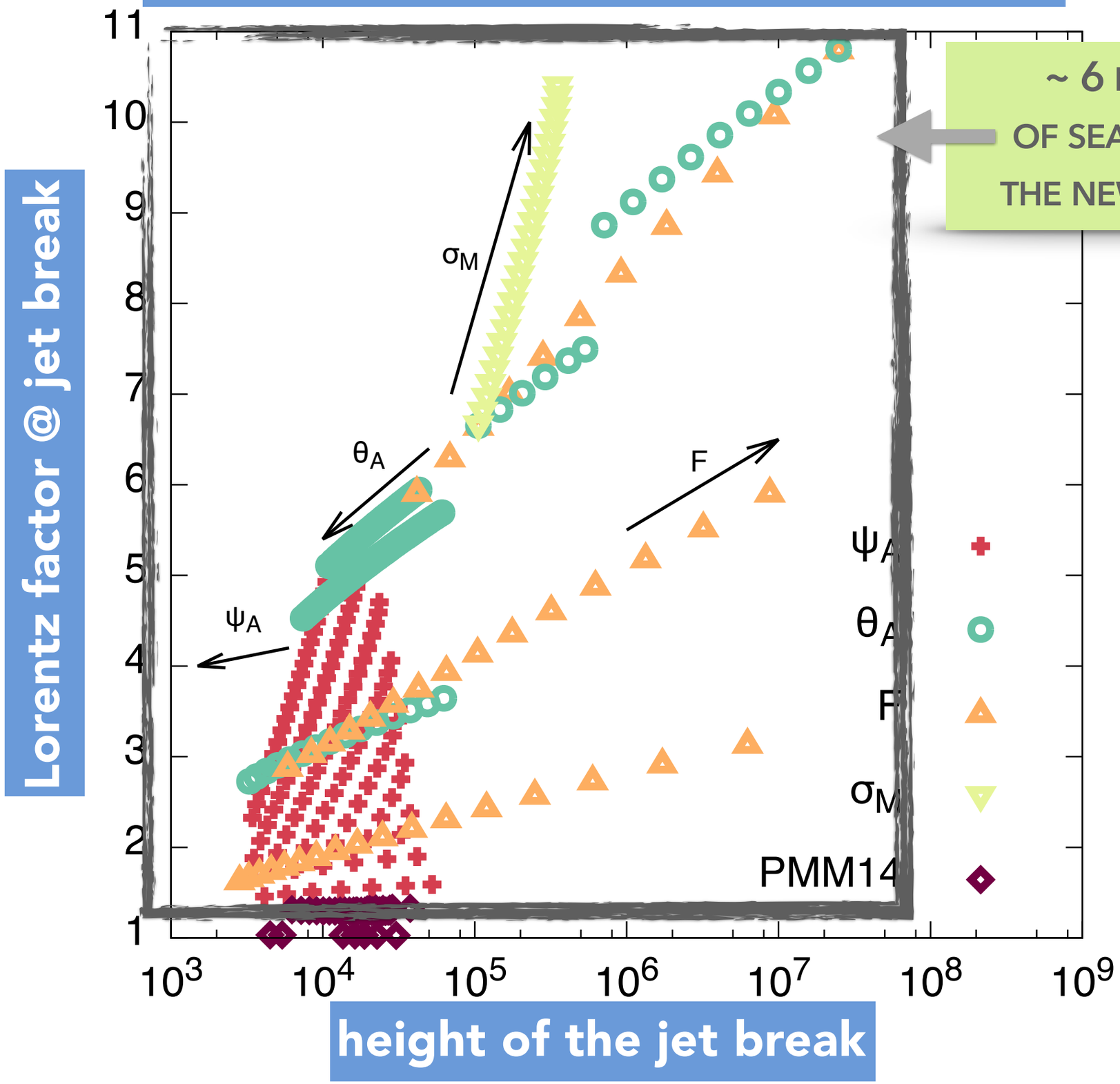
If **MFP = recollimation shock = jet break**

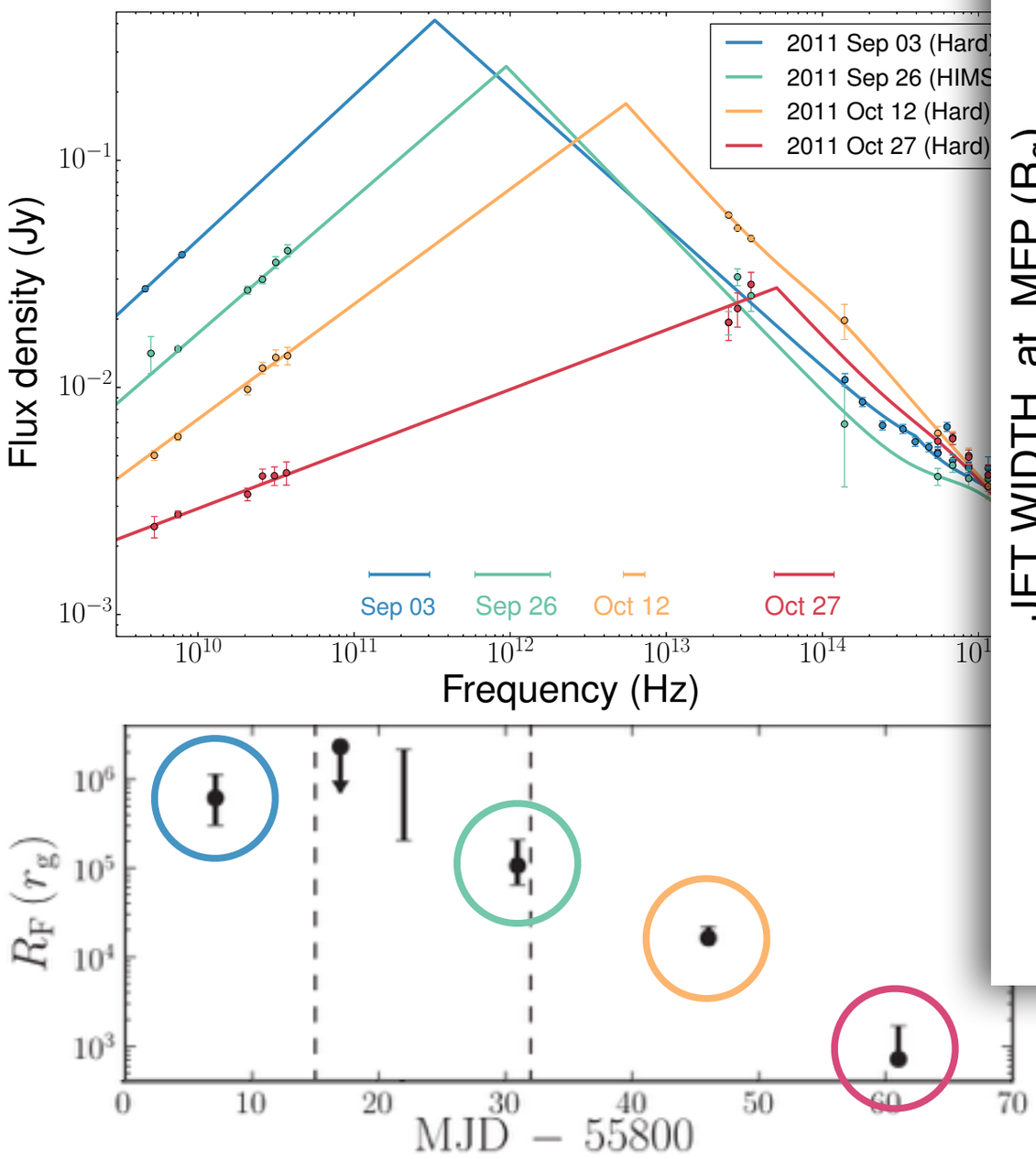


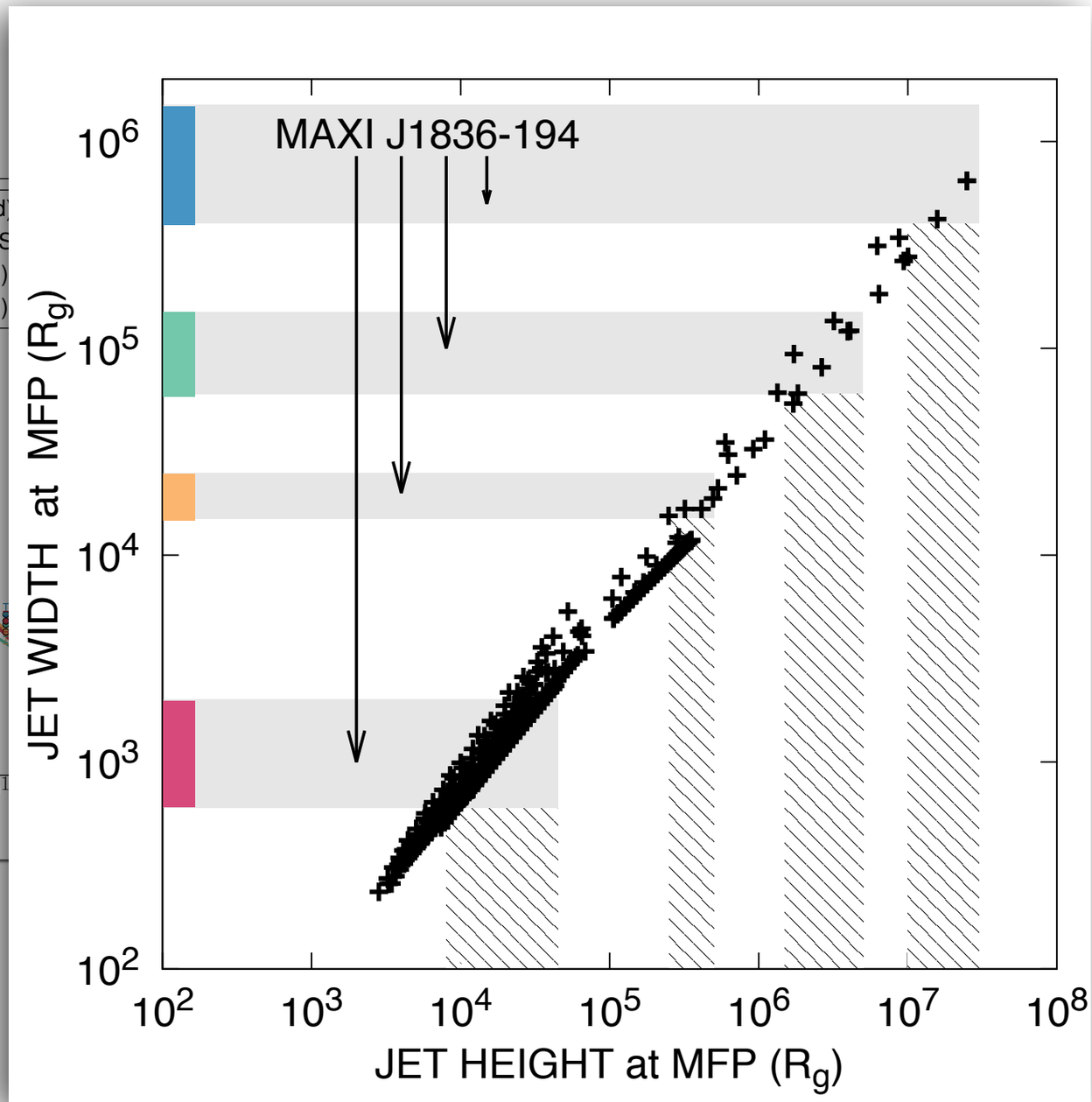
~ 6 MONTHS
OF SEARCH WITH
THE NEW METHOD

RESULTS

EVOLVING JET BREAK FREQUENCY DETECTED IN XRB MAXI J1836-194

Russell et al. 2014





+ Lorentz factor, density, magnetic field, electron temperature, …

APPLICATIONS

MOTIVATION

- We want to model relativistic jets from accreting black holes
- We want a more accurate way to constrain the MHD backbone of jets that produces the radiation we see

GOAL

A "fast" algorithm to couple with a radiative transfer code

+

A large collection of solutions

Ceccobello et al. 2017, submitted to MNRAS

WHAT'S NEXT

- **Expansion of the grid of solutions**
- **Applications to real sources**
- **Coupling with a radiative code**

CONCLUSIONS