

KINETIC SIMULATIONS OF RELATIVISTIC MAGNETIC RECONNECTION

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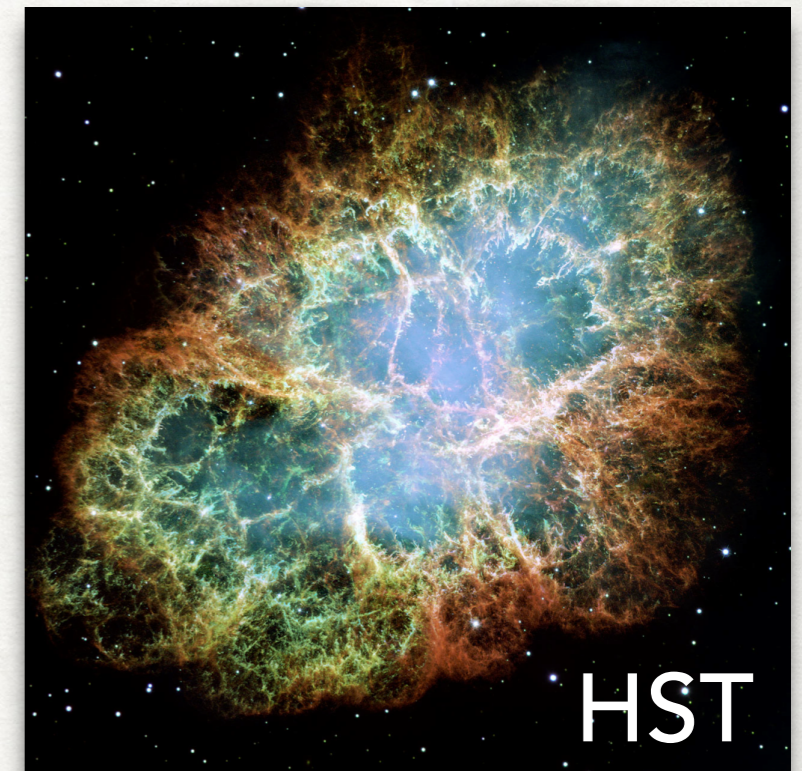
JONATHAN ZRAKE, YAJIE YUAN, WILL EAST, ROGER BLANDFORD
(STANFORD UNIVERSITY)

MAGNETIC FIELDS IN ASTRO- PHYSICS

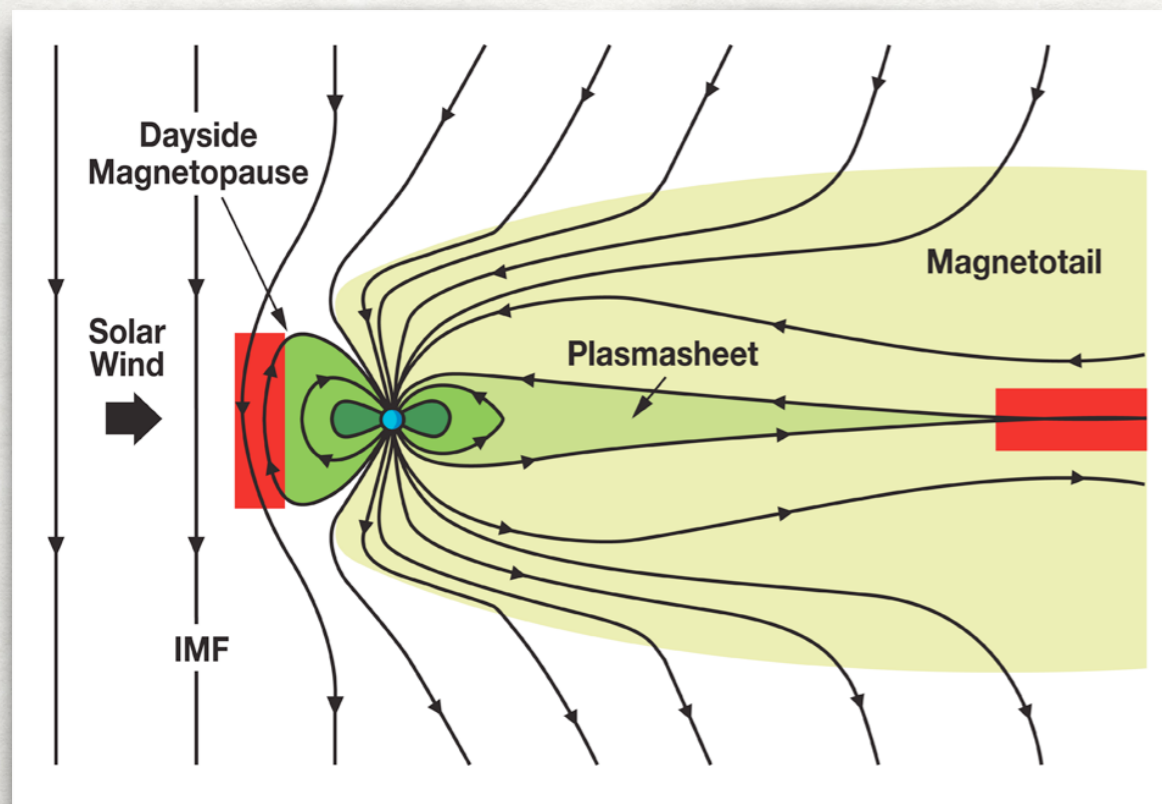
stars (Sun)



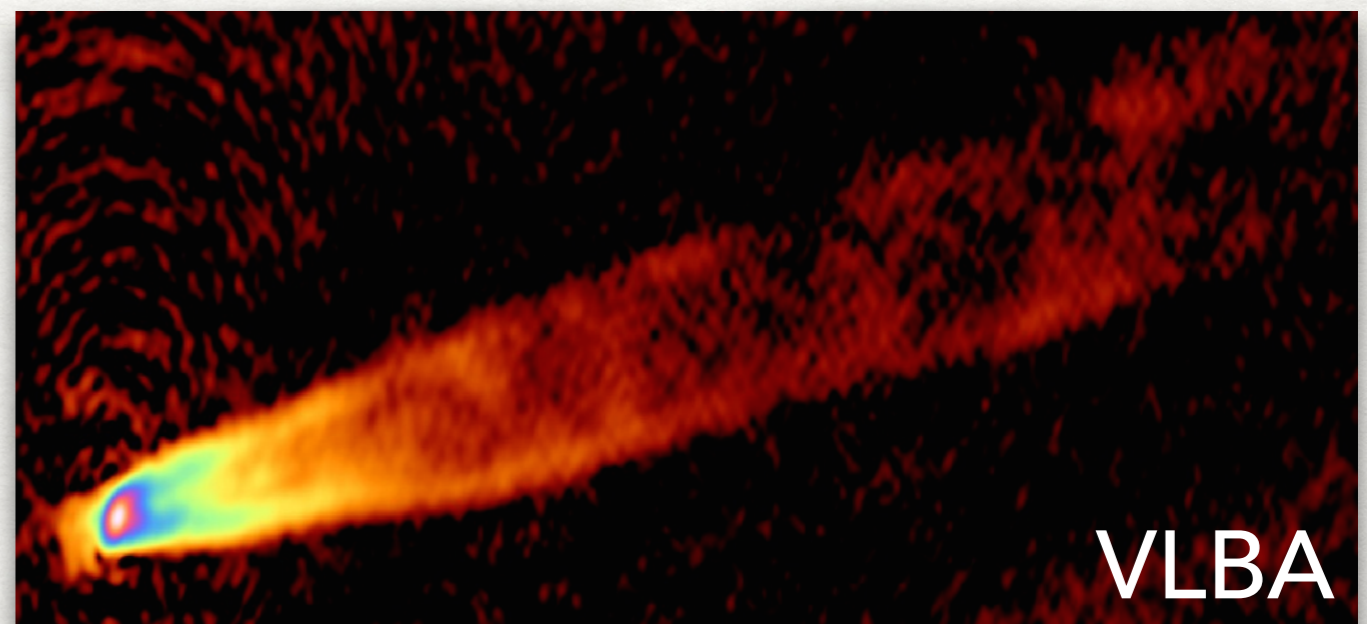
supernova remnants, pulsars



planetary magnetospheres (Earth)

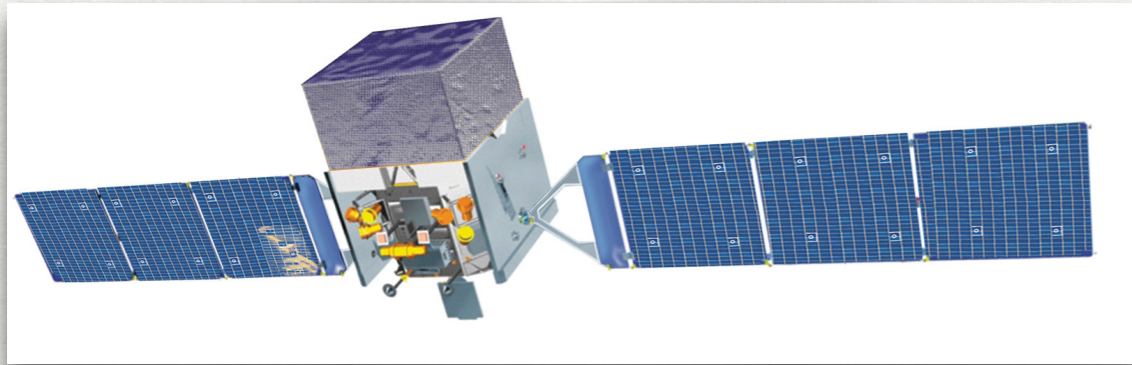
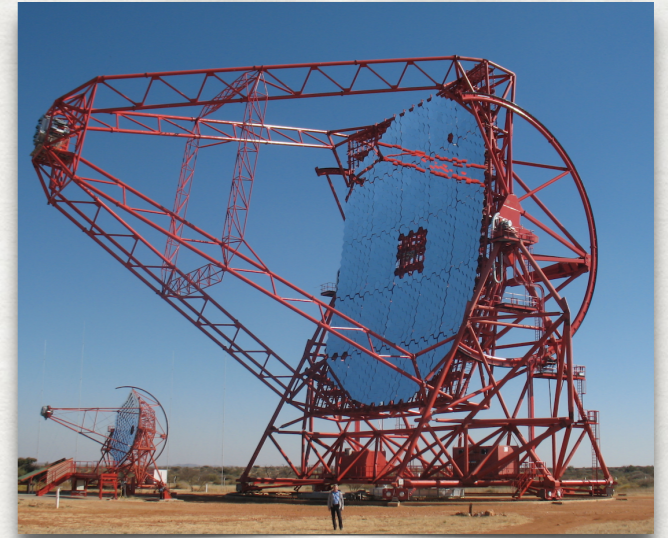


relativistic jets in active galaxies

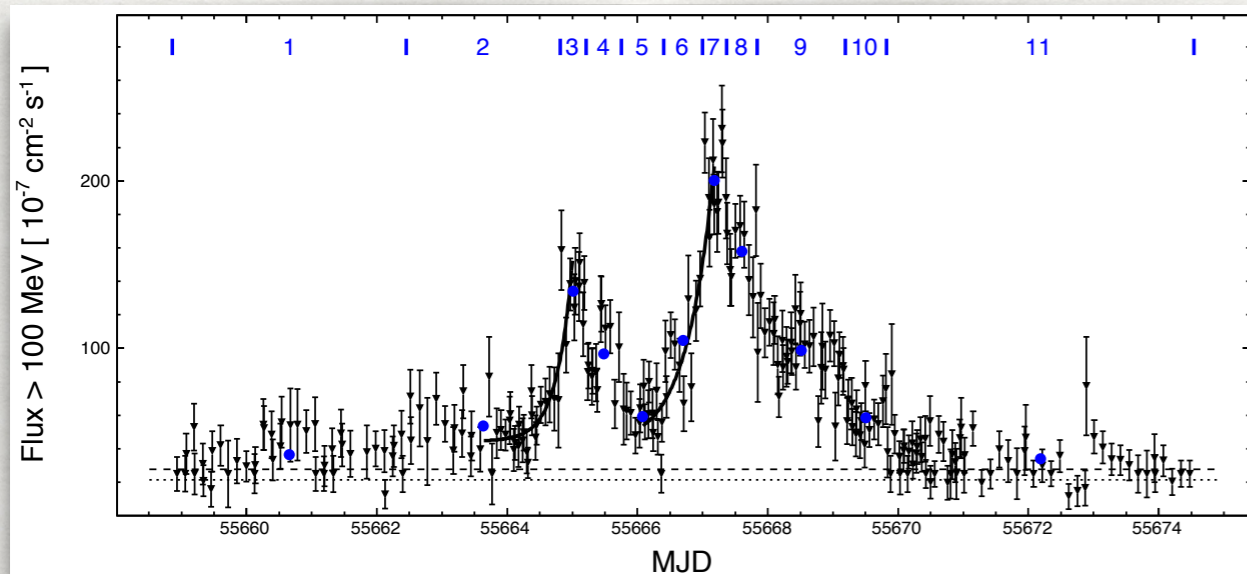


RAPID GAMMA-RAY VARIABILITY

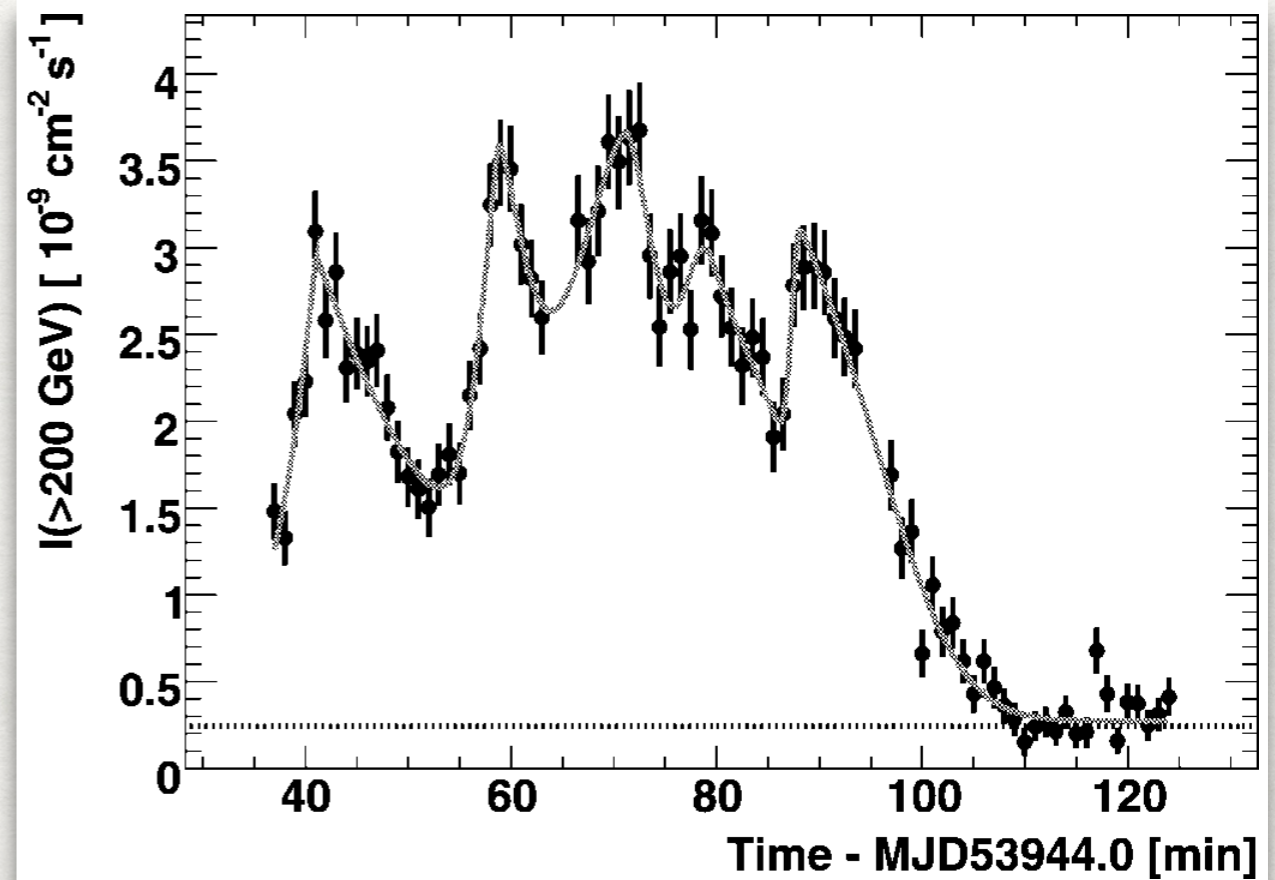
H.E.S.S.
imaging
atmospheric
Cherenkov
telescope



Fermi gamma-ray space telescope



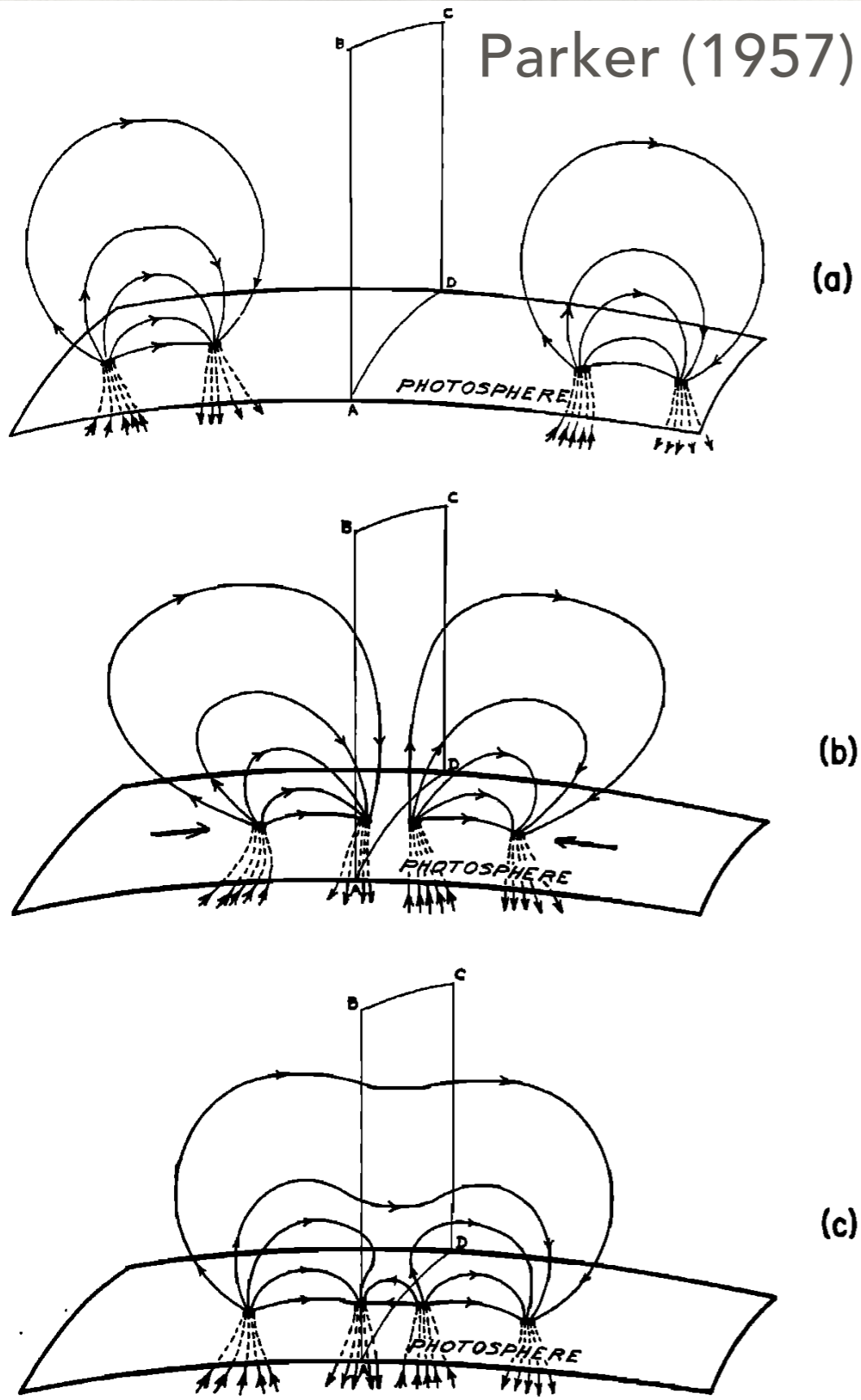
pulsar wind nebula Crab
Buehler et al. (2011)



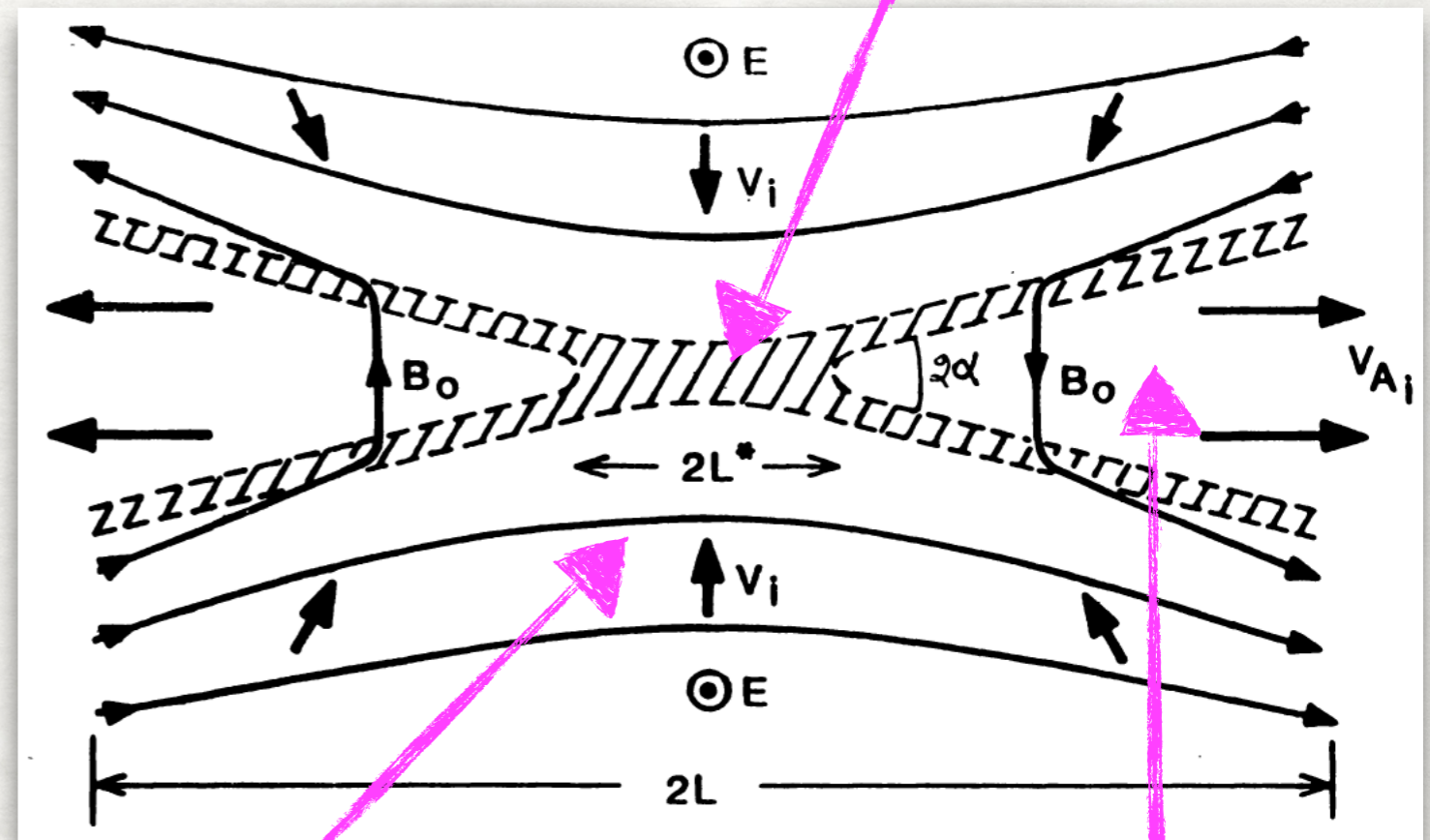
blazar PKS 2155-304
H.E.S.S. Collaboration (2007)

MAGNETIC RECONNECTION

Parker (1957)



magnetic diffusion region (X-point)



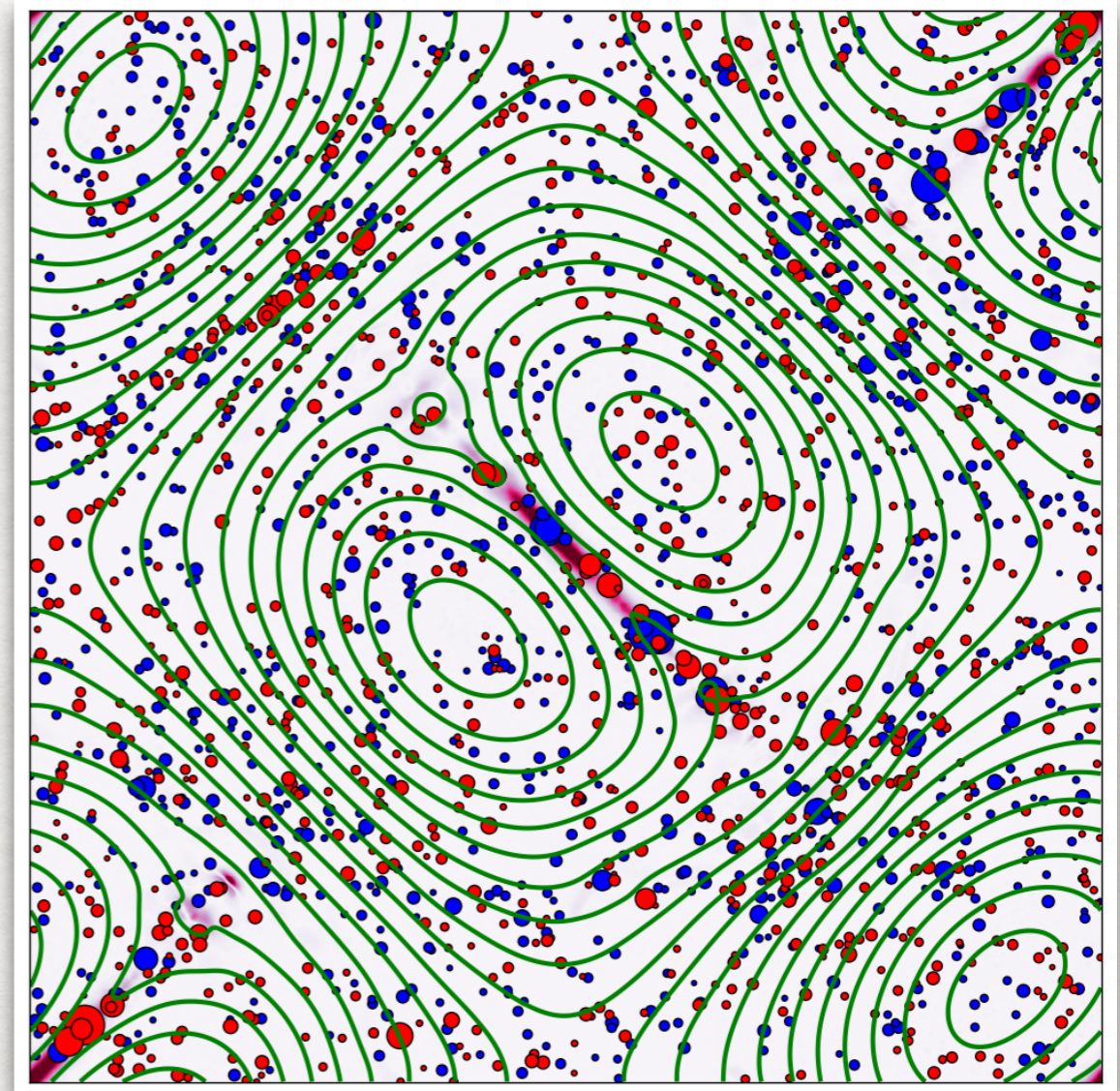
reconnecting magnetic field
(background, upstream)

reconnection outflow
(downstream)

PARTICLE-IN-CELL CODE ZELTRON

- magnetic reconnection requires breaking ideal MHD
- the particle-in-cell algorithm allows to study particle acceleration self-consistently
- radiation reaction implemented for synchrotron and inverse-Compton
- Zeltron was created by Benoît Cerutti (CNRS Grenoble) and is publicly available

<http://benoit.cerutti.free.fr/Zeltron/>

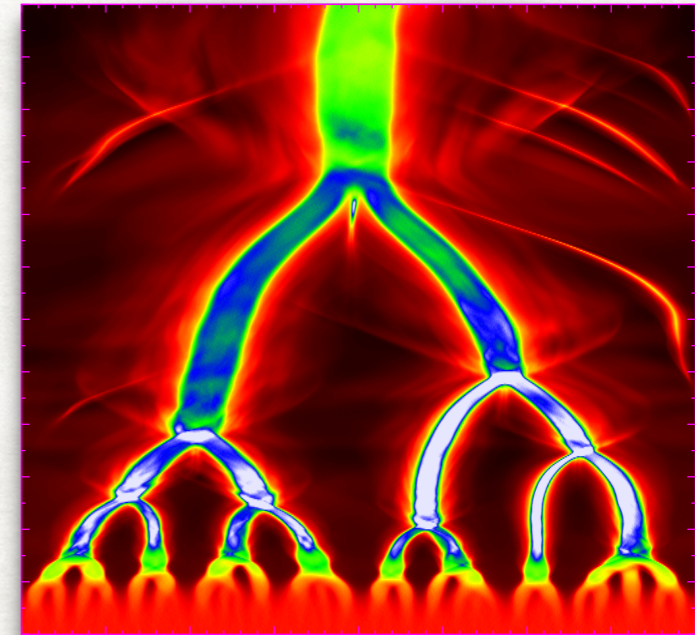


NUMERICAL DETAILS

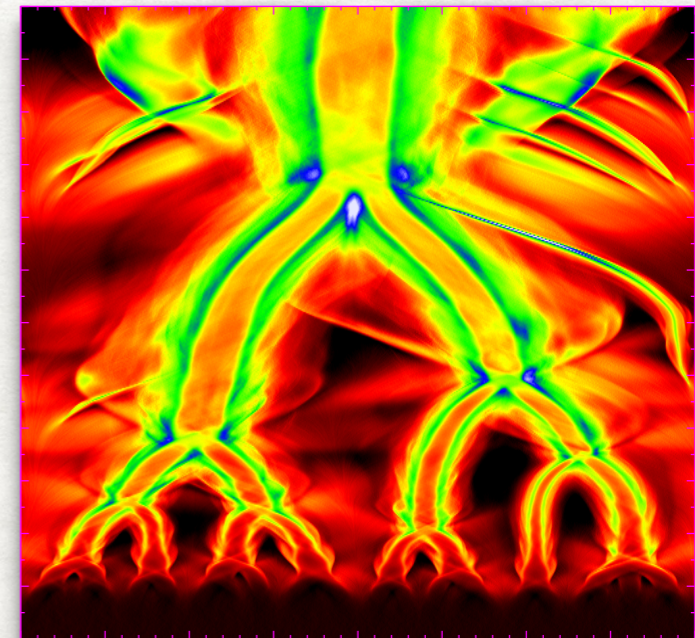
- Zeltron is written in Fortran 90, parallelized with MPI
- staggered Yee grids, explicit FDTD, Boris push
- simple Poisson correction, filtering, current deposition
- scaling verified up to 97k CPUs (NICS/Kraken)
- existing versions:
 - 2.5D or 3D
 - Cartesian or spherical coordinates
 - periodic or conducting boundaries

HARRIS CURRENT LAYER

density diagram

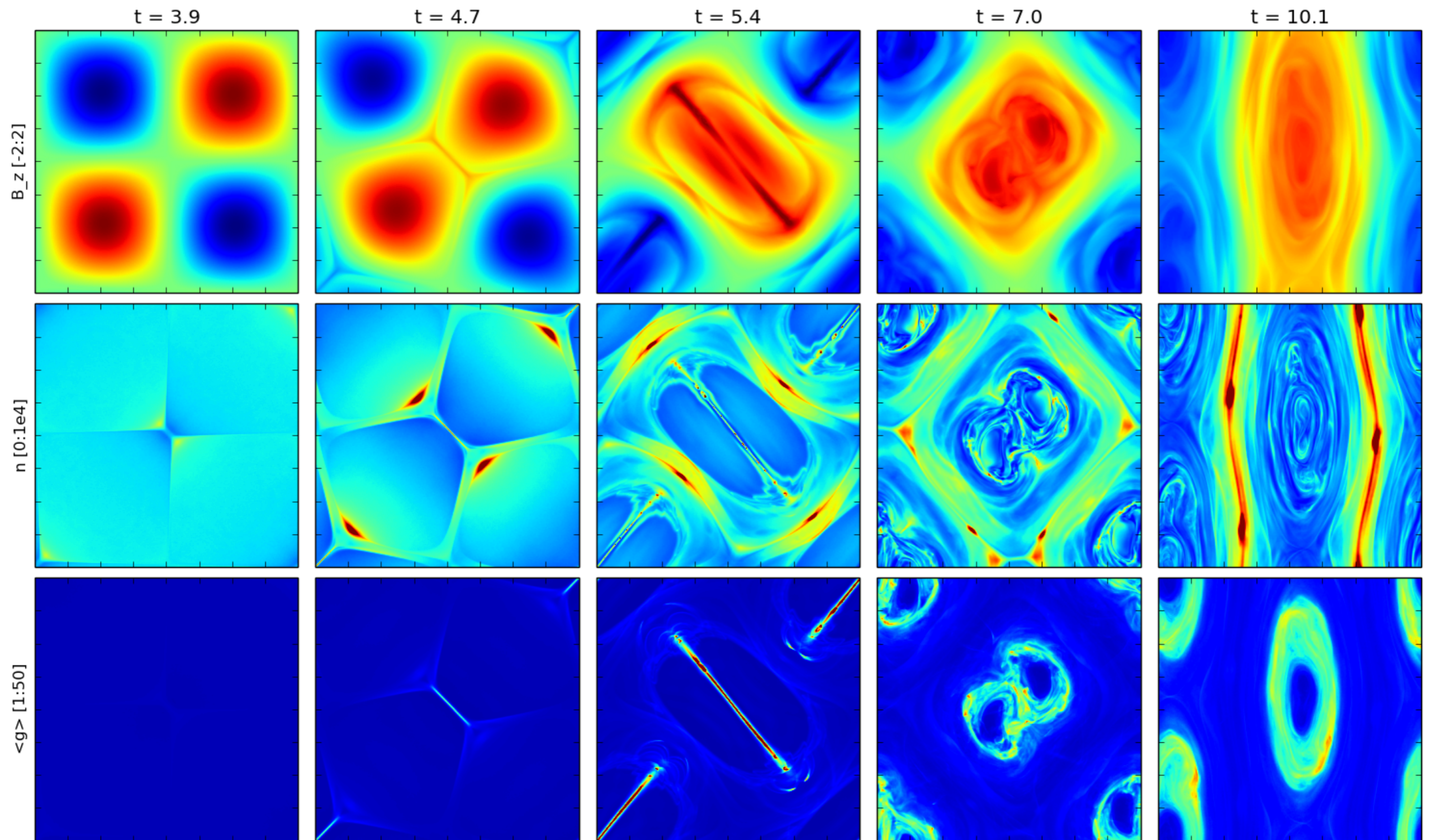


'temperature' diagram

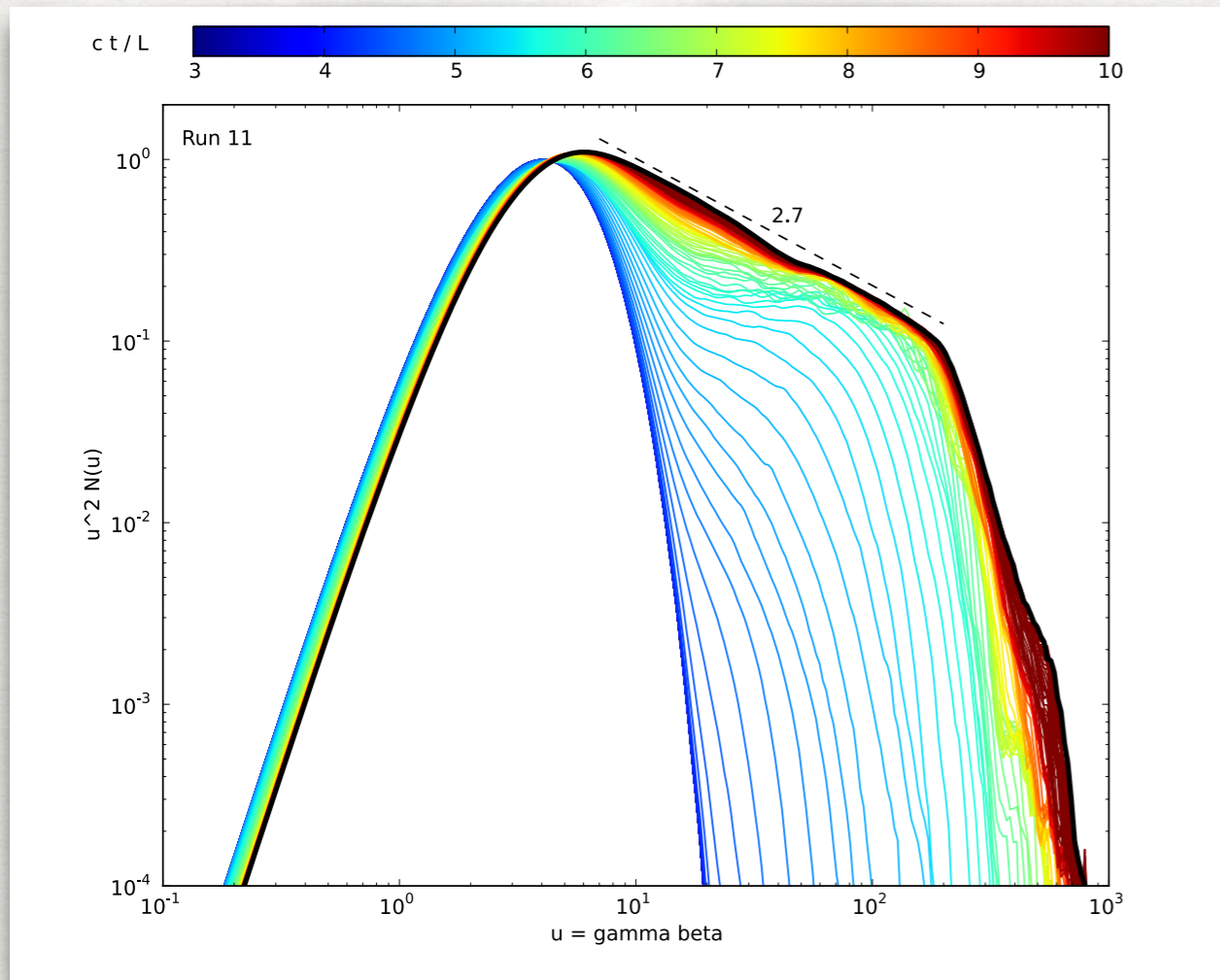


Nalewajko, Uzdensky, Cerutti, Werner & Begelman (2015)

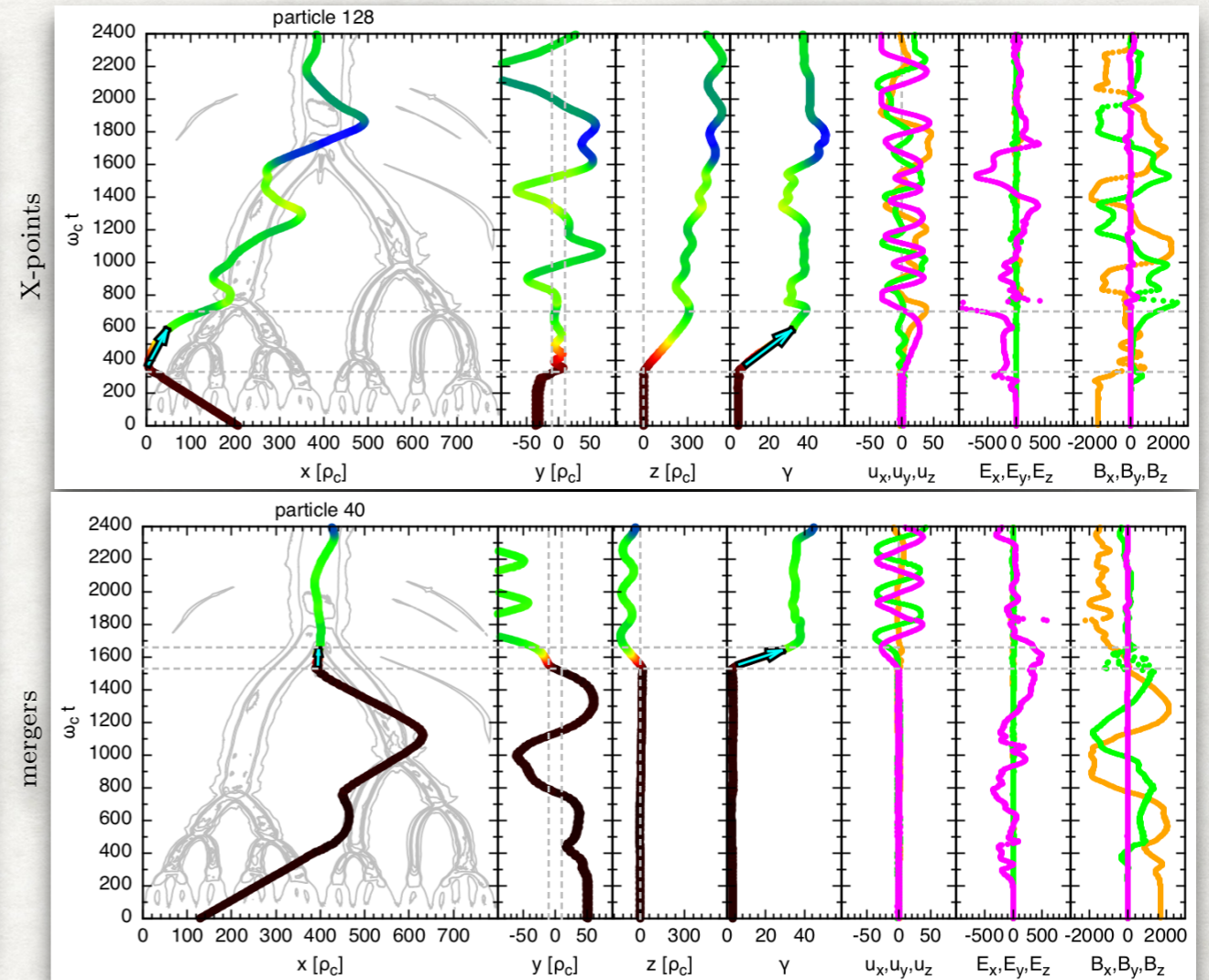
HARMONIC MAGNETIC EQUILIBRIA ('ABC' FIELDS)



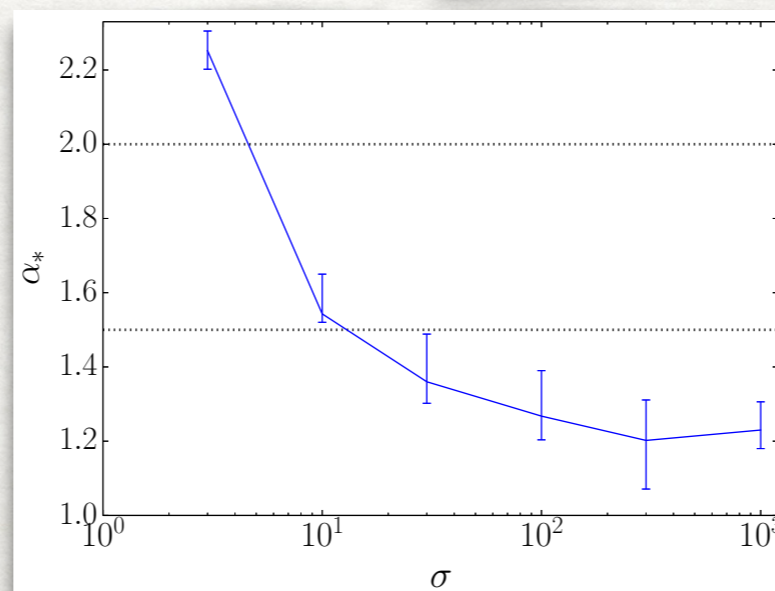
PARTICLE ACCELERATION



evolution of particle momentum distribution (Nalewajko et al. 2016)



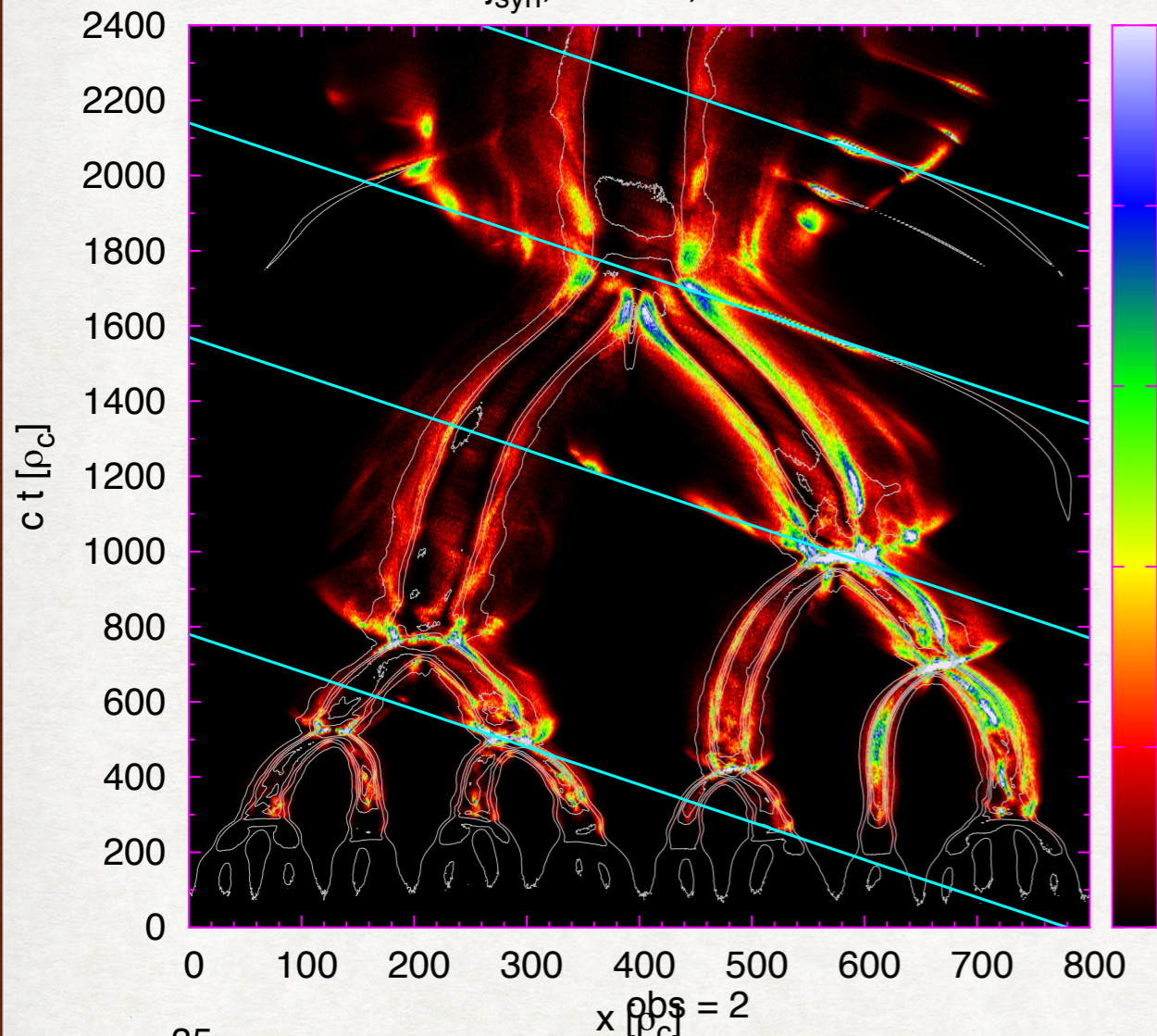
analysis of individual particles (Nalewajko et al. 2015)



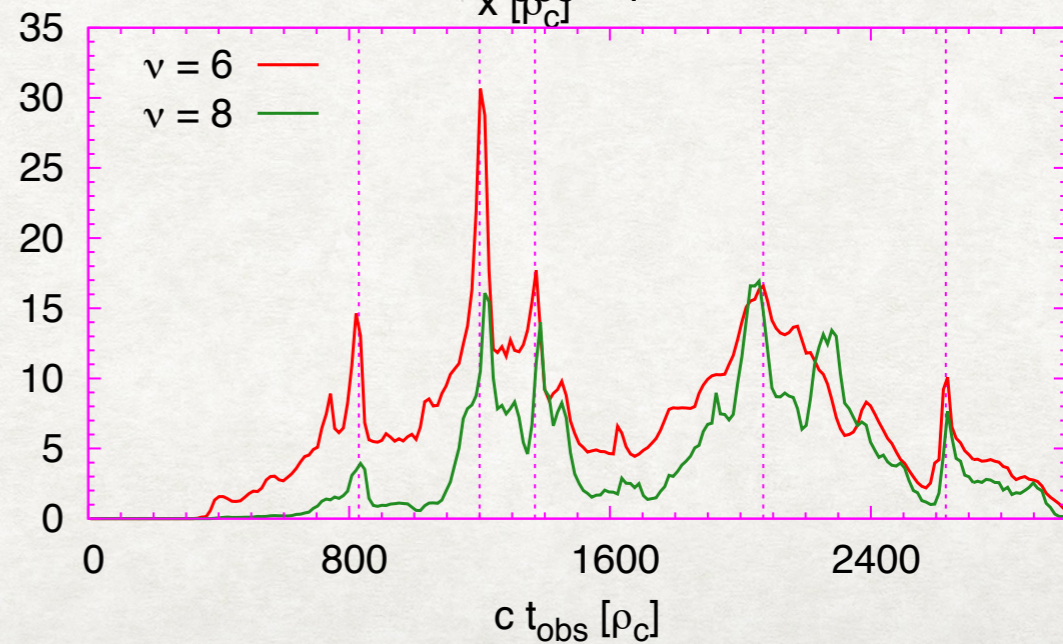
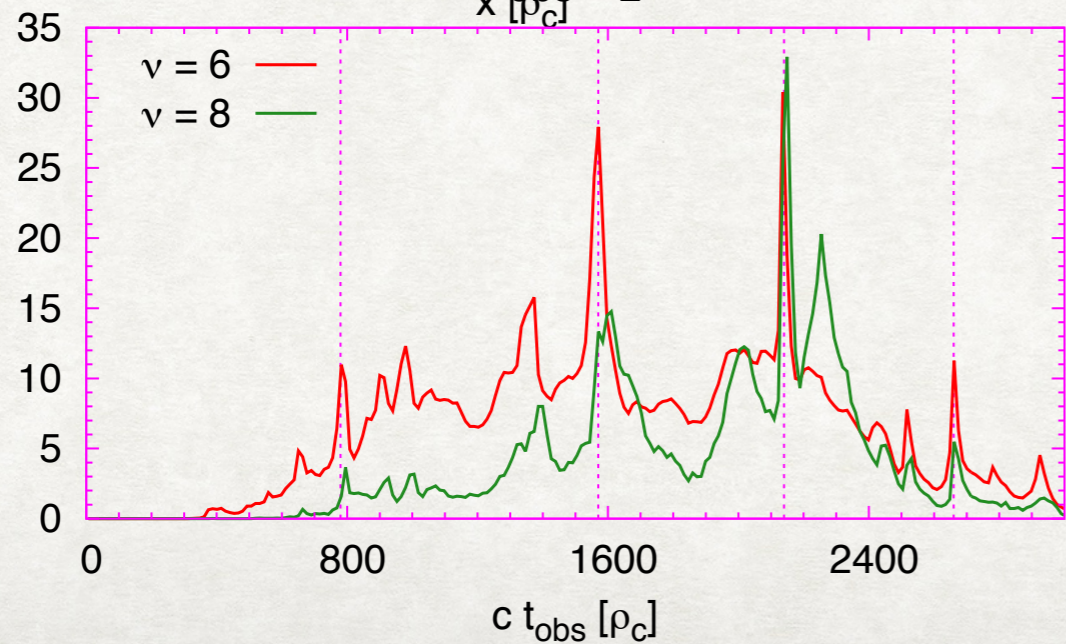
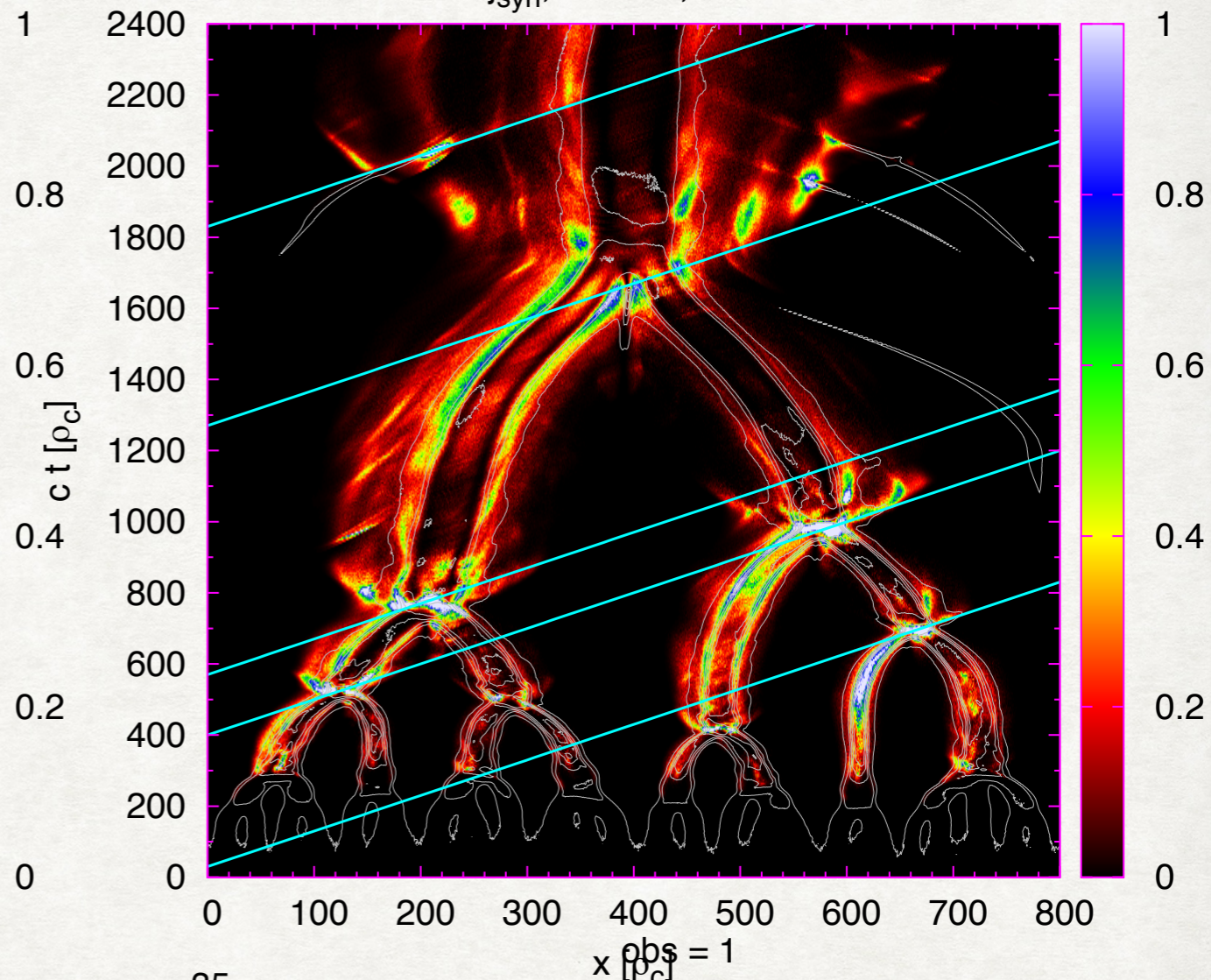
dependence of power-law index on magnetization (Werner et al. 2016)

OBSERVED LIGHT CURVES

$j_{\text{syn}}, \text{obs} = 2, \nu = 6$



$j_{\text{syn}}, \text{obs} = 1, \nu = 6$



A FEW WORDS ABOUT ME

- PhD in astronomy, CAMK PAN, prof. Marek Sikora
- research interests: gamma-ray astrophysics, relativistic jets, blazars, magnetic reconnection
- postdoctoral experience:
University of Colorado Boulder, Stanford University
- computational experience: XSEDE/Stampede, UCB/Janus
- current computational resources: DoE/INCITE/Mira
- currently tenure-track (adjunkt) at CAMK PAN
- 5-year grant SONATA-BIS, funding for 2 graduate students, 1 postdoc (opening next year)