High Energy Astrophysics

Katsuaki Asano

Members (2012-)

Present Members

Staff: K. Asano, K. Kawaguchi
PD: A. Harada
Students: S. To, K. Nishiwaki

Former Members

Staff: T. Terasawa
PD: S. Kisaka, Y. Akaike, S. J. Tanaka, T. Kinugawa
Students: R. Mikami, R. Takeishi, K. Sasaki, N. Hiroshima, W. Ishizaki

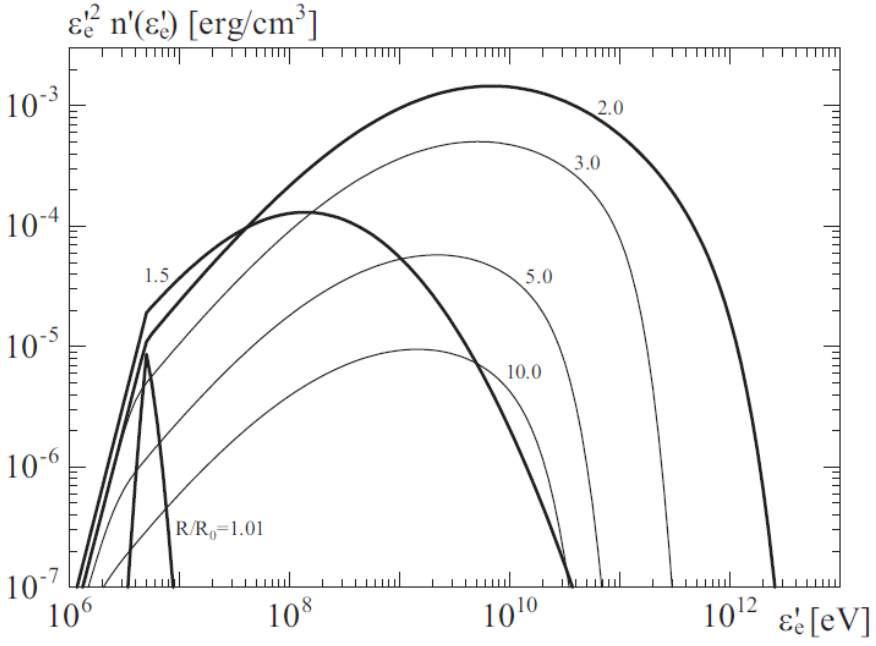
Note: Due to lack of a staff associated with the graduate school, we did not accept students in 2015-2018.
Now we can accept students from 2019.

Research Acitivity (2012-)

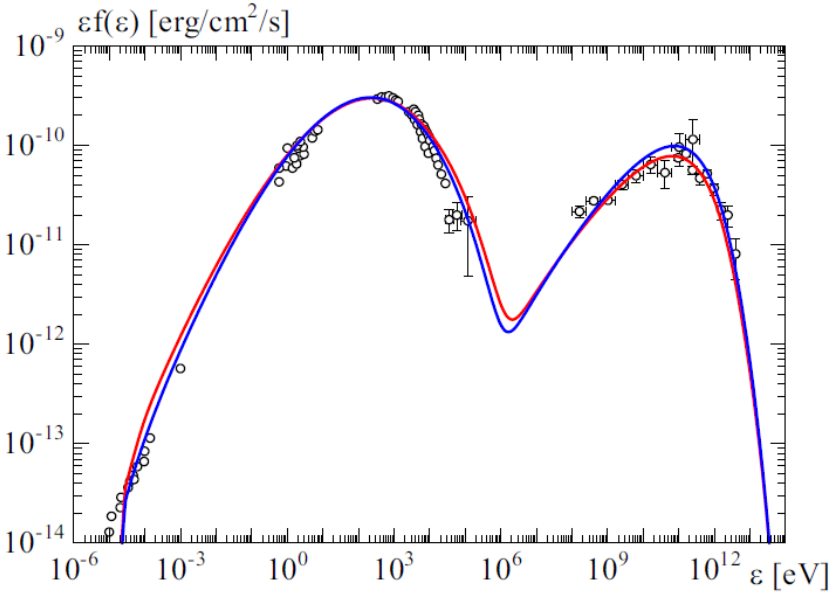
- Theoretical study in high-energy astrophysics (Asano, Kawaguchi, many PDs).
  - Gamma-ray burst, Blazar, Pulsar wind nebula, Compact binary merger etc.
  - Jet formation, Emission mechanism, Particle acceleration etc.
- Data Analysis (Terasawa, Akaike…)
  - Radio observation of giant radio pulses
  - CALET (Akaike)

Non-thermal phenomena

Some of astrophysical objects show very hard photon spectra, which seems inconsistent with the standard shock acceleration theory. We are working on an alternative mechanism: turbulence acceleration.



Evolution of electron energy distribution in a blazar with turbulence acceleration model.



Photon spectrum of Mrk 421 reproduced by our model. (Asano & Hayashida 2018)

Turbulence acceleration models

Gamma-ray burst

Asano & Terasawa 2015
Asano & Meszaros 2016

Blazar

Asano et al. 2014
Asano & Hayashida 2015
Asano & Hayashida 2018

Pulsar wind nebula

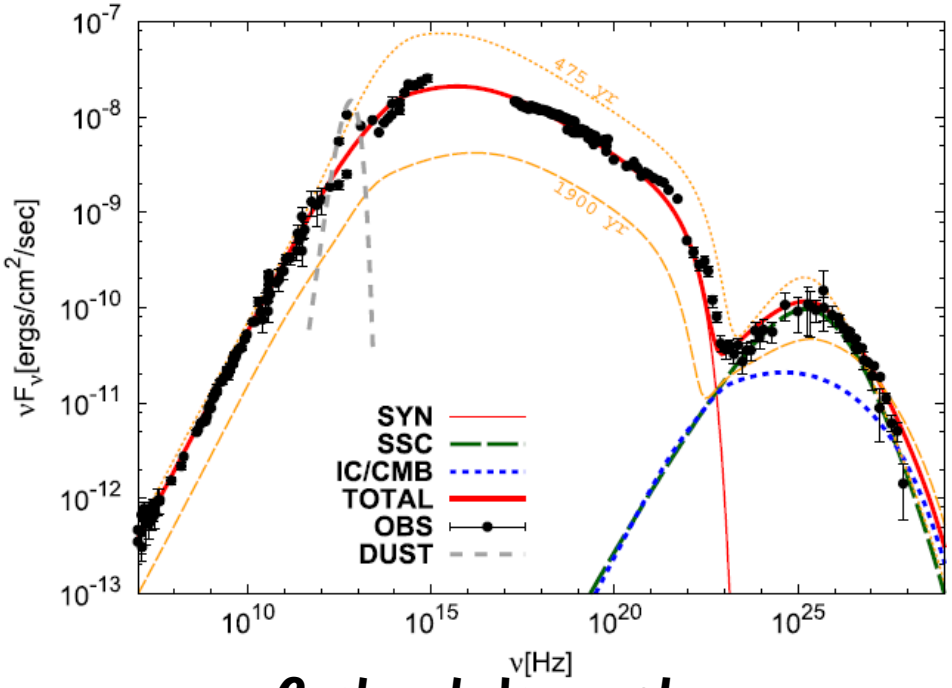
Tanaka & Asano 2017

Fermi Bubble

Sasaki et al. 2015

Fundamental

Teraki & Asano 2019



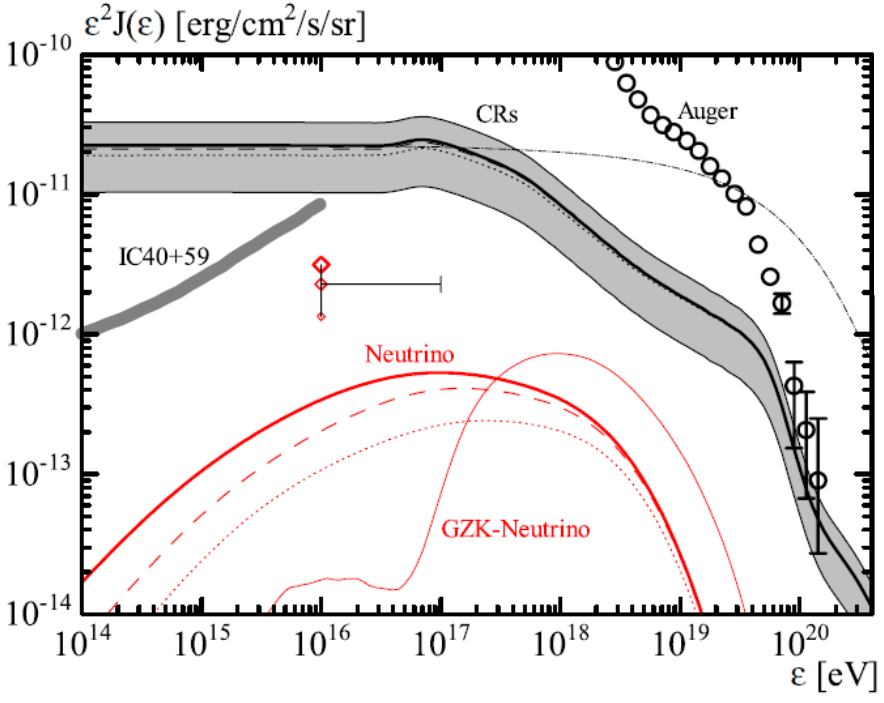
Crab nebula spectrum
Tanaka & Asano 2017

Interaction with large-scale compressible MHD waves via transit-time damping leads to the hard-sphere acceleration, in which the acceleration timescale is independent of the particle energy.

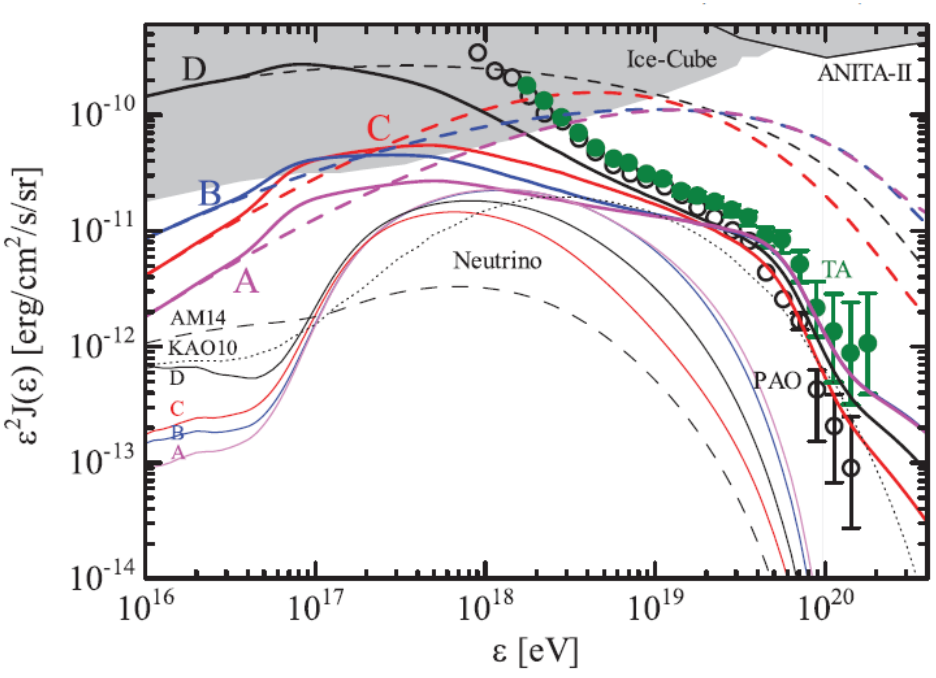
Ultra-high energy cosmic rays and neutrinos

Gamma-ray burst

Asano & Meszaros 2013
Asano & Meszaros 2014
Asano & Meszaros 2016



GRB shock acceleration model.

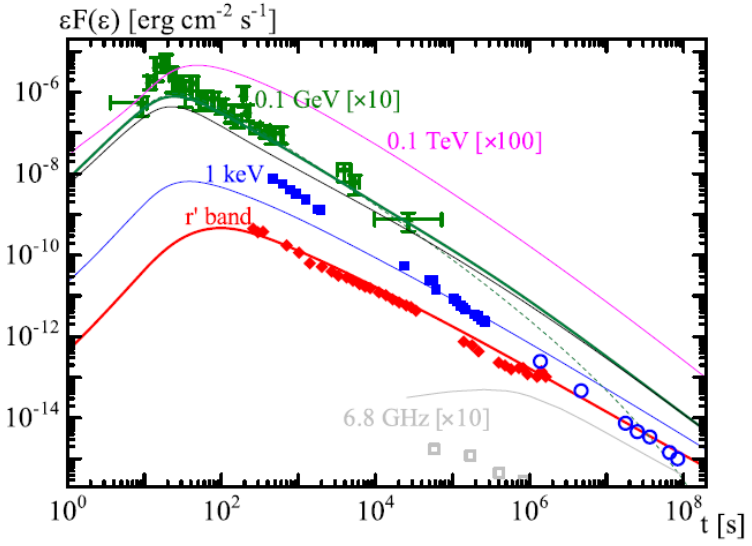


GRB turbulence acceleration model

GRBs are still candidate of UHECR sources. Non-detection of neutrinos is consistent.

Other non-thermal phenomena

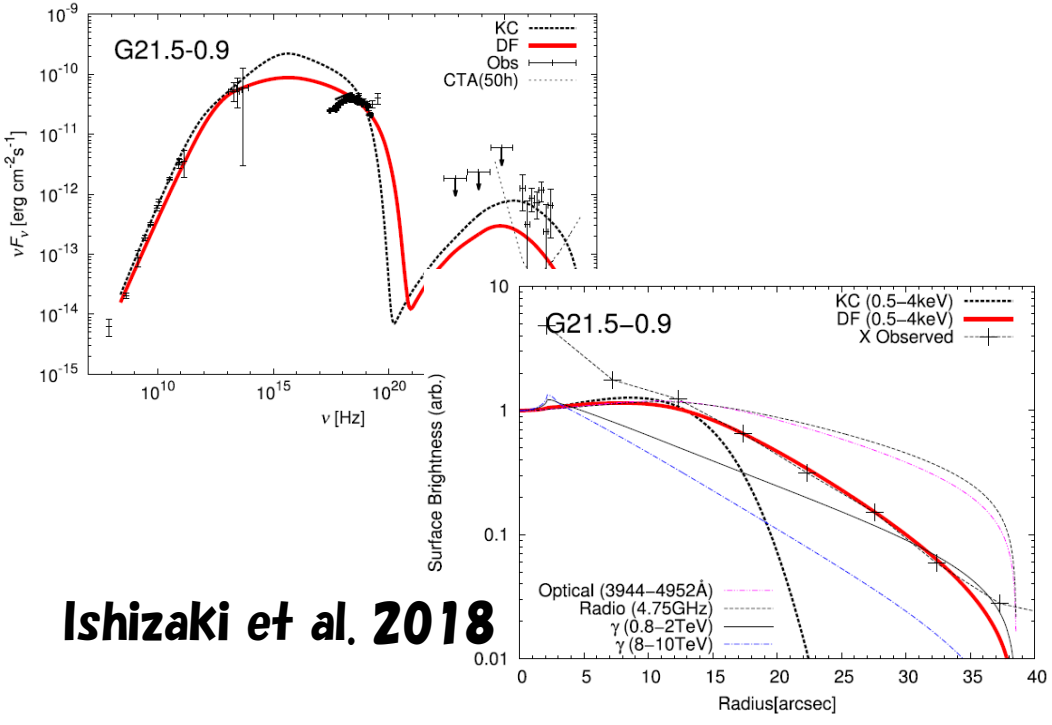
SSC emission in gamma-ray burst afterglow



Fukushima et al. 2017

SSC emission is naturally expected in TeV range. Consistent with the recent MAGIC result.

Spatial profile of pulsar wind nebula.

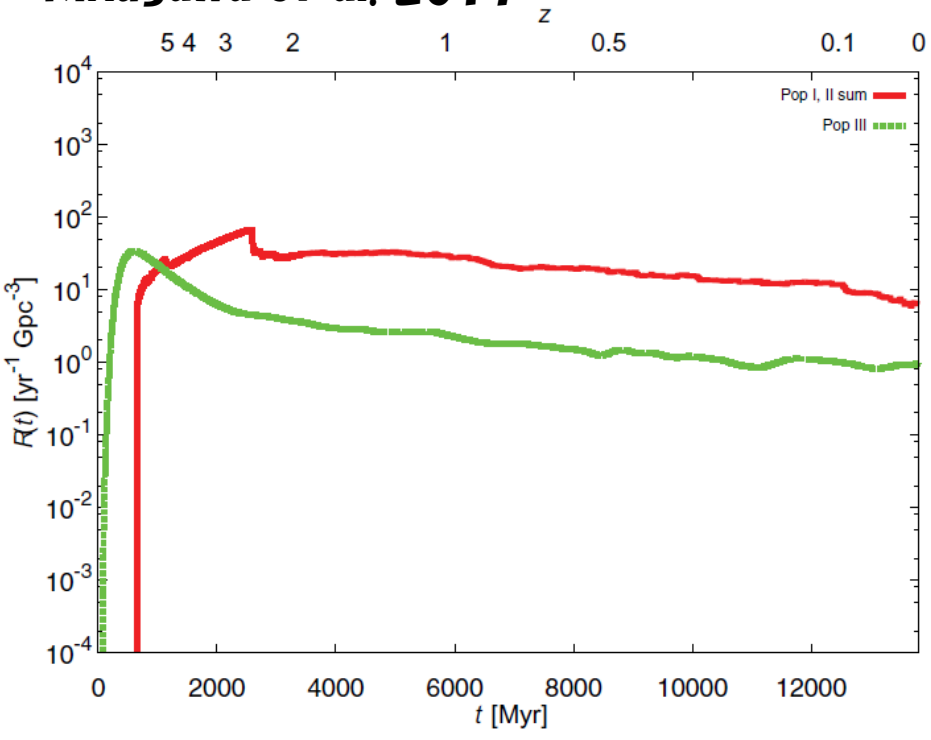


Ishizaki et al. 2018

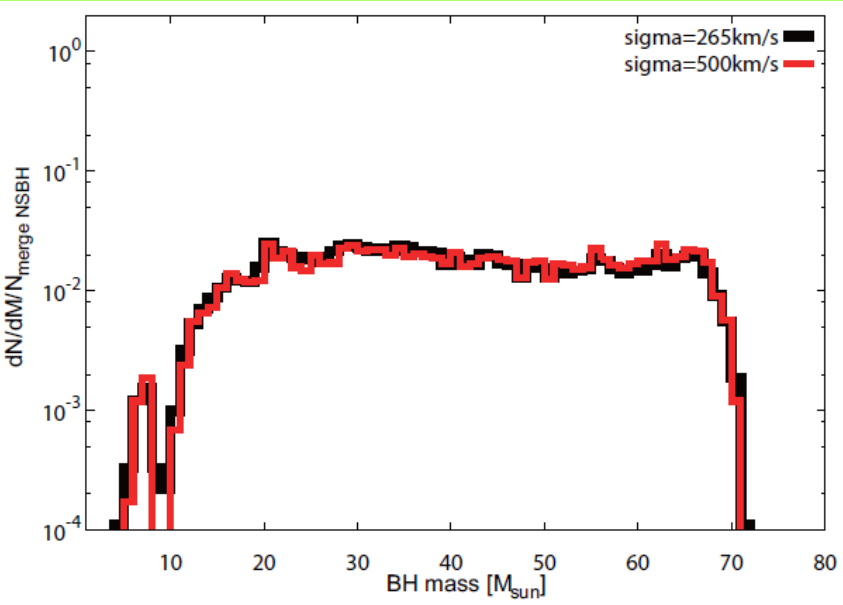
Our diffusion model explains both the spectrum and the spatial profile.

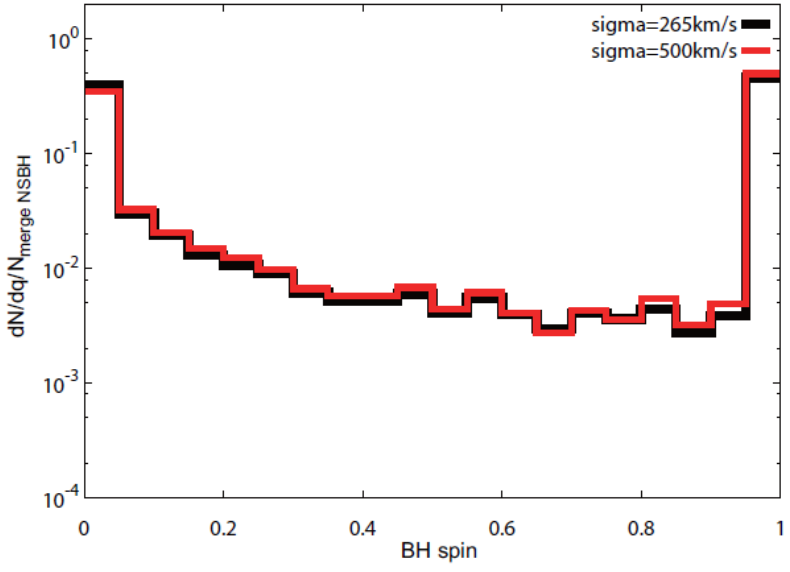
Pop III GW event rate

Kinugawa et al. 2017



NS-BH merger rate in each redshift.

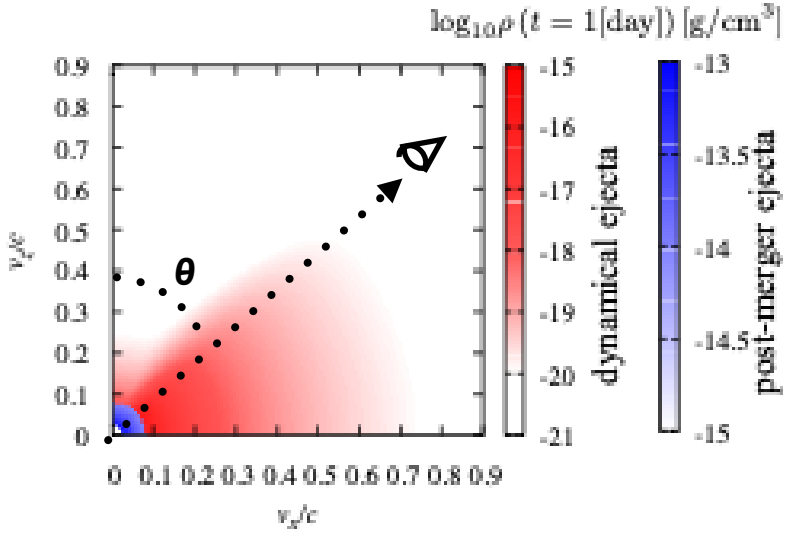




We also estimate GRB rate with binary merger model (Kinugawa & Asano 2017)

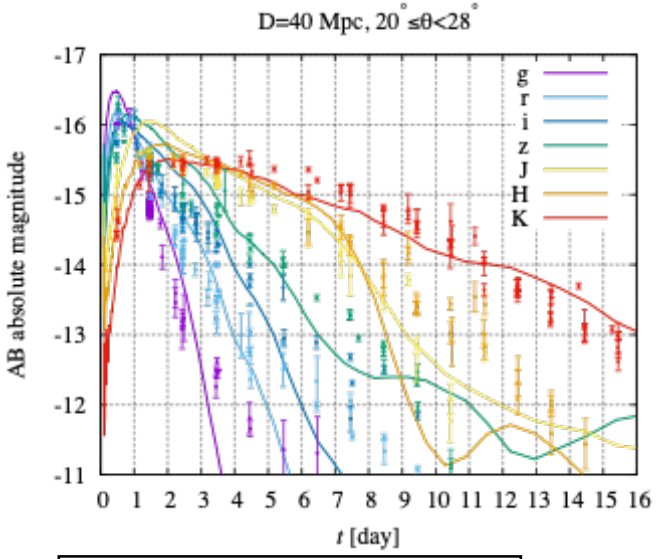
GW170817 Kilonova: multi-component model

K. Kawaguchi, M. Shibata, M. Tanaka, ApJL, 2018

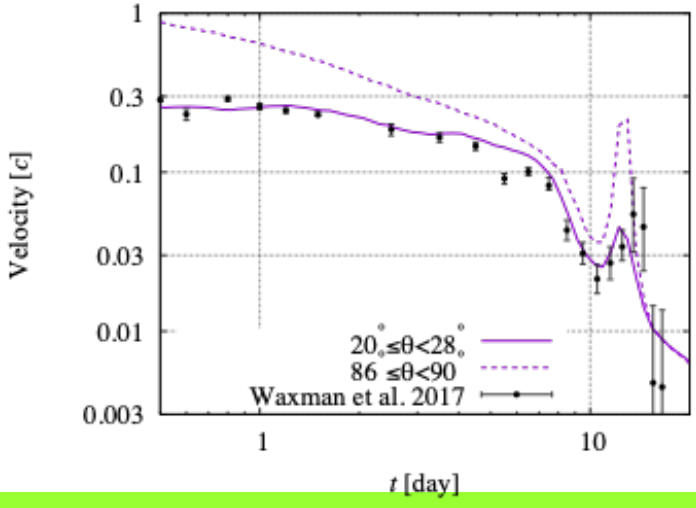


- We perform a radiative transfer simulation to interpret the optical/near-infrared electromagnetic counterparts to GW170817.
- We showed that the observation can be reproduced by a kilonova model of which ejecta profile is consistent with the prediction of numerical-relativity simulations, and the importance of the photon interplay between multiple ejecta components are demonstrated.

Broad-band lightcurves

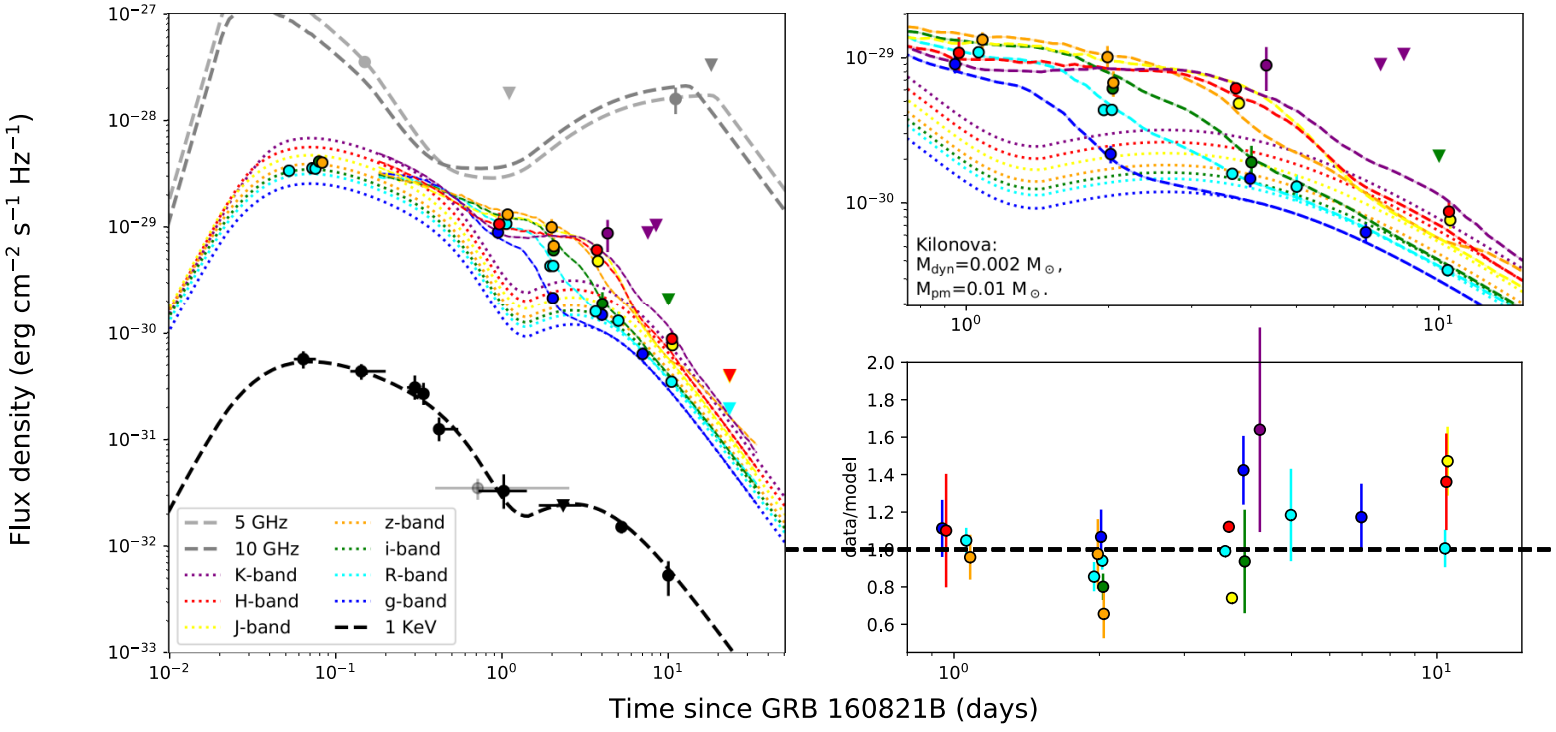


Photospheric velocity



Application to GRB160821B

G. P. Lamb, …, K. Kawaguchi et al., 2019
(arXiv:1905.02159)

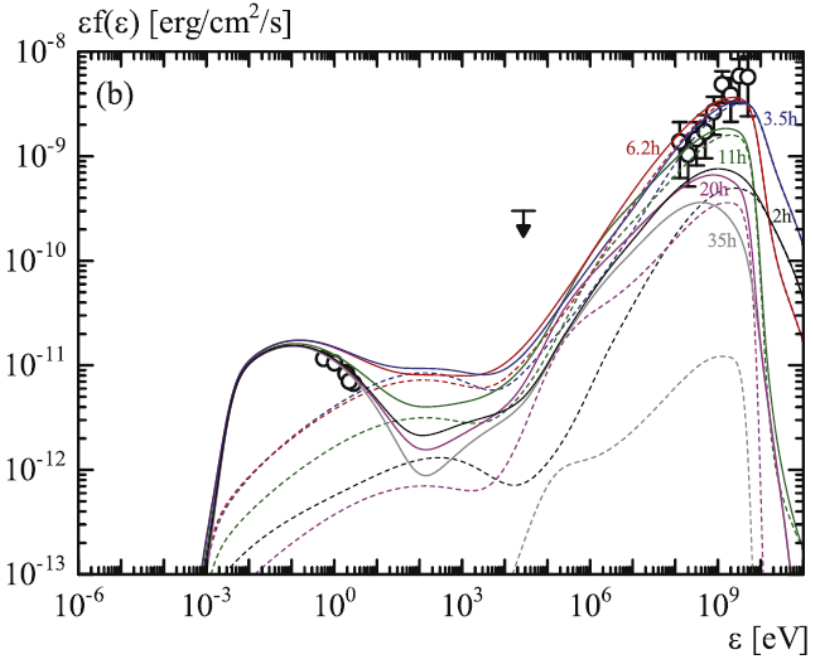


- Our multi-component kilonova models are applied to explain the excess in optical/near-infrared wavelengths found in the observation of the after glow of GRB160821B.
- Ejecta masses estimated from the lightcurve comparison are consistent with the prediction of the numerical simulations, while they are relatively small compared to those estimated in GW170817. This indicates the diversity of kilonovae and could offer some clue to understand short GRBs as well as merger dynamics.

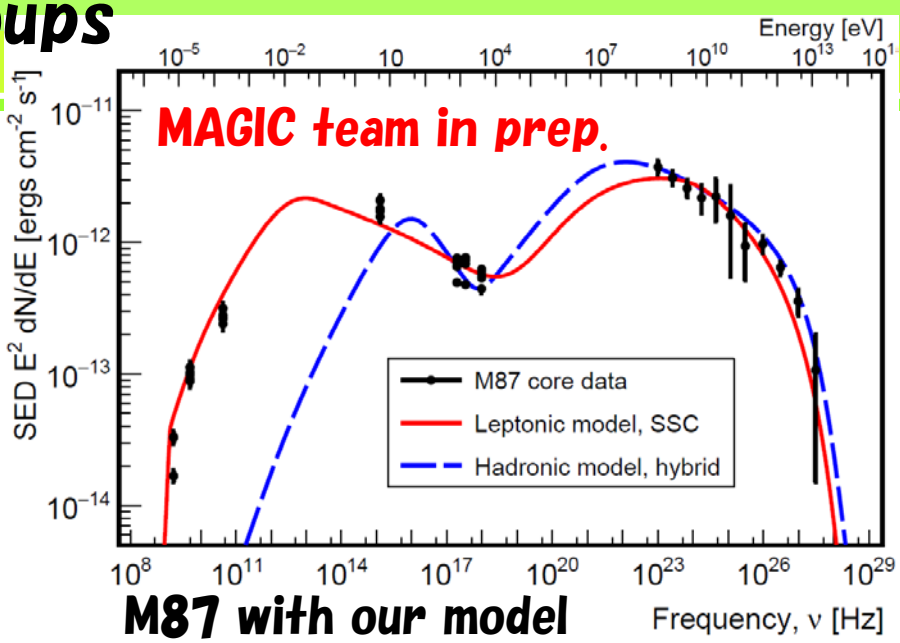
Collaboration with other groups

With CTA members

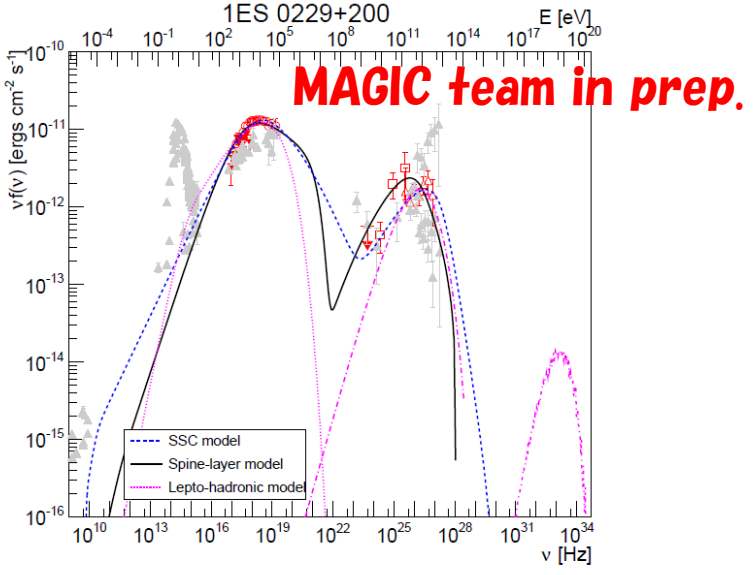
Asano & Hayashida 2015
Ackermann et al. 2016
Asano & Hayashida 2018



3C 279 flare with our model.



M87 with our model

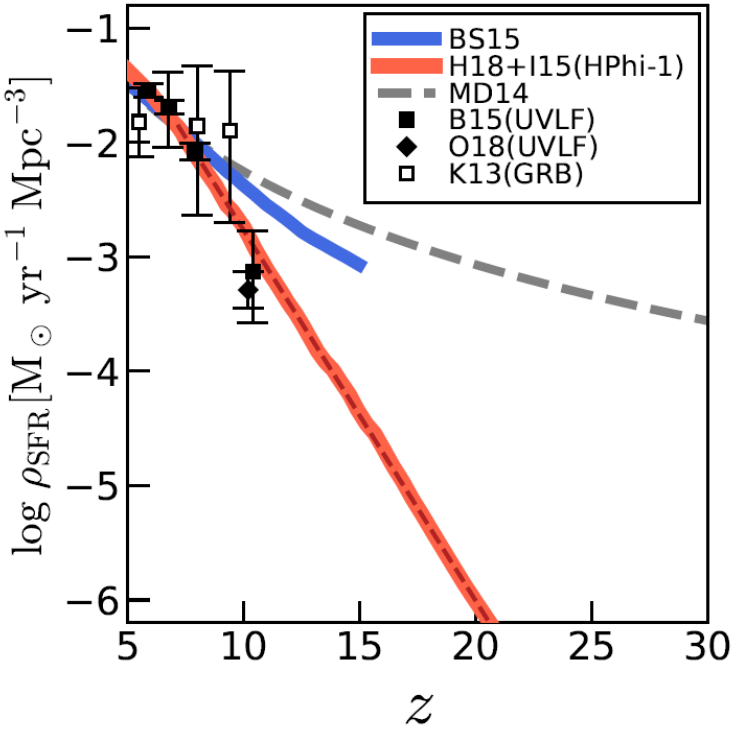


(a) 1ES 0229+200

Extremely hard blazar with our model

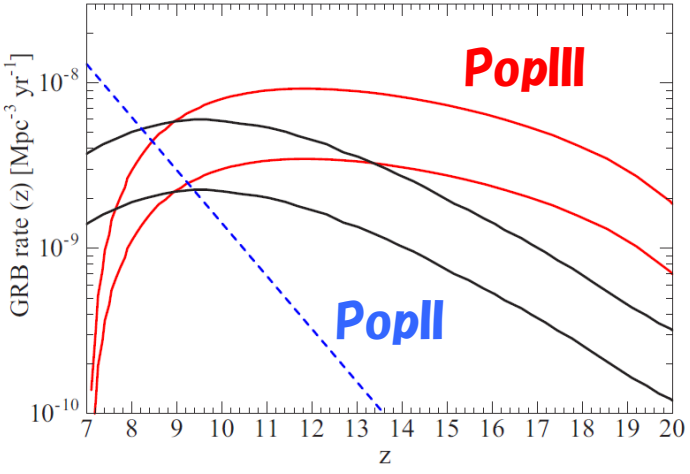
Collaboration with observational cosmology group

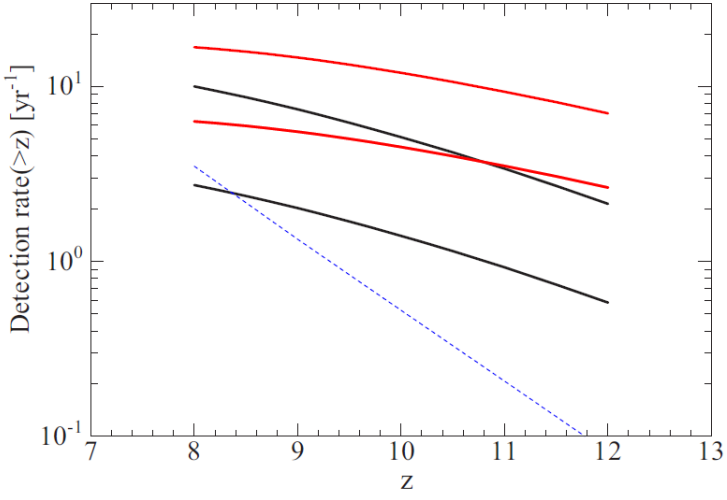
Kinugawa, Harikane, Asano 2019



Pop II Star formation history obtained by Harikane et al. 2018

GRB detection rate at high redshift

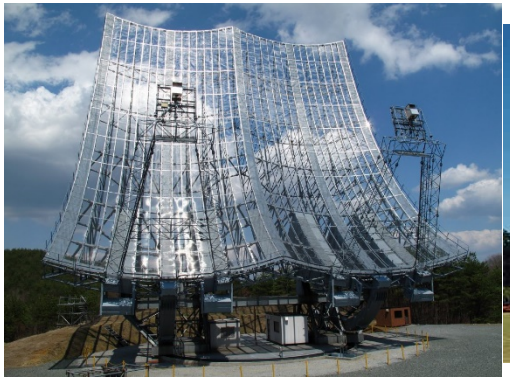




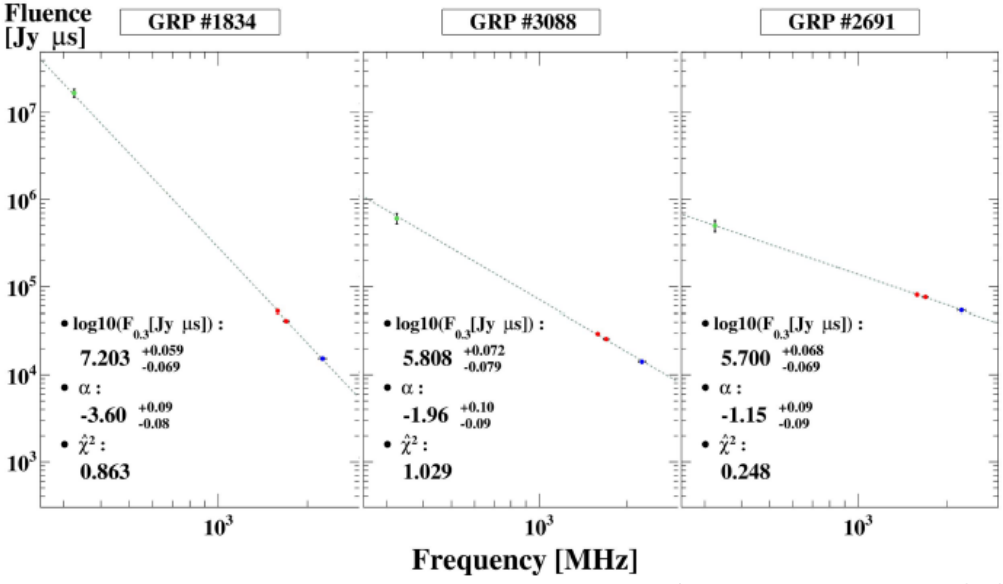
Assuming Lobster-eye optics

Data analysis: giant radio pulse from Crab pulsar

Prof. Terasawa coordinated multi-frequency simultaneous observations.




Iitate 325MHz Kashima 1.7GHz Usuda 2.3/8.4GHz Takahagi 6.7GHz



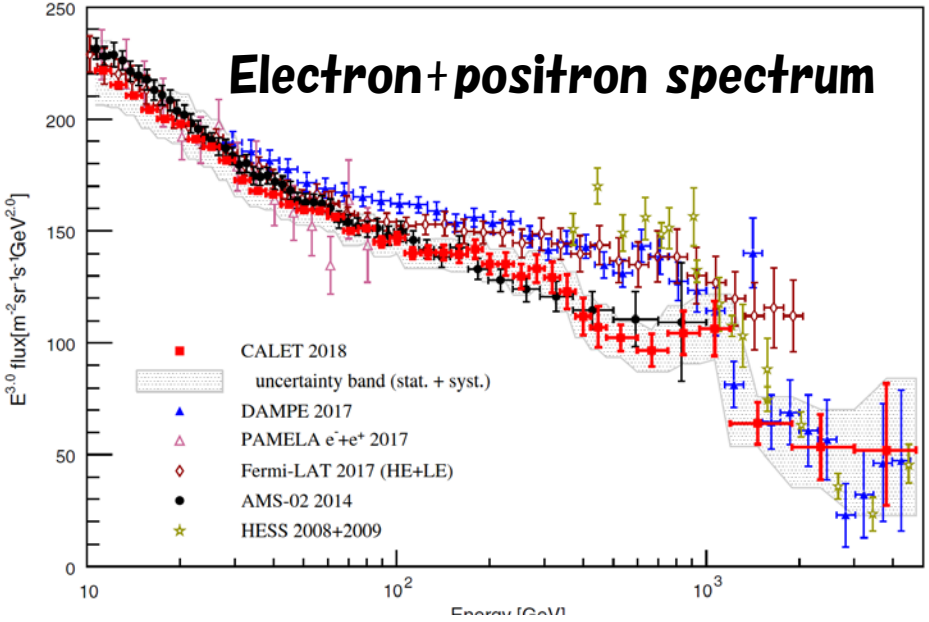
Most of pulses are consistent with single power-law spectra.
Softer, brighter.
Hint for FRB.

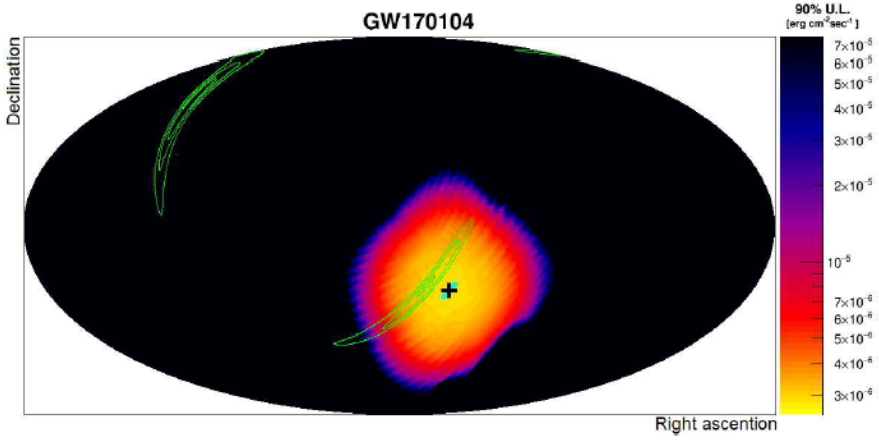
Recently simultaneous observations with NICER have been done.
Correlation with X-ray activity.

Mikami et al. 2016

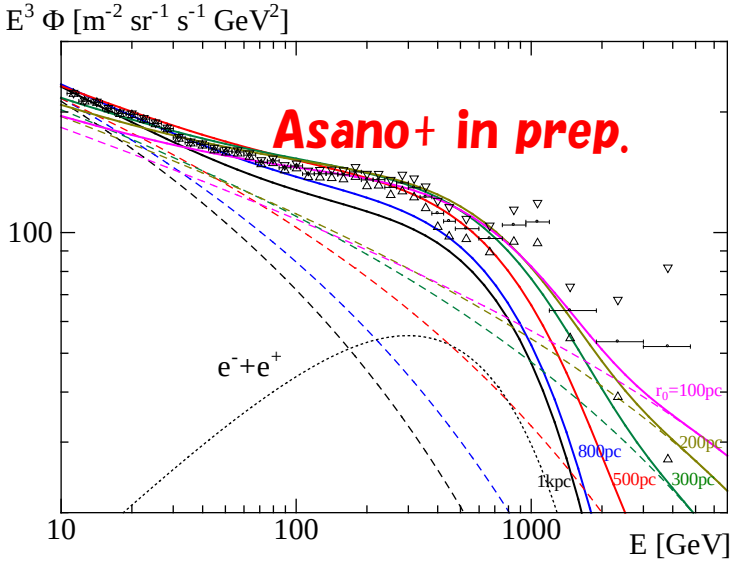
CALET

Dr. Akaike is a very active member of CALET.





Gamma-ray upper limit for a GW event



We are planning to interpret the CALET results.

Workshops etc.

We hold domestic workshops every year.

研究会 Workshops

Gamma-Ray Burst Follow-Up from Ishigaki	2019年2月28日-3月3日
高エネルギー天体現象の多様性	2018年11月20日-21日
ガンマ線バースト研究の新機軸	2017年11月21日-23日
コンパクト天体における高エネルギー現象	2016年10月11日-12日
相対論的ジェットの根元と粒子加速	2016年2月15日-16日
高エネルギー宇宙物理学研究会 2015	2015年11月25日-27日
次の10年の宇宙線研究	2014年11月6日-7日
高エネルギー天体現象小研究会	2014年6月5日-7日
宇宙における粒子加速と電波帯域での突発現象	2014年3月10日-11日
強磁場中性子星の構造と粒子加速・電磁波放出過程	2013年10月10日
宇宙線起源に関連した粒子加速現象	2013年8月21日-23日
パルサー磁気圏における粒子加速と電磁放射	2013年3月12日-13日
被加速電子のスペクトル形成過程	2012年11月5日
宇宙粒子加速：相対論的プラズマ素過程とパルサー・マグネター磁気圏	2012年6月29日
粒子加速に関する小研究会	2012年3月1日-2日

Most of talks are 1 hour or 2 hour talks.

Educational seminars for students in ICRR
- one with CTA group
- one with GW group

Published a textbook on GRB in 2019

Former members

旧メンバー（現役研究者のみ） Former Members

元教員 Former Staff	寺澤敏夫 Toshio Terasawa	2009-2016 現 国立天文台
元PD Former PD	衣川智弥 Tomoya Kinugawa	2016-2018 現 東京大学（天文）
	田中周太 Shuta J. Tanaka	2013-2016 現 青山学院大学
	赤池陽水 Yosui Akaike	2012-2015 現 University of Maryland, Baltimore County
	木坂将大 Shota Kisaka	2012-2014 現 東北大学（学際研）
元学生 Former Student	石崎渉 Wataru Ishizaki	2014-2019 現 京都大学（基研）
	廣島渚 Nagisa Hiroshima	2014-2016 現 理化学研究所
	武石隆治 Ryuji Takeishi	2011-2013 現 Sungkyunkwan University

Active researchers.
Our group have provided a career path for young scientists in high-energy astrophysics.