cherenkov telescope array

The Cherenkov Telescope Array and its potential for GRB observations

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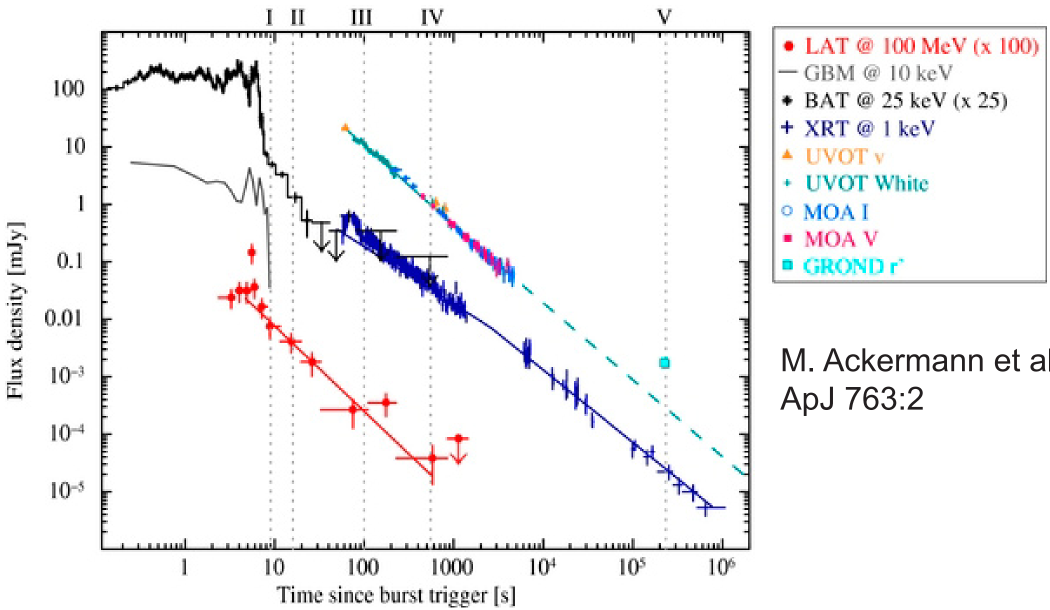
GRBs: Multi-wavelength observations

– afterglows: minutes to days after prompt gamma emission, observed across EM spectrum

– X-ray for all GRBs, optical/radio ~ 50 % (possibly just quick decay for rest)

– Gamma-ray Burst Coordinates Network: real-time dissemination of GRB triggers within seconds; robotic telescopes automatically + large telescopes manually

– >150 follow-ups with redshifts determined

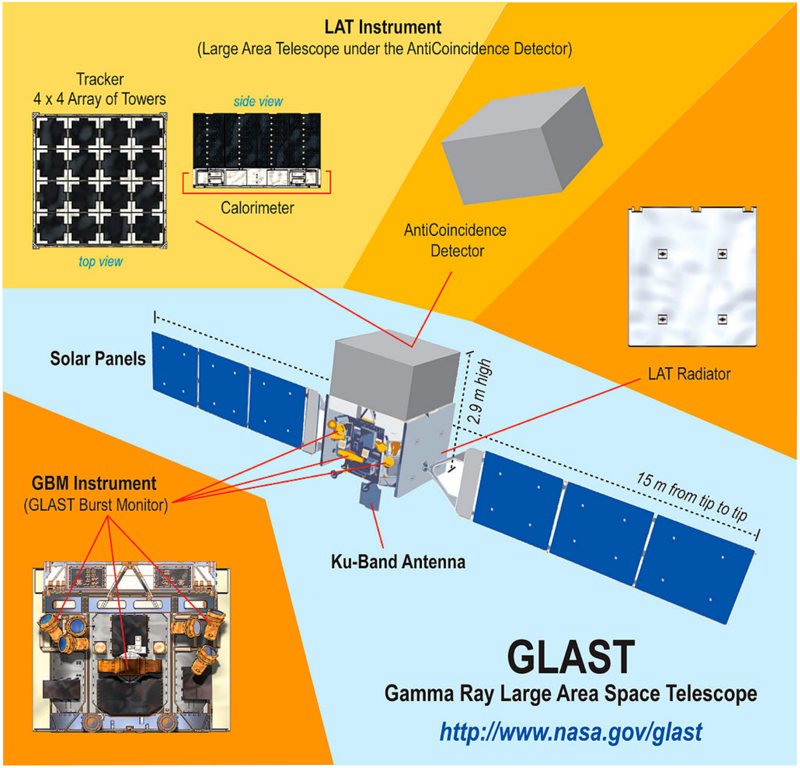


M. Ackermann et al.
ApJ 763:2

Fermi: GRBs at highest energies

– Fermi: Gamma-ray Burst Monitor (GBM) 8 keV to 40 MeV (all-sky) + Large Area Telescope (LAT) 20 MeV to ~ 300 GeV (20 % of the sky)

– GBM: 250 GRB/year, LAT 9/year @100 MeV 5/year @1 GeV,



GRBs in GeV gamma rays

– max photon E observed 95 GeV (130427A)

– only about ~ 10 % of GBM triggers in LAT field of view detected, only 1 % with signal above 10 GeV

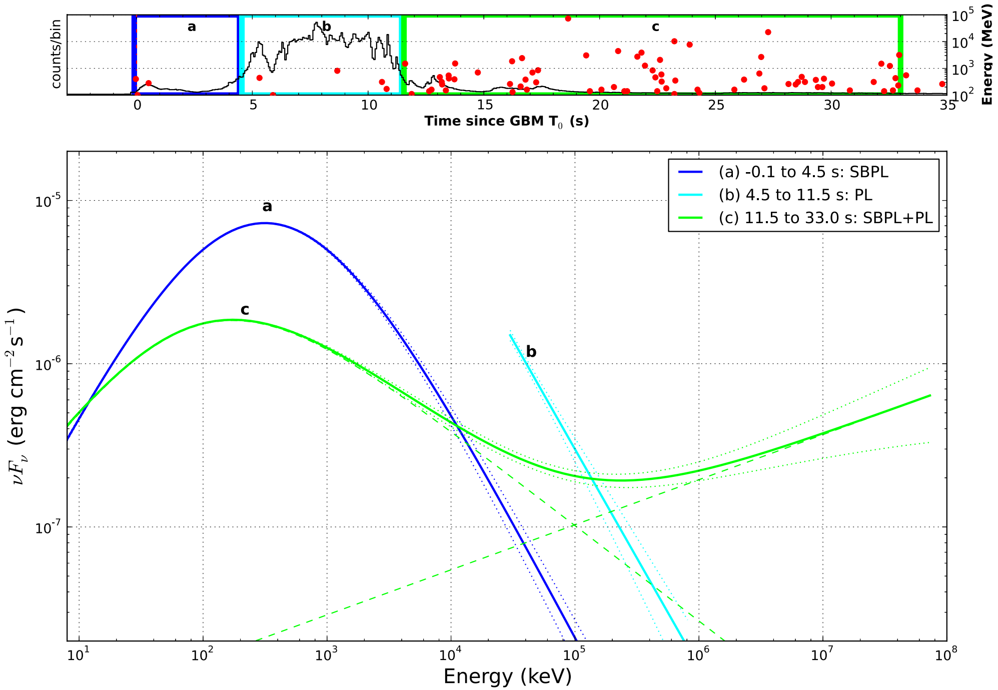
– GeV emission delayed by seconds, persistent to the afterglow phase up to 1000 s

– 30 GeV emission observed up to z ~ 1

GRB 130427A

– upper: GBM curve vs. LAT single hits

– lower: fitted spectra at different times



Fermi-LAT and Fermi-GBM coll. Science 343, 6166, pp. 42–47

GeV observation prospects: IACT

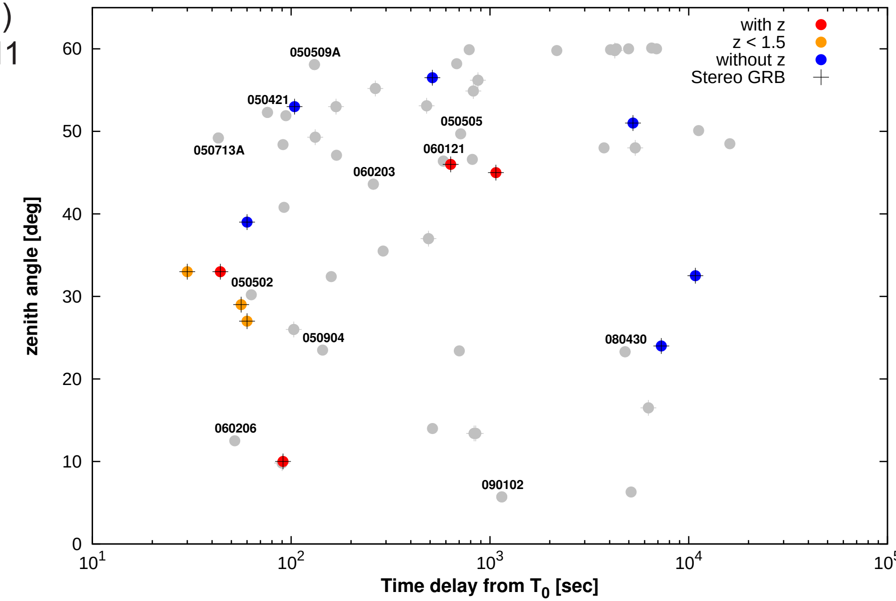
– Fermi-LAT (like any satellite) limited in photons statistics at >10 GeV energies

– all current major ground IACT (Imaging Atmospheric Cherenkov Telescopes) observatories regularly attempt follow-ups, only limits obtained so far

– MAGIC 68 GRBs (2004–2015)

– VERITAS 50 GRBs (2006–2010)
V. Acciari et al., ApJ 743:62, 2011

– H.E.S.S 39 GRBs (2003–2008)
A&A 495:2 (2009) pp. 505-512
+ more 2014–2015



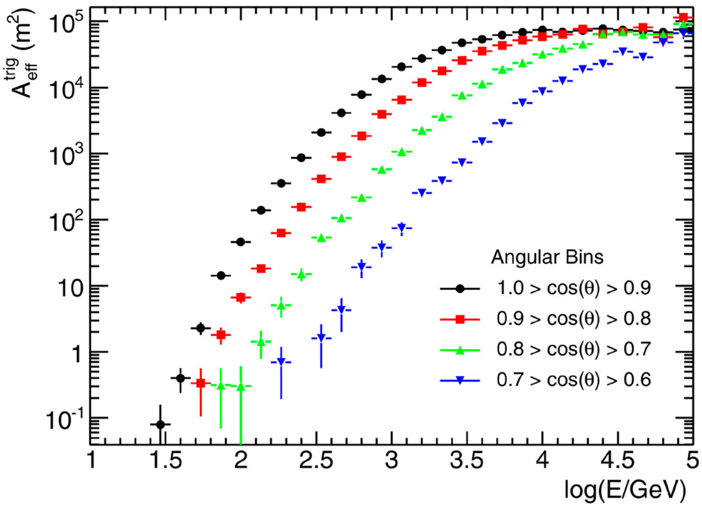
A. Carosi et al. for MAGIC coll. ICRC2015 (809)

GeV observation prospects: HAWC

– High-Altitude Water Cherenkov Gamma-Ray Observatory (HAWC) in Mexico: all-sky coverage, effective area falls rapidly below 1 TeV

– 130427A should be detectable

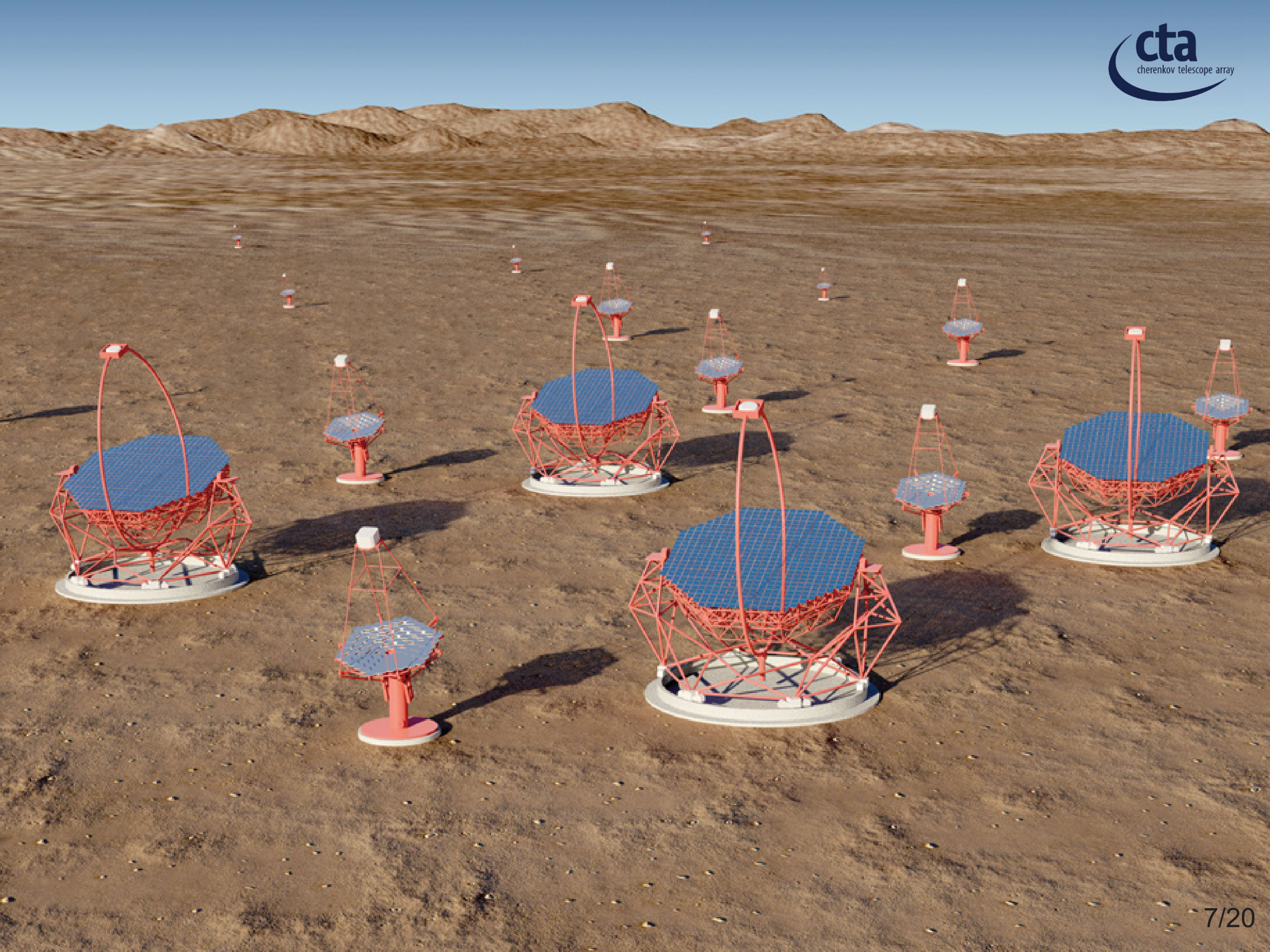
– up to ~ 1 GRB/year expected, can provide (very bright) triggers



D. Zaborov for HAWC coll., arXiv: 1303.1564

more sensitive, fast-responding detector in >10 GeV range needed

– **Cherenkov Telescope Array**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Cherenkov Telescope Array

– 3 sizes of telescopes (Large, Medium and Small: LST, MST, SST)

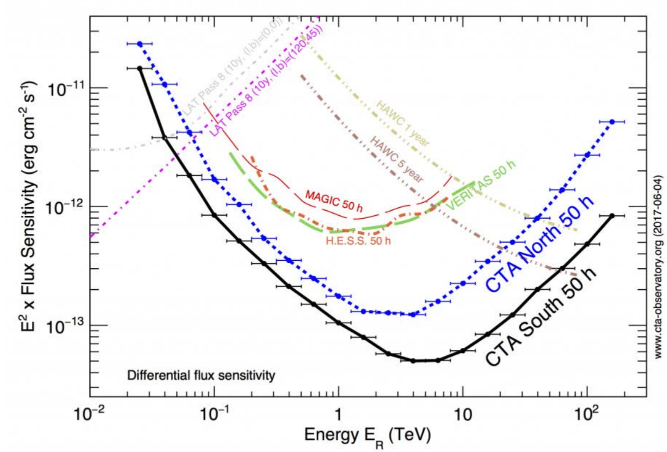
– 2 sites: North: La Palma (Canary Islands), South: Paranal (Chile)

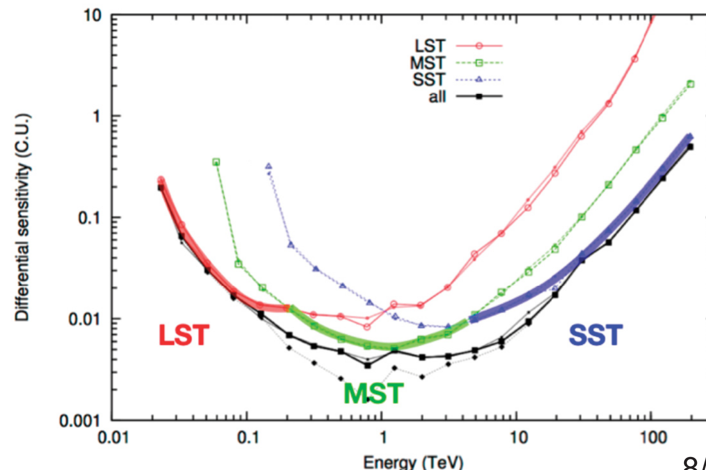
– operation from 2021, full array 2024

– large international collaboration (32 countries)

– 20 GeV to 300 TeV, best sensitivity

– slew times <20 seconds, automatic response to alerts





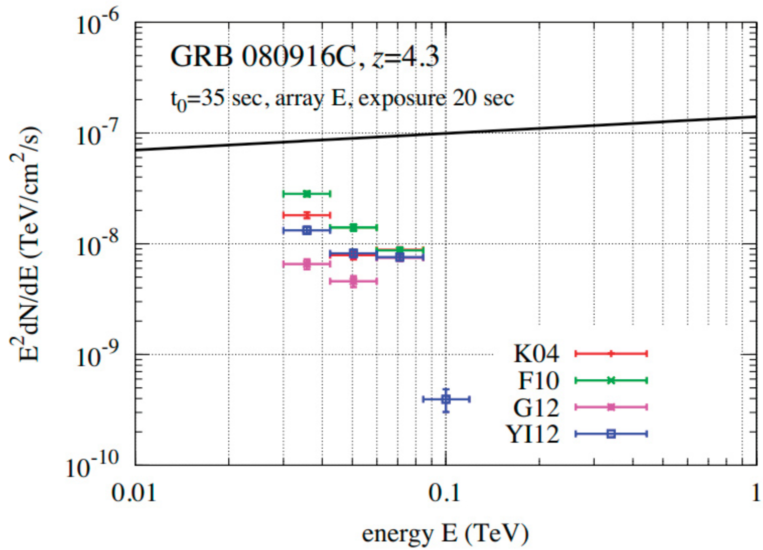
CTA GRB observations

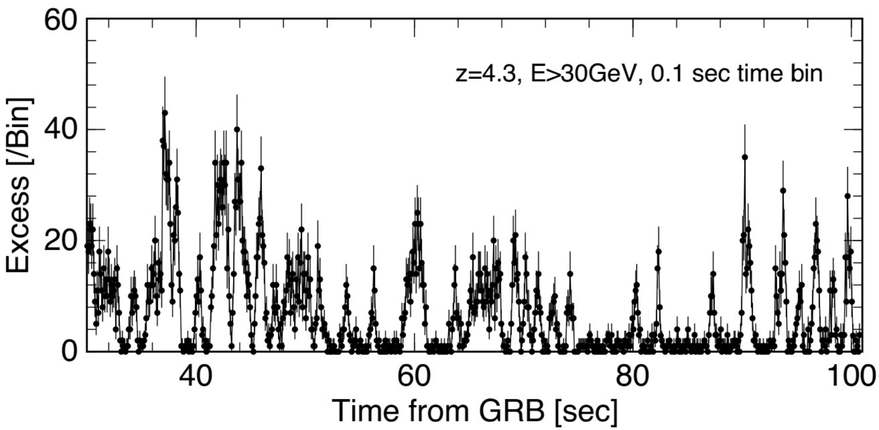
– GRBs part of „Transients“ Key Science Project

– expected ~12 real-time triggers/year/ site to be followed + ~ 1/year/site late follow-up

– detection ~ 1 GRB/yr/site with >100 photons above 30 GeV expected

– up to 10 possible, depending on GRB properties and EBL





(EBL = Extragalactic Background light: attenuation of gamma photons by e^+/e^- pair production)

– possible serendipitous observation during surveys (order of 1 during lifetime)

CTA Large Size Telescopes

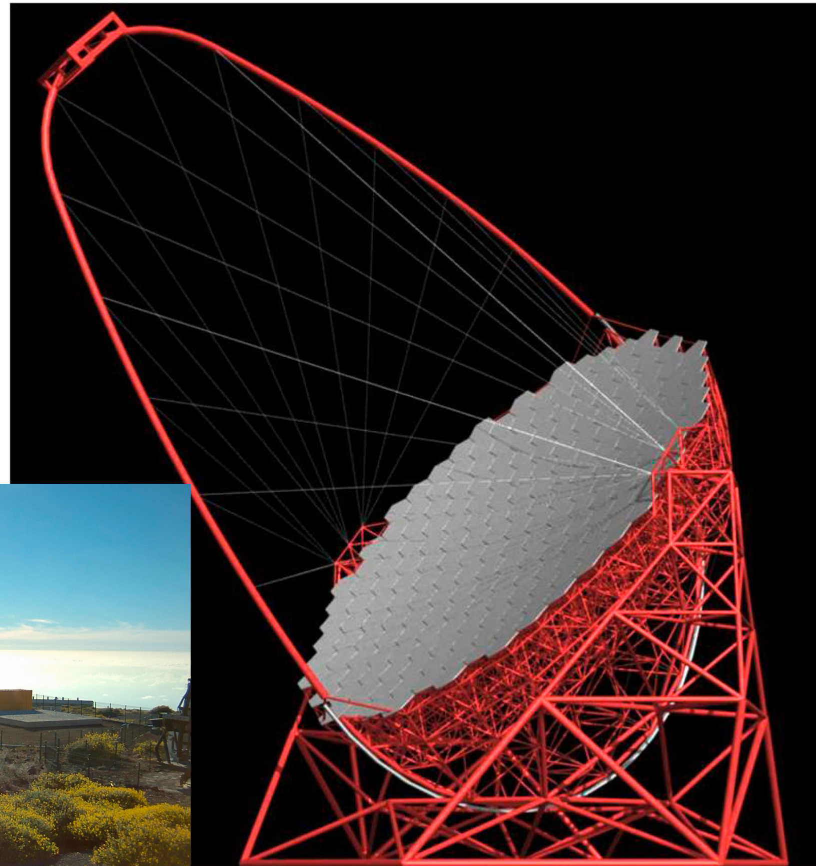
– low-energy range key for GRBs

– 4 per site

– 23 m diameter, 45 m tall, 100 t

– within 20 seconds anywhere

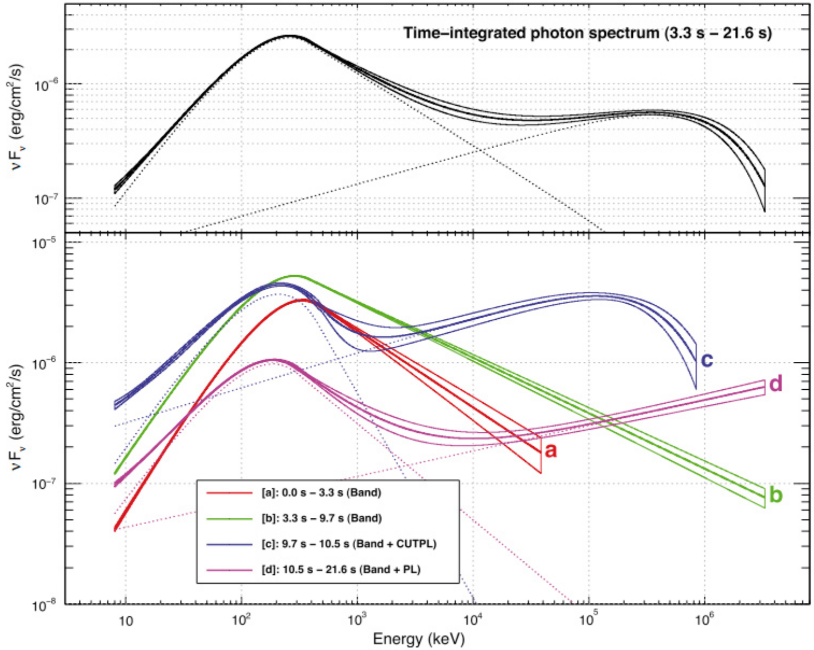
– prototype construction on La Palma already started



Science goals with CTA GRB observations

– determining the velocity of the jet and location of the emission site via intrinsic γγ absorption features and short timescale variability

– determining the mechanisms of particle acceleration and radiation for the prompt emission via time-resolved, broadband spectra

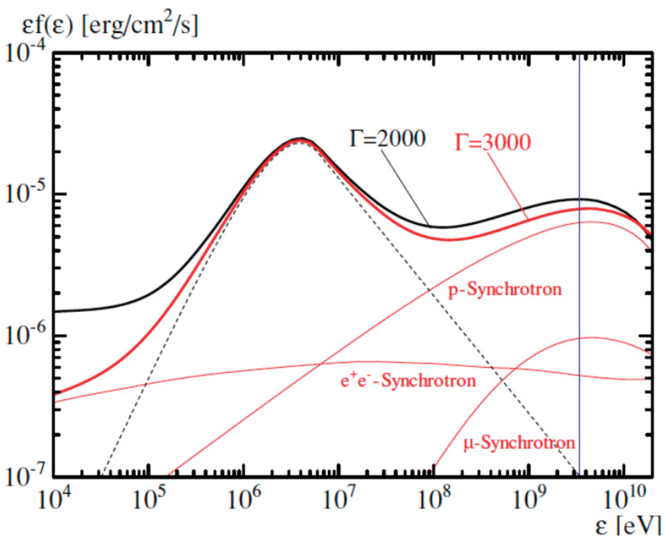


M. Ackermann et al., Fermi Collaboration, ApJ 729 (2011) 114

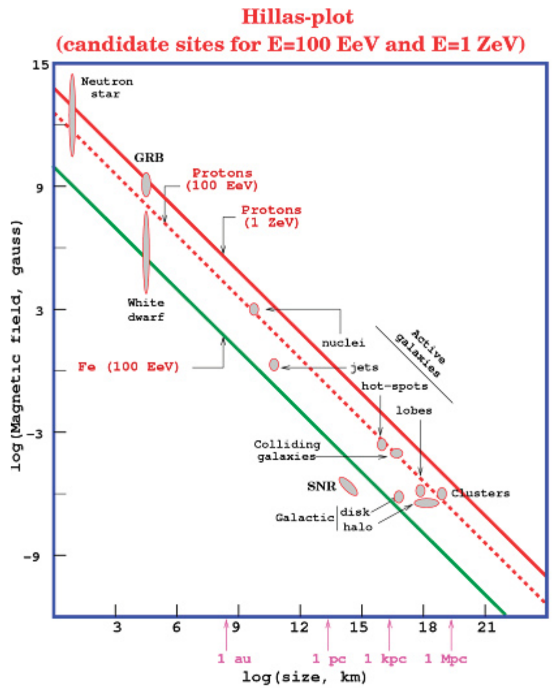
Science goals with CTA GRB observations

– determining the mechanisms of particle acceleration and radiation for the early afterglow emission

– testing the GRB origin of UHECRs by revealing hadronic gamma-ray signatures in time-resolved spectra,



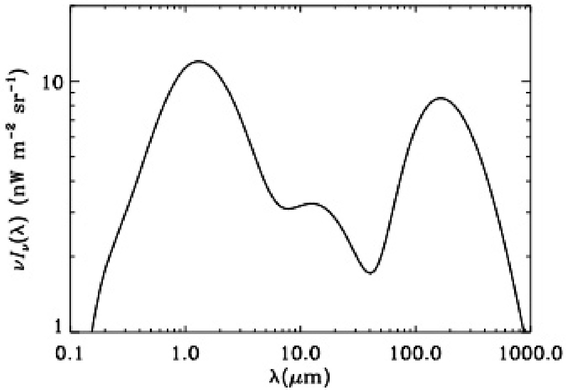
K. Asano, S. Guiriec, P. Mészáros, ApJ (Lett.) 705 (2009) L191.

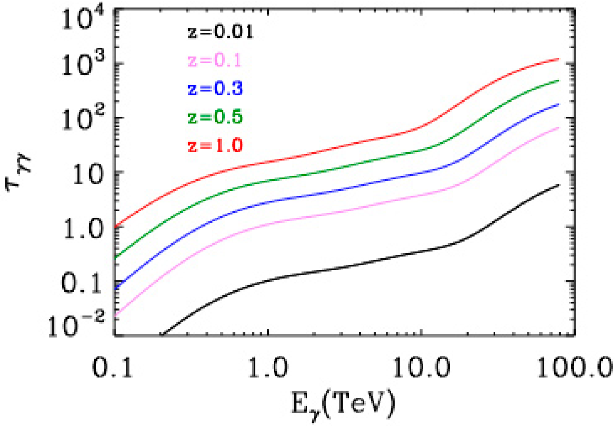


Science goals with CTA GRB observations

– clarifying the global evolution of stars and supermassive black holes (SMBHs) in the universe via γγ attenuation features due to the EBL over a large range of redshifts, potentially beyond the reach of active galactic nuclei (AGN) at z > 2

– testing Lorentz invariance violation (LIV) with high precision via energy dependence of photon arrival times.





E. Dwek, F. Krennrich, Astroparticle Physics 43 (2013), pp. 112–133