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Fermi
Gamma-ray
Space Telescope

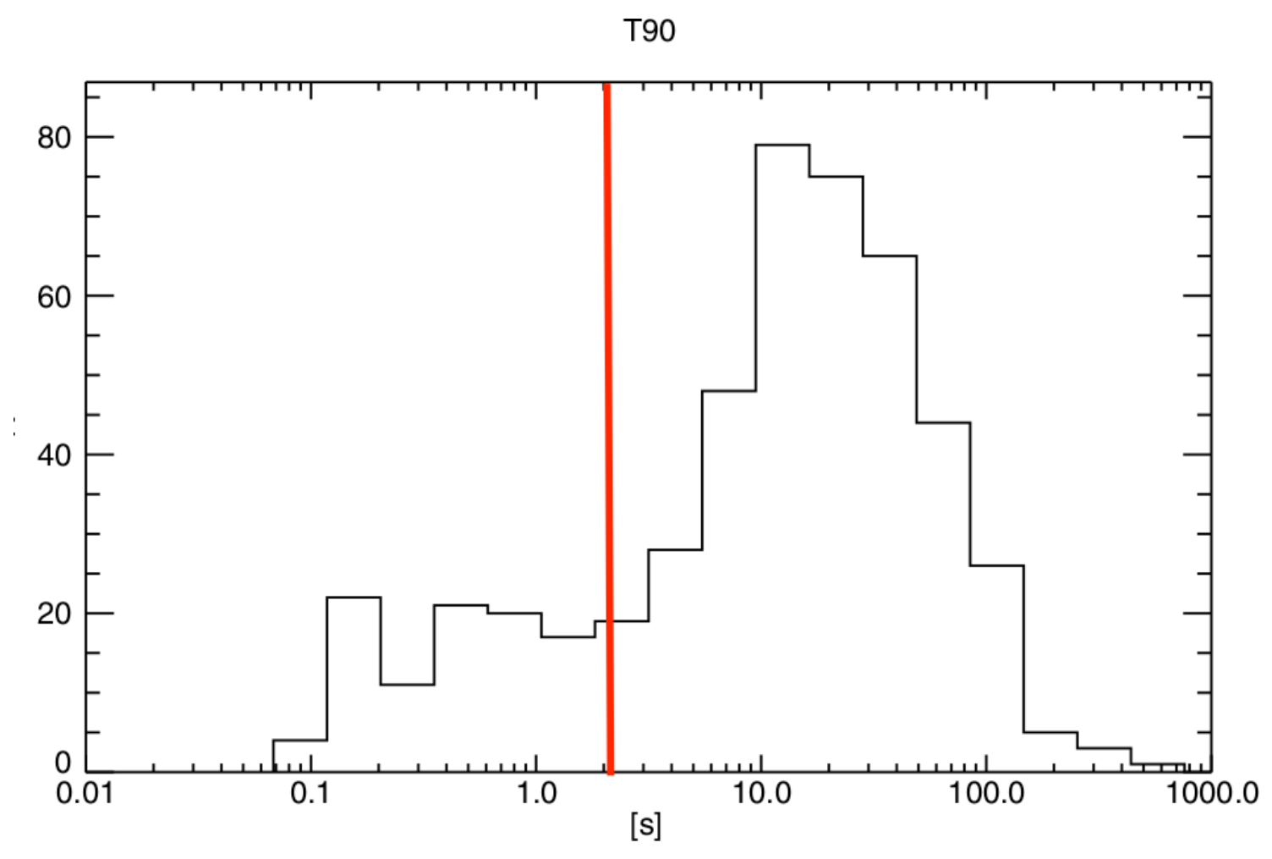
Short γ-ray bursts from compact mergers, *Fermi* GBM and Advanced LIGO/Virgo

Véronique Pelassa, M. Briggs, V. Connaughton[1] and J. McEnery, E. Troja[2]
on behalf of the *Fermi* GBM and LAT Collaborations
[1]University of Alabama in Huntsville
[2]NASA Goddard Space Flight Center

Short Gamma-Ray Bursts (sGRB) are thought to originate from accreting stellar-mass black holes resulting from compact mergers. The gravitational waves emitted during such close-by merger events will be observable after 2015 by the next generation detectors (Advanced LIGO/Virgo). The Gamma-Ray Burst Monitor (GBM) on-board the Fermi space telescope will complement these detectors, providing the gamma-ray counterparts to gravitational waves detections.

GBM currently observes 45 sGRB per year, many of them likely close-by, and some of these are therefore likely to be within the Advanced LIGO/Virgo horizon for detecting compact mergers. In addition to on-board triggers, a ground search for short transients can soon be performed, since the data for individual GBM photon collected over the full orbit will be available. We provide predictions for the rate of joint detections by GBM and the Advanced LIGO/Virgo detectors, and present consequences for the study of the sources of these multi-messenger emissions.

Short γ-ray bursts and compact mergers

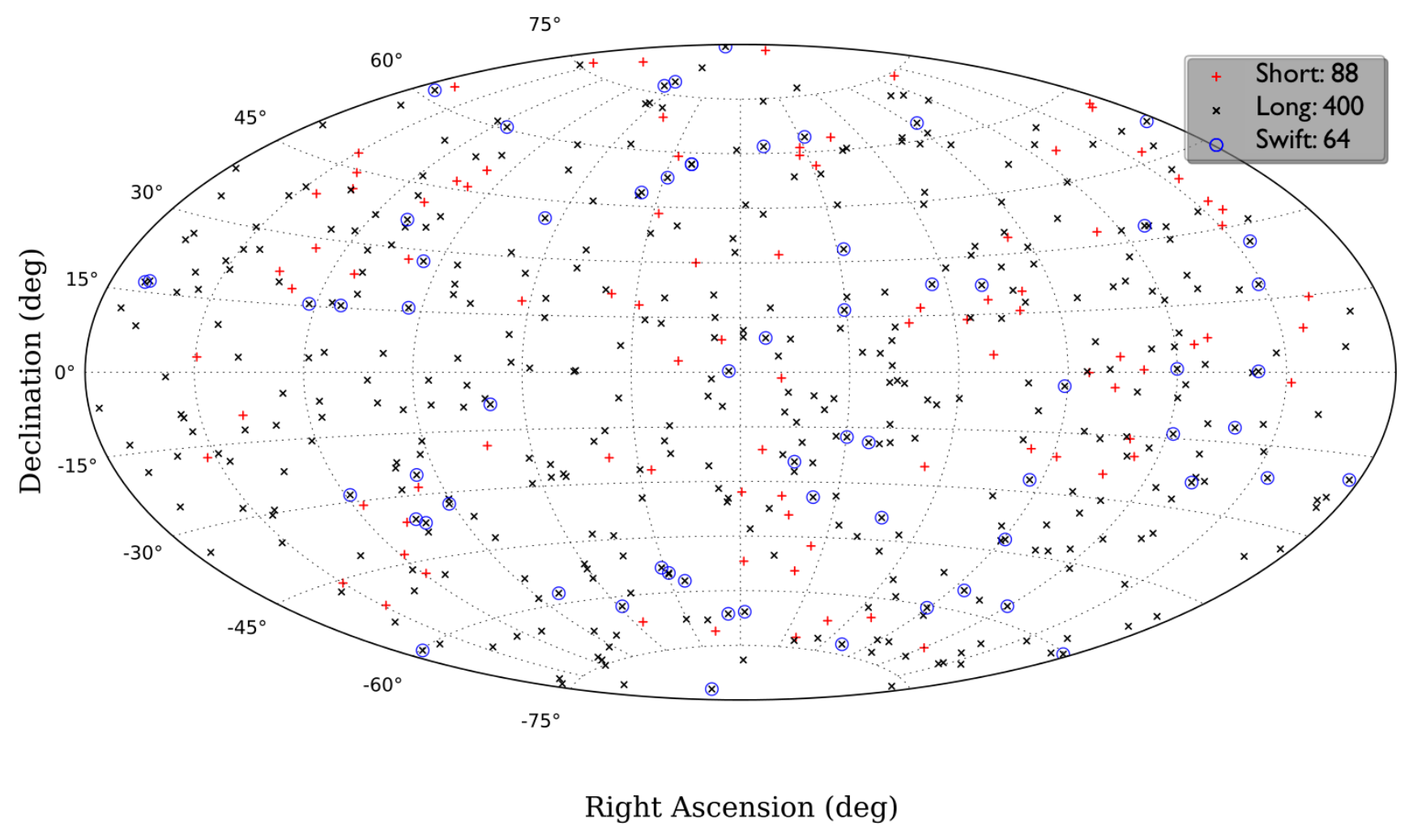


Duration (T_{90}) distribution of *Fermi* GBM GRB [1].

Short γ-ray bursts (GRB) ($T_{90} < 2\,s$) are often assumed to originate from compact binares mergers, while the long GRB (resp. $T_{90} > 2\,s$) would originate from core-collapse SNe.

Electromagnetic signal (EM) and gravitational waves (GW) complementary:
EM → jet physics and progenitor nature(prompt γ-ray emission); distance and progenitor environment (afterglow)
GW → inspiral parameters (mass, radial distance, inspiral rate)

Fermi GBM observations of (short) GRB



Fermi γ-ray bursts observed between July, 2008 and July, 2010 [1].

A wide dynamic range (10 – 40MeV) and several trigger algorithms tuned for short hard bursts balances *Fermi* GBM bkg limited sensitivity, which results in about 44 short GRB detected on-board per year.

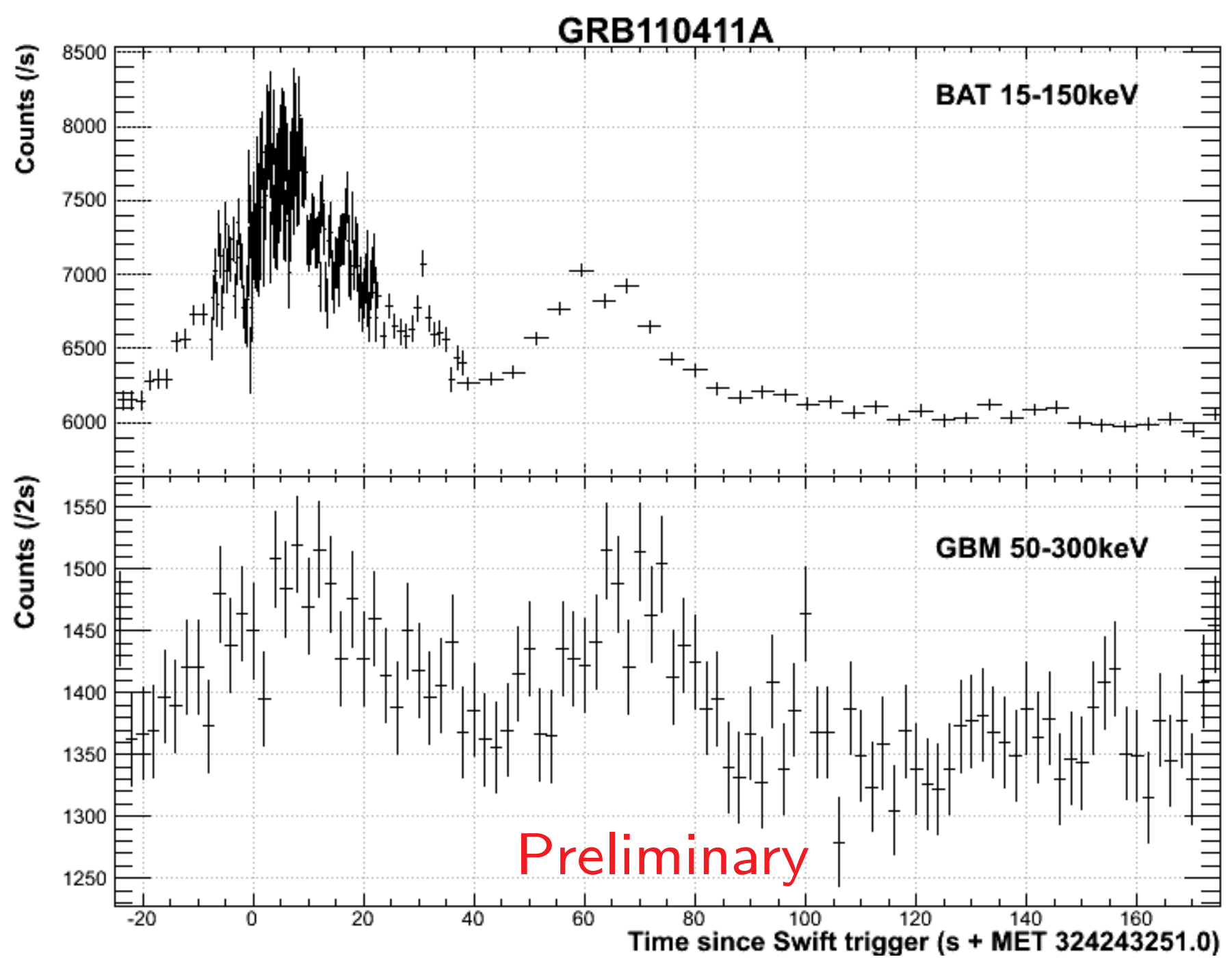
Fermi GBM localizations are too broad for follow-up observations, so most redshifts are unknown. These are most likely bright and/or close-by sources because of the bkg-limited sensitivity of the GBM.

Two-way untriggered search

Searching GW data around known sGRB yields mergers close to the detector's horizon. Such studies in LIGO science runs 5 and 6 have revealed no merger candidiate [2]. Further away Advanced LIGO horizons are promising for joint observations. *(see also L. Blackburn's poster)*

Searching for untriggered sGRB around known GW triggers is possible with the new continuous data taking mode: individual photon data are now available for the full orbit *(see S. Xiong's talk)*. This will increase the sGRB detection rate and the probability for joint EM-GW detections.

A test was ran on existing "segments" of continuous individual photon data, searching for known *Swift* and *Konus* GRB which had not triggered GBM. We found 3 (long) "new" significant GRB detections. There was no known sGRB in the intervals searched.



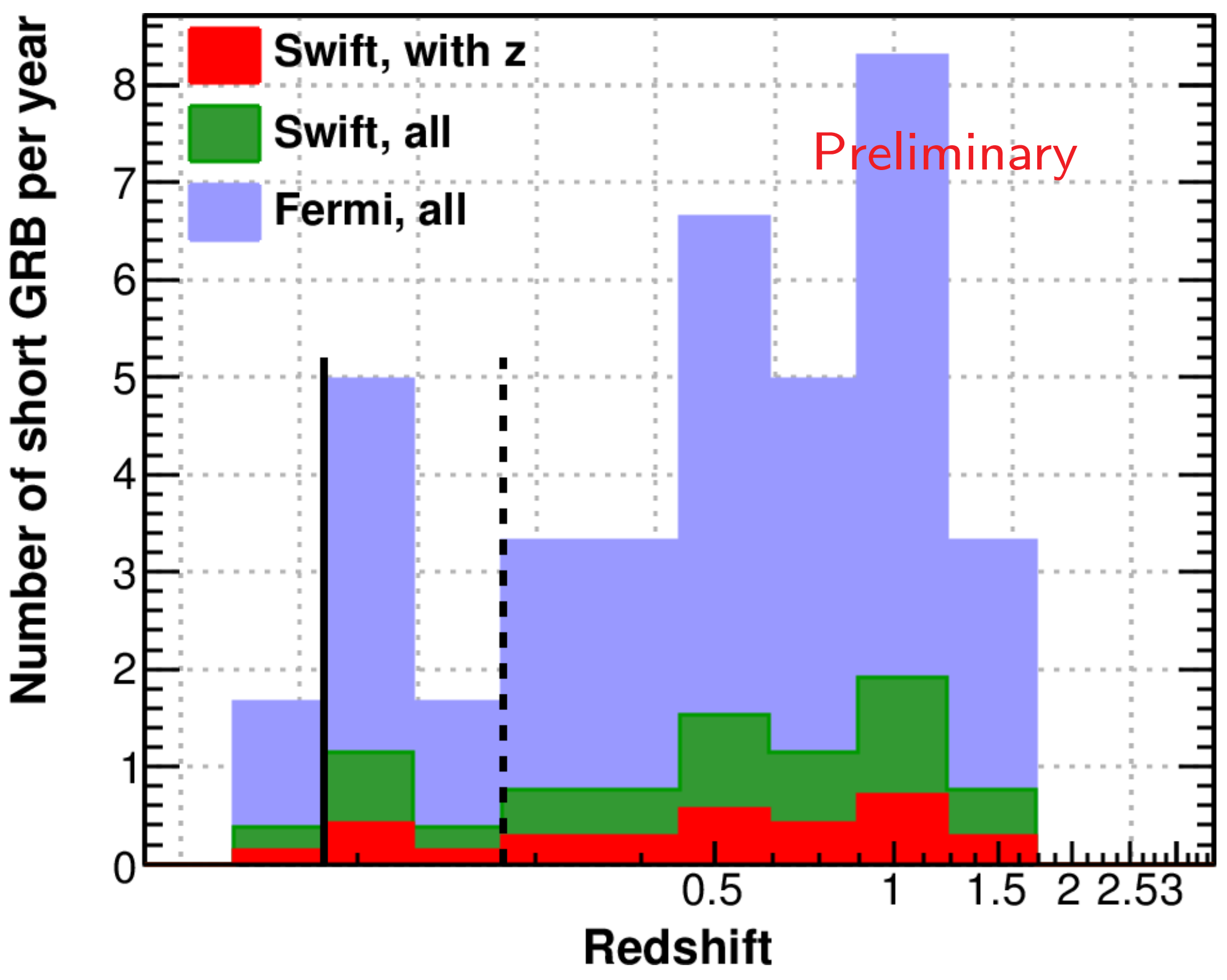
GRB 110411A did not reach the detection threshold (4.5σ above background) in the second brightest NaI detector.

Predictions for GBM & ALIGO

We estimated the future rate of joint observations, i.e. the rate of GBM on-board triggers for sGRB localized within ALIGO horizon.

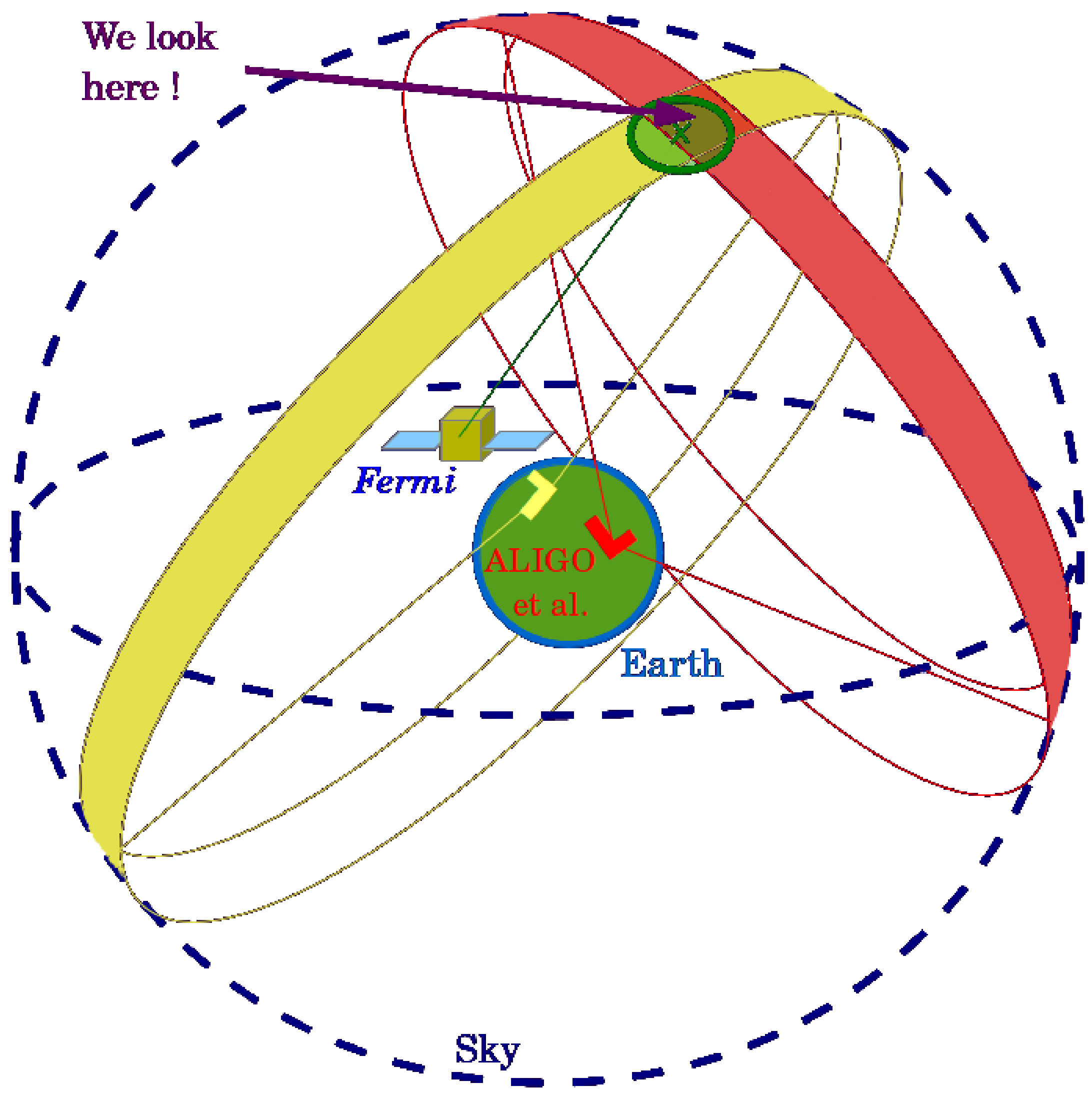
ALIGO horizons for observing face-on mergers [3]: $z = 0.11$ (NS-NS), $z = 0.22$ (NS-BH)

GBM sGRB trigger rate within ALIGO horizons:
N($z < 0.11$) ~ 2 (+4 -1) /yr
N($z < 0.22$) ~ 8 (+6 -3) /yr



Since the redshifts of very few GBM sGRB are known, we assumed the z distribution for GBM sGRB is similar to the distribution of *Swift* sGRB (because the distributions for short + long GRB together are similar) and applied a factor equal to the ratio of GBM to *Swift* sGRB detection rates: 4.3. We also assumed that *Swift* sGRB of known and unknown z have similar distributions.
The rates calculated are independent of the actual jet beaming angle of the sGRB observed.

Ground follow-up of GW triggers



A GW signal detected by one GW detector (interferometer) yields an annulus, so that 2 or more detectors are needed to define a location box (of 5°×5°).

Observers at all wevelengths are enthusiastic over the search for EM counterparts to GW triggers, even if much tiling is required.

A coincident γ-ray detection, even with a large uncertainty radius, will reduce the search area significantly, allowing to get to the source earlier and collect information on the energetics and environment of the transient associated to the merger.

Conclusions

Fermi GBM and Advanced LIGO (>2015) should see coincident Gravitational wave/Electromagnetic emission or rule out NS-BH mergers as the progenitors of short GRB. *Fermi* GBM localizations will be useful to multi-wavelength observations.

References

[1] Paciesas et al. 2012, Astrophys. Journal Suppl. Series 199:18
[2] Abadie et al, 2012, astro-ph/arXiv:1205.2216
[3] Abadie et al. 2010, Class. Quant. Grav. 27: 173001

The 4th International Fermi Symposium, 10/28 – 11/02/12, Monterey, CA
http://fermi.gsfc.nasa.gov/science/mtgs/symposia/2012/

The *Fermi* GBM collaboration acknowledges support for GBM development, operations and data analysis from NASA in the US and BMWi/DLR in Germany.