OPTICALLY IDENTIFIED RELATIVISTIC EXPLOSIONS: STRAWMAN SURVEY RESPONSE

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Committee Request: Strawman Survey

The average partnership time allocation for science and calibration is 2.3 hours per night, corresponding to a 40% usage of ZTF, once weather losses have been included.

For this exercise, assume that 0.6 hours per night (10% of total) can be used for ToO, calibrations, twilight obs, and M31.

For the remaining 30% (1.7 hours per night) the proposers should consider the following schemes:

- A Galactic block of 2 months, e.g., mid-Nov to mid-Jan, for HiCAPS (1620 sq deg in Galactic plane x 3 hours continuous observations)
- a Solar System block of 1 month, e.g., mid-Jan to mid-Feb for superfast rotators experiment. During mid-Nov to mid-Feb, reserve the twilight 12-deg to 18-deg time for twilight experiment.

For the remaining 9 months, mid-Feb to mid-Nov, use one of the strawmen below:

- Strawman - fast: gggg-band survey x 1620 sq deg x 1-day cadence (or RRRR-band or gggR-band)
- Strawman - wide: gi-band survey x 3240 sq deg x 1-day cadence
- Strawman - combo: i-band survey x 6,700 sq deg x 4-day cadence (shadowing a subset of the MSIP CC survey) ggg-band survey x 1600 sq deg x 1-day cadence

Response: Strawman Survey

To reiterate from our proposal, our Figure of Merit (FoM) is simply the number of relativistic outbursts discovered by ZTF. Inherent in this definition is that these sources must be identified, promptly followed up, and distinguished from foreground and background contaminants (e.g., flaring low-mass stars). So we shall evaluate the various proposed observing strategies in this context.

To begin with, the HiCAPS survey is unlikely to yield any fast extragalactic transient discoveries due to the large foreground extinction and crowding in the survey fields. And the areal coverage of the superfast rotator survey (423 deg^2 proposed) is sufficiently small that it is unlikely to contribute discoveries of interest to our project. So we focus exclusively on the possible 9 month surveys ("fast", "wide", and "combo").

Wide: Because it covers the largest area (with a daily cadence), the wide survey would have the largest potential rate of relativistic transient discovery: using the rate of iPTF14yb-like outbursts from our proposal ($\rho \sim 600\,\mathrm{yr}^{-1}$), we would expect to detect approximately 3 such events to be *detected* by ZTF each month (35 total per year).

However, we are quite concerned about the *identification* of our relativistic sources with such a strategy. Because neither g nor r band receives a repeat visit each night, we cannot identify fast transients (via some Δmag / Δt cut with ZTF data alone. **We do not have sufficient resources to obtain follow-up photometry (to search for rapid fading) for a sizeable fraction of the ZTF transient discoveries — as such, we consider the wide survey to be highly detrimental to our proposed science.** Estimating a Figure of Merit for this scenario is challenging, but based on our experience with the Color Me Intrigued survey we anticipate it would be quite low ($\lesssim 5$).

Fast: This is similar to the observing strategy we requested in our White Paper (we requested 6 observations per night over 2500 deg^2 but assumed 40% weather losses, so in practice only 4–5 images per night). For the 9 months of observations from February to November, we calculate a FoM of 18 relativistic transient discoveries.

We would strongly prefer that observations be conducted in a single filter, or at the very least to have the first and last observations be in the same filter (e.g., ggRg, RgRR, ...). This provides the longest time baseline to search for variability, an important consideration for events that may be discovered several hours after the explosion time.

We have a weak preference for R band (minimize dust extinction), but understand that this may be unacceptable for e.g., young supernova searches.

The fast survey is our preferred observational approach for ZTF.

Combo: Because it covers the same area as the Fast survey, a similar number of relativistic transients would occur in the ZTF field-of-view in the course of this survey. However, we would be somewhat limited in our ability to *discover*

Table 1: – Relativistic Transient Discovery Rates

Wide	**Fast**	**Combo**
$\lesssim 5$	18	12–15

them – for example, if the time baseline were short enough (and the transient discovered sufficiently long after explosion), we may not observe sufficient fading in a single night to clearly distinguish from other sources). Some basic simulations with this observing strategy suggest a discovery rate (and thus Figure of Merit) of $\approx 12 - 15$ for this approach. **Thus, while it is not our preferred approach, it would be acceptable for our science objectives.**

These results are summarized in Table 1.

Response: Reviewer Comments We appreciate the efforts of the reviewers of this (and all the other) White Papers. The only question posed was the impact of cadence on our Figure of Merit (and thus our science objectives). As noted by the referee this is challenging to estimate (very sensitive to the assumed light curve shape). Our (admittedly simplistic) simulations suggest that our FoM will decrease by $\approx$ 20–30% between the Fast (4x per night) and Combo (3x per night) surveys.