In the present paper, we focus on the effect on a variable ejection jet of a non-top hat ejection velocity cross section. An analytic model for the effect of a centrally peaked ejection velocity cross section was presented by Raga, Cantó, & Cabrit (1998). These authors show that for decreasing edge-to-center ejection velocity ratios the internal working surfaces (resulting from the ejection time-variability) become progressively more curved. This effect might produce emitting knots with a closer resemblance to some of the bow-shaped knots observed in HH jets.

Some numerical simulations of variable ejection jets have incorporated a non-top hat ejection velocity cross section. For example, Völker et al. (1999) used a quadratic ejection velocity cross section with a factor of 1/2 edge-to-center velocity ratio in variable ejection models. Some of the more recent papers of this group also describe models which incorporate a (presumably quadratic) non-top hat ejection velocity cross section (Rosen & Smith 2003, 2004; Smith & Rosen 2005) with a edge-to-center velocity ratio of 0.7 or 0.8. Dennis et al. (2008) present constant ejection jet models with a quadratic ejection velocity cross section with an edge-to-center ratio of 0.9. Raga et al. (1998) describe an analytic model for leading and internal working surfaces in jets with arbitrary ejection (density and velocity) cross sections, but only present a single numerical simulation of the leading head of a jet with a quadratic velocity cross section with an edge-to-center velocity ratio of 0.8. Raga et al. (2009) also computed variable jet models with a quadratic velocity cross section, and find that even jets with an edge-to-center velocity ratio of 0.8 differ substantially from initially top hat jets. Finally, the paper of Frank et al. (2000) appears to be the only study of a jet with a non-quadratic radial dependence of the ejection velocity. Somewhat surprisingly, a systematic numerical study of the effect on variable jets of different edge-to-center ejection velocity ratios has not yet been made.

In this paper, we present a set of eight axisymmetric, variable jet models (with a sinusoidal ejection variability) in which we explore the effect of varying the edge-to-center ejection velocity ratio. In order to illustrate the possible relevance of non-top hat cross sections for modelling HH jets, we then present a comparison between intensity maps predicted from the models and red [S II] images of the HH 34 jet.

For this purpose, we compute non-top hat, ejection models with the three-mode sinusoidal variability empirically determined for HH 34 by Raga et al. (2002). We explore a set of different edge-to-center ejection velocity ratios, and compare the predicted intensity maps with archival HST images of the HH 34 jet.

The paper is organized as follows. In § 2, we give a short description of the archival HST images of HH 34. In § 3, we describe the single-mode, non-top hat jet models. In § 4, we compare the intensity maps predicted from non-top hat, three-mode models with the HST images of HH 34. Finally, the results are summarized in § 5.

2. THE ARCHIVAL HST IMAGES OF HH 34

The *Hubble Space Telescope* (HST) Wide Field Planetary Camera 2 (WFPC2) data of HH 34 have been retrieved from the *Hubble Legacy Archive* (HLA), for two epochs (1998 & 2007). The processing of the HLA data uses a new calibration pipeline that includes an improved handling of the UV contamination, bias variations and other artifacts[5]. Furthermore, the WFPC2 HLA data have been resampled onto a uniform grid to correct for geometric distorsions, an essential step to determine, for instance, the proper motions of knots along the jet between the two epochs.

The 1998 images were described in detail by Reipurth et al. (2002). The HH 34 archival images from 2007 to our knowledge have not been presented anywhere, and we therefore describe them briefly. The data were obtained during the HST Cycle 16 (October 30, 2007) and belong to program 11179 (PI. P. Hartigan) on the dynamics of clumpy supersonic flows in stellar jets. Like in the 1998 observations (Reipurth et al. 2002) the data were obtained using the standard WFPC2 narrow band filters of Hα (F656N) and [S II]λ 6716+30 (F673N). The final images are the result of multiple co-added exposures (eight for both Hα & [S II]) which are used to mitigate the effects of cosmic rays, and with a total integration time of 9600 sec for each filter.

3. NON-TOP HAT, SINGLE MODE JETS

We have computed a set of models with a time-dependent ejection velocity of the form:

$$v_j(r,t) = \left[v_0 + v_1 \sin\left(\frac{2\pi t}{\tau}\right)\right]\left[1-(1-\sigma)\left(\frac{r}{r_j}\right)^2\right], \quad (1)$$

where t is the time, r is the cylindrical radius (measured across the initial cross secion of the jet), v_0 is the mean axial velocity of the jet, v_1 is the half-amplitude of the axial velocity variability and $\sigma = v_{\rm edge}/v_{\rm axis}$ is the ratio between the ejection velocity at the edge of the jet ($v_{\rm edge}$, at $r = r_j$) and

[5]See e.g. `http://hla.stsci.edu/hla_faq.html#WFPC2`.