S10+G7 and S11+G9 as a function of the initial radius R_c of the starburst. We see that there is clear dependence of ξ_m on R_c, with differences by factors of $\sim$1.7 (for models S11+G9 and S10+G7), and over $\sim$3.5 for model S5+G3.

We should note that the models with the smaller energy injection regions (with $R_c = 50$ pc) have smaller mass ejection efficiencies than the models with larger energy injection regions (with $R_c = 70$ pc, see Figure 7). This is probably due to the fact that in the smaller volumes (covering the denser, inner region of the galaxy) the radiative cooling is stronger. In the models with even larger energy injection regions (with $R_c \geq 90$ pc, see Figure 7), the momentum per unit mass given to the galactic gas is lower, and therefore less material succeeds in escaping from the galactic potential. From these results, we conclude that in our intermediate and high mass galaxy models, variations of factors of $\sim$2 in the efficiencies are to be expected for starbursts (with the same energies) with initial radii in the $R_c = 50$ to 150 pc range.

We have also explored the effect of changing the total number of SPH particles in the simulations. We again choose models S5+G3, S10+G7 and S11+G9 (see above and Tables 1 and 2) as representative of our model grid, keeping a constant $R_c = 150$ pc initial radius for the starbursts, and we compute radiative simulations with more than one order of magintud more of gas, halo and disk particles (1500000, 2000000 and 1500000, respectively) than in the previous models (see § 4). In these new runs we have also changed the softening length to 50 pc, for all the components. In all the new models the mass ejection efficiency increases by a factor of the order of 2. For model S5+G3 this change is a factor of $\sim$1.5, while S10+G7 and S11+G9 suffer changes of factors of $\sim$2.21 and $\sim$1.6, respectively.

Therefore, we seem to obtain at least a partial convergence for the values of the ejection efficiencies in simulations with $\sim 10^6$ gas particles. However, the computing time necessary for these simulations is quite large ($\sim$30 times longer than for the 30000 gas particle models), so that our parameter study has been done at lower resolution.

7. DISCUSSION

MacLow & Ferrara (1999) computed radiative, axisymmetric simulations of the ejection of gas from galaxies due to central starbursts. Their models differ from ours in that the starburst energy is injected as a continuous source term during the 50 Myr of their simulations, while in our models the energy of the starburst is injected instantaneously at the beginning of the simulations.

If we convert their starburst mechanical luminosities into total energies (by multiplying the luminosities by 50 Myr), and use the relation between starburst energy and mass of Table 2, we can find correspondences between their models and ours. We then find that both the mass and metal ejection efficiencies computed by MacLow & Ferrara (1999) are generally consistent with the ones that we have computed, with typical differences of factors $\sim$3. We judge this to be a satisfying agreement given the differences between our models and the ones of MacLow & Ferrara (1999).

Interestingly, the highest SB mechanical energy/lower galactic mass model of MacLow & Ferrara (1999) approximately corresponds to our S5+G2 model (with $M_{\rm SB} = 3 \times 10^4\ M_\odot$ and $M_g = 3 \times 10^7\ M_\odot$). As can be seen in Figure 3, this model lies within the transition from low to high efficiency regimes. Therefore, the models of MacLow & Ferrara (1999) mostly missed the transition between low and high mass loss efficiencies which we are describing in the present paper.

D'Ercole & Brighenti (1999) computed a set of 5 models of galaxies with $M_g < 1.4 \times 10^8\ M_\odot$, similar to our galaxy models G1–G5, in which they inject energies in the range of our S6–S8 starbursts. Their "PEXT" model (see Table 2 of D'Ercole & Brighenti 1999) has parameters similar to our S8+G4 model (see Tables 1 and 2). The PEXT model has a $\xi_m = 0.31$ mass ejection efficiency, which is consistent with the $\xi_m = 0.45$ efficiency obtained from our S8+G5 model. D'Ercole & Brighenti (1999) have studied different possibilities (e.g., having galaxies with no rotation, or having fixed dark matter mass distributions) which have not been explored in our present work.

Fragile, Murray, & Lin (2004) computed mass and metal ejection efficiencies produced in galaxies with $10^9\ M_\odot$ (similar to our galaxy model G9) in which they inject energies in the range of our model S3-S7 starbursts. Their model 5 (see Table 1 of Fragile et al. 2004) has parameters similar to our S7+G9 model. Model 5 has a $\xi_m = 0.016$ mass ejection efficiency and $\xi_Z = 0.99$ metal ejection efficiency (see Table 2 of Fragile et al. 2004), which is consistent with the $\xi_m = 0.006$ and $\xi_Z = 0.805$ efficiencies of our model S7+G9. Fragile et al. (2004) have explored the metal ejection efficiencies for supernova events at different radial positions in the galactic disk. They find that a substantial fraction of the metals is retained in their off-center starburst mod-