



# Internal dynamics of the NGC 3603 Young Cluster

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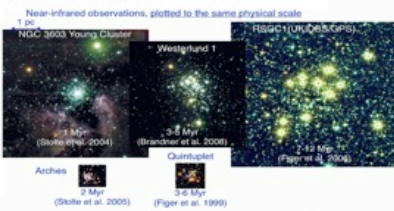


## Abstract:

NGC 3603 Young Cluster (YC) is one of the rare Galactic starburst clusters containing copious numbers of stars over the entire mass range. With high quality astrometric observations of NGC 3603 YC we can distinguish cluster members from field stars based on multi epoch observations with a 10.15yr time-baseline and subsequent high precision proper motion measurements. The proper motion dispersion is then used to estimate of the first NGC 3603 YC internal velocity dispersion which sheds light on the internal dynamics of this young and dense stellar system. The deep and clean color-magnitude diagram allows to identify pre-main sequence/main sequence transition stars as well as stars in the radiative convective gap. We also tentatively detect the deuterium burning sequence and find hints for a second epoch of star formation. Based on proper motion we find no variation in the 1D velocity dispersion for stars with masses between 12.4 M<sub>⊙</sub> and 1.65 M<sub>⊙</sub>, and deduce that the cluster is not yet in virial equilibrium. Adopting a distance of 6.3 kpc, the 1D velocity dispersion amounts to 5.2±0.7 km/s.

## Introduction:

Starburst clusters are spectacular young and dense stellar systems containing copious numbers of massive O-type and Wolf-Rayet stars providing ideal testbeds for studying theories of star and cluster formation and evolution. Unfortunately, extragalactic starburst clusters can only be examined studying integrated properties of their stellar members and the Milky Way hosts only a few of these spectacular objects. However, the latter can be used as templates for massive, extragalactic star formation as observed in e.g. the Antennae Galaxies. The rapid dynamical evolution of the spiral arm clusters, which are experiencing a weaker tidal field, is accelerated, e.g. by gas expulsion (Baumgardt & Kroupa 2007), while for clusters close to Galactic Center, strong tidal forces could lead to a rapid cluster dispersal (Stolte et al. 2008).



NIR observations of known Milky Way starburst clusters. Clusters are ordered according to their ages and plotted to the same physical scale. These images indicate an apparent increase in cluster size with increasing age.

## NGC 3603 YC:

NGC 3603 YC is the most compact and youngest spiral arm cluster (1 Myr, Stolte et al. 2004) hosting 3 Wolf-Rayet and at least 6 O3 and more than 30 later type O-type stars (Moffat et al. 1994).

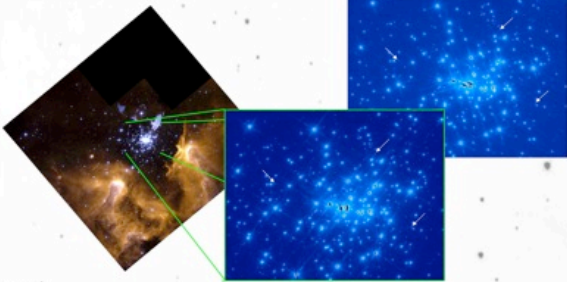
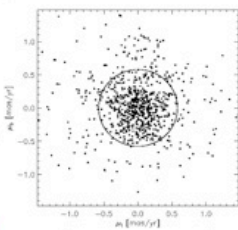


Figure 1

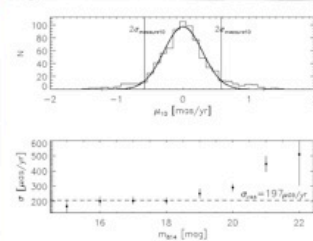
Above: NGC 3603 YC and its vicinity observed with HST/WFPC2 (Brandner et al. 2000) and two F555W-band images (above) of the dense core obtained ~10 yrs apart with the Planetary Camera. White arrows mark 3 stars with a large spatial displacement. These stars are most likely foreground stars. The provided 10yr-baseline allows accurate proper motion measurements of stars in the central area.

Left: Proper motions of detected stars in the NGC 3603 YC reference frame. The 2σ-circle from a Gaussian fit to the proper motion distribution (Figure 2) is shown and stars with proper motions less than 2σ are selected as cluster member candidates.



## Proper Motions (pm):

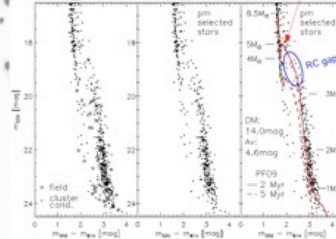
Figure 2



Upper panel: Histogram of the averaged 1D proper motions. A Gaussian fit provides the 2σ-limit for our member selection (vertical lines). Lower panel: Observed pm dispersion as a function of magnitude. For 14.5 mag ≤ m<sub>FRANEC</sub> ≤ 19.5 mag we obtain a standard deviation of σ = 205 ± 26 μas/yr. No variation of the velocity dispersion with stellar mass (for 12.4 M<sub>⊙</sub> ≥ M ≥ 1.65 M<sub>⊙</sub>) has been observed. Hence, we deduce that NGC 3603 YC is not yet virialized. Adopting a distance of 6.3 (6.9) kpc for NGC 3603 YC (Figure 3a,b), the pm dispersion yields a 1D velocity dispersion of 5.2±0.7 (5.7±0.7) km/s and results in a first dynamical mass estimate for NGC 3603 YC of 24,000±3,600 M<sub>⊙</sub> (28,750±3,700 M<sub>⊙</sub>).

## Color-magnitude diagram (CMD):

Figure 3a

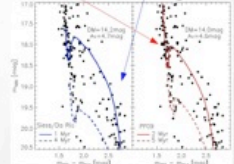


V vs. V-I CMD of the NGC 3603 YC. Visible are main sequence (MS) and pre-main sequence and their transition region. Clearly identified are stars populating the short-lived radiative-convective gap (RC gap; Mayne et al. 2007) and, tentatively, deuterium burning stars. The extension of the MS towards lower masses hints a second epoch of star formation (e.g. Sung & Bessel 2004).

We plot isochrones with solar metallicity and ages of 2 and 5 Myr (PF) and 1 and 4 Myr (Siess), respectively. They resemble well the features of the CMD with two star forming events. Best-fitting isochrones of the two model sets yield slightly different values for distance (6.3 kpc, PF; 6.9 kpc, Siess) and extinction (A<sub>V</sub> = 4.6 mag, PF; A<sub>V</sub> = 4.7 mag, Siess).

PISA-FRANEC (PF): Degl'Innocenti et al. 2008, Tognelli et al. 2009, in prep. Siess et al. (2000) (trans. to obs. plane by Da Rio et al. 2009)

Figure 3b



## Summary:

Two epochs of HST/WFPC2 data, taken ~10 yrs apart, allow accurate proper motion measurement which aid at distinguishing between cluster and field stars. Best-fitting isochrones to the cleaned-up CMD yield an age of 1-2 Myr and a distance of 6.3-6.9 kpc. Further we identify cluster stars in the short-lived radiative-convective gap and, tentatively, detect the deuterium burning turn-off. We also find hints of a second epoch of star formation with an age of about 4-5 Myr. The proper motions allows for the first time to derive the internal velocity dispersion of NGC 3603 YC. For the higher mass population (12.4 M<sub>⊙</sub> ≥ M ≥ 1.65 M<sub>⊙</sub>) we determine the proper motion dispersion to σ = 205 ± 26 μas/yr which corresponds (after consideration of instrumental errors) to the 1D velocity dispersion of 5.2±0.7 km/s at a distance of 6.3 kpc. The dispersion does not vary with stellar mass, hence, we deduce the cluster is not yet virialized.

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Questions? I'm around!