PIPELINE3: Summary of what has been done so far

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1 Background considerations

• Goal is to make GALFIT decomposition models for $\sim$ 2000 galaxies, and to store the results to the archive in a **systematic manner**.

• Several different decompositions/galaxy adds up to more than 10^4 decomposition models $\rightarrow$ need tools for **automatic writing of GALFIT input-files & running of decompositions.**

• The **pipeline models have to be reasonably simple**, which means that it may be impossible to model all the galaxies.

• Quality Control issues: need to make it as convenient as possible for others to check the results of decompositions stored to the archive $\rightarrow$ **store as much visualization as possible besides the GALFIT output-files themselves.**

2 Semi-automatic creation of GALFIT input-files

• The data was made available 4.12.2009. The directory tree, containing Pipeline 1 data for 71 galaxies and Pipeline 2 data for 37 galaxies, has the structure:

```
S4G/PRODUCTS/ARCHIVAL/GALAXY/P1
                            /P2
                            /P3

  P1 contains DATA-images, MASK-images and WEIGHT-images
  P2 contains surface photometry and isophotal ellipse fits,
     including ellipse parameters at 26.5 mag.
```

• **BELOW IS A STEP-BY-STEP SUGGESTION** of how to fill the currently empty P3 slots with results from GALFIT decomposition models (preliminary, subject to change based on the decisions by the S4G team)

$\boxed{\textbf{STEP 1:}}$ CHOOSING GALAXIES TO PROCESS

Compile a LISTFILE = text file listing the identifications of galaxies to be processed with Pipeline 3.

`NOTE: Need to find a way to distribute galaxies among different decomposers`

$\boxed{\textbf{STEP 2:}}$ PREPARING THE DATALIST-TABLE

For the galaxies in LISTFILE, we store into a DATALIST-table the names of the `DATA-image, MASK-image and WEIGHT-image` (in the proper P1 directory; a PSF-image for each galaxy would also be needed, but for the time being we use a toy PSF as described below).

Simultaneously, we fetch the galaxy center location `xc, yc and the 26.5 mag orientation parameters` derived at Pipeline 2, and store them to the same DATALIST-table. NOTE: this table is in no way related to "constraint-file" described in the GALFIT manual.

To perform these operations for all the galaxies in the LISTFILE (=step 2), an idl-procedure is provided

```
s4g_p2_check_driver_f.pro
```

The name stems from the fact that the same procedure can be used for reading and plotting the P2 isophote information on top of P1 data. These plots are useful for example in deciding whether one could cut the fitting region in the decomposition (of course, GALFIT does not require this in order to work properly - cutting will just speed up processing). The procedure is also useful in providing an easy visual check that the IRAF ellipse fitting in P2 has worked as desired.

In the same spirit (providing a possible tool for Quality Control), there is a procedure

```
s4g_mask_check_driver_f
```

which reads and plots the MASK-image from P1. This allows a rapid check that the overall features of the mask are OK (galaxy center not masked out etc. etc). More subtle checks must be carried out separately.

STEP 3: EDITING THE DATALIST-TABLE

Besides telling where the S4G data is located, the table created in STEP 2 has another purpose: it helps to provide initial guesses for GALFIT input parameters.

One reasonable option, discussed in lenght in Marseille, is to make bulge-disk decompositions and bulge-disk-bar decompositions, where the disk ellipticity and position angle are fixed to isophotal values of the outer disk. (Doing such decompositions dues not exclude making other type of decompositions, up to full capacity of GALFIT, as required by the specific scientific problem in hand). As a proxy of the outer disk orientation, the use of 26.5 mag isophotes was discussed. However, since this isophote is not necessarily optimal (for example, the galaxy may terminate before this magnitude level, the image may be too small etc.), one can edit the orientation parameters in the DATALIST-table (for example, utilizing the isophote-plots obtained in STEP 2). Also, in this table one marks the edge-on galaxies, where different fitting functions should be used by GALFIT.

STEP 4: MAKING SIGMA IMAGES, WRITING A FINAL DATALIST-TABLE,

In order to run GALFIT, we need to construct SIGMA-images, telling the statistical uncertainty of each image pixel, in the same units as utilized in the image-to-be-fitted. For making the SIGMA-images a procedure

```
make_sigma_image_new.pro
```

is provided: it utilizes the DATA and WEIGHT-images read from P1, and also provides a visual check of how well the calculated uncertainty matches the uncertainty measured from the image itself, at the sky region (NOTE: The quality control of P3 should adress the still-unexplained factor of 2 between measured/estimated uncertainty).

Other manipulation of DATA-images and MASK-images are also needed: GALFIT does apparantly not handle NaNs (=Not-a-Numbers) used for indicating not valid pixels. Therefore, we construct a new DATA-image where NaNs are replaced by a number, and a new MASK-image where these bad pixels are appended to the originally masked pixel locations. Additionally, the TEXP-keyword in the DATA-image header is set to 1 second, as recommended in GALFIT-manual. Note: these manipulated images are stored on the local working directory, not within the S4G directory tree.

The creation of SIGMA-images, and the manipulation of DATA and MASK-images are all done by the procedure

```
pipeline_2to3_interface_f_new.pro
```

It also modifies the DATALIST-file, adding the new file names pointing to the proper local files.

For the time being, these is a Gaussian PSF image created with IDL, having roughly the same $FWHM \sim 2.8$ pixels as the the actual point-spread-function (however, the tails are missing).

STEP 5: CREATING GALFIT INPUT FILES WITH THE DATALIST

In principle, one can now start making GALFIT decomposition on whatever manner one wishes, and to whatever degree of complexity (the possibilities are almost limitless, see GALFIT documentation).

However, to complete the pipeline task in a reasonable time span (5 person years?) it was discussed in Marseille meeting that the pipeline 3 could contain of the following type of decompositions, performed in a stepwise fashion

- **1-component fits** with 5 free params (total magnitude, sersic n, reff, q, pa)

- **2-component bulge-disk** (or bulge-edgedisk) fits, with 2 new free parameters (disk total magnitude, exponential scale length). In this type of simple models the disk PA and ellipticity would be kept fixed to the 'outer disk' values determined form isophotal analysis. However, it will be no problem to perform also 2-component fits where the disk orientation is free. Also the xc and yc are fixed to the values from pipeline 2. TECHNICAL NOTE: fixing some parameters in the GALFIT input file to their original values is different from using *constraint-files* to limit the allowable range of fitted values (see GALFIT documentation).

- **3-component bulge-disk-bar decompositions**, adding a Ferrers bar with 5 new free params to the solution of the previous 2-component decomposition. However, the details of the bar model are best to decide after some experience has been gained.

- And where appropriate, **4-component models** with a central component added to the model.

In order to ease the burden of running the anticipated more than 10^4 decompositions, we have written several routines, related both to visualization of GALFIT models (see step 6 below), and to semi-automatic creation of GALFIT input files. The procedure

```
datalist_to_ingal_driver_f.pro
```

is made for the latter purpose: at the moment it creates automatically 4 different types of GALFIT input files

```
_b            bulge-decompositions
_bd  or _bz   bulge-disk-decompositions  (or bulge-edgedisk if appropriate)
_brbarmodel   bulge-disk-bar-nucleus-decomposition  (template for 3 and 4 component models)
```

All these GALFIT input parameter files contain the proper input data file names, and write to files identified with the galaxy and the type of decomposition model. The initial guesses are based on the data in the IMAGE-files, and the DATALIST file described above.

At this point, when decompositions have not yet been started, it will be relatively easy to modify this procedure, so that also other type of GALFIT parameter-files could automatically created.

Note: Models significantly more elaborate than those described above would probably require much more working power than currently available for P3.

STEP 6: RUNNING GALFIT

-Running GALFIT can be painful, without extra tools for visualization of the results (basically a fits-file is created containing the fitted model)

For visualization purposes, a procedure

```
galfit_display_new.pro
```

is provided, making it possible to visualize both input and output parameter files. There are also tools for running GALFIT from inside IDL `galfit_run_new.pro`.

The various IDL-based tools mentioned in this summary are collected to **GALFIDL**-package, described in a separate manual-

TODO-items, QUALITY CONTROL

Quality Control issues:

- Are the SIGMA and PSF ok?

etc etc.