

(Introduction to)
The CAOS Problem-Solving
Environment
&
The Software Package CAOS
+
AO Simulations...

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- It is composed of a global interface (the **CAOS Application Builder**), a library of utility routines (the **CAOS Library**), and some scientific packages (the **Software Packages**).
- a **Software Package** is a set of modules dedicated to a given scientific subject (AO, imaging, whatever).

CAOS Problem Solving Environment -1

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The diagram illustrates the architecture of the CAOS Problem Solving Environment. It features a central yellow oval containing the text "CAOS Application Builder". This oval is positioned within a larger blue rectangle. At the bottom-left corner of this rectangle, the text "global interface" is written in a lighter blue color. The entire diagram is set against a dark blue background.

CAOS
Application Builder

global interface

CAOS Problem Solving Environment -1



The diagram illustrates the architecture of the CAOS Problem Solving Environment. It is divided into two main sections by a horizontal line. The top section, labeled 'global interface' at its bottom-left, contains a yellow oval labeled 'CAOS Application Builder'. The bottom section, labeled 'libraries' at its bottom-left, contains two yellow ovals: 'CAOS Library' on top and 'ASTROLIB Library' on the bottom.

CAOS
Application Builder

global interface

CAOS Library

ASTROLIB Library

libraries

CAOS Problem Solving Environment -1

CAOS
Application Builder

global interface

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libraries

packages

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Software Package CAOS

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CAOS Problem Solving Environment -1

CAOS
Application Builder

global interface

CAOS Library

ASTROLIB Library

libraries

Software Package CAOS

Software Package AIRY

Software Package PAOLAC

Software Package SPHERE

Software Package AIRY-LN

packages

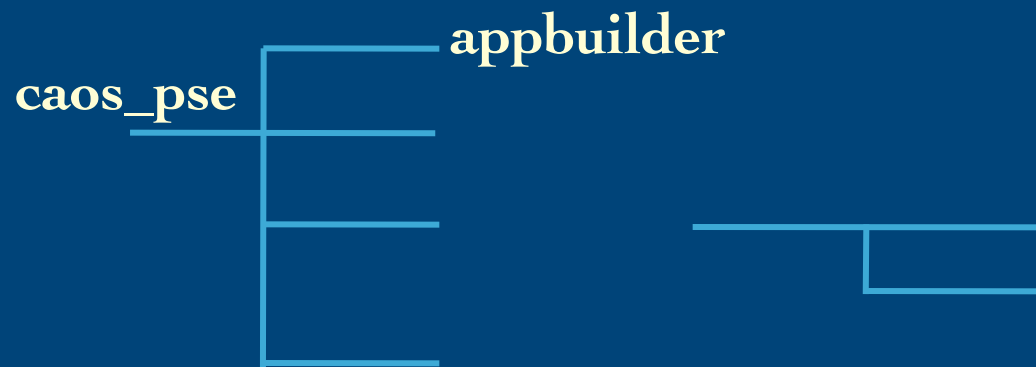
CAOS Problem Solving Environment -2



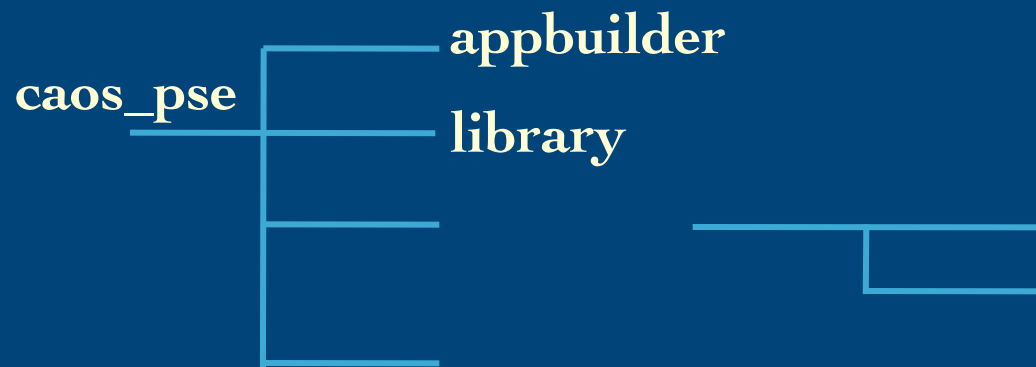
CAOS Problem Solving Environment -2



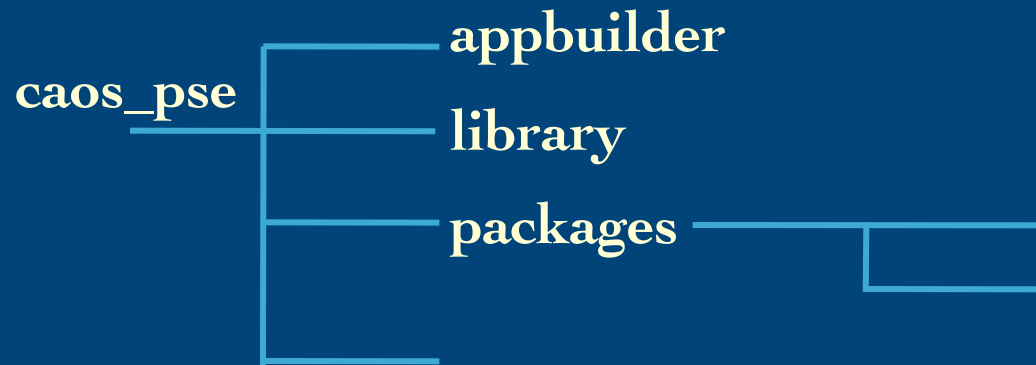
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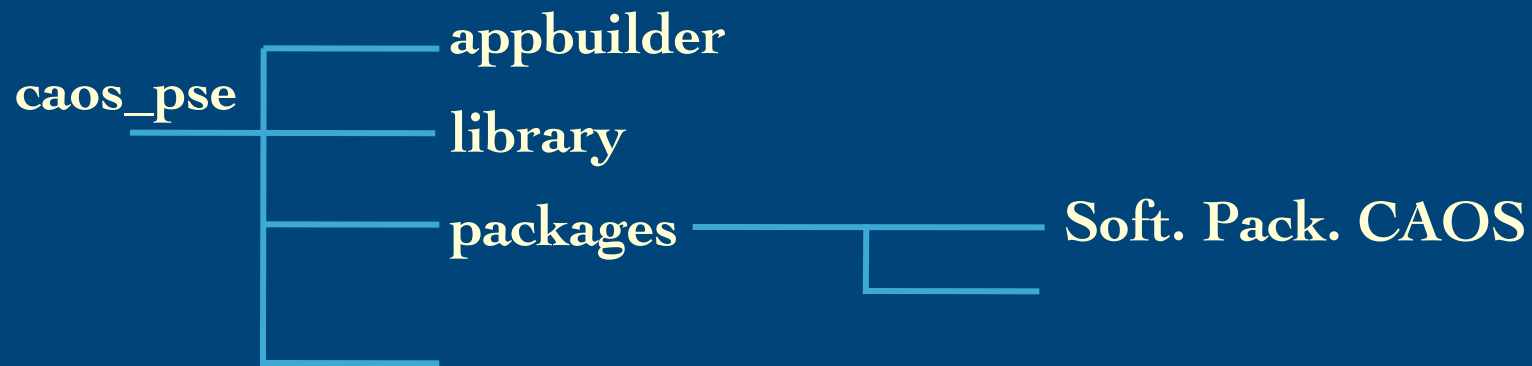
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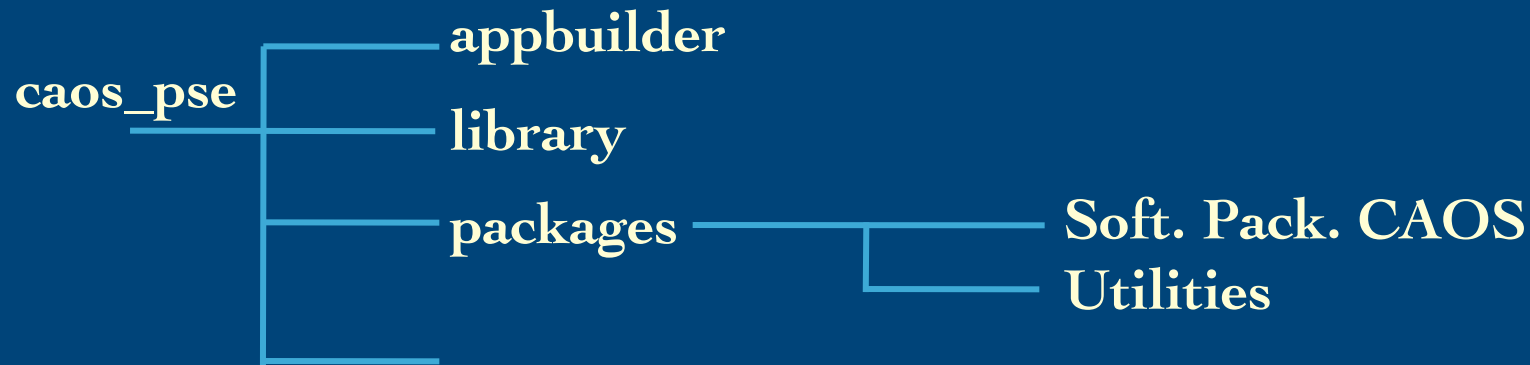
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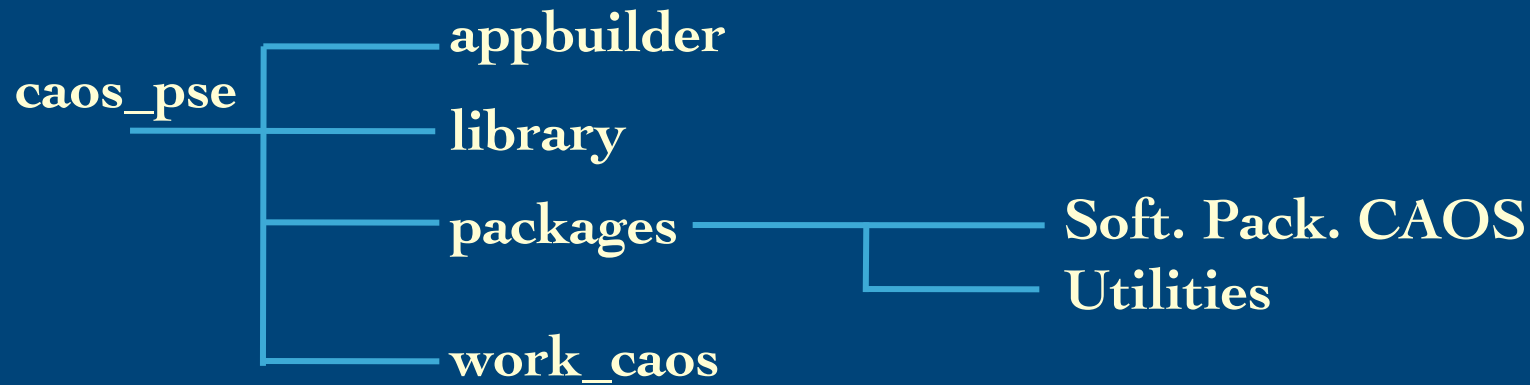
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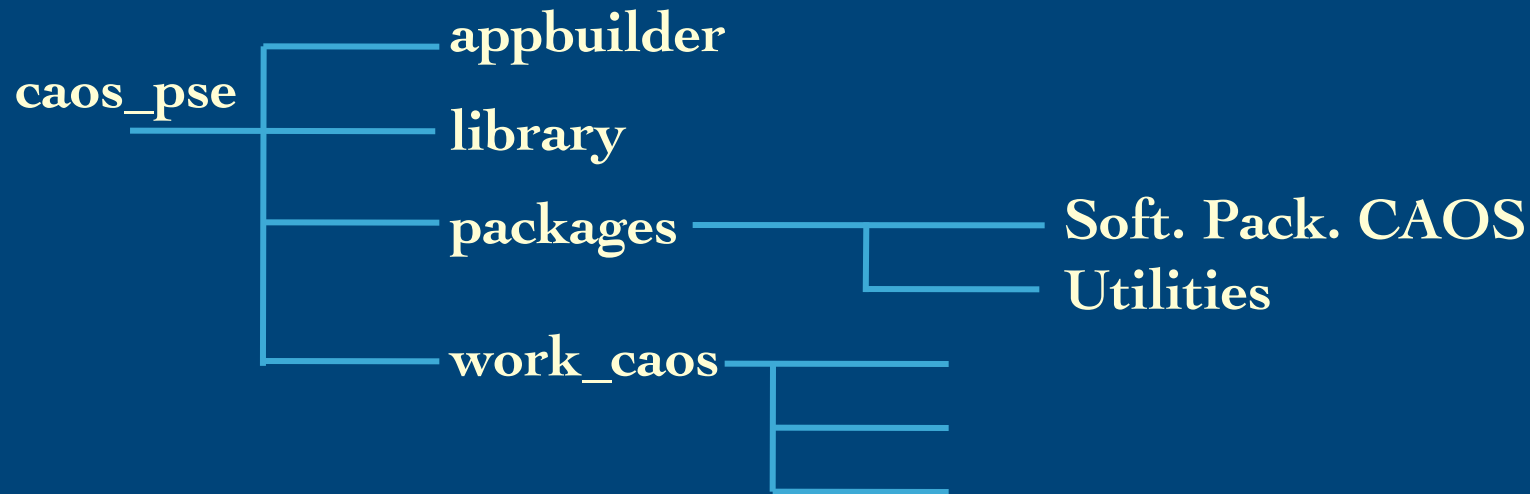
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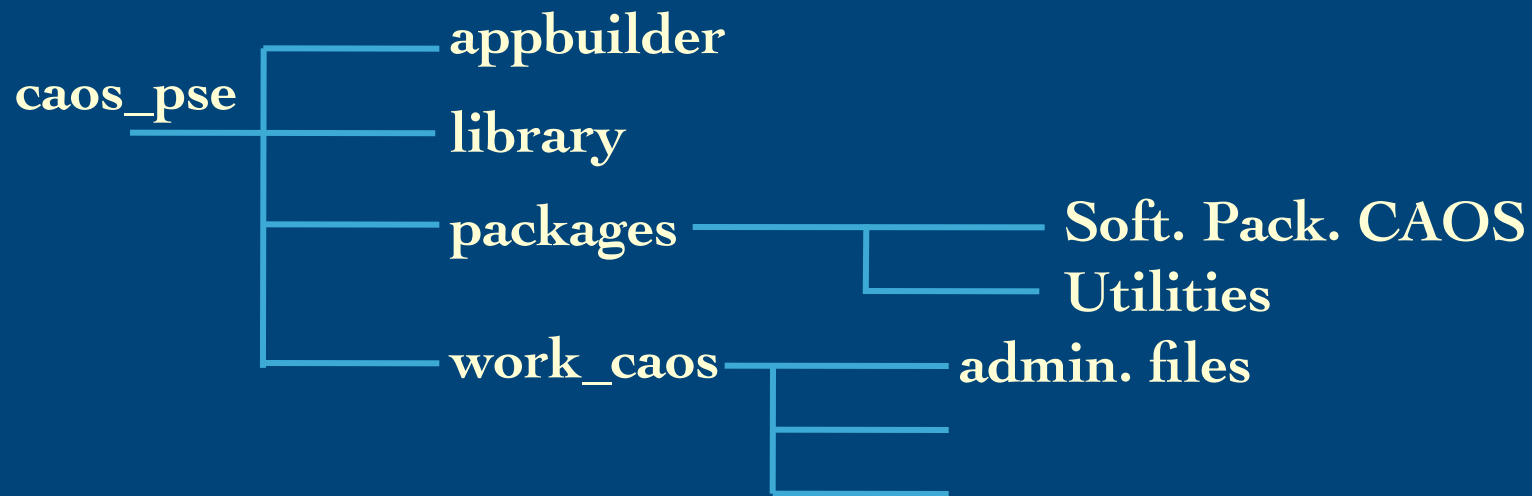
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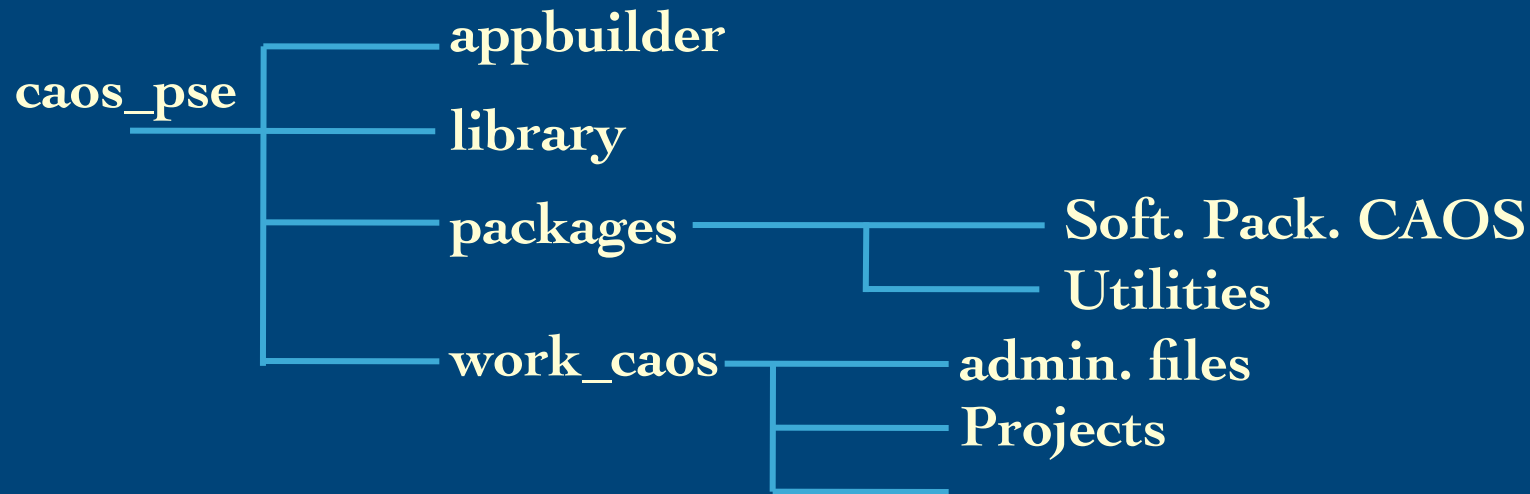
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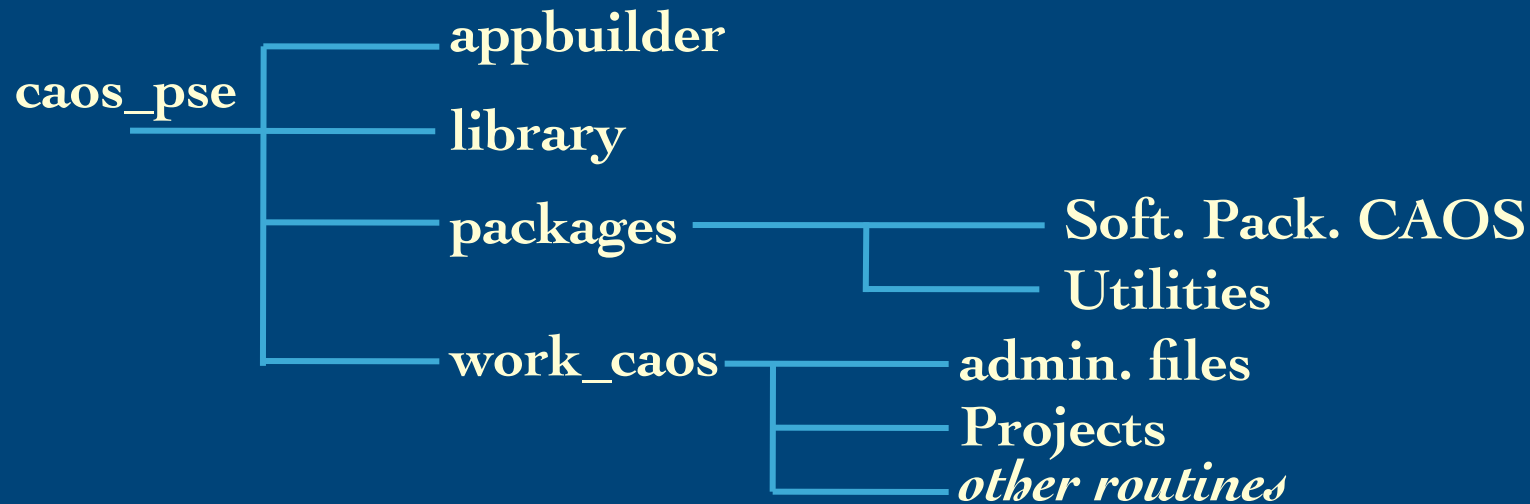
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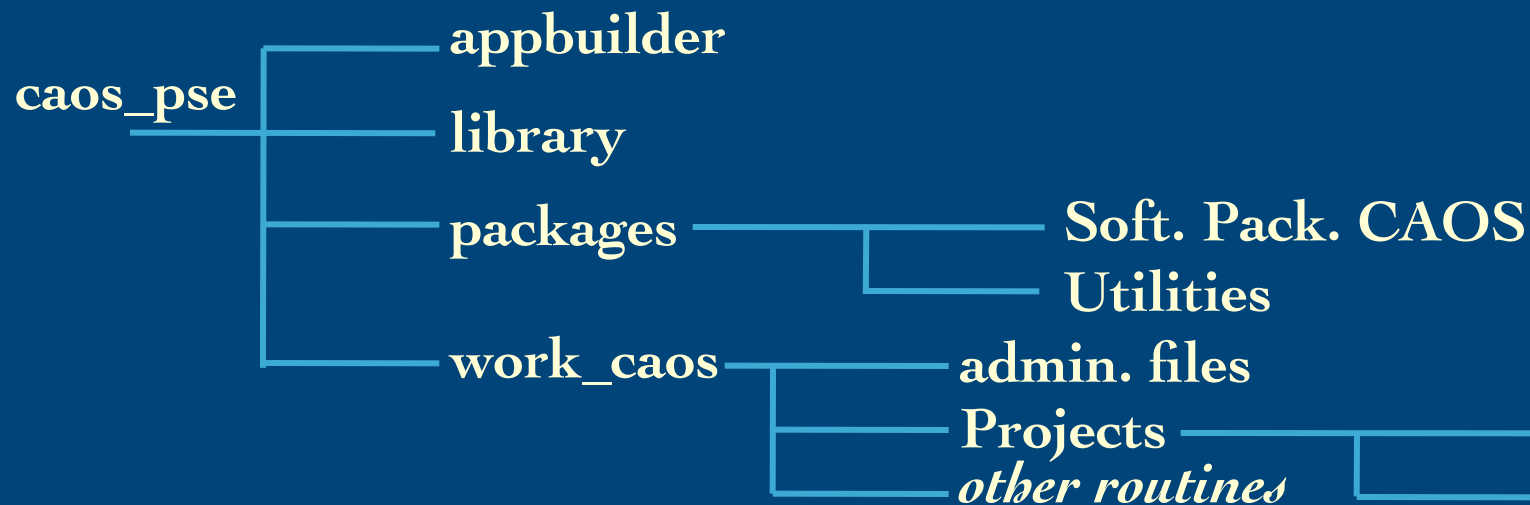
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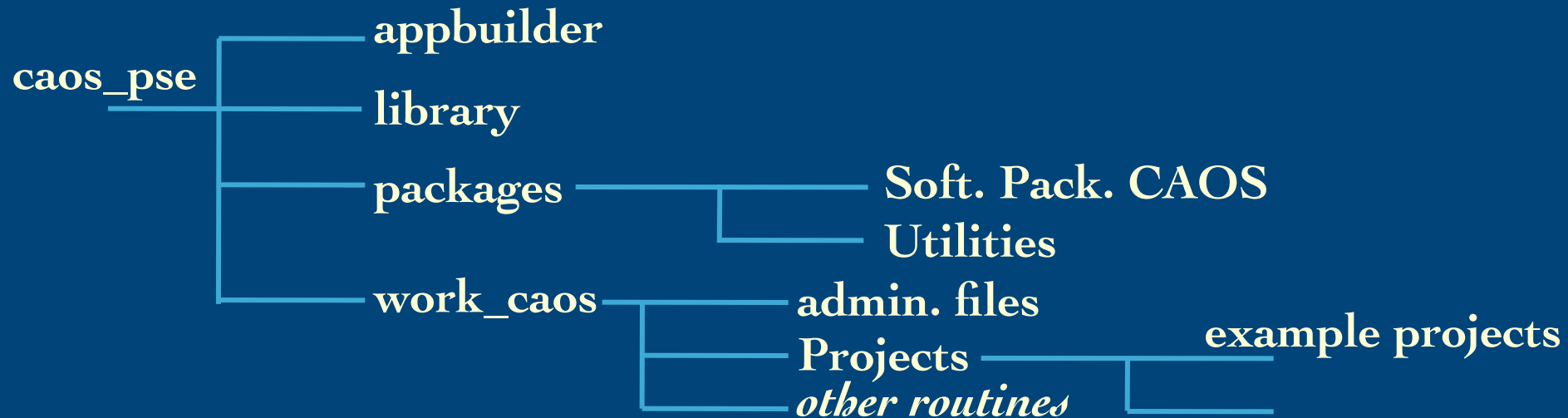
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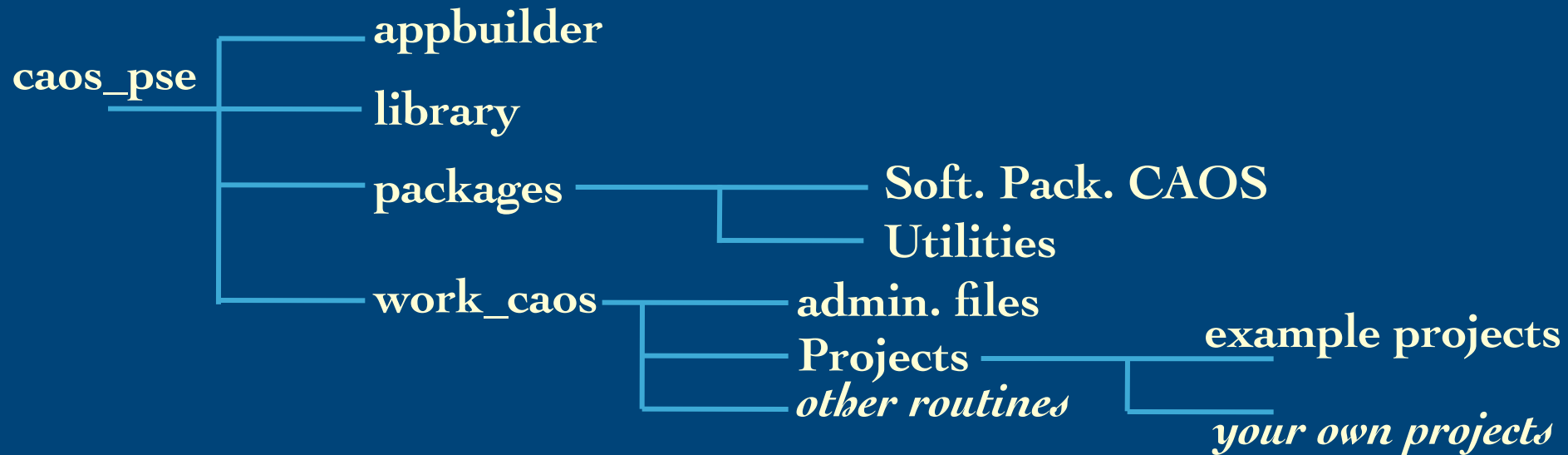
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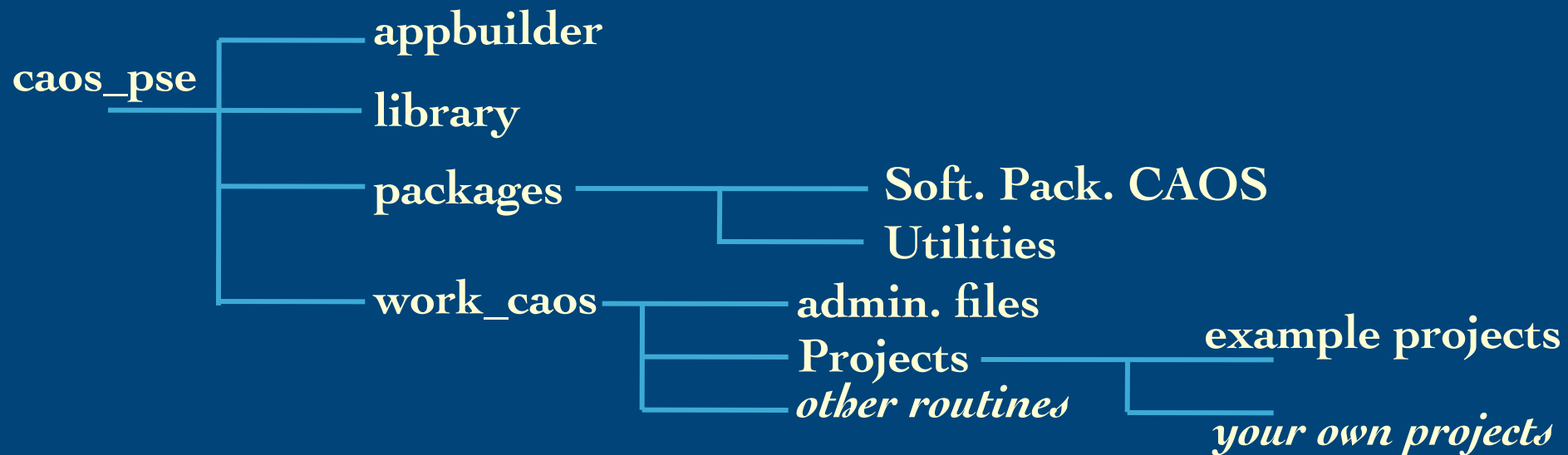
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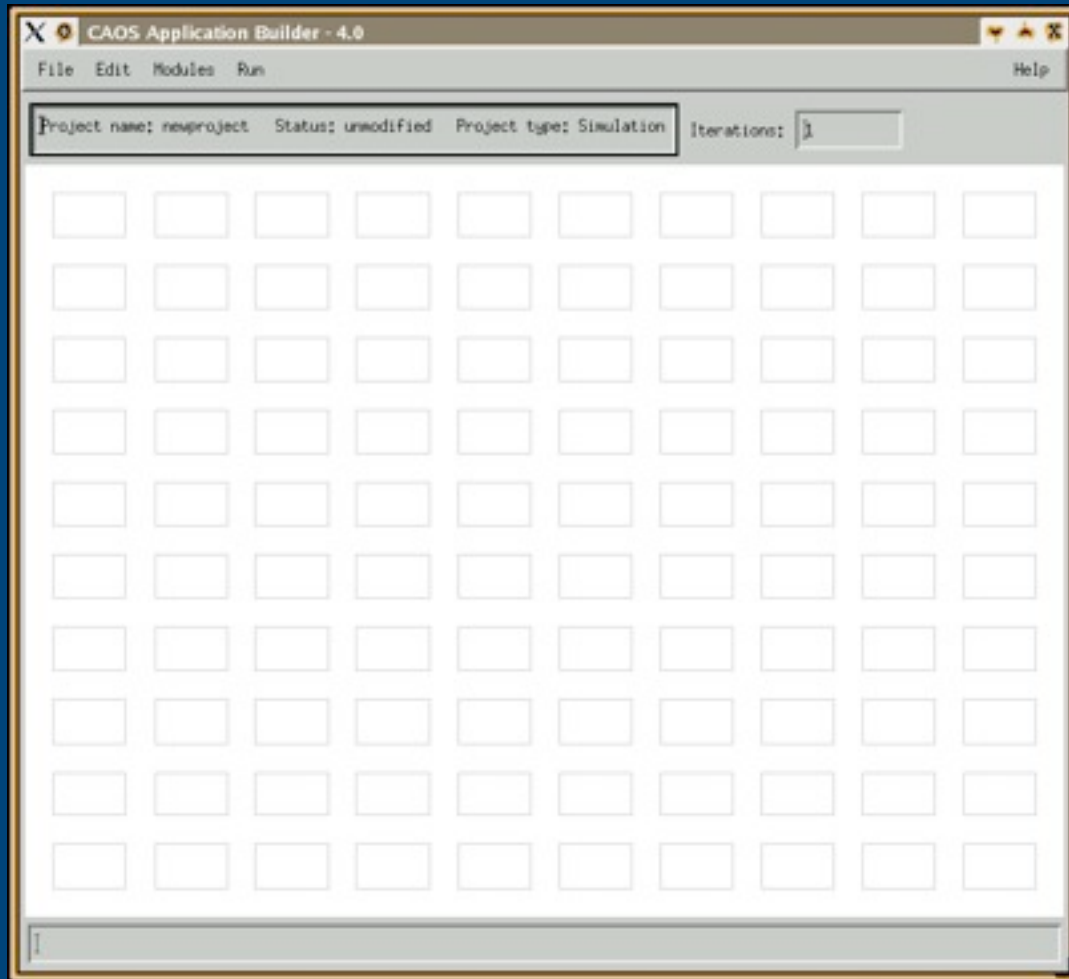
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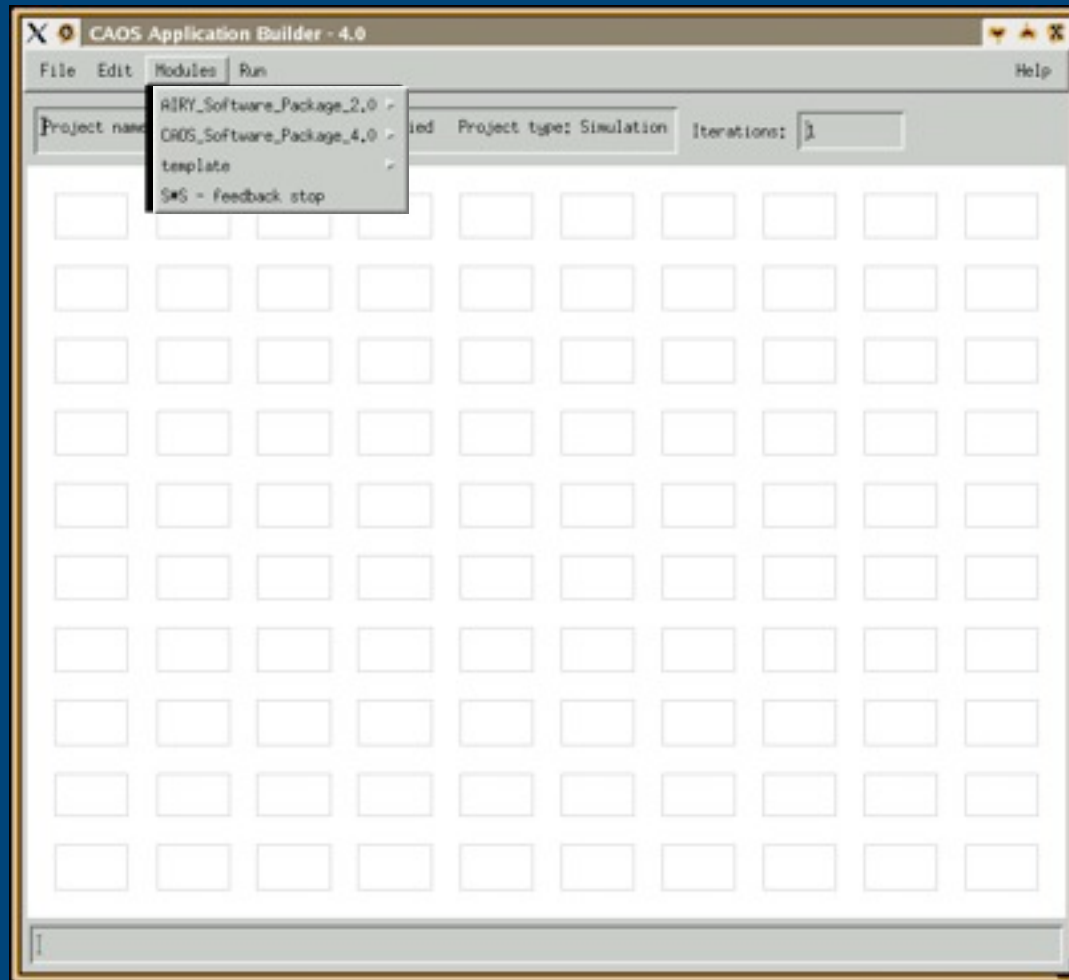
somewhere else: astrolib, *some other library*

CAOS Application Builder

It is essentially a **worksheet** where the user can place small blocks, the modules, and connect them with data paths to form a **project**.



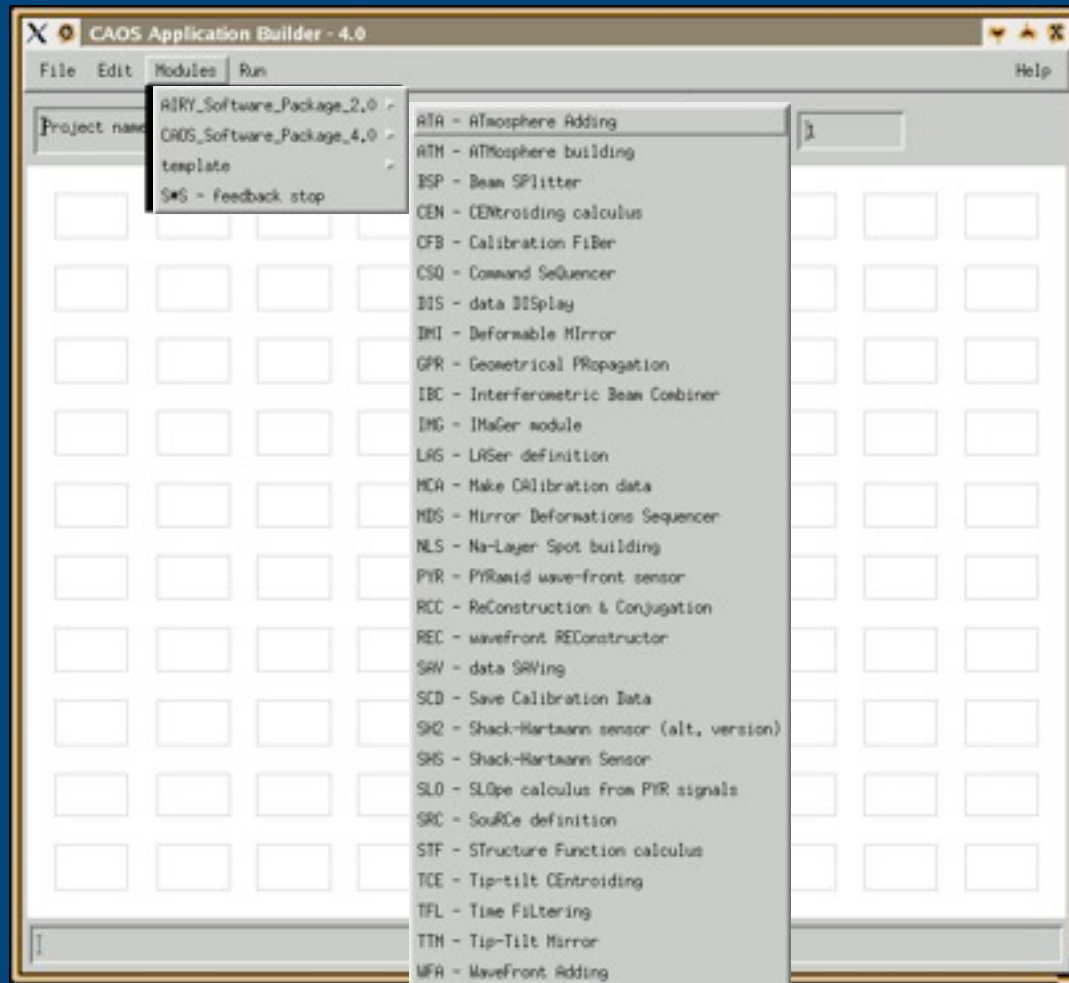
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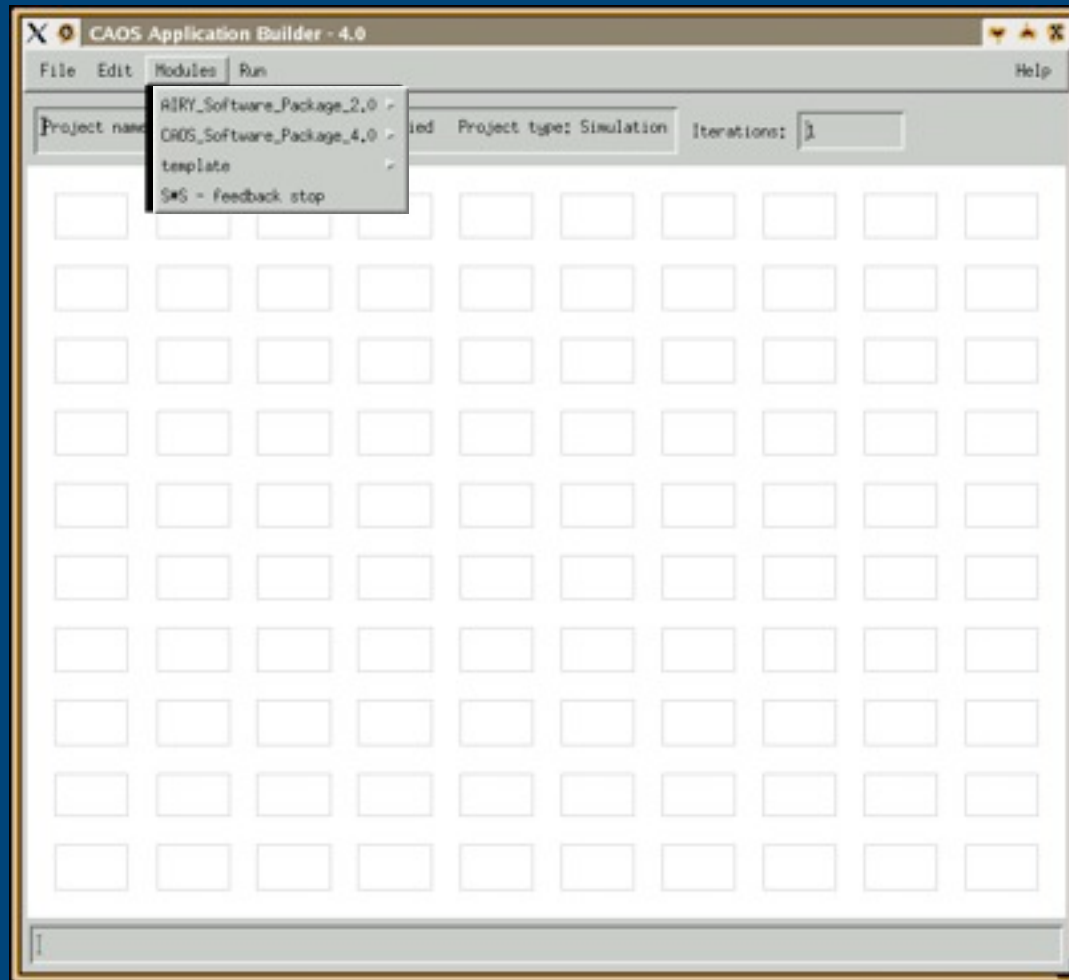
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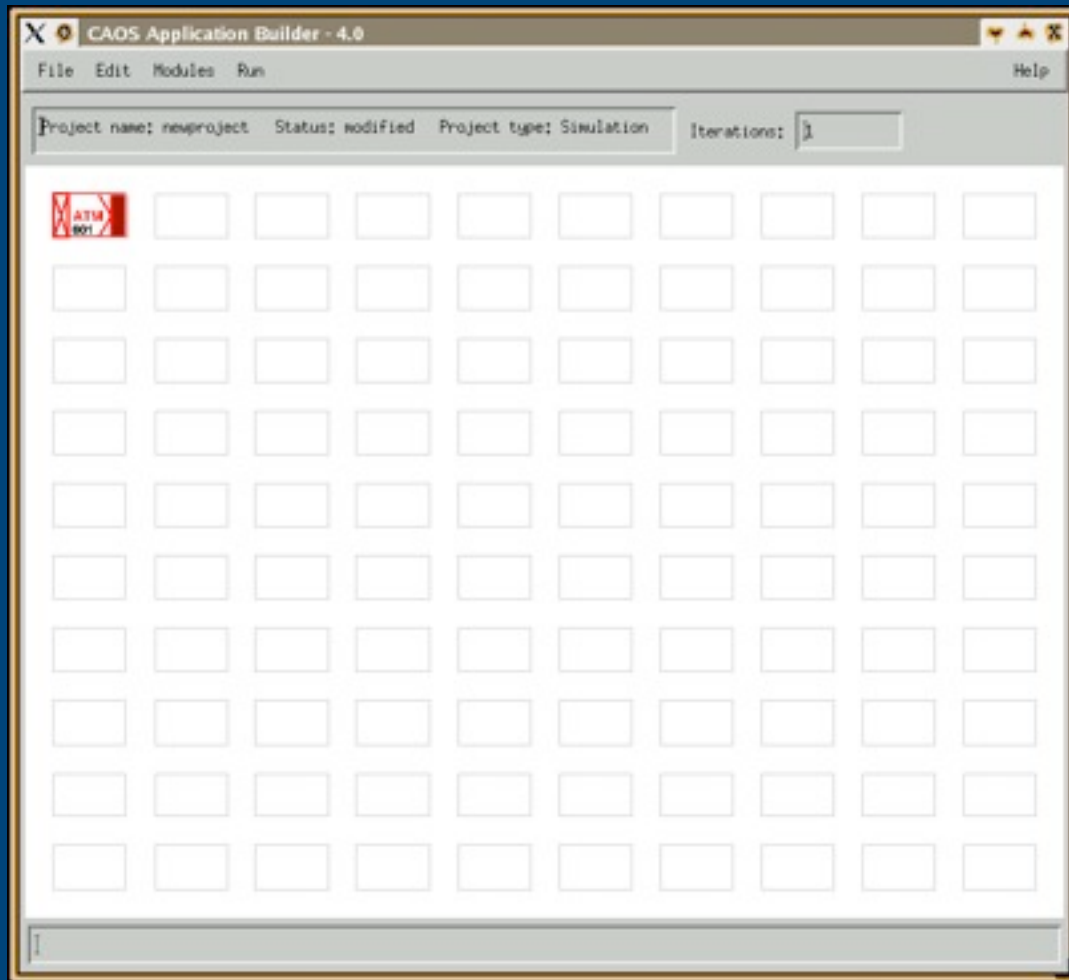
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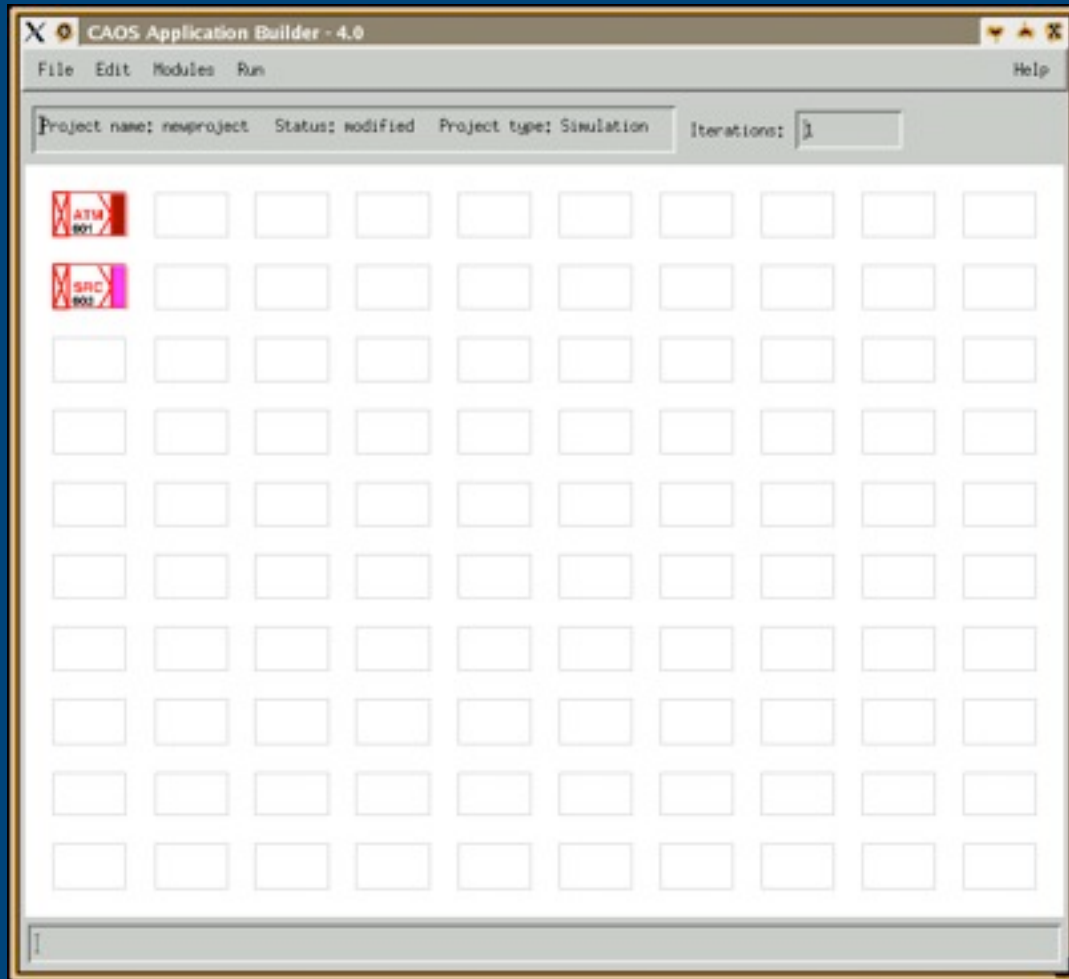
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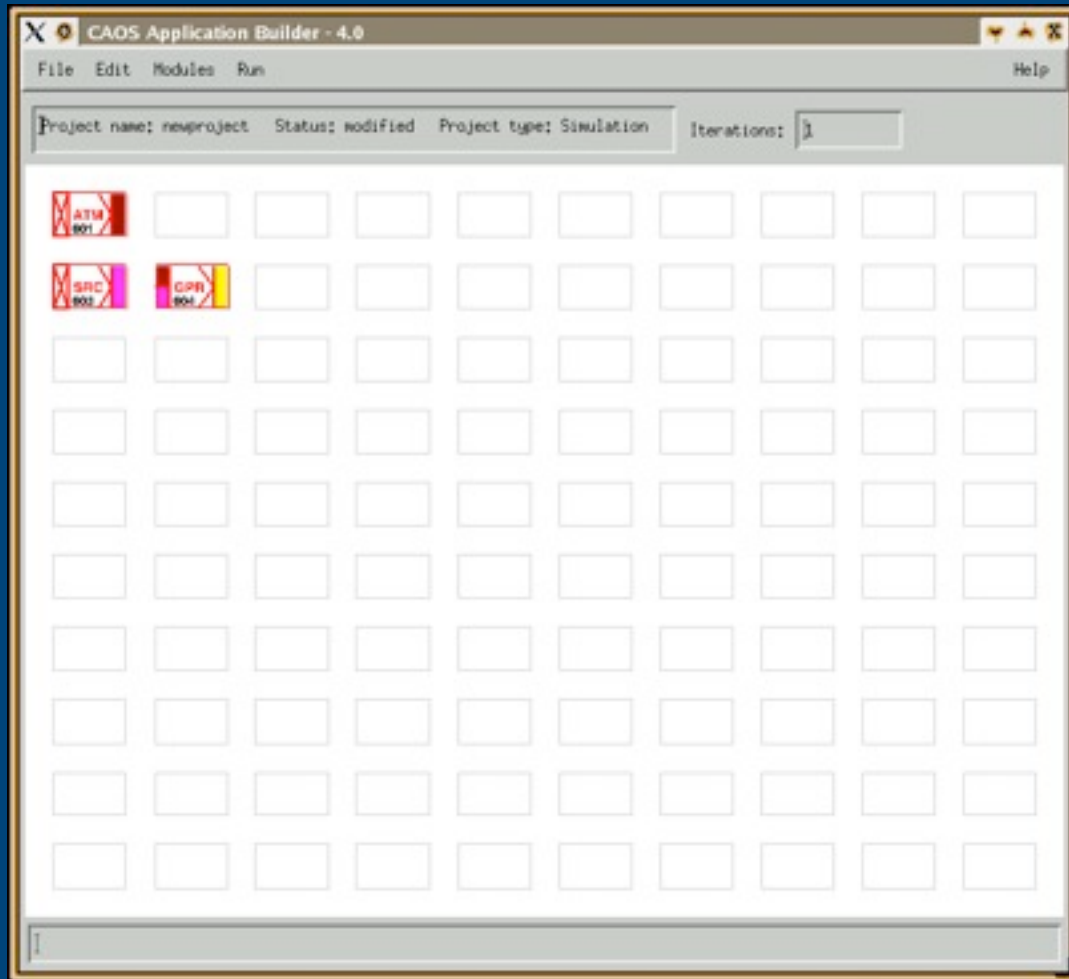
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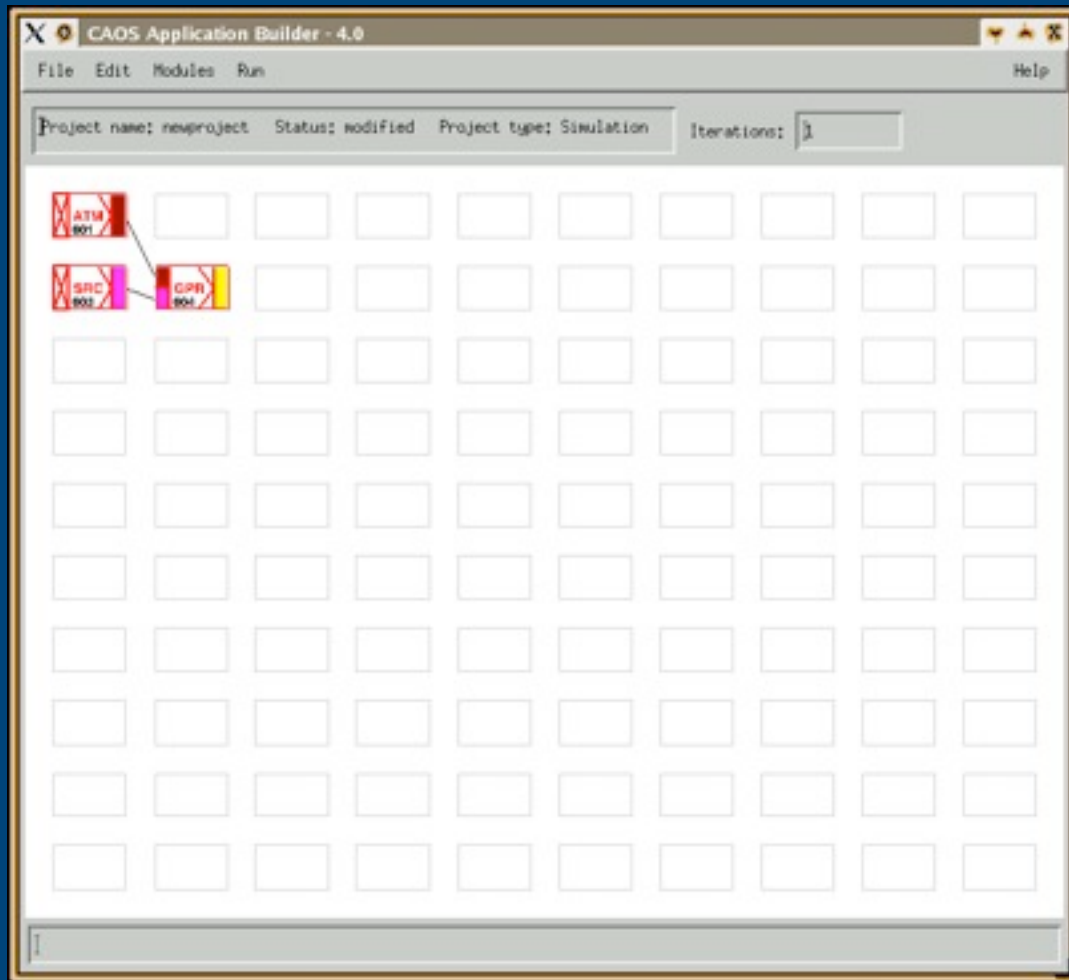
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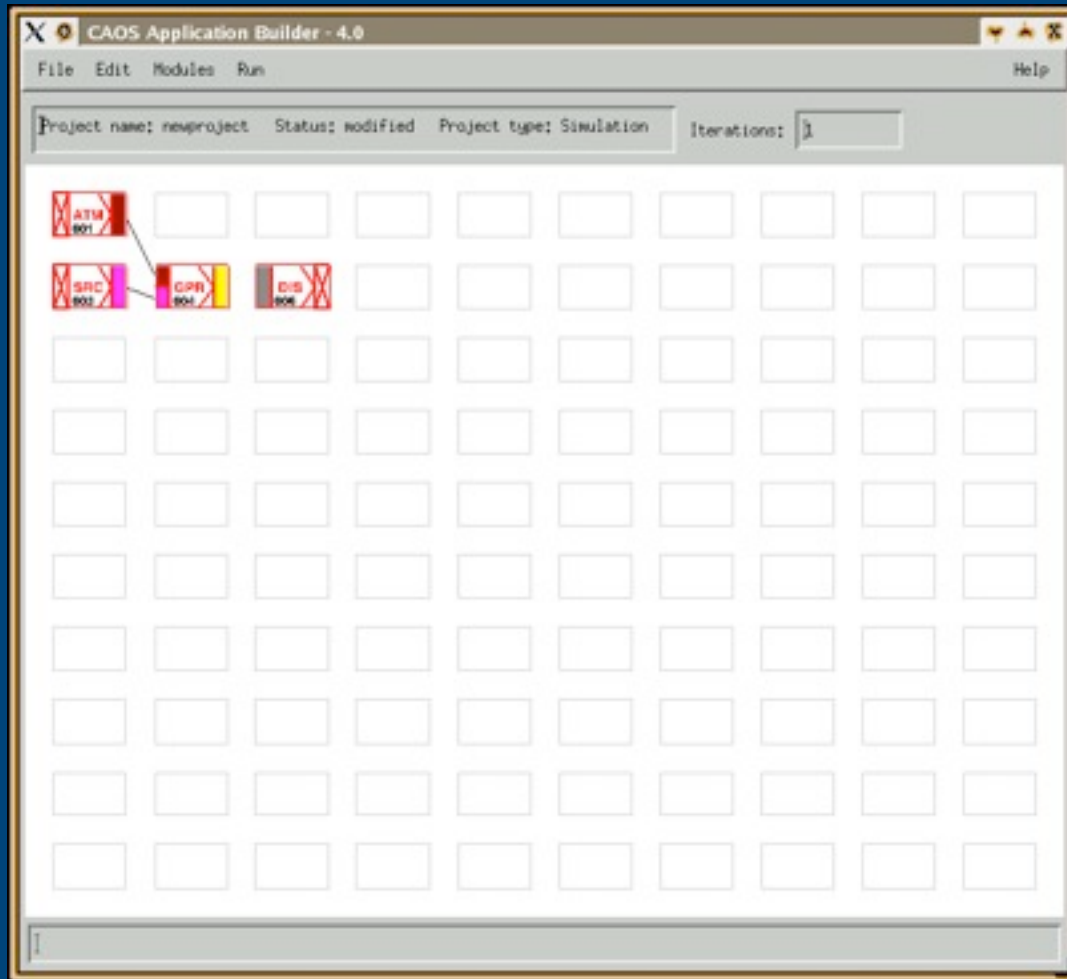
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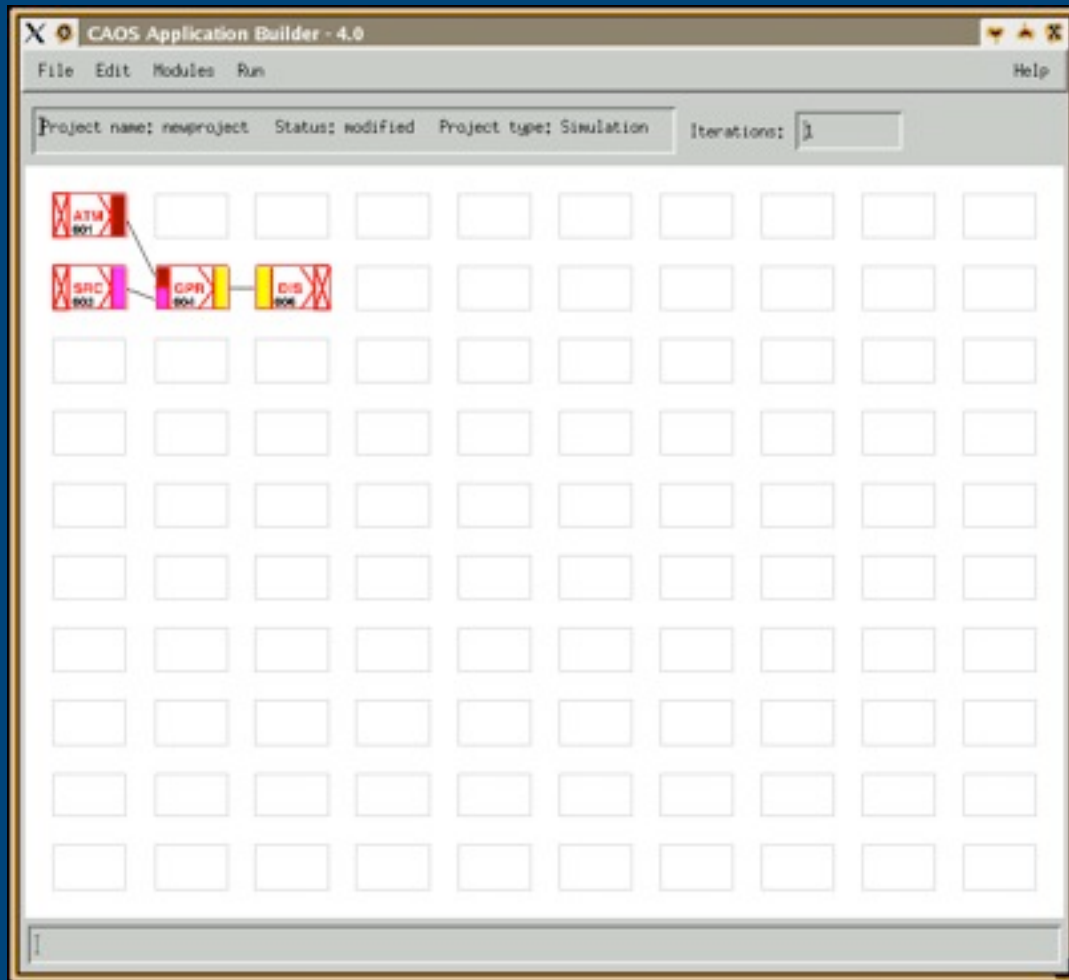
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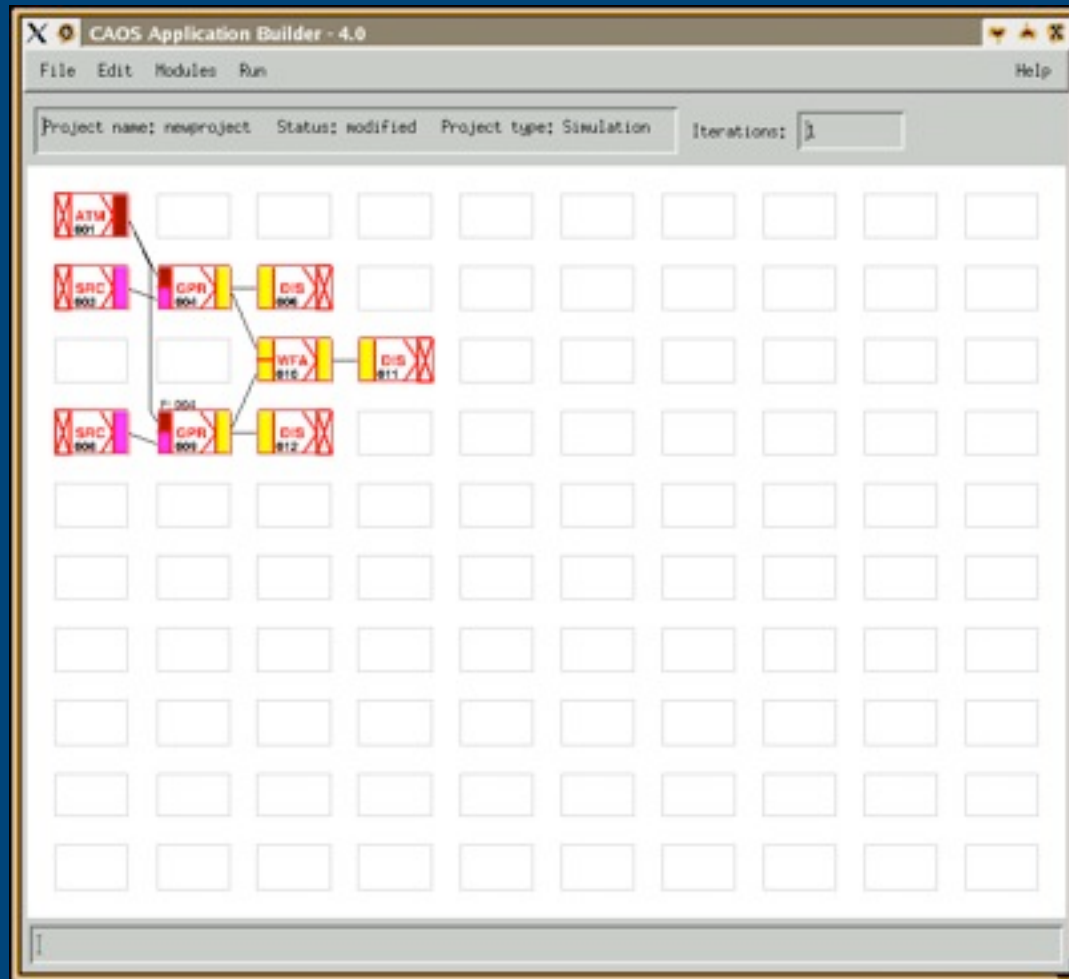
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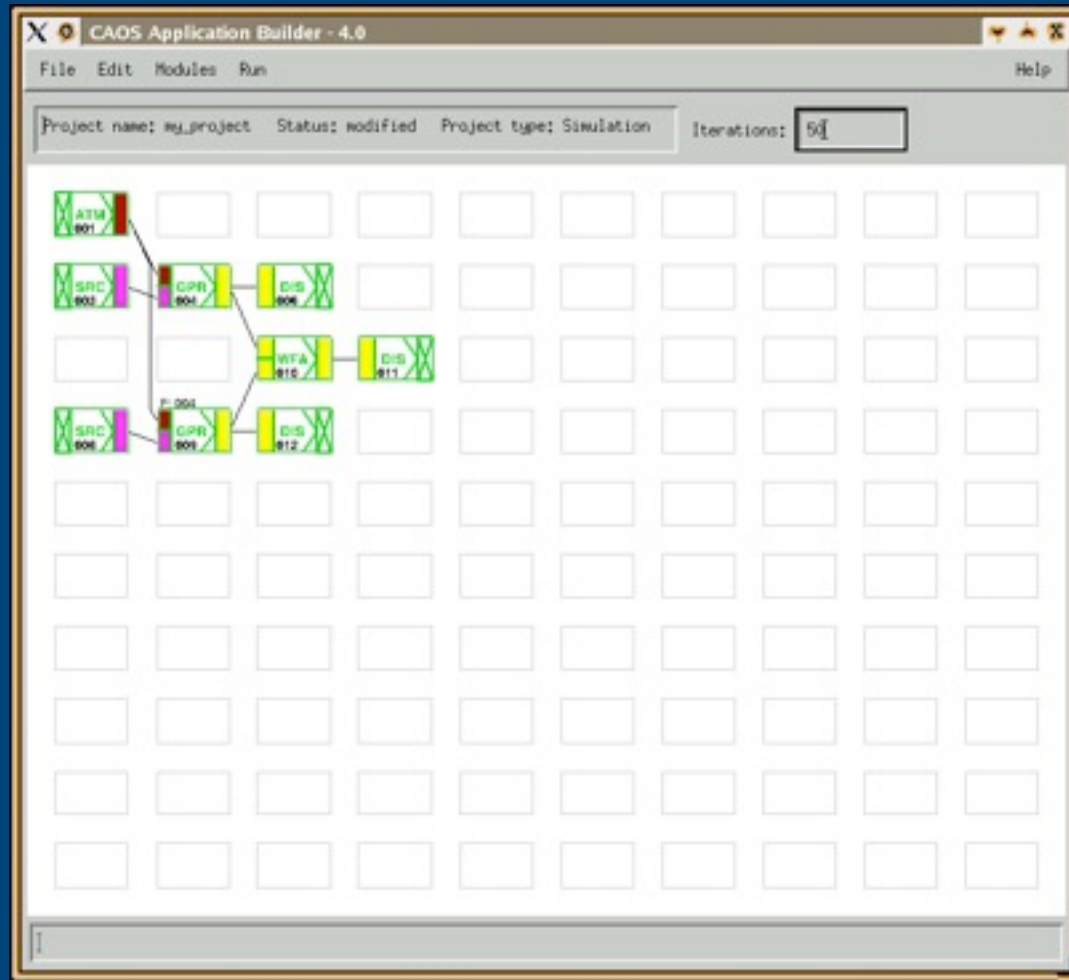
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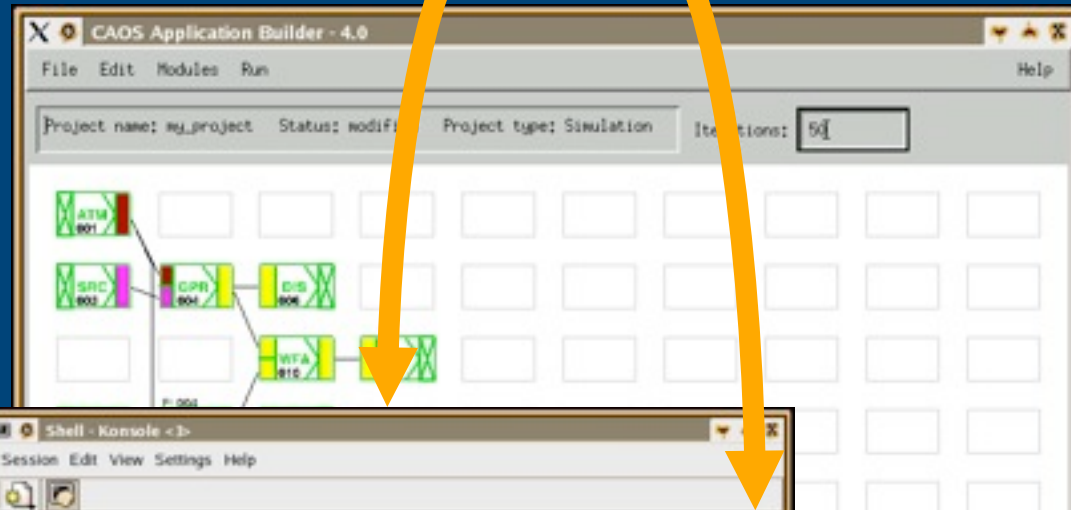
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```
COMMON caos_block, tot_iter, this_iter
ret = mds(0.001_00,
         mds_00001_p,
         INIT=mds_00001_c)
IF ret NE 0 THEN ProjectMsg, "mds"

ret = src(0.002_00,
         src_00002_p,
         INIT=src_00002_c)
IF ret NE 0 THEN ProjectMsg, "src"

ret = gpr(0.002_00,
         0.001_00,
         0.003_00,
         gpr_00003_p,
         INIT=gpr_00003_c)
IF ret NE 0 THEN ProjectMsg, "gpr"

ret = dis(0.003_00,
         dis_00010_p,
         INIT=dis_00010_c)
IF ret NE 0 THEN ProjectMsg, "dis"
```

```
Shell - Konsole <B>
Session Edit View Settings Help

.....
; Initialization;
.....
print, "=== INITIALIZATION... ==="
@Projects/pyr_calib/mod_calls.pro

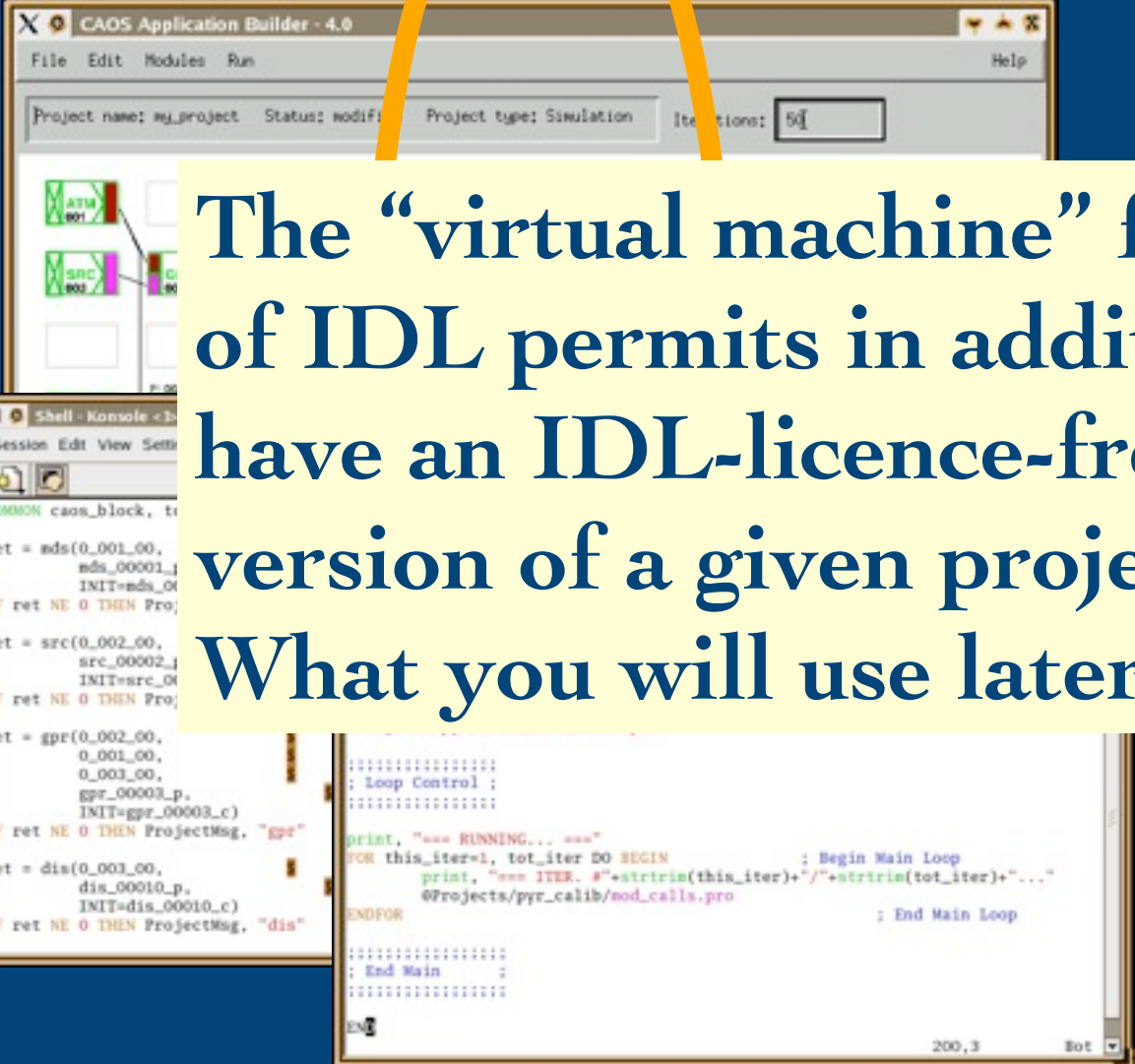
.....
; Loop Control ;
.....
print, "=== RUNNING... ==="
FOR this_iter=1, tot_iter DO BEGIN           ; Begin Main Loop
  print, "=== ITER. #" + strtrim(this_iter) + "/" + strtrim(tot_iter) + "..."
  @Projects/pyr_calib/mod_calls.pro
ENDFOR                                     ; End Main Loop

.....
; End Main ;
.....
END
```

When the project is designed, it can be saved on disk, generating the **IDL code** which implements the simulation program.

CAOS Application Builder

It is essentially a **worksheet** where the user can place small blocks representing modules, connect them with lines to form a flowchart, and generate the IDL code which implements the simulation program.

The image shows two overlapping screenshots of the CAOS Application Builder software. The top screenshot is a 'Project Setup' dialog box with fields for 'Project name: my_project', 'Status: modified', 'Project type: Simulation', and 'Iterations: 50'. Below these fields is a diagram showing three modules: 'ATM 001' (green), 'SRC 002' (green), and 'GPR 003' (green), connected by lines. The bottom screenshot is a code editor window showing IDL code. The code includes comments and function calls for 'mds', 'src', 'gpr', and 'dis' modules, and a main loop for simulation control.

The “virtual machine” feature of IDL permits in addition to have an IDL-licence-free version of a given project... What you will use later on.

CAOS PSE: availability

All (*public!*) parts of the CAOS PSE are available for download:

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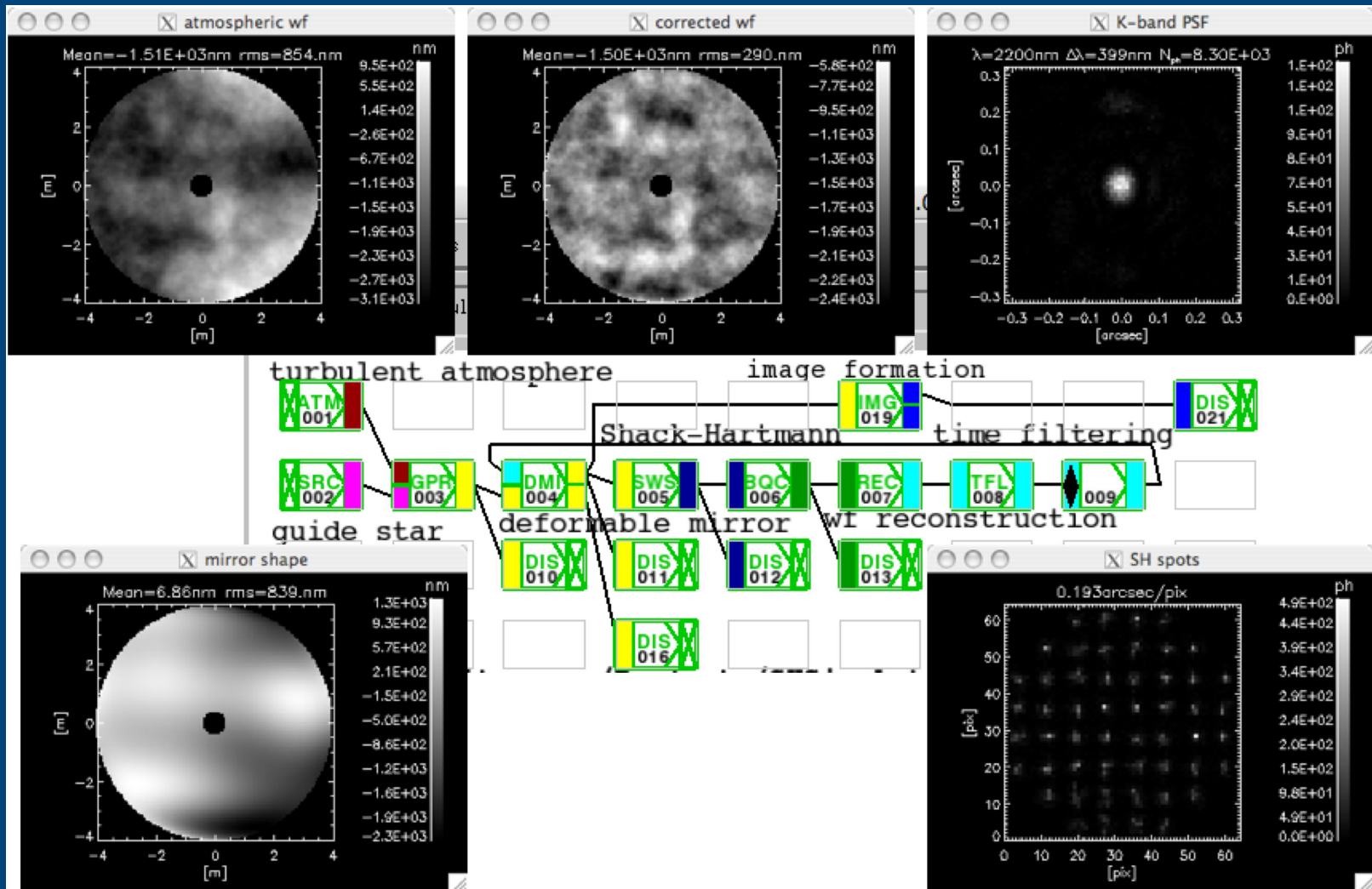
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Current status of the dedicated mailing-lists
(as on september 2016):

- Soft. Pack. CAOS: 117 subscribers,
- Soft. Pack. AIRY: 30 subscribers,
- *Soft. Pack. SPHERE: 23 subscribers,*
- *Soft. Pack. PAOLAC: 3 subscribers.*

End-to-end AO modeling with the Software Package CAOS -1

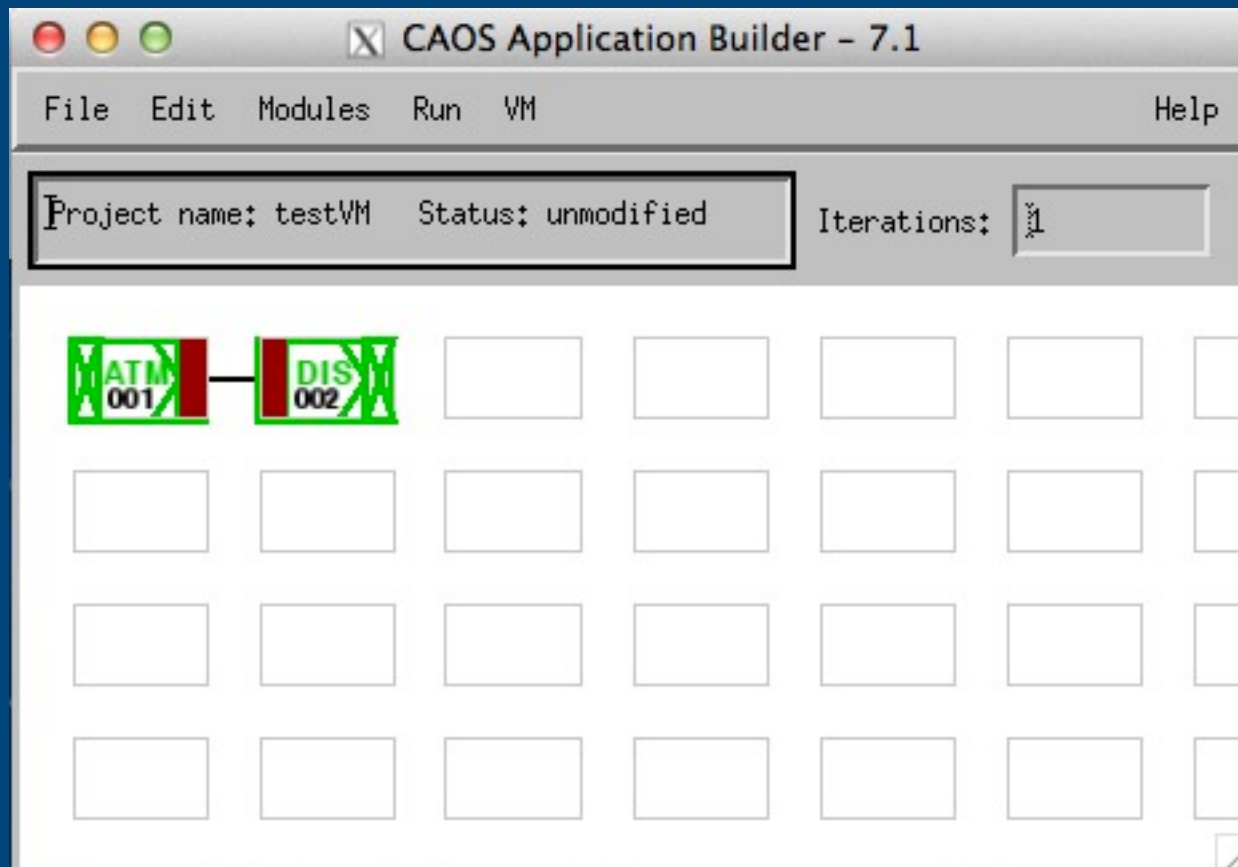


End-to-end AO modeling with the Software Package CAOS -2

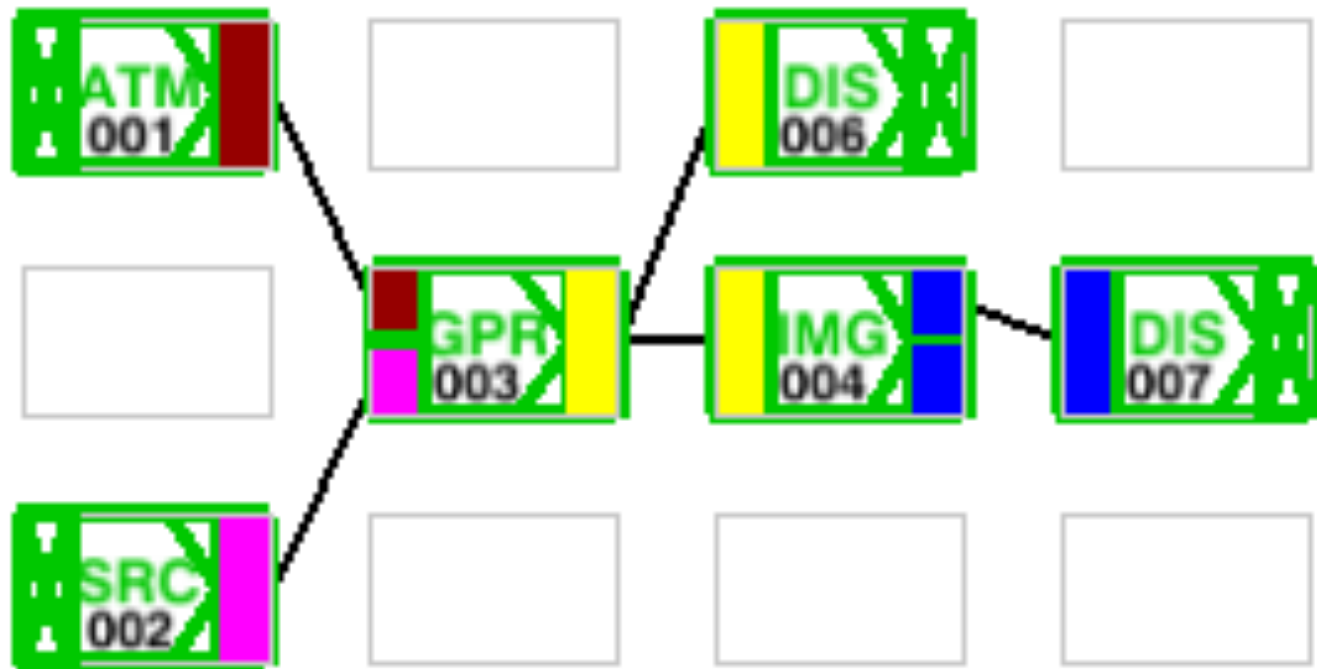
Table 1. The 31 modules of the Software Package CAOS, version 7.0.

Module	Purpose
Optical turbulence & image formation	
ATM - ATMosphere building	-builds the turbulent atmosphere (FFT+subharmonics, Zernike) (see also utility PSG - Phase Screen Generation)
SRC - SouRCe definition	-characterizes the guide star/observed object
GPR - Geometrical PROPagator	-propagates light from source to telescope through atmosphere
IMG - IMAging device	-forms an image of the observed object (+detector noises)
Wavefront sensing	
PYR - PYRamid wavefront sensor	-simulates the pyramid wavefront sensor
SLO - SLOpe computation	-computes the slopes from the pyramid signals
SWS - Shack-Hartman Wavefront Sensor	-simulates the Shack-Hartmann (SH) wavefront sensor
BQC - Barycentre/Quad-cell Centroiding	-compute the signals from the SH spots centroiding calculus
IWS - Ideal Wavefront Sensing	-applies "ideal" wavefront sensing (see text)
TCE - Tip-tilt CEntroiding	-computes and reconstructs tip-tilt
Wavefront reconstruction, control & correction	
REC - wavefront REConstruction	-reconstructs the wavefront
TFL - Time-FiLtering	-applies time-filtering after wavefront reconstruction
SSC - State-Space Control	-applies state-space control
DMI - Deformable Mirror	-simulates the behavior of a deformable mirror (DM)
TTM - Tip-Tilt Mirror	-simulates the behavior of a tip-tilt mirror
Calibration	
CFB - Calibration FiBer characterization	-defines a fiber to be used for calibration purpose
MDS - Mirror Deformation Sequencer	-generates a sequence of DM modes or influence functions
SCD - Save Calibration Data	-saves the calibration data (interaction matrix+set of deformatives)
Wide-field AO	
AVE - signals AVEraging	-averages measurements from various wavefront sensors
COM - COMbine measurements	-combines measurements from various wavefront sensors
DMC - Deformable Mirror Conjugated	-corrects at different conjugated altitudes
Other modelling modules	
LAS - LASer characterization	-defines laser projector characteristics
NLS - Na-Layer Spot definition	-characterizes the Sodium-layer behavior
IBC - Interferometric Beam Combiner	-combines the light from two apertures
COR - CORonagraphic module	-simulates various coronagraphs (Lyot, Roddier&Roddier, FQPM)
AIC - Achromatic Interfero-Coronagraph	-simulates the Achromatic Interfero-Coronagraph
BSP - Beam SPplitter	-splits the light beam
Other utility modules	
WFA - WaveFRont Adding	-adds or combines together wavefronts
ATA - ATmosphere Adding	-adds or combines together atmospheres
IMA - IMAge Adding	-adds or combines together images
STF - STructure Function	-calculates the structure function and compares to theory

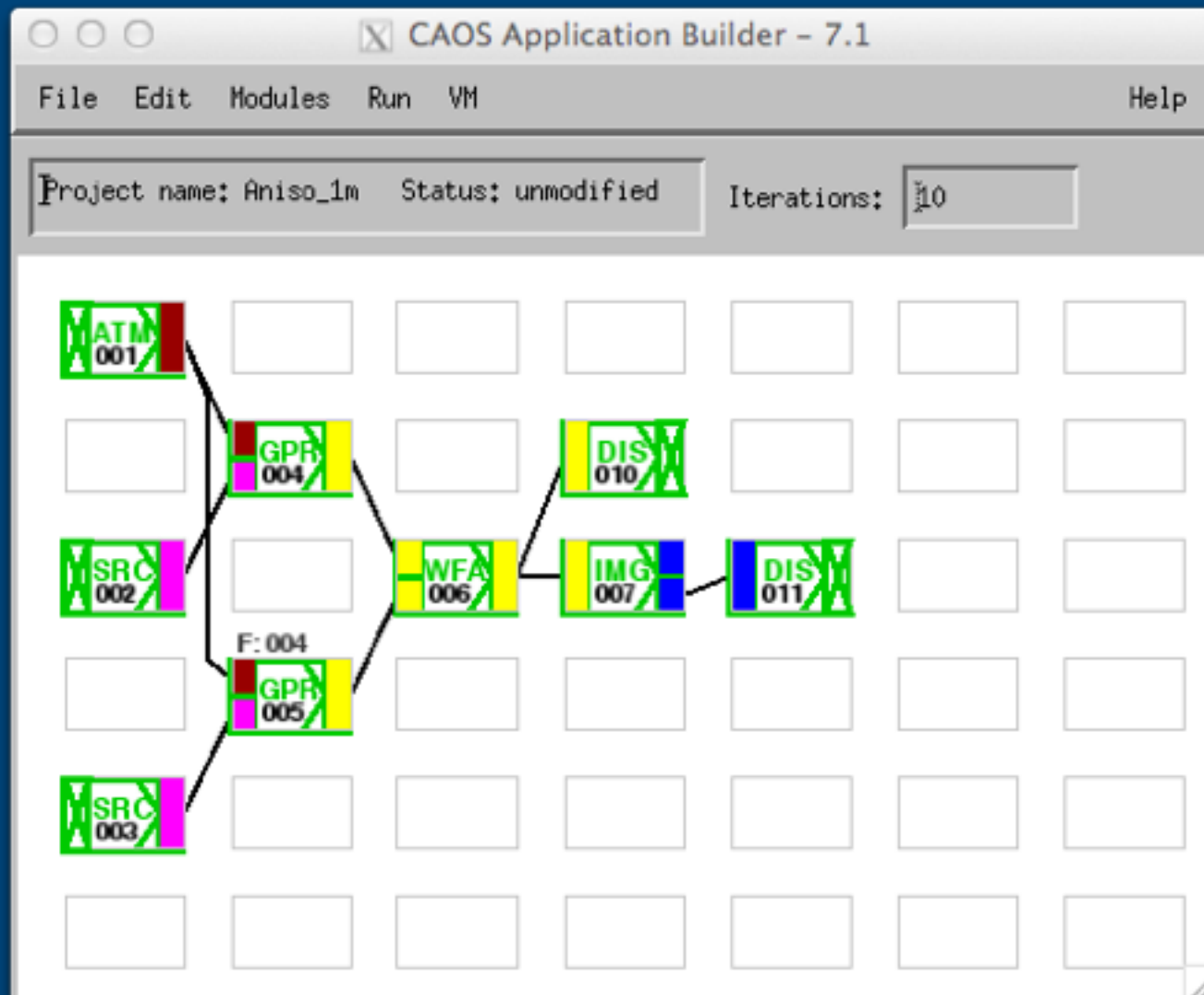
Imaging through the turbulent atmosphere: loss of resolution !



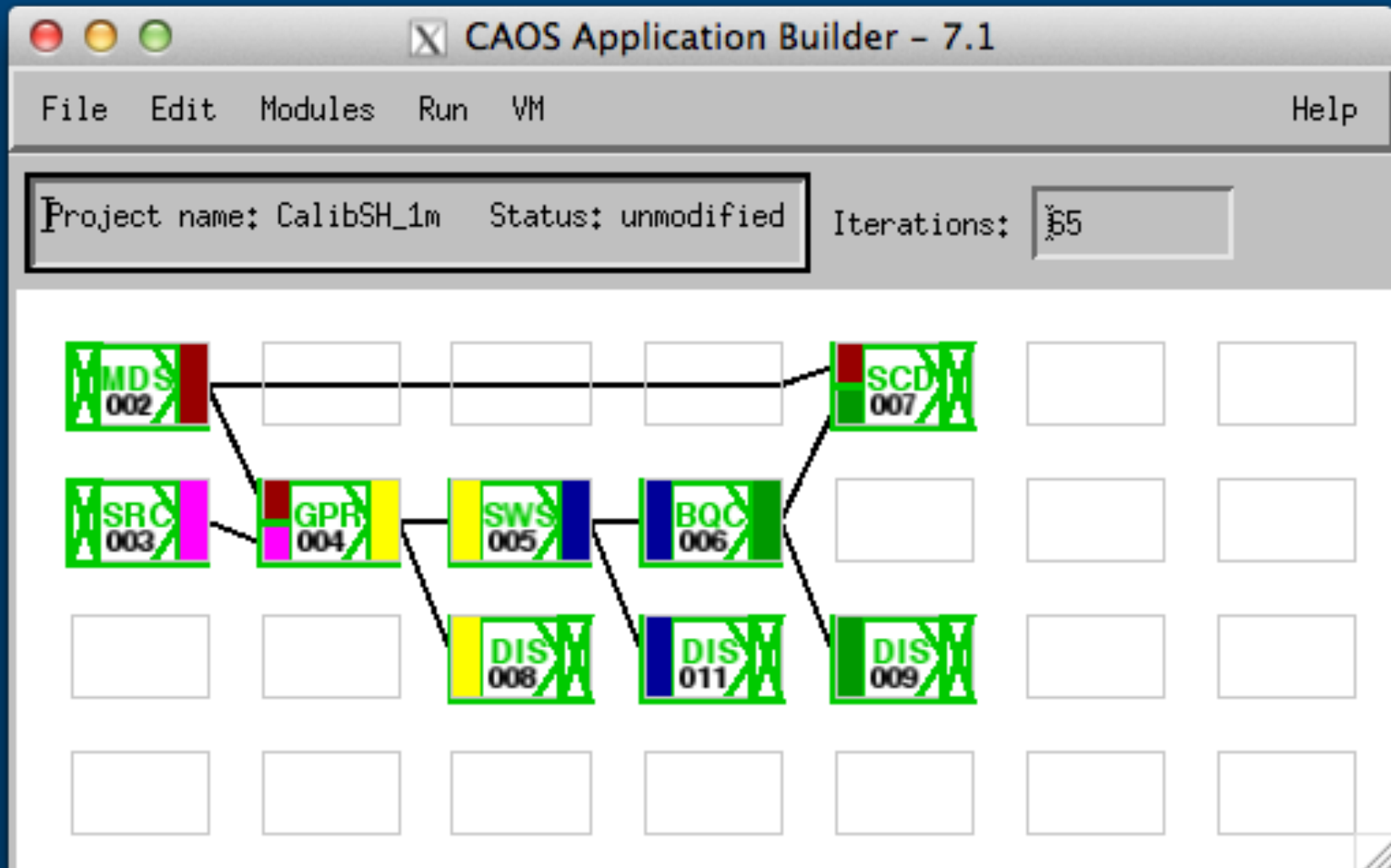
Imaging through the turbulent atmosphere: loss of resolution !



Imaging through the turbulent atmosphere: anisoplanatism !



End-to-end simulation of a complete AO system: calibration



End-to-end simulation of a complete AO system: running...

