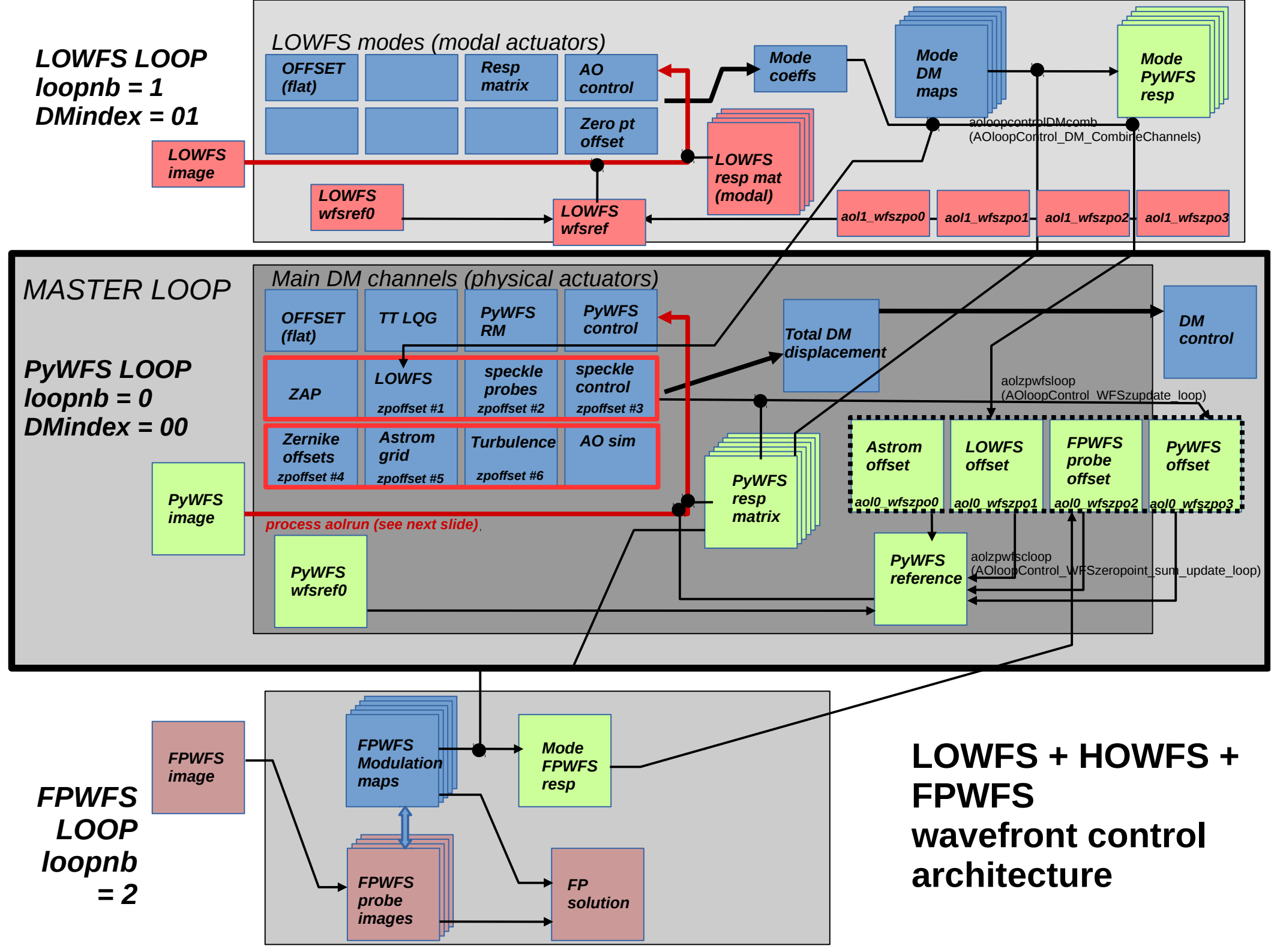
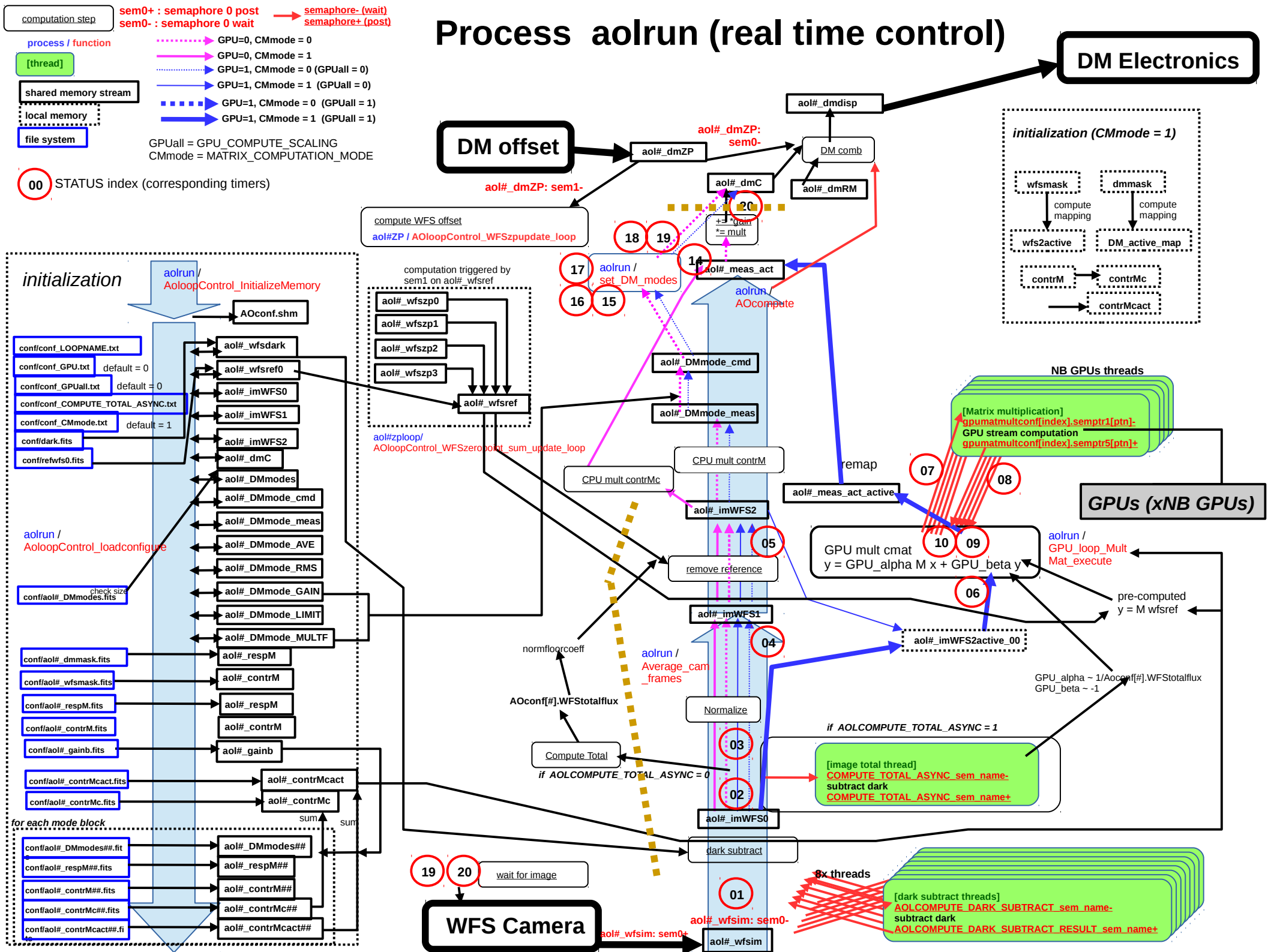

LOWFS LOOP
loopnb = 1
DMindex = 01
LOWFS modes (modal actuators)
OFFSET (flat)
Resp matrix
AO control
Zero pt offset
Mode coeffs
Mode DM maps
Mode PyWFS resp
aoloopcontrolDMcomb
(AOloopControl_DM_CombineChannels)
LOWFS image
LOWFS resp mat (modal)
LOWFS wfsref0
LOWFS wfsref
aol1_wfszpo0
aol1_wfszpo1
aol1_wfszpo2
aol1_wfszpo3
MASTER LOOP
Main DM channels (physical actuators)
OFFSET (flat)
TT LQG
PyWFS RM
PyWFS control
Total DM displacement
DM control
PyWFS LOOP
loopnb = 0
DMindex = 00
ZAP
LOWFS
zpoffset #1
speckle probes
zpoffset #2
speckle control
zpoffset #3
aolzpwfsloop
(AOloopControl_WFSzupdate_loop)
Zernike offsets
zpoffset #4
Astrom grid
zpoffset #5
Turbulence
zpoffset #6
AO sim
Astrom offset
aol0_wfszpo0
LOWFS offset
aol0_wfszpo1
FPWFS probe offset
aol0_wfszpo2
PyWFS offset
aol0_wfszpo3
PyWFS image
PyWFS resp matrix
process aolrun (see next slide)
PyWFS reference
aolzpwfscloop
(AOloopControl_WFSzeropoint_sum_update_loop)
PyWFS wfsref0
FPWFS image
FPWFS Modulation maps
Mode FPWFS resp
FPWFS probe images
FP solution
FPWFS LOOP loopnb = 2
LOWFS + HOWFS + FPWFS
wavefront control architecture


Process aolrun (real time control)
computation step
sem0+ : semaphore 0 post
sem0- : semaphore 0 wait
semaphore- (wait)
semaphore+ (post)
process / function
[thread]
shared memory stream
local memory
file system
GPU=0, CMmode = 0
GPU=0, CMmode = 1
GPU=1, CMmode = 0 (GPUall = 0)
GPU=1, CMmode = 1 (GPUall = 0)
GPU=1, CMmode = 0 (GPUall = 1)
GPU=1, CMmode = 1 (GPUall = 1)
GPUall = GPU_COMPUTE_SCALING
CMmode = MATRIX_COMPUTATION_MODE
00 STATUS index (corresponding timers)
DM Electronics
DM offset
aol#_dmdisp
aol#_dmZP
aol#_dmZP: sem0-
aol#_dmZP: sem1-
DM comb
aol#_dmC
aol#_dmRM
compute WFS offset
aol#ZP / AOloopControl_WFSzpupdate_loop
+= *gain
*= mult
aol#_meas_act
aolrun / set_DM_modes
aolrun / AOcompute
initialization (CMmode = 1)
wfsmask
dmmask
compute mapping
wfs2active
DM_active_map
contrM
contrMc
contrMcact
initialization
aolrun / AoloopControl_InitializeMemory
AOconf.shm
conf/conf_LOOPNAME.txt
conf/conf_GPU.txt
default = 0
conf/conf_GPUall.txt
default = 0
conf/conf_COMPUTE_TOTAL_ASYNC.txt
conf/conf_CMmode.txt
default = 1
conf/dark.fits
conf/refwfs0.fits
aol#_wfsdark
aol#_wfsref0
aol#_imWFS0
aol#_imWFS1
aol#_imWFS2
aol#_dmC
aol#_DMmodes
aol#_DMmode_cmd
aol#_DMmode_meas
aol#_DMmode_AVE
aol#_DMmode_RMS
aol#_DMmode_GAIN
aol#_DMmode_LIMIT
aol#_DMmode_MULTF
aolrun / AoloopControl_loadconfigure
conf/aol#_DMmodes.fits
check size
conf/aol#_dmmask.fits
conf/aol#_wfsmask.fits
conf/aol#_respM.fits
conf/aol#_contrM.fits
conf/aol#_gainb.fits
conf/aol#_contrMcact.fits
conf/aol#_contrMc.fits
aol#_respM
aol#_contrM
aol#_gainb
aol#_contrMcact
aol#_contrMc
sum
sum
for each mode block
conf/aol#_DMmodes##.fits
conf/aol#_respM##.fits
conf/aol#_contrM##.fits
conf/aol#_contrMc##.fits
conf/aol#_contrMcact##.fits
aol#_DMmodes##
aol#_respM##
aol#_contrM##
aol#_contrMc##
aol#_contrMcact##
computation triggered by sem1 on aol#_wfsref
aol#_wfszp0
aol#_wfszp1
aol#_wfszp2
aol#_wfszp3
aol#_wfsref
aol#zploop/ AOloopControl_WFSzeropoint_sum_update_loop
aol#_DMmode_cmd
aol#_DMmode_meas
CPU mult contrM
CPU mult contrMc
aol#_imWFS2
remap
aol#_meas_act_active
NB GPUs threads
[Matrix multiplication]
gpumatmultconf[index].semptr1[ptn]-
GPU stream computation
gpumatmultconf[index].semptr5[ptn]+
GPUs (xNB GPUs)
GPU mult cmat
y = GPU_alpha M x + GPU_beta y
aolrun / GPU_loop_Mult Mat_execute
pre-computed y = M wfsref
remove reference
aol#_imWFS1
aol#_imWFS2active_00
normfloorcoeff
aolrun / Average_cam _frames
AOconf[#].WFStotalflux
Normalize
GPU_alpha ~ 1/AOconf[#].WFStotalflux
GPU_beta ~ -1
Compute Total
if AOLCOMPUTE_TOTAL_ASYNC = 0
if AOLCOMPUTE_TOTAL_ASYNC = 1
[image total thread]
COMPUTE_TOTAL_ASYNC_sem_name-
subtract dark
COMPUTE_TOTAL_ASYNC_sem_name+
aol#_imWFS0
dark subtract
8x threads
[dark subtract threads]
AOLCOMPUTE_DARK_SUBTRACT_sem_name-
subtract dark
AOLCOMPUTE_DARK_SUBTRACT_RESULT_sem_name+
wait for image
WFS Camera
aol#_wfsim: sem0-
aol#_wfsim: sem0+
aol#_wfsim
00
01
02
03
04
05
06
07
08
09
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11
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14
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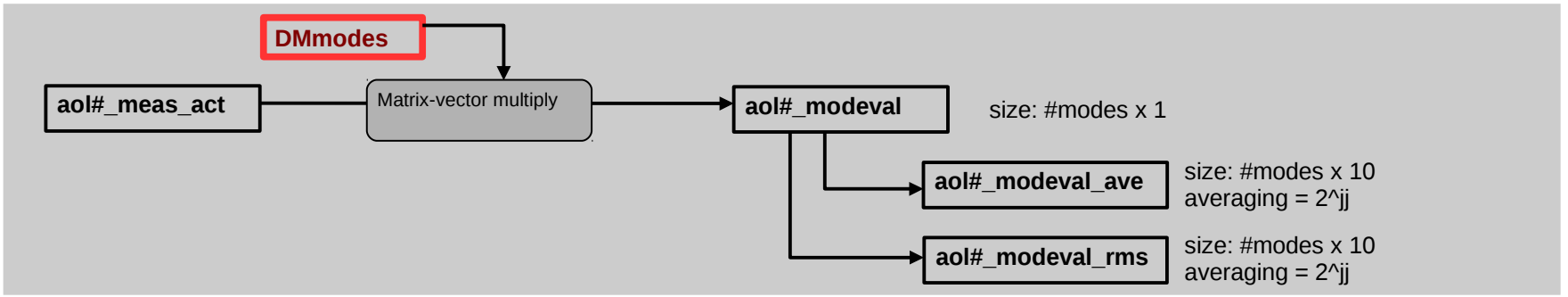
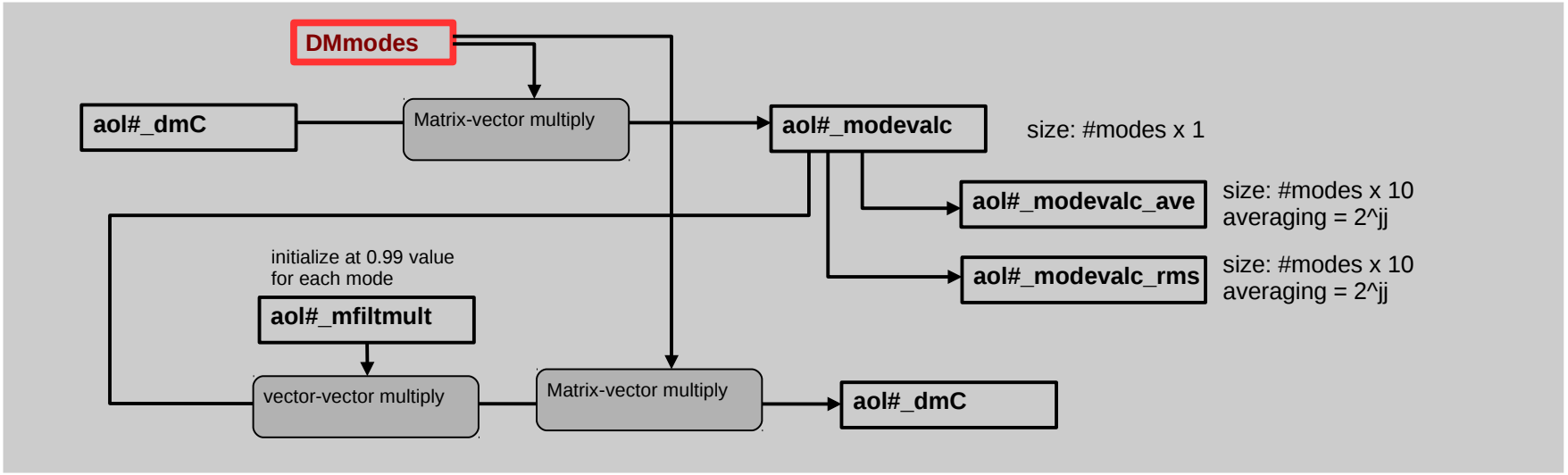
19
20

Auxillary processes

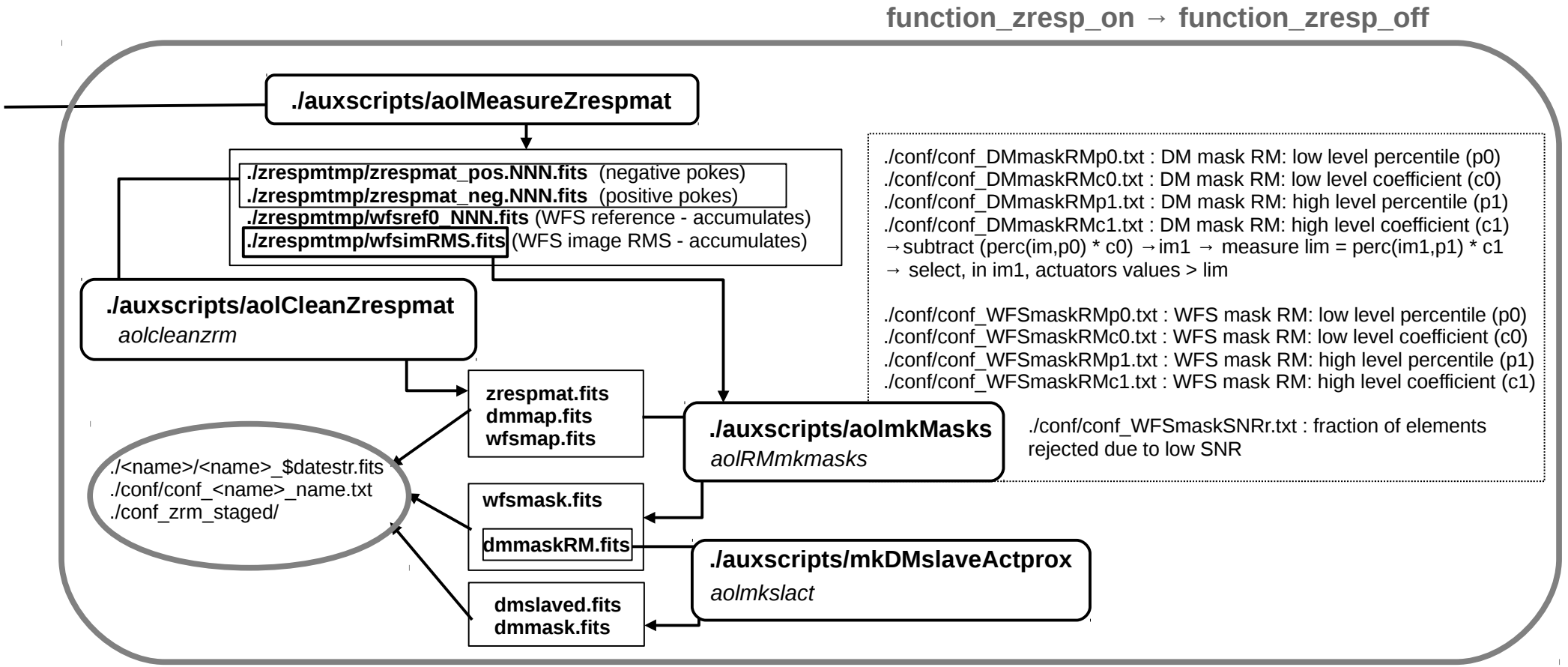
Decompose WFS measurements in modes



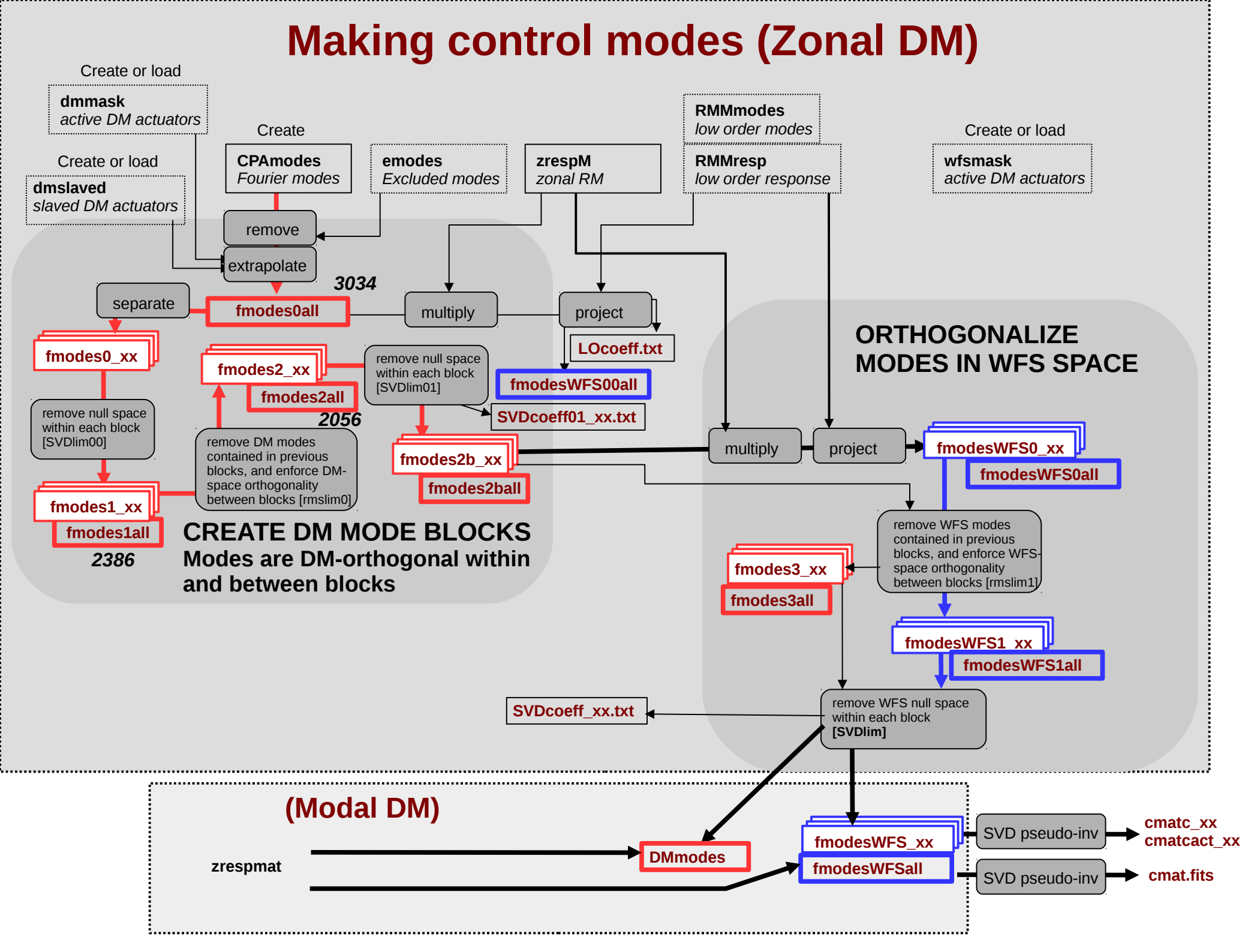
Decompose DM commands in modes + apply modal mult gains



Zonal response matrix acquisition → masks

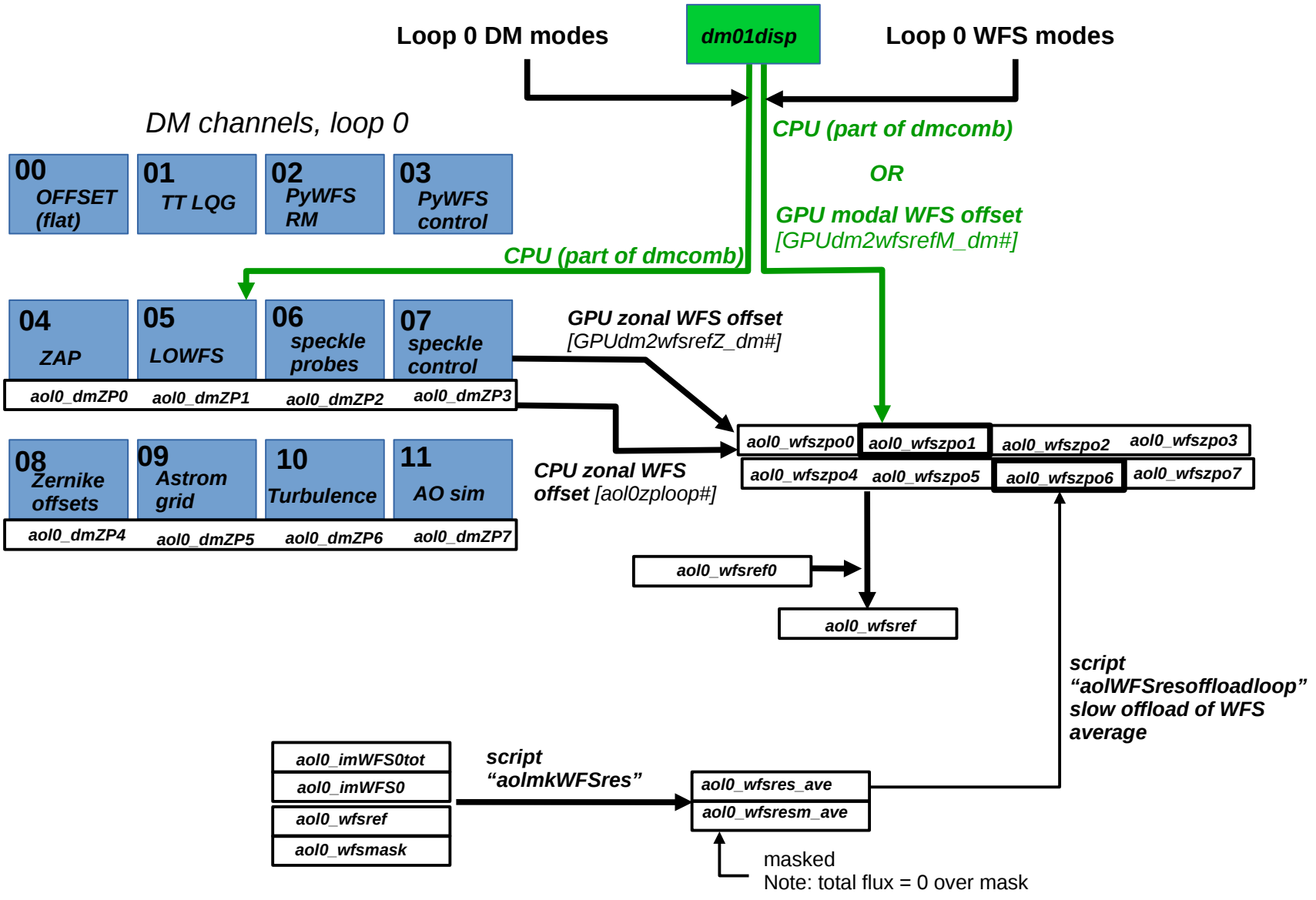


Making control modes (Zonal DM)



OFFSETTING
LOWFS (loop #1) → PyWFS (loop #0)

Green color: process is part of loop #1



[process name] (same name as tmux session)
aol0RT : CPU set

01 status index
00 statusM index
00 statusM1 index
00 timer index

Processes, output to DM (main loop)

gain[m] = loopgain * gainMB[block] * aol0_DMmode_GAIN[m]
mult[m] = loopmult * multfMB[block] * aol0_DMmode_MULT[m]
limit[m] = limitMB[block] * aol0_DMmode_LIMIT[m]

log to disk
[logshim] in aol0log
disk

Telemetry
aol0_modeval_ol_logbuff0
aol0_modeval_ol_logbuff1

Predictive filter block input watch [aol#PFb0watchin]
Open loop mode coefficients buffer for predictive block
aol0_modevalol_PFb0

Predictive filter compute [aol#PFb0comp]
Predicted mode coefficients
aol0_outPFb0

Predictive filter engine [aol#PFb0apply] in aol0RT1
Predicted mode coefficients
aol0_modevalPFb0

Predictive Filter (shown here for block #0)

Extract Open Loop WFS modes [aol#meol] in aol0RT
runs in Cfits

Open loop mode coefficients
aol0_modeval_ol
08
09

subtract
07
latency [frame] = hardlatency_frame + wfsmextrlatency_frame

modal DM correction at time of available WFS measurement
aol0_modeval_dm

modal DM correction, circular buffer
aol0_modeval_dm_C

06

Predicted mode coefficients
aol0_modevalPF

DM map (test) script aolPFcoeffs2dmmap
Predicted DM map
aol0_dmPFout

DM filtering writeback [aol#dmfwb] in aol0RT
script auxscripts/aolmcoeffs2dmmap

Current modal DM correction, filtered
aol0_modeval_dm_now_filt

Extract WFS modes [aol#mexwfs] in aol0RT1
script auxscripts/modesextractwfs

WFS-measured DM mode coefficients
aol0_modeval
03

Current modal DM correction
aol0_modeval_dm_now

sem3 wait
04
loop ARPFgain
06

sem4 wait

block gains
aol0_gainb

aol0_DMmode_GAIN
aol0_DMmode_MULTF

05
Modal filtering (clipping)
aol0_DMmode_LIMIT

sem2 wait
10
Modes → DM actuators

Main process [aol#run] in aol0RT
script auxscripts/aolrun
sem3 wait
02
WFS modes pixels → modes

WFS image
dark subtract
00

if modal
Primary computation → modes or actuators
loop gain
loop mult

Current modal DM correction
aol0_modeval_dm_now

should match

if DMprimaryWrite_ON
100
20

DM Primary Write
physical DM

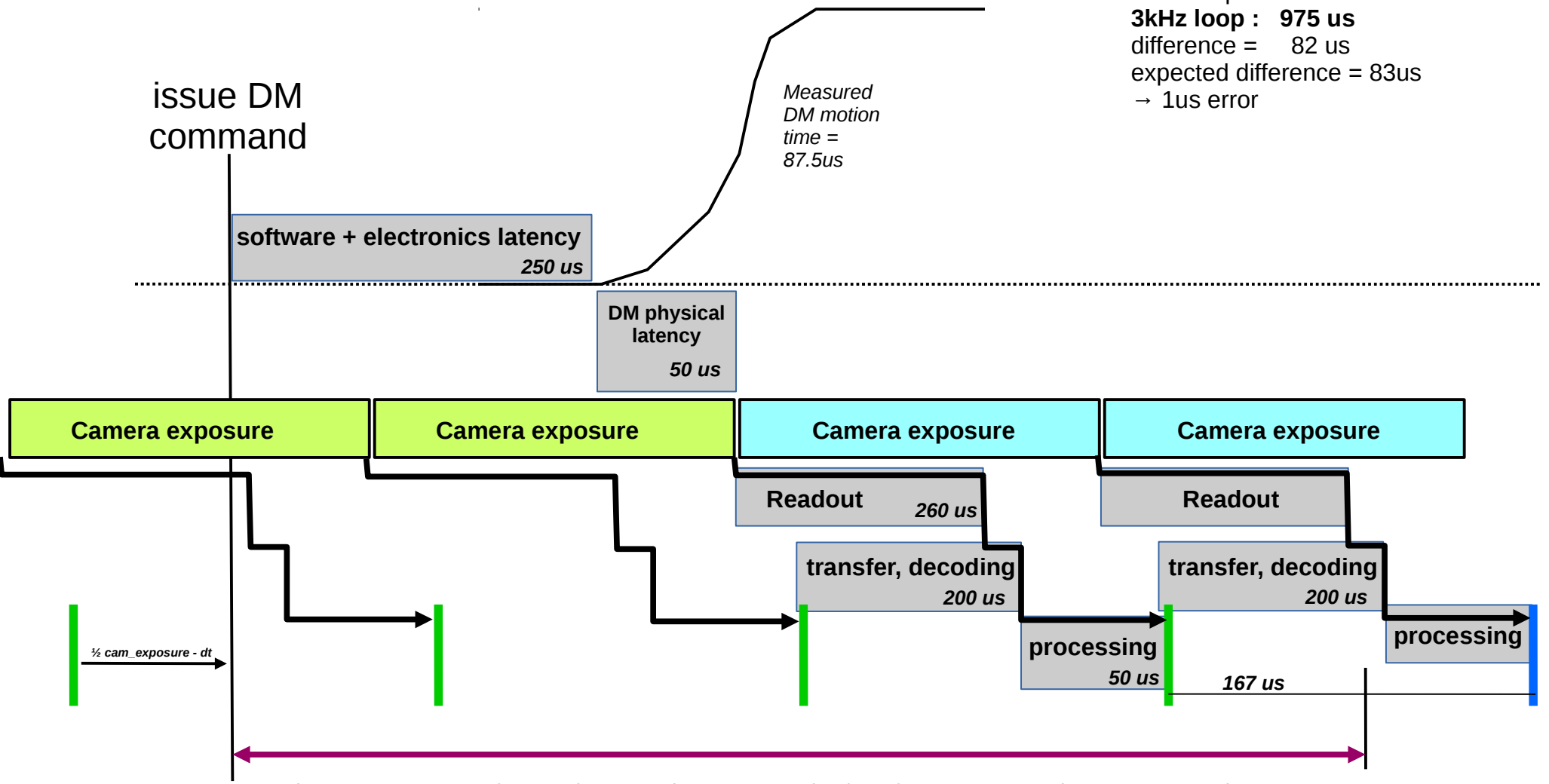
20 01 *complatency_frame (measured by aolMeasureTiming)* 20
20 00 *wfsmextrlatency_frame (measured by aolMeasureTiming)* 20

Note: DM map & coefficients show correction applied
→ open loop = WFS residual – dm
→ Wfresidual = Open loop WF + dm
→ dm = Wfresidual – open loop

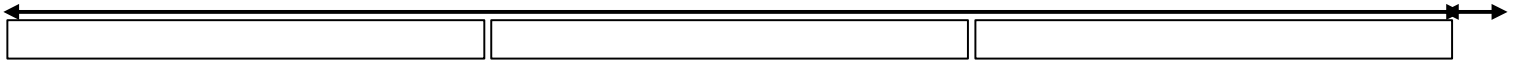
Hardware Latency

Definition:
Time offset between ***DM command issued****, and* ***mid-point between 2 consecutive WFS frames with largest difference***

SCExAO :
2kHz loop : 1057 us
3kHz loop : 975 us
difference = 82 us
expected difference = 83us
→ 1us error

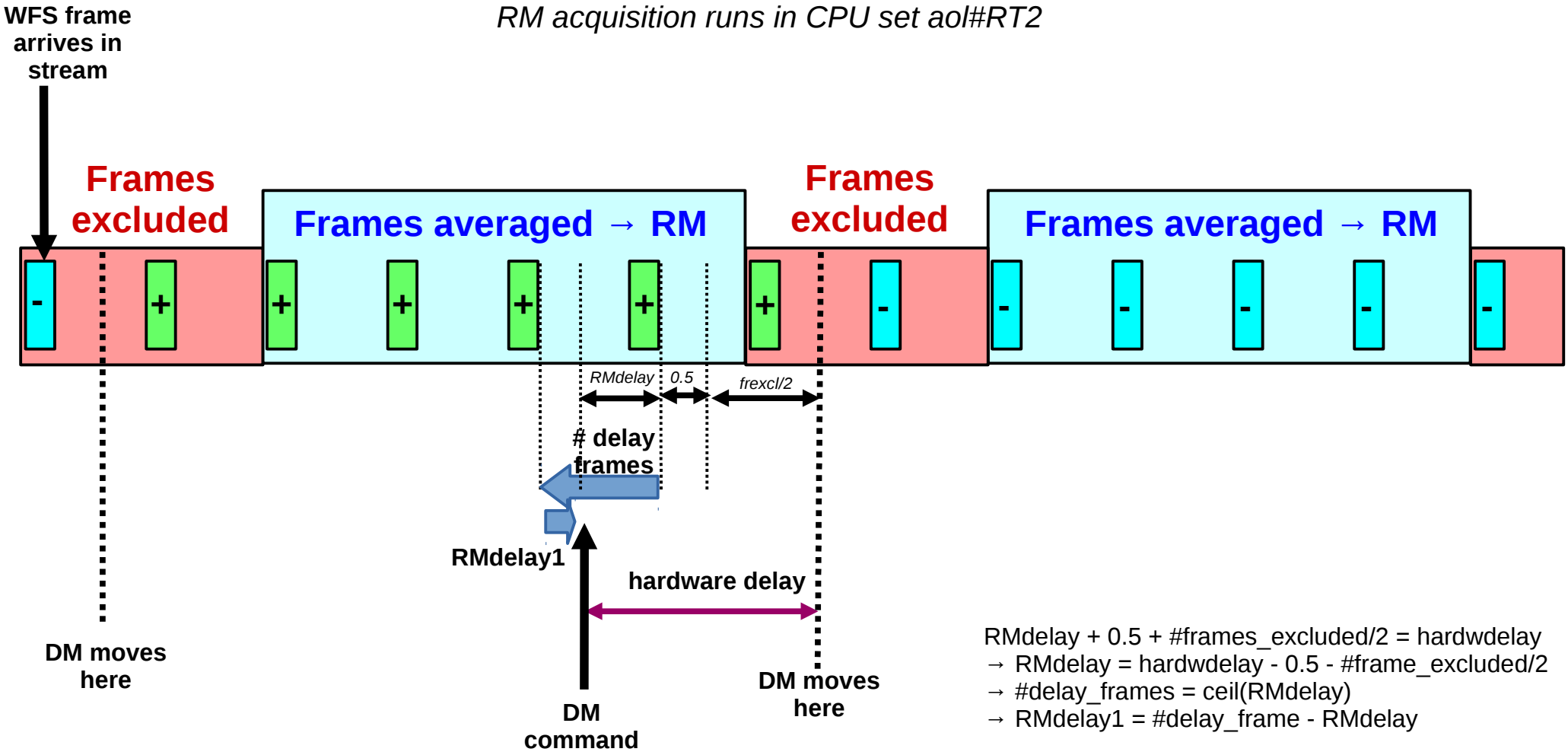


HardwareLatency = DM soft + DM elec + DM phys + CAM readout/transfer + CAM processing + ½ exposure time
HardwareLatency = N x cam_exposure + dt



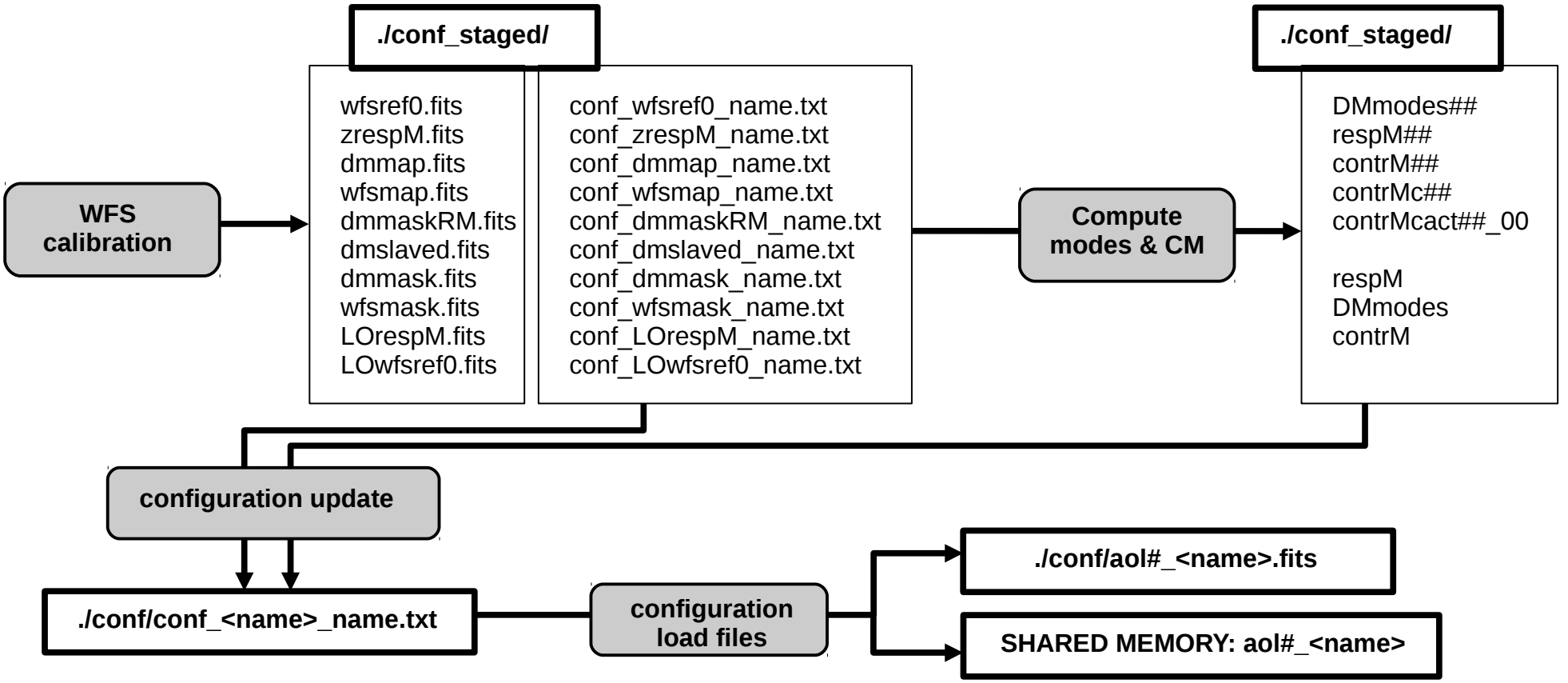
RM acquisition - Timing

RM acquisition runs in CPU set aol#RT2



RMdelay + 0.5 + #frames_excluded/2 = hardwdelay
→ RMdelay = hardwdelay - 0.5 - #frame_excluded/2
→ #delay_frames = ceil(RMdelay)
→ RMdelay1 = #delay_frame - RMdelay

For each file:
conf_<name>_name.txt points to archived file location

conf/conf_<name>_name.txt are read by function ReadConfFile for loading into shared memory and FITS copy to ./conf/aol#_<name>.fits

Work Flow