1.0 Requirements & Test Flow Spec.

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Accuracy Requirements & Test Flow

NISP Calibration Plan

- ❑ Detector chain error < 1%

↳ Characterization Requirements Accuracy

- ❑ Mater Dark & Noise
- ❑ Pixel response correction - NL
- ❑ Persistence Model
- ❑ IPC

↳ Workflow specifications

- ❑ Runs Specification
- ❑ DAS sw
- ❑ QC sw

↳ Characterization Test Plan

- ❑ Test Flow
- ❑ Test Facilities

Characterization accuracy

NISP Calibration Plan
EUCL-CPP-PL-7-002

Ref	Name	Products	Per Pixel accuracy	Comments
NISP-GC-PR-107	Master Dark	Pixel map to subtract the dark from the RAW data	0.01 e-/s 0.005 e-/s (goal)	Parameters: T, RO modes, integration time
NISP-GC-PR-108	Science Noise	Pixel map to evaluate the total noise	< 8%	Parameters: T, RO modes, integration time
NISP-GC-PR-109	Bad pixel	Bad pixel map	< 5% at threshold value	pixels with unusable response for science see [RD5]
NISP-GC-PR-110	Flat Field	Relative spectral response pixel maps	< 1%	Parameters % Wavelength [step 50nm] [range 0.92 to 2.]um
NISP-GC-PR-111	QE	QE maps	< 5%	Absolute value
NISP-GC-PR-112	Linearity	Relative error after non-linearity correction for signal	< 1%	- In range [2-600] e-/s Photometric RO - In range [2-150] e-/s Spectrometric RO
NISP-GC-PR-113	IPC	Mean value or Pixel value to correct the flux	< 5%	
NISP-GC-PR-114	Persistence	Coefficients to correct the persistence contribution to the signal with a chosen model	<5% RMS on the pool	pool of the fit the pool defined by (data - model) / noise

Table 1: Detector ground calibration and error budget.

Set up improvement in progress

DCL data

Analysis in progress

EFF3.1

Analysis TBD

Accuracy Flow down

NI-SCS characterisation requirements: EUCL-CPP-TN-7-004 issue 2

- Dark
  - NISP-C-1-01 to NISP-C-2-08
  - model versus OT in [85K-100K] range
  - All master «Darks»: MAD = Photo, Spectro, Long/short exposure, deglitching
- Noise
  - NISP-C-2-01 to NISP-C-1-17
  - Science Noise, RTN, CDS noise
- Pixel response correction
  - NISP-C-3-01 to NISP-C-3-28
  - Non-linearity, Latency, IPC
  - model versus OT in [85K-100K] range

Accuracy Justification

- **"1%" error on the readout chain verification needs:**
  - Huge statistic: ➔"Rauscher" formula to estimate # expo.
  - But statistics may not be the single driver of the accuracy on the mean per pixel ➔contributions of systematics (electronic and setup)
- **Error evaluation on data**

❑ Verify that statistics is sufficient (true for flux > 10 e/s)

❑ Acquire & Store different samples
  - ❑ to compute the pixel response function correction
  - ❑ to validate the correction error

❑ Control Stability of the Flux: < 1% during 560s

❑ Reproduce the same flux for 20 exposures with darks interleaved.

❑ Mitigate the persistence contribution to the measurement when exposures are repeated many times

Accuracy Justification

In the perfectly imperfect world of Pierre-Simon Laplace

✧ Central limit theorem + experimental error model with independent stochastic variables = Normal Law ➔ 1/✓n

Master Dark < 0.005 e/s

mode	Dark (e/s)	RON (e-)	sigma_s (e/s)	Rel, Error (%)	N_exp Error < 0,005 e/s
PH_Y	0,001	12	0,04	4148,97	69
PH_Y	0,005	12	0,04	839,27	71
PH_Y	0,01	12	0,04	425,49	73
PH_Y	0,1	12	0,05	51,96	109
PH_Y	0,001	14	0,05	4836,77	94
PH_Y	0,005	14	0,05	975,50	96
PH_Y	0,01	14	0,05	492,79	98
PH_Y	0,1	14	0,06	57,61	133
PH_Y	0,001	18	0,06	6213,52	155
PH_Y	0,005	18	0,06	1249,05	157
PH_Y	0,01	18	0,06	628,47	158
PH_Y	0,1	18	0,07	69,57	194
SPE	0,001	12	0,00	492,88	1
SPE	0,005	12	0,01	114,46	2
SPE	0,01	12	0,01	65,83	2
SPE	0,1	12	0,02	15,29	10
SPE	0,001	14	0,01	568,35	2
SPE	0,005	14	0,01	127,69	2
SPE	0,01	14	0,01	71,65	3
SPE	0,1	14	0,02	15,55	10
SPE	0,001	18	0,01	721,22	3
SPE	0,005	18	0,01	155,53	3
SPE	0,01	18	0,01	84,29	3
SPE	0,1	18	0,02	16,17	11

Table 1: Computation with Rauscher formula of the number of exposure needed to achieve 0.005 e-/s (stat only). RON is Read Out Noise

Signal slope error < 0.5% of signal

mode	Flux	Signal	sigma_s	rel. error	N_exposure needed for rel error < 0.5% of S
	e/s	e/s	e/s	%	#
PH_Y	0	0,01	0,05	492,79	971374
PH_Y	2	2,01	0,15	7,41	220
PH_Y	4	4,01	0,20	5,11	105
PH_Y	6	6,01	0,25	4,13	69
PH_Y	8	8,01	0,29	3,56	51
PH_Y	10	10,01	0,32	3,18	41
PH_Y	12	12,01	0,35	2,90	34
PH_Y	14	14,01	0,38	2,68	29
PH_Y	16	16,01	0,40	2,50	26
PH_Y	18	18,01	0,42	2,36	23
PH_Y	20	20,01	0,45	2,24	20
PH_Y	30	30,01	0,55	1,82	14
PH_Y	40	40,01	0,63	1,58	10
PH_Y	50	50,01	0,70	1,41	8
PH_Y	60	60,01	0,77	1,29	7
PH_Y	80	80,01	0,89	1,11	5
PH_Y	100	100,01	1,00	1,00	4
PH_Y	120	120,01	1,09	0,91	4
PH_Y	140	140,01	1,18	0,84	3
PH_Y	160	160,01	1,26	0,79	3
SPE	0	0,01	0,01	71,65	20536
SPE	2	2,01	0,07	3,26	43
SPE	4	4,01	0,09	2,30	22
SPE	6	6,01	0,11	1,88	15
SPE	8	8,01	0,13	1,63	11
SPE	10	10,01	0,15	1,45	9
SPE	12	12,01	0,16	1,33	8
SPE	14	14,01	0,17	1,23	7
SPE	16	16,01	0,18	1,15	6
SPE	18	18,01	0,20	1,08	5
SPE	20	20,01	0,21	1,03	5
SPE	30	30,01	0,25	0,84	3
SPE	40	40,01	0,29	0,73	3
SPE	50	50,01	0,33	0,65	2
SPE	60	60,01	0,36	0,59	2
SPE	80	80,01	0,41	0,51	2
SPE	100	100,01	0,46	0,46	1
SPE	120	120,01	0,50	0,42	1
SPE	140	140,01	0,54	0,39	1
SPE	160	160,01	0,58	0,36	1

Remarks:

- ✓ Not bad estimation of the number of exposures needed in the Test Flow
- ✓ Rauscher formula used ➔ no correlation
- ✓ < 10 e/s WF is statistically starved

Testing approach: constraints

<u>do not denied reality!</u>

- ❑ Keep the schedule under control, with reasonable margin (pump failure, power cut,...): 40 days - 4 SCS in //
- ❑ Two Operating Temperature: 85K and 90K
- ❑ Minimize the number of Cooling Cycles and large operating temperature variation between runs.
- ❑ Two cryos & two SCS/cryo running in parallel except for relative spectral response Run
- ❑ One mono-chromator+QTH
- ❑ 9 months of Acquisition
- ❑ Data acquisition Yield > 70% = Ratio between data stored/day/SCS and 0.5 TB/day/SCS (ideal continuous acq. running)

<u>Yes we can produce High quality Data</u>

- ❑ Avoid long acquisition Run (2 days) with spurious or inoperable exposure inside.
- ❑ Mitigate Persistence effects on low flux measurement or darks due to previous high flux illumination
- ❑ Design a test flow with a scheduling of illuminations with growing intensities to avoid Latency
- ❑ Use NASA acceptance test data to speed up the test flow and to secure data quality and stability with online Data Quality Checking
- ❑ Robust and stable EGSE driven by DAS sw with soft reset procedure and register read out for monitoring
- ❑ Robust and Precise OGSE: flux uniformity < 1% and flux stability over time (600s) < 1% and repeatability of the intensity
- ❑ A reactive Data Quality Cheking in-line (exposure) and off-line (Run) to validate Data before running the next Run
- ❑ Script the Test Flow = Acquisition and QC are preprogrammed
- ❑ Expert System with Warning and Pass/Fail Procedure

Testing approach: Products

Different purposes:

- ❑ Validating the accuracy of 1% on the relative readout chain error flow downed from [AD1] to verify/validate the NI-SCS performances.
- ❑ Producing NI-DS products such as pixel maps for the SGS and SOC.
- ❑ Producing the modeling functions to monitor, measure the effect on the detector chain error due to a different temperature environment in Flight.
- ❑ Estimating the accuracy of the Flight Calibration Procedure of the readout detector chain: test as in flight.

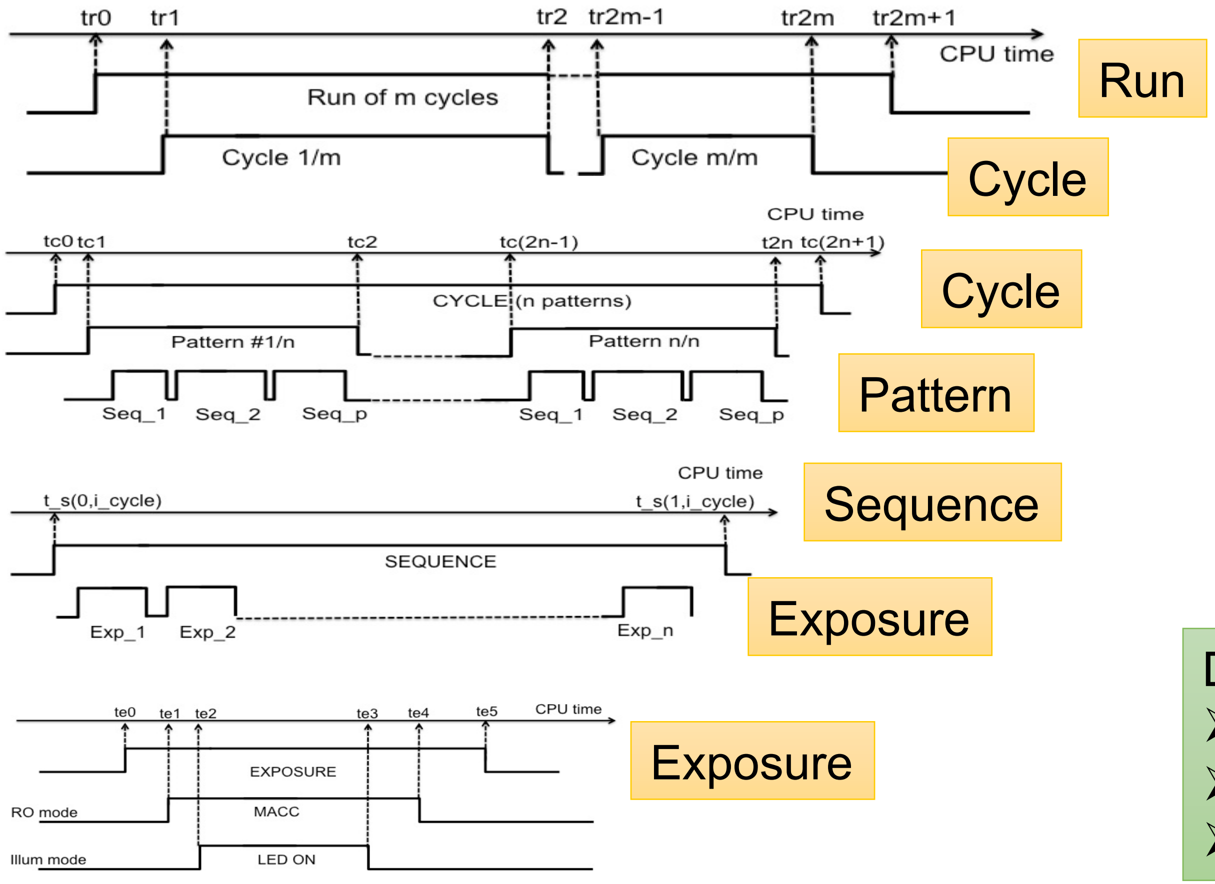
Test approach: processing wrt Runs

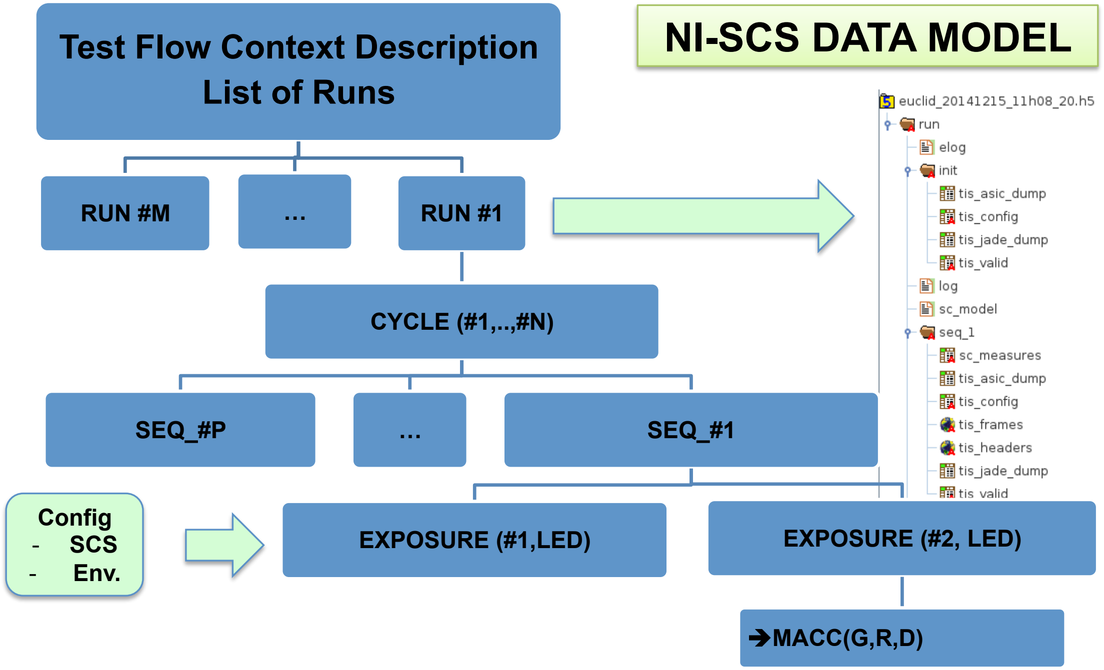
Processing element of the pixel response	Associated Runs
Ref Pixel Subtrac . • Algorithm • DPU comp.	**Science Dark**

Slope, QF
• NL correction
  • LUT(RO mode)
• QF correction
  • LUT(RO mode)
	FF Low F/ Med F/ High F + Dark
	Baseline

IPC correction	**SPR**
Bad pixel Mask • Non connected • LE, HE Baseline • RTN • Noisy • NO QE or No Gain • Hot	**Long Dark** **Baseline** **DNL** **Intercon.** **Science Dark**
Inoperable Pixel Mask Latency • Model, history	**FF Sat. + Dark** **FF Low F/ Med F/ High F + Dark**
Deglitching Bad QF Mask	**FF Low F/ Med F/ High F + Dark**
MAD subtraction • Hot removed	**Science Dark**
Flat Field Correction • Spectral Resp.	**FF vs. λ**

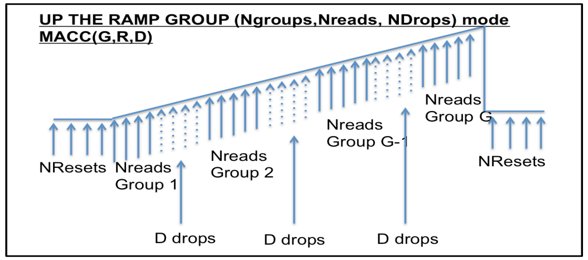
Overview Run description





Data model is self-consistent

- Keep the DoE structure
- Traceability
- Robustness



With this generic description all Euclid modes can be scripted for ground and Flight modes

Specifications of the Runs

Run specification description

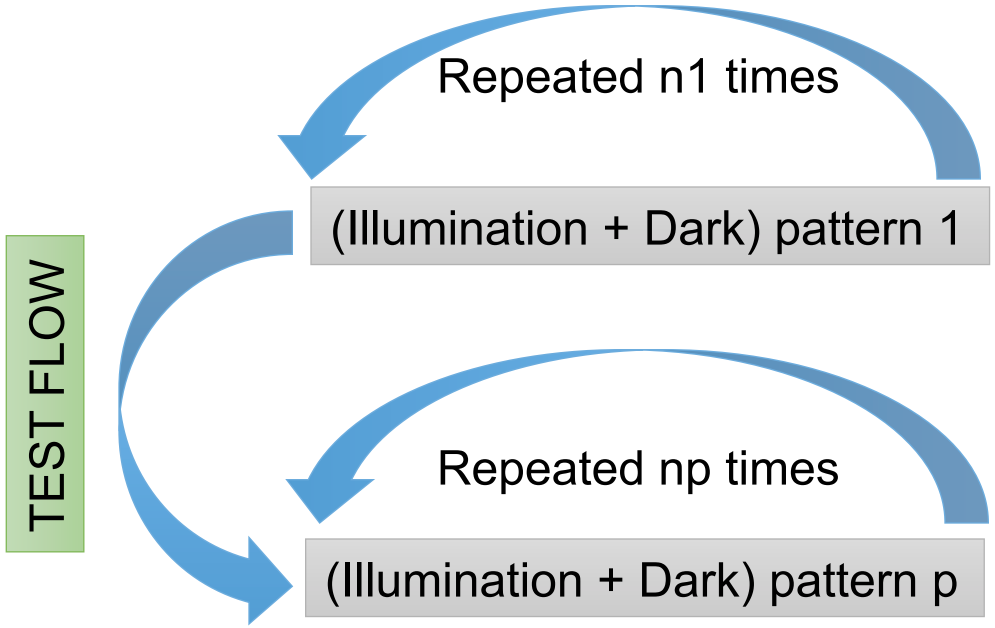
Configuration Level	List Index	Parameter					
Run	**[i_run]**	**name_of_the_run**					
cfg_run		n_cycle, n_scs					
cfg_setup		setup_Id, setup_ver					
cfg_scs		EFF.mcd					
cfg_delay		default					
cfg_env		OT_SCA = 95K, OT_SCE = 140K Shutter = True					
cfg_illu		LED_Id = (from the operator) LED_ver = (from the operator)					
Cycle	**[i_cycle, i_scs]**						
cfg_scs	[i_cycle, i_scs]	scs.mcd					
cfg_ n_iter	[i_cycle]	n_iter					
cfg_n_seq	[i_cycle]	n_seq					
cfg_delay	[i_cycle]	t_c(i) (default)					
cfg_env	[i_cycle]	Shutter = True / False					
cfg_illu	[i_cycle]	LED_uA or FPA_ADU_f or FPA_e_s					
Sequence	**[i_cycle, i_scs, i_seq]**						
cfg_scs	[i_cycle, i_scs, i_seq]	SCS config on purpose					
cfg_delay	[i_cycle, i_seq]	t_e(i)					
cfg_env	[i_cycle, i_seq]	Shutter = True / False					
cfg_illu	[i_cycle, i_seq]	LED_uA or FPA_ADU_f or FPA_e_s					
cfg_wr	[i_cycle , i_scs, i_seq]	True (Default)					
		n_exp	n_rst	n_dprst	n_g	n_f	n_d
cfg_ro	[i_cycle=: , i_seq= 0]	e	1	0	g	1	0
cfg_ro	[i_cycle=: , i_seq= 1]	e'	1	0	g'	1	0

Initial-check run

Run Id = 1.1		Run name = Initial_check					
CFG	**Index**	**Configuration Parameter**					
cfg_run		n_cycle = 3 , n_scs = 2					
cfg_setup		setup_Id, setup_ver					
cfg_scs		scs.mcd[n_scs]					
cfg_delay		default					
cfg_env		OT_SCA = OT1 & OT2 , OT_SCE = 140K Shutter = True					
cfg_illu		LED_Id = (from the operator) LED_ver = (from the operator) LED_uA = 0					
Cycle	**[i_cycle, i_scs]**						
cfg_ n_iter	[i_cycle=]	1					
cfg_n_seq	[i_cycle=]	1					
cfg_env	[i_cycle=0,1] [i_cycle=2]	Shutter = True Shutter = False					
cfg_illu	[i_cycle=0,1] [i_cycle=2]	LED_uA = 0 FPA_ADU_f = 30					
Sequence	**[i_cycle=0, i_scs, i_seq]**						
		n_exp	n_rst	n_drst	n_g	n_f	n_d
cfg_ro	[i_cycle=0, i_seq= 0]	128	1	0	1	1	0
cfg_ro	[i_cycle=1, i_seq= 0]	3	1	0	400	1	0
cfg_ro	[i_cycle=2, i_seq= 0]	3	1	0	400	1	0

Specifications of the Runs

NL – low flux Run



Run Id = 7.1		Run name = NL_Low_Flux					
CFG	**Index**	**Configuration Parameter**					
cfg_run		n_cycle = 9 , n_scs = 1					
cfg_setup		setup_Id, setup_ver					
cfg_scs		scs.mcd[n_scs]					
cfg_delay		default					
cfg_env		OT_SCA = OT1 & OT2 , OT_SCE = 140K Shutter = True					
cfg_illu		LED_Id = (from the operator) LED_ver = (from the operator)					
Cycle	**[i_cycle, i_scs]**						
cfg_ n_iter	[i_cycle=0,-1] [i_cycle=1] [i_cycle=2] [i_cycle=3] [i_cycle=4:7]	1 30 20 10 10					
cfg_n_seq	[i_cycle=0,-1] [i_cycle = 1:7]	1 2					
cfg_env	[i_cycle=0,-1]	Shutter = True					
cfg_illu	[i_cycle=0,-1]	FPA_e_s = 0					
Sequence	**[i_cycle=0, i_scs, i_seq]**						
cfg_env	[i_cycle=1:7, i_seq= 0] [i_cycle=1:7, i_seq= 1]	Shutter = False Shutter = True					
cfg_illu	[i_cycle=1, i_seq= 0] [i_cycle=2, i_seq= 0] [i_cycle=3, i_seq= 0] [i_cycle=4, i_seq= 0] [i_cycle=5, i_seq= 0] [i_cycle=6, i_seq= 0] [i_cycle=7, i_seq= 0] [i_cycle=1:7, i_seq= 1]	FPA_e_s = 4 FPA_e_s = 8 FPA_e_s = 12 FPA_e_s = 16 FPA_e_s = 20 FPA_e_s = 24 FPA_e_s = 28 FPA_e_s = 0					
		n_exp	n_rst	n_drst	n_g	n_f	n_d
cfg_ro	[i_cycle=0,-1, i_seq= 0]	3	1	0	800	1	0
cfg_ro	[i_cycle=1:7, i_seq= 0]	1	1	0	400	1	0
cfg_ro	[i_cycle=1:7, i_seq= 1]	1	1	0	800	1	0

Workflow specifications

<u>Consequences on SW and Test Bench and Test Flow</u>

- ❑ pre-load and execute a List of Runs (Test Flow / OT)
- ❑ Pre-calibrated OGSE Calibration: specified in e-/s
- ❑ Scheduler with an updated context to follow up detector response and stability
- ❑ Quality checking in-line because very long run
- ❑ Quality checking of the Run: raise Warning
- ❑ Procedures to Restart in case of failure

Workflow sta

◆Processing Level

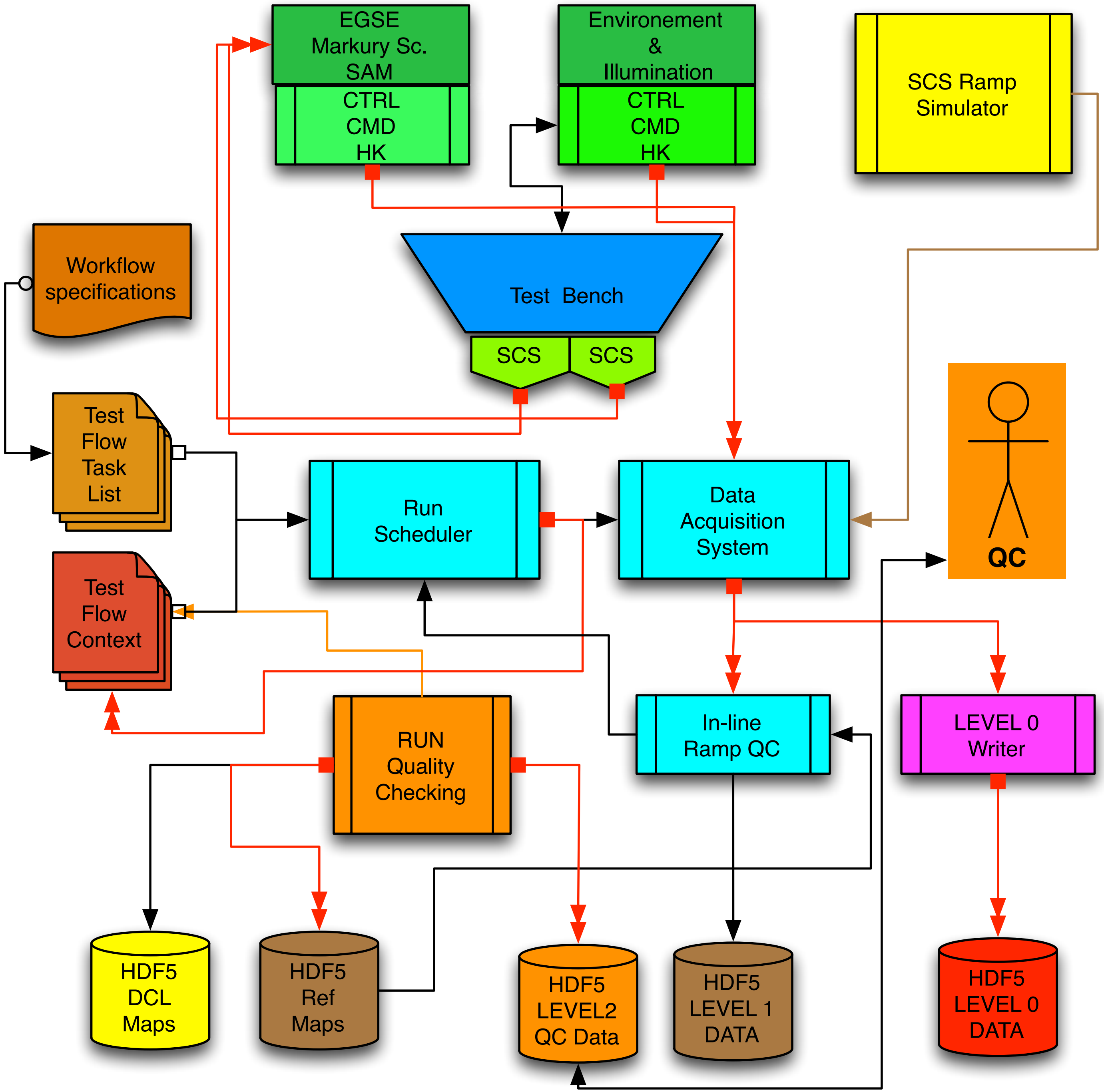
◆ DAS sw: dazeit

➢ ASYNCHRONUS

➢ SELF-UPDATED CONTEXT

◆QC sw: dasein

◆Data Produced during Test Flow



Test Flow Specification QC

❑ Pixel Data are encapsulated into a 9-axis cube with 6 temporal dim. and 3 spatial dim.:

- cycle
  - iteration inside the cycle
    - sequence
      - exposure
        - Group
          - Frame
            - Channel
              - Raw
                - Column

	Index	Axis	Range
Spatial index	Name	Name	Index
	j	Col index of the channel	0 – 63
	i	Raw index	0 - 2047
	o	Output channel index	0 - 31
Temporal Index			
	f	Frame index	0 - n_f-1
	g	Group index	0 - n_g-1
	e	Exposure index	0 - n_exp
	s	Sequence Index	0 - n_seq-1
	it	Iteration	0 - n_iter-1
	c	Cycle index	0 – n_cycle

❑ 2 Data Quality Checking categories:

✧ Internal consistency of the exposure = internal check in QC spec

✧ Consistency of the exposure with existing maps (DCL or EC updates) = external check

Test Flow Specification QC

- ❑ Dark exposure: line, col, channel, array,
  - ✧Baseline check : F1, First CDS, kTC compatible with Master baseline run
  - ✧Dark: CDS-f CDS-f-noise, likelihood slope and QF
  - ✧flatness after DSNU correction (dark – MAD)/dark

- ❑ Flat Field exposure
  - ✧ Baseline check: F1, First CDS, kTC and compatibility with baseline run
  - ✧ Photon Noise check, sqrt(Flux) compatibility
  - ✧Uniformity (Flux/Mean Flux -1)/QE
  - ✧Measured flux compare with requested flux (Flux – Requested Flux)/QE

Test Flow Specification QC

dark

data

#	cube name	h5	(l,o,j,c,lt,s,e,g,f)
1	cds_d	h5	(r.ref(c=1,g=1:)-r.ref(c=1,g=:-1)).mean(e,g)
2	cds_d_dcl	h5	
3	cds_no	h5	(r.ref(c=1,g=1:)-r.ref(c=1,g=:-1)).std(e,g)
4	cds_no_dcl	h5	
5	macc_r	no	r.from_utr_to_macc(c=1,g=-400:,spectro)

2	cds_d_oj	h5	cds_d.mean(o,j)
3	cds_d_lj	h5	cds_d.mean(l,j)
4	cds_d_loj	h5	cds_d.mean(l,o,j)
5	cds_no_l	h5	cds_no.mean(l)
6	cds_no_oj	h5	cds_no.mean(o,j)
7	cds_no_lj	h5	cds_no.mean(l,j)
8	cds_no_loj	h5	cds_no.mean(l,o,j)
9	macc_s	no	macc_r.ref
10	cds_g_lmf	h5	macc_s(g=-1) - macc_s(g=0)
11	cds_g	no	macc_s(g=1:) - macc_s(g=:-1)

cross qua

#				Failed
1	cds_d			1
2	cds_d			1
3	cds_d			1
4	cds_d			05
5	cds_d			05
6	cds_n			2
7	cds_n			2
8	cds_no_oj_x	cds_no_oj_x.percentile(95)	< 0.2	< 0.2
9	cds_no_lj_x	cds_no_lj_x	< 0.1	< 0.2
10	cds_no_loj_x	cds_no_loj_x	< 0.1	< 0.2

Internal quality check

#	name	Processing Element	Warning	Failed
1	cds_d	cds_d.percentile(95)	< 0.08	< 0.1
2	cds_d_l	cds_d_l.percentile(95)	< 0.08	< 0.1
3	cds_d_oj	cds_d_oj.percentile(95)	< 0.08	< 0.1
4	cds_d_lj	cds_d_lj	< 0.1	< 0.1
5	cds_d_loj	cds_d_loj	< 0.1	< 0.1
6	cds_no	cds_no.percentile(95)	< 30	< 30
7	cds_no_l	cds_no_l.percentile(95)	< 20	< 30
8	cds_no_oj	cds_no_oj.percentile(95)	< 20	< 30
9	cds_no_lj	cds_no_lj	< 16	< 18
10	cds_no_loj	cds_no_loj	< 14	< 14
11	llk_d	llk_d.percentile(95)	< 0.08	< 0.1
12	llk_d_l	llk_d_l.percentile(95)	< 0.08	< 0.1
13	llk_d_oj	llk_d_oj.percentile(95)	< 0.08	< 0.1
14	llk_d_lj	llk_d_lj	< 0.1	< 0.1
15	llk_d_loj	llk_d_loj	< 0.1	< 0.1
16	llk_qf	llk_qf.percentile(95)	< 5	< 10
17	llk_qf_l	llk_qf_l.percentile(95)	< 5	< 10
18	llk_qf_oj	llk_qf_oj.percentile(95)	< 5	< 10
19	llk_qf_lj	llk_qf_lj	< 3	< 3
20	llk_qf_loj	llk_qf_loj	< 3	< 3

Ground Testing: diagnosis runs

- ❑Zodi background
  - ❑ Instead of darks 2e/s 100 exposure
  - ❑ NL-low flux and medium flux with Zodi instead of darks (no latency information when zodi replace dark exposure)

- ❑Firmware test and Validation easily automatized

- ❑Calibration modes can be reproduced

- ❑Science modes with Dithers

- ❑“Warm electronic” processing has been implemented (50%)
  - ❑ Slope
  - ❑ QF
  - ❑ Compression   (TBD)

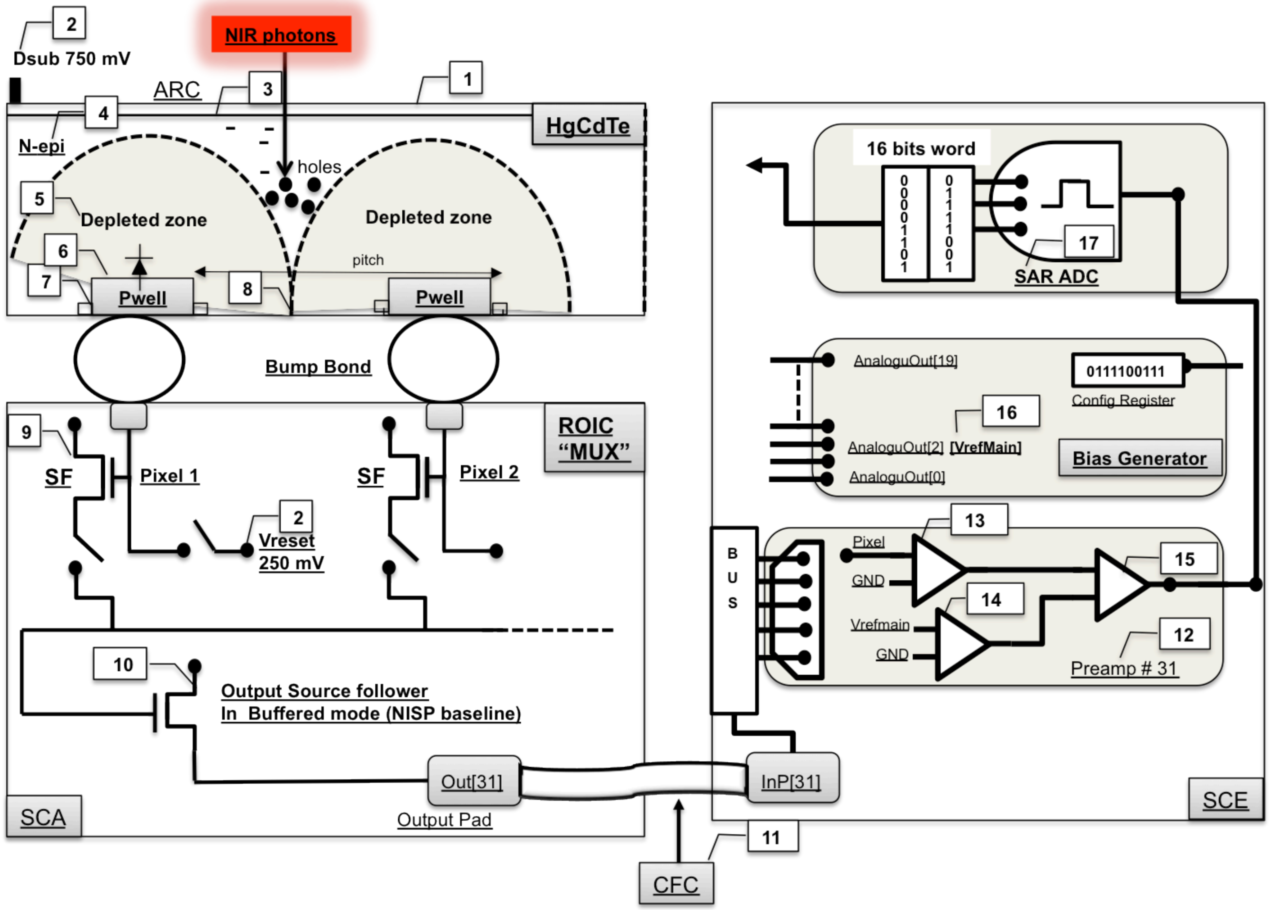
Test Flow and open work

- Telemetry is an open work
- Robustness of Acquisition sw dazeit with improvement on validation testing
- EGSE versus dazeit sw; classify warning and error counter management
- Data integrity validation methodology
- Warning management during the WF; when and where to restart?
- EFF3.1, SPR and All testing
- Intra pixel could be tested at Caltech (TBD) on NRE parts

Backup Next Slide

Detector Chain Error contributions

Simplified View of the Readout Chain and its key points



Measurement	Key points	Main concern for testing
Master Dark	2, 13-14-15	Reference Voltage stability
Noise	5, 6, 9, 10, 13, 14, 15, **16**, 17	Grounding, EGSE PS, EFF tuning
RTN	9	Reproduce long dark exposure with deglitching
Non-linearity	2, **5**, 9, 10, 13, 14,15,17	Stability of the Illumination over the exposure, repeat many exposure, latency contribution t the pixel response due to previous illumination
IPC	6,7	Single Pixel Reset Firmware
Latency "Volume"	2, **5, 6**	Under FWC related illumination Control the quality of the fit Control the Illumination level and the time delay between the Illumination and dark exposure
Latency "Surface"	2, **7, 8**	Above FWC related illumination Control the quality of the fit slow and fast component Control correlation of the fit parameters Control the Illumination level and the time delay between the Illumination and dark exposure
Intra pixel	2, 5	Spot projector with background control
QE	1, 2, 3, 4, 5	Absolute calibration No concern if only the relative spectral response under flat field
Conversion Gain and CVF	2, 5, 6	PTC per pixel is tricky per channel is easier
Baseline	2, 7, 13, 14, 15, 17	Setting at the beginning of the test campaign sensitive to SCE configuration and Firmware to be check by Telemetry measurement along the experiment.