KWFCデータ解析パイプライン
開発の進捗状況

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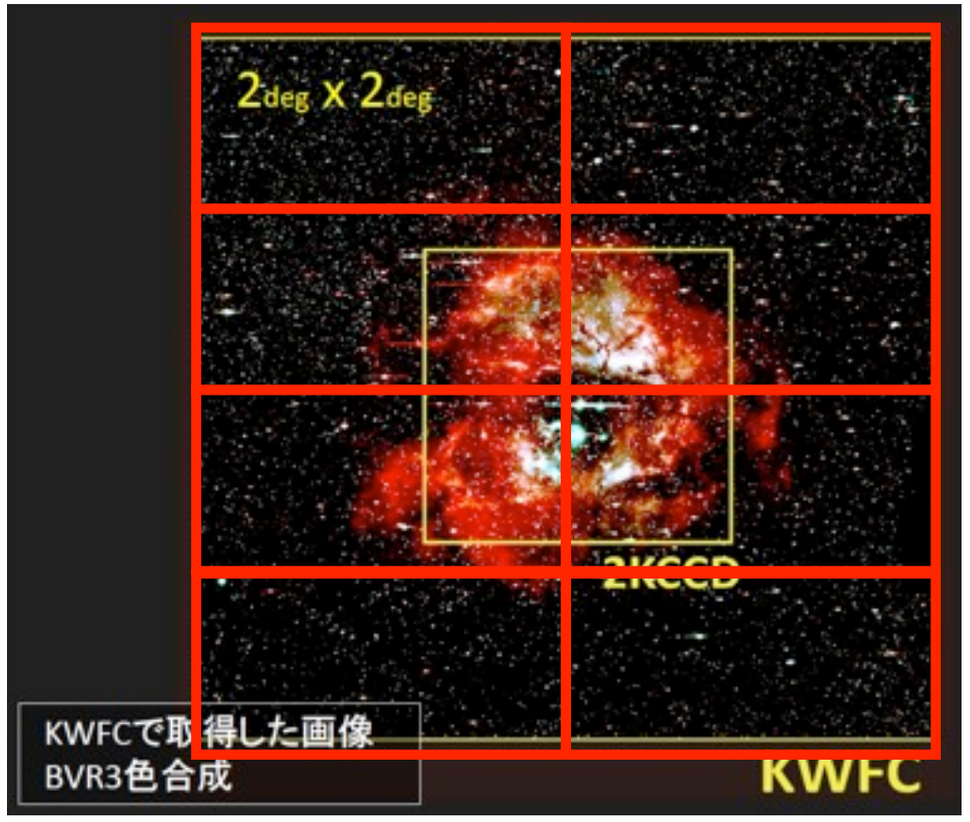
KWFCデータ

- 2k x 4k x 8 CCD (4 MIT + 4 SITe): ~140MB / フレーム

  (1x1 binning, SLOW mode = 8枚読み出し時)
- filter: BVRI, ugi(rz), Hα-on/off: 現在9(+2)枚
- 2deg x 2degという広視野にも関わらずほとんどdistortionなし

  < 1 pixel @ 視野端



KWFCデータ解析パイプライン

- 開発メンバー: Michael Richmond (Rochester Institute of Techonology)、松永典之、諸隈 智貴、家中 信幸(東大・天文センター)、田中 雅臣 (国立天文台)
- 広視野モザイクカメラ
  - すばる望遠鏡主焦点広視野カメラSuprime-Cam
    - 2k x 4k x 10 CCDs
    - データ解析ソフトSDFREDがある
    - ただし、deep survey用に最適化されている
    - 「SDFREDを元にKWFCデータ解析パイプラインを作ろう!!!」
    - engineering観測データを使ってテスト

2011年7月時案

Suprime-Cam reduction

- 画像ファイル名変換・画像確認　namechange.csh
- Bias引き・overscanの切り取り　overscansub.csh
- Flat作り　mask_mkflat_HA.csh
- 感度補正　ffield.csh
- ゆがみ補正・微分大気差補正　distcorr.csh
- PSFあわせ　psfmatch_batch.csh
- Skyの差し引き　skysb.csh
- ~~AG Probeの影をマスク　mask_AGX.csh~~
- 画像のマスク　blank.csh+

1枚ごと

- Matching(組み合わせ規則作り)　makemos.csh
- Mosaicing(組み合わせ)　imcio2a
- 一枚の大きな画像の完成！

10枚まとめて

flux calibration, WCS (astrometry)はこの後: 各自マニュアルで(?)

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KWFC reduction

- 取得データのリスト作成
- bias作り
- bias/overscan引き、overscan切り取り
- フラットフィールド作り
- フラットフィールド
- background測定
- PSFサイズ測定
- sky subtraction
- astrometry (WCS入れ)
- flux calibration (等級ゼロ点、限界等級)

1枚ごと

- stacking w/ SWarp

8枚まとめて

KWFC reduction

- 取得データのリスト作成
- bias作り
- bias/overscan引き、overscan切り取り
- フラットフィールド作り
- フラットフィールド
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- sky subtraction
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- flux calibration (等級ゼロ点、限界等級)

- stacking w/ SWarp

dowhat.pl@パイプライン

```
$do_copy_files = 0;
$do_make_list = 0;
$do_generate_master_bias = 0;
$do_generate_master_flat = 0;
$do_reduce_object_exposures = 0;
$do_measure_background = 0;
$do_measure_psf = 0;
$do_astrom_calib = 1;
$do_sky_subtraction = 0;
$do_measure_zeromaglimmag = 0;
$do_stack_swarp = 0;
```

1枚ごと

8枚まとめて

リアルタイム解析

mode, binningごとに解析

KWFCデータ解析パイプライン

- 使用言語: C, perl(, bash)
- 使用ソフト: wcstools, match (MWR作), xvista (MWR作),
  OPM (松永作),
  http://www.ioa.s.u-tokyo.ac.jp/~nmatsuna/Japanese/software/OPM.html
  SExtractor, SWarp
  http://www.astromatic.net/software/sextractor
  http://www.astromatic.net/software/swarp
- 使用データ: USNO-B1.0, SDSS, Guide Star Catalog(予定)

KWFC fits header

clean_0012302_0.fits

ファイル 編集 フォント

生データ

```
BITPIX  =                  -32 / # of bits per pixel
NAXIS   =                    2 / # of axes in frame
NAXIS1  =                 4100
NAXIS2  =                 2048 / # of bits per pixel
EXTEND  =                    F / Presence of FITS Extension
BZERO   =  0.0                / Reset by div2
BSCALE  =                  1.0 / Real=fits-value*BSCALE+BZERO
BUNIT   = 'ADU     '           / Unit of original pixel values
DATAERR =                    0 / Flag of FITS data error (0:No error)
BIN-FCT1=                    1 / Binning factor of X axis (pixel).
BIN-FCT2=                    1 / Binning factor of Y axis (pixel).
K_RSPEED= 'SLOW    '           / Readout speed of CCDs
K_CDS   = 'CDS     '           / Correlated double sampling process
K_NSMPL =                    1 / # of multi sampling
K_MODE  =                   18 / KWFC readout mode
ORIGIN  = 'Kiso/IoA/U.Tokyo  ' / Institute which created the FITS
OBSERVAT= 'Kiso Observatory  ' / Observatory
TELESCOP= 'Kiso Schmidt      ' / Name of telescope
INSTRUME= 'KWFC    '           / Name of instrument
FMTTYPE = 'KWFC-RAW-OBJECT'    / Format type
FMTVER  = 'Ver20120405'        / [YYYYMMDD] Version of Format type
EXP-ID  = 'KWFC0012302'        / Sequential ID of the exposure
DET-ID  =                    0 / ID of the detector used for this image
FRAMEID = 'KWFC00123020'       / Image number (EXP-ID + DET-ID)
DATA-TYP= 'OBJECT  '           / Data type (OBJECT,SKYFLAT,DOMEFLAT,BIAS,DARK)
OBJECT  = 'KSFJ0905+2024 '     / Identification of object observed
EXPTIME =              180.000 / [s] Exposure time
FILTER01= 'g       '           / Filter name
OBS-MOD = 'Imaging '           / Observation mode
FLAT-LMP= 'OFF     '           / Status of the dome flat lamp (ON|OFF)
FLAT-ND = '1.0     '           / ND filter name for the dome flat lamp
RA      = '09:06.5 '           / Right ascension of telescope pointing
DEC     = '+020:23 '           / Declination of telescope pointing
RADECSYS= 'FK5     '           / The equatorial coordinate system
EQUINOX =              2000.00 / Equinox
ZD      =               43.500 / [deg] Typical Zenith Distance during exposure
ZD-STR  =               43.500 / [deg] Zenith Distance at exposure start
ZD-END  =               44.100 / [deg] Zenith Distance at exposure end
SECZ    =                1.386 / Typical SEC(Zenith Distance)
SECZ-STR=                1.379 / SEC(Zenith Distance) at exposure start
SECZ-END=                1.393 / SEC(Zenith Distance) at exposure end
HA      = '+03:11.2'           / Hour angle (HH:MM.M)
HA-STR  = '+03:06.9'           / Hour angle at exposure start (HH:MM.M)
HA-END  = '+03:09.9'           / Hour angle at exposure end (HH:MM.M)
AZIMUTH =                 82.0 / [deg] Azimuth of the telescope
AZ-STR  =                 82.0 / [deg] Azimuth at exposure start
AZ-END  =                 82.0 / [deg] Azimuth at exposure end
DSLT    =               +78.0 / [deg] Position angle of the dome slit
DSLT-STR=               +78.0 / [deg] Dome position angle at exp start
DSLT-END=               +78.0 / [deg] Dome position angle at exp end
ALTITUDE=               46.200 / [deg] Altitude of the telescope
ALT-STR =               46.500 / [deg] Altitude at exposure start
ALT-END =               45.900 / [deg] Altitude at exposure end
PROP-ID = 'P0002   '           / Proposal ID (CAL for Calibration data)
OBSERVER= 'Mori    '           / Observers name
TIMESYS = 'UTC     '           / Time system used in the header.
DATE-OBS= '2012-05-18'         / Observation start date  (YYYY-MM-DD)
UT      = '11:18:09'           / Medial UTC of the exposure (HH:MM:SS)
UT-STR  = '11:16:38'           / UTC at the start exposure time (HH:MM:SS)
UT-END  = '11:19:41'           / UTC at the end of the exposure (HH:MM:SS)
JST     = '20:18:09'           / Medial JST of the exposure (HH:MM:SS)
JST-STR = '20:16:38'           / JST at the start exposure time (HH:MM:SS)
JST-END = '20:19:41'           / JST at the end of the exposure (HH:MM:SS)
```

ファイル 編集 フォント

```
JST-END = '20:19:41'           / JST at the end of the exposure (HH:MM:SS)
LST     = '12:17.7 '           / Medial LST of the exposure (HH:MM.M)
LST-STR = '12:13.3 '           / LST at the start of the exposure (HH:MM.M)
LST-END = '12:16.4 '           / LST at the end of the exposure (HH:MM.M)
MJD     =          56065.47094 / [d] Mod. Julian Day at the mid exposure
MJD-STR =          56065.46988 / [d] Mod. Julian Day at the exposure start
MJD-END =          56065.47200 / [d] Mod. Julian Day at the exposure end
F-RATIO =                  3.1 / Monochromatic F-Ratio of the camera
FOC-LEN =                 3300 / [mm] Focal length of the telescope
FOC-VAL =                25.00 / [mm] Encoder value of the focus unit
DETECTOR= 'MIT:10-10-5'        / Name of the detector/CCD
GAIN    =                 2.05 / [electron/ADU] AD conversion factor
RNOISE  =                  6.8 / [electron] Readout noise
EFP-MIN1=                   47 / Start X position of effective data region
EFP-MIN2=                   27 / Start Y position of effective data region
EFP-RNG1=                 4100 / X range of effective data region
EFP-RNG2=                 2048 / Y range of effective data region
DOM-TMP =               287.85 / [K] Temperature at the dome floor
DOM-HUM =                 42.0 / Relative humidity at the dome floor (percent)
TEL-TMP =               283.15 / [K] Temperature in the telescope
TEL-HUM =                 50.0 / Relative humidity in the telescope (percent)
DET-TMP =               167.97 / [K] Detector temperature
OUT-TMP =               279.45 / [K] Temperature measured outside the dome
OUT-HUM =                 64.6 / Relative humidity outside the dome (percent)
OUT-WANG=                  357 / [deg] Wind direction
OUT-WND =                  1.1 / [m/s] Wind speed
OUT-PSR =                886.6 / [hPa] Air pressure
SKYIRTMP=               251.05 / [K] Infrared sky temperature
WCS-ORIG= 'KWFC Pipeline Software'   / WCS origin
CUNIT1  =             0.000000 / Unit used in both CRVAL1 and CDELT1
CUNIT2  =             0.000000 / Unit used in both CRVAL2 and CDELT2
LONPOLE =                  180 / [deg] Native longitude of celestial pole
HISTORY  subtracted overscan Mon Jul  9 04:43:33 2012
HISTORY  trimmed overscan Mon Jul  9 04:43:34 2012
HISTORY  effective region [26:2073,46:4145]
HISTORY  sub bias master_bias_0_1x1_SLOW.fits Mon Jul  9 04:43:35 2012
SUBBIAS = 'master bias 0 1x1 SLOW.fits' / subtracted bias fits
HISTORY  div flat master_domeflat_g_0_1x1_SLOW.fits Mon Jul  9 13:43:36 2012
DIVFLAT = 'master domeflat g 0 1x1 SLOW.fits' / divided flat fits
HISTORY  measured background mean (top)  544.0 Mon Jul  9 04:44:05 2012
HISTORY  measured background rms (top)   13.1 Mon Jul  9 04:44:05 2012
HISTORY  measured background mean (btm)  530.0 Mon Jul  9 04:44:05 2012
HISTORY  measured background rms (btm)   12.8 Mon Jul  9 04:44:05 2012
BGAVETOP=                544.0 / background count average in top amplifier
BGRMSTOP=                 13.1 / background count rms in top amplifier
BGAVEBTM=                530.0 / background count average in bottom amplifier
BGRMSBTM=                 12.8 / background count rms in bottom amplifier
HISTORY  number of stars and measured PSF (top)   92  5.60
HISTORY  number of stars and measured PSF (btm)   83  5.55
PSF-TOP =                 5.60 / PSF size in top amplifier in pixel
PSF-BTM =                 5.55 / PSF size in bottom amplifier in pixel
PSFR-TOP=                 0.13 / PSF rms in top amplifier in pixel
PSFR-BTM=                 0.10 / PSF rms in bottom amplifier in pixel
PSF2-TOP=                 5.31 / PSF size in top amplifier in arcsec
PSF2-BTM=                 5.27 / PSF size in bottom amplifier in arcsec
PSF2R-TP=                 0.12 / PSF rms in top amplifier in arcsec
PSF2R-BT=                 0.10 / PSF rms in bottom amplifier in arcsec
CTYPE1  = 'RA---TAN'           / Pixel coordinate system
CTYPE2  = 'DEC--TAN'           / Pixel coordinate system
CRPIX1  =             2097.825 / Reference pixel in X [pixel]
CRPIX2  =              613.235 / Reference pixel in Y [pixel]
CD1_1   =       -2.627886e-04 / WCS matrix [1,1]
CD1_2   =        6.904833e-07 / WCS matrix [1,2]
CD2_1   =        7.311000e-07 / WCS matrix [2,1]
CD2_2   =        2.627081e-04 / WCS matrix [2,2]
CRVAL1  =          135.860965 / Physical value of the reference pixel X
CRVAL2  =           19.616727 / Physical value of the reference pixel Y
OPM_NMAT=                 214 / # of matched stars in the OPM analysis
OPM_RES1=               0.184 / Residual X of matched coordinates
OPM_RES2=               0.181 / Residual Y of matched coordinates
WCSSCS  =                   1 / WCS succeeded (1) or failed (0)
HISTORY   combining 2 images
HISTORY  Sky subtracted by skysb3b (SDFRED), mesh 256x256 sky
HISTORY  subtracted sky ave (top)   546.924
HISTORY  subtracted sky rms (top)    12.225
HISTORY  subtracted sky ave (btm)   532.548
HISTORY  subtracted sky rms (btm)    11.711
ZEROMAG =                21.75 / zeropoint magnitude (for 1 [count/sec])
NZEROMAG=                 188 / number of objects for ZEROMAG calculation
SN5MAG  =                19.71 / S/N=5 magnitude
NSN5MAG =                   2 / number of objects for SN5MAG calculation
HISTORY  zeropoint magnitude  21.75 (for 1 [count/sec])
HISTORY  zeropoint magnitude 188 objects used
HISTORY  S/N=5 magnitude  19.71
HISTORY  S/N=5 magnitude 2 objects used
END
```

解析で追加・変更

KWFCデータ解析パイプライン

- ほぼ完成
  - 混んだ領域のastrometry
  - Johnson-Cousinsフィルター、狭帯域フィルターデータのflux calibration
  - 広がった天体に対するsky subtraction
  - SWarpの実装の改良
  - マニュアル整備
- ~3-4分 / frame (8枚読み出し、1x1 binning) @ orihime
- astrometry: ~0.2 arcsec rms
- リアルタイム解析
  - データ取得後、すぐにパイプライン解析、stacking以外を行う

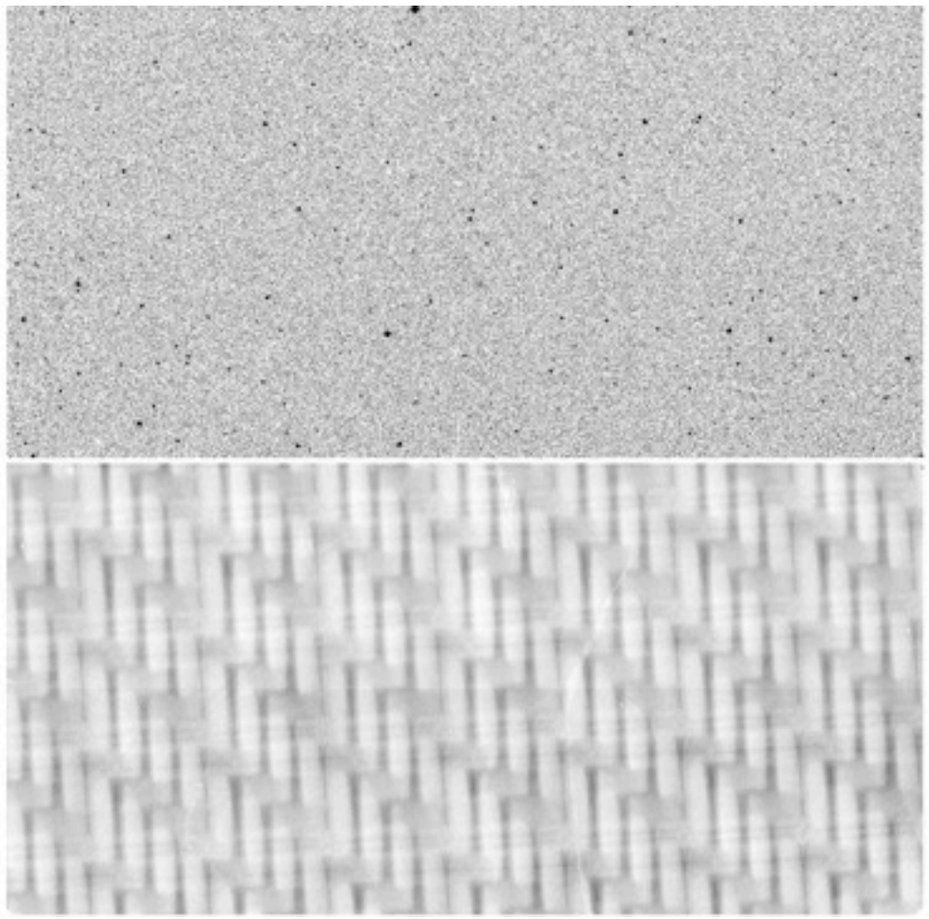
    --> mysqlで結果を管理、phpでブラウザ表示

flat-fielding (uバンド)

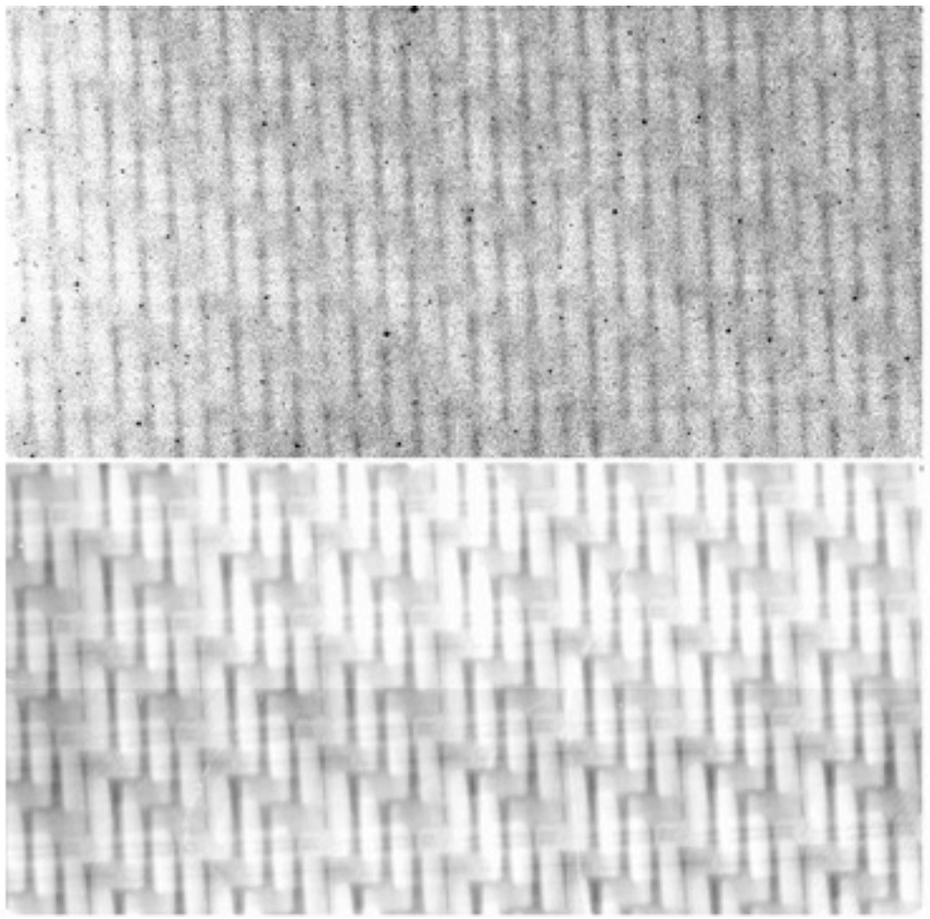
SITe	SITe
SITe	SITe
MIT	MIT
MIT	MIT

- 短波長側のフィルターでの板チョコ模様@chip 1

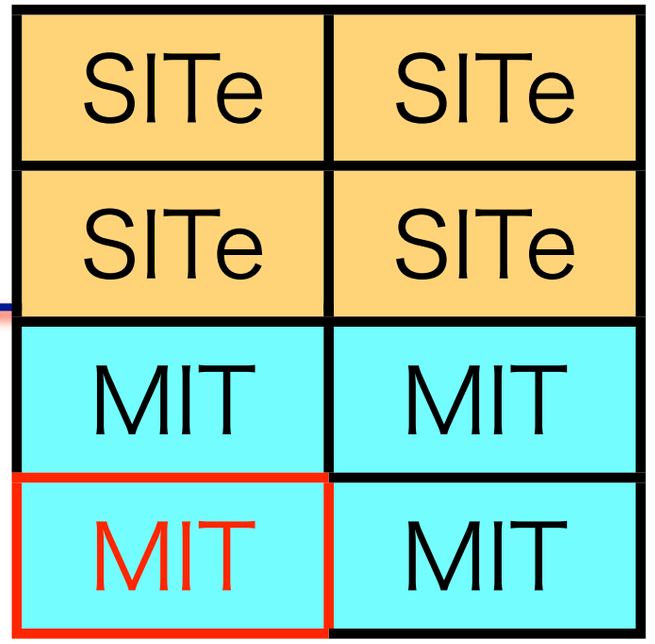
sky flat



dome flat

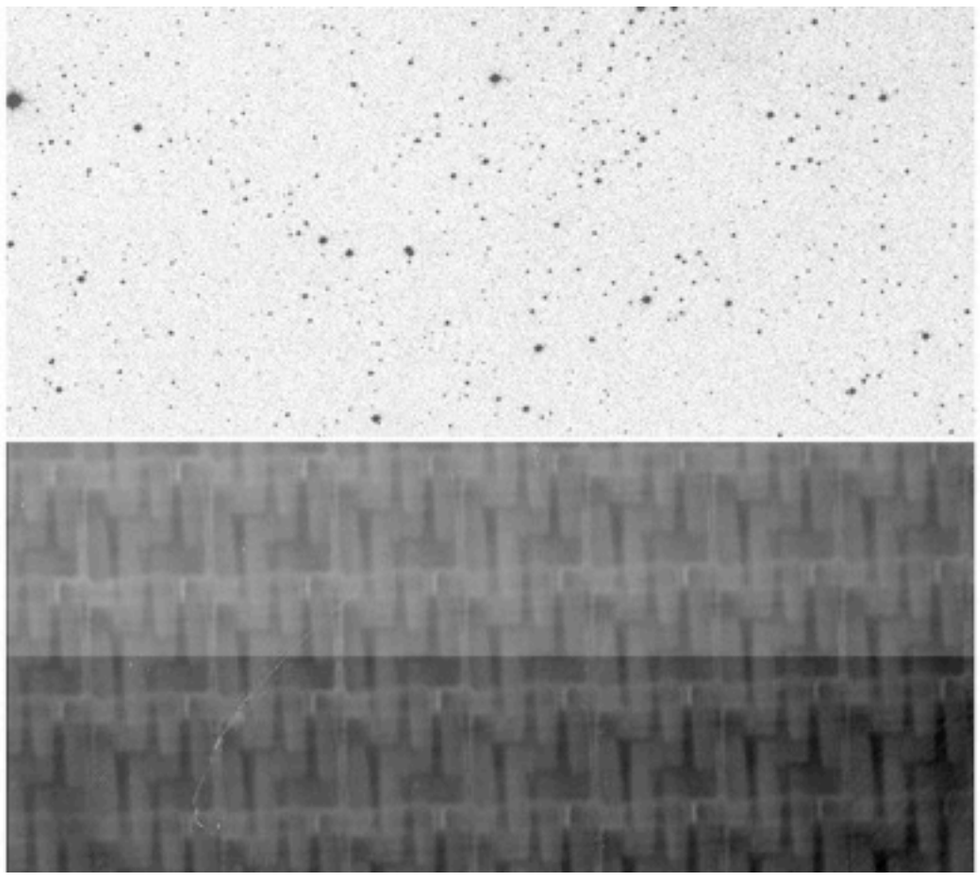


flat-fielding (gバンド)

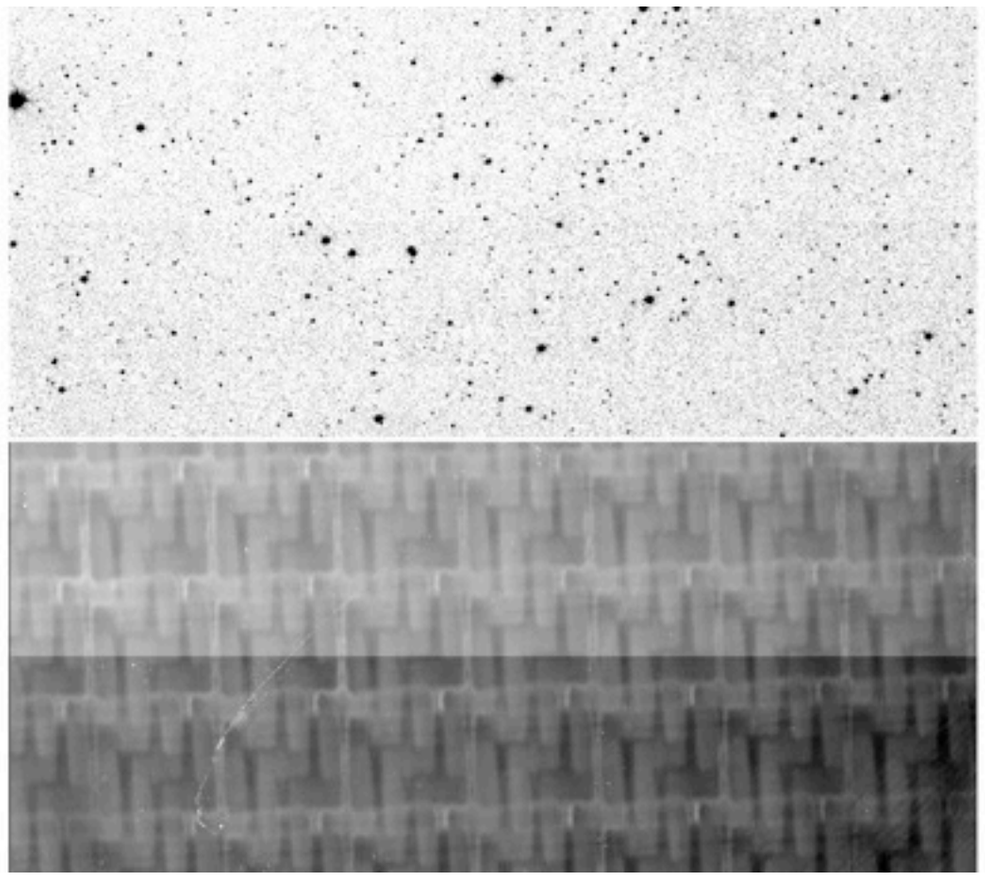


- 短波長側のフィルターでの板チョコ模様@chip 1

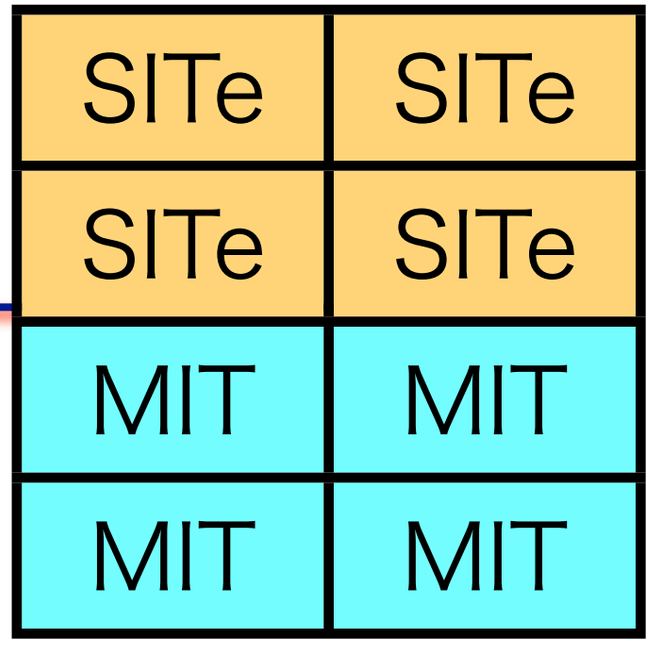
sky flat



dome flat

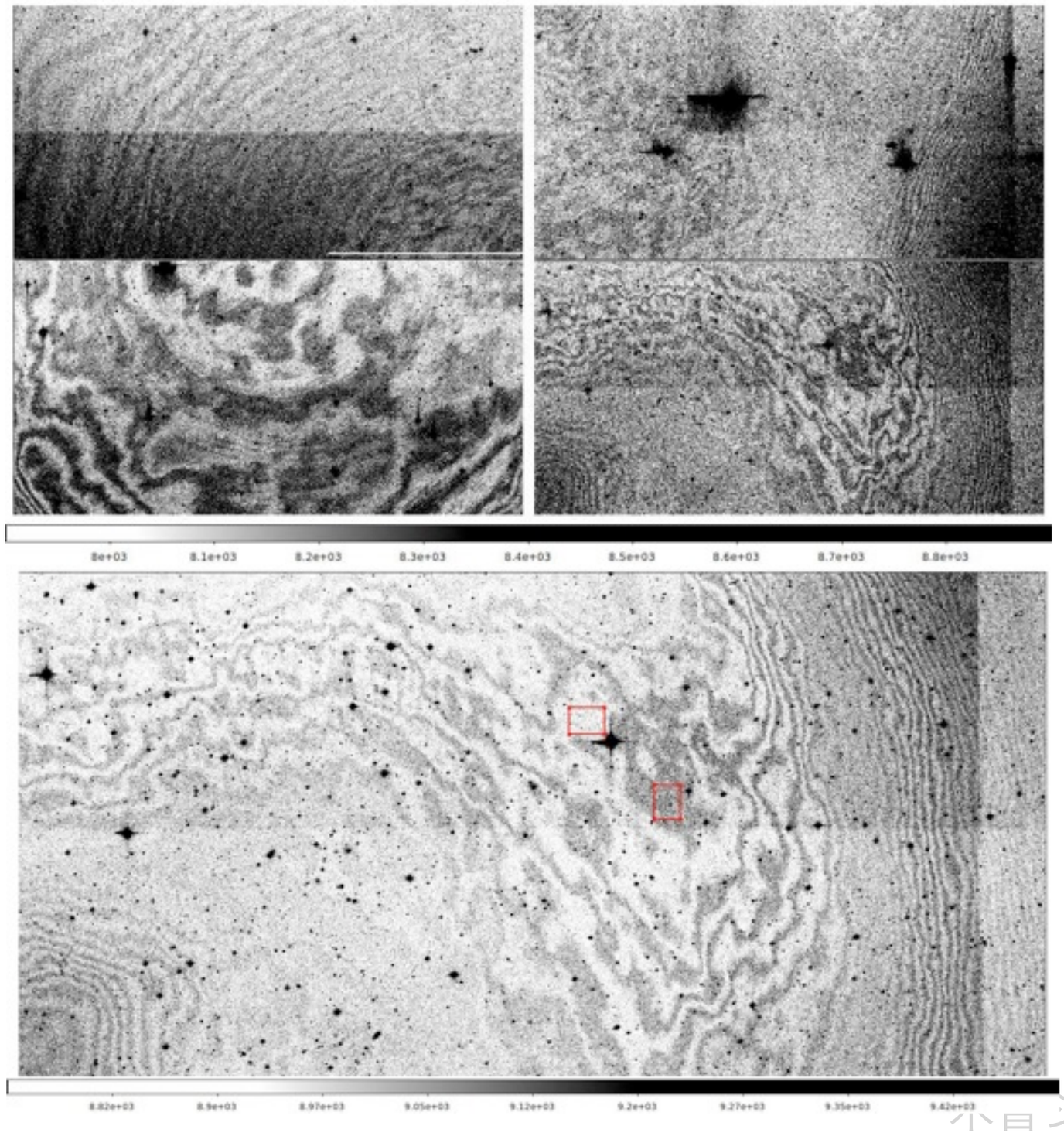


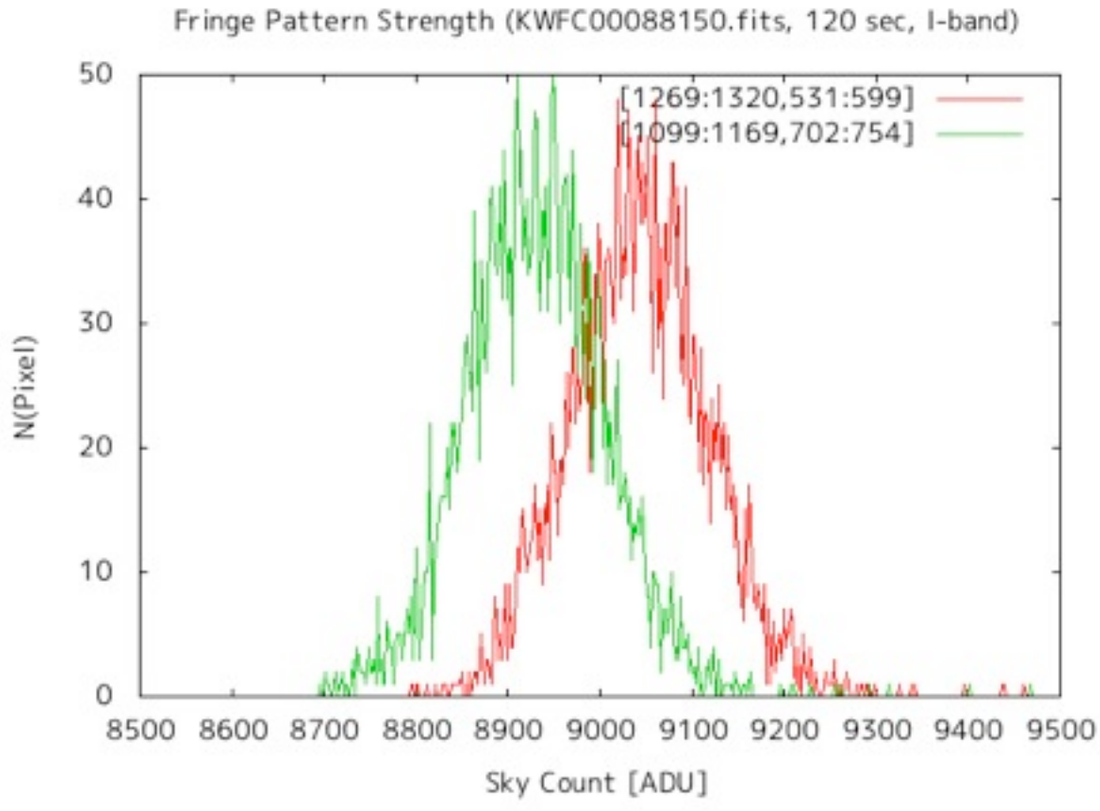
注意事項



- CCD 1はuバンドでの感度が他のCCDの1/10程度。
  - astrometryもあまりできない。
- uバンドはSITeの方がMITの1-2倍感度がよい。
- 特にu,g(,B?V?)バンドはドームフラットだとフラットパターンが消えない。天体データを使ってスカイフラットを作るべし。
  - u: ~0.01-0.1 [ADU/sec/pixel]
  - g: ~1 [ADU/sec/pixel]
  - Ic: ~10 [ADU/sec/pixel]

Fringe


8e+03
8.1e+03
8.2e+03
8.3e+03
8.4e+03
8.5e+03
8.6e+03
8.7e+03
8.8e+03
8.82e+03
8.9e+03
8.97e+03
9.05e+03
9.12e+03
9.2e+03
9.27e+03
9.35e+03
9.42e+03


Fringe Pattern Strength (KWFC00088150.fits, 120 sec, I-band)
[1269:1320,531:599]
[1099:1169,702:754]
N(Pixel)
Sky Count [ADU]
0
10
20
30
40
50
8500
8600
8700
8800
8900
9000
9100
9200
9300
9400
9500

calibration data

- bias, flat-field, dark (不要)
- PROP-ID="CAL"で取得後すぐに全ユーザ使用可能。
- 観測用PC(encke)のどこかに置きます。

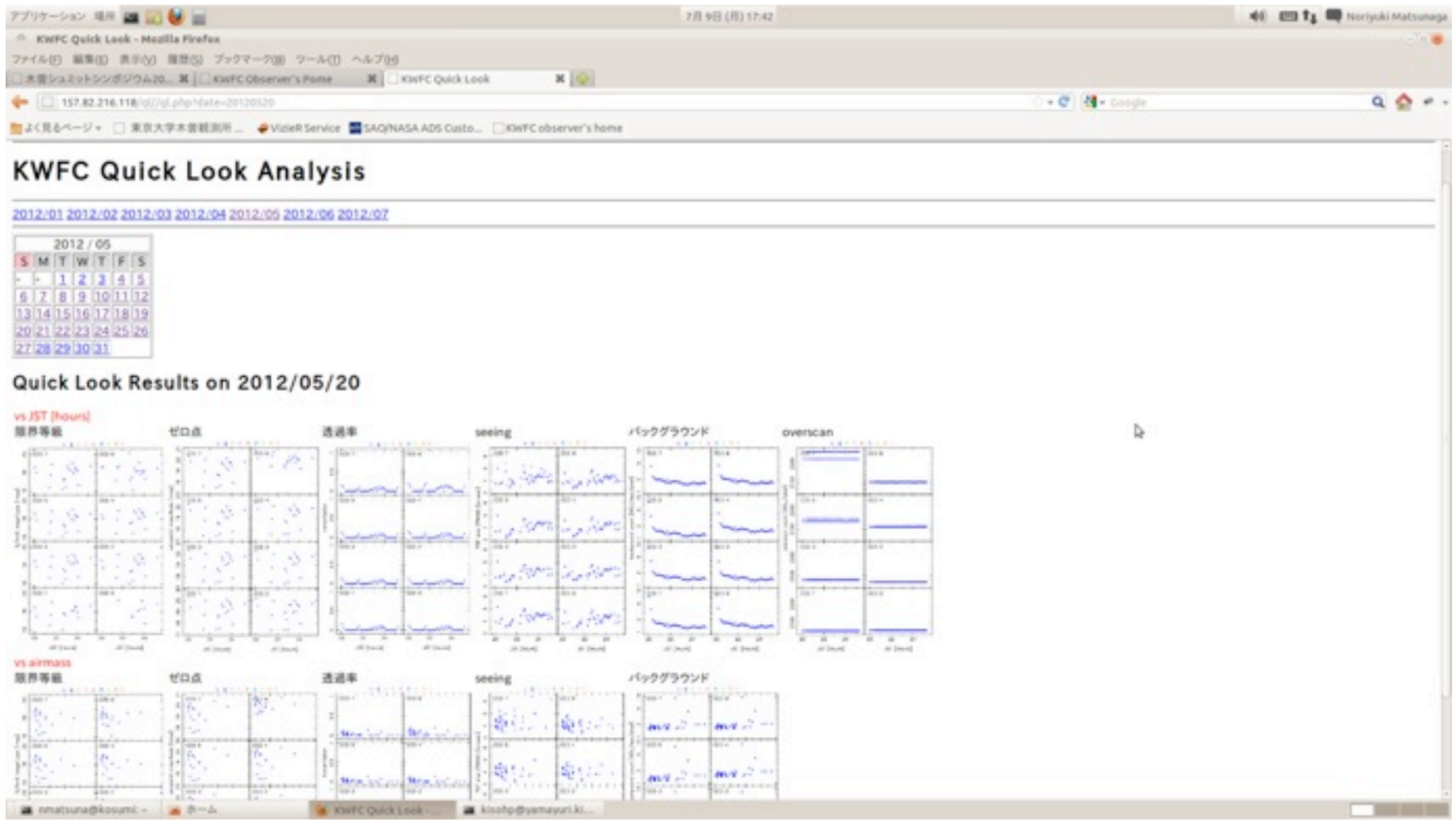
リアルタイム解析

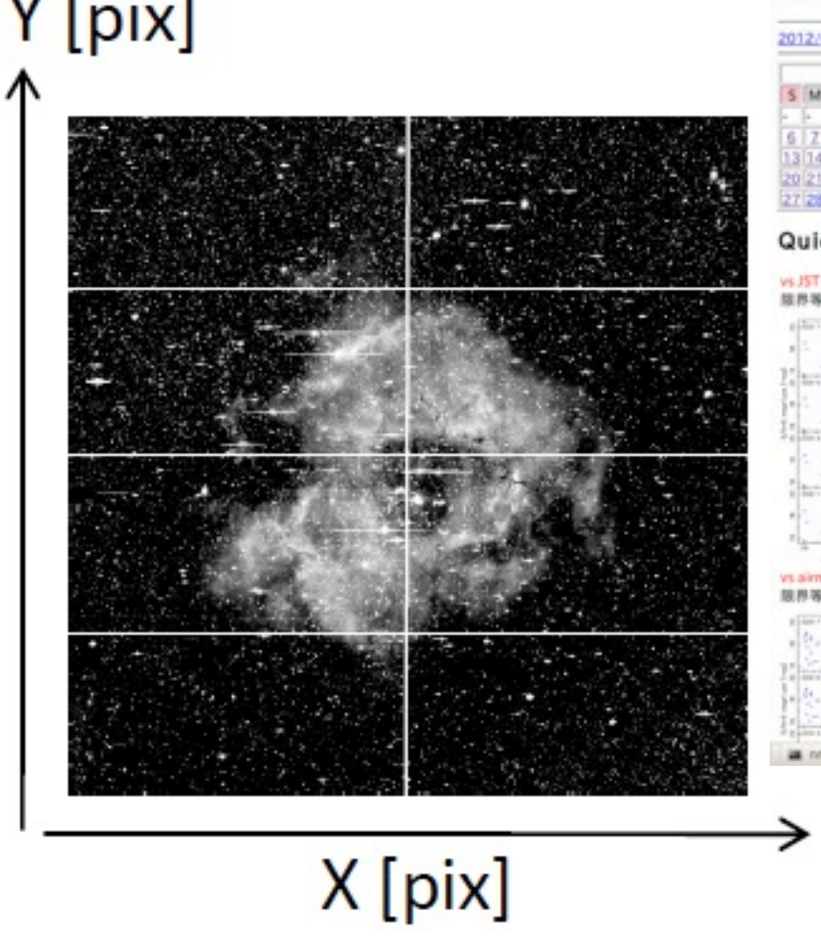
- データ読み出し後、すぐに解析
  - seeing
  - transmission
  - background
  - …

観測用PC(encke)の

~/kwfc_data[1/2]/[yyyymmdd]/clean

の下にあります





157.82.216.118/ql//ql.php?date=20120520

よく見るページ ▾ 東京大学木曽観測所 ... VizieR Service SAO/NASA ADS Custo... KWFC observer's home

KWFC Quick Look Analysis

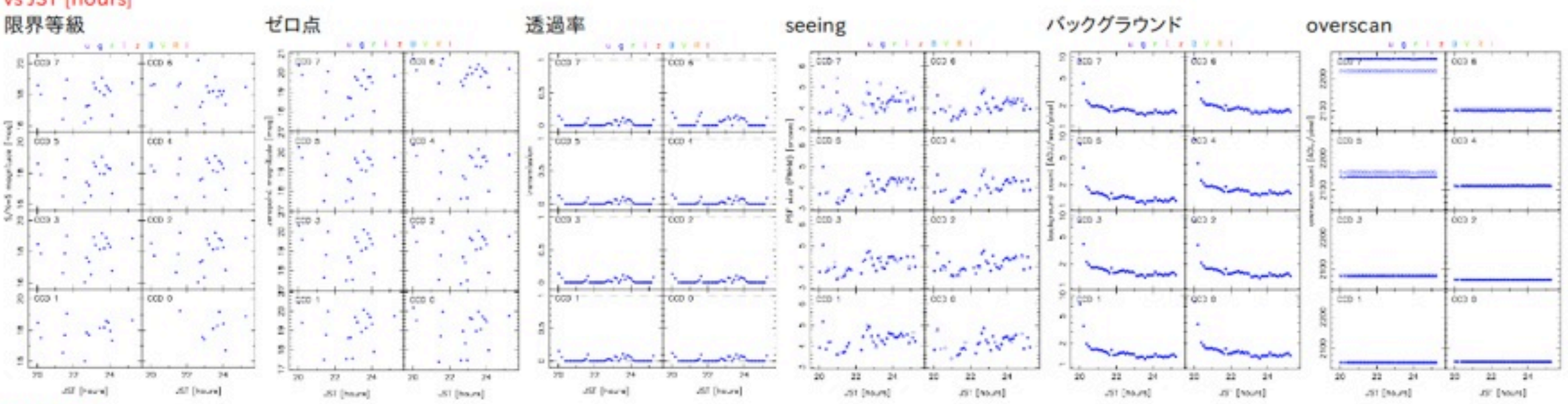
2012/01 2012/02 2012/03 2012/04 2012/05 2012/06 2012/07

2012 / 05						
S	M	T	W	T	F	S
-	-	1	2	3	4	5
6	7	8	9	10	11	12
13	14	15	16	17	18	19
20	21	22	23	24	25	26
27	28	29	30	31		

Quick Look Results on 2012/05/20

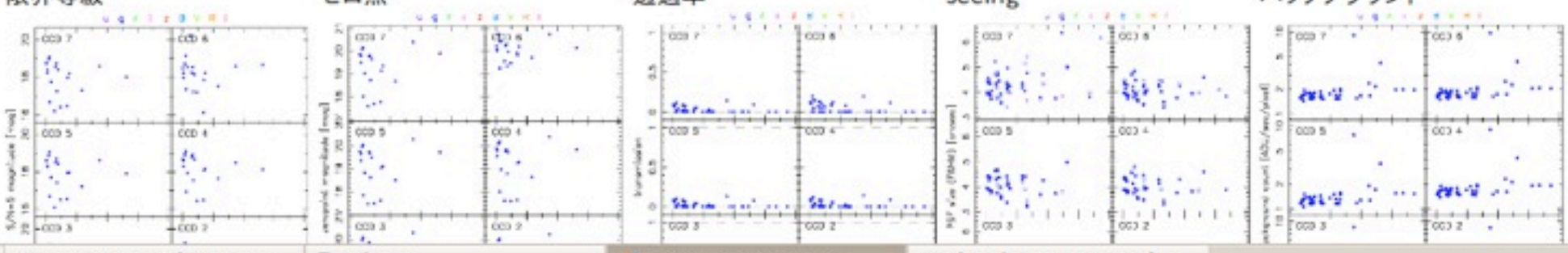
vs JST [hours]

限界等級 ゼロ点 透過率 seeing バックグラウンド overscan



vs airmass

限界等級 ゼロ点 透過率 seeing バックグラウンド



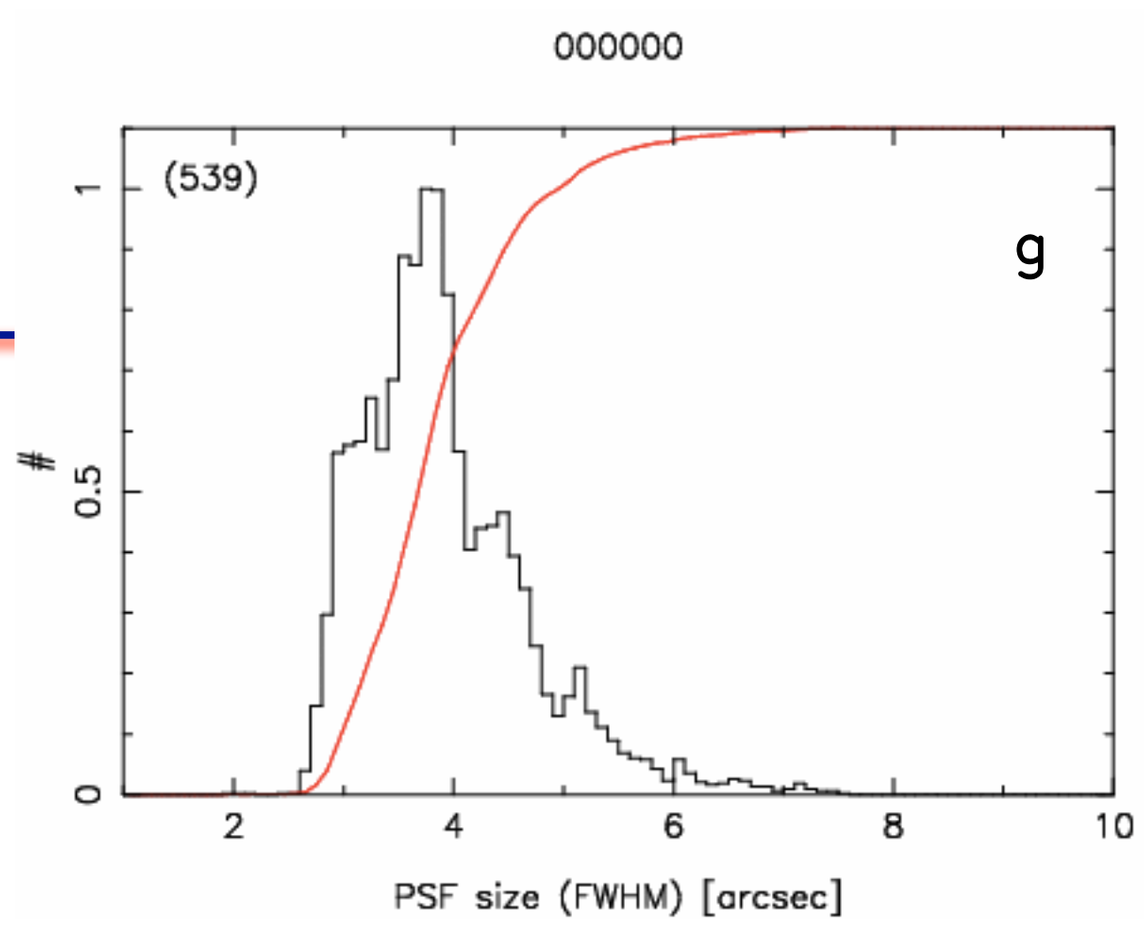
nmatsuna@kosumi: ~ ホーム KWFC Quick Look - ... kisohp@yamayuri.ki...

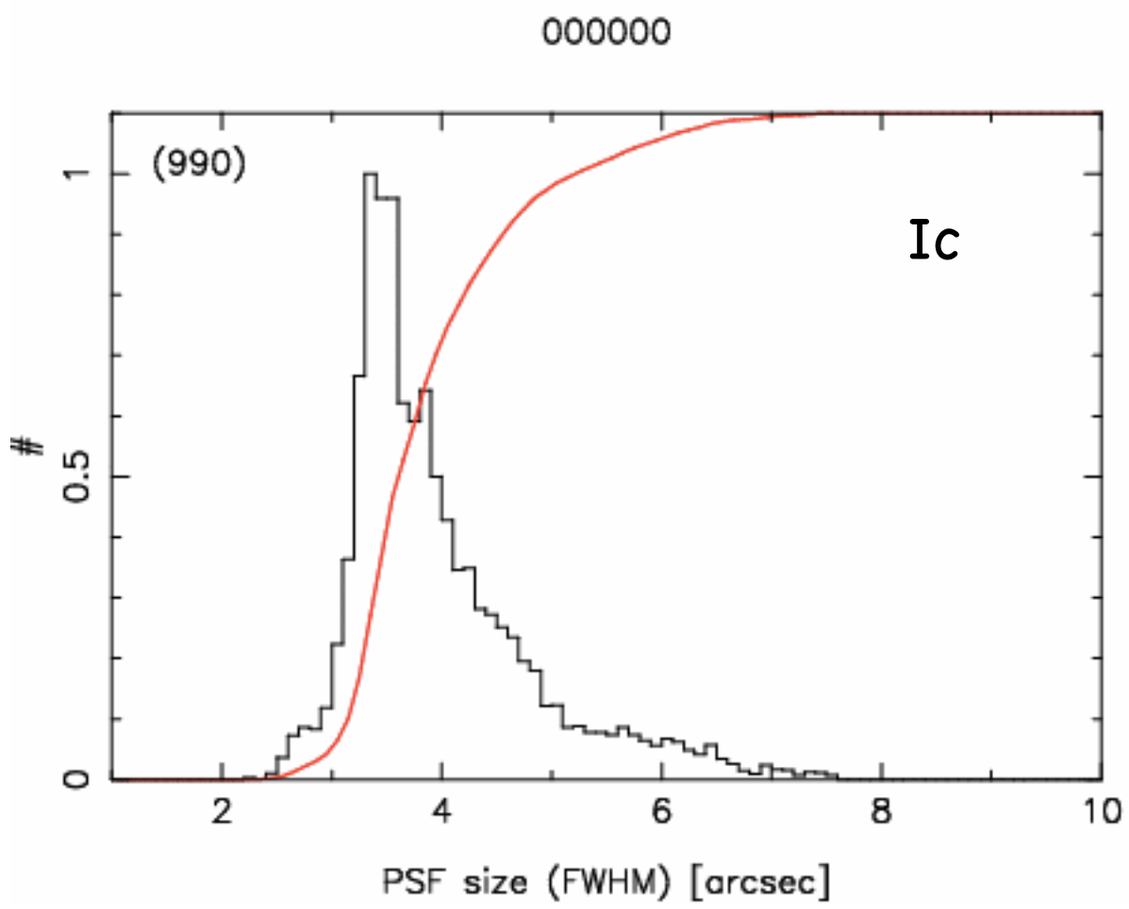
X [pix]

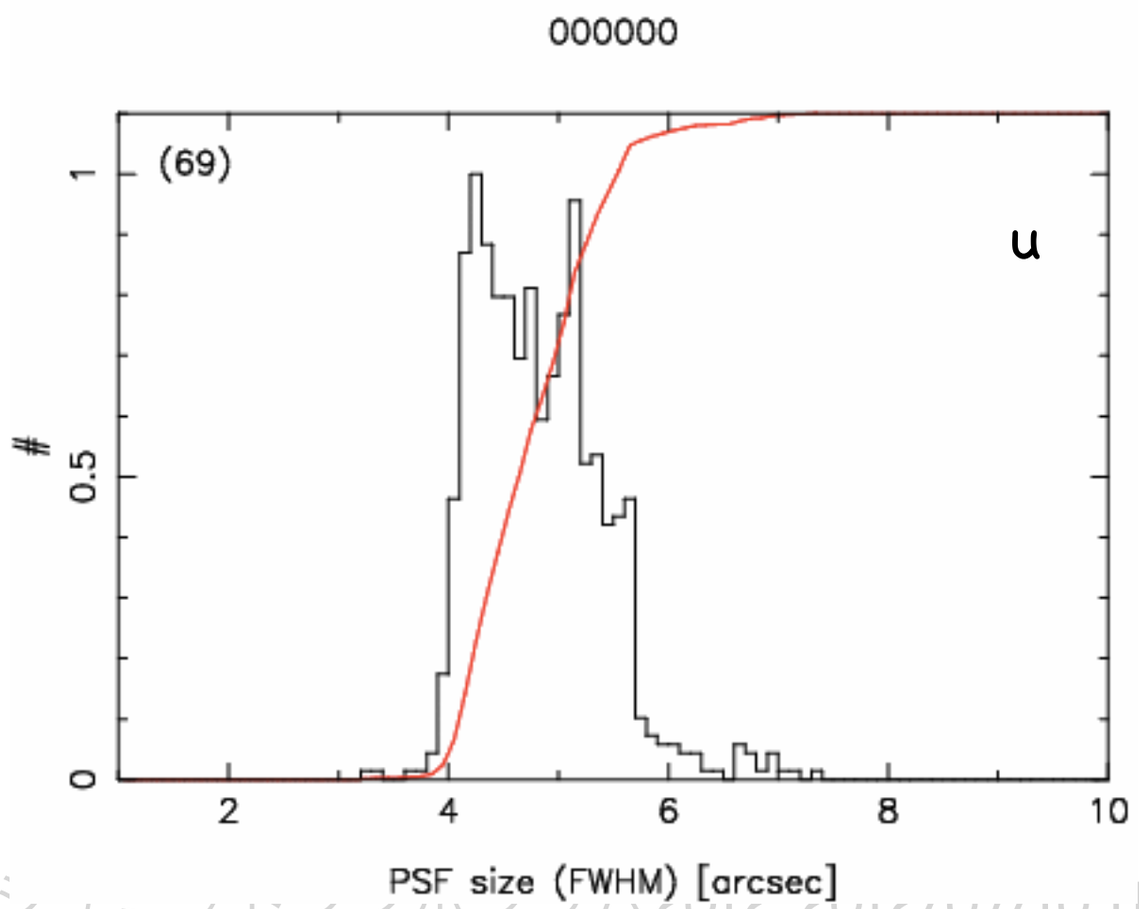
seeing統計

g, Ic: 4 arcsec弱

u: 4-5 arcsec? (統計小)







データの受け渡し

+ 観測所まわりのネットワークは細い。ネットワーク転送は当面は難しい。
+ 取得したデータを持ち帰るためにUSB HDDを持ってきてください。

約30GB/晩 (晴れると1晩200ショット程度)

観測@木曽

1回/1ヶ月

データ輸送 by 人

観測18ヶ月後にSMOKAへ

web公開@天文センター

(アクセス制限あり)

議論中

まとめ

- 2kCCDからの大きな変更点: CCD1枚 --> CCD8枚。
- ほぼ全自動のデータ解析パイプラインほぼ完成。
- 整備期間中にマニュアルとともに公開したい。
- リアルタイム解析システム(観測条件のモニタ等)構築