XMM-Newton CDF-S sources vs. Chandra 4Ms & E-CDF-S sources

Francisco J. Carrera, Cristian Vignali, ...

XMM-CDF-S meeting, Cervia, 31-May-2012

Summary of work

- Cross-correlation using Likelihood Ratios
  - Merging of all available information
- Generation of Bayesian SNR map (2-10keV)
- Generation of finding charts
- FITS files and web page
- Iterations with Cristian Vignali:
  - (Objective) criteria about blending of Chandra sources to form a XMM-Newton source
  - (Objective) criteria about “new” XMM-Newton sources

Starting catalogues

- XMM-Newton:
  - pwxd-eml-merged-2-10-3-4sigma.fits (411 sources):
    - Includes: `RA,Dec, RA_err, PWXD_Signif, Exp_time, Offax, DET_ML, FLUX, REDSHIFT`
    - Added: `num_X, FLUX28`
  - SUMMARY.Jan2012.txt (189 sources)
    - Includes: `zOABo,OABoNotes`

- Chandra:
  - CDF-S: Xue+11 Tables 3,6 (Supplementary +1000)
  - E-CDF-S: Lehmer+05 Tables 2,6 (Supplementary +1000)
    - Includes: info. on optical/NIR/MIR/VLA counterparts (Xue+11, Silverman+10)
    - Includes: `RA,Dec,errpos,HFlux,dCX,zadopt`
    - Added: `n_C, ID` (E-CDF-S:E), `localDens` ($N(>S)$ Luo+10)

Cross-correlation using Likelihood Ratios (Pineau+11)

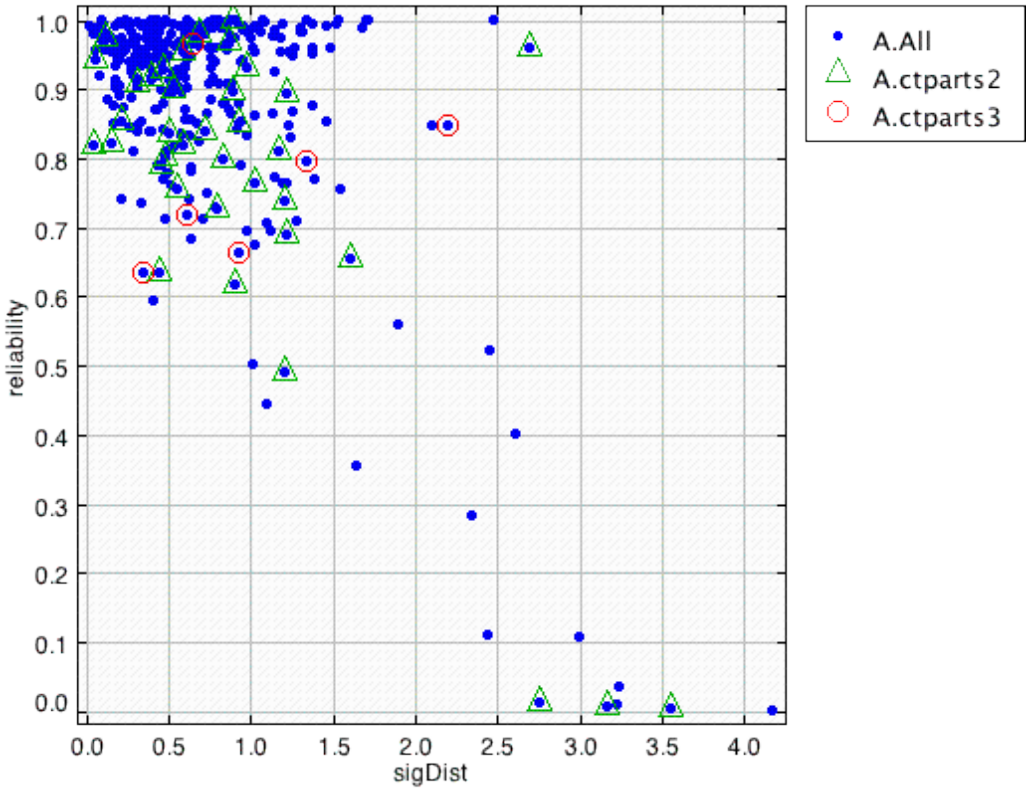
- If r is mutual distance, σ is combined positional error and λ is `localDens`:

$$LR \propto \exp(-r^2/2\sigma^2)/2\lambda$$

- $LR \Rightarrow P$ using simple constant prior $P(H_{\rm cp})$:
  - from iterative procedure
- For each pair XMM-Newton - Chandra (`XCID`):
  - `angDist`: r
  - `sigDist`: r/σ
  - `reliability`: P (independently for all pairs for same XMM)
- Merged CDF-S 4Ms,E-CDF-S, removed duplicates
- Setting "Good" pairs as `reliability`≥0.7
  - Ignoring pairs with $P/P_{\rm max}<0.03$ (chosen "by eye")
  - Ignoring pairs for XMMsou with `RA_err`>> (5 sou)

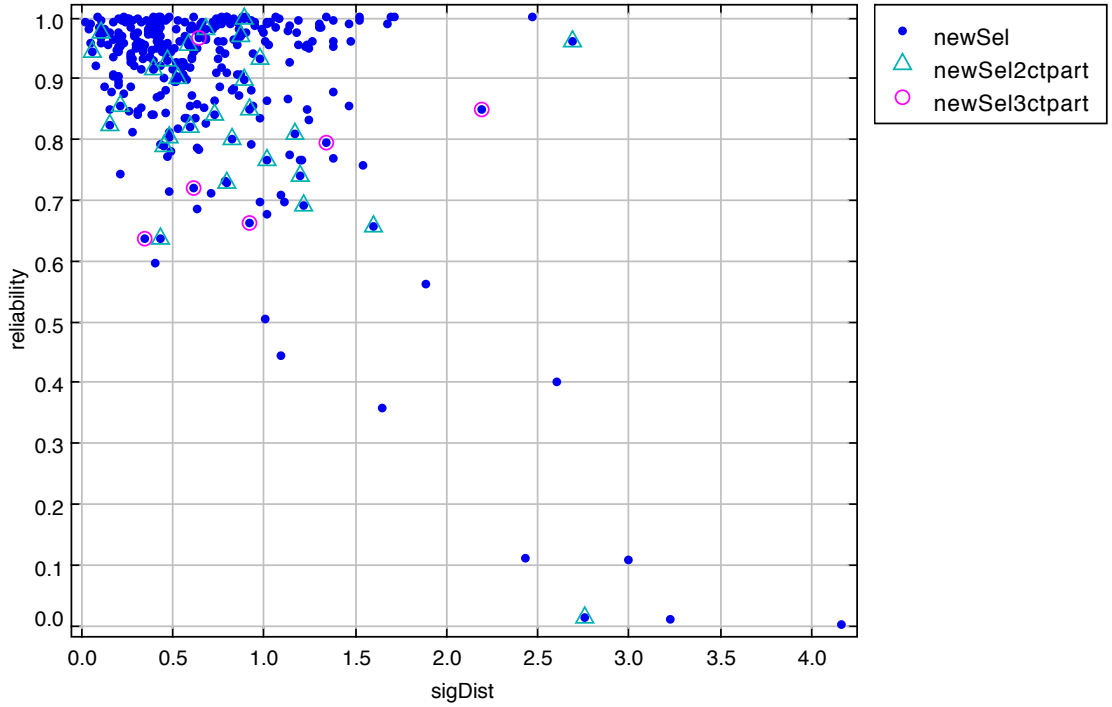
X-corr using Likelihood Ratios: results

- Out of the 411 XMM sources:
  - 58: no Chandra counterpart
    - 6 outside Chandra 4Ms & E-CDF-S
    - Checking rest (see later and Cristian's talk)
  - 353: ≥1 Chandra counterpart ($P/P_{max}>0.03$)
    - 310: 1 ctpart
    - 37: 2 ctparts
    - 6: 3 ctparts
  - 326/353 (92%): $P_{max}\geq 0.7$
  - 297/353 (84%): $P_{max}\geq 0.8$
  - 232/353 (66%): $P_{max}\geq 0.9$



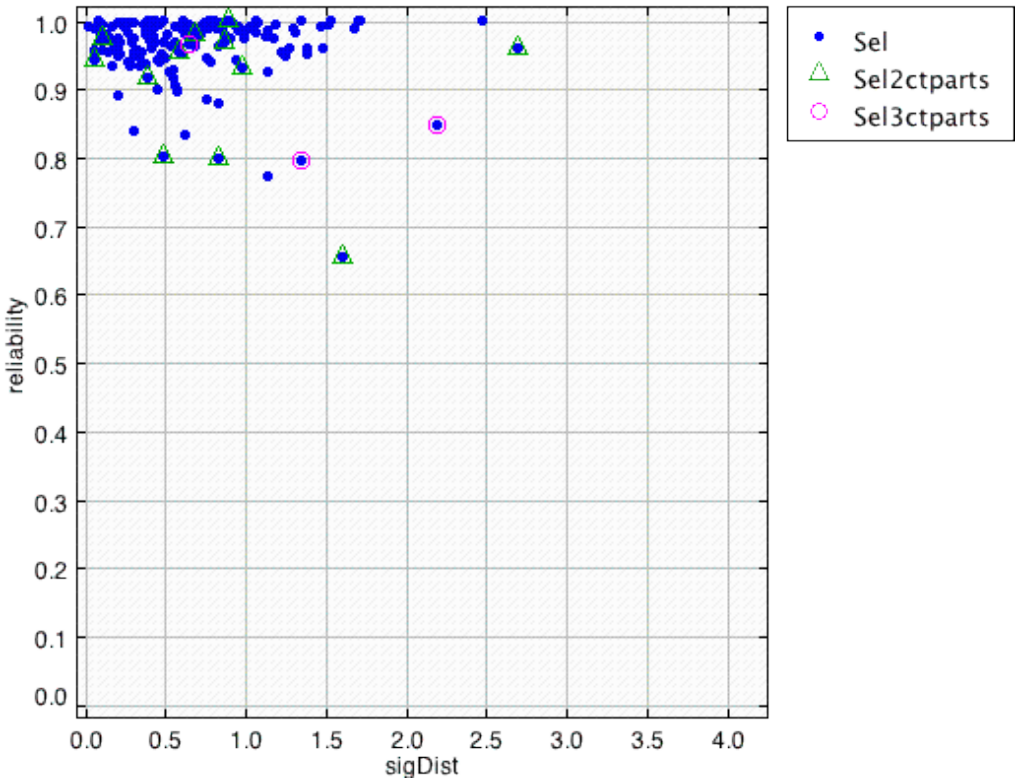
X-corr using Likelihood Ratios: results

- 337 XMM sources with `PWXD_Signif`≥4, `DET_ML`≥4.6:
  - 18: no Chandra counterpart
  - 319: ≥1 Chandra counterpart ($P/P_{max}>0.03$)
    - 303: 1 ctpart
    - 28: 2 ctparts
    - 6: 3 ctparts
  - 299/319 (94%): P_{max}≥0.7
  - 276/319 (87%): P_{max}≥0.8
  - 218/319 (68%): P_{max}≥0.9



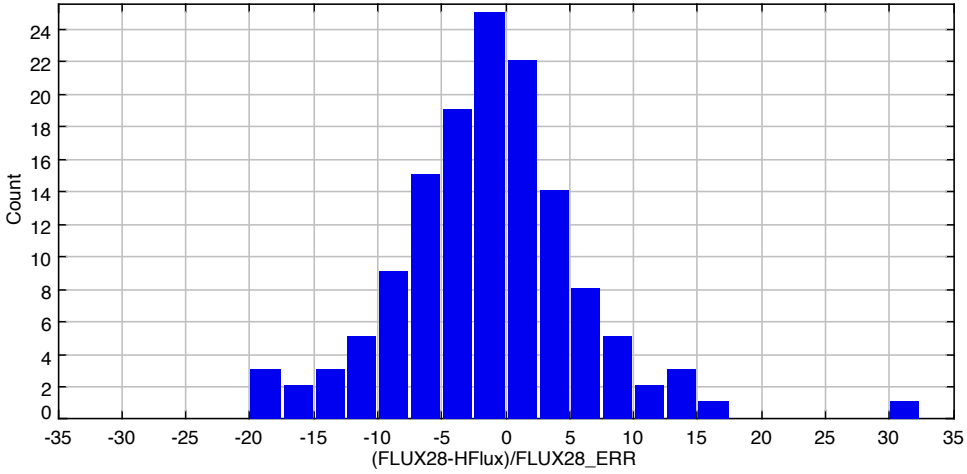
X-corr using Likelihood Ratios: results

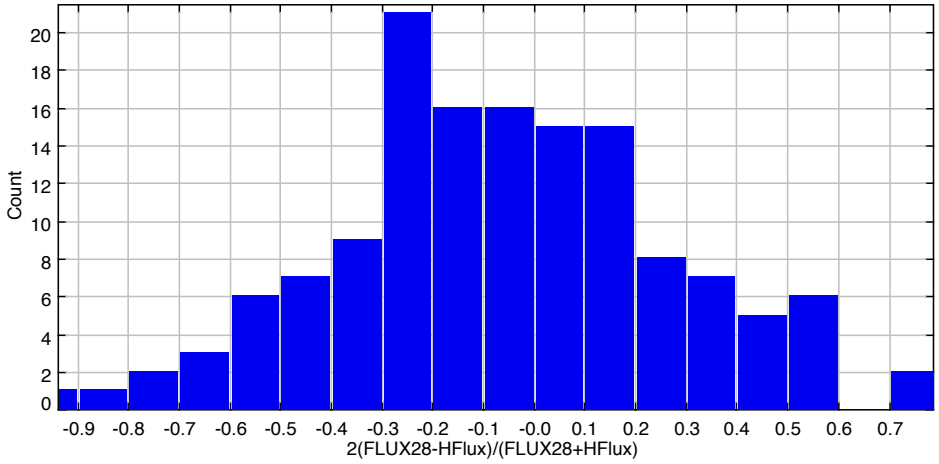
- 171 XMM sources with `PWXD_Signif`≥8, `Exp_time`≥10^6s:
  - 0: no Chandra counterpart
  - 171: ≥1 Chandra counterpart ($P/P_{max}>0.03$)
    - 156: 1 ctpart
    - 12: 2 ctparts
    - 3: 3 ctparts
  - 170/171 (99%): P_{max}≥0.7
  - 167/171 (98%): P_{max}≥0.8
  - 157/171 (92%): P_{max}≥0.9
  - 147/171: P_{max}≥0.9 & 1 ctpart
    - let's do some statistics...



Statistics on “good quality counterparts”

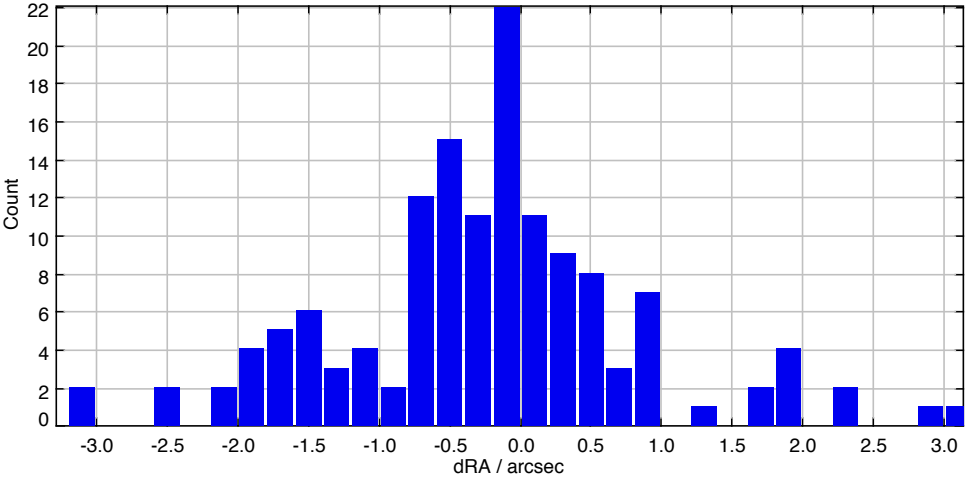
- PWXD_Signif≥8, Exp_time≥10^6s, P≥0.9, single ctpart: 147
  - (FLUX28-HFlux)/FLUX28_ERR = $N(0,1)$?
    - One sou. FLUX28>10^{-13}cgs ⇒ Using only FLUX28<10^{-13} cgs & Chandra det. (140)
    - Average: -1.2
    - Standard Deviation=7.1
  - 2(FLUX28-HFlux)/(FLUX28+HFlux) (140):
    - Average: -0.06
    - Standard Deviation: 0.33

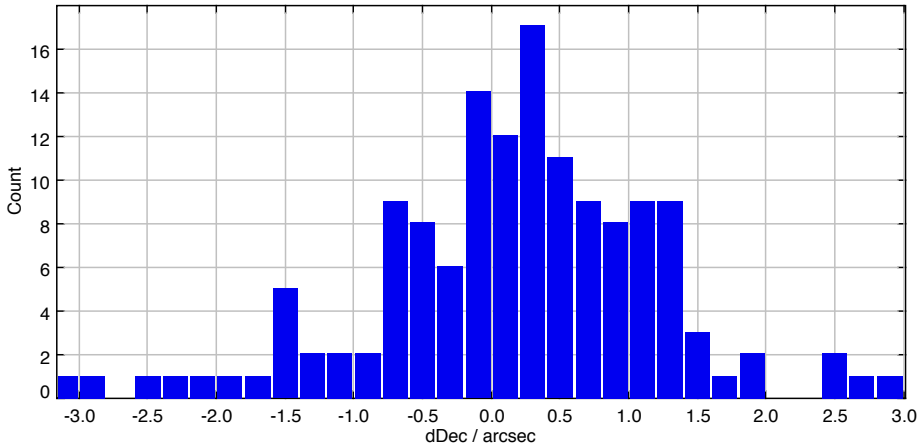




Statistics on “good quality counterparts”

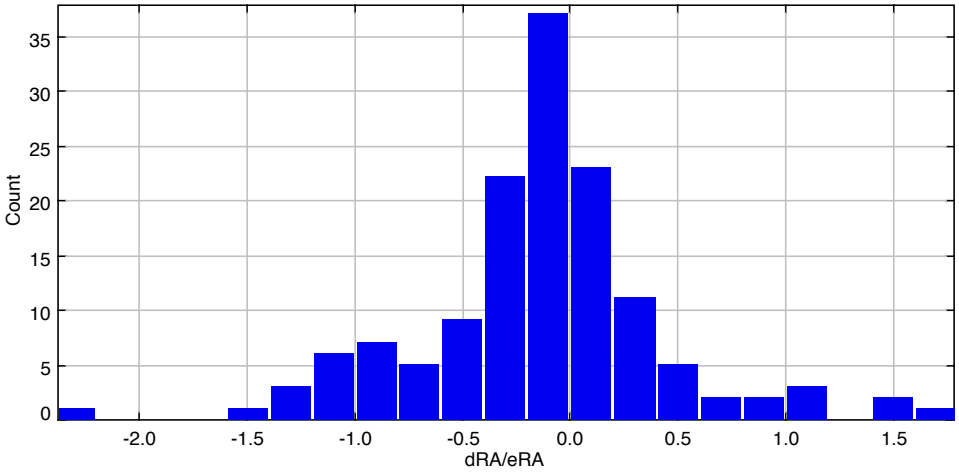
- PWXD_Signif≥8, Exp_time≥10^6s, P≥0.9, single ctpart: 147
- Using only FLUX28<10^{-13} cgs & Chandra det.:140
  - dRA=(RA_X-RA_C)*cos(Dec_X)*3600:
    - Average: -0.23 (normalizing to combined angular pos. err.: -0.13)
    - Standard Deviation=1.07 (0.58)
  - dDec=(Dec_X-Dec_C)*3600:
    - Average: 0.17 (0.10)
    - Standard Deviation: 1.03 (0.49)

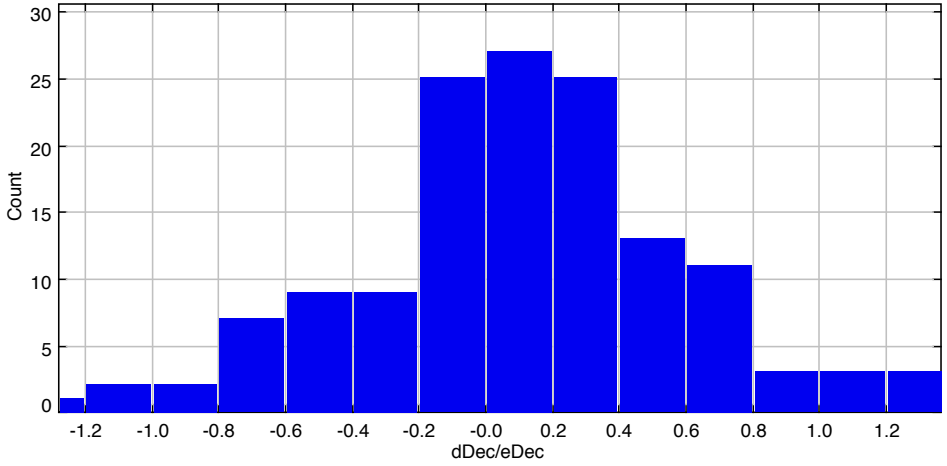




Statistics on “good quality counterparts”

- PWXD_Signif≥8, Exp_time≥10^6s, P≥0.9, single ctpart: 147
- Using only FLUX28<1E-13 cgs & Chandra det.:140
  - dRA=(RA_X-RA_C)*cos(Dec_X)*3600/errPos:
    - Average: -0.23 (normalizing to combined angular pos. err.: -0.13)
    - Standard Deviation=1.07 (0.58)
  - dDec=(Dec_X-Dec_C)*3600/errPos:
    - Average: 0.17 (0.10)
    - Standard Deviation: 1.03 (0.49)

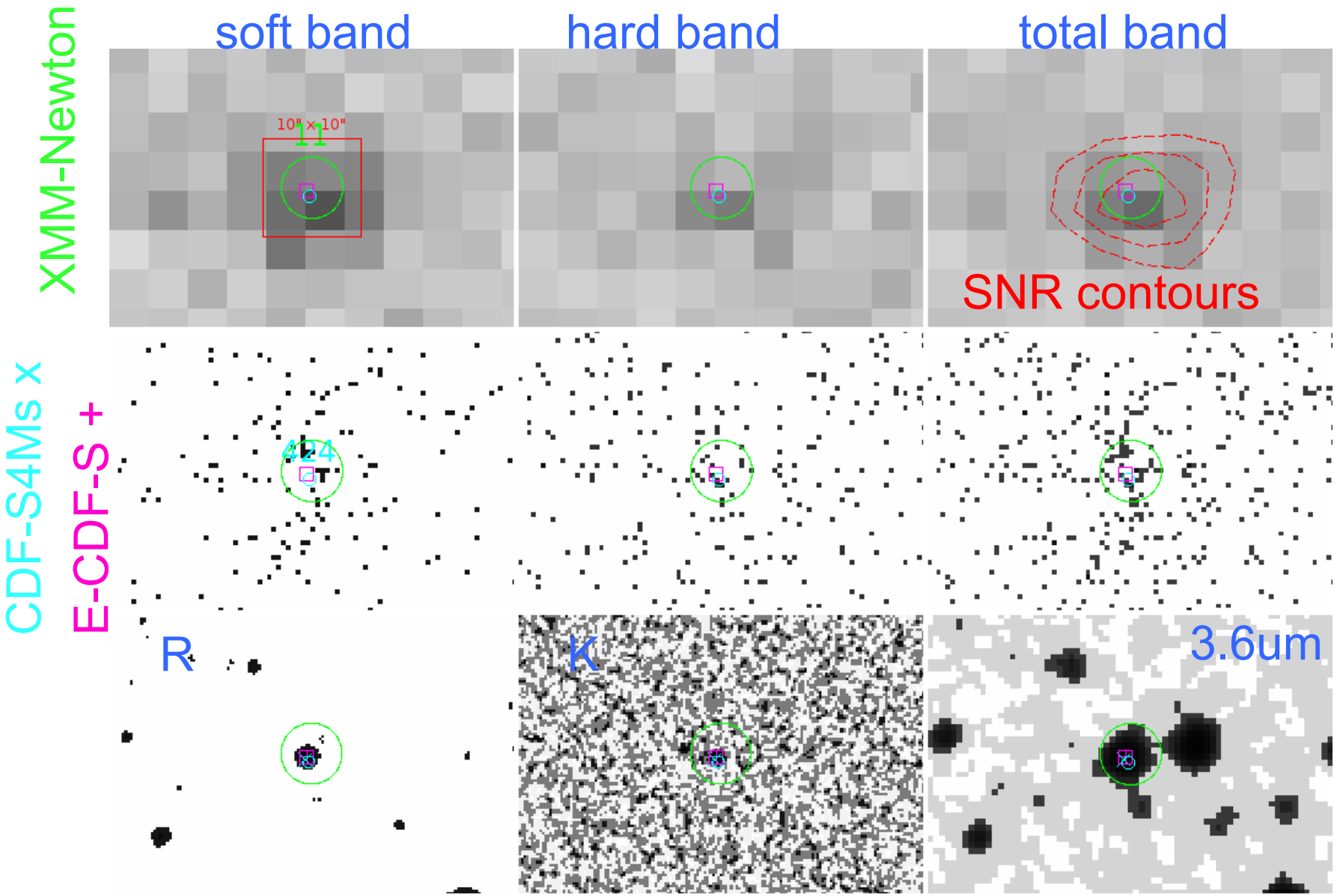




Generation of Bayesian SNR map (2-10keV)

- Using 2-10keV total (sources+bgd), bgd and exposure time images
- Checked that for `Exp_time`≥1Ms gaussian statistics apply
- Using:
  - Flat prior: countrate c≥0
    - Source can't have negative countrate (possible if "pure" Gaussian statistics)
  - Gaussian PSF (Rovilos+12): FWHM=10.5arcsec
- For each pixel calculating probability of countrate of a source in that pixel $P(c)$ ⇒ SNR
- Appear as SNR=2,3,...10 contours in finding charts

Generation of finding charts



- XCID: 11_424

FITS files and web page (updated 4 May 2012)

- EVERYTHING copied over to

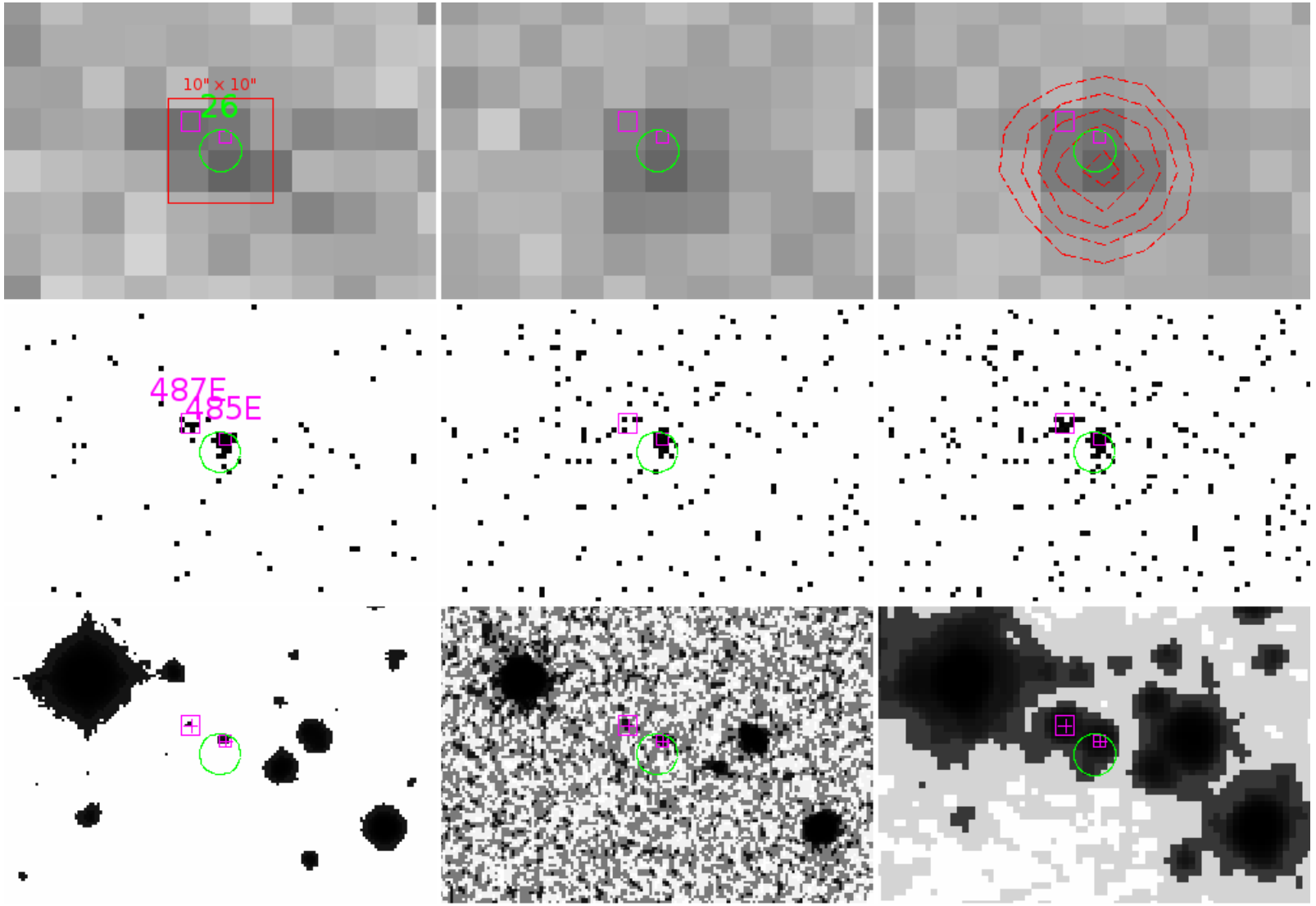
http://venus.ifca.unican.es/~carreraf/XMM_CDF-S/

- Explanations under `AAAREADME.txt`
  - EVERYTHING in `web.tar`
  - For simple-minded users:
    - `XMM_Chandra_crossID.fits`
    - HTML file under `Fcharts/`
  - For users interested in cross-ID issues:
    - `XMM_Chandra_crossID_check.fits`

Iterations with Cristian Vignali

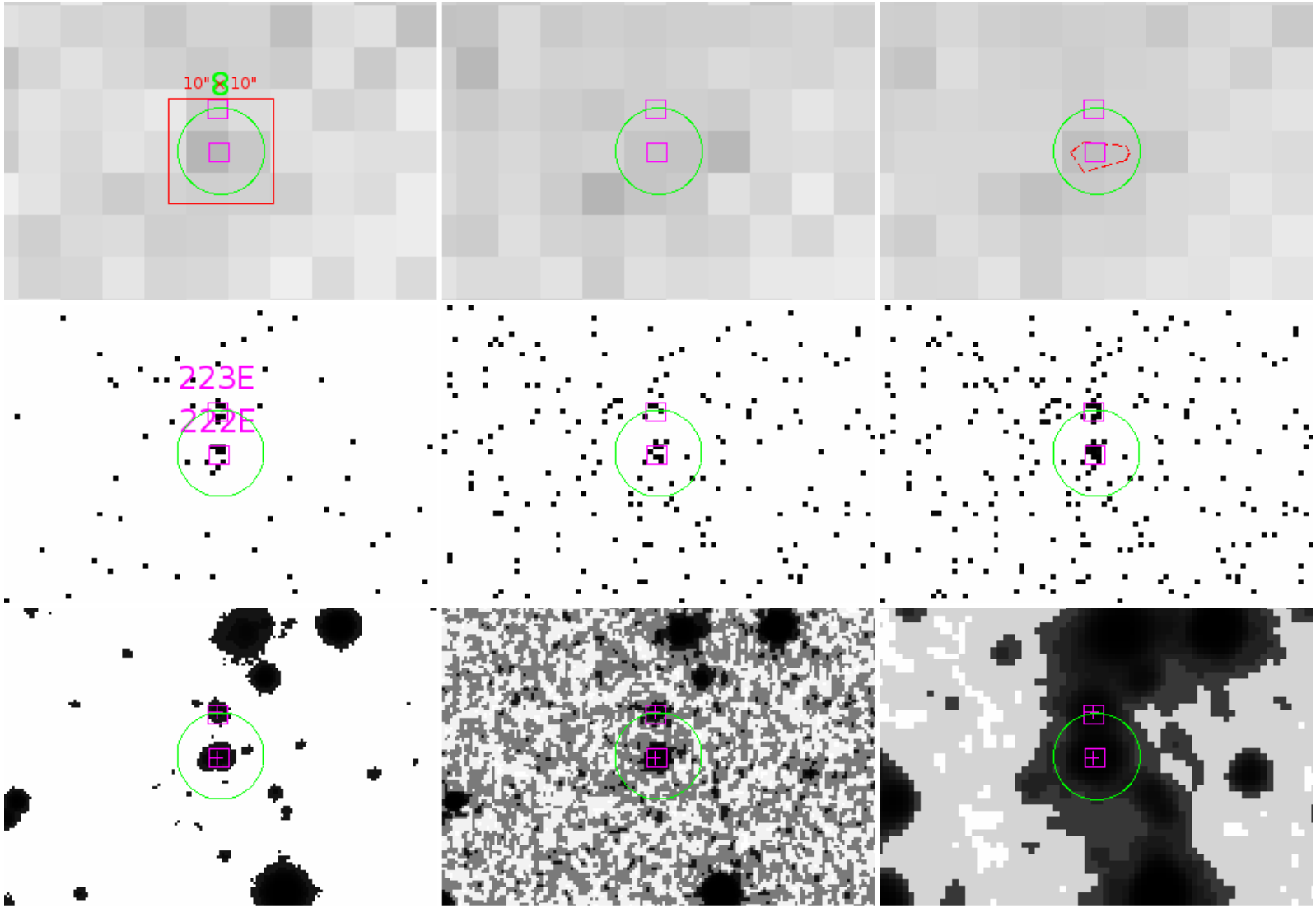
- More thorough analysis of optical/NIR/MIR ctparts and redshifts
- Rich variety of issues comparing Chandra/XMM-Newton sources, generally in agreement, but:
  - (Objective) criteria about blending of Chandra sou.⇒ XMM-Newton sou.
  - (Objective) criteria about “new” XMM-Newton sou.

Example of probable not blend



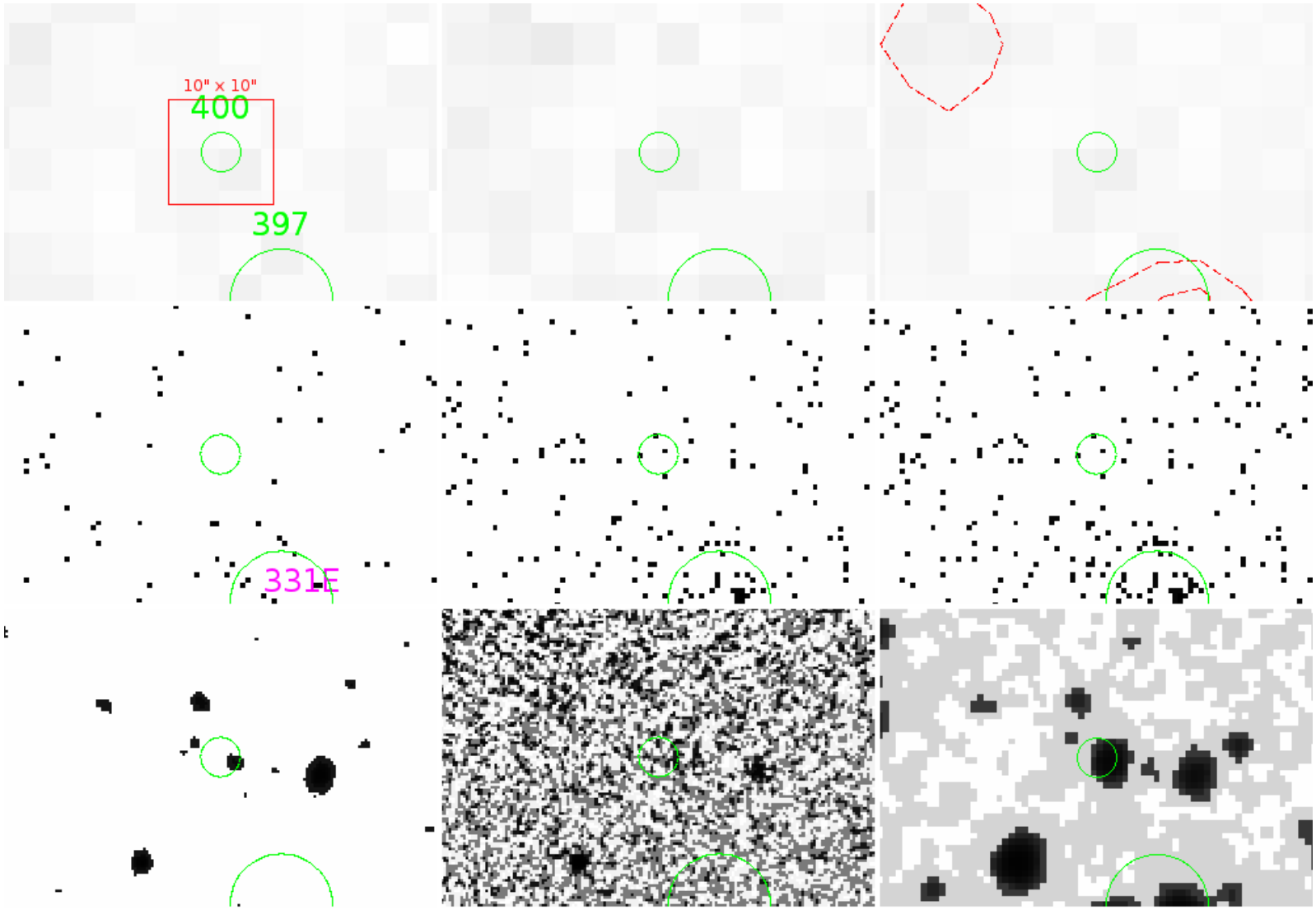
- XMM#26 `FLUX28`=(3.1±0.4)×10^{-15} cgs round contours
  - 485E: P=0.98 `HFlux`=4.7×10^{-15} cgs 487E: P=0.77 `HFlux`<1.3×10^{-15} cgs

Example of possible blend



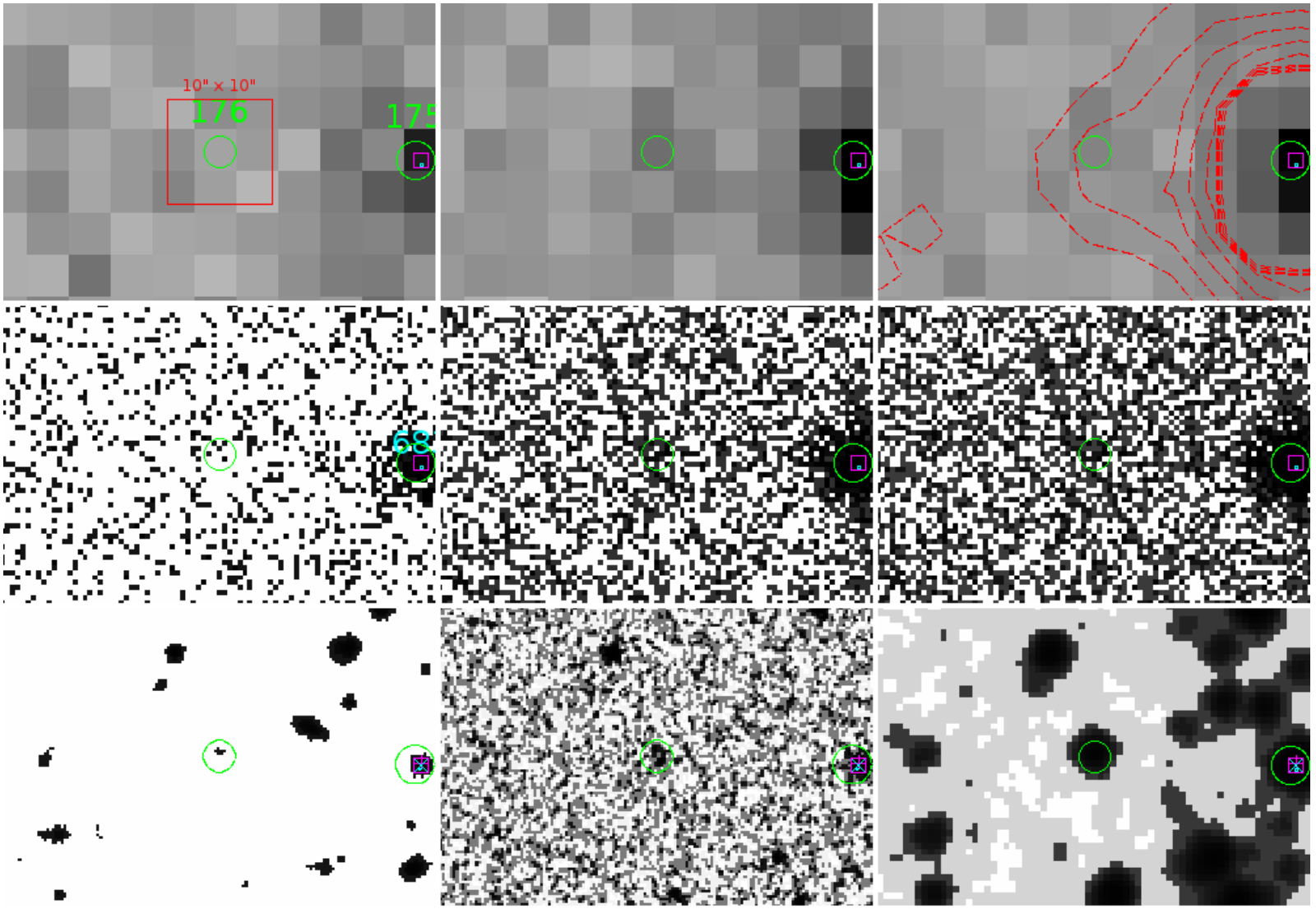
- XMM#8: no emldetect
  - 222E: P=0.82 `HFlux`=1.1×10^{-15} cgs 223E: P=0.71 `HFlux`<1.2×10^{-15} cgs

Example of spurious source



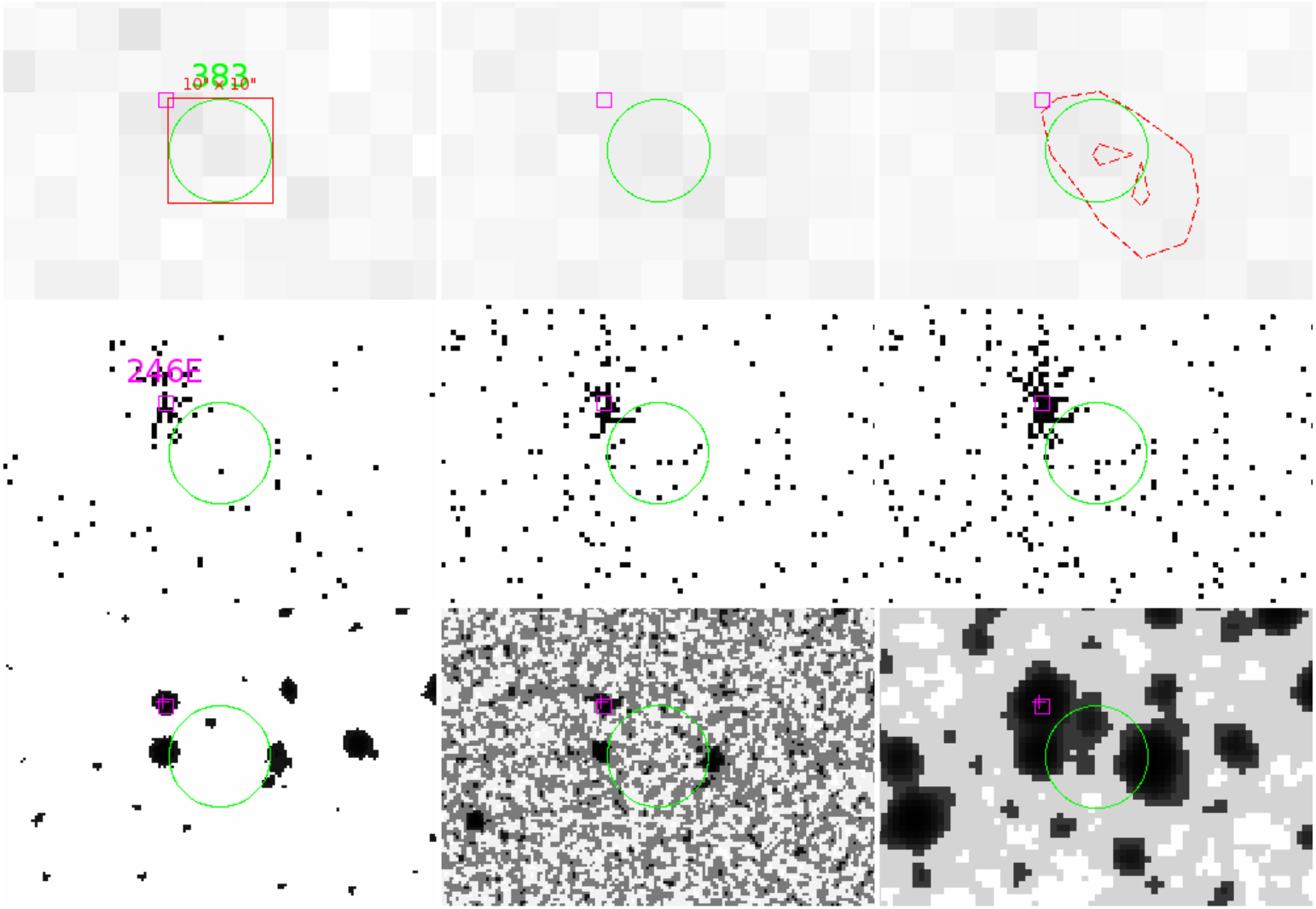
- XMM#400: no emldetect
  - No nearby Chandra source (outside 4Ms area)

Example of new source



- XMM#176: FLUX28=(1.51±0.17)×10^{-15} cgs
  - Hint of hard Chandra source

Example of source with large distance



- XMM#383: