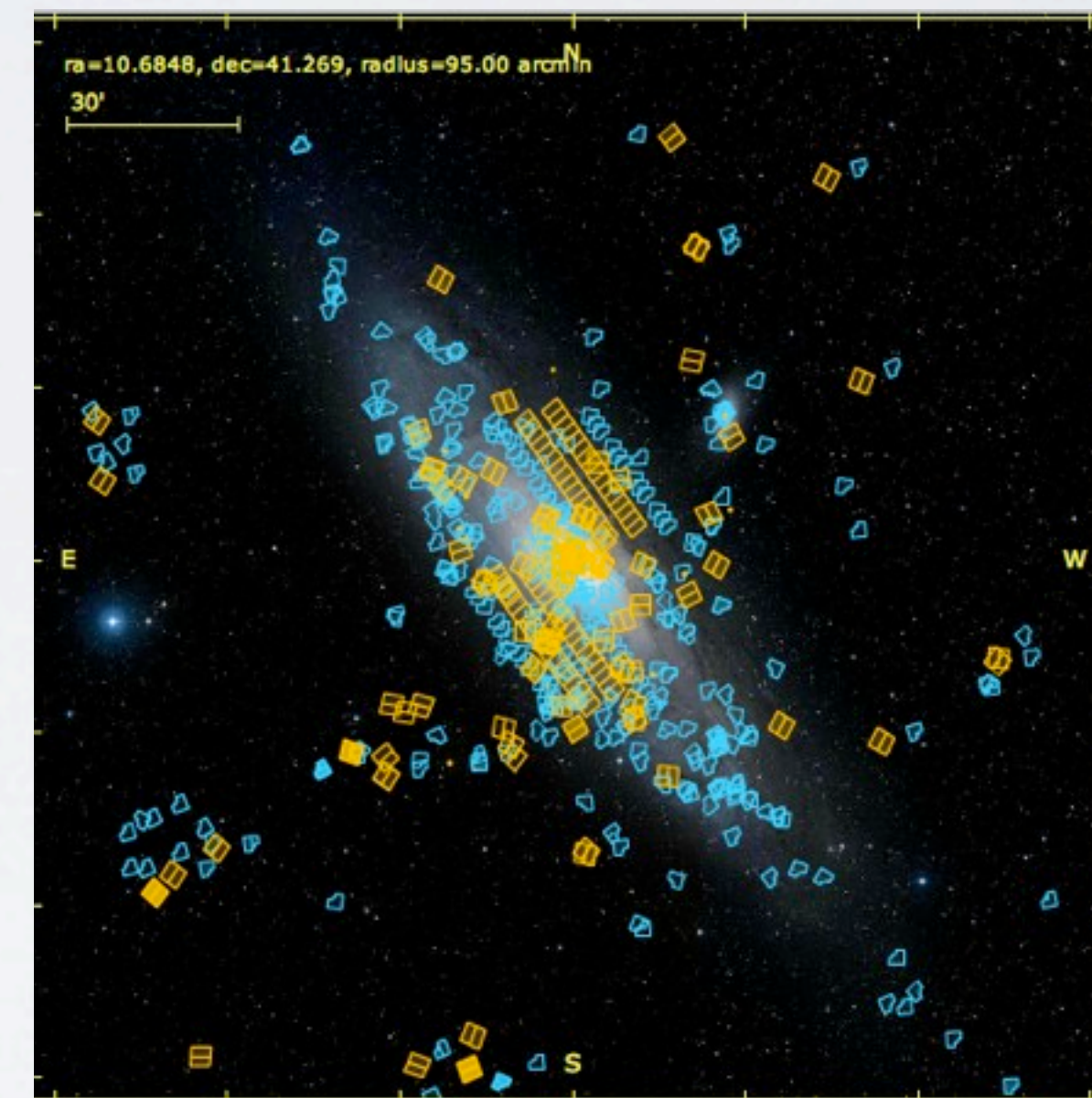# SCIENCE POTENTIAL FOR THE HUBBLE SOURCE CATALOG

Steve Lubow
November 8, 2012

BUILDING CATALOG

- Determine mosaics

- Determine nearby source pairs with some threshold separation

- Minimize pair separations by adjusting image positions (astrometric correction)

- Determine matching sources across images
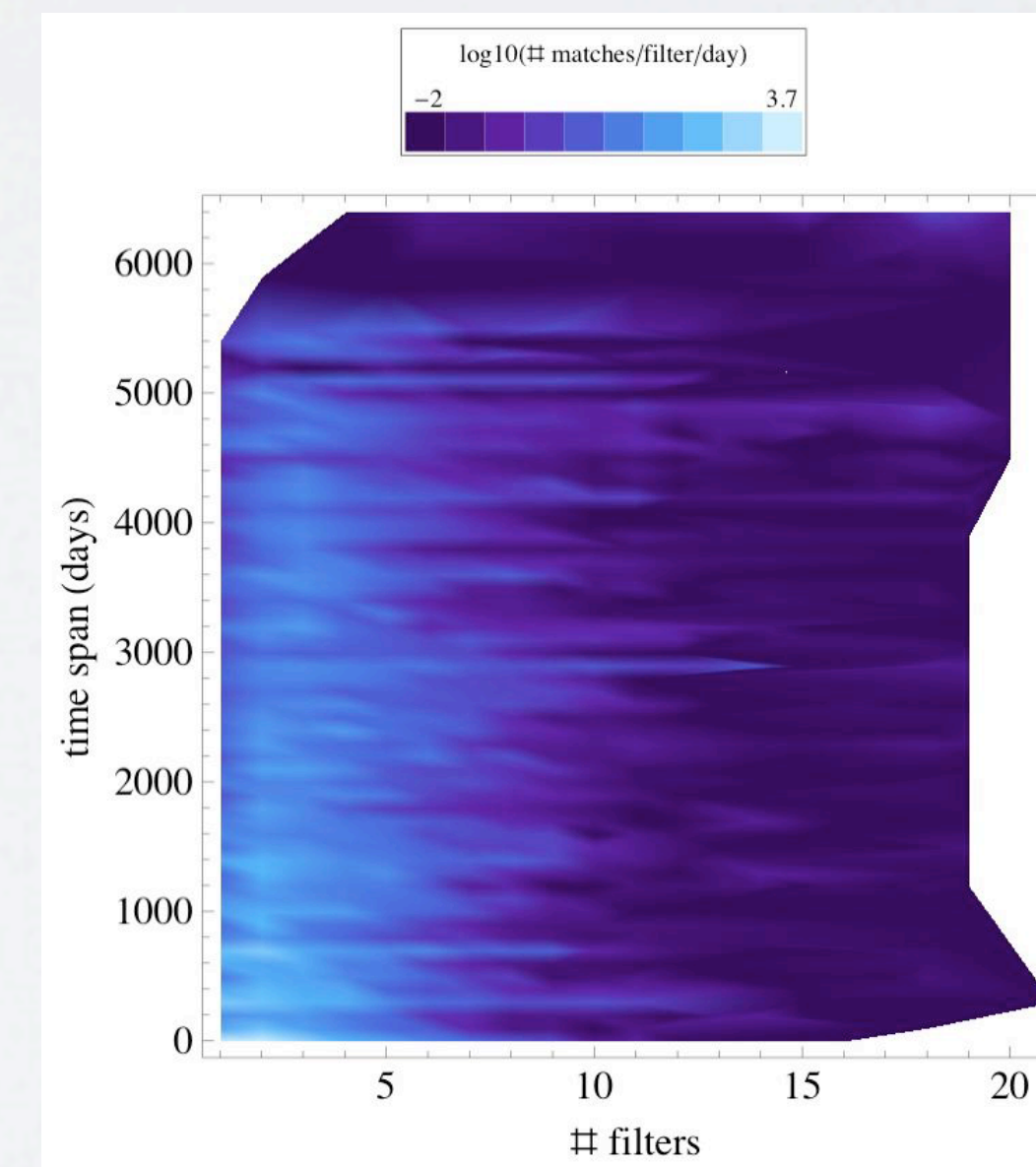
- Build catalog

PROPERTIES OF MATCHES

- First correct astrometry, then determine matching sources.

- Distribution of positional sigma for matches involving more than one visit.

- Astrometric corrections made for about half the WFPC2 and ACS/WFC images

- Matches cover a broad range of times (hours to 17 y) and filters

FLUX DIFFERENCE DISTRIBUTION

$$f_{i,j} = \frac{|f_i - f_j|}{max(f_i, f_j)}$$

- Matching based only on position

- Consider pairs of sources in same match with same instrument/detector/filter

- Determine flux distribution difference

- Most pairs have small flux differences, a few percent. So, few false matches.

- What accounts for large flux differences?
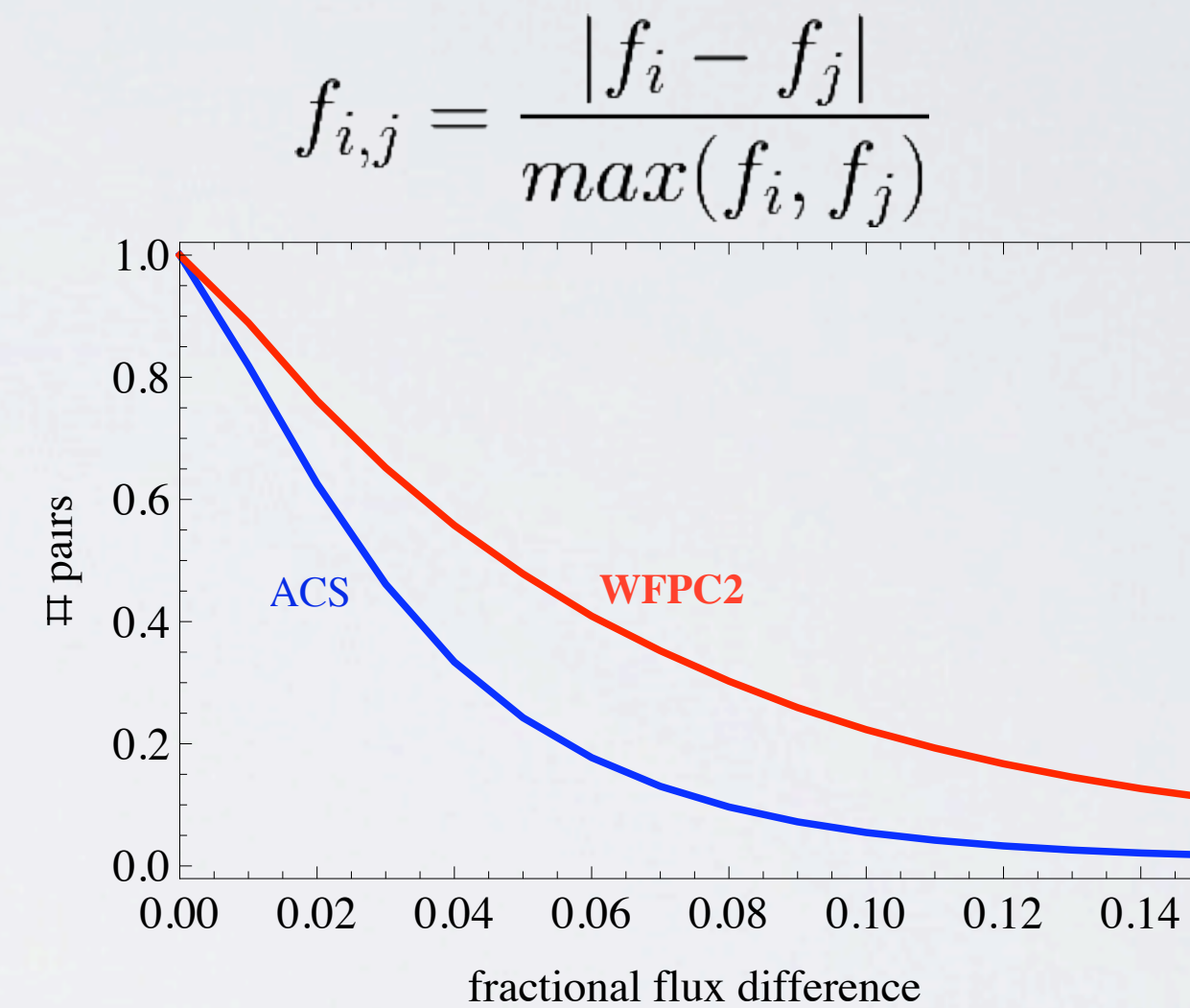
LARGE FLUX DIFFERENCES

- Preliminary investigation of > 2X flux variations

- Time spans from hours to years

- Some sources have real time variations

- Others involve random matches due to bad image alignment, sources contaminated with CRs, etc.

Cases With > 2X Flux Differences

TIME VARIABLE SOURCES

- Examined some matches with large flux variations

- Some appear real

- Example show evidence ~ 1000 min variations in 2 filters

- Nearby sources shows much smaller variations (e.g., Match A)

USE CASES

- A few examples to show science potential and test catalog accuracy/completeness.

- Demonstrate current capabilities and areas for improvement in data and tools.

- Does the catalog recover/discover variable objects?

- Can the catalog be used for photometry?

TIME VARIABILITY

• Forms search for supernova progenitor by position
  - Bright SN2004DG. Found in single epoch ACS. Not found at earlier epoch covered by WFPC2.

• Forms search for known supernova by position
  - Faint SN Thames (Riess, Strolger, et al 2007). Detected changes in brightness, position, and CI.
  - Several SN not found.

• Database search for objects with large flux variations.
  - Find some GRBs
  - Also find various problems: poorly aligned images, etc.

SN2004DG

Object name **sn2004dg** resolved by **NED (via SANTA cache)** to **SN 2004dg** (SN)
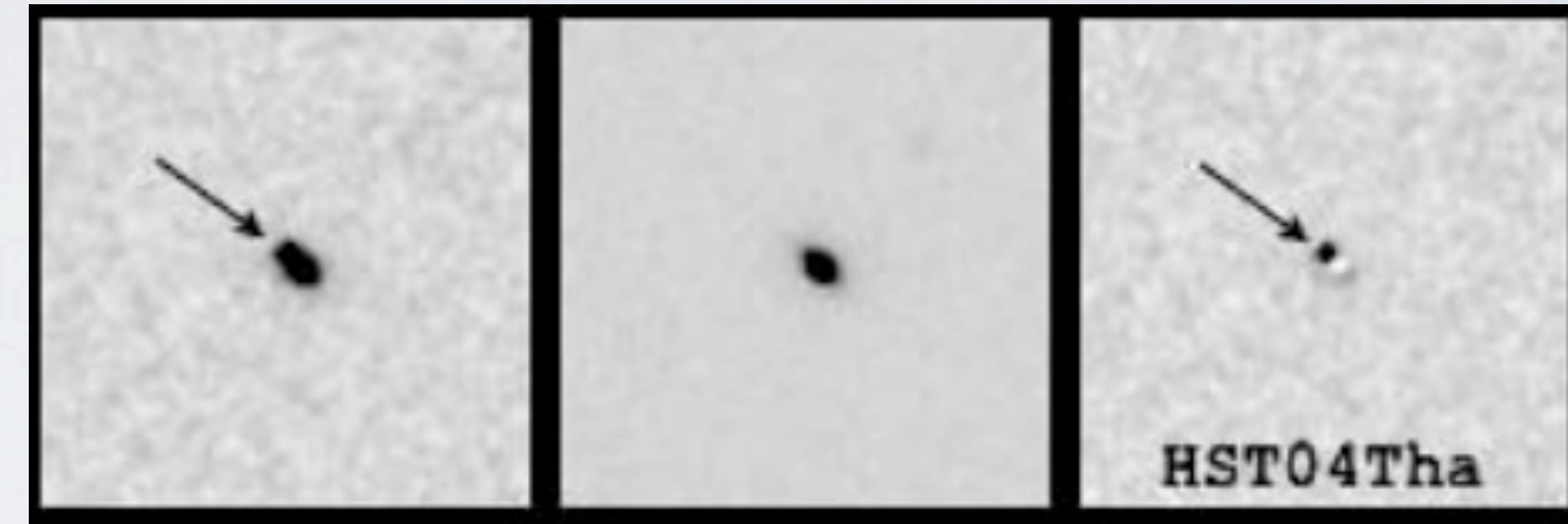**RA:** 14 59 58.96 **Dec:** 1 53 25.58 **(J2000)**

number of rows returned = 10

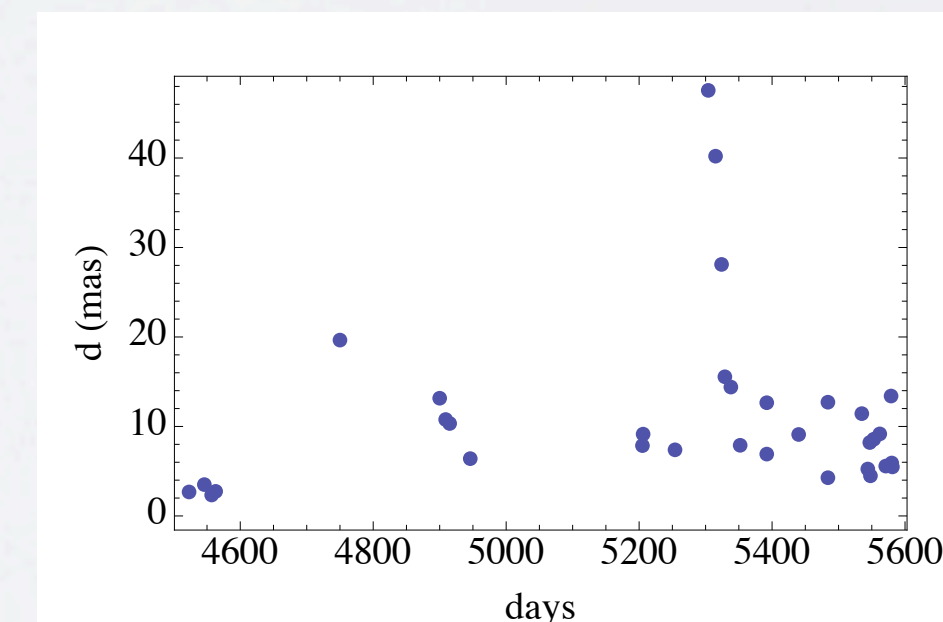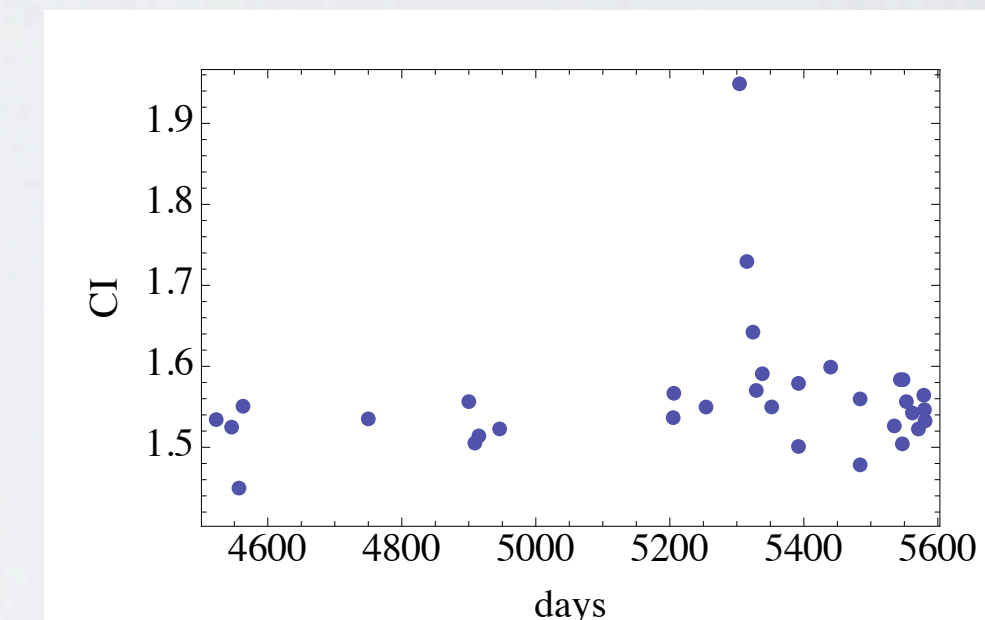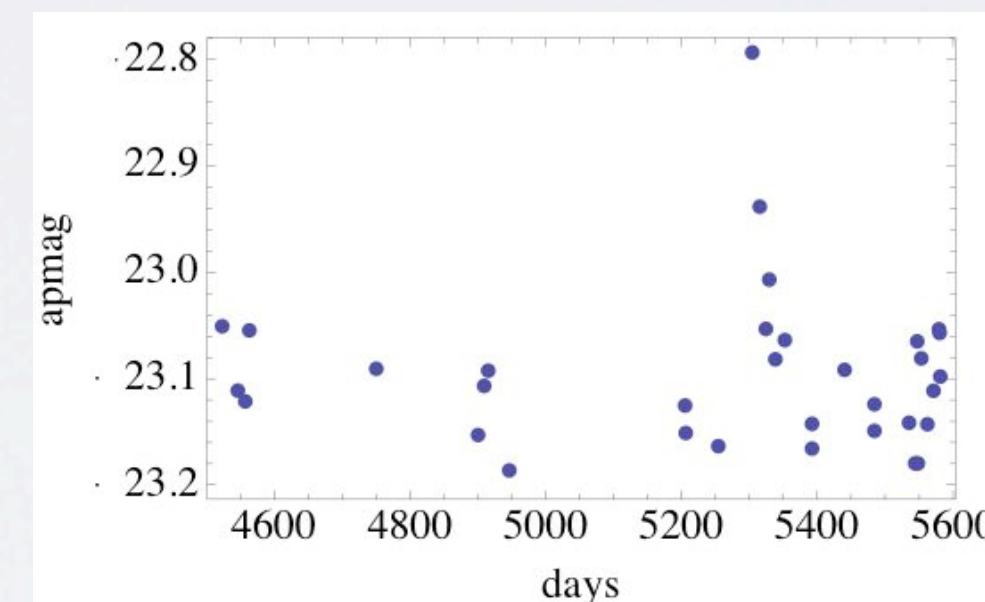| Match ID	Mem ID	Source ID	Det	Target Name	Image Name	Match RA (J2000)	Match DEC (J2000)	Aperture	Exp Time	Obs. Start Time	Obs. Stop Time	FluxAper2	ApMag	T
1213361	1	2135569197	Y	SN2004DG	HST_10187_02_ACS_WFC_F435W	14 59 58.995	+01 53 25.30	WFC1	1600	2005-03-10 16:32:06	2005-03-10 17:01:03	21.182	21.910	
1213361	2	2135569197	Y	SN2004DG	HST_10187_02_ACS_WFC_F555W	14 59 58.995	+01 53 25.30	WFC1	1400	2005-03-10 17:04:06	2005-03-10 18:17:17	72.115	20.831	
1213361	3	2135569197	Y	SN2004DG	HST_10187_02_ACS_WFC_F814W	14 59 58.995	+01 53 25.30	WFC1	1700	2005-03-10 18:20:11	2005-03-10 18:50:48	323.339	19.469	
1213401	1	2135569288	Y	SN2004DG	HST_10187_02_ACS_WFC_F555W	14 59 58.938	+01 53 26.42	WFC1	1400	2005-03-10 17:04:06	2005-03-10 18:17:17	1.702	25.154	
1213401	2	2135569288	Y	SN2004DG	HST_10187_02_ACS_WFC_F814W	14 59 58.938	+01 53 26.42	WFC1	1700	2005-03-10 18:20:11	2005-03-10 18:50:48	6.911	23.790	
1213401	3	2135569288	N	SN2004DG	hst_10187_02_acs_wfc_f435w	14 59 58.938	+01 53 26.42	WFC1	1600	2005-03-10 16:32:06	2005-03-10 17:01:03			
			N	NGC5806	hst_06359_85_wfpc2_f606w_wf			PC1-FIX	600	1997-04-30 15:28:07	1997-04-30 15:39:22			
			N	NGC5806	hst_08632_99_wfpc2_f300w_wf			PC1	1000	2001-03-20 03:21:14	2001-03-20 03:40:34			
			N	NGC5806	hst_09042_93_wfpc2_f814w_wf			WFALL	460	2001-07-05 15:29:14	2001-07-05 15:40:04			
			N	NGC5806	hst_09042_93_wfpc2_f450w_wf			WFALL	460	2001-07-05 15:14:14	2001-07-05 15:25:04			
Match ID	**Mem ID**	**Source ID**	**Det**	**Target Name**	**Image Name**	**Match RA (J2000)**	**Match DEC (J2000)**	**Aperture**	**Exp Time**	**Obs. Start Time**	**Obs. Stop Time**	**FluxAper2**	**ApMag**	**T**

March 2005

July 2001
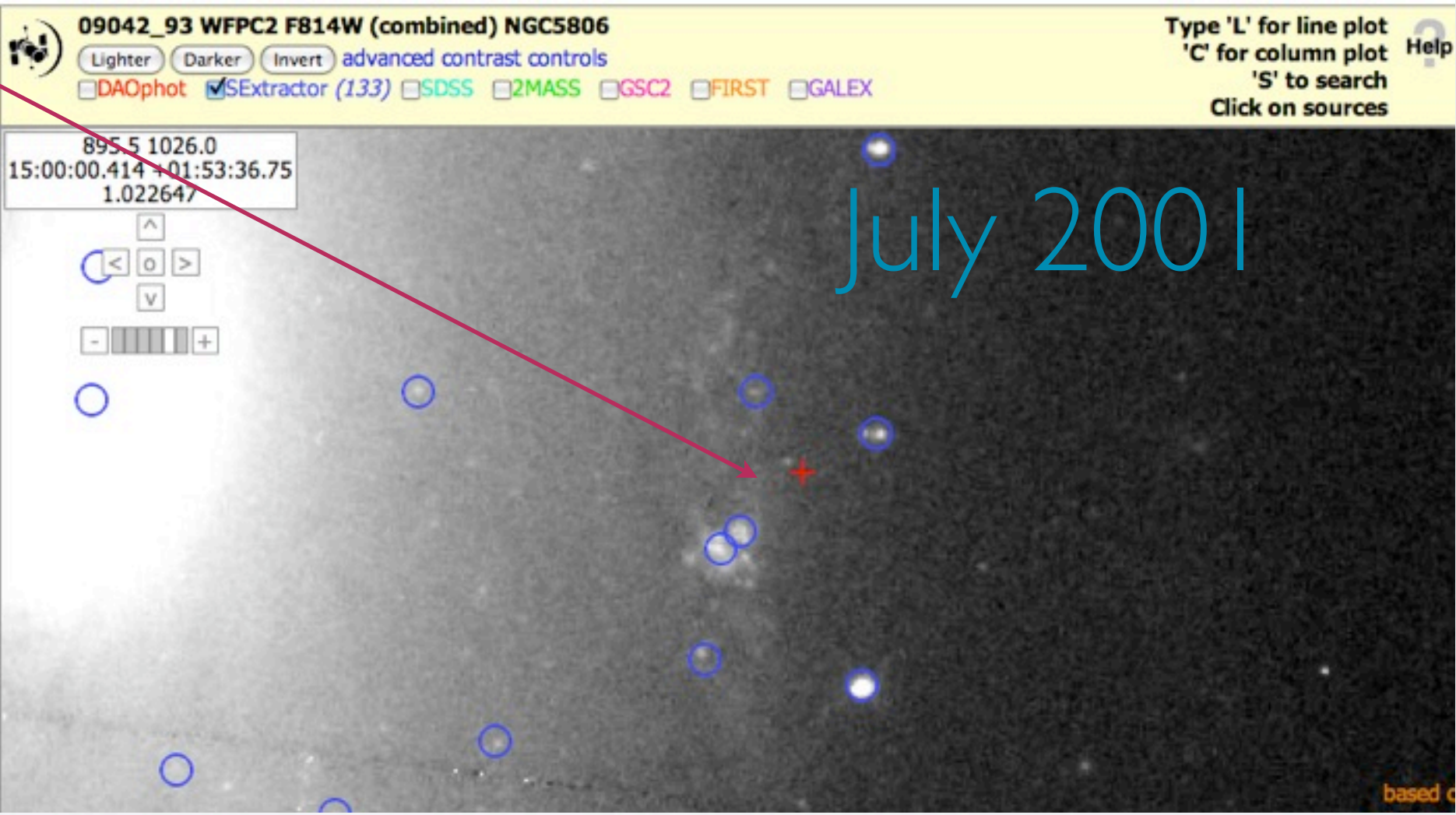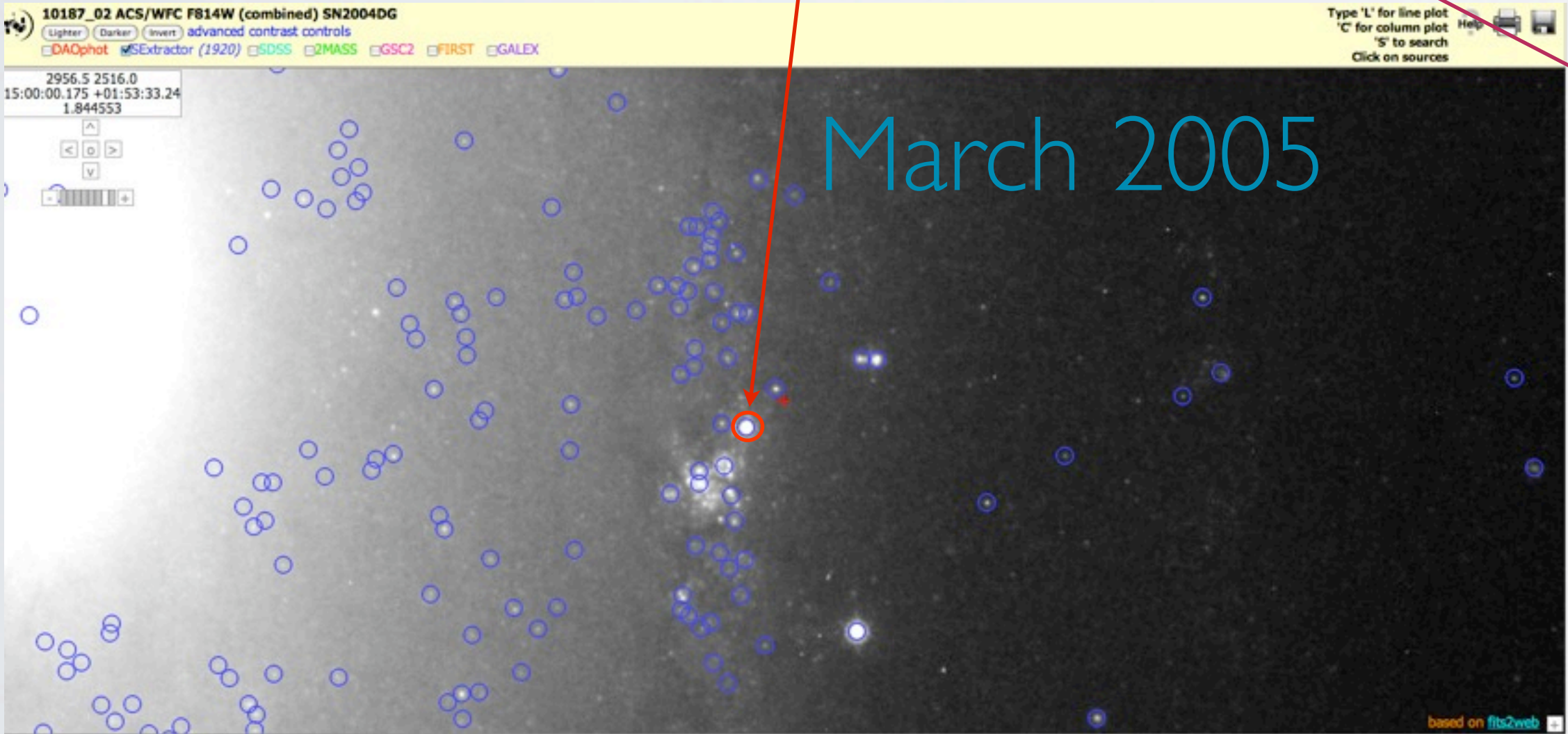
SN THAMES

- Forms search based on known position

- Select filter F850LP

- Change in mag, d (position offset), and CI (concentration index)

- Drop off in follow-on observations

- Several other cases not found, e.g., SN too far from galaxy

- Can we find others? All sky search based on mag, d, and CI changes?

Riess et al 2007

GRB021004

HLA_CAT Search Results

number of rows returned = 7

Match ID	Mem ID	Det	Target Name	Image Name	Match RA (J2000)	Match DEC (J2000)	D	D Sigma	Mode	Aperture	Exp Time	Obs. Start Time	Obs. Stop Time	FluxAper2	ApMag
512414	1	Y	GRB021004	HST_9405_7g_ACS_WFC_F435W	00 26 54.681	+18 55 41.57	0.858	2.187	ACCUM	WFC1	2040	2003-07-26 02:03:22	2003-07-26 05:23:26	1.930	24.659
512414	2	Y	GRB021004	HST_9405_7g_ACS_WFC_F814W	00 26 54.681	+18 55 41.57	0.858	2.187	ACCUM	WFC1	1920	2003-07-26 00:12:48	2003-07-26 02:00:26	2.555	24.654
512414	3	Y	GRB021004	HST_9405_6k_ACS_WFC_F435W	00 26 54.681	+18 55 41.57	0.998	2.187	ACCUM	WFC1	1200	2002-10-11 17:43:49	2002-10-11 18:06:46	16.497	22.486
512414	4	Y	GRB021004	HST_9405_6k_ACS_WFC_F606W	00 26 54.681	+18 55 41.57	0.998	2.187	ACCUM	WFC1	1200	2002-10-11 16:29:05	2002-10-11 17:39:51	62.294	21.891
512414	5	Y	GRB021004	HST_9405_6k_ACS_WFC_F814W	00 26 54.681	+18 55 41.57	0.998	2.187	ACCUM	WFC1	1205	2002-10-11 15:59:35	2002-10-11 16:25:15	53.833	21.482
512414	6	Y	GRB021004	HST_9405_77_ACS_WFC_F606W	00 26 54.681	+18 55 41.57	2.215	2.187	ACCUM	WFC1	1840	2002-10-22 18:11:34	2002-10-22 19:54:11	13.543	23.552
512414	7	Y	GRB021004	HST_9405_7f_ACS_WFC_F606W	00 26 54.681	+18 55 41.57	2.777	2.187	ACCUM	WFC1	1920	2003-05-31 02:36:12	2003-05-31 03:16:01	4.653	24.600

Oct 2002

May 2003
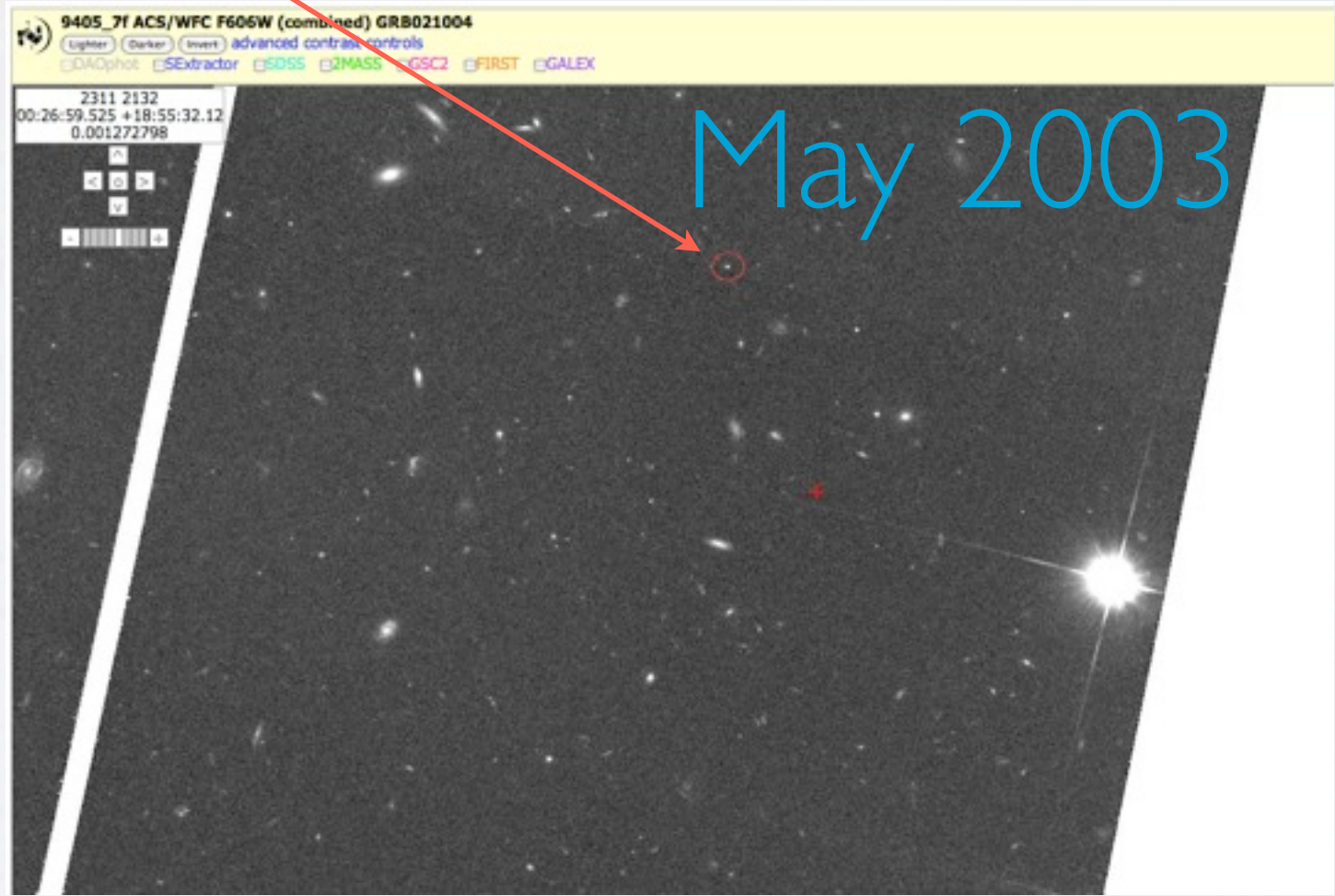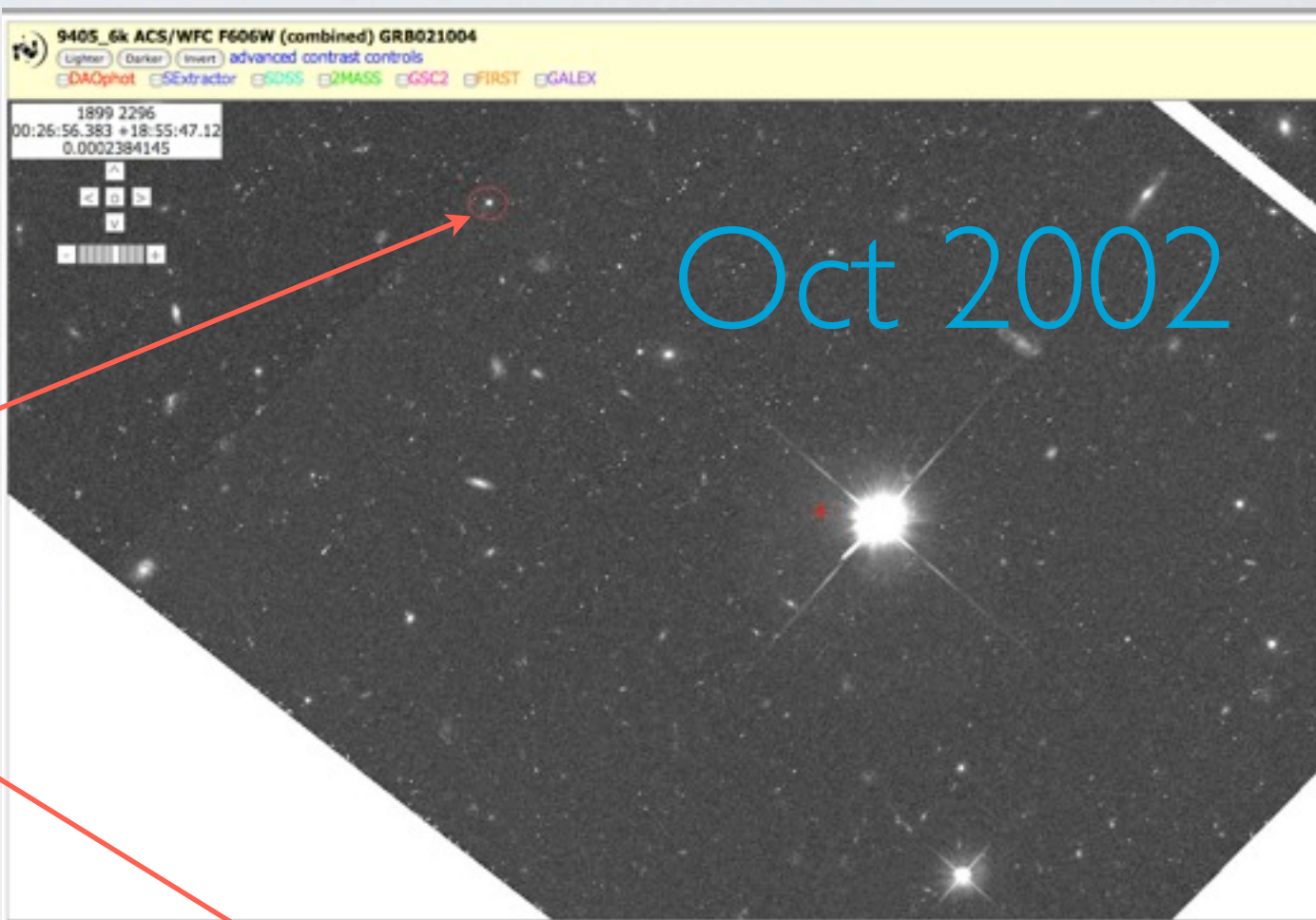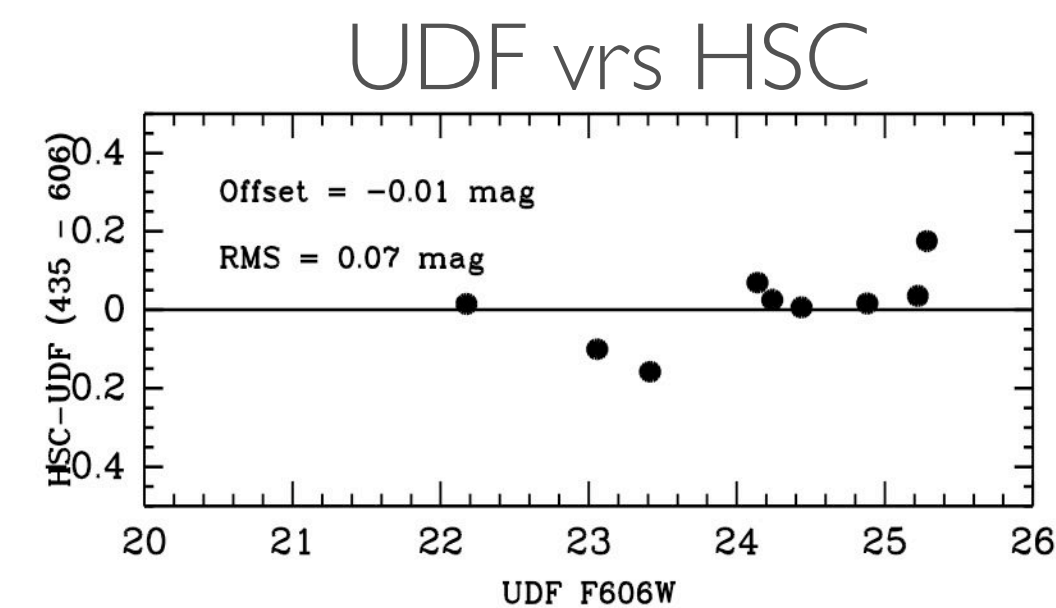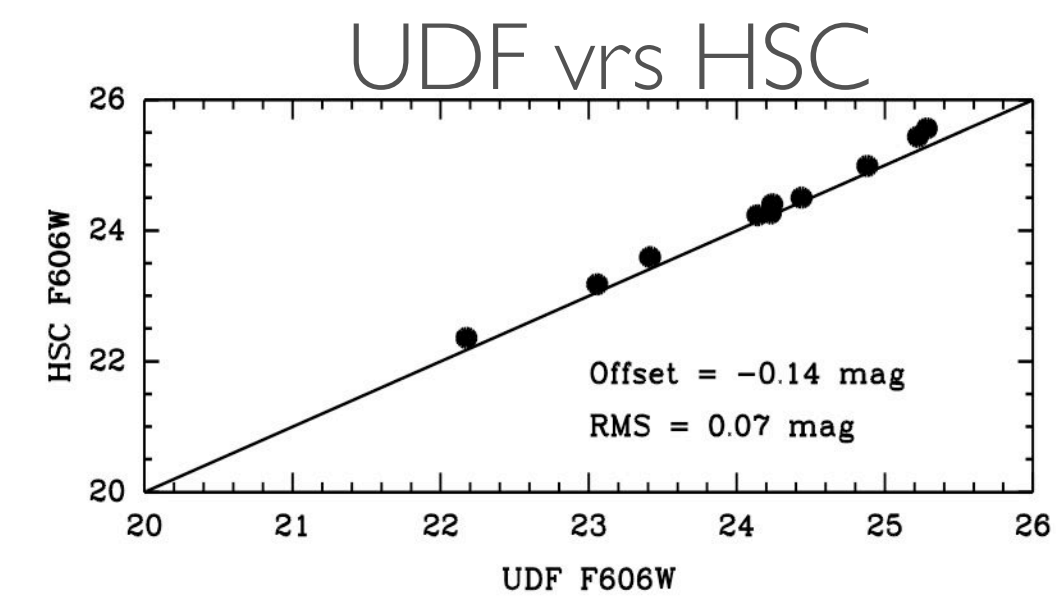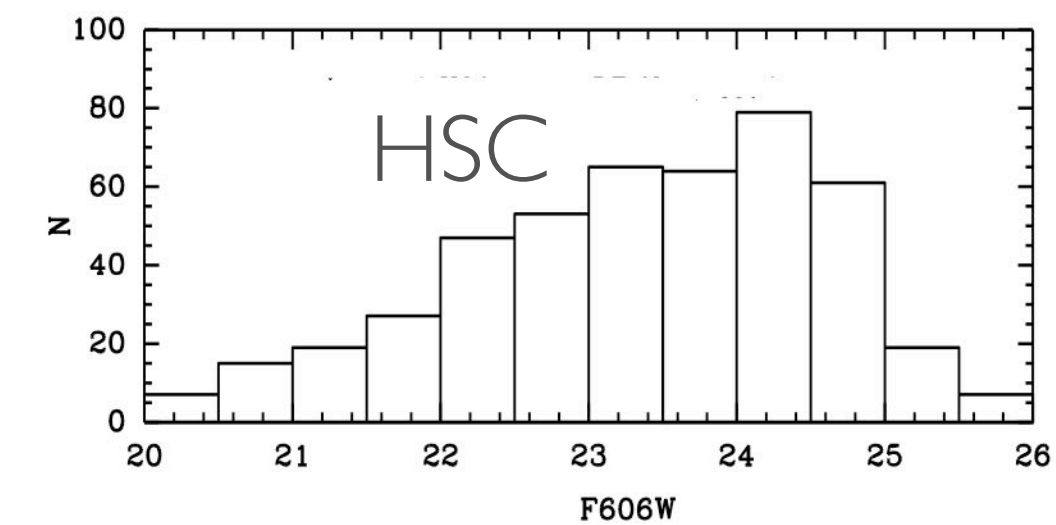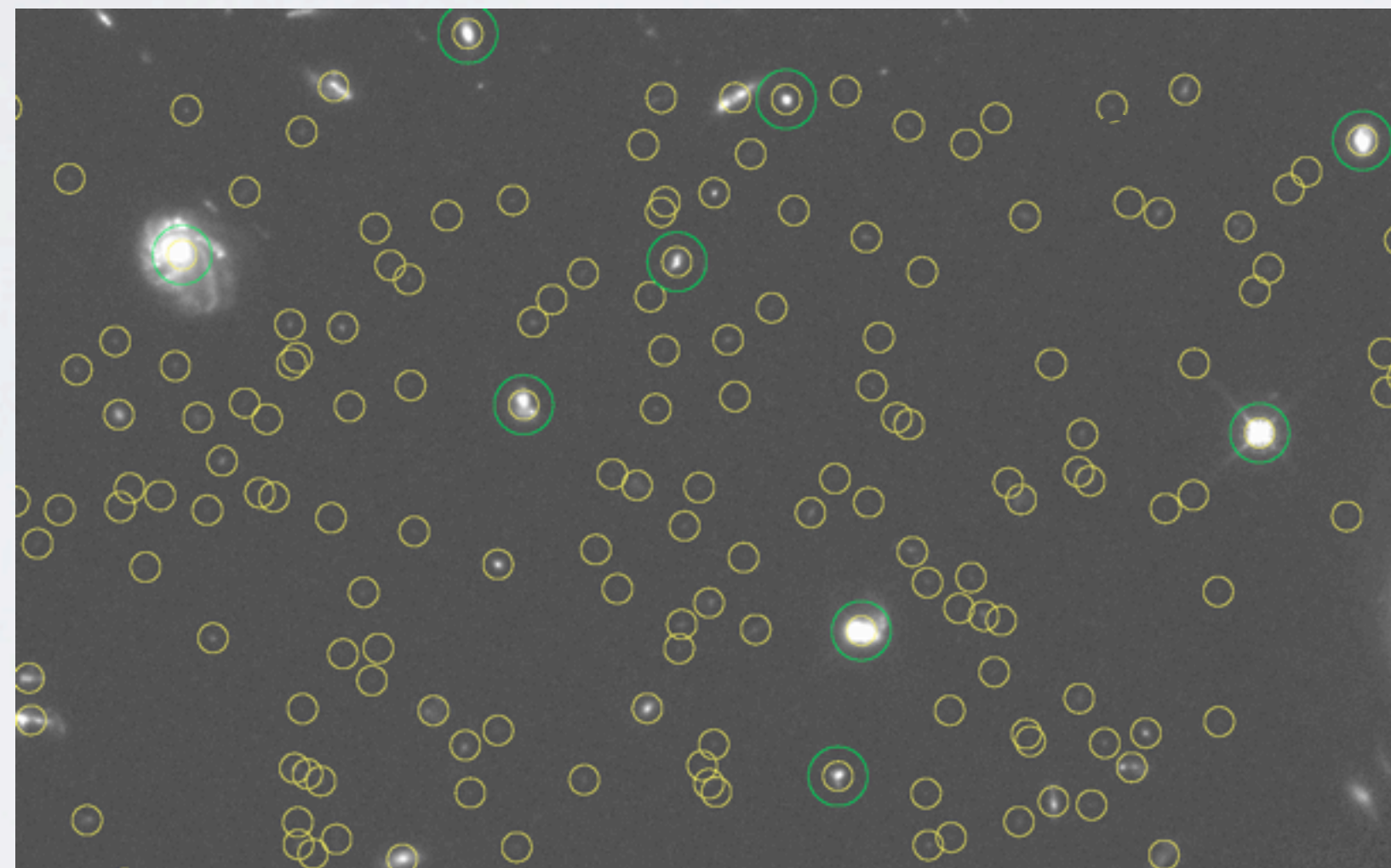
- Database search for flux changes > 2x, point sources, within 10 mas from match position

- 4K records of pairs: 9 records describe 4 GRBs

- 600 records of pairs with extreme flux variations > 10x. Includes bad images and GBR021004. What else is there?
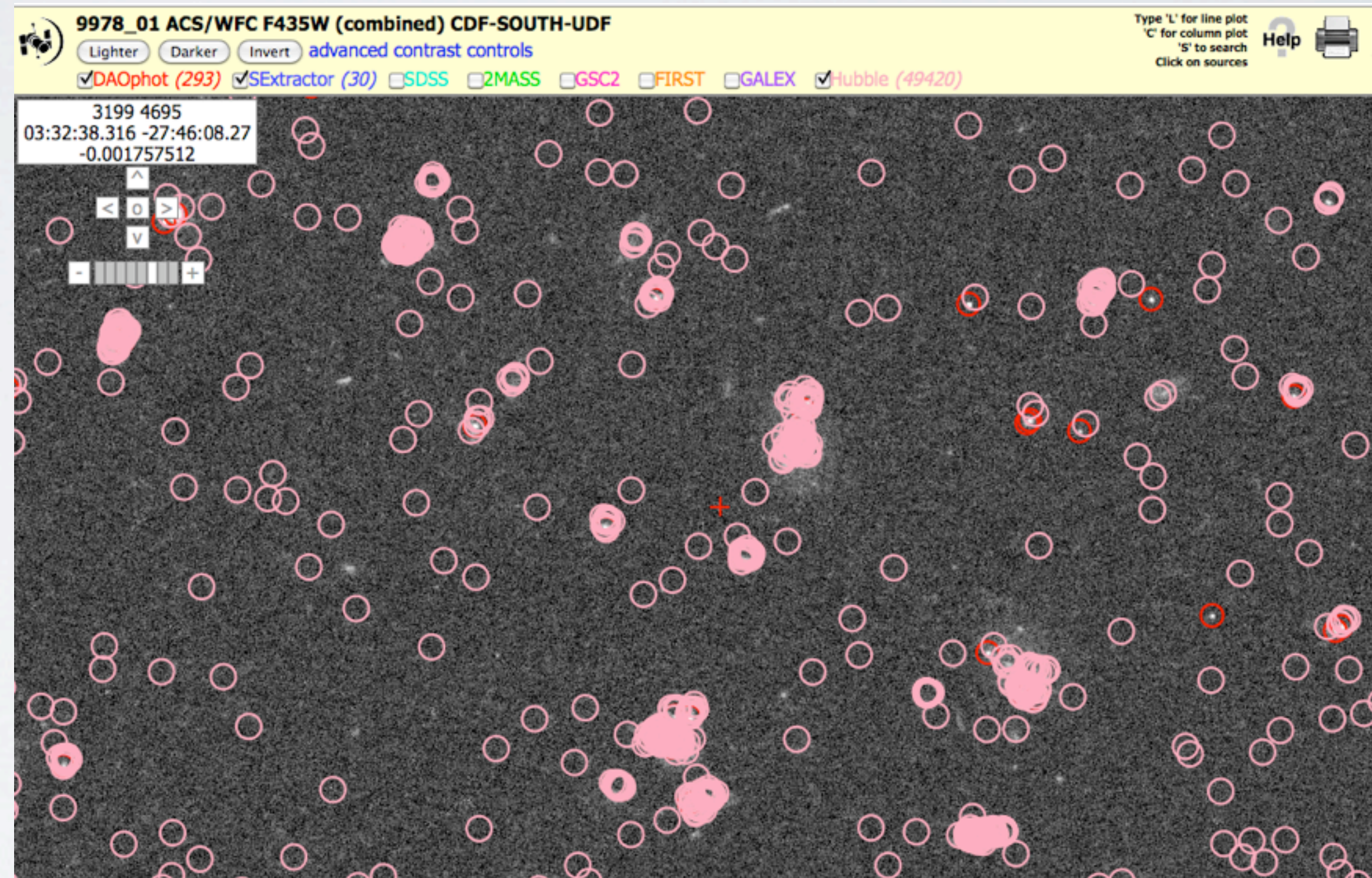
COMPARISON OF HSC AND UDF

- HSC goes to about 25 mag.

- ~0.14 mag photometric offset

- Colors agree well

HSC
UDF

UDF FIELD

- Illustrates problems with current source lists

- Also possibly matching limited by too fine a scale.

LIMITATIONS

- About 50% of Images have astrometric corrections
  - About 80% of images have source lists
  - About 40% of images with source lists have no astrometric corrections
  - Of these, about 60% are nonoverlapping and so cannot be improved. Will get better with more instruments, e.g., WFC3.
  - Some not corrected because offset too large (to be improved in future)

- Source list quality limited
  - Lack of consistency in detections
  - Problems with subtracting background, edge effects, etc.
  - Large absolute astrometric errors ~ 1 arc-sec still present in some images. May improve with new astrometry initiative.
  - WFC3 source lists much improved. Plan similar improvements for ACS and WFPC2.

- Matching of sources is conservative (few false matches)
  - Cases of nearby matches that should be merged (nearly same flux)
  - Need to adjust parameters or alter the algorithm

PLANS

- Improve Source Lists

    - Run improved software for WFPC2 and ACS
    - Apply improved absolute astrometric corrections

- Adjust astrometric correction parameters and matching parameters

- Include WFC3

- Explore cases of large flux variations and fix/reject bad images.

- SQL CASJobs Interface

- Develop more use cases