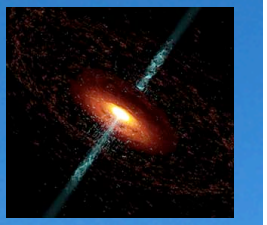
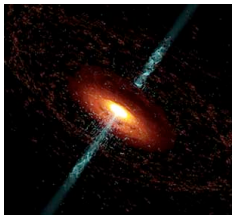


Flux Density Monitoring with the SMA

Mark A. Gurwell

A Unique Resource



I. The SMA Calibrator Database

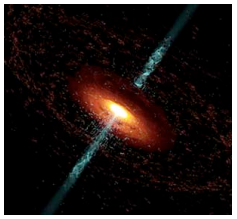
What is it, and what is is used for?

II. Blazar Observations and Multi-Wavelength Campaigns

A few examples

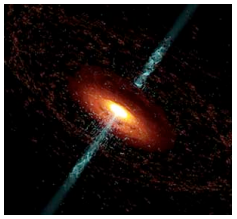
III. Independent Programs

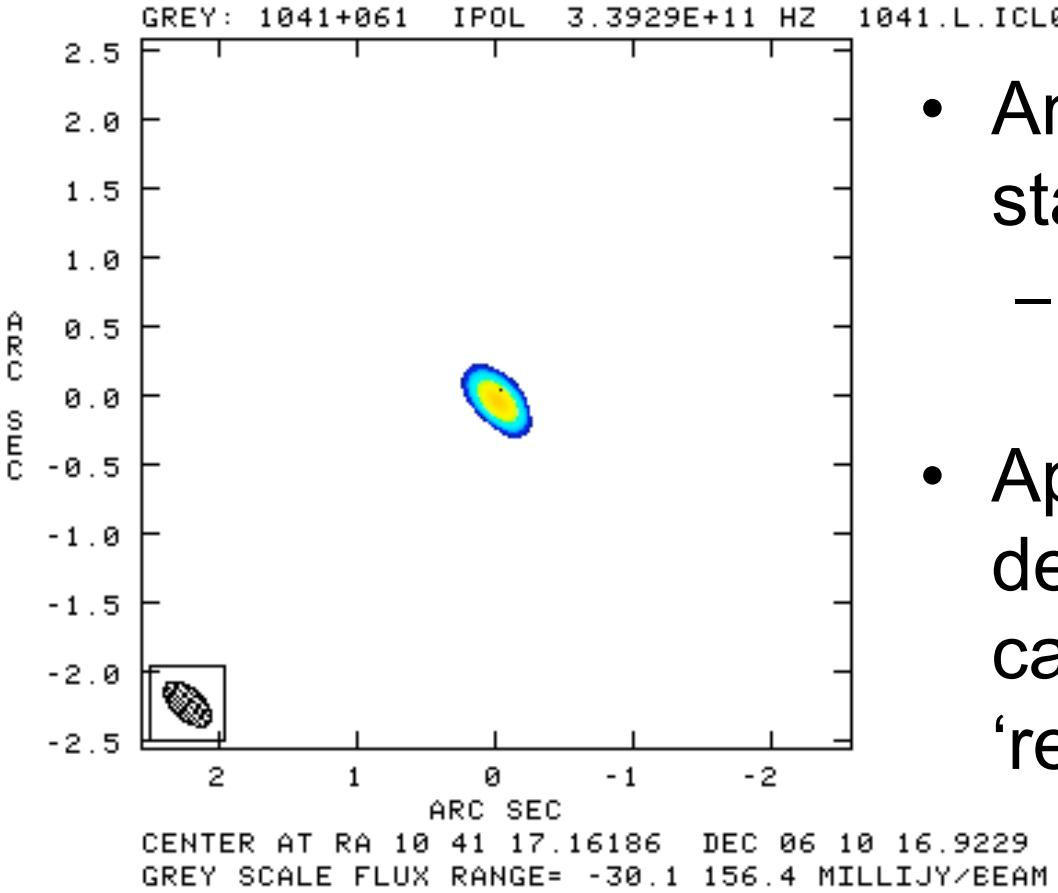
I. What is the Calibrator Database?



- available, relatively bright sources
  - effectively point sources at resolutions offered by the SMA (sizes <<100 mas)
- nearly exclusively quasars
  - flux densities from 100 mJy to >40 Jy at 1.3 mm
- used to calibrate science observations
  - Phase gains (‘seeing’)
  - Amplitude gains (‘approximate flux scale’)

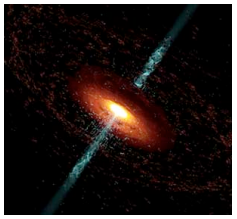
Quasars as Calibrators





- Analogous to guide stars in adaptive optics
  - Timescales generally significantly longer
- Apply corrections determined on calibrator to target to ‘remove atmosphere’

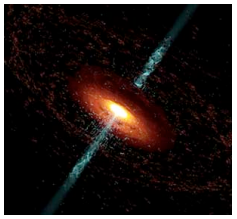
Rationale for the Database



- Positions of quasars (very) well known
  - VLA, VLBA positions used, typical Δ ~ few mas
- Flux densities are variable
  - Often by large factors
  - Timescales of < 1 day through years
- Unlike stock market, past performance is (somewhat) indicative of future value
  - Strong quasars usually strong, but still uncertain

Desirable to (accurately) track calibrator flux densities for planning, executing and calibrating science observations

SMA Calibrator Database



SMA Observer Center: Submillimeter Calibrator List - Mozilla Firefox <2>

File Edit View History Bookmarks Tools Help

SMA Observer Center

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Preparing to Observe
After Observing
Tools
Specs
Contact Us
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Submillimeter Calibrator List

Compiled by Mark Gurwell, Tue Apr 14 14:32:03 2009.

To sort the list by distance from a source, enter the source position (J2000):
(please use only integers in these fields)

Source RA: h m s Sort
Source Dec: d m s

Highlights indicate sources with
3mm flux > 4 Jy
1mm flux > 2 Jy
850µm flux > 2 Jy

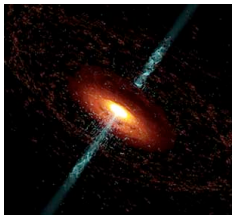
Click here to scroll down to plots.

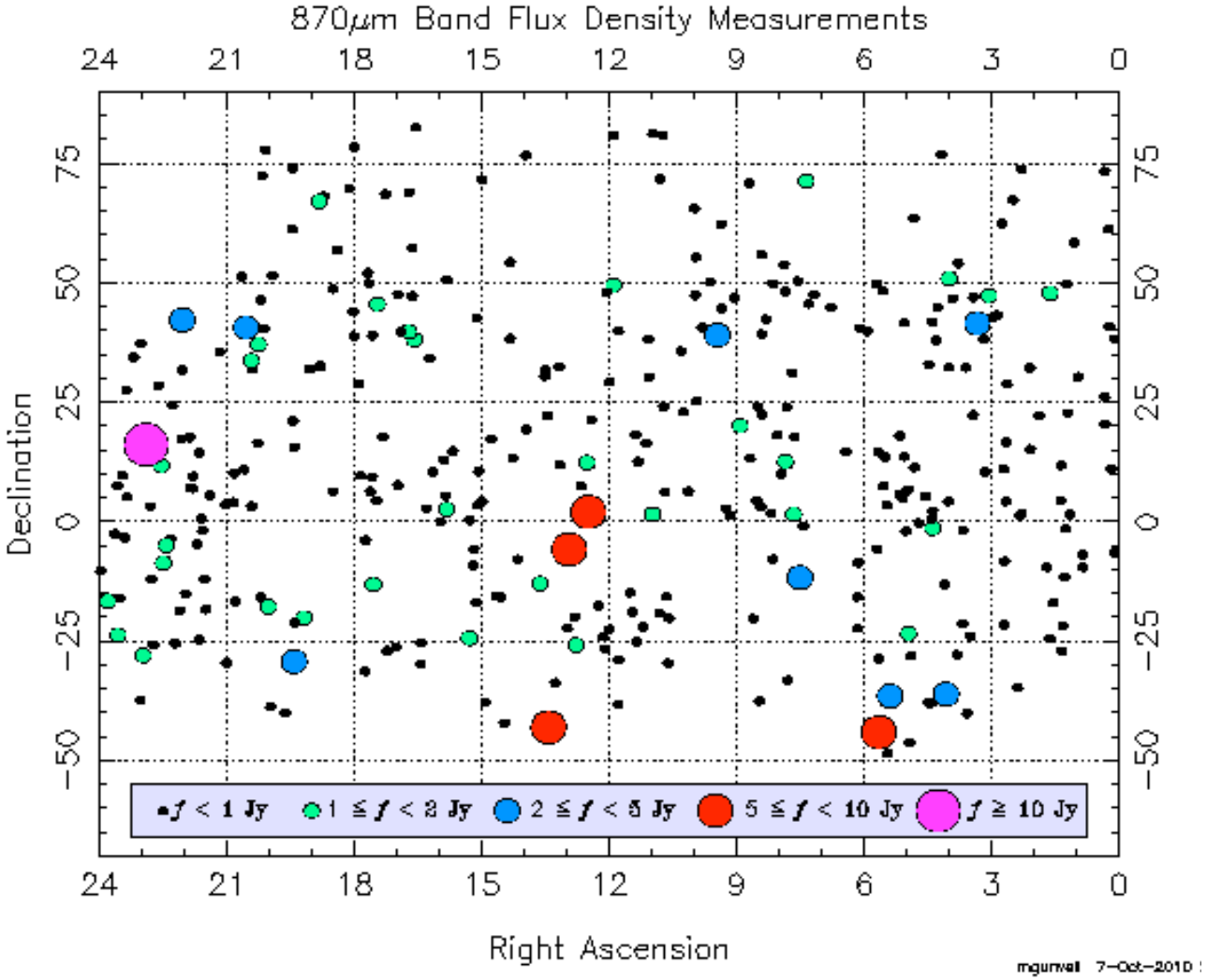
Source Name		J2000 Coordinates (from VLA)		Band	Last Obs. Date	Obs.	Flux Density (Jy) 30.0 day avg	Light Curves
common	IAU (J2000)	RA	Dec					
atca cal	0004-476	00:04:35.640	-47:36:19.73	3mm	18 May 2007	ATCA	0.88 ± 0.08	plot / data
--	0005+383	00:05:57.1754	+38:20:15.148	3mm	12 Feb 2004	OVRO MMA	0.65 ± 0.03	
				1mm	01 Dec 2008	SMA	0.36 ± 0.03	plot / data
				850µm	11 Nov 2008	SMA	0.22 ± 0.06	
--	0006-063	00:06:13.8928	-06:23:35.335	3mm	20 May 2007	ATCA	1.56 ± 0.08	
				1mm	16 Jan 2009	SMA	0.95 ± 0.08	plot / data
				850µm	20 Nov 2008	SMA	0.56 ± 0.05	
--	0010+109	00:10:31.0058	+10:58:29.504	3mm	12 Feb 2004	OVRO MMA	2.41 ± 0.10	
				1mm	16 Dec 2008	SMA	0.51 ± 0.03	plot / data
				850µm	19 Oct 2008	SMA	0.86 ± 0.08	
--	0010+174	00:10:33.9906	+17:24:18.761	3mm	12 Feb 2004	OVRO MMA	0.36 ± 0.03	plot / data
				1mm	15 Mar 2002	OVRO MMA	0.39 ± 0.17	
--	0012-399	00:12:59.9080	-39:54:25.836	3mm	18 May 2007	ATCA	0.43 ± 0.04	plot / data
--	0013+408	00:13:31.1302	+40:51:37.144	3mm	12 Feb 2004	OVRO MMA	0.61 ± 0.03	
				1mm	09 Dec 2008	SMA	0.64 ± 0.04	plot / data
				850µm	22 Oct 2008	SMA	0.43 ± 0.07	
--	0014+612	00:14:48.8154	+61:17:43.852	3mm	12 Feb 2004	OVRO MMA	0.45 ± 0.03	
				1mm	09 Dec 2008	SMA	0.20 ± 0.04	plot / data
				850µm	22 Oct 2007	SMA	0.19 ± 0.05	

Done

- Data on >400 quasars
- Flux history accessible online
- 1.35 mm, 1.1 mm and 850 μm SMA measurements
- Flux scale tied to solar system 'primary' calibrators (Uranus, Neptune, Mars, Titan, Ganymede, Callisto)

Sky Distribution



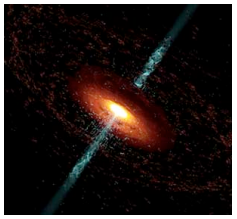


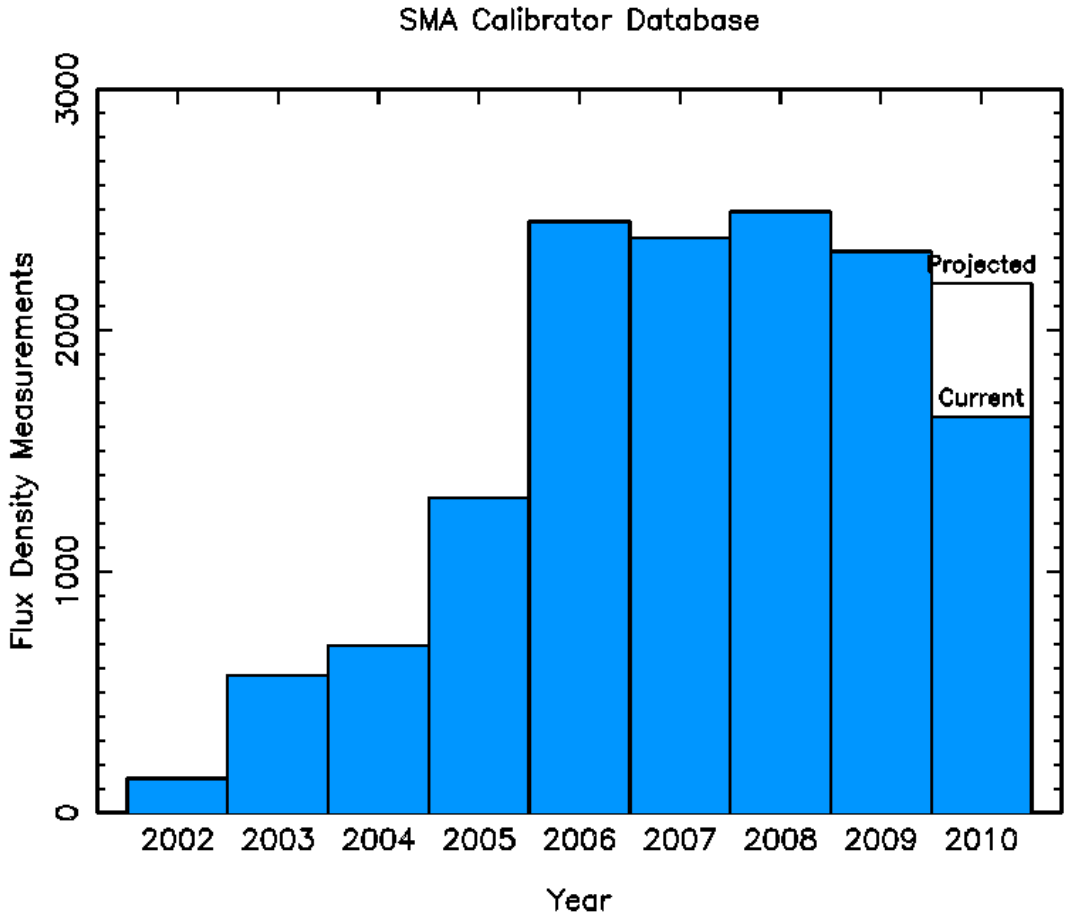
Most <1 Jy

Typically <30 above 2 Jy

$F_\nu \propto \nu^{-(0.5\pm0.4)}$

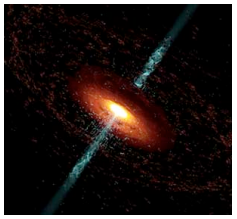
Size and Growth of Database

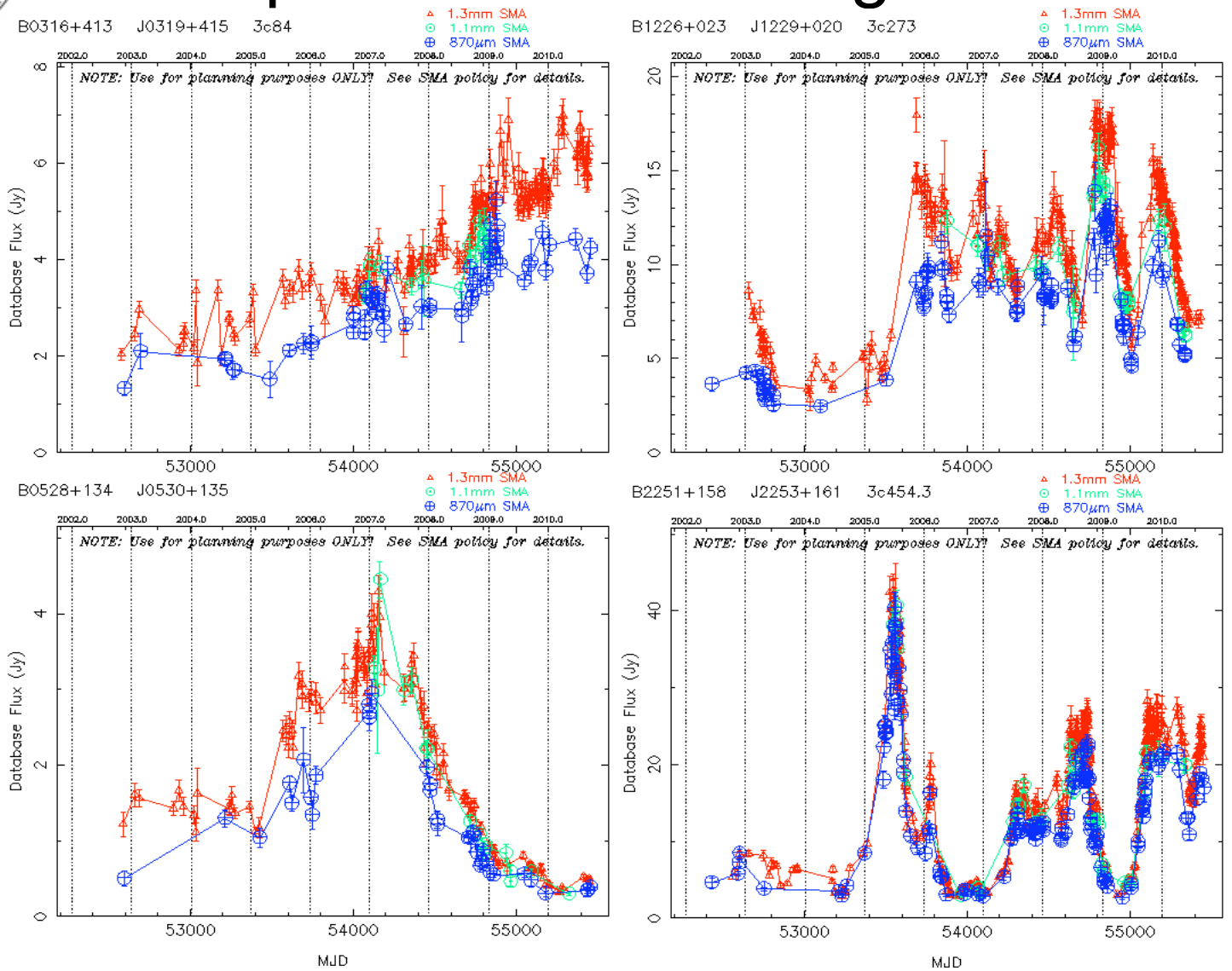




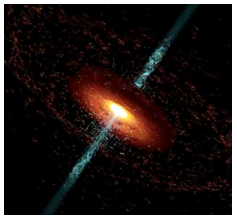
- Over 14000 measurements
- Adding ~2400/yr
- From regular science tracks and dedicated ‘flux’ and baseline calibration observations

Example MM/SubMM Light Curves





II. Blazar/AGN Observations



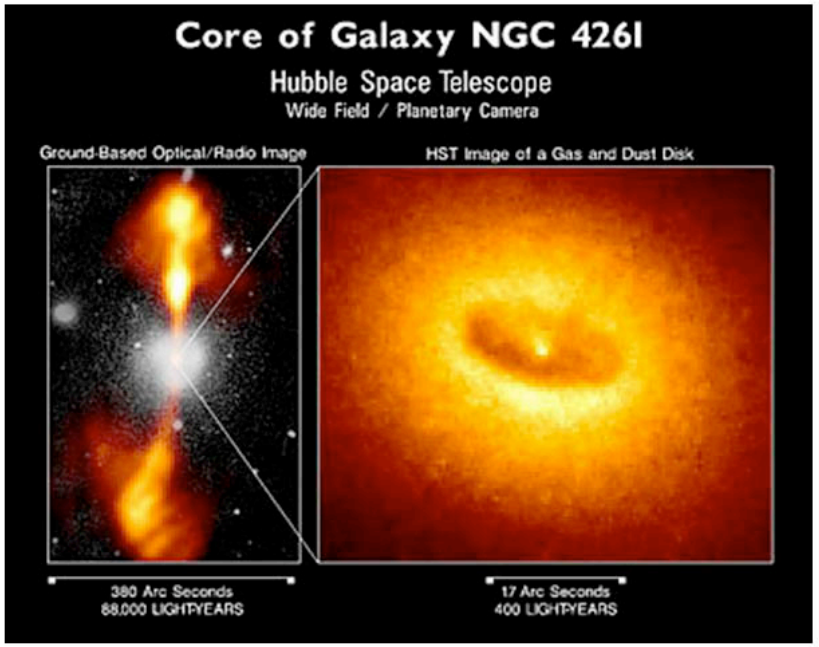
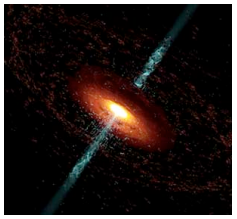
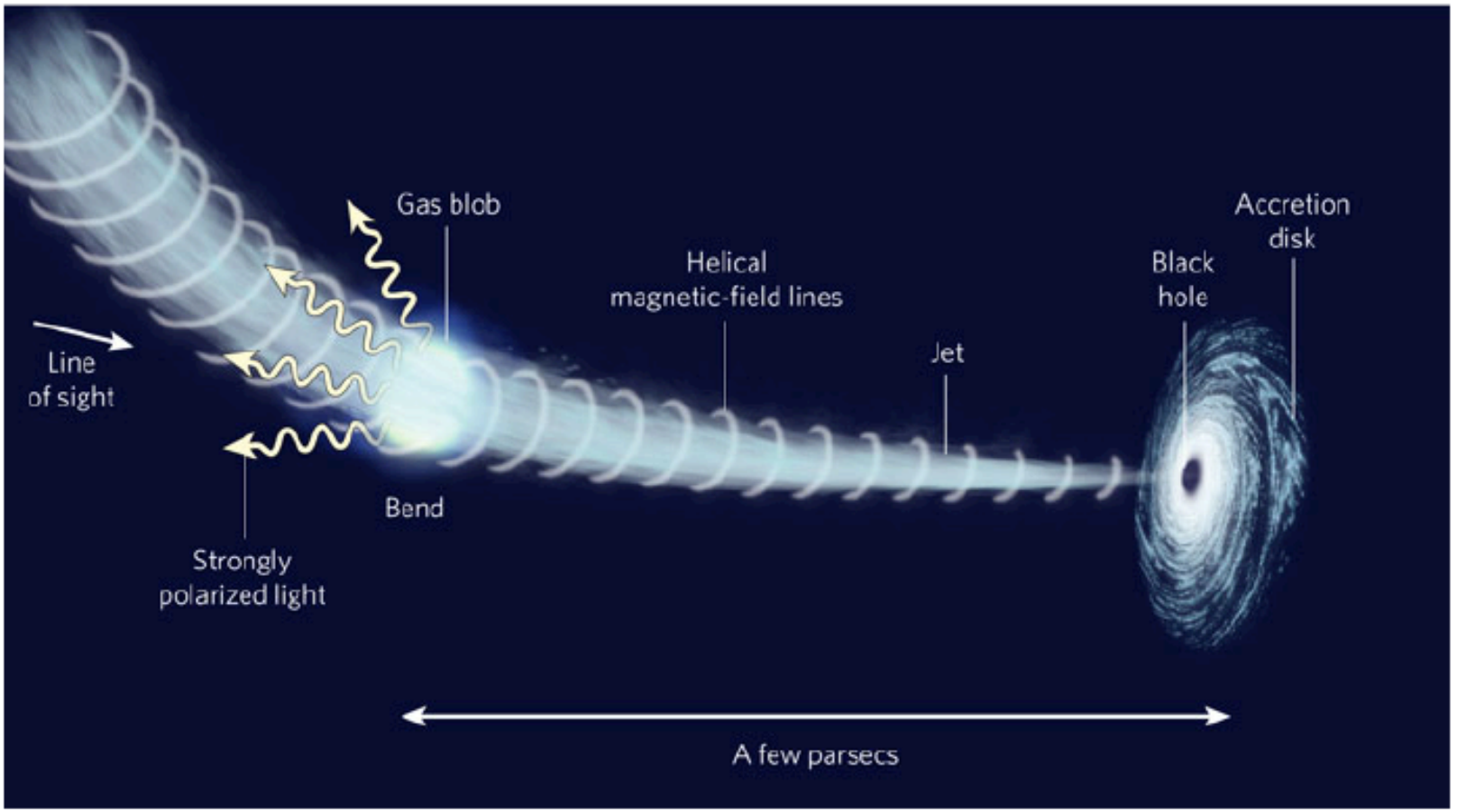


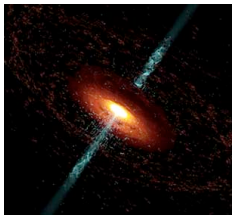
Figure 5: Active galaxy NGC 4261 at radio and optical wavelengths.

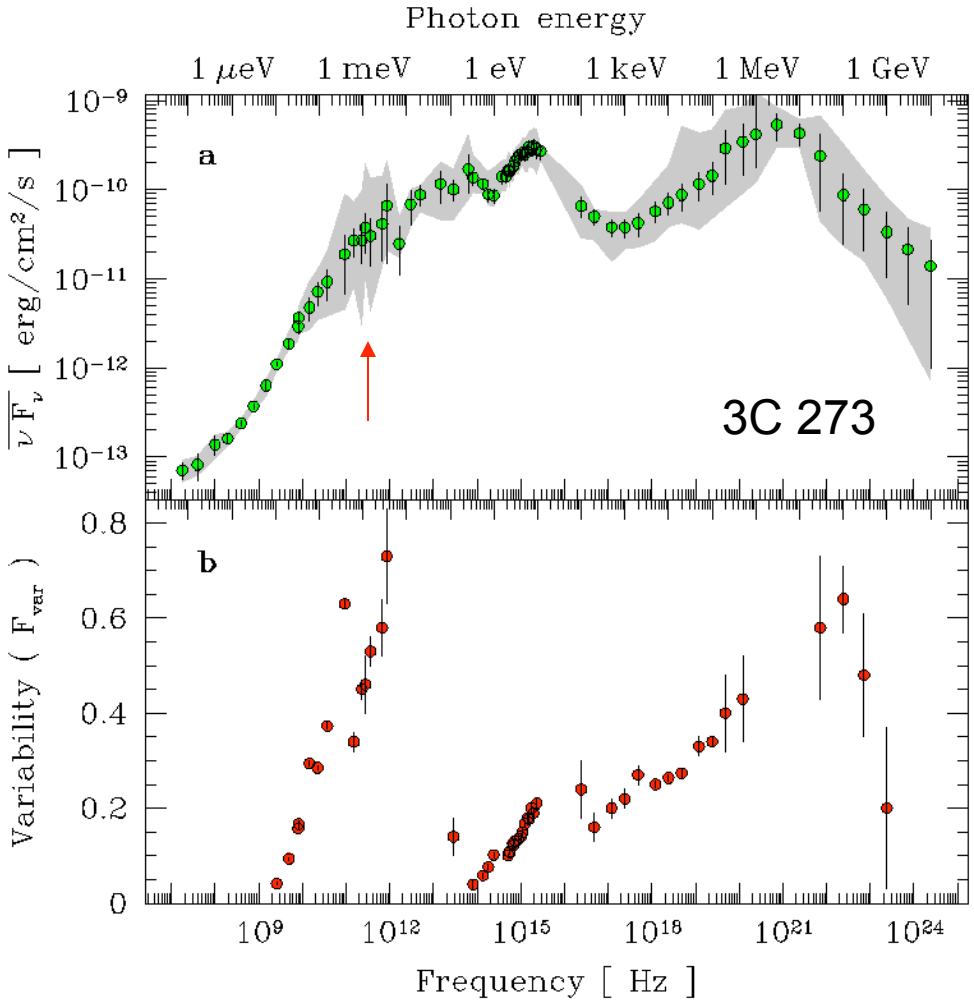
Blazar Model





Quasar/blazar SEDs



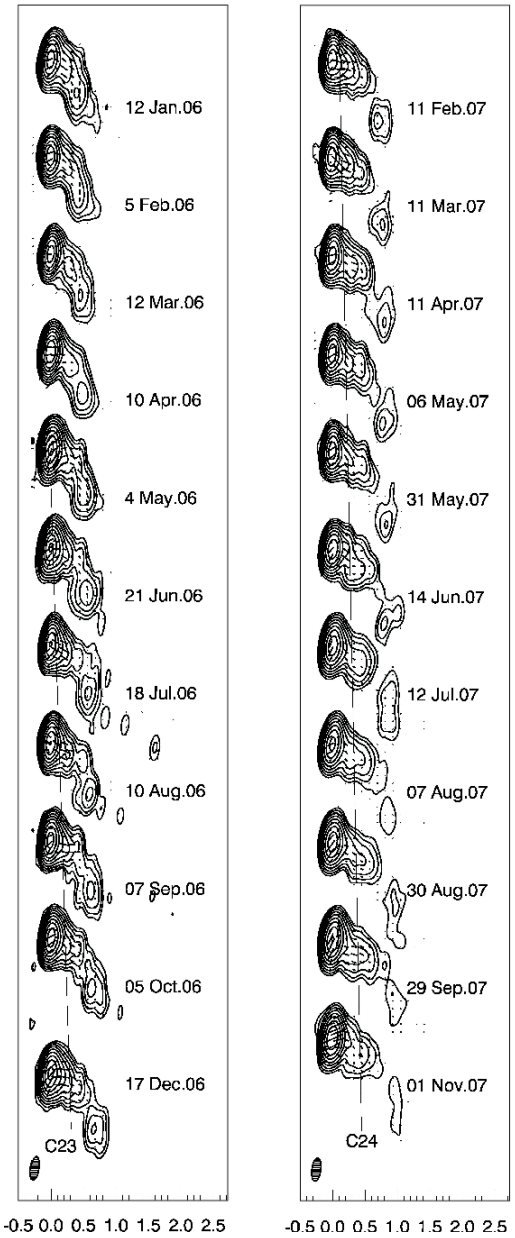


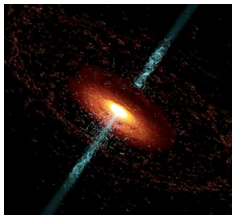
- Quasar/blazar emission
  - bimodal SED
  - Low peak synchrotron, high peak inverse Compton scattering
- Flare time delay related to relative location of emitting regions
- submm is closest band usable from ground for low end of synchrotron peak

3C279 - Radio Flare

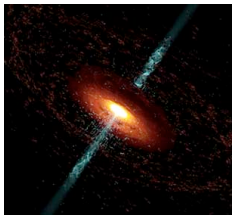
VLBA monitoring of 3C279

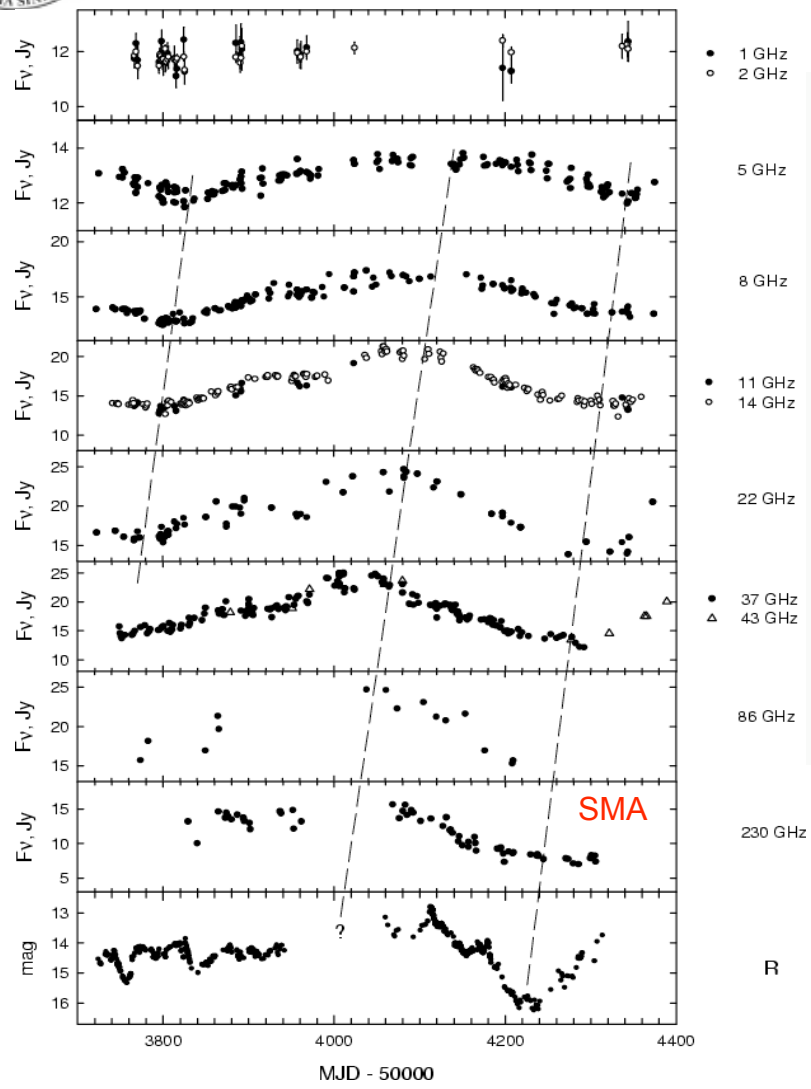
2006-2007 superluminal ejection along jet axis captured

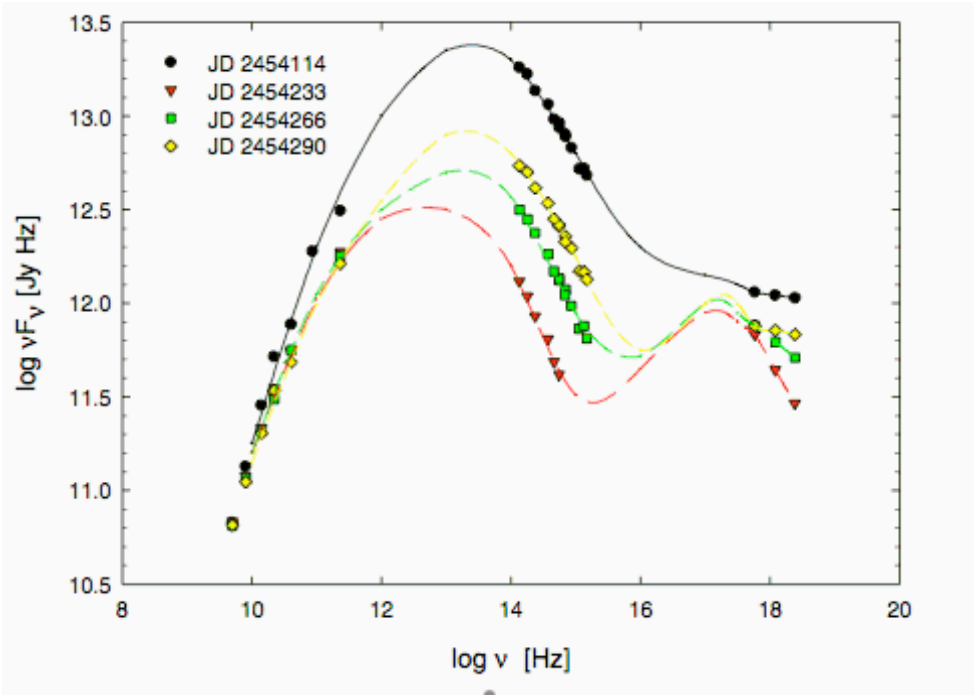




3C279 - Flare Propogation

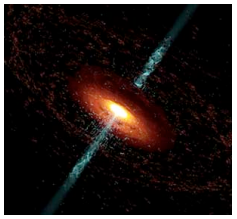


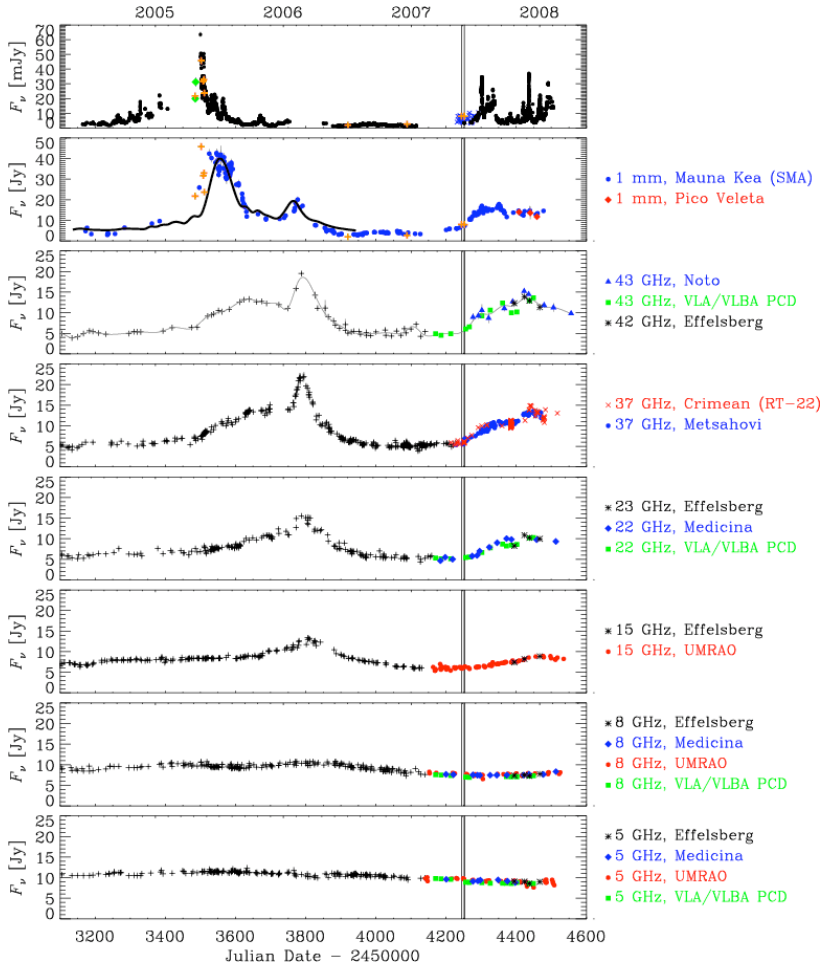


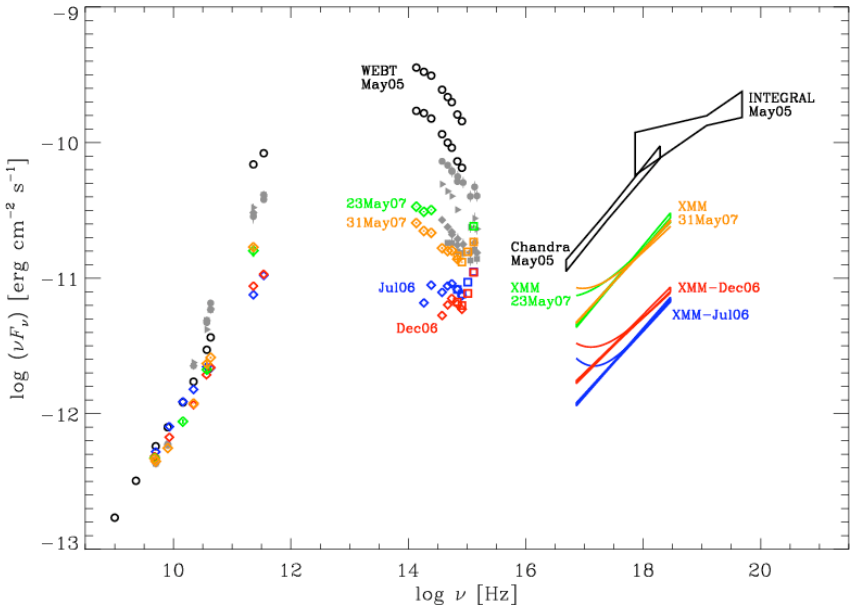


Larionov et al 2008

3C454.3 Flare Propogation

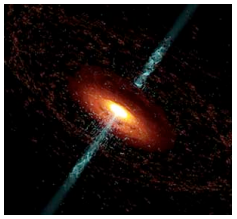


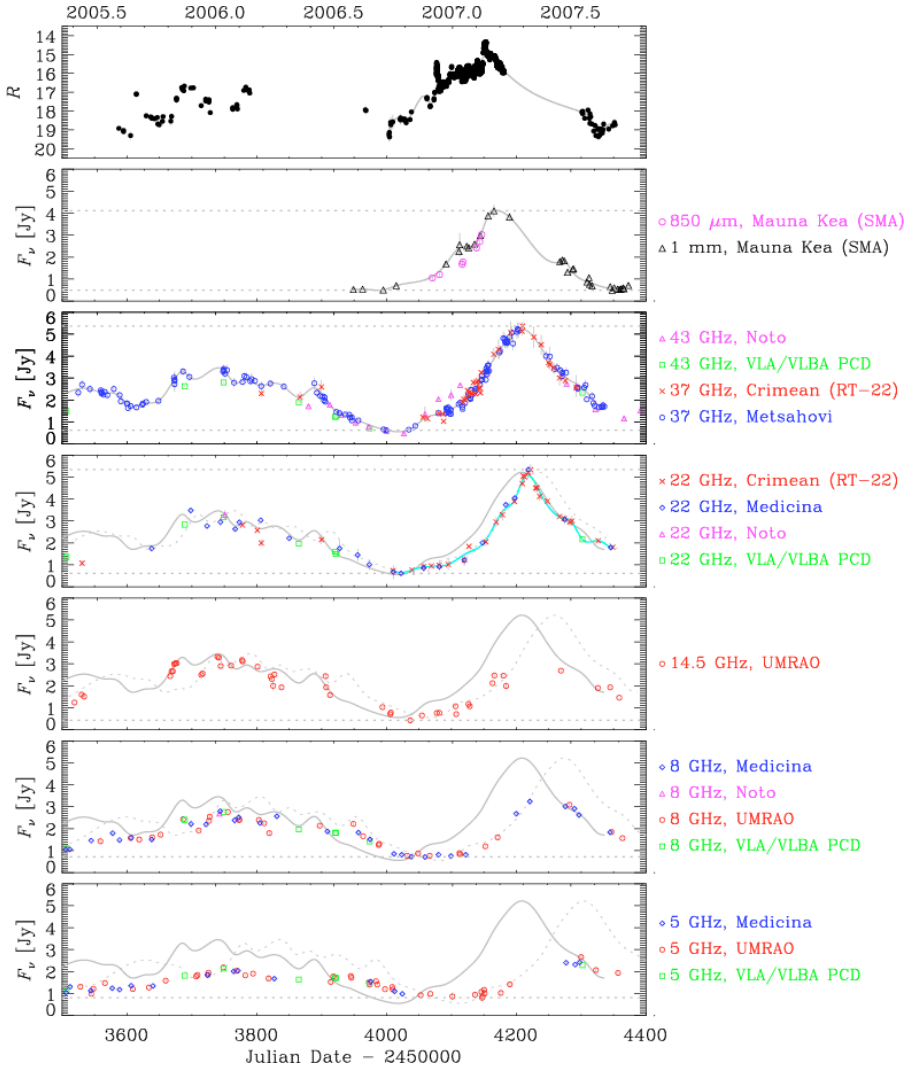




Raiteri et al 2008A.

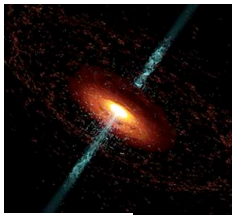
0235+164 Flare Propogation

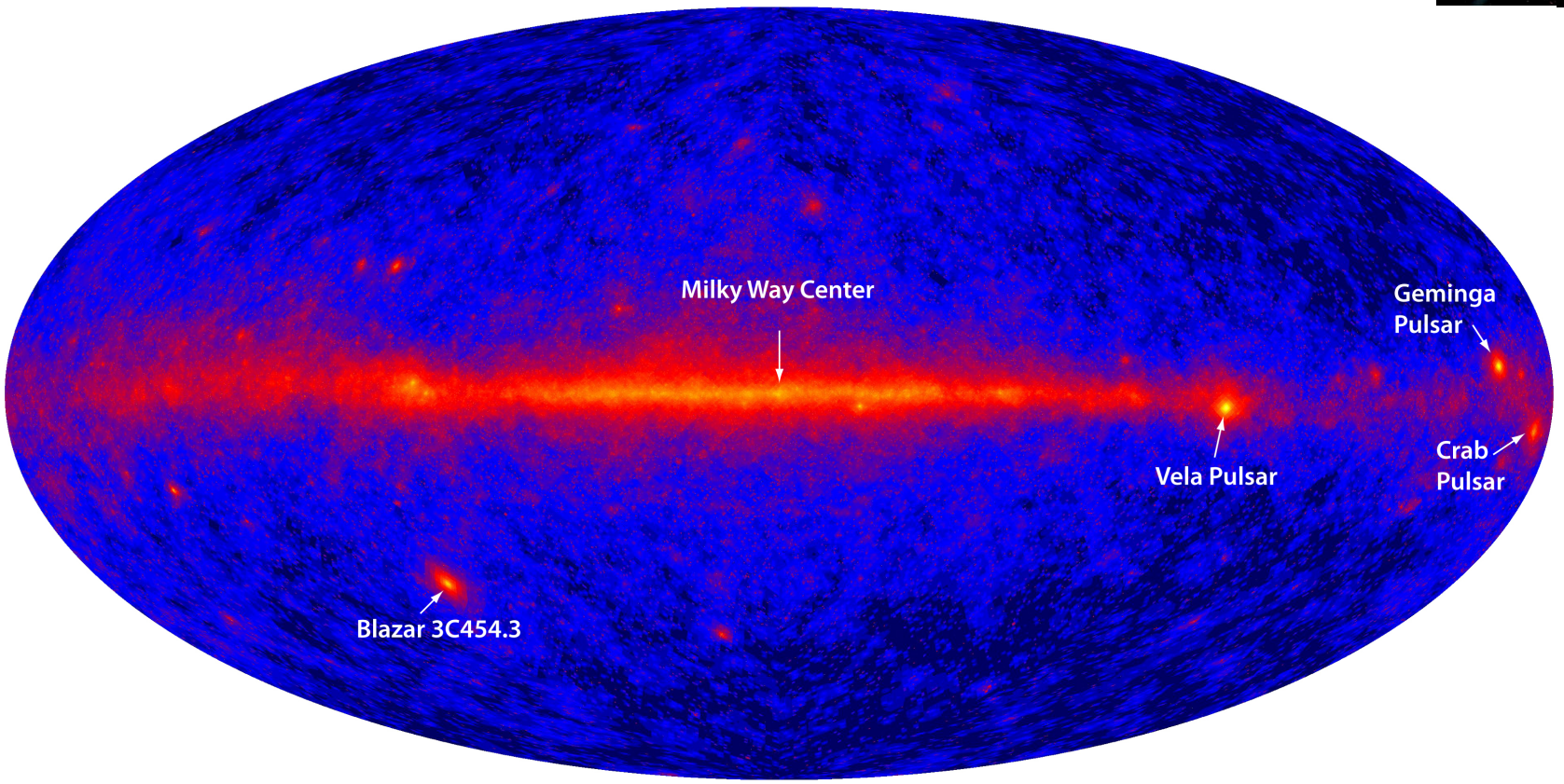




Raiteri et al 2008B

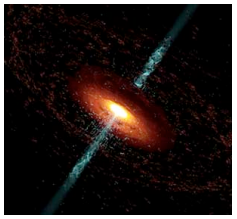
Blazars Blazing

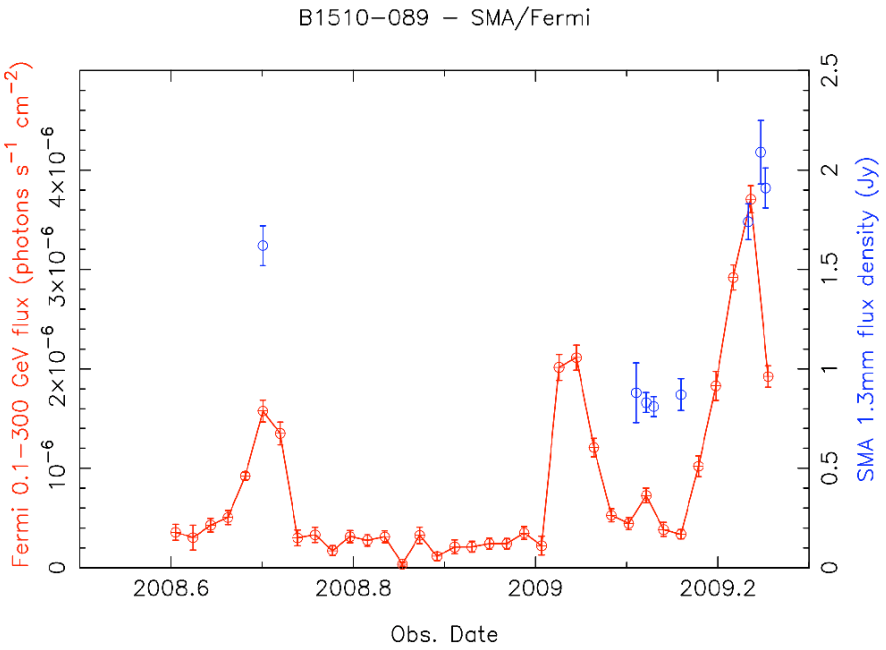


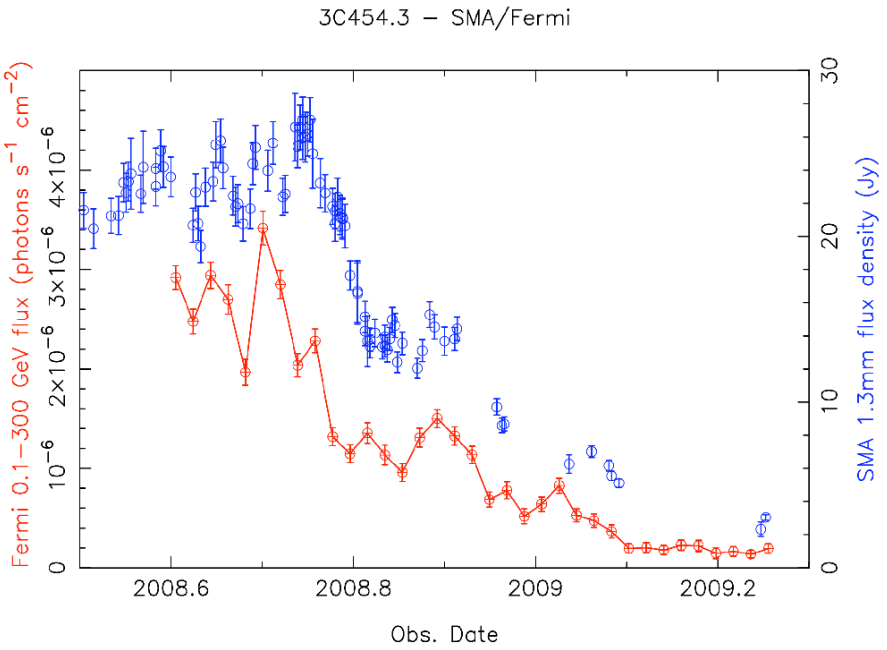


The Gamma Ray Sky - Fermi

Gamma-ray/mm/submm correlation

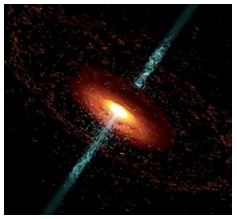


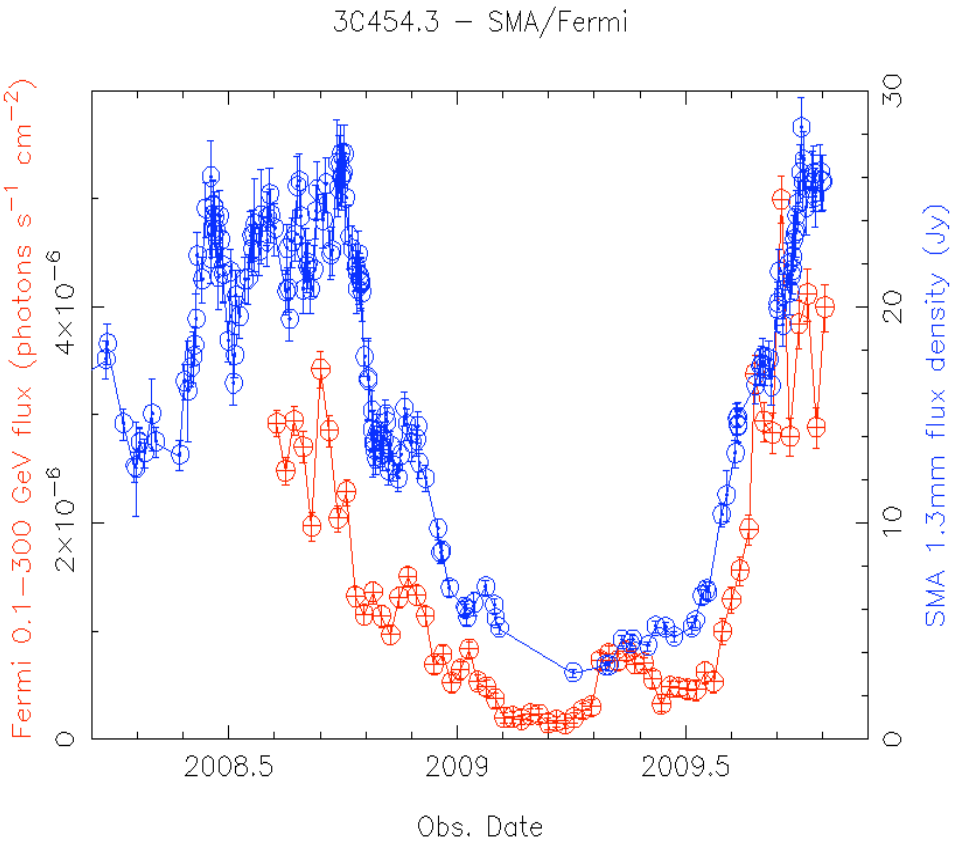


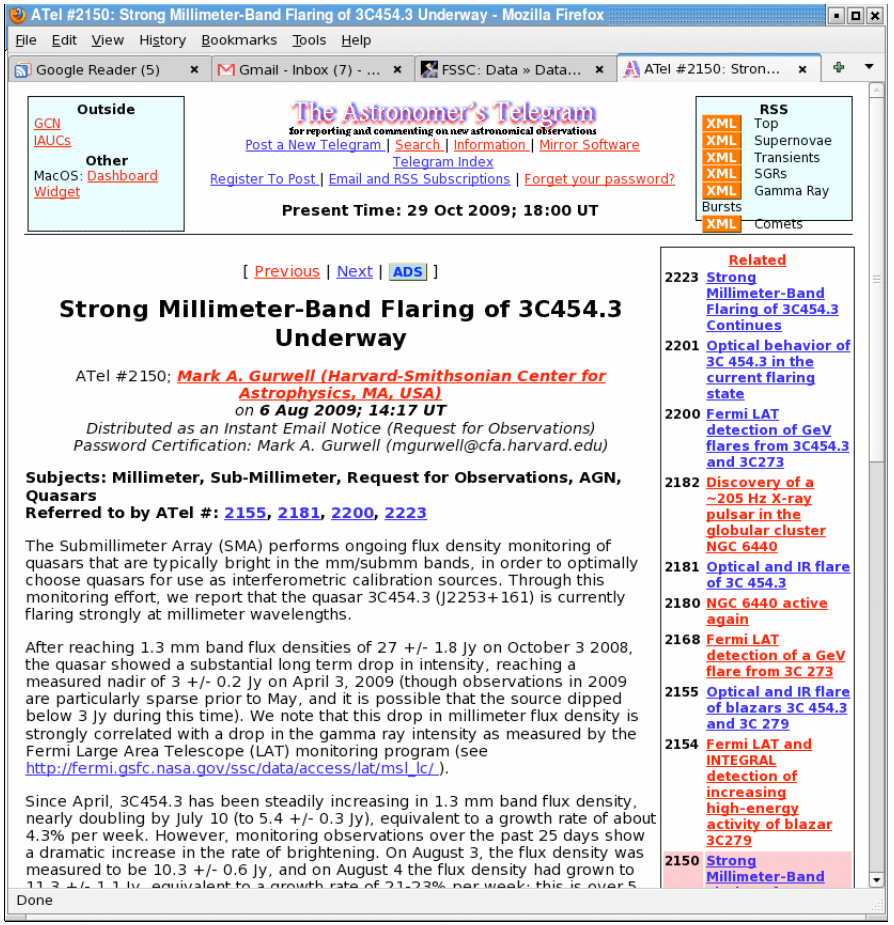


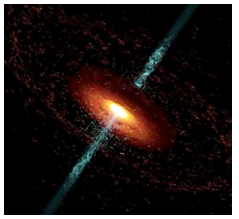
Wehrle et al (ongoing)

Gamma Ray/MM Correlation II



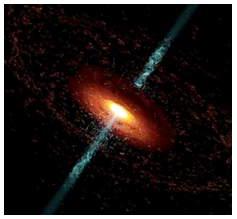






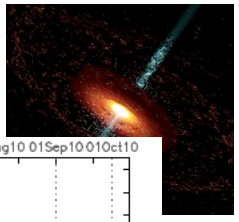
- Currently 16 publications using general SMA flux density monitoring results
- Many more in progress as Fermi observation baseline increases and more flaring sources are discovered

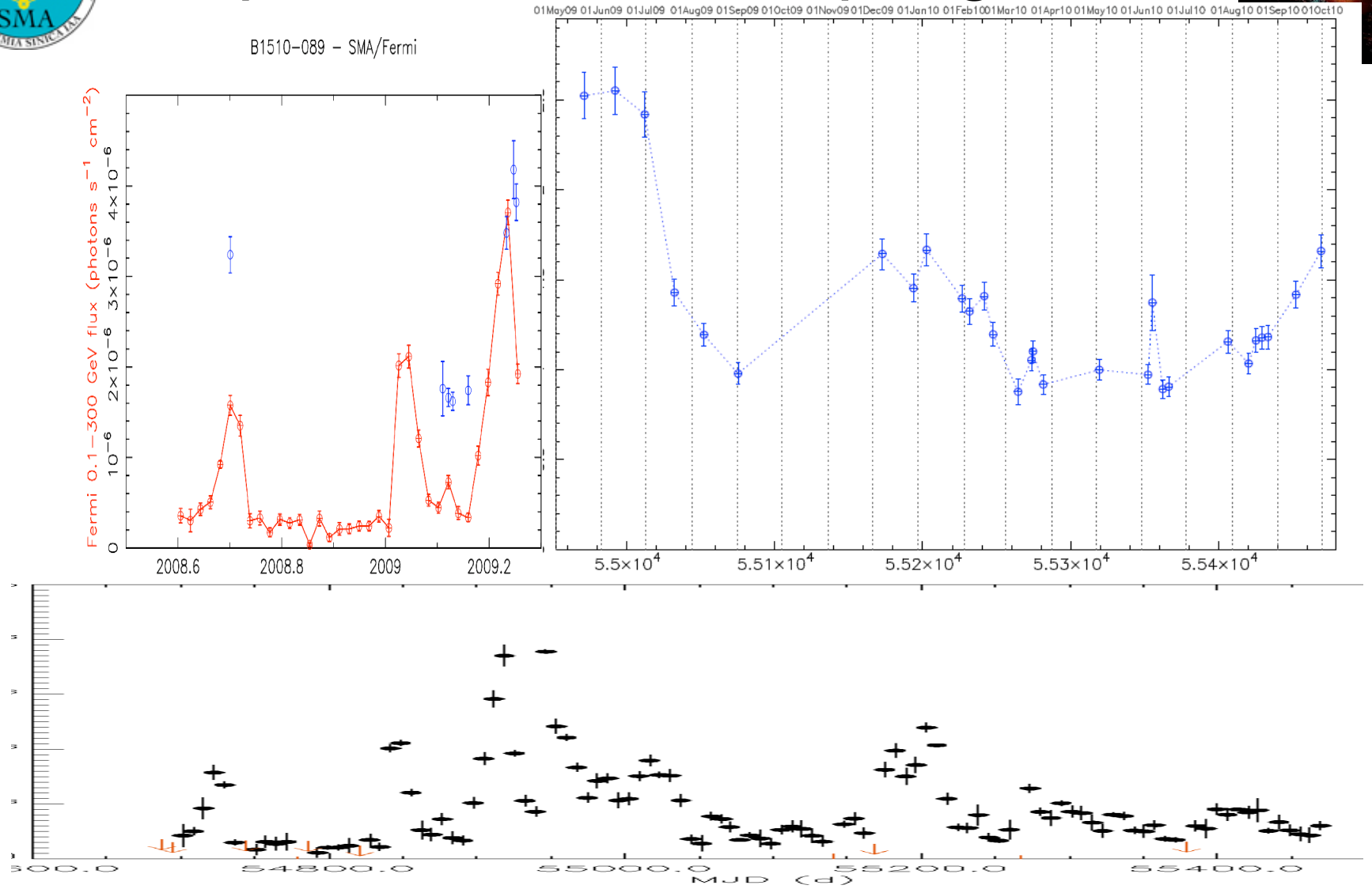
III. Independent Programs



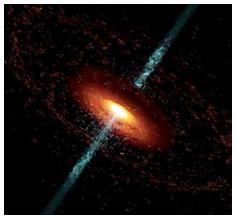
- General flux monitoring not sampled enough in some cases, or not at all in others
- Several proposals accepted for monitoring of specific sources with a regular cadence, with impacts on scheduling
  - Ann Wehrle, Fermi LAT Bright Source catalog
  - Ian McHardy, M81*
  - Aneta Siemiginowska, FSRQs

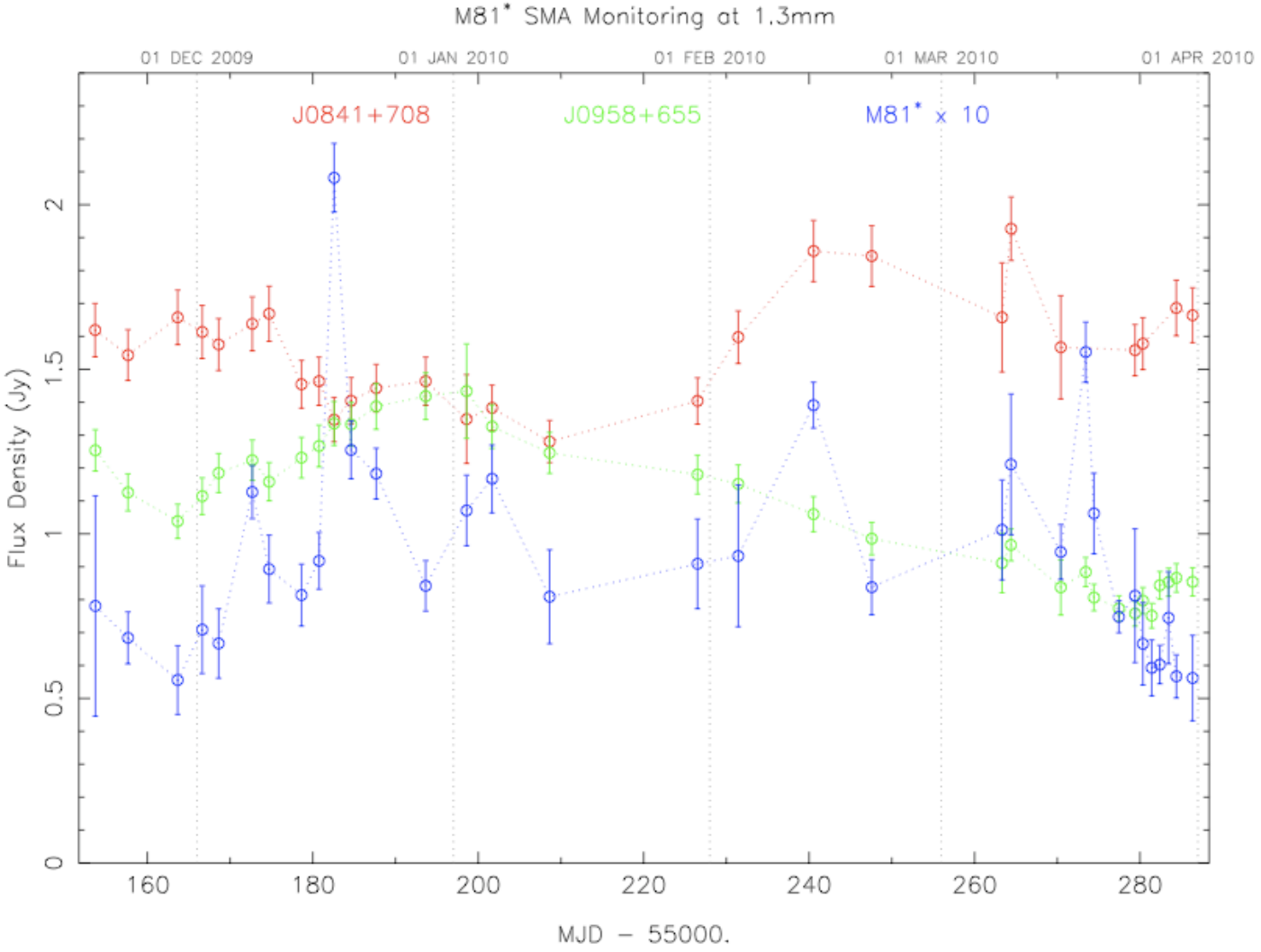
Improved Time Sampling



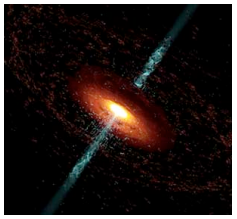


M81* Monitoring





Summary



- SMA Calibrator Database is a nearly unique, accessible resource for the mm/submm flux density history of several hundred quasars

- The SMA data occupy the highest frequency band easily available from the ground for the synchrotron peak in blazars, providing critical information on the shape of the SED of these sources and the location of the emitting regions

END