Compact Radio sources at Low Z (CORALZ)
A progress report

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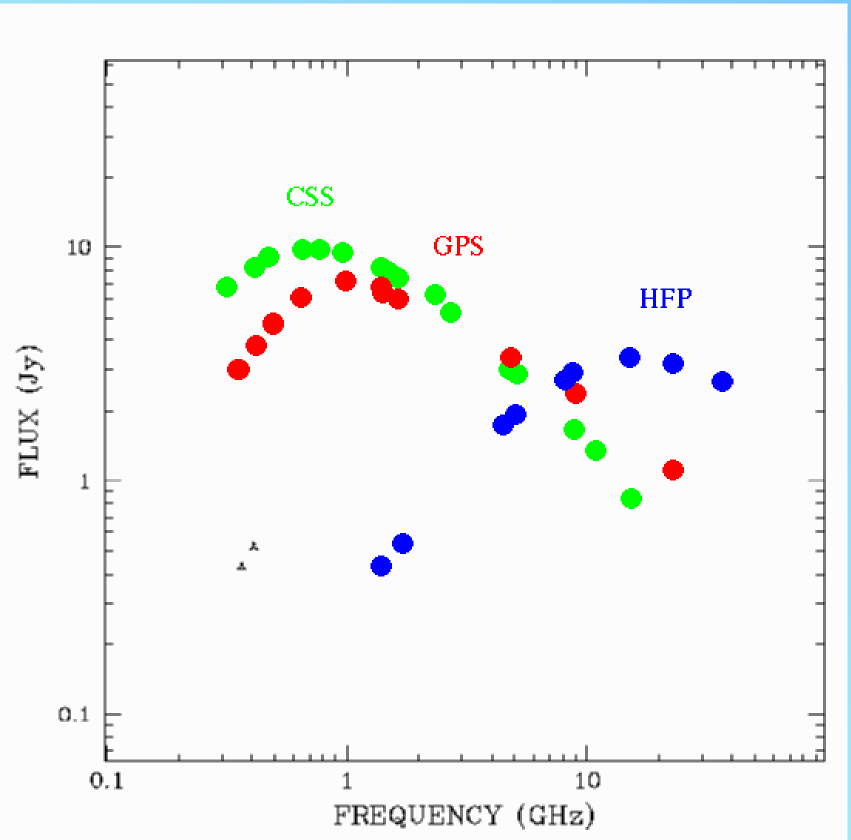
Vague definition based on position of turnover frequency
High-Frequency Peakers (HFP): peak at > 5 GHz
GHz-Peaked Spectrum (GPS): peak at ~ 1 GHz
Compact Steep Spectrum (CSS) : peak at ~ 100 MHz
Turnover frequency anti-correlates with their size (SSA)



Existing samples:
HFP bright (Dallacasa et al. 2000)

GPS bright (Stanghellini et al. 1998)
GPS faint (Snellen et al. 1998)

CSS bright (Fanti et al. 1990)
CSS medium (B3VLA-CSS, Fanti et al. 2001)

Nearby (z< 0.2) compact sources very rare: 10 in complete samples

Sample selection

FIRST survey @ 1.4 GHz (White et al. 1997)

$\Rightarrow$ 1515 point-like sources with $S_{peak} > 100$ mJy
($30^{\circ} < \delta < 57.5^{\circ}$, $b > 30^{\circ}$)

$\Rightarrow$ 77 objects with APM extended sources of $e < 16.5^{m}$ (R) and $o < 19.5^{m}$ (B) within 10“

After visual inspection (filter out spurious objects and artifacts)

$\Rightarrow$ **28 objects at $0.008 < z < 0.232$**

Completeness of the sample

Completeness as a function of redshift

- Uncertainty in the APM magnitudes (~0.5^m)
- Dependence of raw APM magnitudes on angular size of the object
- Range in absolute magnitudes of the radio galaxies
- Large bright galaxies can cause artifacts in the APM and can be missed.

$\Rightarrow$ Complicated redshift selection function

Completeness of the sample

Completeness as a function of redshift

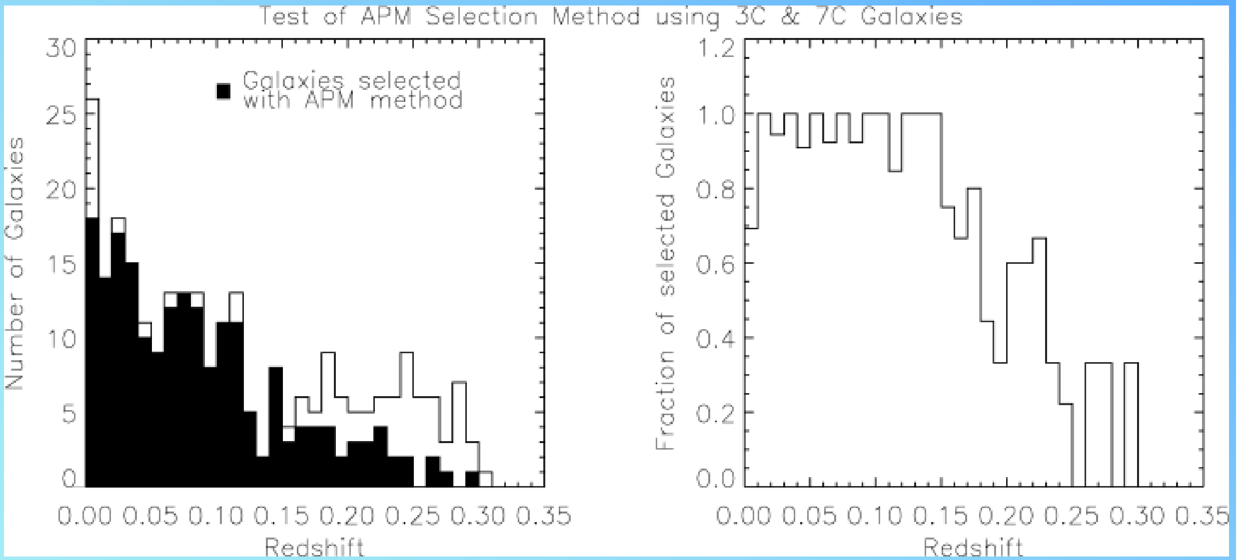
NED to select all known radio galaxies in 3C and 7C at $z < 0.3$ located within the APM survey region.

⇒ 268 nearby radio galaxies with similar radio flux density and luminosity range

⇒ Cross-correlation with APM

⇒ 95% completeness in $0.005 < z < 0.16$

⇒ **17 sources in complete CORALZ sample**



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Completeness of the sample

Completeness and reliability of optical identifications

- Combined uncertainty in the optical and radio: ~ 0.7“
- 24/28 sources have radio-optical positional offsets < 1.5“
- Maximum likelihood method (De Ruiter et al. 1977):
  cut-off 2“ ⇒ **97% completeness, 98% reliability**

Selection bias against the most compact sources

- Source selection at 1.4 GHz ⇒ HFPs

⇒ CLASS (Myers et al. 2003): sources with estimated $S_{1.4GHz}$ > 100 mJy (based on 8.4-5 GHz spectral index):

⇒ 455 additional sources (5 identified with bright APM galaxies, but steep spectral index probably caused by variability)

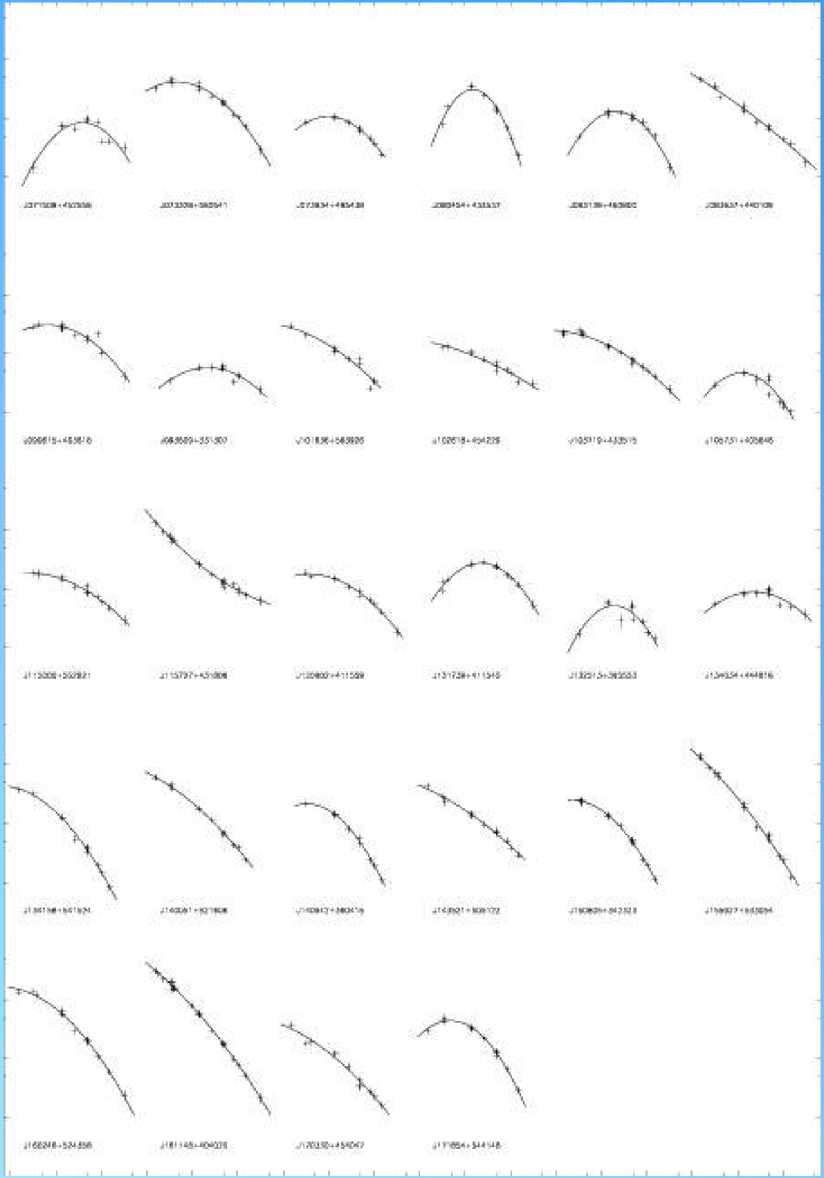
IAU Name	S	Radio Position (J2000) RA	Dec.	Δ_{pos} (arcsec)	z	$S_{1.4\,GHz}$ (mJy)	$L_{5.0\,GHz}$ ($W\,Hz^{-1}$)	radio spectrum ν_{peak} (GHz)	S_{peak} (mJy)	α_{h}
The Complete CORALZ sample at $0.005 < z < 0.16$										
J073328+560541	F	$07^h33^m28^s.64$	$+56°05'41''.9$	0.5	0.104	394	24.68	460	420	−0.87
J073934+495438	F	$07^h39^m34^s.89$	$+49°54'38''.9$	0.5	0.054	107	23.63	950	100	−0.88
J083139+460800	F	$08^h31^m39^s.81$	$+46°08'00''.7$	0.2	0.127	131	24.62	2200	130	−0.81
J083637+440109	F	$08^h36^m37^s.83$	$+44°01'09''.4$	0.2	0.054	139	23.66	<150	>580	−0.65
J090615+463618	F	$09^h06^m15^s.52$	$+46°36'19''.0$	0.3	0.085	314	24.49	680	300	−0.69
J102618+454229	F	$10^h26^m18^s.28$	$+45°42'29''.5$	0.5	0.153	105	24.55	180	150	−0.41
J103719+433515	F	$10^h37^m19^s.34$	$+43°35'15''.2$	1.0	0.023	129	22.96	<150	>250	−0.62
J120902+411559	F	$12^h09^m02^s.80$	$+41°15'59''.4$	0.7	0.095	147	24.26	370	170	−0.71
J131739+411545	F	$13^h17^m39^s.21$	$+41°15'46''.0$	0.3	0.066	249	24.37	2300	270	−0.68
J140051+521606	F	$14^h00^m51^s.62$	$+52°16'06''.6$	0.9	0.116	174	24.36	<150	>760	−0.91
J140942+360416	F	$14^h09^m42^s.46$	$+36°04'16''.0$	0.5	0.148	143	24.45	330	220	−1.34
J143521+505122	F	$14^h35^m21^s.68$	$+50°51'22''.8$	0.3	0.099	141	24.20	<150	>450	−0.69
J150805+342323	F	$15^h08^m05^s.68$	$+34°23'23''.3$	0.7	0.045	130	23.35	<230	>250	−1.31
J160246+524358	F	$16^h02^m46^s.39$	$+52°43'58''.7$	0.7	0.106	576	24.75	<150	>1610	−1.10
J161148+404020	F	$16^h11^m48^s.55$	$+40°40'20''.9$	0.3	0.152	553	25.03	<150	>4340	−1.09
J170330+454047	F	$17^h03^m30^s.38$	$+45°40'47''.1$	0.2	0.060	119	23.54	<150	>380	−0.88
J171854+544148	F	$17^h18^m54^s.40$	$+54°41'48''.2$	0.1	0.147	329	24.86	480	440	−1.35
Other nearby sources in the sample										
J093609+331308	C	$09^h36^m09^s.37$	$+33°13'08''.6$	0.1	0.076	55	23.84	2200	57	−0.38
J101636+563926	F	$10^h16^m36^s.10$	$+56°39'26''.9$	0.3	0.232	108	24.91	<150	>300	−0.74
J105731+405646	C	$10^h57^m31^s.17$	$+40°56'46''.0$	0.0	0.008	47	21.59	1250	46	−1.09
J115727+431806	F	$11^h57^m27^s.60$	$+43°18'06''.8$	1.5	0.229	256	25.25	<150	>2170	−0.44
J132513+395552	C	$13^h25^m13^s.40$	$+39°55'53''.0$	0.6	0.074	56	23.69	1900	50	−1.04
J134035+444817	C	$13^h40^m35^s.20$	$+44°48'17''.4$	1.0	0.065	82	23.89	2300	90	−0.39
J155927+533054	F	$15^h59^m27^s.66$	$+53°30'54''.7$	1.2	0.178	182	24.67	<150	>1840	−1.19
Compact radio sources located towards probably random foreground galaxies										
J071509+452555	C	$07^h15^m09^s.94$	$+45°25'55''.9$	2.6	0.042	74	23.52	3800	84	−0.50
J080454+433537	F	$08^h04^m54^s.91$	$+43°35'37''.2$	3.4	0.123	360	24.78	1500	310	−1.80
J115000+552821	F	$11^h50^m00^s.15$	$+55°28'21''.1$	2.6	0.130	143	24.57	<230	>180	−0.56
J134158+541524	F	$13^h41^m58^s.54$	$+54°15'24''.7$	8.3	0.063	125	23.52	<150	>430	−1.30

Radio follow-up with Effelsberg, VLA, and existing surveys (Cambridge, Texas, CLASS etc.)

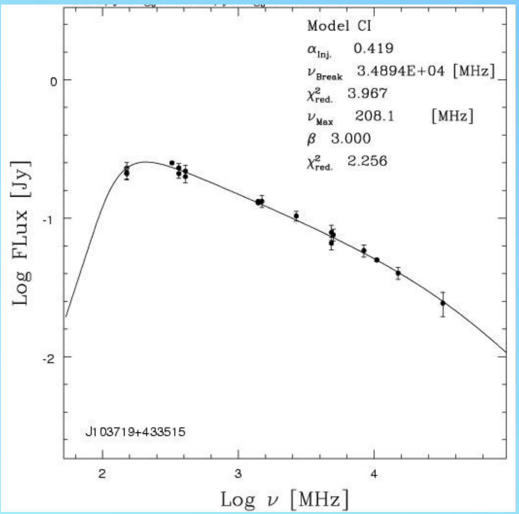
All sources (except J1016+5639) defined as GPS(6) or CSS(10).

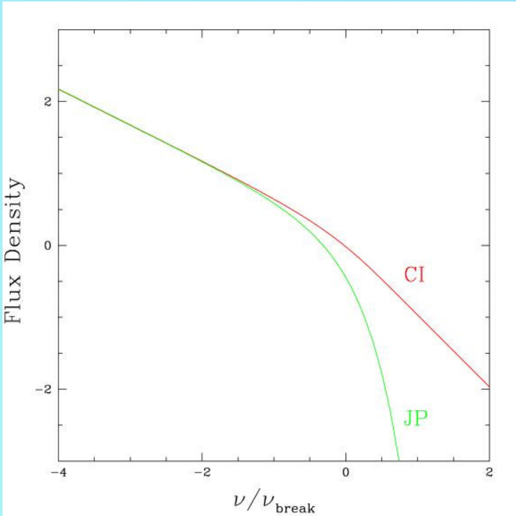
Flux density variability:
7 sources with deviation from best fit > 3σ.
=> 5 sources CLASS selected
=> 2 sources FIRST, one at z=0.232

=> Variability plays minor role



Spectral Ageing Analysis



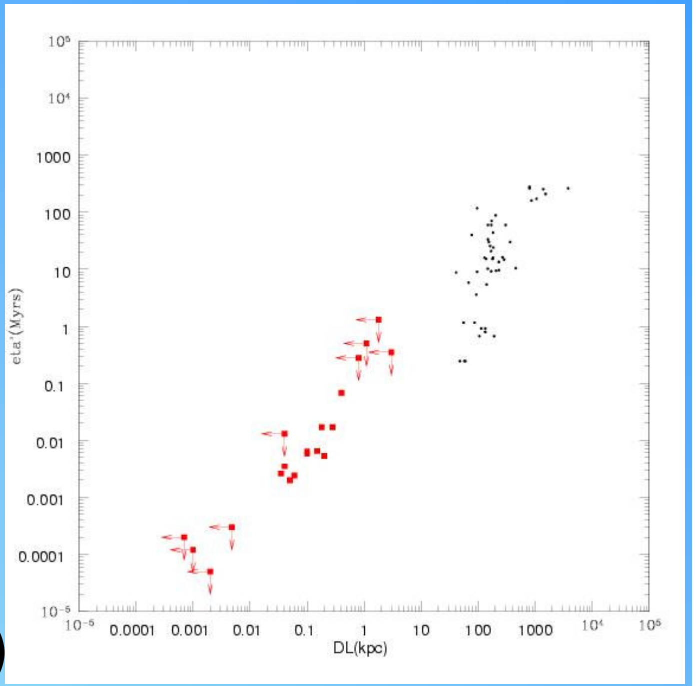


Fit of synchrotron loss models to radio spectrum

⇒ Break frequency ν_{br}

$$\tau_{syn} \propto \frac{\sqrt{B}}{B^2 + B_{IC}{}^2} \frac{1}{\sqrt{(1+z)\nu_{br}}}$$

⇒ $\tau_{syn} = 50 \ldots < 1.3 \cdot 10^6$ a (cmp. Murgia et al. 1999)



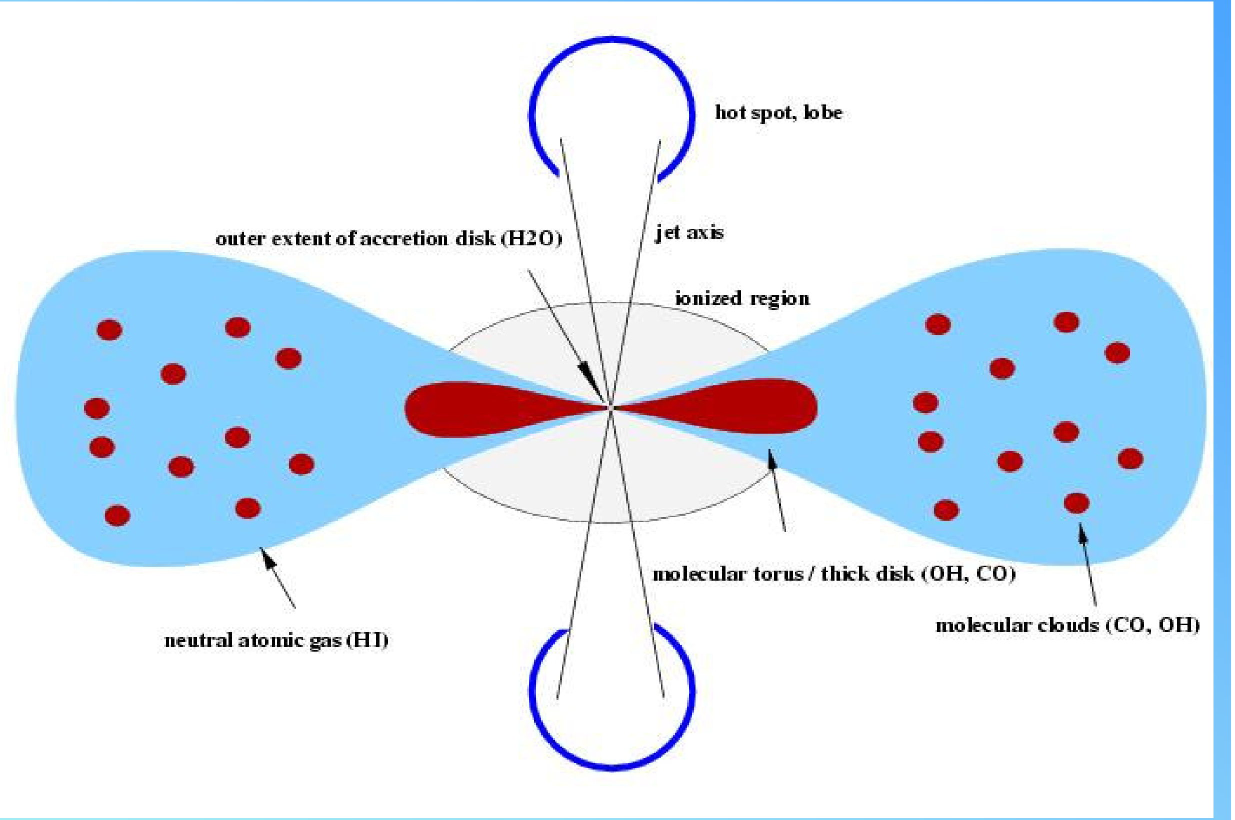
Expansion velocity: 0.002c …0.4c

Compare with dynamic age

The structure of young AGN

AGN in compact radio sources: higher gas and dust contents
radio continuum emission `illuminates' the Interstellar Medium

- Radio morphology
- dust emission
- HI absorption
- CO emission
- Megamasers
- Optical spectroscopy

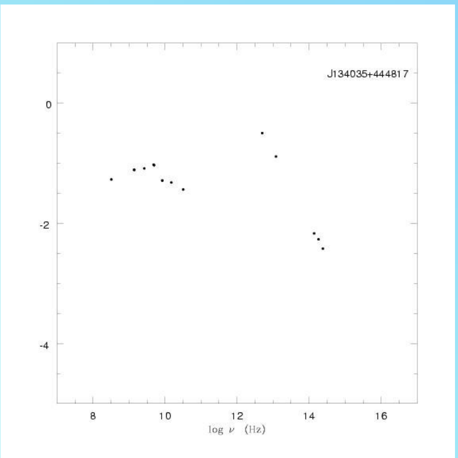


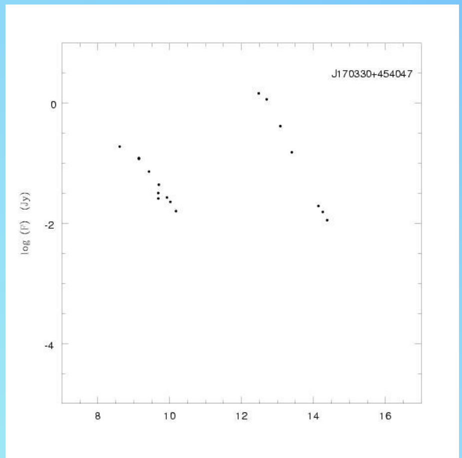
Dust emission

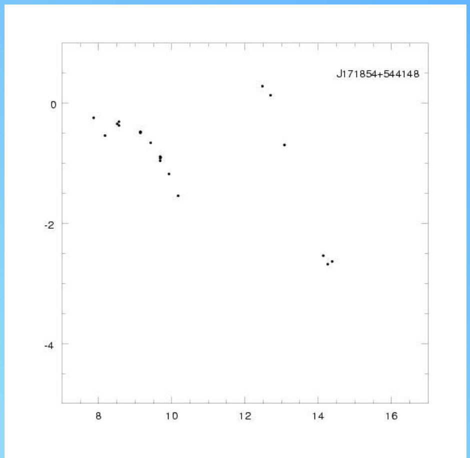
- Three sources detected by IRAS
- Pico Veleta – MAMBO (250 GHz) in course to disentangle synchrotron and dust contribution
- JCMT - SCUBA/SCUBA2 observations (850μ, 450μ)
- Tentative dust masses: $1.7 \cdot 10^3\ M_\odot$ - $9.6 \cdot 10^6\ M_\odot$ (two-temperature approximation: 40 – 120 K)

⇒ slightly lower than the ones reported by Fanti et al. (2000)

⇒ frustration scenario can be ruled out





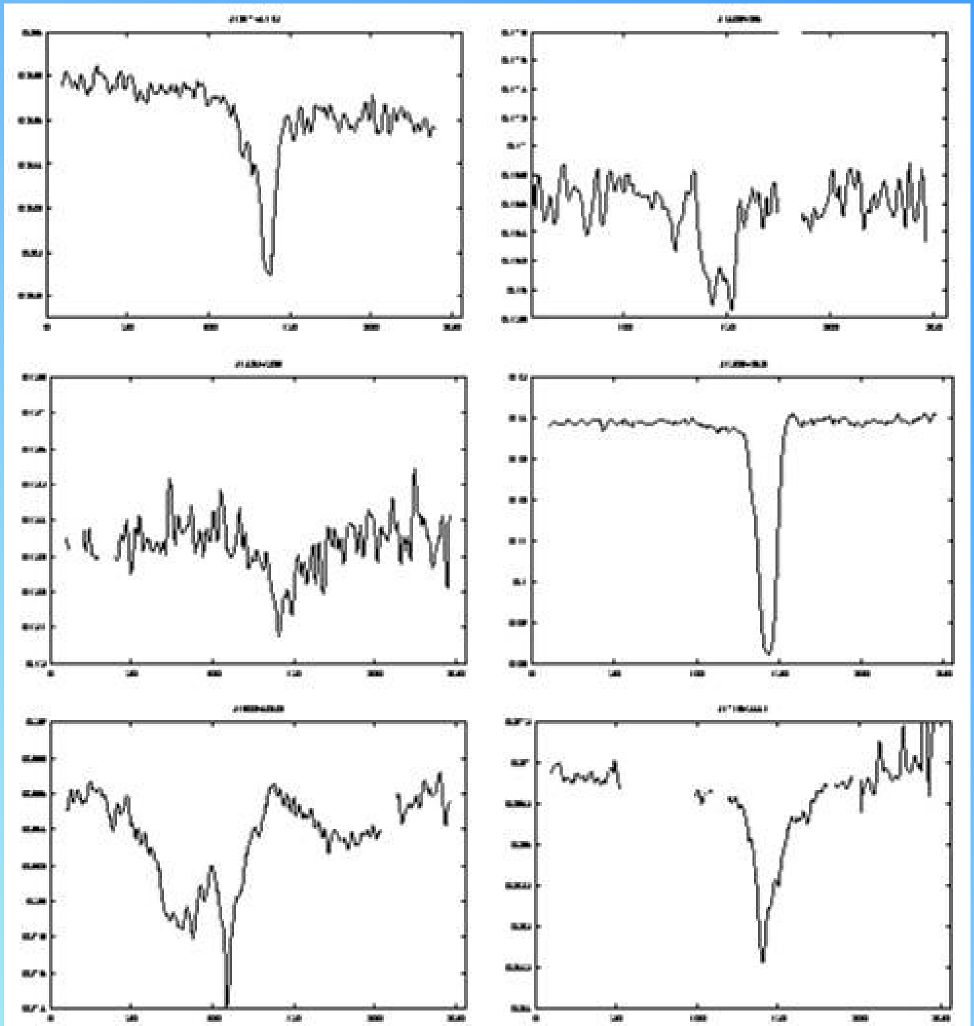


HI absorption

24/24 observed with WSRT
15/24 analysed
6/15 detected: ~ 40%
Vermeulen et al. (2003): 33%

CORALZ column densities:
$5.8 \cdot 10^{20}$ cm^{-2} …$1.2 \cdot 10^{22}$ cm^{-2}

All lines fall in the most sensitive range of 1.4-GHz VLBI. High-resolution mapping of first two sources currently under analysis.



CO emission

No systematic study so far; few sources observed as part of other samples

Typical gas masses: some $10^{10}\,M_\odot$ (based on CO(1-0))

Pico Veleta:

CO(1-0) @ 115 GHz

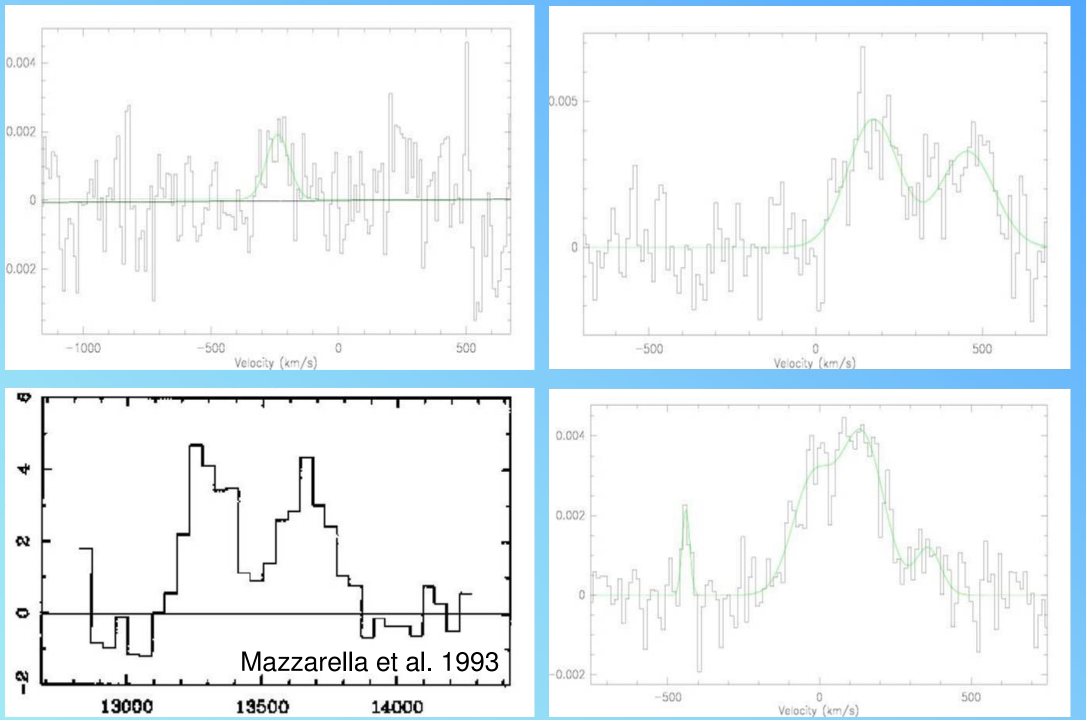
Ongoing programme

6/18 sources observed

4 detections

Corresponding H_2 masses:

$1.2 \cdot 10^8\,M_\odot \ldots 3 \cdot 10^{10}\,M_\odot$



Conclusion

CORALZ:

- First statistically complete sample of young sources at z<0.16
- Selection only based on compactness and vicinity
- Number of nearby young sources increased by a factor 3
- Follow-up programmes:
    - spectral/dynamic ageing
    - dust content
    - HI absorption
    - CO
    - Megamasers
    - Optical spectroscopy