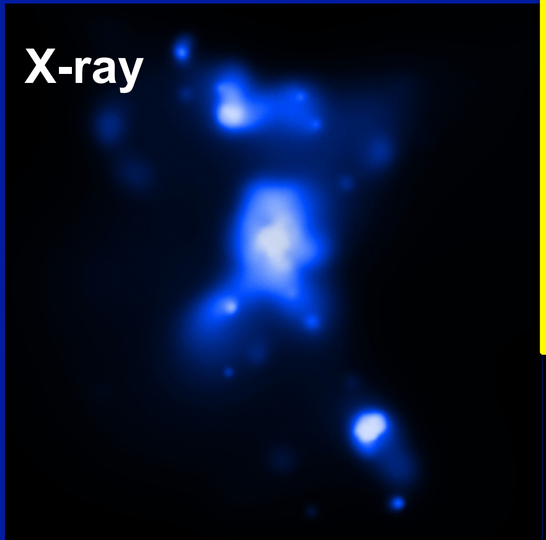
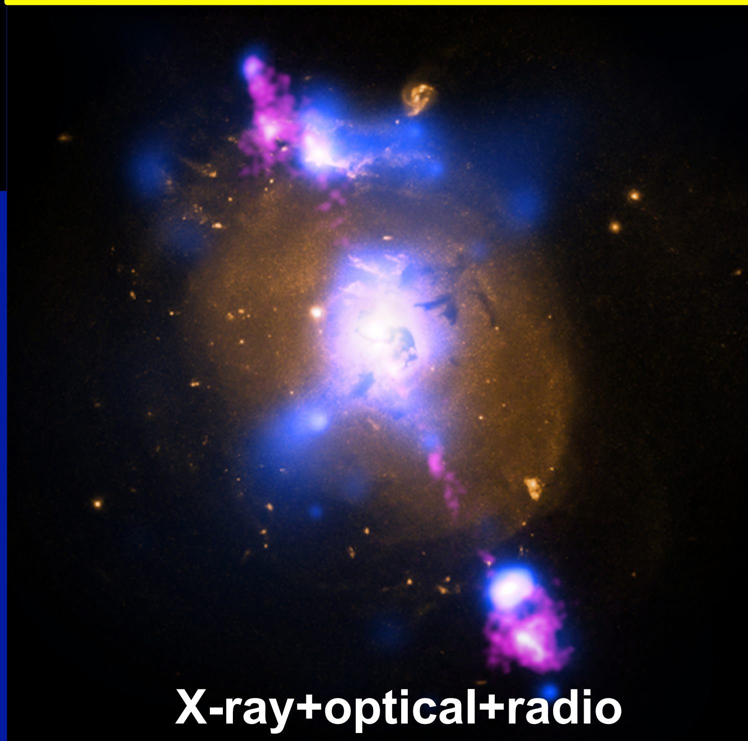
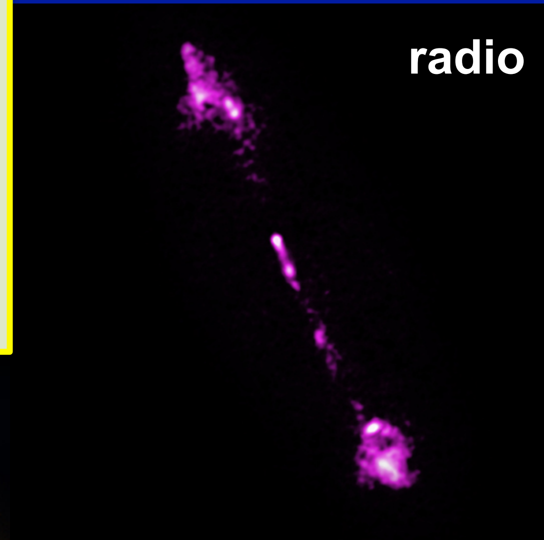
Chandra analysis of 4C+29.30

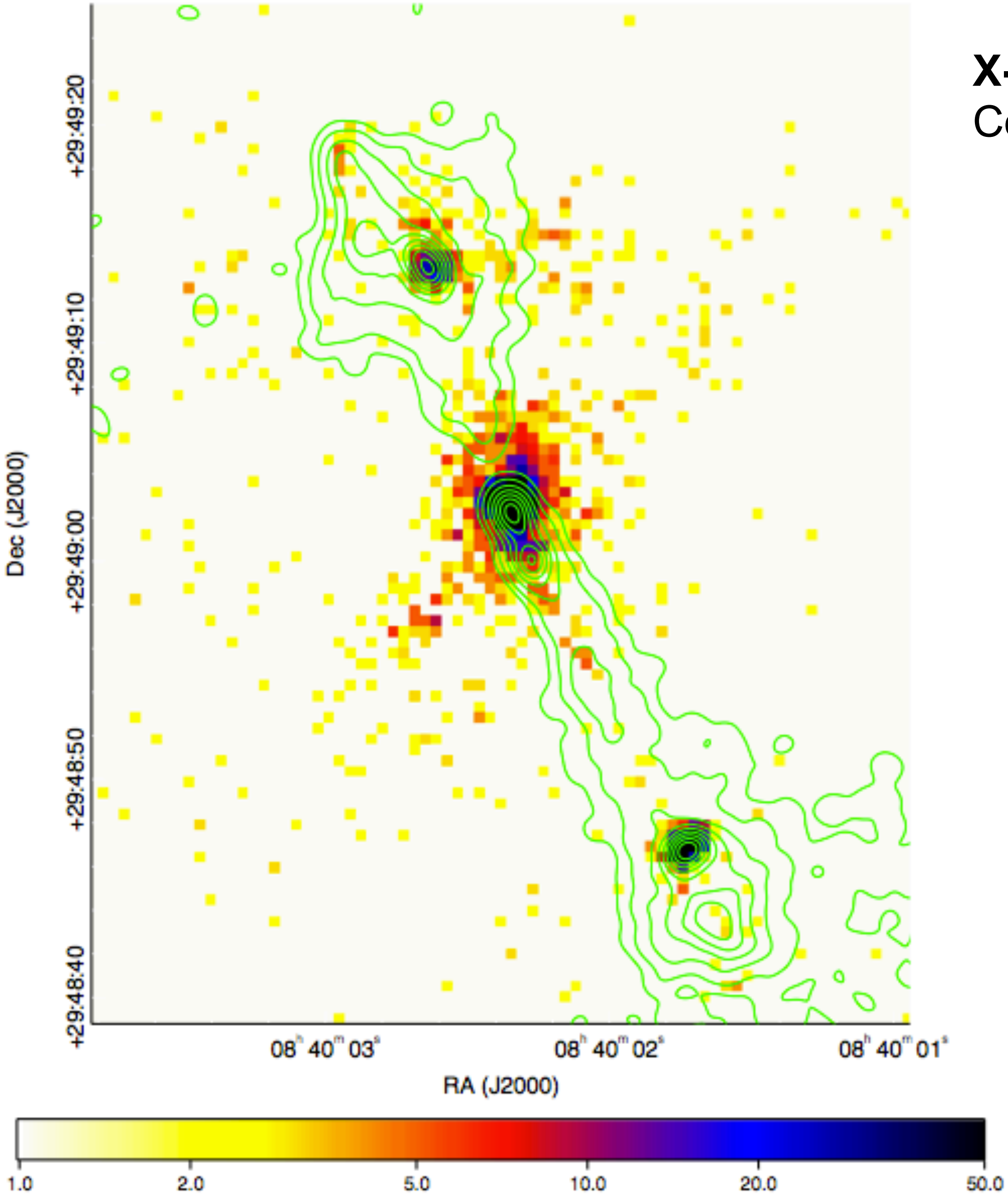
RA=08 40 02.35; DEC=29 49 02.6
z=0.065
$N_{H,Gal}=4.23\times10^{20}\ cm^{-2}$

4 long exposures *Chandra*, 284.5ks
Transitional radio morphology FRI-FRII ($L_R \approx 10^{42}$ erg/s)

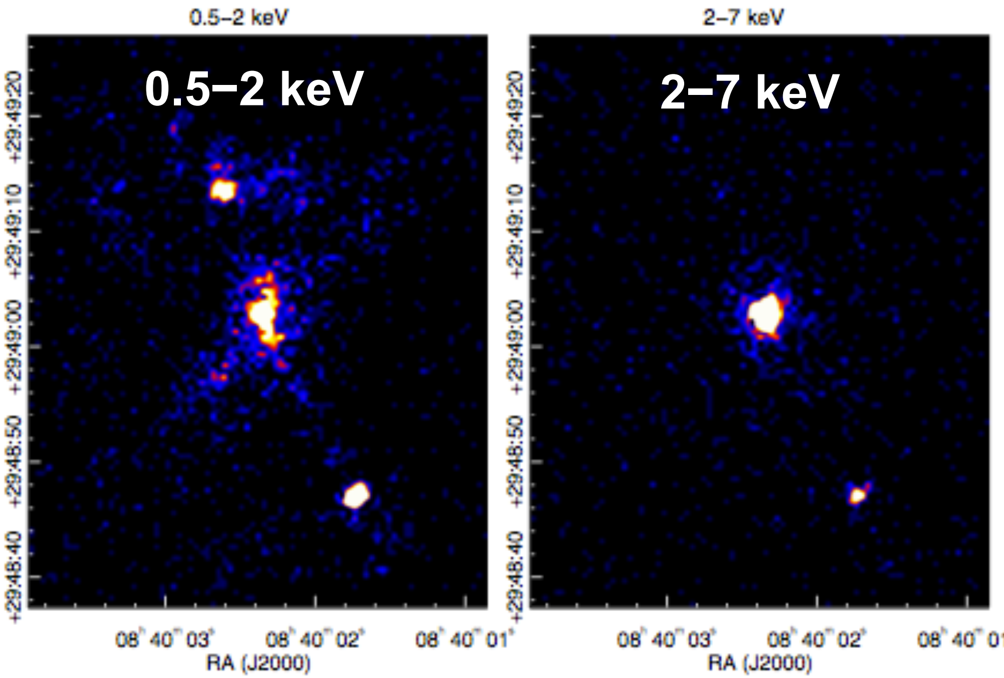




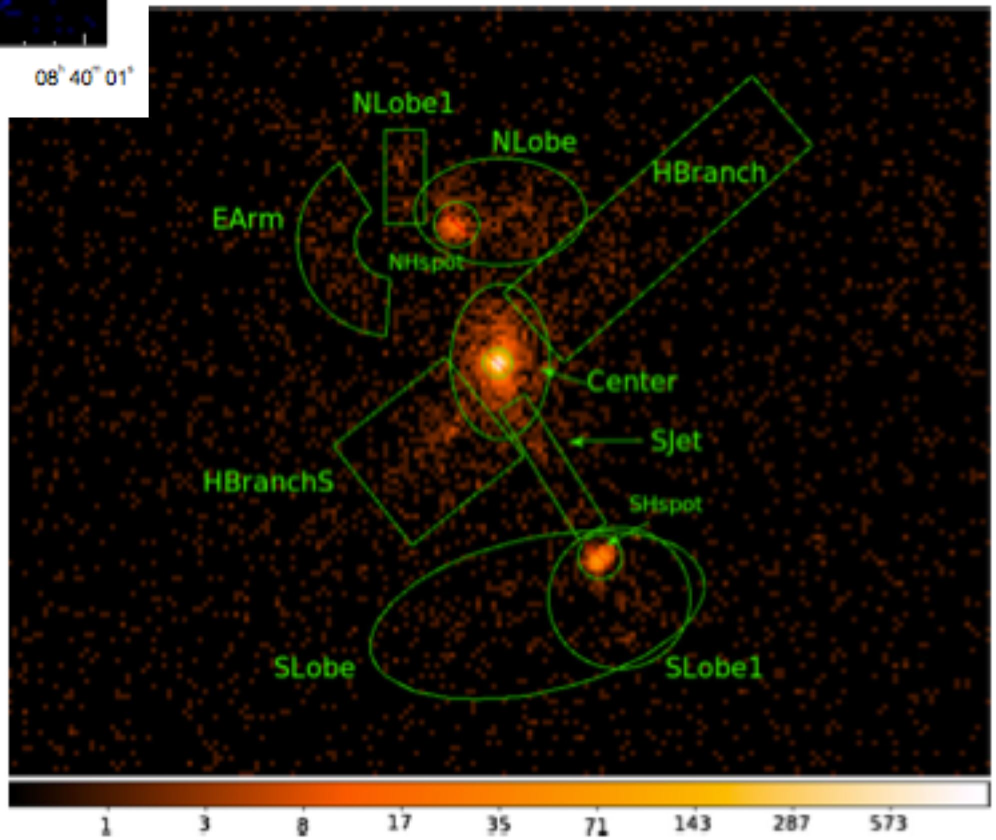




X-ray: 0.5-7 keV combined image
Contours from **VLA** 1.45 GHz map



Significant structures in the soft band
Most of the hard emission from the nucleus



PLAN

MAIN

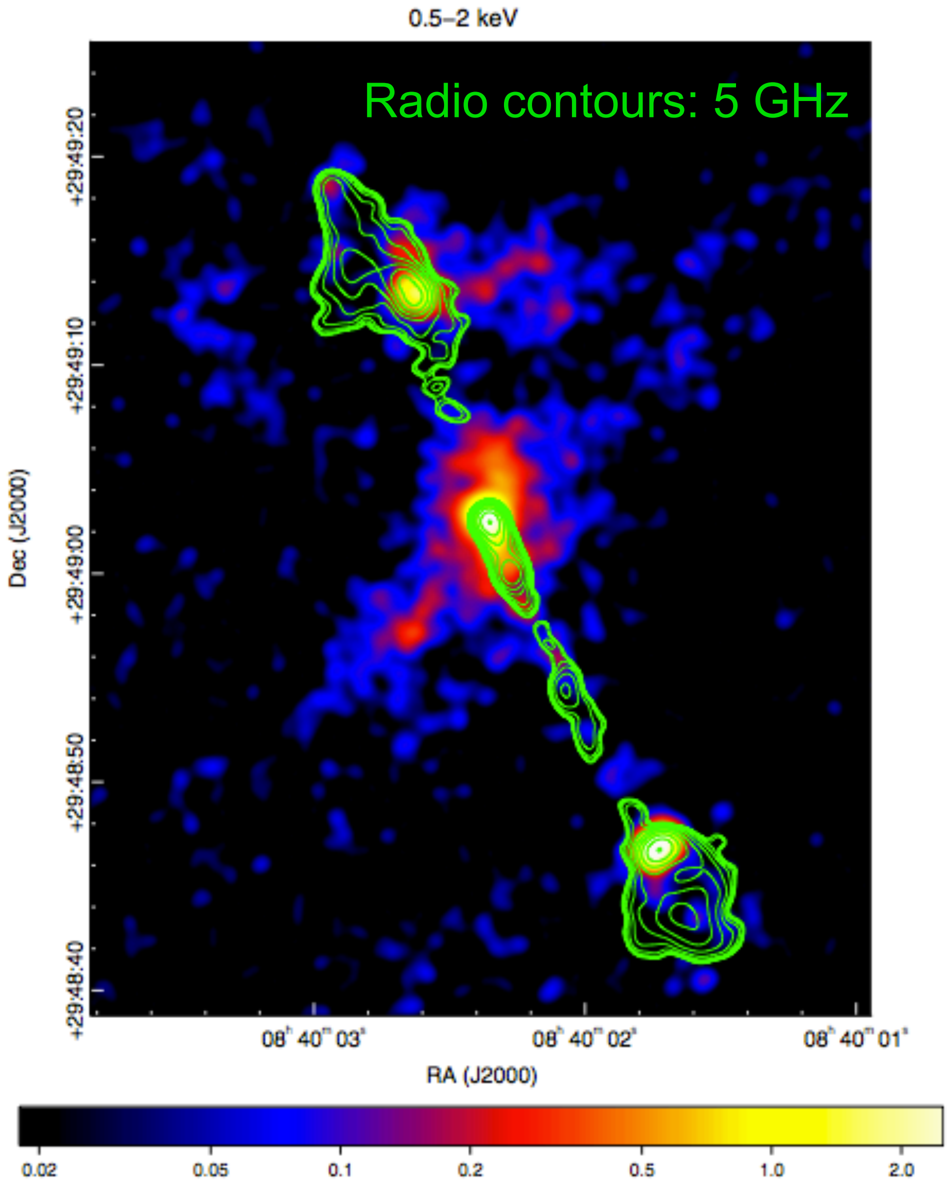
1. Compare the X-ray emitting regions to the radio components from 1.5 and 5GHz maps

2. Extraction and analysis of *Chandra* spectra from the mosaic image (core, jets, lobes, extended features, …)

Proper (but longer) way to proceed: spectral extraction from the four individual pointings, then merge the X-ray spectra

OPTIONAL

1. Extraction of spectra using XMM data (nucleus, extended emission, etc.), spectral analysis and comparison to *Chandra* results
2. Simultaneous *Chandra* (or XMM) and *Swift*/BAT (70month) spectral analysis of the nucleus



How to proceed (I)

All spectral products should be extracted from the individual pointings and then combined (**MATHPHA, ADDARF, ADDRMF** – FTOOLS – and **COMBINE_SPECTRA** within CIAO). The spectral extraction is typically done using the CIAO tool **SPECEXTRACT**.

A way to overcome this lengthy procedure consists of

i. extracting the spectra (source and background) from the mosaic using **DMEXTRACT**;
ii. producing ARF and RMF from one of the 4 pointings (choosing the longest one, 11688, T=123 ks) using the **SPECEXTRACT** tool (see the *Chandra* tutorial for details); this would create the source and background spectra (which you will not use – you use those from the mosaic) and the ARF+RMF (which you will use);
iii. associating the source spectrum (from the mosaic) to the background file (from the mosaic) and the ARF and RMF matrices (from the individual pointing) using the ftool **GRPPHA**, and group the data to a minimum number of counts to apply χ^2 statistics;
iv. ARFs should be produced for every "source of interest" in the field (e.g., the core, the lobes, the hot spots, etc.), again from a single pointing.

How to proceed (II)

SOURCE

```
punlearn dmextract
pset dmextract infile="../4c29.30_2015_merged_evt.fits.gz[sky=region(nucleus.reg)]
[bin pi]"
pset dmextract outfile=4c29_30_r1p5_nucleus.pi
pset dmextract verbose=2
dmextract clobber+
```

define the region of interest

BACKGROUND

```
punlearn dmextract
pset dmextract infile="../4c29.30_2015_merged_evt.fits.gz[sky=region(back.reg)][bin
pi]"
pset dmextract outfile=4c29_30_r1p5_nucleus_bgd.pi
pset dmextract verbose=2
dmextract clobber+
```

GRPPHA

```
grppha 4c29_30_r1p5_nucleus.pi 4c29_30_r1p5_nucleus_c20.pi comm="group min
20 & chkey BACKFILE 4c29_30_r1p5_nucleus_bgd.pi & chkey RESPFILE
4c29_30_r1p5_nucleus.rmf & chkey ANCRFILE 4c29_30_r1p5_nucleus.corr.arf &
exit”
```

How to proceed (III)

CHECKS on the BACKSCAL (ratio of back vs. source areas)

dmkeypar 4c29_30_r1p5_nucleus.pi BACKSCAL echo+
--> 4.3548145383623e-07

dmkeypar 4c29_30_r1p5_nucleus_bgd.pi BACKSCAL echo+
--> 1.0533010170724e-05

BACKSCAL=15**2/3.05**2=24.2
vs. 1.05e-5/4.35e-7=24.2

(where 15 and 3.05 are the background and source extraction radius, in pixels, respectively)

OK!

Main publications

① Siemiginowska et al. 2012, ApJ, 750, 124
Chandra data

② Sobolewska et al. 2012, ApJ, 758, 90
XMM-*Newton* + *Swift*/BAT data