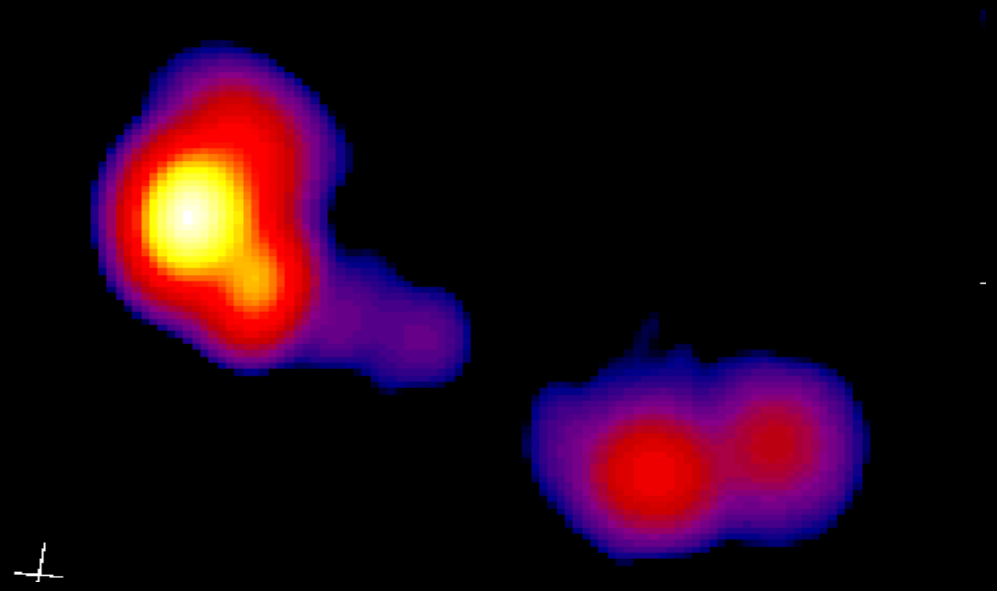
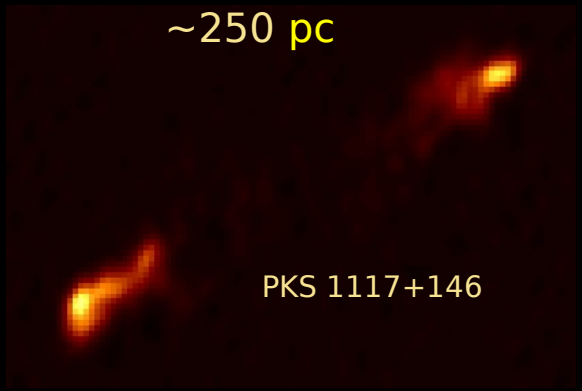
Physics and Evolution of Young Radio Galaxies (YRG)

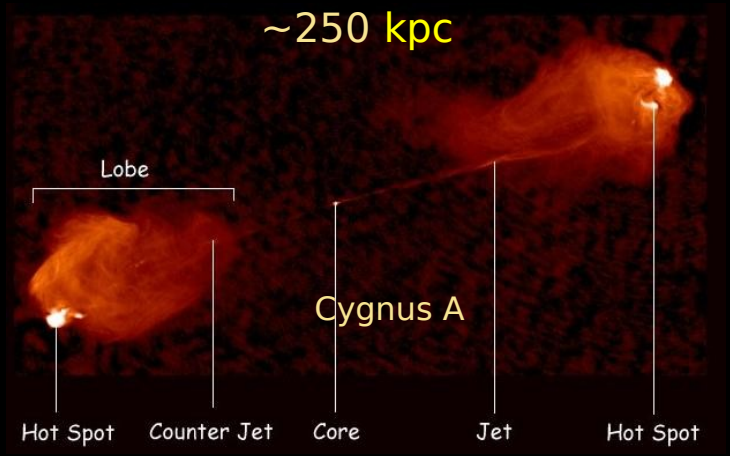


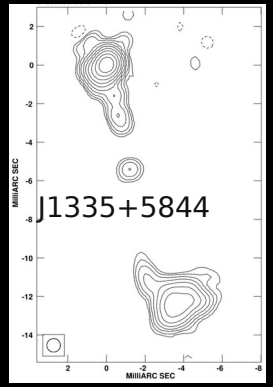
Carlo Stanghellini - audizioni INAF - 10 maggio 2022

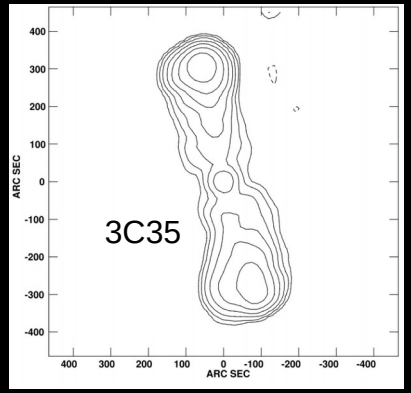
YRG



Classical Double







Nomenclatura

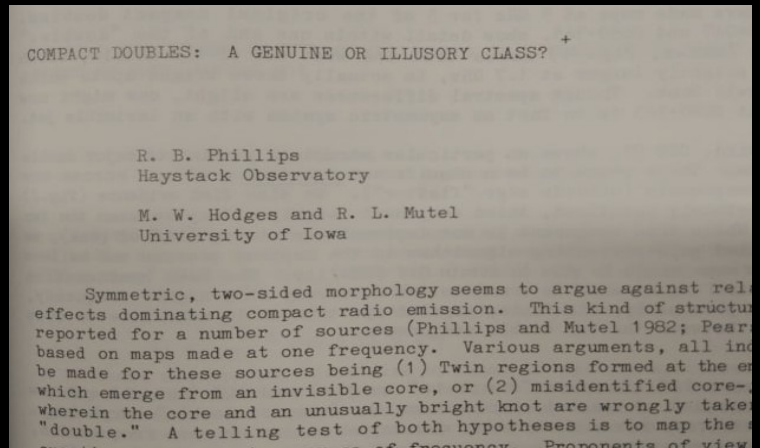
Le YRG consistono di classi di oggetti classificate con acronimi diversi in base ai criteri di selezione

CSS, GPS, HFP, CSO, MSO, etc...

ma sono intrinsicamente raggruppabili sotto un’unica linea di ricerca

Linea di ricerca tradizionale per INAF

- La prima menzione di questa classe di radiosorgenti (symmetric compact double) é di Phillips and Mutel (1982,1983)
- I primi studi (all'interno di IRA, allora IRA-CNR) risalgono agli stessi anni

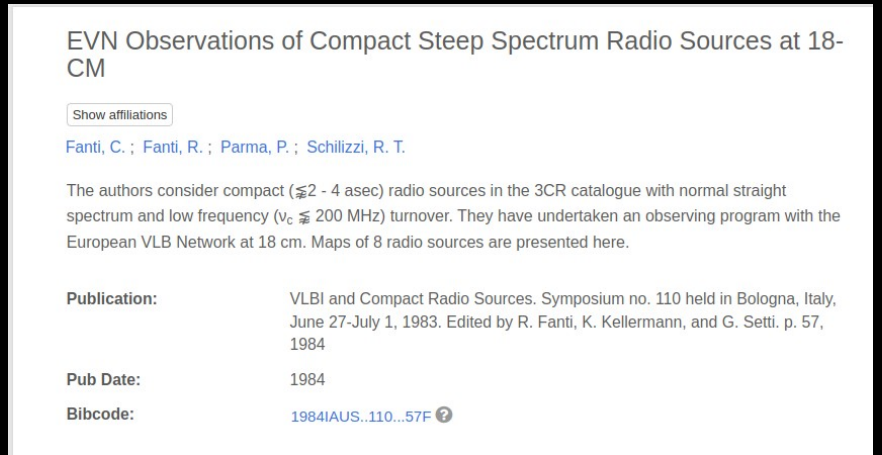


COMPACT DOUBLES: A GENUINE OR ILLUSORY CLASS? +

R. B. Phillips
Haystack Observatory

M. W. Hodges and R. L. Mutel
University of Iowa

Symmetric, two-sided morphology seems to argue against rel
effects dominating compact radio emission. This kind of structu
reported for a number of sources (Phillips and Mutel 1982; Pear
based on maps made at one frequency. Various arguments, all in
be made for these sources being (1) Twin regions formed at the e
which emerge from an invisible core, or (2) misidentified core-
wherein the core and an unusually bright knot are wrongly take
"double." A telling test of both hypotheses is to map the



EVN Observations of Compact Steep Spectrum Radio Sources at 18-CM

Show affiliations

Fanti, C. ; Fanti, R. ; Parma, P. ; Schilizzi, R. T.

The authors consider compact (≲2 - 4 asec) radio sources in the 3CR catalogue with normal straight spectrum and low frequency ($\nu_c \lesssim$ 200 MHz) turnover. They have undertaken an observing program with the European VLB Network at 18 cm. Maps of 8 radio sources are presented here.

Publication: VLBI and Compact Radio Sources. Symposium no. 110 held in Bologna, Italy, June 27-July 1, 1983. Edited by R. Fanti, K. Kellermann, and G. Setti. p. 57, 1984

Pub Date: 1984

Bibcode: 1984IAUS..110...57F

Forte interesse dagli anni ´90

“Workshop on Compact Steep Spectrum and GHz-Peaked Spectrum radio sources”

1st Dwingeloo 1990

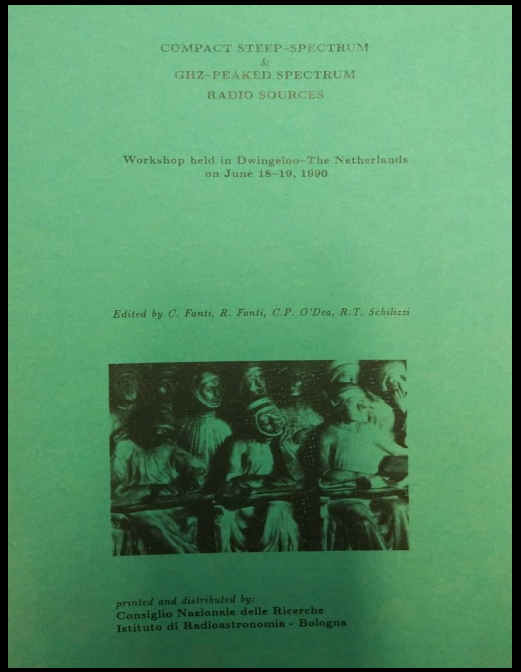
2nd Leiden 1996

3rd Kerastari 2002

4th Riccione 2008

5th Rimini 2015

6th Torun 2021


COMPACT STEEP-SPECTRUM
&
GHZ-PEAKED SPECTRUM
RADIO SOURCES

Workshop held in Dwingeloo–The Netherlands
on June 18–19, 1990

Edited by C. Fanti, R. Fanti, C.P. O'Dea, R.T. Schilizzi

printed and distributed by:
Consiglio Nazionale delle Ricerche
Istituto di Radioastronomia - Bologna

Forte interesse dagli anni ´90

“Workshop on Compact Steep Spectrum and GHz-Peaked Spectrum radio sources”

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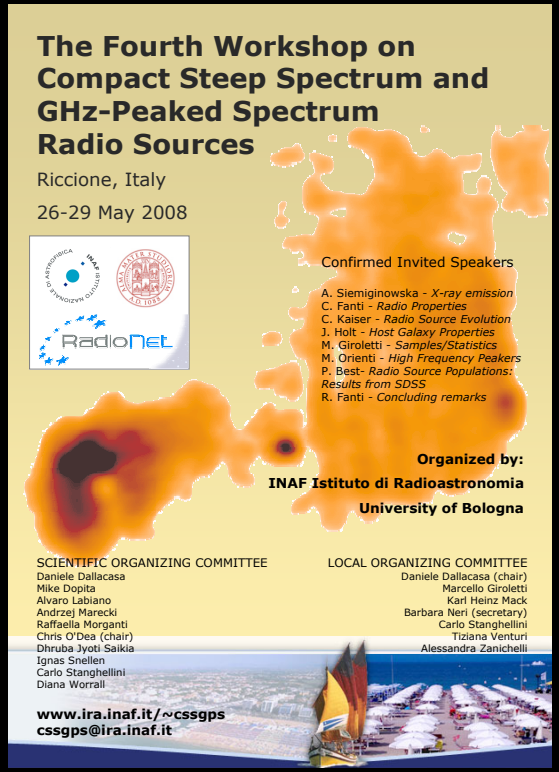


Leadership INAF

Tutti i lavori significativi su questa linea di ricerca citano articoli di ricercatori INAF.

Nella review di O'Dea and Saikia (2021) sono citati 100 articoli (su ~700) **con ricercatori INAF come primo autore**.

Dopo 40 anni di ricerca su questo tema, perché ha senso continuare ad investirci tempo e risorse?

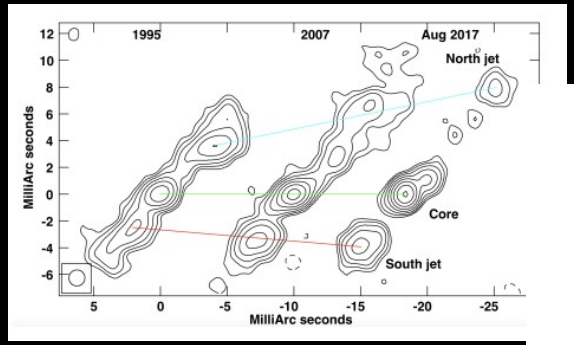
Il problema di fondo

La natura delle YRG

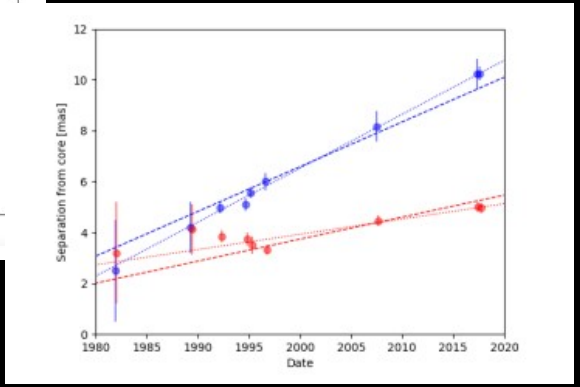
- *cresceranno fino a diventare doppie classiche? (youth scenario)*
- *scompariranno prima di crescere ed espandersi oltre la galassia ? (short lived)*
- *rimarranno confinate a tempo indeterminato? (frustration scenario)*

Stato dell’arte (I)

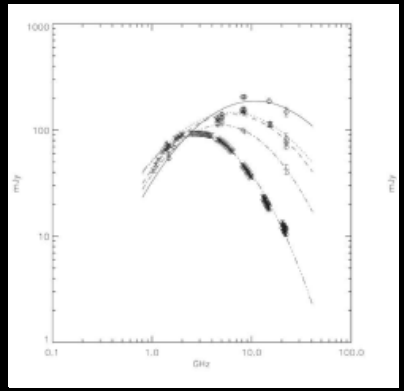
young/expanding



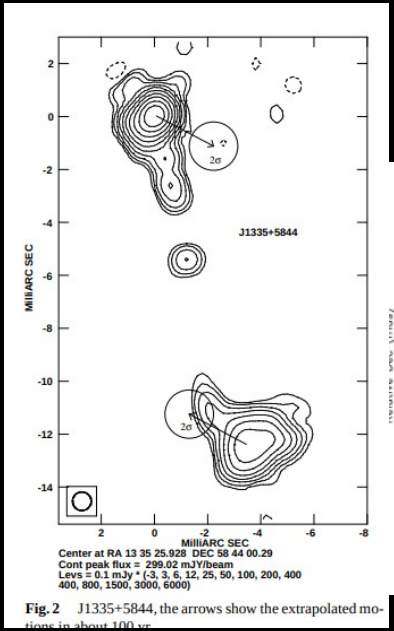
Principe et al. 2020



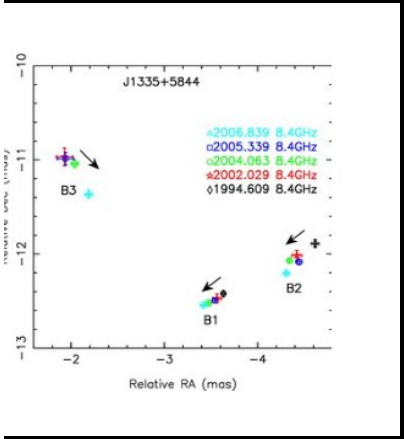
Orienti e Dallacasa 2021



confined/frustrated

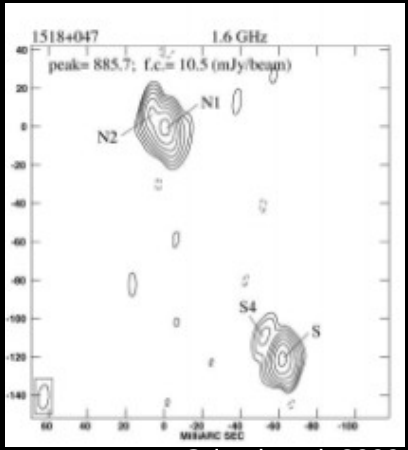


Stanghellini et al. 2009



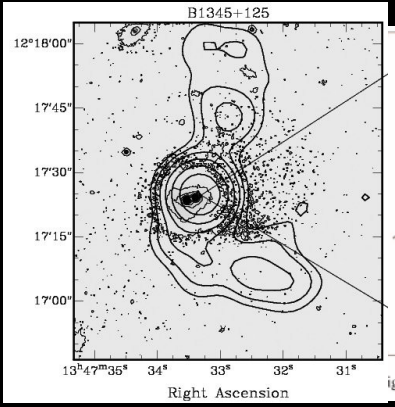
An et al. 2012

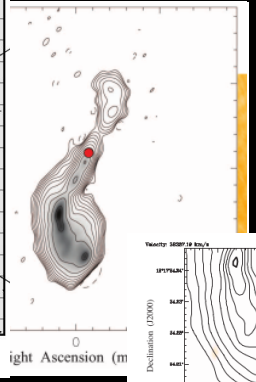
dying/short lived

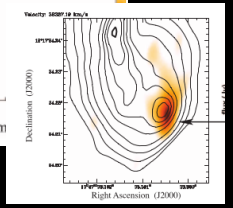


Orienti et al. 2009

restarted





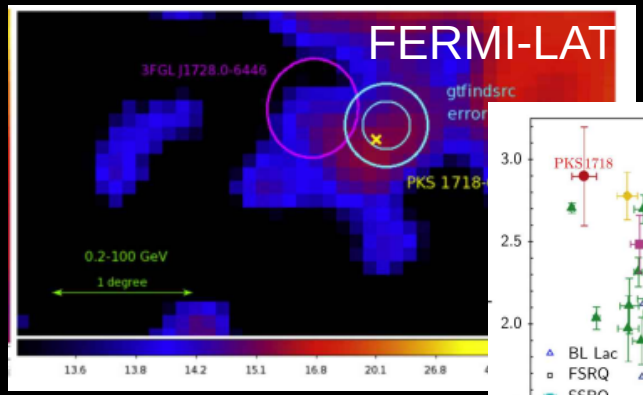


Stanghellini et al. 2005

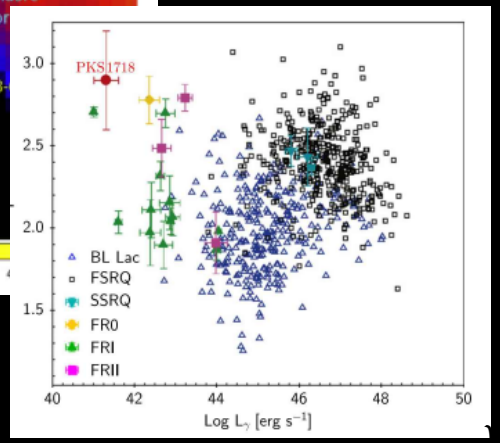
Interaction/outflow

Morganti et al. 2013

Stato dell'arte (II)



Migliori et al. 2016



First detection in γ-ray

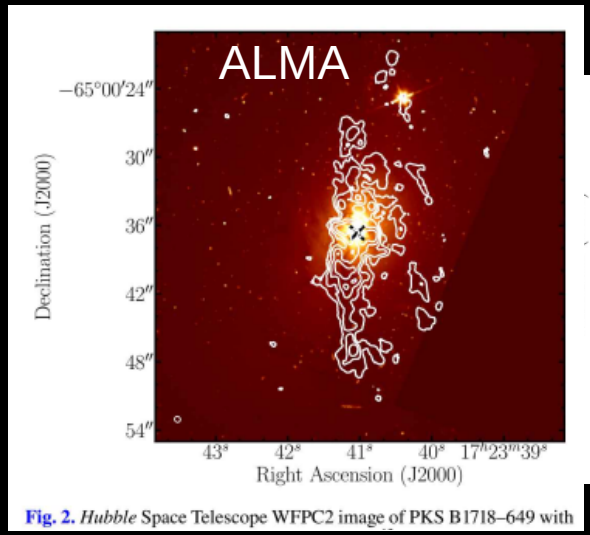
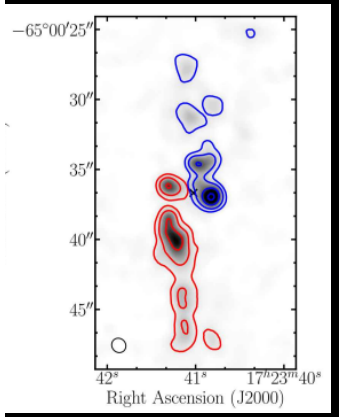
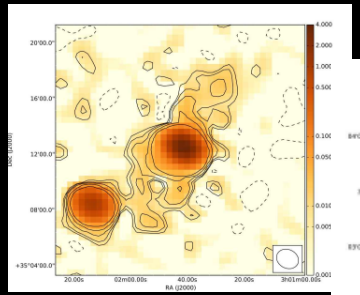


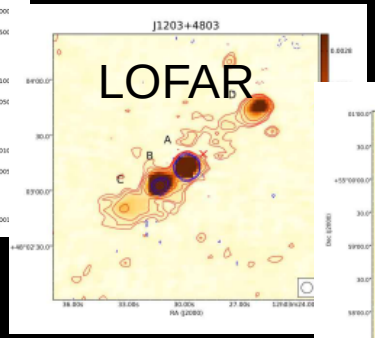
Fig. 2. *Hubble* Space Telescope WFPC2 image of PKS B1718–649 with

Maccagni et al. 2018

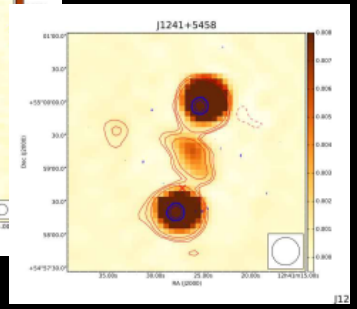


Molecular gas fuelling the AGN





Brienza 2018



Restarted radio sources

YRG at High-Energies

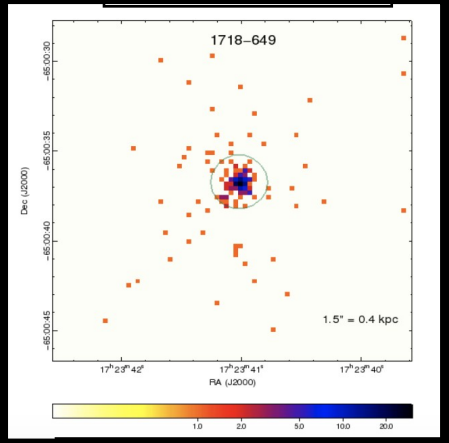
X-rays: sample studies with snapshots + dedicated studies with deep, broadband observations

- nature of the high-energy emission (accretion? young radio structures? Siemiginowska+'16,Migliori+'14)
- probe of the environment (obscuration, Ostorero+'10'17, Nustar observations in Bronzini et al. in prep.)
- young sources in hard X-ray selected giant RGs (Bruni+'19,'20)

Gamma-ray studies with Fermi:

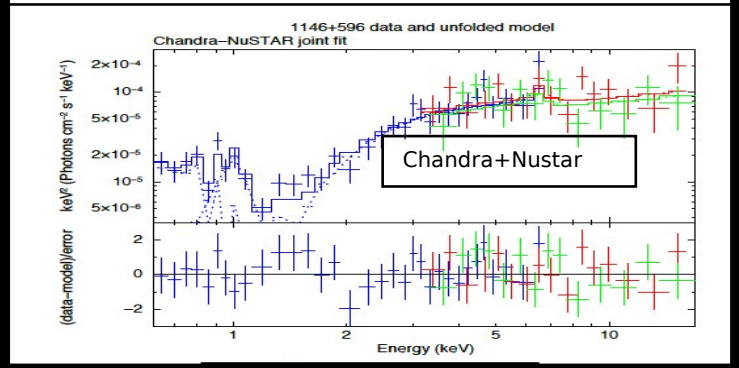
- individual studies (Principe+'20) + CSO in the 4LAC
- first stacking analysis for a sizeable YRS sample with 11 years of Fermi data (Principe+'21)

XMM/Chandra snapshots



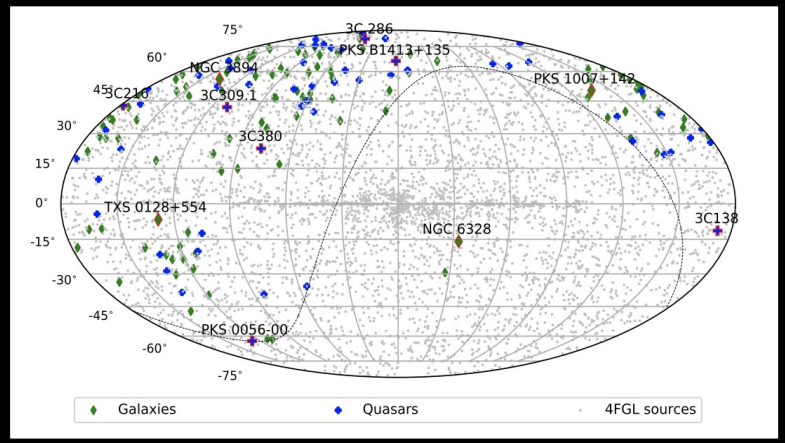
Siemiginowska+16
Sobolewska+19

CSO 1146+596 broadband X-ray spectrum



Bronzini+in prep

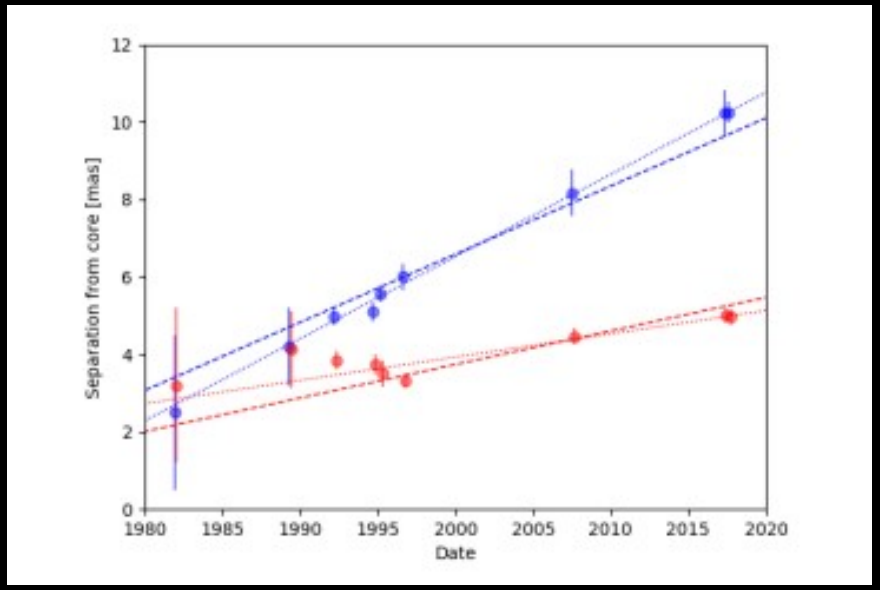
Sky map of young radio sources & 4FGL sources

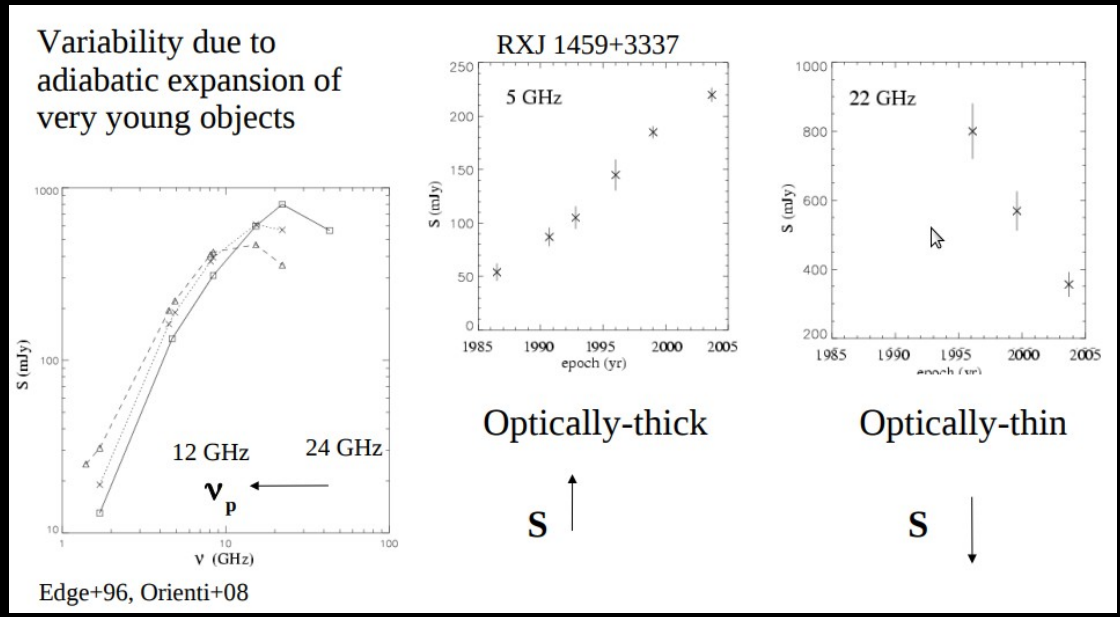


Principe+'21

Direzione futura della ricerca (I)

Misurare moti propri o espansione adiabatica puó richiedere decenni





Il gravitational lensing puó essere di aiuto - lensing magnification ----> tempi scala ridotti

Direzione futura della ricerca (II)

Natura ed evoluzione delle YRG:

- contributo relativo di sorgenti in espansione, frustrate, short lived
  - distribuzione statistica di dimensioni e moti propri di un campione ampio
  - meccanismo responsabile del turnover (FFS vs SSA) – osservazioni profonde a bassa frequenza
- radiosorgenti di bassa luminosita` - short lived? - contributo delle FR0

AGN feedback:

- presenza di outflows
- interazione con l'ambiente
- SFR e contenuto molecolare

Simulazioni numeriche

- propagazione della radiosorgente compatta e confronto con i dati osservativi

Direzione futura della ricerca (III)

I nuovi strumenti

ASKAP – Norris et al 2011; Allison et al 2016

LOFAR – Snellen et al. 2009; Shimwell et al 2019

SKA – Falcke et al. 2004; Kapinska et al. 2015; Afonso et al. 2015; Norris et al. 2011

ngVLA – Patil et al. 2018

Nuove survey radio profonde sono destinate a fornire campioni estesi di YRG a bassa luminosita` e alto z.

Il team INAF

Competenze specifiche: radio, alte energie, simulazioni numeriche

- 16 ricercatori INAF di 5 strutture (IRA,OAS, IAPS, OAC, OATo) – 1.3 fte + 0.6 extra
- 9 ricercatori associati INAF (1.0 fte)

  - inclusi 6 TD

Ranieri Baldi, Marisa Brienza, Gabriele Bruni, Alessandro Capetti, Pietro Cassaro, Annalisa Celotti, Daniele Dallacasa, Filippo D'Ammando, Gabriele Giovannini, Marcello Giroletti, Paola Grandi, Rocco Lico, Elisabetta Liuzzo, Filippo Maccagni, Francesca Panessa, Karl Heinz Mack, Giulia Migliori, Matteo Murgia, Monica Orienti, Luisa Ostorero, Giacomo Principe, Paola Rossi, Cristiana Spingola, Carlo Stanghellini, Eleonora Torresi

Progetti in corso (I)

- ES101A/B (Old radio activity in two young radio galaxies) - **EVN+eMerlin** at 18 cm - 12+8 hours, **PI Stanghellini** - observed on 1/6 Mar 2022
- BS309 (Diffuse emission at mas scale in a young radio galaxy: relic or shocked winds?) - **VLBA** at 90/50 cm – **PI Stanghellini** - 8 hours to be scheduled in first semester 2022
- EM157 (What drives an outflow? The radio emission of MaNGA 1-166919 at mas scales) - **EVN+eMerlin** at 18 cm - 5 hours, **PI Migliori** - observed on 3 Nov 2021
- EG113A/B (Unveiling the pc-scale structure of the gamma-ray young radio galaxy PKS1007+142) - **EVN/eMerlin** at 18 cm - 2x10 hours, **PI Giroletti** - observed on 2/10 Mar 2022
- EAVN21B-231 - (Structural evolution in two compact radio sources) - East Asian VLBI Network (**EAVN**) at 1.3 cm – **PI Giroletti** - 20 hours observed in November 2021 and being correlated
- BO064 (VLBA observations of low-power jets in compact symmetric objects)- **VLBA** at 6 cm - 37 hours - **PI Orienti** - observed in 2021
- EG111 **eMerlin+EVN** at 6 cm – 24 hours – **PI Giovannini** - scheduled on 14-15-16/06/2022

Progetti in corso (II)

Non solo VLBI

- 19A-082 (Observations of FR0 as young radio sources candidates) **JVLA** at 6 and 18 cm- 9 observing blocks da agosto ad ottobre 2019 – **PI Baldi**
- 35-22 (Probing restarting activity in giant radio galaxies: young cores and duty cycle) – **Effelsberg** – 20 hours – **PI Bruni –** proposal approved

Non solo Radio

- ID: 23700588 (Extended X-ray emission around a young AGN radio jet) – **CHANDRA** 60 ksec PI: Sobolewska (CfA); **Co-I INAF: Migliori, Ostorero**
- ID 24700051 (First CHANDRA observations of 6 highly magnified lensed sources in search for binary and offset agn in the early Universe) **CHANDRA – PI Spingola** - submitted

Criticitá (I)

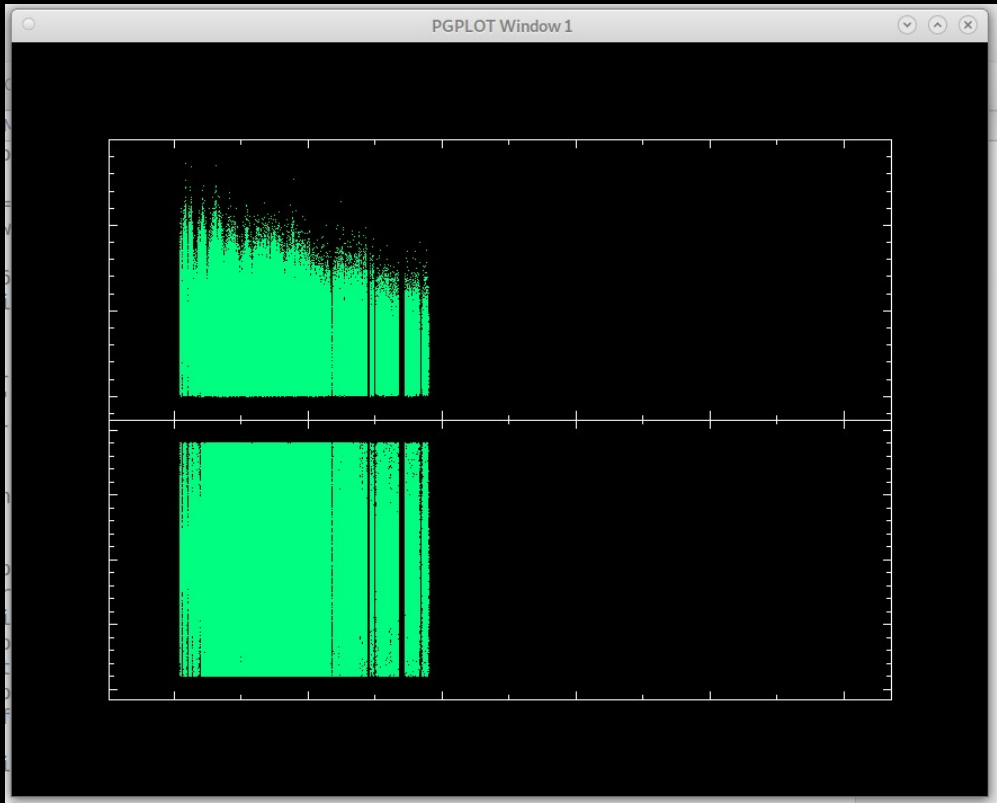
Rischio di perdere la leadership acquisita in seguito a:

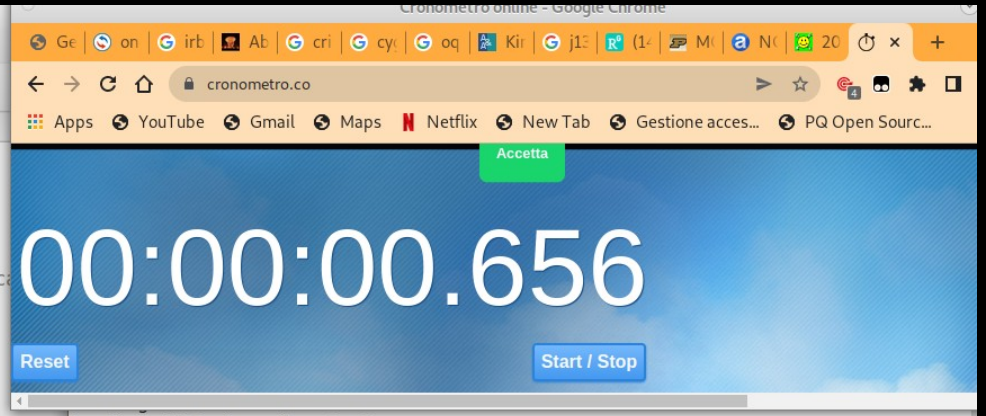
- Perdita di competenze importanti (pensionamenti) e conseguente necessitá di adeguato turnover
- Mancanza di fondi per progetti specifici su YRG

Soluzione: YRA for YRG

- 6 ricercatori TD su questa linea di ricerca (tesi, dottorato, post doc)
- 4 di questi a FTE 0 perché pagati ora su altri progetti
- 2 di questi sono post doc all’estero

DIFMAP



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Reading IF 5 channels: 5..5
Reading IF 6 channels: 6..6
Reading IF 7 channels: 7..7
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 %PGPLOT, Use environment variable PGPLOT_FONT to specify the location of the PG
PLOT grfont.dat file.

0>projplot
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Using default options string "m3"
Move the cursor into the plot window and press 'H' for help
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Move the cursor into the plot window and press 'H' for help
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ta

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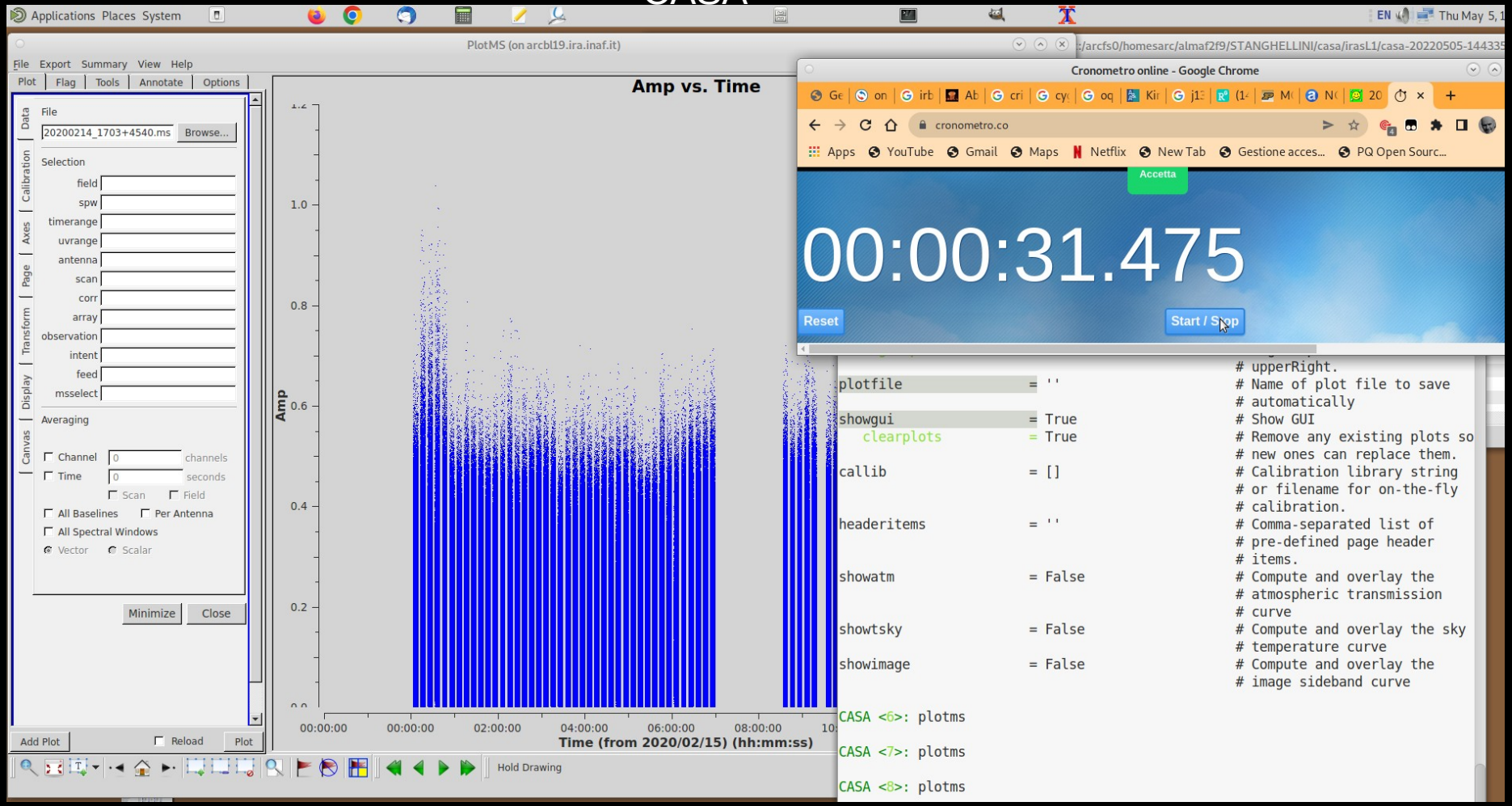
CASA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Minimize Close
Add Plot Reload Plot
Amp vs. Time
Amp
Time (from 2020/02/15) (hh:mm:ss)
Hold Drawing
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cronometro.co
Apps YouTube Gmail Maps Netflix New Tab Gestione acces... PQ Open Sourc...
Accetta
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Reset
Start / Stop
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# automatically
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clearplots = True # Remove any existing plots so
# new ones can replace them.
callib = [] # Calibration library string
# or filename for on-the-fly
# calibration.
headeritems = '' # Comma-separated list of
# pre-defined page header
# items.
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# atmospheric transmission
# curve
showtsky = False # Compute and overlay the sky
# temperature curve
showimage = False # Compute and overlay the
# image sideband curve
CASA <6>: plotms
CASA <7>: plotms
CASA <8>: plotms

Per affrontare le criticitá

- GTO / GO Grant (normal) - coord Carlo Stanghellini - *Discovering the origin of parsec scale radio emission in young radio galaxies by VLBI observations* - 19 keu per hardware e missioni
- GTO / GO Grant (normal) collegato anche ad altre schede - coord Monica Orienti - *VLBA observations of low-power jets in compact symmetric objects* - 49 keu per Post Doc position, hardware e missioni