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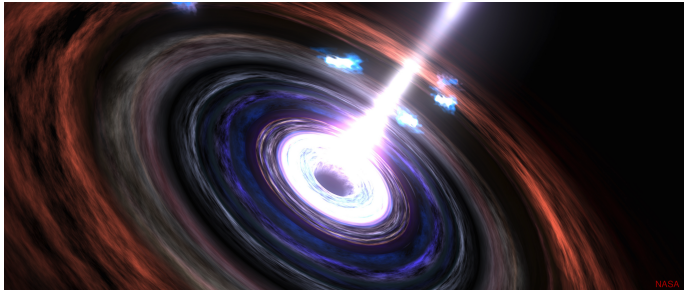

Study on the classification of blazars with machine learning techniques using multiwavelength information

Konstantin Pfrang

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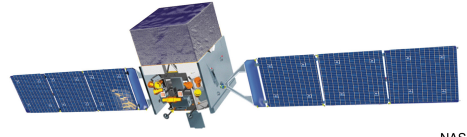
School for Astroparticle Physics 2016

Motivation

3FGL catalog

- *Fermi* LAT
- 3033 γ-ray sources
- Energies from 100 MeV to 300 GeV



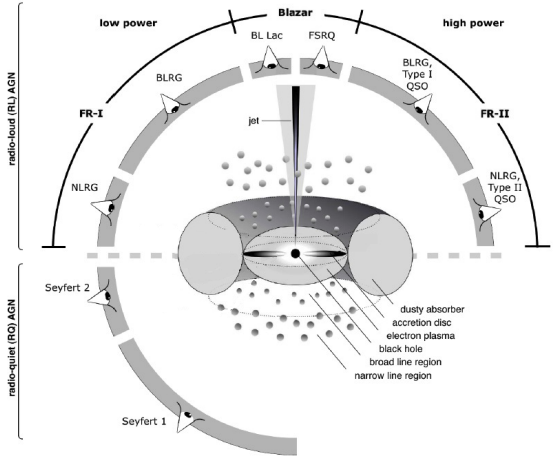
NASA

	# objects
AGNs	1744
non-AGNs	279
unassociated	1010
AGNs of uncertain type	573

$\Rightarrow$ Classification using machine learning

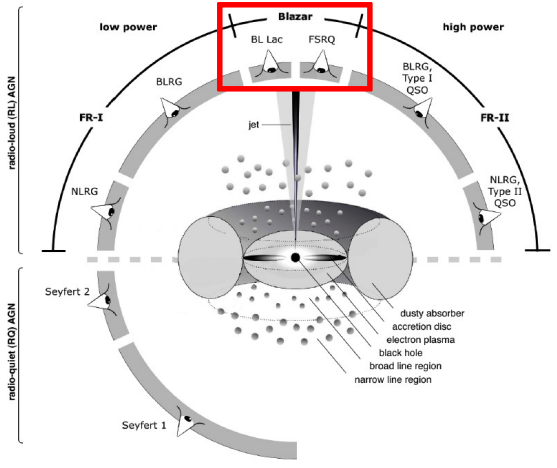
How is the performance of the classification using MWL information?

Active Galactic Nuclei



Beckmann & Shrader (2012)

Active Galactic Nuclei



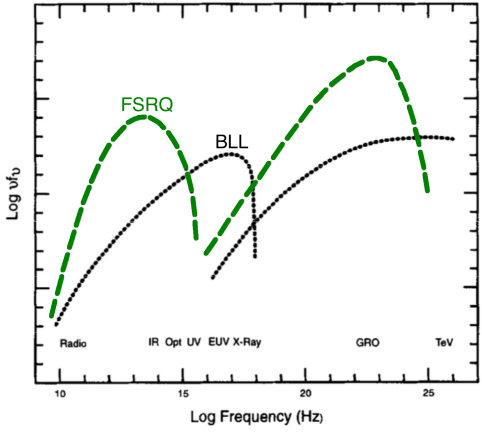
Beckmann & Shrader (2012)

Blazars

- Classification in BLLs and FSRQs
- FSRQs more luminous

Differentiation based on fluxes

Spectral Energy Distribution (SED)

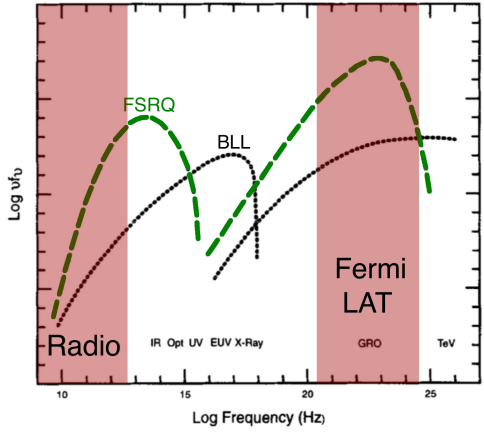


Multiwavelength approach for AGN classification

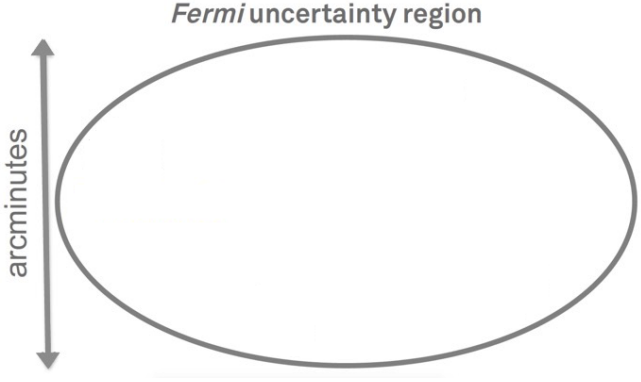
- Experiments not able to record whole SED
- Remove restriction to one energy level

$\Rightarrow$ Search for counterparts

Spectral Energy Distribution (SED))

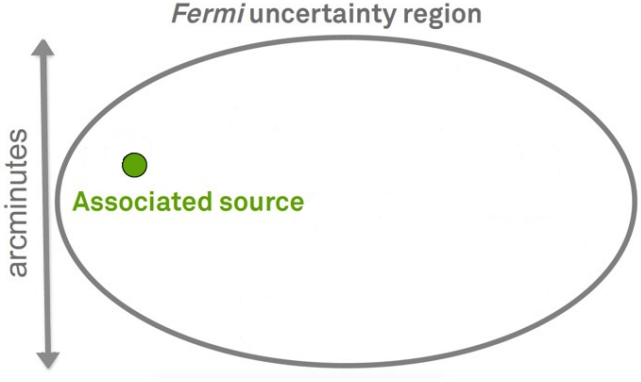


Search for counterparts



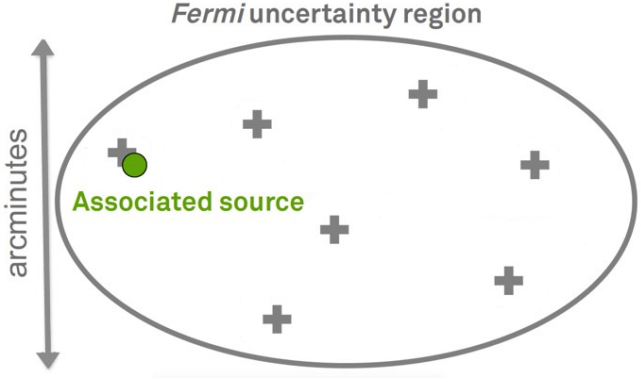
1. **catalog:** 3FGL
   - 95% uncertainty region

Search for counterparts



1. **catalog:** 3FGL
   - 95% uncertainty region
   - associated source in other catalog

Search for counterparts

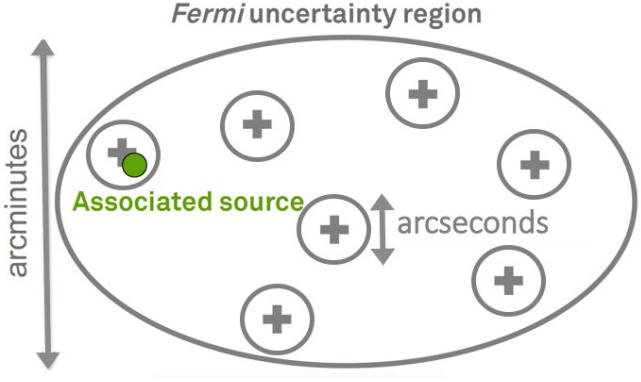


radio sources

2. catalog: NVSS

- NRAO VLA Sky Survey
- 1.8 million sources at 1.4 GHz

Search for counterparts

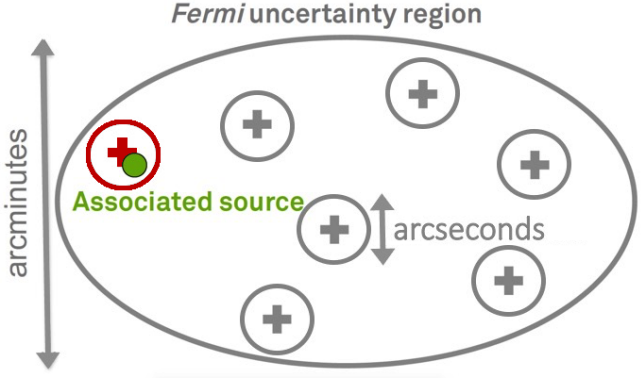


radio sources

2. catalog: NVSS

- NRAO VLA Sky Survey
- 1.8 million sources at 1.4 GHz
- Uncertainties significant smaller

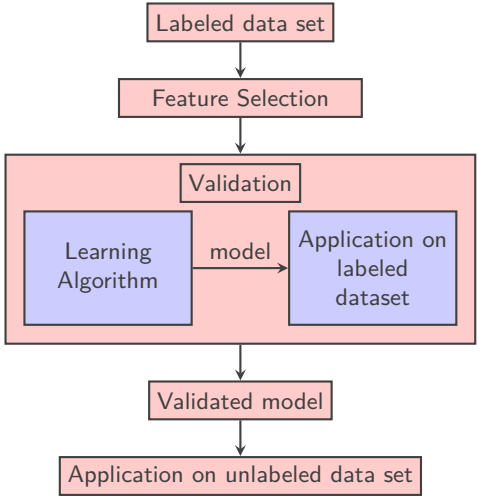
Search for counterparts



Association of 3FGL to NVSS counterpart!

Classification using data mining

Validation of model essential!



Preparation of data set

- Counterpart search

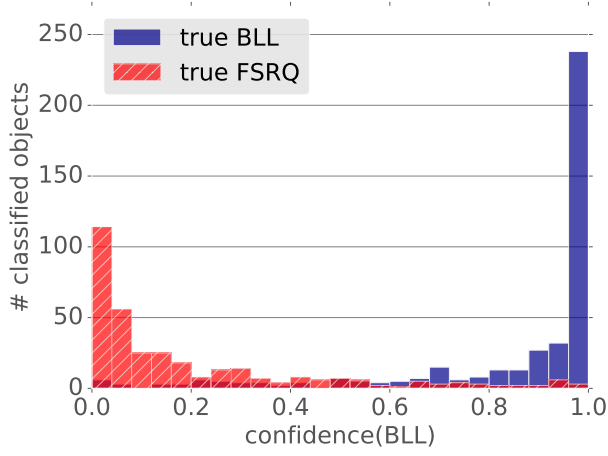
total Blazars	**766**
BLLs	422
FSRQs	344

- Feature generation through combination of different wavelengths
- Feature selection to reduce number of attributes

total attributes	**345**	
3FGL	28	
NVSS	2	Selected attributes
combined	20	

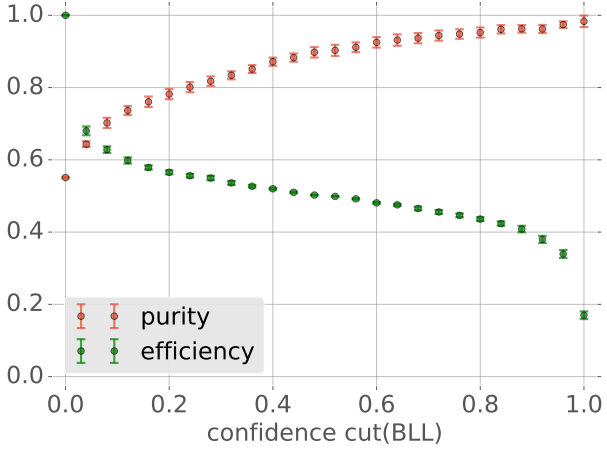
Performance estimation

- Confidence cut:
  least score for classification
- Performance heavily dependent on
  choice of confidence cut



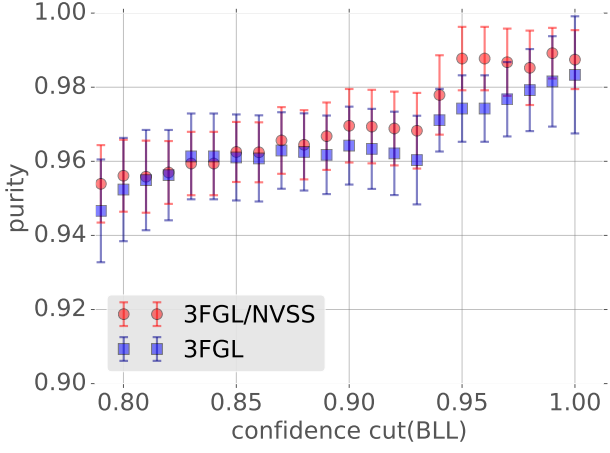
Performance estimation

- Purity:
  Ratio of correctly and falsely classified objects
- Efficiency:
  Ratio correctly classified events to total number of the class



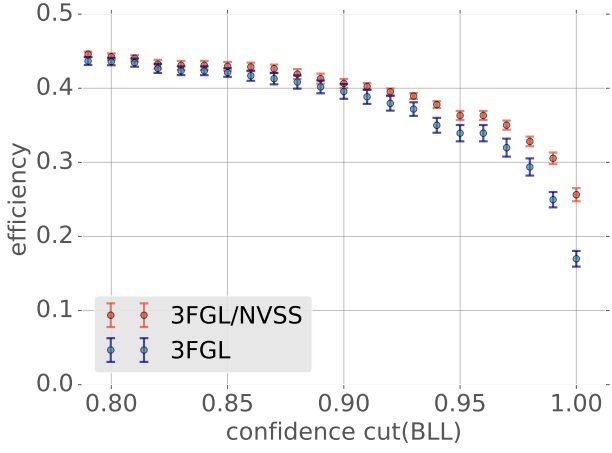
⇒ Trade off between efficiency and purity

Performance estimation



Performance estimation

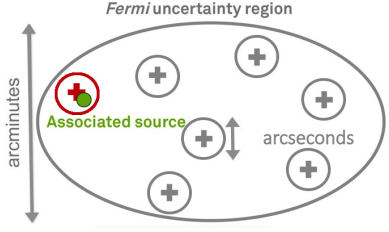
	3FGL	3FGL/NVSS
purity	≥ 0.97	
# BLLs	226 ± 2	283 ± 3
# FSRQs	68 ± 1	94 ± 1

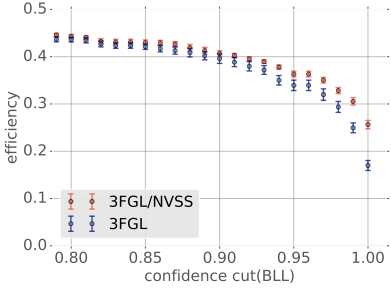


$\Rightarrow$ Tremendous improvement using MWL information!

Conclusion

- Method for counterpart search to 3FGL objects
- Classification of blazars using machine learning
- Improved efficiency using MWL information

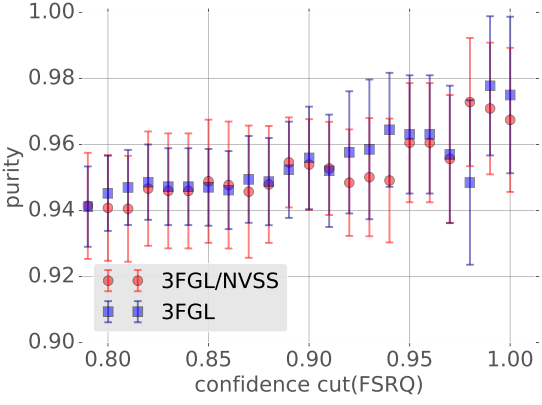


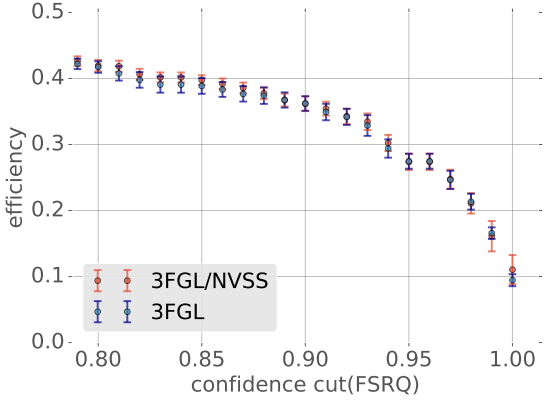


Outlook

- Extension to more wavelengths
- Possibility for counterpart search for unassociated sources

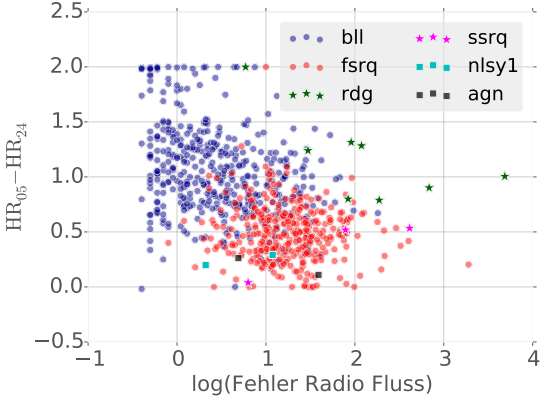
Backup - quality FSRQ-classification

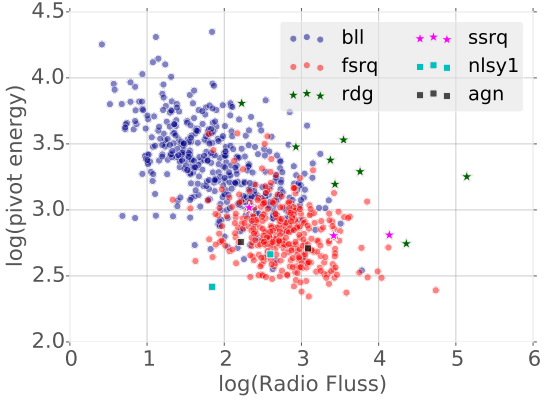




- FSRQ classification not as efficient and pure as for BLLs
- Possible reason: subclasses of BLLs (LBL's SED very similar to FSRQ's!)

Backup


bll
fsrq
rdg
ssrq
nlsy1
agn
$HR_{05} - HR_{24}$
log(Fehler Radio Fluss)


bll
fsrq
rdg
ssrq
nlsy1
agn
log(pivot energy)
log(Radio Fluss)