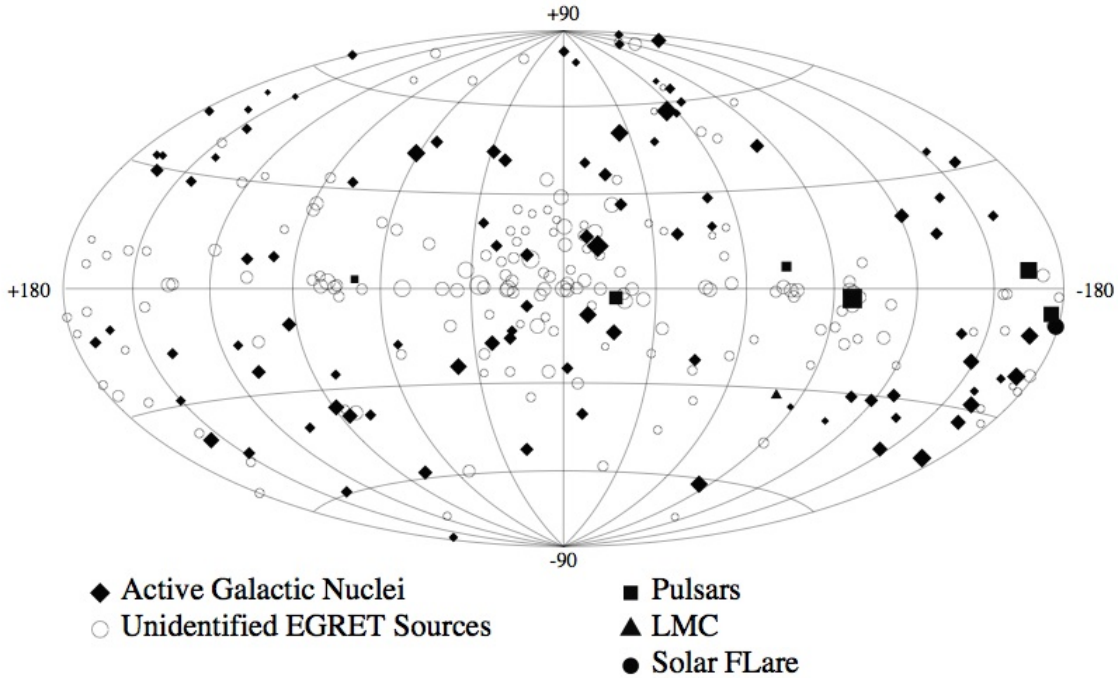
« *SOURCE IDENTIFY* » test on the THIRD EGRET CATALOG (3EG)

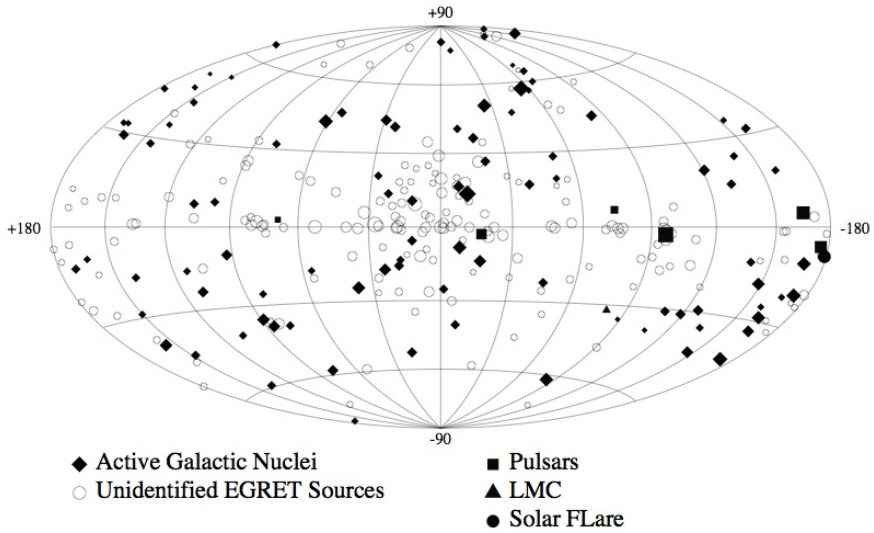


The third EGRET catalog (Hartman et al. 99)

Vincent LONJOU & Jürgen Knödlseder

EGRET catalog and sources identifications

Hartman et al. 1999



- **170 unidentified sources, 63%**
- **66 high confidence Blazars** (BL Lac objects, flat-spectrum radio quasars or unidentified flat spectrum radio sources)
- **27 low confidence Blazars**
- 5 pulsars
- +1991 solar flare, Large Magellanic Cloud

Mattox, Hartman, et al. 2001
APJSS, 135, 155

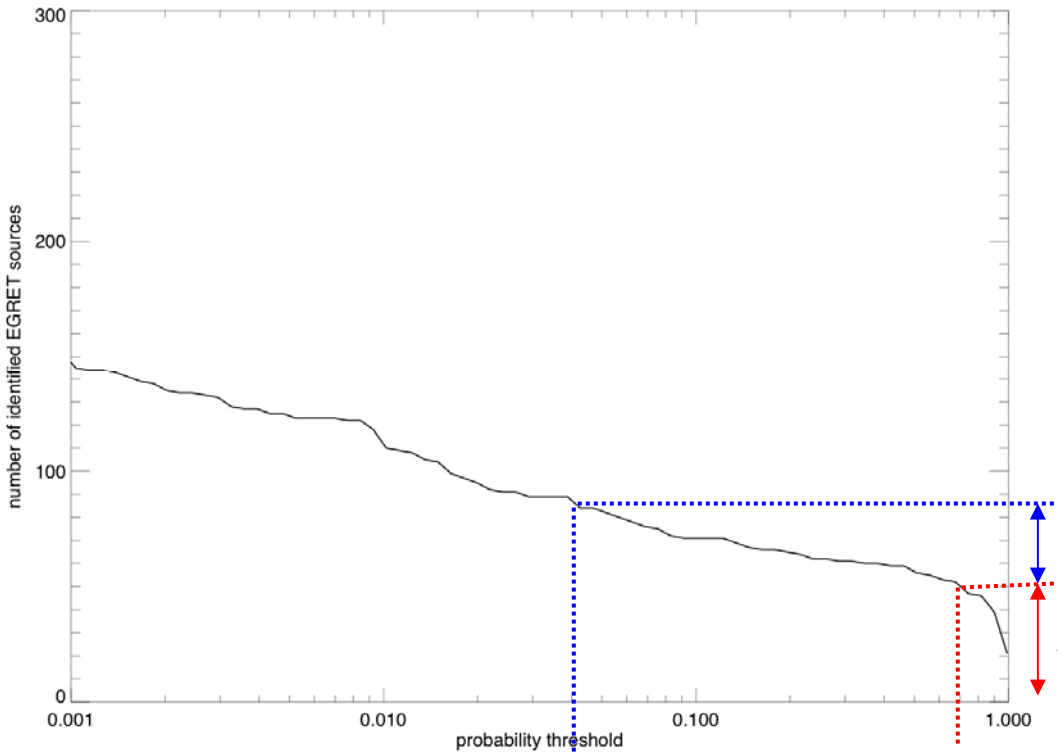
« A quantitative evaluation of potential radio identifications for 3EG EGRET sources »

- **46 high confidence Blazars** (45 high confidence from *Hartman et al. 1999* + 1 low confidence)
- **37 low confidence Blazars** (21 high confidence from *Hartman et al.1999* + 3 low confidence + **15 new**)

Mattox et al. blazar identification

Method: Bayesian approch. Determine the probability of identification as a function of :

- angular distance between radio counterpart and 3EG source
- spectral index of the radio counterpart
- radio flux



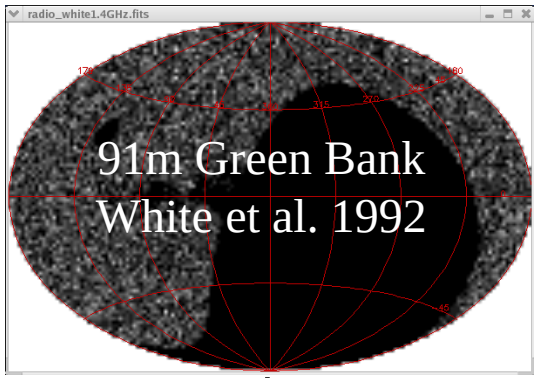
37 low probability blazar identification

46 high probability blazar identification

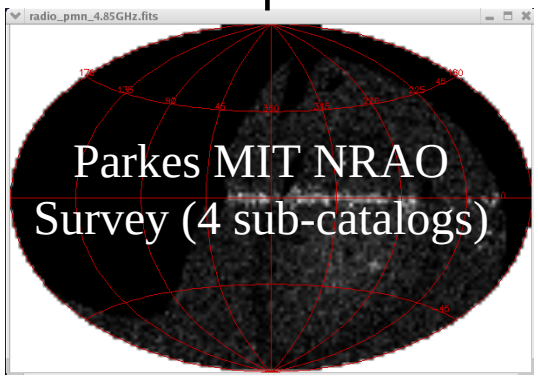
70%

4% (criteria not obvious)

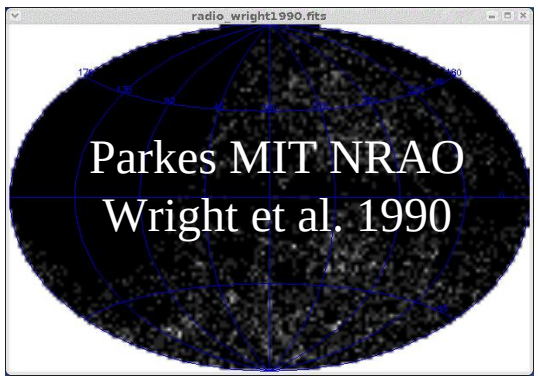
Creation of a meta-catalog similar to *Mattox et al.*



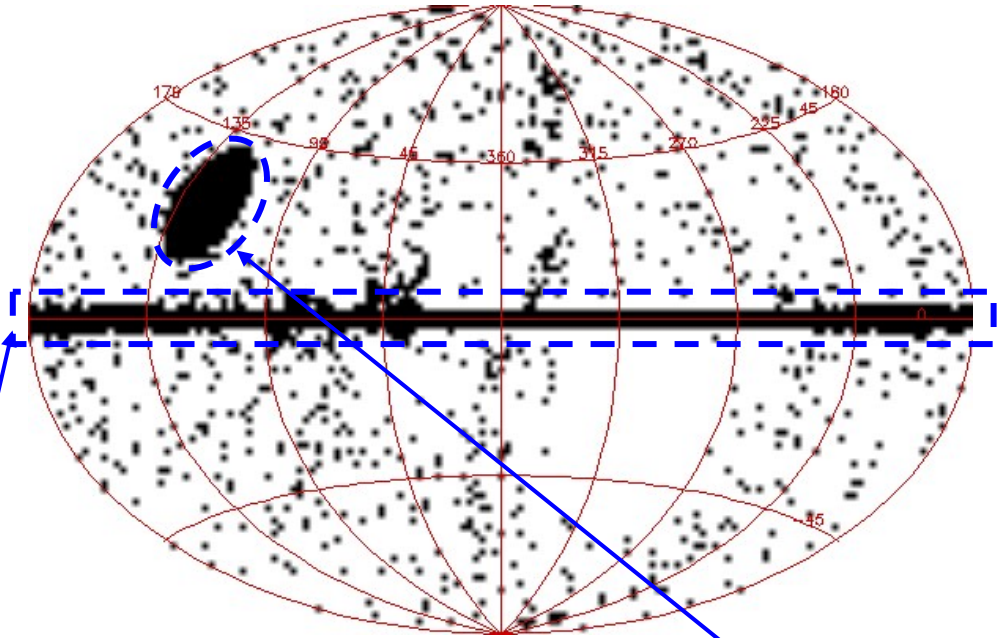
+



+



« Binary » sky exposure



Observationnal constraints

« Source confused » region -3°<b<3° has been removed

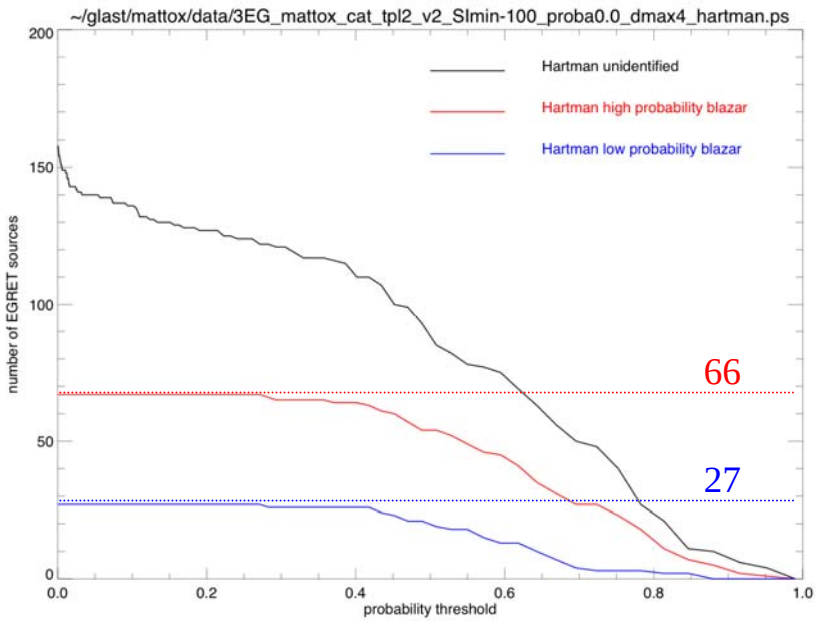
- 101226 radio sources (mostly 4.85 Ghz and 1.4 GHz)
- 36152 have a spectral index (1/3)
- 6765 have a spectral index > -0.5 (Mattox blazar identification criteria)

Test of *source identify* with 3EG - « Mattox catalog »

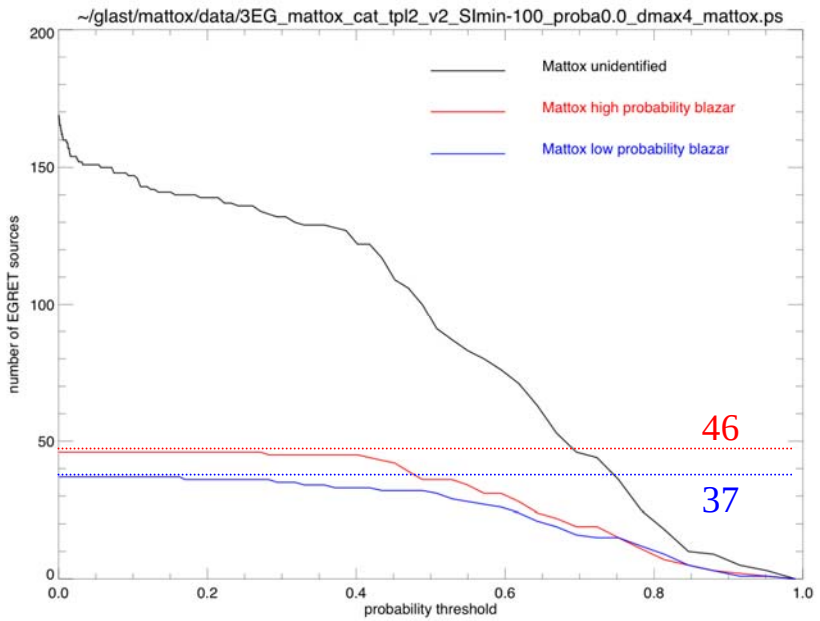
Run 1: no constraint, try to make an identification with the 101226 sources

- with a probability threshold of 0.4 :
  - ☐☐~90% of the blazars find by Hartman and Mattox
  - BUT we made also ☐~ **130 wrong identifications**.

Hartman et al. 1999

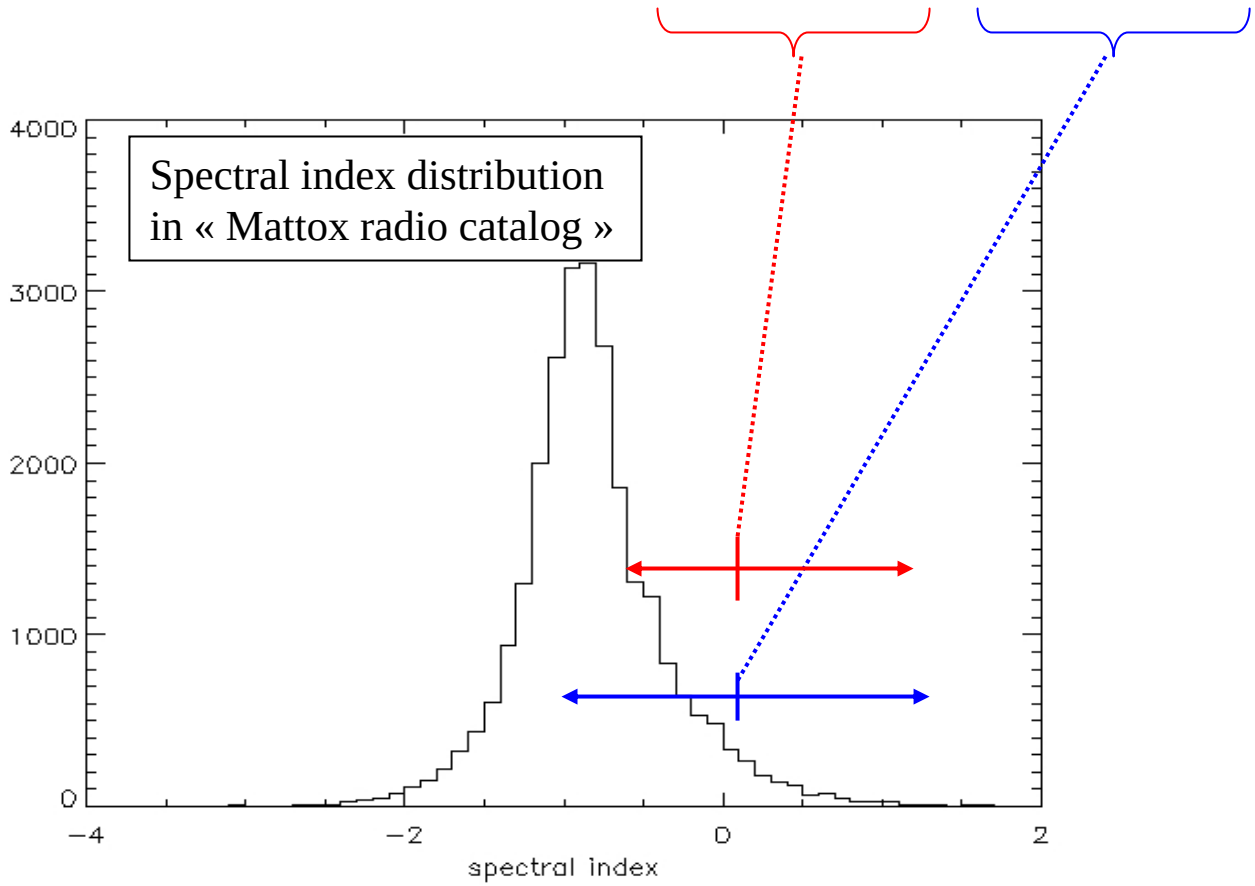


Mattox et al. 2001



Spectral index properties of *Mattox et al.* Blazars

	Mattox radio catalog	Mattox High probability	Mattox low probability
Min spectral index	-3.76	**-0.6**	**-1**
Mean spectral index	-0.82	**0.12**	**0.12**
Max spectral index	2.9	**1.1**	**1.2**

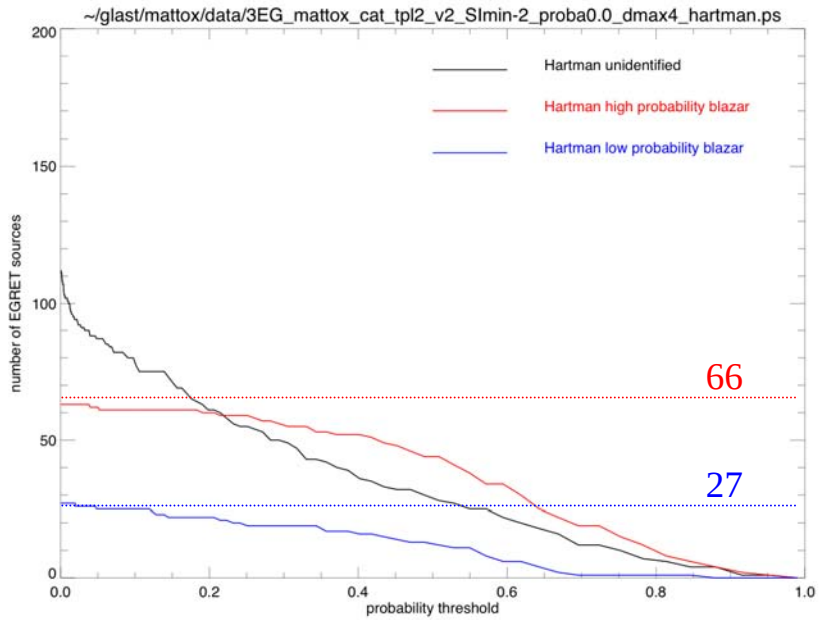


Test of *source identify* with 3EG - « Mattox catalog »

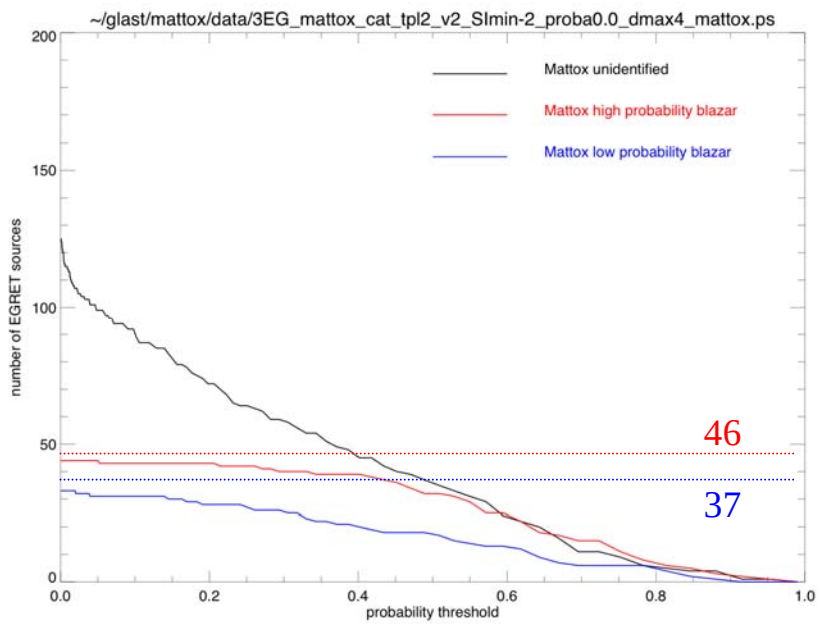
Run 2: spectral index > -2 (suppress about 66% of the sources for which we don't have any spectral index)

The spectral index plays a crucial role in the blazar identification. By suppressing all the sources with no spectral index or low spectral index we reduce the number of wrong blazar identifications by a factor of 2 or 3.

Hartman et al. 1999



Mattox et al. 2001

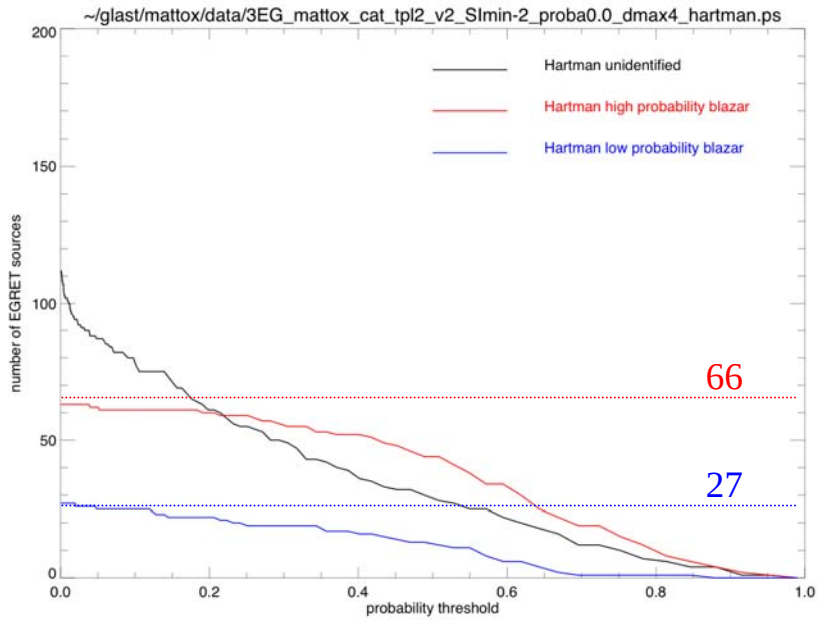


Test of *source identify* with 3EG - « Mattox catalog »

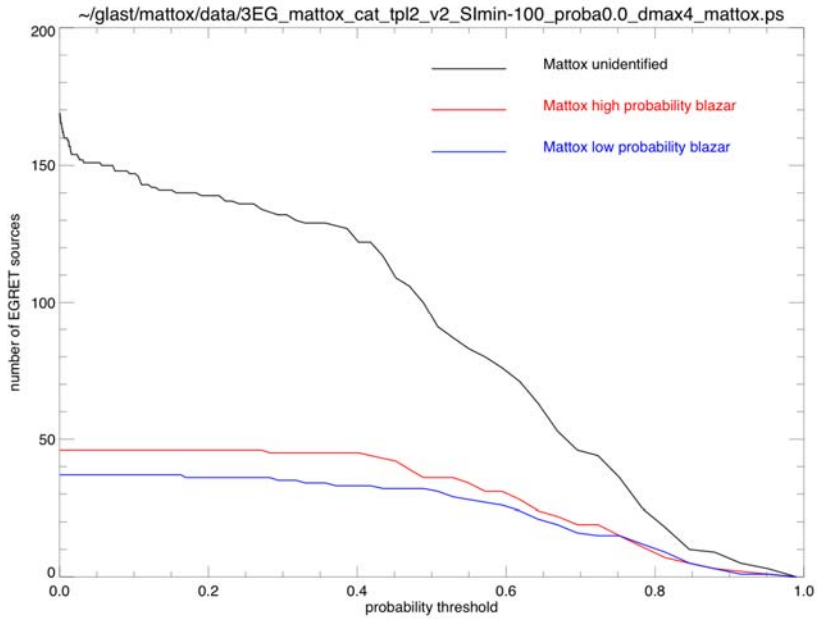
Run 2: spectral index > -2 (suppress about 66% of the sources for which we don't have any spectral index)

The spectral index plays a crucial role in the blazar identification. By suppressing all the sources with no spectral index or low spectral index we reduce the number of wrong blazar identifications by a factor of 2 or 3.

Hartman et al. 1999



Mattox et al. 2001

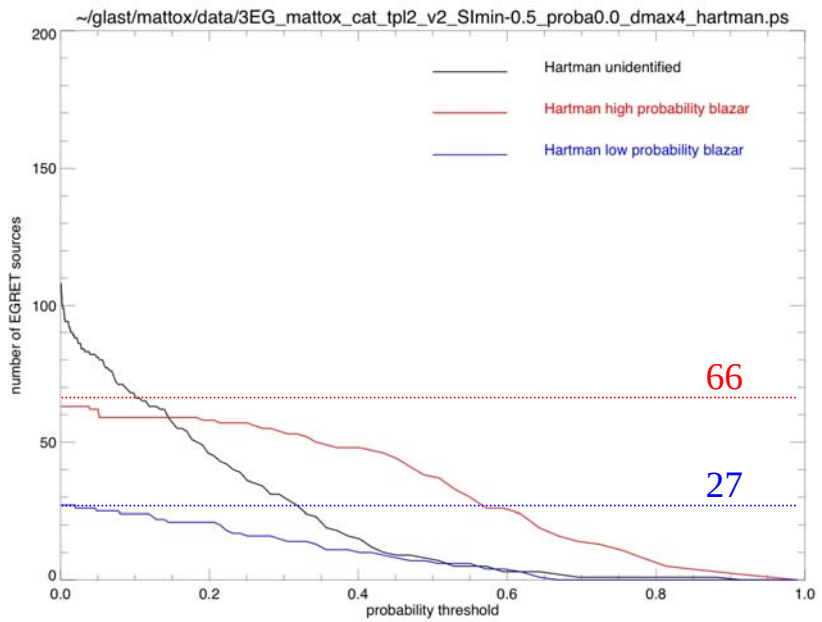


Test of *source identify* with 3EG - « Mattox catalog »

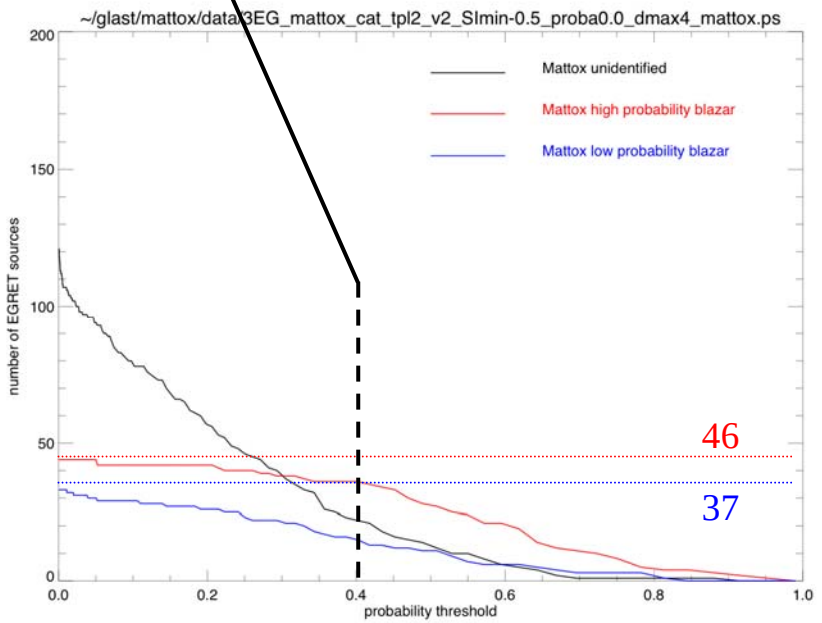
Run 3: spectral index > -0.5 (*Mattox* high probability blazar identification criteria)

- With a probability threshold of 0.4
  - ☐~ 80% of the high probability blazar
  - ~30-40% of low probability blazar
  - BUT we made ~ 20 wrong identifications.

Hartman et al. 1999

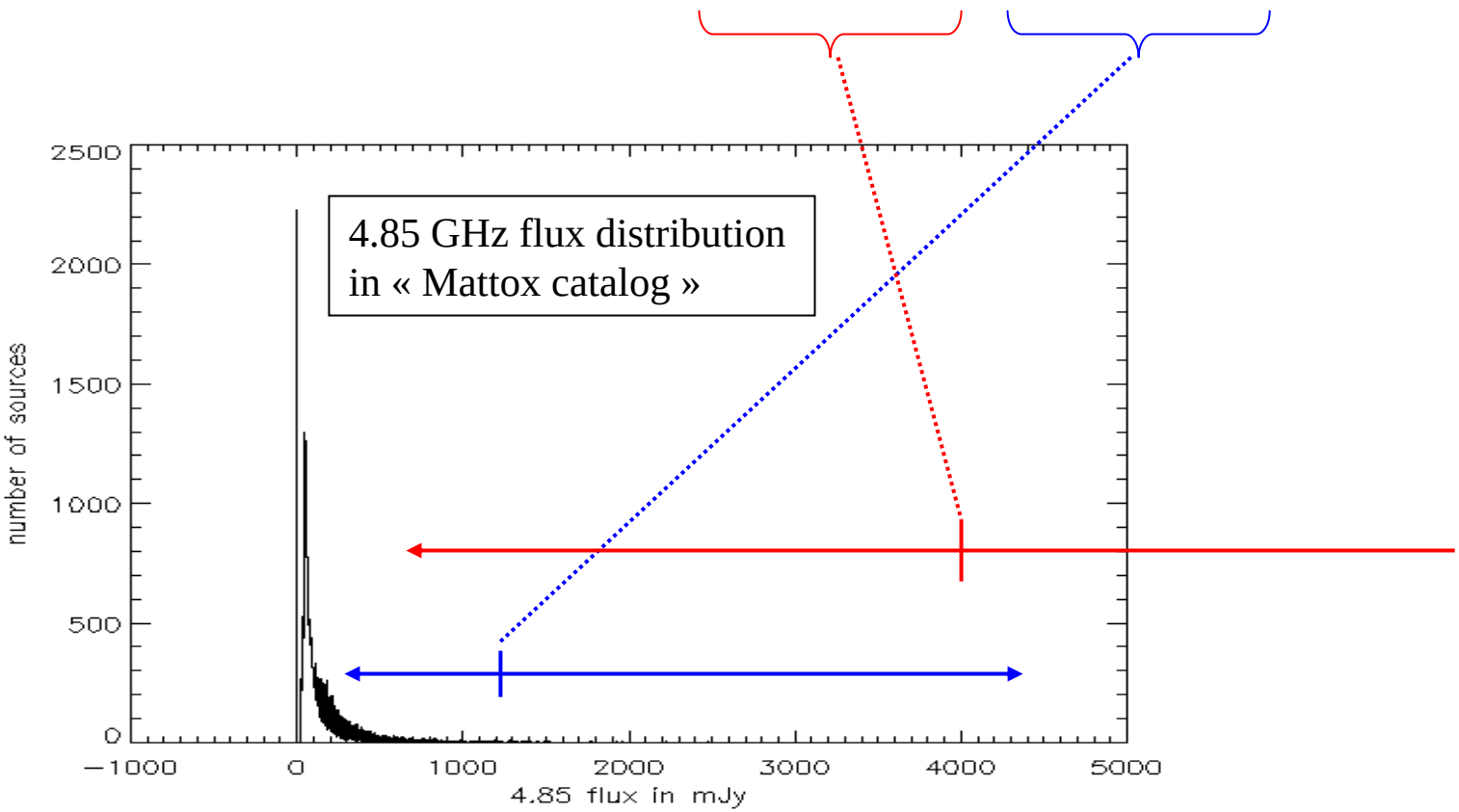


Mattox et al. 2001



Flux properties of *Mattox et al.* Blazars

	Mattox radio catalog	*Mattox* High probability	*Mattox* low probability
Min 4.85 GHz flux (mJy)	0	**407**	**260**
Mean 4.85 GHz flux (mJy)	150	**3949**	**1232**
Max 4.85 GHz flux (mJy)	67600	**44940**	**4506**

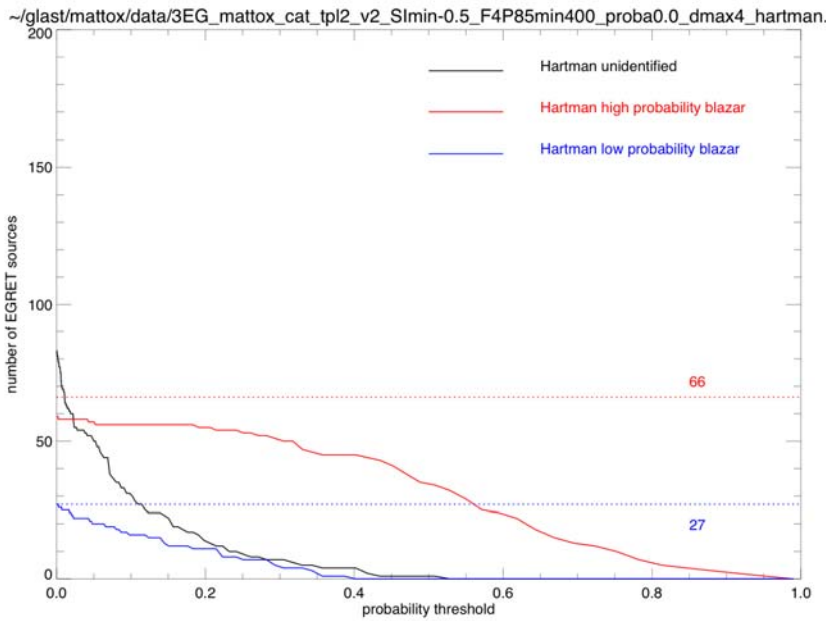


Test of *source identify* with 3EG - « Mattox catalog »

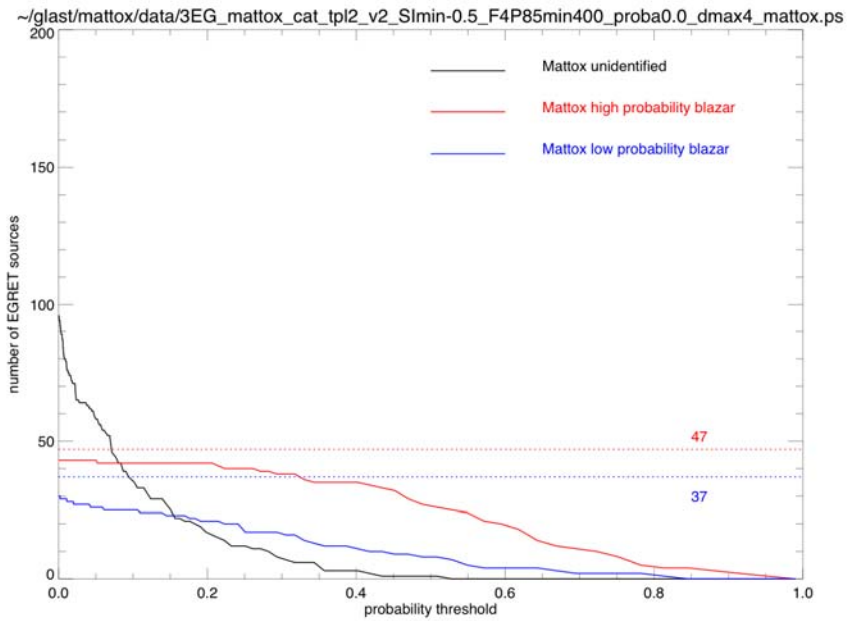
Run 5: spectral index > -0.5 + 4.85 GHz Flux > 400 mJy

Mattox et al. high probability identification limits

Hartman et al. 1999



Mattox et al. 2001



Exact *Mattox et al.* calculation

$$p(id/r) = \frac{\left[\frac{\eta}{1-\eta}\right] LR}{\left[\frac{\eta}{1-\eta}\right] LR + 1}$$

Probability of identification

$$LR = 3\frac{r^2}{\psi^2} e^{-r^2(3\psi^{-2} - R0^{-2})}$$

Likelihood Ratio

$$\eta = 0.2(1 - e^{-0.07 \times F_{4.85GHz}{}^{2.3}})$$

« a priori » of EGRET's detecting a radio source (cf. Mattox et al. 97)

With

- $F_{4.85Ghz}$: radio source flux at 4.85 GHz in mJy
- α : spectral index
- R0 : f ($F_{4.85Ghz}$, α)
  : mean distance between sources which have at least a flux of $F_{4.85Ghz}$ and at least a spectral index of α
- ψ : 95% confidence radius in the direction of the counterpart

Exact *Mattox et al.* calculation

```
./gtsrcid \
  srcCatName="../cat/3EG.fits" \
  srcCatQty='3EG,RAJ2000,DEJ2000,theta95' \
  srcCatPrefix="3EG" \
  cptCatName="../cat/radio_mattox_cat_tpl2_allSI_v4.fits" \
  cptCatQty='ID,RAJ2000,DEJ2000,GLON,GLAT,FLUX_4P85,SI' \
  cptCatPrefix="mattox_v4" \
  outCatName="data/${RUN_ID}.fits" \
  outCatQty01="N100mJy(SI)=@N100mJy(SI)_GB_mattoxHyp.txt" \
  outCatQty02='F4P85=$@mattox_v4_FLUX_4P85$>0?$@mattox_v4_FLUX_4P85$:1' \
  outCatQty03='rho=($N100mJy(SI)$*(F4P85/100)**(-1.5))/16300' \
  outCatQty04='R0=(#pi*rho)**(-0.5)' \
  outCatQty05='R=arccos(sin($@3EG_DEJ2000$*2*#pi/360)*sin($@mattox_v4_DEJ2000$*2*#pi/360)+c
  outCatQty06='eta=0.2*(1-exp((-0.07)*($@mattox_v4_FLUX_4P85$/1000)^2.3))' \
  outCatQty07='LR2=$@3EG_theta95$<sqrt(3)*R0?((-1)*R^2)*((3/($@3EG_theta95$)^2)-(1/(R0)^2))
  outCatQty08='LR=3*((R0/$@3EG_theta95$)^2)*exp(LR2)' \
  outCatQty09='p_mattox=((eta/(1-eta))*LR)/((eta/(1-eta))*LR+1)' \
  probMethod="p_mattox" \
  probThres="0.0" \
  select01='$@mattox_v4_SI$>=-10' \
  select02='$@3EG_theta95$<sqrt(3)*R0' \
  select03='$@mattox_v4_SI$>=-0.6' \
  maxNumCtp="100" \
  chatter="4" \
  clobber="yes" \
  debug="no" \
  mode="ql"
mv gtsrcid.log "log/${RUN_ID}.log"
```

Likelihood ratio

Probability of identification

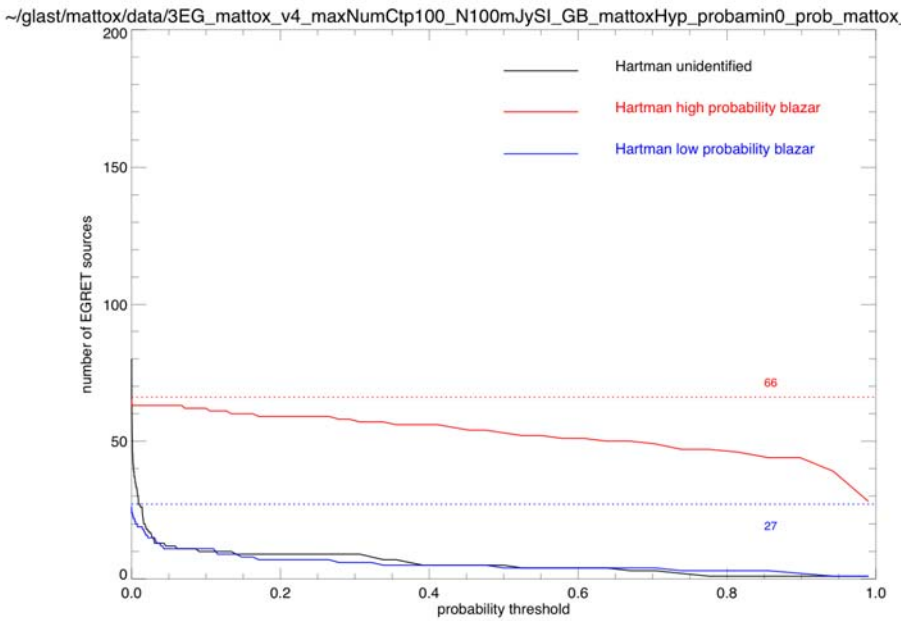
Spectral index lower limit

→ We will provide script examples

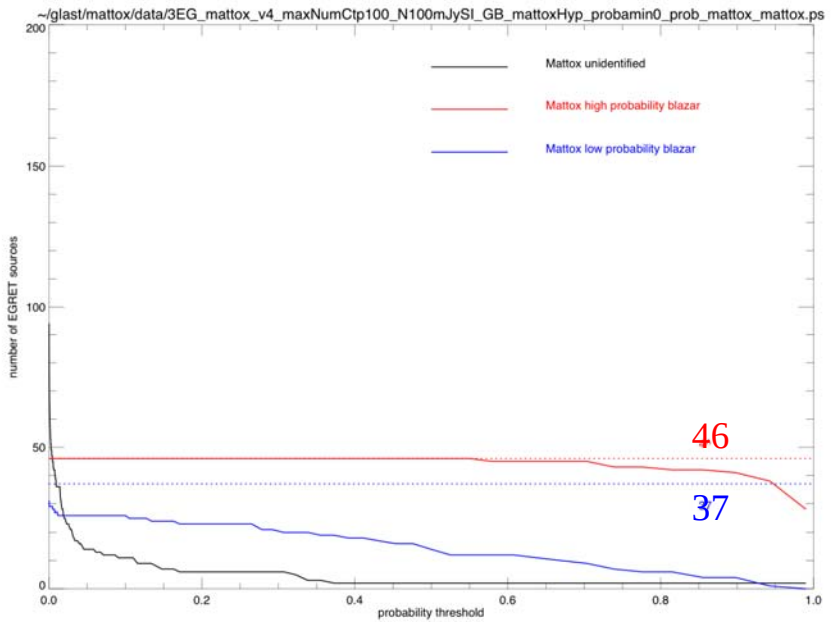
Exact *Mattox et al.* calculation

Run 6: exact *Mattox et al.* probability p(id/r)

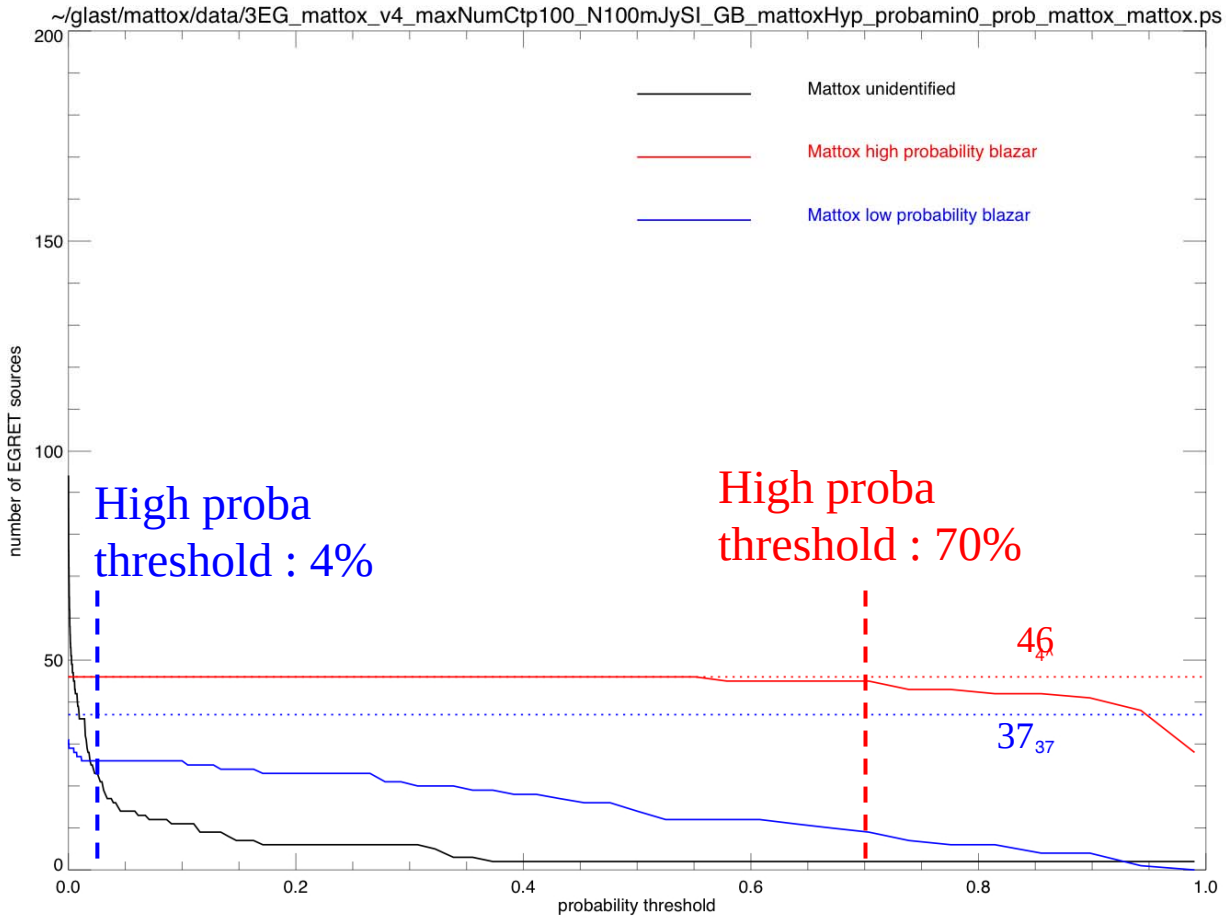
Hartman et al. 1999



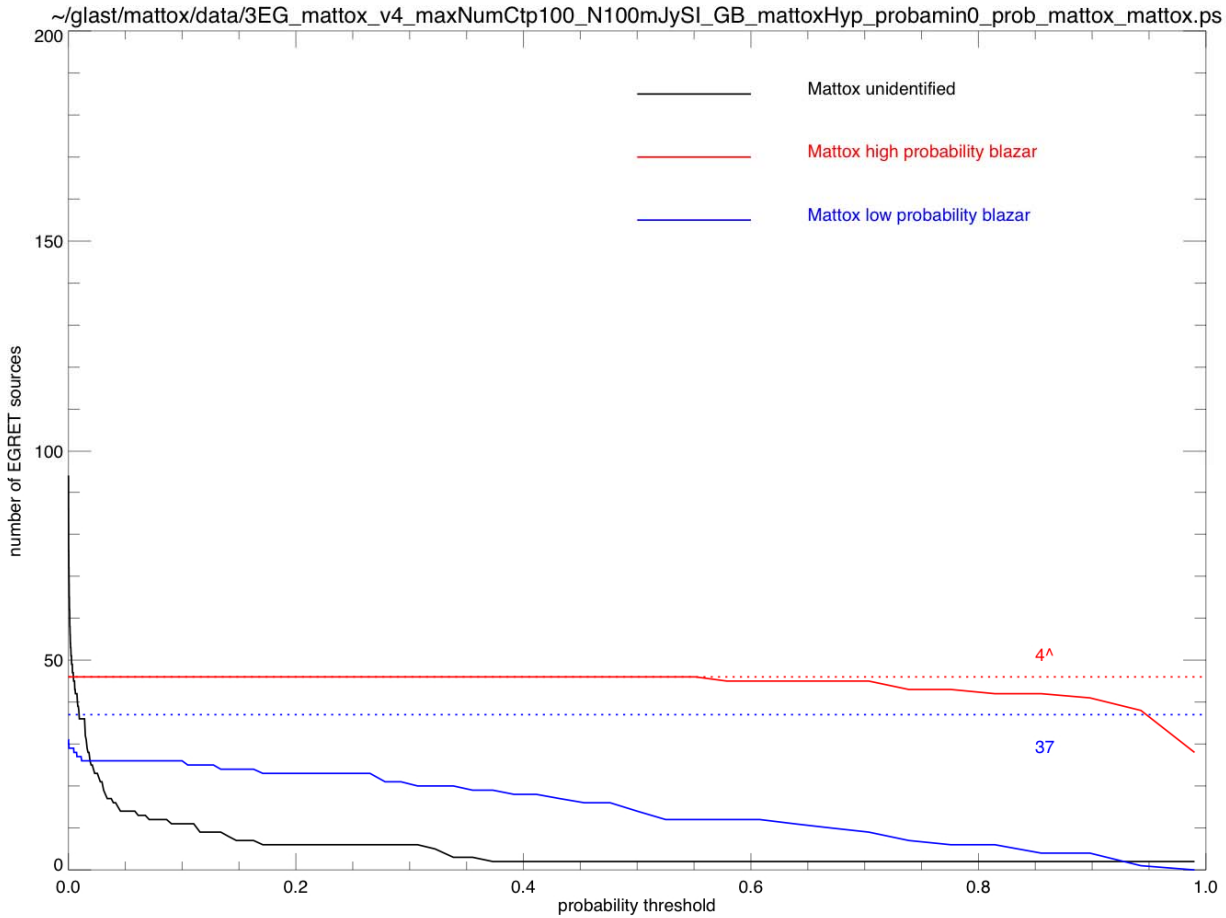
Mattox et al. 2001



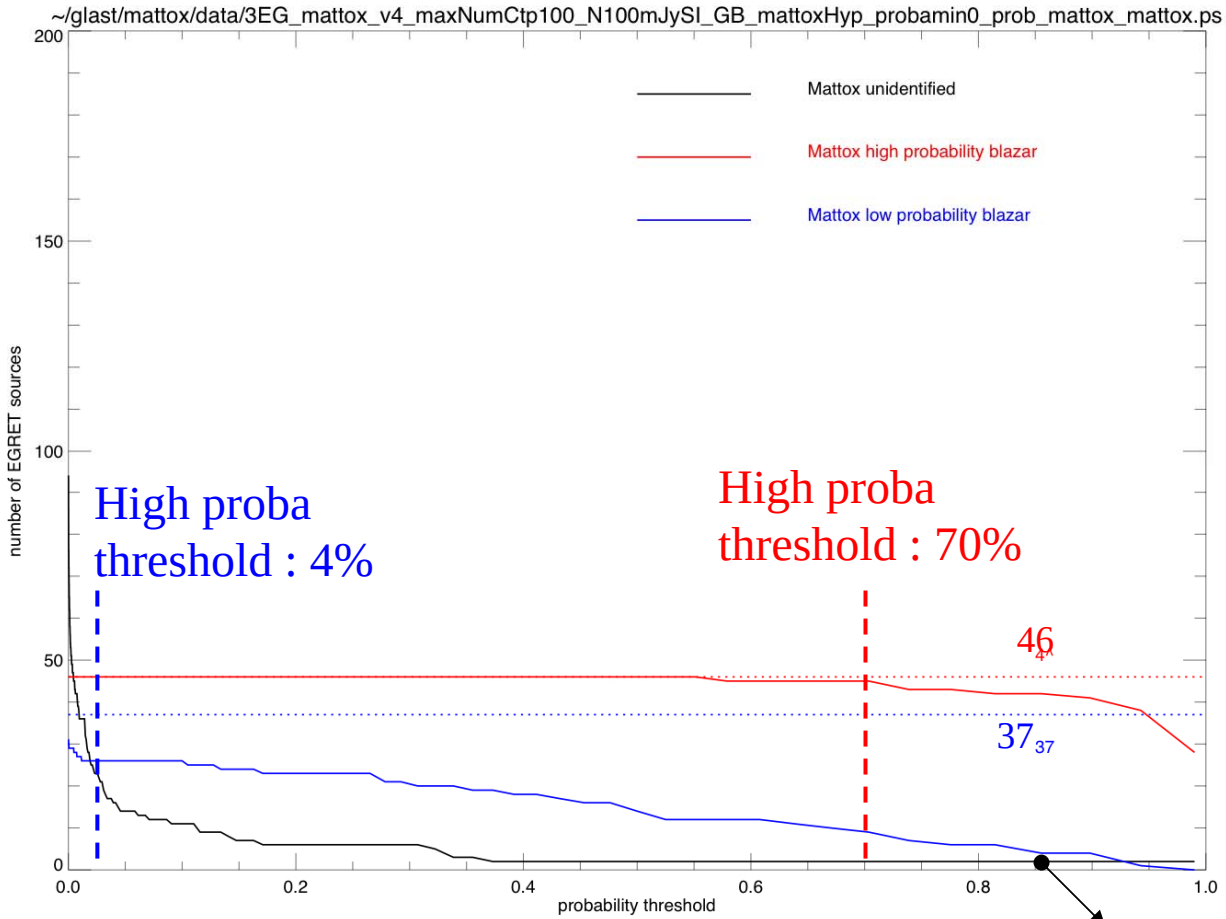
Exact *Mattox et al.* calculation



Exact *Mattox et al.* calculation



Exact *Mattox et al.* calculation

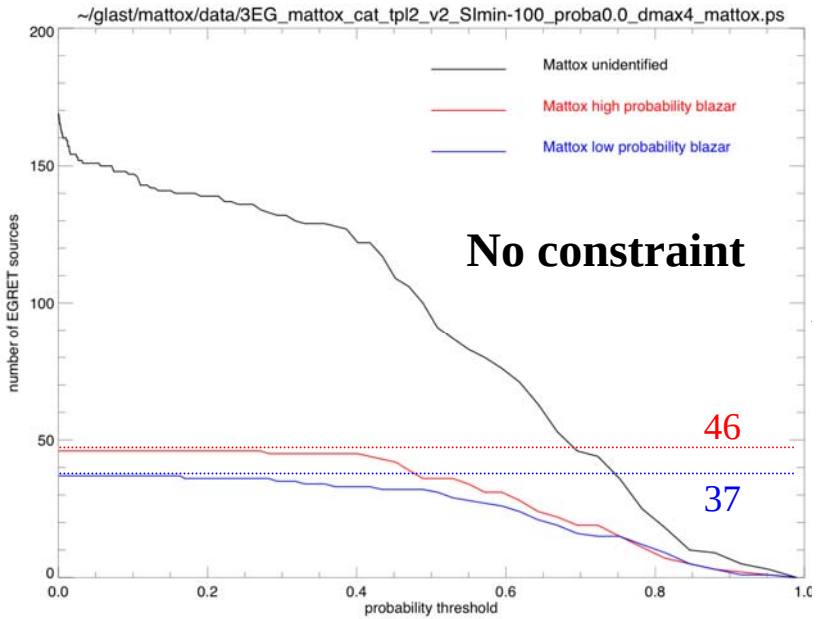


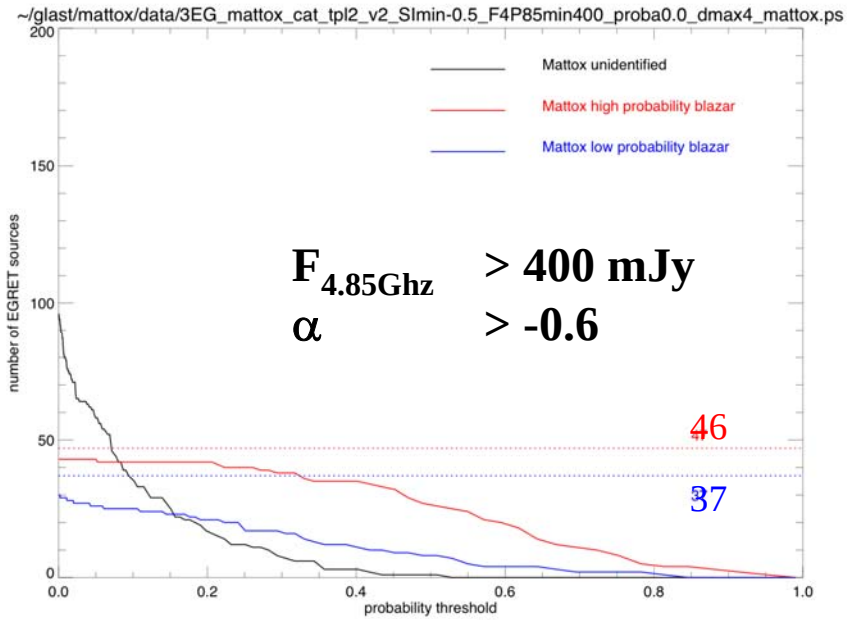
3 effects can explain the little differences :

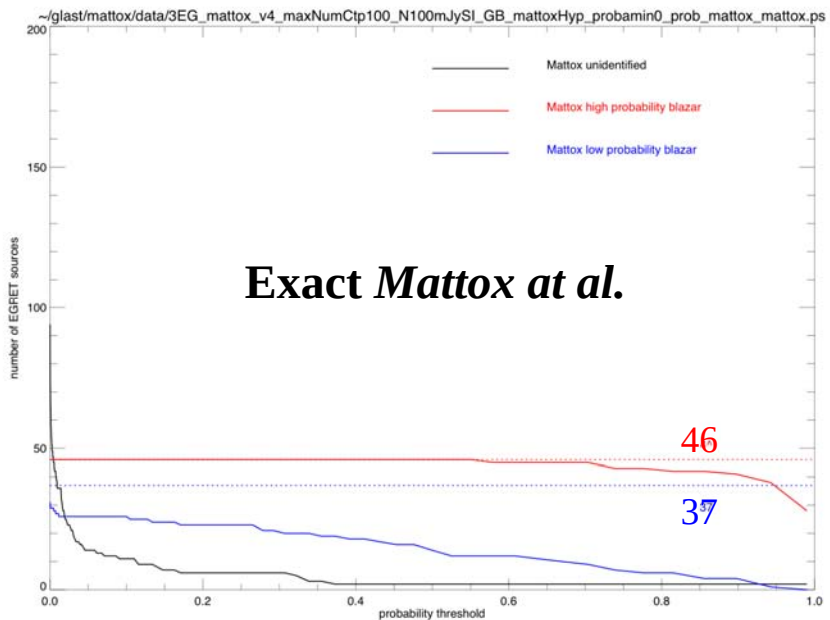
- R0 calculation (factor 1 to 5)
- *Mattox et al.* use ellipitic contour / We use circular
- No contraints on α in this example

1 wrong identification with a high probability: LMC rejected by *Mattox et al.* : « …because of the poor resolution of PMN survey »

Summary


~/glast/mattox/data/3EG_mattox_cat_tpl2_v2_SImin-100_proba0.0_dmax4_mattox.ps
Mattox unidentified
Mattox high probability blazar
Mattox low probability blazar
No constraint
46
37
number of EGRET sources
probability threshold


~/glast/mattox/data/3EG_mattox_cat_tpl2_v2_SImin-0.5_F4P85min400_proba0.0_dmax4_mattox.ps
Mattox unidentified
Mattox high probability blazar
Mattox low probability blazar
F4.85Ghz > 400 mJy
α > -0.6
46
37
number of EGRET sources
probability threshold


~/glast/mattox/data/3EG_mattox_v4_maxNumCtp100_N100mJySI_GB_mattoxHyp_probamin0_prob_mattox_mattox.ps
Mattox unidentified
Mattox high probability blazar
Mattox low probability blazar
Exact Mattox at al.
46
37
number of EGRET sources
probability threshold

Conclusion

- **Validation of « source identify » :**
  - fast (1 to 10 s)
  - modularity

- **We are able to reproduce what has been done on EGRET data**

- **To be done:**
  - test others methods :
    - probability method
  - test others catalogs :
    - radio (VLA Sky Survey, …)
    - X (ROSAT, …)
    - Pulsars / AGN …
  - continue the development, find / correct eventual bugs (DC2)