

Status of $\eta \rightarrow \mu^+ \mu^-$ analysis (background rejection)

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Data sample

1. **sample** (runs: 30300-34169, $L_{\text{int}} = 535.42 \text{ pb}^{-1}$)

allrad 2004, data 2004

- studies of the efficiency

for signal and the shape of distribution of inv-mass of muons
after cuts

2. **sample** (runs: 30300-31000, $L_{\text{int}} = 88.10 \text{ pb}^{-1}$)

data, allrad, allphys and continuum (eeg100, pho5mmg, ppgphok5)

- checking the contributions from continuum

- compare MC and DATA sample

- how much continuum events were rejected after cuts

How many signal events we expect in 2004?

$$L_{\text{int}}(\text{runs:30300 - 34169}) = 535.42 \text{ [pb}^{-1}\text{]}$$

$$\sigma (\eta \rightarrow \mu^+ \mu^-) = 3100 \times 1.3 \times 10^{-2} \times 5.8 \times 10^{-6} = 0.23 \times 10^{-3} \text{ [nb]}$$

thus:

$$N_{\eta \rightarrow \mu^+ \mu^-} = L_{\text{int}} \times \sigma = \mathbf{125} \text{ events}$$

ANALYSIS level1: basic_request
selection events on the farm level (R.Versaci help)

1. TRACKS: at least two tracks from the IP
($r_{pca} < 4 \text{ cm}$, $z_{pca} < 10 \text{ cm}$)

2. CLUSTERS:

in time, neutral

zero clusters: Energy (50 - 250 MeV)

exactly one cluster: Energy ($> 250 \text{ MeV}$)

ANALYSIS level1: basic_request selection events on the farm level

Purpose of selection:

Take event where:

tracks: **select** ≥ 2 candidates for muons

cluster: **select** $== 1$ cluster for radiative photon

- how many events of the signal survived ?

$N_{\eta \rightarrow \mu^+ \mu^- (\text{survived})} = 97$ events (2004),

which consist **77,6%** of total signal events

ANALYSIS level2: C++ code (M. Jacewicz help)

select_tracks $N_{\text{tracks}} == 2$, \min_{rpca} , opposite charges (+1/-1)

missing_mass2($P_{\phi} - [P_{\mu+} + P_{\mu-}]$) $\text{abs}(x) < 5000$.

$\sum \vec{p}_{\text{tracks}}(LAB_{\text{Frame}})$ $(590 < x < 640)$ [MeV/c]

cos_mumu_lab $(-0.75 < x < -0.2)$

nclu_intime_neutral $(0 < x < 2)$

cos_eta_gamma $(x < -0.999)$

cos_mumu_eta $(x < -0.999)$

opening_angle(cluster,photon) $(x < 1.2 [^\circ])$

AFTER: select_tracks

runs: 30300-31000

CUT: missing_mass2 $\text{abs}(x) < 5000$.

MC rescaled
with
LSF factors

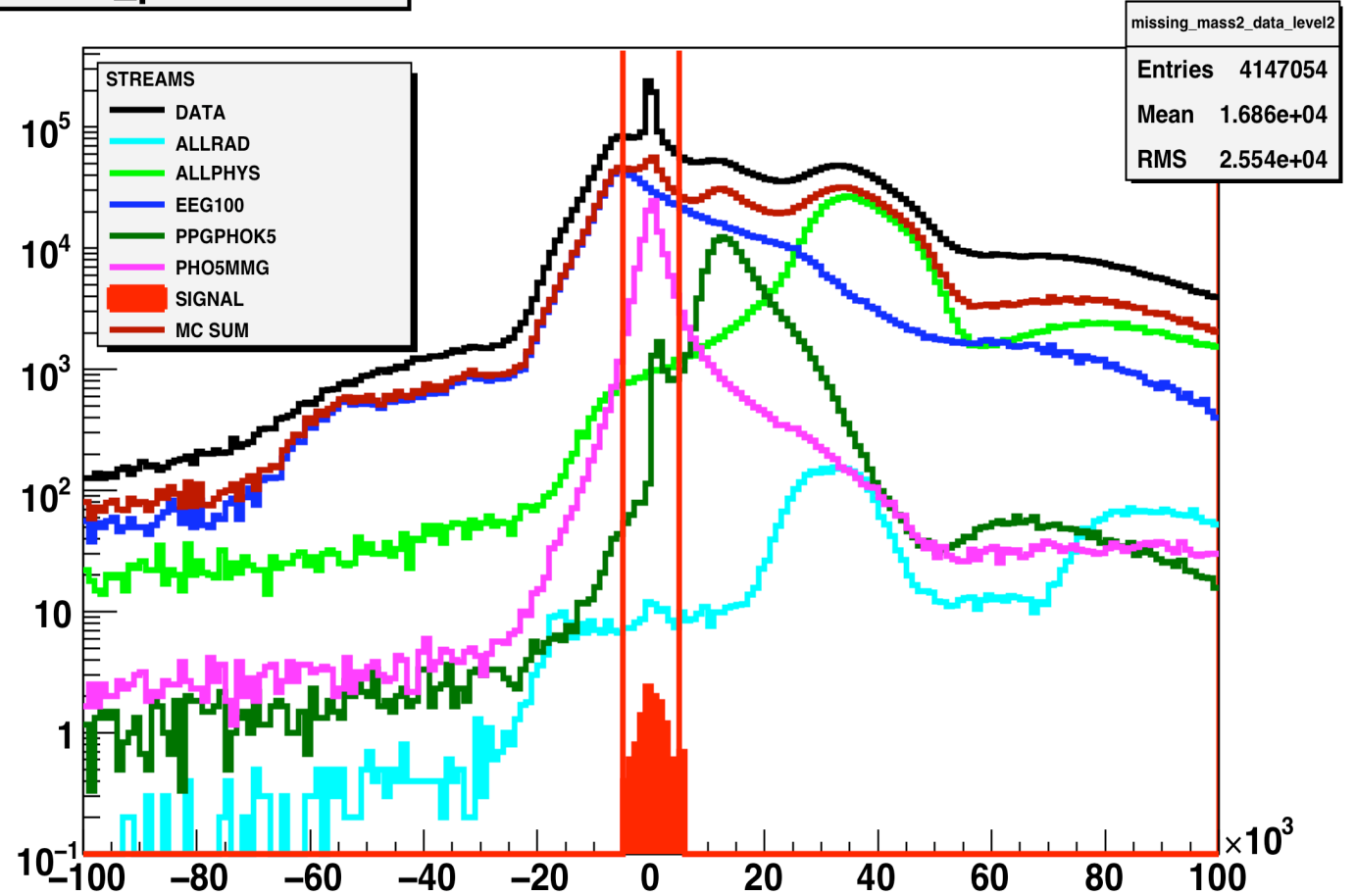
$\text{allrad}_{\text{LSF}} = 10$
 $\text{allphys}_{\text{LSF}} = 1$
 $\text{eeg100}_{\text{LSF}} = 0.5$
 $\text{pho5mmg}_{\text{LSF}} = 6$
 $\text{ppgpkok5}_{\text{LSF}} = 6$

$N_{\text{MC}} < N_{\text{DATA}}$

allrad contains signal

mm_phimumu

2009-10-03



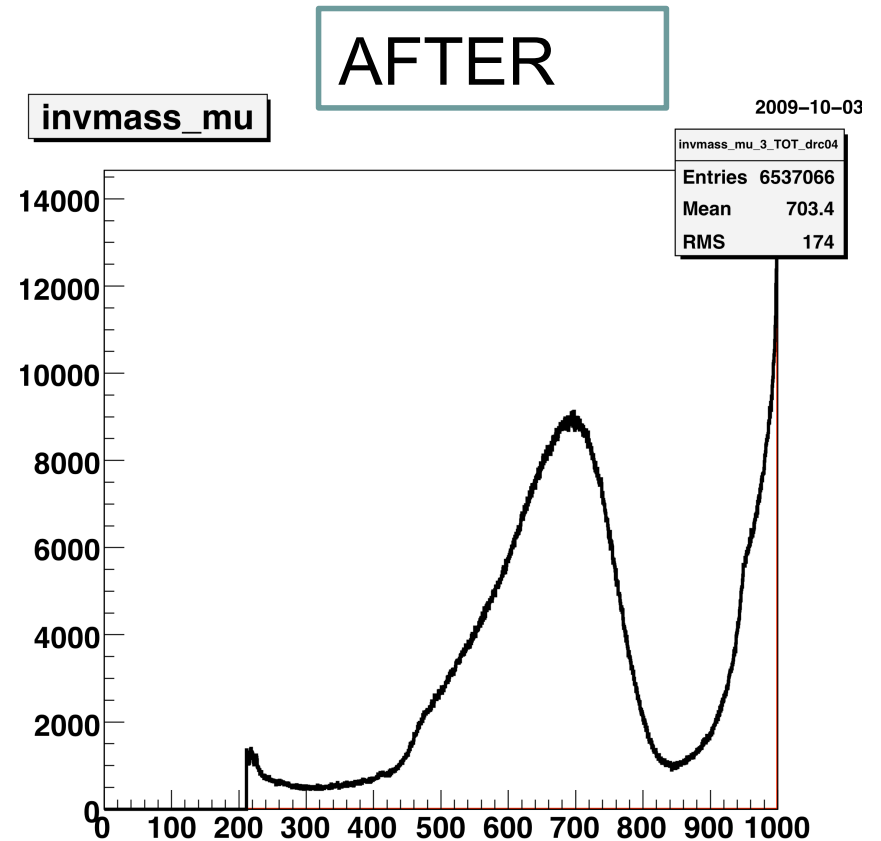
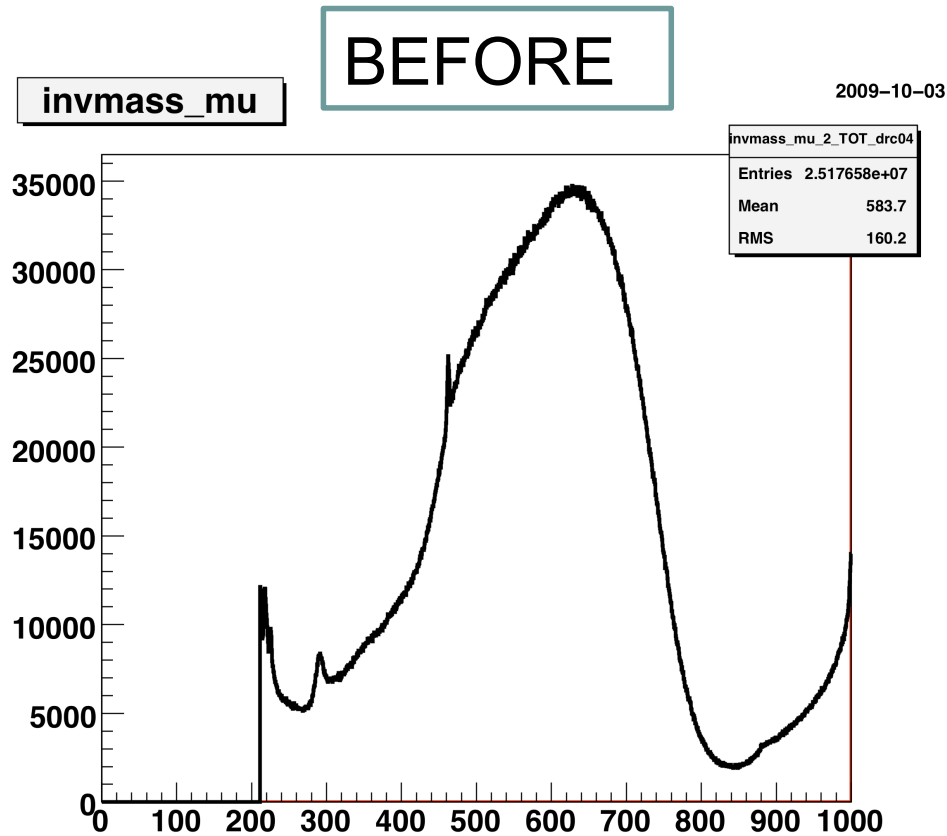
DATA 2004

inv_mass_mumu

assuming tracks are muons

2004	BEFORE	AFTER
data	25'176'584	6'537'066
signal	82.3	73.9

$\epsilon_{\text{signal}} = 89.8\%$ data reduced by factor 4



AFTER: missing_mass2($P_\phi - [P_{\mu^+} + P_{\mu^-}]$)

runs: 30300-31000

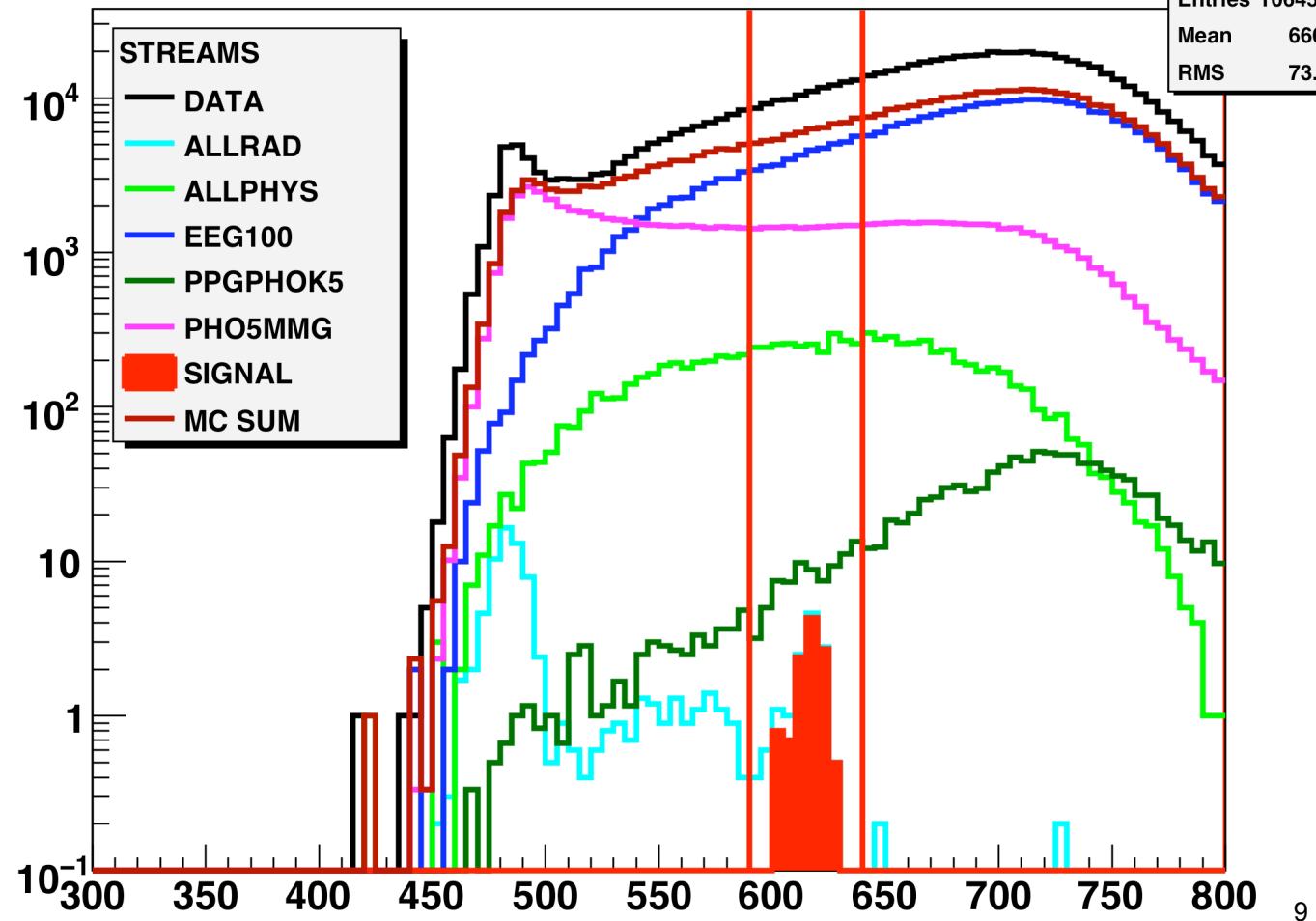
CUT:

$$\sum \vec{p}_{tracks} (LAB_{Frame})$$

($590 < x < 640$) [MeV/c]

sum_pmod_mu_lab

2009-10-03



DATA 2004

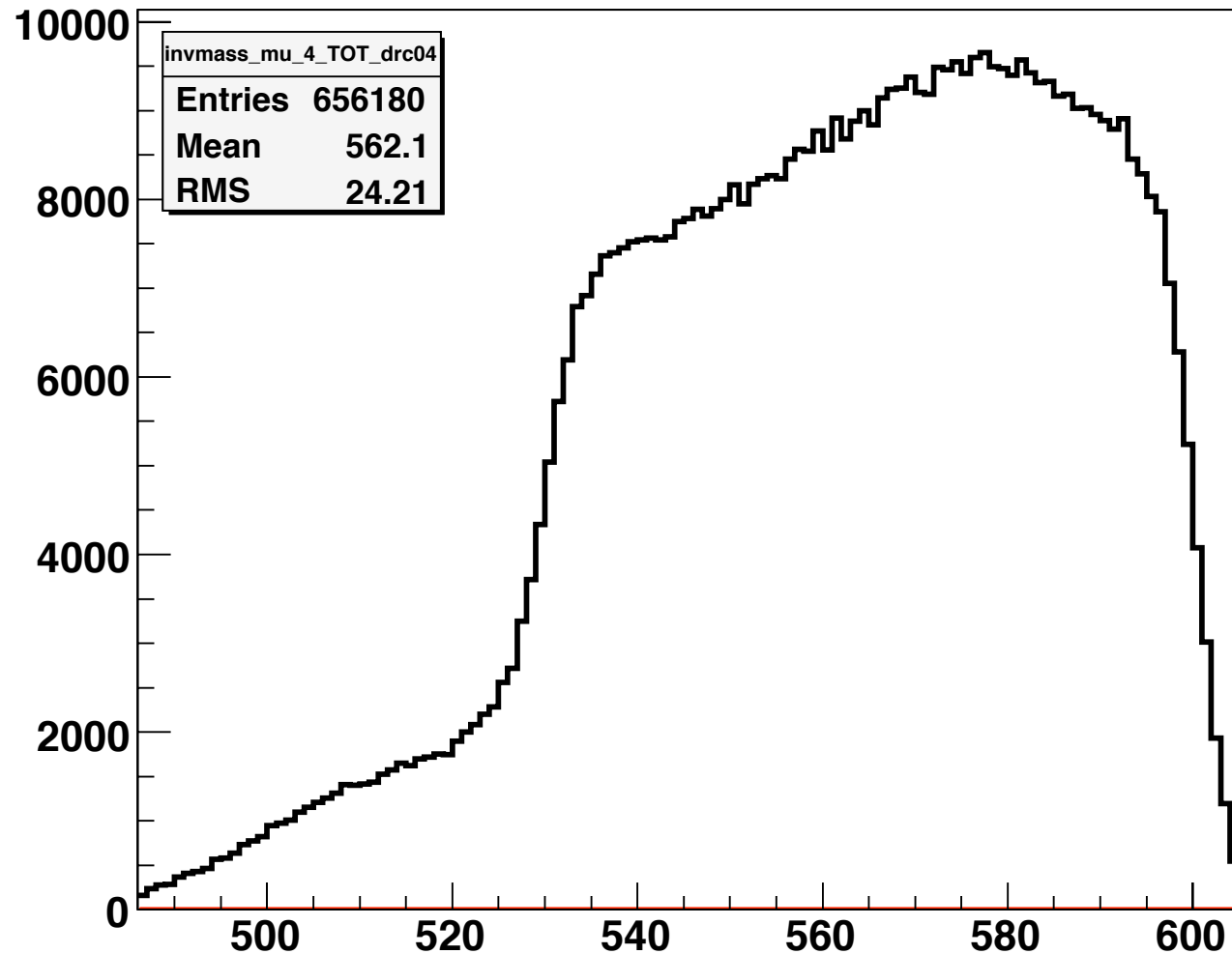
inv_mass_mumu

$\epsilon_{\text{signal}} = 100.0 \%$

2004	BEFORE	AFTER
data	6'537'066	656'180
signal	73.9	73.9

invmass_mu

data reduced by factor 10 !!!



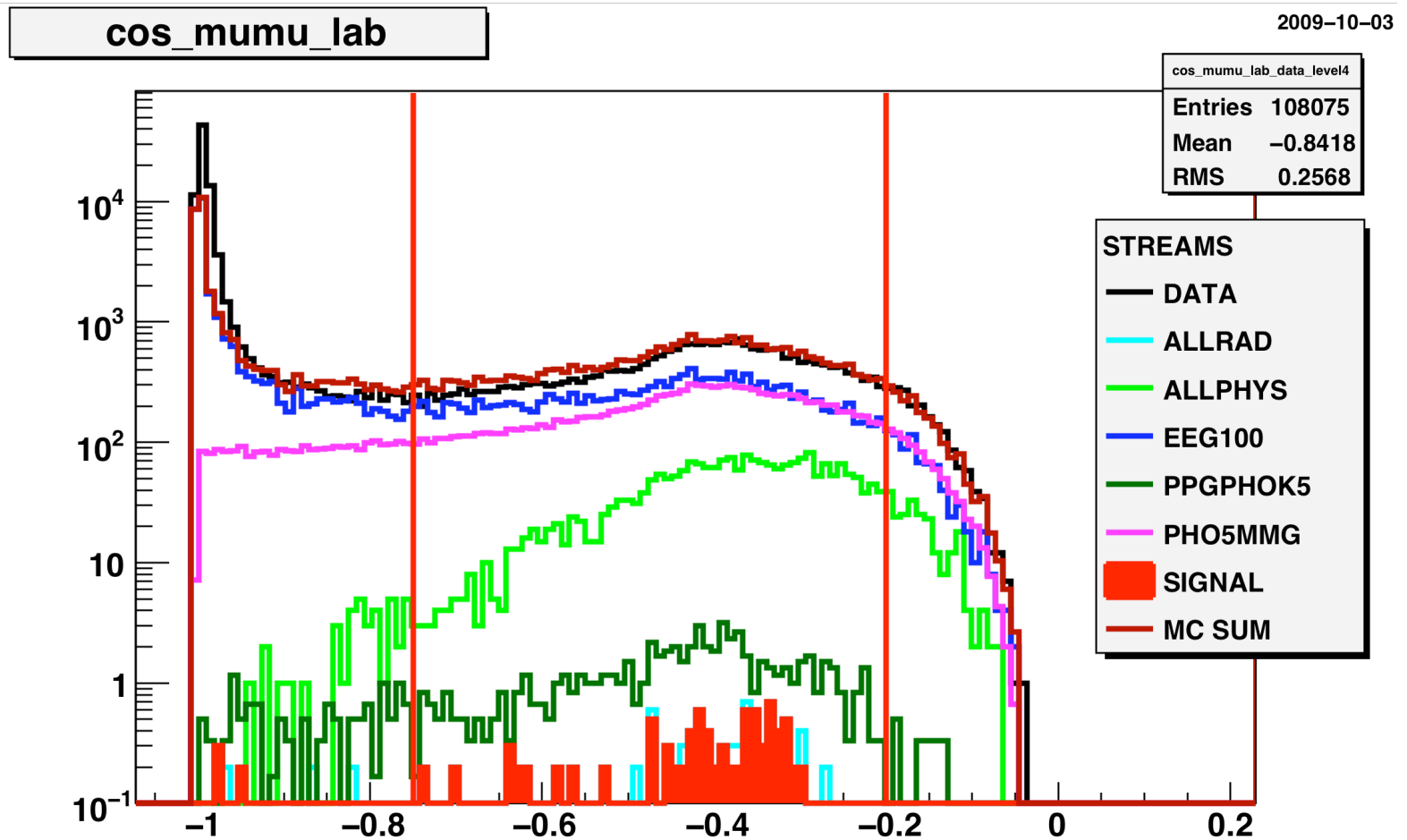
very nice

AFTER: $\sum \vec{p}_{tracks}(LAB_{Frame})$

runs: 30300-31000

CUT: cos_mumu_lab

$(-0.75 < x < -0.2)$



DATA 2004

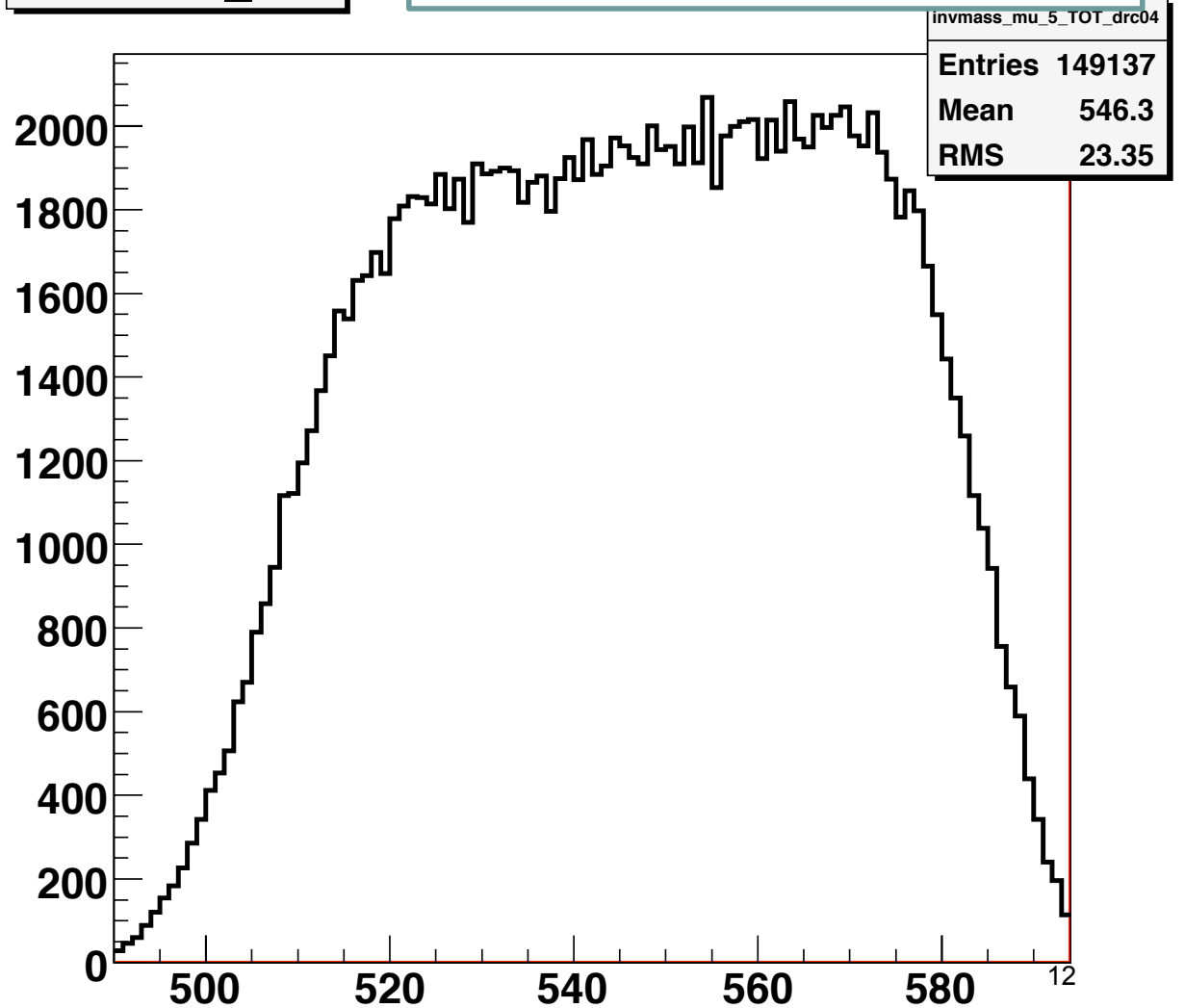
inv_mass_mumu

$\epsilon_{\text{signal}} = 86.3 \%$

2004	BEFORE	AFTER
data	656'180	149'137
signal	73.9	63.8

invmass_mu

data reduced by factor 4⁻⁰⁴



AFTER: cos_mumu_lab

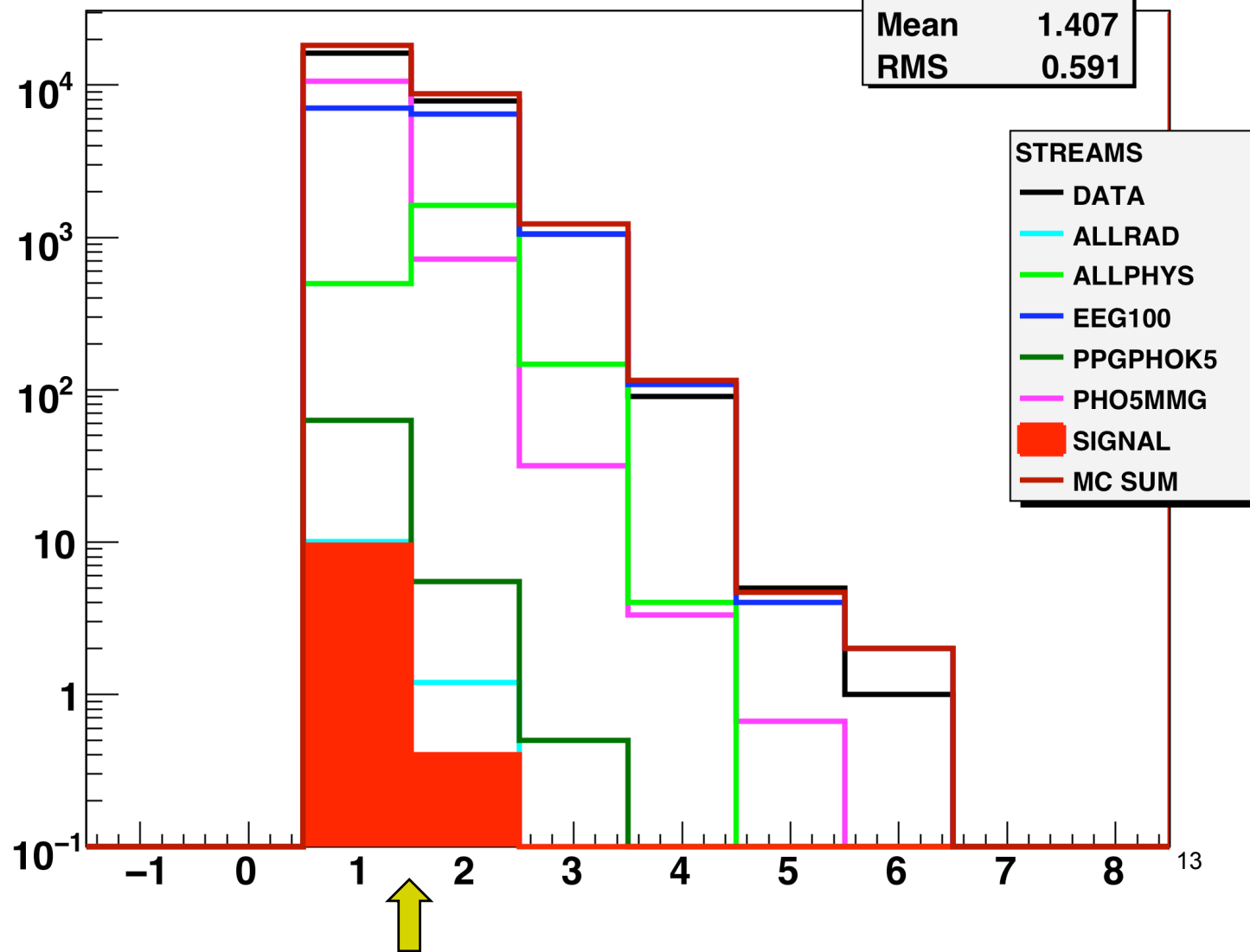
runs: 30300-31000

CUT: nclu_intime_neutral (x < 2)

nclu_intime_neutral

nclu_intime_neutral_data_level6 2009-10-03

Entries	25145
Mean	1.407
RMS	0.591



DATA 2004

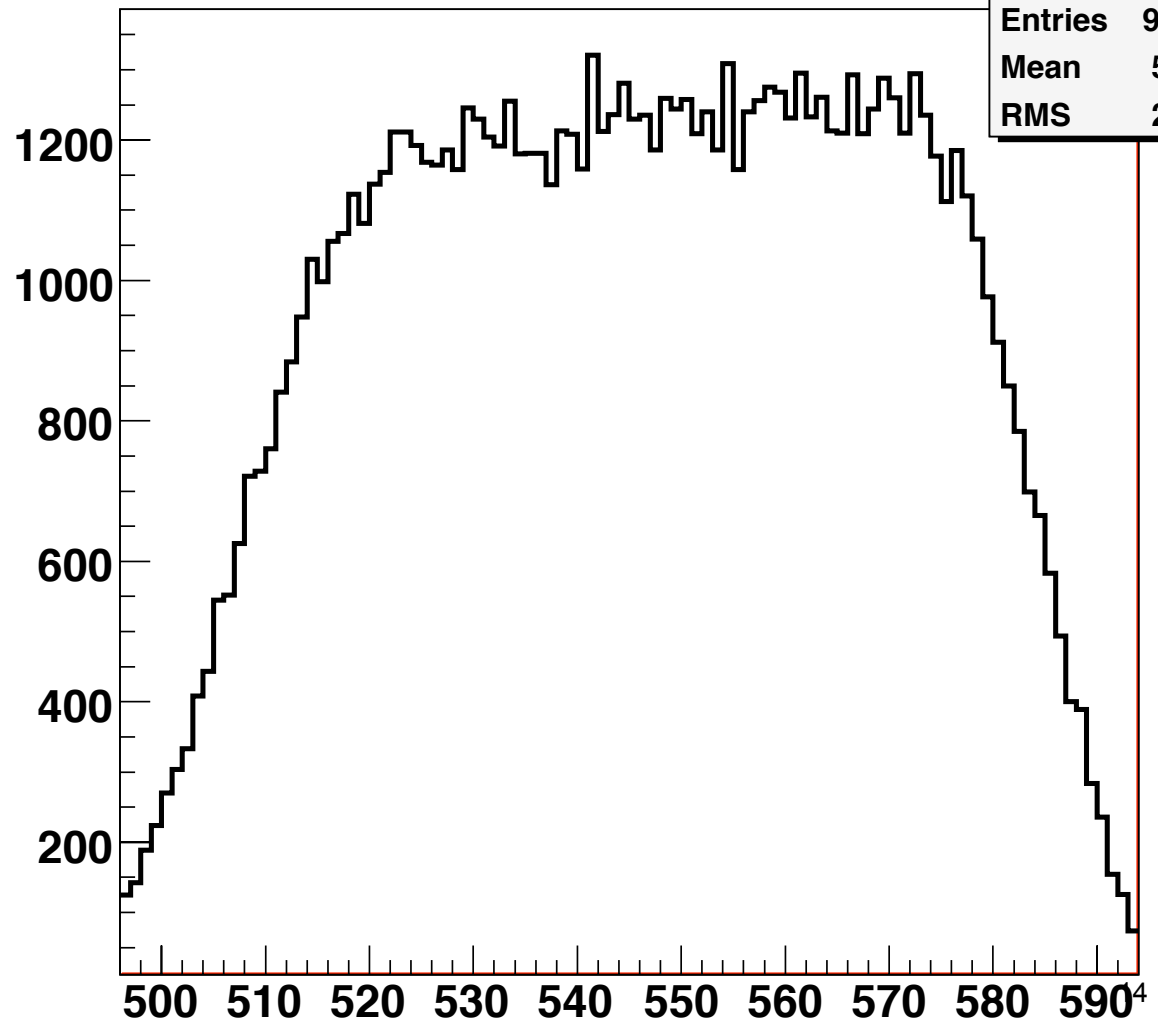
inv_mass_mumu

$\epsilon_{\text{signal}} = 95.3\%$

2004	BEFORE	AFTER
data	149'137	95'162
signal	63.8	60.8

invmass_mu

data reduced by 30%



AFTER: nclu_intime_neutral

runs: 30300-31000

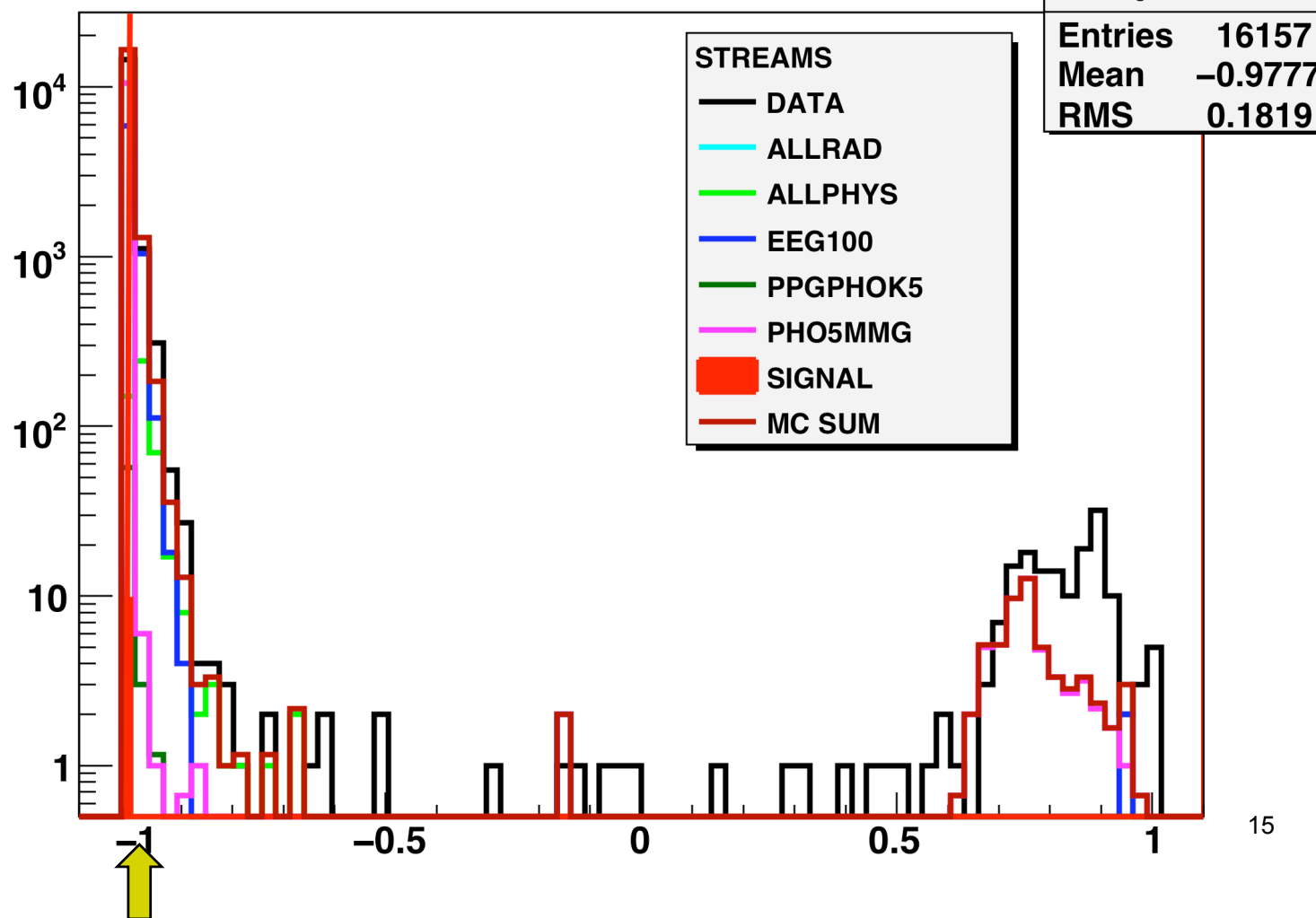
CUT: cos_eta_gamma

($x < -0.999$)

Φ REST
FRAME

cos_eta_gamma

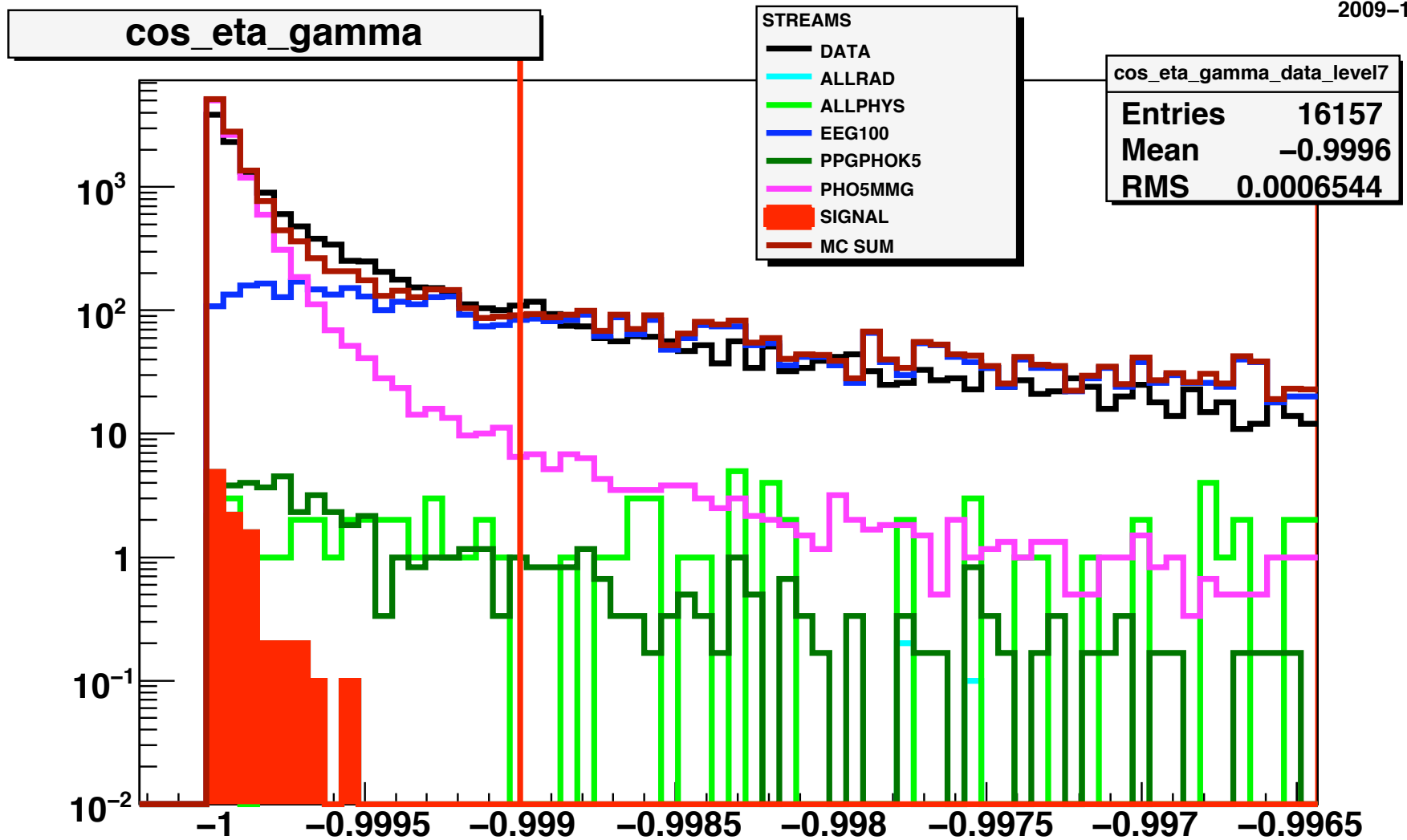
2009-10-03



ZOOM IN

BUT situation could be much better !!!!

very promising for kill $\mu\mu\gamma$ events



DATA 2004

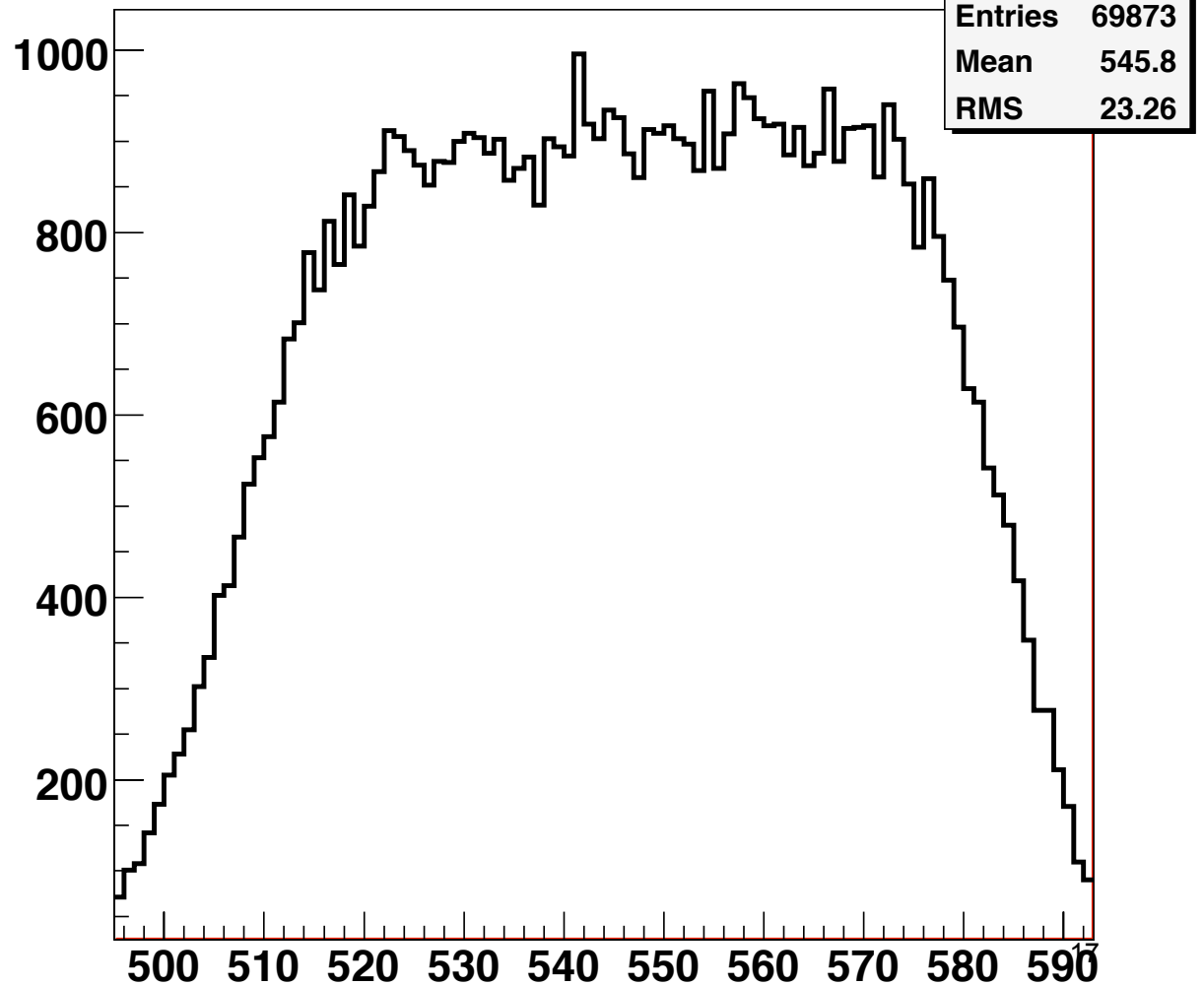
inv_mass_mumu

$\epsilon_{\text{signal}} = 100.0 \%$

2004	BEFORE	AFTER
data	95'162	69'873
signal	60.8	60.8

invmass_mu

data reduced by 30%



AFTER: cos_eta_gamma

runs: 30300-31000

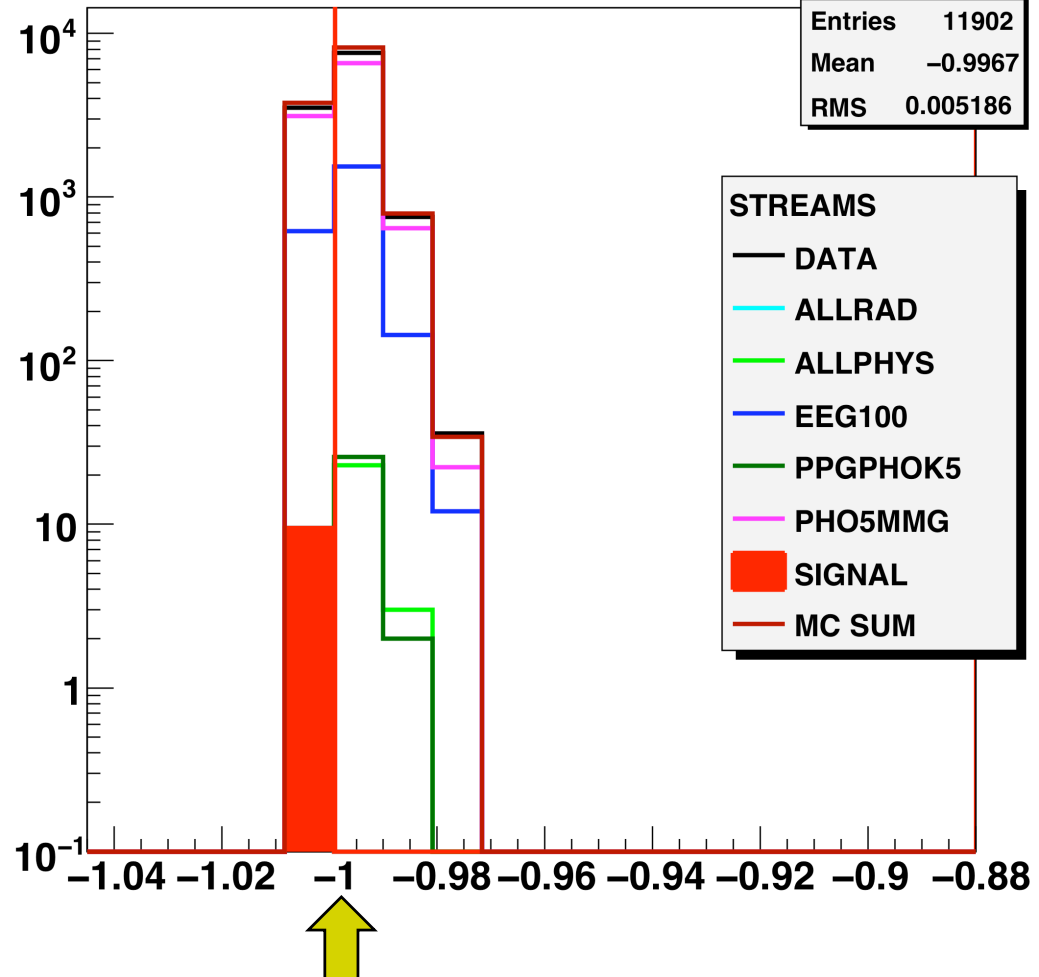
CUT: cos_mumu

($x < -0.999$)

η REST FRAME

cos_mumu_eta

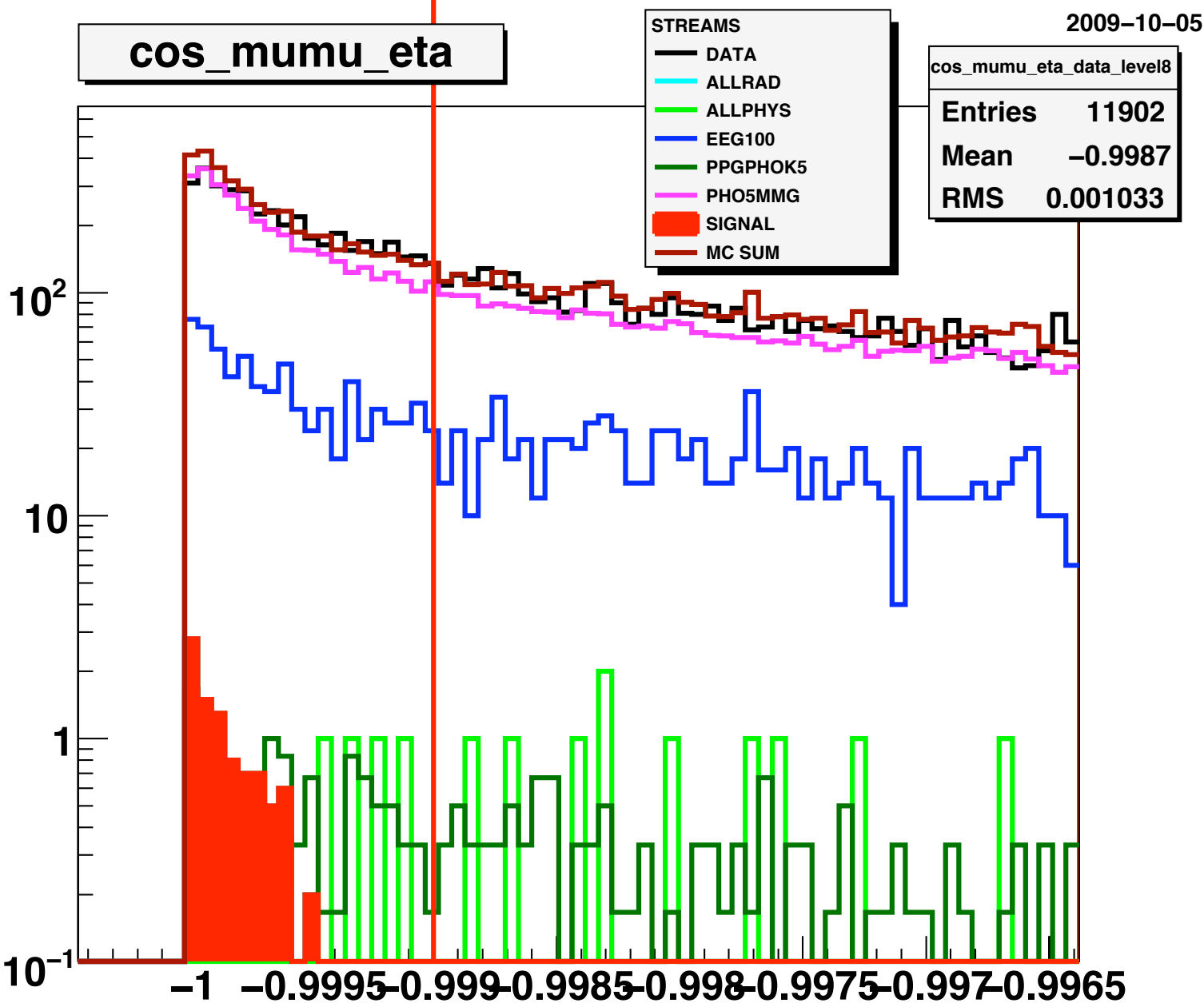
2009-10-03



ZOOM IN

promissing

BUT situation could be better also here



DATA 2004

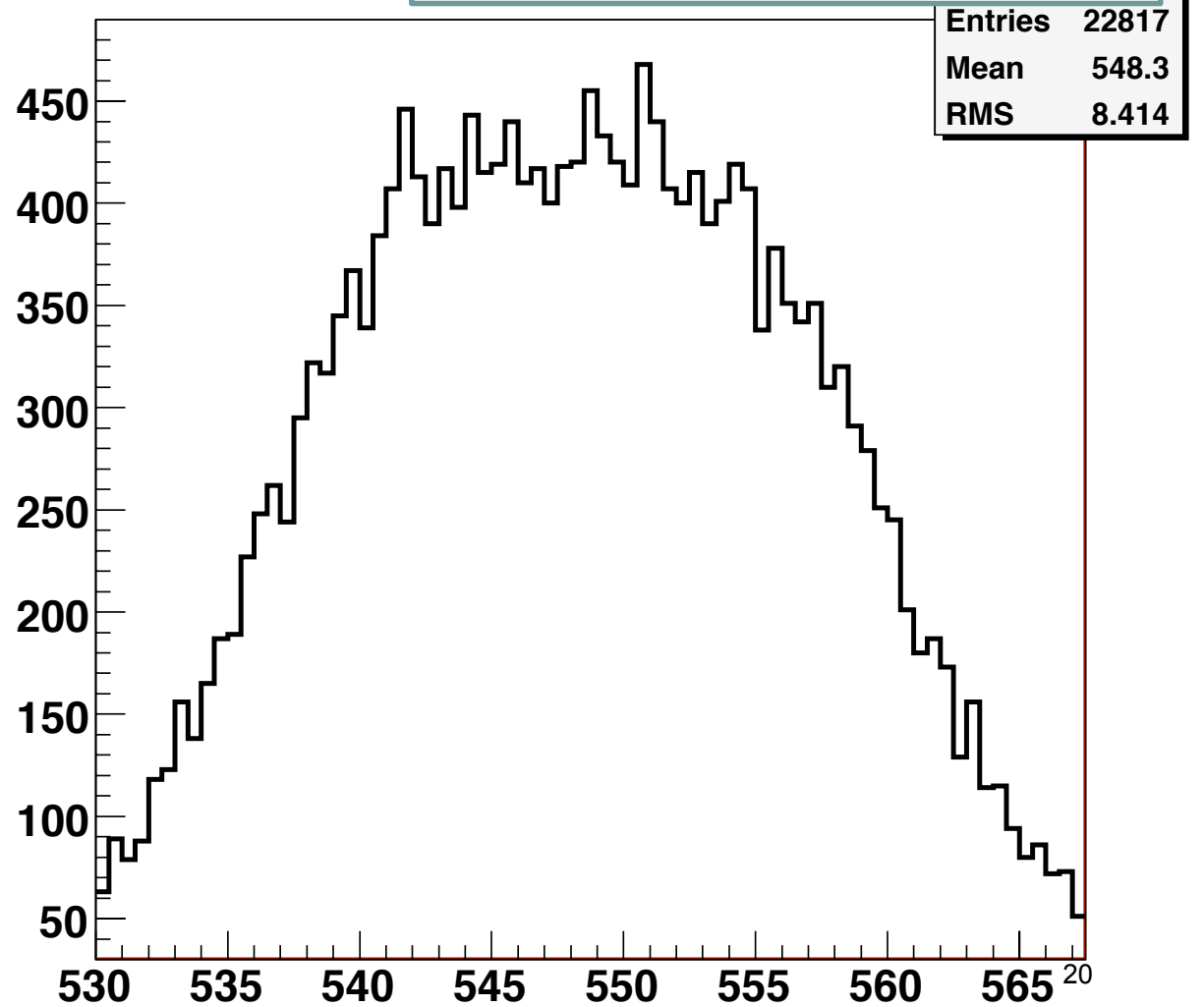
inv_mass_mumu

$\epsilon_{\text{signal}} = 100.0 \%$

2004	BEFORE	AFTER
data	69'873	22'817
signal	60.8	60.8

invmass_mu

data reduced by factor 3

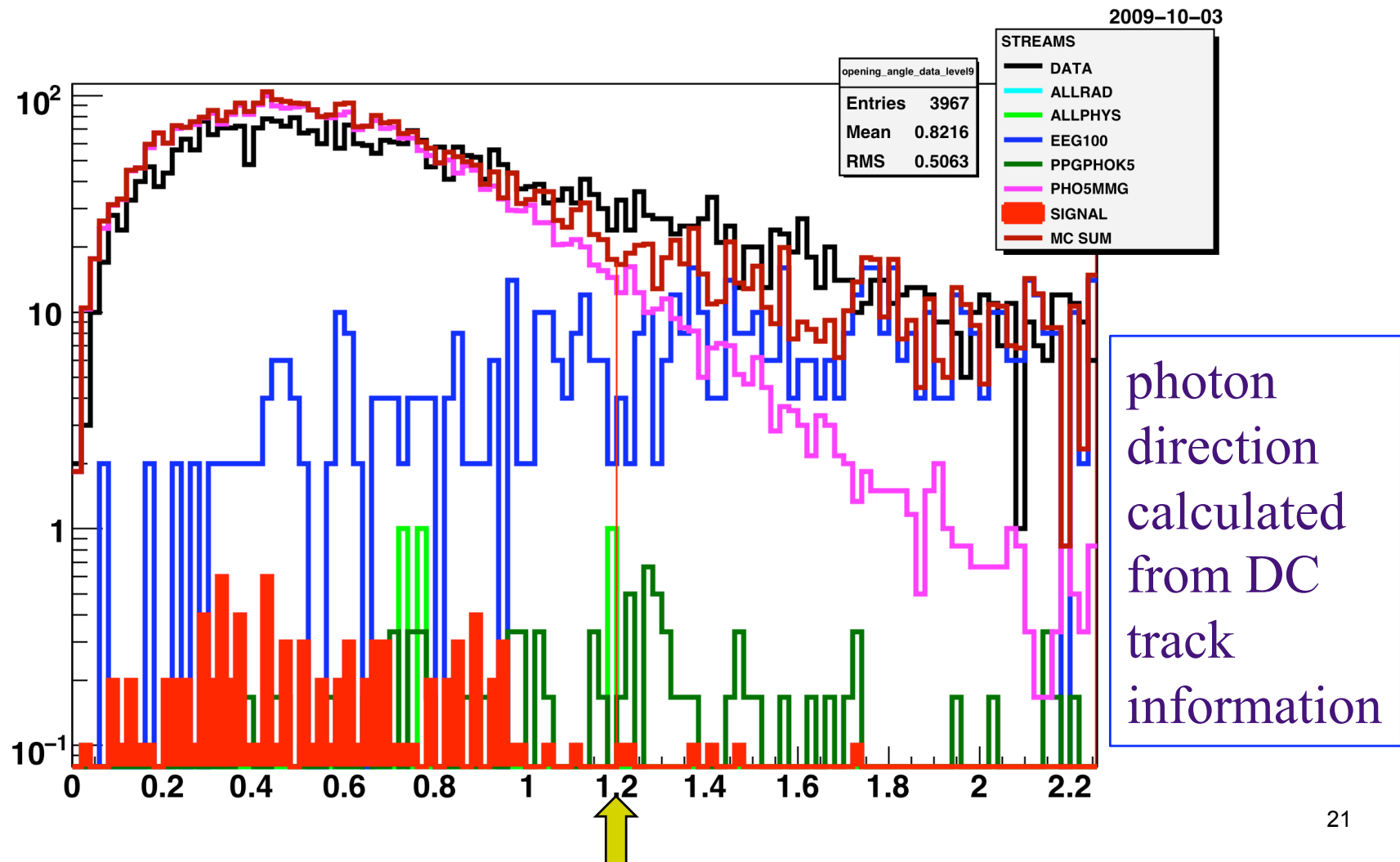


AFTER: cos_mumu_eta

runs: 30300-31000

CUT: opening_angle(cluster, photon)

($x < 1.2$ [°])



DATA 2004

inv_mass_mumu

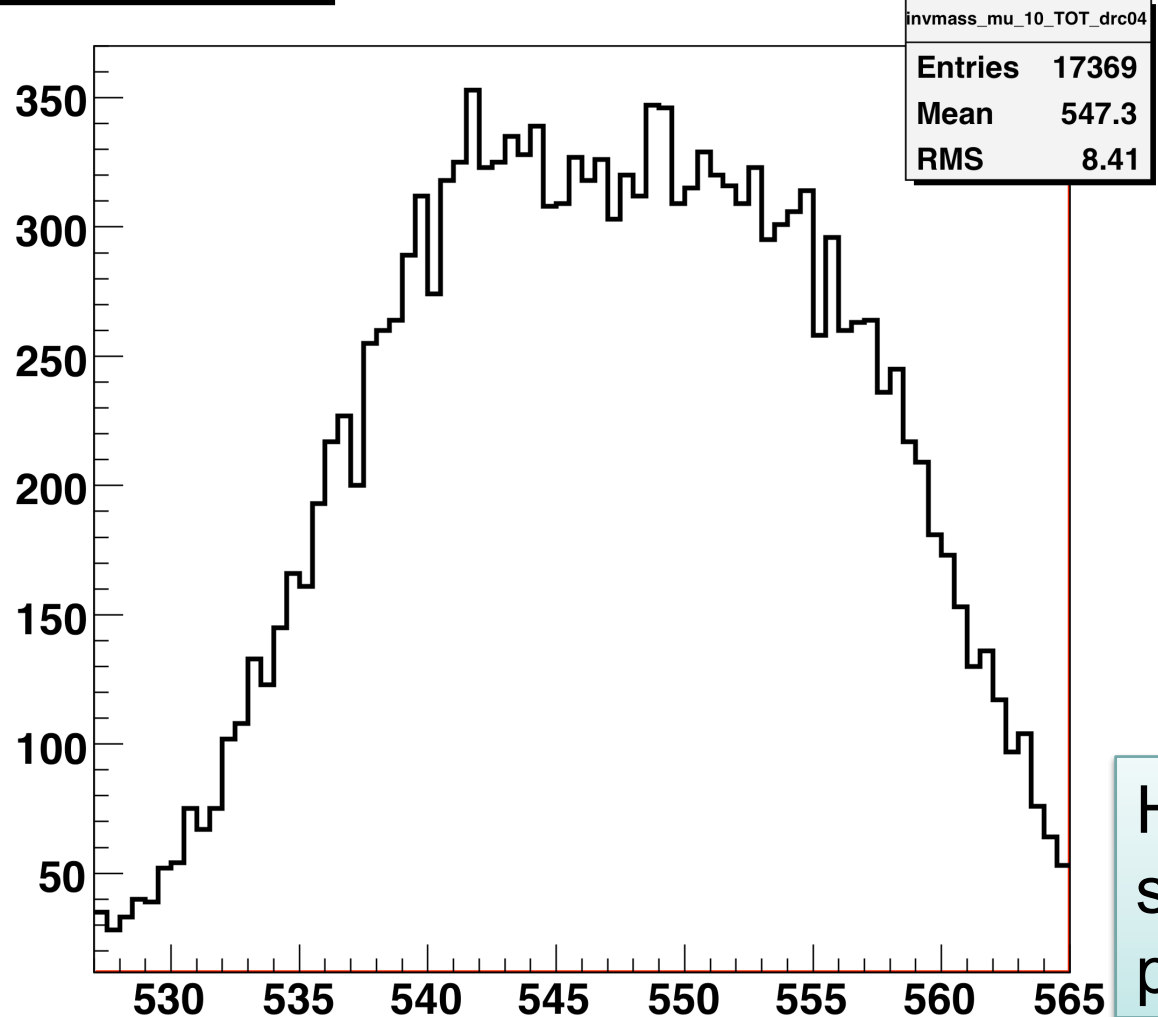
2004	BEFORE	AFTER
data	22'817	17'369
signal	60.8	58.3

invmass_mu

$\epsilon_{\text{signal}} = 95.8 \%$

2009-10-03

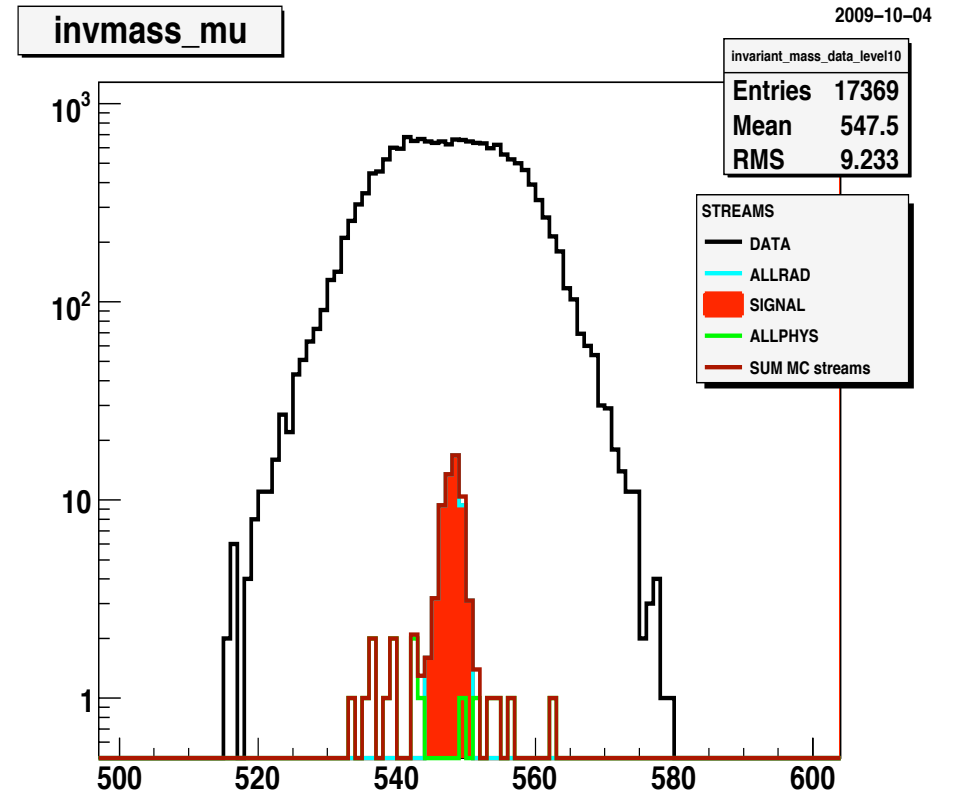
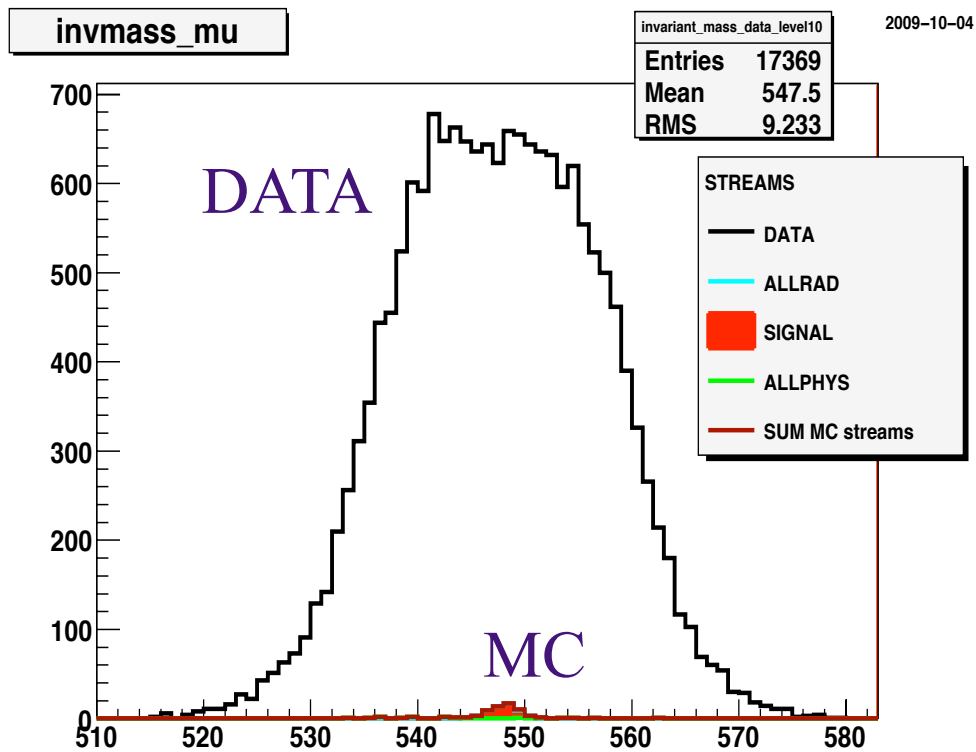
data reduced by 20%



Total signal selection efficiency 46.6%

How many events should be seen on this plot ?

At present only allrad, allphys, data for 2004 were produced, production for continuum is necessary



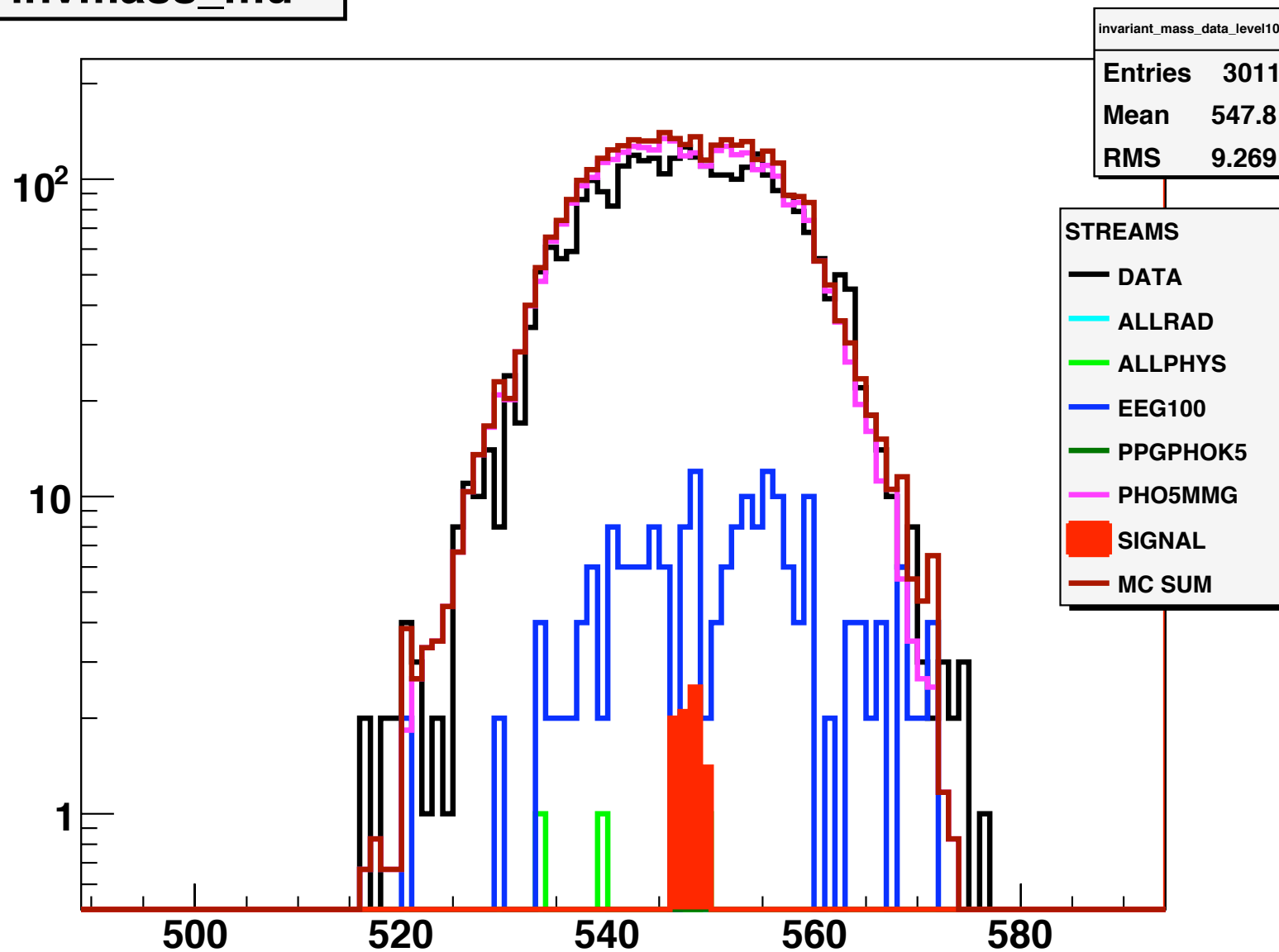
The rest events in data comes from continuum.

After all cuts

runs: 30300-31000

invmass_mu

2009-10-05





To be honest: What we are able to reject ?

runs: 30300-31000, after rescaling with LSF

AFTER	sign	allrad	allphys	data	eeg100	ppg	mmg
sele_tracks	13	23745.6	773437	4147054	1085548	1407759.3	130340.8
miss_mass2	11.4	91.6	9477	1064578	314660	5969.8	101742.6
Σp_tracks	11.4	13.6	2546	108075	44136	83.2	14598.8
cos_mumu_lab	9.9	11.4	2276	25145	14664	69.2	11343.2
nclu_intime_neu	9.5	10.1	497	16157	7058	63.2	10584.8
cos_eta_gamma	9.5	9.5	29	11902	2312	37.2	10396.2
cos_mumu_eta	9.5	9.5	4	3967	720	10.3	3467.5
opening_angle	8.9	8.9	3	3011	196	4.2	3266.2²⁵

SUMMARY 1

1. we weren't able to reject events from the continuum (the worst events == $\mu\mu\Upsilon$)
2. efficiency for the signal after whole selection: 46.6%

now:

S/B $\approx 9/3300 \approx 1/360$

Situation isn't easy



SUMMARY 2

1. great reduction of background from phi decays
2. we hope code without bugs (especially I hope)

FUTURE:

- a) production continuum for whole 2004
- b) try another cuts , change ordering
- b) kinematic fit ?
- c) TOF ?