Status report on $\eta \longrightarrow \pi^-\pi^+\gamma$

PRE-SELECTION STUDIES

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Phi decays working group meeting, 29 Sep 2008

Motivation

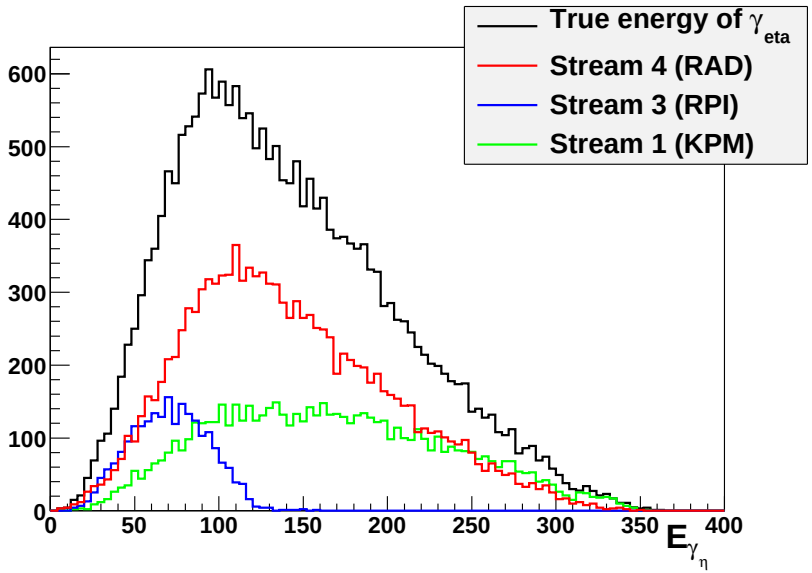
- BR, background to $\eta \to e^+e^-\gamma$, $\eta \to \mu^+\mu^-\gamma$
- Study of theoretical models
  - *B.Borasoy and R.Nissler, hep-ph arXiv:0705.0954*
    Inconsistency in the old measurements of the γ spectrum
  - $\Gamma(\eta \to \pi^-\pi^+e^+e^-)/\Gamma(\eta \to \pi^-\pi^+\gamma)$ Theor. accuracy: 1-2%
  - Dalitz plot (anomalous (triangle box) vs resonant contribution (VDM))

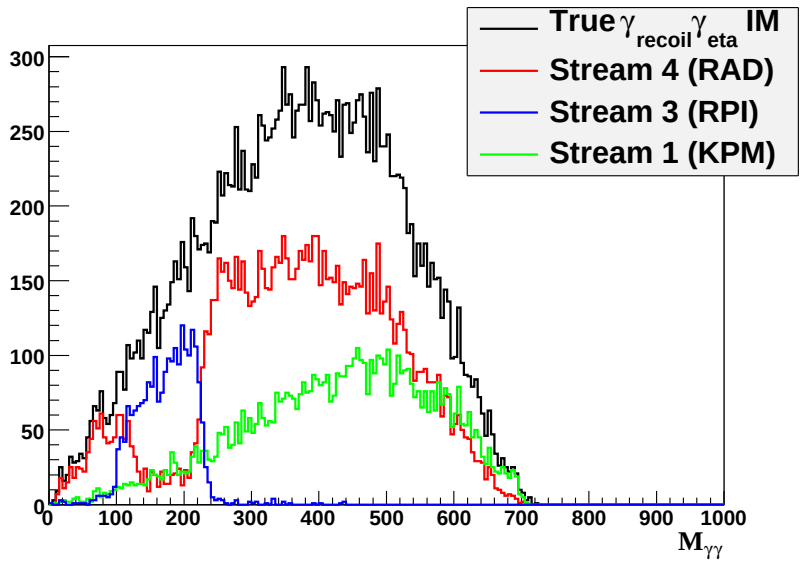
Signal / Background

Reaction:	X-section $\sigma[\mu b]$
$\phi \to \eta\gamma,\ \eta \to \pi^-\pi^+\gamma$	2.04×10^{-3}
$\phi \to \eta\gamma,\ \eta \to \pi^-\pi^+\pi^0$	9.87×10^{-3}
$\phi \to \eta\gamma,\ \eta \to e^+e^-\gamma$	0.30×10^{-3}
$\phi \to \pi^+\pi^-\pi^0$	0.46
$e^+e^- \to \omega\pi^0$	0.14×10^{-3}

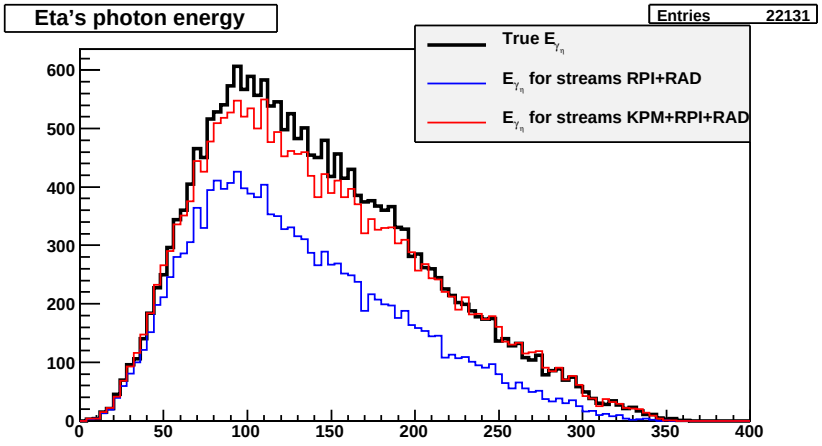
- Charged η decays (most frequent):
  $\eta \to \pi^-\pi^+\pi^0 \quad (22.73 \pm 0.28) \times 10^{-2}$
  $\eta \to \pi^-\pi^+\gamma \quad (4.60 \pm 0.16) \times 10^{-2}$
  $\eta \to e^+e^-\gamma \quad (6.8 \pm 0.8) \times 10^{-3}$
  $\eta \to \mu^+\mu^-\gamma \quad (3.1 \pm 0.4) \times 10^{-4}$

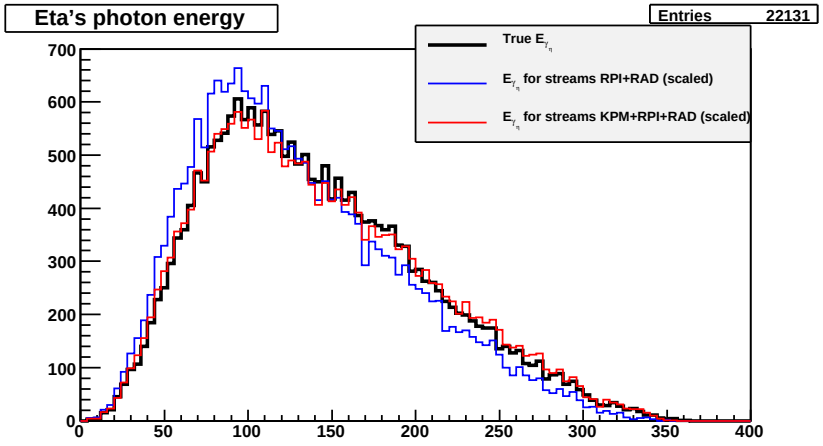
Photons' spectra 1

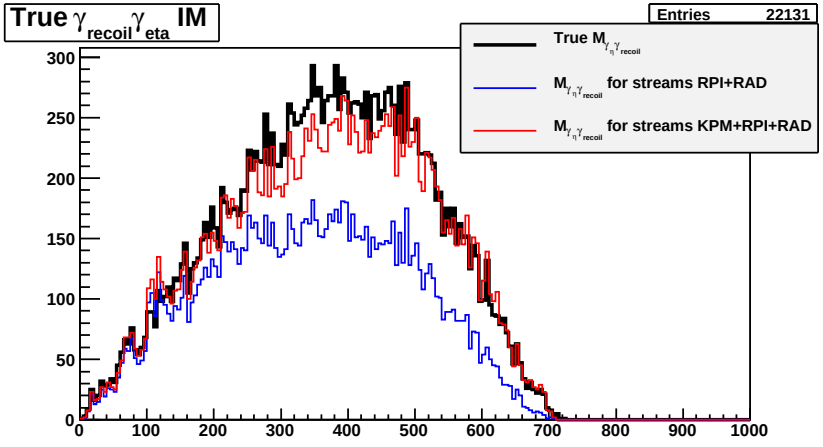


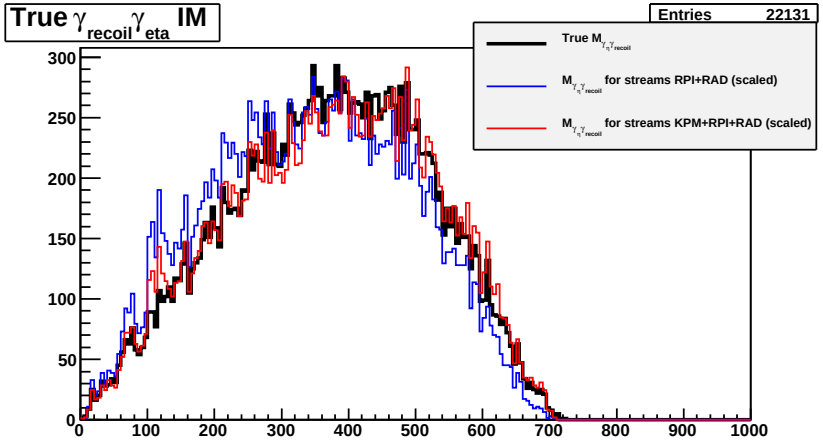


Photons' spectra 2

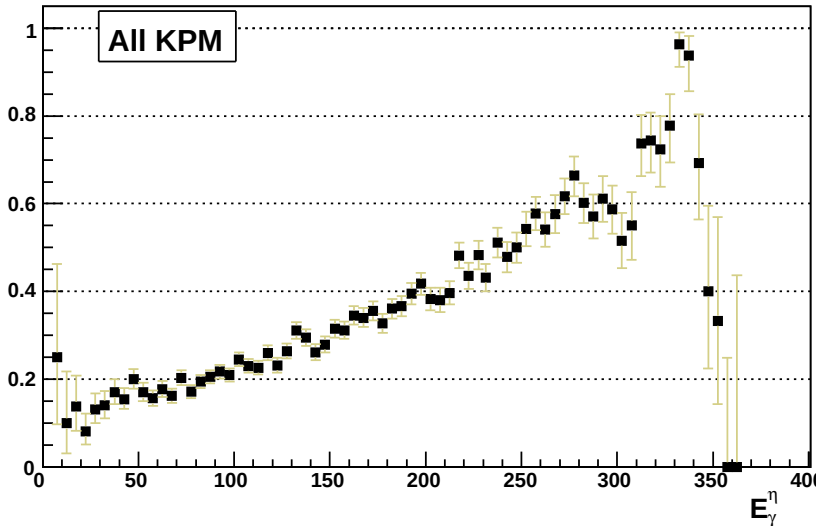


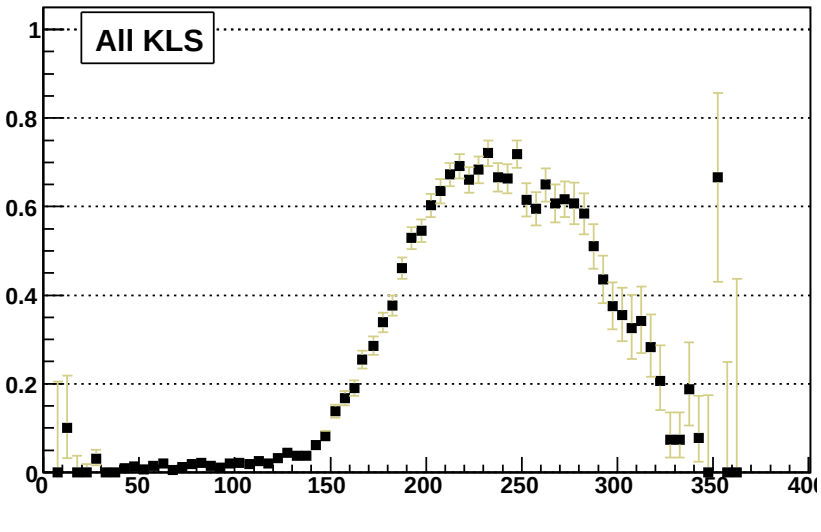


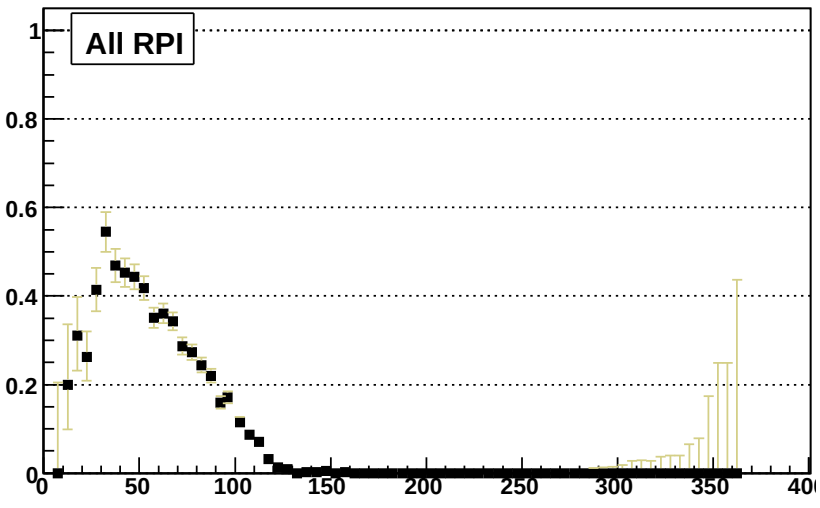


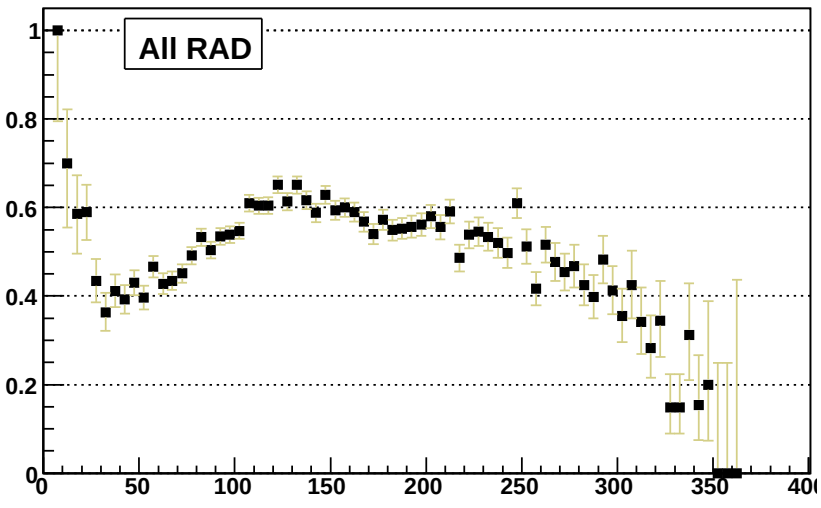


Efficiencies 1









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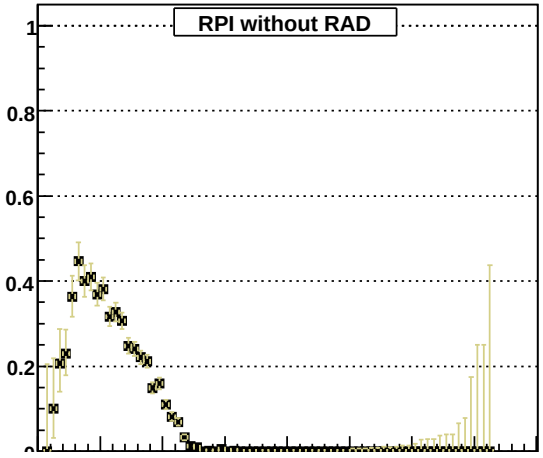
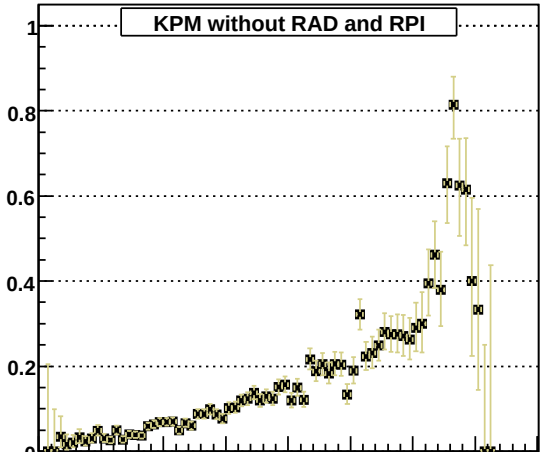
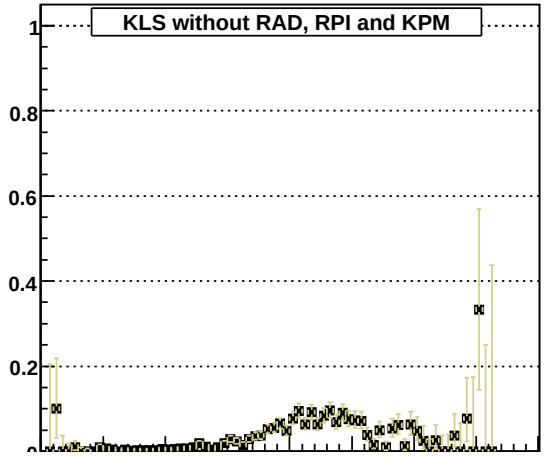
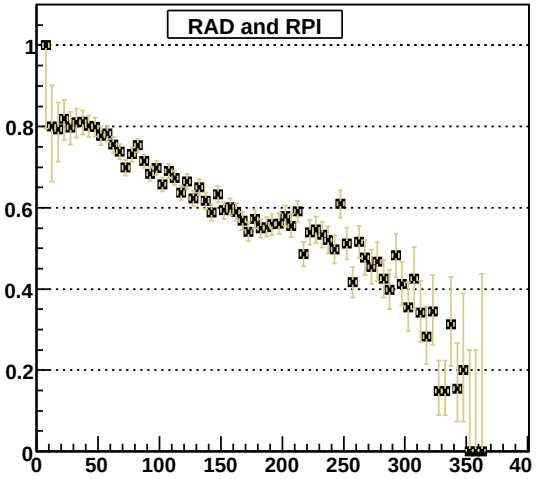
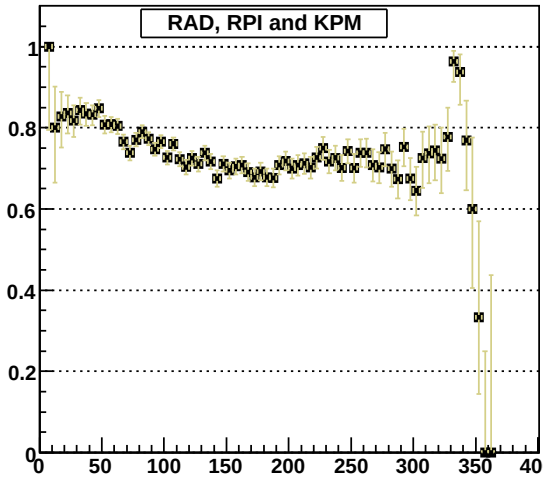
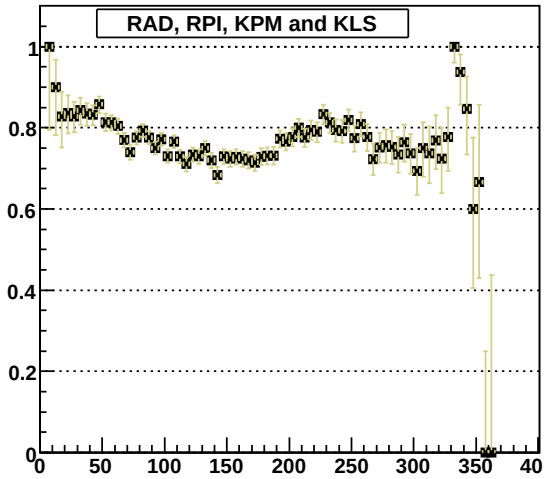




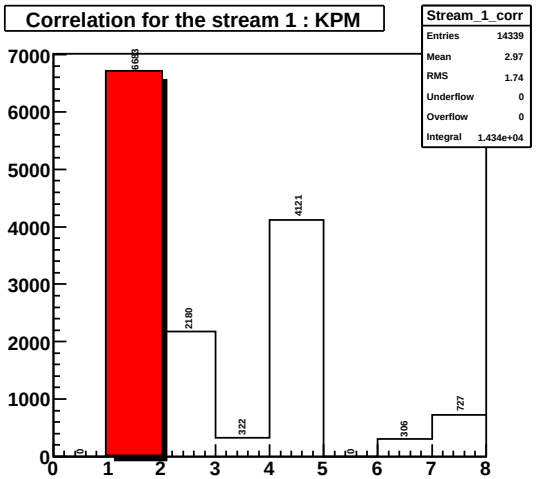


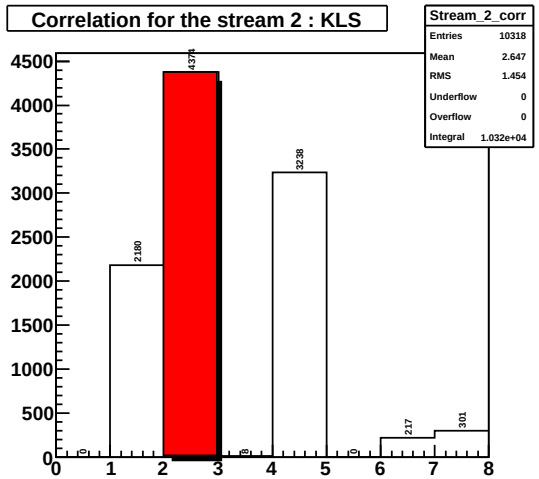


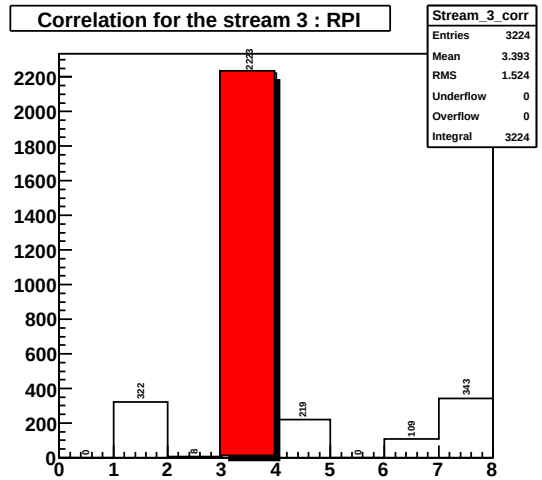


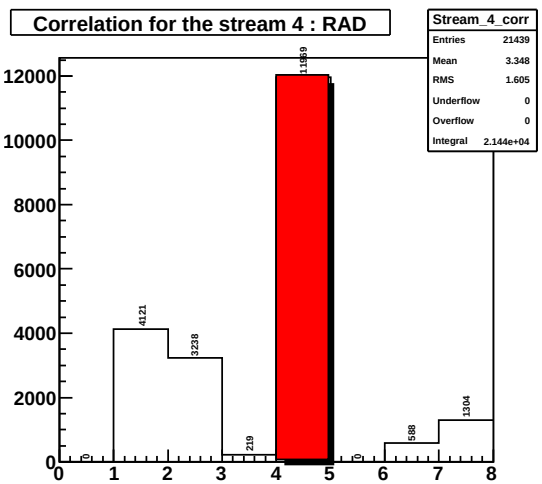


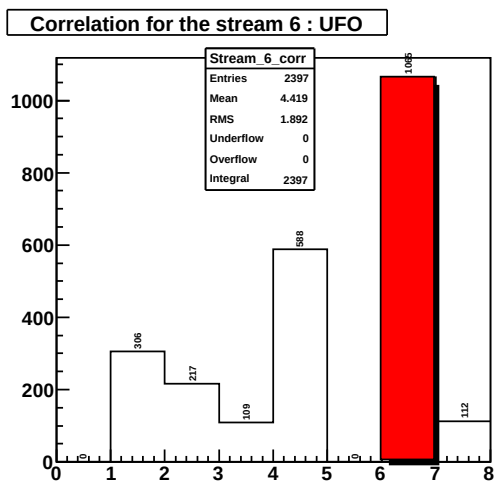
Stream correlation for MC charged rad. stream (65)

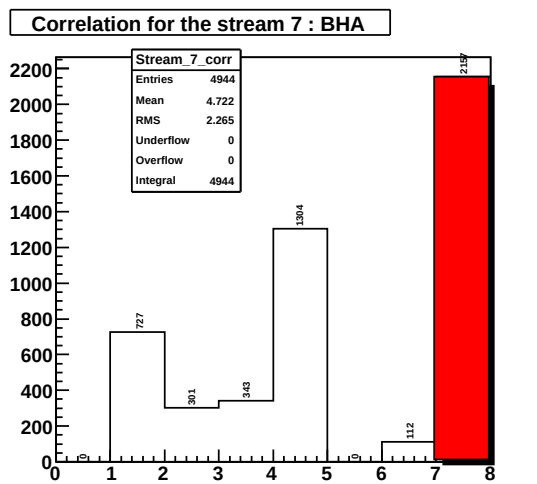








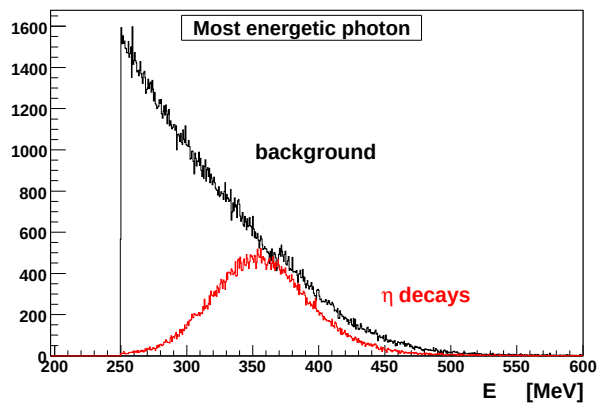




Preselection 1

- $\phi \longrightarrow \eta\gamma \qquad \longrightarrow$
- no kinematical fit (instead find constraints that pick out all signals)
- MC 2005 (all phys), runs: 34410 $\div$ 34499, $\mathbf{L}_{int}$ = 12.7 pb^{-1}
- Running: *RAD*, *RPI* & $\overline{RAD}$, *KPM* & $\overline{RAD}$ & $\overline{RPI}$
- $\geq$ 2 prompt photons $|t_{cl}\text{-}l_{cl}/c| < 5\sigma_t$
- most energetic photon with $E_\gamma \geq$ 250 MeV assumed 'recoil'
- $\geq$ 1 vertex with two tracks and balanced charge, selecting closest to the IP

- $\eta \longrightarrow \pi^-\pi^+\gamma$ *signal*
- $\eta \longrightarrow \pi^-\pi^+\pi^0$ *normalization*
- $\eta \longrightarrow e^+e^-\gamma$ *for later*



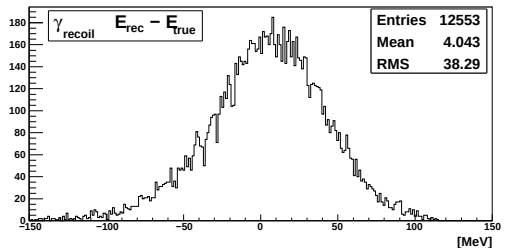
Preselection 2

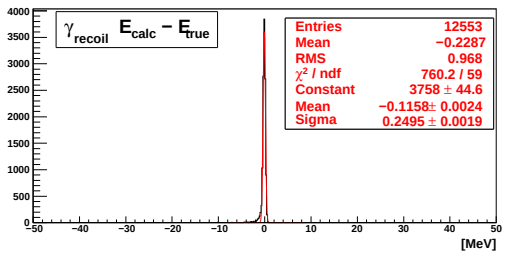
Calculation of $E_{\gamma recoil}$

- Good angular but bad energy resolution for photons
- Help with 2-body kinematics of $\phi \rightarrow \eta\gamma$

$$\vec{p}_\eta = \vec{p}_\Phi - \vec{p}_\gamma$$

$$E_\gamma = \frac{m_\Phi^2 - m_\eta^2}{2 \cdot (E_\Phi - \mid \vec{p}_\Phi \mid \cdot \cos\theta)}$$





where $\cos\theta$ is an angle between Φ and γ^{recoil}

Preselection 3

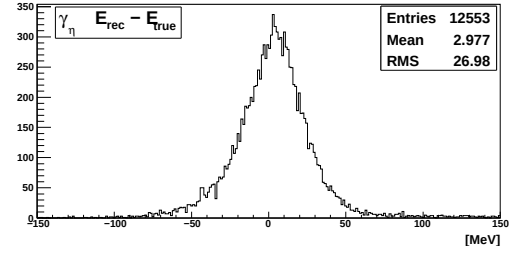
Calculation of $E_{\gamma\eta}$

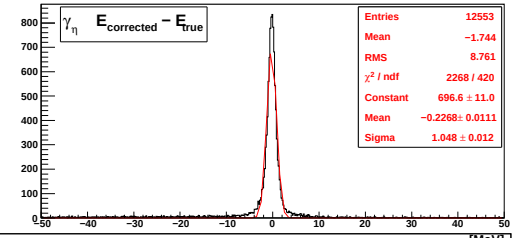
Having corrected the energy of the recoil photon we can calculate

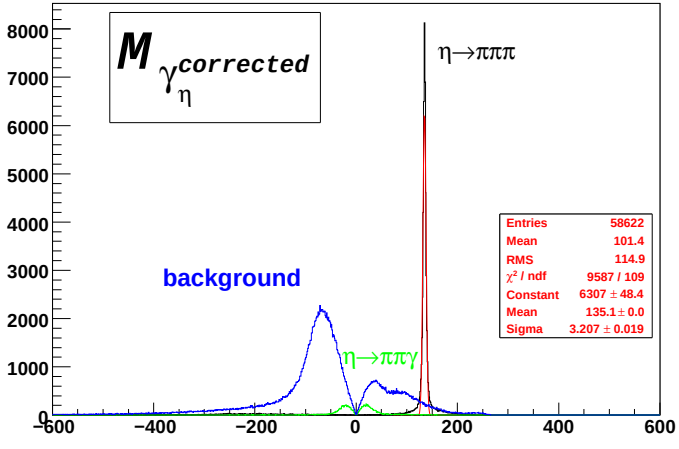
$$\mathbb{P}^{calc}_{\gamma\eta} = \mathbb{P}_{\Phi} - \mathbb{P}_{\pi^+} - \mathbb{P}_{\pi^-} - \mathbb{P}^{recoil}_{\gamma}$$

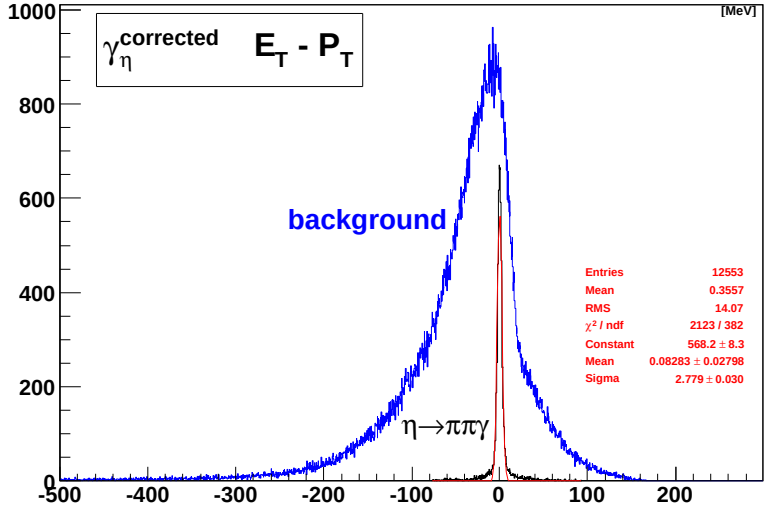
and look at the energy $E^{calc}_{\gamma\eta}$:

Possible constraints:





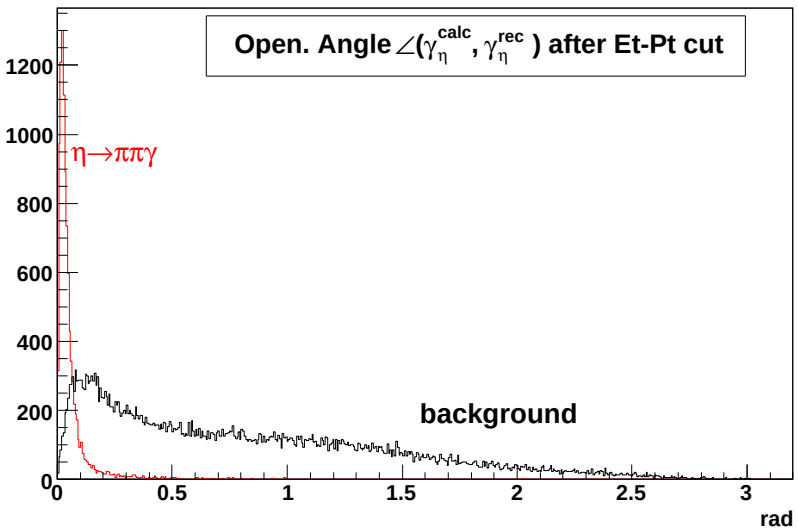




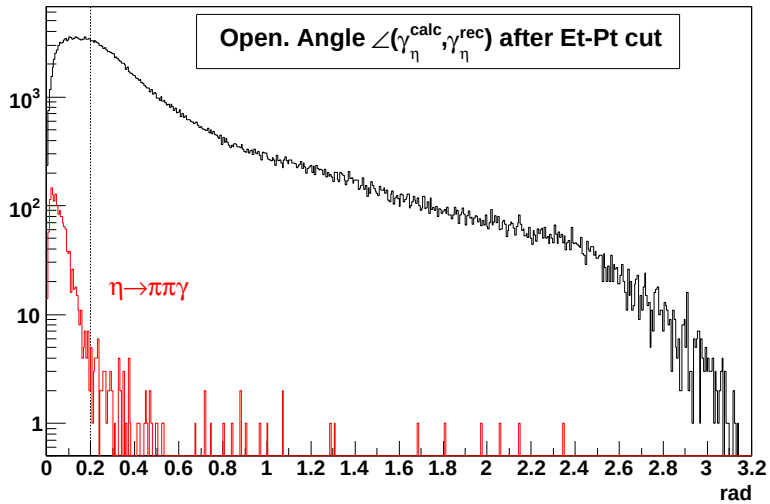
Preselection 4

- From candidates - neutral clusters, we select the closest to $\mathbb{P}^{calc}_{\gamma_\eta}$
- Opening angle to the calculated γ_η effectively rejects background

RAD STREAM



RPI STREAM

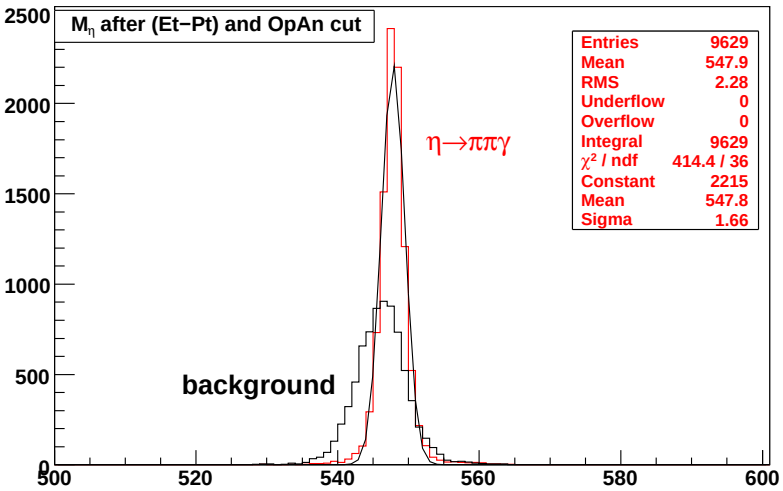


Result

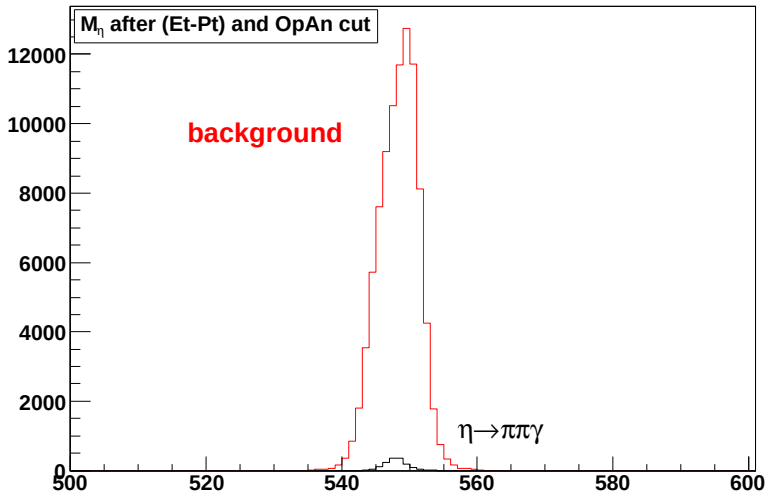
Invariant mass of η

- For the calculation of the $\mathbf{M}_{\eta}$ one can correct the photon energy using calculated value

RAD STREAM

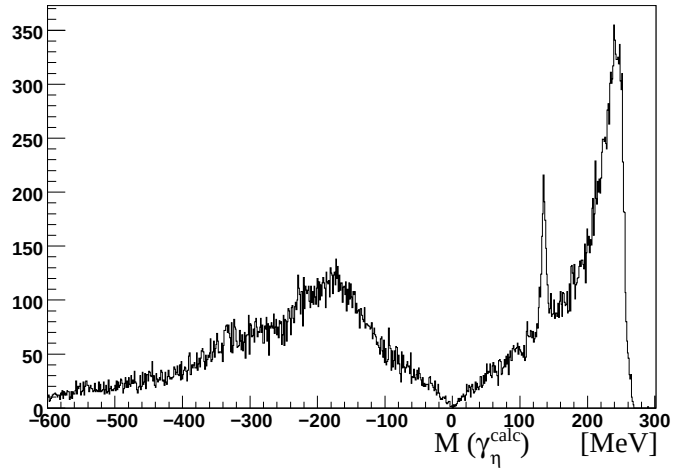


RPI STREAM

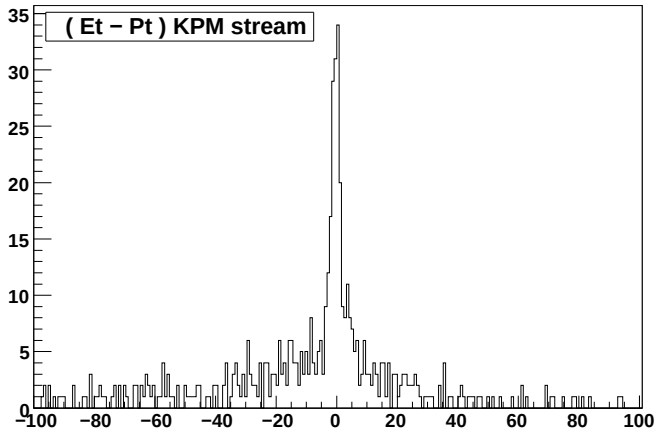


KPM stream

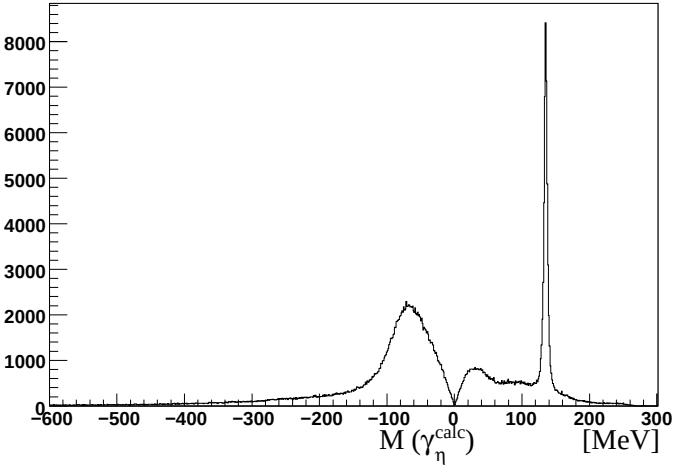
KPM



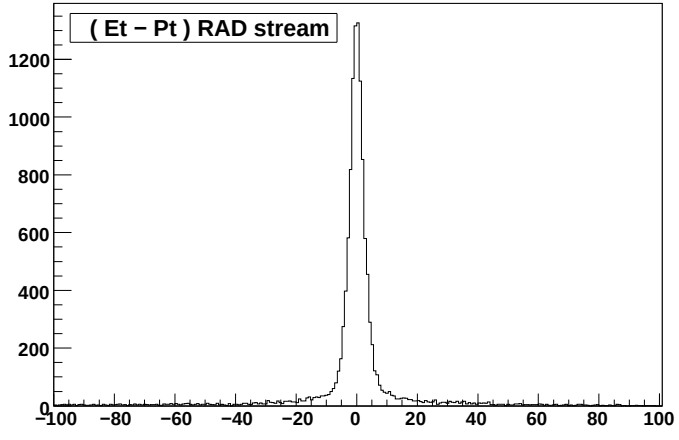
KPM



RAD



RAD



Statistics 1

	total on DST	pre-selection $\geq$ 2 prompt clusters	Event signature (tracks)
RAD	1194777	383475	
$\eta \to \pi^-\pi^+\gamma$	22131	17619 (80%)	12553 (57%)
$\eta \to \pi^-\pi^+\pi^0$	105791	90089 (85%)	58622 (55%)
$\eta \to e^+e^-\gamma$	839	684 (81%)	421 (50%)
background	1060351	273177 (26%)	230217 (22%)
RPI	3647348	1203355	
$\eta \to \pi^-\pi^+\gamma$	2032	1691 (83%)	1549 (76%)
$\eta \to \pi^-\pi^+\pi^0$	39	30 (77%)	20
$\eta \to e^+e^-\gamma$	17	14 (82%)	14
background		1201613 (33%)	1145623 (31%)
KPM	12370050	92491	
$\eta \to \pi^-\pi^+\gamma$	2221	1190 (54%)	588 (26%)
$\eta \to \pi^-\pi^+\pi^0$	13703	8133 (59%)	3879 (28%)
$\eta \to e^+e^-\gamma$	128	96 (75%)	68 (53%)
background		79690	43577

Per-cent values are calculated w.r. to the total number of the events for given stream (and NOT to the total value given by the BR)

Statistics 2

	M_γ (135±15 MeV)	Et-Pt (-10 MeV ÷ 10 MeV)	Opening Angle (0 ÷ 0.2 rad)
RAD			
$\eta \to \pi^-\pi^+\gamma$		10321 (47%)	9629 (43%)
$\eta \to \pi^-\pi^+\pi^0$	46181 (44%)		
background	5745 (0.5%)	40533 (4%)	7595 (0.7%)
RPI			
$\eta \to \pi^-\pi^+\gamma$		1439 (71%)	1359 (67%)
$\eta \to \pi^-\pi^+\pi^0$	—		
background	—	211304 (6%)	84089 (2%)
KPM			
$\eta \to \pi^-\pi^+\gamma$		259 (12%)	182 (8%)
$\eta \to \pi^-\pi^+\pi^0$	1225 (9%)		
background	1434	2683	61

Per-cent values are calculated w.r. to the total number of the events for given stream (and NOT to the total value given by the BR)

Track selection

- to use vertex bank or not? (at the pre-selection level)
  - in 20% of selected vertexes at least for one track pion hypothesis is wrong (muon)
  - lower efficiency
  - are the track parameters better? For pions, electrons ...
- if not more work is needed to investigate the alternatives

Conclusions

- plan was to analyze events from 3 streams: RAD, RPI, KPM, but is KPM worth the effort?
- worse track reconstruction in KPM and hence rejection of signal events (left with $>$ 1% of total BR)
- pre-selection criteria without kinematic fit
- good background reduction in RAD, KPM
- still flooded with background in RPI

TO DO:

- track selection
- add $\eta \rightarrow e^+e^-\gamma$ to pre-selection
- repeat analysis of Ilaria (RAD stream only)

Spares

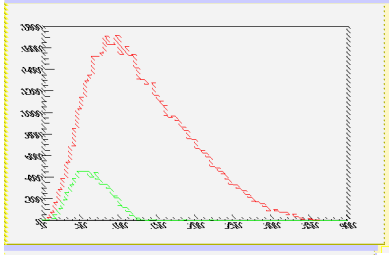
Introduction

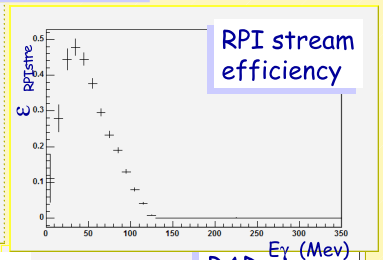
- Previous analysis in KLOE:

  Ilaria Villella (Uni. di Napoli) presented during Capri'03:

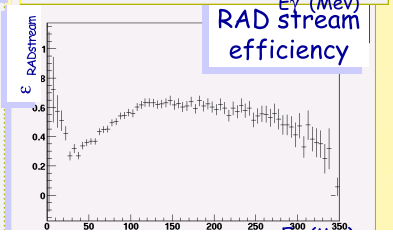
  - $\mathbf{L}_{int}$ = 29 pb^{-1}, selected 18508 events
  - Could not use single streaming algorithm because all of them cut into kinematical distributions
  - Planned analysis on 100 pb^{-1} (?)

γ η spectrum





Eγ (Mev)

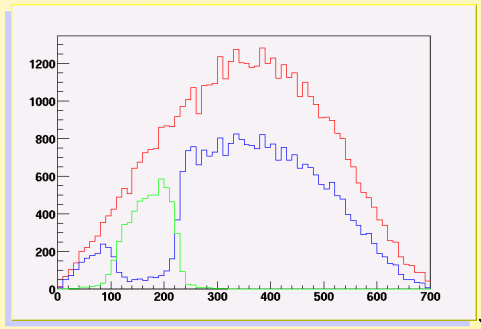


Invariant mass of two photons

— MC true

— MC true
RAD Stream

— MC true
RPI Stream



Mγ γ (MeV)

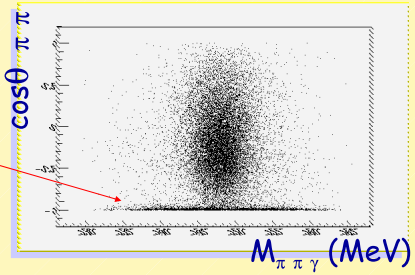
Branching Ratio Accuracy

We select N=18508 events ⇒our BR 3% below PDG'02 value

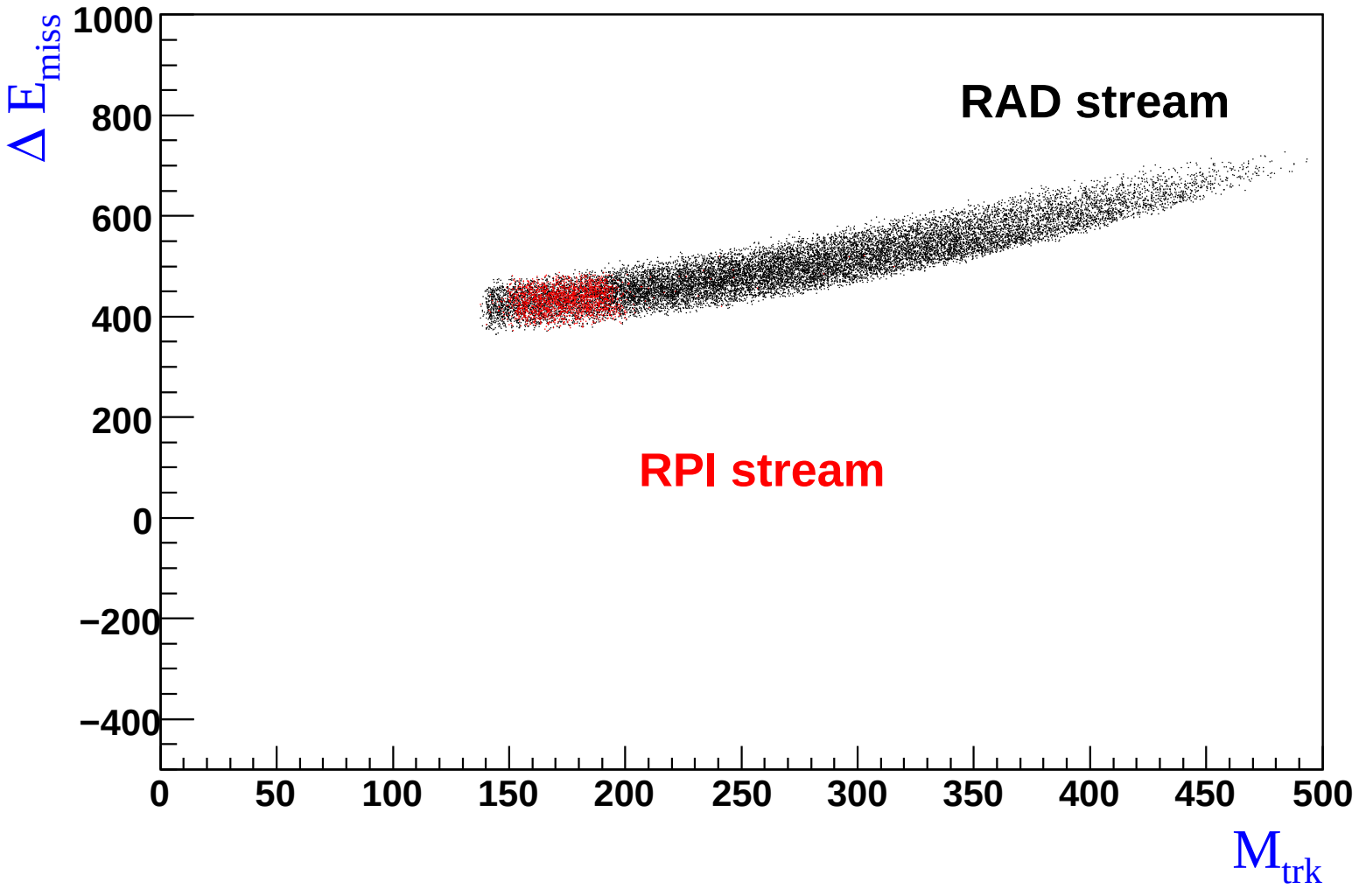
preliminary

$\Rightarrow \sigma_{BR}/BR = 7 \times 10^{-3}$

There is still background



Shark plot


ΔE_{miss}
1000
800
600
400
200
0
−200
−400
0
50
100
150
200
250
300
350
400
450
500
M_{trk}
RAD stream
RPI stream