

***Status report on the
 $\eta \rightarrow e^+ e^- e^+ e^-$ analysis***

Blessing fit to data and number of events for CIPANP

BR: theory & experiment

CMD-2

$< 6.9 \times 10^{-5}$

Theoretical predictions

$(2.52 - 2.64) \times 10^{-5}$

In $\eta \rightarrow \pi\pi e e$ analysis we have observed 1555 events,
assuming as lower bound the same efficiency,

we expect at least 155.5 events

Data sample

Using drc/mrc streams
with ETA4C tag

1733 pb⁻¹ data 2004/05

167531 pb⁻¹ MC signal only

3447 pb⁻¹ MC all_phys(2/3) 2004/05

1751 pb⁻¹ MC allrad 2004/05

242 pb⁻¹ data offpeak ($\sqrt{s} = 1000$ MeV)

MC signal accounts for FSR and run by run conditions

Event selection

EVCL algorithm ETA4CTAG:

- ≥ 4 tracks from the Interaction Point
- 1 high energy neutral cluster ($E_{cl} \geq 250$ MeV)
- 0 medium energy neutral cluster ($50 \leq E_{cl} \leq 250$ MeV)

Track selection

Tracks are required to come from a cylinder around the IP:

$$R \leq 4 \text{ cm}$$

$$h/2 = 10 \text{ cm}$$

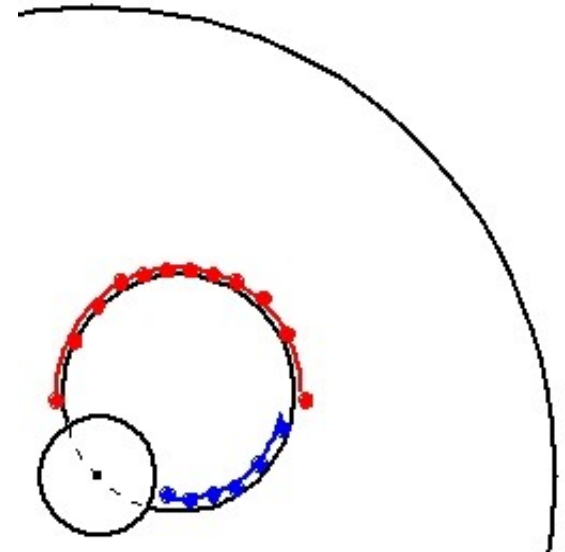
Check on broken tracks is applied:

$$\Delta P_T < 4.5 \text{ MeV}$$

$$\Delta P_Z < 3 \text{ MeV}$$

≥ 2 positive and ≥ 2 negative tracks are requested

Tracks are ordered by momentum



Kinematic fit

A kinematic fit to the ϕ meson is performed for all the events having # good tracks ≥ 4

The 22 inputs are:

- 4 tracks x 3 momenta
- x,y,z,E,t of the neutral cluster
- x,y,z of the IP
- \sqrt{s} and f momentum

The 5 constraints are:

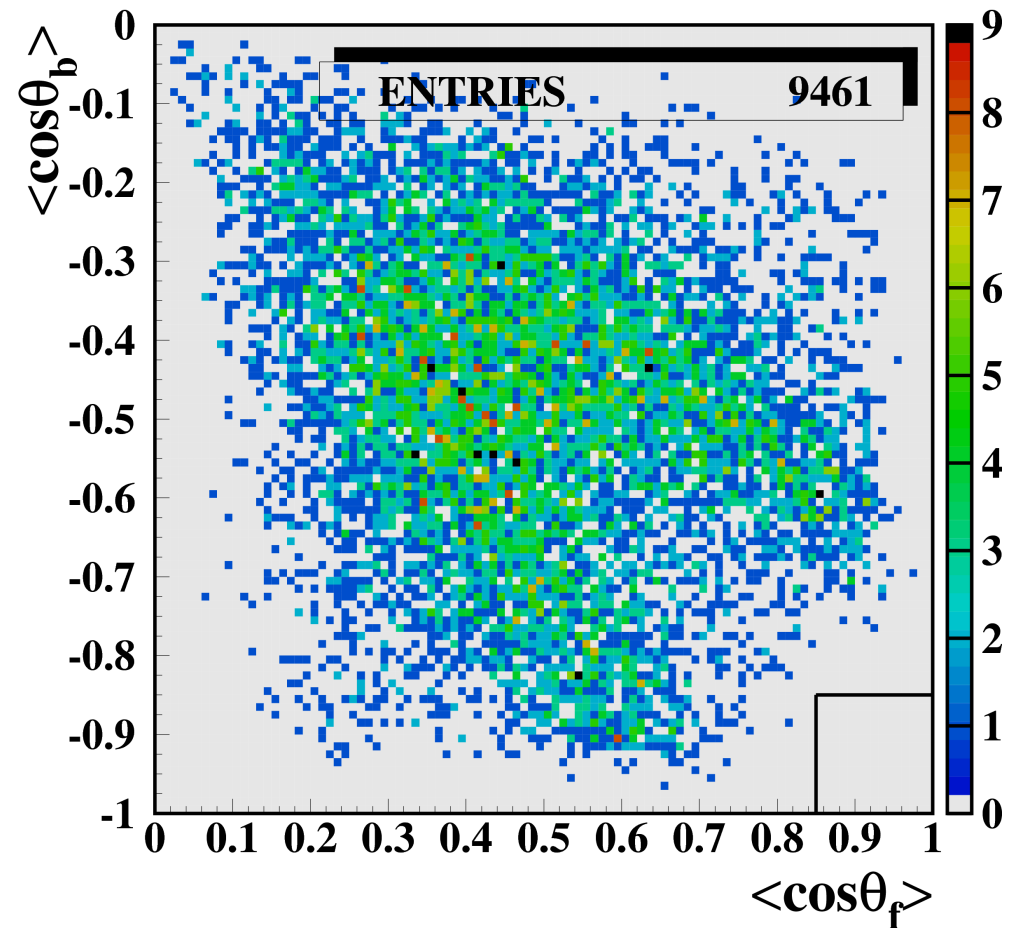
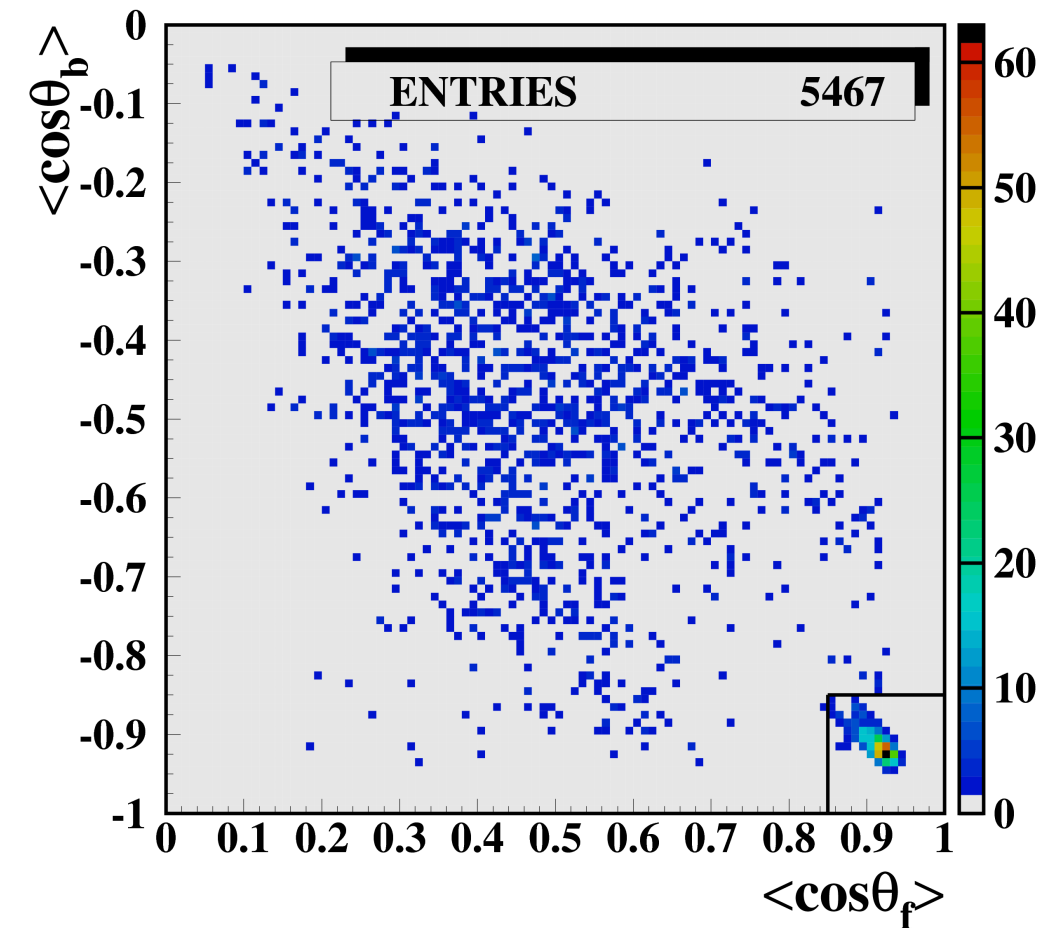
- Four momentum conservation
- Photon time of flight ($cT_{\gamma} = R_{\gamma}$)

Background rejection - step 1

$\langle \cos\theta_f \rangle < 0.85$.and. $\langle \cos\theta_b \rangle > -0.85$

Data

MC all_phys



Background rejection - step 2

$$600 \text{ MeV} < \sum_{i=1}^4 |\vec{p}_i| = s4p < 700 \text{ MeV}$$

Data

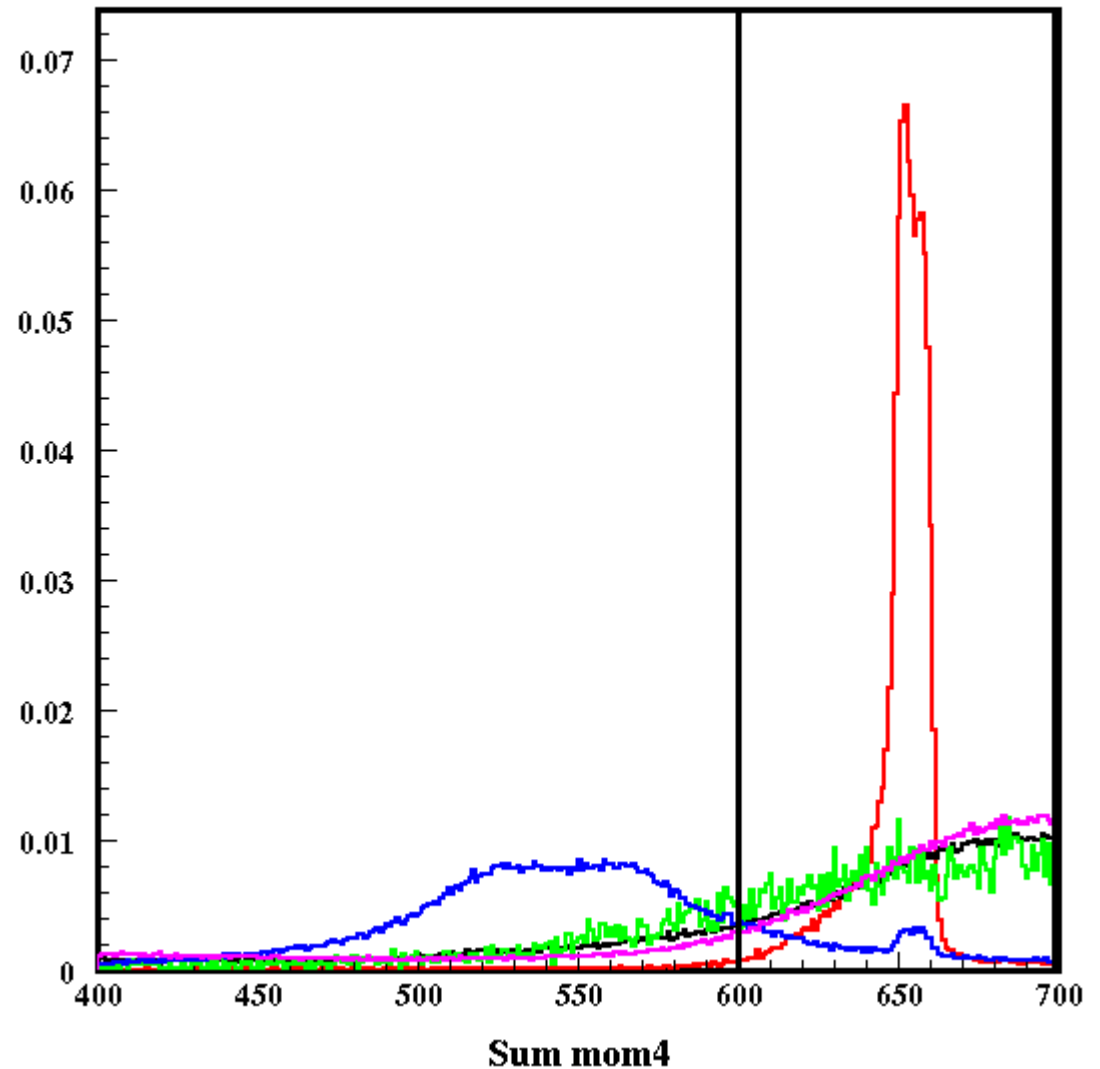
Continuum

allrad

Signal $\eta \rightarrow e^+e^- e^+e^-$

all_phys (kaons + 3pions)

Histograms not
scaled for luminosity



Background rejection - step 3

$$\chi^2_{KF} < 10000$$

Data

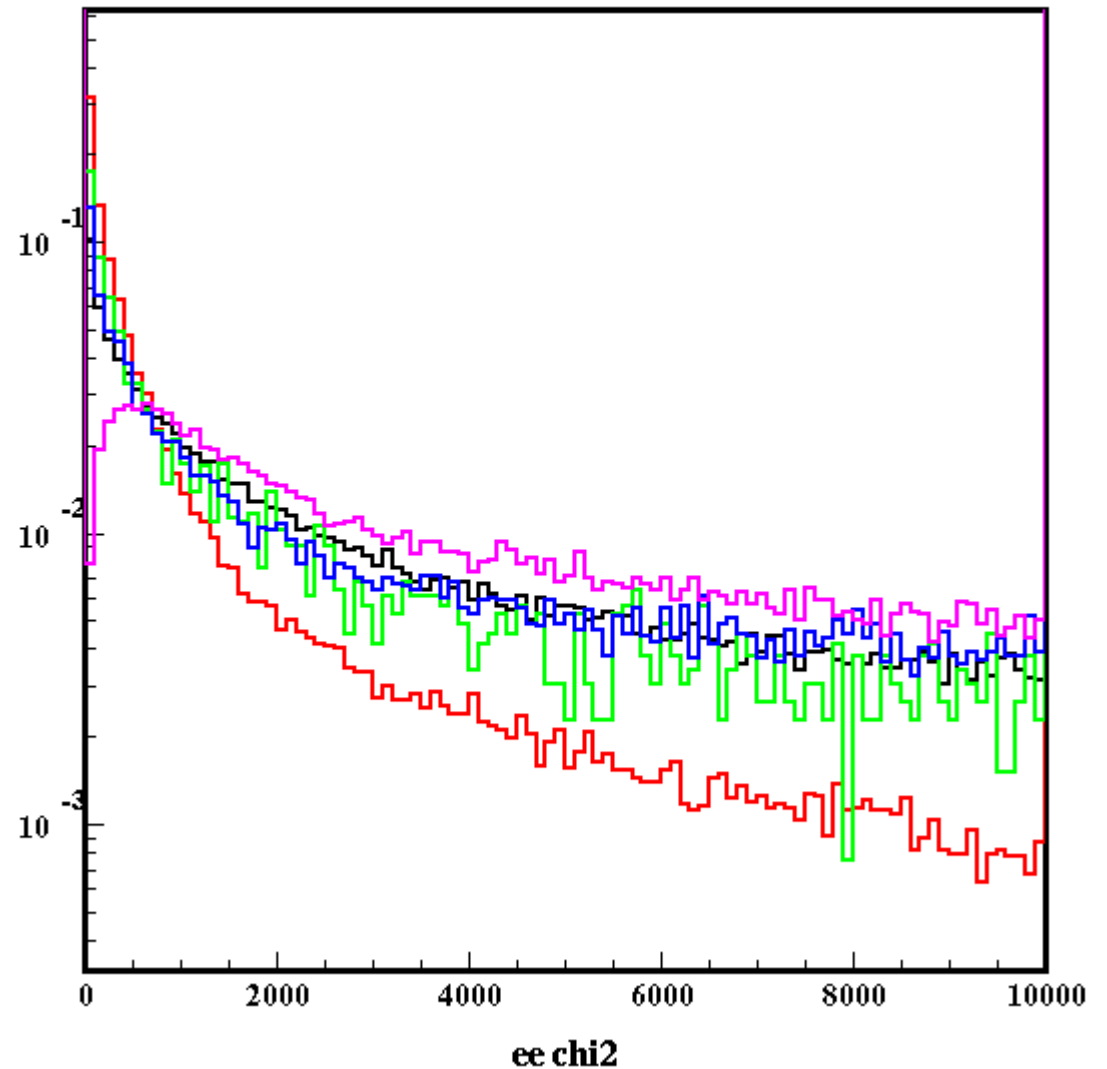
Continuum

allrad

Signal $\eta \rightarrow e^+e^- e^+e^-$

all_phys (kaons + 3pions)

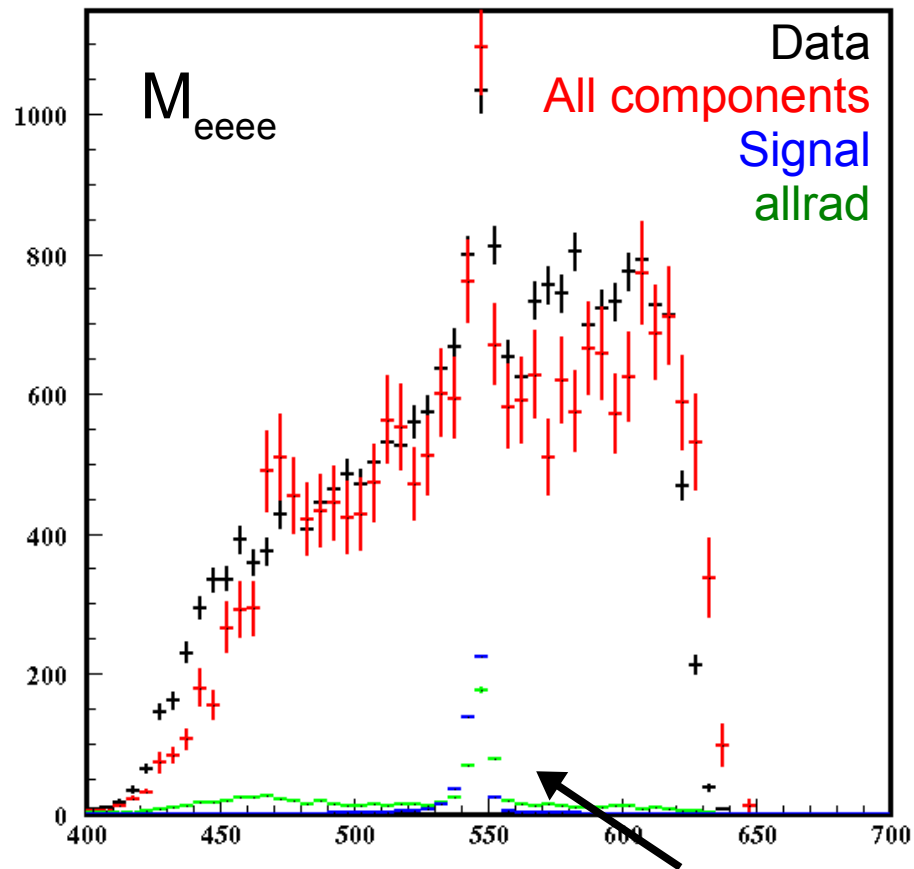
Histograms not
scaled for luminosity



Background from η decays

Fixing all_phys and allrad with the luminosity

Fitting with offpeak and signal MC between 470 and 620 MeV

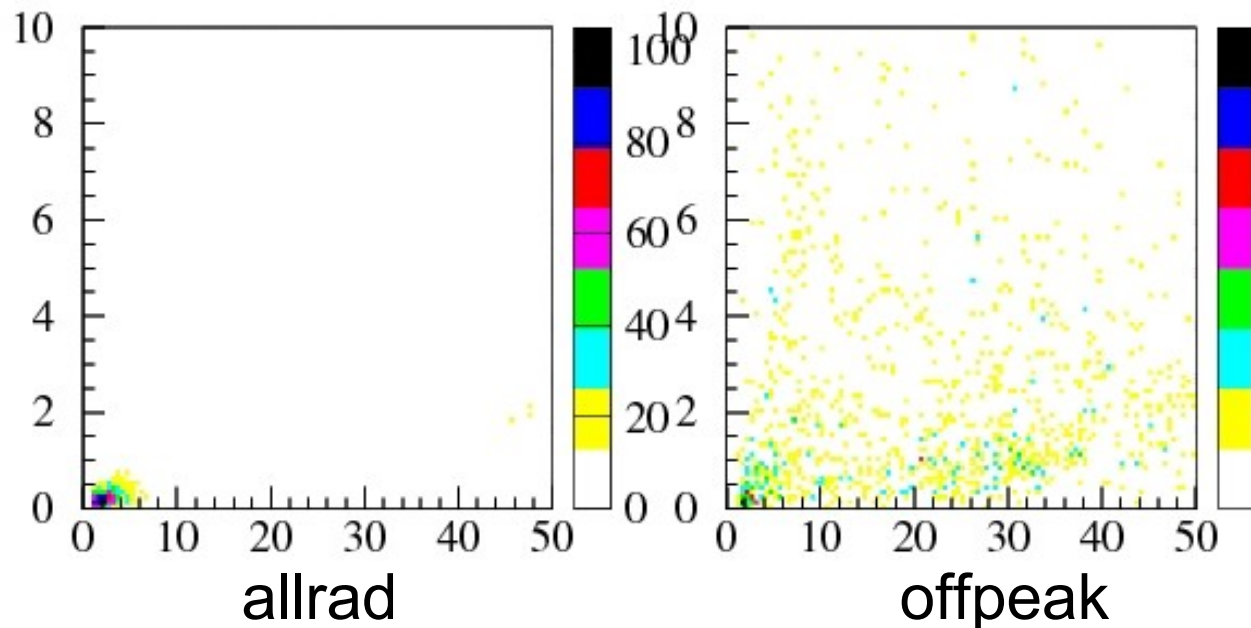
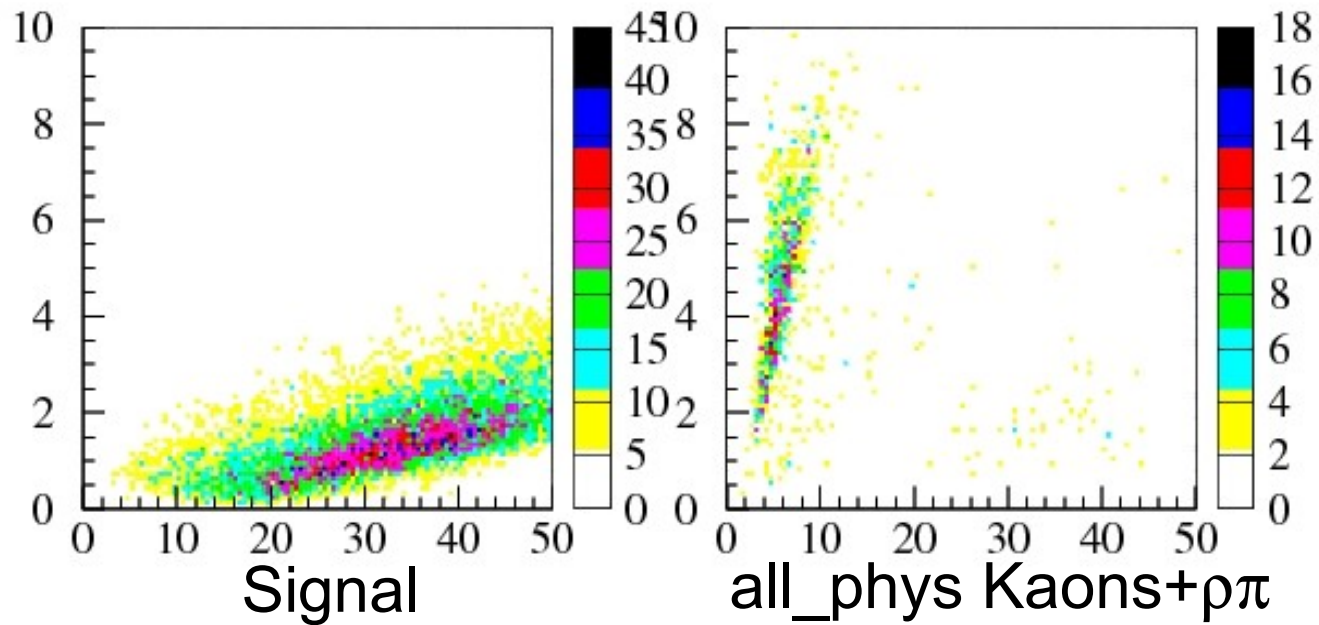


Mainly due to:

- $\eta \rightarrow e e \gamma$ with photon conversion
- $\eta \rightarrow \gamma \gamma$ with double photon conversion

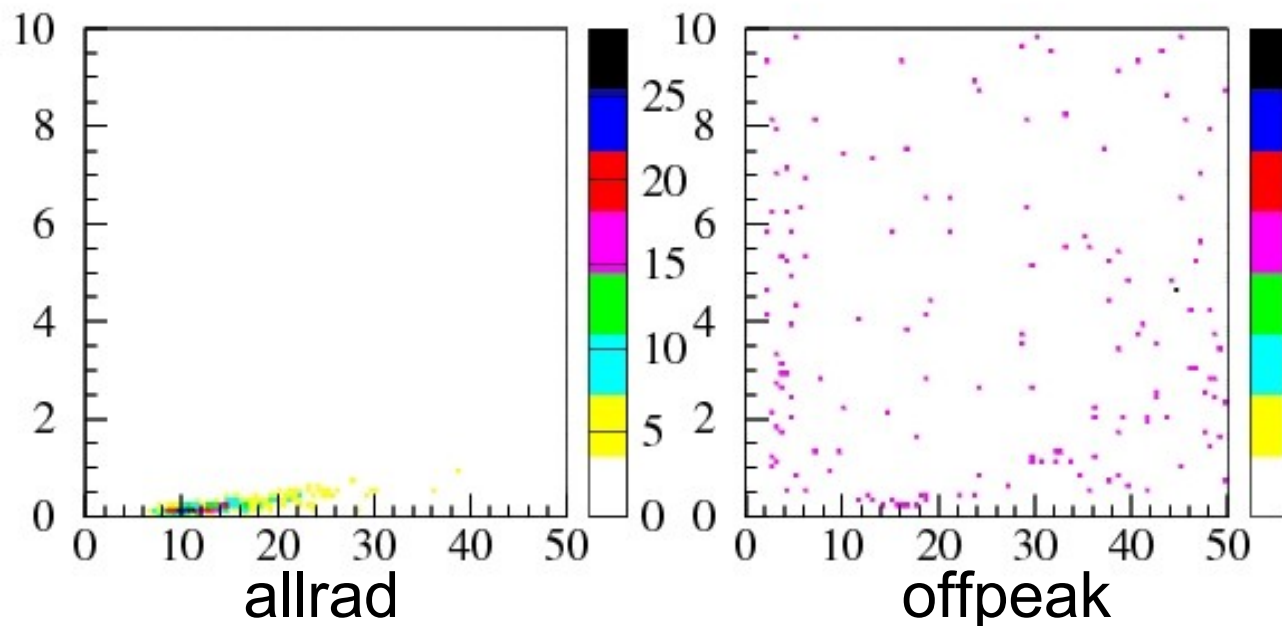
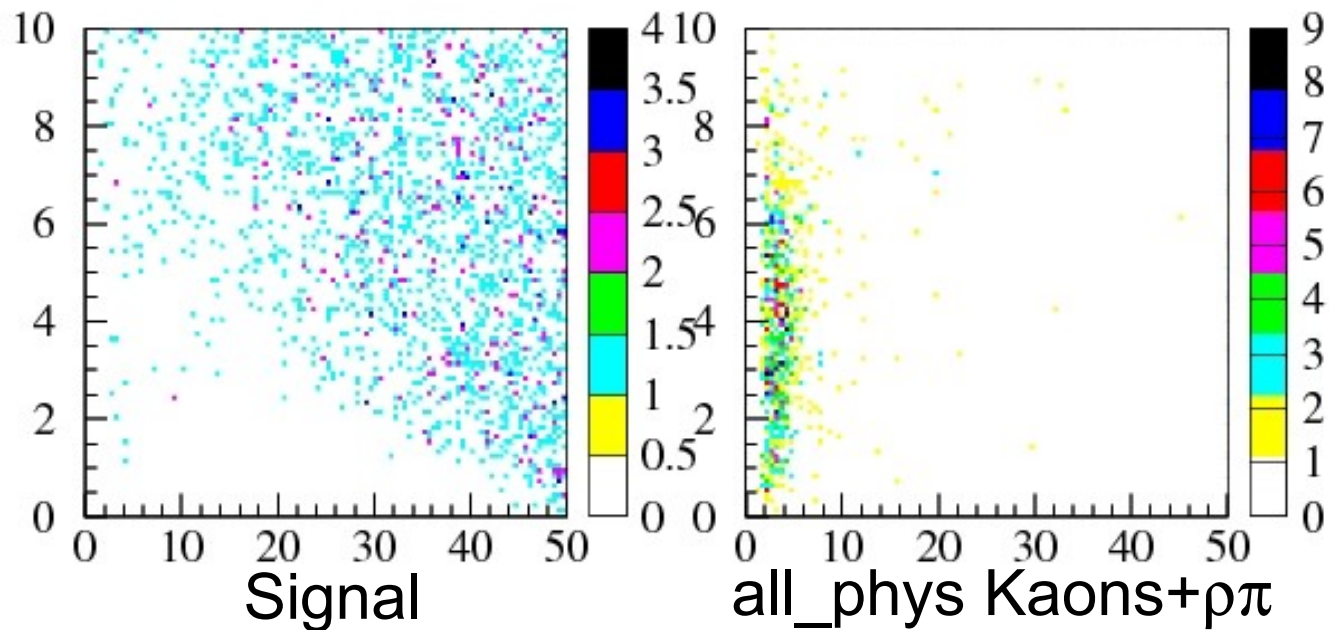
~1:1 Signal:Background from other eta decays

Cut on γ conversion on BP



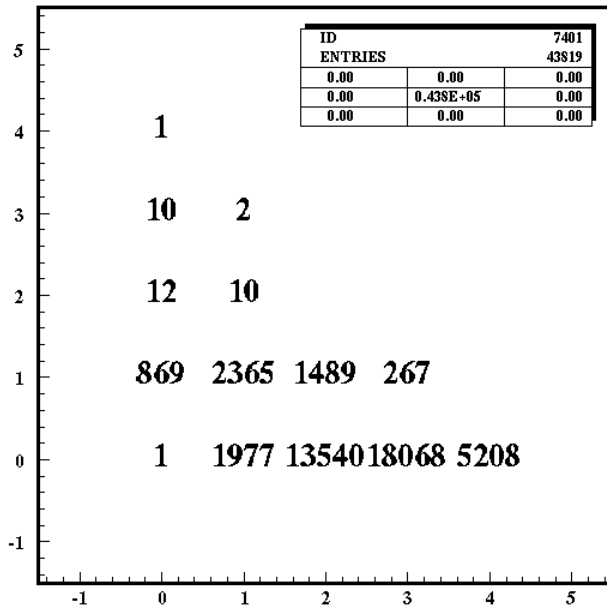
Dee@BP > 2 cm
.or.
Mee@BP > 10 MeV

Cut on γ conversion on DCW

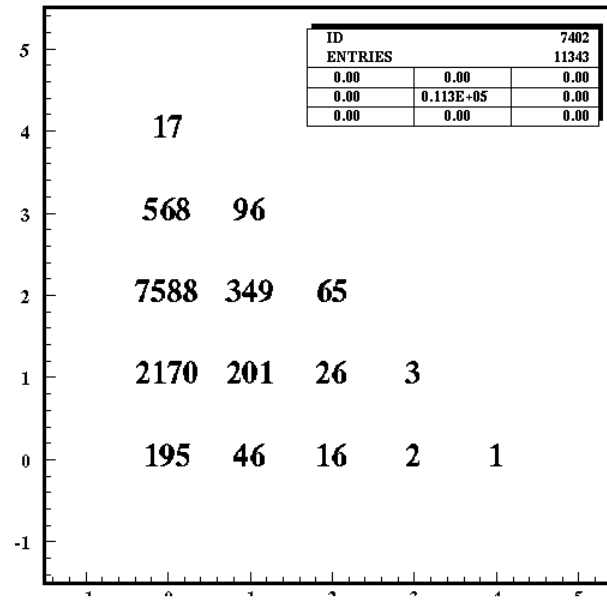


Dee@DCW > 2 cm
.or.
Mee@DCW > 30 MeV

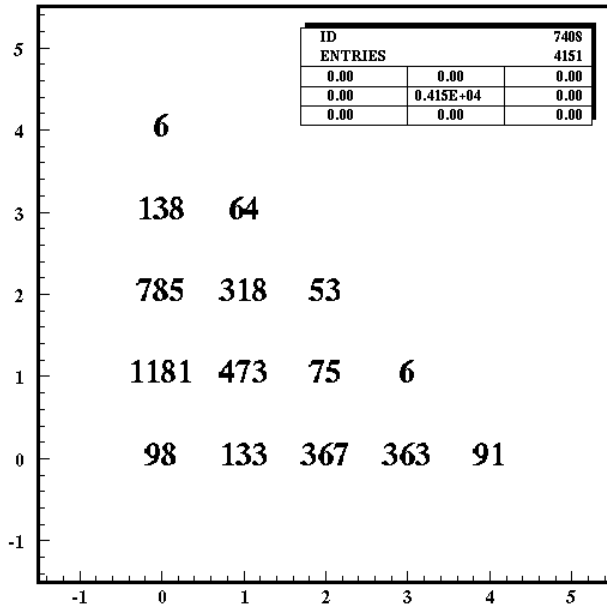
Cut on Time of Flight



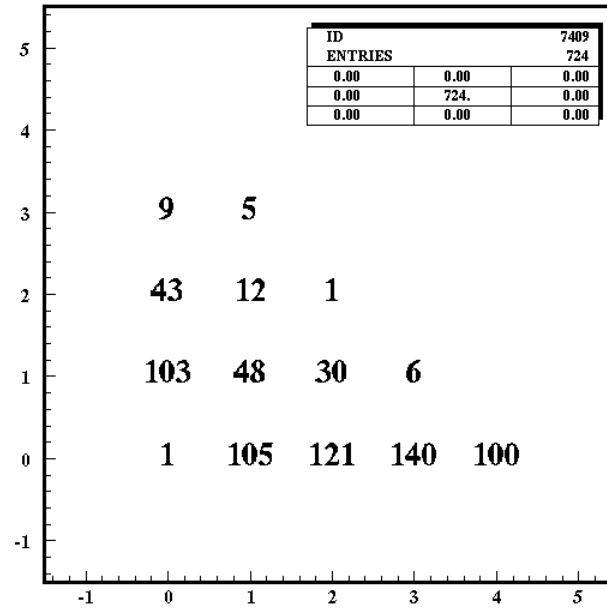
Signal



all_phys Kaons+ $\rho\pi$



allrad

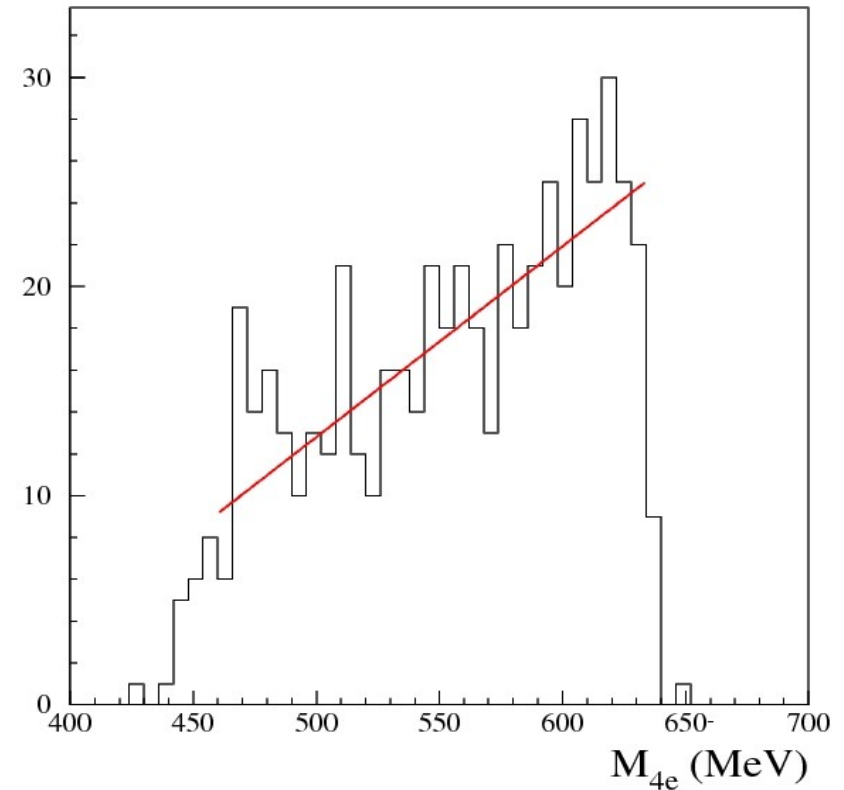
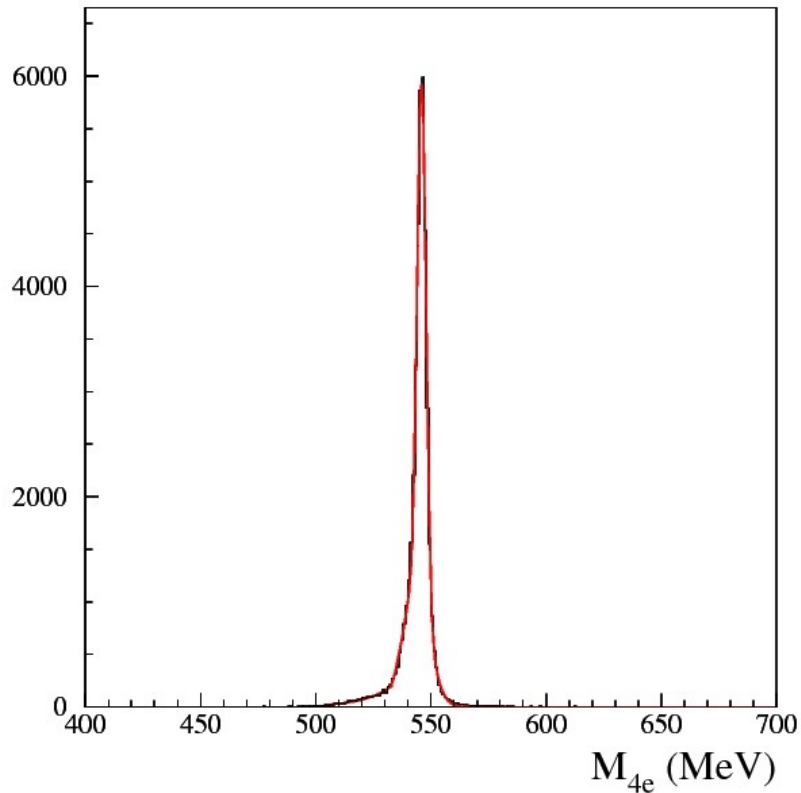


offpeak

#pions
VS
#electrons

#electrons > 0
.and.
#pions < 2

Fit shapes: signal MC and off-peak data

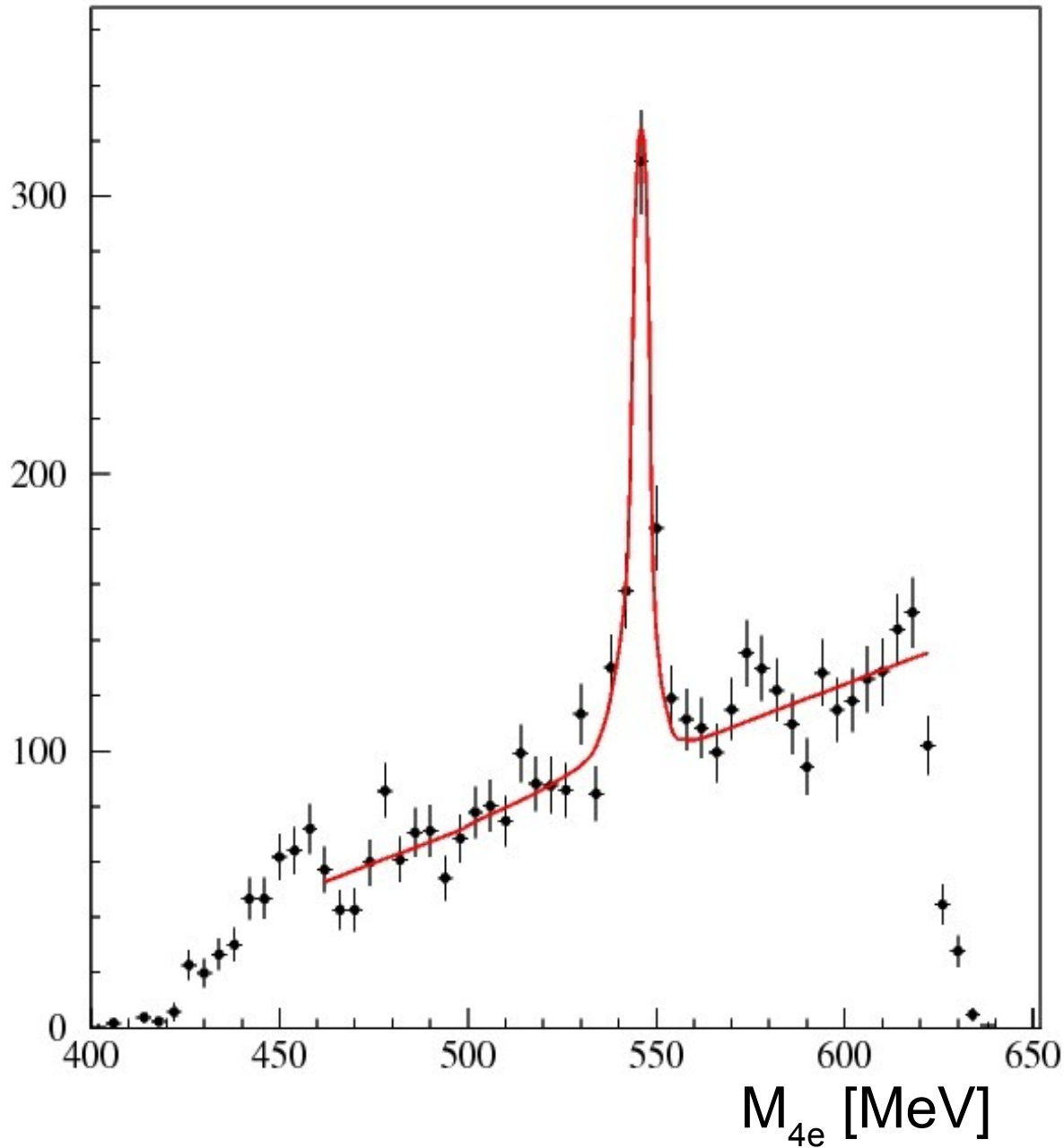


1 fit signal (2 gaussians + p3) and offpeak (p1)

2 subtract background from ϕ decays (all_phys and allrad)
using luminosity

3 use the obtained shapes to fit the data

Fit data



$$\chi^2/\text{dof} = 61/39$$

$$\# \text{events} = 413 \pm 31$$

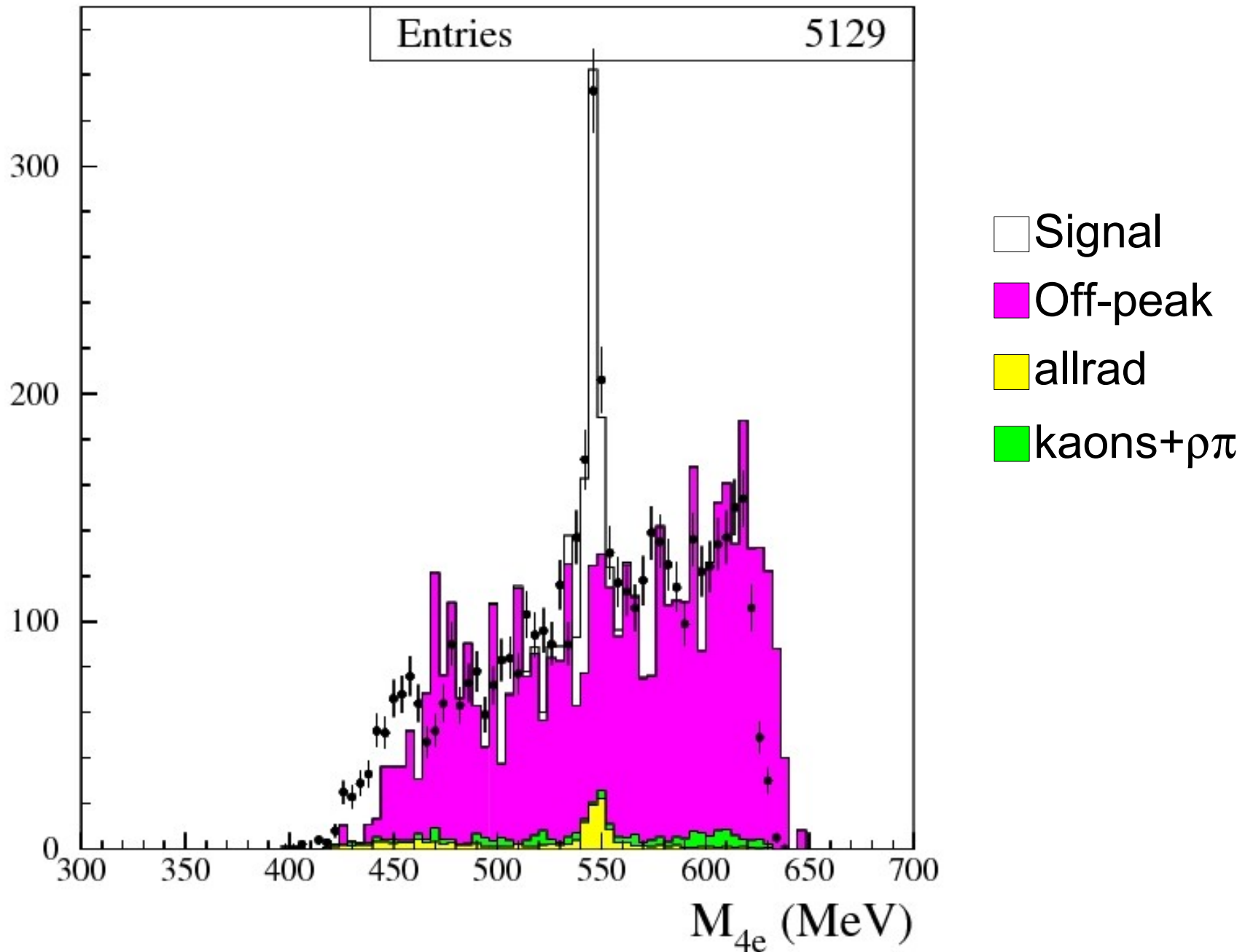
$$\text{Efficiency} = 0.21$$

(from MC)

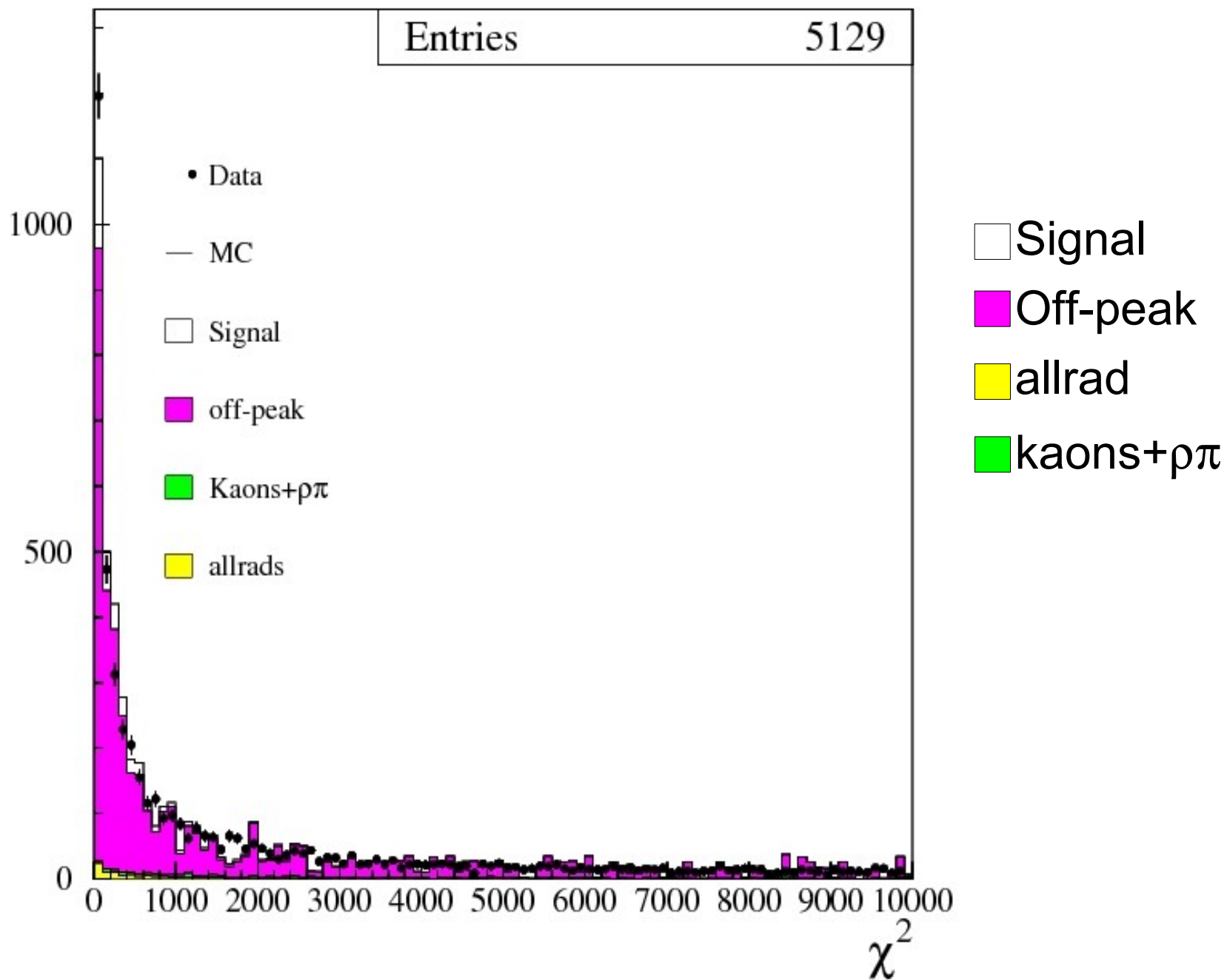
$$\text{BR} = (2.73 \pm X) \times 10^{-5}$$

$$\text{Theoretical predictions:}$$
$$(2.52 - 2.64) \times 10^{-5}$$

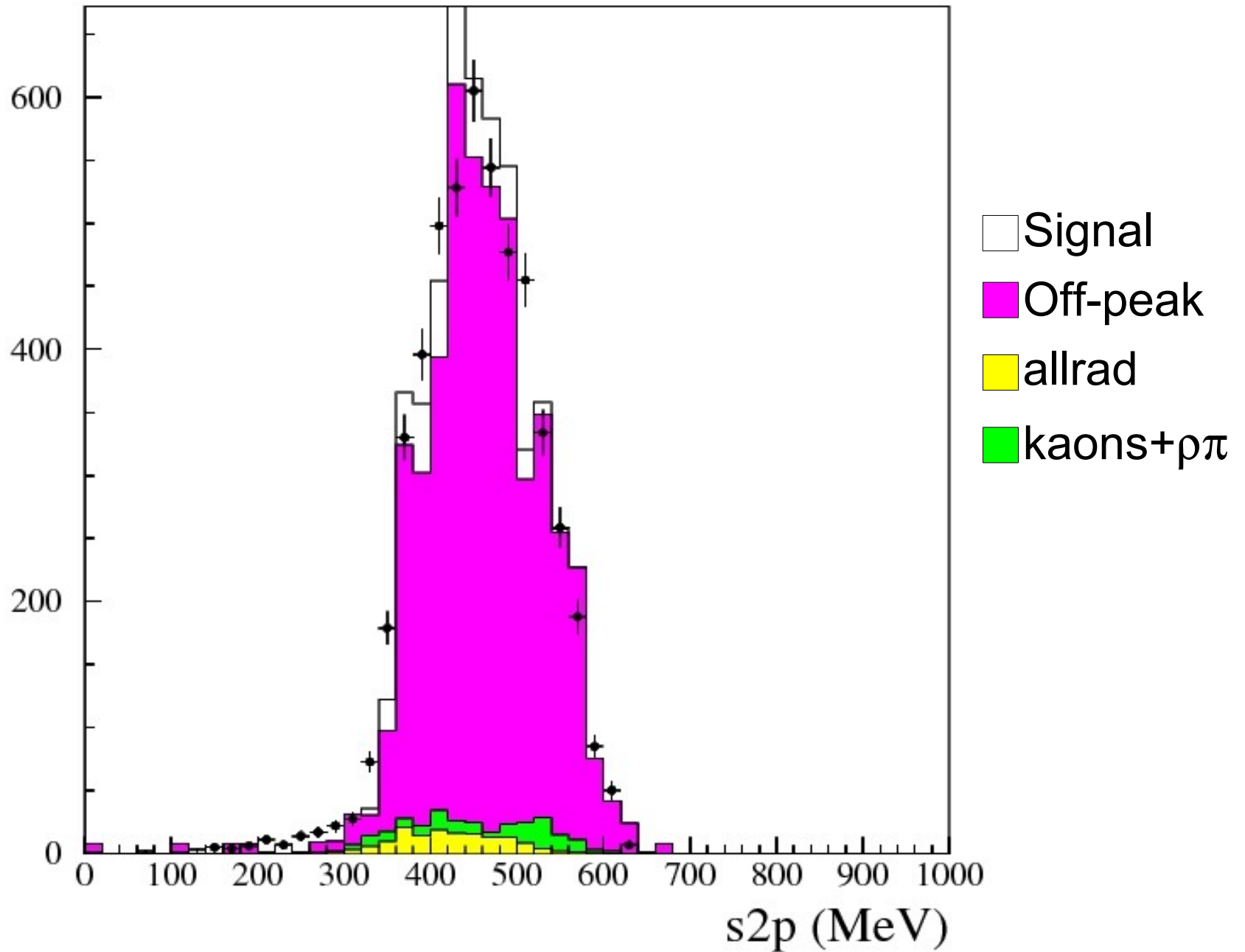
Data-MC comparison: M_{eeee}



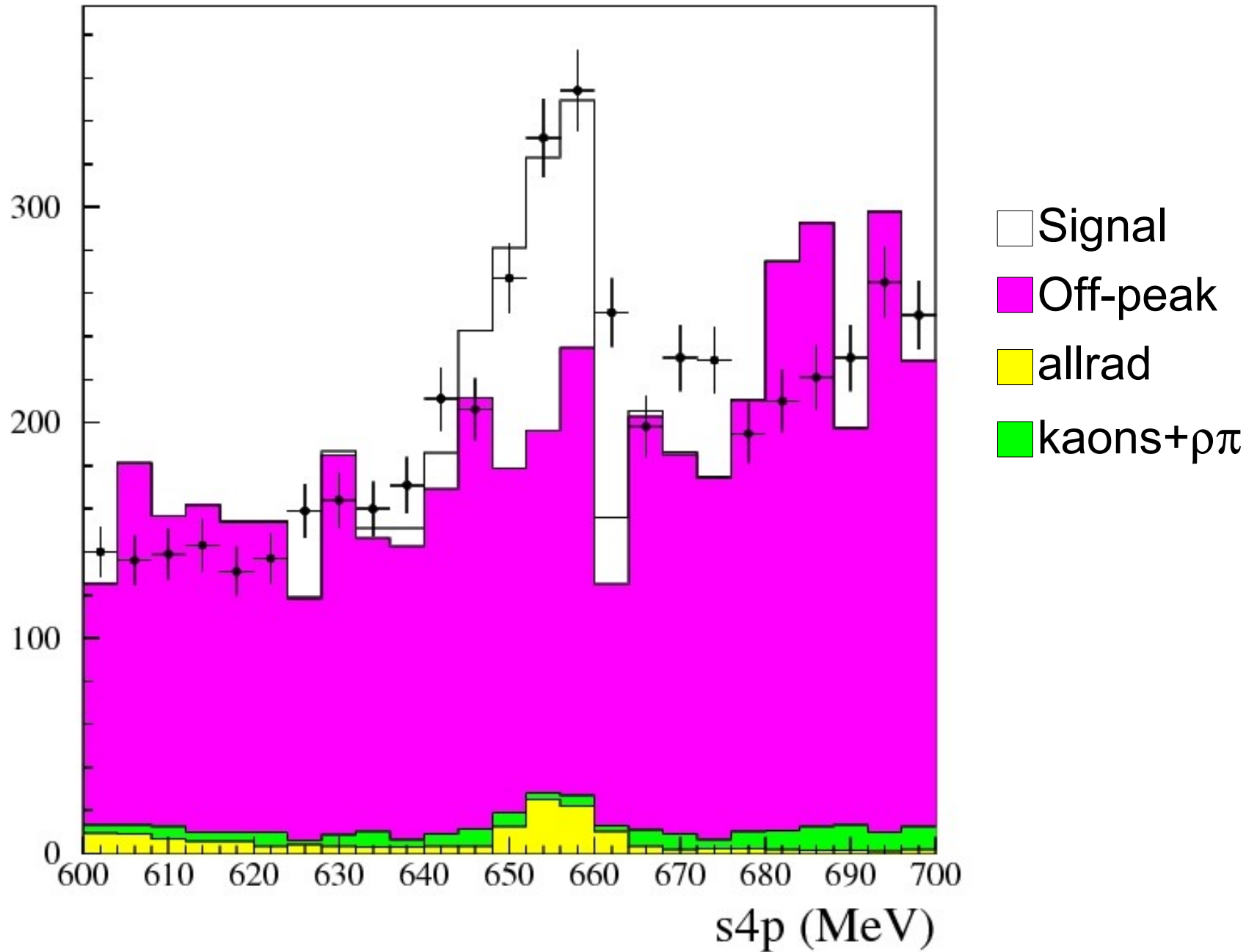
Data-MC comparison: χ^2



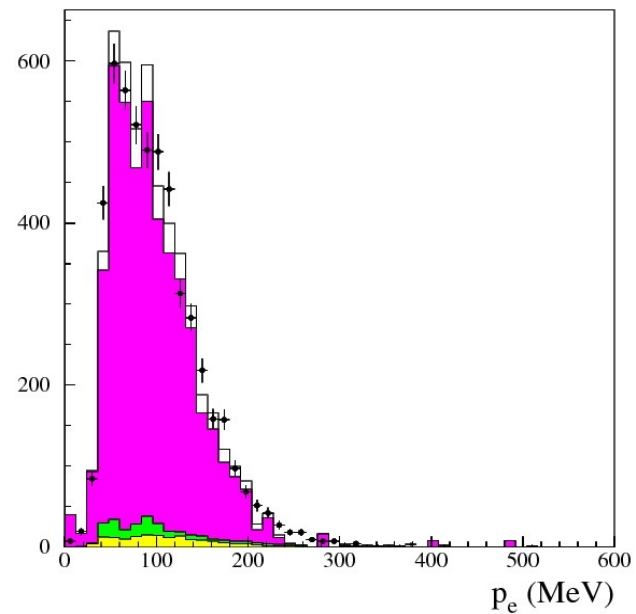
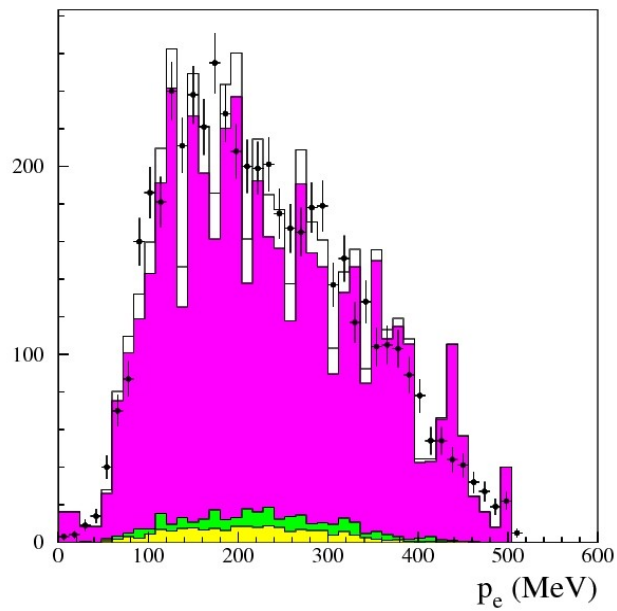
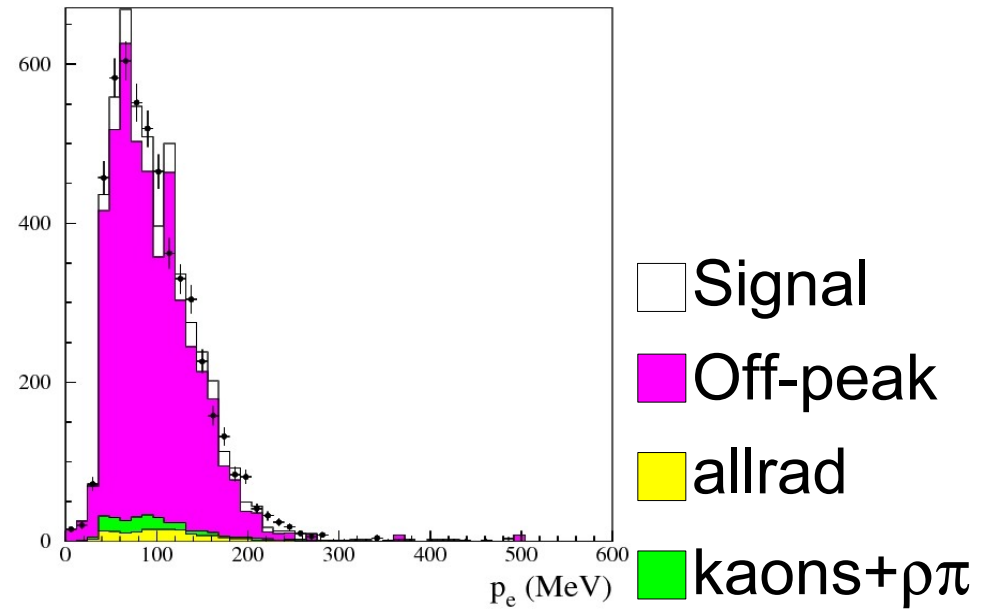
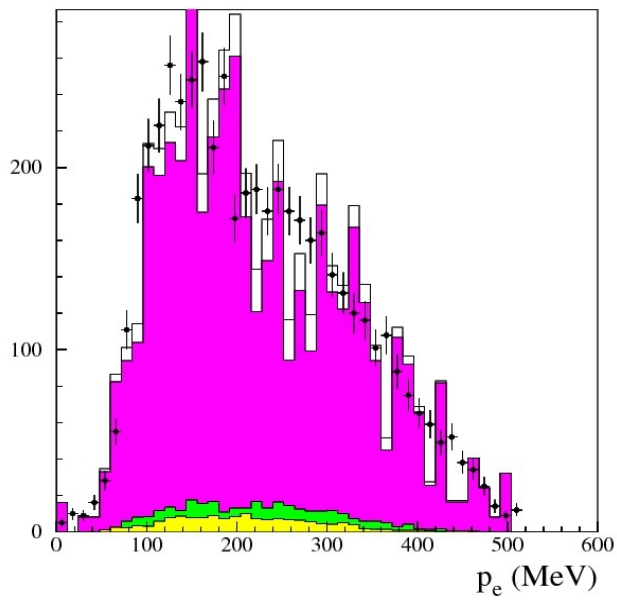
Data-MC comparison: s2p



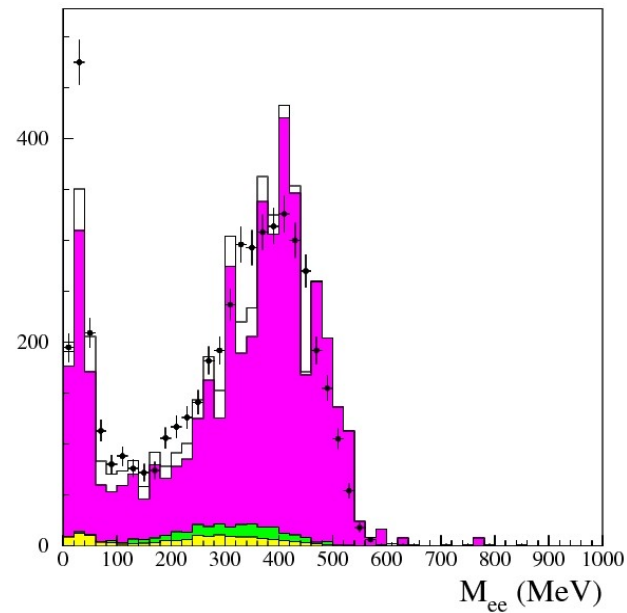
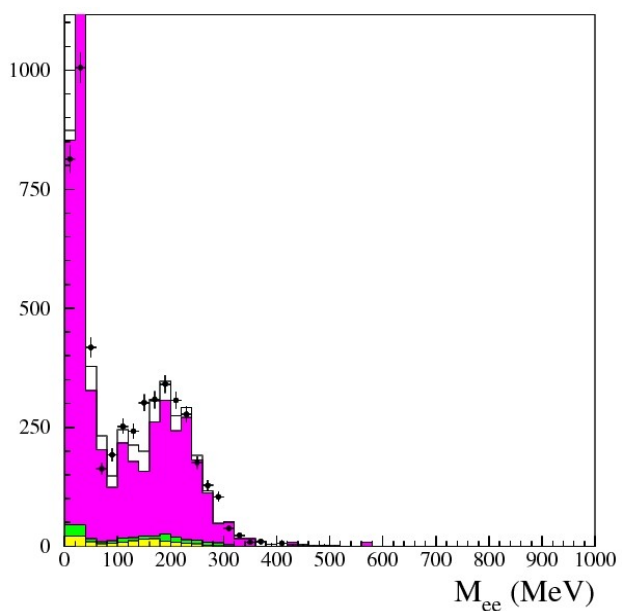
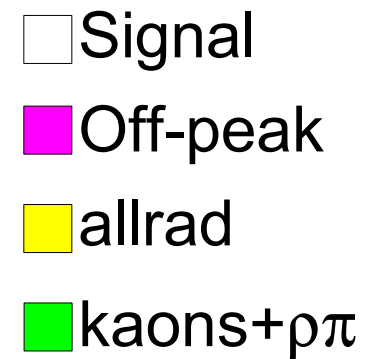
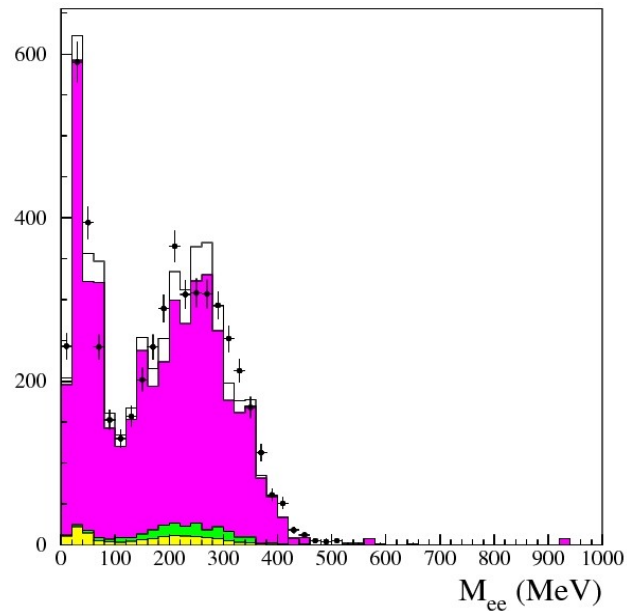
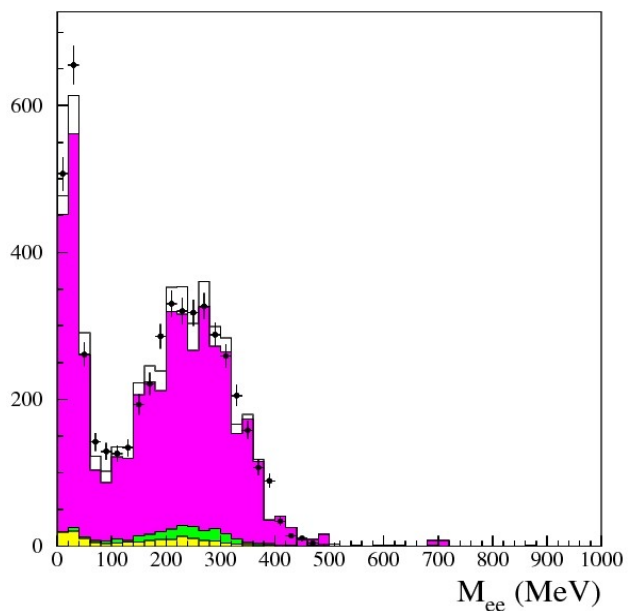
Data-MC comparison: s4p



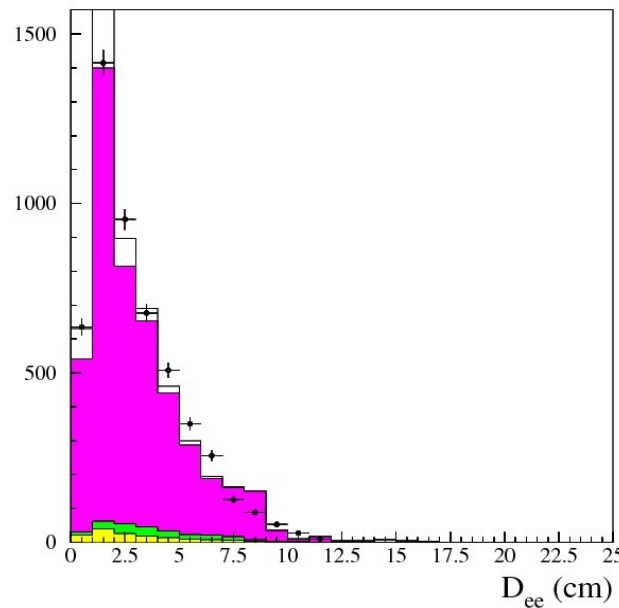
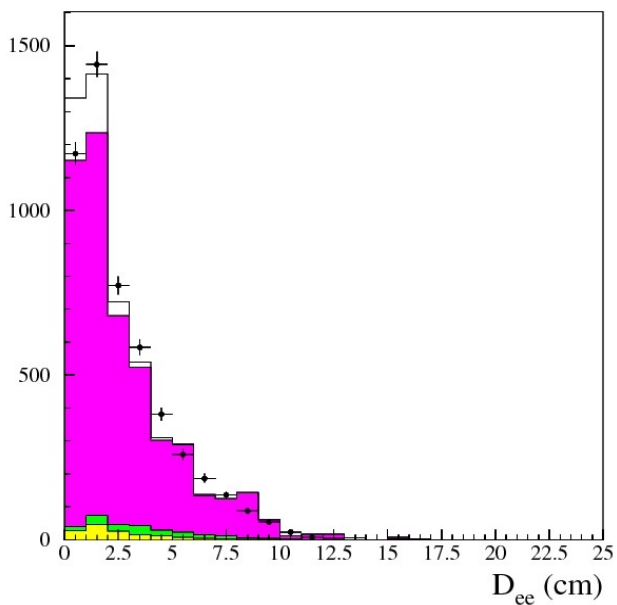
Data-MC comparison: momenta



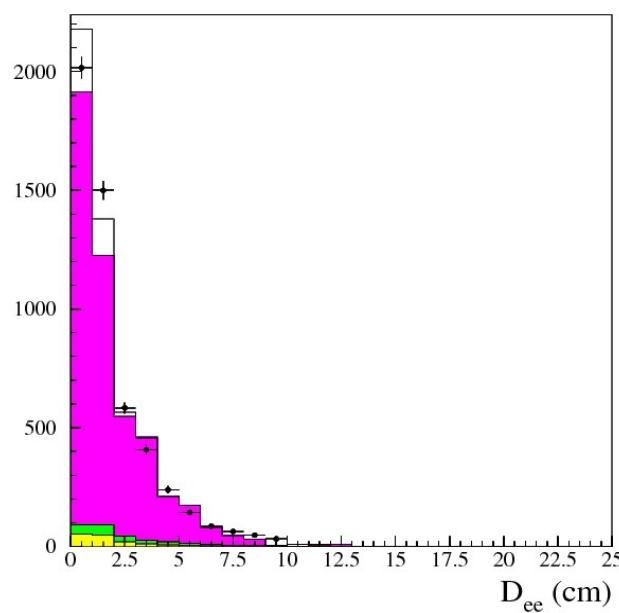
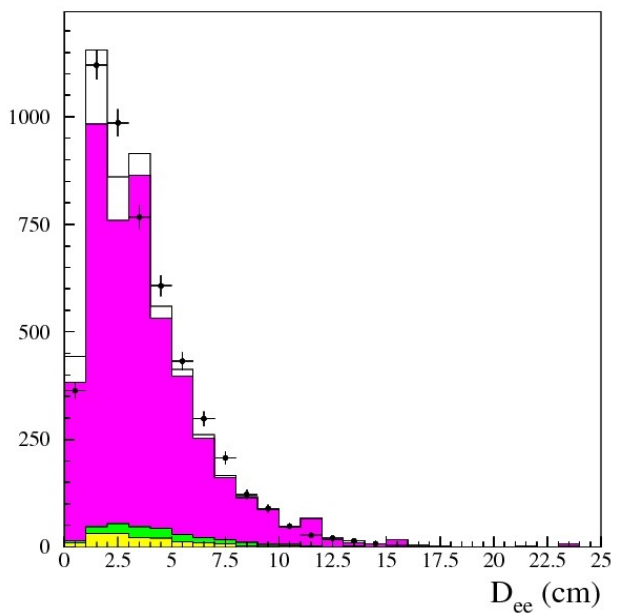
Data-MC comparison: M_{ee}



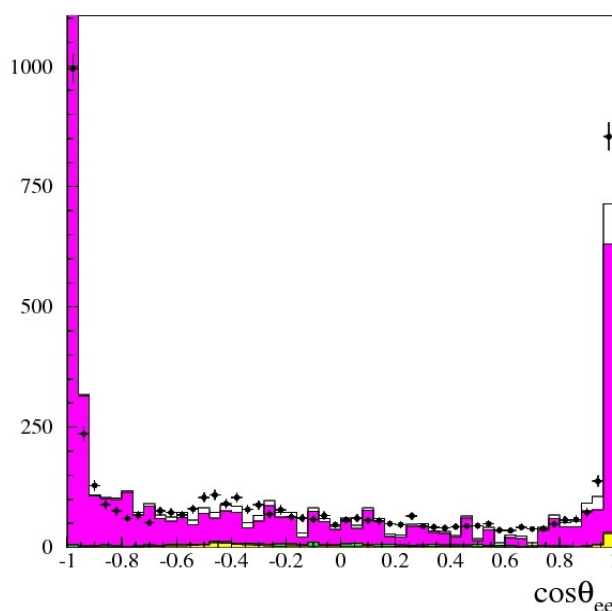
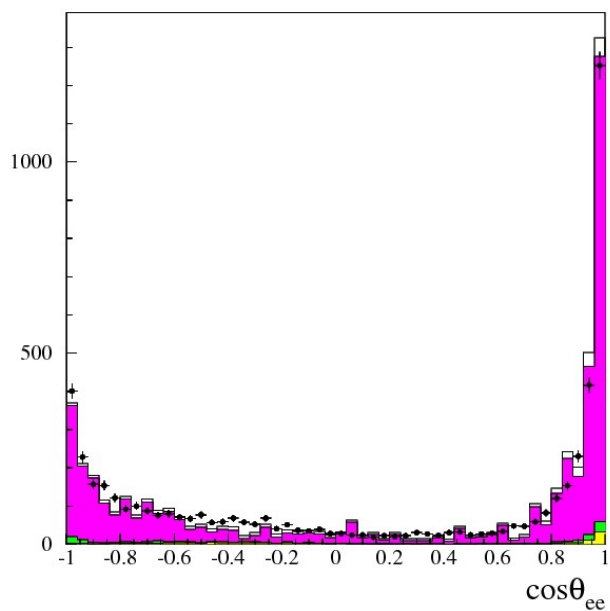
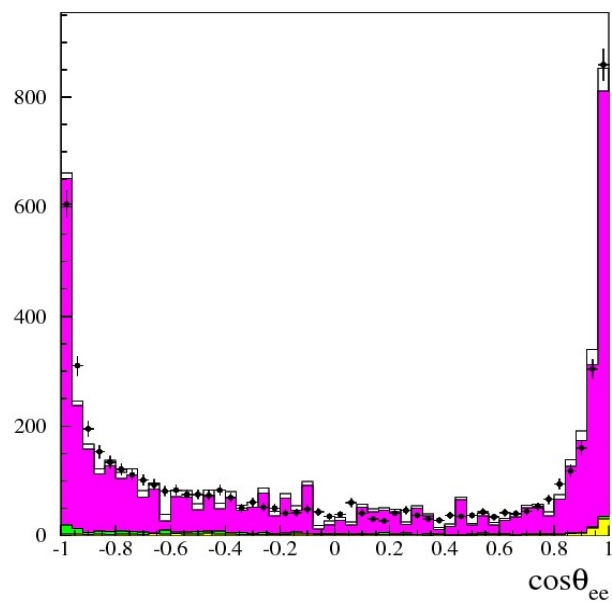
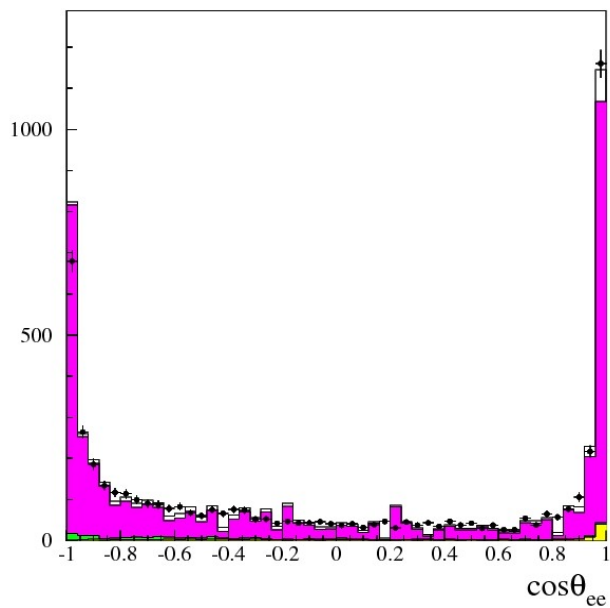
Data-MC comparison: D_{ee}



□ Signal
■ Off-peak
■ allrad
■ kaons+ $\rho\pi$

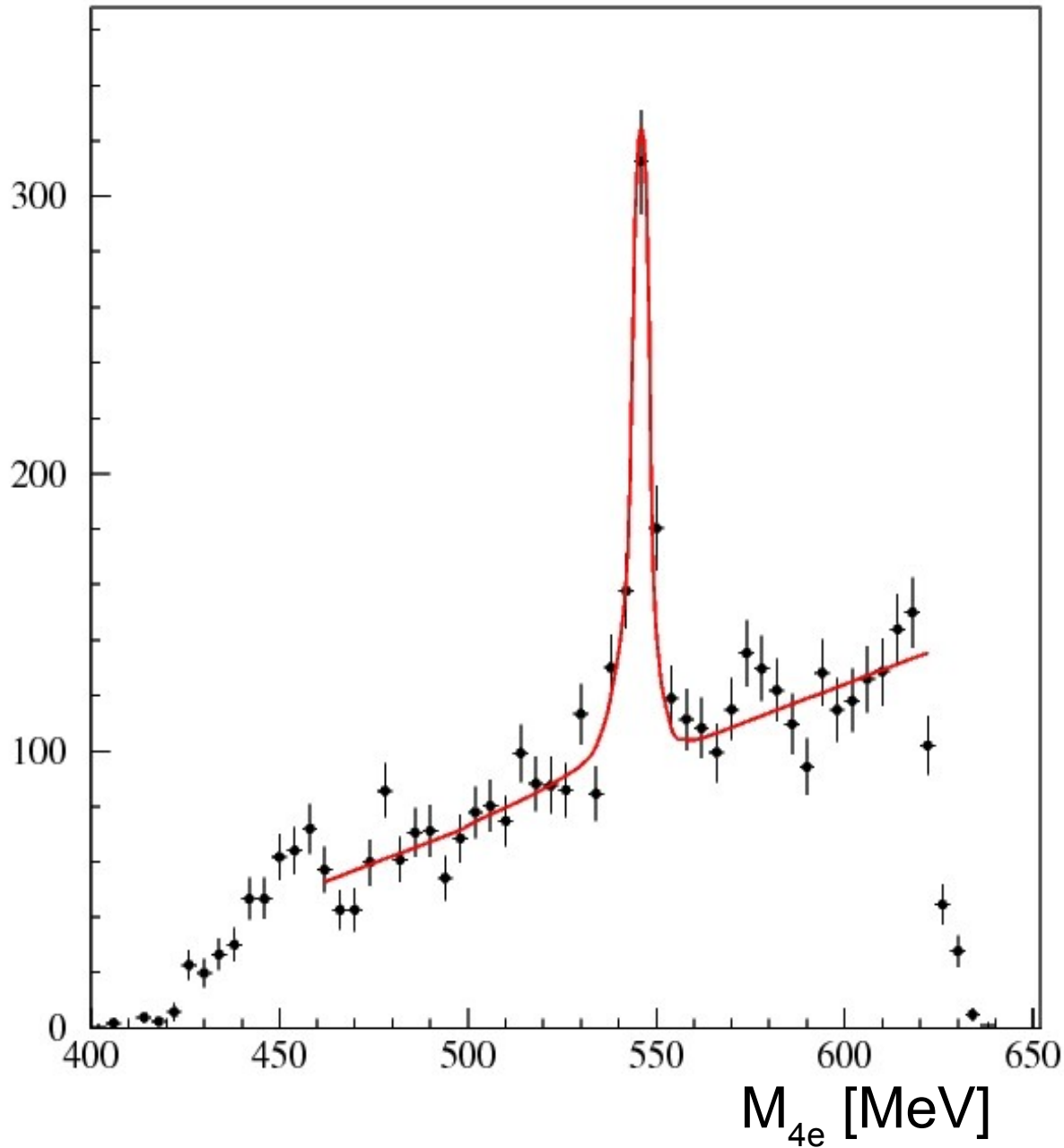


Data-MC comparison: θ_{ee}



- Signal
- Off-peak
- allrad
- kaons+ $\rho\pi$

Proposal for CIPANP



Show the fit and
the number of events

Don't give
either efficiency
or branching ratio

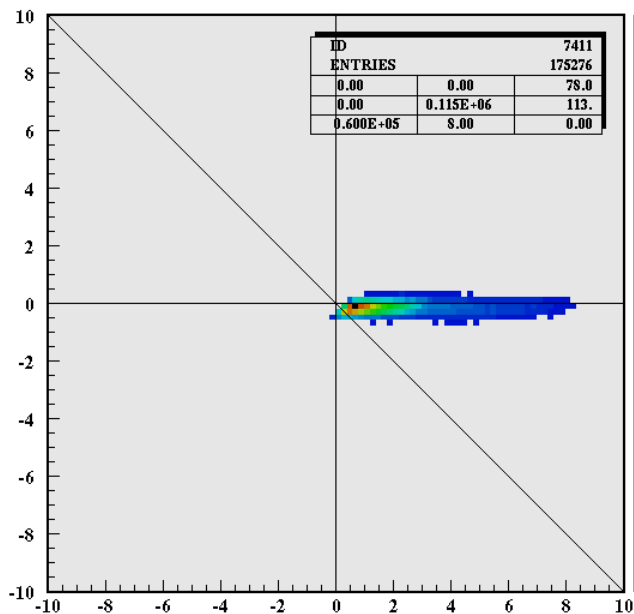
Backup slides

Fit description

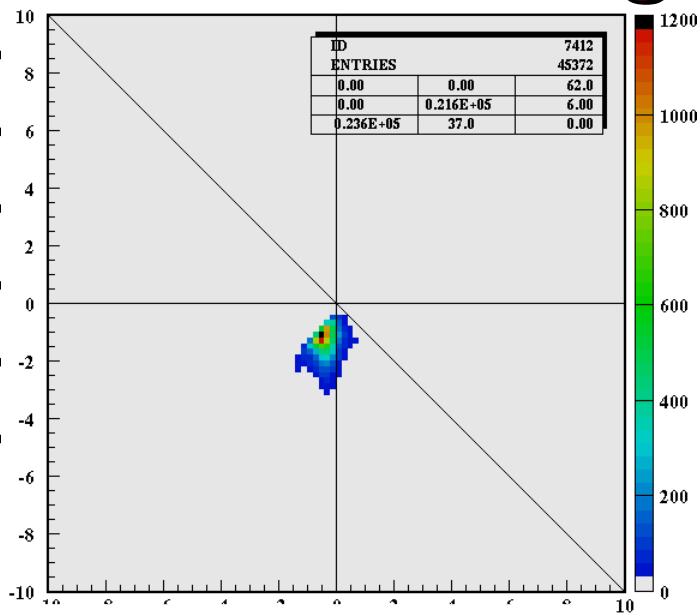
- Stand alone program using HBOOK and MINUIT
- Components that can be used:
MC signal, MC all_phys, MC allrad, Data offpeak
- Possible to fit both whole spectrum and sidebands
- Possible to fix scale factors using luminosity

Same as $\eta \rightarrow \pi\pi e e$

Cut on Time of Flight

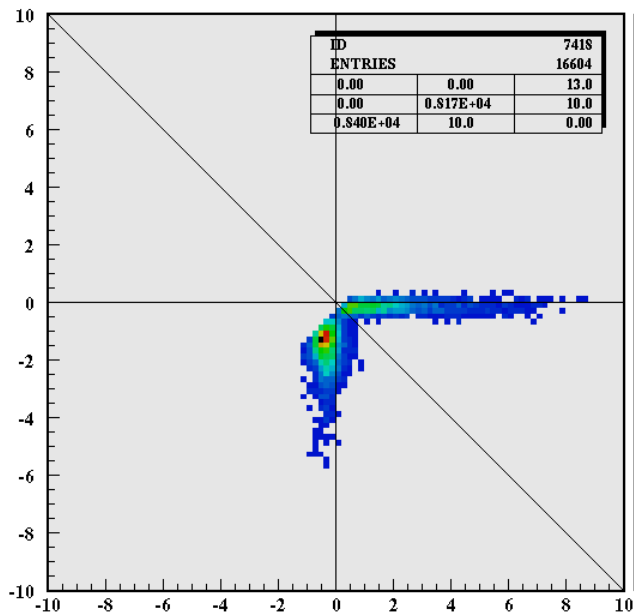


Signal

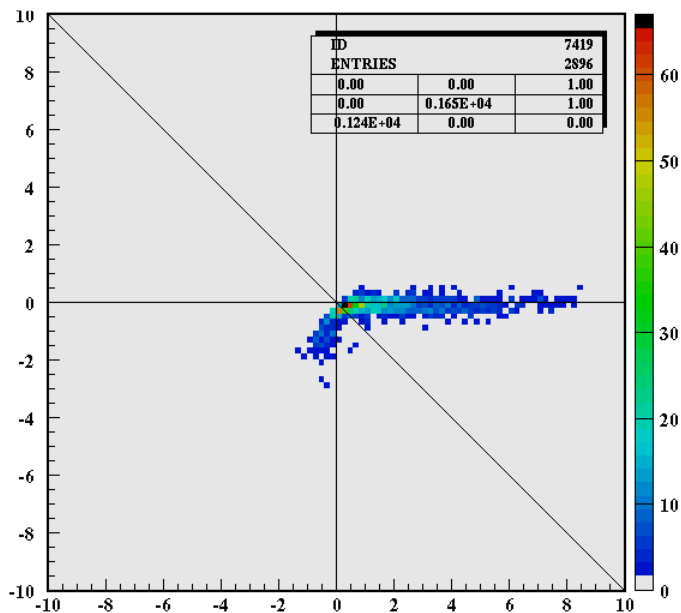


all_phys Kaons+ $\rho\pi$

$$\Delta t = t_{\text{track}} - t_{\text{cluster}}$$



allrad



offpeak