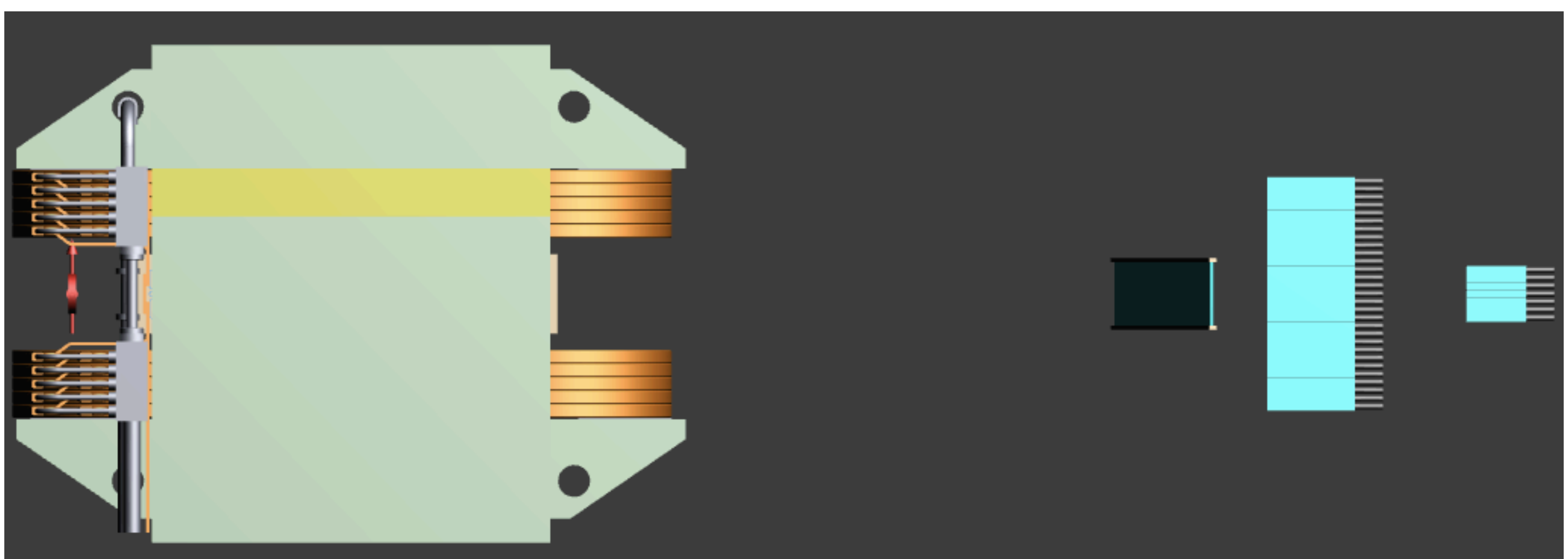
Istituto Nazionale di Fisica Nucleare

First thoughts on two and three photon signals

Federica Giacchino, Federica Oliva, Gabriele Piperno



PADME General Meeting - 9 gennaio 2019

Starting point: Barbara's slide

From 19/12/2018 analysis meeting

A signal (SM or not)
- available MC data? Enough statistics?
- sensitivity; sensitivity as a function of background level

Foreseen background channels
- list
- theoretical quantitative estimate
- available MC data for each channel? Enough statistics?

Basic selection of the signal and background(s)
- ideal selection i.e. list of variables and cuts
- already tested/built on MC data?
- rough evaluation of selection efficiency on MC
- are these variable already available on reconstructed data?

Limiting factors / needed figures of merit:
- calibrations: energy? time? position? for one detector in particular?
- resolution: energy? time? position?
- MC statistics?

First considerations

These interactions can be considered both as a background to the Dark Sector physics and as interesting physics channels themselves.
Up to now the $\gamma\gamma(\gamma)$ have been seen mainly from the background point of view.

A MC already exists, but it is based on the initial PADME design:

POT: 5000 → 20000(?)

bunch duration: 40 ns → 200 ns (is it possible to implement the real shape?)

design detector geometry → final detector geometry

beam spot size: 1×1 mm^2 → 2×2.5 mm^2

Angular spread simulated as 1% energy spread, is this realistic?

Magnetic field? It also changed during data acquisition

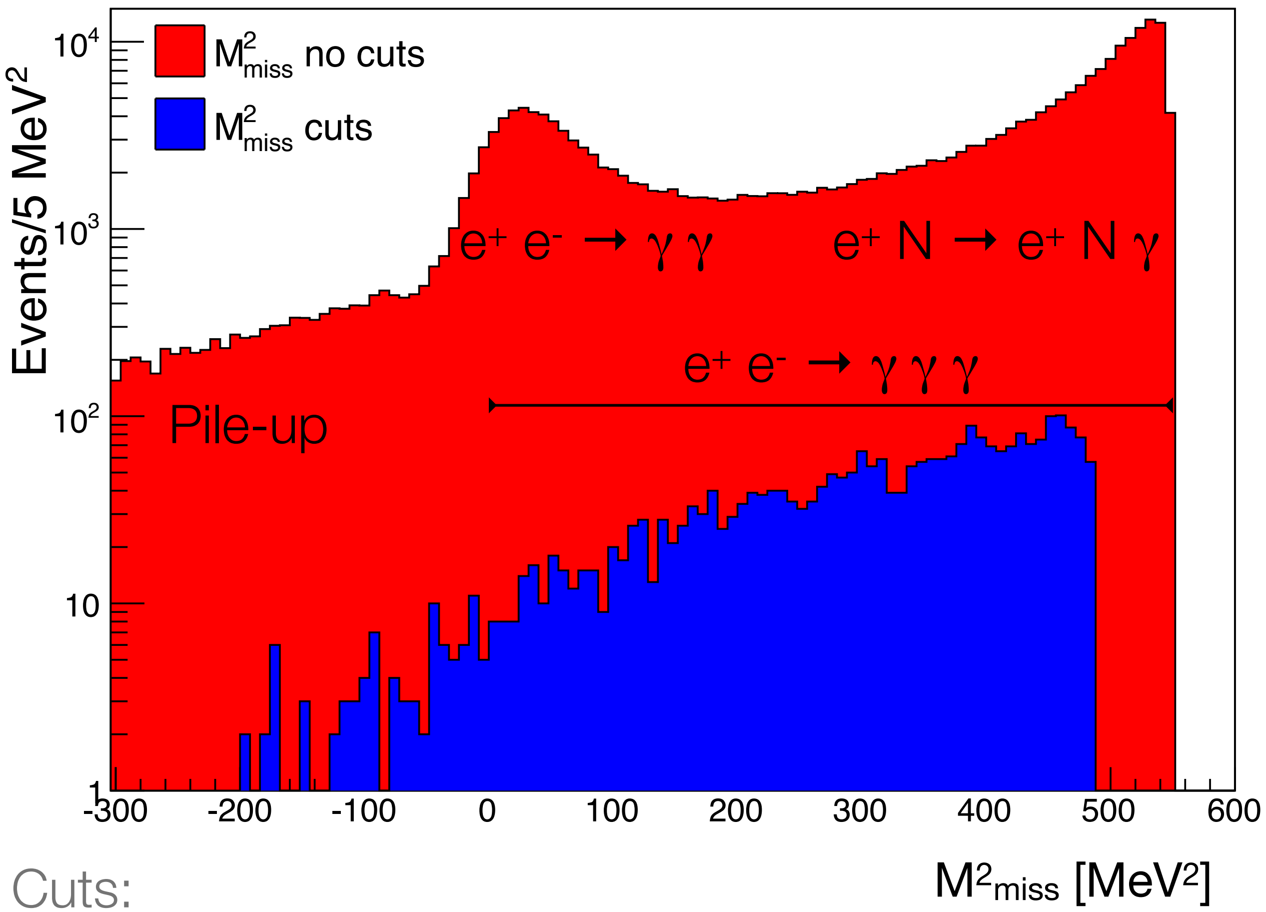
The current MC can anyhow help us to understand the needed number of POT to have a sufficient statistics, but backgrounds can be different and in particular ECal time resolution is a major point (probably more than energy resolution).

No one of us three knows how to run the MC, Geant4 and where the code is

Main backgrounds to A' search

Main backgrounds:

- $e^+ e^- \to \gamma \gamma (\gamma)$
- $e^+ N \to e^+ N \gamma$
- pile-up

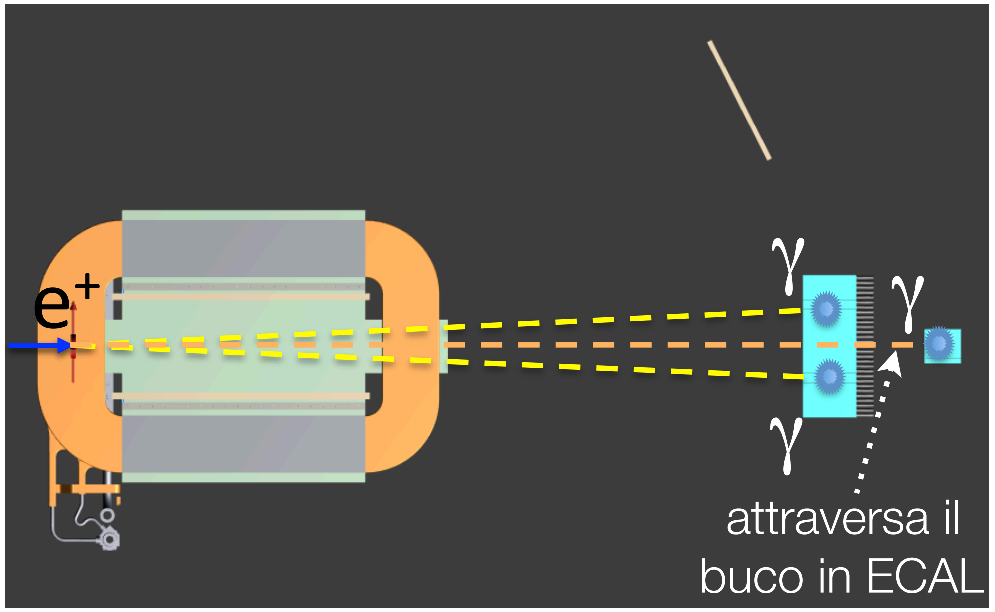


Cuts:

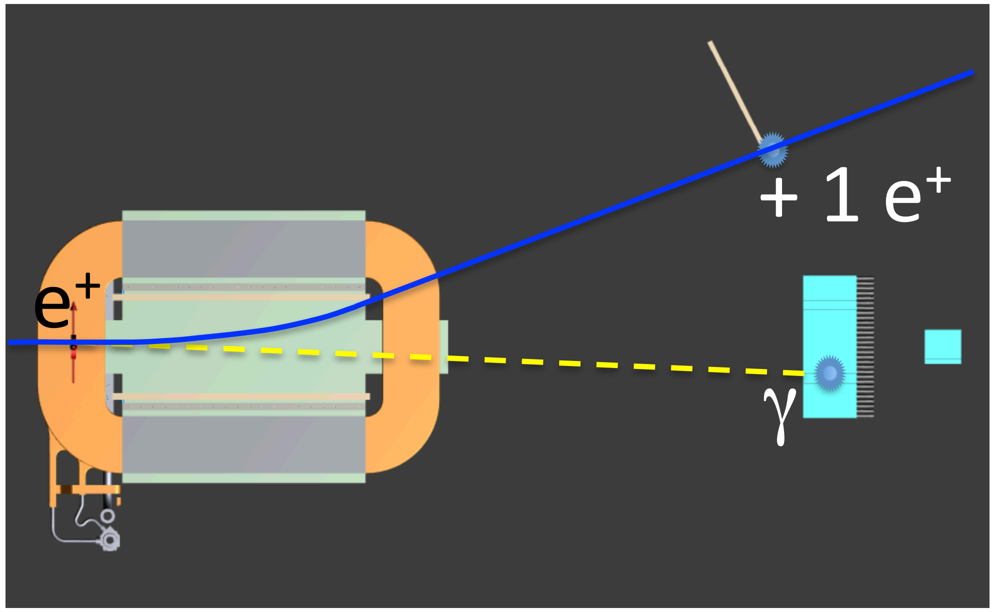
- 1 cluster in ECAL fiducial volume
- no particles in vetoes
- no γ in SAC w/ $E_\gamma > 50$ MeV
- 20-150 MeV < E_γ < 120-350 MeV (depending on $m_{A'}$)

Backgrounds geometry

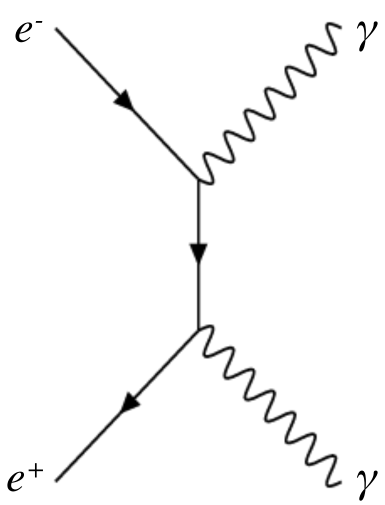
Annihilation (+ISR): $e^+ e^- \to \gamma \gamma (\gamma)$



Bremsstrahlung: $e^+ N \to e^+ N \gamma$

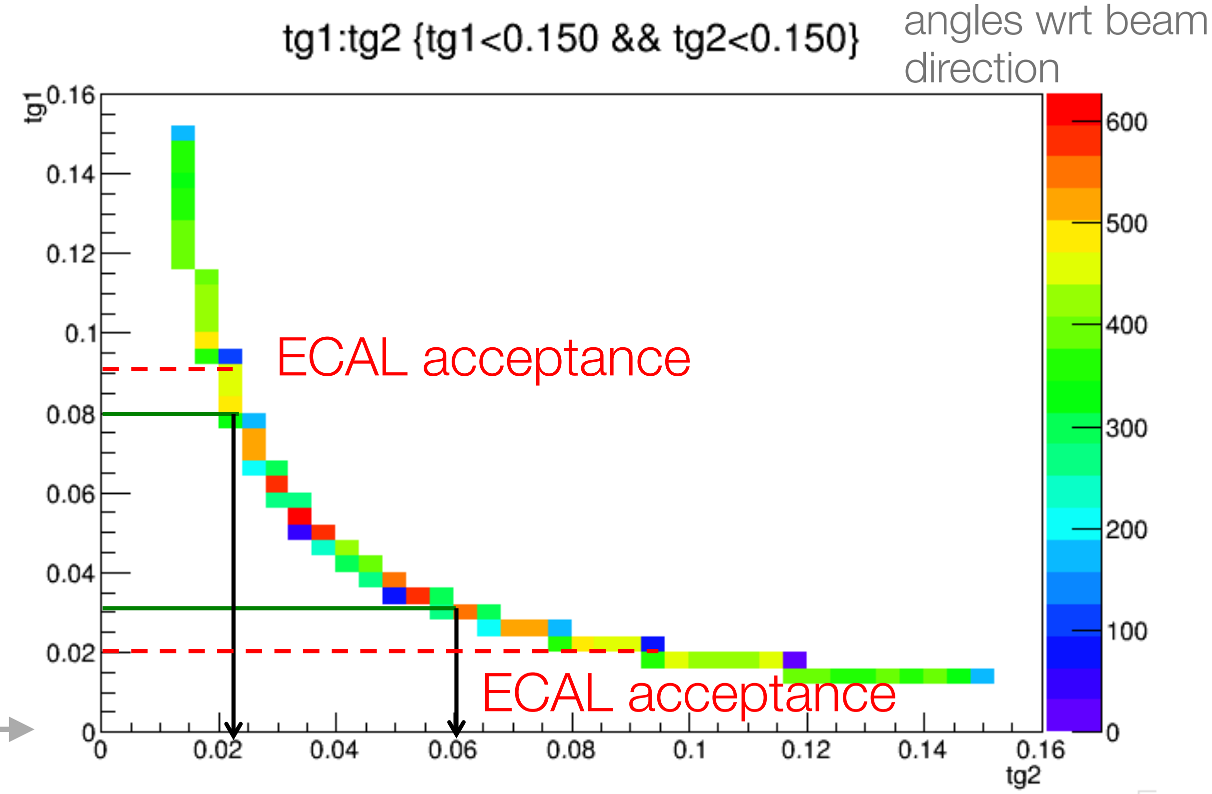


γ γ channel



- Missing mass corresponds to 1 γ → background centred at zero

Angular correlation between the 2 produced γs



No requirements on γs (only event geometry)

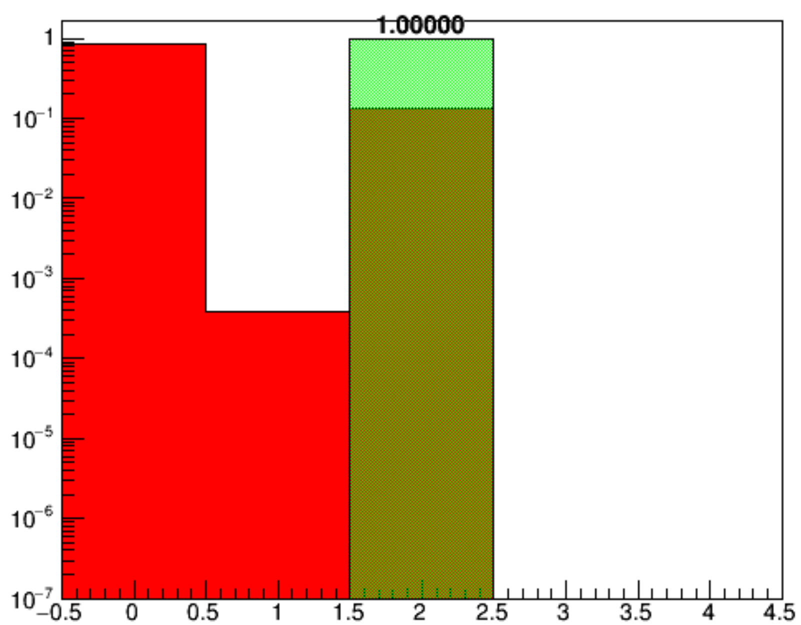
Requiring 1 γ in ECAL w/:

30 < θ < 80 mrad

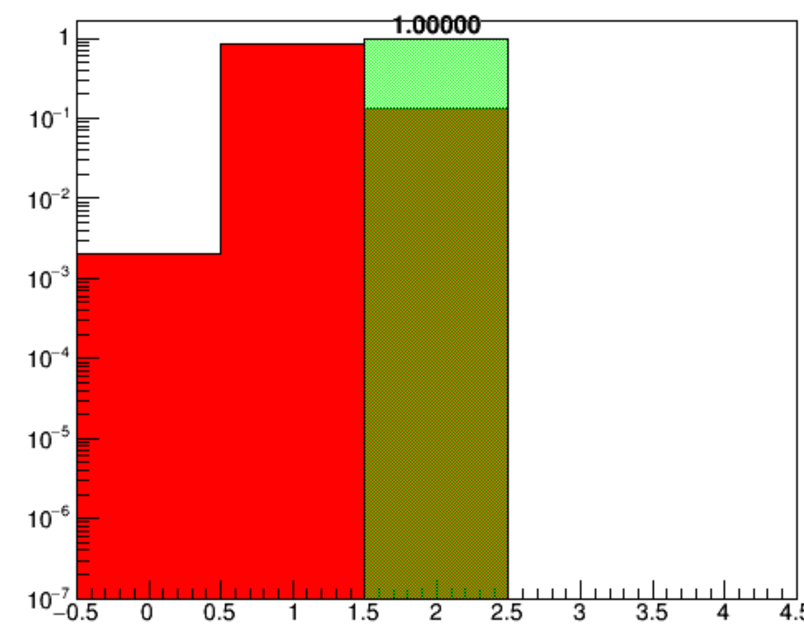
10 < E_γ < 500 MeV

X-axis: # γ in ECAL or ECAL+SAC

ECAL

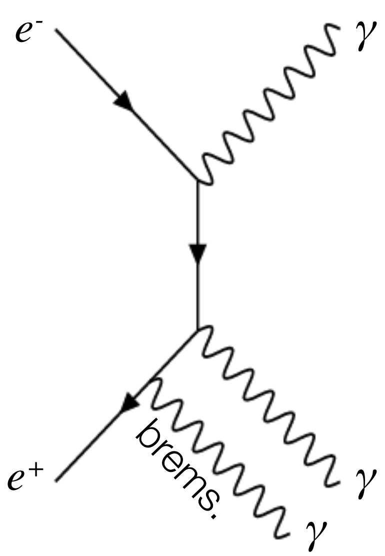


ECAL+SAC



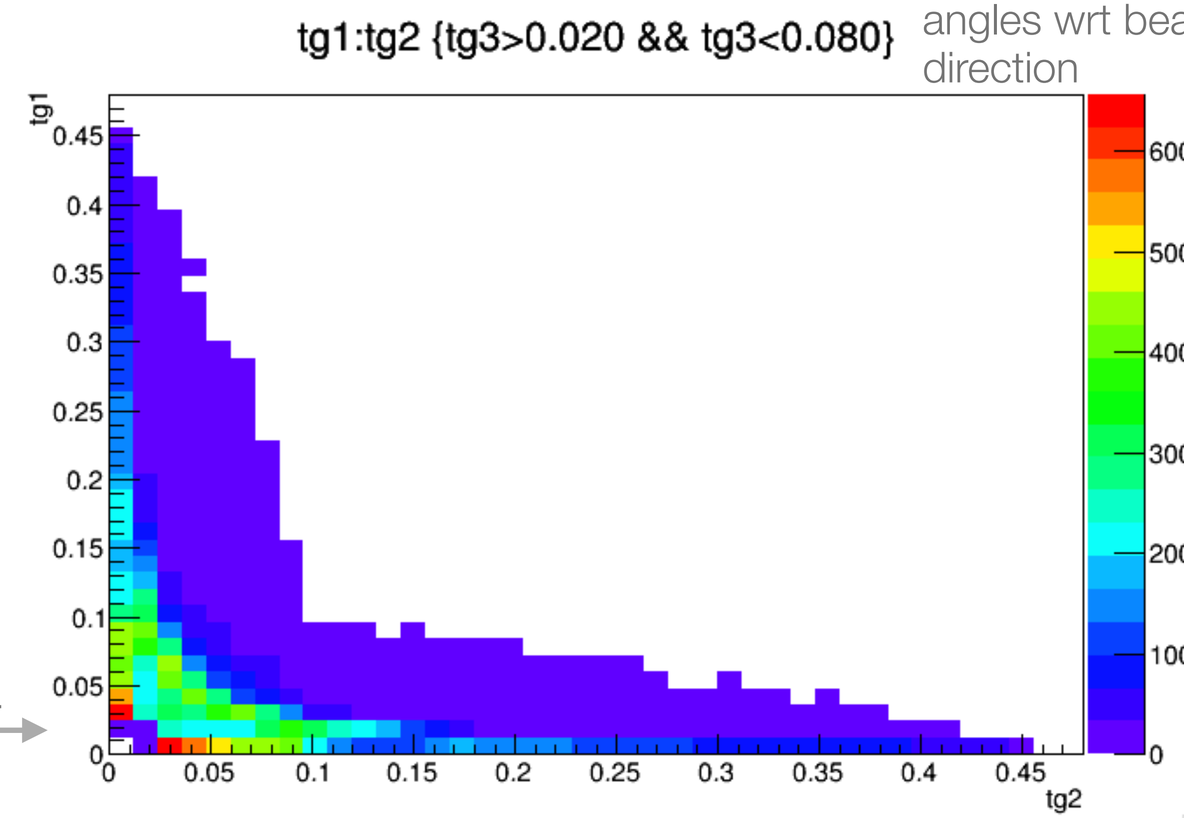
ECAL can (virtually) remove the 2 γs background

γ γ γ channel



- Missing mass corresponds to 2 γs → background centred on a wide range

angles wrt beam direction



Angular correlation between 2 γs requiring that the third is in ECAL

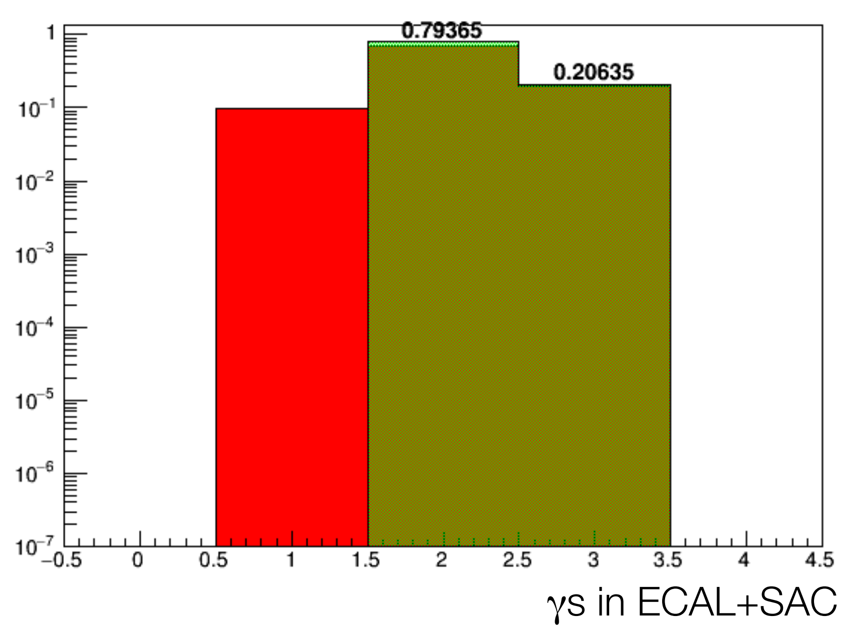
No requirements on γs (only event geometry)

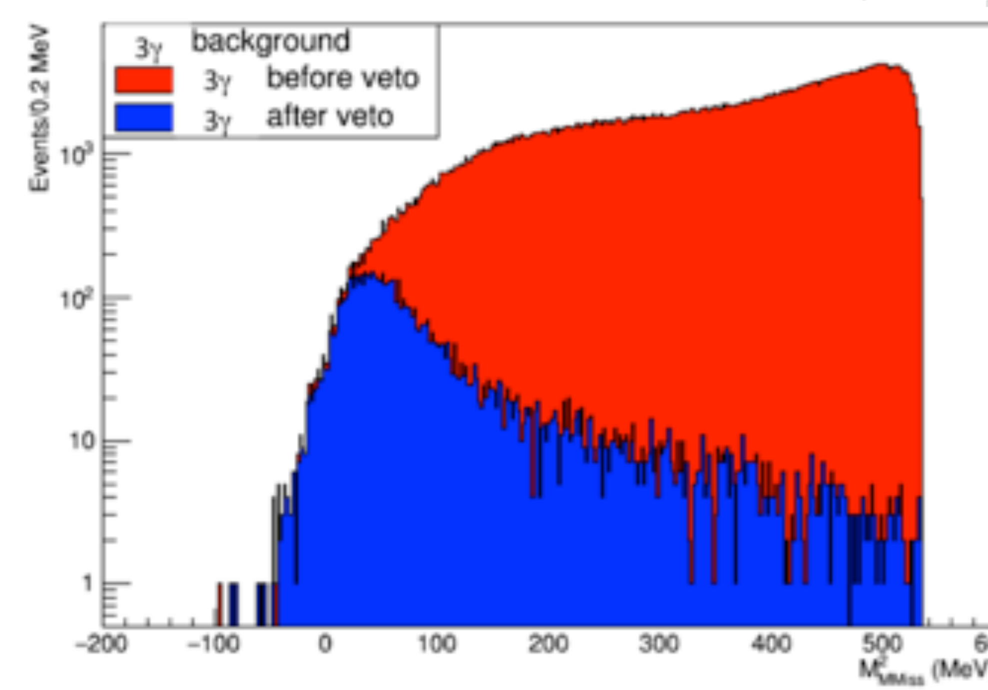
Requiring 1 γ in ECAL w/:

30 < θ < 80 mrad

10 < E_γ < 500 MeV

ECAL+SAC



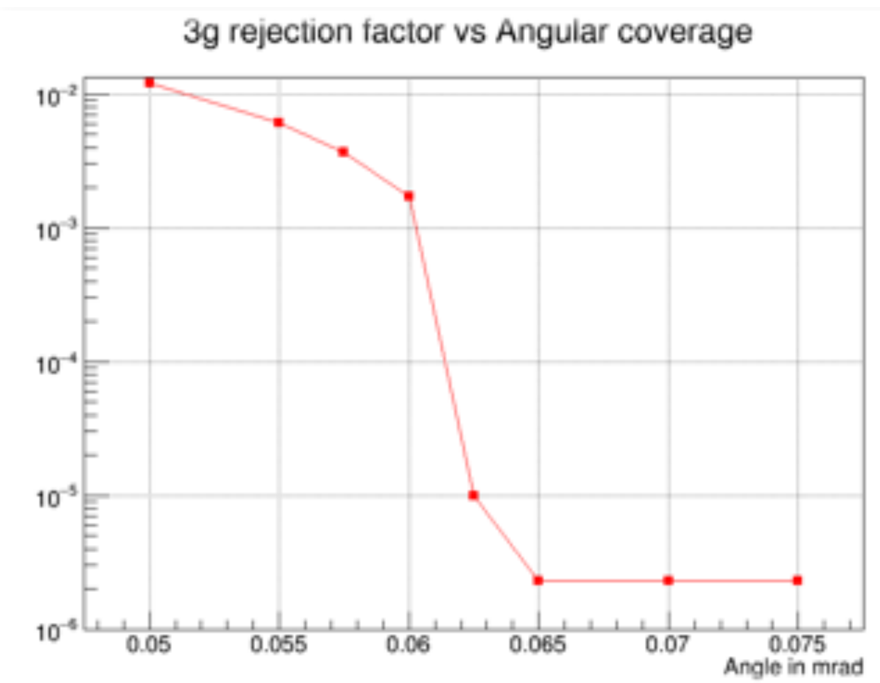


ECAL+SAC can (virtually) remove the 3 γs background

γ γ (γ) origin and reduction

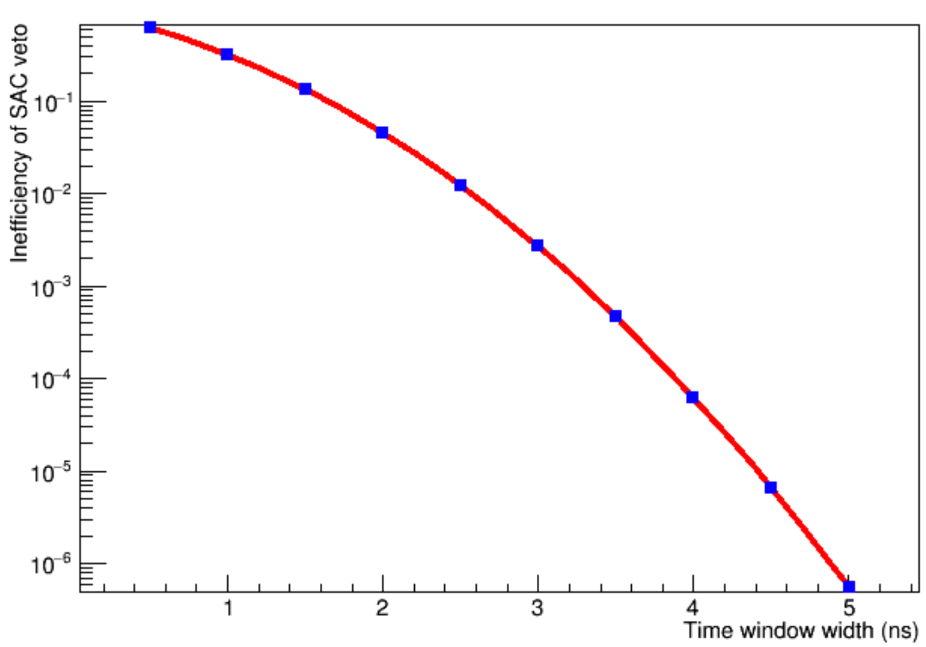
Possible γ γ (γ) background origins:

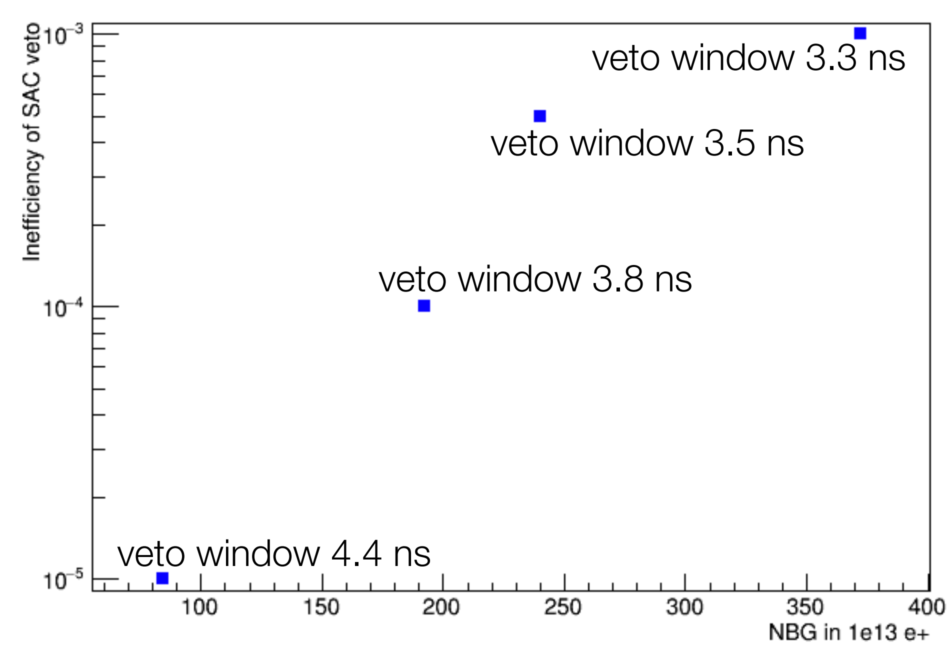
- clustering and level 0 trigger algorithms inefficiencies
- two photons overlap
- large angle scattering
- one or two γs considered as belonging to another event
- geometrical lost in ECal crack



γ γ (γ) backgrounds reduction depends on:

- cluster definition
- cuts on event topology
- ECal acceptance (needed absolute ECal positioning)
- veto time interval choice





$\gamma\,\gamma\,(\gamma)$ backgrounds, fundamental points

Fundamental points to study $\gamma\,\gamma\,(\gamma)$ backgrounds:

- implement experiment final geometry in simulations
- implement in $\gamma\,\gamma\,(\gamma)$ MC angular correlation w/
  - primary e^+ direction
  - beam spot dimensions
- cluster definition and γ separation efficiency as a function of
  - energy threshold
  - minimum energy to define a cluster
  - interval to define a “good” γ
  - variables intervals for each $m_{A'}$ (each def. takes different background components)
- SAC veto interval (balancing between acceptance and inefficiency)

$e^+ e^- \to \gamma\,\gamma$ cross section measurement at low energy

\# $\gamma\,\gamma$ events in detector

$$\frac{N_{\gamma\gamma}}{Acc_{\gamma\gamma}} = \mathcal{L}_{int} \cdot \sigma(e^+ e^- \to \gamma\gamma)$$

$\gamma\,\gamma$ events acceptance in detector

Measuring:

- $N_{\gamma\,\gamma}$
- Luminosity

Knowing:

- $Acc_{\gamma\,\gamma}$

→ Cross section measurement:

$e^+ e^- \to \gamma\,\gamma$

GEANT4 never tested at so low energies

Backup