FCC-ee detector occupancy

WG11 Detector Design Meeting

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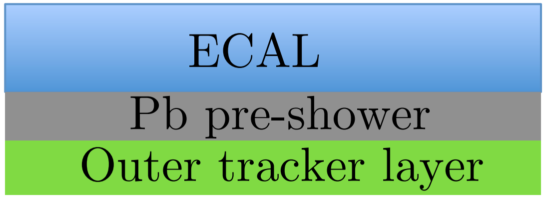
Goal

- Explore the typical structure of possible FCC-ee detector
  - Pre-shower installation
  - Cluster separation



- Study the typical distance, in a FCC-ee like environment, between
  - Photons
  - Photons and hadrons
- Understand which granularity is needed to recognize ECAL hadronic contribution
- Understand the typical "pixel size" of the pre-shower.

Outline

- Generate typical events in FCC-ee like scenario
- Propagate particles up to a reasonable distance for the detector tracker outer layer
- Analyze distance distribution between particles
- Infer limitation and feasibility

Generation

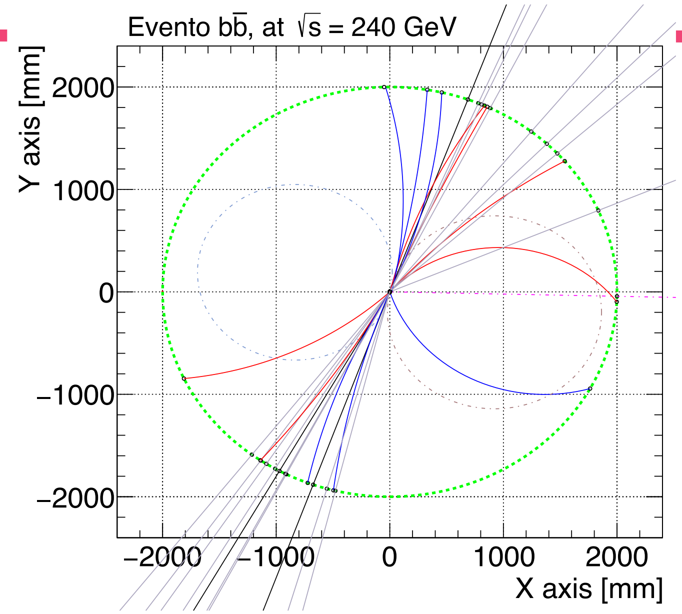
- PYTHIA8 (standalone) generation:
  - e^+e^- to γ/Z, including ISR and FSR
  - $\tau\tau$ or bb final states (5k events each)
  - Center of mass energy 91 GeV and 240 GeV

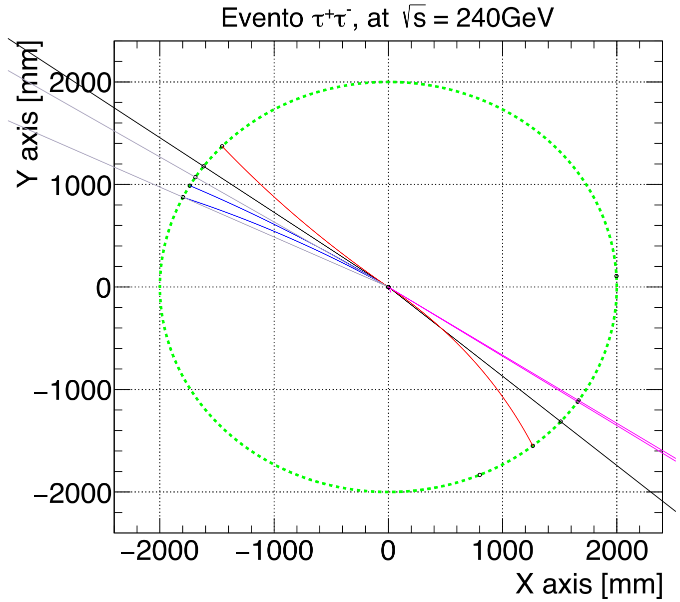
- By "hand" propagation of MC particles
  - Final states particles from 10 mm to 2 m
  - 2T axial homogeneous magnetic field
  - Barrel only, 10m full length that is $-2.3 < \eta < 2.3$ (affect minimally normalized distribution)

- In future may be interesting to include matter interactions (multiple scattering, photon conversion...)

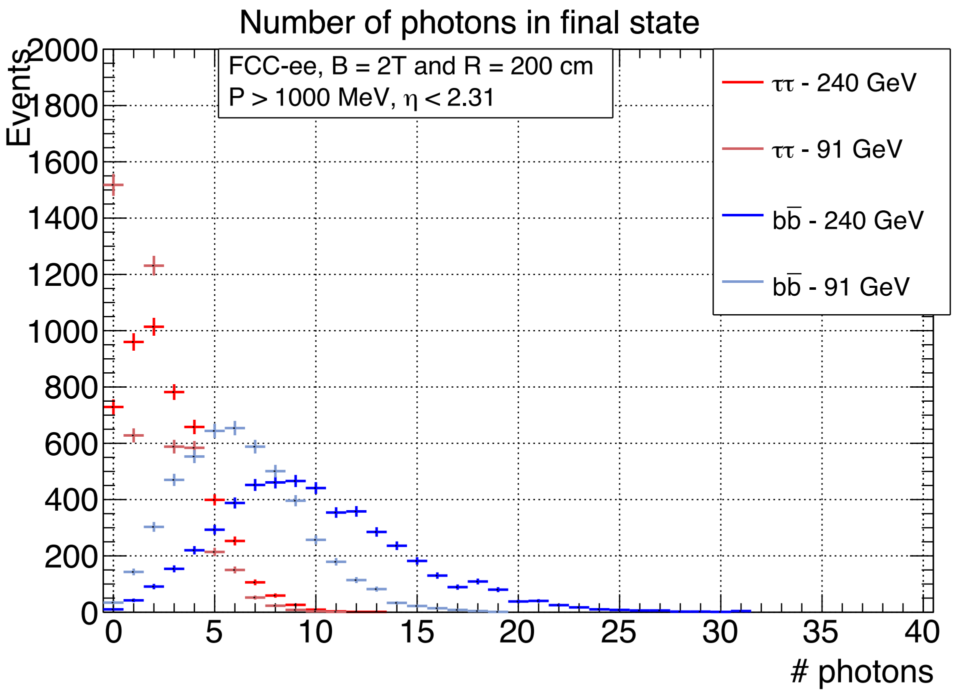
Final state particles

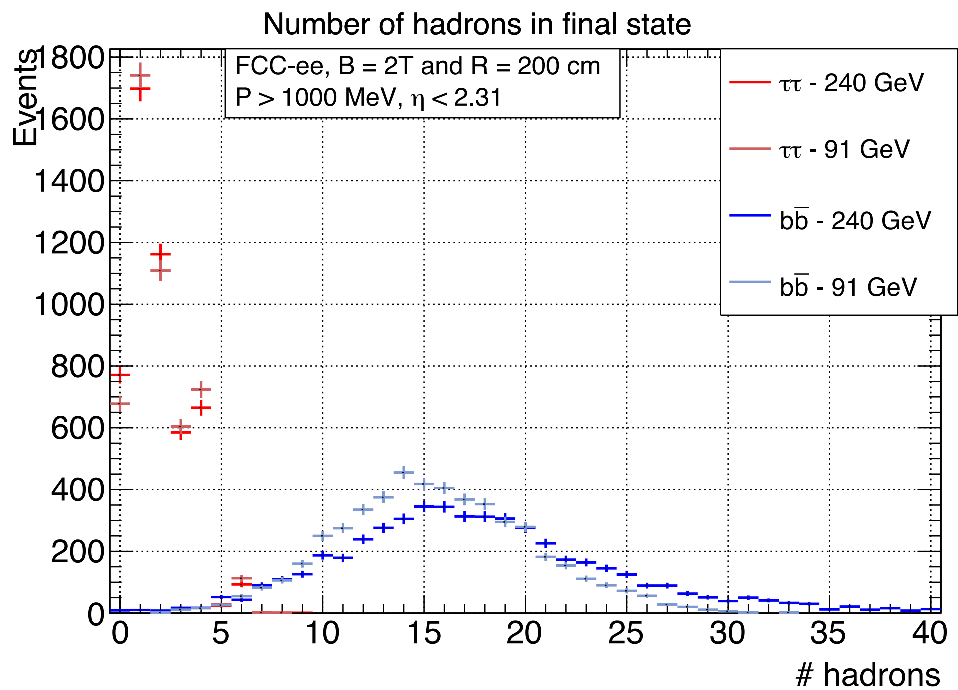
- Charged particles reaching a radius of 2m (P_T>0.6 GeV)
  - Charged leptons
  - Hadrons
- Neutral particles with P>1 GeV
  - Photons
  - Neutral hadrons





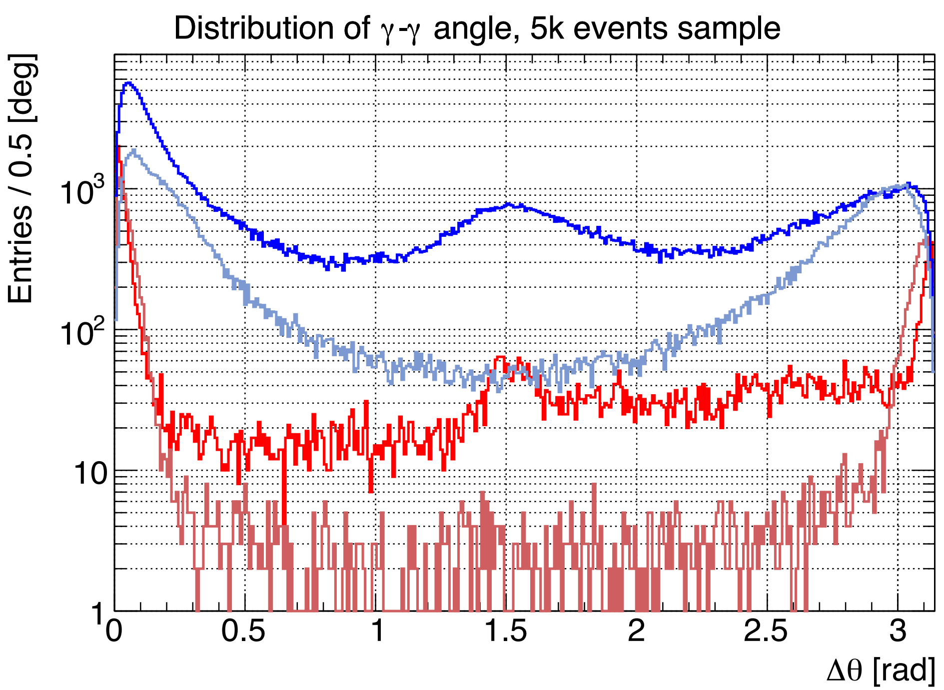
Production characteristic

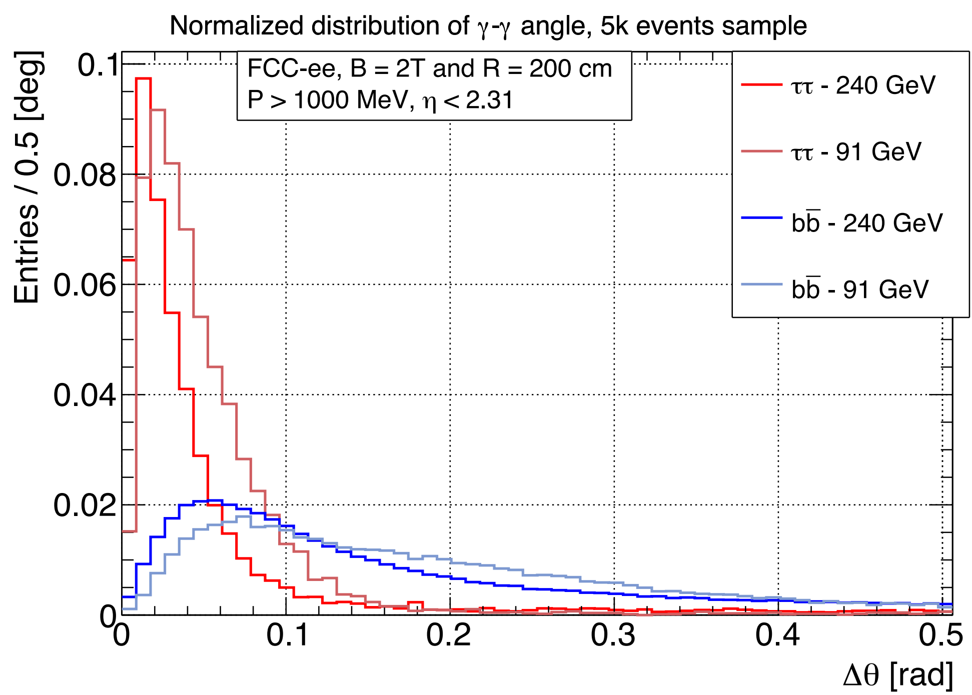




- Two opposite regimes:
  - b events are more crowded
  - tau events has less particles and narrower jets
- Both can contribute to limiting cases
- Center of mass energy change affect more photon production

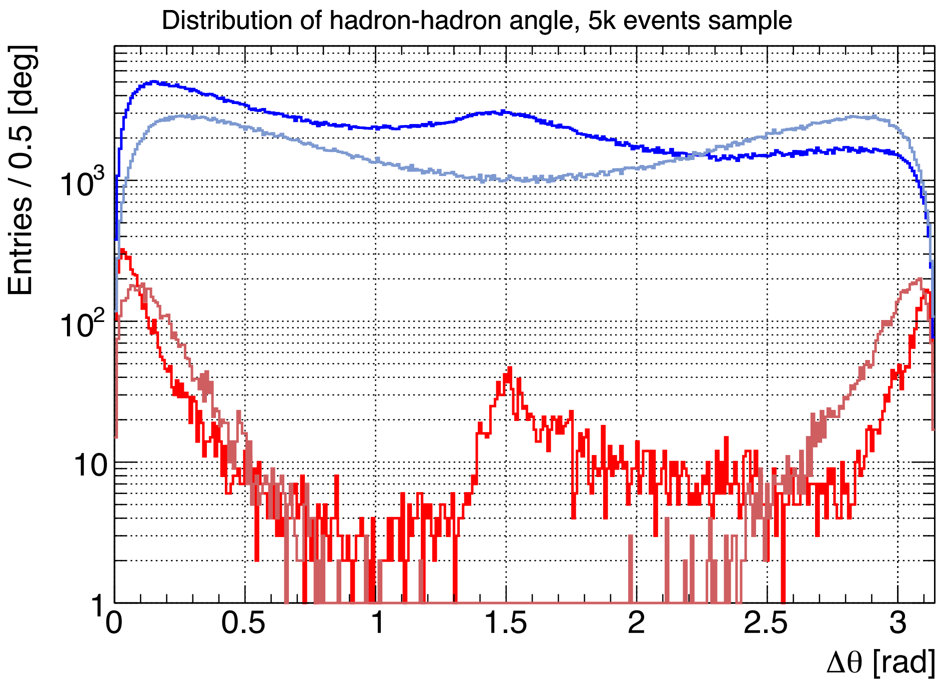
Photon-Photon

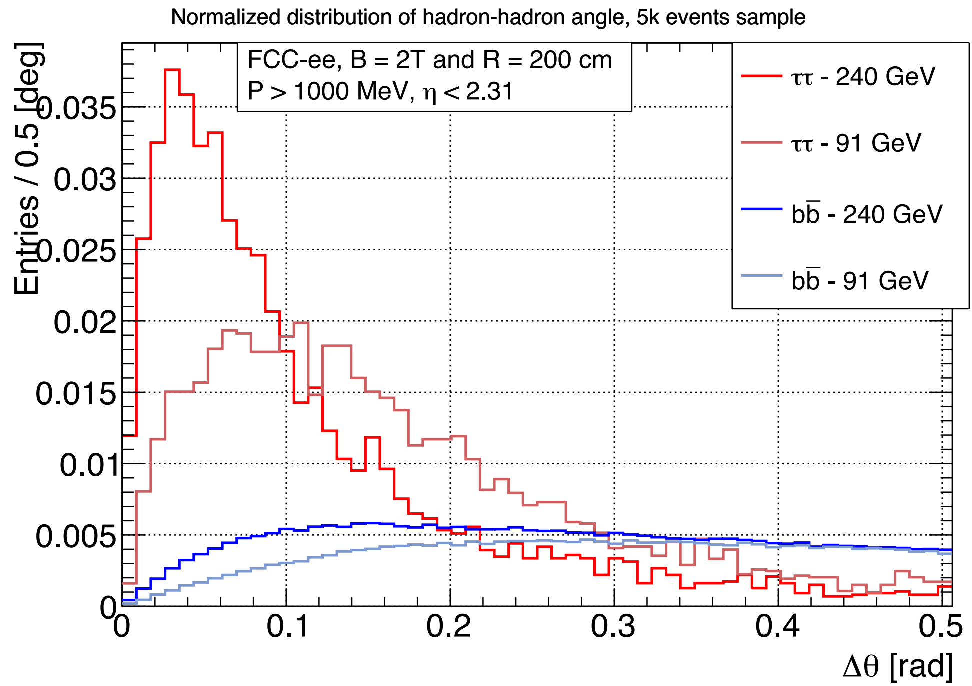




- Peak at small angles due to neutral pions
- Probability for γ pair from the same fermion to be in the same 10 cm pad:
  - ττ @ 240 GeV: 33%
  - ττ @ 91 GeV: 34%
  - bb @ 240 GeV: 6%
  - bb @ 91 GeV: 4%

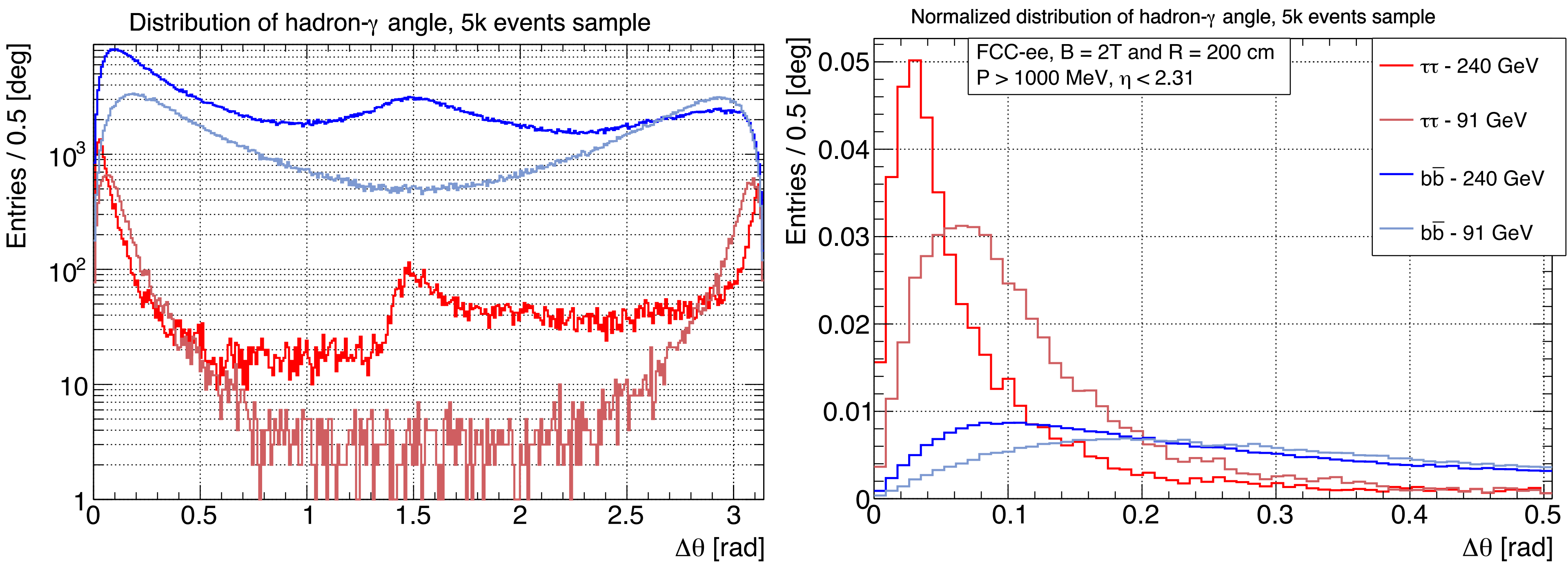
Hadron-Hadron





- Probability for 2 hadrons in the same fermion to be in the same 10 cm pad:
  - ττ @ 240 GeV: 28%
  - ττ @ 91 GeV: 10%
  - bb @ 240 GeV: 2%
  - bb @ 91 GeV: 1%

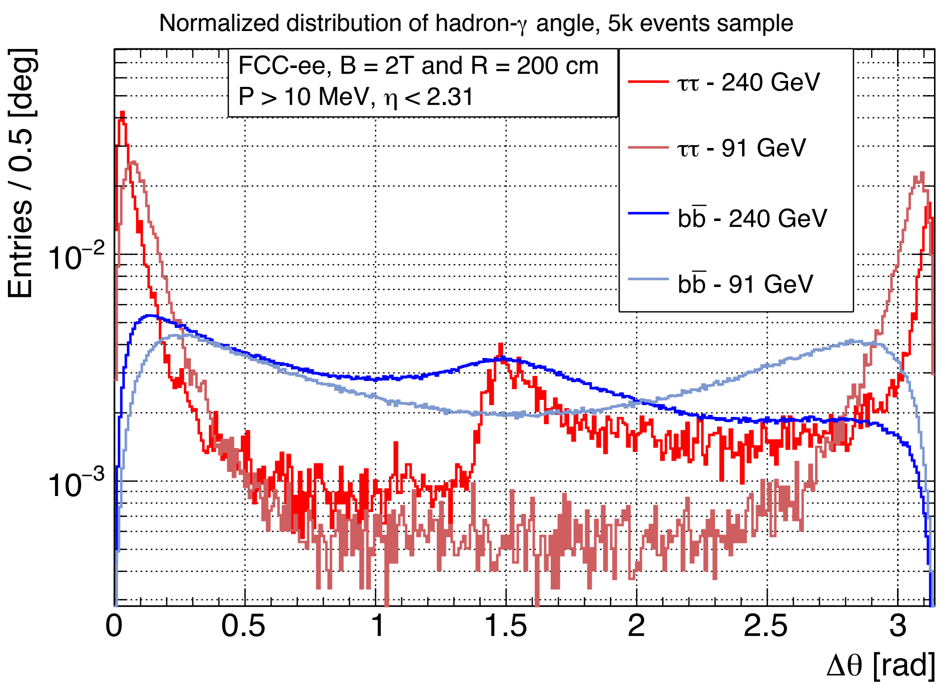
Hadron-Photon

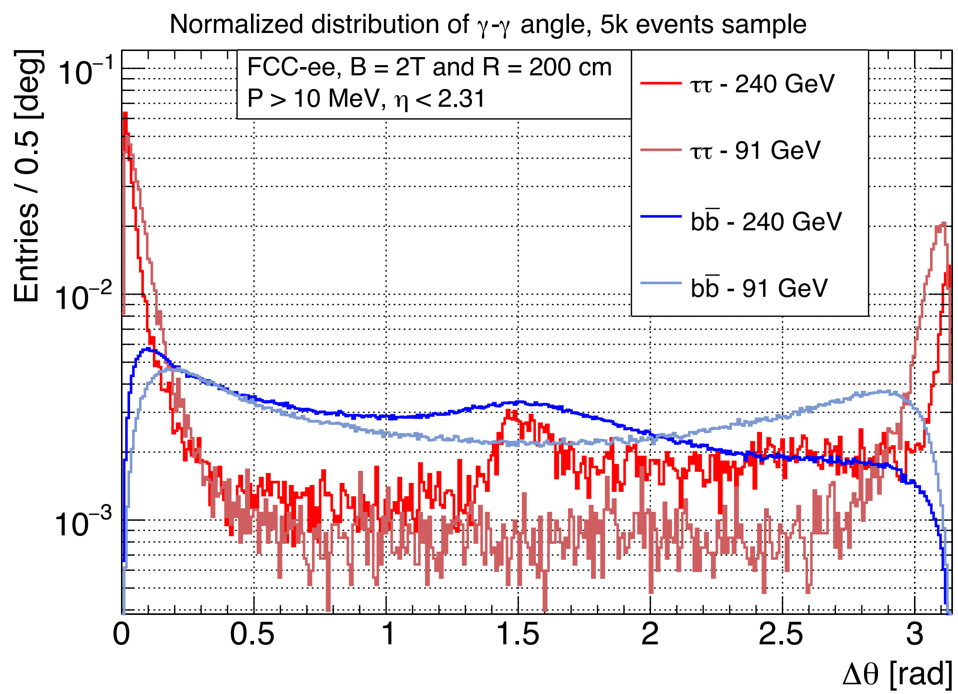


- Probability for hadron-photon pair from the same fermion to be in the same 10 cm pad:
  - $\tau\tau$ @ 240 GeV: 38%
  - $\tau\tau$ @ 91 GeV: 18%
  - bb @ 240 GeV: 4%
  - bb @ 91 GeV: 2%

Wider range

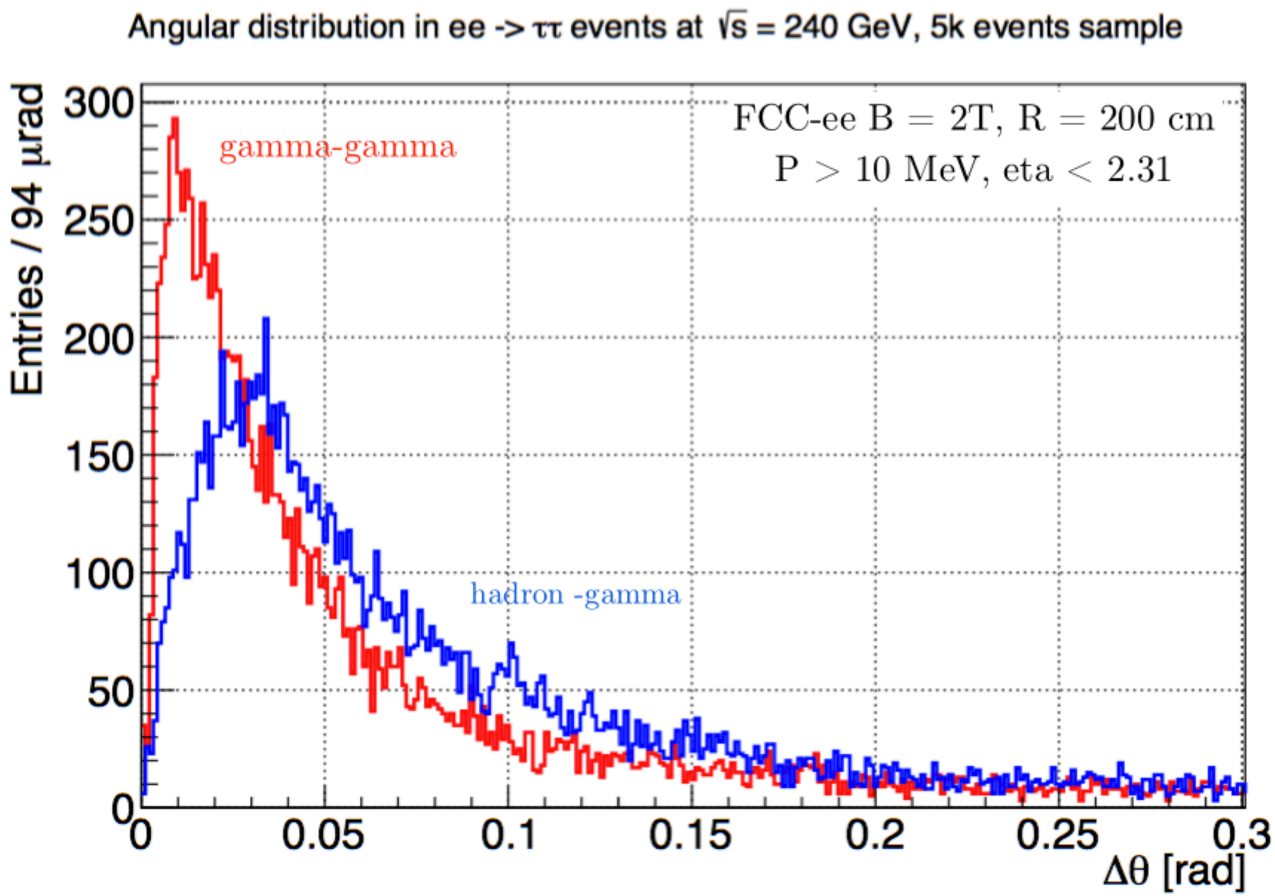
Looser energy cut: P>10 MeV





- Probabilities to be in the same 10 cm pad is lower than 2% in bb events
- tau events
  - Most stringent requirements from 240 GeV simulation

Collinear tau-tau production



- Probability for hadron-photon to be in the same 10cm pad: 38%
- Probability for photon-photon to be in the same 10cm pad: 55%
- About a factor 2 less if normalized to the whole event instead that per hemisphere

Conclusions

- At $\sqrt{s}$=240 GeV a large number of events has at least a pair of photons (P>1GeV) in 10x10 cm^2 area
  - 79 % of bb and 55% of tau events
  - If 2 layer only silicon strip modules are installed ambiguity will be dominant
- For hadrons pair this effect is much smaller (order 1%)
  - Charged particles propagation in magnetic field
- Typical distances between photon(P>1GeV) and hadron inside the same hemisphere
  - 5 cm for tau events @240 GeV (13 cm for 91 GeV)
  - 20 cm for bb events @240 GeV, much larger distribution