Status of π^0 reconstruction

Mario Merola, Elisa Manoni, Claudia Cecchi, Guglielmo de Nardo

9th Belle II Italian meeting

23/05/18

Outline

- *Official π^0 lists in software release-01*
- *π^0 and η in data*

π^0 lists in release-01-00

- Definition of photons and π^0 lists with fixed efficiency (max purity) based on energy, dt99 (time containing 99% of the signal), E1/E9 and invariant mass cuts

https://stash.desy.de/projects/B2/repos/software/browse/analysis/scripts/stdPhotons.py

- Lists optimized for Phase II backgrounds (BG16 campaign): "pi0eff20", 30, 40, 50, 60. Details in the Torben's talk:

https://kds.kek.jp/indico/event/25459/session/10/contribution/137/material/slides/0.pdf

- Define efficiency and purity as

$$\varepsilon = \frac{n(\gamma\gamma)_{matched\,\&\,sel}}{n(\pi^0)_{truth}}$$

$$P = \frac{n(\gamma\gamma)_{matched\,\&\,sel}}{n(\gamma\gamma)_{sel}}$$

matched: > 50% of the generated photon energy is matched to the ECLCluster digits

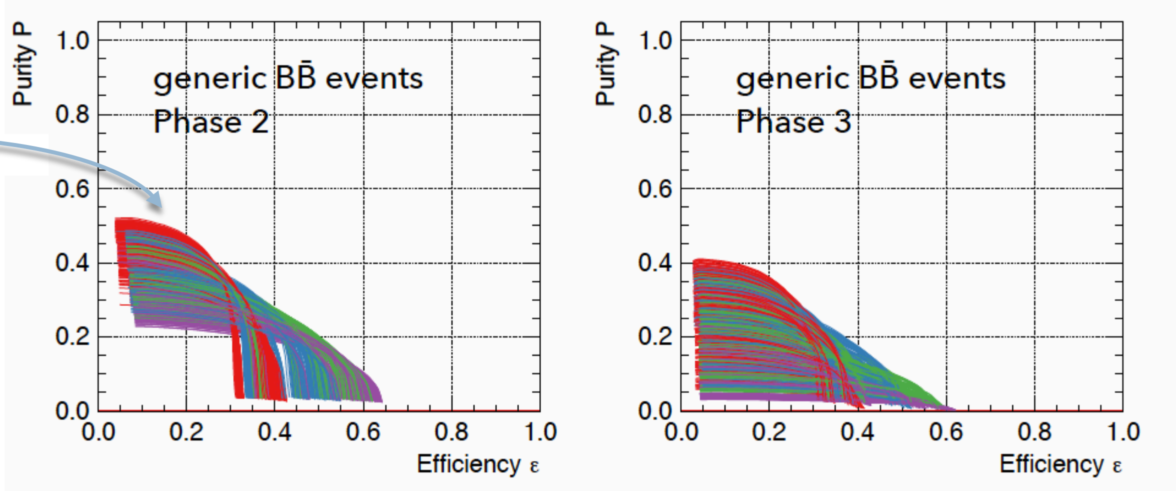
sel: selected by the pi0 list (in CDC acceptance)

truth: MC pi0s

π^0 efficiency and purity in MC

Purity vs efficiency

- E_{FWD}: (20, 30, 50, 75) MeV
- E_{BRL}: (**20**, **30**, **50**, **75**) MeV
- E_{BWD}: (20, 30, 50, 75) MeV
- abs(t/dt99): (0.5, 1.0) for E < (0, 100) MeV
- E1oE9: 0.5 for E < (0, 75) MeV



Each curve is obtained increasing the pi0 mass window

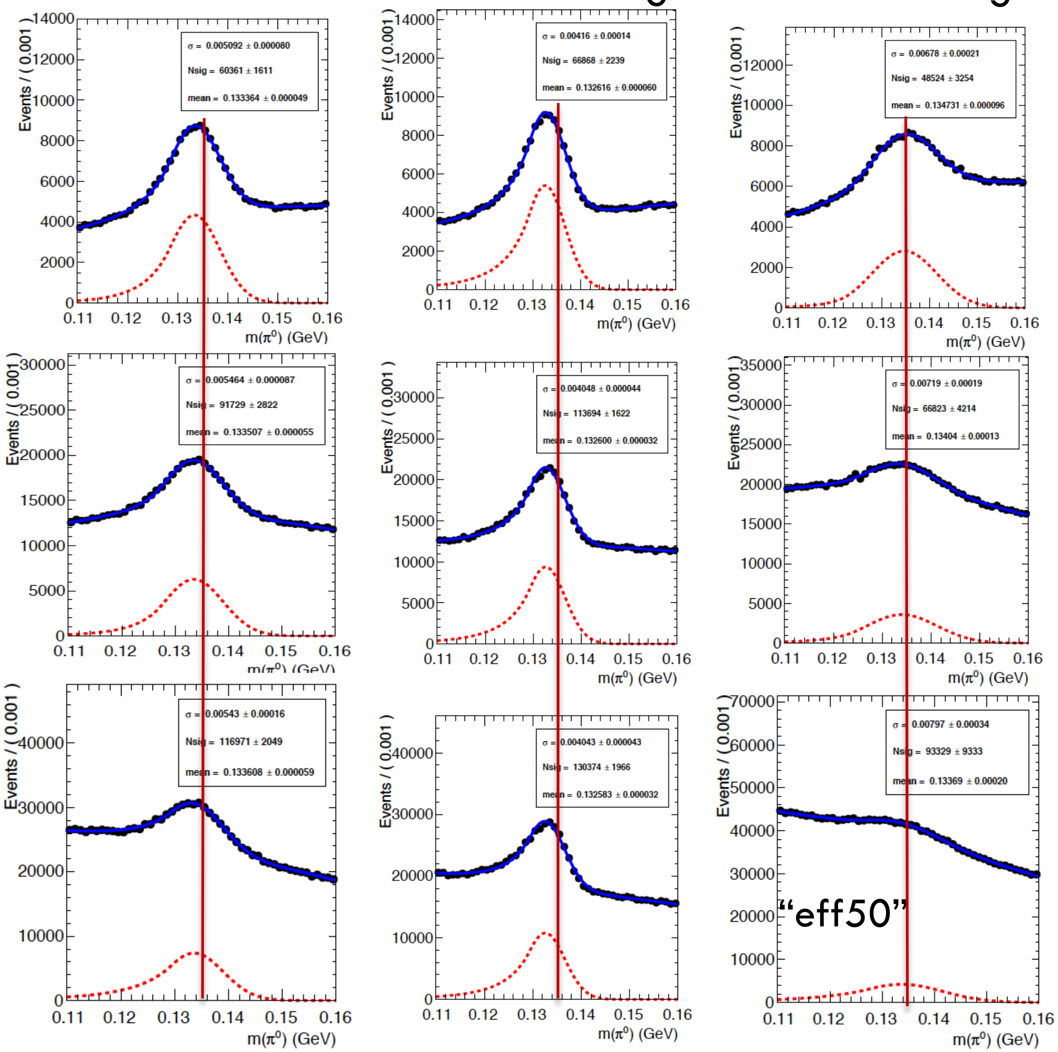
π^0 resolution in MC

Phase II | Phase III – bg0 | Phase III – bg1

pi0eff20

pi0eff40

pi0eff60



σ (MeV)	eff20	eff40	eff60
phase II – bg1	5.0	5.5	5.4
phase III – bg0	4.2	4.0	4.0
phase III – bg1	6.8	7.2	8.0 (eff50)

- Reasonable resolution, sensitive to bkg level
- Expected small shift in the central mass value towards lower π^0 mass due to photon low energy tails

π^0 and η in the first data and comparison with phase 2 MC

Data

- Experiment 3, runs 112-1355 (25 April – 12 May), corresponding to an integrated luminosity of about 5.6 / 5.9 pb^{-1} (measured with Bhabha / $\gamma\gamma$ events)
- Skimmed with 'hlt_hadron' flag, i.e. at least 3 tracks from the IP region and veto on Bhabha events.

Good tracks:
pt>0.15GeV,
|d0|< 2 cm,
|dz|< 5 cm

Selection: π^0 and η candidates are reconstructed pairing photons passing the following cuts:

- $E_\gamma > 150$ MeV (>300 MeV for η)
- #crystals per ecl cluster > 1.5
- E9/E21 > 0.9
- $17^\circ < \theta < 150^\circ$ (CDC acceptance)

π^0 and η in the first data and comparison with phase 2 MC

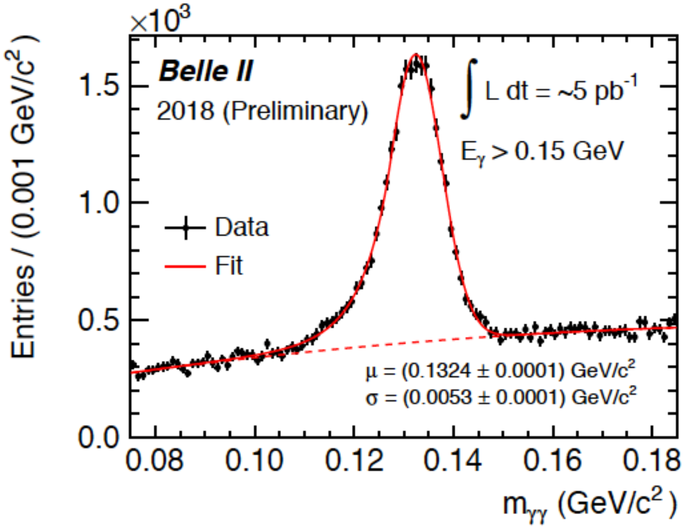
Data / MC samples skimmed with 'hadron_hlt':

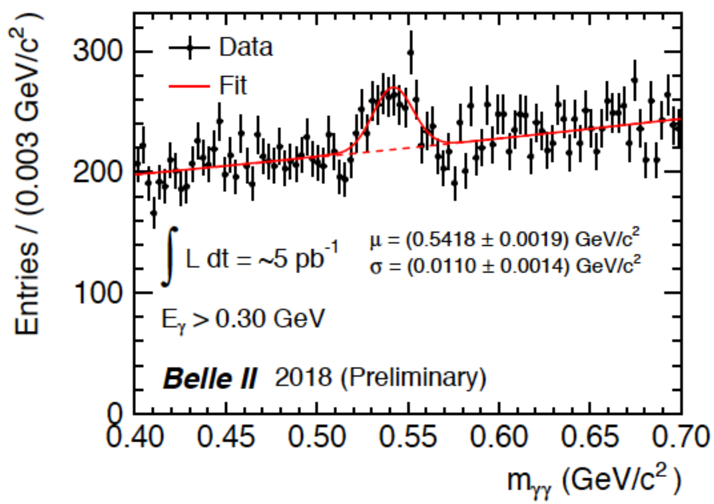
Data: /ghi/fs01/belle2/bdata/users/karim/skims/release-01-02-03/DB00000382/prod00000002/e0003/

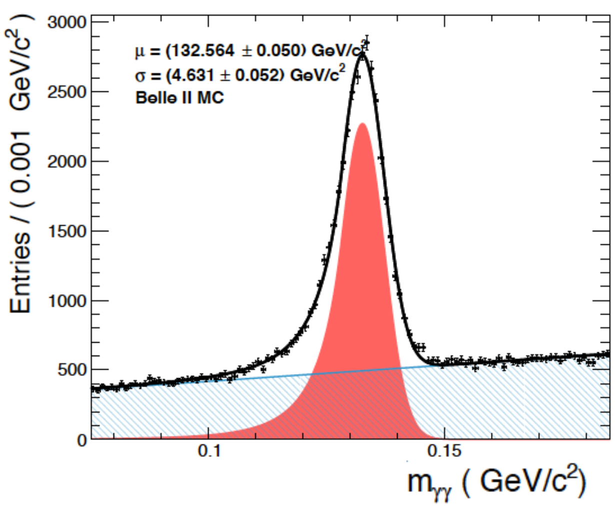
MC: /ghi/fs01/belle2/bdata/users/jbennett/release-01-00-02/DB00000294/MC10/

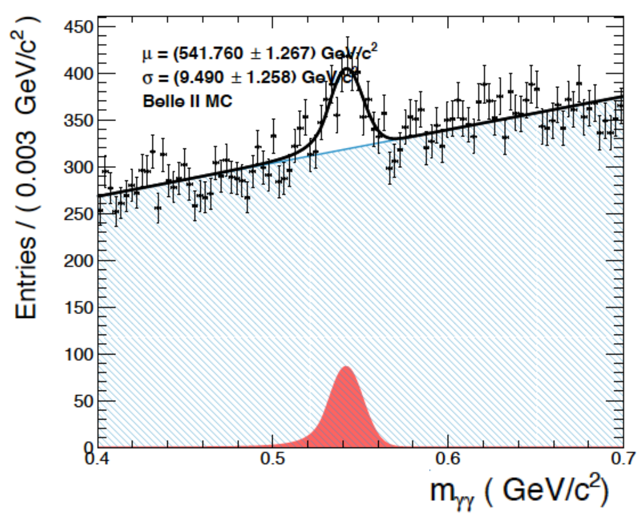
The skimmed MC samples (qqbar, tau pairs and generic BB) are Phase 2 MC10 with beam background.

π^0 and η in the first data and comparison with phase 2 MC









Summary and plans

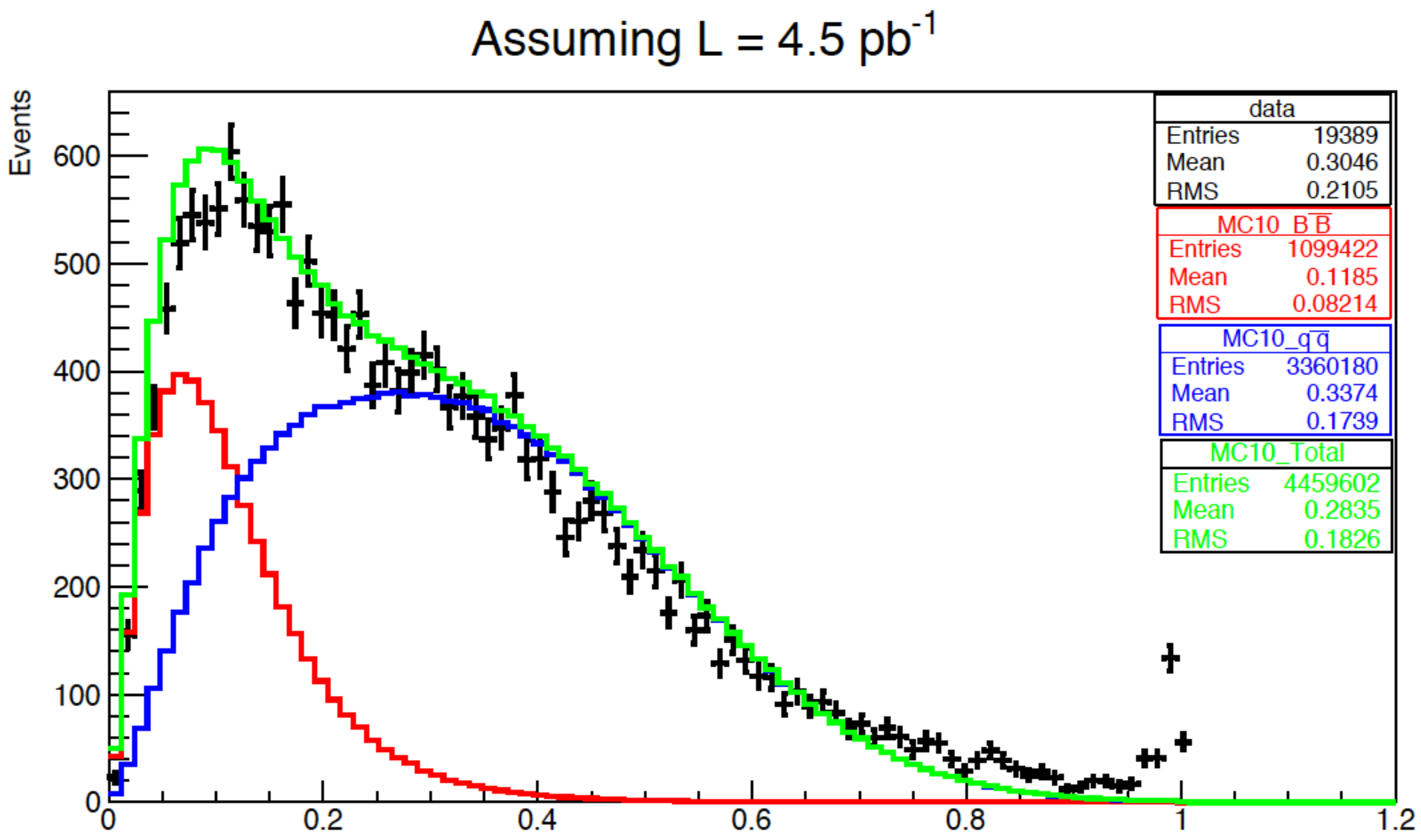
- Pi0 resolution determination depending on Crystal Ball + Chebyshev pol. fit stability. Consider instead fitting the pi0 peak and then taking the 68% range on the right and left: sigma_68 = (left_68+right_68)/2

- First look at data, clear pi0 and eta peaks. Comparison with MC10 shows a reasonable agreement with the following caveat:
  - 1 cm shift of the IP point for some runs → impact on photon kinematics
  - Energy scale correction of about 2% → precise (crystal-by-crystal) calibration needed
  - ECL timing shift by -45 ns (to be fixed in FPGAs) → overestimation of background and energy corrections

- Next steps:
  - Beam bkg overlay using real bkg events ?
  - MC normalization to data using official luminosity measurements

From Torben's talk at Software Workshop

Backup


Assuming L = 4.5 pb-1
Events
600
500
400
300
200
100
0
0.2
0.4
0.6
0.8
1
1.2
data
Entries 19389
Mean 0.3046
RMS 0.2105
MC10_B B
Entries 1099422
Mean 0.1185
RMS 0.08214
MC10_q q
Entries 3360180
Mean 0.3374
RMS 0.1739
MC10_Total
Entries 4459602
Mean 0.2835
RMS 0.1826

R2

KL lists

- Default K_L particle lists for analysis have been defined
- Currently they are based on KLM clusters only:
  - all: for study and debugging
  - veryloose: $0.5 < E < 10$ GeV, $-10 < t < 100$ ns
  - loose (default): requires in addition KlId* (from MVA) > 0.04
  - tight: KlId > 0.2
- Cuts (as well as KlId) are tuned on K_L from generic $B\bar{B}$
- Available in master (b1cdef50b9638f220467c6a588b1be16dd363586)
- Definitions will be refined as we gain experience in K_L analyses

*https://confluence.desy.de/pages/viewpage.action?spaceKey=BI&title=Klong+ID

KL lists efficiencies

- For generic $B\bar{B}$:

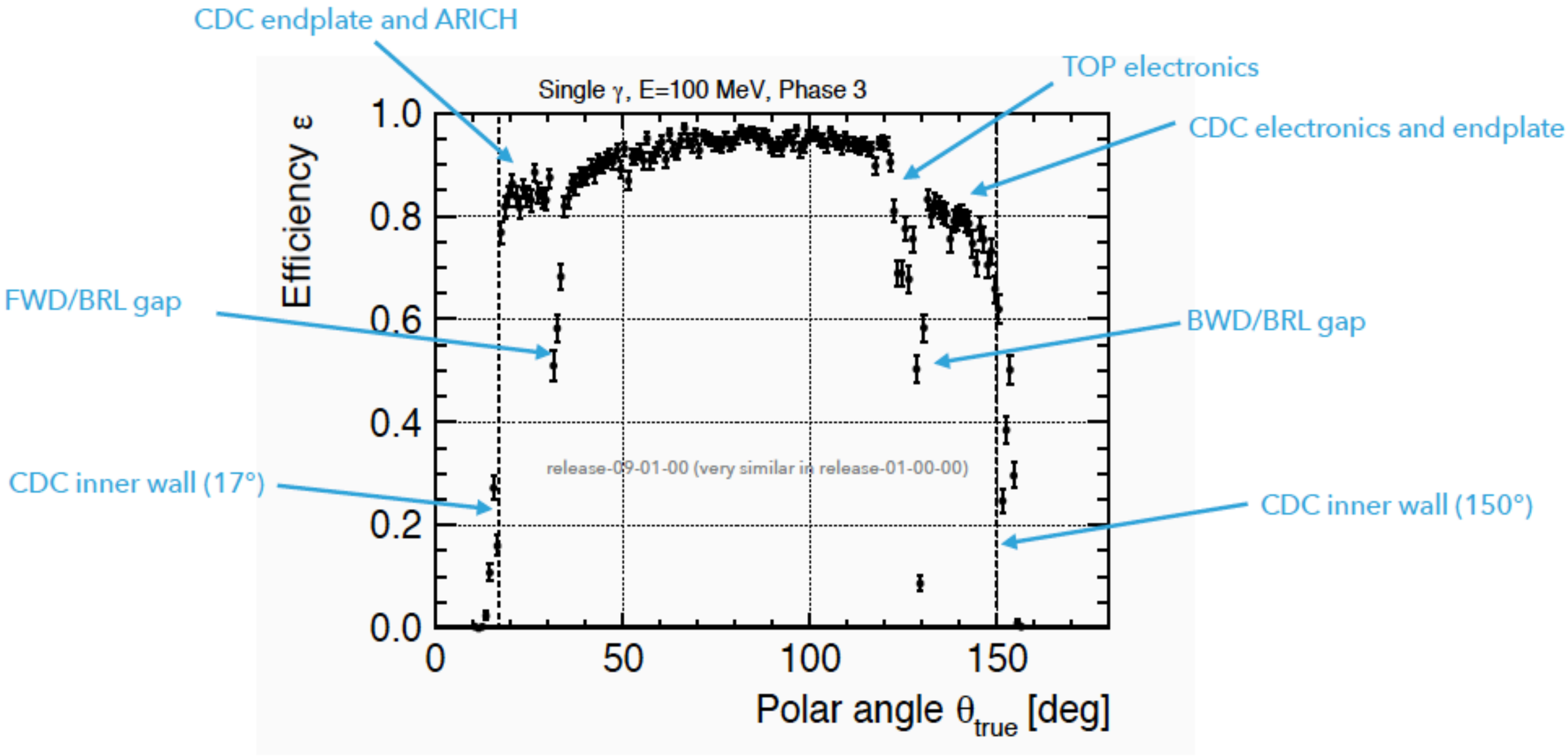
Bkg 0x **Bkg 1x**

	all	veryloose	loose	tight
Eff. (%)	23.5 (24.6)	20.6 (21.8)	18.9 (20.2)	10.1 (10.9)
S/S+N (%)	7.7 (5.2)	7.7 (7.2)	18.0 (13.8)	34.5 (33.6)
Multip./evt	2.6 (3.4)	2.3 (2.7)	1.5 (1.8)	1.2 (1.2)

- In general single K_L cluster multiplicity > 1
- Efficiency = (# K_L with al least 1 matched cluster) / (# MCTruth-K_Ls)
- Purity = (# Truth-matched clusters) / (all clusters)

Photon efficiency in basf2 (MC)

By far largest effect on photon (in-)efficiency are pair conversions. Pair conversions occur in material: We need the correct material in our geometry.



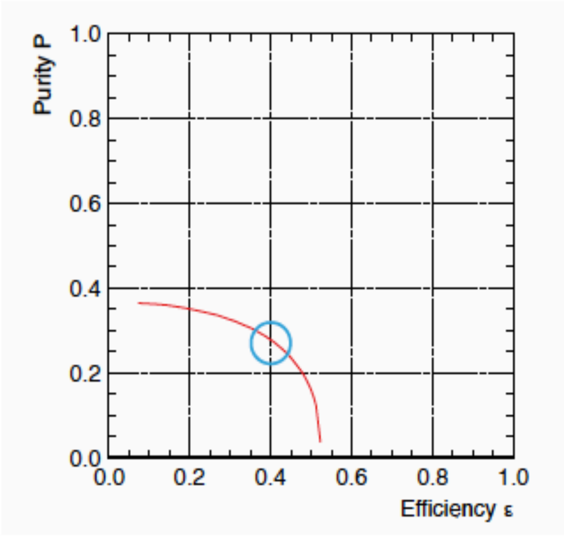
Note about MC matching

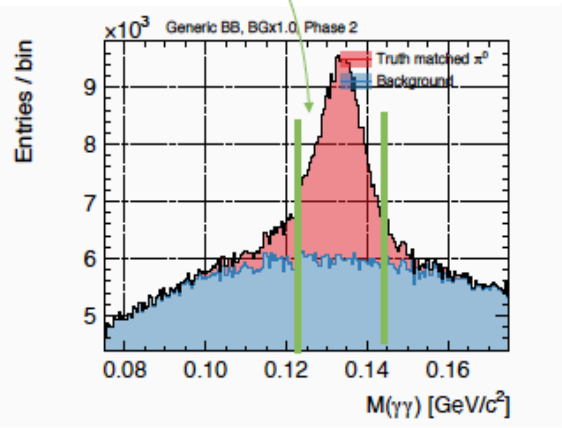
- Difference between nominal and “measured” efficiency due to the different definitions of mc matching at analysis level and at ecl clusters level
  - at analysis level I simply require that the reconstructed photon has at least 50% of the energy of the true photon ***
  - at ecl cluster level we require that at least 50% of true photon energy is deposited in the crystals belonging to that cluster (crystals can be shared among different clusters)

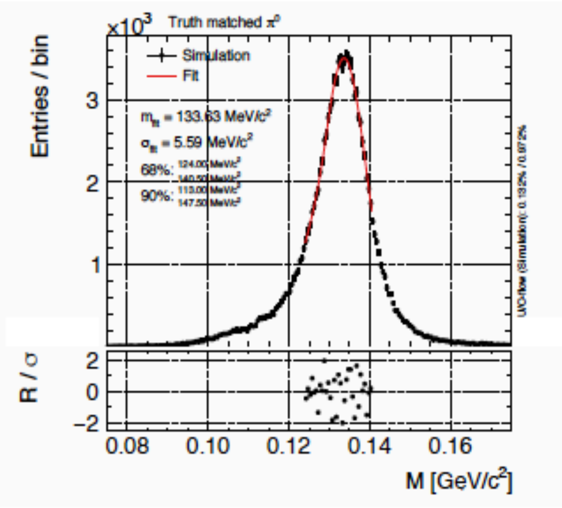
*** Caveat: the modular analysis MC matching **by default** requires that the fraction of the energy deposited by the MC particle in the crystals belonging to the cluster is at least 20% of the total cluster energy and at least 30% of the true photon energy ⟶ need to be studied and optimized
https://confluence.desy.de/display/BI/Photon+and+ECL+variables

Purity vs efficiency: example ε=0.4

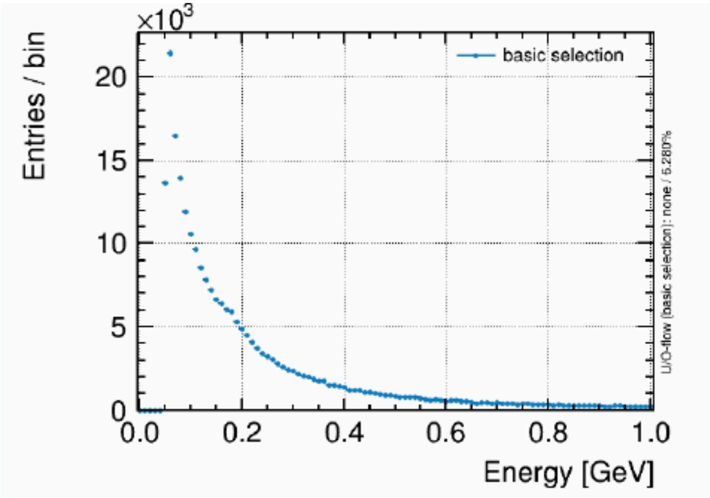
	eff	pur	massmin	massmax	eminfwd	eminbrl	eminbwd	emindt99	dt99	emine1oe9	e1oe9
275	0.4	0.2781	0.1227	0.1413	0.075	0.03	0.075	0.1	0.5	0.1	0.5
284	0.4	0.2769	0.1195	0.1435	0.075	0.03	0.050	0.1	0.5	0.1	0.5
270	0.4	0.2739	0.1240	0.1405	0.075	0.03	0.075	0.1	1.0	0.1	0.5
205	0.4	0.2734	0.1064	0.1571	0.075	0.05	0.075	0.1	1.0	0.1	0.5
207	0.4	0.2734	0.1064	0.1571	0.075	0.05	0.075	0.1	0.5	0.0	0.5

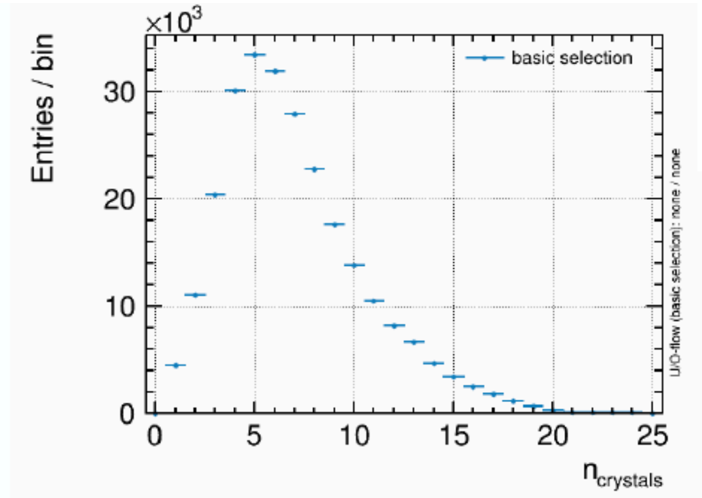




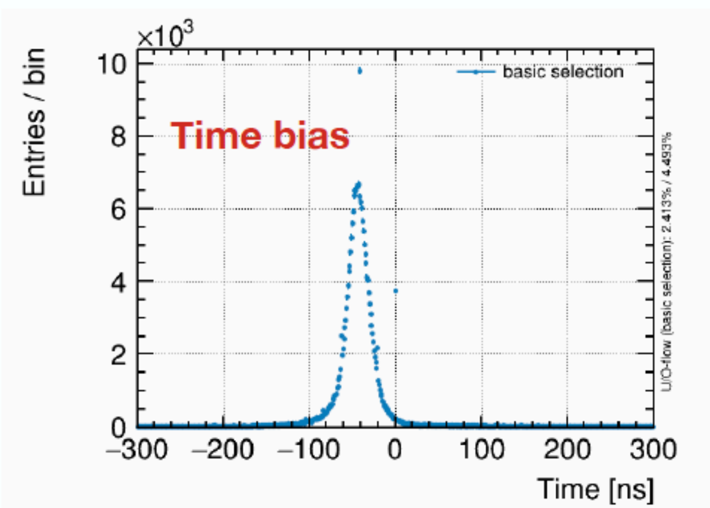


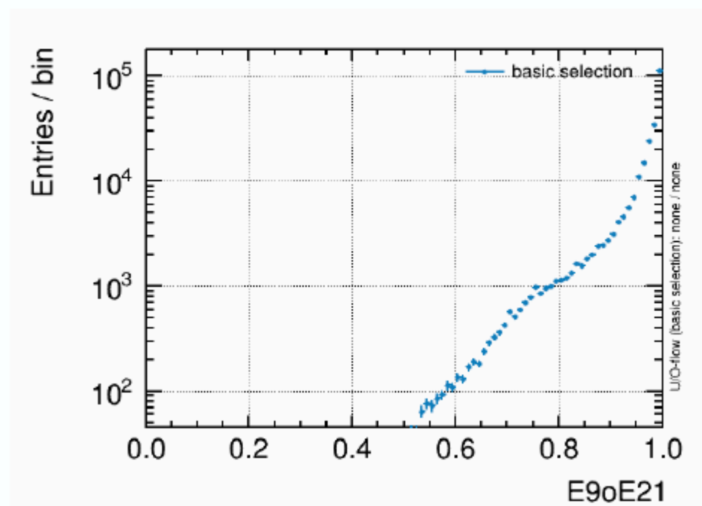
Photons in data





> 0 good tracks
> 1.5 crystals
in CDC acceptance





Systematics

Chris Hearty