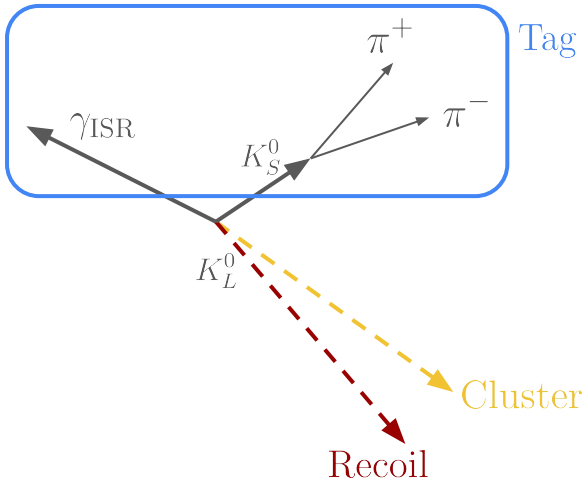
# Service task

**KL efficiency integration in the Systematic Framework**

$$e^+e^- \to \Phi(K_S^0 K_L^0)\gamma_{\mathrm{ISR}}$$

- Clean environment
- Strong signature: 1 hard photon and 2 pion tracks (KS)
- Correct the γ ISR energy using the 2-body decay hypothesis of the initial ($e^+e^-$) and intermediate (Φ) states
- Calculate the recoil/missing momentum of γ ISR and KS to get the expected 4-momentum of KL ➡ ***tag events***
- Search KLM clusters and/or ECL clusters along the pMiss direction ➡ ***probe events***

KL identification efficiency $\varepsilon = \dfrac{N^{\mathrm{sig}}(\mathrm{probe})}{N^{\mathrm{sig}}(\mathrm{tag})}$



# Service task

***Ideal workflow*** (as for the PID systematic studies)

1. Produce ntuples and apply selections to tag events
2. Fit the recoil mass and obtain sWeights (centrally once)
3. Provide ntuples with sWeigths to users (centrally once)
4. Each user applies the cluster selections (to data and MC samples) and count the sWeighted passed events

→ ***Warning:*** sWeights work correctly if correlations between recoil mass and cluster variables are small

***First step:*** fit the recoil mass distribution for both tag and probe events, and check for any effects of changes in the shape of the recoil mass distribution before and after cluster selections

# Service task

**Data:** phigamma skim release 6, exp18

**MC:** MC15rd, hhISR collection, exp18

**Tag events:**

- $E^*(\gamma) > 4.7$ GeV
- $\gamma$ ISR energy correction
- $0.490\ \text{GeV}/c^2 < m(KS) < 0.504\ \text{GeV}/c^2$
- $-0.85 < \cos\theta(KS) < 0.95$
- $0.4\ \text{GeV}/c^2 < m\text{Recoil} < 0.53\ \text{GeV}/c^2$
- $1.3\ \text{GeV}/c < p\text{Miss} < 4.5\ \text{GeV}/c$
- 1 KS and 1 $\gamma$ ISR which pass previous cuts

**KLM cluster candidates:**

- KLM cluster with the smallest angle to pMiss

**ECL cluster candidates:**

- ECL cluster with the smallest angle to pMiss

**KLM&ECL cluster candidates:**

- KLM cluster with the smallest angle to pMiss
- ECL cluster with the smallest angle to pMiss

**NB:** to determine KL-ID efficiency, additional selections must be applied (KLM cluster layers, ECL cluster energy, …)

# Service task

**Fit model:**

- **Signal peak:** double sided Crystal Ball function (mu, sigmaL, sigmaR, alphaL, nL, alphaR, nR)
- **Background:** Argus function (c, end-point, p)

- Fit the recoil mass distribution for MC events
- Comparison between the signal yield estimated with the fit and the true signal yield
- Fit the recoil mass distribution for real data

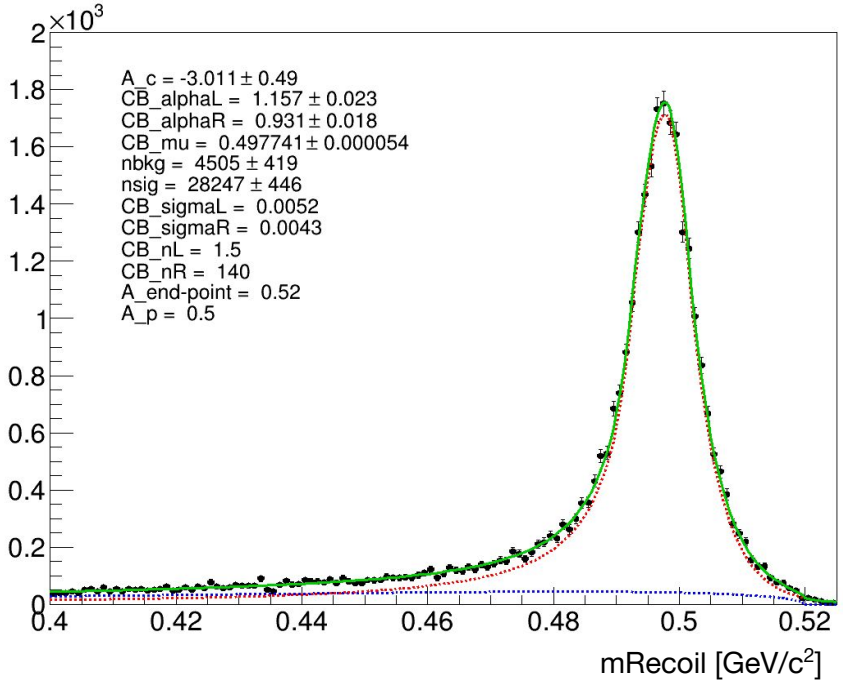
**NB:** true signal events are selected from the true KLs produced in the MC that are tagged

| | MC | Data |
|---|---|---|
| CB_mu | free | free |
| CB_sigmaL | 0.0052 | 0.0052 |
| CB_sigmaR | 0.0043 | 0.0043 |
| CB_alphaL | free | free |
| CB_nL | 1.5 | 1 |
| CB_alphaR | free | free |
| CB_nR | 140 | 120 |
| A_c | free | free |
| **A_end-point** | **0.52** | **0.525** |
| A_p | 0.5 | 0.5 |
| nsig | free | free |
| nbkg | free | free |

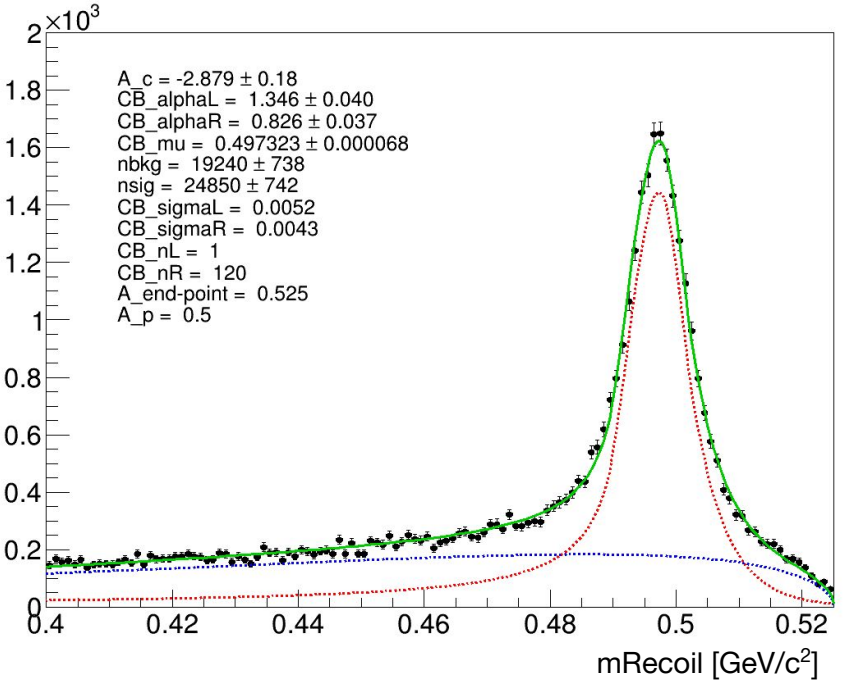
# Service task

## Tag events

**MC15rd, hhISR, exp18**



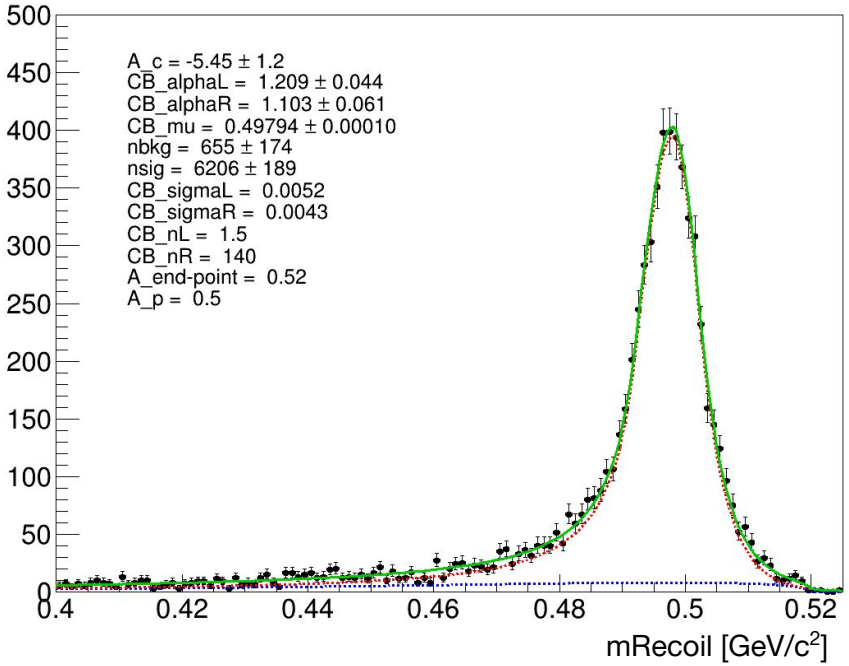

**Data, rel6, exp18**



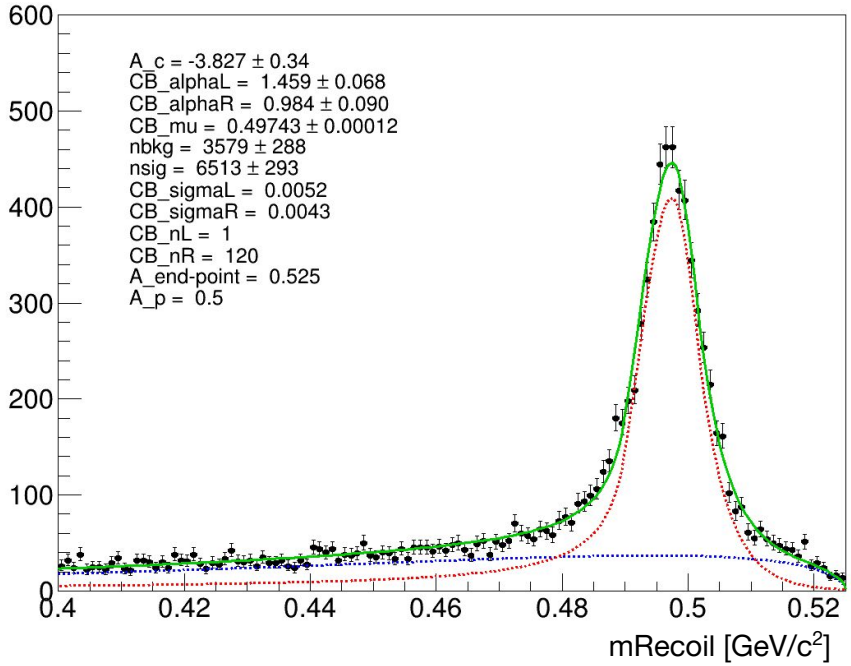
# Service task

## Probe events: KLM cluster candidates

**MC15rd, hhISR, exp18**



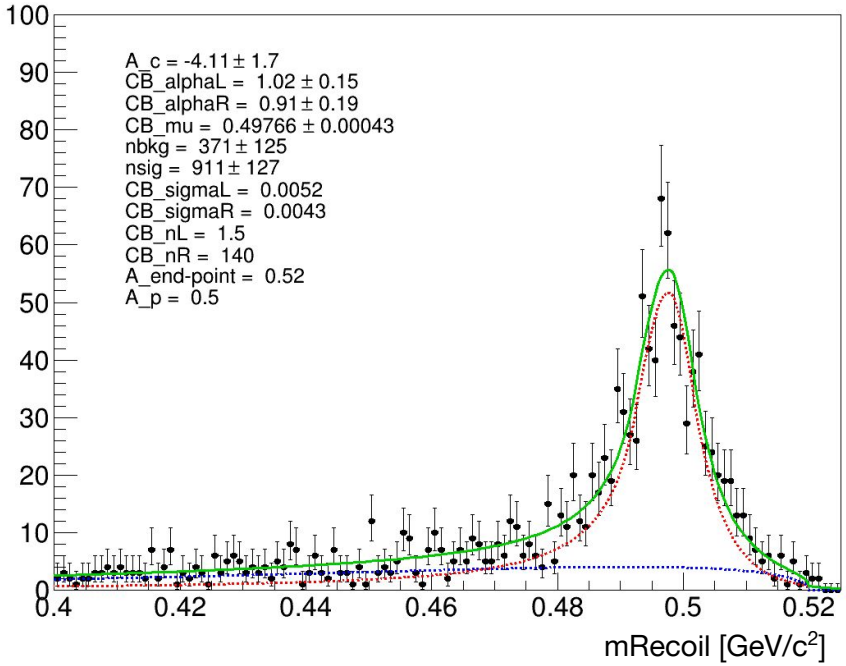

**Data, rel6, exp18**



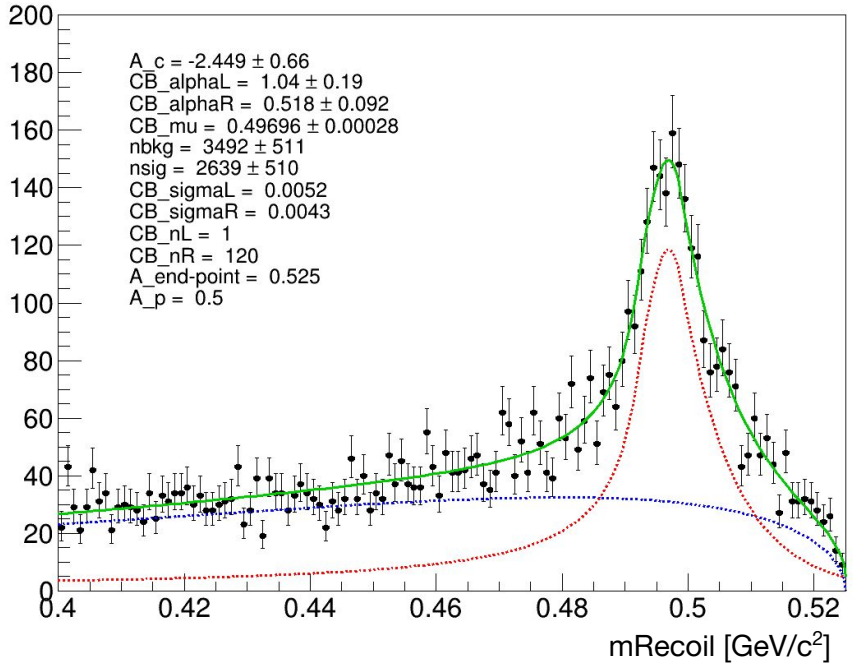
# Service task

## Probe events: ECL cluster candidates

### MC15rd, hhISR, exp18



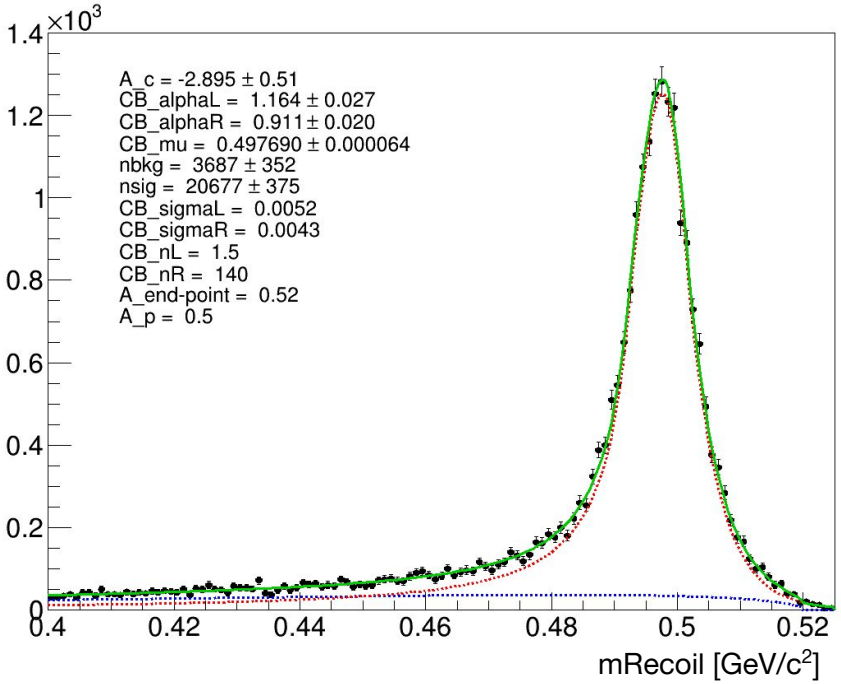

### Data, rel6, exp18



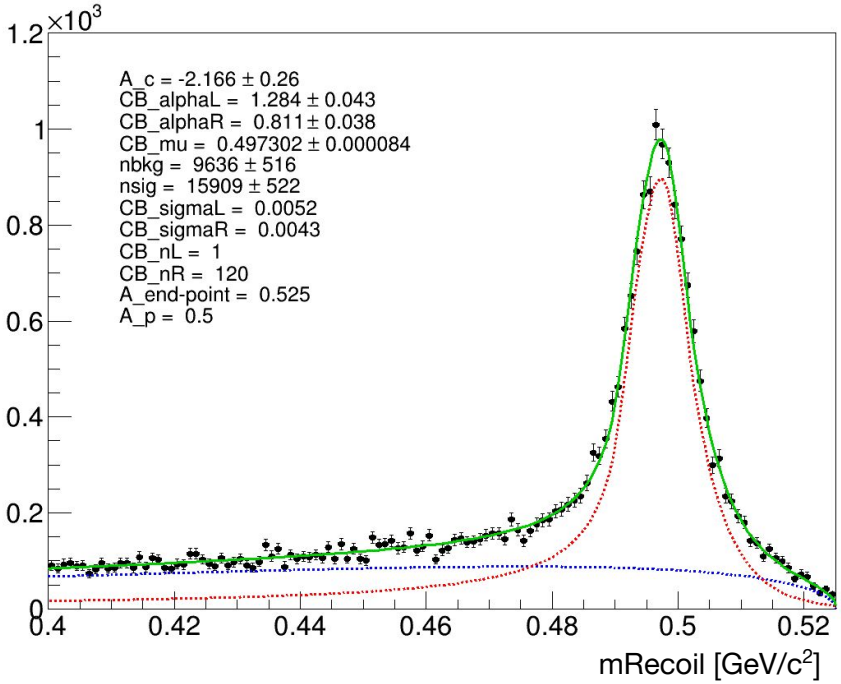
# Service task

## Probe events: KLM&ECL cluster candidates

**MC15rd, hhISR, exp18**




**Data, rel6, exp18**



# Service task

***First step:*** fit the recoil mass distribution for both tag and probe events, and check for any effects of changes in the shape of the recoil mass distribution before and after cluster selections

- ➡ We observe **changes in the background shape before and after cluster selections**, in both the MC and data
- ➡ We observe **changes in the background shape based on missing moment region**, in both the MC and data

***Second step:***

- **calculate sWeights for tag events only**
- determine the signal yields for probe events by counting the sWeighted events that pass cluster selections
  - ➡ comparison between the signal yield for sWeighted events and the signal yield estimated with the fit

# Service task

| | MC15rd, hhISR, exp18 | | | | | Data, rel6, exp18 | | |
|---|---|---|---|---|---|---|---|---|
| | MC | **Fit** | diff. (%) | **sWeights** | **diff. (%)** | **Fit** | **sWeights** | **diff. (%)** |
| TAG | 28659 | 28247 | 1.4 | 28247 | / | 24850 | 24850 | / |
| KLM | 6511 | **6206** | 4.7 | **6488** | **4.5** | **6513** | **7164** | **10** |
| ECL | 879 | **911** | 3.6 | **900** | **1.2** | **2639** | **2023** | **23** |
| KLM&ECL | 21078 | **20677** | 1.9 | **20674** | **0.01** | **15909** | **14999** | **5.7** |

*Second step:*

- calculate sWeights for tag events only
- determine the signal yields for probe events by counting the sWeighted events that pass cluster selections

➡ **For real data, the relative difference between the signal yields is quite large in all the cases** (KLM, ECL and KLM&ECL)

# Service task

## KL efficiency integration in the Systematic Framework

Produce only ntuples without fitting the recoil mass distribution in the Systematic Framework

- Allow users perform the fit before and after their selections
- Provide some examples of analysis scripts

Provide ntuples with sWeigths calculated centrally once

- One sWeight for each representative (KLM and/or ECL) cluster selection
- Accept large systematic uncertainties in the estimation of signal yields
- This might be error prone for inexperienced users

*To do:*

- Add MC15rd usd, ccbar, tautau (for exp18)
- Check all possible cluster variables to be used for selections
- Start producing ntuples in the Systematic Framework