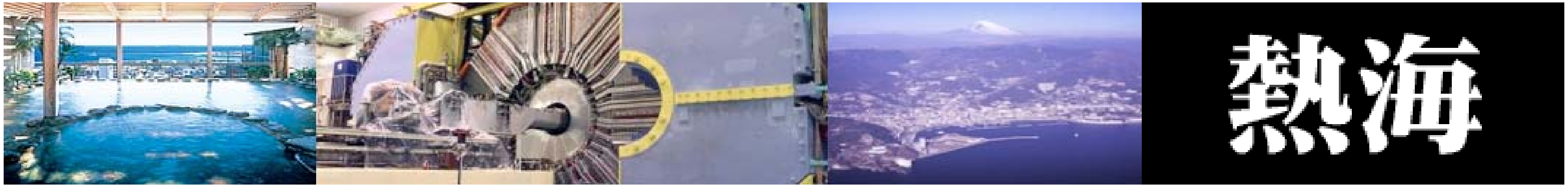

BNM 2008, 3rd Int. Workshop on B Factories and New Measurements
Atami, Japan, January 24-26, 2008

Fast simulator for Super-Belle

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In summer 2007, we started to work on fsim6(*), a fast simulator for Belle/Super-Belle; today I will tell you:

1. Why we are interested in a fast simulation for Super-Belle?

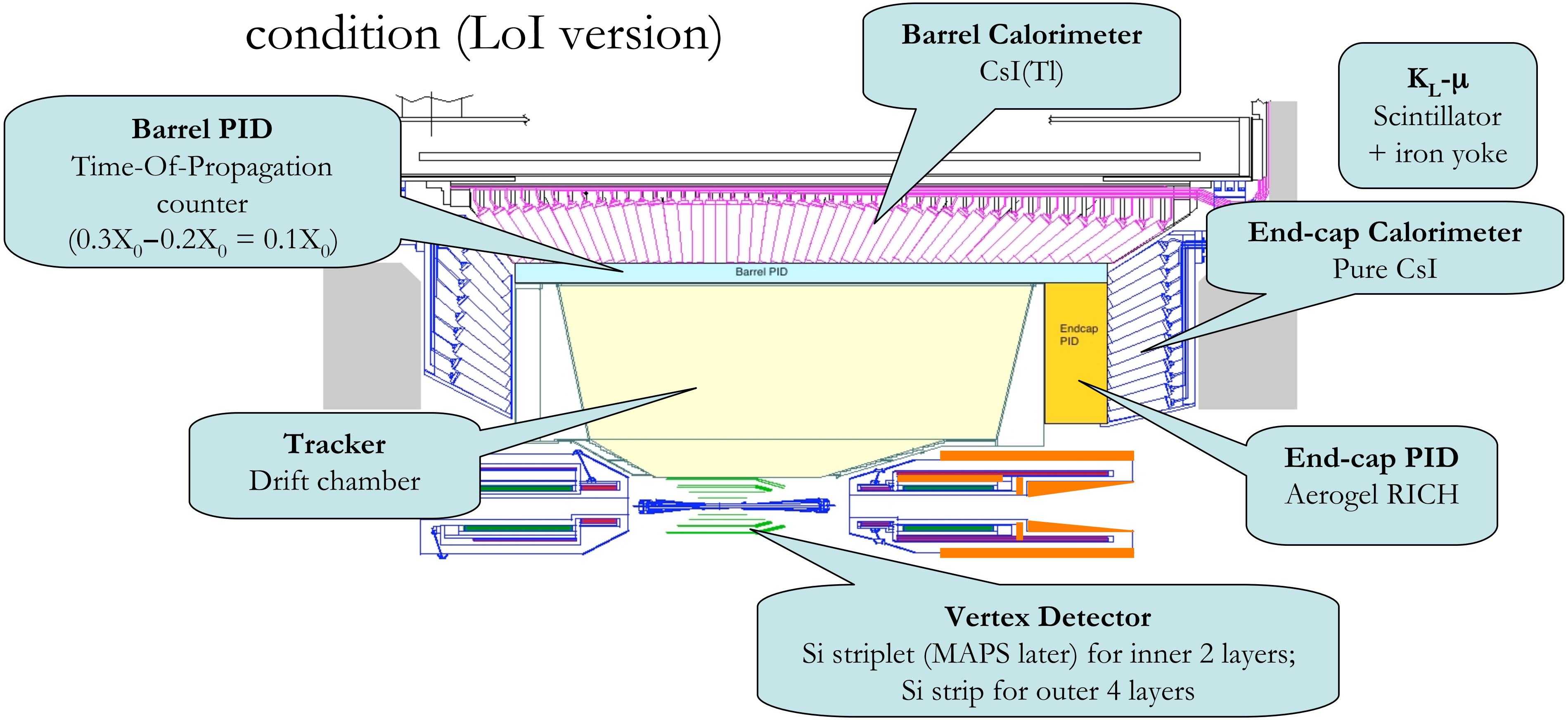
2. What has been implemented so far?

3. What we are working on at the moment?

(*) fsim6 is a rewrite of the old Belle fast simulator fsim5 in C++

Baseline Design

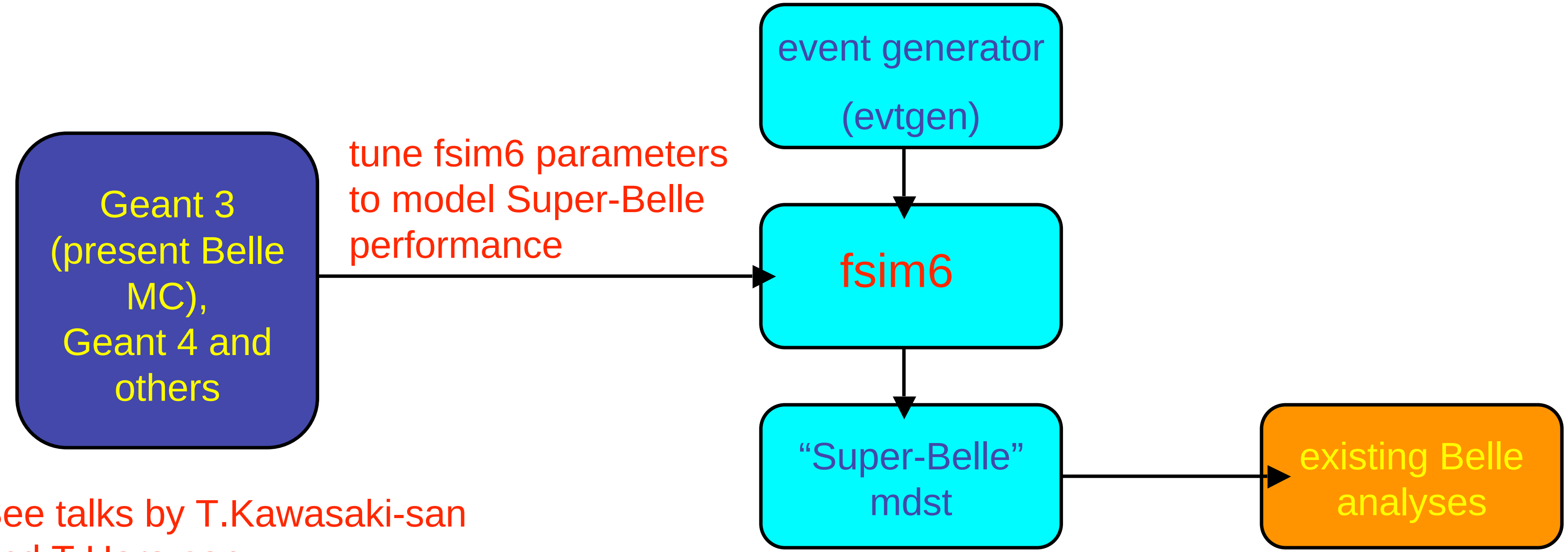
Performance same as Belle under 20 times higher background condition (LoI version)



SuperKEKB Letter of Intent (LoI) (KEK Report 04-4)

Motivation

- Validate the LoI design using a couple of benchmark physics analyses
  - TCPV in $B \rightarrow \phi K_s$, $\pi\pi$, …
  - $B \rightarrow \tau\nu$, $D^{(*)} \tau\nu$ (missing energy modes)
  - $\tau \rightarrow \mu\gamma$ (LFV)
  - …
- Feedback from physics analysis to detector design
  - Material budget of inner detectors
  - Beam pipe radius
  - Requirements on particle id.
  - …



See talks by T.Kawasaki-san and T.Hara-san

- Fsim6 is tuned using full detector simulation
- Fsim6 output should be as close as possible to present Belle mdst, to take advantage of existing Belle analyses

→ Large data sets and different detector setups can be studied quickly in terms of actual physics performance in the benchmark modes

What fsim6 can do

- Estimate signal efficiency and number of expected events
- Estimate resolution in different observables
- Assess performance of part. id. and related objects (flavor tag)
- Estimate backgrounds as long as they mainly come from physics processes

What fsim6 can't do

- Estimate backgrounds that mainly come from the detector or beam background
- Simulate different background conditions, a change of the beam pipe radius, the B field, the material in the detector, …
  - These things must be simulated using Geant (or else) and then implemented into fsim6
  - fsim6 just parameterizes the detector performance
  - It doesn't know how these parameters change

Present fsim6 status (2007121400)

	done?	
Tracking (helix param. resolution and correlations)	yes	Only present Belle tuning available
Neutrals	yes	Tuning for two Super-Belle scenarios (‘realistic’ and ‘conservative’)
ATC (part. id. based on aerogel counter, time-of-flight and drift chamber)	yes	It ‘works somehow’, code for Super-Belle part. id. present
Electron id.	no	Working on implementing track-cluster matching
Muon id.	yes	Probably only present Belle

ECL parameterization

- Energy resolution modeled with Crystal Ball function

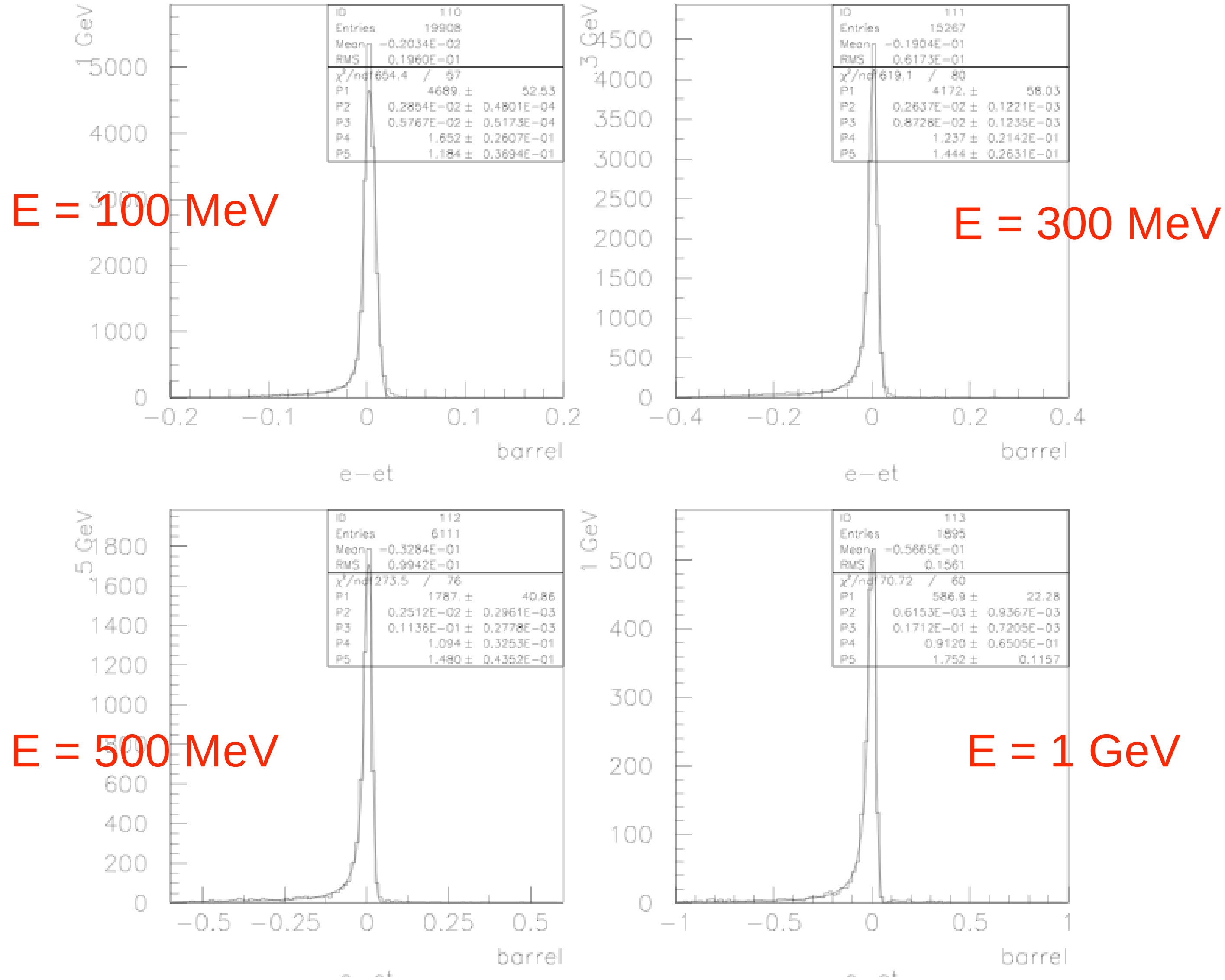
$$f(x;\alpha,n,\bar{x},\sigma) = N \cdot \begin{cases} exp(-\frac{(x-\bar{x})^2}{2\sigma^2}), & \text{for } \left|\frac{x-\bar{x}}{\sigma}\right| < \alpha \\ A \cdot (B - \frac{x-\bar{x}}{\sigma})^{-n}, & \text{for } \left|\frac{x-\bar{x}}{\sigma}\right| \geqslant \alpha \end{cases}$$

$$A = (\frac{n}{|\alpha|})^n \cdot exp(-\frac{|\alpha|^2}{2}),$$

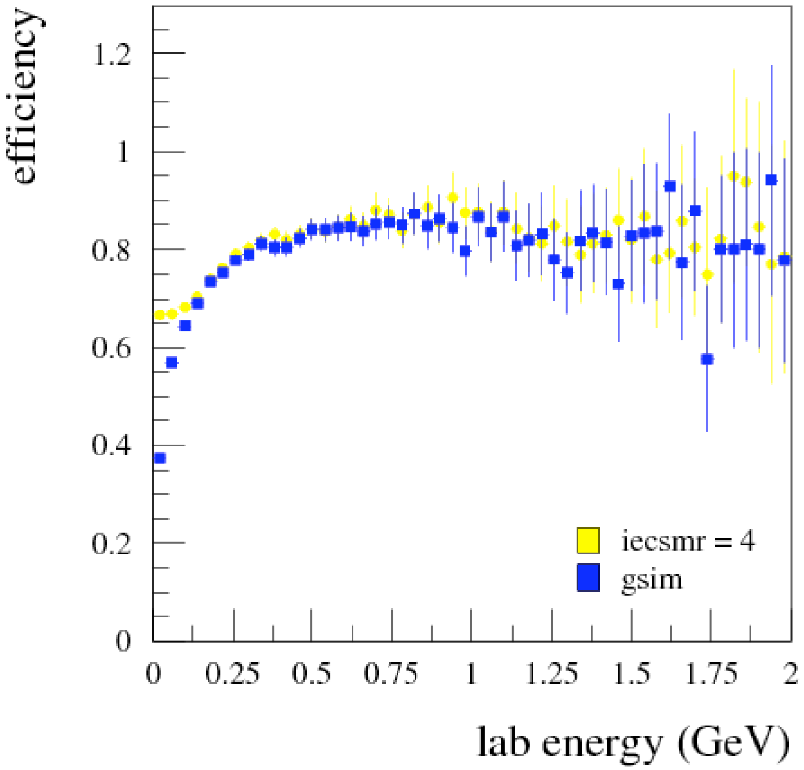
$$B = \frac{n}{|\alpha|} - |\alpha|,$$

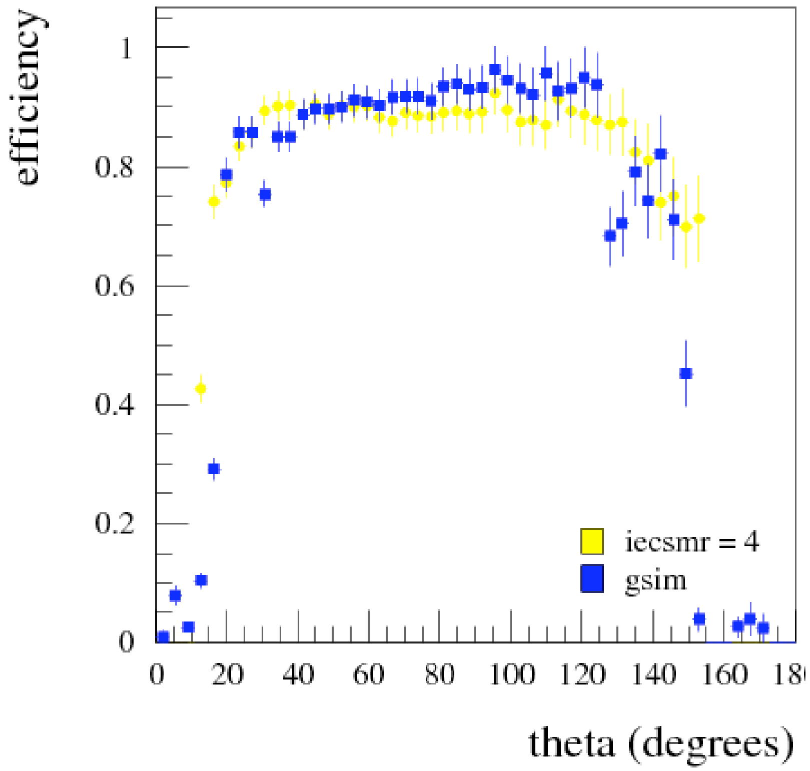
- The Crystal Ball parameters and the gamma efficiency are measured for six energy values (100 MeV, 300 MeV, 500 MeV, 1 GeV, 2 GeV and 3.5 GeV), and for the forward ($12.4<\theta<31.5$ deg), barrel ($31.5<\theta<128.6$ deg) and backward ($128.6<\theta<154.6$ deg) regions separately
- Between these energies, the parameters are interpolated with log(E)

E.g., fit in the barrel region (to gsim data)

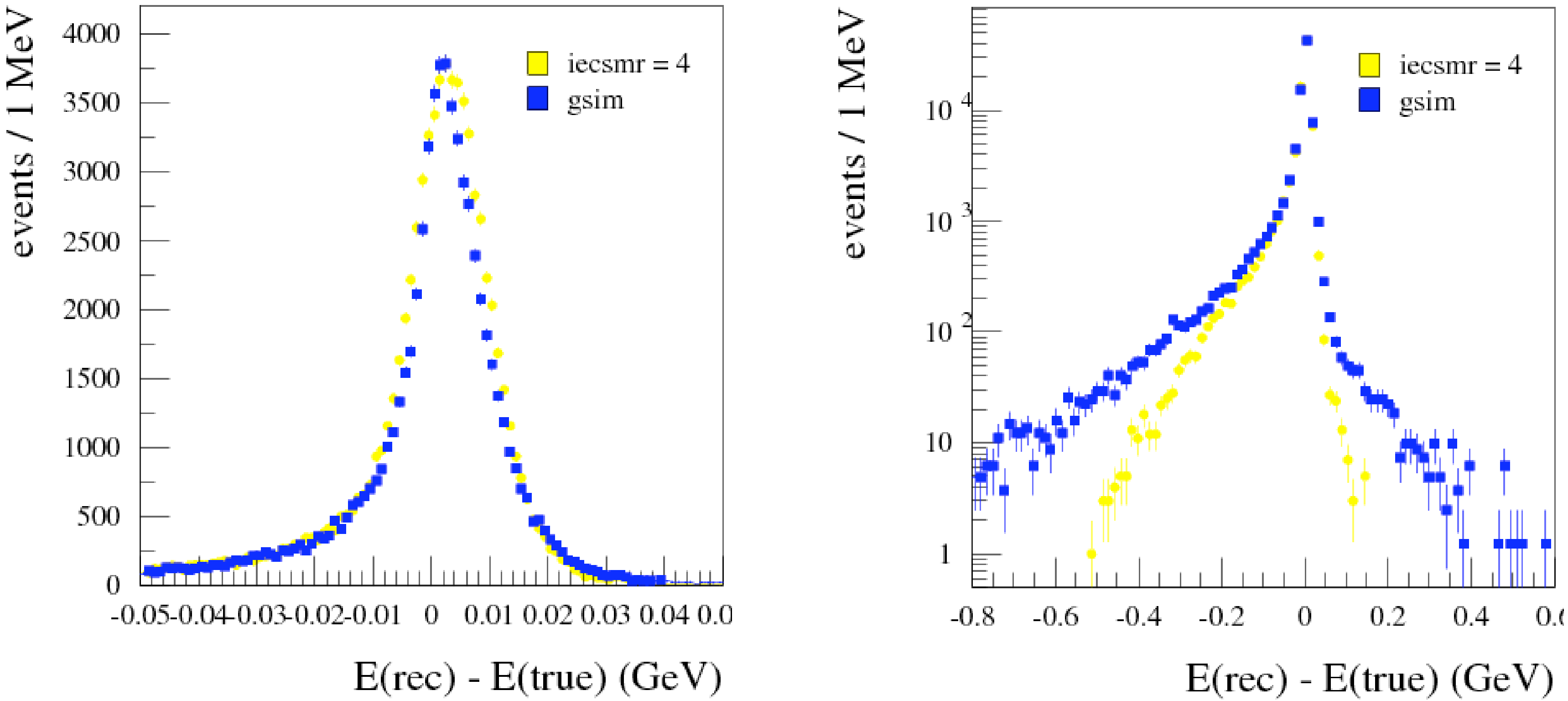


Efficiency


efficiency
1.2
1
0.8
0.6
0.4
0.2
0
0
0.25
0.5
0.75
1
1.25
1.5
1.75
2
iecsmr = 4
gsim
lab energy (GeV)

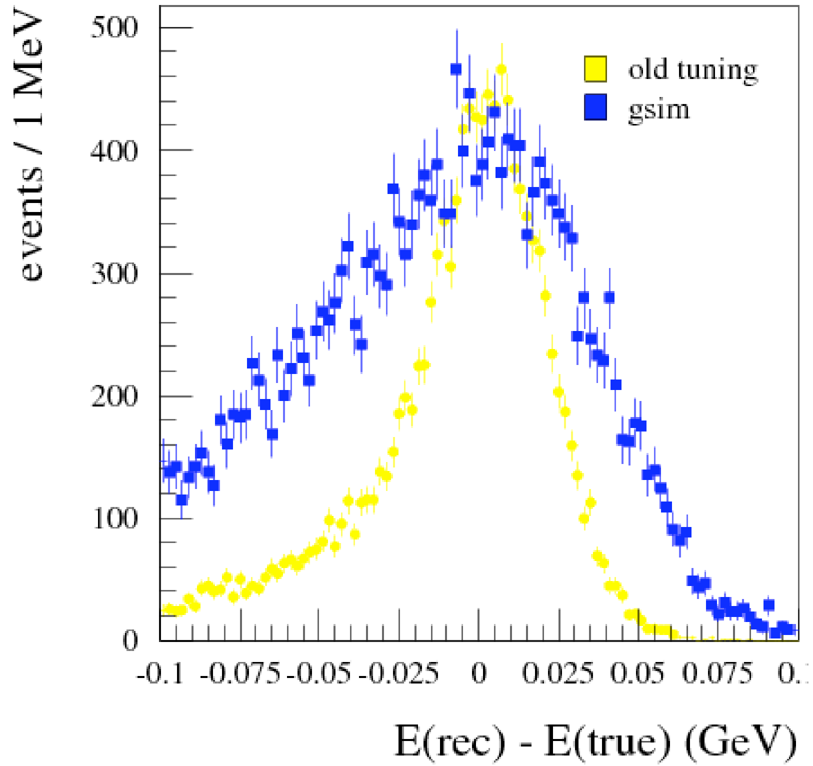

efficiency
1
0.8
0.6
0.4
0.2
0
0
20
40
60
80
100
120
140
160
iecsmr = 4
gsim
theta (degrees)

Energy resolution

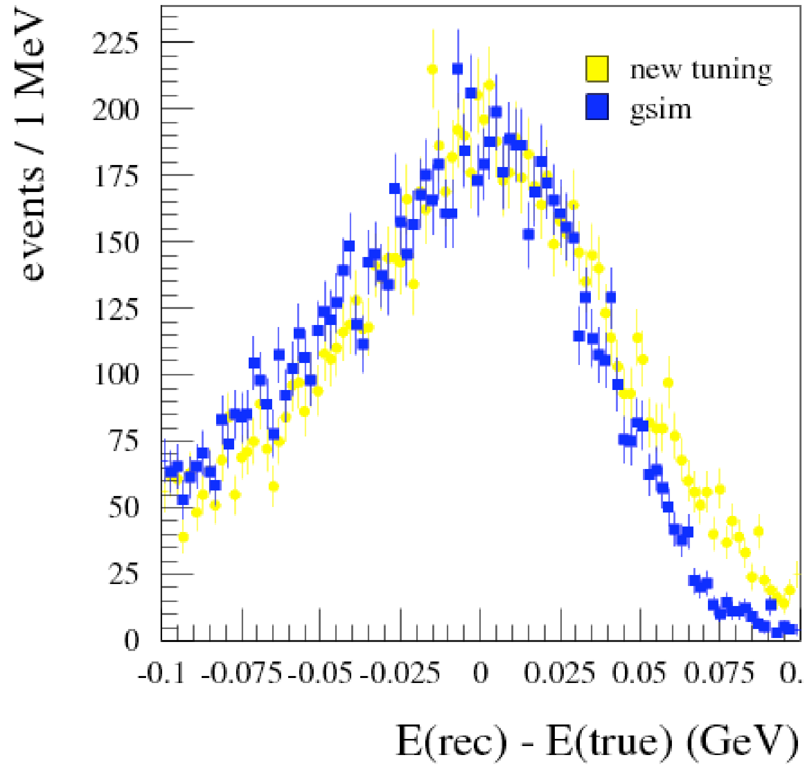


B → K*γ Monte Carlo

tuning only up to 1 GeV



tuning up to 3.5 GeV



Electron id.

- Belle electron id. uses five discriminantes
  1. Matching track-cluster
     (match is better for electrons than for other particles)
  2. E/p
  3. Transverse shower shape (E9/E25)
  4. Ionization in the drift chamber (dE/dx)
  5. Light yield in the aerogel cherenkov counter

The variables #1 to #3 require track-cluster matching which is not implemented in present fsim6

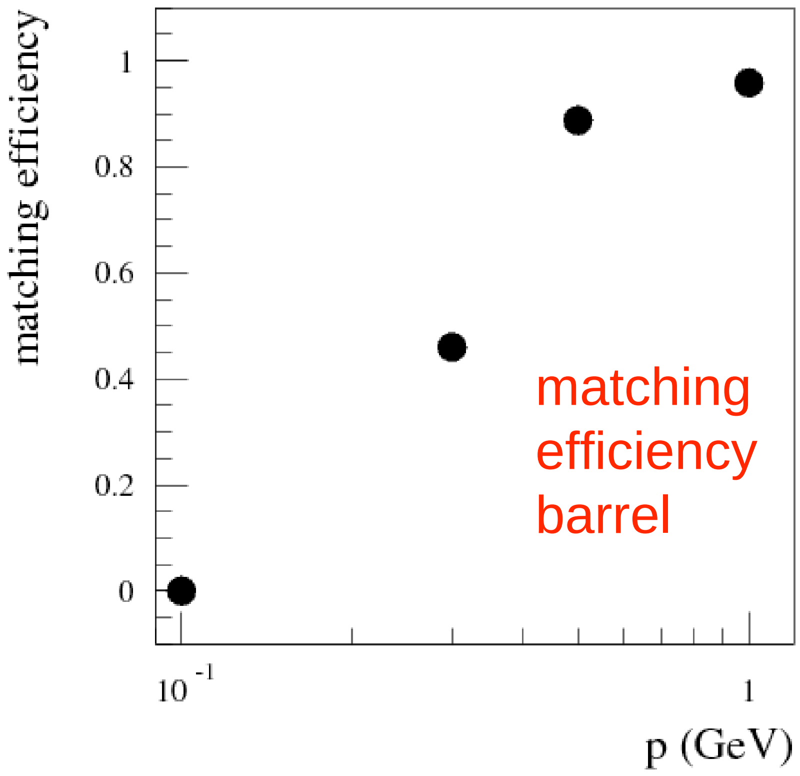
MDST_ECL_TRK

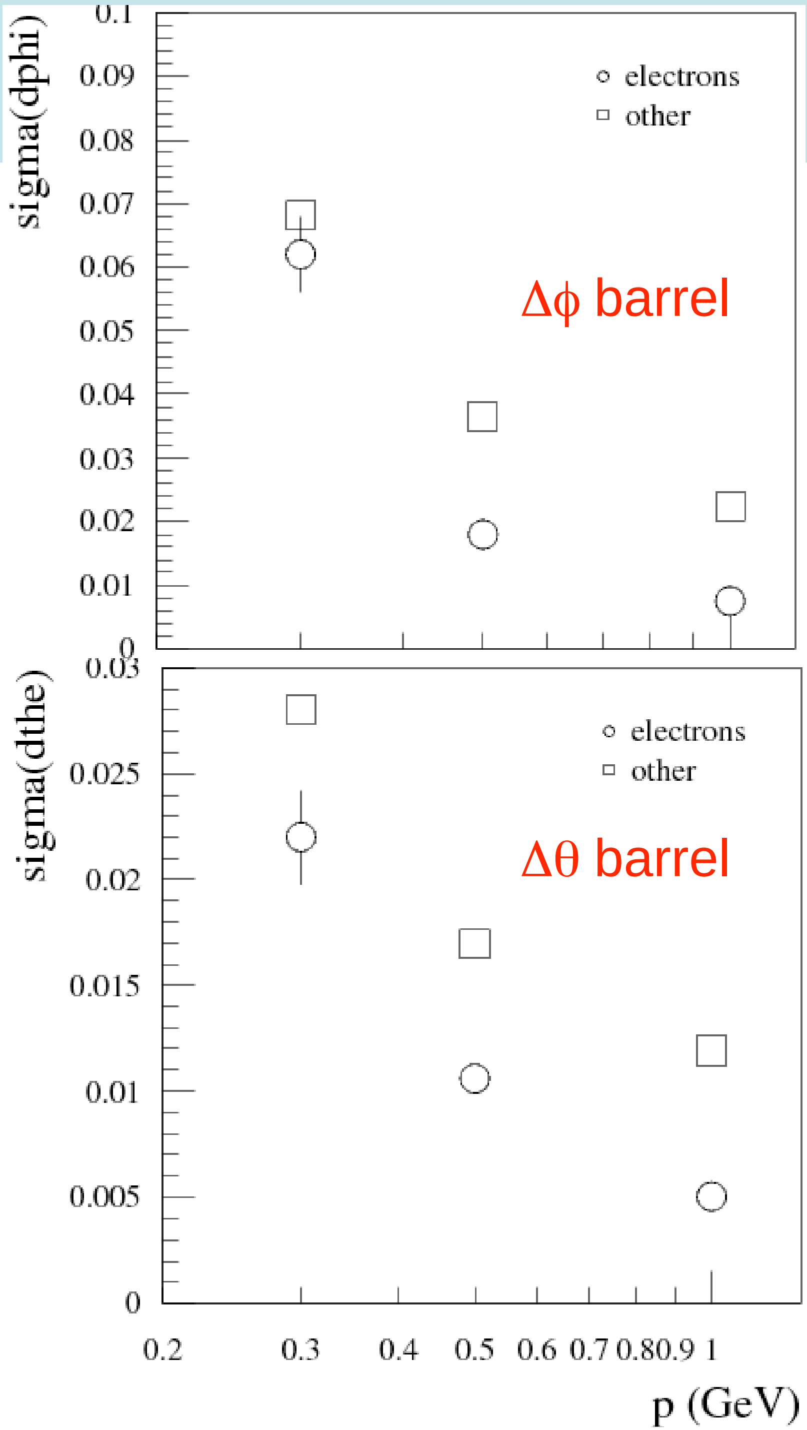
- This table encodes the track-cluster matching information and needs to be implemented
- It contains many informations (e.g., shower position at the front face of the crystall) which would require the implementation of full ECL geometry
- Fortunately, for eid only the polar and azimuthal angle difference between track and cluster momenta, $\Delta\theta$ and $\Delta\phi$, need to be parameterized

$$\chi^2 \equiv \left(\frac{\Delta\phi}{\sigma_{\Delta\phi}}\right)^2 + \left(\frac{\Delta\theta}{\sigma_{\Delta\theta}}\right)^2$$

(χ^2 is the discriminant used by the eid software)

Parameterizing eid





Linear with log(p)?

Summary

- We attempt to validate the Super-Belle design on benchmark physics analyses
- Therefore we have implemented a fast simulator which can be tuned to different detector configurations
- Fsim6 is working but things are left to be done

Backup slides

The CKM mechanism

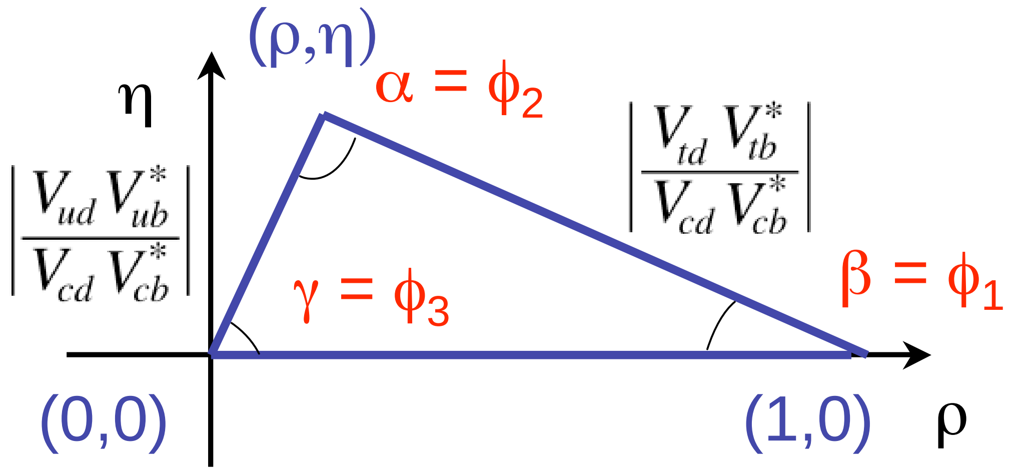
- The charged current interaction in the SM

$$-\mathcal{L}_{W^\pm} = \frac{g}{\sqrt{2}}\, \overline{u_{Li}}\, \gamma^\mu\, (V_{\rm CKM})_{ij}\, d_{Lj}\, W_\mu^+ + {\rm h.c.}$$

$$V_{\rm CKM} = \begin{pmatrix} V_{ud} & V_{us} & V_{ub} \\ V_{cd} & V_{cs} & V_{cb} \\ V_{td} & V_{ts} & V_{tb} \end{pmatrix}$$

[Kobayashi, Maskawa, Prog. Theor. Phys. 49, 652 (1973)]

- V_{CKM} is a unitary 3x3 matrix;
  it contains three real parameters and one complex phase
- Its unitarity is commonly represented by the unitarity triangle



$$\alpha \equiv \varphi_2 \equiv \arg\left(-\frac{V_{td}V_{tb}^*}{V_{ud}V_{ub}^*}\right)$$

$$\beta \equiv \varphi_1 \equiv \arg\left(-\frac{V_{cd}V_{cb}^*}{V_{td}V_{tb}^*}\right)$$

$$\gamma \equiv \varphi_3 \equiv \arg\left(-\frac{V_{ud}V_{ub}^*}{V_{cd}V_{cb}^*}\right)$$

Belle Detector