Limits to Performance For Imaging Cherenkov Detectors at a Super B Factory.

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-General Considerations

-Some physics examples

-Defining Performance Metrics

-Thinking about performance:Simple Models

-Summary

- **PID detector requirements may be sensitive to**

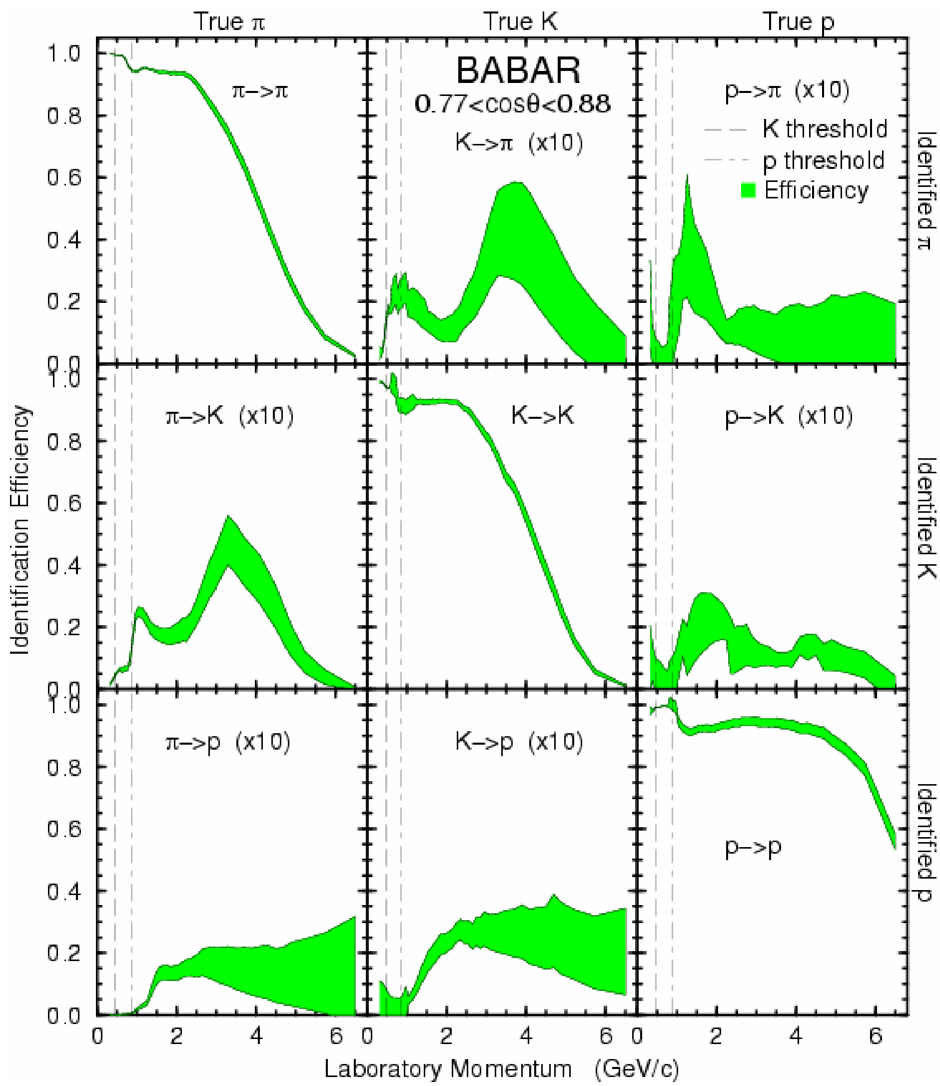
1. **Backgrounds….both pattern recognition and robustness.**
2. **Machine Asymmetry (The larger the boost, the harder to do PID.)**
3. **Good tracking. Existence of reasonable $1/\beta^2$ dE/dx.**
4. **Physics Needs:**

- **B Physics Channels?**
- **Run on 5s?**
- **Charm or τ physics?**

- **For now, assume that**

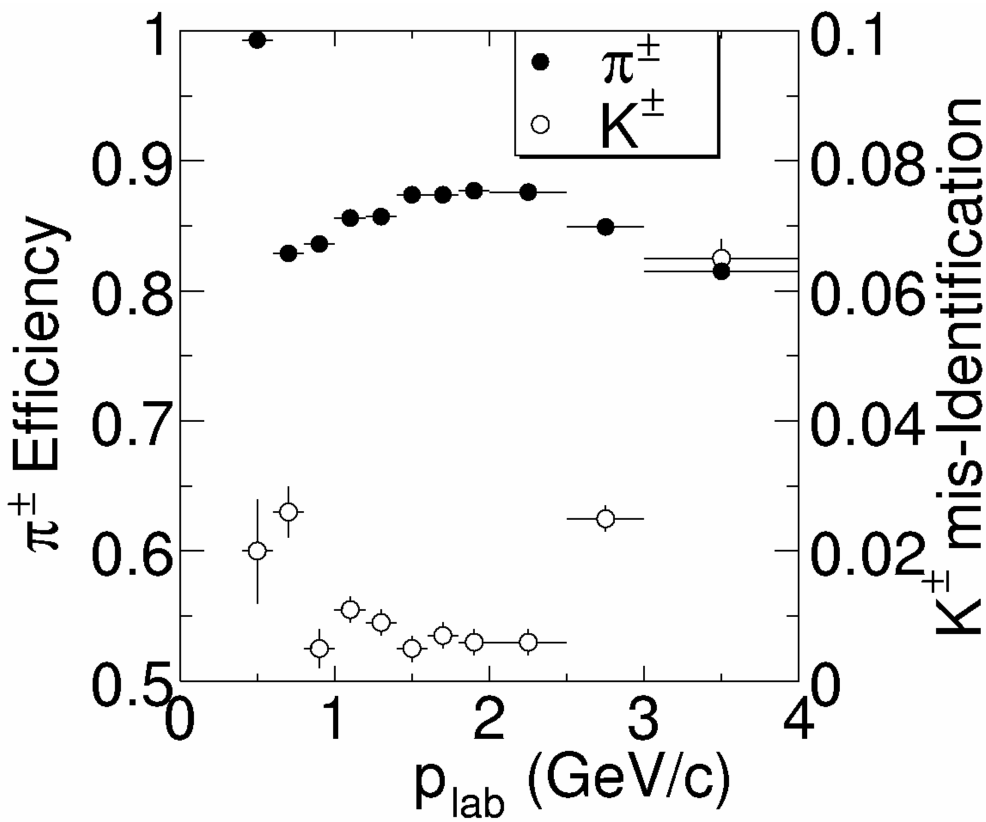
1. **Backgrounds can be handled. (Detectors and radiators proposed are likely to be sufficiently radiation hard. Pattern recognition must be carefully simulated.)**
2. **Boost ~same as Belle (or less than BaBar)**
3. **dE/dx and tracking ~ like now .**
4. **So what about the physics needs?**

How well do present PID systems work (a few BaBar examples)?



- From inclusive qqbar studies. Calibrated with control samples.
- Performance reasonably well understood. Limited in many cases by physics processes (scattering, decays, interactions, delta rays, etc.)
- ID efficiency limited by resolution at higher momenta for K-pi.
- ~0.1% Mis-id at low moment…1-2% in Cherenkov region.

Example II- B to ργ



- B to ργ topology identical to $K^{*}\gamma$, which is expected to have ~20x the BF. Need to reject Kaons by positive pion ID.
- Optimized cuts give ~1/2-1 percent K mis-id for most of the events.
- Mis-Id not the dominant source background for the BF limit on ργ of 1.6 x 10^{-6}.

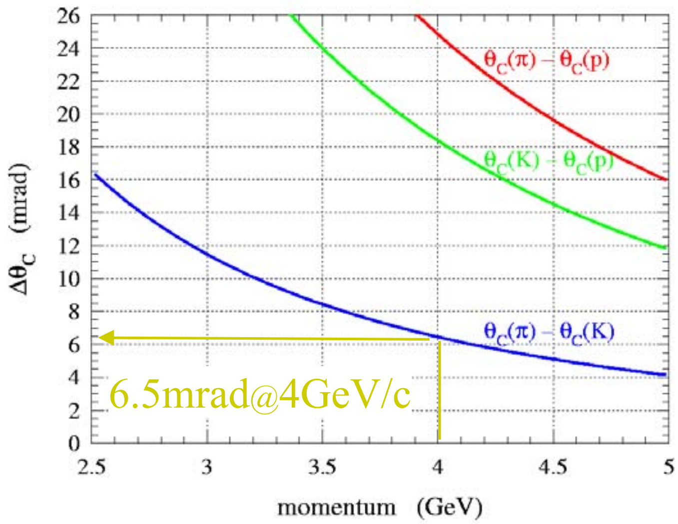
➔ Unless BF of "signal/background" ratio is very small, the present Mis-Id is probably sufficient… Would be useful to have some specific channels that require better Mis-Id performance.

Defining the PID Performance Metric

Conceptual Issues

•Often characterized as "N_σ"

π–K



P (GeV)	4σSep (mrad)	Θ_c(tot) (4 σ)
4	6.5	1.6
5	4.2	1.0
6	2.9	0.7

$$N_\sigma \approx \frac{\left(m_1^2 - m_2^2\right)}{\left(2p^2\sqrt{n^2-1}\,\sigma[\,\theta_c(\mathrm{tot})]\right)}.$$

•In a simple model, the total resolution on Cherenkov angle scales as:

$$\sigma[\,\theta_c(\mathrm{tot})] = \frac{\sigma[\theta_c]}{\sqrt{N_{pe}}} \oplus [\theta(\mathrm{tracking})] \oplus [\theta(\mathrm{cor})]$$ where

$$\sigma[\theta_c] = \sqrt{\sigma[\theta_{\mathrm{Production}}]^2 + \sigma[\theta_{\mathrm{Transport}}]^2 + \sigma[\theta_{\mathrm{Imaging}}]^2 + \sigma[\theta_{\mathrm{Detection}}]^2}$$

In practice, the correlated and tracking pieces are ~1.5 mrad in BaBar.

Defining the PID Performance Metric

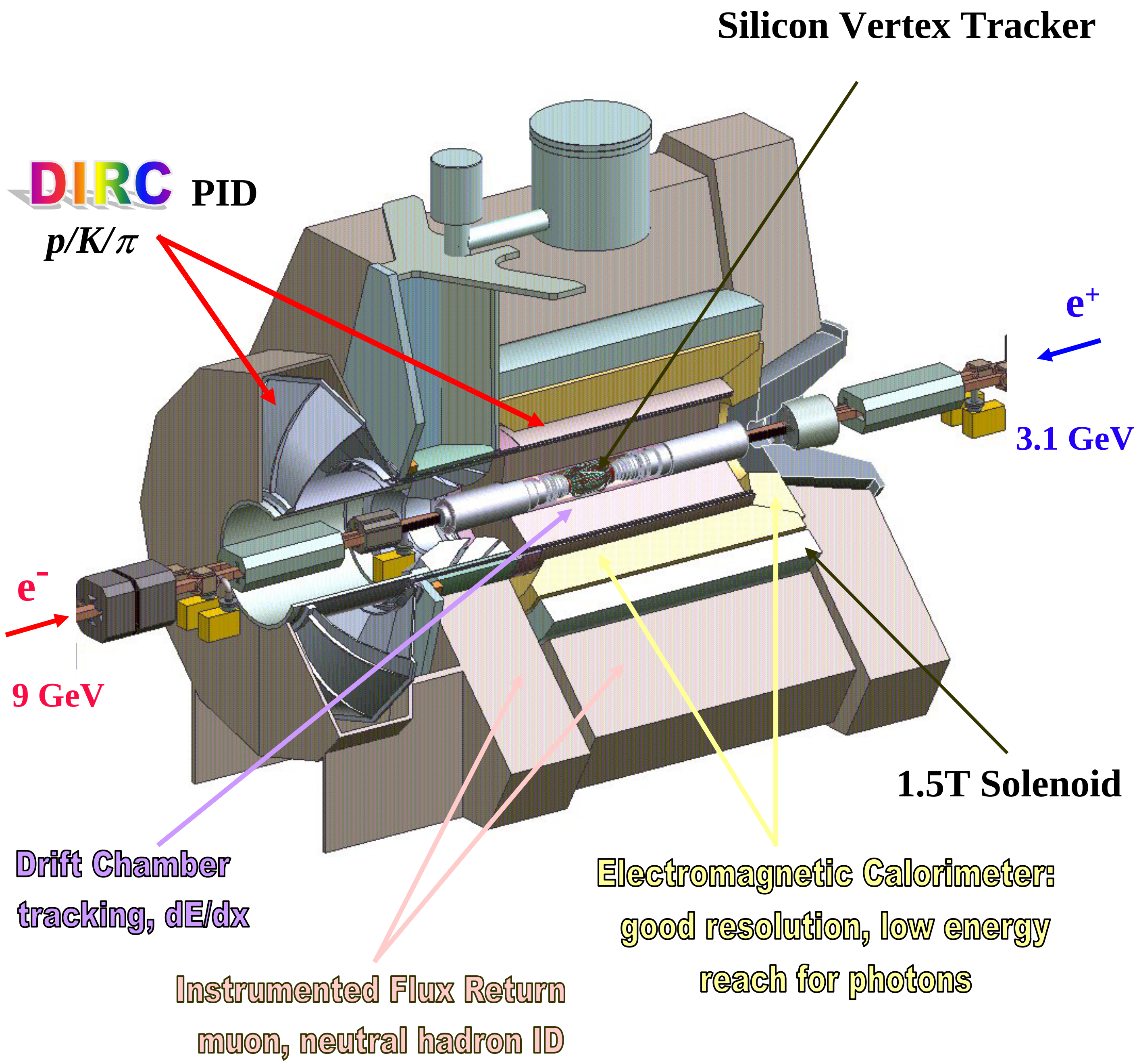
N_σ

- Improving N_σ is often taken as improving PID performance and/or momentum range. However, once an adequate separation is attained, it is not clear how much this really improves physics.
- Cherenkov Central tracking is a large component of the overall separation ….to do much better than now need<< 1 mrad, including alignment and multiple scattering components
- Improving $\sigma(\theta_c)$ for each Cherenkov photon tends to cost pixels (and $ or Y)

MIS-ID

- Not Gaussian…
- Physics effects produce separation tails (decays, scattering, delta rays, interactions)
- May be able to "improve" with post DIRC tracking…Needs more study

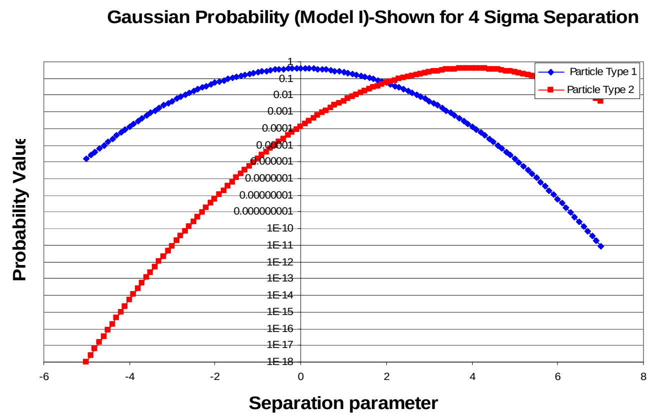
The BaBar Detector



Thinking about Performance Metrics- Very Simplified Model I

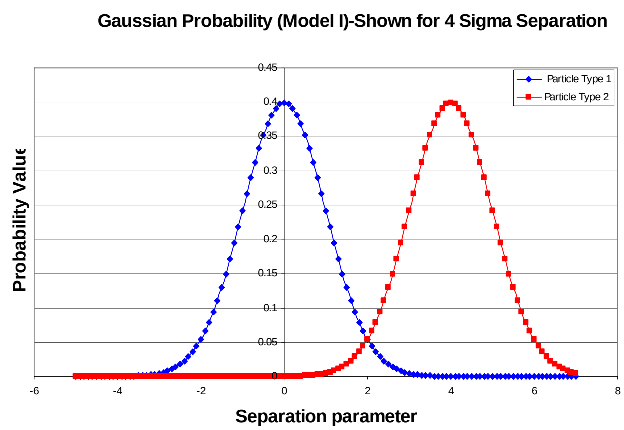
Gaussian PDFs for

Both Particles

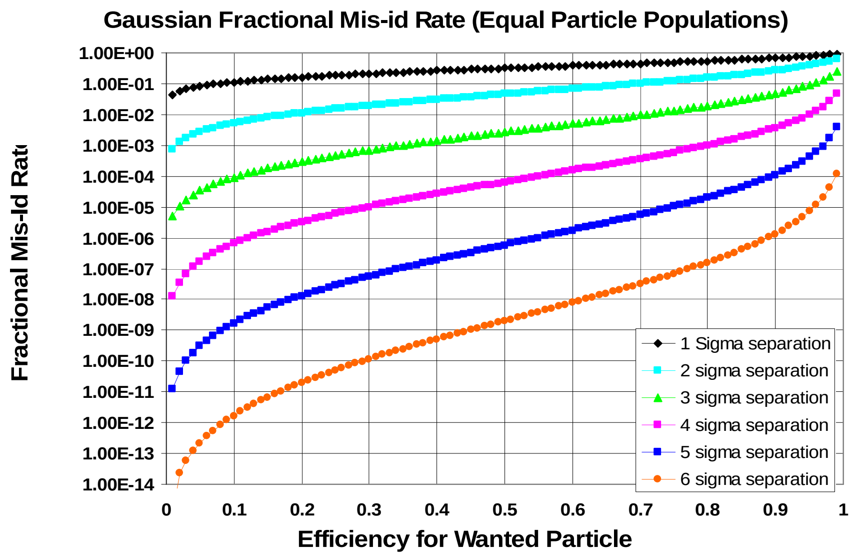


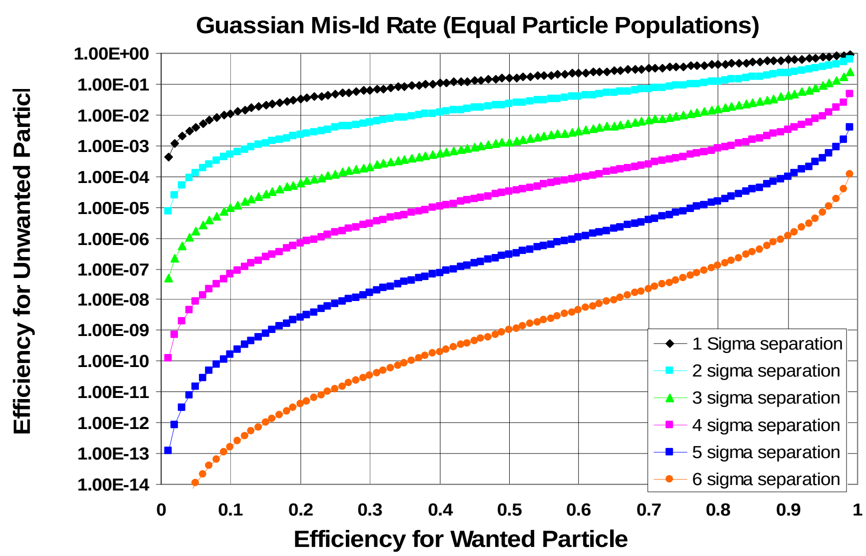
Equal Particle

Populations



Model I- Performance





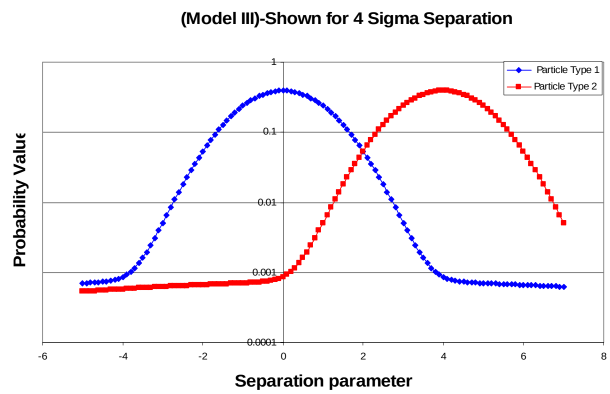
Model III

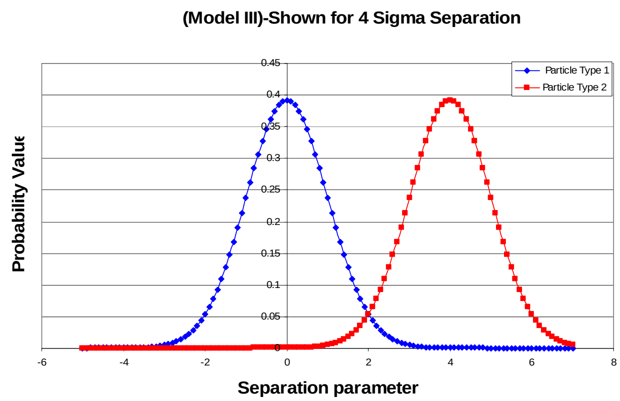
98% of each particle type has a measured Gaussian at the correct central value with width 1

+

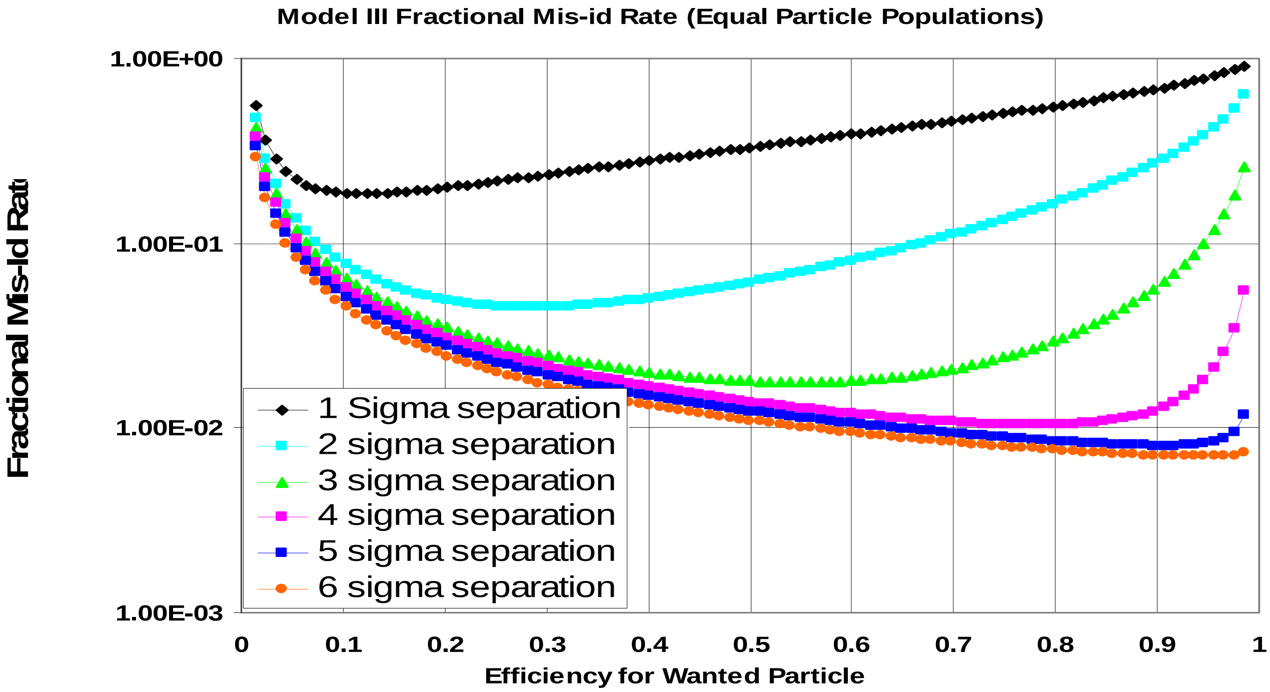
2% of each particle type has a measured Gaussian at the correct central value but with a width of 10.

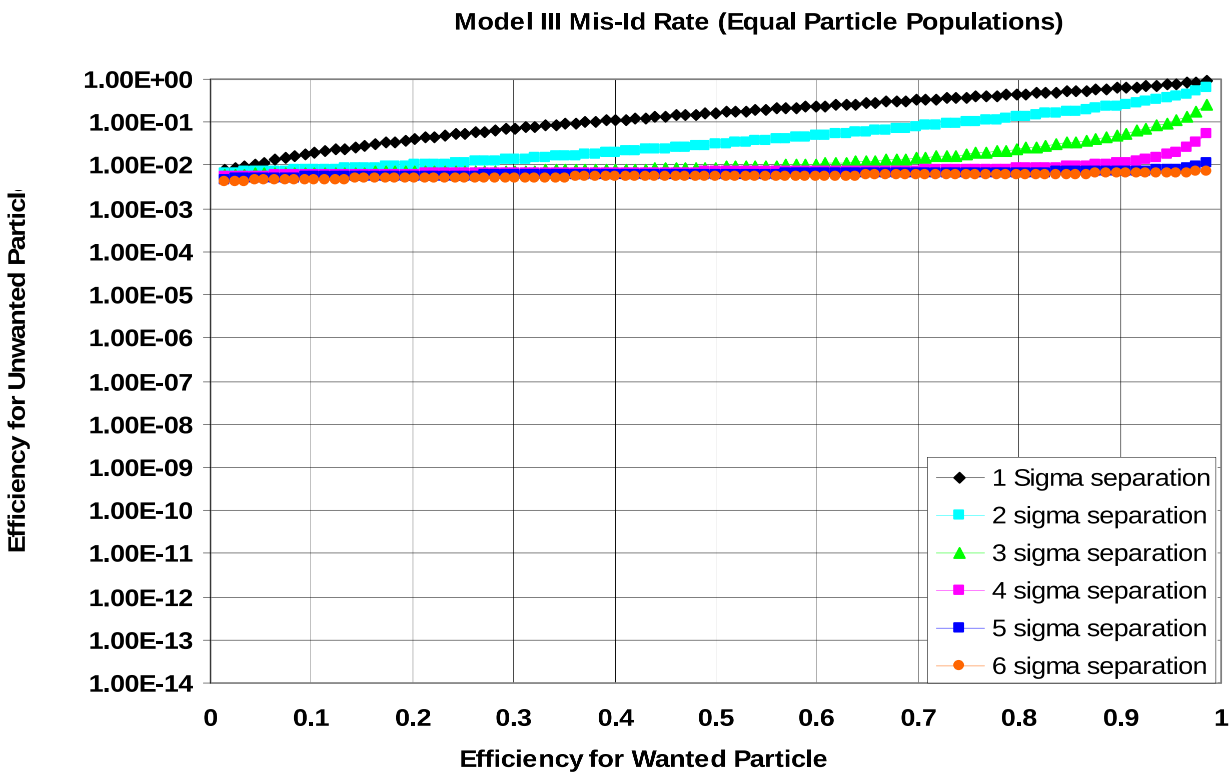
Equal populations for type 1 and type 2 particles





Model III-Performance





Summary

- Although there will be many challenges in handling the high luminosity at a Super-B Factory, it is not clear that improving physics performance (wrt to BaBar) is especially helpful. …..would be very useful to have clearer physics examples.

- Distinguish between better (N_σ) separation (giving a larger momentum range), and better Mis-id performance.

- Reducing Mis-id could likely benefit from post-PID tracking. Should understand this better.

➔ There are some useful areas for careful simulation studies.