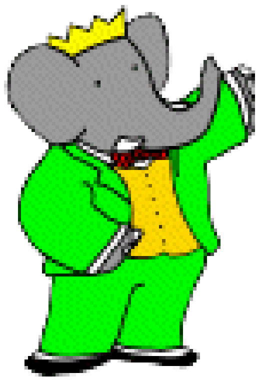

Inclusive BR($b \to s\gamma$) with a fully reconstructed B

Clare Brown

Royal Holloway University

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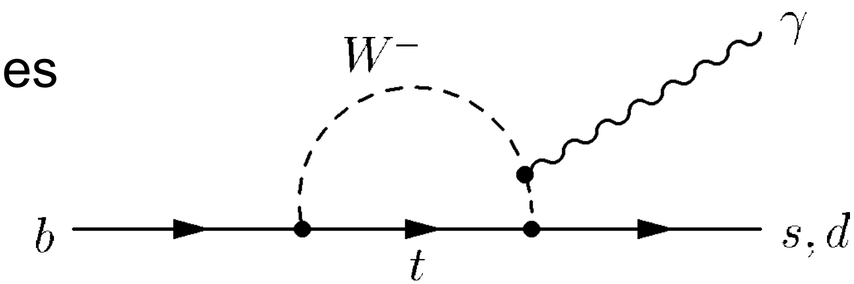
Why study b $\rightarrow$ sγ ?

- Possibility of new non-SM particles entering in the loop.



- We are unable to measure the parton level decay rate for b->sγ, however:

HQET $\Rightarrow$ $$\Gamma\left(B \rightarrow X_s\gamma\right) = \Gamma(b \rightarrow s\gamma) + \Delta^{nonpert}$$

- Next to leading order calculations for BR(B->$X_s\gamma$):

$(3.29 \pm 0.33)\cdot 10^{-4}$	Kagan&Neubert
$(3.60 \pm 0.30)\cdot 10^{-4}$	Gambino&Misiak

- Theoretical uncertainty ~ 10%, mainly from contribution of higher order diagrams in the expansion.

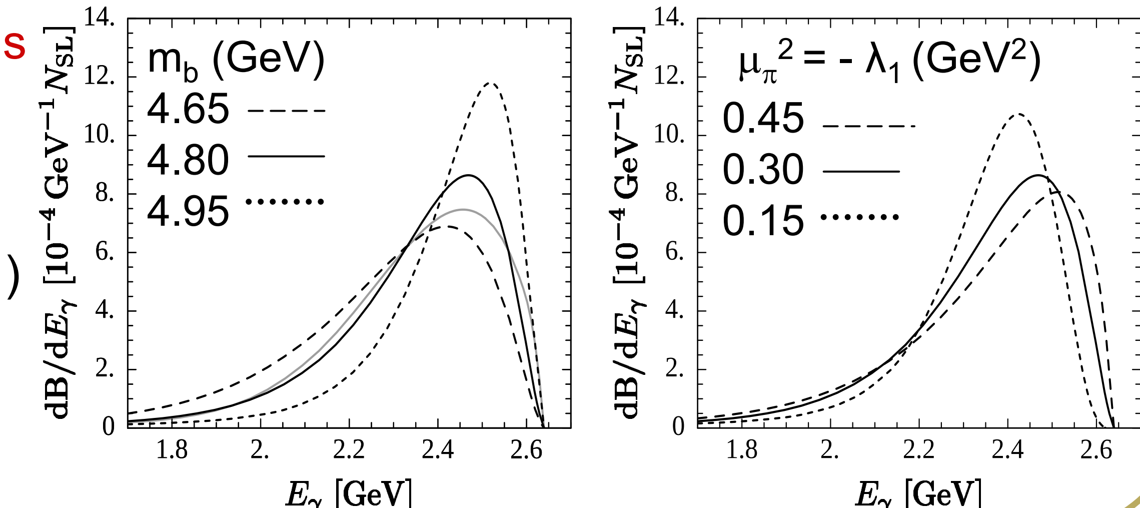
The signal model

We select signal photons and measure the integral of the photon energy spectrum to determine BR(B->$X_s\gamma$).

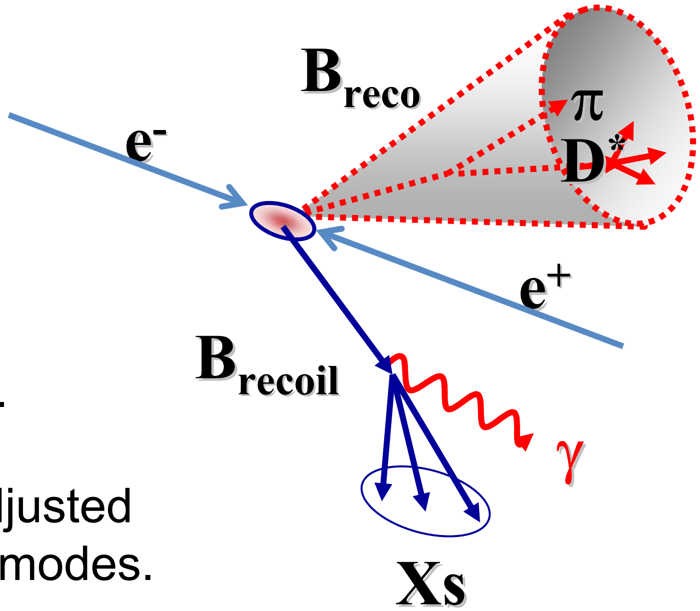
Due to the strong force the b quark fragments into B meson, and Xs into a spectrum of K* resonances.

The b quark interacts with the spectator quark ⇒ scale dependence in m_b.
It also has Fermi momentum p_F from its confinement in the meson.

The shape function depends on m_b and p_F.
Spectrum is smeared with
$\langle E\gamma \rangle \approx m_b / 2$
The width (first moment, λ_1) depends on p_F



Advantages of a reconstructed B



Breco (Brecoil) kinematics are well known.

$E\gamma$ spectrum is measured in the B rest frame.

Luminosities of samples and B reconstruction efficiencies are not needed, as normalization is taken from # reconstructed B's before selection.

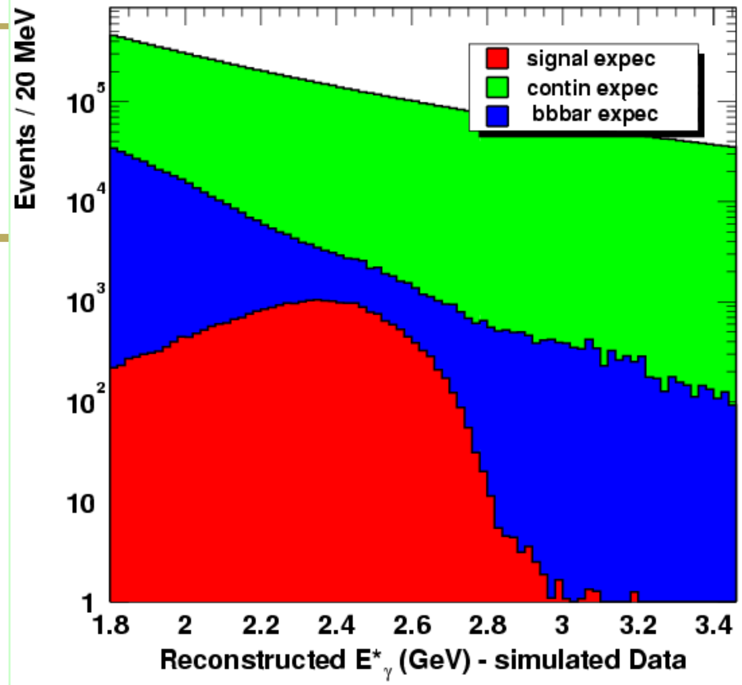
The purity of the Breco sample can be easily adjusted by selecting a sub-sample of the reconstructed modes.

Continuum events can be estimated and subtracted by performing a fit to M_{ES}.

Fully hadronic reconstruction of one B determines tagging of charge and B flavour.
$\Rightarrow$ We can measure BR(B->Xsgamma) and α_{CP} in B0 and ChgB separately.

Disadvantage: Small B reconstruction efficiency ~ 0.4 %

Analysis concept

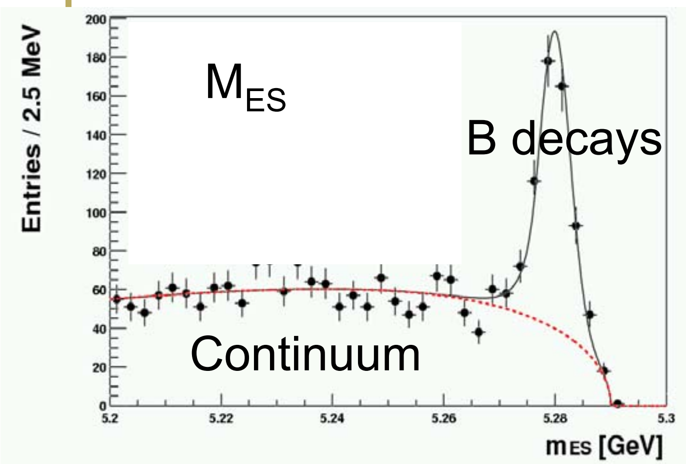


Signal: A fully reconstructed B decay &
A high energetic photon in the event.

Backgrounds: from other B decays &
continuum background
$(u\bar{u}, d\bar{d}, s\bar{s}, c\bar{c})$

• Selection criteria and a Fisher Discriminant are designed to suppress background.

• Continuum is estimated from a fit to M_{ES} of the Breco and subtracted.



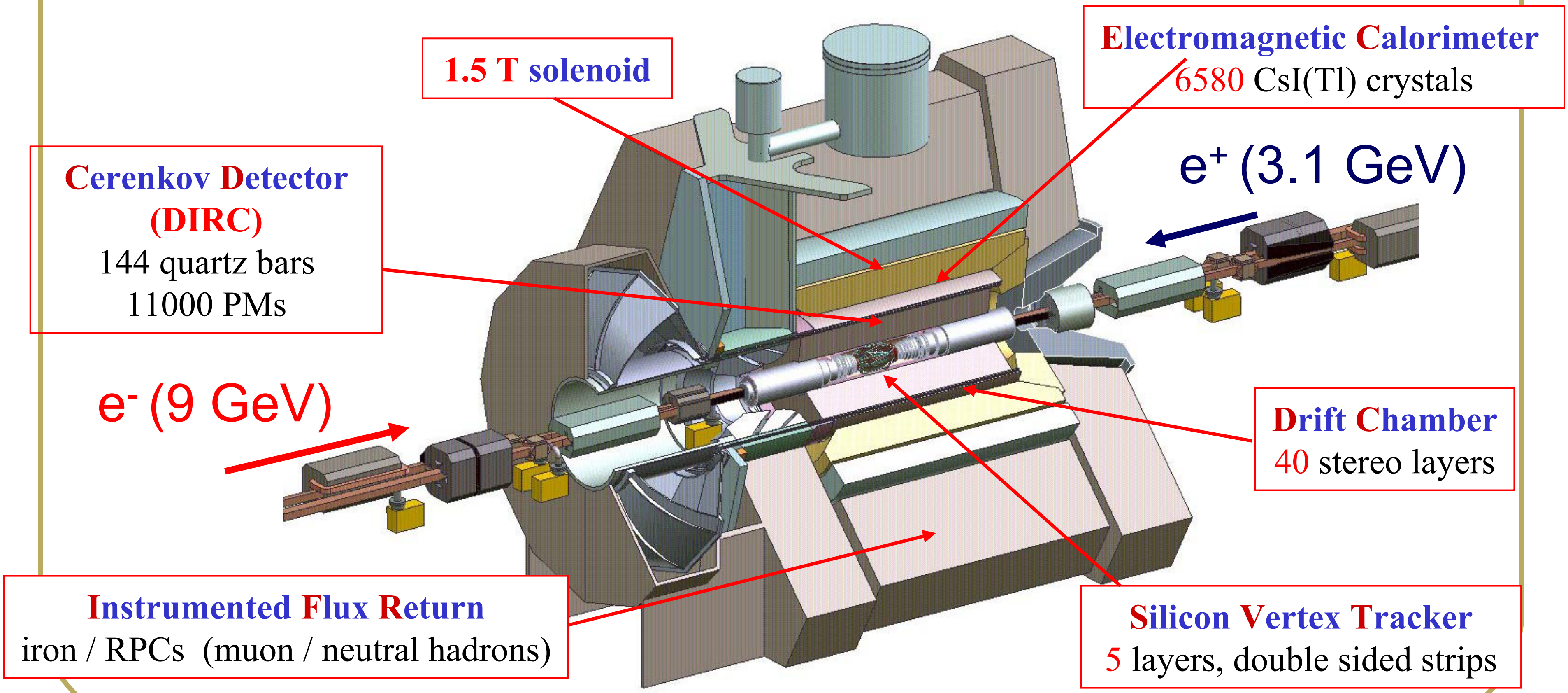
$$M_{ES} = \sqrt{(\sqrt{s}/2)^2 - P*_B{}^2}$$

• The # BBbar background events in the same peaking component as signal are estimated from MC

• The signal yield is extracted from a binned χ^2 fit to $E\gamma$ distribution of events that pass the selection.

The Data

82 fb-1 of data (1999-2002) collected at the BaBar detector



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Selection criteria

We require: 1 fully reconstructed B decay (Breco)

Summary of selection Criteria	
B_{reco} candidate	int-pur>0.25
Minimum photon energy	$E_\gamma > 1.3$ GeV
Quality cut	LAT< 0.45
Bump isolation cut	Bump separation$> 40cm$
π^0 veto	$115\,\mathrm{MeV}/c^2 < M_{\gamma\gamma} < 155\,\mathrm{MeV}/c^2$
η veto	$508\,\mathrm{MeV}/c^2 < M_{\gamma\gamma} < 588\,\mathrm{MeV}/c^2$
Fisher	$F > 0.2$
ρ veto	$620\,\mathrm{MeV}/c^2 < M(\pi^0,\pi) < 920\,\mathrm{MeV}/c^2$

70% of the Pi0 background comes from B->D*ρ, ρ->π0π+, π0->γ1γ2

For multiple candidates, we select the most energetic photon (only 0.2% with Eγ>1.9GeV)

Fisher Discriminant

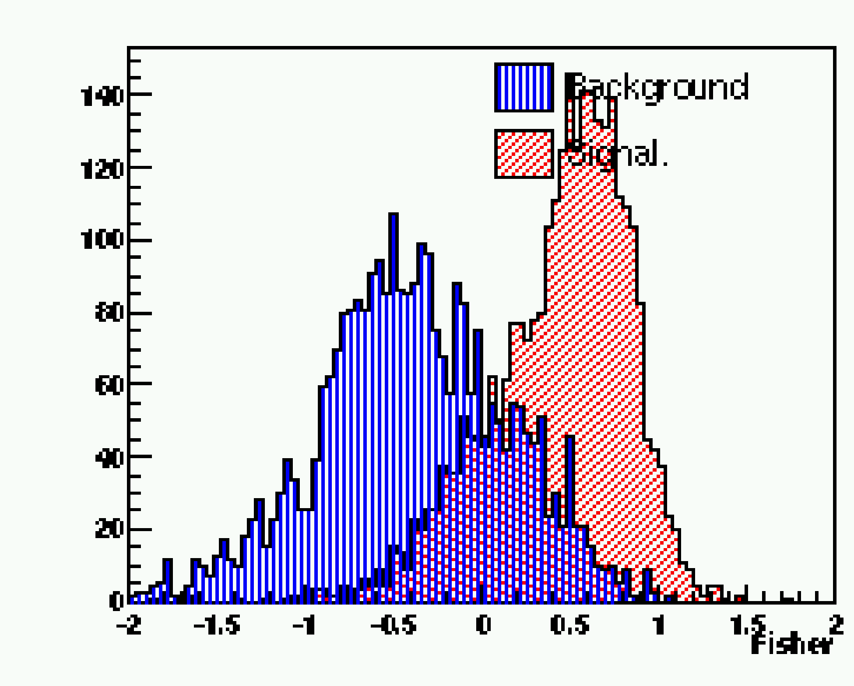
(A linear discriminant technique taking care of correlations between variables).

We use event topology to discriminate between signal and continuum background.
- Continuum events are jet like
- BBbar events (incl. signal) are isotropic

28 Fisher Variables:

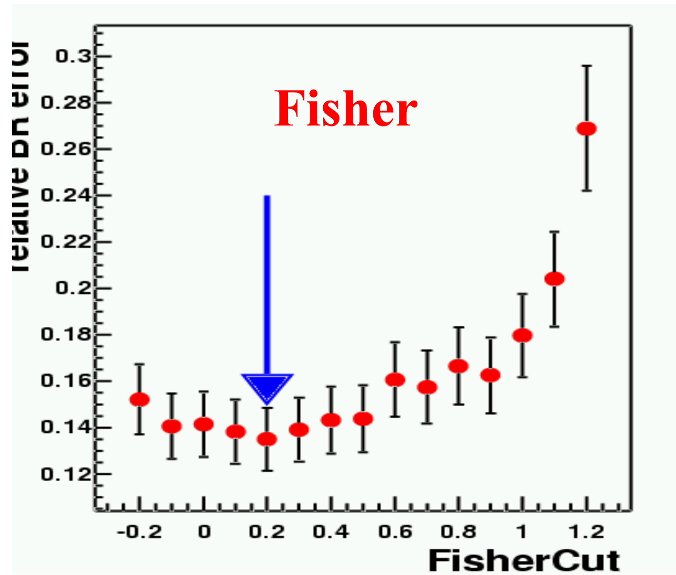
CosTBB, CosGamTreco(il), R2,R2Neu, Thrust,ThrustNeu, ThrustBreco, Energy cones

linear correlation with Eγ <20%, and with charged and neutral multiplicity of the Xs < 15%.



The variables

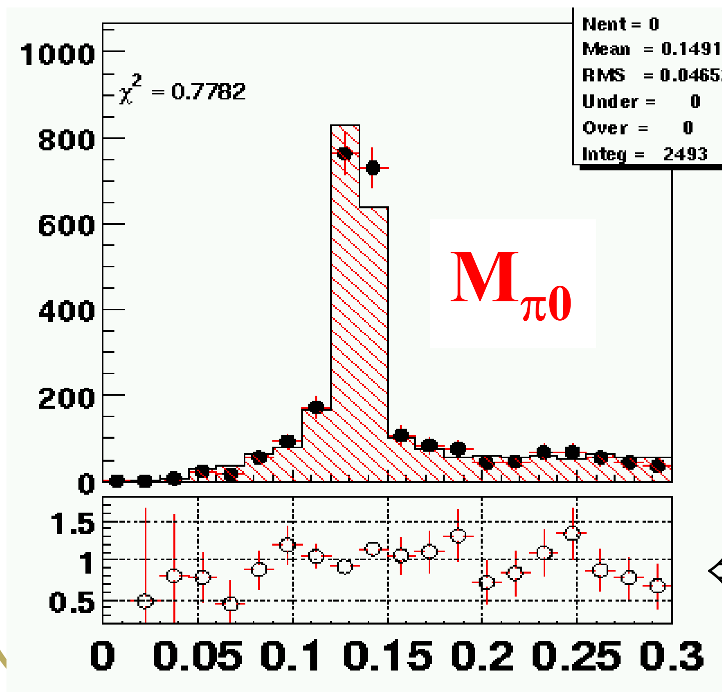
Selection criteria are optimized by varying the cut and minimizing the relative branching fraction error, using MC samples.



Selection efficiencies:

Signal 40%

BBbar 0.02%



⇐ Good Data – MC agreement for variables

Extraction of *BR*($B \to X_s\gamma$)

The branching ratio is extracted using the Eγ distribution

$$Br(B \to Xs\gamma) = \frac{N^{sig}_{TRUE}}{N^{B}_{TRUE}} = \frac{N^{sig}}{N^{Breco} \cdot \varepsilon^{sel}} \cdot \frac{\varepsilon_{tag}^{all}}{\varepsilon_{tag}^{sig}}$$

N^{Sig} is the signal contribution to be extracted for Eγ>1.9GeV → fit

N^{Breco} is the number of Reco B before any cut →m_{ES} fit on data

ε^{sel} is the selection efficiency for signal events

$\varepsilon^{All(sig)Tag}$ is the Breco tagging efficiency in a generic(sig) decay.

} → MC

Extraction of Nsig

Samples are divided into bins of Eγ.

For each bin, the M_{ES} distribution of the Breco is fitted with Argus & Crystal Ball functions and the combinatorial background is subtracted.

N^{Sig} extracted from a binned χ^2 fit:

$$\chi^2(C_s, C_b) = \sum_{i=0}^{\#bins} \left(\frac{N_i^{meas} - C_s N_i^{MC(b\to s\gamma)} - C_b N_i^{MC(bkgd)}}{\sqrt{\delta N_i^{meas\,2} + \delta N_i^{MC\,2}}} \right)^2$$

Cs and Cb are the normalizations of Sig and Bkgd components (free parameters)

The last bin contains events with Eγ>1.9 GeV

$$N_{last}^{sig} = N_{last}^{meas} - C_b \cdot N_{last}^{MC(bkgd)}$$

$b \to d\gamma$

The B->$X_d\gamma$ component is subtracted.

According to the SM expectation BR(B->$X_d\gamma$) and BR(B->$X_s\gamma$) are in the ratio $|V_{td}/V_{ts}|^2$ assuming same efficiency for both components.

BR reduced by (4.0±1.6)%

Fit Validation

Generic BBbar MC is used instead of data (~ 240 fb-1).
Result : *Br = (3.16 ± 0.43(stat)) •10-4*
in good agreement with the input generator value (Br = 3.29 •10-4).

A check on data was performed using a Pi0 control sample
*(π**0** Veto inverted* & no *Bump isolation cut)*
Fit result is consistent with a *no signal hypothesis.*: *NSig =0.5± 10*

Things to do

Plans for improvement:

- Add more data
- Improve selection (Fisher Discriminant and Pi0 & Eta vetos)
- Re-optimize cuts
- Study systematics
- Extract result.

We will have a result by the summer!!!