Detector Geometry Working Group
Charges, Activities, Results and Expected Results

Matteo Rama , Achille Stocchi

Cahier des charges

The SuperB detector as described in the Conceptual Design Report has a number of options not yet defined that have a large impact on the overal detector geometry. As the MC simulation tools for the detector are rapidly maturing, we believe it is timely to set up a Detector Geometry Working Group (DGWG) to study the physics tradeoffs of the open CDR detector options with the goal of being able to finalize the global geometry and define the subsystems of the SuperB detector within a relatively short time frame, between six months and a year. The DGWG main task will be to examine critically the open questions detailed below and provide to the proto-technical board the information necessary to make the relevant decisions.

Do we need a forward PID (eventually backward) ?

Do we need a backward EMC ?

Internal geometry of SVT / Space between SVT and DCH

The amount of absorber on the IFR ?

Strategy

- We want to evaluate the physics reach of a set of benchmark channels as a guideline for the optimization of the detector

Some results already obtained

	H^+ high $\tan\beta$	Minimal FV	Non-Minimal FV (1-3)	Non-Minimal FV (2-3)	NP Z-penguins	Right-Handed currents
$\mathcal{B}(B \to X_s \gamma)$		■		●		●
$A_{CP}(B \to X_s \gamma)$				■		●
$\mathcal{B}(B \to \tau\nu)$	■-CKM					
$\mathcal{B}(B \to X_s l^+ l^-)$				●	●	●
$\mathcal{B}(B \to K\nu\overline{\nu})$				●	■	
$S(K_S \pi^0 \gamma)$						■
β			■-CKM			●

+ $\tau \to \mu\gamma$

■ Golden mode for a given scenario

● Non-golden, but still sensitive to deviations from the SM

-CKM requires high precision on CKM parameters (obtainable with SuperB)

+ possibly include channel at Psi(3770)

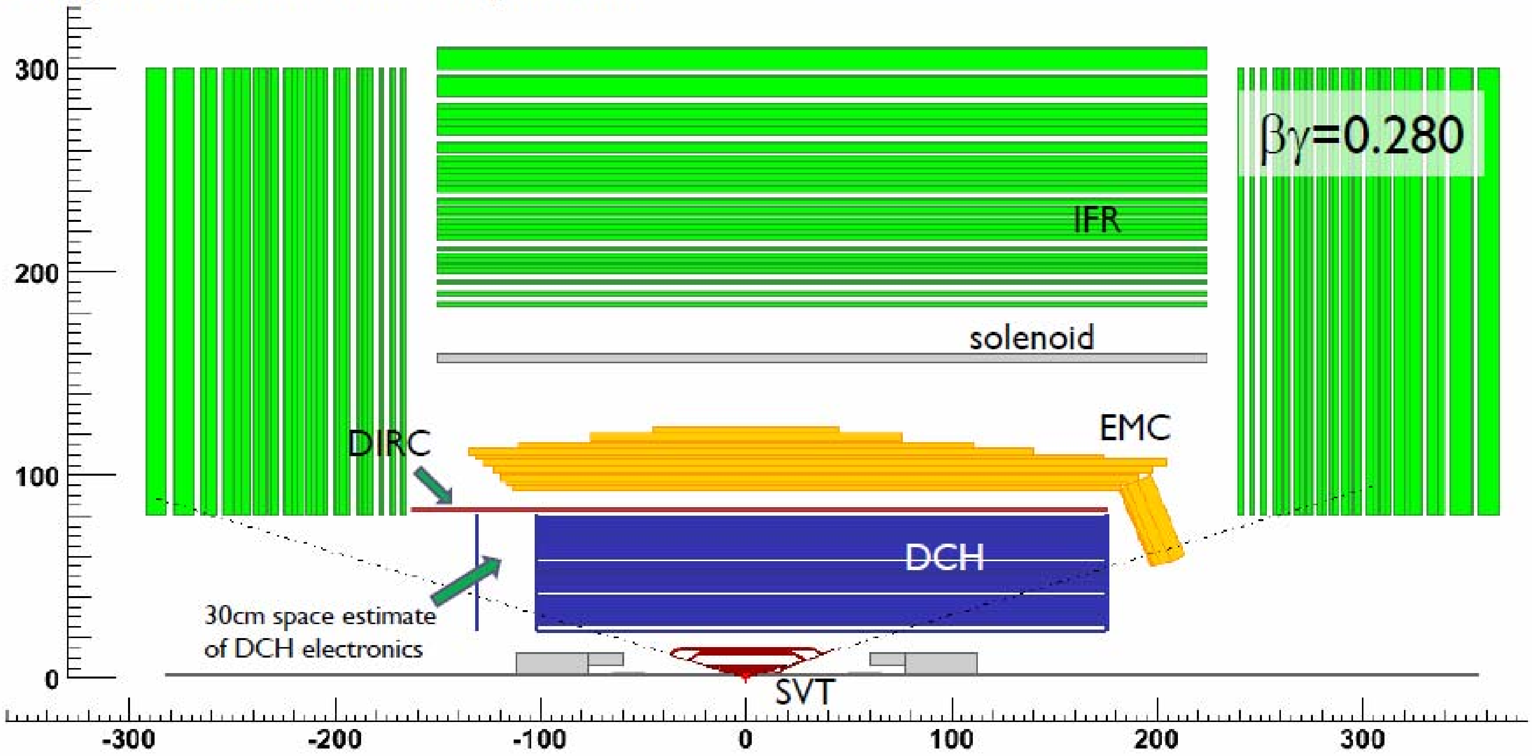
+ BReco: reconstruction of flavour-tagging B decays is crucial ingredient for SuperB physics program (including benchmark channels above)

Different configurations can be now used (available in FastSim)

	SVT	DCH	PID	EMC	IFR
0	5 layers+L0	"babar"	DIRC	fwd LYSO	baseline
1	5 layers+L0	"babar"+bwd+fwd	DIRC	fwd LYSO	baseline
2	5 layers+L0	"babar"+bwd	DIRC+fwd	fwd LYSO	baseline
3	5 layers+L0	"babar"+fwd	DIRC	fwd LYSO+bwd	baseline
4	5 layers+L0	"babar"	DIRC+fwd	fwd LYSO+bwd	baseline
5	5 layers+L0	"babar"	DIRC	fwd CsI+LYSO+bwd	baseline

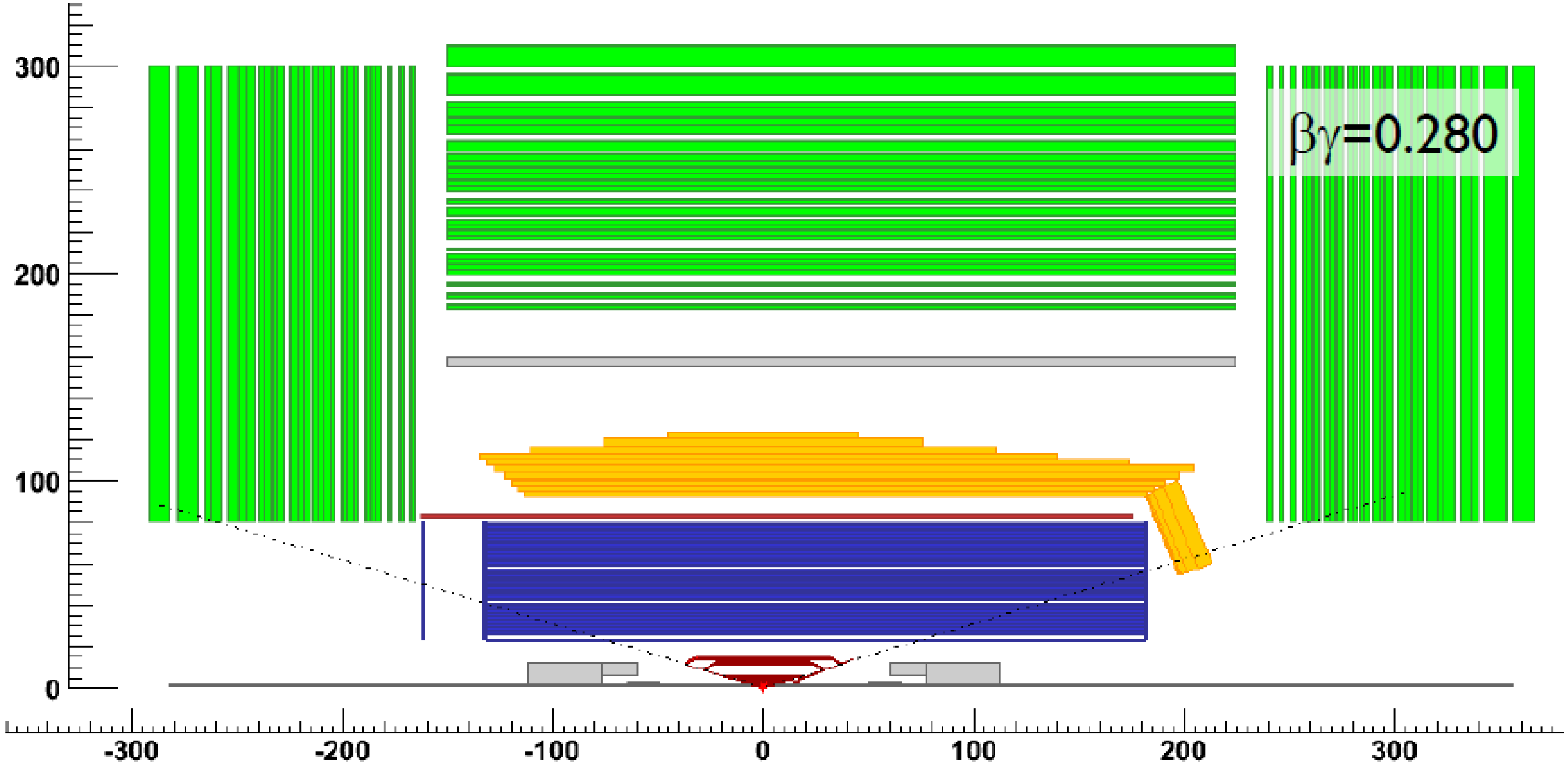
#0

Not really an option. Only considered for comparison with other configurations.



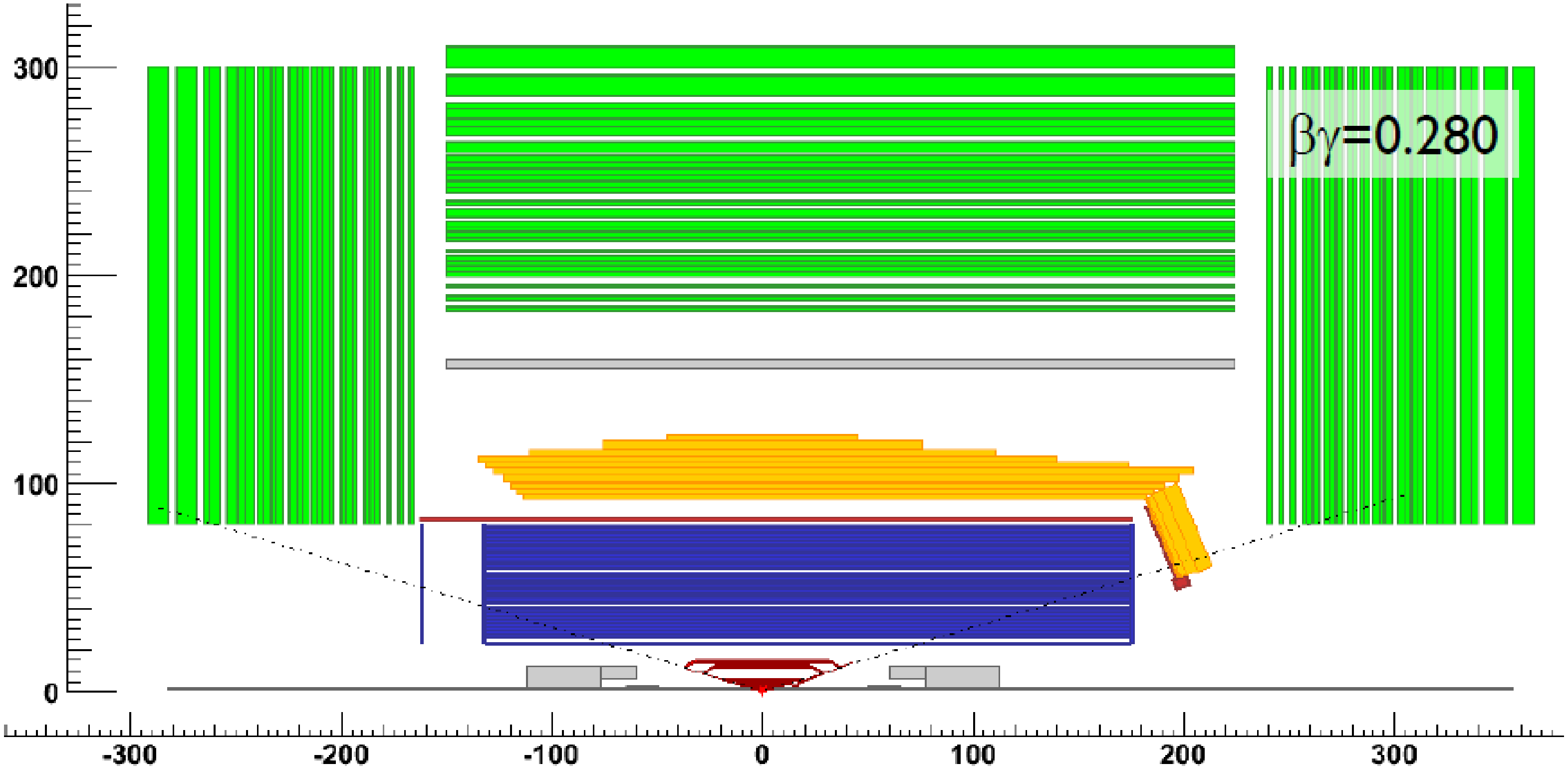
#1

	SVT	DCH	PID	EMC	IFR
0	5 layers+L0	"babar"	DIRC	fwd LYSO	baseline
1	5 layers+L0	"babar"+bwd+fwd	DIRC	fwd LYSO	baseline
2	5 layers+L0	"babar"+bwd	DIRC+fwd	fwd LYSO	baseline
3	5 layers+L0	"babar"+fwd	DIRC	fwd LYSO+bwd	baseline
4	5 layers+L0	"babar"	DIRC+fwd	fwd LYSO+bwd	baseline
5	5 layers+L0	"babar"	DIRC	fwd CsI+LYSO+bwd	baseline



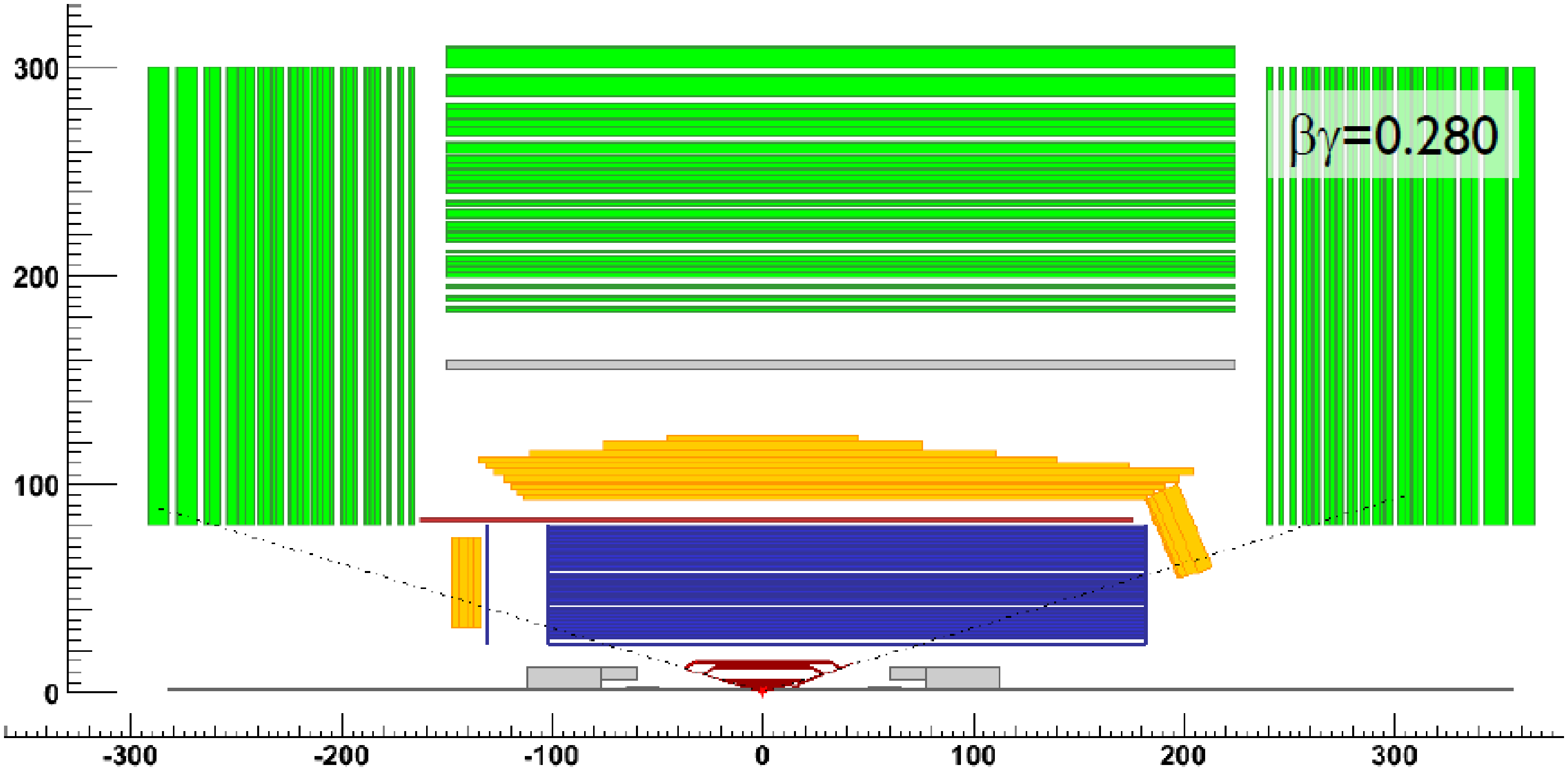
#2

	SVT	DCH	PID	EMC	IFR
0	5 layers+L0	"babar"	DIRC	fwd LYSO	baseline
1	5 layers+L0	"babar"+bwd+fwd	DIRC	fwd LYSO	baseline
2	5 layers+L0	"babar"+bwd	DIRC+fwd	fwd LYSO	baseline
3	5 layers+L0	"babar"+fwd	DIRC	fwd LYSO+bwd	baseline
4	5 layers+L0	"babar"	DIRC+fwd	fwd LYSO+bwd	baseline
5	5 layers+L0	"babar"	DIRC	fwd CsI+LYSO+bwd	baseline



#3

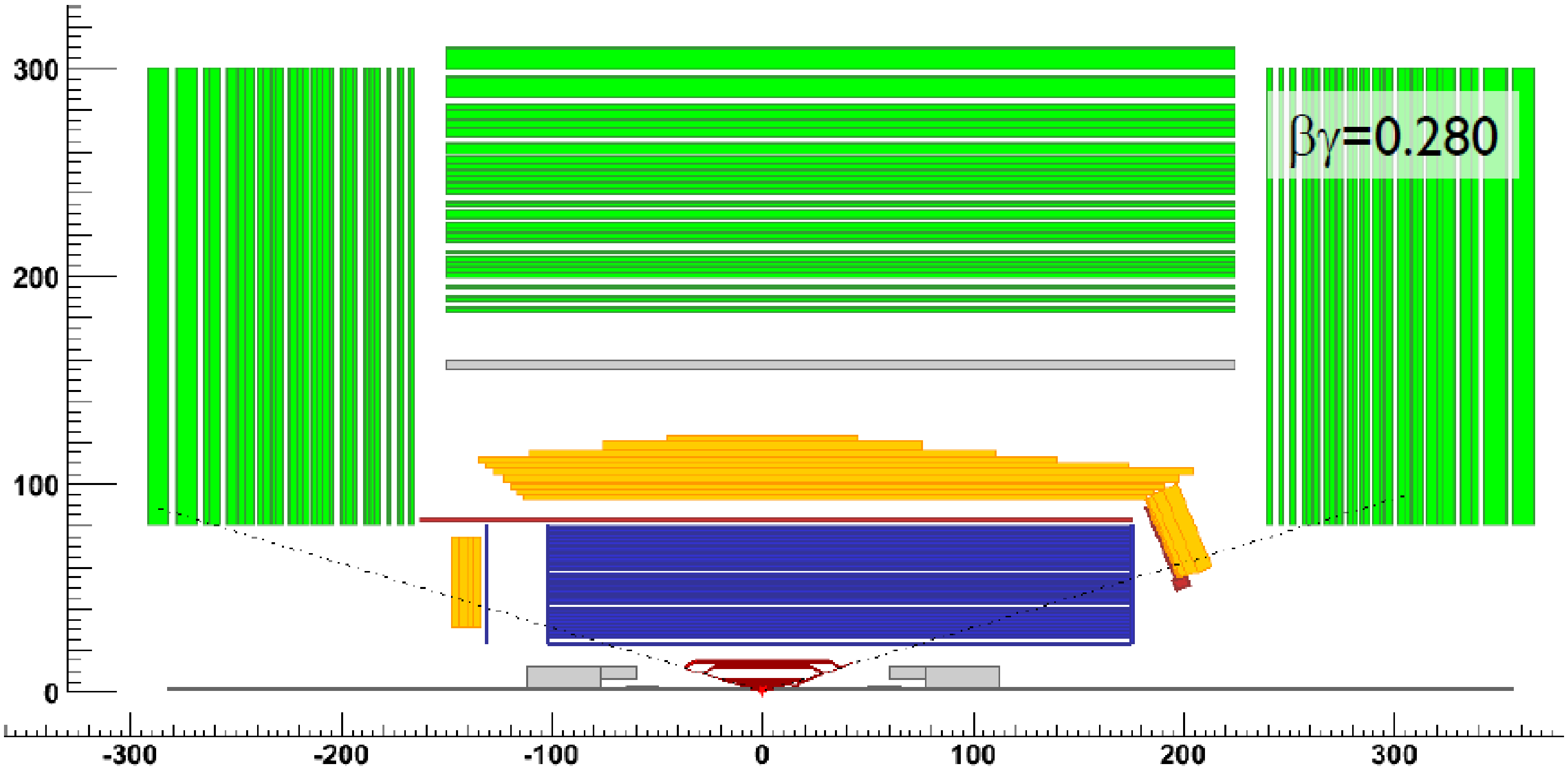
	SVT	DCH	PID	EMC	IFR
0	5 layers+L0	"babar"	DIRC	fwd LYSO	baseline
1	5 layers+L0	"babar"+bwd+fwd	DIRC	fwd LYSO	baseline
2	5 layers+L0	"babar"+bwd	DIRC+fwd	fwd LYSO	baseline
3	5 layers+L0	"babar"+fwd	DIRC	fwd LYSO+bwd	baseline
4	5 layers+L0	"babar"	DIRC+fwd	fwd LYSO+bwd	baseline
5	5 layers+L0	"babar"	DIRC	fwd CsI+LYSO+bwd	baseline



#4

SuperB++

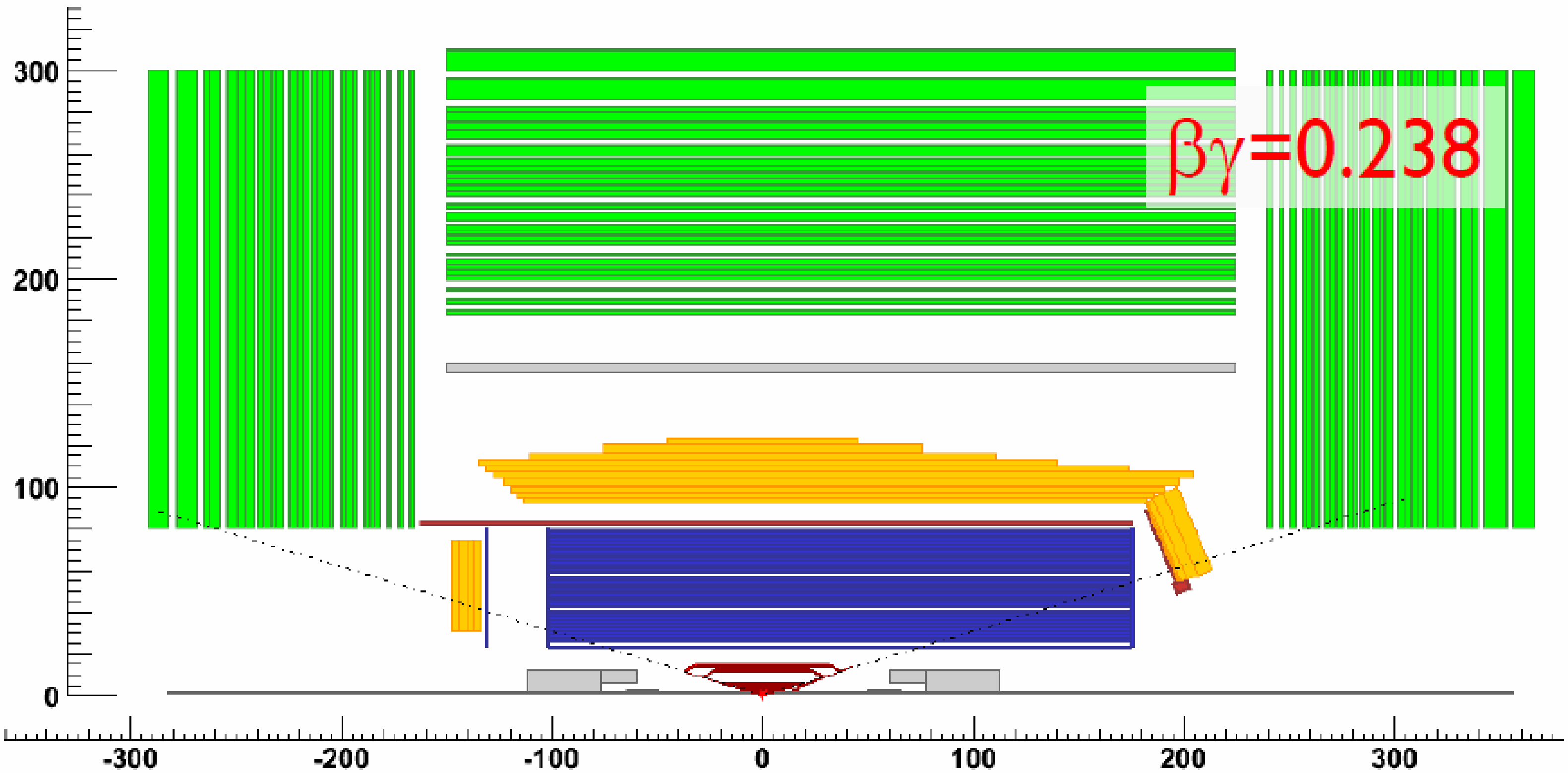
	SVT	DCH	PID	EMC	IFR
0	5 layers+L0	"babar"	DIRC	fwd LYSO	baseline
1	5 layers+L0	"babar"+bwd+fwd	DIRC	fwd LYSO	baseline
2	5 layers+L0	"babar"+bwd	DIRC+fwd	fwd LYSO	baseline
3	5 layers+L0	"babar"+fwd	DIRC	fwd LYSO+bwd	baseline
4	5 layers+L0	"babar"	DIRC+fwd	fwd LYSO+bwd	baseline
5	5 layers+L0	"babar"	DIRC	fwd CsI+LYSO+bwd	baseline



#4a

as #4 but with reduced boost

	SVT	DCH	PID	EMC	IFR
0	5 layers+L0	"babar"	DIRC	fwd LYSO	baseline
1	5 layers+L0	"babar"+bwd+fwd	DIRC	fwd LYSO	baseline
2	5 layers+L0	"babar"+bwd	DIRC+fwd	fwd LYSO	baseline
3	5 layers+L0	"babar"+fwd	DIRC	fwd LYSO+bwd	baseline
4	5 layers+L0	"babar"	DIRC+fwd	fwd LYSO+bwd	baseline
5	5 layers+L0	"babar"	DIRC	fwd CsI+LYSO+bwd	baseline

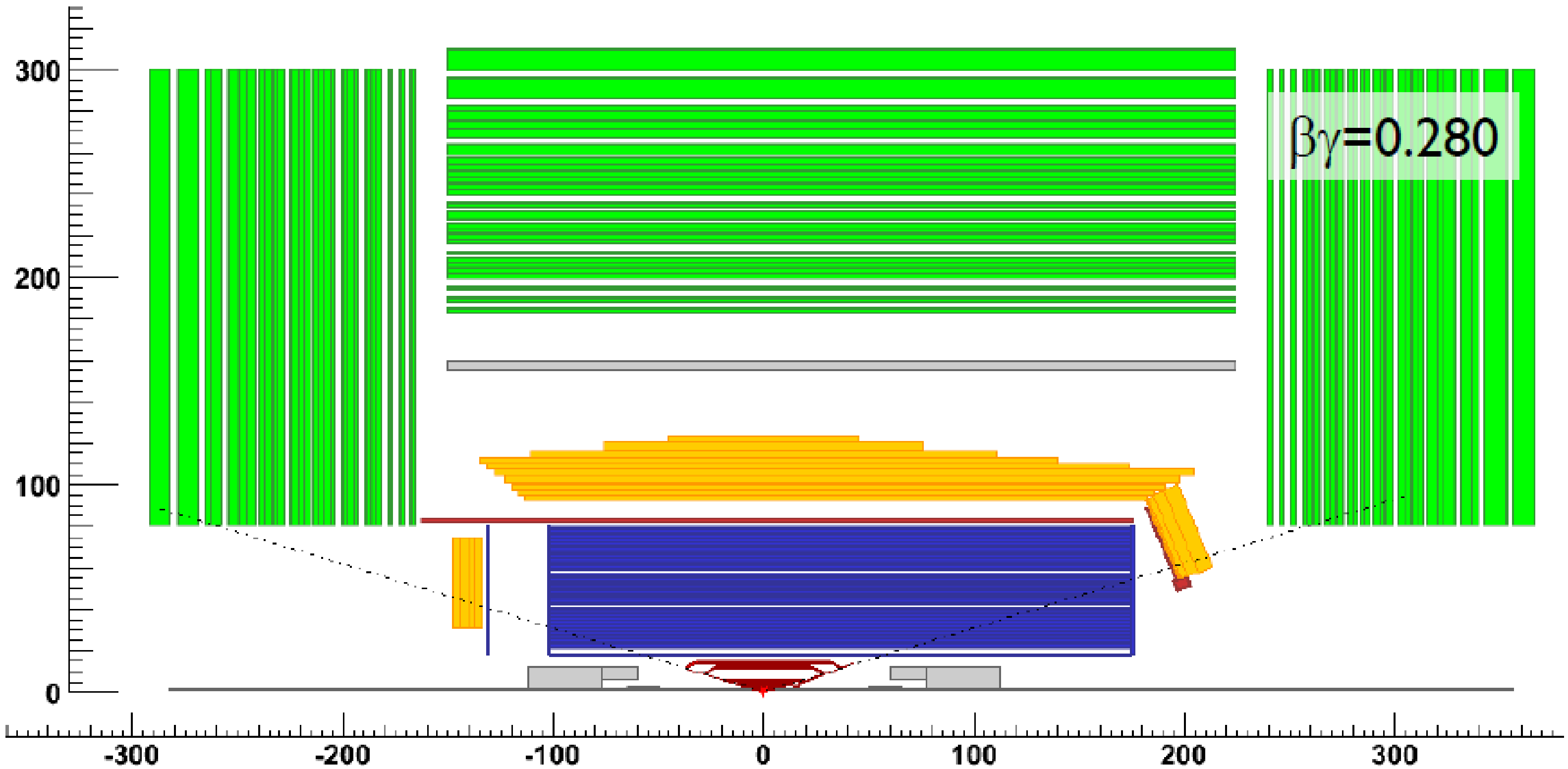


#4b

SuperB++

as #4 but with reduced SVT-DCH transition radius

	SVT	DCH	PID	EMC	IFR
0	5 layers+L0	"babar"	DIRC	fwd LYSO	baseline
1	5 layers+L0	"babar"+bwd+fwd	DIRC	fwd LYSO	baseline
2	5 layers+L0	"babar"+bwd	DIRC+fwd	fwd LYSO	baseline
3	5 layers+L0	"babar"+fwd	DIRC	fwd LYSO+bwd	baseline
4	5 layers+L0	"babar"	DIRC+fwd	fwd LYSO+bwd	baseline
5	5 layers+L0	"babar"	DIRC	fwd CsI+LYSO+bwd	baseline

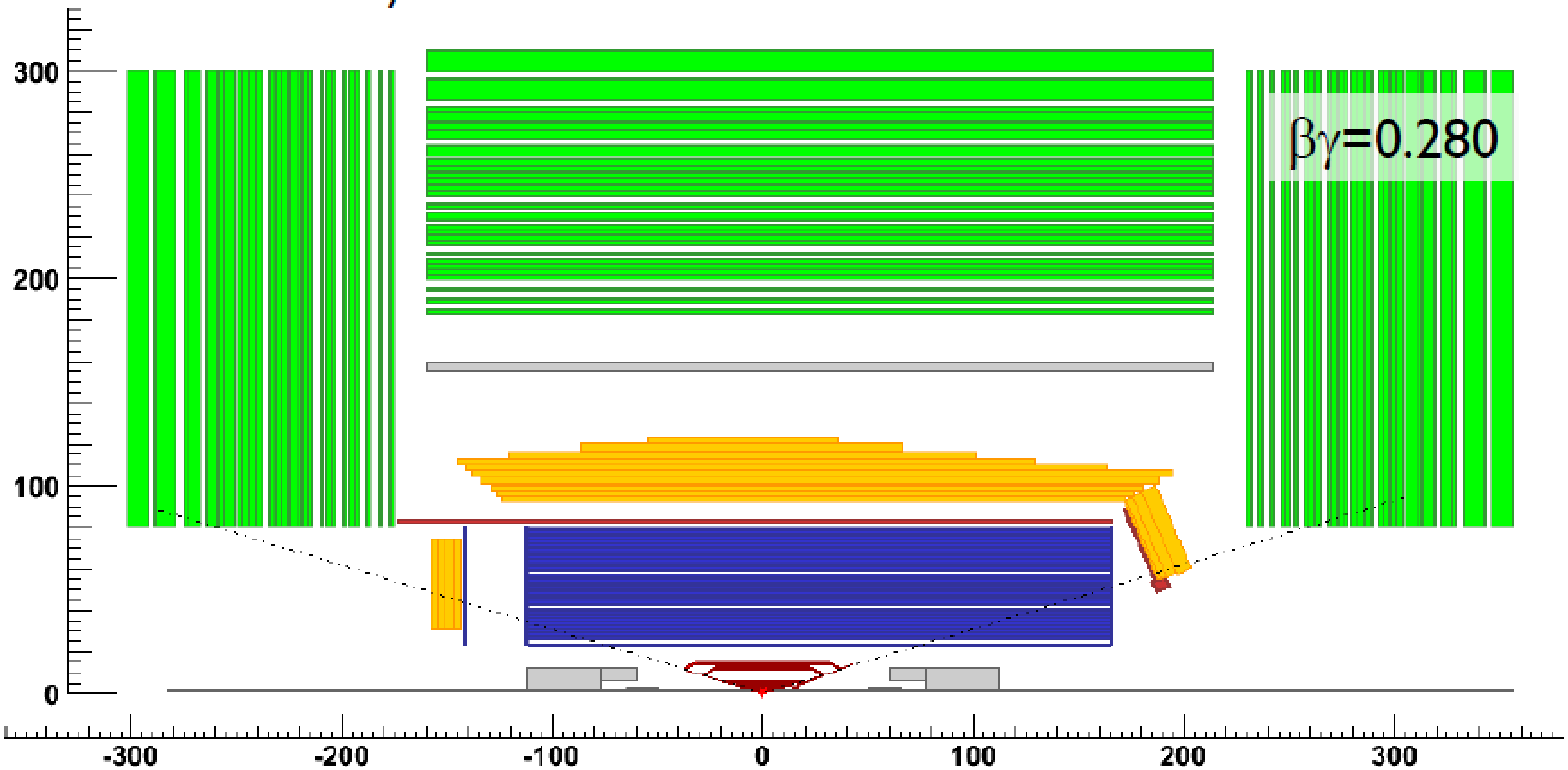


#4c

SuperB++

as #4 but with the IP shifted by +10cm w.r.t. DCH and outer systems

	SVT	DCH	PID	EMC	IFR
0	5 layers+L0	"babar"	DIRC	fwd LYSO	baseline
1	5 layers+L0	"babar"+bwd+fwd	DIRC	fwd LYSO	baseline
2	5 layers+L0	"babar"+bwd	DIRC+fwd	fwd LYSO	baseline
3	5 layers+L0	"babar"+fwd	DIRC	fwd LYSO+bwd	baseline
4	5 layers+L0	"babar"	DIRC+fwd	fwd LYSO+bwd	baseline
5	5 layers+L0	"babar"	DIRC	fwd CsI+LYSO+bwd	baseline



We give in the following some example of the work which is going on.
We already got some relevant results.

Extend the DCH inner radius or extend the SVT ?

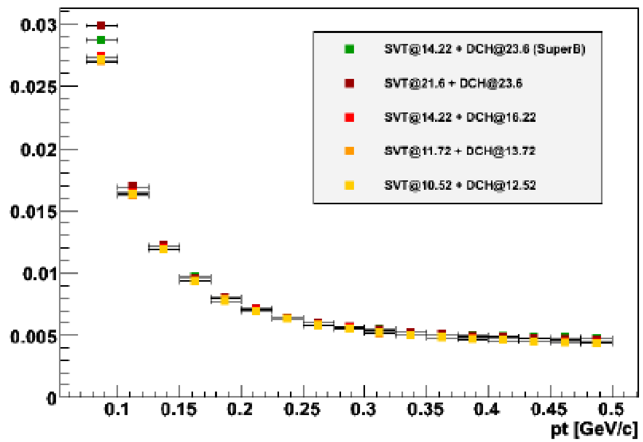
Nicola Neri (Pisa), Gabriele Simi (Maryland), Matteo Rama (Frascati)

single charged π particles with:

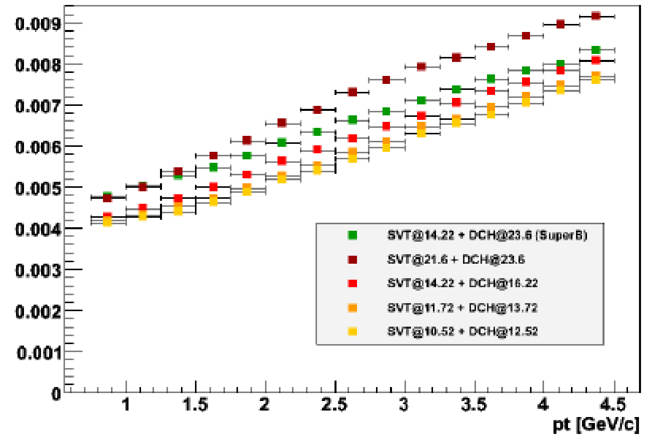
- pt in [0.05,4.5] GeV/c
- cosTheta in [-1,1]
- Phi in [0,2π]

σ(pt)/pt vs pt

Low momentum

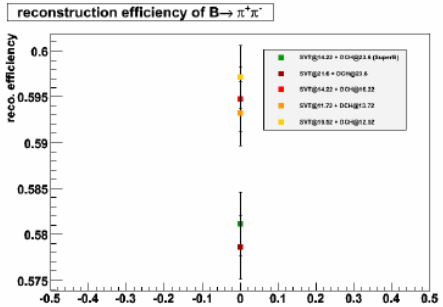


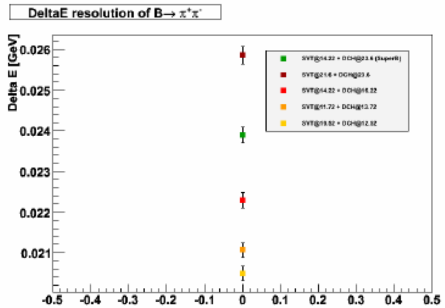
high momentum

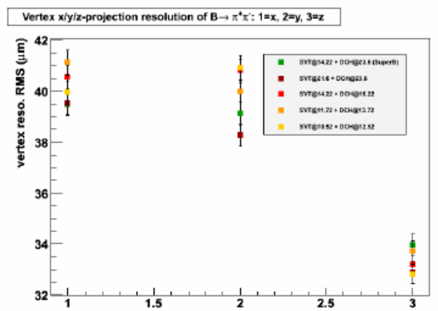


The configuration with extended SVT @ 21.6 cm gives worst pt resolution

$B \to \pi^+\pi^-$: summary







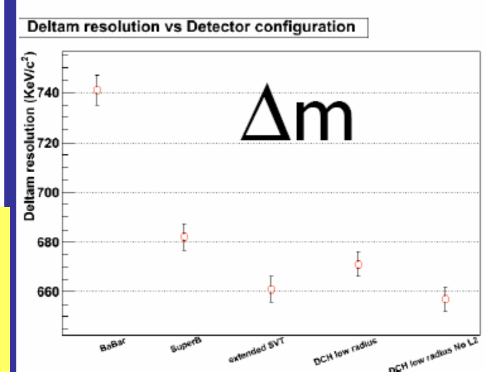
- best performance with small DCH inner radius:
  - ΔE resolution improves up to 25%
  - ~2% (absolute) reco. efficiency increase
  - vertex resolution variation negligible

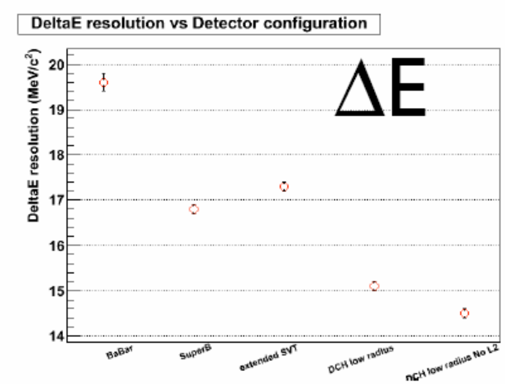
Comparison between the configuration with DCH at lower radius wrt enlarging SVT radius:

DCH at lower radius has

→ Better momentum resolution
→ Better ΔE and Δm resolution
→ Better reconstruction efficiency
→ Similar resolution on the track parameters

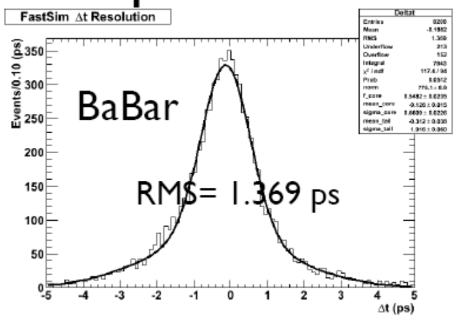
Reconstruct $B^0 \to D^{*-} K^+$ with $D^{*-} \to \bar{D}^0 \pi^-$

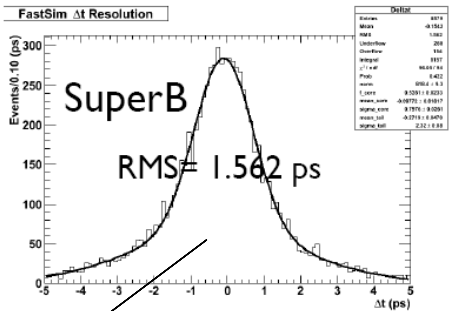


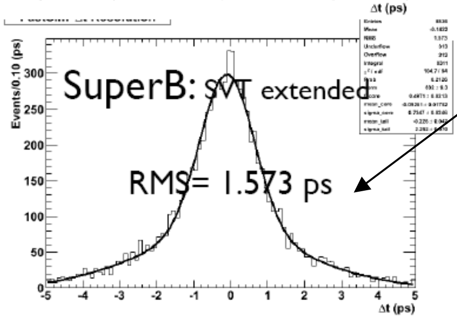


Δm (soft pion) resolution improves wrt BaBar configuration. ΔE resolution reflects the improvements in momentum reconstruction for DCH with lower radius.

Proper Time Resolution $B^0 \rightarrow K_S K_S$







19

...but the overall error is similar wrt SuperB baseline.

Overall the error is similar

Toy MC results:
per Event Error on S

$\sigma_{BaBar} = 1.431$

$\sigma_{SuperB} = 1.608$ (+12%)

$\sigma_{ExtSVT} = 1.608$ (+12%)

No efficiency correction applied though SuperB has larger acceptance

Reduction in sensitivity at high lumi is mitigated by the systematic error:

$\sigma = \sigma_{stat}/\sqrt{N} \oplus \sigma_{syst}$

$B^0 \rightarrow K_S \pi^0 (\gamma)$

	rms[ps]	f_{good}[%]	$\sigma_S/\sigma_S^{nominal}$	$\sigma_C/\sigma_C^{nominal}$
babar	1.84	69	0.90	0.98
nominal	2.19	72	1	1
expanded	2.71	88	1.07	1.00

SuperB sensitivity 10% worst wrt Babar.
An extra 10% degradation in the extended SVT configuration

No evidence of improvements in enlarging the SVT radius also for TD measurement in special modes as $B^0 \rightarrow$ KS KS and KS π^0 (γ)

Chih-hsiang Cheng (CalTech), Nicola Neri (Pisa), Gabriele Simi (Maryland)

Effect of the reduced boost on S measurements

$\beta\gamma$ 0.280 → 0.238

$B^0 \to \phi K_S$

βγ	0.283	0.238
S	0.70414 ± 0.00175	0.70325 ± 0.00187
C	-0.00105 ± 0.00122	-0.00289 ± 0.00125
b_core	-0.1158 ± 0.0038	-0.0929 ± 0.0034
b_tail	-0.8376 ± 0.0241	-0.7653 ± 0.0204
f_out	0.0078 ± 0.0004	0.0100 ± 0.0002
f_tail	0.1773 ± 0.0027	0.1779 ± 0.0023
s_core	1.1230 ± 0.0056	1.1314 ± 0.0049

9

- Resolution function is not perfect, but does not cause bias in uncertainty comparison.
- Error on S changes by +6.9%.

It does not change the result if we relax $\sigma(\Delta t)$ cut in reduced boost so that #events in the fit are the same.

Note that it is a complete « Babar » analysis with FastSim !

$B^0 \to K_S K_S$

Toy MC results:

Per Event Error on S

$\sigma_{BaBar} = 1.431$

$\sigma_{SuperB} = 1.608$ (+12%)

$\sigma_{RedBoost} = 1.689$ (+18%)

No efficiency correction applied though SuperB has larger acceptance

Reduction in sensitivity at high lumi is mitigated by the systematic error:

$\sigma = \sigma_{stat}/\sqrt{N} \oplus \sigma_{syst}$

From Babar→ SuperB we loose already 12% on S sensitivity
With reduced boost lost on sensitivity from 12% → 18%

for the analyzed channels the reduced boost correspond to a reduction of ~15% on number of events.

Elisa Manoni (Perugia), Alejandro Perez (LAL), Francesco Renga (Roma I)

For the physics studies we have now implemented Breco a la Babar in the FastSim
Is one of the main tool for these studies

Nicolas Arnaud (LAL), Leonid Burmistrov (Perugia), Evgeniy Kravchenko (Budker INP),
Elisa Manoni(Perugia) Alejandro Perez (LAL), Achille Stocchi(LAL) Francesco Renga (Roma I)

Need of Forward PID ?

BRECO SIDE

- Look for $B^+ \to D^{0(*)} l \nu$ and $B^0 \to D^{+(*)} l \nu$ ($l = e/\mu$)
- D^0/D^+ reconstructed in 6 decays channels:
  - $D^0 \to K^-\pi^+, K^-\pi^+\pi^-\pi^+, K^-\pi^+\pi^0, K^0_s\pi^+\pi^-$
  - $D^+ \to K^-\pi^+\pi^-, K^0_s\pi^+$
- Also look also for D* decays:
  - $D^{*+} \to D^0\pi^+, D^+\pi^0$ (slow pions)
  - $D^{*0} \to D^0\pi^0, D^0\gamma$
- Form a $D^{(*)}l$ pair adding a hard lepton

Studies of $B \to K \nu \nu$ with semileptonic BRECO

Mainly two configurations have to be tested :
→ FPID : with the coverage of DCH
→ FPID : "TOF-like"

Efficiency	BaBar FullSim	BaBar FastSim (v03)	BaBar FastSim (v09)
Tag-Side	0.00530	0.00543	0.00593
Signal-Side	0.217	0.210	0.229

Signal Sample: selection efficiency

Tagging efficiency

	BaBar	SuperB	
D^0 Dec. Channel	DIRC+FwdDch	DIRC+FwdDch	DIRC+FwdPiD
$K^-\pi^+$	0.001256	+9.7%	+7.6%
$K^-\pi^+\pi^-\pi^+$	0.001681	+4.9%	+9.6%
$K^-\pi^+\pi^0$	0.003307	+6.7%	+6.1%
$K^0_s\pi^+\pi^-$	0.000463	+11.0%	+7.2%
Average	0.006707	+7.1%	+7.3%

Signal efficiency

	BaBar	SuperB	
D^0 Dec. Channel	DIRC+FwdDch	DIRC+FwdDch	DIRC+FwdPiD
--------	0.227	+5.7%	+2.5%

A dedicated FPID allows a gain of ~10% on signal efficiency (BRECO+signal side)
Almost as much as we gain from the better acceptance due to the reduced boost

Performance of Backward EMC

A. Rakitin, A. Chivukula
(CalTech)

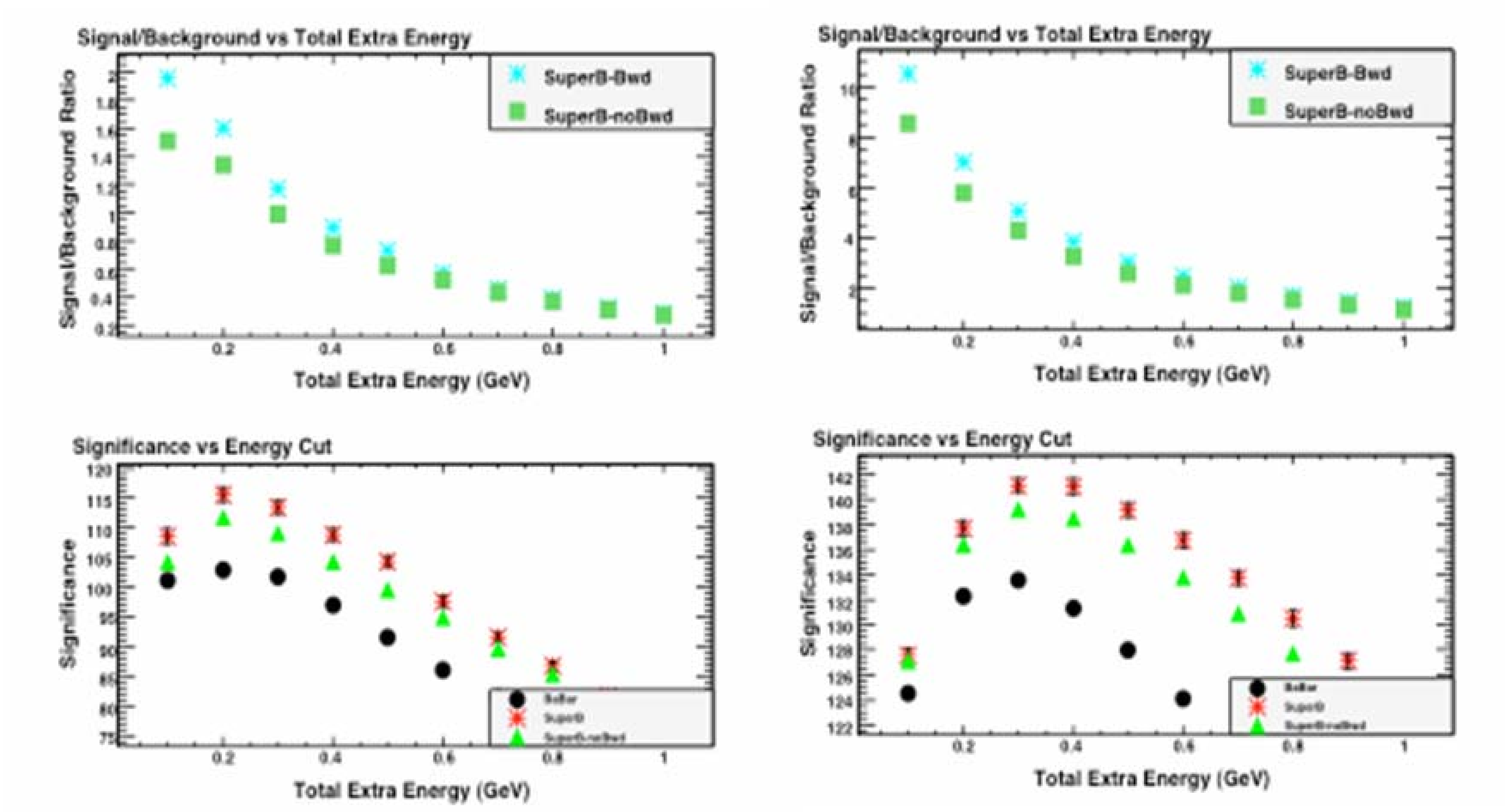
Using B→ τ ν with hadronic BRECO analysis

Many possible background :

Studied !

Decay	Lost particles	BF	BF ratio
Signal $B^+ \to \tau^+\nu_\tau$	–	$(1.4 \pm 0.4) \times 10^{-4}$	1.00
$B^+ \to \overline{D^0}\ell^+\nu_\ell$	$\overline{D^0}$ decay product(s)	$(2.24 \pm 0.11)\%$	160
$B^+ \to D^{*0}\ell^+\nu_\ell$	D^{*0} decay product(s)	$(5.68 \pm 0.19)\%$	406
$B^+ \to D^-\pi^+\ell^+\nu_\ell$	D^- decay product(s) and π^+	$(4.2 \pm 0.5) \times 10^{-3}$	30
$B^+ \to D^{*-}\pi^+\ell^+\nu_\ell$	D^{*-} decay product(s) and π^+	$(6.1 \pm 0.6) \times 10^{-3}$	44
$B^+ \to \overline{D^{**0}}\ell^+\nu_\ell$	$\overline{D^{**0}}$ decay product(s)	a few %	$\mathcal{O}(10^2)$
$B^+ \to \pi^0\ell^+\nu_\ell$	π^0 photon(s)	$(7.7 \pm 1.2) \times 10^{-5}$	0.55
$B^+ \to \eta\ell^+\nu_\ell$	η photon(s)	$(6 \pm 4) \times 10^{-5}$	0.43
$B^+ \to \eta'\ell^+\nu_\ell$	η' decay product(s)	$(1.7 \pm 2.2) \times 10^{-5}$	0.12
$B^+ \to \omega\ell^+\nu_\ell$	ω pion(s)	$(1.3 \pm 0.6) \times 10^{-4}$	0.93
$B^+ \to \rho^0\ell^+\nu_\ell$	ρ^0 pion(s)	$(1.28 \pm 0.18) \times 10^{-4}$	0.91
$B^0 \to D^-\ell^+\nu_\ell$	D^- decay product(s)	$(2.17 \pm 0.12)\%$	155
$B^0 \to D^{*-}\ell^+\nu_\ell$	D^{*-} decay product(s)	$(5.16 \pm 0.11)\%$	369
$B^0 \to \overline{D^0}\pi^-\ell^+\nu_\ell$	$\overline{D^0}$ decay product(s) and π^-	$(4.3 \pm 0.6) \times 10^{-3}$	31
$B^0 \to D^{**-}\ell^+\nu_\ell$	D^{**-} decay product(s)	a few %	$\mathcal{O}(10^2)$
$B^0 \to \rho^-\ell\nu$	ρ^- pion(s)	$(2.47 \pm 0.33) \times 10^{-4}$	1.76
$B^0 \to \pi^-\ell\nu$	π^-	$(1.34 \pm 0.08) \times 10^{-4}$	0.96

B->D^0 l ν Background   B->D^{**0} l ν Background



Signal vs Background: .2 GeV to .3 GeV Range in Extra Energy

Distinct advantage with backwards EMC vs. without, but magnitude of the advantage varies from 15% to 60%

B.F. Weighted Average → S/B Increase ~ 24%

IFR Optimisation

G. Cibinetto (Ferrara)

Parameter to optimize
→ Amount of absorber
→ Width of scintillator bars
→ evaluate the worst allowed time resolution

Quantities to look at :
→ μ identification
→ π rejection

Full Sim, needed for hadron showers
→ to generate single particle events /events+background
+ reconstruction code.

Work done sine Perugia meeting

- Write more GDML description of the IFR: 2 configurations already done (CDR like and BaBar like). DONE
- Write digitization and clusterization DONE
- Write a track fitter and extract relevant information. DONE
- Write a cut-based muon selector similar to the first one used in BaBar. in progress
- Test different configurations (BaBar like, CDR like, some hybrid). in progress
- Make a proposal
  preliminary results expected for the SLAC meeting

Preliminary analyses

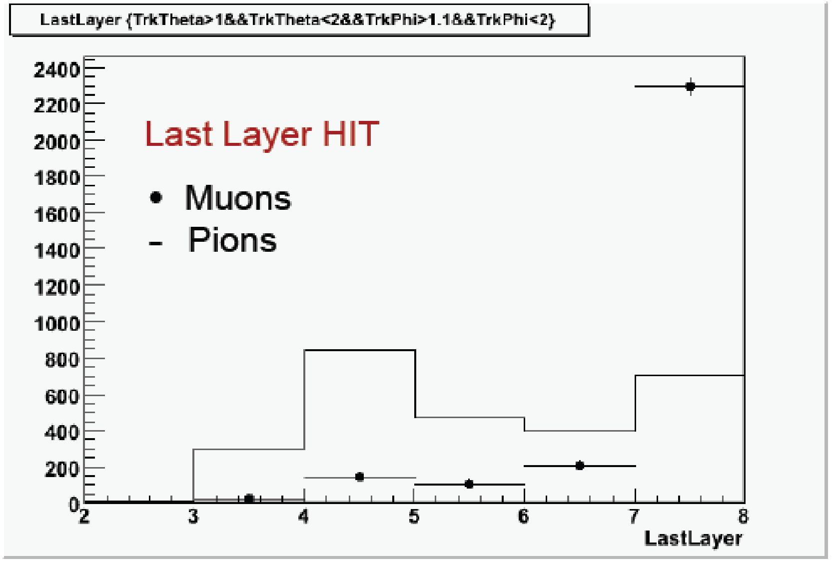
We simulated with Bruno 10000 muons and 10000 pions with momentum 0.5GeV < p < 4GeV.

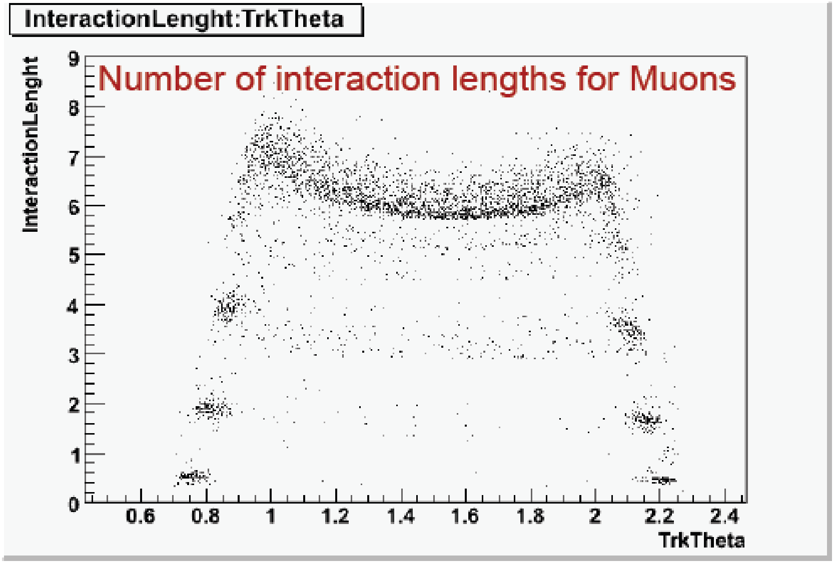
First we use the CDR like configuration of the IFR

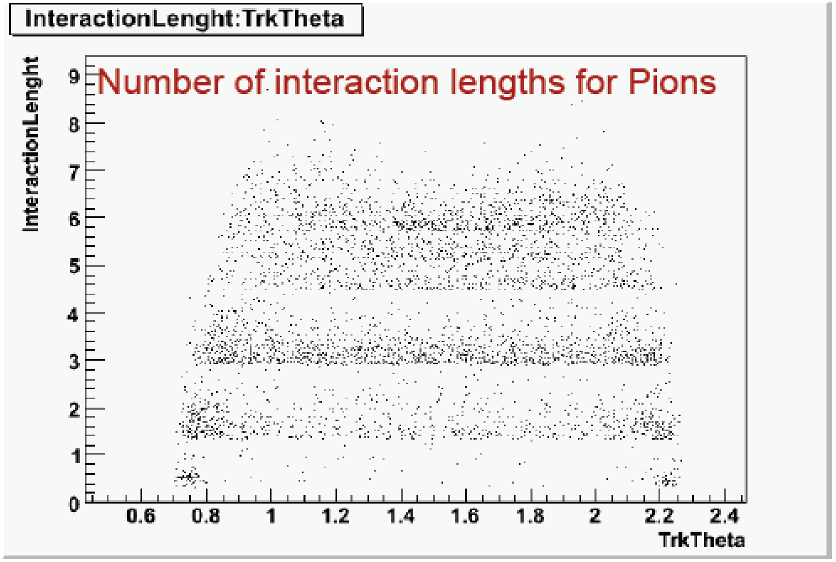
Magnetic field switched OFF - no inner detector (for debug purpose)

Only one sextant of the barrel.

Added random noise corresponding to 1.5% occupancy



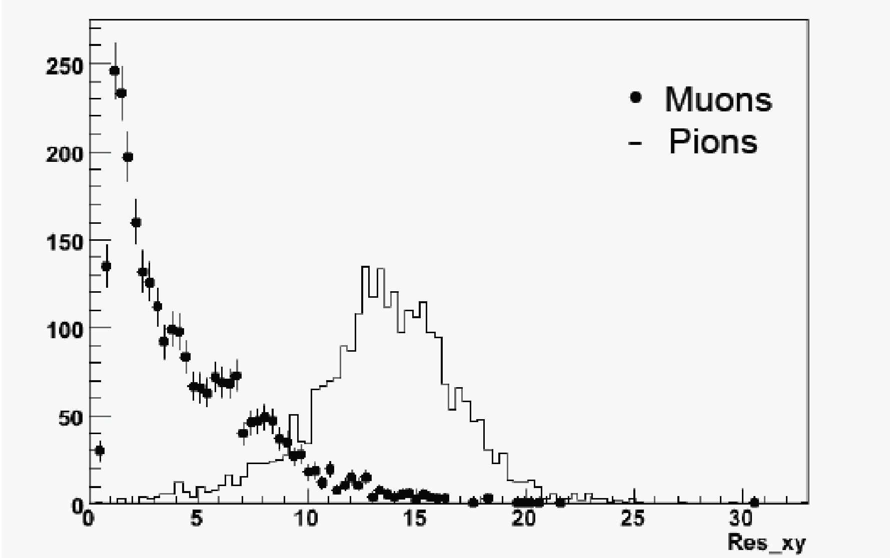




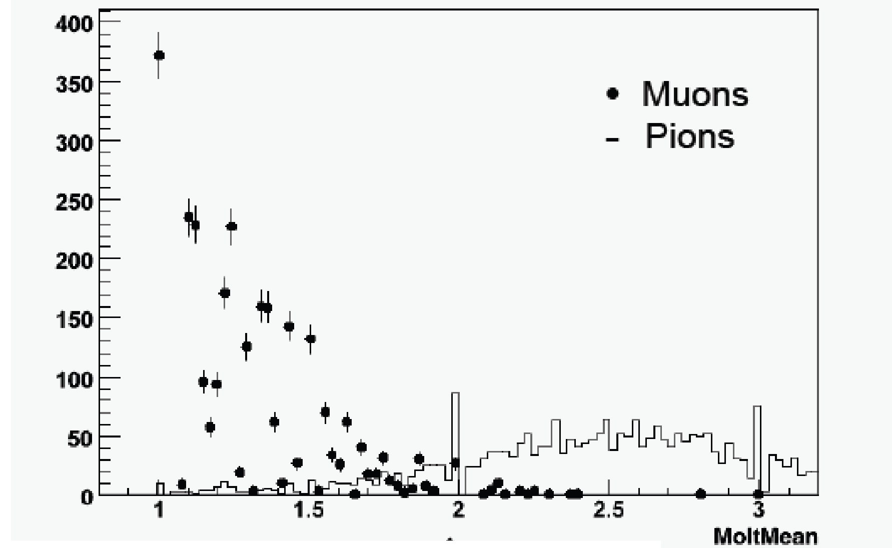
Track Reconstruction

To get an idea of the transverse development of the shower

Residual distribution of the hits (from linear fit to tracks)



Average multiplicity of hit strips per cluster



Ready for performances and optimization studies.

From previous activities :

→ It is better to extend the inner radius for the DCH than to extent the SVT

→ 10% lost in sensitivity for time dependent analyses if the boost is reduced

→ Forward PID gives a gain of 10% in efficiency for some important analysis $B \rightarrow K\nu\nu$

→ Backward EMC gives significant improvements in channel as $B \rightarrow \tau\ \nu$ (order of 25% on S/B)

→ IFR : Ready for performances and optimization studies.

Massive production of events with FastSim started.
Aim for new results for this meeting.

2009 September production.

From David Brown !

2009 September Production Status

jobs	Kevents/Job	Generator	DG	script error	hung	crash	# Successful	<sec>/event	Run # range	Mevents
500	50	B0B0bar	1	42	7	1	450	0.35	110000-110499	22.5
500	100	B0B0bar	1	9	22	2	454	0.35	130000-130499	45.4
500	100	B+B-	1	12	20	2	466	0.35	150000-150499	46.6
500	100	B0B0bar	4	9	17	6	468	0.38	120000-120499	46.8
500	100	B+B-	4	7	18	3	472	0.38	140000-140499	47.2

~50M B0
~50M B+

Per detector geometry
DG#1 - basic SuperB
DG#4 - SuperB++

Directories and Files

Logfile Directory at CNAF:	/storage/gpfs_babar6/sb/brownd/Production/production_log/
Log files	DG_[1,4]/[B0B0bar,B+B-]_generic/$RUNNUM/job.out, job.err
Data Directory at CNAF:	/storage/gpfs_babar6/sb/brownd/2009_September/FastSim/
Data files	DG_[1,4]/[B0B0bar,B+B-]_generic/$RUNNUM/$ANALYSIS.root

Output

		Selection rate				
Analysis	KByte/event	B0 DG1	B+ DG1	B0 DG4	B+ DG4	total size MBytes
Hadronic K*nunu	5.4	5.60%	7.10%	6%	7.70%	40000
Sin2Beta	2.7	2.30E-05	1.80E-06	2.20E-05	1.60E-06	70

Ex : K nu nu with hadronic Breco.

For this meeting we expect new results

Wednesday 07 October 2009

13:30->*15:30* **Parallel - DGWG** (Convener: Matteo Rama (*LNF*) , Achille Stocchi (*LAL)*

Chaired by Nicolas Arnaud

13:30	**plans for RICH optimization (20')**	**Evgeniy Kravchenko (*Budker INP*)**
13:50	**B->K(*)nu nubar with SL and HAD tag (20')**	**Alejandro Perez (*LAL*)**
14:10	**BReco tag (20')**	**Elisa Manoni (*PG*)**
14:30	**PID selectors (20')**	**Leonid Burmistrov (*LAL*)**

Thursday 08 October 2009

13:30->*15:30* **Parallel - DGWG** (Convener: Matteo Rama (*LNF*) , Achille Stocchi (*LAL*)

Chaired by David Brown

13:30	**internal geometry of SVT (20')**	**Nicola Neri (*Universita' di Pisa & INFN*)**
13:50	**update on B->tau nu (20')**	**Alexander Rakitin (*Caltech*)**
14:10	**G4 studies of forward EMC (TBC) (20')**	**Stefano Germani (*PG*)**
14:30	**IFR (20')**	**Gianluigi Cibinetto (*FE*)**