(how we can evaluate the) SuperB physics reach in presence of background

Matteo Rama
Laboratori Nazionali di Frascati

3 June 2012

Outline

- Implications of a thicker shield on detector performance

  +

- What we already have and what we need to estimate the detector performance

- Evaluating the physics reach vs background

- Example of preliminary studies

The issue

- The background rate seen by the EMC using a 3.5cm-thick tungsten shield* is very high
  - need to increase the shield thickness

- The additional material can only be placed outside
  - as a consequence the inner radius of the DCH must increase

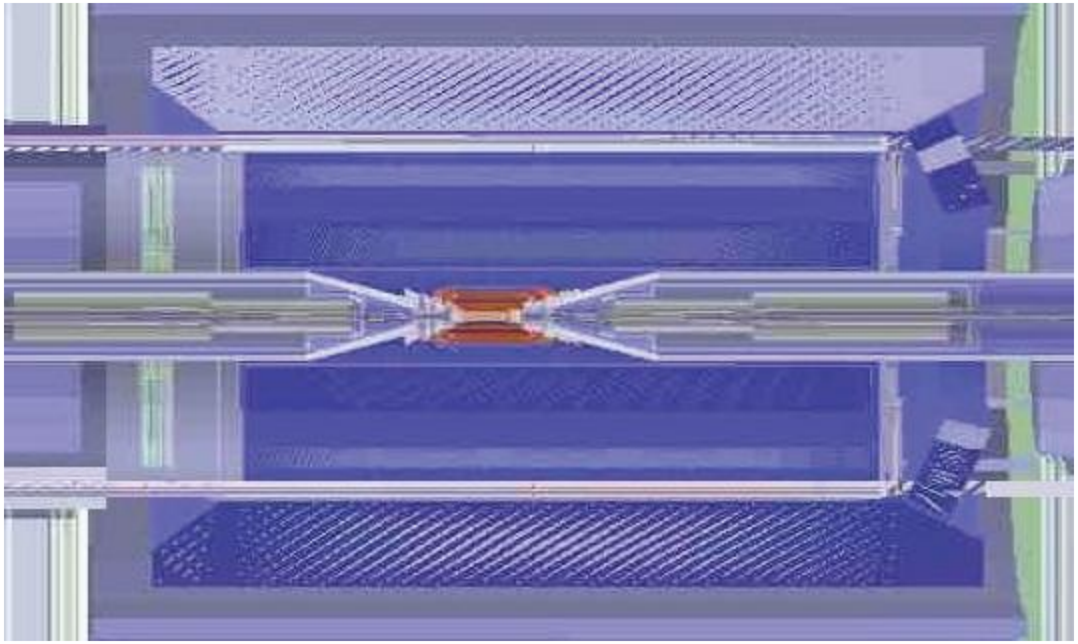
- We want to quantify the benefits and drawbacks of a thicker shield and smaller drift chamber
  - how much thicker?

* D. Hitlin has proposed to investigate the use of depleted uranium instead of tungsten.

Implications of thicker shield on detector geometry

thicker shield ➔ larger inner DCH radius

In next slides: how can we quantify the implications on detector performance and on physics?



Implications for tracking

Legend:

FS=FastSim; **pat rec**=pattern recognition

green: available; **orange**: available but work needed; **red**: not available

-)<physical/geometric effect> **-)<impact on performance>**	**tool to estimate the impact on performance**
-) smaller DCH trajectory sagitta, less reco hits -) p measurement degradation -) lower tracking efficiency	 **FS** **FS**
-) less DCH dE/dx measurement hits -) DCH dE/dx measurement degradation	 **FS**
-) larger distance between DCH and SVT -) larger error in matching the DCH and SVT tracks, impact on pat. rec.	 **pat rec N/A**
-) reduced DCH occupancy -) better pat. recognition performance, higher tracking efficiency -) better track reconstruction quality -) benefits on trigger performance (seem small)	 **Hit merging/confusion with FS**, **pat rec N/A** **Hit merging/confusion with FS**, **pat rec N/A** **Hit merging/confusion with FS**, **pat rec N/A**
-) reduced SVT occupancy -) better standalone pat. rec. for low pt tracks, higher tracking efficiency -) better low pt track reconstruction -) better measurement of d0,z0 track parameters (improved vertexing)	 **Hit merging/confusion with FS**, **pat rec N/A** **Hit merging/confusion with FS**, **pat rec N/A** **Hit merging/confusion with FS**, **pat rec N/A**

Pattern recognition

To have a full understanding of the effects of background on tracking
a full reconstruction with pattern recognition is needed

Pattern recognition is beyond the FastSim scope. We can try using BaBar data to some extent.

It's probably time to start thinking about the SuperB event reconstruction
Problem common to SVT and DCH. Joint effort desirable to share knowledge, ideas and manpower.

Hit merging and hit confusion

<u>Pattern recognition effects in FastSim are partially taken into account in 4 steps:</u>

1. **Creation of reconstructed hits**
   Loop over all the charged PacSimTracks and create the reconstructed hits in SVT and DCH. The hits are stored into a reco. hit map for later use.

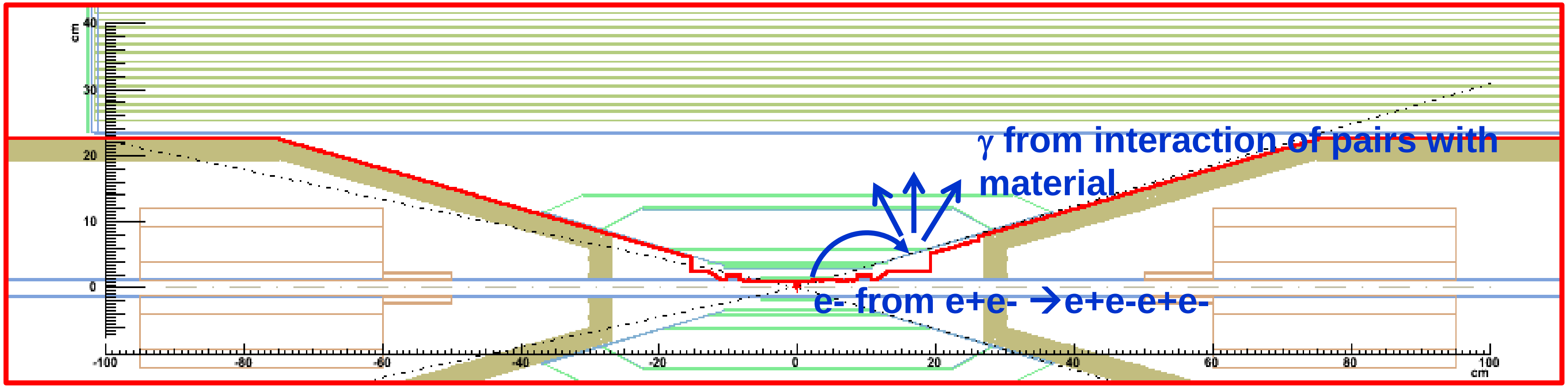
2. **'Hit merging'**
   If two reco. hits are 'close enough' (in space and time) they are merged into a single hit with modified spatial position and resolution. One of the two original reco. hits is removed.

3. **Track fit**
   The reco hits associated to a given charged PacSimTrack are fitted to create the corresponding reco. track. *No pattern recognition:* FastSim knows which reco. hits belong to a given particle. However, a few reco. hits might have been removed or modified in the previous step.

4. **'Pat. rec. confusion'**
   Nearby hits on different tracks are compared. Depending on their χ^2 w.r.t. the tracks they might be assigned to the other track.

But…

background on SVT and DCH



-) Background on SVT L0 is mostly given by e+/- from e+e- →e+e-e+e- (pairs)
-) Background on outer SVT layers and on DCH is mostly composed of photons originating from pairs interacting with IR material or from Bhabhas.

In fastsim photons do not create reco. hits in SVT and DCH ➔ tracking not sensitive to photon background.

Possible solutions:

1) change fastsim so that photons (from bkg frames) can create hits on SVT and DCH
2) IDEA. For low energy background particles replace the concept of "background frames" with that of "background hit maps": background hits are not created by background particles: they are sampled from collection of hits produced with Geant4
   ➔ **this concept might also be applied to the EMC**

Implications for barrel/fwd EMC

Legend:

FS=FastSim; **pat rec**=pattern recognition

green: available; **orange**: available but work needed; **red**: not available

-)<physical/geometric effect> **-)<effect on performance>**	**tool to estimate the impact on performance**
-) less photon background (neutron background is comparable) -) better energy and angular resolution -) larger cluster reconstruction efficiency [check] -) less energy not associated to the reconstruction of physics event (e.g. better discriminating power of E_extra)	 **FS (+bruno)** **FS (+bruno)** **FS**

work needed:

-) tune the fullsim/fastsim resolutions in the case of NO bkg

-) check that the clustering algorithms used in fullsim and fastsim studies give similar results

-) check that the fullsim/fastsim resolutions at different bkg levels (1x,3x,…) are in reasonable agreement

Implications for FDIRC

Legend:

FS=FastSim; **pat rec**=pattern recognition

green: available; **orange**: available but work needed; **red**: not available

-)<physical/geometric effect> **-)<effect on performance>**	**tool to estimate the impact on performance**
FDIRC/FTOF: -) less background on detector and readout -) better K/π separation	**FS with input from subsystem**

work needed:

-) The PID group will estimate the performance vs background level of FDIRC and fastsim will be configured accordingly

Implications for IFR

Legend:

FS=FastSim; **pat rec**=pattern recognition

green: available; **orange**: available but work needed; **red**: not available

-)<physical/geometric effect> **-)<effect on performance>**	**tool to estimate the impact on performance**
IFR: -) less background on detector and readout -) better μ/K_L identification	**Bruno + FS**

work needed:

-) tuning of Geant4 model prototype with real prototype

-) tuning of SuperB IFR Geant4 model following the previous step

-) tuning of FS according to SuperB IFR Geant4 model

-) best solution seems to implement an IFR background hit map

summary

detector	performance vs background rates in FastSim (FS)	main development needs
SVT	FS takes into account "hit merging/hit confusion" effects of two nearby charged tracks. No real pattern recognition.	**Development of background hit map** **No pat rec**
DCH	see SVT	See SVT
FDIRC (and TOF)	Must be evaluated outside FS and then parametrized.	**'External' estimate of performance vs background**
barrel/fwd EMC	"Automatically evaluated" at reconstruction level.	**Tuning of fastsim and fullsim cluster reconstruction vs bkg level** **(Development of background hit map)**
IFR	Could be evaluated at reconstruction level once the bkg hits are overlapped to the event	**Understanding of background effect on reconstruction with fullsim** **Development of background hit map**

some possible decay modes usable as benchmarks

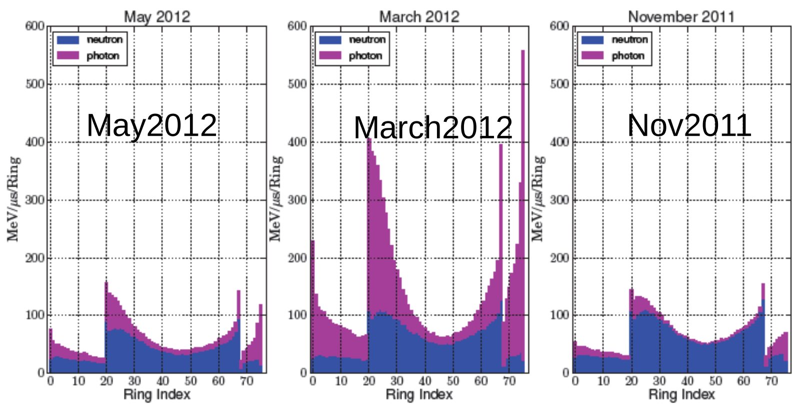
example of decay modes	Sensitive to	ready?
-) had breco (standalone)	track eff, gamma/pi0 eff, hadron PID, soft pi+/pi0 eff	YES
-) SL breco (standalone)	as had breco + lepton PID	YES
-) B→K(*)nu nubar (+breco)	hadron PID, E_extra in EMC (E_extra) (+breco)	YES
-) B→Xs gamma (+breco)	pi0/gamma reco. (+breco)	
-) B→tau nu (+breco)	lepton PID, hadron PID (+breco)	?
-) B→Xs l+l-	lepton PID, hadron PID, …	
-) time dep. measurements: e.g.		
-) B→Phi K0s	track reco, vertexing	YES
-) B→K0s pi0 gamma	track reco, pi0/gamma reco	
-) tau→mu gamma	muon PID, gamma reco	?
-) D0 time-dep measurements	track reco, vertexing	?
-) D*+ → D0pi+, D0→X selection	pi soft eff.	?
-) D0→gamma gamma	gamma/pi0 reco	?

YES: analysis code ready and someone is using it
YES: analysis code ready
?: there might be someone interested

shield outside the detector

The optimization of detector geometry as a function of the background rates must be done after it's not possible to reduce the rates further using *external* shields. E.g. ~10+10 cm of iron+boron-loaded polyethylene.
What is the plan on this regard?

EMC energy flux per ring



neutrons
photons

C. Cheng

SVT studies

N. Neri

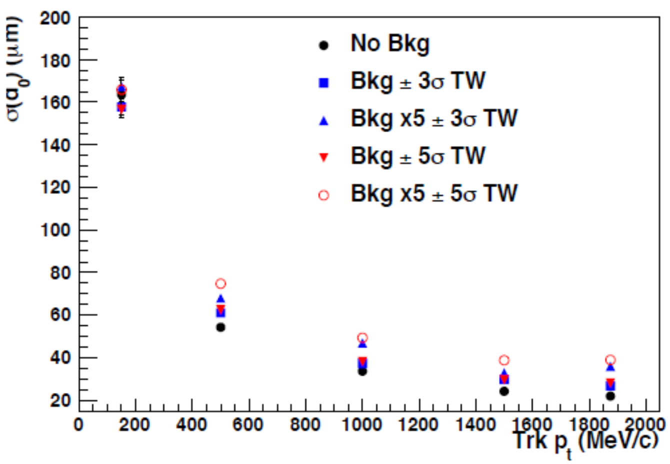
A temporary workaround to make SVT studies with the correct rates:

- Scale the offline time windows to obtain identical rates as in FullSim using the factor R=Rate(FullSim)/Rate(FastSim) evaluated on cluster rates.
    - This way all bkg sources are effectively included in FastSim
- Study how background rates affect track parameters
- Study the effect on sin2β_eff measurement in B0→Phi K0s

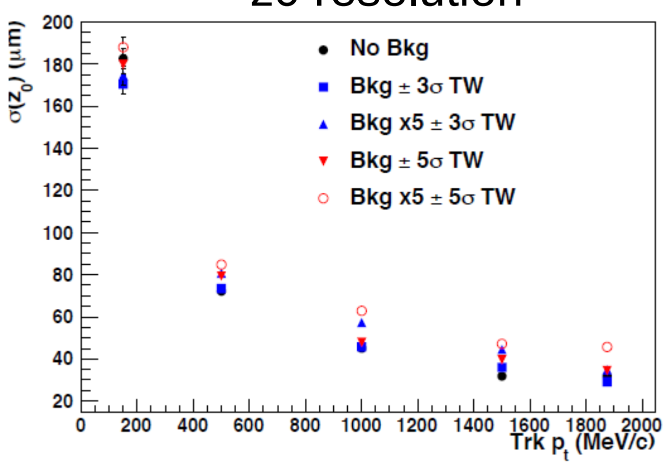
Layer	Trk rate FastSim MHz/cm^2	Cluster FastSim MHz/cm^2	Track FullSim All Bkg MHz/cm^2	Cluster FullSim All Bkg MHz/cm^2	Ratio FullSim/FastSim R	RMS t0 σ(t0) (ns)	Effective window (μs) ±5σ(t0)×R
L0	1.23E+00	2.86E+00	1.625E+00	4.103E+00	1.43E+00	10	1.43E-01
L1	6.76E-02	1.91E-01	2.169E-01	5.397E-01	2.83E+00	15	4.24E-01
L2	3.20E-02	9.12E-02	1.623E-01	3.928E-01	4.31E+00	15	6.46E-01
L3	6.87E-03	1.70E-02	7.939E-02	2.080E-01	1.22E+01	25	3.06E+00
L4	4.61E-04	1.44E-03	2.237E-02	3.699E-02	2.57E+01	46	1.18E+01
L5	2.55E-04	8.36E-04	1.402E-02	2.234E-02	2.67E+01	80	2.14E+01

SVT studies

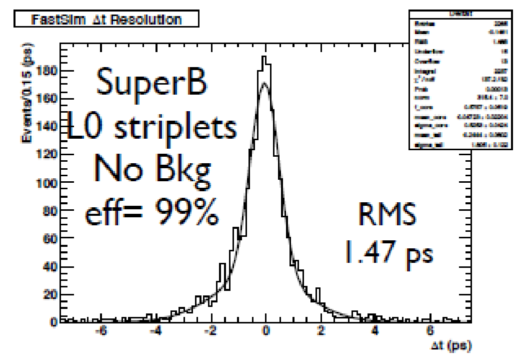
d0 resolution

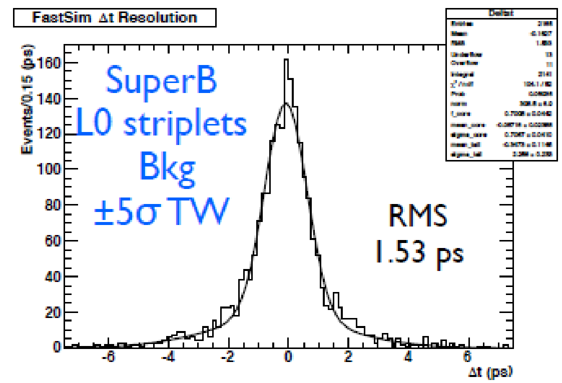


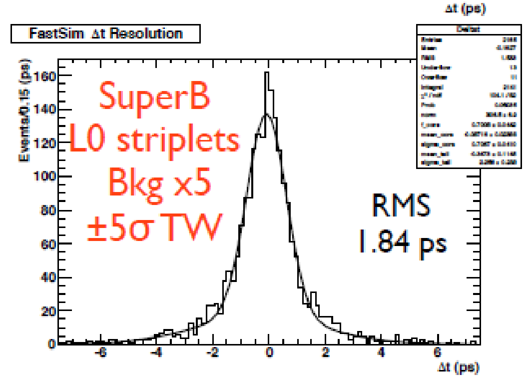
z0 resolution



Δt resolution



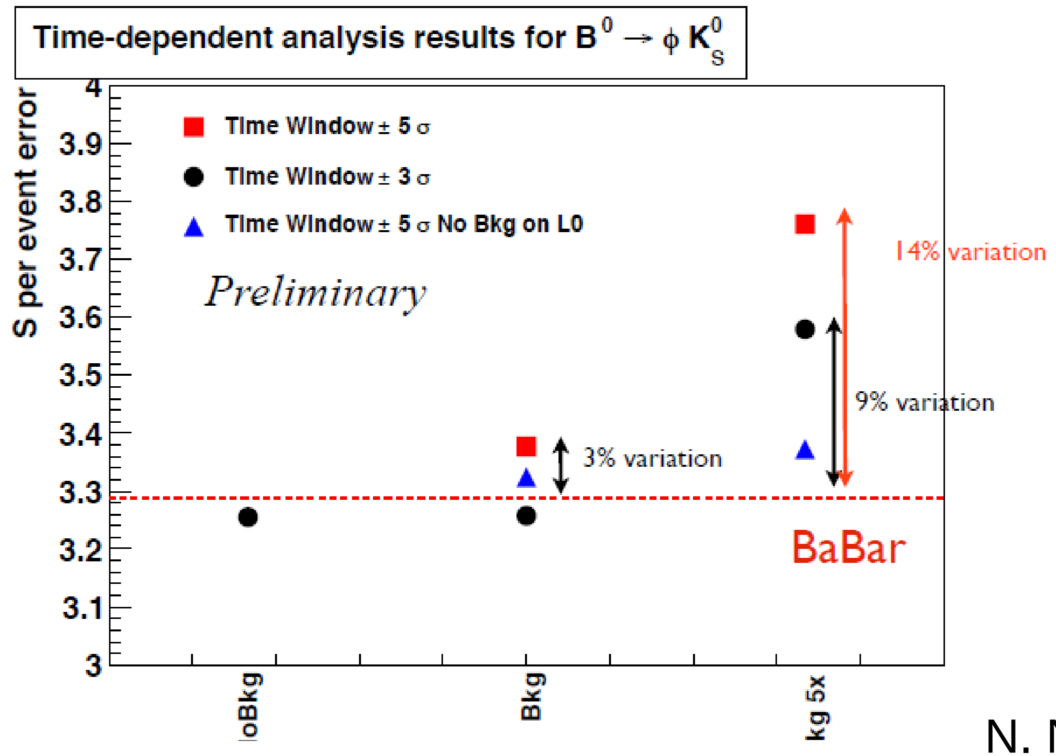




- 4%, 25% change in RMS of Δt residual wrt no bkg.

N. Neri

S=sin 2β_eff



N. Neri

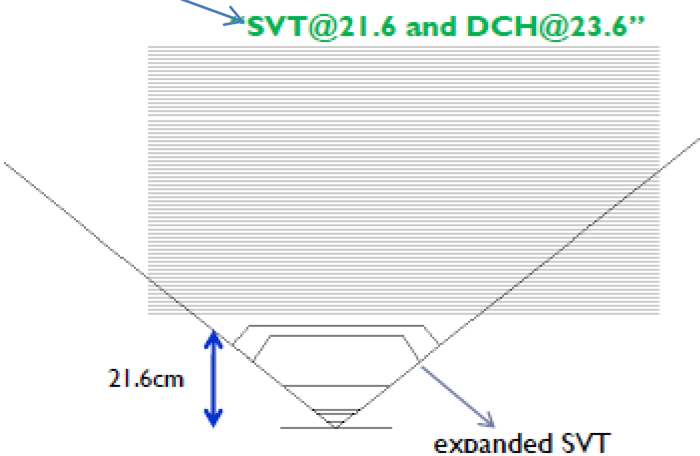
- Main results
  - sizable worsening in d0 and z0 resolution at x5 bkg rates.
  - sizable effect on S per event error: 9% (14%) worsening with x5 bkg and ±3σ (±5σ) time window cut. Small change with nominal bkg (3%).
- SVT performance seems to be very good in presence of bkg and reasonably good in presence of 5x bkg.

tracker performance vs SVT outer radius and DCH inner radius

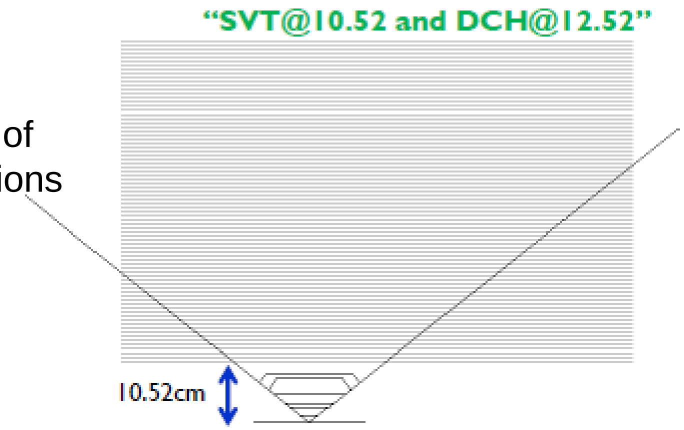
done within the Detector Geometry Working Group

SVT outer radius

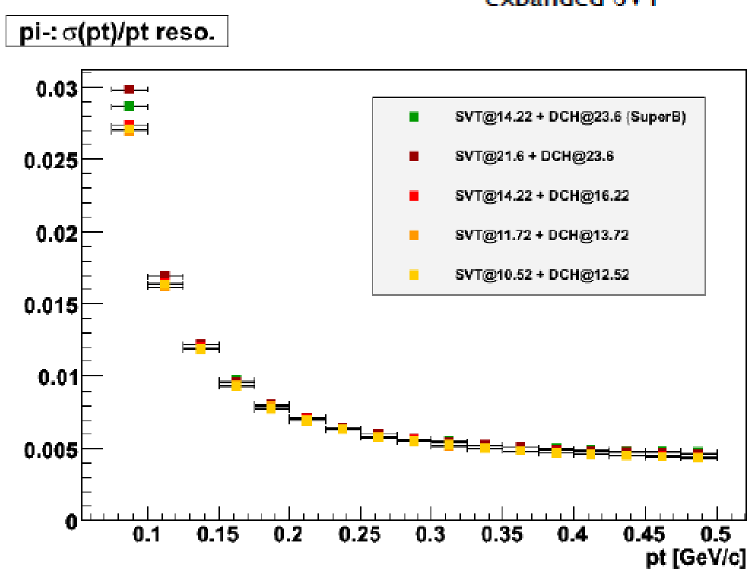
DCH inner radius

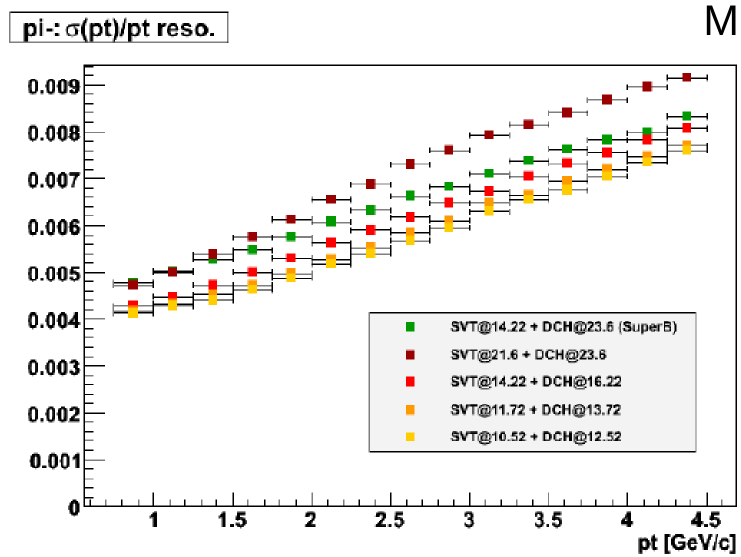


examples of configurations

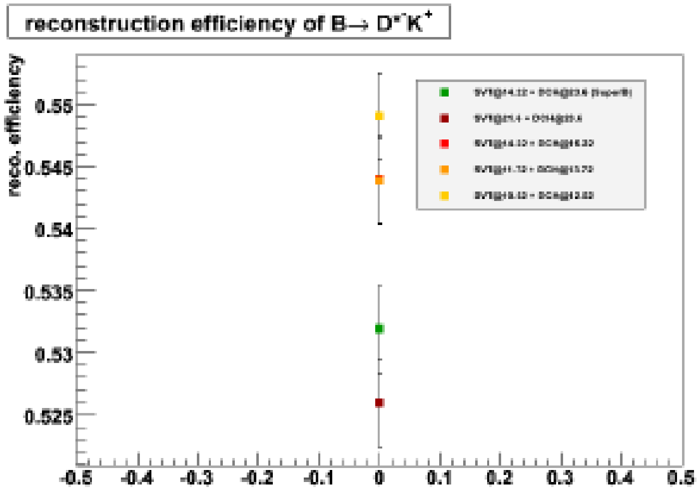


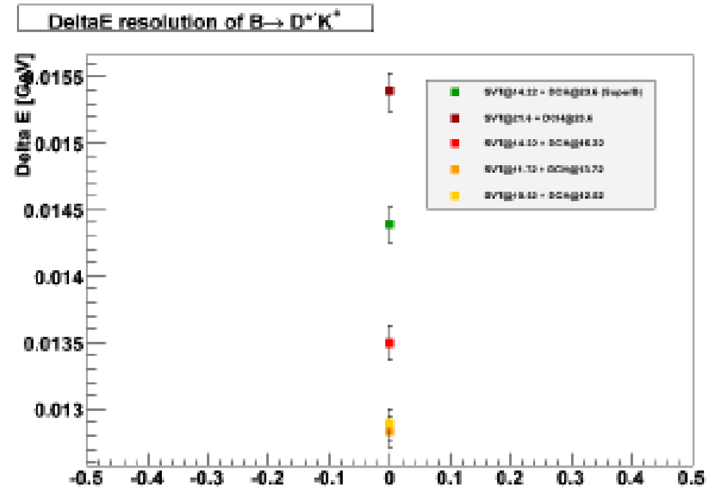
M. Rama



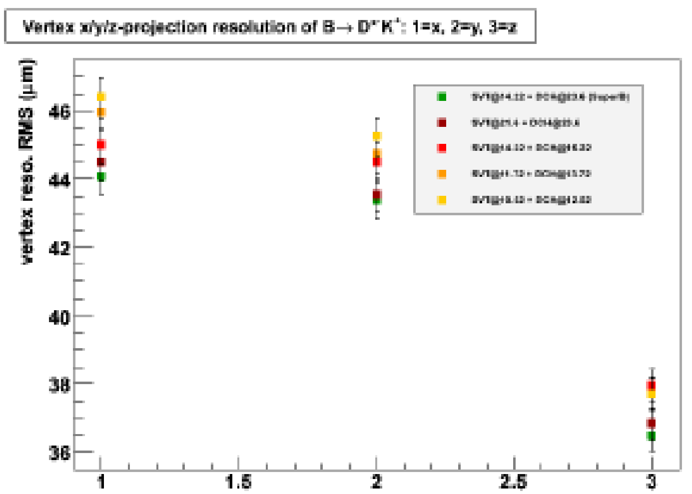


B→D*⁻K⁺ : summary





M. Rama

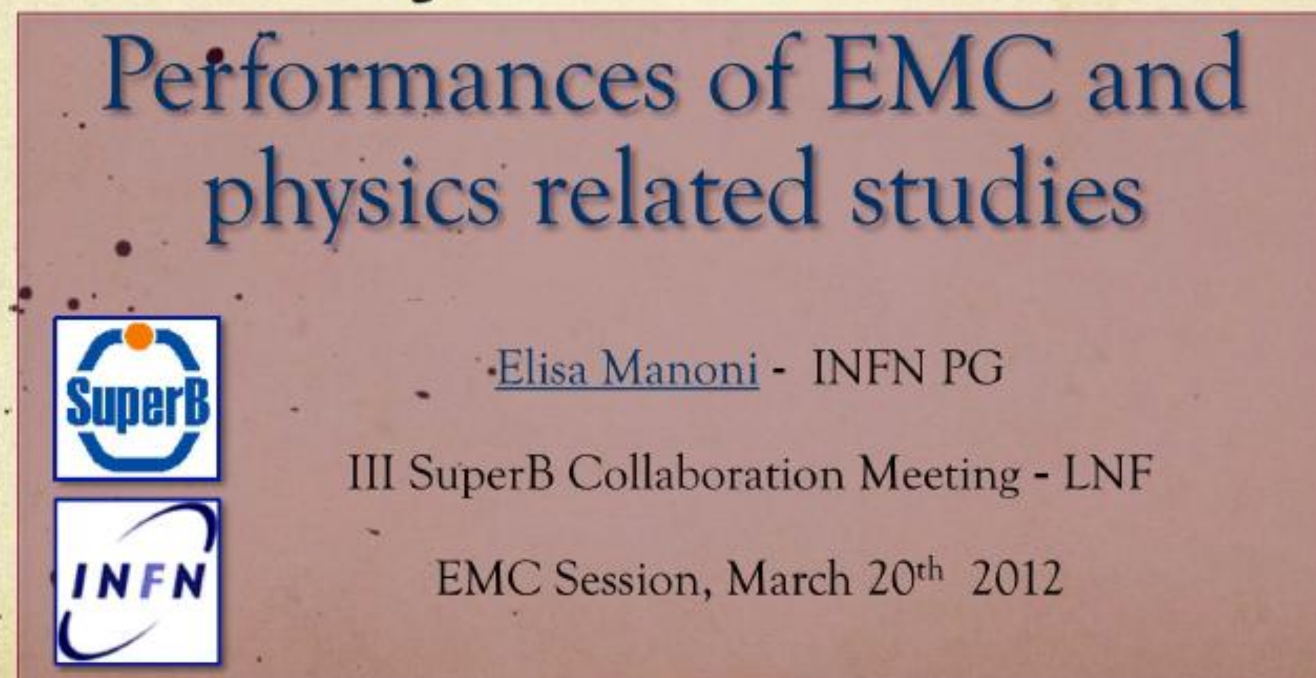


- best performance with small DCH inner radius:
  - ΔE resolution improves up to 20%
  - ~2% (absolute) reco. efficiency increase
  - vertex resolution variation negligible

no machine background available at that time, and max inner DCH radius considered was 23.6 cm

HAD breco + B→K*nunubar study vs background

E. Manoni



The study will be updated with new background rates

Conclusions

- Impact on physics of different bkg configurations with FastSim studied
  - radiative bhabha (+ neutrons) ; no machine bkg, 1x bkg, 3x bkg
- HAD B_{reco} side (BB generic sample)
  - higher reco efficiency mainly due to combinatoric
  - π^0 mass distribution suffering from high combinatoric contamination + peak shift with increasing bkg → use tighter requirements on π^0 lists?
- $B^+ \to K^{*+} \nu\nu$ signal MC studies
  - lower B_{sig} efficiency probably due to higher extra-trtacks multiplicity ?
  - E_{extra} shapes loose peaky shape at low energy with increasing bkg → important to compare signal MC and BB generic E_{extra} shape to evaluate the discriminating power (high BB stats needed)

Conclusions

- FastSim allows to estimate the sensitivity of even complex SuperB physics analyses as a function of the detector configuration
- But it has not been designed to include the kind of machine background we know today
  - Background simulations were not available at that time
- It’s possible to deal with background properly, but some development is needed, concerning all subsystems
- Pattern recognition is out of FastSim scope. We need a SuperB full reconstruction

backup slides

Detector Geometry WG studies

Summary of results [e

The table collects the links to the slides documenting the most recent results for a given topic. Previous versions of the studies, when available, are listed in the other table.

System	Most recent studies	Notes
SVT	Time-dependent measurements as a function of the layer0: Frascati09 Tracking performance as a function of the SVT outer radius: Perugia09 Perugia09 Time-dependent measurement with B->KsKs and B->Kspi0(g) as a function of the SVT outer radius: Perugia09 Perugia09 Tracking performance as a function of the number of layers: Frascati09 Degradation of sin2beta error when the boost goes from 0.28 to 0.238: Perugia09 Perugia09	
DCH	Tracking performance as a function of the DCH inner radius: Perugia09 Tracking as a function of the DCH length: CalTech10 dE/dx as a function of the DCH length: Fracati09 Tracking as a function of stereo angle and cell layout: Annecy10	
Forward PID	B->K(*)nunubar and B->tau nu SL tag with/without fTOF: CalTech10 B->K(*)nunubar HAD tag with/without fTOF: CalTech10 Impact of fwd PID material on gamma and pi0 reconstruction: Frascati11 Elba11	
EMC	B->K(*)nunubar and B->tau nu SL tag with/without backward EMC: Elba11 B->K(*)nunubar HAD tag with/without backward EMC: Elba11 B->tau nu HAD tag: Elba11	
IFR	Optimization of muons selection: Elba10	
Other	EMC and PID angular coverage as a function of IP position: proto tech board 7 july 10 mass resolution and reco efficiency vs B field: CalTech10	

Report of the forward PID task force:
Elba11
Report of the backward EMC task force:
Elba11

http://mailman.fe.infn.it/superbwiki/index.php/Detector_Geometry_Working_Group_portal

FDIRC shield: BRN implementation

- Steel-lead-steel sandwich (2.5-10-2.5 cm)
- Boron-loaded (5%) polyethylene (10 cm)