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Impact of the Pile Up on the BeamCal Performance

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Outline

Motivation

Experimental Situation

Electron Finder

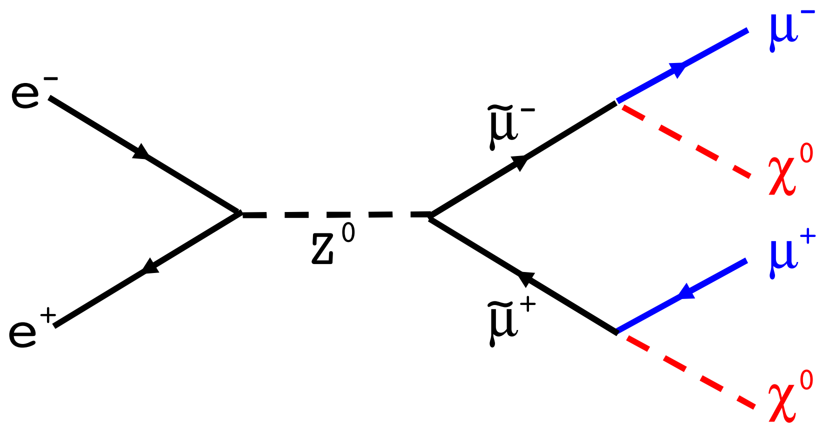
Electron Recognition Efficiency
- 500GeV
- 1000GeV

Impact of the Pile-Up on BeamCal Performance
- Efficiency
- Fake Rate

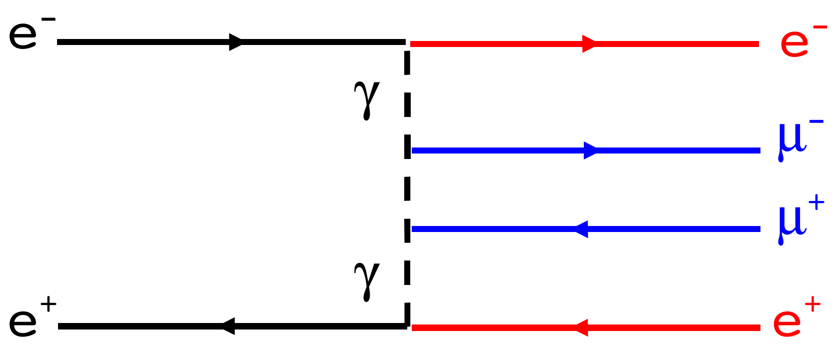
Summary

Motivation

High energy electron identification in the BeamCal is particularly important for new particle searches.



The Physics:
production of SUSY particles
Signature:
$\mu^+ \mu^-$ + missing energy



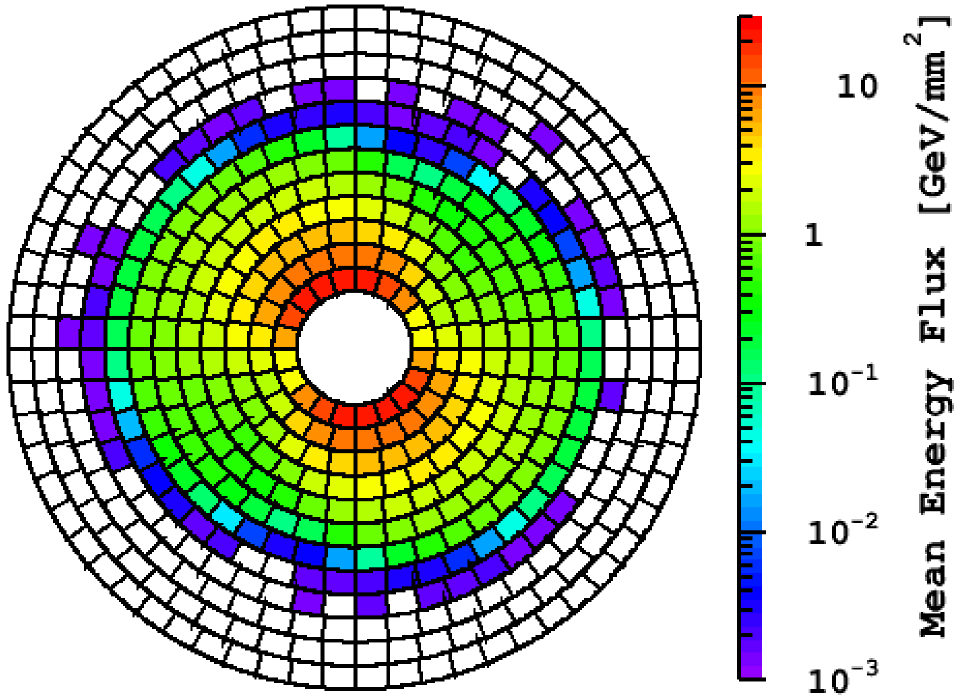
The Background:
two-photon events
Signature:
$\mu^+ \mu^-$ + missing energy (if electrons are not tagged)

NEED:
- Excellent electron identification efficiency
- Coverage down to as small angle as possible

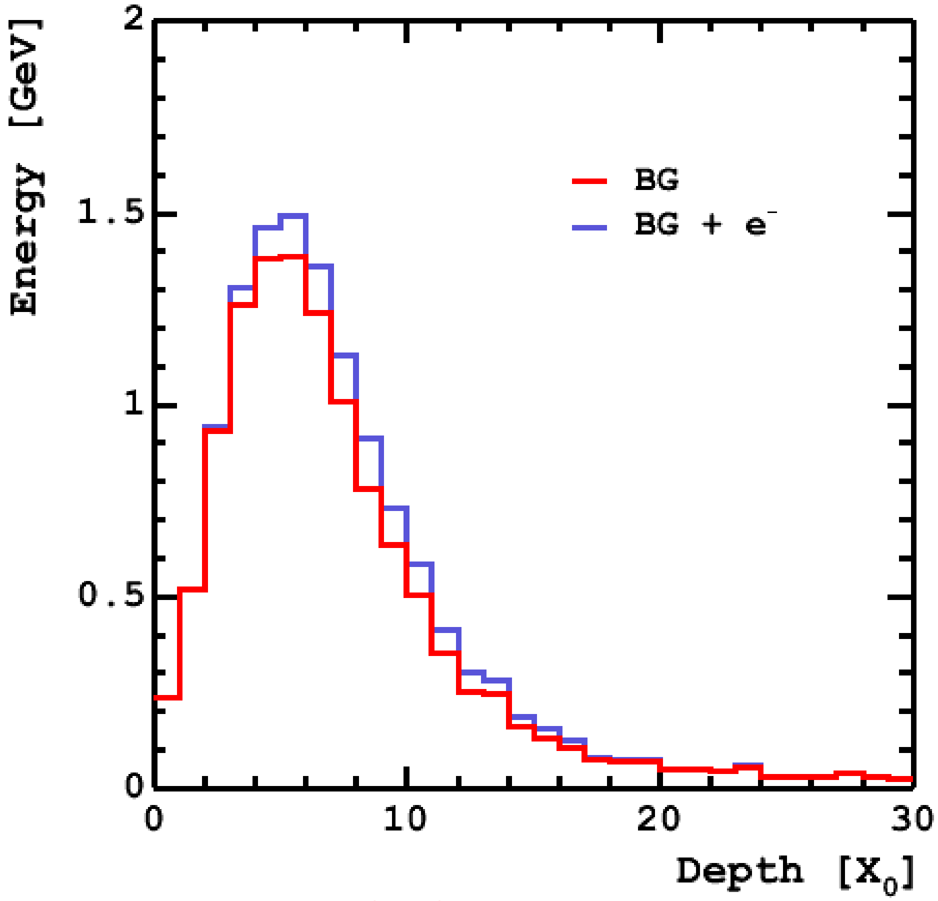
Experimental Situation -- Beamstrahlung

BeamCal will be hit by beamstrahlung remnants carrying about 20 TeV of energy per bunch crossing.

The distribution of this energy per bunch crossing at $\sqrt{s}$ = 500GeV



100GeV electron on top of beamstrahlung

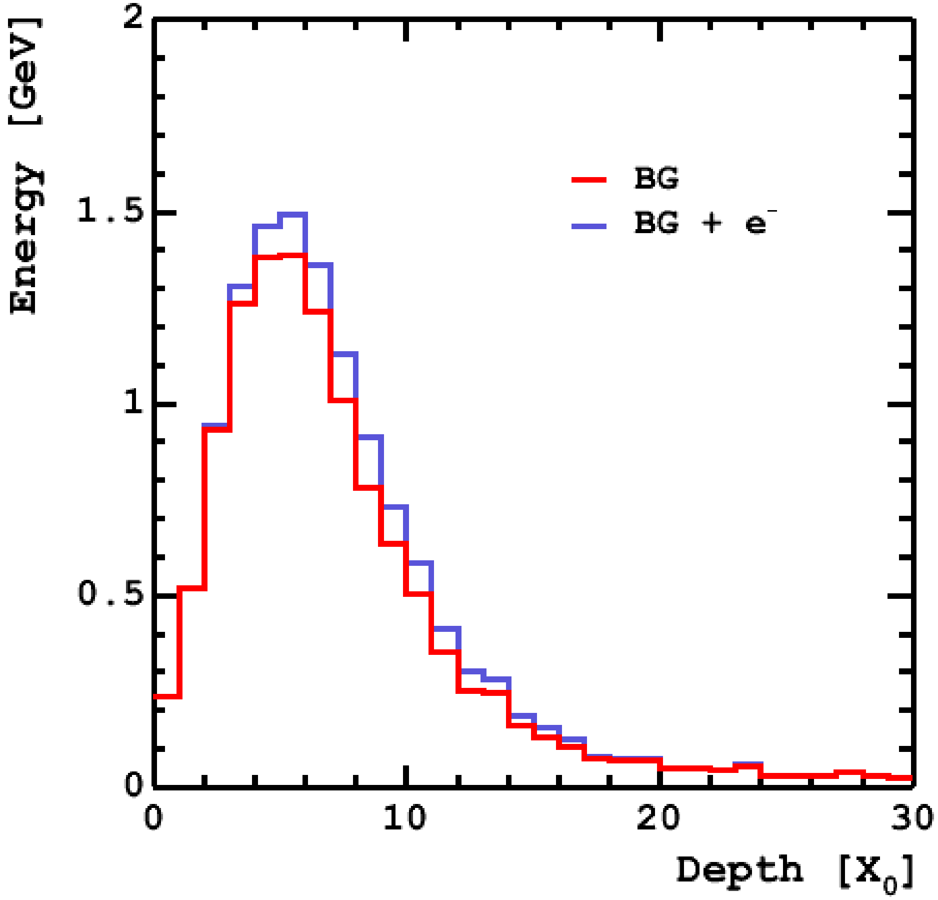


Severe background for electron recognition

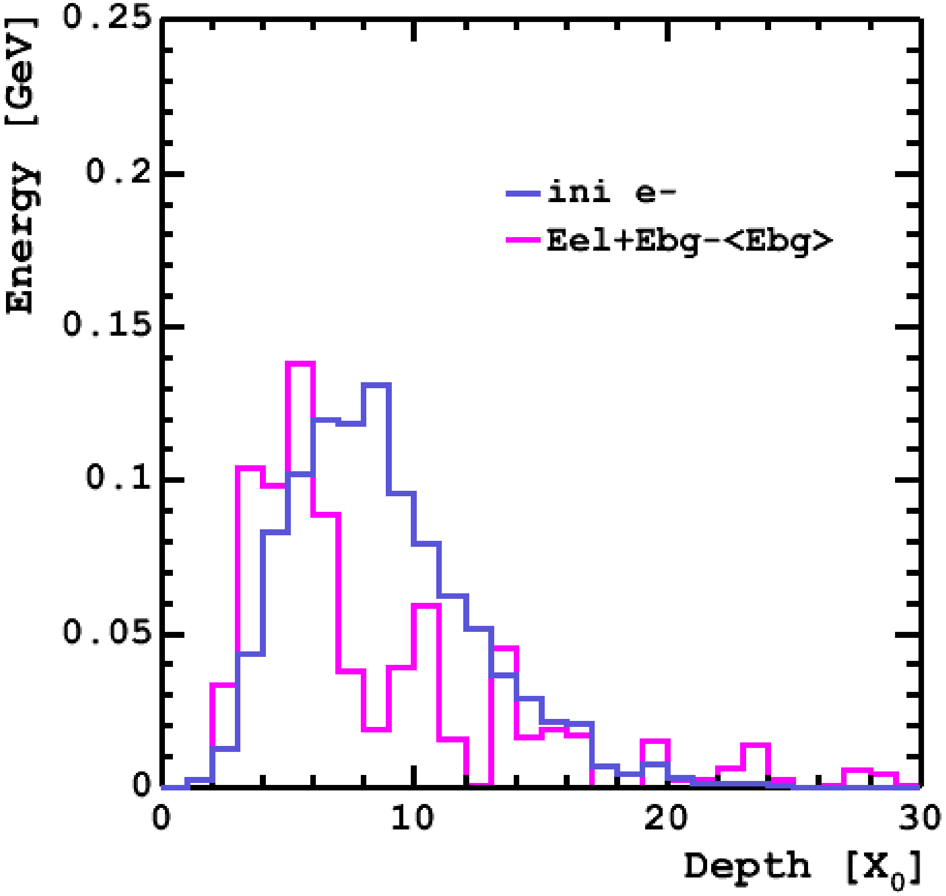
Electron Finder

- subtraction of average beamstrahlung background
- compare resulting deposition with background RMS

100GeV electron on top of beamstrahlung



Subtraction of average background

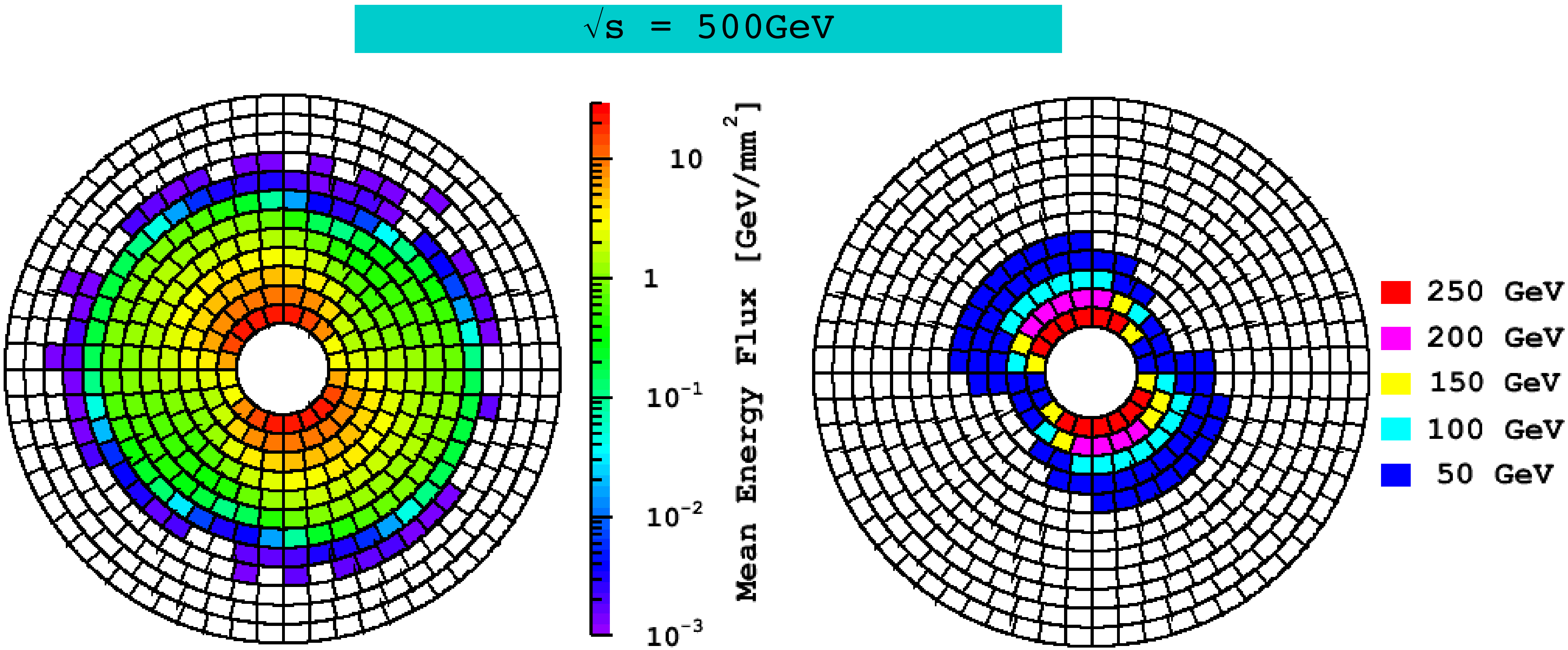


- It Works!
- Background fluctuations can mimic electron signal

Electron Recognition Efficiency -- $\sqrt{s}$ = 500GeV

Fake rate is less then 1%

Cells are colored when the efficiency is less then 90%



Electrons with energy more then 100 GeV are identified fairly well

Consistent Software Package

HBEER(Ebg, Eel) -- (High Background) Efficiency of Electron Recognition

Function of 2 parameters:

- Ebg – BG energy density in GeV/mm^2
- Eel – electron energy in GeV

Comes in 2 flavours:

- Fortran77
- C

BED(x, y) – Background Energy Density

Function of 2 parameters:

- x,y – coordinates on LCal front in cm

Comes in 2 flavours:

- Fortran77
- C

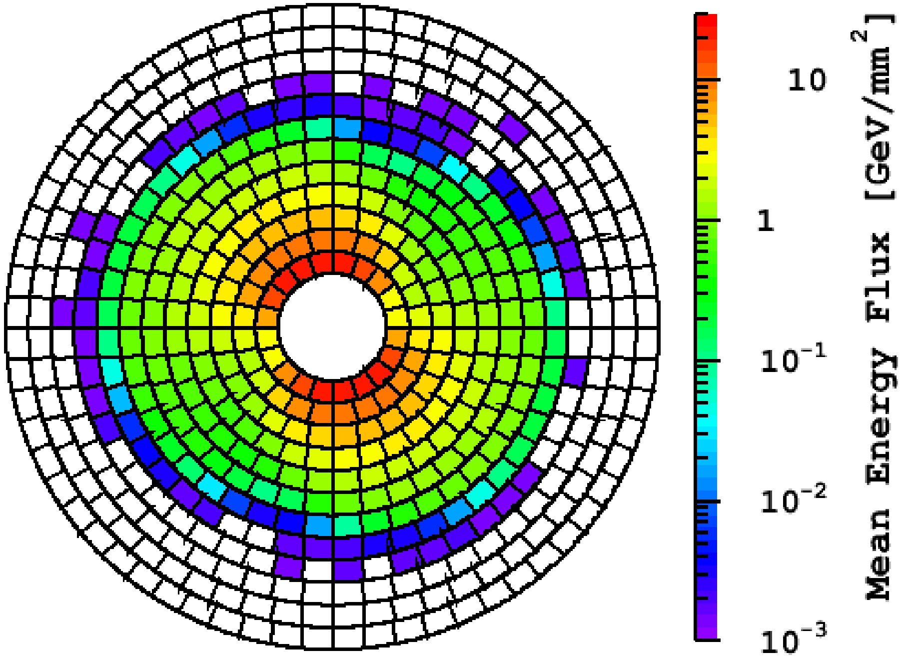
Comes with raw BG data files:

- TESLA head-on option
- TESLA with crossing-angle 2×10 mrad
- NLC with crossing-angle 2×10 mrad

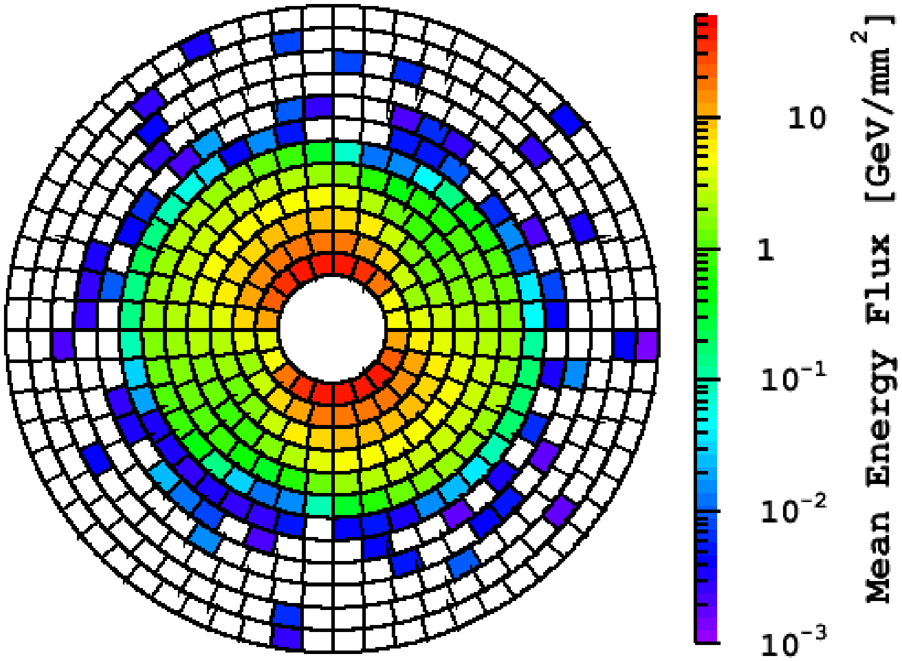
Experimental Situation -- $\sqrt{s}$ = 1TeV

$\sqrt{s}$ [GeV]	Charge [10^{10}]	σ_x / σ_y [nm]	β_x / β_y [mm]	$\gamma\varepsilon_x$ / $\gamma\varepsilon_y$ [mrad]
500	2	554 / 5.0	15 / 0.40	10 / 0.03
1000	1,4	350 / 2.5	15 / 0.40	8 / 0.015

$\sqrt{s}$ = 500GeV



$\sqrt{s}$ = 1000GeV



$\sqrt{s}$ = 1000 GeV vs. $\sqrt{s}$ = 500 GeV

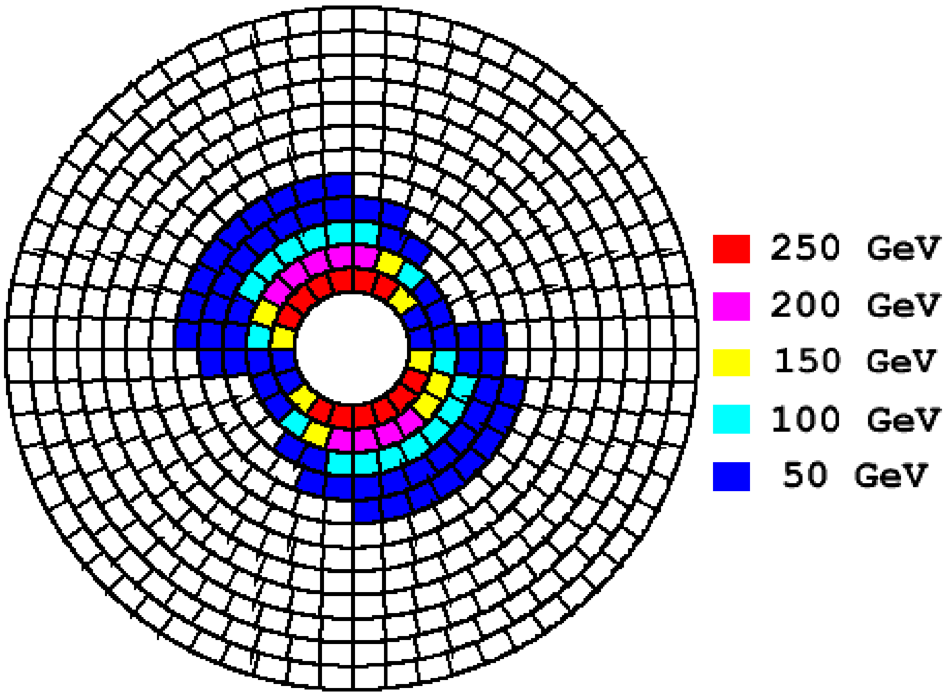
- Inner part is more suffered
- Pairs flux is squeezed

Electron Recognition Efficiency -- $\sqrt{s}$ = 1TeV

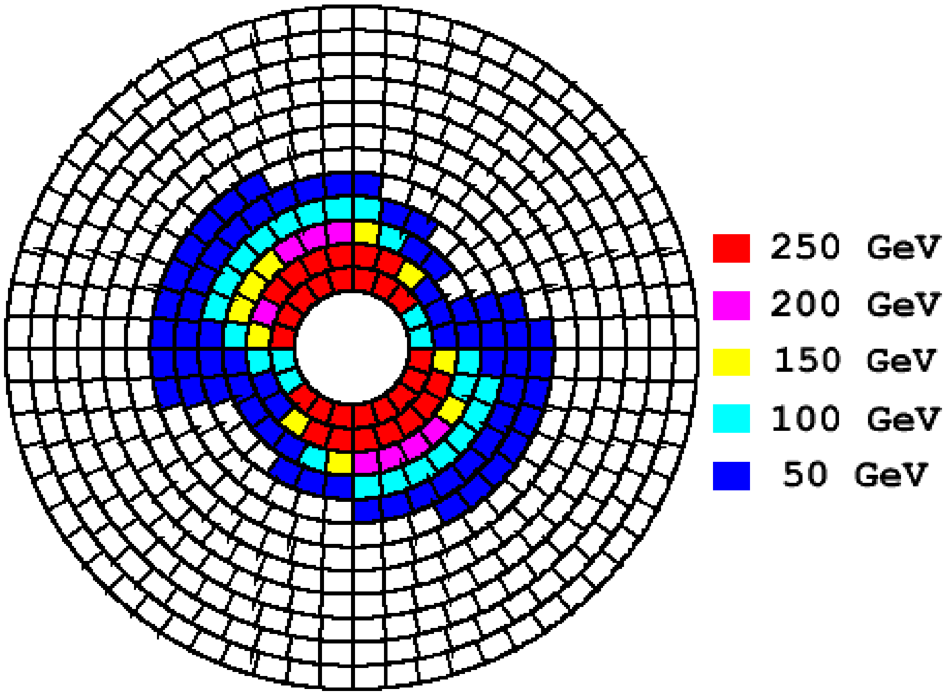
Fake rate is less then 1%

Cells are colored when the efficiency is less then 90%

$\sqrt{s}$ = 500GeV

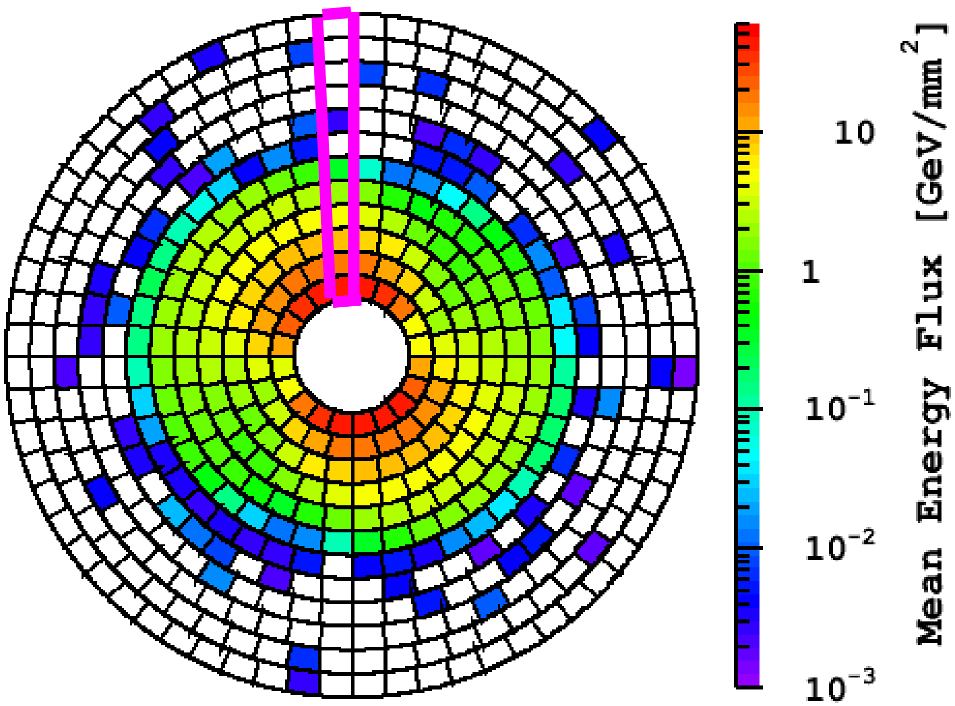


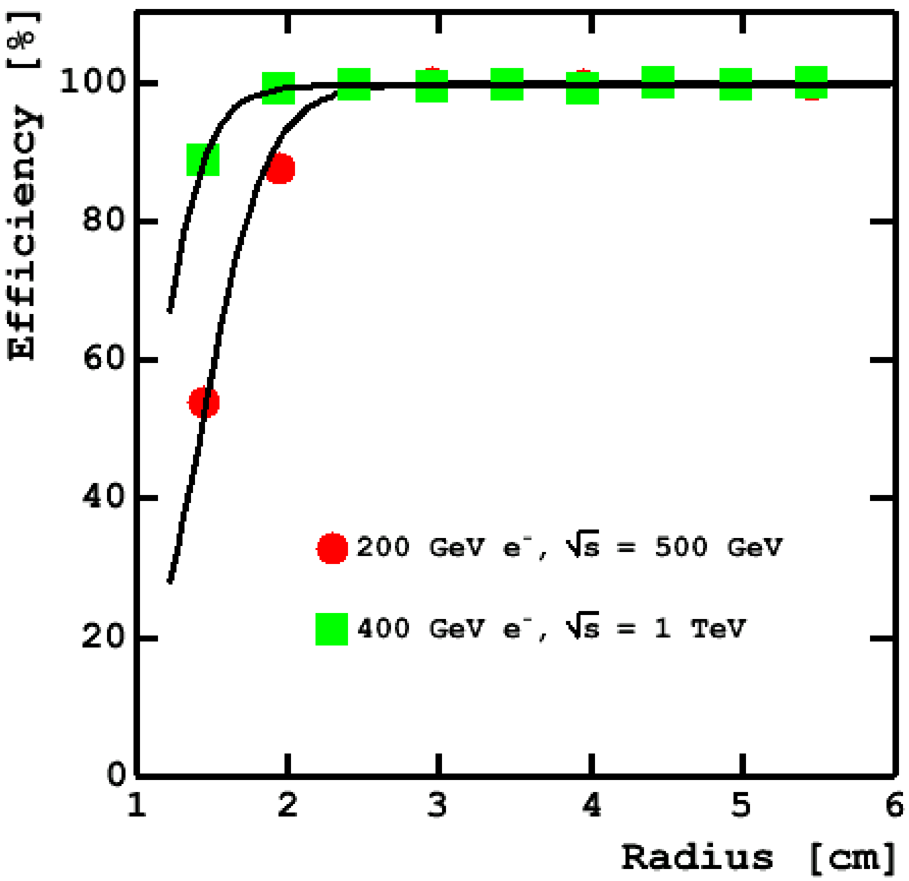
$\sqrt{s}$ = 1000GeV



For the same e^- energy 'blind spot' is larger relative to 500 GeV option.

Electron Recognition Efficiency -- √s = 1TeV





- For √s =1 TeV the efficiency can be even better
- Performance depends on bunch charge

Pile Up Study -- The Motivation

Two competitive LC designs:

- NCL based on 'warm technology'
- TESLA based on 'cold technology'

To study physics potential to make a choice

For physics study one the major differences is inter bunch spacing:

- 337 ns for TESLA
  -> easy to distinguish single bunch crossings
- 1.4 ns for NLC
  -> challenge for detector
  -> most likely signal from several BX is superimposed before readout (so called 'pile up')

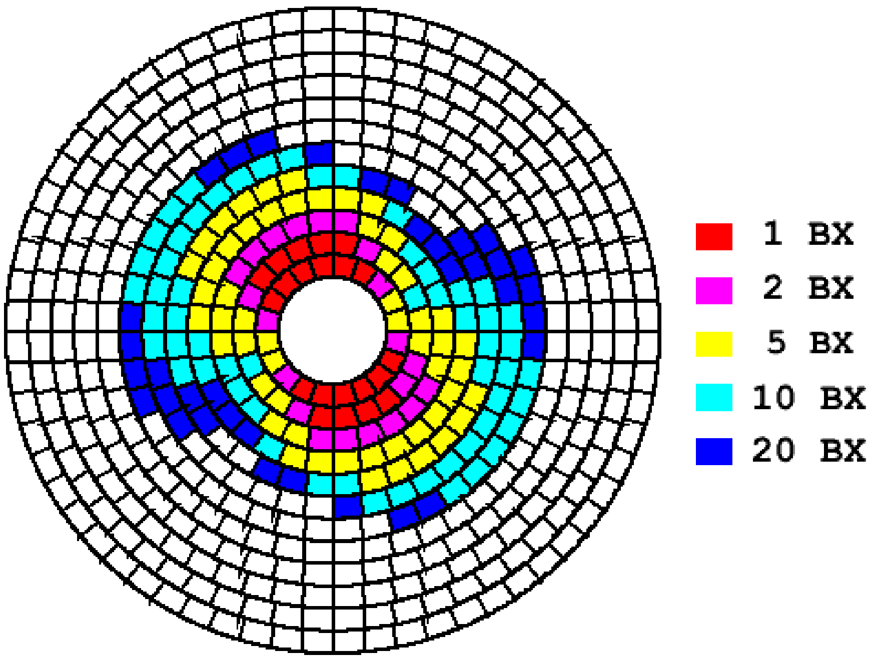
$\rightarrow$ **Pile up study:**

overlay 2, 5, 10, 20 BX

Pile Up Effect -- Efficiency Degradation

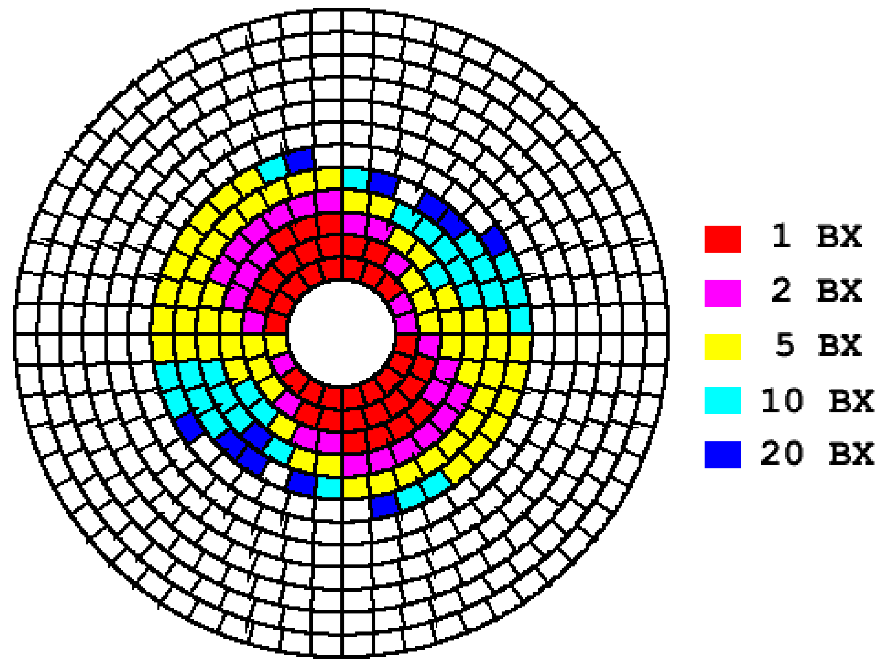
The fake rate is kept to be less then 1%
The electron energy is 200 GeV
Cells are colored when the efficiency is less then 90%

$\sqrt{s}$ = 500GeV



strong efficiency degradation
degradation saturation after 10 BX

$\sqrt{s}$ = 1000GeV

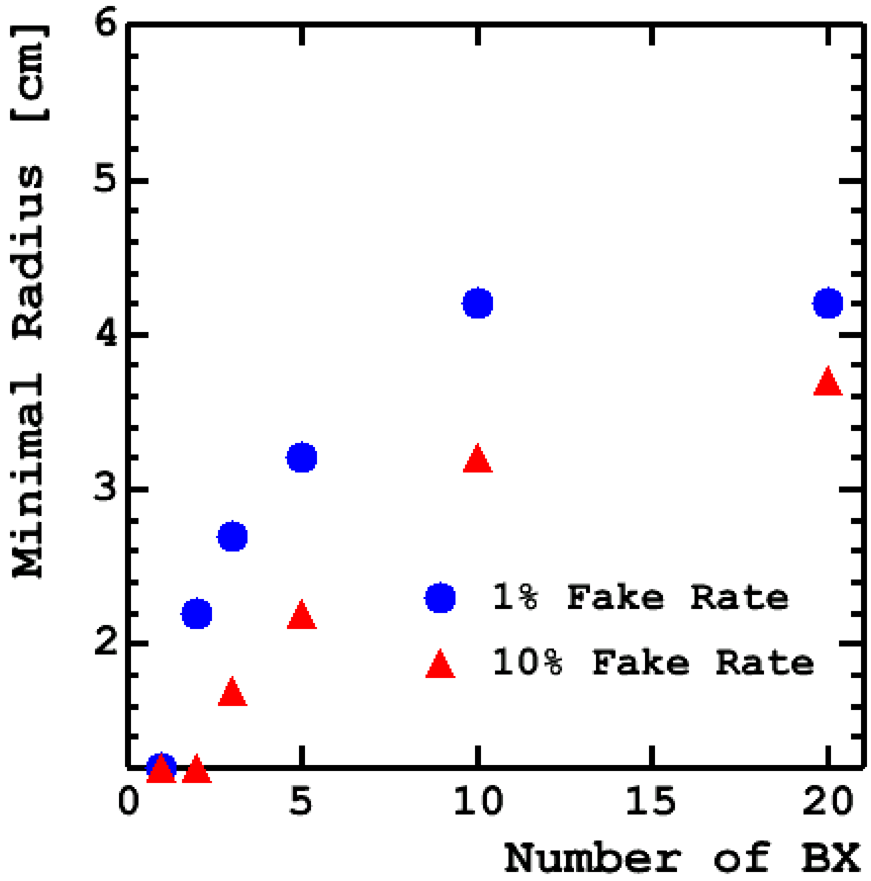


the degradation is even faster
saturation after 5 BX

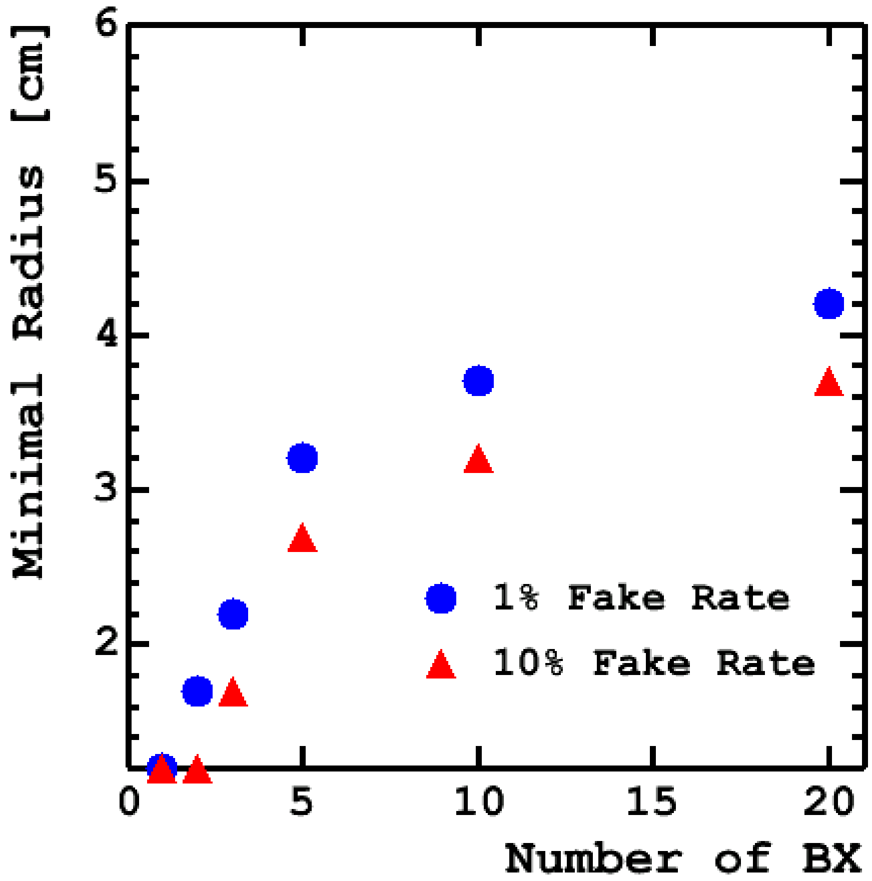
Pile Up Effect -- Fake Rate Growth

The efficiency is kept to be similar to the 1BX case

√s = 500GeV



√s = 1000GeV



strong efficiency degradation
degradation saturation after 10 BX

the degradation is even faster
saturation after 5 BX

Summary

- At $\sqrt{s}$ = 1000 GeV electron identification efficiency can be better relative to 500 GeV option.
- Performance depends on bunch charge.

- **Pile up highly deteriorates the BeamCal performance.**
- Saturation of the degradation take place.