laSalle
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The role of the PS/SPD in the trigger

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Introduction

- http://indico.cern.ch/getFile.py/access?contribId=25&sessionId=5&resId=1&materialId=slides&confId=67047
- Are the PS/SPD necessary in the LHCb Upgrade?
- Now, their role at L0 is:
  - Confirm ECAL clusters as electromagnetic (PS)
  - Distinguish γ/e (SPD)
    - Photon conversion ~40% (with M1)
  - SPD multiplicity as GEC, luminosity monitor, …
- For the upgrade, the current plan is to use an interaction trigger without PS/SPD.
  - What would be losing by doing that?
  - Still useful for PID? (not covered in this talk)

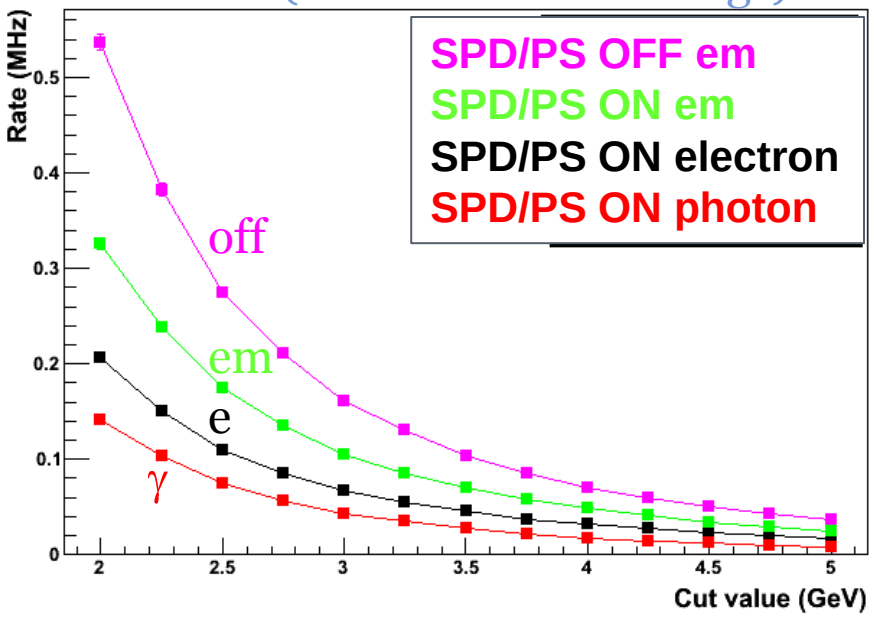
MC samples

- MC 2010
- Upgrade ML 2.1
  - (Still includes M1)
- 7 TeV per beam
- MagDown, 25 ns
- Lumi 2, 5, 10, 20 ($\cdot 10^{32}$ $cm^{-2}s^{-1}$)
  - Non-empty BX frequency ~12, 22, 28, 30 MHz

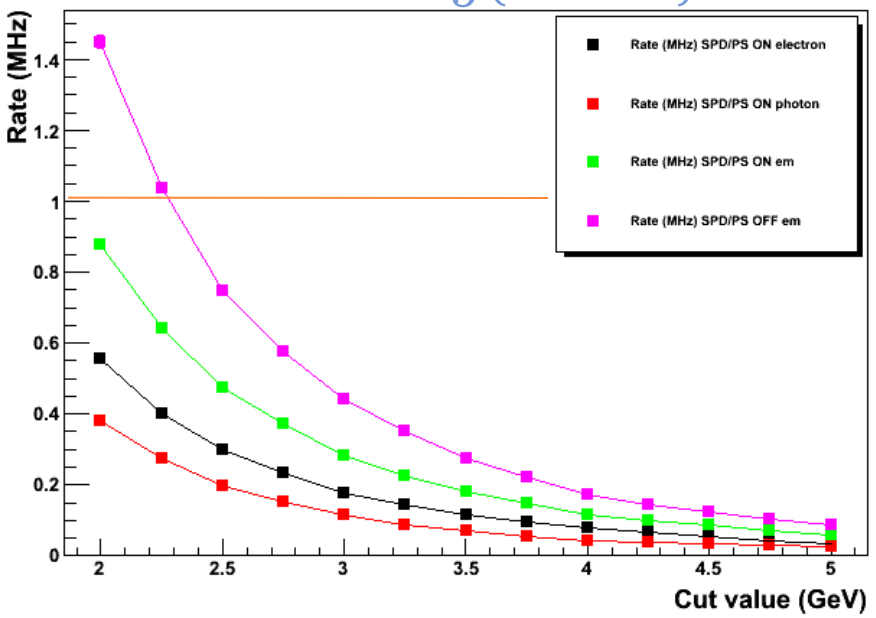
- 100k MinBias, 35-50k Bs2PhiGamma, 35-50k Bd2Kstaree events per luminosity
- Stripping selections used for signal samples
  - p_T (γ)>2 GeV
  - p_T (e)>300 MeV

Rate

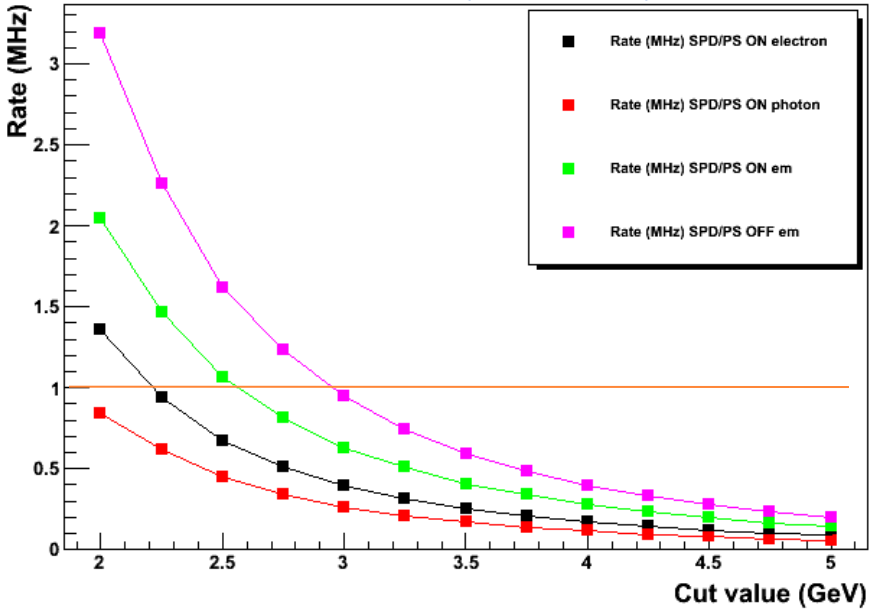
Lumi 2 (12 MHz of vis. X-sings)



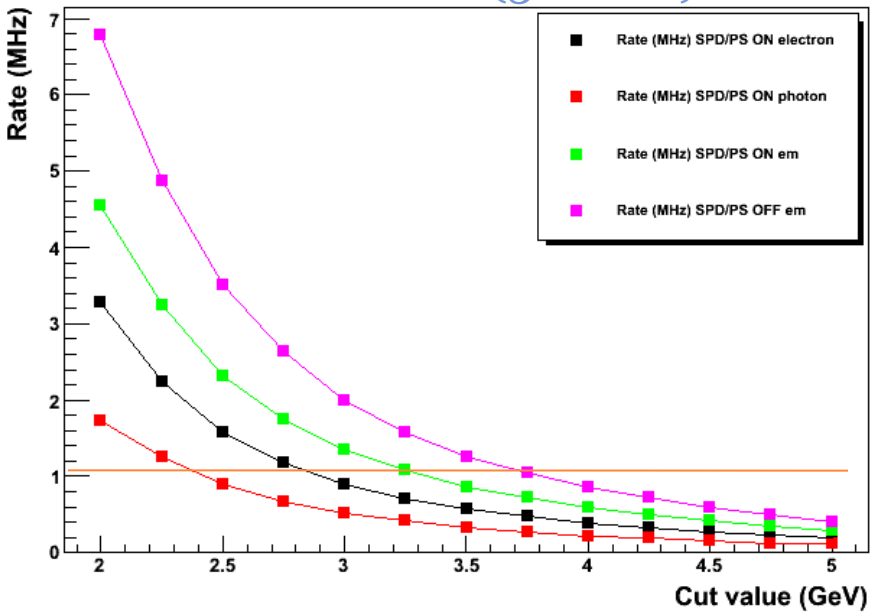
Lumi 5 (22 MHz)



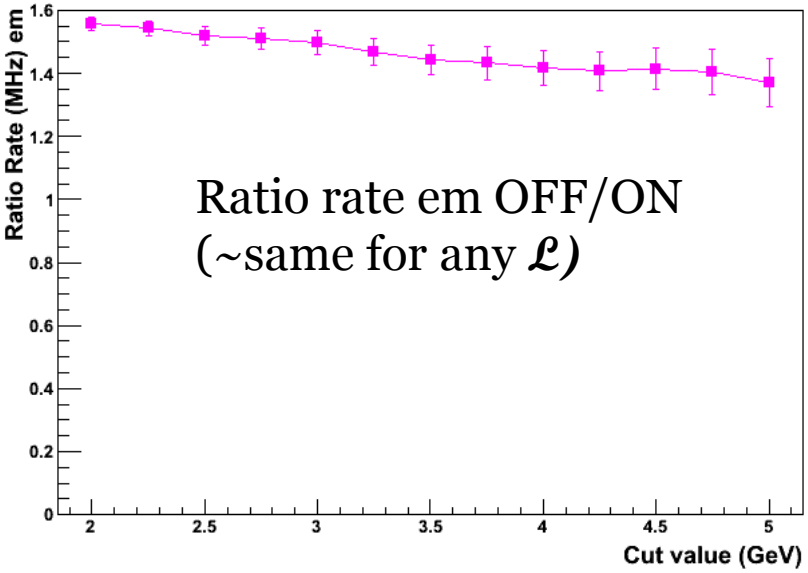
Lumi 10 (28 MHz)



Lumi 20 (30 MHz)



- Use of an interaction trigger (provide seeds for HLT algorithms) to reduce the input of the EFF to 5 MHz.
- Reduce electromagnetic candidates to 1 MHz (which is the acceptable rate?).
  - Without electron/photon distinction.
- This is possible with a cut of E_T for ECAL clusters (e.g. 3 GeV at 10^{33} $cm^{-2}s^{-1}$).



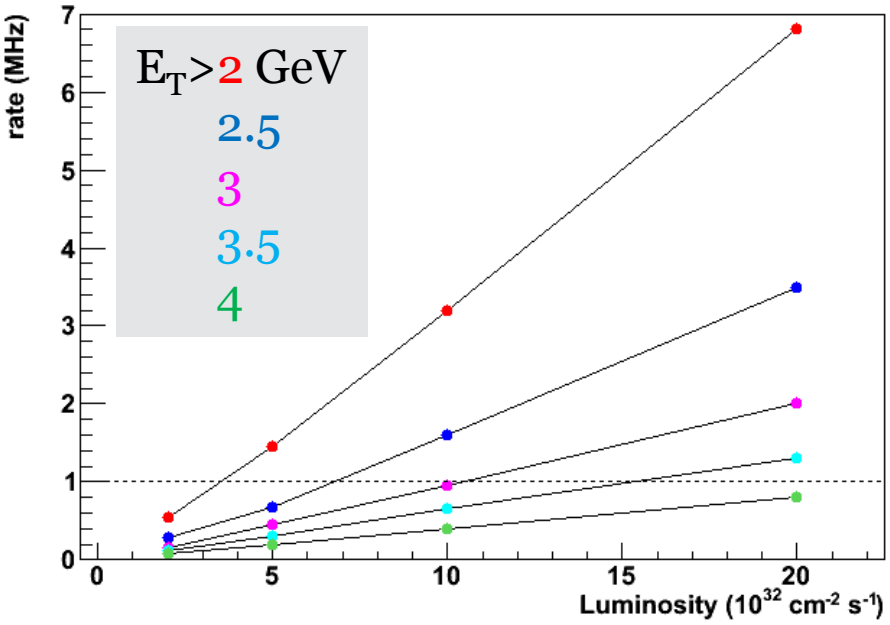
Ratio rate em OFF/ON
(~same for any $\mathcal{L}$)

~50% increase of rate without PS/SPD
Thus, number of T-stations confirmation needed in HLT

Another point of view, PS rejects 1/3 of ECAL clusters (hadrons, some photons?)

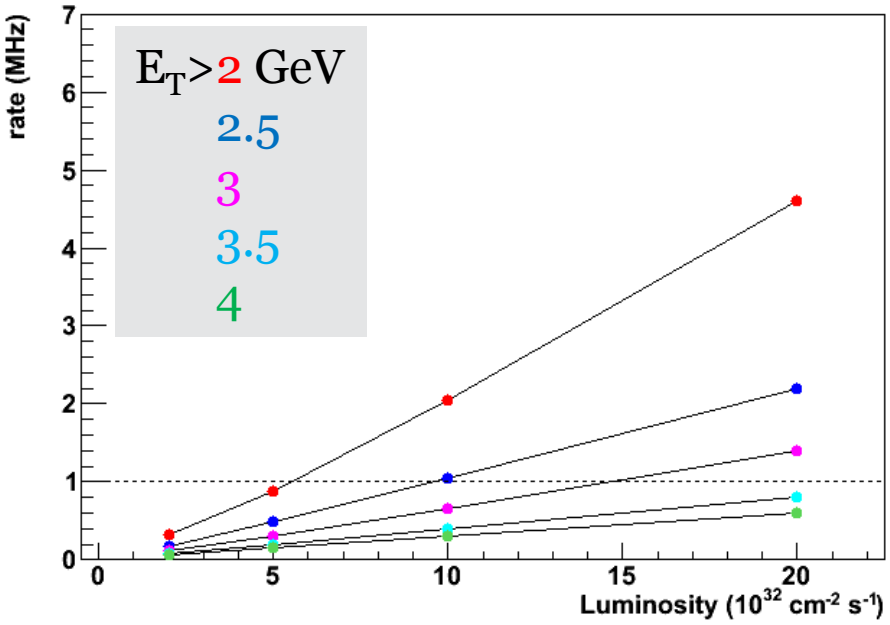
Rate vs luminosity

Rate ECAL candidates
(SPD/PS em OFF)



i.e. without SPD/PS

Rate em candidates
(SPD/PS em ON)



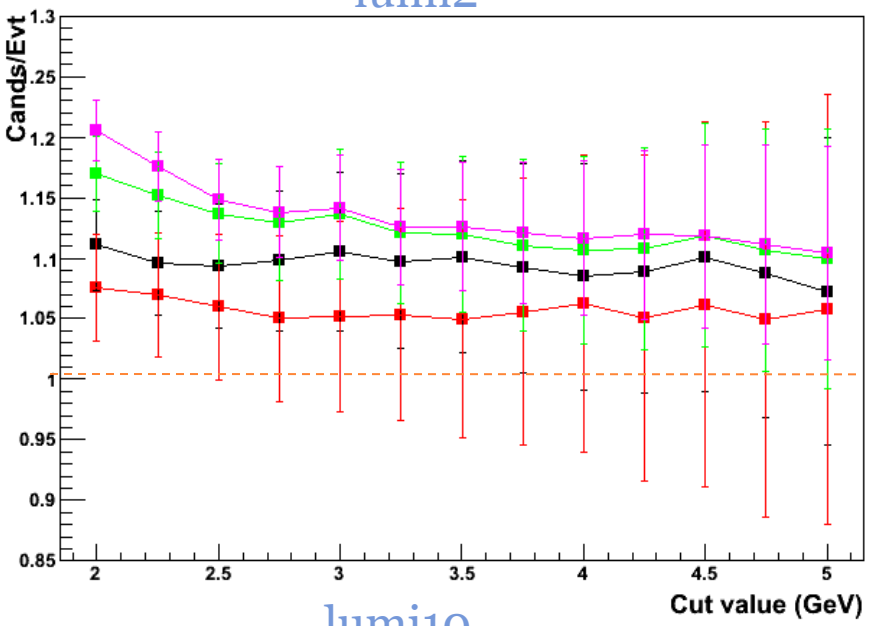
i.e. with SPD/PS

↓

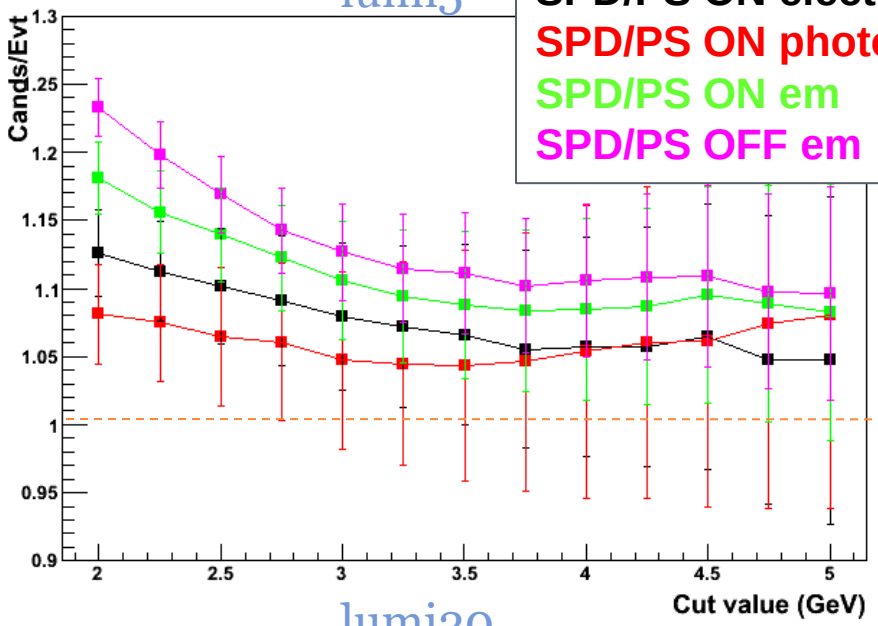
Lower rates with more loose E_T cuts

Number of candidates per accepted event

lumi2

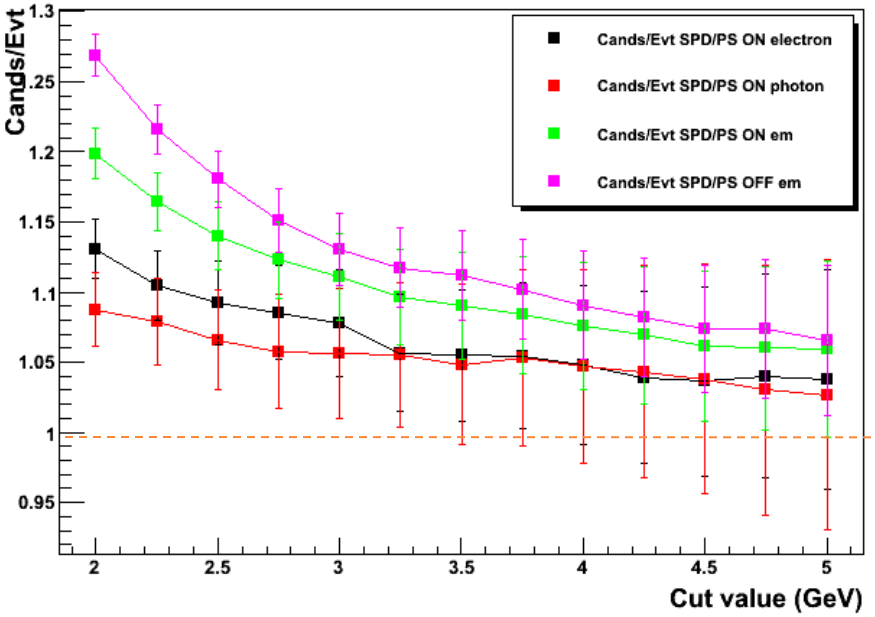


lumi5

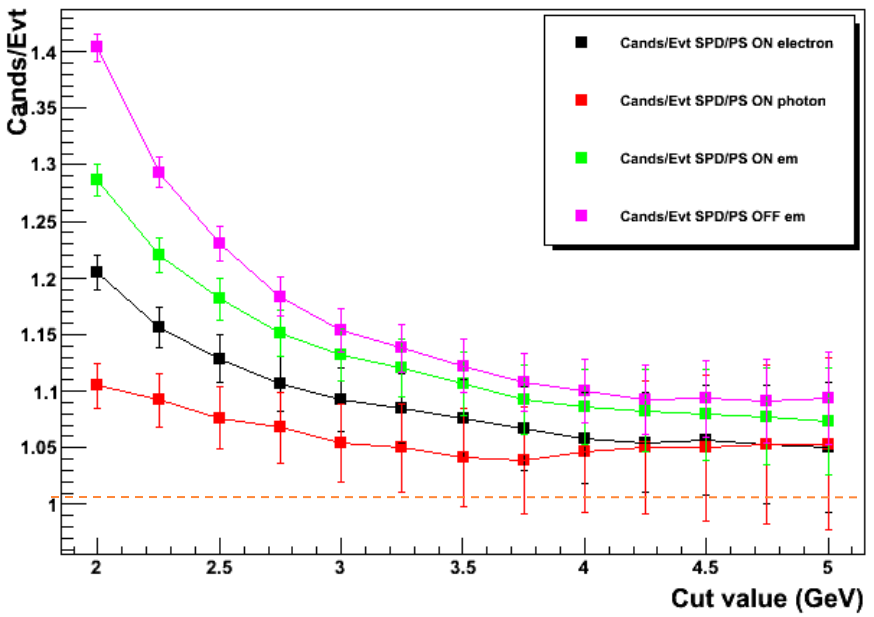


SPD/PS ON electron
SPD/PS ON photon
SPD/PS ON em
SPD/PS OFF em

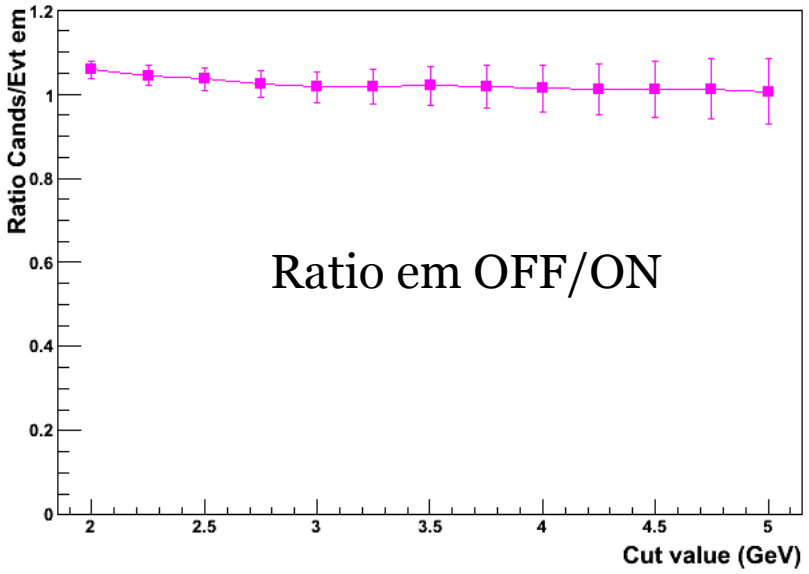
lumi10



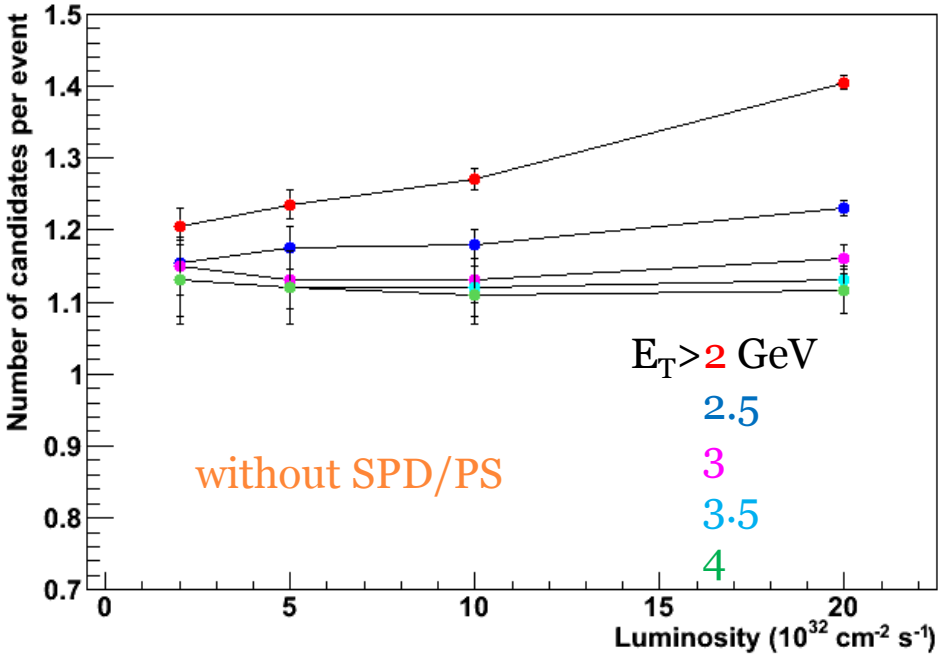
lumi20



- As shown, increased trigger rate due to increased rate of visible collisions at high luminosity, as expected.
- But number of candidates per event approximately the same at high E_T.



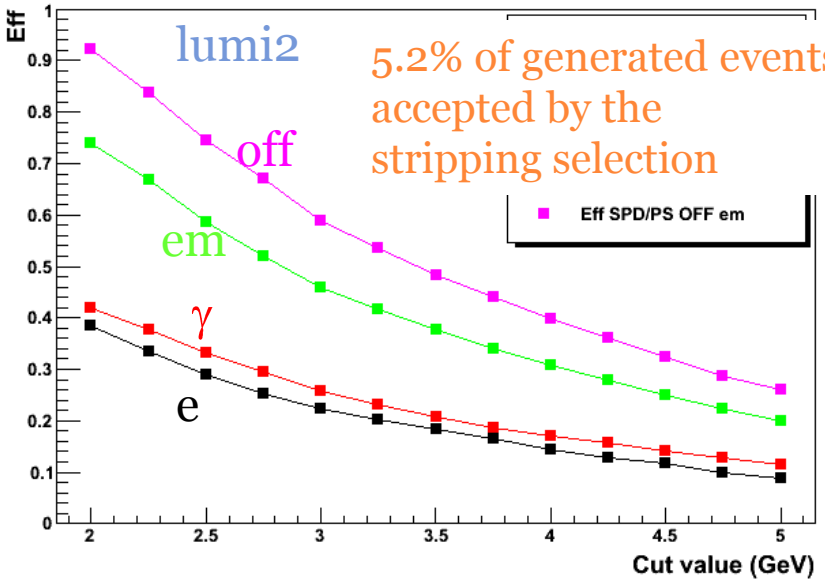
Increase of the number of candidates per accepted event <5% without PS/SPD

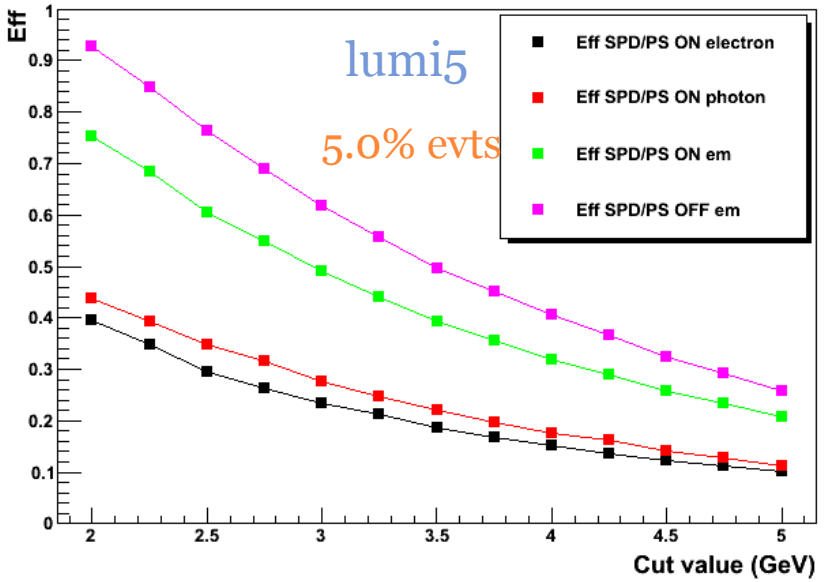


Number of candidates vs $\mathcal{L}$ is flat at high E_T

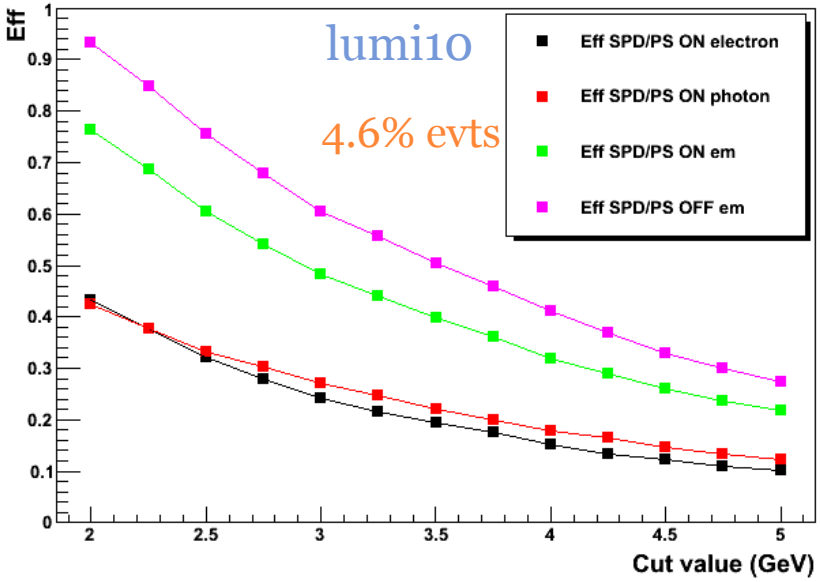
$B_s \rightarrow \phi\gamma$

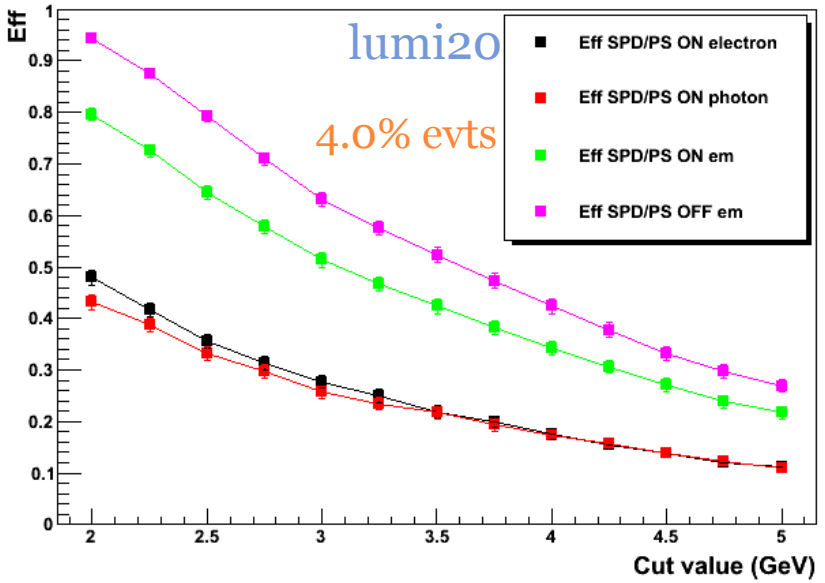
$B_s \rightarrow \phi\gamma$ Efficiency, photons



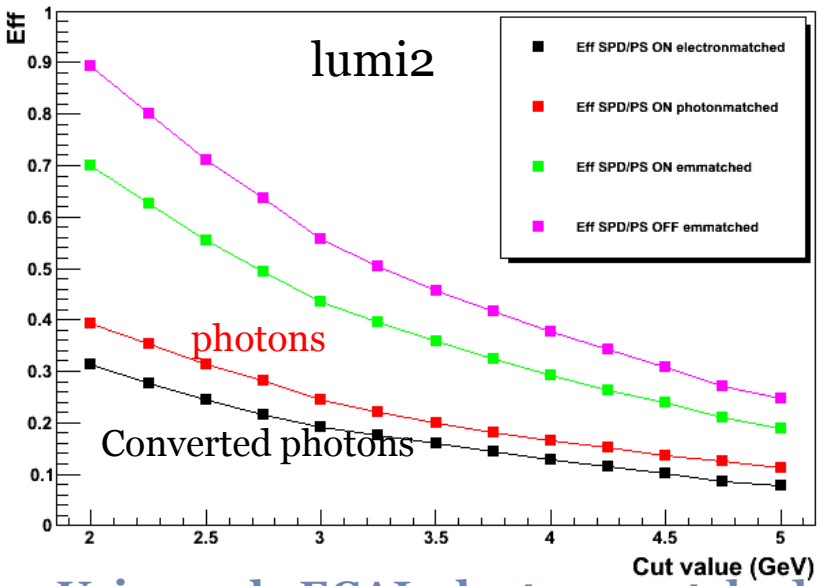


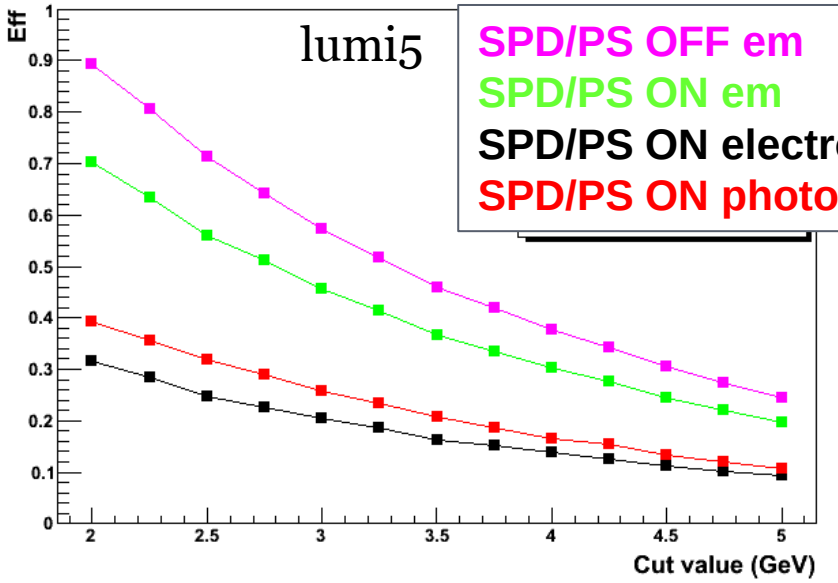
Efficiency of L0 on stripped events ($p_T(\gamma)>2$ GeV)



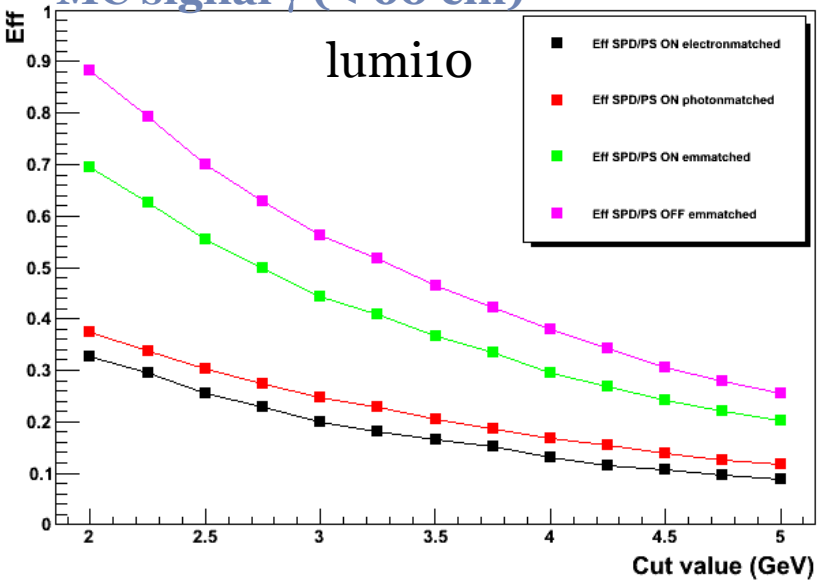


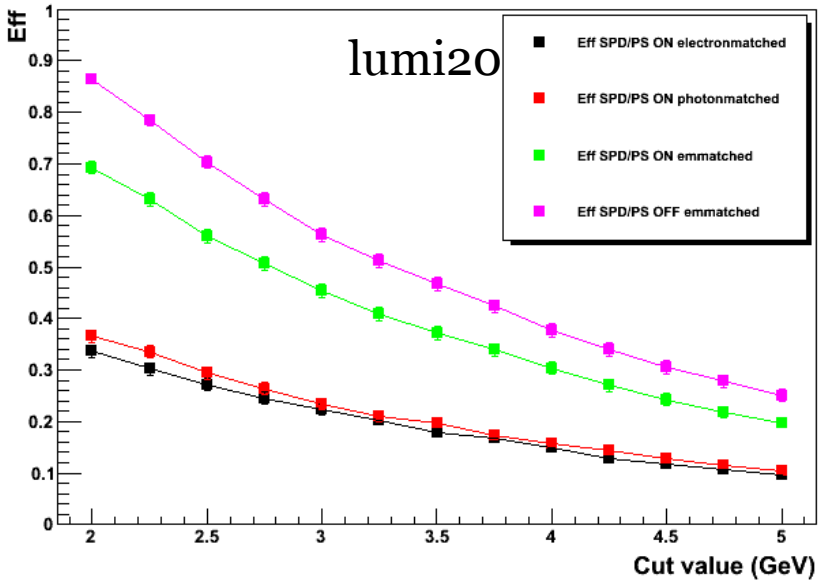
$B_s \to \phi\gamma$ Efficiency, photons

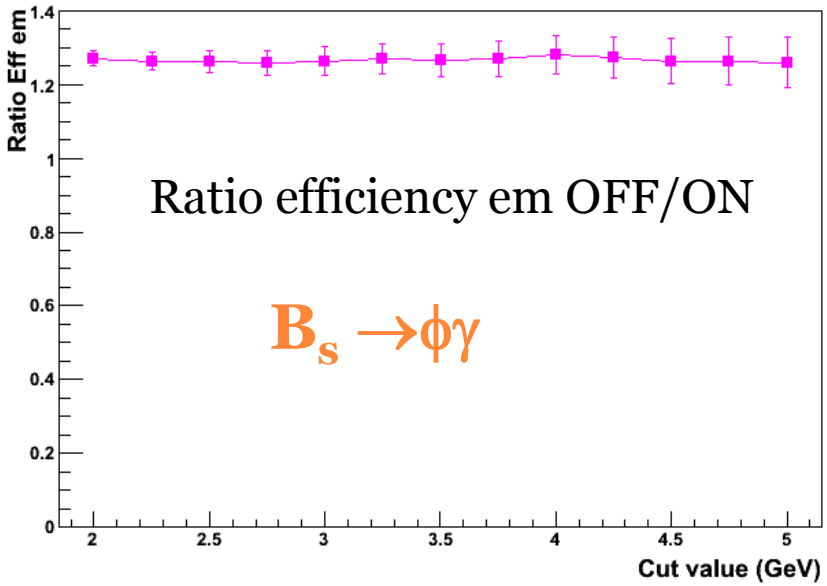




Using only ECAL clusters matched to MC signal γ (< 60 cm)

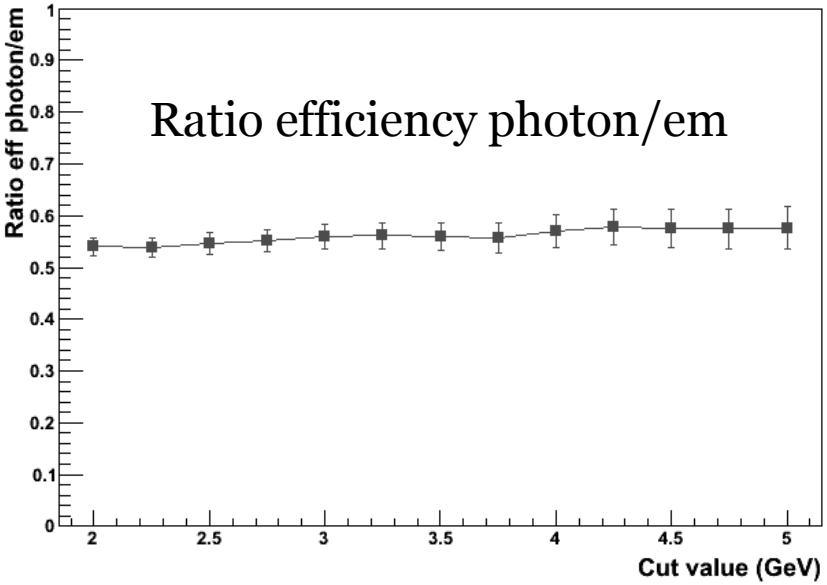






PS kills 20% of em (photon) clusters
(higher efficiency with no PS requirement)

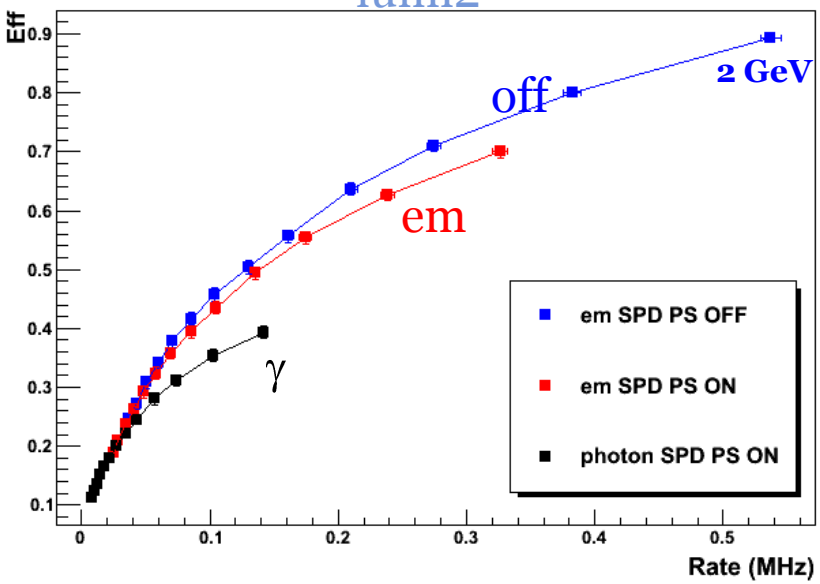
MC matched clusters



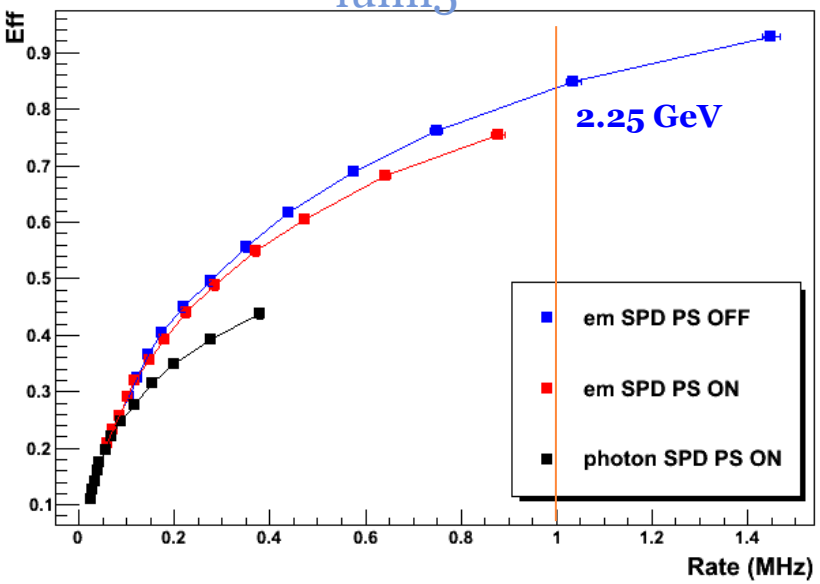
SPD identifies as photon 55-60%
of kept em clusters
(slightly lower at lumi $2 \cdot 10^{33}$, probably
due to higher pile-up)

Efficiency (photons) vs rate

lumi2

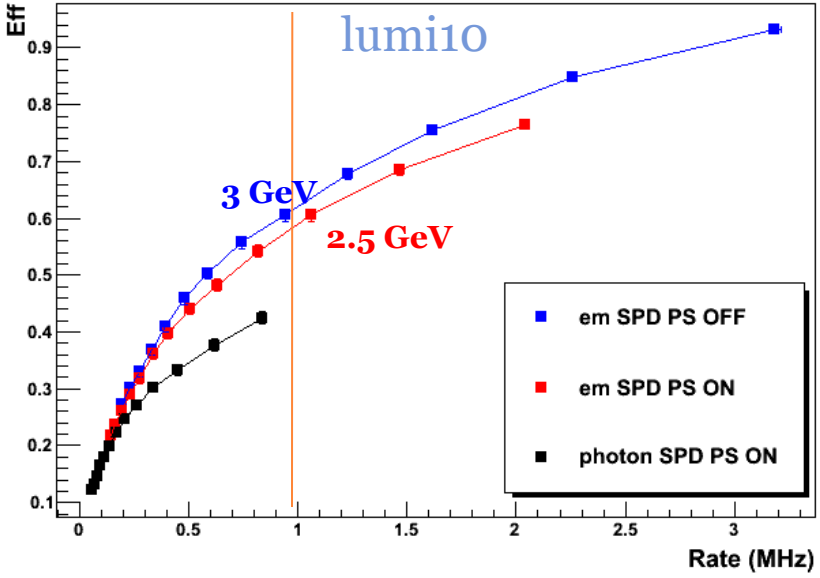


lumi5

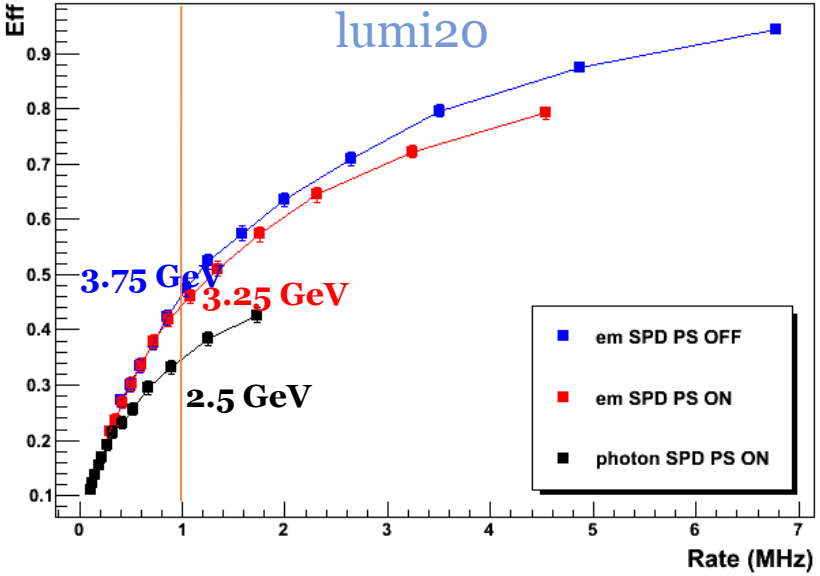


Highest efficiency without PS/SPD for a given rate

lumi10

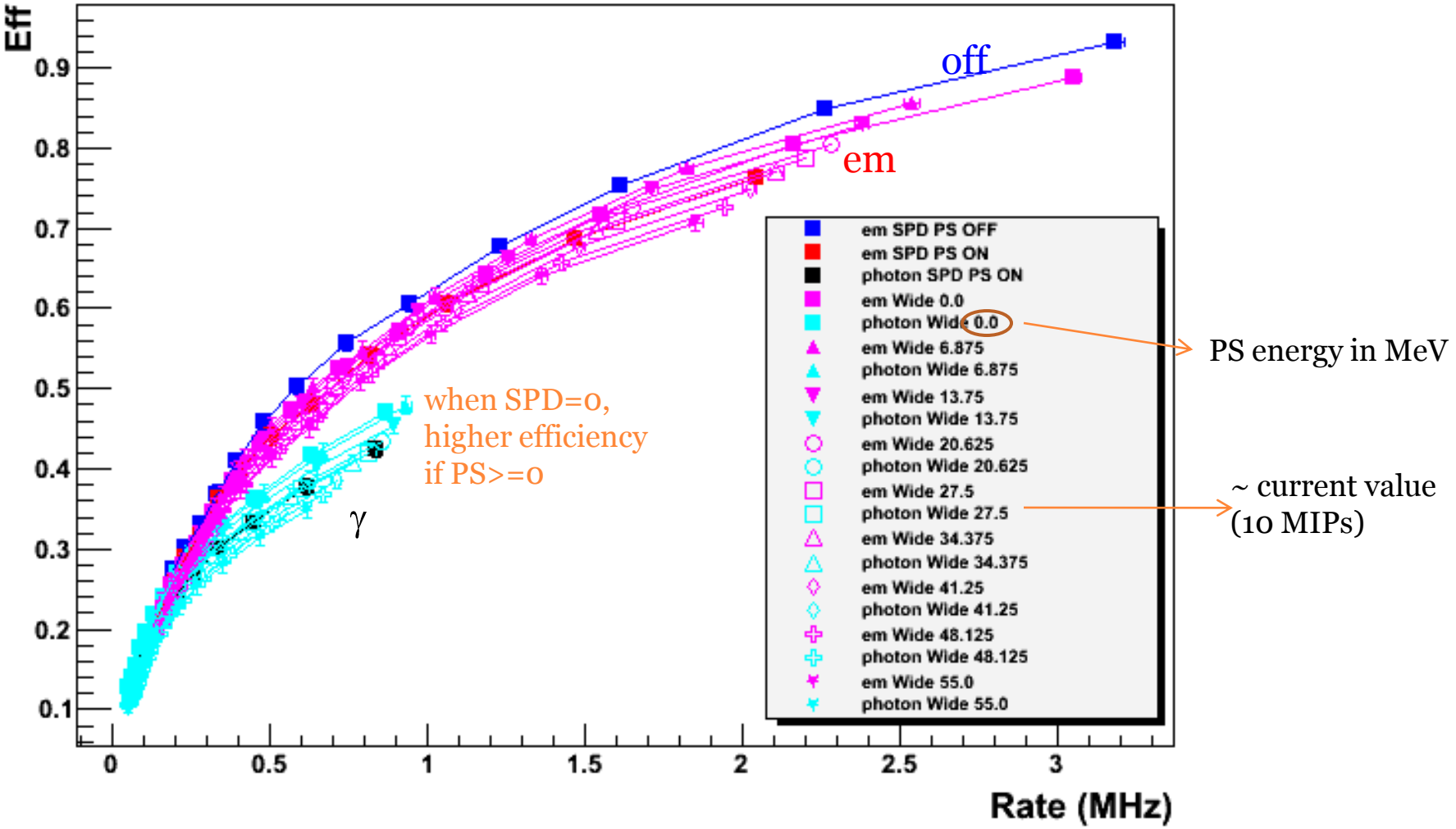


lumi20

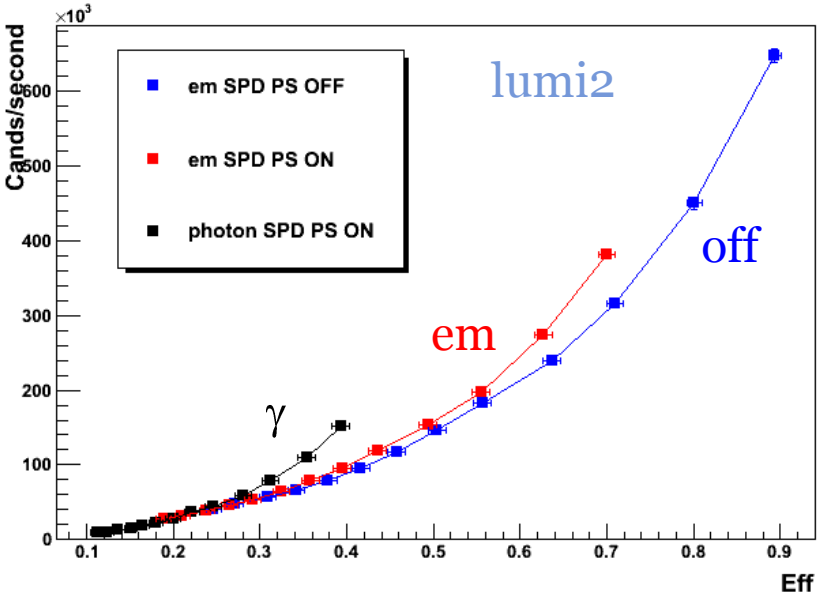


Current Lo photon trigger can be improved (for non-converted photons) if SPD=o and no requirement on the PS energy

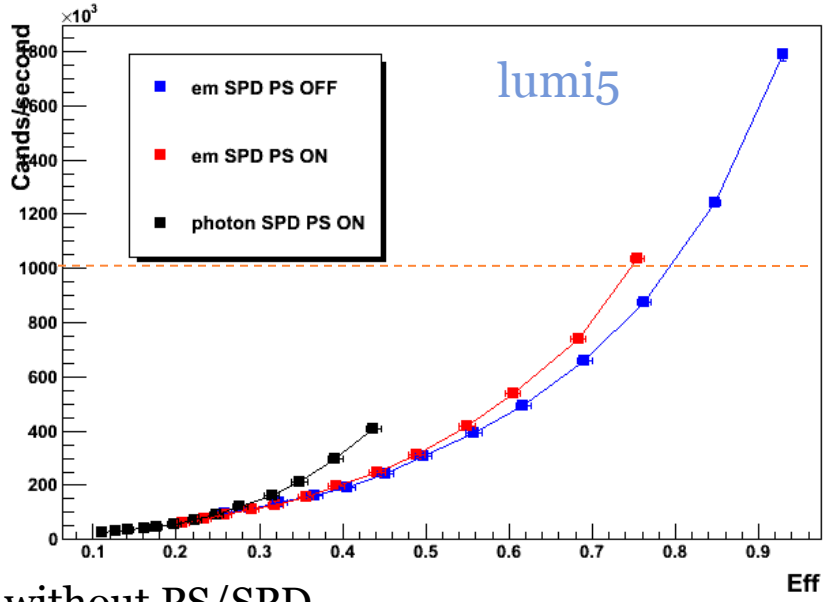
For different PS energy cuts, without the <=2 cells requirement



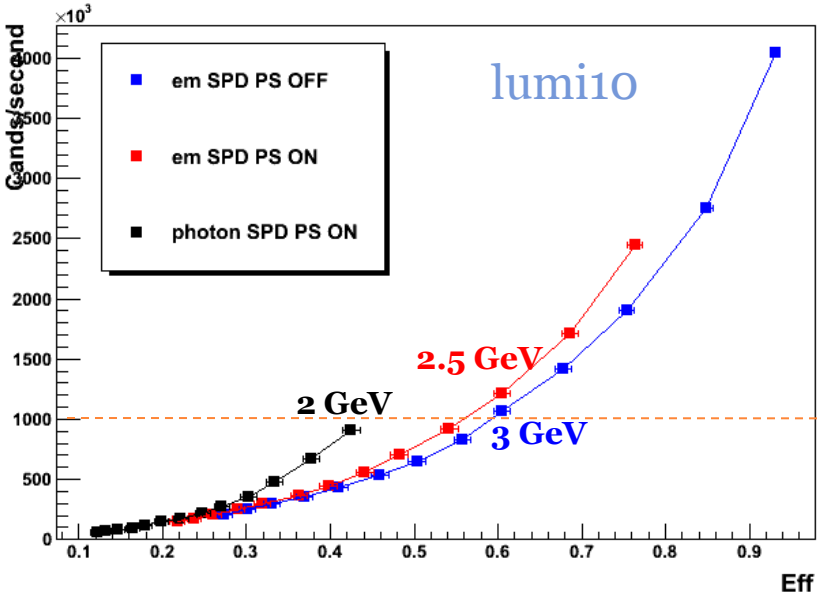
Photon candidates/second vs efficiency

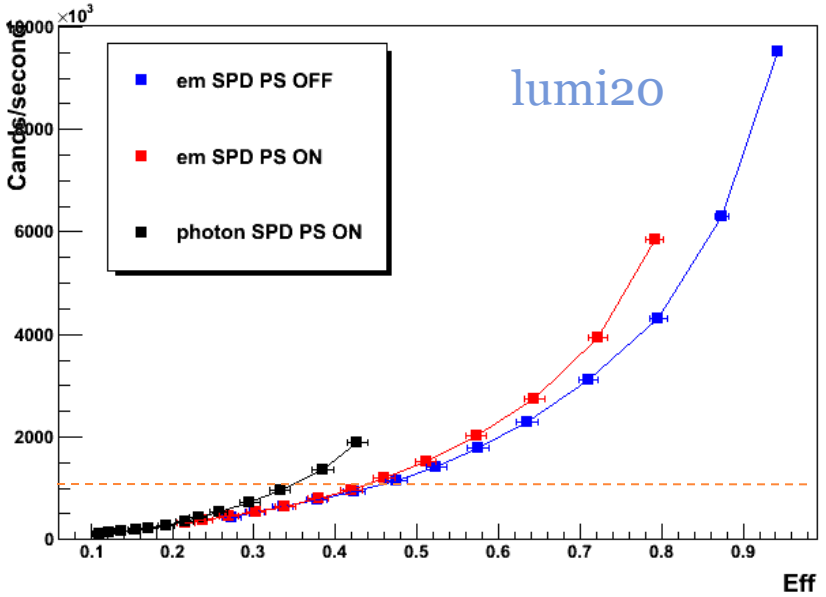


1 M



Less candidates per second at a given efficiency without PS/SPD

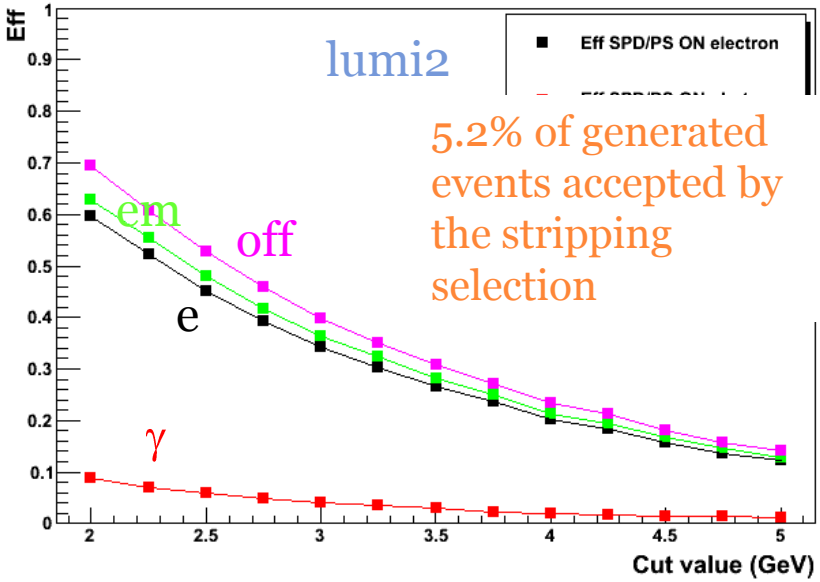




$B^0 \rightarrow K^* e^+ e^-$

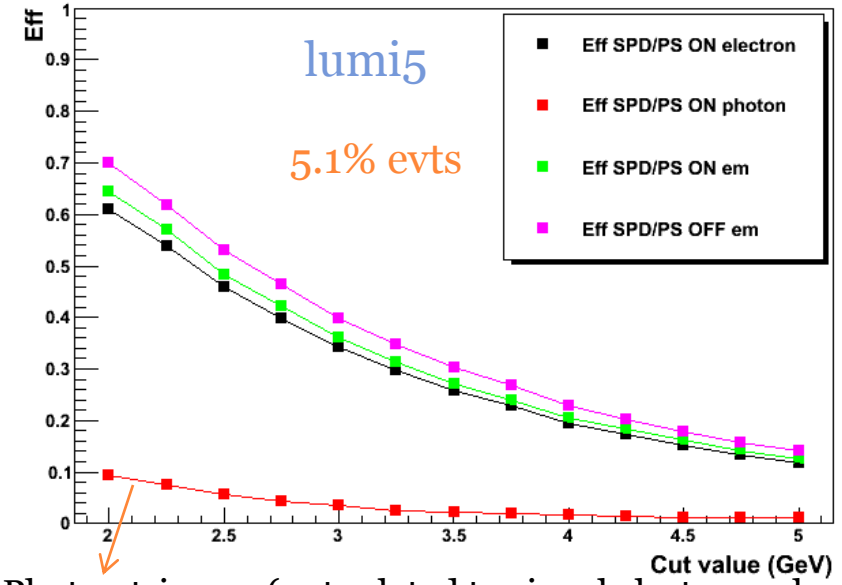
Efficiency, electrons

$B^0 \to K^* e^+ e^-$

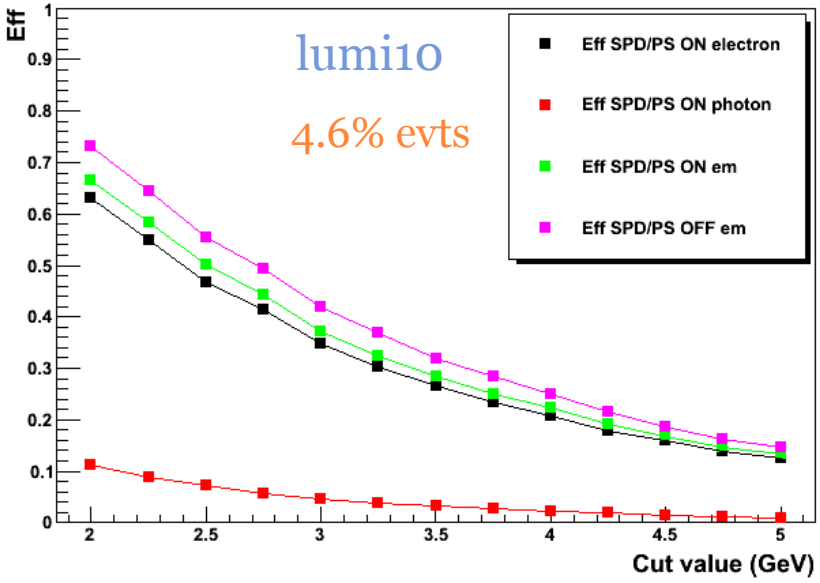


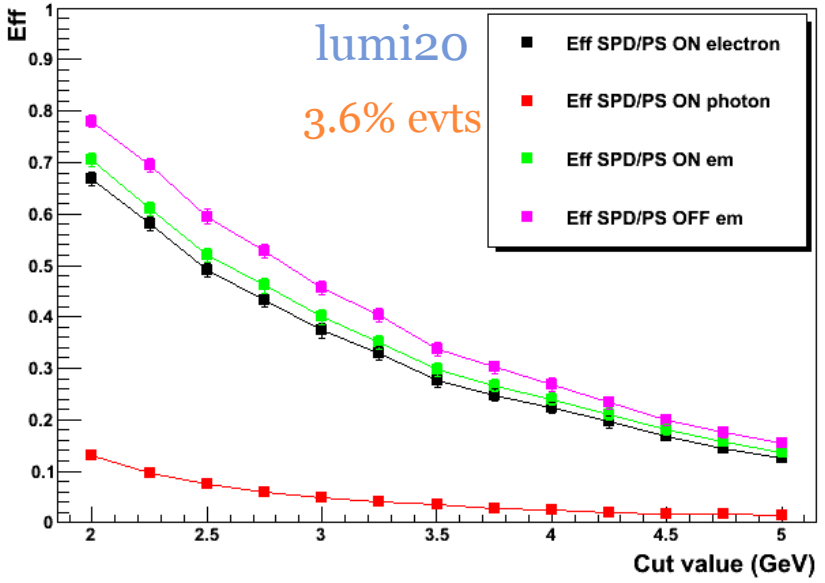
5.2% of generated events accepted by the stripping selection

$p_T(e)>0.3$ GeV in stripping



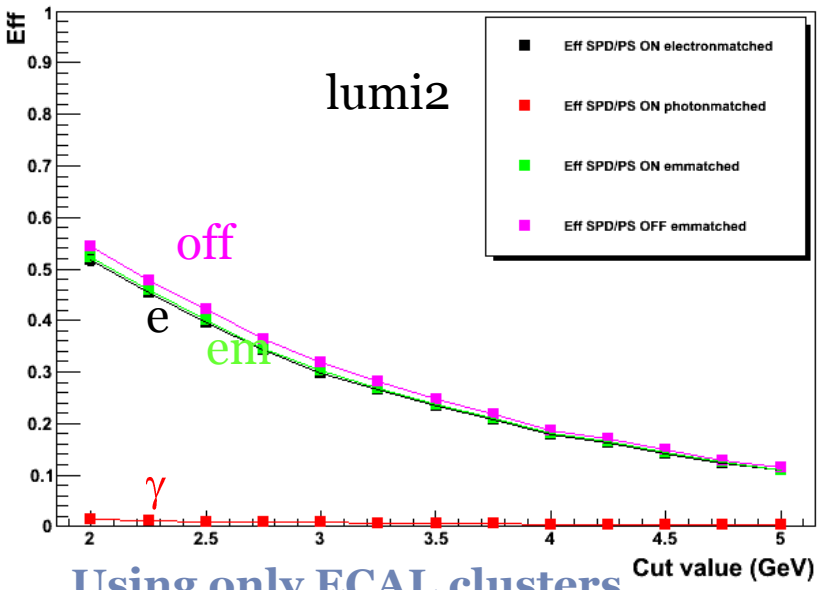
Photon triggers (not related to signal electrons clusters)

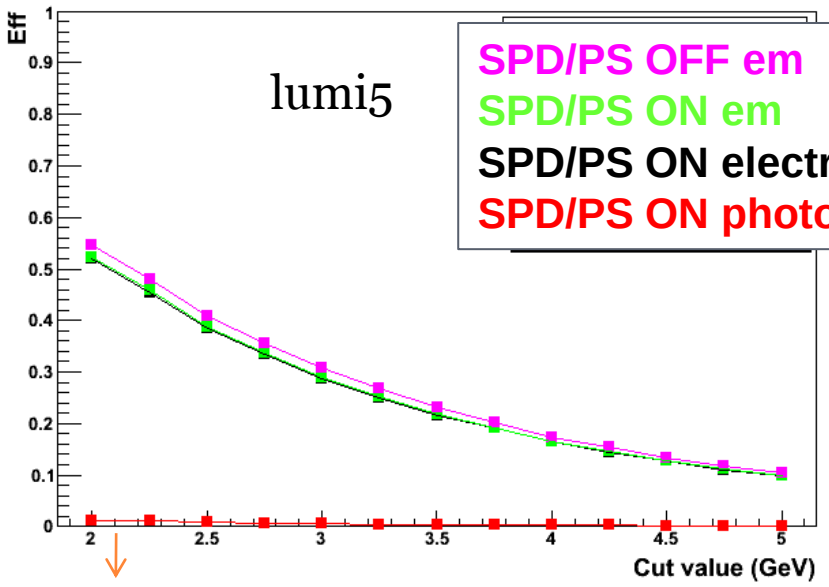




Efficiency, electrons

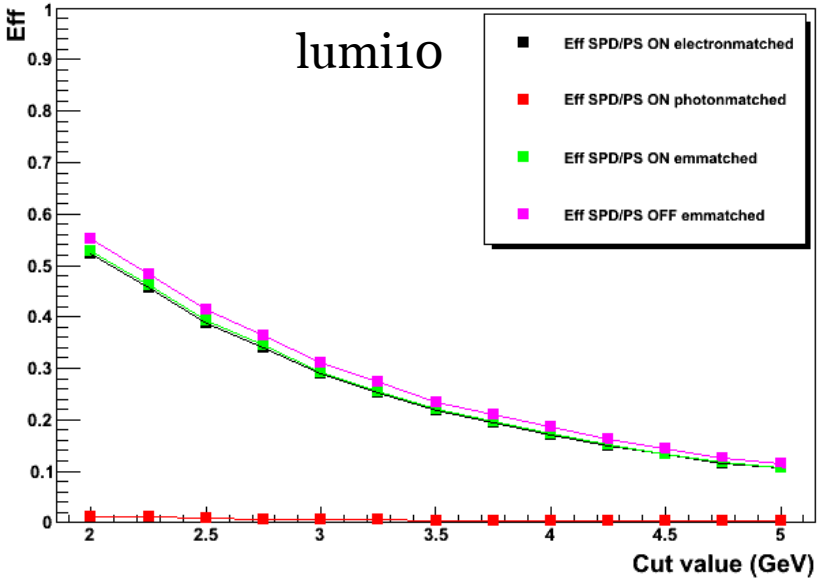
$B^0 \rightarrow K^* e^+ e^-$

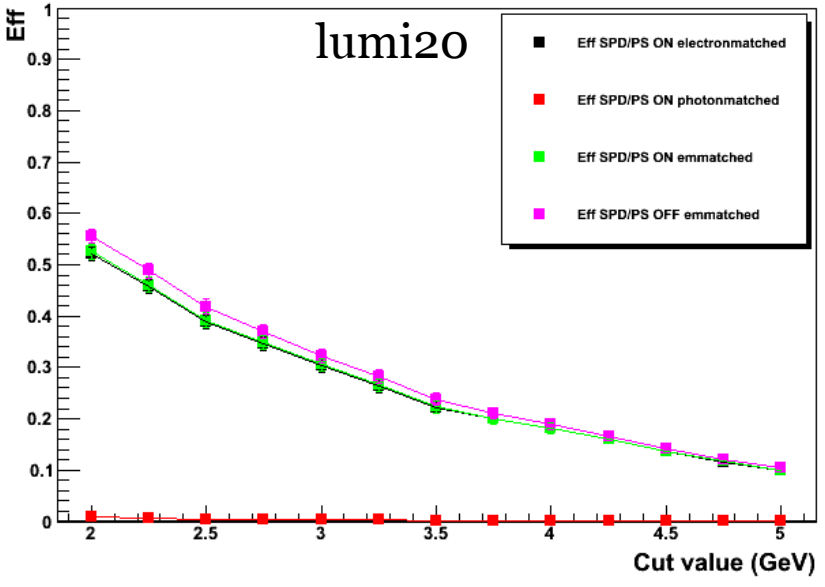




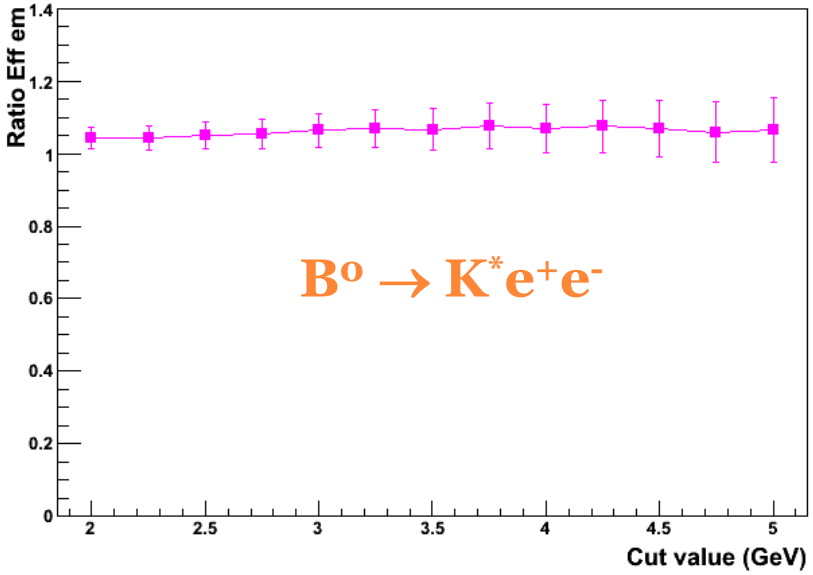
Using only ECAL clusters matched to MC e (< 60 cm)

→ photon triggers disappear



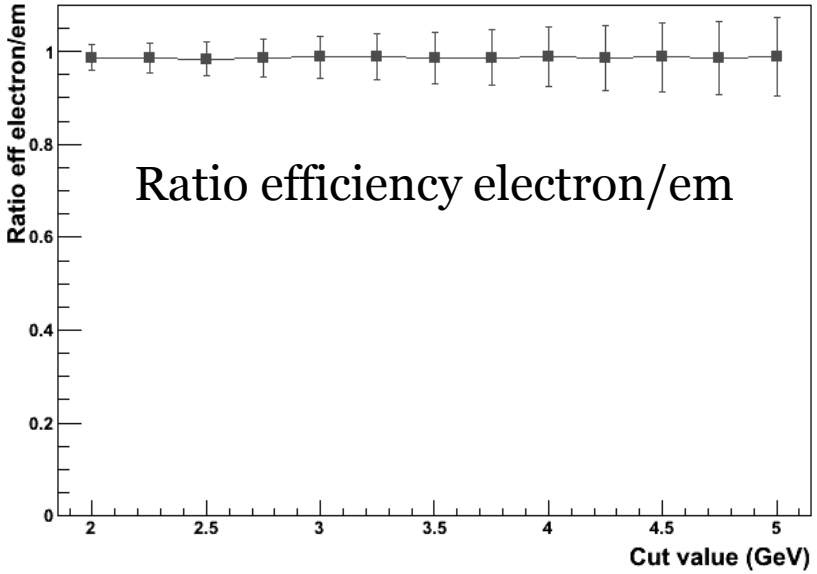


Ratio efficiency em OFF/ON



PS kills 5% of events with em (electron) clusters

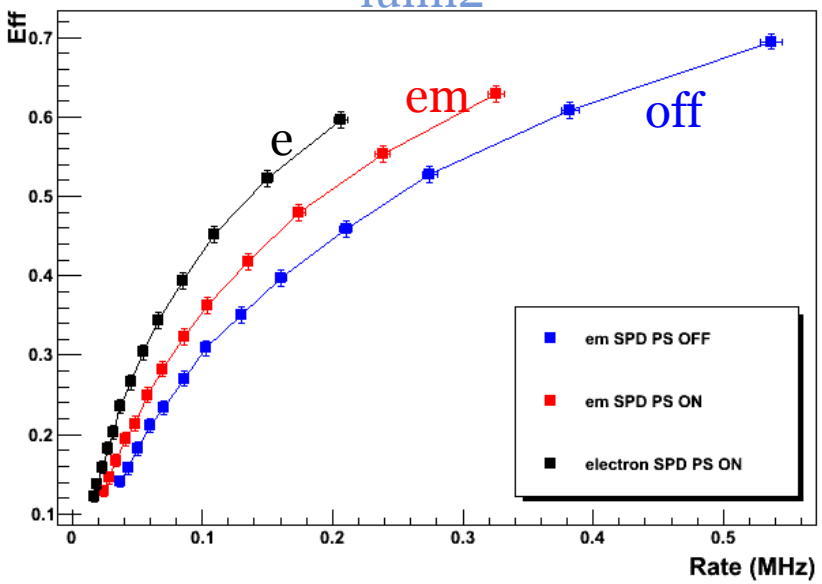
MC matched clusters



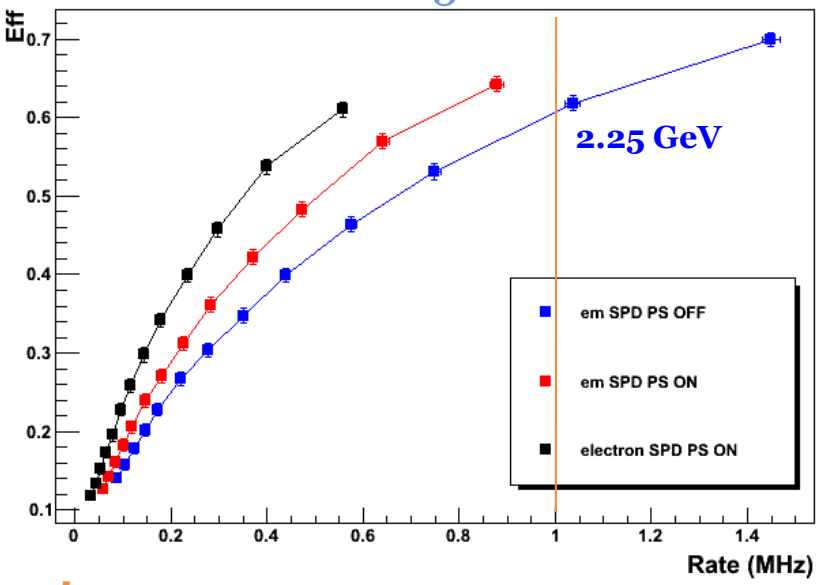
SPD identifies as electron 99% of remaining signal electron clusters

Efficiency (electrons) vs rate

lumi2

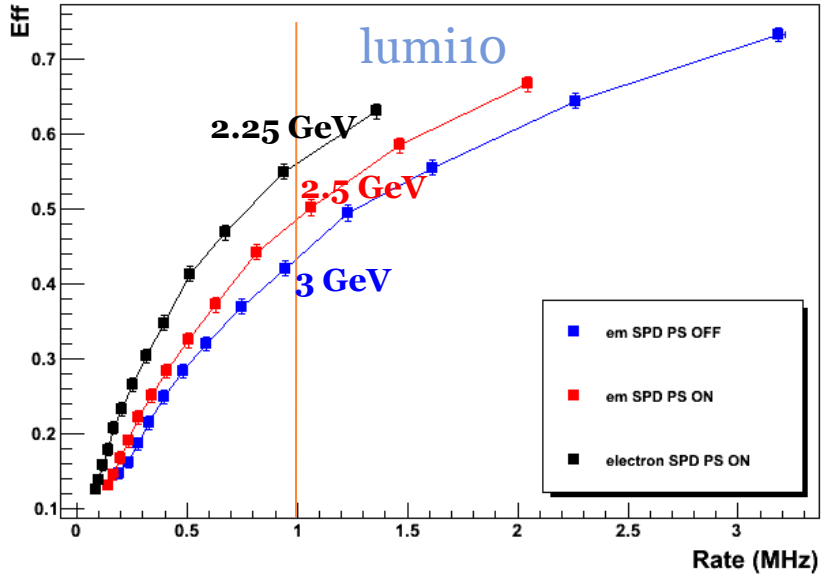


lumi5

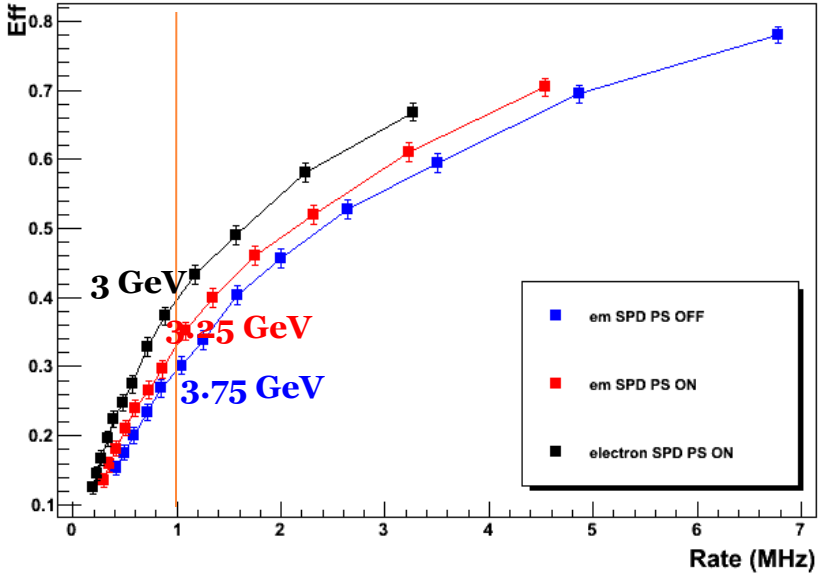


Highest efficiency with PS/SPD for a given rate

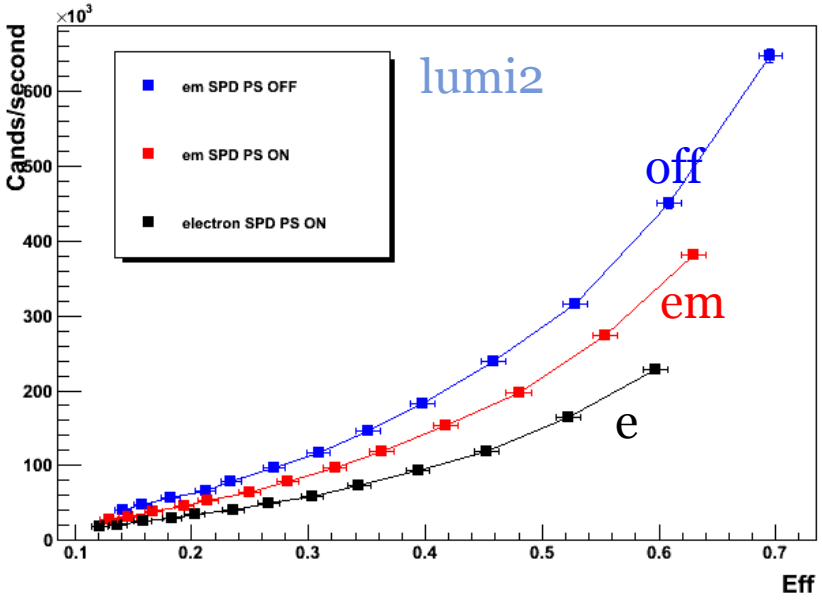
lumi10

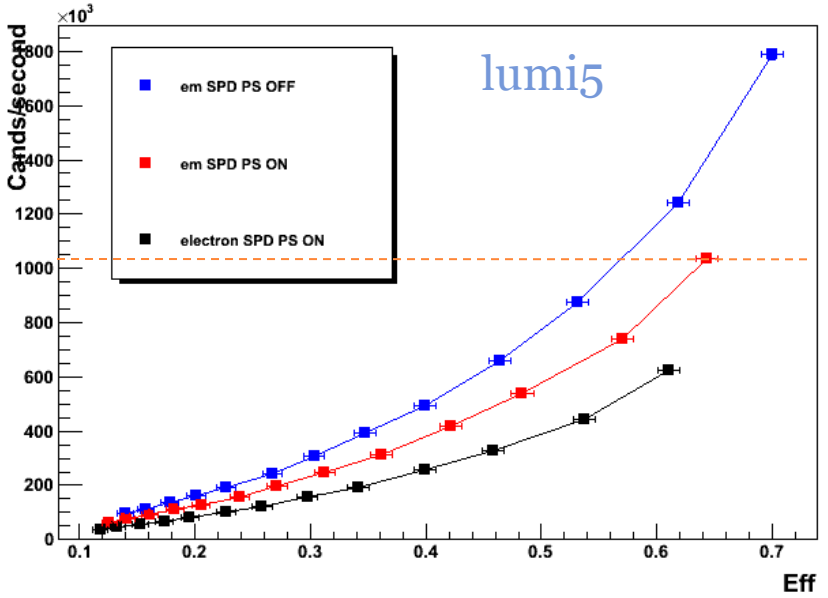


lumi20

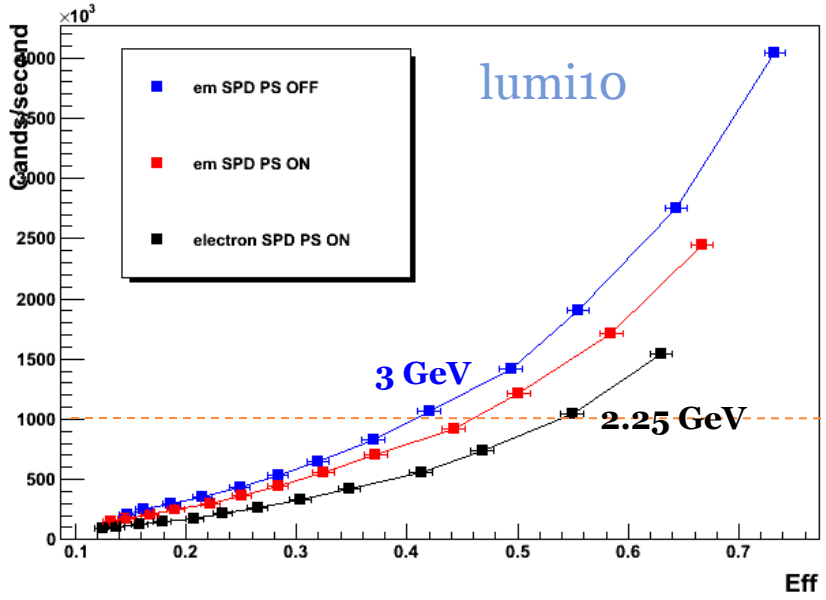


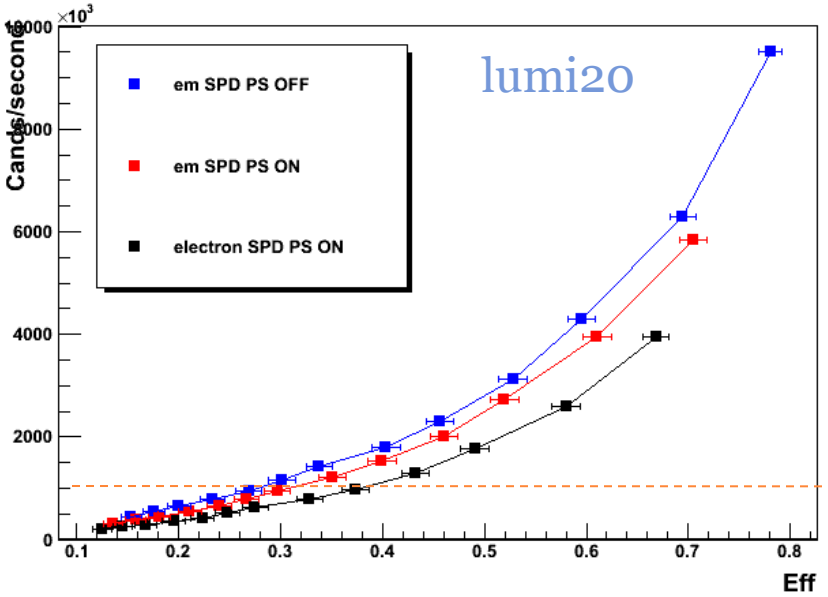
Electron candidates/second vs efficiency





Less candidates per second at a given efficiency for L0 electrons with PS/SPD





Conclusions

- Results are similiar at any luminosity.
  - Main difference is the rate of visible pp collisions.
  - Using the PS/SPD to confirm electromagnetic clusters reduces the rate by a factor 1/3 for a given E_T cut.
- Photons:
  - Higher efficiency **without the PS/SPD** (with higher E_T cut to keep same rate).
    - PS rejects 20% of em clusters.
      - For photons, it is better the case without any PS requirement. There are photons that deposit energy in the PS below the current threshold.
    - SPD rejects 40% of remaining clusters.
      - Converted photons are triggered as electrons.
      - Without M1, less photon conversions, the performace of the current L0 γ should be better.
- Electrons:
  - **PS/SPD electron** provides higher signal efficiency with a lower E_T cut at a given rate.
- The rate can be reduced without PS/SPD by a harder E_T cut.
  - Drawback: relative loss of efficiency around 20% for signal electrons.
    - Acceptable or recoverable through the hadronic part of the decay?
- What about the effect on Particle Identification when removing the PS/SPD?

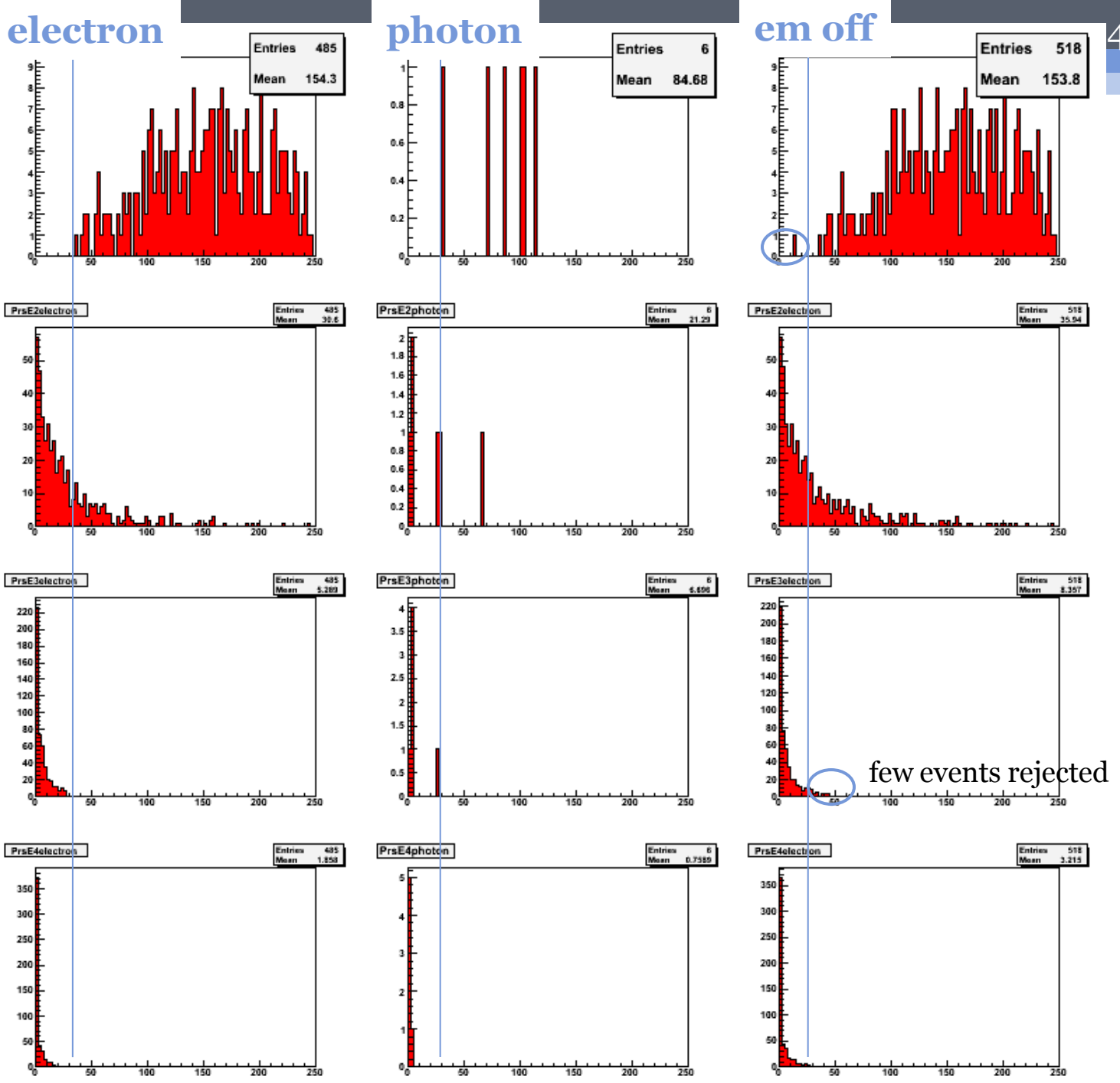
SPARES

$B^0 \rightarrow K^* e^+ e^-$

E_{PS} (MeV) of the four PS cells

Threshold at ~10 MIP

Lo electron if ≤2 cells above threshold & SPD = 1

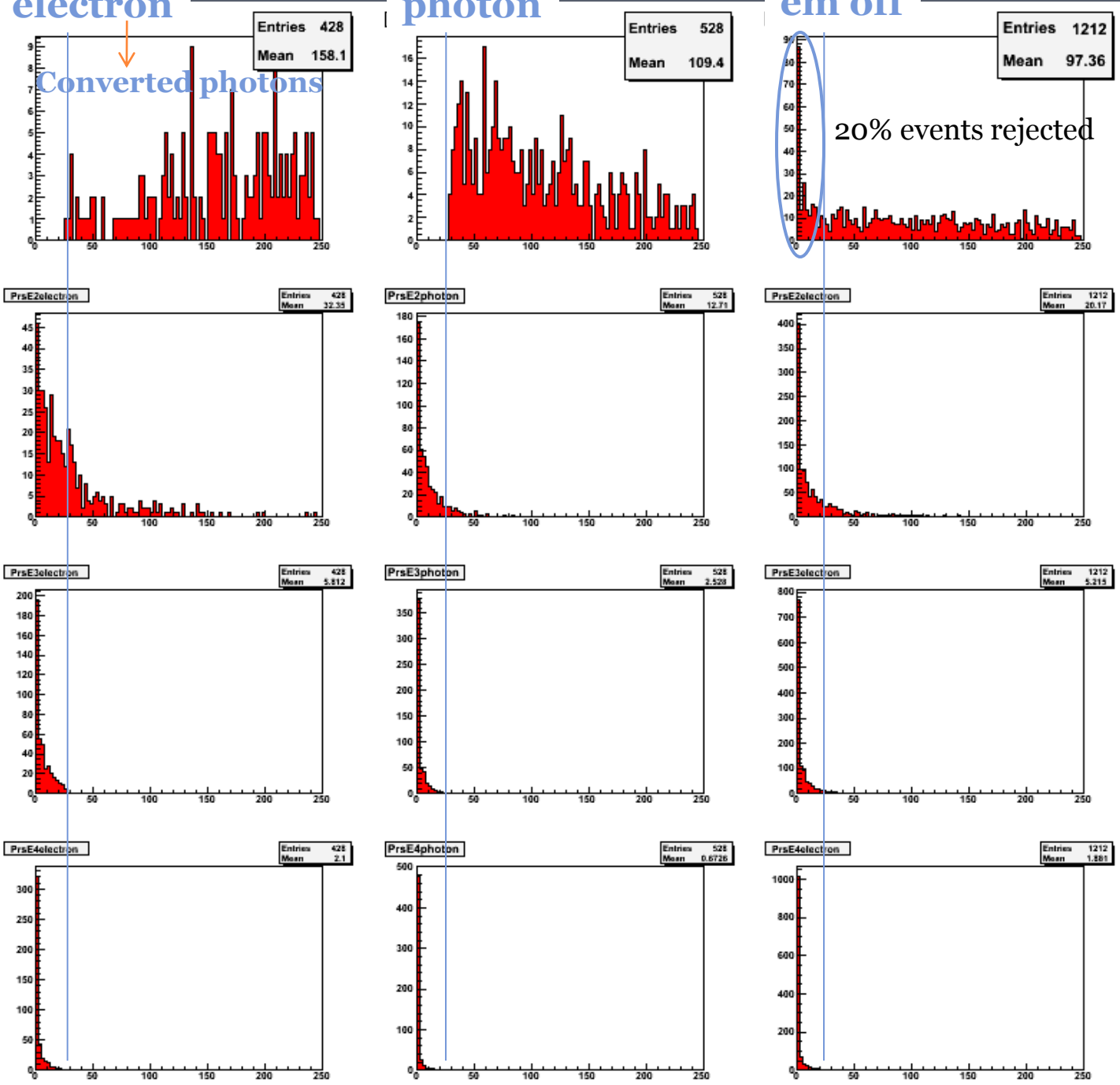


$B_s \rightarrow \phi\gamma$

There are photons that do not deposit enough energy in PS, thus discarded

Threshold at ~10 MIP

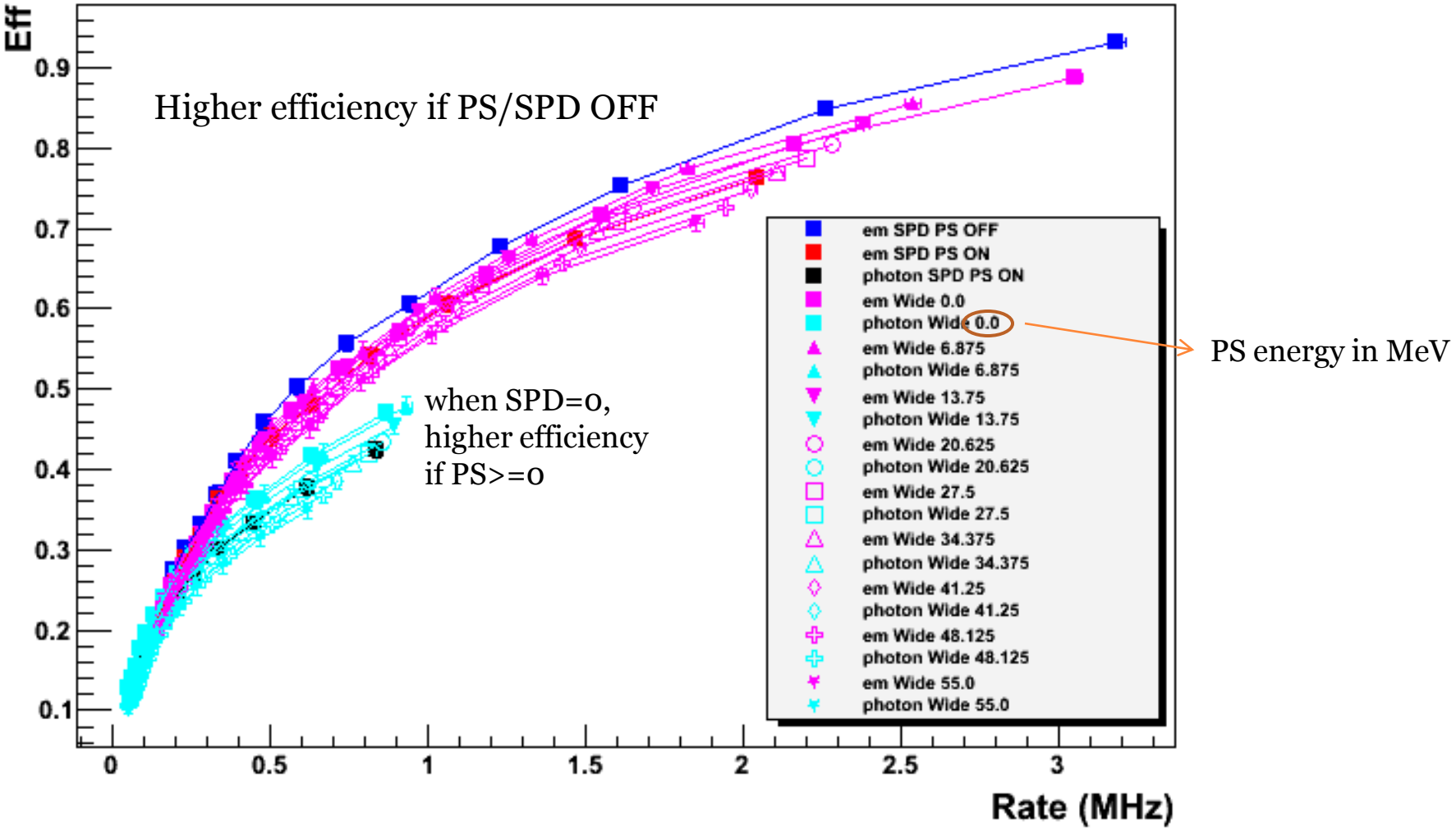
Lo photon if ≤2 cells above threshold & SPD=0



$B_s \rightarrow \phi\gamma$

For different PS energy cuts

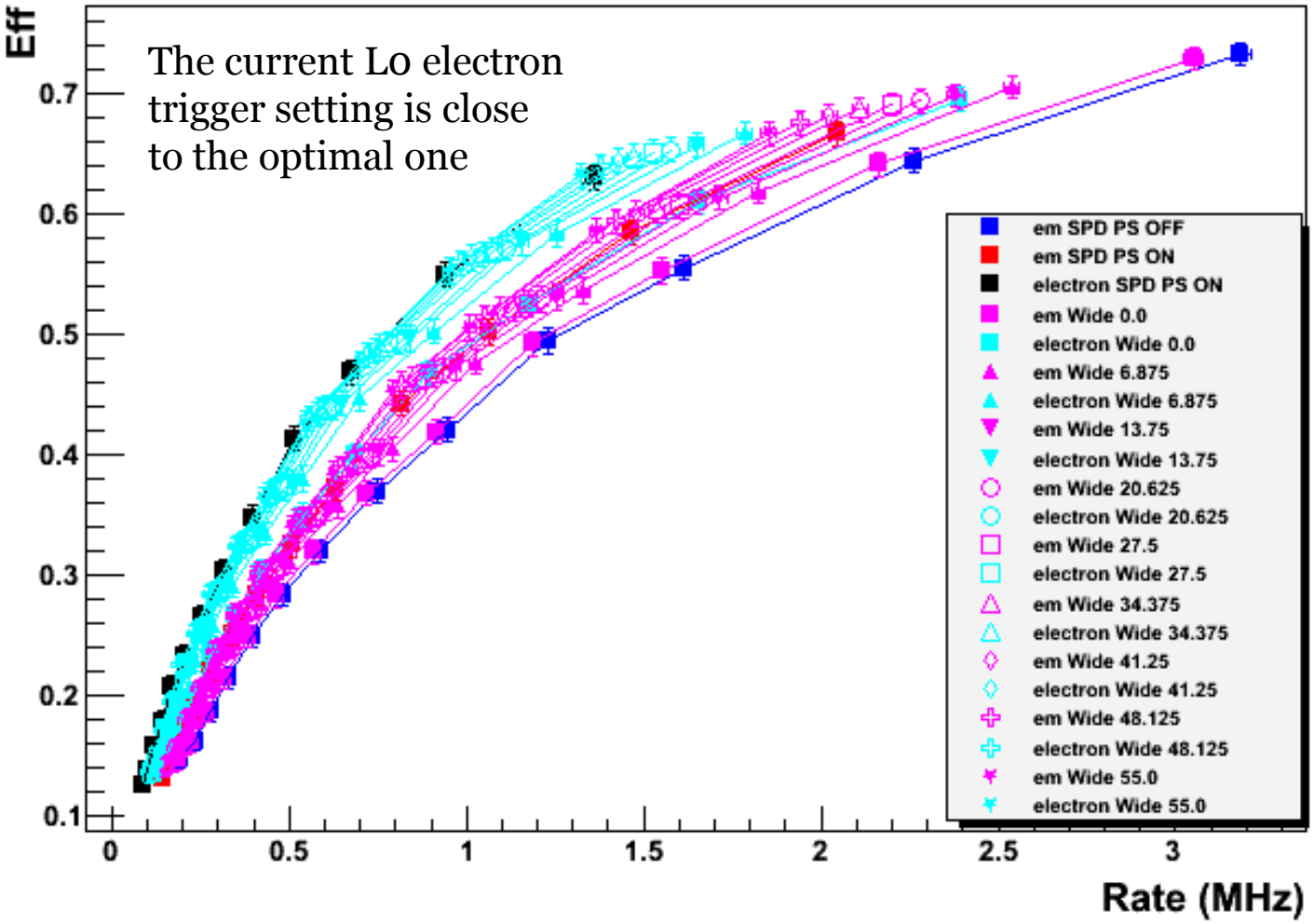
Without the <=2 cells requirement



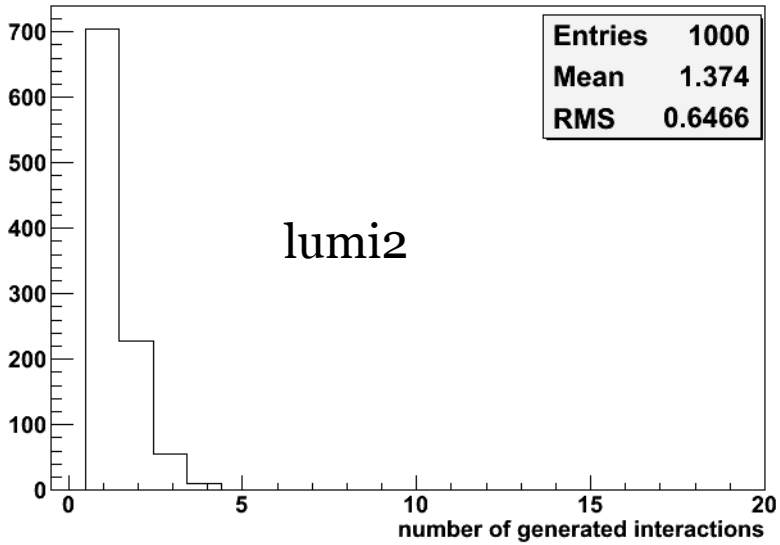
$B^0 \rightarrow K^* e^+ e^-$

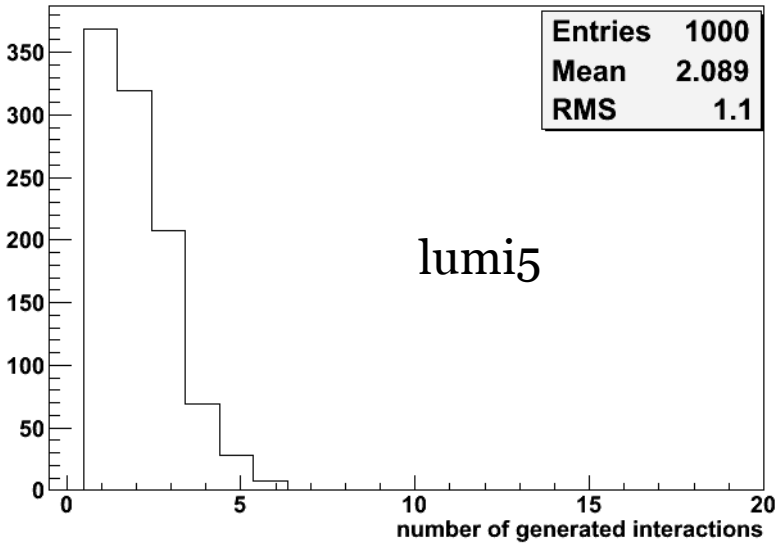
For different PS energy cuts

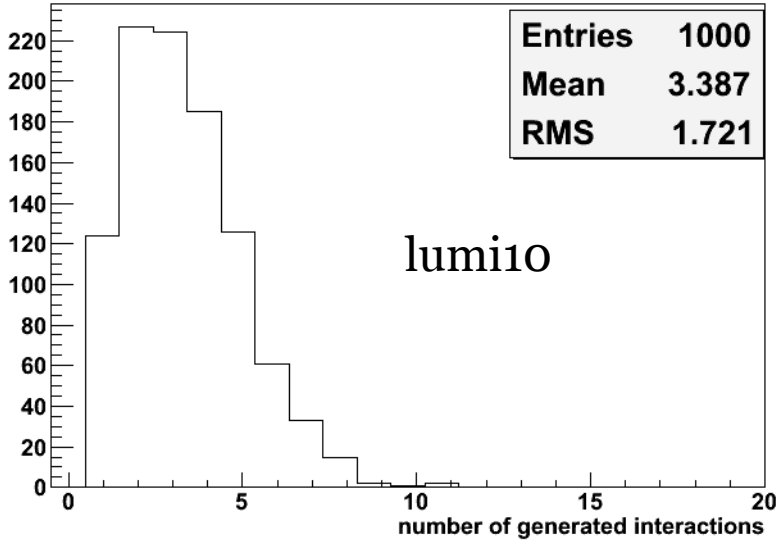
Without the <=2 cells requirement

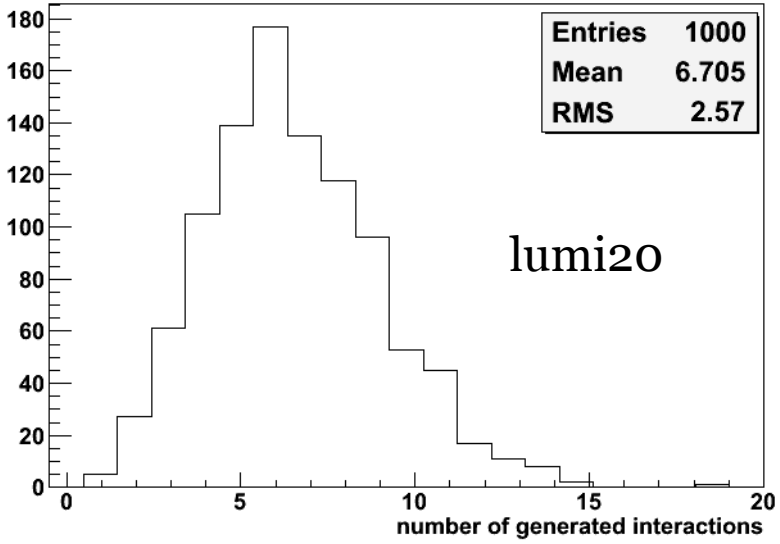


interactions/event









Stripping selections

SelBd2eeKstar

```
# DiLepton (e+e-)
DiLeptonForBd2LLKstar.InputLocations = ["StdLooseElectrons"]
DiLeptonForBd2LLKstar.DecayDescriptor = "J/psi(1S) -> e+ e-"
DiLeptonForBd2LLKstar.DaughtersCuts = {"e+": "(PT>300*MeV) & (MIPCHI2DV(PRIMARY)>1)" }
DiLeptonForBd2LLKstar.CombinationCut = "AM<5500*MeV"
DiLeptonForBd2LLKstar.MotherCut = "(VFASPF(VCHI2/VDOF)<25)"

# Kstar
Kstar2KPiForBd2LLKstar.InputLocations = ["StdTightPions", "StdTightKaons"]
Kstar2KPiForBd2LLKstar.DecayDescriptor = "[K*(892)0 -> K+ pi-]cc"
Kstar2KPiForBd2LLKstar.DaughtersCuts = {"K+":  "(PT>350*MeV) & (P>3000*MeV) & (MIPCHI2DV(PRIMARY)>3)",
                                        "pi-": "(PT>300*MeV) & (P>3000*MeV) & (MIPCHI2DV(PRIMARY)>3)"
                                        }
Kstar2KPiForBd2LLKstar.CombinationCut = "(ADAMASS('K*(892)0')<200*MeV)"
Kstar2KPiForBd2LLKstar.MotherCut = "(VFASPF(VCHI2/VDOF)<25)"

# Bd-> ee Kstar
PreselBd2Kstaree.InputLocations = ["DiLeptonForBd2LLKstar", "Kstar2KPiForBd2LLKstar"]
PreselBd2Kstaree.DecayDescriptor = "[B0 -> K*(892)0 J/psi(1S)]cc"
PreselBd2Kstaree.DaughtersCuts = {"K*(892)0": "ALL",
                                  "J/psi(1S)": "ALL"}
PreselBd2Kstaree.CombinationCut = "(ADAMASS('B0')<1200*MeV)"
PreselBd2Kstaree.MotherCut = "(BPVIPCHI2()<64) & (VFASPF(VCHI2/VDOF)<(36.0/4.0)) & (BPVVDCHI2>9) & (BPVDIRA>0.999)"

# final selections
hardee    = "(INTREE( (ID=='J/psi(1S)') & (BPVVD>1.0*mm) ))"
hardKstar = "(INTREE( (ABSID=='K*(892)0') & (ADMASS('K*(892)0')<130*MeV) & (BPVIPCHI2()>1.0) & (BPVVDCHI2>1.0) ))"
hardB     = "(ADMASS('B0')<1000*MeV) & (BPVIP()<0.05*mm)“

from Configurables import FilterDesktop
SelBd2eeKstar = FilterDesktop("SelBd2eeKstar")
SelBd2eeKstar.InputLocations  = ["PreselBd2Kstaree"]
SelBd2eeKstar.Code = hardee + " & " + hardKstar + " & " + hardB
```

Bs2PhiGamma

```
def combineBs(self, name = "MakeBs2PhiGamma" ):
    """
    Define the Bs
    """
    _stdPhi4Bs = DataOnDemand(Location = "Phys/StdLoosePhi2KK")
    _phi4BsFilter = FilterDesktop ("PhiFilterFor"+name)
    _phi4BsFilter.Code = "(MINTREE(ABSID=='K+', MIPCHI2DV(PRIMARY))> %(TrIPchi2Phi)s) & (ADMASS('phi(1020)') <
%(PhiMassWinT)s*MeV) & (VFASPF(VCHI2/VDOF) < %(PhiVCHI2)s)" % self.getProps()

    Phi4Bs =  Selection ("Phi2KKFor"+name
                ,Algorithm = _phi4BsFilter
                ,RequiredSelections = [_stdPhi4Bs])

    _stdgamma = DataOnDemand(Location = "Phys/StdLooseAllPhotons")
    _gammaFilter = FilterDesktop("GammaFilterFor"+name)
    _gammaFilter.Code =  "(PT> %(photonPT)s*MeV)"  % self.getProps()
    Gamma =  Selection ("GammaFor"+name
               ,Algorithm = _gammaFilter
               ,RequiredSelections = [_stdgamma])

    _Bs2PhiGamma = CombineParticles ( name
                    ,DecayDescriptor = "B_s0 -> phi(1020) gamma"
                    ,CombinationCut = "(ADAMASS('B_s0')<%(BsMassWin)s*MeV)"  % self.getProps()
                    ,MotherCut = "(acos(BPVDIRA) < %(BsDirAngle)s) & (BPVIPCHI2() < %(BsPVIPchi2)s)" % self.getProps()
                    ,ReFitPVs = True)
    Bs2PhiGamma = Selection ( "Sel"+name
                  ,Algorithm = _Bs2PhiGamma
                  ,RequiredSelections = [Gamma, Phi4Bs])

    return Bs2PhiGamma
```

```
class StrippingB2XGammaConf(LHCbConfigurableUser):
    """
    Definition of B -> X Gamma stripping
    """
    __slots__ = {
                'TrIPchi2Phi'        : 10      # Dimensionless
                ,'TrIPchi2Kst'       : 10      # Dimensionless
                ,'PhiMassWinL'       : 40      # MeV
                ,'PhiMassWinT'       : 15      # MeV
                ,'KstMassWinL'       : 200     # MeV
                ,'KstMassWinT'       : 100     # MeV
                ,'KstMassWinSB'      : 200     # MeV
                ,'BsMassWin'         : 1000    # MeV
                ,'BoMassWin'         : 1000    # MeV
                ,'BMassWinSB'        : 2000    # MeV
                ,'BsDirAngle'        : 0.02    # radians
                ,'BoDirAngle'        : 0.02    # radians
                ,'BDirAngleMoni'     : 0.06    # radians
                ,'BsPVIPchi2'        : 15      # Dimensionless
                ,'BoPVIPchi2'        : 15      # Dimensionless
                ,'photonPT'          : 2000    # MeV
                ,'PhiVCHI2'          : 15      # dimensionless
                ,'KstVCHI2'          : 15      # dimensionless
                }
```