Background studies for the VTX geometry optimisation

Paweł Łużniak (Łódź University)

lupawel@mail.desy.de

LCWS08, Chicago

Outline of the analysis

- Consider different VXD geometries

  vary inner radius, thickness and resolution

- Include beam induced background and physics backgrounds

- Study flavour tagging performance

- Simulate Higgs boson BRs measurement at ILC

  based on fast simulation tools

PhD thesis prepared at the Łódź University

Vertex Detector layout

Cos Θ = 0.96
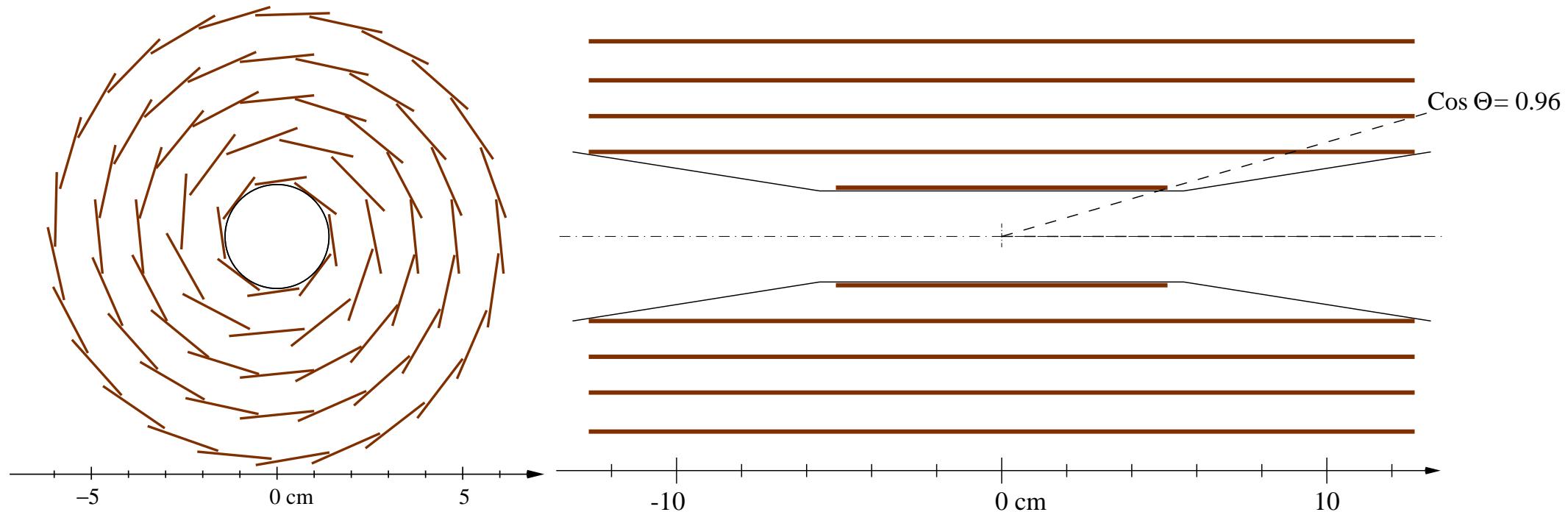
| Layer	Radius	No. of ladders	Ladder width
1	8 - 18 mm	8	19 mm
2	26 mm	11	22 mm
3	37 mm	16	22 mm
4	48 mm	20	22 mm
5	60 mm	25	22 mm

B = 4T

Thickness $0.05 - 0.3\% \ X_0$

Spatial resolution $2 - 8\mu m$

# Jet flavour tagging in presence of e^+e^- background

- e^+e^- **pairs from beamstrahlung (background) simulated using Guinea-Pig for nominal accelerator parameters @ 500 GeV.**

- **14 mrad crossing angle.**

- **ILC detector simulation:**

  - **All charged particles tracked through Vertex Detector (VTX), accounting for multiple scattering and energy loss (own software tools)**

  - **Other detector components simulated using SGV 2.30 (fast simulation tool)**

- **VTX readout: 20 times per bunch train (1 readout cycle = 131 BX)**

- **Tracks detected in the central tracker refitted with hits from VTX (both physics and background hits) selected with Kalman Filter (own software tools)**

- **Vertices reconstructed with ZVTOP, jet tagging with NN**
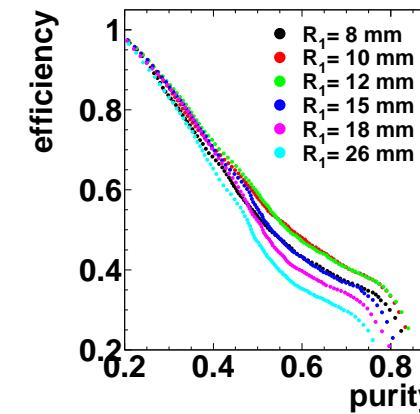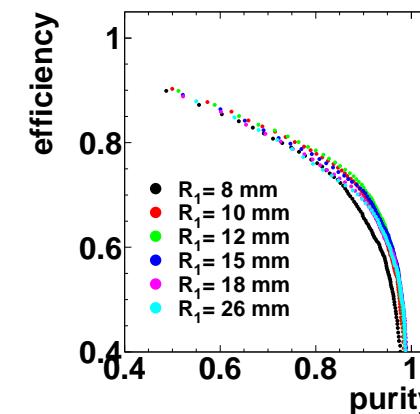
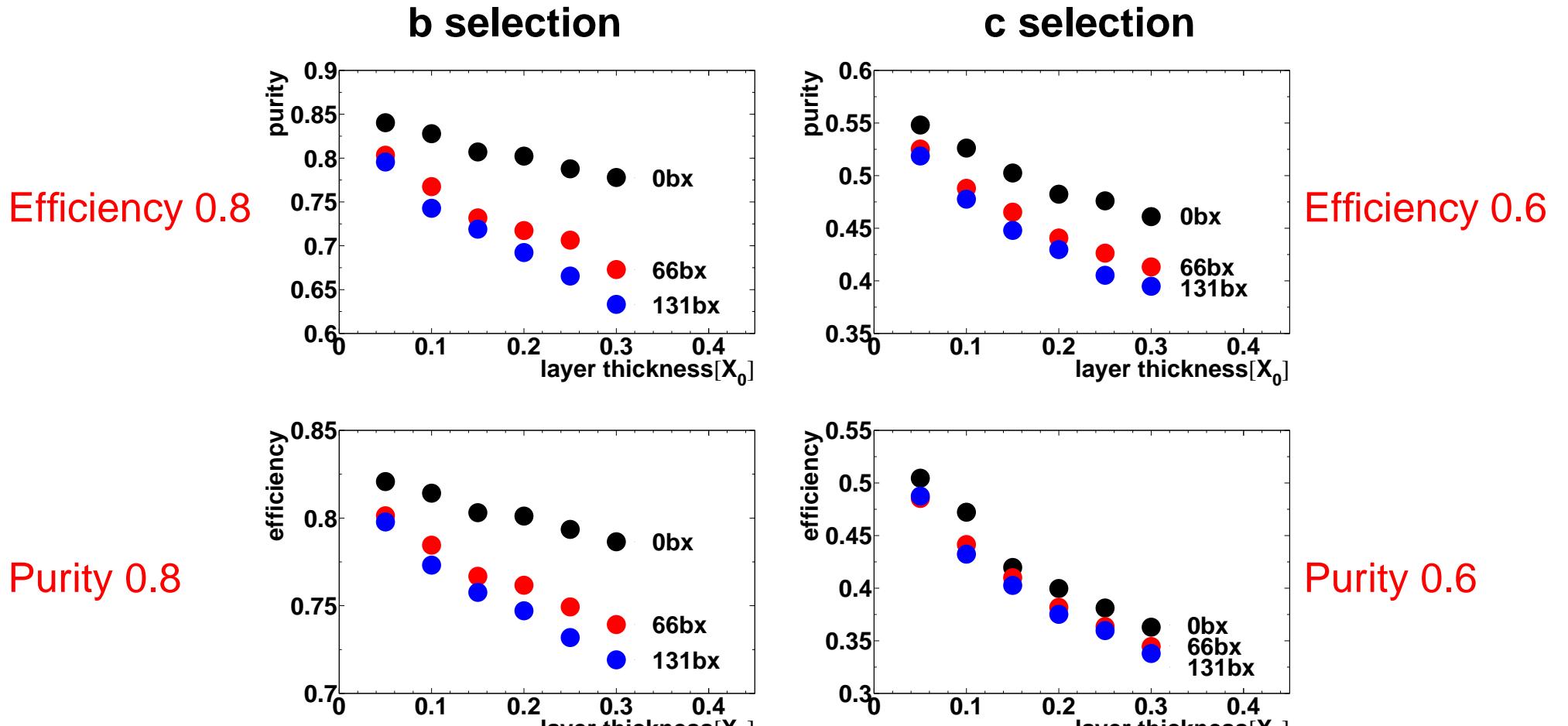# Jet flavour tagging performance

background: 0 bx
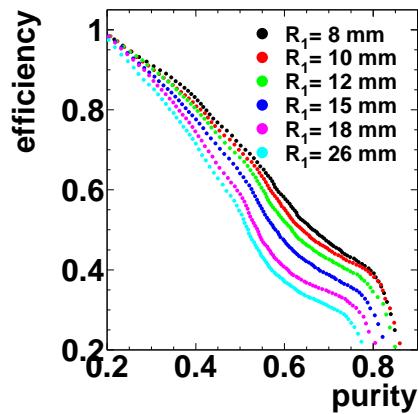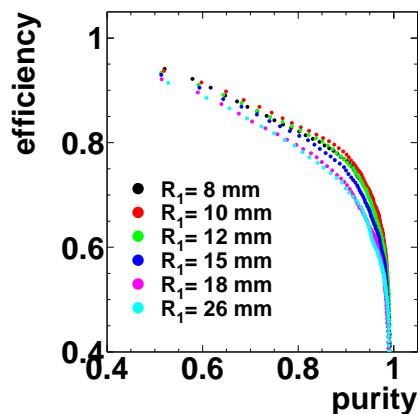
background: 66bx
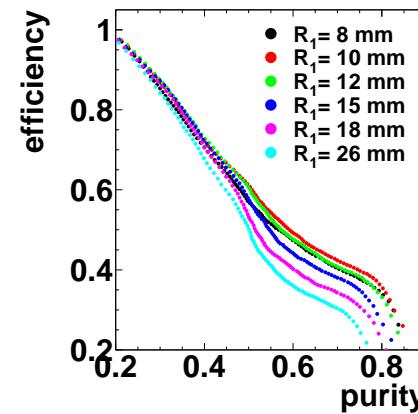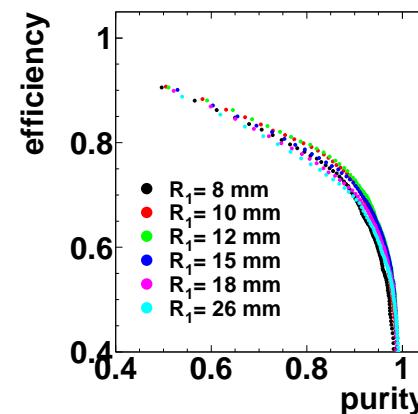
background: 131bx

Jet flavour tagging performance

b selection

c selection

Efficiency 0.8

Efficiency 0.6

Purity 0.8

Purity 0.6

Spatial resolution 4 μm, radius of the first layer 15 mm.

Jet flavour tagging performance

b selection

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Efficiency 0.6

Purity 0.8
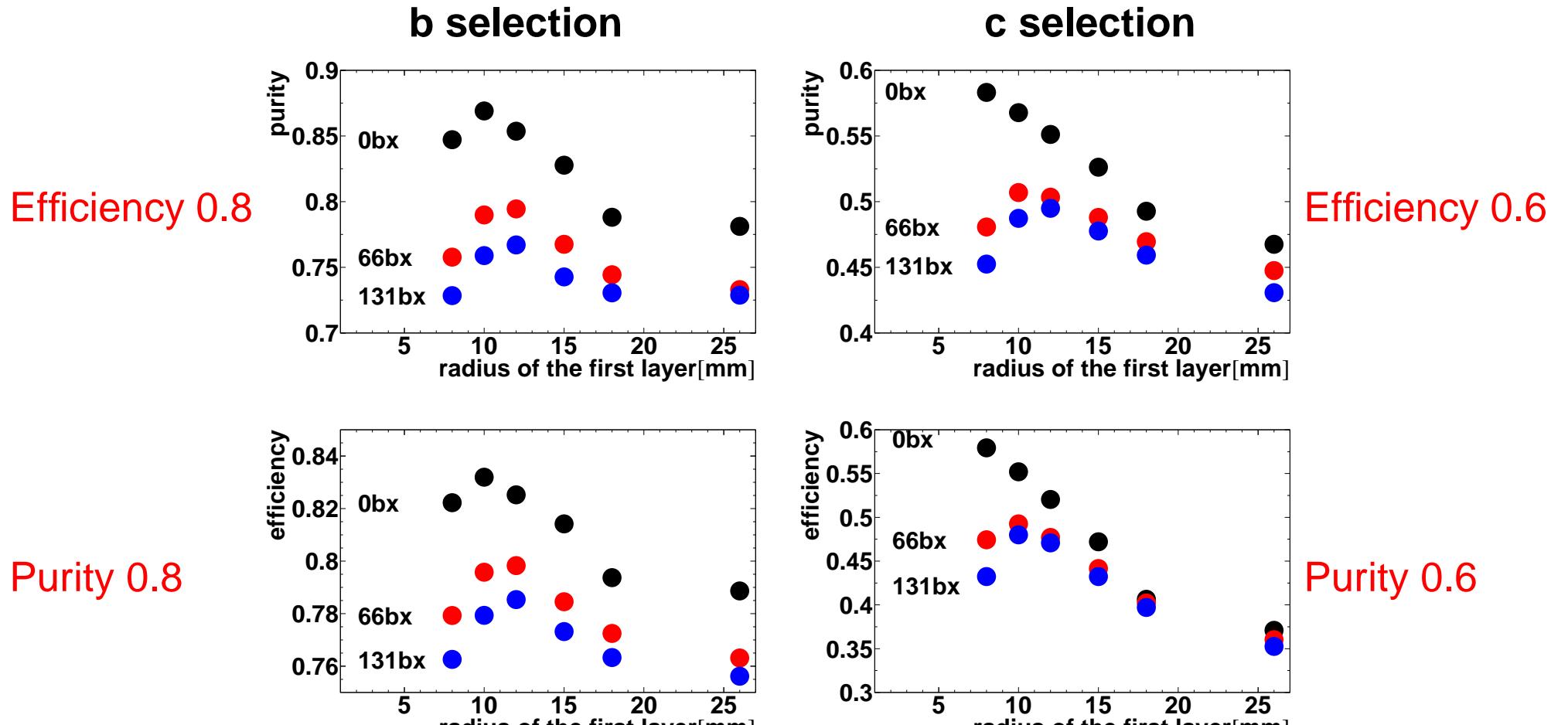
Purity 0.6

Spatial resolution 4 μm, layer thickness 0.1% X_0. R$_1 = 26$ mm - only 4 layers.

Jet flavour tagging performance
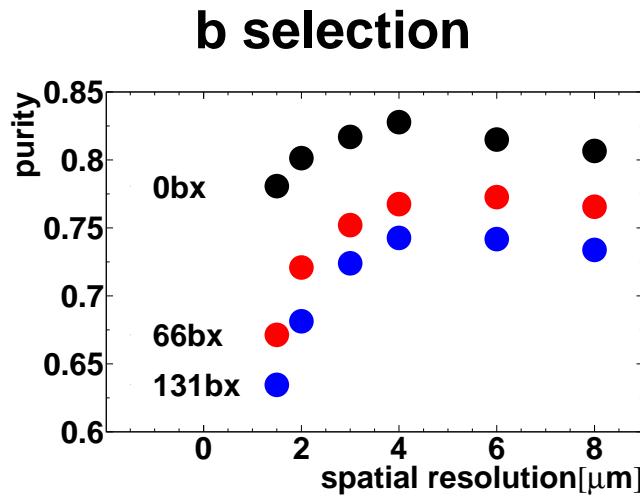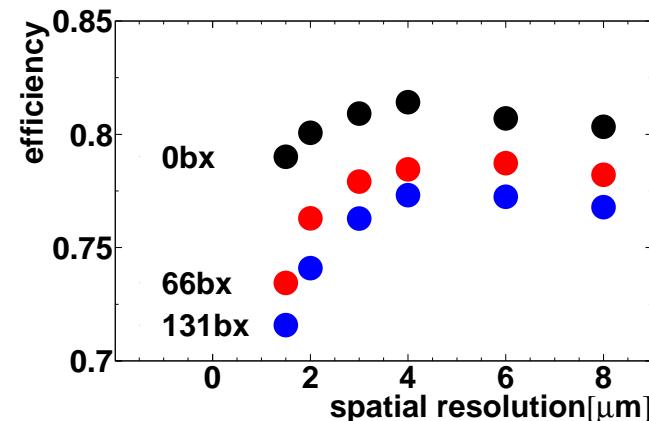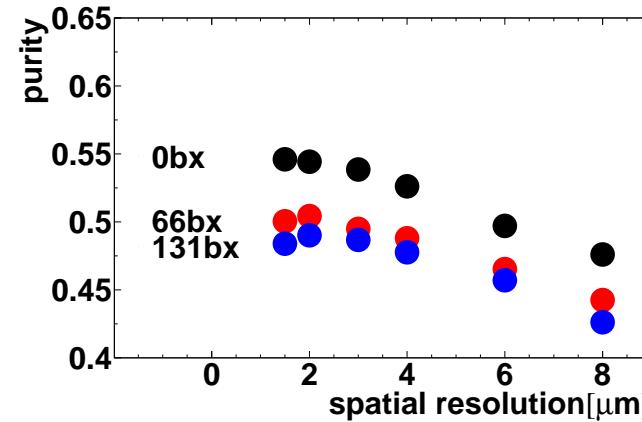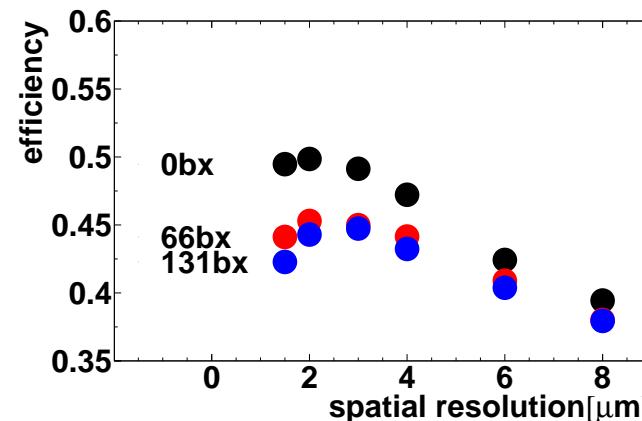
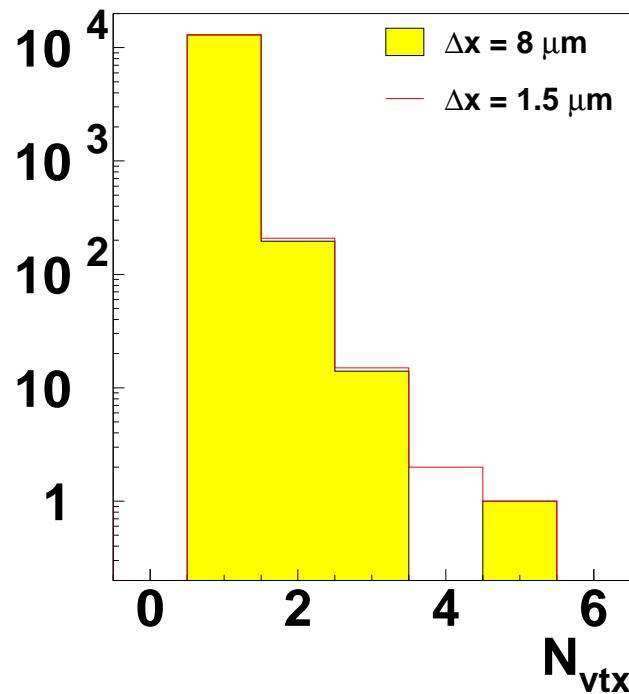**Layer thickness 0.1% X_0, radius of the first layer 15 mm.**
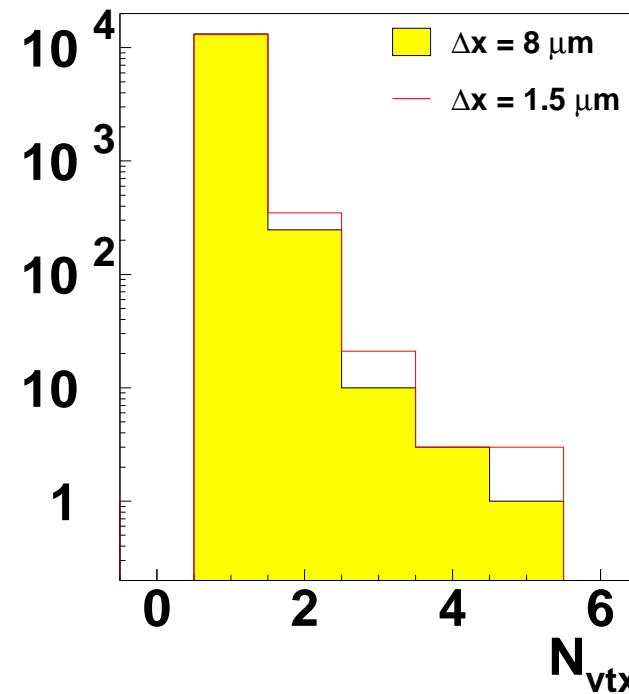
Jet flavour tagging performance

Same NN tagging algorithm used in all cases!

For spacial resolution $< 4\mu m$ number of reconstructed secondary vertices for u,d,s jets increases:
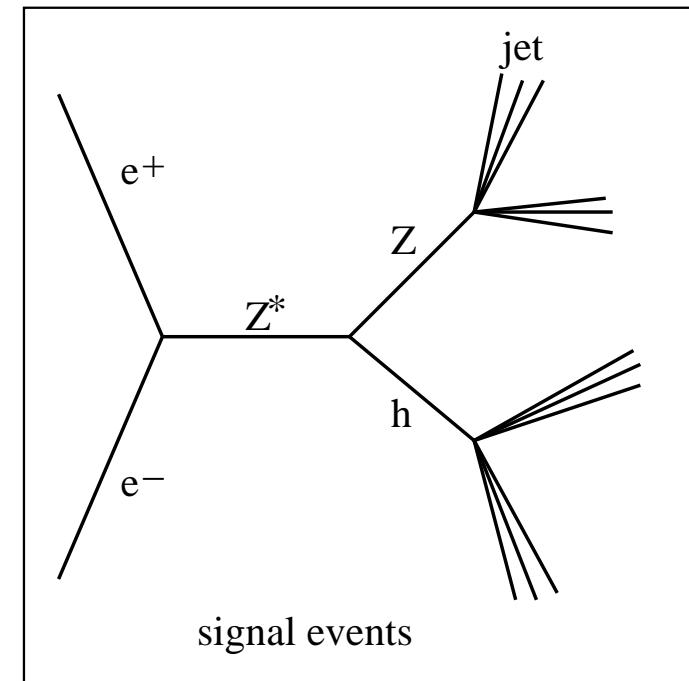

background: 0 bx

background: 131bx

Physics analysis

- **Event generator - PYTHIA :**
  Signal: $e^+e^- \to Zh \quad (h \to c\bar{c}, \; h \to b\bar{b})$

  – **SM:** $\mathbf{M}_h$ = **127 GeV**
  – **MSSM:** $\mathbf{M}_A$ = **350 GeV,**
    $\mathbf{M}_2$ = **200 GeV,**
    $\mathbf{A}_{\tilde{f}}$ = **2450 GeV,**
    $\mathbf{M}_h$, Γ_h, **b. r. from HDECAY**
    $\mathbf{M}_h$ = **127 GeV**

  Background: $e^+e^- \to W^+W^-,$
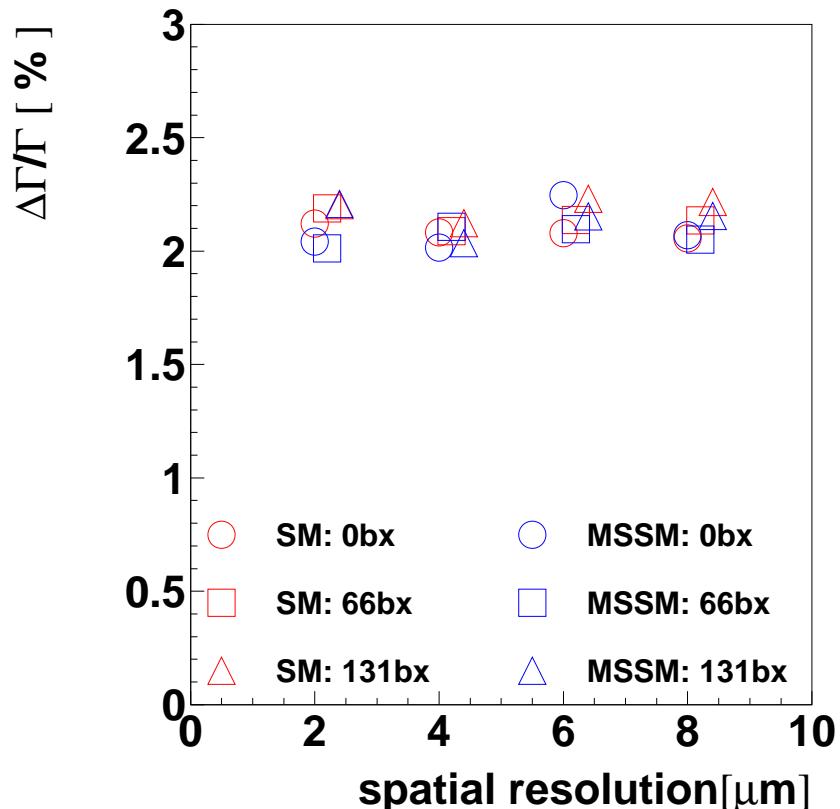 $e^+e^- \to q\bar{q}, \; e^+e^- \to ZZ$, **other higgs decays**

- **Centre of mass energy 500 GeV**

- **Corresponding luminosity 500 fb^{-1}**

- e^+e^- **background generated with Guinea-Pig**

- **Vtx. reco. with ZVTOP, jet tagging with NN**

signal events

- **Detector:**

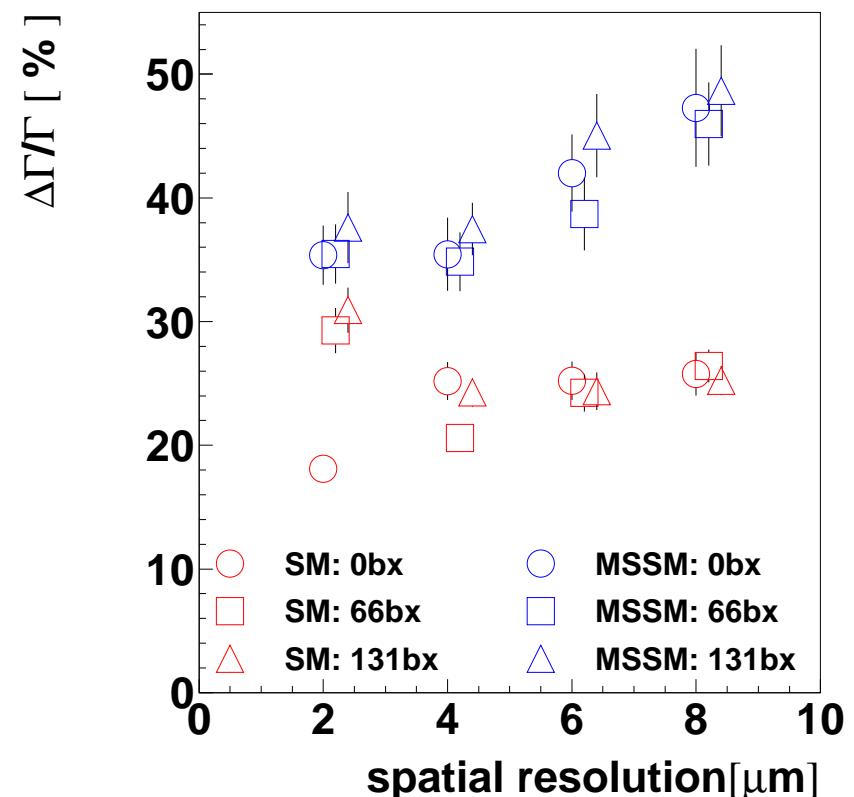 – **Simulation à Grande Vitesse 2.30**

  – **The entire ILC detector as in TESLA TDR**

  – **Varying VXD parameters (long barrel)**

Measurement of the Higgs Boson Branching Ratios
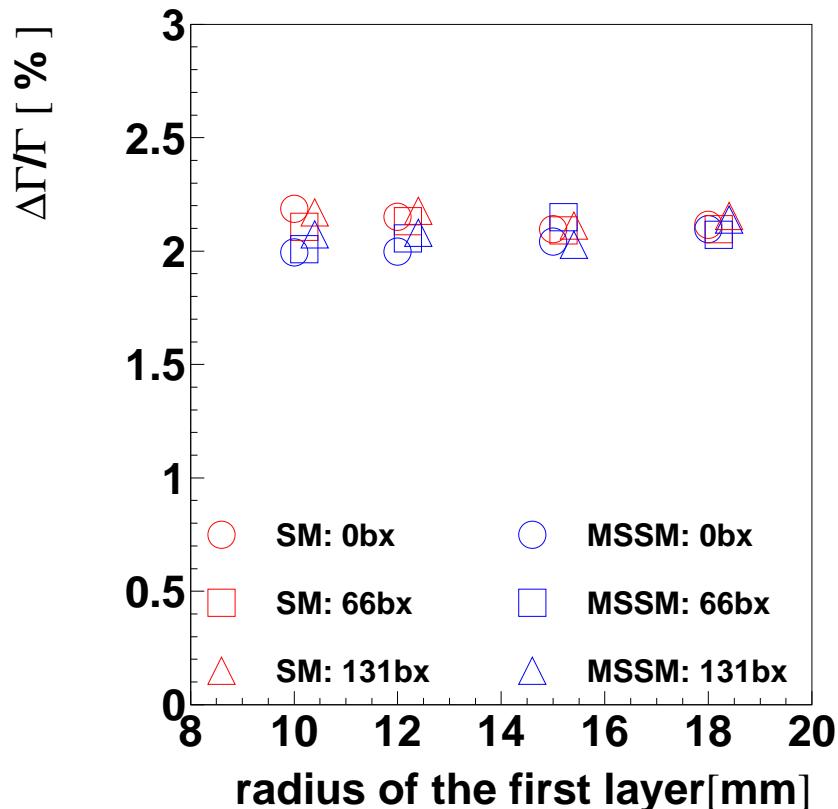
$$H \to b\bar{b}$$

$$H \to c\bar{c}$$

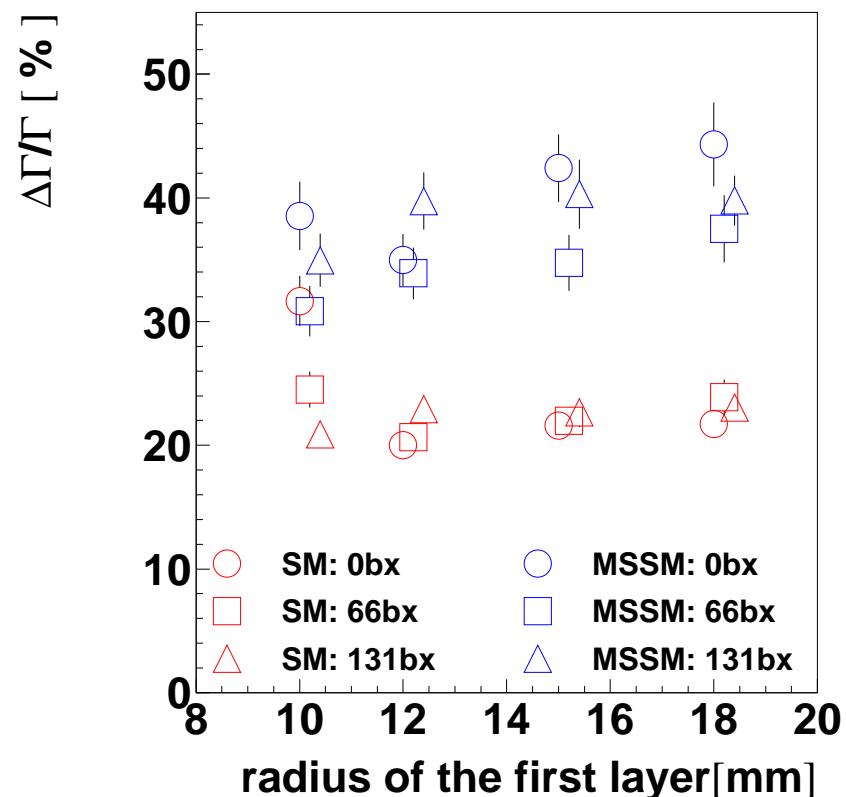**Layer thickness 0.1% X_0, radius of the first layer 15 mm.**

Measurement of the Higgs Boson Branching Ratios

$H \to b\bar{b}$

$H \to c\bar{c}$

Spatial resolution 4 μm, layer thickness 0.1% X_0. R$_1 = 26$ mm - only 4 layers.

Conclusions

- **Spatial resolution better than 4 μm reduces performance of jet flavour tagging due to increased probability of reconstructing fake secondary vertices, especially in presence of e^+e^- background. Retraining of the NN might improve results.**

- **Reduced layer thickness improves jet flavour tagging performance and reduces impact of e^+e^- background on jet flavour tagging.**

- **In presence of e^+e^- background radius of the first layer should not be smaller then 12 mm, otherwise jet flavour tagging performance is reduced.**