FCC ee MDI workshop, CERN
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FCC beam pipe and flavour tagging

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Introduction

Candidate beam pipes

1) 0.5 mm of Be

2) 2 mm of Be + 50 μm of Au

Subjects discussed

- Material budget
- IP resolution
- Effort to extrapolate to flavour tagging performance

Material budget estimation

Particles crossing in 90 deg the thick beam pipe will see

- 1.4% X_0 due to Au
- 0.6% X_0 due to Be

Polar angle θ^0	Material Budget X_0 %	
	Thin BP	Thick BP
85	0.15	2.1
40	0.23	3.2
20	0.42	6.1
10	0.84	11.9

Overall MB of VXD including layers + support & services 1 – 3% X_0

See Gigi's talk but also ILC and CLIC detectors

Impact Parameter resolution

Figure of merit for the design of a VXD

Expressed by parametric equation

$$\sigma_{IP} = a \oplus b/p\sin^{3/2}\theta$$

$$a \leq 5\mu m,\ b \leq 10\mu m\ GeV$$

ILD requires a < 5 μm and b < 10μm GeV

- Parameter a : depends on distance from IP and lever arm
- Parameter b : on material budget and distance from IP

We need something similar for studies like the Higgs couplings

Full simulation studies of IP resolution using single particles for the 2 candidate beam pipes

- CLIC detector model
- ILC software
- Compare the results with the required performance

Parameter b

Expresses the multiple scattering

Approximate expression

$$b = R_{int} \cdot 13.6\ \mathrm{MeV} \cdot z \cdot \sqrt{x/X_0}\ \left[1 + 0.038 \cdot \ln\left(\frac{x}{X_0\ sin\theta}\right)\right]$$

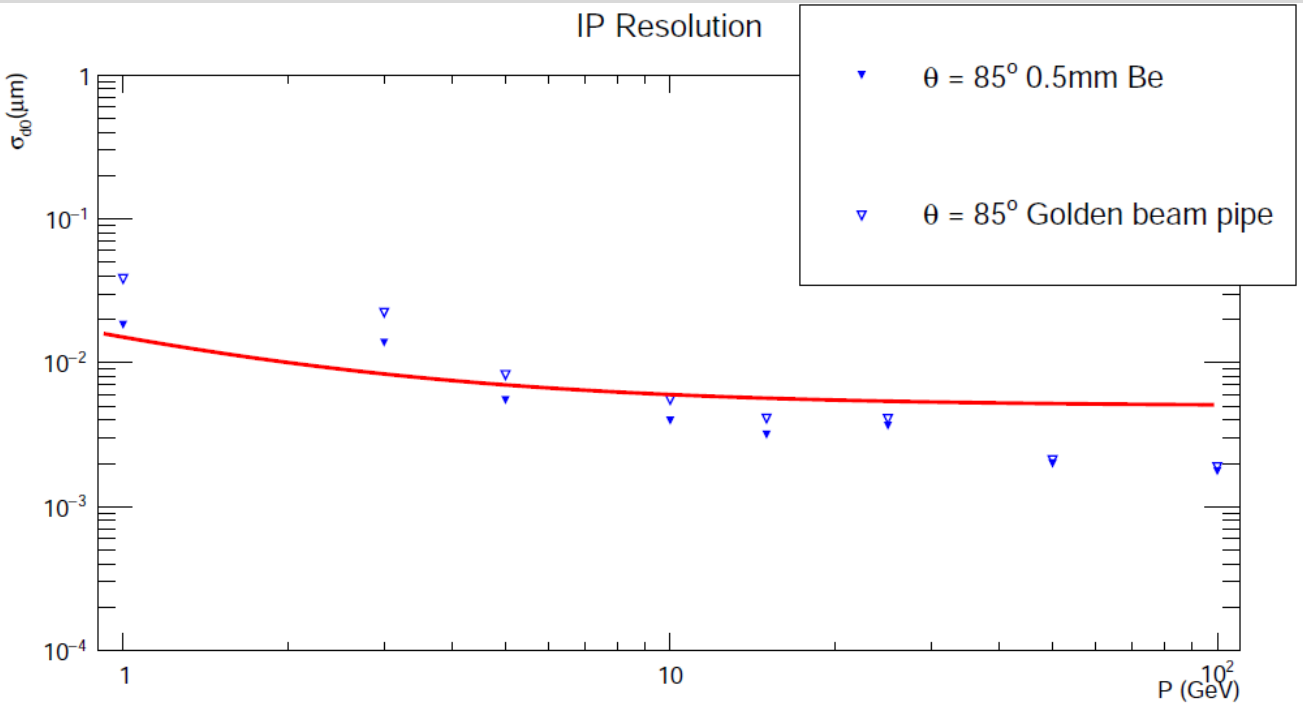
Rint is the distance of the innermost measurement to the IP

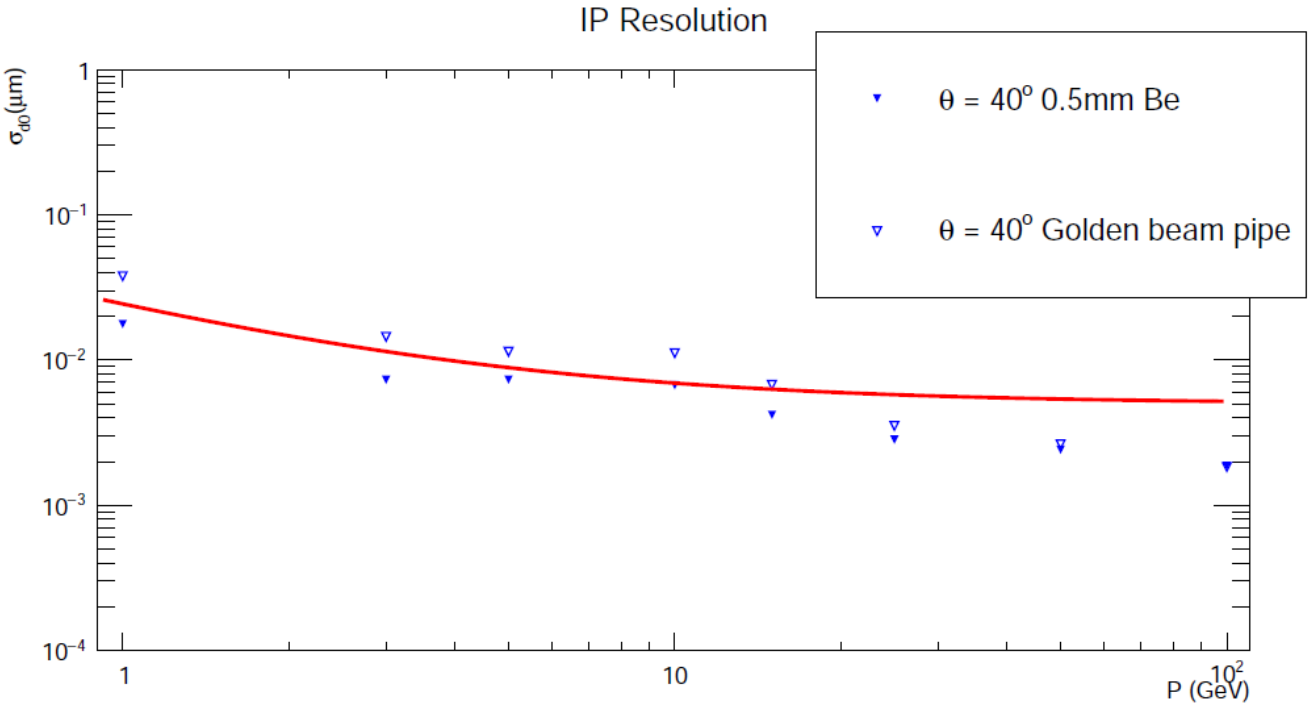
E.g for our 2 candidate beam pipes alone

$B^{thick} / B^{thin} \sim 4$

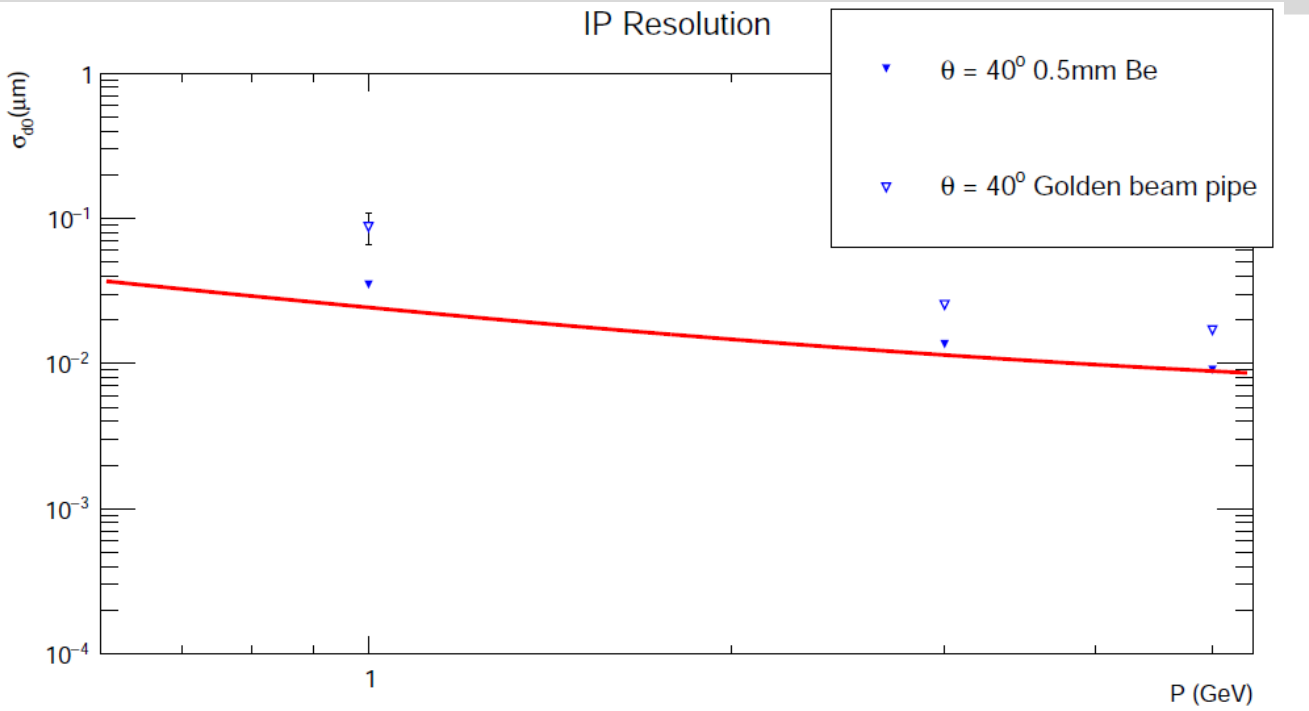
This could be partially compensated by going closer to IP

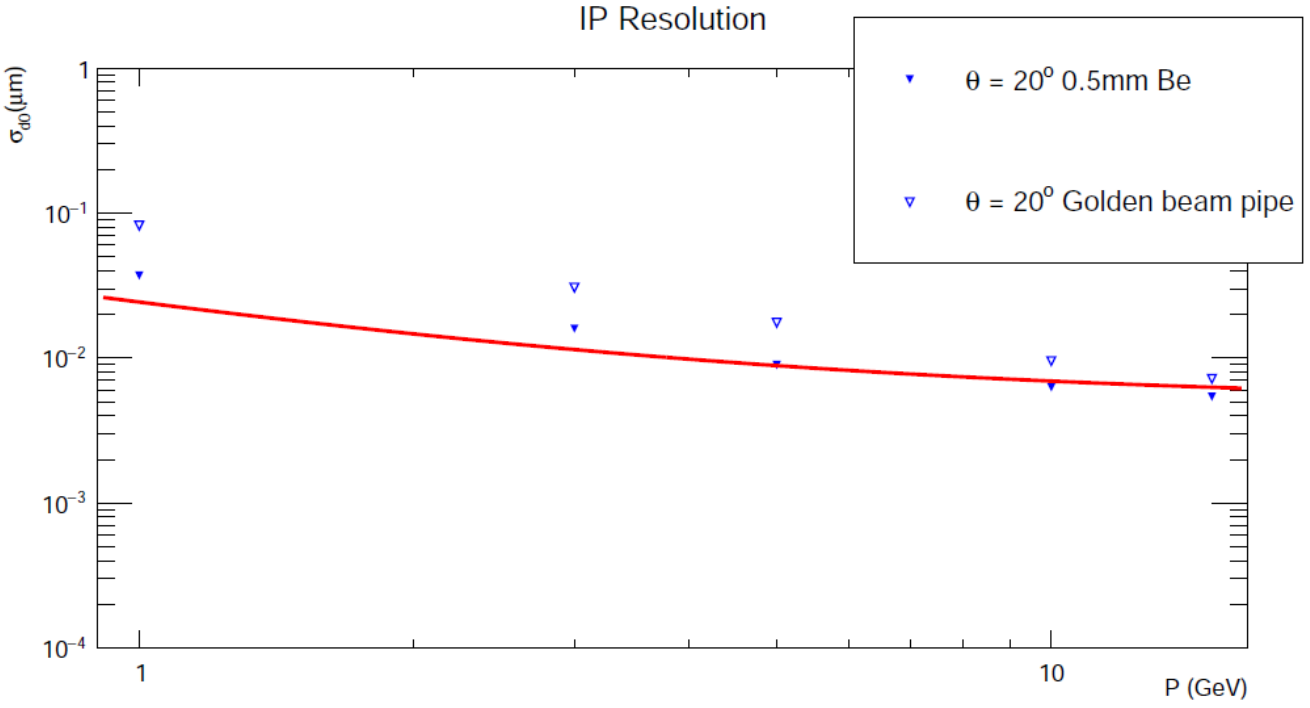
Muons


IP Resolution
θ = 85° 0.5mm Be
θ = 85° Golden beam pipe
σd0 (μm)
1
10⁻¹
10⁻²
10⁻³
10⁻⁴
1
10
10²
P (GeV)


IP Resolution
θ = 40° 0.5mm Be
θ = 40° Golden beam pipe
σd0 (μm)
1
10⁻¹
10⁻²
10⁻³
10⁻⁴
1
10
10²
P (GeV)

Electrons


IP Resolution
θ = 40° 0.5mm Be
θ = 40° Golden beam pipe
σd0(μm)
1
10⁻¹
10⁻²
10⁻³
10⁻⁴
1
P (GeV)


IP Resolution
θ = 20° 0.5mm Be
θ = 20° Golden beam pipe
σd0(μm)
1
10⁻¹
10⁻²
10⁻³
10⁻⁴
1
10
P (GeV)

What's been done in ILD

In ILD the beam pipe consists of 0.5 mm Be

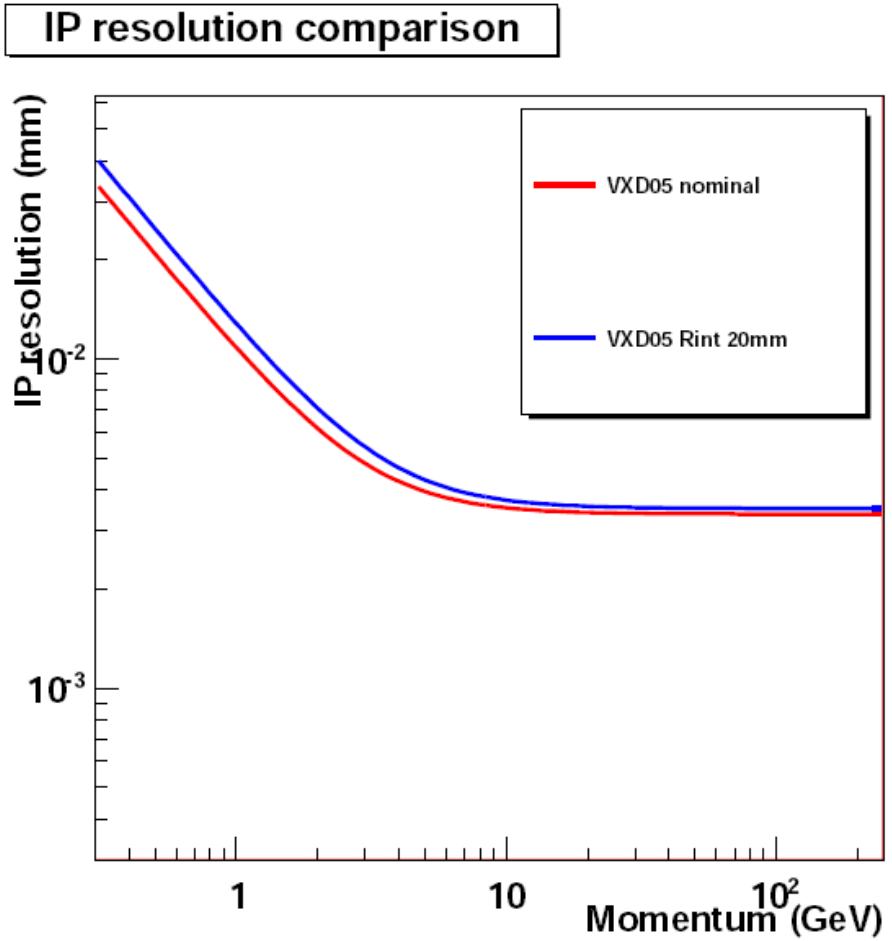
They studied the dependence of flavour tagging perfomance to

- VXD layer thickness
- Distance of innermost layer to the IP

We will try to map the effect on IP resolution after their modifications to the effect on flavour tagging performance

Example : moving innermost layer from 15 mm →20 mm

- Expected to degrade a by ~ 12 % and b ~ 25 %
- Of course, overall IP resolution depends on momentum
- And tracks inside a b(c) jet feature a broad range of momenta…

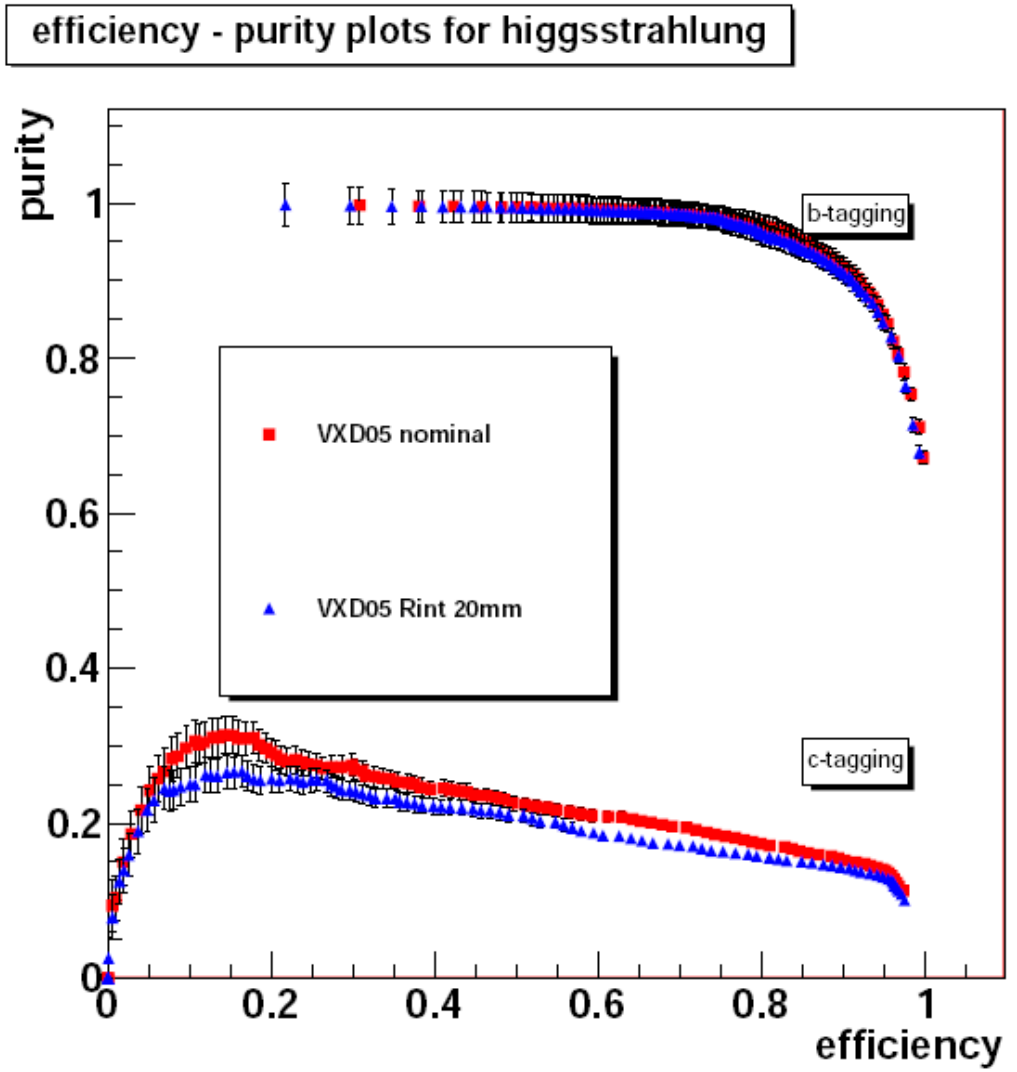


ILD flavour tagging (I)

B – tagging robust vs IP resolution changes

C – tagging is sensitive

- Overall degradation in purity ~15 – 20 %



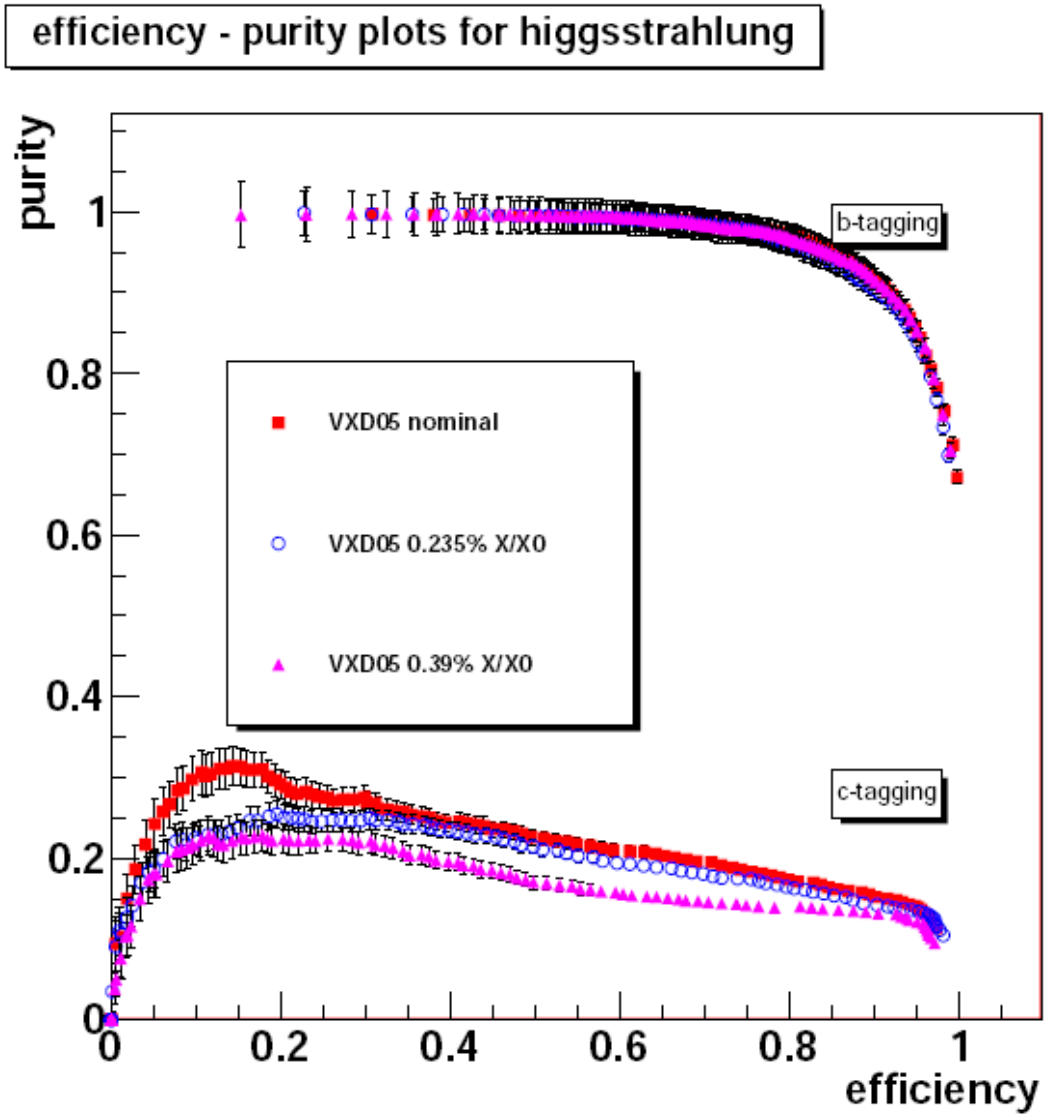
ILD flavour tagging (II)

From ILD

Studying thickness of VXD layers

C – tagging very sensitive

- 30 – 50 % degradation going from 0.16% / layer to 0.39 % / layer



Summary

Beam pipe thickness ~ 2% of radiation length

- Comparable with whole VXD ~ 1 – 3 %

From which 1.4 % comes from 50μm of Au and the remaining 0.6 % from 2mm of Be

Effect on IP resolution can be compansated

- by moving closer the VXD to IP

- Some material lighter than gold is possible?

C - tagging useful probe to evaluate the material budget