Impacts of Inner radius of beampipe

Zhijun Liang and Gang Li

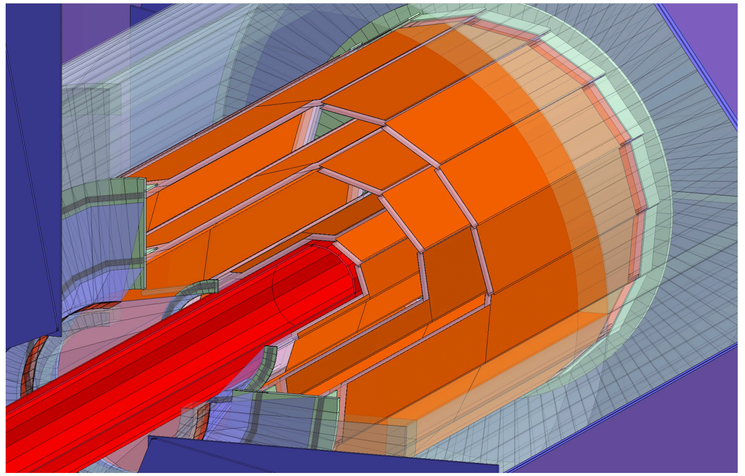
MDI study group meeting

Motivation

- CEPC is a precision machine of Higgs and EW & QCD & flavor physics, sensitive to new physics
- VXD performance essential for lots of physics objects/goals: jets, tau, …
- Performance of VXD depends on several aspects:
  - ✓ Radius of the inner most layer and material in front of it
  - ✓ Single point resolution
  - ✓ Machine/mini jet backgrounds
  - ✓ Power/cooling/support/cables → materials
  - ✓ And sophisticated algorithm

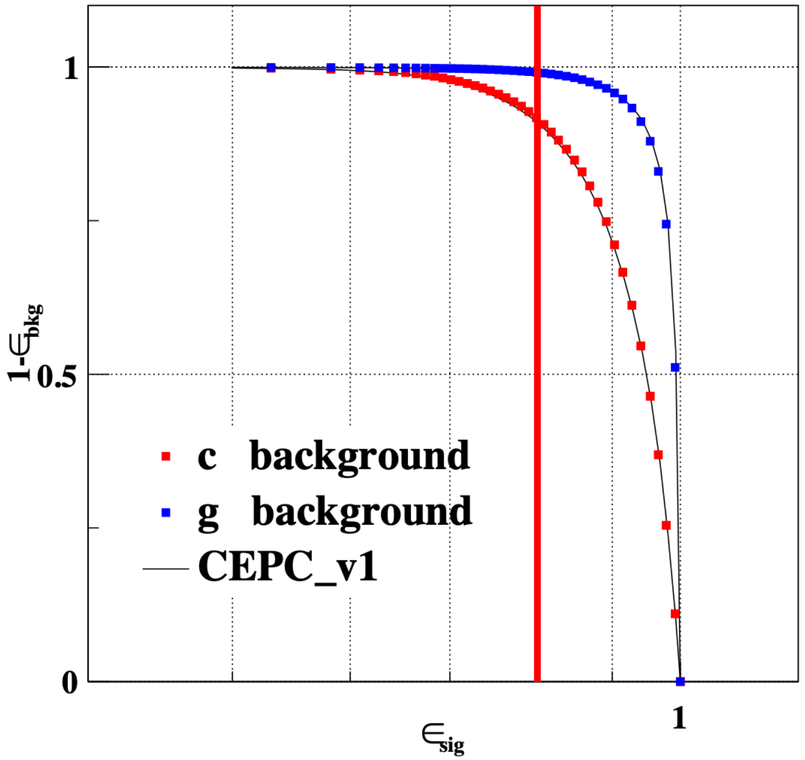
Baseline parameters of the CEPC VXD in CDR

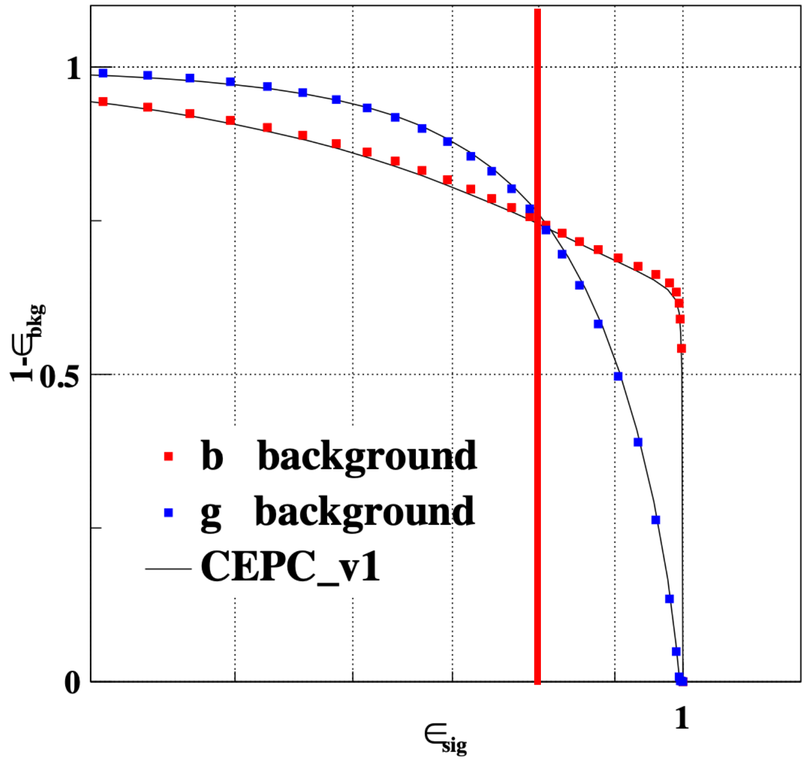
	R(mm)	*Z*(mm)	single-point resolution(μm)	material budget
Layer 1	16	62.5	2.8	0.15%/X_0
Layer 2	18	62.5	6	0.15%/X_0
Layer 3	37	125.0	4	0.15%/X_0
Layer 4	39	125.0	4	0.15%/X_0
Layer 5	58	125.0	4	0.15%/X_0
Layer 6	60	125.0	4	0.15%/X_0



Too ideal in simulation
Rather Challenging: cables, support, cooling, …

b- and c-tagging performances





80% b-tagging eff. : Reject 90% c and 99% o jets

80% c-tagging eff. : Reject 75% b and 75% o jets

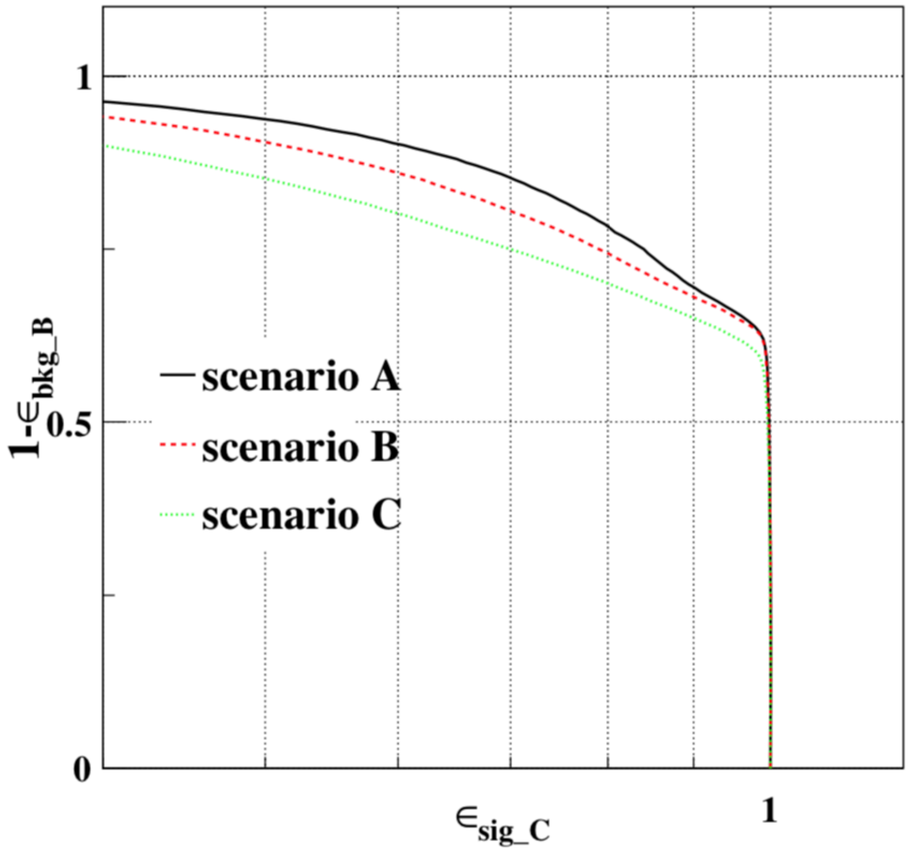
VXD optimization with full simulation and Flavor tagging

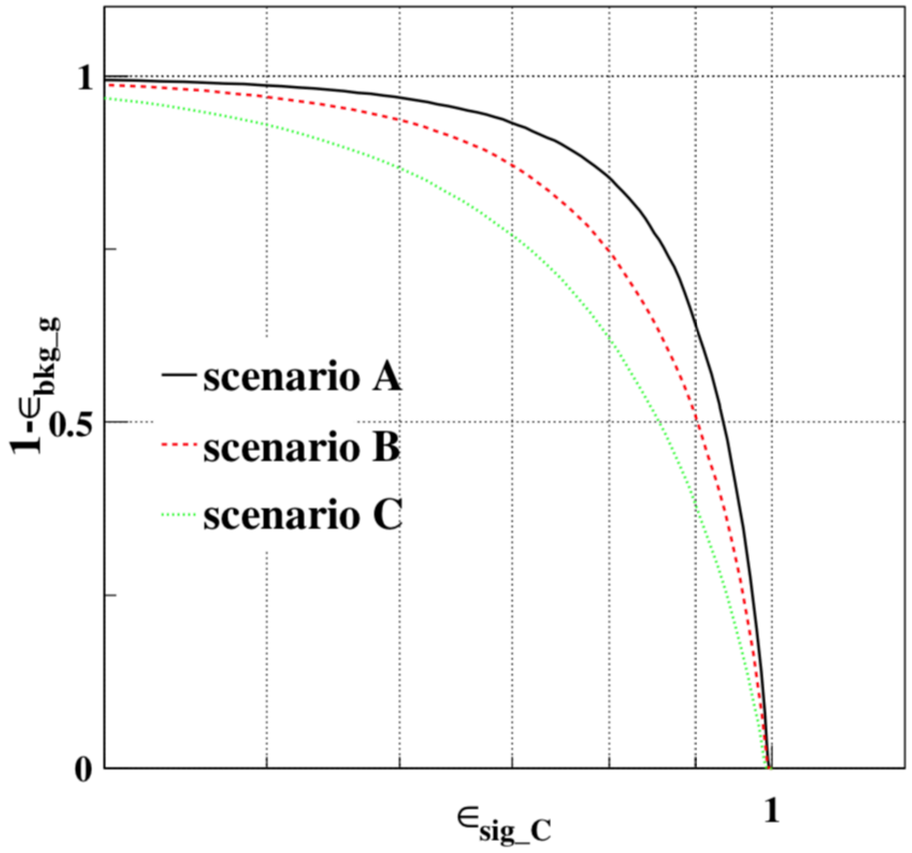
Z. Wu et al 2018 JINST 13 T09002

- ✓ Three key issues of vertex detector investigated
  - ➢ Radius of inner layer
  - ➢ Material budget
  - ➢ Pixel resolution(s)
- ✓ 3 scenarios
- ✓ The relative statistical uncertainties simply parameterized in the study
- ✓ VXD → flavor tagging-> statistical uncertainties of measurements

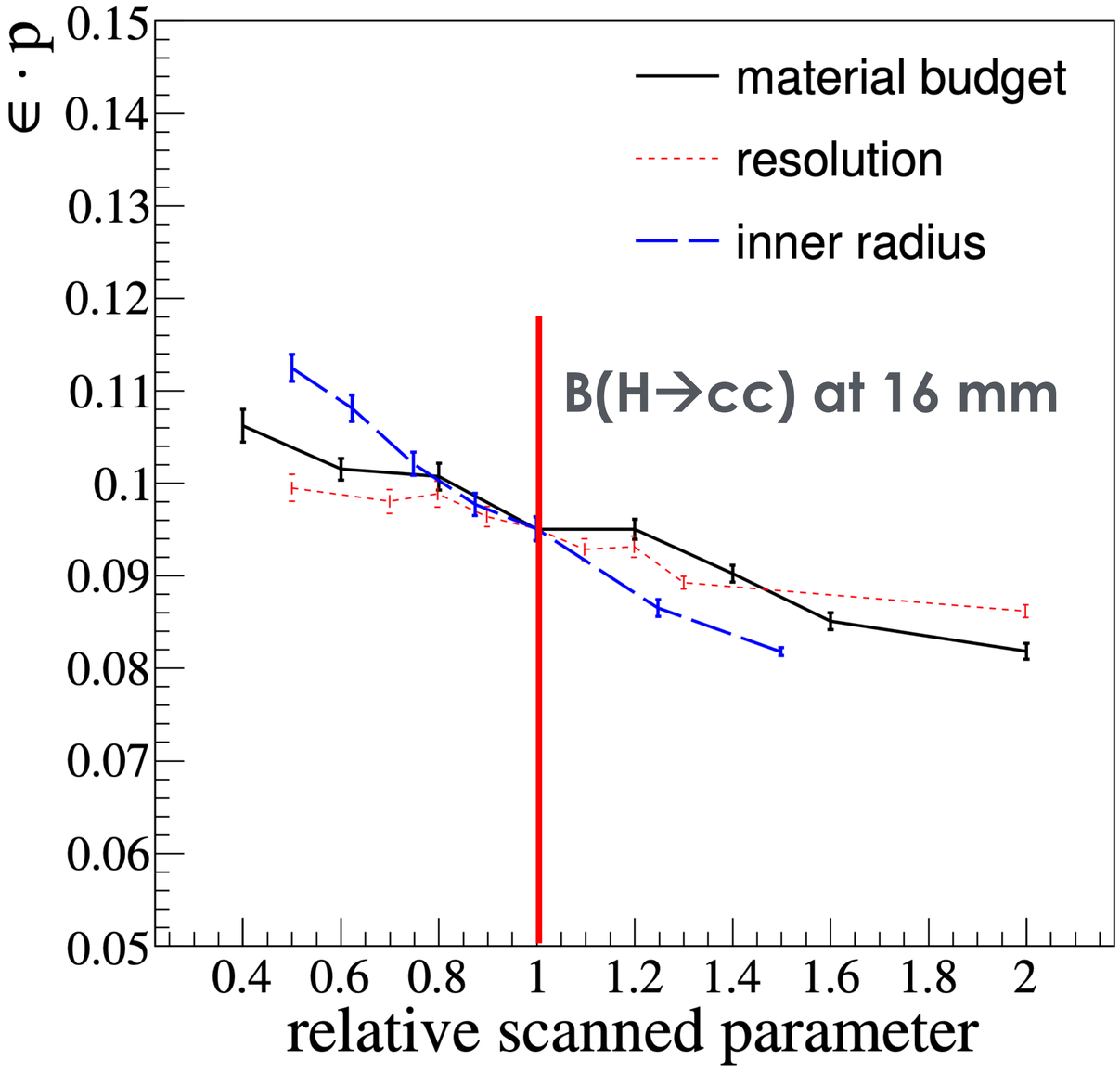
	Scenario A (Aggressive)	Scenario B (Baseline)	Scenario C (Conservative)
Material per layer/X_0	0.075	0.15	0.3
Spatial resolution/μm	1.4 - 3	2.8 - 6	5 - 10.7
R_{in}/mm	8	16	23

C-tagging performances





- The Smallest Beampipe: only 0.5 mm, radius: 6.5-7.0 mm
- 1st layer at 8.0 mm
- 2nd moved accordingly
- 3rd layer and disks unchanged



- H→cc is only ~ 2.7%
- Its statistical uncertainty depends more on detector performance
- In particularly sensitive to the inner radius

$$\frac{\delta_\mu}{\mu} \propto \frac{\sqrt{S+B}}{S} \propto \frac{1}{\sqrt{\epsilon \cdot p}}$$

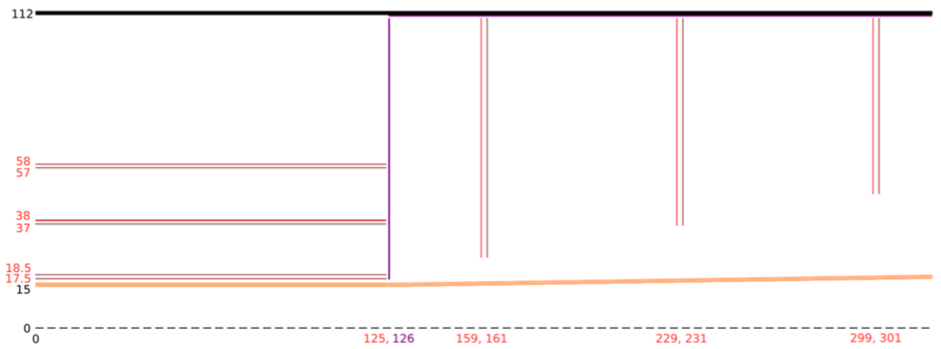
Flavour tagging with smaller beam pipe

FCC-ee

- Alternative FCC-ee interaction region with smaller beam pipe radius
- Innermost barrel layer moved from 17.5 mm to 12.5 mm, outer radius unchanged
- Vertex disks unchanged

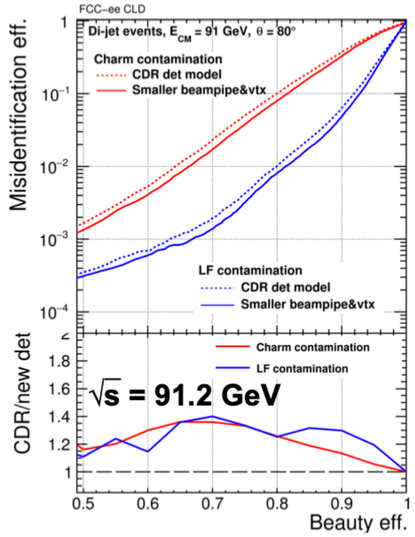
Same study

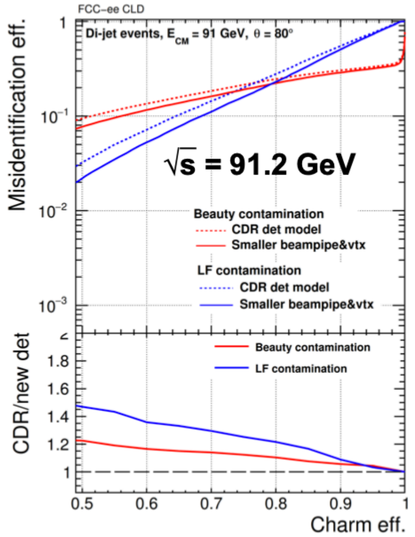
Vertex barrel layer	Radius for the default model [mm]	Radius for the new model [mm]
Layer 1	17.5	12.5
Layer 2	18.5	13.5
Layer 3	37	35
Layer 4	38	36
Layer 5	57	57
Layer 6	58	58

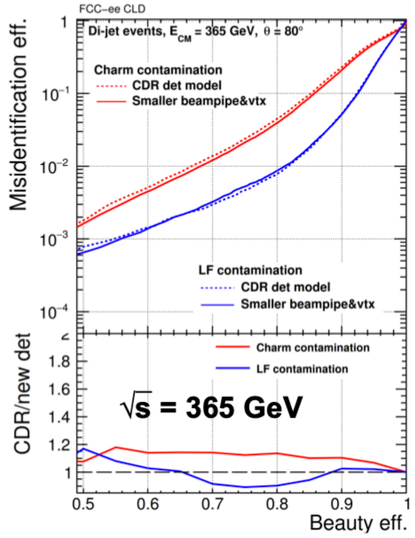


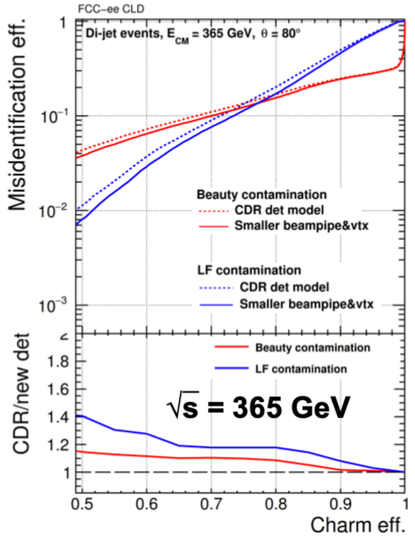
default model

Smaller beam pipe: barrel







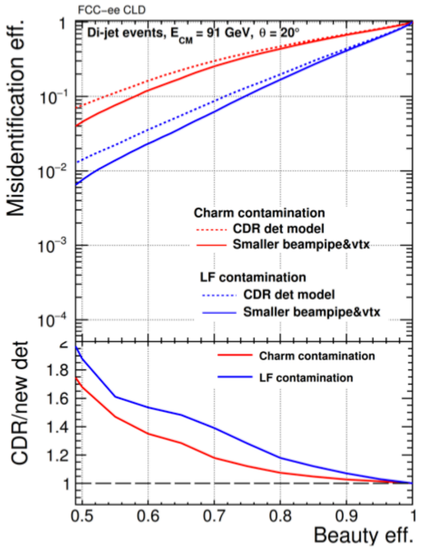


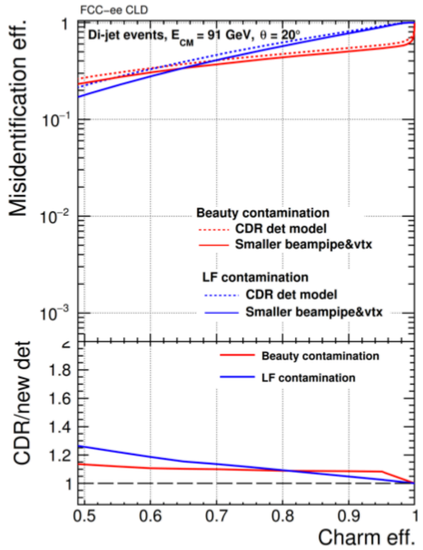
- $e^+e^- \rightarrow q\bar{q}$ events with θ(q) = 80°
- "Truth" tracking

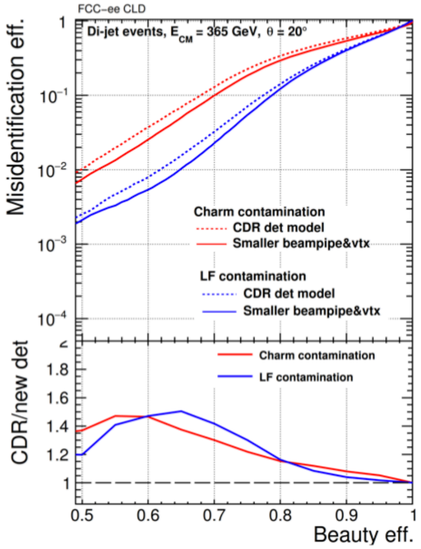
→ Sizeable improvement for charm at both energies and beauty at 91.2 GeV

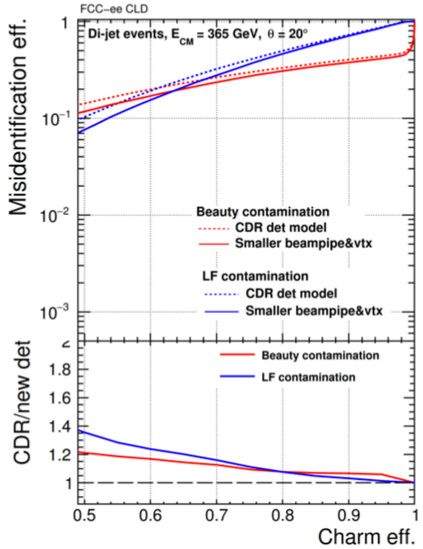
Similar conclusion

Smaller beam pipe: forward









- $e^+e^- \rightarrow q\bar{q}$ events with θ(q) = 20°
- "Truth" tracking

→ Larger impact compared to the barrel region

End cap more significant

Summary

- Inner radius of beampipe and some other aspects of VXD studied with full simulation
- Sizable effect on c-tagging, therefore on H→cc study
- Generally speaking, a smaller beampipe is favored by H→cc, if technical problems could be solved
- More careful study needed
  - ✓ Realistic beampipe/detector design: more materials
  - ✓ Backgrounds: smarter tracking algorithms
  - ✓ Well understood tracking and vertexing software