Choice of L* : requirements from detector

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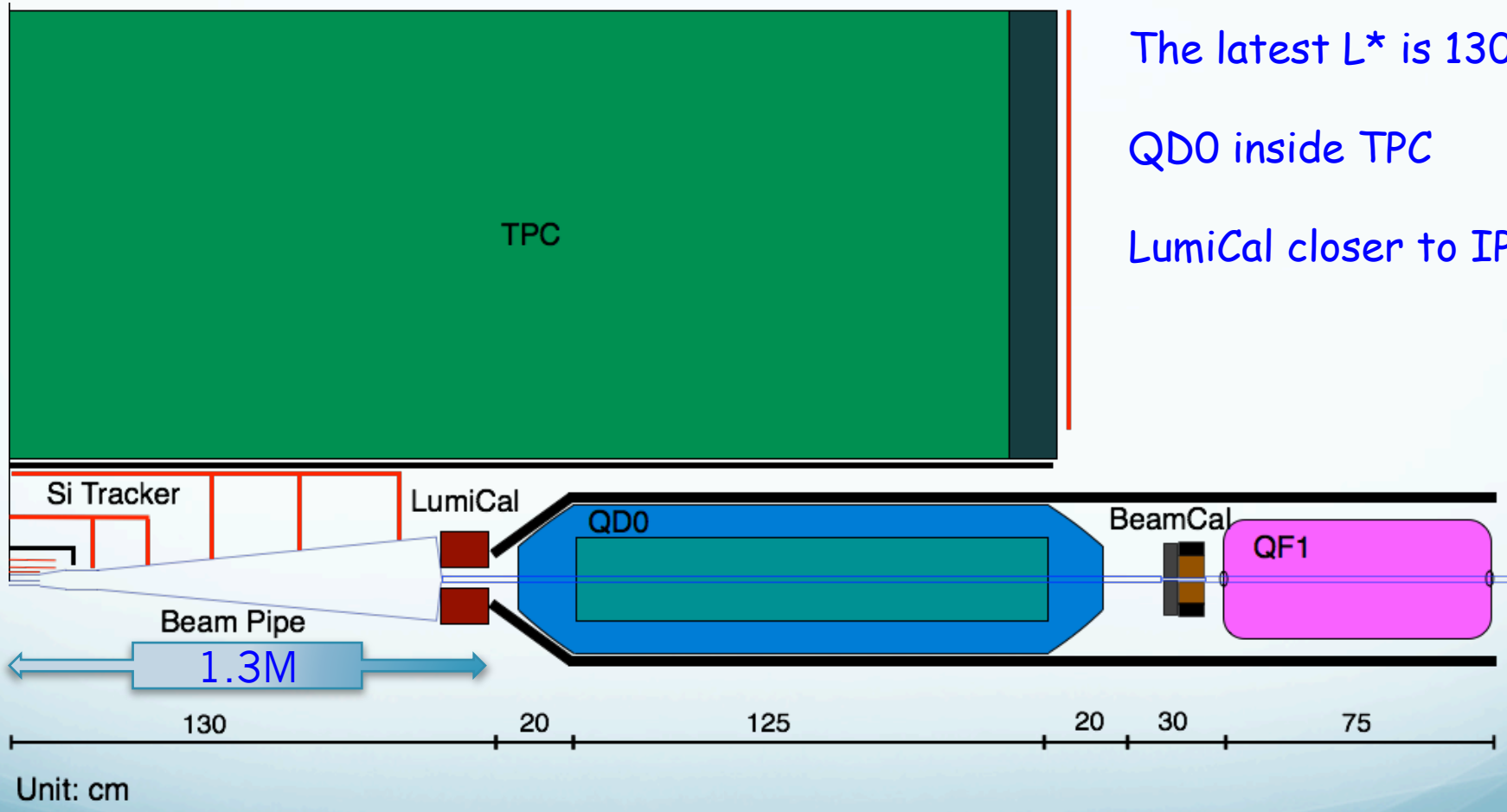
Outline

- Introduction
- Tracker performance/Flavortag
- Luminosity
- Backgrounds(see Hongbo's talk)
- Summary and discussion

Machine-Detector interface

- Luminosity is one of the key parameters of Higgs factories, which requires smaller L* and leads essential complications and more backgrounds at IR
- These complications and backgrounds challenge both the machine and detector designs, such as shielding, detector performance, support, cooling …

Overlay of baseline design



The latest L* is 130cm

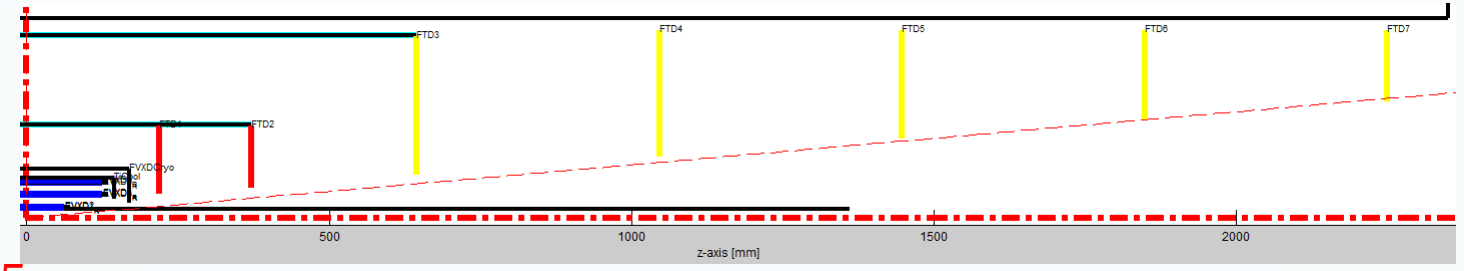
QD0 inside TPC

LumiCal closer to IP

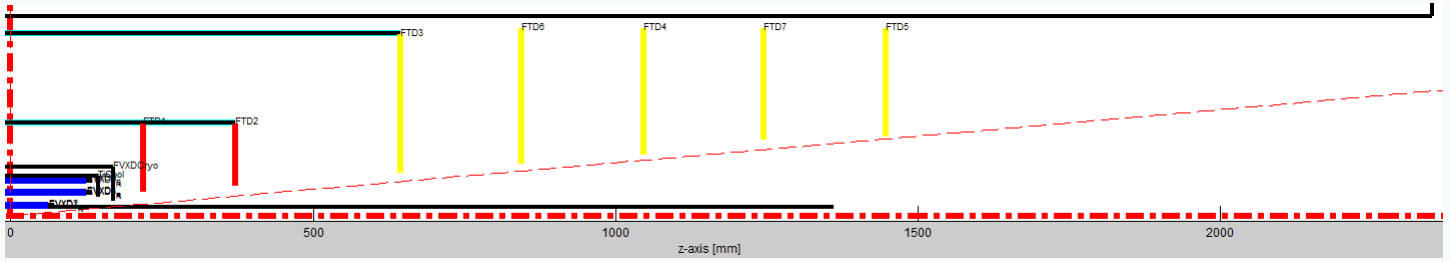
Performance of tracker

ILC

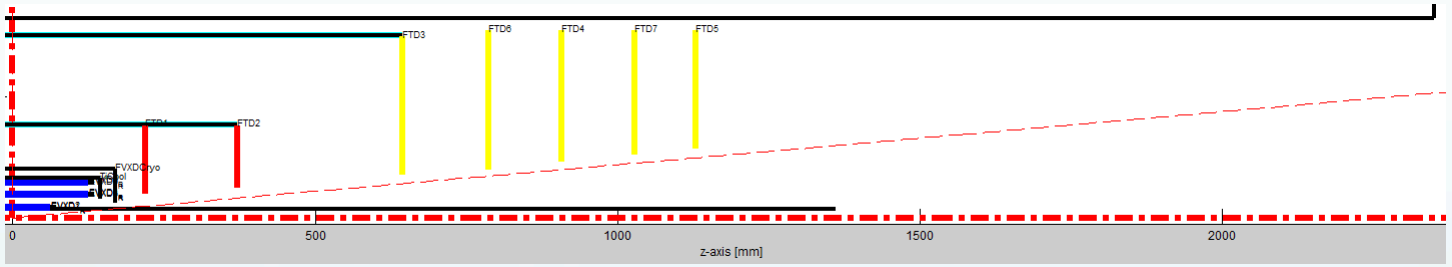
VTX/FTD



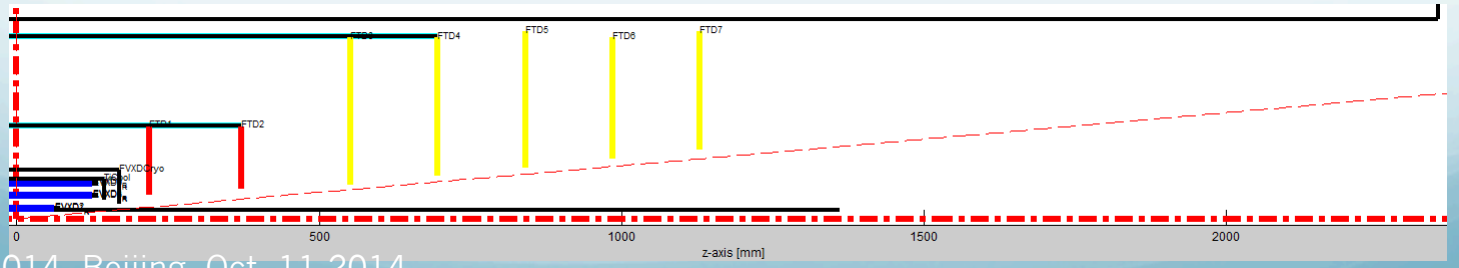
L*=1.5m

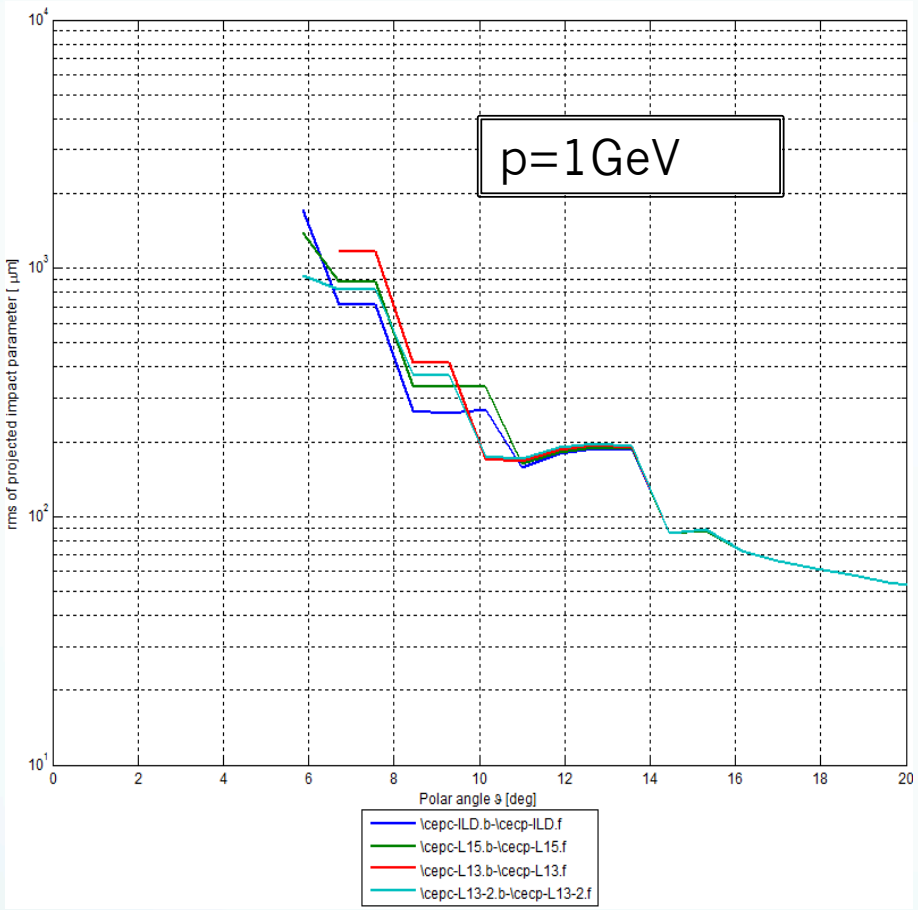


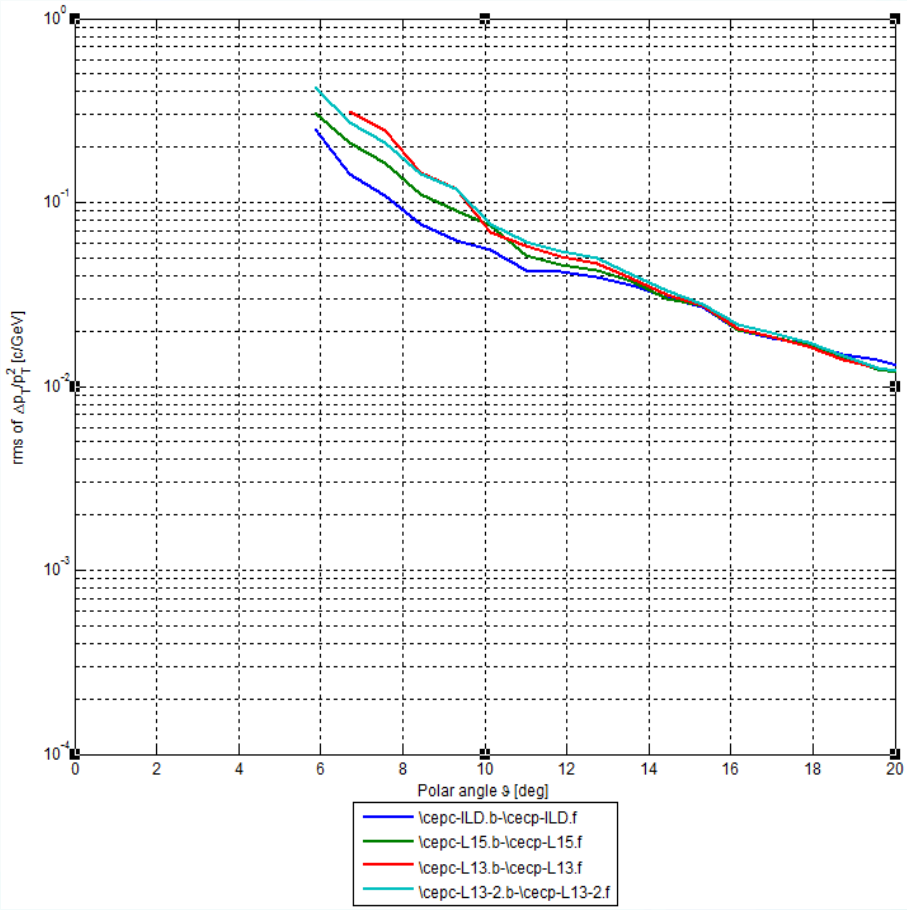
L*=1.3m



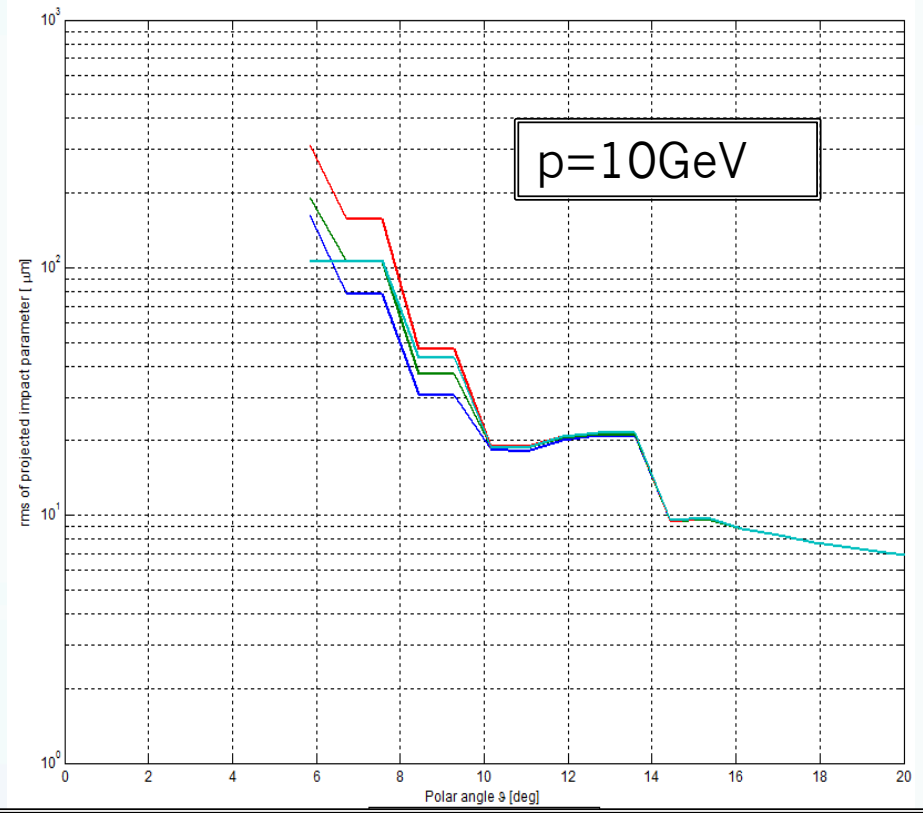
L*=1.3m, Reduced distance of FTD3 to IP

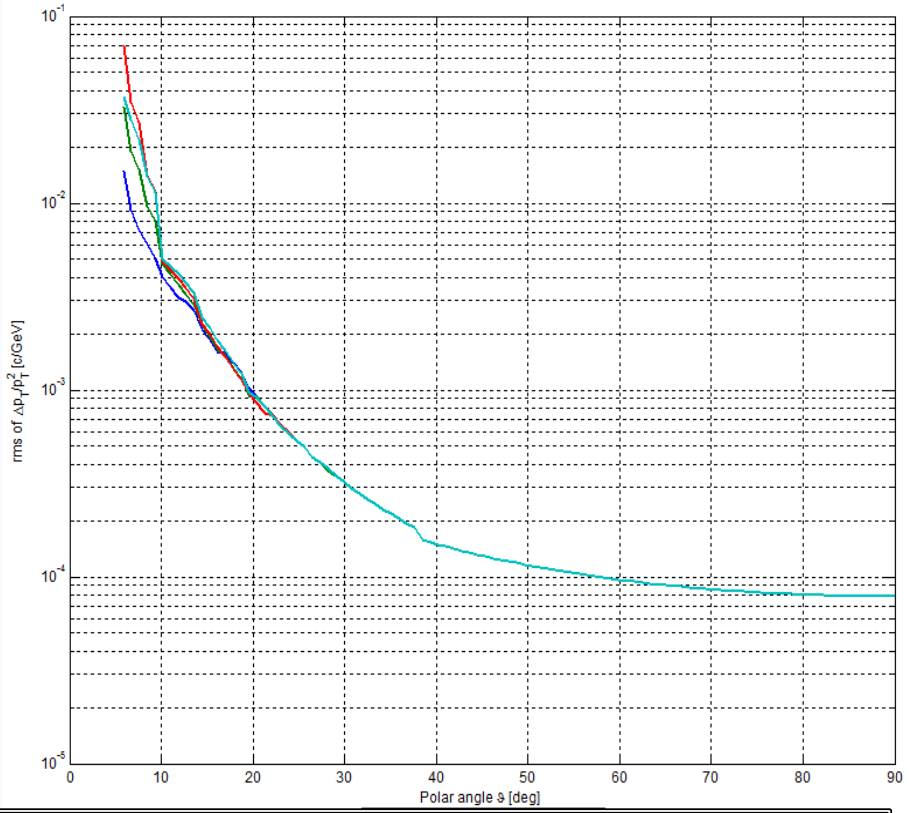






1, ILC
2, L*=1.5
3, L*=1.3
4, L*=1.3, reduced distance of FTD 3 to IP

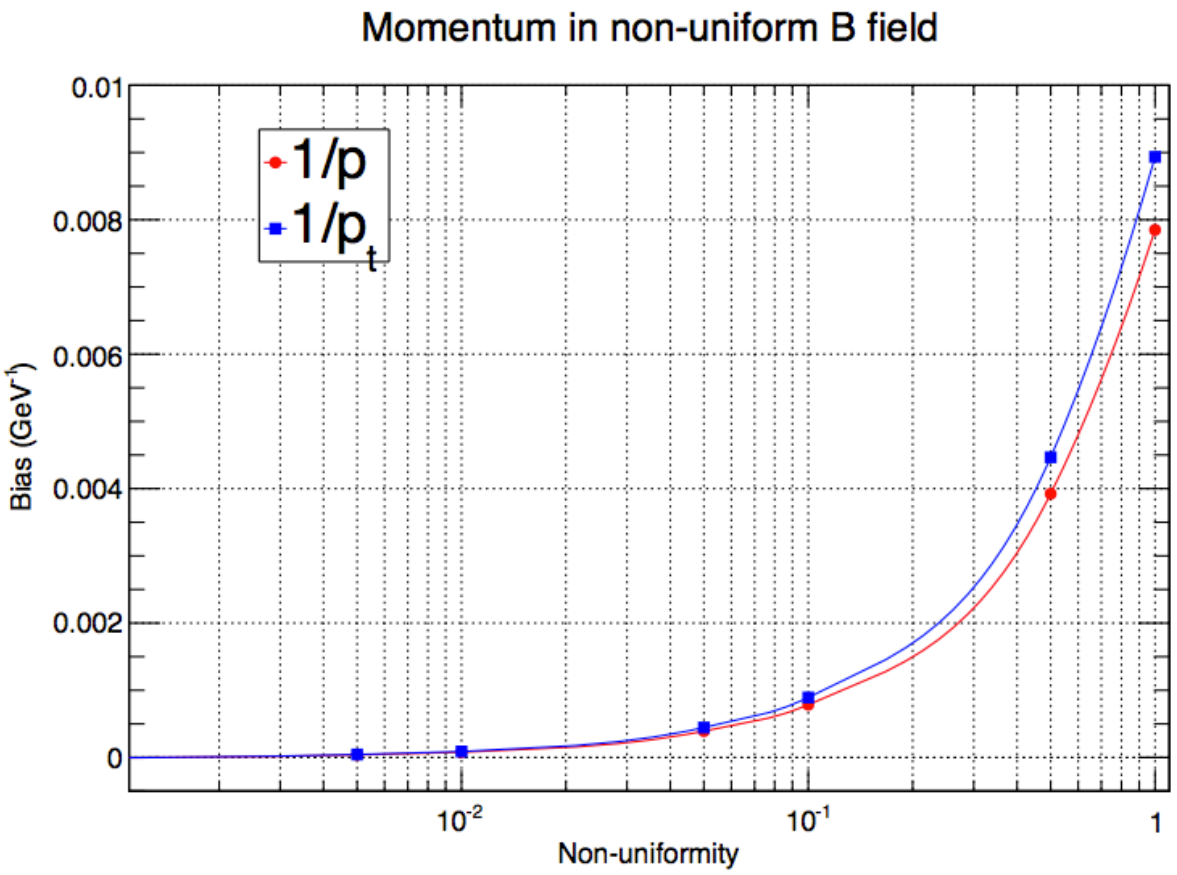




1, ILC
2, L*=1.5
3, L*=1.3
4, L*=1.3, reduced distance of FTD 3 to IP

The smaller L* leads worse momentum/position resolutions
But they will be partially compensated by optimizing the VTX/FTD.
Of course background/material budge should be taken into account.

Distorted the detector magnetic field
the non-uniform field → bias of track momentum



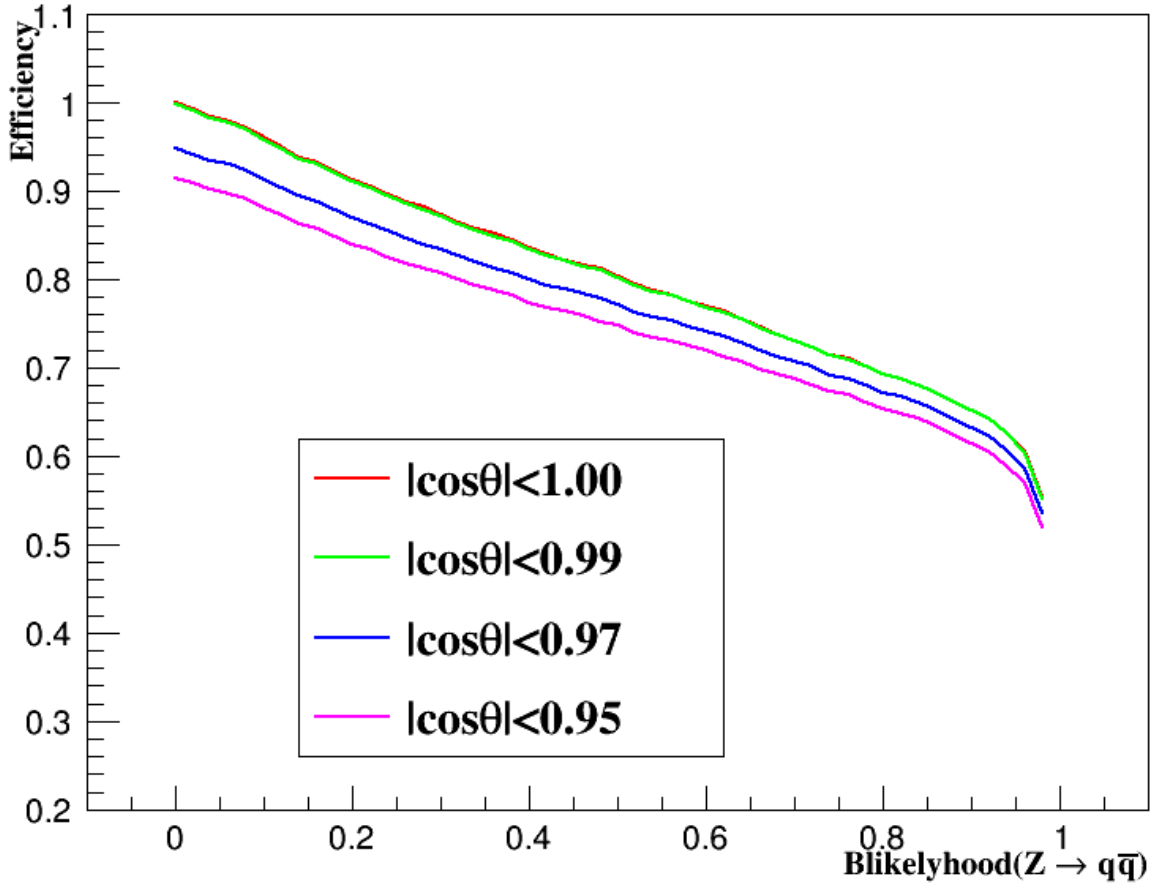
TPC simulation shows
10% non-uniform→0.1% bias

Exact map of the magnetic field can be used to remove the bias

How to get the map in the limited space, Measurement + calculation?

Performance of jet flavor tag

If we have to decrease the coverage of detector, 5-10% flavor tag efficiency is lost, the jet resolution also gets worse by ~5%



Luminosity determination

Key requirements of a precise Luminosity measurement

- Good understanding on **theory** side
- Excellent knowledge of **geometry**
- Very high and well-known **trigger** efficiency
- Low and well-understood **backgrounds**

Examples

- L3 (working at Z pole, 91 GeV)
- ILC (500 GeV)

L3-lum precision

- Uncertainties:
  - Experimental: 0.08% (1993), 0.05% (1994)
  - Limited MC statistics: 0.06%
  - Theoretical cross section: 0.11%
  - Final: 0.15% (1993), 0.14% (1994)
- Specific detector:
  - Luminosity monitor (BGO calorimeter)
  - 3-layer silicon tracker

L3-precision (cont.)

- Design: 1%
- BGO only: 0.6%
- Requirement: 0.1%
- BGO + silicon tracker: <0.1%

L3-BGO

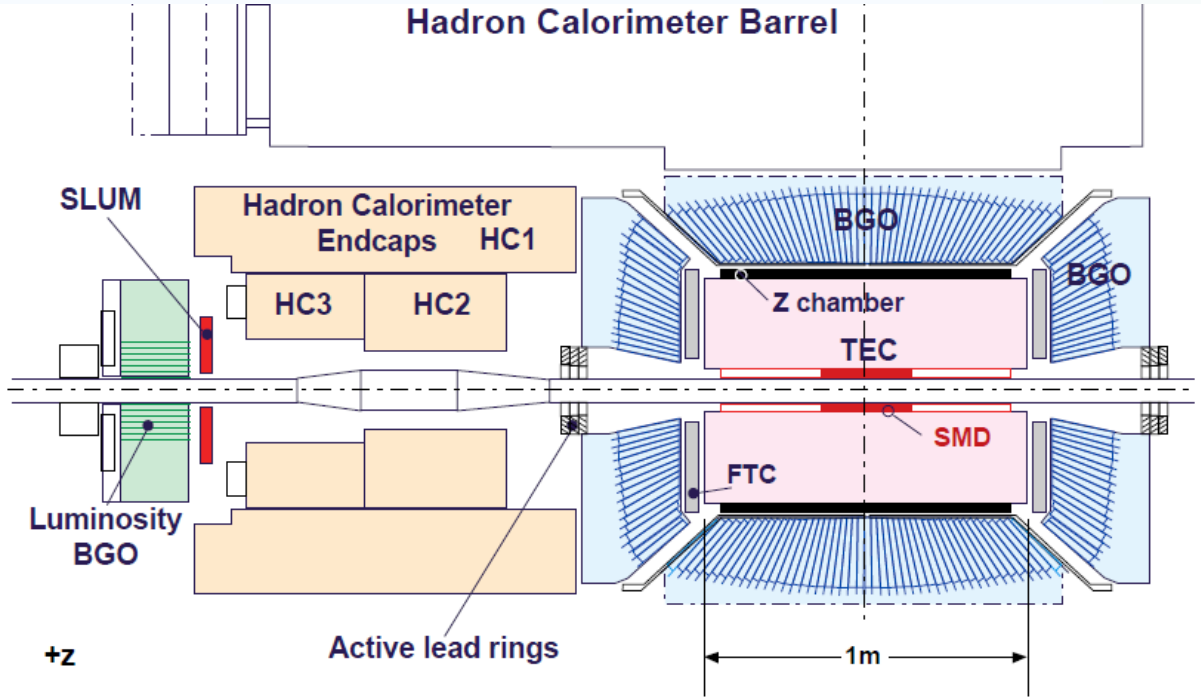


Figure 1: Side-view of the central region of the L3 experiment on the $+z$ side, showing the beam pipe and the position of the luminosity BGO calorimeter and the silicon tracker (SLUM).

L3-BGO-geometry

Distance of the front from the I.P.	2730 mm
Minimum radius	68 mm
Maximum radius	192 mm
Crystal length	260 mm
Crystal length in radiation lengths	24
Number of crystals per sector	19
Angular coverage of a sector	22.4°
Number of sectors per side	16

- Geometry precision: 1~2 μm
- Position precision: 6 μm
- Protection:
  - separate during filling ring
  - 8cm thick lead shield

L3-silicon tracker

Distance of central layer from the I.P.	2650 mm
Minimum radius	76 mm
Maximum radius	154 mm
Wafer size in ϕ	24°
r wafer small strips	64×0.500 mm
r wafer large strips	16×1.875 mm
r wafer medium strips	16×1.000 mm
SiO_2 insulation between strips	0.1 mm
φ wafer strip size	0.375°
Layer spacing	40 mm

L3-lum-generator

- BHLUMI 2.01 (4.03)
- $0.020<\theta<0.200$ rad (polar angle)

L3-lum alignment

- Use Bhabha events (and optical instruments?)
- Detector positions:
  - The total distance between the **-z and +z silicon** detectors using survey measurements (0.4mm).
  - The position of the **BGO** modules in the **silicon** reference frame.
  - The **transverse** position of the **silicon** with respect to the beam axis (2μm).
  - The **longitudinal** position of the **silicon** with respect to the vertex (0.3mm).

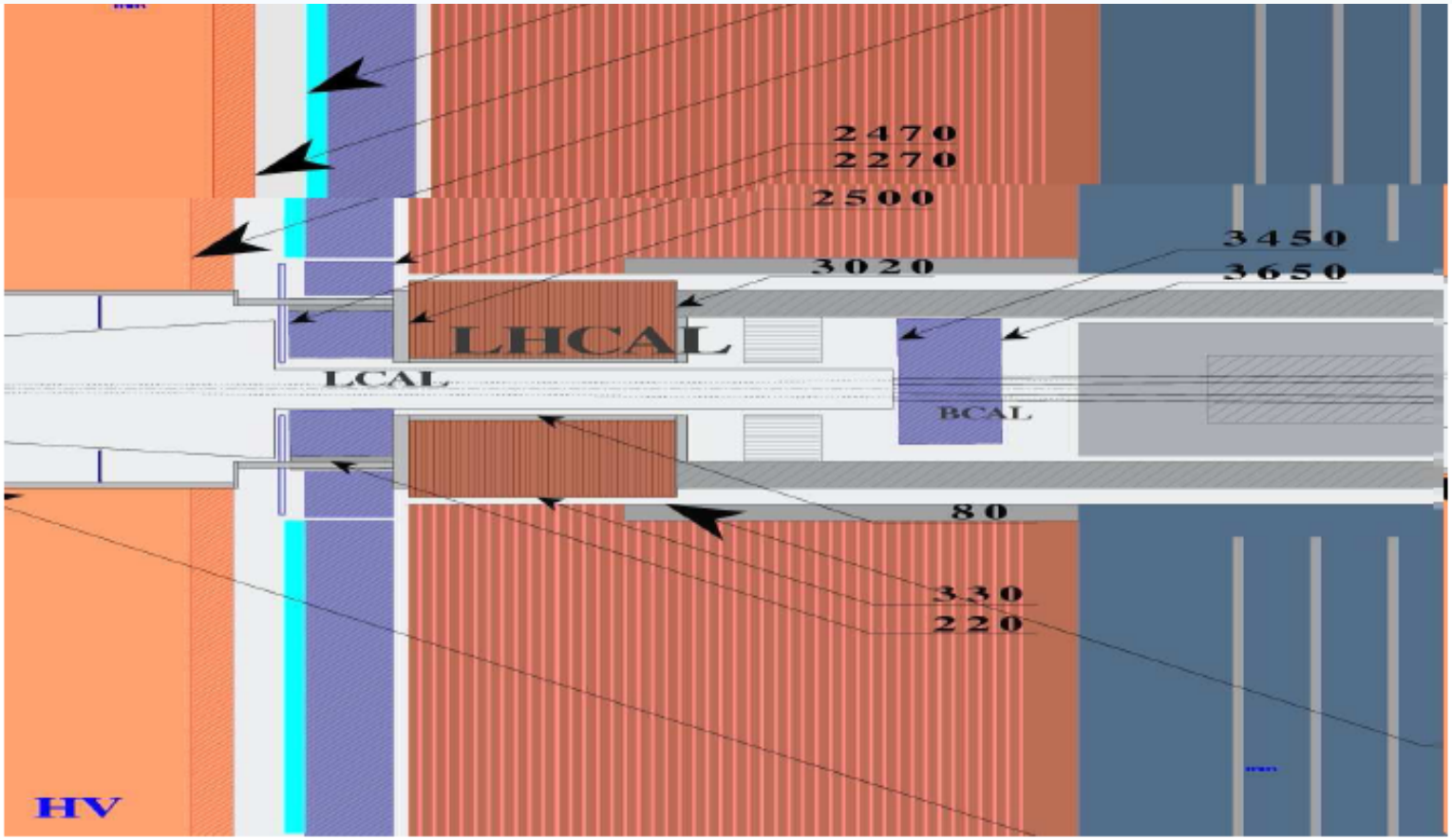
L3-lum measurement

- BGO: high eff trigger, clean backgrounds
- Silicon: precisely defined fiducial volume

ILC-lum review

- Precision: 0.01% goal
- Specific detectors:
  - luminosity detector (**LumiCal**) for precise measurement of the Bhabha event rate;
  - the beam calorimeter (**BeamCal**) and the beamstrahlung photons monitor (**GamCal**): fast feed-back
- Reference: arxiv.org/1010.5992

ILC-LumCal



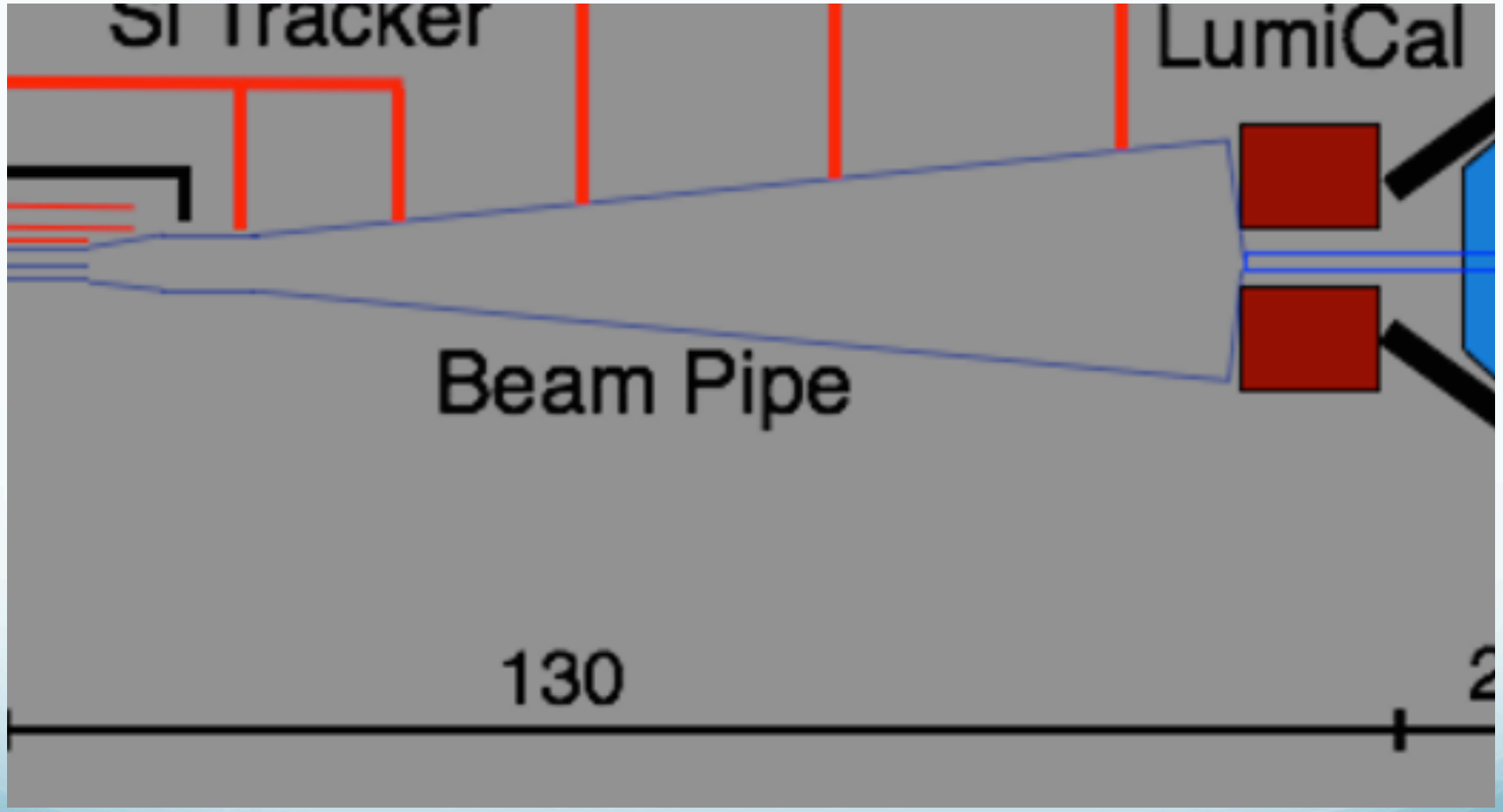
ILC-LumCal geometry

Parameter	Value
Distance from the IP	2270 mm
Number of Radial divisions	64 (0.75 mrad pitch)
Number of Azimuthal divisions	48 (131 rad pitch)
Number of Layers	30
Tungsten thickness	3.5 mm
Silicon thickness	0.3 mm
Support thickness	0.6 mm
Layer gap	0.1 mm
Inner radius	80 mm
Outer radius	190 mm

Table 5.1: Baseline properties of LumiCal.

- Polar coverage: 35 to 153 mrad

CEPC: LumiCal to IP: only ~115cm



Goal and challenges

- 0.1% precision is achievable, a specific luminosity detector is necessary.
- Key requirements :
  - Good understanding on **theory** side (0.05%, can be improved)
  - Excellent knowledge of **geometry** (L: mm; T: μm -> 0.05% with a closer LumCal, we must have a precise monitor of IP position)
  - Very high and well-known **trigger** efficiency (?)
  - Small and well-understood **backgrounds** (under control, 0.05%)
- Event selection (0.05%), others (0.05%)
- 0.1% is enough?

Summary and discussion

- CEPC adopts smaller L* design as baseline
- This really challenges both accelerator and detector designs.
- The backgrounds seem under control (Hongbo's talk).
- The momentum resolution can be improved by optimizing the VXD/FTD and by an exact magnetic field map.
- The jet flavor tag efficiency loses some efficiency and jet resolution becomes a bit worse if coverage becomes smaller, but the statistics will compensate.
- Luminosity measurement is really a big challenge, still needs more study.
- More should be considered: Calorimeter, support of QD0, cooling, …

Extras

重要的事情不在于FTD34567
而在于得到240GeV CEPC的下图（500GeV ILC）
确定FTD1和VXD1的位置 （与d0分辨大致线性相关）
目前束流管没有变，FTD1， VXD1也没有变。

Detector element	Hit density (hits/mm^2/BX)
VXD1	3.2×10^{-2}
VXD6	2.4×10^{-4}
SIT2	4.0×10^{-5}
FTD1	10^{-3} - 10^{-5}
FTD7	1.0×10^{-5}