# TRACKER RESOLUTION AND RECOIL MASS IN ZH @ 250GEV

Fabrice Couderc

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JLC @ LPSC, Grenoble

# INTRODUCTION

- Context:
  - CEA/Irfu LC-TPC team (LC = Leptonic Collider!)
    - synergy ILC/FCC…
  - What if the TPC resolution is worsened "for instance" due to a large ion charge in a continuous machine?
  - Try to understand the impact on the physics
  - Only back of the enveloppe calculations

Warning ⇒ this is no real stuff…

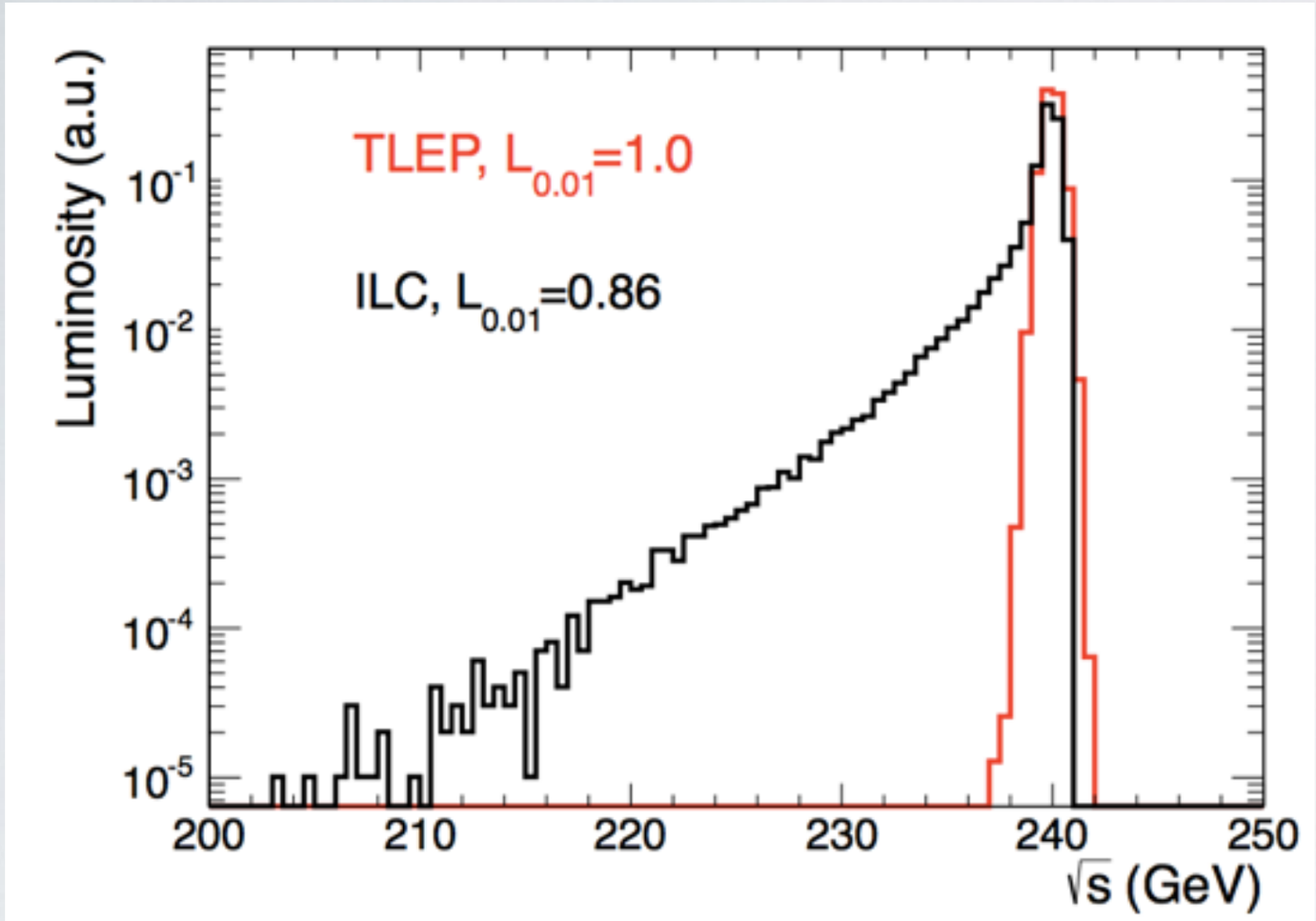
# RECOIL MASS RESOLUTION

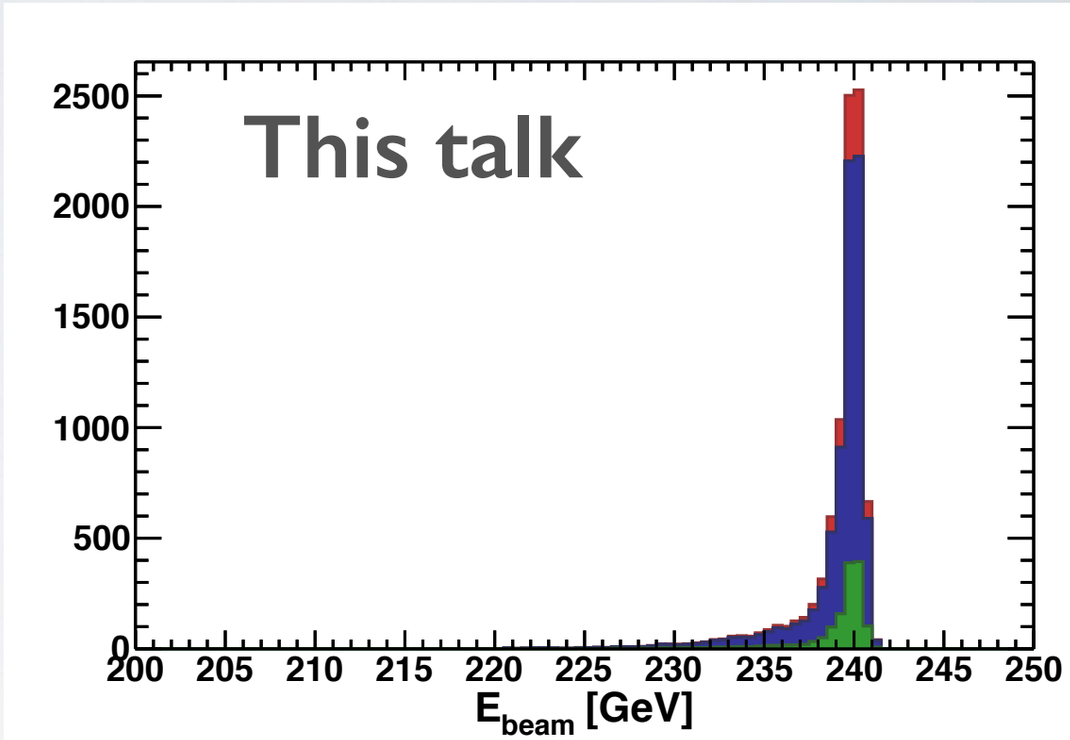
- Recoil mass resolution against $Z\mu\mu$ as a benchmark for the tracker resolution

- At ILC: $\sigma(1/pT) = 2\ 10^{-5}$ / GeV @ 50GeV so the tracker resolution negligible vs beam energy spread

- Here just generate events with Pythia and smear them with flat resolution and beam energy spread, no ILD simulation

# BEAM ENERGY SPREAD




Curves used to smear the center of mass energy
gaussian core: 32 MeV

# FAST SIMULATION

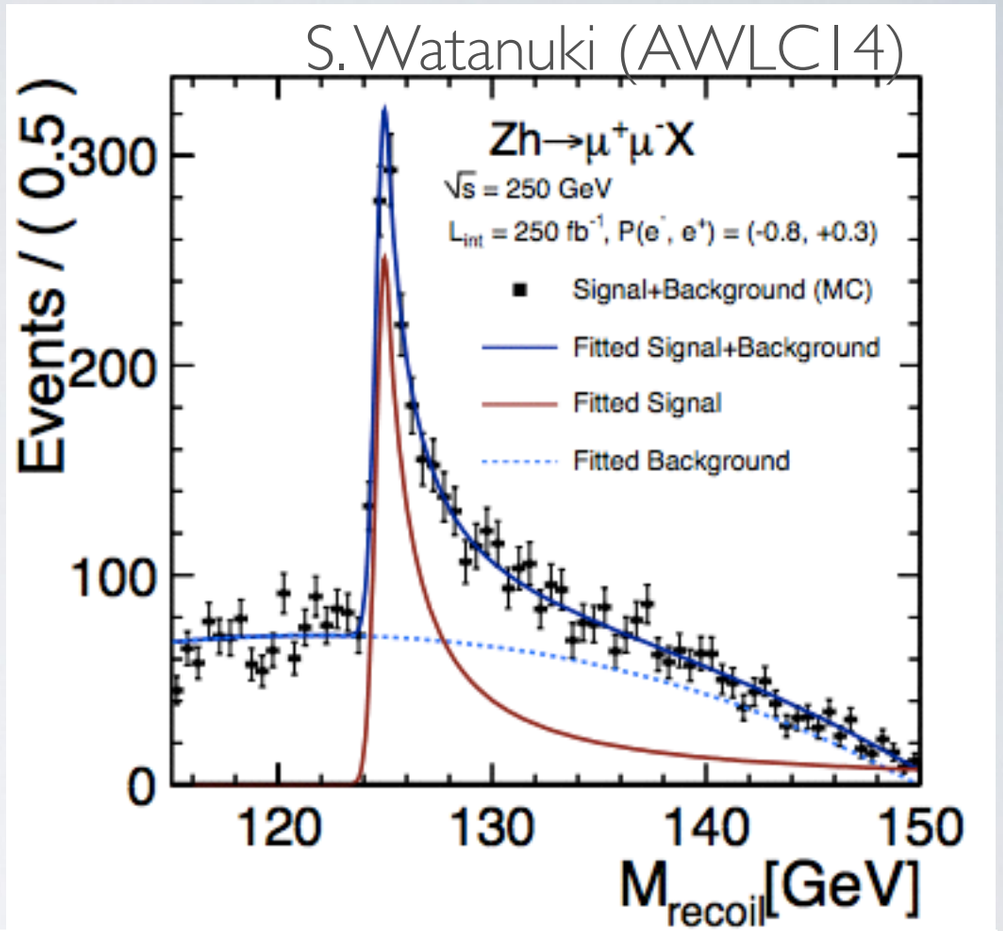
- $E_{CM}$ = 240 GeV
- No polarisation (NB $\sigma_{ZH}$[pol.] = 1.5 x $\sigma_{ZH}$[unpol.])
- Pythia8 simulation:

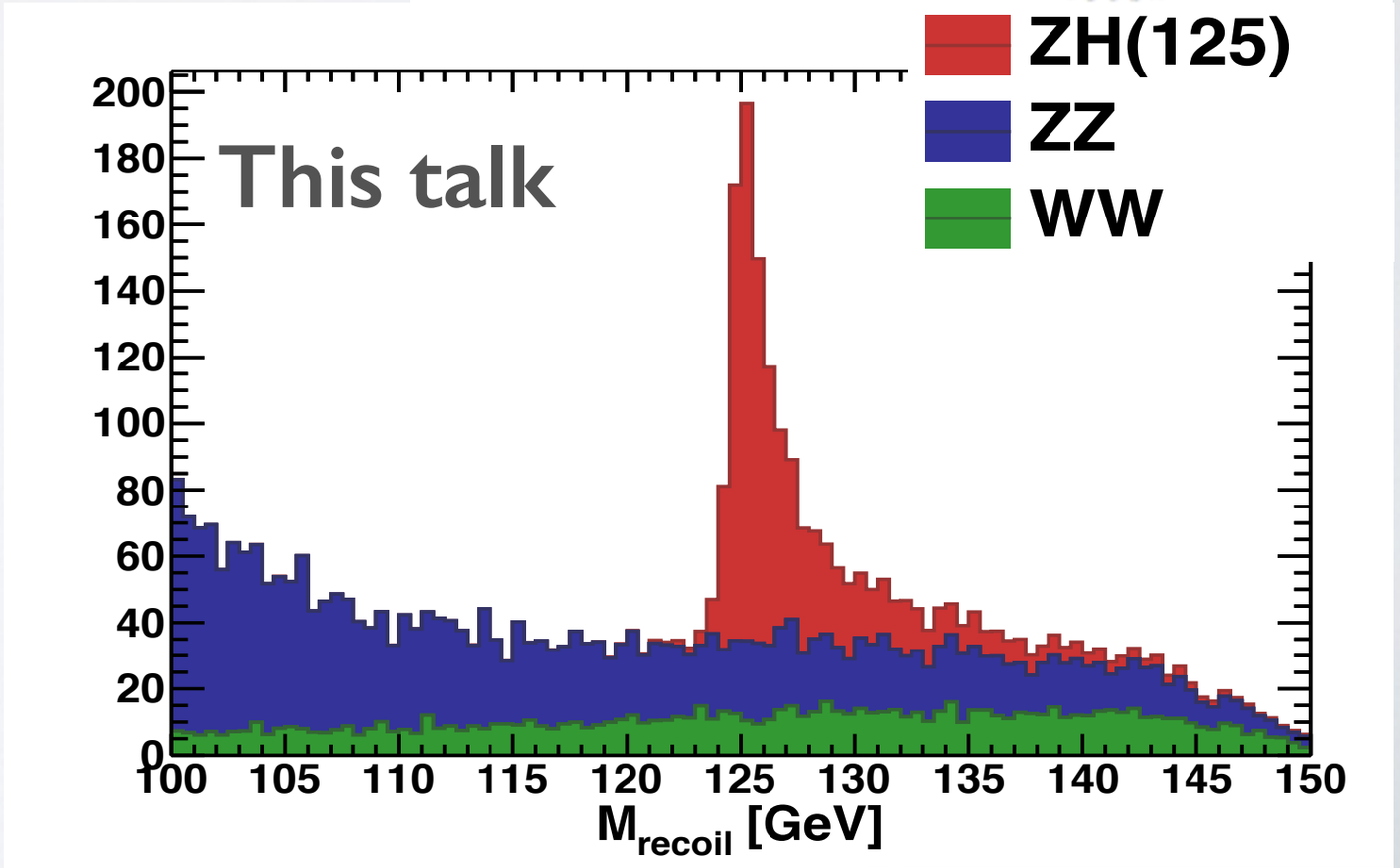
| | | |
|---|---|---|
| ee -> Z(**μμ**)H | **σ** = | 6.6 fb |
| ee -> WW(**μμ**) | **σ** = | 190.6 fb |
| ee -> ZZ | **σ** = | 1362.0 fb |

- Normalised to pythia cross sections
- CM beam energy smeared
- L = 250 $fb^{-1}$

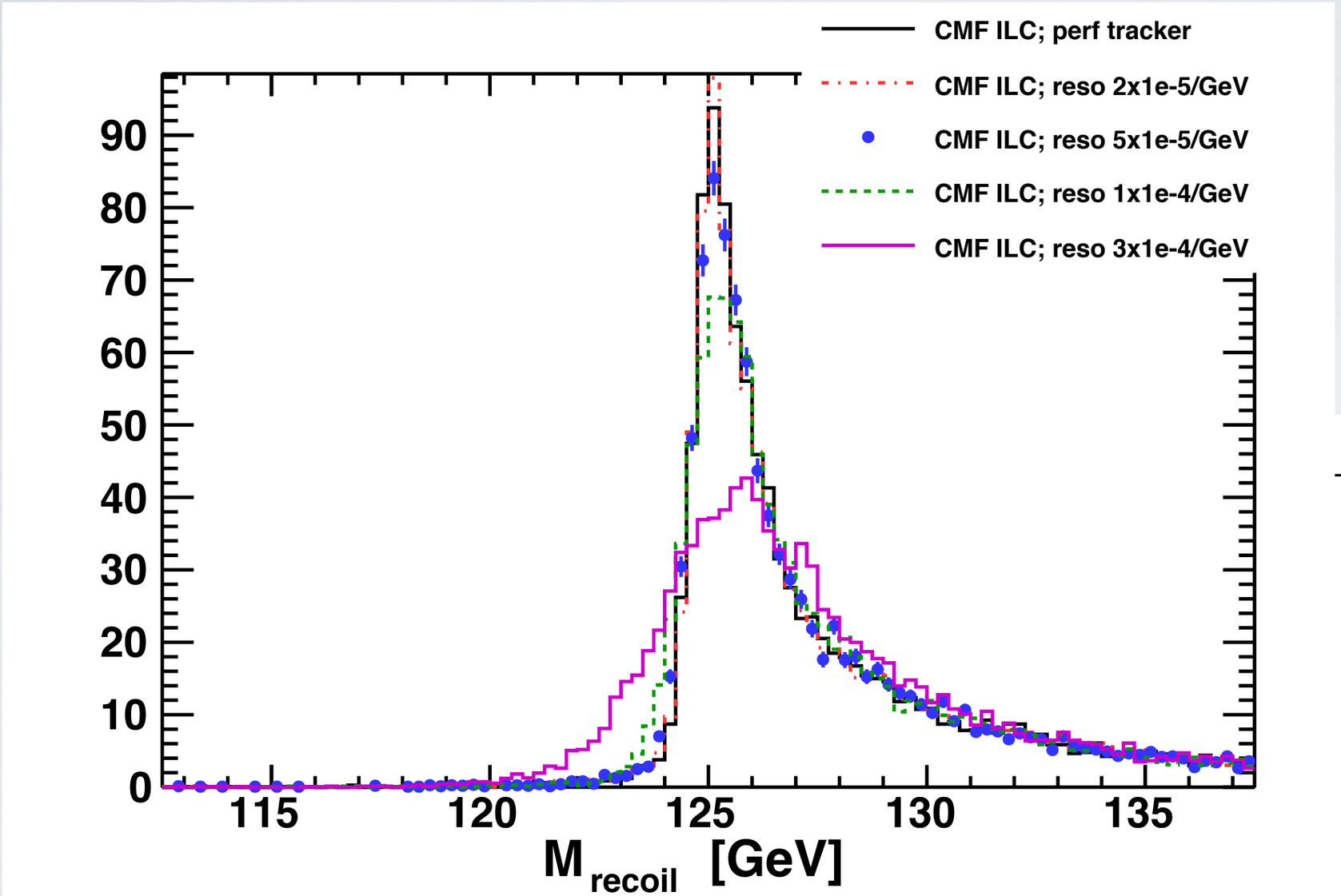
# CUTS

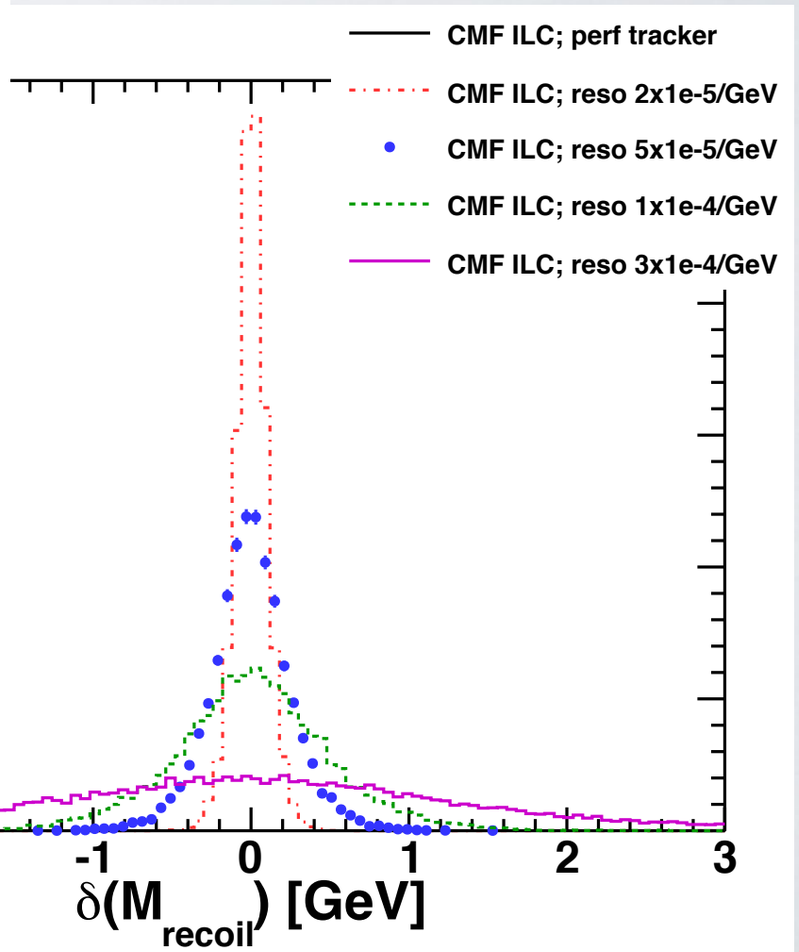
- Extremely simplified cuts
- | M[**μμ**] - 91.2 | < **5** GeV
- pZ[**μμ**] < 50 GeV
- pT[**μμ**] > 10 GeV



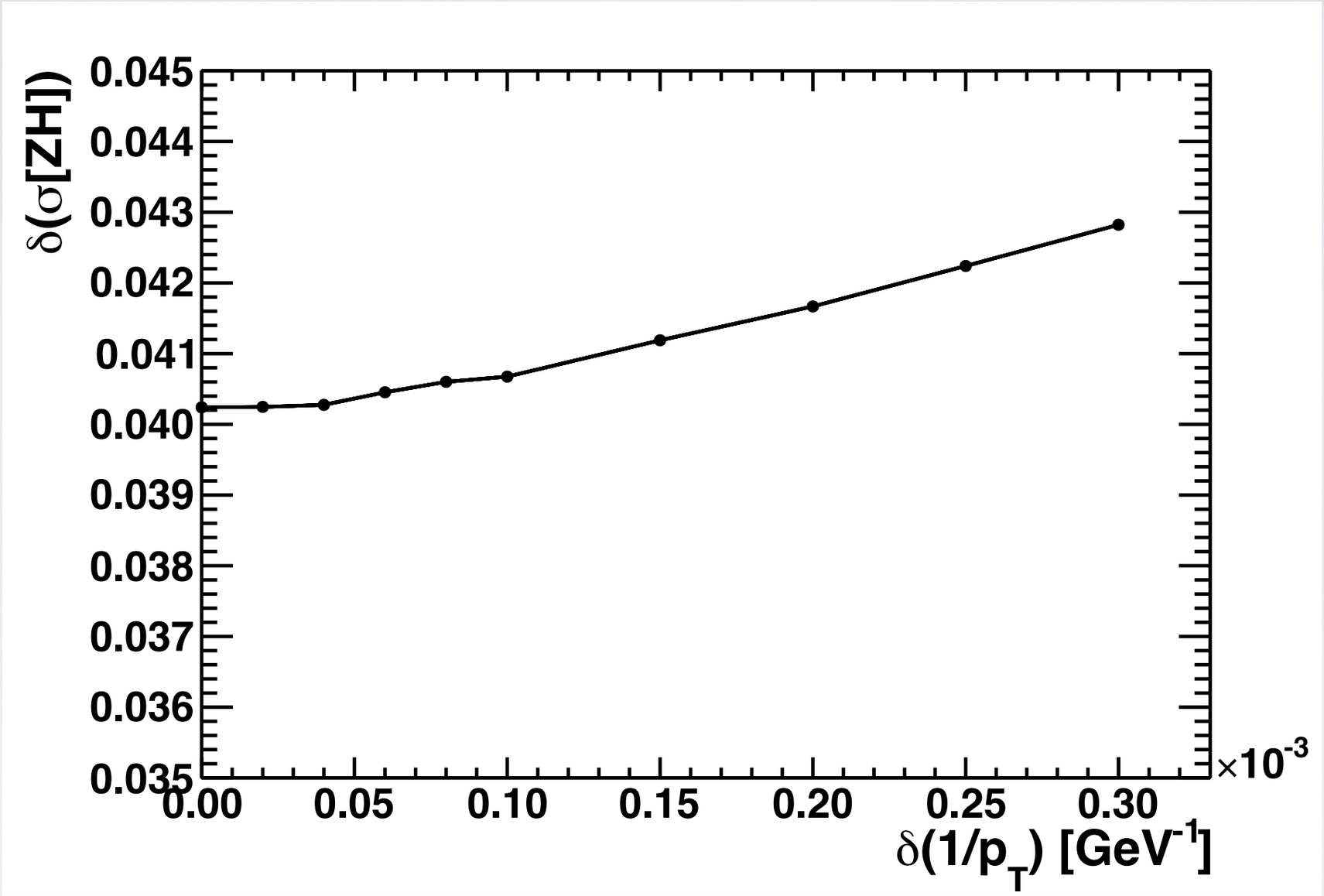
# RECOIL MASS RESOLUTION




tracker resolution only

# STAT PRECISION ON **ZH** XSEC




$$\delta(\sigma[ZH]) = 1 / \sqrt{(\Sigma_i s_i^2 / (s_i + b_i))}$$

Not a real fit so this overestimates the actual sensitivity (bkg and mH perfectly known)

# TRACKER RESOLUTION ULTRA-FAST SIM

$$y = y_o + \sqrt{R^2 - (x - x_o)^2}$$

$$y \approx y_o + R\left(1 - \frac{(x - x_o)^2}{2R^2}\right)$$

$$y = \left(y_o + R - \frac{x_o}{2R^2}\right) + \frac{x_o}{R}x - \frac{1}{2R}x^2$$

$R^2 >> (x - x_o)^2$

$$R = \frac{p}{0.3B} \qquad \frac{\delta p}{p} = \frac{\delta R}{R}$$

Understand impact of TPC on pT resolution (2D only)

- quadratic helix approximation
- ideal case (no multiple scattering…)
- Track pT = 50 GeV

# ILD TRACKER (TDR)

## vertex

| | $R$ (mm) | $\lvert z\rvert$ (mm) | $\lvert\cos\theta\rvert$ | $\sigma$ ($\mu$m) |
|---|---|---|---|---|
| Layer 1 | 16 | 62.5 | 0.97 | 2.8 |
| Layer 2 | 18 | 62.5 | 0.96 | 6 |
| Layer 3 | 37 | 125 | 0.96 | 4 |
| Layer 4 | 39 | 125 | 0.95 | 4 |
| Layer 5 | 58 | 125 | 0.91 | 4 |
| Layer 6 | 60 | 125 | 0.9 | 4 |

## central tracker

| SIT (baseline = false double-sided Si microstrips) | | | | | |
|---|---|---|---|---|---|
| | Geometry | | Characteristics | | Material |
| R [mm] | Z [mm] | cos $\theta$ | Resolution R-$\phi$ [$\mu$m] | Time [ns] | $X_0$ [%] |
| 153 | 368 | 0.910 | R: $\sigma$=7.0 | 307.7 (153.8) | 0.65 |
| 300 | 644 | 0.902 | z: $\sigma$=50.0 | $\sigma$=80.0 | 0.65 |
| **SET (baseline = false double-sided Si microstrips)** | | | | | |
| | Geometry | | Characteristics | | Material |
| R [mm] | Z [mm] | cos $\theta$ | Resolution R-$\phi$ [$\mu$m] | Time [ns] | $X_0$ [%] |
| 1811 | 2350 | 0.789 | R: $\sigma$=7.0 | 307.7 (153.8) | 0.65 |
| ETD (baseline = single-sided Si micro-strips) | | | | | |
| | Geometry | | Characteristics | | Material |
| R [mm] | Z [mm] | cos $\theta$ | Resolution R-$\phi$ [$\mu$m] | | $X_0$ [%] |
| 419.3-1822.7 | 2420 | 0.985-0.799 | x: $\sigma$=7.0 | | 0.65 |

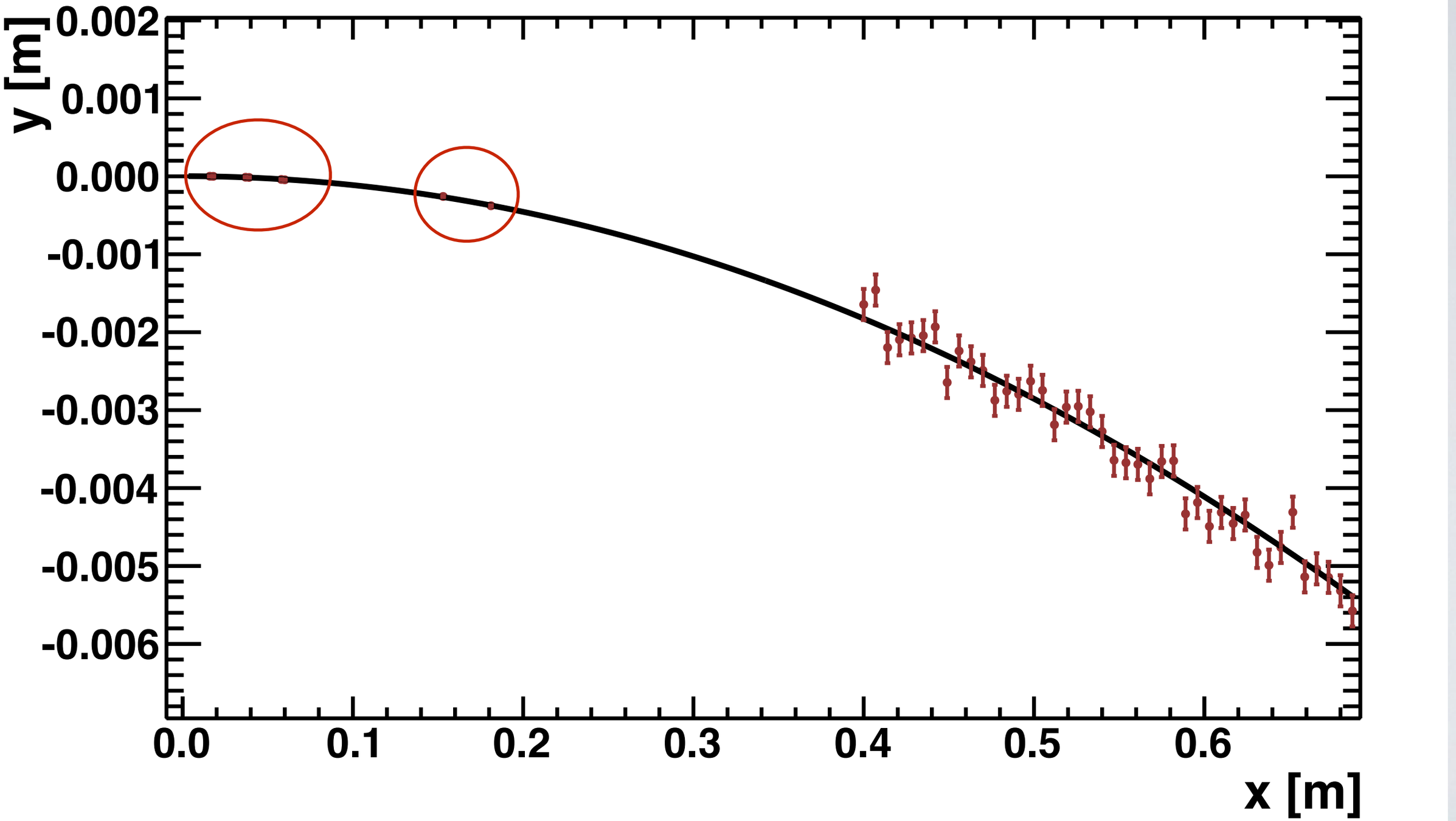
## TPC

| Parameter | |
|---|---|
| Geometrical parameters | $r_{in}$ 329 mm; $r_{out}$ 1808 mm; z $\pm$ 2350 mm |
| Solid angle coverage | up to $\cos\theta \simeq 0.98$ (10 pad rows) |
| TPC material budget | $\simeq 0.05\ X_0$ including outer fieldcage in $r$<br>$< 0.25\ X_0$ for readout endcaps in $z$ |
| Number of pads/timebuckets | $\simeq$ 1-2 $\times 10^6$/1000 per endcap |
| Pad pitch/ no.padrows | $\simeq$ 1$\times$ 6 mm$^2$ for 220 padrows |
| $\sigma_{\text{point}}$ in $r\phi$ | $\simeq$ 60 $\mu$m for zero drift, $<$ 100 $\mu$m overall |
| $\sigma_{\text{point}}$ in $rz$ | $\simeq 0.4 - 1.4$ mm (for zero – full drift) |
| 2-hit resolution in $r\phi$ | $\simeq$ 2 mm |
| 2-hit resolution in $rz$ | $\simeq$ 6 mm |
| dE/dx resolution | $\simeq$ 5 % |
| Momentum resolution at B=3.5 T | $\delta(1/p_t) \simeq 10^{-4}$/GeV/c (TPC only) |

TPC: about 200 points in 1.4m

$B_z = 3.8\,T$

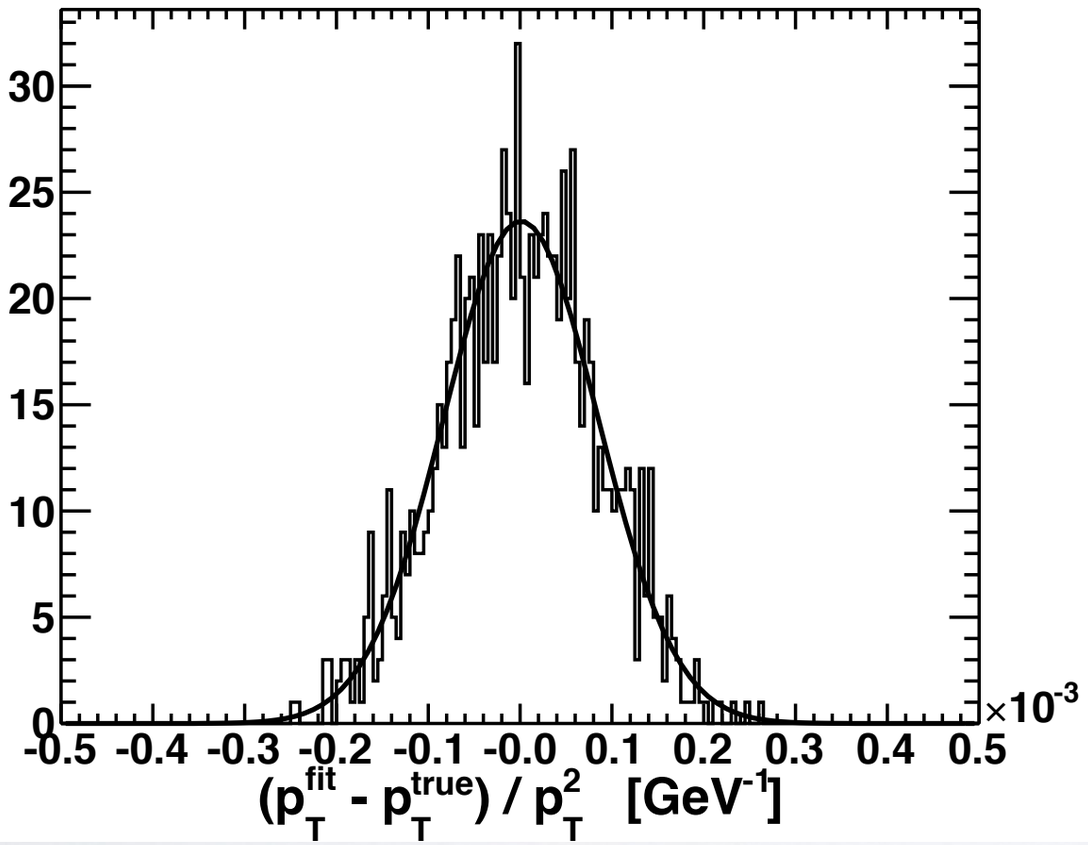
# FIT EXAMPLE


y [m]
0.002
0.001
0.000
-0.001
-0.002
-0.003
-0.004
-0.005
-0.006
0.0
0.1
0.2
0.3
0.4
0.5
0.6
x [m]

# TRACKER RESOLUTION

TPC only

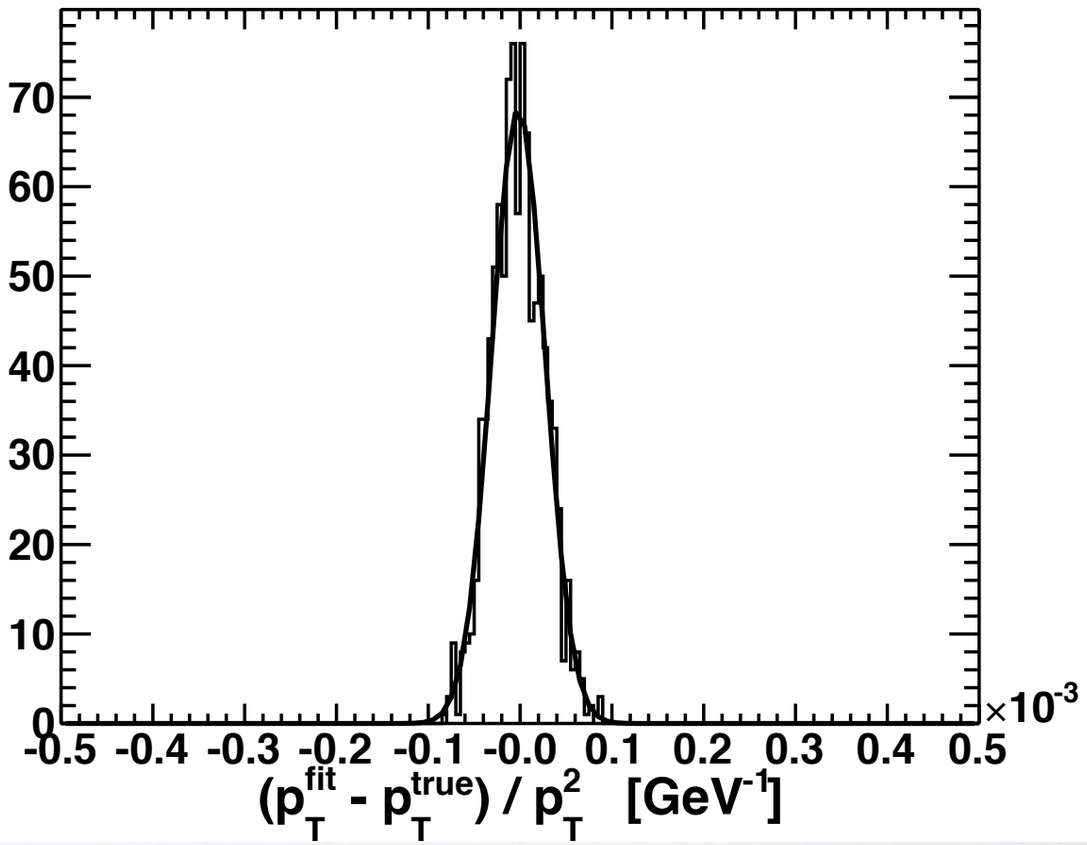
$\sigma_{r\varphi} = 100\mu m$




$\Rightarrow \sigma(1/pT) = 8.5 \times 10^{-5}$ / GeV

Full Tracker

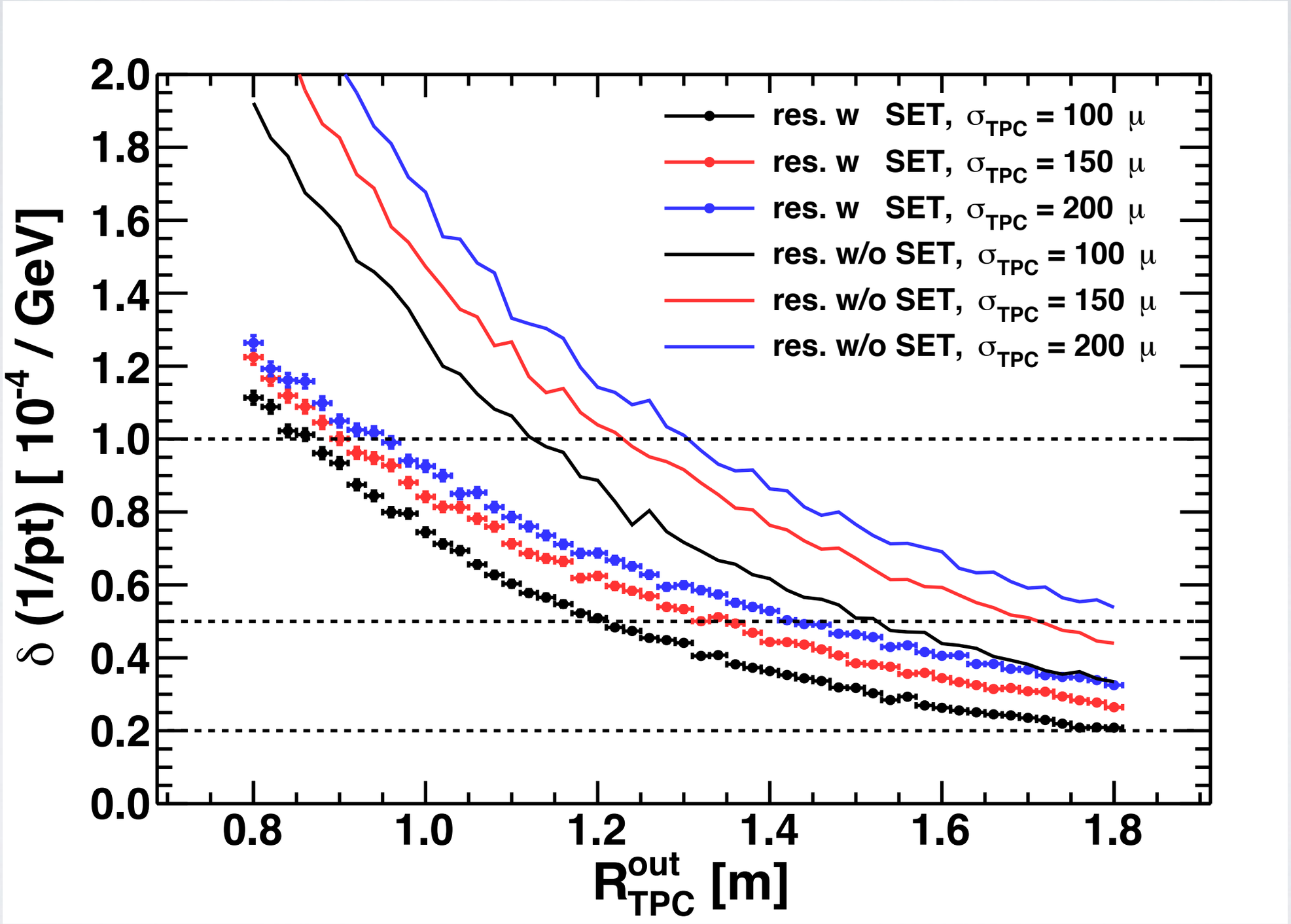
$\sigma_{r\varphi} = 100\mu m$




$\Rightarrow \sigma(1/pT) = 2 \times 10^{-5}$ / GeV

matches actual ILD-TPC numbers

# TRACKER RESOLUTION VS TPC



# CONCLUSIONS

- Only allows to get rough ideas: needs to be done with a real simulation and real analysis
- Precision on **σ**ZH@240GeV not the only benchmark for TPC optimisation:
    - mH precision should be more affected
    - TPC patter recognition, dE/dx id
    - …
- With all these cautions a worsened TPC resolution might be ok for instance due to:
    - a worsened **σ**(r**φ**) in more demanding environment
    - a smaller TPC radius if needed
    - …