Energy Loss Simulation for the CDF Run II W Mass Measurement

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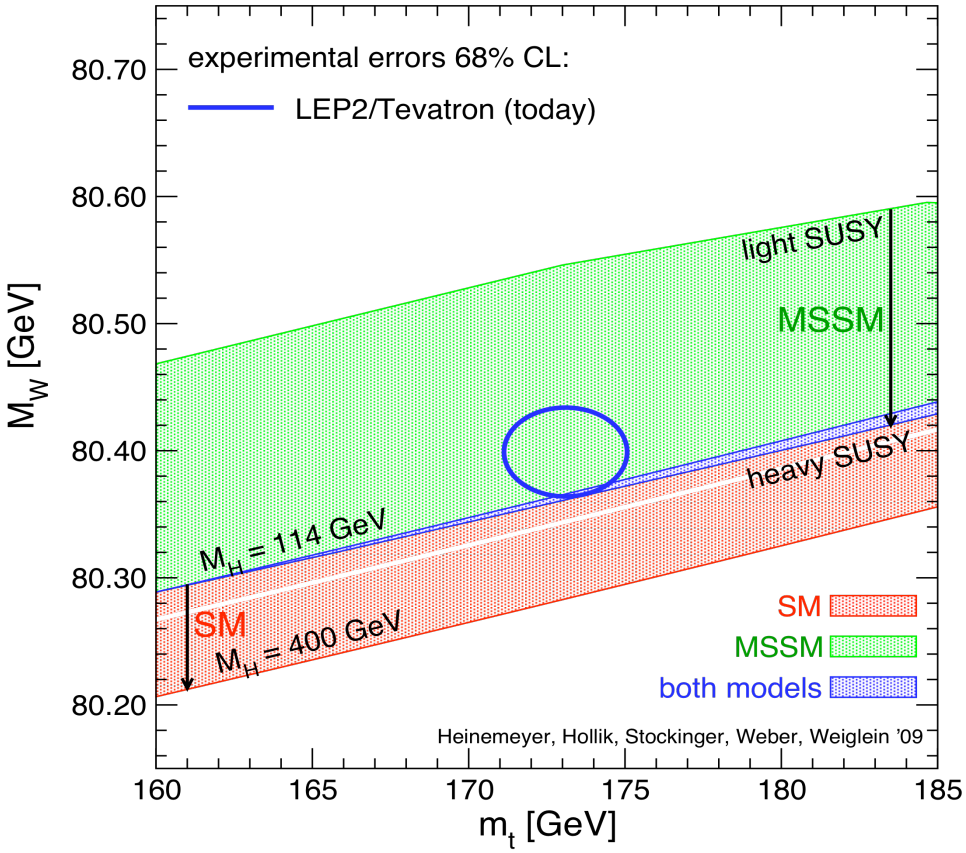
Why Measure the W Mass ?

Test of the Standard Model

Indirect constraint on Higgs mass

If LHC discovers Higgs, can compare indirect and direct mass measurements for indications of beyond the Standard Model physics

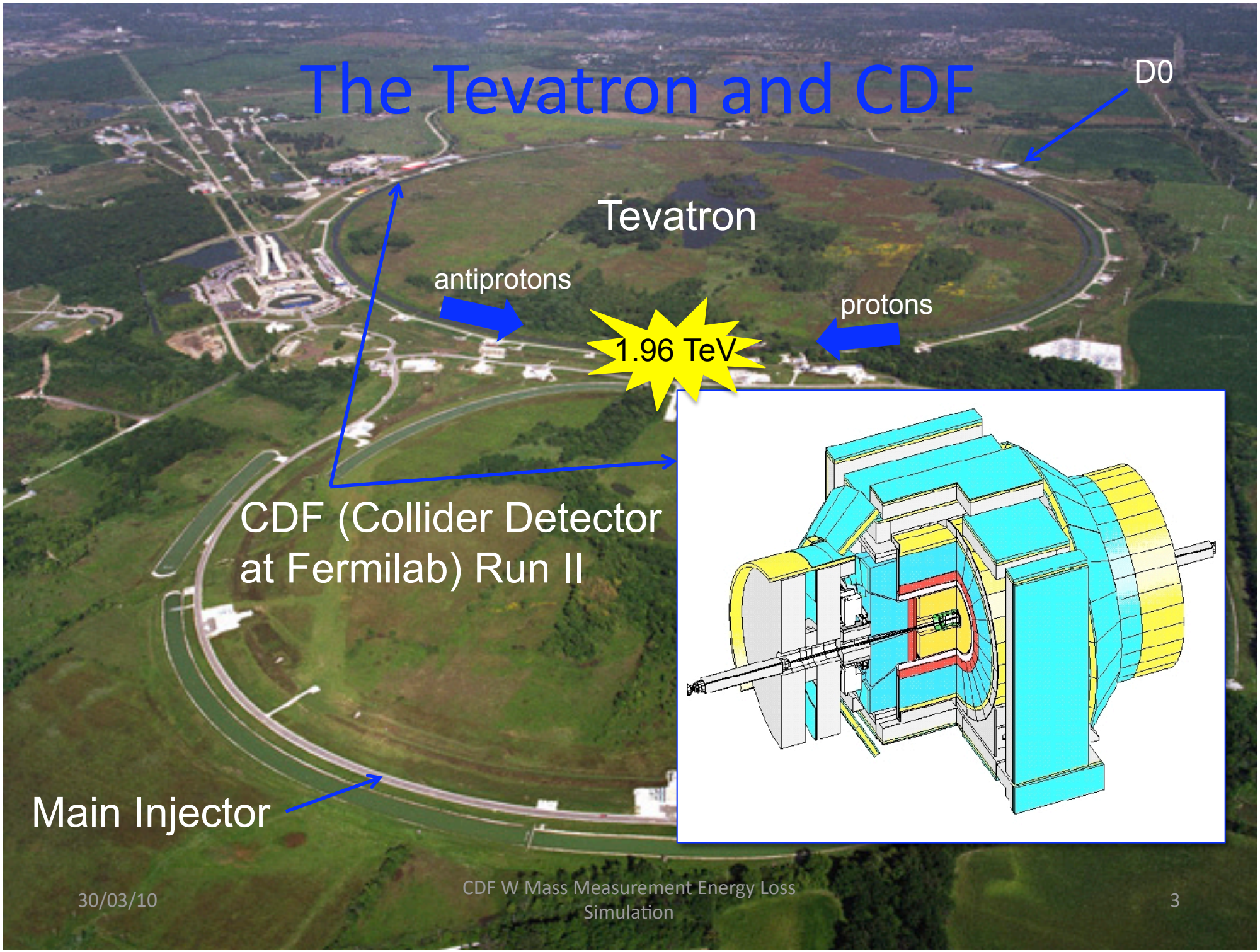


CDF Run II W Mass Measurement

Aim: Measure the W mass to an accuracy of 25 MeV/c^2

Using approximately 2.4/fb of data collected at CDF Run II

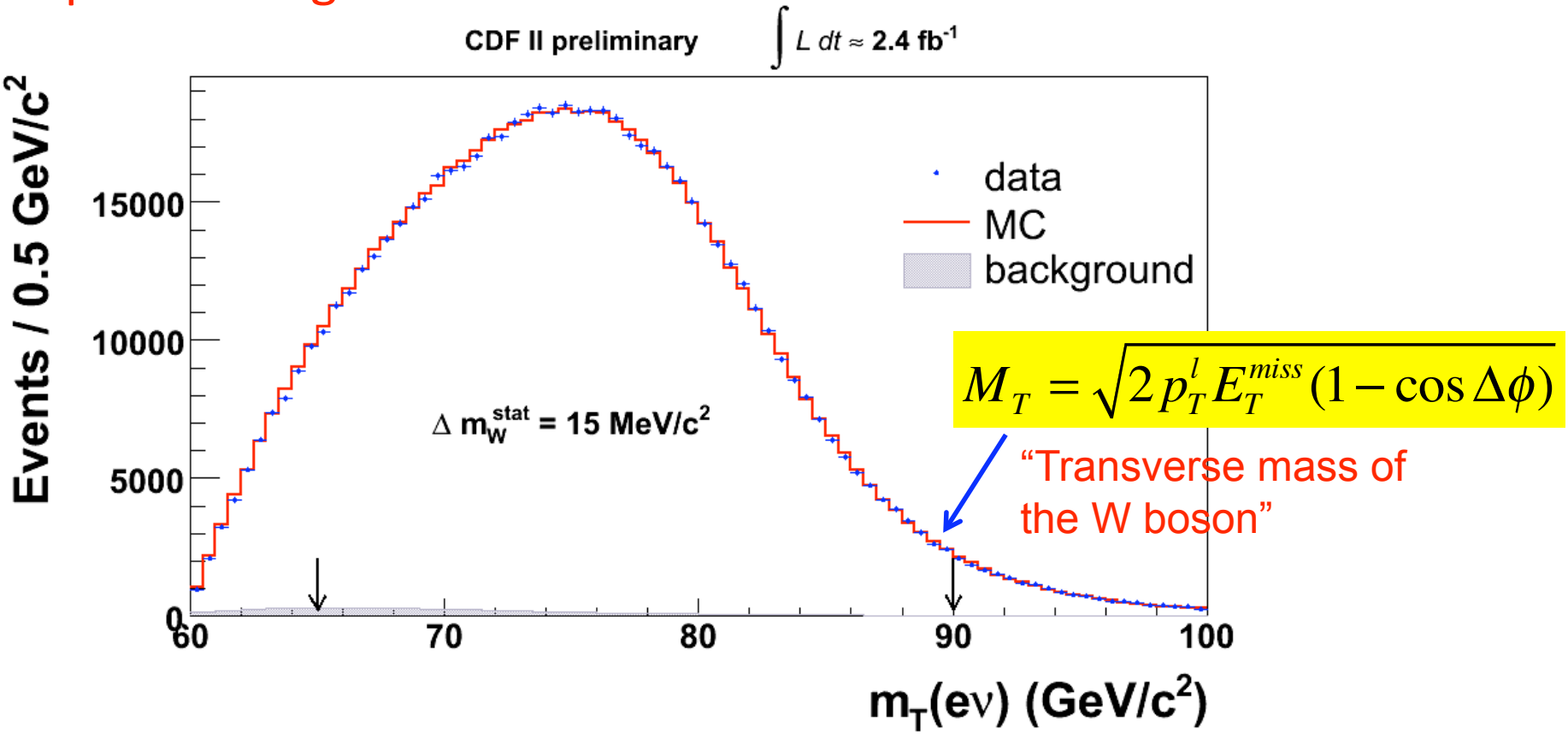
The Tevatron and CDF



How to Measure the W Mass?

Two Channels: $W \to e\nu_e$ $W \to \mu\nu_\mu$

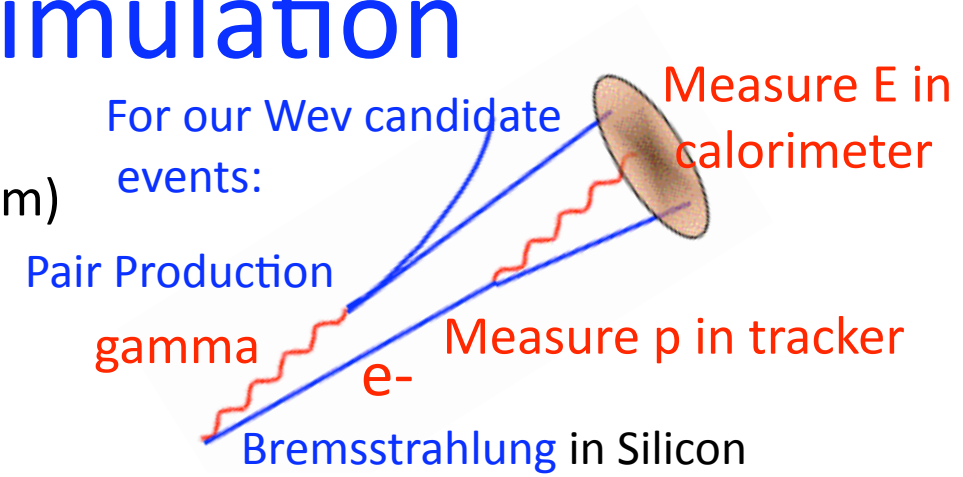
Template Fitting Procedure:

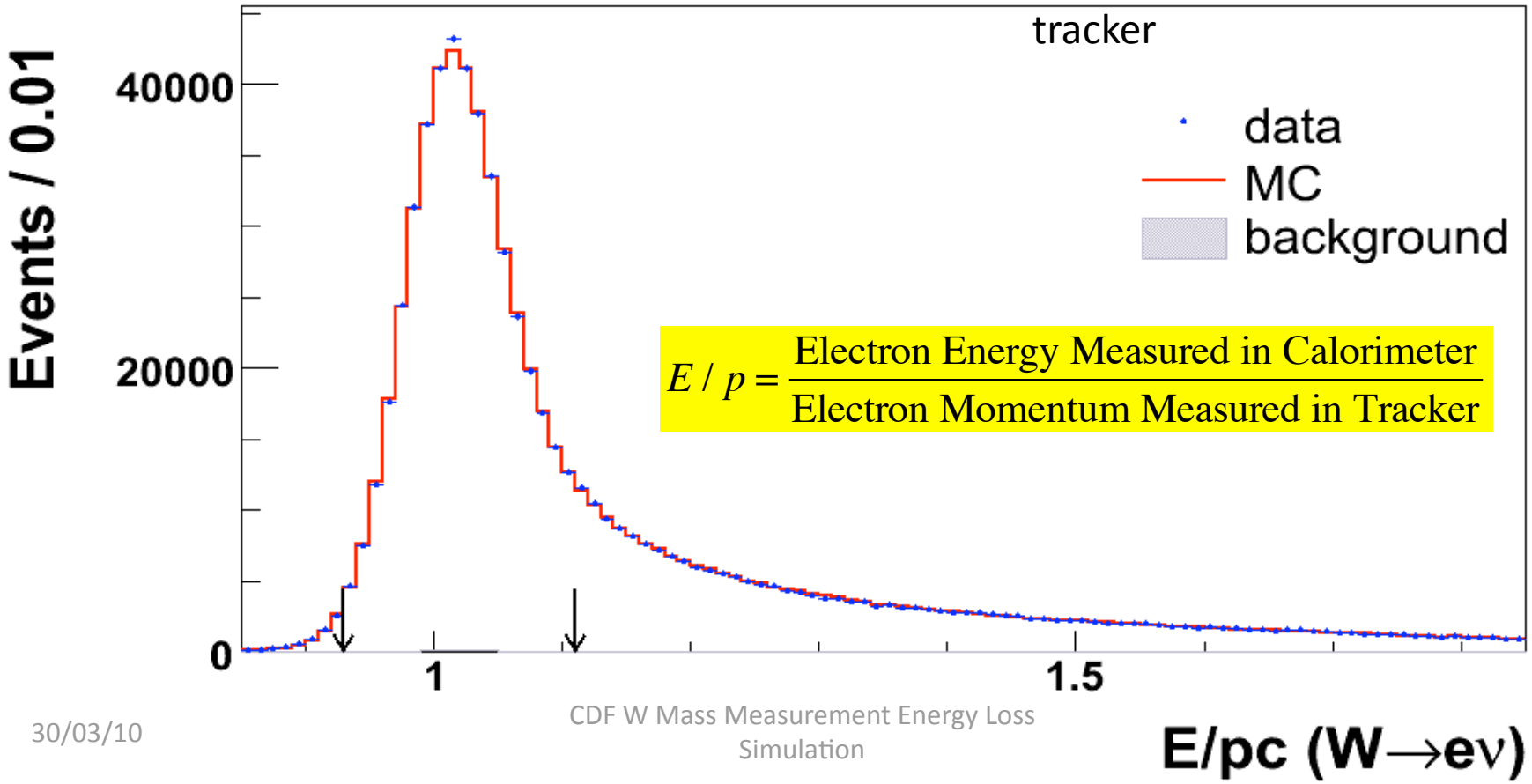


UCL Fast Simulation

Use our own fast simulation for MC

- Fast (> 100 Faster than GEANT based CDFSim)
- Can Control physics models used
- Can tune specifically for W mass analysis
- e.g. E/p scale





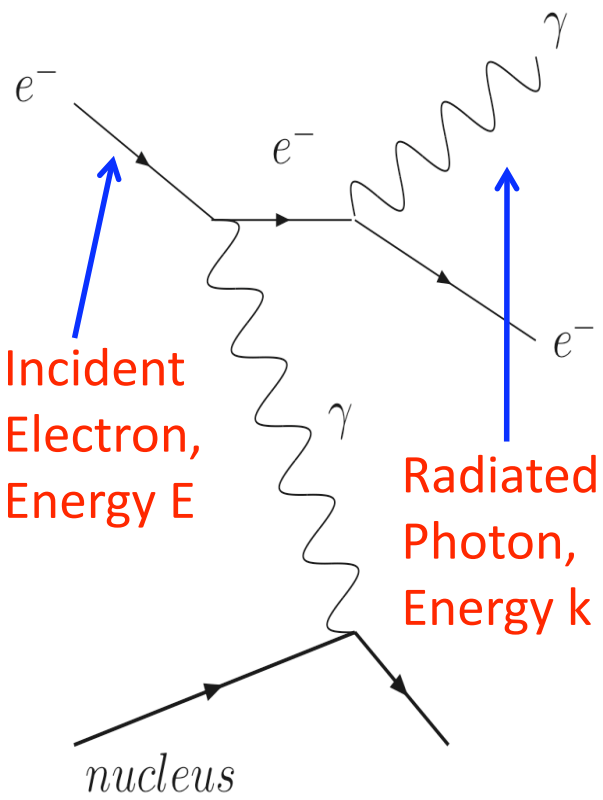
The Bremsstrahlung Spectrum

We are interested in the energy spectrum of the radiated photon

Many different models
e.g. GEANT 4.9.2:

$$\frac{d\sigma}{dk} = \frac{4\alpha r_e^2}{3k}\left[\xi(s)\{y^2 G(s) + 2[1+(1-y)^2]\phi(s)\}\right.$$

$$\left.\times[Z^2(F_{el}-f)+ZF_{inel}]+(1-y)\frac{Z^2+Z}{3}\right]\times\left[\frac{k^2}{k^2+k_p^2}\right]$$

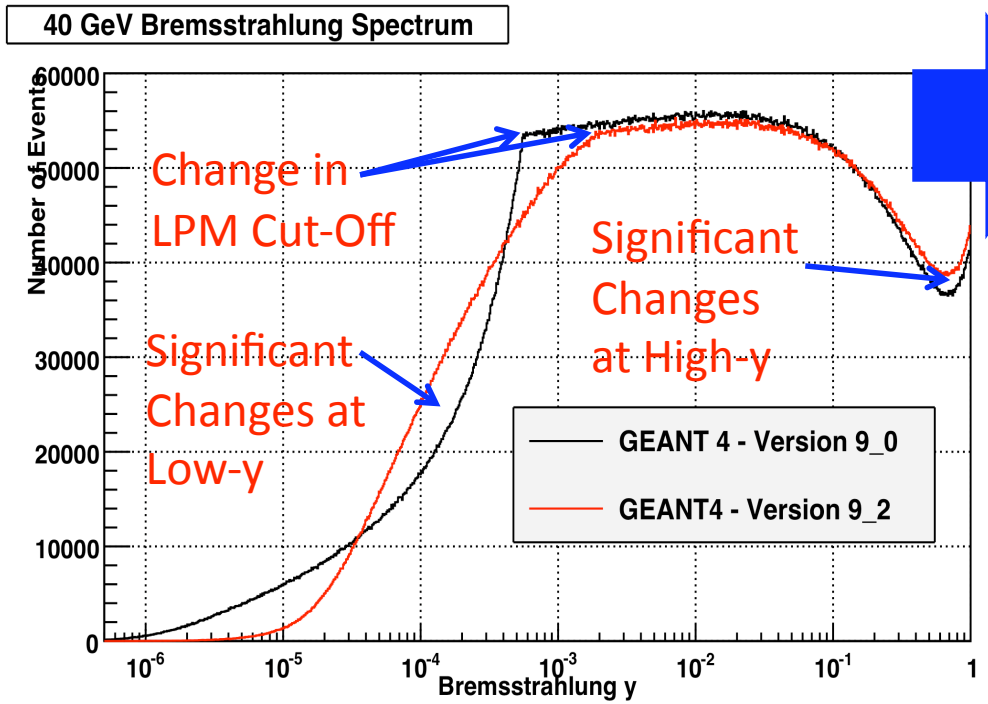


Matter Effects: LPM effect and Dielectric Effect

Important when $\frac{k}{E} < \frac{E}{E_{LPM}}$ where $E_{\mathrm{LPM}} = \frac{\alpha m^2 X_0}{4hc}$

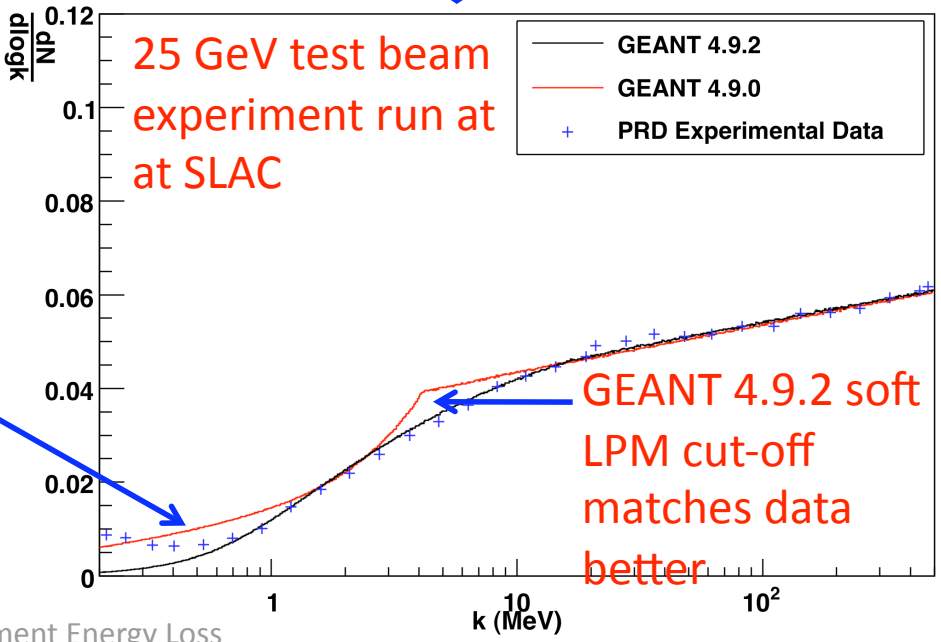
Bremsstrahlung

Release of new GEANT 4.9.2 with new model for Bremsstrahlung (19/12/2008)



Validate against actual experimental data to see which is best for our energy regime…

$$y_{\text{eff}} = \frac{k_{\text{eff}}}{E} = \frac{\sum \text{Radiated Photon Energy}}{\text{Incident Electron Energy}}$$



Two Element Model

Use detailed material map of
- Radiation Lengths
- Bethe-Bloch Equation Constants

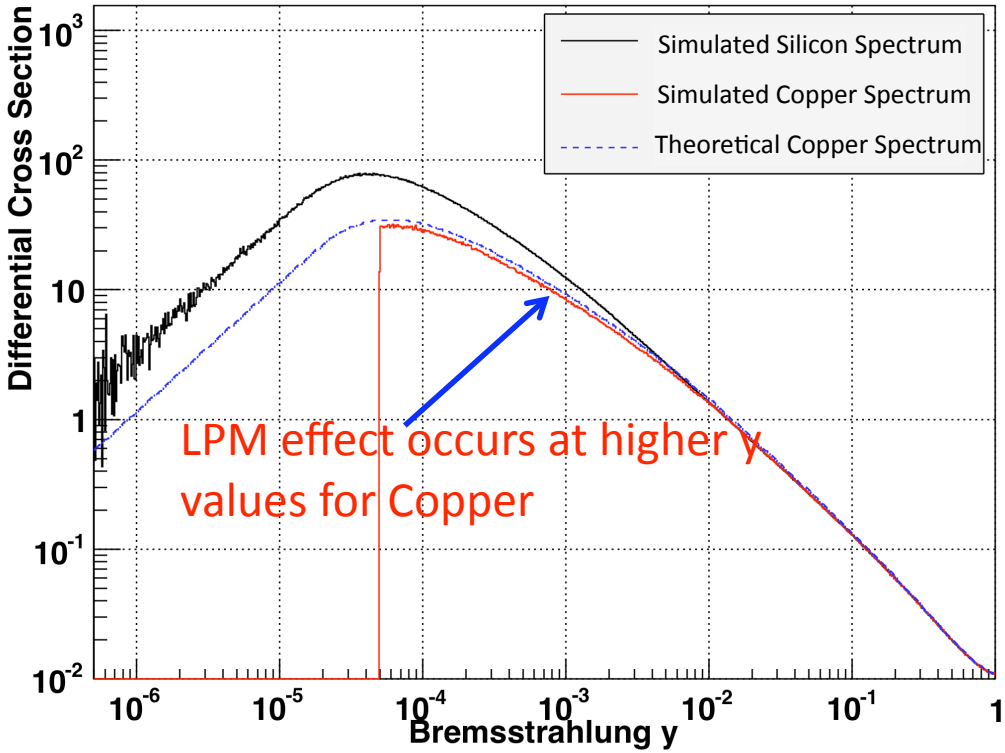
For each layer of the map:

$$\sum_i \frac{x_i}{X_{0,i}} \qquad \sum_i x_i C_{dEdx,i}$$

thickness of material *i* in layer

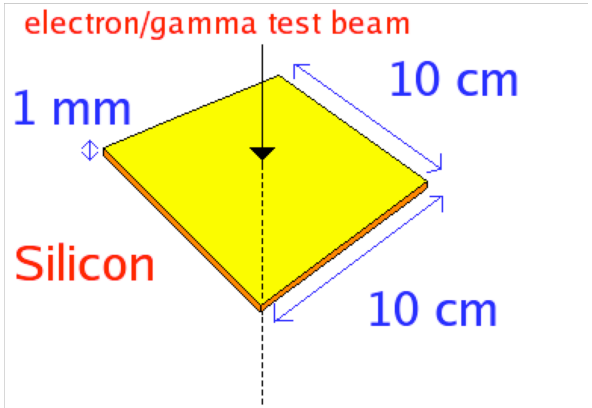
Radiation length of material *i*

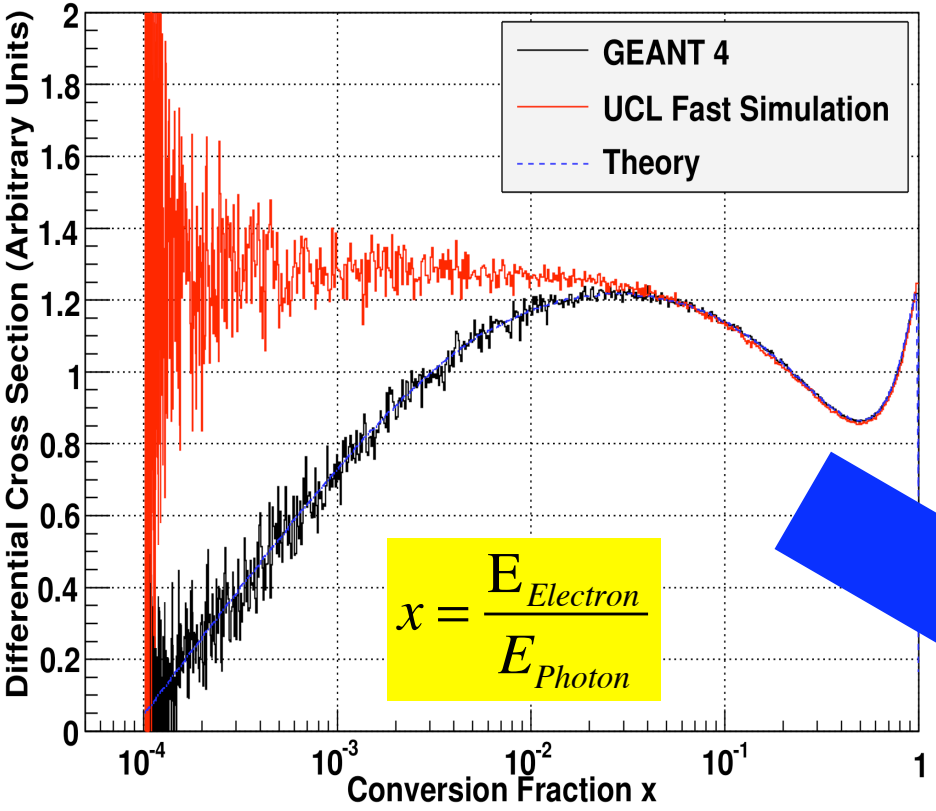
Bethe-Bloch equation constant of material *i*



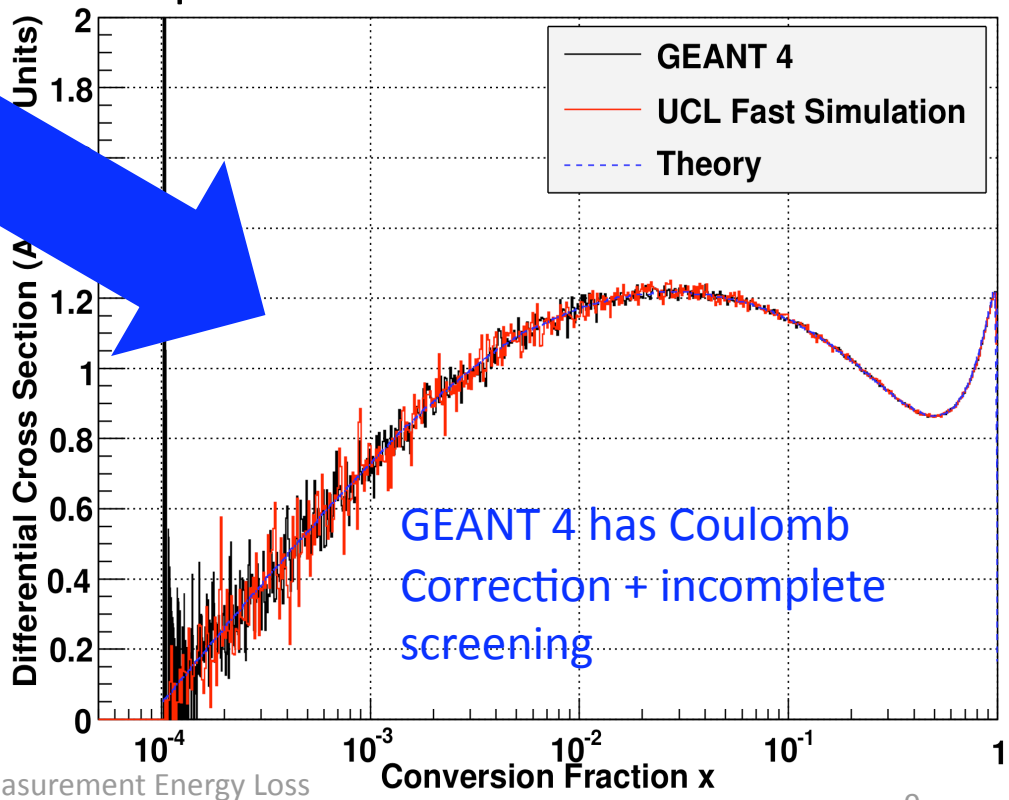
LPM effect is dependant on material
- Can't capture LPM physics by just getting total radiation length correct
- Study effect of modelling all the material as alternating layers of two differents elements

Pair Production





Compare our pair production simulation to GEANT4's using a virtual test beam setup



Update our simulation to match GEANT4's

Cross check against theoretical papers

Conclusions

Measuring W mass to 25 MeV requires us to constrain individual systematic errors to just a few MeV

Must use the best available energy loss model to reduce energy loss systematic as far as possible

Energy loss modelling in UCL Fast Simulation now uses the most accurate and sophisticated models available

Composition of tracking detector has been studied and modelled

Still generating final energy loss systematic, but it is looking likely it will be less than 7 MeV