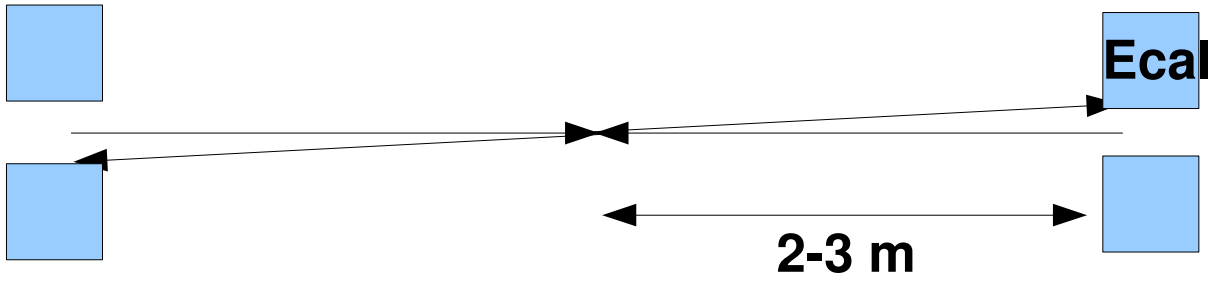
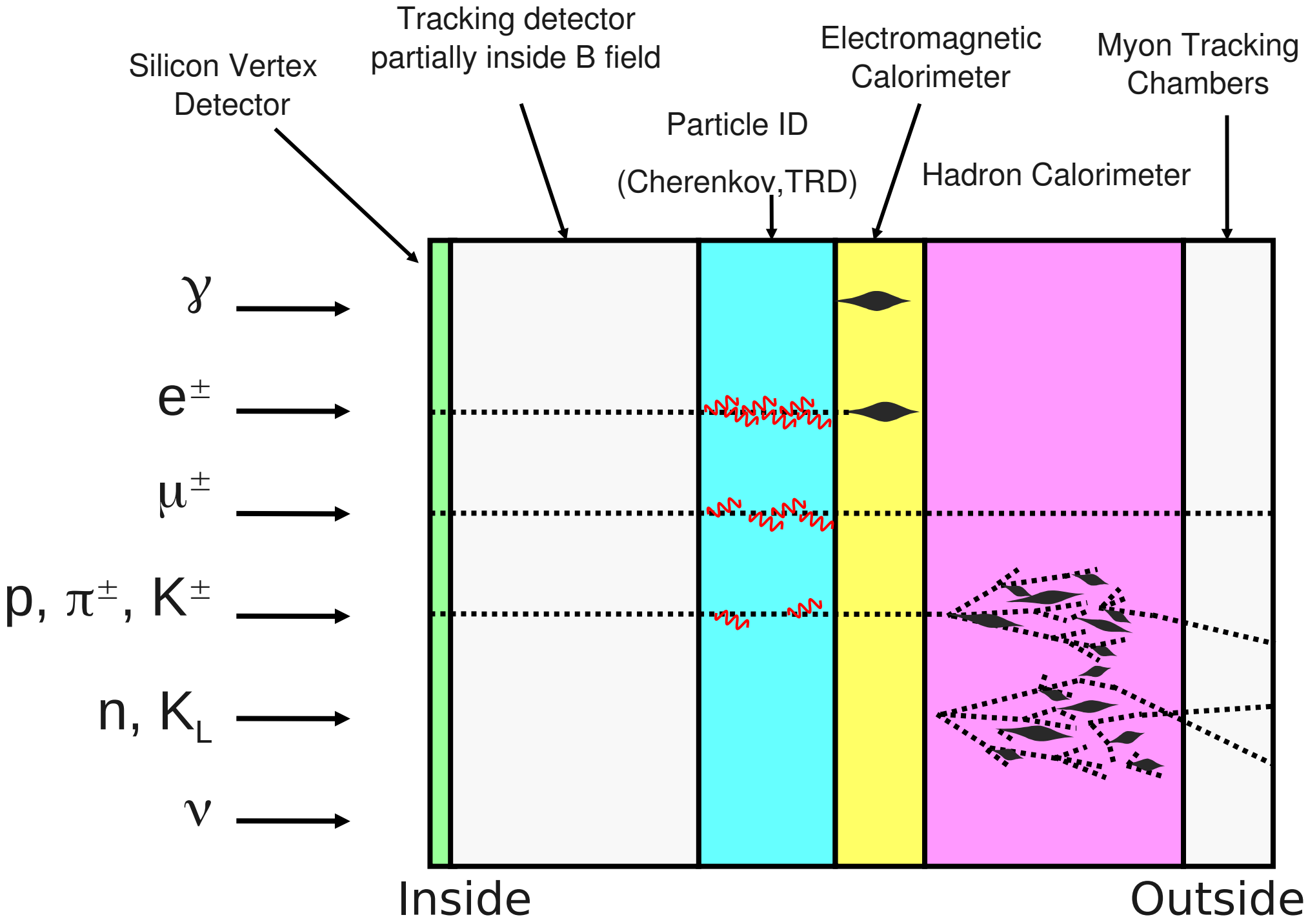
3.2.3 Measurement of the resonance curve

- **Measurement of Bhabha events at very small scattering angles:**



Principle of a Particle Detector

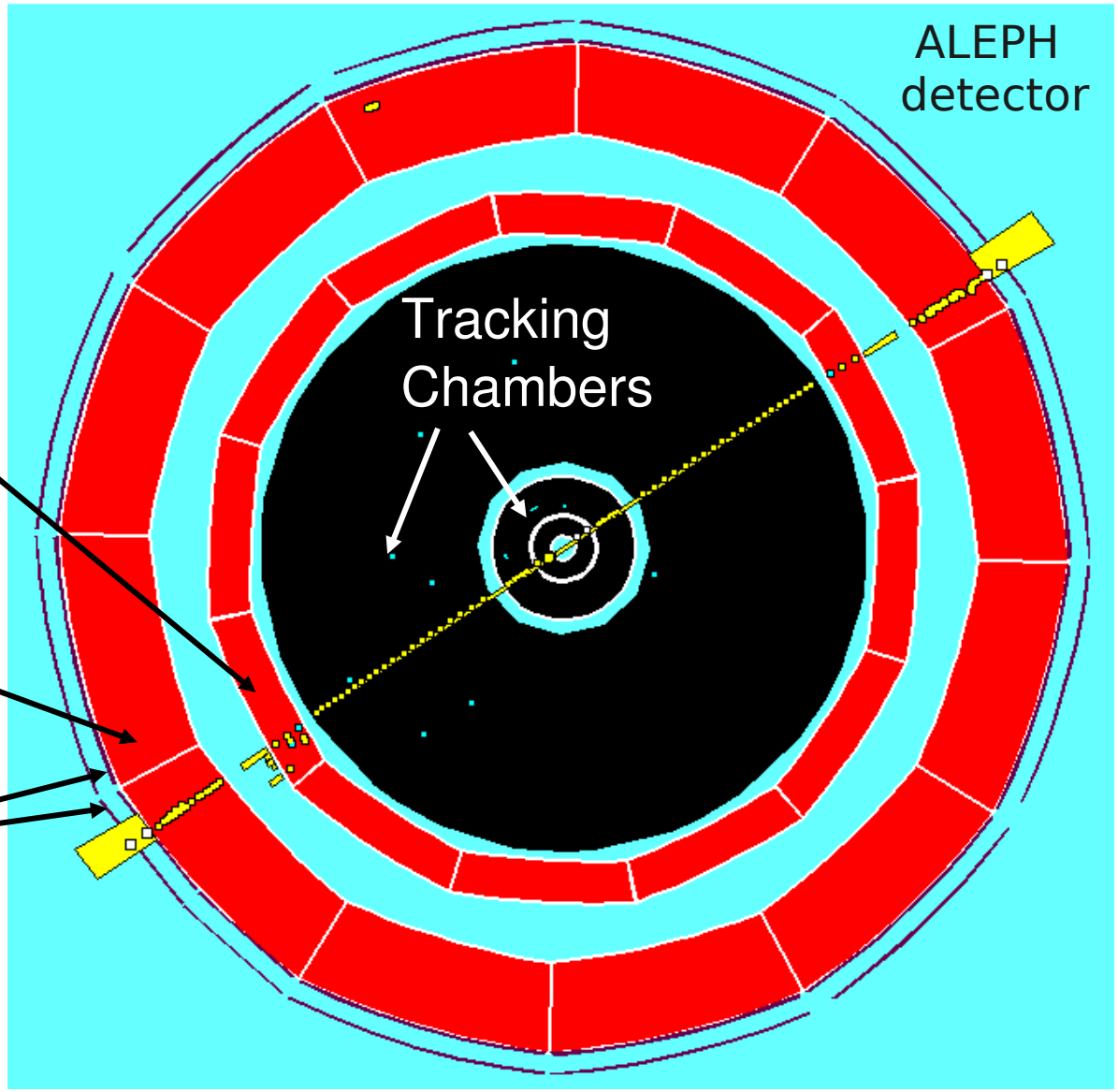
Modular Construction



c) Selection:

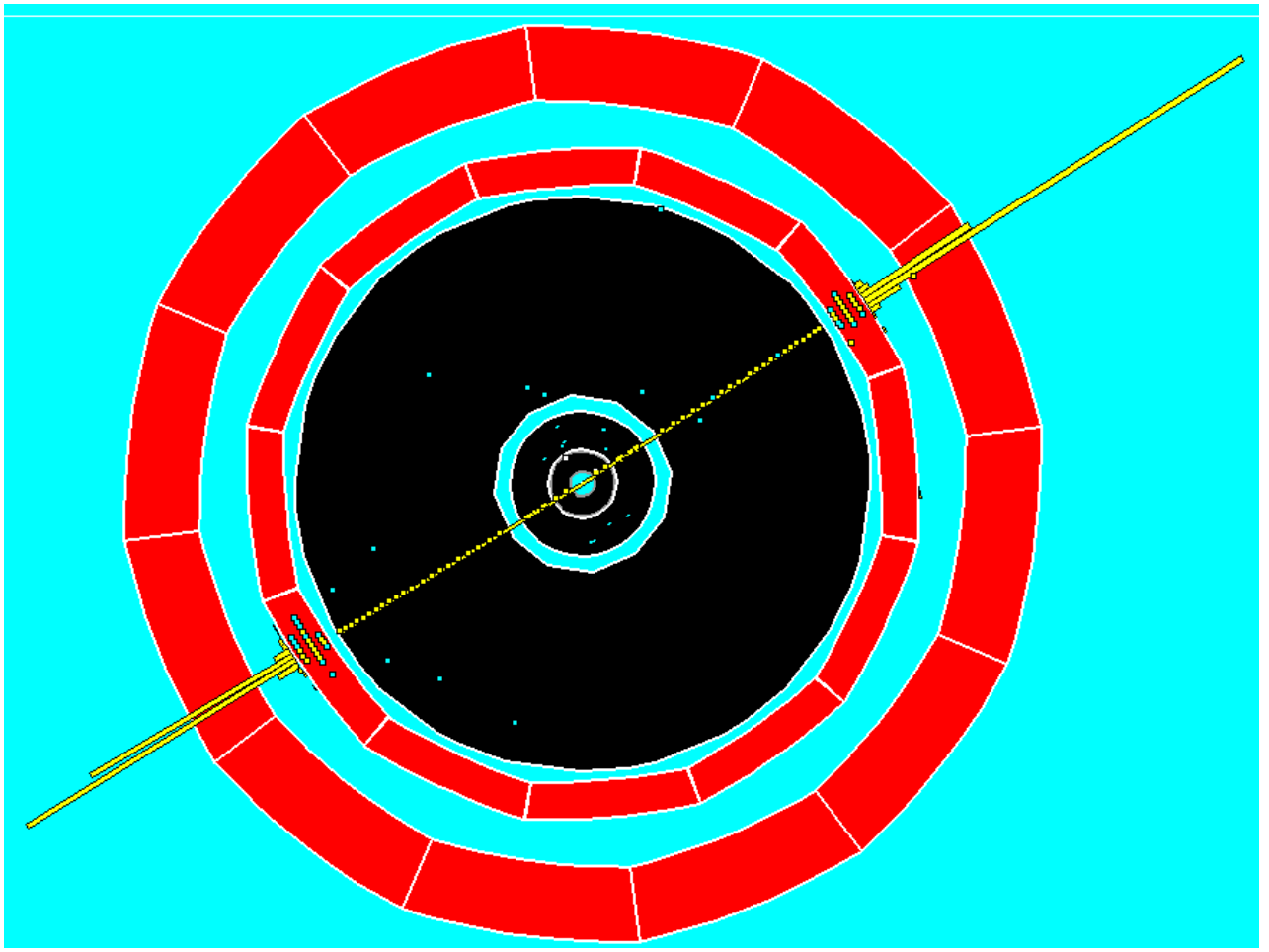
Invisible:

$e^+e^- \rightarrow \mu^+\mu^-$:



- two tracks, each of momentum $M_Z/2$
- minimally ionizing tracks through both calorimeters
- signals from traversing the myon chamber

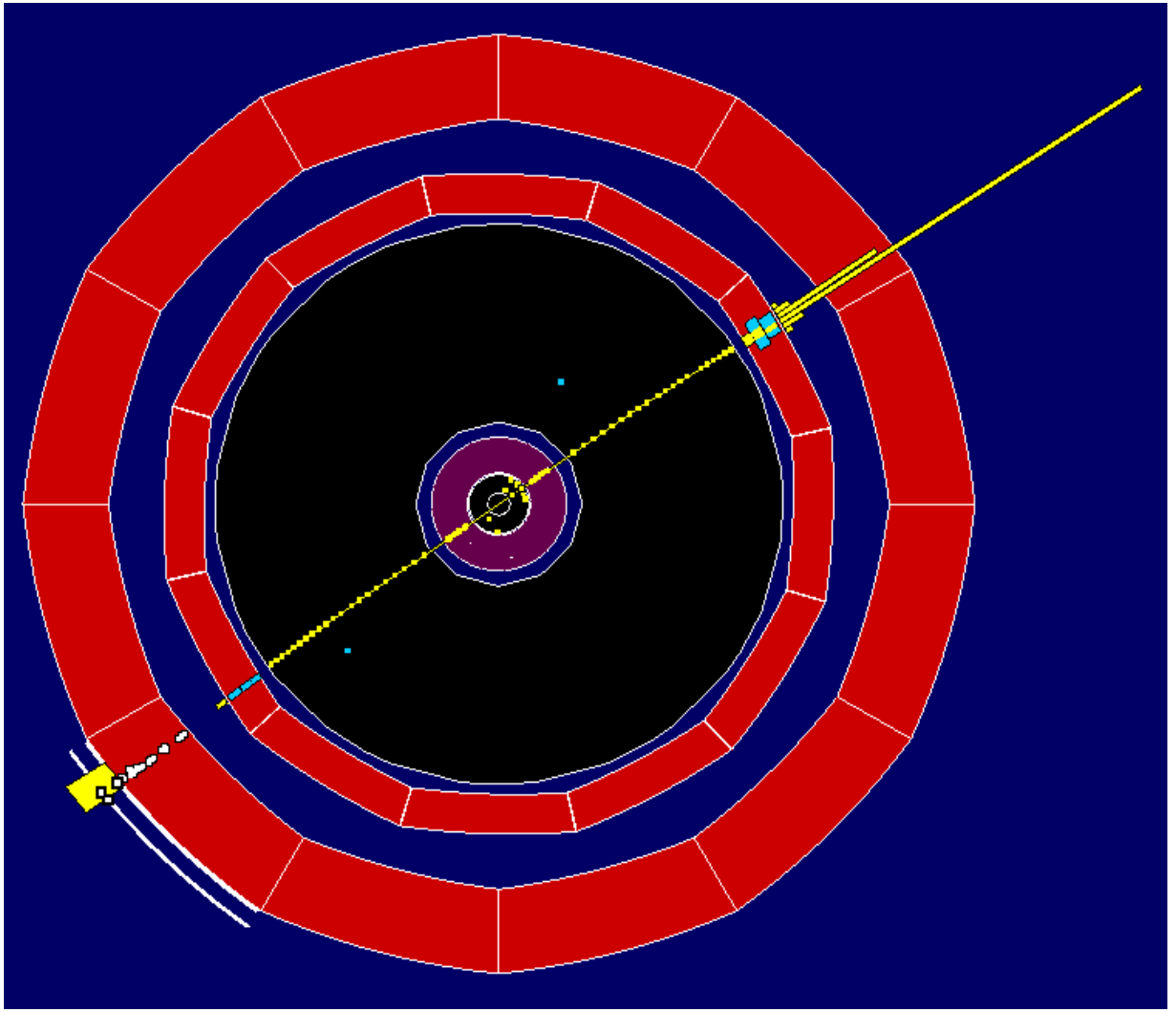
$e^+e^- \rightarrow e^+e^-$:



- two tracks, each of momentum $M_Z/2$
- two e.m. showers, each of energy $M_Z/2$

$e^+ e^- \to \tau^+ \tau^-$

Average τ decay-length: 2mm

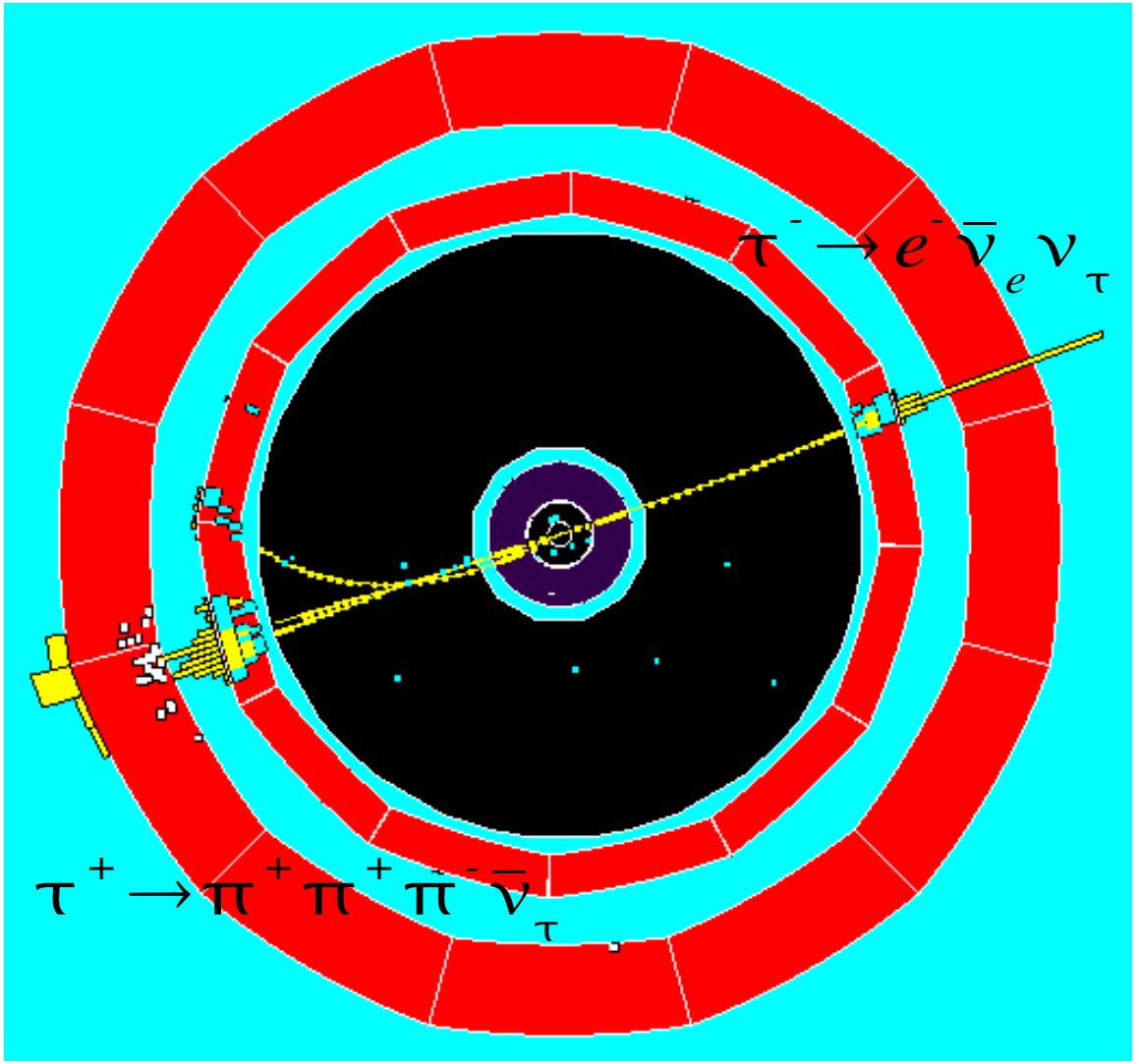


$\tau^+ \to e^+ \nu_e \bar{\nu}_\tau$

$\tau^- \to \mu^- \bar{\nu}_\mu \nu_\tau$

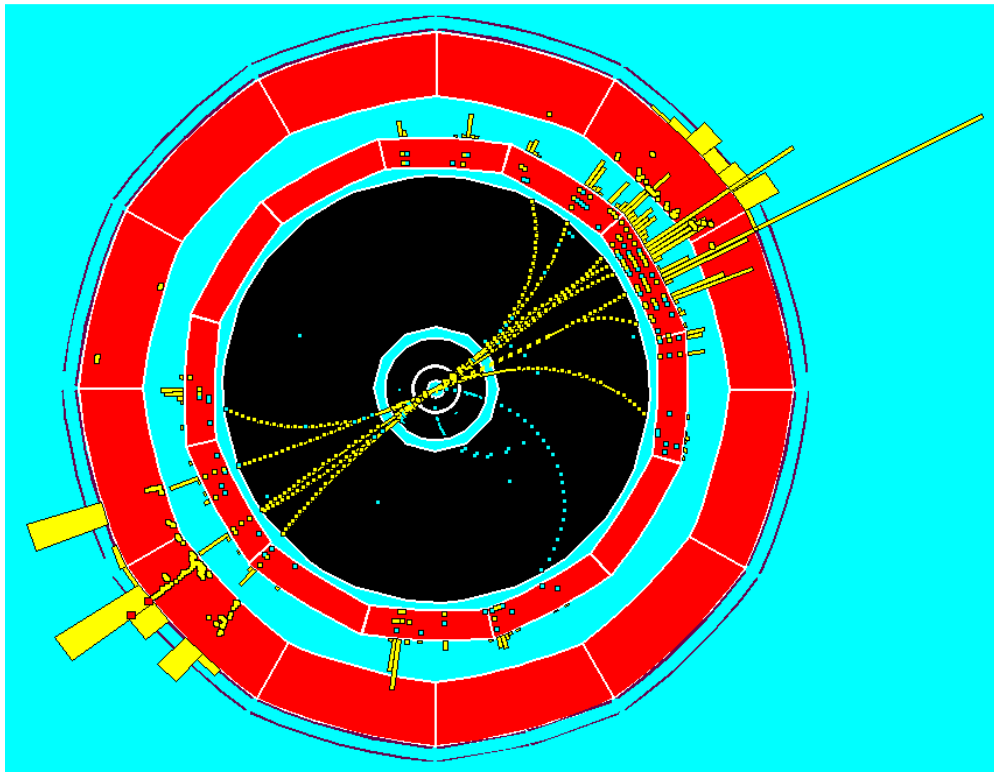
- two tracks with momentum < $M_Z/2$; missing energy
- One muon and one electron

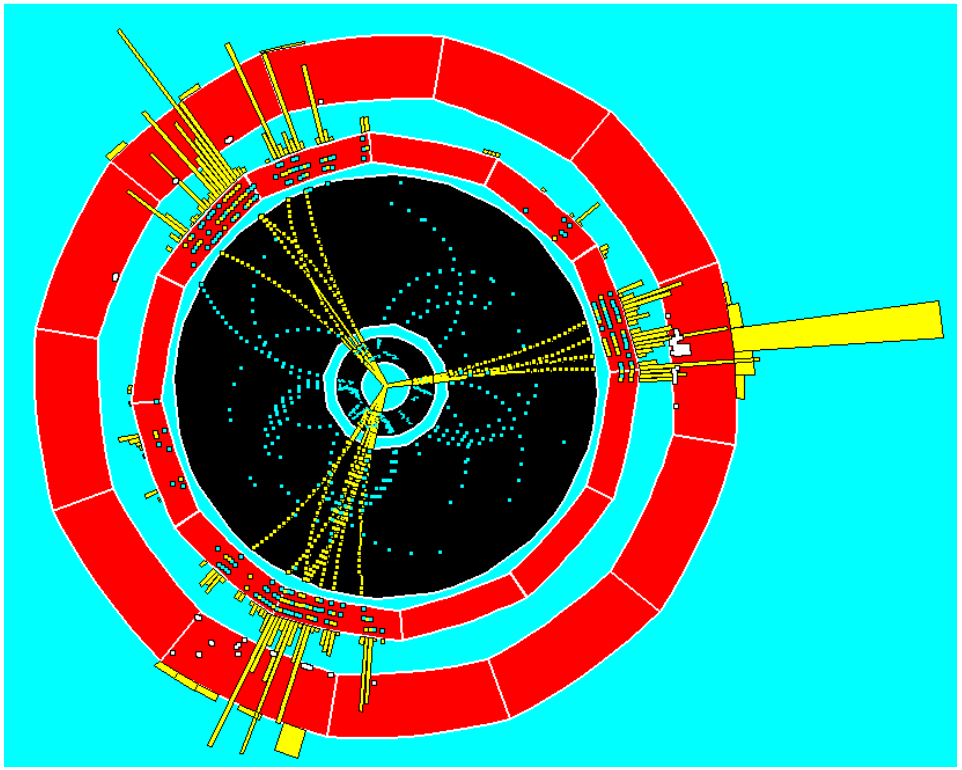
$e^+ e^- \to \tau^+ \tau^-$



- Missing Energy
- Small Multiplicity
- Single Leptons with momentum < $M_Z/2$
- Jet-like Structure with 1- 5 Hadrons and total momentum < $M_Z/2$

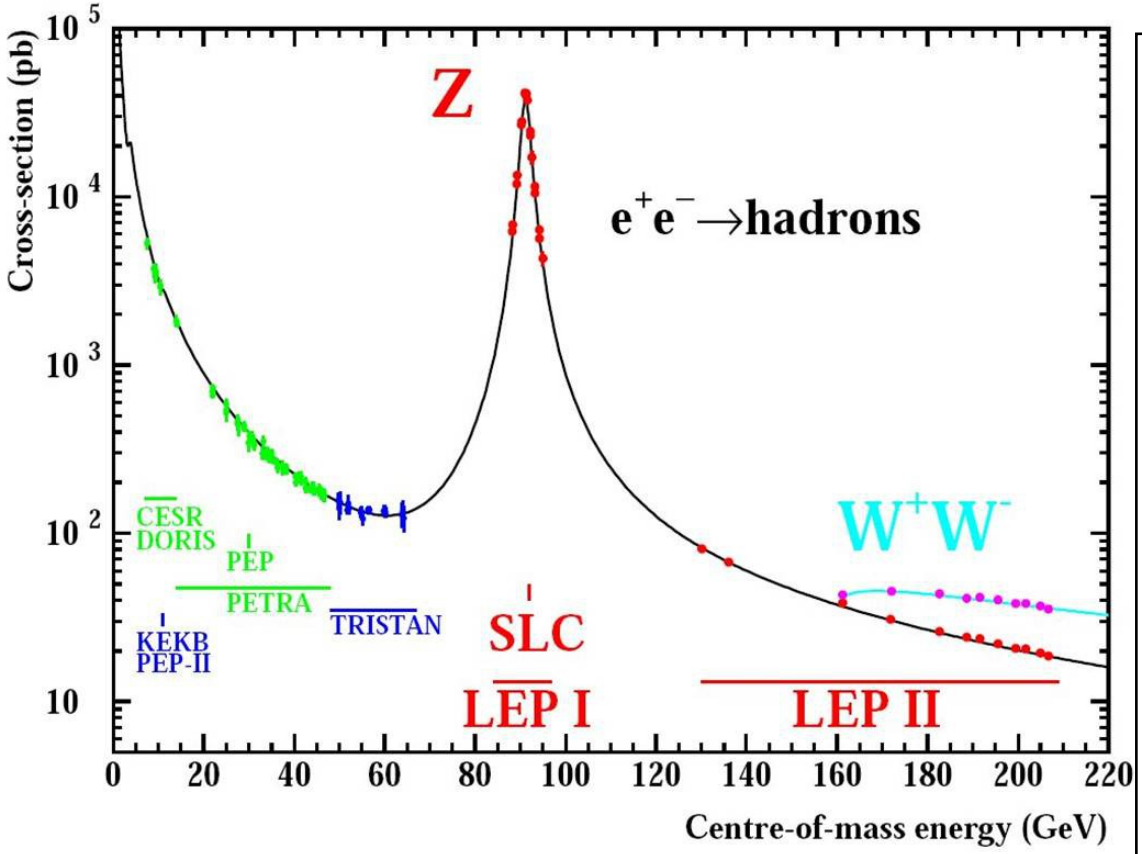
$e^+e^- \rightarrow q\bar{q}(g)$:

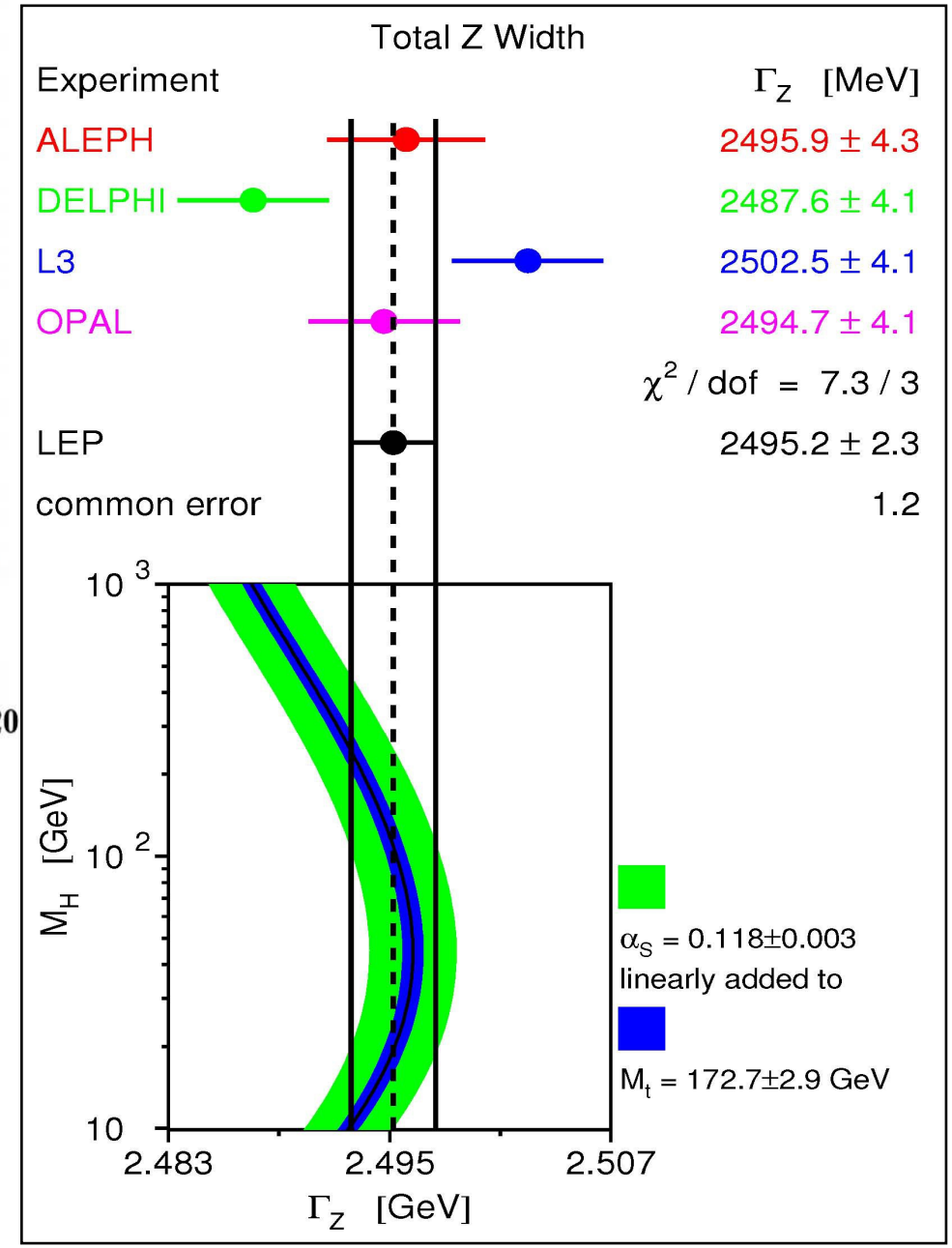




- Two (or more) Jets of Hadrons
- Total Momentum $\approx$ 0
- Total energy $\approx$ e^+e^- CMS-energy

Z resonance-curve and total width





$$M_Z = (91.1876 \pm 0.0021)\ GeV$$

$$\Gamma_Z = (2.4952 \pm 0.0023)\ GeV$$

$$\sigma_h^0 = (41.486 \pm 0.053)\ nb\ (10^{-33}\ cm^2)$$

SM test: measurement of M_Z, G_F, α

=> Prediction: $\Gamma_Z = 2.496\ GeV$ $\sigma_h^0 = 41.47\ nb$

3.2.4 Partial Widths

Z Partial Widths

$$R_{e,\mu,\tau} = \Gamma_h / \Gamma_{e,\mu,\tau}$$

$$R_e = 20.804 \pm 0.050$$

$$R_\mu = 20.785 \pm 0.033$$

$$R_\tau = 20.764 \pm 0.045$$

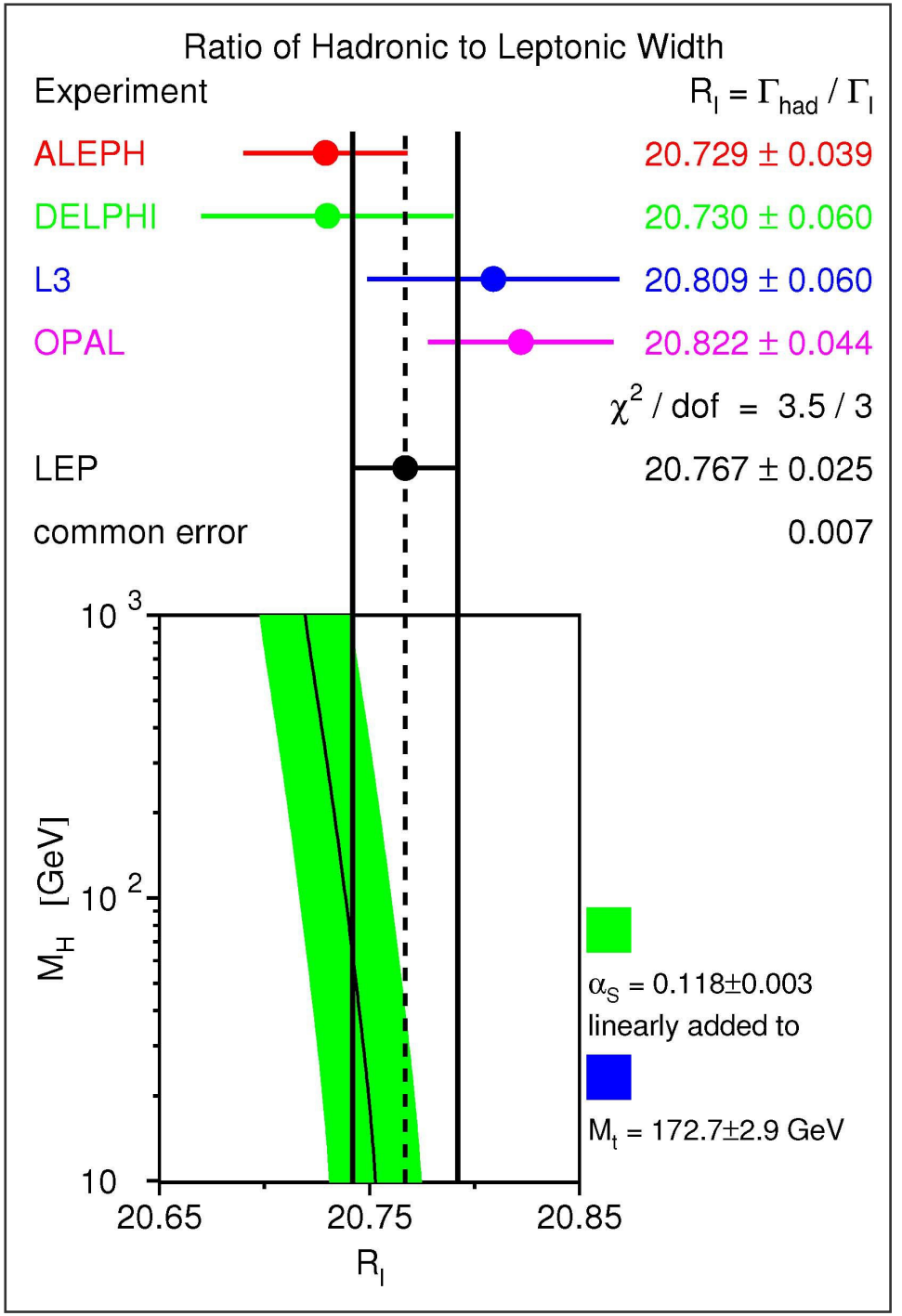
$$\Gamma_Z = (2.4952 \pm 0.0023)\ GeV$$

$$\Gamma_h = (1.7444 \pm 0.0020)\ GeV$$

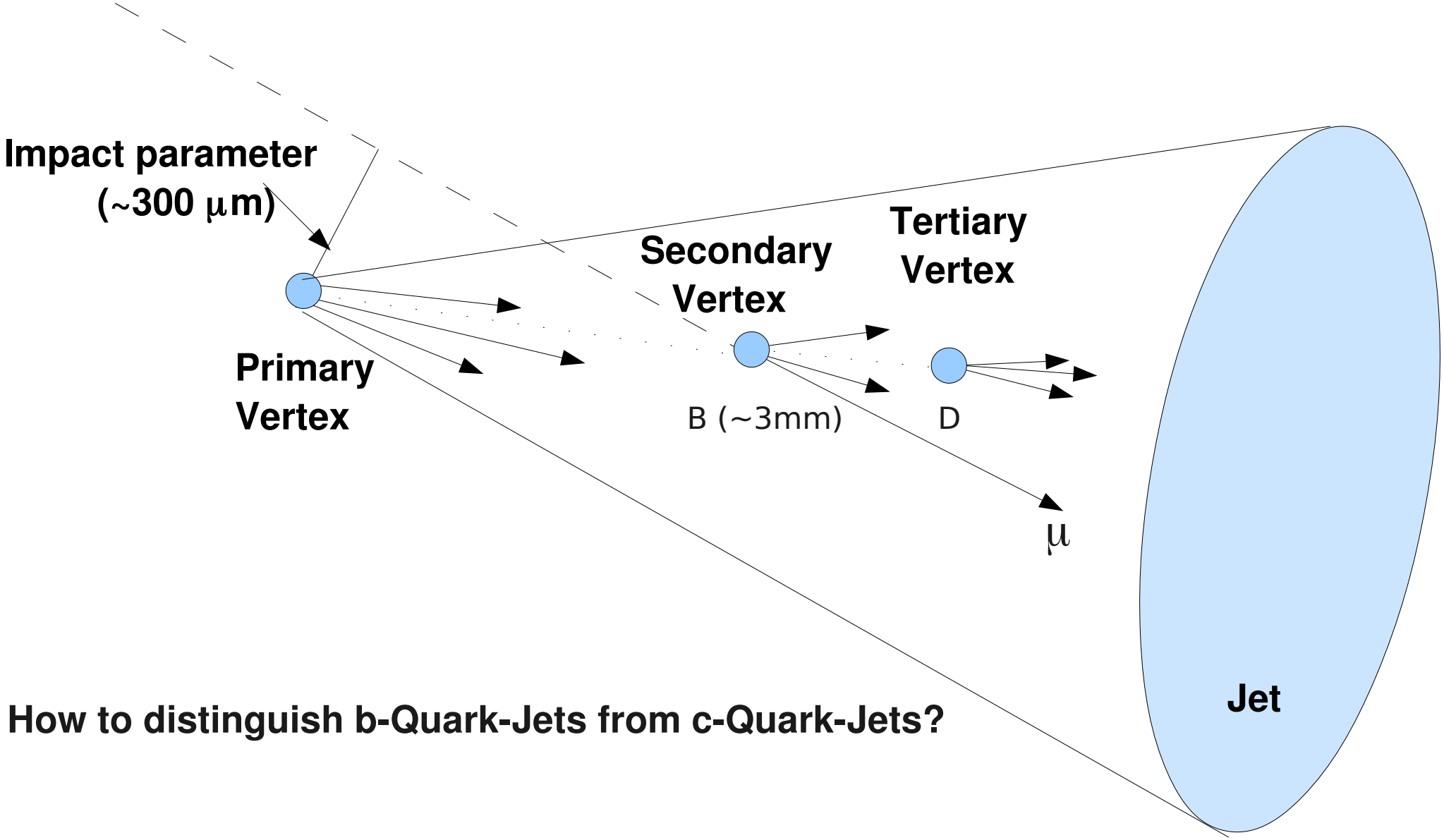
$$\Gamma_{lep} = (0.083984 \pm 0.000086)\ GeV$$

$$\Gamma_{inv} = (0.4990 \pm 0.0015)\ GeV$$

What does χ^2/dof mean?
Why does R_l depend on α_s?

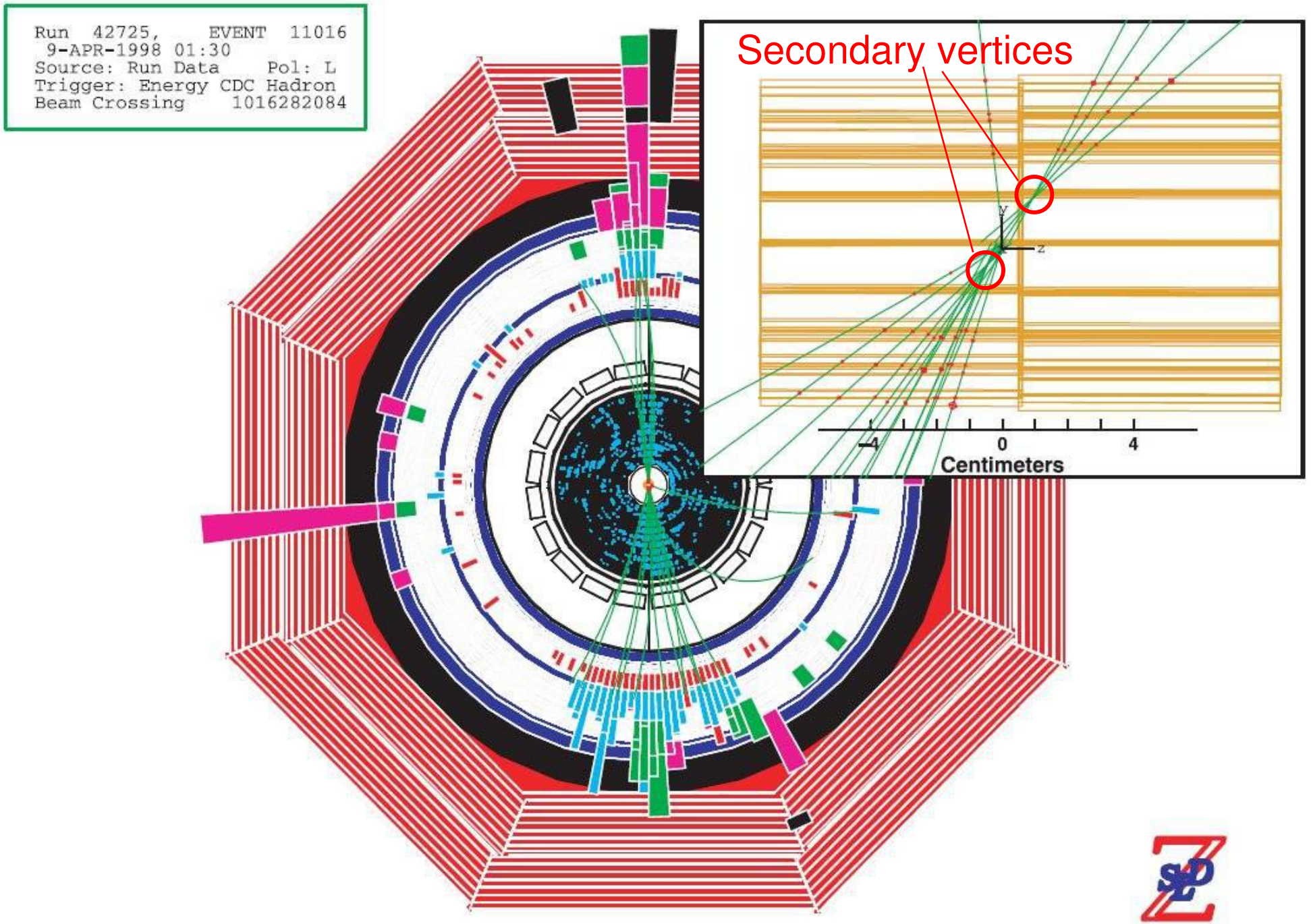


3.2.4 Partial Widths

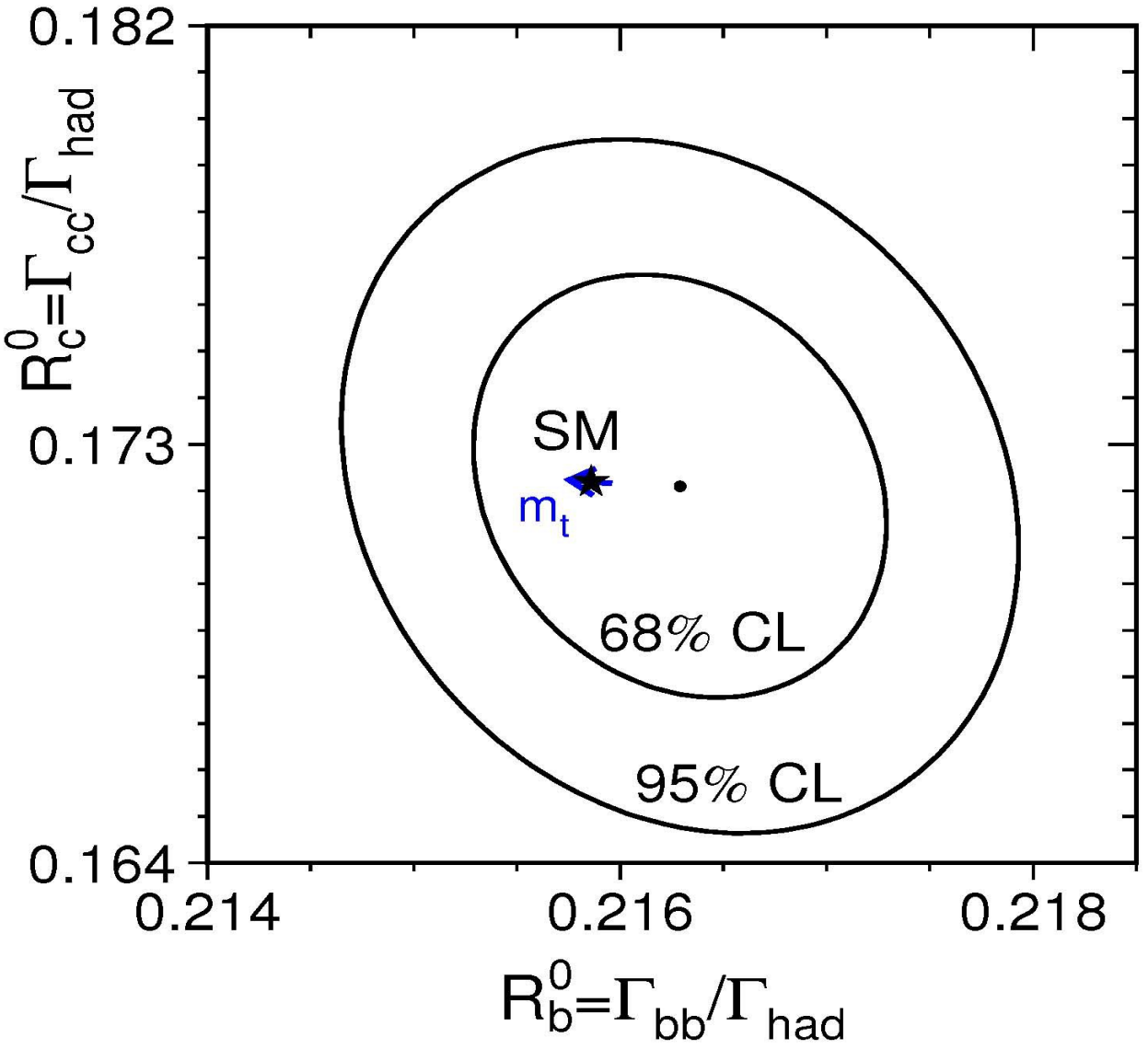


How to distinguish b-Quark-Jets from c-Quark-Jets?

Selection: $e^+e^- \to c\bar{c}, b\bar{b}$:



$R_c = 0.1721 \pm 0.0030$



Why do R_c and R_b have different values?

Why is R_b sensitive to m_t?

$R_b = 0.21629 \pm 0.00066$

3.2.5 Number of light neutrino flavors

Z-Resonance curve for different N_ν

$$\Gamma_h = \Gamma_Z - \Gamma_e - \Gamma_\mu - \Gamma_\tau - N_\nu \cdot \Gamma_\nu$$