Weak mixing angle measurement at D0

Siqi Yang

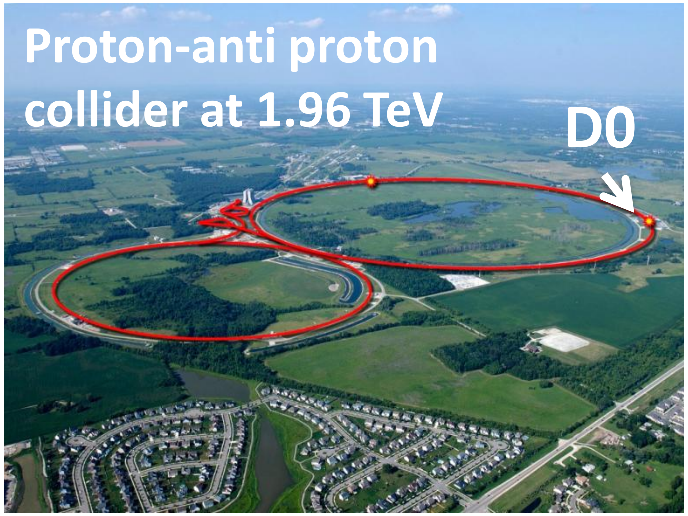
University of Science and Technology of China

On behalf of the DØ Collaboration

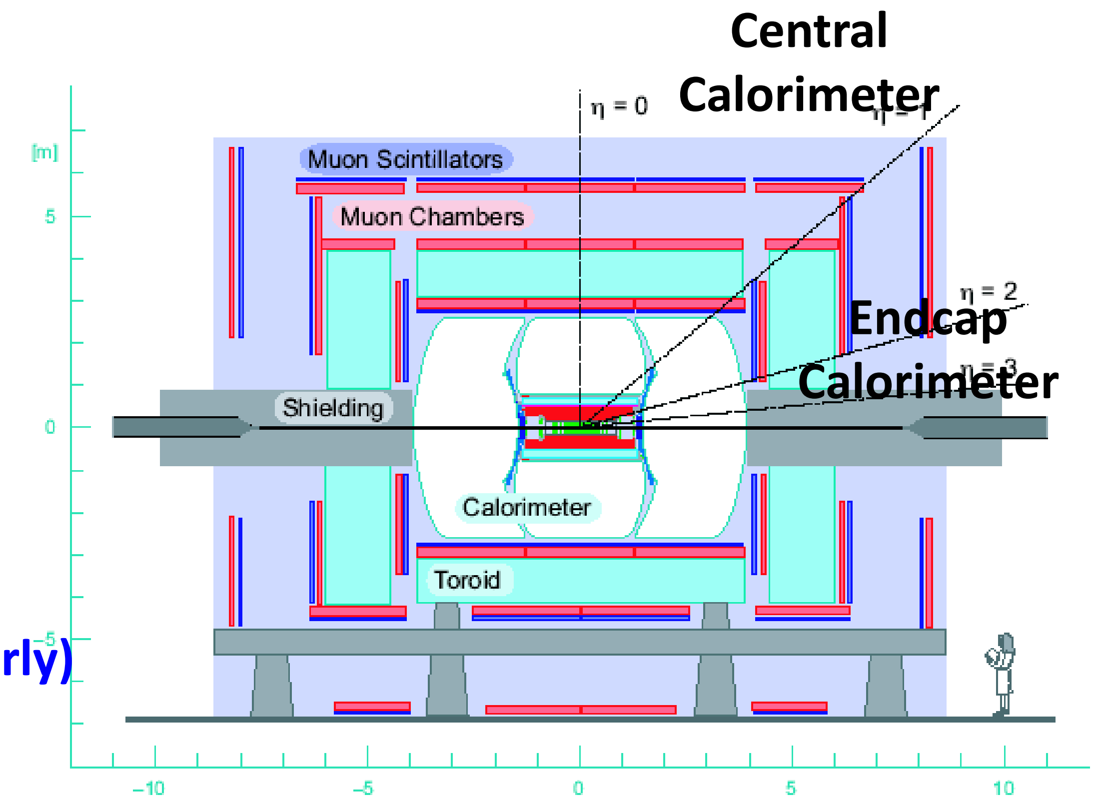
3rd LHCP

4, Sept. St. Petersburg

Tevatron and D0 detector



The D0 detector

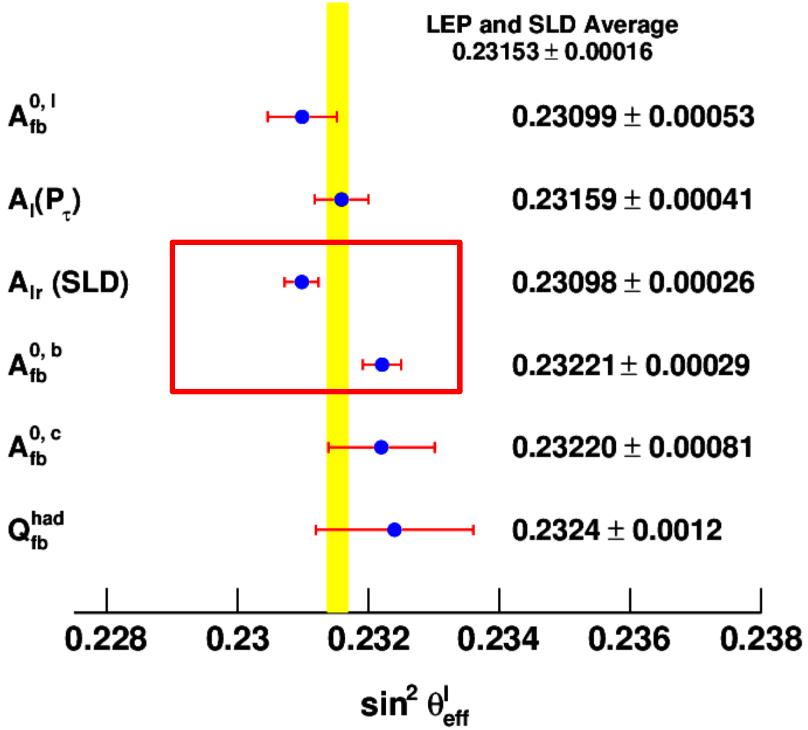


- **Tracking:**
  - **Central Fiber Tracker (CFT) + Silicon Micro-Tracker (SMT)**
  - **2T solenoid (reversed regularly)**
- **Calorimeter**
  - **Liquid Ar**
  - **EM + HAD**
- **Muon System**

Motivation (1)

The weak mixing angle ($\sin^2\theta_W$) measurement

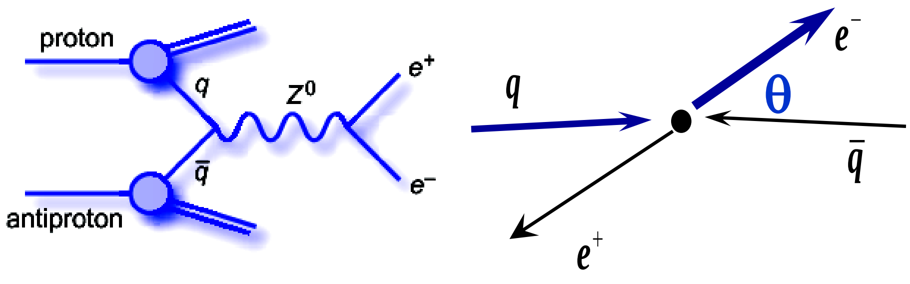
- The weak mixing angle is a fundamental parameter at Standard Model
- The most precise results differ by 3.2σ
  - LEP combined b quark result: 0.23221±0.00029
  - SLD lepton result: 0.23098±0.00026
- Extremely interesting to do the measurement on hadron collider with Z-light quark couplings involved

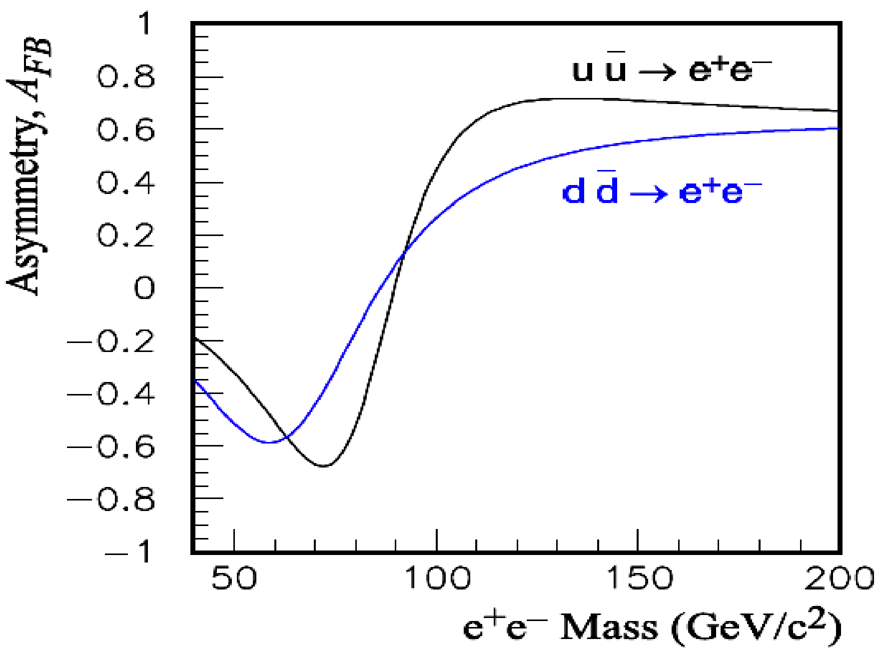


Motivation (2)

$\sin^2\theta_W$ from the Forward-Backward Charge Asymmetry (A_{FB})

- A_{FB} from Drell-Yan Z to e^+e^- events are sensitive to the weak mixing angle





Z-light quark coupling:

$$g_V^i \equiv t_{3L}(i) - 2q_i \sin^2\theta_W \ ,$$

$$g_A^i \equiv t_{3L}(i) \ ,$$

cosθ > 0: forward

cosθ < 0: backward

$$A_{FB} = \frac{\sigma_F - \sigma_B}{\sigma_F + \sigma_B}$$

Motivation (3)

Previous results (D0 5.1 fb^{-1}), electron channel: Phys. Rev.D 84, 012007 (2011)

$$\sin^2\theta^l_{eff} = 0.2309 \pm 0.0008(stat.) \pm 0.0006(syst.)$$

Error sources	$\Delta \sin^2\theta_W$
Statistical	0.00080
Systematics	0.00061
PDF	0.00048
EM scale/resolution	0.00029
MC stat.	0.00020
EM-ID	0.00008
Bkg. Modeling	0.00008
Charge MisId	0.00004
Higher order	0.00008
Total uncertainty	0.00102

Dominate uncertainties:

- **Statistics**
- **PDFs**
- **Electron energy measurement**

Expect a more precise result with D0 full data set (9.7 fb^{-1}).

$\sin^2\theta_W$ AFB measurement in $Z \rightarrow e^+e^-$ events

- **Data and MC simulations:**
  - Full D0 RunII dataset (9.7 fb^{-1}) from 2001 to 2011
  - MC from pythia + NNPDF2.3

- **Event selection:**
  - 2 high p_T electrons (p_T > 25 GeV) in Central Calorimeter (CC) or Endcap Calorimeter (EC) with spatial track match
  - 200% increase in statistics in integrated luminosity
  - 85% increase for fixed luminosity:
    - $|\eta_{det}|$ extended from 1.0 to 1.1 for CC, from 2.5 to 3.2 for EC
    - Include electrons near the calorimeter module boundary
    - Include EC-EC events
    - Track reconstruction improvements
  - Very low backgrounds contribution (< 1.0 %)

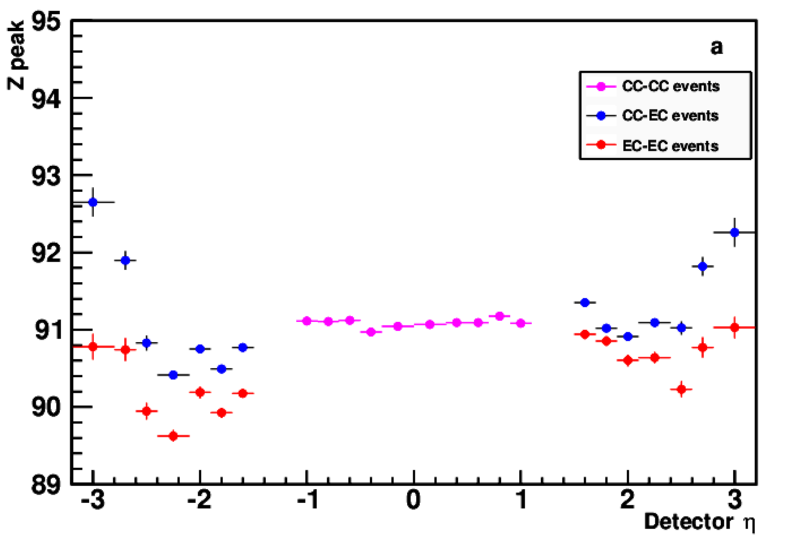
Electron Energy Calibration (1)

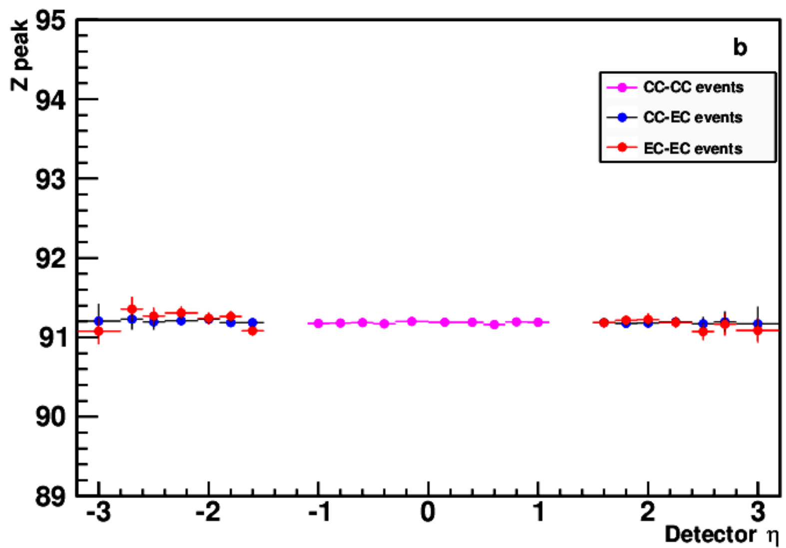
- **Previous analysis:**
  - **An overall scale factor applied on MC electron energy**
  - **Factor determined by data-MC mass distribution comparison**

- **New energy calibration method:**
  - **Separately for data and MC**
  - **Correct energy as a function of L_{inst} and η_{det}**
  - **Tune the correction factors by correcting Z mass peak to LEP (91.1875 GeV)**

Electron Energy Calibration (2)

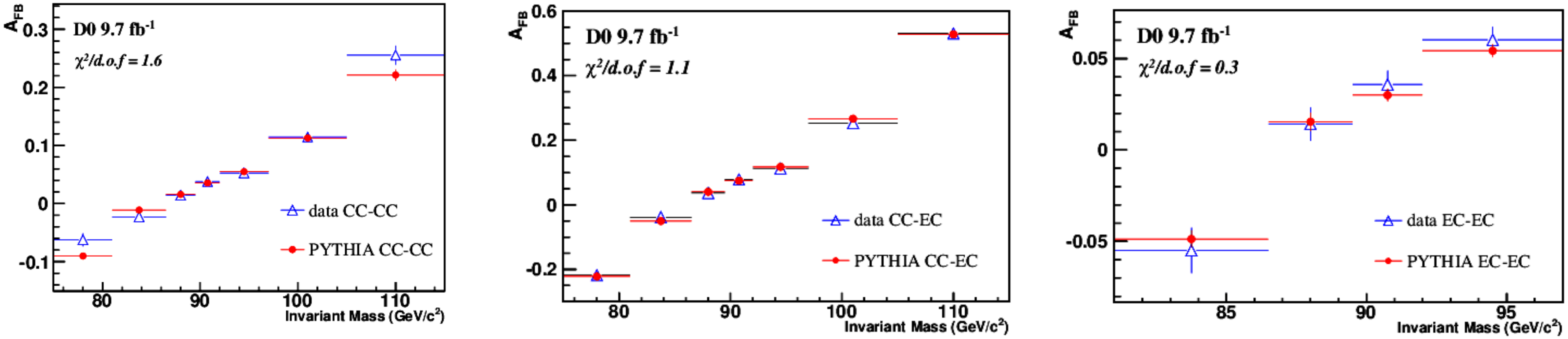
- After New energy calibration:
  - Z peak L_{inst} dependence negligible
  - Z peak η_{det} dependence reduced from 2 GeV to 100 MeV (data) and 10 MeV (MC)





Z peak dependence with η_{det} before (a) and after (b) energy calibration.

Results



$\sin^2\theta_W$ extracted from A_{FB} distribution

	CC-CC	CC-EC	EC-EC	Combined
$\sin^2\theta_W$	0.23142	0.23143	0.22977	0.23139
Statistical	0.00116	0.00047	0.00276	0.00043
Systematic	0.00009	0.00009	0.00019	0.00008
Energy Calibration	0.00003	0.00001	0.00004	0.00001
Energy Smearing	0.00001	0.00002	0.00013	0.00002
Background	0.00002	0.00001	0.00002	0.00001
Charge Misidentification	0.00002	0.00004	0.00012	0.00003
Electron Identification	0.00008	0.00008	0.00005	0.00007
Fiducial Asymmetry	0.00002	0.00001	0.00001	0.00001
Total	0.00116	0.00048	0.00277	0.00044

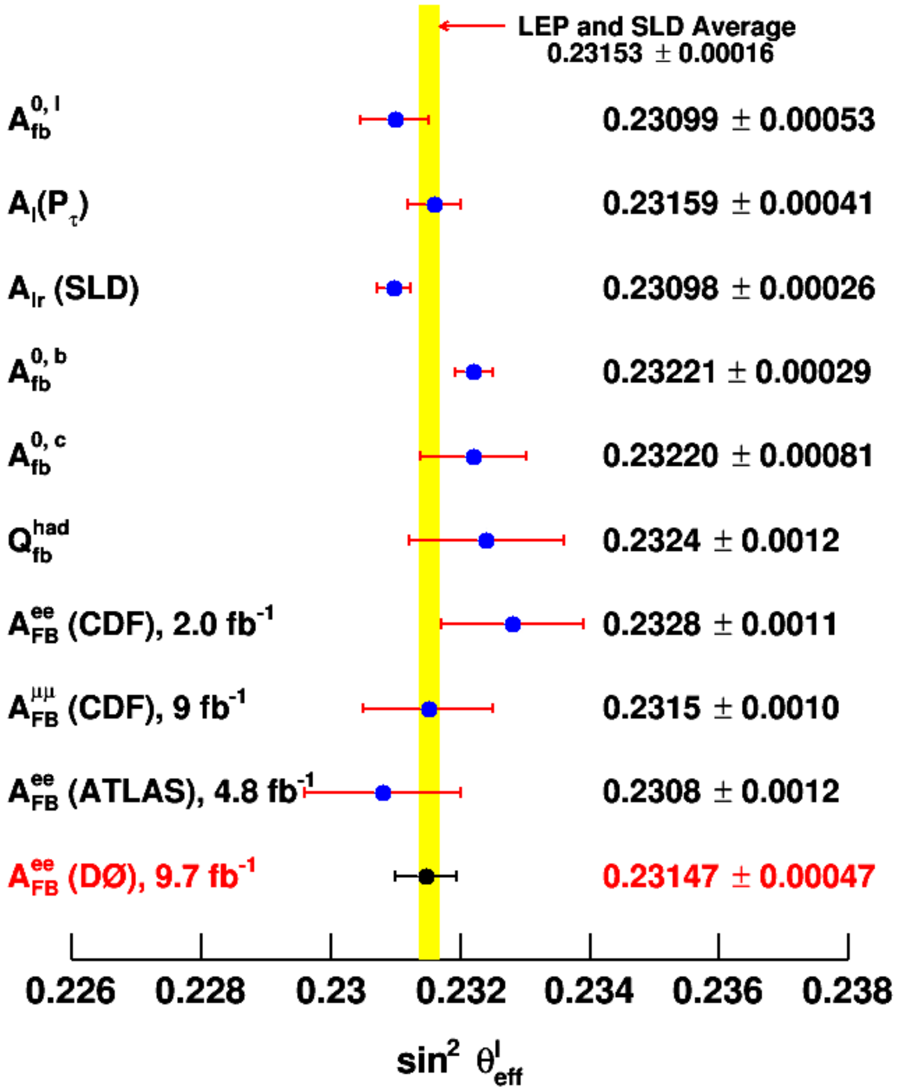
The measured $\sin^2\theta_W$:

$$\sin^2\theta_W = 0.23139 \pm 0.00043(stat.) \pm 0.00008(syst.) \pm 0.00017(PDF)$$

With on-shell renormalization scheme, higher order correction:

$$\sin^2\theta_{eff}^{l} = 0.23147 \pm 0.00047$$

Comparison with other experiments



The most precise measurement from light quark interaction;

Precision close to the best LEP and SLD results; Result close to the average.

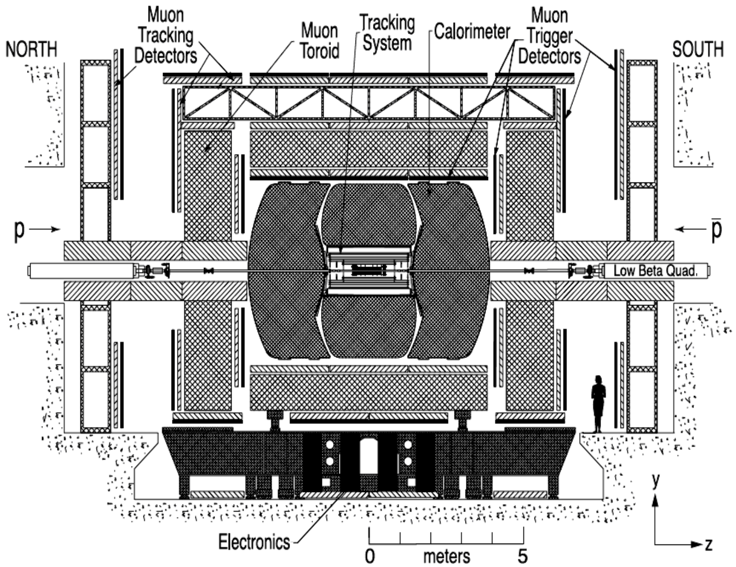
Phys. Rev. Lett. 115, 041801(2015)

Summary

- **We measured the weak mixing angle as 0.23147 ± 0.00047:**
  - **The most precise result from light quark interactions**
  - **Close to the best LEP and SLD measurement precision**
  - **Significantly improved by extending the acceptance and apply a new energy calibration method**

Backup

D0 detector



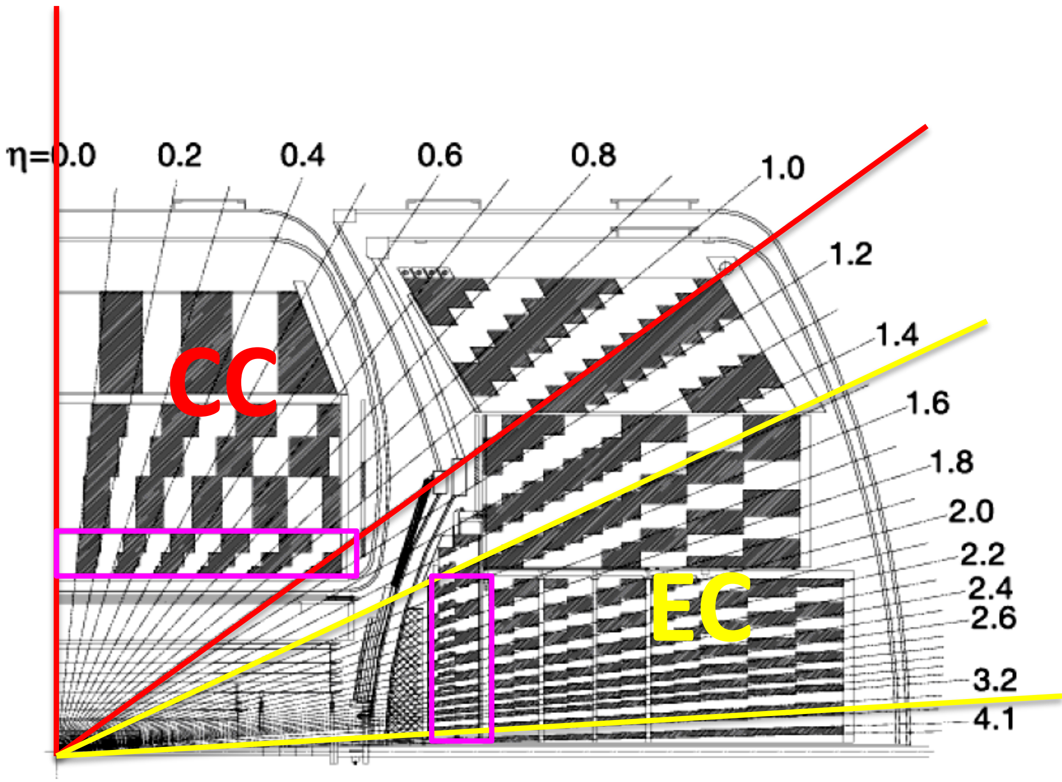
DØ Detecting system

Calorimeter:

|η|<1.1: Central Calorimeter (CC)

1.5<|η|: Endcap Calorimeter (EC)

** only 1.5<|η|<3.2 used here



DØ Calorimeter

Why chose electron channel?

Liquid Argon Calorimeter provides a precise energy measurement

Collins-soper frame