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Measurement of the Muon Anomalous Magnetic Moment to 0.7 ppm

Results from the Data of 2000

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Muon g-2 Collaboration

$$a_\mu = \frac{\omega_a}{\frac{e}{m_\mu}\langle B \rangle}$$

Muon g-2 Collaboration

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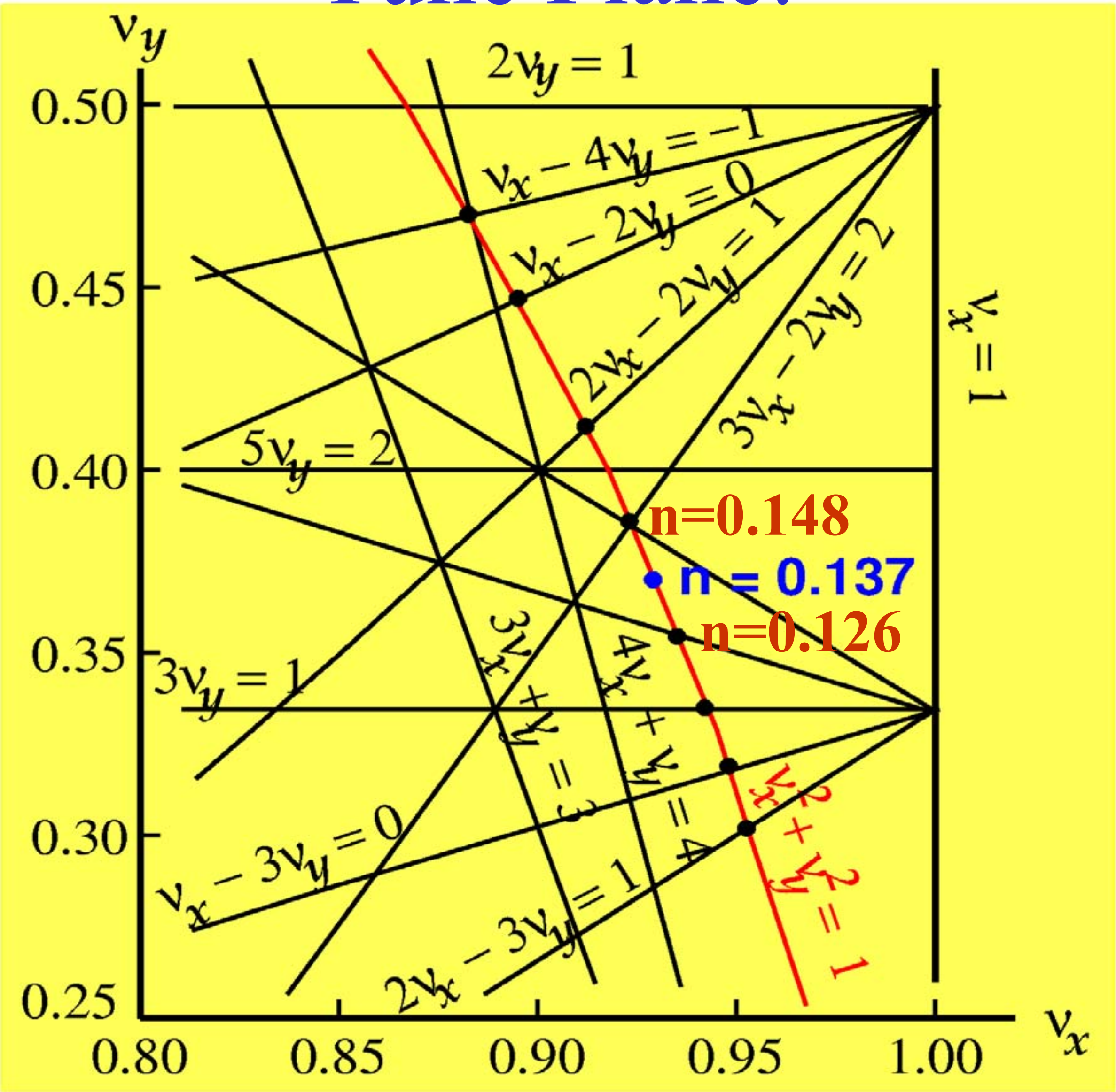
- The Muon Storage Ring: $B \approx 1.45T$, $P_{\mu} \approx 3.09$ GeV/c
- Inner Ring of Detectors
- High Proton Intensity from AGS
- Muon Injection

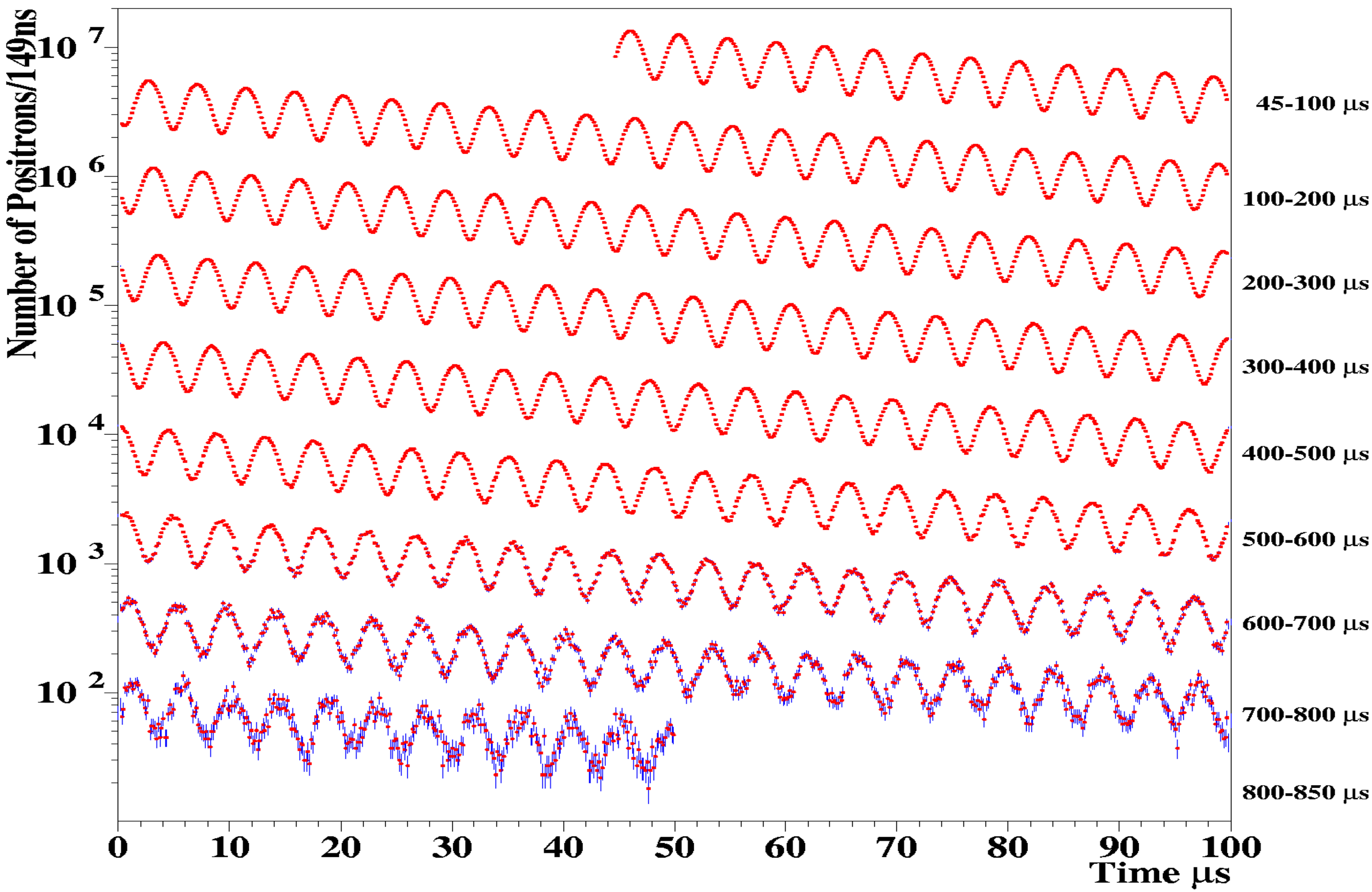
Weak Focusing Ring.
Tune Plane:



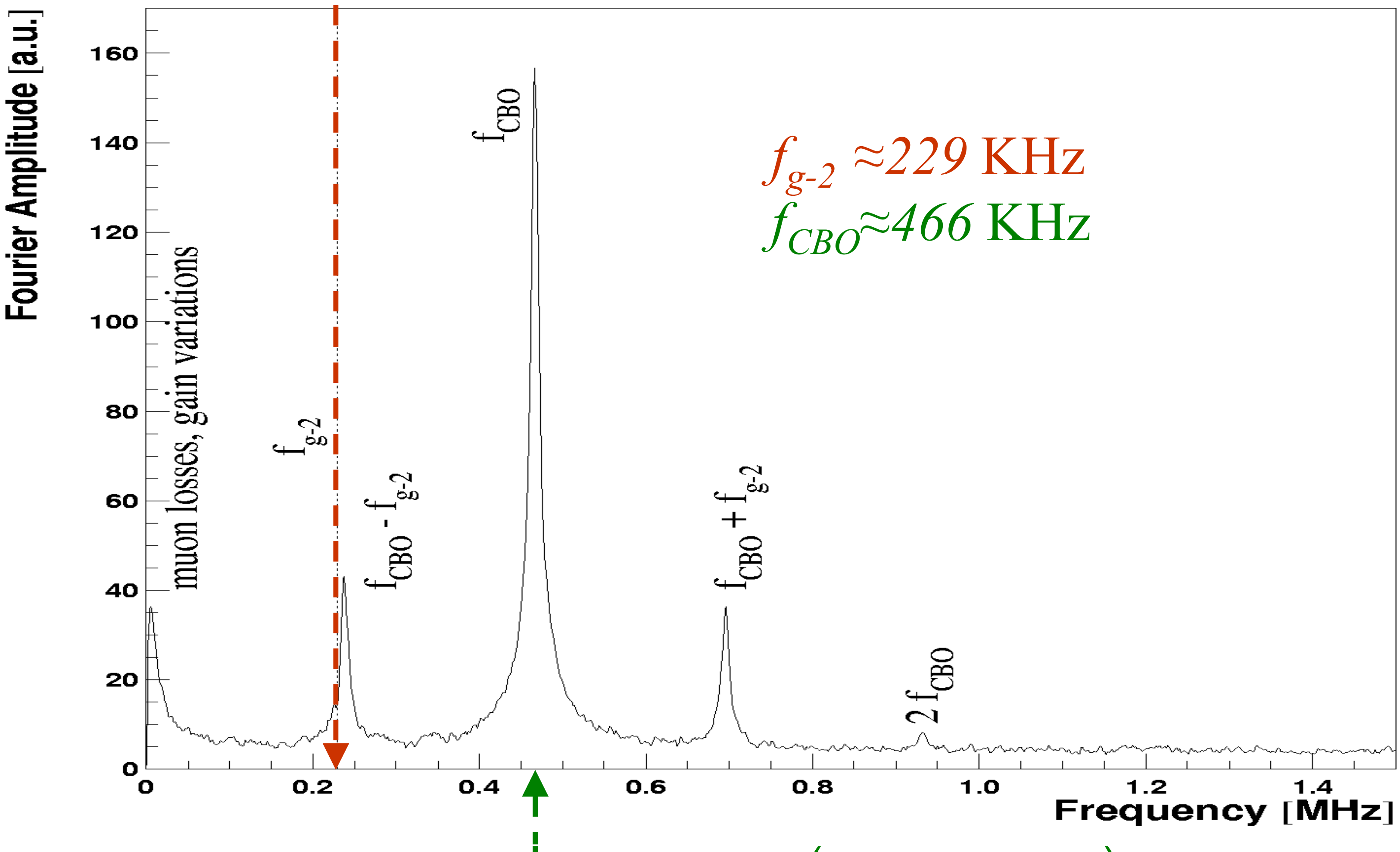
Field Focusing Index: n=0.137

4 Billion e^+ with E>2GeV

$$dN/dt = N_0 e^{-\frac{t}{\tau}}\left[1 + A\cos(\omega_a t + \phi_a)\right]$$



5-parameter Function Not Quite Adequate. Fourier Spectrum of the Residuals:



$$f_{CBO} \approx f_C\left(1-\sqrt{1-n}\right)$$

Modulation of N_0, A, ϕ_a with f_{cbo}:

$$dN/dt = N_0(t)e^{-\frac{t}{\tau}}\left[1 + A(t)\cos\left(\omega_a t + \phi_a(t)\right)\right]$$

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$$N_0(t) = N_0\left[1 + A_N e^{-\frac{t}{\tau_{cbo}}}\cos(2\pi f_{cbo} t + \phi_N)\right]$$

$$A(t) = A\left[1 + A_A e^{-\frac{t}{\tau_{cbo}}}\cos(2\pi f_{cbo} t + \phi_A)\right]$$

$$\phi_a(t) = \phi_a + A_\phi e^{-\frac{t}{\tau_{cbo}}}\cos(2\pi f_{cbo} t + \phi_\phi)$$

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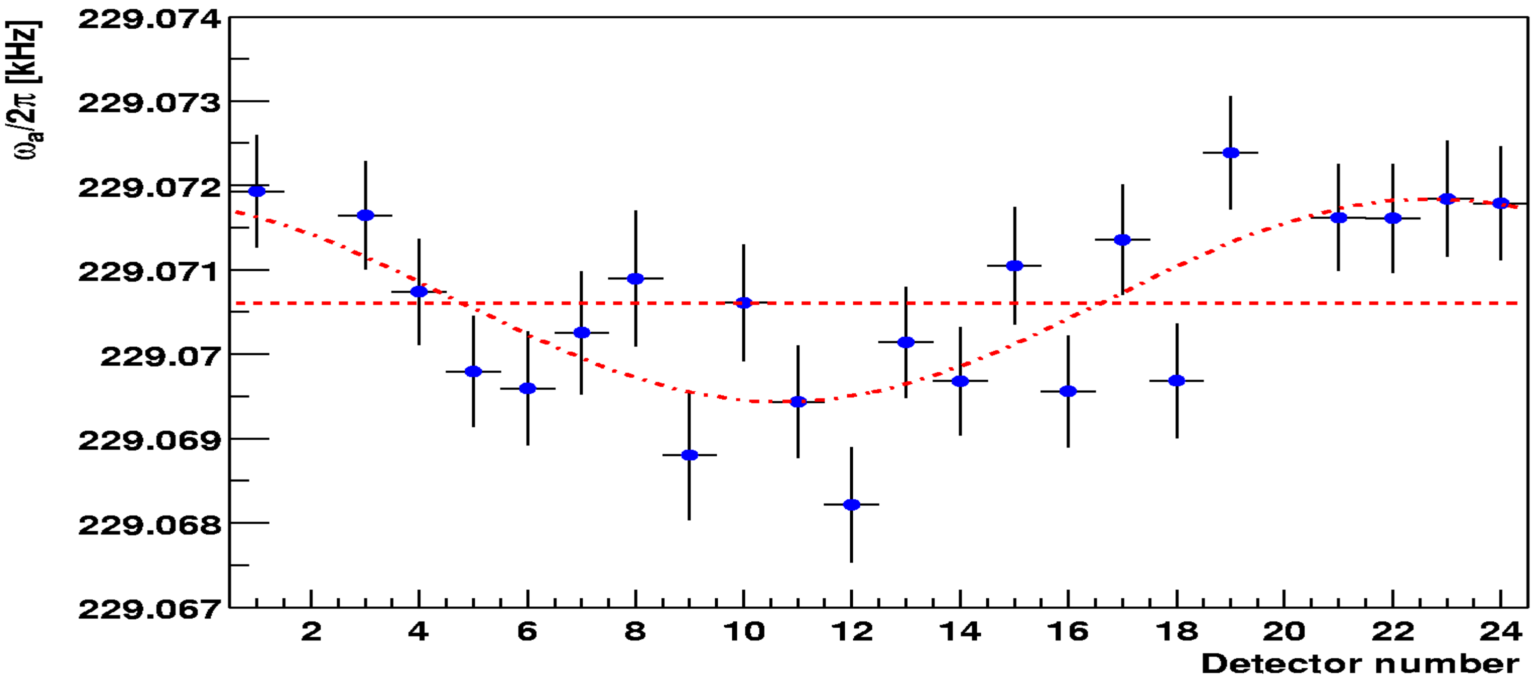
Amplitudes of A_N, A_A, A_ϕ, Consistent with Values from MC Simulations.

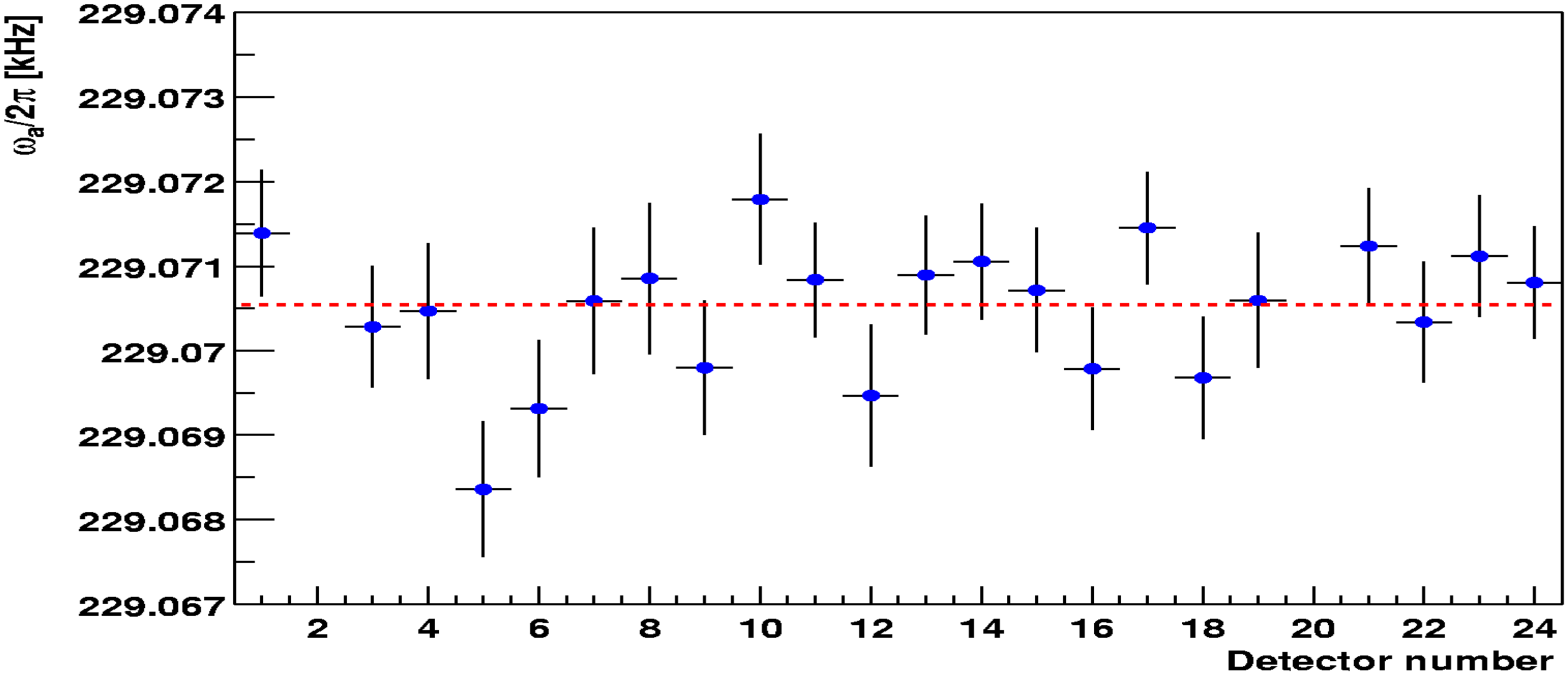
Fit *dN/dt* of each Detector Separately with the 5-parameter (ideal) Function. Then Fit ω_a versus Detector:

- Straight line fit: χ^2/dof=59/21, $\omega_a/2\pi=229070.60\pm0.14$ *Hz*
- Sine wave fit: χ^2/dof=24/19, $\omega_a/2\pi=229070.64\pm0.14$ *Hz*



Fit *dN/dt* with the 5-parameter Function including the Modulation of N_0, A, ϕ_a with f_{cbo}. Fit ω_a versus Detector:

- Straight line fit: χ^2/dof=24/21, $\omega_a/2\pi = 229070.54 \pm 0.16$ *Hz*



Four Independent Analyses of ω_a Using Various Studies:

- Function Modulating N_0, A,   with f_{cbo}.

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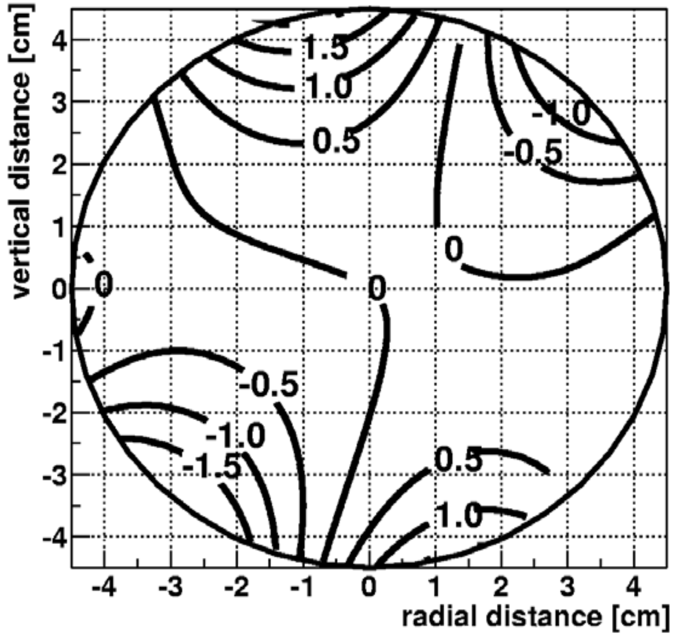
Systematic Uncertainties for the ω_a Analysis.

Source of Errors	Size [ppm]
Coherent Betatron Oscillations (CBO)	0.21
Pileup	0.13
Gain Changes	0.13
Lost Muons	0.10
Binning & Fitting Procedure	0.06
Others	0.06
Total	0.31

Magnetic Field Measurement



Multipoles [ppm]

	normal	skew
Quad	0.24	0.29
Sext	-0.53	-1.06
Octu	-0.10	-0.15
Decu	0.82	0.54

Systematic Uncertainties for the ω_p Analysis.

Source of Errors	Size [ppm]
Absolute Calibration of Standard Probe	0.05
Calibration of Trolley Probe	0.15
Trolley Measurements of B-field	0.10
Interpolation with Fixed Probes	0.10
Uncertainty from Muon Distribution	0.03
Others	0.10
Total	0.24

Computation of a_μ:

$$a_\mu = \frac{\omega_a}{\frac{e}{m_\mu}\langle B\rangle} = \frac{\omega_a/\omega_p}{\mu_\mu/\mu_p - \omega_a/\omega_p}$$

- *Analyses of ω_a and ω_p are Separate and Independent ("**<u>Blind Analysis</u>**"). When Ready, only then, Offsets are Removed and a_μ is Computed.*

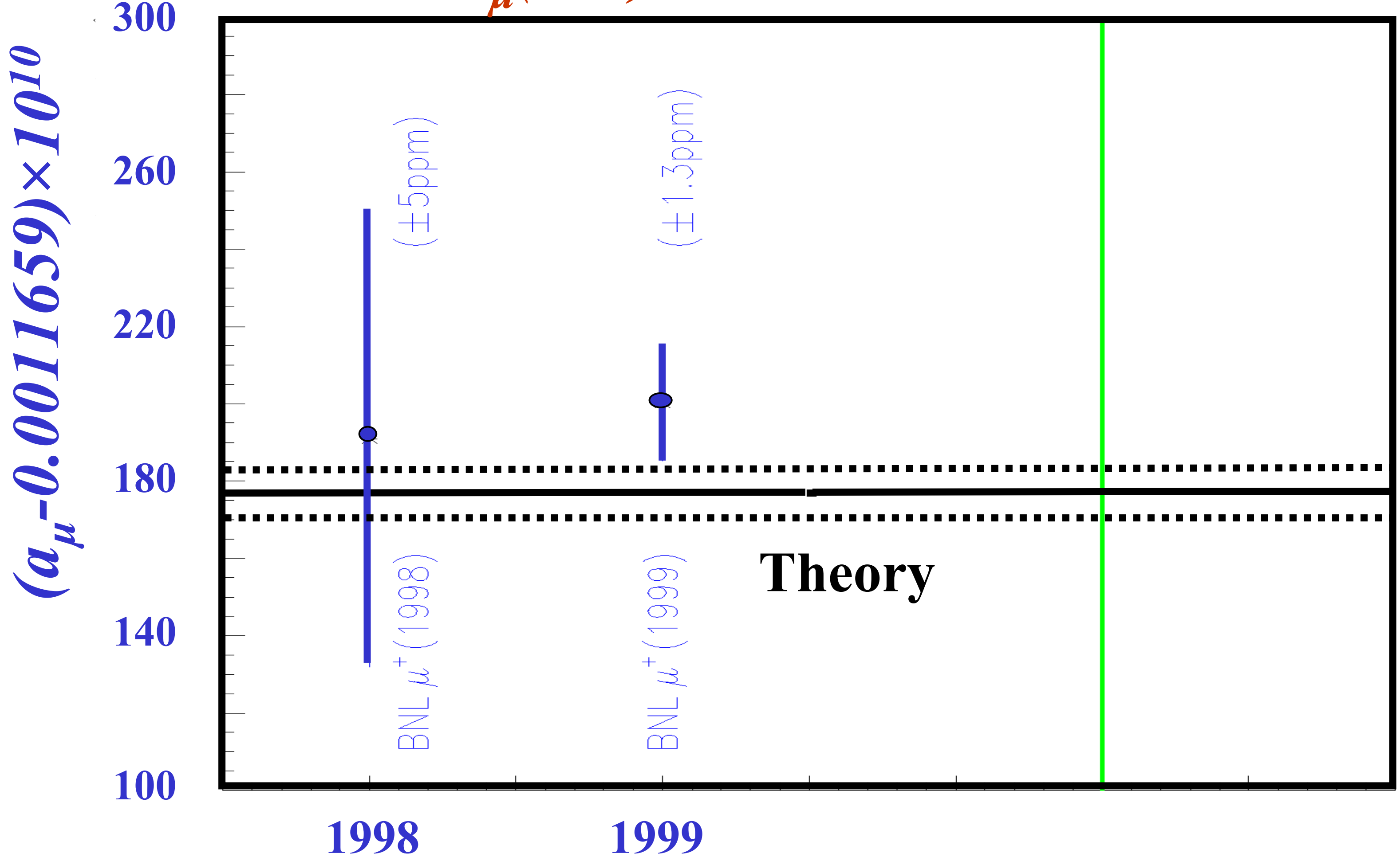
Results

$a_\mu(SM)=11\ 659\ 178(7)\times10^{-10}$ (0.6 ppm)

See, e.g., review article by J. Hisano, hep-ph/0204100

Also talks by Z. Bern and T. Teubner at ICHEP02

Caution: More $a_\mu(SM)$ out there and more to come!



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From the Data of 2000:

$a_\mu(exp) = 11\ 659\ 204(7)(5) \times 10^{-10}$ (0.7 ppm)

Exp. World Average:

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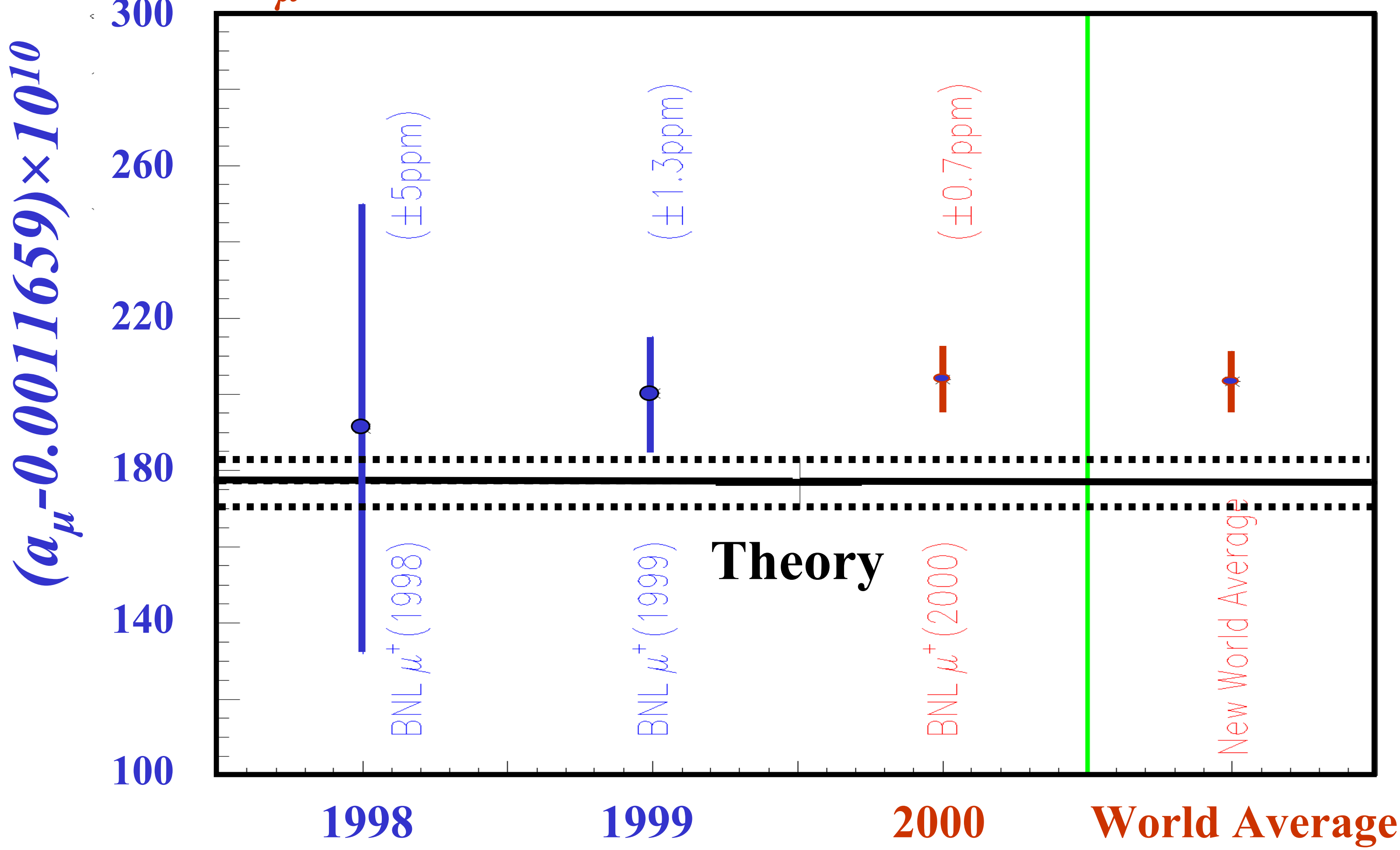

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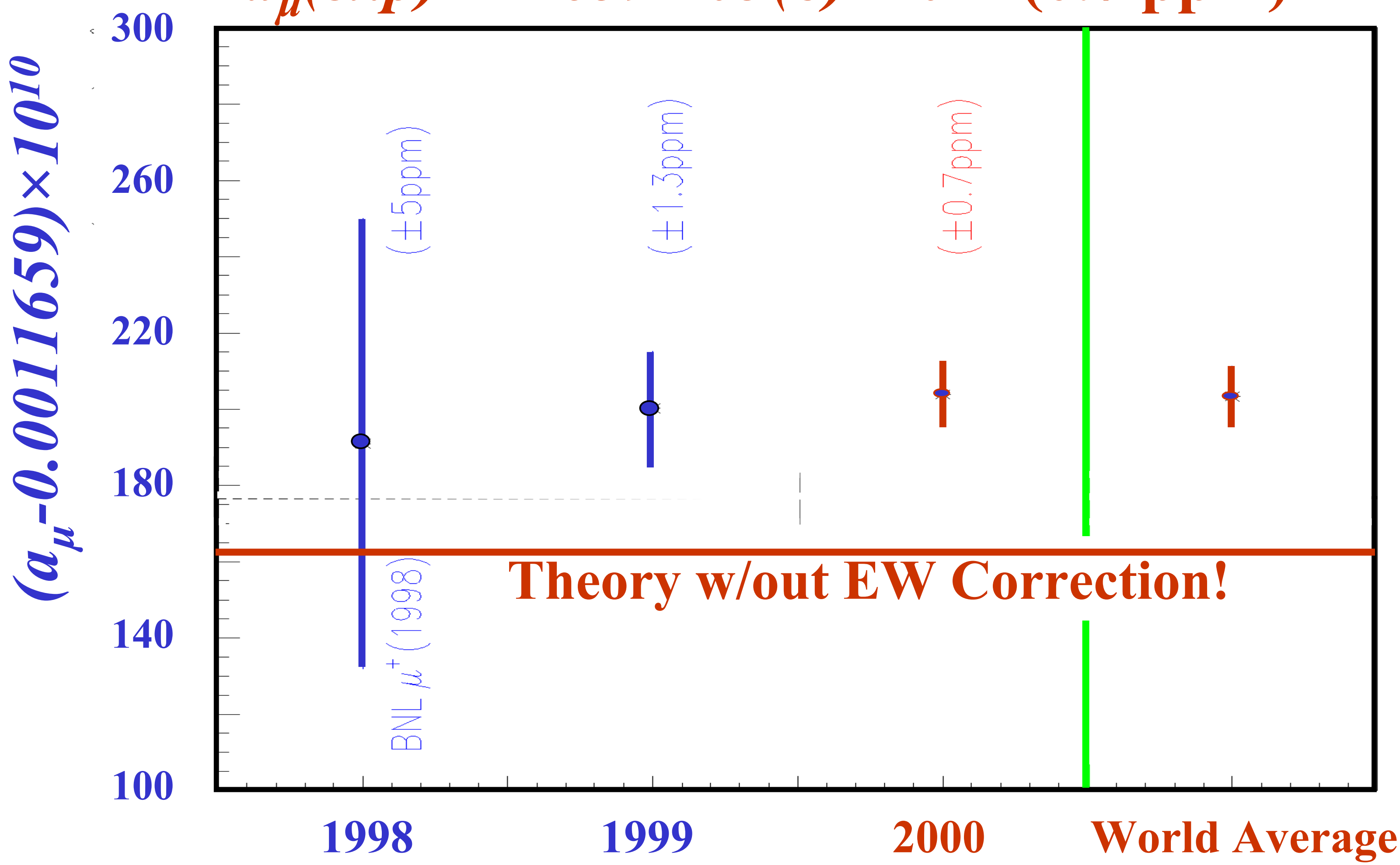

Outlook

- In 2001 we have collected 3 Billion electrons with E>2GeV from a run with negative muons (μ^-). Run at n=0.122 and n=0.142.

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- We have scientific approval for more running time aiming to collect an extra 6 Billion electrons.
- However, the President's budget does not include running time for the AGS & now is in Congress' hands.

Summary:

- ***$a_\mu(exp)=11\ 659\ 203(8)\times10^{-10}$* (0.7 ppm); Sensitive to EW Contribution.**
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- New evaluation of *a_μ(SM)* is to be announced soon by Davier, Eidelman, *et al.*, including new e^+e^- data.
- More data from Novosibirsk, Beijing, … will even further improve knowledge of *a_μ(had1)*.

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- Stay Tuned!