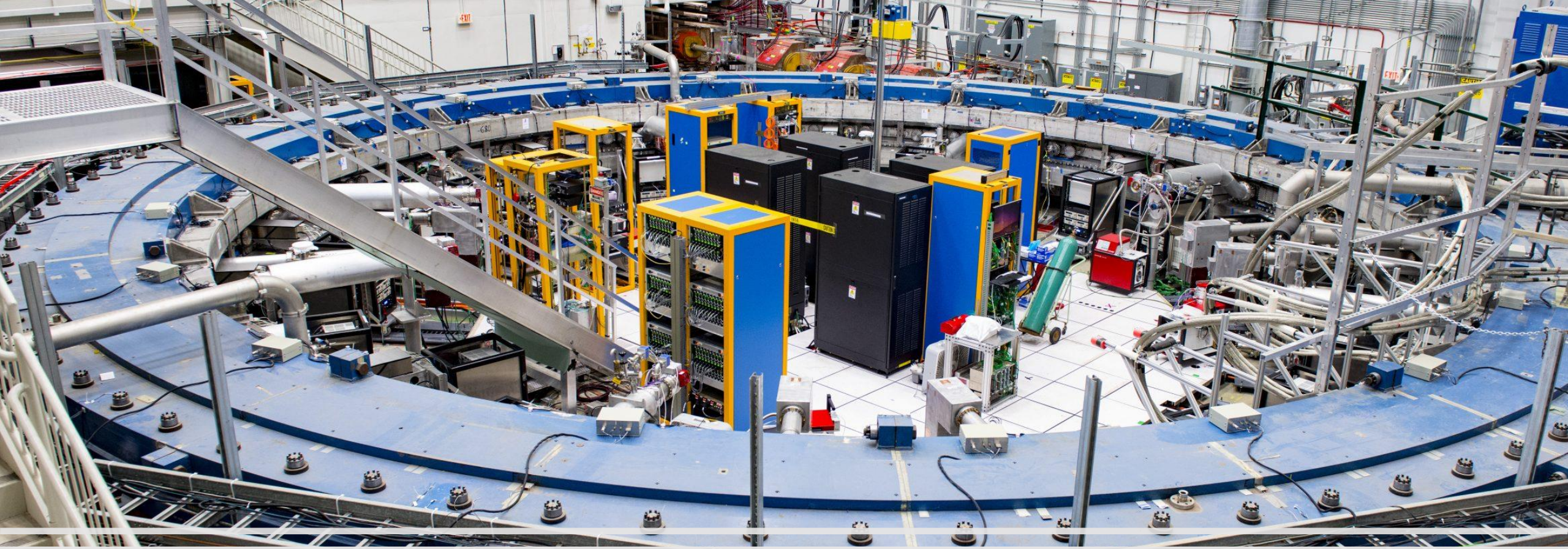


Systematic error of E989 due to beam dynamics

Lorenzo Cotrozzi, Unipi

106° Congresso Nazionale SIF 14 – 18 Settembre 2020

Anomalia magnetica

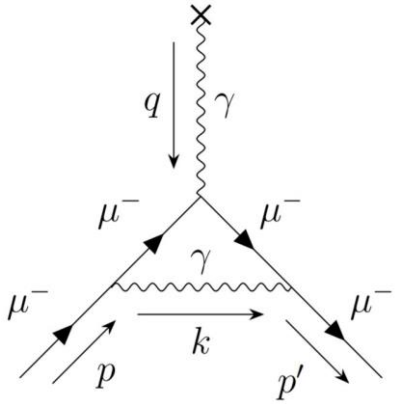
- g-factor del muone

$$\vec{\mu} = g\frac{q}{2m}\vec{S}$$

- Equazione di Dirac

$$(i\gamma^{\mu}_{\alpha\beta}\partial_{\mu} - m\delta_{\alpha\beta})\psi_{\beta}(x) = 0 \qquad \Rightarrow \qquad g = 2$$

- Correzioni di QFT: Schwinger, 1948



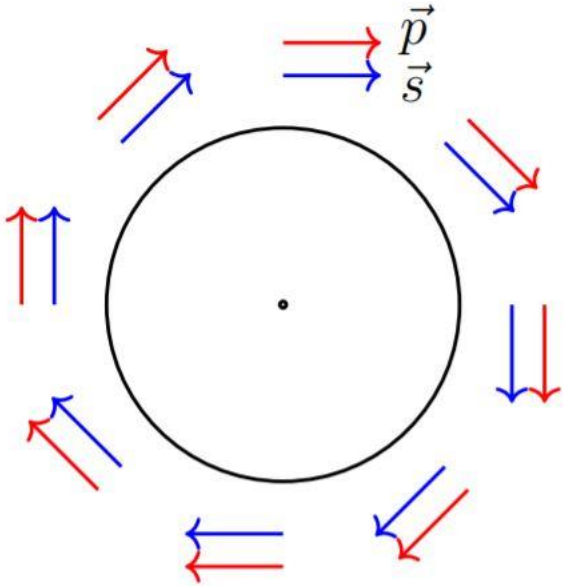
$$\Rightarrow \qquad a_{\mu} \equiv \frac{g_{\mu} - 2}{2} \approx \frac{\alpha}{2\pi}$$

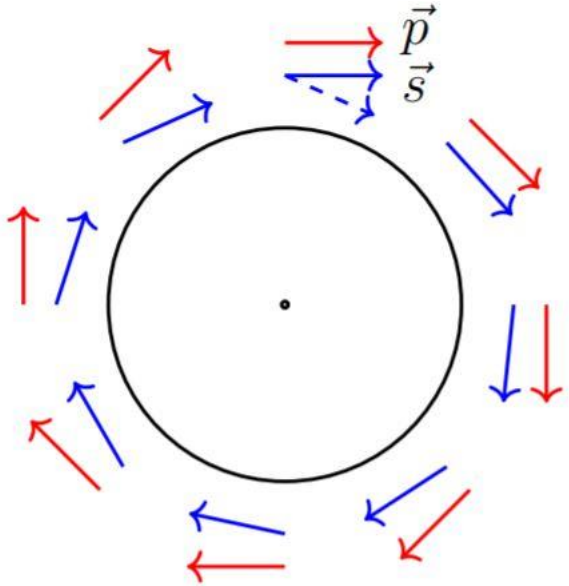
- Beyond Standard Model

$$a_{\mu}^{exp} - a_{\mu}^{SM} = 279(76) \times 10^{-11}$$

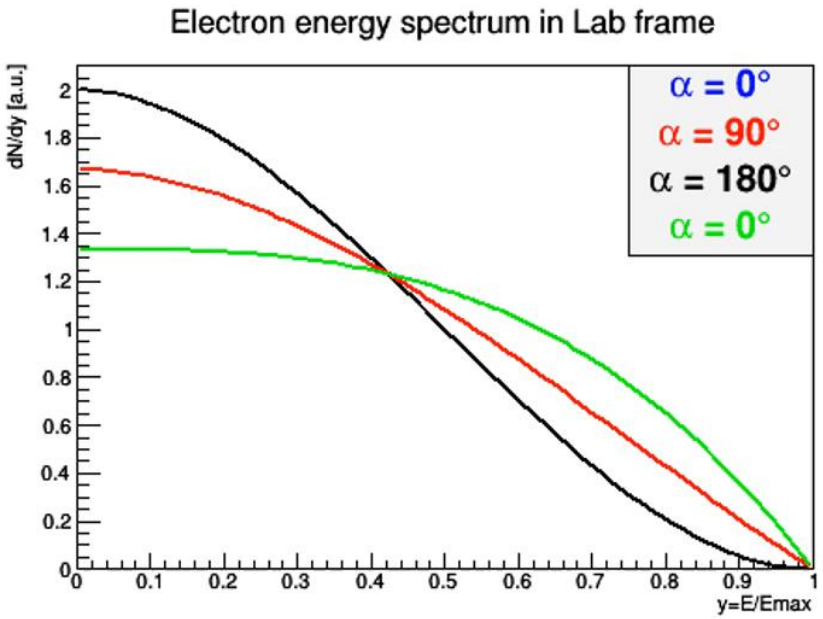
Frequenza anomala di precessione

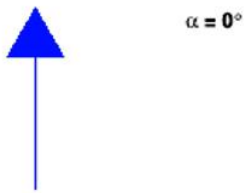
- Muoni in campo magnetico



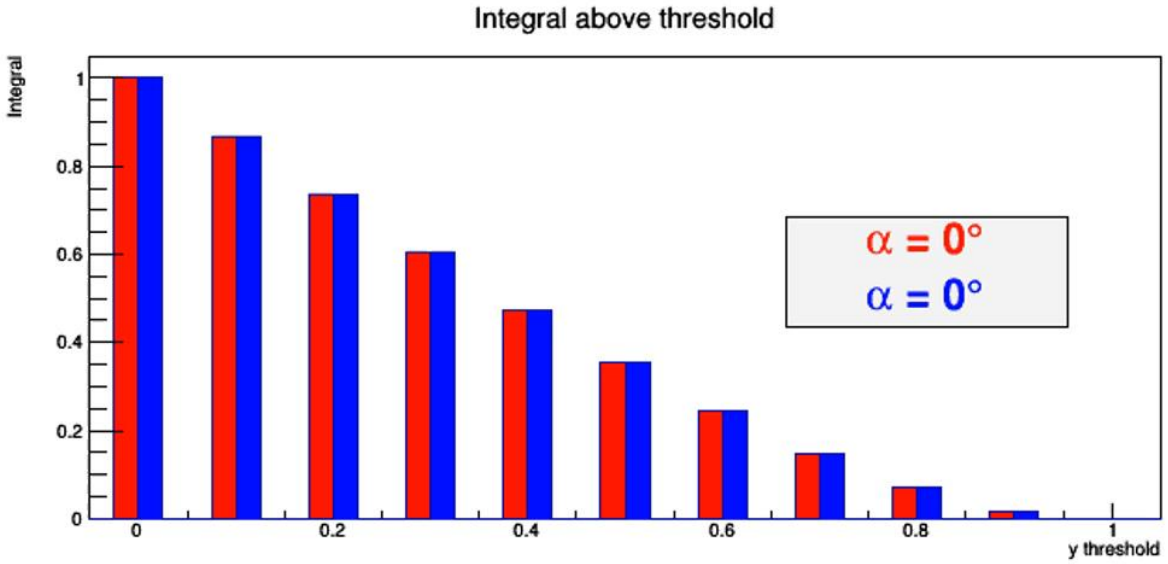


$$\vec{\omega}_a = \vec{\omega}_s - \vec{\omega}_c = -\frac{e}{mc}\, a_\mu \vec{B}$$





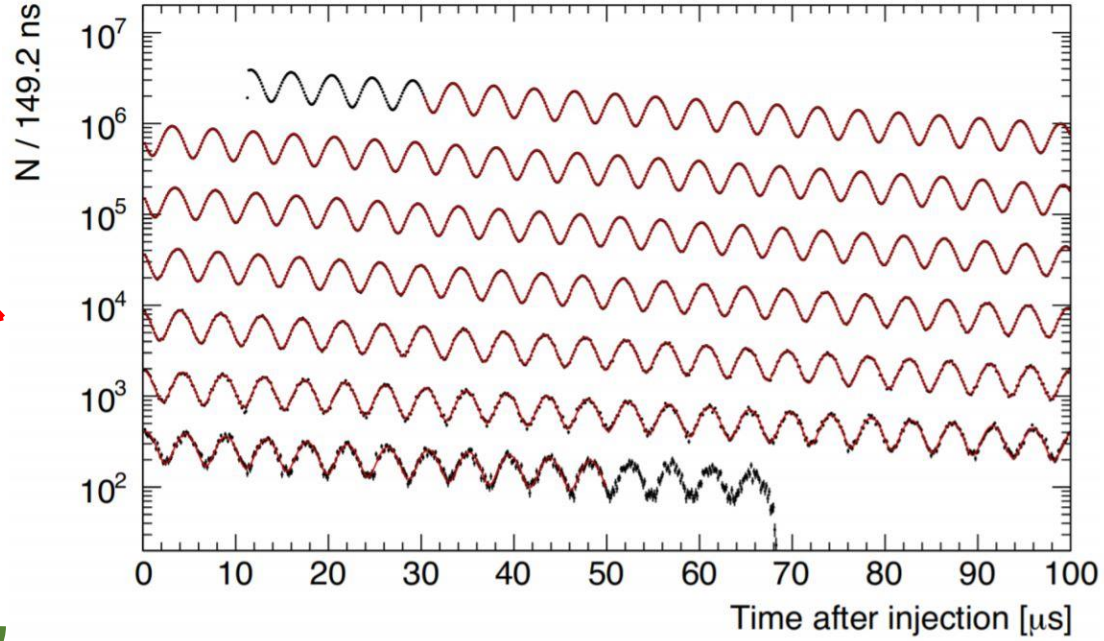
Red arrow: μ momentum
Blue arrow: μ spin



Errori sistematici

Guadagno

Pileup



Lost muons

(Vedere presentazione di M. D. Galati)

CBO

E-field and pitch

Effetti di rivelatore

(Vedere presentazione di P. Girotti)

Effetti di fascio

Coherent Betatron Oscillation

- Funzione a 5 parametri

$$N_{5par}(t) = N_0 e^{-\frac{t}{\tau}}[1 + A\cos(\omega_a t + \phi)]$$

- Aggiungo 4 parametri

$$N_{9par}(t) = N_{5par}(t) \cdot \left[1 - A_{CBO} e^{-\frac{t}{\tau_{CBO}}} (\cos(\omega_{CBO} t) + \phi_{CBO})\right]$$

- Altri 4 parametri (verticale)

Frequenza	Simbolo	Valore tipico [MHz]
Ciclotrone	ω_C	6.71
Precessione anomala	ω_a	0.23
CBO	ω_{CBO}	0.37
CBO verticale	ω_v	2.19

E-field e Pitch

- A priori

$$\vec{\omega}_a = \vec{\omega}_s - \vec{\omega}_c = -\frac{e}{mc}\left[a_\mu \vec{B} - \left(a_\mu - \frac{1}{\gamma^2 - 1}\right)\vec{\beta} \times \vec{E} - a_\mu \left(\frac{\gamma}{\gamma + 1}\right)\left(\vec{\beta} \cdot \vec{B}\right)\vec{\beta}\right]$$

$$\boldsymbol{\gamma = 29.3} \qquad \boldsymbol{\vec{\beta} \cdot \vec{B} = 0}$$

- Momento magico e fascio perpendicolare al campo magnetico

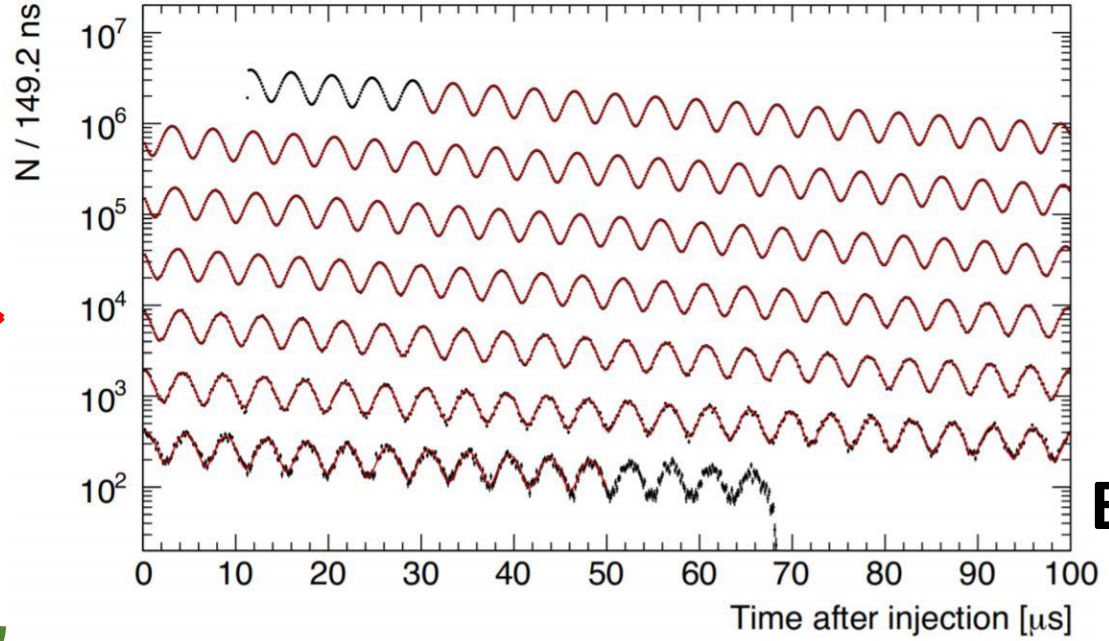
- Correzioni: n =0.107, R_0 =7112 mm

$$C_E = -2n(1-n)\beta^2 \frac{<x_e^2>}{R_0^2} \qquad C_P = -\frac{n}{4}\frac{<y^2>}{R_0^2}$$

Errori sistematici

Guadagno: 20ppb

Pileup: 40 ppb



Lost muons: 20 ppb

CBO: 30 ppb

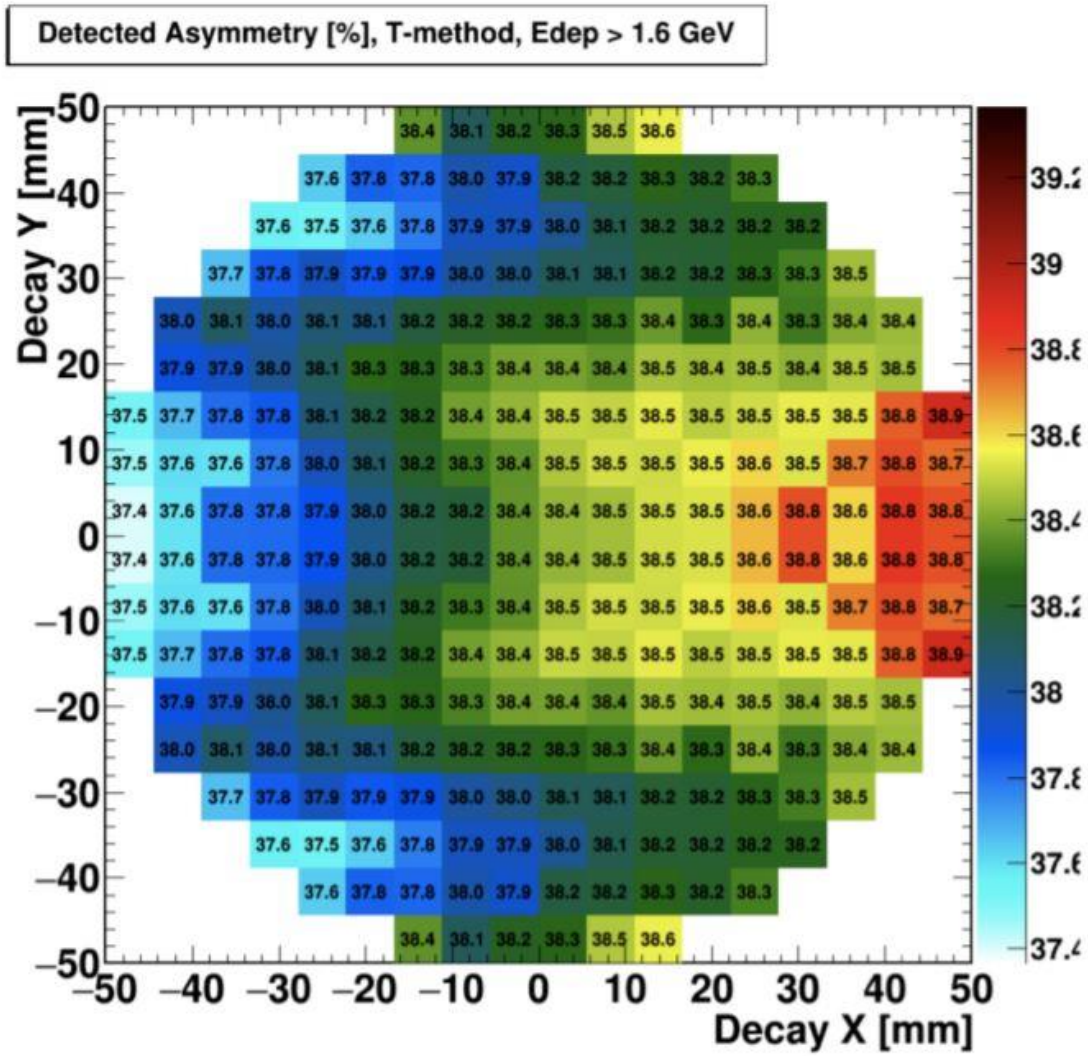
E-field and pitch: 30ppb

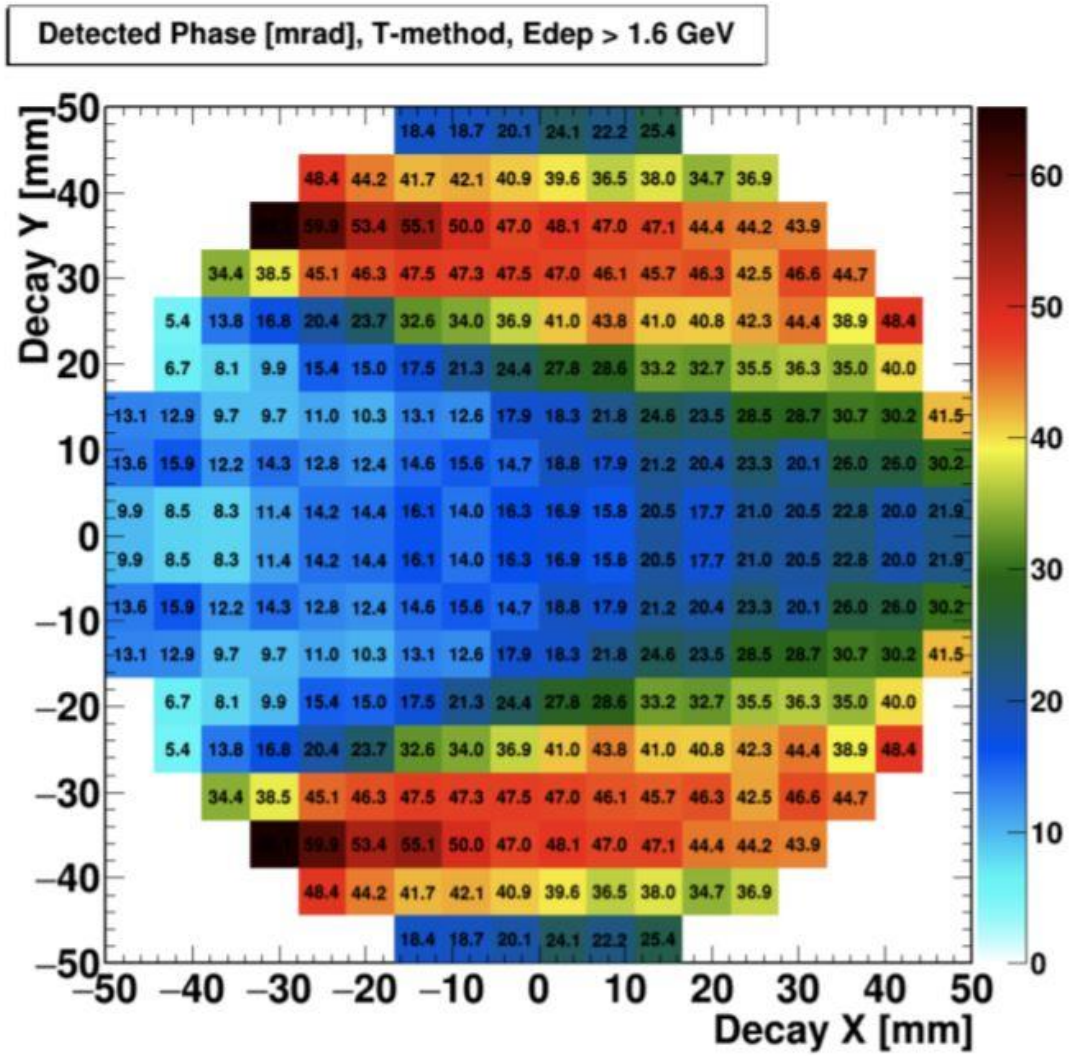
Effetti di rivelatore

Effetti di fascio

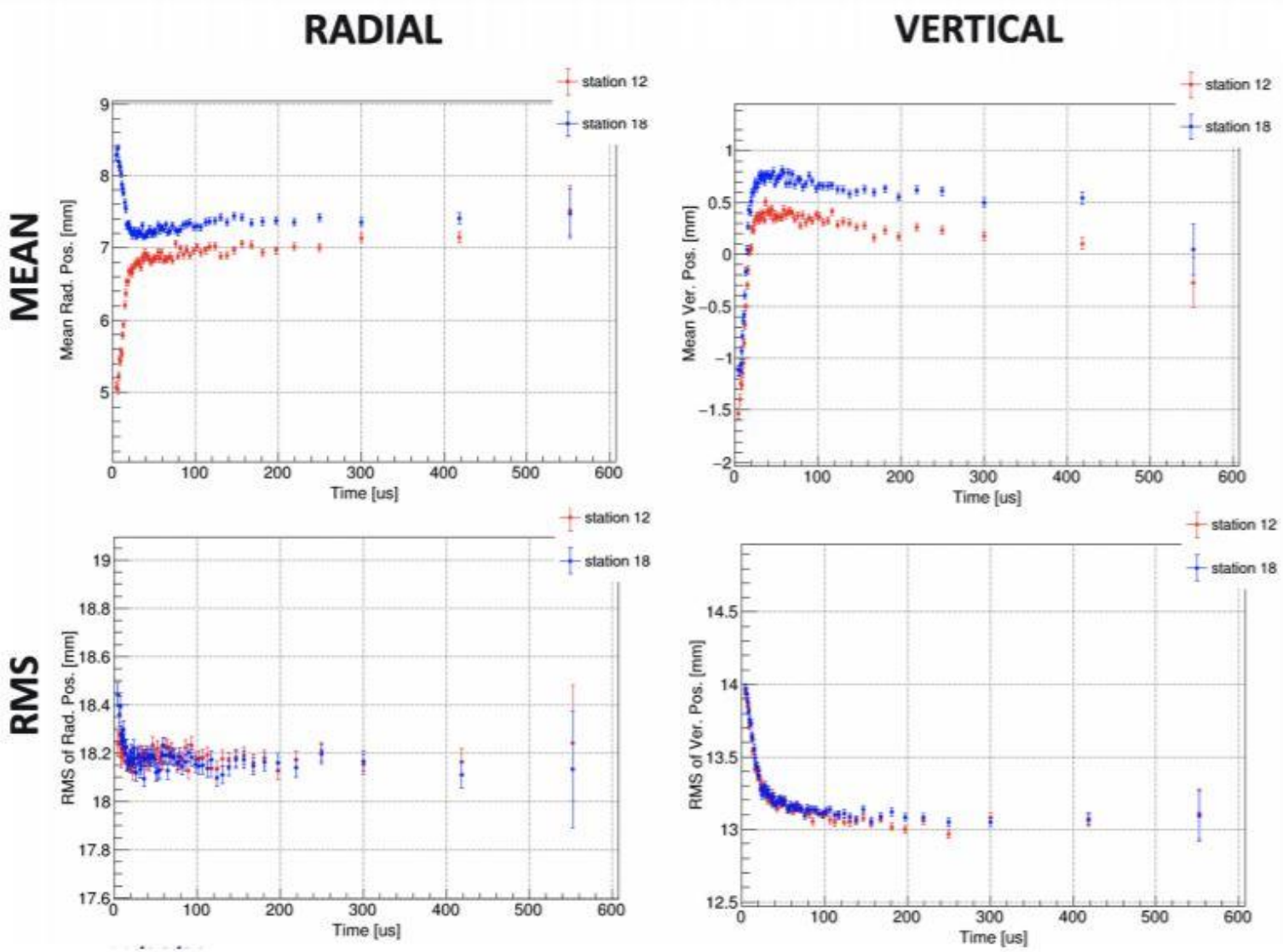
Phase Acceptance: 90 ppb!

Phase Acceptance - Detector

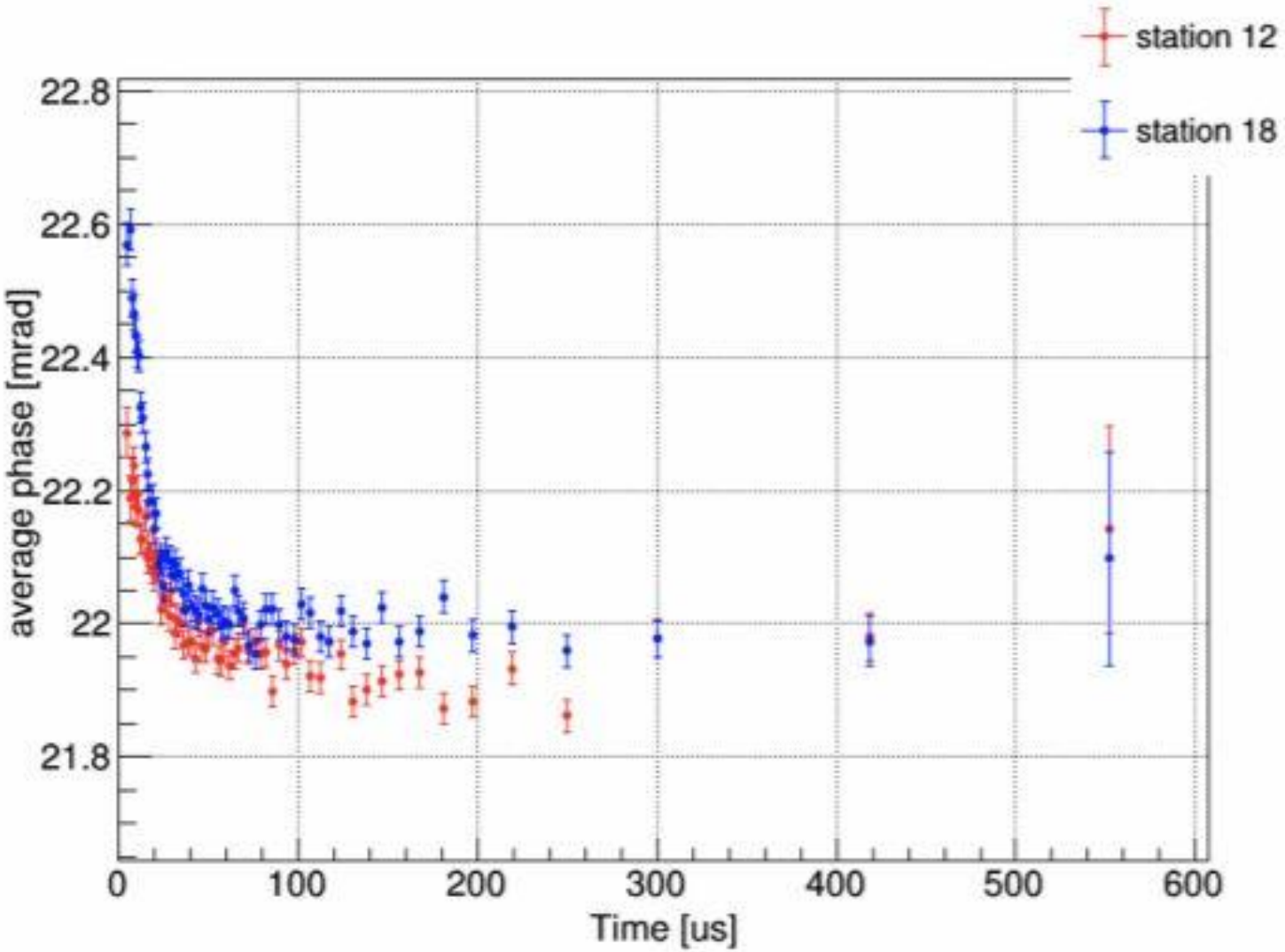




Phase Acceptance - Fascio



Phase Acceptance - Risultato



Run1: 90 ppb («bad resistors»)

Run2: stimati 50 ppb

Conclusioni

- Sistematiche su ω_a ben conosciute

- Prossimi periodi di presa dati: tenere sotto controllo phase acceptance

- Sistematico totale: l'obiettivo è tenerci sotto 70 ppb