DAP — Muon g-2

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Kolja asked me to share an earlier experience — thank you,

This experience is from “different physics” than EIC, but some aspects may carry over, or just illustrate some of what has been said already.

EIC Detector-1 computing and software WG mtg.
July 13, 2022

BNL-E821 — Muon g-2 ($g_\mu - 2 = 2a_\mu$)

$$a_\mu = \frac{R}{\lambda - R}$$ is a combination of (at least) *thr*ee quantities,

1) $\omega_a \sim 229\,\mathrm{kHz}$ (presently) statistics limited,

2) $\omega_p \sim 61\,\mathrm{MHz}$ systematics dominated, e.g. 0.05 ppm absolute probe

3) $\lambda = \frac{\mu_\mu}{\mu_p} \sim 3$ 30ppb uncertainty (th.+data) or 120 ppb (data),

$$R = \frac{\omega_a}{\omega_p} \sim 3 \cdot 10^{-3}$$ blind analysis (essential), requires both 1) and 2) to be sufficiently constant.

Note: There is *a lot* (more) to this, but this is obviously not a muon g-2 talk
Instead, I will share some experiences with data-preservation for ω_p

BNL-E821 — Muon g-2

Time scales:

150 ns	cyclotron period τ_c
4.4 μs	τ_a
64 μs	dilated muon lifetime $\gamma\tau$

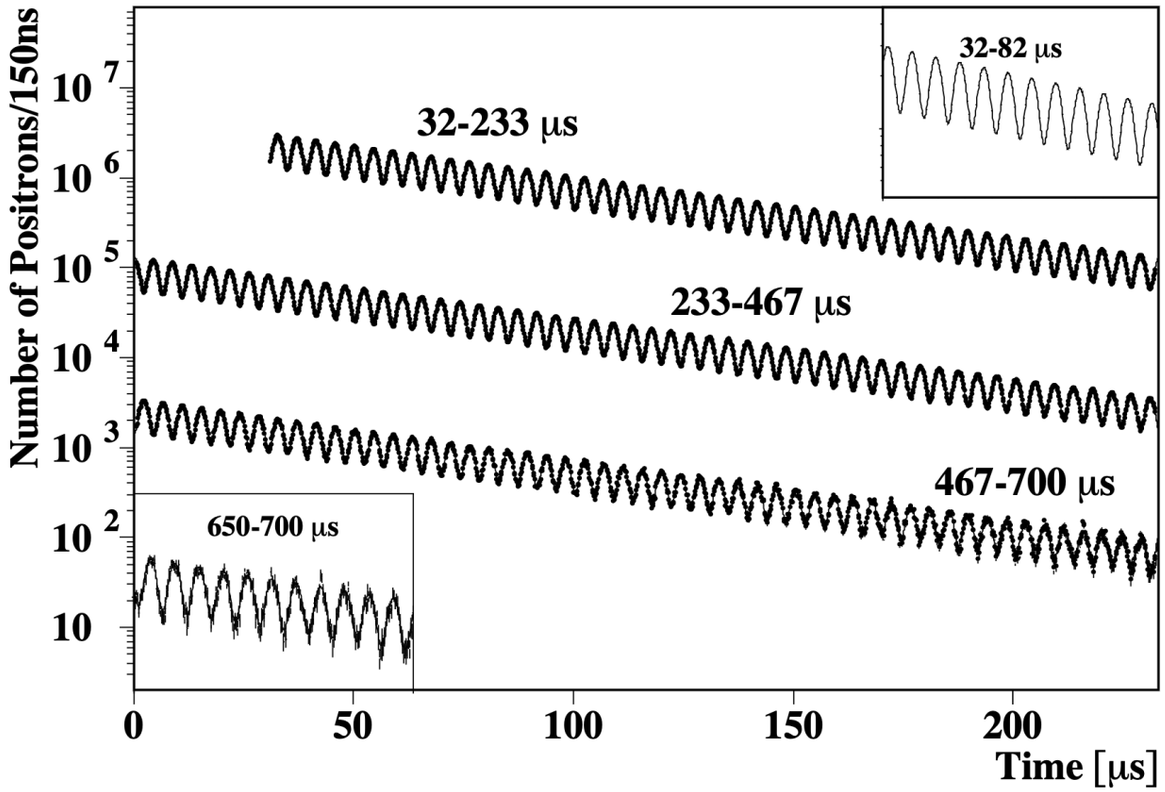
Experimental sequence:

$t = 0$		beam injection
35 −	500 ns	kick onto orbit
0 −	15 μs	beam scraping (collin
5 −	40 μs	calorimeters gate on
45 −	1000 μs	$g-2$ measurement
1000 −	μs	data storage to tape
33 ms		cycle repeats

$$p_\mu = 3.1\,\mathrm{GeV/c}, \quad B = 1.45\,\mathrm{T}, \quad r = 7.1\,\mathrm{m}$$

Inflector magnet	A. Yamamoto et al., NIM **A491** 23 (2002)
Ring magnet	G.T. Danby et al., NIM **A457** 151 (2001)
Kicker magnet	E. Efstathiadis et al., NIM **A496** 8 (2003)
Quadrupoles	Y.K. Semertzidis et al., NIM **A503** 458 (2003)
NMR system	R. Prigl et al., NIM **A394** 349 (1997)
Calorimeters	S. Sedykh et al., NIM **A455** 346 (2000)

Muon g-2 — Two iconic figures



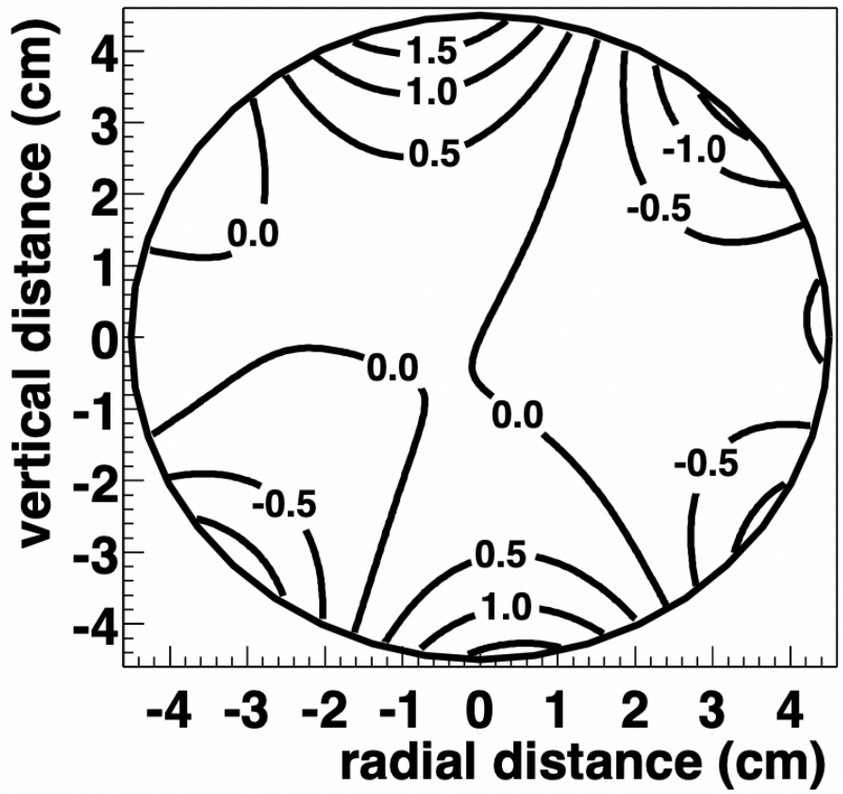
← Muon decay and the combination of spin precession and momentum rotation,

$$\omega_a$$

Reproduced from PRL 86 (2001) 2227

Magnetic field uniformity over the muon storage region in ppm →

$$\omega_p$$



Multipoles [ppm]	Normal	Skew
Quad	-0.28	0.11
Sext	-0.72	-0.45
Octu	0.09	0.01
Decu	1.04	0.38

Muon g-2

Experiment data taking at BNL stopped in **2001** as RHIC was brought online for physics,

Most analysis completed towards the end of 2003; statistics limited result,

Several efforts to resume — success at FNAL, first data released in **2021**,

FNAL effort makes use of the same measurement concept and ring magnet,

=> valid needs for many studies including those based on prior data;
my take on the timeframe is ~2010 through ~2015

How can this be accommodated when the collaborations have only partial overlap and the analysis is intrinsically blinded?

For the field frequency, we handled this by noting the need was for studies, not a full re-analysis of the prior result,

Field measurement is/was systematics limited, unlike muon g-2 itself,
Make a sizable fraction, but <u>not</u> all, of the field (calibration) data available,
Uhm, how? Main cluster evolved considerably, access changed, etc.
This relied in the end on personal archives ("painful" then, obviously not practical for EIC)

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A few things I learned in the process,

- perhaps there was or was not a formal data plan — I wasn't attuned to such at the time,
- if there was, it had little to do with enabling the field studies for the FNAL effort,
- it helped to have at least one colleague around who had done the work, hands-on, before,
- it was easier to do, say, a year later than a decade later,
- a simple data format, though not too simple, was very helpful as well,
- data formats really must be documented, including units,
- analysis code was written in a standard, time-tested language with interfaces for data input and plotting output,
- code and data were actually kept together in the same (personal) archive, together with scans of logbooks, and *some* environmental (~ slow-control or conditions db) data,
- "scatter-gather" of additional environmental data would seem impossible to me — even though the studies (methods) were documented,

My take aways:

- an unexercised data-plan is like an untested back-up,
- access seems at least as important as archive,
- different timescales present different challenges,
- some aspects will likely carry over to EIC, but undoubtedly helpful to consider HERA and other efforts.