

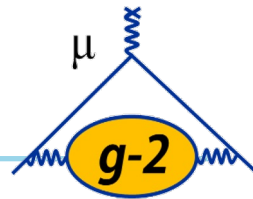
Enhancing equity diversity and inclusion in particle physics: the experience of the Muon g-2 collaboration



Anna Driutti (University and INFN Pisa)
On behalf of the Muon g-2 Collaboration
Saturday 20th July 2024



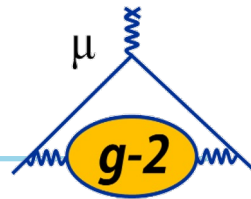
The Muon g-2 Collaboration



The **mission of the collaboration** is to measure with unprecedented precision (goal: 140 ppb) the **anomalous magnetic moment of the muon**.

Have a **diverse collaboration** with a variety of backgrounds is an asset to solve the complex problems we encounter, and an **inclusive and equitable environment** help us to maximize the productivity of the collaboration.

The Muon g-2 Collaboration



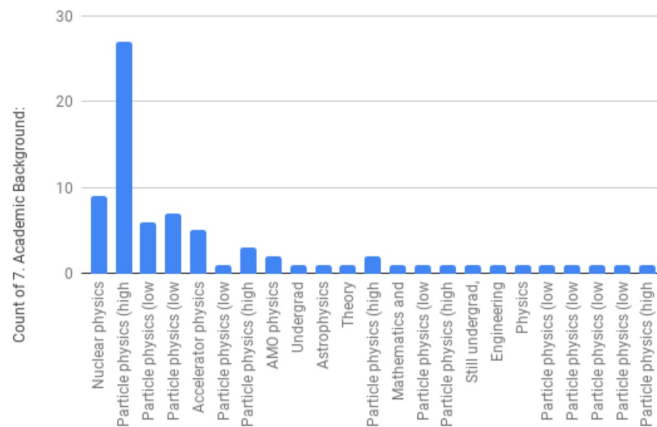
Muon g-2 Collaboration

7 countries, 33 institutions, 181 collaborators

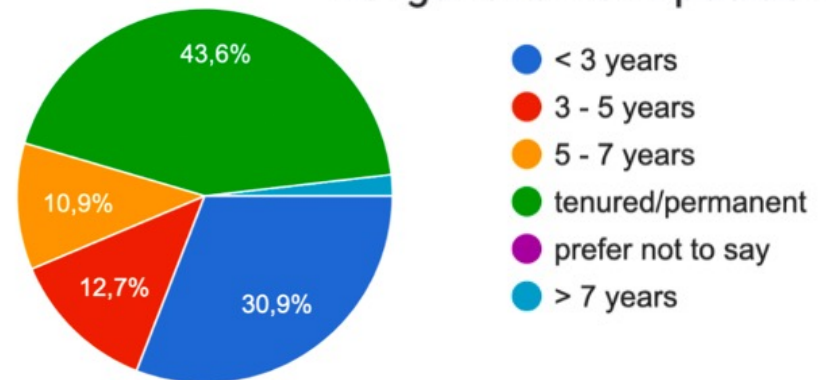


- **200 members** with a variety of backgrounds:
 - Different **home institutions**
 - Different **countries of origin**
 - Different **scientific research disciplines**
 - Different **career stages**

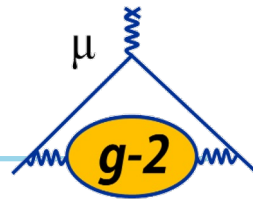
Academic Background



Length of time in position



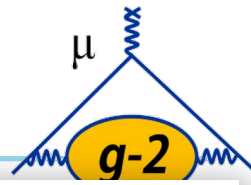
Muon g-2 ED&I Committee and g2Early



The collaboration strives to maintain an **inclusive and equitable work environment** that also promotes the **professional development** and **career advancement** of all members.

- ED&I Committee:
 - composed by at least four members elected by the collaboration every two years
 - chair of the institutional board is an ex-officio member and acts as the liaison to the collaboration
- g2Early (Early Career):
 - Subset of the collaboration that comprises students, postdoctoral researchers and collaborators who hold equivalent non-permanent positions

The Early Career Group (g2Early)



- Early career members of the collaboration
- Additional bylaws to the collaboration bylaws

Muon g-2 Collaboration – “g2early” bylaws

March 2024

Contents

Definition and role of g2early

Membership of g2early

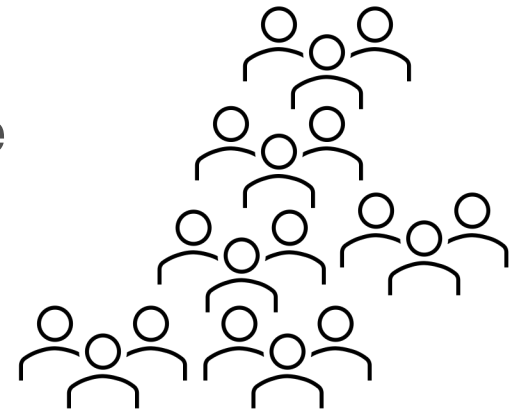
Leadership of g2early

Committee election procedures

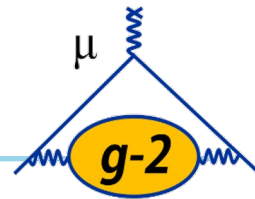
Changes to the g2early bylaws




- G2early committee (elected every year) comprises:
 - Institutional Board representative
 - Analysis Coordinator meeting representative
 - Speaker Committee representative
 - Publication Committee representative
 - Executive Board representative



G2early Initiatives



- Slack channel dedicated to communications only between members
- Monthly meeting with spokespersons
- Closed doors meeting at each collaboration meeting:
 - Discussion of issues
 - Organize presentations with the goal of helping early career member to learn the details of the experiment and the theory of g-2 in a friendly environment
 - Invite speakers for formative lessons (e.g., lecture on public speaking)
- Organize social events

 gm2early

 slack

Description

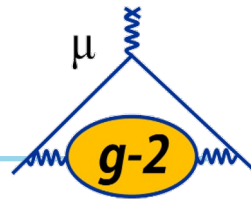
discuss early career issues or talk to likeminded folk

THIS IS INTENDED TO BE A RESOURCE FOR YOU, BASED ON EXPERIENCES I HAVE HAD (BOTH POSITIVE AND NEGATIVE).

WE CAN DISCUSS THROUGHOUT OR ADDRESS OTHER TOPICS IF YOU PREFER TO TALK ABOUT THOSE!

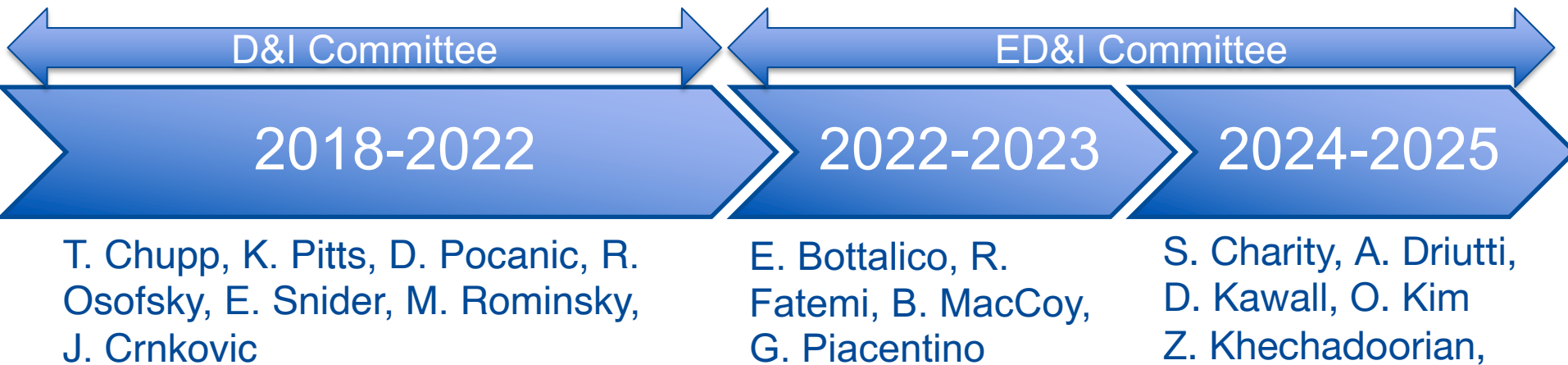


The Muon g-2 ED&I Committee

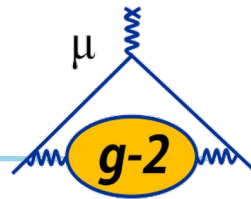


Responsibilities of the committee:

- Maintaining and promoting the g-2 Code of Conduct
- Annual tracking/presentation of collaboration demographics, distribution of talks and management staffing
- Facilitating student mentorship
- Maintaining a webpage, including access to annual report information
- Defining a policy for collaboration ombudspersons



The code of conduct



Muon g-2 Collaboration Code of Conduct

Expected Conduct

It is the responsibility of everyone to ensure that all Muon g-2 Collaboration members are welcomed, included, listened to, and respected. People should work to provide an environment that encourages the free expression and exchange of ideas. People should also promote equality of opportunity and fair treatment for all colleagues.

Meeting Conduct

Meeting Chair(s) Responsibilities
Respectful Communication
Listen to Others

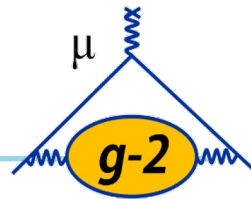
Repudiated Conduct

Marginalization
Discrimination
Scientific Misconduct
Harassment
Bullying
Abuse of Power

Implementation & Enforcement

Guidelines for people witnessing or experiencing infractions

The Muon g-2 ED&I Web Page



Muon g-2 Internal

- Bookmarks
- Safety
- Collaboration
- Org Chart
- Documentation
- BOE & CDR Browser
- Emailing Lists
- Reviews
- Redmine
- Pictures
- Readytalk Archive
- Speakers Committee
- Publications Committee
- ED & I Committee**

ED & I Committee

Comments to the ED&I Committee

Submit a comment or suggestion for the ED&I Committee [here](#).

See all public suggestions [here](#).

Private anonymous comment or suggestion

Comments or suggestions viewable by the collaboration

ED&I Committee Members

- Anna Driutti
- David Kawall
- On Kim
- Saskia Charity
- Zepyoor Khechadorian

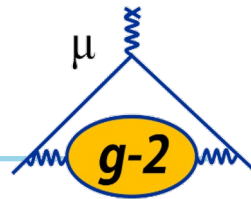
Documentation available to the collaboration

Documentation and Resources

ED&I Committee documentation is located at [DocDB 25025](#).

For reference, the original documentation from the initial D&I Committee is located at [DocDB 18359](#).

ED&I Committee Initiatives



At each collaboration meeting the ED&I Committee organizes an activity such as:

- Updates from the committee
- External speakers
- Discussions about movies or articles related to equity, diversity and inclusion in Physics

Picture a Scientist

Discussion Forum
July 22, 2021

Steps Toward Equity in Physics

Edmund Bertschinger
MIT Department of Physics and Program in
Women's and Gender Studies

Muon g-2 Fall Meeting
December 3, 2020

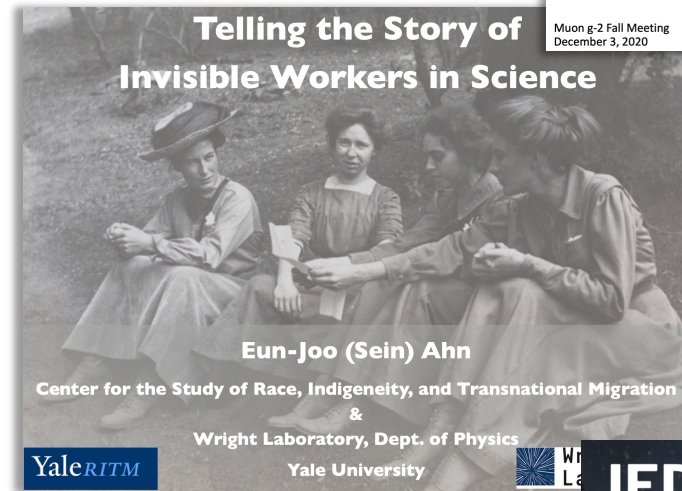


EDI Update

Muon g-2 Collaboration Meeting

Sandra Charles

June 29, 2022



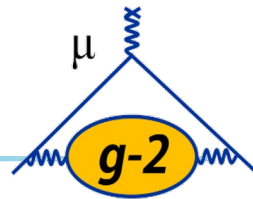
JEDI across Physics

Initiatives, updates, and resources

Dr. Jessica Esquivel



Connecting with other group/resources

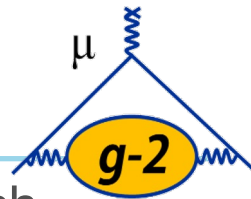


- The ED&I committee quarterly meets with the chief ED&I officer of Fermilab and the ED&I groups from other Fermilab collaborations
- Members of the Muon g-2 ED&I Committee participate to the Code of Conduct (CoC) workshop held by Fermilab in 2022 – Main goal of the workshop was reviewing CoCs and their role in promoting ED&I within Fermilab and its collaborations
- G2early career members participated in the Aurora Pride Parade



rmilab's first official participation in Pride was at the Aurora Pride Parade on June 12. Photo: Tim Skirvin

Outreach



- The Muon g-2 Collaboration members participate to many outreach events, also the experiment is always open to visits and there are virtual tours available.

What is inside the black room?

The laser calibration system! For this experiment, determining the correct energy of the particles is essential.

A series of 6 lasers fire a known amount of light through a network of lenses and fibers to determine the response of 1296 lead fluoride crystal detectors around the ring.

How to make a muon beam?

Protons from the Fermilab accelerator are smashed into a target at nearly the speed of light, creating pions and muons. After traveling more than 1 mile, only muons are left, and a set of **magnetic quadrupole lenses** (pictured) focus the muon beam into the storage ring.

Proton Beam From Accelerator → Target → Protons, Pions, and Muons → Magnetic Quadrupole Lenses (Pictured) → Muon Storage Ring

How do we get muons into the ring? - Inflector Magnet

The inflector magnet cancels out the main ring magnetic field by producing a 1.45 T field in the opposite direction.

$$1.45\text{ T} + 1.45\text{ T} = 0\text{ field on incoming muons}$$

1.45T is 29,000 times larger than the Earth's magnetic field!

Muons travel through the inflector into the ring

The inflector magnet sits in a hole in the main magnet iron

Actual aperture size: 1.7 m x 2.57 ft long

Calorimeters record muon decays

There are 24 calorimeters sitting on the inside radius of the ring.

Lead fluoride crystals make the muon decays visible.

A fast camera, called SiPM, records the light.

The images are processed by custom made digitizers.

How do we make the magnetic field uniform?

A slice of the magnet shows the tools used to make a smooth magnetic field.

Custom electronics deliver up to 2 Amps of current to 200 coils

>9000 iron strips wallpaper the top and bottom of the magnet. For success, the field needs to be the same everywhere to 50 parts per million.

1400 lb iron pole pieces were placed to 25 microns...smaller than the width of a human hair!

KICKER

65,000 volts x 5000 amps in 100 billionths of a second: KICK MUONS to the correct orbit.

KICKER KICKS MUONS

Cables over Ring

Blumlein Shaping

Thyratron Switch

Capacitors

High Voltage

Feed to Electromagnet

Kick to Orbit

Where are the muons?

After going around the ring several times, muons decay into positrons (positive electrons) and neutrinos. Positrons bend into the center of the ring and some go through the straw tracking station.

When a positron hits a gas atom in a straw, it knocks off electrons. These electrons get amplified and make a signal in the straw called a hit. We connect the hits just like playing 'connect the dots' and the circle we make points to where the muon was when it decayed.

1 Particle travels through a straw filled with gas, producing electrons.
2 Electrons are detected as they hit the wire in the center of the straw and the time recorded.
3 Look at all straws hit at the same time.

How is a muon beam vertically centered in the ring?

Answer: Electrostatic quadrupole system.

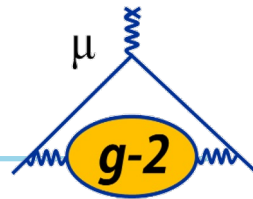
High voltage is applied to aluminum plates inside of the ring to keep muons vertically centered.

8 Quads (set of 4 plates) are placed around the ring.
20,000 to 30,000 volts are applied to the plates.

Black cabinets are the high voltage power supplies.

Quad extensions connect the plates to the power supplies.

Conclusions



- The Muon g-2 collaboration seeks to preserve an inclusive and equitable work environment, where respect is given and received by all members.
- Two ways in which the Muon g-2 Collaboration is trying to effectively promote and develop equity, diversity and inclusion within the experiment are the **ED&I Committee** and the **g2early group**.

Thank you for the attention!