

HEAD 21, Horseshoe Bay, TX
April 10, 2024

GR SIG Splinter Session



Future Innovations in Gamma Rays

*Science Analysis Group
-updates & status-*

Milena Crnogorčević, on behalf of
the FIG SAG leadership



FIG-SAG

FIG SAG Motivation & Goals



...to explore gamma-ray science priorities, necessary capabilities, new technologies, and theory/modeling needs drawing on the 2020 Decadal **to inspire work toward 2040.**

FIG SAG Motivation & Goals



...produce a report to help and inform NASA about topics and the community's priorities leading into Decadal Reports focusing on science drivers, necessary capabilities, and prioritizing the future of gamma-ray astronomy.



Welcome & Introduction to FIG SAG

The screenshot shows the top portion of the FIG SAG website. At the top left is the NASA logo. To its right is a dark navigation bar with white text for 'Home', 'PhysPAG', 'Science Interest Groups', 'Science Analysis Groups', 'Mission Studies', and 'Resources'. Below the navigation bar is a large banner image of a colorful galaxy. Overlaid on the left side of the banner is the text 'Physics of the Cosmos' in a large white font, followed by 'Exploring fundamental questions regarding the physical forces of the universe' in a smaller white font. Below the banner are three dark blue buttons with white text: 'FIG SAG Home', 'SAG Leadership', and 'SAG Events'.

Future Innovations in Gamma Rays (FIG SAG)

- Future Innovations in Gamma Rays Science Analysis Group Terms of Reference, Draft [\[PDF\]](#)

<https://pcos.gsfc.nasa.gov/sags/figsag.php>



FIG SAG Terms of Reference

1. **Gamma-ray Science Priorities:** Identify opportunities uniquely afforded by gamma-ray observations.
2. **Gamma-ray Mission Capabilities:** Which science objectives are only done or best done by space-based gamma-ray missions, considering the current missions in extended operation and funded missions in development.
3. **Technology Investment:** What new technologies/methodologies exist and what is needed to achieve the science priorities.
4. **Theory and Analysis Needs:** What advances do we need to make in theory and analysis to achieve the science priorities.
5. **Synergies with Other Programs:** How do these goals tie to the broader astrophysics and physics community. What are the timelines to align with current priorities in multi-messenger astronomy.

How to convey the importance of gamma-ray astronomy?



How to convey the importance of gamma-ray astronomy?



Multimessenger
astronomy



How to convey the importance of gamma-ray astronomy?



Multimessenger
astronomy



multiwavelength
astronomy

How to convey the importance of gamma-ray astronomy?



We risk our message to be:
'our only importance is in how well
we support other subfields'

How to convey the importance of gamma-ray astronomy?



We risk our message to be:
'our only importance is in how well
we support other subfields'

We should not expect that
any mission will be funded
primarily due to its ability
to support other facilities.



It is strategically important to define
gamma-ray science
in terms of
gamma-ray science



Monthly Virtual Meetings



February 29	Gamma-ray Science Priorities
March 21	Theory/Modeling/Analysis/Fundamental Physics Needs
April 25	Technology Investment
May 30	Gamma-ray Mission Capabilities
June 24 – 28	FIG SAG Workshop at Michigan Tech (registration opening soon)
TBD	Synergies with Other Programs and Agencies
TBD	Broadening the Gamma-ray Science to the Whole Astrophysics community




Meeting structure

Lead-up:

- Topic information emailed to the listserv and Slack workspace (~2 weeks notice)
- Topical polls sent to the topical channels (~1 week)
- Discussion topics, open questions, breakout sessions planned based on the poll responses

Thursday, March 14th ▾

 **Simple Poll** APP 2:23 PM

What analysis/theory/modeling Topics are you interested in?

1 Plasma Physics Theory & Modeling (Standard Model Physics) 6
@Qi Feng, @Tyler Parsotan, @Constantinos Kalapotharakos, @Stella Boula, @Michelle Hui, @SRINIVASA ABHIRAM

2 Nuclear Modeling & Simulations (Cross sections & Lines) 5
@Carolyn Kierans, @Milena Crnogorčević, @Richard O'Shaughnessy, @Jocelyn Read, @SRINIVASA ABHIRAM

3 Data Analysis & Simulations Methods 14
@Fabio Gargano, @Qi Feng, @Carolyn Kierans, @Milena Crnogorčević, @Tyler Parsotan, @Constantinos Kalapotharakos, @Kelly Malone, @Leonardo Di Venere, @Stephen Lesage, @Elisabetta Bissaldi, @Francesco de Palma, @Michelle Hui, @Jocelyn Read, @Varun Bhlerao

4 Particle Physics Modeling & Simulations (Beyond Standard Model) 3
@Qi Feng, @Milena Crnogorčević, @SRINIVASA ABHIRAM



Meeting structure

During:

- 90 min total on Zoom
- All-group discussions (recorded) combined with breakout sessions (not recorded) for more in-depth discussions
- Notes and Summaries available after the meeting

Meeting 1: Gamma-ray Science Priorities


Document Structure:

- General Information & Resources
- Science Topics Summaries:
 - [Nature of Dark Matter/Dark Energy](#)
 - [Formation and Merging of Supermassive Black Holes](#)
 - [Origins of Heavy Elements in our Galaxy](#)
 - [Sources of Cosmic Ray Accelerations](#)
 - [Existence of Life in Our Galaxy](#)
 - [Questions not Included Above](#)

General Information & Resources

Date & Time: February 29, 2026, 1 PM GMT-5, Zoom.

Presentation Slides:  [Gamma-ray Science Priorities](#)

Video recording:  [Meeting1_Zoom_recording.mp4](#)

Timeline of the Video recording:

4:30 – 11:50: Welcome & Introduction to FIG SAG

11:50 – 32:00: General Group Discussion

32:00 – 53:40: Breakout session 1 (Only DM & Dark Energy Breakout Room recorded)


53:40 – 1:20:00: General Group Discussion

1:20:00 – 1:44:00: Breakout session 2 (Only DM & Dark Energy Breakout Room recorded)

1:44:00 – end: Concluding remarks

Science Topics Summaries

Nature of Dark Matter/Dark Energy

Link to the notes:  [Nature of Dark Matter/Dark Energy](#)

Summary: We discuss the future of Dark Matter and Dark Energy searches, focusing on the potential contributions of gamma-ray observations and the synergies between various types of astronomical objects. We discuss the construction of telescopes with better spectral resolutions, such as ~50 eV, that would be able to pin down the 511 eV line and search the substructure of emission lines to identify DM candidates. We also discuss the importance of building a compelling case for gamma-ray research in identifying DM candidates, referencing Fermi's role, and the potential for future observatories about reaching the thermal relic line. We also highlight the importance of integrating the gamma-ray searches within the already-existing and future optical and radio observatories infrastructure to gain a better understanding of DM. We discuss



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TBD

Synergies with Other Programs and Agencies

TBD

Broadening the Gamma-ray Science to the Whole Astrophysics community

Overview of Science Priorities Discussion



Nature of Dark Matter/Dark Energy

511 keV emission, thermal relic (or else?), Galactic Center Excess, PSF improvements, GeV polarization to help identification of ALPs

Formation and Merging of Supermassive Black Holes

Origins of Heavy Elements in our Galaxy

nuclear line datasets; angular resolution

Sources of Cosmic-ray Accelerators

MeV gap, proton transport, energy and imaging resolution, polarization, high-precision timing

Existence of Life in Our Galaxy

techno signatures, biological signatures, host star activity & effects on the habitable zone



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Overview of Theory & Simulations Discussion

Plasma Physics Theory & Modeling (Standard Model Physics)

PIC codes, MHD codes, hybrid models. Current models insufficient to explain time-dependent data. Insufficient timing data on AGN/magnetars

Nuclear Modeling & Simulations (Cross sections & Lines)

Combined atomic and nuclear model; gaps in nuclear physics; 511 annihilation line; different nuclear networks get different yields; map from HPC to a phenomenological model; AI for gamma-spectra

Data Analysis & Simulation Methods

Challenges in multimission analysis; GRBs - connecting observational signatures with physical models.

Particle Physics Modeling & Simulations (Beyond Standard Model)

GC excess is tested against rudimentary models of DM; better astrophysical understanding; background worries



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June Workshop



June Workshop

Date June 24 – 28, 2024 at Michigan Tech

Registration O P E N! Check <https://pcos.gsfc.nasa.gov/sags/gsag/events/workshops/June-2024/June-2024.php> to fill out the form!

Abstracts Due April 30. Travel intention appreciated by April 15.

Talks Plenaries (Mon & Fri): *Overall strategy, messaging, complementarity with current missions and future facilities in other bands/messengers*
Parallel sessions (Tues, Wed, Thurs): *Talks & discussion to help develop the arguments for science priorities and baseline cases for categories of observable*

Goals of the June workshop



1	2	3	4
		Scientific Measurement Requirements	
Science Goals	Science Objectives	Observables	Physical Parameters

See more: https://smd-cms.nasa.gov/wp-content/uploads/2023/04/Launchpad_Session3_STM_18Nov2019_smf_final.pdf



Final product: Report

1. **Overview:**
 - a. Status Quo, context of current gamma-ray missions & facilities
2. **Primary Baseline Science Cases:**
 - a. Details about the science and required sensitivity, etc
3. **Secondary and tertiary Baseline Science Cases**
 - a. Details about science cases that require slightly less sensitivity, etc
 - b. What science cases can be accomplished per observable requirement?
4. **Complementarity**
 - a. Gamma rays first messaging, but also broader context of multiwavelength and mutlimessenger



Synergies as Secondary

- While synergies are secondary in terms of messaging, they are a full section of the report on their own. How can future gamma-ray missions:
 - complement the fleet of NASA missions
 - multi-messenger astronomy
 - ground-based facilities
- Are there key facilities that set necessary timelines for future gamma-ray missions?
- What synergies exist with other agencies?
 - Efforts in detector technology, electronics research and development, data analysis techniques, laboratory astrophysics, modeling methods, software, data archiving?



General Info

Website

<https://pcos.gsfc.nasa.gov/sags/figsag.php>

Slack Workspace

https://join.slack.com/t/figsag/shared_invite/zt-282mbwfeb-vfP~x~jz9OYYZkOhoS0rOg

All-group listserv

fig-sag@lists.nasa.gov

Chairs e-mail addresses

Michelle Hui (c.m.hui@nasa.gov)

Chris Fryer (fryer@lanl.gov)

Co-chairs e-mail addresses

Paolo Coppi (paolo.coppi@yale.edu)

Milena Crnogorčević (milena.crnogorcevic@fysik.su.se)

Tiffany Lewis (tiffanylewisphd@gmail.com)

Marcos Santander (jmsantander@ua.edu)

Zorawar Wadiasingh (zorawar.wadiasingh@nasa.gov)

Google Drive

https://drive.google.com/drive/folders/1ucUW9TTghyb7P_u2_QY-aqkwB3Nf41TV?usp=sharing

TODAY!!!



307 - Future Innovations in Gamma-ray Science Analysis Group

Special Session

Granite Ballroom ABC

5:20 PM CT - 6:50 PM CT