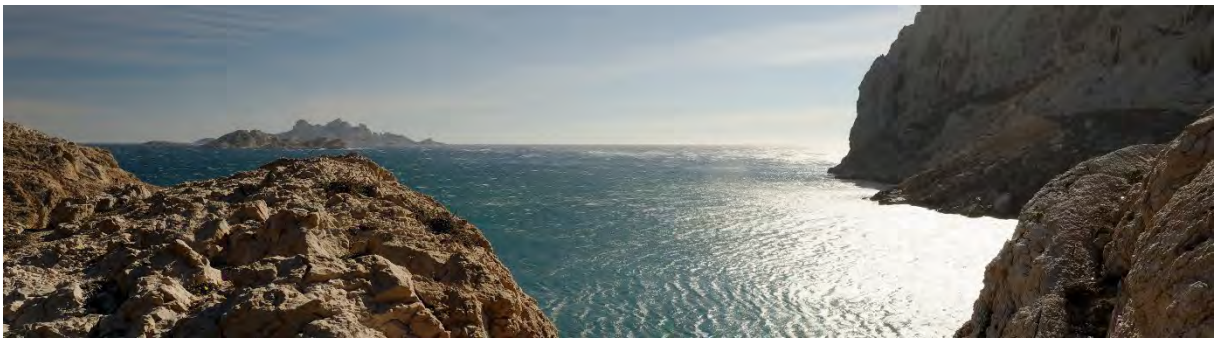
OPMs: The future of magnetoencephalography?



Program

Marseille, 2-3 Oct. 2025,
Amphithéâtre Gastaut, Jardin du Pharo,
58 Boulevard Charles Livon, Marseille 13007

Institut de Neurosciences des Systèmes

amU Aix Marseille Université

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MEG MARSEILLE

Program at a glance

	Thursday Oct. 2	Friday Oct. 3	
08:15	Registration opens		
8:45 - 9:00	Opening remarks		
9:00 - 9:30	Gareth Barnes University College London, UK	Matthew Brookes The University of Nottingham, UK	9:00 - 9:30
9:30 - 10:00	Jan Mathijs Schoffelen Radboud University, NL	Sarang Dalal Aarhus University, Denmark	9:30 - 10:00
10:00 - 11:00	Coffee break	Elizabeth Davenport Univ. of Texas Southwestern, US	10:00 - 10:30
		Coffee break	10:30 - 11:15
11:00 - 11:30	Okito Yamashita ATR, Japan	Francesca Bonini Aix-Marseille University, FR	11:15 - 11:45
11:30 - 12:00	Tim Bardouille Dalhousie University, CA	Julien Jung Neurosci Research Center, Lyon, FR	11:45 - 12:15
12:00 - 12:30	Lauri Parkkonen Aalto University, Finland	Xavier De Tiège Université libre de Bruxelles, Belgium	12:15 - 12:45
12:30 - 14:00	Lunch (included)	Lunch (included)	12:45 - 14:00
14:00 - 14:30	Fabrice Wallois Jules Verne Univ. of Picardie, FR	**Visit OPM facilities**	14:00 - 17:30
14:30 - 15:00	Margot Taylor SickKids Research Institute, CA		
15:00 - 15:30	Caroline Witton Aston University, UK		
15:30 - 16:00	Coffee break		
16:00 - 17:30	**Are OPMs the future of MEG?** Roundtable animated by: Fabrice Wallois Margot Taylor Nathalie George James Bonaiuto		

19:00 - 21:00	**Conference cocktail**

Detailed scientific program - Thursday October 2nd

8:45-9:00 am Opening remarks

Cutting-edge OPM Methods 1

Moderators: Nathalie George & Marie-Constance Corsi

9:00-9:30 am **Gareth Barnes** – University College London, UK

Ground truth for OPM imaging

9:30-10:00 am **Jan-Mathijs Schoffelen** – Radboud University, NL

Optimal configuration of OPMs with fixed channel counts

10:00-11:00 am coffee break

Cutting-edge OPM Methods 2

Moderators: Mathilde Bonnefond & Annalisa Pascarella

11:00-11:30 **Yamashita Okito** – ATR, Japan

From Sensor Placement to Current Source Imaging: Algorithms for OPM-MEG

11:30-12:00 **Tim Bardouille** – Dalhousie University, CA

Mobile MEG: The opportunities and challenges of a moveable system

12:00-12:30 **Lauri Parkonnen** – Aalto University, Finland

High-resolution MEG with OPMs

12:30am -2:00 pm on-site lunch

New frontiers in Brain Development with OPM

Moderators: Aurélie Bidet-Caulet & Anne Caclin

2:00-2:30 pm **Fabrice Wallois** – Jules Verne University of Picardie, France

OPM-MEG in newborn and epileptic children

2:30-3:00 pm **Margot Taylor** – SickKids Research Institute, CA

OPM-MEG and the developing mind: Unlocking brain function in toddlers

3:00-3:30 pm **Caroline Witton** – Aston University, UK

Clinical MEG using 4Helium OPM sensors

3:30-4:00 coffee break

4:00-5:30 pm Round Table – OPMs: the future of MEG ?

Fabrice Wallois – Jules Verne University of Picardie, France

Nathalie George – ICM Paris Brain Institute, France

Margot Taylor – SickKids Research Institute, CA

James Bonaiuto - Lyon Neuroscience Research Center, France

Detailed scientific program - Friday October 3rd

Clinical applications of OPM 1

Moderators: Victor Lopez

9:00-9:30 am **Matthew Brookes** – The University of Nottingham, UK

Development of a novel OPM-MEG platform, and its application in clinical populations

9:30-10:00 am **Sarang Dalal –** Aarhus University, Denmark

Fetal visual evoked responses measured with OPMs

10:00-10:30 am **Elizabeth Davenport** – University of Texas, Southwestern, USA

Building the Path Toward Clinical OPM-MEG: Lessons from Early US Experience

10:30-11:15 am coffee break

Clinical applications of OPM 2

Moderators: Fabrice Bartolomei & Emmanuel Barbeau

11:15-11:45 am **Francesca Bonini** – Aix-Marseille University, France

Simultaneous SEEG-MEG recordings: from SQUID to OPM

11:45-12:15 am **Julien Jung –** Lyon Neuroscience Research Center, France

Clinical Potential of ^{4}He OPM-MEG: A Comparison with SQUID-MEG for Detecting Interictal Epileptic Activity

12:15-12:45 am **Xavier De Tiège** – Université Libre de Bruxelles, Belgium

OPM-MEG for epilepsy and early brain development

12:45 am-2:00 pm on-site lunch

2:00-5:30 pm Visit of OPM platform at Timone Hospital

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Aix Marseille Université

Institute of language, communication and the brain
Aix Marseille Université

IBiSA Infrastructures en Biologie Santé et Agronomie

LABEL PLATEFORME AIX-MARSEILLE

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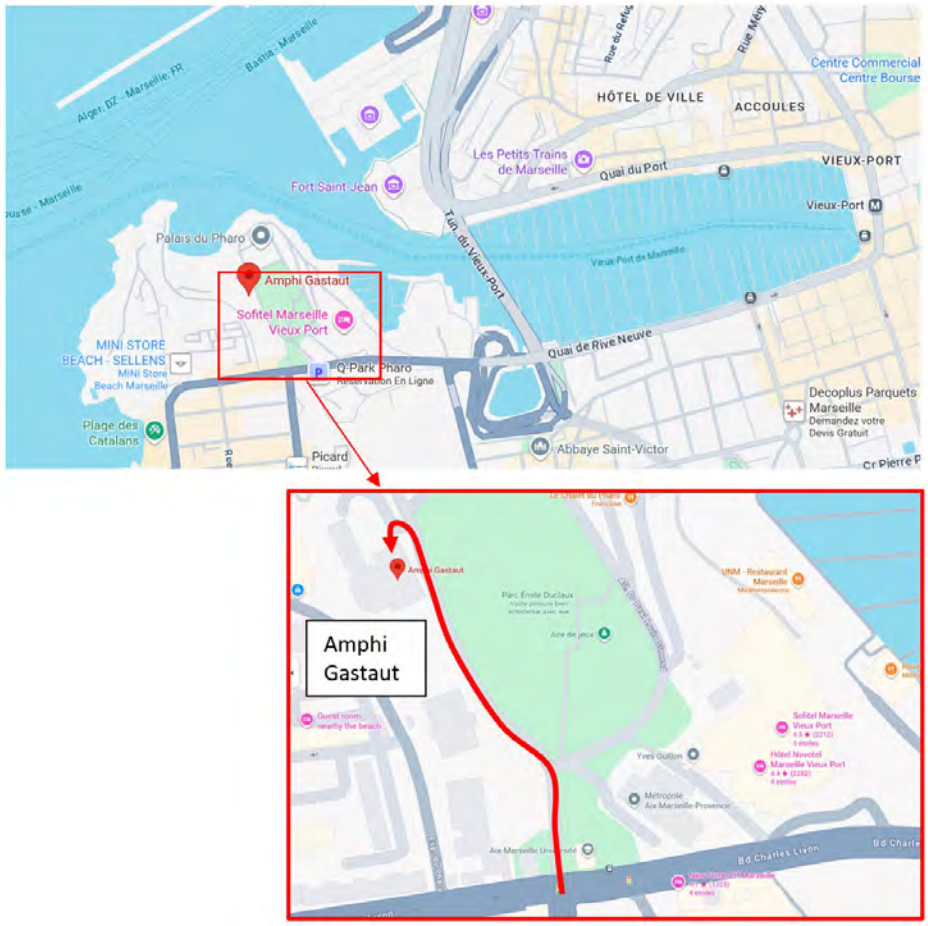
Maria Benkasmi, Joëlle Forestier, David Lizard, Caroline Modena & Audrey Moreau

Main Venue

Amphithéâtre Gastaut, Aix-Marseille University, Esplanade du Pharo, 13007 Marseille

Registration will be at the right side entrance, not the main one. From the Pharo entrance on Charles Livon boulevard, follow the signs.



Public transportation

From Marseille-Provence airport

Take the bus to Marseille at the airport, between terminal 1 and terminal 2. The bus line is L091 with a single stop at the final destination: Saint Charles station ("**Gare Saint Charles**").

From train station (Gare Saint Charles)

Take Metro M1 (Blue Line) from Saint-Charles station towards La Fourragère and get off at Vieux-Port.

From Vieux-Port, take Bus 83 (Direction: "Rond-Point du Prado") and get off at "Pharo Catalans" (~10 minutes)

Boat Ride & Cocktail Thursday 2nd 7:00 to 9:00 pm

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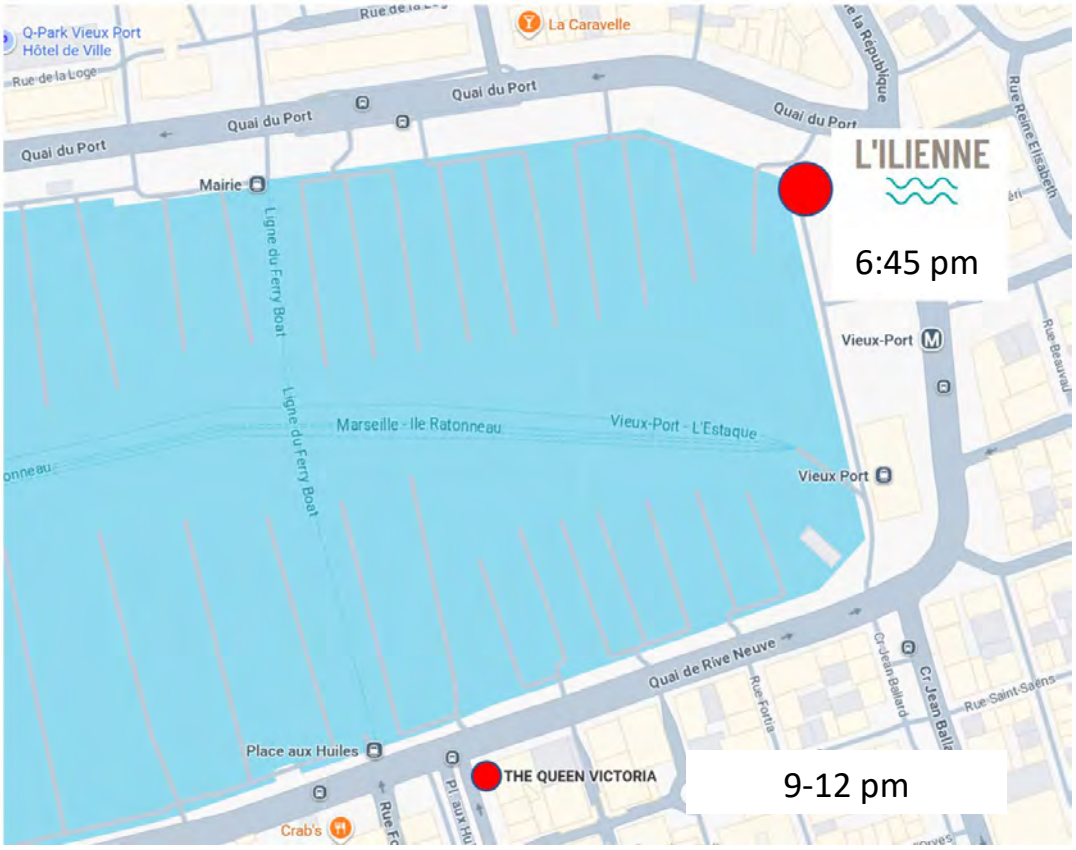
The boat (Ilienne) will depart from the old port ("Vieux port"), on the right side when looking at the port. **Please arrive 15 min in advance with your conference badge. Bring warm clothes/windbreaker as it can be chilly at night at sea.**

After the boat ride, part of the Queen Victoria will be open (at own's expense), with possibility of dinner.

Public transportation

Metro M1 stop "Vieux Port".



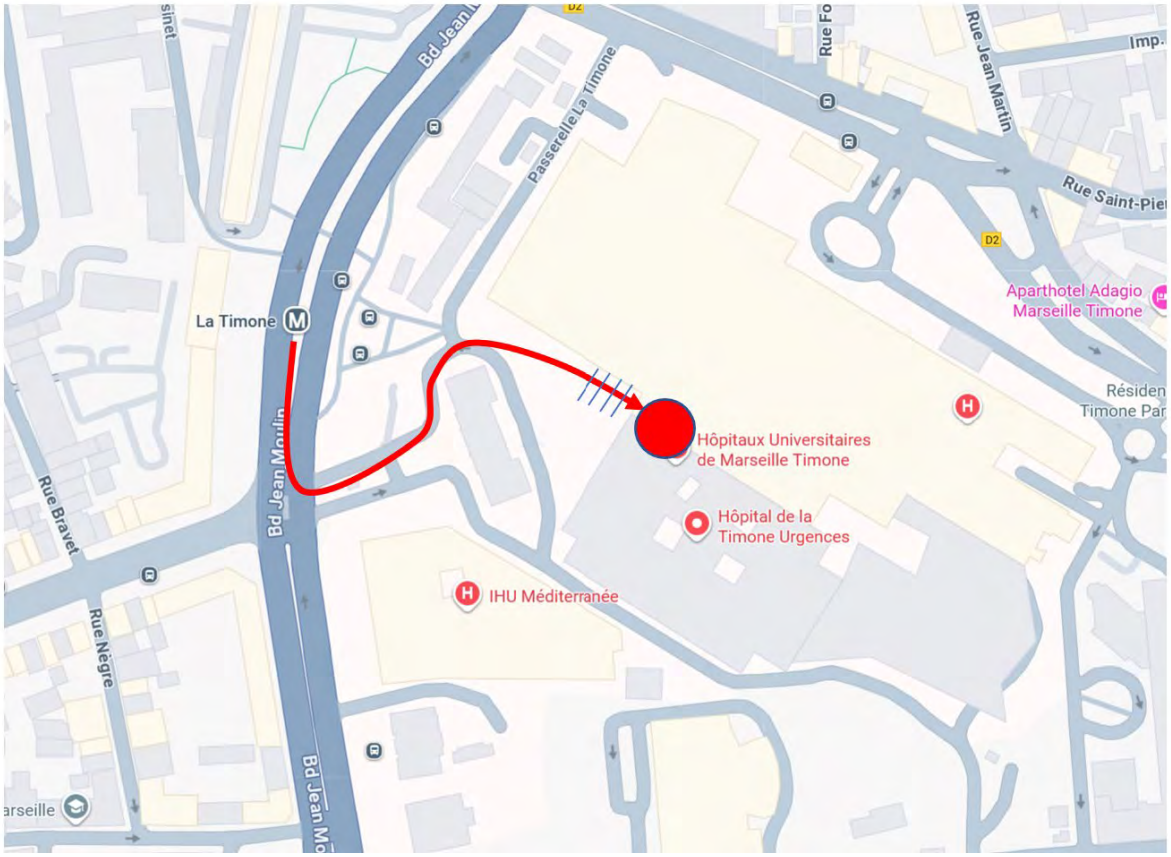
Visit of OPM facilities Friday 3rd 2:00 to 5:30pm

A blank schedule with the groups will be available at the reception desk. Please fill it out (first come, first served).

To access the center, please follow the map. From the “La Timone” metro station, enter the hospital and turn around the historical building on the left side. Go up the stairs into the main hall, conference staff will be there to guide you to the facilities.

Public transportation

Metro M1 stop “La Timone” (from old port “Vieux Port”, head towards “La Fourragère”).



Abstracts

Optimal configuration of OPMs with fixed channel counts

Jan-Mathijs Schoffelen
Radboud University, NL

Recent technological developments have brought optically pumped magnetometers (OPMs) within reach of the larger neuroscientific community. The current state-of-the-art consists of whole-head systems that measure the magnetic field at >100 locations. OPM sensors can be constructed to measure the field in either 1, 2, or 3 orientations. Consequently, the number of channels can differ from the number of sensors. This allows for magnetoencephalography (MEG) system designs with multiple measurement orientations at fewer locations, many locations with fewer orientations, or, ideally, many locations with multiple orientations. Yet, due to budget constraints, starting OPM groups are typically getting fewer sensors than what could, in principle, be accommodated in a whole head helmet-like arrangement. Furthermore, implementing multiple orientations in a single sensor comes at a cost and hardware companies are still optimizing the trade-offs between sensor designs. To guide the OPM systems design, it is relevant to know the optimal spatial distribution and sensing orientation of OPMs. We performed a simulation study in which we kept the total number of channels constant. We compared 3 synthetic 192-channel OPM arrays that were composed of either monoaxial, biaxial or triaxial sensors, where the sensors were placed at either 192, 96, or 64 measurement locations, respectively. We simulated multiple instances of an MEG signal due to a dipolar source in the brain, contaminated by various combinations of noise, considering sensor noise, brain noise, and noise induced by head (and sensor) movements in the residual ambient magnetic field. An optimal design of the MEG system serves both to record the activity of the brain, as well as the environmental noise that is to be suppressed. We performed dipole fits and evaluated the localization error and the amplitude of the estimated dipole moment. We cleaned the data using various spatio(temporal) cleaning strategies prior to fitting the dipoles. Our observations confirm earlier work, in that 1) the sensing orientation radial to the head is in general more optimal to pick up activity from the brain than tangential directions, but that 2) adding sensing orientations tangential to the head surface helps in suppressing ambient noise sources. Yet, we did not observe a clear improvement comparing triaxial with biaxial OPMs. Given that triaxial sensing may come at the expense of reduced spatial sampling over the head and reduced signal-to-noise for individual channels, we conclude that, given a fixed number of channels, biaxial sensors may be preferred with the currently available technology.

From Sensor Placement to Current Source Imaging: Algorithms for OPM-MEG

Okito Yamashita
Advanced Telecommunications Research Institute International, Japan

Optically pumped magnetometers (OPMs) are compact, lightweight, and room-temperature magnetoencephalography (MEG) devices that enable wearable and flexible brain measurement. However, for the system with a limited number of OPM sensors, careful array design is critical, especially when targeting specific regions of interest (ROIs). We propose a method called Sensor array Optimization based on Resolution Matrix (SORM), which sequentially places sensors to optimize the inverse filter for ROI sensitivity and minimum source leakage based on the resolution matrix of the minimum norm estimate (MNE). Simulation and real OPM-MEG data analysis demonstrate that SORM is effective not only with MNE but also with other estimation methods. These results suggest that SORM is valuable for applications such as brain-machine interfaces and clinical diagnostics using limited OPM sensors.

OPM-MEG and the developing mind: Unlocking brain function in toddlers

Margot J. Taylor
Director of Functional Neuroimaging, Diagnostic & Interventional Radiology
Senior Scientist, NMH, Research Institute
Hospital for Sick Children
Professor, University of Toronto, CA

An optimal use of OPM technology is being able to scan young children. I will present some of our data focussed on children 1-5 years of age (n>200), including young children with autism, using child-friendly protocols: video-based resting states, moving visual circles (which elicit gamma band activity) and emotional faces. We are finding significant age-related changes in periodic, evoked and aperiodic signals that vary with brain region and relate to emerging behaviours. OPM technology is transforming neuroimaging research in toddlers and young children and advancing our understanding of brain-behaviour relations over the early years of life.

Clinical MEG using ^{4}Helium OPM sensors

Caroline Witton
Aston University, UK

At Aston University we have a long experience of clinical MEG recordings for patients with epilepsy who are candidates for neurosurgery, using a cryogenic MEG system. However the need to record from younger children, with smaller heads, has led us to the use of OPM-MEG. In this talk I will describe preliminary studies comparing the data from our cryogenic and OPM-MEG system, from both healthy

volunteers and child patients with epilepsy. As well as examining data quality and exploring some case reports, I will talk about some of the challenges of using each system and consider the clinical future for OPM-MEG.

Development of a novel OPM-MEG platform, and its application in clinical populations

Matthew Brookes
The University of Nottingham, UK

OPM-MEG offers a potentially transformative platform for functional neuroimaging with the promise of high-performance, wearable instrumentation that can be used across the lifespan. In this talk, I will describe our recent research which has centred on the development and application of this technology. I will discuss our development work, including validation of a new integrated and miniaturised electronics platform; our efforts to develop novel calibration systems; and our research towards the development of a 384-channel system. Following this, I will discuss our latest applications, including measurement of neurodevelopment in children as young as 6 months old, and characterisation of abnormal neural oscillatory patterns in patients with MS (in multiple postures; sitting/standing) and in patients with Parkinson's disease (undertaking a naturalistic movement task).

Fetal visual evoked responses measured with OPMs

Sarang S. Dalal & Lars H. Pedersen
Aarhus University, Denmark

Fetal MEG, the magnetic signals generated by the developing brain of the human fetus, can be measured with magnetometers placed on the mother's abdomen. We attempted to measure fetal MEG responses to light flashes with optically pumped magnetometers (OPMs).
We placed 16 FieldLine OPMs over the abdomen during the third trimester of pregnancy. The measurements were made while the mother relaxed on her side on an MEG-compatible bed in a magnetically shielded room. 1200 red light flashes of 2 ms duration were projected onto the abdomen to elicit fetal brain responses. Both maternal and fetal cardiac signals were clearly evident in the raw data. The data were then averaged across trials and processed with independent components analysis (ICA) to remove cardiac interference and other artifacts. This revealed an evoked response peaking between 190 and 240 ms, consistent with literature showing SQUID-based fetal visual evoked responses. The evoked response topographies were concentrated over the lower abdomen, consistent with the head-down fetal positions that were observed with ultrasound, and distinguishing it from fetal and maternal cardiac signals. To our knowledge, these are the first OPM measurements of the fetal visual response.

Clinical Potential of ^{4}He OPM-MEG: A Comparison with SQUID-MEG for Detecting Interictal Epileptic Activity

Denis Schwartz[1,2], Jean-Michel Badier[4], Tjerk P. Gutteling[1,2], Sébastien Daligault[1], Etienne Labyt[3], Francesca Bonini[4,5], **Julien Jung**[2,6]

(1) CERMEP-Imagerie du Vivant, MEG Departement, Lyon, France
(2) CRNL, UMR_S 1028, INSERM, CNRS, Lyon University 1, HCL, Lyon, France.
(3) MAG4Health, 9 Av Paul Verlaine 38100 Grenoble, France
(4) Aix Marseille Univ, INSERM, INS, Inst Neurosci Syst, Marseille, France
(5) APHM, Timone hospital, Epileptology and cerebral rythmology, Marseille, France
(6) HCL, Hospital Pierre Wertheimer, Functional Neurology and Epileptology Lyon, France

Conventional MEG systems rely on SQUID sensors but face limitations that restrict their broader clinical use. Optically pumped magnetometers (OPMs), particularly helium-based ^{4}He-OPMs, offer significant advantages such as lightweight, flexible, and motion-tolerant headsets, making them especially promising for epilepsy monitoring during natural movements and seizures. In this presentation, we will report our experience using a 5-sensor ^{4}He-OPM MEG system's ability to detect interictal epileptiform discharges (IEDs).

We compared its performance against traditional SQUID-MEG in 7 patients and conducted combined intra-cerebral SEEG and MEG recordings in one patient to verify detection of deep brain epileptic activity. Results showed that both systems detected IEDs with similar signal quality in 5 of 7 patients. IEDs were visually detected in the same 5 patients using both modalities, while 2 patients showed no IEDs with either method. The SQUID-MEG detected a total of 975 IEDs (mean 195 ± 137), compared to 417 IEDs detected by the 4He-OPM-MEG (mean 83 ± 97). At the group level, the SQUID-MEG showed a higher signal-to-noise ratio (SNR) than the 4He-OPM-MEG, but the difference was small. However, the 4He-OPM-MEG had significantly higher maximum spike amplitudes (3.76 pT vs. 1.66 pT), with a large effect size. Additionally, for the 4He-OPM-MEG, radial measurements had slightly higher SNR and spike amplitudes compared to tangential measurements. Notably, the ^{4}He-OPM system successfully recorded epileptic activity from deep brain regions, validated by SEEG. These findings support the clinical potential of lightweight, high-sensitivity ^{4}He-OPM MEG systems, opening new avenues for epilepsy diagnosis and broader MEG accessibility in clinical and research environments.