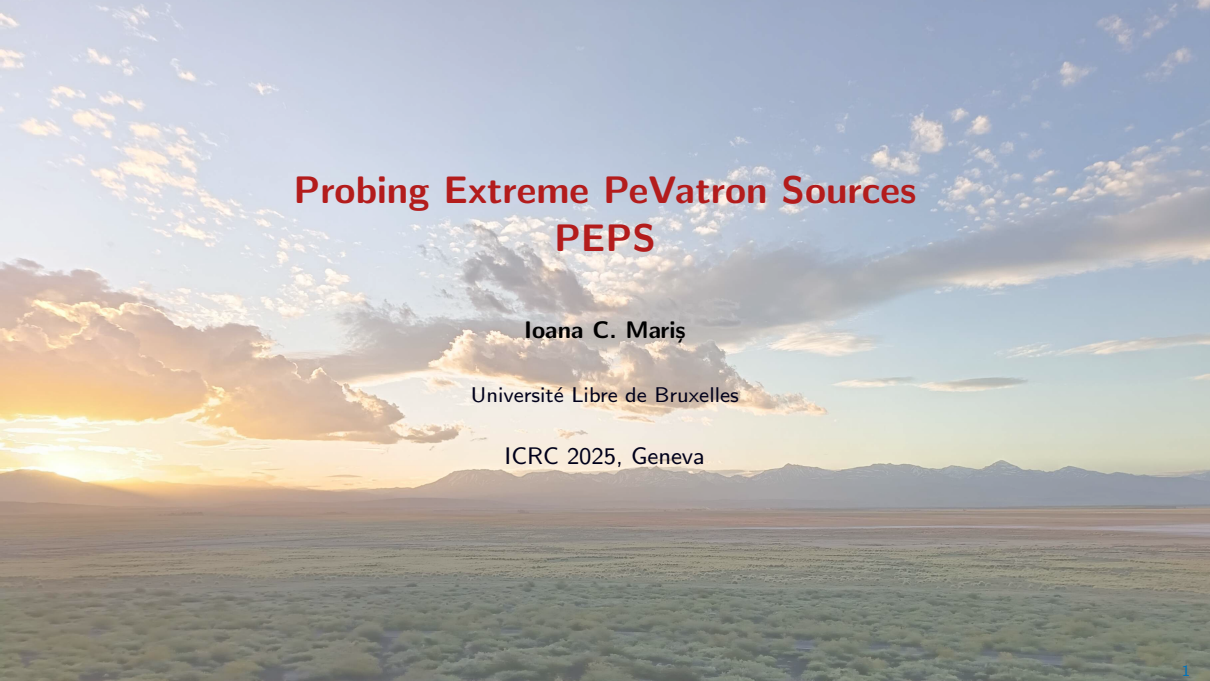




# Probing Extreme PeVatron Sources PEPS

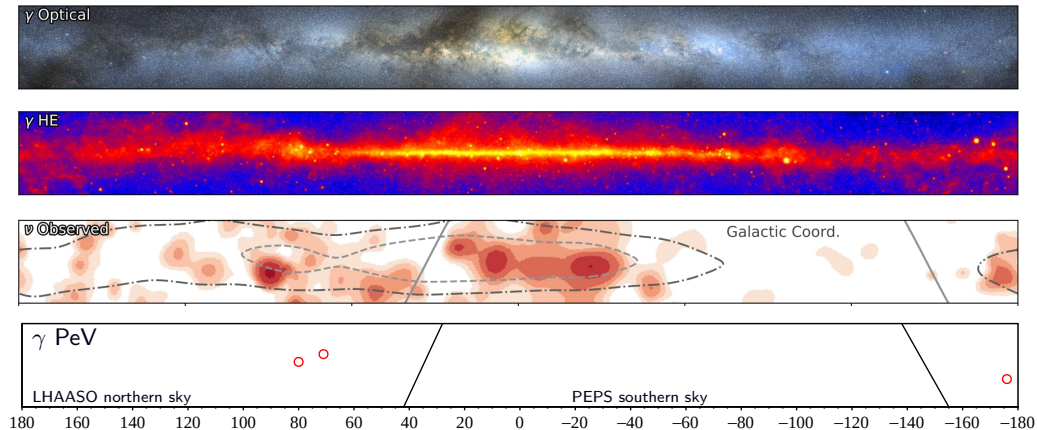
**Ioana C. Mariş**

Université Libre de Bruxelles

ICRC 2025, Geneva

# PEPS: Breaking the energy frontier

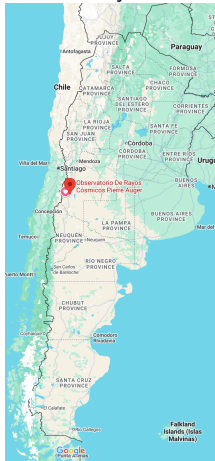
10 km<sup>2</sup> detector to measure gamma-rays between 1 PeV and 50 PeV



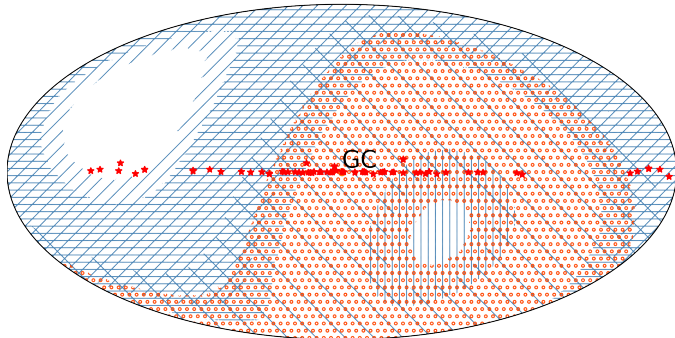
Discovery potential in the new energy range with  
a unique view of the Galactic Center and southern galactic sky!

# Looking at the southern sky for extreme galactic sources

At the Pierre Auger Observatory



Complementary with LHAASO/HAWC and a good coverage of the Galactic plane and Galactic Center. Good overlap with SWGO/ALPACA (measuring at lower energies)



/// LHAASO

|||| IceTop

\\ SWGO

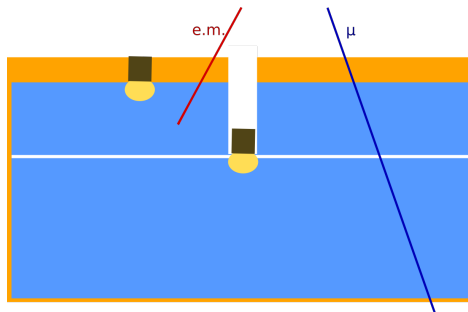
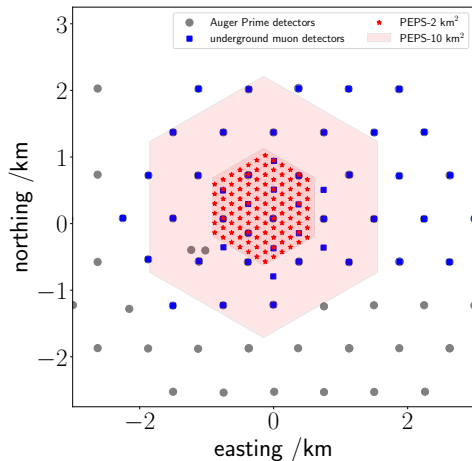
== HAWC

oooo PEPs

red points: TeVCat sources (tevcat.org)

# Aim and approach

PEPS Phase I: a 2-km<sup>2</sup> surface detector of water-Cherenkov detectors

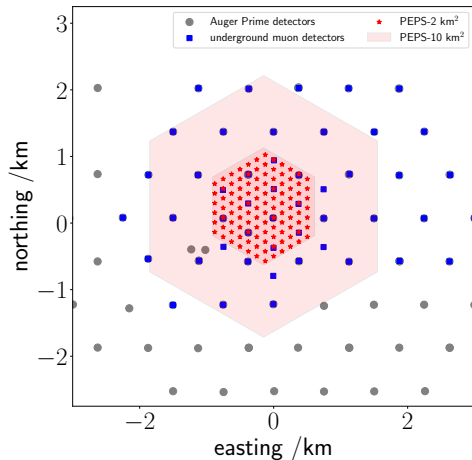


Layered Water Cherenkov detectors optically separated

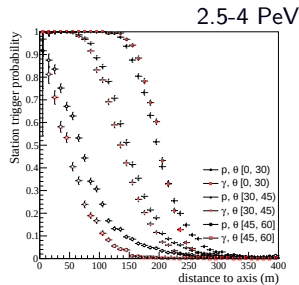
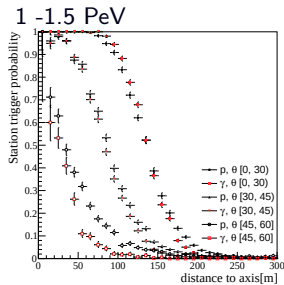
(A. Letessier-Selvon, P. Billoir, M. Blanco, ICM, M. Settimo, NIM A767 (2014), arxiv:1405.5699)

# Aim and approach

## PEPS Phase I: a 2-km<sup>2</sup> surface detector of water-Cherenkov detectors



Corsika/EPOS-LHC, Geant4

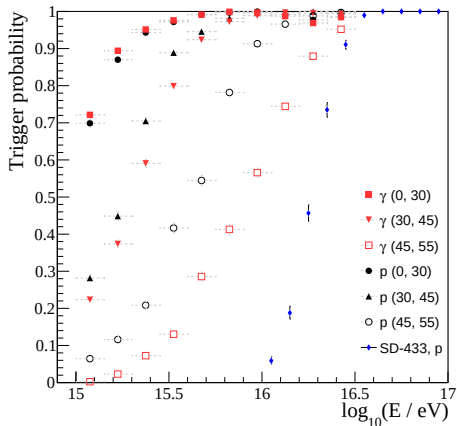


An array with a spacing of 145 m between the detectors

prod. of simulations by N. Gonzalez and E. Santos

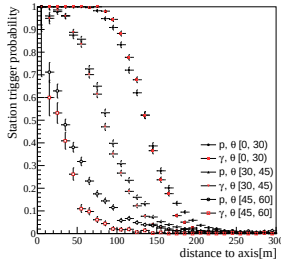
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## PEPS Phase I: a 2-km<sup>2</sup> surface detector of water-Cherenkov detectors

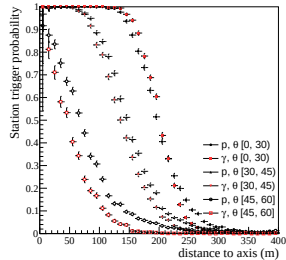


Corsika/EPOS-LHC, Geant4

1 - 1.5 PeV



2.5-4 PeV



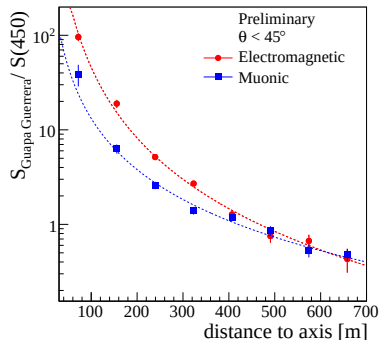
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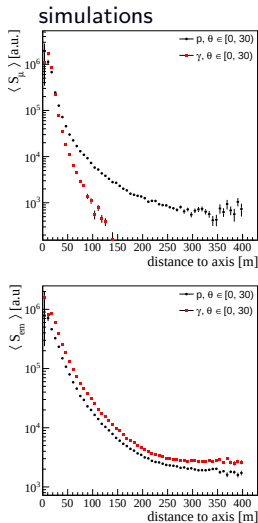


# Photon-proton separation

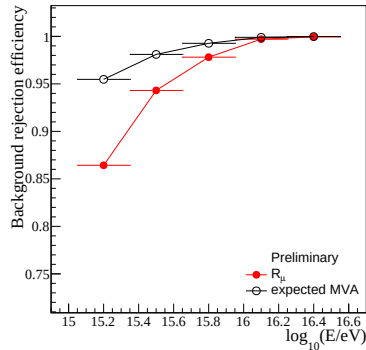
Data from prototypes



Average LDFs with two months of data in 2014 ( $E > 10$  PeV)



at 50% photon efficiency

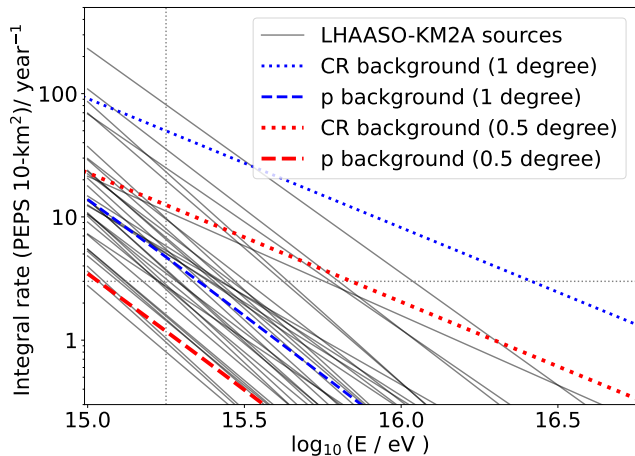


Basic separation variables, summed over N stations (not optimized):

$$R_\mu = \frac{1}{N} \sum_i^N S_{\mu} \cdot r^{1.5}$$

# Discovery of extreme PeVatrons in the Southern sky?

## What is the maximum available energy in our Galaxy?



Extrapolations of the LHAASO sources

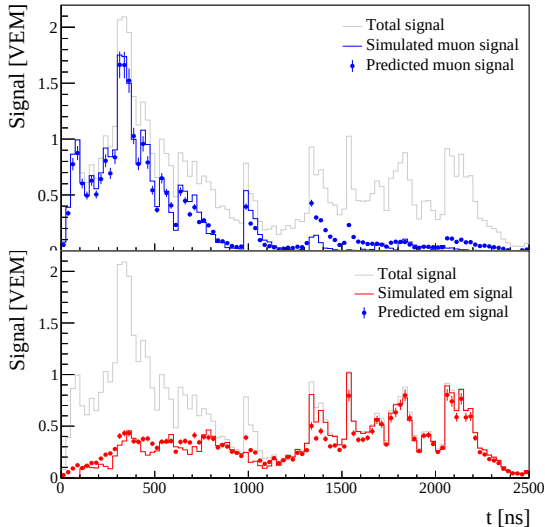
Between 30 and 400 events/ year above 1 PeV

Between 1 and 100 events/ year above 3 PeV

Background depends on the angular resolution (expected between 0.3 to 1 degrees) and separation power (this plot, 3e-4). RNN expected to improve sensitivity (O.Zapparata, PhD thesis, Auger coll., JINST 16 (2021) P07016)

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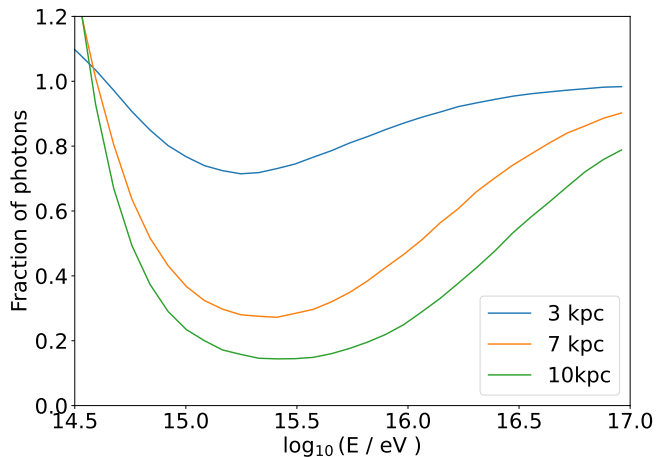
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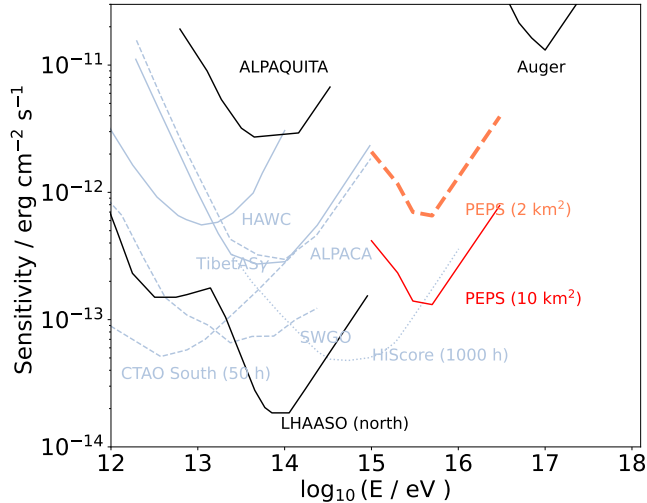
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$\gamma$ - $\gamma$  interactions important at distances larger than 5 kpc

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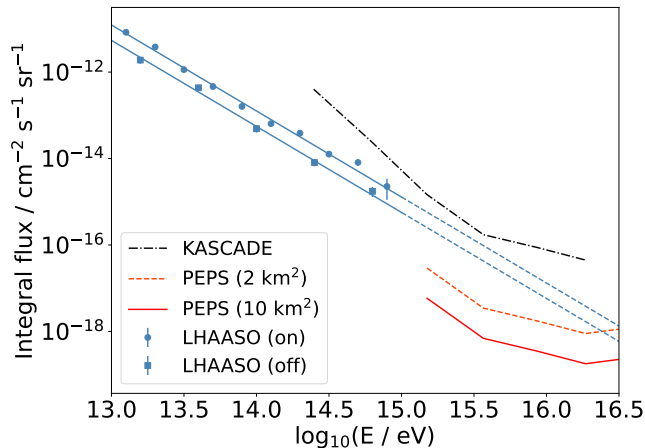
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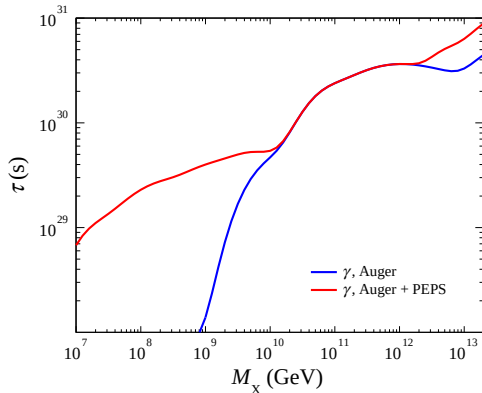
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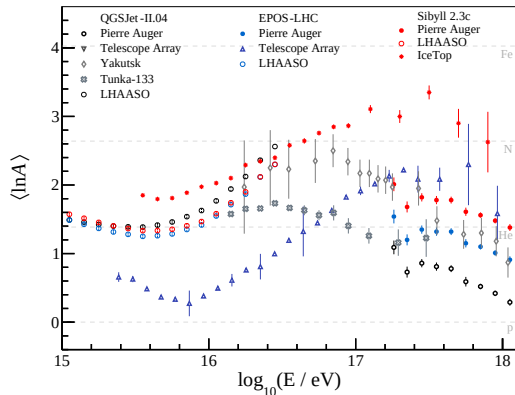
An extra component in the diffuse flux?

# Super-heavy dark matter and charged cosmic rays



from O. Deligny

Probes of meta-stable super-heavy dark matter  
Models with the SHDM decaying into  
low-multiplicity (e.g. sterile neutrinos, spin 3/2  
particles)



Extend down in energy the Auger measurements  
(allows for a cross-calibration between fluorescence  
and surface detectors)

# Detector design and construction

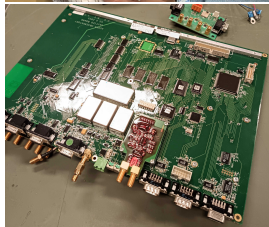
Base the design on robust segmented detectors, leveraging previous expertise and similarities to SWGO  
(2 detectors operating since 2014)

Use decommissioned components for non-critical parts  
(Pierre Auger Observatory unified boards and solar panels)

Build 3 prototypes in 2025/2026  
( testing components and adapting electronics in Brussels)



(2014)



(2024)

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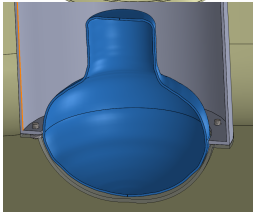
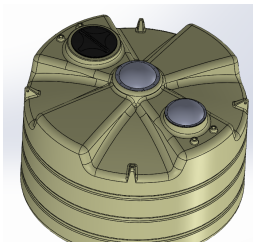
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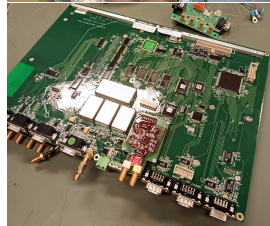
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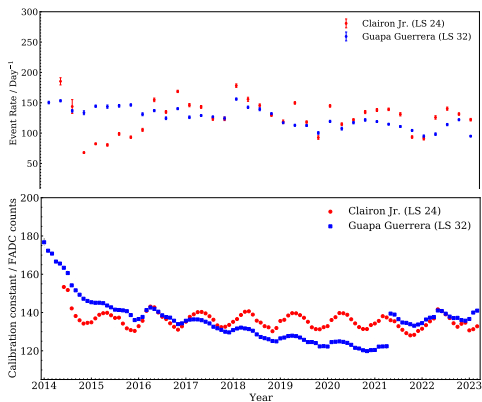


drawings by L. Mendez



(2024)

# Stability and calibration of the detector

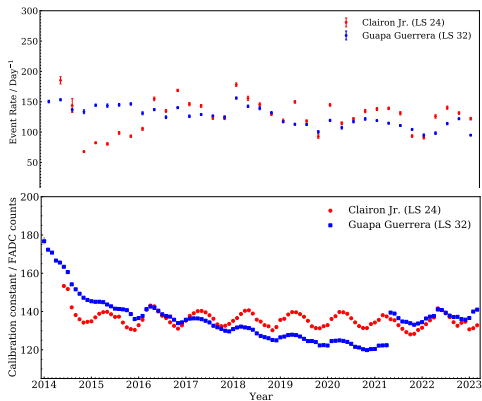


Use existing infrastructure of the Auger Observatory for assembling, water purification, and deployment  
Optimisation of the PEPS geometry (reduce the diameter from 3.6 m to 3 m)

PEPS can be fully operational in 2.5 years

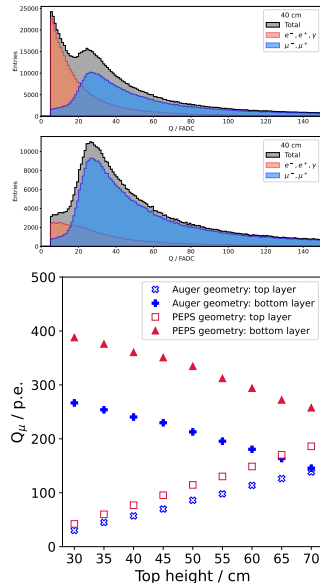


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# Probing Extreme PeVatron Sources (PEPS)

- The worlds largest observatory for gamma-rays in the energy range 1-50 PeV
- First observation of the most energetic gamma-rays in the Milky Way Galaxy as seen from the Southern sky
- PEPS 2-km<sup>2</sup>: A pioneering first step towards a future 10-km<sup>2</sup> array

# Interested in PEPS?

Join the mailing list:



[https://listserv.vub.be/mailman/postorius/  
lists/peps.listserv.vub.be/](https://listserv.vub.be/mailman/postorius/lists/peps.listserv.vub.be/)

Become a supporter



<https://forms.gle/mcxYJCYhy3bxZQm57>

Current Suporters: Markus Roth, Chaitanya Priyadarshi, Michael Prouza, Markus Risse, Jonas Glombitza, Bohdan Hnatyk, Adrian C. Rovero, Frank G. Schröder, Rossella Caruso, Mateo Fernandez Alonso, Martina Bohacova, Andrea Parenti, Nicolas Gonzalez, Vladimír Novotný, Armando di Matteo, Fabian Schüssler, Ingo Allekotte, Petr Travnicek, Jiri Blazek, Alessio Porcelli, Benjamin Flaggs Olga Sergijenko, Julian Rautenberg, Paula Gina Isar, Michael DuVernois, Ruben Conceição, Sven Querchfeld, Katarina Simkova, Katie Mulrey