

Max-Planck-Institut für Physik (Werner-Heisenberg-Institut)

# DARK MATTER DATA CENTRE DARK MAILER DALA CENIRE Heerak Banerjee (TUM) Nahuel Ferreiro Iachellini (MPP)





# Dark Matter





- Galactic Rotation Curves of spiral galaxies
- Velocity Distribution in elliptical galaxies and globular clusters
- Mass estimation in galaxy clusters.
  Dark Matter : Visible Matter = 5:1
- Gravitational Lensing
- CMB anisotropy acoustic peaks : COBE (1992), BOOMERang (2000), WMAP (2012), PLANCK (2015)
- Structure Formation





# $10^{-22} eV$

# Dark Matter



~100 Solar Masses

Lightest Supersymmetric Particle





# Looking for Dark Matter



DAMA/LIBRA\*, ANAIS\*\*, CLEAN\*\*\*

not operating anymore \*\* functioning \*\*\* under construction/upgrading \*\*\*\* planned/proposed





# Looking for Dark Matter





Time (day)



# DARK MATTER DATA CENTER

Forschung

Aktuelles

# THE DARK MATTER DATA CENTER (INTEGRATED INTO ODSL)

Fostering Data and Information Sharing for The Dark Matter Community

# Open Data, Open Science!

ORIGINS

Open science has become a pillar in the research world and it's fuelling exchange of knowledge, data and ideas. The extraordinary impact of open science accelerates scientific research and the creation of new knowledge. We believe that open data is deeply rooted in the scope and spirit of fundamental research and we support this culture, offering a place where data from experiments and phenomenology can meet.

# Dark Matter

Dark matter searches are an extraordinary endeavor of the human kind to shed light on one of the biggest mysteries of the cosmos and the physics that governs it. The understanding of the composition of our Universe expands through a variety of experimental approaches and a rich zoo of models and ideas. The discovery of dark matter and the investigation of its nature must follow complementary paths, for no single evidence would uniquely identify the nature of dark matter making up our Universe.

# Bringing Experiments and Theories Together

With the ORIGINS Dark Matter Data Center we want to fully leverage the potential of open science to bring together observations from different experiments, the implications of different models and all the associated software. At the DMDC we aim at increasing accessibility to scientific process and knowledge, open data and open source software: key ingredients for the nourishing of open science (From "Open Data to Open Science" Earth and Space Science doi:10.1029/2020EA001562), by offering a repository for experimental data, models and code. The Dark Matter Data Center supports data comparison, combination and interpretation using clear and reproducible methodologies, easing the usability of this data, enabling one to make the most out of it. Our sights are set on sharing knowledge in all its relevant forms: data, methodologies and software with the ultimate goal of offering a consistent and unified view of the field in all its facets.

## Overview

- Explore Data
- Publish Data
- Publish Code
- Simulate and Compare

## Team







has made available

- CRESST
- XENON

## Available software

## Submit data or software

## Simulate

with your model (Coming Soon!)

# DARK MATTER DATA CENTER

# Open Data! Open Science!

Efficiency of Research

Reliability of Results

Resilience to societal challenges ORIGINS

Forschung Aktuelles

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Fostering Data and Information Sharing for The Dark Matter Community

# Open Data, Open Science!

Excellence Cluster

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Heerak Banerjee (TUM)



Postdoc and ODSL Fellow

# CN-1//CN-3//CN-7//ODSL//P-S/ RU-A / RU-B / RU-D



Dr. Nahuel Ferreiro Iachellini (MPP) Postdoc and ODSL Fellow @ ferreiro(at)mpp.mpg.de



# Available Datasets

Click on a Collaboration to view the datasets it has made available

- CRESST
- XENON

# Available software

## Submit data or software

## Simulate

Simulate event rates for listed experiments with your model (Coming Soon!)





# **Heerak Banerjee** Phenomenologist with experience in astroparticle searches and data analysis



We have been seeded by funds from the ORIGINS Cluster. An interdisciplinary research network, funded within the framework of the Excellence Strategy of the German Federation. It investigates the development of the Universe from the Big Bang to the emergence of life.

The Max Planck Computation and Data Facility provides us with the necessary computational power. The public data is stored on the MPCDF servers to be fetched from our website on the ORIGINS domain. The Binders and the online services run on MPCDF servers as well.

# The Team

Nahuel Ferreiro Iachellini Experimentalist with background in direct searches with cryogenic detectors







# For Example...

# Data from Experiments



- Documented
- Easily findable (Metadata)
- Directly citable (Publication &
- Usage Instructions (Also in form of JuPyTer notebooks)

# XENON1T S2-Only Data Release

Detector Module	XENON1T
Material	Liquid Xenon
Technology	Dual-phase time projection chamber
Fiducial mass	2 tonne
Total exposure	356770 Kg days
Threshold	0.7 keV for NR, 0.186 keV for ER
Acceptance region	150-3000 Photoelectrons
Citeable sources	Phys. Rev. Lett. <b>123</b> , 251801
Data and Description	https://github.com/XENON1T/s2only_data_release

An example analysis for using this data release to constrain a model of Dark Matter has been provided by the Collaboration in the form of a JuPyTer Notebook

Click here to launch a binder for a JuPyTer session with the notebook pre-loaded: 👩 Jaunch binder

Resource	description
DetA AR	Recoil energies in the acceptance region
C3P1_DetA_cuteff	Cut efficiency
C3P1_DetA_eff_AR_Ca	Fraction of events from the Ca recoil band in the ROI
C3P1_DetA_eff_AR_0	Fraction of events from the O recoil band in the ROI
C3P1_DetA_eff_AR_W	Fraction of events from the W recoil band in the ROI
C3P1_DetA_full	Energies of events surviving da selection
C3P1_DetA_DataRelease_SD	Spin dependent limit
C3P1_DetA_DataRelease_SI	Spin independent limit



# For Example...

# Data from Experiments



- Easy Visualization (Recoil energies, time series, limits, etc.)
- Interactivity



Spin-Independent exclusion plot



Angloher, G. *et al.* (CRESST collaboration) (2017), arXiv:1701.08157 Angloher, G. *et al.* (CRESST collaboration), Eur. Phys. J. C **76**, 25 (2016), arXiv:1509.01515 Angloher, G. *et al.* (CRESST-II collaboration), Eur. Phys. J. C **74**, 3184 (2014), arXiv:1407.3146 Abdelhameed, A. H. *et al.* (CRESST collaboration) (2019), arXiv:1905.07335 Abdelhameed, A. H. *et al.* (CRESST collaboration), Phys. Rev. D **100**, 102002 (2019) Aprile, E. *et al.* (XENON collaboration), Phys. Rev. Lett. **123**, 251801 (2019), arXiv:1907.11485







Usage through user-friendly web-GUI

# For Example...



# WimPyDD

WimPyDD is a object-oriented and customizable Python code that calculates accurate predictions for the expected rates in WIMP direct-detection experiments within the framework of Galilean-invariant nonrelativistic effective theory. WimPyDD handles different scenarios including inelastic scattering, WIMP of arbitrary spin and a generic velocity distribution of WIMP in the Galactic halo.

WimPyDD is written by Stefano Scopel, Gaurav Tomar, Sunghyun Kang, and Injun Jeong.



# arXiv:2106.06207



# What we need from the Collaborations

# Event Data

- Post efficiency and selection cuts.
- Preferably full data and not just published ROI
- Photoelectrons, heat, timestamp, positions, etc. as available.

# Background Info

Detector Response

Analysis Pipeline

- Numerical background data and/or background models. Preferably for each component
- detector parameters, etc.
- In essence, information required to generate simulated signal at an experiment from predicted cross section.
- Analysis used by the collaboration to generate published exclusions using published data.
- As publishable software, in the form of Binders, JuPyTer Notebooks, etc. •

• Efficiencies, thresholds, cuts, quenching factor, conversions from recoil energy to



# Intersection between experimentalists and theorists in the DM community

# For the Collaborations

Data preservation (DOI assignment if needed, nonexclusivity)

Full reproducibility of published resuts

Easy usage (Binders and friendly web-GUI)

Facilitate proper and maximum utilization of data by the community

For Phenomenologists
Instructions and examples of data analyses
Virtual machines and computing power
Online visualization
Persistence, usability and citability of new model



- Ease and maximize the utilization of published data

In brevity

# Establish a repository for the technical aspects behind publications

Build a comprehensive catalog of data and models in the field of DM

