



# DARK MATTER DATA CENTER

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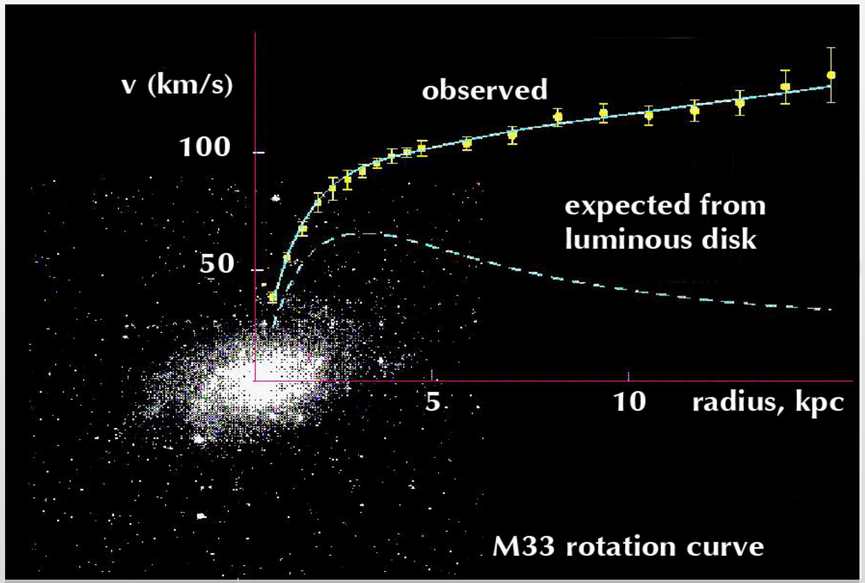
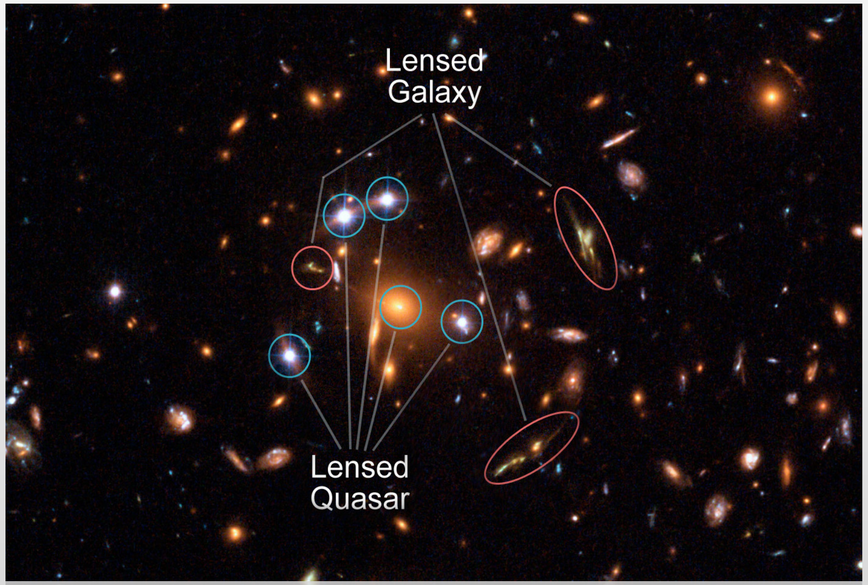
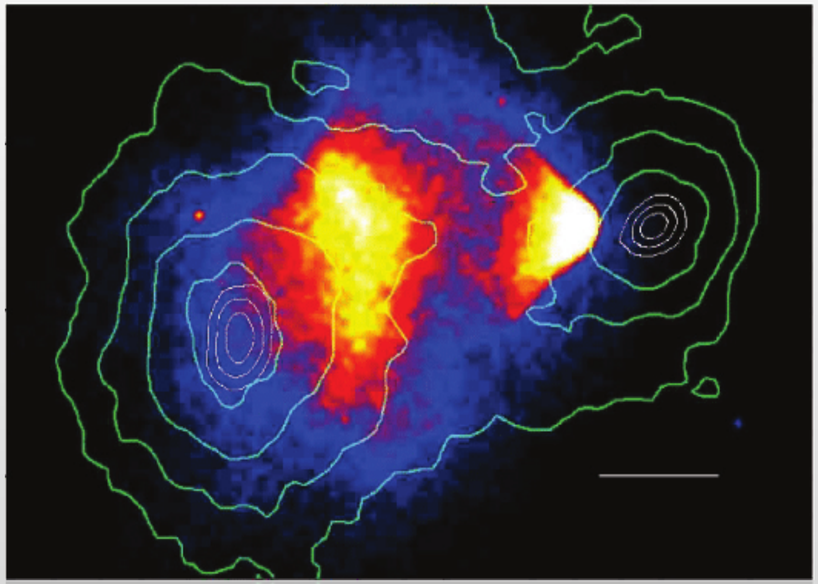
# All Roads Lead to…Dark Matter!

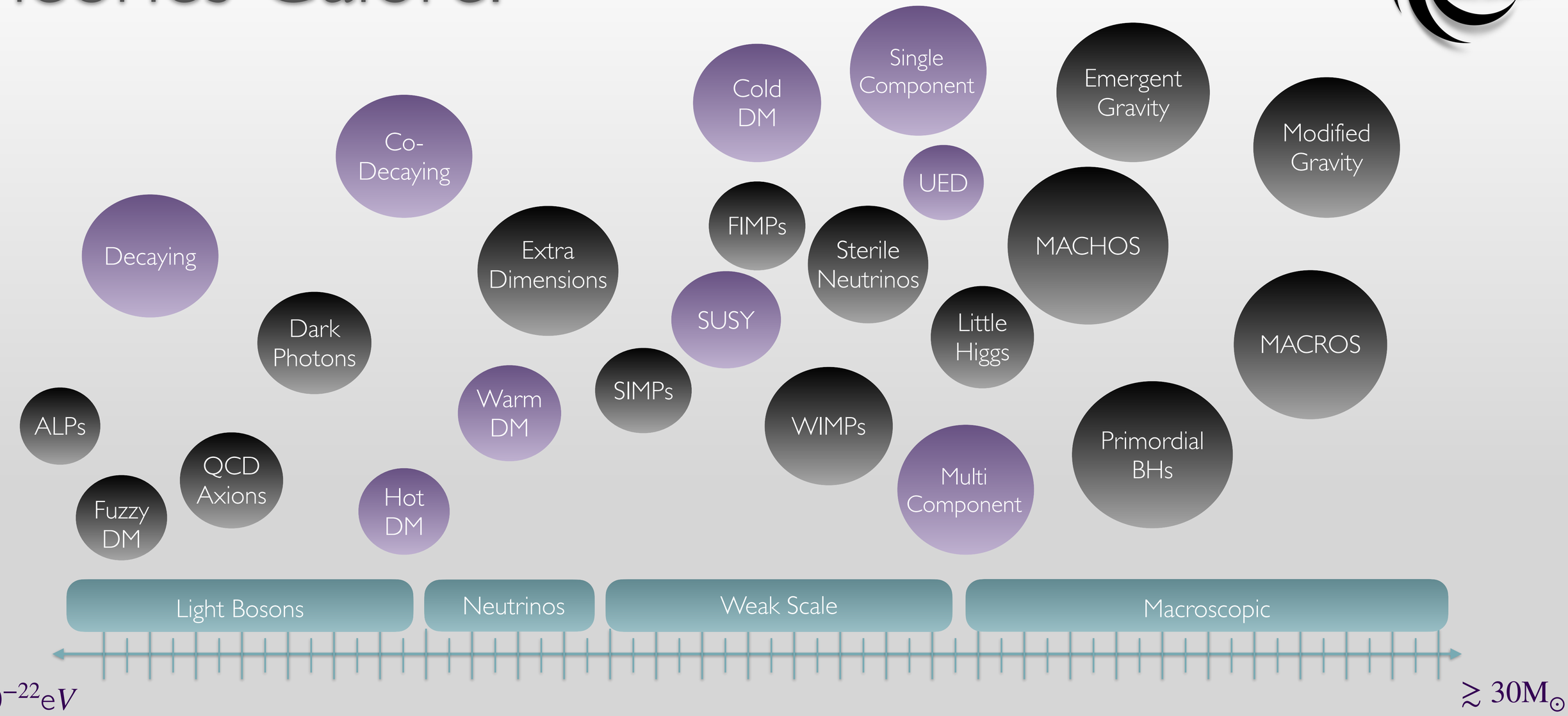


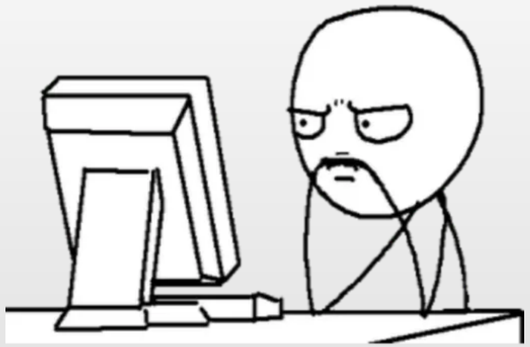



- ✓ Galactic Rotation Curves of spiral galaxies
- ✓ Velocity Distribution in elliptical galaxies and globular clusters
- ✓ Mass estimation in galaxy clusters. Dark Matter : Visible Matter = 5:1
- ✓ Gravitational Lensing
- ✓ CMB anisotropy acoustic peaks : COBE (1992), BOOMERang (2000), WMAP (2012), PLANCK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

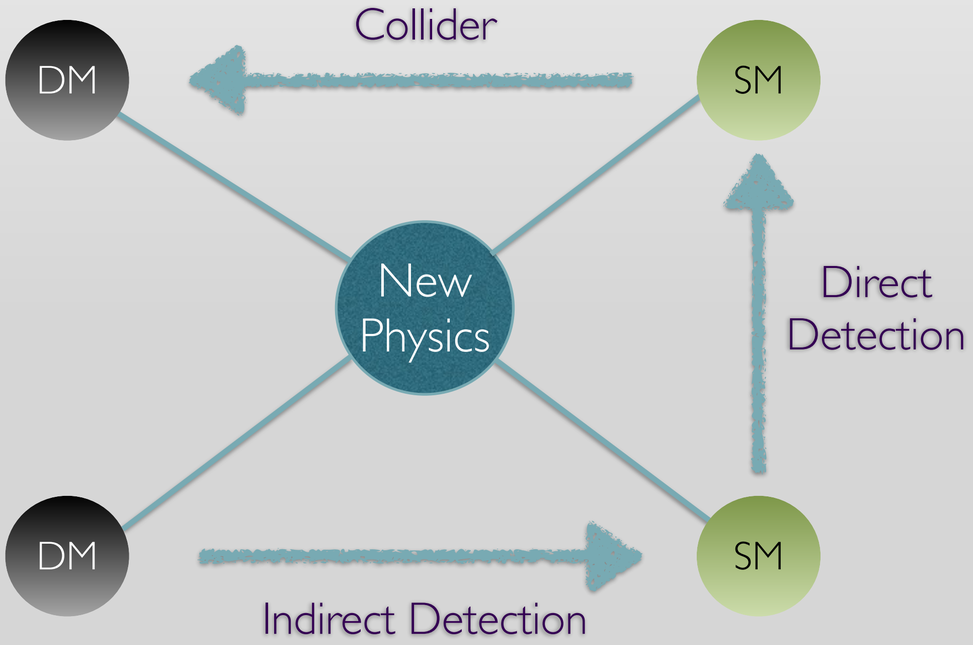
# Theories Galore!

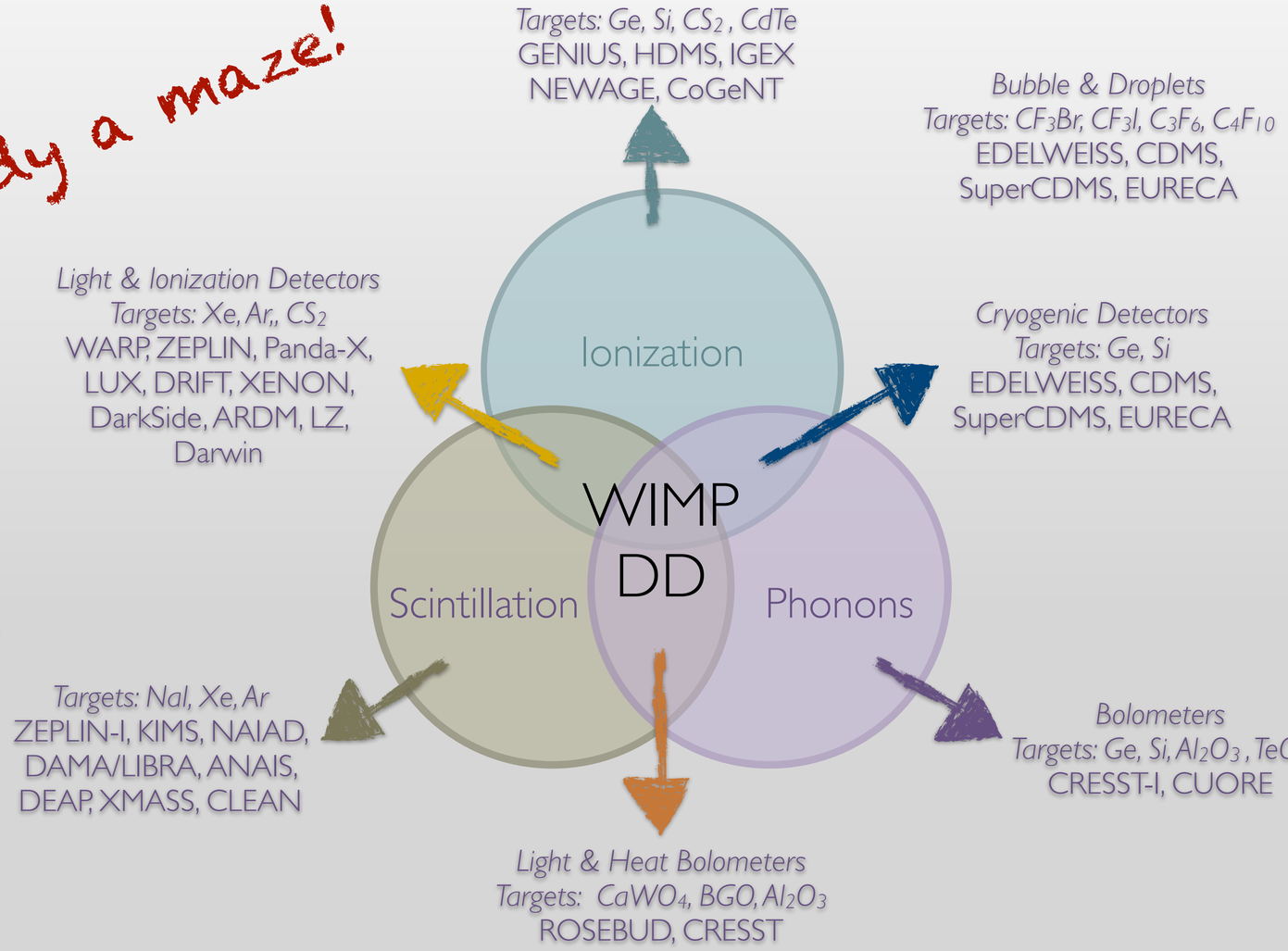


# Threading a Needle in the Dark…

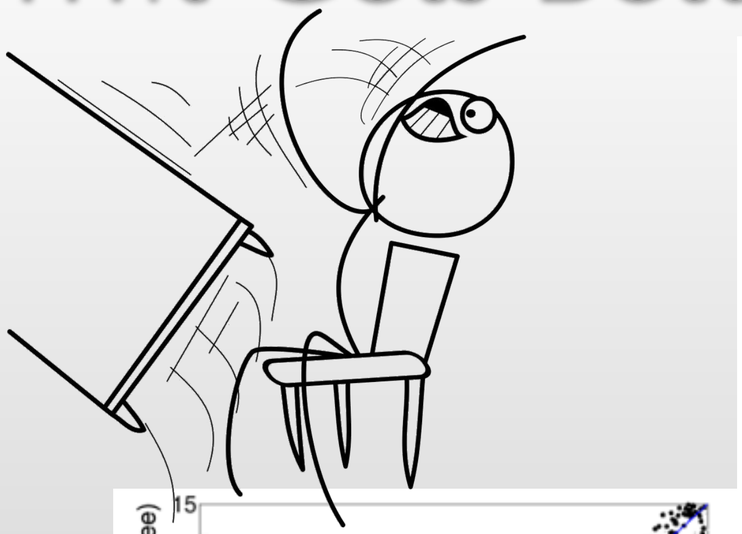


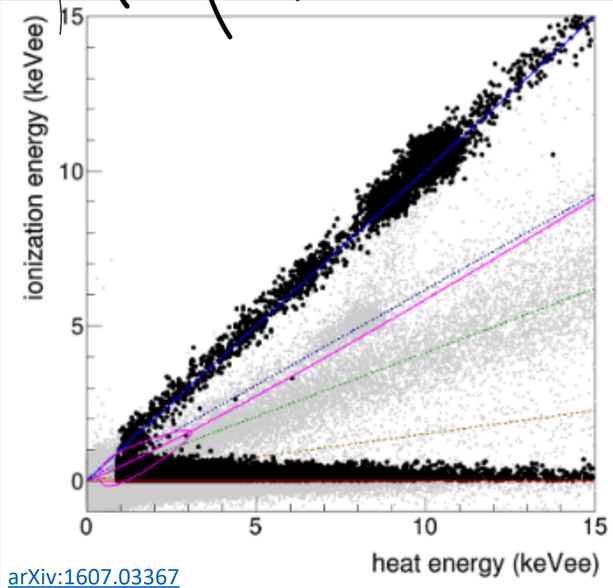
already a maze!



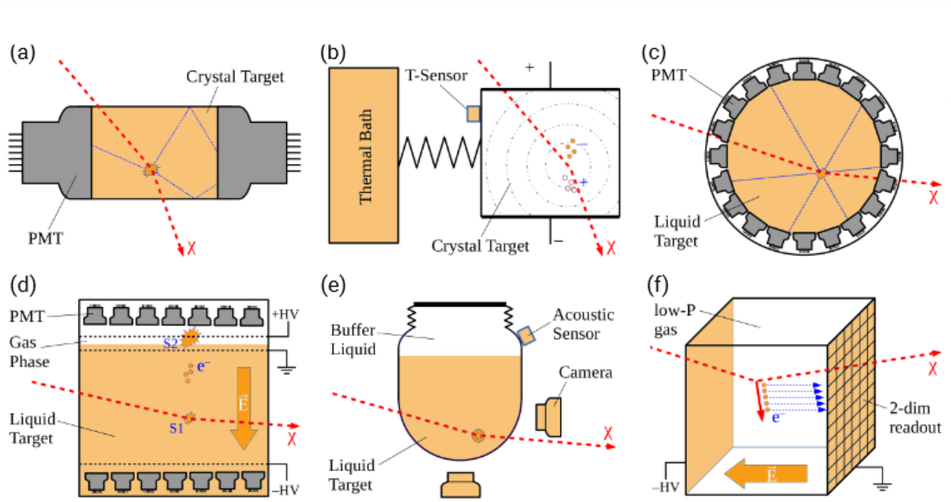



# …It Gets Better!

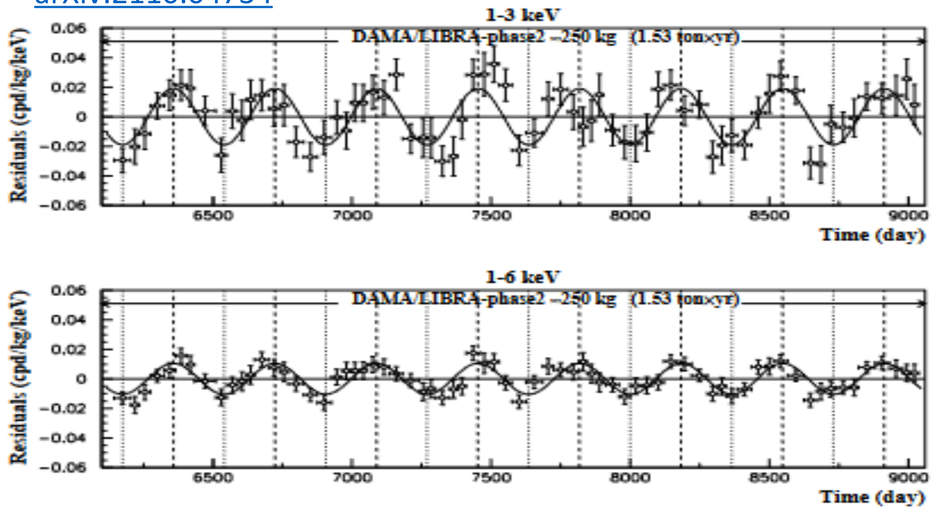


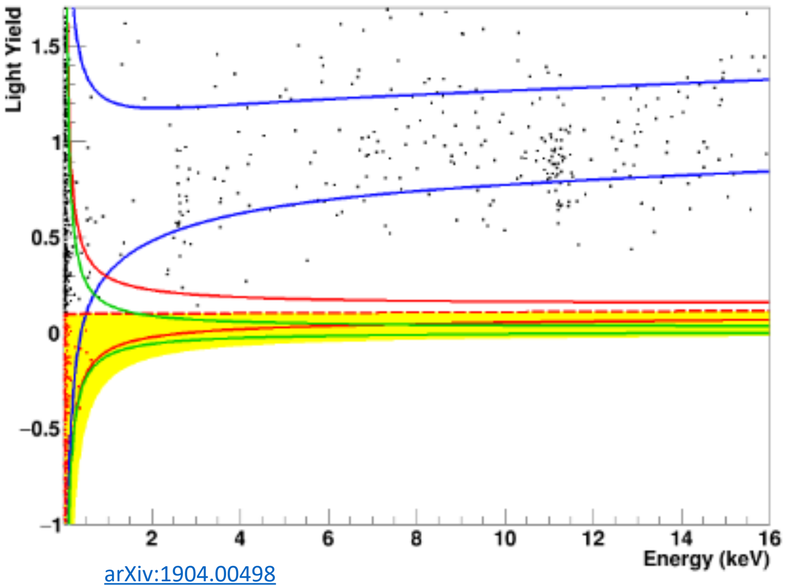



arXiv:1607.03367

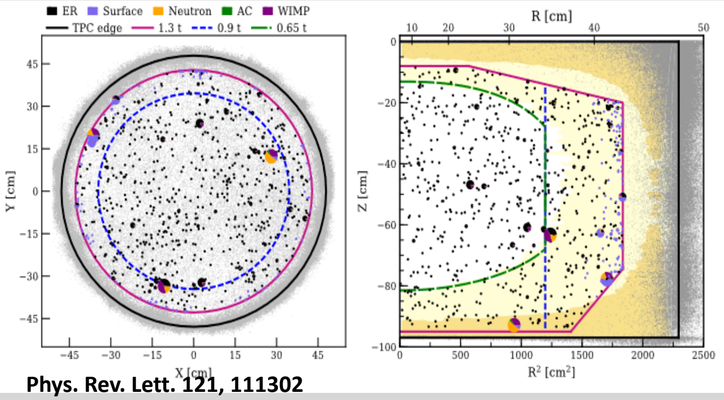



arXiv:2110.04734




arXiv:1904.00498




Phys. Rev. Lett. 121, 111302

# The Dark Matter Data Center

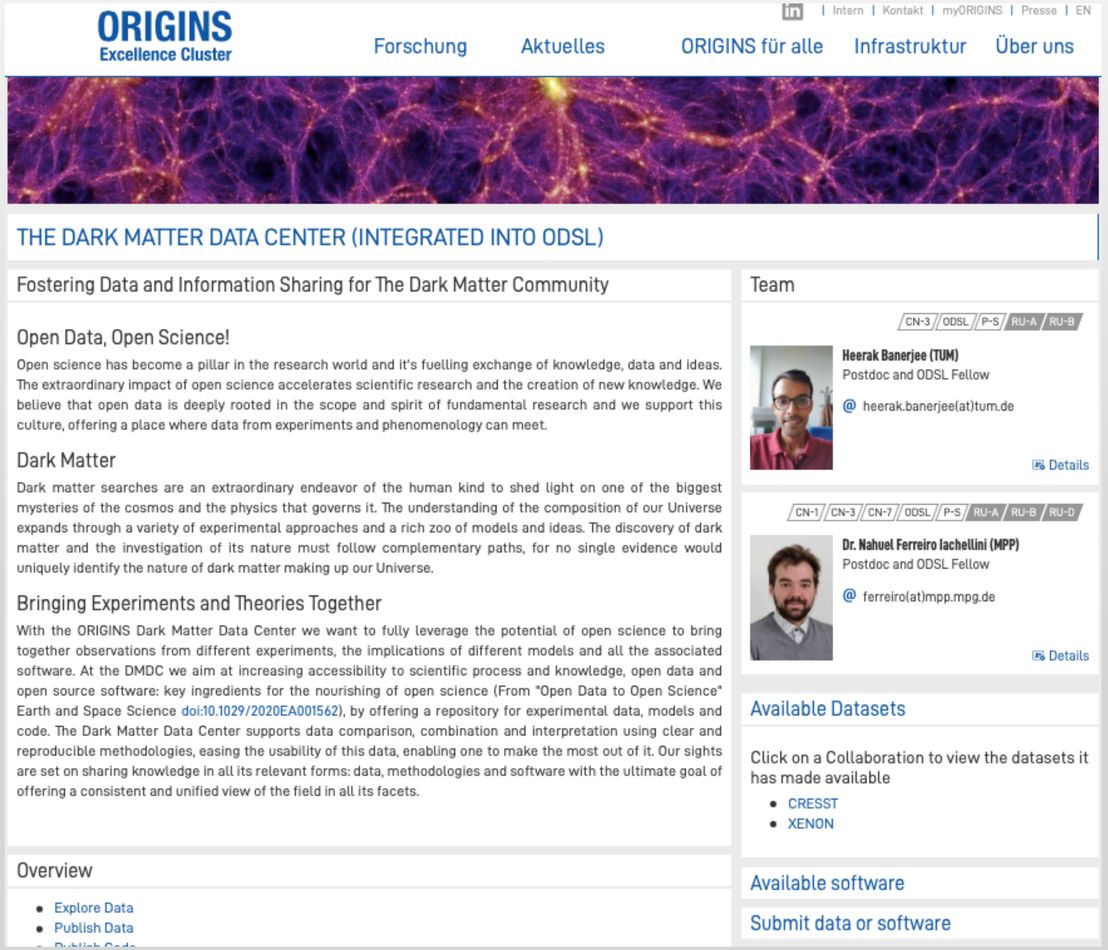
Open Data!

Open Science!

Efficiency of Research

Reliability of Results

Resilience to societal challenges



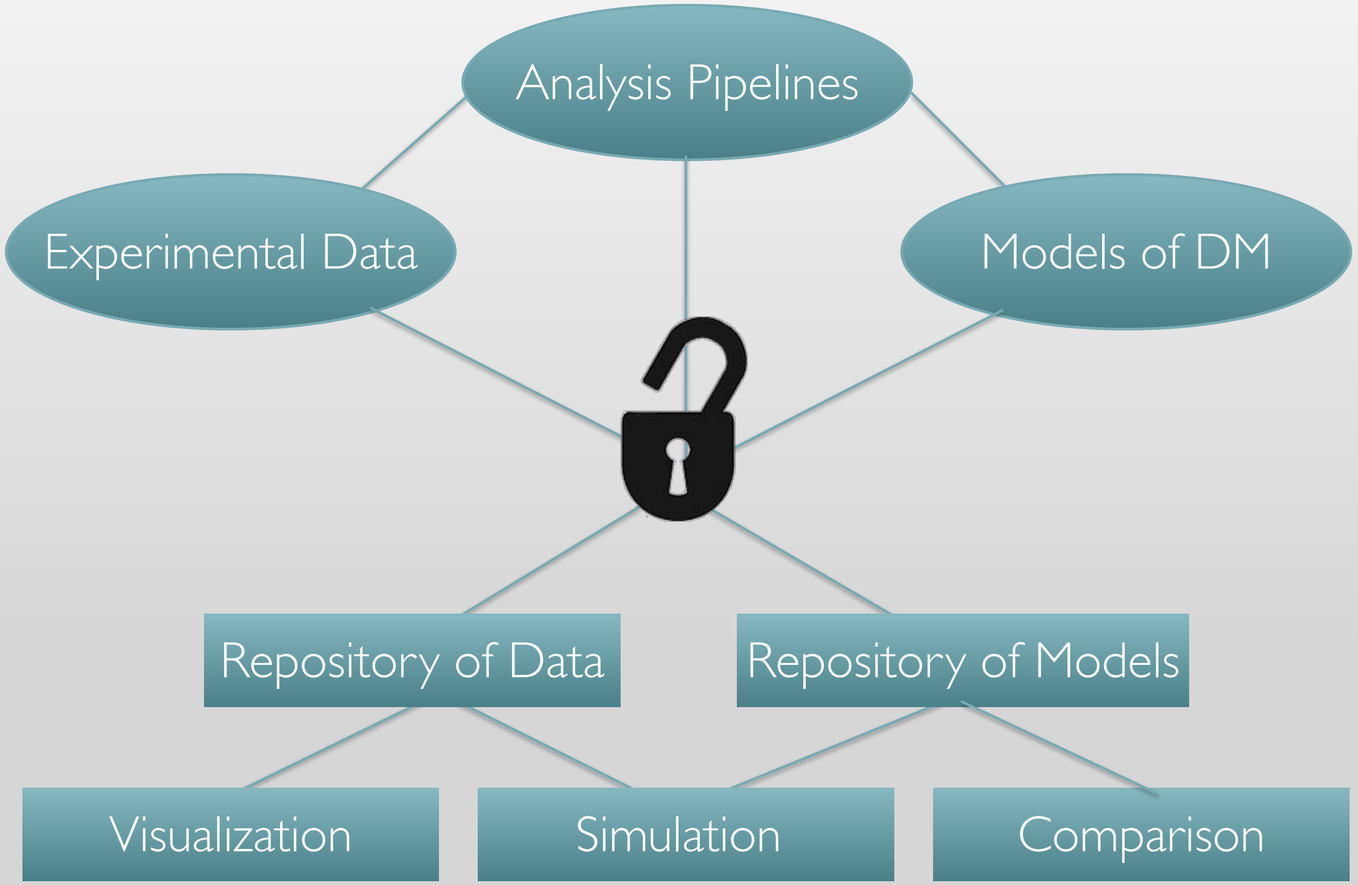
# The Team

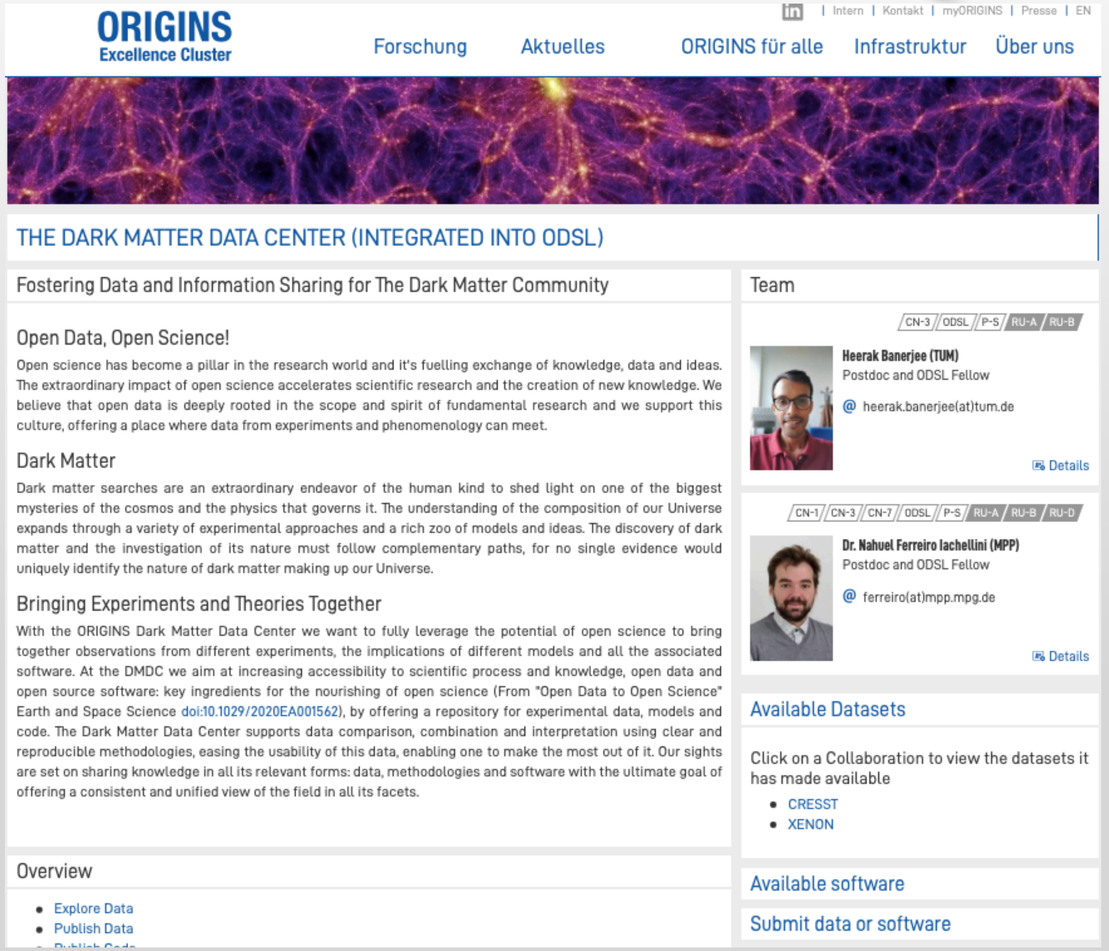
***Heerak Banerjee***
*Phenomenologist with experience in astroparticle searches and data analysis*

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

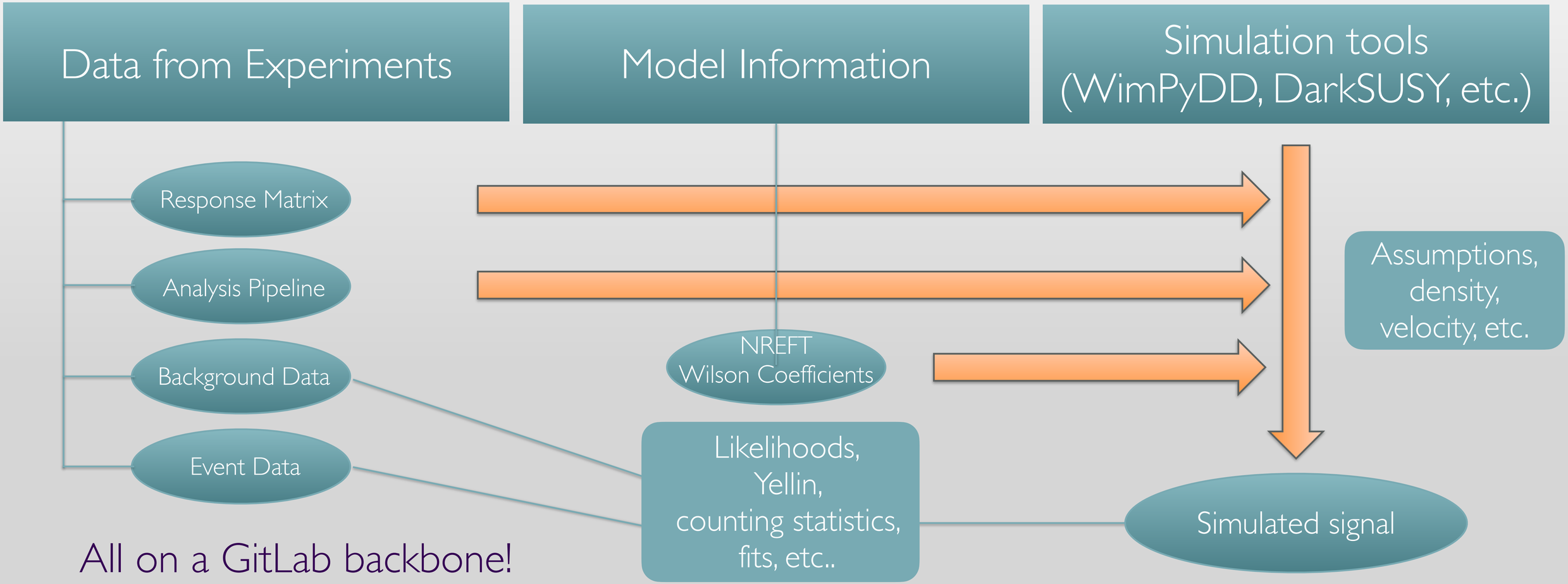
The Max Planck Computation and Data Facility provides us with the necessary computational power. The public data is stored on the MPCDF servers to be fetched from our website on the ORIGINS domain. The Binders and the online services run on MPCDF servers as well.

# The Dark Matter Data Center



# A Little More Detail




All on a GitLab backbone!

# For Example

## Data from Experiments

- Response Matrix
- Analysis Pipeline
- Background Data
- Event Data

- Documented
- Easily findable (Metadata)
- Directly citable (Publication & DOI)
- 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. **123**, 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: launch 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_O | 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

- Response Matrix
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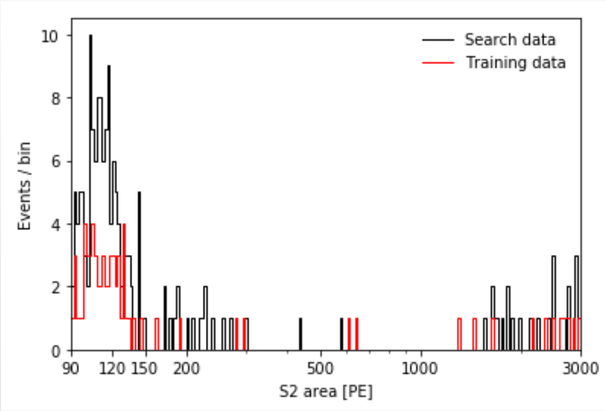
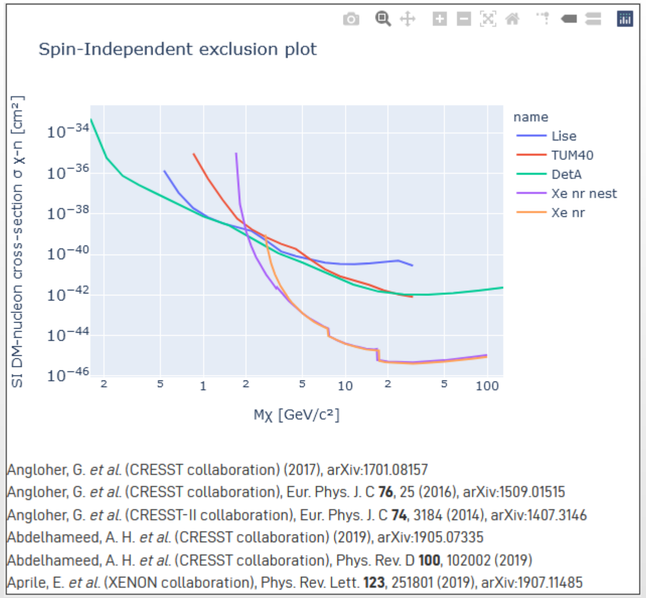
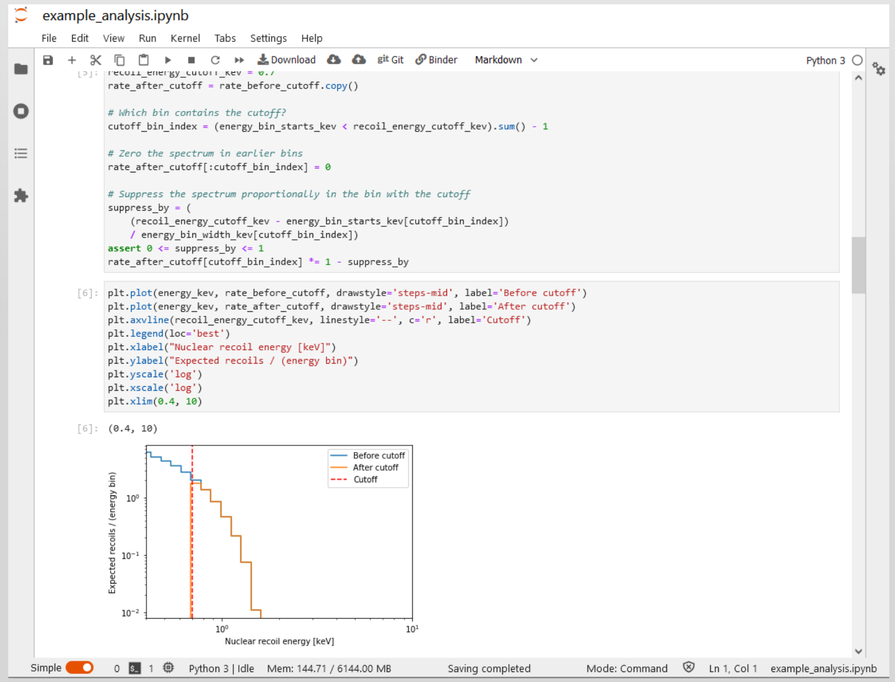




Angloher, G. *et al.* (CRESST collaboration) (2017), arXiv:1701.08157
Angloher, G. *et al.* (CRESST collaboration), Eur. Phys. J. C **76**, 25 (2016), arXiv:1509.01515
Angloher, G. *et al.* (CRESST-II collaboration), Eur. Phys. J. C **74**, 3184 (2014), arXiv:1407.3146
Abdelhameed, A. H. *et al.* (CRESST 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


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



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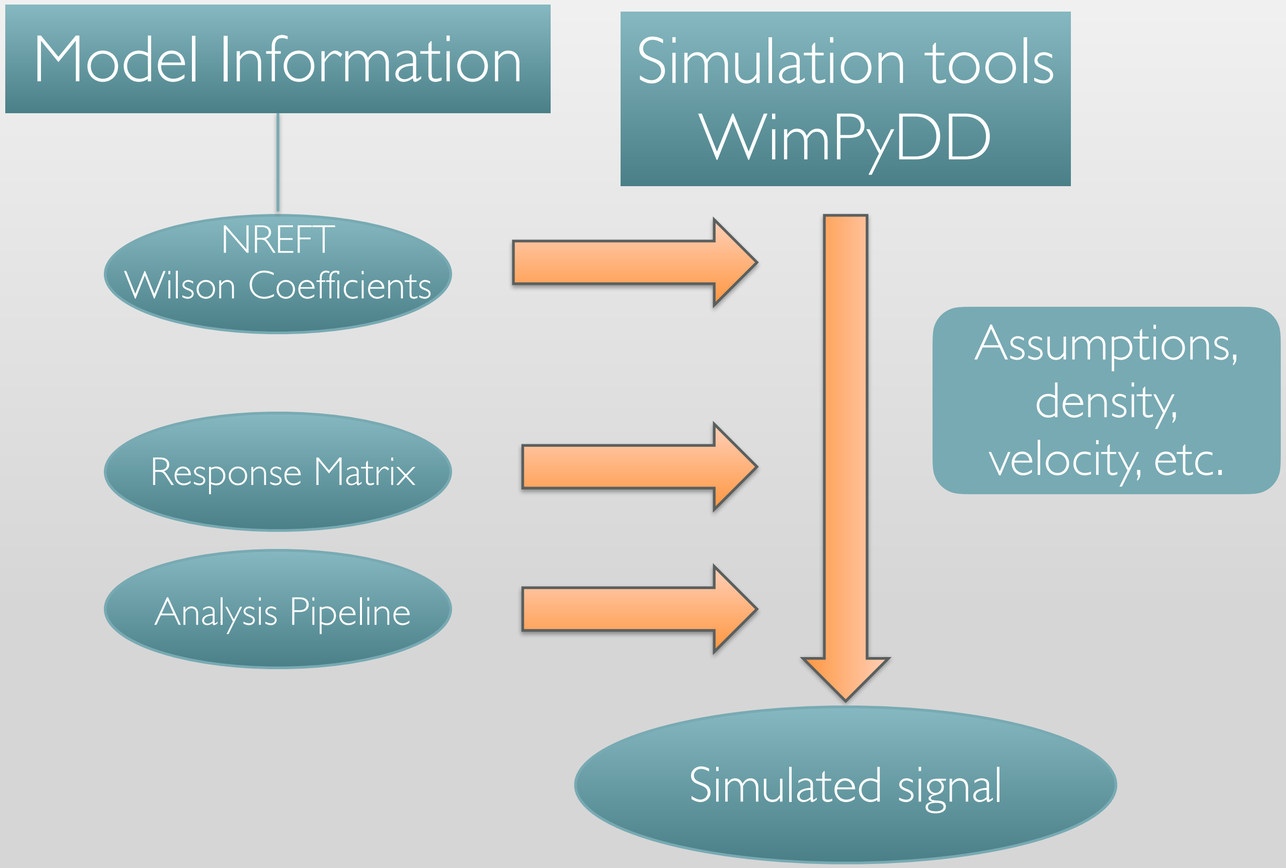
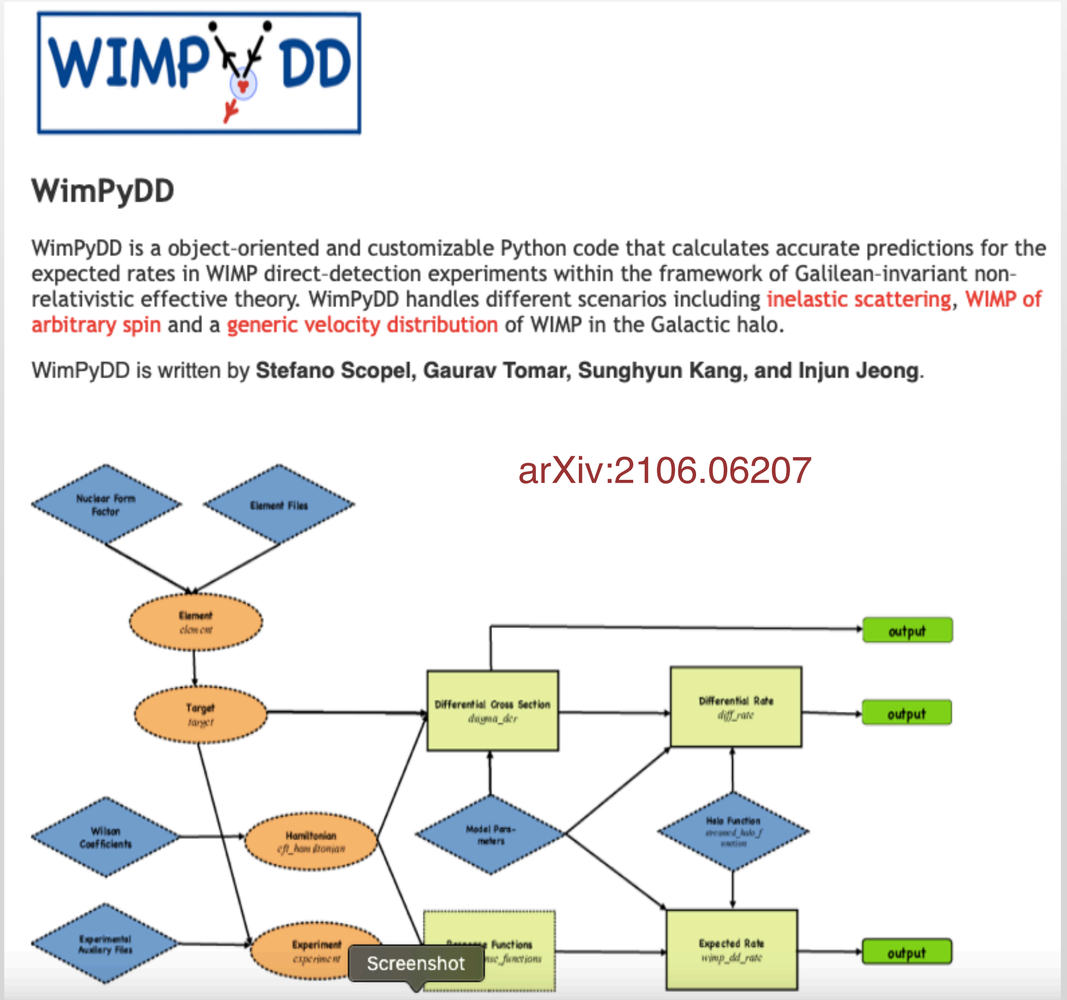



Usage through user-friendly web-GUI



# 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**

- Numerical background data and/or background models.
- Preferably for each component

**Detector Response**

- Efficiencies, thresholds, cuts, quenching factor, conversions from recoil energy to detector parameters, etc.
- In essence, information required to generate simulated signal at an experiment from predicted cross section.

**Analysis Pipeline**

- Analysis used by the collaboration to generate published exclusions using published data.
- As publishable software, in the form of Binders, JuPyTer Notebooks, etc.

# From Theorists/Phenomenologists

**Simulation Tools**

- New tools for simulating predicted signal at experiments.
- Publishable as downloadable package. DOI assignment.
- Run online as an integrated tool or on a Binder.

**Physics Model Info**

- Pertinent interaction vertices as NREFT coefficients, limits on their strengths, dependencies.
- Background model(s) used (if new ones used).

**Implementation**

- Experiments used, method used for comparison, tool used for simulation.
- Packaged to be run online on a Binder.
- Connected to published work. Please provide sources of citeable data/software.

**Analysis Pipeline**

- Packaged tool using all of above describing workflow for publication.
- Primary tool for reproducibility of publication.
- To run as a Binder online.

We provide support in preparation!

# Intersection between experimentalists and theorists in the DM community

| For the Collaborations | For Phenomenologists |
|---|---|
| Data preservation (DOI assignment if needed, non-exclusivity). Workflow preservation. | Instructions and examples of data analyses |
| Full long-term reproducibility of published results | Virtual machines and computing power |
| Easy usage (Binders and friendly web-GUI) | Online visualization |
| Facilitate proper and maximum utilization of data by the community | Persistence, usability and citability of new models |

# In Brevity

- Establish a repository for the technical aspects behind publications
- Ease and maximize the utilization of published data
- Build a comprehensive catalog of data and models in the field of DM

## THANK YOU!

Please visit us at: https://www.origins-cluster.de/odsl/dark-matter-data-center

Please contact us at heerak.banerjee@tum.de, banerjee@mpp.mpg.de, ferreiro@mpp.mpg.de
if you would like to submit data/model or need support for your project!