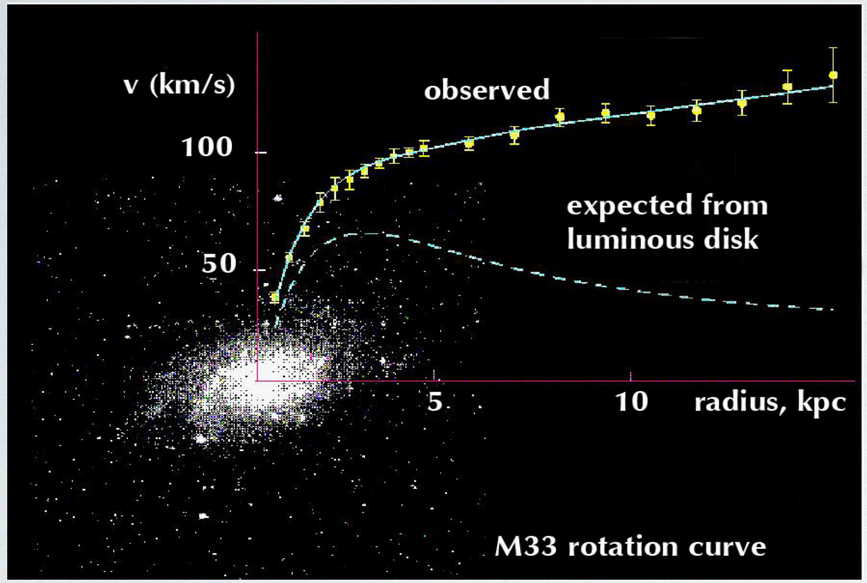
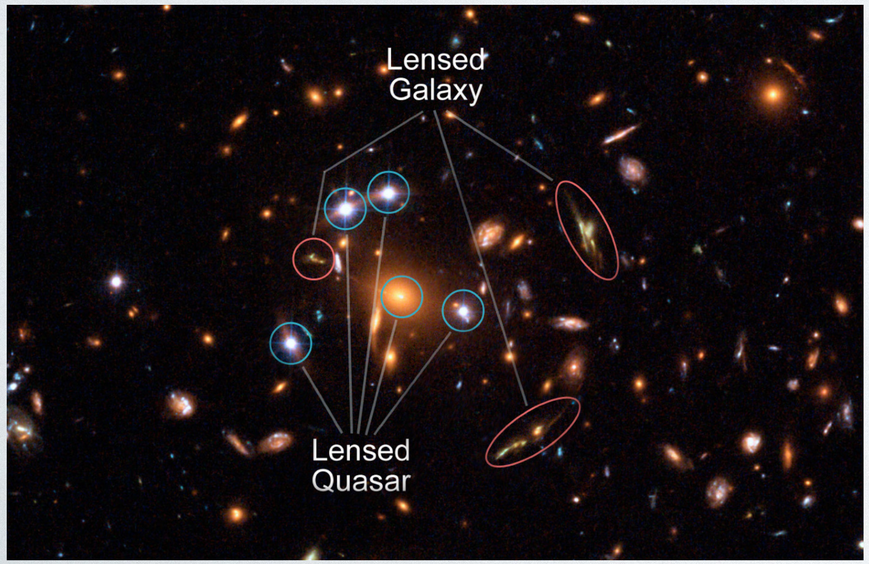
DARK MATTER DATA CENTRE

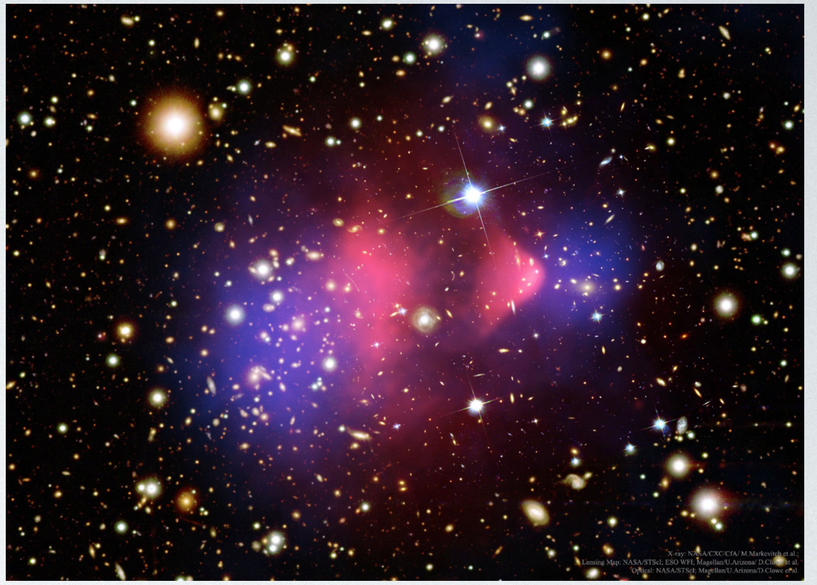
Heerak Banerjee (TUM)
Nahuel Ferreiro Iachellini (MPP)

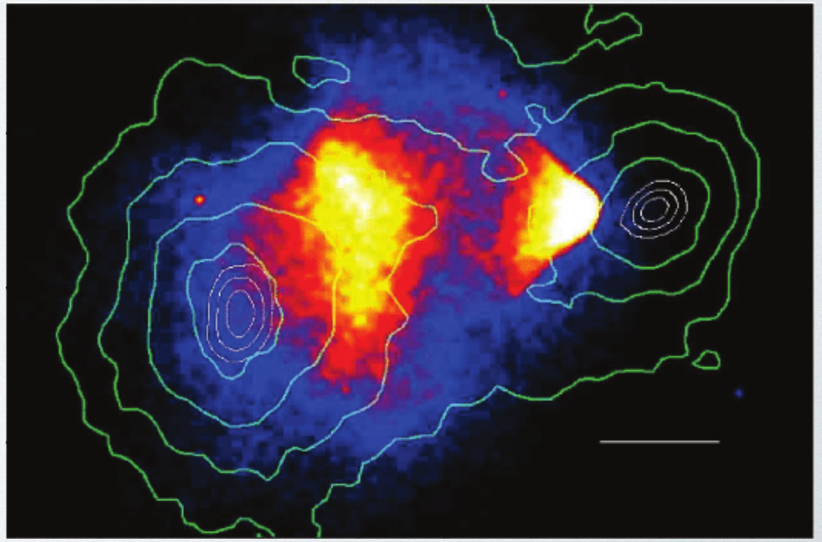
Dark Matter





- 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





Dark Matter

$10^{-22} eV$

Bosonic

Fermionic

Macroscopic

Gravity

Bose-Einstein Condensates

Fuzzy DM

Warm DM

Cold DM

- QCD Axions
- Axion-like-particles
- Neutrinos
- Sterile Neutrinos
- Lightest Supersymmetric Particle
- Extra dimensions
- Composite Higgs
- Little Higgs
- WIMPs
- Primordial Black Holes
- Massive Compact Halo Objects (MaCHO)
- Modified Gravity

Weakly Interacting

Decaying

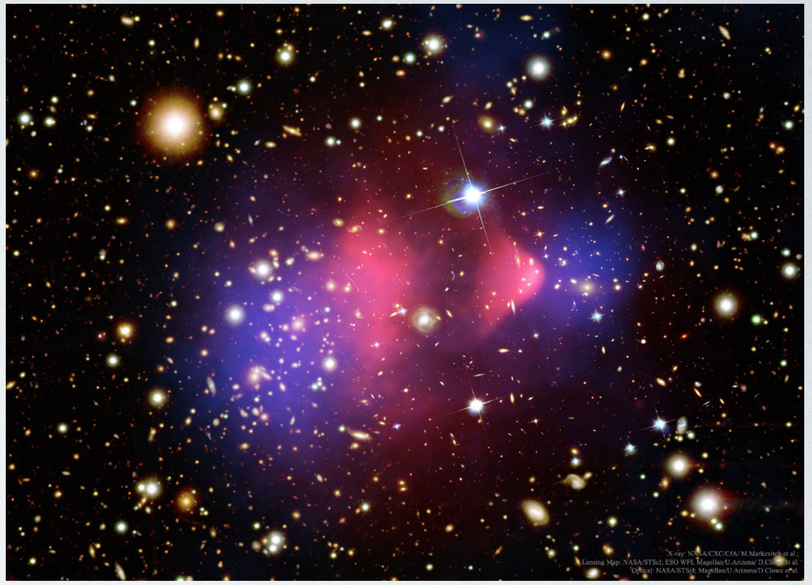
Self-Interacting

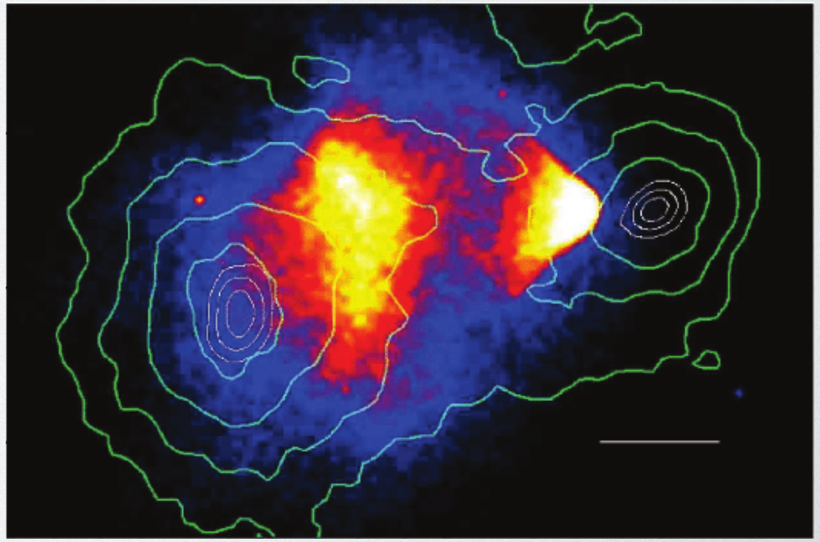
Co-decaying

Single-Component

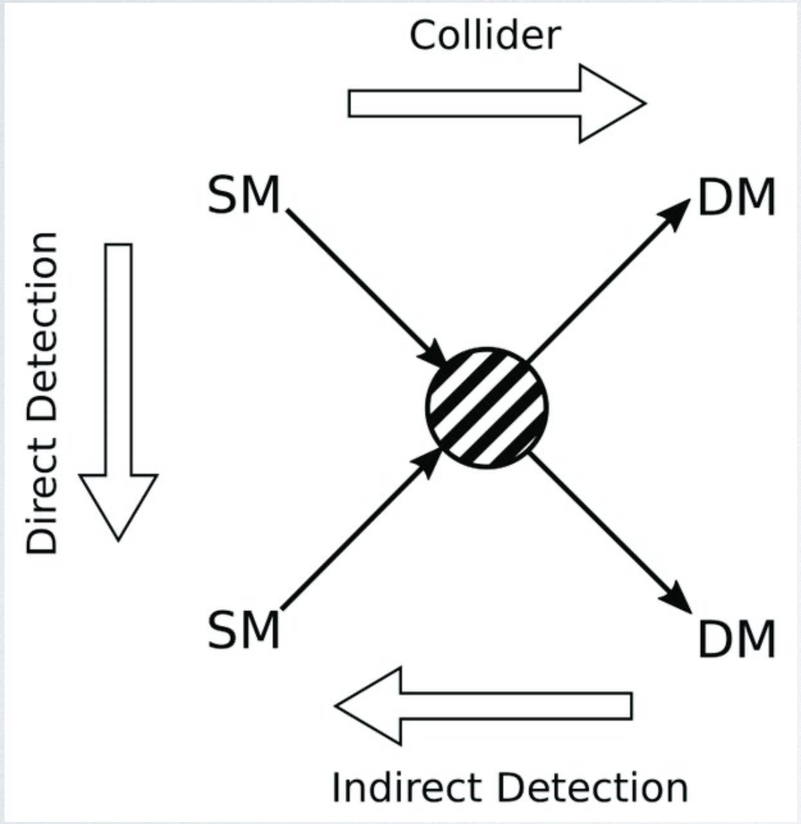
Multi-Component

~100 Solar Masses





Looking for Dark Matter



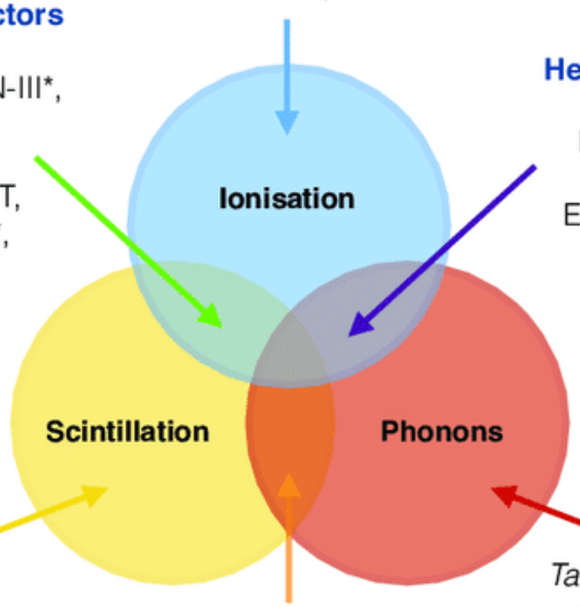
Still not exhaustive!

WIMP Direct Detection

Ionisation detectors
Targets: Ge, Si, CS_2, CdTe
GENIUS*, HDMS*,
IGEX NEWAGE*, CoGeNT*

Light and ionisation detectors
Targets: Xe, Ar, CS_2
WARP*, ZEPLIN-II*, ZEPLIN-III*,
Panda-X*, LUX**,
DRIFT-I*, DRIFT-II**,
XENON100***, XENON1T,
DarkSide50**, ARDM***,
LZ***, Darwin****
Cold (~LN_2)

Heat and Ionisation bolometers
Targets: Ge, Si
EDELWEISS-I*,-II*, CDMS**,
SuperCDMS***,
EDELWEISS-III***.EURECA****
Cryogenic
(<50mK)



Scintillators
Targets: NaI, Xe, Ar
ZEPLIN-I*, KIMS*, NAIAD*,
DAMA/LIBRA*, ANAIS**,
DEAP-3600***, XMASS** ,
CLEAN***

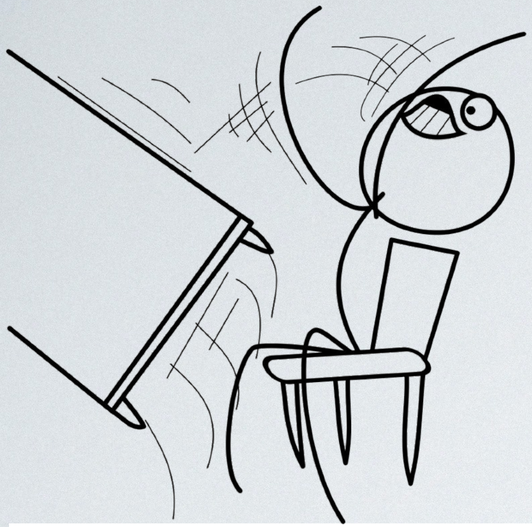
Bolometers
Targets: Ge, Si, AL_2O_3, TeO_2
CRESST-I*, CUORE-0**

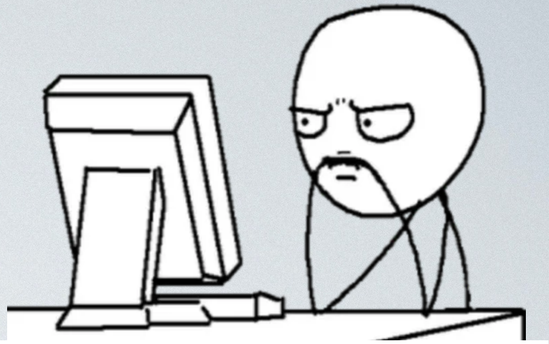
Light and Heat Bolometers
Targets: $CaWO_4$, BGO, AL_2O_3
RESEBUD*, CRESST**
Cryogenic (<50mK)

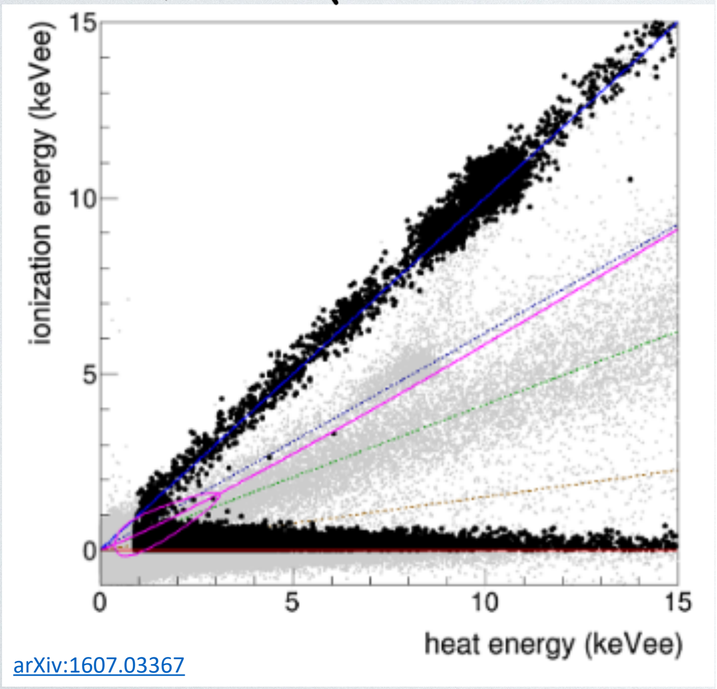
Bubbles and Droplets
Tragets: CF_3Br, CF_3I, C_3F_8, C_4F_{10}
COUPP*, PICASSO*, SIMPLE**,
PICO-2L**, PICO-60**,
PICO-250****

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

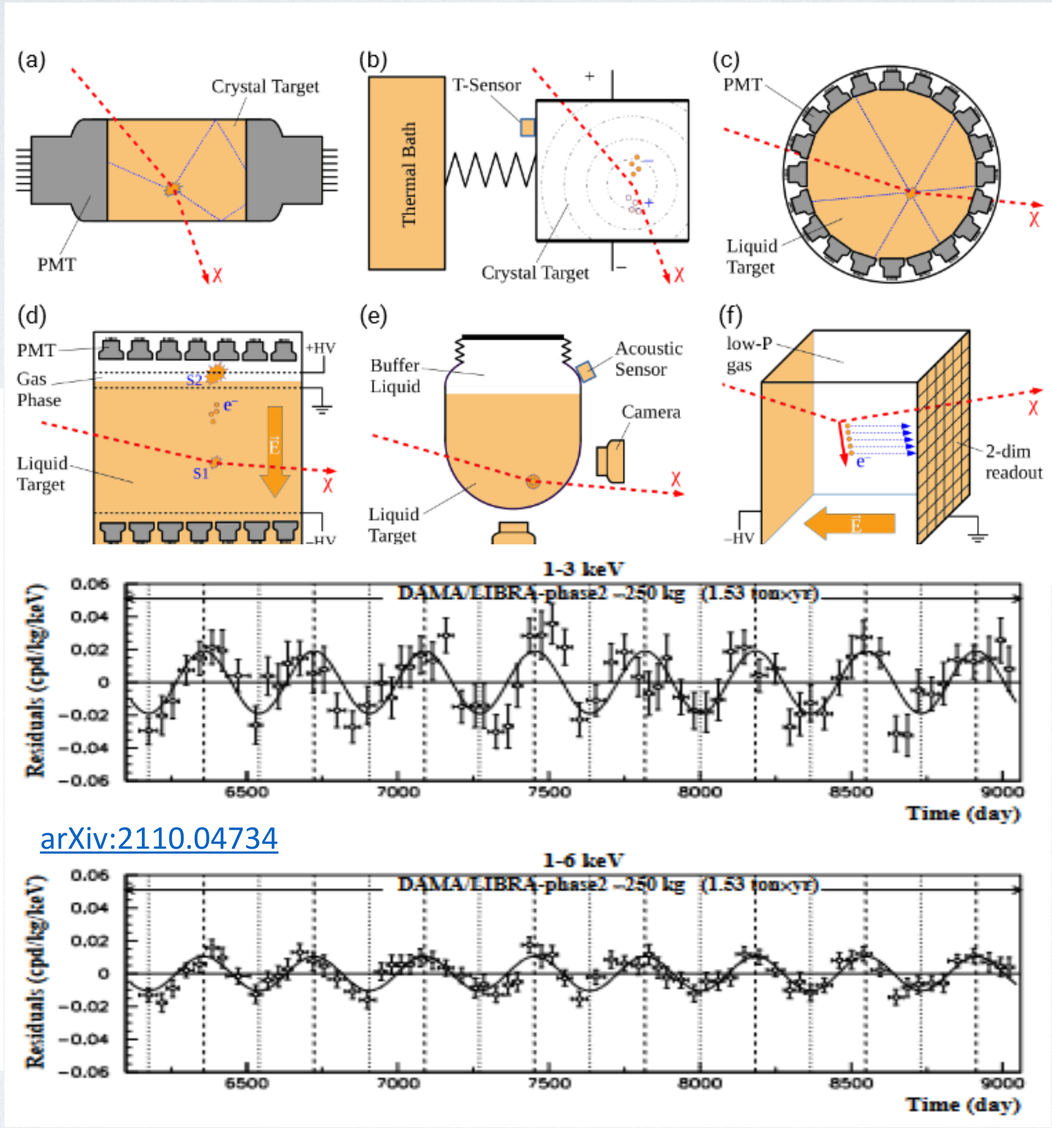
Looking for Dark Matter

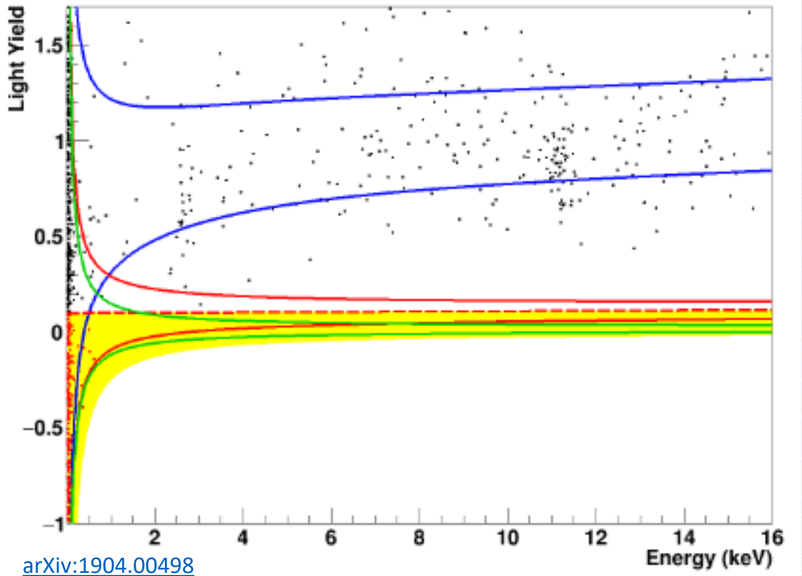




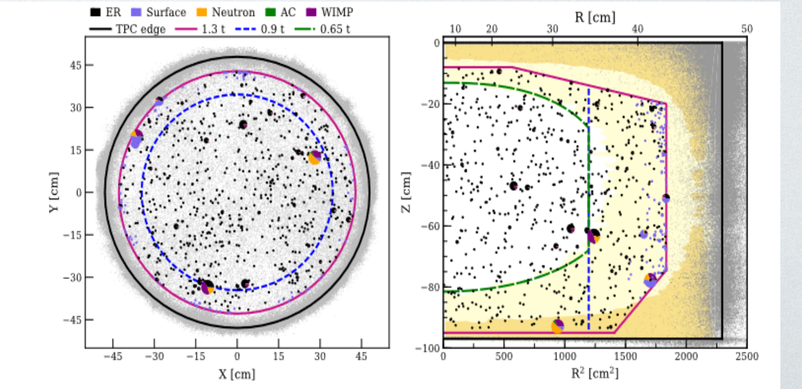


arXiv:1607.03367



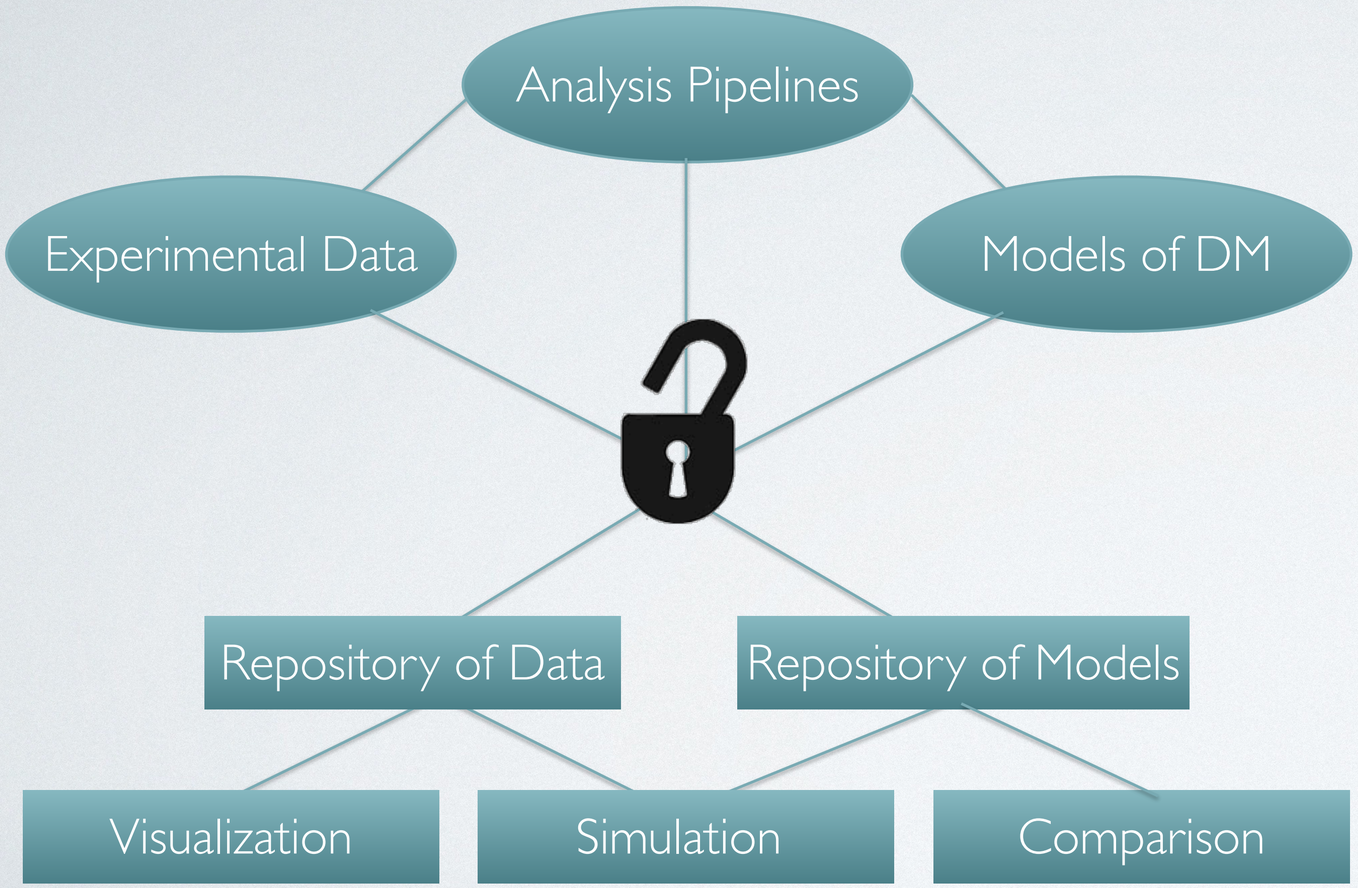


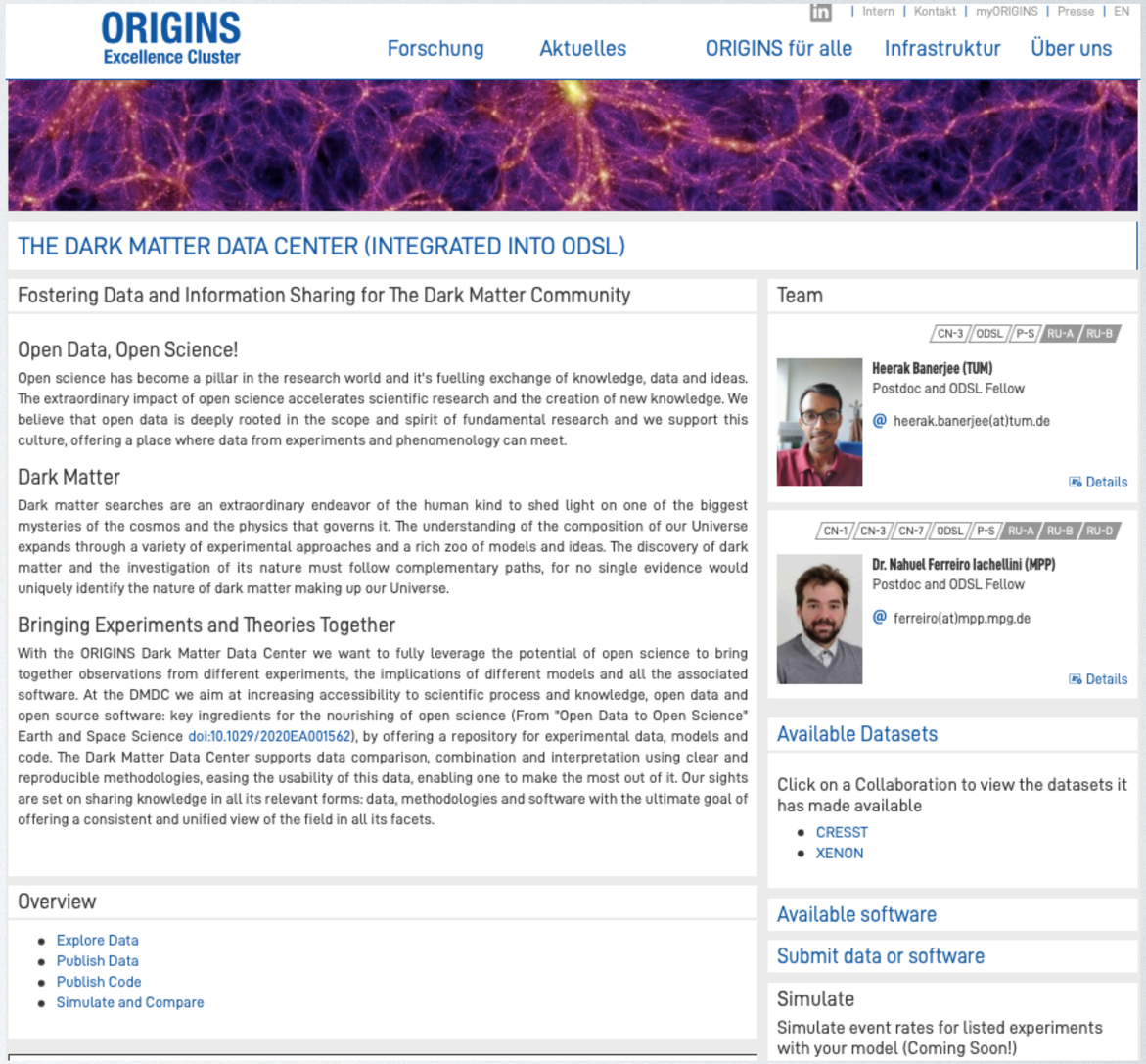
arXiv:1904.00498



Phys. Rev. Lett. 121, 111302

DARK MATTER DATA CENTER





DARK MATTER DATA CENTER

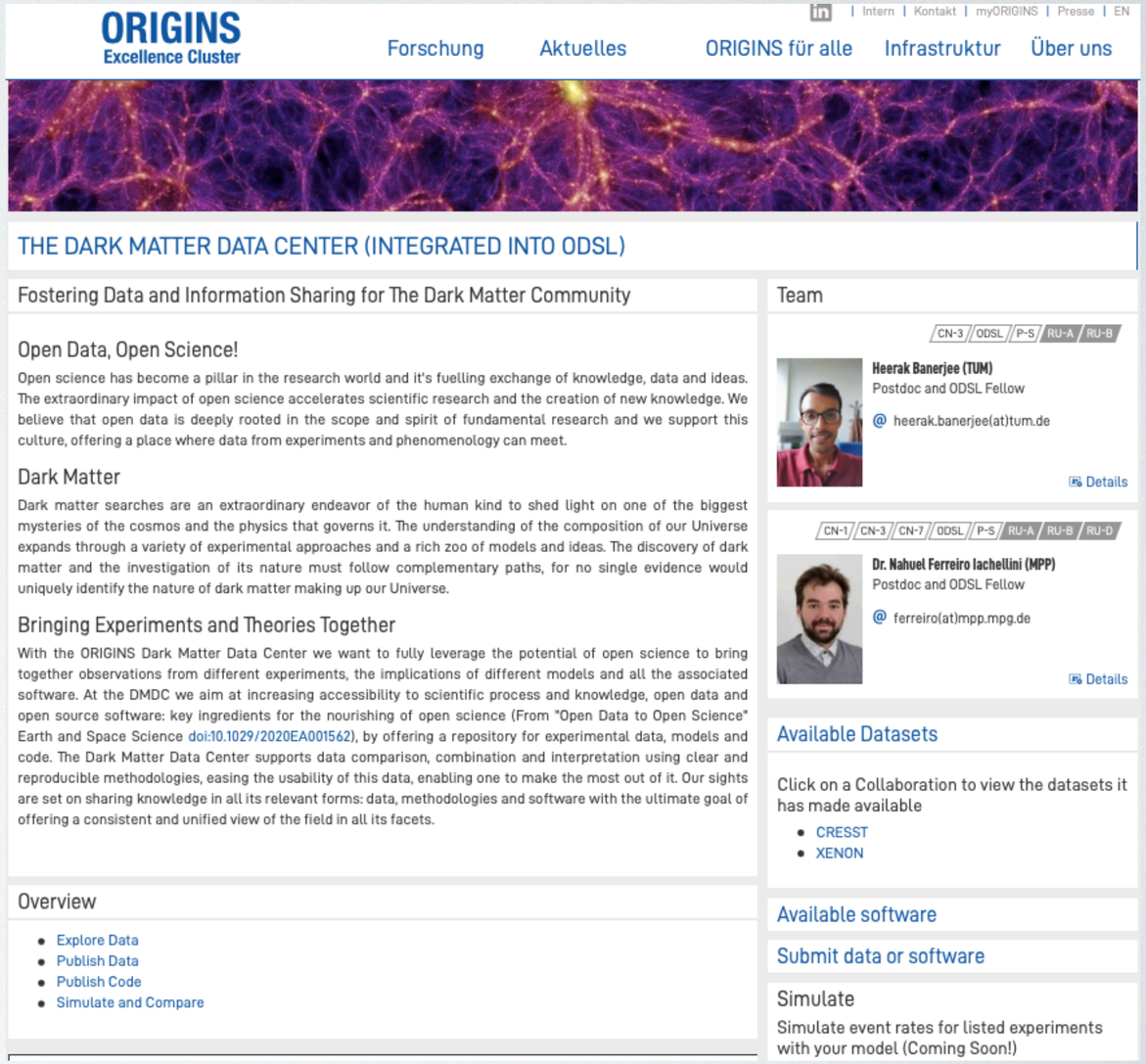
Open Data!

Open Science!

Efficiency of Research

Reliability of Results

Resilience to societal challenges



The Team

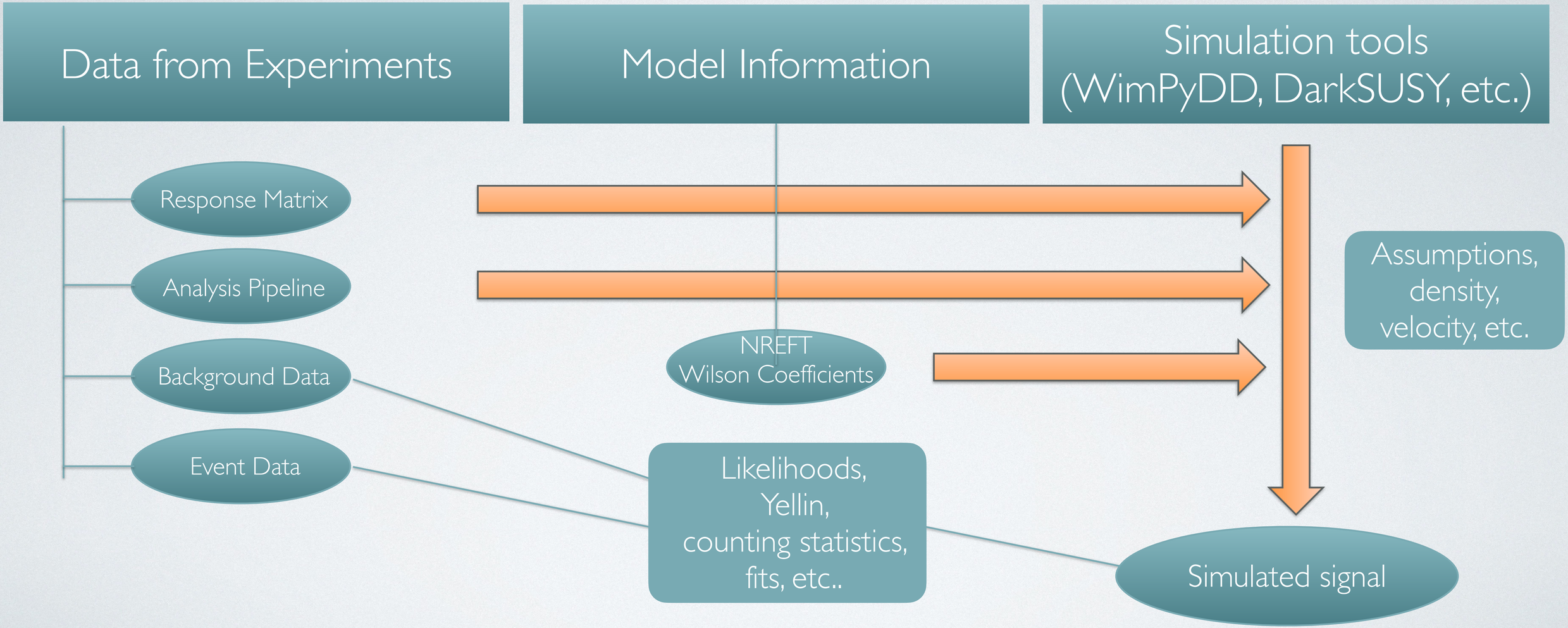
Heerak Banerjee
Phenomenologist with experience in astroparticle searches and data analysis

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

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.

A Little More Detail



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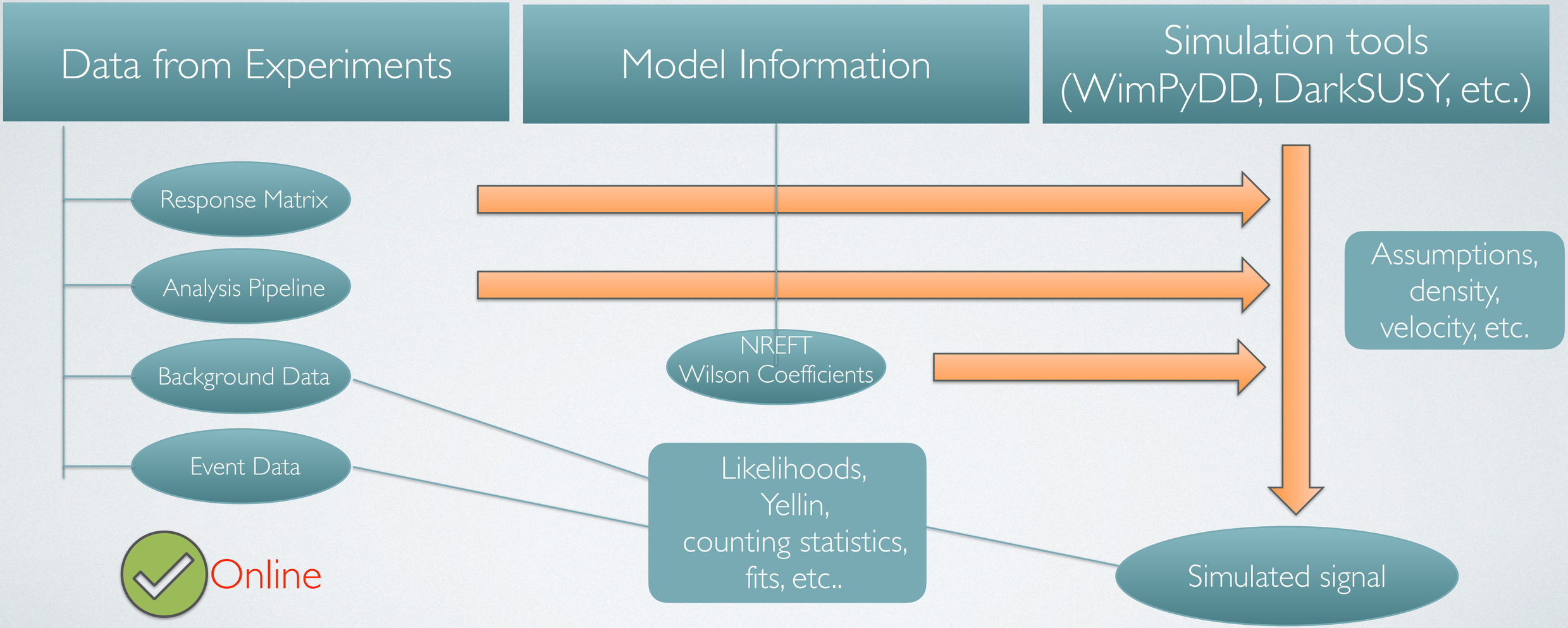
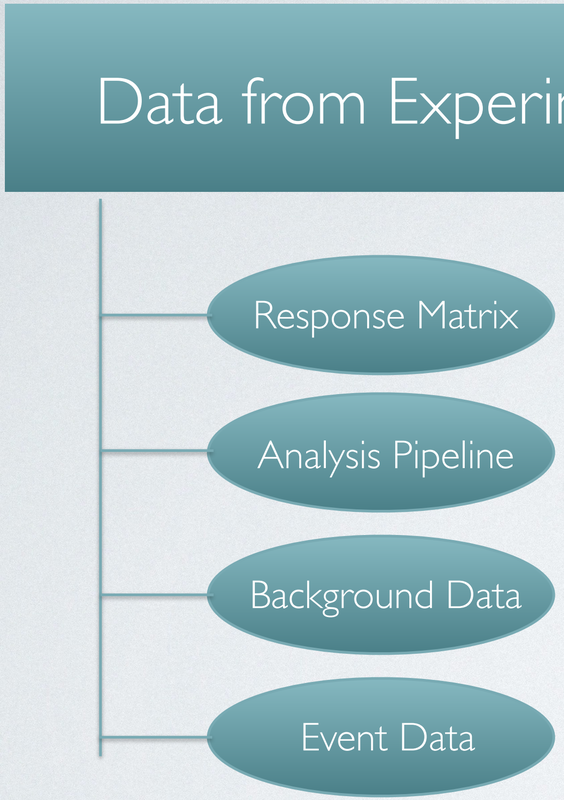


For Example…



- 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

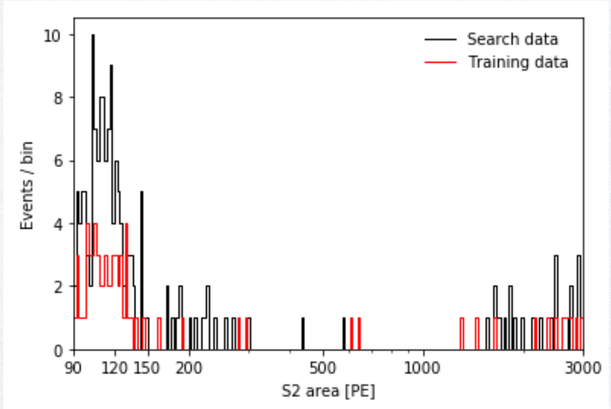
Resource	description
DetA AR	Recoil energies in the acceptance region
C3P1_DetA_cuteff	Cut efficiency
C3P1_DetA_eff_AR_Ca	Fraction of events from the Ca recoil band in the ROI
C3P1_DetA_eff_AR_O	Fraction of events from the O recoil band in the ROI
C3P1_DetA_eff_AR_W	Fraction of events from the W recoil 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

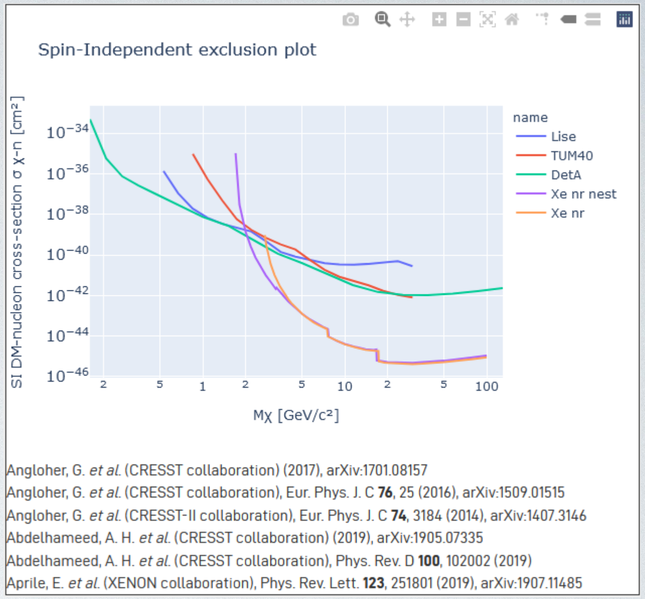
For Example…

Data from Experiments

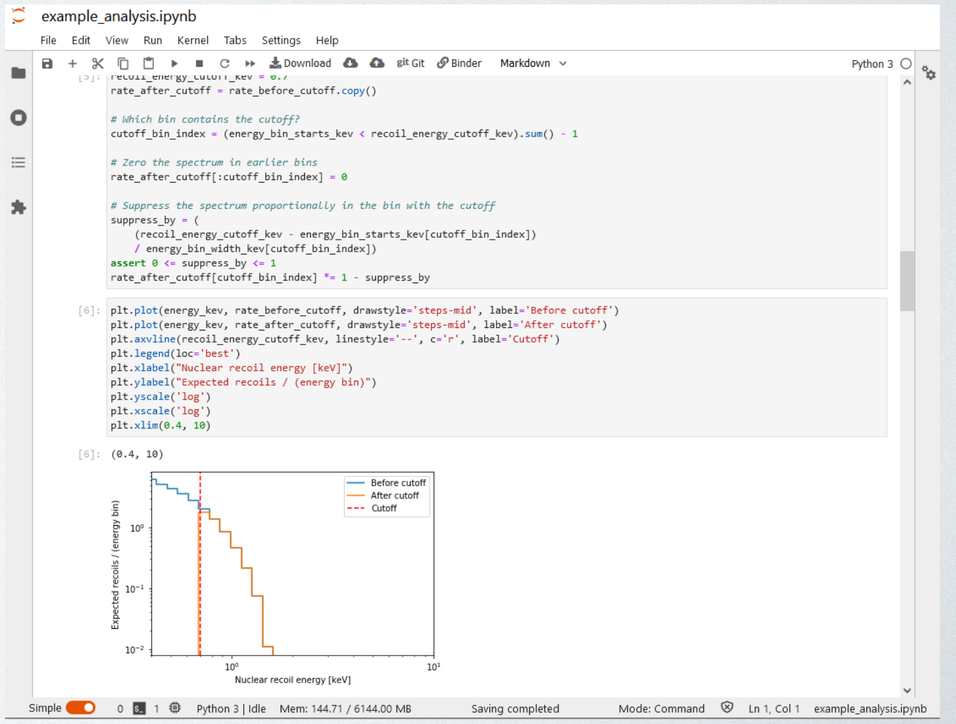
- Response Matrix
- Analysis Pipeline
- Background Data
- Event Data

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





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



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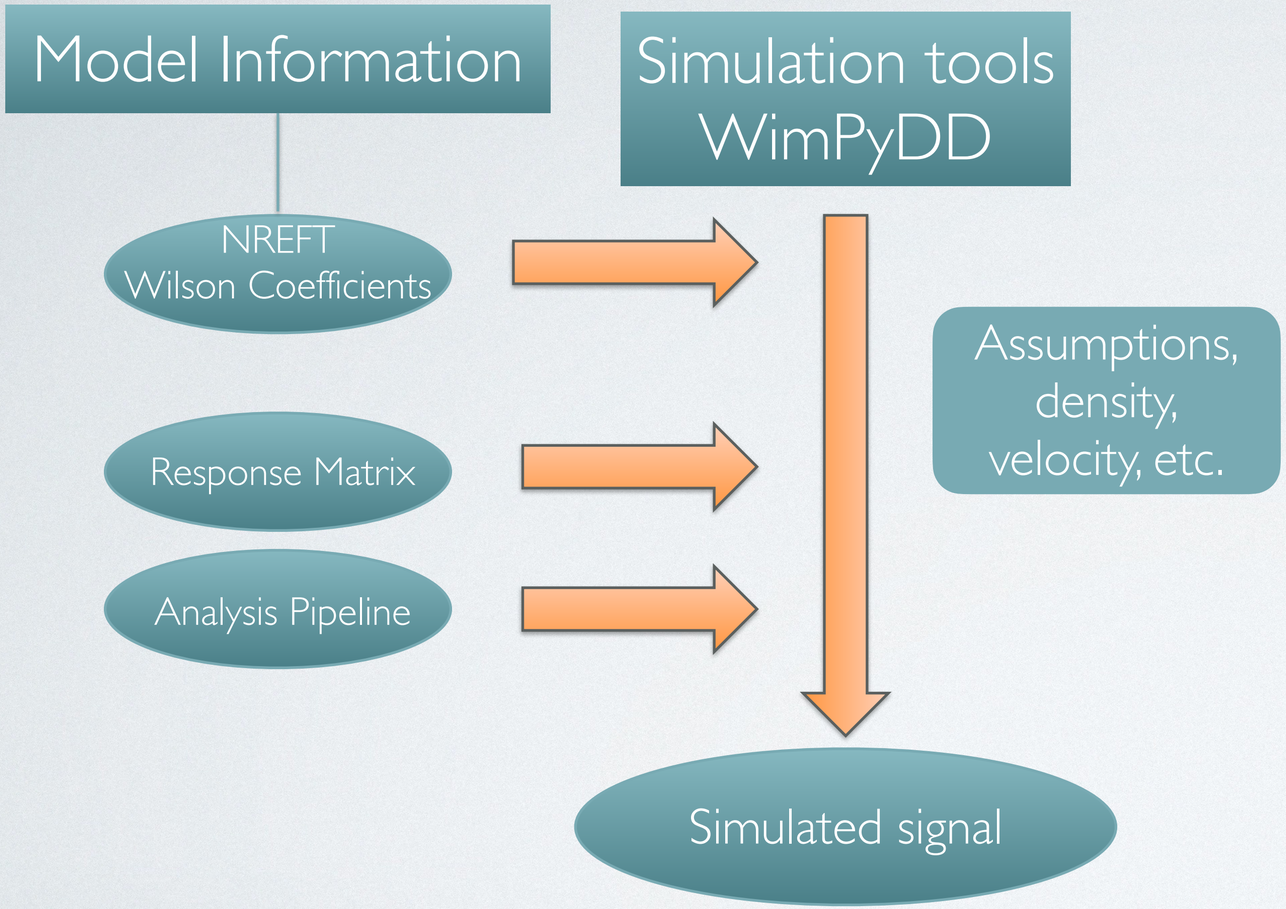

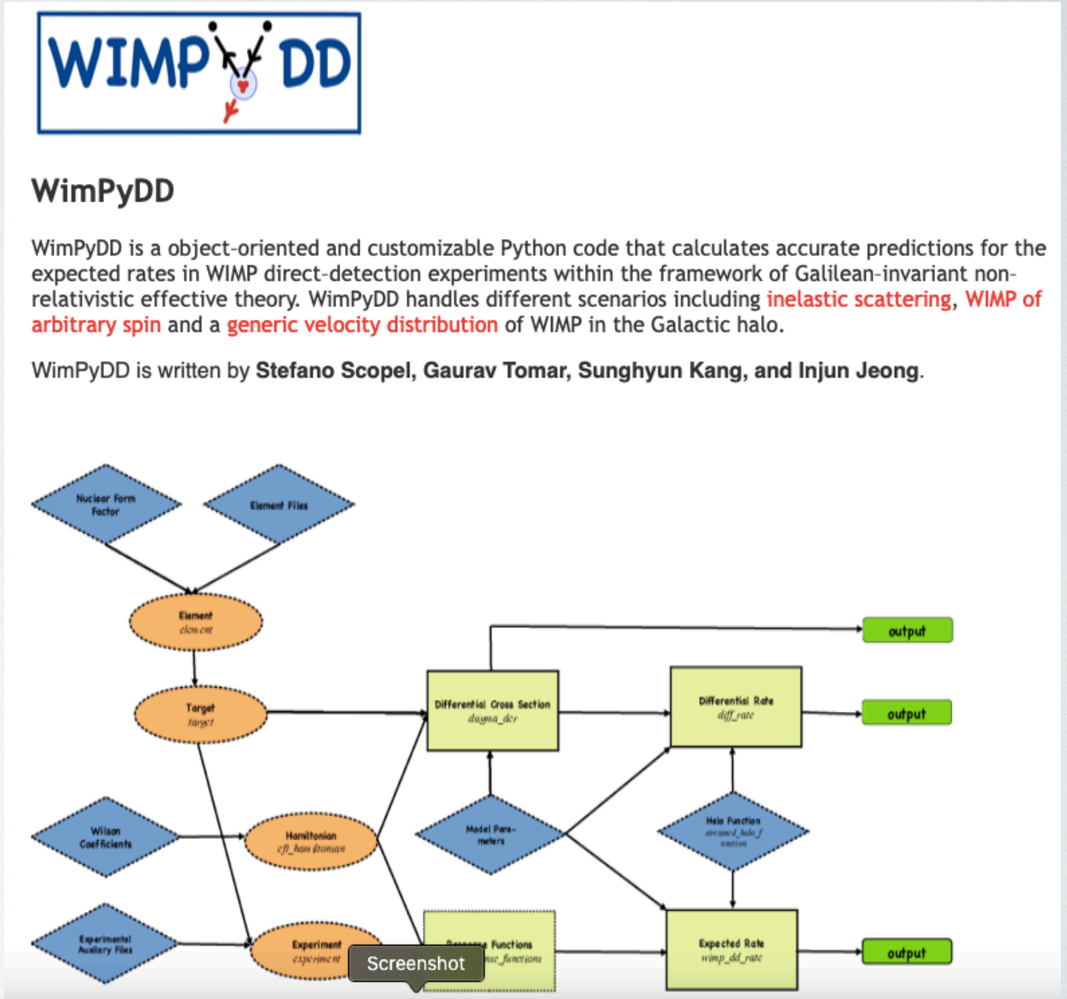

Usage through user-friendly web-GUI

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

- 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.

Intersection between experimentalists and theorists in the DM community

For the Collaborations	For Phenomenologists
Data preservation (DOI assignment if needed, non-exclusivity)	Instructions and examples of data analyses
Full reproducibility of published resuts	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