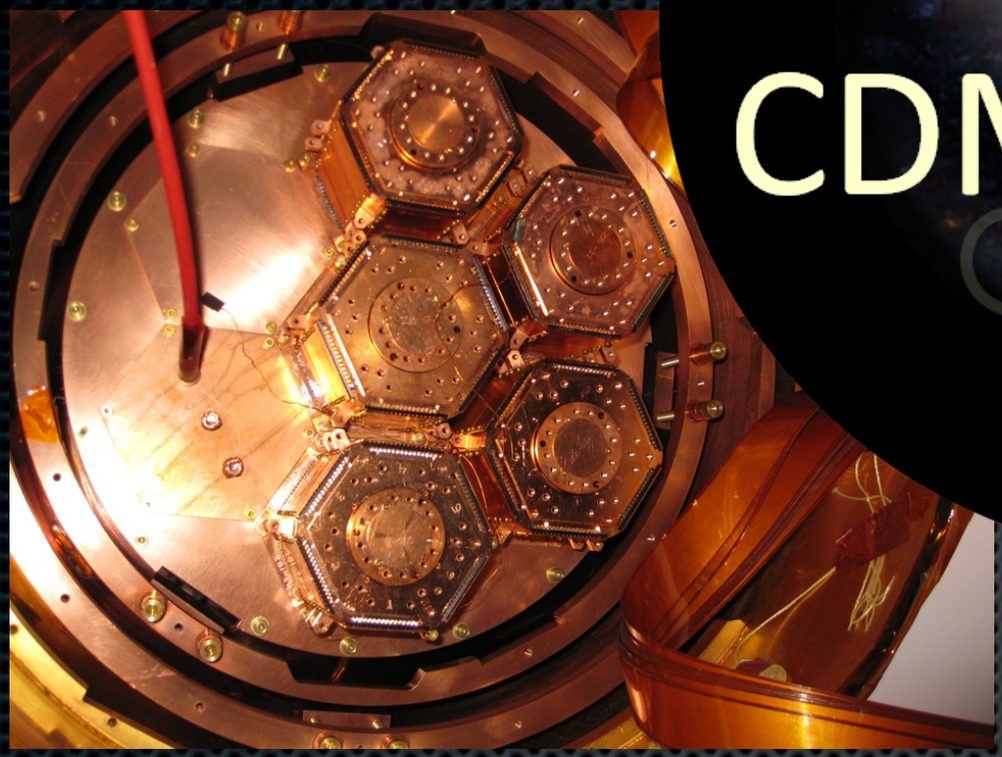
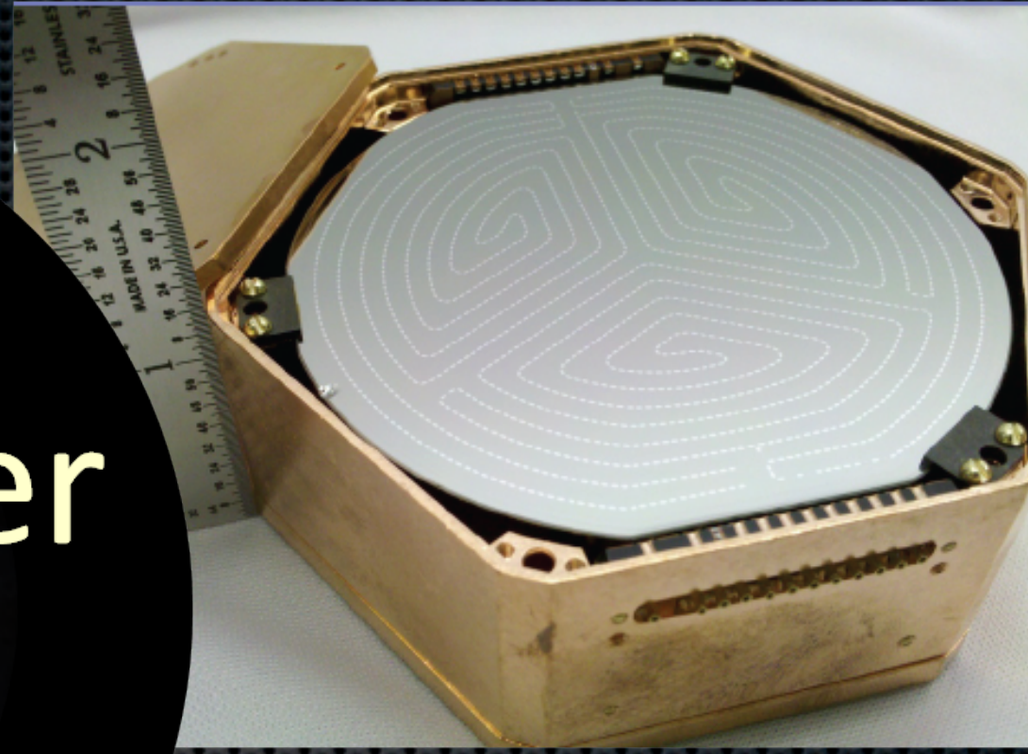




# SuperCDMS

WNPCC 2012

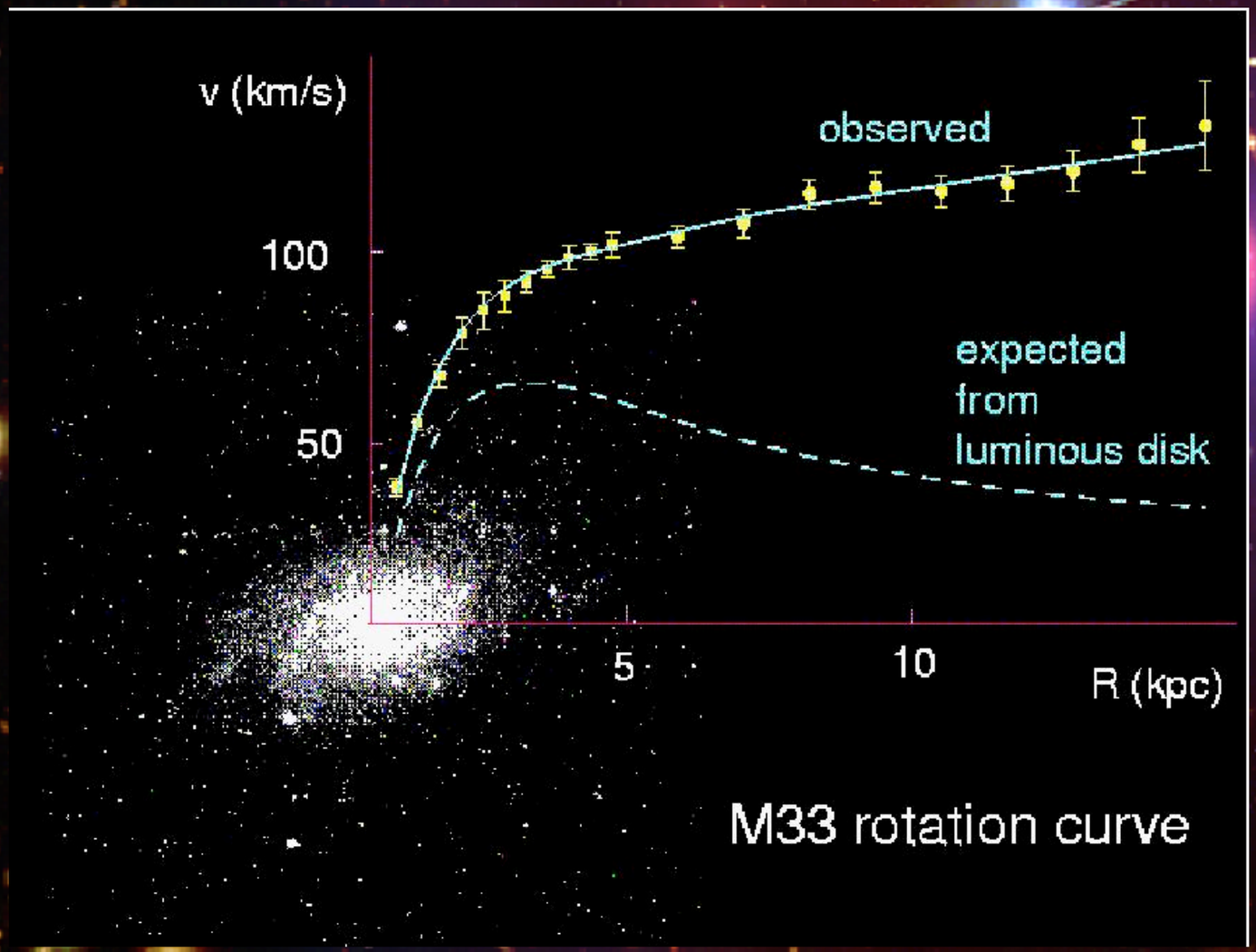
# The Cryogenic Dark Matter Search Experiment and The CDMS-EDELWEISS Combined Result

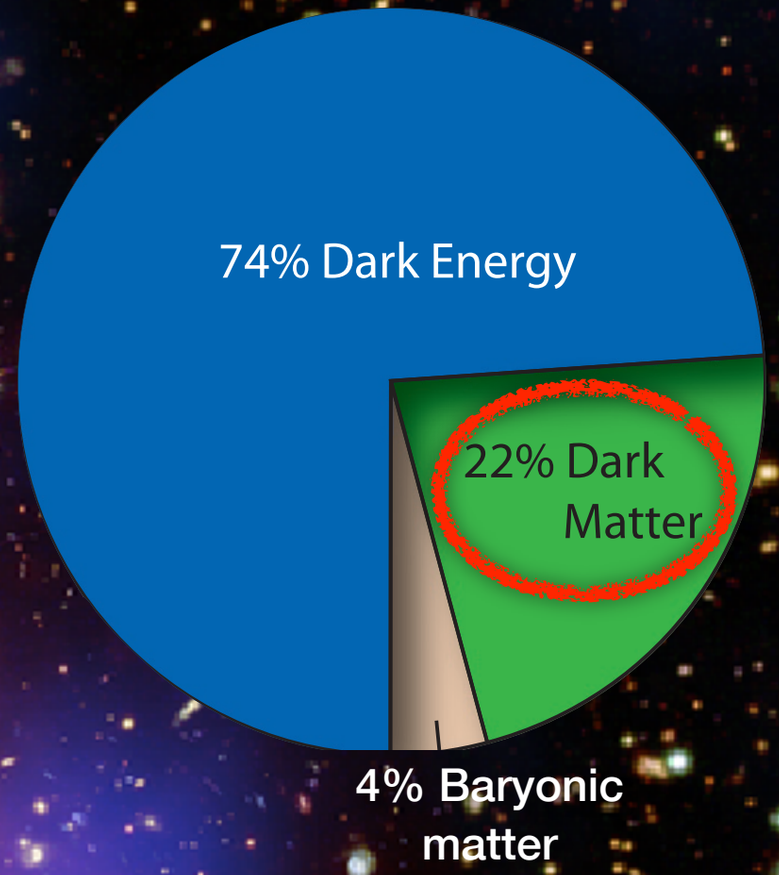

Yohan Ricci* for the CDMS collaboration

*yohanricci@owl.phy.queensu.ca

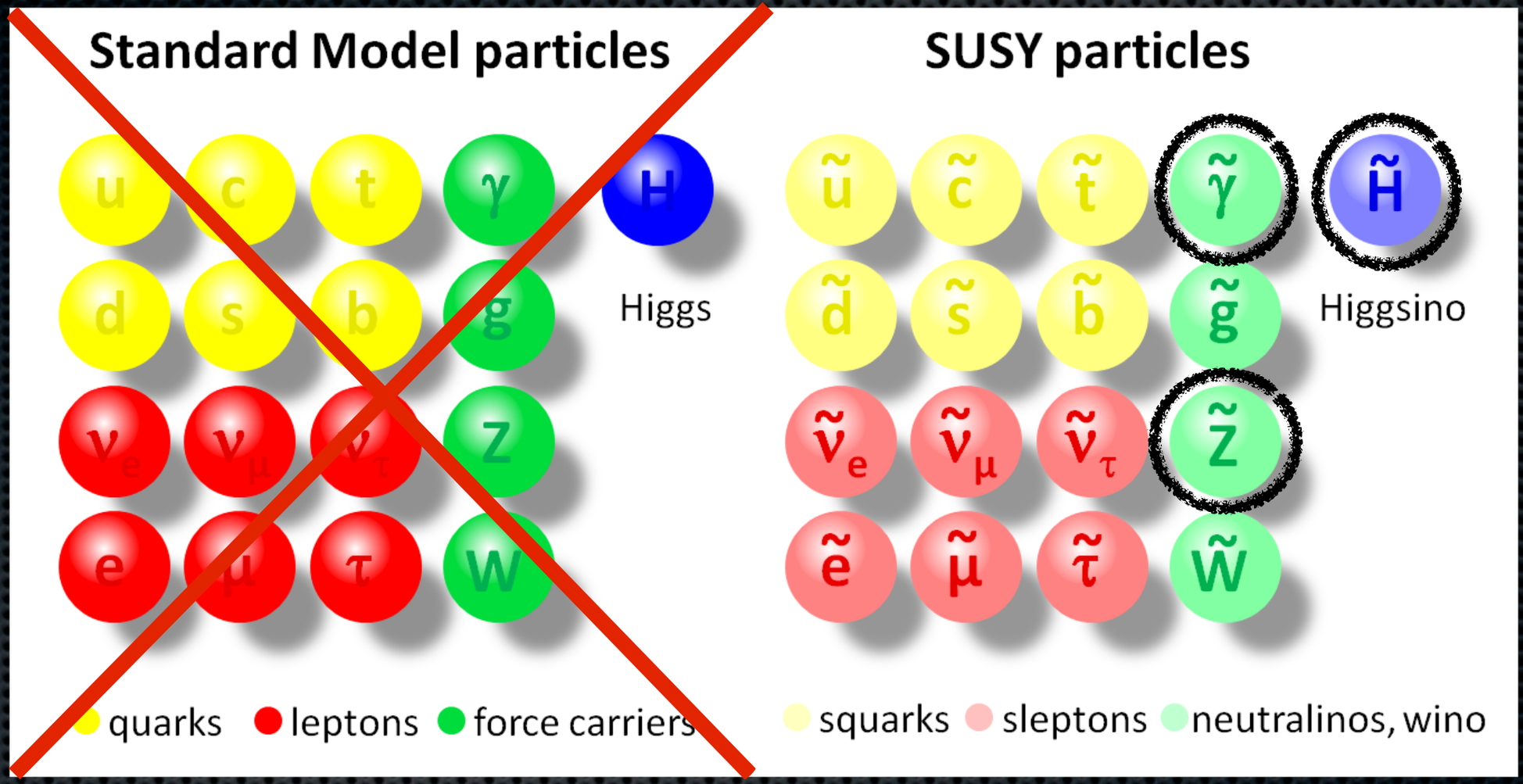
Queen's University

# Dark Matter ?


v (km/s)
100
50
observed
expected
from
luminous disk
5
10
R (kpc)
M33 rotation curve


74% Dark Energy
22% Dark
Matter
4% Baryonic
matter

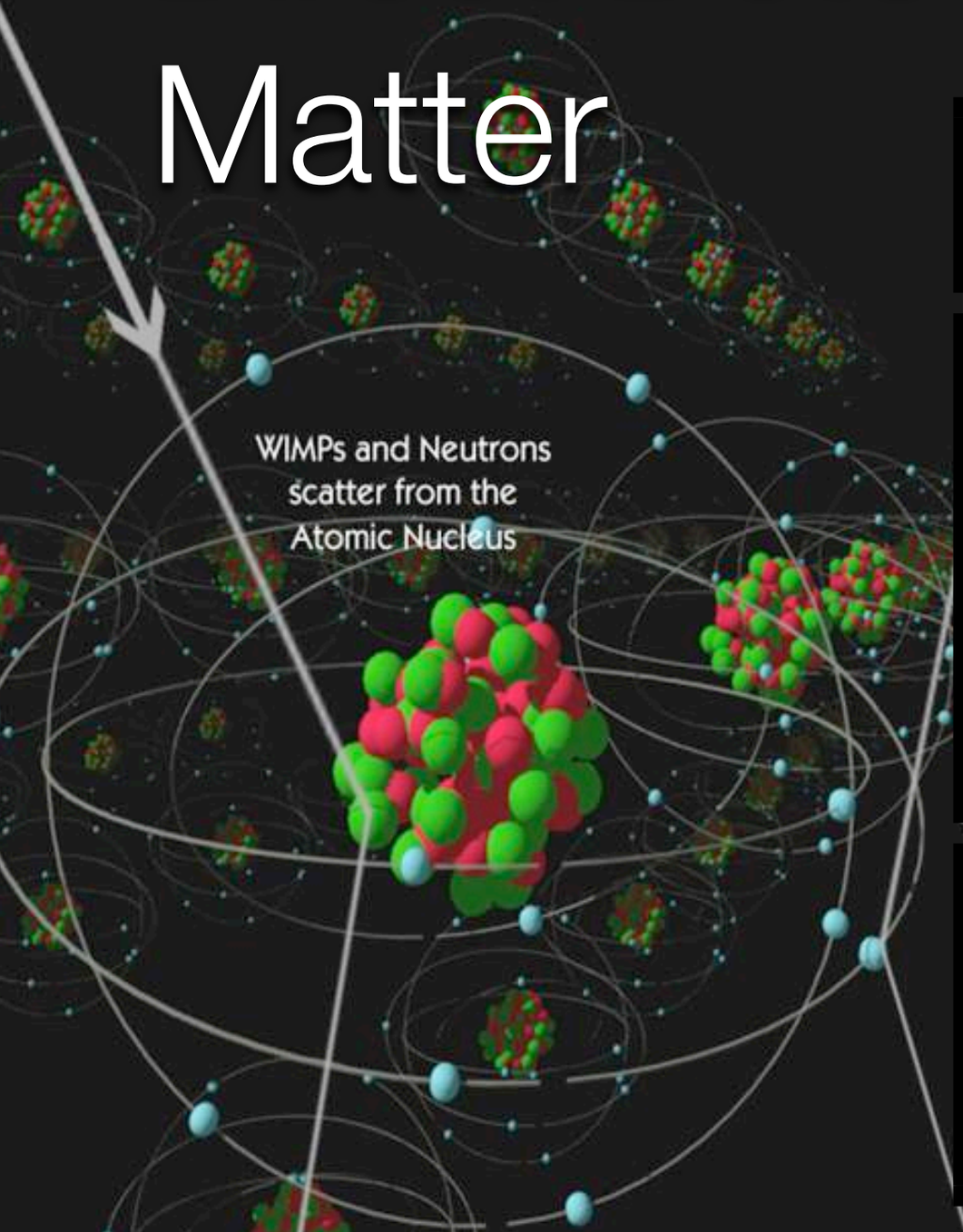
# DM Candidates




Most searched candidates : the **lightest neutralino** $\chi$

- Weakly Interactive Massive Particle (**WIMP**)
- Scattering cross section $\sigma_{\text{W-nucleon}}$ **<< 1 pb** ($10^{-36}$ $cm^2$)
- Mass ≈ **1 GeV-10 TeV**

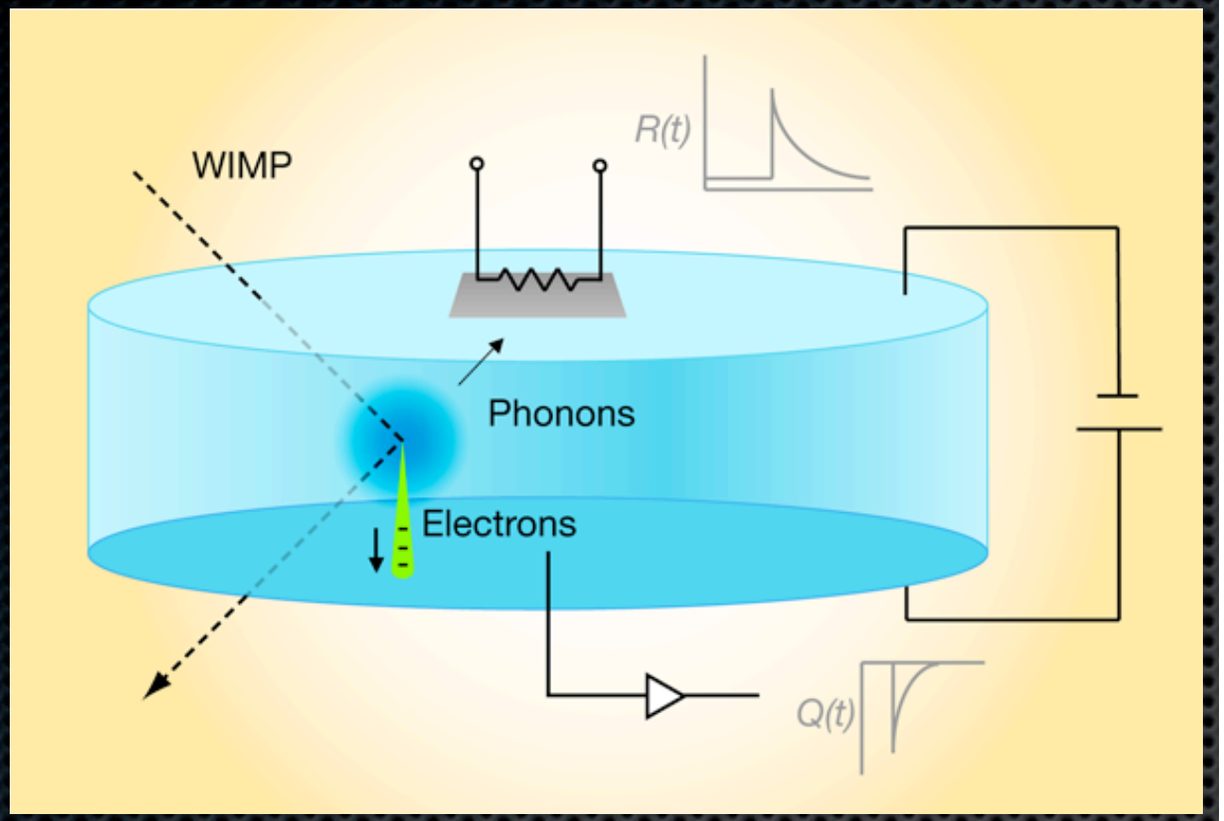
# Direct Detection of Dark Matter



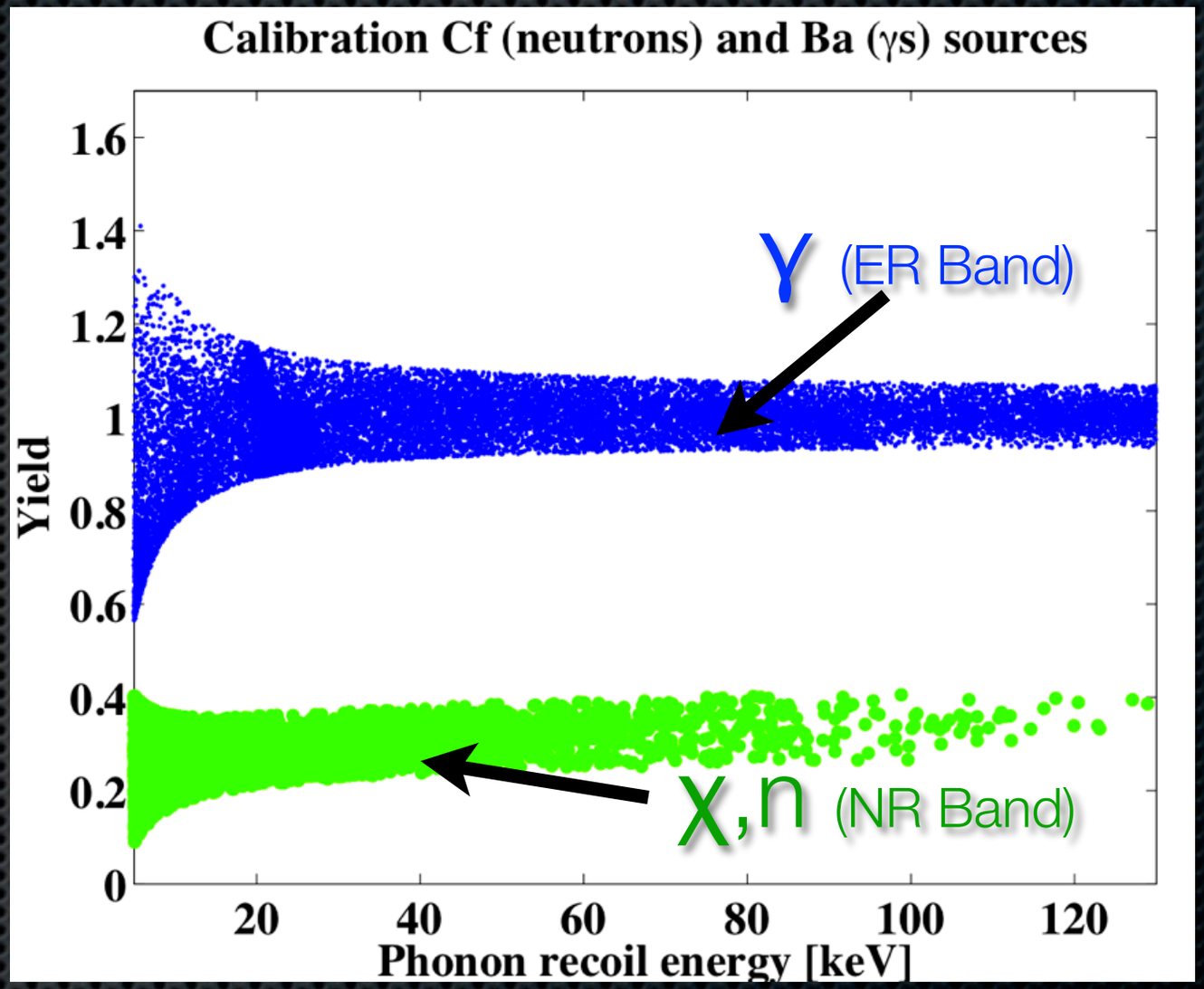

| | Signal | Background |
|---|---|---|
| **Nuclear Recoil (few keV)** | **WIMPs** < 1 event per month per kg | Neutrons :<br>● Radiogenic<br>● Cosmogenic |
| **Electron Recoil** | | ● Photons<br>● Electrons |

**Need to shield from radiogenic and cosmogenic background => shielding + underground operation**

# CDMS Detection Techniques

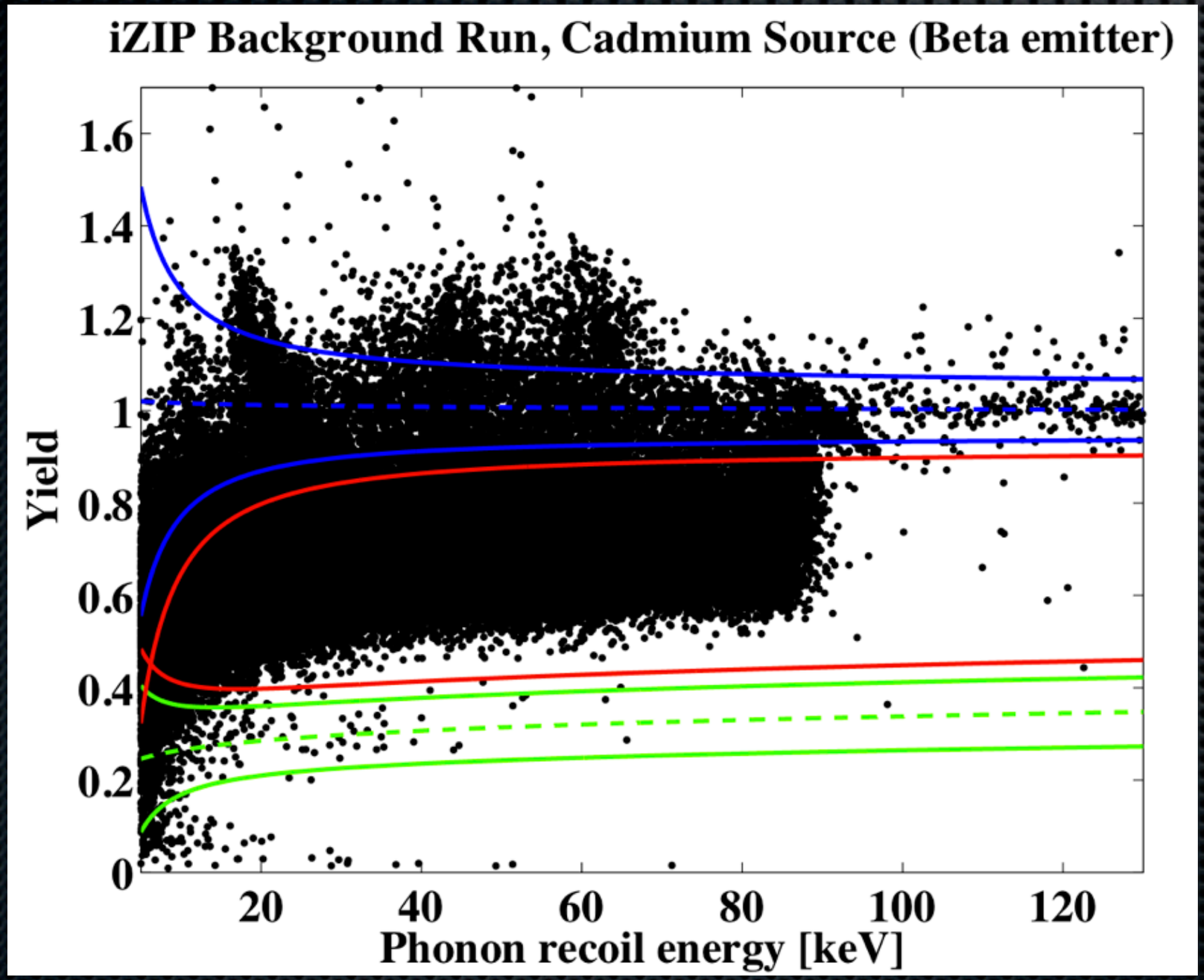



*Karl van Bibber, Physics 2, 2 (2009)*
*illustration: Alan Stonebraker*




- **Germanium crystals** operated at ≈ **40 mK**
- Operated in a **mine under 2100 mwe**, at Soudan MN
- **Phonons** collection => **energy** + **position** information
- **Electrons and holes** (ionization) collection => **particle ID**
- **Ionization/Phonon** signal = **“Yield” discrimination**

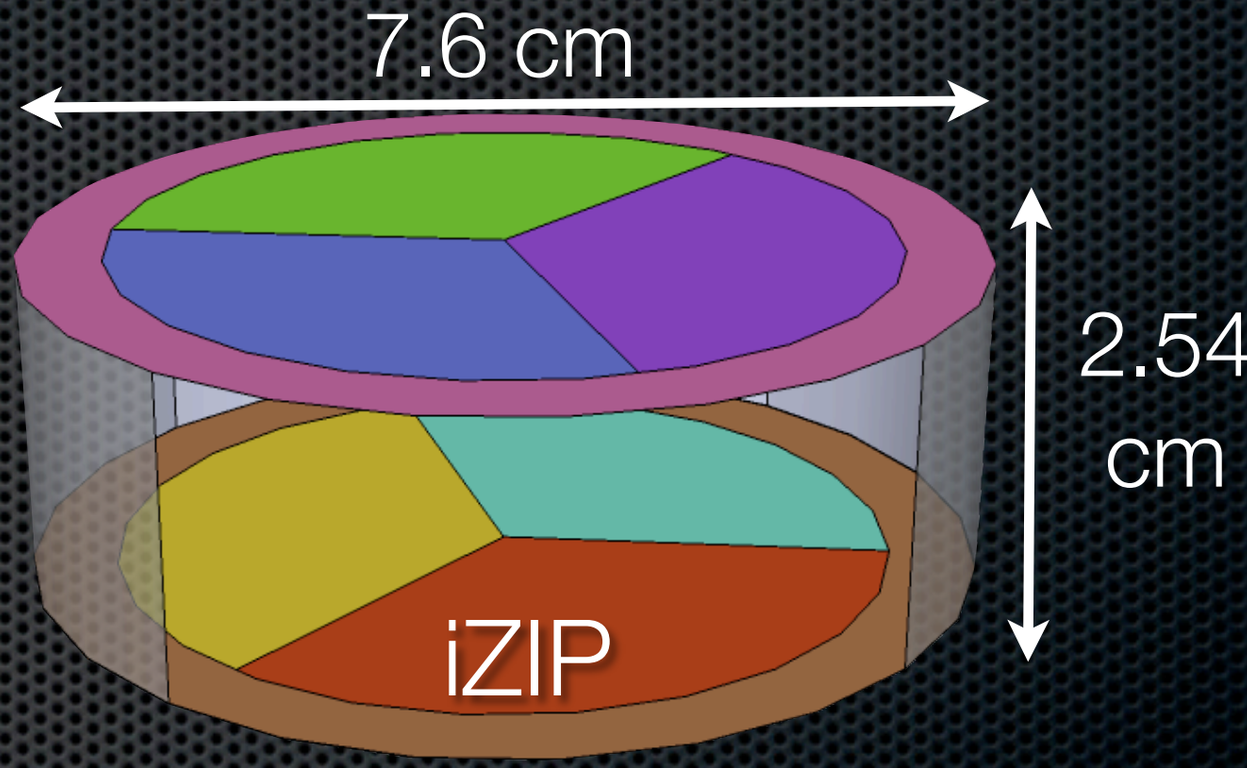
# Surface events

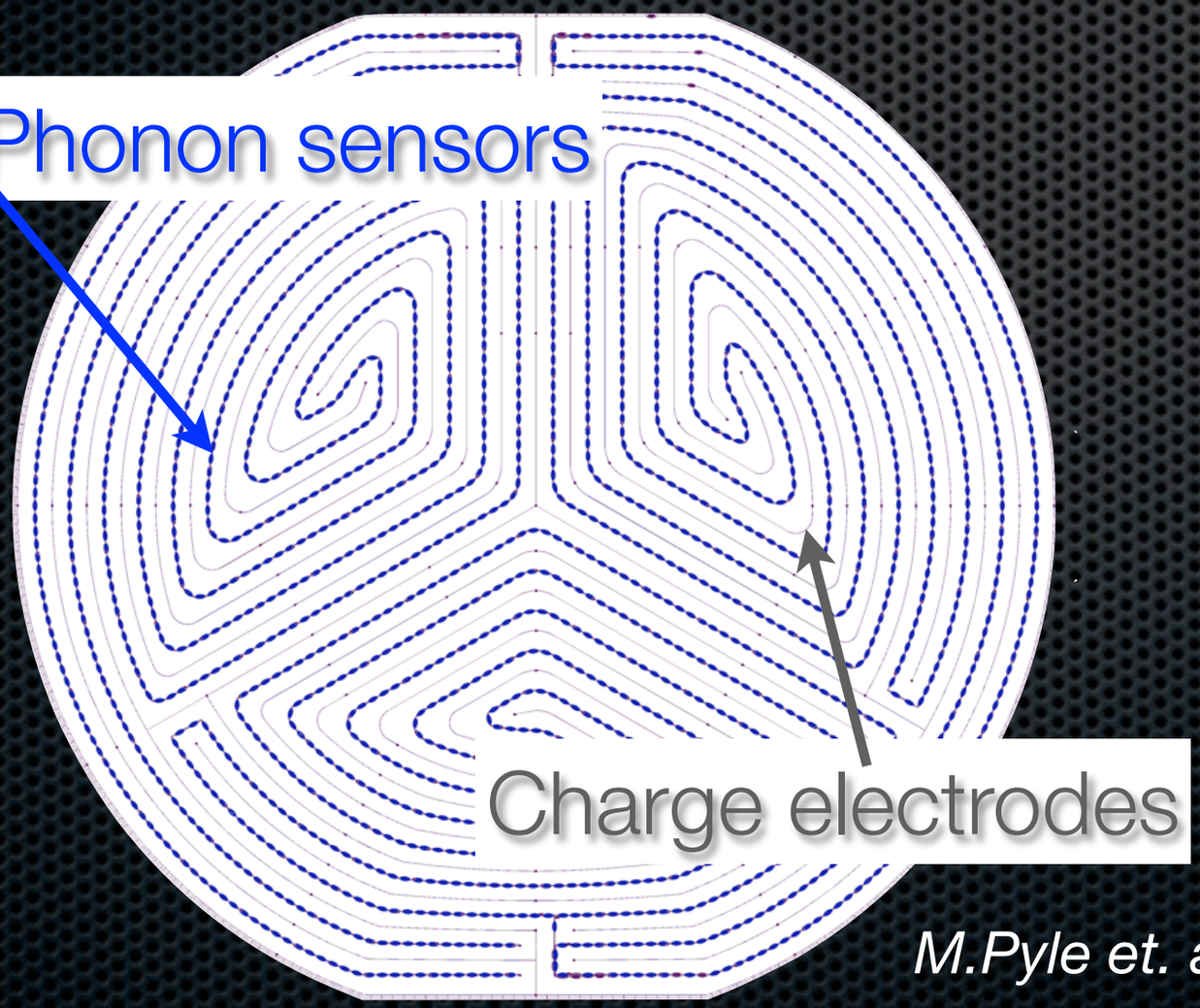



- **Bad charge collection** at surfaces
- **yield only based discrimination for surface events ≈ 1/1000**
- **“leakage”** in Nuclear Recoil band mainly from **βs**

=> **need extra discrimination**

# The new iZIP detector

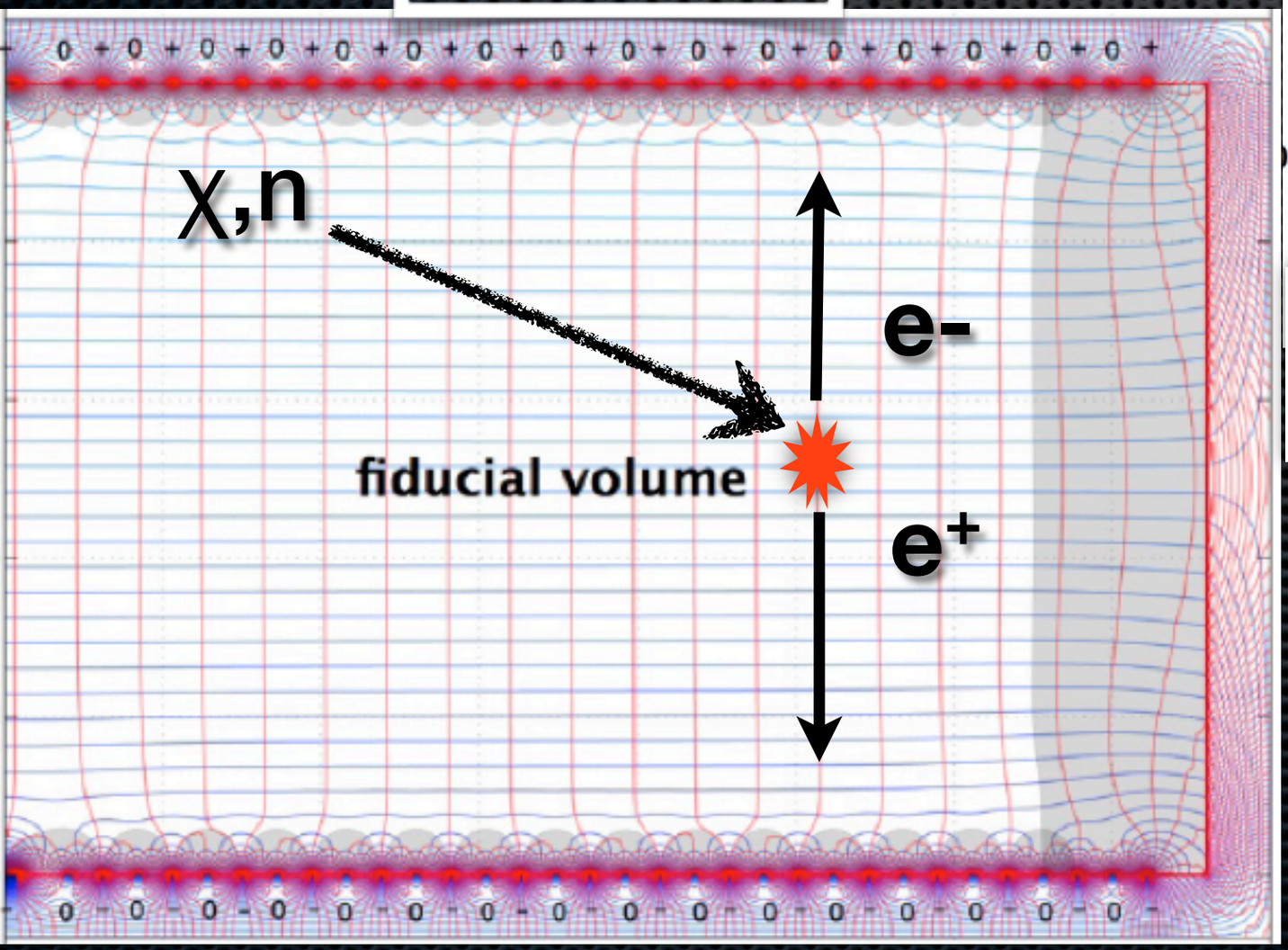




- **New interleaved geometry** on both sides
- **More target mass** per detector

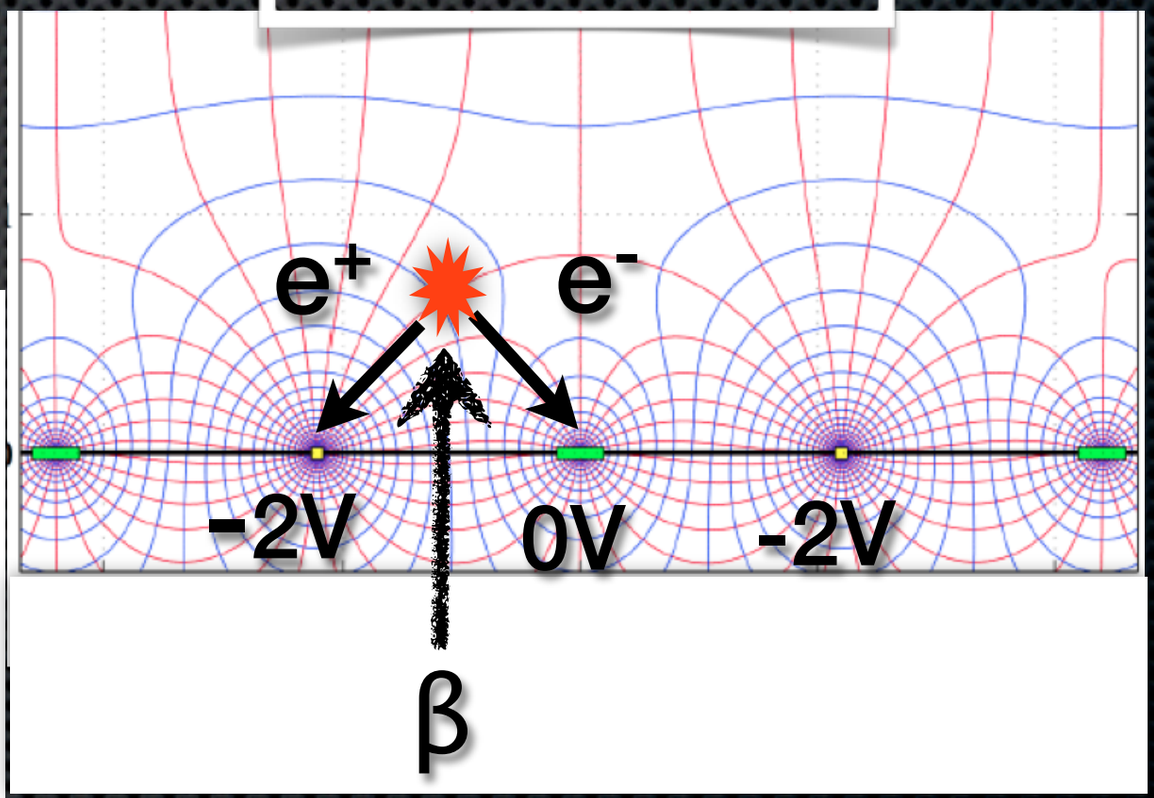
*M.Pyle et. al., AIP Conf. Proc. 1185, pp. 223-226*

# Charge based Bulk/Surface discrimination

Bulk event



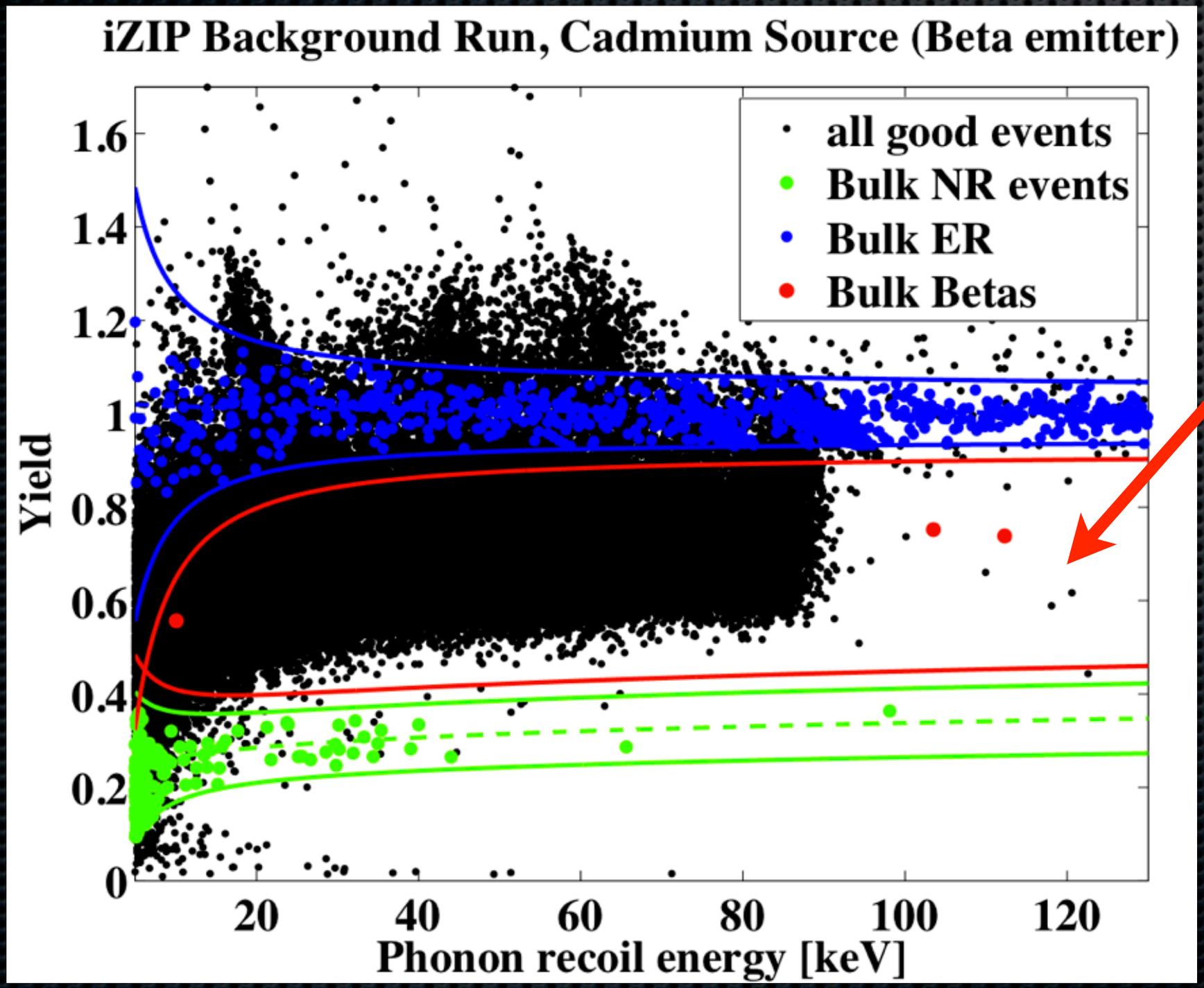

Surface event




- Asymmetric charge collection

  => **Bulk vs surface event charge based discrimination**

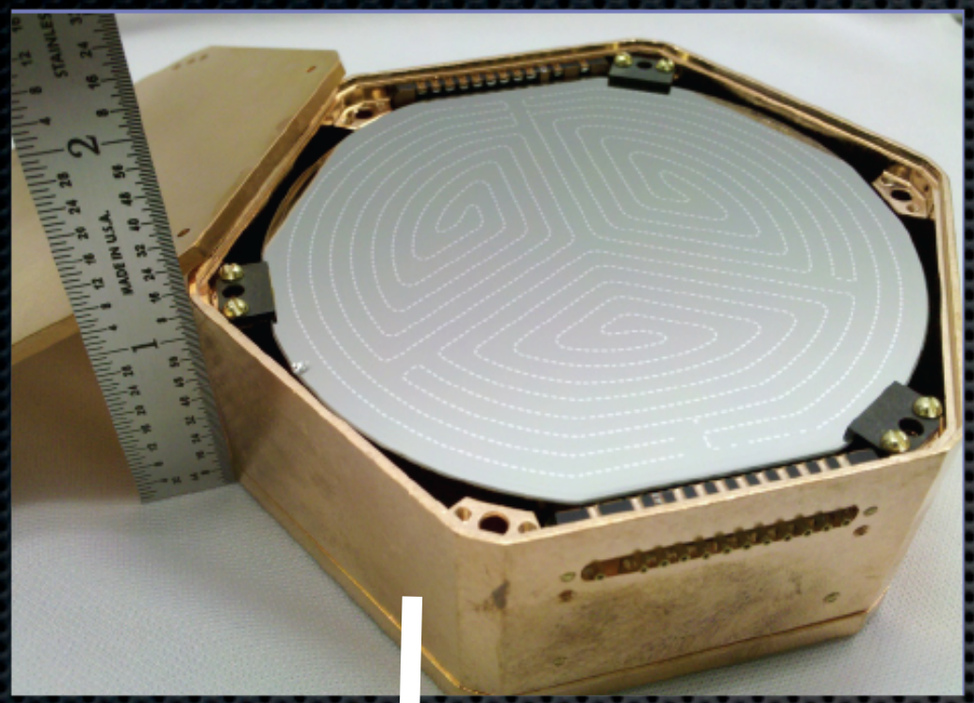
# Charge based Bulk/Surface discrimination

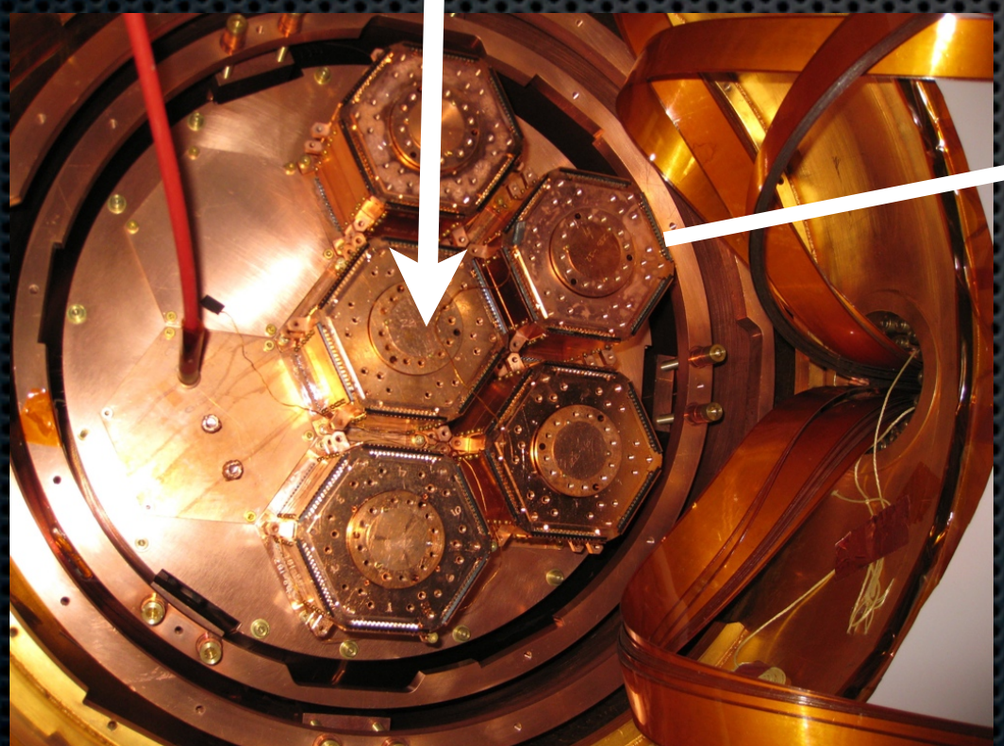



In β band, only 3 events (red dots) pass the charge symmetric cut

**=> Charge discrimination ≈1/33000 !**

# SuperCDMS @ Soudan

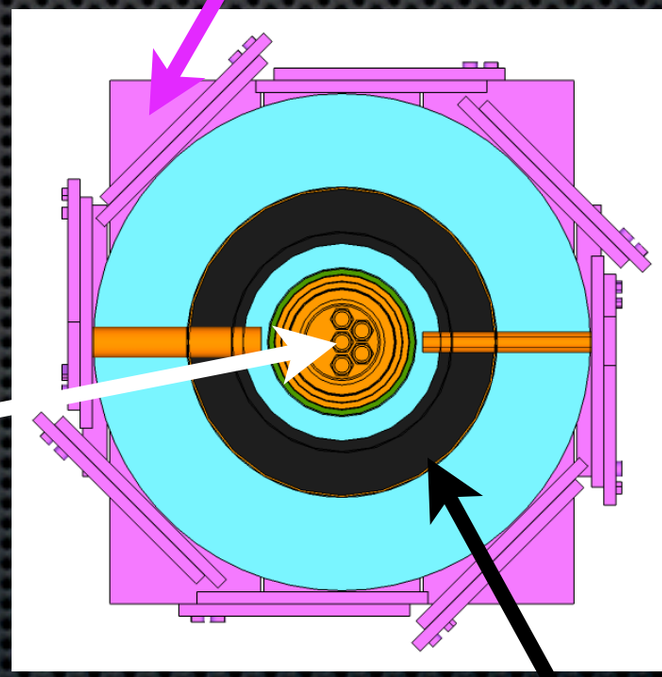


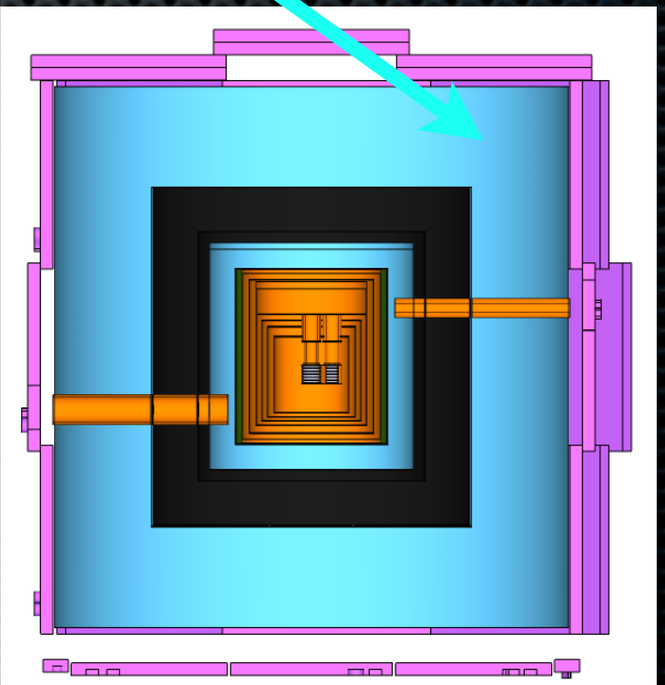


**Currently running with 15 iZIP detectors, 10 kg**

Muon veto

Neutron shield





Top view

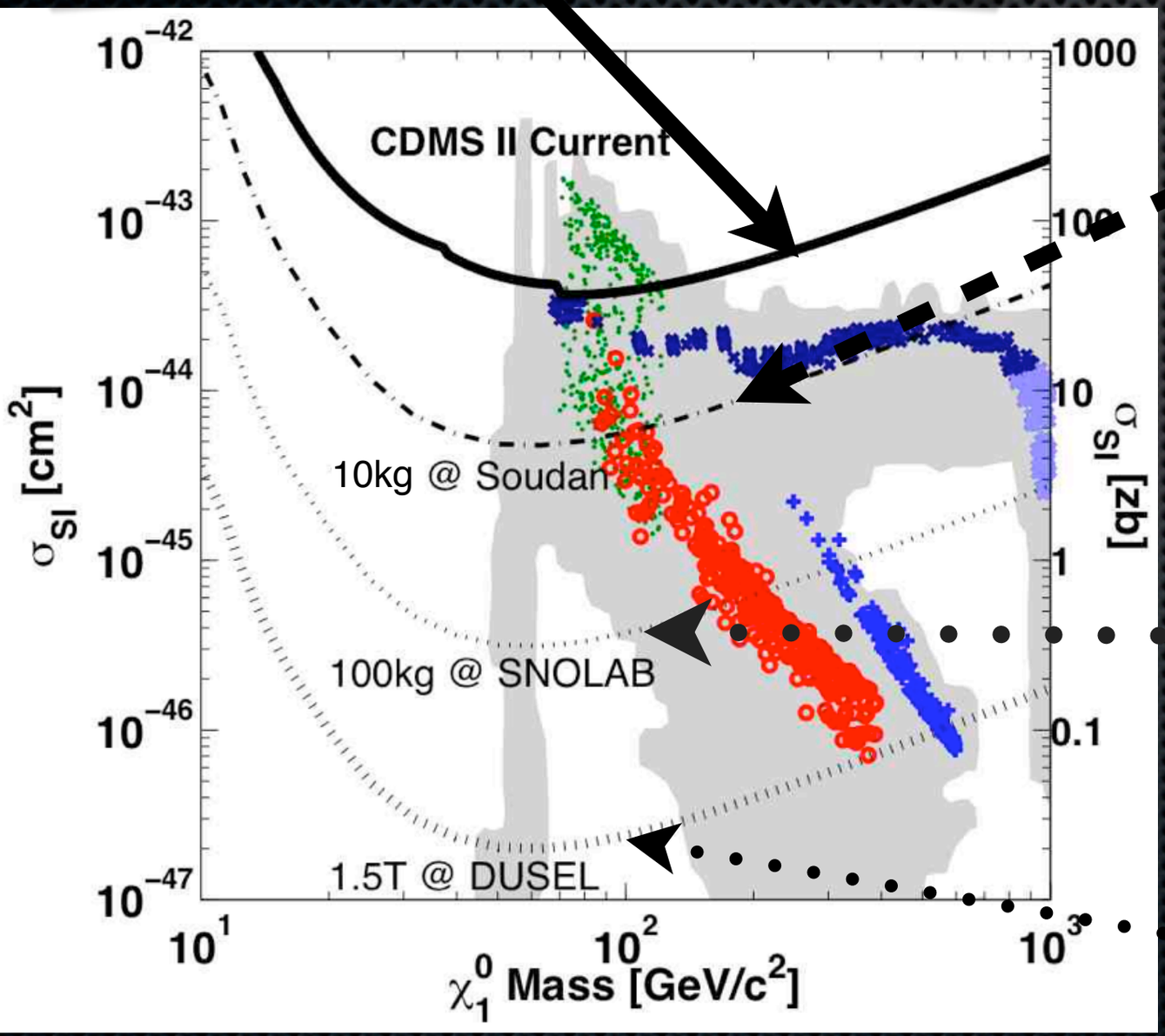
Side view

**Lead shielding**

# Prospects & Goals

**300 kg.d, 3.5 × $10^{-44}$ cm²**
*Z. Ahmed et al., Science 327, 1619 (2010).*

*Soudan mine : 2100 mwe*




**SuperCDMS run started last November for 2 ys**
**1200 kg.d, 5 × $10^{-45}$ cm²**

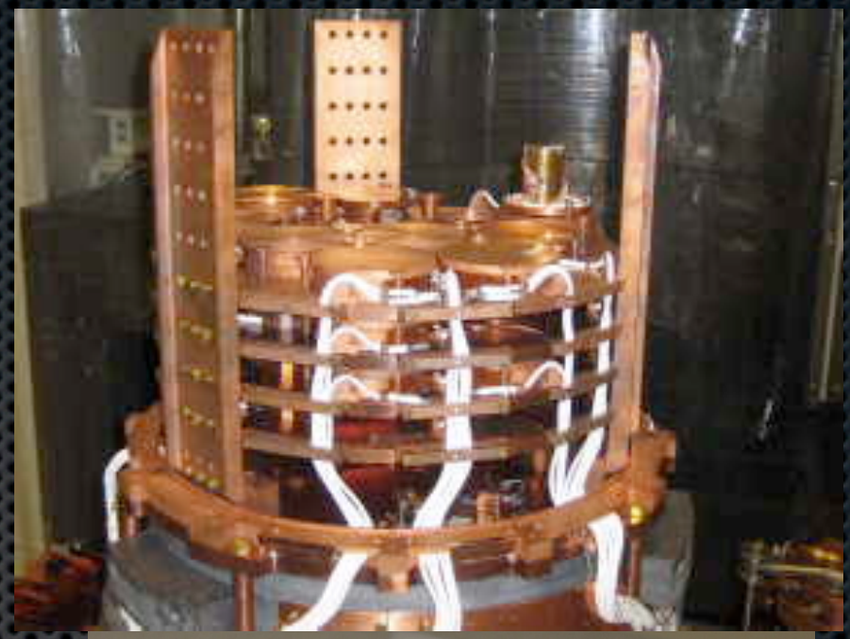
SNOLAB
MINING FOR KNOWLEDGE
CREUSER POUR TROUVER... L'EXCELLENCE

*6000 mwe*

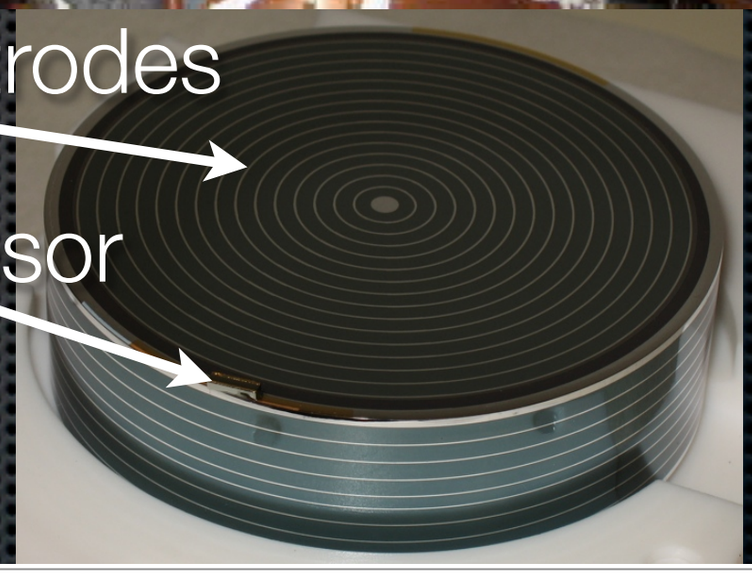
**100 kg.y , 3 × $10^{-46}$ cm²**

**1.5 T.y , 2 × $10^{-47}$ cm²**

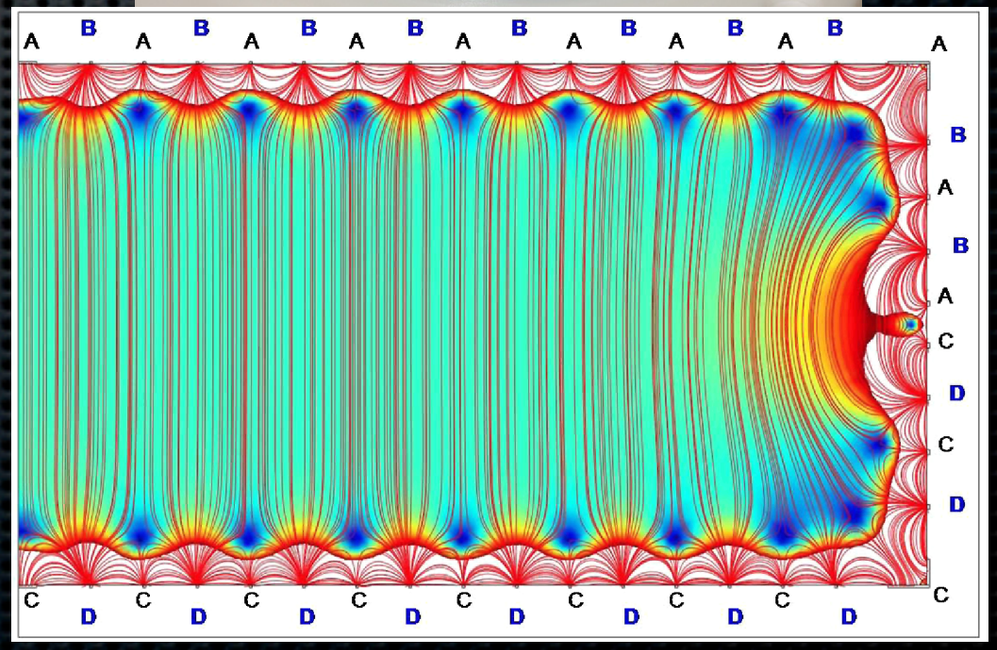
# The Edelweiss Experiment



Expérience pour DEtecter Les WIMPs En Site Souterrain

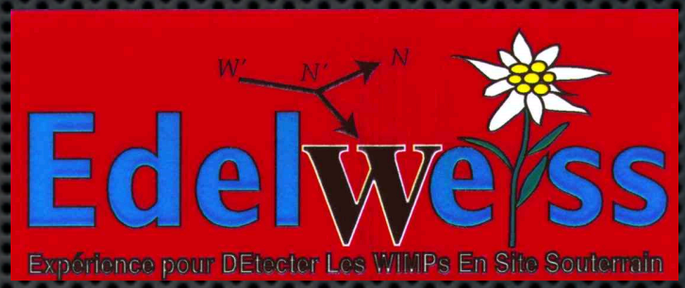



- Situated **under 4800 mwe rock** overburden in the Frejus tunnel between Italy and France
- Uses **germanium** detectors at **low T**
- Measures **thermal phonons** to get the **Nuclear Recoil energy**
- Uses **interleaved charged electrodes** to measure ionization



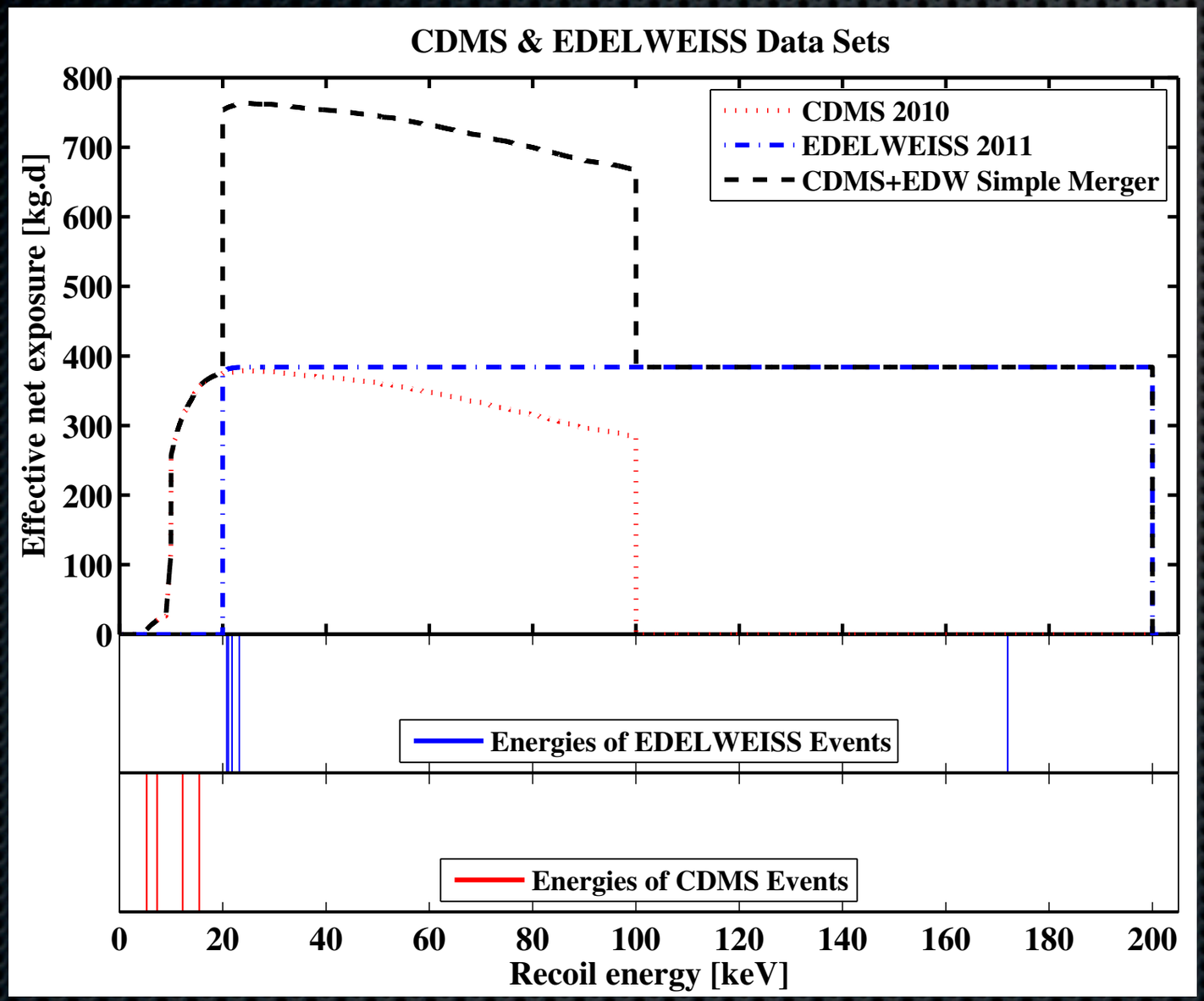
# CDMS-EDELWEISS Combination


+




- **Motivations**
  - very similar technology
  - very similar exposure and background
  - same methods to derive limits
- **Goals** :
  - **Setting a more sensitive limit** on WIMP-nucleon cross section
  - **Learning** more about **candidate events**

# CDMS-EDELWEISS Data Sets



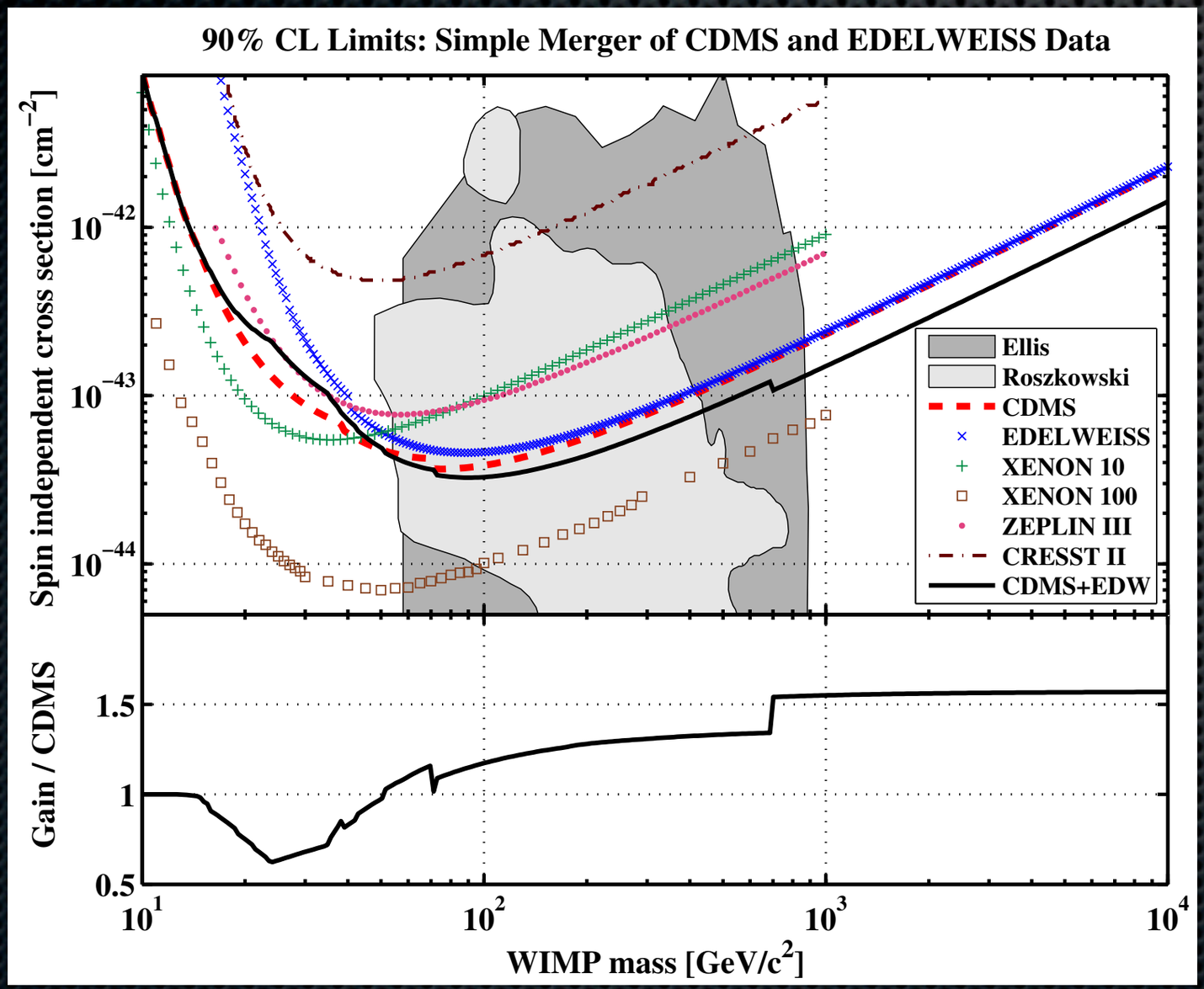

*Z. Ahmed et al., Phys. Rev. D, vol. 84, p. 011102, Jul 2011,*

- ≈ 380 kg.day max exposure for both experiments
- Summed exposures ≈ **760 kg.day** max
- 4 CDMS events
- 5 EDELWEISS events

=> **Optimum interval* method** applied on the **summed exposure** and on the total of **9 events**

**S. Yellin, Phys. Rev. D 66, 032005 (2002)*

# CDMS-EDELWEISS Results




*Z. Ahmed et al., Phys. Rev. D, vol. 84, p. 011102, Jul 2011*

- **Gain > 1 above 50 GeV** and up to 1.6 above 700 GeV
- A **minimum cross section** of **3.3 x $10^{-44}$ cm$^2$** for a 90 GeV WIMP is excluded at 90% C.L.
- the 0-background hypothesis is excluded at a >99.8% CL.

# Summary

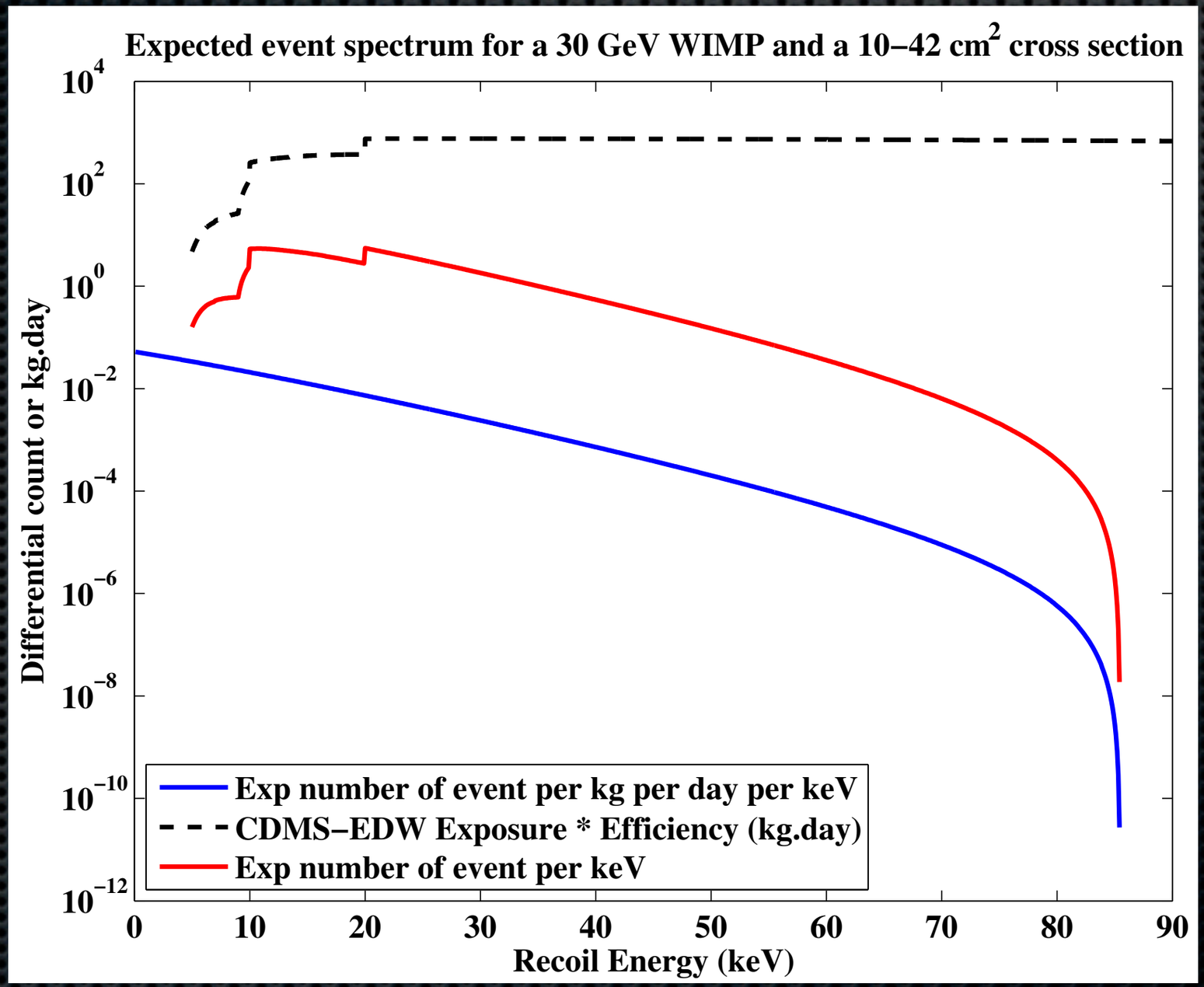
- **CDMS** is **currently running** with **15 new iZIP** detectors representing a **10 kg target mass**

- The new **iZIP design** and the **target mass** will lead to an **improved limit on the WIMP-nucleon scattering cross section** within 2 years

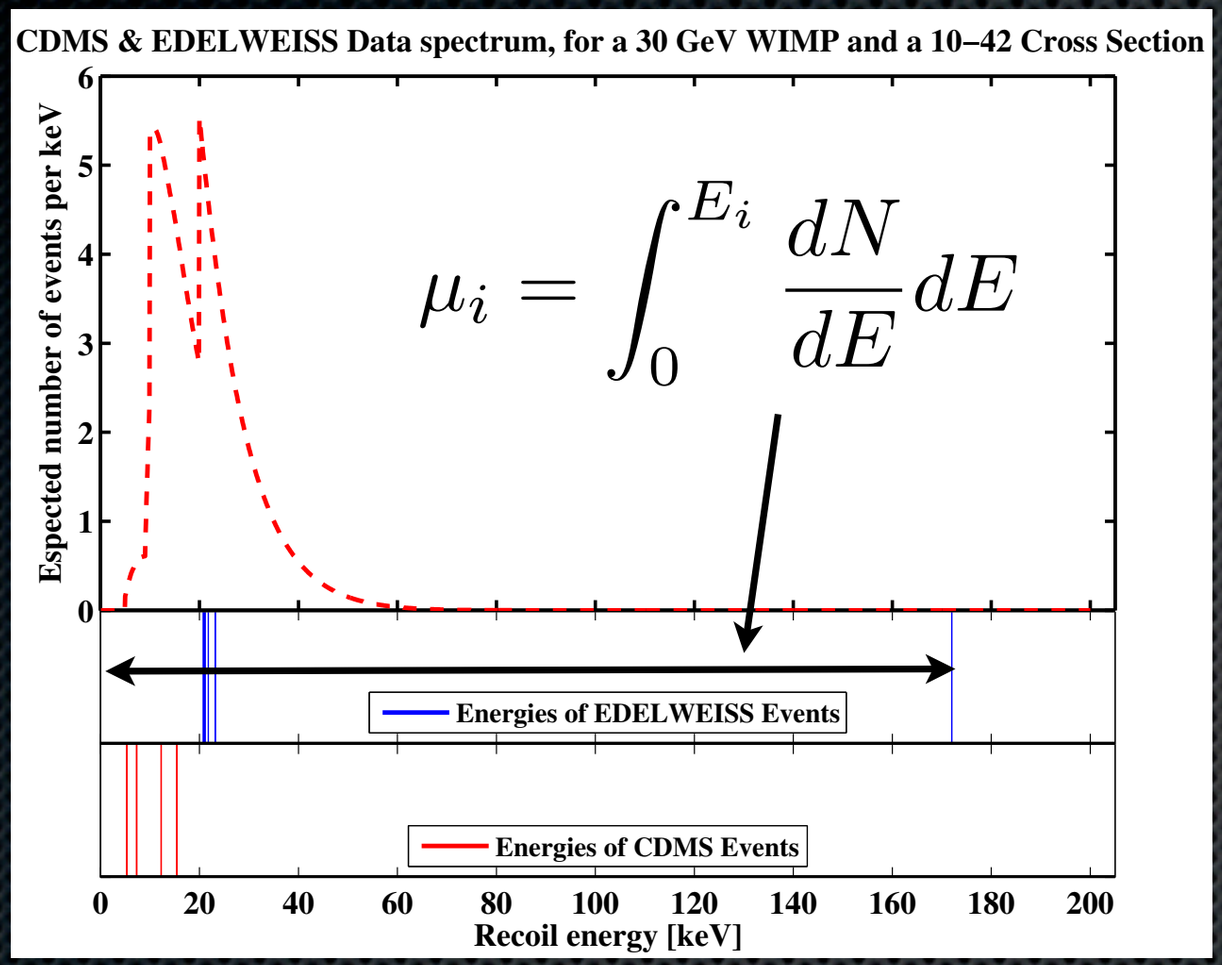
- **CDMS-EDELWEISS** combination has set a **more stringent limit than both experiments alone** above 50 GeV

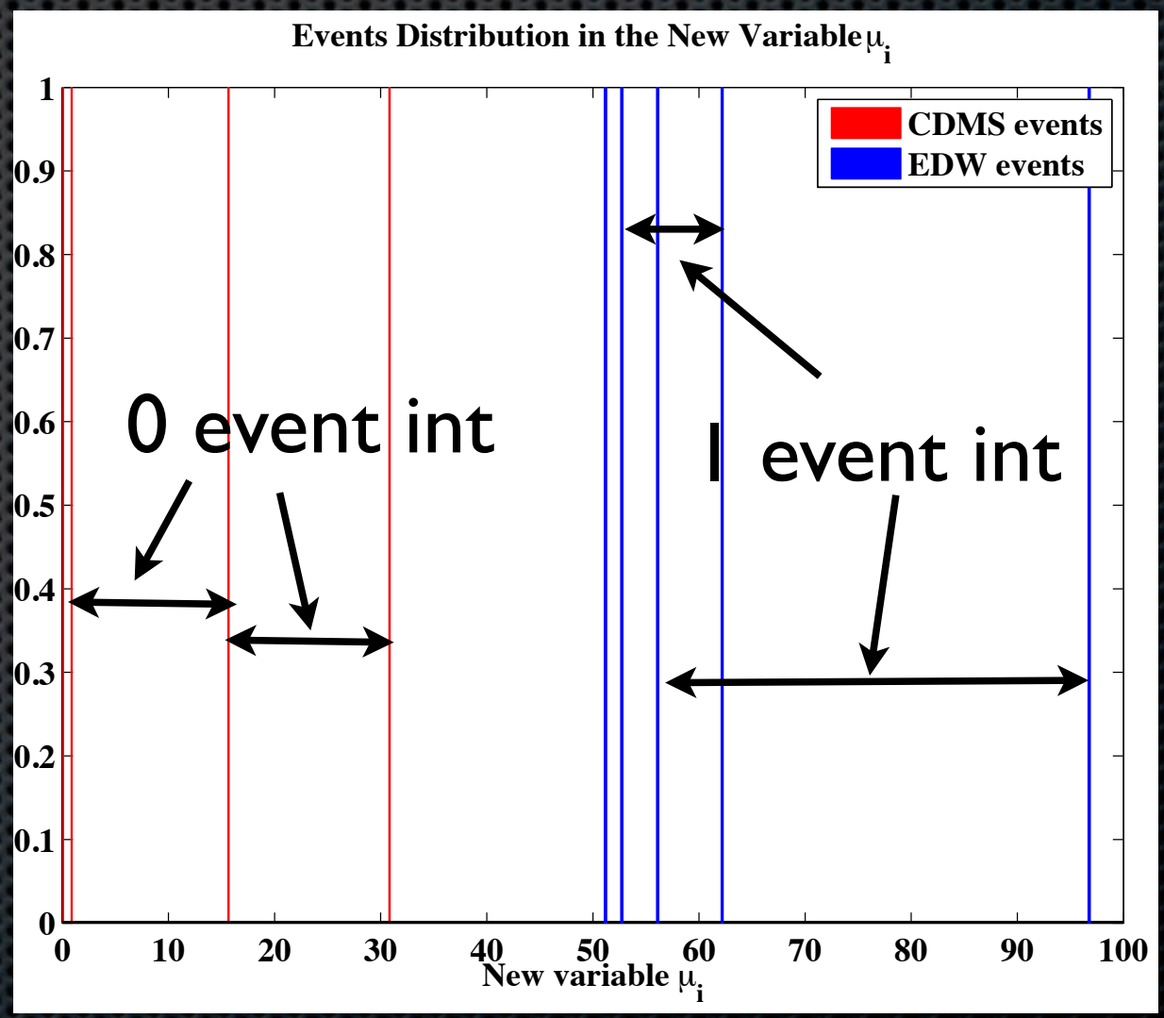
=> The combination is the first of this type in dark matter search

# Backup


Expected event spectrum for a 30 GeV WIMP and a 10−42 cm2 cross section
Differential count or kg.day
Recoil Energy (keV)
Exp number of event per kg per day per keV
CDMS−EDW Exposure * Efficiency (kg.day)
Exp number of event per keV

# Backup


CDMS & EDELWEISS Data spectrum, for a 30 GeV WIMP and a 10−42 Cross Section
$\mu_i = \int_0^{E_i} \frac{dN}{dE} dE$
Expected number of events per keV
Energies of EDELWEISS Events
Energies of CDMS Events
Recoil energy [keV]


Events Distribution in the New Variable $\mu_i$
CDMS events
EDW events
0 event int
1 event int
New variable $\mu_i$