

Cryogenic Dark Matter Search (CDMS)



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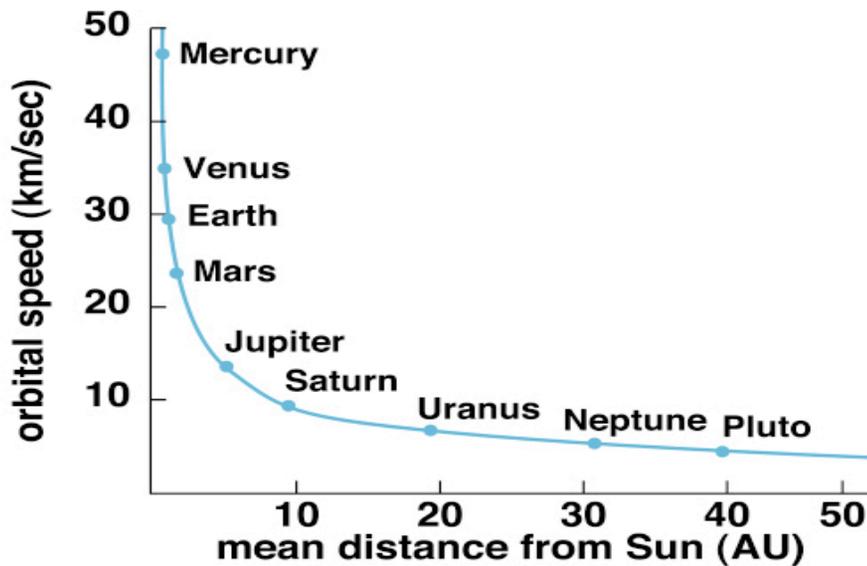
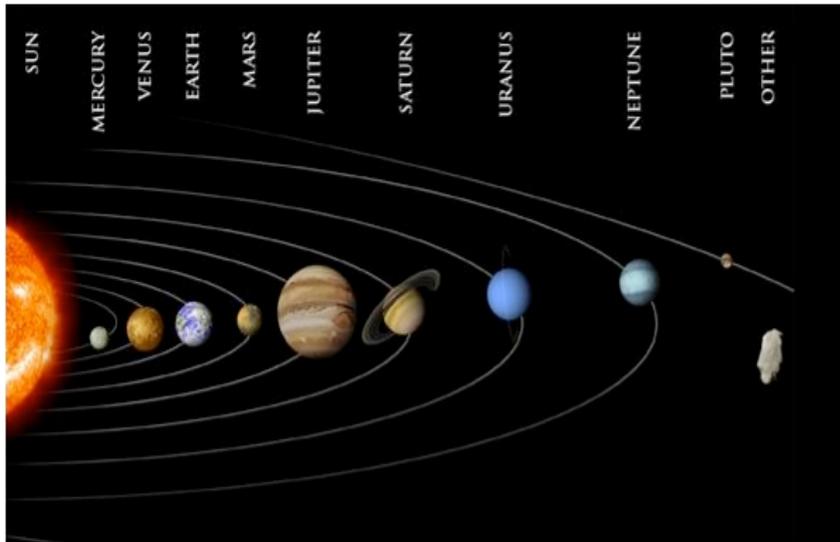
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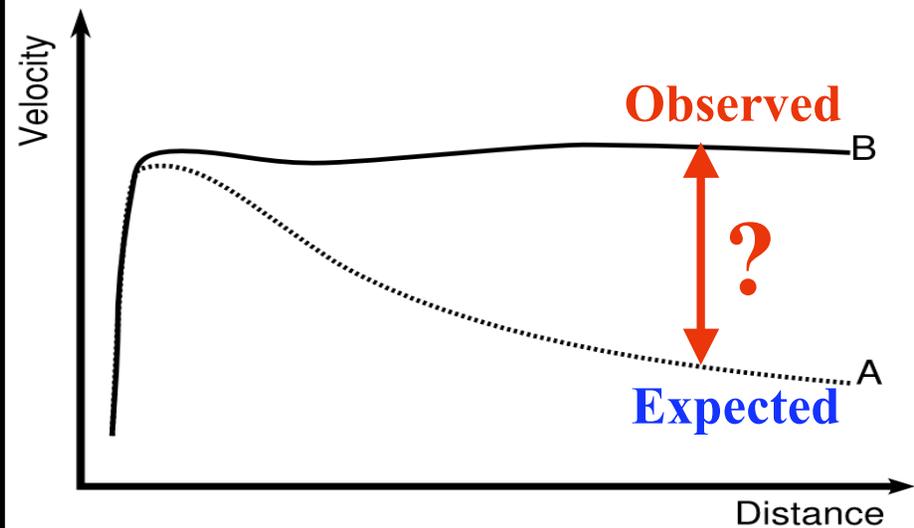
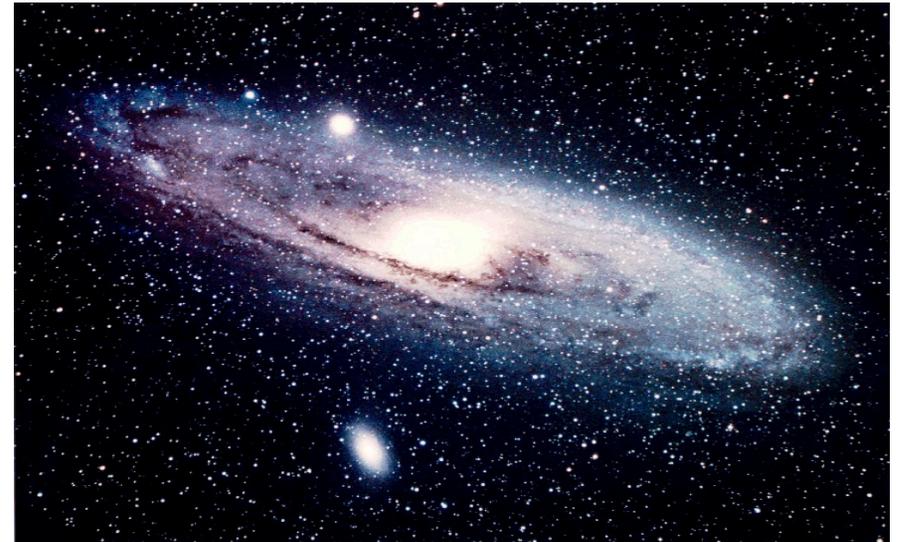
- 1. Introduction**
- 2. CDMS experiment**
- 3. Recent results**
- 4. Current status & future**
- 5. Summary**

Dark Matter : There is something invisible

Solar System

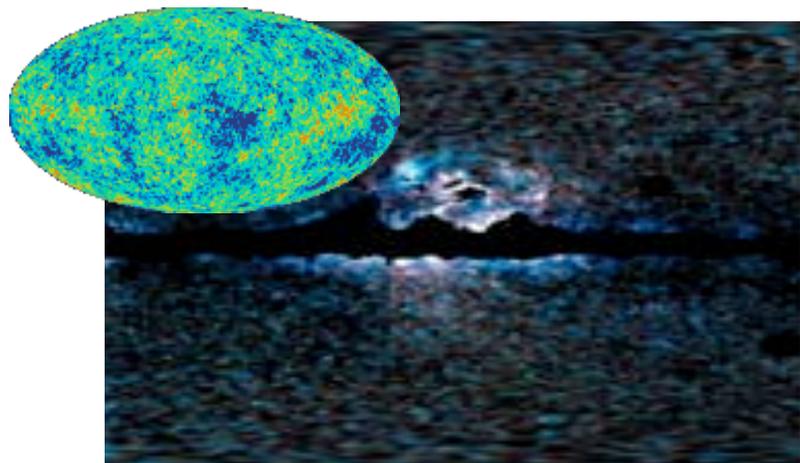


Spiral Galaxy

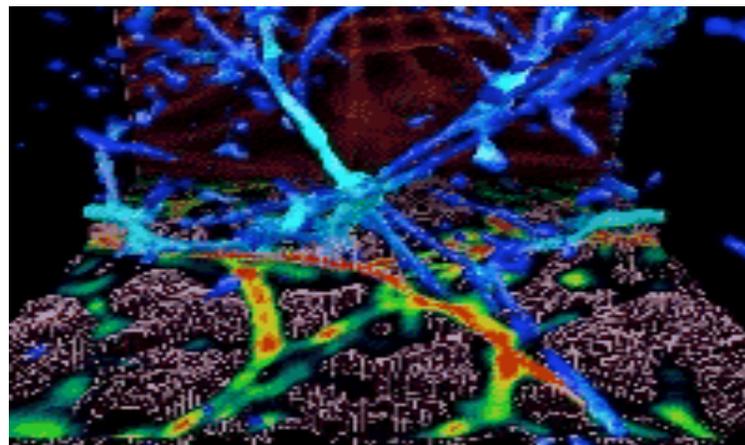


(b)
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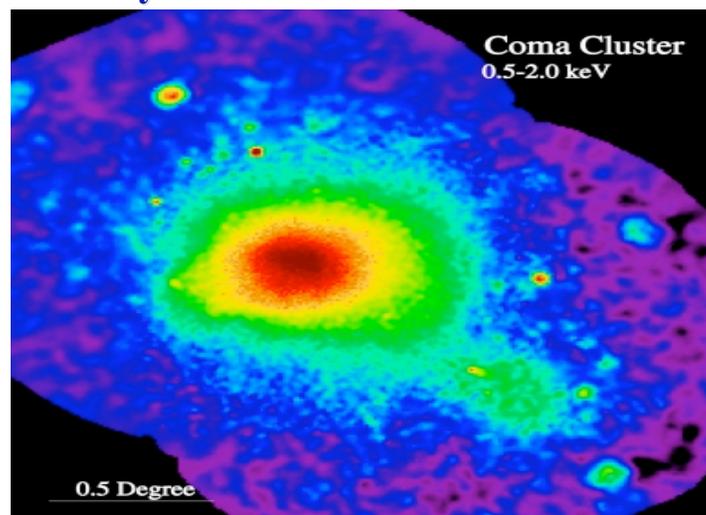
CMB



Large scale structure



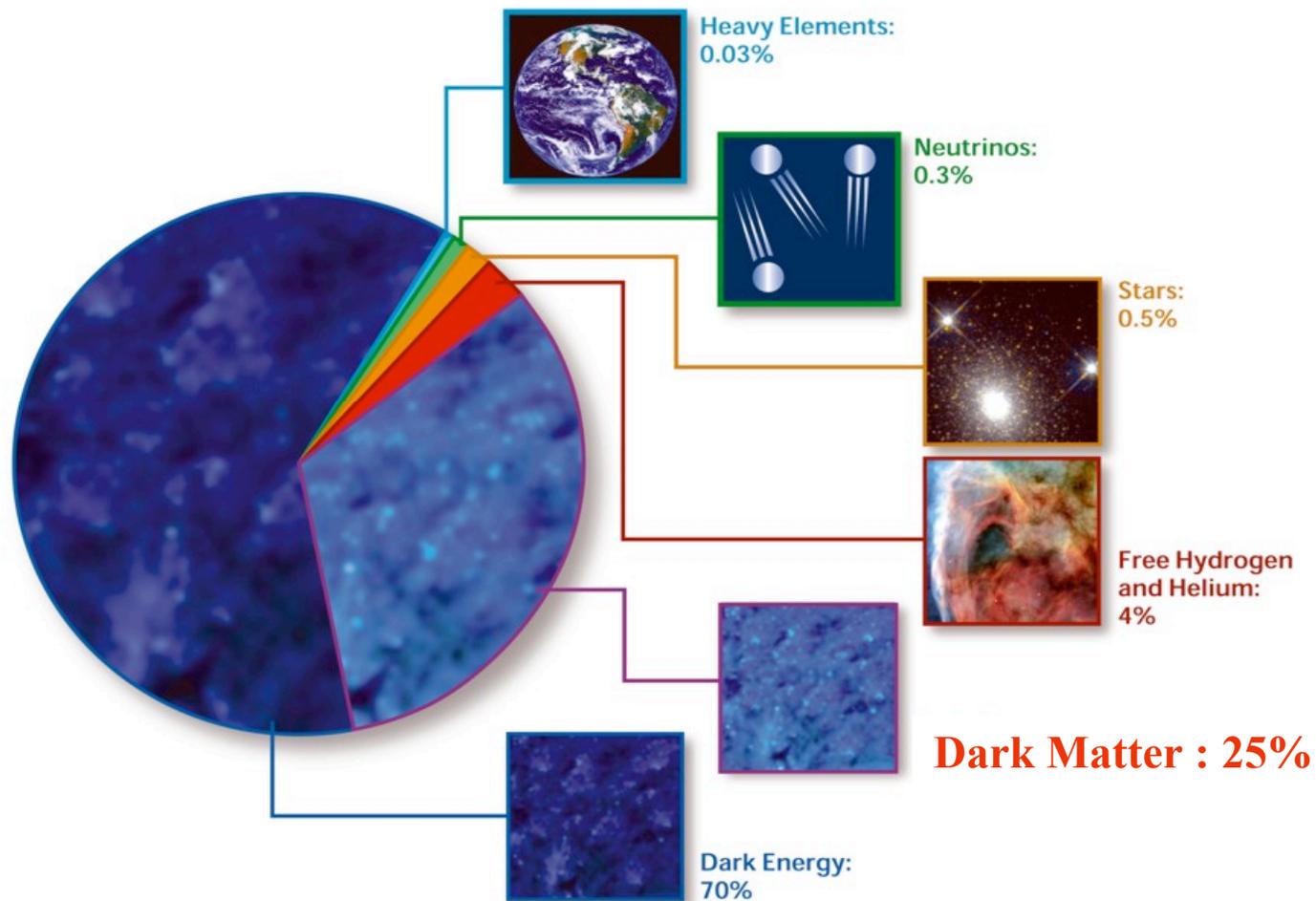
Galaxy clusters



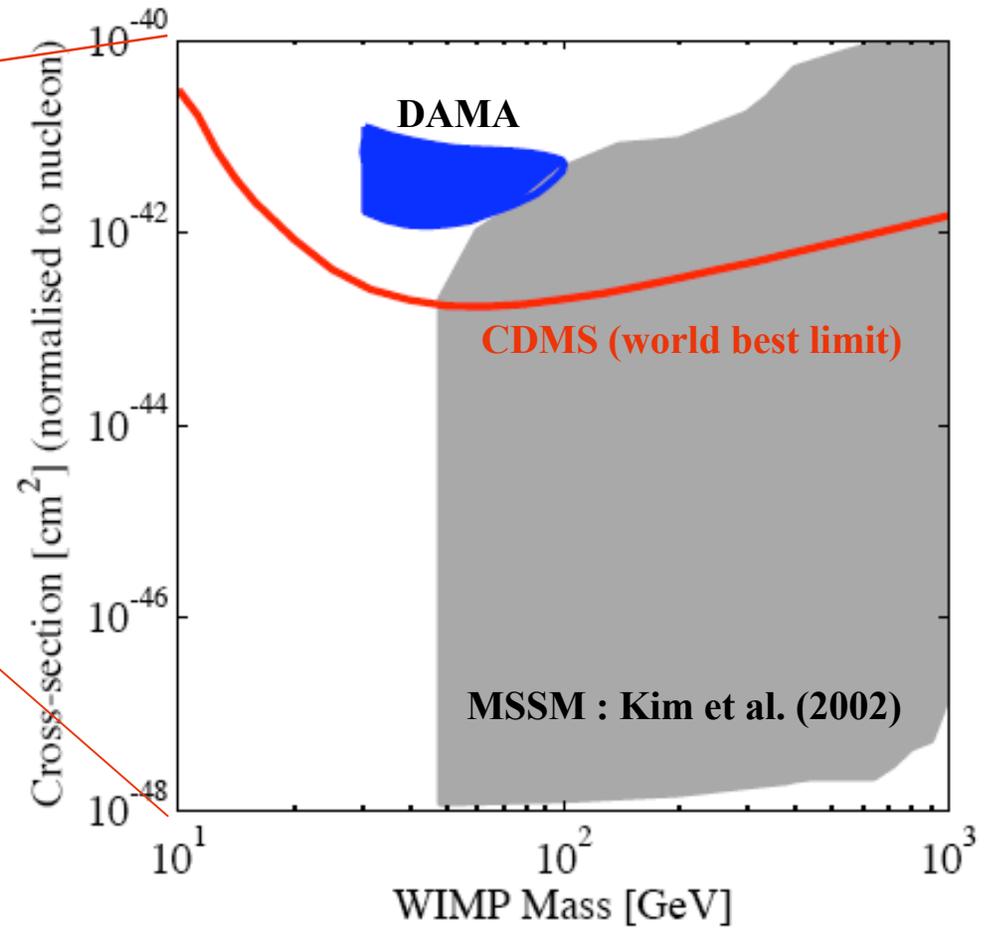
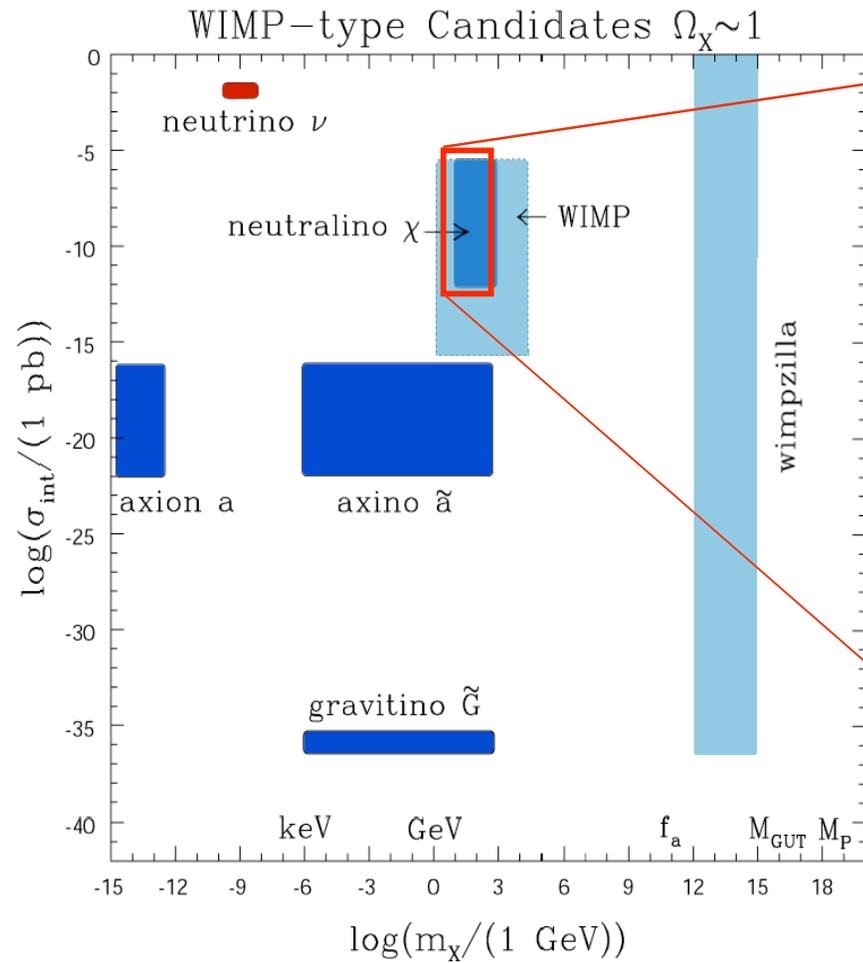
Gravitational lensing



Budget of the Universe



World map of Dark Matter & where we are



L. Roszkowski



Photo from Z.Frei and E.Gunn

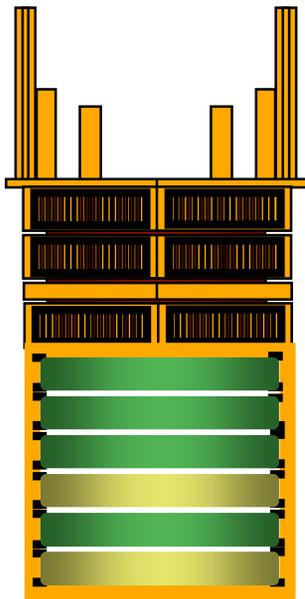
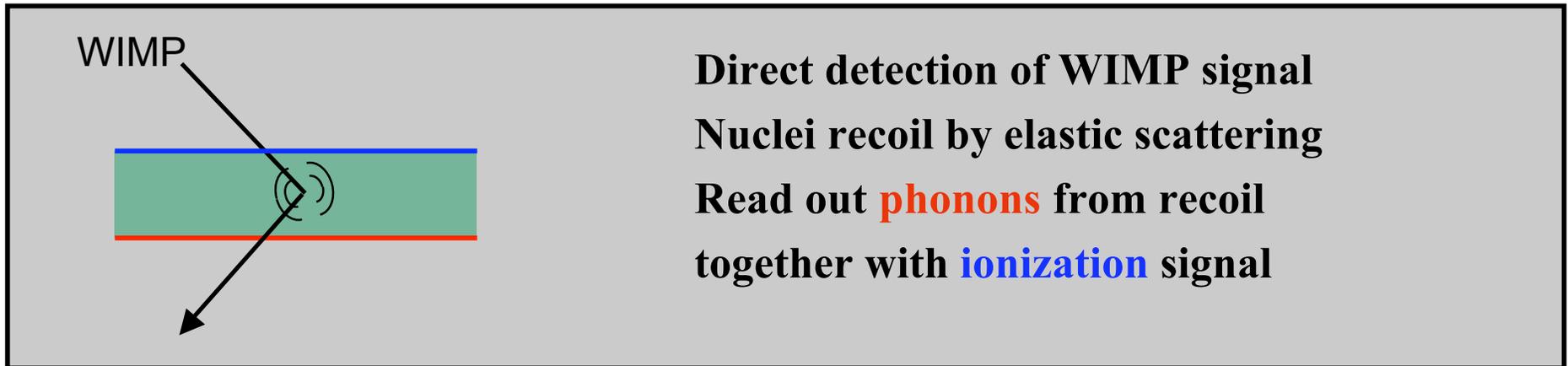
- **Spherical Halo Model** ($\rho \sim 1/r^2$)
- **Energy spectrum & rate depend on WIMP distribution in Dark Matter Halo**

$$\frac{dR}{dE} \propto \sigma \rho \int_{v_{\min}}^{v_{\text{esc}}} \frac{f(v)}{v} dv$$

- **Assume isothermal Maxwell-Boltzmann velocity distribution**
- **$V_0 = 230$ km/s (WIMP velocity against detector)**
- **$V_{\text{esc}} = 650$ km/s (escape velocity of WIMP from galactic halo)**
- **$\rho = 0.3$ GeV / cm³**
- **Energy spectrum of recoils is featureless exponential with $\langle E \rangle \sim 50$ keV**

Invisible ?





Weakly interacting

WIMP mean free path in Ge $\sim 10^{10}$ m

The event will single scatter

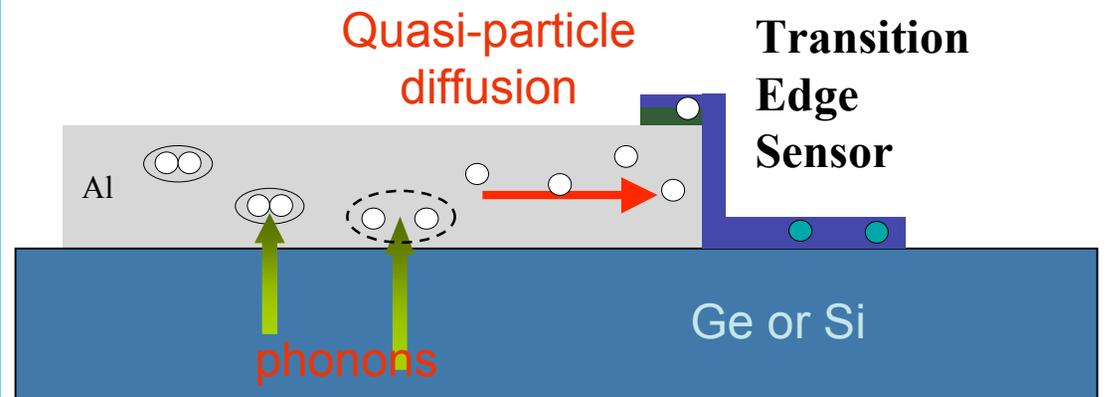
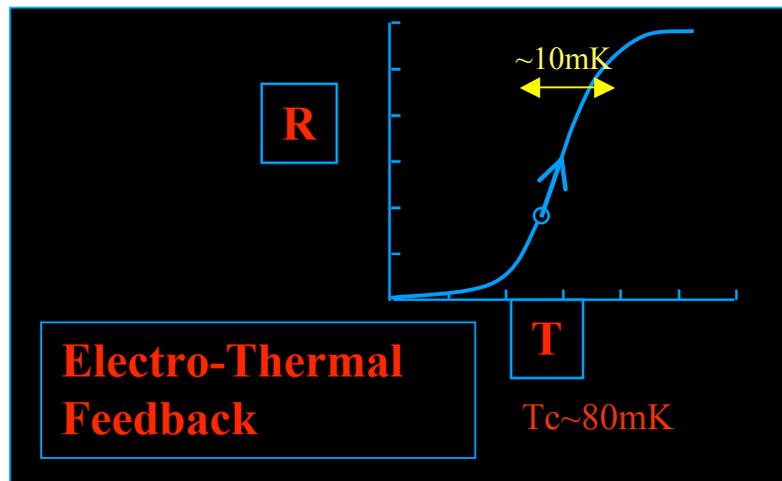
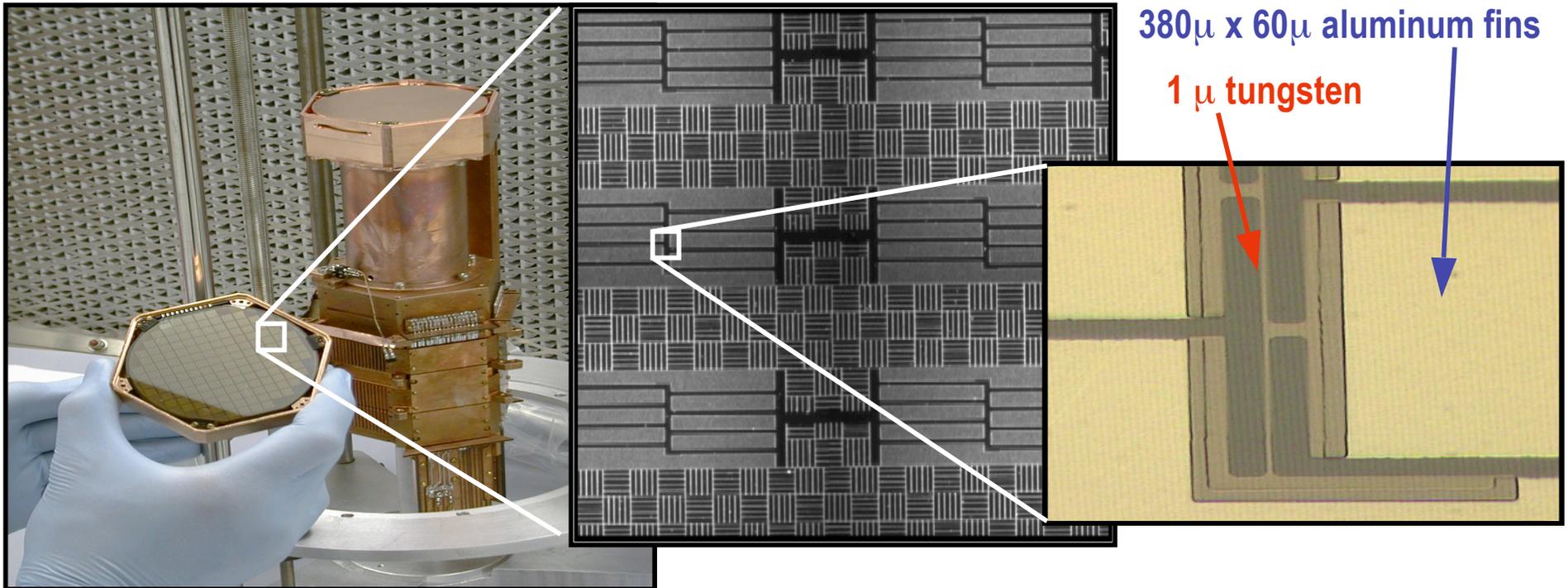
while Neutron will multiple scatter

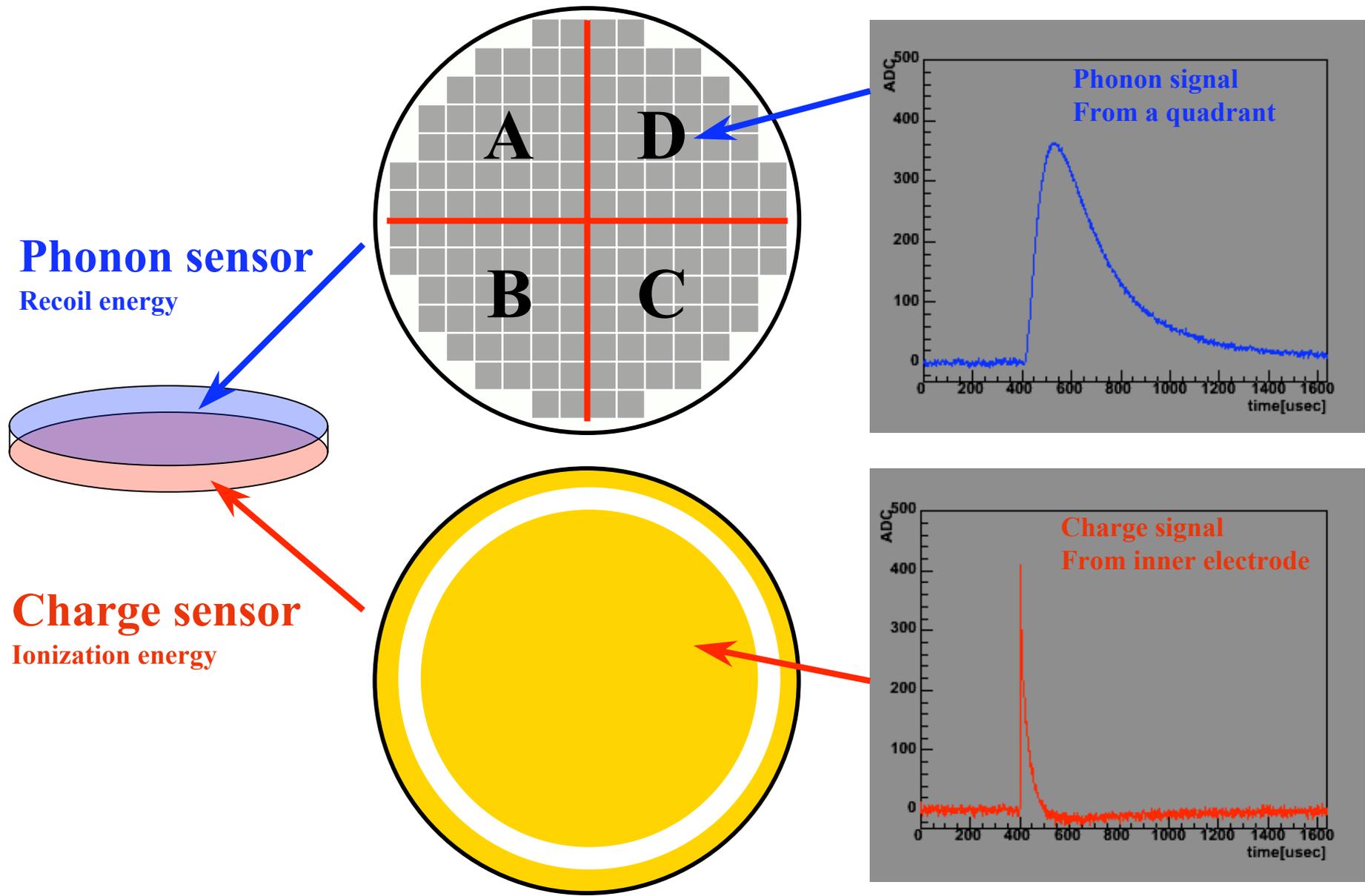
Interaction rate $\propto A^2$

Use both Ge(73) and Si(28) targets

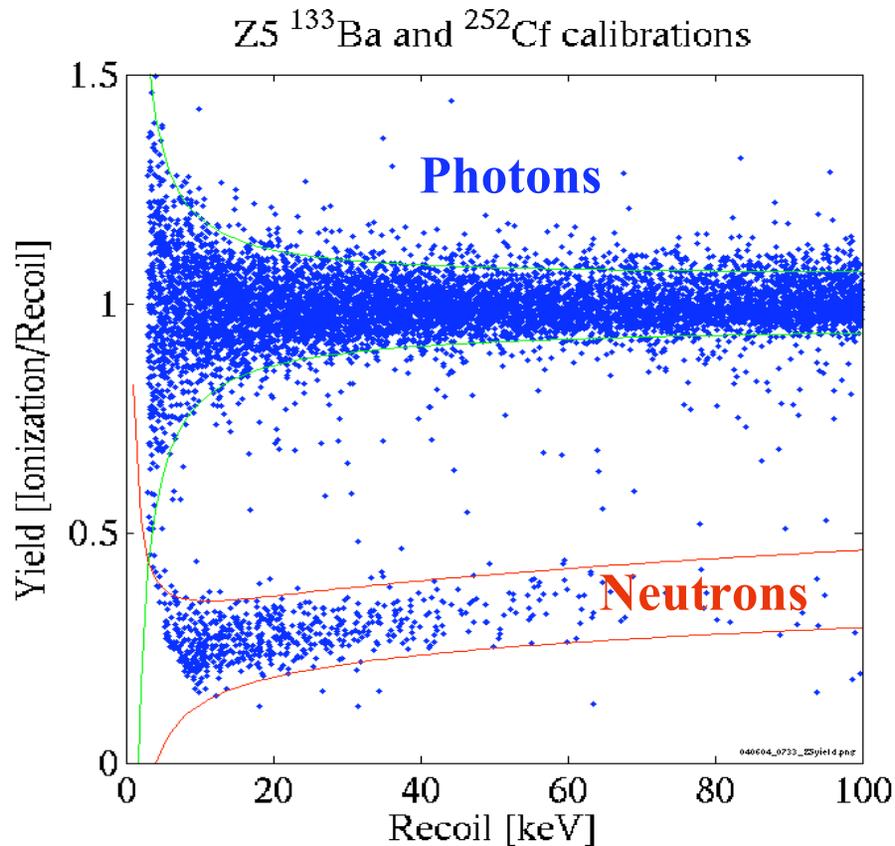
$R(\text{Si}/\text{Ge}) = \sim 1/6$

while Neutron $R(\text{Si}/\text{Ge}) \sim 1$

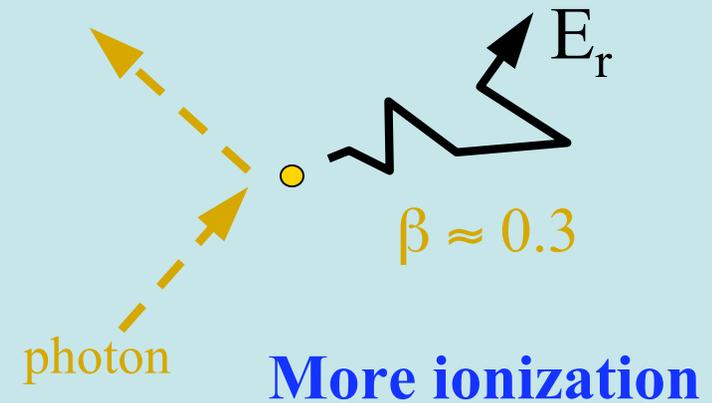




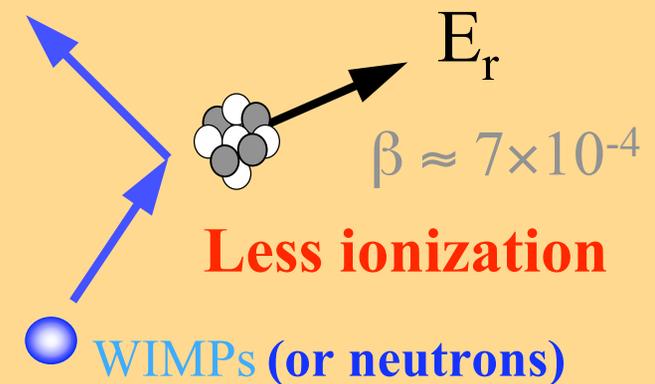
Ionization Yield = $E(\text{ionization}) / E(\text{recoil})$



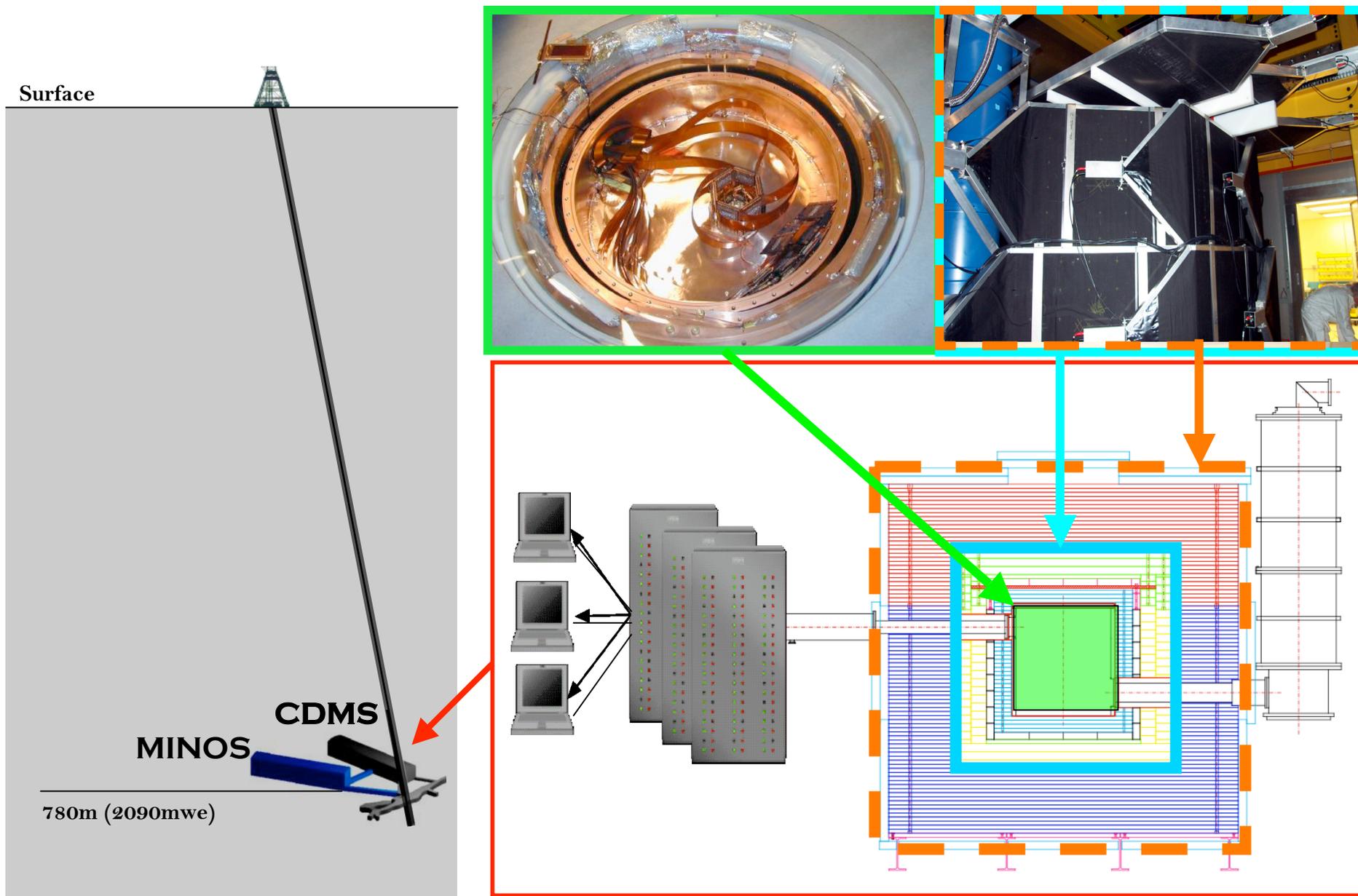
Electron recoils



Nucleus recoils



Experimental setup in the Soudan mine



Why deep-underground ?

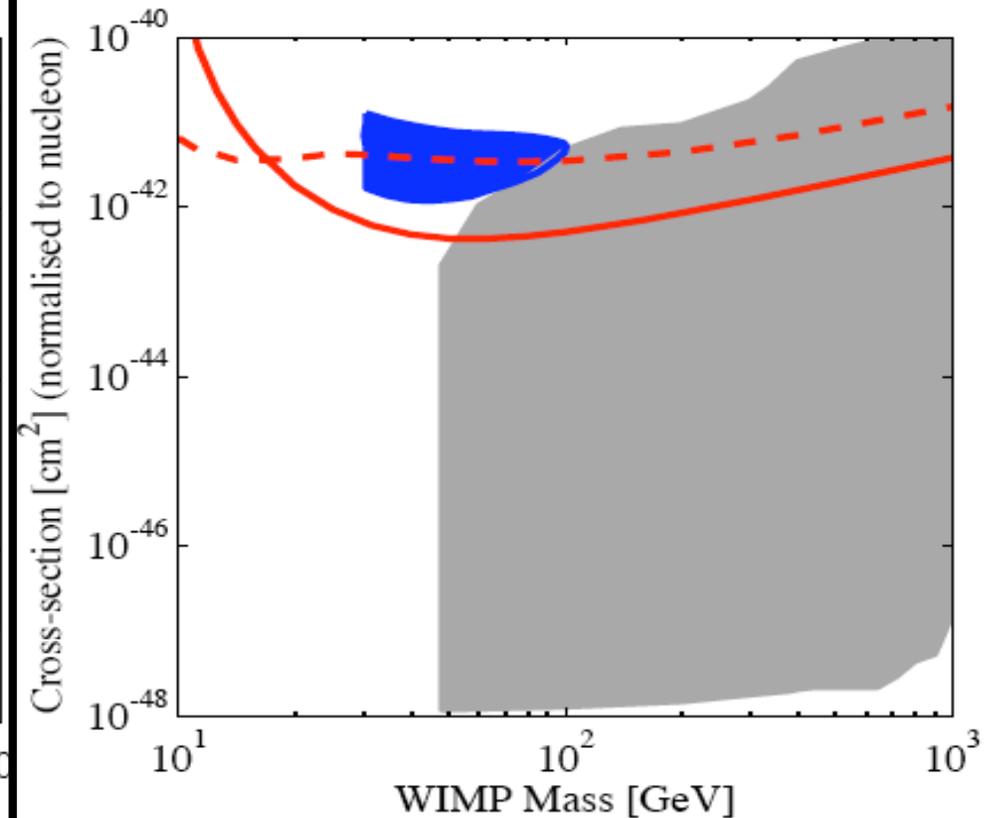
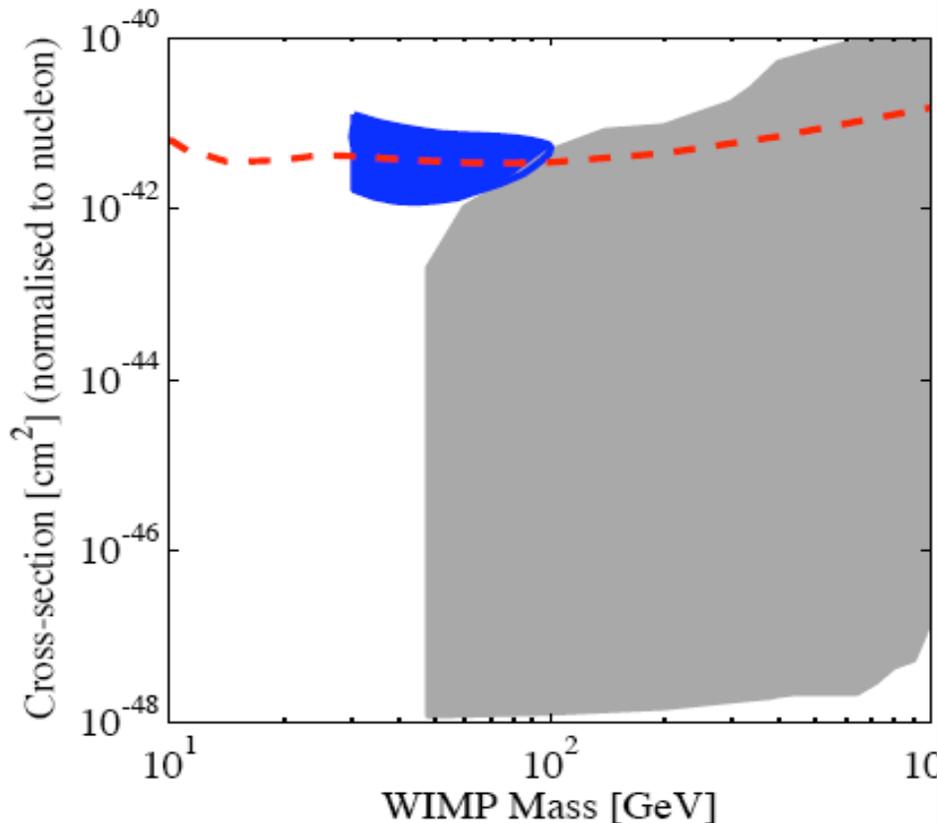
15

Stanford

- 2001-2002 operation
- **12m underground ($50\mu\text{s}/\text{m}^2$)**
- 28 kg-days detector exposure
- Single Tower (4Ge + 2Si detector)
- **20 nuclear recoil events**

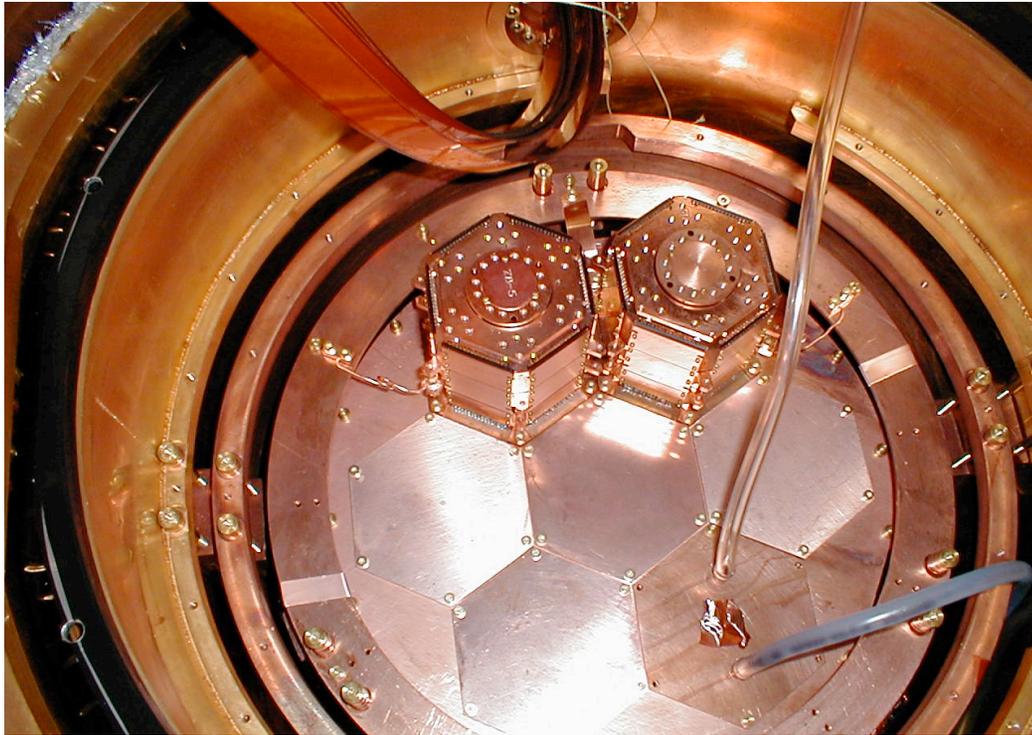
Soudan

- 2003 operation
- **780m underground ($0.004\mu\text{s}/\text{m}^2$)**
- 19 kg-days detector exposure
- Single Tower (4Ge + 2Si detector)
- **1 nuclear recoil events**

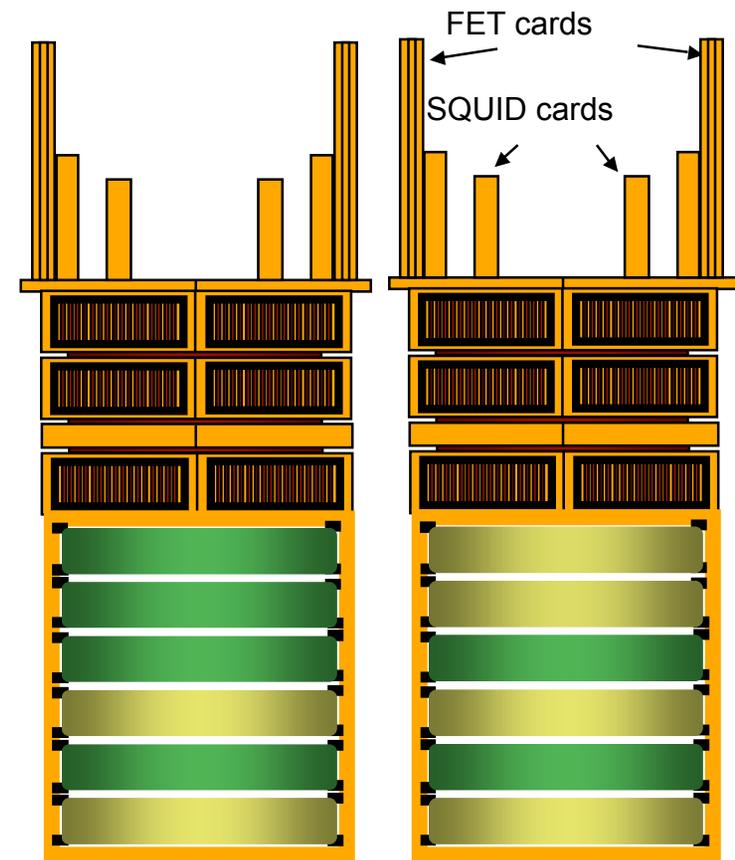


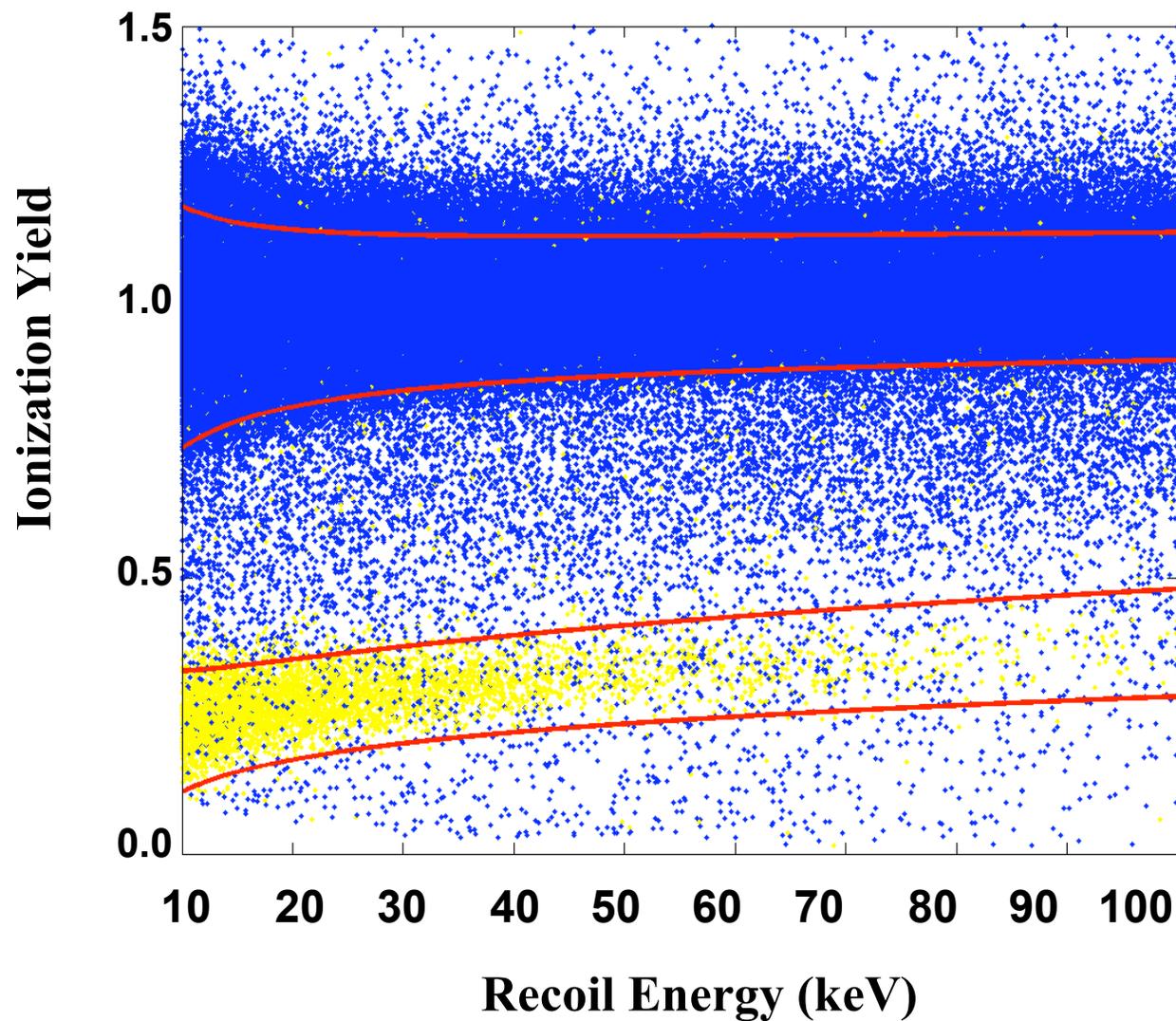
2 towers operation (2004)

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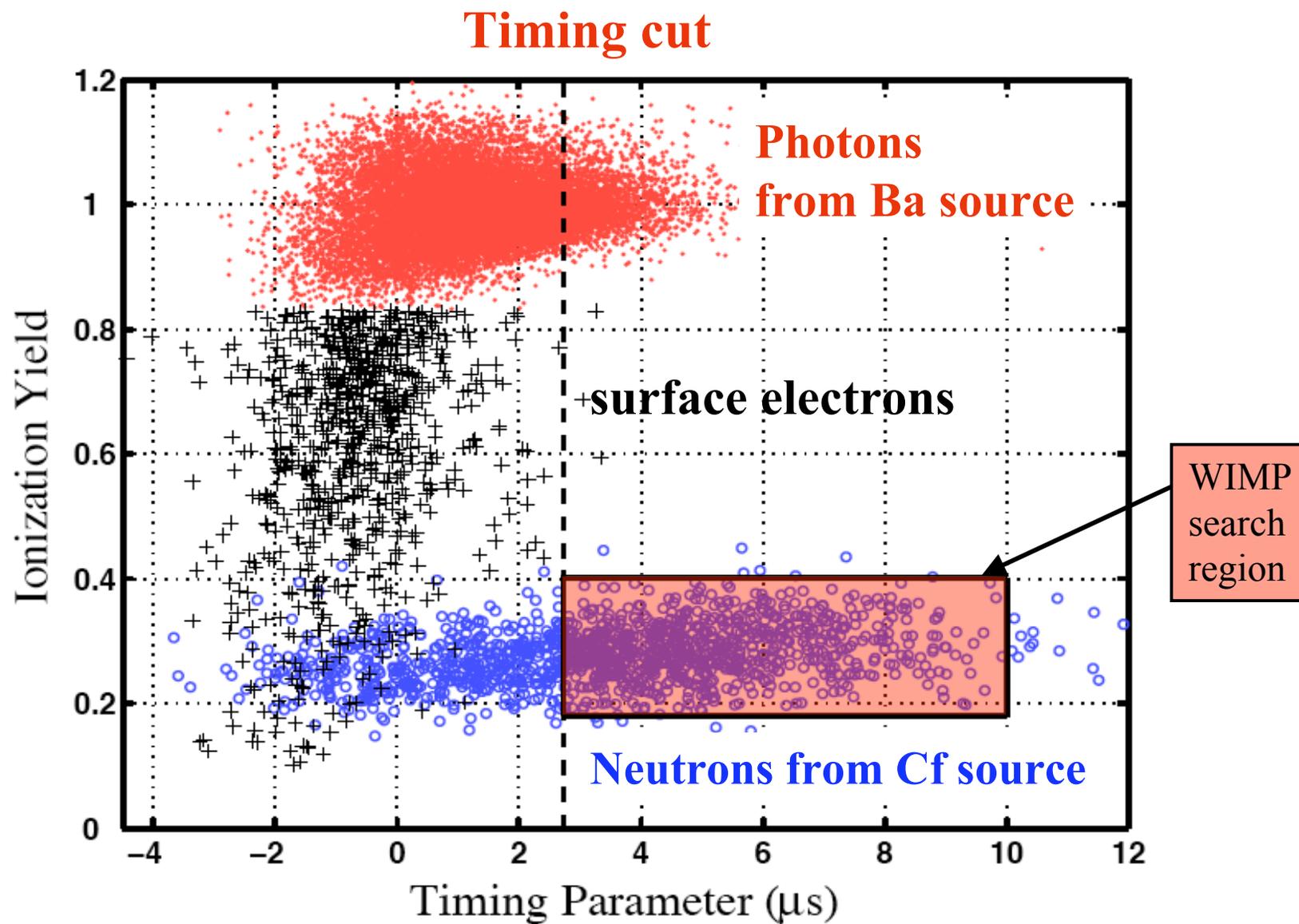
6 Ge (6 x 0.25kg) and 6 Si (6 x 0.1kg) detectors
Detector live time : 74 days

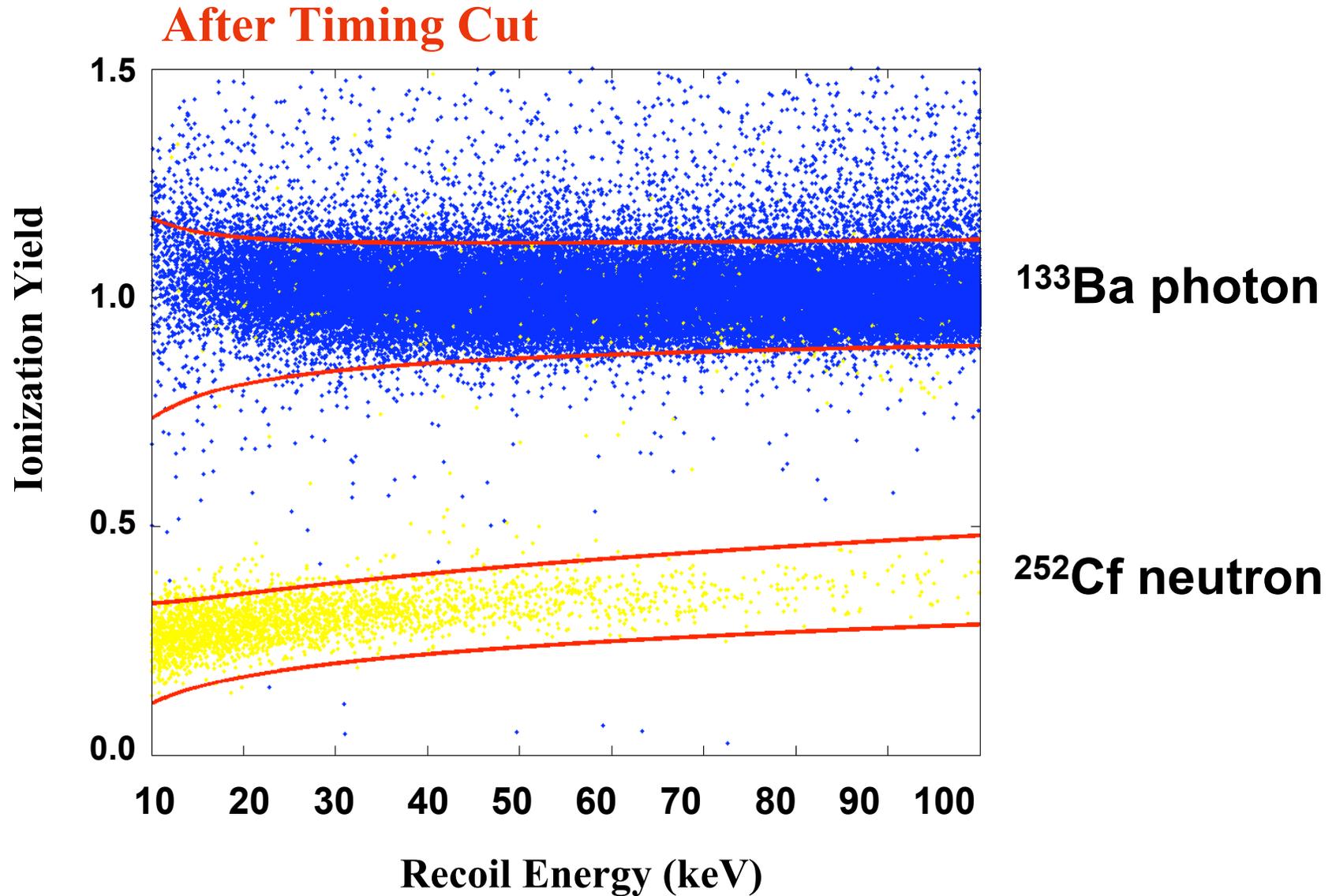


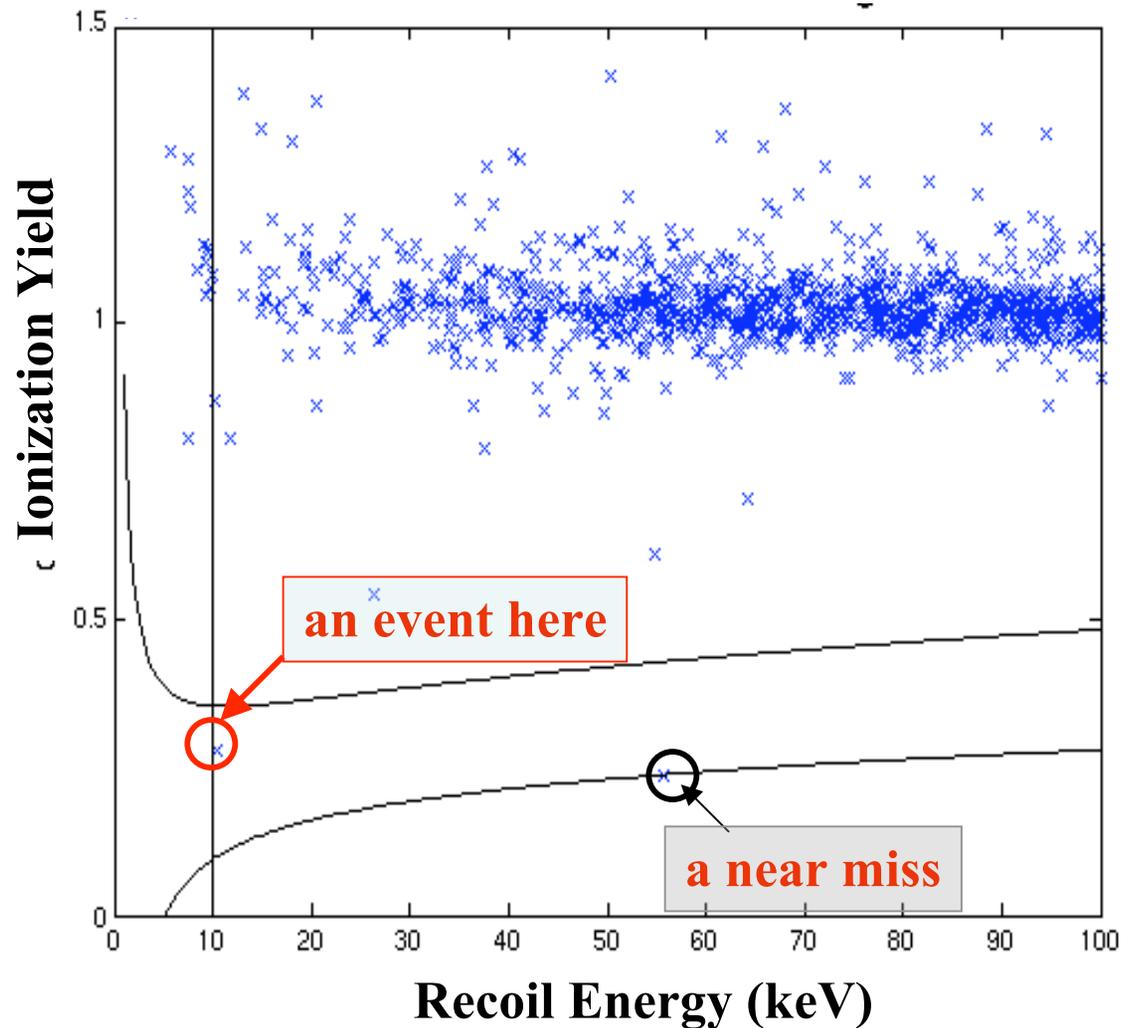


^{133}Ba
Photon source

^{252}Cf Neutron





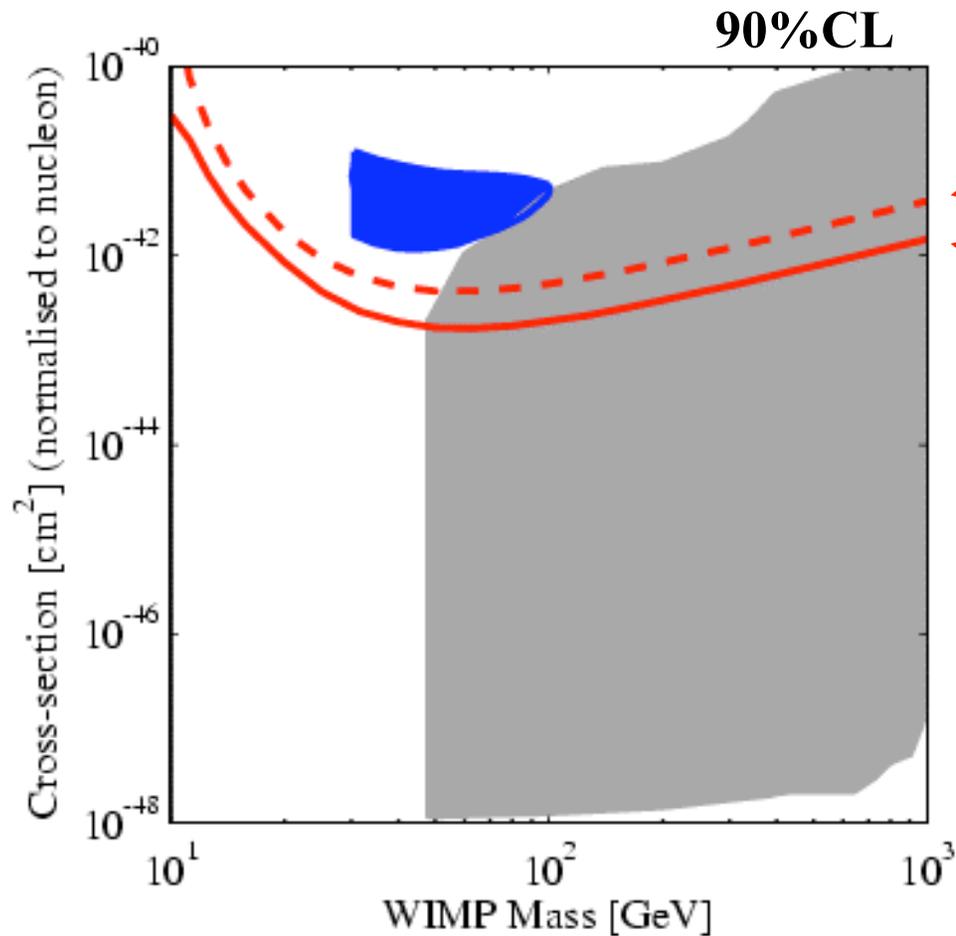


All the cuts were blind

74 detector live-days,
1.25kg Ge detectors
Estimated background
 0.4 ± 0.2 (stat.) ± 0.2 (syst.)

**After timing cut
(reject electrons)**

Experimental WIMP limits (Spin Independent)



CDMS (1 tower)

CDMS (2 tower)

Standard assumption

Spherical Halo Model

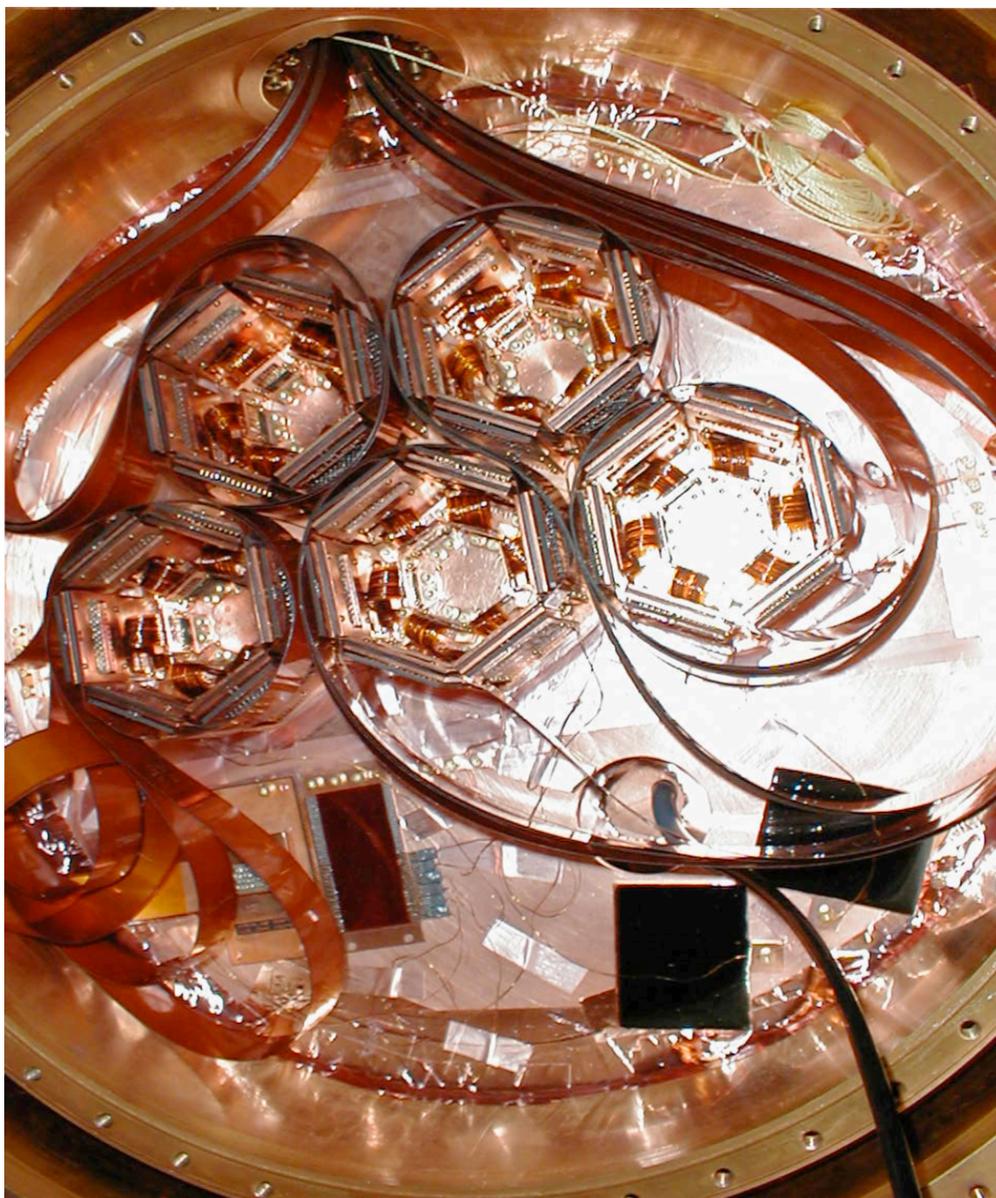
MB velocity distribution

$V_0 = 230 \text{ km/s}$

$V_{\text{esc}} = 650 \text{ km/s}$

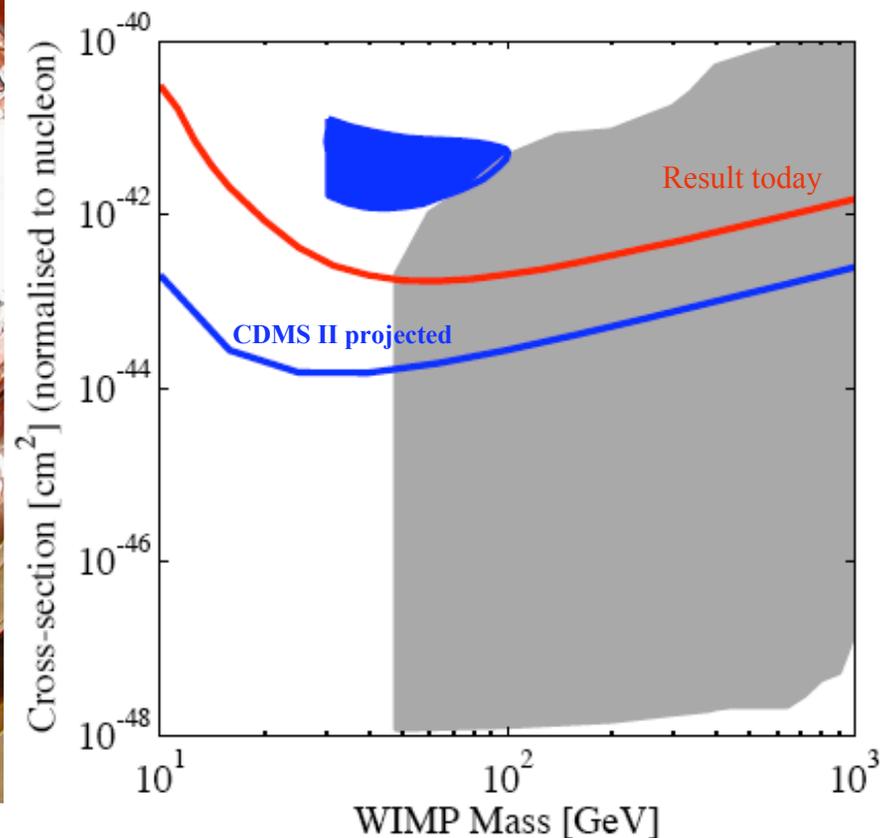
$\rho = 0.3 \text{ GeV / cm}^3$

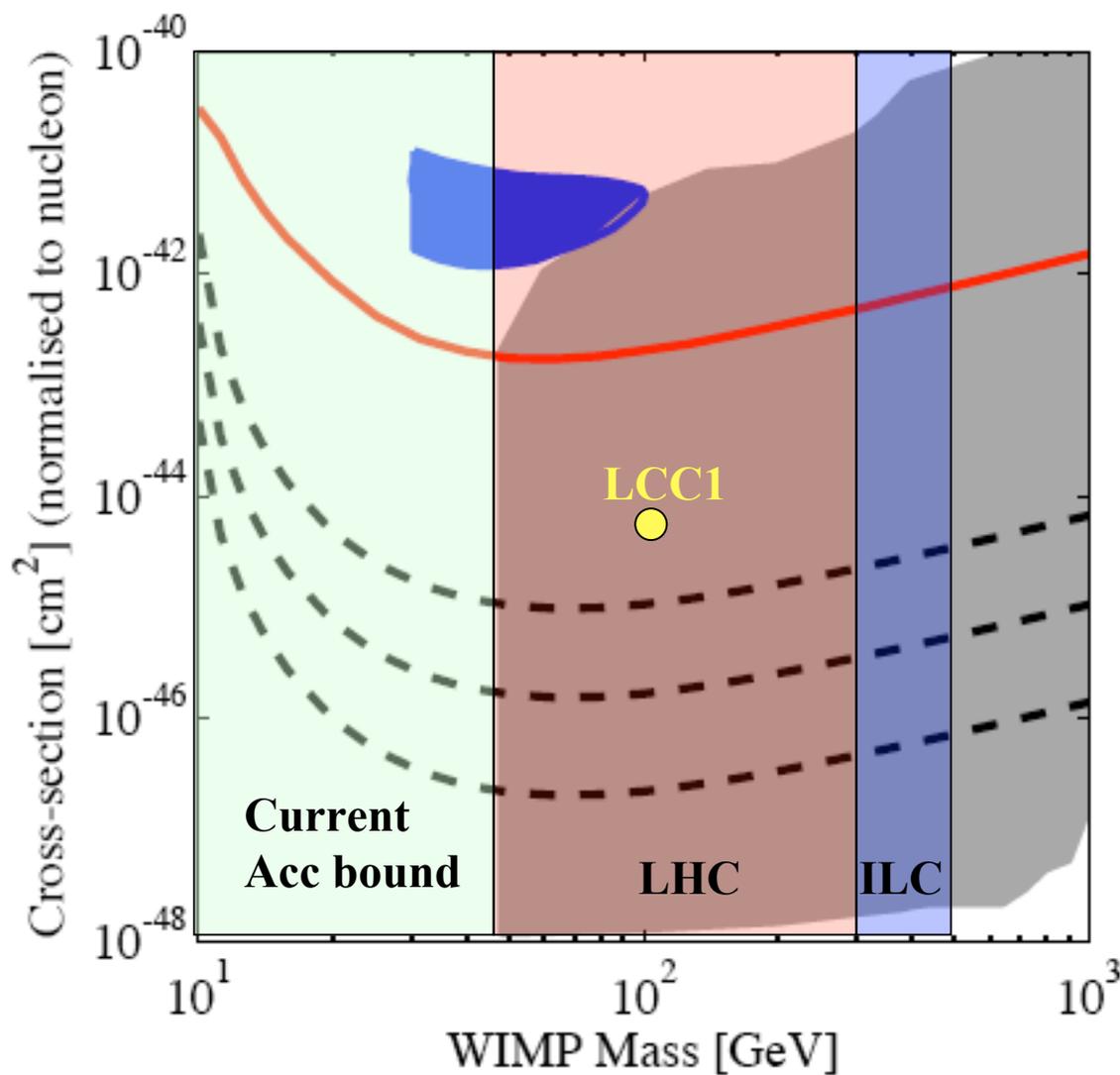
**Factor 10x better
WIMP search sensitivity
than any other experiments**



Now commissioning

- 30 detectors (5 towers x 6 detectors)
- 4.75 kg of Ge, 1.1 kg of Si detectors
- Run through 2006--2007
- **Improve sensitivity further 10x**



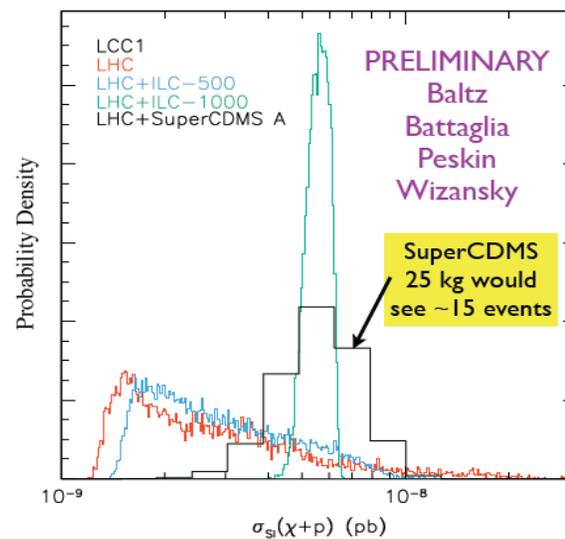


Result today

SuperCDMS-A: 25kg

SuperCDMS-B: 150kg

SuperCDMS-C: 1000kg



- No signs of WIMPs yet

- WIMP search limit (SI) is now 10x lower than any other experiment
- Starting to probe mSUGRA region

- Five tower operation is now (2006) commissioning

- Operation through 2006--2007
- **10x** WIMP discovery potential compared to the current sensitivity

- Strong case for expansion of target mass to 25 kg (SuperCDMS : phase I)

- **100x** WIMP discovery potential compared to the current sensitivity
- Proven technology to pursue the next phase of direct detection exp