University of Zurich

Xe XENON Dark Matter Project

Status of the XENON100 experiment for WIMP direct detection

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University of Zurich (UZH)

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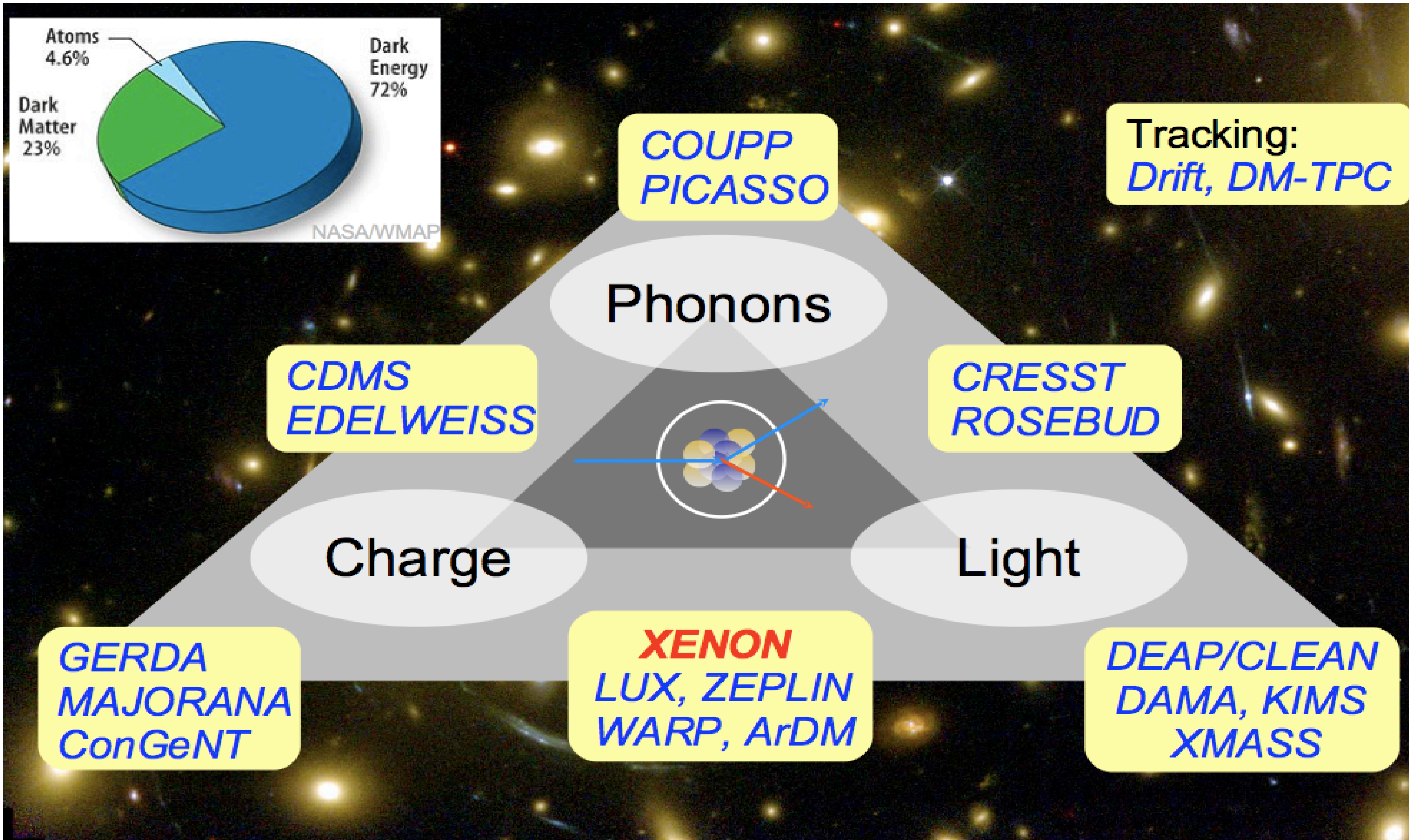
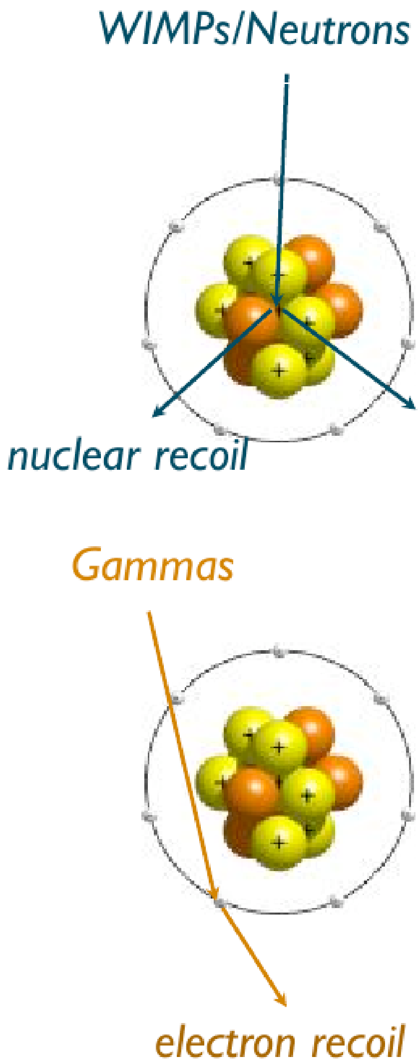
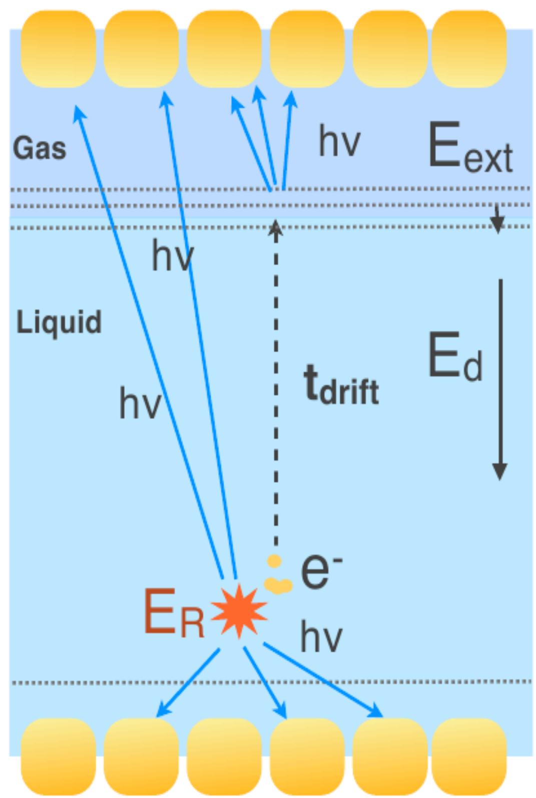
Dark Matter Direct Detection

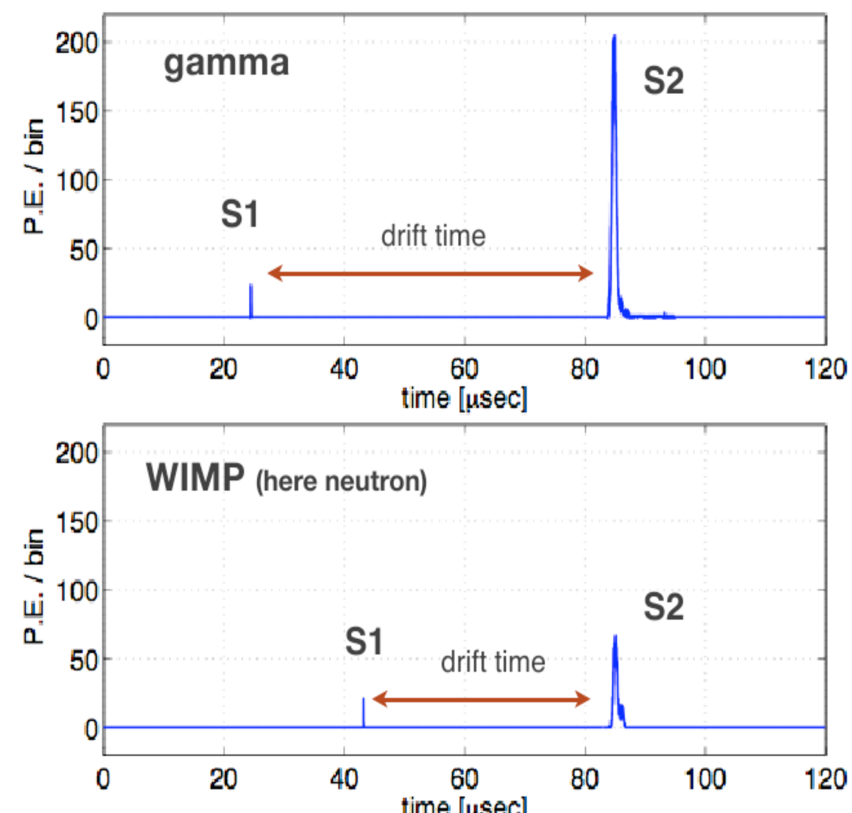


Double phase TPC

- Primary scintillation signal (S1)
- Electrons drift over 30 cm max distance
- Electrons are extracted and accelerated generating secondary scintillation signal
- The time difference between the two signals gives information on event position in z



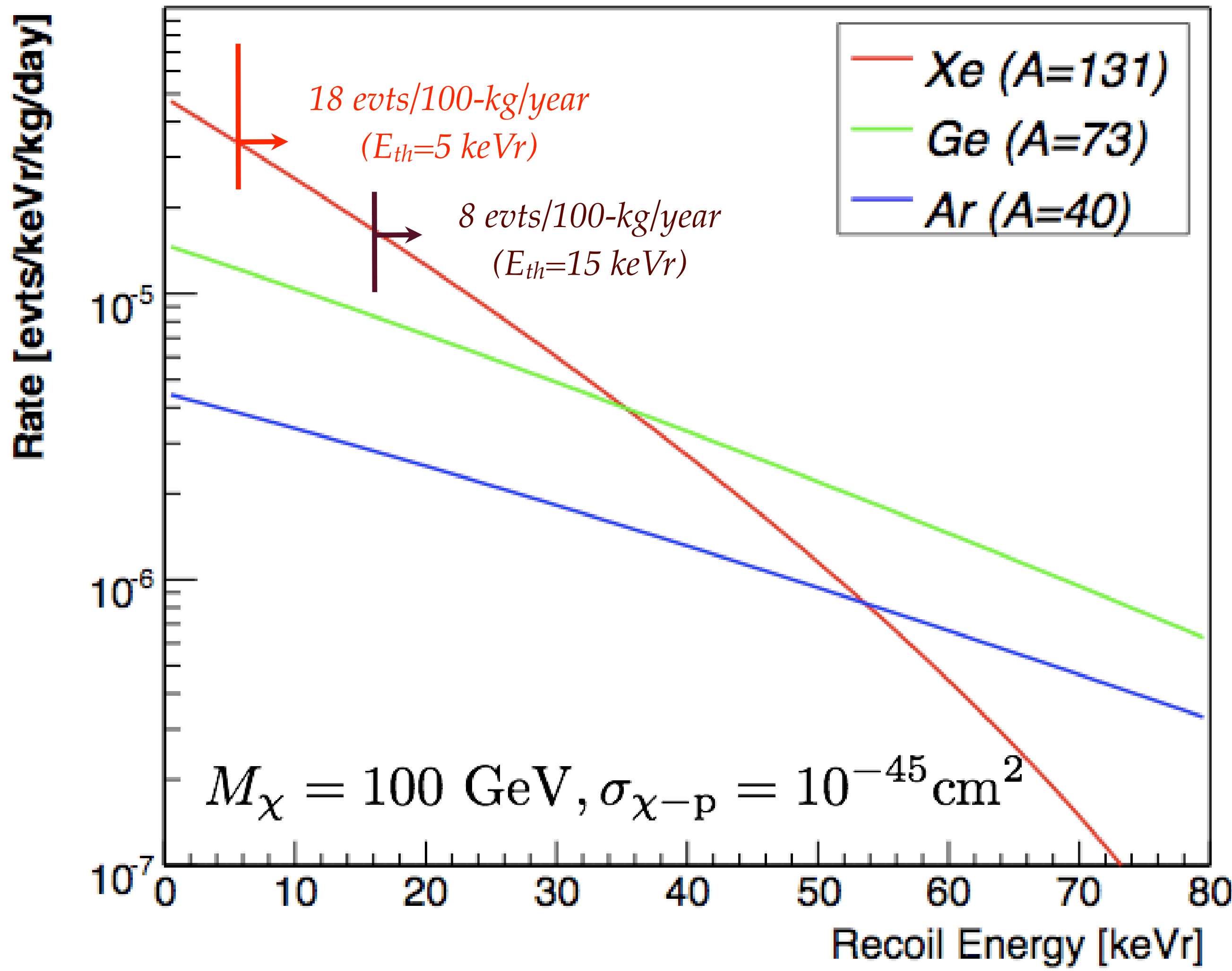




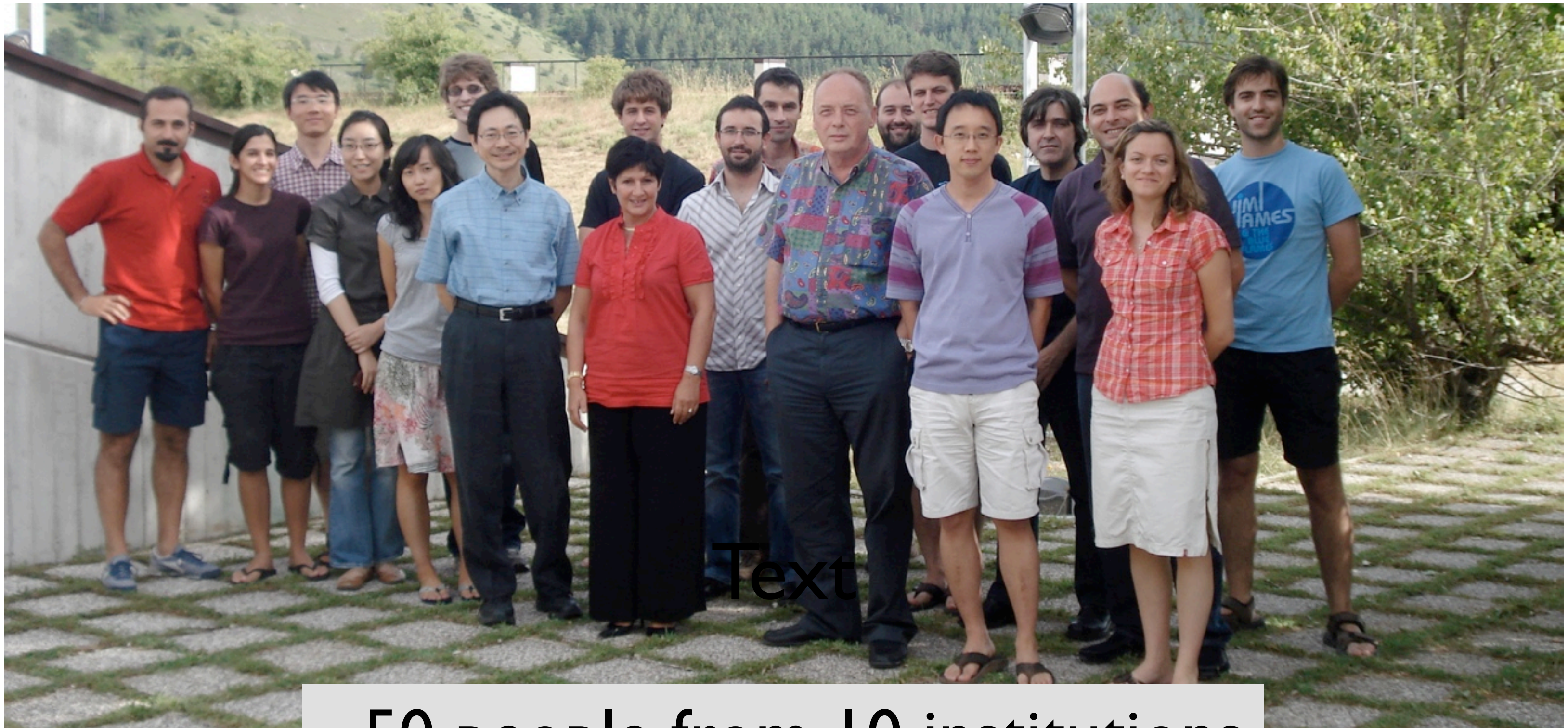
Why Liquid Xenon?

- ✓ large mass (ton scale)
- ✓ easy cryogenics
- ✓ low energy threshold (a few keV)
- ✓ A~131 (good for SI)
- ✓ ~50% odd isotopes (SD)
- ✓ background suppression
  - good self shielding features (~3 g/cm^3)
  - low intrinsic radioactivity
  - gamma background discrimination
  - position sensitive (TPC mode)

WIMP Scattering Rates



The Collaboration



~50 people from 10 institutions

Columbia
E. Aprile

Rice
U. Oberlack

UCLA
K. Arisaka
H. Wang

U Zürich
L. Baudis

Coimbra
J.A.M Lopes

LNGS
F. Arneodo

Subatech
D. Thers

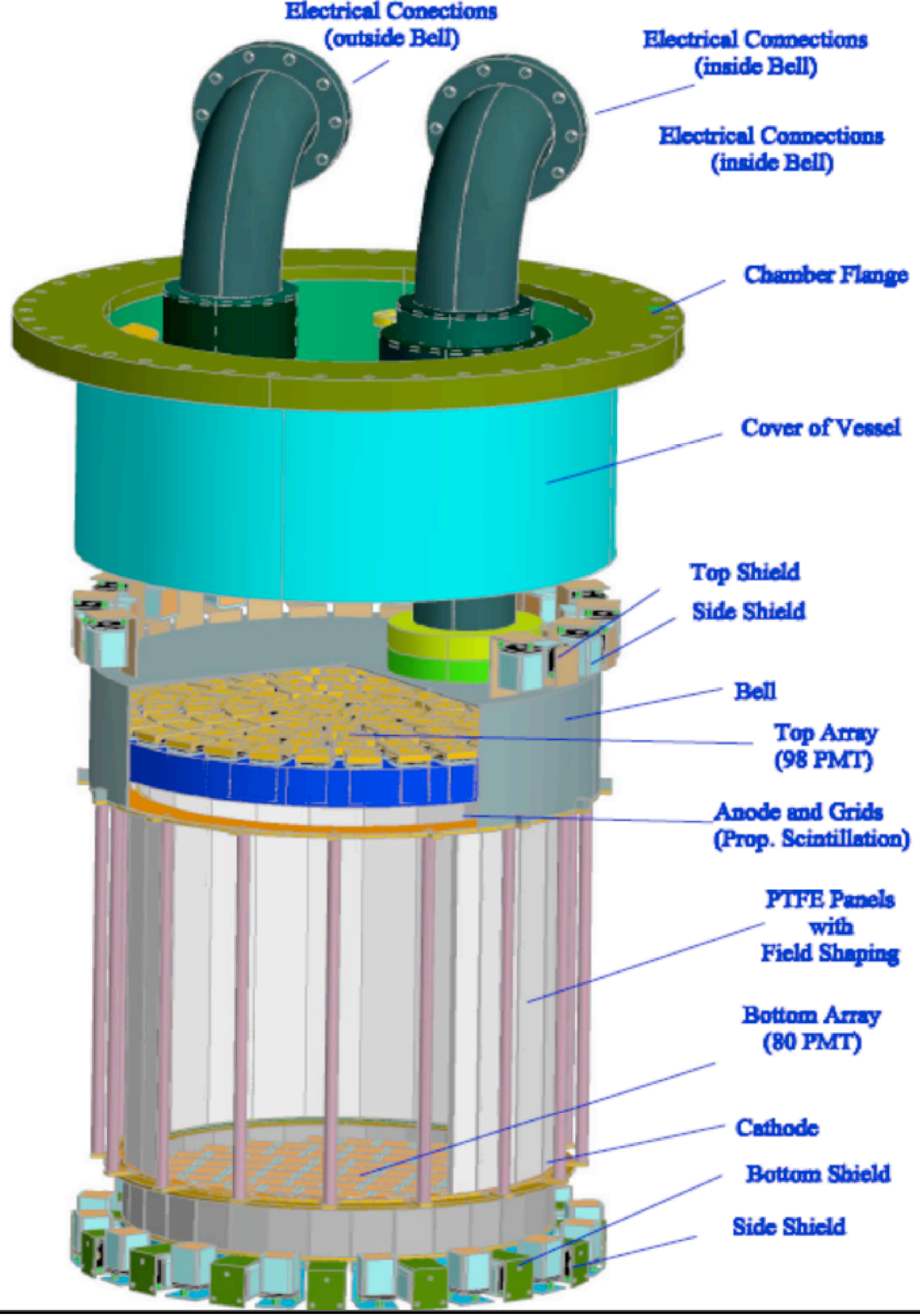
Münster C.
Weinheimer

Waseda
N. Hasebe

SJTU
K. Ni

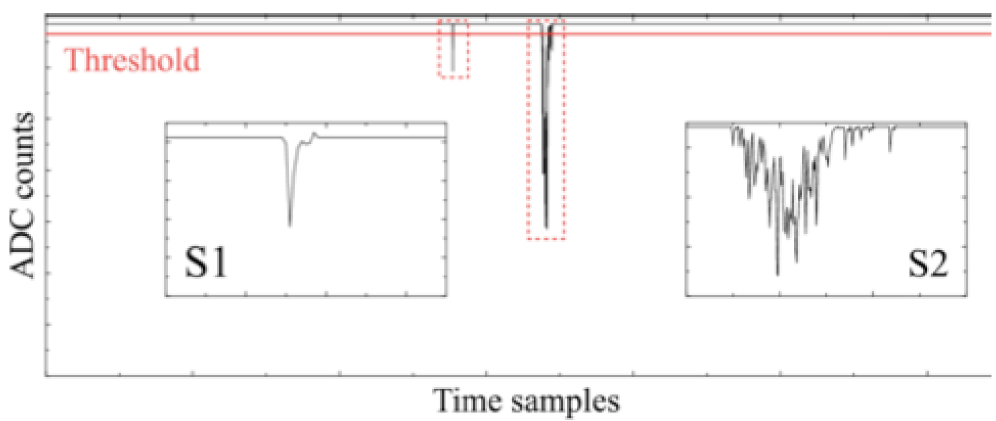
Xenon100: design

- ~170 kg total / ~65 kg target LXe (15 cm radius , 30 cm drift)
- Active LXe veto – improved shield (Pb,Poly,Cu,N2 purge)
- New high QE (>32%@175nm) low activity 1” R8520 PMTs (total 242 PMTs)
- Cryocooler and feed-through outside the shield

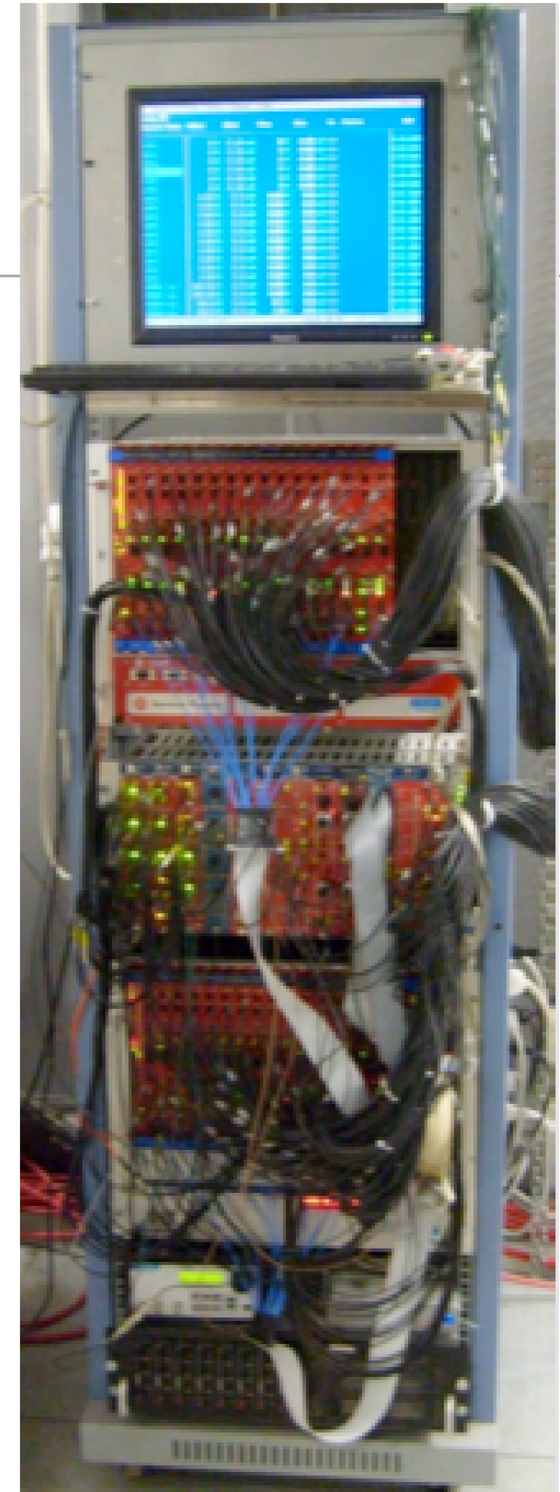


Xenon100: Data Acquisition

- CAEN V1724 100 MHz digitizer (14 bit resolution)
- Circular buffer -> dead time free
- Integrated FPGA for zero length encoding



- Slow control to monitor the detector crucial parameters
- sms alarms are sent to people on shift in case of emergency



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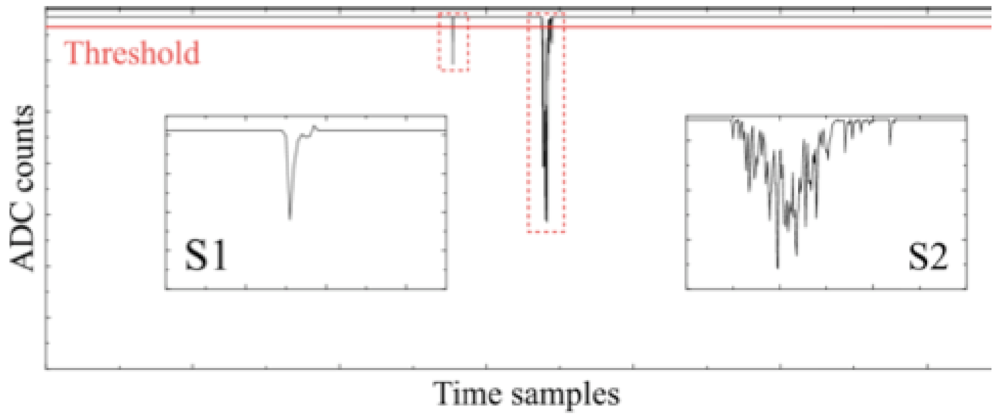

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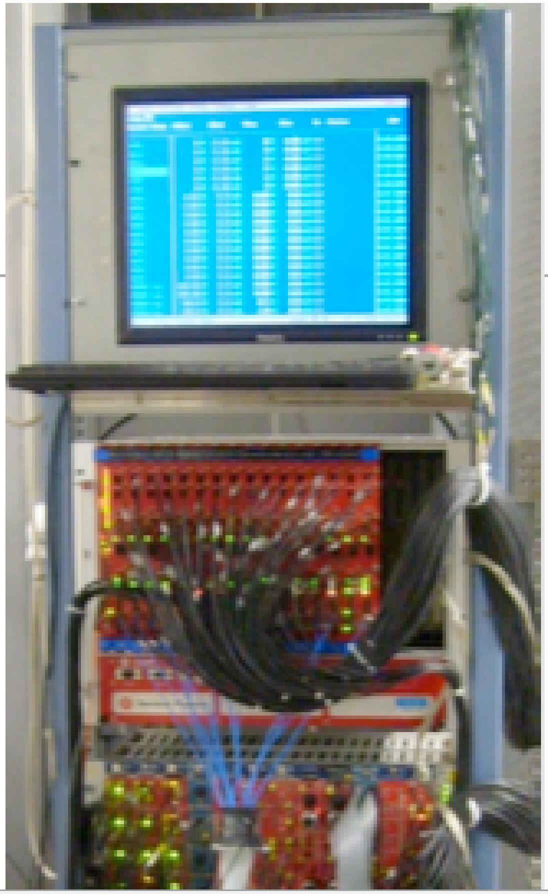
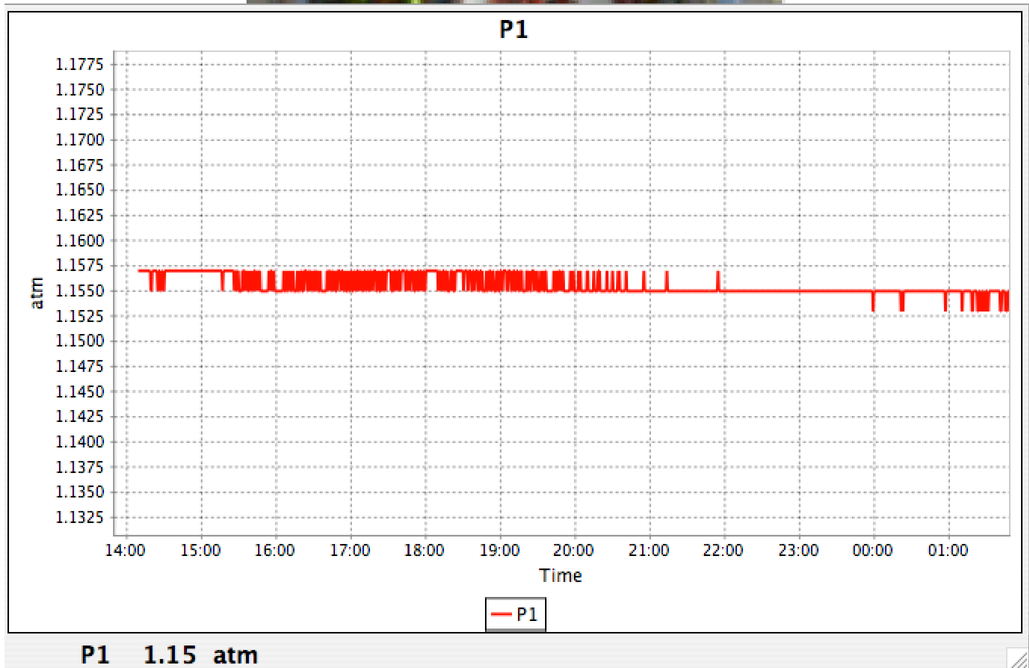
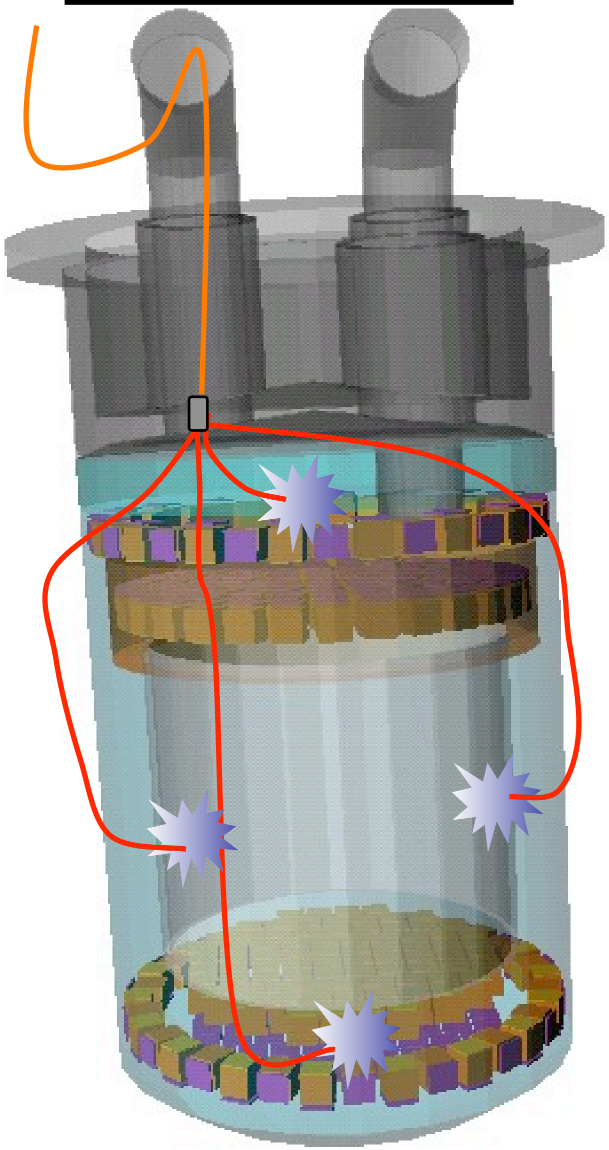
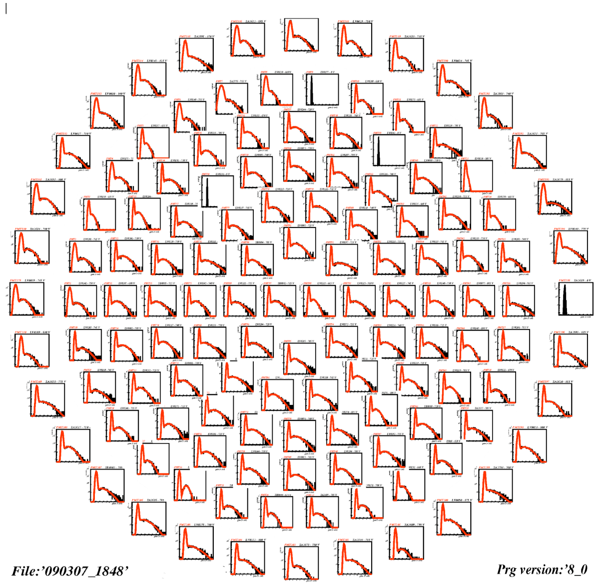


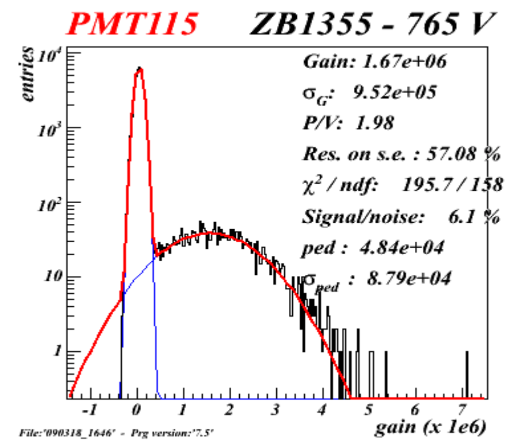


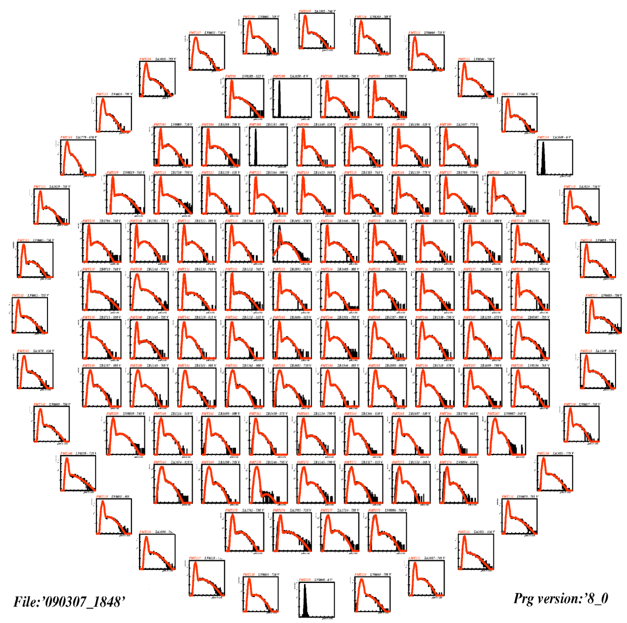
Xenon100: PMT light calibration

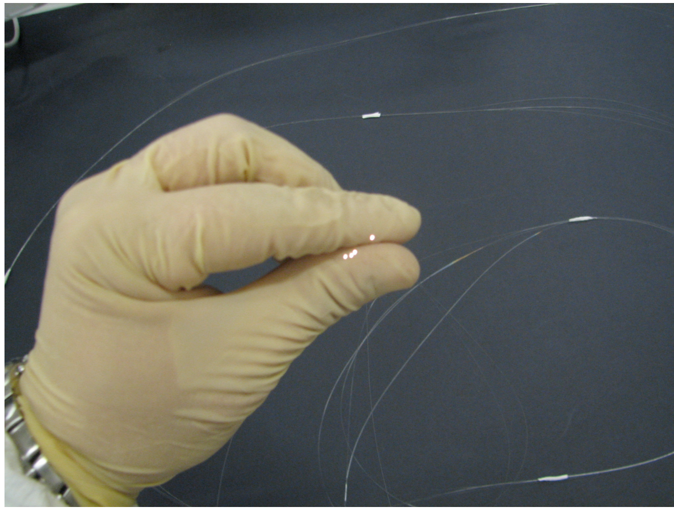
4 optical fibers



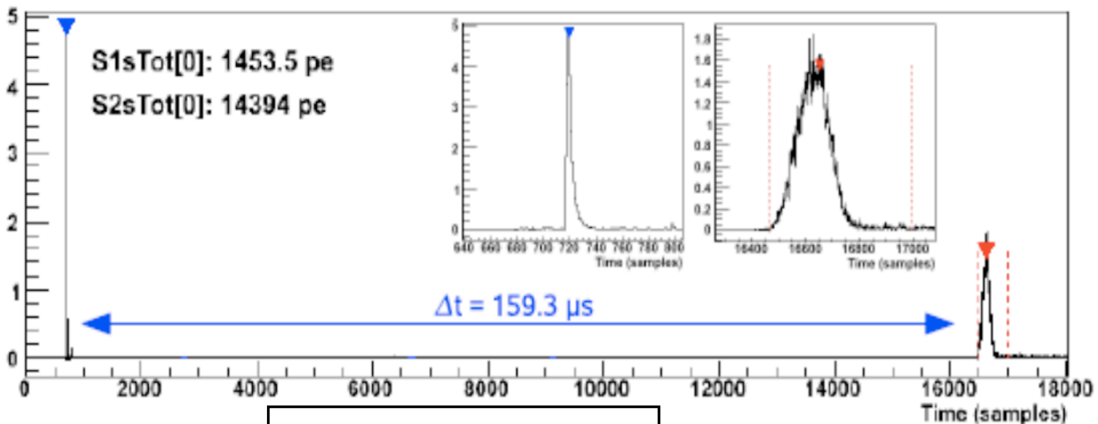






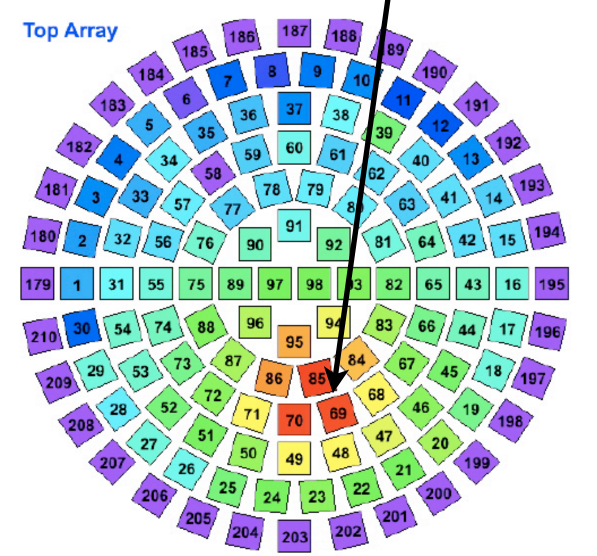


Xenon100: Position reconstruction



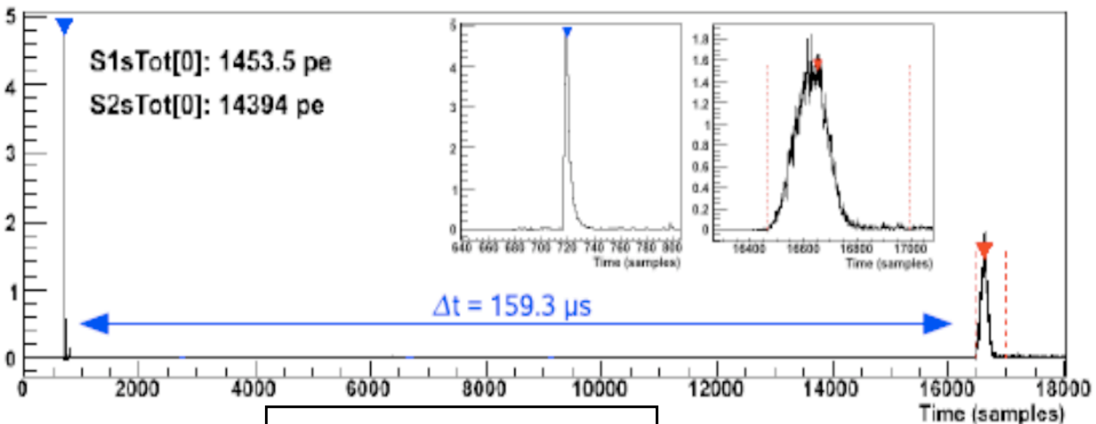
drift time -> z

Very localized S2 hit pattern (xy position information)



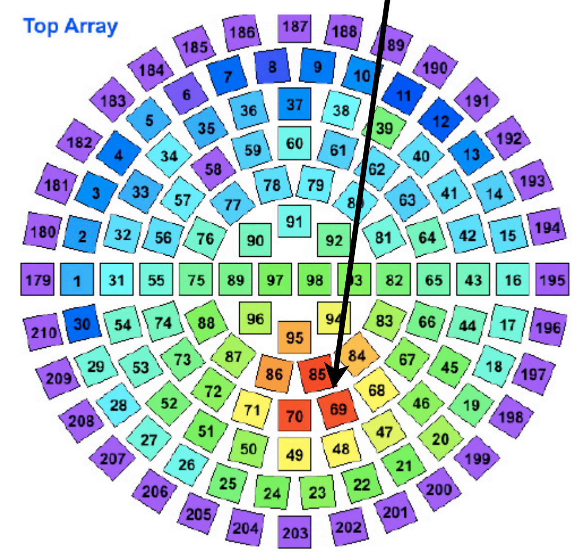
3 different methods for xy position reconstruction:
neural network
support vector machine
Least squares minimization

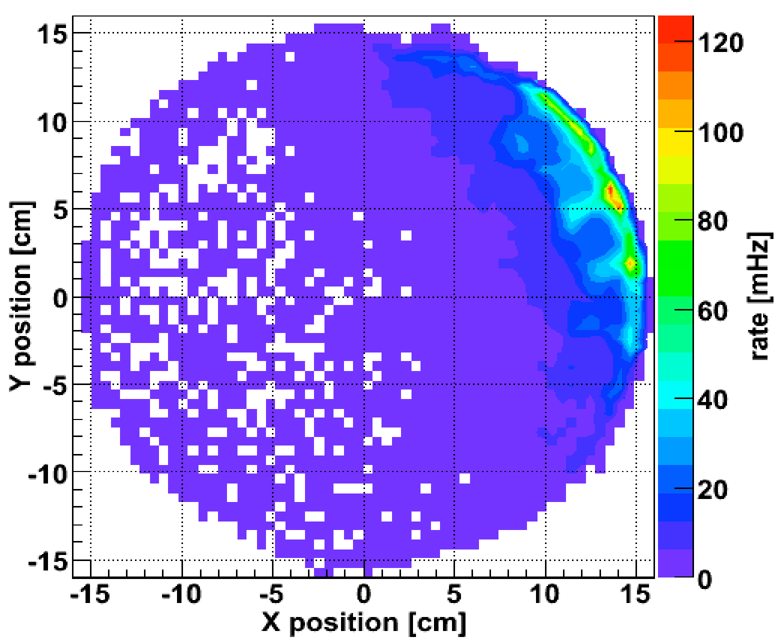
Xenon100: Position reconstruction



drift time -> z

Very localized S2 hit pattern (xy position information)



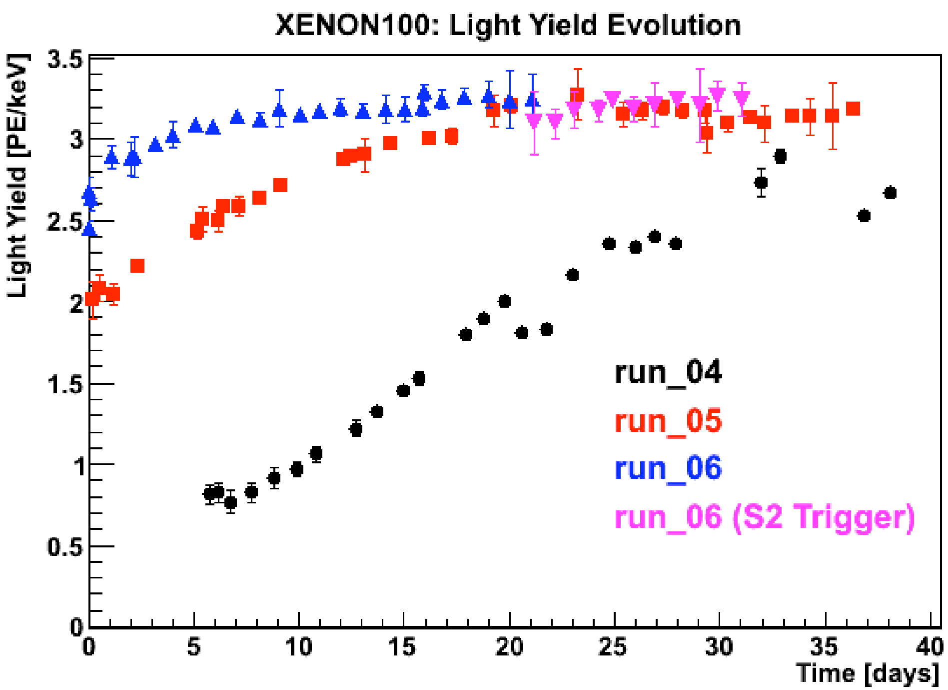


Cs137 from the side

3 different methods for xy position reconstruction:
neural network
support vector machine
Least squares minimization

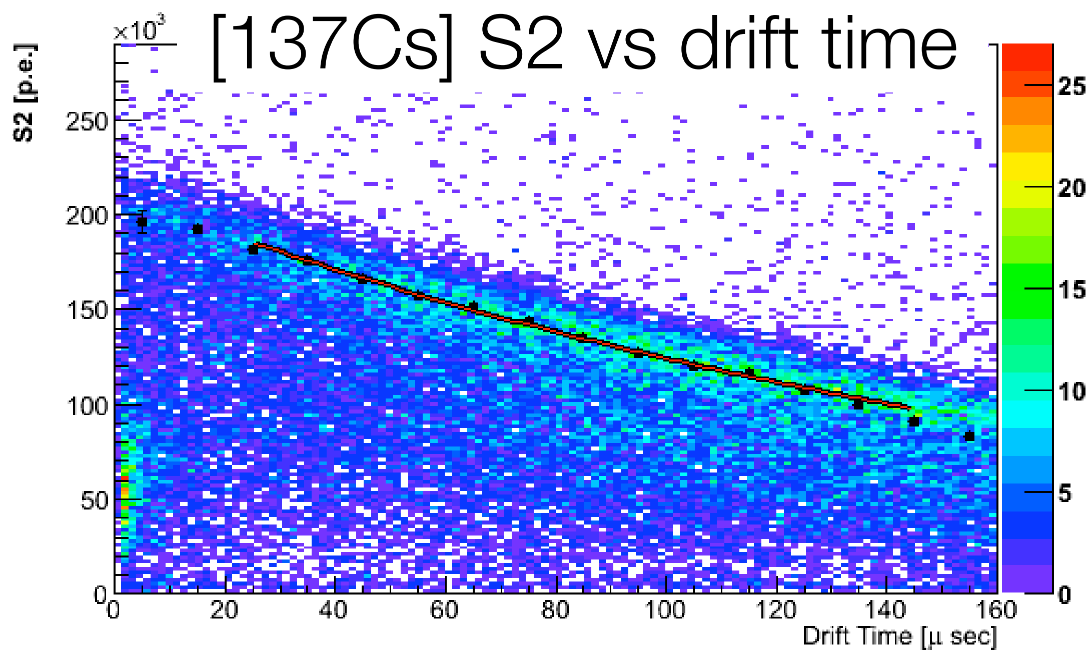
Xenon100: light yield and electron lifetime

Light yield reached the maximum in few days



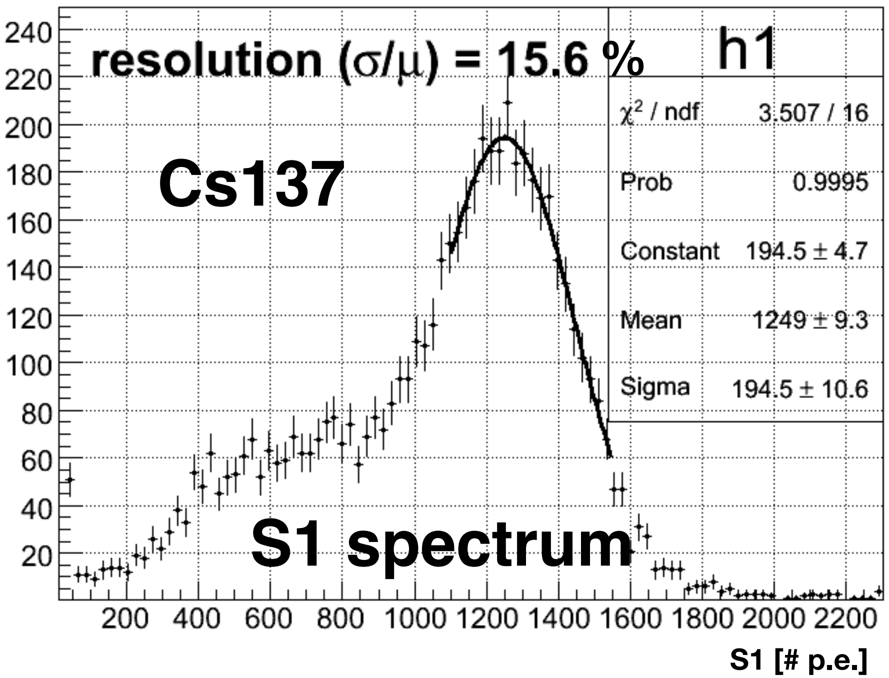
(started 5/9/09, after earthquake)

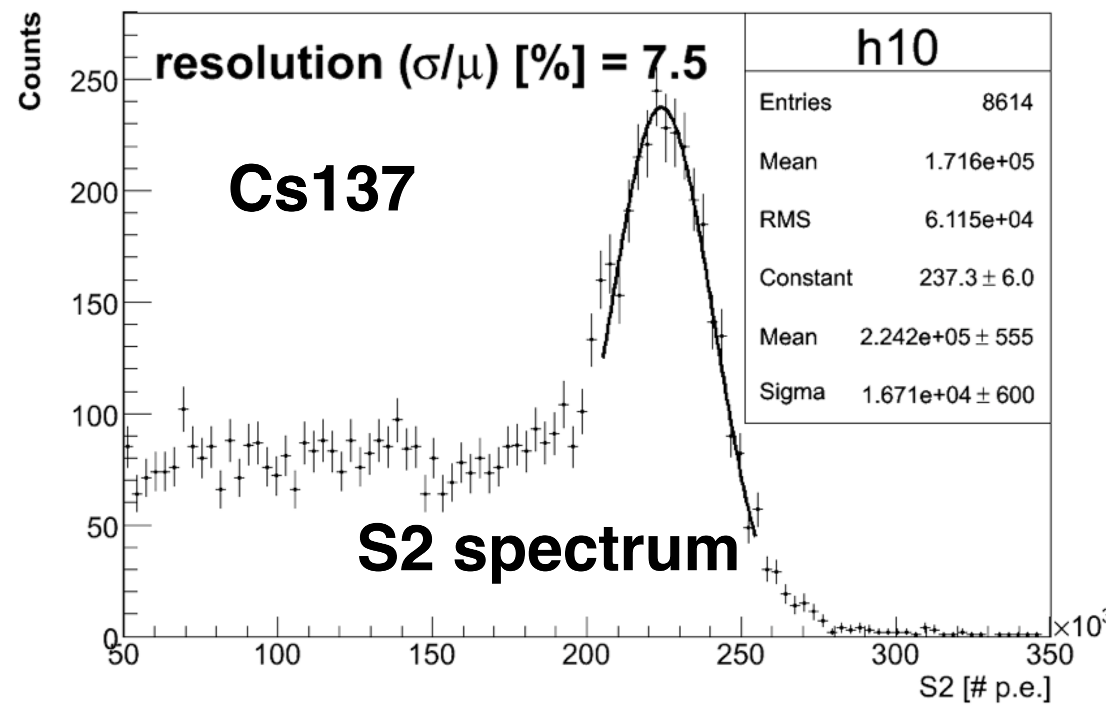
Electron lifetime longer than the total drift length



- Recirculation in gas phase 10 SLPM
- Hot getter (SAES) for impurity removal

Xenon100: gamma calibration

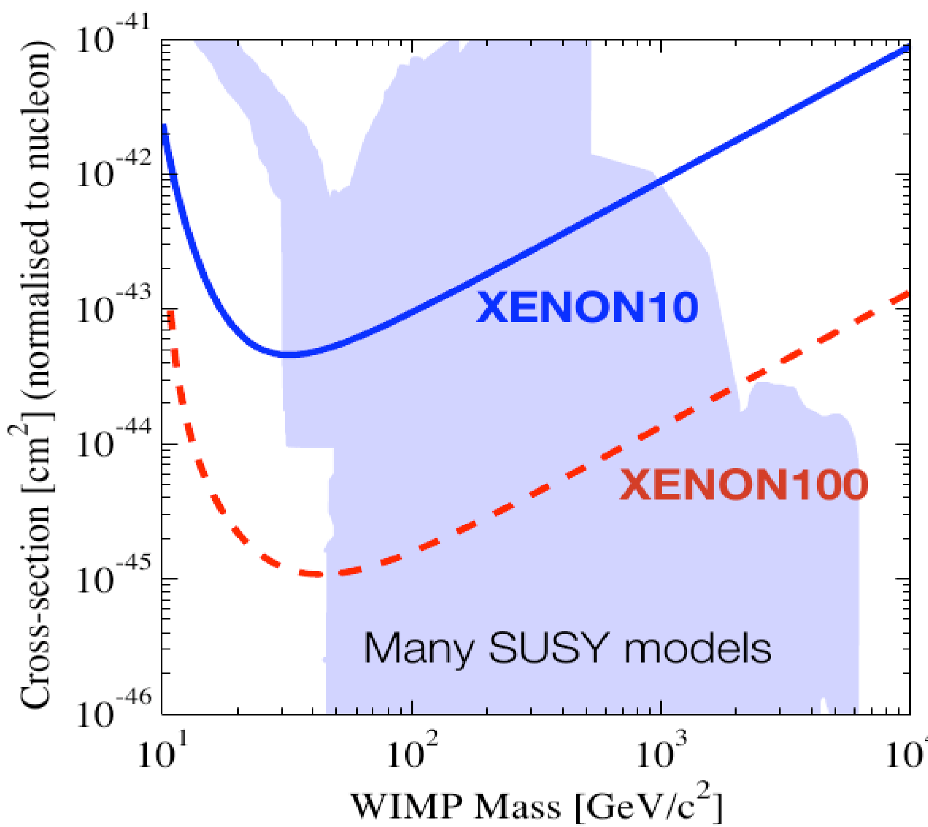




Calibration data are being taken every day in order to check detector performances, stability and purity evolution.

Xenon100: goals

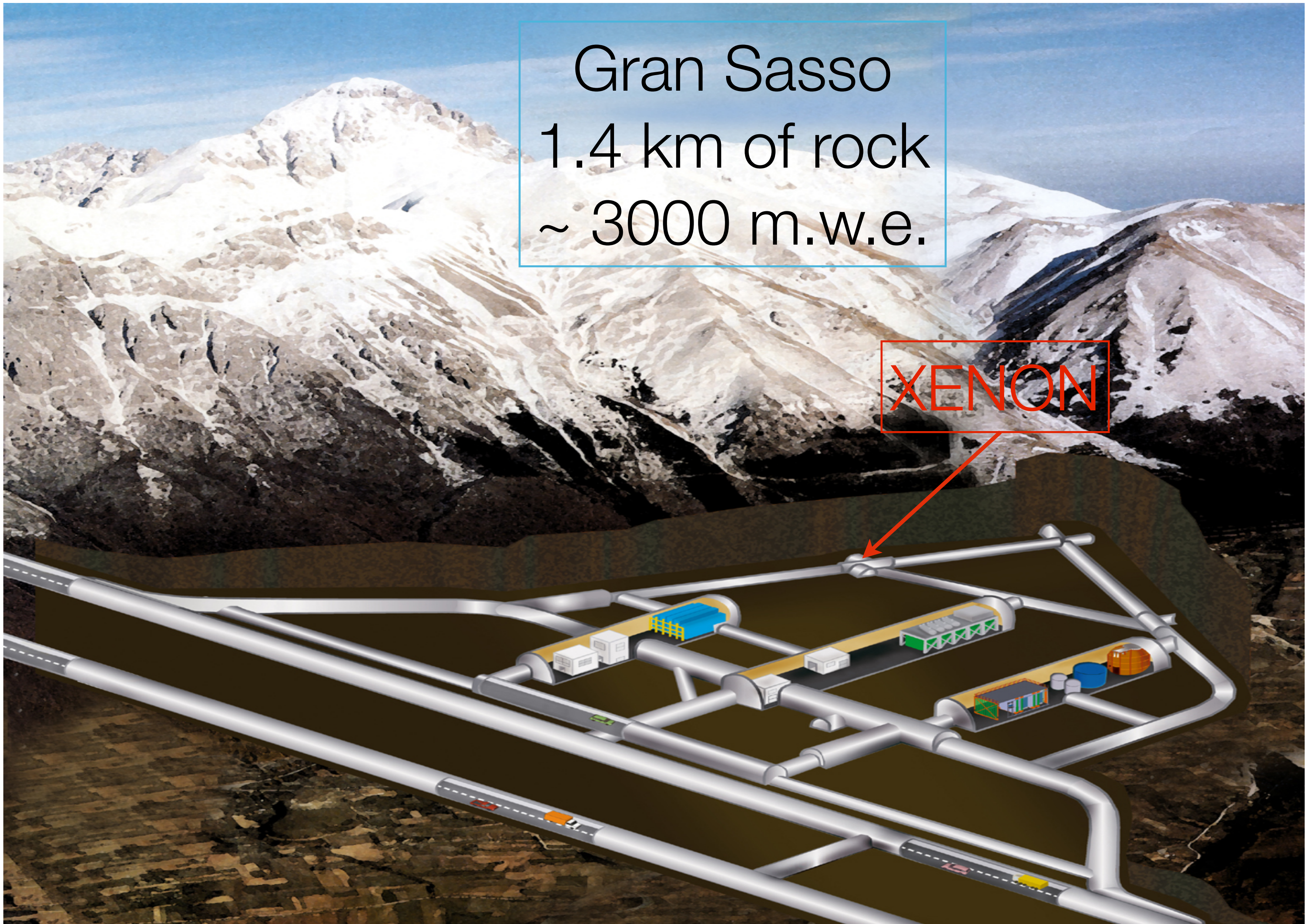
- Improve the sensitivity ~ 50 times over XENON10.
- Assuming same energy threshold and same discrimination power as XENON10, the required background in the fiducial volume needs to be 100 times lower with a mass increase of a factor 10.



XENON10 SI limit: PRL100, 021303 (2008)

What was done in order to reduce the radioactive background?

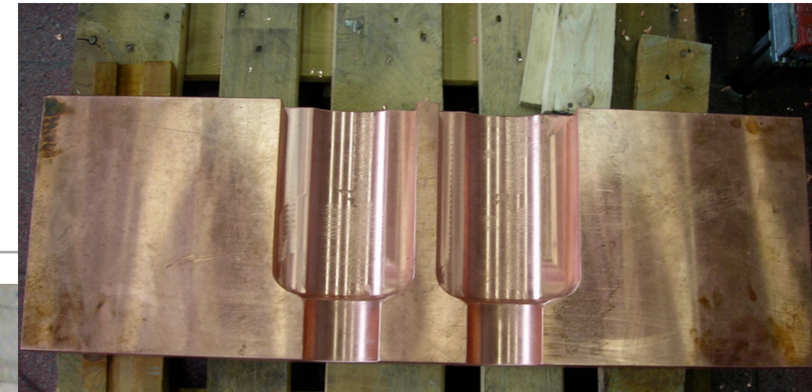
Install the detector underground...



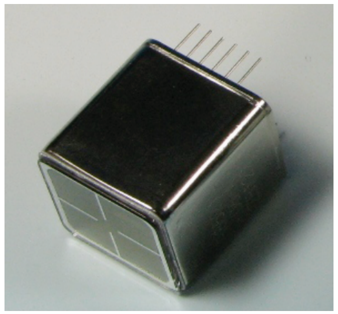
Most of the stuff goes outside of the shield...

Improve the shield...

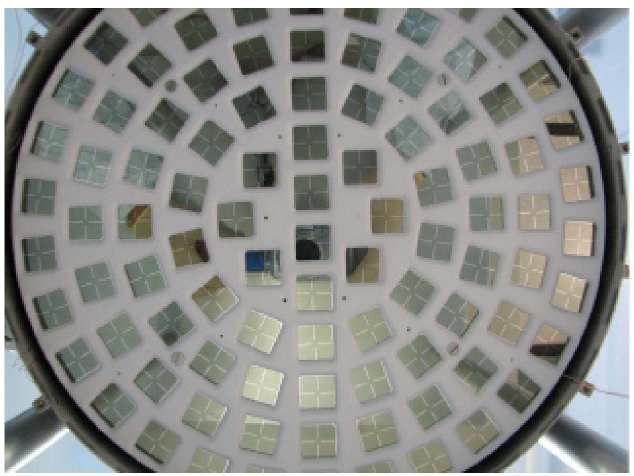
- 5 cm thick layer of Low activity OFHC Copper

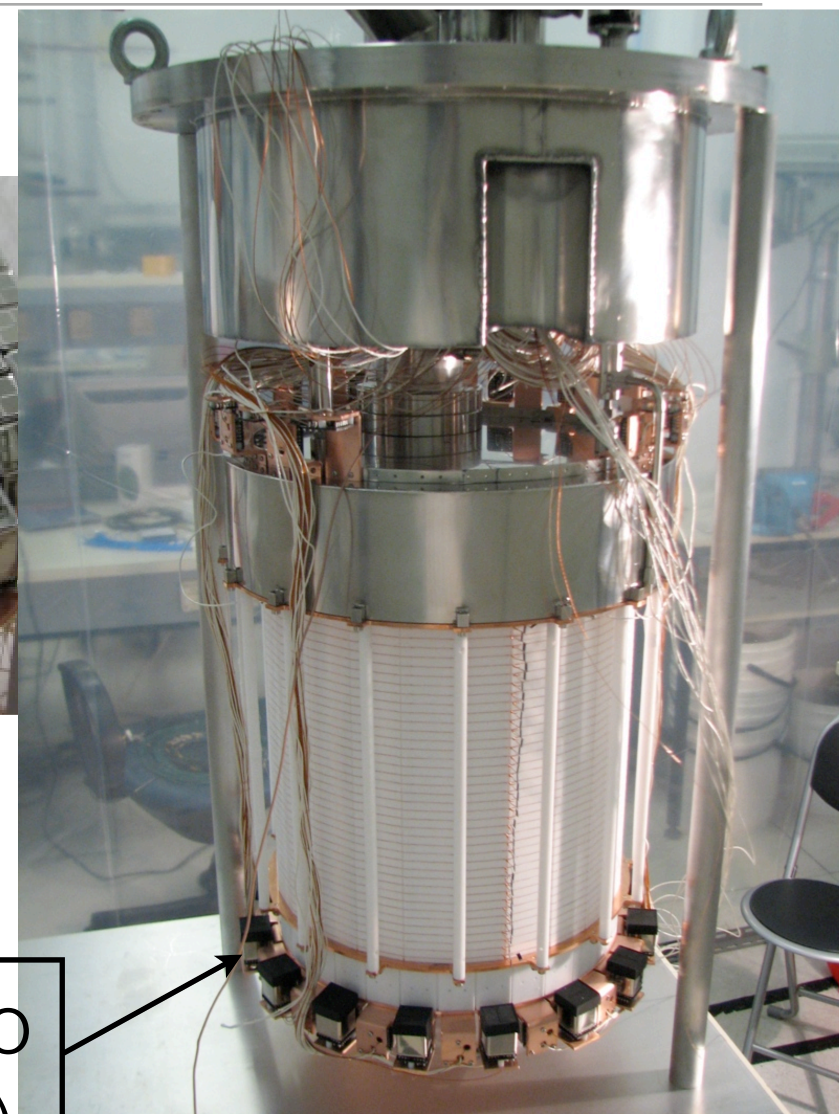


What is inside has to be carefully selected



242 (Hamamatsu R8520) 1"x1"
low radioactivity PMTs





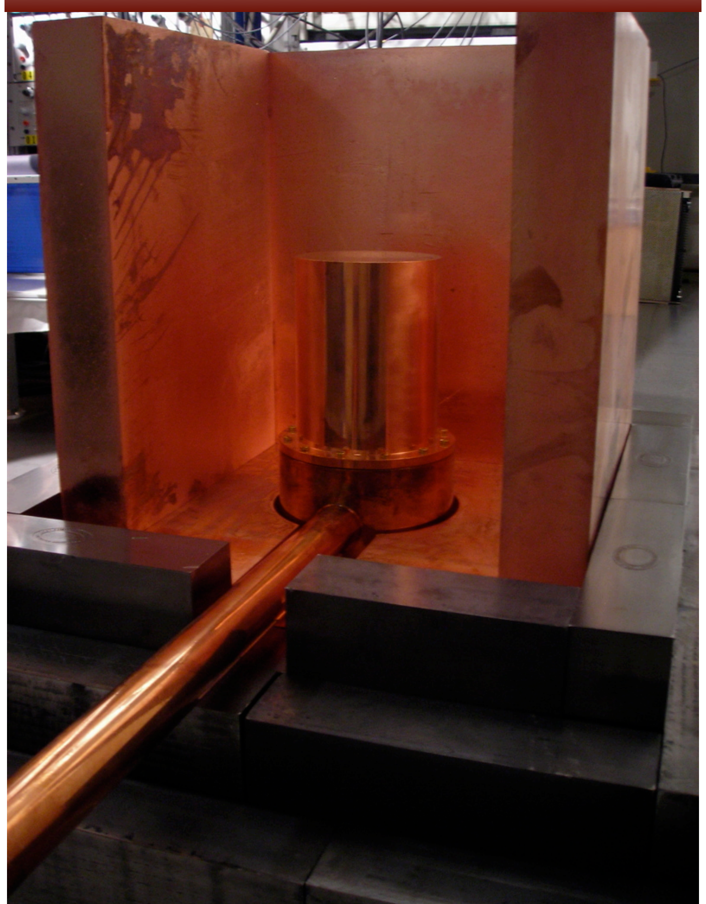
SS
PTFE
Copper
Cables
Screws

100 kg LXe Active veto
(side, top and bottom)

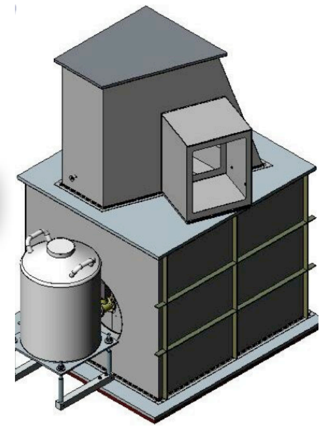
Low level HPGe counting for material screening

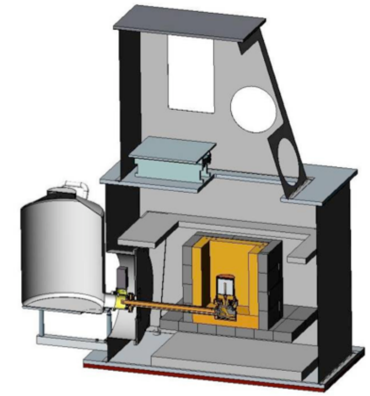
Dedicated detector

GATOR



LNGS screening facility





Material screening results (selection)

Stainless Steel

Material	238U [mBq/kg]	232Th [mBq/kg]	60Co [mBq/kg]	40K [mBq/kg]
25 mm SS Nironit (flange and bars)	< 1.3	2.9 ± 0.7	1.4 ± 0.3	< 7.1
2.5 mm SS Nironit (bottom cryo)	< 2.7	< 1.5	13 ± 1	< 12

Inner detector materials

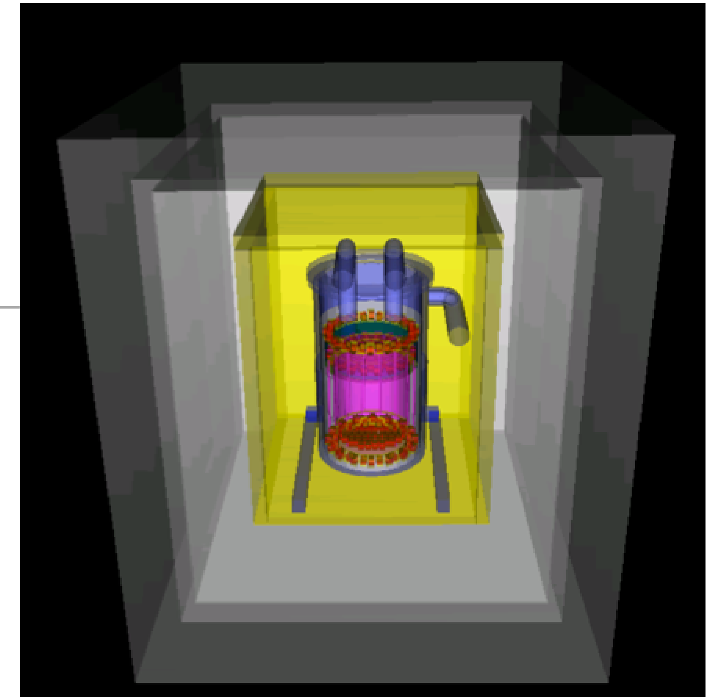
PMT Bases (Cirlex)	65 ± 8	31 ± 10	< 3.6	< 66
Teflon (in use)	< 0.31	< 0.16	< 0.11	< 2.25
Copper (TPC inner structure)	< 0.22	< 0.21	0.21 ± 0.07	< 1.34
Small Screws (SS)	< 9.2	16 ± 4	9 ± 3	< 46.4

PMTs

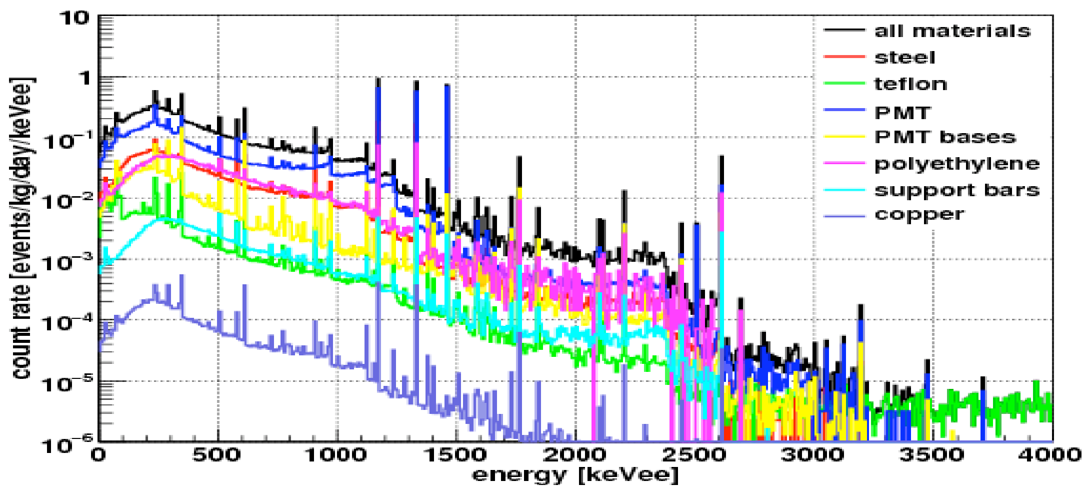
	238U [mBq/PMT]	232Th [mBq/PMT]	60Co [mBq/PMT]	40K [mBq/PMT]
39 PMTs	0.12 ± 0.01	0.11 ± 0.01	1.5 ± 0.1	6.9 ± 0.7
48 PMTs	0.11 ± 0.01	0.12 ± 0.01	0.56 +/- 0.04	7.7 +/- 0.8
22 HQE PMTs	< 0.64	0.18 ± 0.06	0.6 ± 0.1	12 ± 2
23 HQE PMTs	0.16 ± 0.05	0.46 ± 0.16	0.73 ± 0.07	14 ± 2

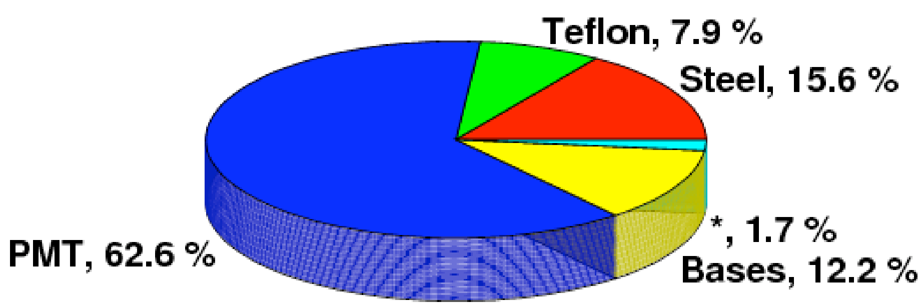
Special thanks to Matthias Laubenstein (LNGS screening facility)

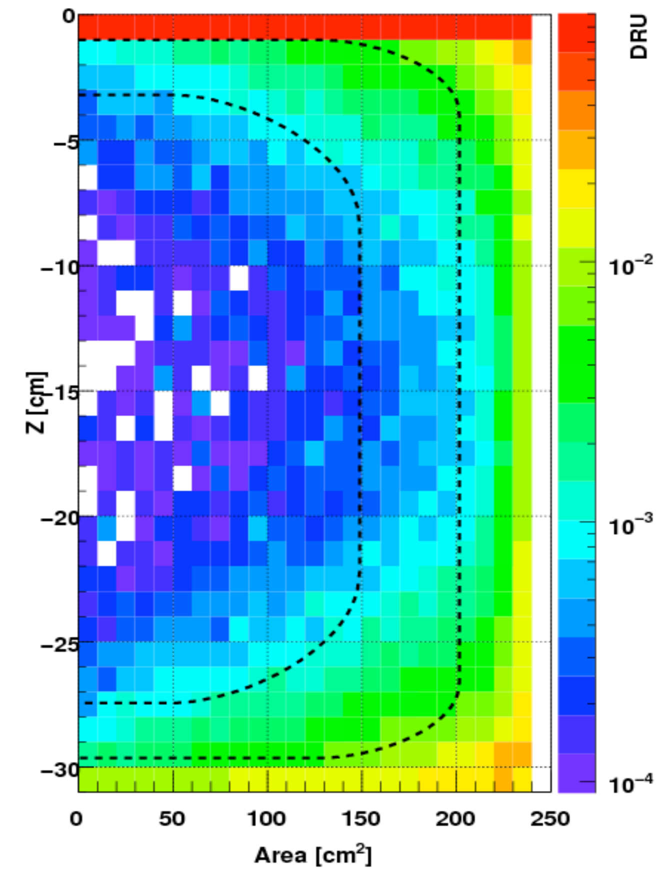
Gamma background



Single electron recoils





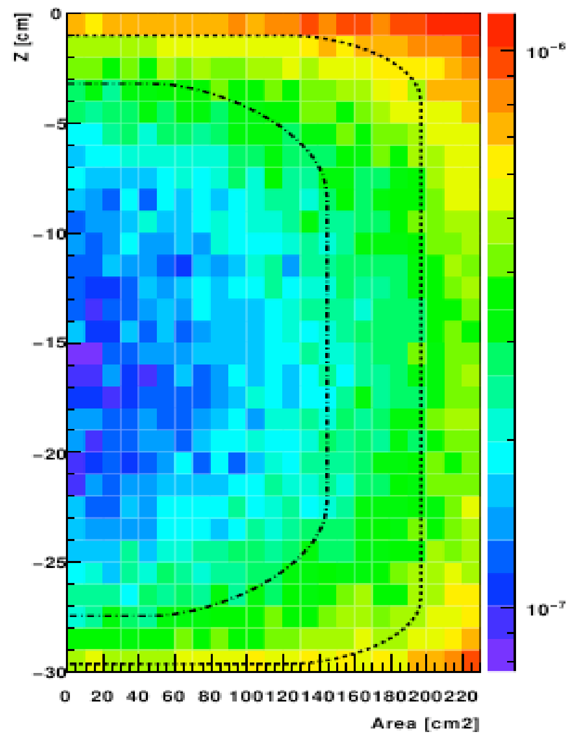


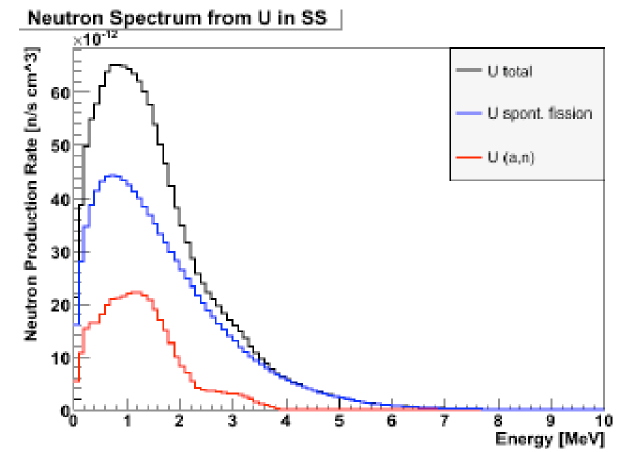
Total electron recoil rate (mDRU) [5,100] keV_{ee}:

24.05 ± 0.17 (50 kg)   9.07 ± 0.14 (30 kg)

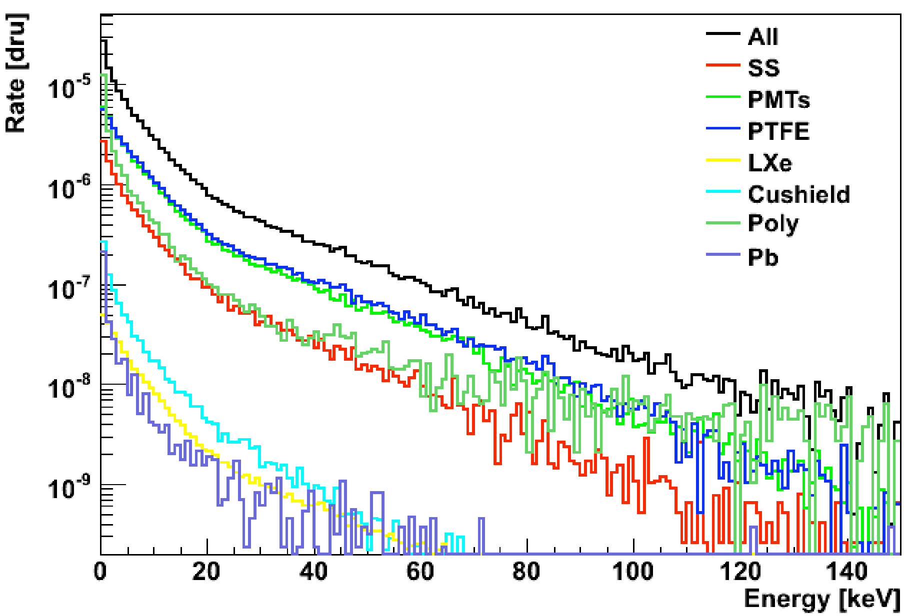
Neutron background

SOURCES4A code





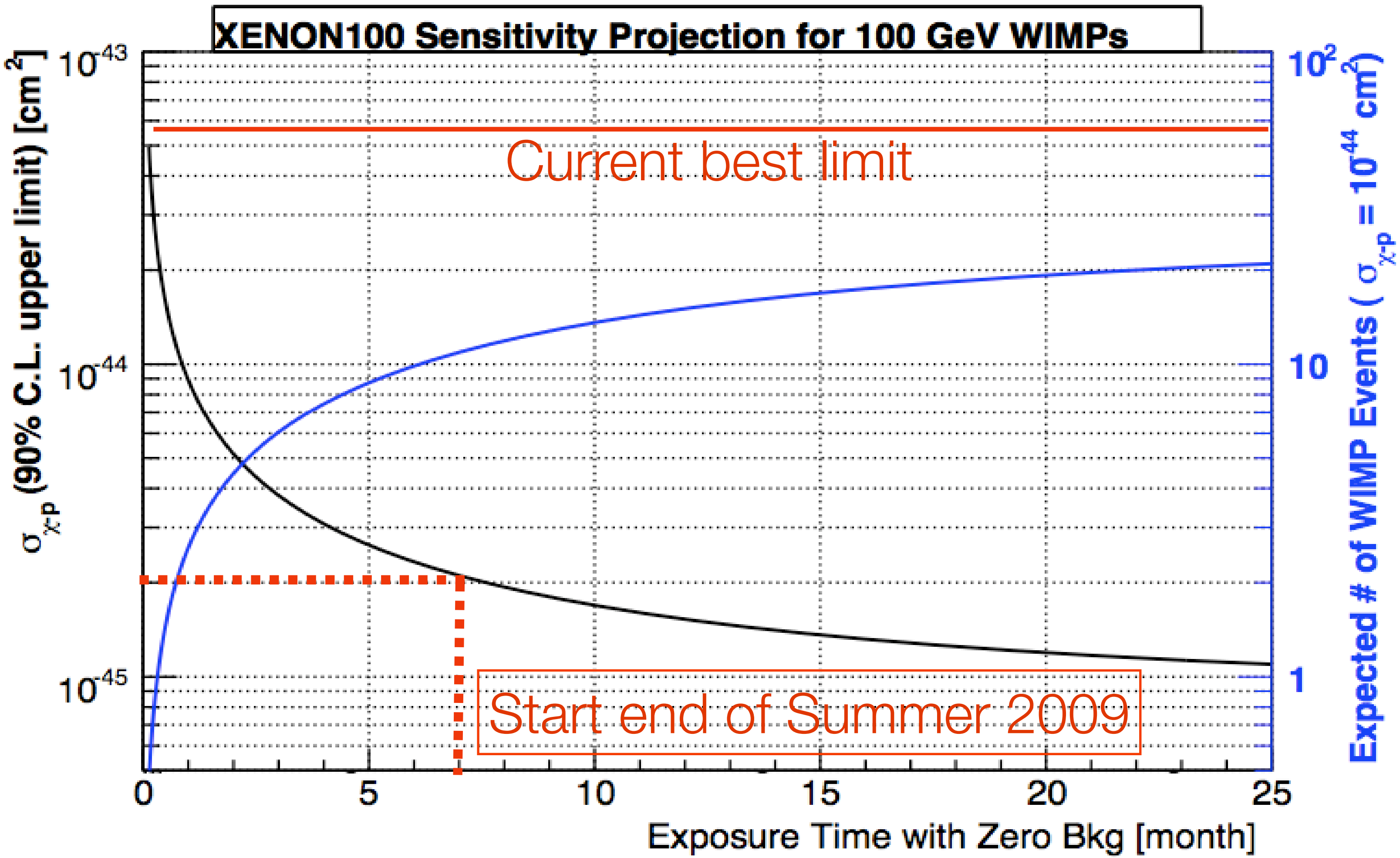
Single nuclear recoils in the whole active volume from materials



Total single nuclear recoil rate [5,27] keV_r (including rock and muons)

1.62 n/year (50 kg) 0.60 n/year (30 kg)

Conclusions



Great discovery potentials: ~ 2 x 10^{-45} cm^2 in 7 months

Thank you