XENON
Dark Matter Project

Universität Zürich
Physik-Institut

Background Predictions for the Xenon100 Experiment at the Gran Sasso Underground Laboratory

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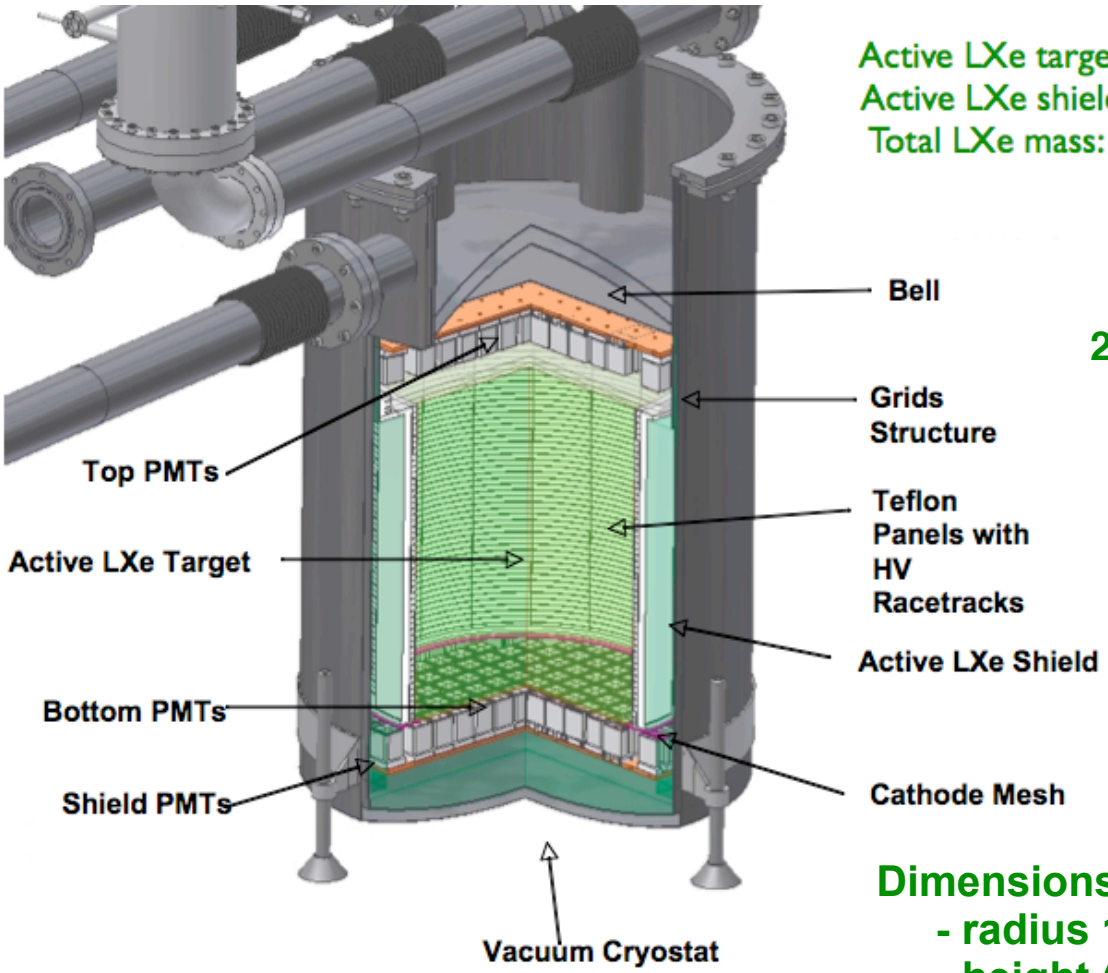
DPG Spring Meeting, Freiburg, March 3, 2008

The main features of XENON100 detector:



Active LXe target: 70 kg
Active LXe shield: 80 kg
Total LXe mass: 150 kg

242 Photomultiplier Tubes in Total:
98 in the top PMT array
80 in the bottom array
64 in the veto (top/bottom)

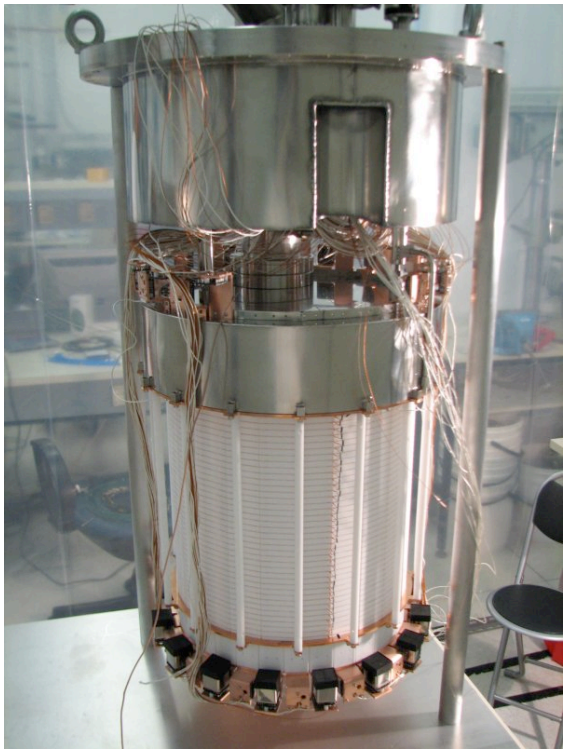
Dimensions of the Liquid Xenon target:
- radius 15 cm ;
- height (drift length) 30 cm.

Active side/top/bottom shield is ~3 cm thick.

Cryocooler and feed-throughs are outside the shield.

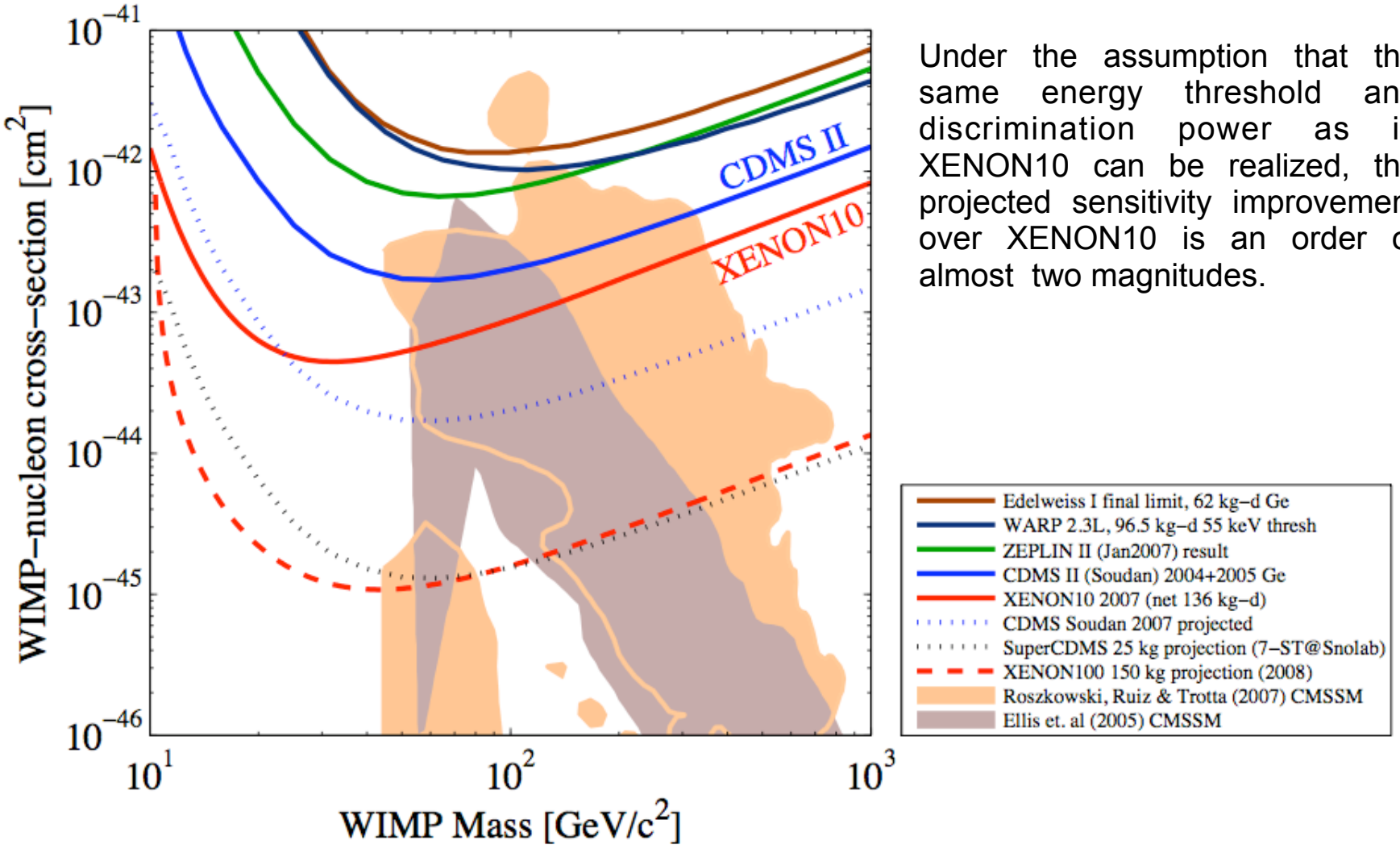
Current status of the XENON100 experiment:

The detector is assembled and moved underground in XENON10 shield (20 cm of lead + 20 cm of polyethylene) improved with a 5 cm layer of high-purity copper inside to reduce the gamma-background coming from a polyethylene layer.



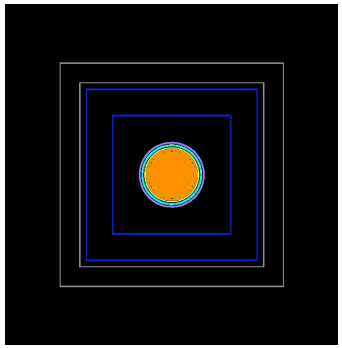
Filling with Xenon and purification with circulation started the last week.

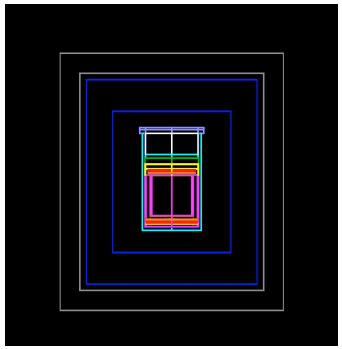
Expected sensitivity of XENON100:

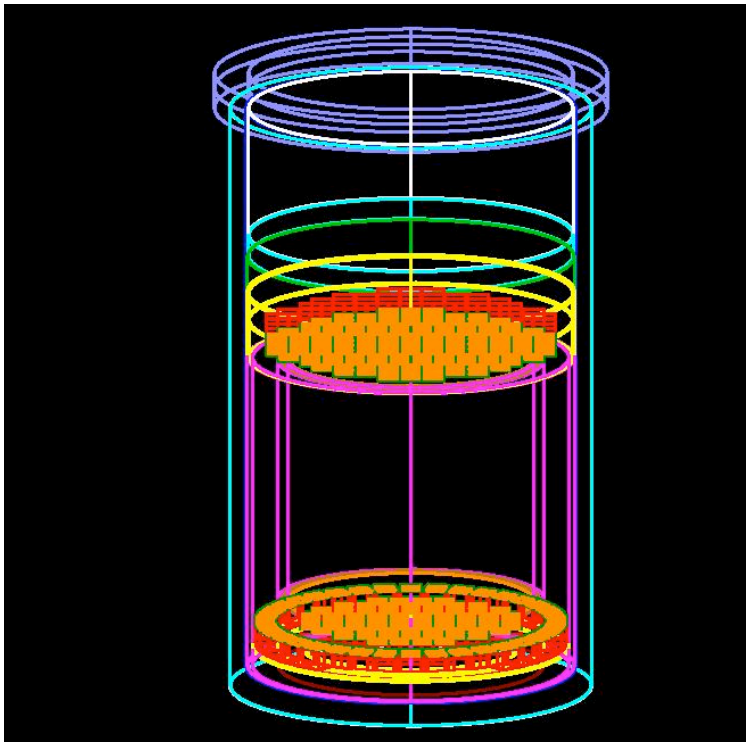


Under the assumption that the same energy threshold and discrimination power as in XENON10 can be realized, the projected sensitivity improvement over XENON10 is an order of almost two magnitudes.

At this stage simplified model of the XENON100 detector is used for Monte-Carlo simulations with Geant4







Assumptions:

- flat flanges instead of dished plates;
- all 64 veto PMTs observe only side shield;
- some teflon and copper pieces are simplified;
- stainless steel pipes to the outside are missing.

XENON100: radioactive contamination

All materials were screened at LNGS with high purity Ge-spectrometers

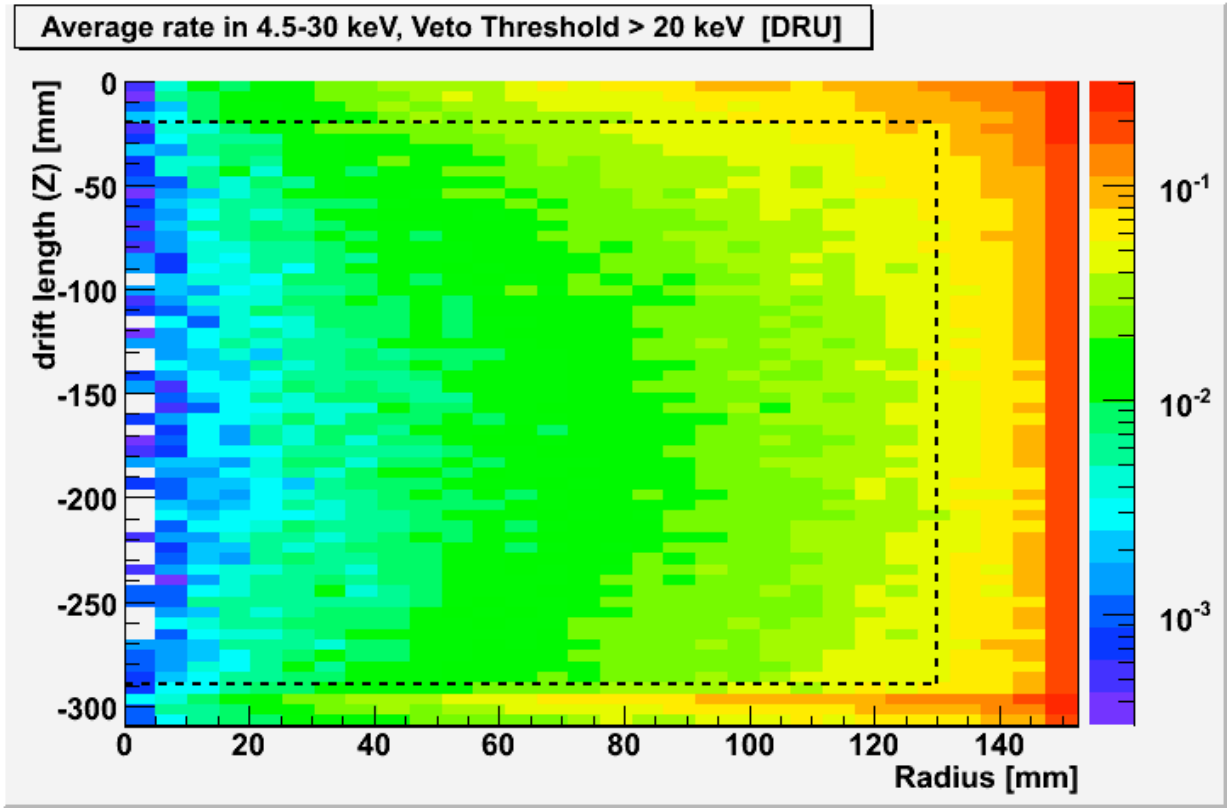
(mostly upper limits are given by measurements and presented in the following table)

Material	Th-232 (mBq/kg)	U-238 (mBq/kg)	K-40 (mBq/kg)	Co-60 (mBq/kg)	amount of material
Stainless Steel	**2.4**	**1.9**	**10.5**	**8.5**	**65.4 kg**
Teflon	**0.44**	**0.87**	**6.2**		**8.49 kg**
PMT	**0.21 mBq/PMT**	**0.25 mBq/PMT**	**9.30 mBq/PMT**	**0.59 mBq/PMT**	**242 pieces**
Polyethylene	**2.69**	**3.54**	**5.88**	**0.90**	**1542 kg**
Copper	**0.023**	**0.020**			**1636 kg**

Gamma-BG from polyethylene shield is “simulated” with the copper layer inside with the following configuration:

5 cm on the top back and side walls;
5 mm on the bottom;
no copper on the door.

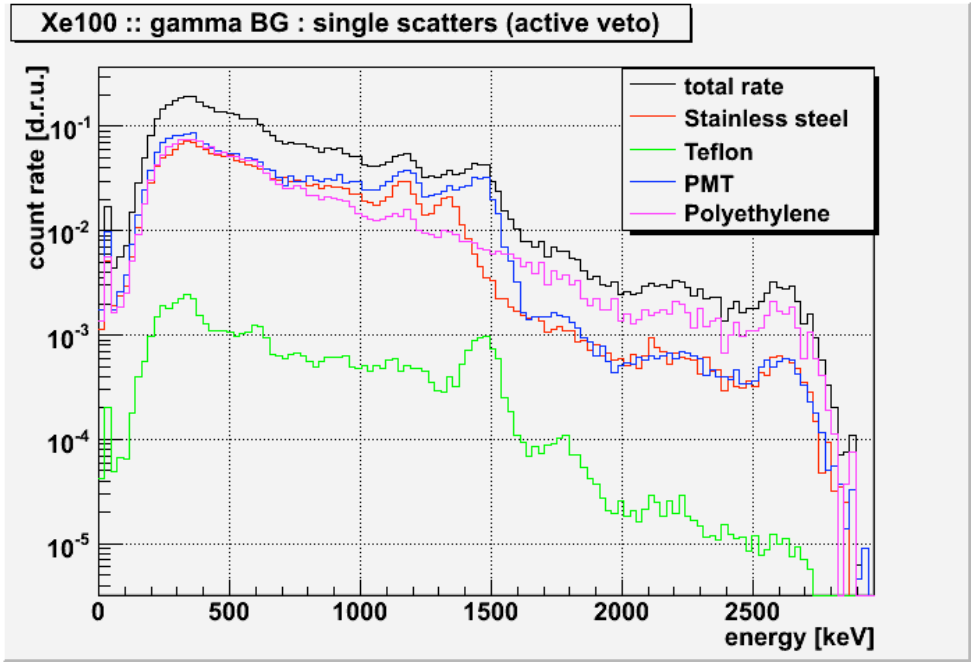
The optimal fiducial volume was computed using single scatters rate as a function of position information:



Based on this information, optimal fiducial volume is chosen to be 40.9 kg of LXe (radius 130 mm and 20 mm cut on the top and bottom along Z axis).

Single scatters rate in XENON100

in the energy region of 4.5 – 30. keV
with energy threshold 20 keV in the Active Veto
(fiducial volume 40.9 kg)



Material	rate [mdru]
Stainless steel	2.01 ± 0.22
Teflon	0.68 ± 0.04
PMT	4.91 ± 0.60
Polyethylene	3.09 ± 0.29
Copper	0.026 ± 0.002
Total	10.72 ± 0.69

Gaussian smearing is applied based on the resolution function of the PMTs from Xe10.

Neutrons from natural radioactivity:

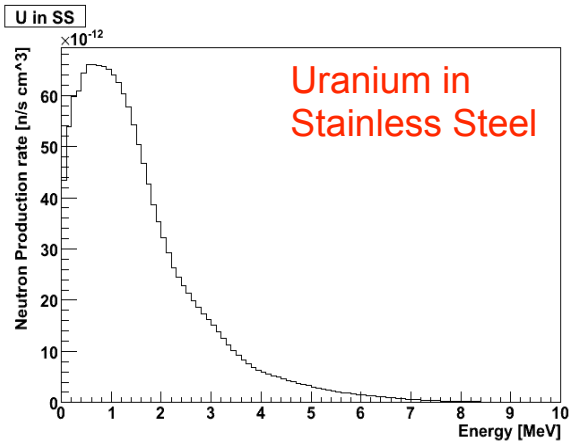
- (α, n) reaction of α's from natural α-emitters (U, Th) with light target nuclei
- spontaneous fission (U^{238})

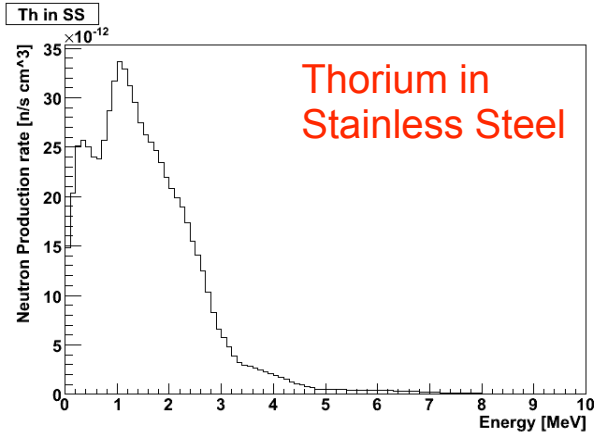
The modified code **SOURCES-4A** (Wilson et al., Carson et al., Lemrani et al.) is used to calculate **neutron fluxes** and **energy spectra** from U/Th contamination in several materials.

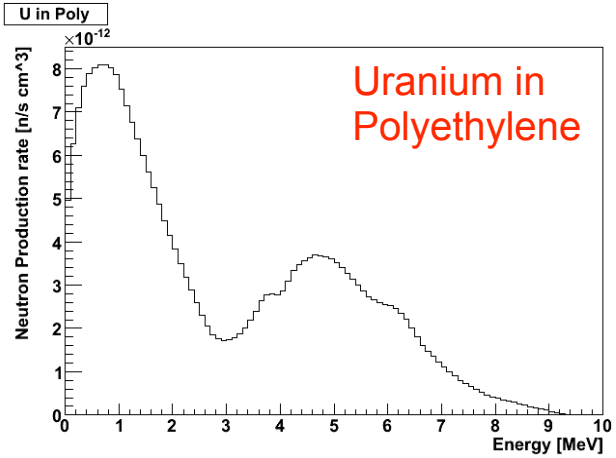
The cross-sections of (α,n) reaction updated to recent experimental results.

Neutron spectra

For 10ppb U and 10ppb Th



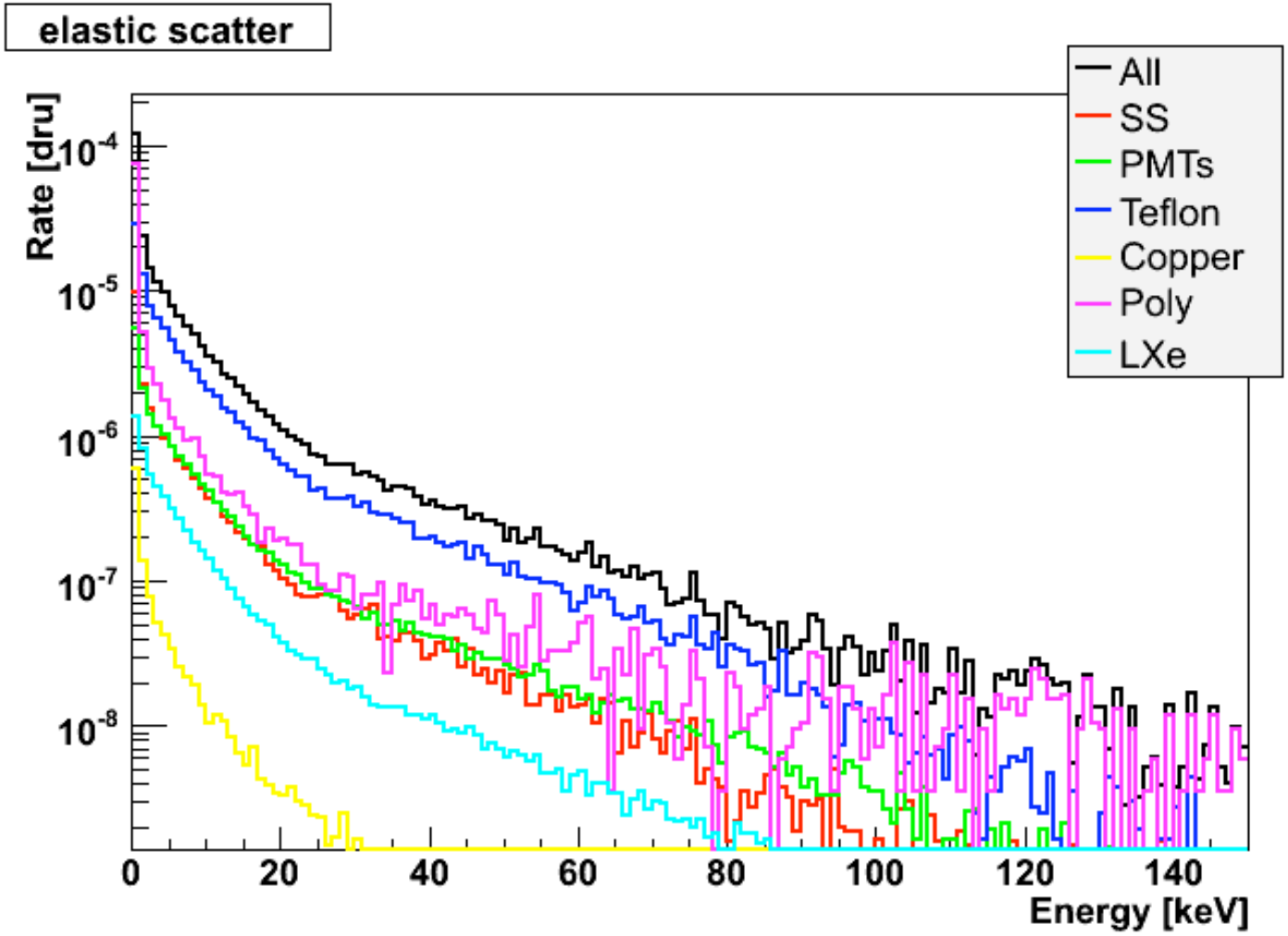




Neutron Background in XENON100

Single scatters in the fiducial volume (40.9 kg)

Single scatters: 45%, Multiple scatters: 55%



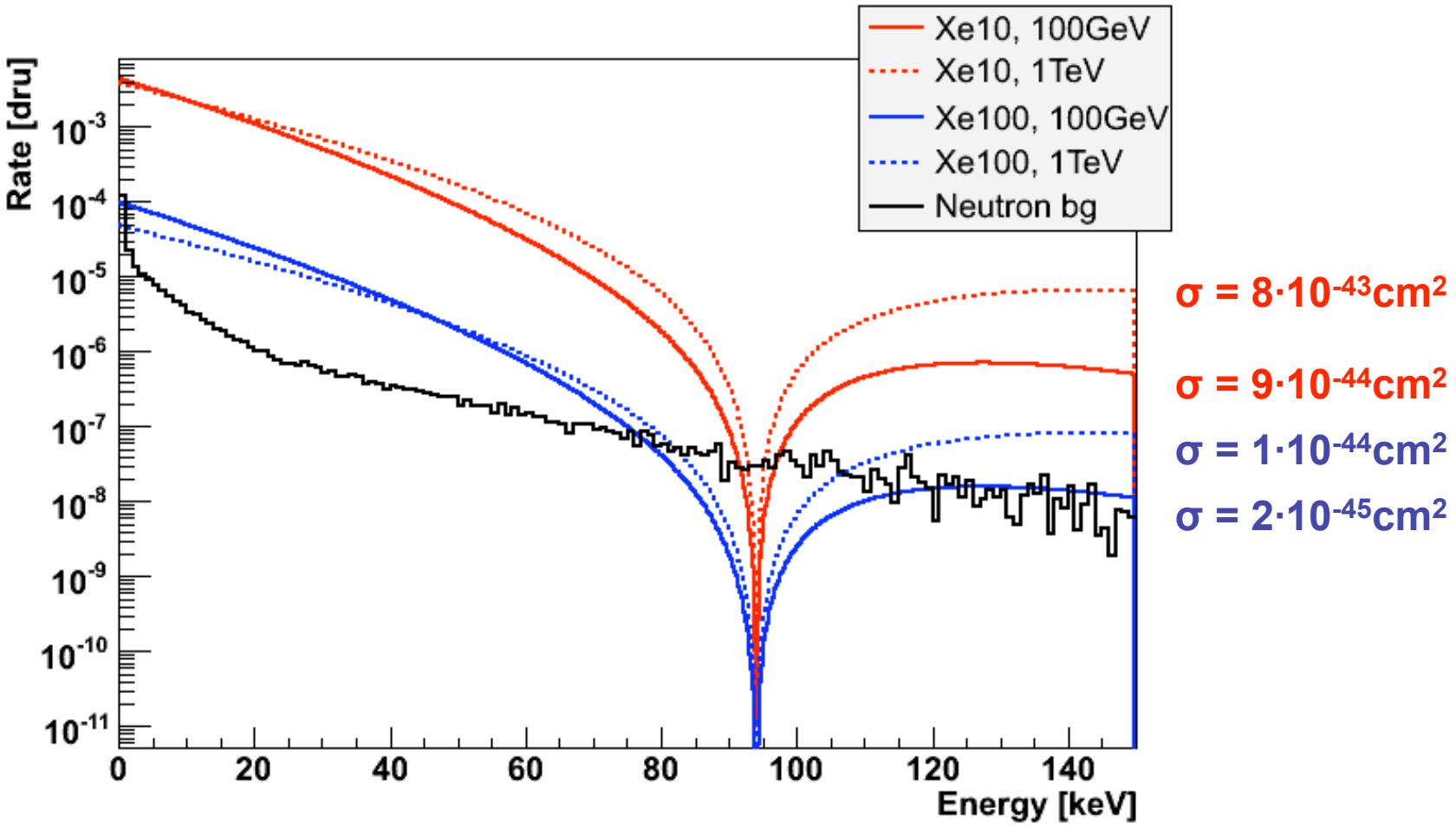
Neutron rates (single elastic scatters) in XENON100

in the energy region of 4.5 – 26.9 keV

Material	Neutron rate [mdru]
Stainless steel	(2.93 ± 0.03) e-4
PMTs	(3.18 ± 0.02) e-4
Teflon	(16.26 ± 0.08) e-4
Copper	(0.110 ± 0.002) e-4
Poly	(4.87 ± 0.10) e-4
LXe	(1.07 ± 0.01) e-4
Total	**(2.85 ± 0.02) e-3**

The total neutron BG from detector materials and passive shield in XENON100 is **0.9 single neutron recoils/year**

Expected WIMP rates vs Neutron Background



$\sigma = 8 \cdot 10^{-43} cm^2$

$\sigma = 9 \cdot 10^{-44} cm^2$

$\sigma = 1 \cdot 10^{-44} cm^2$

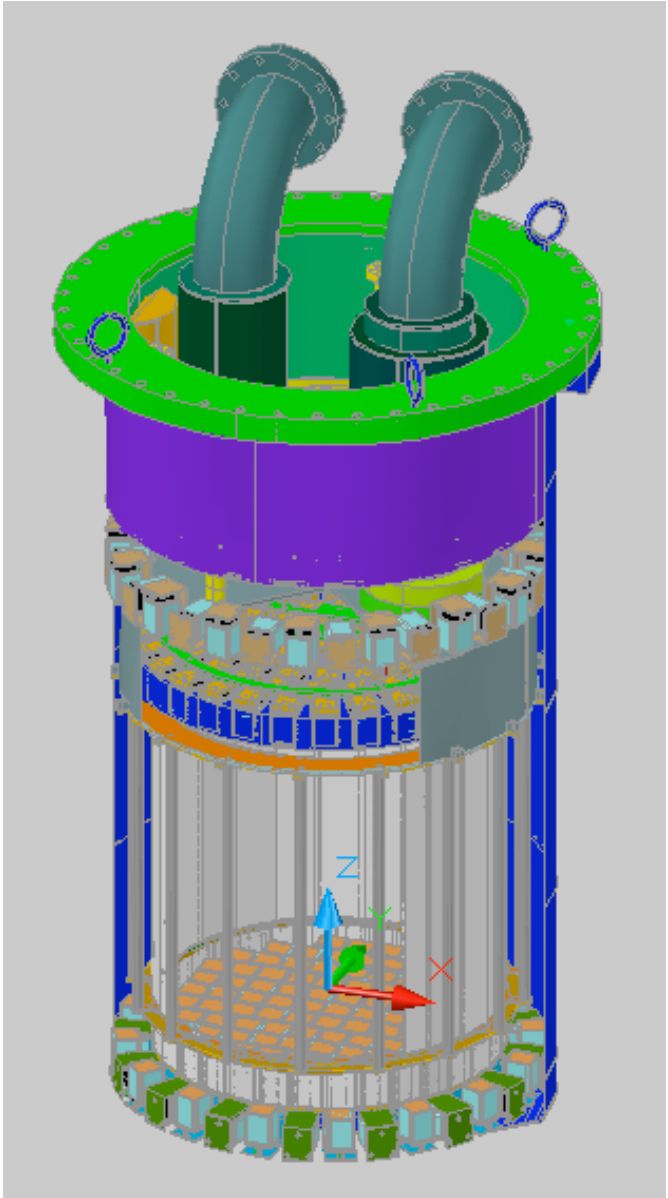
$\sigma = 2 \cdot 10^{-45} cm^2$

Current plans for Monte-Carlo simulations:

- corrected and more detailed geometry
  (based on the updated AutoCAD drawings
  and actual measurements)
+ update on BG simulations;

- simulations of muon-induced neutron background;

- light collection efficiency simulations.



XENON100 collaboration:

Columbia University

Rice University

University of Coimbra

Universität Zürich
Physik-Institut

INFN
Istituto Nazionale
di Fisica Nucleare

Laboratori Nazionali del Gran Sasso