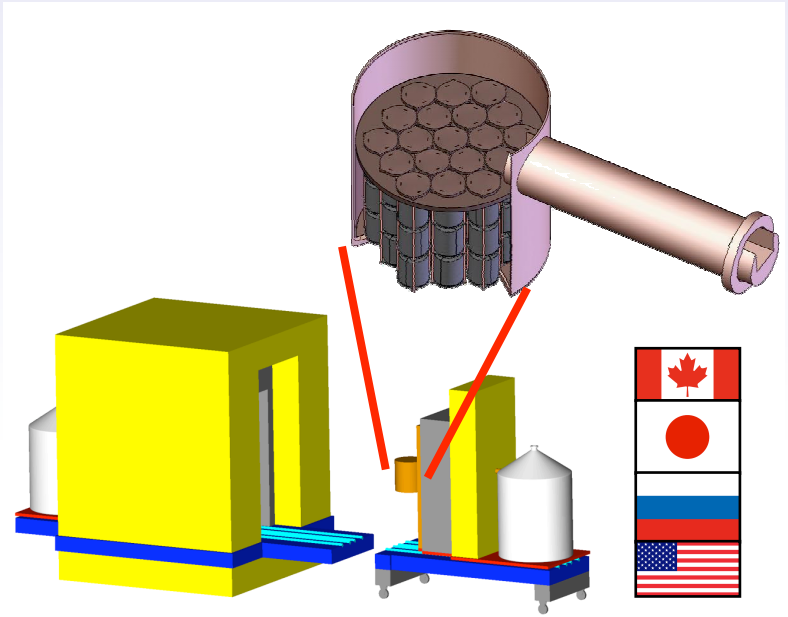
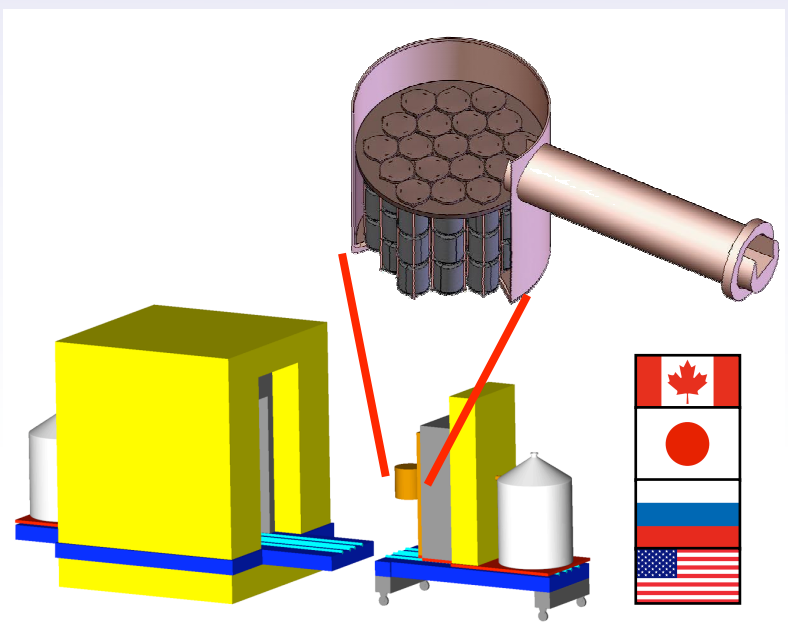
MAJORANA Update

- U.S. Nuclear Physics Long Range Plan
  - Planned 0νββ Program
- MAJORANA Status
- Technical Updates
  - Detector Technologies (Kai Vetter)
  - Cu Technologies (Craig Aalseth)



MAJORANA Update

- U.S. Nuclear Physics Long Range Plan
  - Planned 0νββ Program
- MAJORANA Status
- Technical Updates
  - Detector Technologies (Kai Vetter)
  - Cu Technologies (Craig Aalseth)



U.S. Nuclear Physics Long Range Plan

Every ~5 years U.S. Nuclear Physics Community writes a long range plan to guide the funding agencies (DOE & NSF). Currently this process is underway and a new plan will be completed at end of 2007.

In May 2007, the LRP Working Group agreed on the four major recommendations that will define the future program, including:

We recommend a targeted program of experiments to investigate neutrino properties and fundamental symmetries. These experiments aim to discover the nature of the neutrino, yet unseen violations of time-reversal symmetry, and other key ingredients of the new standard model of fundamental interactions. Construction of a Deep Underground Science and Engineering Laboratory is vital to US leadership in core aspects of this initiative.

- Neutrinos and Fundamental symmetries now integral part of N.P. program
- Plan recommends support of CUORE and MAJORANA in the near-term.
- In the longer-term anticipates support of a 1-ton scale experiment.

Experimental Program in 0νββ

Previous Expts.
~ 1 eV
~kg scale

→

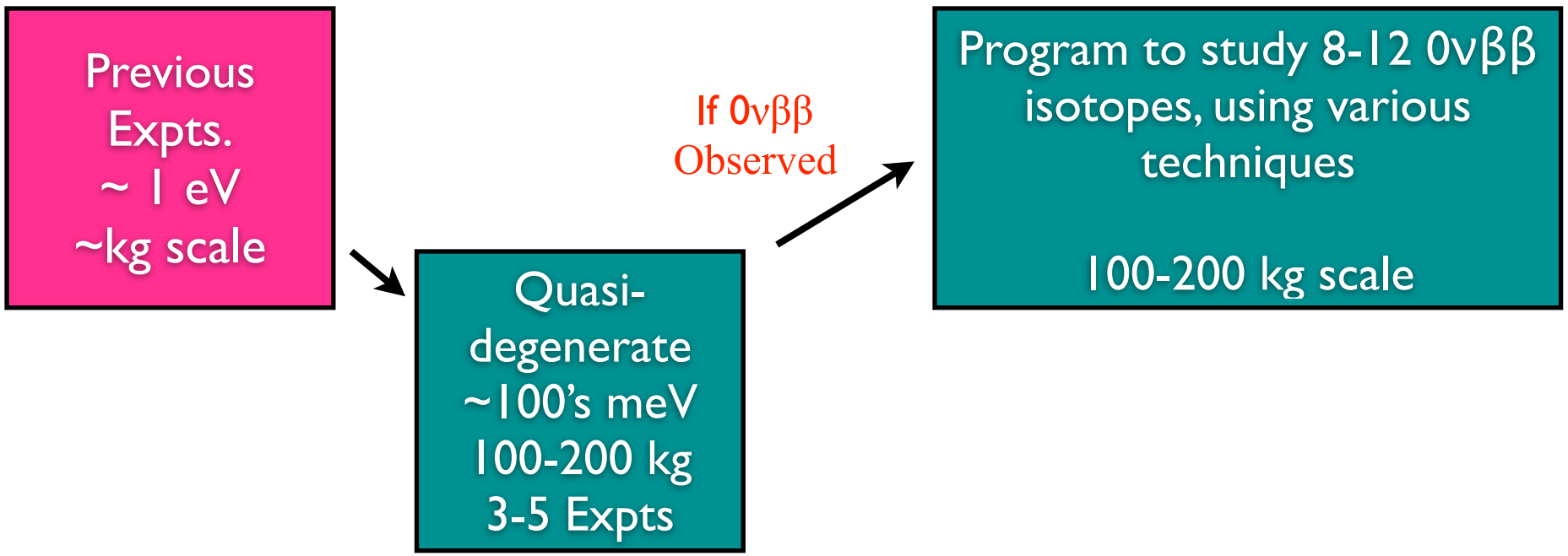
Quasi-degenerate
~100's meV
100-200 kg
3-5 Expts

1980 - Present

2007 - 2014

2013 - 2020

Experimental Program in 0νββ

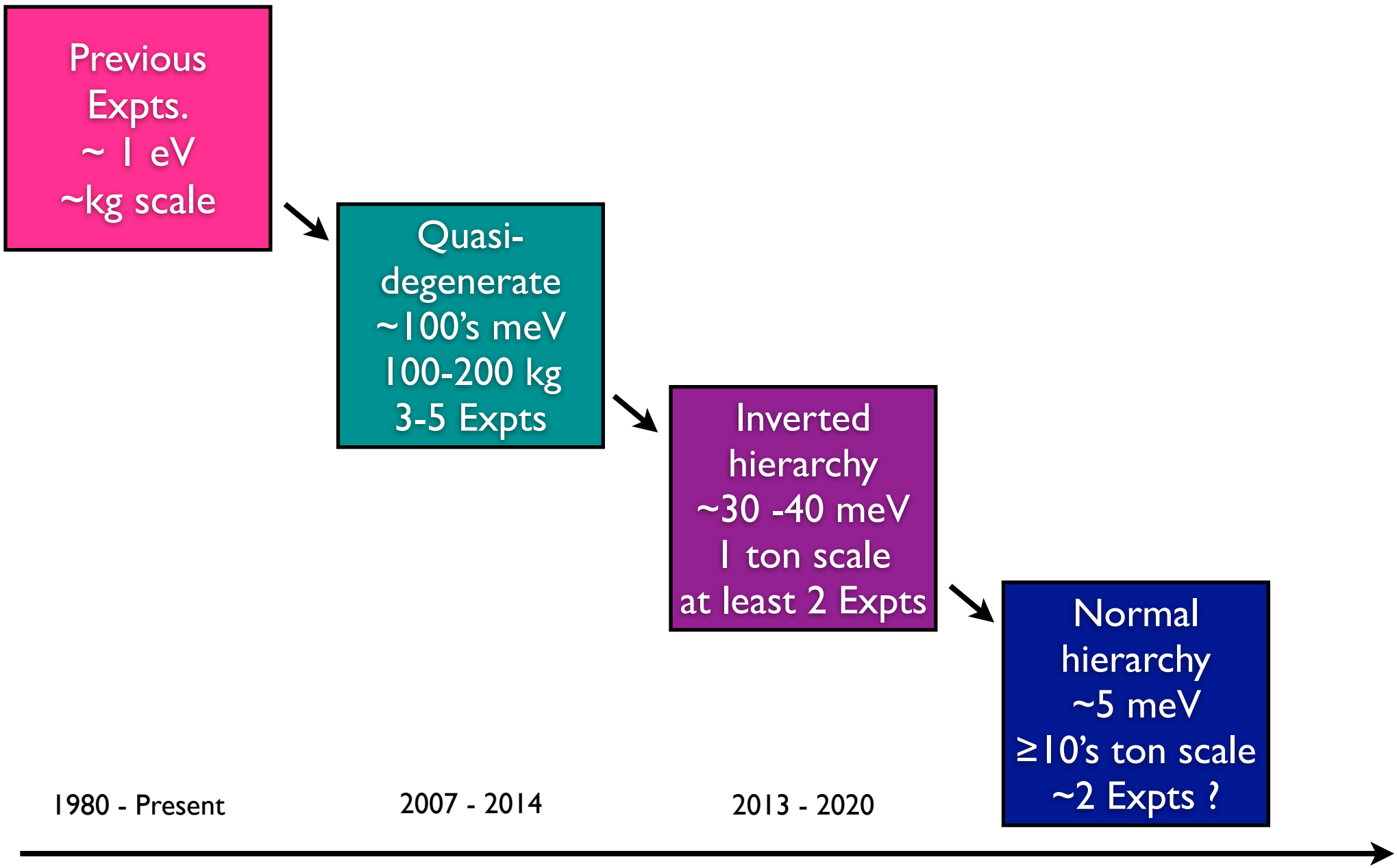


1980 - Present

2007 - 2014

2013 - 2020

Experimental Program in 0νββ



Envisioned U.S. Program

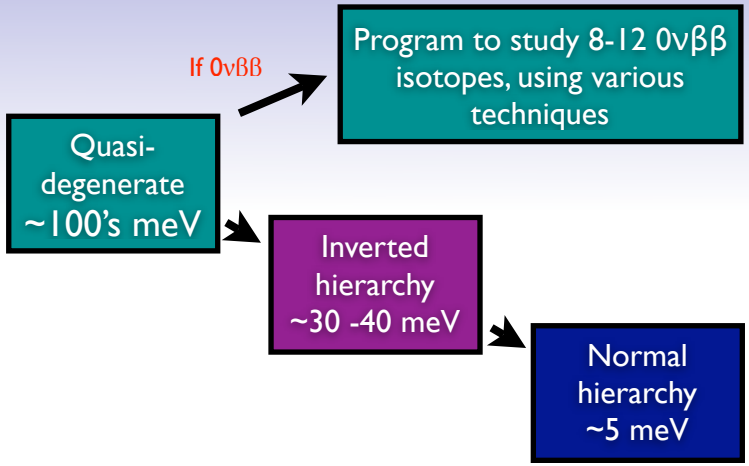
Quasi-degenerate
~100's meV
100-200 kg
3-5 Expts

2008 - 2013

- Explore quasi-degenerate region
- Demonstrate backgrounds and technologies needed for 1-ton scale

- ^{130}Te : CUORE (200 kg bolometer at Gran Sasso) [European, U.S. NP]
- ^{136}Xe : EXO200 (200 kg liquid TPC at WIPP) [U.S. HEP]
- ^{76}Ge : MAJORANA (60 kg at DUSEL) [U.S. NP]
  GERDA (initially 40 kg) [European]
  } would merge for 1-ton
- US NP involvement and/or proposed 1-ton R&D (smaller investments)
  - ^{150}Nd : SNO+ (56 kg in scint. at SNOLAB) [Canada - U.S. NP]
  - ^{136}Xe : HP Xe gas TPC R&D
  - ^{82}Se : SuperNEMO [Europe]; ^{116}Cd : COBRA [Europe]; ^{100}Mo : MOON [Japan]

Envisioned U.S. Program



2013 - 2019

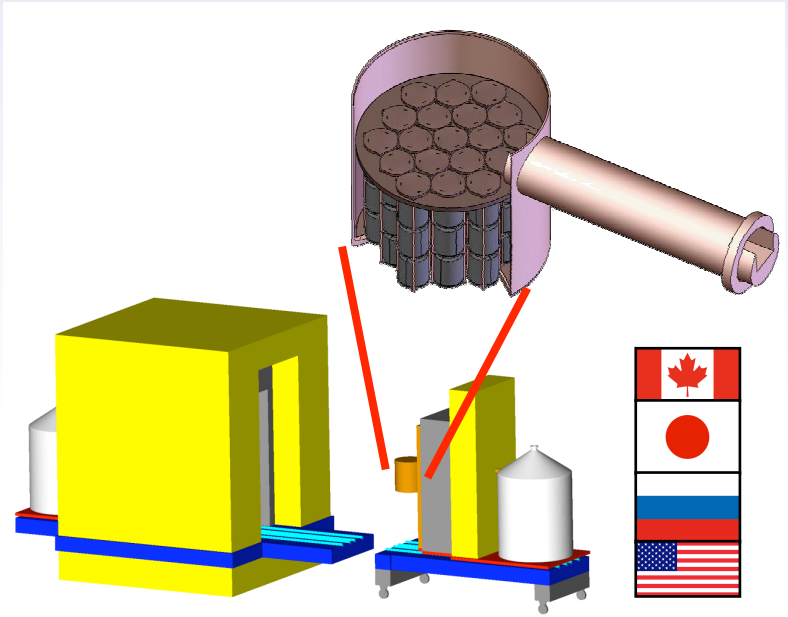
If 0νββ-decay is observed in 100 to 200 kg scale experiments → proceed with a program to study 0νββ isotopes, using various techniques.

- Must understand NME at 20% level — strong theory needs.
- Kinematical studies and measurements of excited state 0νββ decays will possibly require 1-ton scale experiment.

If 0νββ-decay is not observed, select the most promising isotope/technique for mounting a 1-ton scale experiment (likely at DUSEL).

MAJORANA Update

- U.S. Nuclear Physics Long Range Plan
  - Planned 0νββ Program
- MAJORANA Status
- Technical Updates
  - Detector Technologies (Kai Vetter)
  - Cu Technologies (Craig Aalseth)



DOE Pre-conceptual Design Review (Nov. 06)

Recommendation

As part of an alternatives analysis, develop the minimal MAJORANA option (detector design, research and development (R&D) needs, cost and schedule) needed to test the KKDC result and/or demonstrate the feasibility of the long-term technology and background reduction for a ton-scale ^{76}Ge experiment.
Submit to the agencies by July 1, 2007.

Minimal MAJORANA Option - What is it?

1-ton R&D Goals:

- Demonstrate technical feasibility (ROI Bkg. <= 1 ton/year).
- Explore detector technologies (p-type and n-type).
- Demonstrate feasibility of scalability, cost, schedule.
- Be as complementary as possible with GERDA.

Science Goals:

- Test KKDC as part of 1-ton feasibility demonstration.

Cost Goals:

- Budget in the range of $20M.
- Explore options of combination of funding sources from DOE & NSF.

Schedule Goals

- Given late start of funding, attempt to be as competitive as possible
  ⇒ phased approach (multiple cryostats)

MAJORANA Demonstrator (60 kg)

Revised Reference Design

- Based on 60 kg of Ge crystals
  - A mixture of p-type and n-type crystals.
  - p-type: point-contact (40 kg)
  - n-type: modest to highly segmented (20kg)
  - 30 kg of 86% enriched ^{76}Ge crystals
  - 30 kg of natural or depleted Ge
- 2 or 3 independent, ultra-clean, electroformed Cu cryostat modules
- Enclosed in a low-background passive shield and active veto
- Located deep underground (4500 mwe)

Background Specification Goal

in the 0νββ peak region of interest (4 keV at 2039 keV)

~ 1 count/ROI/t-y (after analysis cuts)

MAJORANA Status Summary

Pursuing "R&D" funding to build a prototype ^{76}Ge module (~60 kg total mass) as part of a longer-term program to develop a 1-ton 0νββ-decay experiment.

- Received preliminary support as part of the FY2007 DUSEL R&D funding process (from both DOE and NSF).
- Summer 2007 - The collaboration will submit a "R&D" proposal covering the full development of the prototype module. (Estimated total cost of $20M with most of the R&D funding requested in FY09-11.)

Spare Slides

U.S. Nuclear Physics Long Range Plan

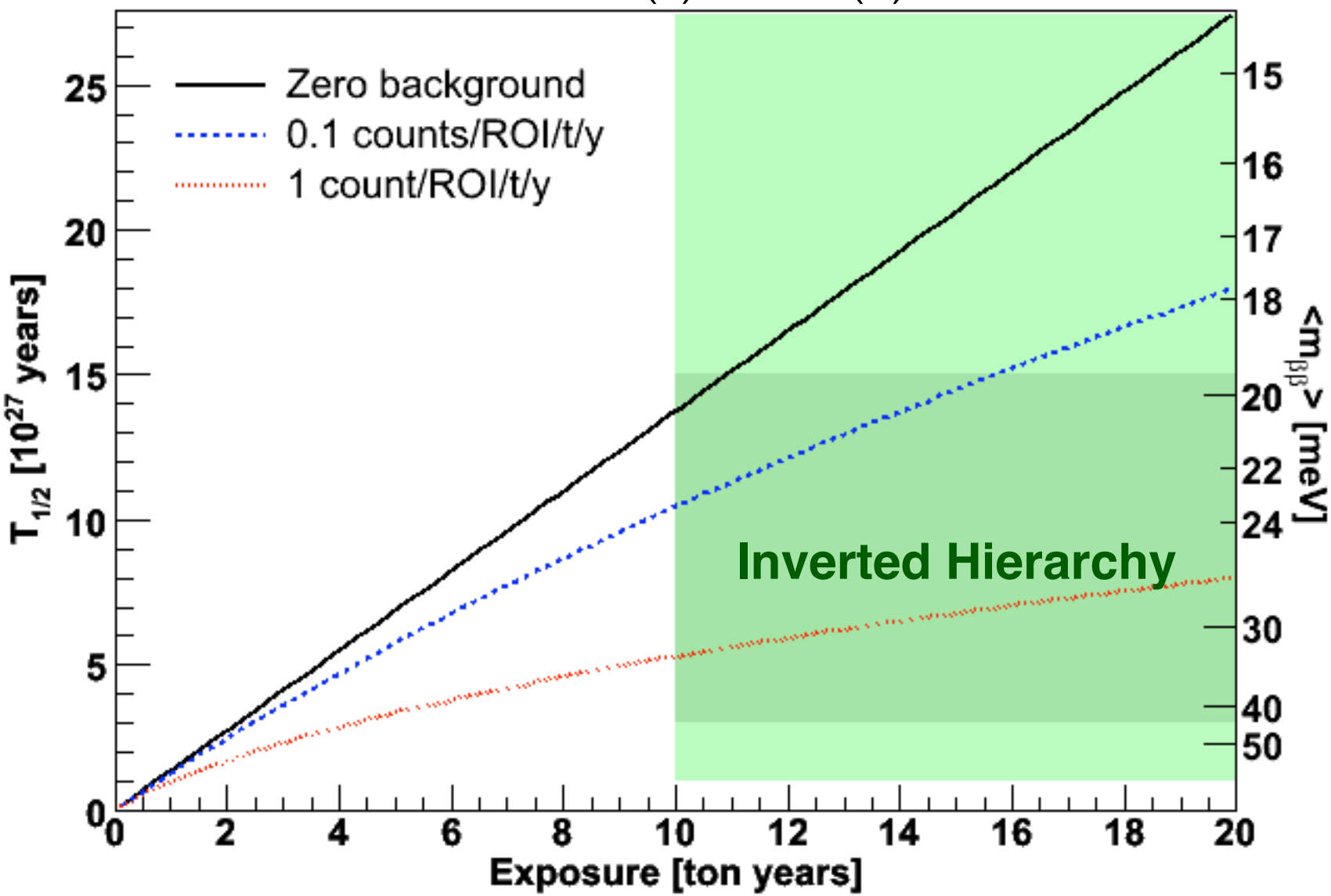
Recommendations

- **We recommend completion of the 12 GeV Upgrade at Jefferson Lab. The Upgrade will enable new insights into the structure of the nucleon, the transition between the hadronic and quark/gluon descriptions of nuclei, and the nature of confinement.**
- **We recommend construction of the Facility for Rare Isotope Beams, FRIB, a world-leading facility for the study of nuclear structure, reactions and astrophysics. Experiments with the new isotopes produced at FRIB will lead to a comprehensive description of nuclei, elucidate the origin of the elements in the cosmos, provide an understanding of matter in the crust of neutron stars, and establish the scientific foundation for innovative applications of nuclear science to society.**
- **We recommend a targeted program of experiments to investigate neutrino properties and fundamental symmetries. These experiments aim to discover the nature of the neutrino, yet unseen violations of time-reversal symmetry, and other key ingredients of the new standard model of fundamental interactions. Construction of a Deep Underground Science and Engineering Laboratory is vital to US leadership in core aspects of this initiative.**
- **The experiments at the Relativistic Heavy Ion Collider have discovered a new state of matter at extreme temperature and density—a quark-gluon plasma that exhibits unexpected, almost perfect liquid dynamical behavior. We recommend implementation of the RHIC II luminosity upgrade, together with detector improvements, to determine the properties of this new state of matter.**

Scaling up and backgrounds

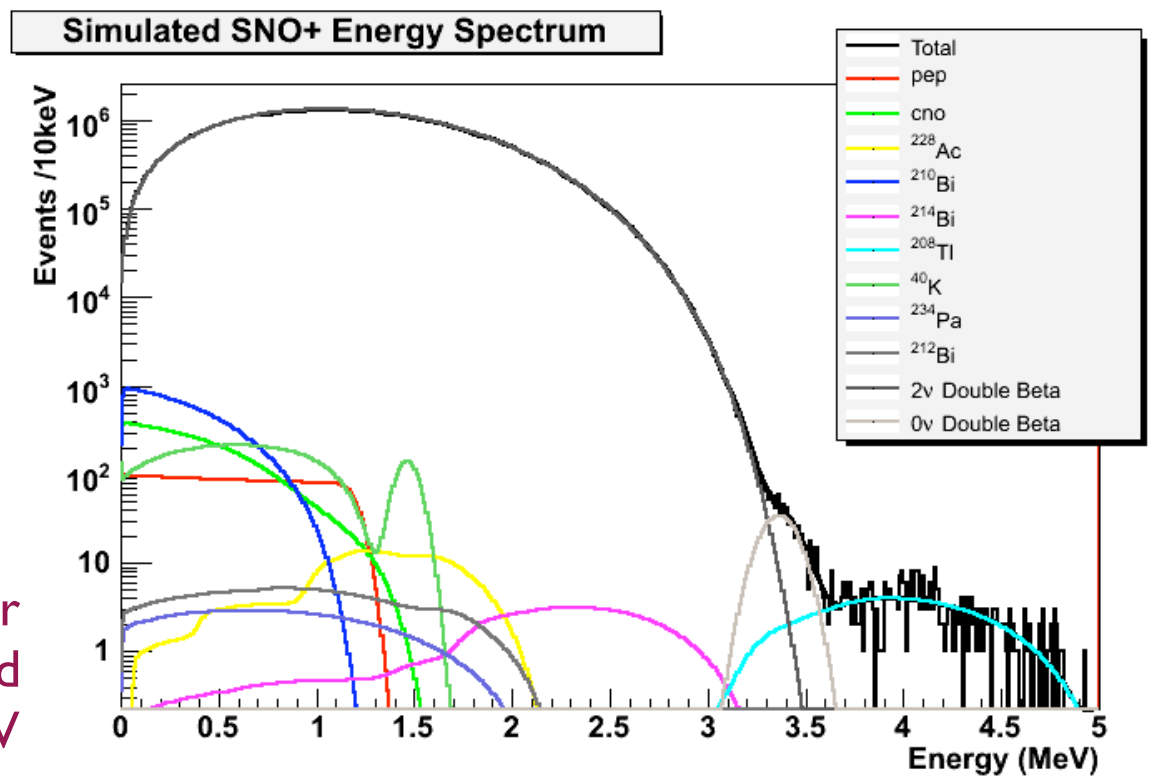
^{76}Ge Example

$T_{1/2}^{0\nu} = \ln(2) N \epsilon t / \mathrm{UL}(B)$



SNO+ (Canada - U.S. - U.K. - Germany -Portugal)

- ^{150}Nd (5.6% abundance) 0.1% loaded in scintillator.
- Initial plan is to use 1 ton of ^{nat}Nd (56 kg of ^{150}Nd)
- Expects to operate at SNOLAB by 2011-2012
- Utilizes substantial investment in SNO
- Initial success in loading into pseudocumene and also in linear alkylbenzene
- Technical challenge - available light with loaded scintillator
- Considering enrich-ment option
- Shape Measurement



1 yr
500 kg of ^{150}Nd
$\langle m_{ee} \rangle$ = 150 meV