

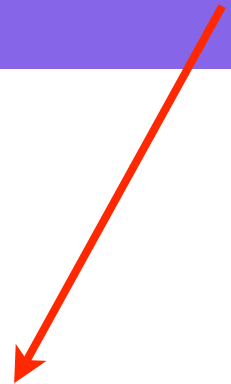
The CLEAN and DEAP Research Programs

James Nikkel
Yale University

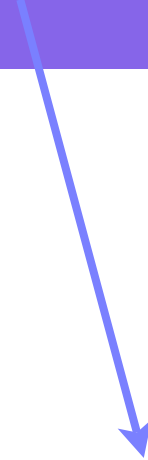
CLEAN

—

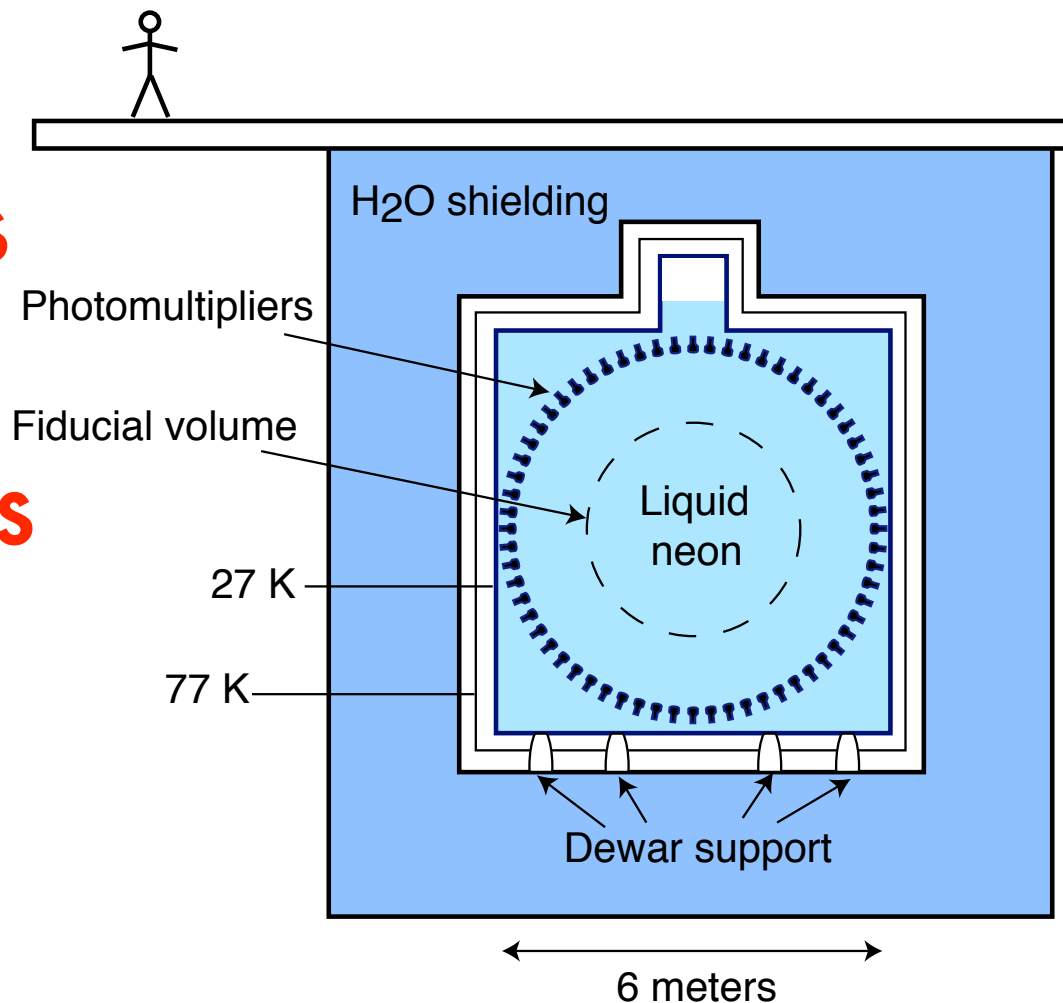
DEAP



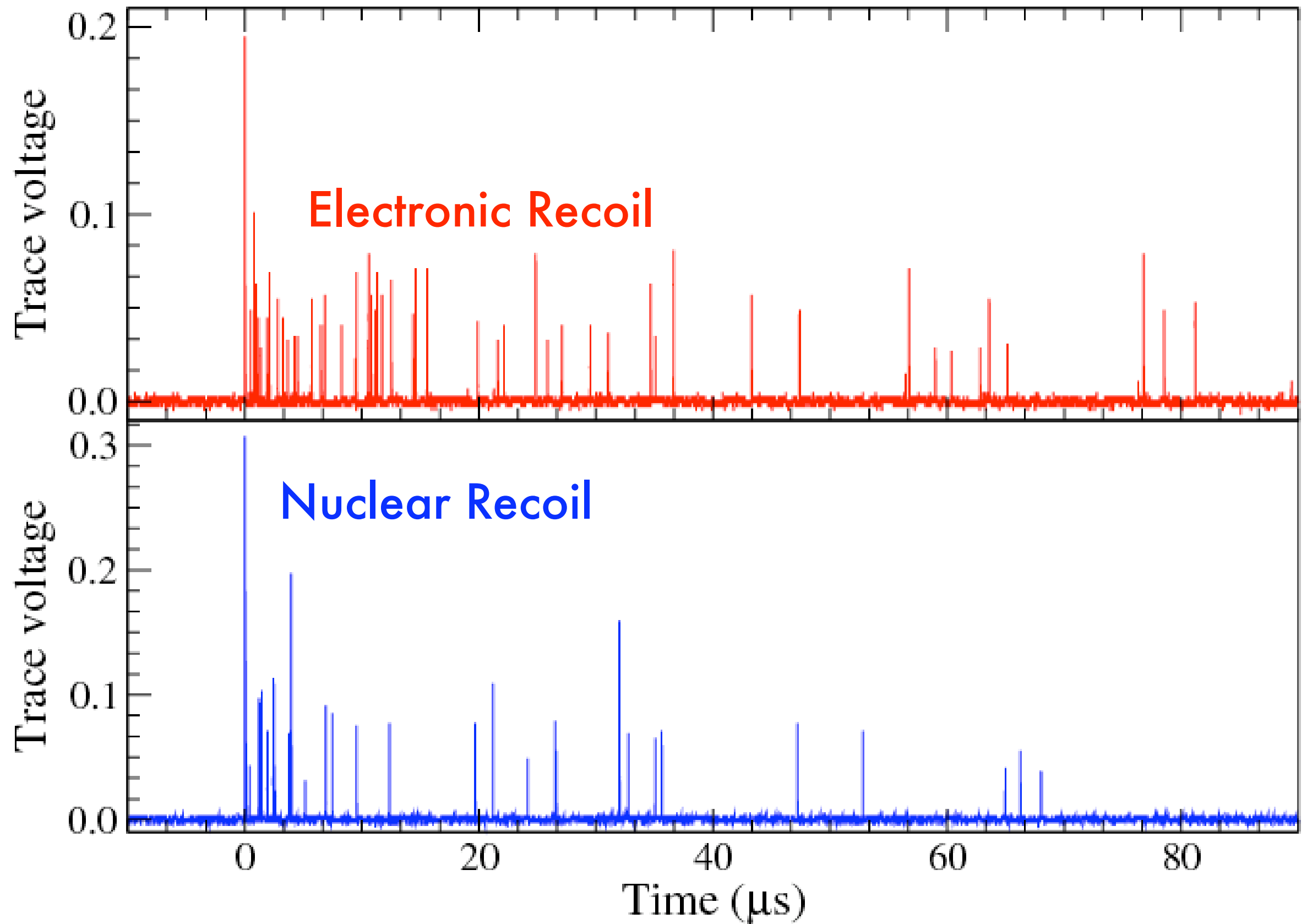
Cryogenic
Low
Energy
Astrophysics
with
Noble liquids



Dark matter
Experiment
with
Argon
PSD



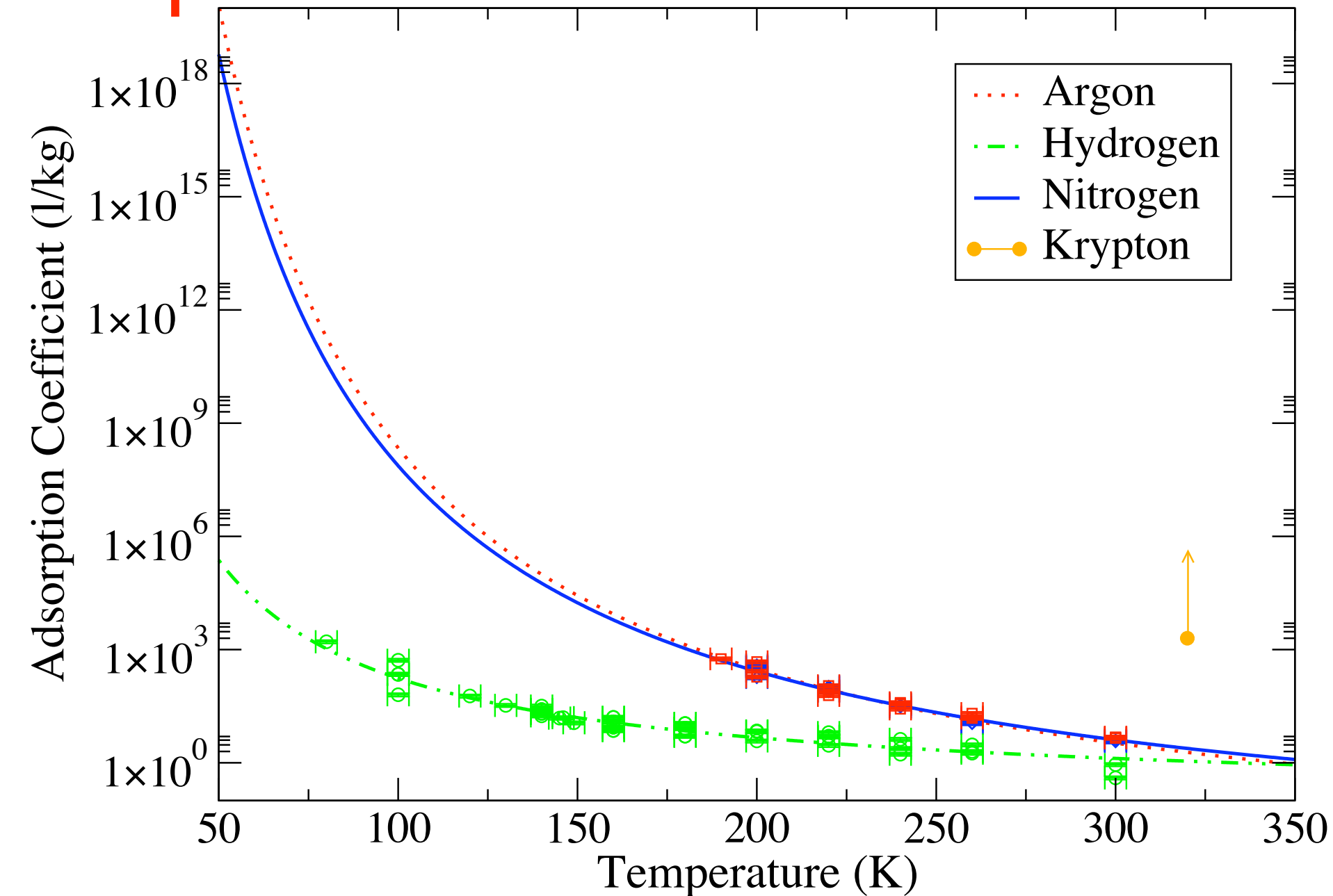
Example of PMT traces



Why Neon and Argon?

Purification

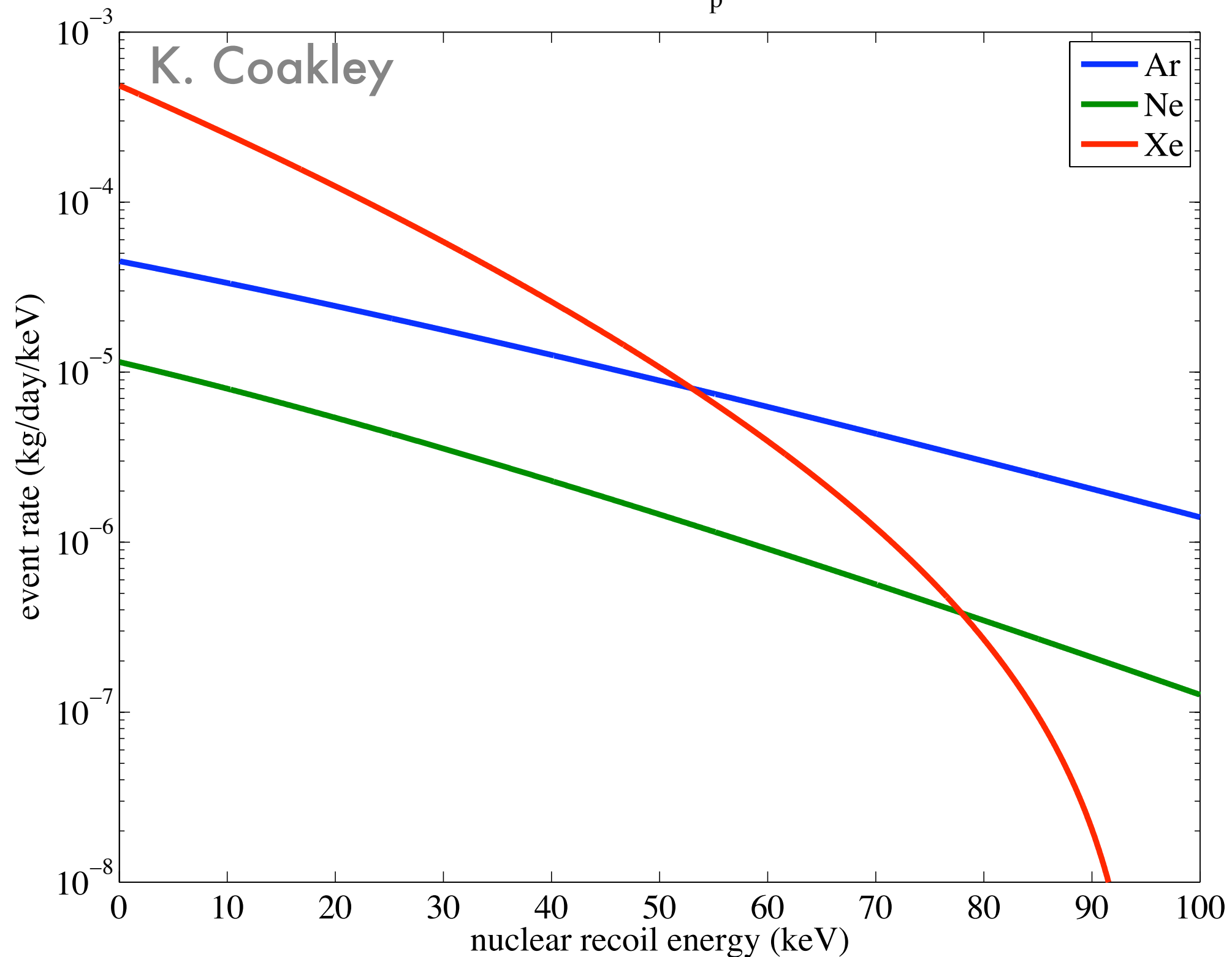
Neon is easily
purified with charcoal



Argon
can be
purified
with a
getter
and
charcoal

Neon/Argon swap

100 GeV WIMP $\sigma_p = 10^{-44} \text{ cm}^2$



Backgrounds

Neutrons

(α, n) neutrons from
surrounding material

Shield active
detector volume

Tag neutron
events
via capture

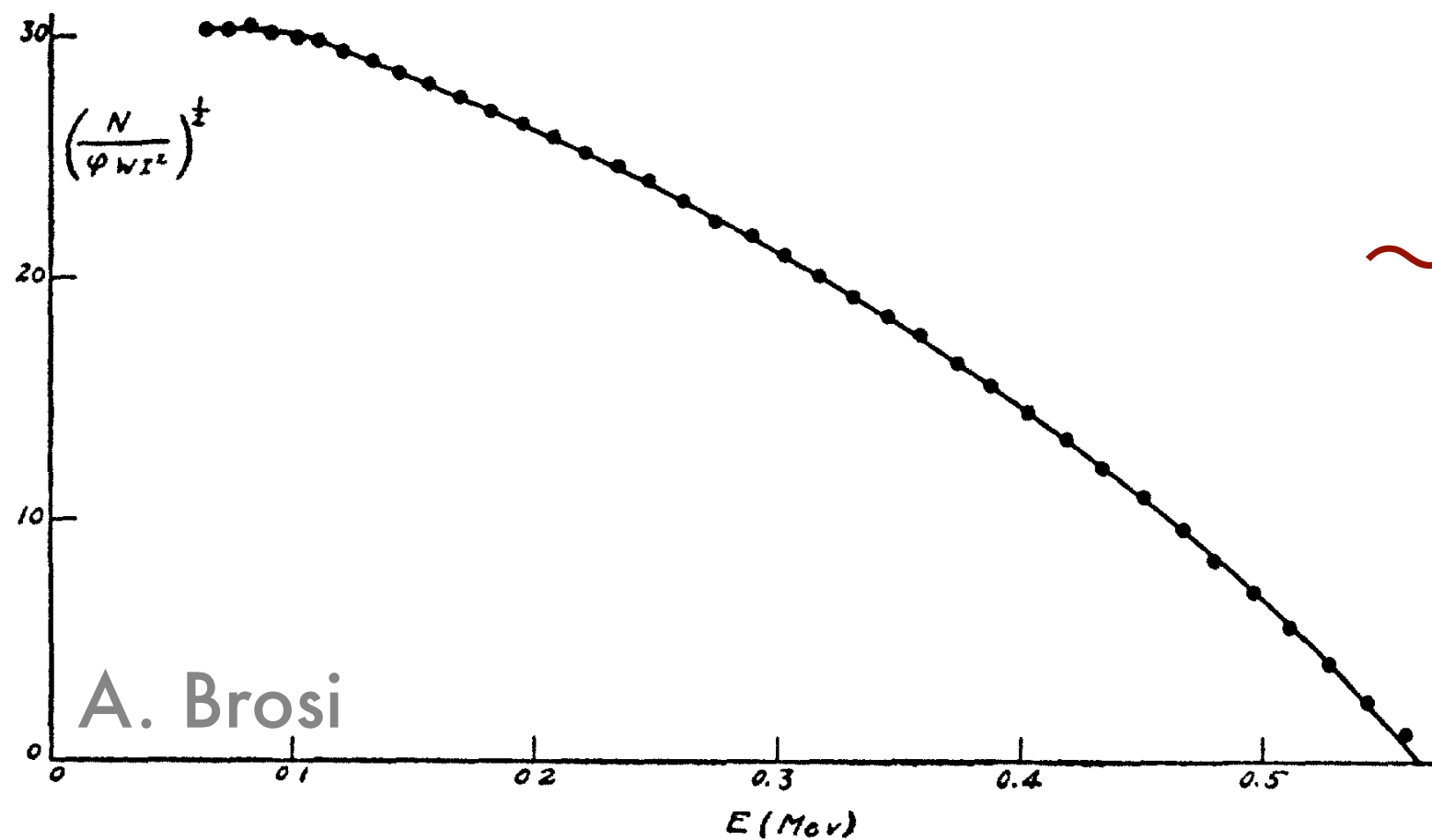
Radon

Surface
contamination from
handling in air

Handle in radon-free
atmosphere

Contain decay
products

Argon-39



$\sim 0.9 \text{ Bq/Kg}$

Ar³⁹ reduction?

- Centrifuge separation
- Underground deposits

Current Detectors

MicroCLEAN



- Liquid neon / liquid argon test bench
- Maximize light collection with 2 PMTs
- Signal yield ~ 5 pe / keVee
- Nuclear recoil scintillation efficiency
- Pulse shape discrimination

**PT805 Pulse
Tube
Refrigerator**

Gas in
Gas out

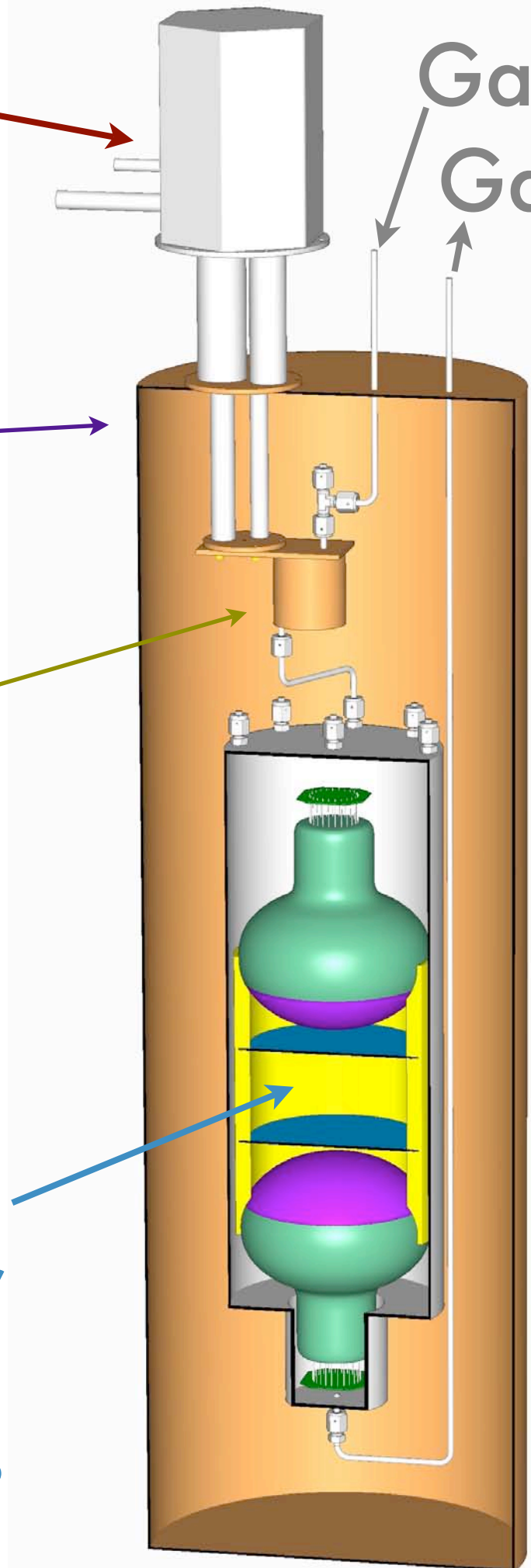
**Heat Shield
on
1st Stage**

**Liquefier
on
2nd Stage**

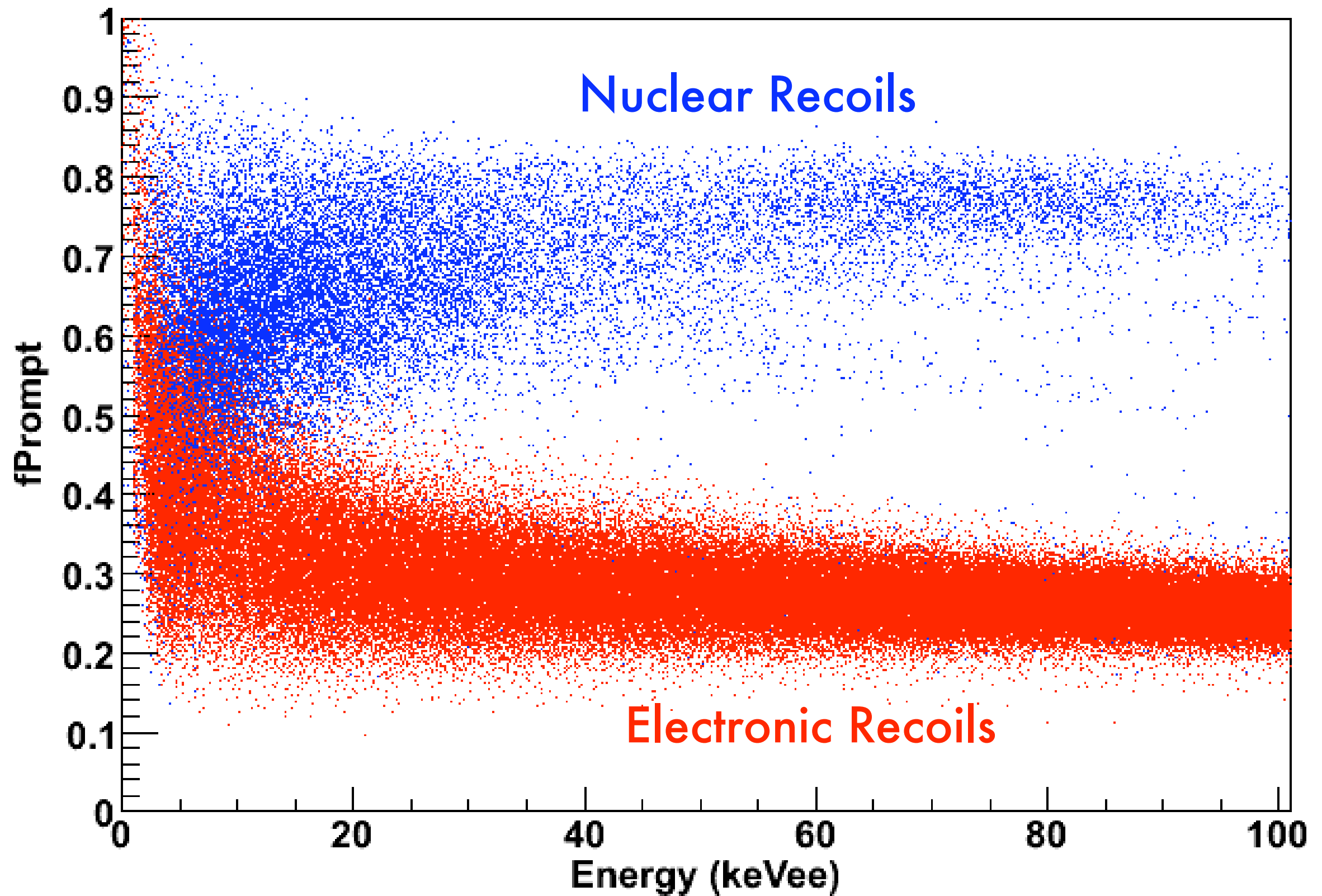
Start with ultra-high
purity gas, run
through a getter
before introducing to
central volume.
Circulate at ~ 2 l/min
through getter.

**Central volume:
20 cm diameter
10 cm high
3.1 litres**

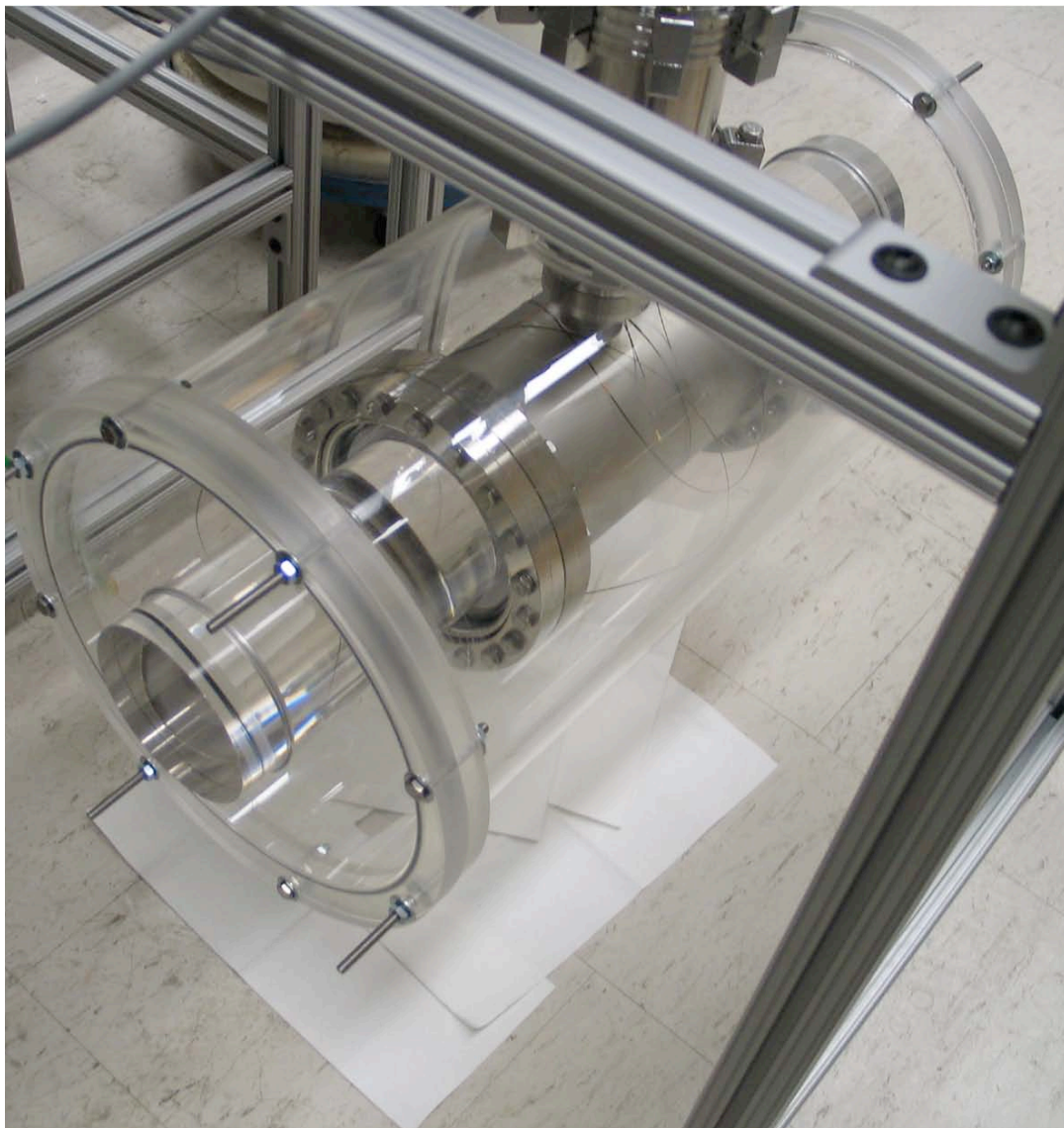
**Hamamatsu
R5912-02-MOD
20 cm
PMTs**



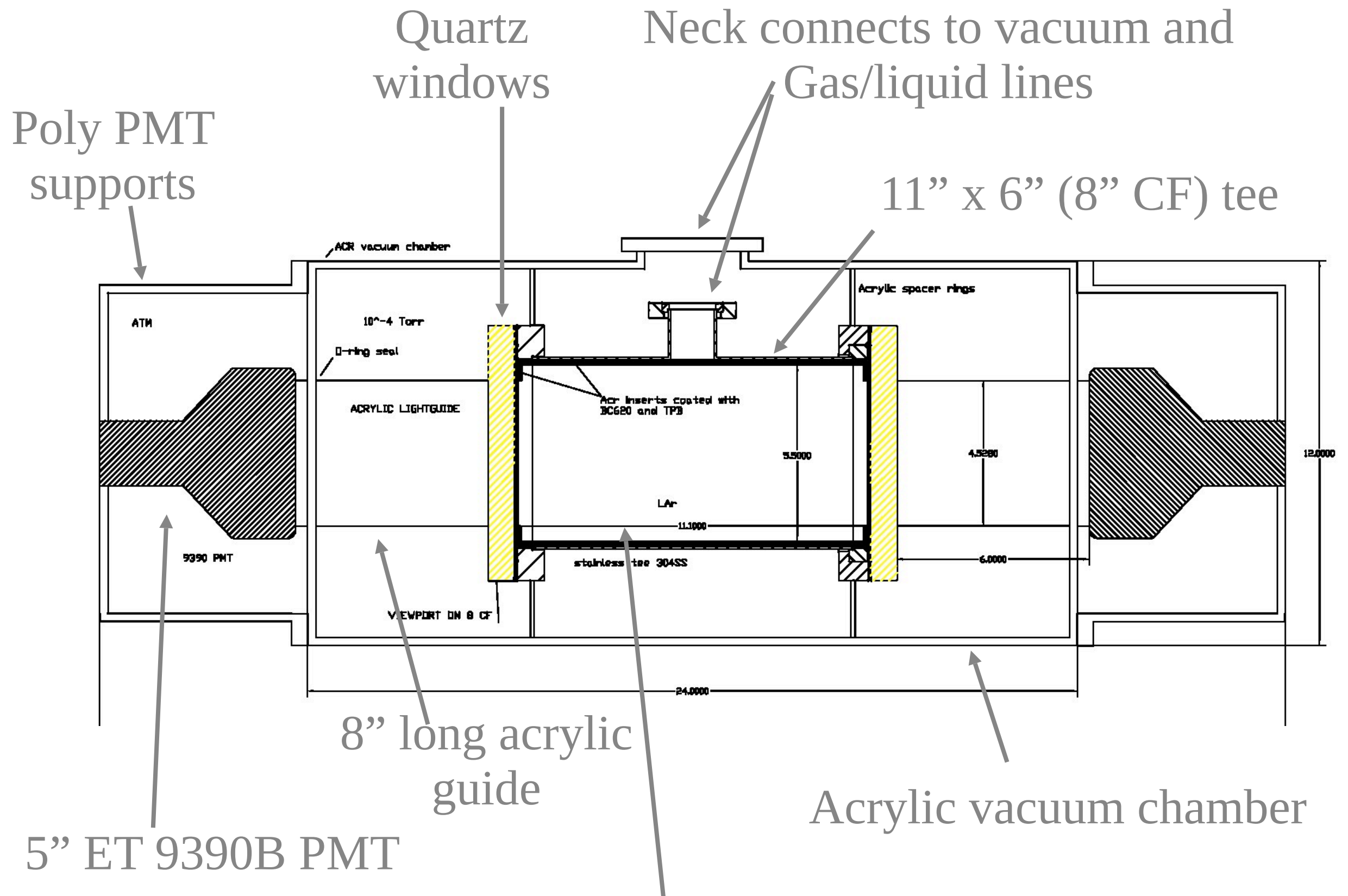
Discrimination



DEAP-1

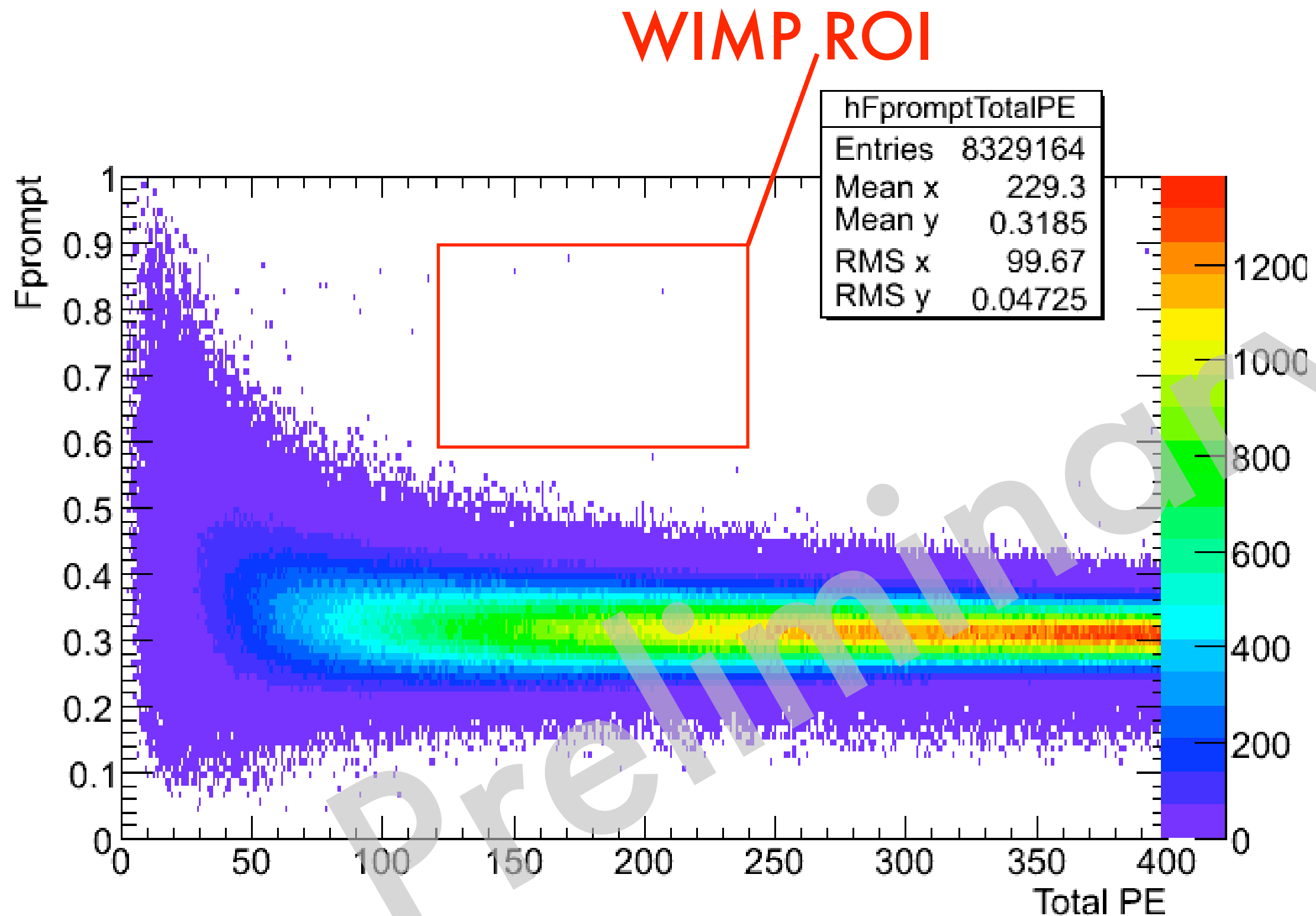


- A 7 kg liquid Argon detector using 2 PMTs
- Calibration with γ 's, n's (tagged Na-22 and AmBe)
- Demonstration of PSD at the level of 1 in 10^8



7 kg LAr

Na-22 data F_{prompt} distribution



Total about 145 hrs of data

Future Detectors

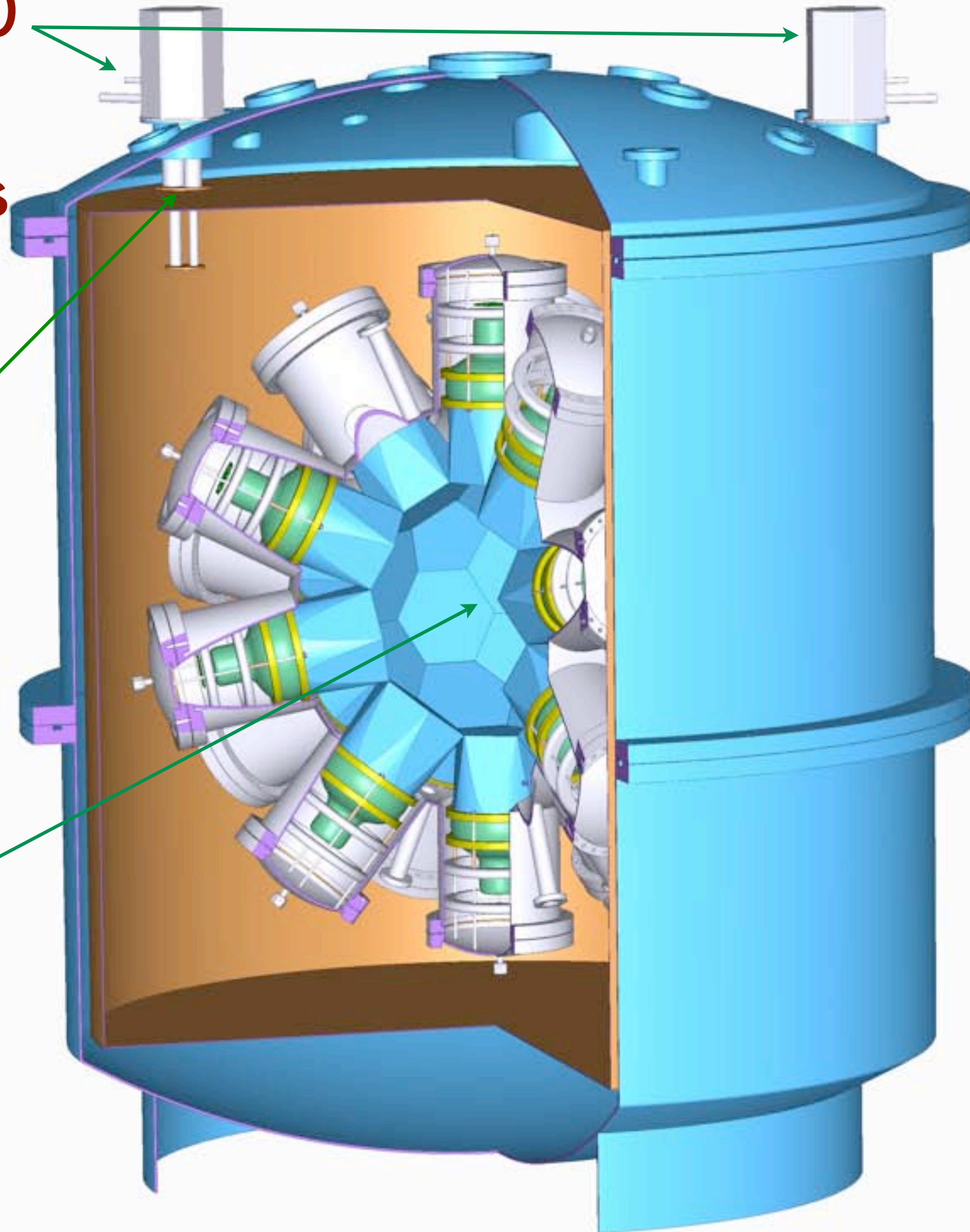
MiniCLEAN-100

- Dark matter detector with a sensitivity of $9 \times 10^{-45} \text{ cm}^2$ at 100 GeV
- Liquid neon and liquid argon capable
 - 89 kg LNe / 104 kg LAr

PT805/PT810
Pulse Tube
Refrigerators

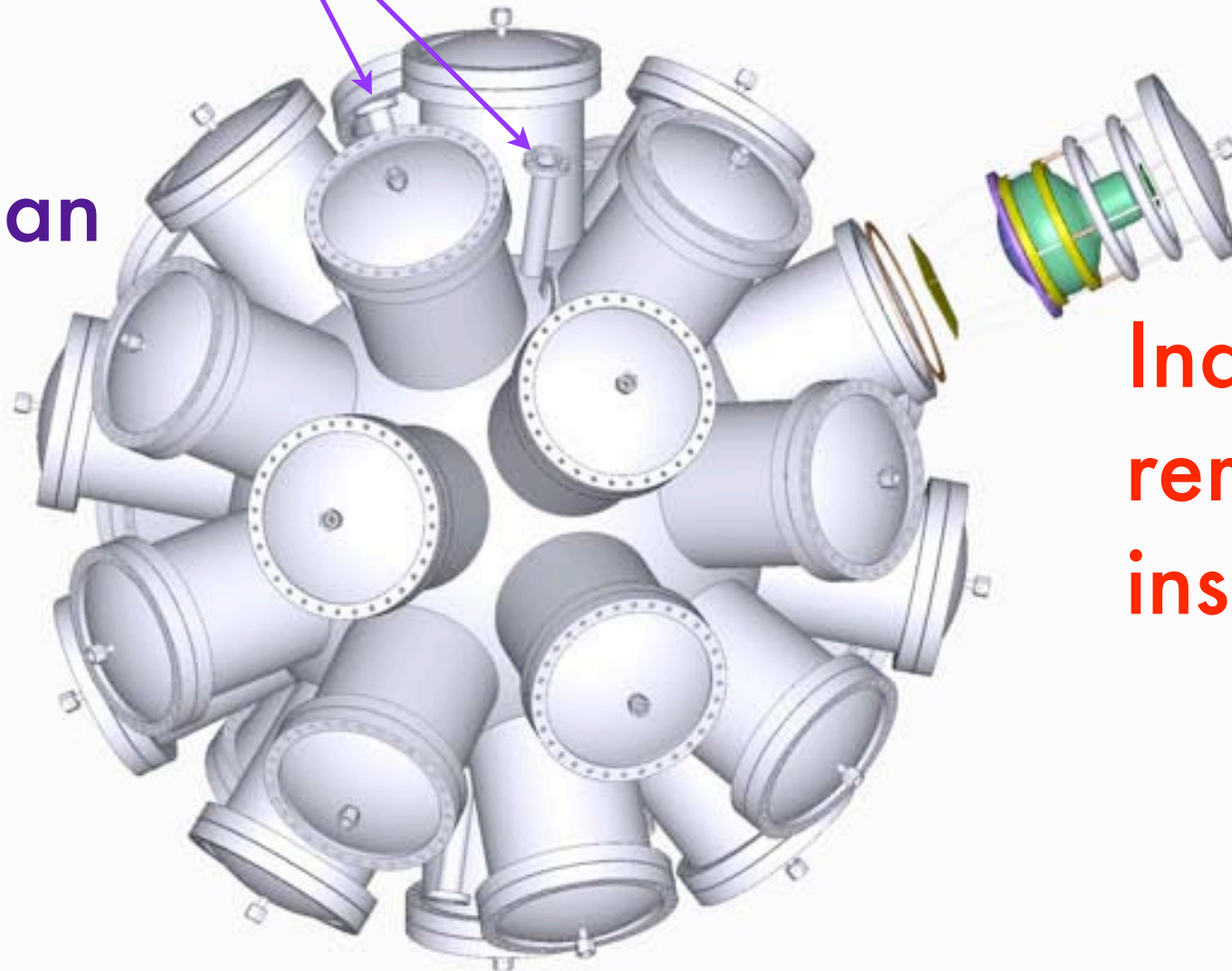
Heat Shield
on
1st Stage

74 litre
central
volume



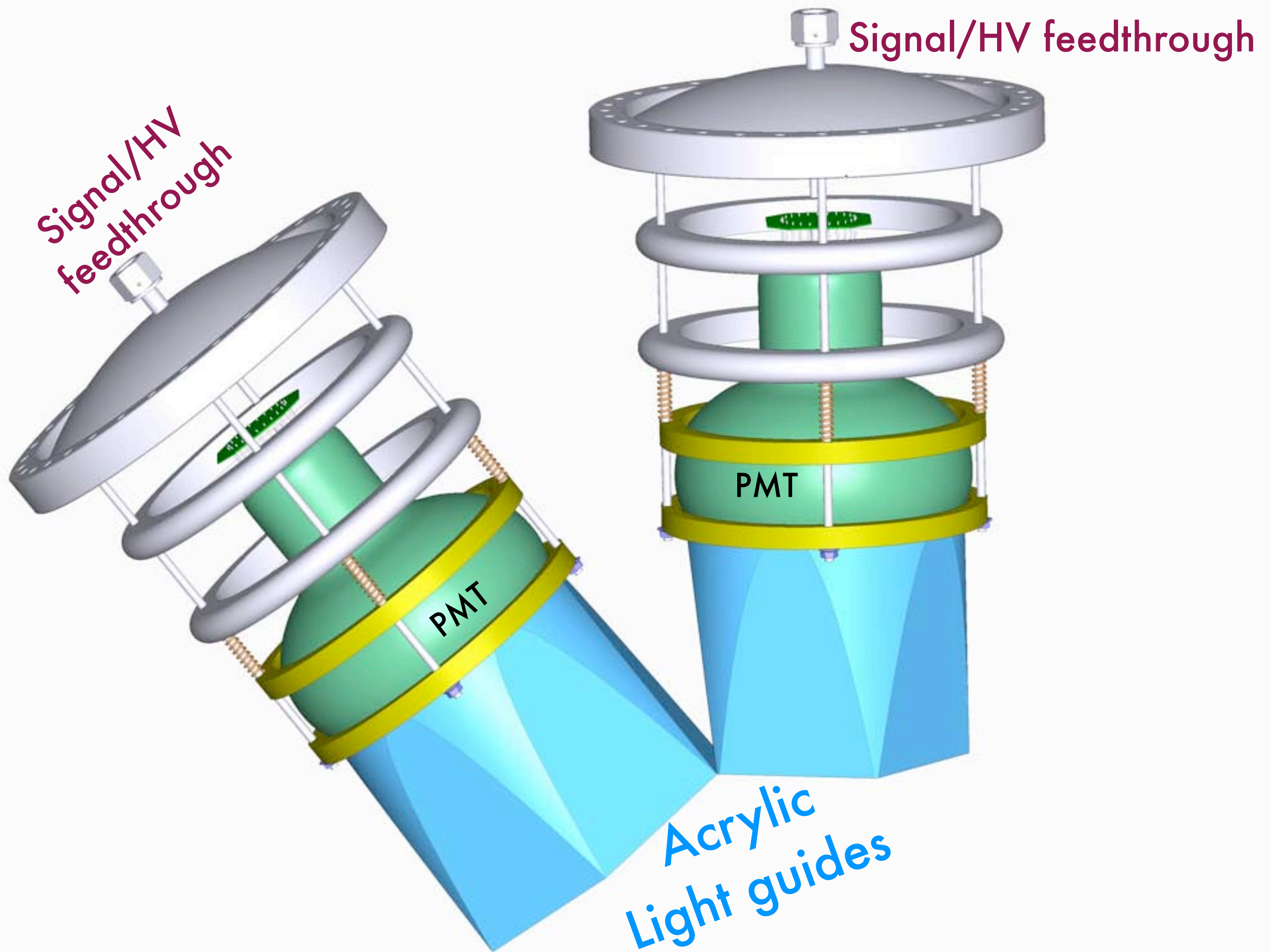
Gas/access ports

Inner Vacuum Can
(IVC)

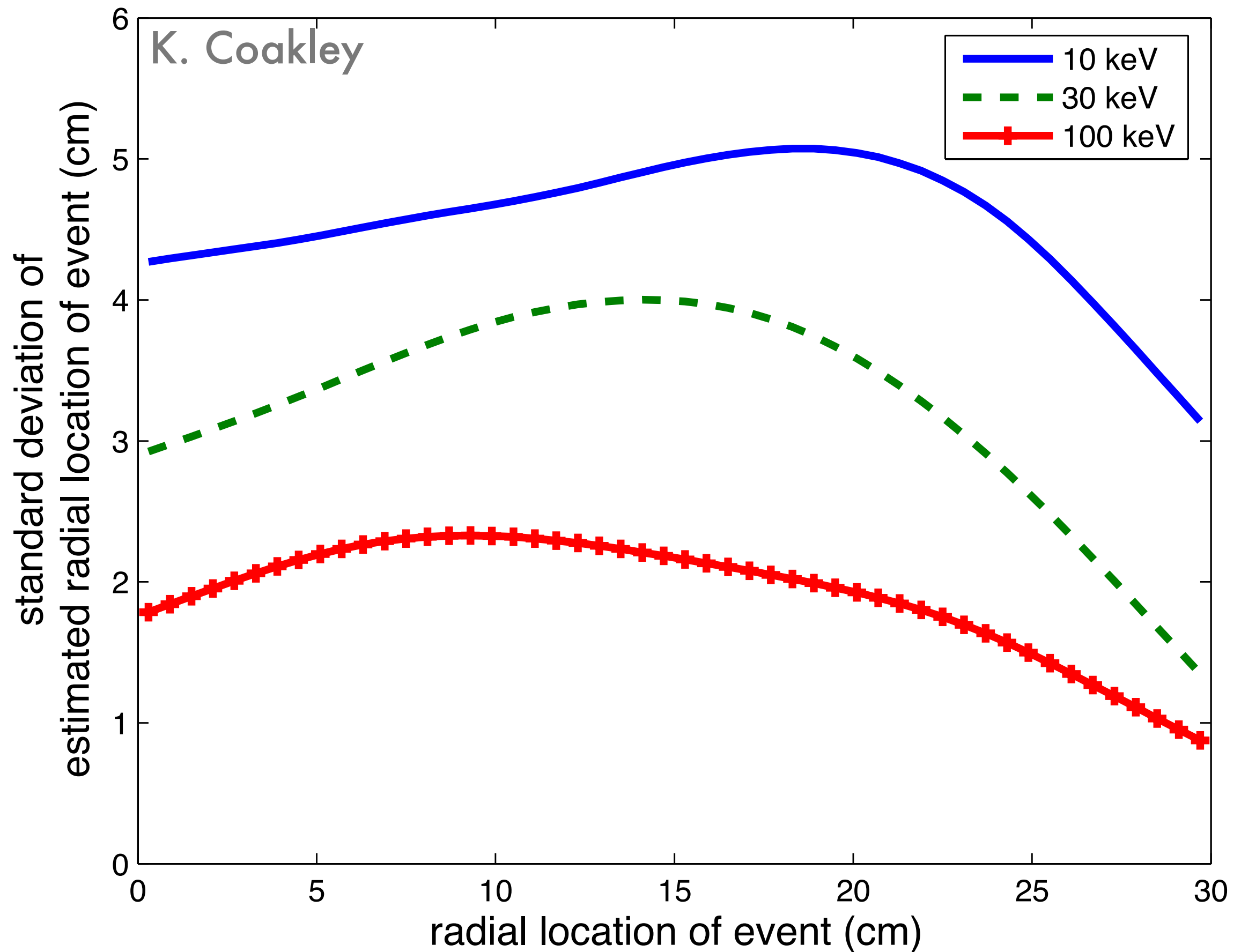


Individually
removable
inserts

- 86 cm diameter central sphere
- 32 x 12" Conflat nipples
- 1.5 m overall diameter



Position reconstruction

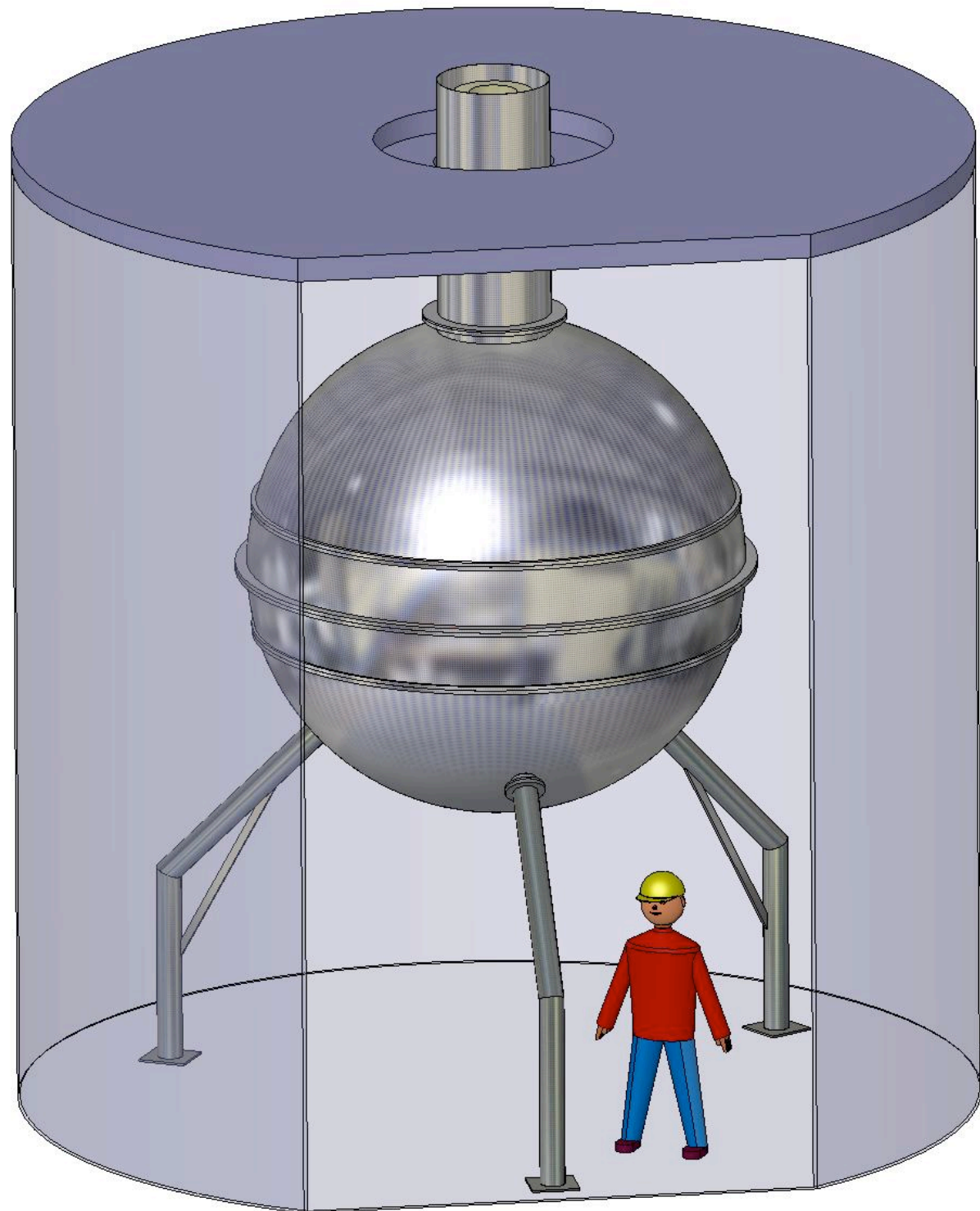


Background Study

D-M. Mei & A. Hime

Component	Material	U/Th	Yield (n / yr)	Yield in Target (n / kg /yr)	Yield in ROI (n / kg /yr)	Yield in ROI* (n / kg /yr)
Fiducial Sphere	15 kg Quartz	3 ppb	19.1	0.090	0.029	0.004
	5 kg SS	3 ppb	4.0	0.009	0.003	0.001
PMT Sphere	20 kg SiO ₂	30 ppb	255	0.055	0.018	0.003
	4 kg B ₂ O ₃	30 ppb	2295	0.495	0.162	0.023
	85 kg SS	3 ppb	68.7	0.024	0.010	0.001
Outer Cryostat	125 kg SS	3 ppb	101	0.033	0.013	0.002
Total			2743	0.706	0.235	0.034

DEAP/CLEAN 3600

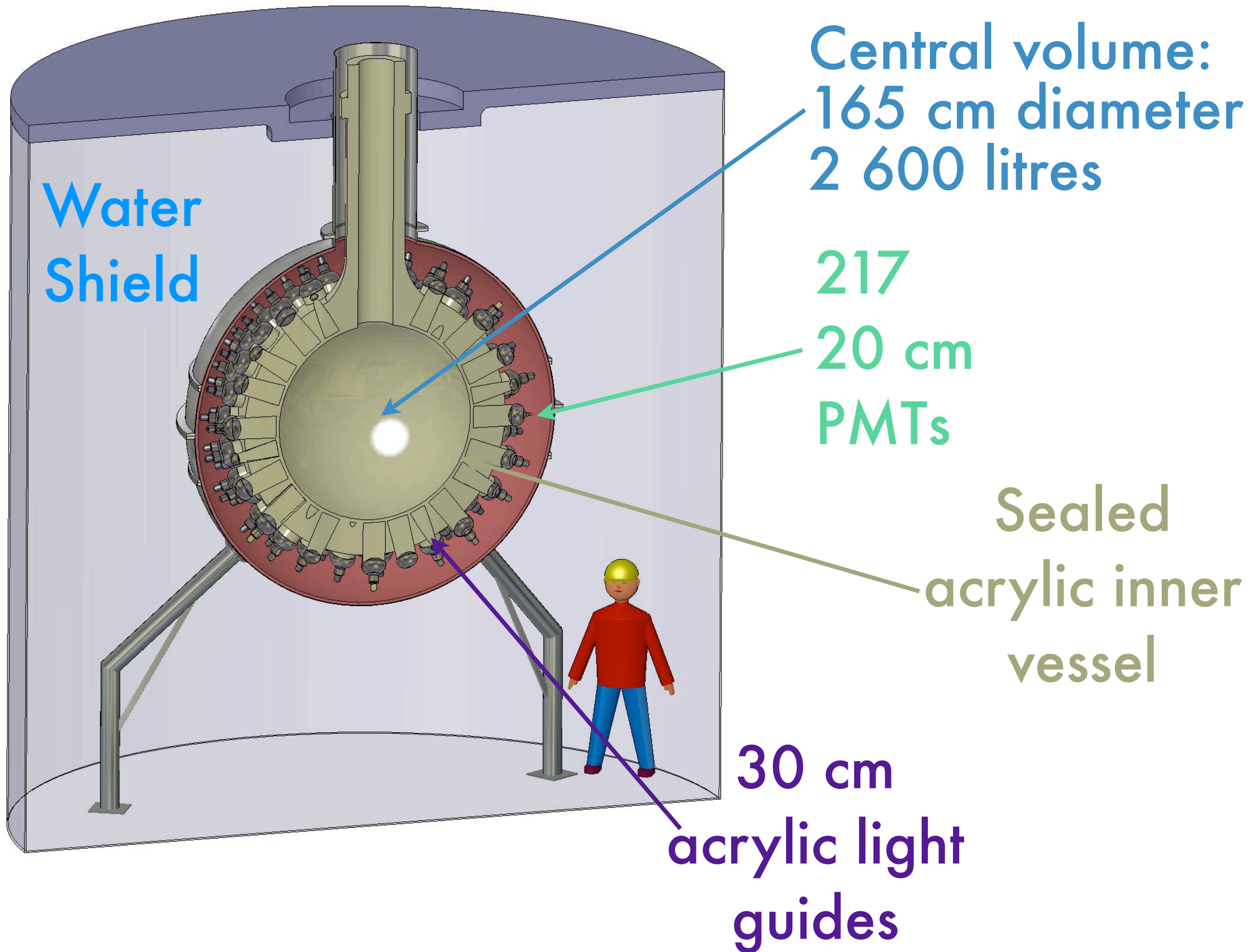


- Dark matter detector with a sensitivity of $3 \times 10^{-46} \text{ cm}^2$ at 100 GeV
- Liquid neon and liquid argon capable
 - 3.1 tonne LNe
 - 3.6 tonne LAr

Collaborating Institutions

- Boston University: E. Kearns
- Carleton University: K. Graham
- LANL: A. Hime
- NIST, Boulder: K. Coakley
- University of North Carolina: R. Henning
- Queen's University: M. Boulay, A. Hallin
- SNOLAB: F. Duncan
- University of South Dakota: D. Mei
- University of Texas, Austin: J. Klein
- Yale University: D. McKinsey

Cryostat option



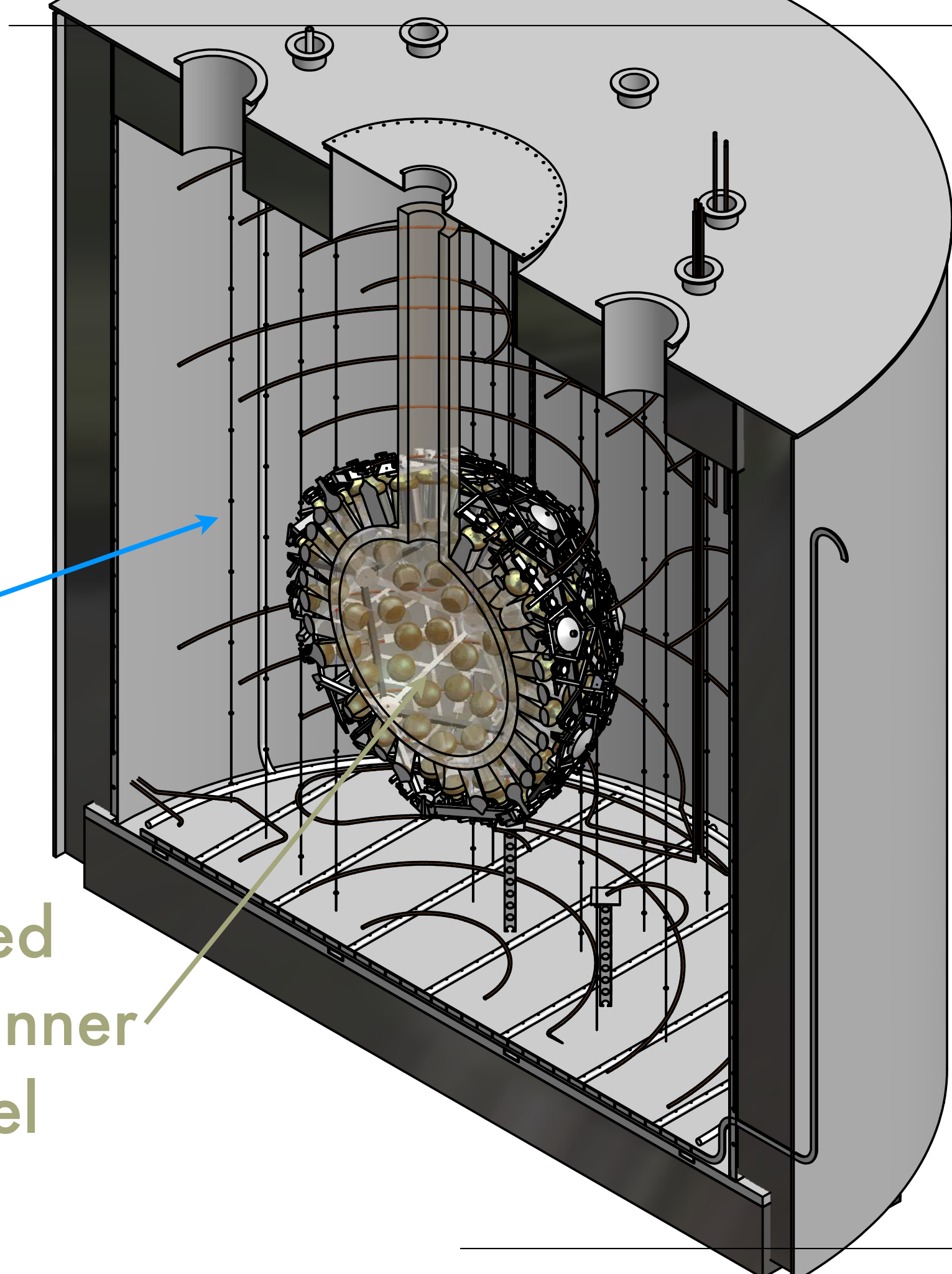
Ice option

Central volume:
165 cm diameter
2 600 litres

Ice with no
cryostat

Reduced
background
by eliminating
steel
cryostat

Sealed
acrylic inner
vessel

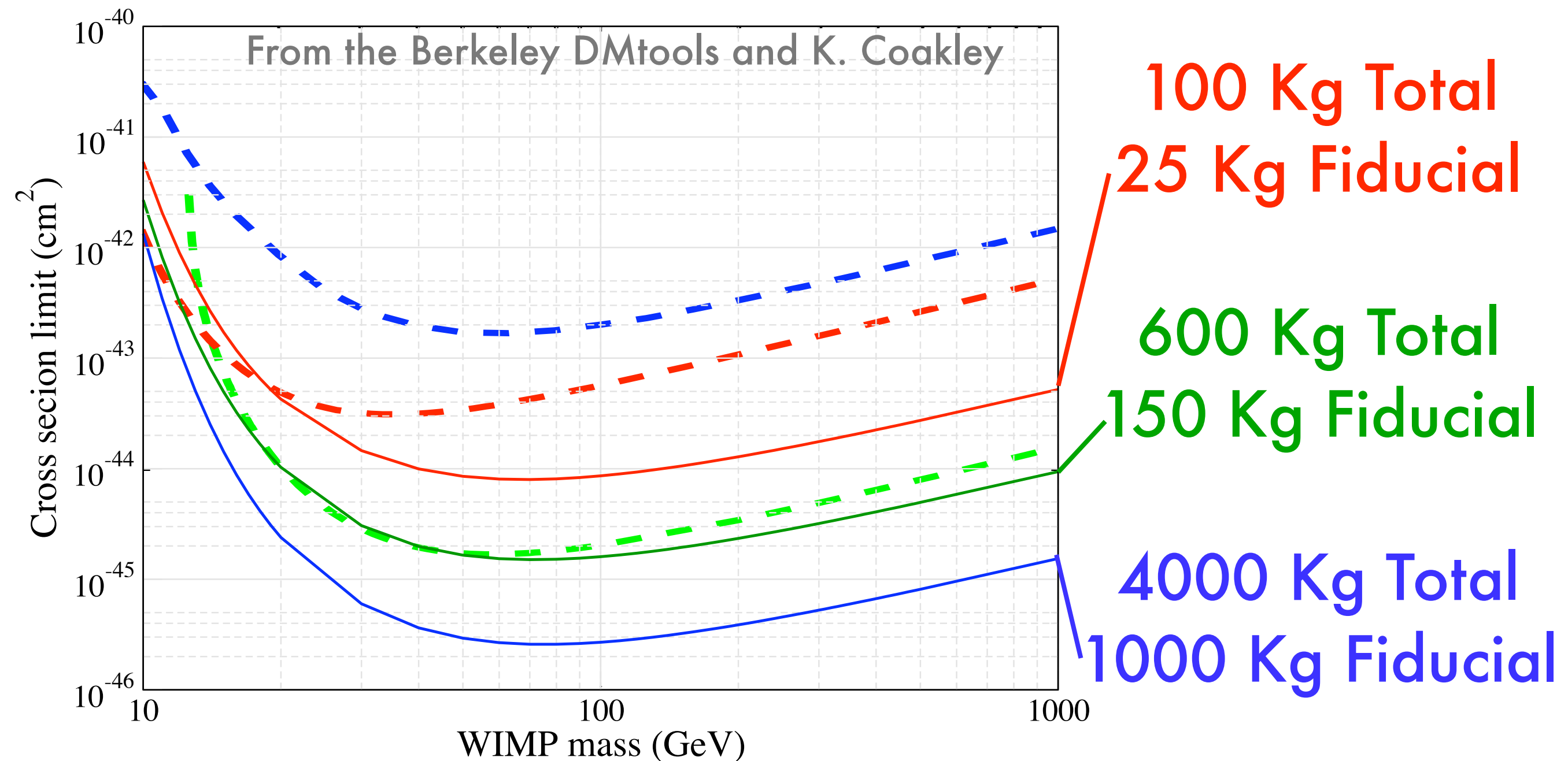


Exclusion limits

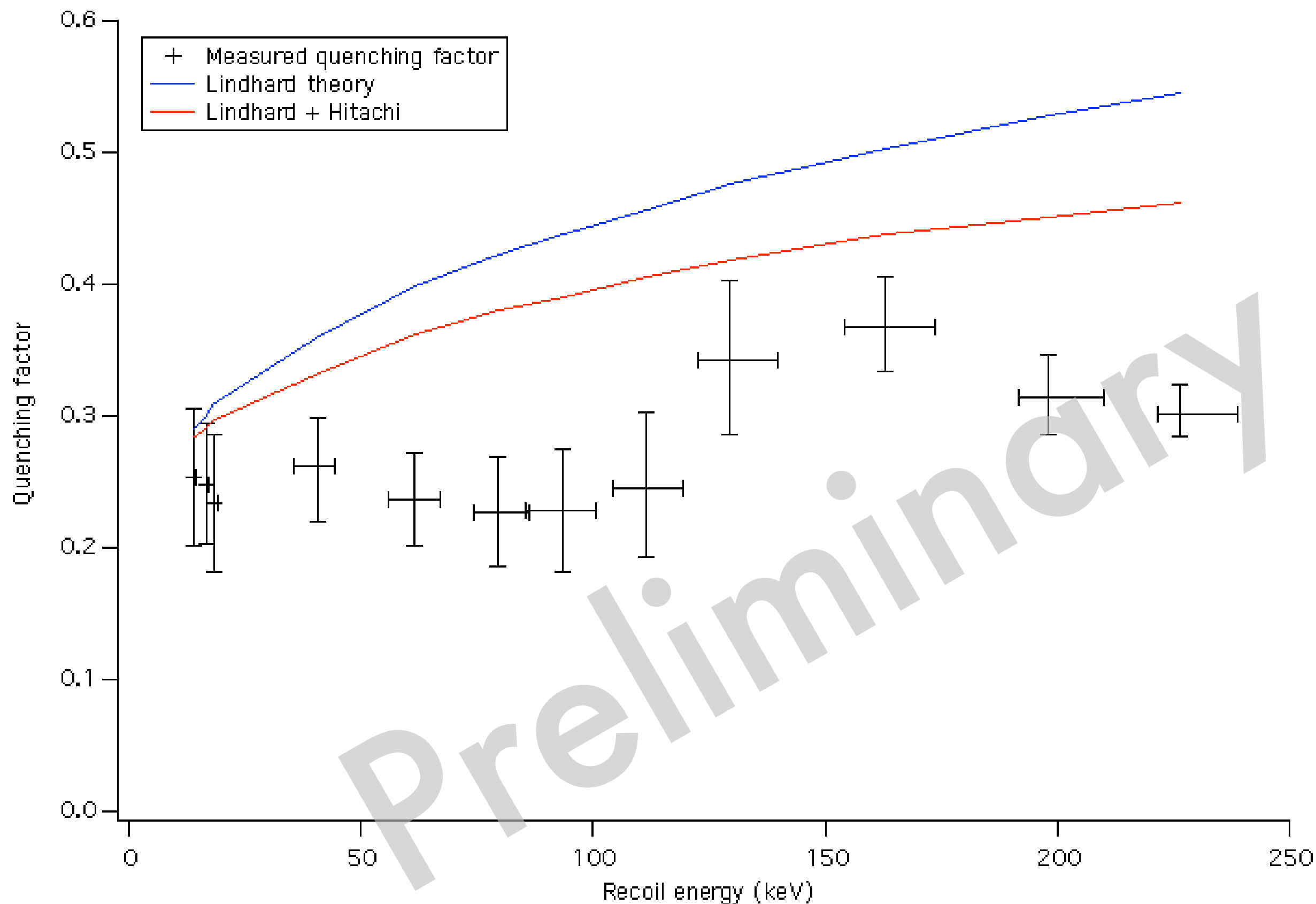
DATA listed top to bottom on plot

- CDMS (Soudan) 2004 + 2005 Ge (7 keV threshold)
- XENON10 2007 (Net 136 kg-d, BG Subtract)
- LUX 300 kg LXe Projection

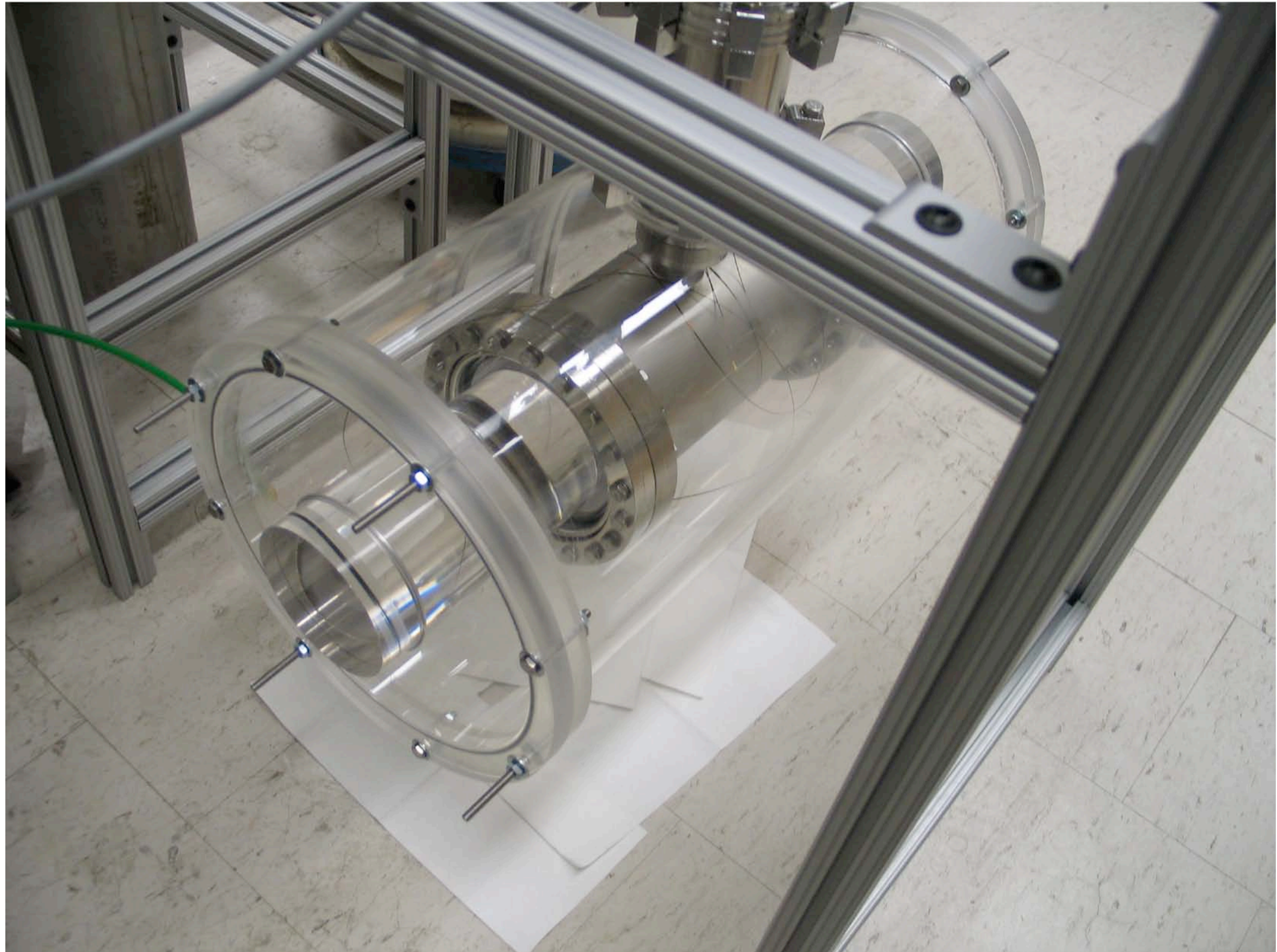
Argon:



Nuclear recoil scintillation efficiency



Argon chamber



SAES getter

Ar liquefying
chamber

Dark box

Water shielding



**PT805/PT810
Pulse Tube
Refrigerators**



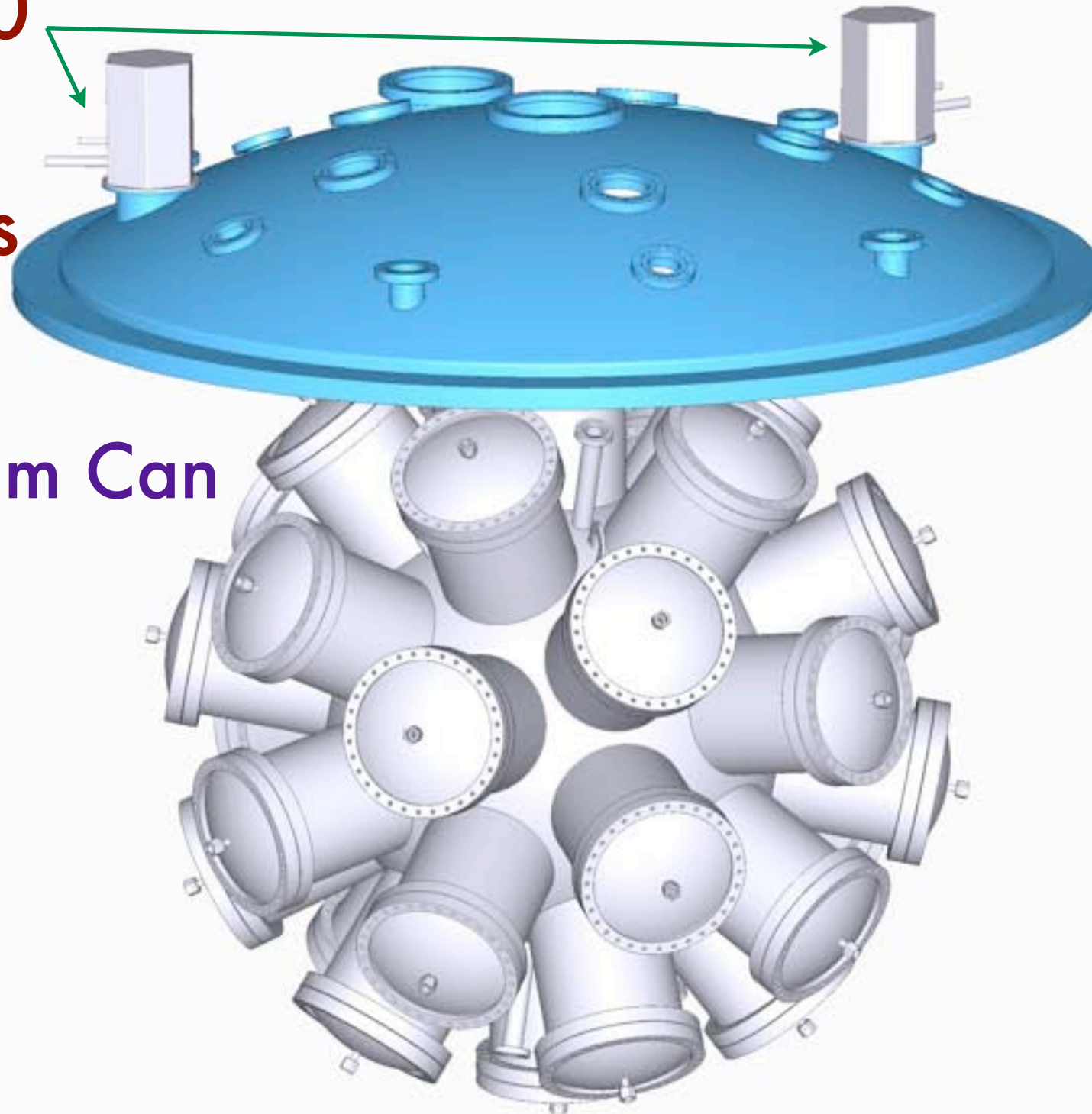
**Outer Vacuum Can
(OVC)**

**2 m diameter
2.3 m tall**

PT805/PT810
Pulse Tube
Refrigerators



PT805/PT810 Pulse Tube Refrigerators



Inner Vacuum Can (IVC)

- 86 cm diameter central sphere
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PT805/PT810
Pulse Tube
Refrigerators

Heat Shield
on
1st Stage

