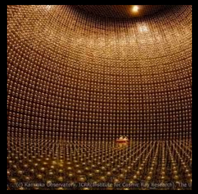
New Particle Searches At Yemilab Large Neutrino Detector

Sunny Seo
Center for Underground Physics
ibs

“Physics of Dark Cosmos”
LaValse Hotel, Busan, 2022



2022.10.23

Outline

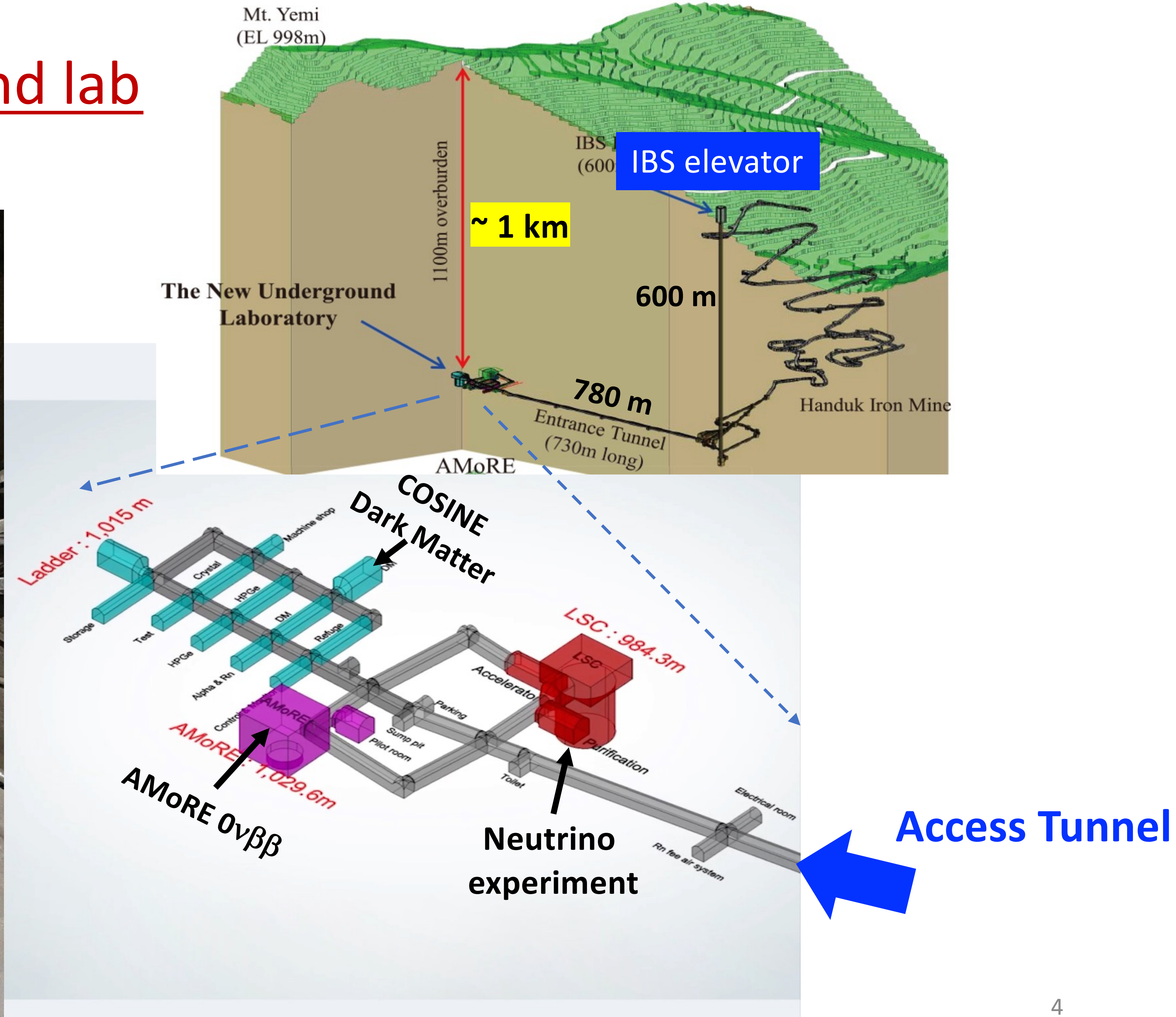
- Introduction to Yemilab
  Large Neutrino Detector
- Dark photon search
- Sterile Neutrino Search

Yemilab @ Handuk Iron Mine

➢ 1st deep underground lab dedicated to science in Korea

Yemi underground lab

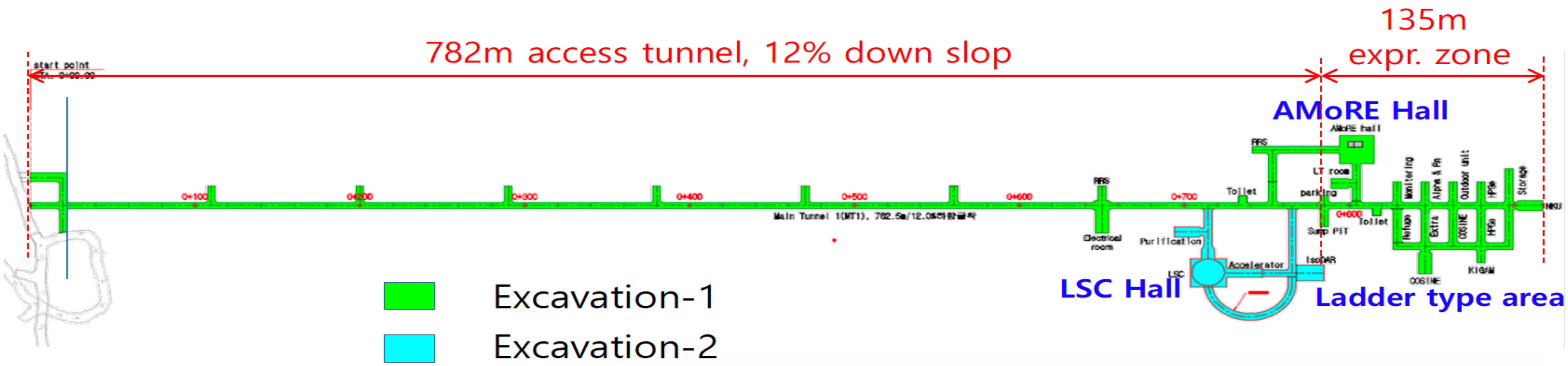
~1 km depth



❖ Yemilab Constructions (2017.09 – 2022.09, 60 months)

K.S. Park
@Yemilab Workshop

- ➢ Yemilab construction had two steps
- ➢ 1st construction (2017.09 – 2020.08)
  - Tunnel excavation : 70% of whole Yemilab volume
  - Building cage system
  - Purchase of surface office building
- ➢ 2nd construction (2021.06 – 2022.09)
  - LSC tunnel excavation : 30% of whole Yemilab volume
  - Electricity, machinery, refuge, toilets
  - Hoist, detector room, clean rooms for AMoRE-II
  - Renovation of surface office



❖ Media Coverage on "Yemilab Opening"

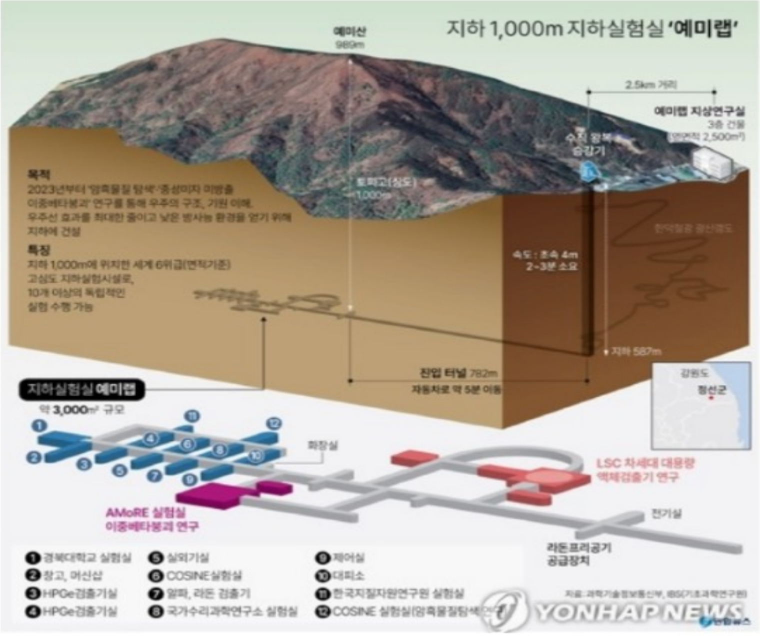
Oct. 5th, 2022

기초과학연구원, 암흑물질탐색·중성미자 연구 2023년부터 본격 실험

2022-10-05
오상미 기자 osm@mtnews.net

▲ 강원도 정선군 예미랩 지상연구실에서 5일(수) 기초과학연구원(IBS) 예미랩 준공식이 개최됐다.

[기계신문] 과학기술정보통신부(이하 '과기정통부')와 기초과학연구원(IBS)은 5일(수) 강원도 정... 예미랩 준공식을 개최했다.



한경 IT·과학

지하 1100m 어둠 속에서 '우주 암흑물질의 비밀' 푼다

이해성 기자

입력 2022.08.11 16:54 수정 2022.08.12 05:42 지면 A14

IBS, 세계적 연구기관 도약

기초과학硏 '예미랩' 내달 준공
강원도 철광 지하에 연구시설

은하의 근원 '암흑물질' 규명 도전

오늘의 주요뉴

동아사이언스

과학

강원 정선 지하 1000m에서 우주 비밀 밝힌다

2022.10.05 14:00

| 기초과학연구원 고심도 지하실험시설 '예미랩' 5일 준공

과기부·기초과학연, 세계 6위 규모 지하실험실 '예미랩' 준공

기사입력 : 2022년10월05일 15:34 | 최종수정 : 2022년10월05일 15:34

가 + 가 - 프린트

5일 강원도 정선군서 준공식 개최
기존 실험실 10배·세계 6위 규모

[단독] 지하 1km 아래 '거대 실험실'…그곳에 우주 비밀이 있다

중앙일보 | 입력 2022.08.19 10:50 업데이트 2022.08.19 16:40

최준호 기자 구독

[최준호의 첨단의 끝을 찾아서]IBS 지하실험연구단 정선 예미랩

우주의 수수께끼 풀러 1000m 땅속으로 들어가다

이근영 기자 + 구독

YouTube 팝콘뉴스TV

이웃과 함께하는 팝콘뉴스

#이웃공동체 #상생경제 #MZ열전 #오피니언

우오현 SM그룹 회장 "세계 최초 암흑물질 발견 위해 적극 협력"

SM한덕철광산업, 정선 '예미랩 지하실험실' 완공

정찬혁 기자 (hyuck277@daum.net) | 기사입력 2022/10/07 [13:43]

The 1st Yemilab Workshop

Oct.15-18, 2022

Oct 15 – 18, 2022
High-1 Resort, Grand Hotel Convention Tower 5th floor
Asia/Seoul timezone

https://indico.ibs.re.kr/event/531/

This is a Hybrid Workshop. Registered participatns will get ZOOM connection info.

- Overview
- Timetable
- Contribution List
- Registration
- Participant List
- Venue
- Accommodation
- Meals and Banquet
- Gondola and Hiking
- LOC
- Covid Situation
- Visa & Entrance to Korea

Contact

sunny.seo@ibs.re.kr

Welcome to the 1st Yemilab Workshop!

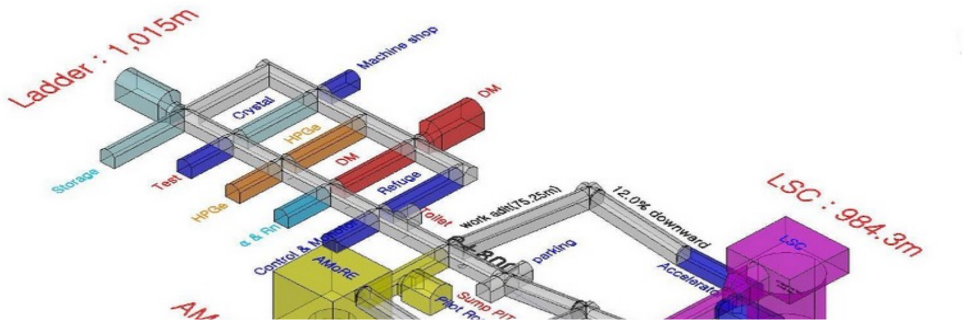
Yemilab is the first deep underground lab dedicated to science in Korea and its construction was successfully finished recently. To celebrate the kick-off of the Yemilab, we are organizing this workshop and cordially invite world experts in underground physics. New ideas, technologies, or perspectives will be shared in this workshop.

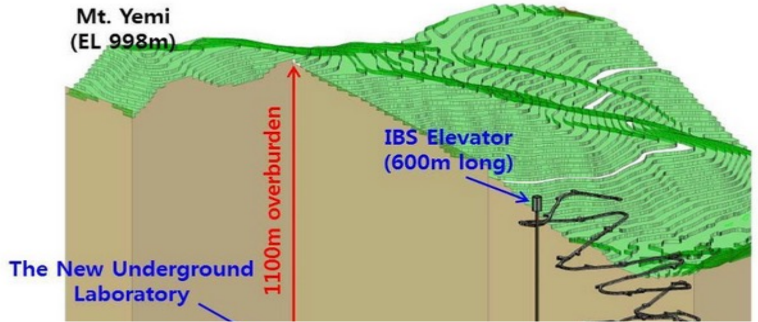
Anyone who is curious or excited about Yemilab is very welcome to join us!

No registration fee.

Free meals for all in-person participants who register **by Oct. 6 (Th)**.

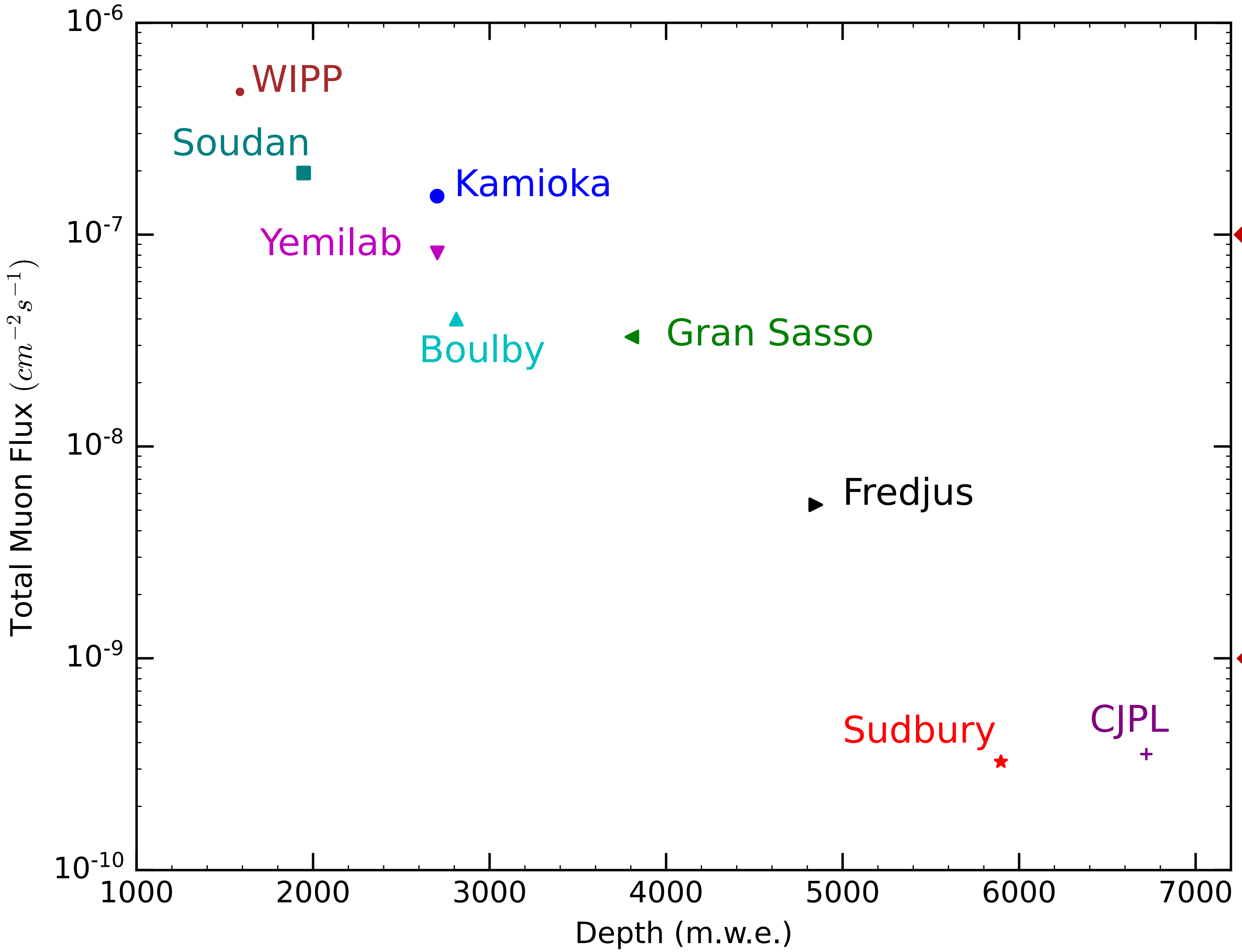
- 10/15 (Sat): Arrival, Registration, Reception
- 10/16 (Sun): Yemilab Tour
- 10/17(M)-18(Tu): Physics Workshop, Banquet





Muon Fluxes @ World Underground Labs

❑ **Yemilab** is the **6th** largest underground lab in the world.



~86 muons/day/m^2

< 1 muons/day/m^2

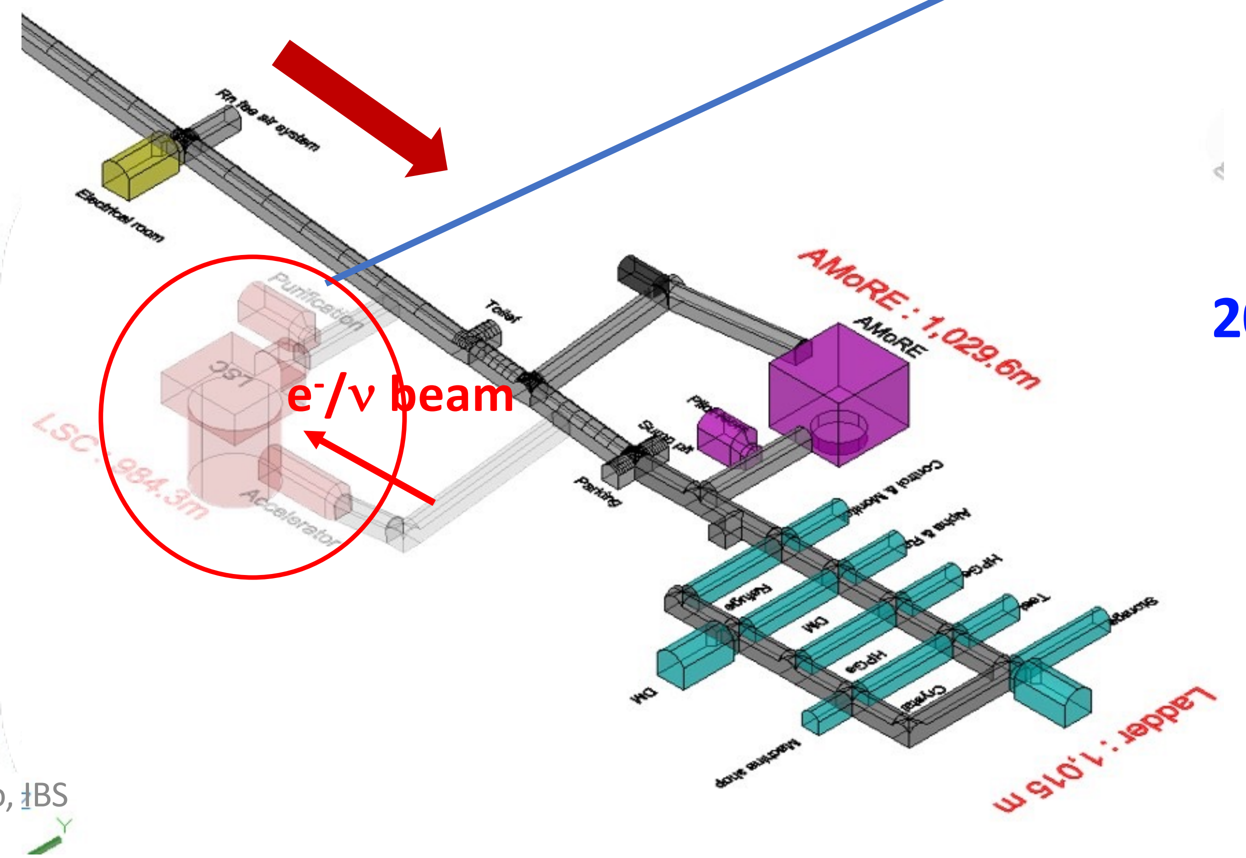
Large ν Detector (LSC) @Yemilab

LSC = Liquid Scintillation Counter

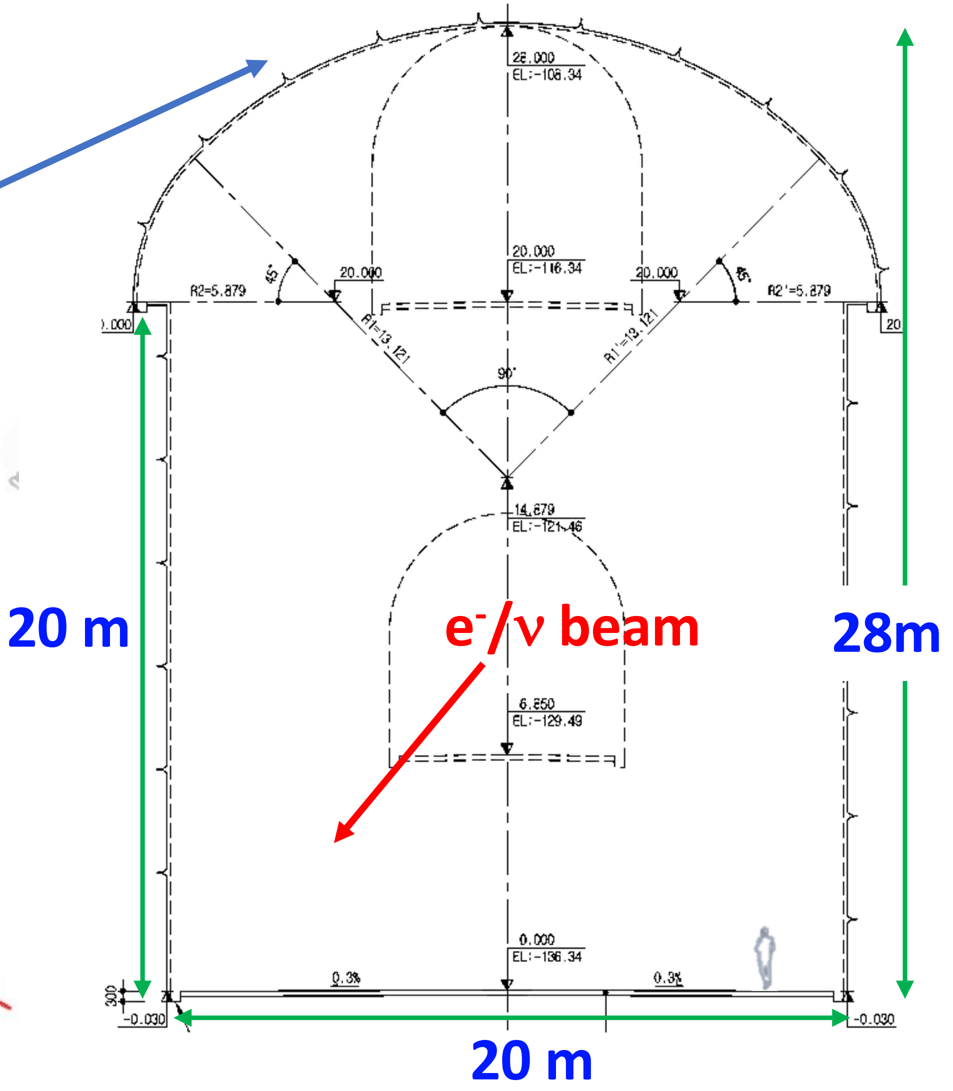
LSC Pit: 20 m (D) x 20 m (H)

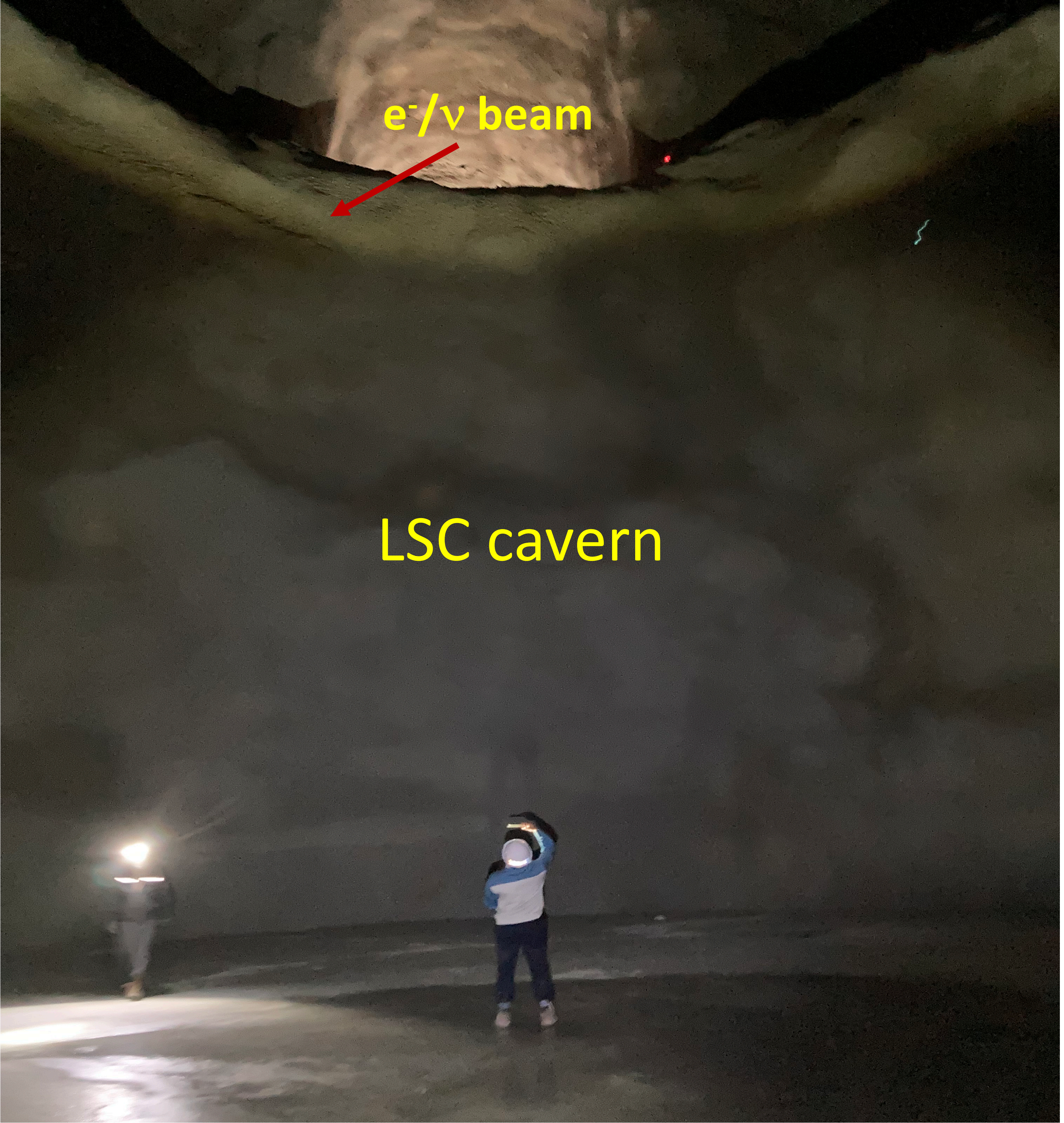
LSC Hall construction:
June 2021 – Feb. 2022

Tunnel entrance



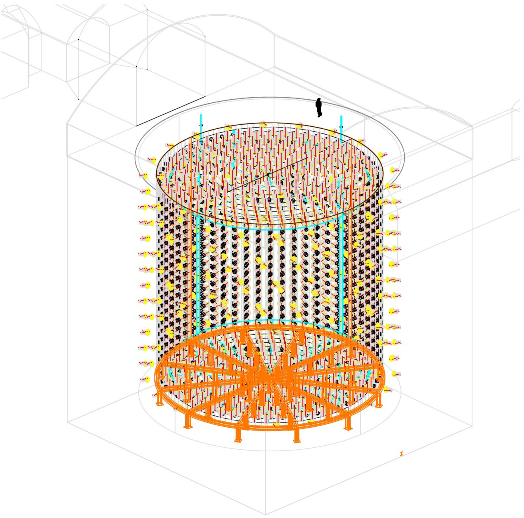
LSC Hall

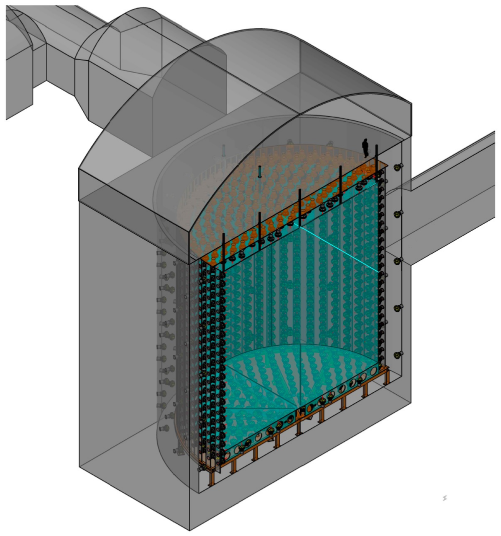


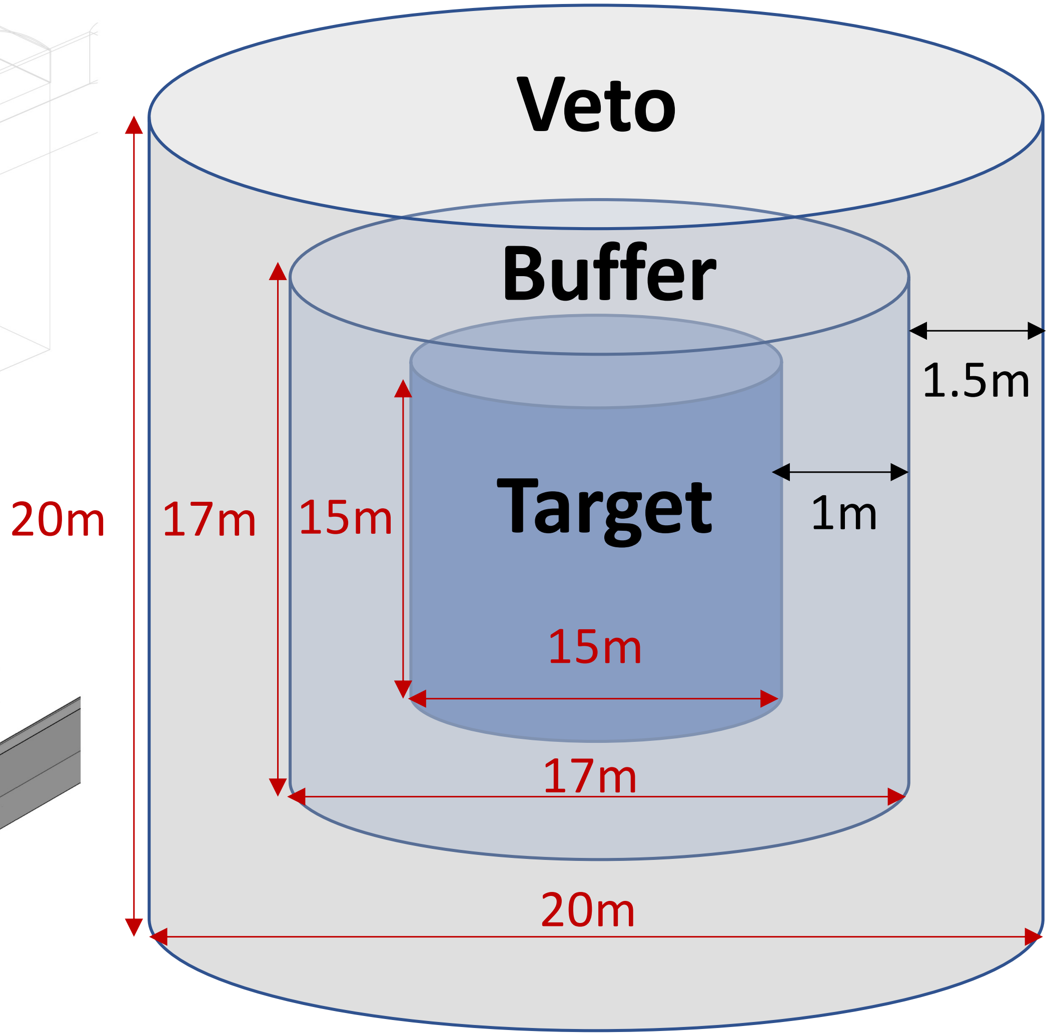

e^-/ν beam
LSC cavern


Oct. 5, 2022
LSC cavern
e^-/ν beam

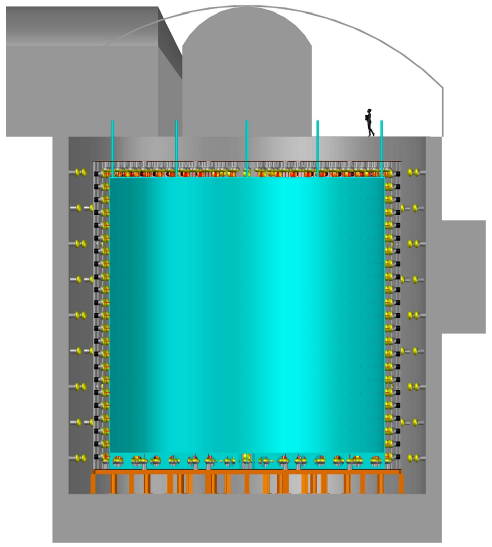
Candidate Detector Design







Target: 2.26 kton LS
Buffer: 1.14 kton mineral oil
Veto: 2.41 kton water



1200(1800,2400) x 20 inch PMTs = 20% (30, 40)% coverage

Why LS Detector ?

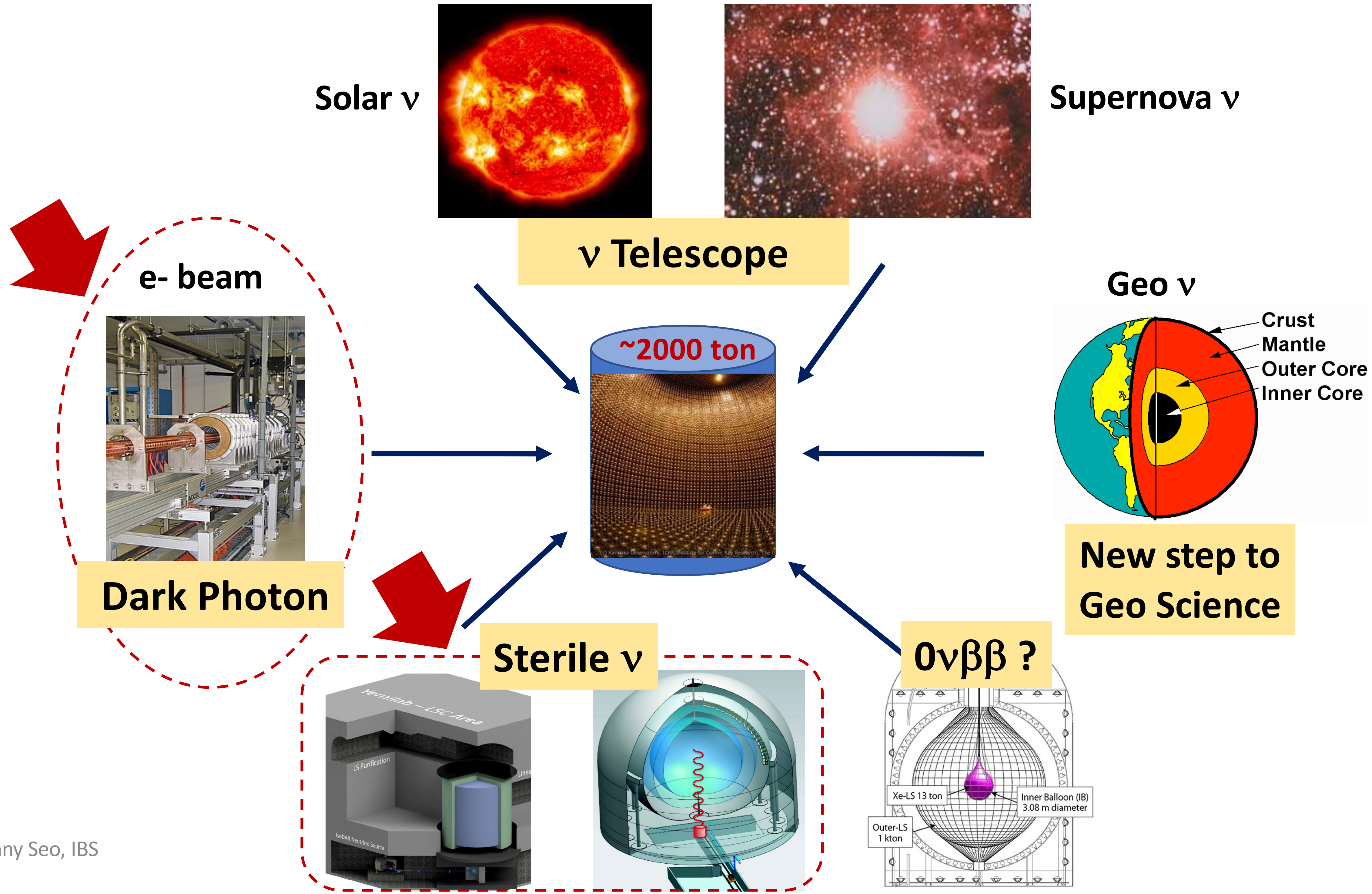
❑ Light yield of LS is high.

→Good energy resolution, low threshold of energy

→Good for physics at O(1~10 MeV)

- ✓ Discovery of neutrino in 1956 was done using LS detector by **Rines and Cowan**'s team.
- ✓ θ_{13} in PMNS matrix was discovered using LS detectors in 2012 by **Daya Bay & RENO**.
- ✓ Many sterile neutrino search experiments using reactors use LS detector (**NEOS, PROSPECT, STEREO** etc).
- ✓ **Borexino** solar ν experiment used LS detector.
- ✓ **JUNO** is a LS detector to determine ν mass ordering.

Broad Physics Program



Standard Model has been very successful

But…

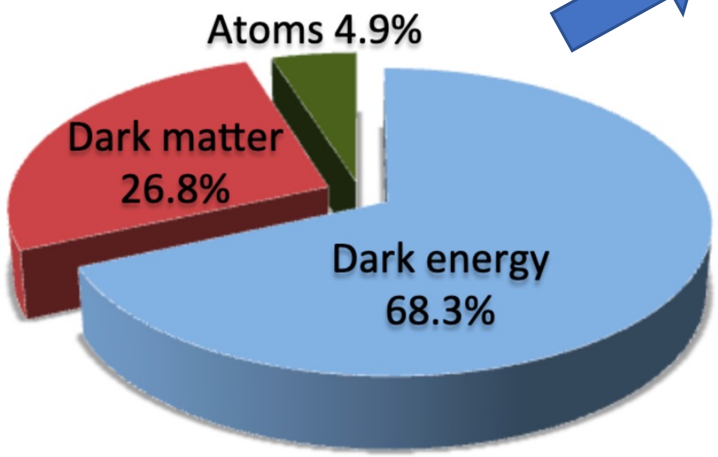
~~proton radius: 7 σ discrepancy~~

0.877 fm vs **0.842 fm**

Anomalous magnetic moment of muon: $a_\mu = (g_\mu - 2)/2$

e^+ excess in cosmic rays (PAMELA, FERMI, AMS)

Dark sector ?



Excess of events of unknown origin (DAMA/LIBRA, CoGENT)

$\bar{p}$ excess in cosmic rays (AMS)

Dark Photon (DP) ϕ, γ', A'

❖ DP is the simpleset and most popular hypothetical particle in a dark sector.

- DP can mediate interaction w/ dark matter.
- DP itself can be a candidate of dark matter.
- DP can be searched via vector portal.

$$\mathcal{L} \supset -\frac{1}{4} F'_{\mu\nu} F'^{\mu\nu} + \frac{\epsilon}{2} F'_{\mu\nu} F^{\mu\nu} + \frac{m_\phi^2}{2} A'_\mu A'^\mu$$

DP field strength tensor

$U(1)_D$ gauge field

ε: "kinetic mixing" parameter

Dark Photon Search Experiments

- ❑ Beam dump (thick target)
- ❑ Fixed target (thin target)

e^- beam: **E137**, KEK, Orsay, E141, E774, NA64, BDX, LDMX, HPS

e^+ beam: MMAPS, VEPP-3, PADME

γ beam: GlueX, LEPS2, LEPS, and FOREST

p beam: SHiP, NA62, FASER, REDTOP, SeaQuest

- ❑ Collider Exp.

e^+e^-: Belle-II, KLOE-2

pp: LHCb

- ❑ Astrophysical Obs.

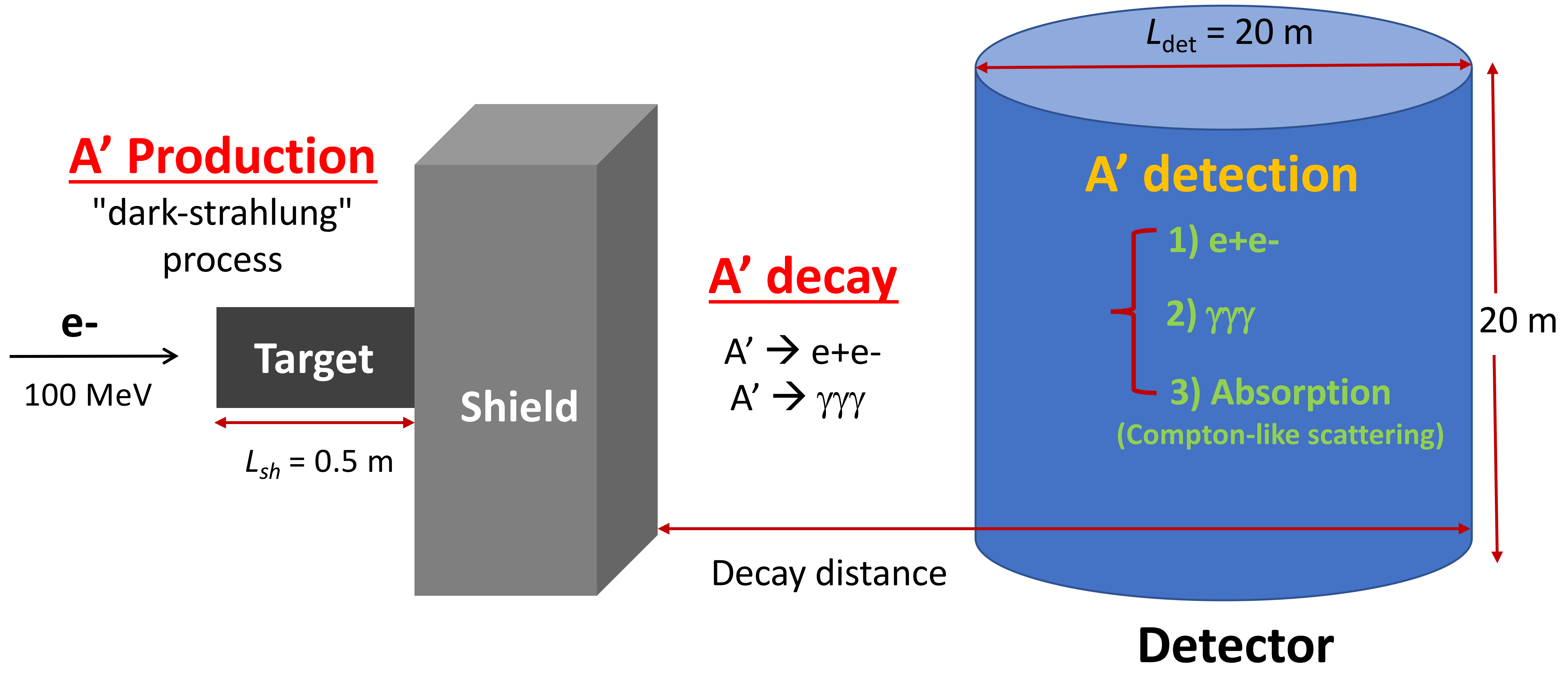
SN 1987A, Sun etc.

➢ **Increased interest on Dark Photon Search !!**

Dark Photon Search Scheme w/ LSC

- **Currently, no DP search experiments at underground.**

  Izaguirre, Krnjaic, Pospelov, PRD 92, 095014 (2015)

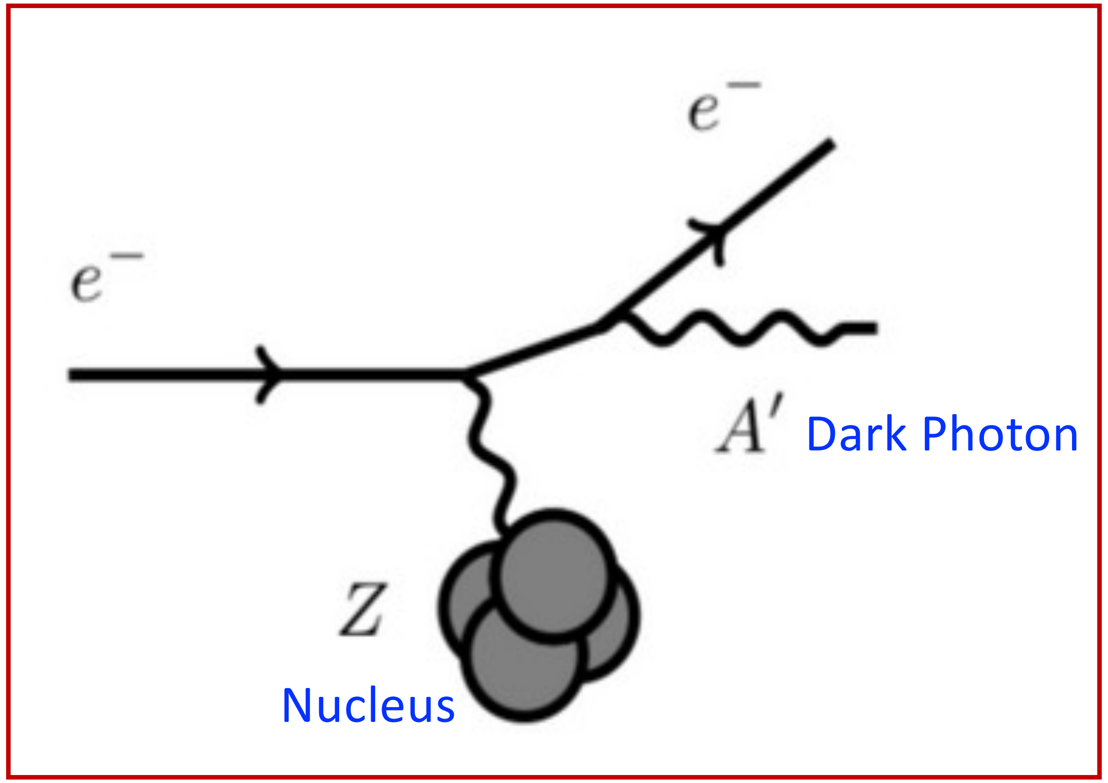


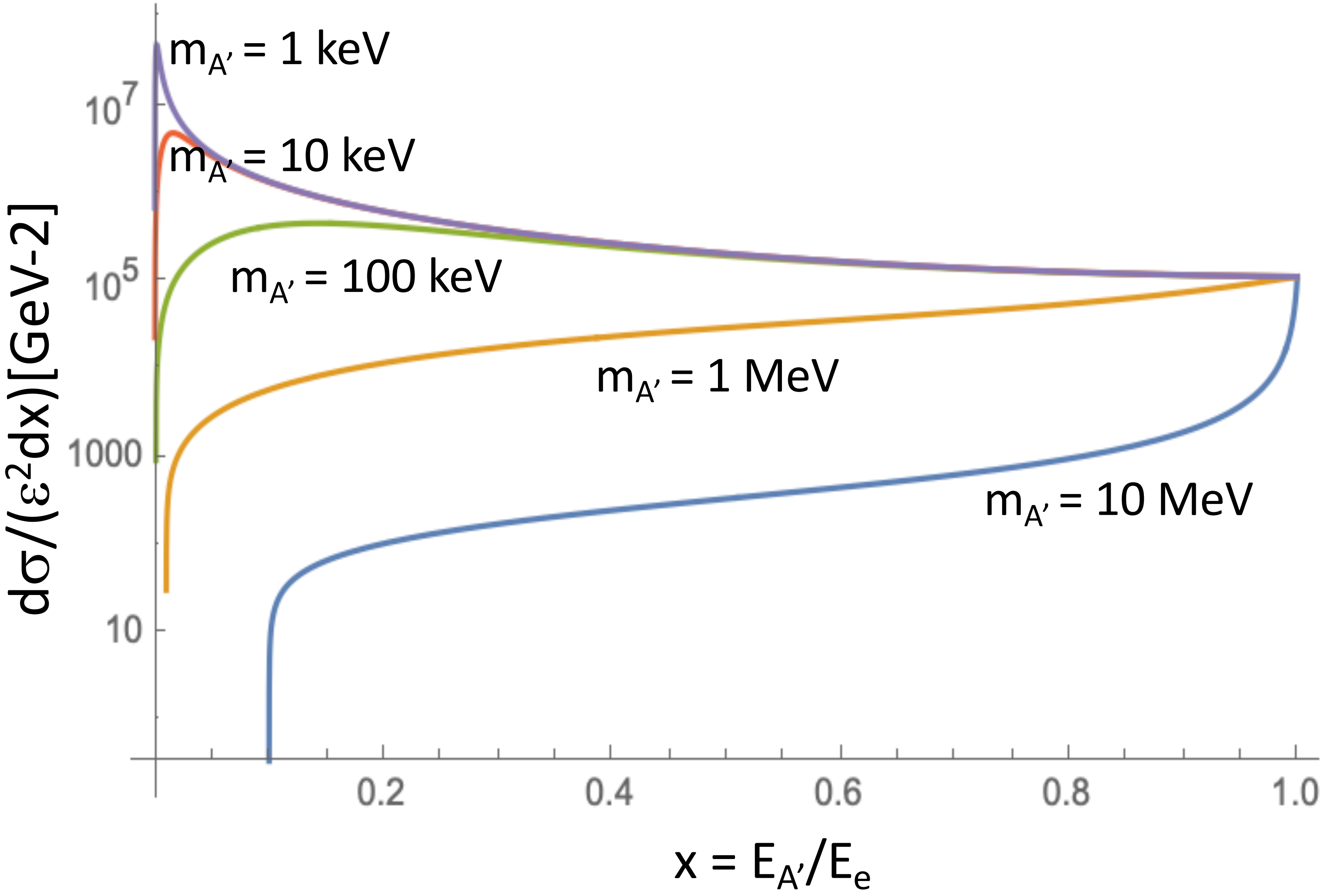
Dark Photon Production

e⁻ beam

“Bremsstrahlung-like” process

“Dark-strahlung”





E137, KEK, Orsay, E141, E774, NA64, BDX, LDMX, HPS

Dark Photon Detections

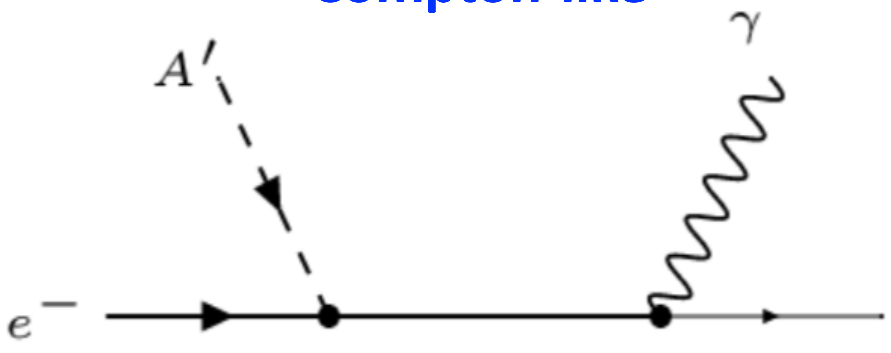
❑ Visible Decays

A’ → e+ e- (> 1 MeV)

A’ → γγγ (< 1 MeV)

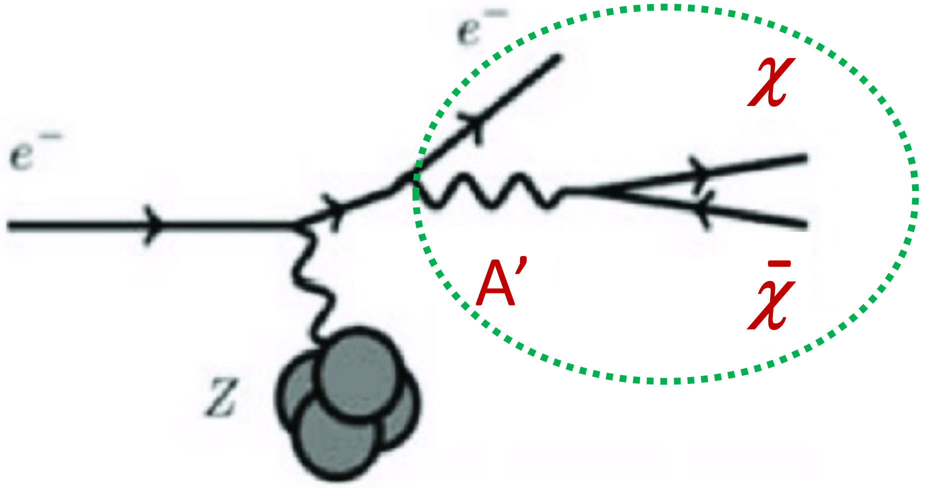
❑ Absorption

Compton-like



In our study,
we considered **only visible decay & absorption**.

❑ Invisible Decays



Expected # of Dark Photons

- ❑ **Production: "dark-strahlung"**
- ❑ **Detection : *A' → e+e- or 3γ, or A' absorption***

$$N_\phi \approx \frac{N_e X}{M} \int_{E_{\min}}^{E_0} dE \int_{x_{\min}}^{x_{\max}} \times dx \int_0^T dt I_e(E_0, E, t) \frac{d\sigma}{dx} e^{-L_{\rm sh}\left(\frac{1}{l_\phi}+\frac{1}{\lambda}\right)} \left(1 - e^{-L_{\rm dec}/l_\phi}\right)$$

DP production x-section

only decay signal

Liu & Miller: PRD 96, 016004 (2017)

We should add an additional term of DP absorption signal to decay signal.

$$\mathrm{x}[1 - \exp(-L_{dec}/l_\phi - L_{det}/\lambda_{det})]$$

decay or absorption signal

where,
L_{det}: detector length
λ_{det}: DP abs. length in detector

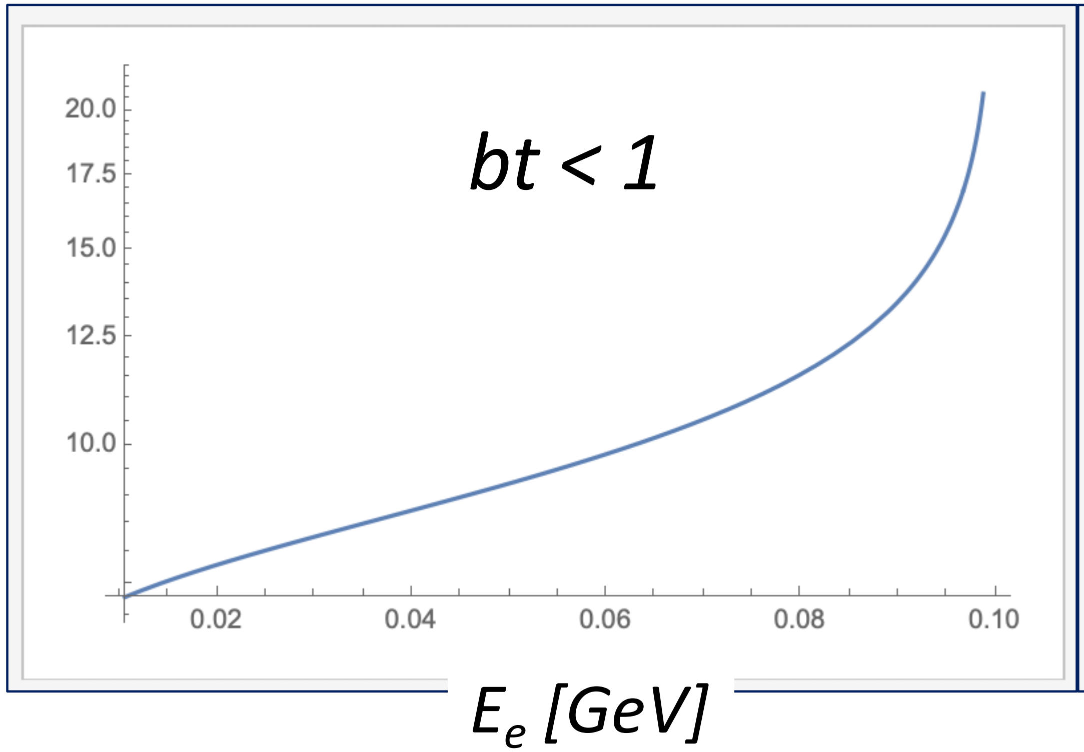
(Continued…)

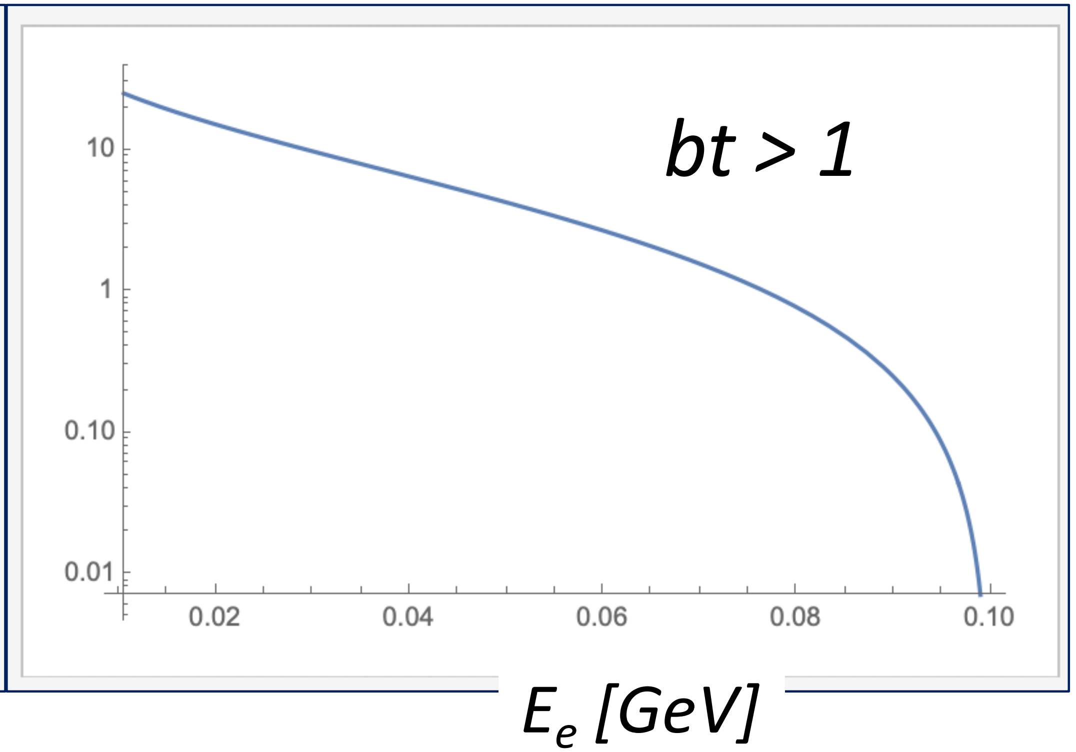
e- spectrum at *t* radiation length in beam target

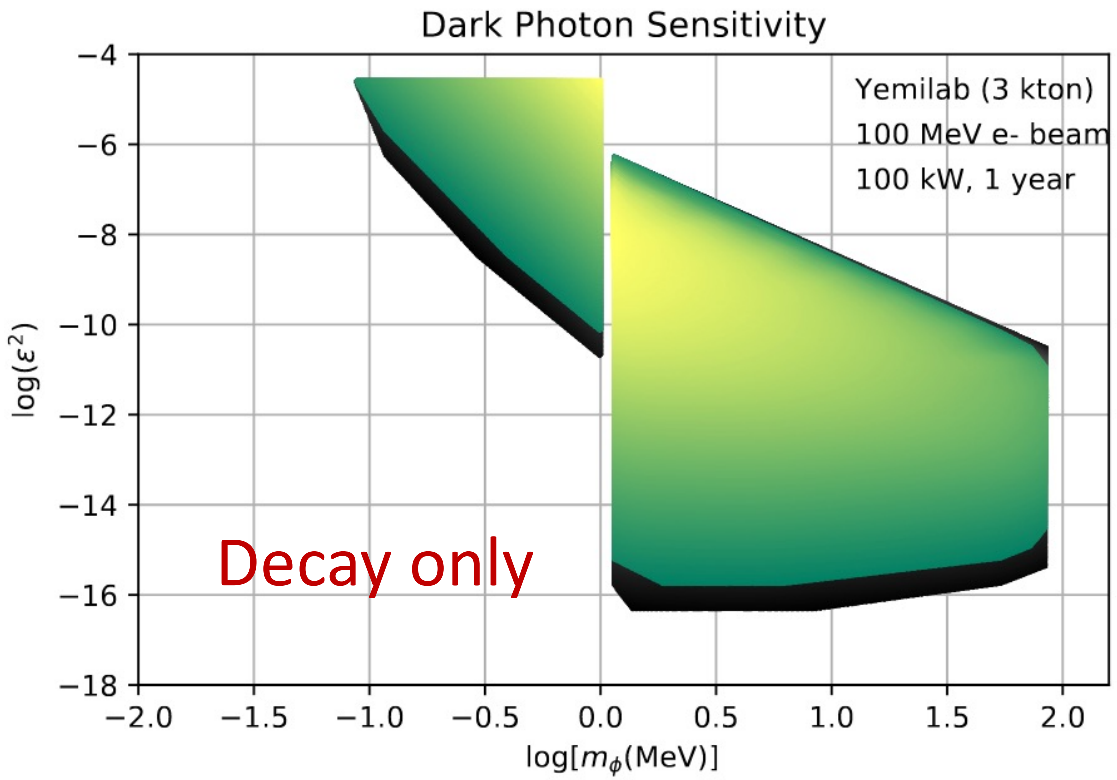
$$I_e(E_0, E, t) = \frac{\left(\ln \frac{E_0}{E}\right)^{bt-1}}{E_0 \Gamma(bt)},$$

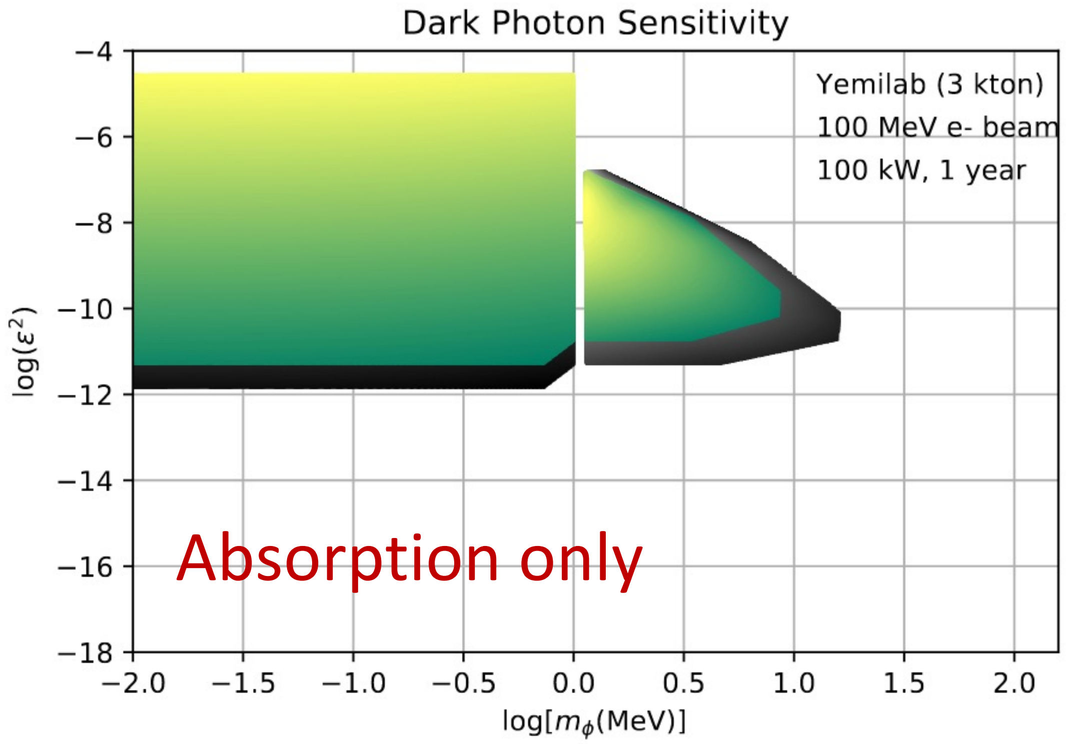
Thick target approximation
(Tsai, 1974)

(b = 4/3 for vector particle)






Dark Photon Sensitivity
Yemilab (3 kton)
100 MeV e- beam
100 kW, 1 year
Decay only
log(ε²)
log[m_ϕ(MeV)]


Dark Photon Sensitivity
Yemilab (3 kton)
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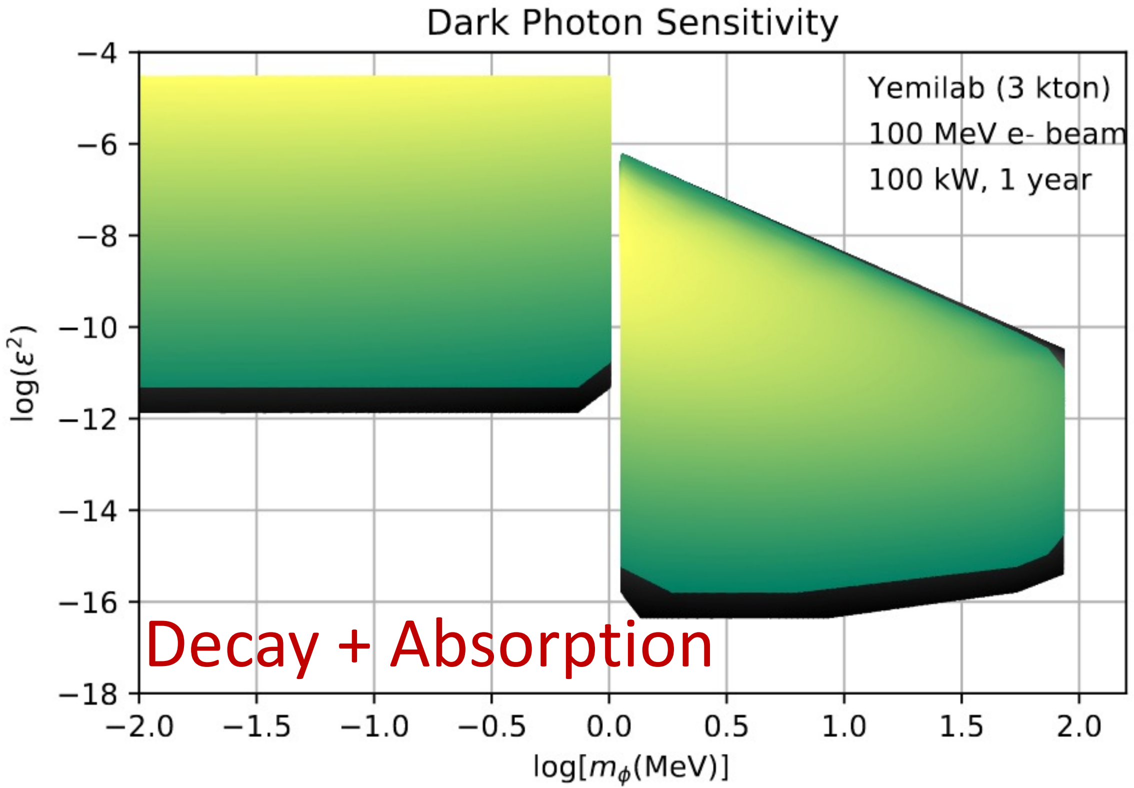

Dark Photon Sensitivity
Yemilab (3 kton)
100 MeV e- beam
100 kW, 1 year
Decay + Absorption
log(ε²)
log[m_ϕ(MeV)]

Rough Background Estimation

Signal = Beam (ON – OFF) data ~ 0 events

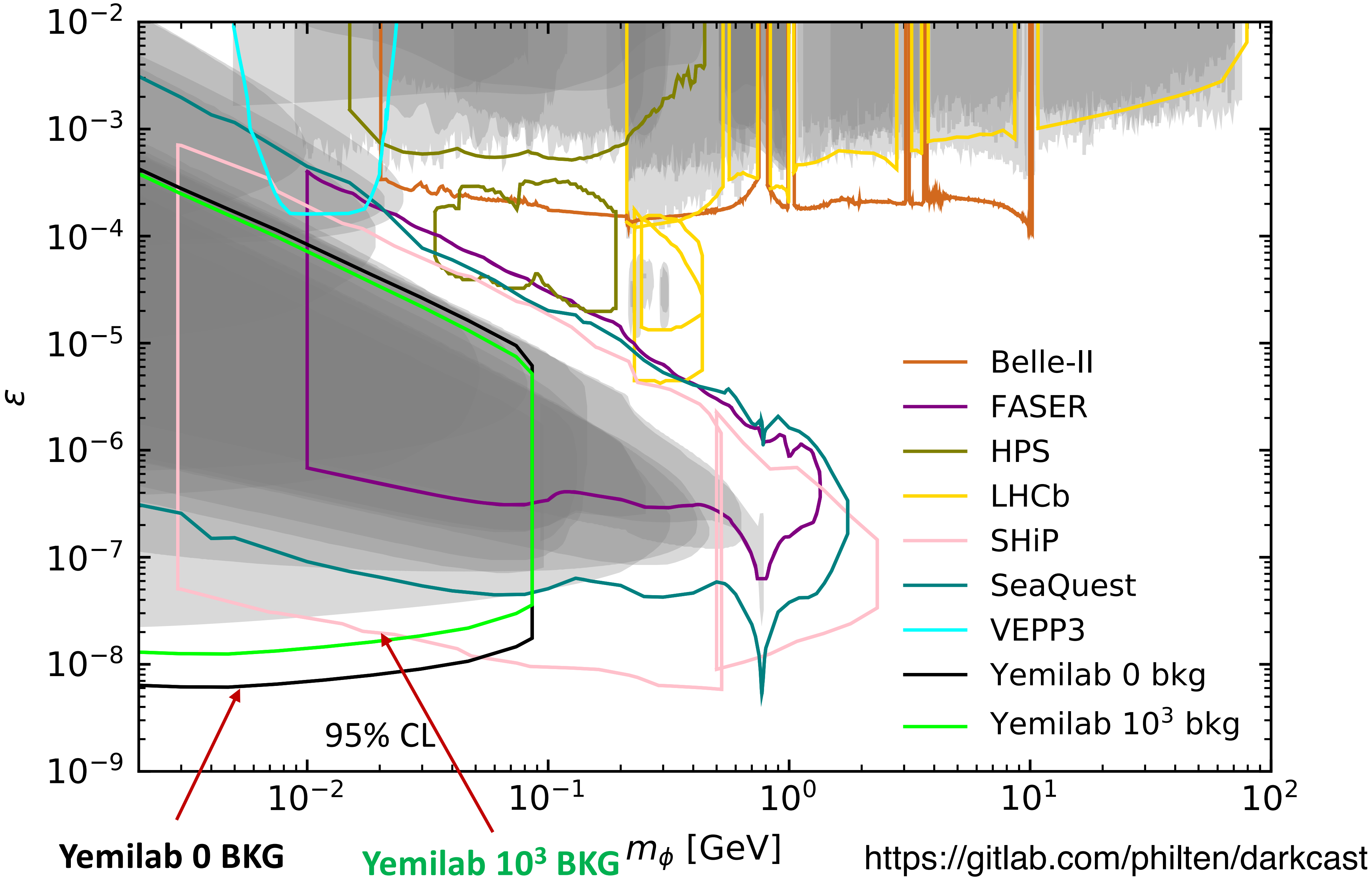
→ # of background events in beam OFF data can affect our sensitivity

Background types	#. BKG events (/year/1 kton fiducial vol.)	Comments
Solar ν (^{8}B), residual, external BKG	935	Estimated from Borexino arXiv:1709.00756
Atmospheric ν	67	Estimated from Borexino *J.Phys.Conf.Ser.* 675 (2016) 1, 012014
Neutrons from beam	0	Block w/ rocks (few meters) & 5 MeV cut
ν from beam	0	negligible
Total	1002	

23

Current Limits & Future Projections

S.H. Seo & Y.D. Kim
JHEP04(2021)135



Best "direct" DP search sensitivity in $M_{\phi} < 30$ MeV (10^3 BKG)

$\gamma \rightarrow$ A' Oscillations ($m_\phi < 1$ MeV)

- $\gamma \longrightarrow$ A' oscillation @ target (**T**ungsten)

$$P(\gamma \to A') = \epsilon^2 \times \frac{m_\phi{}^4}{(\Delta m^2)^2 + E_\gamma^2 \Gamma^2},$$

1812.02719
1804.10777
1501.07292

- A' $\longrightarrow \gamma$ oscillation @ detector (**W**ater)

$$P(A' \to \gamma) = \epsilon^2 \times \frac{m_\phi{}^4}{(\Delta m^2)^2 + E_\gamma^2 \Gamma^2} \times \Gamma L,$$

$$\text{where } \Delta m^2 = \sqrt{(m_\phi^2 - m_\gamma^2)^2 + 2\epsilon^2 m_\phi^2 (m_\phi^2 + m_\gamma^2)} \approx |m_\phi^2 - m_\gamma^2|, \; m_\gamma = \sqrt{4\pi\alpha n_e / m_e}$$

$$P(\gamma \leftrightarrow A') = \epsilon^4 \times \frac{m_\phi^8}{\left((m_\phi^2 - m_\gamma^{\mathrm{T}\,2})^2 + E_\gamma^2 \Gamma_{\mathrm{T}}^2\right) \times \left((m_\phi^2 - m_\gamma^{\mathrm{W}\,2})^2 + E_\gamma^2 \Gamma_{\mathrm{W}}^2\right)} \times \Gamma_{\mathrm{W}} L,$$

$$N_\phi^{\mathrm{osc}} \approx N_{\mathrm{e}} \times \int_{E_\gamma^{\mathrm{min}}}^{E_\gamma^{\mathrm{max}}} dE_\gamma P(\gamma \leftrightarrow A') \int_0^T dt \left(I_\gamma^{(1)}(t, E_\gamma) + I_\gamma^{(2)}(t, E_\gamma) \right)$$

Tsai & Whitis, Phys.Rev. 149 (1966) 1248-1257

Photon flux per electron

PHYSICAL REVIEW VOLUME 149, NUMBER 4 30 SEPTEMBER 1966

Thick-Target Bremsstrahlung and Target Considerations for Secondary-Particle Production by Electrons*

Y. S. TSAI AND VAN WHITIS
Stanford Linear Accelerator Center, Stanford University, Stanford, California
(Received 15 April 1966)

$$I_\gamma(t,k)=I_\gamma^{(1)}(t,k)+I_\gamma^{(2)}(t,k)+I_\gamma^{(3)}(t,k)+\cdots.$$

1st/2nd/3rd/… generation Brem photons

$$kI_\gamma^{(1)}(t,k)=e^{-(7/9)t}\int_0^t \frac{e^{(7/9)t'}}{\Gamma(\frac{4}{3}t'+1)}\left(\ln\frac{1}{u}\right)^{(4/3)t'} \times\left\{u+\sum_{n=0}^{\infty}\frac{1}{n!(n+\frac{4}{3}t'+1)}\left[\tfrac{4}{3}(-1)^n-u^2\right] \times\left(\ln\frac{1}{u}\right)^{n+1}\right\}dt',$$

where $u=k/E_0$.

Eq.24

$$I_\gamma^{(2)}(t,k)=\frac{2}{k}\int_x^1 dv\int_v^1\frac{dy}{y^2}\frac{1}{D_1}\left[\frac{N_1-N_2}{D_1D_2}-\frac{N_3-N_2}{D_2D_3}+\frac{tN_2}{D_3}-\frac{N_3-N_2}{D_3^2}\right],$$

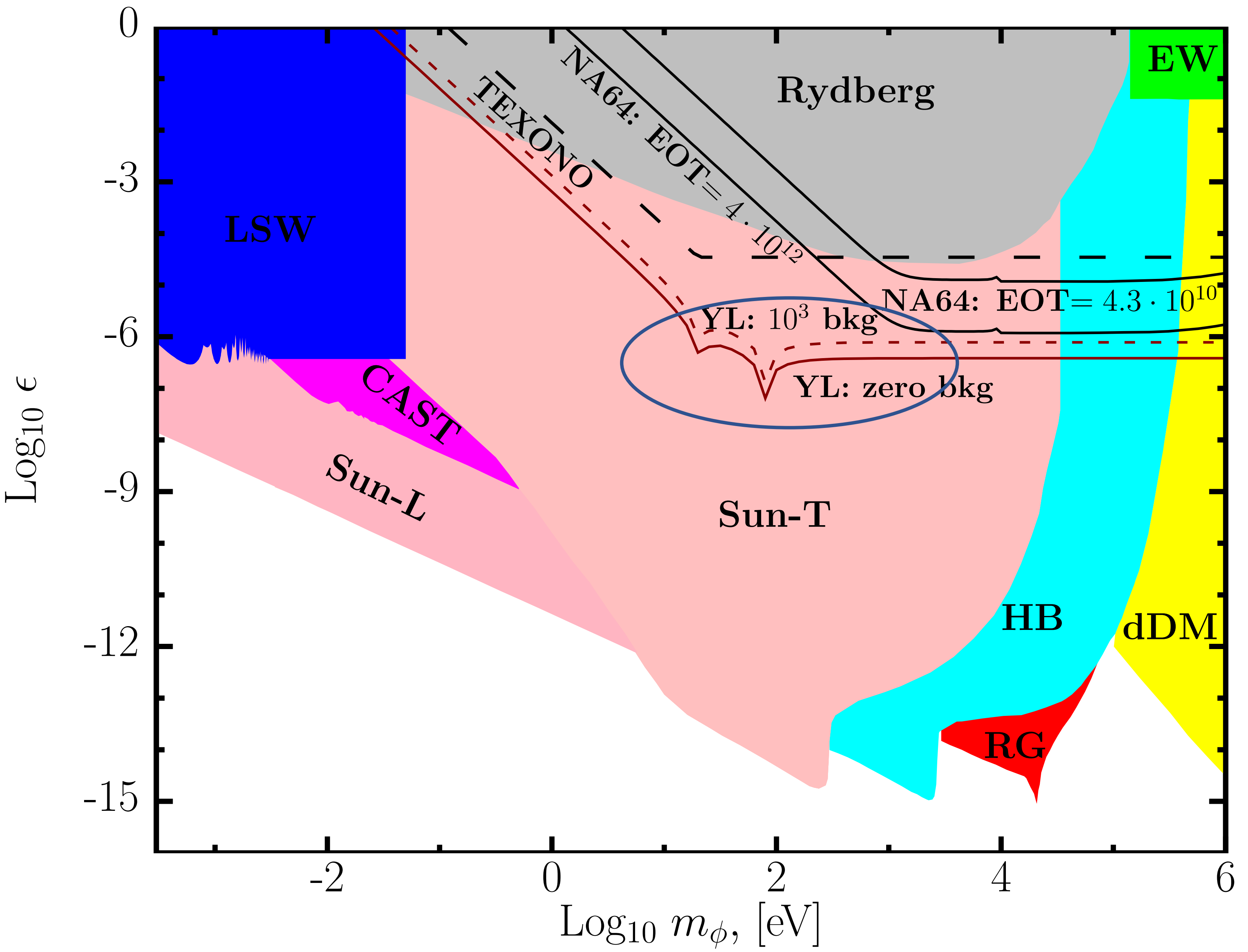
where

$$x=k/E_0,\quad (v=E/E_0,\ y=k'/E_0),$$
$$D_1=(7/9)+\tfrac{4}{3}\ln(1-y),$$
$$D_2=\tfrac{4}{3}\ln((y-y^2)/(y-v)),$$
$$D_3=(7/9)+\tfrac{4}{3}\ln[1-v/y],$$
$$N_1=(1-y)^{(4/3)t},$$
$$N_2=e^{-(7/9)t},$$
$$N_3=[1-v/y]^{(4/3)t}.$$

Eq.29

γ → A' Oscillation Sensitivity

S.H. Seo & Y.D. Kim
JHEP04(2021)135



***m_ϕ* < 1 MeV**

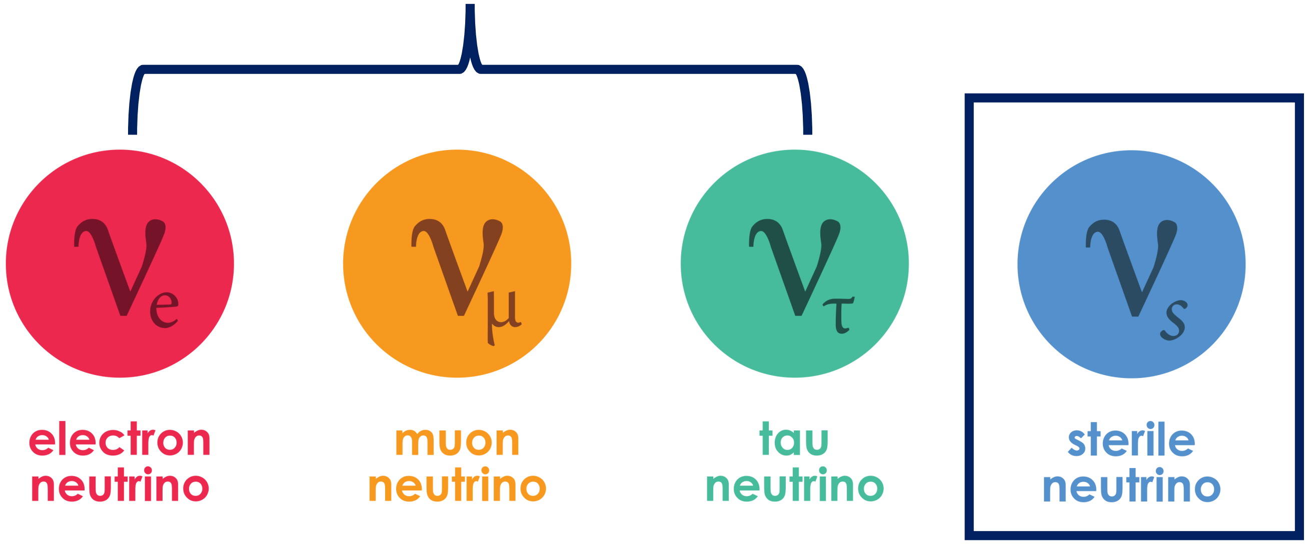
Best "direct" DP search sensitivity at sub-MeV region

Big question

Why only 3 flavors of ν ?

Is there a 4th flavor of neutrinos ?

3 + 1



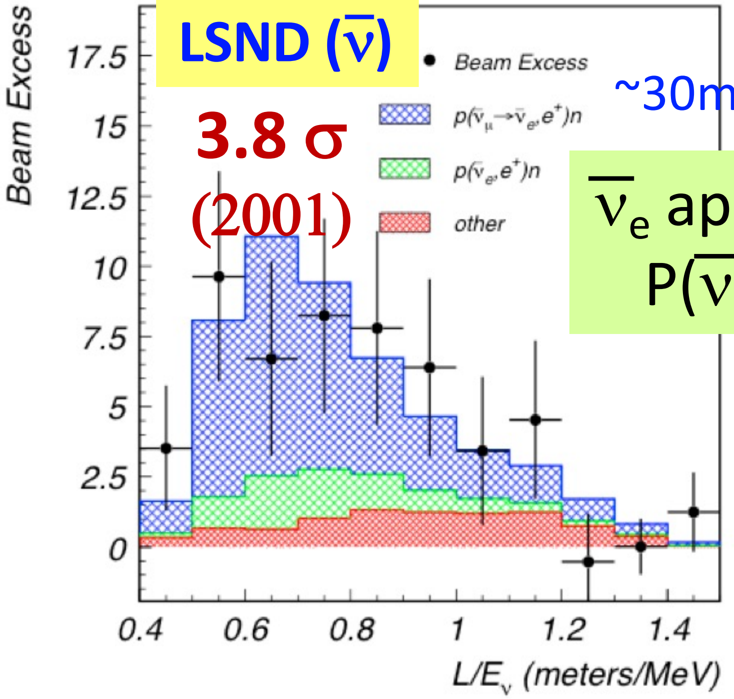
There are experimental hints !

Smoking Guns of Sterile Neutrinos at ~eV?

LSND ($\bar{\nu}$)

3.8 σ (2001)

~30m/30MeV



$\bar{\nu}_e$ appearance

$P(\bar{\nu}_\mu \to \bar{\nu}_e)$

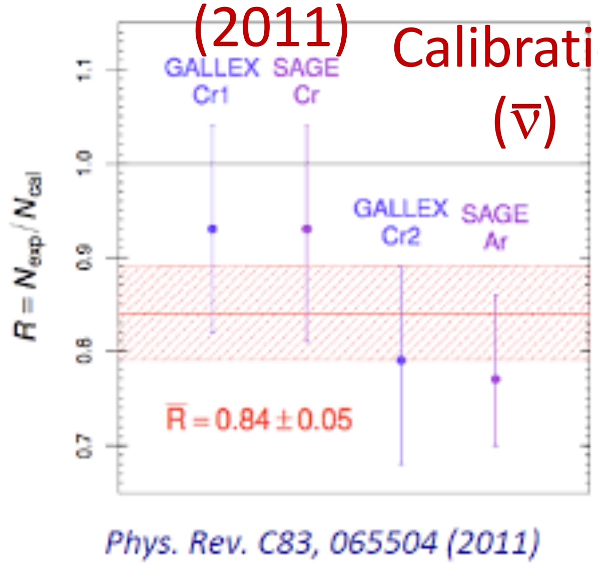
ν_e disappearance

$P(\nu_e \to \nu_e)$

GALLEX/SAGE

3σ (2011)

Source Calibration ($\bar{\nu}$)



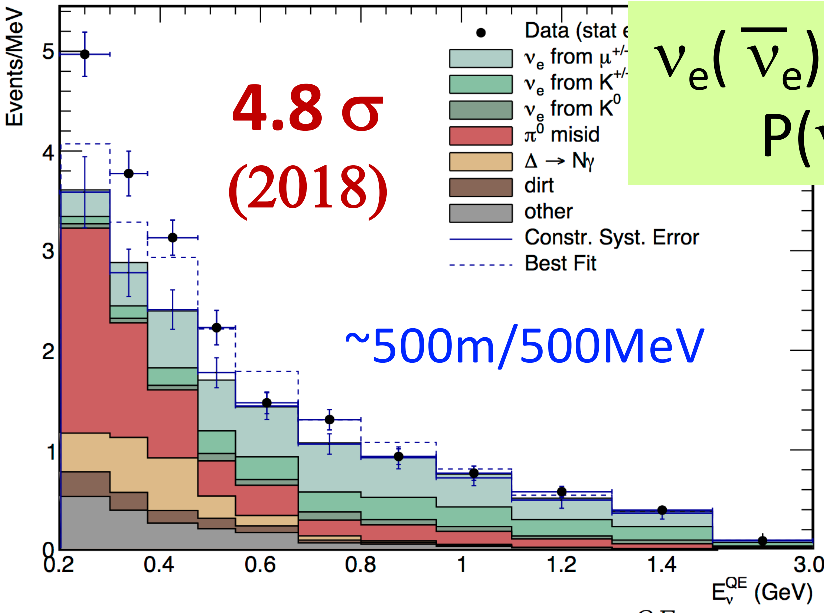
Phys. Rev. C83, 065504 (2011)

3σ~4σ evidences

MiniBooNE (ν, $\bar{\nu}$)

4.8 σ (2018)

~500m/500MeV



ν_e($\bar{\nu}_e$) appearance

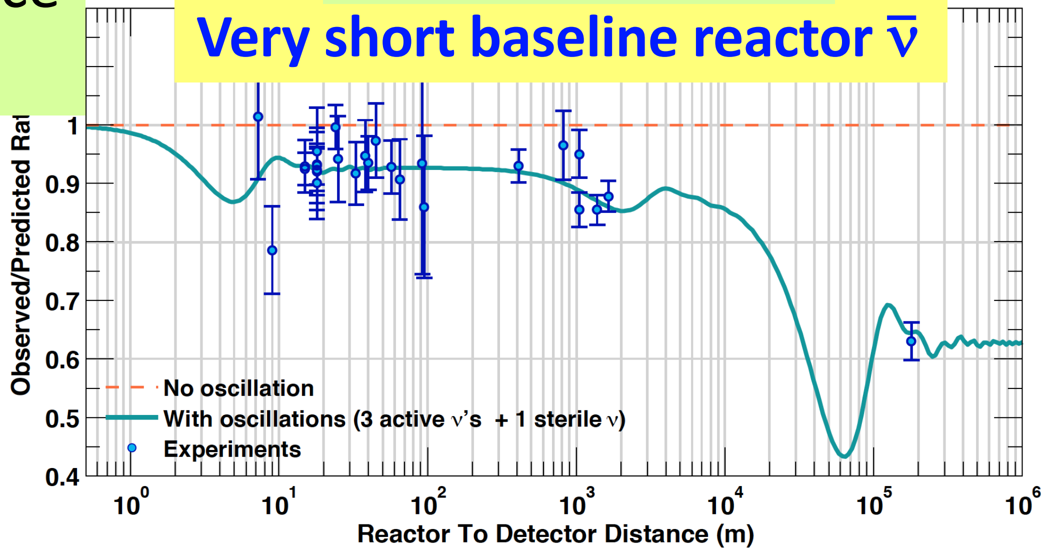
$P(\nu_\mu \to \nu_e)$

$\bar{\nu}_e$ disappearance

$P(\bar{\nu}_e \to \bar{\nu}_e)$

3σ (2011)

Very short baseline reactor $\bar{\nu}$

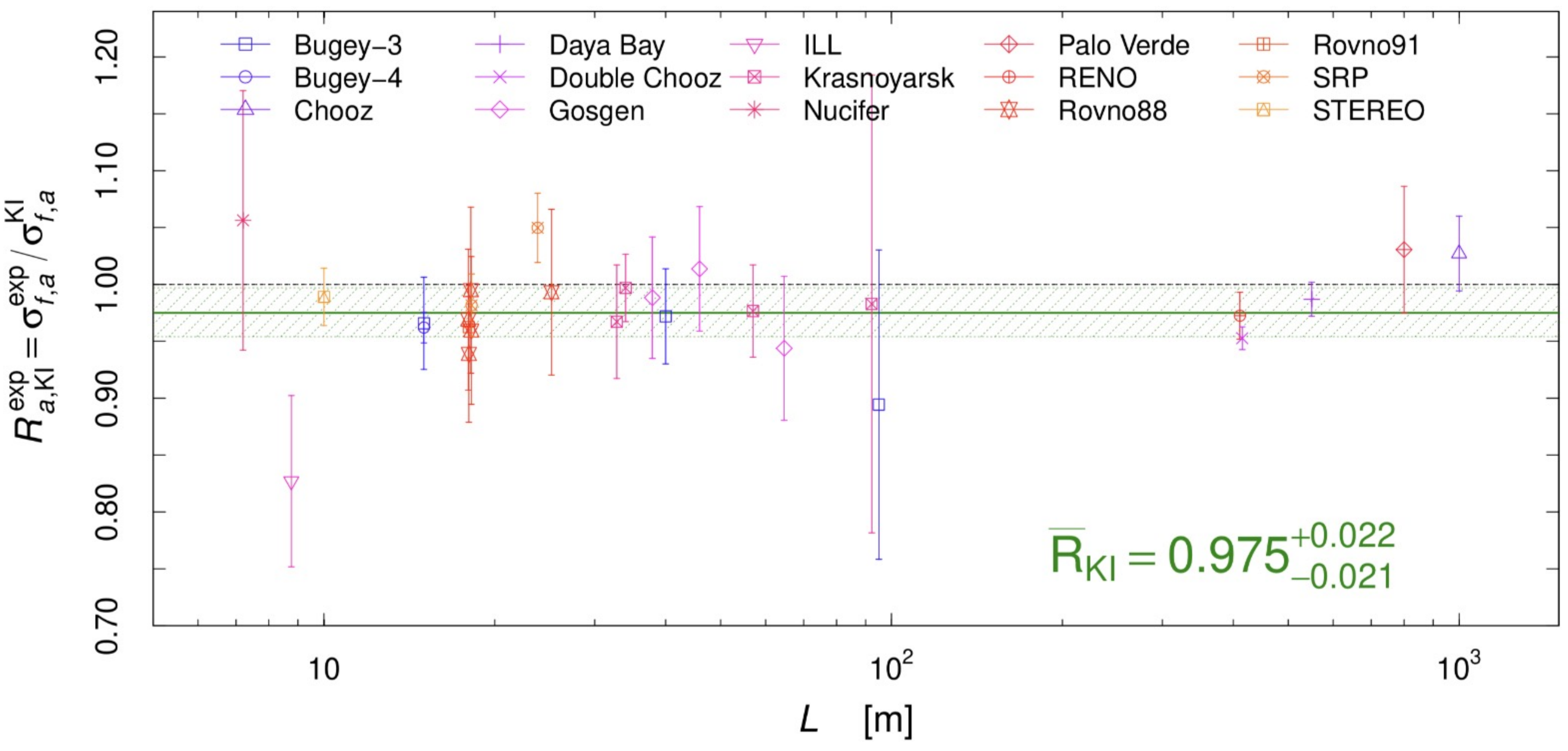


reactor ν

With updated input data to flux calculation
(new β spectra from ^{235}U fission)

Kopeikin Skorokhvatov Titov arXiv:2103.01684
Berryman Huber arXiv:2005.01756
Giunti Li Ternes Xin arXiv:2110.06820

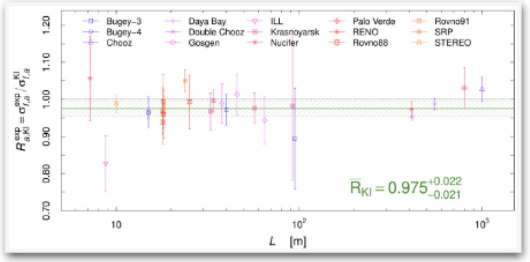
J. Kopp
@Nu2022



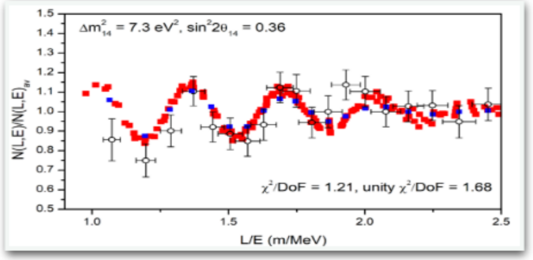
→ Reactor ν flux anomaly disappears !

Short-Baseline Anomalies: Current Status

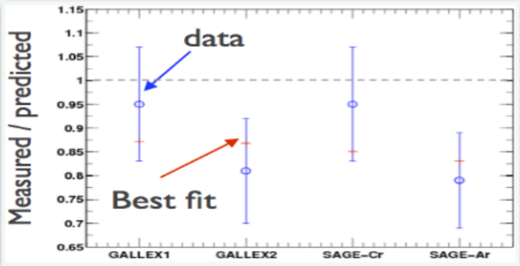
J. Kopp
@Nu2022



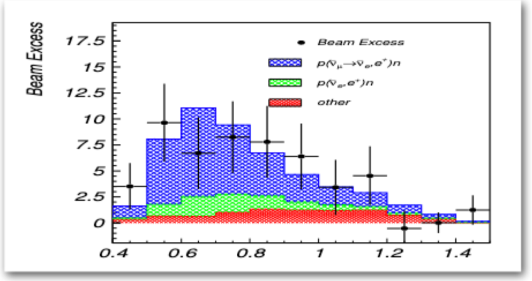
reactor flux anomaly
resolved with new input data
to flux calculation



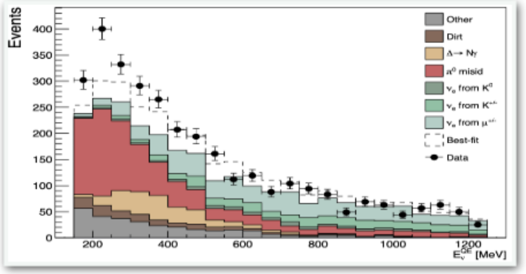
reactor spectra
is there really an anomaly?



gallium anomaly
unresolved, recently reinforced



LSND
unresolved



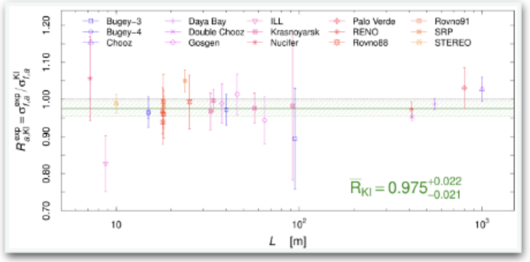
MiniBooNE
unresolved

Still unresolved

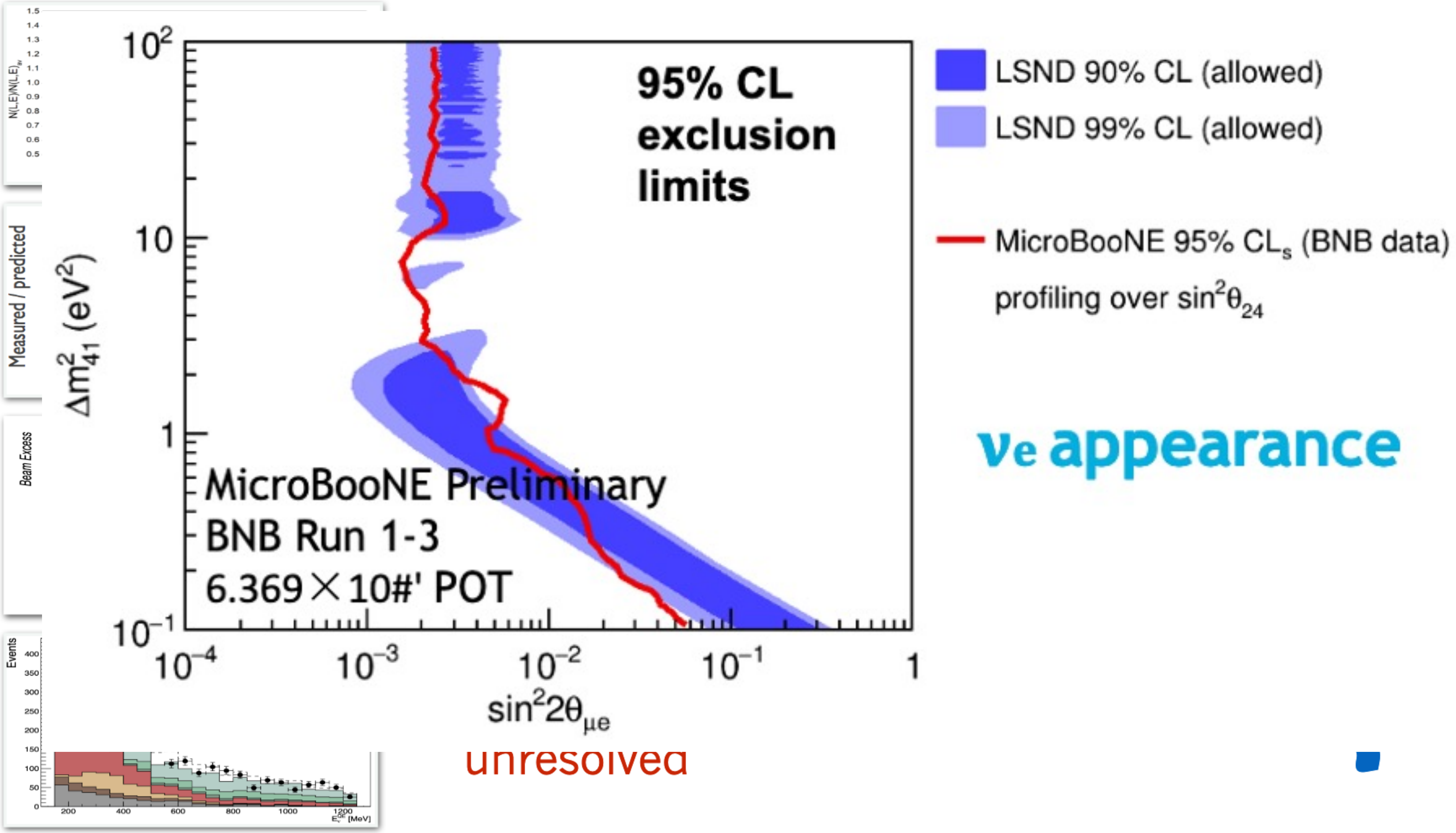
31

Short-Baseline Anomalies: Current Status

J. Kopp
@Nu2022



reactor flux anomaly
resolved with new input data
to flux calculation

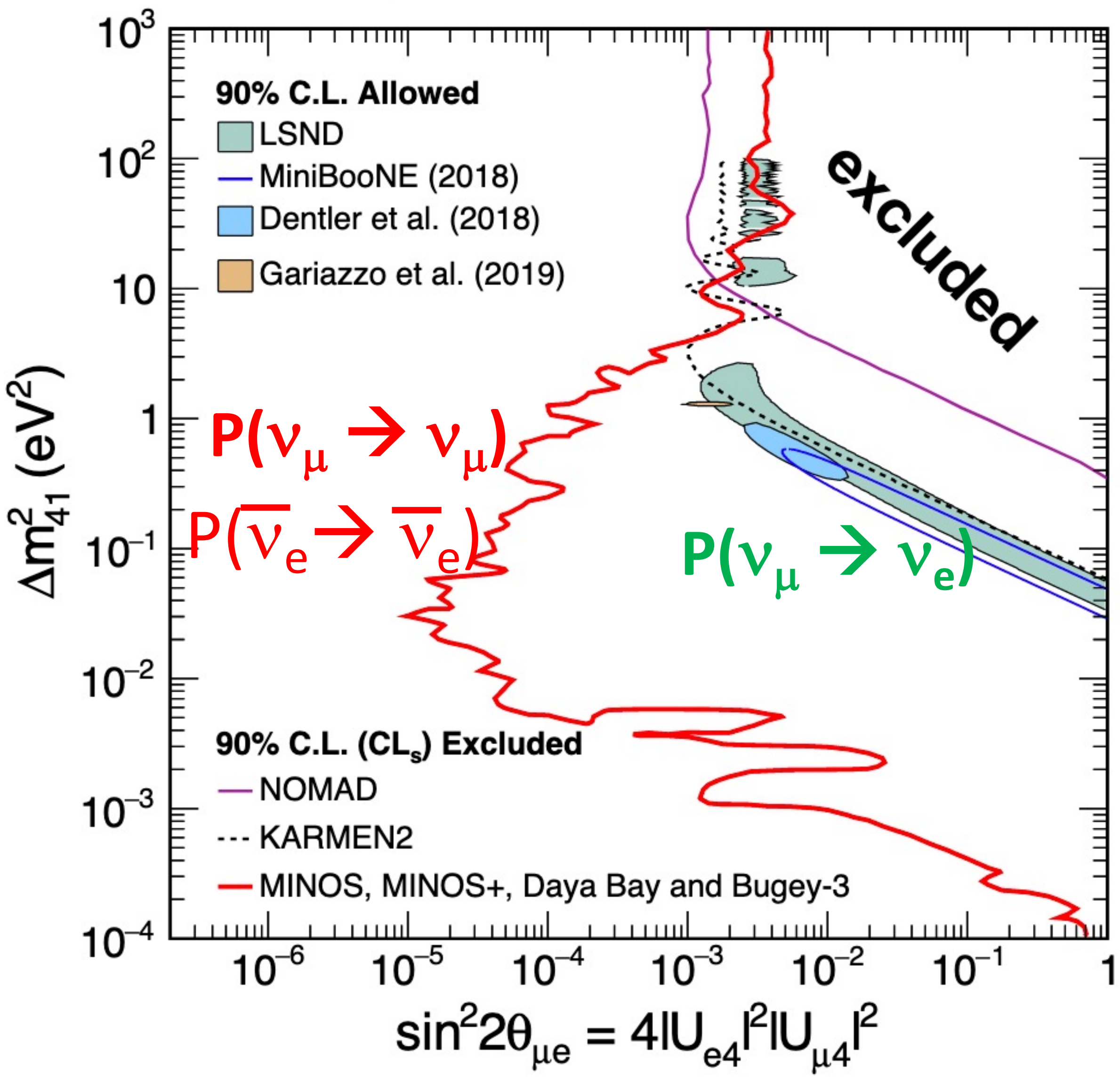


νe appearance

Still
unresolved

unresolved

PRL 125, 071801 (2020)



- Some disagreements between MiniBooNE & MicroBooNE
- The tension between appearance and disappearance channels

→ Need a more complex sterile ν model ?

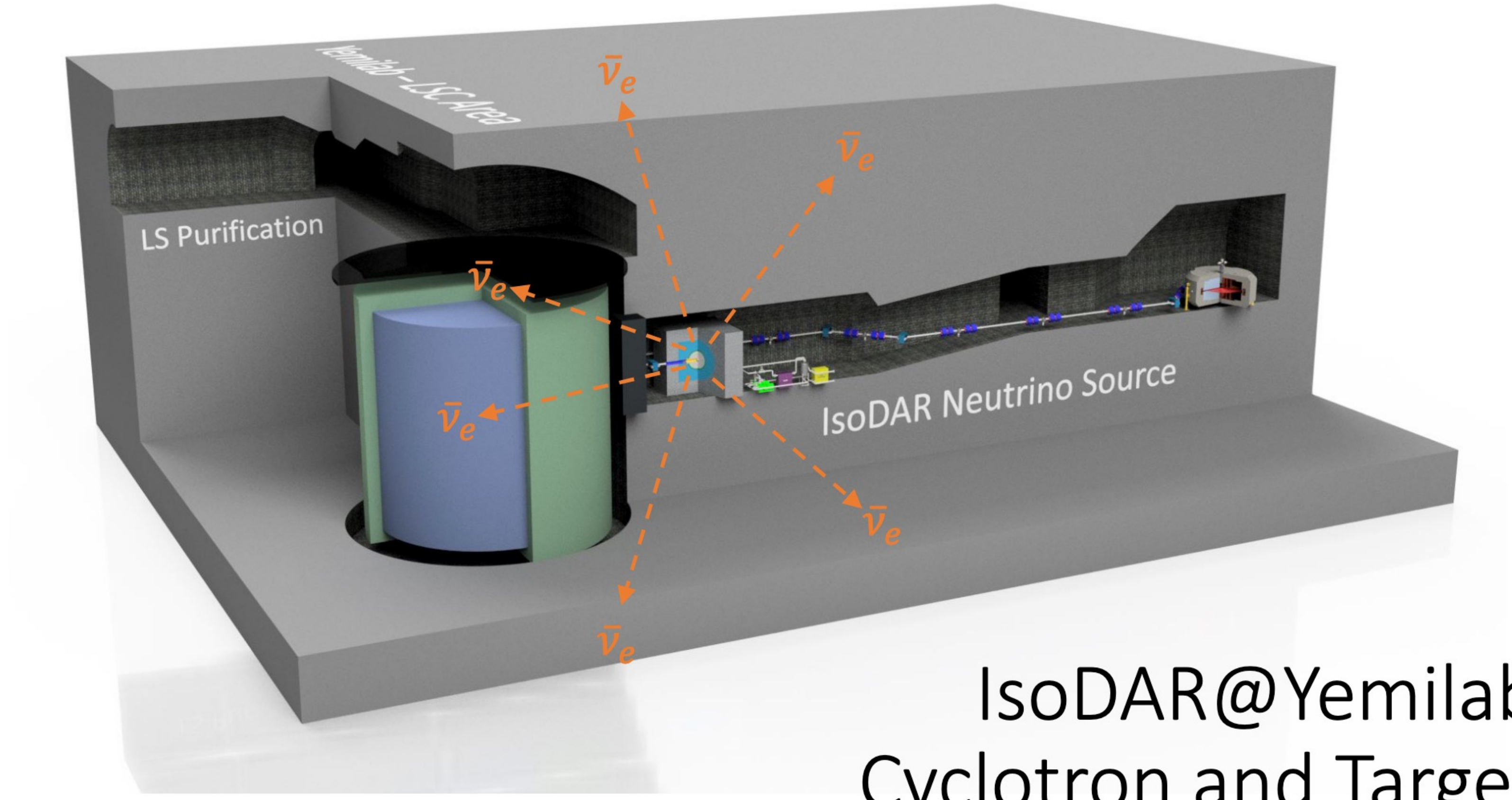
(if new physics is indeed the source of the anomalous results)

➢ IsoDAR@Yemilab can test more complex sterile ν model.

[1] Sterile neutrino search with IsoDAR @Yemilab

Isotope **D**ecay **A**t **R**est

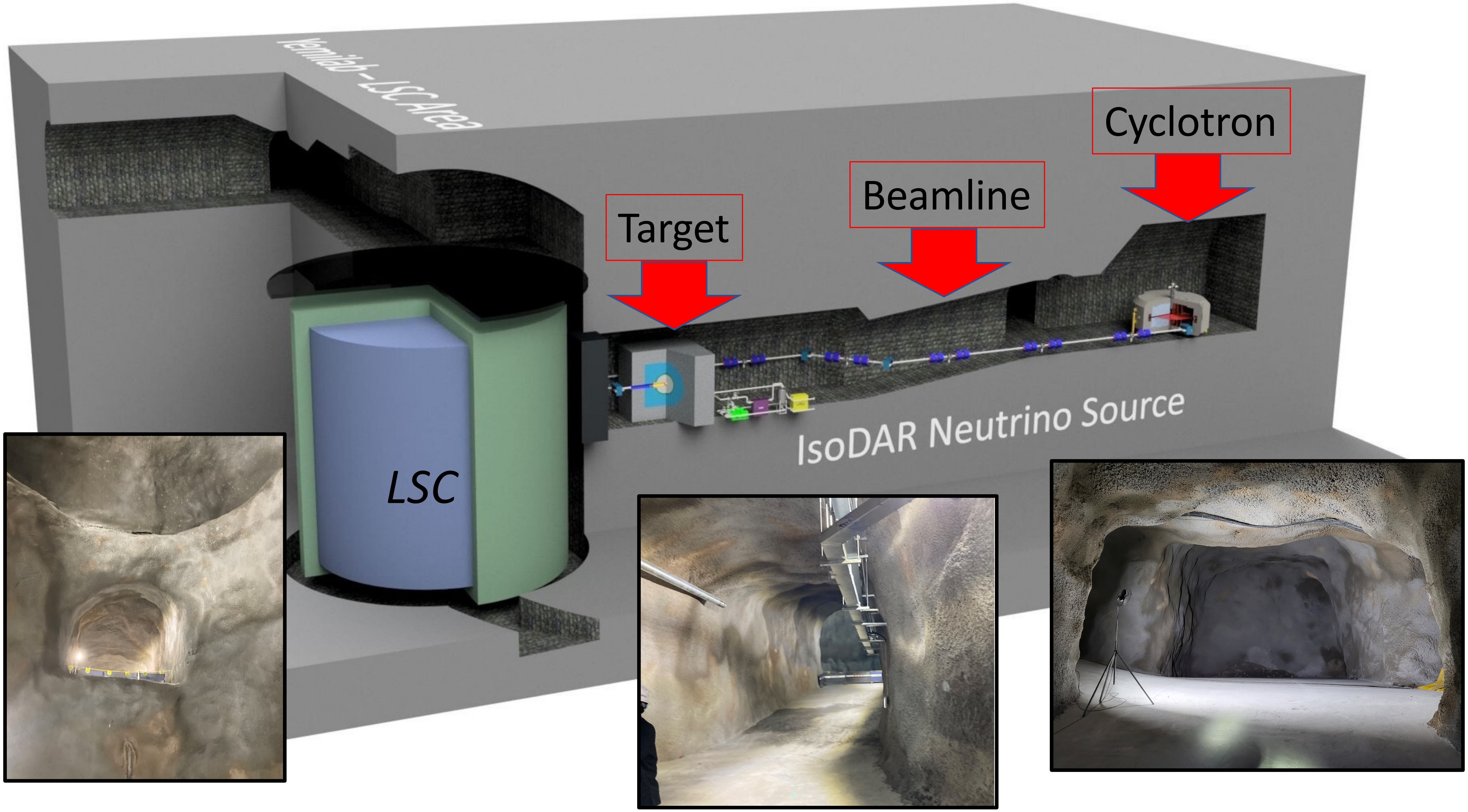
→ This method has never been tried!



IsoDAR@Yemilab
Cyclotron and Target

Publications:

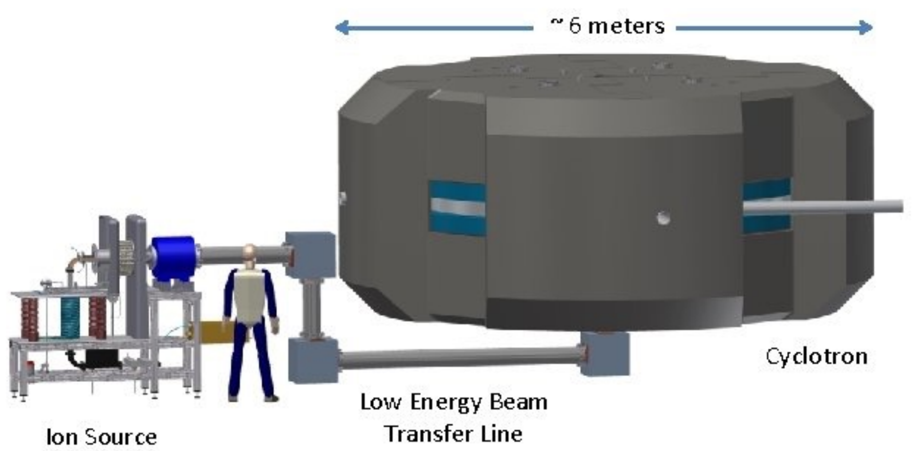
arXiv:2111.09480 (**PRD**.105.052009)
arXiv:2201.10040 (submitted to **JINST**)
arXiv:2110.10635

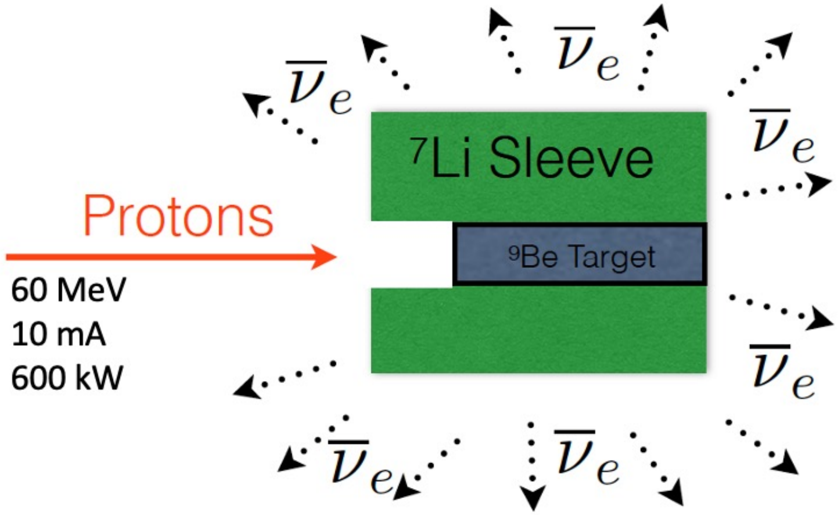


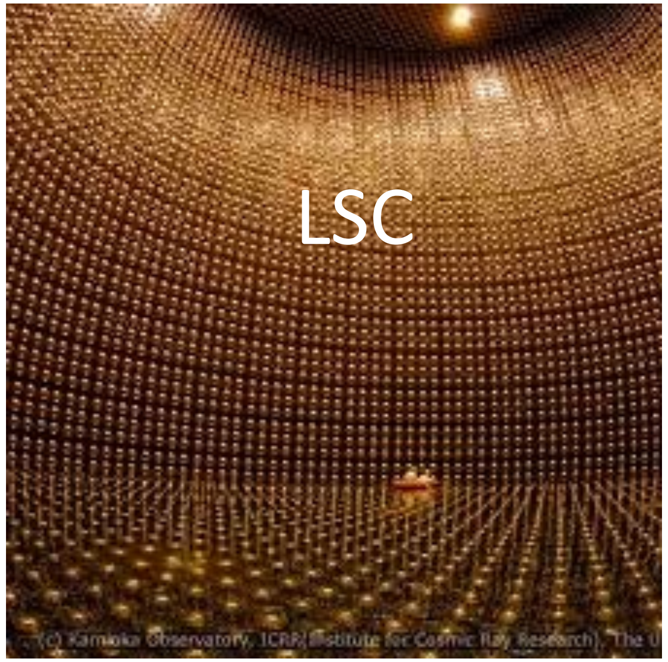
JINST 17 (2022) 09, P09042, https://arxiv.org/abs/2201.10040

❑ Sterile ν search w/ IsoDAR@Yemilab

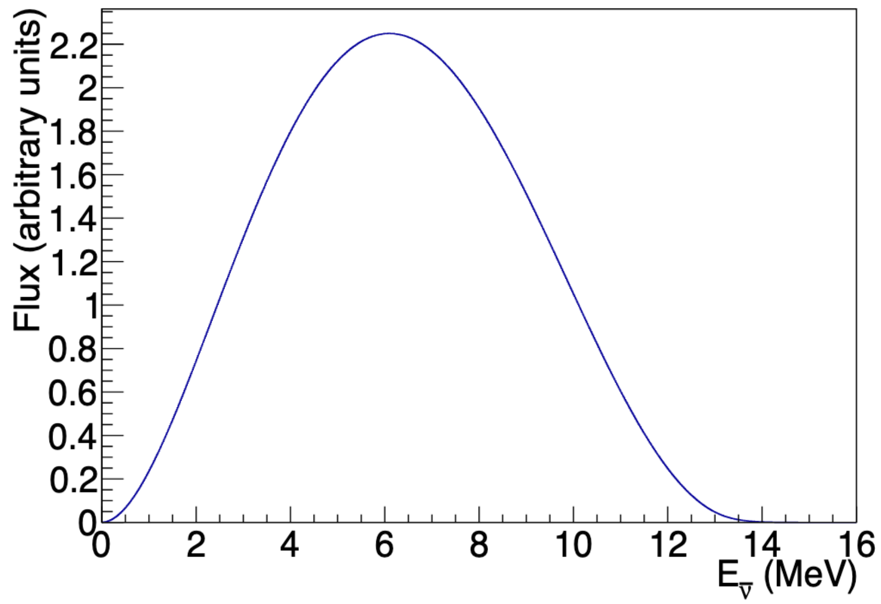
The IsoDAR Cyclotron and Ion Source







IsoDAR $\overline{\nu}$ spectrum



(1) $p + {}^9\mathrm{Be} \rightarrow {}^8\mathrm{Li} + 2p$

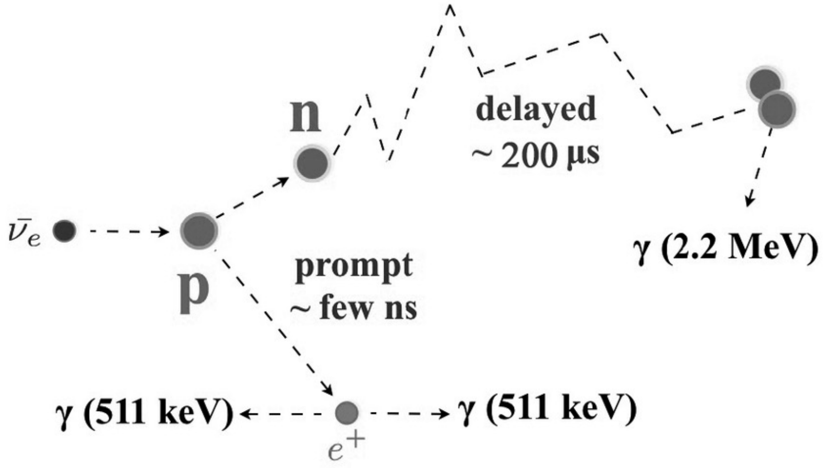
(2) $p + {}^9\mathrm{Be} \rightarrow {}^9\mathrm{B} + n$

$n + {}^7\mathrm{Li} \rightarrow {}^8\mathrm{Li} + \gamma$

$${}^8\mathrm{Li} \rightarrow {}^8\mathrm{Be} + e^- + \overline{\nu}_e$$

IBD interaction

$$p^+ + \overline{\nu}_e \rightarrow e^+ + n^0$$

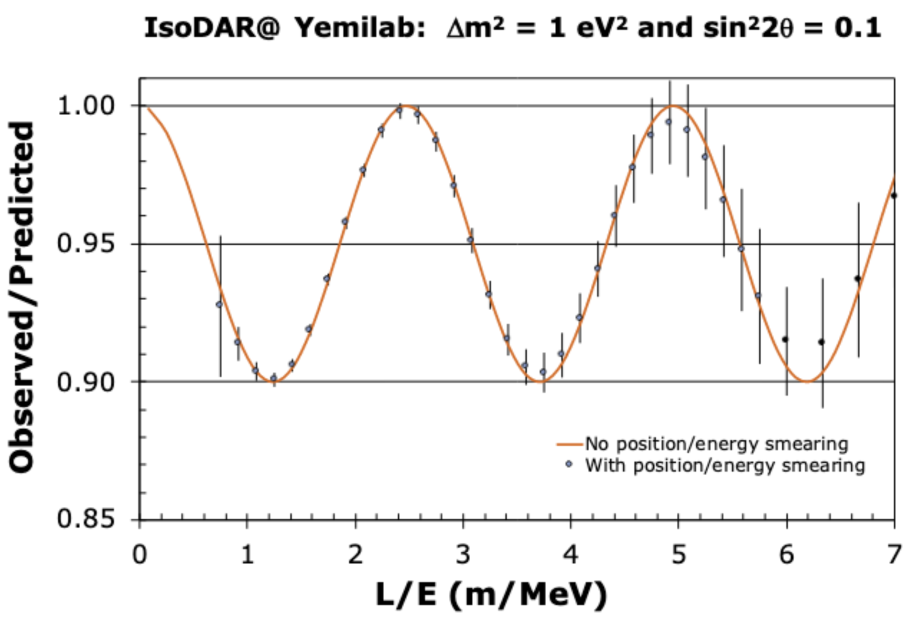


Sterile ν Search w/ IsoDAR@Yemilab

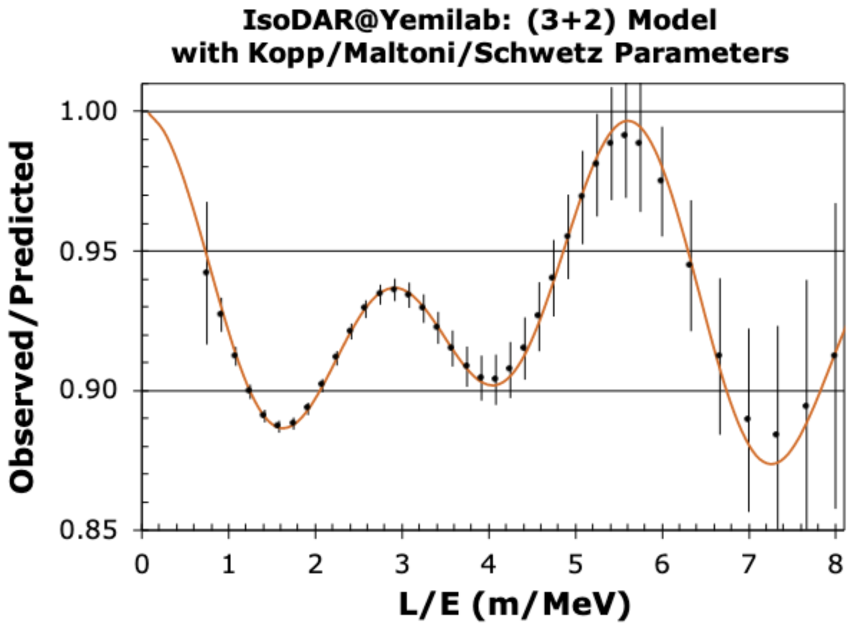
Possible Models & Signatures

arXiv:2111.09480
PRD 105 (2022) 5, 052009

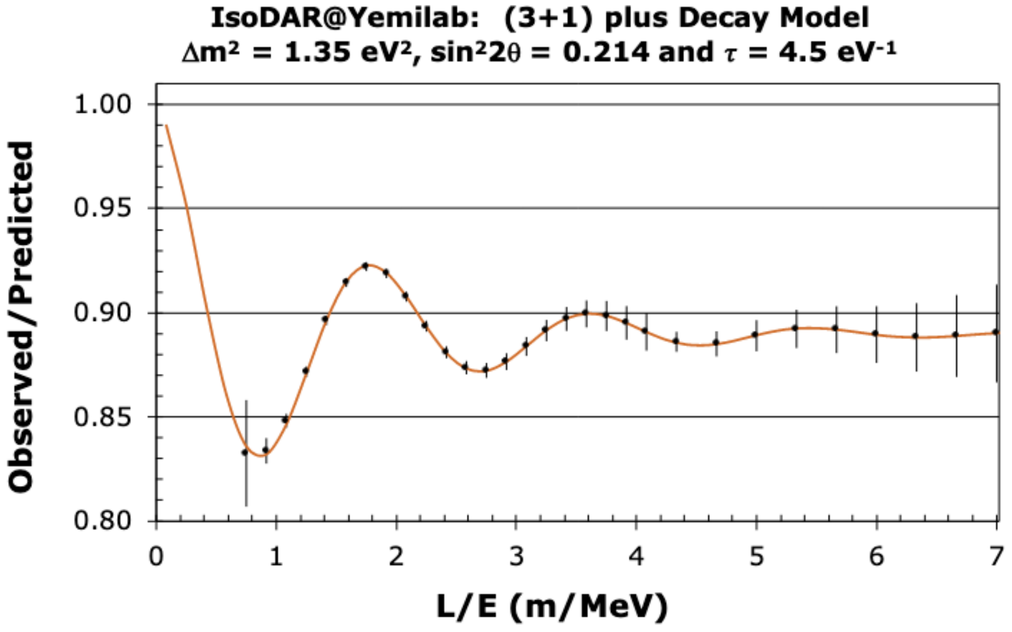
(3+1) ν



(3+2) ν



(3+1) ν + ν_s decay



→ IsoDAR@Yemilab can well distinguish different new physics models.

- The (3+1)+decay model significantly reduces the tension between appearance and disappearance experiments, improving the global-data goodness-of-fit.

1910.13456

IsoDAR@Yemilab Performance

Accelerator	60 MeV/amu of H_2^+
Beam Current	10 mA of protons on target
Beam Power (CW)	600 kW
Duty cycle	80%
Protons/(year of live time w/ 100% duty)	1.97×10^{24}
Run period	5 years
Live time	5 years×0.80=4.0 years
Target	^{9}Be with 99.99% pure ^{7}Li sleeve
Neutrino creation point spread (1σ)	41 cm
$\overline{\nu}$ source	^{8}Li β decay (6.4 MeV mean energy flux)
$\overline{\nu}$ flux during 4.0 years of live time	1.147×10^{23} $\overline{\nu}_e$
$\overline{\nu}$ flux uncertainty	5% (shape-only is also considered)
Location	Yemilab
Fiducial mass	2.57 ktons
Distance between source and target (min-max)	9.5-25.9 m
Fiducial radius	7.5 m
IBD Detection efficiency	100%
Vertex resolution	12 cm/$\sqrt{E\ (\mathrm{MeV})}$
Energy resolution	3.0%/$\sqrt{E\ (\mathrm{MeV})}$
Angular resolution	under study
Visible energy threshold (IBD and $\overline{\nu}_e$-electron)	3 MeV
IBD event total (w/ 100% efficiency)	2.02×10^6
$\overline{\nu}_e$-electron event total (after cuts, 34% efficiency)	7060

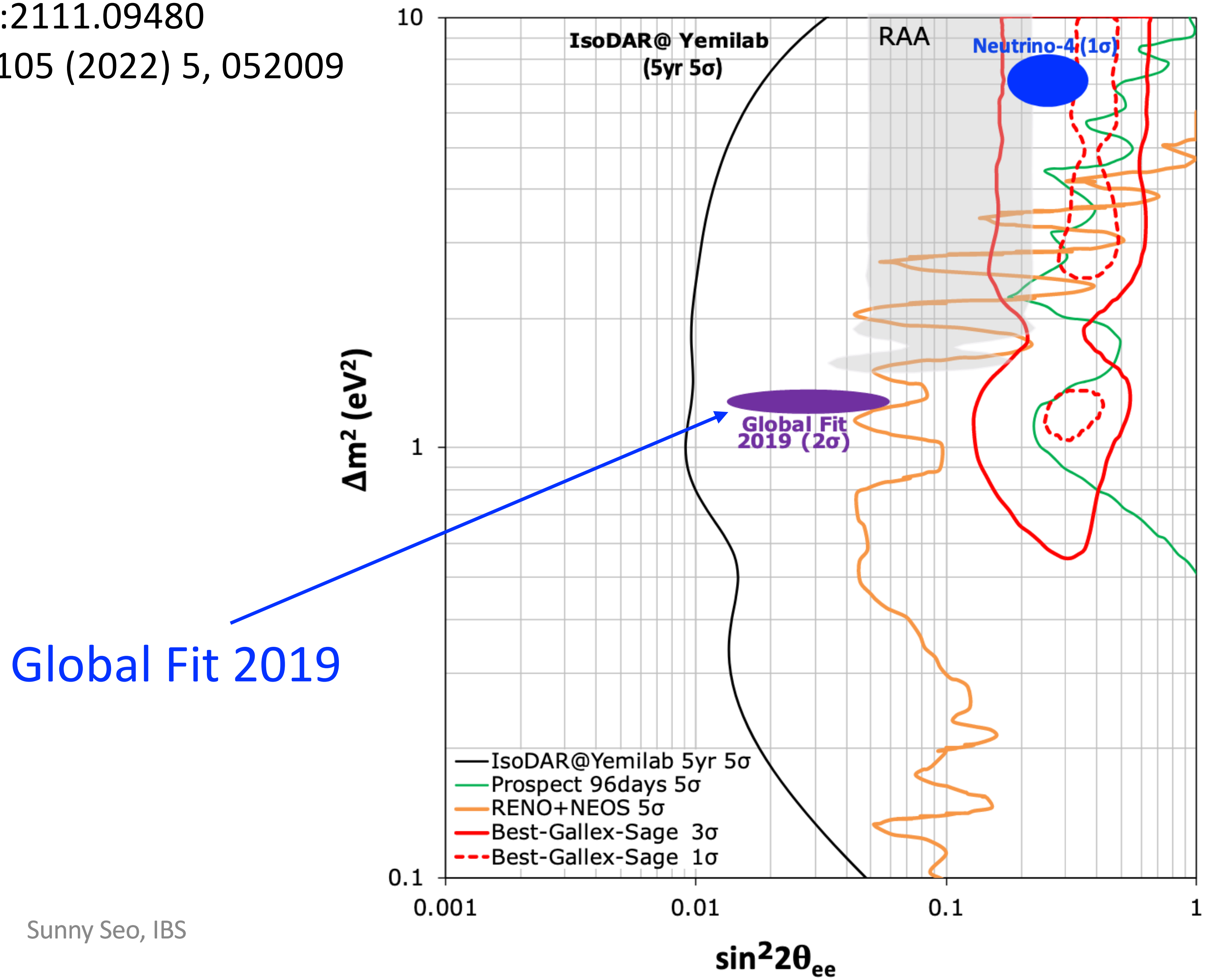
2 M IBD events/5 yrs
~7000 ES events/5yrs

"Detector at Yemilab" assumptions are basically consistent with "KamLAND—897 tons, but bigger (and with the *possibility* of directional reconstruction)"

Sterile neutrino search Sensitivity

IsoDAR @Yemilab $P(\overline{\nu}_e \rightarrow \overline{\nu}_e)$

arXiv:2111.09480
PRD 105 (2022) 5, 052009

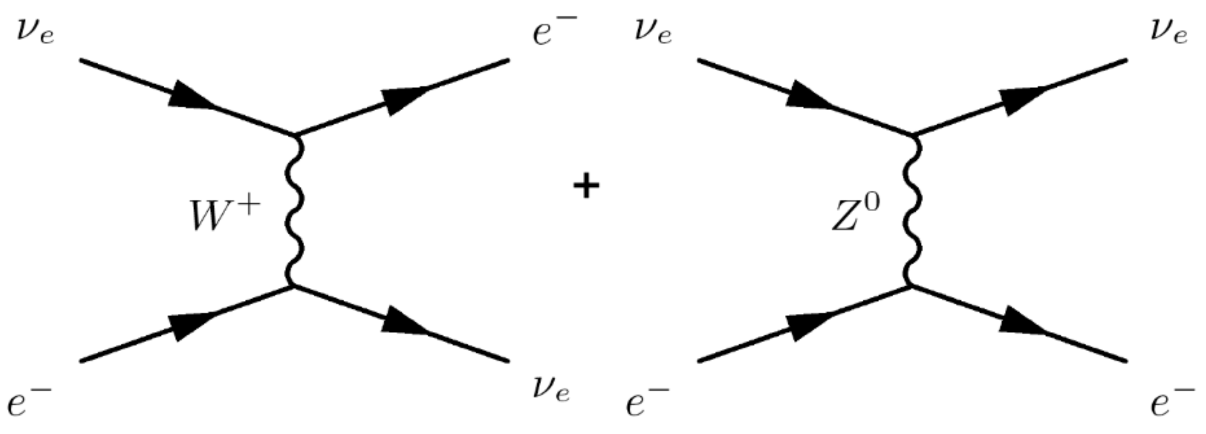


- World-leading result
- Definite conclusion on (3+1) ν or not

Advantage:
Unlike reactor/accelerator ν, IsoDAR has very well defined ν flux and shape.

❑ New physics search w/ IsoDAR@Yemilab

$$\text{ES};\ \bar{\nu}_e + e^- \rightarrow \bar{\nu}_e + e^-$$



$$\frac{d\sigma}{dT} = \frac{2G_F^2 m_e}{\pi}\left[g_R^2 + g_L^2\left(1 - \frac{T}{E_\nu}\right)^2 - g_R g_L \frac{m_e T}{E_\nu^2}\right]$$

$$g_R = \tfrac{1}{2}(g_V - g_A),\ g_L = \tfrac{1}{2}(g_V + g_A)$$

$$g_L = \frac{1}{2} + \sin^2\theta_W, \quad g_R = \sin^2\theta_W$$

$$[\sin^2 2\theta_W = (4\pi\alpha)/(\sqrt{2}G_F M_Z^2)]$$

NSI's alter the Standard Model couplings:

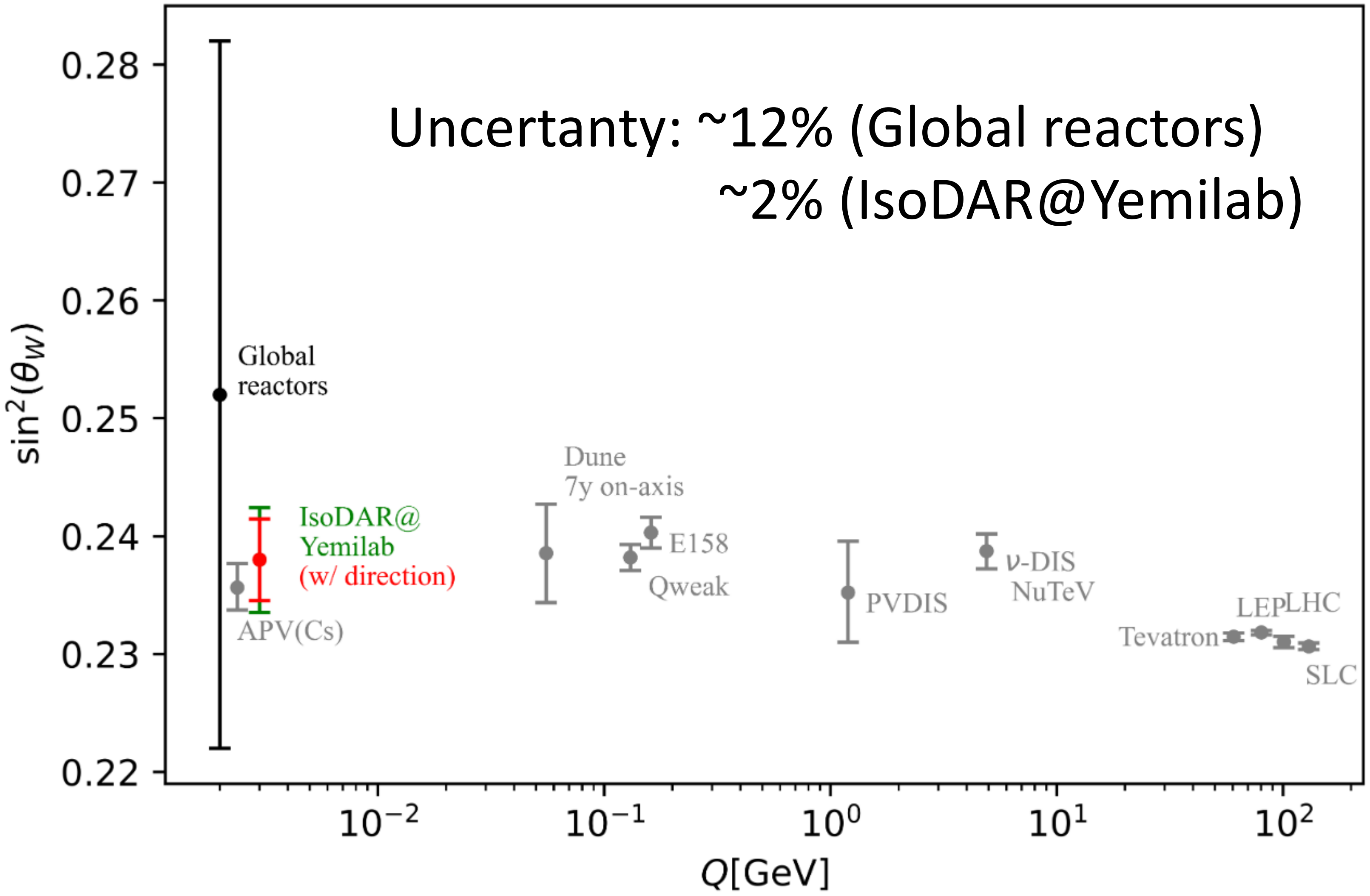
$$\bar{g}_R \equiv g_R^e + \varepsilon_{ee}^{eR}, \qquad \bar{g}_L \equiv 1 + g_L^e + \varepsilon_{ee}^{eL}.$$

$$\sigma(\varepsilon_{ee}^{eR}, \varepsilon_{ee}^{eL}) = \frac{2m_e G_F^2 E_\nu}{\pi}\left(\bar{g}_L^2 + \frac{1}{3}\bar{g}_R^2\right).$$

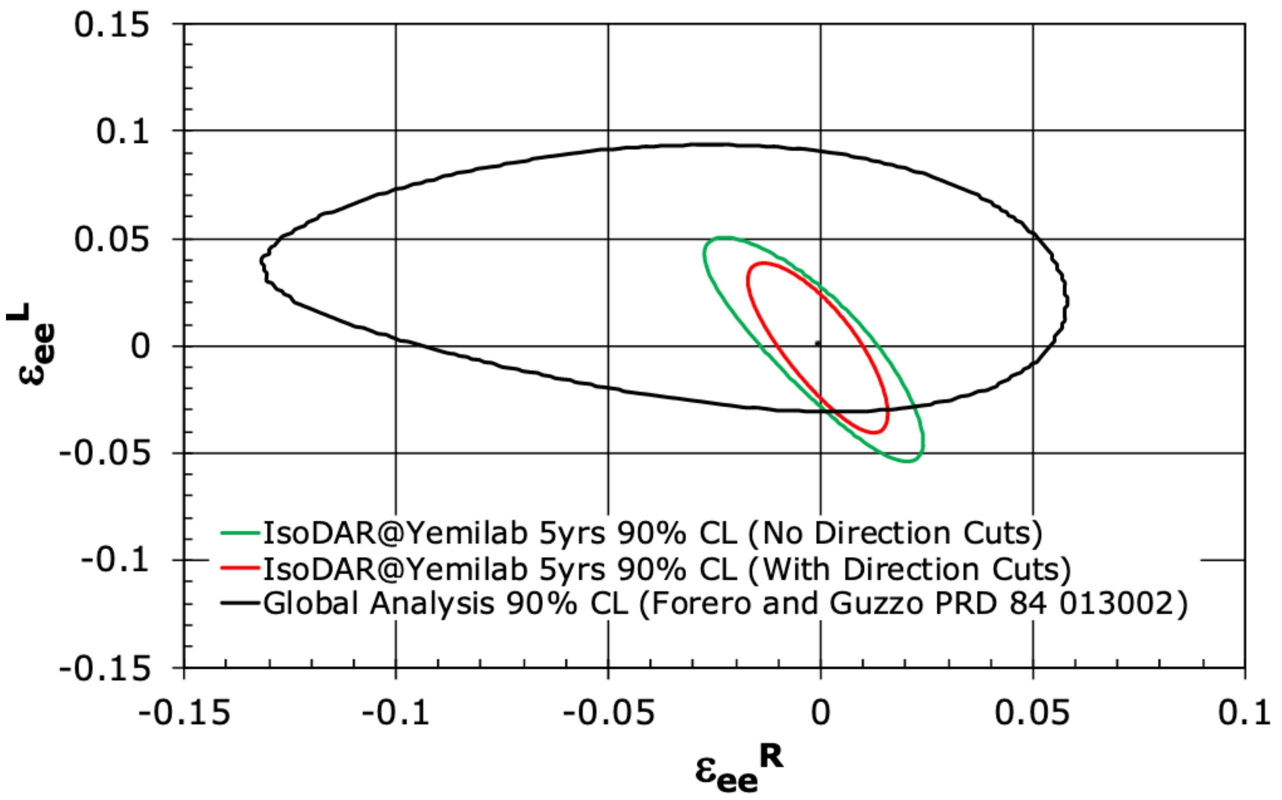
IsoDAR@Yemilab Elastic Scattering Events

arXiv:2111.09480
PRD 105 (2022) 5, 052009

Weak mixing angle θ_W measurement
assuming standard ν interaction



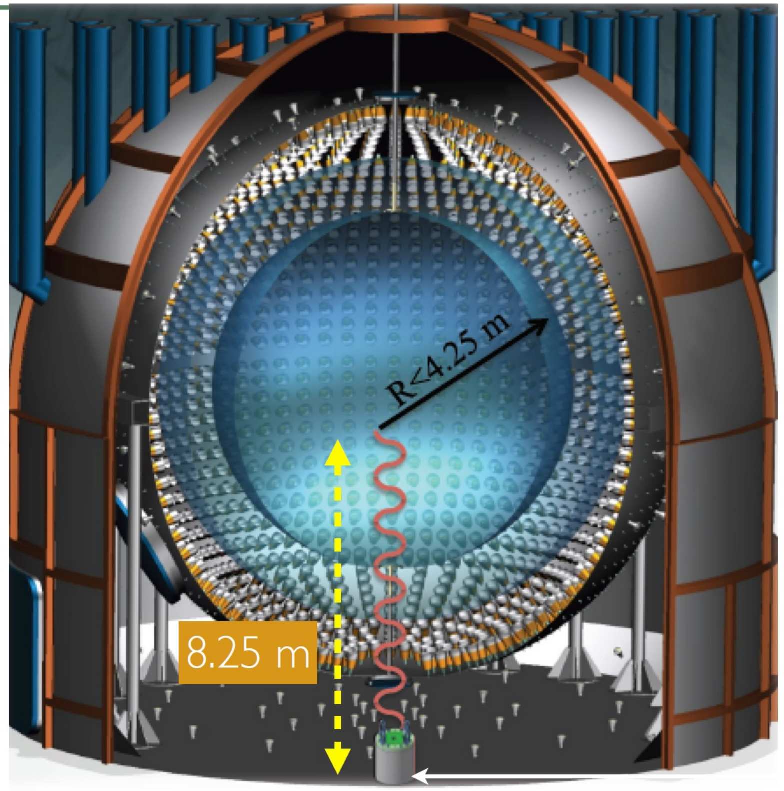
NSI



[2] Sterile ν search w/ radioactive sources

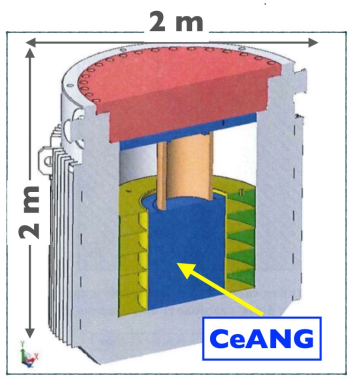
$P(\nu_e \rightarrow \nu_e)$

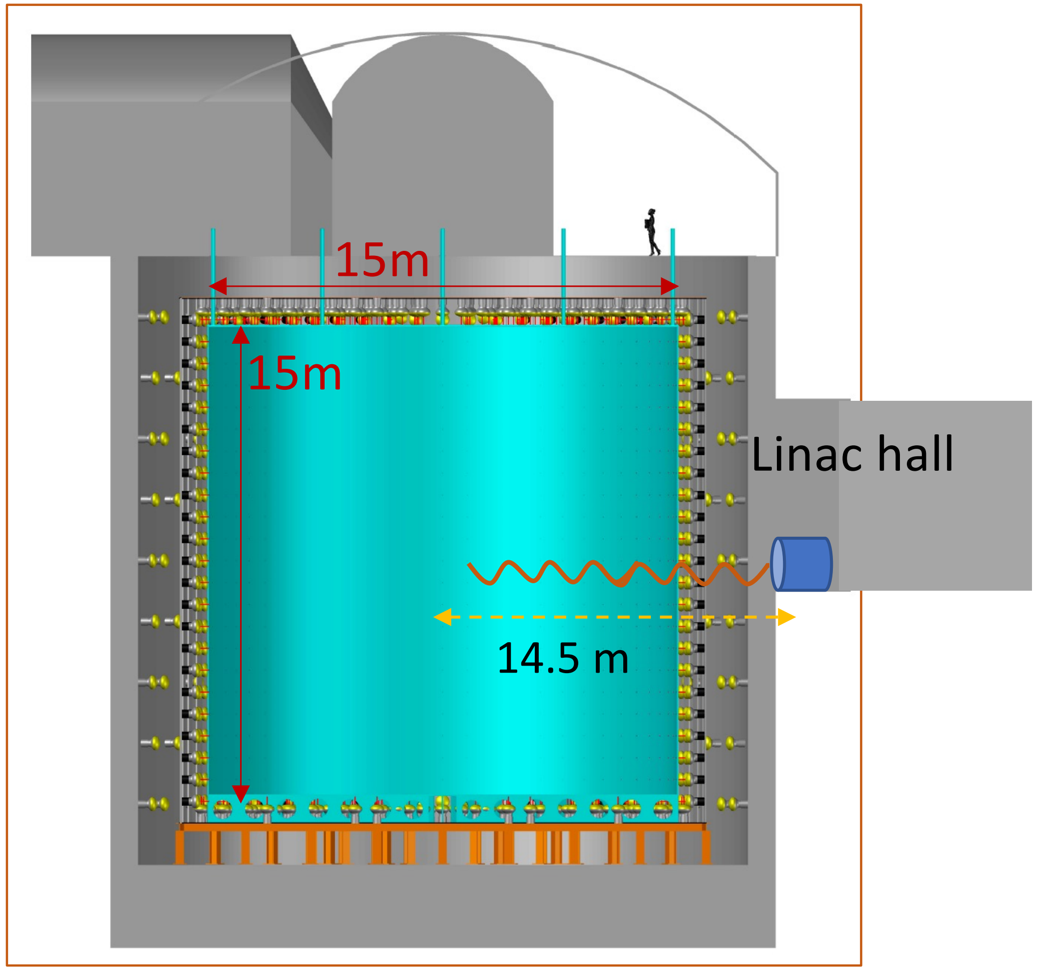
The Borexino detector and SOX



Useful data: distance range 4 - 12.25 m
(Yemilab will be better)

Source
inside shield





Distance range: 7 – 22 m

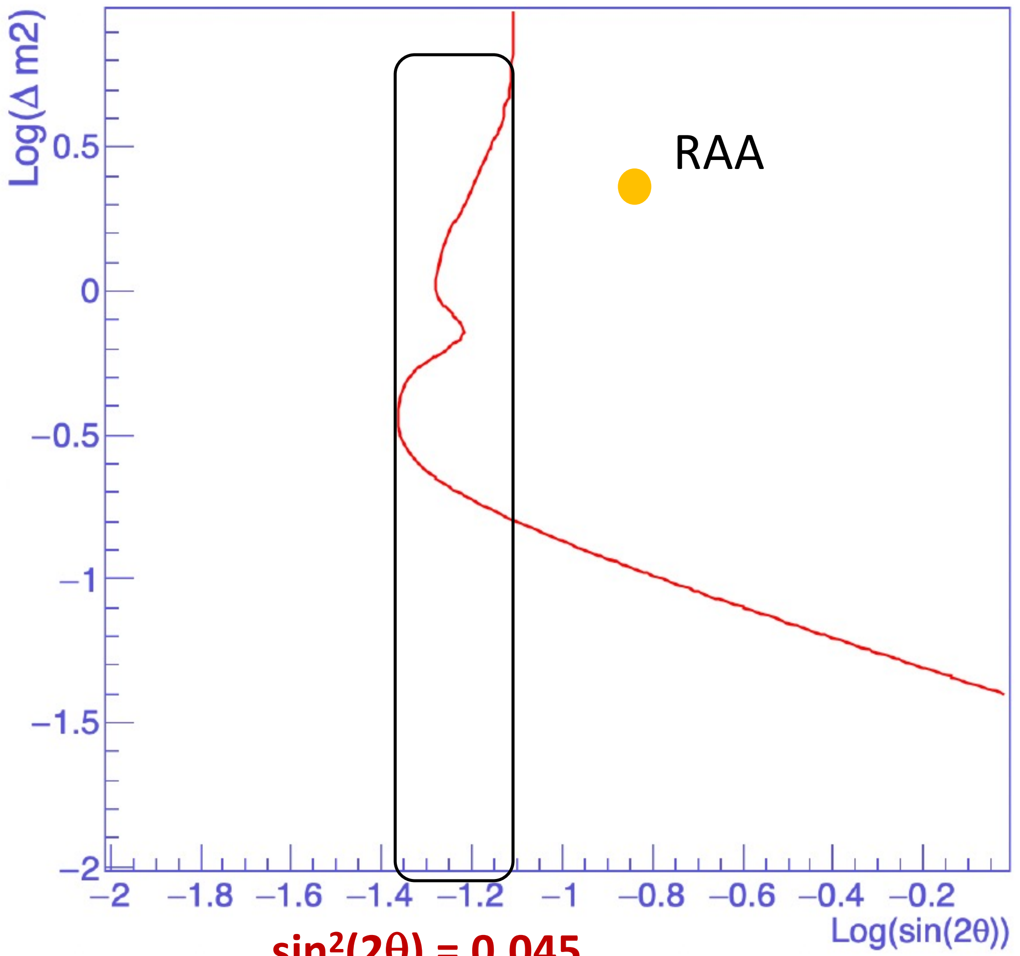
LSC @Yemilab

[2] Sterile ν Search Sensitivity w/ Radio-Source

Radio-active source

$P(\nu_e \rightarrow \nu_e)$

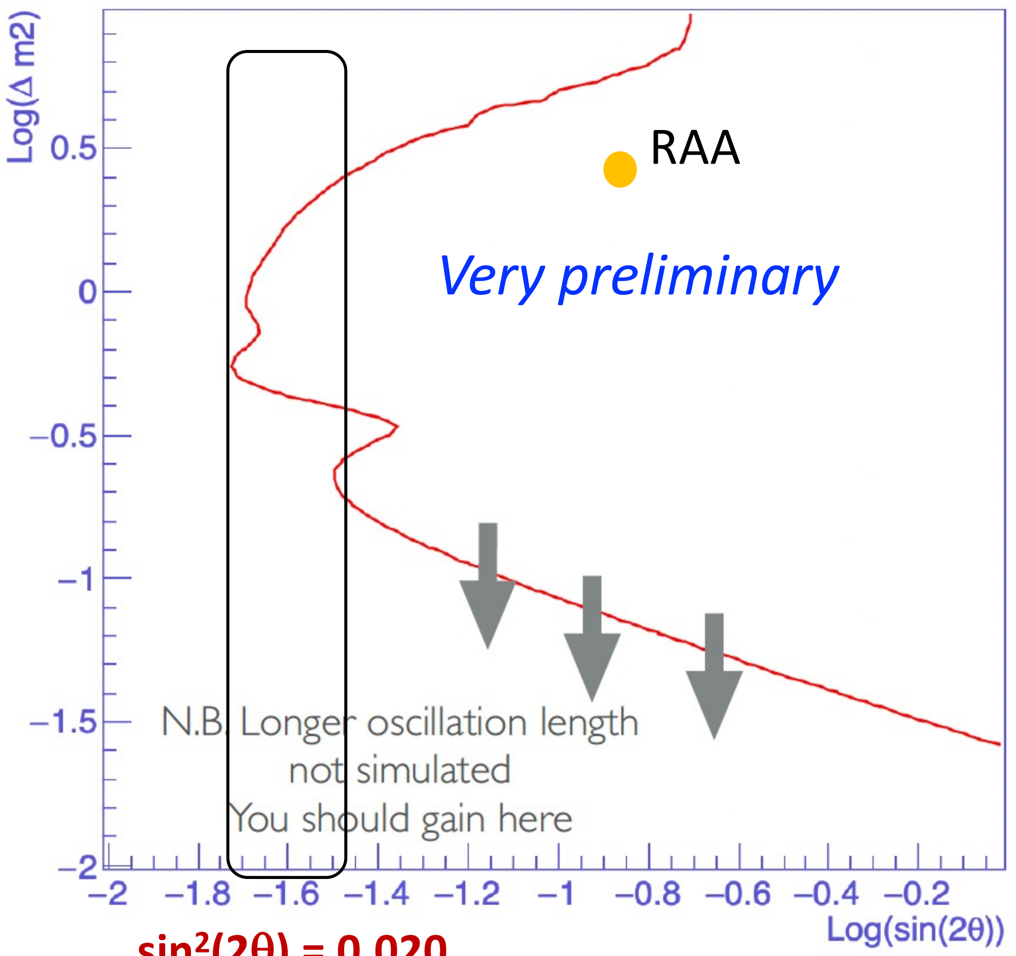
SOX original



$sin^2(2\theta)$ = 0.045

Ce-144 100 kCi

Yemilab



$sin^2(2\theta)$ = 0.020

Ce-144 100 kCi

M. Pallavicini
Seminar @CUP-IBS

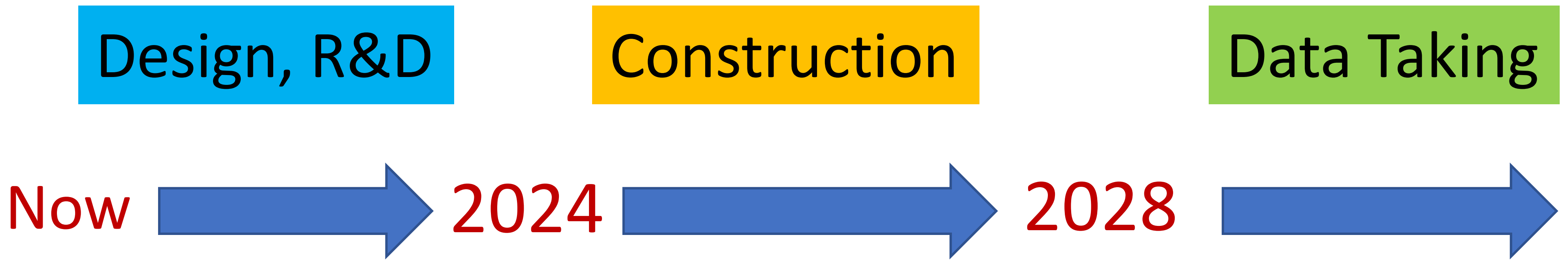
❑ **White Paper** on the large neutrino LS detector is currently being prepared.

Current Authors

- **LS purification**: JayBenziger (Princeton), Mingang Yeh (BNL)
- **IsoDAR**: Jose Alonso (MIT), Janet Conrad (MIT), Mike Shaevitz (Columbia), Joshua Spitz (Michigan), Daniel Winklehner (MIT)
- **Sterile nu** search w/ radioactive sources: Marco Pallavicini (Genoa U.)
- **$0\nu\beta\beta$**: Yeongduk Kim (IBS)
- **Solar ν**: Sunny Seo (IBS)
- **Supernova ν**: Jost Migenda (King's college, London)
- **SN Relic ν**: Michael Wurm (Mainz U.)
- **Geo ν**: Steve Dye (Hawaii U.)
- **New physics search**: Doojin Kim (Texas A&M), Jongchul Park (CNU)
- Introduction, Site, Detector: Sunny Seo (IBS)

Rough Timeline

LSC @Yemilab



We need funding for the LSC detector.

The construction depedns on when we get the funding.

Summary & Conclusion

- In new Yemilab, a **cavern** for ν detector (~2.3 kton LS) is ready.

→ multi-purpose detector: **sterile ν**, **dark photon**, **solar ν**, geo ν, etc.

- 1 year operation of 100 MeV-100 kW e^- beam (2×10^{23} EOT):
  best "direct" dark photon search sensitivity
  in O(1 eV) < M_ϕ < 30 MeV (assuming 10^3 bkg events/year)

- IsoDAR@Yemilab: best sensitivity for sterile ν search
  in $P(\bar{\nu}_e \to \bar{\nu}_e)$ channel. Can test different new physics models.

- IsoDAR@Yemilab: good $\sin^2\theta_W$ measurement at Q ~ 3 MeV.

→ Constrain NSI