tightly linked to **LiquidO**, **AM-OTech/CLOUD**, and **SuperChooz** collaborations/consortia & specially **EDF**

S U P E R C H O O Z

European Innovation Council

La Thuille 2023 Conference
11th March 2023 — La Thuille, Italia

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IJCLab (Orsay)
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cnrs
eDF

~50 years of neutrino oscillations…

huge experimental/theory effort

[discovery⊕establishment ⇔ Nobel 2015]

status on neutrino oscillation knowledge…

Standard Model(3 families)
[leptons & quarks]
&
PMNS$_{3x3}$(θ_{12},θ_{23},θ_{13})
&
±Δm² & **+δm²**

no conclusive sign of any extension so far!!
(inconsistencies vs uncertainties)

must measure all parameters→characterise & test (i.e. over-constrain) ***Standard Model***

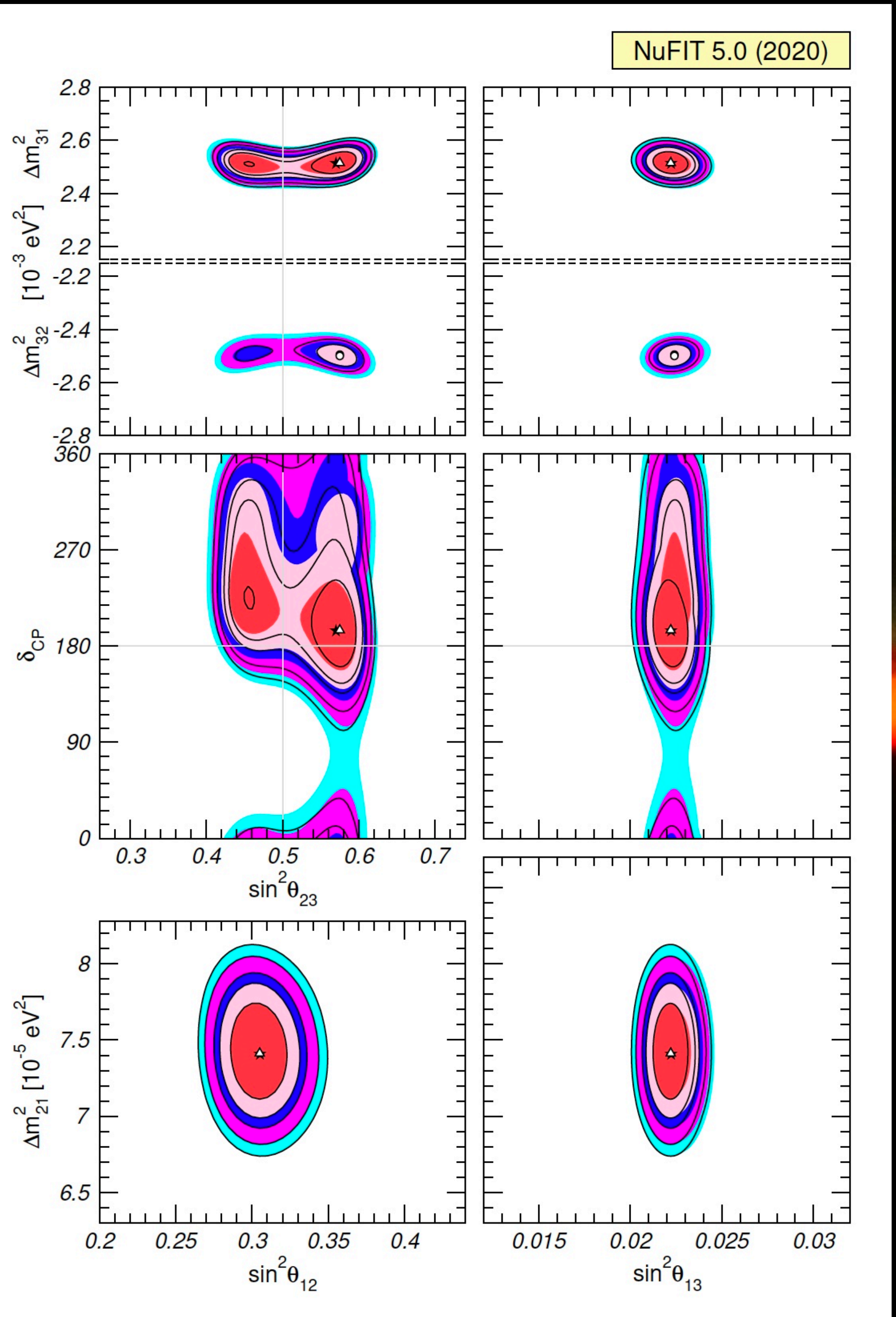
	today			≥2030		
	best knowledge		global	foreseen	dominant	source
θ_{12}	3.0 %	SK⊕SNO	2.3 %	<1.0%	JUNO	reactor
θ_{23}	5.0 %	NOνA+T2K	2.0 %	≲1.0%	DUNE⊕HK	beam (octant)
θ_{13}	1.8 %	DYB+DC+RENO	**1.5 %**	**1.5 %**	DC⊕DYB⊕RENO	reactor
+δm²	2.5 %	KamLAND	2.3 %	≲1.0%	JUNO	reactor
|Δm²|	3.0 %	T2K+NOνA & DYB	1.3 %	≲1.0%	JUNO⊕DUNE⊕HK	reactor & beam
Mass Ordering	**unknown**	SK et al	NO @ **~3σ**	@5σ	JUNO⊕DUNE⊕HK	reactor⊕beam
CPV	**unknown**	T2K	3/2π @ **≲2σ**	**@5σ?**	DUNE⊕HK⊕ALL	reactor⊕beam

(**now**) (reactor-beam)

JUNO⊕DUNE⊕HK will lead precision in the field (→**Mass Ordering & CPV**) **except θ_{13}!**

NOTE: ORCA⊕PINGU⊕IceCube complementary (Mass Ordering & Δm² measurements)

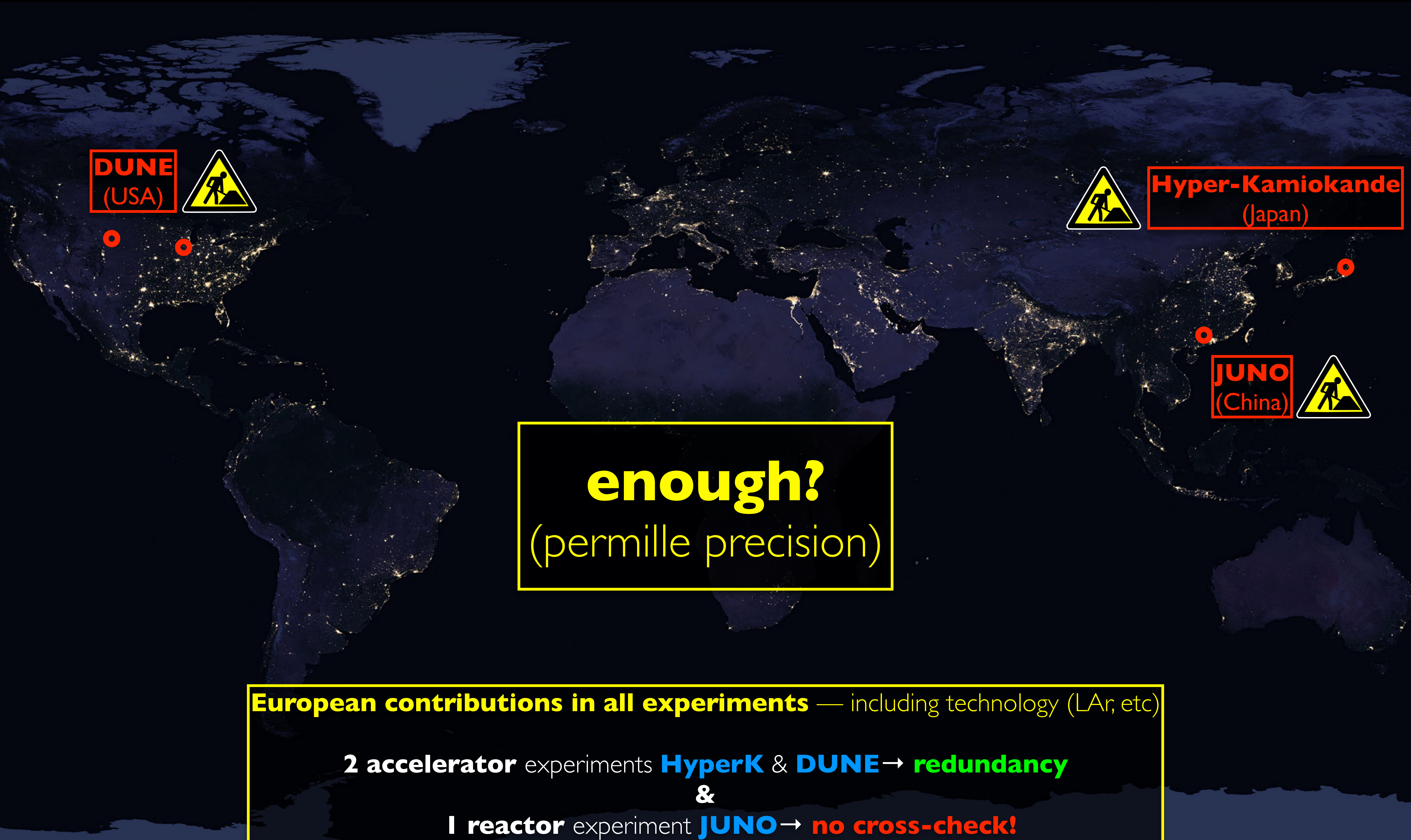
Anatael Cabrera (CNRS-IN2P3 @ LAL - LNCA)



NuFIT 5.0 (2020)

		Normal Ordering (best fit)		Inverted Ordering ($\Delta\chi^2 = 2.7$)	
		bfp $\pm 1\sigma$	3σ range	bfp $\pm 1\sigma$	3σ range
without SK atmospheric data	$\sin^2\theta_{12}$	$0.304^{+0.013}_{-0.012}$	$0.269 \to 0.343$	$0.304^{+0.013}_{-0.012}$	$0.269 \to 0.343$
	$\theta_{12}/^\circ$	$33.44^{+0.78}_{-0.75}$	$31.27 \to 35.86$	$33.45^{+0.78}_{-0.75}$	$31.27 \to 35.87$
	$\sin^2\theta_{23}$	$0.570^{+0.018}_{-0.024}$	$0.407 \to 0.618$	$0.575^{+0.017}_{-0.021}$	$0.411 \to 0.621$
	$\theta_{23}/^\circ$	$49.0^{+1.1}_{-1.4}$	$39.6 \to 51.8$	$49.3^{+1.0}_{-1.2}$	$39.9 \to 52.0$
	$\sin^2\theta_{13}$	$0.02221^{+0.00068}_{-0.00062}$	$0.02034 \to 0.02430$	$0.02240^{+0.00062}_{-0.00062}$	$0.02053 \to 0.02436$
	$\theta_{13}/^\circ$	$8.57^{+0.13}_{-0.12}$	$8.20 \to 8.97$	$8.61^{+0.12}_{-0.12}$	$8.24 \to 8.98$
	$\delta_{CP}/^\circ$	195^{+51}_{-25}	$107 \to 403$	286^{+27}_{-32}	$192 \to 360$
	$\frac{\Delta m^2_{21}}{10^{-5}\ \text{eV}^2}$	$7.42^{+0.21}_{-0.20}$	$6.82 \to 8.04$	$7.42^{+0.21}_{-0.20}$	$6.82 \to 8.04$
	$\frac{\Delta m^2_{3\ell}}{10^{-3}\ \text{eV}^2}$	$+2.514^{+0.028}_{-0.027}$	$+2.431 \to +2.598$	$-2.497^{+0.028}_{-0.028}$	$-2.583 \to -2.412$
		Normal Ordering (best fit)		Inverted Ordering ($\Delta\chi^2 = 7.1$)	
		bfp $\pm 1\sigma$	3σ range	bfp $\pm 1\sigma$	3σ range
with SK atmospheric data	$\sin^2\theta_{12}$	$0.304^{+0.012}_{-0.012}$	$0.269 \to 0.343$	$0.304^{+0.013}_{-0.012}$	$0.269 \to 0.343$
	$\theta_{12}/^\circ$	$33.44^{+0.77}_{-0.74}$	$31.27 \to 35.86$	$33.45^{+0.78}_{-0.75}$	$31.27 \to 35.87$
	$\sin^2\theta_{23}$	$0.573^{+0.016}_{-0.020}$	$0.415 \to 0.616$	$0.575^{+0.016}_{-0.019}$	$0.419 \to 0.617$
	$\theta_{23}/^\circ$	$49.2^{+0.9}_{-1.2}$	$40.1 \to 51.7$	$49.3^{+0.9}_{-1.1}$	$40.3 \to 51.8$
	$\sin^2\theta_{13}$	$0.02219^{+0.00062}_{-0.00063}$	$0.02032 \to 0.02410$	$0.02238^{+0.00063}_{-0.00062}$	$0.02052 \to 0.02428$
	$\theta_{13}/^\circ$	$8.57^{+0.12}_{-0.12}$	$8.20 \to 8.93$	$8.60^{+0.12}_{-0.12}$	$8.24 \to 8.96$
	$\delta_{CP}/^\circ$	197^{+27}_{-24}	$120 \to 369$	282^{+26}_{-30}	$193 \to 352$
	$\frac{\Delta m^2_{21}}{10^{-5}\ \text{eV}^2}$	$7.42^{+0.21}_{-0.20}$	$6.82 \to 8.04$	$7.42^{+0.21}_{-0.20}$	$6.82 \to 8.04$
	$\frac{\Delta m^2_{3\ell}}{10^{-3}\ \text{eV}^2}$	$+2.517^{+0.026}_{-0.028}$	$+2.435 \to +2.598$	$-2.498^{+0.028}_{-0.028}$	$-2.581 \to -2.414$

flagship neutrino experiments…



enough?
(permille precision)

European contributions in all experiments — including technology (LAr, etc)

2 accelerator experiments **HyperK** & **DUNE** → **redundancy**
&
1 reactor experiment **JUNO** → **no cross-check!**

Anatael Cabrera CNRS-IN2P3 / IJCLab (Orsay) - LNCA (Chooz) Laboratories

any room for **new physics?**

SMv1.1: knowns & unknowns…

Weak Flavour Neutrinos (**3**): **ν(e)**, **ν(μ)**, **ν(τ)** — observed **3!** (same as quarks)

Mass Neutrinos (**3**): **ν(1)**, **ν(2)**, **ν(3)** — assumed **≥3!** [tight cosmology constraints]

SuperChooz?

PMNS matrix (3x3; *a la CKM*): ***U***, *assumed* ***unitarity*** (→***violation?***) — discovery!

HyperK⊕DUNE

- mixing parameters (**3**): θ_{13}, θ_{12}, θ_{23} (octant**?**) — derived ***J*** [Jarlskog invariant]
- CP-violation parameter (**1**): **δ?** — unknown [*SM*]

Mass Squared Differences (**2**): δm^2 (i.e. Δm^2_{12})
Δm^2 (i.e. Δm^2_{13} or Δm^2_{23})

Mass Ordering (*MO*):
+δm^2 (solar data — observed!)

JUNO⊕DUNE et al

±?Δm^2 → which is the lightest neutrino ν(1) or ν(3)**?** — unknown [*SM*]

many

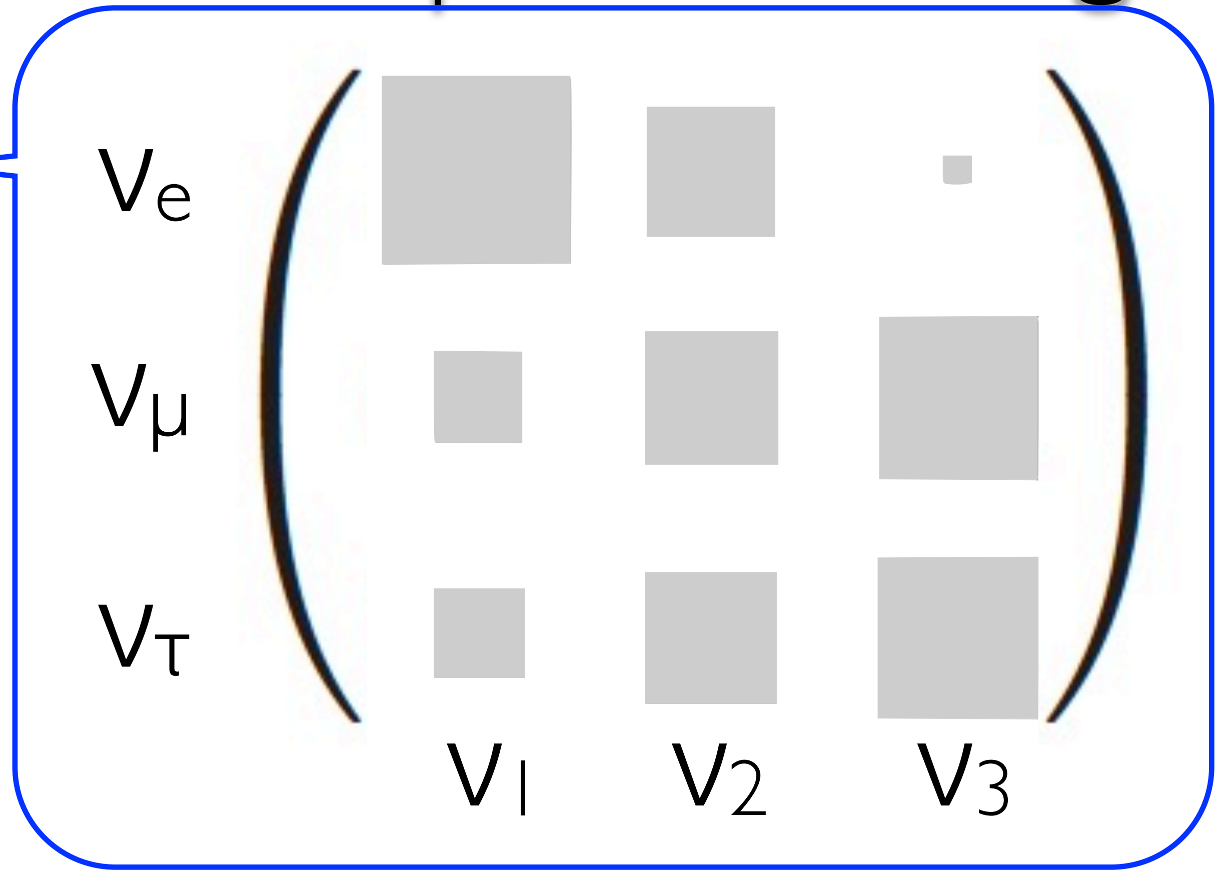
Mass Hierarchy (*MH*): **the mass of the neutrino?** — discovery!
[→why so much smaller than charged leptons?]

ββ

Neutrino Nature: **Majorana?** — discovery!

SM's leptonic mixing sector (PMNS)…

$$\begin{pmatrix} U_{e1} & U_{e2} & U_{e3} \\ U_{\mu 1} & U_{\mu 2} & U_{\mu 3} \\ U_{\tau 1} & U_{\tau 2} & U_{\tau 3} \end{pmatrix}$$



consider full matrix structure

(not just composition)

why shape?

- **large mixing** but a **small one**!
- **largest CP-violation** (SM)
- **any symmetry behind? [or Nature's caprice?]**

U_{3x3} unitary?

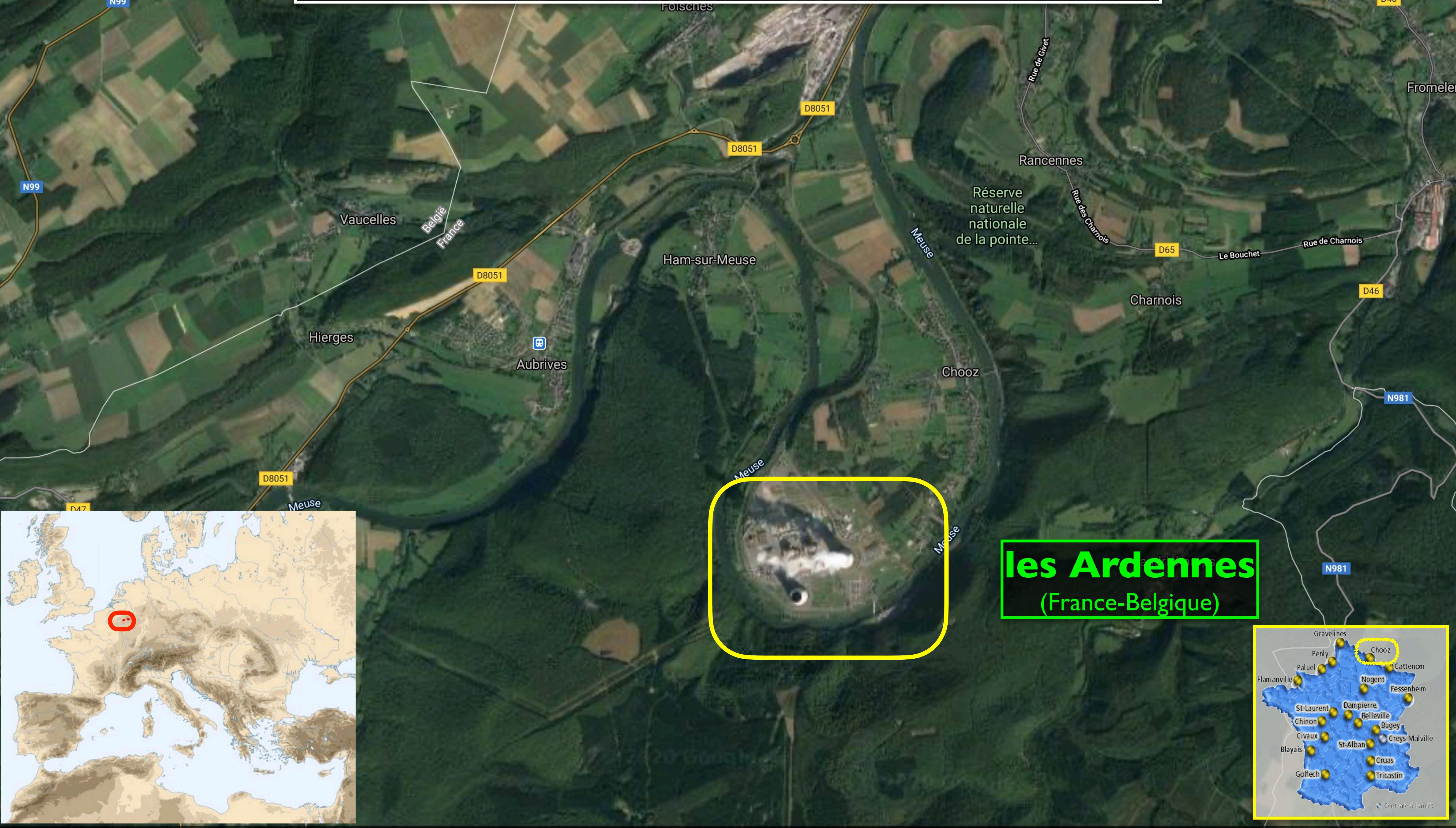
[assumed!!, not demonstrated]

neutrino unique in Standard Model… **more discoveries?**

SUPERCHOOZ

the new opportunity…

somewhere in the middle of Europe, there is Chooz…



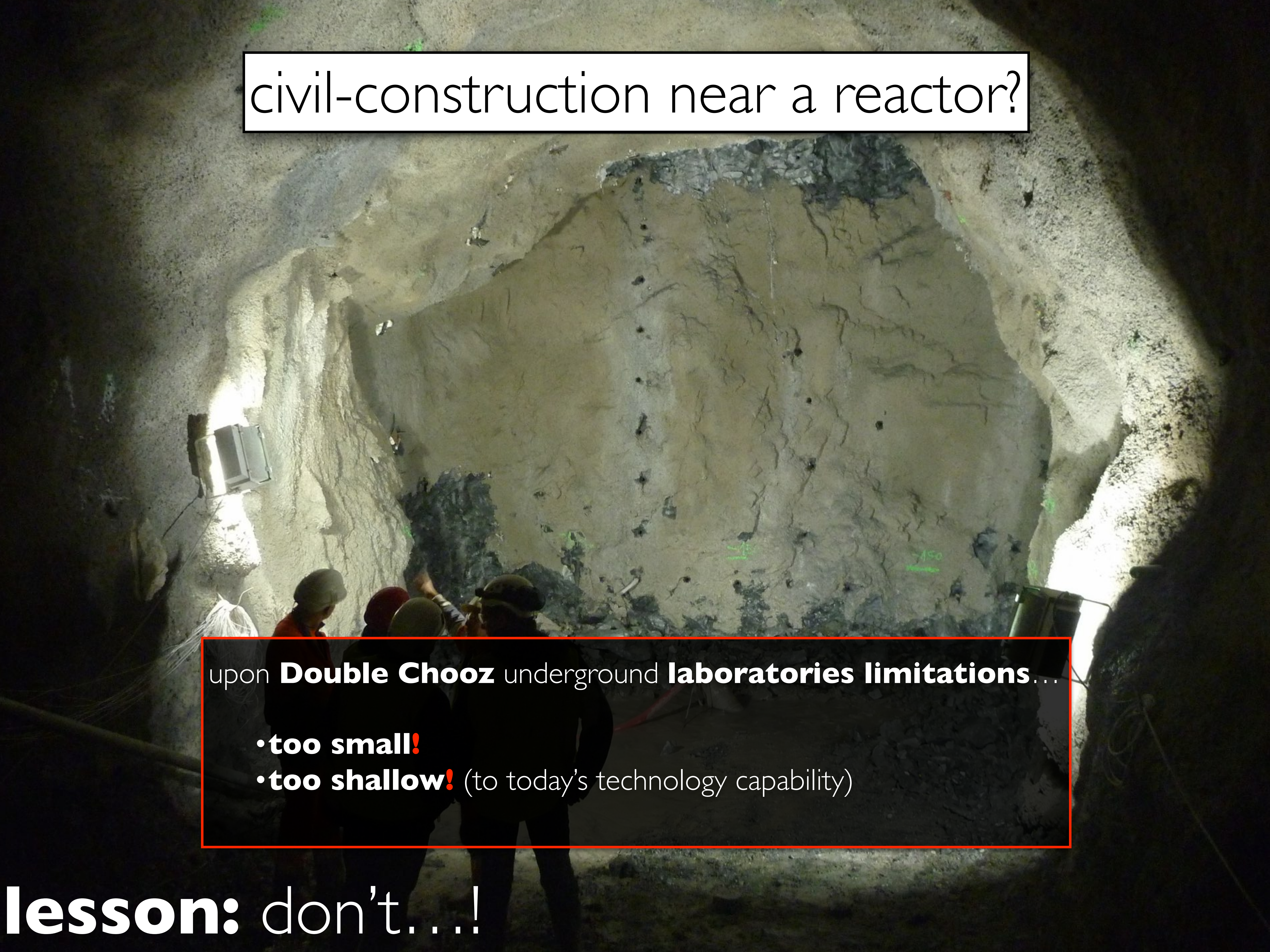
maybe Chooz?

Chooz *is tiny cute little village in the Ardennes*

Chooz = powerful reactor(s) ⊕ overburden

Chooz-B nuclear reactor plant: 2x N4 reactors [4.2GW$_{thermal}$ each]

civil-construction near a reactor?



upon **Double Chooz** underground **laboratories limitations**…

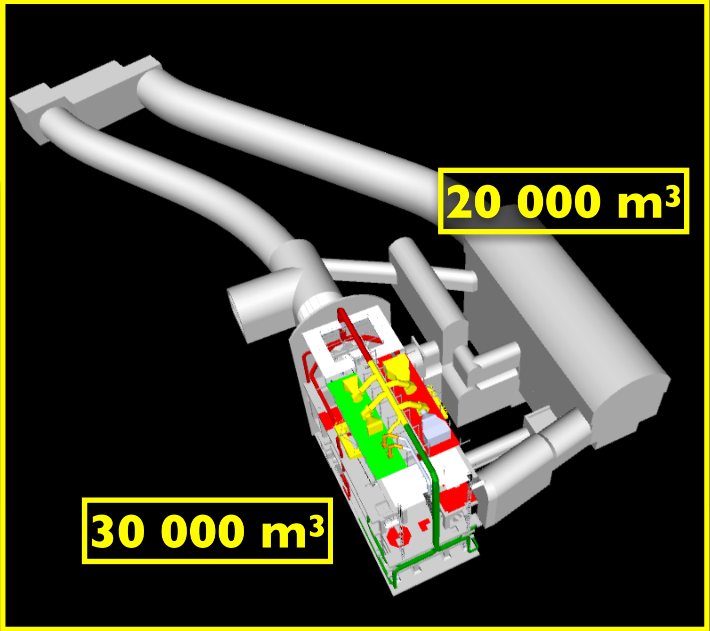
- **too small!**
- **too shallow!** (to today's technology capability)

lesson: don't…!

physics at Chooz: **future?**

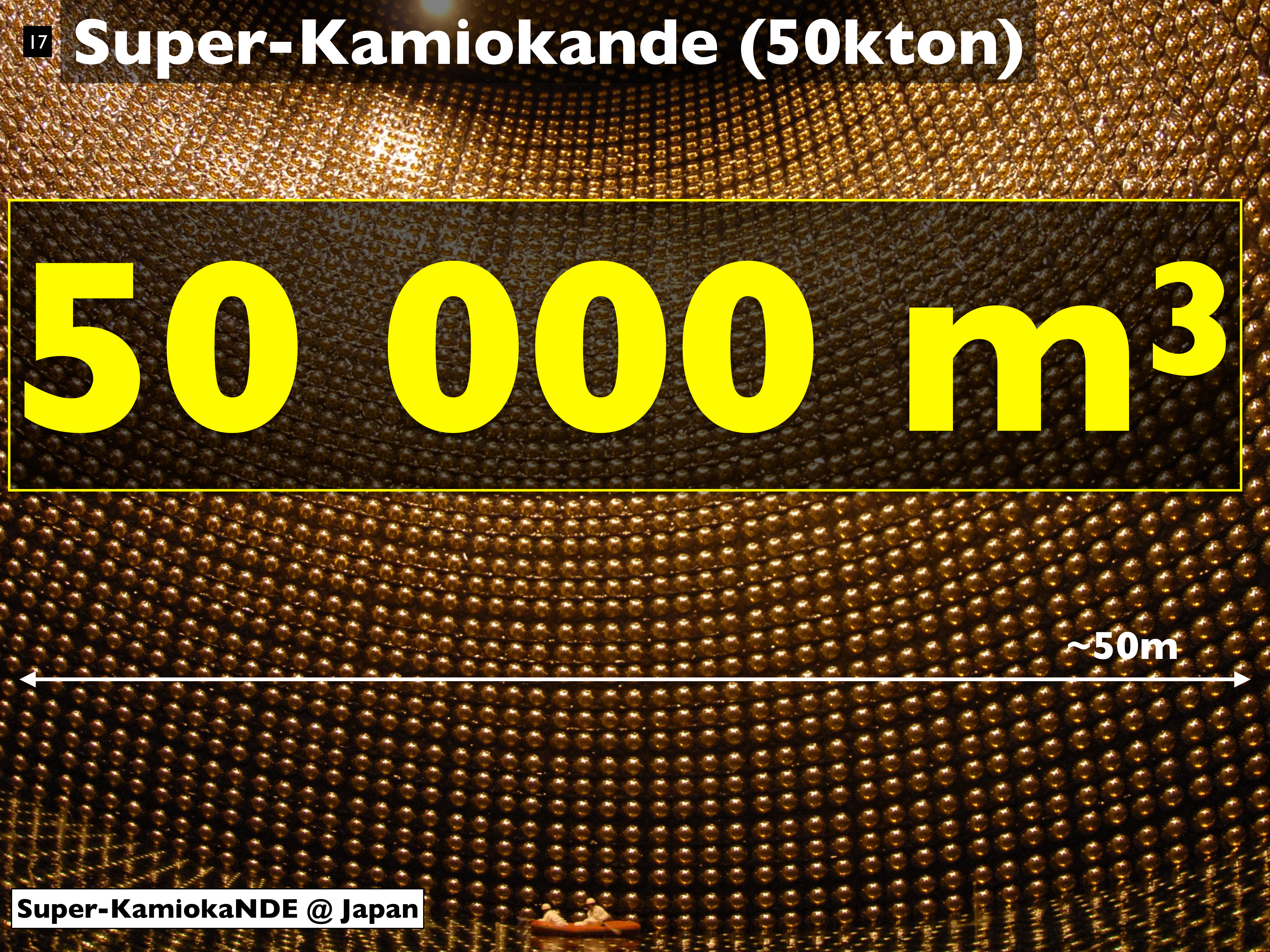
an underground **unknown**…

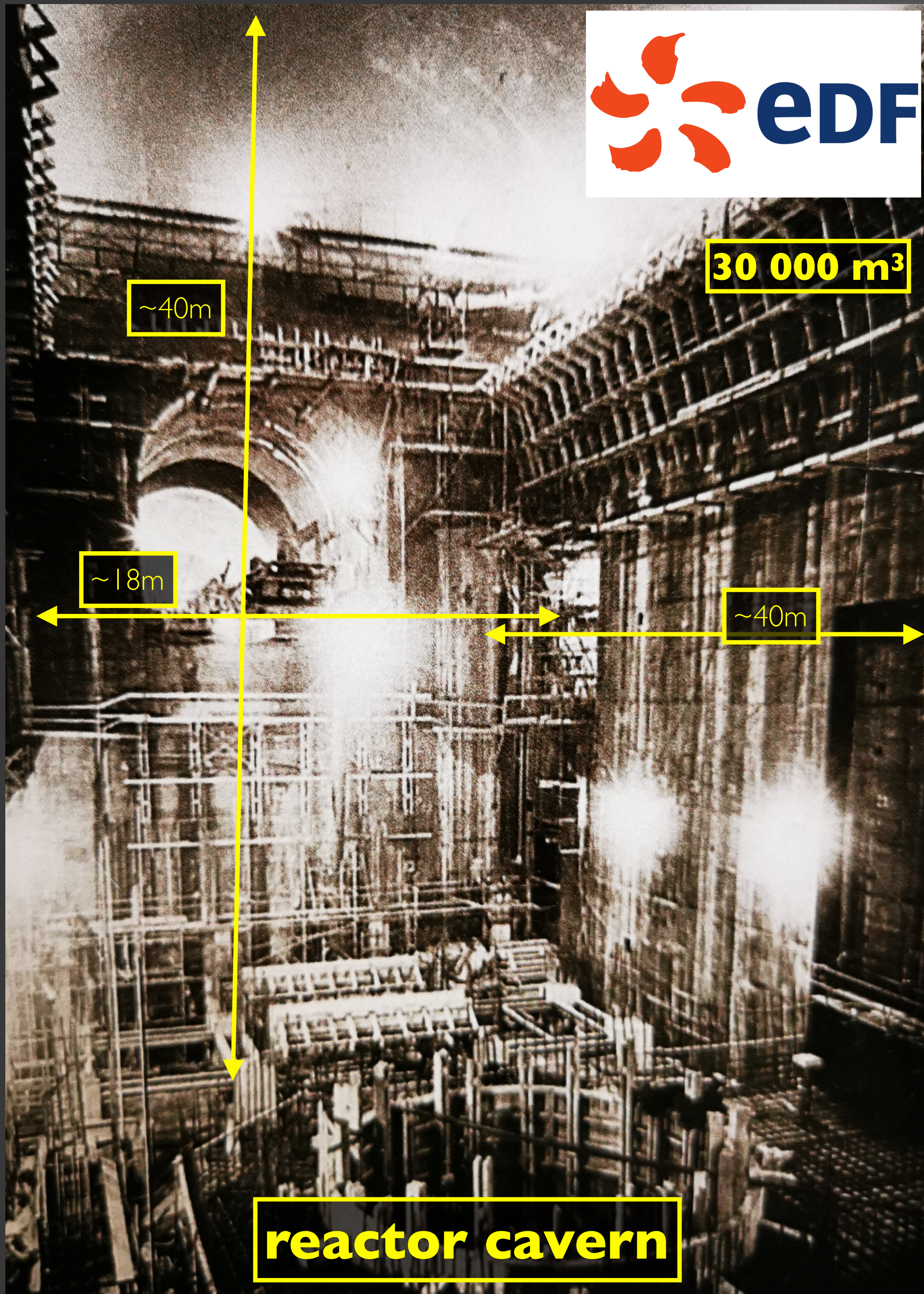
huge caverns (already built) of the **size of Super-Kamiokande** right next to **Chooz reactors!**
(unique site in France-Belgium / Europe / World?)



Chooz-A for science?

Super-Kamiokande (50kton)





R

construction caverns [1962-1967]

SuperChooz cavern is built (60's)…

historical opportunity!! one of the largest underground laboratories in Europe — built!!

IJCLab⊕Subatech teams — Octobre 2020

CNRS/IN2P3 direction — March 2022

EDF⊕CNRS exploring (2018)…

(despite COVID)

S U P E R C H O O Z

experimental scenario…

SuperChooz Signature September 2022 — CNRS-EDF

SuperChooz Pathfinder starts…

SuperChooz
@Superchooz

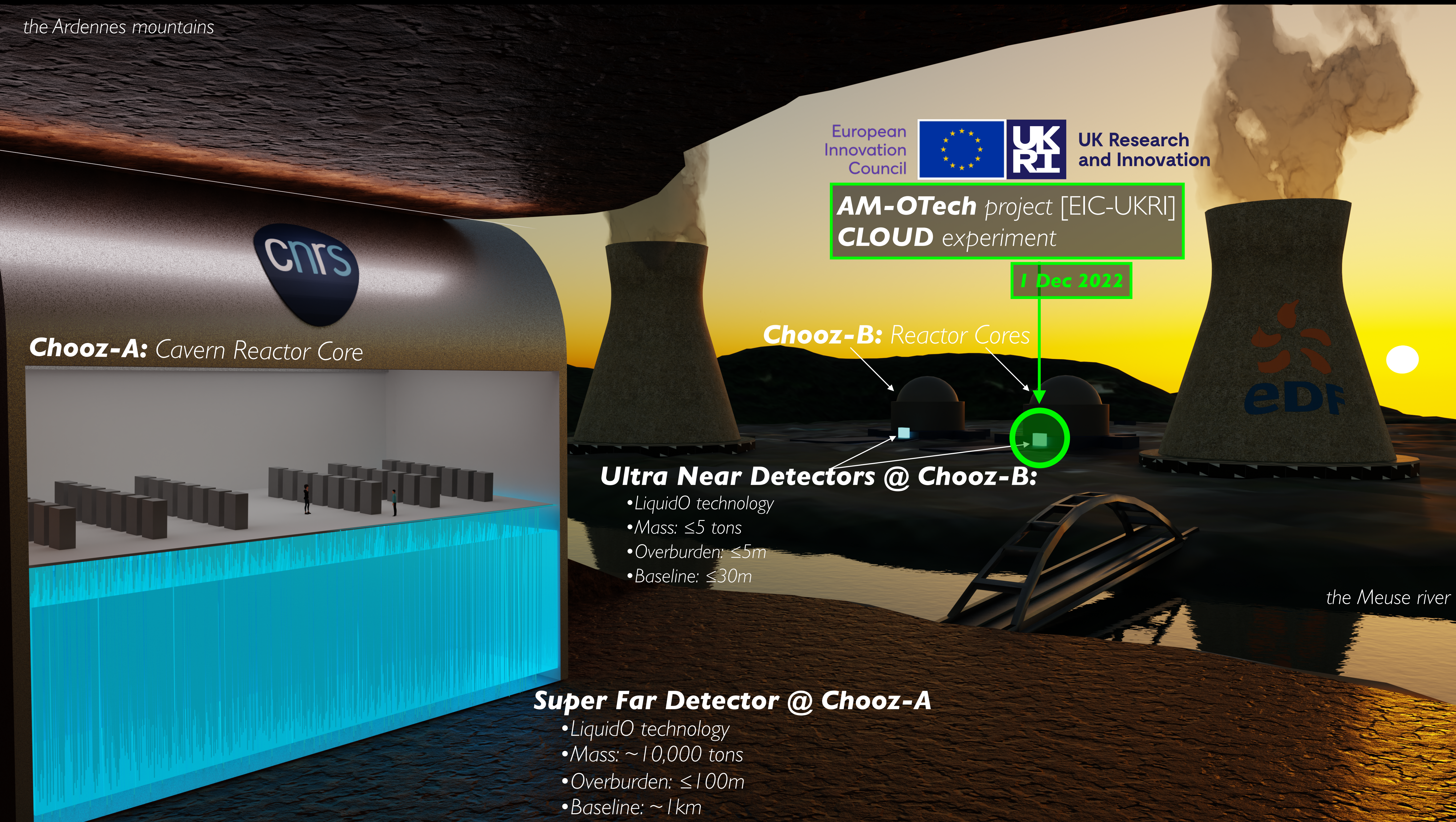
We are delighted to announce that the #SuperChooz agreement between @EDFofficiel and @CNRS directions was signed on the 7th Sept 2022 (twitter.com/IN2P3_CNRS/sta...), thus officially starting the so-called “SuperChooz Pathfinder” exploration era.

S U P E R C H O O Z

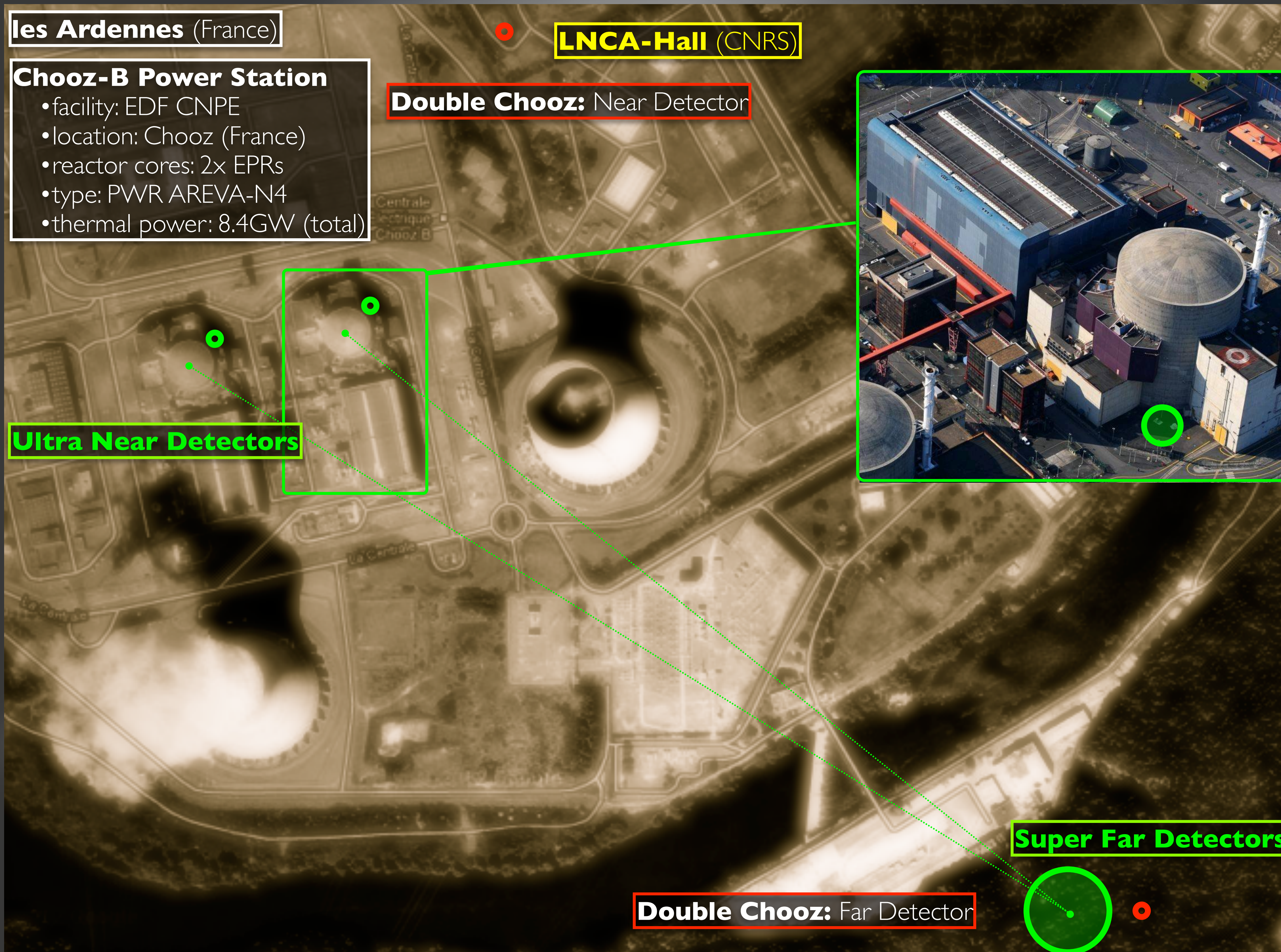
pathfinder [2022-2028]

exploration is now official...

SuperChooz experimental setup…



SuperChooz → new laboratory facilities — beyond the existing **LNCA** (key support!)

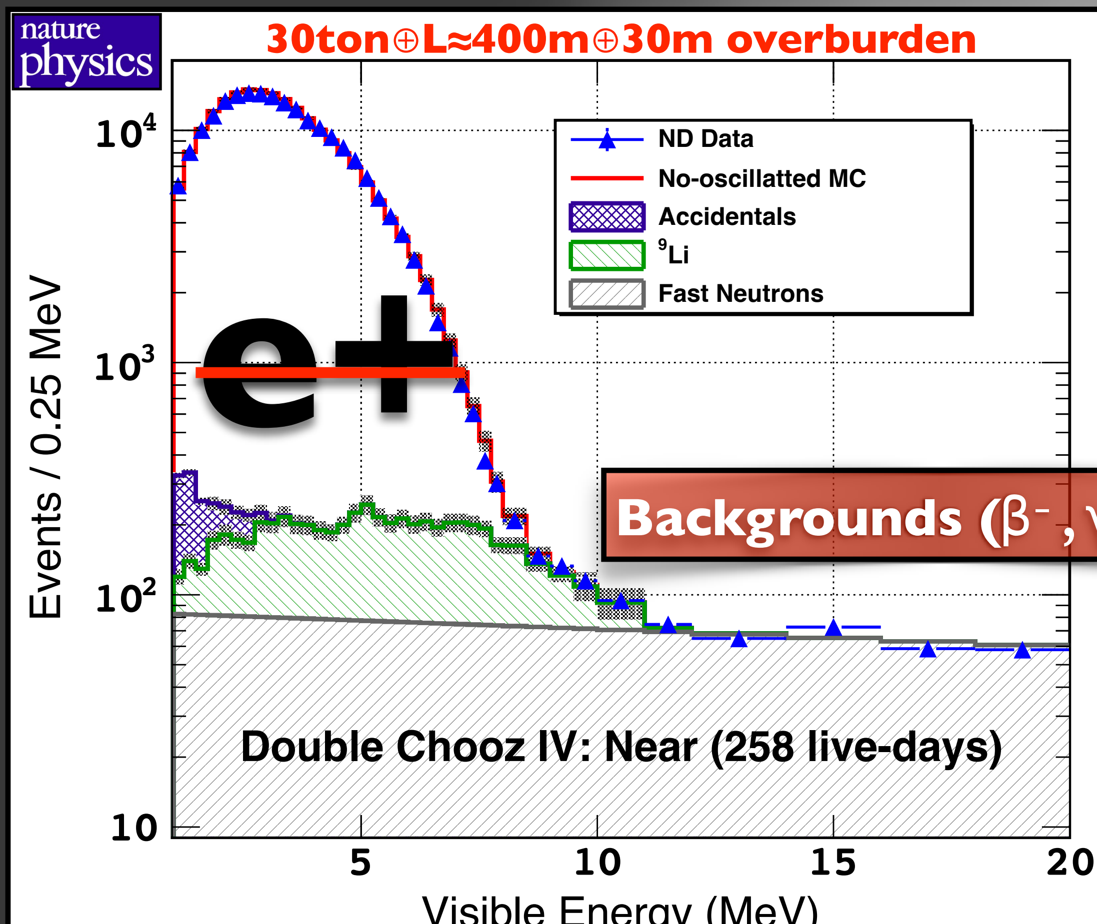


Anatael Cabrera (CNRS-IN2P3) — IJCLab / Université Paris-Saclay (Orsay)

SUPERCHOOZ

experimental demonstration

experimental demonstration I



Article | Published: 20 April 2020

Double Chooz θ_{13} measurement via total neutron capture detection

The Double Chooz Collaboration

Nature Physics **16**, 558–564 (2020) | Cite this article

- **no Gd** needed a priori — simpler
- extreme precision **single/multi-detector(s)**
  ⟹<u>simpler detectors</u> (avoid multi-volumes)
- control of **all systematics at per mille**
- **geometrical full flux cancellation systematic**
  ⟹**fewer reactors sites** is better!
- exquisite **energy control absolute/relative**
- Chooz site **full background knowledge**

DC-ND:
Signal ≈ 816 ν/day (average over cycle)
BG(β⁻,α,γ,p) ≈ 39 day^{-1} (“*some per day*”)

Signal/BG ≈ 21→30 within IBD region [0.5,9.0]MeV

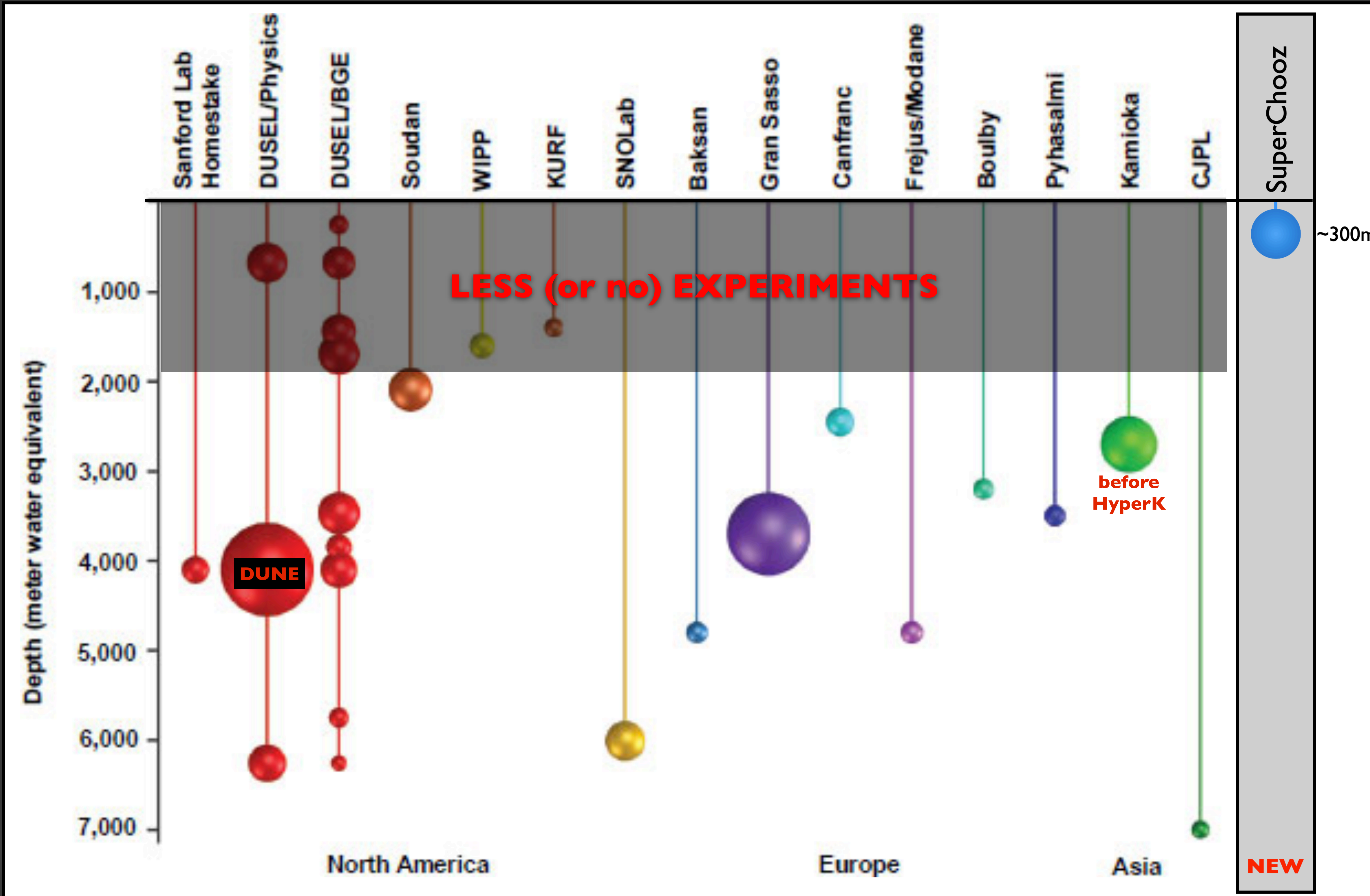
systematics can be controlled: ~0.1% (each)
[flux, background, <u>detection</u>]

energy control: ≲0.5%

enough?

Double Chooz data & expertise…

Anatael Cabrera (CNRS-IN2P3) — IJCLab / Université Paris-Saclay (Orsay)



ISSUE!!! overburden <100m rock (or <300 mwe)

world underground volume…

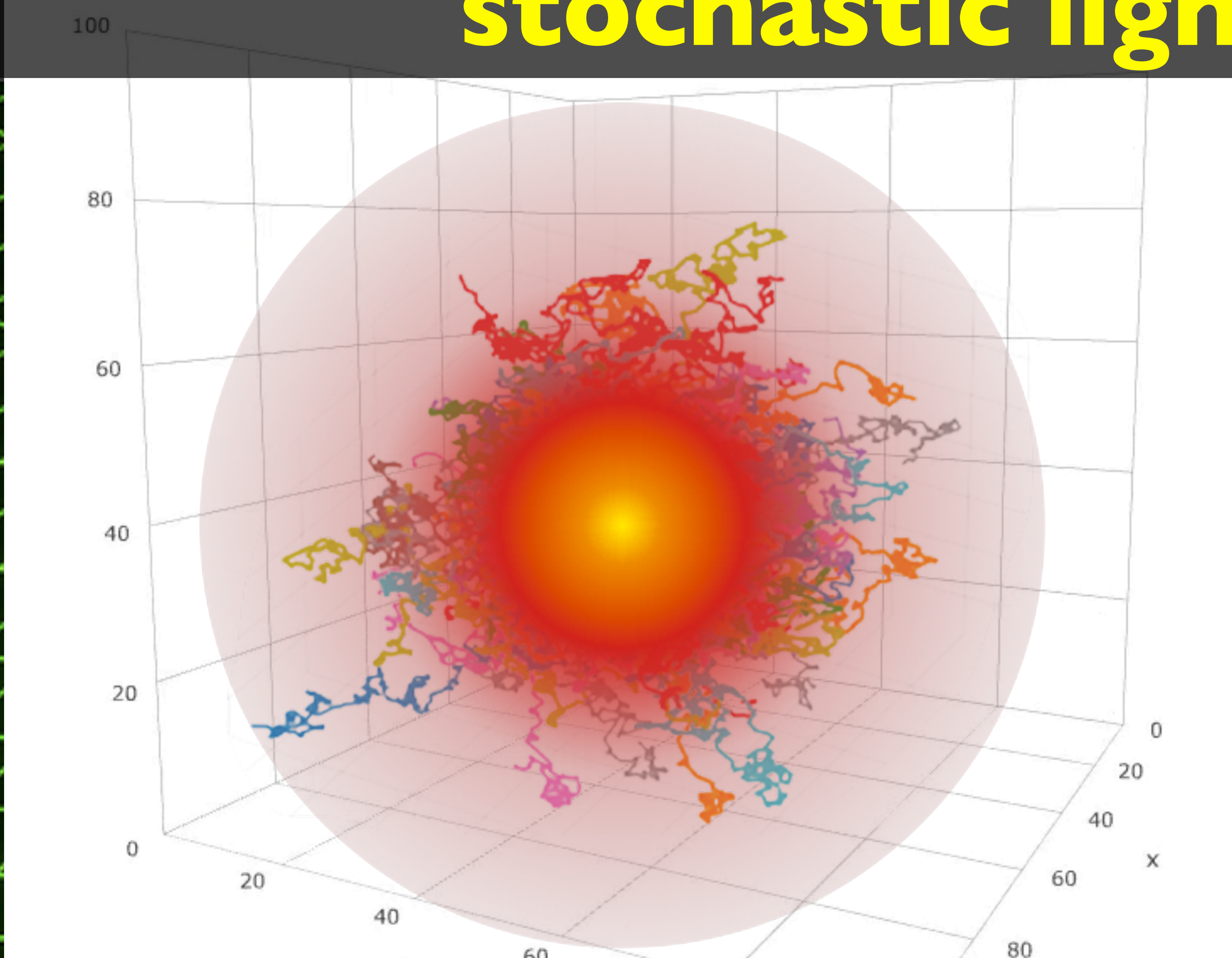
experimental demonstration II

LIQUIDO

new technology — the breakthrough

today's liquid scintillator technology: transparent. . .

stochastic light confinement



LiqudiO→ photon's "random walk" (self-confinement)

- **scattering→random walk→light ball** [order 1cm]
  - scattering <u>mean-free-path order 1mm</u>: x10^{-4} smaller than usual
- **lossless scattering:**
  - **Mie scattering:** achromatic & tiny losses ["cloudy" touch]
  - **Rayleigh scattering:** chromatic & lossless
  - **Internal Reflection** (Snell's law lossless)
  - **warning:** <u>avoid reflection</u> (losses @ order ~1%/reflection)

LiquidO ⇔ unique stochastic light confinement

⟹ **must NOT be transparent!!**

Transparency
λ(scattering)**≥10m**

Rayleigh & Mie Scattering
λ(scattering)**≤1cm**

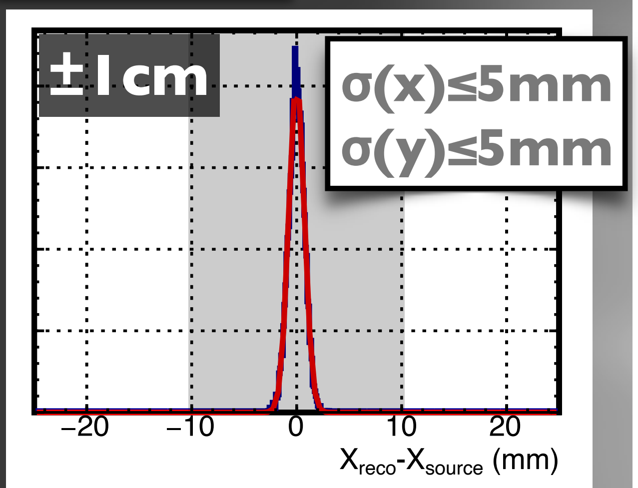
inducing light to a point (lossless)...

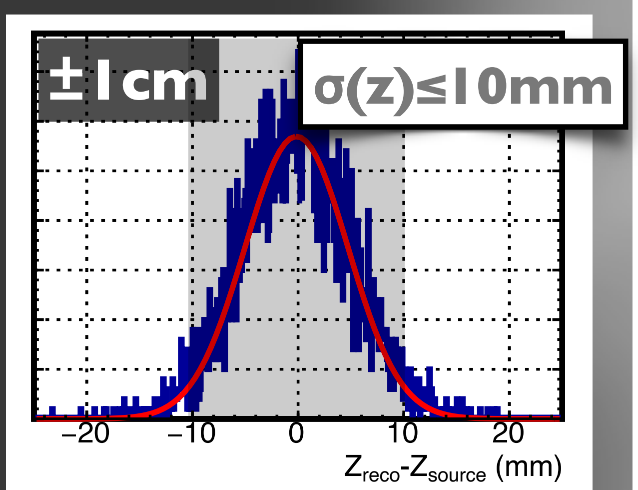
LiquidO ↔ stochastic light confinement

Topology (X,Y) direct & native (PID)→ possible **sub-mm vertex precision**

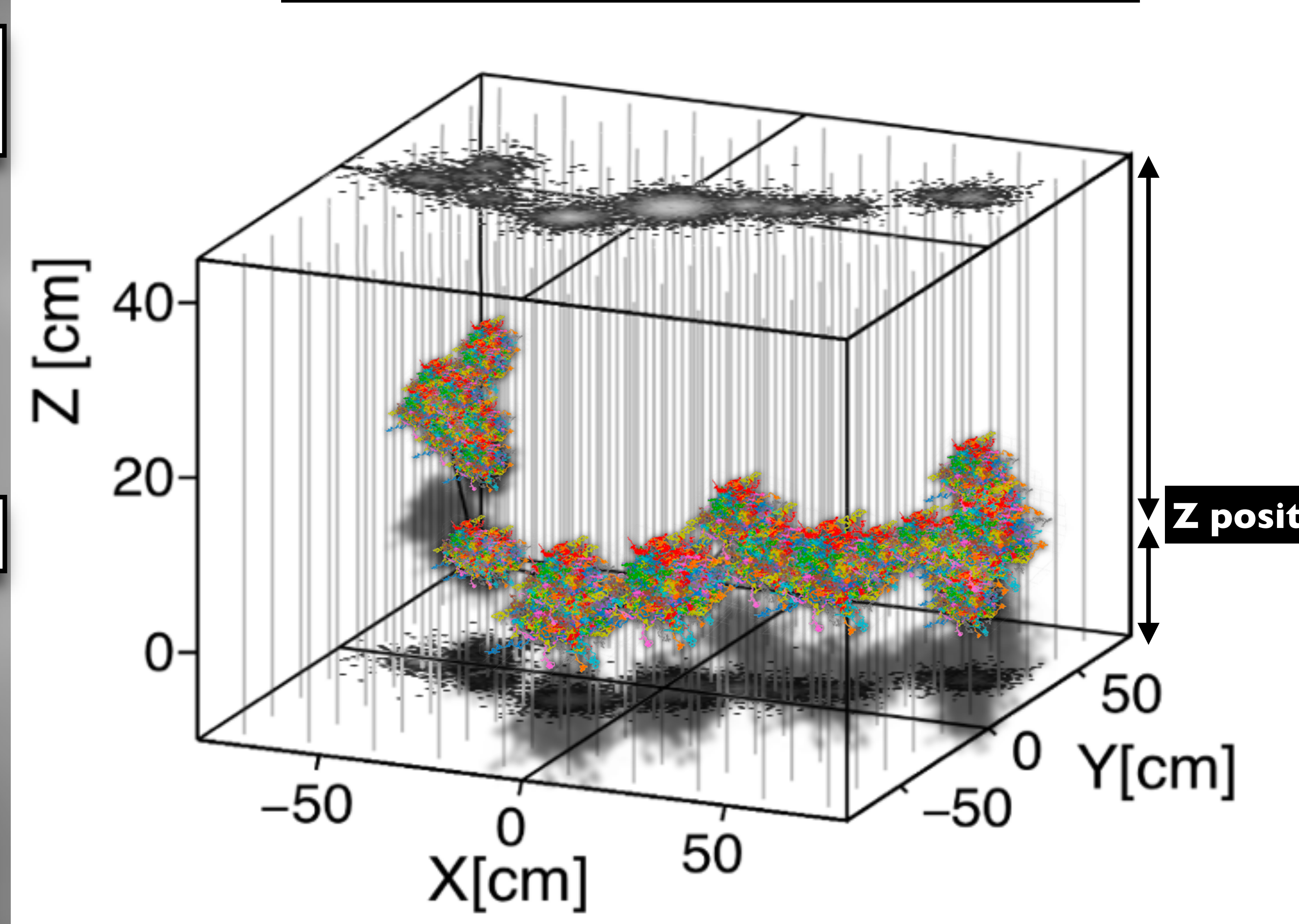
Vanilla LiquidO: 1D lattice (fibres along Z-axis only)

~0.5MeV



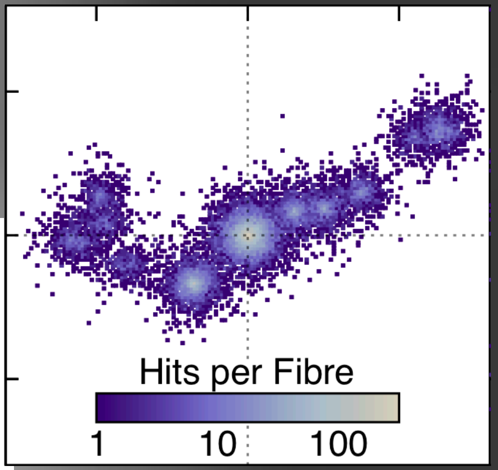


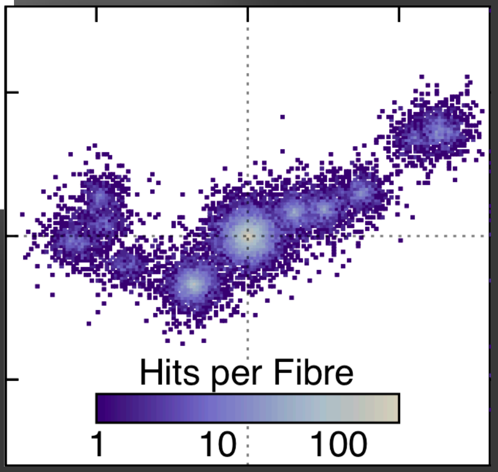
TOP VIEW: (X,Y) Projection→ direct readout



Z position: Δt (time difference)

BOTTOM VIEW: (X,Y) Projection→ direct readout



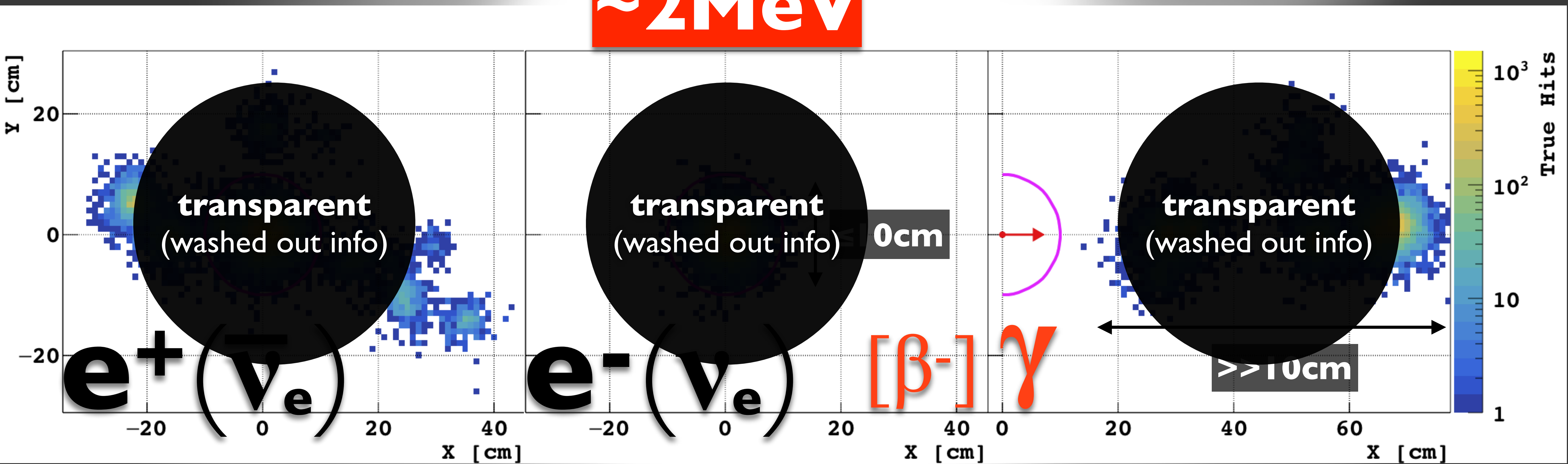


LiquidO can have up 3 orthogonal fibre lattice orientations (3D)

unprecedented PID@MeV…

potential: reduce overburden/shielding

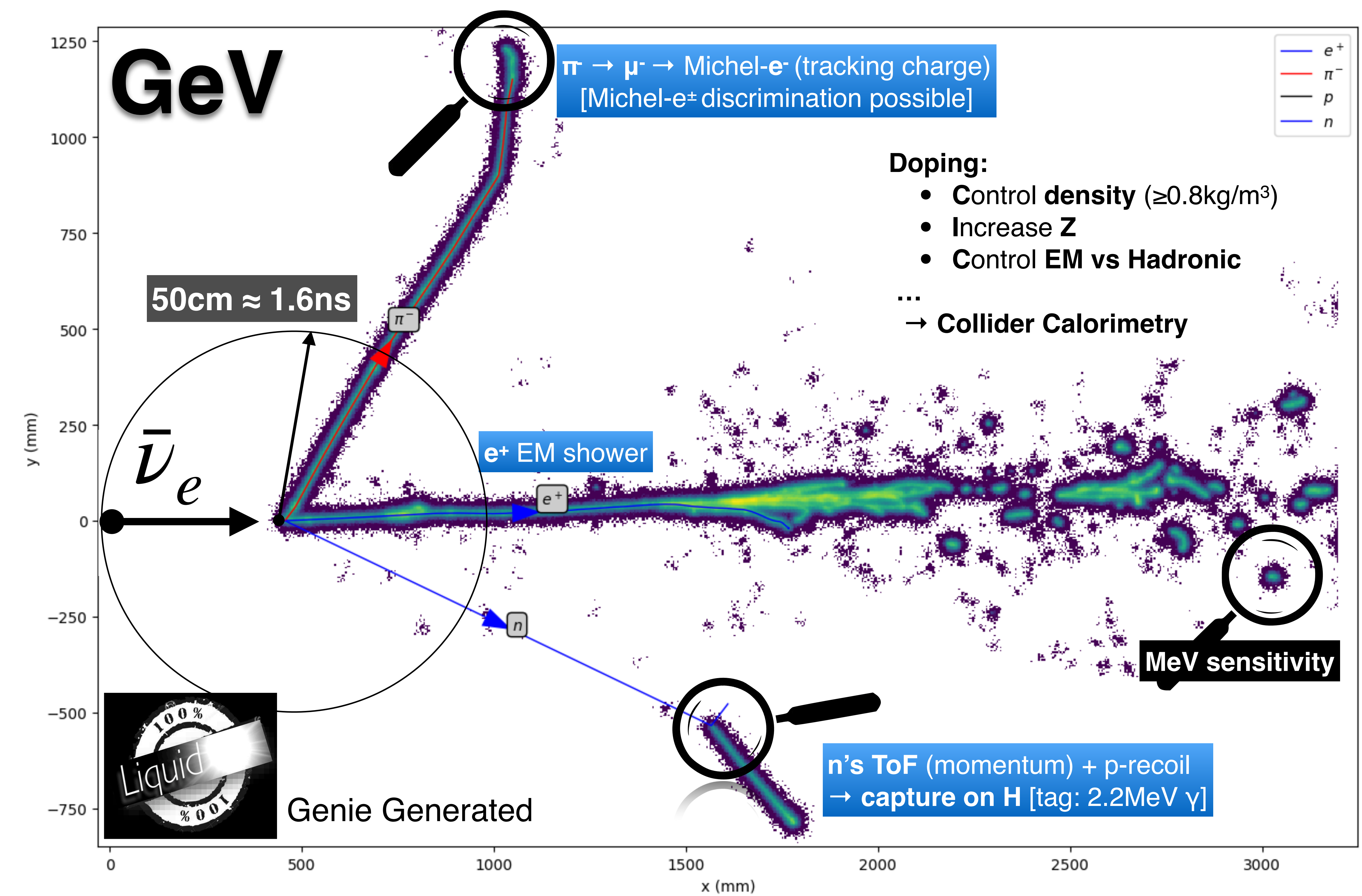
~2MeV



opacity→ (native) self-segmentation

needless segmentation: problematic @ 1MeV (pollution, cost⊕complex, etc)

~1MeV: reactor, geoneutrino, solar, etc



Stochastic calorimetry order 0.1% [~10⁵ PE/GeV] — excellent control of non-stochastic

≥100MeV: accelerator, atmospheric, p-decay, etc

Anatael Cabrera (CNRS-IN2P3) — IJCLab / Université Paris-Saclay (Orsay)

experimental demonstration III

a priori no showstopper

SuperChooz : ~9 700 m³

some **common technology** but **not methodology**

- scintillator: ✓ (improvement)
- fibres ✓ (improvement)
- ~~segmentation~~ ✗ (simplification, cheaper, less BG)
- light collection: ✓ (improvement expected)
- photo-detector: ✓ (simplicaition with SiPM)
- MeV optimisation→**Scaling R&D [≥2024]**

SuperChooz (~10kton) similar dimensions as **NOvA (~14kton)** & one module of **DUNE (~10kton)**

First Release at CERN July 2019 (detector seminar)

https://indico.cern.ch/event/823865/

nature communications physics

Article | Open Access | Published: 21 December 2021

Neutrino physics with an opaque detector

LiquidO Consortium

Communications Physics 4, Article number: 273 (2021) | Cite this article

Abstract **COVID delayed**

In 1956 Reines & Cowan discovered the neutrino using a liquid scintillator detector. The neutrinos interacted with the scintillator, producing light that propagated across transparent volumes to surrounding photo-sensors. This approach has remained one of the most widespread and successful neutrino detection technologies used since. This article introduces a concept that breaks with the conventional paradigm of transparency by confining and collecting light near its creation point with an opaque scintillator and a dense array of optical fibres. This technique, called LiquidO, can provide high-resolution imaging to enable efficient identification of individual particles event-by-event. A natural affinity for adding dopants at high concentrations is provided by the use of an opaque medium. With these and other capabilities, the potential of our detector concept to unlock opportunities in neutrino physics is presented here, alongside the results of the first experimental validation.

www.nature.com/articles/s42005-021-00763-5

latest experimental results @ Neutrino 2022 (June 2022)

on behalf of the **LiquidO consortium**…

publication under preparation

DOI 10.5281/zenodo.6697273

https://zenodo.org/record/6697273#.Y4DDdezMLfv

proof-of-concept: *simulation* & data [**μ-LiquidO**]

physics potential — appetiser

latest prototype detector results [mini-LiquidO]

physics potential — more precision

LiquidO Official WEB: https://liquido.ijclab.in2p3.fr/

LiquidO Consortium*

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invention/conception 2012-2013 — since 2016 consortium (~20 institutes & 10 countries)

SuperChooz's pilot project

C L O U D

European Innovation Council

UK Research and Innovation

project: "**AntiMatter-OTech**"

first LiquidO-based experiment...

CLOUD = "**C**hooz **L**iquid**O** **U**ltranear **D**etector"

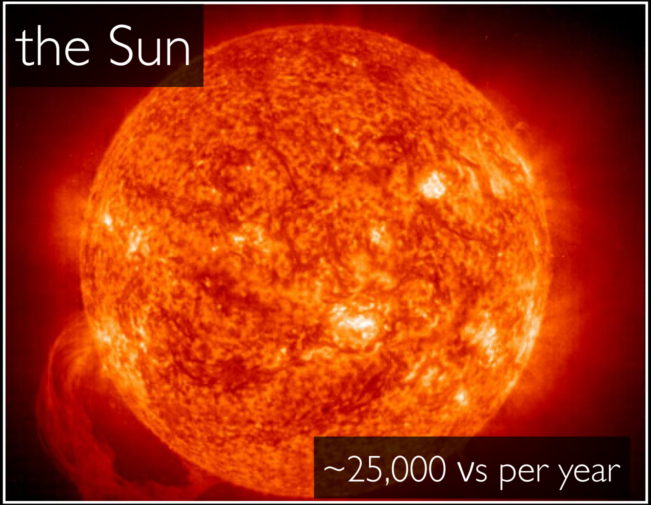
experimental setup…

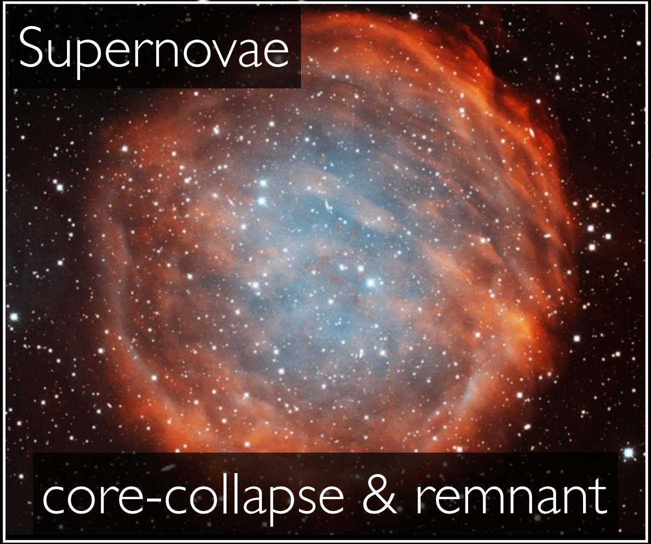
SUPERCHOOZ

scientific programme…(so far)

neutrino sources…

large **SuperChooz** detector→ **vast physics programme!**



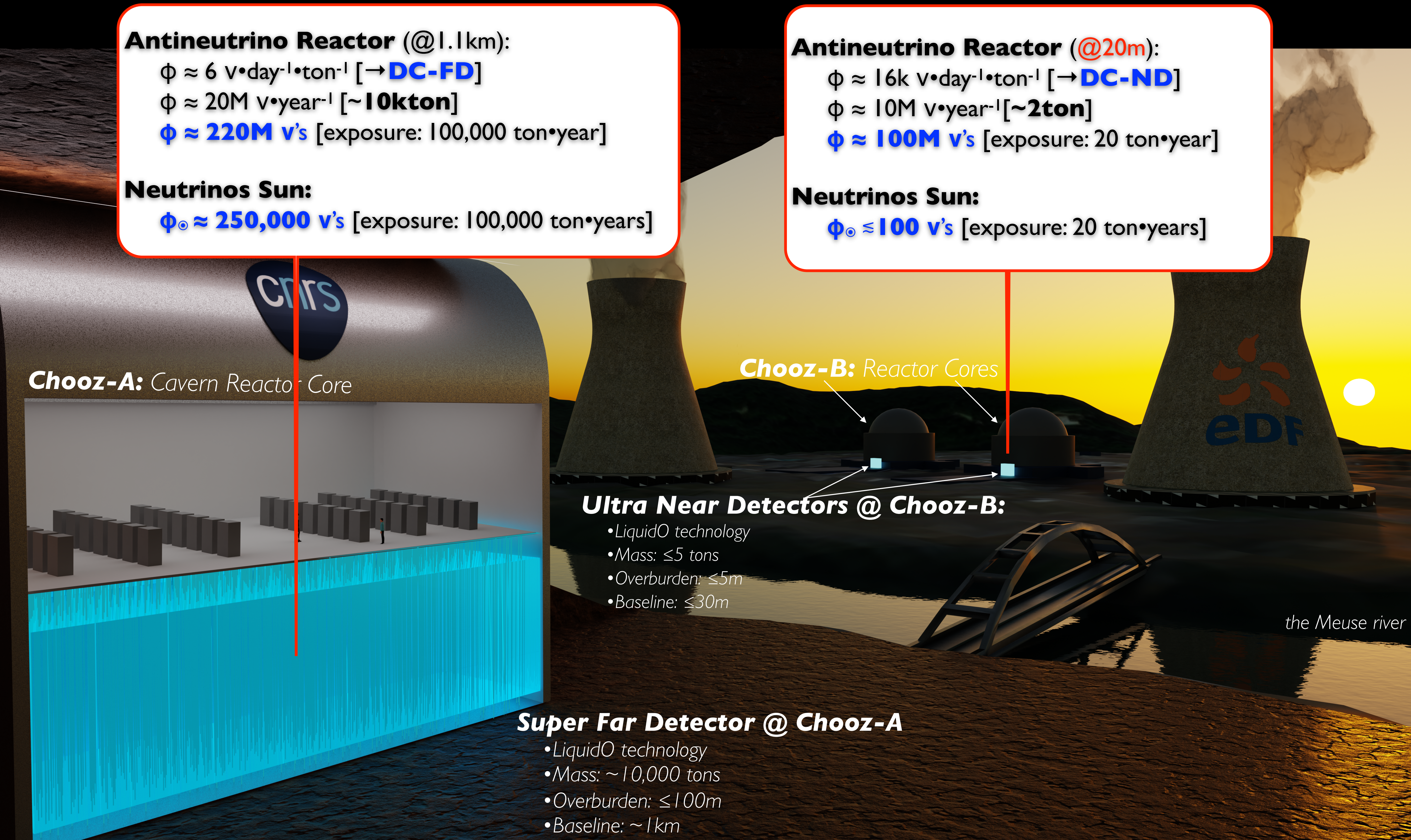


…also **atmospherics**!!

geoneutrino? yes, but huge irreducible background by reactor neutrinos!!

SuperChooz rates…

10 years exposure



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detection: all about coincidences…

the power of coincidences

low energy (≤3MeV) neutrinos interactions benefit by interactions leading to coincidences

Reines et al 1956

(neutrino discovery)

CC: $\bar{\nu}_e + p \rightarrow e^+ + n$

($\tau \approx 220\mu s$ for only H⊕C)

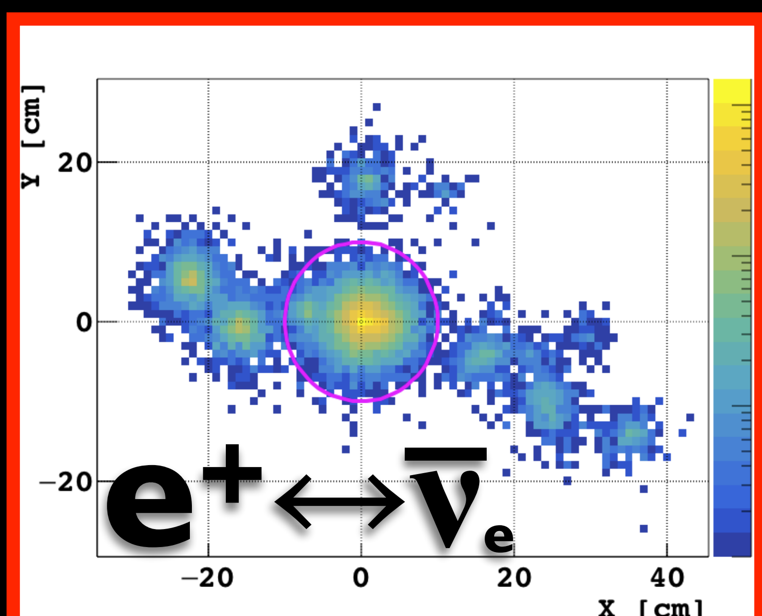
Raghavan et al 1977

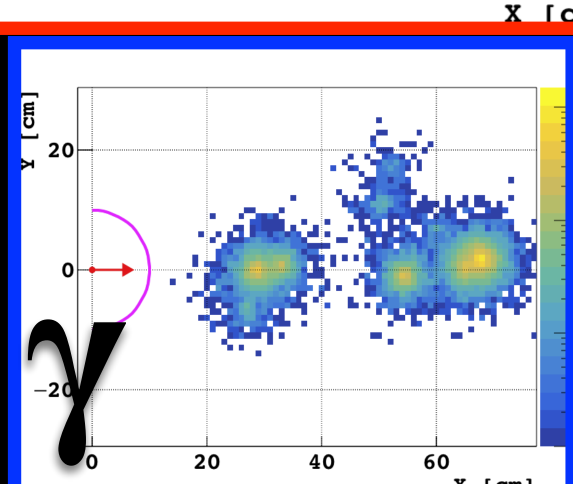
(pp solar neutrino — unobserved)

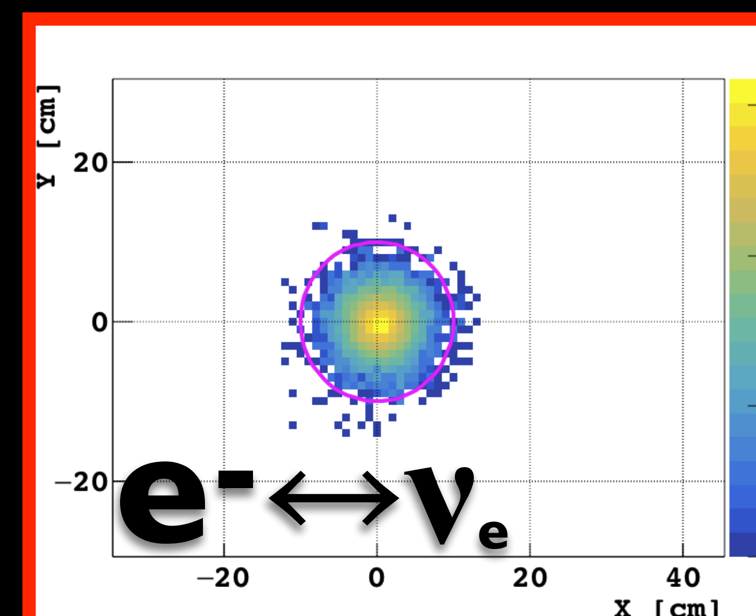
CC: $\nu_e + {}^{115}In \rightarrow e^- + \gamma + \gamma/e^-$

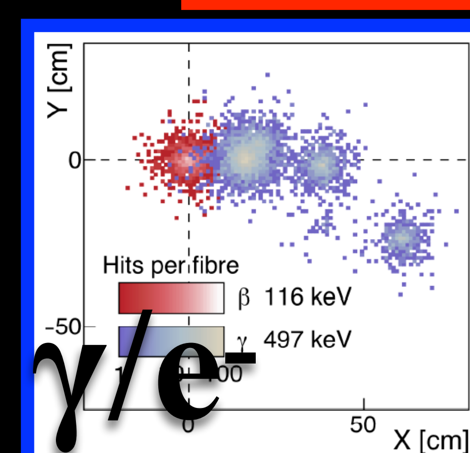
($\tau \approx 4.7\mu s$ decay of **Sn***)

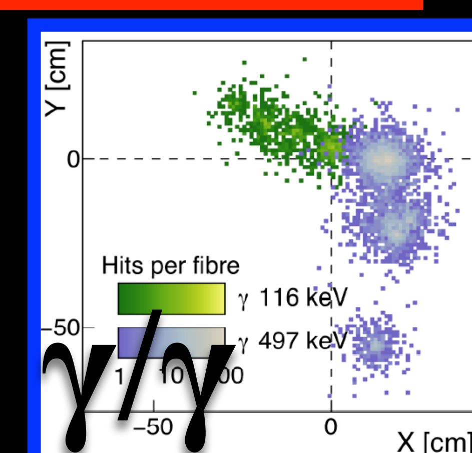
major **R&D** by **LENS** *et al* [many years]











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SUPERCHOOZ

preliminary physics programme…

rationale...

- high precision SM's neutrino oscillation

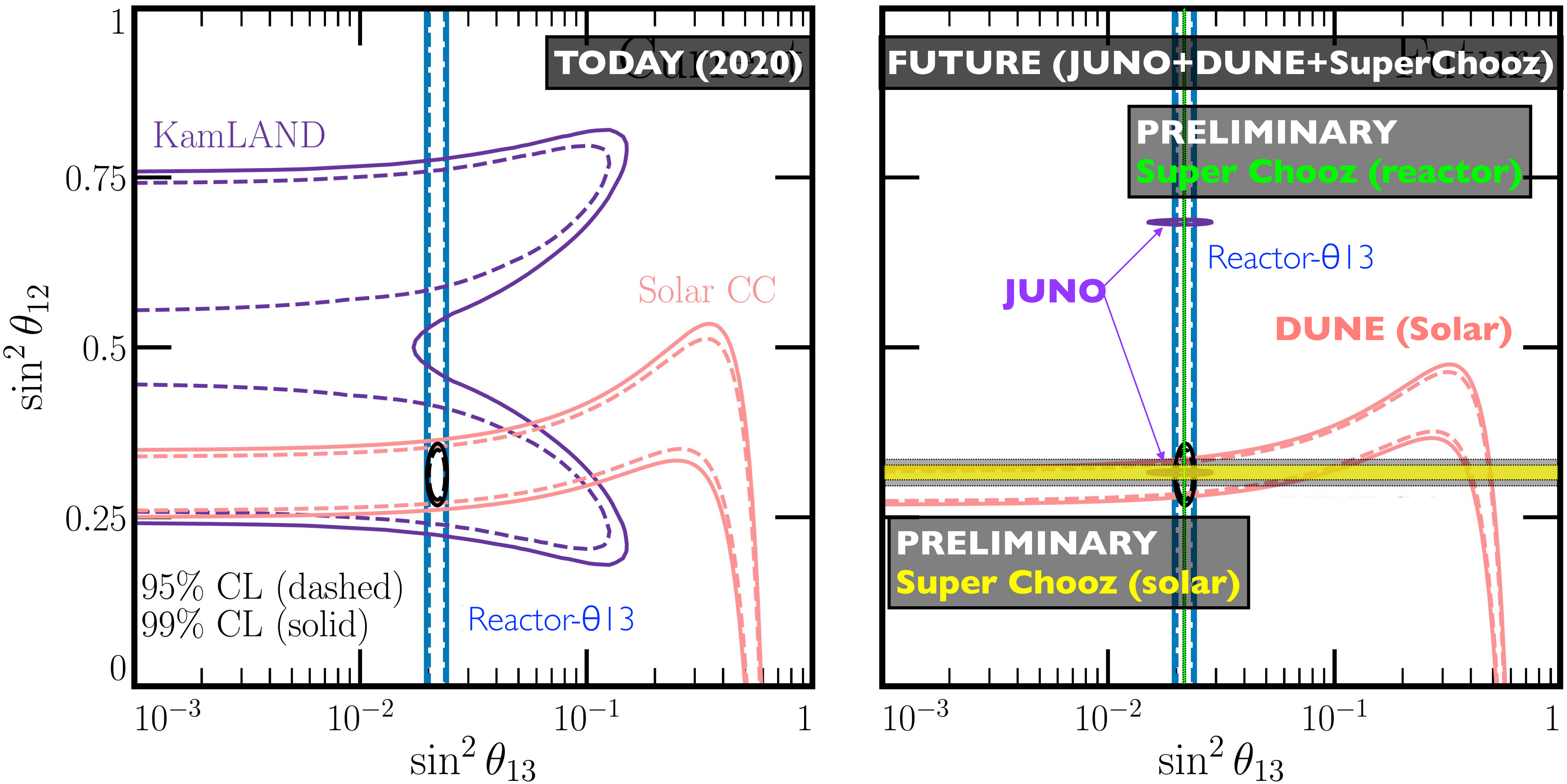
$\Longrightarrow$ synergise with JUNO & HK$\oplus$DUNE

- neutrinos probing BSM $\longrightarrow$ discoveries?

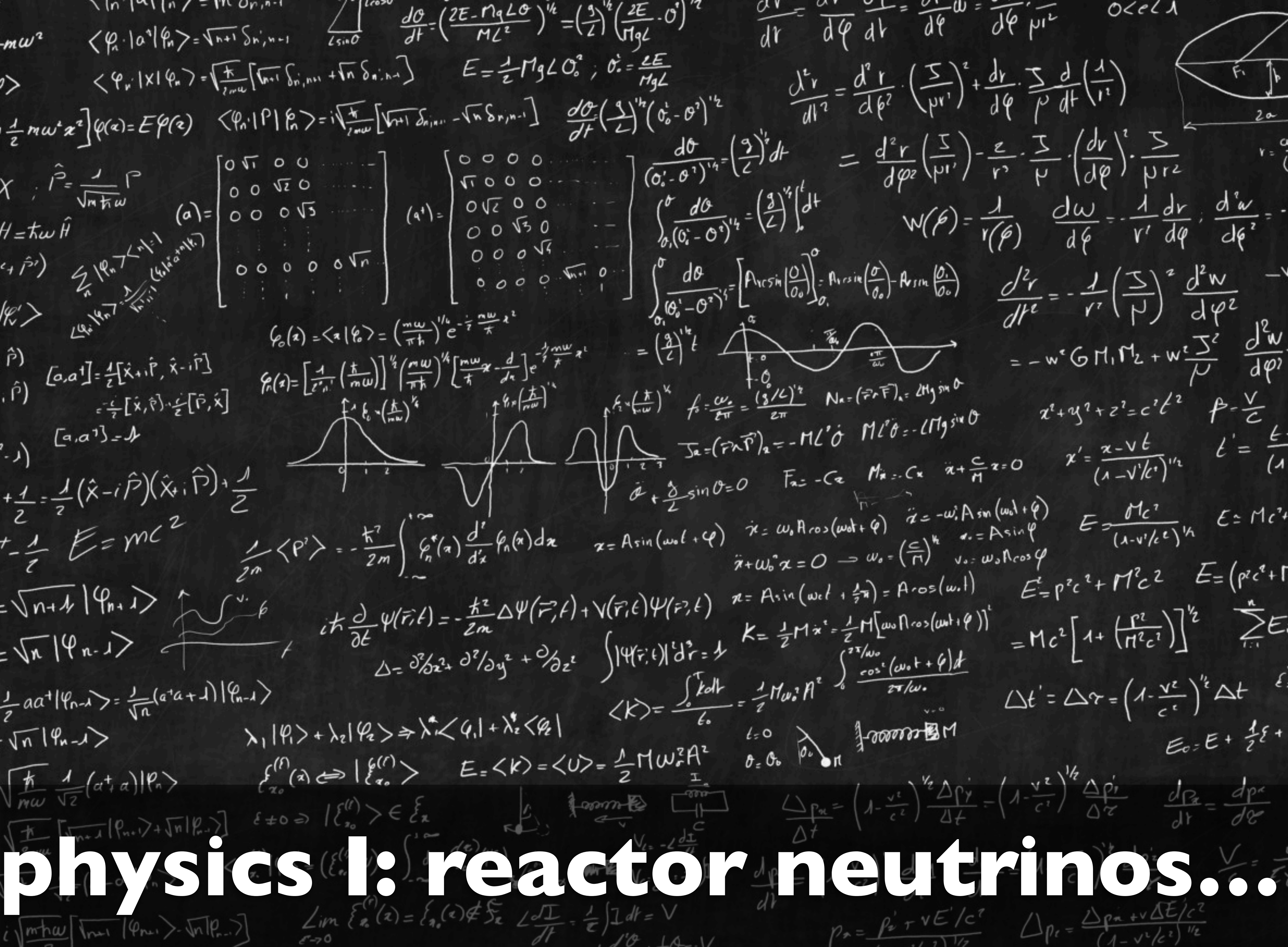
$\Longrightarrow$ beyond today's paradigm?

Super Chooz potential under investigation…

Plot: hacked version from original in ***Ellis, Kelly & Weishi-Li at* arXiv:2008.01088**



Super Chooz: the smallest but powerful…

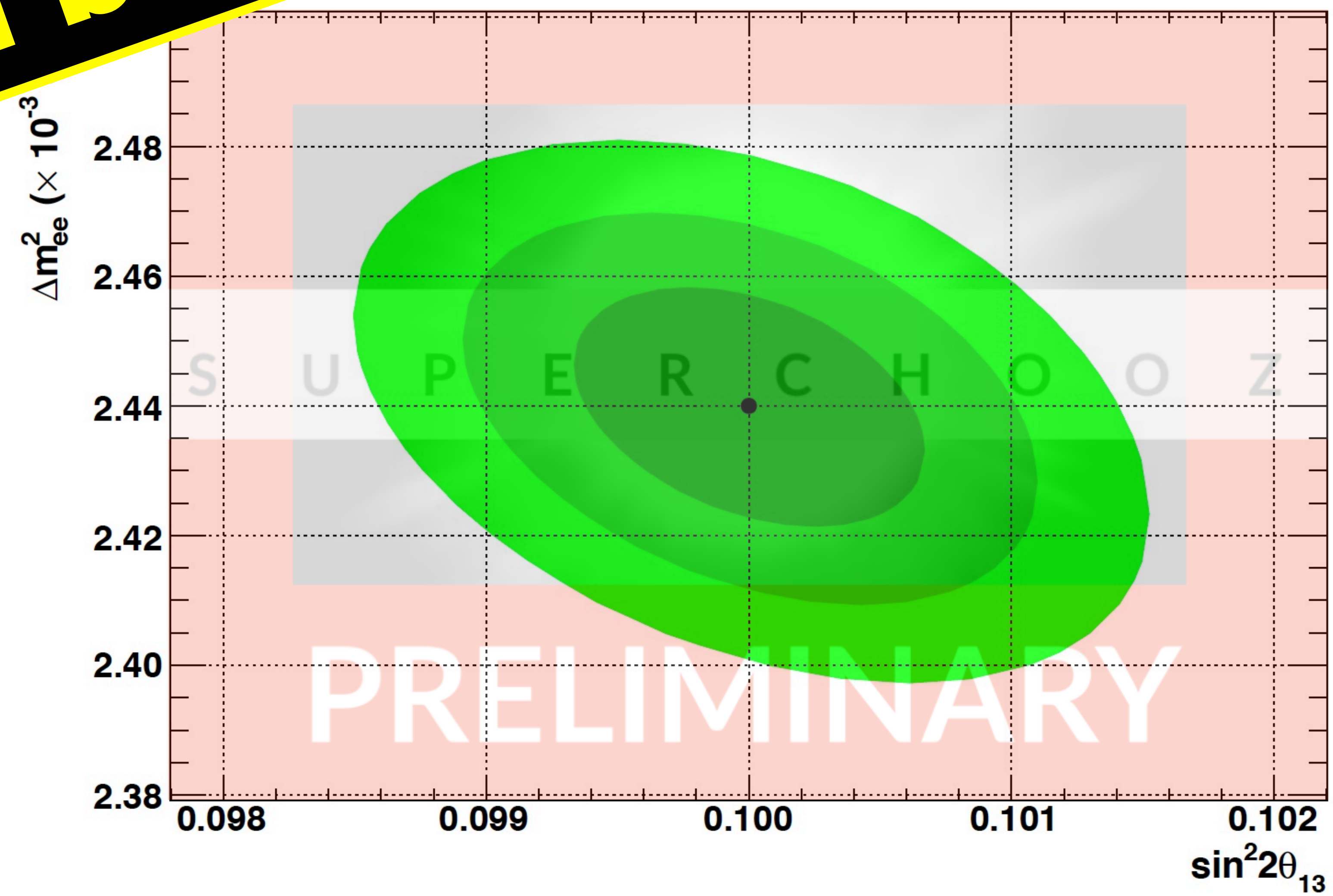


physics I: reactor neutrinos...

overall θ13⊕Δm²(ee) sensitivity…

Input Δm^2_{ee} unc.	Output Δm^2_{ee} unc.	$\sin^2 2\theta_{13}$ unc.
1% Free	≤0.5%	≤0.5%
	≥3x	≥6x

world best

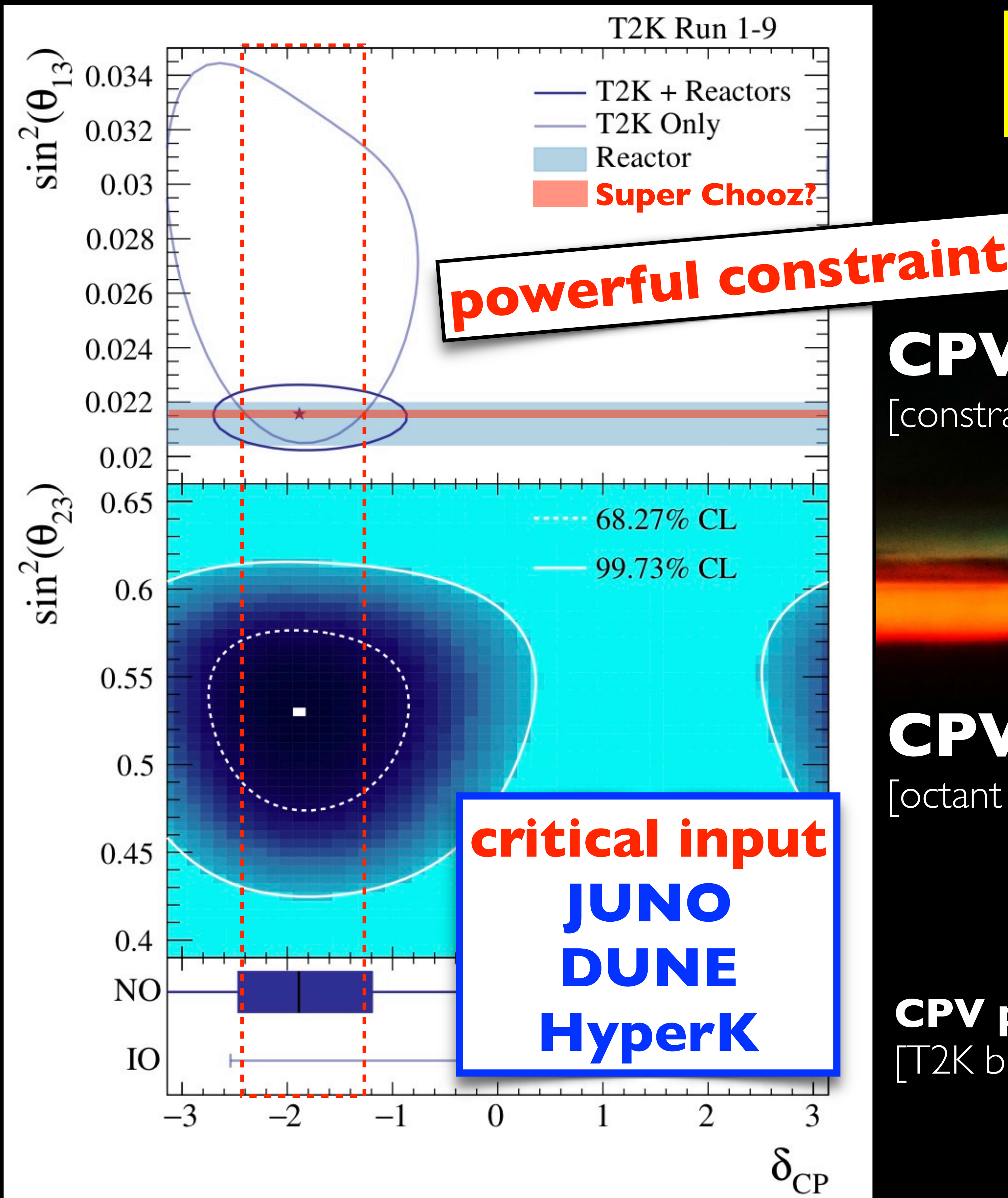


[first time] sub-percent measurement of θ13⊕Δm²(ee)

why θ_{13} & $|\Delta m^2|$? (reactor)

- world most precise θ_{13}!! [permille precision]
  - (unique) cross-check JUNO's Δm^2
- PMNS' shape: the smallest term?
- synergies: extra precision on
  - Hyperk$\oplus$DUNE's CP violation
    - (simultaneously) resolve octant-θ_{23}?
    - PMNS' shape: the largest term!
  - JUNO's Mass Ordering (oscillation)

T2K⊕reactor best knowledge CP-Violation…



θ13 implications

CPV phase vs θ13

[constrained by reactor]

CPV phase vs θ23

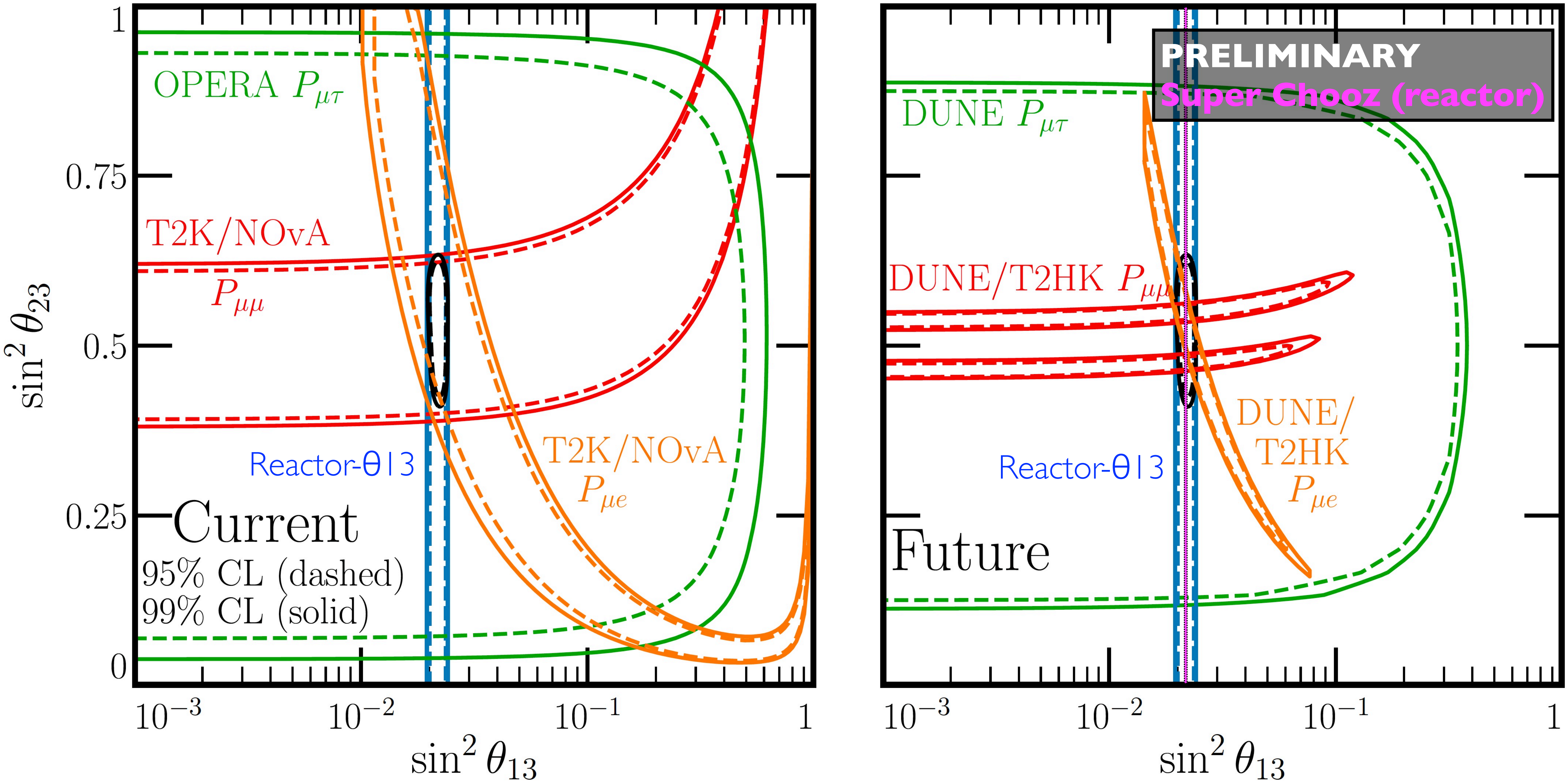
[octant ambiguity]

CPV phase vs (Atmospheric) Mass Ordering

[T2K blinded]

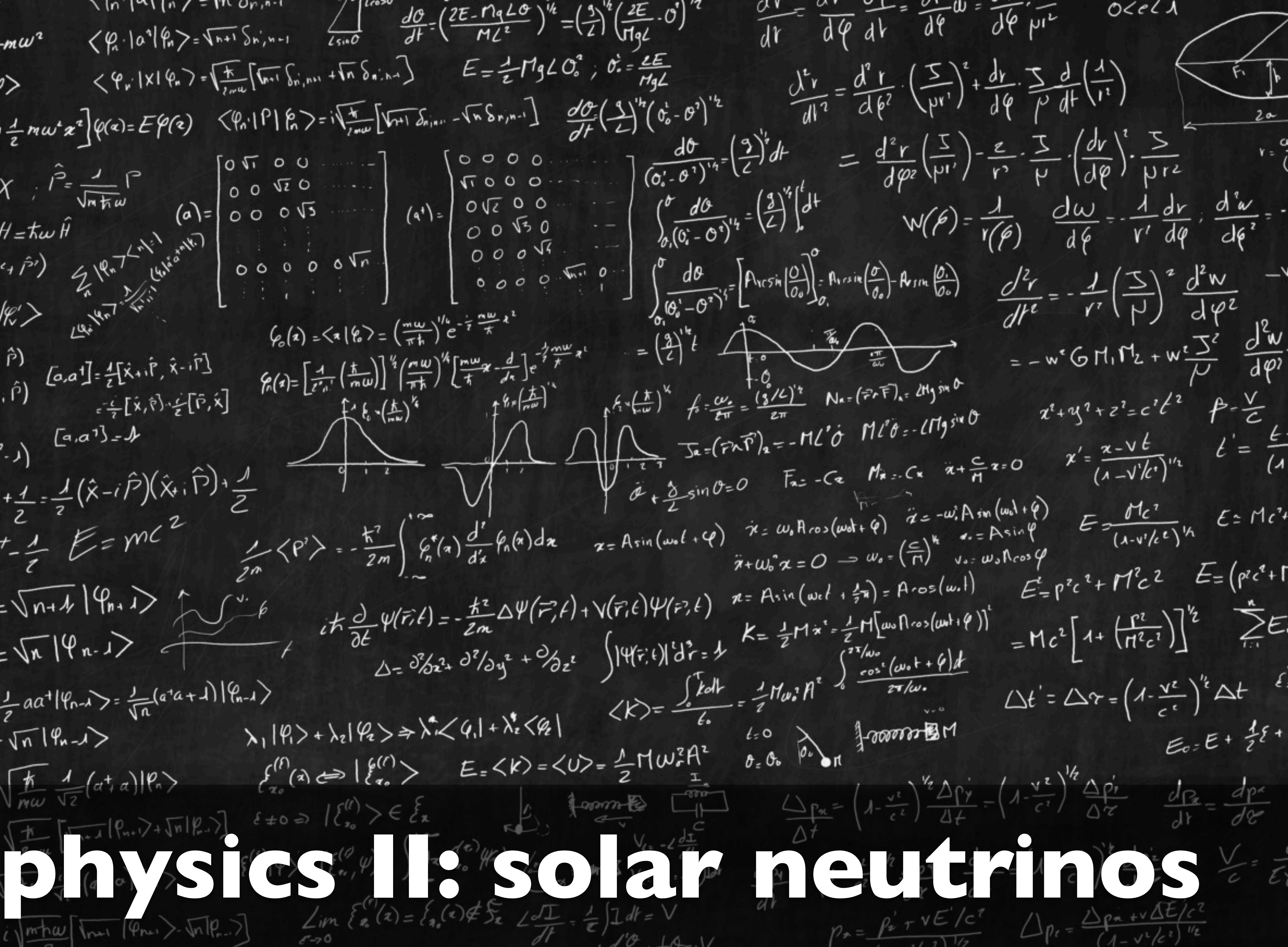
Super Chooz potential under investigation…

Plot: hacked version from original in ***Ellis, Kelly & Weishi-Li at* arXiv:2008.01088**



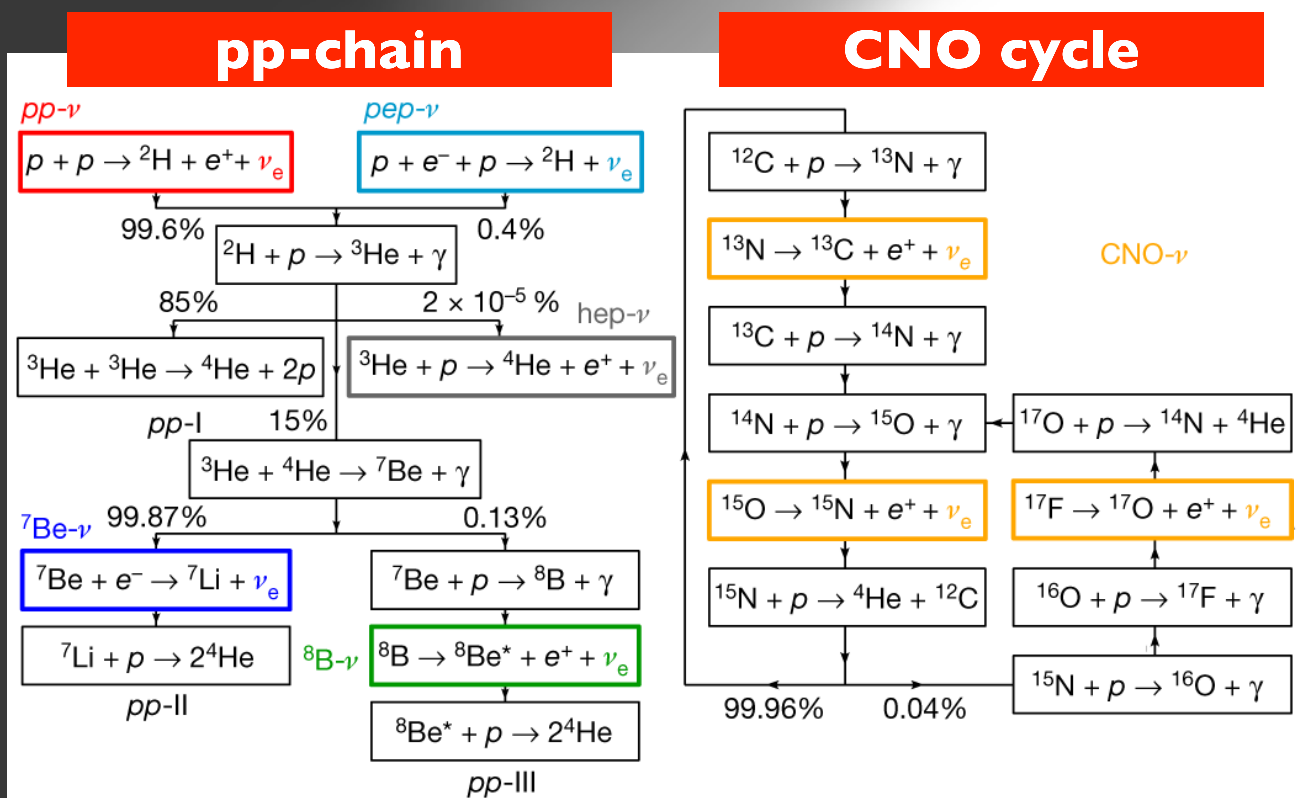
synergy: SC θ13 may help to resolve the "θ23 octant" ambiguity
(HK and DUNE) measured the combined effect of θ13⊕θ23 (harder to disentangle)

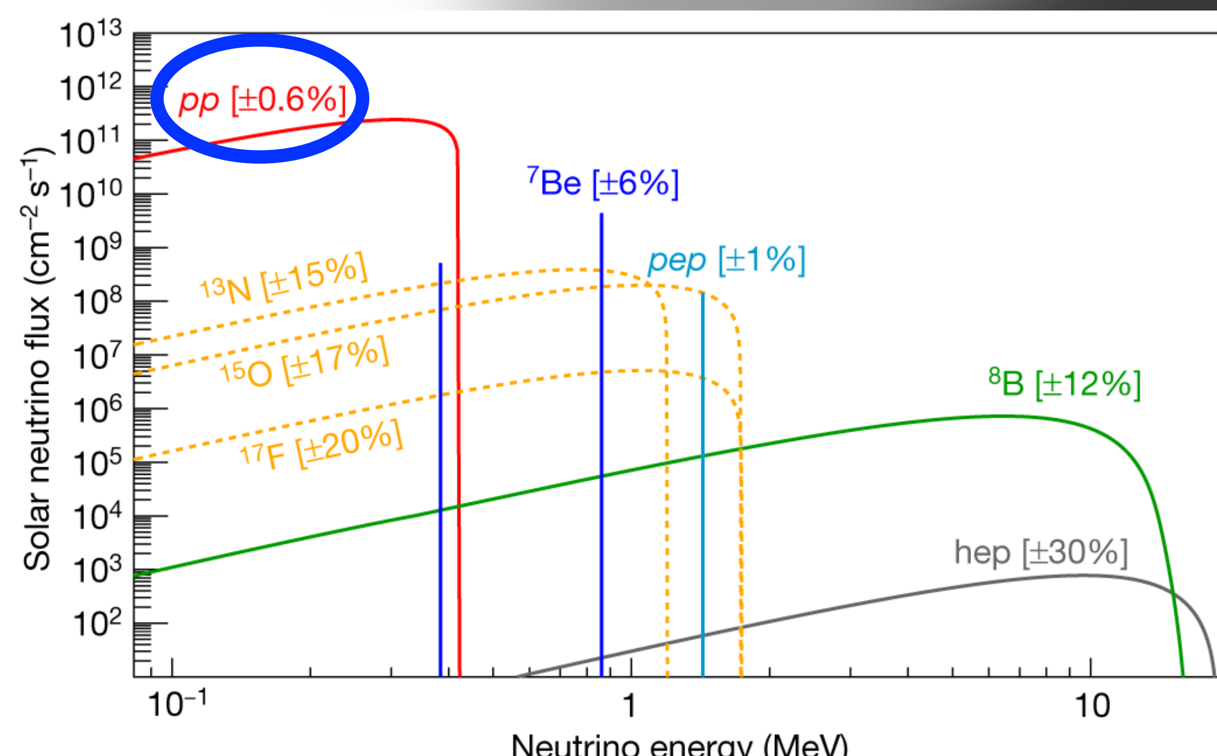
Super Chooz: the smallest but powerful…



physics II: solar neutrinos

Sun's inner-most insight…



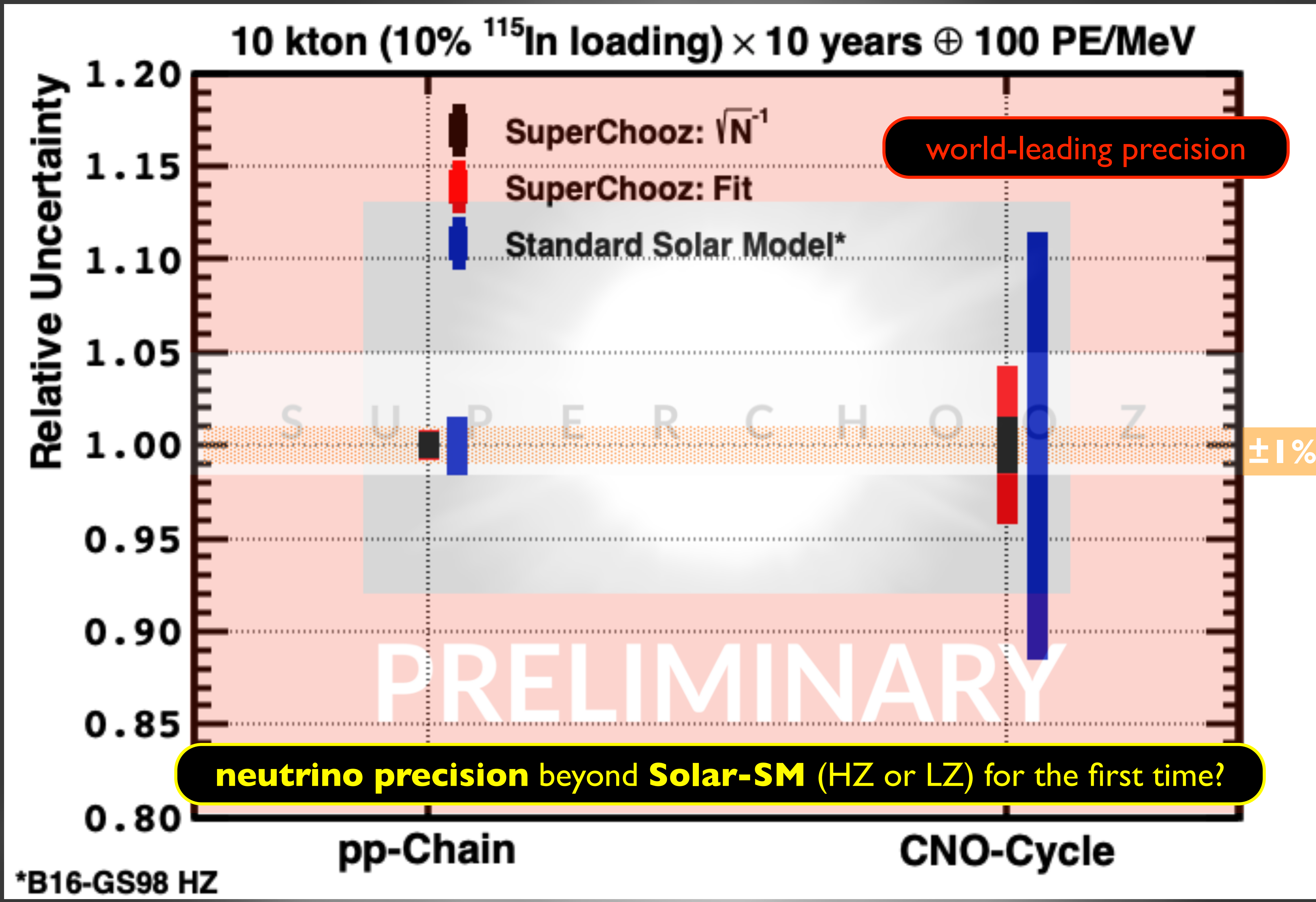


2 main reactions…

- **pp Chain** (dominant in Sun, still)
- **CNO Cycle** (most stars dominant)

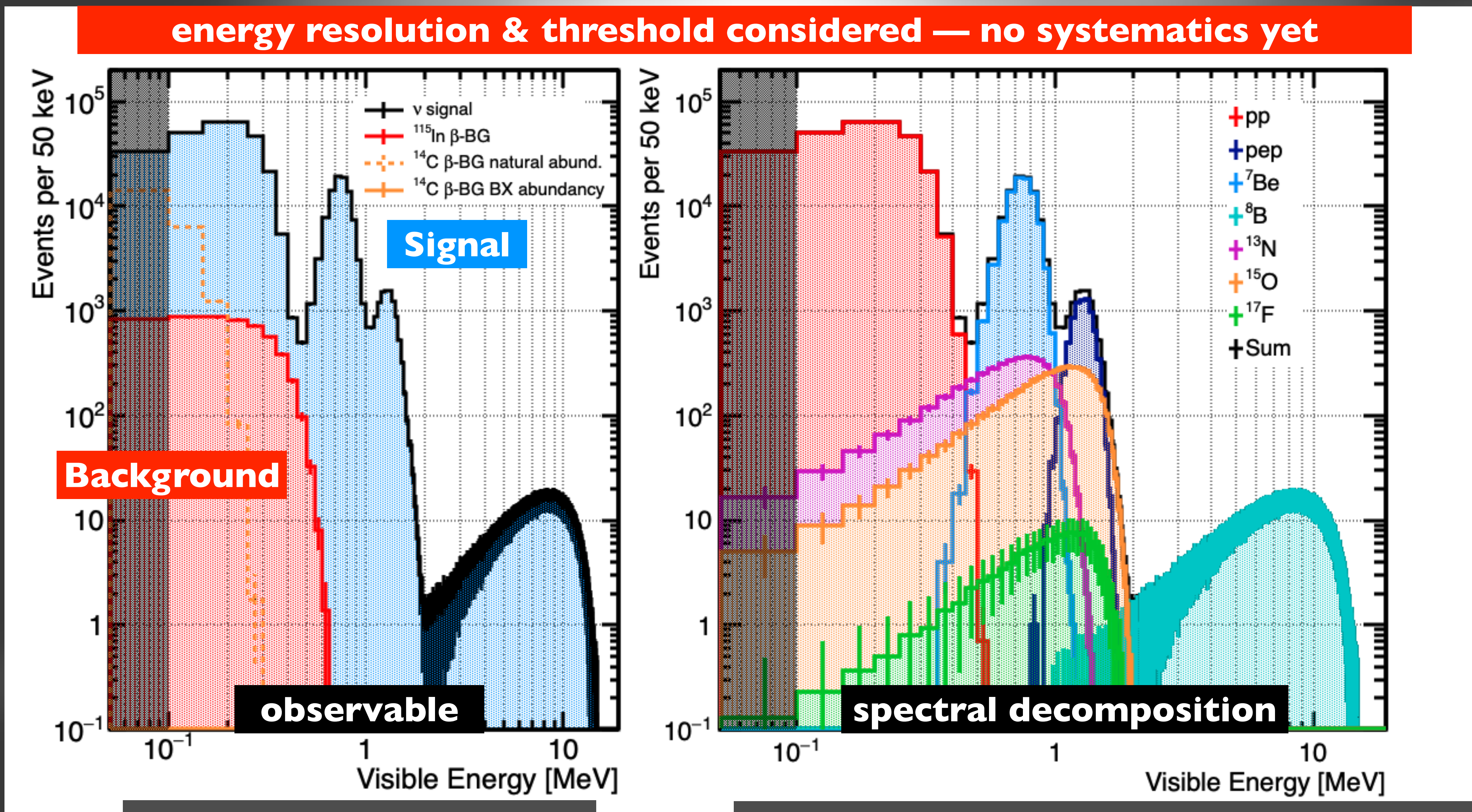
spectral precision "Solar-SM" (SSM)

- **SuperChooz** up to sub-% precision on everything
- probe **beyond-SSM** & **beyond-SM?**



highest precision solar physics…

solar spectra extraction…



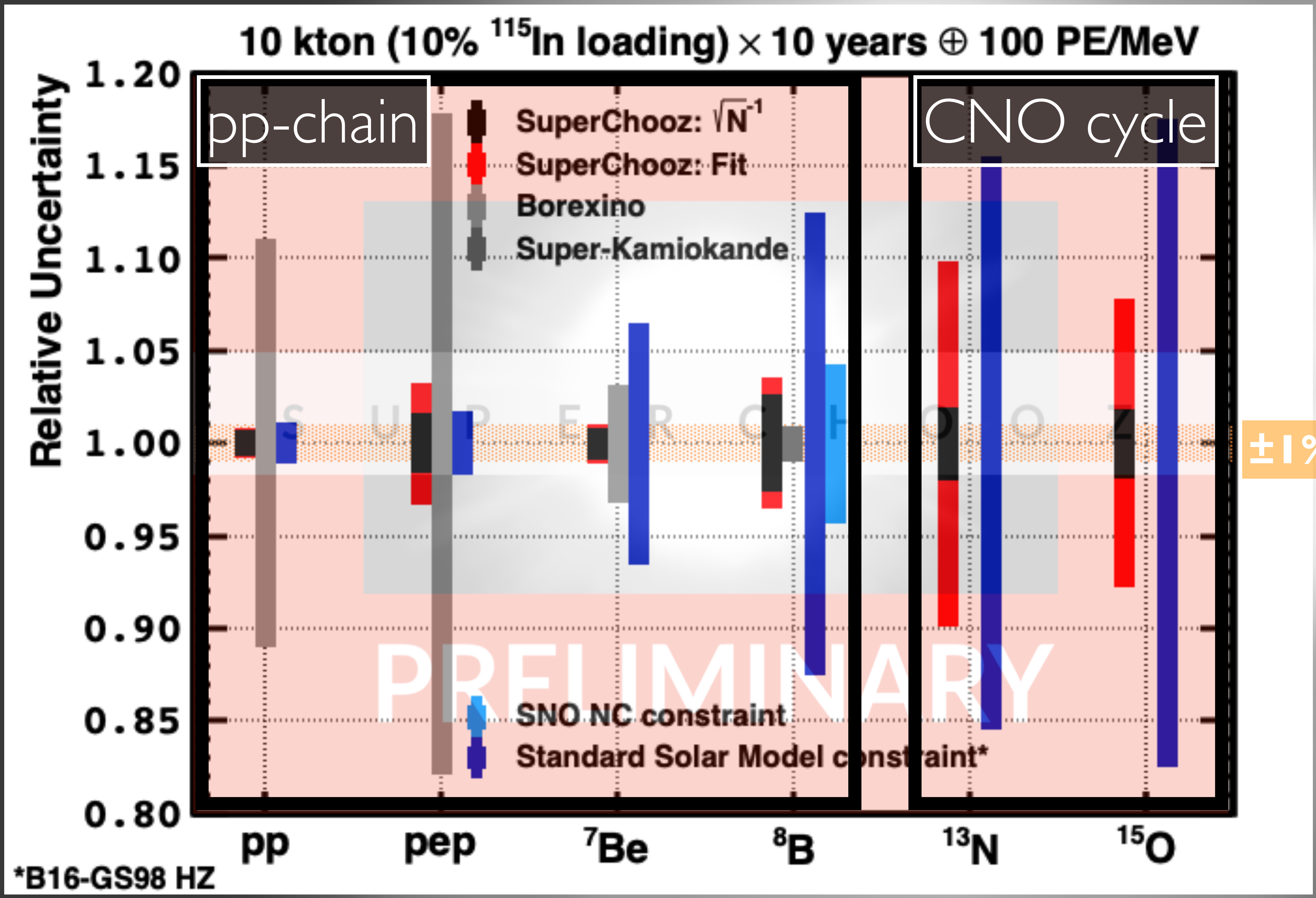
Signal to BG ≥10x

Background-less ≥0.5MeV
[LENS *et al.*]

Full Spectral Information:

- Neutrino Energy (CC interaction)
- High Statistics: **10%** (In loading) x **10 years**
- Light level: **≥100PE/MeV** (thershold: 0.1MeV)

ultimate solar spectra knowledge?



Event Rates (10% load)

- **pp: ~250,000** [0.2%]
- **pep: ~7,700** [1.1%]
- **^{7}Be: ~85,000** [0.3%]
- **CNO: ~9,700** [<2%]
- **^{8}B: ~2,200** — good by SK!
- **hep: ~4** — unlikely

→**30%** loading**? ~3x stats?**

Flux Information:

- **SSM prediction**
- **SNO-NC** for **ϕ(^{8}B)**

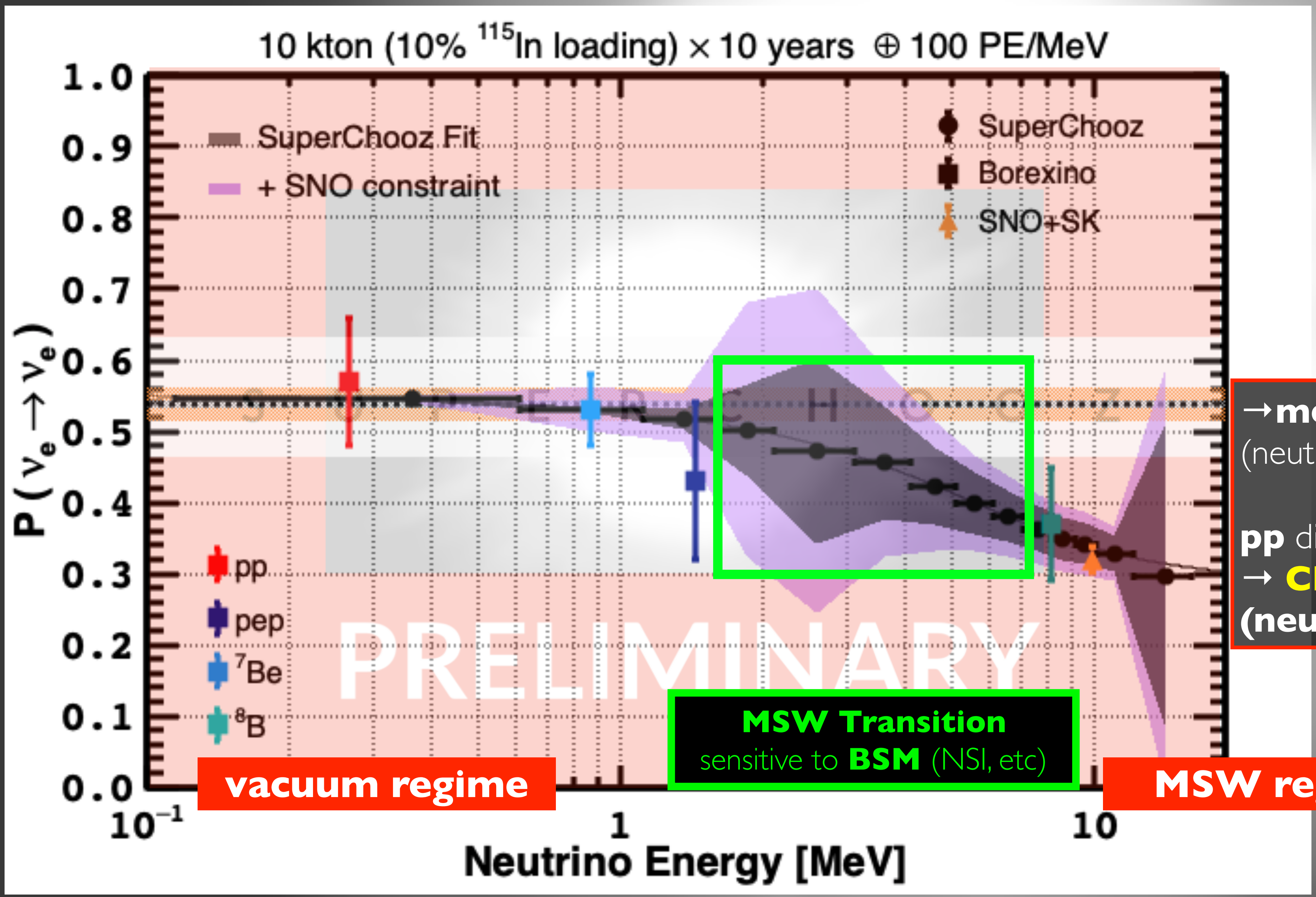
low systematics (fiducial volume, efficiency, energy, In-fraction, etc)→ **under final evaluation**

ISSUE: exclusive Indium cross-section knowledge? Possible ~1%? [a la Ga]

neutrino oscillation transition…

In-interaction: neutrino energy scan (impossible for elastics scattering)

today's precision on θ_{12}



→**measure θ12 & δm²** (neutrino)

pp direct comparison with **JUNO**[≤0.5%]
→ **CPT violation?**
(neutrino vs anti-neutrino)

solar neutrinos: longest baseline neutrino with few % precision→ new physics?

use ϕ(SNO-NC) for ⁸B control [1.5,10] MeV — ultimate limitation?

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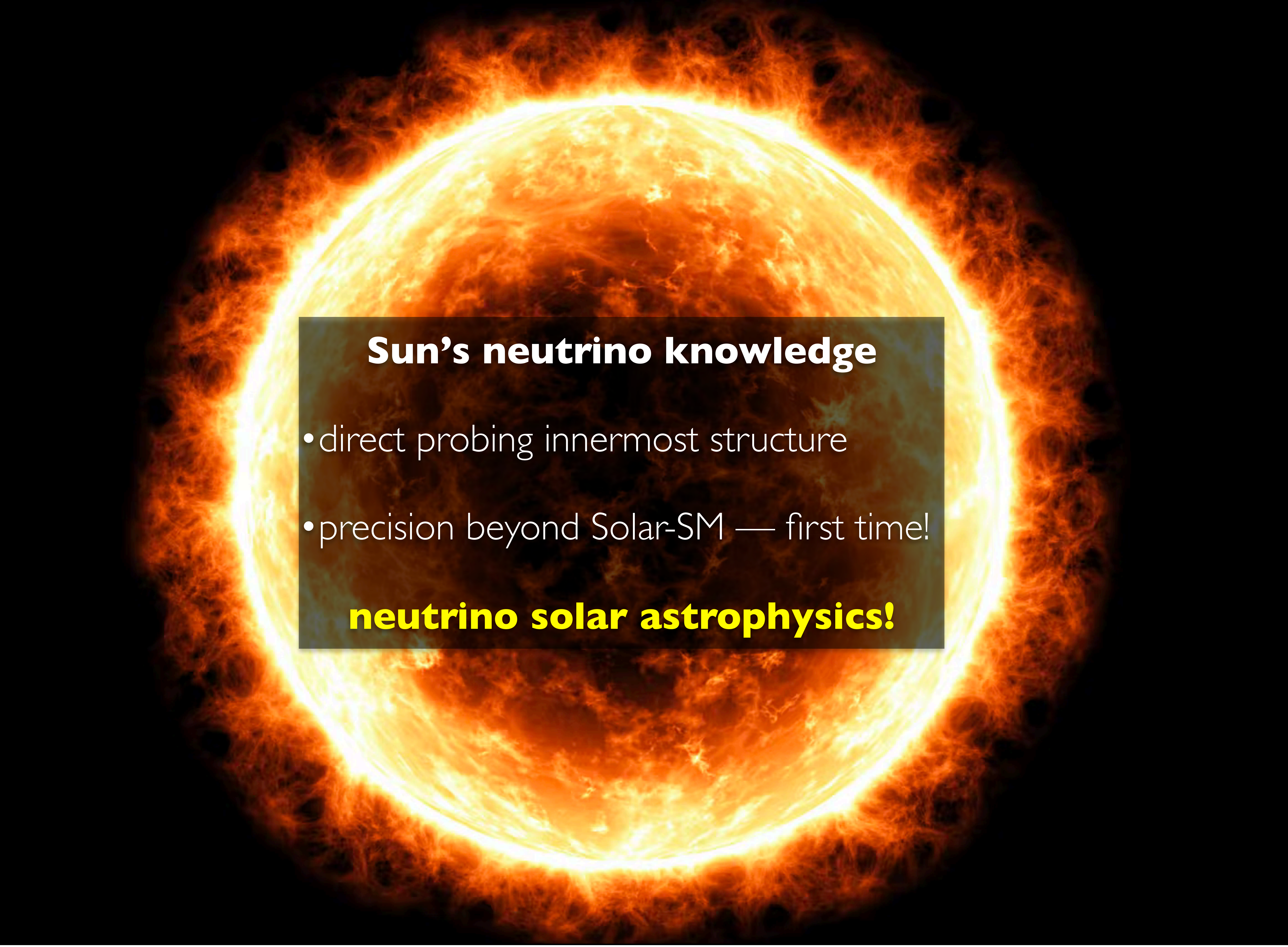

Sun's neutrino knowledge

- direct probing innermost structure
- precision beyond Solar-SM — first time!

neutrino solar astrophysics!

(historically) **symmetries crucial in neutrino manifestation**

neutrino oscillation implied…

→ no need of the **lepton-flavour number** (**L_i**)

→ discrepancies in flux normalisation — **unitarity violation?**

⟹ **new phenomenology** manifesting as **symmetry violation**

physics III: fundamental symmetries

beyond-SM neutrino oscillations (Łi)

CP Violation? [SM ⟶ foreseen in CKM and PMNS]

- (indirectly) HyperK⊕DUNE knowledge on θ_{13}

  ⟶ extra precision on θ_{23} ? [backup]

Unitarity Violation? [BSM] — discovery potential

- @UND: reactor absolute flux (up to 0.5%?) — CLOUD
- @SFD: solar-pp absolute flux (up to 0.6%?)

CPT Violation? [BSM] — discovery potential

- θ_{12} by both SuperChooz⊕JUNO — difference?

Baryon# Violation? proton-decay [multi-mode] — discovery potential

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S U P E R C H O O Z

main conclusions…

status on neutrino oscillation knowledge…

SuperChooz is designed cover the full ***SM picture*** (3 families) [synergy]

SuperChooz explore the ***SM***'s consistency/completeness→ **BSM discovery?**

SuperChooz = SC

	today				≥2030		
	best knowledge		global		foreseen	dominant	source
θ_{12}	3.0 %	SK⊕SNO	2.3 %	≤0.5%	JUNO⊕**SC**	reactor⊕solar
θ_{23}	5.0 %	NOvA+T2K	2.0 %	≲1.0%?	DUNE⊕HK [**SC**]	beam (octant)
θ_{13}	1.8 %	DYB+DC+RENO	1.5 %	**≤0.5%**	**SC**	reactor
$+\delta m^2$	2.5 %	KamLAND	2.3 %	<0.5%	JUNO⊕**SC**	reactor⊕solar
$\lvert\Delta m^2\rvert$	3.0 %	T2K+NOvA & DYB	1.3 %	<0.5%	JUNO⊕DUNE⊕HK⊕**SC**	reactor⊕beam
Mass Ordering	**unknown**	SK et al	NMO @ ≤3σ	@5σ	JUNO⊕DUNE⊕HK	reactor⊕beam
CP	**violation?**	T2K+NOvA	3/2π @ ≤2σ	**@5σ?**	DUNE⊕HK [**SC**]	beam driven
CPT	**violation?**	—	—	**<1%?**	**SC**	reactor⊕solar
Unitarity	**violation?**	—	—	**<1%?**	**SC**	reactor⊕solar
Baryon#	**violation?**	—	—		JUNO⊕DUNE⊕HK⊕**SC**	

reactor⊕solar main channels of **SC**, but low energy **atmospherics under study…**

neutrinos back to Europe?

(high precision)

historical opportunity for Europe's neutrino science (fundamental & innovation)...

Anatael Cabrera CNRS-IN2P3 / IJCLab (Orsay) - LNCA (Chooz) Laboratories

thanks to **EDF** teams & support,
LiquidO consortia,
AM-OTech consortia,
CLOUD collaboration,
and **SuperChooz** team.

Дякую…
thanks…
merci…
고맙습니다…
ありがとう…
danke…
obrigado…
спасибі…
grazie…
谢谢…
hvala…
gracias…
شكرا…

S U P E R C H O O Z

new **flagship neutrino physics** project based in **Europe** [>2030]
(once **JUNO⊕HyperK⊕DUNE** are **running**)

new detector [**LiquidO**] ⊕ **new site** [Chooz-A] ⊕ **new physics**

EDF

cnrs

https://liquido.ijclab.in2p3.fr/

anatael@in2p3.fr

HEP-European Physics Society
(July 2019 @ Ghent Belgium)

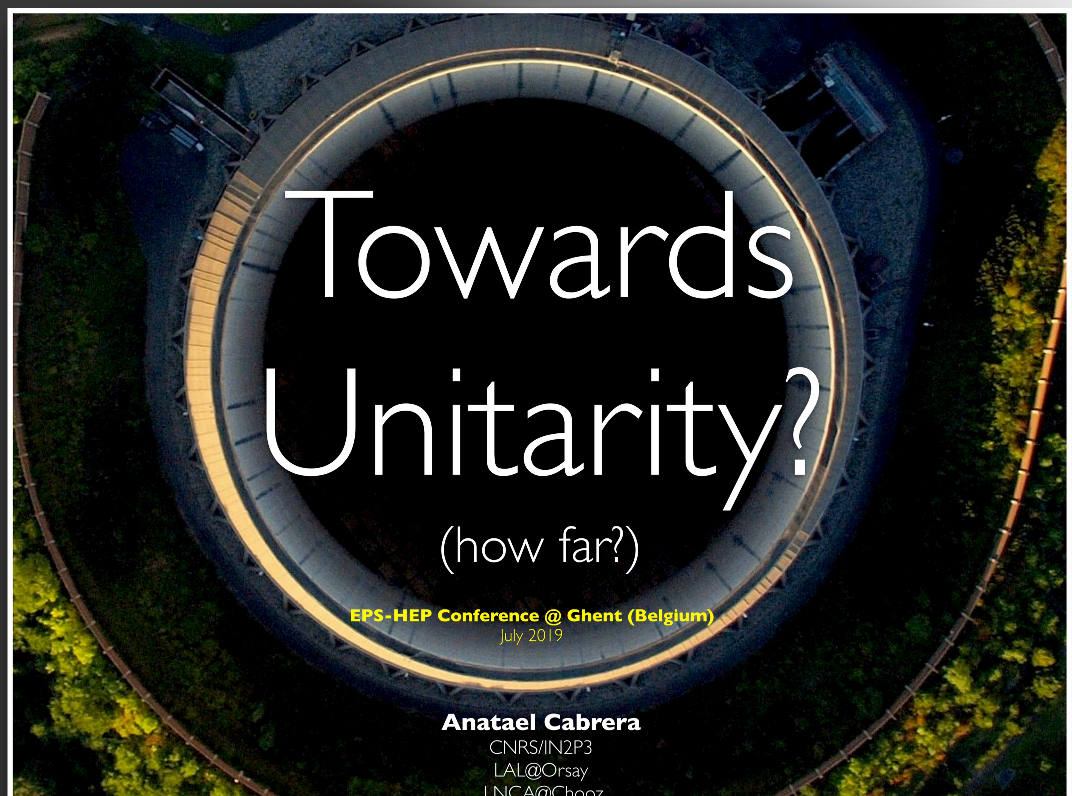
EP Seminar

The SuperChooz Experiment: Unveiling the Opportunity

by Dr Anatael CABRERA (IJCLab - IN2P3/CNRS)

Tuesday 29 Nov 2022, 11:00 → 12:00 Europe/Zurich

222/R-001 (CERN)



https://indico.cern.ch/event/577856/contributions/3421609/

https://indico.cern.ch/event/1215214/

https://zenodo.org/record/7504162

https://liquido.ijclab.in2p3.fr/

complementary references…