LNCA

(neutrino underground laboratory)

GDR-Neutrino @ APC (Paris)
May 2017

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CNRS / IN2P3
APC Laboratory (Paris, FR)
LNCA Underground Laboratory (Chooz, FR)

location & facilities…

"Laboratoire Neutrino de Champagne-Ardennes" (LNCA) [CNRS-CEA-EdF-Region-EU]

(de facto)

national underground facility⊕huge anti-ν flux

(heavily used by Double Chooz)

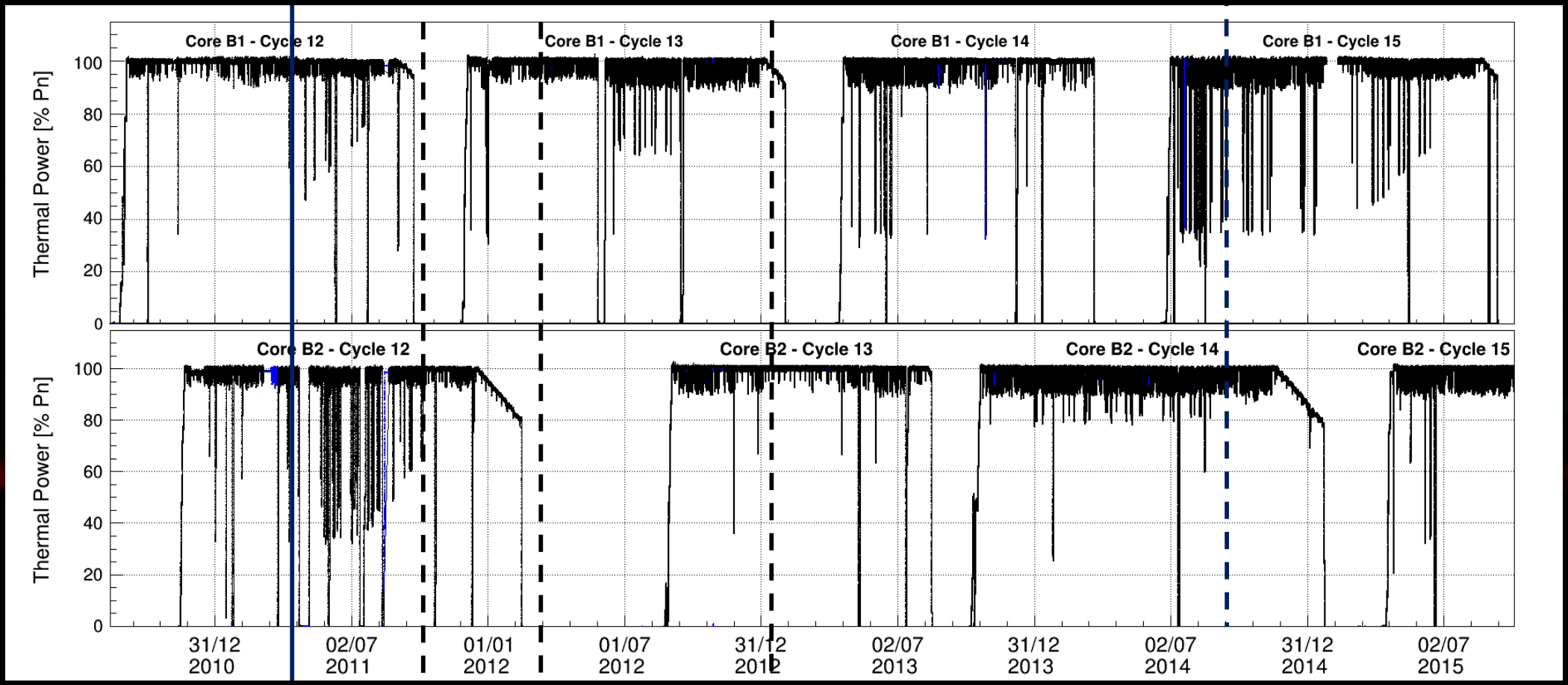
LNCA laboratory…

Near Lab
<L>≈410m
~30ν day^{-1} ton^{-1}
~120 mwe

Far Lab
<L>≈1050m
~6ν day^{-1} ton^{-1}
~300 mwe

Chooz Reactors
Power: 8.5GW^{thermal}⇒ ~10^{21}ν/s
(2x N4 reactor)

2 powerful N4 reactors…



flux uncertainty (state of the art): ~6% [~3%!!]

[power uncertainty: ~0.5%]

facilities…

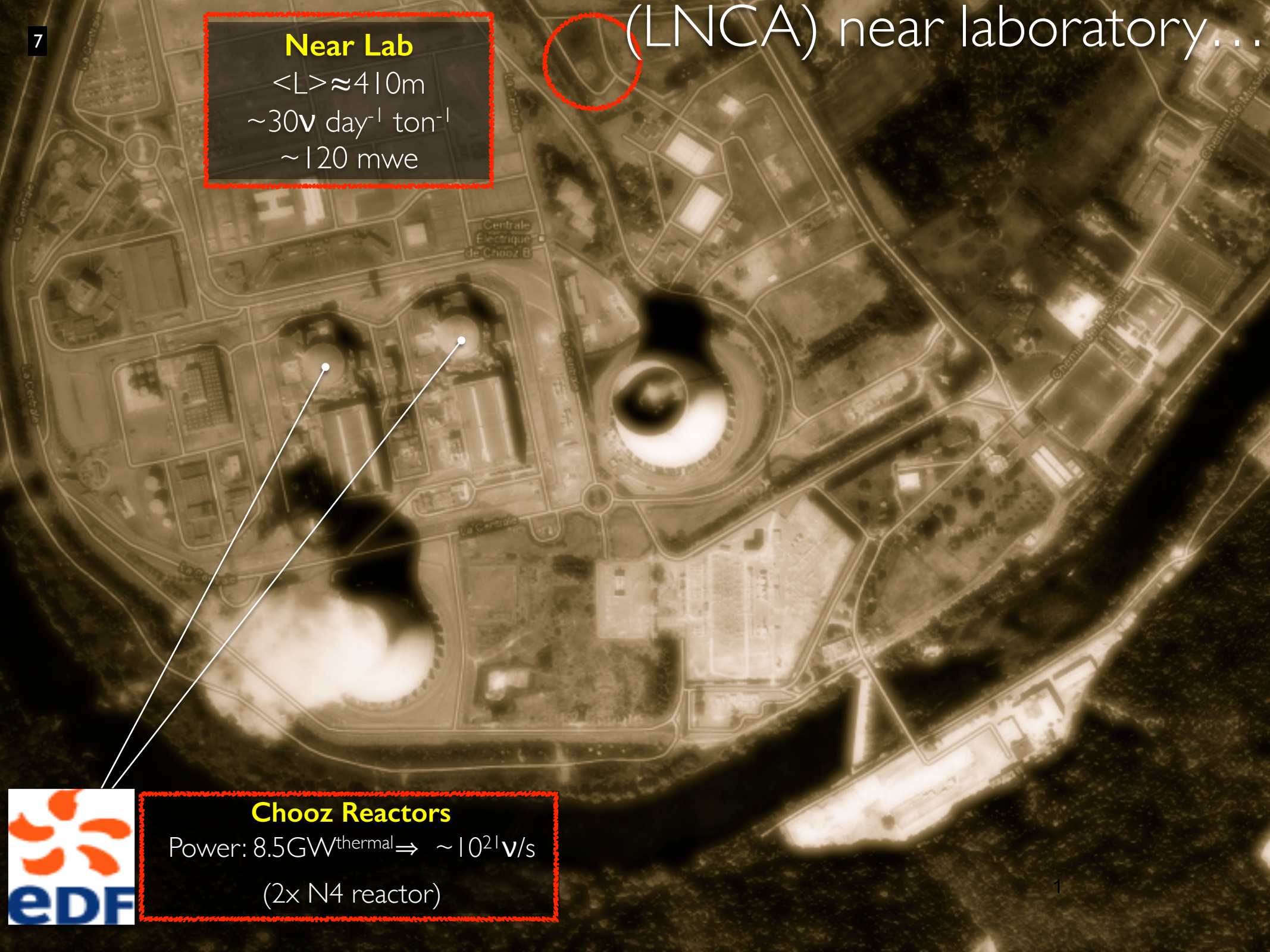
- **375m^2 near hall** (out reactor perimeter)
[~400m from reactors]

- **?m^2 far hall** (in reactor perimeter)
[~1000m from reactors]

- **storage surfaces?** (now: DC liquid containers)
[during DC→ EdF provided office space]

working within perimeter is NOT easy!
(operations under EdF & even ASN)

(LNCA) near laboratory…



far hall — a few features…

THE NEAR LAB HALL…

- built for the Double Chooz experiment (near detector site)

- average distance to reactors: **~410m**
- average rate of IBD interactions: **~30 per day per ton** (2 reactors ON)

- average overburden: **~40m rock** (**~100mwe**)
- cosmic **μ** rate **Φ(μ)** **~5.1x10^{-4}m^{-2}s^{-1}** (i.e. **~300/s** as measured by DC's IV)
- cosmic **μ** induced neutron rate: **Φ**(n) [absolute value being estimated by DC]

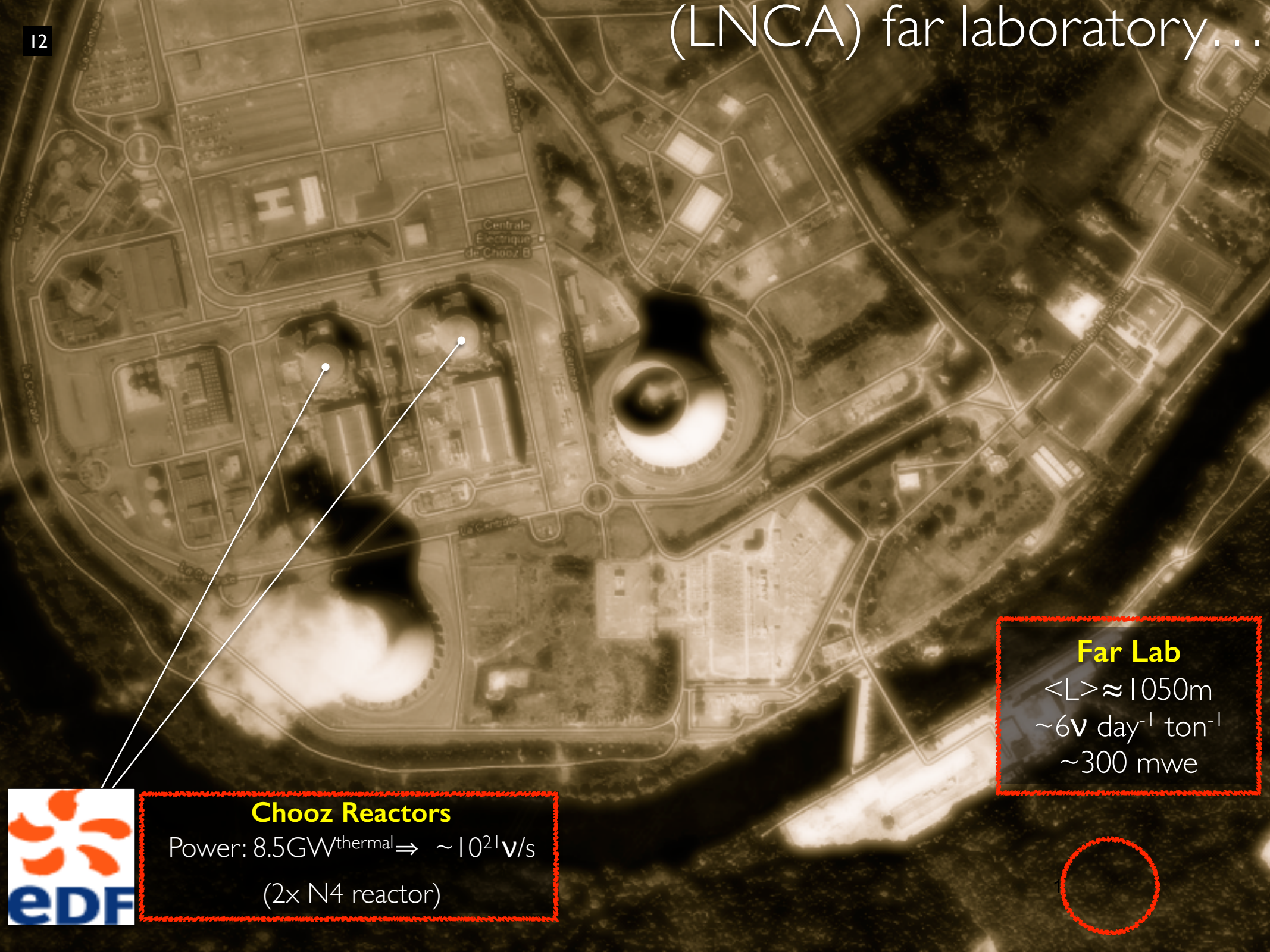
- status now:
  -Double Chooz Near Detector

Each 4.2GW^{thermal} @400m is equivalent in flux to a ~10MW^{thermal} @20m

cute but better ~4GW @ 20m→ several 100x ν's [à la Bugey]

(if you like **μ**'s, you will enjoy)

(LNCA) far laboratory…



Chooz Reactors

Power: 8.5GW^{thermal}⇒ ~10^{21}ν/s

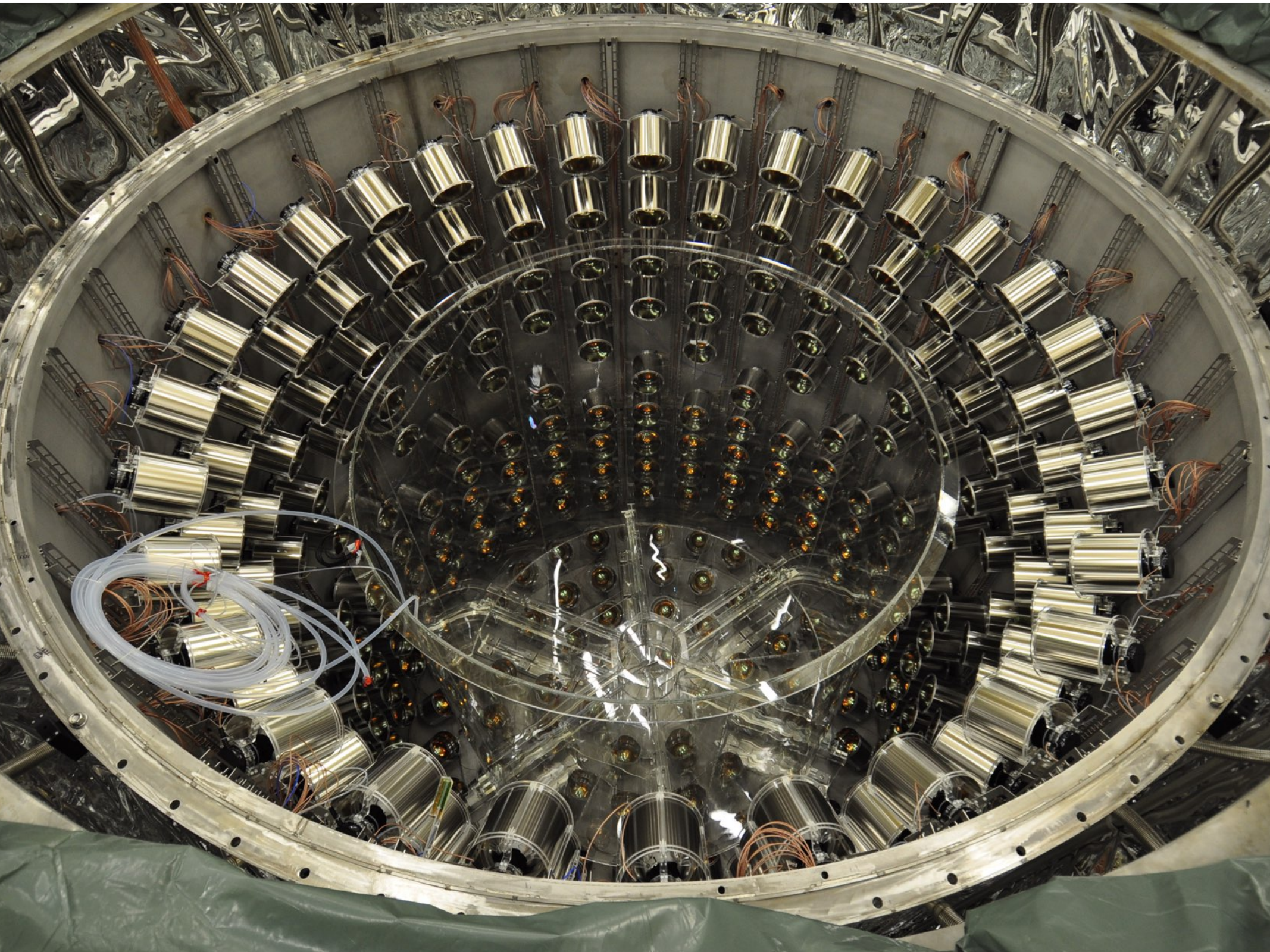
(2x N4 reactor)

Far Lab

<L>≈1050m

~6ν day^{-1} ton^{-1}

~300 mwe



far hall — a few features…

The FAR LAB HALL…

- built for the CHOOZ experiment, while refurbished for the Double Chooz experiment

- average distance to reactors: **~1050m**
- average rate of IBD interactions: **~6 per day per ton** (2 reactor ON)

- average overburden: **~100m rock (~300mwe)**
- cosmic μ rate **$\Phi(\mu)$ ~$7.5 \times 10^{-5} m^{-2} s^{-1}$** (i.e. **~40/s** as measured by DC's IV)
- cosmic μ induced neutron rate: Φ(n) [absolute value being estimated by DC]

- status now:
  - -Double Chooz Far Detector

cooling facilities…

— beer mastering region —

(rain too!)

a historic account…

(short but explosive history)

LNCA: now only DC (so far)

(1990s') far hall→ CHOOZ (θ13)

(2010's) near hall→ Double Chooz (θ13)

[LNCA started here]

(a long story short)

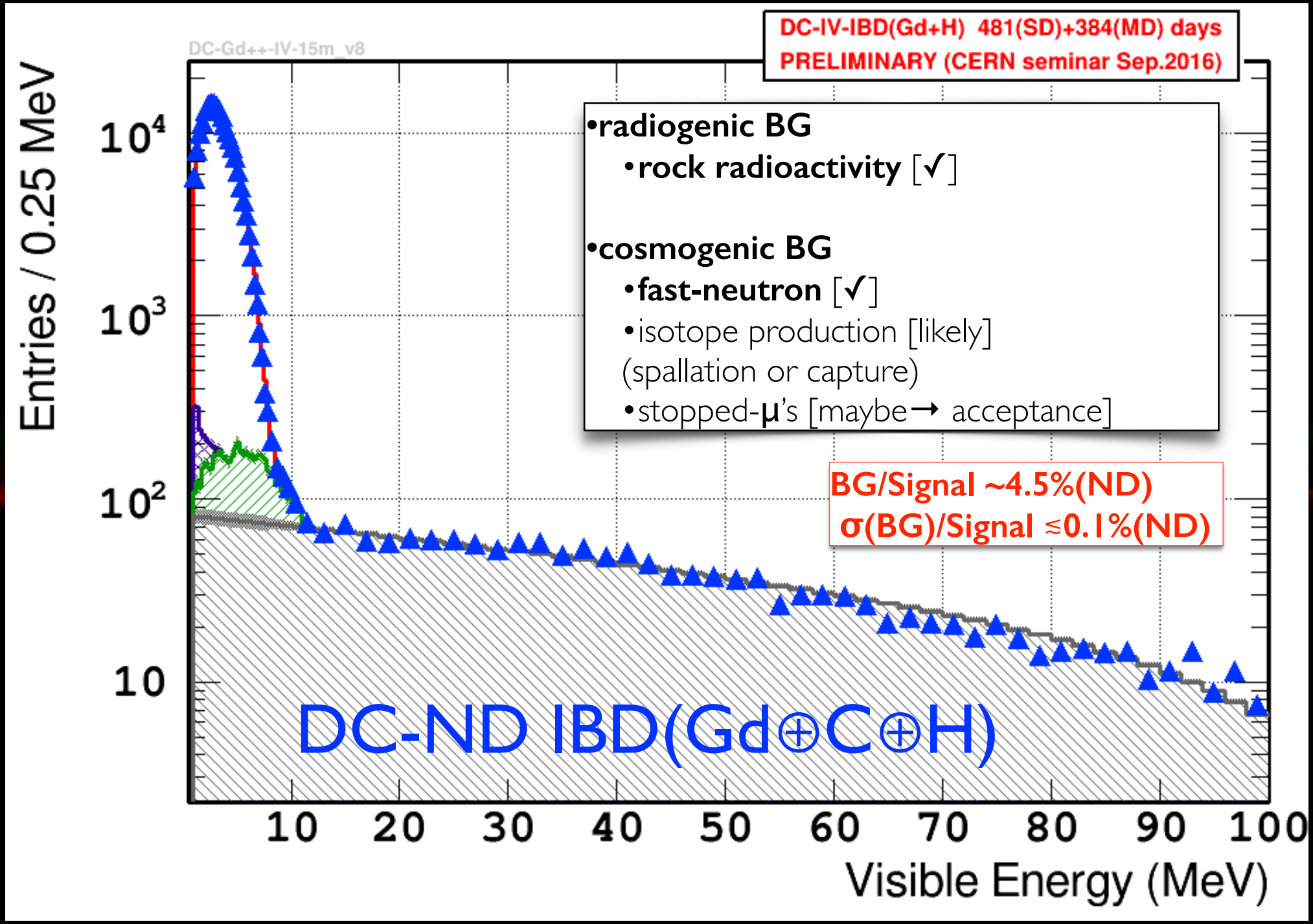
the first director…

much of the effort behind the existence of LNCA (& DC)…

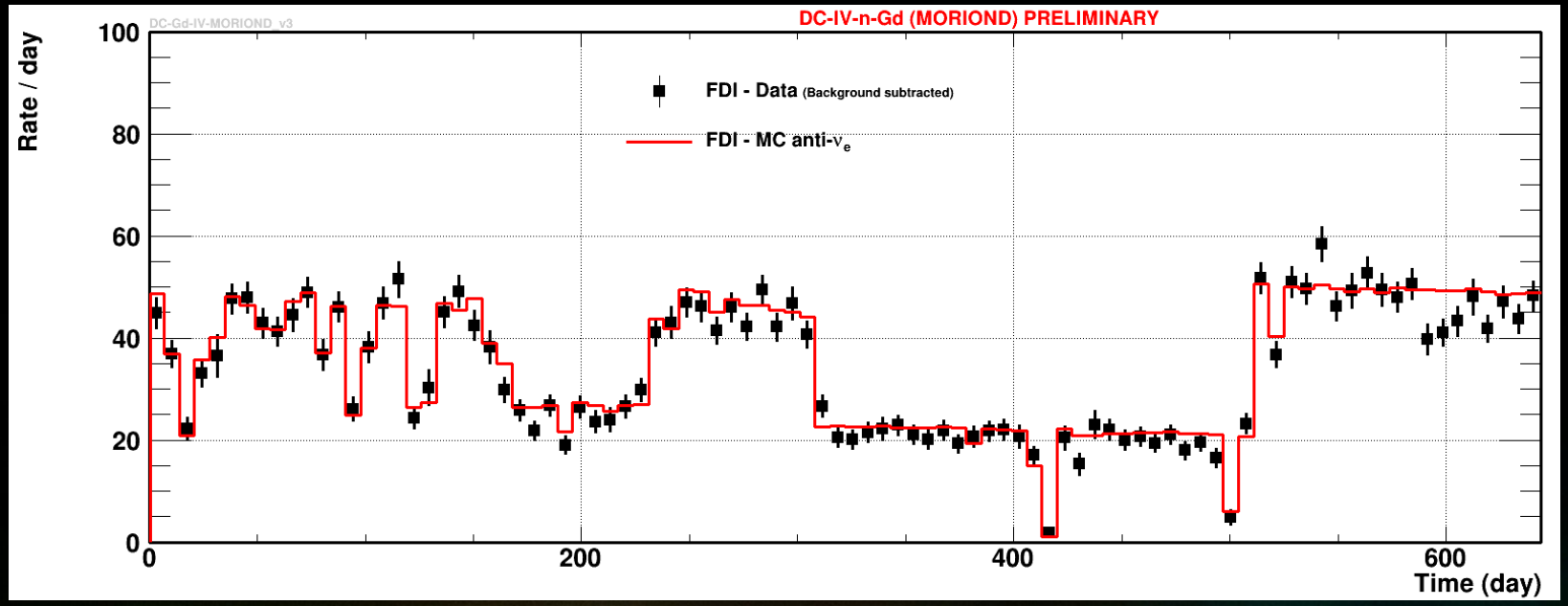
Hervé de Kerret

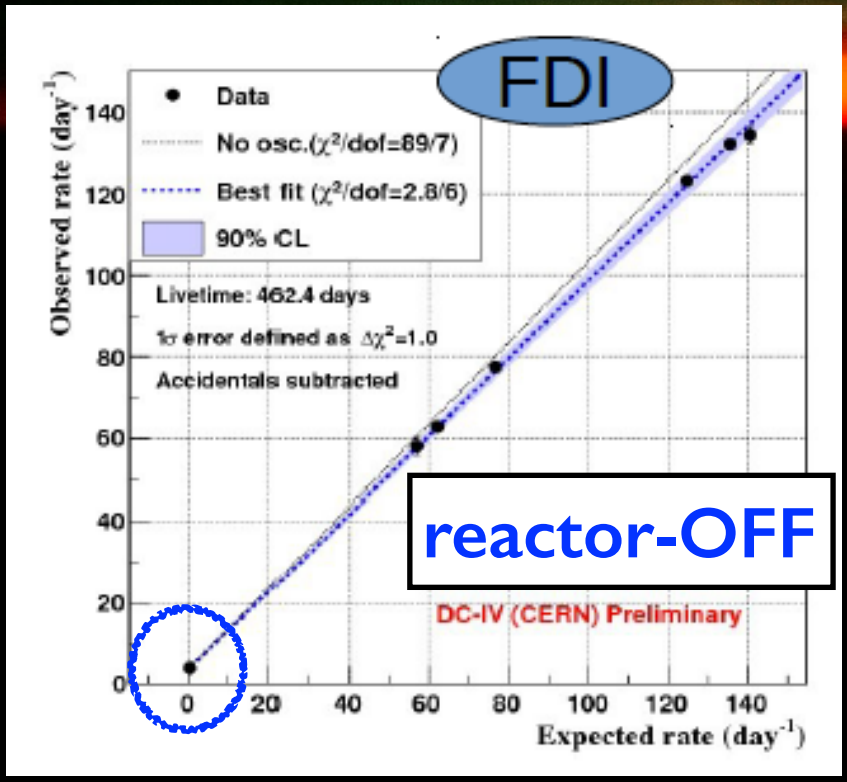
doing science @ LNCA…

DC provides Signal & BG (including spectra)…



reactor rate modulation: a powerful tool…





reactor modulation

⇒ power experimental tool!

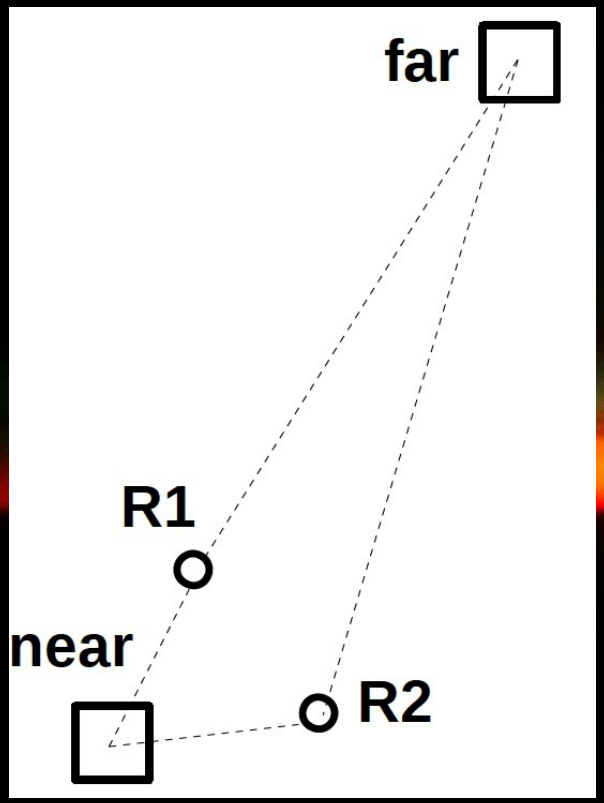
- rate measurement (θ13)
- first observation?

[need several cycles→ commercial reactor]

~iso-flux site⇒ ND is "perfect" monitor…

iso-flux: ND "sees" R1 & R2 the same as FD

(**ND & FD has SAME acceptances**)

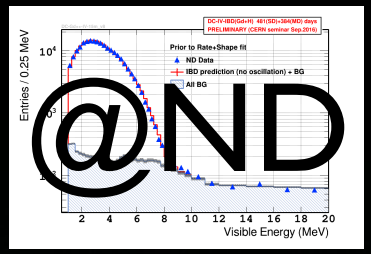


DC is almost iso-flux (i.e. just geometry)

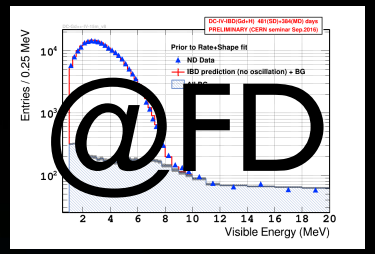
⇒ 2 critical implications (left)

(critical implication 1)

ND spectrum provides DIRECTLY FD reference spectrum (a little θ13 distorsion exists)



= α

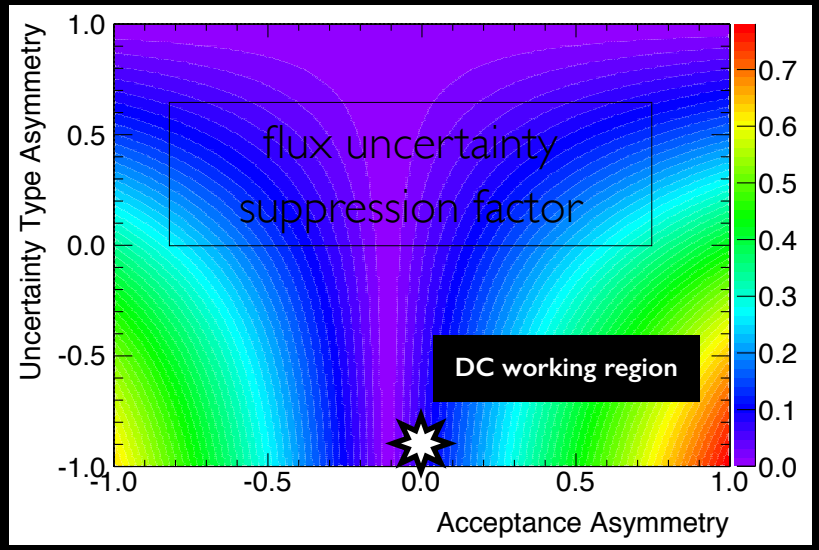


raw spectrum (@ND)

converted reference spectrum (like if @ FD)

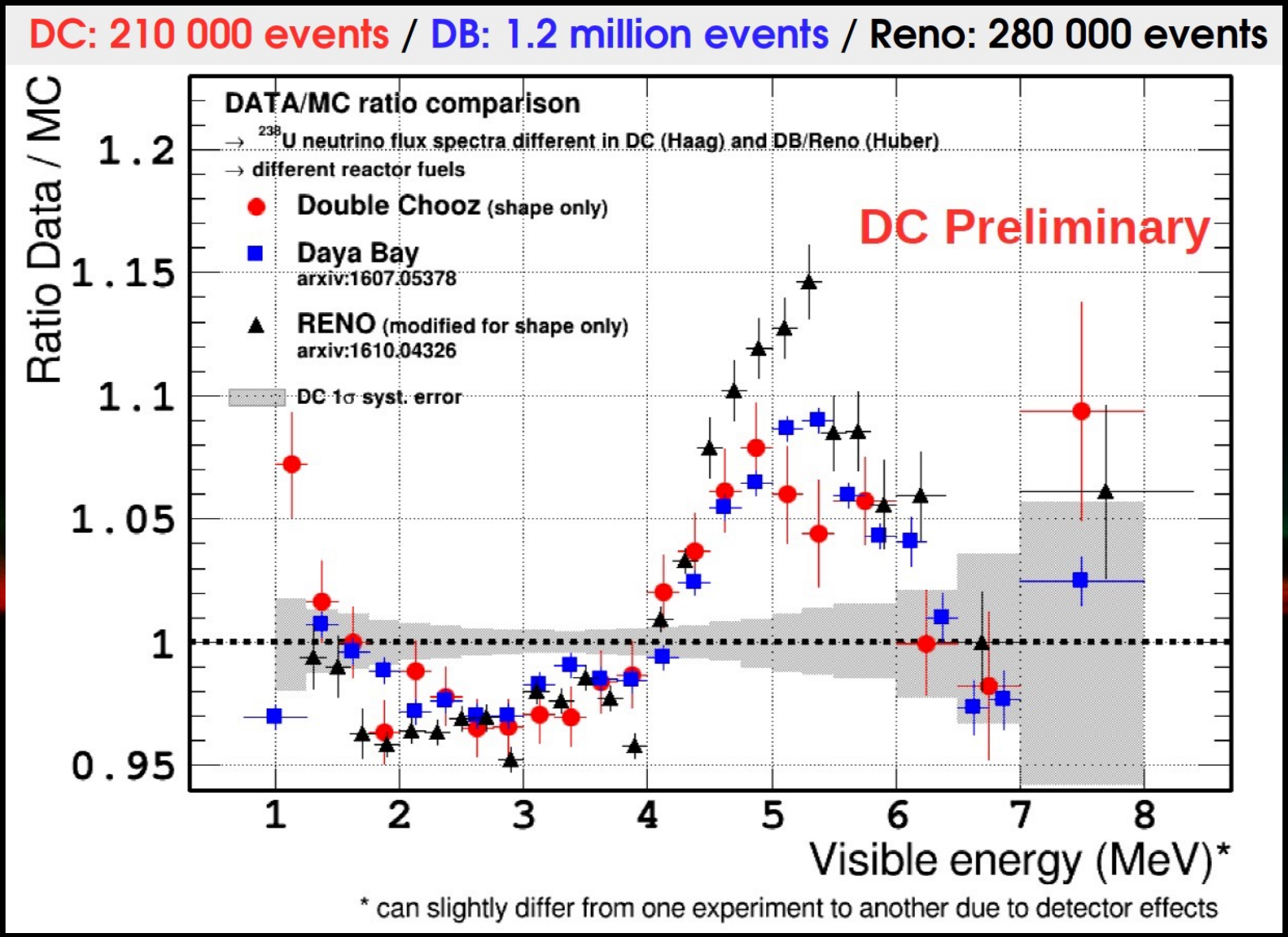
(critical implication 2)

ND provides almost total flux error cancellation in both rate & shape (i.e. effective "perfect" monitor)



arXiv:1501.00356

high precision spectral shape (distorsion)…



remarkable DYB≈DC (while different ^{238}U treatment)

non-trivial agreement: different BG, response, etc (all corrected)

the "Chooz" family…

CHOOZ

- ruled out Kamiokande's $\nu_\mu \rightarrow \nu_e$ [so, solution must be $\nu_\mu \rightarrow \nu_\tau$!!]
- best limit $\theta 13$ for decades
- first handle on IBD-directionality

Double Chooz

- (**2011**)
  - ~2σ deficit where CHOOZ saw nothing ($\leq 1\sigma$) → $\theta 13$ signature?

    [consistent with T2K excess → combined⊕marginalised ~3σ's]

    (2012) confirmed by DYB (observation), followed by RENO
- (**2014**)
  - ~3σ spectral distortion (FD) [confirmed RENO & DYB with ND's]
- (**2016**: seminar @ CERN → publications soon)
  - ~2.2σ DYB discrepancy? (~1.5σ with RENO) [→ $\theta 13$-experiments must resolve]
  - world most precise rate+shape reactor spectrum? [superseded Bugey3(~20m)]
  - world most precise $<\sigma_{IBD}>$? [superseded Bugey4(~20m)]
  - world most IBD-directionality? [superseded CHOOZ (1050km)]

LNCA future (≥2019-2020)…

"Laboratoire Neutrino de Champagne-Ardennes" (LNCA) [CNRS-CEA-EdF-Region-EU]

(de facto)

national underground facility⊕huge anti-ν flux

(heavily used by Double Chooz)

what's next @ LNCA?

- anti-**ν** (ex. IBD) detector facility (R&D)
- single-detector experiment (ND)
- multi-detector experiment (ND⊕FD)
- other ideas?

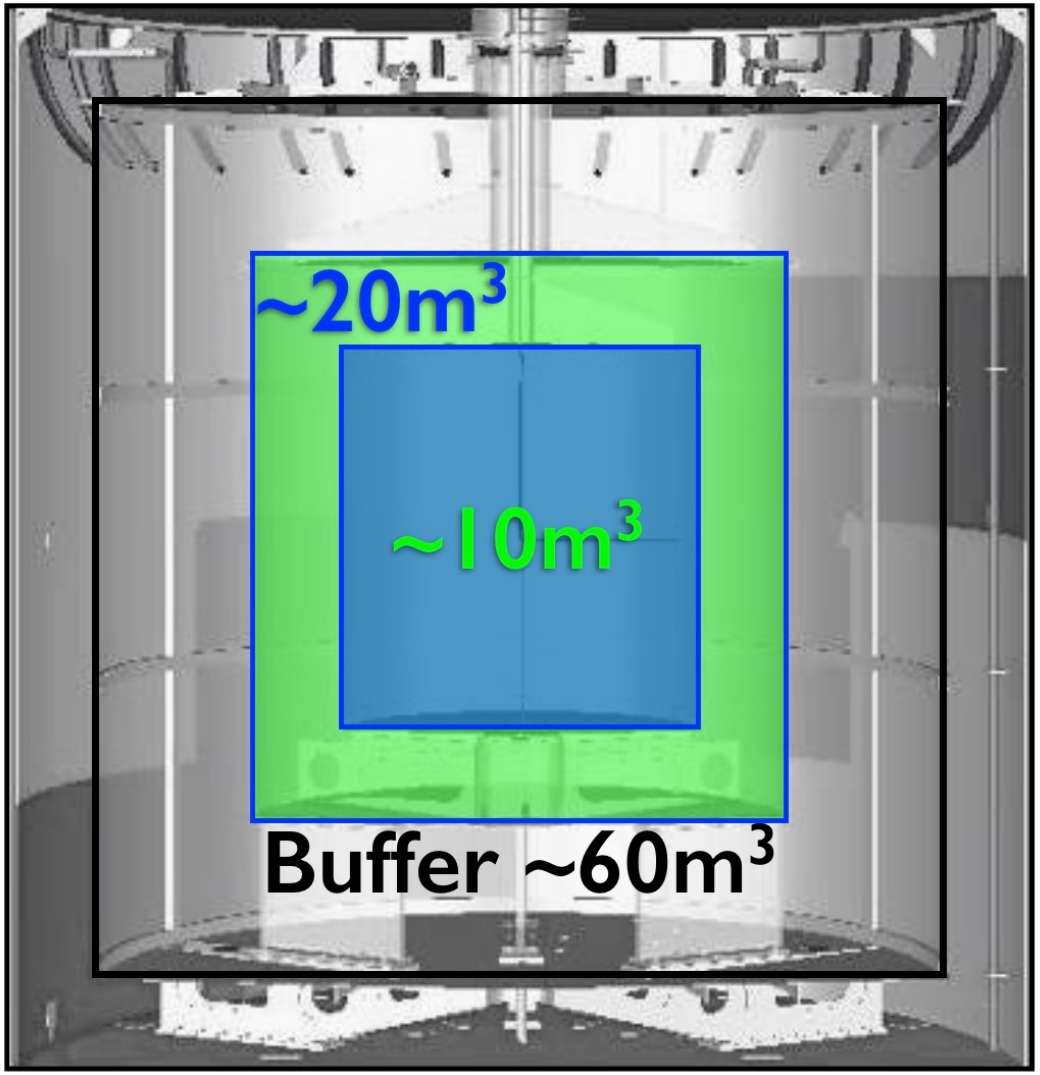
(considerations)

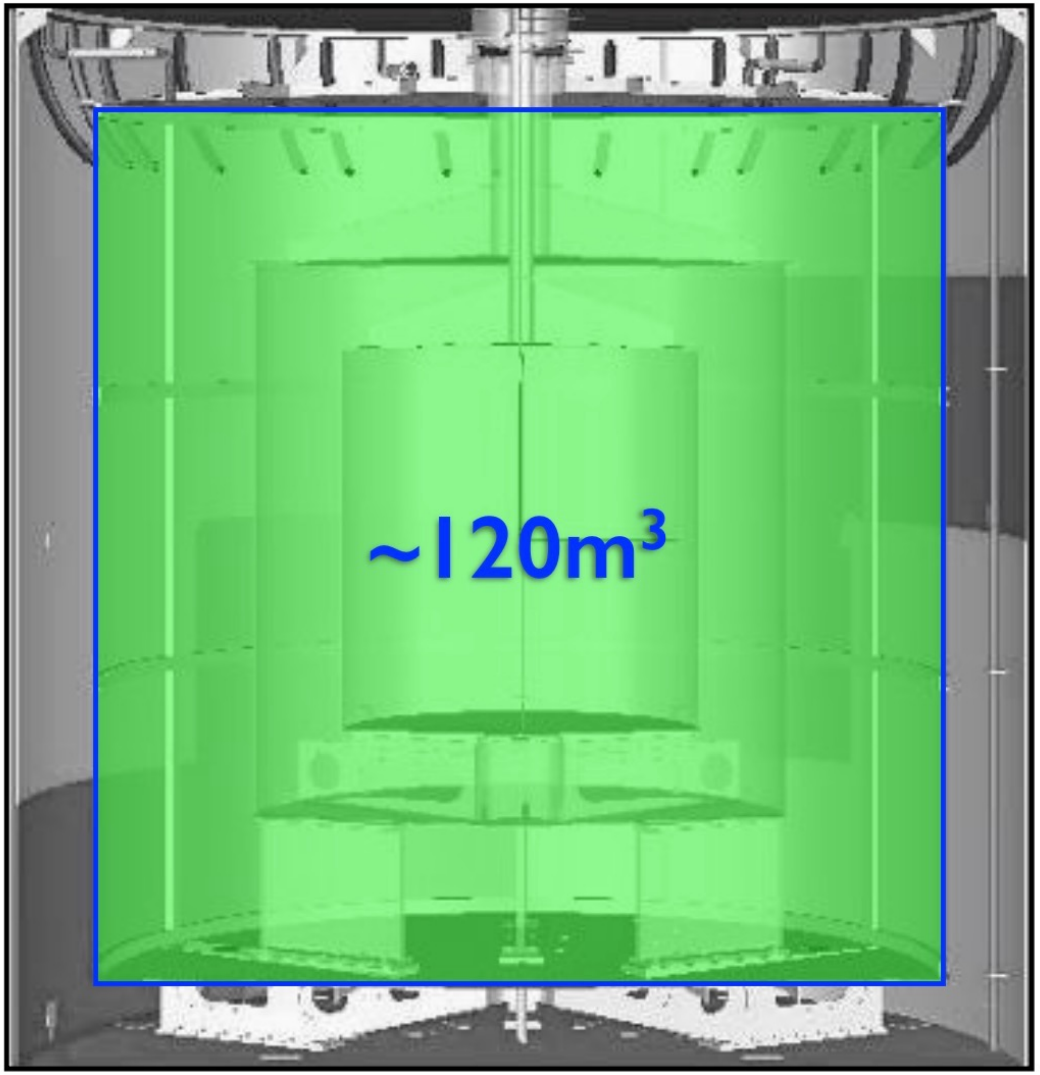
- working within reactor is complex: **modifications are hard!**

(i.e. envisage your physics within existing resources)

- rare signals (electron/coherent scattering) go closer "NND"?

LNCA beyond DC…





Double Chooz

(rock-γ's: ≤5/s & neutrons: ≤[4,40]/day*)

detector region

(rock-γ's: ??/s & neutron: ??/day*)

(*) measured via coincidence (not singles)

LNCA requests…

none

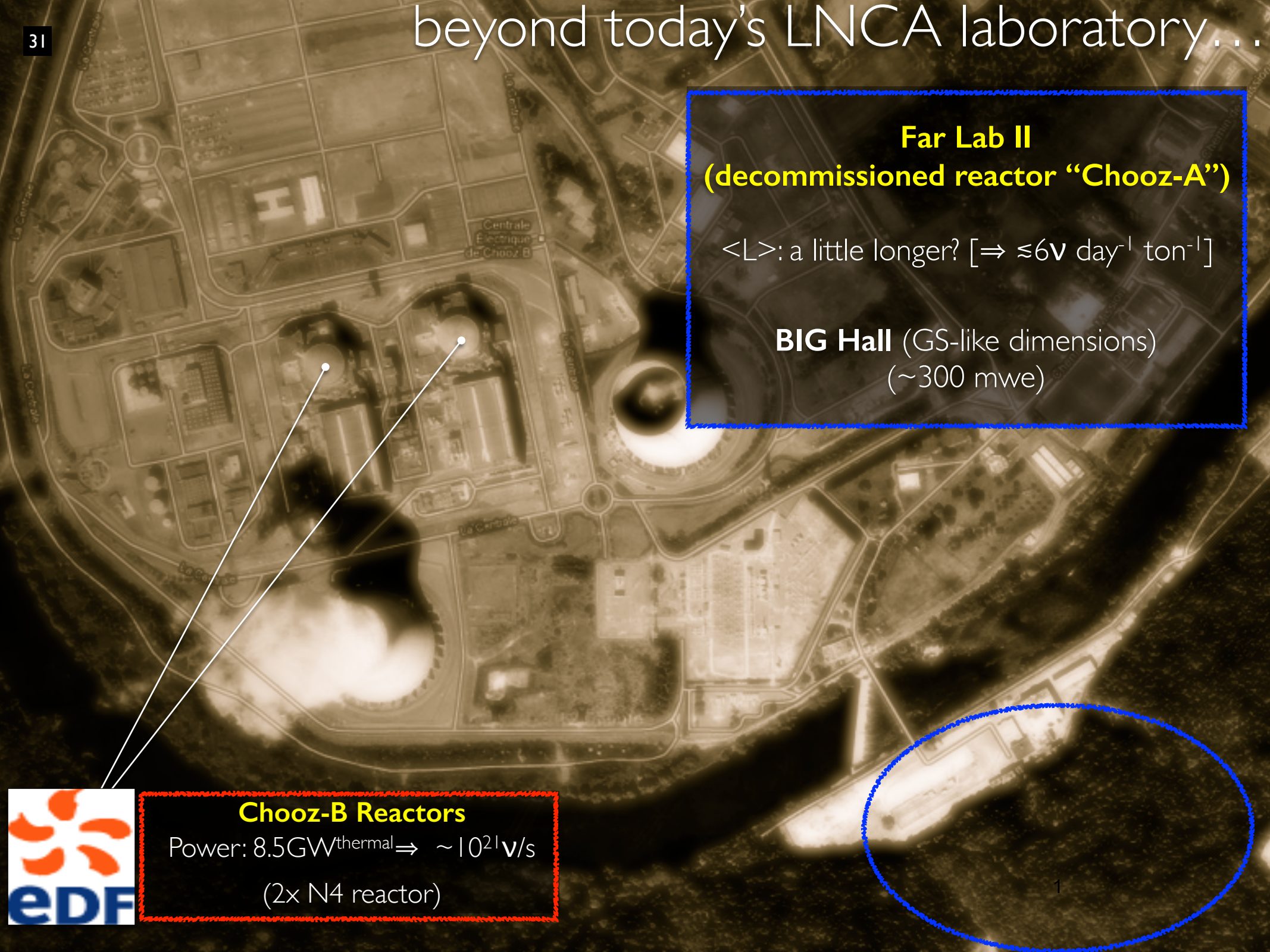
(a few ideas/rumours)

strong invitation here to think & consider LNCA for physics

(much ν-physics away from Europe)

[DC maintains LNCA]

beyond today's LNCA laboratory…



Far Lab II
(decommissioned reactor "Chooz-A")

<L>: a little longer? [⇒ ≲6ν day^{-1} ton^{-1}]

BIG Hall (GS-like dimensions)
(~300 mwe)

Chooz-B Reactors
Power: 8.5GW^{thermal}⇒ ~10^{21}ν/s
(2x N4 reactor)

1