Overview over Underground Laboratories

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Disclaimer

The material I am presenting is taken from talks on the web with some updates from Bettini+Piquemal. Talks are especially

- E. Coccia, TAUP 2009
- A. Bettini, TAUP 2003
- G. Gerbier, IWDD 2009
- F. Duncan, SNOlab workshop 2010

My view is the one of an experimentalist: what lab is the best location for my experiment?

Characteristics of labs

- Shielding depth:
  how deep and uniform → muon flux
- Type of rock, concrete, wall:
  → gamma, radon and neutron flux
- Size:
  how large are the hall(s)?
- Access:
  horizontal (by car, truck, tram) or vertical (by lift)
- Infrastructure underground:
  electricity, ventilation, crane, safety installation, …
- Infrastructure above ground:
  offices, workshops, chemistry, …
- Community:
  other experiments, theory division, …
- Location:
  shops, companies, airports, ….
- "Political" situation:
  burocracy, social or ethnical conflicts
- Distance to CERN, Fermilab, JPARC, …

Order of importance depends on experiment !!!

Depth might not be the most important feature:

GERDA: shielding with low Z material →
muon flux less important, but large volume

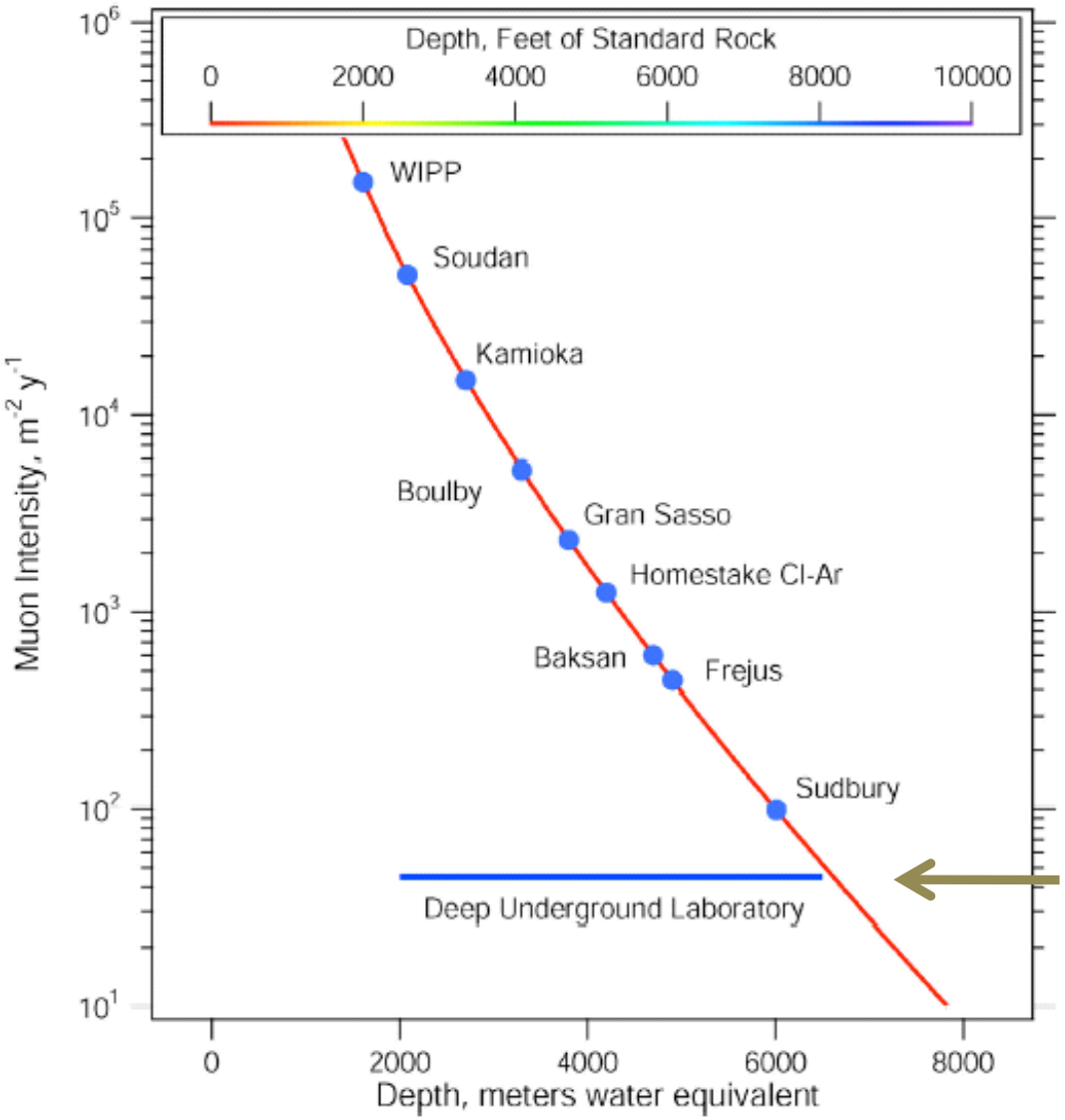
Majorana: shielding with high Z material →
small volume but larger depth required

Radon background: "vacuum tight" experiment →
radon level not so important

Neutron + gamma background can be shielded e.g. by water →
background from sources close to detector dominate

Large volume cryogenics or organic liquids →
safety major concern

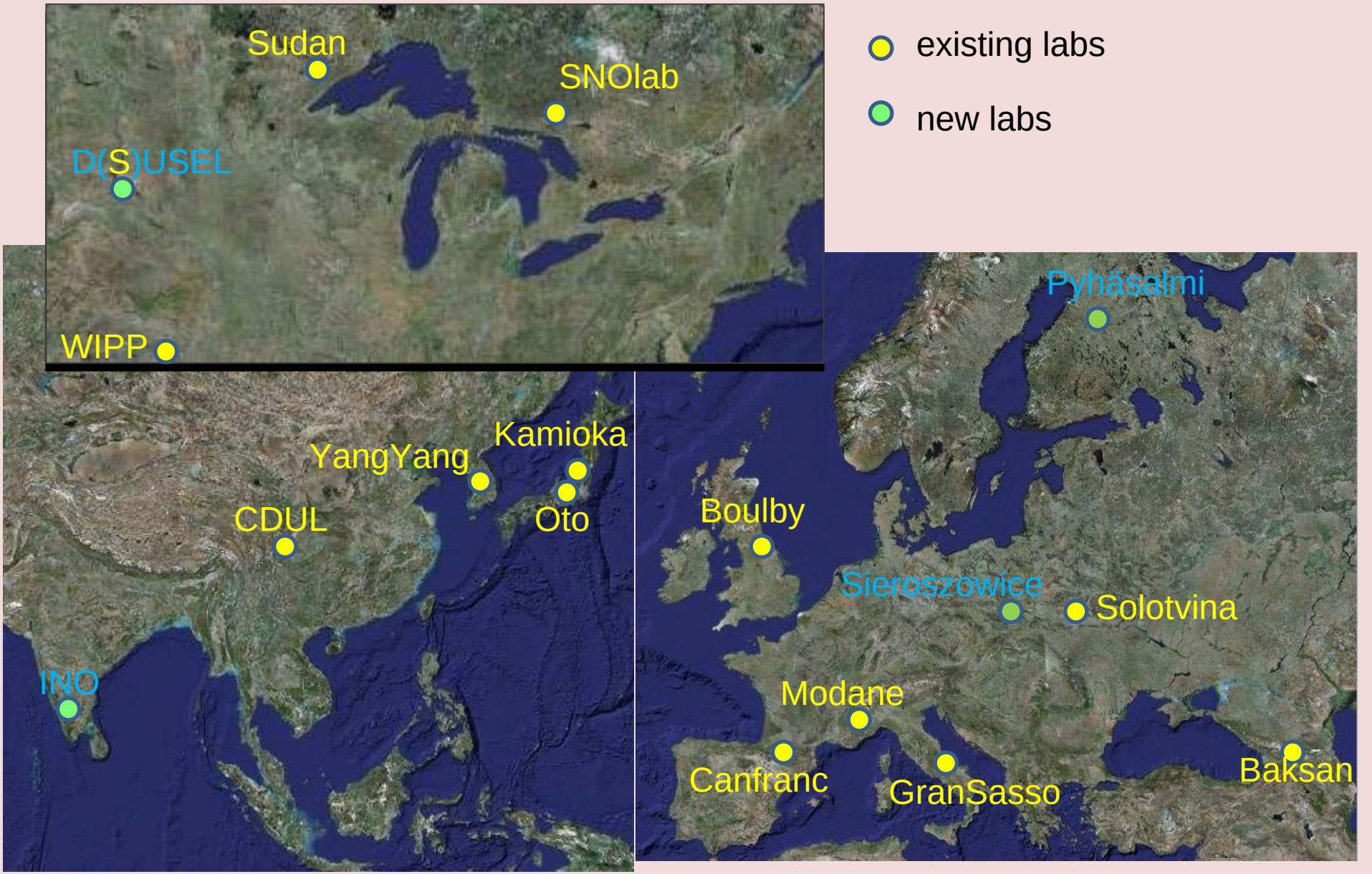
Muon flux versus depth



~1700 m w.e. → factor 10 in muon flux

target for deep labs like DUSEL (USA) or CJPL (China), see following talks

Lab locations



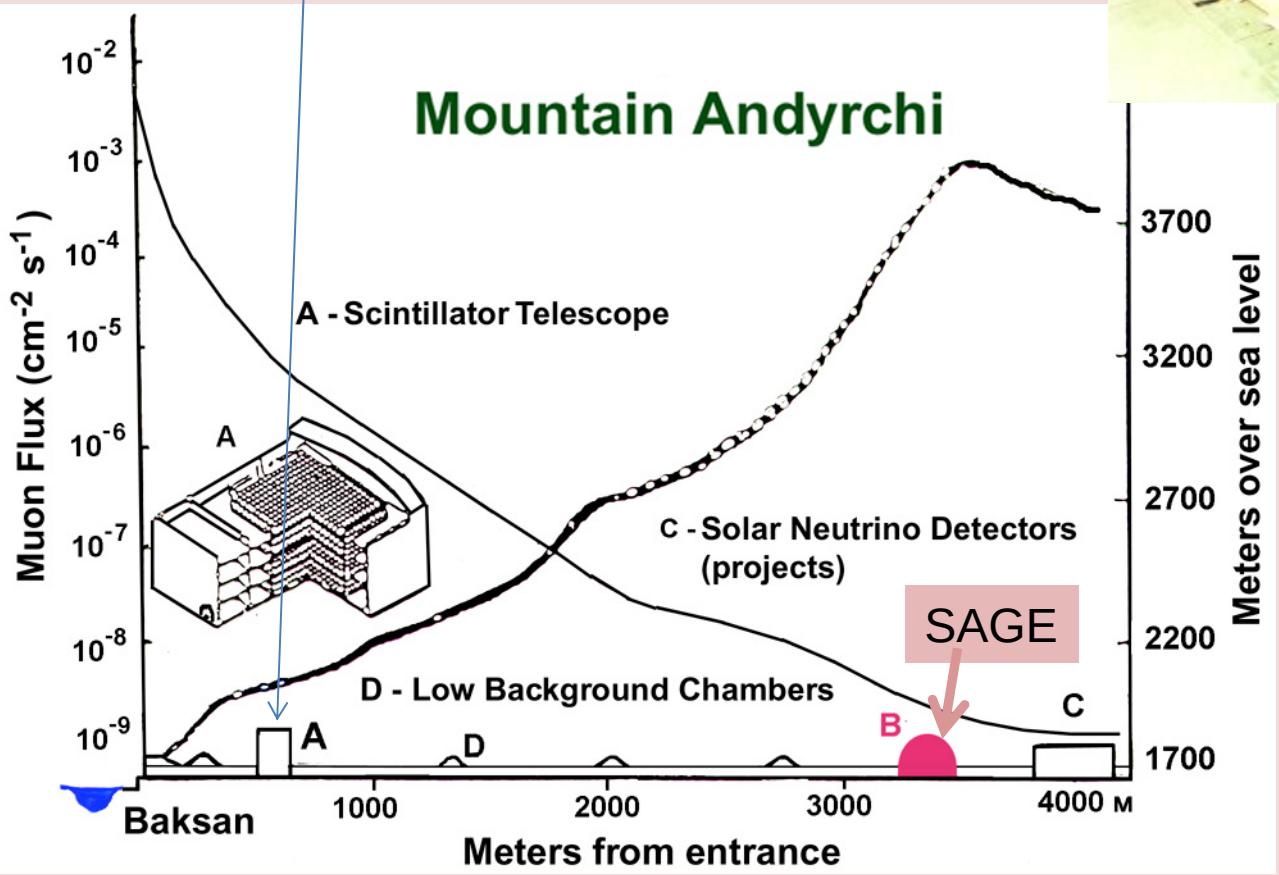
existing labs

new labs

LAB	Country	depth [m w.e.]	volume [10^3 m^3]	users	access	experiments
			Europe			
GranSasso	Italy	3200	180	750	horiz.	DM, 0νββ, solar ν, accelerator. CERN beam, supernova SN
Modane	France	4800	4(+60)	100	horiz.	DM, 0νββ (proton decay, SN)
Canfranc	Spain	2400	9	200	horiz.	DM, 0νββ
Boulby	Britain	2800	5	70	vert.	DM
Baksan	Russia	4700	40	70	horiz.	0νββ, solar ν, SN
Solotvina	Ukraine	1000	5	11	vert.	0νββ
Pyhäsalmi	Finland	300(-4k)	1+?	20	horiz.	cosmic ray (proton decay SN)
Sieroszowice	Poland	2200	26	-	vert.	
			North America			
SNOlab	Canada	6000	46	300	vert.	DM, 0νββ, solar ν, supernova
WIPP	USA	1600	24	100	vert.	0νββ
Sudan	USA	2100	16	250	vert.	DM, Fermilab beam
S(D)USEL	USA	4000 (7000	10 300)	100 1000	vert.	DM, 0νββ everything)
			Asia			
Kamioka	Japan	2700	60	300	horiz.	DM, 0νββ, ν mix. JPARC beam, SN
Oto Cosmo	Japan	1300	1	20	horiz.	DM, 0νββ
INO	India	3000	(56)		horiz.	atm. ν
CJPL	China	7500	4	?	horiz.	DM, 0νββ ,

Baksan Neutrino Observatory

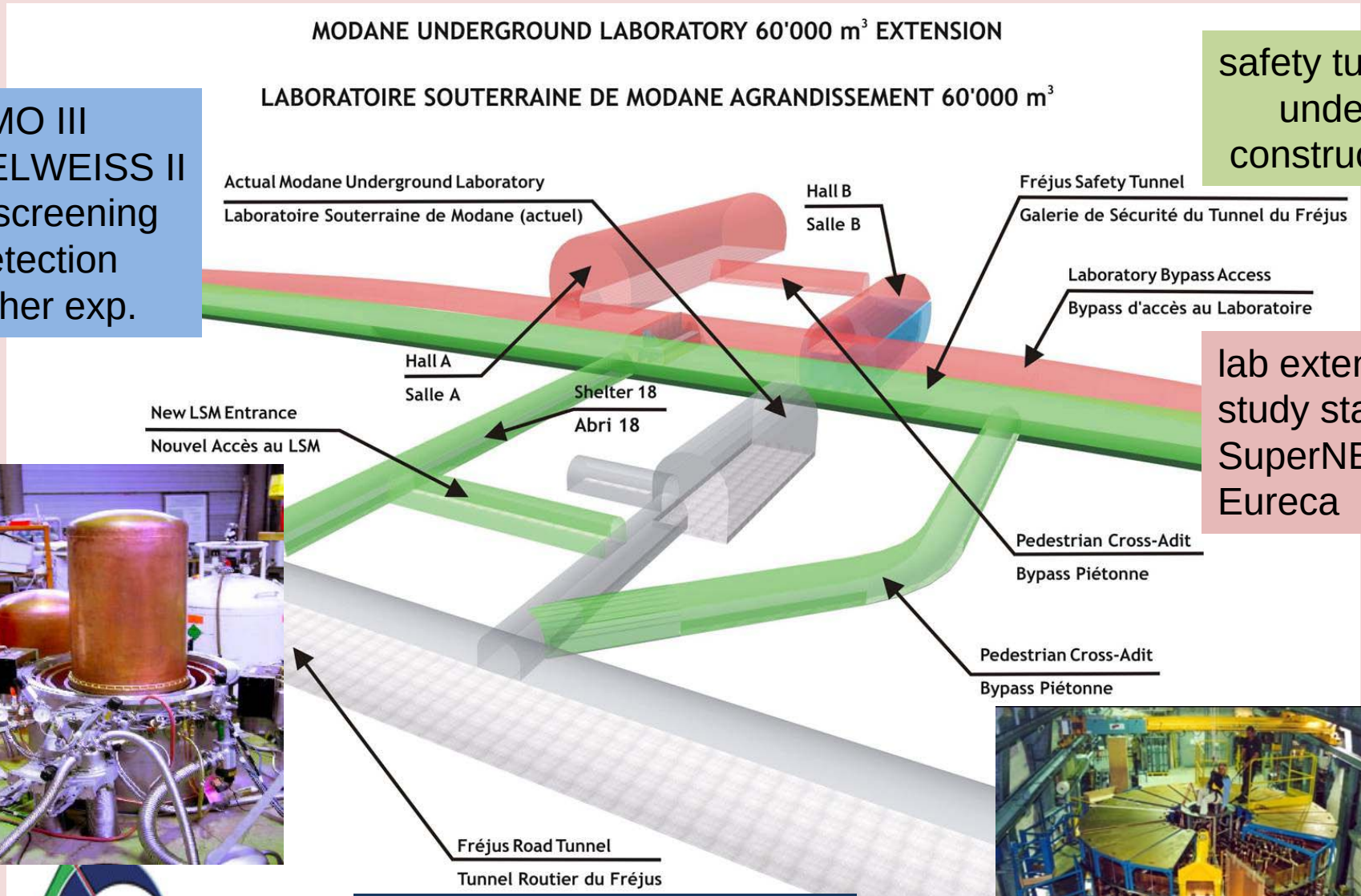
BUST: 1st large scintillator telescope
for the detection of solar neutrinos (1978)



Laboratoire Souterrain de Modane

NEMO III
EDELWEISS II
Ge screening
n detection
& other exp.

safety tunnel under construction

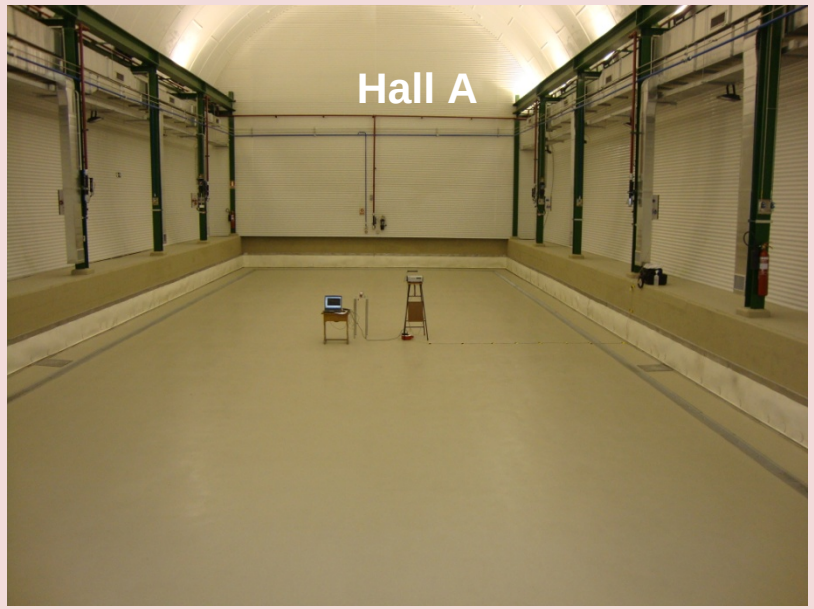


lab extension study stage: SuperNEMO, Eureca

➢4000 m w.e required for p decay.

Laboratorio Subterraneo de Canfranc

Handover of the underground structures to the LSC Consortium 30.6.2010



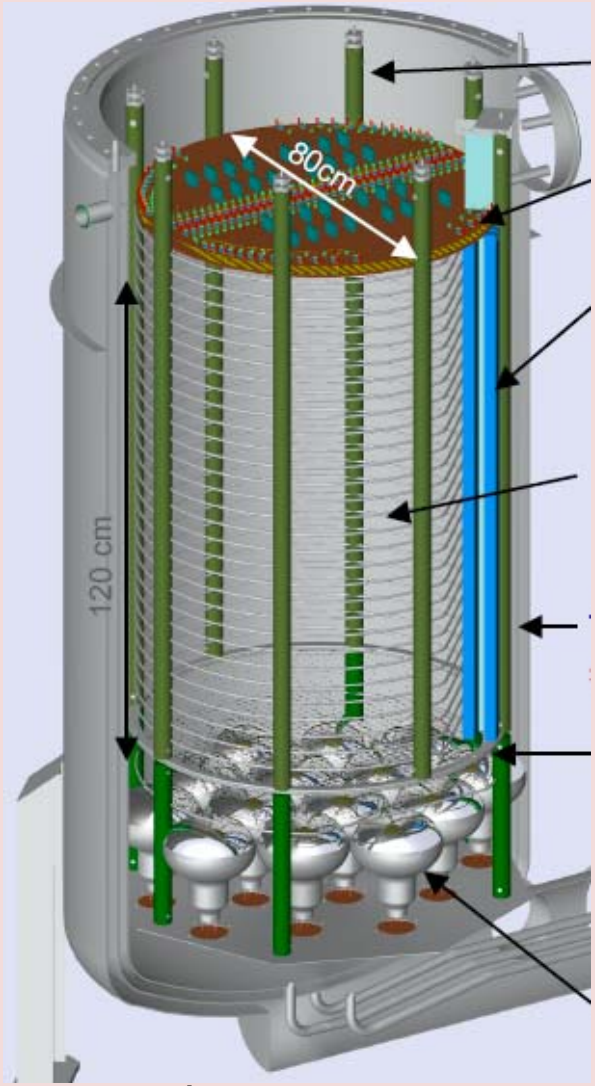
Depth: 800 m

Muons: $0.47 \times 10^{-2}\ \mu\ m^{-2}\ s^{-1}$

Ventilation: 11.000 m^3/h

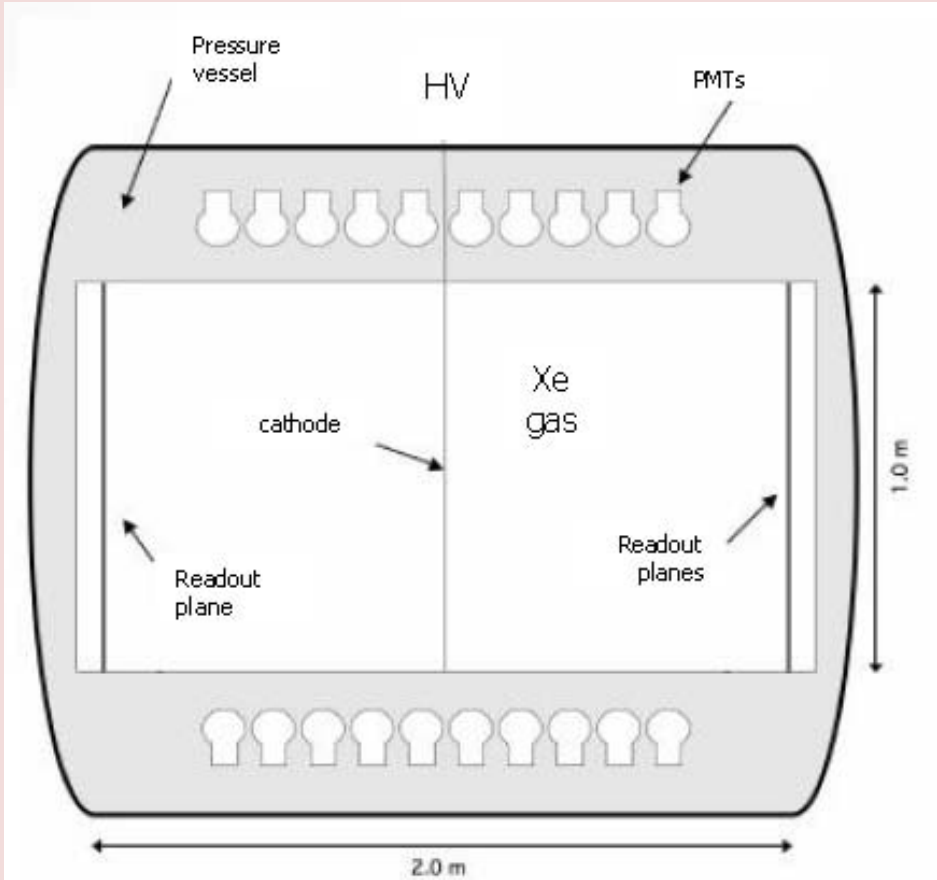
Operative budget: ≈1600 k€/yr

ArDM



Ar two-phase TPC,
tetst of 1 ton prototype at CERN
installation in 2011

NEXT

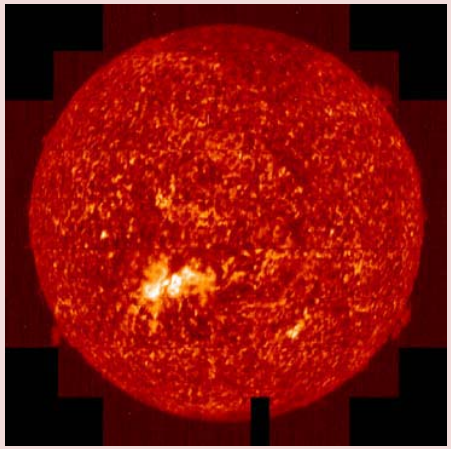


10 bar gas TPC with ^{136}Xe (100 kg)
FWHM resolution ~1% feasable
prototypesin 2011 at LSC

Laboratori Nazionali del Gran Sasso

biggest laboratory in the world with widest physics program,
construction finished in 1987,
rock shielding sufficient for current experiments, (3100+x) m w.e.
good above ground facilities

LNGS physics



solar+geo ν

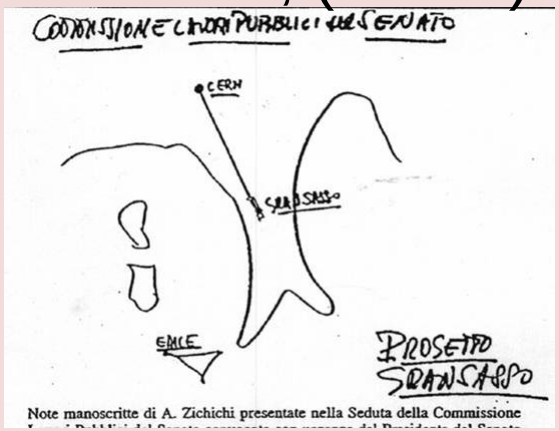
Borexino

supernova ν

LVD

CERN beam

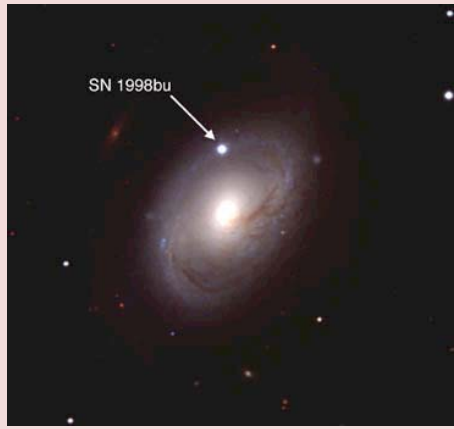
OPERA, (Icarus)



Note manoscritte di A. Zichichi presentate nella Seduta della Commissione

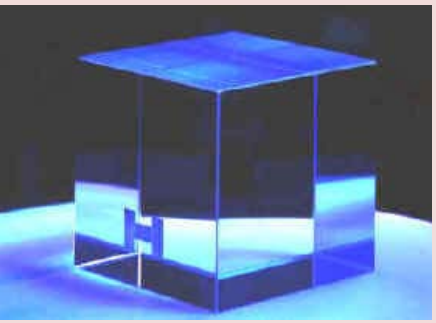
dark matter

Dama/Libra,
Cresst,
Xenon,
WARP



0νββ

Cuore, Lucifer
GERDA



nuclear astro physics

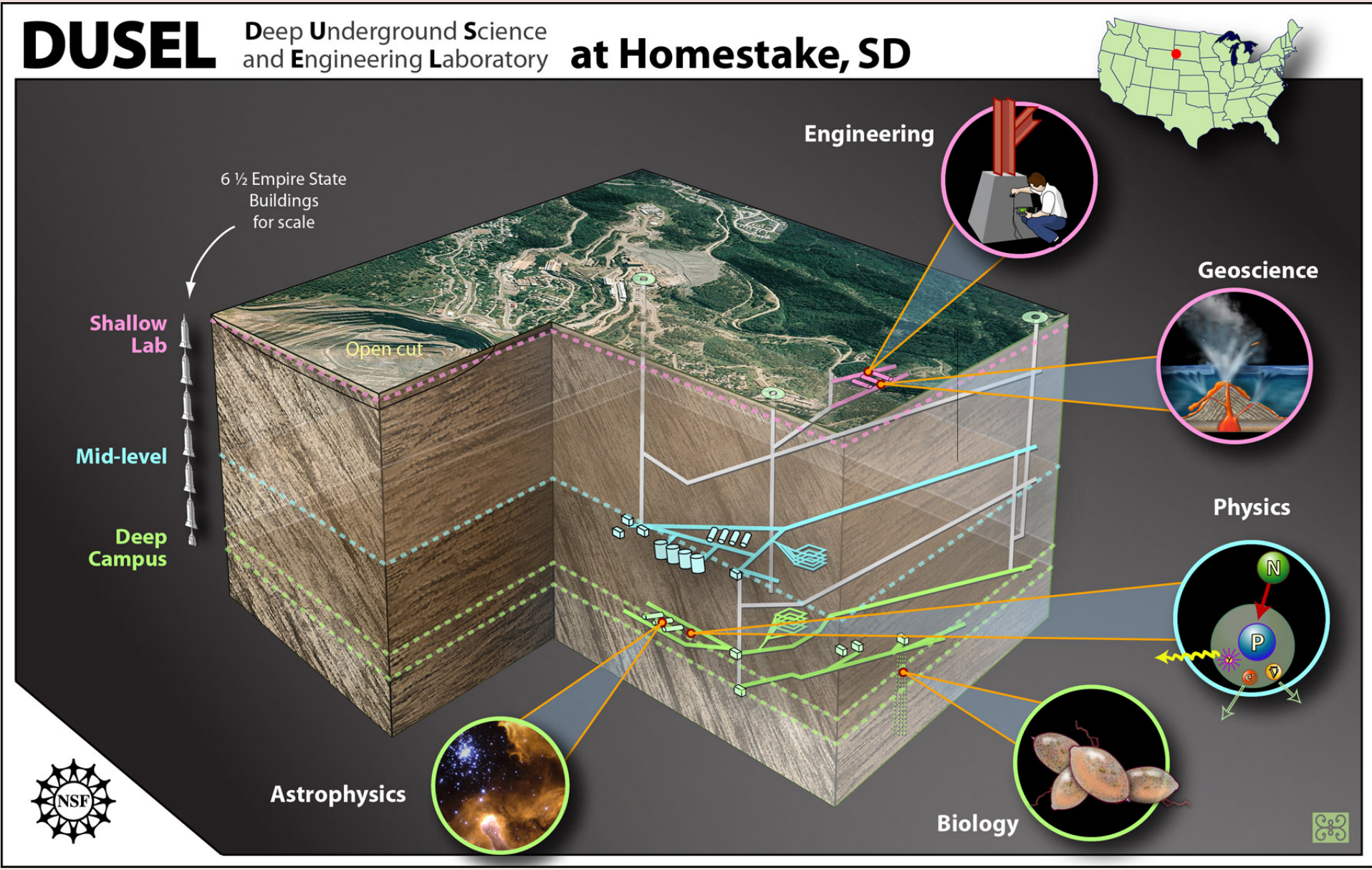
Luna

SNOLAB

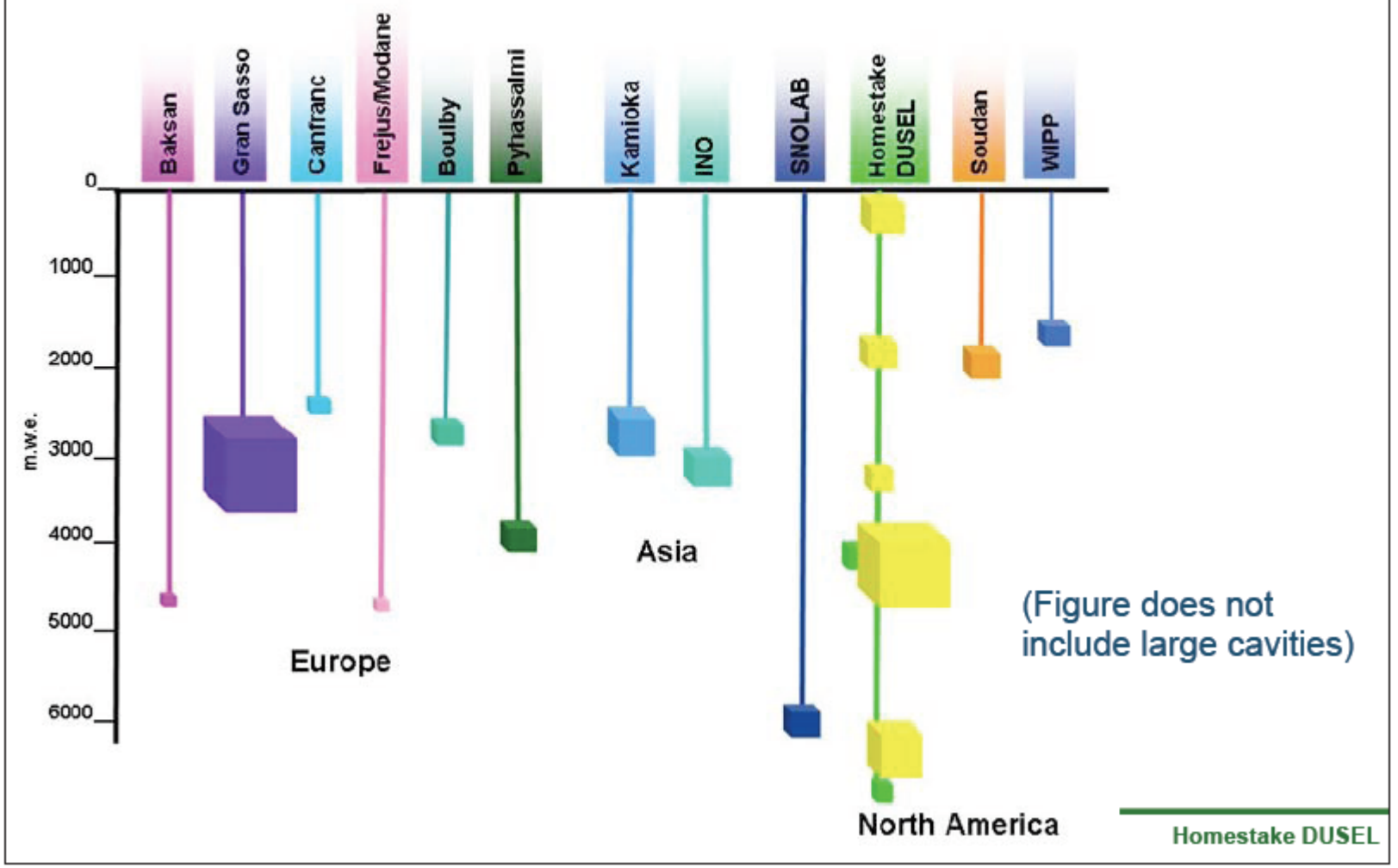
successful transformation from SNO to SNOlab !!
my impression: very successful transition,
good support for experiments
independent exp halls → improved safety

Experiment Program

The vision


DUSEL
Deep Underground Science and Engineering Laboratory
at Homestake, SD
Engineering
6 ½ Empire State Buildings for scale
Shallow Lab
Mid-level
Deep Campus
Open cut
Geoscience
Physics
N
P
Astrophysics
Biology
NSF

Providing Critical Research Space, Especially at Great Depths

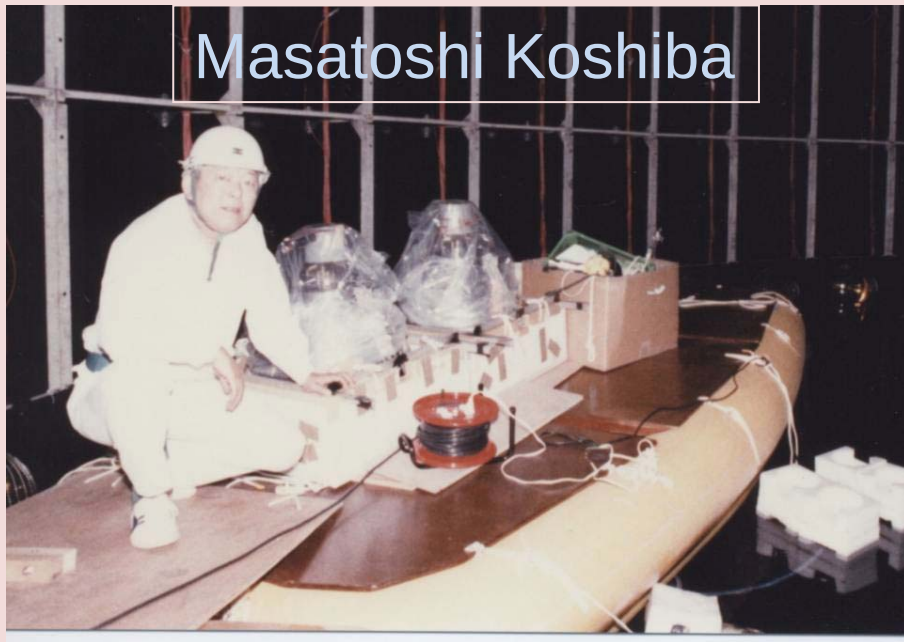


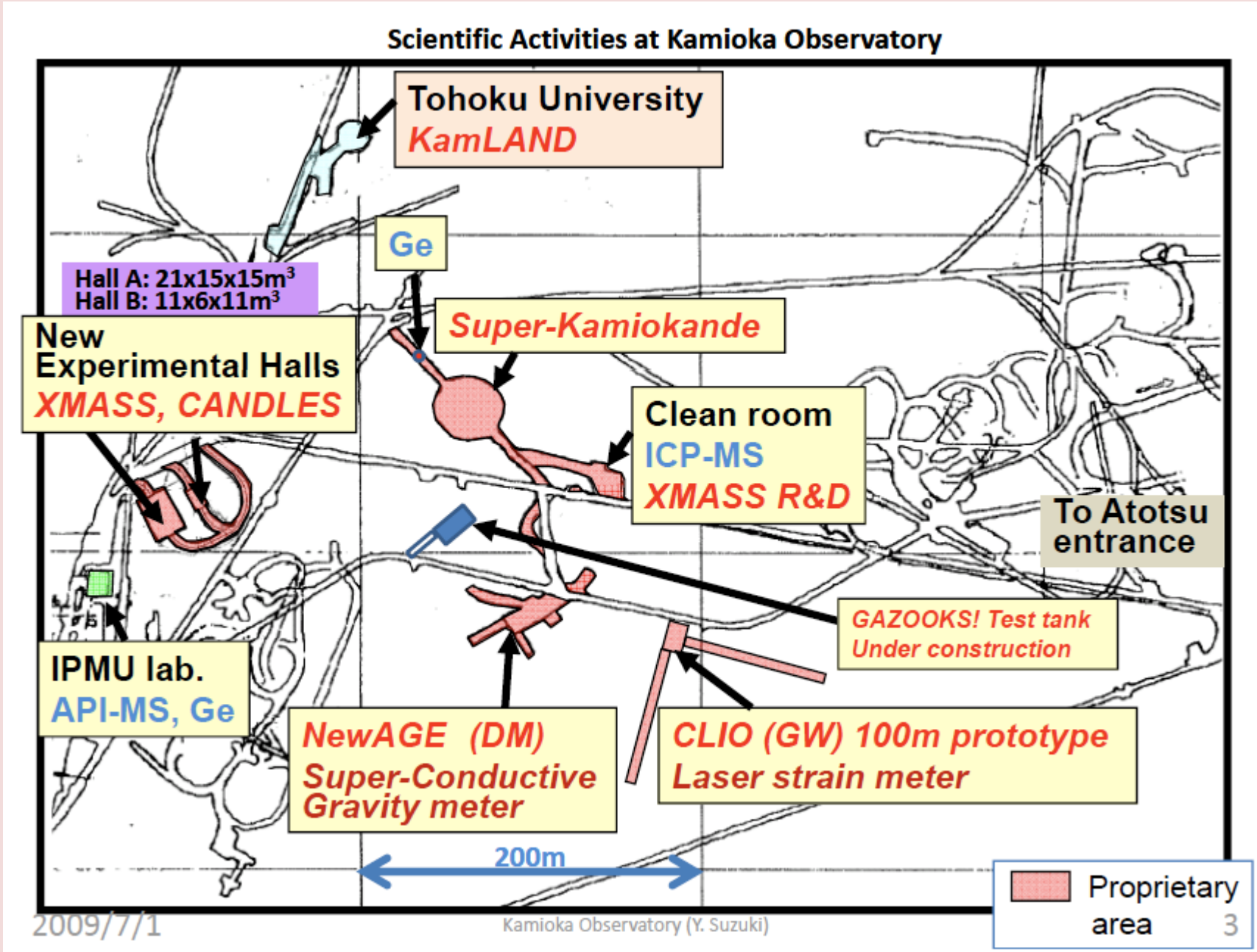
Space available for LUX and Majorana demonstrator at 4850 level, first experiments

Kamioka Observatory

Founded in 1983 by M. Koshiba to host KamikaNDE (=Nucleon Decay Exp)
1996 Super-Kamiokande started (3kt → 50 kt water Cherenkov detector)

in the last year: K2K and T2K beams, new halls for Kamland, …
transition to a facility




Scientific Activities at Kamioka Observatory
Tohoku University
KamLAND
Ge
Hall A: 21x15x15m3
Hall B: 11x6x11m3
Super-Kamiokande
New
Experimental Halls
XMASS, CANDLES
Clean room
ICP-MS
XMASS R&D
To Atotsu
entrance
GAZOOKS! Test tank
Under construction
IPMU lab.
API-MS, Ge
NewAGE (DM)
Super-Conductive
Gravity meter
CLIO (GW) 100m prototype
Laser strain meter
200m
Proprietary
area
2009/7/1
Kamioka Observatory (Y. Suzuki)
3

(personal) summary & conclusions

- many labs are(have) upgrading (Canfranc, Modane, SNOlab, Kamioka)

- many new labs are under construction/planned (INO, CJPL, DUSEL)
  this development is opposite to HEP: labs are “closing” (DESY, Stanford, …)

- what are the important design parameters for a lab?
  proton decay exp. require big size,
  future DM exp. large depth,
  for me infrastructure is very important

- the size/cost of the experiments is increasing
  → I expect that the number of experiments will decrease
  Why is the number of laboratories increasing?

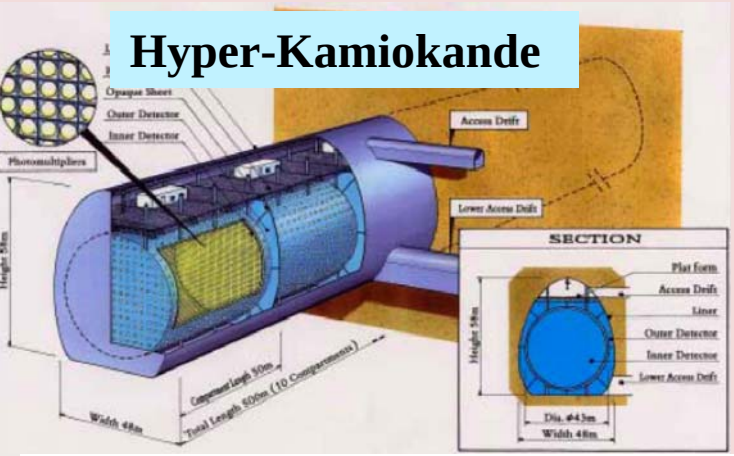
- from what I see: our chinese colleagues are very ambitious and
  with the deepest underground lab China can play a major role in the future

‘Megaton’ Detector

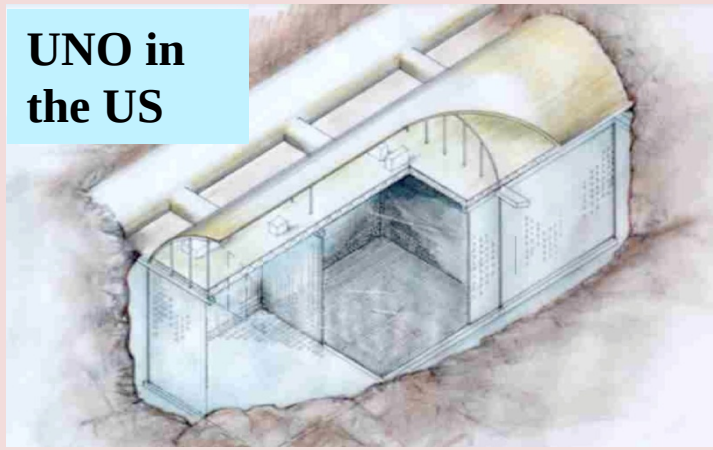
- **nucleon-decay**
- **long baseline neutrinos from accelerator**
- **SN neutrinos**

Three water Cherenkov proposals ⇒≈ 10-20 times present Super-K

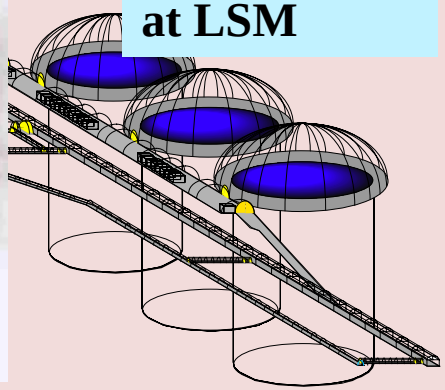
Hyper-Kamiokande

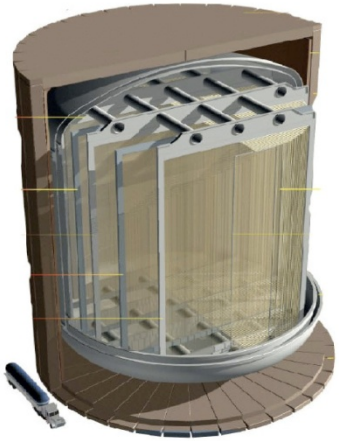


UNO in the US



MEMPHIS at LSM

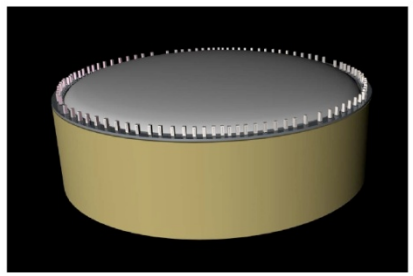


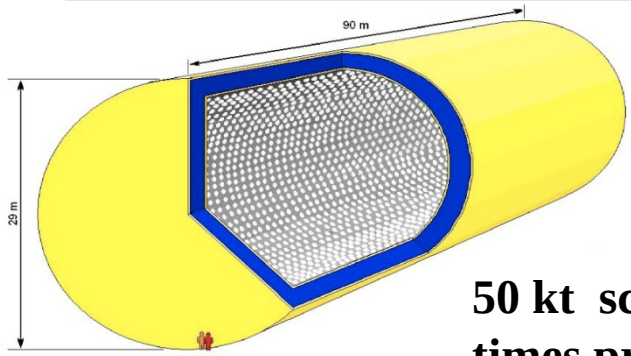


LANNDD

100 kt scale LAr

≈300 times present technology





LENA, HSD

50 kt scintillator ≈ 50 times present technology

LAGUNA R&D proposal to FP7:comparison of the techniques and possible sites in Europe

From A. Bettini, TAUP2007