PHYSICS

WITH A

MULTI-MW PROTON SOURCE

Concluding remarks

EURISOL

CERN

ECFA

ESGARD

beta-beam

NuPECC

CARE

Physics with Megawatt

- Long-range programme in ν physics:

  superbeam, β beam, ν factory
- Complementary programme in μ physics:

  rare μ decays, μ properties, μ colliders?
- Next-generation facility for nuclear physics

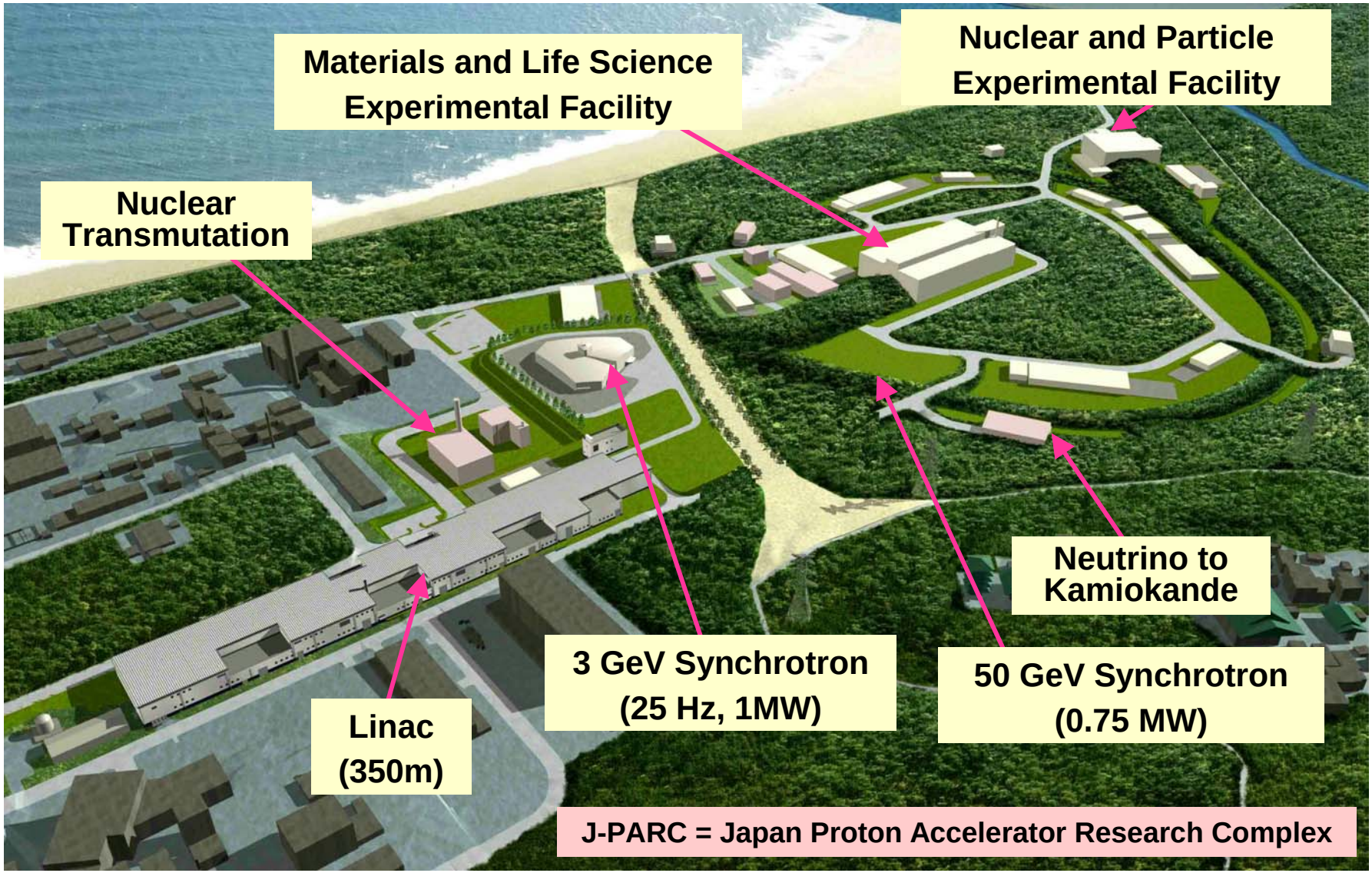
  also tests of SM, nuclear astrophysics
- Synergy with CERN programme:

  LHC, CNGS ν, ISOLDE, heavy ions, β beam

Interesting project – and CERN would be a good place for it

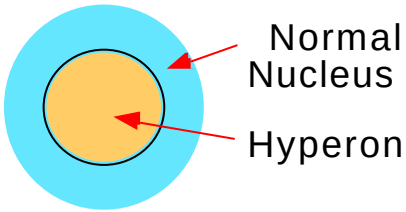
The reference facility: J-PARC

0.75 MW at start, evolving



Nuclear and Particle Physics

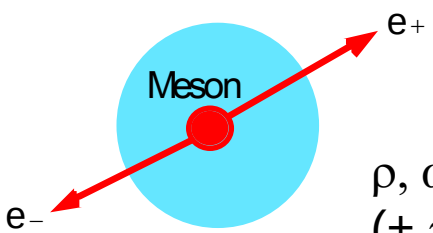
Baryon Implantation



Hypernucleus

- High resolution spectroscopy for S = -1 hypernuclei
- S = -2 hypernuclei

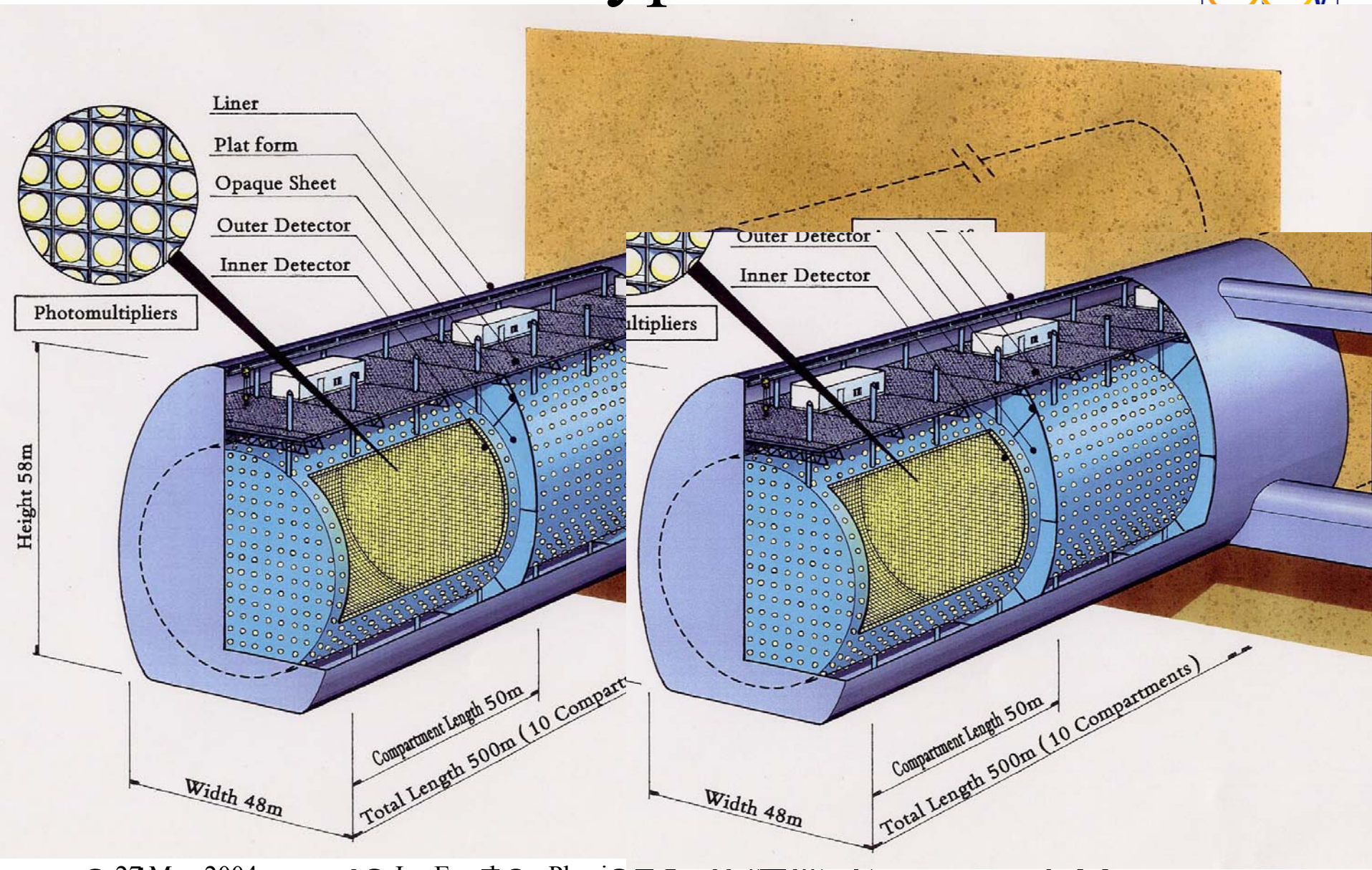
Meson Implantation



ρ, ω, ϕ, J/Ψ, etc.
(+ π, K, σ, etc.)

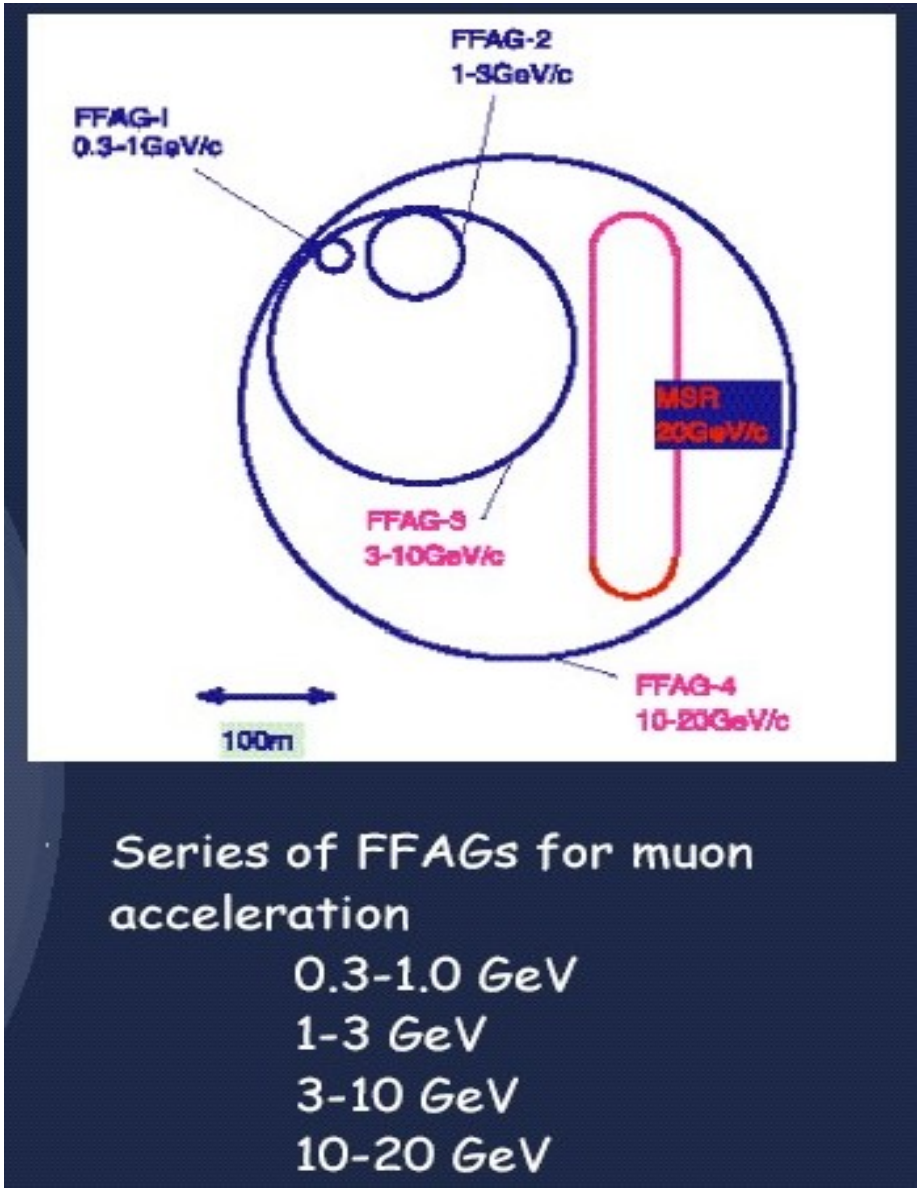
Neutrino conventional beam (0.75 MW)
then multi MW Superbeam
later Neutrino Factory

2 Detector Hyper-Kamiokande

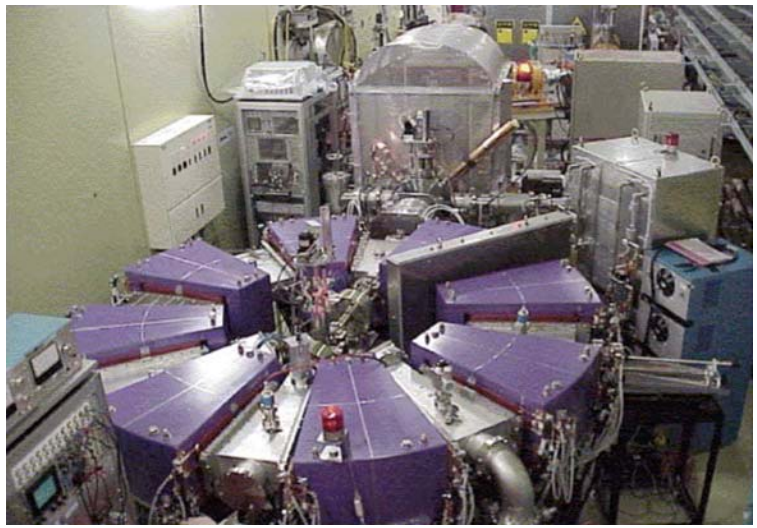


2 detectors×48m ×50m ×250m, Total mass = 1 Mton

The Japanese Neutrino Factory Concept



Large aperture accelerators (FFAG)



p.o.p. prototype

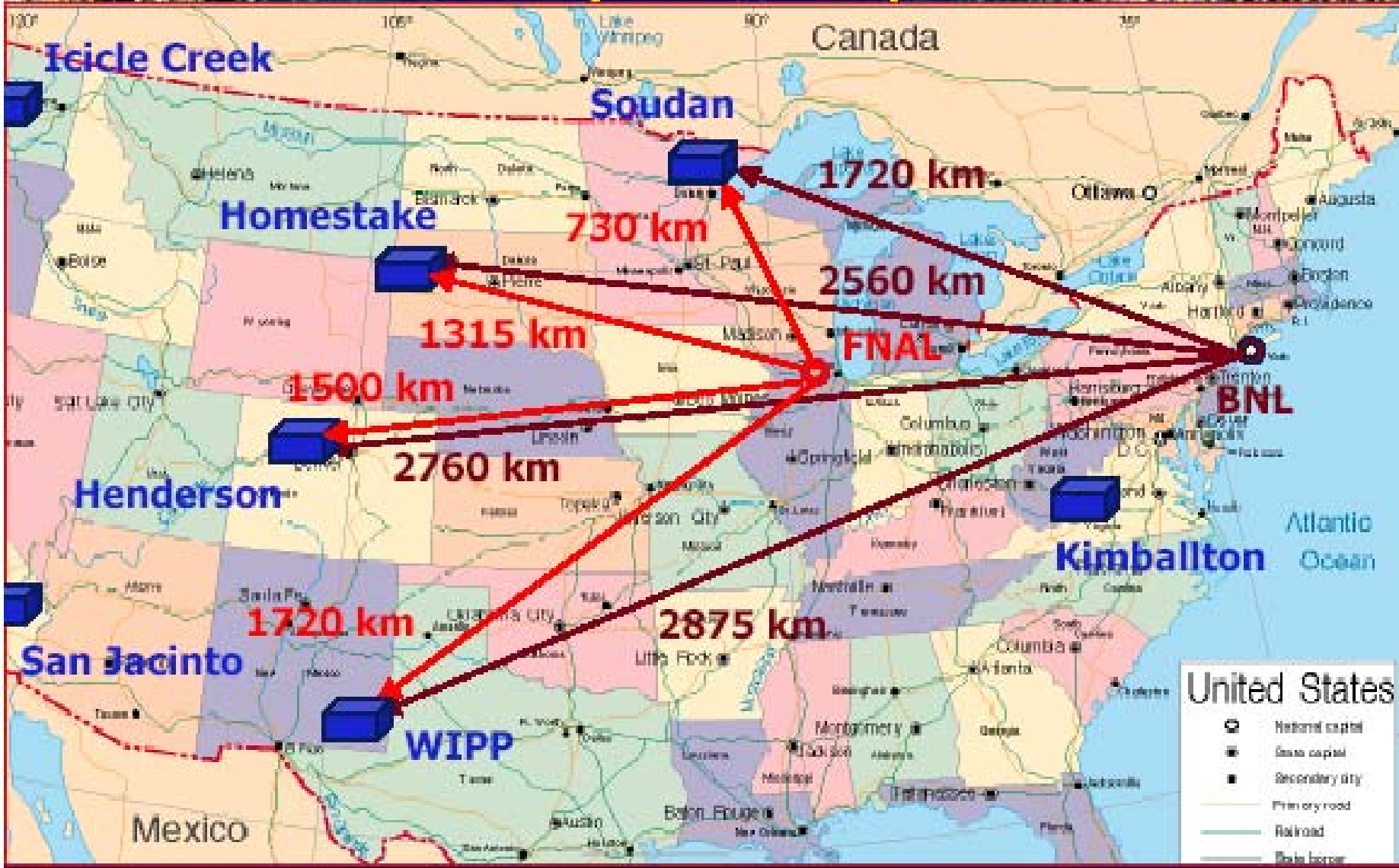
The Ultimate neutrino facility and…

first step to muon colliders

High Power Proton Drivers
Fermilab and Brookhaven

- Fermilab and Brookhaven concepts have several elements in common:
  - Increase the repetition rate of the existing machine (MI or AGS)
  - Decrease the fill time of the existing machine by using a (sc) linac
  - Increase the injected beam intensity by using a linac (or synchrotron)
  - Rely on previously developed SCRF technologies
- Both conceive of upgrade paths that could go another factor of 2-4
- **The BNL concept features a 1.2 GeV superconducting linac as the injector into the (upgraded) AGS**
- **Fermilab has two implementations under evaluation**, each with capability to inject into the Main Injector and to provide stand-alone 8 GeV beams:
  - **8 GeV synchrotron** (with 600 MeV linac injector)
  - **8 GeV superconducting linac**

NUSEL Candidate Sites and Potential Superbeam Experiments

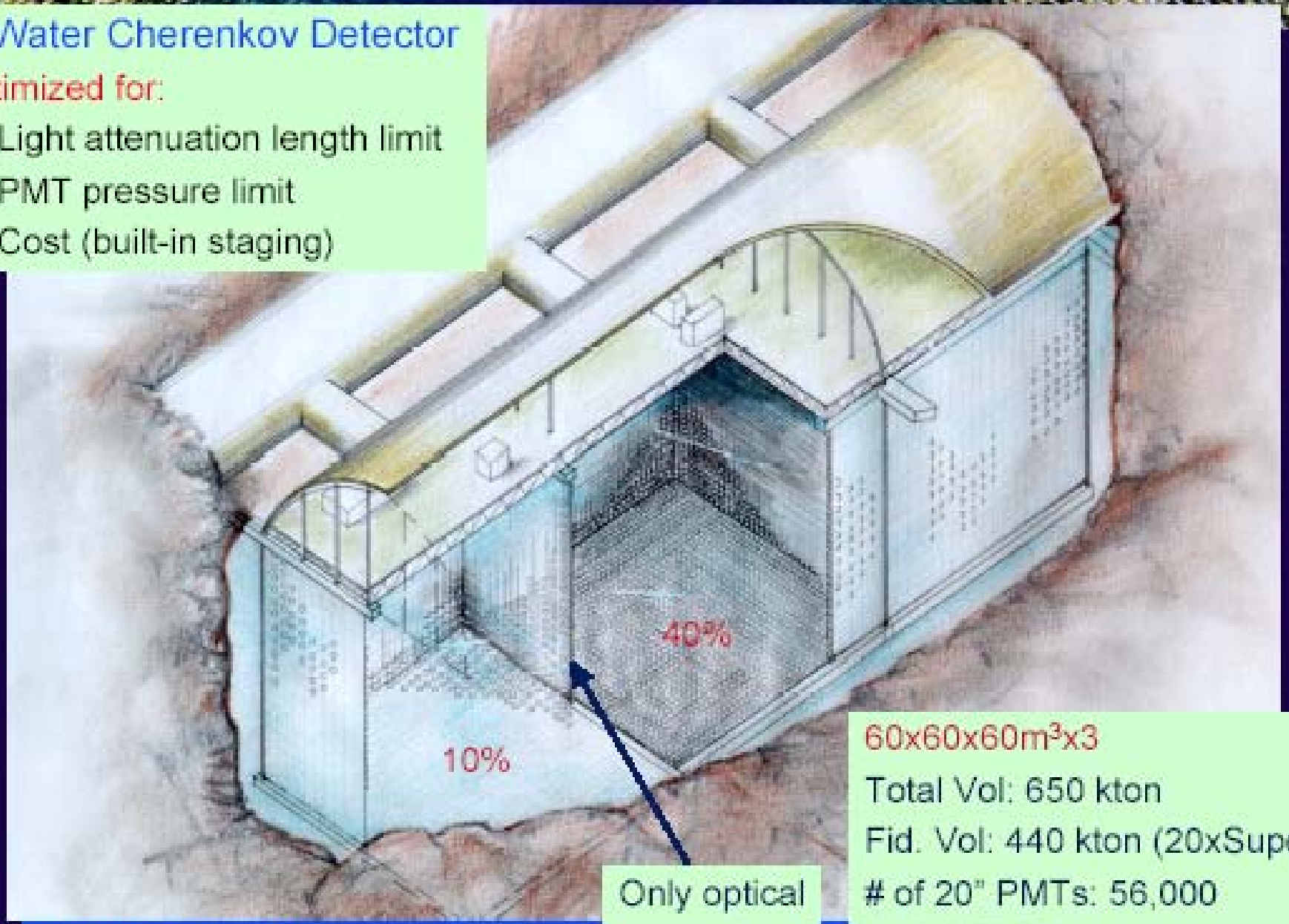


UNO Detector Conceptual Design

A Water Cherenkov Detector

optimized for:

- Light attenuation length limit
- PMT pressure limit
- Cost (built-in staging)



$60x60x60m^3x3$

Total Vol: 650 kton

Fid. Vol: 440 kton (20xSuperK)

# of 20" PMTs: 56,000

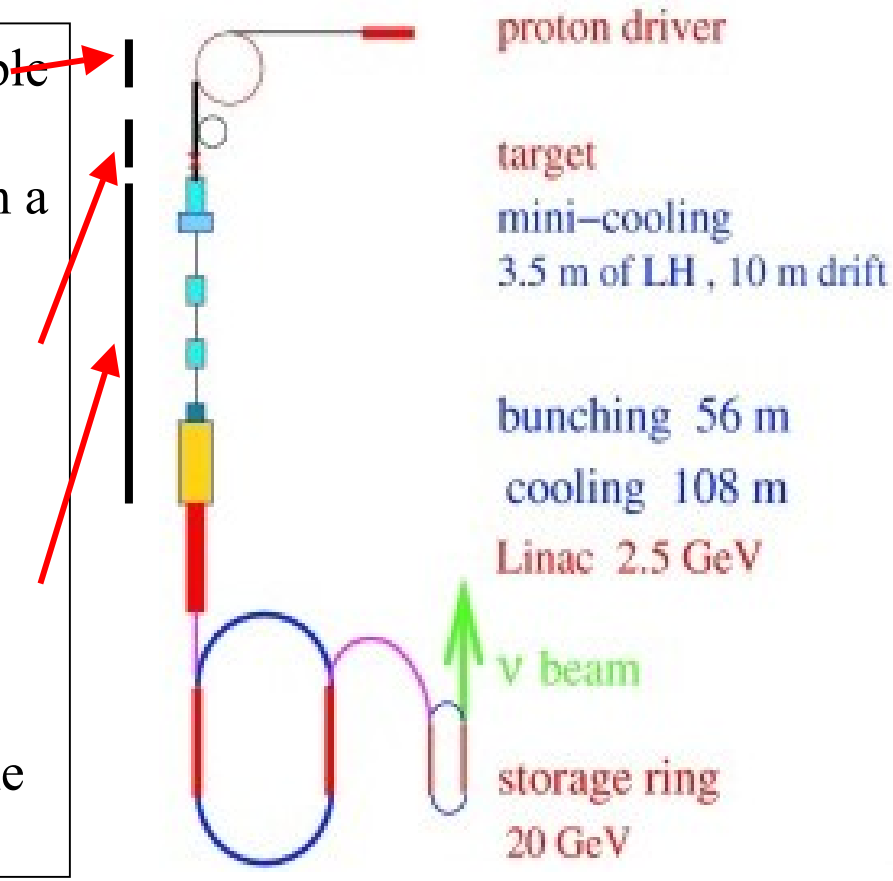
# of 8" PMTs: 14,900

US Neutrino Factory Concept - 1

Example: US Design Study 2

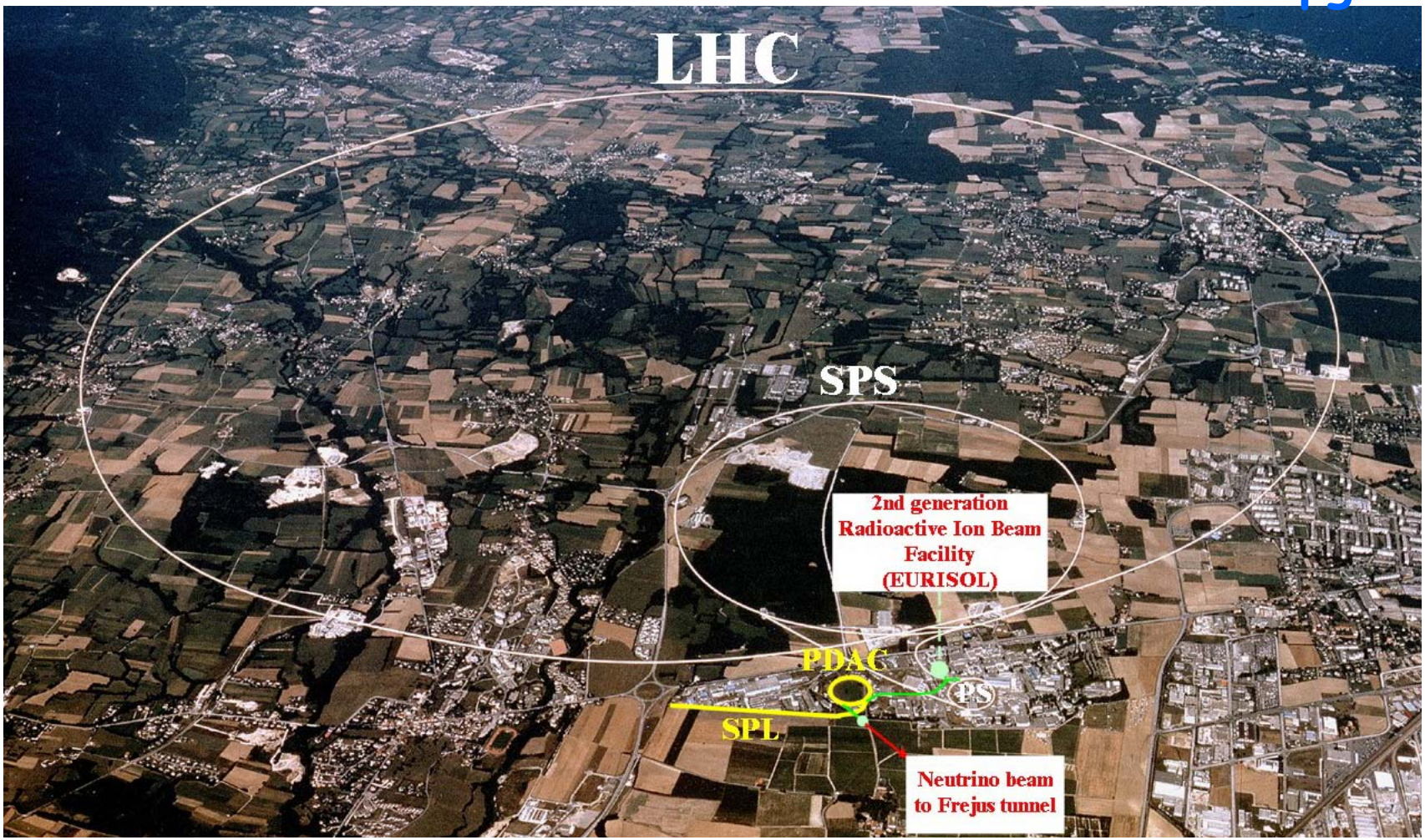
1. Make as many charged pions as possible
   - ✹ INTENSE PROTON SOURCE

   (In practice this seems to mean one with a beam power of one or a few MW)
2. Capture as many charged pions as possible
   - ✹ Low energy pions
   - ✹ Good pion capture scheme
3. Capture as many daughter muons as possible within an accelerator
   - ✹ Reduce phase-space occupied by the μs
   - ✹ Muon cooling – needs to be fast other-wise the muons decay

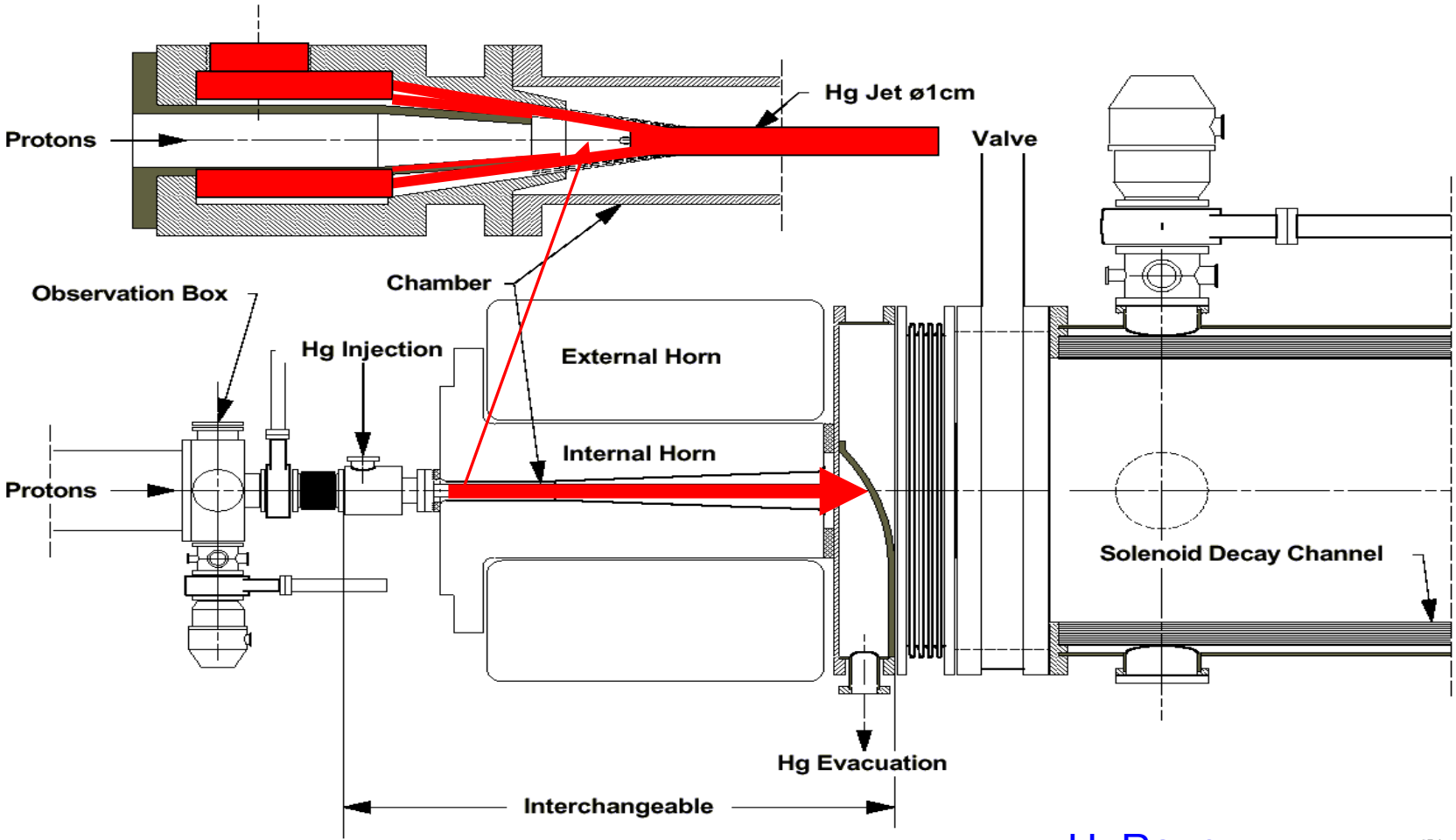


European MWatt complex:
combination of SPL+rings

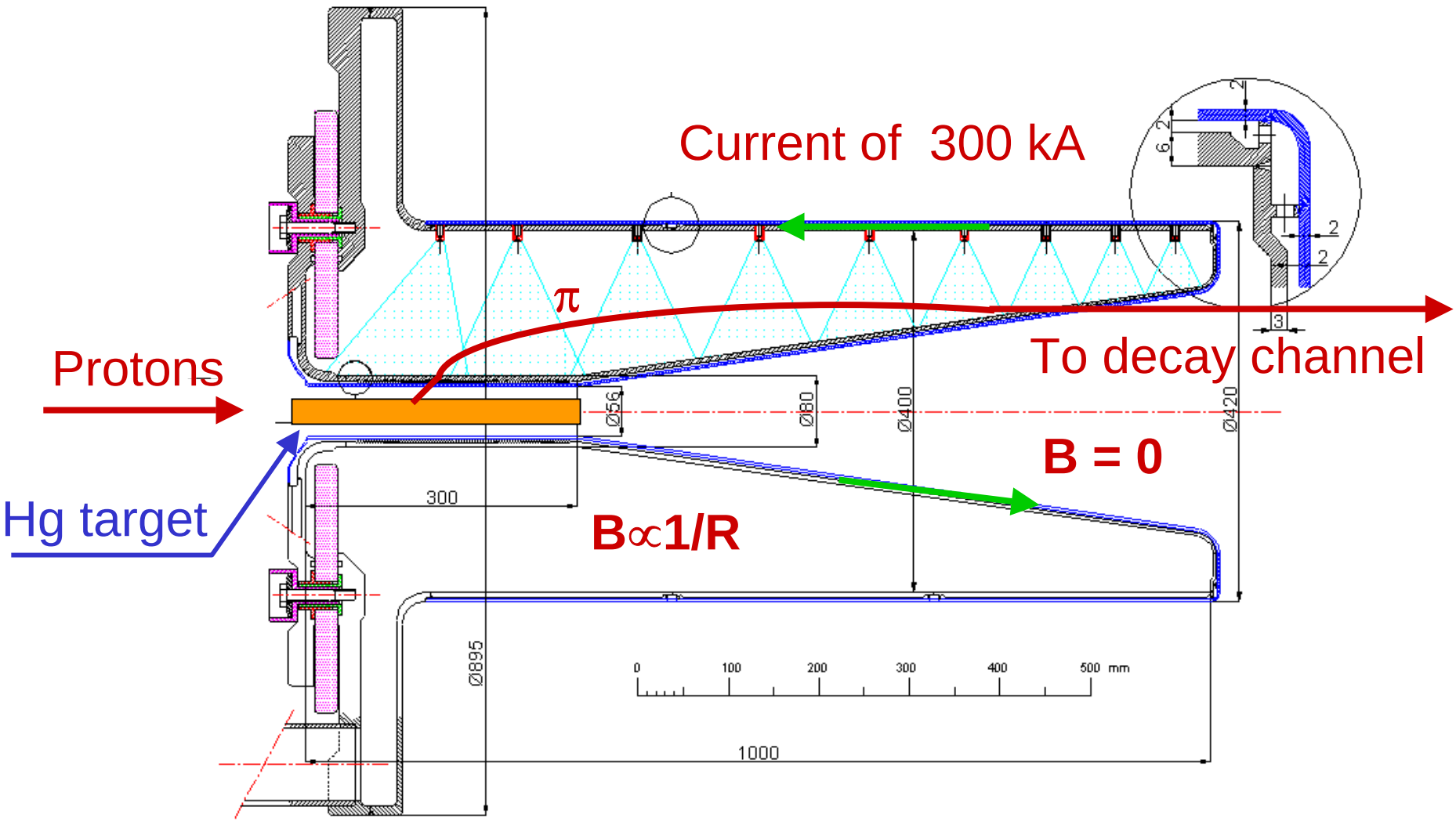
in synergy
with LHC upgrades



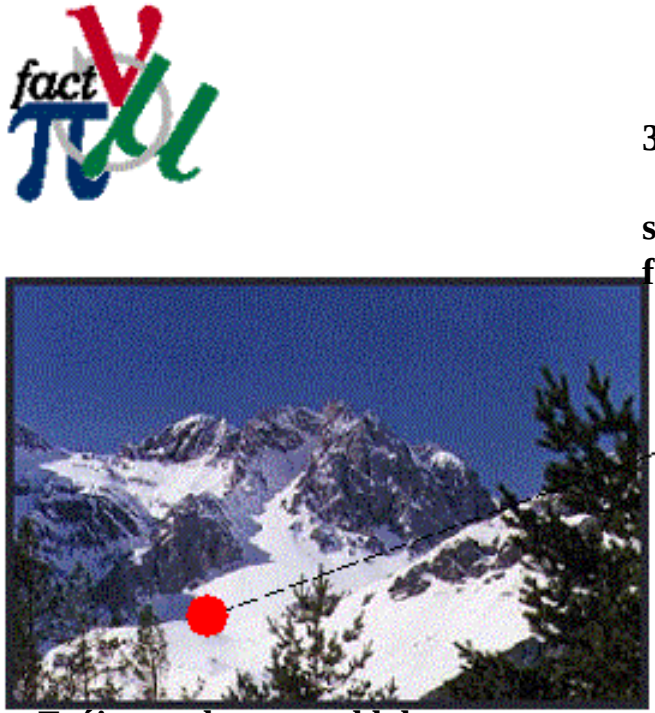
MWatt targetry
Ex: Hg-jet p-converter target



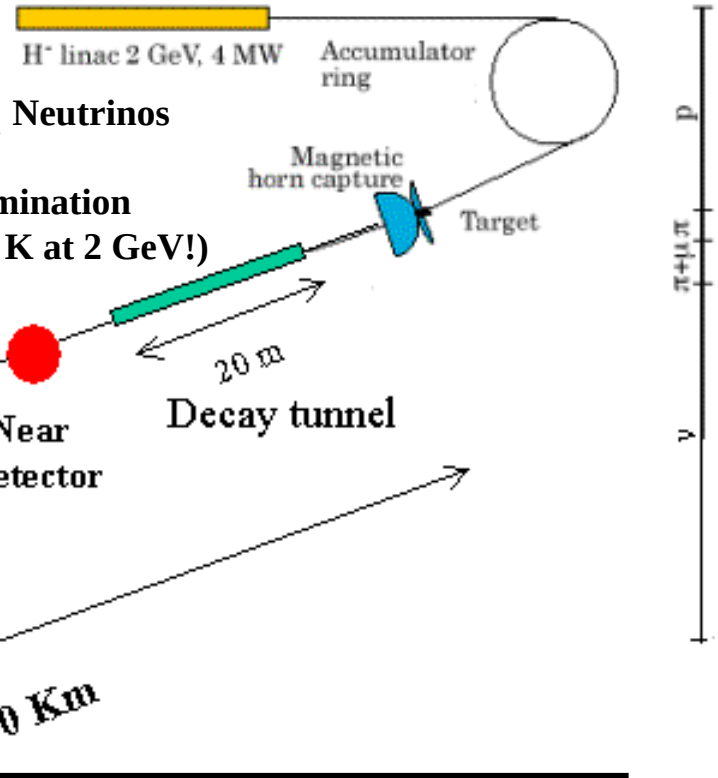
Mwatt pion/muon collection systems
Ex: Horn focusing system



CERN-SPL-based Neutrino SUPERBEAM



Fréjus underground lab.



300 MeV ν_μ Neutrinos

small contamination from ν_e (no K at 2 GeV!)

A large underground water Cerenkov (400 kton) UNO/HyperK or/and a large L.Arg detector.

also : proton decay search, supernovae events solar and atmospheric neutrinos. Performance similar to J-PARC II

There is a window of opportunity for digging the cavern stating in 2008 (safety tunnel in Frejus)

first indications of support within EU agencies

“Memorandum of Understanding”
between
French (IN2P3/CNRS, DSM/CEA)
and Italian (INFN) Institutions

……

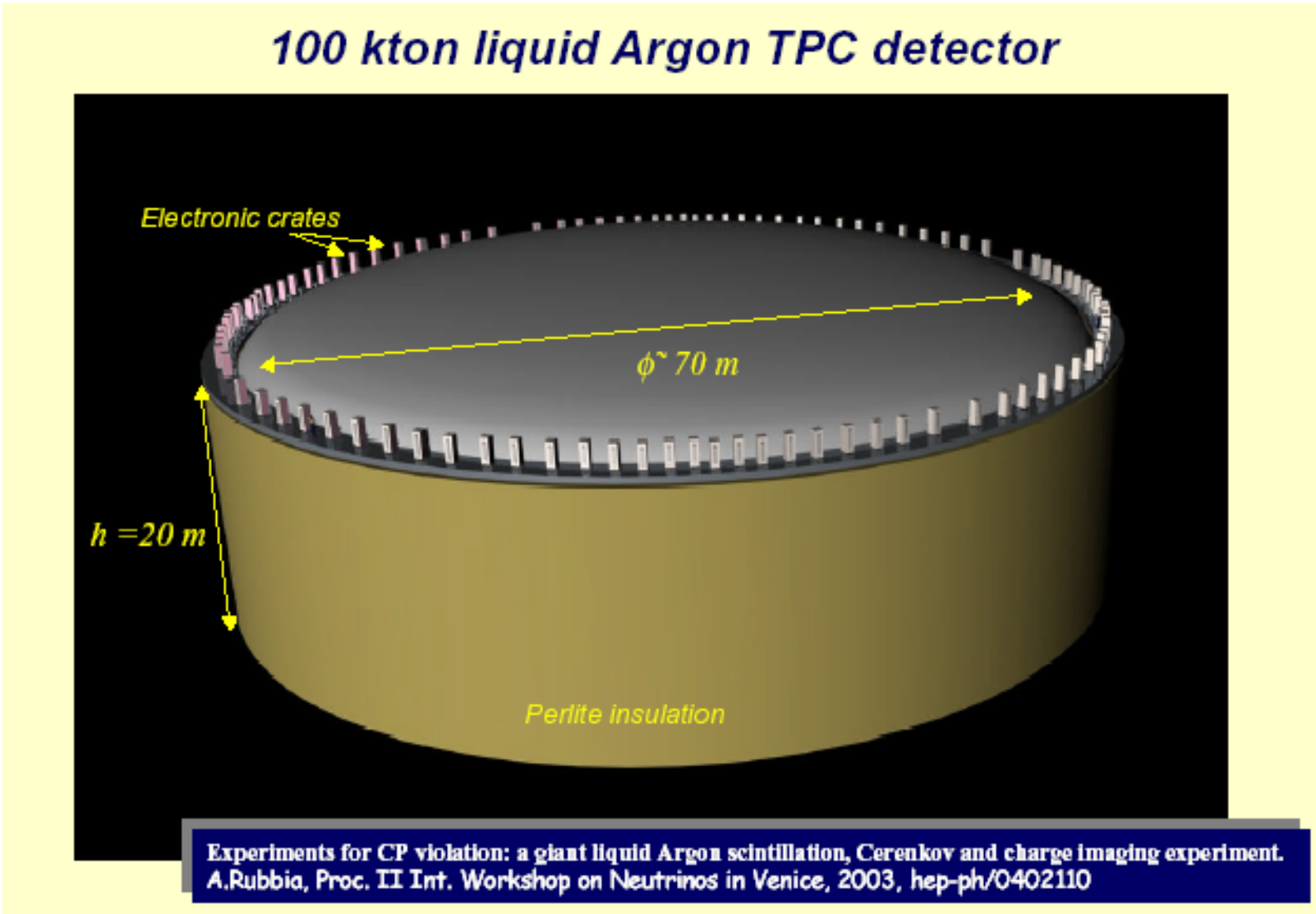
« The DSM, IN2P3 and the INFN agree to **prepare the design of a very Large Underground Laboratory in the new Fréjus tunnel**, with complementary features with respect to the Gran Sasso laboratory, to be submitted as a joint proposal to the French and Italian governements.

The institutions aim at associating the Fréjus and Gran Sasso laboratories in a single entity, a European Joint Laboratory, **open to the world scientific community** to carry out advanced experiments in particle, astroparticle and nuclear physics in the coming decades, on topics such as matter stability, neutrino mixing and mass, stellar collapses and nuclear astrophysics »

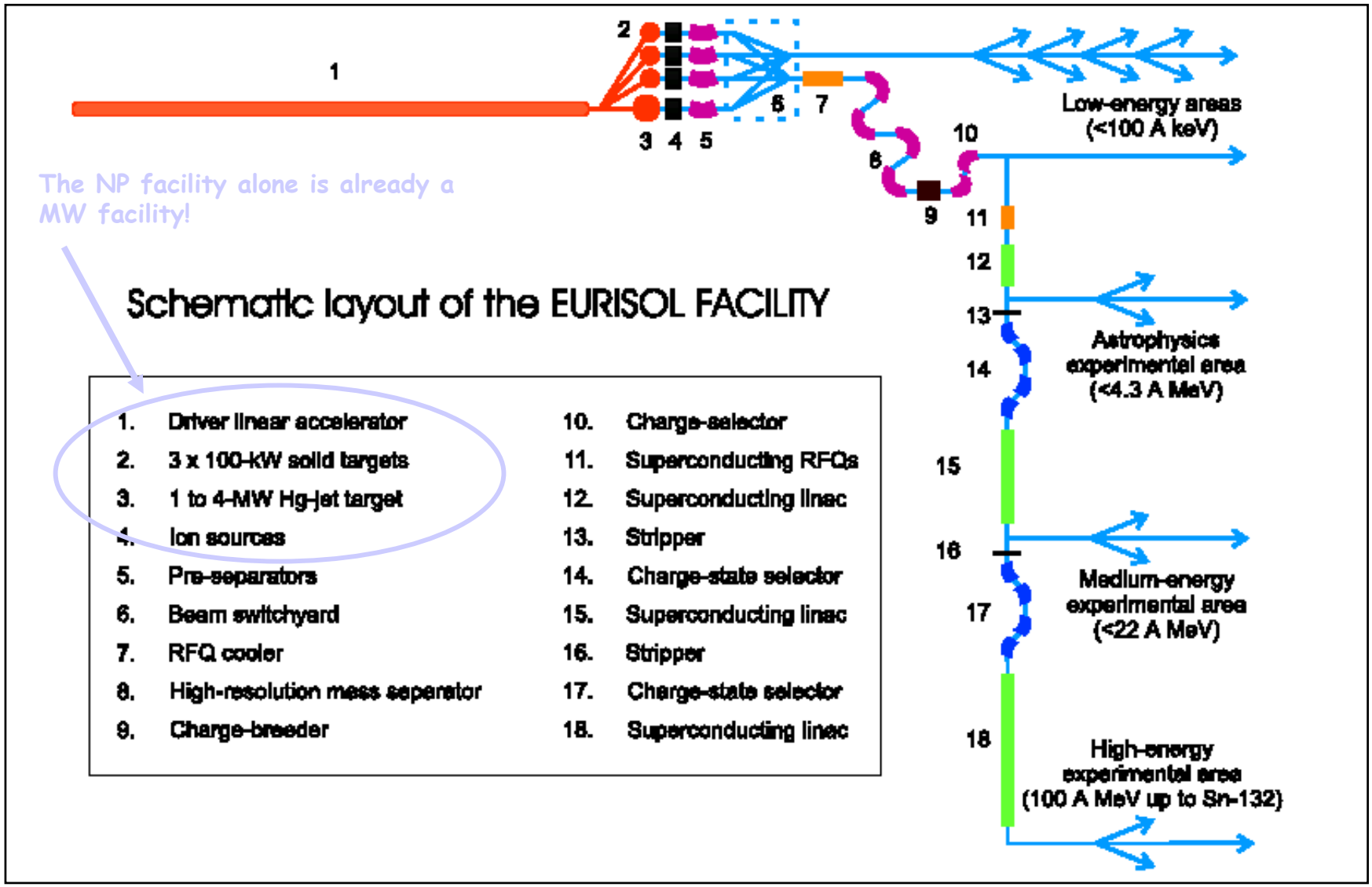
……..

Detectors ….. again UNO/HyperK

but also



EURISOL Overall Baseline Layout



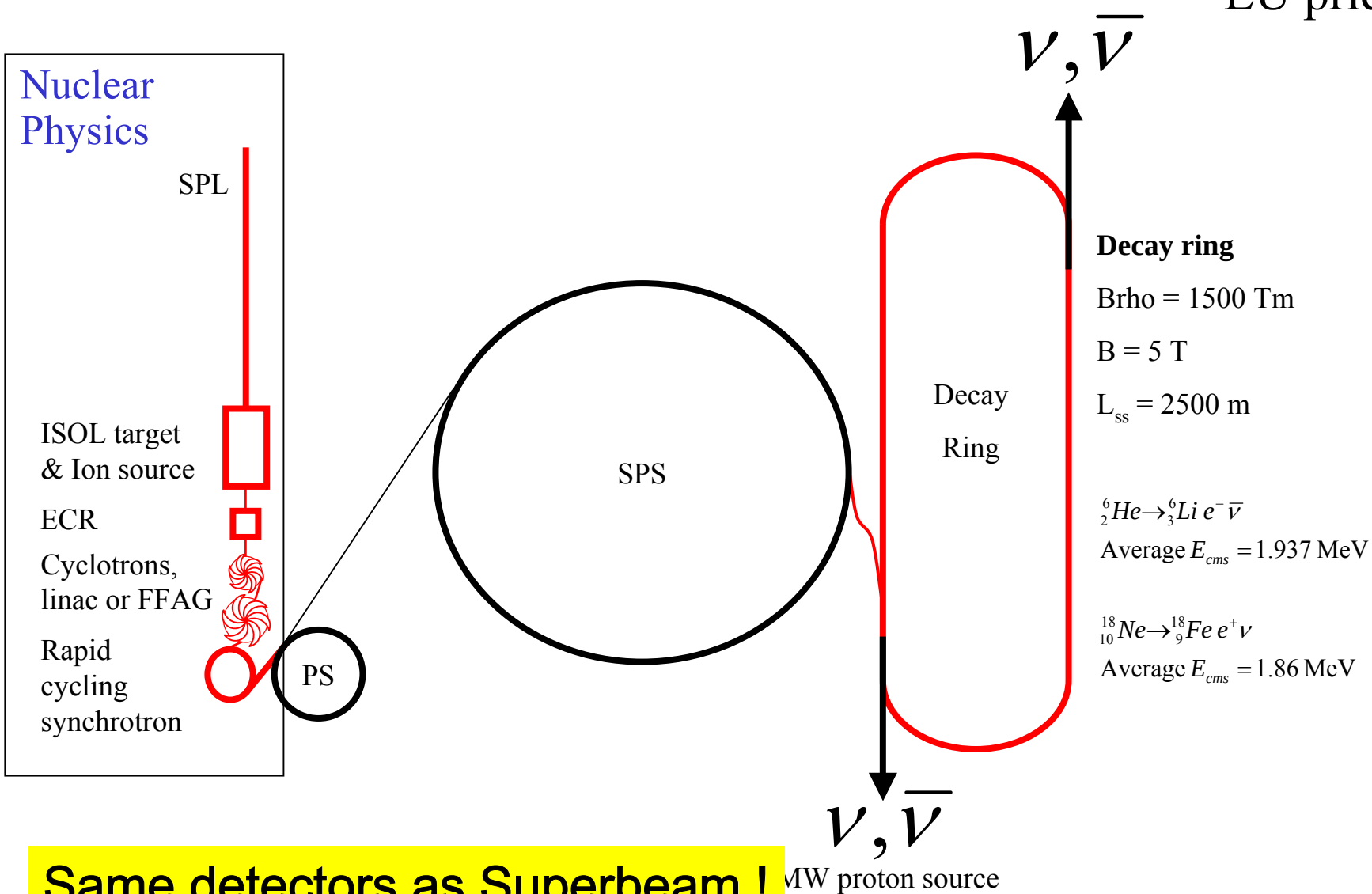
The NP facility alone is already a MW facility!

Schematic layout of the EURISOL FACILITY

1.	Driver linear accelerator	10.	Charge-selector
2.	3 x 100-kW solid targets	11.	Superconducting RFQs
3.	1 to 4-MW Hg-jet target	12.	Superconducting linac
4.	Ion sources	13.	Stripper
5.	Pre-separators	14.	Charge-state selector
6.	Beam switchyard	15.	Superconducting linac
7.	RFQ cooler	16.	Stripper
8.	High-resolution mass seperator	17.	Charge-state selector
9.	Charge-breeder	18.	Superconducting linac

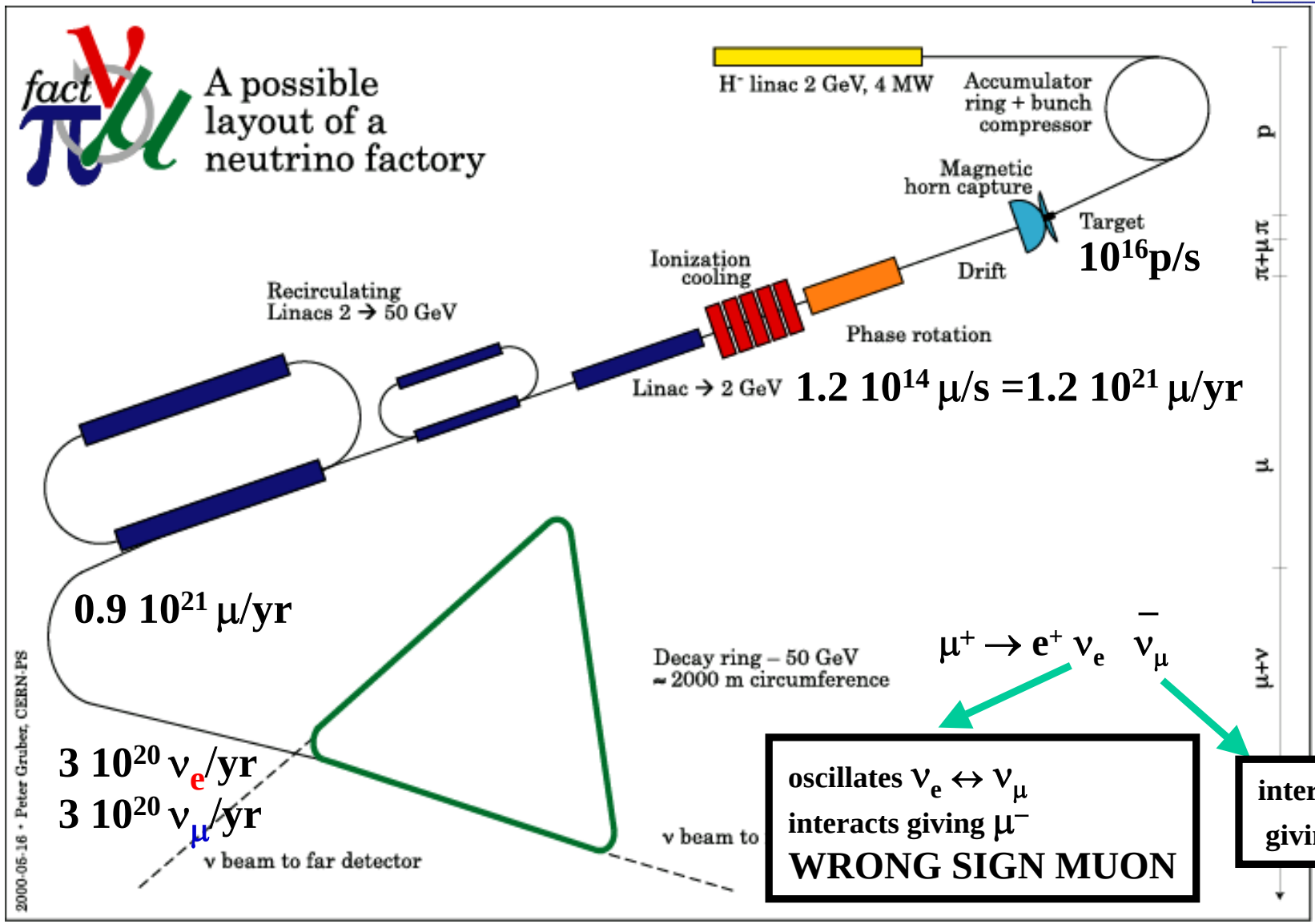
CERN: β-beam baseline scenario

EU pride

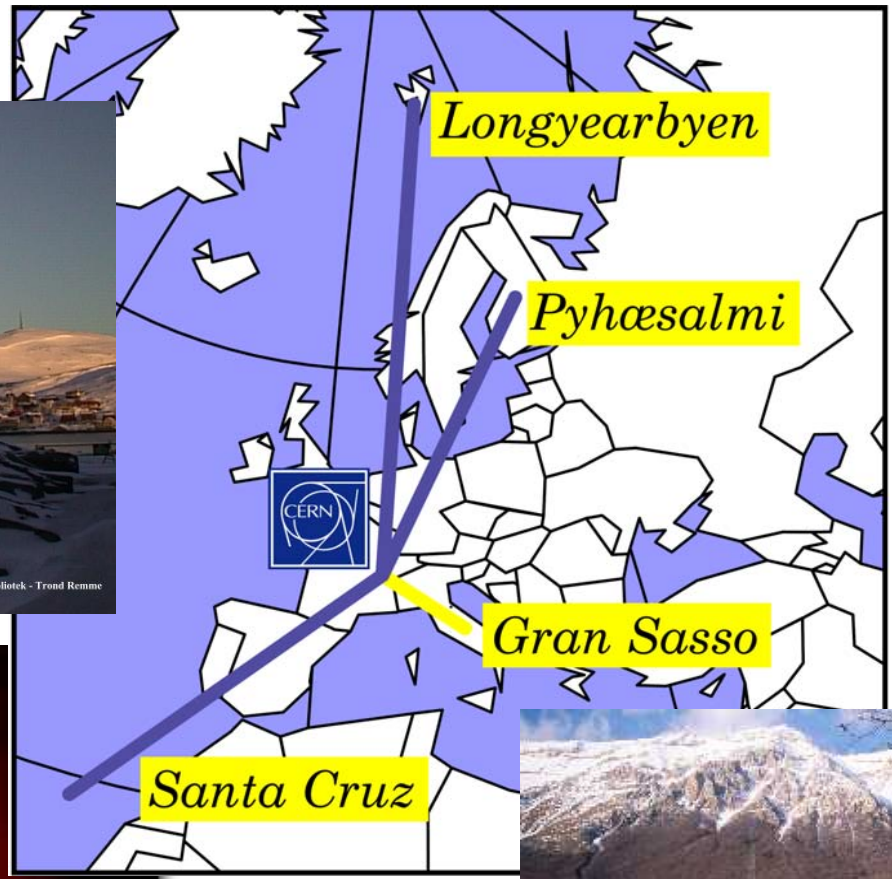


Same detectors as Superbeam !

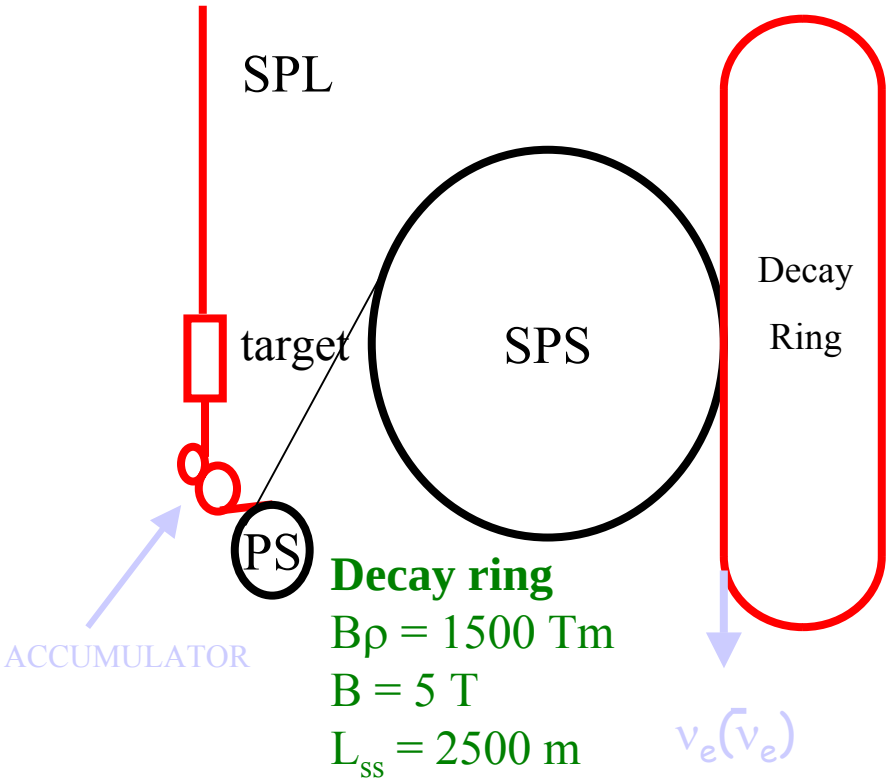
-- Neutrino Factory -- CERN layout

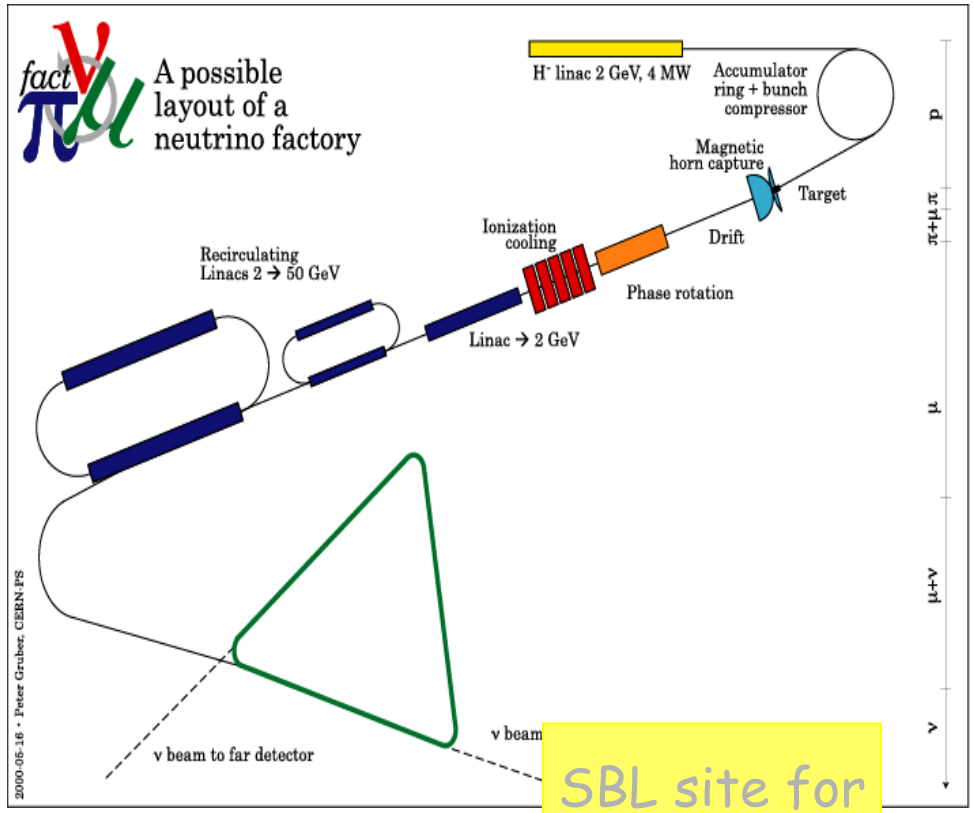


Old and new european underground laboratories



NB: near-detector sites essential





SBL site for the νFact

Common near design for both SuperBeam and β-beam?

with a Multi MW proton source

A generalized Jungian approach?

- Intersection of interests from HEP, NP and AP communities; and international community (Japan: Hyper-Kamiokande, Europe: CERN/Fréjus (133 km) initiatives
  - A well organized international effort with a common physics goals and strong mutual support can bring a successful experiment somewhere in the world

MMW-CERN, May. 2004 Chang Kee Jung

International R&D !!!!!

Superbeam and Neutrino Factory R&D

Proton driver (and accumulator etc..)

Target area, targetry & collection

Muon Ionization Cooling.

Acceleration.

Detectors

Superbeam/Neutrino factory FP6 design study proposal in preparation for early 2005

--> be ready for decisions in 2010!

NB Nearly all of the accelerator R&D has, from the start, had a healthy level of global collaboration. Examples: MUSCAT, MUCOOL, Targetry, HARP, Design Studies I and II, …

Targetry & Collection: Proposal to test a 10m/s Hg Jet in a 15T Solenoid with an Intense Proton Beam

Note: The solenoid is under construction, and the Hg-jet under development.

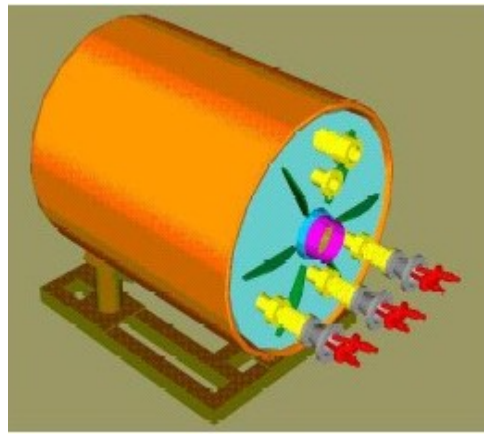
CERN-INTC-2003-033
INTC-I-049
26 April 2004

A Proposal to
the ISOLDE and Neutron Time-of-Flight Experiments
Committee

Studies of a Target System for a 4-MW, 24-GeV Proton Beam

J. Roger J. Bennett[1], Luca Bruno[2], Chris J. Densham[1], Paul V. Drumm[1], T. Robert Edgecock[1], Tony A. Gabriel[3], John R. Haines[3], Helmut Haseroth[2], Yoshinari Hayato[4], Steven J. Kahn[5], Jacques Lettry[2], Changguo Lu[6], Hans Ludewig[5], Harold G. Kirk[5], Kirk T. McDonald[6], Robert B. Palmer[5], Yarema Prykarpatskyy[5], Nicholas Simos[5], Roman V. Samulyak[5], Peter H. Thieberger[5], Koji Yoshimura[4]

Spokespersons: H.G. Kirk, K.T. McDonald
Local Contact: H. Haseroth

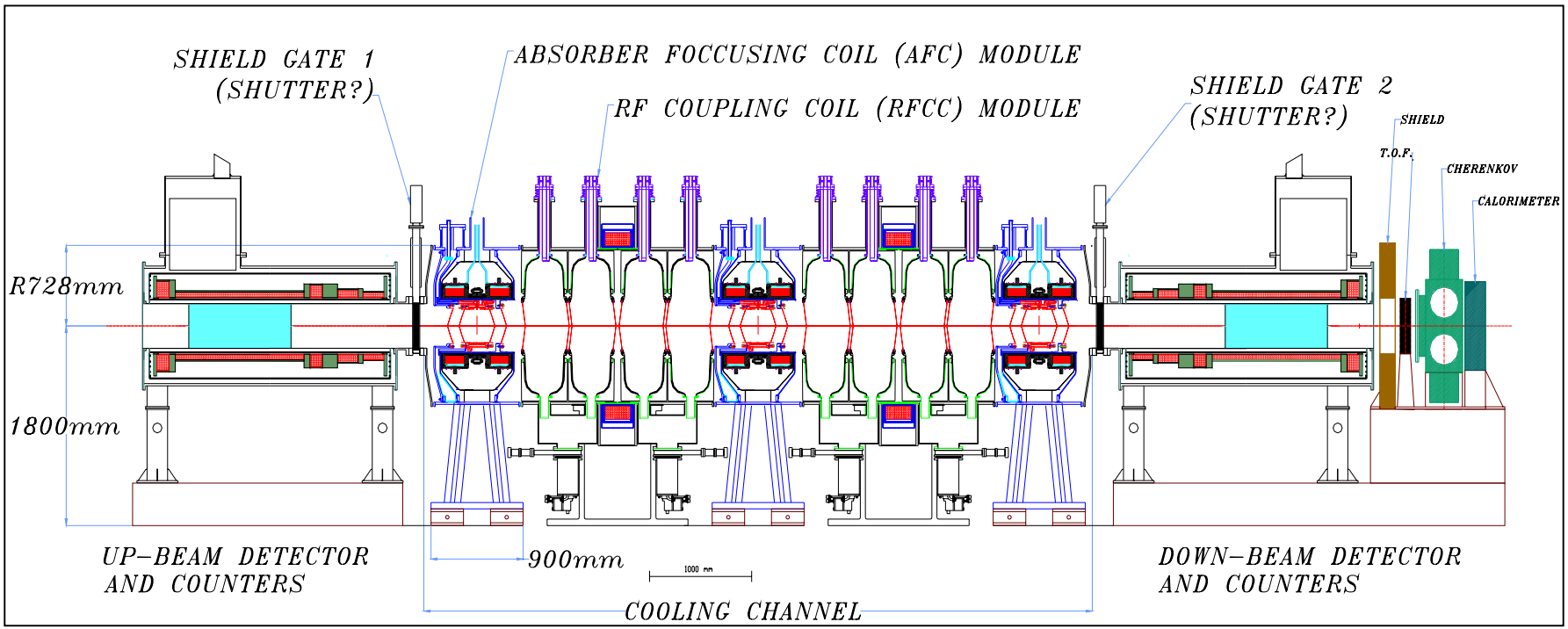


Participating Institutions

1) RAL
2) CERN
3) KEK
4) BNL
5) ORNL
6) Princeton University

MICE – a Global Muon Ionization Cooling Experiment

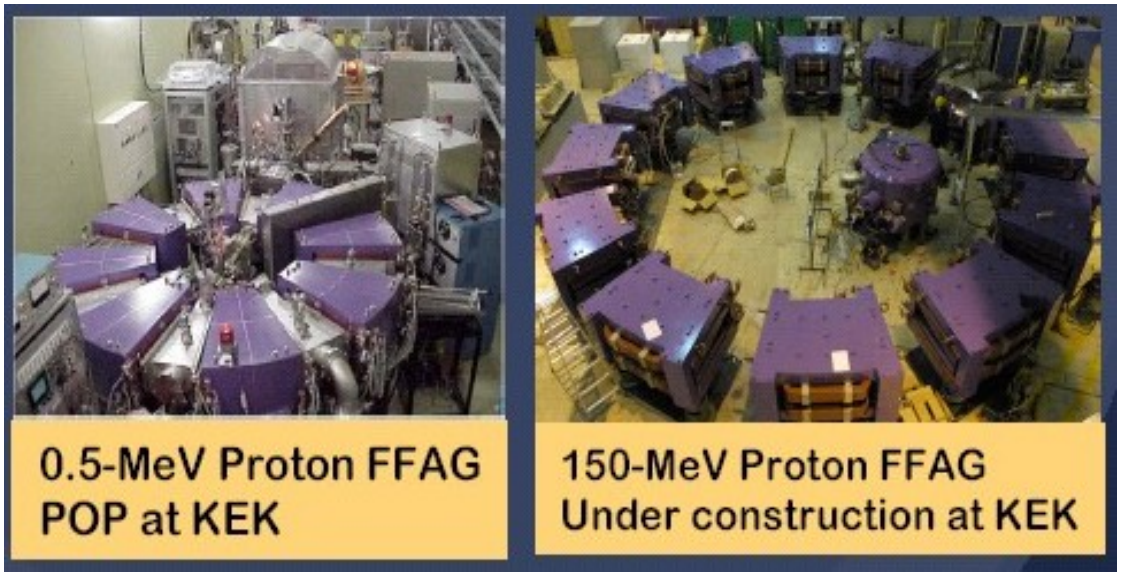
Build & operate a section of a realistic cooling channel & measure its performance in a muon beam (at RAL) for various operation modes & beam conditions.

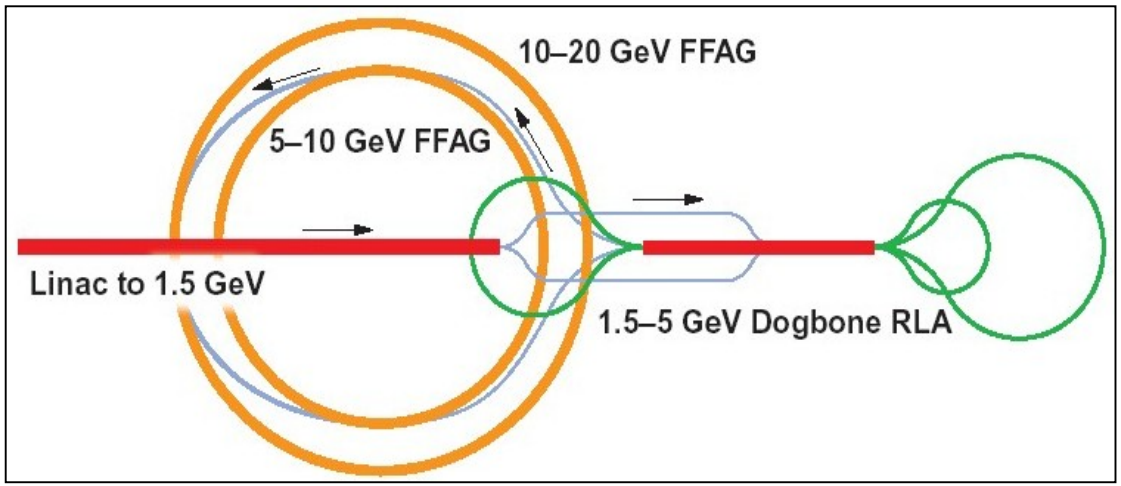


Has Scientific Approval and is seeking funding.

NB US, Europe and Japan !!!!!!!!

Acceleration





New US Acceleration Scheme … still evolving

Much progress in Japan with the development and demonstration of large acceptance FFAG accelerators.

Latest ideas in US have lead to the invention of a new type of FFAG (so-called non-scaling FFAG) which is interesting for more than just Neutrino Factories & may require a demonstration experiment (plans are developing)

Perhaps US & Japanese concepts are merging to produce something better ??

Neutrino Factory: towards cost reduction

	Study 2	Now	Factor
PHASE ROTATION			
Beam Line (m)	328	166	51 %
Acceleration (m)	269	35	13 %
Acc Type	Induction	Warm RF	
COOLING			
Beam Line (m)	108	51	47 %
Acceleration (m)	74	34	46 %
Absorbers	Liquid Hydrogen	Solid Li or LiH	
ACCELERATION			
Beam Line (m)	3261	$\approx$ 700	$\approx$ 21 %
Tun Length	1494	$\approx$ 700	$\approx$ 47 %
Acc Length	288	$\approx$ 130	$\approx$ 45 %

Conclusions:

An european strategy, based on a new powerful

MWatt proton Driver

comprising part or all of

Superbeam

Eurisol/Betabeam

Neutrino Factory

will receive careful attention