CERN SPL : Parameters and Program

few snapshots

admittedly ν - centric

of the debate at & around CERN
on accelerator neutrino physics and
Multi Mega Watt physics
in general

….. RCS also or instead of SPL …
….. the LHC upgrade in the background

Main conclusion

MMW and ν's back on the EU map, maybe

positive signals , after meager years of LHC crisis

1) EU approval (HIPPI and BENE)

2) attention of CERN & National Agencies
…. more vigourous R&D soon maybe

can CERN envisage a high intensity (M-MW) frontier
besides its high energy (M-TeV) frontier
undisputed mandate
?

Second conclusion

A rich ν program appears possible around a SPL

two options

1) high energy ν……. NuFact (& Superbeam)

2) low energy ν …….. Betabeam (& Superbeam)

but it so does with other drivers too , most likely

Third conclusion …. what deadlines

LHC (& upgrade)
will be the first priority

Next HE project .. CLIC

<u>Will there be a window for a MMW investment?</u>

PLANS MUST BE READY BY 2009 or SO

During 2004, 2 Multi Mega Watt Workshops in Europe

Physics with a MMW proton source

CERN, 25-27 May

most emphasis on

few GeV SC proton > 4 MW linac (SPL)

RCS as a possible alternative

neutrino physics and more ….

High Intensity Frontier Workshop HIF04

Elba, 5-8 June

most emphasis on

30 GeV rapid cycling several MW synchrotron (RCS)

linac as a possible injector

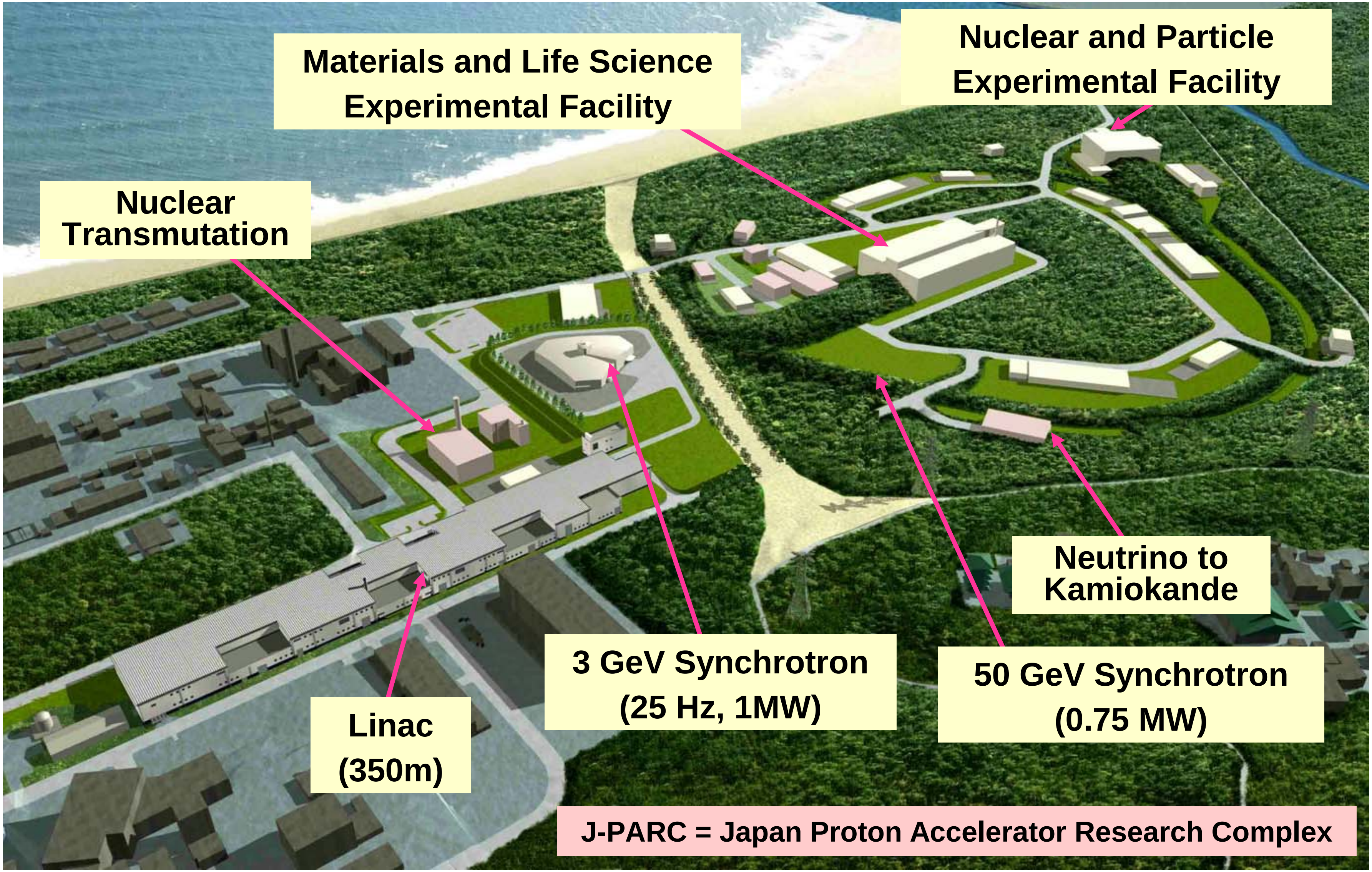
hadronic physics and more (see Bettoni)

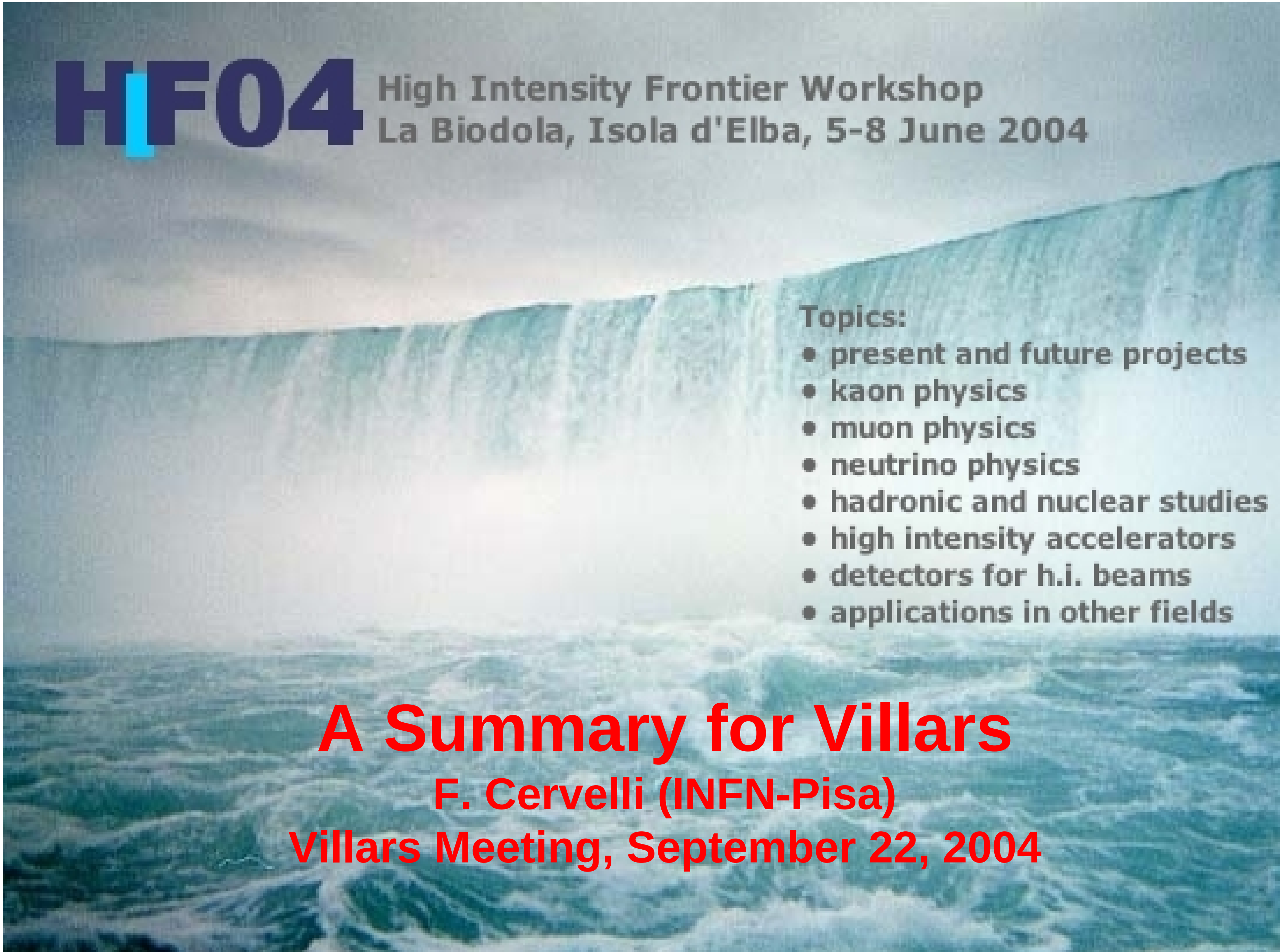
Peer review process starting

CERN SPSC "Cogne IX" Week Villars, 22-28 Sep

Personal prejudice "Best would be to conceive of a realistic road map to both…. "

The reference facility: J-PARC
MMW at low & high E





A Summary for Villars

F. Cervelli (INFN-Pisa)

Villars Meeting, September 22, 2004

"the SPL Workshop?"

Summary of Multi Mega Watt (MMW) Workshop

See http://proj-bdl-nice.web.cern.ch/proj-bdl-nice/megawatt-summaries/WorkshopSummary-3.71.doc

- Highlights & outlook for MMW physics

  admittedly ν - centric

- Rich & debated spectrum of options (**π decay channel, μ & β storage ring….**

  energy, baseline , detector mass & density …

  but consensus on highest priority : **High Power** MMW Drivers
MMW Targets
MMW Collectors

- Tentative timeline & recommendations

Workshop on

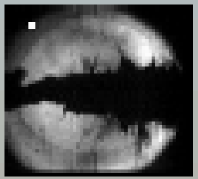
PHYSICS

WITH A

MULTI-MW PROTON SOURCE

CERN, Geneva, May 25-27, 2004

The workshop explores both the short- and long-term opportunities for particle and nuclear physics offered by a multi-MW proton source such as a proton linear accelerator or a rapid-cycling synchrotron. This source would provide Muon and Electron Neutrino beams of unprecedented intensity, superior slow Muon and possibly Kaon facilities, as well as a world-leading Radioactive Ion Beam facility for Nuclear, Astro- and fundamental physics.



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L. Ghilardi (CERN), G. Giudice (CERN),
E. Gschwendtner (Geneva), M. Lindroos,
V. Palladino (co-chair), M. Vretenar (CERN)

BENE+EURISOL

http://physicsatmwatt.web.cern.ch/physicsatmwatt/

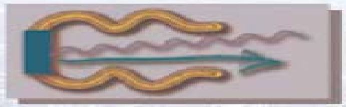
Annual Meeting
CARE

Coordinated **A**ccelerator **R**esearch in **E**urope
supported by the European Community (FP6 Research Infrastructures Action)

Nov. 2-5, 2004, DESY Hamburg, Germany

Progress and Status Reports of Joint Research Activities (JRA):

Superconducting RF



Photoinjectors

HIPPI

High Intensity Pulsed Proton Injection

NED

High Field Magnets R&D

And Networking Activities:

ELAN

Linear Colliders

HEHIHB

Proton Accelerators

BENE

Neutrino Beams

International Program Committee:

R. Aleksan (CEA/DAPNIA and CNRS/IN2P3)
A. Devred (CEA/DAPNIA)
R. Garoby (CERN)
T. Garvey (CNRS/IN2P3)
A. Ghigo (INFN)
O. Napoly (CEA/DAPNIA)
V. Palladino (INFN)
D. Proch (DESY)
F. Richard (CNRS/IN2P3)
W. Scandale (CERN)

Local Organization:

A. Brinkmann
A. Goessel
K. Lando
H. Mais
R. Mayer
S. Mette
W.-D. Moeller
I. Nikodem
D. Proch
D. Reschke

Information and Registration
http://care04.desy.de
Contact: care04@desy.de

On the first two days of the Annual Meeting, Nov. 2 and 3, there will be the ECFA/BENE Workshop
The Future of Accelerator Neutrino Experiments in Europe
(see http://bene.na.infn.it/Events/20041102/Agenda.html)

CARE
Coordinated Accelerator R&D in Europe

15 M€

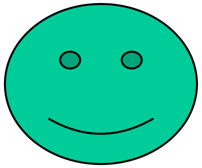
Networking Activities
(3 subprojects)

N2: ELAN
(Electron linear accelerators & colliders)
(F. Richard/Orsay)

600KE

N3: BENE
(Beams for European NeutrinoExperiments)
(V. Palladino/INFN)

500KE / 220 scientists



N4: HEHIHB
High Energy and High Intensity Hadron Beams
(H. Haseroth/CERN)

400KE

Joint Research Activities
(5 subprojects)

JRA1: SRFCAV
(SRF Cavity)
(D. Proch/DESY)

2600KE

JRA2: SRFTECH
(SRF Technology)
(T. Garvey/ORSAY)

2600KE

JRA3: PHIN
(Photo-Injector)
(A. Ghigo/INFN)

3600KE

JRA4: HIPPI
(High Intensity Proton Pulsed Injector)
(R. Garoby/CERN)

3600KE

← **NB: this is the R&D towards a MW Injector for the p driver !!!**
(first 200 MeV)
CNGS !!!!, LHC

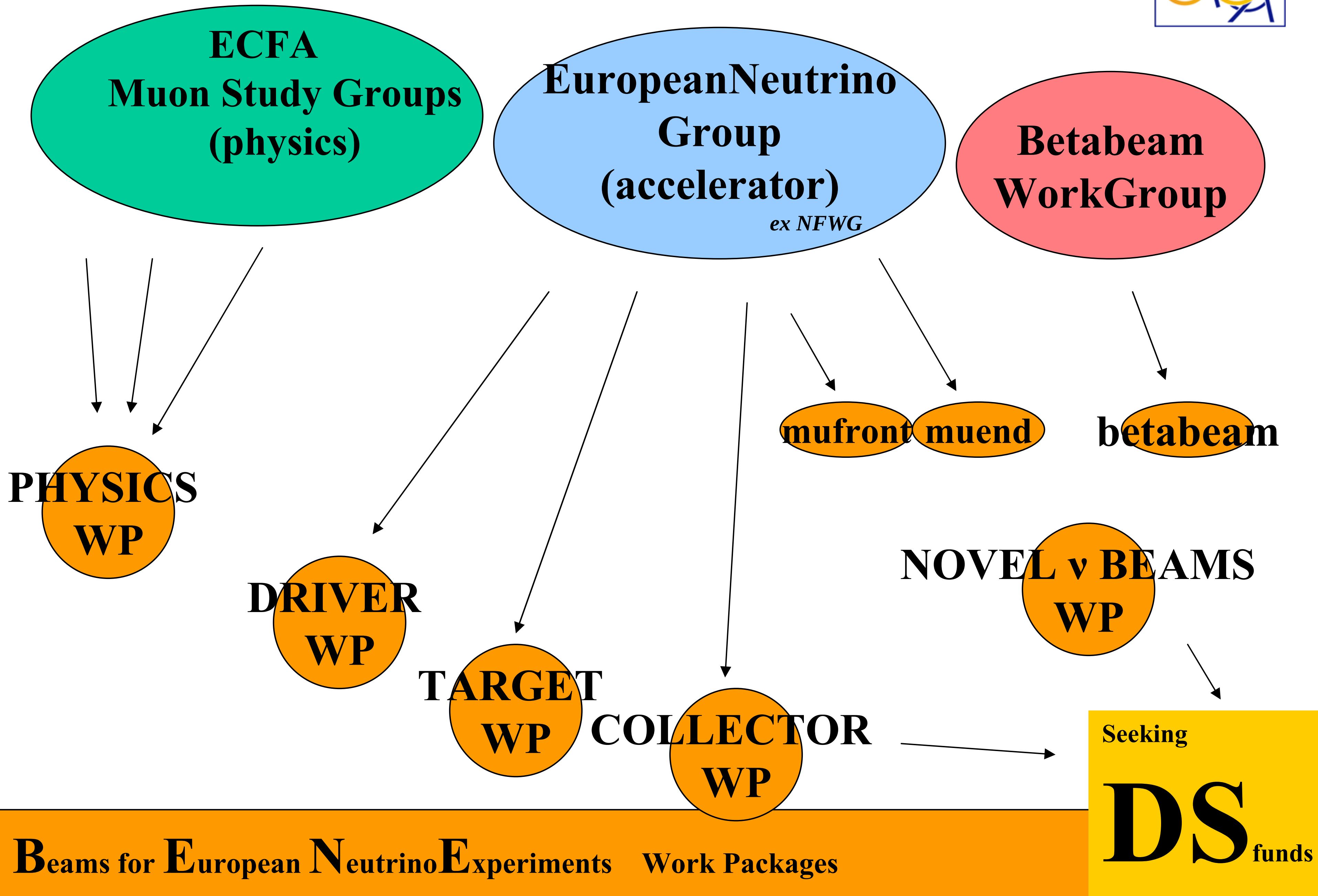
!

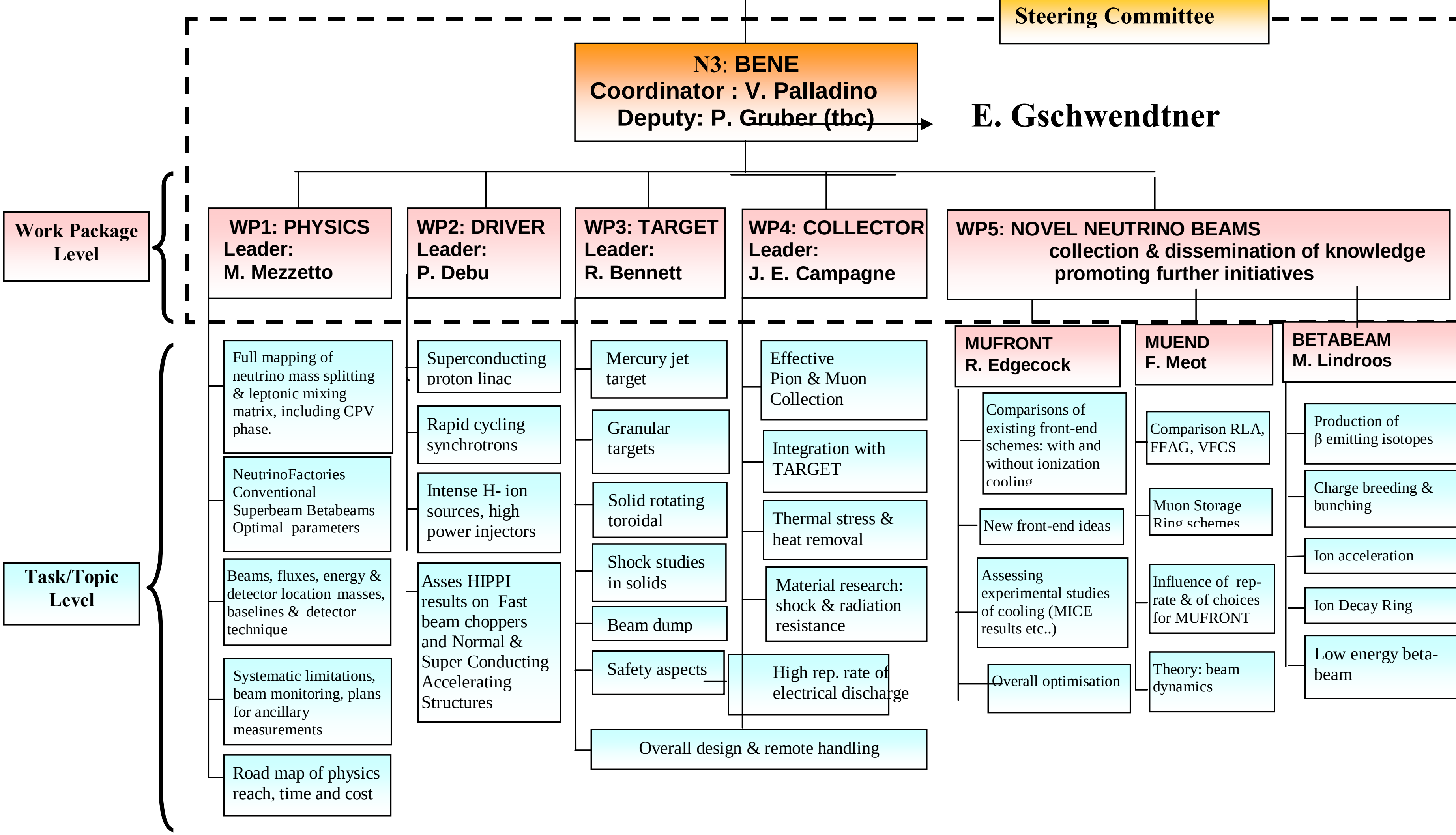
JRA5: NED
(Next European Dipole)
(A. Devred/Saclay)

1000KE

NB EC co-funding scheme !

BENE as an integrating activity … Joint ECFA/BENE activities





1

PHYSICS ENG …. the accelerator sector

… from BENE proposal :

coordinate and integrate the activities of the accelerator and particle physics communities working together, in a worldwide context,

towards **achieving superior neutrino (ν) beam facilities for Europe.**

1) to establish a road map for upgrade of our present facility and the design and construction of new ones

2) to assemble a community capable of sustaining the technical realisation and scientific exploitation of these facilities

220 signatures

3) to foster a sequence of carefully prioritized&coordinated initiatives capable to establish, propose and execute the R&D efforts necessary to achieve these goals.

A road map with three phases of EU initiative in neutrino Physics ?

2006 2009 2014 >2014

CNGS

EU-T2K …..

CH, France, Italy, Spain, UK
UA1/NOMAD magnet

T2H (4 MW, 1 Mton) ?

Super Conventional beam !!!!

R&D

targets, horns

cooling, reacceleration

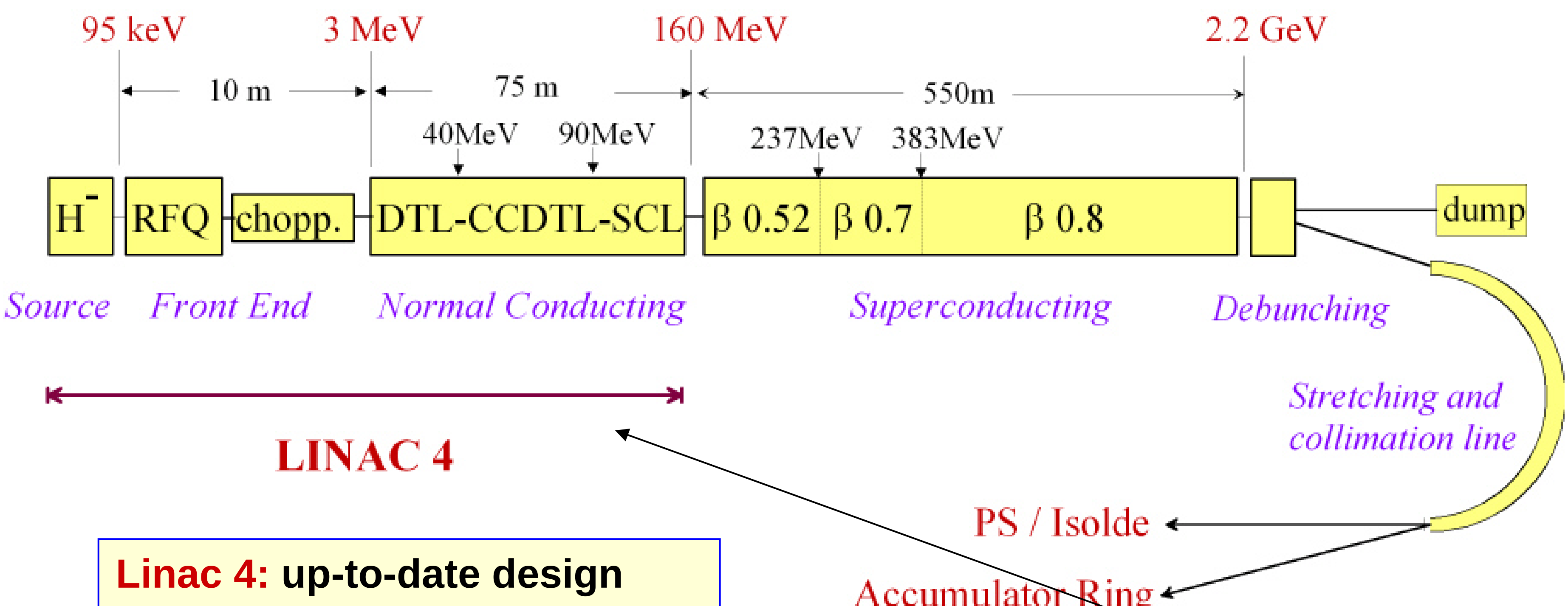
New EU Neutrino Complex?

Super Conventional beam?
Novel beams!!!!!!!!!!!!!!!!

“SPL workshop” ?

SPL block diagram (CDR 1)

being built



Linac 4: **up-to-date design**
Superconducting linac: **CDR 1**

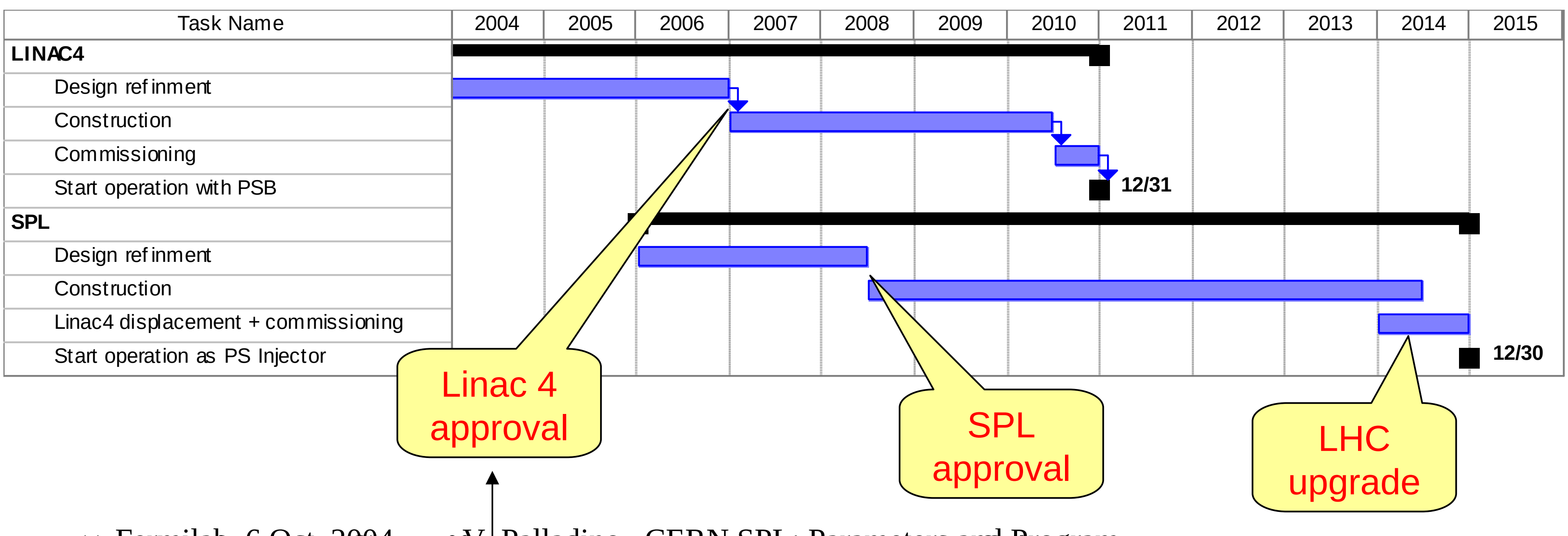
HIPPI is its R&D !

Proposed Roadmap

Consistent with the content of a talk by L. Maiani at the “Celebration of the Discovery of the W and Z bosons”. Contribution to a document to be submitted to the December Council *(“CERN Future Projects and Associated R&D”).*

Assumptions:

- construction of Linac4 in 2007/10 *(with complementary resources, before end of LHC payment)*
- construction of SPL in 2008/15 *(after end of LHC payments)*



“Physics at SPL” Workshop, late May 04 **in view of Cogne IX Sep 04**

SPL beam characteristics (CDR 1)

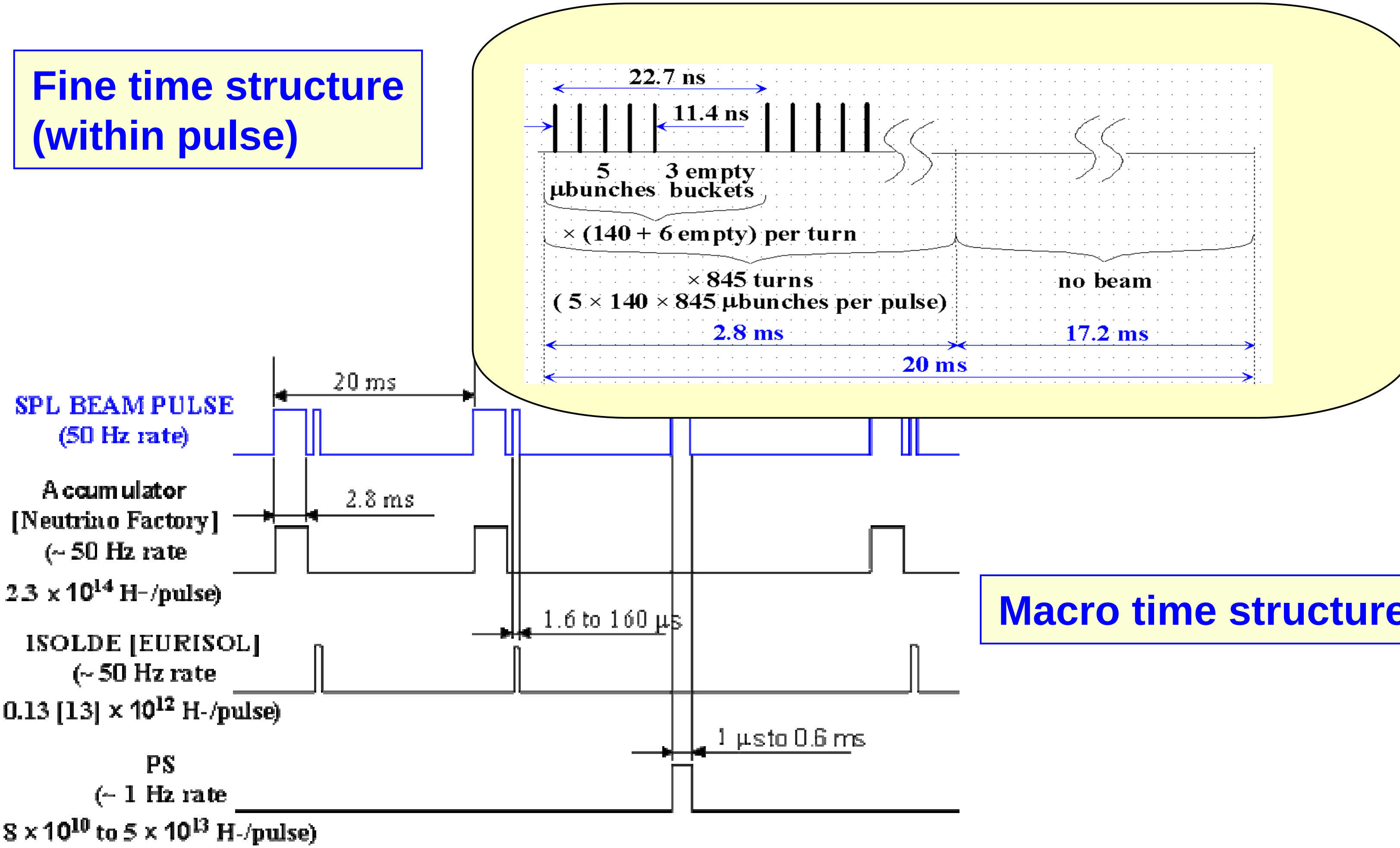
4-5 GeV possible

Ion species	**H^-**	
Kinetic energy	**2.2**	**GeV**
Mean current during the pulse	**13**	**mA**
Duty cycle	**14**	**%**
Mean beam power	**4**	**MW**
Pulse repetition rate	**50**	**Hz**
Pulse duration	**2.8**	**ms**
Bunch frequency (minimum distance between bunches)	**352.2**	**MHz**
Duty cycle during the pulse (nb. of bunches/nb. of buckets)	**62 (5/8)**	**%**
Number of protons per bunch	**$4.02\ 10^8$**	
Normalized rms transverse emittances	**0.4**	**π mm mrad**
Longitudinal rms emittance	**0.3**	**π deg MeV**
Bunch length (at accumulator input)	**0.5**	**ns**
Energy spread (at accumulator input)	**0.5**	**MeV**
Energy jitter during the beam pulse	**$< \pm 0.2$**	**MeV**
Energy jitter between pulses	**$< \pm 2$**	**MeV**

SPL beam time structure (CDR 1)

Fine time structure (within pulse)

Macro time structure

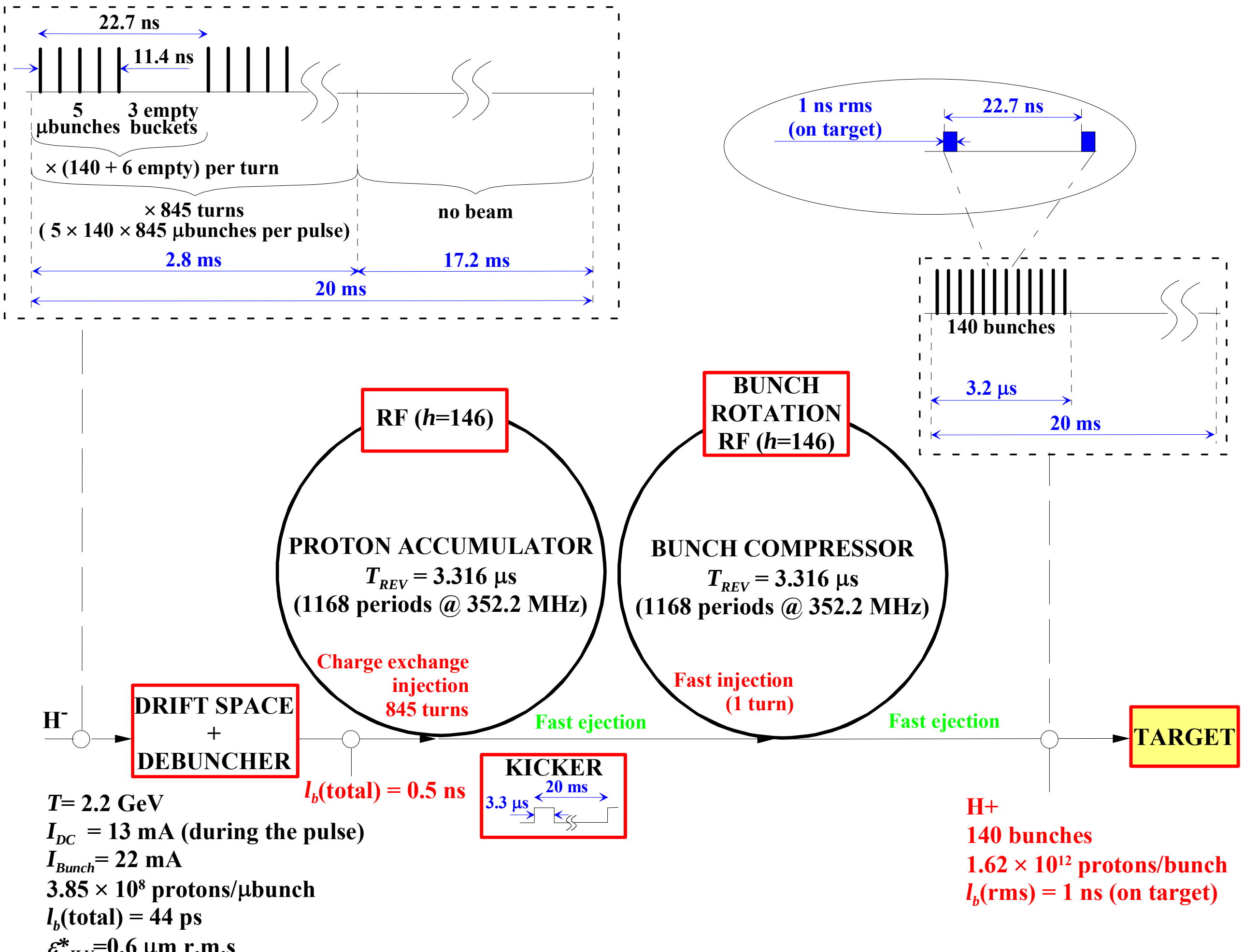


SPL acceleration systems (CDR 1)

W A R M – C O L D

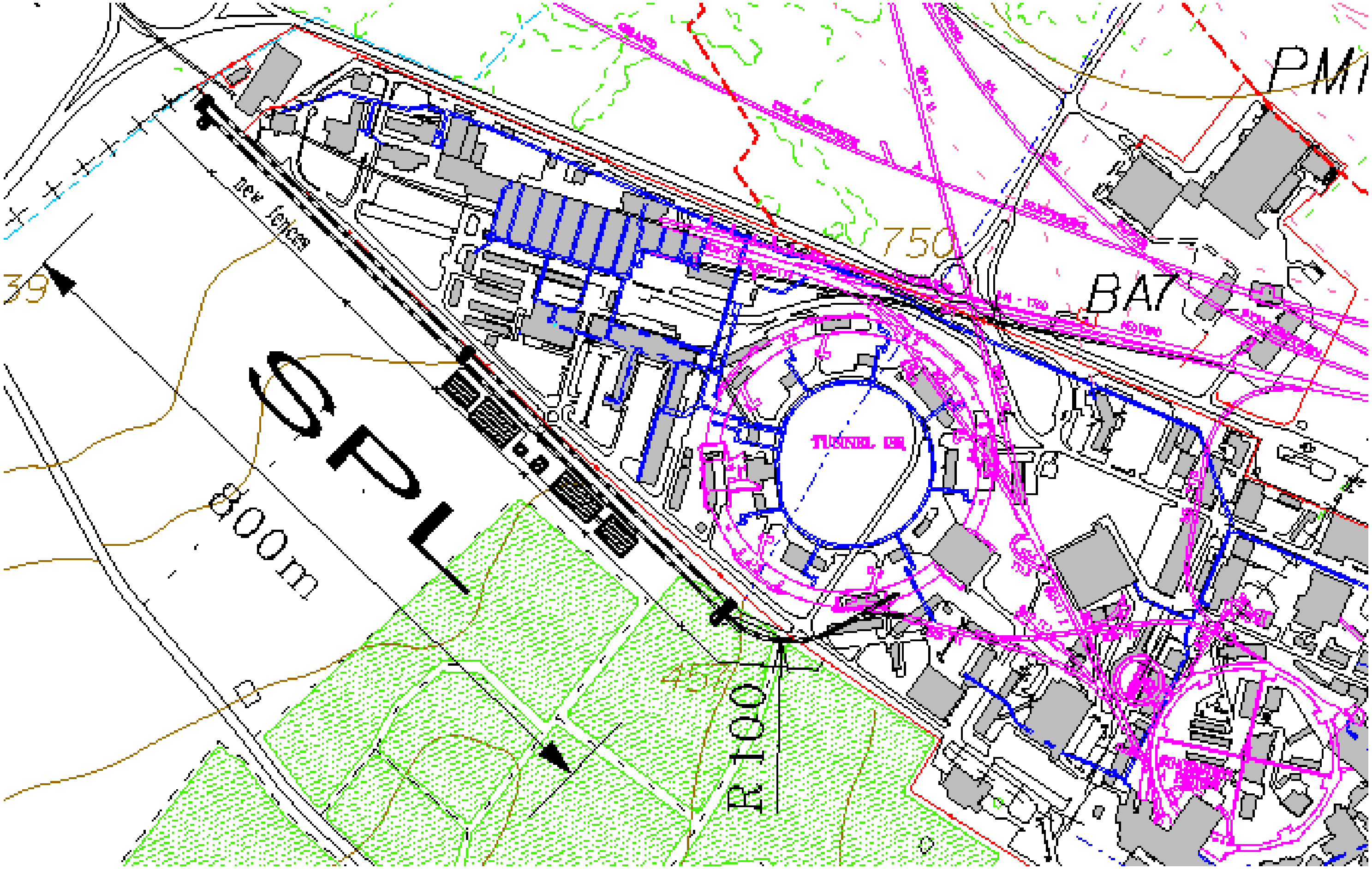
Section	Input energy (MeV)	Output energy (MeV)	Nb. of cavities	Peak RF power (MW)	Nb. of klystrons	Nb. of tetrodes	Nb. of Quads	Length (m)
LEBT	-	0.095	-	-	-	-	-	2
RFQ	0.095	3	1	0.9	1	-	-	6
Chopper line	3	3	3	0.1	-	3	6	3.7
DTL	3	40	3	4.1	5	-	111	16.7
CCDTL	40	90	27	4.8	6	-	28	30.1
SCL	90	160	20	12.6	5	-	21	27.8
β=0.52	160	236	27	1	-	28	9	67
β=0.7	236	383	32	1.9	-	32	16	80
β=0.8 I	383	1111	52	9.5	13	-	26	166
β=0.8 II	1111	2235	76	14.6	19	-	19	237
Debunching	2235	2235	4	-	1	-	2	13
Total			245	49.5	50	63	238	649.3

Accumulator and Compressor

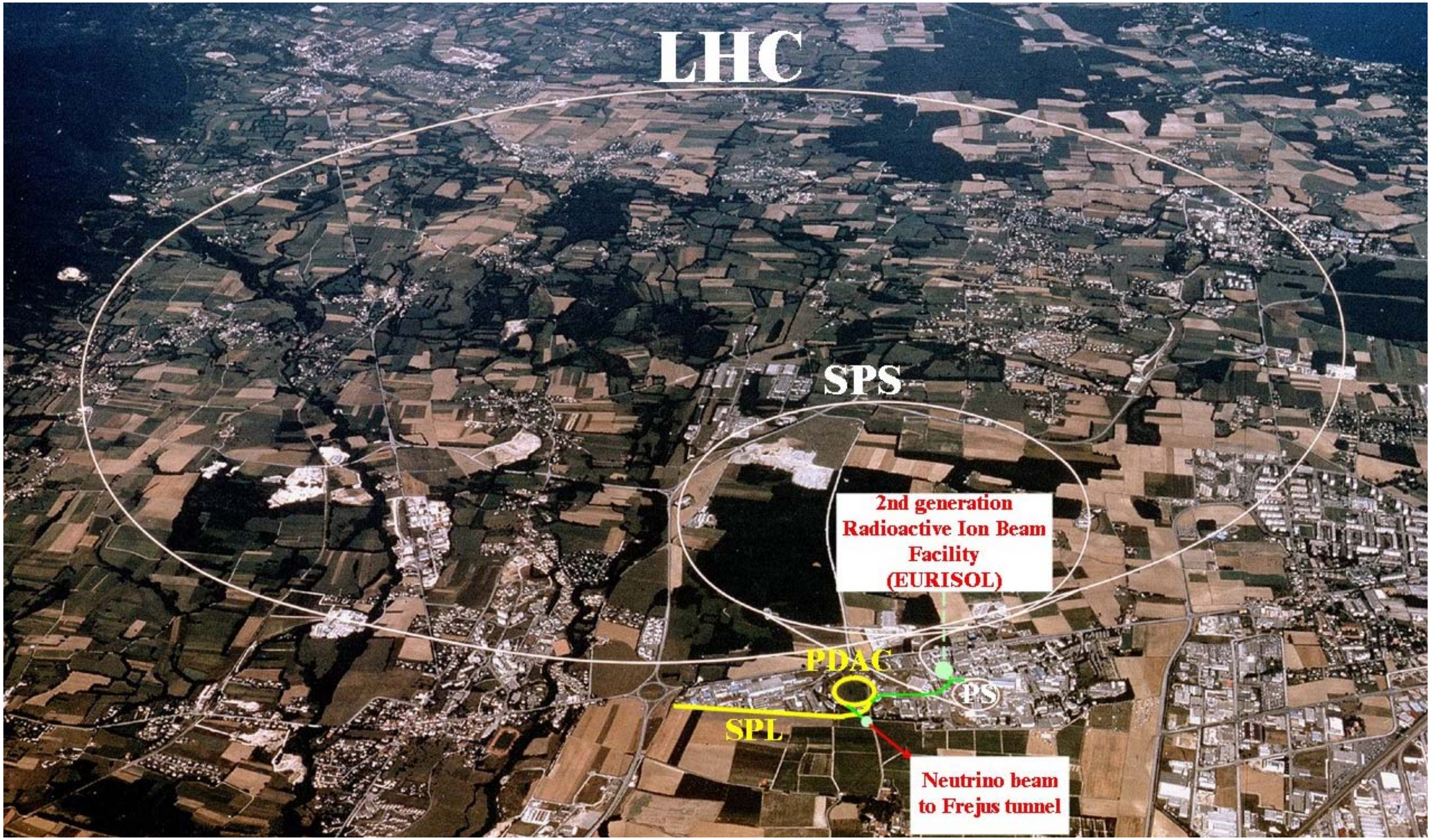


Parameter	Value	Unit
Mean beam power	**4**	MW
Kinetic energy	**2.2**	GeV
Repetiton rate	**50**	Hz
Pulse duration	**3.3**	µs
Number of bunches	**140**	
Pulse intensity	**2.27 $\times 10^{14}$**	p/pulse
Bunch spacing (Bunch frequency)	**22.7 (44)**	ns (MHz)
Bunch length (σ)	**1**	ns
Relative momentum spread (σ)	**5×10^{-3}**	
Norm. horizontal emittance (σ)	**50**	µm.rad

Layout (CDR 1)



SPL on the CERN site



“SPL workshop” ? …….. not in the intentions
more in practice
as 4MW SPL CDR I exists,
no MMW RCS is as advanced

“SPL workshop ….…….. in a way, as a general approach

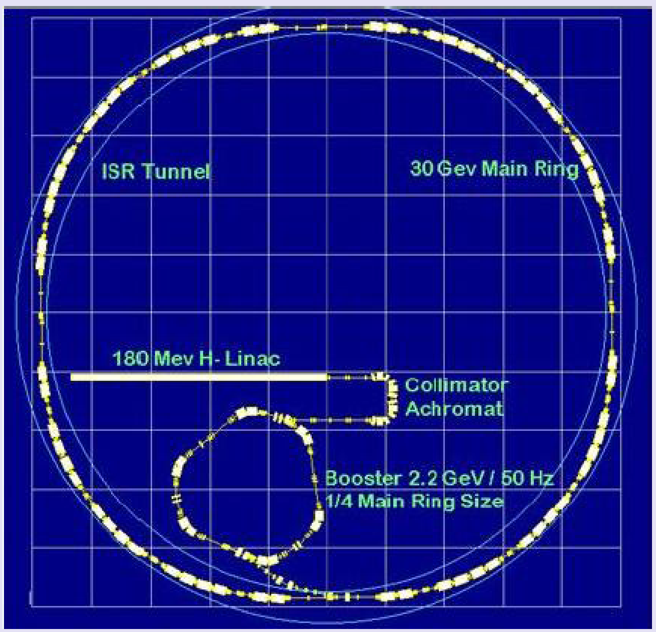
E_p no higher than necessary
just as high max/proton
as many p as possible … MMW !!!!

Max means here max number of ν parents

Typical 30 GeV RCS

MMW, in principle

A 30 GeV, 8 Hz Synchrotron as Possible Replacement for CERN PS



- 180 MeV H^- Linac with 2.5 MeV fast beam chopper
- Achromatic arc with high normalised dispersion
- Momentum ramping for injection painting
- bunch compression

ASTeC

C.R. Prior MW Proton Drivers using Rapid Cycling Synchrotrons

The 2 options that have emerged for ν's

NB: beam + detector configurations

n o v e l b e a m s

manipulate & accelerate ν parents !

Neutrino Factory **μ storage ring** ….. ν_μ & ν_e

(& μ accelerator complex!)

needs Large Magnetic Detector

(SuperMINOS, Li-Ar in B)

order 50 Ktons LNGS ! new lab ?

BetaBeam **β storage ring** … pure ν_e

(& EU accelerator complex)

need Very Large Detector (water C, Li-Ar)

the same as p-decay detectors

100-1000 Ktons ie new lab

Conventional beam **π decay channel** … ν_μ (0.1-1% ν_e)

not compelling ….. but for free with NuFact, same detector as Betabeam

NB : $\bar{\pi}$ $\bar{\mu}$ $\bar{\beta}$ possible, in all cases, for CP, T & CPT studies

The key to novel neutrino beams

the re- acceleration of the neutrino parent !!!

ν **Flux** $\approx$ $(N_{parent} / L^{2}) \, \gamma_{parent}^{2}$ **basic kinematics**

ν **Rate** $\approx$ $\gamma_{parent}^{3} / L^{2}$

ν**-osc Rate** $\approx$ $E^{3} \sin^{2}(L/E) / \, / L^{2}$

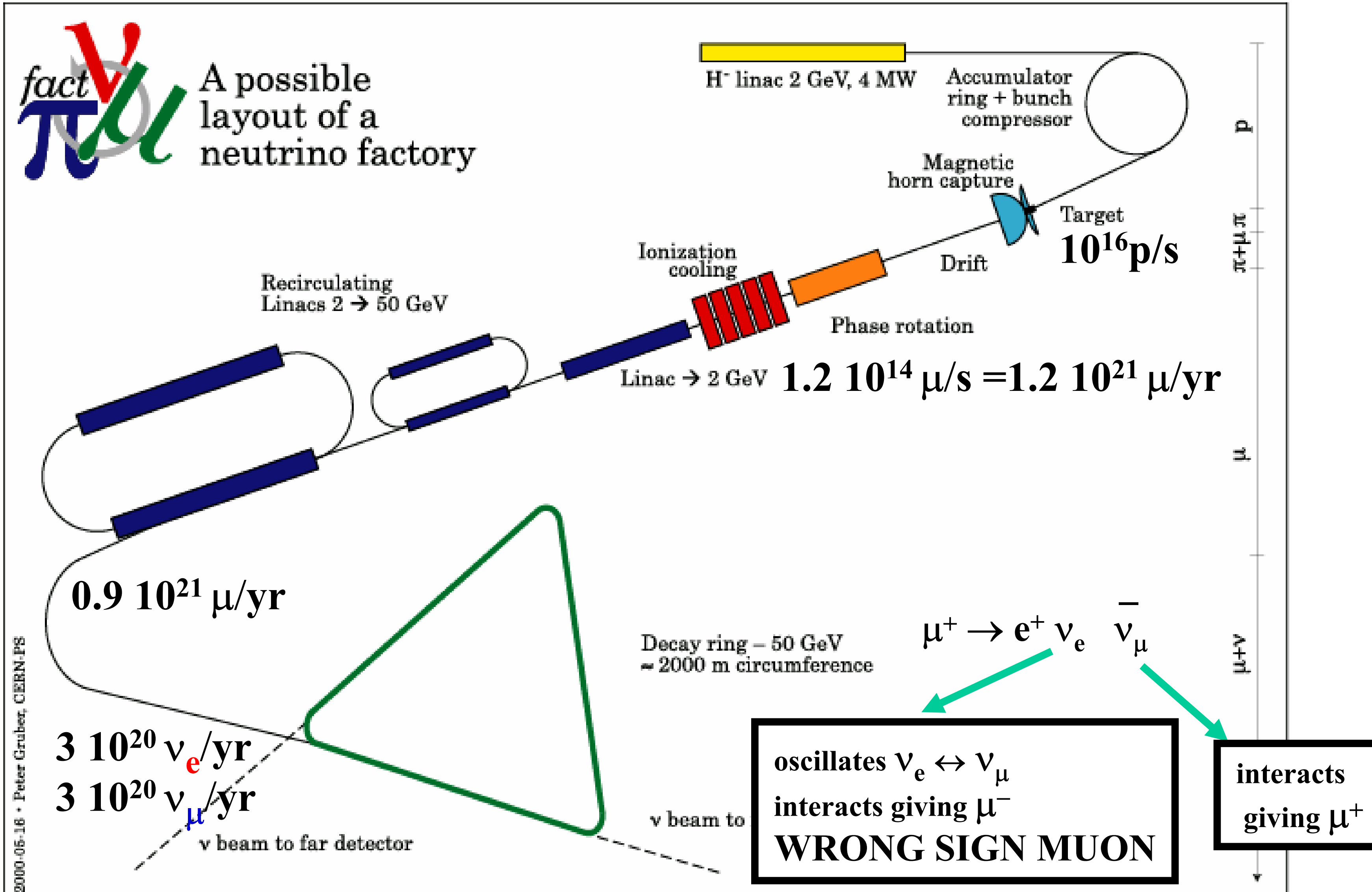
ν/parent grows very rapidly with E_{parent}

NB 1) not necessarily with E_{proton} **N_{parent} !!!**

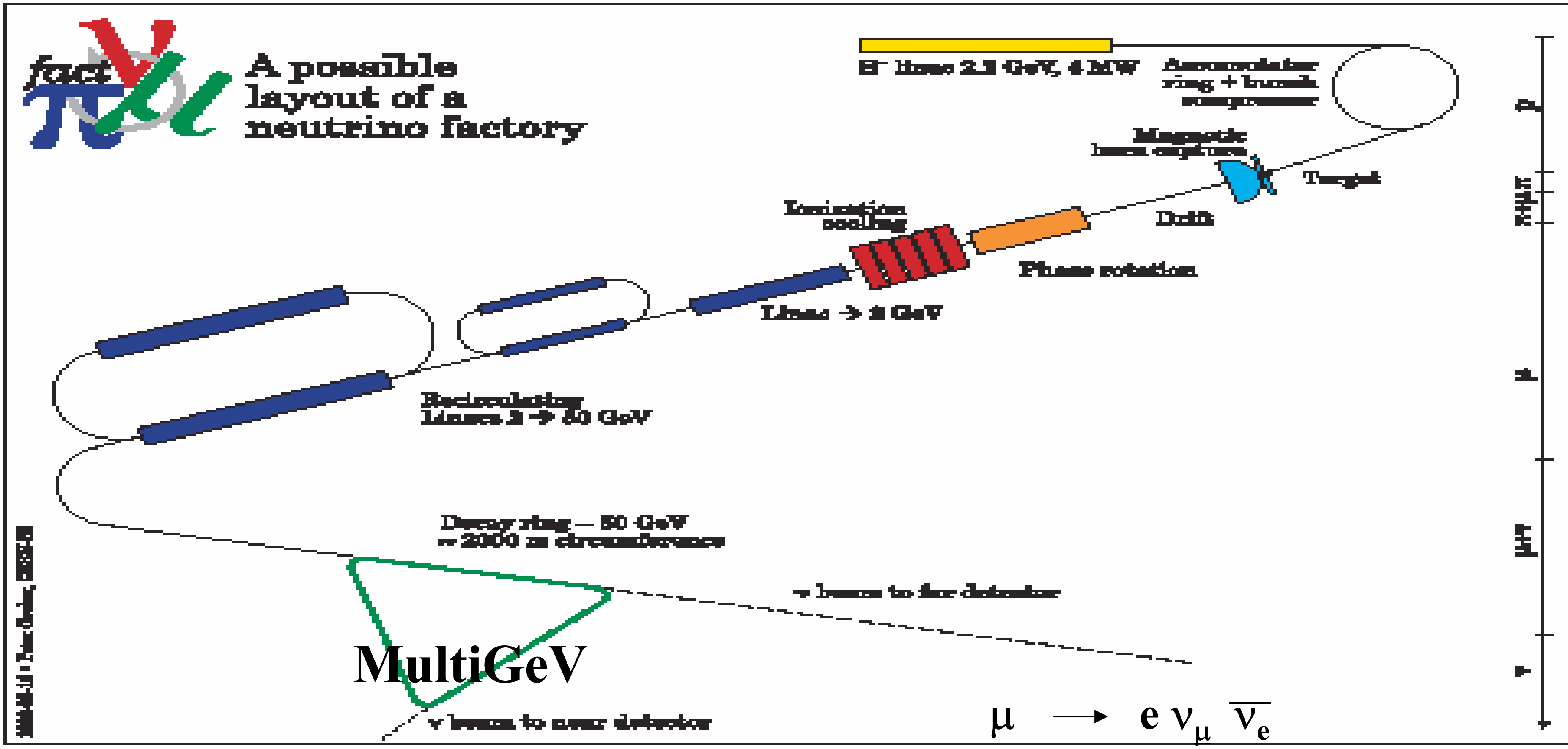
2) low E has independent merits **no matter effects**

ie no fake CP V

-- Neutrino Factory -- CERN layout



Neutrino Factory: CERN Scheme



$\mu \longrightarrow e\, \nu_\mu\, \bar{\nu}_e$

Disappearance	Appearance	Appearance … Wrong Charge Signature		
$\bar{\nu}_e \longrightarrow \bar{e}$ deficit	$\nu_\mu \longrightarrow \nu_e \longrightarrow e$ excess	$\bar{\nu}_e \longrightarrow \bar{\nu}_\mu \longrightarrow \bar{\mu}$ excess	Golden	!
Ferr $\nu_\mu \longrightarrow \mu$ deficit	$\nu_\tau \longrightarrow \tau$ excess	$\bar{\nu}_\tau \longrightarrow \bar{\tau}$ excess	Silver	

Magnetic detector

The matrix of neutrino transition probability

P_{ee}=1- …..

$P_{e\mu}$=
- $- 4 \,\mathrm{Re}\, J_{e\mu}^{13} \sin^2\Delta_{13}$
- $- 4 \,\mathrm{Re}\, J_{e\mu}^{23} \sin^2\Delta_{23}$
- $\pm 8J \sin\Delta_{12} \sin\Delta_{23} \sin\Delta_{13}$

golden

$P_{e\tau}$= -
- $- 4 \,\mathrm{Re}\, J_{e\tau}^{13} \sin^2\Delta_{13}$
- $- 4 \,\mathrm{Re}\, J_{e\tau}^{23} \sin^2\Delta_{23}$
- $\pm 8J \sin\Delta_{12} \sin\Delta_{23} \sin\Delta_{13}$

silver

BetaBeam, NuFact

$P_{\mu e}$ =
- \- 4 …
- \- 4 …
- \- (± 8J….

$P_{\mu\mu}$=1- …..

$P_{\mu\tau}$=
- $- 4 \,\mathrm{Re}\, J_{\mu\tau}^{13} \sin^2\Delta_{13}$
- $- 4 \,\mathrm{Re}\, J_{\mu\tau}^{23} \sin^2\Delta_{23}$
- $\pm 8J \sin\Delta_{12} \sin\Delta_{23} \sin\Delta_{13}$

SuperBeam, NuFact

$P_{\tau e}$ = ……

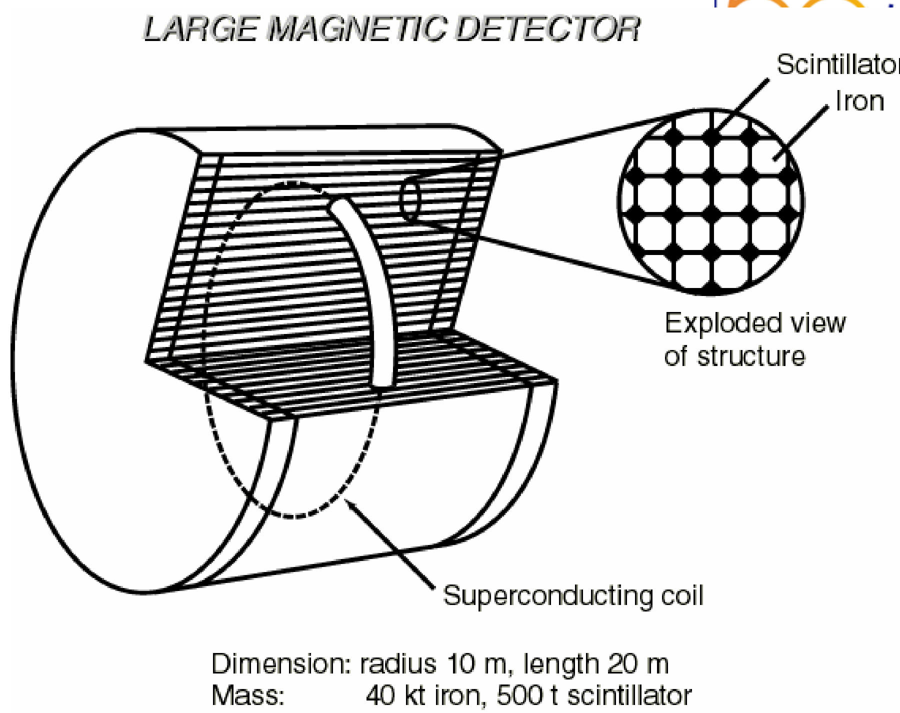
$P_{\tau\mu}$= …..

$P_{\tau\tau}$=1- …..

The Neutrino Factory does them all !

Detector

Cervera et al



- Iron calorimeter
- Magnetized
  - Charge discrimination
  - B = 1 T
- R = 10 m, L = 20 m
- Fiducial mass = 40 kT

Also: L Arg detector: magnetized ICARUS
Wrong sign muons, electrons, taus and NC evts *-> *Bueno et al*

Events for 1 year

Baseline	$\bar{\nu}_\mu$ CC	ν_e CC	ν_μ signal (sin$^2 \theta_{13}$=0.01)
732 Km	3.5×10^7	5.9×10^7	1.1×10^5
3500 Km	1.2×10^6	2.4×10^6	1.0×10^5

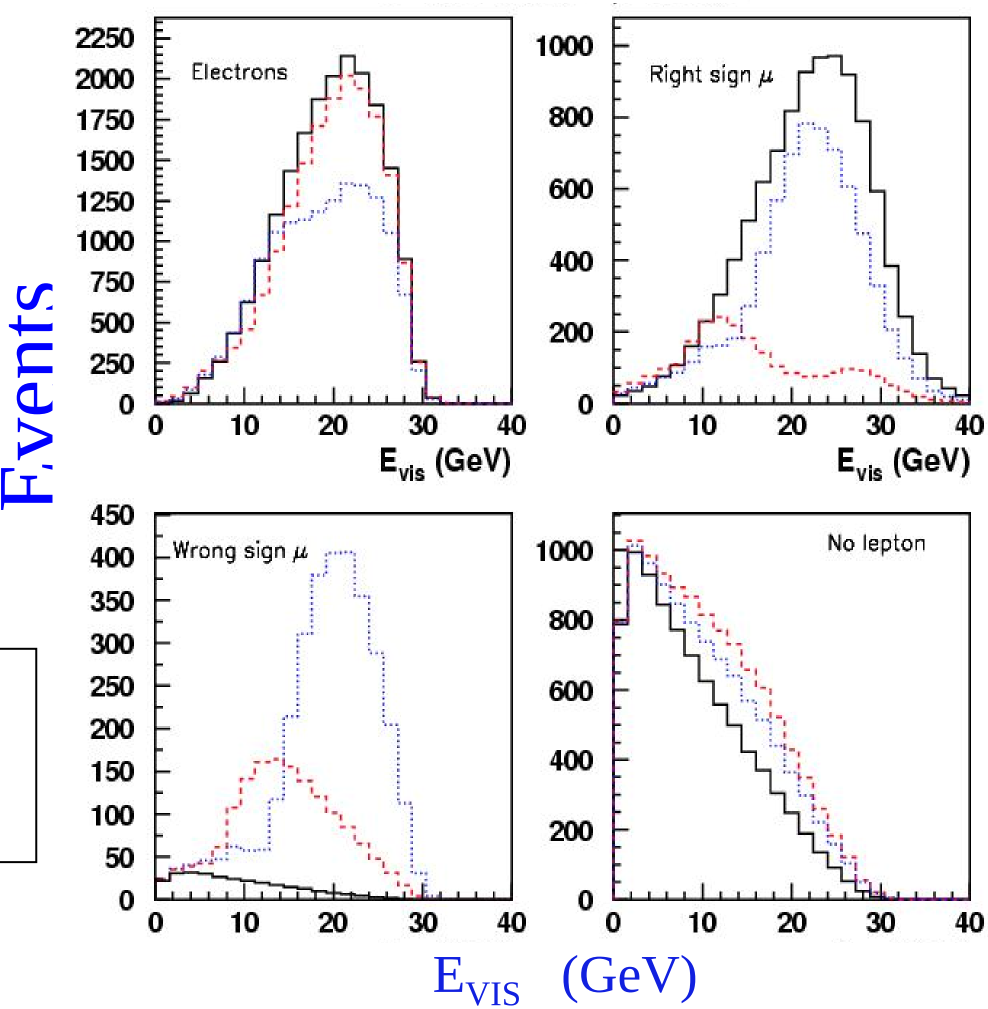
CF ν_e signal at J-PARC =40

Oscillation parameters can be extracted using energy distributions

Simulated distributions for a 10kt LAr detector at L = 7400 km from a 30 GeV nu-factory with 10^{21} μ^+ decays.

a) right-sign muons
b) wrong-sign muons
c) electrons/positrons
d) positive τ-leptons
e) negative τ -leptons
f) no leptons

X2 (μ^+ stored and μ^- stored)



Bueno, Campanelli, Rubbia; hep-ph/0005007

Note: $\nu_e \to \nu_\tau$ is specially important (Ambiguity resolution & Unitarity test): ***Gomez-Cadenas et al.***

Old and new european underground laboratories

BENE and EURISOL

approval of BENE and HIPPI

July 03

fruitful confrontation with RIB NUPECC community

EURONS, EURISOL ……. Rad Ion Beams

could **work together towards a betabeam**

could **share a MWatt p-driver**

Moriond 03

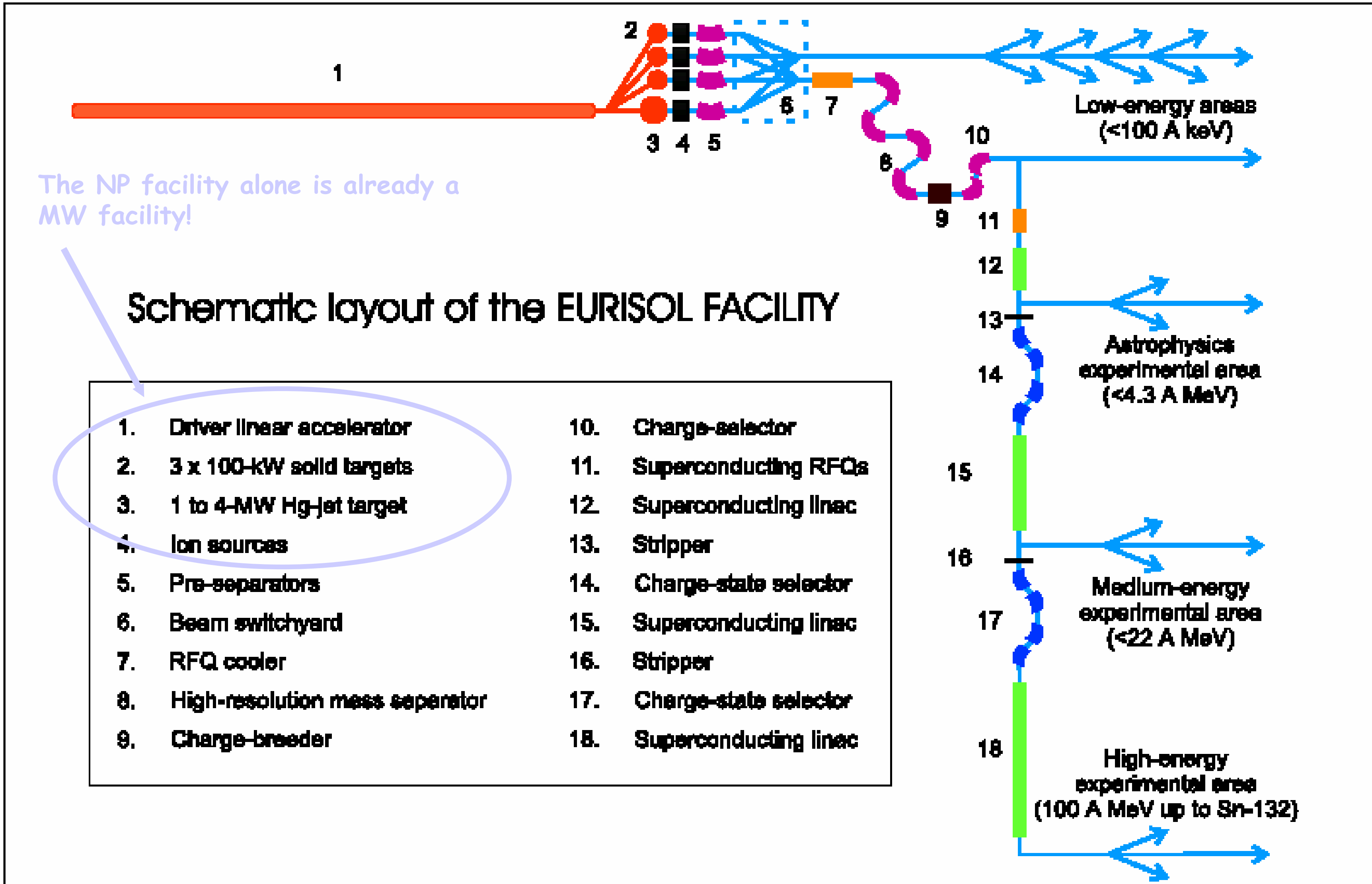
new management taking office at CERN

→ **MWW Workshop**

first major BENE event

EURISOL Overall Baseline Layout

Ganil? CERN? LNL?



EURISOL Design Study

- **Total budget is 33293300 (9161900 from EU)**
- **Start date:** 1 January 2005
- **Objective:** TDR for end of 2008
- **Objective: TDR enabling the Nuclear physics and Neutrino physics communities to take a decision about a future facility**
- **2009:** Fix site and apply for EU construction project

Eurisol Design Study Tasks

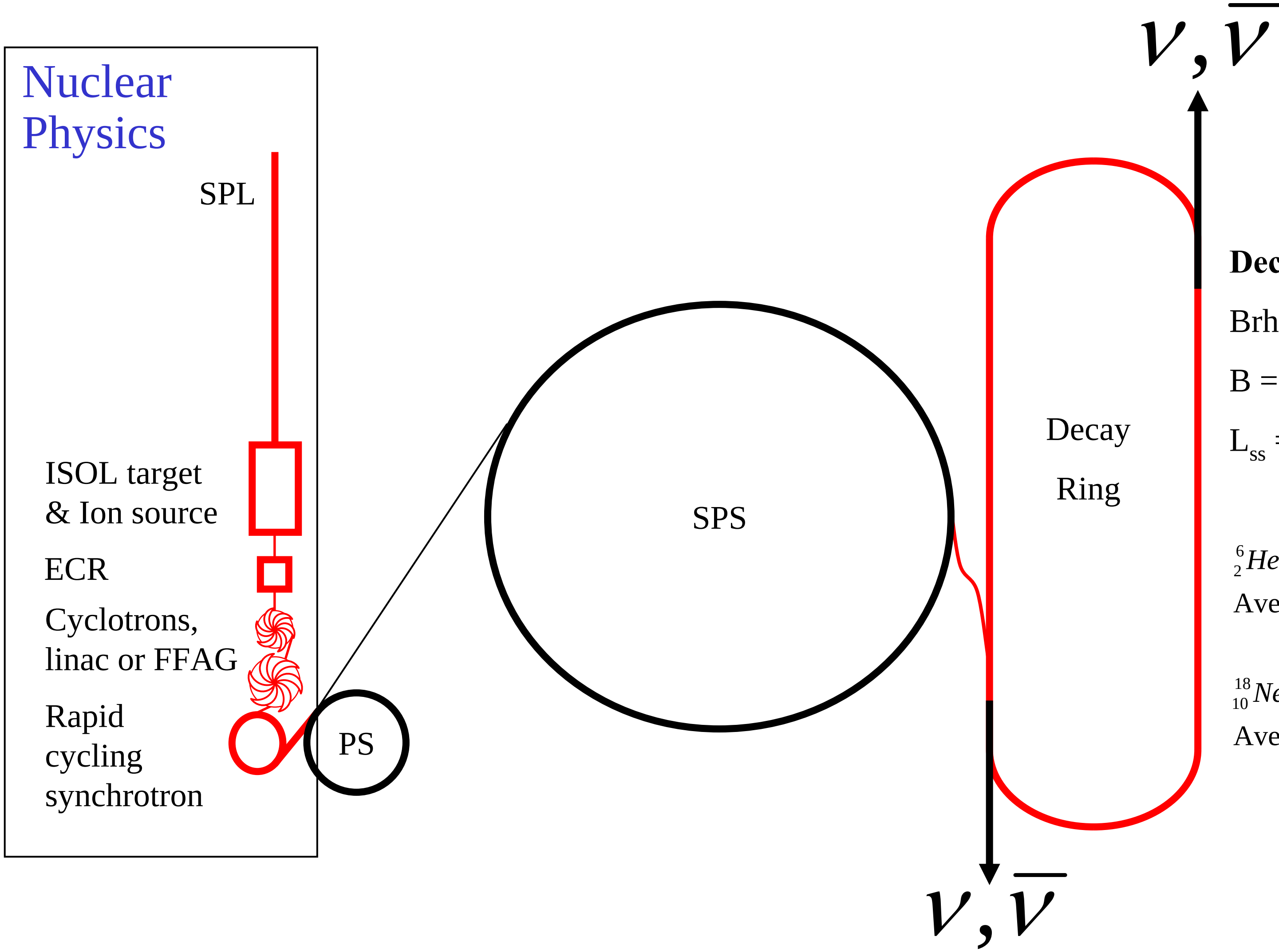
- Preparatory meeting for EURISOL design study in Orsay.
- First drafts presented by task coordinators.

1. Proton Accelerator (Alberto Facco, INFN-LNL)
2. Heavy-Ion Accelerator (MH. Moscatello, GANIL)
3. Cryomodule Development (S. Bousson, IPNO)
4. Direct Target/Ion Source (J. Lettry, CERN)
5. Solid Converter-Target/Ion Source (L. Tecchio, INFN-LNL)
6. Liquid-Metal Target/Ion Source (F. Groeschel, PSI)
7. Safety and Radioprotection (D. Ridikas, CEA-Saclay)
8. Beam Preparation (A. Jokinen, JYFL)
9. Physics and Instrumentation (R. Page, U. Liverpool)
10. Beam Intensity Calculations (K.H. Schmidt, GSI)
11. Beta-Beam Aspects (M. Benedikt, CERN)
12. Co-ordination and Layout (Not yet allocated)

≈1 MEuros out of ≈ 10

CERN: β-beam baseline scenario

EU pride



Decay ring

Brho = 1500 Tm

B = 5 T

L_{ss} = 2500 m

$^{6}_{2}He \rightarrow ^{6}_{3}Li\, e^{-} \bar{\nu}$

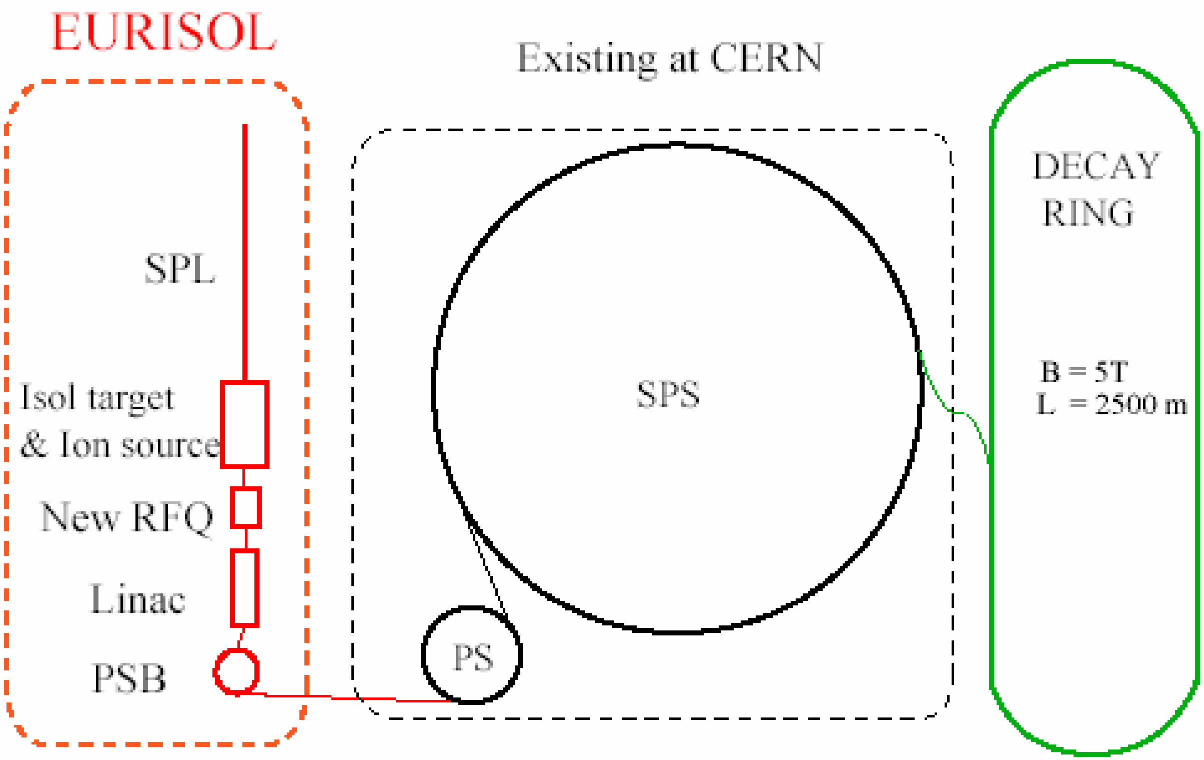
Average $E_{cms} = 1.937$ MeV

$^{18}_{10}Ne \rightarrow ^{18}_{9}Fe\, e^{+} \nu$

Average $E_{cms} = 1.86$ MeV

Beta Beam (P. Zucchelli: Phys. Lett. B532:166, 2002)

M. Lindroos et al., see http://beta-beam.web.ch/beta-beam



- 1 ISOL target to produce He^6, 100 μA, $\Rightarrow 2.9 \cdot 10^{18}$ ion decays/straight session/year. $\Rightarrow \overline{\nu}_e$.
- 3 ISOL targets to produce Ne^{18}, 100 μA, $\Rightarrow 1.2 \cdot 10^{18}$ ion decays/straight session/year. $\Rightarrow \nu_e$.
- The 4 targets could run in parallel, but the decay ring optics requires:

$$\gamma(Ne^{18}) = 1.67 \cdot \gamma(He^{6}).$$

Target values for the decay ring

^{6}Helium^{2+}
- In Decay ring: 1.0x10^{14} ions
- Energy: 139 GeV/u
- Rel. gamma: 150
- Rigidity: 1500 Tm

^{18}Neon^{10+} (single target)
- In decay ring: 4.5x10^{12} ions
- Energy: 55 GeV/u
- Rel. gamma: 60
- Rigidity: 335 Tm

- The neutrino beam at the experiment should have the "time stamp" of the circulating beam in the decay ring.
- The beam has to be concentrated to as few and as short bunches as possible to maximize the number of ions/nanosecond. (background suppression), aim for a duty factor of 10^{-4}

Intensities

Stage	^{6}He	^{18}Ne (single target)
From ECR source:	2.0×10^{13} ions per second	0.8×10^{11} ions per second
Storage ring:	1.0×10^{12} ions per bunch	4.1×10^{10} ions per bunch
Fast cycling synch:	1.0×10^{12} ion per bunch	4.1×10^{10} ion per bunch
PS after acceleration:	1.0×10^{13} ions per batch	5.2×10^{11} ions per batch
SPS after acceleration:	0.9×10^{13} ions per batch	4.9×10^{11} ions per batch
Decay ring:	2.0×10^{14} ions in four 10 ns long bunch	9.1×10^{12} ions in four 10 ns long bunch

Only β-decay losses accounted for, add efficiency losses (50%)

Decay losses

- Losses during acceleration are being studied:
  - Full FLUKA simulations in progress for all stages (M. Magistris and M. Silari, *Parameters of radiological interest for a beta-beam decay ring*, TIS-2003-017-RP-TN)
  - Preliminary results:
    - Can be managed in low energy part
    - PS will be heavily activated
      - New fast cycling PS?
    - SPS OK!
    - Full FLUKA simulations of decay ring losses:
      - Tritium and Sodium production surrounding rock well below national limits
      - Reasonable requirements of concreting of tunnel walls to enable decommissioning of the tunnel and fixation of Tritium and Sodium

Multiple beta beam regimes

Low energy ……. $\gamma_{ion} \approx$ 1-10 E_{ν_e} few 10 MeV (C. Volpe)

neutrino reactions
nuclear (astro-)physics,
solar , supernovae

Medium energy …. $\gamma_{ion} \approx$100 E_{ν_e} few 100 MeV (M . Mezzetto)

massive low density detector
very large !!!!

baseline

High energy ……… $\gamma_{ion} \gtrsim$500 E_{ν_e} GeV & multi GeV (P. Hernandez & al.)

denser, smaller, farther detectors

same as NuFact?

NB Main issues are technical !!!

may well be an evolutive process (M. Lindroos)

France+Italy

… Europe

FREJUS EOI SUMMARY

A. De Bellefon, J. Bouchez, L.Mosca et al.

June 3, 2003

Astroparticle Observatory

N decay

S-Novae

atmo ν

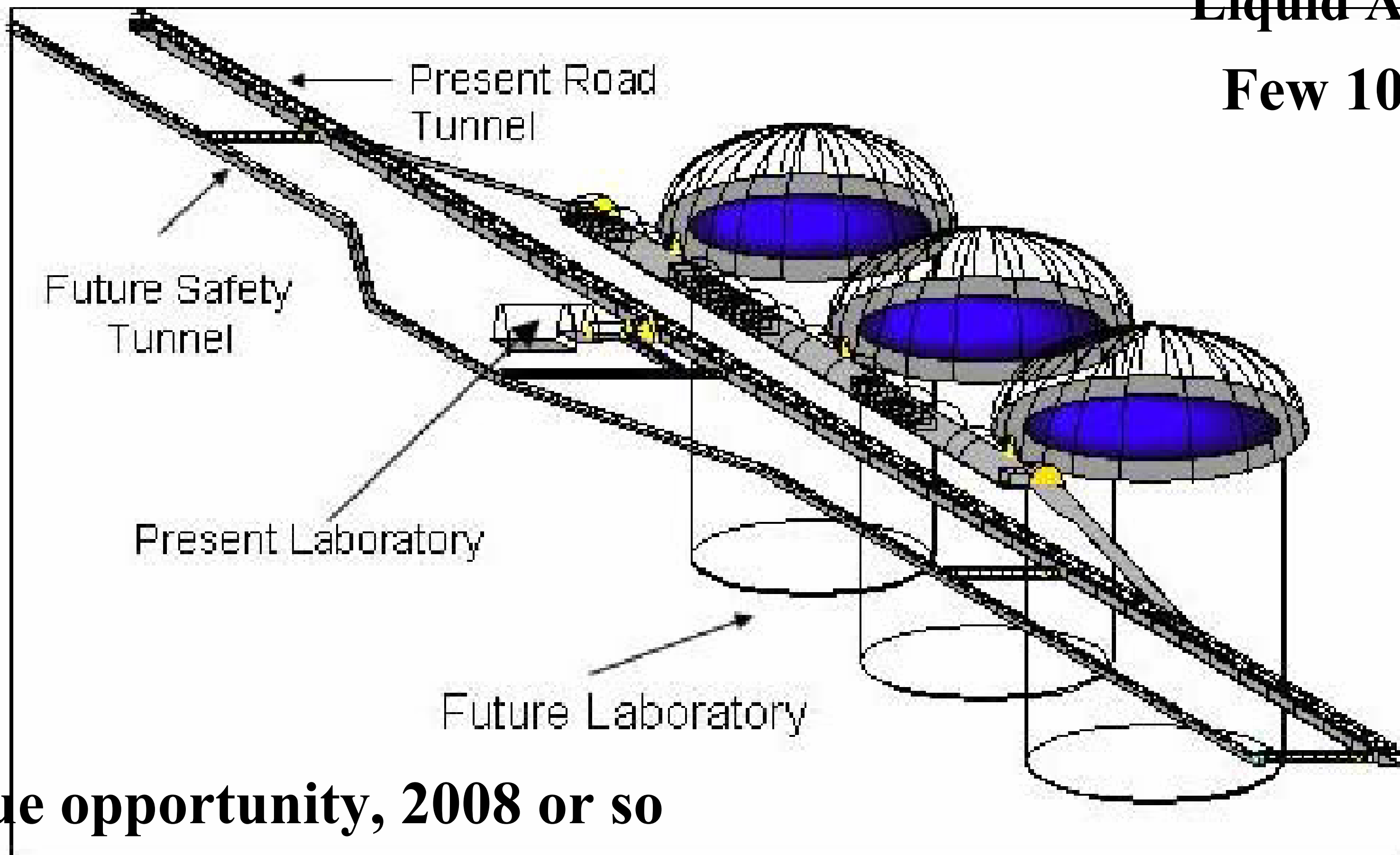
Abstract

A Megaton Physics project in the Fréjus underground site, focalised on Proton Decay, Neutrinos from Supernovae, Atmospheric Neutrinos and Neutrinos from a long-baseline, is presented and compared with competitor projects in Japan and USA sites. The advantages of the European project are discussed, including the possibility of a neutrino long-baseline from CERN, at a magic distance.

UNO, Hyper-K

Liquid Argon

Few 100 MeV



Unique opportunity, 2008 or so

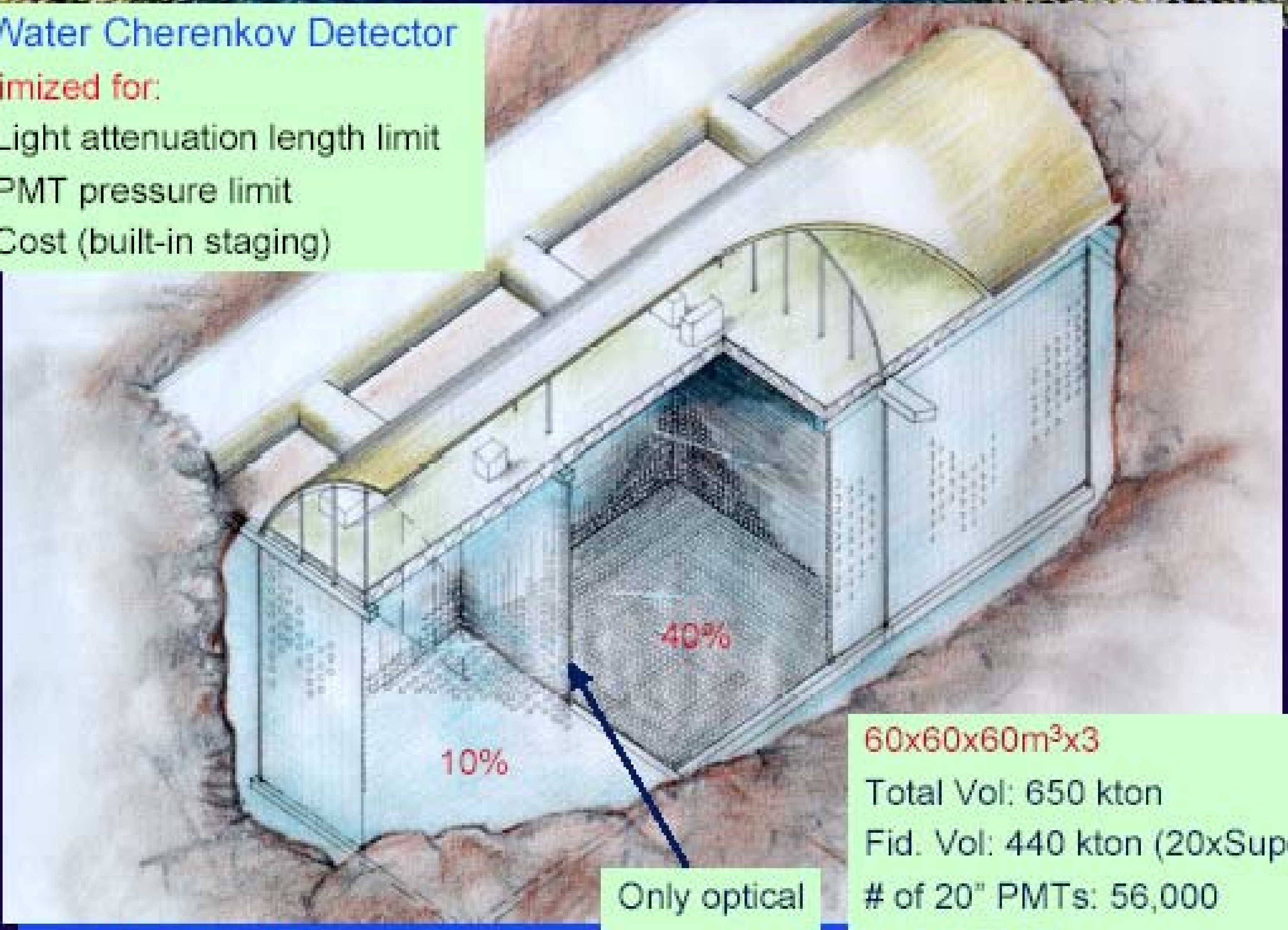
Figure 2: *Proposal for a new excavation in the Fréjus tunnel* .

UNO Detector Conceptual Design

A Water Cherenkov Detector

optimized for:

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



Only optical separation

60x60x60m^{3}x3

Total Vol: 650 kton

Fid. Vol: 440 kton (20xSuperK)

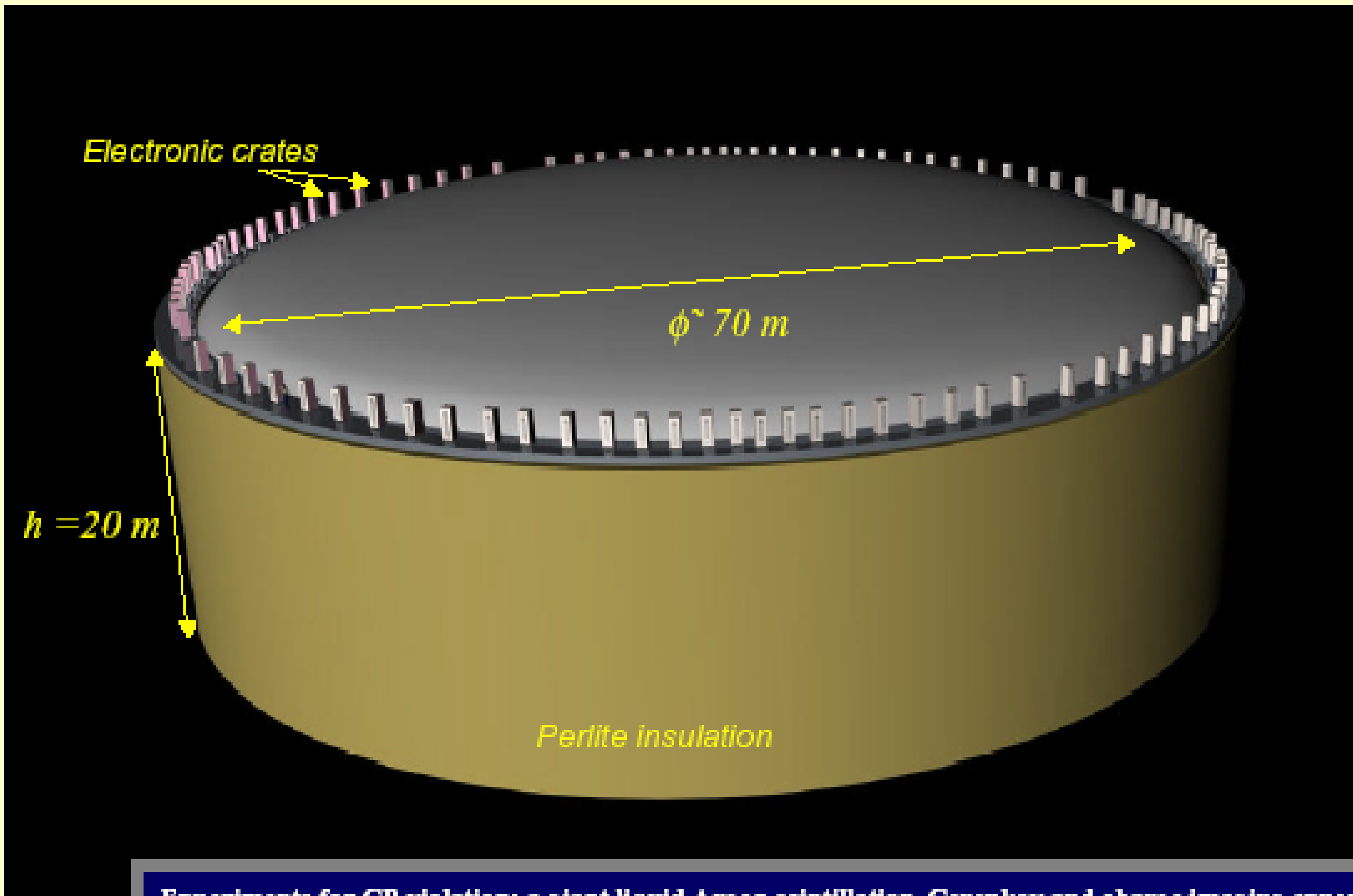
# of 20" PMTs: 56,000

# of 8" PMTs: 14,900

Detectors ….. again UNO/HyperK

but also

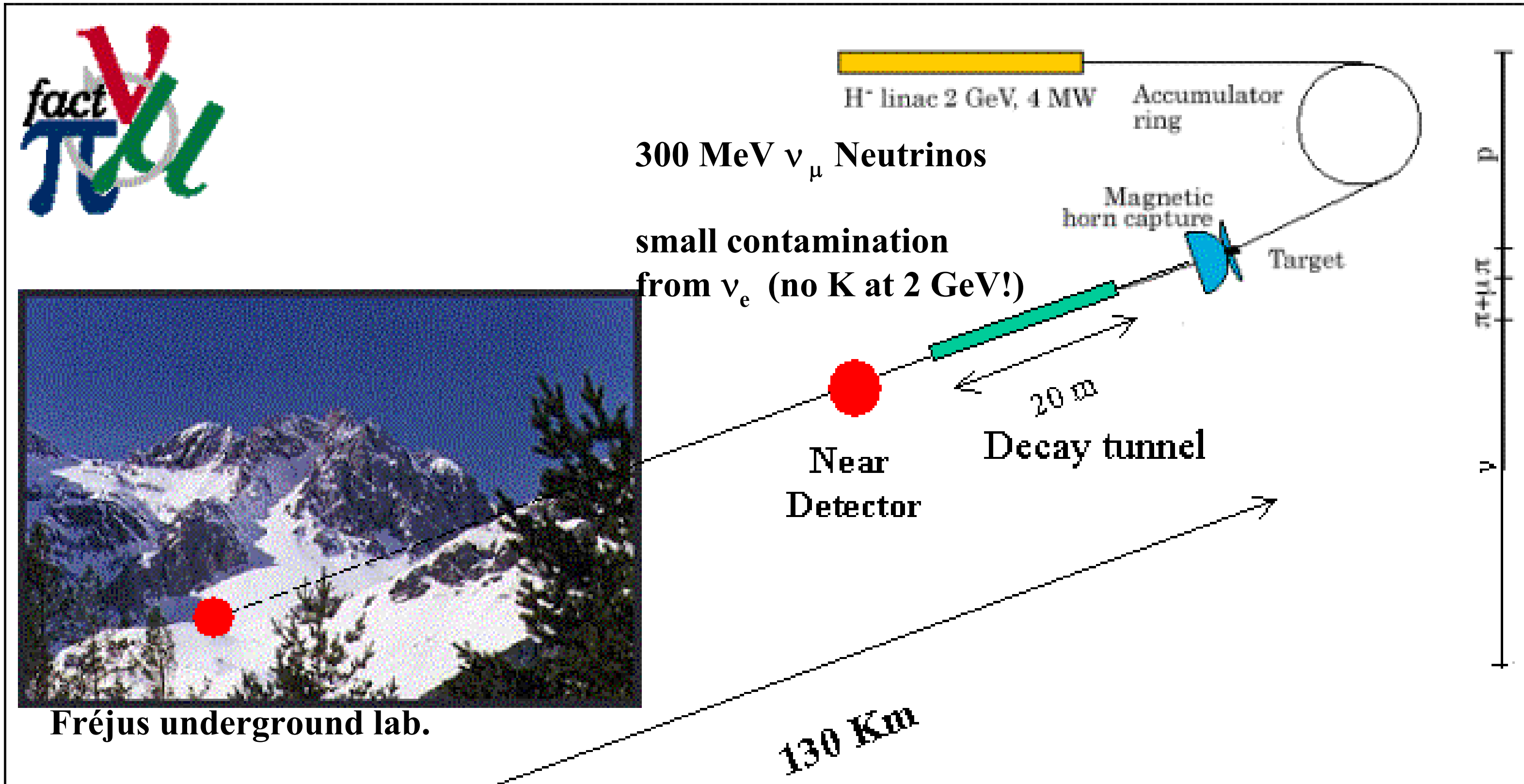
100 kton liquid Argon TPC detector



Experiments for CP violation: a giant liquid Argon scintillation, Cerenkov and charge imaging experiment.
A.Rubbia, Proc. II Int. Workshop on Neutrinos in Venice, 2003, hep-ph/0402110

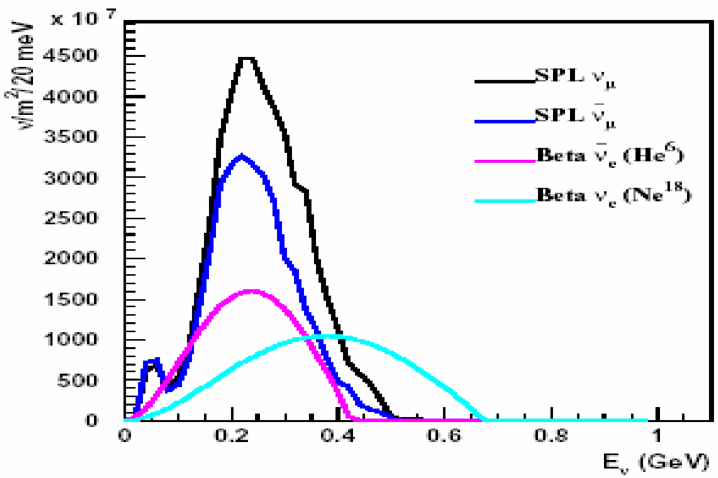
CERN-SPL-based Neutrino SUPERBEAM

Same detectors as Superbeam !

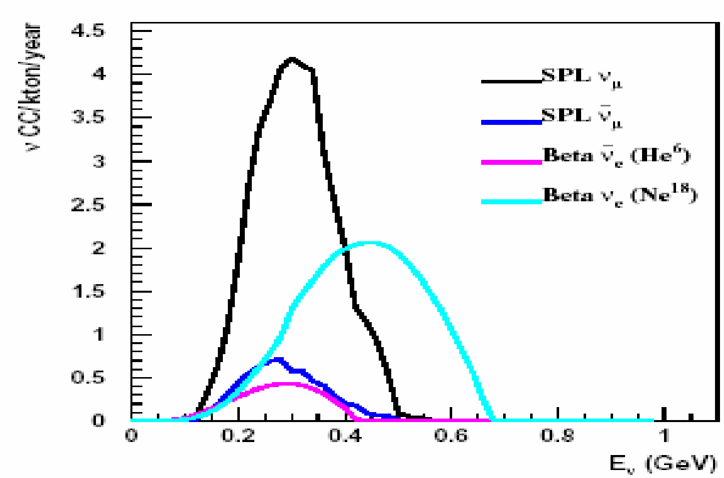


A large underground water Cerenkov (400 kton) UNO/HyperK or/and a large L.Arg detector.
also : proton decay search, supernovae events solar and atmospheric neutrinos. Performance similar to J-PARC II
There is a window of opportunity for digging the cavern stating in 2008 (safety tunnel in Frejus)

Fluxes



CC Rates



	Fluxes @ 130 km $\nu/m^2/yr$	$< E_\nu >$ (GeV)	CC rate (no osc) events/kton/yr	$< E_\nu >$ (GeV)	Years	Integrated events (440 kton $\times$ 10 years)
SPL Super Beam						
ν_μ	$4.78 \cdot 10^{11}$	0.27	41.7	0.32	2	36698
$\overline{\nu}_\mu$	$3.33 \cdot 10^{11}$	0.25	6.6	0.30	8	23320
Beta Beam						
$\overline{\nu}_e\ (\gamma = 60)$	$1.97 \cdot 10^{11}$	0.24	4.5	0.28	10	19709
$\nu_e\ (\gamma = 100)$	$1.88 \cdot 10^{11}$	0.36	32.9	0.43	10	144783

1. Mezzetto, "Beta Beams", Villars, September 24 2004 10

$\delta m^2_{12} = 7 \cdot 10^{-5}\ eV^2$, $\theta_{13} = 1°$, $\delta_{CP} = \pi/2$, sign$(\Delta m^2) = +1$

	Beta Beam		SPL-SB	
	^6He ($\gamma = 60$)	^{18}Ne ($\gamma = 100$)	ν_μ (2 yrs)	$\overline{\nu}_\mu$ (8 yrs)
CC events (no osc, no cut)	19710	144784	36698	23320
Oscillated at the Chooz limit	681	5304	1491	1182
Oscillated	1	118	2	34
δ oscillated	-12	54	-27	16
Beam background	0	0	140	101
Detector backgrounds	1	397	37	50

δ-oscillated events indicates the difference between the oscillated events computed with $\delta = 90°$ and with $\delta = 0$.

$A_{\not{CP}} = \dfrac{P_\nu - P_{\bar\nu}}{P_\nu + P_{\bar\nu}}$ **$\nu/\bar\nu$ asymmetry**

$\nu_e \rightarrow \nu_\mu$	**at NuFact + Betabeam**
$\nu_\mu \rightarrow \nu_e$	**Superbeam**

$A_{\not{T}} = \quad \longrightarrow \quad \longleftarrow$ **asymmetry …**

$\nu_e \leftrightarrow \nu_\mu$	**at NuFact?**
$\nu_e \leftrightarrow \nu_\mu$	**Betabeam + Superbeam**

$A_{\not{C}PT}$ **both asymmetries**

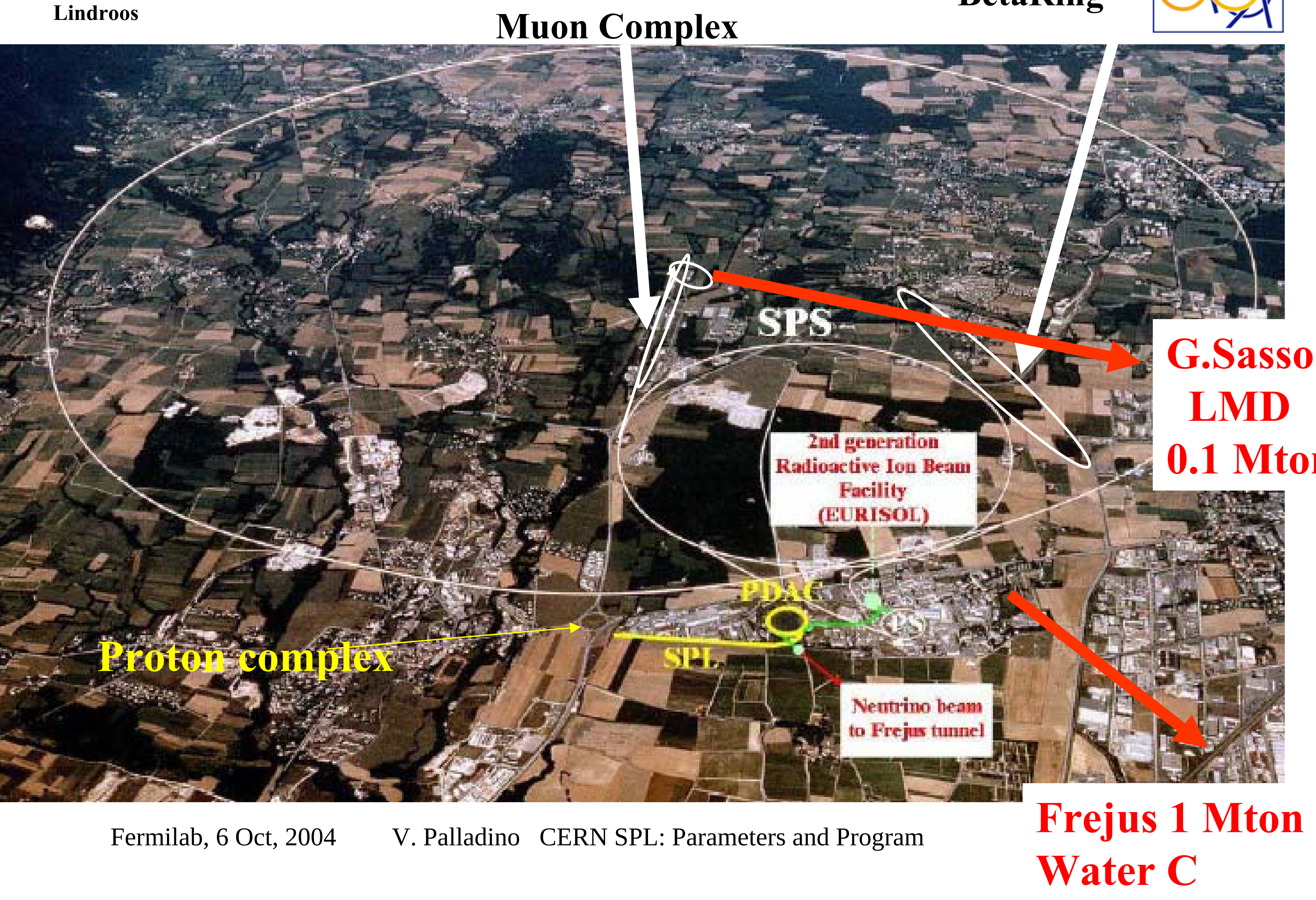
Betabeam +

Superbeam

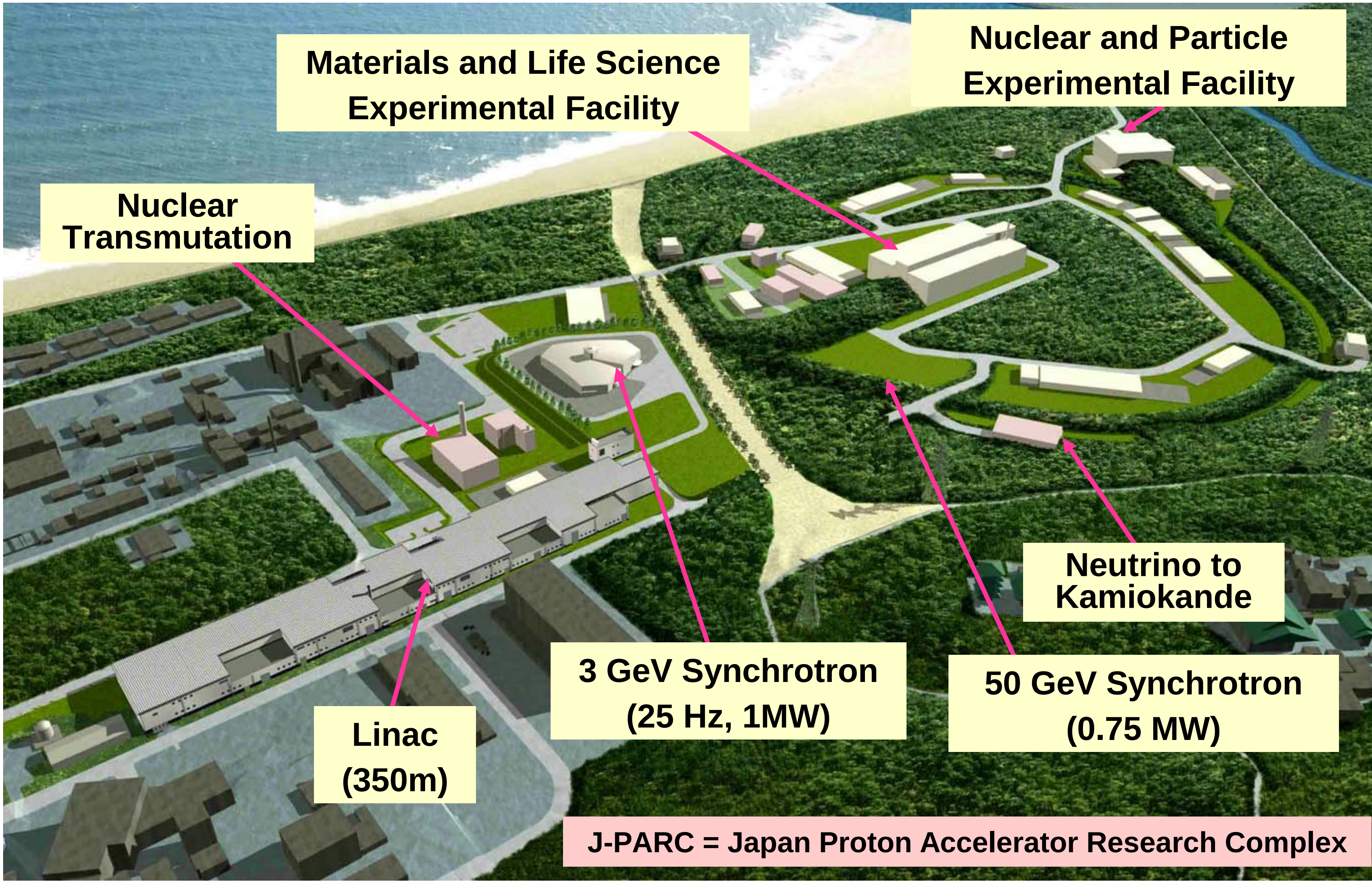
All of great interest!

Garoby
Haseroth
Lindroos

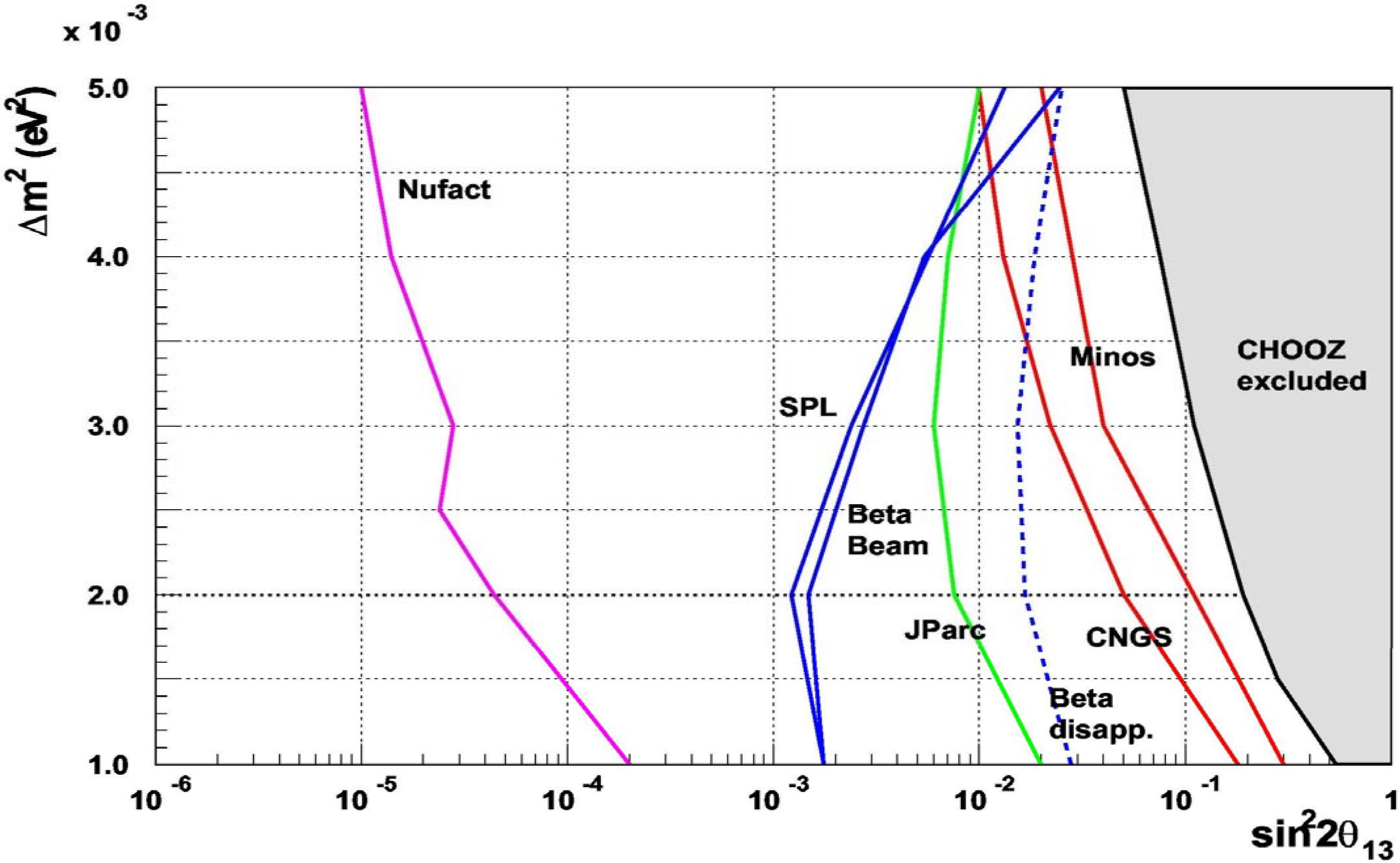
EU Neutrino Complex



Joint Particle and Nuclear Venture



Physics Reach: the third mixing angle



Physics Reach: CPV

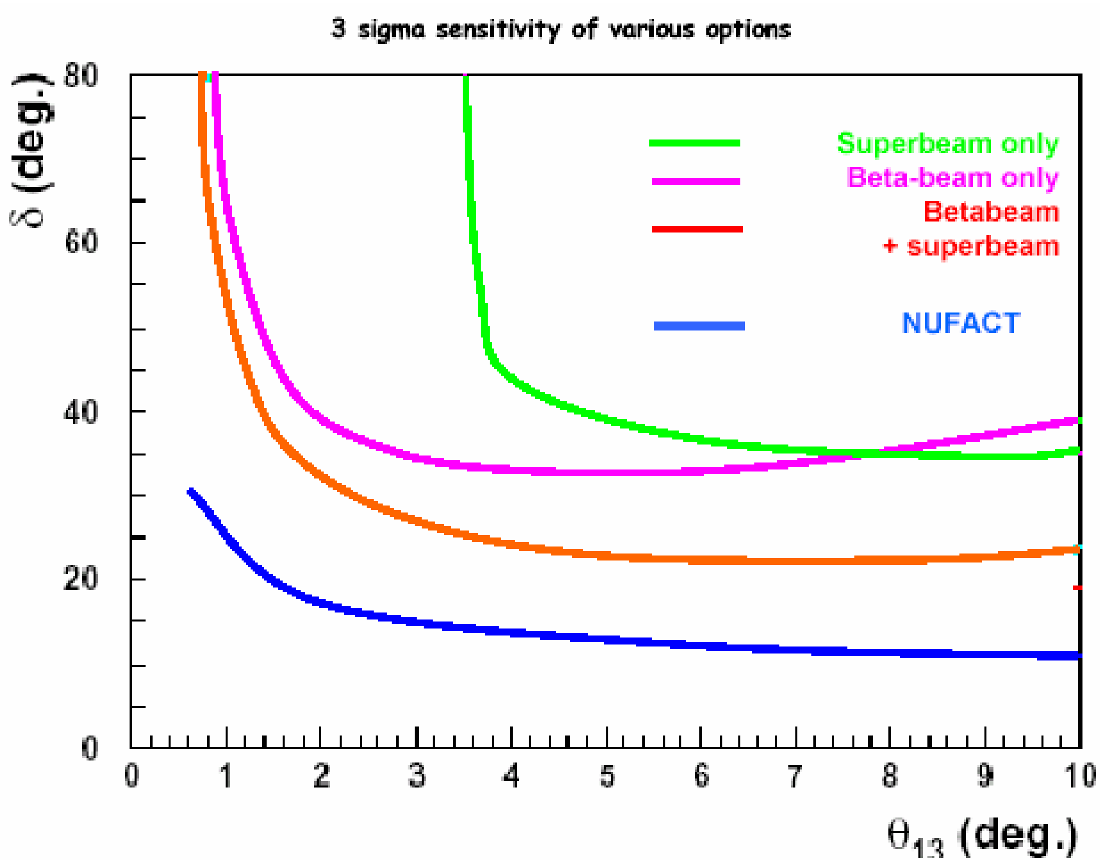
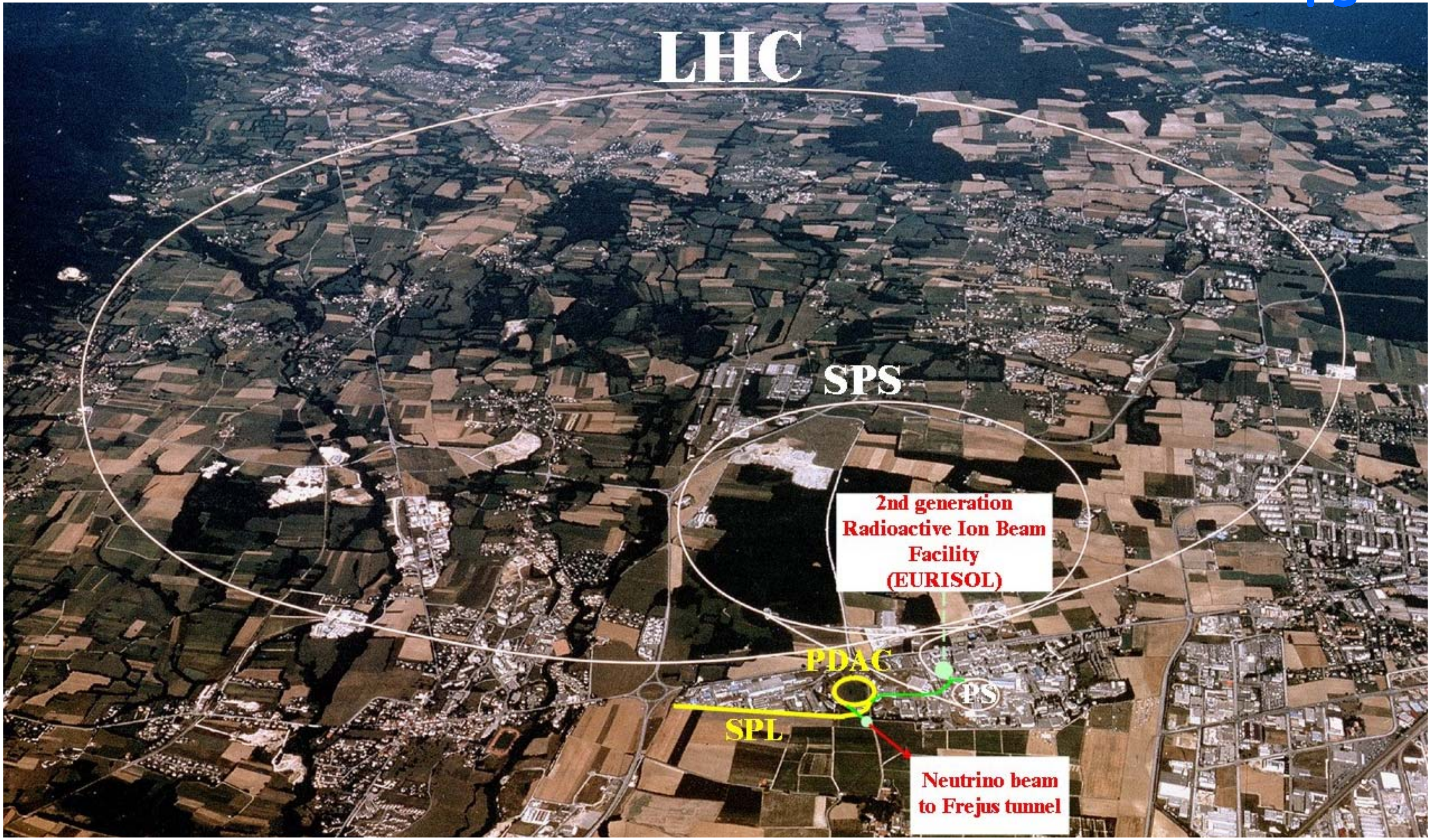


Figure 7 : 99%CL δ sensitivity of the beta-beam, of the SPL-SuperBeam, and of their combination, see text. Dotted line is the combined Superbeam+beta-beam sensitivity computed for sign(Δm_2)=-1. Sensitivities are compared with a 50 GeV Neutrino Factory producing $2\times10_{20}\mu$ decays/straight section/year, and two 40 kton detectors at 3000 and 7000 km

European MWatt complex:
combination of linac+rings

in synergy with LHC upgrades



LHC upgrade and MMW

Table 1 Possible improvement to the accelerator complex
("RCS"=Rapid Cycling Synchrotron, "HEP"=High Energy Physics, "mMW"=multi-MW, "SC"=Superconducting)

Present accelerator	Replacement accelerator	Improvement	INTEREST FOR			
			LHC upgrade	Neutrino physics beyond CNGS	Radio-active ion beams beyond ISOLDE	Physics with kaons and muons
Linac2	Linac4	50 → 160 MeV H+ → H-	+	0 (if alone)	0 (if alone)	0 (if alone)
PSB	2.2 GeV RCS for HEP	1.4 → 2.2 GeV 10 → 250 kW Brightness ×2	+	0 (if alone)	+	0 (if alone)
	2.2 GeV/mMW RCS	1.4 → 2.2 GeV 0.01 → 4 MW Brightness ×2	+	+++ for super-beam and beta-beam	+ (too short beam pulse)	0 (if alone)
	2.2 GeV/50 Hz SPL	1.4 → 2.2 GeV 0.01 → 4 MW Brightness ×2	+	+++ for super-beam and beta-beam	+++	0 (if alone)
PS	50 GeV SC PS for HEP	26 → 50 GeV Intensity ×2 Brightness ×2	++	0 (if alone)	0	+
	50 GeV/5 Hz RCS	26 → 50 GeV 0.1 → 4 MW Brightness ×2	++	++	0	+++
SPS	1 TeV SC Synchrotron	0.45 → 1 TeV Intensity ×2 Brightness ×2	+++	?	0	+++

R.Garoby
W. Scandale

Main conclusion

MMW and ν's back on the EU map, maybe

positive signals , after meager years of LHC crisis

1) EU approval (HIPPI and BENE)

2) attention of CERN & National Agencies
…. more vigourous R&D soon maybe

can CERN envisage a high intensity (M-MW) frontier
besides its high energy (M-TeV) frontier
undisputed mandate
?

Second conclusion

A rich ν program appears possible around a SPL

two options

1) high energy ν……. NuFact (& Superbeam)

2) low energy ν …….. Betabeam (& Superbeam)

but it so does with other drivers too , most likely

Third conclusion …. what deadlines

LHC (& upgrade)
will be the first priority

Next HE project .. CLIC

<u>Will there be a window for a MMW investment?</u>

PLANS MUST BE READY BY 2009 or SO

The end