BENE04
Beams for European Neutrino Experiments
Summary

Towards
a consensual road map
for
accelerator based neutrino programs in Europe

A complex multi-parameter problem

BENE04

1) Summary of a very intense & productive year
initiatives
results …. physics case WP1+2
…. technical WP3+4+5

2) Summary of a lively workshop Nov 2-3

thank you, Dieter & Helmut
Profs Wagner & Klanner
everybody in DESY
all participants

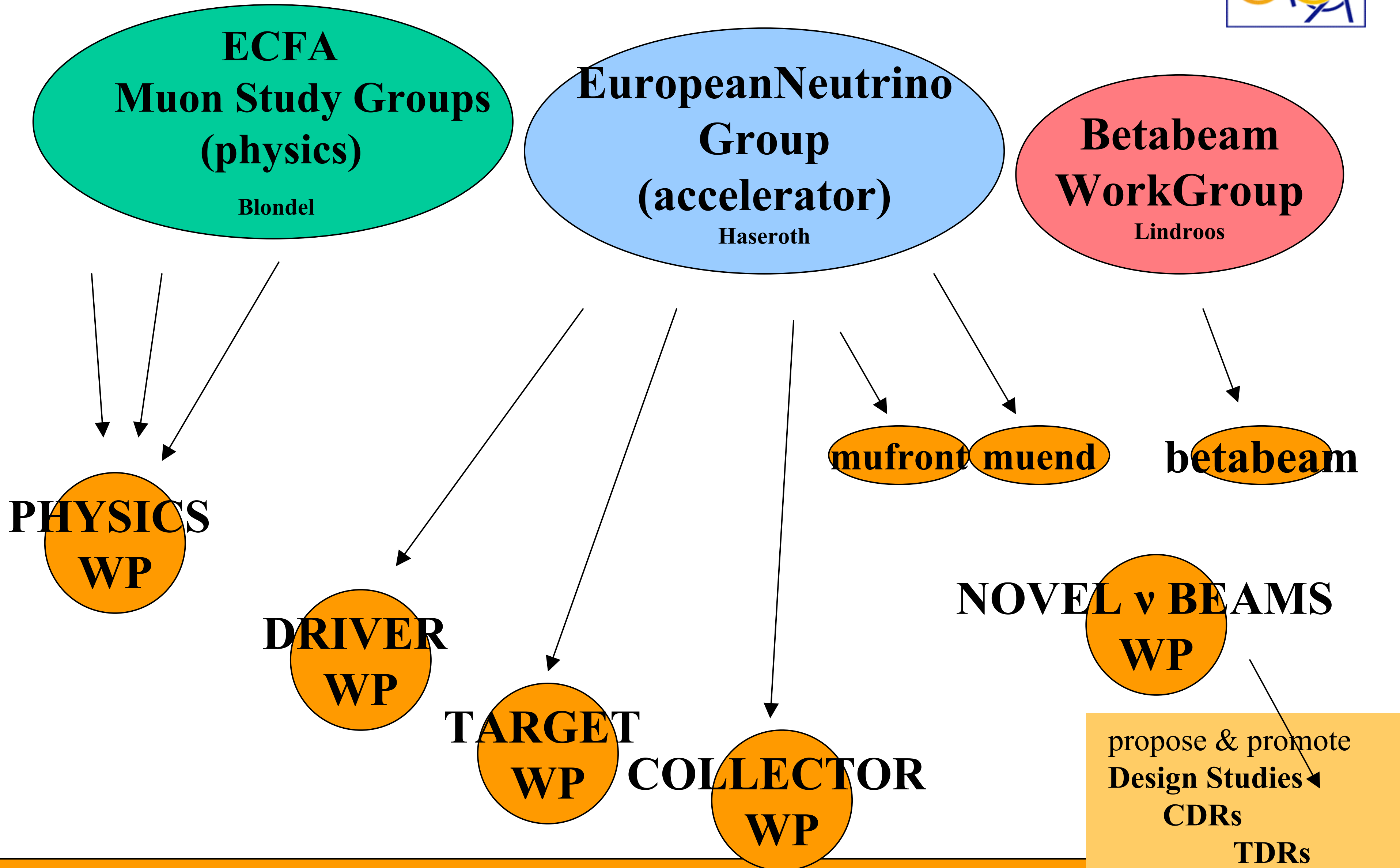
BENE04 Workshop in DESY — Tue, Nov. 2, 2004, Seminar Room 2

Meeting	Time	Speaker	Subject
	11:00 - 11:05	**Welcome**	
Plenary BENE	11:05- 11:35	**A. Ringwald**	Neutrinos in the universe
Plenary PHYSICS	11:35 - 12:05	**M. Lindner**	Neutrino Oscillations: phenomenology
Plenary PHYSICS	12:05 - 12:35	**D. Wark**	Neutrino Oscillations: experiments
Lunch			
Plenary BENE	14:00 - 14:20	**J. Dainton**	EU Neutrinos after the SPSC Cogne IX meeting
Plenary ENG	14:20 - 14:50	**H. Haseroth**	Superbeam & NuFactory Overview
Plenary ENG	14:50 - 15:20	**R. Garoby**	HIPPI and high intensity p-drivers
Plenary ENG	15:20 - 15:50	**R. Bennett**	High Power Targets
Coffee	15:50 - 16:10		
Plenary ENG	16:10 - 16:30	**H. Kirk**	Target experiment (TT2a)
Plenary/ENG	16:30 - 16:50	**J.-E. Campagne**	Collection of neutrino parents
Plenary/ENG	16:50 - 17:20	**U. Bravar**	Muon front end, ionization cooling, MICE
Plenary/ENG	17:20 - 17:50	**K. Long**	Neutrino factory activities in the UK
Plenary ENG	17:50 - 18:10	**F. Meot**	Acceleration of muons: FFAGs and more
Plenary ENG	18:10 - 18:30	A. Caldwell (tbc)	Frictional muon cooling

BENE04 Workshop in DESY — Wed, Nov. 3, 2004

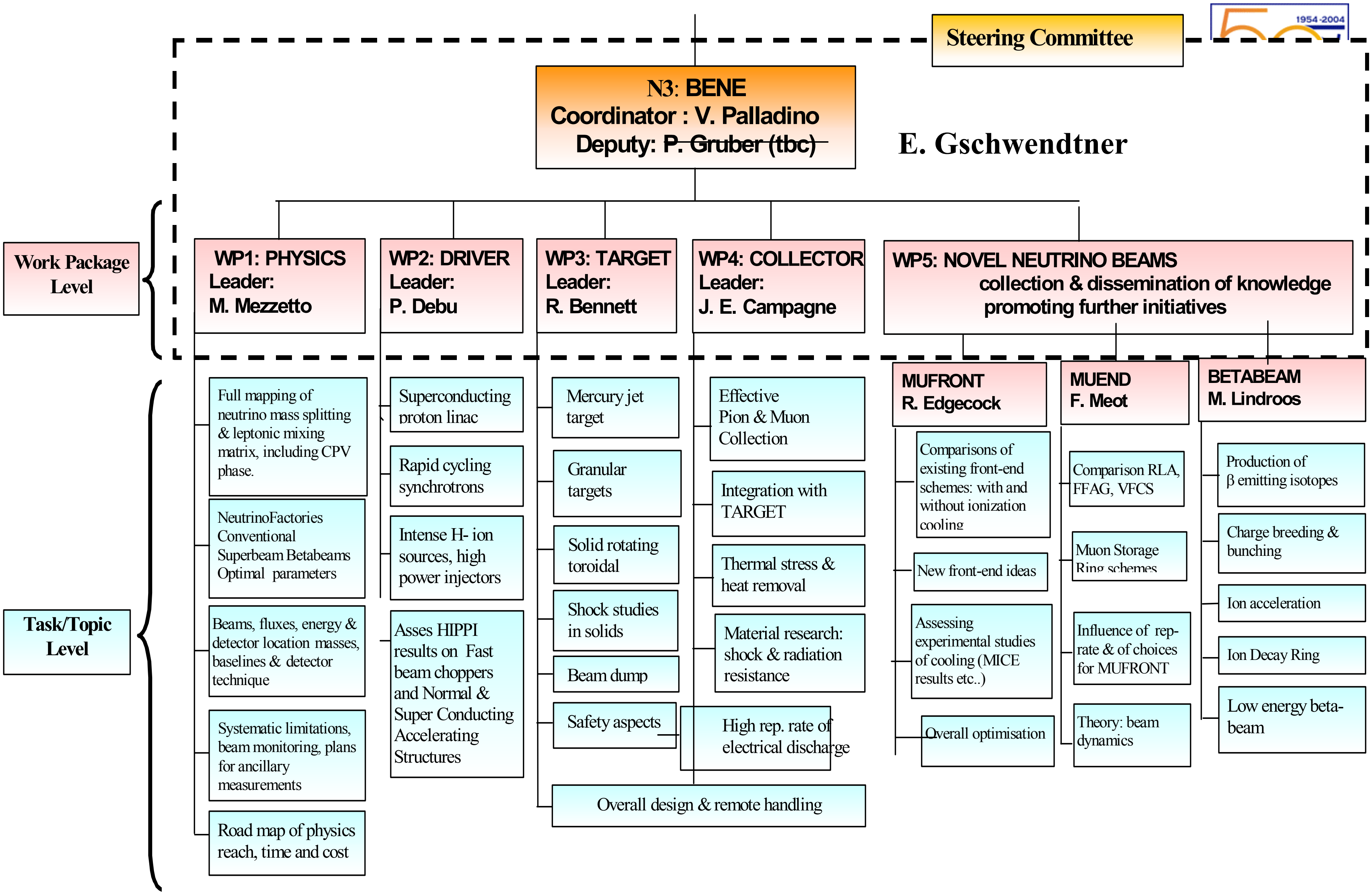
Meeting	Time	Speaker or Convenor	Subject
PHYSICS/parallel	09:00 – 10:30	**M. Mezzetto/P. Hernandez/C. Cavata**	WP1-PHYSICS & WP2-DRIVER, agenda
ENG/parallel	09:00 – 10:30	**R.Bennet/J.E.Campagne**	WP3-TARGET & WP4-COLLECTOR, agenda
ENG/parallel	09:00 – 10:30	**R. Egecock/F. Meot**	WP5a&b-MUFRONT & MUEND, agenda
Coffee	10:30 – 11:00		
PHYSICS/parallel	11:00 - 12:30	**M. Mezzetto/P. Hernandez/C. Cavata**	WP1-PHISICS & WP2-DRIVER
ENG/parallel	11:00 - 12:30	**R.Bennet/J.E.Campagne**	Joint WP3-TARGET & WP4-COLLECTOR
ENG/parallel	11:00 - 12:30	**R. Egecock/F. Meot**	WP5a&b-MUFRONT & MUEND
Lunch			
Plenary ENG	14:00 - 14:20	**Y. Kadi**	Spallation target development for the EU ADS Project
Plenary ENG	14:20 – 14:50	**M. Lindroos**	ISOL, EURISOL & neutrino Betabeams
Plenary ENG	14:50 - 15:20	**M. Zisman**	NuFact & Betabeam News from US APS Study:
Plenary BENE	15:20 - 15:50	**A. Donini**	Leptonic Mixing: beams and baseline options
Coffee	15:50 - 16:10		
Plenary BENE	16:10- 16:40	**P. Strolin**	Detectors for future neutrino experiments
Plenary BENE	16:40 - 17:10	**C. Hagner**	The complementary reactor approach: DCHOOZ
Plenary BENE	17:10 - 17:40	E. Fernandez/R. Klanner DISCUSSION ROUND TABLE	General physics road map
	17:40 - 18:10		R&D's tasks ahead of us: choices & priorities
	18:10 - 18:30		Contributions from new laboratories

BENE thrives on three pre-existing centers of initiative ……….



propose & promote
Design Studies
CDRs
TDRs
R&D Proposals

N3: BENE (Beams for European NeutrinoExperiments) Work Packages


Steering Committee
N3: BENE
Coordinator : V. Palladino
Deputy: P. Gruber (tbc)
E. Gschwendtner
Work Package Level
WP1: PHYSICS Leader: M. Mezzetto
WP2: DRIVER Leader: P. Debu
WP3: TARGET Leader: R. Bennett
WP4: COLLECTOR Leader: J. E. Campagne
WP5: NOVEL NEUTRINO BEAMS collection & dissemination of knowledge promoting further initiatives
MUFRONT R. Edgecock
MUEND F. Meot
BETABEAM M. Lindroos
Task/Topic Level
Full mapping of neutrino mass splitting & leptonic mixing matrix, including CPV phase.
NeutrinoFactories Conventional Superbeam Betabeams Optimal parameters
Beams, fluxes, energy & detector location masses, baselines & detector technique
Systematic limitations, beam monitoring, plans for ancillary measurements
Road map of physics reach, time and cost
Superconducting proton linac
Rapid cycling synchrotrons
Intense H- ion sources, high power injectors
Asses HIPPI results on Fast beam choppers and Normal & Super Conducting Accelerating Structures
Mercury jet target
Granular targets
Solid rotating toroidal
Shock studies in solids
Beam dump
Safety aspects
Overall design & remote handling
Effective Pion & Muon Collection
Integration with TARGET
Thermal stress & heat removal
Material research: shock & radiation resistance
High rep. rate of electrical discharge
Comparisons of existing front-end schemes: with and without ionization cooling
New front-end ideas
Assessing experimental studies of cooling (MICE results etc..)
Overall optimisation
Comparison RLA, FFAG, VFCS
Muon Storage Ring schemes
Influence of rep-rate & of choices for MUFRONT
Theory: beam dynamics
Production of β emitting isotopes
Charge breeding & bunching
Ion acceleration
Ion Decay Ring
Low energy beta-beam

… 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.

HARP, MuSCAT
MICE
TT2a
E-FFAG
………

road map issues ….. of neutrino & accelerator physics together

The physics of ν transitions is proving extremely rewarding
and demands long term experimentation with accelerator ν

EU accelerator ν are an endangered species
may extinguish after CNGS & upgrades
a strong initiative is needed

thrive on the richness of options: Superbeams, NuFact, Betabeam + specific detectors

Preliminary conclusion: all options very promising

to first comparative appraisal

NuFact most attractive & challenging
head towards it !

Preliminary road map:

pursue NuFact R&D … driver, target, collection …. μ complex

have CDR ready by LHC startup

build a Superbeam along the way?

almost free

combine them with a Betabeam?

may exploit sinergies with CERN & EURISOL & GSI

A LARGE & EARLY FRACTION OF THE EFFORT IS COMMON (DRIVER and more ..)

new shapshot yesterday at BENE04

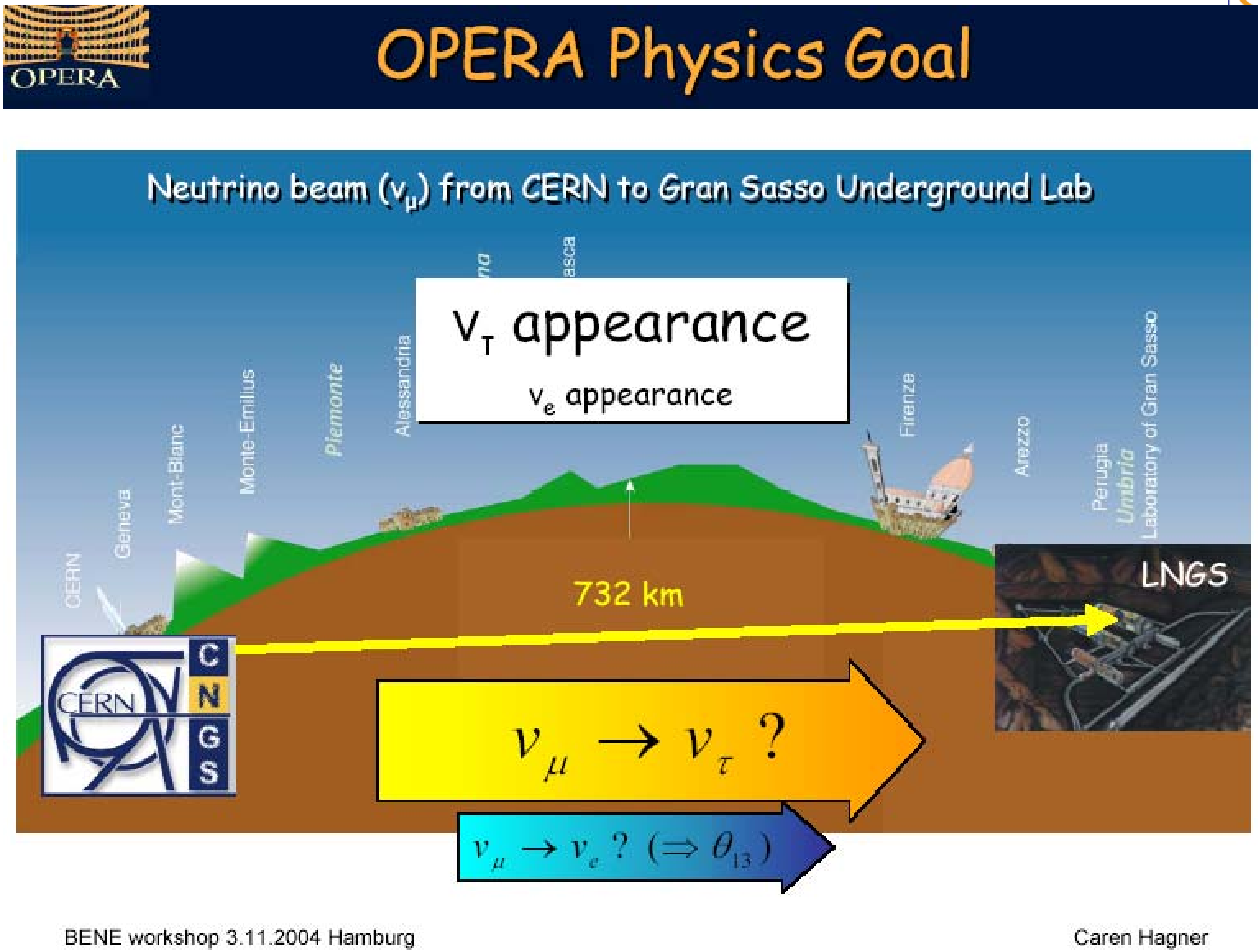
Survived the big risk **53 participants**

Did attract new people ……………
Germany?
Holland?
Scandinavia?
Poland, Latvia ?

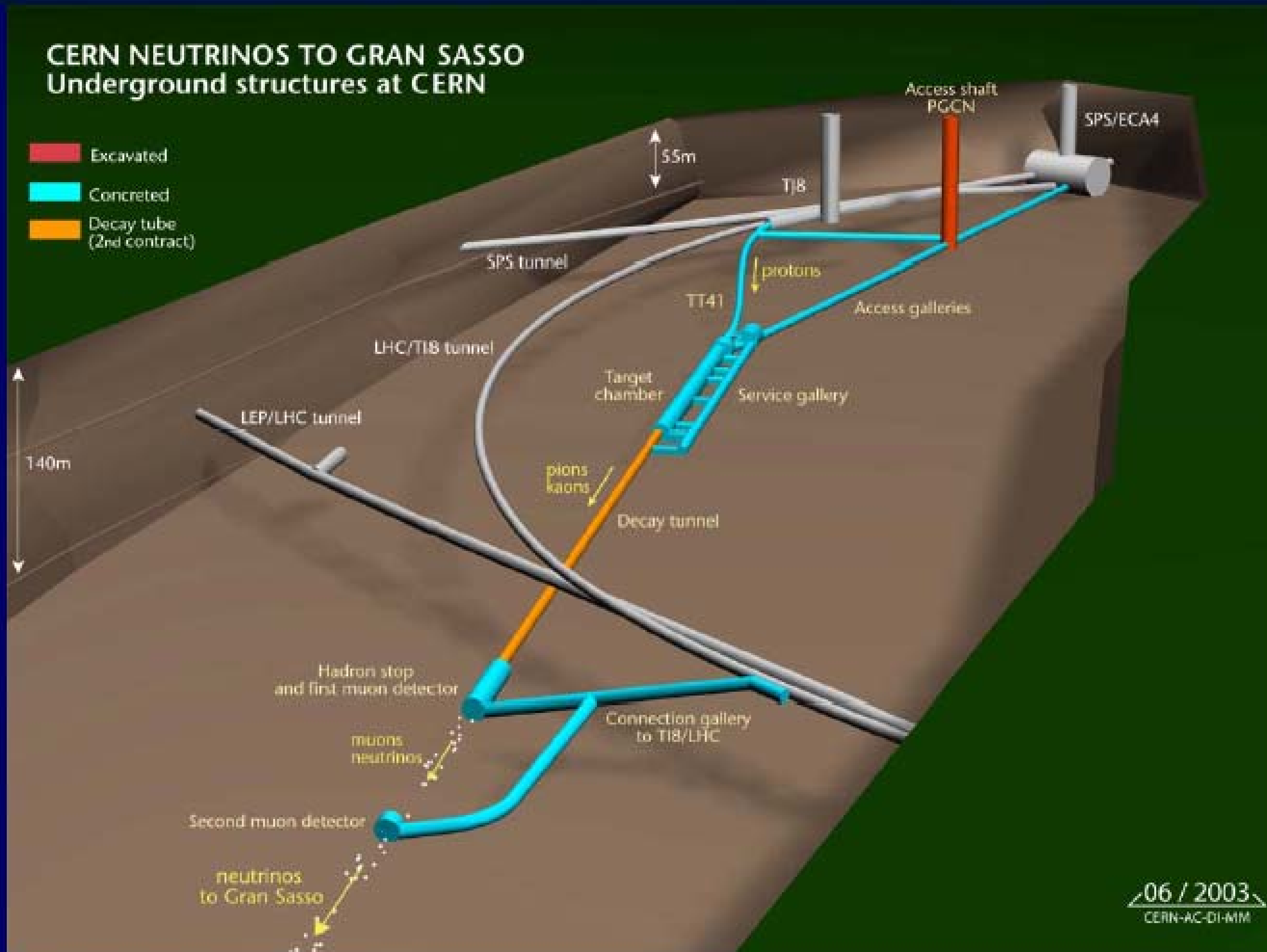
Did progress on the work

Scientific & Technical
Consensus ….

C. Hagner - The present program moves on time

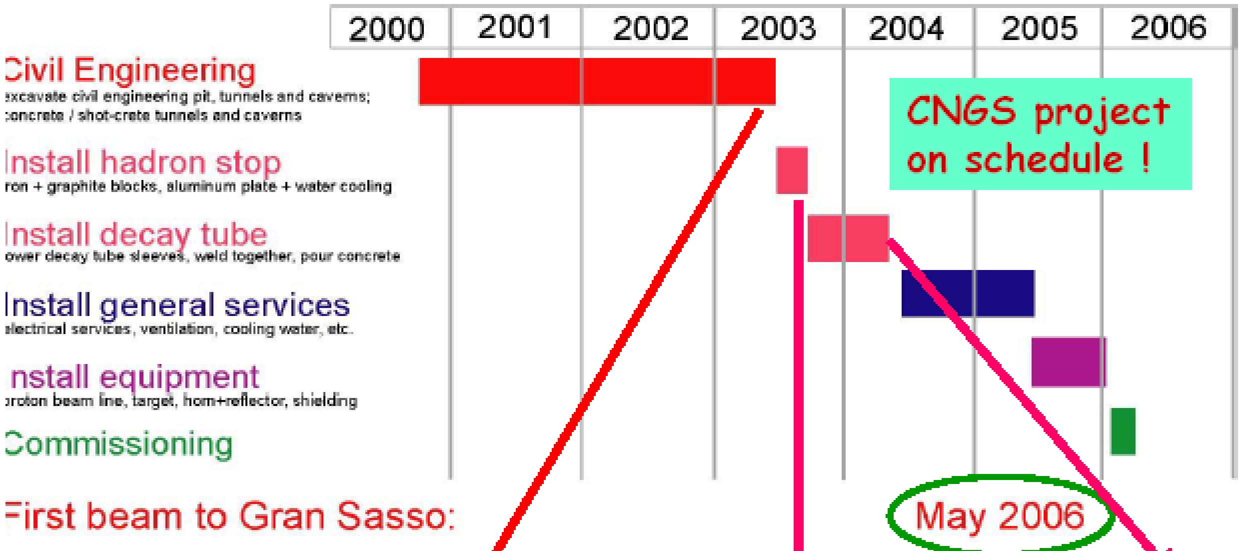


CNGS neutrino beam



BENE workshop 3.11.2004 Hamburg Caren Hagner

Congratulation, Konrad!



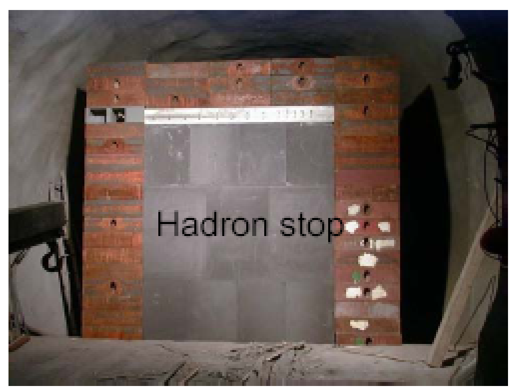
CNGS project on schedule !

First beam in May 2006

Intensity increase (1.5) under study with dedicated machine tests

Decay tube installed and vacuum tested

Civil engineering completed



Hadron stop installed

Congratulations, Yves!

Conclusions

- Despite difficulties at LNGS
  installation of OPERA experiment following schedule

- Completion of Supermodule 1 foreseen Sept 05
  Completion of SM2 Feb 06, SM2 filled in Sept 06
  OPERA needs physics run in 2006 to start physics program

- Efficiency and background based on robust numbers from previous experiments: improvements under study

- In order to cover the SuperK allowed range of Δm^2:
  - At least nominal beam conditions ($4.5\ 10^9$ pot/year) needed!
  - Even more protons on CNGS target are needed
    - either by increasing number of CNGS cycles
    - or (and) increasing proton intensity in the SPS
    - → multi-turn ejection from PS to SPS is urgently needed

13.8
is
conceivable!

BENE workshop 3.11.2004 Hamburg   Caren Hagner

John Dainton
Villars 2004
November 2nd 2004
ECFA BENE @ DESY

Strategy (and action)

Benedikt
Garoby

- start 2004/5:
  - PS: multi-turn ejection
  - increase SPS intensity (impacts all machines)
  - 0.9s PSB repetition

- Linac 4 design

  → construction decision @ end 2006

- prepare decision on optimum future accelerator
  - study of a Superconducting Proton Linac (SPL)
  - alternative scenarios for the LHC upgrade

↳ context for SPSC strategy and input

MMW power?

John Dainton
Villars 2004
November 2nd 2004
ECFA BENE @ DESY

With upgrades

Benedikt
Garoby

- (i) PSB repetition period of 0.9 s
  (ii) 7×10^{13} ppp in SPS
  (iii) Linac4 injecting into PSB

	Standard (i)	CNGS x2 batch (i)+(ii)	Linac 4 (i)+(ii) +(iii)	Basic user's request
CNGS flux [$\times 10^{19}$ pot/year]	4.7 (4.5)	7.0 (4.5)	7.5 (4.5)	4.5
FT spills [$\times 10^{5}$ /year]	3.2 (3.4)	3.0 (5.1)	3.2 (5.6)	7.2
E Hall spills [$\times 10^{6}$/year]	2.3	2.3	2.3	2.3
NTOF flux [$\times 10^{19}$ pot/year]	1.7	1.6	1.7	1.5
ISOLDE flux [μA] [no. pulses/hour]	3.0 2126	2.45 1722	6.2 2160	1.9 1350
72 bunch train for LHC at PS exit [$\times 10^{11}$ ppb]	1.5	1.5	2	1.3 (2*)

John Dainton
Villars 2004
October 7th 2004
CERN seminar

Villars 2004

John Dainton
Villars 2004
October 7th 2004
CERN seminar

Villars 2004

1. Framework
2. Machines and Beams
3. Heavy Ions
4. Neutrinos
5. Soft and Hard Protons
6. Antiproton Physics
7. Flavour Physics
8. Other Topics
9. Summary

Note 8/10/04: Overheads are here exactly as presented apart from a small number of bugs which have been fixed, and apart from the inclusion of some overheads skipped in the seminar because of time pressure.

John Dainton
Villars 2004
October 7th 2004
CERN seminar

Charge

- "to review present and future activities and opportunities in fixed-target physics, and to consider possibilities and options for a future fixed target programme at CERN"
  - globally important
  - realistic (beams + resources)
  - short, intermediate, and long term
- from the SPC

SPSC not in approval/rejection mode !

John Dainton
Villars 2004
November 2nd 2004
ECFA BENE @ DESY

CNGS Horizon

- nominal (1999)
  - 2.4×10^{13} *p* /extraction
  - 4.8×10^{13} *p* /cycle
  - 4.5×10^{19} *p* /year

eg 200 days
55% efficiency
LHC MD
LHC fill
FT

- 2nd look (2001)
  - 3.5×10^{13} *p* /extraction
  - 7×10^{13} *p* /cycle
  - X3 ? 13.8×10^{19} *p* /year ?

target rods ?
windows ?
heating: target, horn ?
shielding ?

- R&D underway

NB decommissioning cost
>> construction cost

John Dainton
Villars 2004
October 7th 2004
CERN seminar

SPSC

- ν physics has noble history at CERN
- ν physics is in a new golden era
  - CERN beginning again pivotal global role
- CNGS commitment to ~ end of decade vital
  - 2006 important: COMPASS then CNGS @ end 06
  - CNGS crucial up to 2011 (window @ 4.5×10^{19} pot/yr)
  - CNGS + COMPASS ? multi-turn xtraction
    longer running period
  - no compelling case for extending CNGS beyond 2011 @ realisable pot/yr (< ~ 3x 4.5×10^{19} pot/yr)

C2GT

because

neutrino flavour transitions DO exist

... beyond a reasonable doubt .... SNO

by now, multiple evidence ..

Solar ν deficit no more ....

... it is $\nu_e \rightarrow \nu_{active}$ instead ... appearance!

almost max mix $(\theta_{12} \sim \pi/6)$

$\lambda_{solar} \sim$ 200 Km/1 MeV $(\Delta m_{12}^2 \sim 7.1\ 10^{-5}\ eV^2)$

→ even visible @Japanese reactors

Terrestrial (atmospheric) ν_μ deficit confirmed

.... looks much like $\nu_\mu \rightarrow \nu_\tau$

max mix $(\theta_{23} \sim \pi/4)$

$\lambda_{atmo} \sim 10^4$ Km/1 GeV $(\Delta m_{23}^2 \sim 2\ 10^{-3}\ eV^2)$

NB: thou λ_{solar} surprisingly only ~30 times larger (MSW)

still $\Delta m_{12}^2 << \Delta m_{23}^2 \approxeq \Delta m_{13}^2$

so only 2 wavelenghts exist .... $\lambda_{13} \approxeq \lambda_{23} \equiv \lambda_{atmo}$

The matrix of neutrino transition probability

P_{ee}=1- …..

$P_{e\mu}$=

$P_{e\tau}$=

$P_{\mu e}$ =

$P_{\mu\mu}$=1- …..

$P_{\mu\tau}$=

$P_{\tau e}$ = …….

$P_{\tau\mu}$= …..

$P_{\tau\tau}$=1- …..

The matrix of neutrino transition probability

P_{ee}=1- …..

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

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

J's mixings
Δmass splittings

three, but two

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

$P_{\mu\mu}$=1- …..

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

J CPV phase

$P_{\tau e}$ = …….

$P_{\tau\mu}$= …..

$P_{\tau\tau}$=1- …..

The matrix of neutrino transition probability

Solar (SuperK,SNO)
LBL Reactors (Kamland)

$P_{ee} = 1 - \ldots\ldots$

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

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

$P_{\mu e} = - 4 \ldots$
$- 4 \ldots$
$- 4 \ldots$
$- (\pm 8J\ldots.$

$P_{\mu\mu} = 1 - \ldots\ldots$

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

Atmo
K2K, NuMI, CNGS

T & CP violating term $e^{-i\delta}$
universal

$P_{\tau e} = \ldots\ldots$

$P_{\tau\mu} = \ldots\ldots$

$P_{\tau\tau} = 1 - \ldots\ldots$

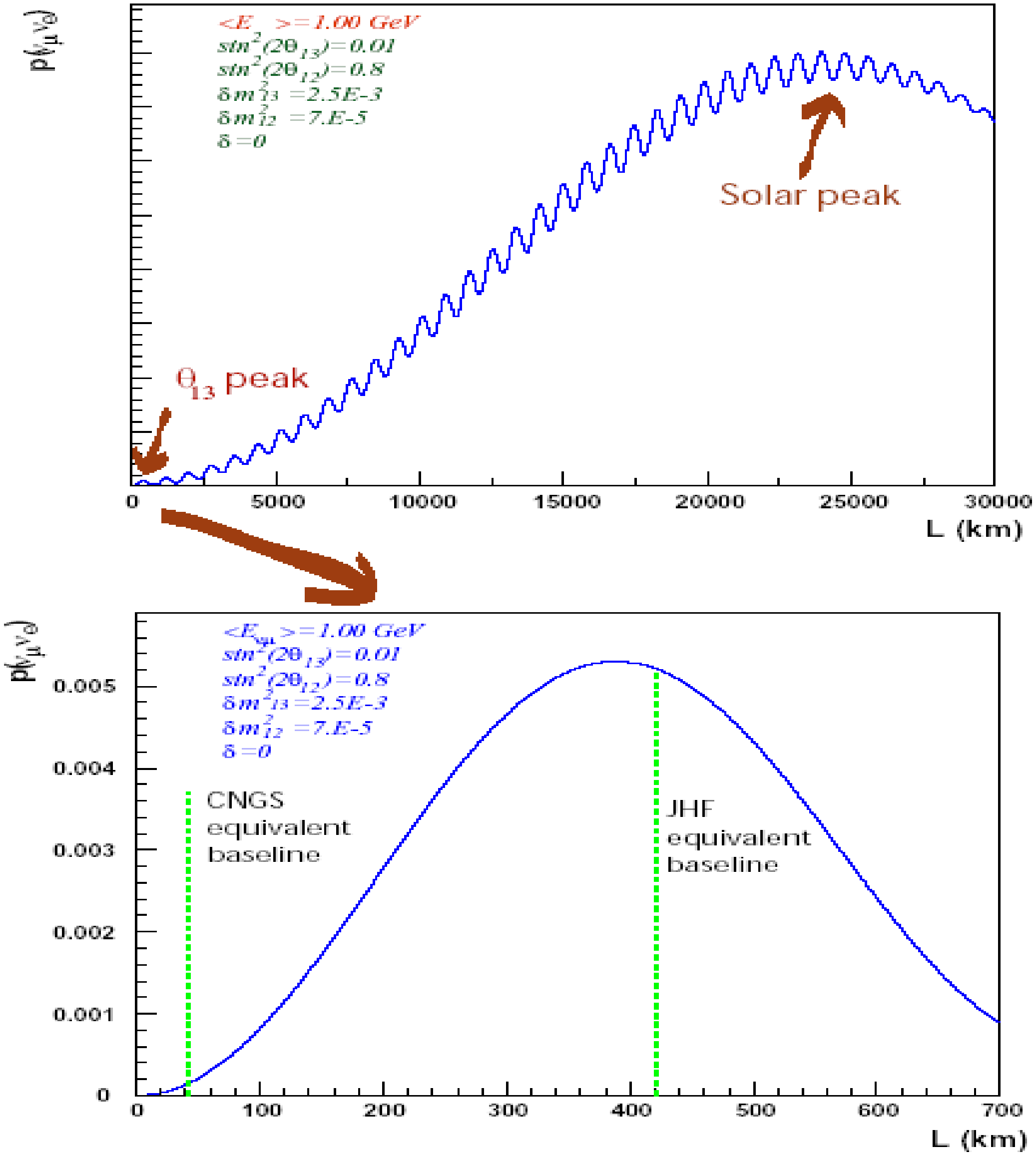
Experiments ahead of us, for decades ……..

Why subleading?

solar $\nu_e \rightarrow \nu_{active}$

terrestrial $\nu_\mu \leftrightarrow \nu_\tau$

$\leftrightarrow \nu_e$



M. Mezzetto, "Introduction to Physics", ENG meeting, CERN, March 26, 2003. . 8

2004: a useful first year of life for BENE

BENE week in February at CERN

The Yellow Report CERN 04-002

BENE week in May at CERN

MMW Workshop 25-27 May

Sign up sheet

The Workshop Report to SPSC

Approval of BetaBeam Design Study, within EURISOL

Nasty cancellation of call for NuFact Design Study

ready for next call and try NEST, meanwhile

SPSC Villars recommends future neutrino initiative 22-28 Sep

BENE04 Workshop today at DESY

Waiting for December: 1) Research Board

2) Scientific Policy Committee

before the CERN Council

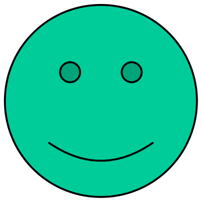
John Dainton
Villars 2004
October 7th 2004
CERN seminar

SPSC

- Future neutrino facilities offer great promise for fundamental discoveries (such as CP violation) in neutrino physics, and a post-LHC construction window may exist for a facility to be sited at CERN.
- CERN should arrange a budget and personnel to enhance its participation in further developing the physics case and the technologies necessary for the realization of such facilities. This would allow CERN to play a significant role in such projects wherever they are sited.
- A high-power proton driver is a main building block of future projects, and is therefore required.
- A direct superbeam from a 2.2 GeV SPL does not appear to be the most attractive option for a future CERN neutrino experiment as it does not produce a significant advance on T2K.
- We welcome the effort, partly funded by the EU, concerned with the conceptual design of a β-beam. At the same time CERN should support the European neutrino factory initiative in its conceptual design.

2004 <u>may</u> have brought us

a Betabeam Design Study



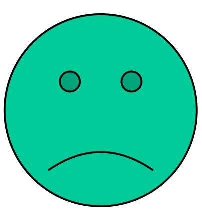
a construction window 2010-20?

budget & personnel ?

recognition of MMW driver?

Will know only if we <u>keep initiative in 2005</u> & beyond

2004 <u>did not</u> bring us



a NuFact & SuperBeam Design Study

earliest possible start 2007

can ESGARD help?

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 …. a question

LHC (& upgrade)
will be the first priority

Next HE project .. CLIC

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

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

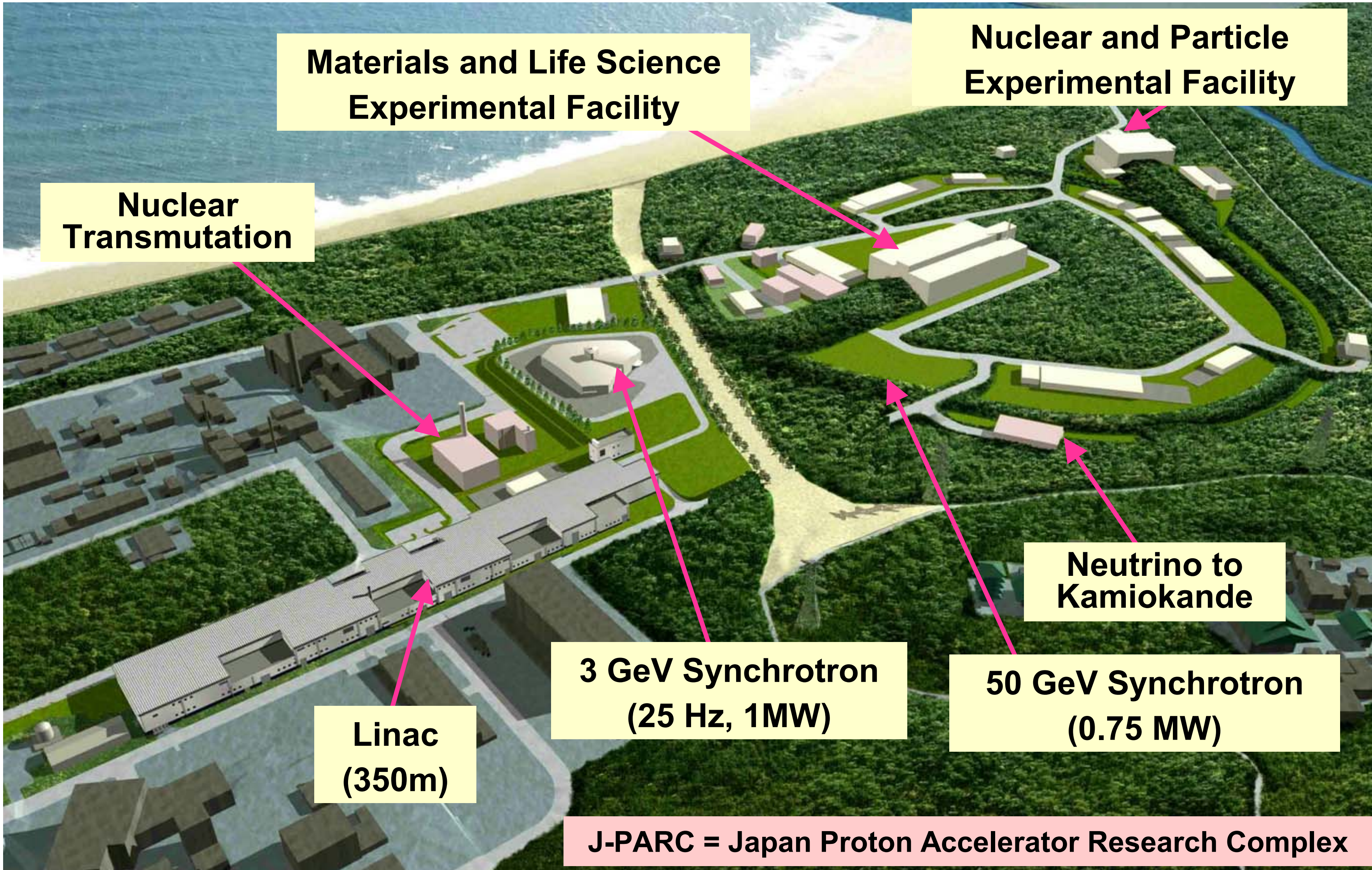
hadronic physics and more (see Bettoni)

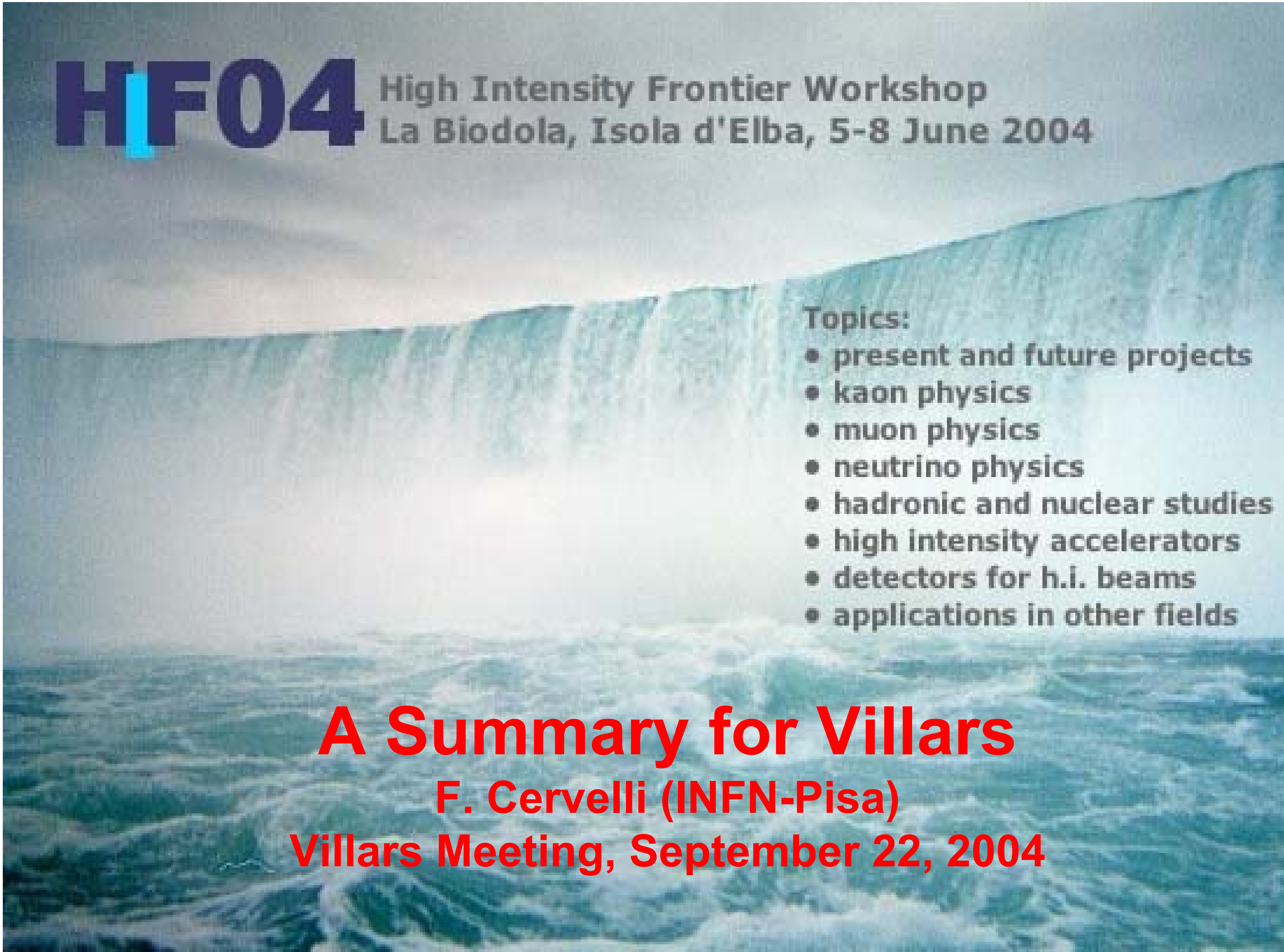
Peer review process starting

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

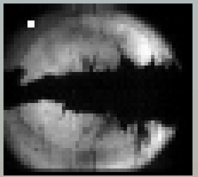
PHYSICS

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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BENE+EURISOL

Local Organizing Committee:
M. Benedikt (CERN), A. Blondel, P.Butler (co-chair),
L. Ghilardi (CERN), G. Giudice (CERN),
E. Gschwendtner (Geneva), M. Lindroos,
V. Palladino (co-chair), M. Vretenar (CERN)

EURISOL

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

Physics with Megawatt

- Long-range programme in ν physics:
  superbeam, β beam, ν factory

unique and compelling

- 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

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

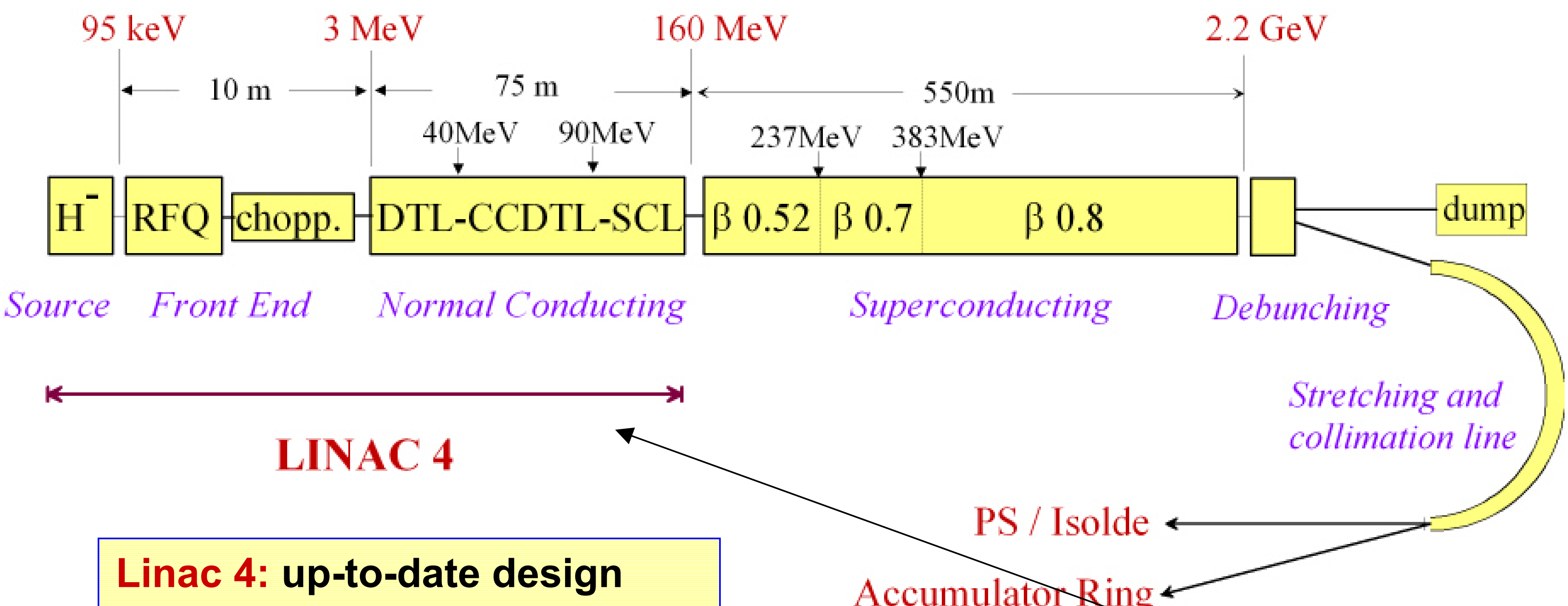
New EU Neutrino Complex?

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

"SPL workshop" ?

SPL block diagram (CDR 1)

being built



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

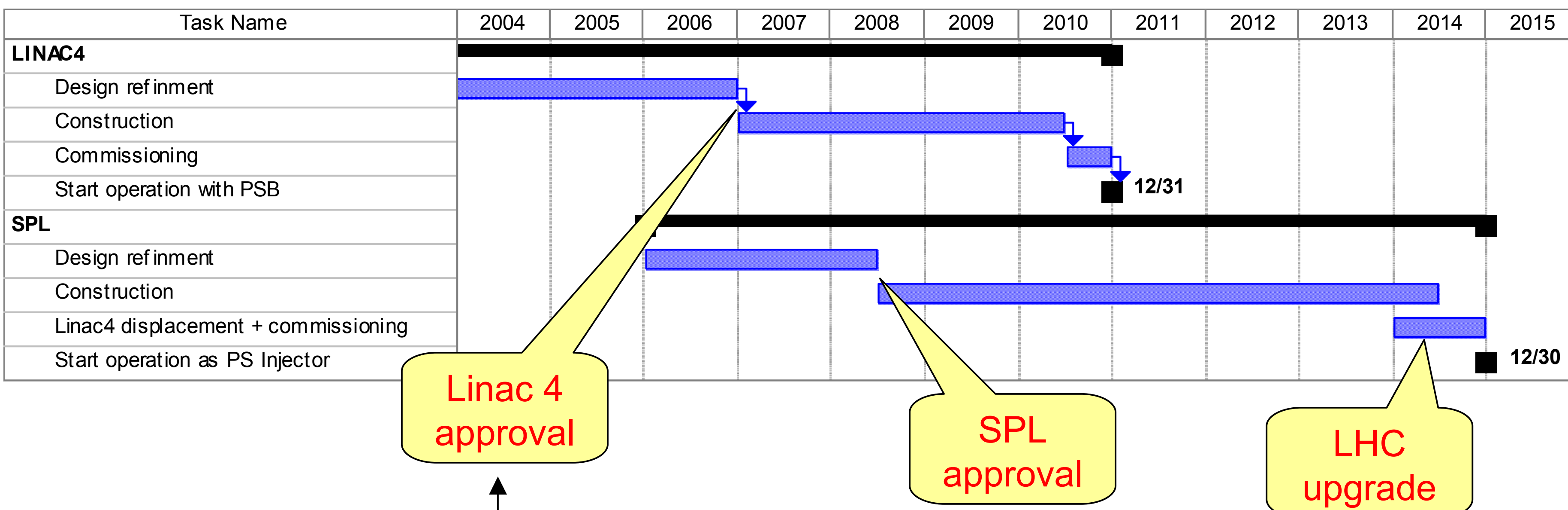
HIPPI is its R&D !

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)*



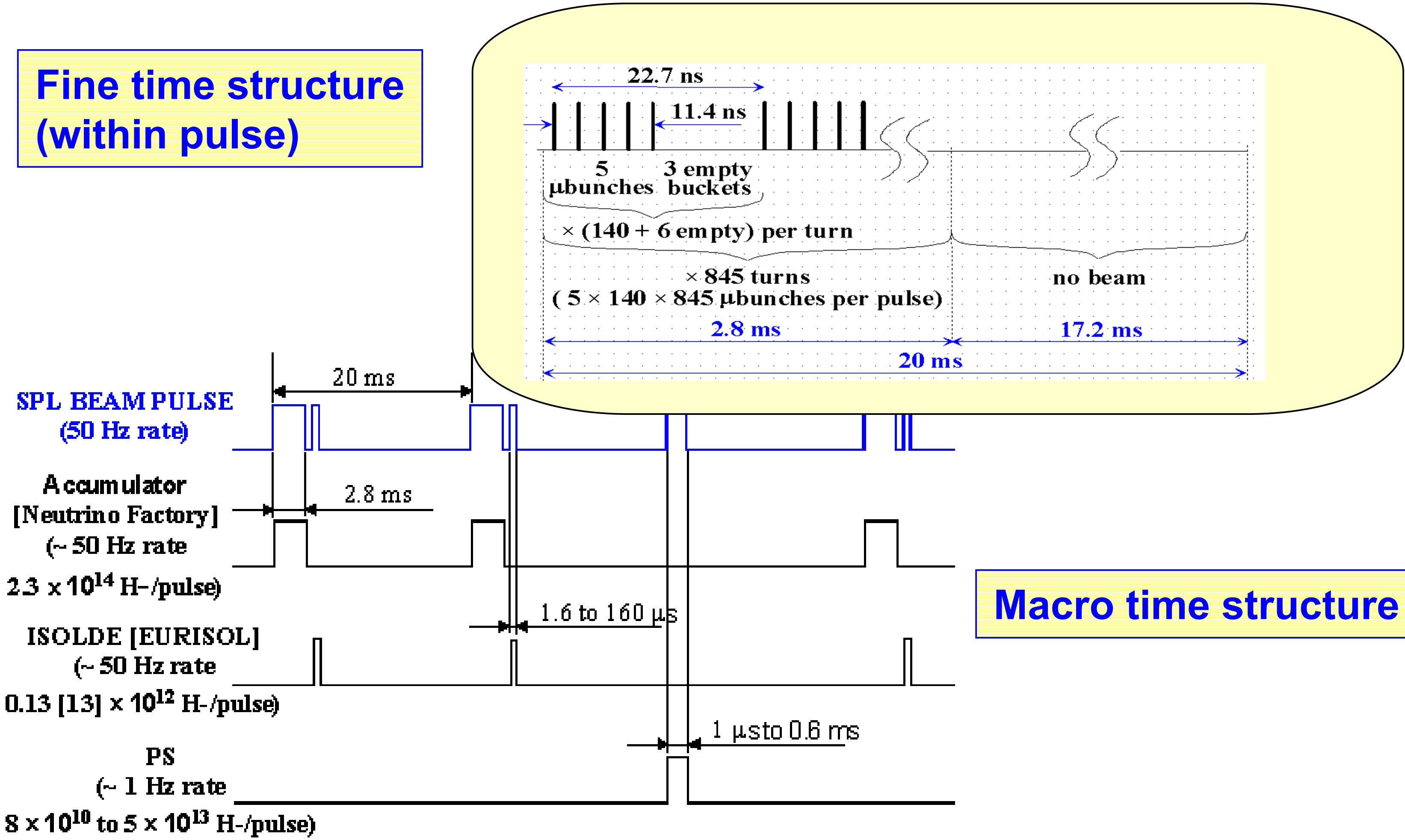
“Physics at SPL” Workshop, late May 04 **in view of Cogne IX Sep 04**

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)

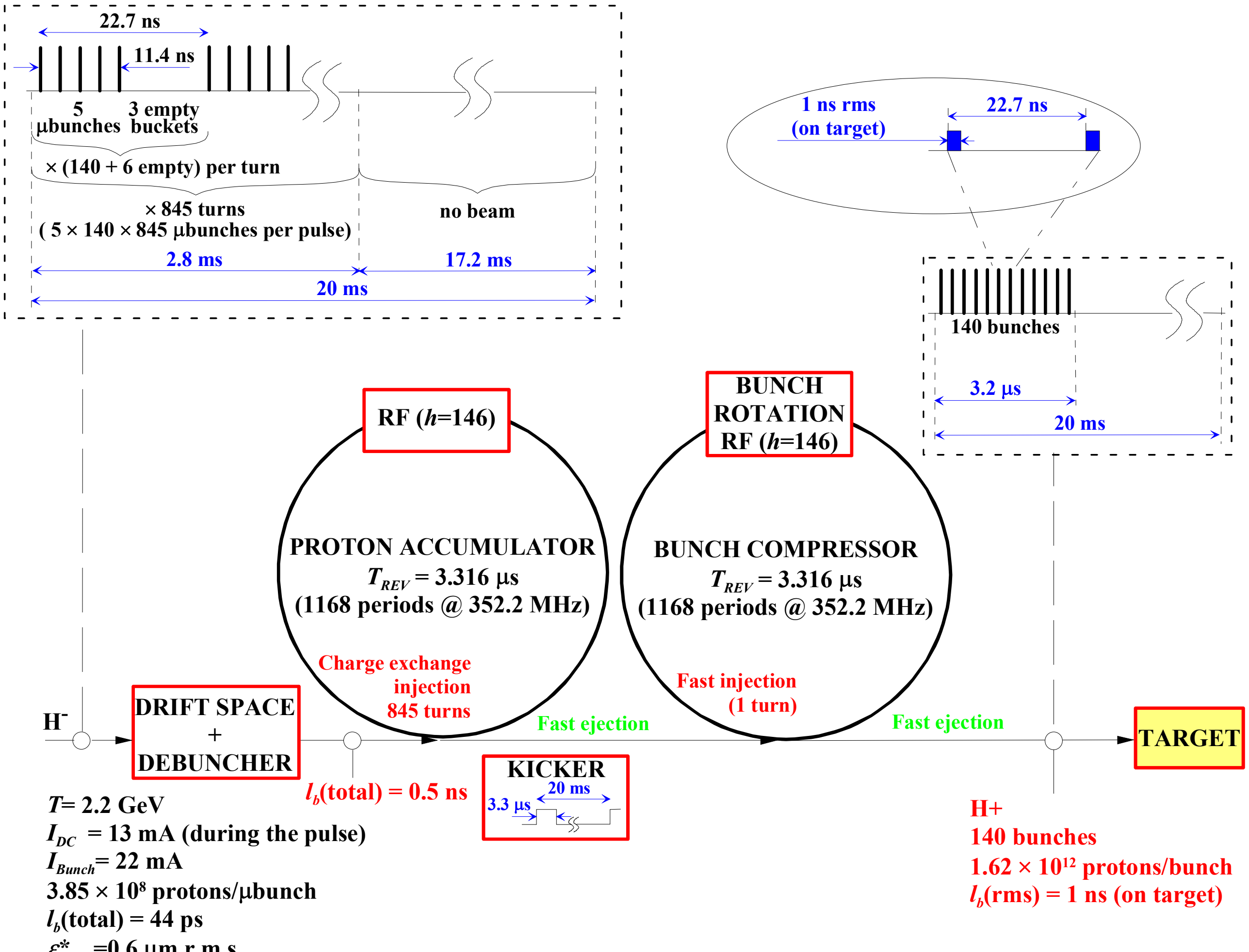


SPL acceleration systems (CDR 1)

W A R M – C O L D

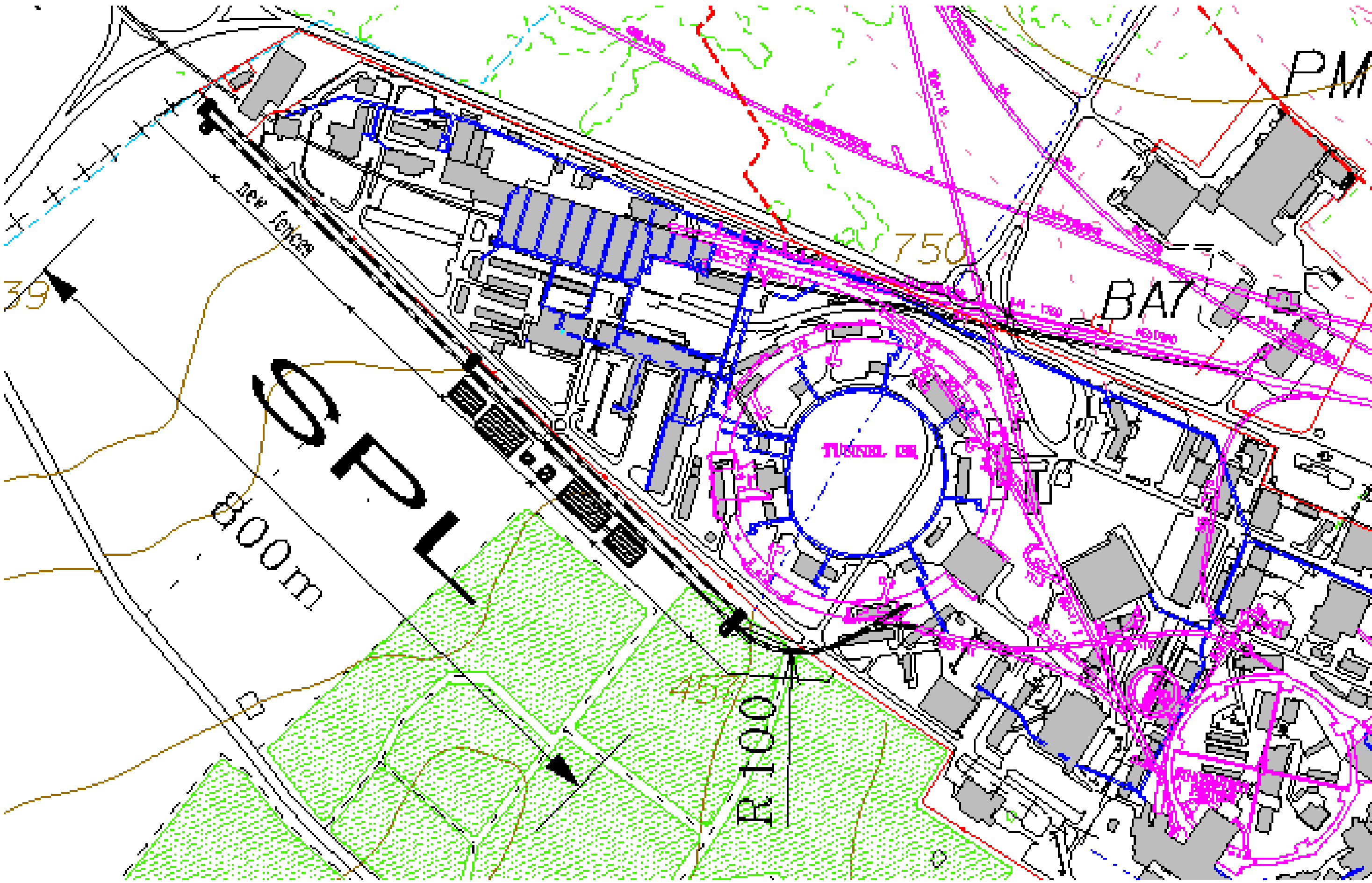
Section	Input energy (MeV)	Output energy (MeV)	Nb. of cavities	Peak RF power (MW)	Nb. of klystrons	Nb. of tetrodes	Nb. of Quads	Length (m)
LEBT	-	0.095	-	-	-	-	-	2
RFQ	0.095	3	1	0.9	1	-	-	6
Chopper line	3	3	3	0.1	-	3	6	3.7
DTL	3	40	3	4.1	5	-	111	16.7
CCDTL	40	90	27	4.8	6	-	28	30.1
SCL	90	160	20	12.6	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

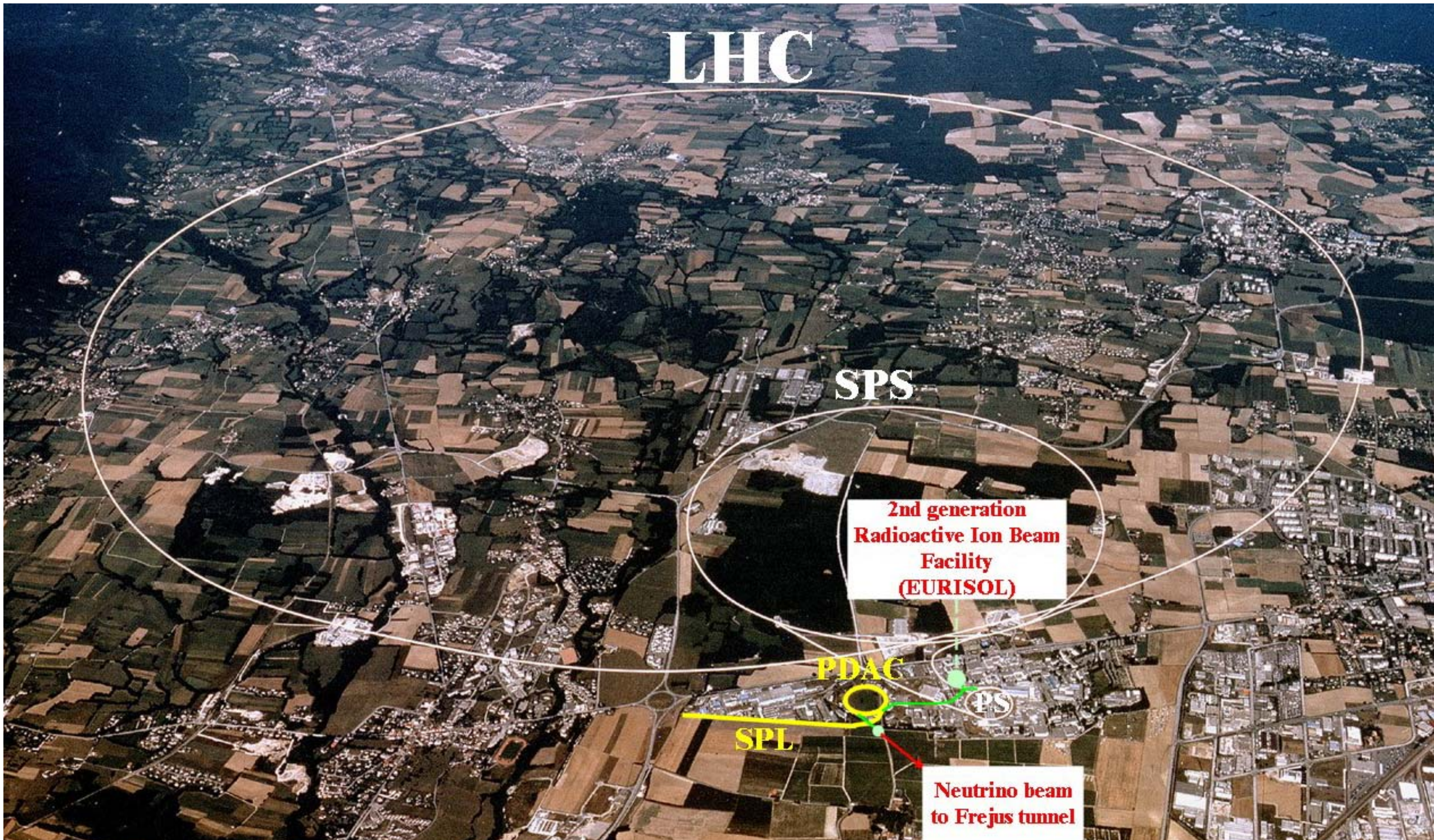


Parameter	Value	Unit
Mean beam power	4	MW
Kinetic energy	2.2	GeV
Repetiton rate	50	Hz
Pulse duration	3.3	μs
Number of bunches	140	
Pulse intensity	2.27 $\times 10^{14}$	p/pulse
Bunch spacing (Bunch frequency)	22.7 (44)	ns (MHz)
Bunch length (σ)	1	ns
Relative momentum spread (σ)	5×10^{-3}	
Norm. horizontal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

Layout (CDR 1)



SPL on the CERN site



Physics with a MMW proton source
CERN, 25-27 May

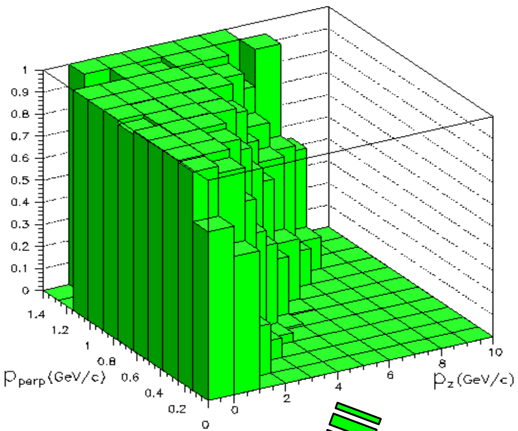
"SPL workshop" ? …….. not in the intentions
more in practice
as 4MW SPL CDR I exists,
no MMW RCS is as advanced

"SPL workshop ………… in a way, as a general approach

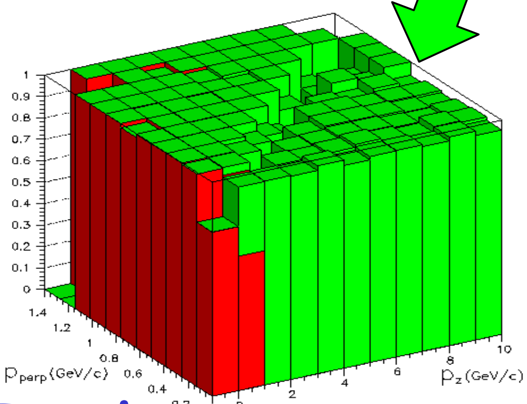
E_p no higher than necessary
just as high max/proton
as many p as possible … MMW !!!!

Max means here max number of ν parents

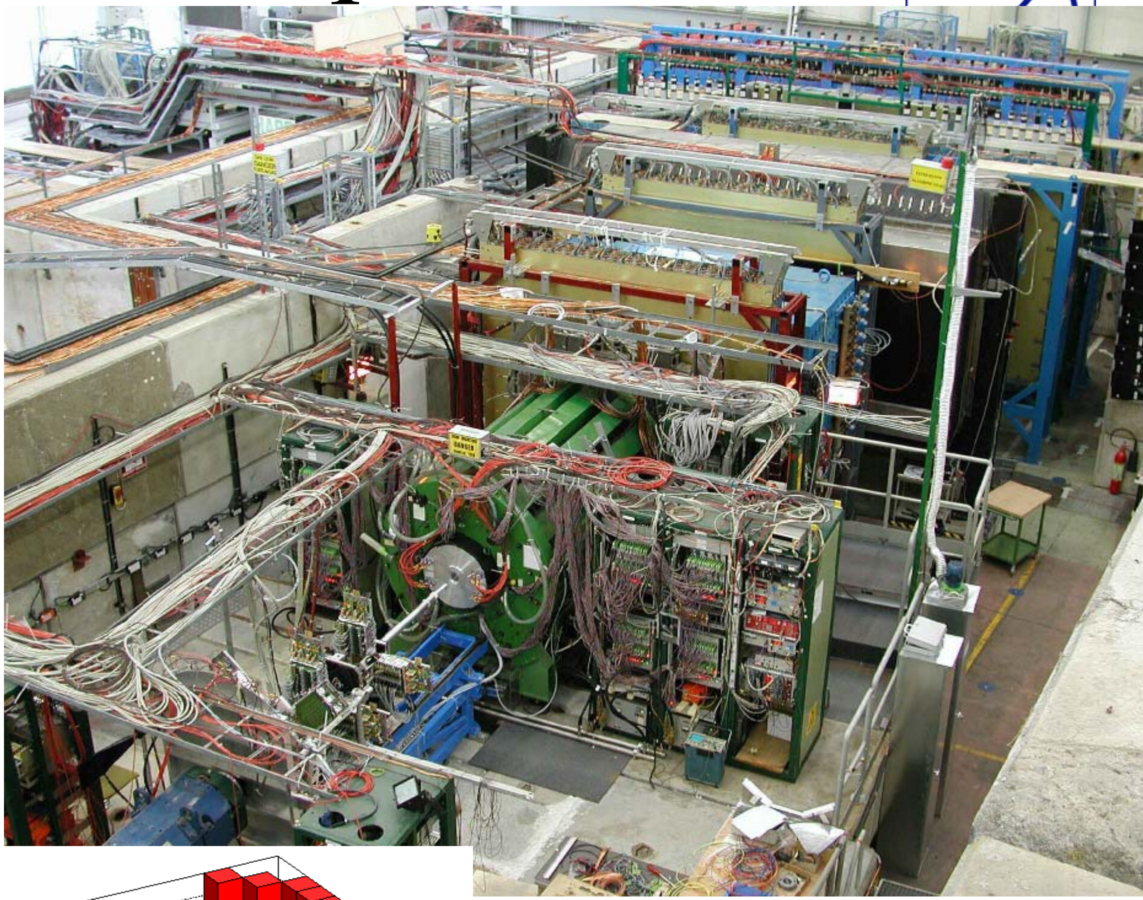
The HARP experiment

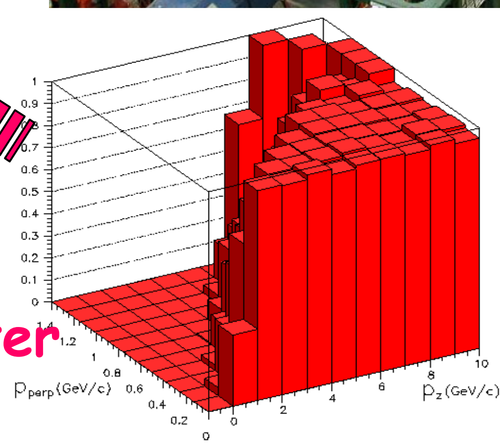


TPC



Total Acceptance





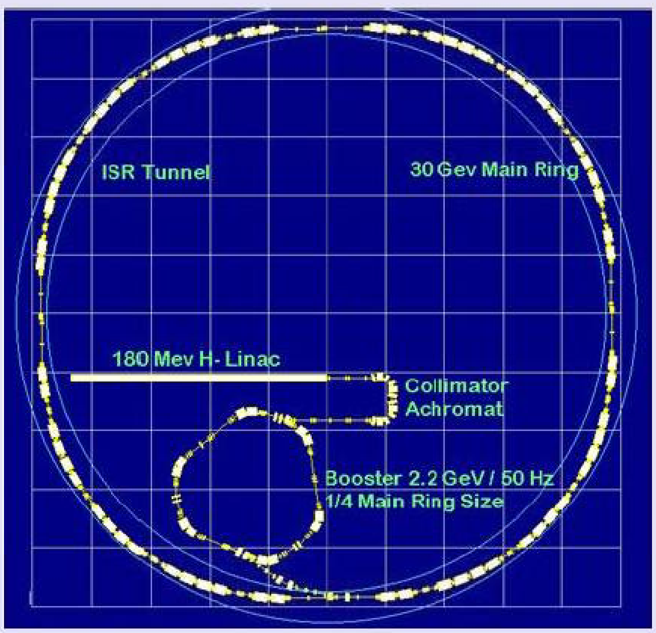
Forward Spectrometer

Scan
CERN PS
energy range
… RCS is an option

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

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

order 50 Ktons
LNGS !
new lab ?

manipulate & accelerate ν parents !

(& μ accelerator complex!)

needs Large Magnetic Detector

(SuperMINOS, Li-Ar in B)

BetaBeam β storage ring ... pure ν_e

(& EU accelerator complex)

100-1000 Ktons
ie new lab

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

the same as p-decay detectors

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** $\approx E^{3} \sin^{2}(L/E) / / L^{2}$

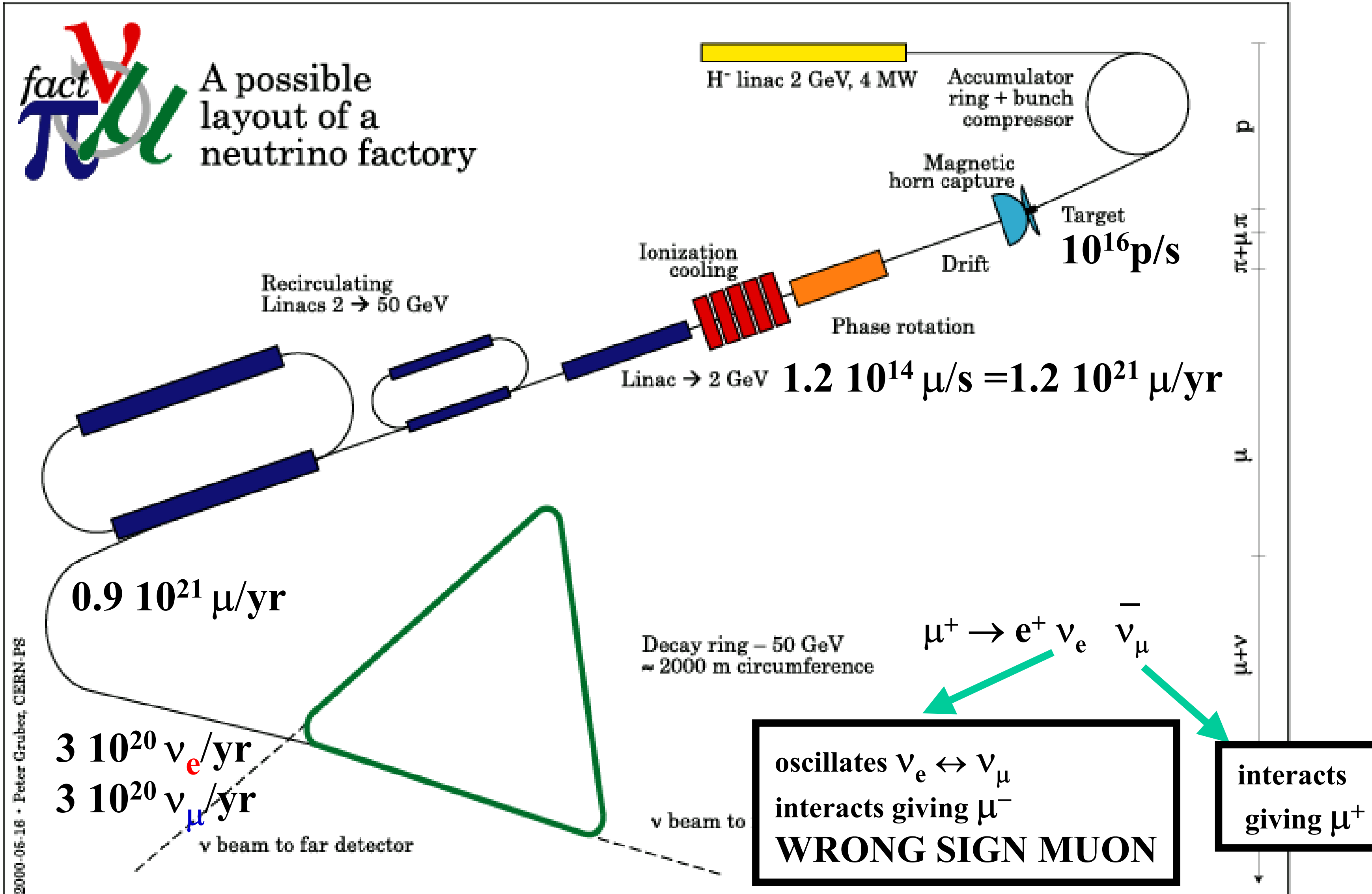
ν/parent grows very rapidly with E_{parent}

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

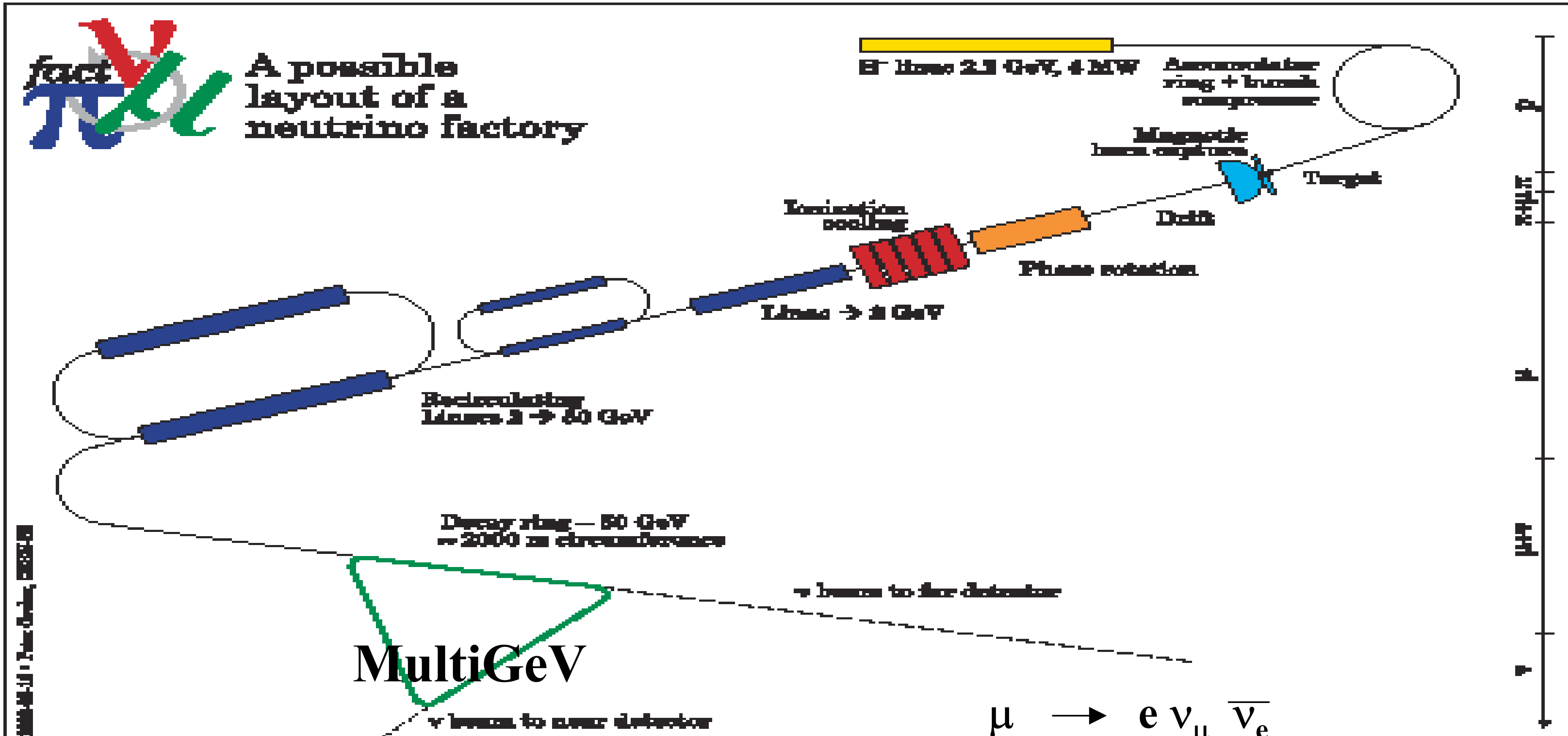
2) low E has independent merits **no matter effects**

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		
$\bar{\nu}_e \rightarrow \bar{e}$ deficit	$\nu_\mu \rightarrow \nu_e \rightarrow e$ excess	$\bar{\nu}_e \rightarrow \bar{\nu}_\mu \rightarrow \bar{\mu}$ excess	Golden	!
$\nu_\mu \rightarrow \mu$ deficit	$\nu_\tau \rightarrow \tau$ excess	$\nu_\tau \rightarrow \bar{\tau}$ 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

$P_{\tau e}$ = …….

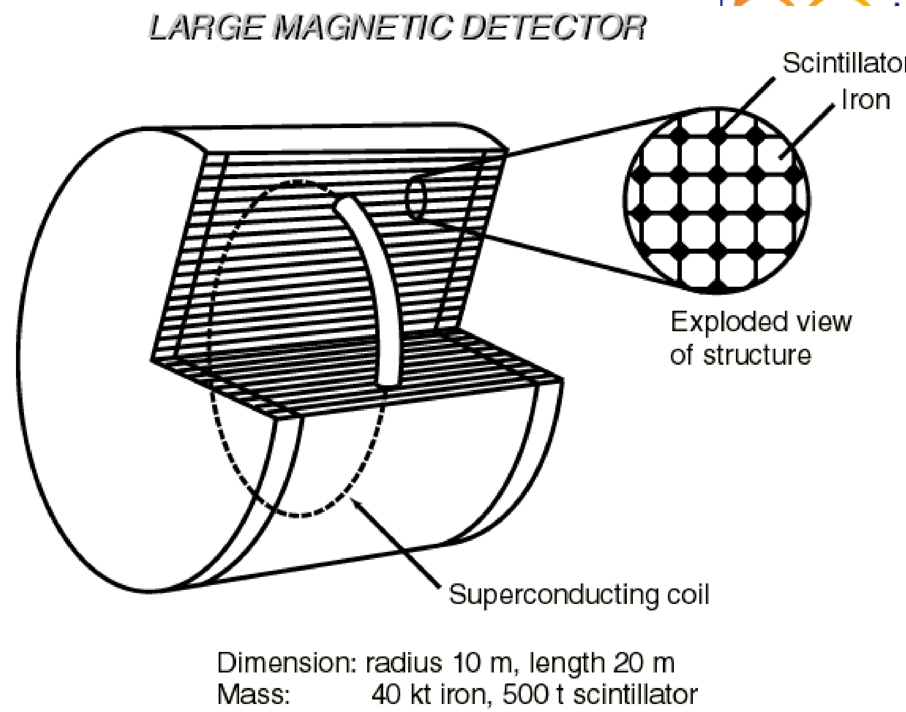
$P_{\tau\mu}$= …..

$P_{\tau\tau}$=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 θ_{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

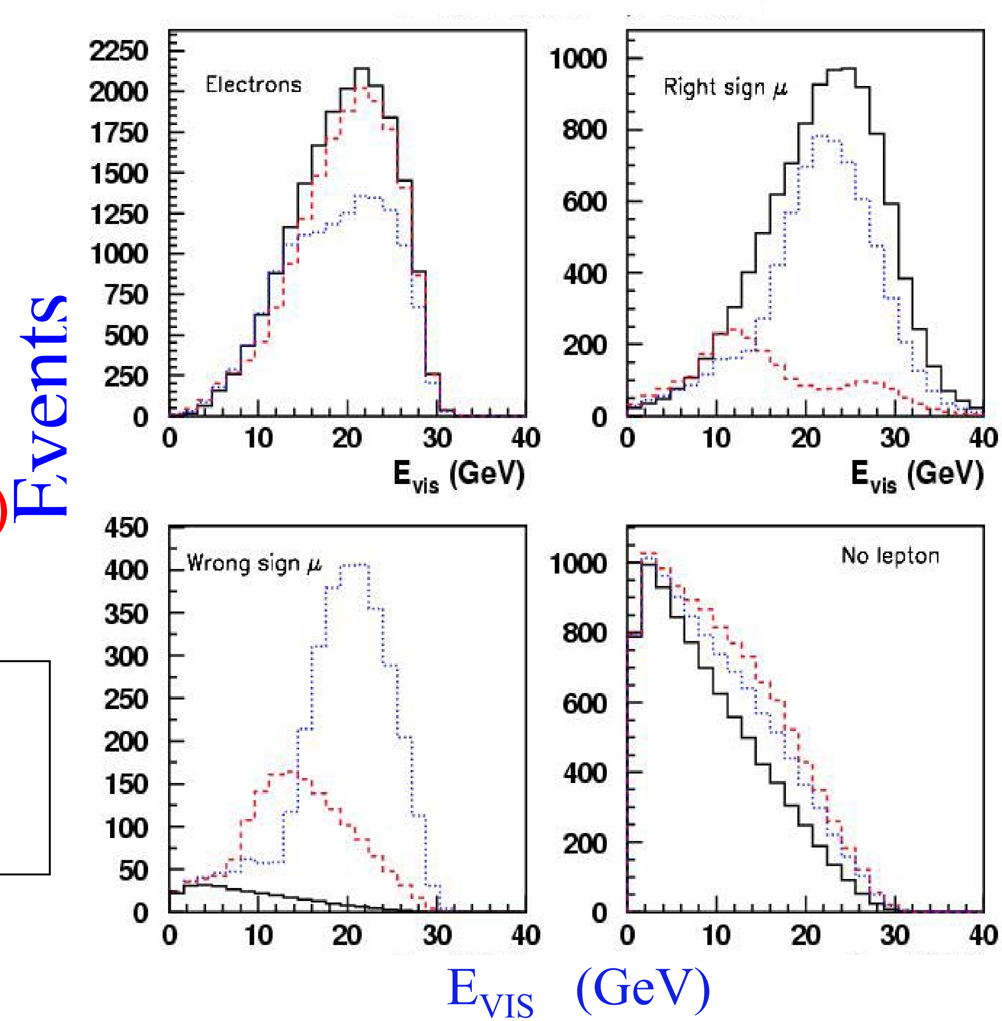
CF ν_e signal at J-PARC =40

Oscillation parameters can be extracted using energy distributions

- 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)

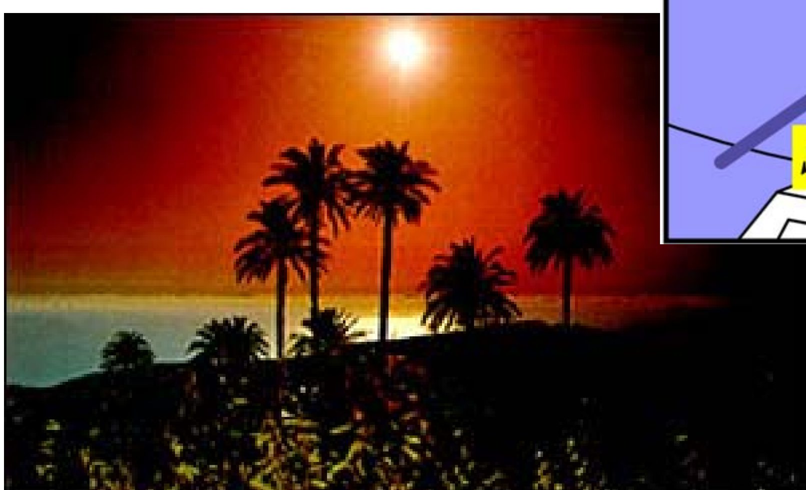
Simulated distributions for a 10kt LAr detector at L = 7400 km from a 30 GeV nu-factory with 10^{21} μ^+ decays.



Bueno, Campanelli, Rubbia; hep-ph/0005007

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

Old and new european underground laboratories



Cost Savings

- Not practical to do a bottom-up costing of our new design so we scaled from FS2
  - we have done well with the major cost items, but savings on the lesser items are not yet exploited
  - these are hardware-only costs (no ED&I, burden, escalation, contingency)

	All ($M)	No PD ($M)	No PD & Tgt. ($M)
FS2	1832	1641	1538
FS2a-scaled (%)	67	63	60

Why These Choices?

- Areas selected could markedly reduce facility cost
  - RF bunching and phase rotation section shorter than induction linac version, and uses less expensive components
    - original version took 25% of total cost
    - new scheme keeps both μ^- and μ^+ simultaneously
  - RLAs were major cost (23%) of Study II design
    - large aperture FFAG magnets accommodate energy swing without need for separate arcs
      - avoids large-aperture splitter-recombiner magnets
  - increased acceptance downstream should allow reduction in cooling requirements (20% of facility cost)
- Note that replacement systems are not free!

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

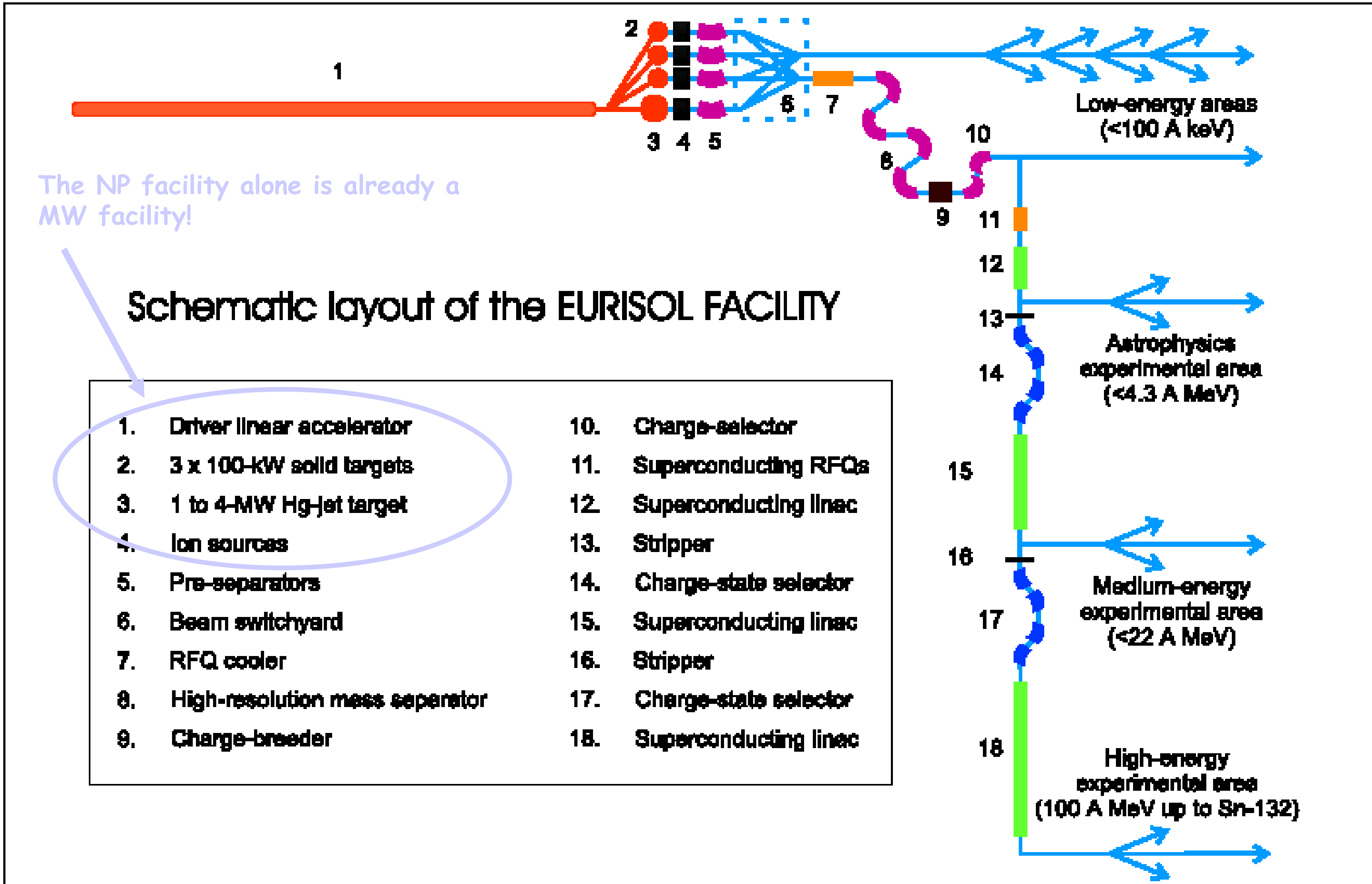
new management taking office at CERN

→ **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.

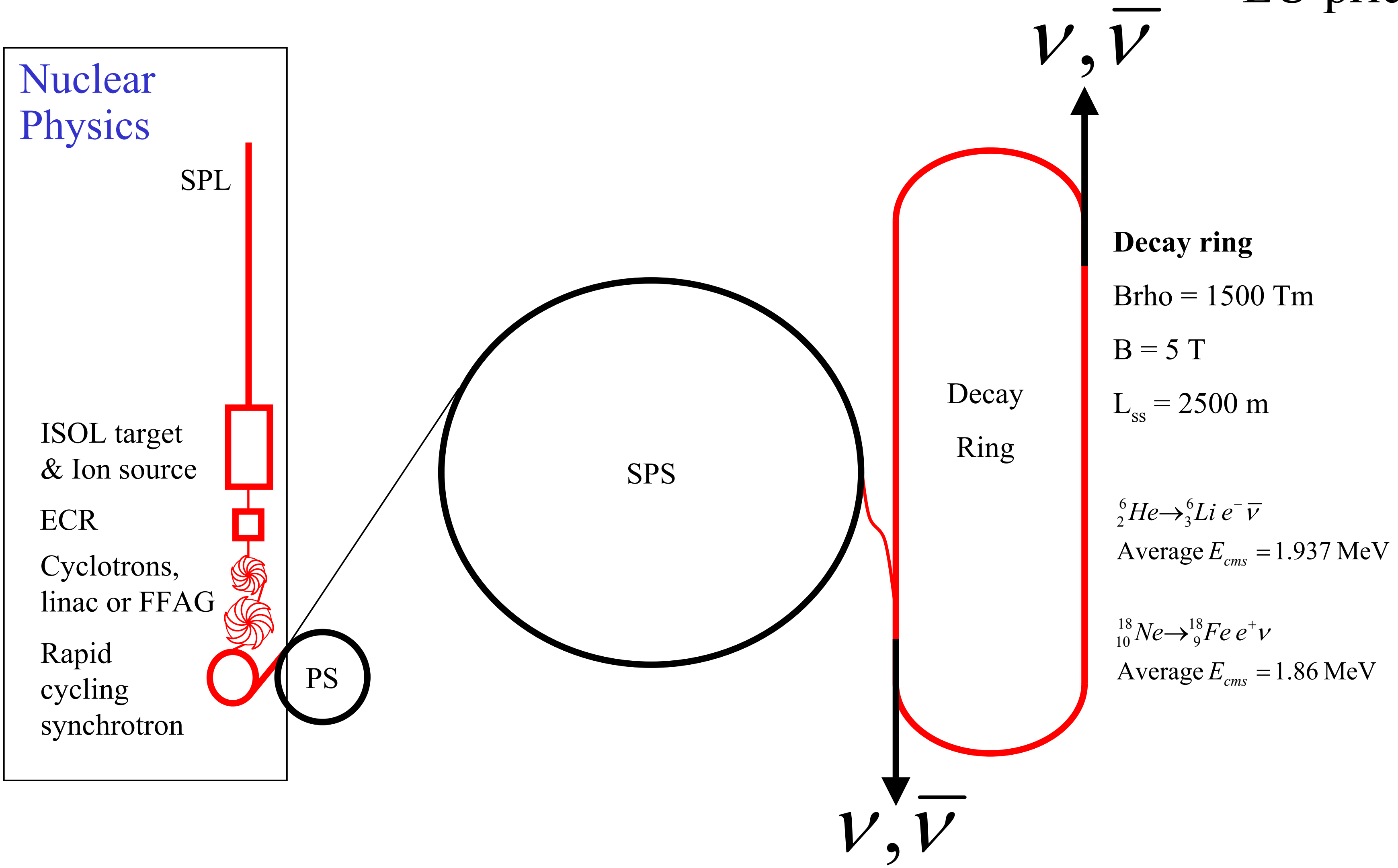
1. Proton Accelerator (Alberto Facco, INFN-LNL)
2. Heavy-Ion Accelerator (MH. Moscatello, GANIL)
3. Cryomodule Development (S. Bousson, IPNO)
4. Direct Target/Ion Source (J. Lettry, CERN)
5. Solid Converter-Target/Ion Source (L. Tecchio, INFN-LNL)
6. Liquid-Metal Target/Ion Source (F. Groeschel, PSI)
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)

BENE WP5c

≈1 MEuros out of ≈ 10

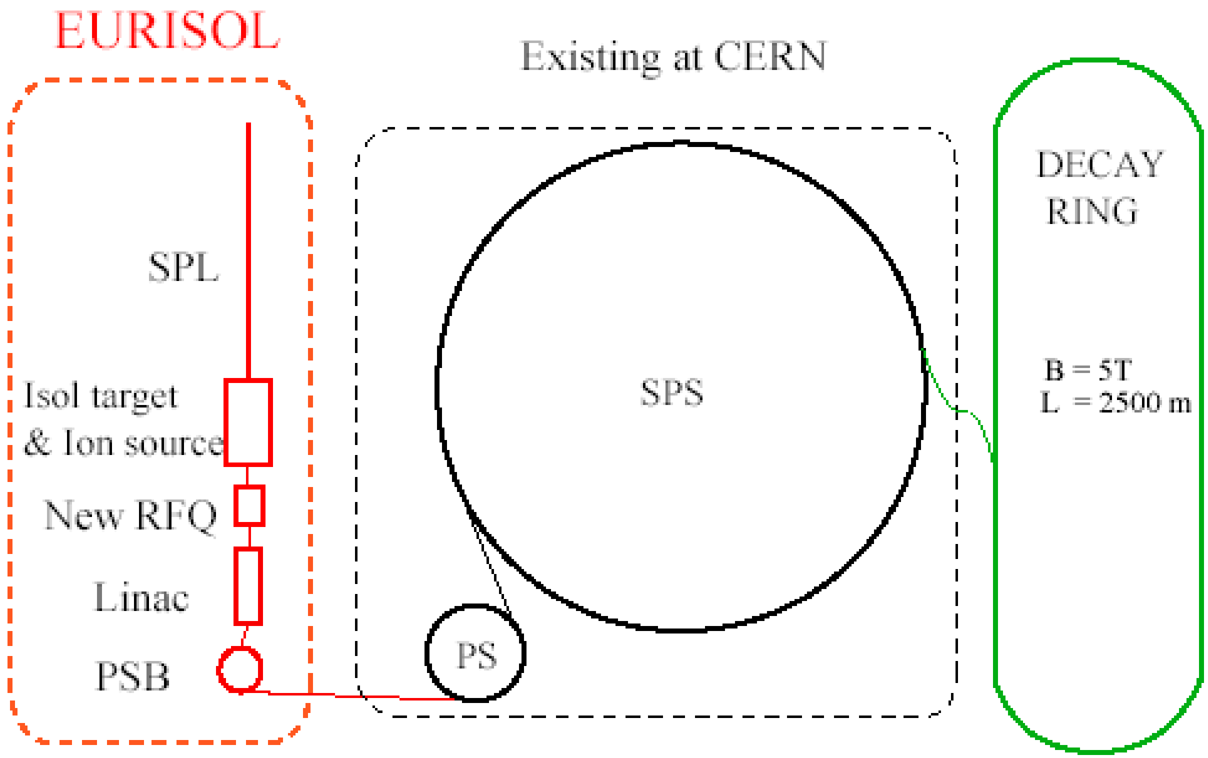
CERN: β-beam baseline scenario

EU pride



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:

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

M. Mezzetto, "Beta Beams", Villars, September 24 2004. 9

Target values for the decay ring

^{6}Helium^{2+}

- In Decay ring: 1.0×10^{14} ions
- Energy: 139 GeV/u
- Rel. gamma: 150
- Rigidity: 1500 Tm

^{18}Neon^{10+} (single target)

- In decay ring: 4.5×10^{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

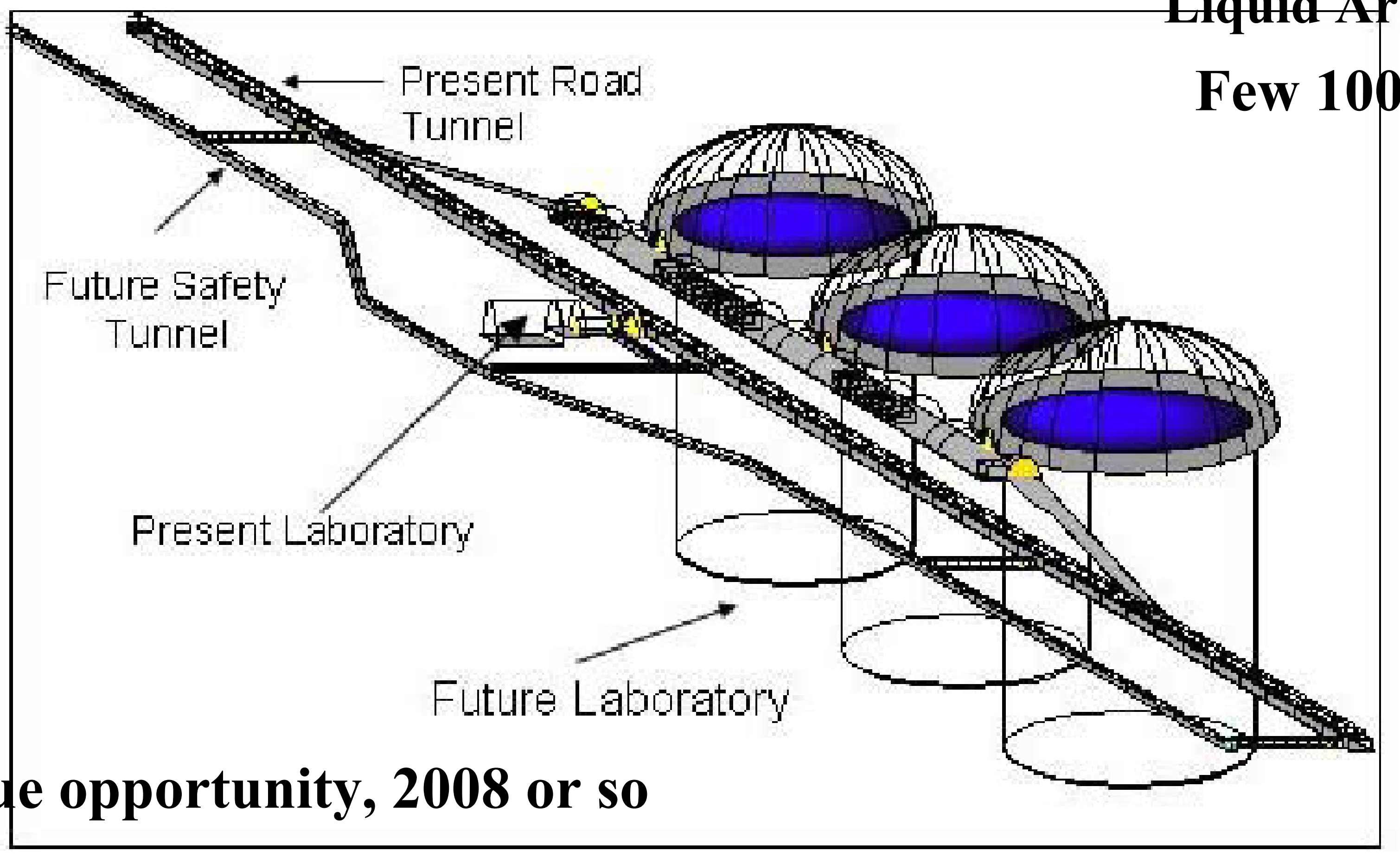
Astroparticle Observatory
N decay
S-Novae
atmo ν

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

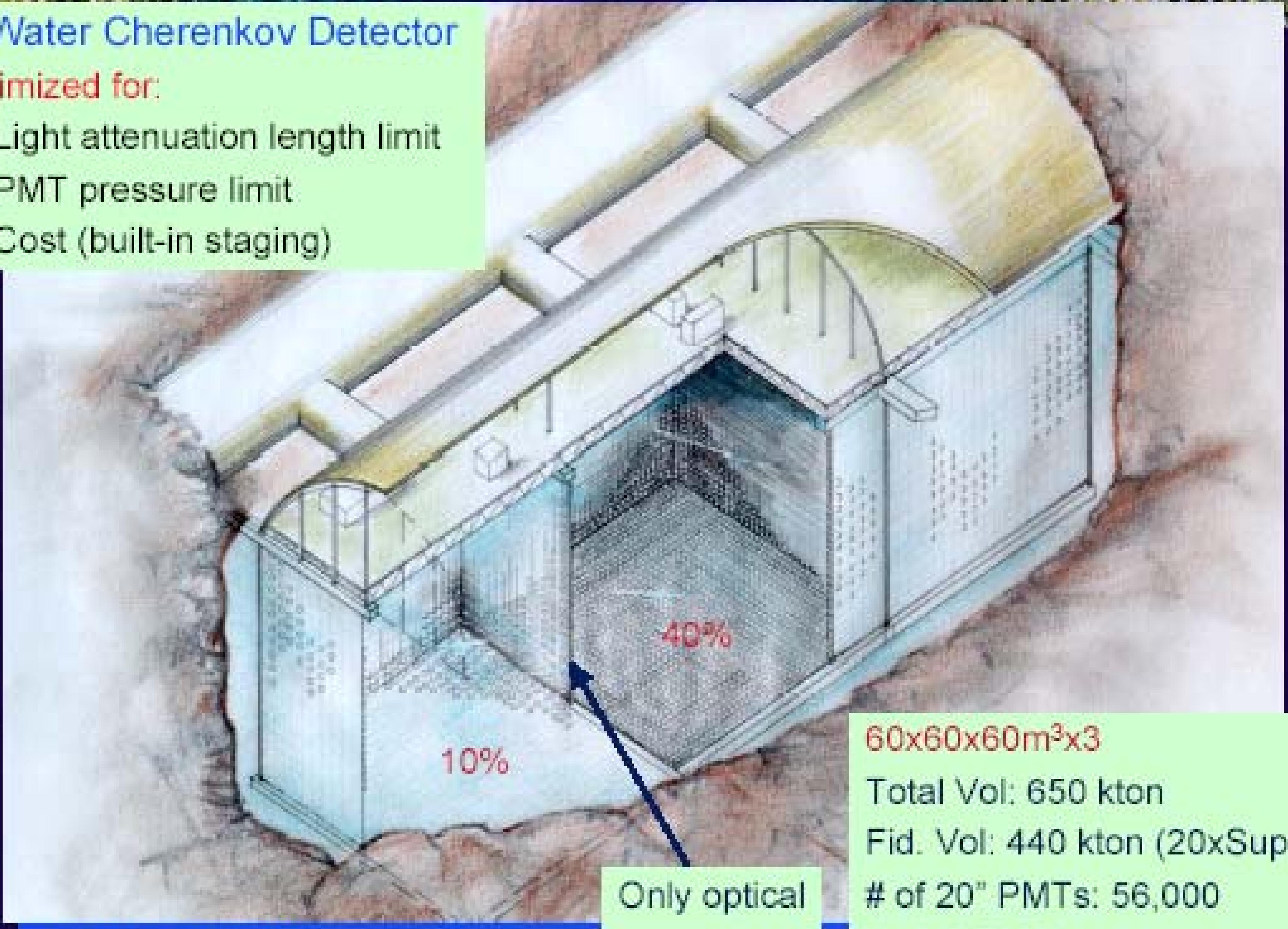
Figure 2: *Proposal for a new excavation in the Fréjus tunnel* .

UNO Detector Conceptual Design

A Water Cherenkov Detector

optimized for:

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



Only optical separation

60x60x60m³x3

Total Vol: 650 kton

Fid. Vol: 440 kton (20xSuperK)

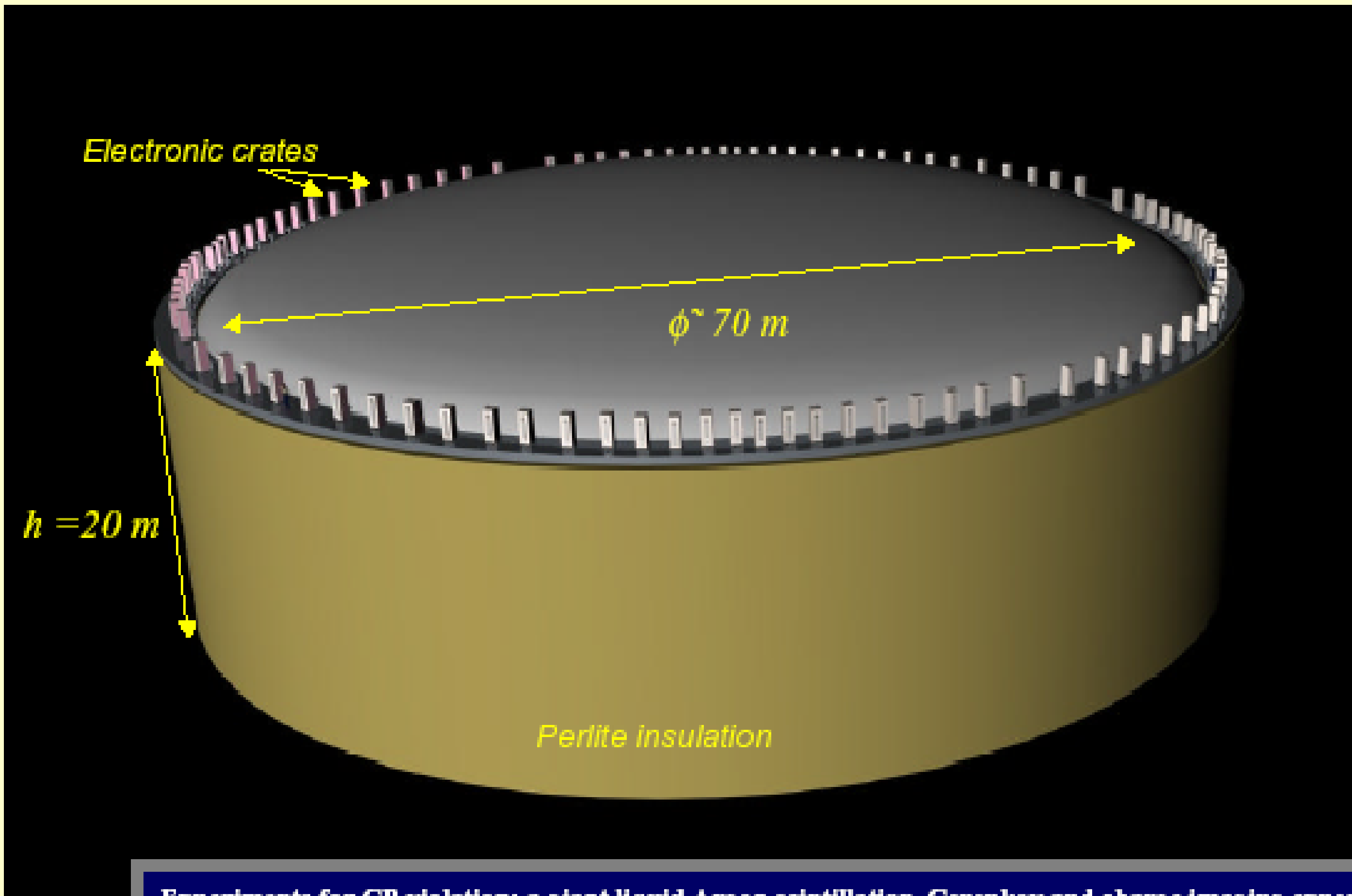
# of 20" PMTs: 56,000

# of 8" PMTs: 14,900

Detectors ….. again UNO/HyperK

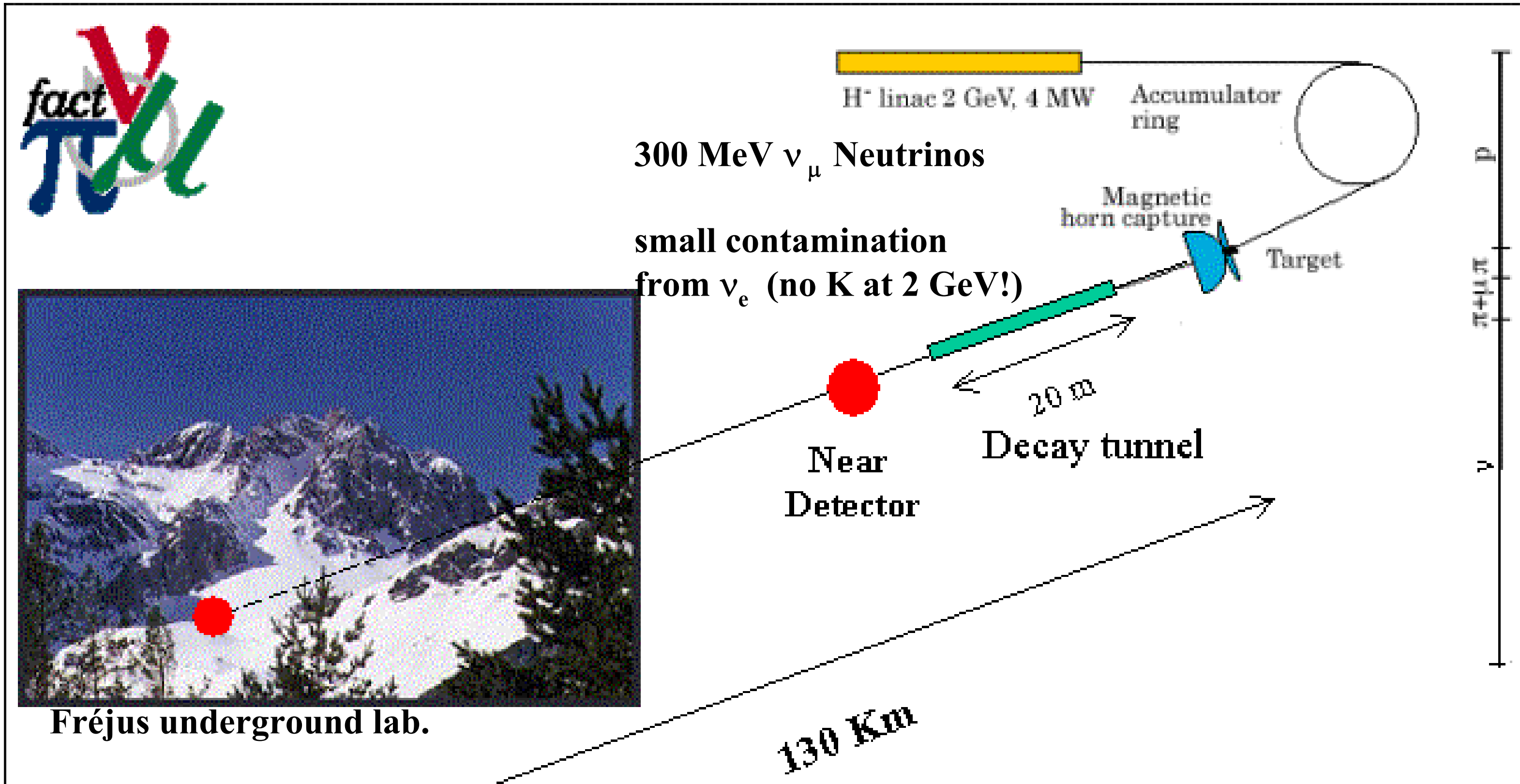
but also

100 kton liquid Argon TPC detector



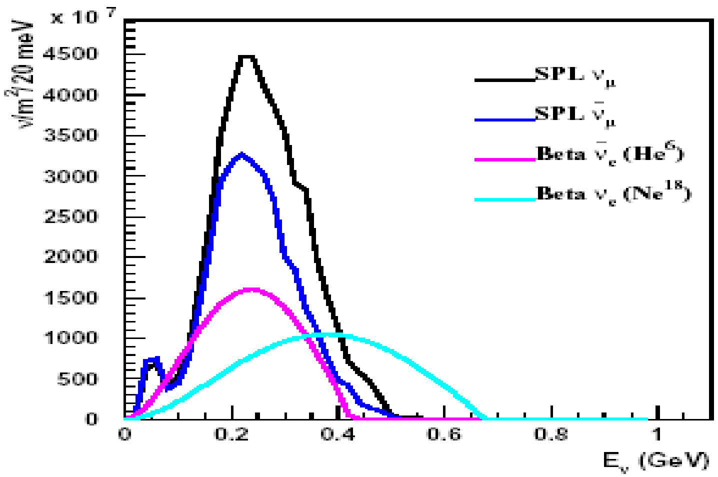
Experiments for CP violation: a giant liquid Argon scintillation, Cerenkov and charge imaging experiment.
A.Rubbia, Proc. II Int. Workshop on Neutrinos in Venice, 2003, hep-ph/0402110

Same detectors as Superbeam !

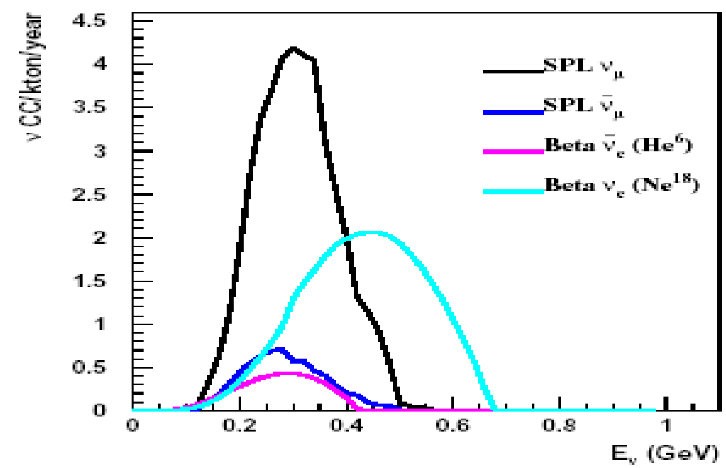


A large underground water Cerenkov (400 kton) UNO/HyperK or/and a large L.Arg detector.
also : proton decay search, supernovae events solar and atmospheric neutrinos. Performance similar to J-PARC II
There is a window of opportunity for digging the cavern stating in 2008 (safety tunnel in Frejus)

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
ν_e $(\gamma = 100)$	$1.88 \cdot 10^{11}$	0.36	32.9	0.43	10	144783

M. 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 $\delta = 0$.

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

$A_{\not{CPT}}$ **both asymmetries**

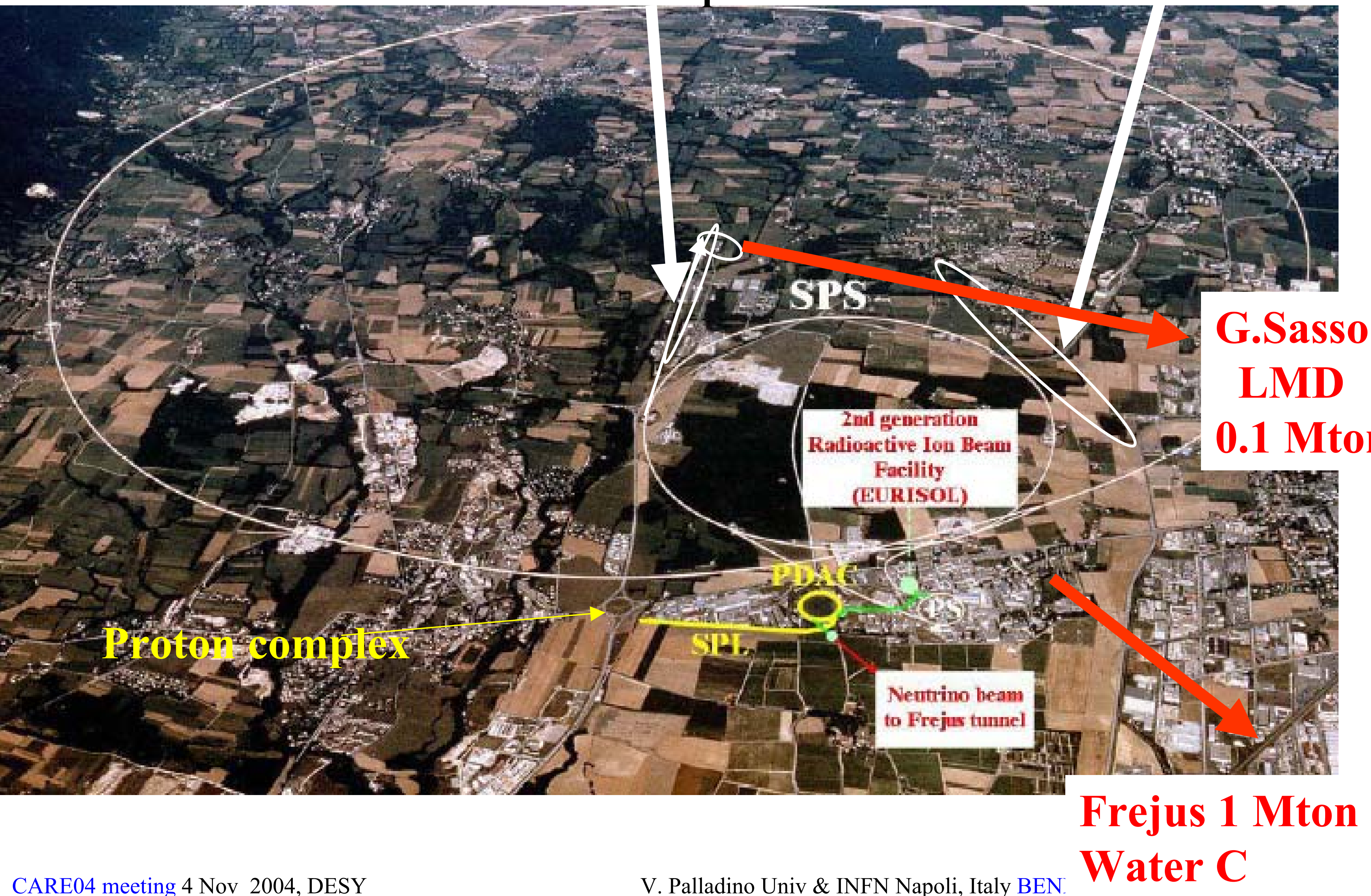
Betabeam +

Superbeam

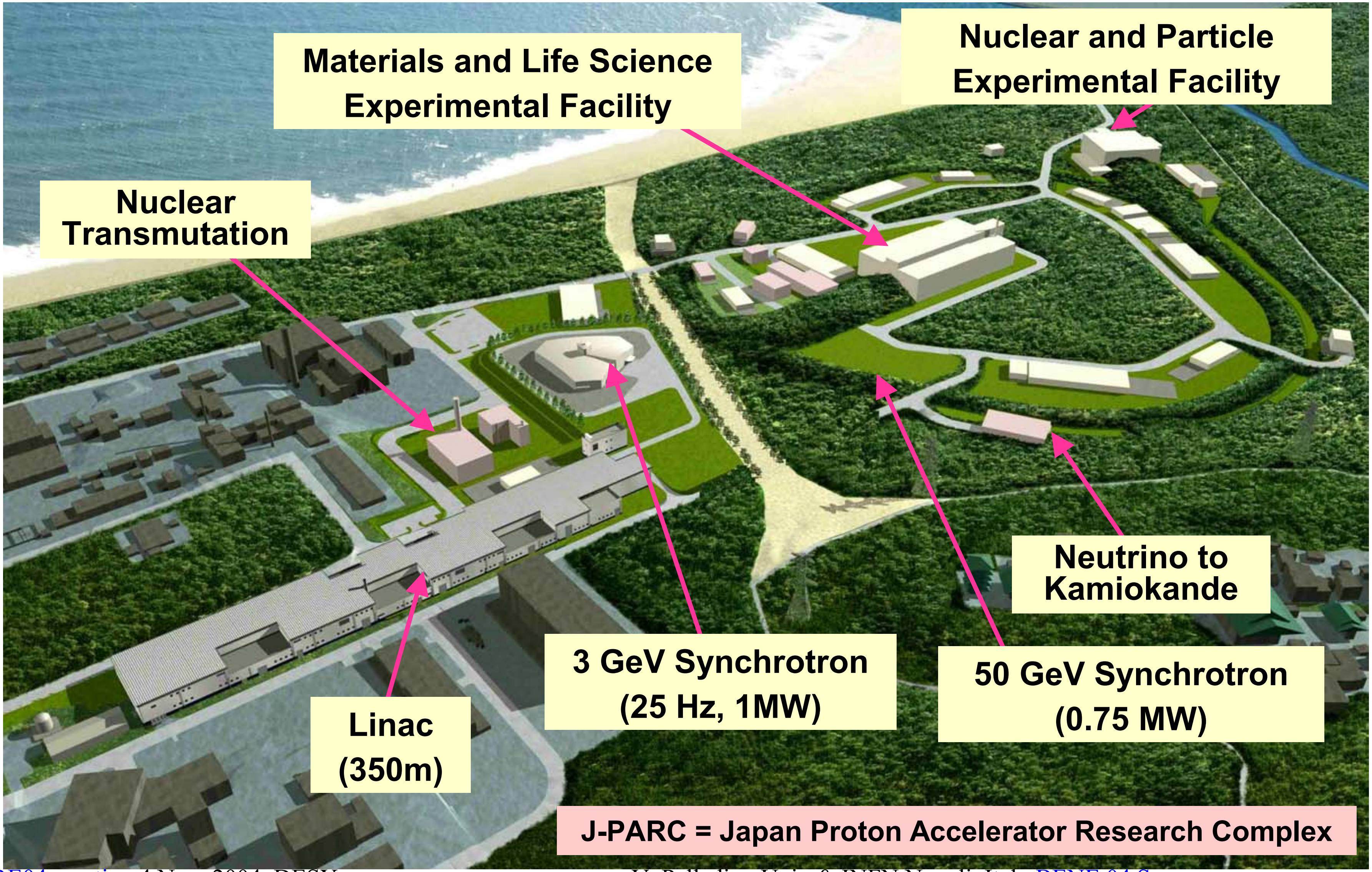
All of great interest!

EU Neutrino Complex

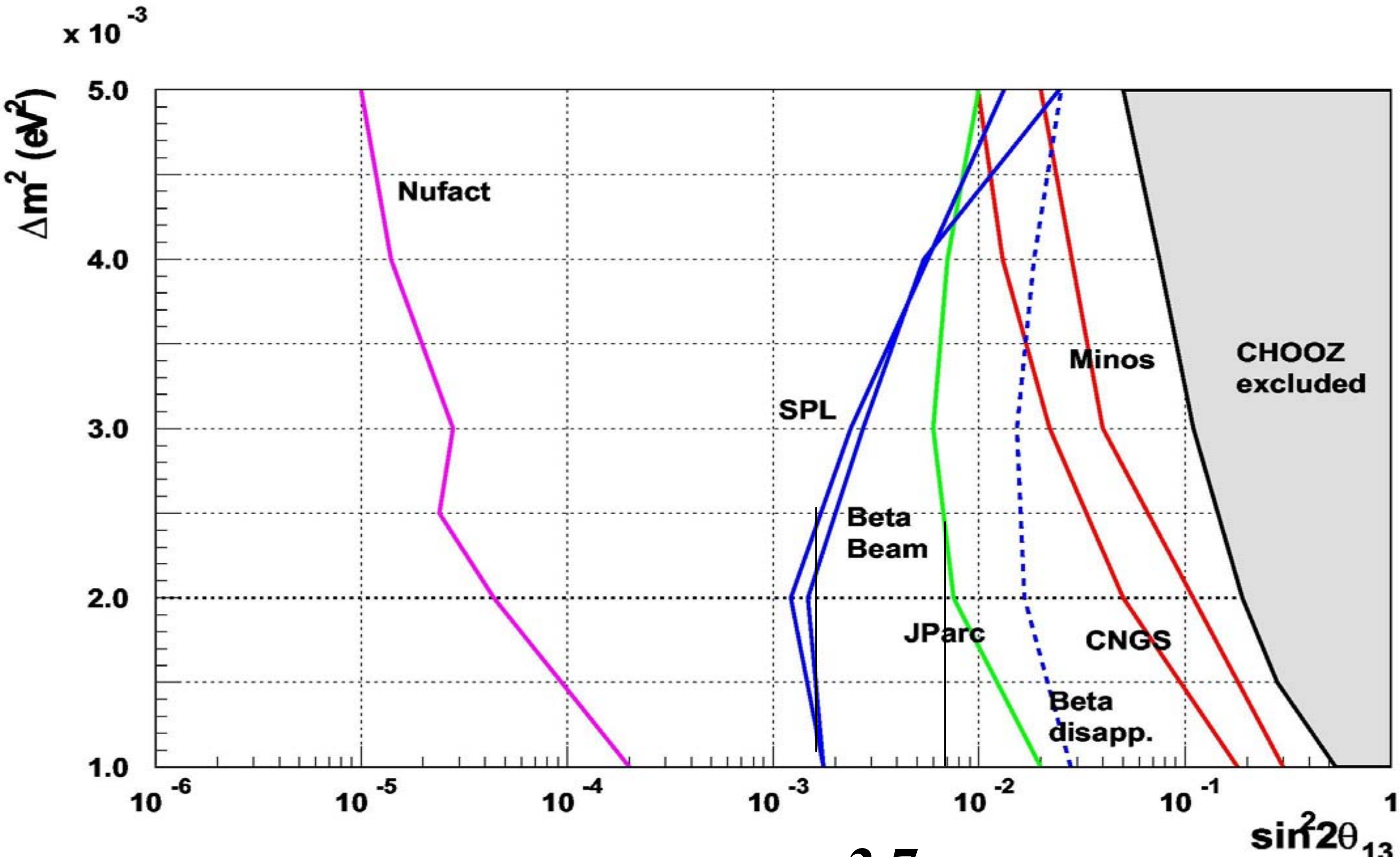
Garoby
Haseroth
Lindroos



Joint Particle and Nuclear Venture

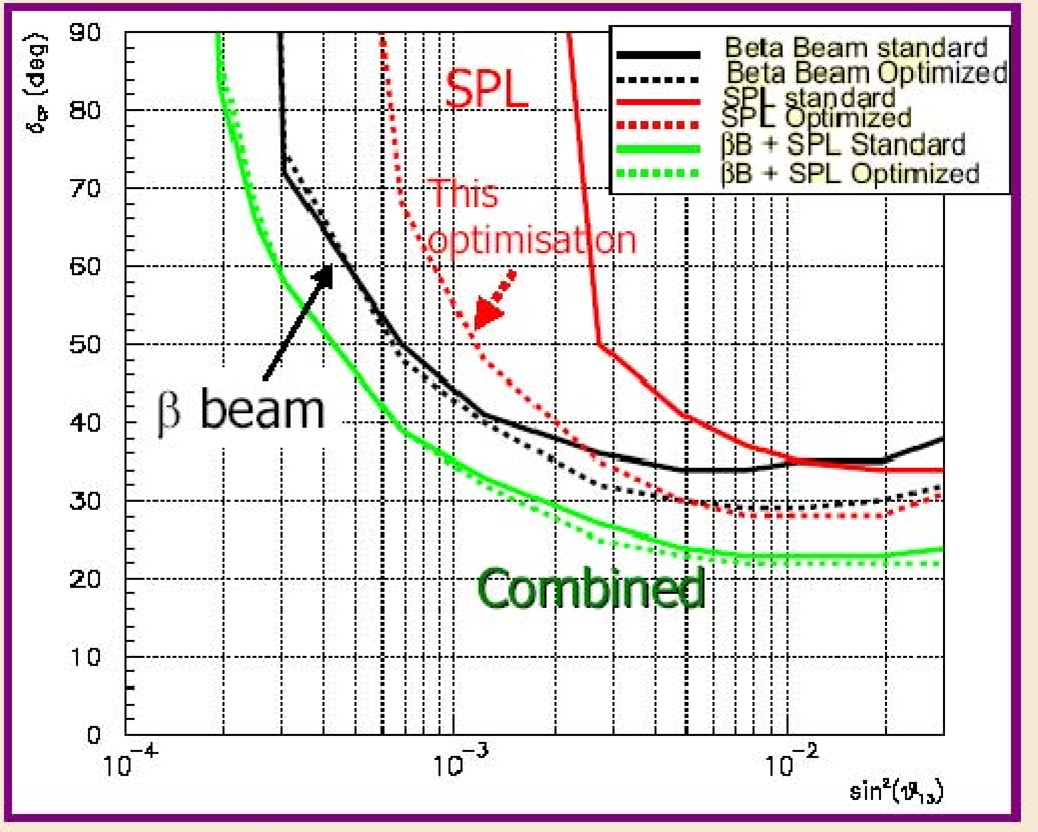


Physics Reach: the third mixing angle



3.7

Super Beam & beta Beam



3σ discovery potential curves

M. Mezzett
Villars SPSC (

Physics Reach: CPV

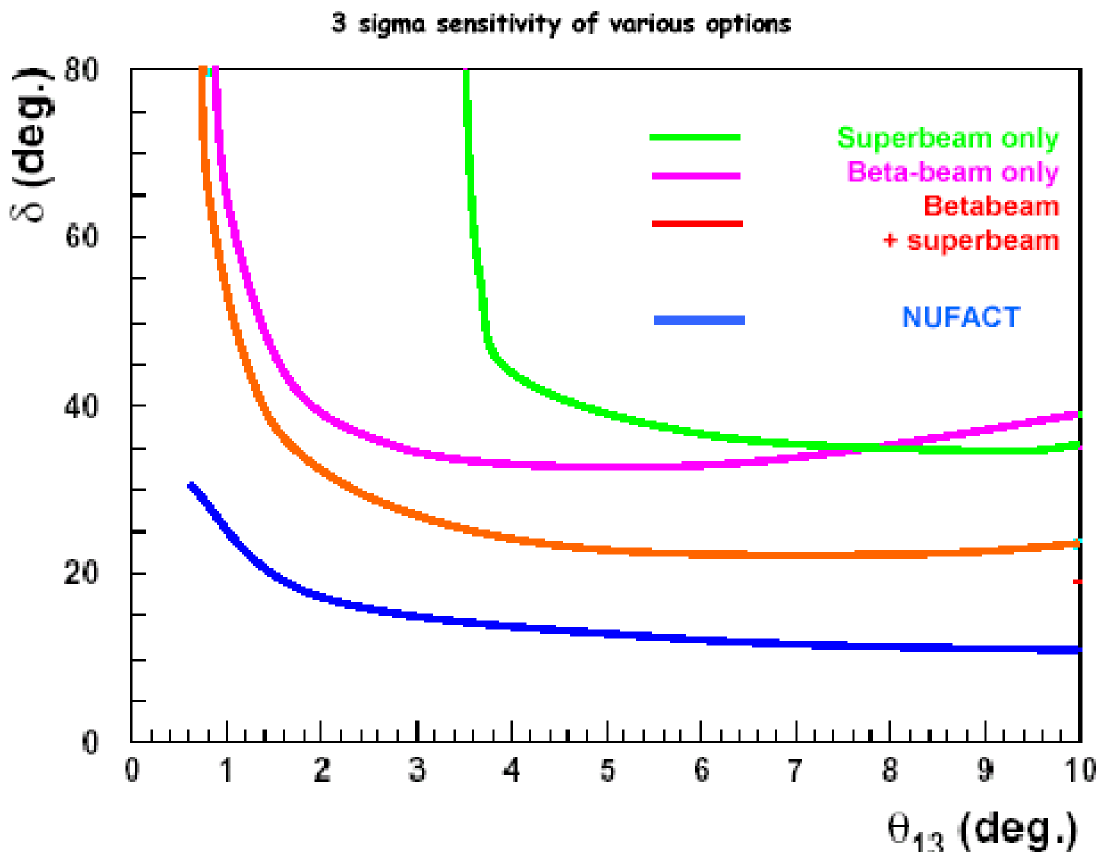
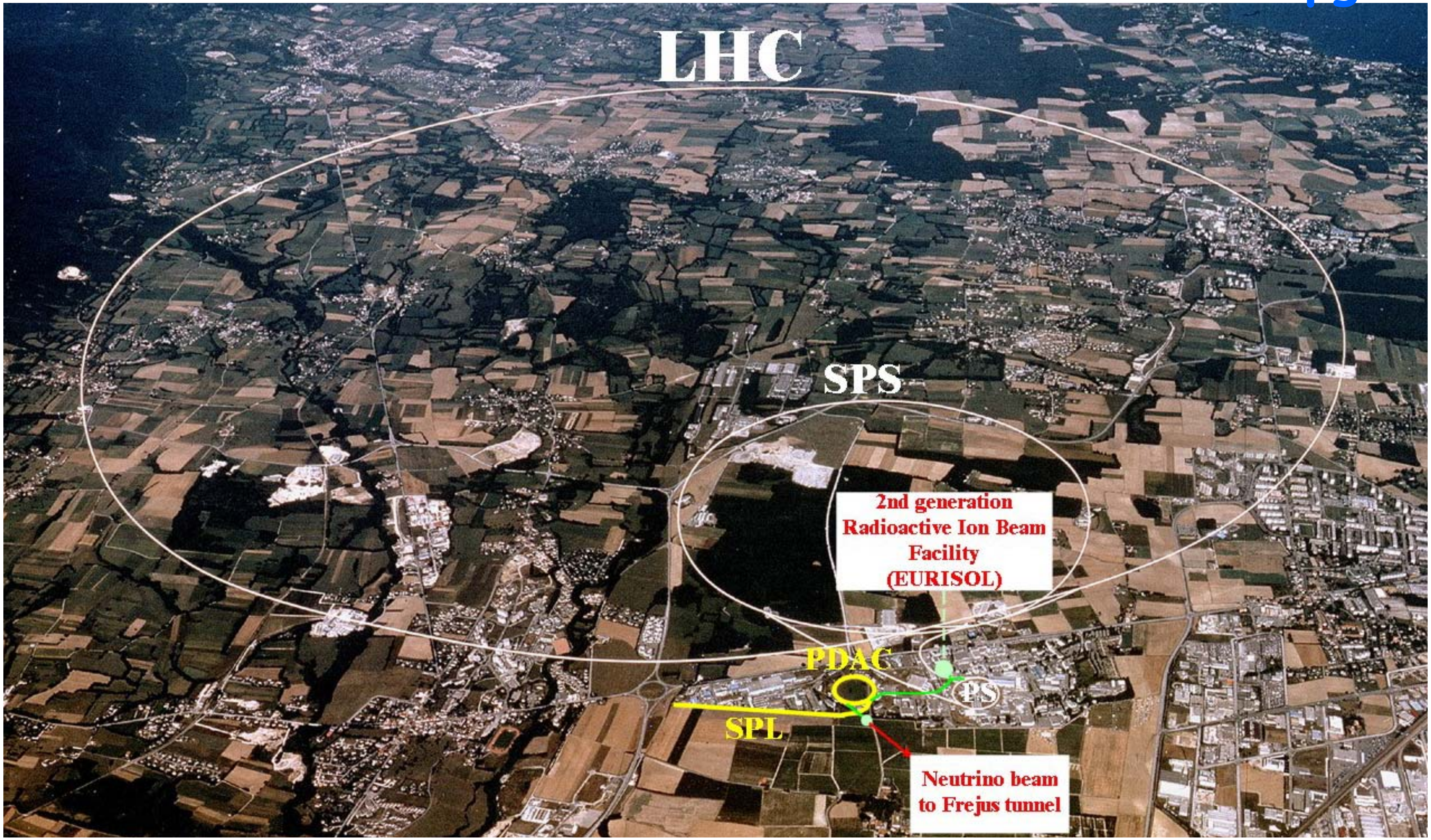


Figure 7 : 99%CL δ sensitivity of the beta-beam, of the SPL-SuperBeam, and of their combination, see text. Dotted line is the combined Superbeam+beta-beam sensitivity computed for sign(Δm_2)=-1. Sensitivities are compared with a 50 GeV Neutrino Factory producing $2\times10^{20}\mu$ decays/straight section/year, 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

Linac developments (6/20): Preliminary comparison of drivers at CERN

Present accelerator	Replacement accelerator	Improvement	INTEREST FOR			
			LHC upgrade	ν physics beyond CNGS	RIB beyond ISOLDE	Physics with k and μ
Linac2	Linac4	50 → 160 MeV $H^+ \rightarrow H^-$	+	0 (if alone)	0 (if alone)	0 (if alone)
PSB	2.2 GeV RCS* for HEP	1.4 → 2.2 GeV 10 → 250 kW	+	0 (if alone)	+	0 (if alone)
	2.2 GeV/mMW RCS*	1.4 → 2.2 GeV 0.01 → 4 MW	+	+++ (super-beam, β-beam, ν factory)	+ (too short beam pulse)	0 (if alone)
	2.2 GeV/50 Hz SPL*	1.4 → 2.2 GeV 0.01 → 4 MW	+	+++ (super-beam, β-beam, ν factory)	+++	0 (if alone)
PS	SC PS*/** for HEP	26 → 50 GeV Intensity x 2	++	0 (if alone)	0	+
	5 Hz RCS*/**	26 → 50 GeV 0.1 → 4 MW	++	++ (ν factory)	0	+++
SPS	1 TeV SC SPS*/**	0.45 → 1 TeV Intensity x 2	+++	?	0	+++

* with brightness x2 ** need new injector(s)

R.G. 1 2/11/2004

A MMW proton driver is the key issue, worldwide !!!!!!!

CONCLUSIONS

- It seems likely that a new intense proton source will be proposed for construction at FNAL in near future
- Similar in scope to the Main Injector Project (cost/schedule)
- A 8 GeV Synchrotron or a Superconducting Linac appear to be both technically possible. However the SCRF linac strongly preferred if it can be made affordable
- The FNAL management has requested that the 8 GeV linac design be developed including cost & schedule information
- A Technical Design will be developed (charge to Bill Foster)
- The Physics Case needs to be developed (charge to Steve Geer) and of course the goal of this workshop
- These will make it possible to submit a Proton Driver project to the DOE for approval and funding

B. Kephart

Bringing it all Together

We wish to perform a proof-of-principle test which will include:

- A high-power intense proton beam (16 to 32 TP per pulse)
- A high (≥ 15T) solenoidal field
- A high (> 10m/s) velocity Hg jet
- A ~1cm diameter Hg jet

Experimental goals include:

- Studies of 1cm diameter jet entering a 15T solenoid magnet
- Studies of the Hg jet dispersal provoked by an intense pulse of a proton beam in a high solenoidal field
- Studies of the influence of entry angle on jet performance
- Confirm Neutrino factory/Muon Collider Targetry concept

BROOKHAVEN NATIONAL LABORATORY

Harold G. Kirk

Proposal to Isolde and nToF Committee

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

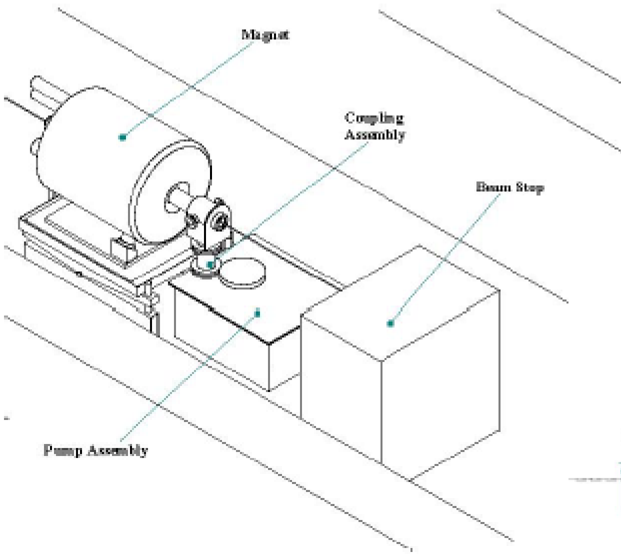
Participating Institutions

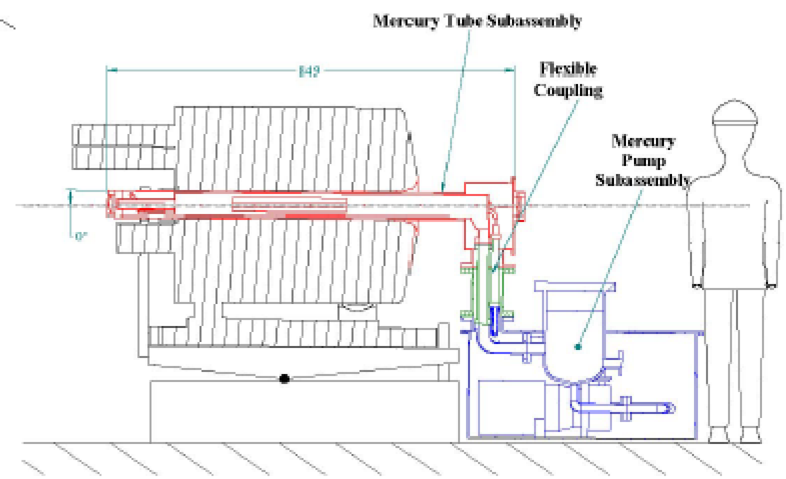
1) RAL
2) CERN
3) KEK
4) BNL
5) ORNL
6) Princeton University

Proposal submitted April 26, 2004

Harold G. Kirk

The Experimental Footprint



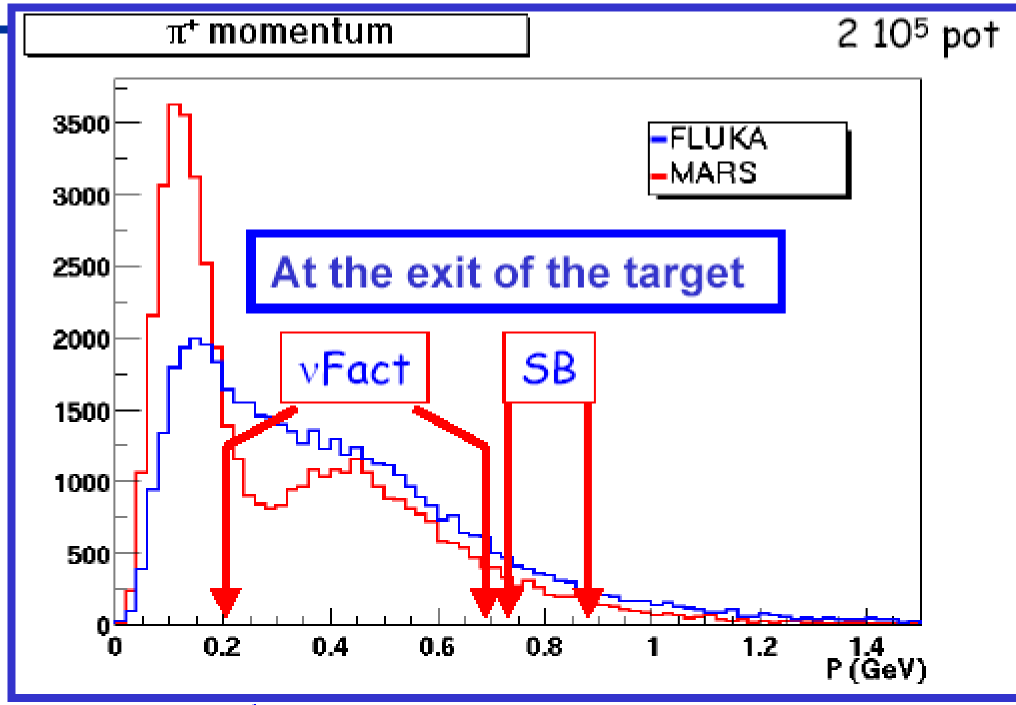


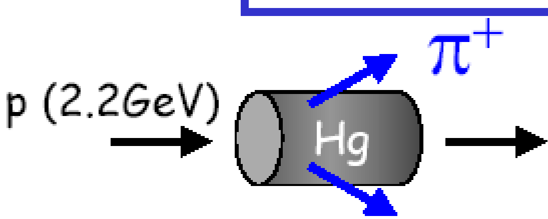
BROOKHAVEN NATIONAL LABORATORY

Harold G. Kirk

WP4 COLLECTION

Pion momentum





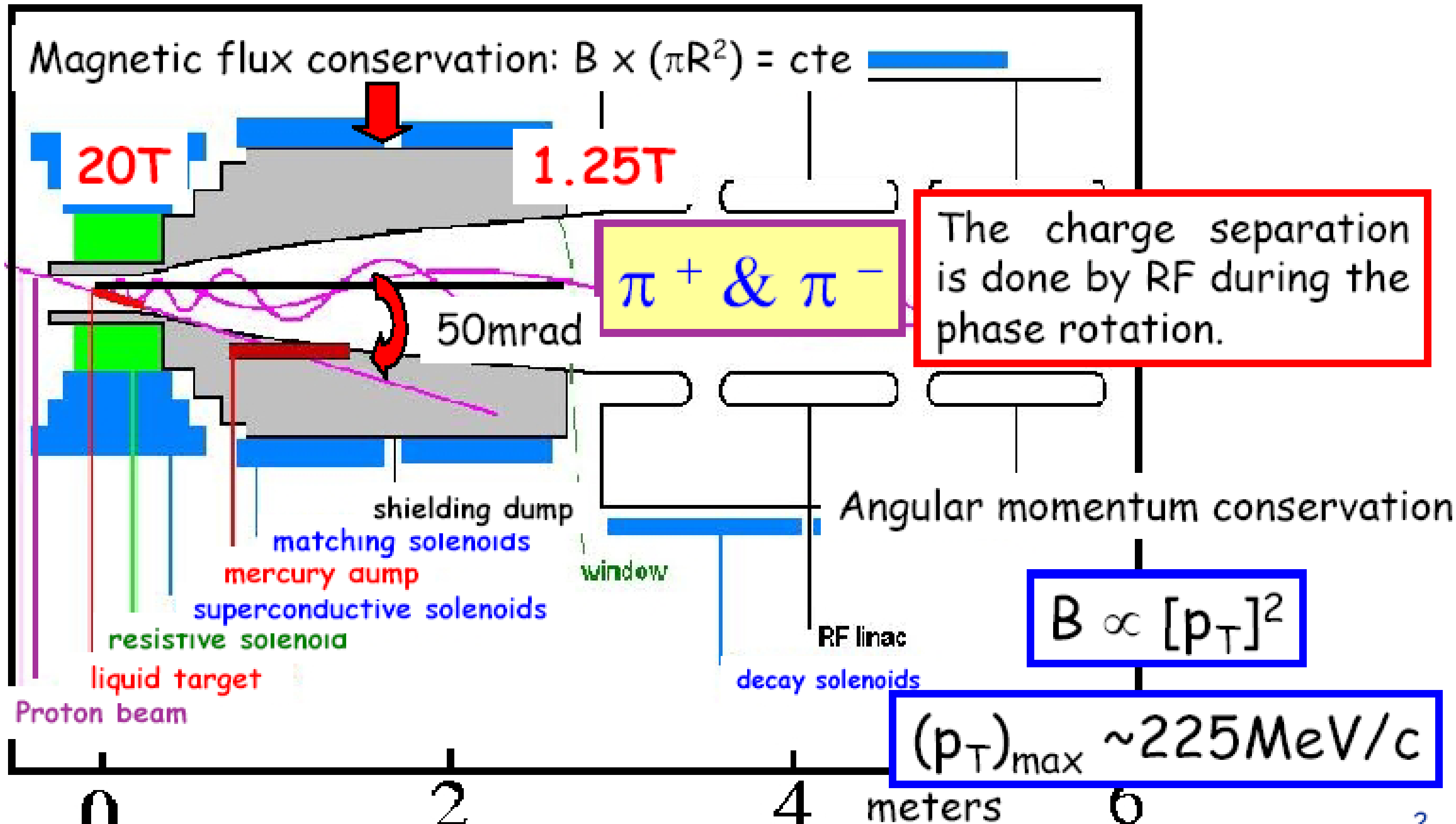
$\varnothing$ = 15mm, L = 2.3λ_I =300mm

π+(no cut)/p.o.t = 0.24 (FLUKA & MAR.

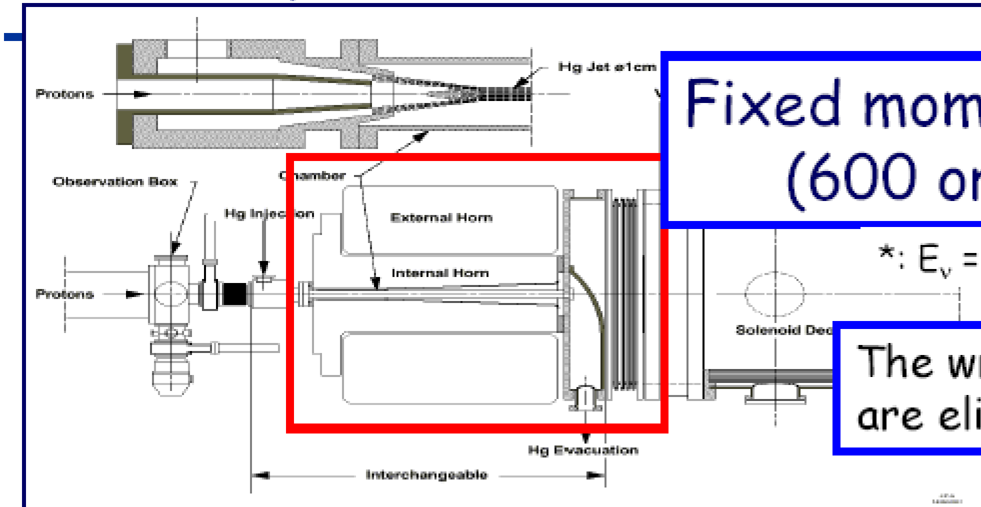
ECFA/BENE Workshop DESY
Presentation by J.E Campagne

A. Cazes thesis

Solenoid style of collection



Horn style of collection



Fixed momentum focalisation (600 or 800)* MeV/c

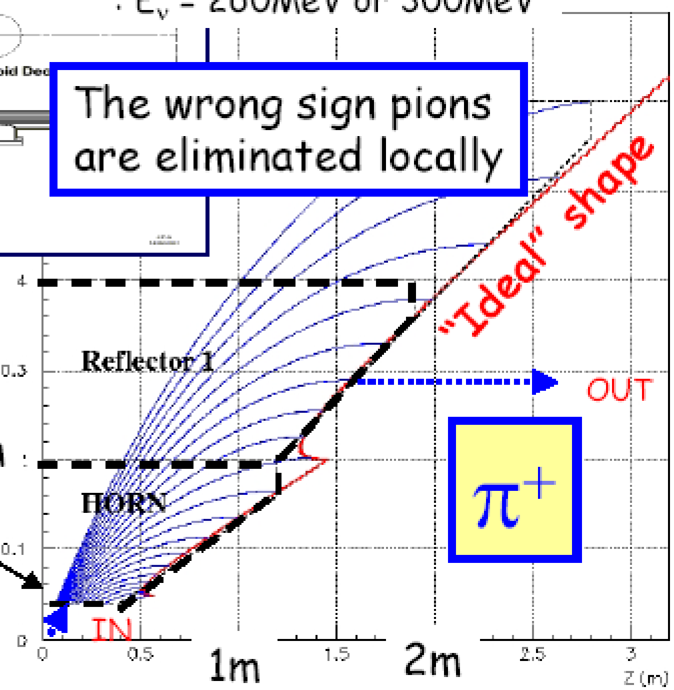
*: E_ν = 260MeV or 300MeV

The wrong sign pions are eliminated locally

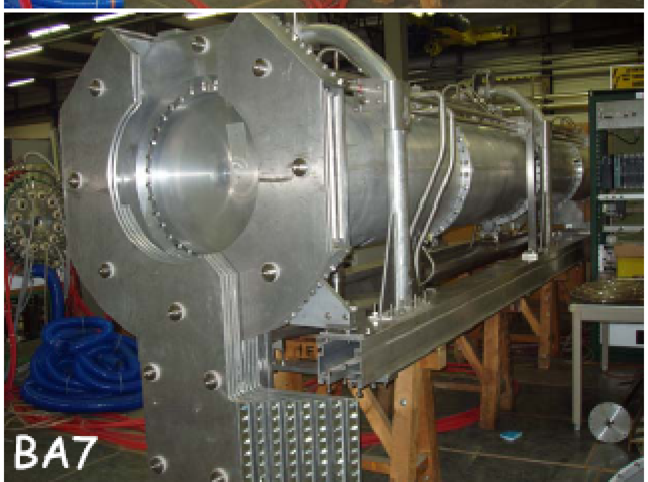
$B_\phi(r) \propto I_{cur}/r$

$I_{cur} \sim (300 \div 600)$ kA

r_{min} limited by Target size



First Horn at CERN 7th April 04

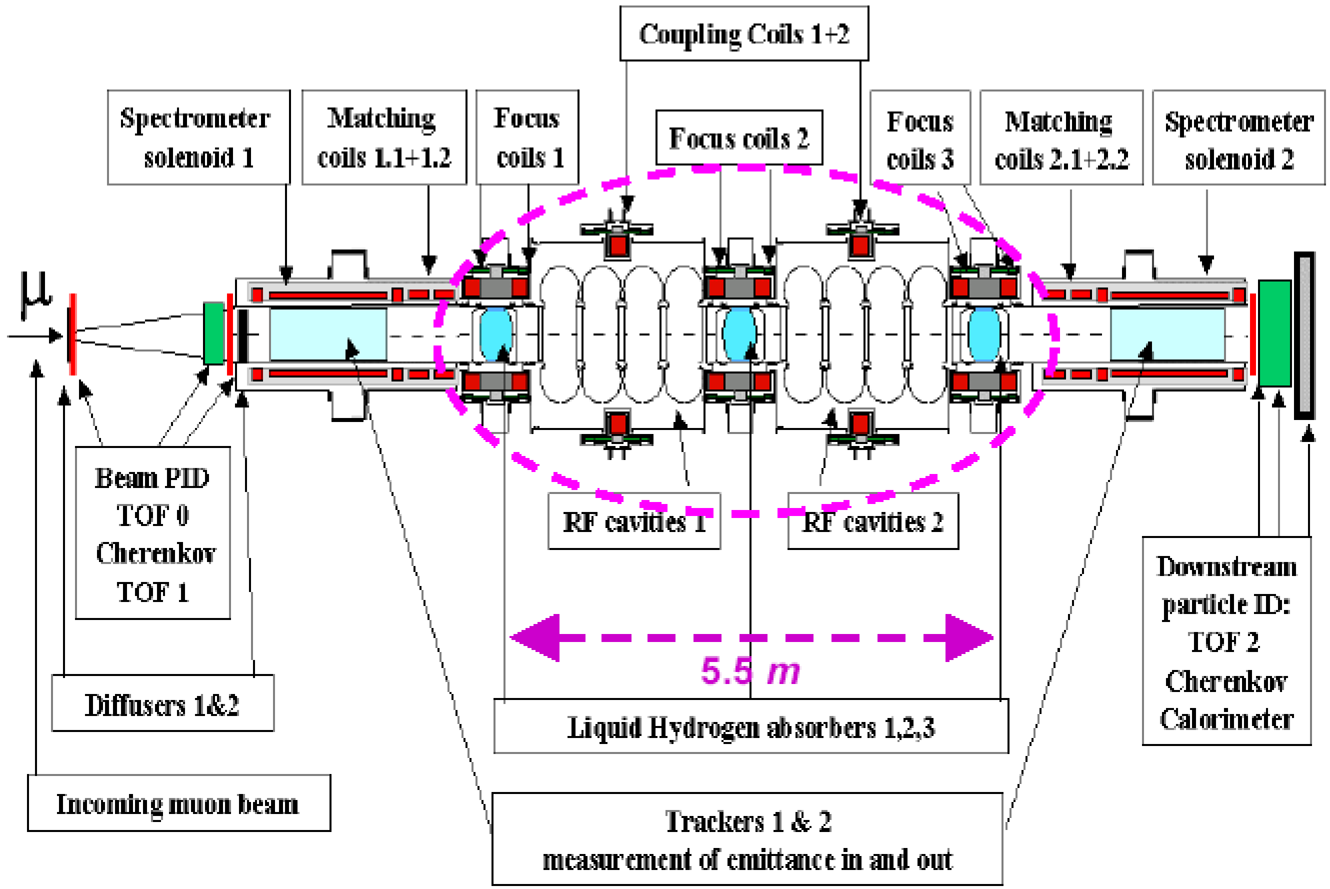


The 1st Horn had successfully passed a 65,000 double nominal pulses test early may 04.

/BENE Wor (2 10^7 double-pulses in 5 years) 4

Presentation by J.L Campagne

MICE Layout

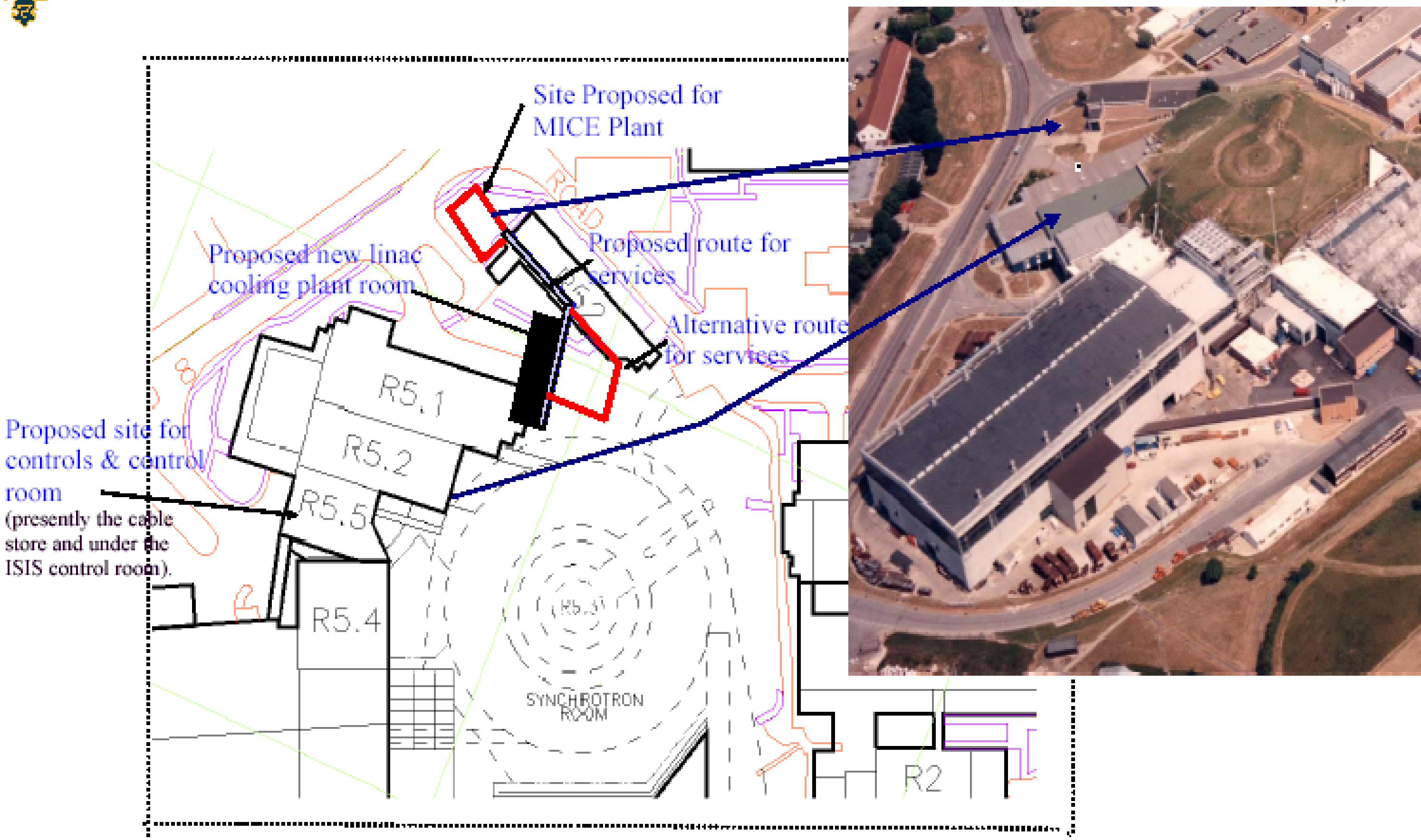


MICE: The International Muon Ionization Cooling Experiment

Ulisse Bravar
University of Oxford

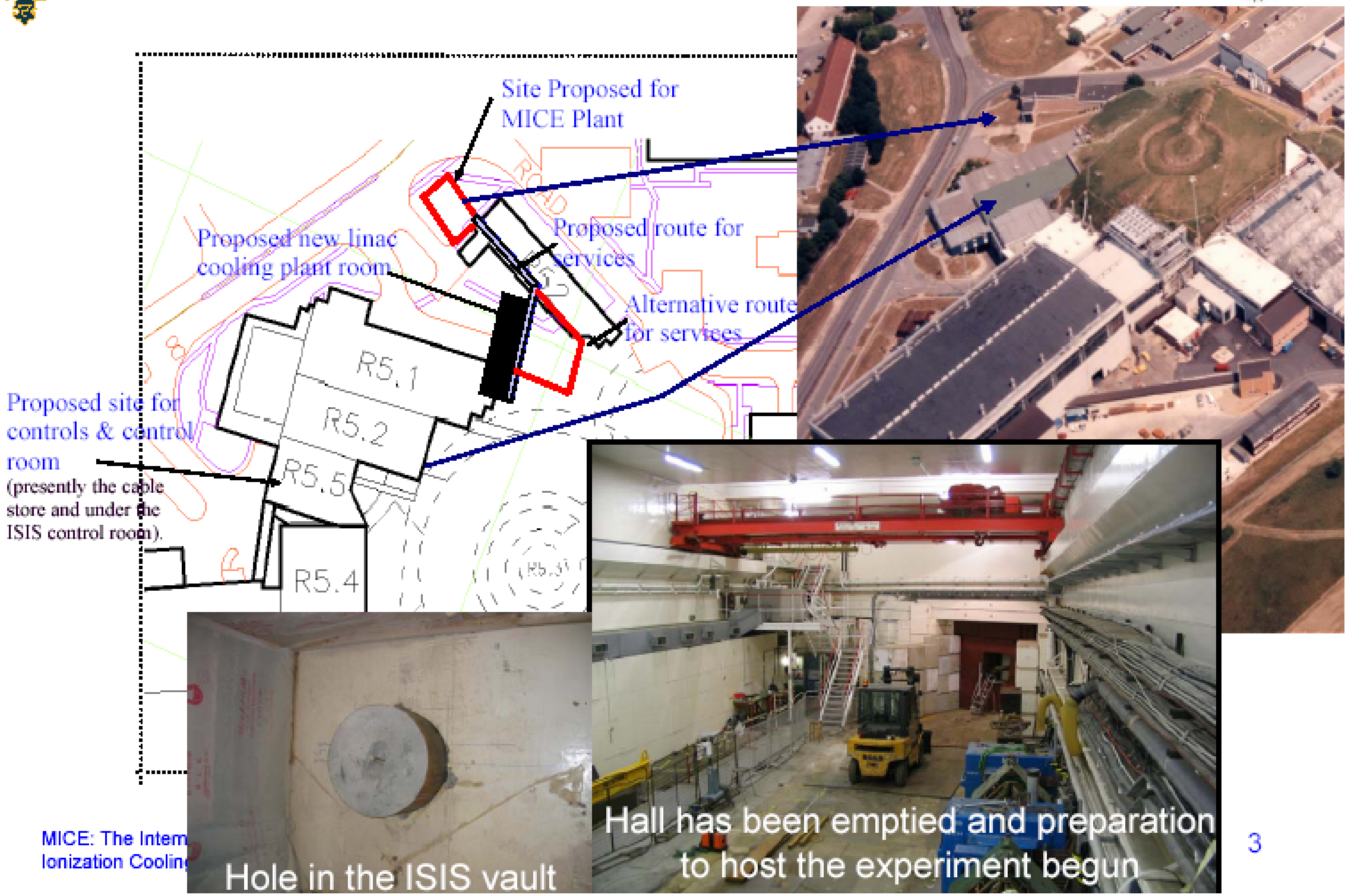
CARE/BENE 04 1

MICE at RAL



Site Proposed for
MICE Plant
Proposed new linac
cooling plant room
Proposed route for
services
Alternative route
for services
Proposed site for
controls & control
room
(presently the cable
store and under the
ISIS control room).
R5.1
R5.2
R5.5
R5.4
SYNCHROTRON
ROOM
R2

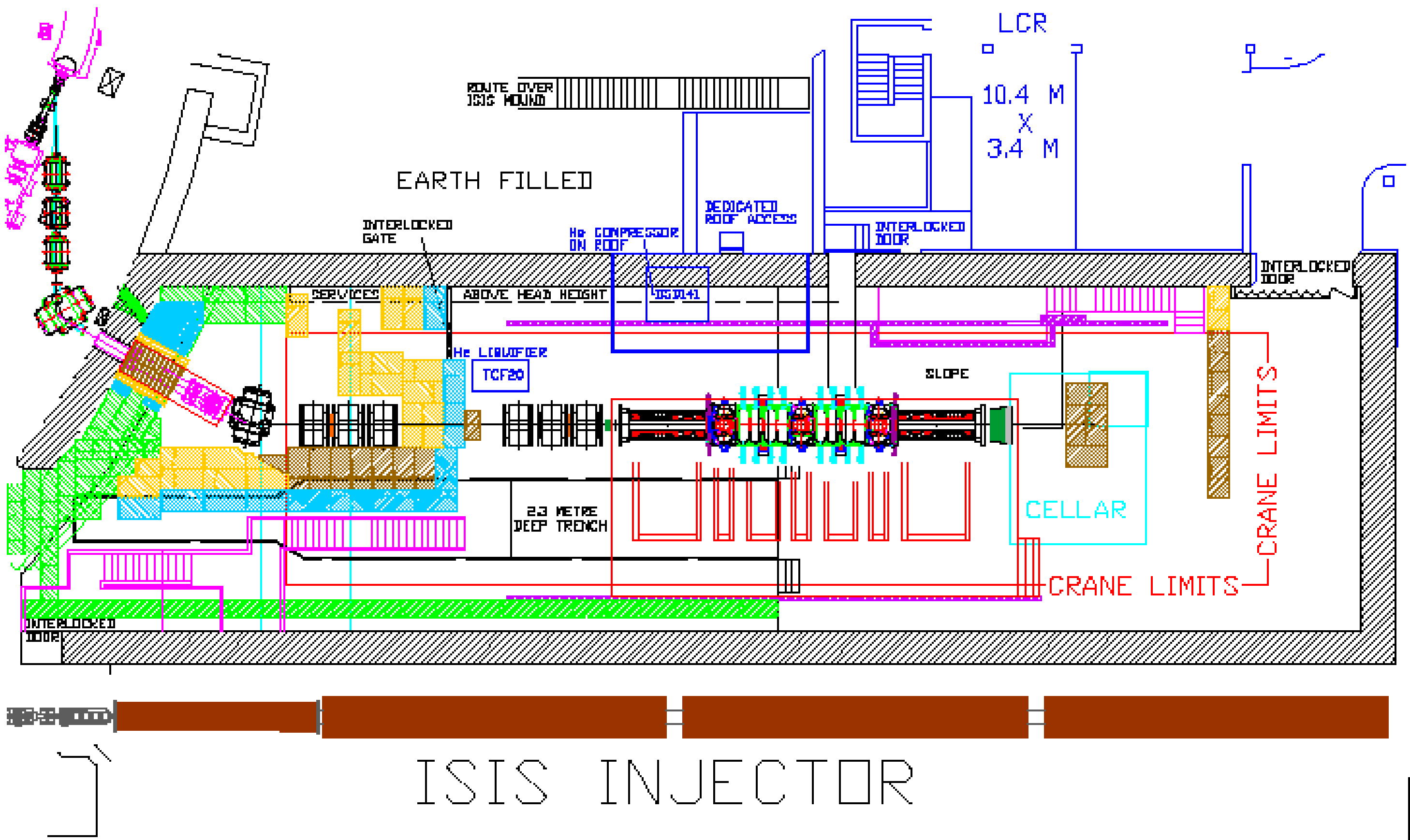
MICE at RAL



MICE: The Intern... Ionization Coolin...

3

MICE Layout at RAL



F. Méot
CEA DAPNIA/SACM
& CERN AB/ABP

Fixed Field Alternating Gradient Synchrotrons for muons, and more

Introduction

Heard at ICFA-HB2004 : one of the most active fields in accelarator physics and technology.

Only 5 FFAG machines operated :
- 3 electron machines by the MURA Lab., 50's
- 2 proton machines by KEK, these last years
- 3 facilities in construction in Japan
- the neutrino factory studies triggered strong R&D activity.

Gave rise to the concept of "non-scaling" FFAG.
- many applications investigated, e.g. proton driver, hadrontherapy.

• 1st	FFAG99 (Dec. 1999)	KEK	PoP
• 2nd	FFAG workshop (July 2000)	CERN	
• 3rd	FFAG00 (Oct. 2000)	KEK	
• 4th	FFAG02 (Feb. 2002)	KEK	
• 5th	FFAG workshop (Sept. 2002)	LBL	
• 6th	FFAG03 (July 2003)	KEK	
• 7th	FFAG workshop (Sept. 2003)	BNL	
• 8th	FFAG workshop (Mar. 2004)	TRIUMF	
• 9th	FFAG04 (Oct. 2004)	KEK	

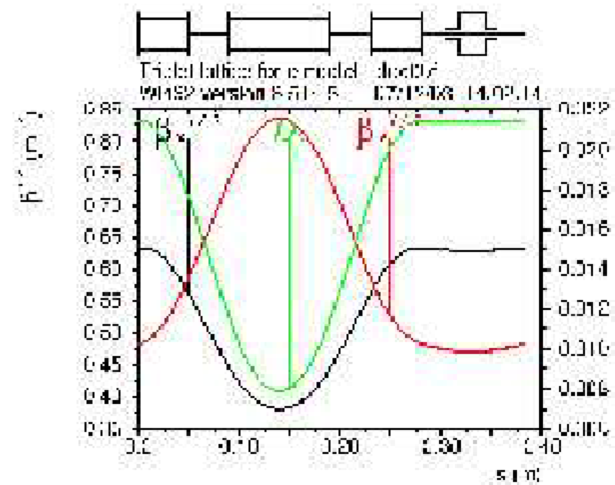
New concepts, new technologies reactivate the interest in the method.
"The rebirth of the FFAG", M. Craddock, CERN Courrier, July 2004.

Conclusion (back to the 50's !) : an e-model of a non-scaling muon FFAG

"Since no non-scaling FFAG has ever been built, there is interest in building a small model which would accelerate electrons and demonstrate our understanding of non-scaling FFAG design. " [Review of Current FFAG Lattice Studies in North America, JS Berg et als, 2004]

Main tasks : demonstrate (fast) Xing of resonances. Demonstrate near-crest fast acceleration.

Energy	*MeV*	10 to 20
number of turns		5 to 11
circumference	*m*	17
lattice		FDF
tune variation		<0.5
number of cells		45
cell length	*m*	0.38
RF drift length	*cm*	10
CF magnets:		
- length F/D	*cm*	5 / 10
- field F/D	*G*	375 / 107
- gradient F/D	*T/m*	6 / -5
- apertures	*cm*	1.2×1.8
alignement tolerances		
gradient tolerances		
length variation	*rel.*	$2\ 10^{-3}$
RF frequency	*GHz*	3
peak RF voltage	*kV*	<80
h		171
RF power	*kW*	<1.5
max. I (beam loading)	mA	100



Technical progress is remarkable in all sectors

A full NuFact & Superbeam Design Study is ready & necessary

DRIVER ………. Consolidate SC Linac studies
Enhance RCS effort

TARGET …….. Target experiment ready
needs men and resources

COLLECTOR… LAL effort should be saved

MUFRONT… MICE

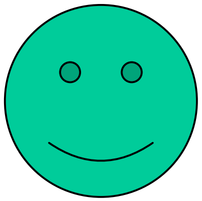
MUEND … e-FFAG model

As it is for Betabeam (WP5c)

How to bridge to FP7?   Jan 07?   Can ESGARD help?

2004 may have brought us

a Betabeam Design Study



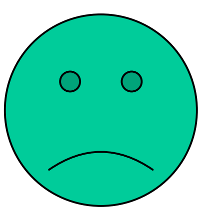
a construction window 2010-20?

budget & personnel ?

recognition of MMW driver?

Will know only if we keep initiative in 2005 & beyond

2004 did not bring us



a NuFact & SuperBeam Design Study

earliest possible start 2007

can ESGARD help?

BENE Week, CERN 14-16 Mar

BENE05 with CARE05 in the Fall

Jan05	Feb05	Mar05	Apr05	May05	Jun05	Jul05	Aug05	Sep05	Oct05	Nov05	Dec05
1	1	1 La Thuile	1	1	1	1 LP05	1	1	1	1	1
2	2	2 La Thuile	2	2	2	2 LP05	2	2	2	2 HARPCM i	2
3	3	3 La Thuile	3	3	3	3 LP05	3	3	3	3 HARPCM	3
4	4	4 La Thuile	4	4	4	4 LP05	4	4	4	4 HARPCM i	4
5	5	5 La Thuile	5	5	5	5	5	5	5	5	5
6	6	6	6	6	6 WIN05	6	6	6	6	6	6
7	7	7	7 NNN05	7	7 WIN05	7	7	7	7	7	7
8	8	8	8 NNN05	8	8 WIN05	8	8	8	8	8	8
9	9	9 HARPCM &	9 NNN05	9	9 WIN05	9	9	9	9	9	9
10	10 MICE	10 HARPCM &	10	10	10 WIN05	10	10	10	10	10	10
11	11 MICE	11 HARPCM &	11	11	11 WIN05	11	11	11	11	11	11
12	12 MICE	12	12	12	12 Nufact05	12	12	12	12	12	12
13	13	13	13	13	13 Nufact05	13	13	13	13	13	13
14	14 US MC	14 BENE	14	14	14 Nufact05	14	14	14	14	14 MICE?	14
15	15 US MC	15 BENE	15	15	15 Nufact05	15	15	15	15	15 MICE?	15
16	16 US MC	16 BENE	16	16	16 Nufact05	16	16	16	16	16 MICE?	16
17 RALBETA	17 US MC	17	17	17	17 Nufact05	17	17	17	17	17 MICE?	17
18 RALBETA	18	18	18	18	18 Nufact05	18	18	18	18	18	18
19	19	19 Moriond EW	19	19	19 Nufact05	19	19	19	19	19	19
20	20	20 Moriond EW	20	20	20 Nufact05	20	20	20	20	20	20
21	21	21 Moriond EW	21	21	21 NUFACT05	21 EPS HEP	21	21	21	21	21
22	22 Venice	22 Moriond EW	22	22	22 NUFACT05	22 EPS HEP	22	22	22	22	22
23	23 Venice	23 Moriond EW	23	23	23 NUFACT05	23 EPS HEP	23	23	23	23	23
24	24 Venice	24 Moriond EW	24	24	24 NUFACT05	24 EPS HEP	24	24	24 BENE?	24	24
25	25 Venice	25 Moriond EW	25	25	25 NUFACT05	25 EPS HEP	25	25	25 BENE?	25	25
26	26	26 Moriond EW	26	26	26 NUFACT05	26 EPS HEP	26	26	26 BENE?	26	26
27	27 La Thuile	27 Easter	27	27	27	27	27	27	27 CARE?	27	27
28	28 La Thuile	28	28	28	28 LP05	28	28	28	28 CARE?	28	28
29		29	29	29	29 LP05	29	29	29	29	29	29
30		30	30	30	30 LP05	30	30	30	30	30	30
31		31		31		31	31		31		31

NuFact05 Int. Workshop June 21-26, LNF

School June 12-20

NNN05 Int. Workshop at Frejus, 7-9 April

Interim BENE Report late 2005
General Document along NuFact05 Prodeedings

(progress on) Definition of Proton Driver Strategy
LHC upgrade …. SC Linac/RC Synchro

BENE, Eurisol, Eurotrans, FixedTarget
EMCOG

SPSC, SPC ….. ESGARD, ECFA ….

Advance on World Wide Design Study(US/EU/J)
Application to EU programs …. NEST
….. I3?

On going R&D projects HARP, MUSCAT, HIPPI
LALhorns
TT2a, MICE, eFFAG

The end