Possible Future Contributions from CERN to a Neutrino Factory Study

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for the

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REPORT OF THE WORKING GROUP
ON THE FUTURE OF ACCELERATOR-BASED PARTICLE PHYSICS IN EUROPE

The Working Group makes the following recommendations:

For the long-term:

a co-ordinated collaborative R&D effort to determine the feasibility and practical design of a neutrino factory based on a high-intensity muon storage ring**;**

a co-ordinated world-wide R&D effort should be made to assess the feasibility and estimate the cost of a 3-5 TeV e^+e^- linear collider (CLIC), a very large hadron collider (VLHC) and a muon collider; in particular, R&D for CLIC is well advanced and should be vigorously pursued.

The central role of CERN in Europe must continue and will be essential as the fulcrum of the long-term future of particle physics. The Working Group considers it essential that, through CERN, Europe should be able to play a key role in the exploration of the multi-TeV horizon that will open in the post-LHC era.

Proton Driver:	Design and model work on SPL
HARP:	Measurement of pion production (energy, angle etc. as function of proton energy and target material
Target:	Measurements at Grenoble (injection of mercury beams into high field magnet, 17 T). Test with ISOLDE beam (energy 1.4 GeV, similar energy density as in proton driver)
Horn:	Measurements of vibrations, fatigue, irradiation in ISOLDE beam
Cooling:	Computer simulations with PATH and ICOOL Refurbish RF power amplifier for MICE (may need external funding). Measurement of scintillation fiber detectors.

RF cavities

Tests at (40 and) 80 MHz with strong solenoidal fields

Detectors

Test of scintillating fibers

Muon Linac:

Computer simulations

Recirculating Linear Accelerators (RLAs):

Computer simulations

Decay Ring:

Computer simulations

Other Possible Scenarios:

FFAGs (Fixed Field Alternating Gradient) machines with large acceptances to accelerate muons (with or without cooling)

Betabeams (decay of e.g. ^{6}He or ^{18}Ne in a ring to produce neutrino beams)

NOTE:

What I have shown now looks like that we do not need you!

All these activities could certainly be executed in principle by CERN people, but we are not experts in all fields and we have by far not enough people. In the "good old days" (last three years) we had 14 FTEs/year and 1.3MCHF (last year), this year's "budget" is officially at zero and we have 3 FTEs.

The American Neutrino Factory and Muon Collider Collaboration had an order of magnitude more means (5 to 9.2 M$ from DOE and NSF + support from the labs + from different other sources) and there are still lots of open questions.

Experimental work is also urgently needed.

Possible and desired activities in the context of a larger European collaboration for a Neutrino Factory based on input from the NFWG steering group

Proton Driver Scenario I:

SPL

H^- source development (a long-term development based on the ECR design), the 350 MHz test place, a CCDTL prototype at high power and the chopper pulser. High priority is also given to beam dynamics studies and to studies of linac accelerating structures. At a lower priority are the tests of a high power amplitude and phase modulator and some preliminary developments of low level electronics for pulsed SC cavities.

Accumulator and compressor Rings

Writing up, cost estimate…

Proton Driver Scenario II:

Fast cycling synchrotrons

Lattice for 30 GeV RCS in ISR tunnel:

(high gamma-t ~35-40, Momentum compaction |alpha1|<0.01)

Target for pion production

The EURISOL collaboration plans to set up a collaboration on a high power Uranium target for the production of intense Radioactive Ion Beams beams. CERN and other European neutrino physics laboratories should participate in two EU networks for which the plans will be discussed in the next EURISOL steering committee meeting. One is for developing high power molten metal proton to neutron converters and one is for defining safety, radioactivity handling, layout, support laboratories and cost of the target station.

Study of target and collection for Neutrino Super beams

Pion collection

Complete the design and evaluation of the four horn pion collection system. A key parameter is the free space to leave for the dump of the primary beam.

Muon collection and acceleration:

Start the design of a single RLA from 2 to 50GeV. Key issues : design an injection system and spreaders. Maximize the momentum acceptance for isochronous arcs. Isochronous versus non-isochronous ?

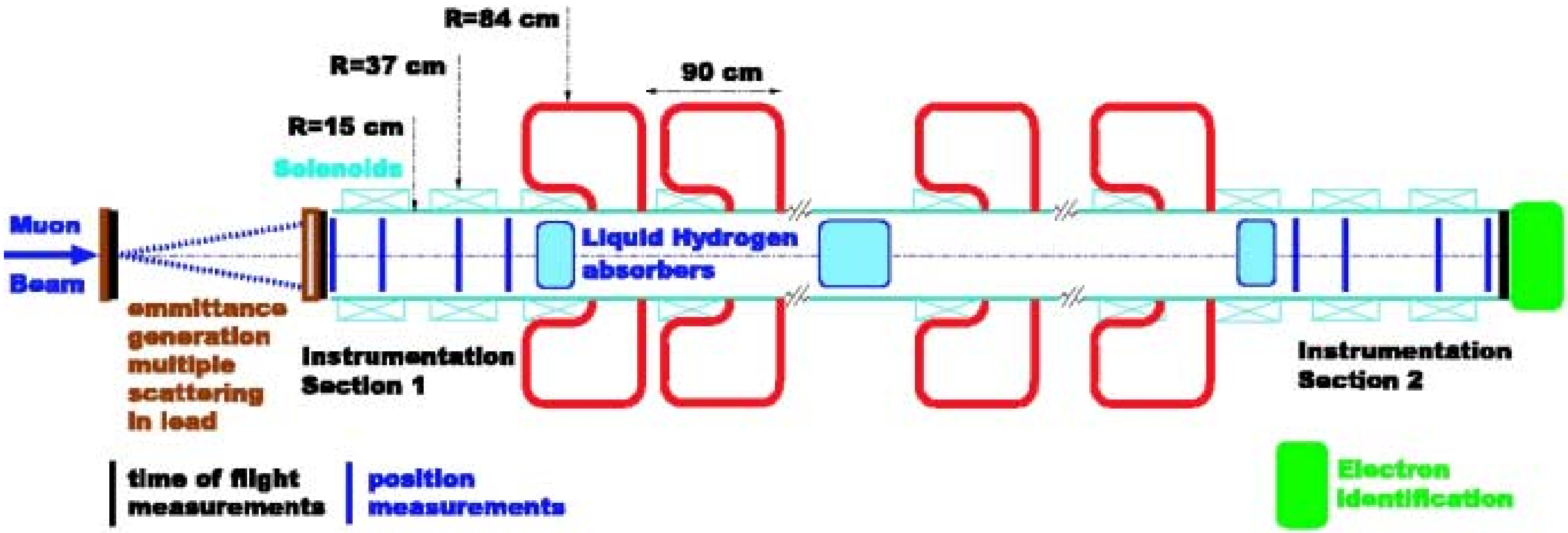
RLAs with isochronous horizontal arcs at 200 MHz.

Comments: In the 350 MHz scheme, the longitudinal acceptance of the whole complex is limited to 0.1 eV.s. It is of paramount importance to increase muon longitudinal acceptance well above 0.1 eV.s. For comparison, pion longitudinal emittance is larger than 1 eV.s. The RF power consumption should be highlighted as clearly as for linear colliders.
These comments apply to the front end as well.

Scenario I:

Phase rotation and cooling

-optimization of the decay channel
-phase rotation system at 88MHZ-optimization with field map
-alternative phase rotation system (double bend)
-cooling at 88 MHz-study of (equilibrium) emittance
-cooling at 88 MHz-acceptance
-quadrupolar cooling channel-theory and simulations
-refinement of the design after results of 88MHzRF tests
-matching to the recirculators
-simulation of a cooling experiment at 200MHz


R=84 cm
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Solenoids
Muon
Beam
Liquid Hydrogen
absorbers
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scattering
in lead
Instrumentation
Section 1
Instrumentation
Section 2
time of flight
measurements
position
measurements
Electron
identification

Scenario II:
FFAGs without or with cooling

(a) Ring Cooler:
Works well on paper. Should work in FFAGs too. Main problem: Injection/extraction. Japanese are on the way to solve it for FFAGs (?). If they succeed (and they have to, otherwise their Nufact scenario drowns), the cooling ring may become a viable alternative to other schemes.

(b) Isochronous (non-scaling) FFAG lattices for muon acceleration. The interest of such lattices is for alternatives to RLAs that allow for more turns in one ring. This again is the basic idea of the Japanese Nufact, but they go for scaling, hence non-isochronous, FFAGs which limits on to low-frequency RF systems (10-20 MHz). The isochronous ring would allow higher RF frequencies, thus higher gradients.

Decay ring

Study of decay ring with larger acceptances for FFAG scenario.

Cost estimates for different machine layouts or at least subsystems to provide guidance to the designers.

Study of Beta beams

International collaborations for NUFACT R&D
preliminary list

SPL : IPHI , acceleration to 120 MeV CEA Saclay, INFN Legnaro

Recirculator and accumulator: RAL

Target: Isolde, BNL, EPFL Lausanne, Grenoble, PSI

Horn: Uni Crakow, discussions with France (Orsay?)

Phase rotation and cooling: MICE →

> MICE (40 Institutes signed the LOI)
>
> Host Lab: RAL
>
> Beam: RAL & PSI
>
> H2 absorbers: MUCOOL (US, Japan, Oxford)
>
> RF cavities: US, RF power CERN/RAL/FNAL
>
> Spectrometer detectors read-out, software
>
> European institutions: TOF=Milano-Padova
> TPG= Legnaro-Gva
> sci-fi= ICL/RAL-FNAL
>
> open issues:
>
> spectrometer solenoids (Saclay?/Frascati?)
>
> focus solenoids (RAL/Oxford? …)
>
> more modern RF power, LiH absorbers …..

RLA, Storage ring: FNAL, Frascati

FFAG (Japan, RAL)

HARP (24 Institutes)

MUSCAT (10 Institutes)

International collaborations for NUFACT R&D preliminary list

SPL : INFN Legnaro, CEA Saclay

Recirculator and accumulator: RAL

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Horns: Uni Crakow, discussions with France

Phase rotation and cooling:

INFN Frascati,

RAL

Mucool collaboration (IIT chicago, Fermilab, BNL, etc..)

KEK, Uni Osaka

Consortium of European universities (EuNuFact incl Uni.Geneva)

PSI

RLA and Storage ring: Fermilab, INFN frascati

HARP (24 Institutes)

MUSCAT (10 Institutes)