IDS-NF and Euroν WP3

Accelerator working group activities

Euroν - WP 3 and the IDS

The Euroν - WP 3 is an integral part of the international design effort IDS-NF

- To integrate additional EU partners into IDS
- End to end simulation (target to decay rings) for performance and cost evaluation.
- Proton beam handling after target & safety issues
- Input of new ideas from new members……

IDS - aims

- To deliver an interims design report until 2010
  with a first costing to be 50-70% accurate

- To deliver an reference design report until 2012
  End to end simulations of muon linac
  Performance evaluation of facility
  costing to be 30-50% accurate

WP3 - Objectives

…….The ISS also established that the remaining crucial issues that must be addressed through the Design Study are: the muon front-end, including the ionisation- cooling channel; the large-aperture, rapid, acceleration systems; and the target and the handling of the high- power proton beam that emerges from the pion-production target. In addition, in order to assess quantitatively the performance of the Neutrino Factory it is essential to develop an end-to-end simulation of the accelerator complex……

……Detailed simulations of the baseline ionisation-cooling channel will be performed with a view to establishing both the performance and the cost. In parallel, the potential of alternative ionisation-cooling options will be investigated to establish whether they are feasible and to determine whether they offer a performance or cost advantage……...

……Consideration of the handling of the high-power proton beam that emerges from the target will be limited to the key issues that pertain to the Neutrino Factory: the safe handling of the beam power…….

……The end-to-end simulation developed in the course of the Design Study will be used to evaluate the performance of the facility.

WP3 - Milestones

Milestone	month (from start)
Evaluation of baseline front-end	15
Evaluation of acceleration systems	18
Evaluation of performance of alternative cooling and acceleration	24
Specification of proton-beam handling system	24
Benchmark costing for muon front-end and acceleration systems	30
Initial health-and-safety evaluation of proton-beam handling system	38
Cost and Performance evaluation complete	40
Comparison of physics performance of all facilities	43

WP3 - Deliverables

1 Completed review of ionisation-cooling and muon front end

15 month

2 Completed review of muon acceleration

18 month

3 Completed simulation of baseline and alternative ionisation-cooling channel, including a cost and performance analyses for reference muon front end.

30 month

4 Completed simulation of baseline and alternative muon acceleration system and the decay rings and evaluation of reference design for spent proton-beam handing system, including a cost and performance analyses.

38 month

5 Complete end-to-end simulation and evaluation of the performance of the Neutrino Factory as input to the comparison

42 month

How will the work be performed ?

1) Review phase ~ first 12 month

   integration of new partners into the NF-IDS effort review of baseline design, definition on proton beam requirements and identification of a detailed work plan.

2) Integration of new ideas ~ 24 month

   Effective contributions to the NF-IDS effort concentrating on muon front end and fast acceleration. Preparation of end to end simulation.

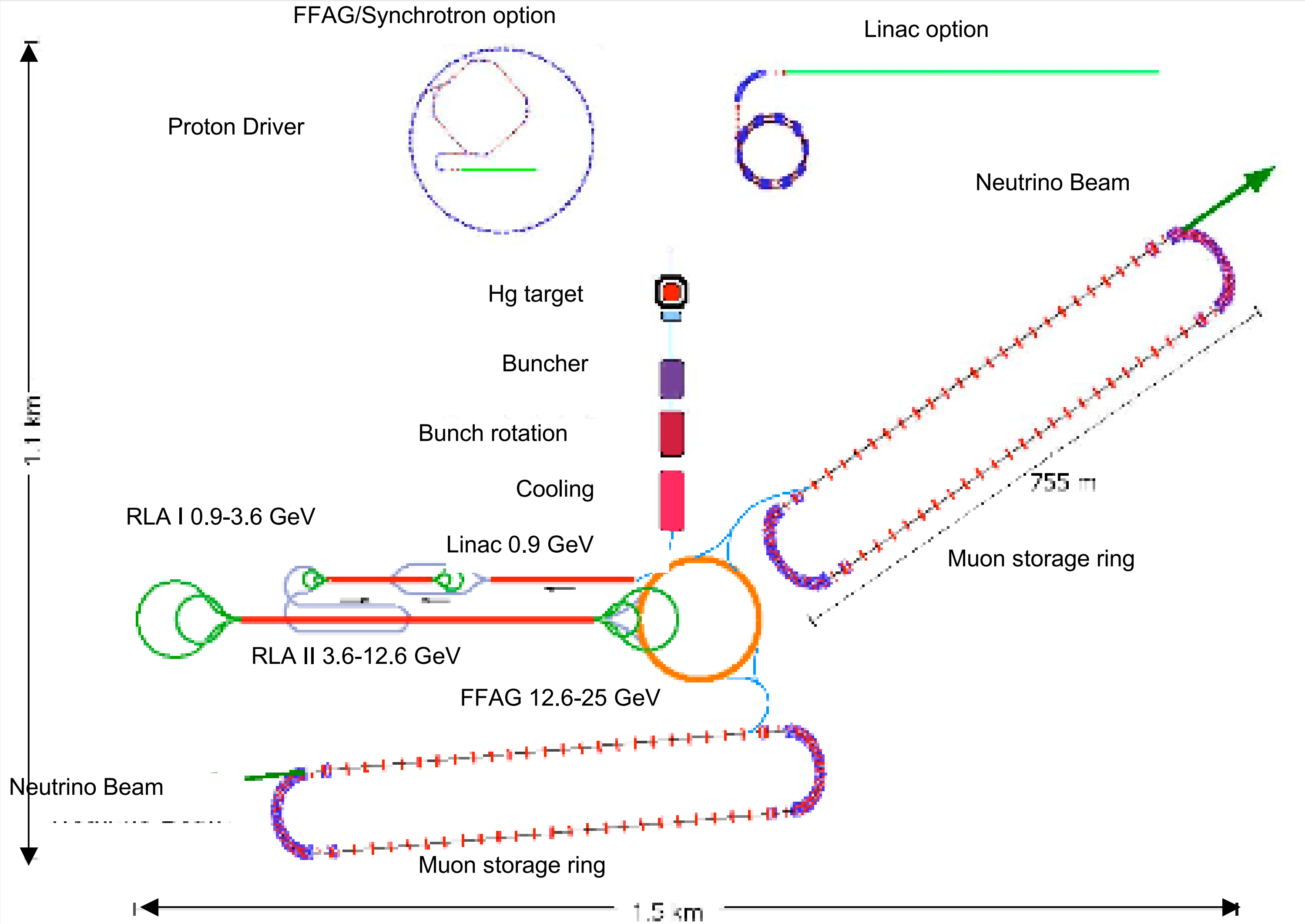
3) Performance evaluation phase ~ last 12 month

   End to end simulation of (new) baseline design, performance and cost evaluation, writing up.

Organisation of the working group

System Sub-system	Task list Performed	 Required	Coordinators	Comments
Target	Optics Tracking 1 Tracking 2	CDR IDR costing	C.Densham (RAL), H.Kirk (BNL)	Particle production must be revisited when HARP results are included in MARS/Geant4
Muon front-end ***Capture***	Optics Tracking 1	Tracking 2 CDR IDR costing		
Bunching and phase rotation	Optics Tracking 1	Tracking 2 CDR IDR costing	C.Rogers (ASTeC), D.Neuffer (FNAL)	Risk mitigation: evaluate to what extent minor lattice revisions are required if it is demonstrated that the baseline gradient can not be achieved in the magnetic field.
Cooling	Optics Tracking 1	Tracking 2 CDR IDR costing		Risk mitigation: evaluate to what extent minor lattice revisions are required if it is demonstrated that the baseline gradient can not be achieved in the magnetic field.
Acceleration ***Linear accelerators***	Optics	Tracking 1 Tracking 2 CDR IDR costing	A.Bogacz (JLab), J.Pozimski (ICL)	
FFAG	Optics Tracking 1	Tracking 2 CDR IDR costing	S.Berg (BNL), S.Machida (RAL)	While initial optics and tracking work has been done, the fact that an injection and extraction scheme has not been proposed implies that it is necessary to revisit both the optics analysis and the tracking.
Storage ring		Optics Tracking 1 Tracking 2 CDR IDR costing	C.Prior (ASTeC), ANO	Present lattices store muons of a single charge only. A modification of the optics is required to allow positive and negative muons to be stored simultaneously.

The IDS baseline-overview



The IDS baseline-proton driver and target

Sub-system	Parameter	Value
Proton driver	Average beam power (MW)	4
	Pulse repetition frequency (Hz)	50
	Proton kinetic energy (GeV)	10±5
	Proton rms bunch length (ns)	2±1
	Number of proton bunches per pulse	3
	Sequential extraction delay (μs)	≥17
	Pulse duration, liquid-Hg target (μs)	≤40
Target: liquid-mercury jet	Jet diameter (cm)	1
	Jet velocity (m/s)	20
	Solenoidal field at interaction point (T)	20
Pion collection	Tapered solenoidal channel Length (m)	12
	Field at target (T)	20
	Diameter at target (cm)	15
	Field at exit (T)	1.75
	Diameter at exit (cm)	25

The IDS baseline-muon front end

Sub-system	Parameter	Value
Decay channel	Length (m)	100
Adiabatic buncher	Length (m)	50
Phase rotator	Length (m)	50
	Energy spread at exit (%)	10.5
Ionisation cooling channel	Length (m)	80
	RF frequency (MHz)	201.25
	Absorber material	LiH
	Absorber thickness (cm)	1
	Input emittance (mm rad)	17
	Output emittance (mm rad)	7.4
	Central momentum (MeV/c)	220
	Solenoidal focussing field (T)	2.8

The IDS baseline-muon accelerator

Sub-system	Parameter	Value
Acceleration system	Total energy at input (MeV)	244
	Total energy at end of acceleration (GeV)	25
	Input transverse acceptance (mm rad)	30
	Input longitudinal acceptance (mm rad)	150
Pre-acceleration linac	Final total energy (GeV)	0.9
RLA(1)	Final total energy (GeV)	3.6
RLA(2)	Final total energy (GeV)	12.6
NFFAG	Final total energy (GeV)	25
Decay rings	Ring type	Race track
	Straight-section length (m)	600.2
	Race-track circumference (m)	1,608.80
	Number of rings (number of baselines)	2
	Stored muon energy (total energy, GeV)	25
	Beam divergence in production straight (γ-1)	0.1
	Bunch spacing (ns)	≥100
	Number of μ decays per year per baseline	$5*10^{20}$

Task list for each section of NF acc.

- Lattice Design
- Particle tracking 1
- Particle tracking 2 (review - Euroν)
- Alignment error studies
- Definition of interfaces for end to end simulation
- EM simulations of RF and magnets for field mapping and costing

Proton driver

- R&D for the proton driver is decoupled from IDS as a hosting lab specific solution is assumed,………but required beam parameters on target have been defined.

Proton driver projects:

- CERN LINAC 4 / SPL
- Fermilab Project X
- RAL - ISIS upgrade

Proton driver options

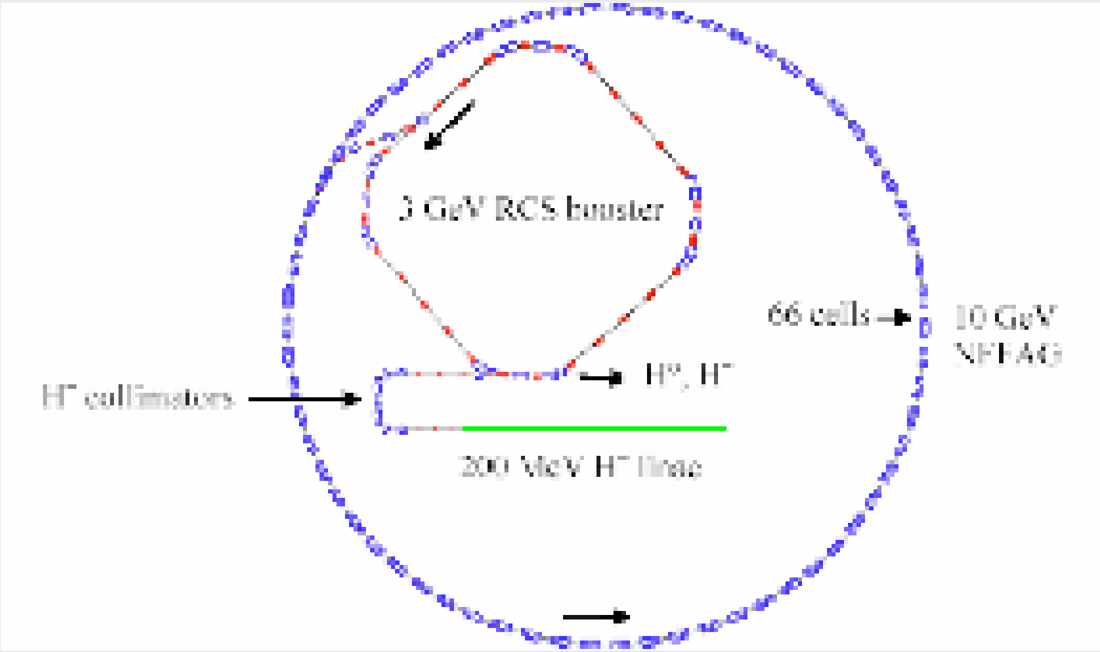
- **an H^- linac with a 50-Hz booster RCS and a 50-Hz non-scaling, non-linear, fixed-field alternating gradient (NFFAG) driver ring**

- an H^- linac with pairs of 50 Hz booster and 25 Hz driver synchrotrons (RCS)

- **an H^- linac with slower cycling synchrotrons and two holding rings**

- **a full energy H^- linac with an accumulator and bunch compression ring(s)**

The Linac, RCS, NFFAG option (RAL)



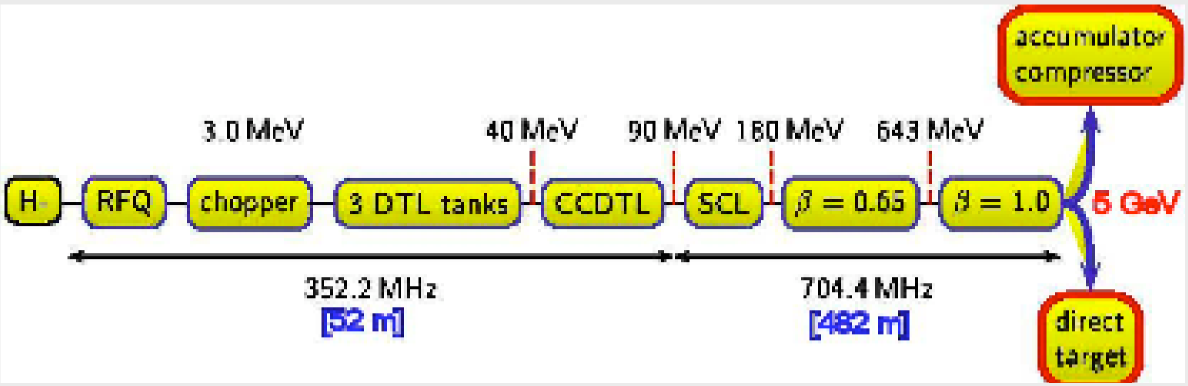
Beam power (MW) 4

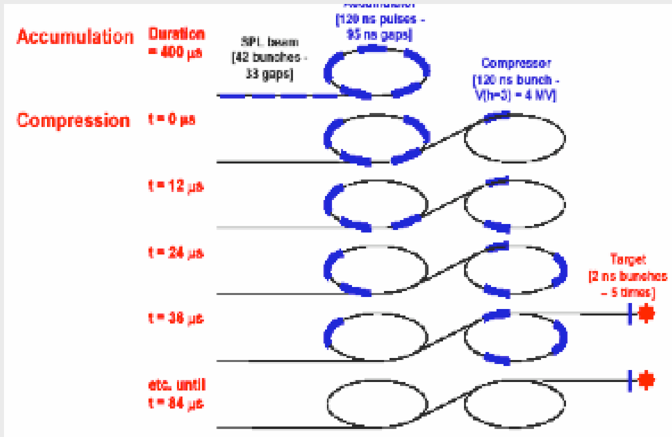
Beam energy (GeV) 10

Repetition rate (Hz) 50

Linac/compressor ring option at CERN & Project X

Beam power (MW) 4	Beam power (MW) 200 kW/2.3 MW
Beam energy (GeV) 5	Beam energy (GeV) 8 / 120
Repetition rate (Hz) 50	Repetition rate (Hz) <1
Average current (mA) 40	Average current (mA) 30





Capture, Phase rotation and cooling

➢ Determination of usable yield		done
➢ revision from HARP		24 month
➢ Lattice design		done
➢ Particle Tracking 1		done
➢ PT 2	started	9 month
➢ Pre engineering of RF and magnets		19 month
➢ End to end simulation		34 month
➢ Costing of components		24/42 month

RF cavities in magnetic fields

Problem :

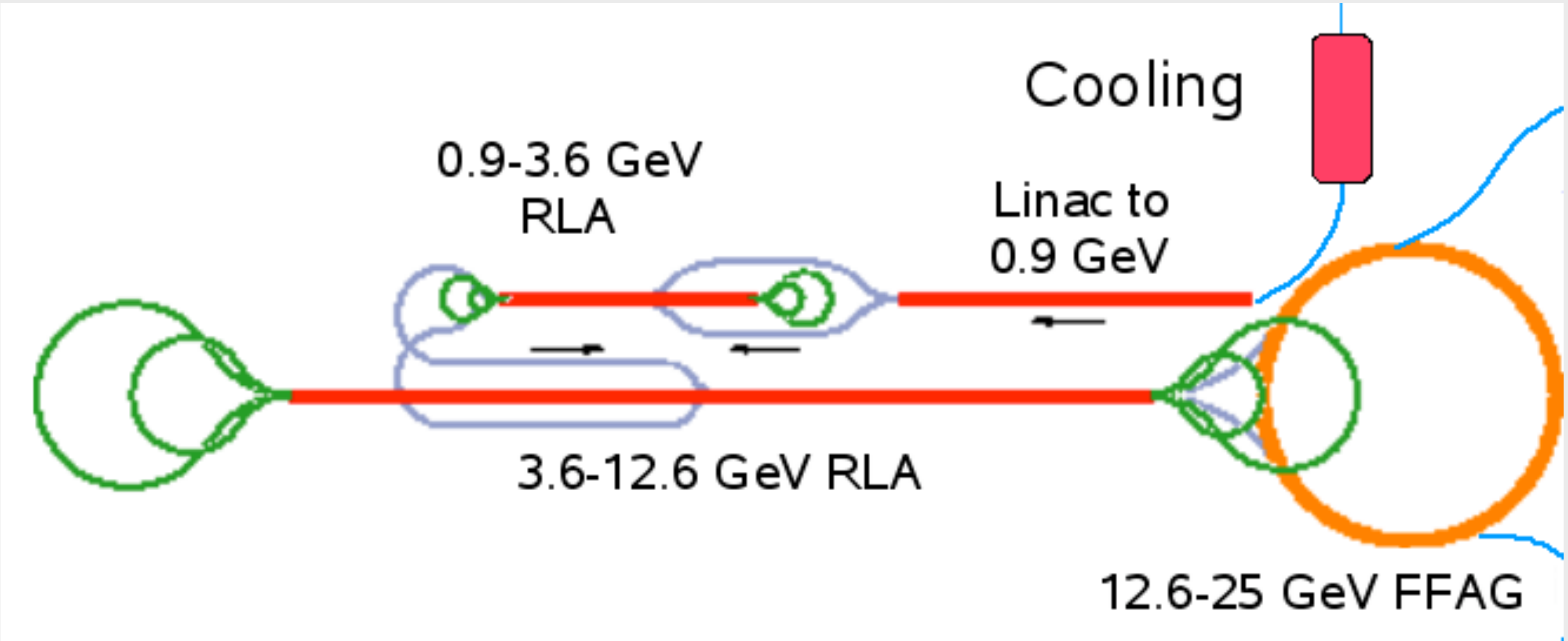
To contain the beam within the acceptance of the cooling channel transversal focussing (solenoids 5T) is required together with an field gradient in the cavities of ~ 15 MV/m

High magnetic fields degrades the available accelerating voltage (dark currents, RF breakdown) to below 10 MV/m and causes damage of RF cavities

Extensive experimental program underway to investigate this problem (surface roughness, coating, magnetic isolation)

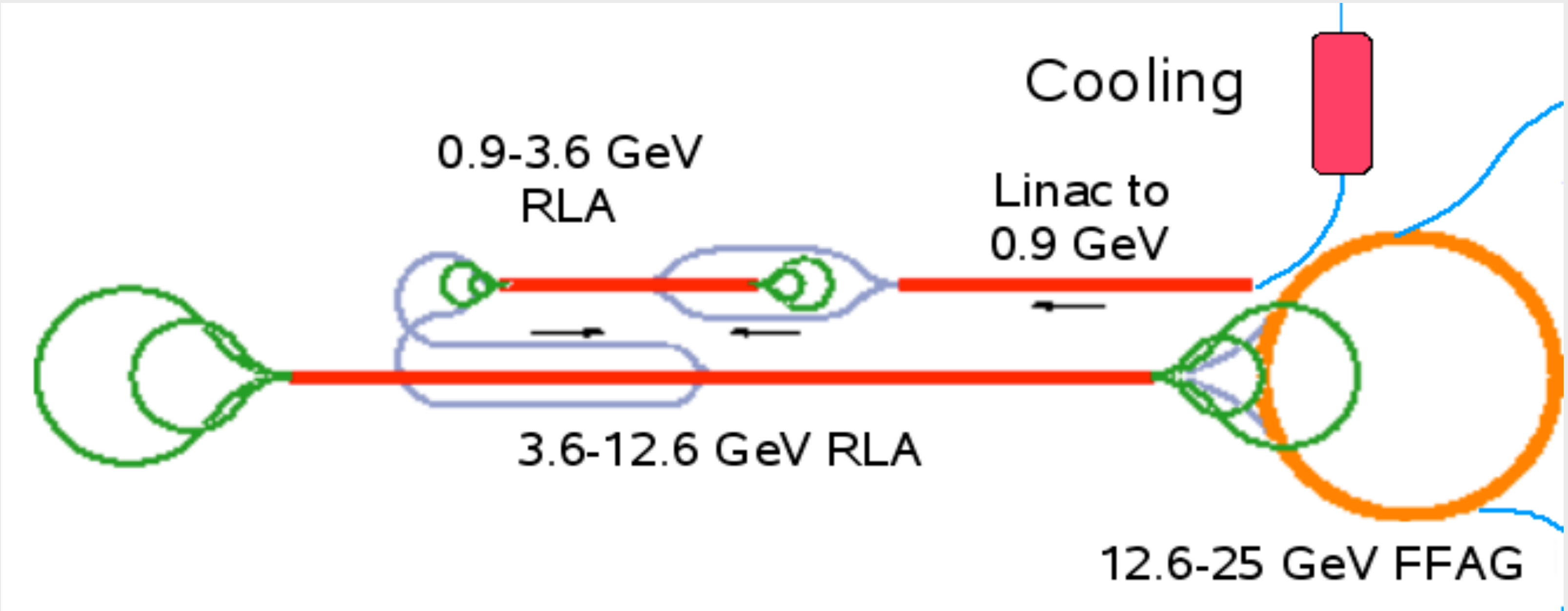
=> Achievable gradient will strongly influence the design of muon front end.

Fast acceleration – Linac / RLA



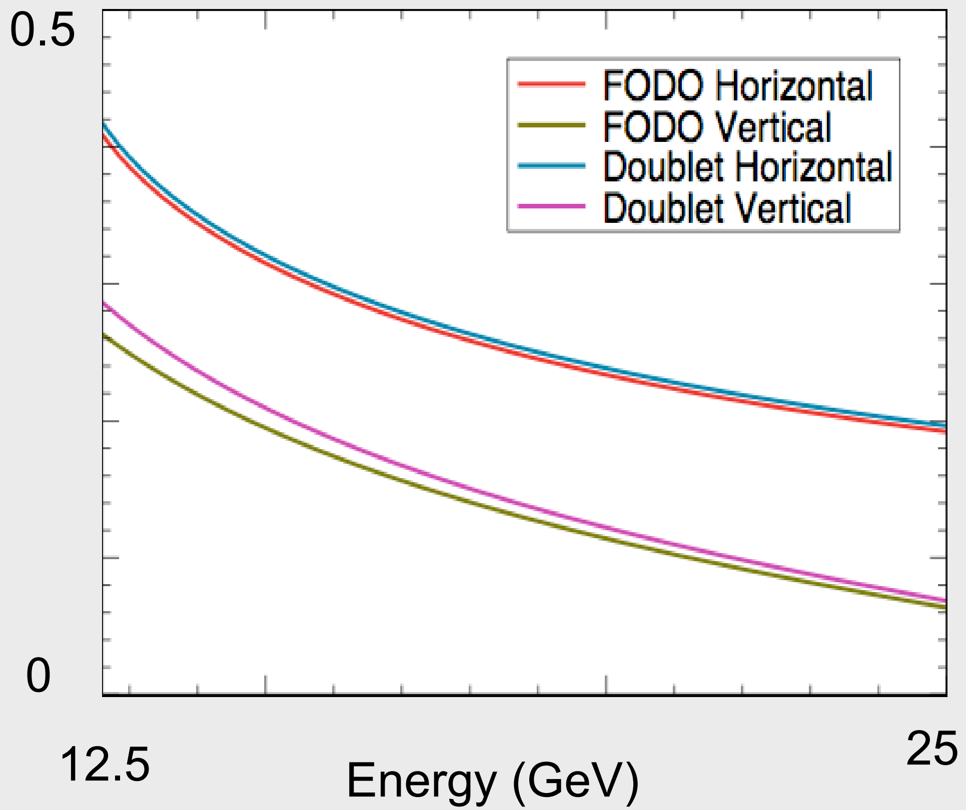
- Lattice design — done
- Particle Tracking 1 — done
- Particle Tracking 2 — started — 12 month
- Pre engineering of modules and magnets — 19 month
- Costing of components — 24/42 month

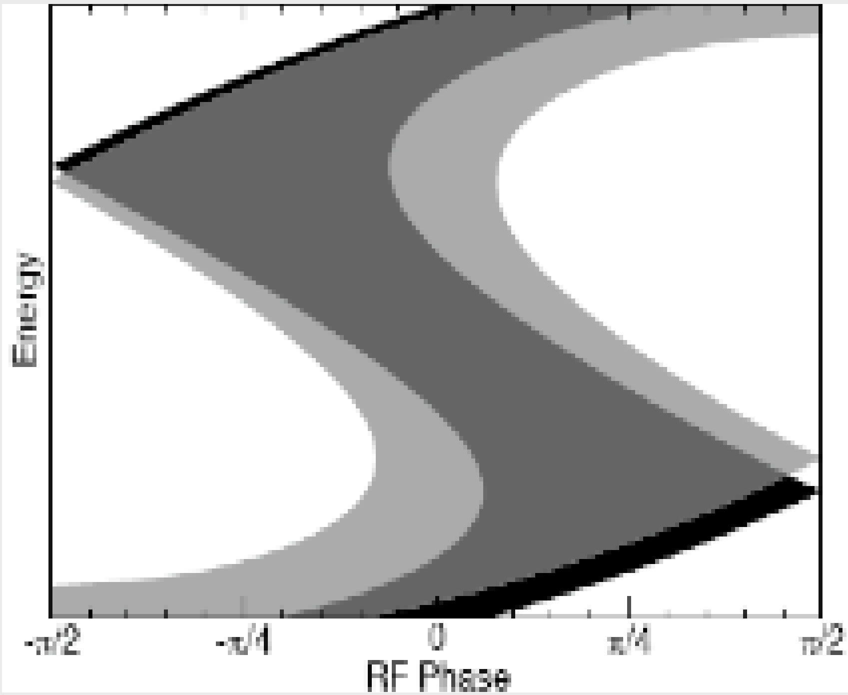
Fast acceleration - FFAG



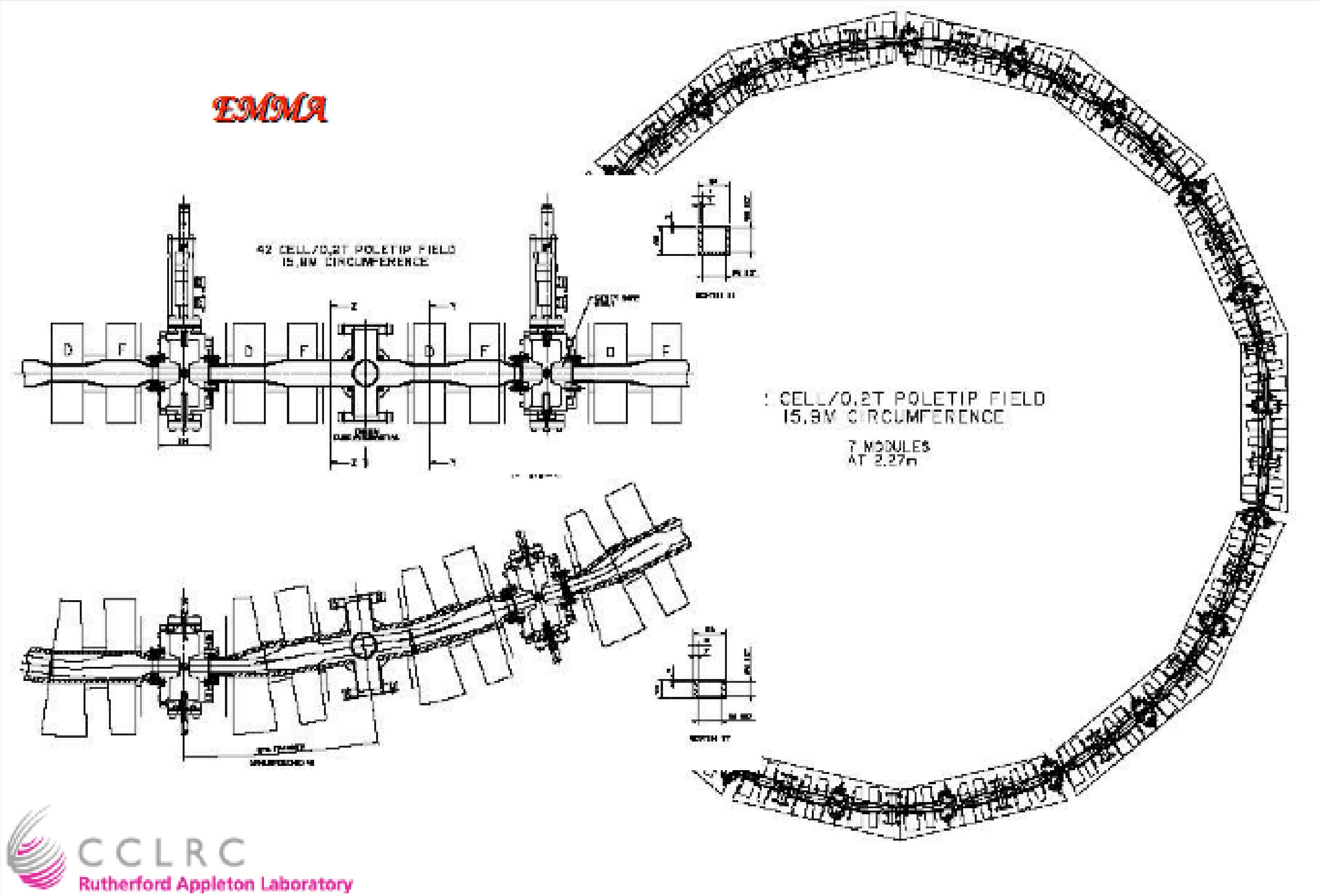
➢ Lattice design		mainly done
➢ Injection & extraction	started	12 month
➢ Particle Tracking 1		24 month
➢ Particle Tracking 2		24 month
➢ Pre engineering of RF and magnets		19 month
➢ Costing of components		24/42 month

ns FFAG -Cell tune & phase slip





EMMA - first NS FFAG under construction



- ØProof of principle
- ØElectrons
- Ø3 m inner radius
- ØAcceleration from 10-20 MeV
- ØDisplaced quadrupoles

Decay rings

Ø Lattice design		done
Ø Particle Tracking 1	started	9 month
Ø PT 2	started	9 month
Ø Pre engineering of magnets		19 month
Ø Definition of beam diagnostics		24 month
Ø End to end simulation		34 month
Ø Costing of components & rings		24/42 month
Ø Scaling and costing for LENF		36 month

Summary

- Euroν started

  - in person WG3 meetings aligned with IDS
  - recruitment and coordination nearly finished

- IDS
  - Tasks and partners identified
  - Main issues identified and work started
  - Work focuses on problems to be solved for a design report in 2010 / 2012 rather than new ideas

Next Meetings :

Euroν - annual meeting (now)

Nufact (Chicago, July 2009)

IDS plenary meetings (next in September in India)

additional telephone meetings + individual exchange on specific subjects