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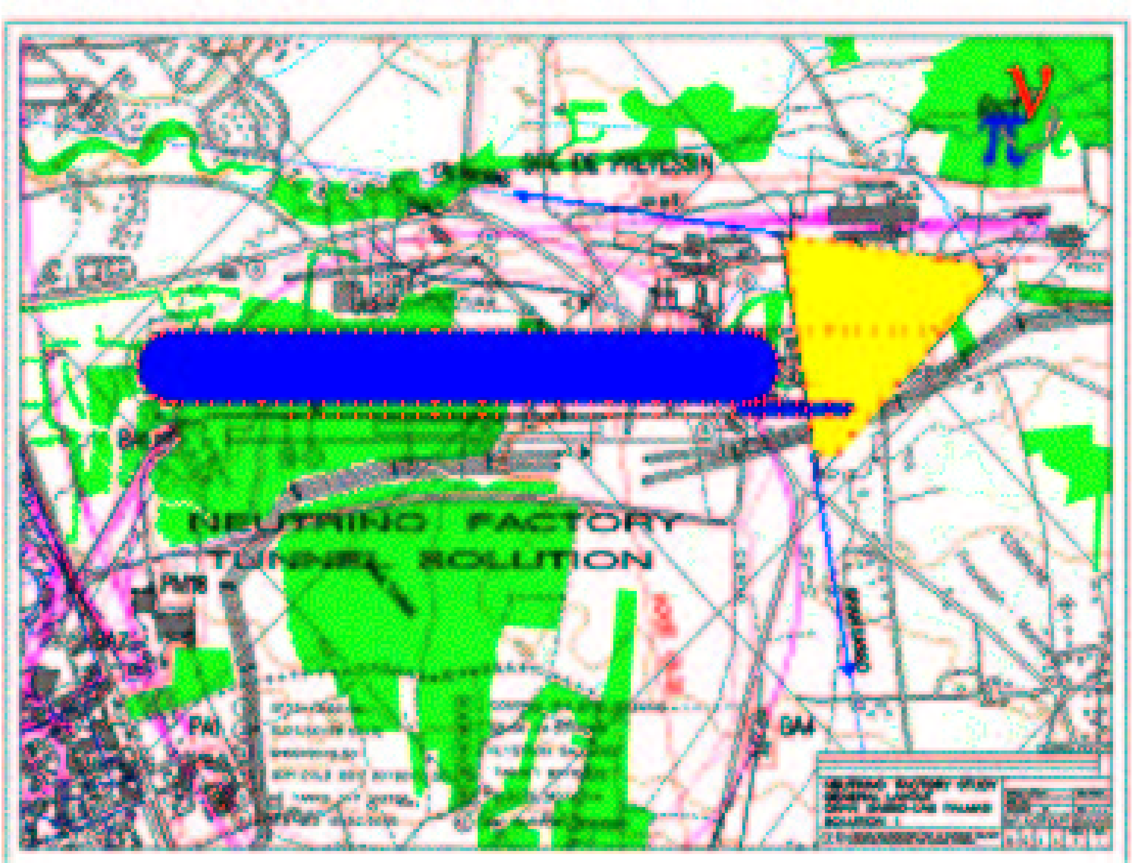
μ-νFact ACCELERATION : WORKS AND PLANS ON EUROPE SIDE

Contents

Present reference scheme in Europe : CERN design



- Pre-acceleration 0.3⟶ 3 GeV,
- followed by RLA1 that takes the beam from 3 to 11 GeV, drawn from US StudyI design,
- followed by RLA2 that takes the beam from 11 to 50 GeV ; assumes LEP cavity frequency, optics derived from former ELFE hadronic probe design,
- followed by 50 GeV triangle muSR.
- Transverse acceptance : 1.5 π cm
- CDR : CERN NuFact Note 122.

		Pre-acc.	**RLA1**	**RLA2**
kinetic energy	GeV	$0.3 \rightarrow 3$	$3 \rightarrow 11$	$11 \rightarrow 50$
number of pass		1	4	4
acceptance	πcm/πeV.s	3/0.1	1.5/0.1	1.5
linac length	m	450	2×350	2×1900
RF	MHz	88/220	220	352
	MV/m	4/10	4	4

Reminder - early works on multi-GeV RLA

ALS-Supra

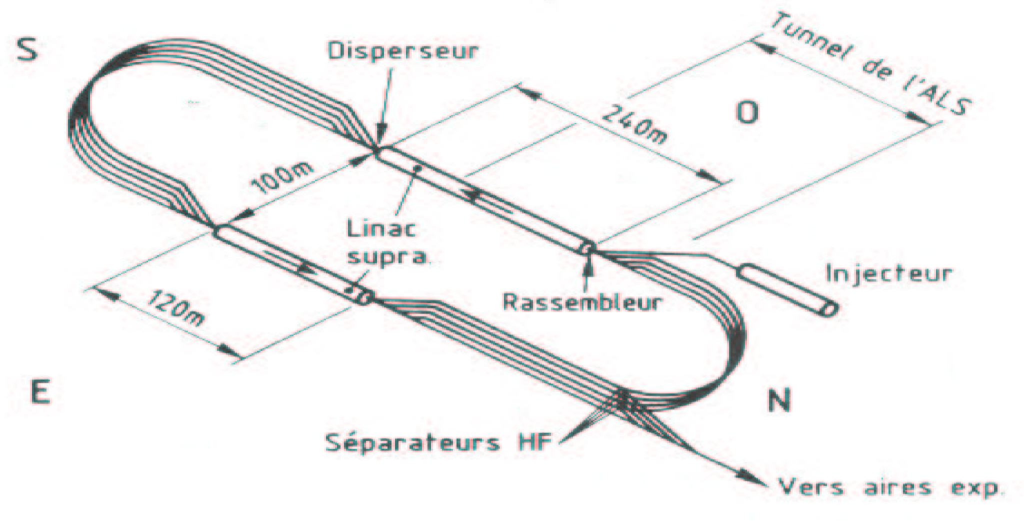
• First studies were launched at Saclay in 1986, with goal of :
- designing a multi-GeV hadronic probe for nuclear physics,
- in view of replacing the 730 MeV Saclay Linac "ALS" (100 μA, <2 % duty cycle).

• These studies yielded a National project, a 6 GeV RLA, "ALS-Supraconducteur" - **Fig. below**
[CDR : Aspects techniques d'un accélérateur supraconducteur de 6 GeV, Dep. Phys. Nucl. Saclay (1987)]

• The ALS-Supra design was performed in the context of the CEBAF construction, and based
- on CEBAF/Cornell 1.5 GHz SCRF cavity and system parameters
- on emerging experience on SCRF technologies in Europe and in particular at Saclay, within the GECS Group (which eventually drew GECS in early 1990's to the TTF collaboration).
- on CEBAF machine design studies.

The ALS-Supra design studies were performed by Theory Group, SATURNE, Saclay.

Characteristics of "ALS-Supraconducteur" :
- cavity : 2K, 5-cell, 1.5 GHz, 9 MV/m
- 6 GeV in 5pass $\times$ $(0.4 + 0.8)$ GeV linacs
- 50 MeV injection



ELFE : Electron Lab For Europe

• Next step : 1992, design study of ELFE 15 GeV hadronic probe launched, following NuPECC recommendations [CDR : "Blue Book", RME02, ISN, Grenoble (1994)] - **see Fig.**

• Preference went to single linac configuration in view of easier further 30 GeV upgrade (in particular 1! spreader & recombiner).

• Optimum number of pass : flat within 3-5, determined from economical compromise accounting in particular for
- savings on linac length
- an upper value of the number of arcs

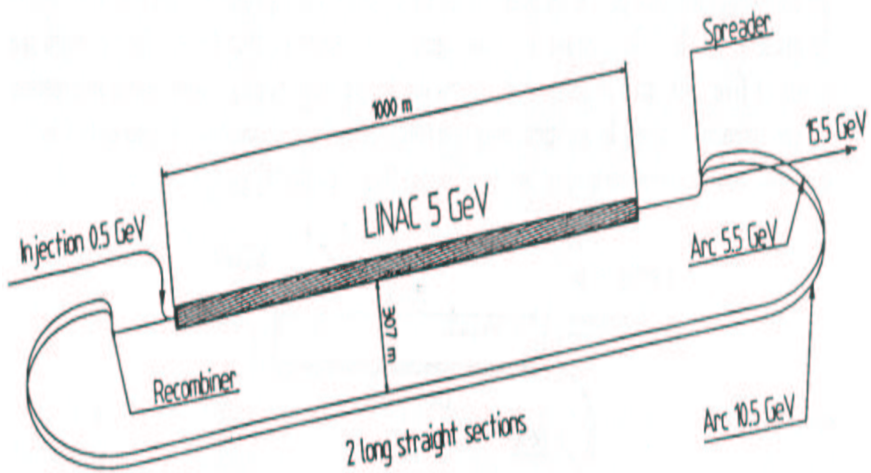
(limited by deleterious effects of SR that impose larger size high energy arcs. Note that, *this consideration does not hold for* $\mu RLA \Rightarrow$ in particular these can stand high field dipoles).

• Some aspects of ELFE, relevant to former μRLA design :
- choice of a FODO linac lattice, which allows adequate orbit and envelop control for all pass,
- injection energy is taken high enough to insure geometrical and momentum acceptance in linac lattice at all pass ($Ef/Ei = 30$),
- arcs are isochronous, and second order achromat : drawn from SATURNE lattice.

Machine design studies involved Labs from G, I, N, F.

Characteristics of ELFE :
- RF cavity : 2K, 5-cell, 1.3 GHz, 10 MV/m
- 15.5 GeV in 3pass × 5 GeV linac

(1 km long, 50% filling factor, upgradable to 30 GeV)
- 500 MeV injection (*hence,* $Ef/Ei \gg 10$)



ELFE @ CERN

- Following the earlier ELFE design, ELFE @ CERN study launched by NuPECC and CERN in 1998 with the idea of using the 3.5 GeV, 352 MHz LEP RF system.

- That yielded a 25 GeV racetrack recirculator [CDR : "ELFE at CERN", CERN-99-10 (1999)].

- single linac,
  . injection 800 MeV + 3.5 GeV×7 pass (a rather large value as to spreader/recombiner design),
  . 100 μA, 100% duty cycle,

- reference site CERN,

Early μRLA design

- A step towards present CERN scheme : the PJK design [NIM A 451 (2000) 265].

- PJK produces sets of reference parameters, and early versions of
- a μRLA1 design : a 4-pass, 2 to 8 GeV machine, and of
- a μRLA2 design : 4-pass, 8 to 30 GeV ;

- These two machines lean on known technologies and existing earlier RLA studies :
- both were based on ELFE@CERN design, and so inherit from earlier ALS-Supra and ELFE studies,
- both are based on use of 352 MHz LEP RF cavities.

. In μRLA1 : a single 4-cell cavity per half-FODO cell, $4\lambda_{RF}$ long, yielding specified acceptance of 1.6 πcm at 2 GeV.

. In μRLA2 : LEP RF cavity modules used as they are, one module per half-cell, same half-cellength as in ELFE ($17.5\lambda_{RF}$)

- Design of recombiners/spreaders in μRLA1 not solved.

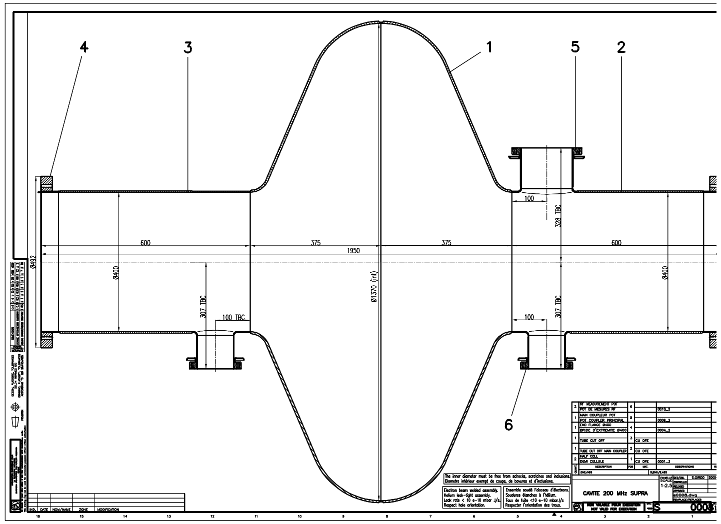
PJK parameters

π/p yield (cf. MARS data)		GeV_p^{-1}	0.01	
top μ energy		GeV	30	
geom. acceptance, norm,	RLA1	πcm		
			1.65	arc-pipe ϕ 14 cm
	RLA2	πcm	1.5	arc-pipe ϕ 8 cm
	μSR	πcm	1.5	
relative momentum spread,	RLA1	rms	0.045	
	RLA2	rms	0.011	
	μSR	rms	0.003	

A 2 to 50 GeV single RLA

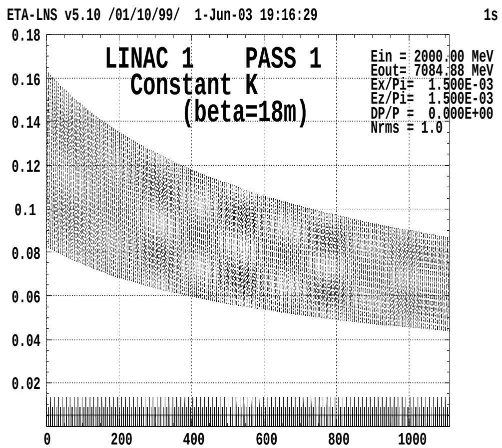
- A recent study [NuFact Note104 (2001)] shows the possibility
  . from viewpoint of focusing in the Linac,
  . to evolve towards a single 50 GeV recirculator, 4-pass
  . with total linac length (1.1 + 1.4 km) close to half that of μRLA2.

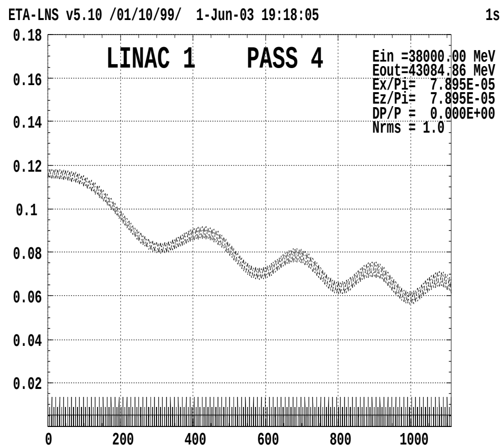
- The first linac uses 220 MHz RF, 8.8 MV cavity (13 MV/m), 360 mm aperture (parameters drawn from the Cornell/CERN 200 MHz test cavity, **see Fig.**).
The second linac uses either 220 MHz, or higher frequency RF.



Cornell/CERN 200 MHz cavity (measured 10 MV/m, 7.5 MV in cavity).

- Possible geometry in the first linac :
- one quad every λ_{RF}, one single-cell cavity per half FODO cell, yielding $< V >= 3.2$ MV/m in the linac, the acceptance reaches $\boxed{7\ \pi\text{cm}}$ (envelopes : **see Fig.**) ;
- a possible choice with relaxed focusing : 3 cavities per half-FODO cell, $< V >= 4.8$ MV/m in the linac, yields $\boxed{3.5\ \pi\text{cm}}$ acceptance, more than twice that of μRLA1-2 design.





Plans for near future

- Questions of general order relevant to RLA design need be answered in order to converge on parameters :

- top energy,

- SCRF technology capabilities,

- economical optimum of number of pass (e.g., RF savings vs. multi-pass complexity),

- goal acceptance (cooling or not ?),

- injection conditions, (minimum) injection energy, which means in particular a scheme for pre-acceleration $\rightarrow$ with goal of 0.5 π eV.s ?

- arcs technology (separate, FFAG...) $\rightarrow$ arc magnets technology

- software developments, in particular tracking tools, capable of correct simulation of large amplitude motion in large aperture cavities or magnets.

- In the closest future, complete *our* single-RLA design :

- longitudinal motion,

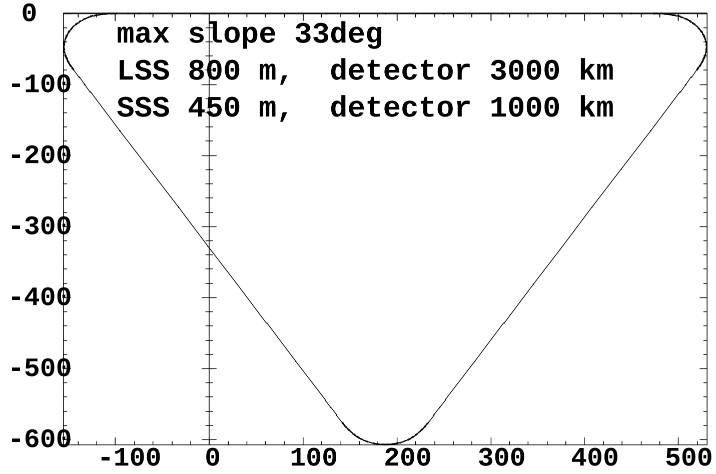
- arcs, spreaders, recombiners,

- perform full 6-D tracking (we have codes including motion in cavities, from e-RLA experience, e.g. DYNAC)

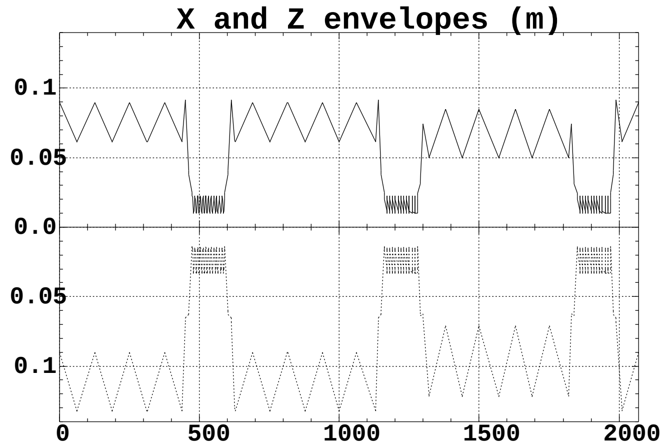
- strategies for envelope and orbit control in the linac (acceptance vs. injection energy, strong focusing)

- sensitivity to errors

Muon storage ring



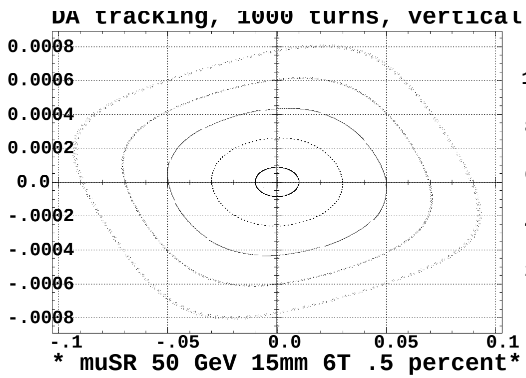
• Substantial work has been performed. Yielded 12 NuFact Notes and two types of rings :

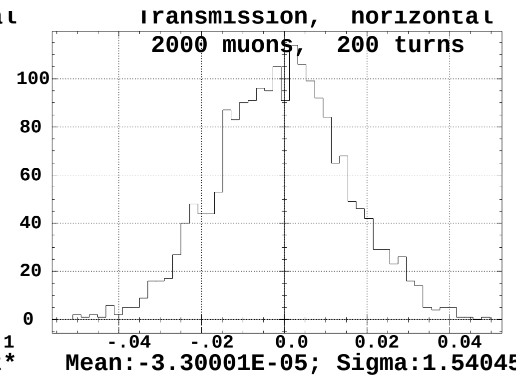


• Earlier geometry : plane bow-tie. Two long baselines, elevation minimized. Rejected due to the too complicate installation vs. gain wrt triangle.

• Present design : triangle. Compact arcs ⇒ decay straight ratio ≈ 60% (36+21). The 33 deg slope allows 1000 and 3000 km distant detectors. Design is for 1.7πcm, $0.5\% dp/p$. Polarization in orbit plane can be maintained with RF.

• Future : based on the CERN site triangle geometry :
- Converge on beam properties : divergence in decay straight, tolerances, impact of straight ends.
- Beam polarization : seems a prerequisite, calls for spin dynamics studies.
- Power deposition due to decay > 100W/m ; peaks from decay e^+/e^-. Needs further studies, develop tracking tools. This impacts on machine optics.





FFAG activities

• Signicant signs of activity exist

- July 2000's FFAG workshop hosted by CERN

- participation and contributions in FFAG workshops

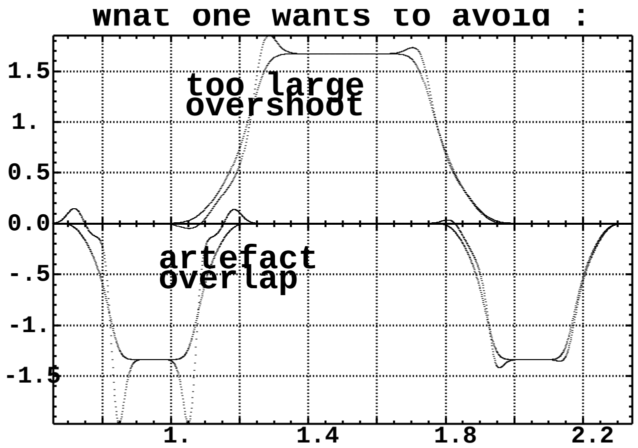
on the following themes :

. A common denominator has been, works on quasi-isochronous optics.

. Works on low-beta optics for beam cooling.

• Activity does go on, though sort of saw-tooth, teeth tend to be at the vicinity of international meetings, due to availability of people.

• Means for high-precision 6-D DA tracking in FFAG magnets exist (FM, FFAG02)



CONCLUSION

The Europe side needs men-year