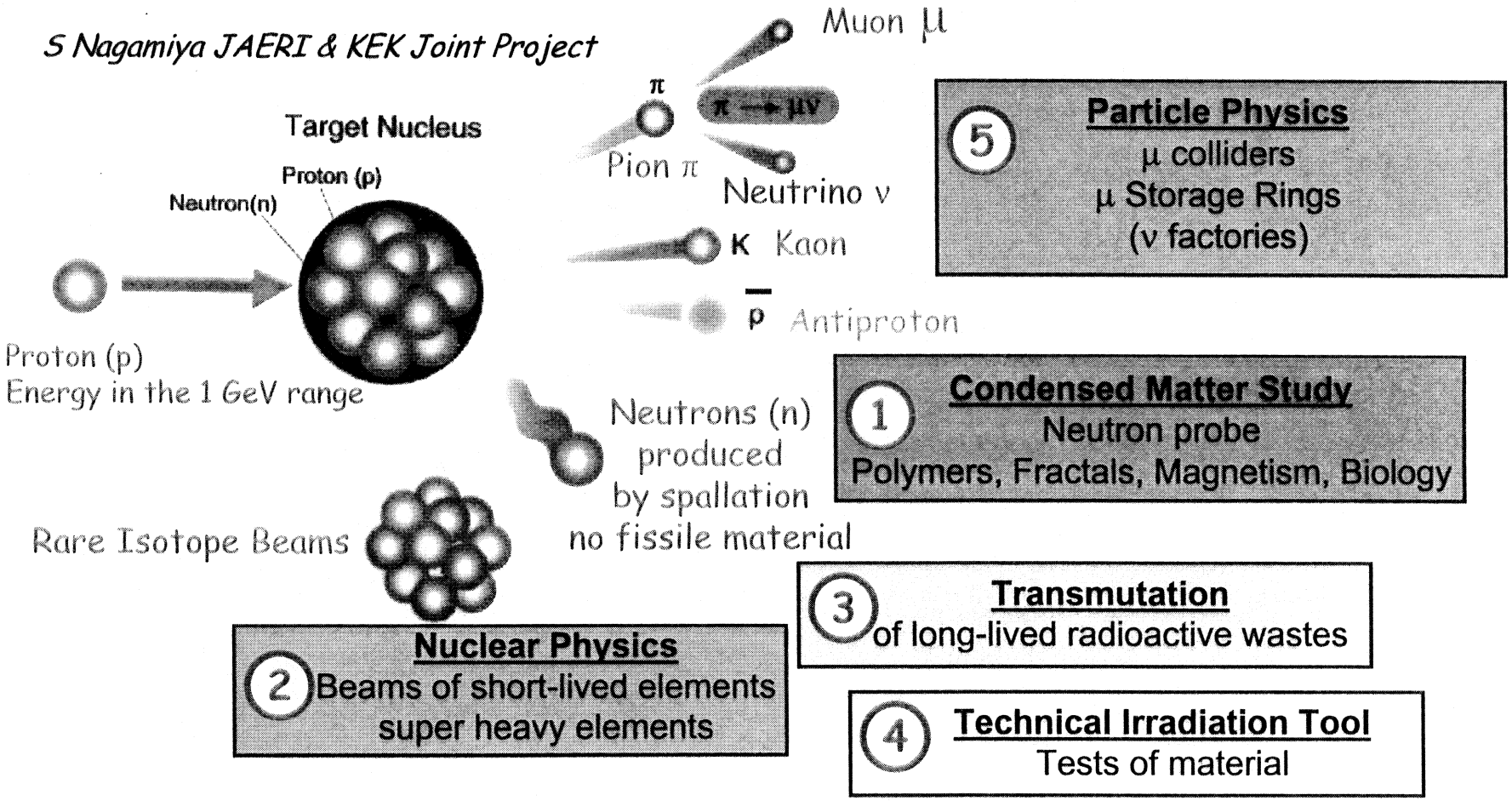
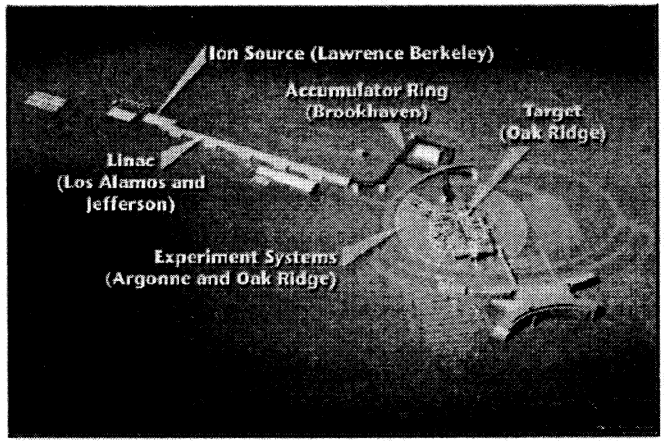
Secondary Beams produced by a **high energy proton** in a target 5 applications in fundamental and applied Research

S Nagamiya JAERI & KEK Joint Project

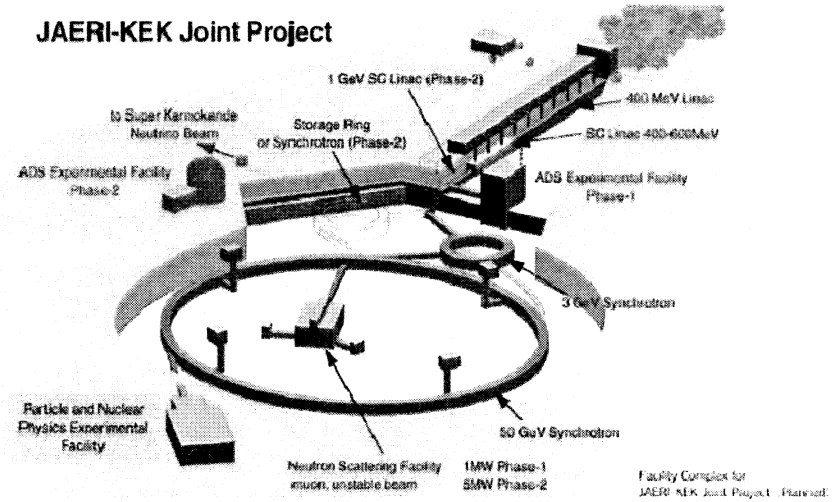


2 different strategies in US and Japan



SNS (Oak Ridge, USA)
stand-alone facility
uniquely dedicated
to neutron scattering
RIA and ATW are being
considered separately

Joint Project (Tokaï, Japan)
and KOMAC (Korea)
multi-purpose facilities
combining ① ② ③ ④ ⑤
footprint of particle
physics
highly marked.

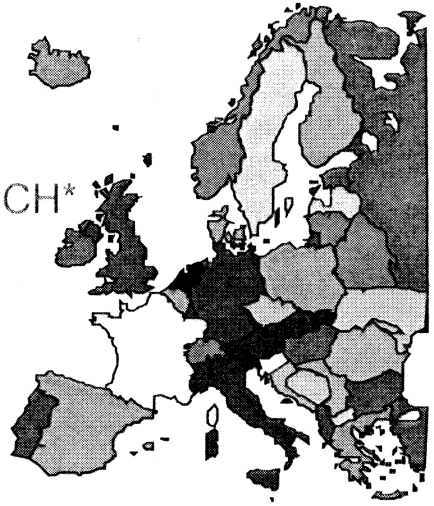


Europe case

Present status

- 5 stand-alone projects are being prepared separately in parallel by the different communities (ESS, Neutrinos, RNB, ADS, Irradiation tool, etc...), with individual costs in G Euro unit.
- Each of them can only be envisaged in large European collaboration.
- Each of them would require some 10-15 years to be completed. Obviously, individual communities would prefer a dedicated facility, but priorities will be difficult to establish. Competition will be hard.

ESS, ISIS, AUSTRON, MUNICH
GANIL, LEGNARO, GSI, SIRIUS, ESS*, MUNICH*
TWG, TRASCO, MYRRHA
J HOROWITZ, MUNICH*
CERN



Proposed Approach

Similarities between project requirements
☛ synergies could be exploited in a large collaboration
between disciplines at Europe level with concerted consequences
on long term planning of existing large facilities.

Funding agencies will inevitably ask to follow this approach !

The proposal to review and to analyse

- the compatibilities between disciplines with regards to accelerator characteristics, targets, instruments, infrastructures, environmental and safety aspects, ...
- the time scale and maturity of the different applications
- the overlaps and synergies
- the costs to the different communities

This will allow :

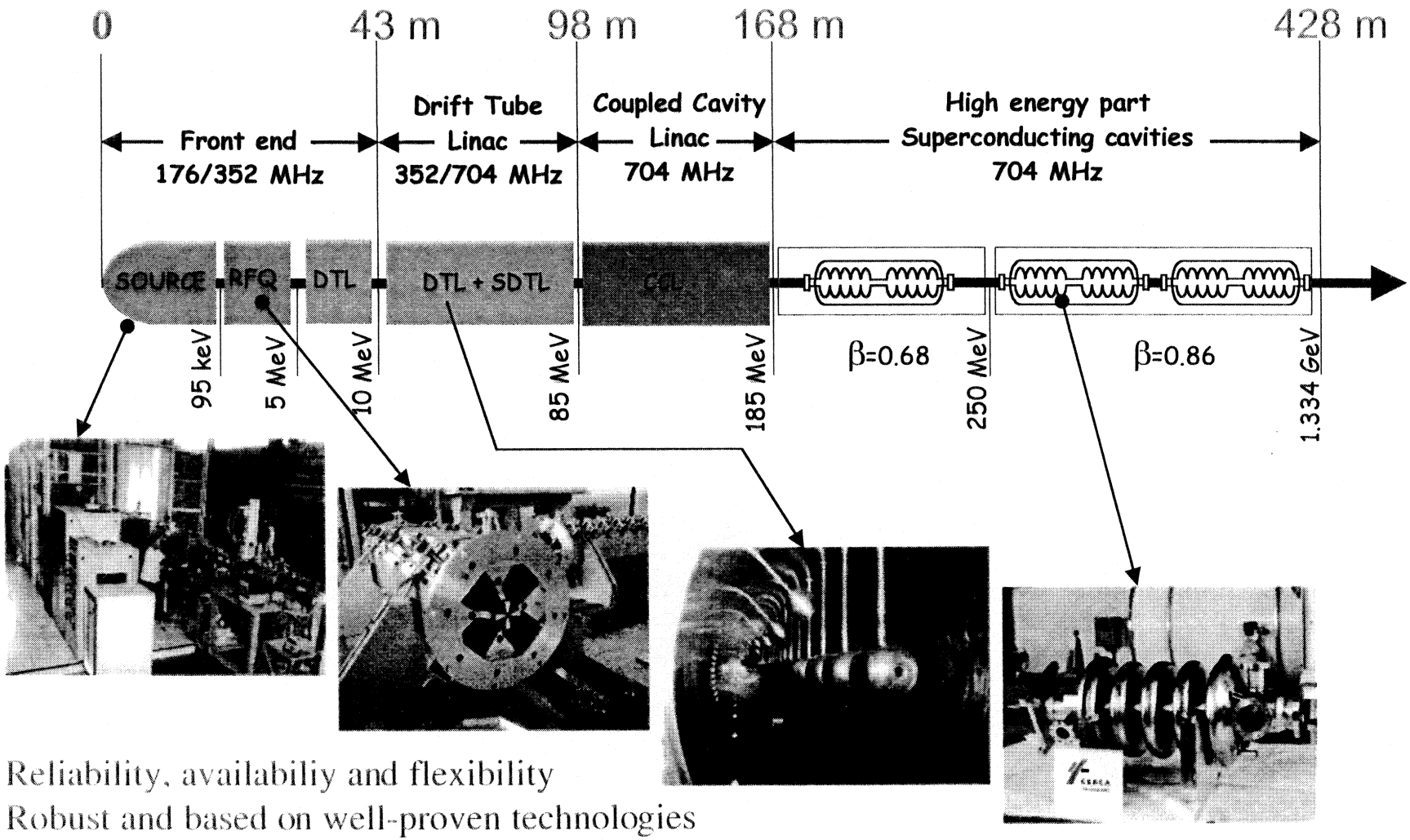
- to compare multipurpose with stand-alone facilities,
- to possibly recommend regrouping certain applications

Typical parameters for applications ...

User	Beam Power	Energy	Current	
Condensed matter	5 MW	1.3 GeV	3.75 mA	ESS project
Radioactive Ions from protons from neutrons	 ~ 200 kW ~ 5 MW	 > 200 MeV ~ 1 GeV	 ~ 1 mA ~ 5 mA	EURISOL project
Transmutation 100 MWth demo Industrial system	 ~ 5 MW ~ 50 MW	 ~ 600 MeV ~ 1 GeV	 ~ 10 mA ~ 50 mA	
Irradiation tool	> 10 MW	~ 1 GeV	10 mA	SPALLAX
Muons - Neutrinos	4 MW	2 GeV	2 mA	SPL (CERN)

➡ many similarities in requirements for HPPA drivers
to serve pulses at 50 Hz to all applications
The power would then be adjusted by adapting the individual pulse length
This will result in a very robust operation of the driver since :
peak current, space charge, focusing and RF tuning will remain constant

Architecture of the Linac



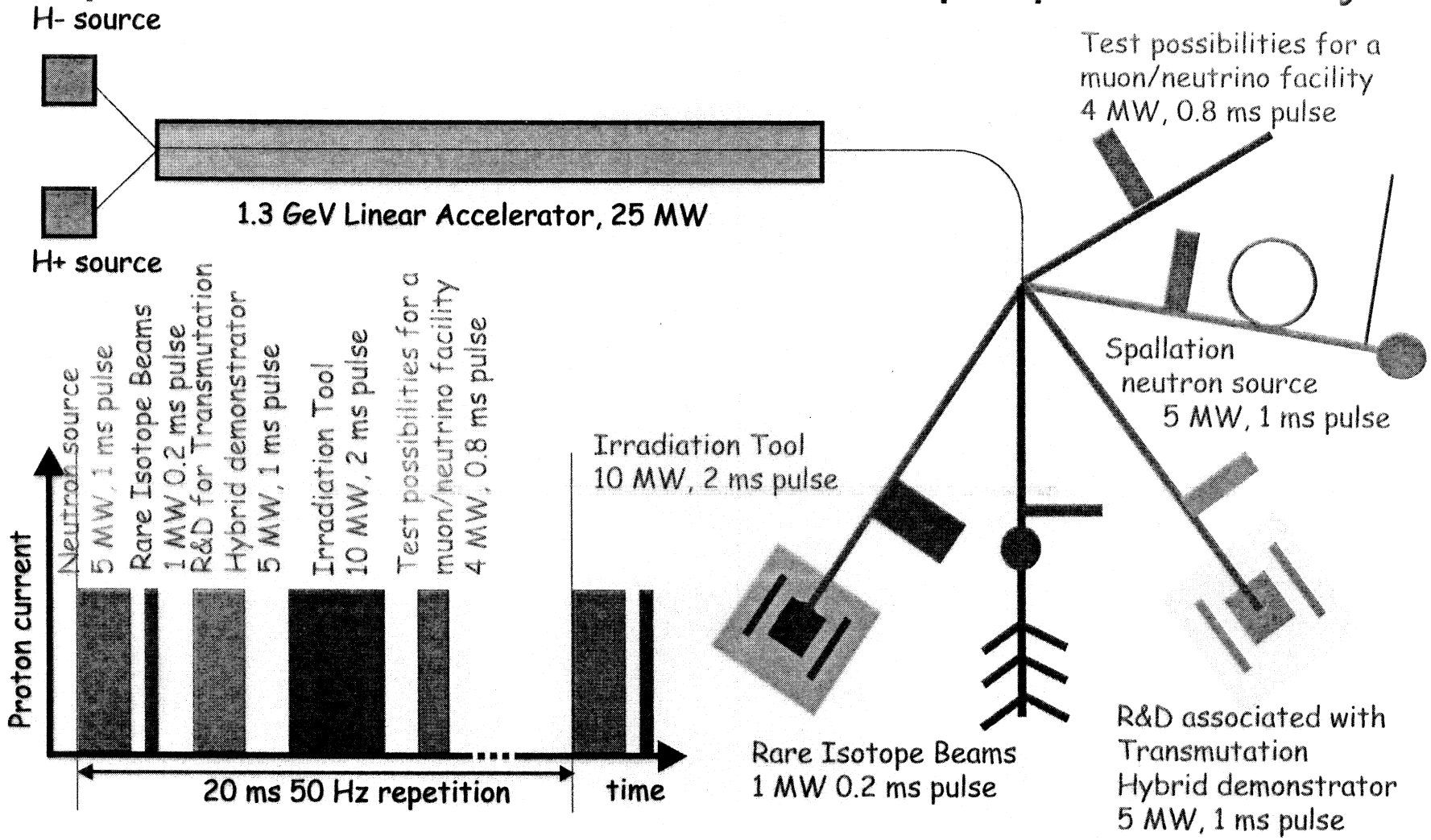
Reliability, availabiliy and flexibility

Robust and based on well-proven technologies

Major concern : minimisation of beam losses (< 1W/m for hands-on maintenance)

⇒ careful beam-dynamics design (to minimize the risk of halo formation & emittance growth)

Operation of a HPPA for a multipurpose facility

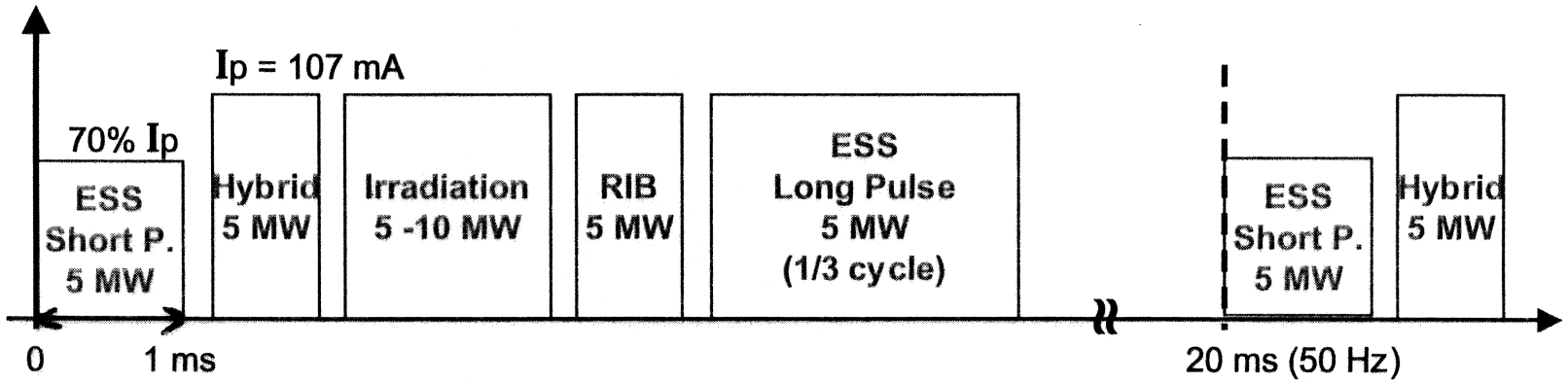


Fixed peak current

Power adjusted by pulse width for independent tuning of each user

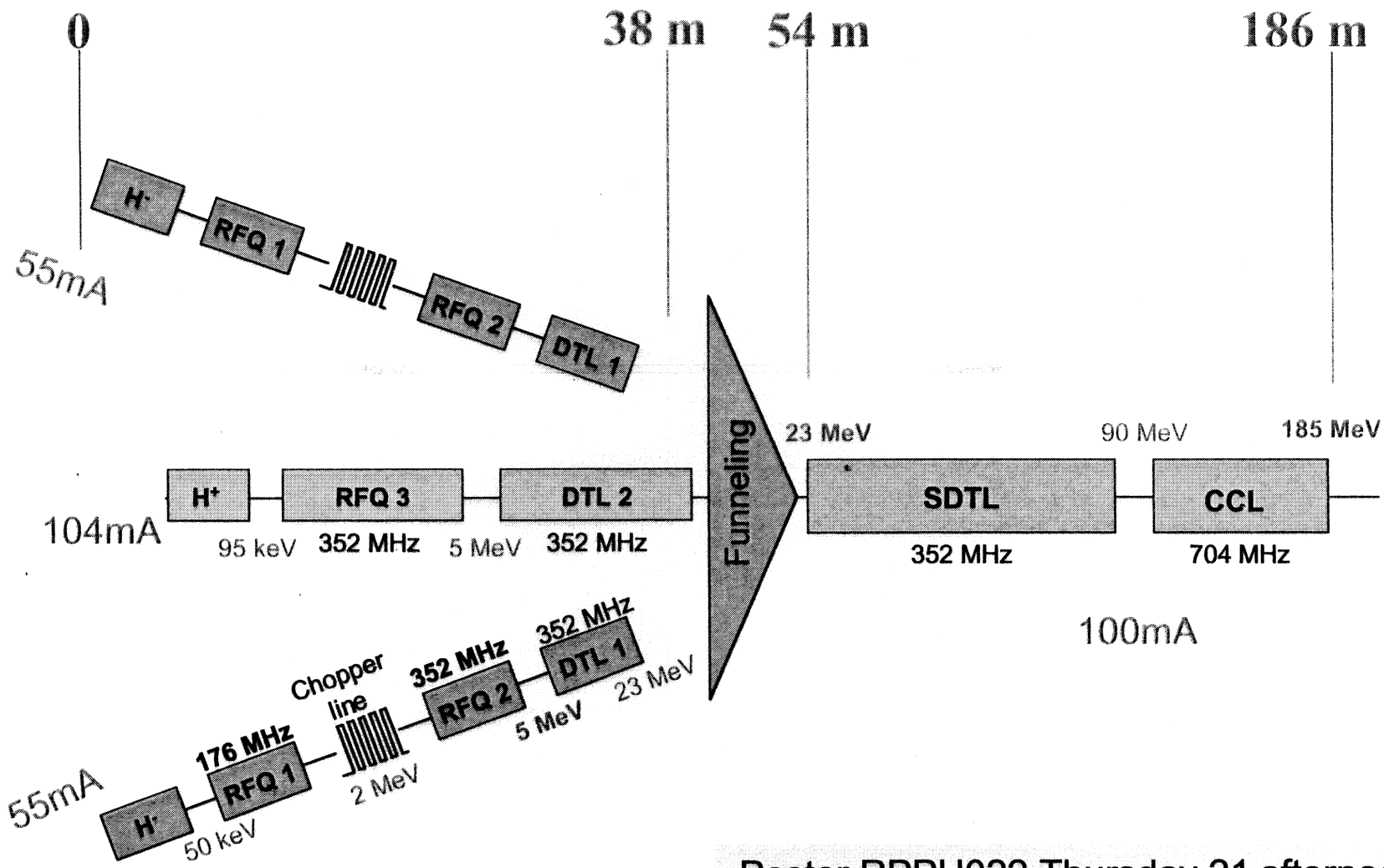
Typical pulse sequence

(for a 1.334 GeV linac and 107 mA peak current)



- A series of 50 Hz pulses distributed over the 20 ms period
- each pulse duration adjusted to satisfy the desired power of a given application
- H^+ for all current pulses except for short pulse of spallation neutron source : chopped H^- beams for a proper injection into a compressor ring
- bunch charge Cst for all pulses (to keep space charge Cst) chopped H^- ~ 70% H^+
- total beam power of 25 MW with a duty cycle of 25%
- interval between successive pulses ~ 100 μs
  to operate fast switching magnets without beam loss

Low Energy Linac scheme



Poster RPPH022 Thursday 21 afternoon
(R. Ferdinand et al)

High Energy Linac scheme

Poster RPPH021 Thursday 21 afternoon
(A. Mosnier et al)

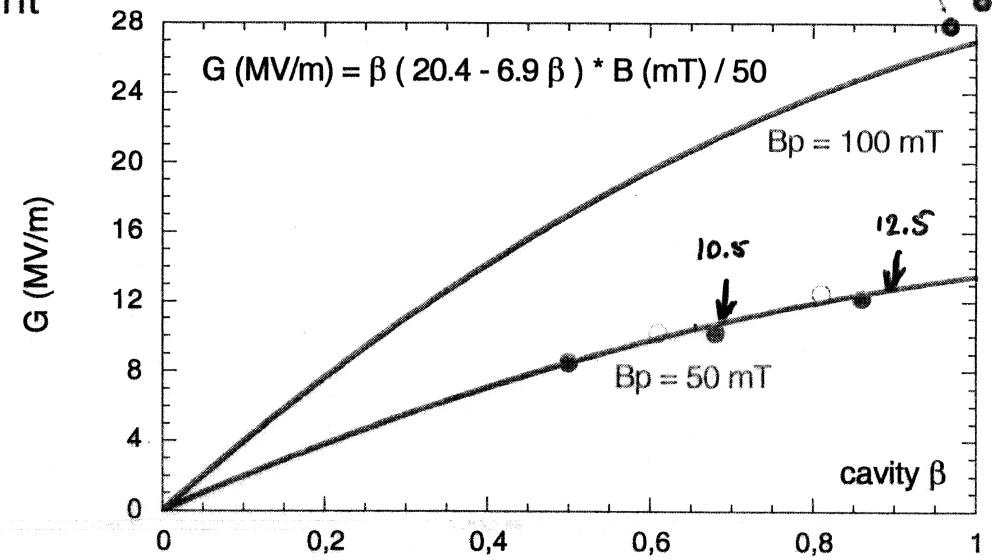
185 MeV 450 MeV 1334 MeV

$\beta = 0.68$	$\beta = 0.86$
15 modules 3 cavities (5cells) ⇒ length = 92.25 m	23 modules 4 cavities (5cells) + 1 spare ⇒ length = 204.6 m

- Transition energy between NC & SC fixed at 185 MeV
  (below 200 MeV, energy gain per real-estate meter for SC < 2 MeV/m and
  design of SC cavities for b < 0.6 complicated by stiffness & microphonics issues
- for the present design : 50 mT peak magnetic field selected
  (conservative factor of 2 lower than the surface field aimed at TESLA project)
- entire SRF linac inferred from an optimisation of the linac length
  (in terms of number of cells per cavity, number of cavities per module, etc)
- 3 fundamental constraints :
  - max Eacc below a prescribed value, which depends on the cavity "beta"
  - longitudinal phase advance per cell below 90° for stability reasons
  - beam power per cavity below the input coupler capability

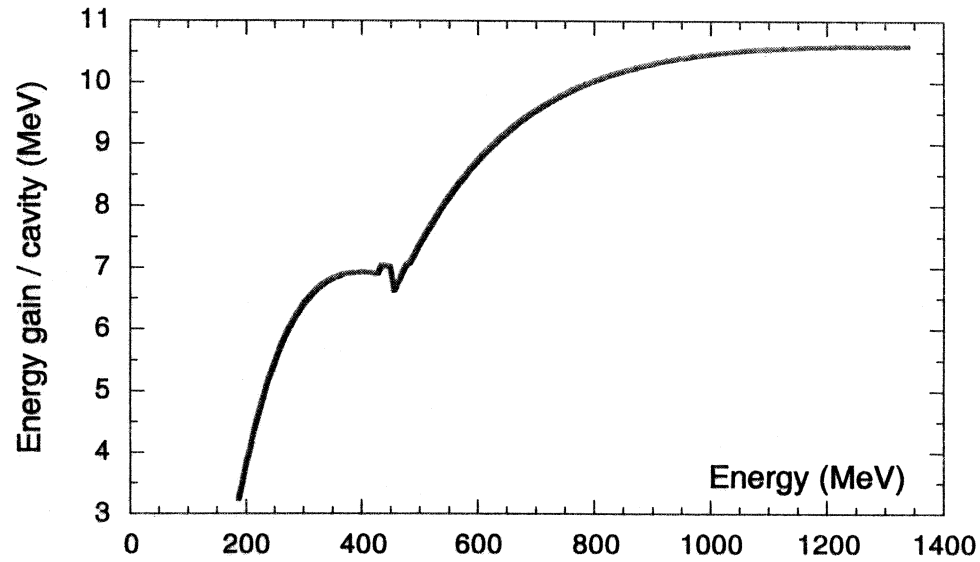
empirical law for the setting of gradient
in proton linac
as a function of the cavity "beta"

expected gradients for two values
of peak magnetic field,
+ data of the cavities designed
by the French-Italian collaboration
and for the SNS Linac,
with peak surface fields of 50 mT
and 27.5 MV/m



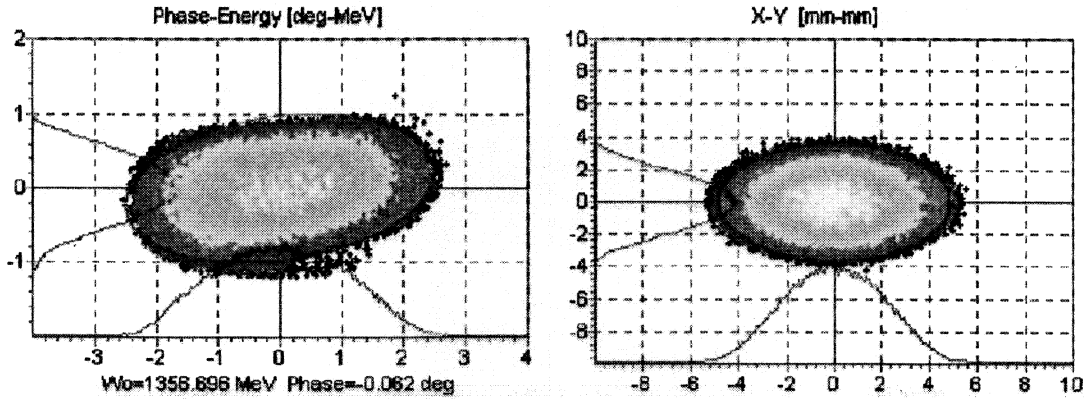
Energy gain per cavity
as a function of beam energy
(Phis = -25°)

Assuming 2 couplers per cavity
=> maximum beam power
of 1 MW per cavity

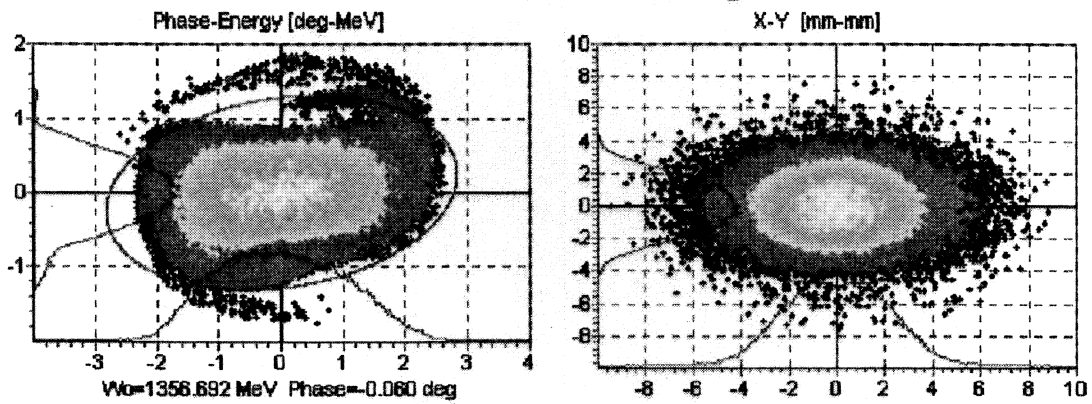


Multiparticles simulations ...

In the error free machine first with a matched input beam
to check the overall architecture as well as beam matching



Second with a mismatched input beam
to test the robustness of the linac design



End-to-end simulations w/o errors showed excellent beam qualities
without significant beam tails (only 10^{-3} particles outside 3 times the rms size)

Poster RPAH013 Thursday 21
morning
(N. Pichoff et al)

Conclusions

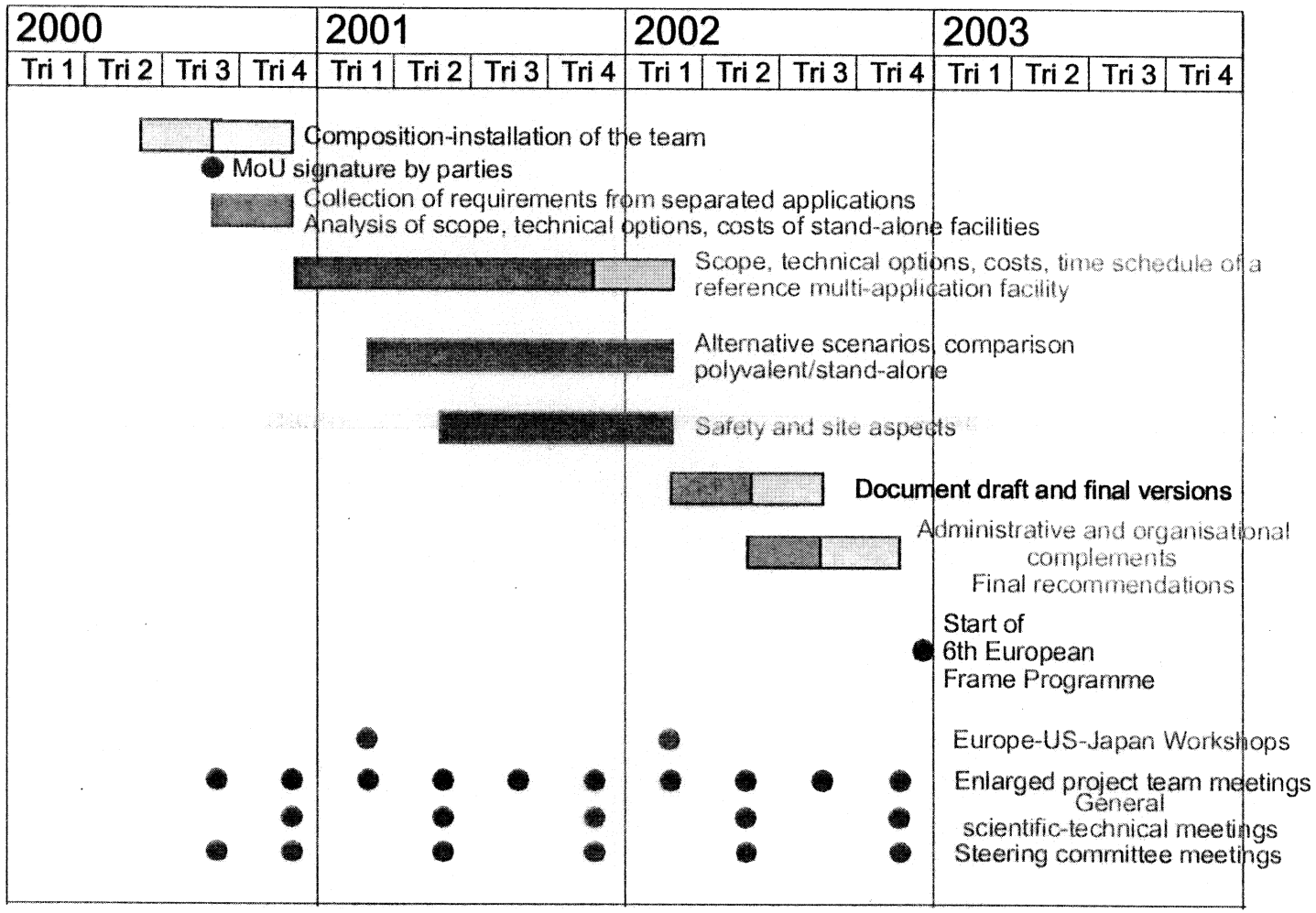
✓ The idea of a multi-application facility is technically achievable with today's technology and the architecture of a robust accelerator of the 25 MW class has been designed

✓ Following this feasability study :

- most possible scenario = ESS-like facility to start with (short + long pulses version) for condensed matter study

- upgrade & flexibility integrated in the design will allow for accomodating other applications at a later stage

Main tasks and milestones of the 2 year feasibility study



http://web.concert.free.fr

SNS Construction costs limit set at 1.412 G$

COmbined Neutron Centre for European Research and Technology

CONCERT

De-scoping on Conventional Facility, Instruments, Accelerators

Projected Cost Baseline

	10/00 Baseline $M	1/01 (A) Baseline $M	Potential Cost Changes $M	Project Initiatives $M	Projected Baseline $M
1.2 Project Support	75.5	75.9	2.7 (1)	-8.0 (8)	70.6
1.3 Front End	19.2	19.4			19.4
1.4 Linac Systems	256.8	253.8	-1.5 (7)	0.0 (9)	252.3
1.5 Ring and Transfer Systems	130.5	140.2	2.7 (2)	-5.5 (10)	137.4
1.6 Target Systems	91.9	90.0	-0.2 (4)		89.8
1.7 Instrument Systems	93.0	53.3		6.7 (11)	60.0
1.8 Conventional Facilities	300.3	265.9	2.3 (3)	43.6 (12)	311.8
1.9 Integrated Controls	58.3	58.1	2.2 (5)		60.3
BAC	1,025.5	956.7			1,001.6
Contingency	167.2	220.2			177.3
	20.2%	32.5% (6)			24.6% (14)
TEC	1,192.7	1,176.9			1,178.9
R&D	107.5	104.7	-2.0 (2)	0.0 (13)	102.7
Pre-Ops	111.5	130.1			130.1
TPC	1,411.7	1,411.7			1,411.7

(A) IPS Rev 134

(1) EU office (3.1M), other project office (0.8K), 3D modeling (144k), Lease (3.6M), Reduce ORNL OH (-8.4M)

(2) PCRs in system 1/01

(3) 1.8.2.3 bid change orders thru Dec 00 ($97k), K/J incentive fee (552k), changes to ASD requirements (1.4M).

(4) Potential PCRs (-0.3M), PCRs in system 1/01 ($6K)

(5) Potential PCRs

(6) Contingency percentage based on ETC of $676.8M (actuals thru 12/00)

(7) PCRs in System 1/01 (3.8M), Potential PCRs (-4.2M), Raise Davis Bacon labor rate used in estimating installing planning (2.8M)

(8) Reduce Project Support (-5M), additional reductions to ORNL OH (-3M)

(9) Put 3 cryomodules back into baseline w/o raising budget.

(10) Reduce BM, EDIA (-5.5M), add sextupoles into baseline w/o raising budget.

(11) Provide 5 instruments 6.7M.

(12) Title I estimate increase (79.9M) plus reductions to Title I estimate increase that remain afte (27.4M), savings on commodities (-13.5M), GFE (-4.5M), Knoxville labor factor (-3M), borro

(13) PSR R&D performed by LANL w/o increase to R&D budget.

(14) Contingency percentage based on 279.6M cost+commitments thru 12/00

Basic Costs : 1.002 G$

Contingency : 0.177 G$

Sub-total : 1.178 G$

R&D : 0.130 G$

Pre-Ops : 0.130 G$

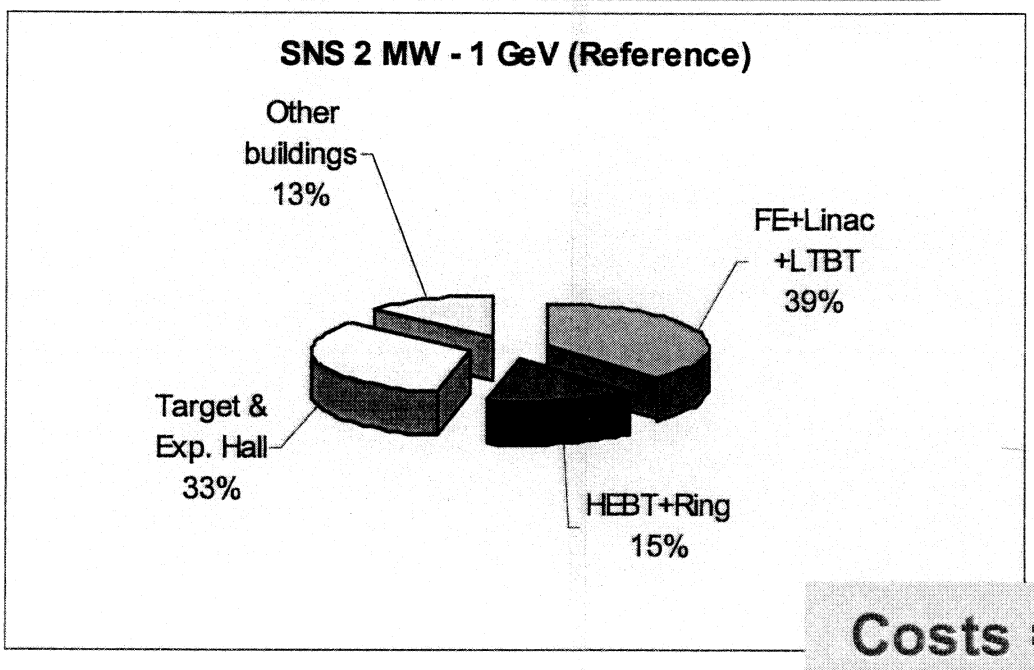
Construction Costs : 1.412 G$

⇨ 1 SNS construction costs unit = 1.4 G$

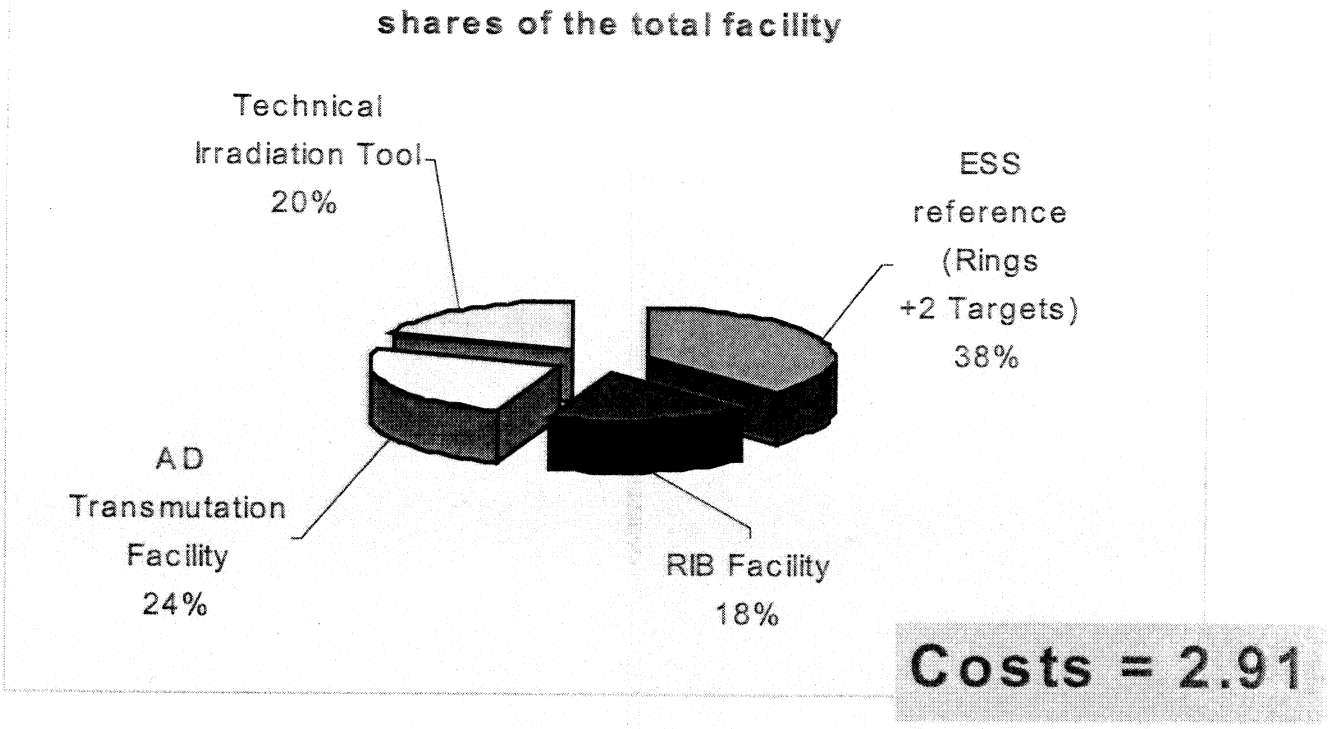
SNS Project Overview

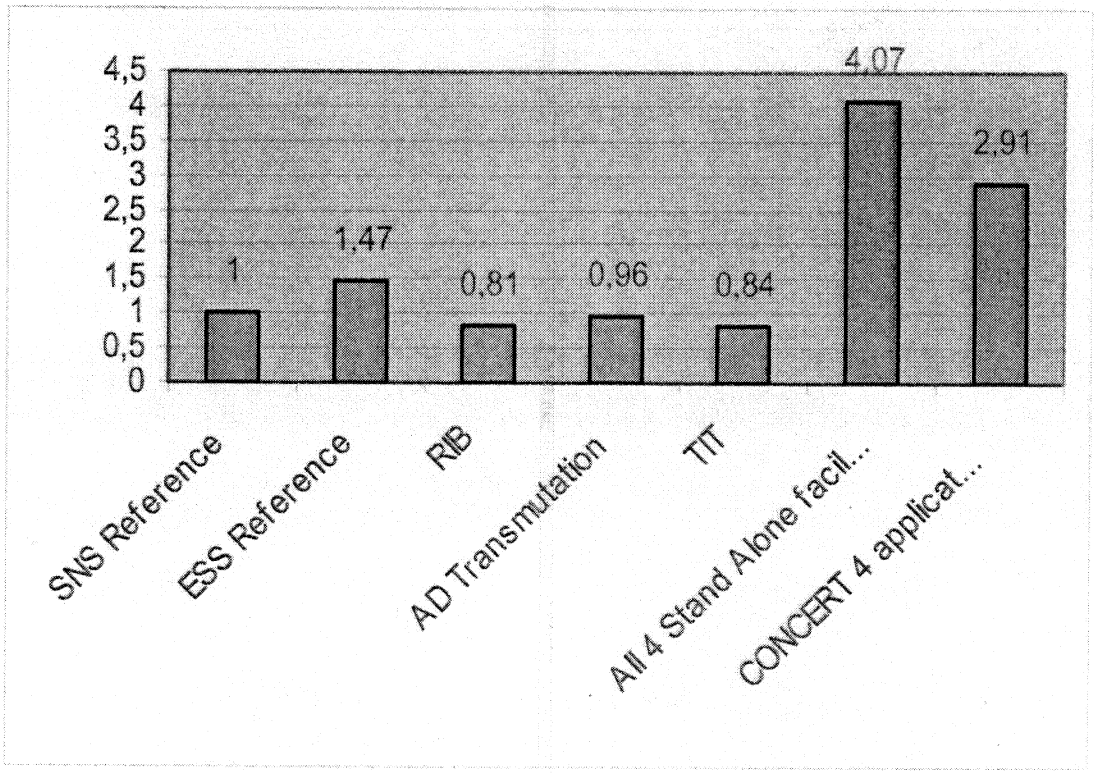
SNS 2 MW / 1 GeV + 1 Target

Total linac	365
HEBT+Ring	146
Target & Exp. Hall	320
Other buildings	125
Total	**955**



Costs = 1


shares of the total facility
Technical Irradiation Tool 20%
ESS reference (Rings +2 Targets) 38%
AD Transmutation Facility 24%
RIB Facility 18%
Costs = 2.91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SNS Reference
ESS Reference
RIB
AD Transmutation
TIT
All 4 Stand Alone facil...
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