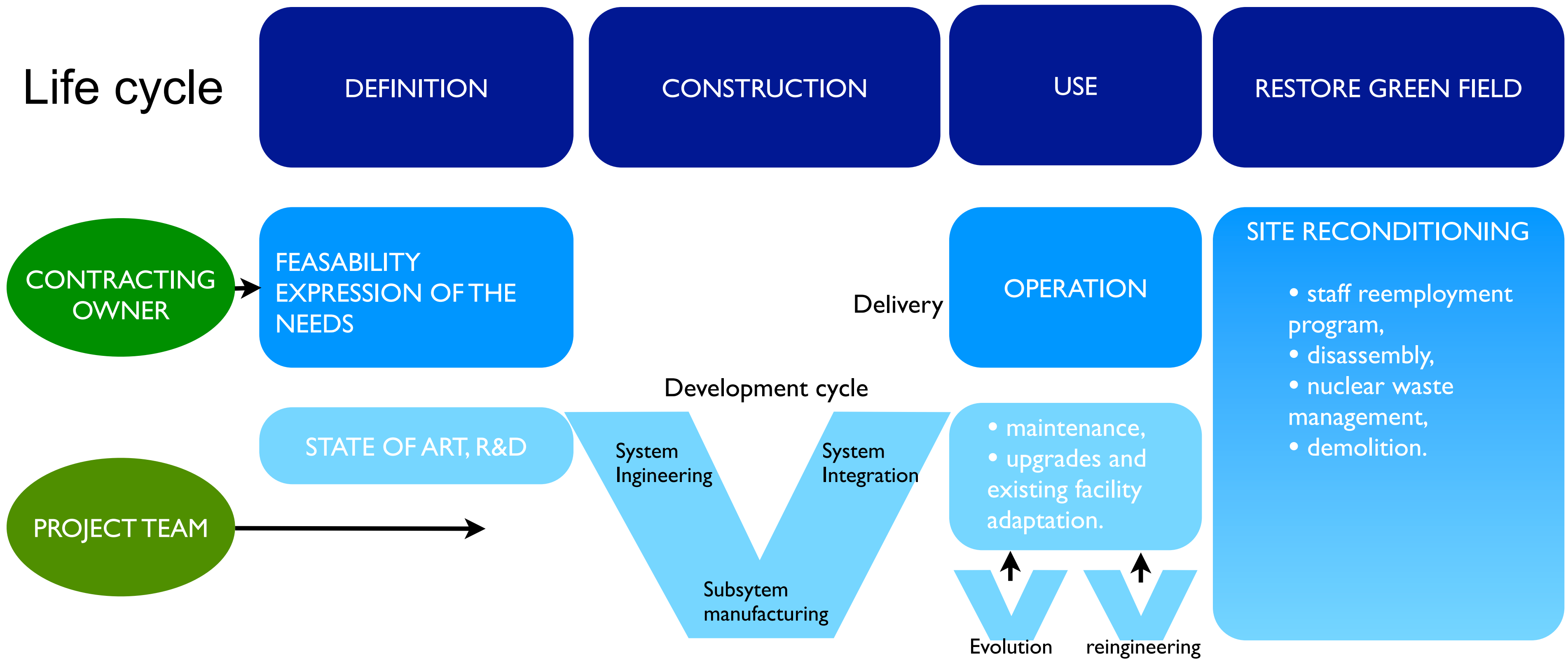
The ESS linac: Status and plans

TTC Meeting February 28th 2011
Milano

Romuald Duperrier
on behalf of
the accelerator DU collaboration team

Facility cycle

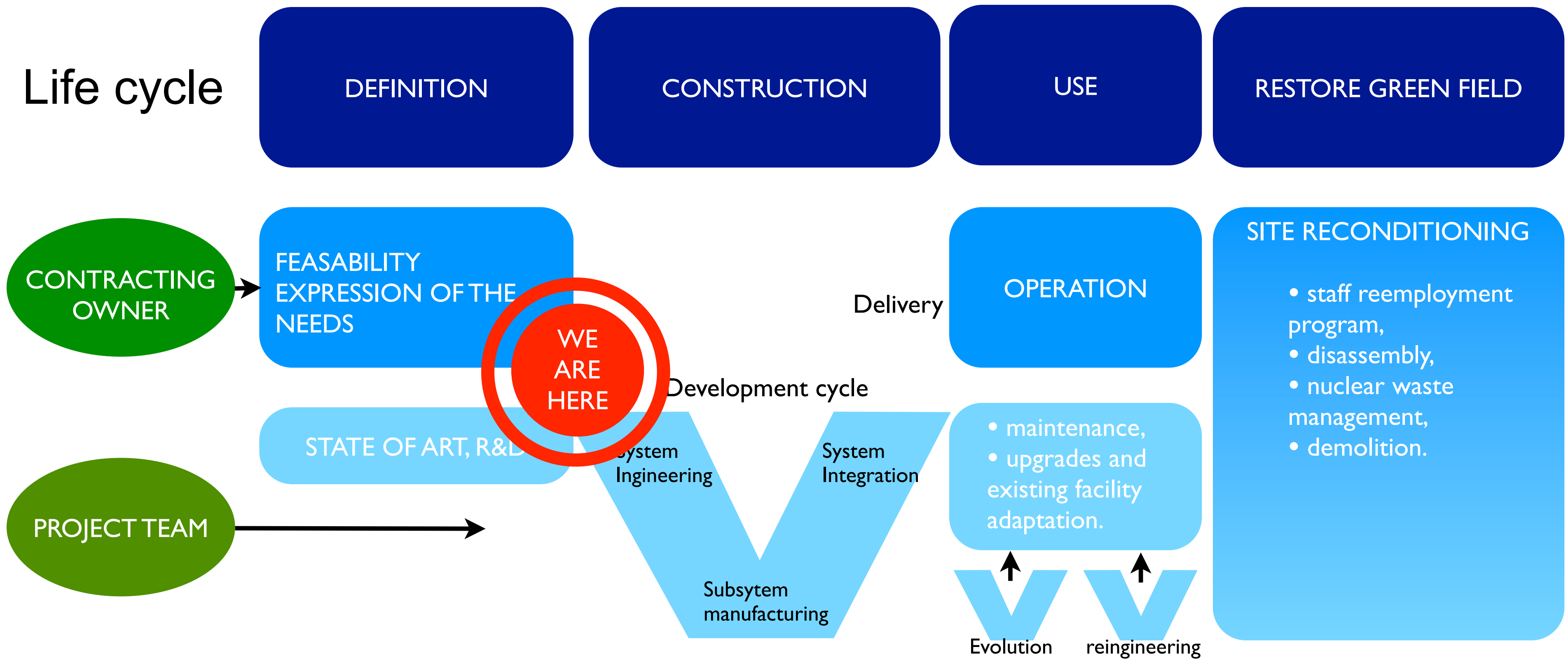


Needs for the Design Update phase (?):

1. design and pre-build a 5 MW long pulse ($\leq$ 2 ms @ $\leq$ 20Hz),

2. estimate required changes for upgrades.

Facility cycle

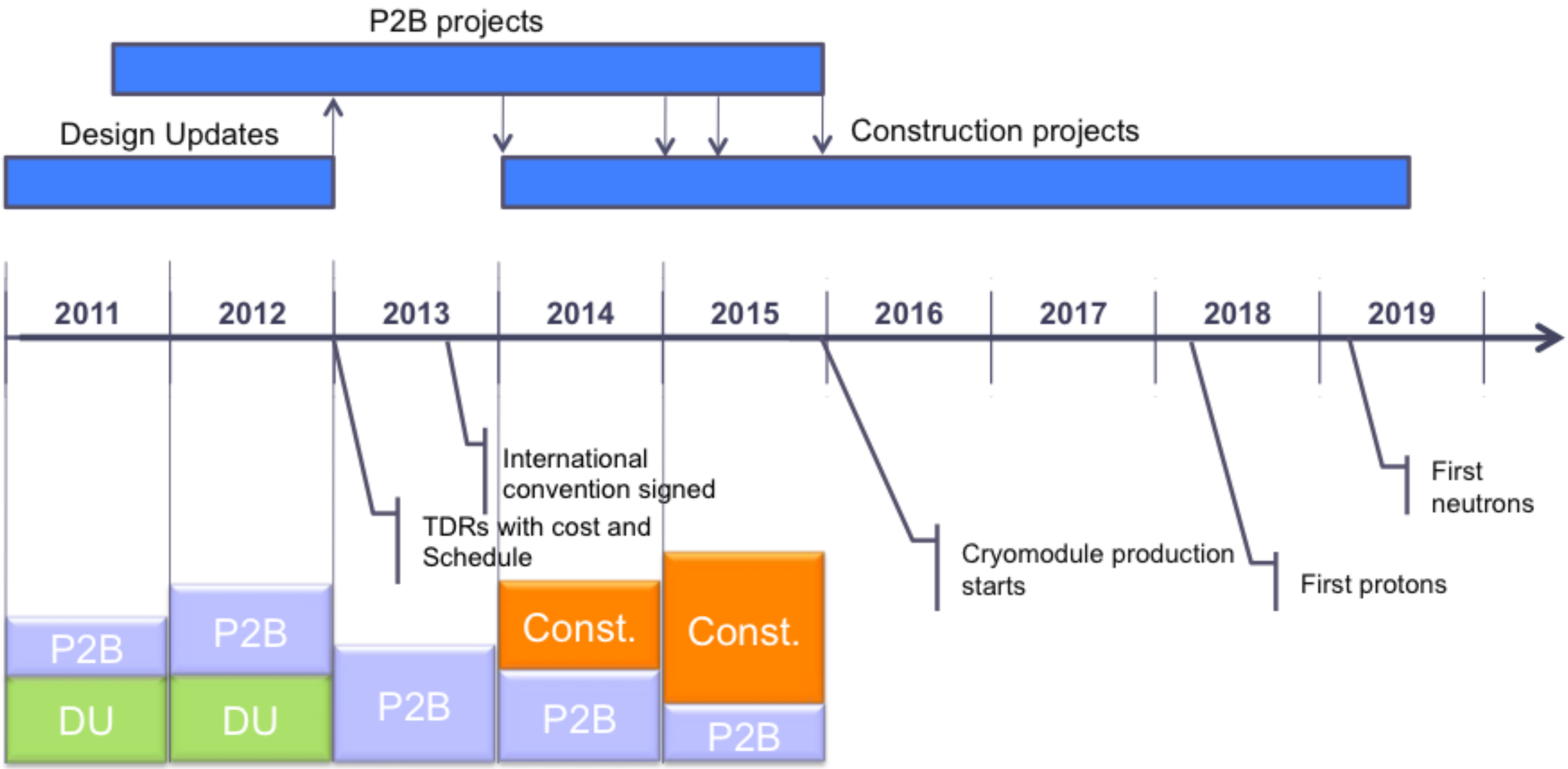


Needs for the Design Update phase (?):

1. design and pre-build a 5 MW long pulse (≤ 2 ms @ ≤ 20Hz),

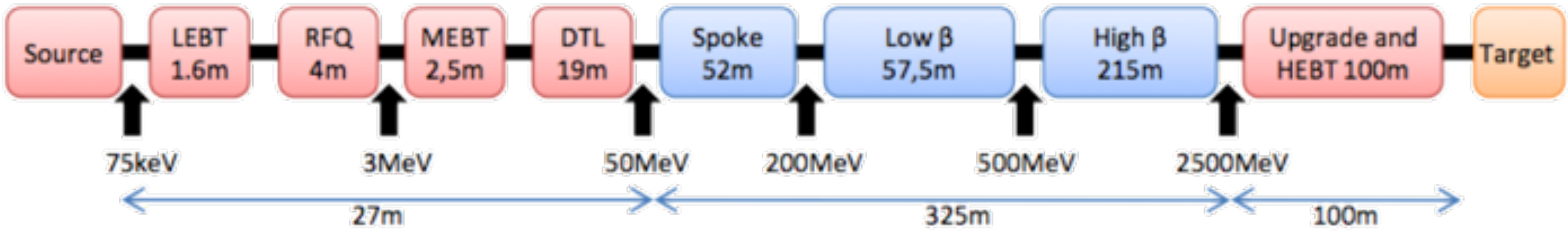
2. estimate required changes for upgrades.

Projects



P2B projects
Design Updates
Construction projects
2011
2012
2013
2014
2015
2016
2017
2018
2019
International convention signed
TDRs with cost and Schedule
Cryomodule production starts
First protons
First neutrons
P2B
DU
P2B
DU
P2B
Const.
P2B
Const.
P2B

Present linac architecture

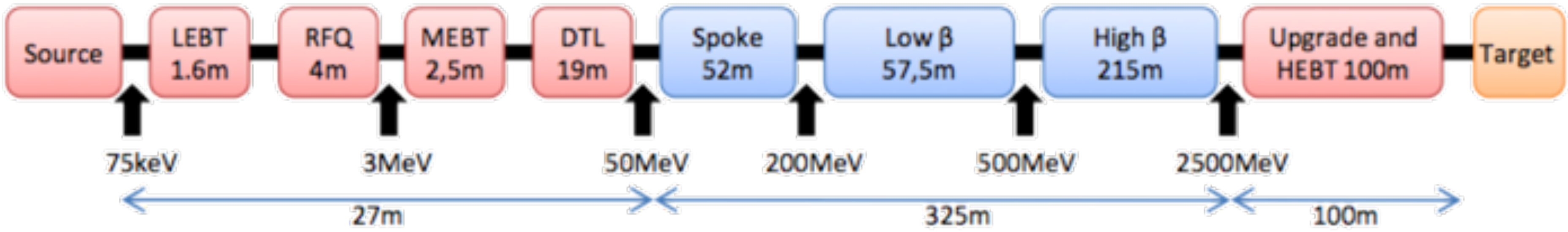


- This architecture is mainly an evolution of the SNS linac with less critical subsystems: H^- source, fast chopping, Pils RFQ, ring injection.

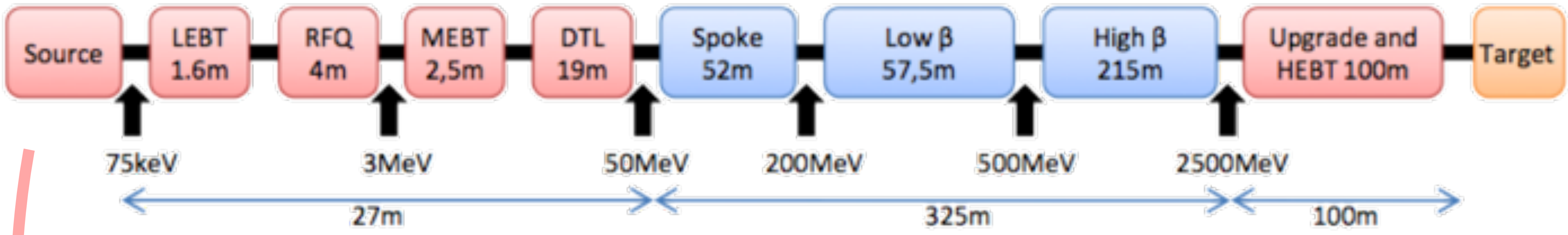
- Main innovation (risk?): Spoke Resonators are used to enhance the flexibility and the accelerating efficiency at medium energy.

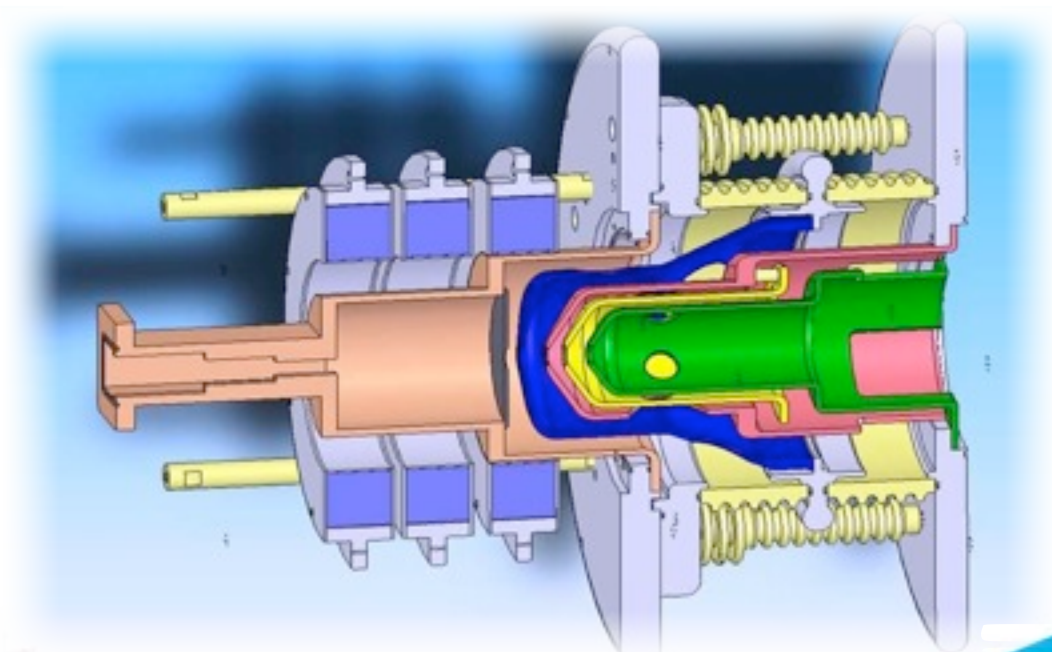
- More robust than 2003 design: lower peak current for the same power (higher energy) without any extra length (power coupler limitation) and no funnelling.

Review of the subsystems



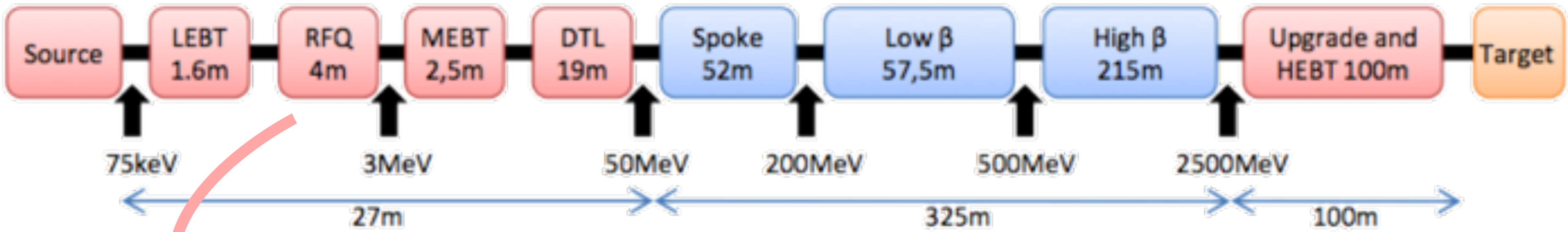
Review of the subsystems

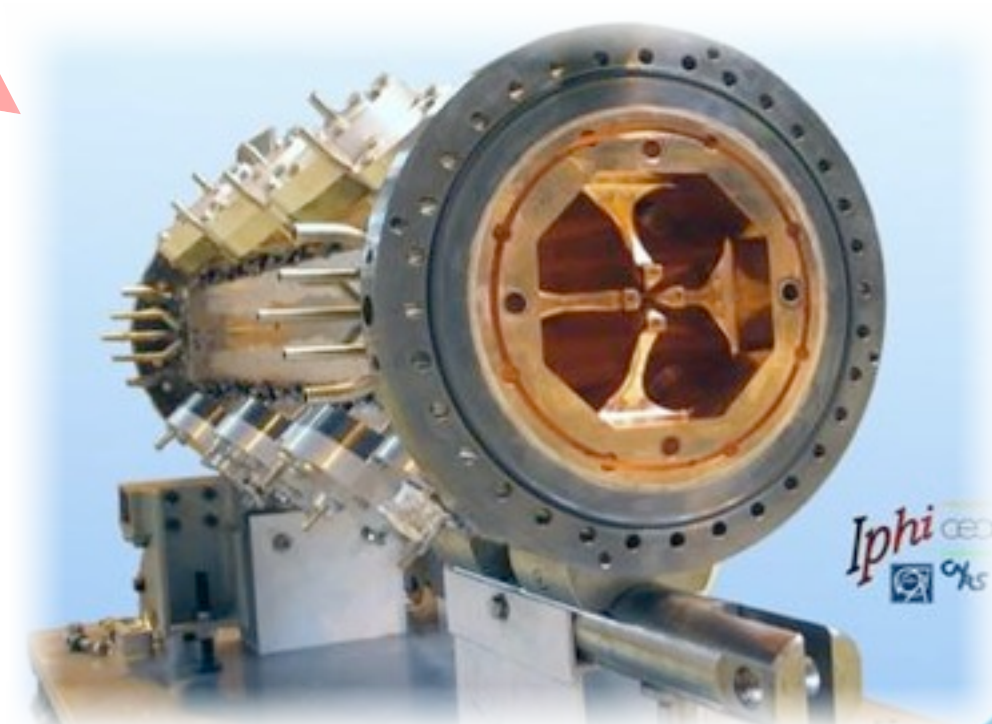




SILHI proton source performances at Saclay

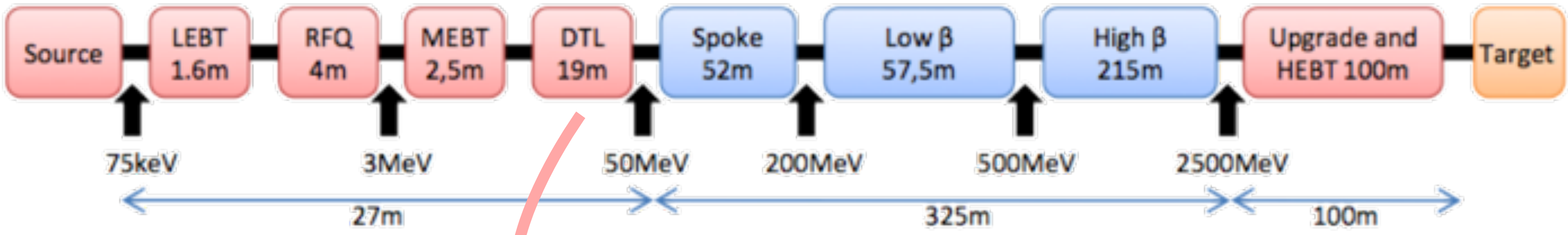
Review of the subsystems

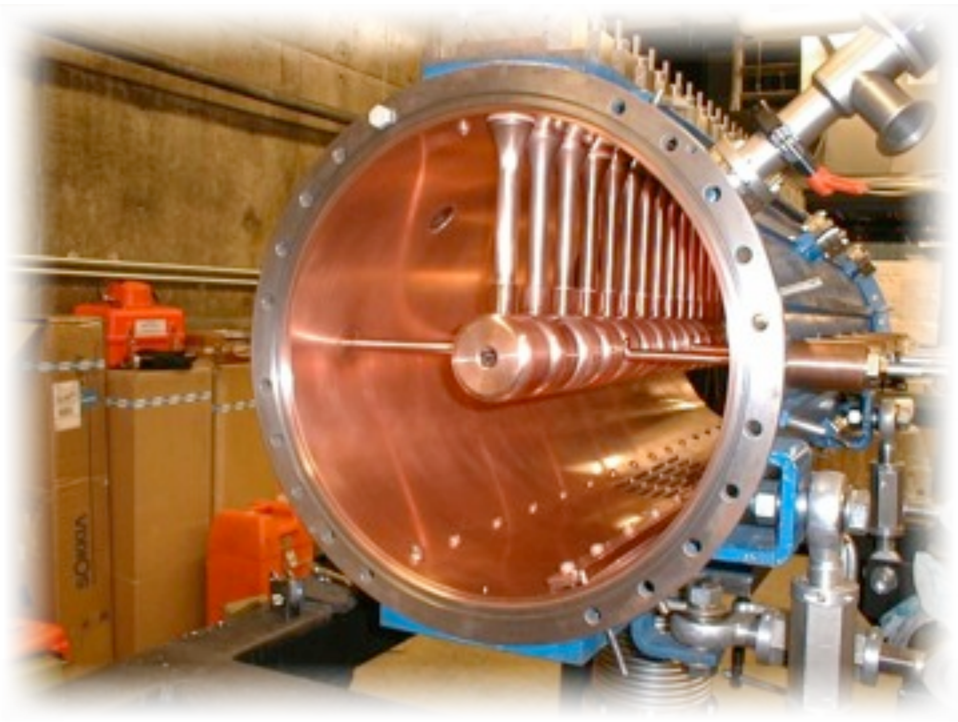




Four vanes structure is the more capable to handle high current beam and high frequency.

Review of the subsystems

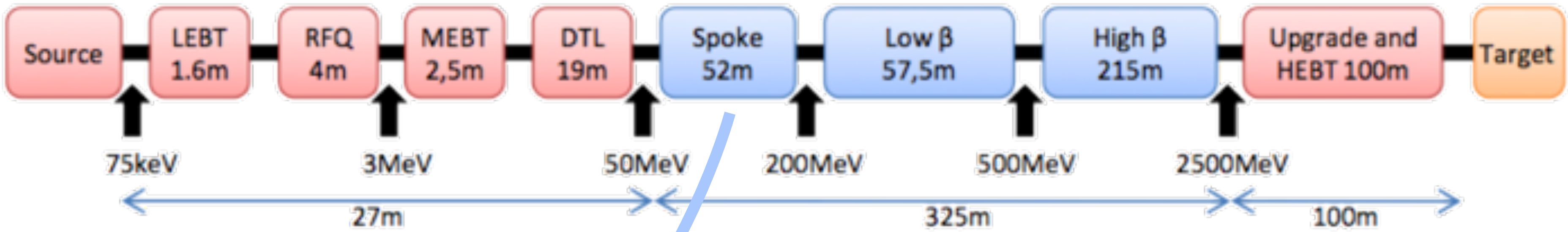




www.jpaw.com

- A huge positive feedback since many decades.
- The best accelerating efficiency after an RFQ for protons.

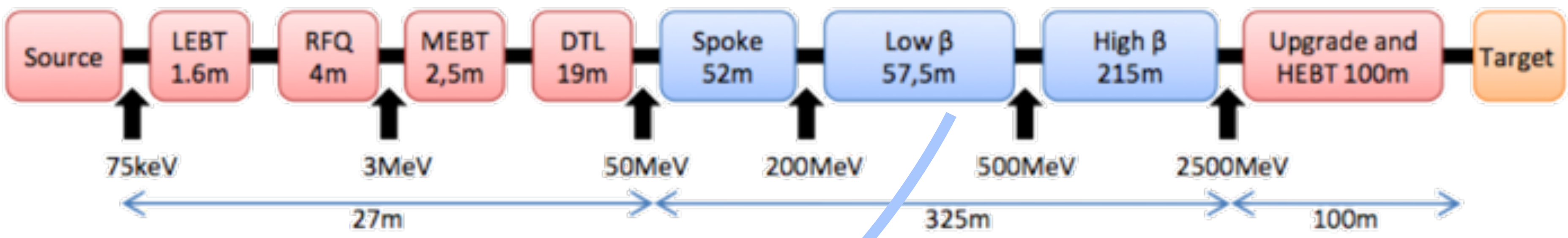
Review of the subsystems

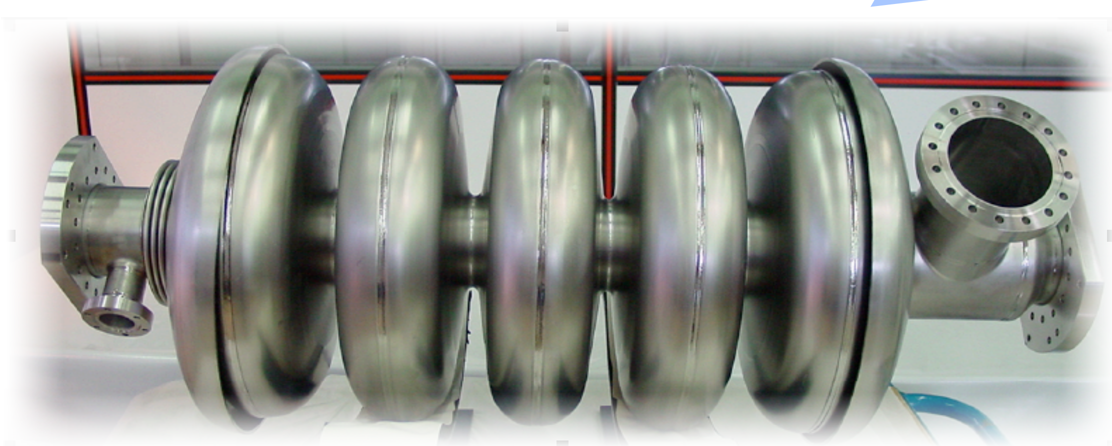



SC Triple spoke cavity [ANL]

- The main innovation in ESS linac: tuning acceptance and larger aperture while keeping a good accelerating efficiency.
- No identified technical problem («go, no go»).

Review of the subsystems





704 MHz SC elliptical cavity
β 0.65
[CEA/CNRS]

- Excellent feedback from SNS and Flash operation.
- The reference gradient is still an open question for reliable operation (SPL synergy, coupler limitation any way).

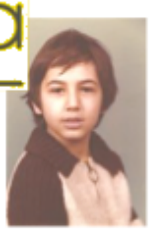
Status of the ADU effort (1/2)

- Excellent feedback from the TAC for the architecture.
- A plan B was suggested in case the spoke initiative fails: longer DTLs section (up to 100 MeV) and a $\beta = 0.5$ elliptical SC section.
- The ADU project plan is presently refined and the planning is being consolidated. WBS is complete.
- The present architecture is already the result of a functional analysis from the long pulse need. This analysis phase is continuing and will include upgradability.
- The exchanges with the ESS top management are continuing to define top level requirements for the linac (functions, constraints and their associated performances and priorities).
- First subsystem specifications will follow. Several specs will be established after a convergence on interfaces (target, ...).

Status of the ADU effort (2/2)

- Risk analysis for the DU has been conducted:
  - very short time for ADU: choose existing technological solutions when they match the ESS linac requirements,
  - contract asap with experienced partners.
- Negociations between ESS and external contributors status:
  - Orsay/Saclay ✔
  - Arhus University ✔
  - INFN Catania/Legnaro ✔
  - Uppsala ✔
  - Rostock ✔
  - Desy ✔
  - ESS-Bilbao ✔
- Documentation and communication plan setting-up.

8 WPs for the ADU



Romuald Duperrier
(30 years ago)

Steve Peggs

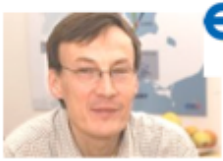
Cristina Oyon

Josu Eguia

Work Package (work areas)

1. Management Coordination – ESS (Mats Lindroos)
2. Accelerator Science – ESS (Steve Peggs)
3. Infrastructure Services – Tekniker, Bilbao (Josu Eguia)
4. SCRF Spoke cavities – IPN, Orsay (Sebastien Bousson)
5. SCRF Elliptical cavities – CEA, Saclay (Guillaume Devanz)
6. Front End and NC linac – INFN, Catania (Santo Gammino)
7. Beam transport, NC magnets and Power Supplies – Århus University (Søren Pape-Møller)
8. RF Systems – Uppsala university (Roger Ruber)

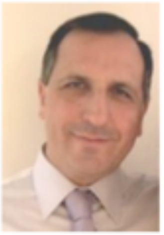
Guillaume Devanz



Mats Lindroos

Roger Ruber

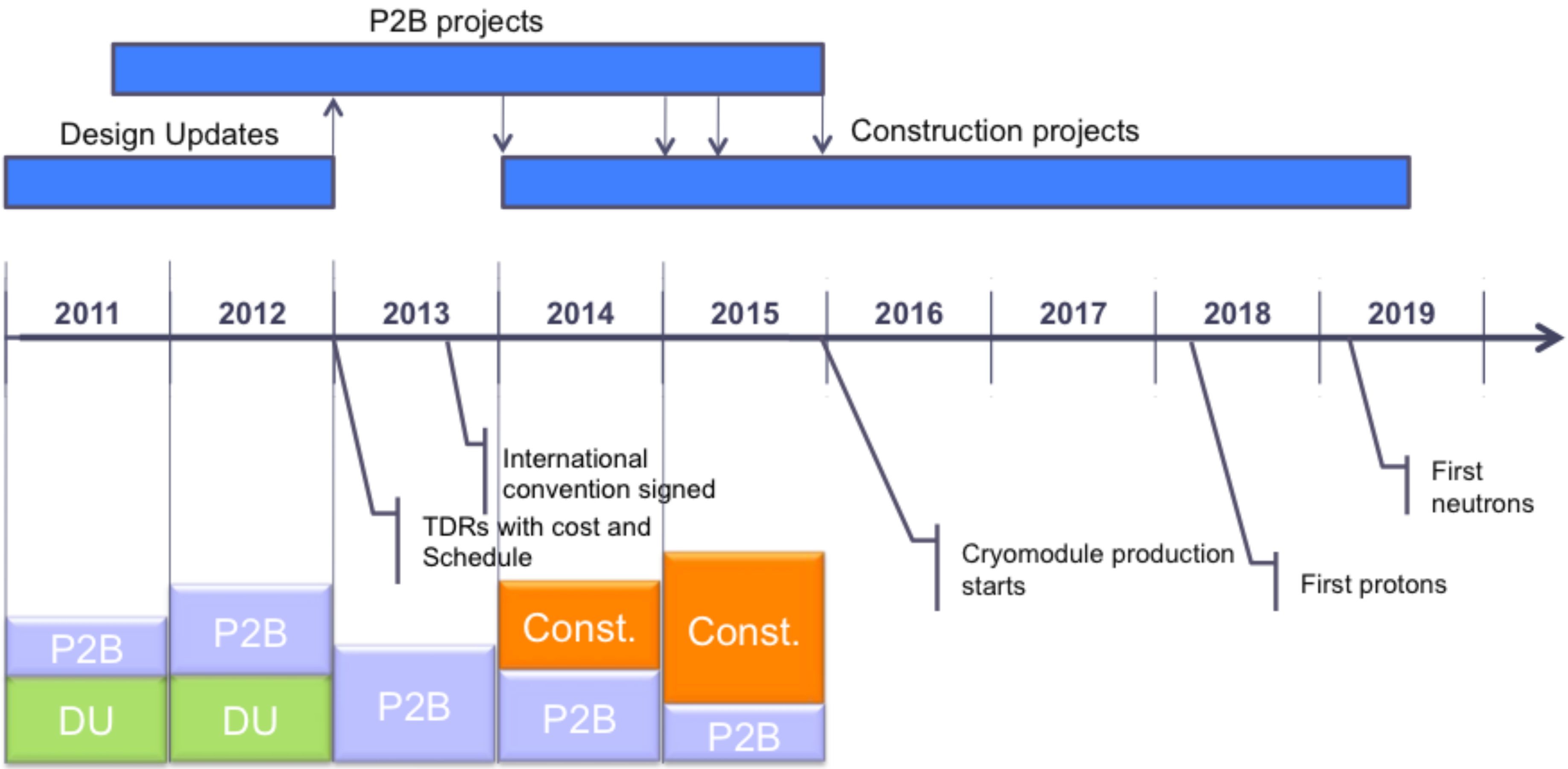
Søren Pape Møller



Santo Gammino

Sebastien Bousson

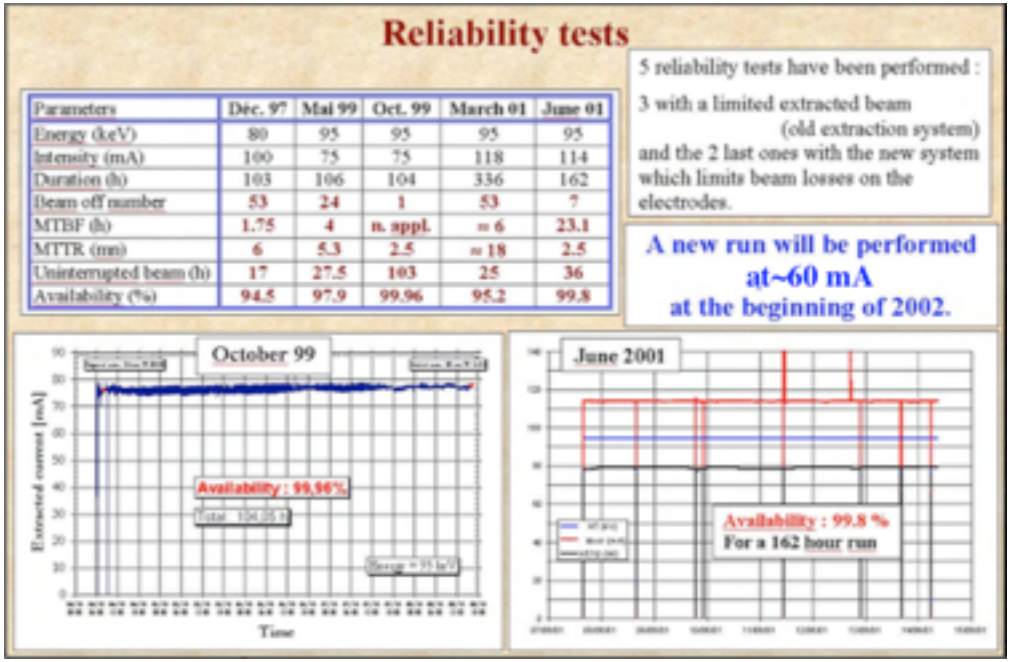
Prototyping



Prototyping

- Source test
- RFQ test
- Elliptical and Spoke resonators
- Cryomodules
- DTL drift tube
- RF test stands
- Focusing SC linac unit with instrumentation
- Modulators

SILHI proton source performances at Saclay



Parameters	Déc. 97	Mai 99	Oct. 99	March 01	June 01
Energy (keV)	80	95	95	95	95
Intensity (mA)	100	75	75	118	114
Duration (h)	103	106	104	336	162
Beam off number	53	24	1	53	7
MTBF (h)	1.75	4	n. appl.	≈ 6	23.1
MTTR (mn)	6	5.3	2.5	≈ 18	2.5
Uninterrupted beam (h)	17	27.5	103	25	36
Availability (%)	94.5	97.9	99.96	95.2	99.8

No feedback with an ESS like pulsing

Prototyping

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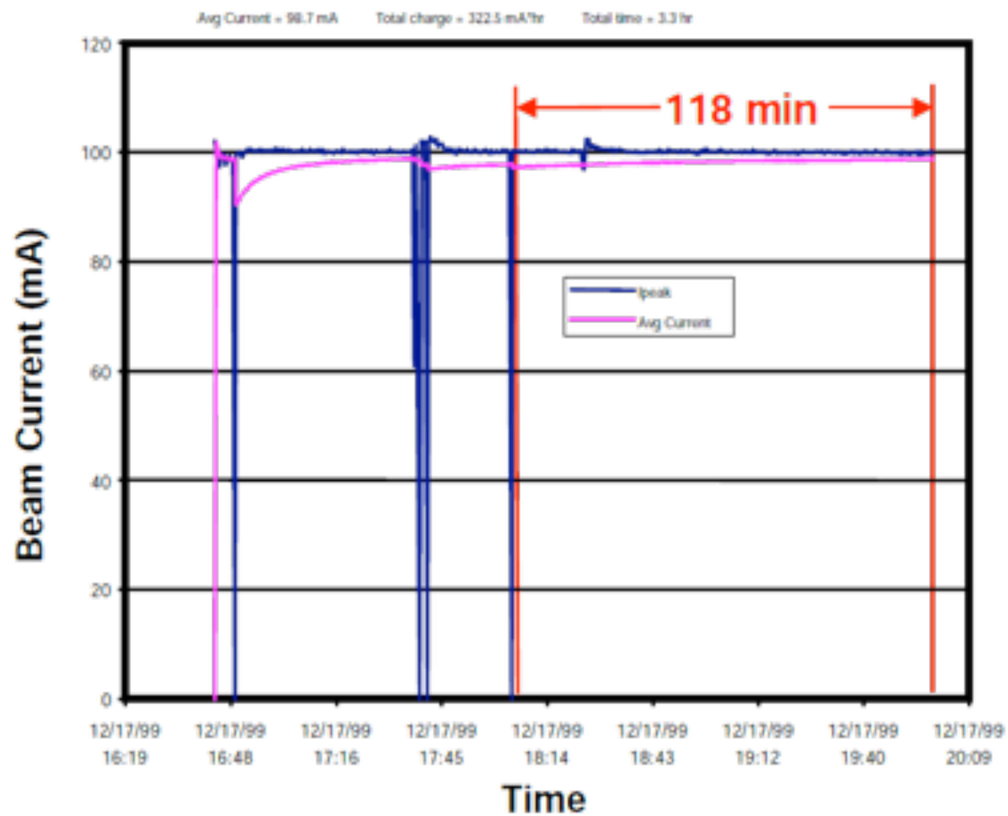
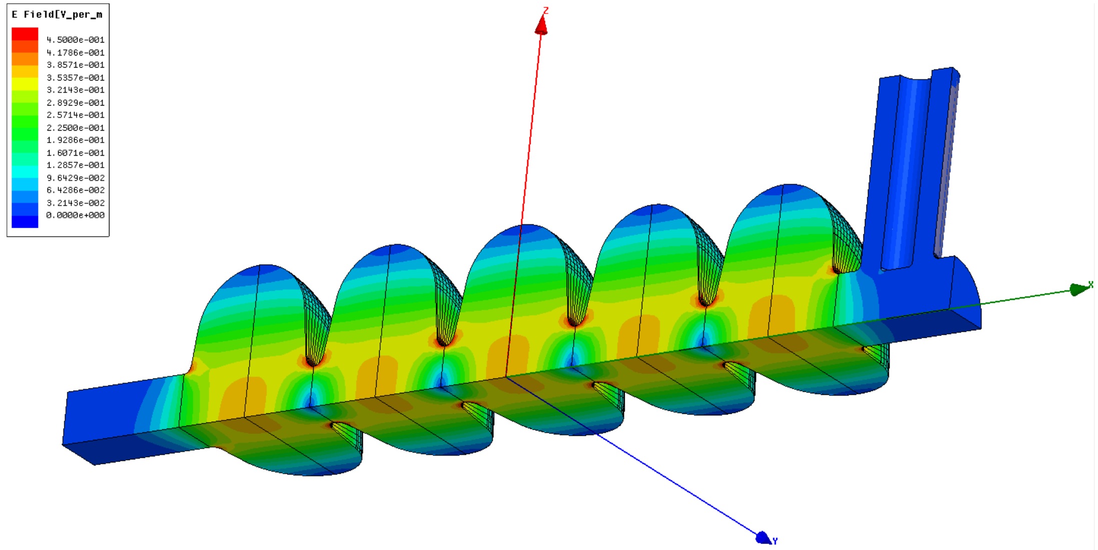
LEDA RFQ beam test at Los Alamos



No feedback with an ESS like pulsing for current > 30 mA

Prototyping

ESS beta 0,86 5 cells 704,42 MHz
[CEA/Saclay]



- Source test
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- 8 elliptical and 4 spokes resonators are planned during P2B.
- Qualify asap manufacturer capabilities (Spokes).

Prototyping

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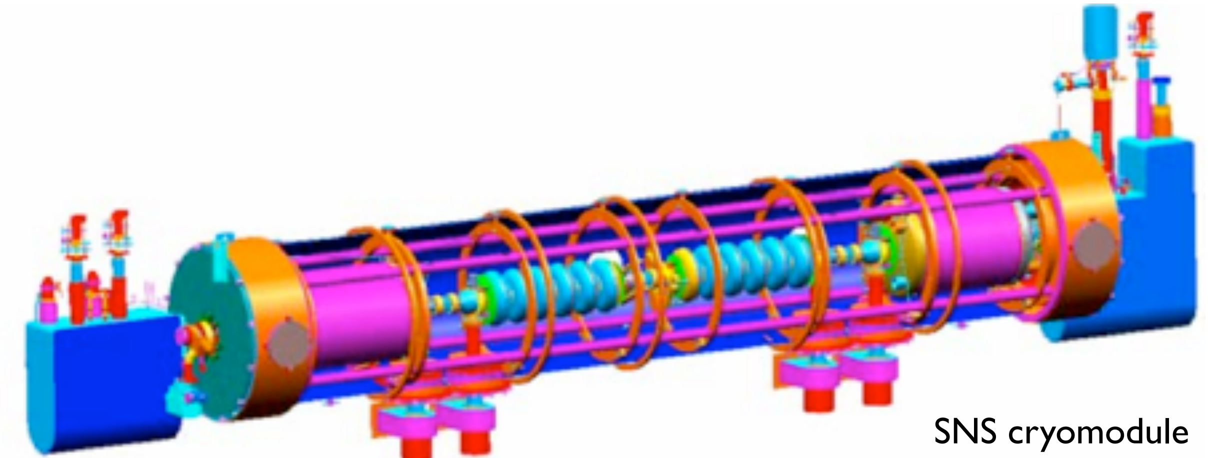
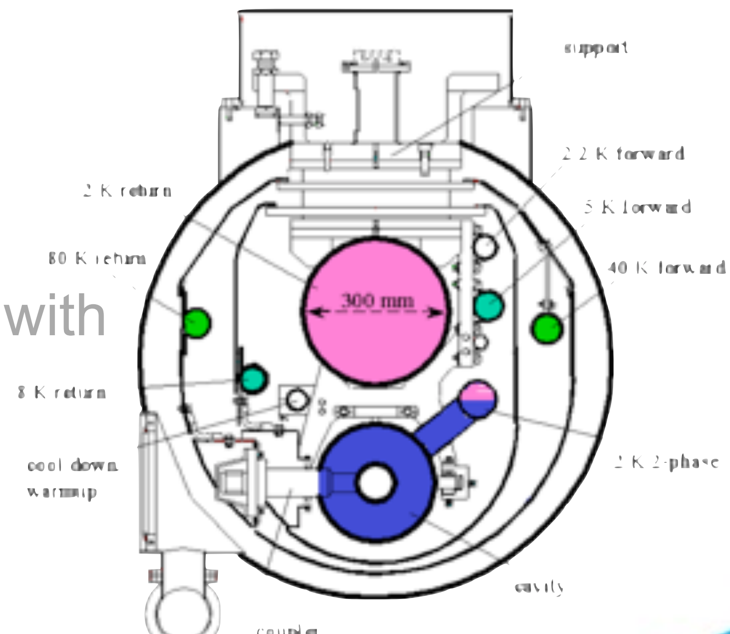


SNS cryomodule design



Tesla/ILC/XFel cryomodule design

- Mechanical and cryogenic optimization,
- Energy,
- Beam tuning,
- Upgrading.

Prototyping

- Source test
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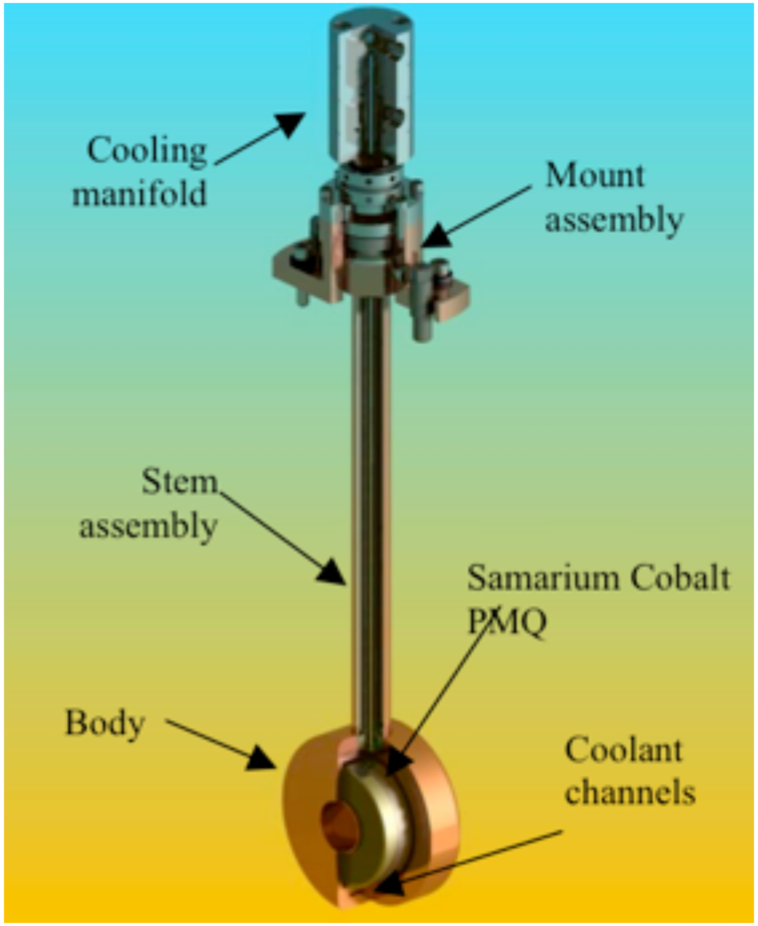
SNS drift tube design



Mechanical optimization

Prototyping

- Source test
- RFQ test
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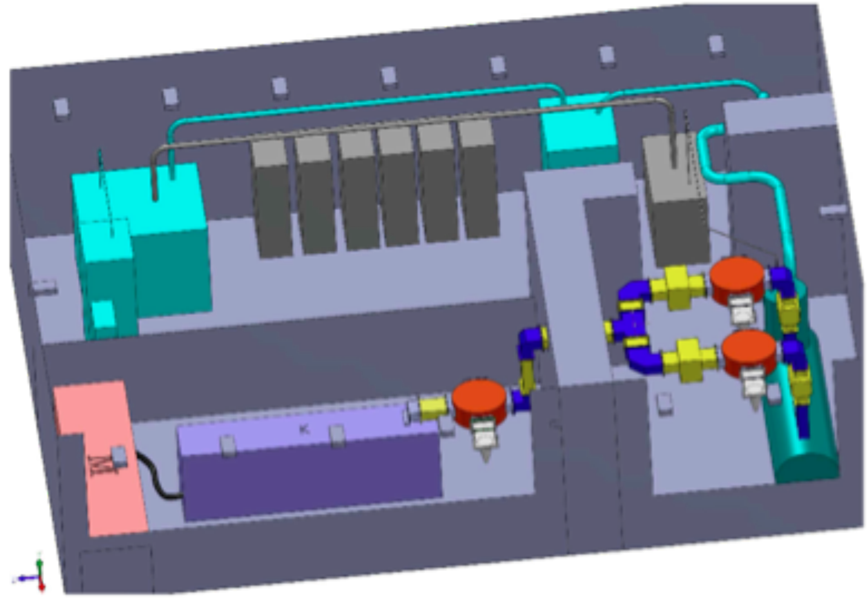
- Modulators

Future Uppsala test stand



- Several test stands already available or under construction for the two frequencies (Orsay, Saclay, Uppsala, CERN).
- Optimisation of the RF distribution.
- Investments for contruction phase.

Prototyping

- Source test
- RFQ test
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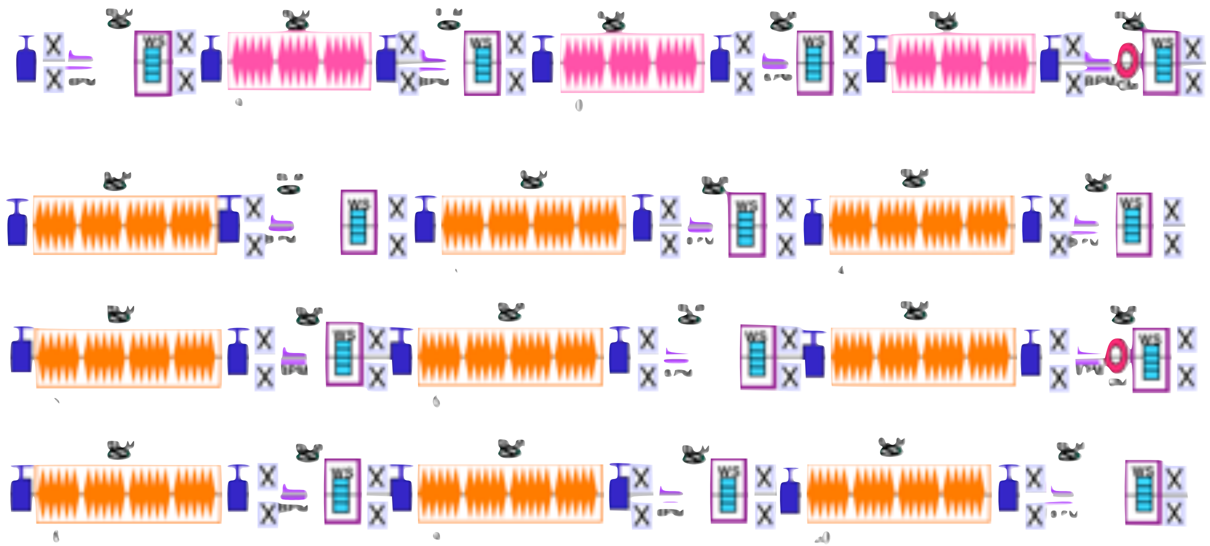
SNS diagnostics in SC Linac



- Mechanical and cryogenic optimization
- Upgradability issues

Prototyping

SNS HVCM

- Source test
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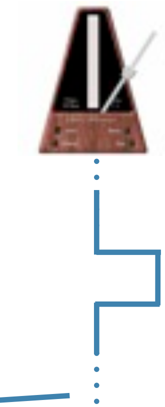
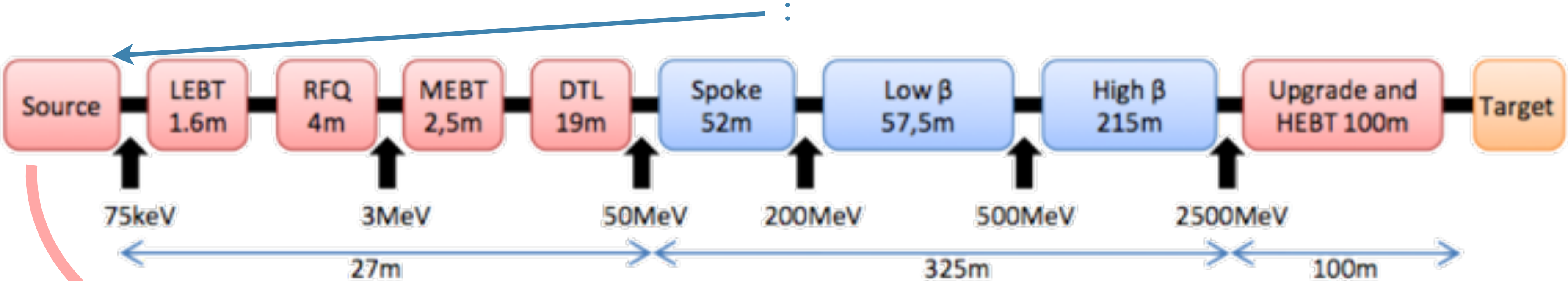
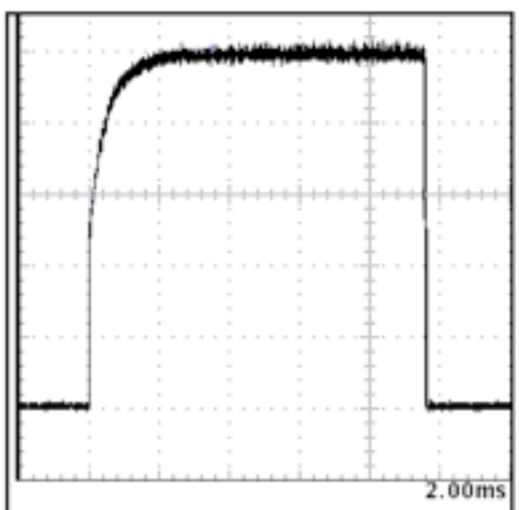
Reliability and cost optimization

Time structure: how to?



- **IS RF power supply is triggered.**

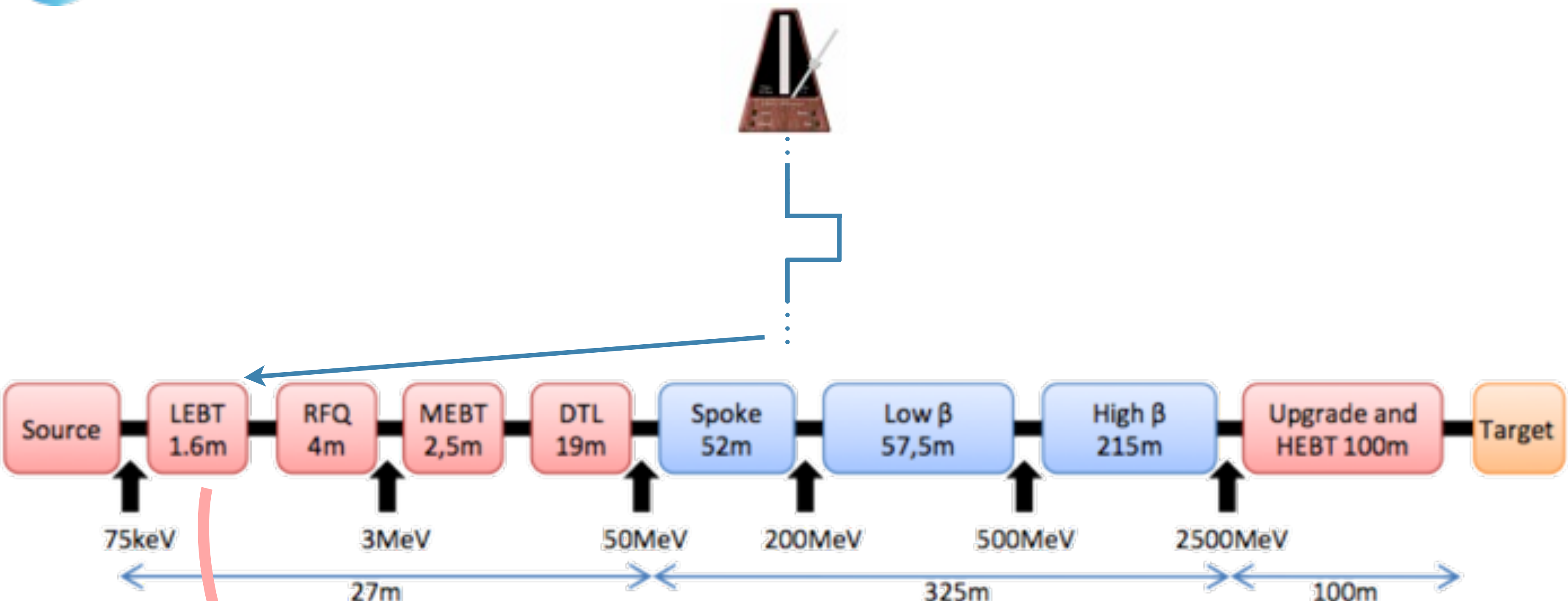


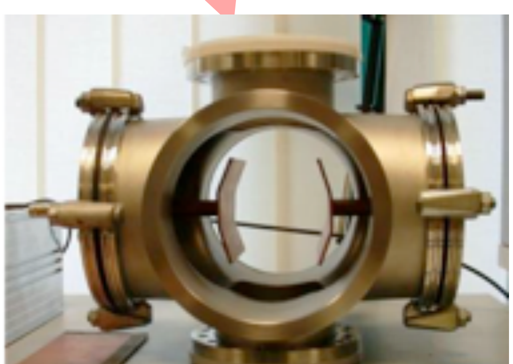


80 mA proton pulse
[SILHI, CEA]

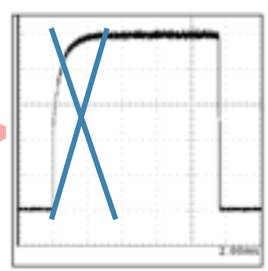
- **The extracted pulse has a rise time ~ 2 ms. The fall time is 40 µs.**

Time structure: how to?





Spiral 2 slow chopper
[Caruso et al, Linac'08]

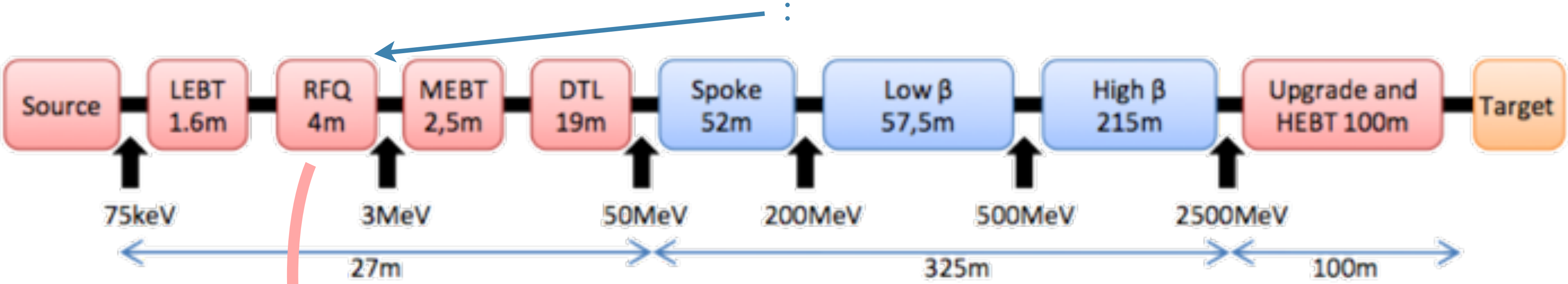


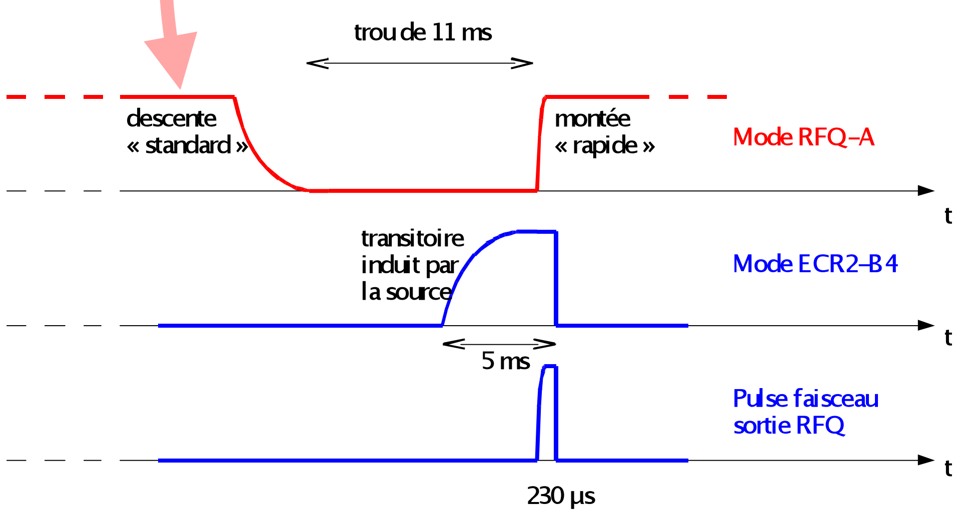
- The rise time (and fall time) can be reduced to less than 100 ns with a electrostatic chopper (minimized mismatches).
- Need to be carefully optimized (LEBT transients)

Time structure: how to?

- The rise time can also be reduced by clever superposition of the RF and beam pulses (~ 100 µs).

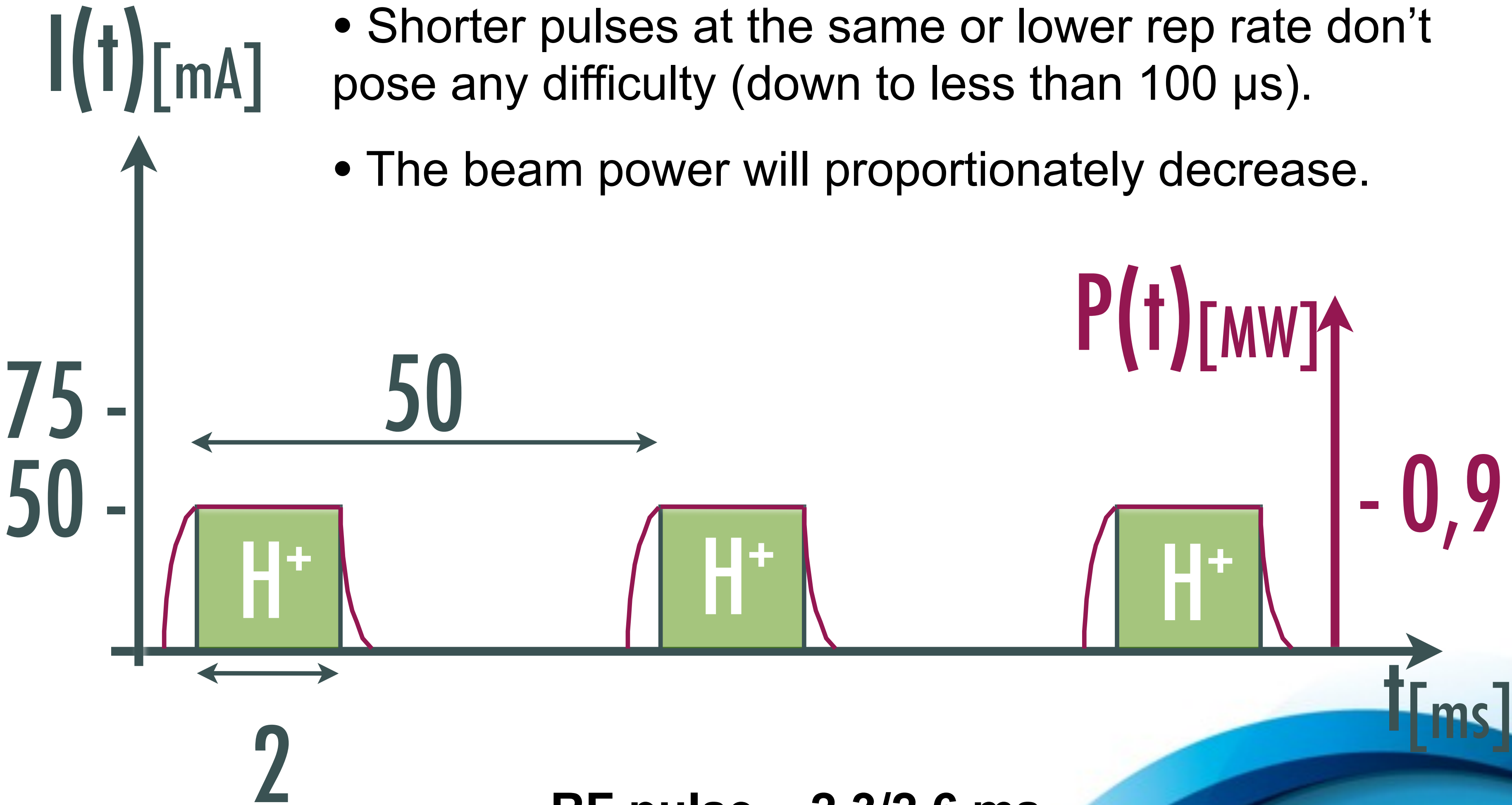
- This method adds beam loss in RFQ.





Shorter beam pulse?

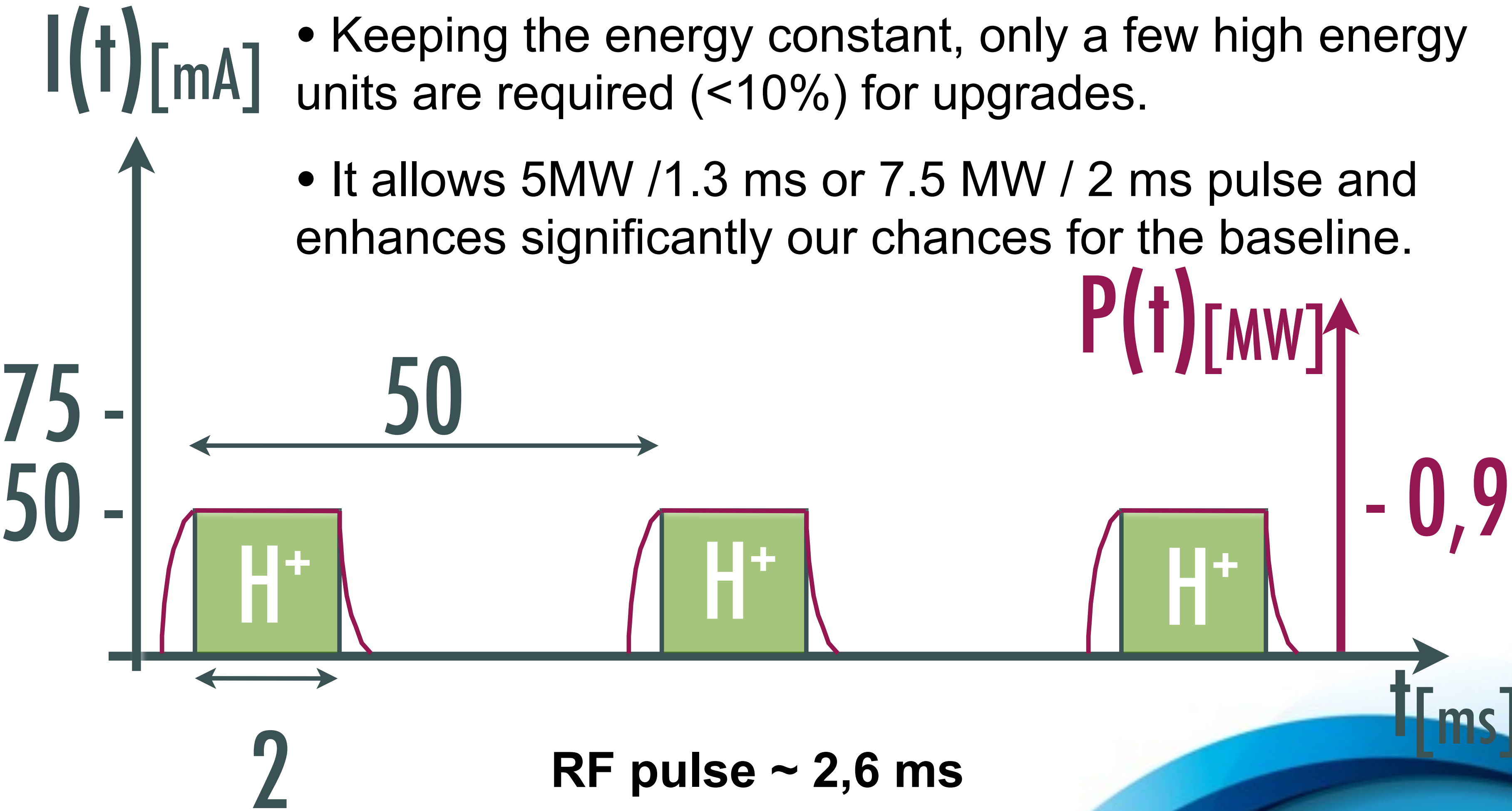
- The main difficulty for the RF system is the highest rep rate with the longer pulse.
- Shorter pulses at the same or lower rep rate don't pose any difficulty (down to less than 100 μs).
- The beam power will proportionately decrease.



RF pulse ~ 2,3/2,6 ms

Shorter beam pulse?

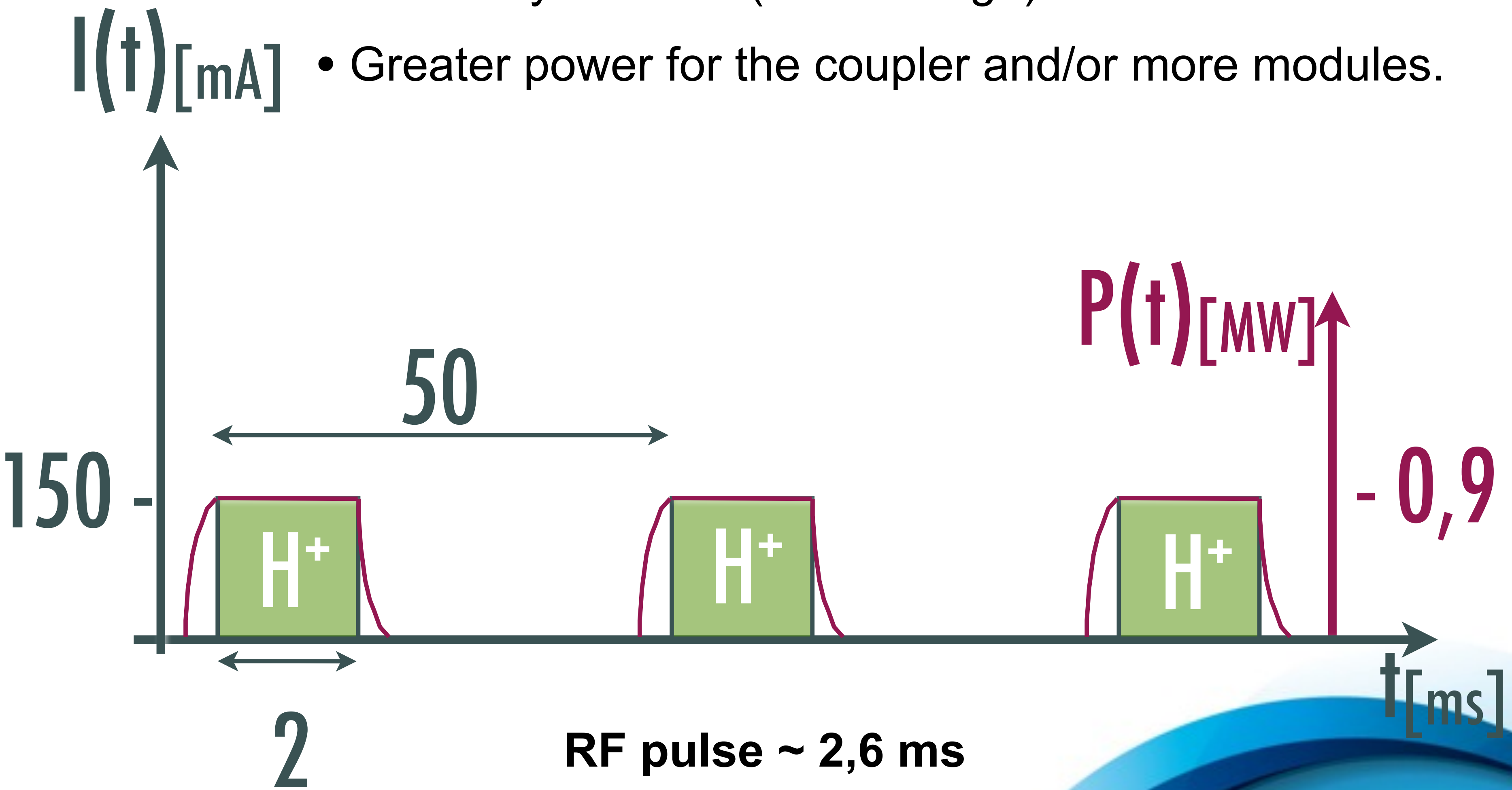
- The present strategy is to already tailor the machine for 75 mA (+ a margin for reliable operation, tbd) even if the baseline is 50 mA @ 2 ms (this is mandatory for the FE).
- Keeping the energy constant, only a few high energy units are required (<10%) for upgrades.
- It allows 5MW /1.3 ms or 7.5 MW / 2 ms pulse and enhances significantly our chances for the baseline.



RF pulse ~ 2,6 ms

ESS ultimate goal: 15 MW

- The plan is to increase the peak current up to 150 mA.
- This would be performed with a double front end followed by a funnel (2003 design).
- Greater power for the coupler and/or more modules.



RF pulse ~ 2,6 ms

Energy flexibility

- The energy can be reasonably decreased down to a few hundred MeVs. The main limitation would come from the mismatch in energy with the long focusing period in the elliptical cavity section.
- Bunch structure is still needed for BPMs. A dedicated study would show if it is needed to keep ON a few cavities (others would be detuned).

Reliability and cost

- Keeping the power constant, reliability is driven by the duty cycle and pulse current trade-off.
- High peak current pushes the Front End at the boundary of what would be the state-of-art.
- High duty cycle is a possible source of RF station failure.
- This can be relaxed by increasing energy. Up to ~2.5 GeV, no extra length.
- Feedback from existing facilities is welcome to concentrate on «what is important».

Thank you!

Any question?

TTC Meeting February 28th 2011
Milano

EUROPEAN SPALLATION SOURCE

Romuald Duperrier
on behalf of
the accelerator DU collaboration team