# A New 180 MeV $H^-$ Linac for Upgrades of ISIS

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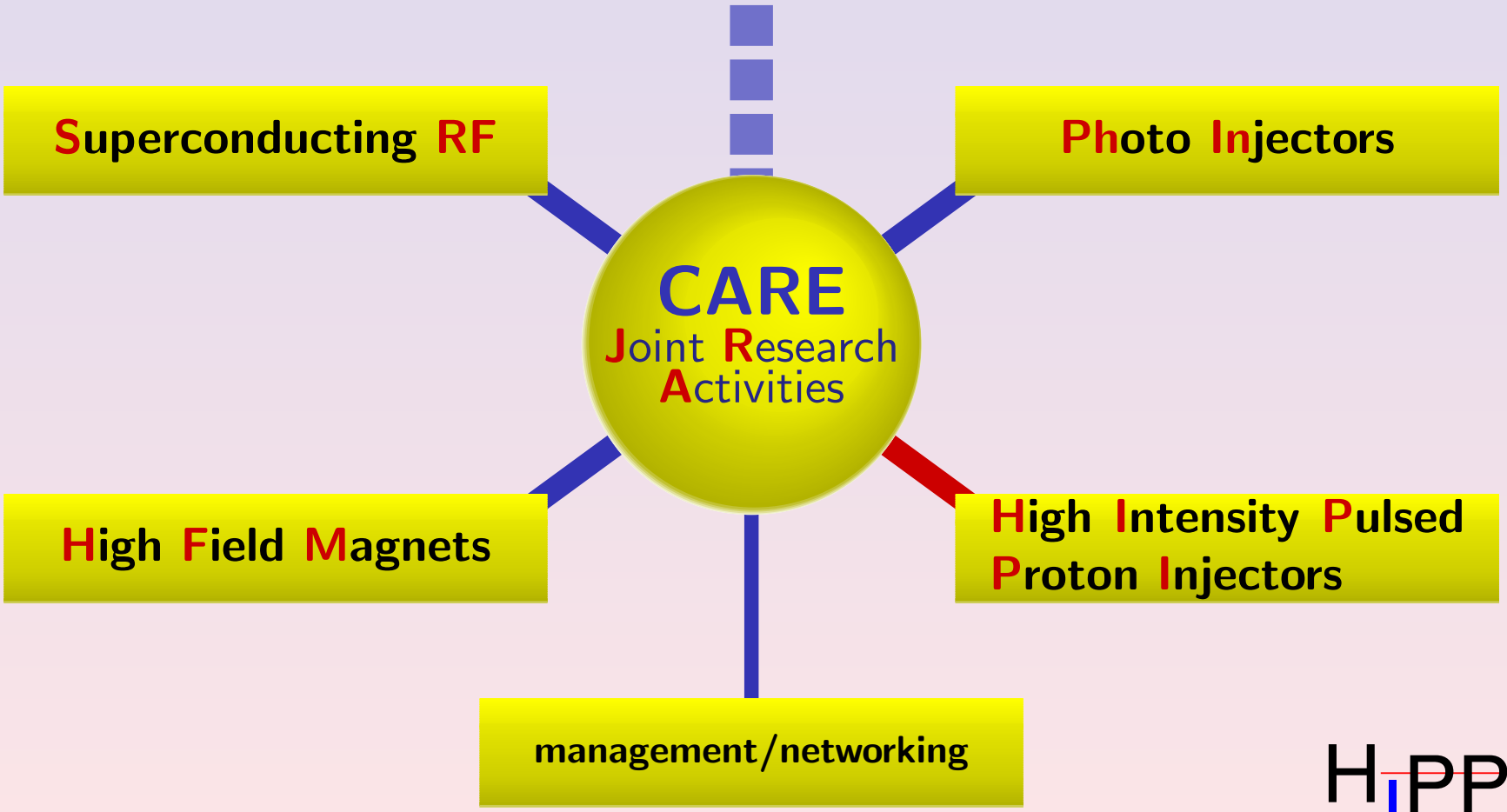
# EU 6th Framework Progamme

## Integrating Activities



## Work Packages & Institutes

**WP1: Normal Conducting Accelerating Structures**

**WP2: Superconducting Accelerating Structure**

**WP3: Beam Chopper**

**WP4: Beam Dynamics, Diagnostics, Collimation**

INFN Istituto Nazionale di Fisica Nucleare

IN2P3-Orsay

IAP Frankfurt

GSI

CCLRC Rutherford Appleton Laboratory

CERN

LPSC-Grenoble

Forschungszentrum Jülich

CEA-Saclay

HIPPI

# Motivation for a new 180 MeV Linac at RAL

...basis for 3 different ISIS upgrade scenarios:

1. **0.5 MW:** injection into the ISIS synchrotron at higher energy (reduced space charge forces allow higher injection current),
2. **1-4 MW:** front-end for a 800 MeV linac using the ISIS synchrotron as an accumulator/compressor ring,
3. **4-5 MW:** injector linac for a new chain of fast cycling synchrotrons,

Furthermore it can provide an alternative front-end for future spallation sources, waste transmutation facilities, or neutrino factories.

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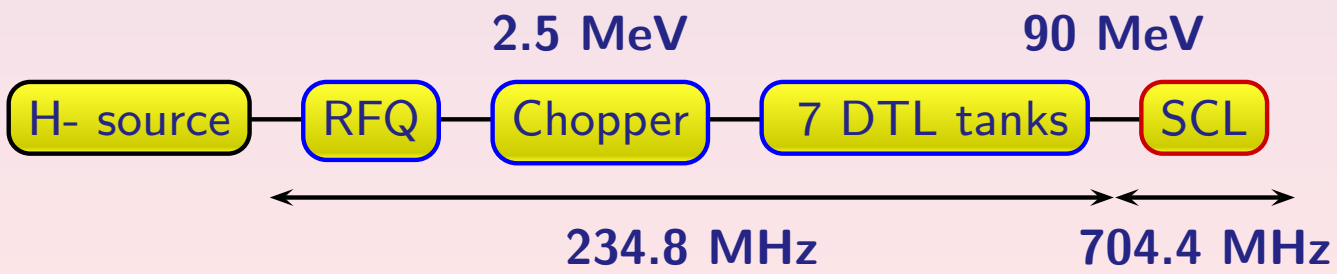
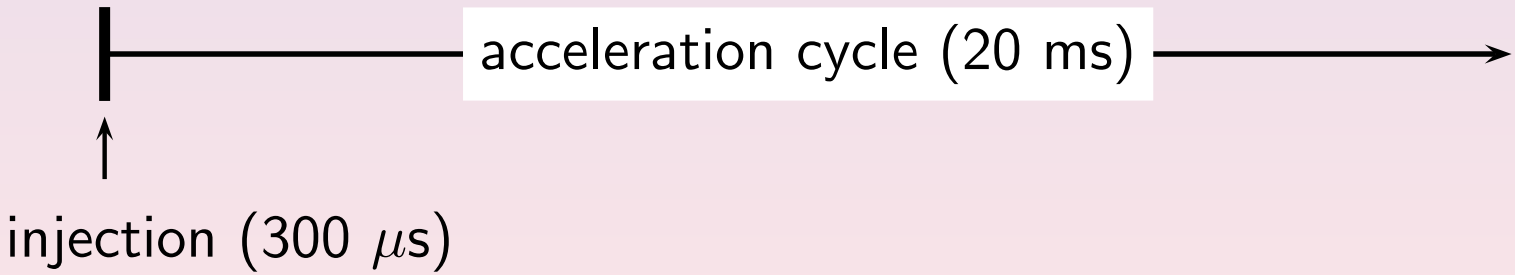
# Parameters to raise ISIS to 0.5 MW

| | 'old linac' | 'new linac' | |
|---|---|---|---|
| **energy** | 70 | 180 | MeV |
| **frequency** | 202.5 | 234.8/704.4 | MHz |
| **pulse length** | 200 - 250 | 300 | $\mu$s |
| **chopping** | – | 35 out of 118 | bunches |
| **peak current** | 20 | 57/171 | mA |
| **rep rate** | 50 | 50 | Hz |
| **output power** | 17 | 110 | kW |
| **length** | 55 | 90 | m |
| **duty cycle** | 1-1.25 | 1.5 | % |

**Tentative Layout:**



# Linac Timing



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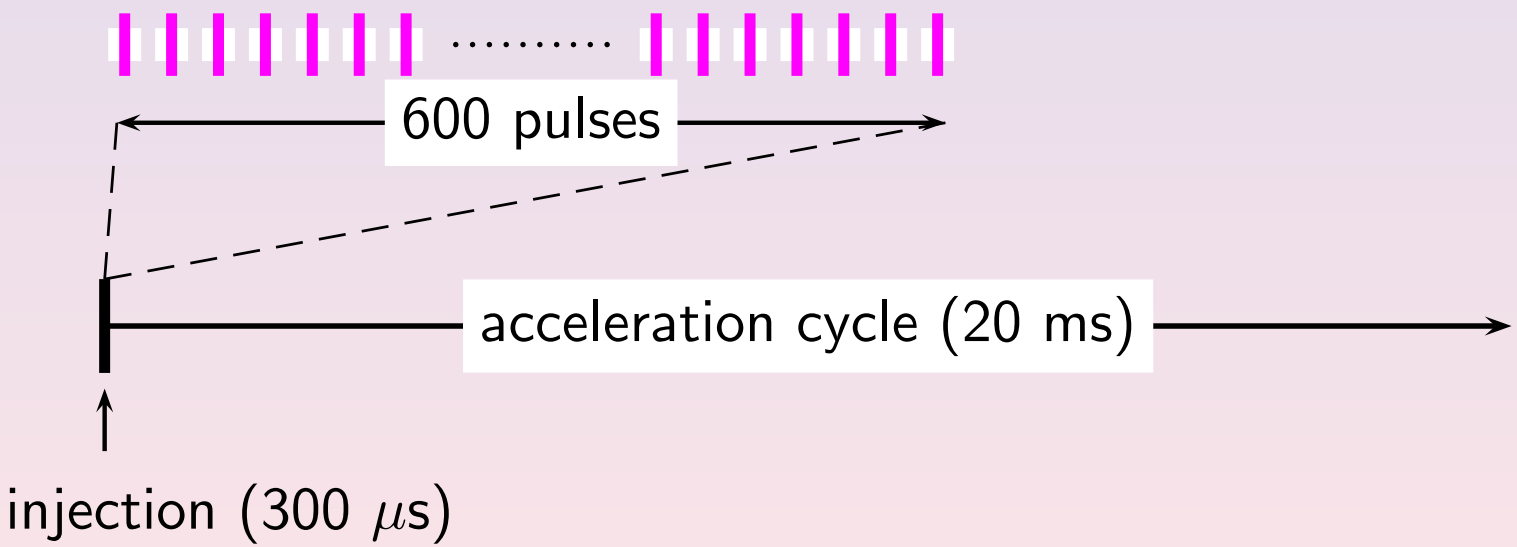

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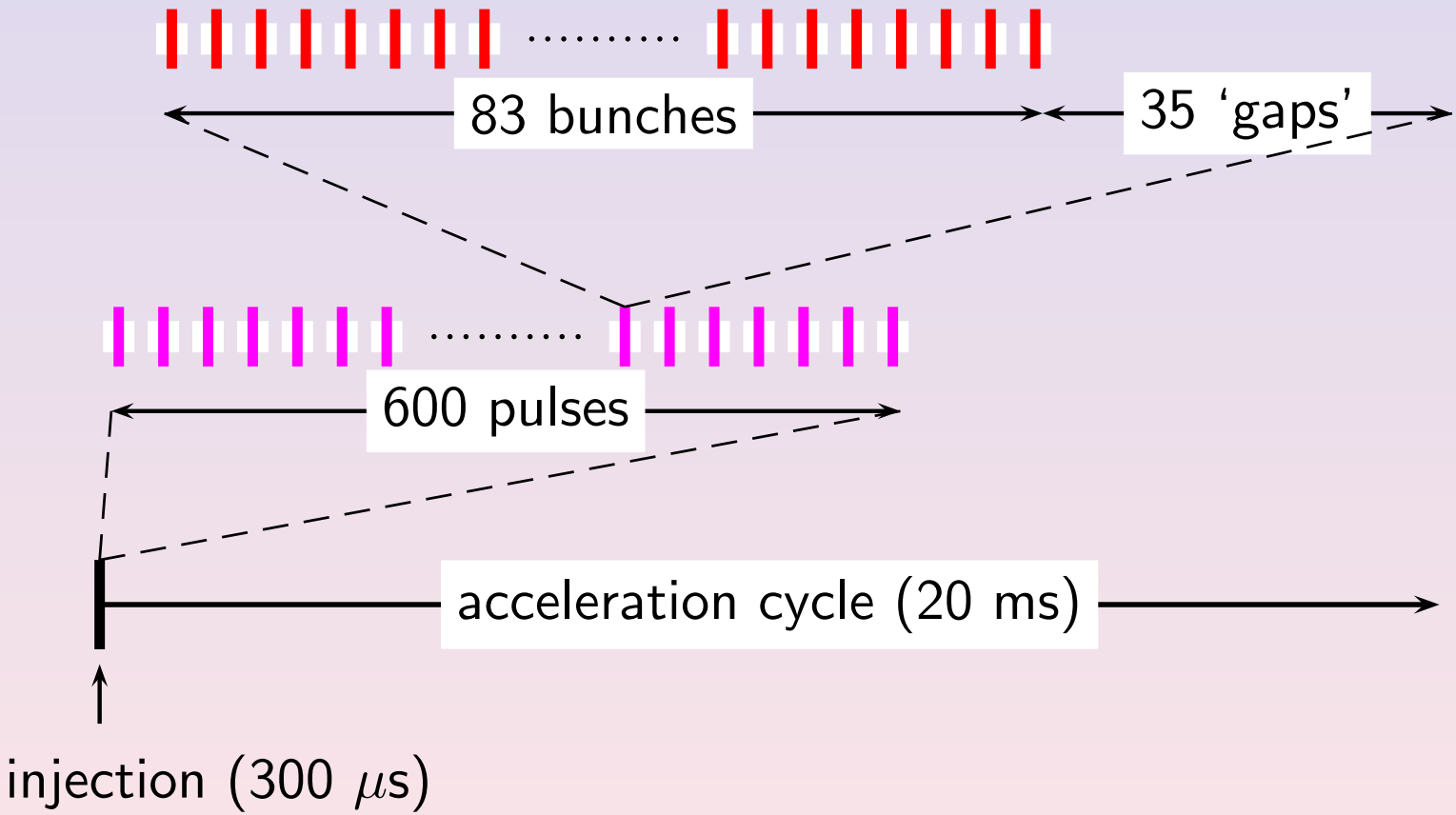
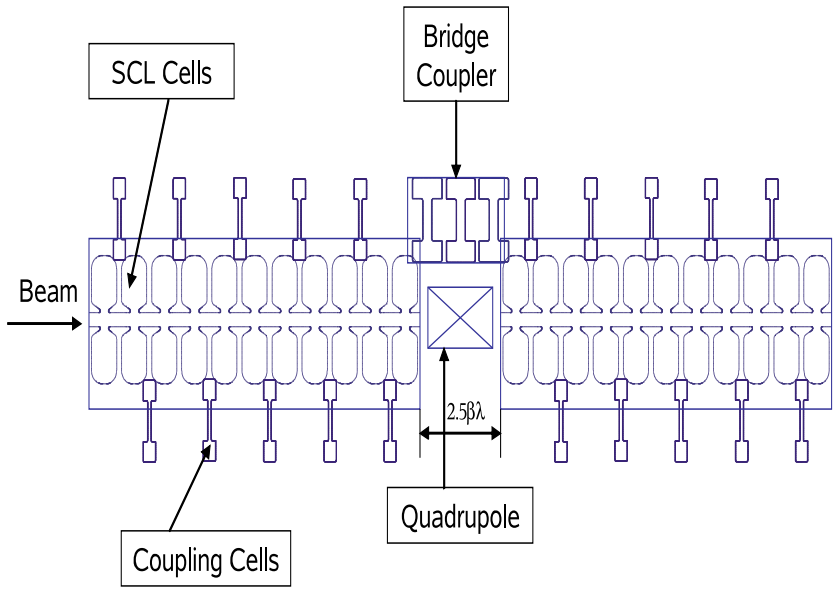
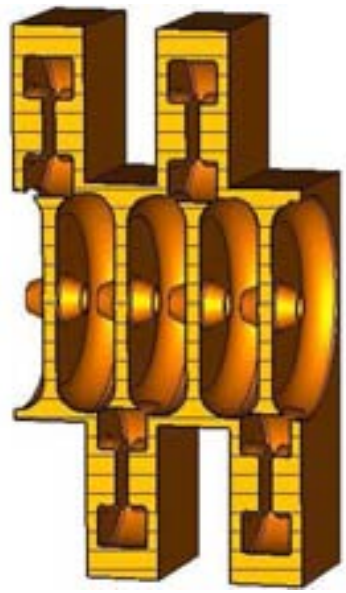



**chopper rise time: $\approx$ 3.4 ns**

# Frequency Choice (high energy part >90 MeV)




M. Vretenar,E. Benedico



A. Millich

The **S**ide **C**oupled **L**inac from 90 to 180 MeV (704.4 MHz) is identical to the Linac4 design at CERN ⇒ less R&D and lower costs for both labs.

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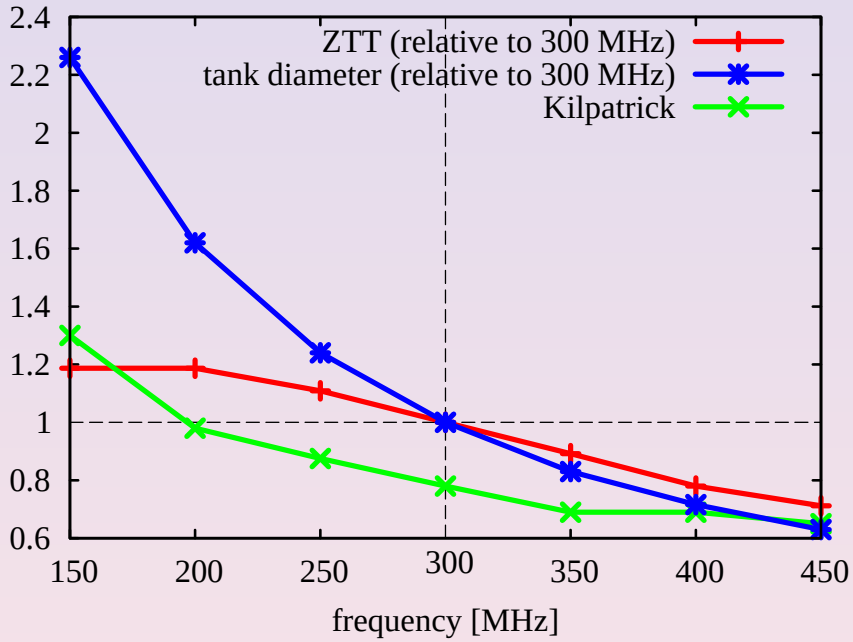
# Frequency Choice (low energy part <90 MeV)

## 234.8 MHz or 352.2 MHz ??

- The diameter of DTL quadrupoles is independant of the frequency choice!
- Low frequencies provide more length for DTL quadrupoles and raise the chopper switching time!




352.2 MHz instead of 234.8 MHz would reduce $ZT^2$ by 22% and reduce the tank diameter by 41% (15 MeV, gap/$\beta\lambda = 0.3$).

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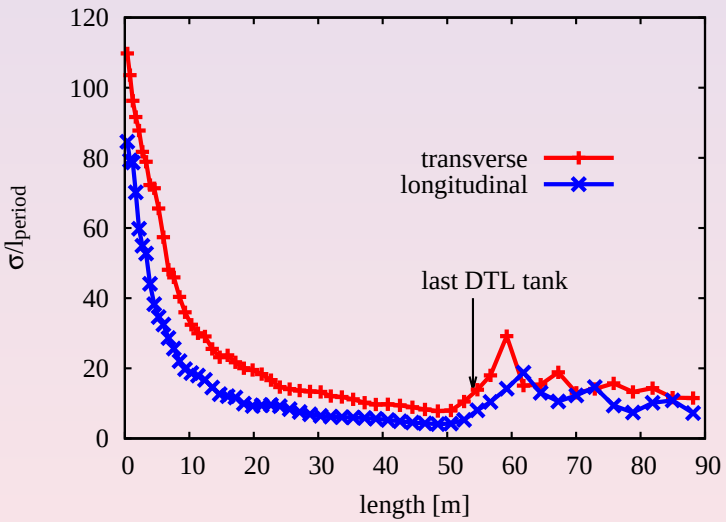
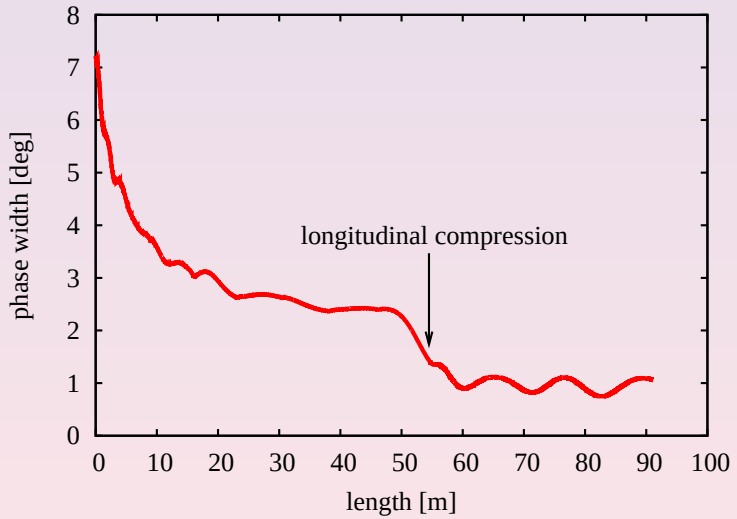
# Matching across a Triple Frequency Jump

**Goal: smooth phase advance per metre across all transitions**

- DTL: compensation of 'missing gaps between tanks' with increased longitudinal focusing before and after transition.
- DTL/SCL: field & phase ramp in last DTL tank ($\Rightarrow$ short matching line).



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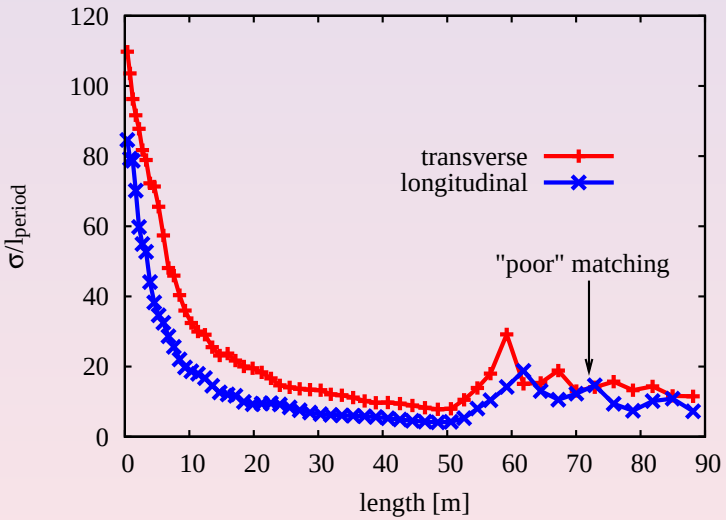
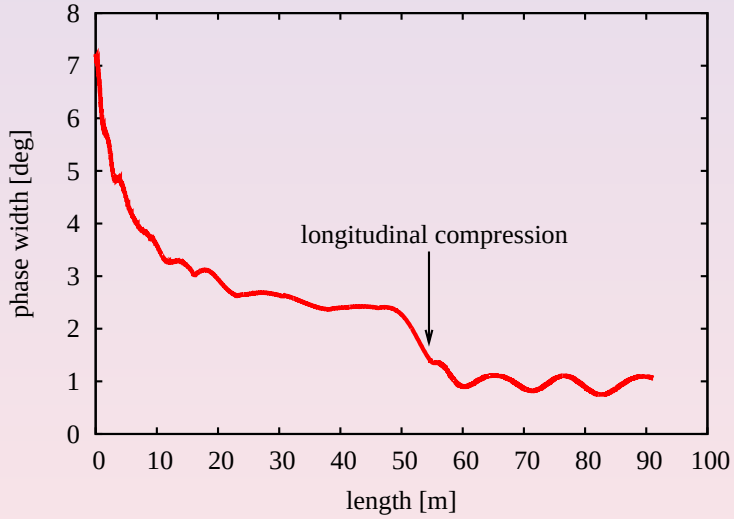
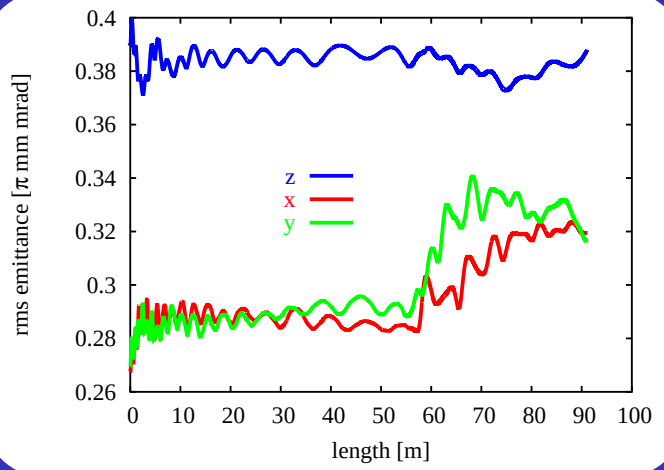


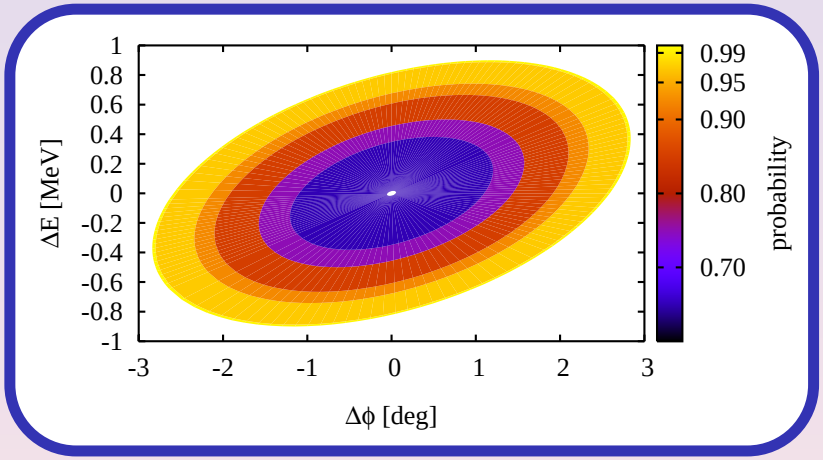

**Matching remains tricky!!**

# Nominal Beam & RF Errors




Emittance evolution with 'imperfect' matching (6D Waterbag).

Probability for final energy & phase jitter due to ±0.5%, ±0.5 deg (rms) RF errors (uncompensated).




- despite 'imperfect' matching only 20% rms emittance growth across the transition,
- frequency jump amplifies energy & phase jitter, compensation possible with debunching cavity (used in present linac).

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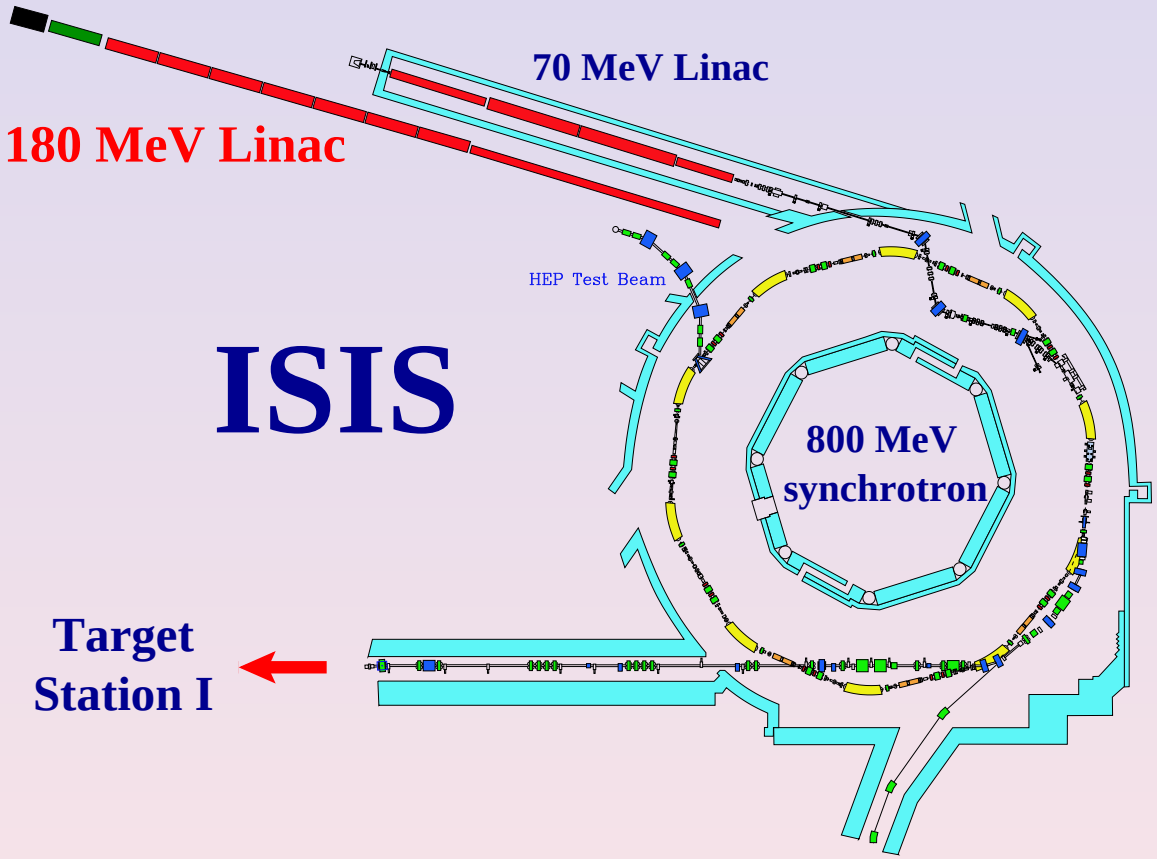
70 MeV Linac
180 MeV Linac
HEP Test Beam
ISIS
800 MeV
synchrotron
Target
Station I
Target
Station II

# Site Layout

# Summary

- A first design for a 180 MeV linac at RAL is studied, using a difficult scenario:
  - 6 DTL transitions & triple frequency jump $\rightarrow$ difficult matching, large energy & phase jitter,
  - high current design (57/171 mA) $\rightarrow$ strong tune depression (0.5), high peak power, high RF efficiency ($P_{beam}/P_{total} \approx 0.5$),
- so far even this difficult design seems feasible,
- **backup solution:** increase injection time from 300 $\mu$s to 400 $\mu$s $\rightarrow$ reduce peak currents by 33%,
- low frequency front-end $\rightarrow$ eases chopper design, provides more space for DTL quadrupoles, reduces alignment precision,

# Outlook

- future designs will look at:
  - improve transition matching,
  - reducing transition energy for frequency jump, and replace parts of the DTL with an SDTL structure,
- detailed chopper line and RFQ design,
- detailed synchrotron studies (beam dynamics, injection, extraction, instabilities),
- preparations for a full scale front-end test at RAL have started ($H^-$ source, chopper, RFQ).

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