Proton Drivers based on Rapid Cycling Synchrotrons

Christopher R. Prior

Accelerator Science & Technology Centre, ASTeC
CCLRC Rutherford Appleton Laboratory

Trinity College
University of Oxford, United Kingdom

Neutrino Factory Workshop, Frascati, June 2005
1. Proton Drivers based on Rapid Cycling Synchrotrons
Proton Driver Designs: Synchrotron-Based

General issues to be addressed

- Realisation of $\sim 4$ MW of beam power at appropriate repetition rate at pion target
- Accumulation of beam
  - Balance between linac current and number of injection turns
  - $\text{H}^-$ foil stripping, foil heating and lifetime, phase space painting
- Trapping and acceleration
  - beam instabilities (electron cloud)
  - space charge problems
- Nanosecond bunch compression
5 GeV, 50 Hz, 4 MW RCS design

- Booster rings for proton accumulation and initial acceleration
- Main rings for remaining acceleration and bunch compression
- Pairs of rings reduce space charge
- Doubling radius, halving frequency leads to acceptable $\frac{dB}{dt}$ and RF voltages
- Repetition rate restored by extracting on alternate half cycles.
- Compression at 5 GeV relies on $\gamma \rightarrow \gamma t$ and additional 0.5 MV of RF at $h = 24$. 
About 70 mA of H\textsuperscript{−} needed from ion source

Achieved at RAL (see Jürgen Pozimski’s talk)

Beam chopper (70%) - mature, EU-funded, programmes at CERN and RAL

Synchrotron models use phase space (dispersion) painting, RF voltage modulation and RF steering to achieve very low loss ring injection.
Final compression enhanced by addition by $h = 24$ voltage and achieved by converging on isochronous conditions.
Same general principles and similar procedure for injection painting. Normal bunch rotation achieves ns compression.
ISIS upgraded to a 4 MW Proton Driver

Progressive development
0.5 MW to 1 MW to 2.5 MW to 5 MW, with phases for bunch compression and target testing, resulting in a combined neutron/neutrino facility.
Comment

- The target is arguably the most difficult part of the whole NF facility (c.f. ESS experience).
- The proton driver needs to take account of target limitations (shock, heating) in its choice of energy and the length and structure of the bunch train.
- The driver energy and target geometry determine the pion/muon distribution and affect the design of the capture channel.
- The need is to maximise the number of muons entering the accelerating system.
- Particularly close collaboration is therefore needed between driver, target and muon front-end working groups to produce the optimum operable system overall. This will inevitably mean a compromise between all regions of study.