

# High Intensity Longitudinal Dynamics Studies for an ISIS Injection Upgrade



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ISIS

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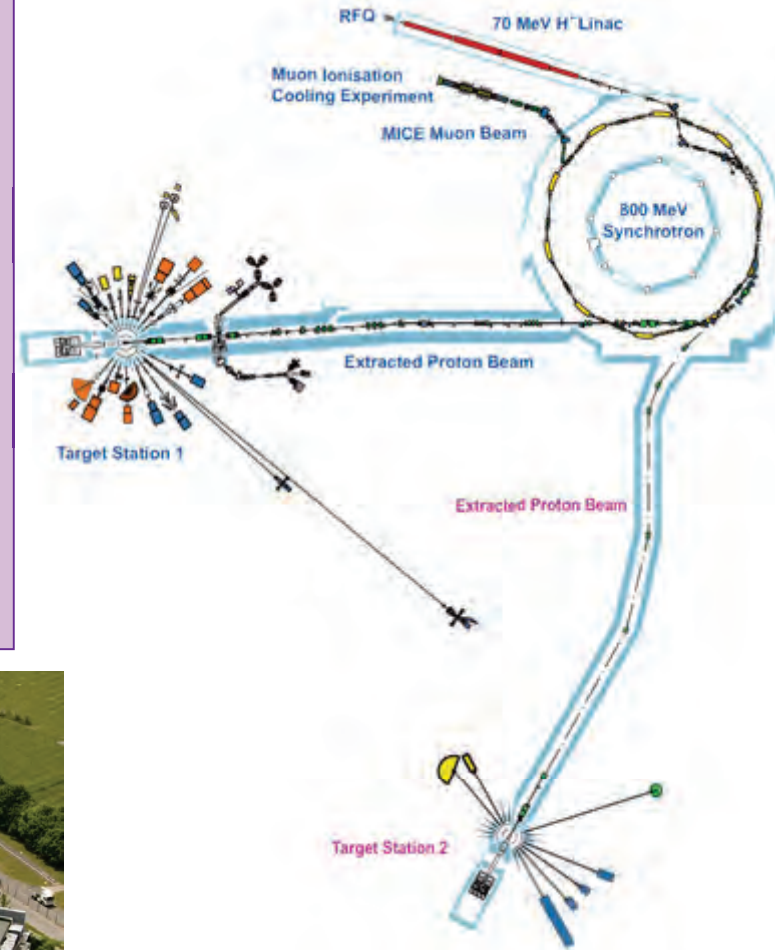




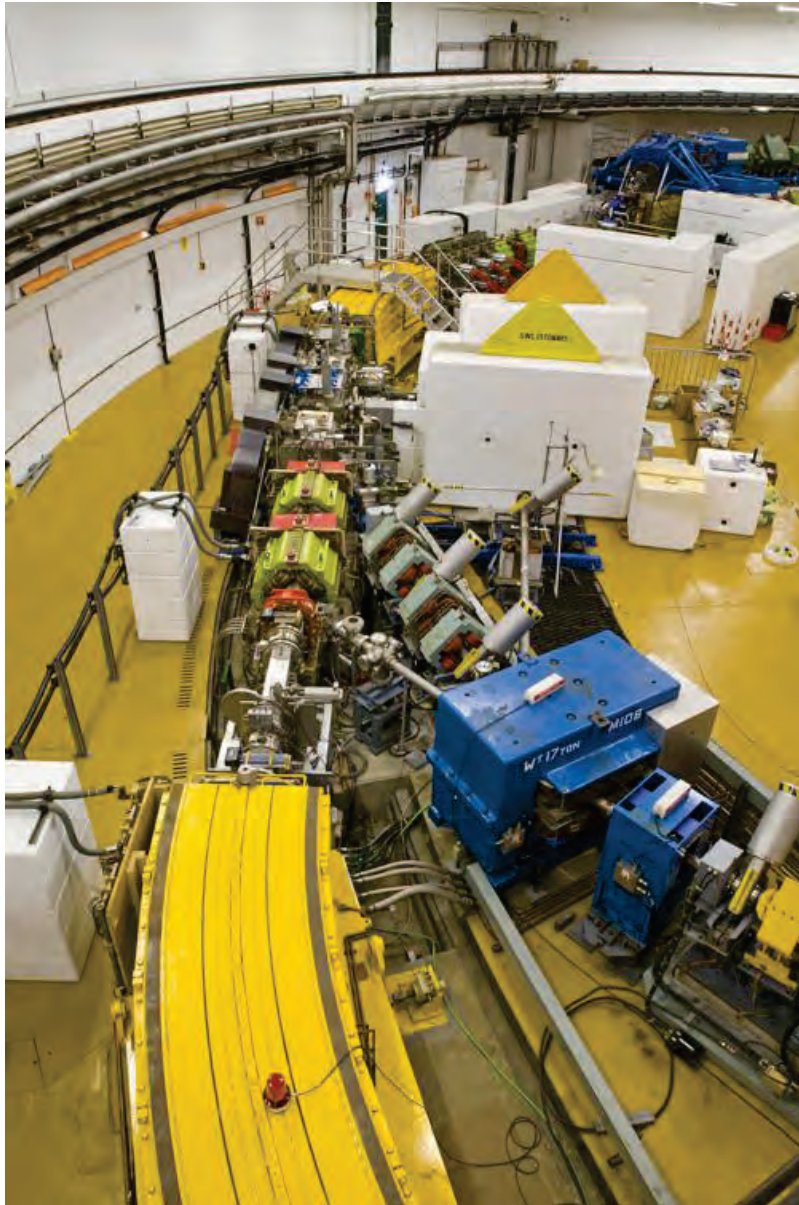
# Introduction

- 70 MeV H<sup>-</sup> DTL
- Charge-exchange injection
- 50 Hz, sinusoidal main magnet
- 800 MeV RCS, 10 super periods
- $3 \times 10^{13}$  protons, 0.2 MW
- RF: 6 h=2 cavities, 160 kV/turn and 4 h=4 cavities, 80 kV/turn

$$V = V_{h=2} \sin \varphi - V_{h=4} \sin(2\varphi + \theta)$$



# ISIS Injection – Longitudinal

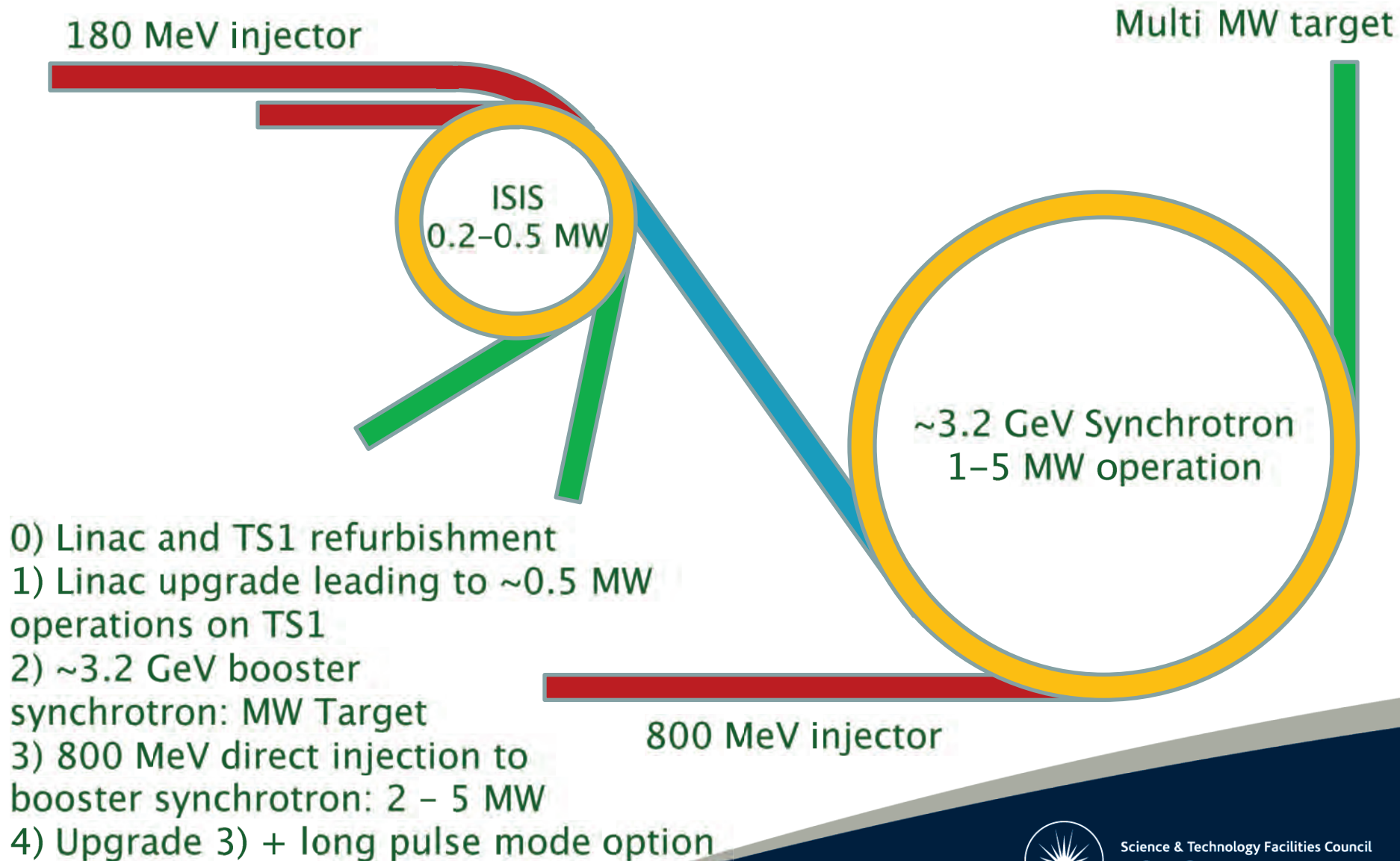


- ~ 200  $\mu\text{s}$  pulse length
- ~ 135 turns
- ~ 98 % efficiency
- $3 \times 10^{13}$  protons per pulse
- RF frequency constant
- 'Adiabatic' capture





# ISIS Upgrades

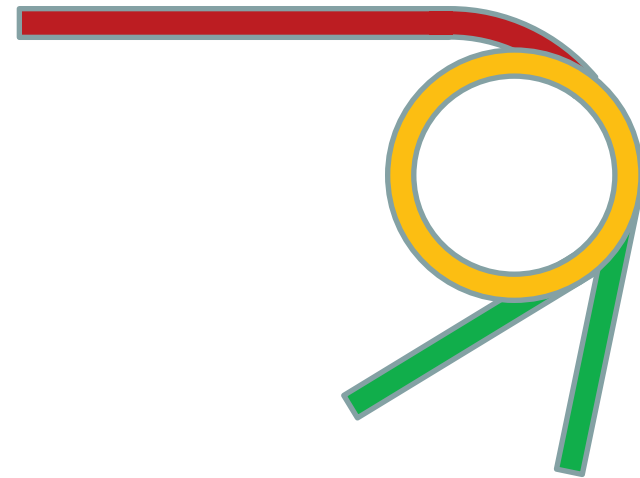


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# ISIS Injection Upgrade

- 0.5 MW  $\Rightarrow 8 \times 10^{13}$  protons
- 43 mA injected
- ~500 turns,  $\pm 110^\circ$  RF phase
- $dp/p = \pm 0.3 - 1.0 \times 10^{-3}$
- Injected energy ramp



## Constraints:

- Adiabatic changes
- Beam loss
- Bunching factor
- Instability threshold
- Momentum spread
- RF parameters

“Injection and Stripping Foil  
Studies for a 180 MeV Injection  
Upgrade at ISIS” – WEO3C01



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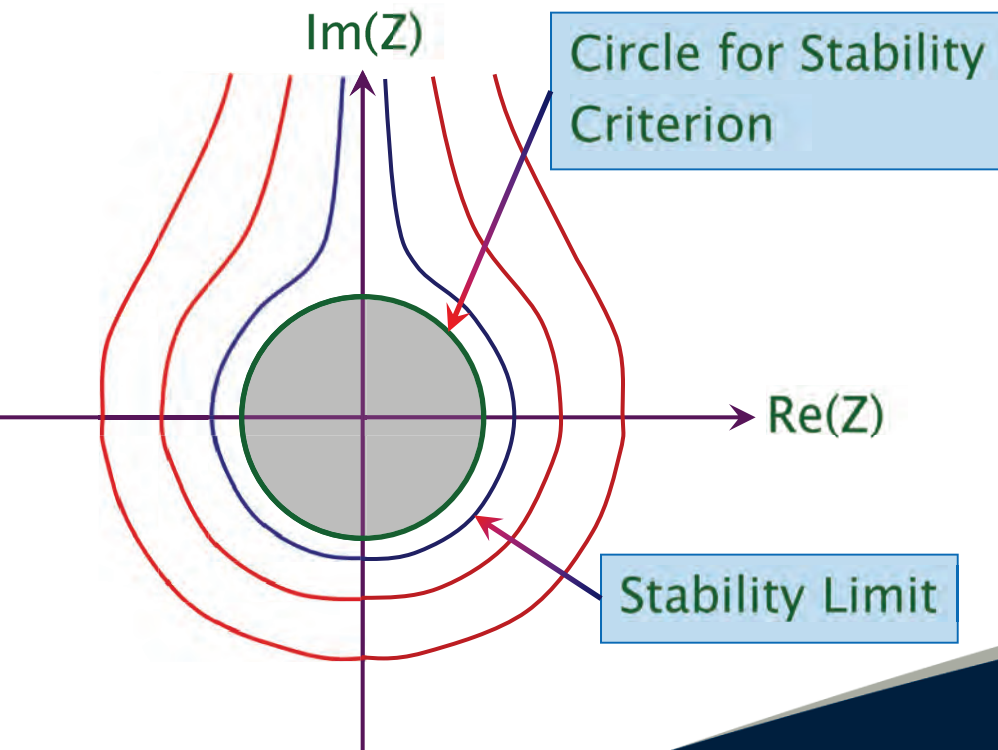
# KSB Stability Parameter

## Keil–Schnell–Boussard Stability Criterion

## Stability Parameter

$$\left| \frac{Z}{n} \right| \leq F \frac{E|\eta|}{e\beta^2} \frac{(\Delta E(\varphi)/E)^2}{I(\varphi)}$$

$$\frac{Z_{sc} e\beta^2}{F|\eta|E} \frac{I(\varphi)}{(\Delta E(\varphi)/E)^2} \leq 1$$



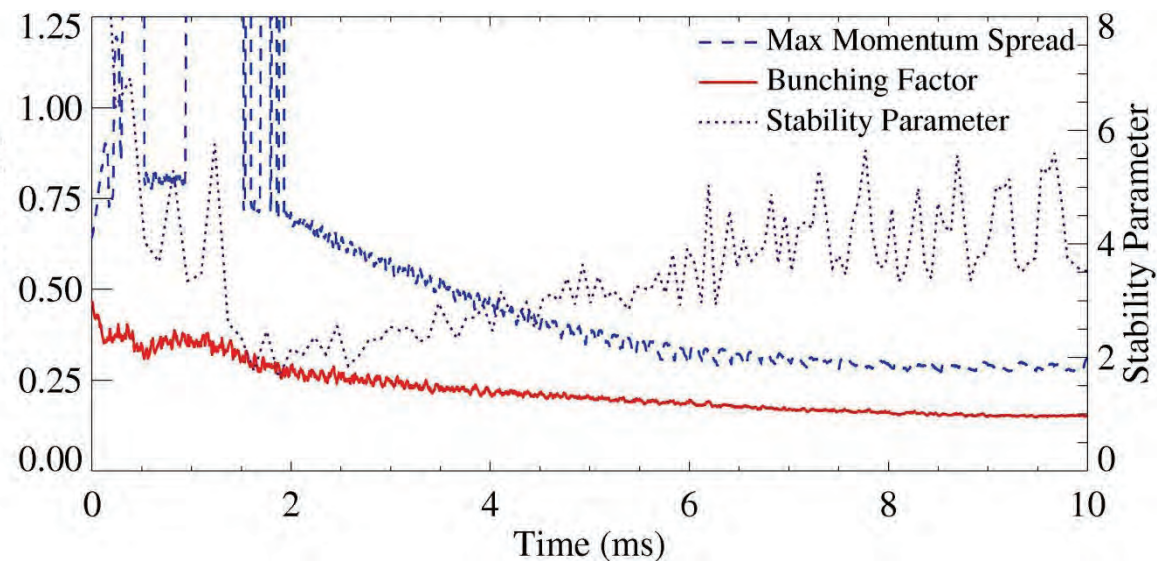
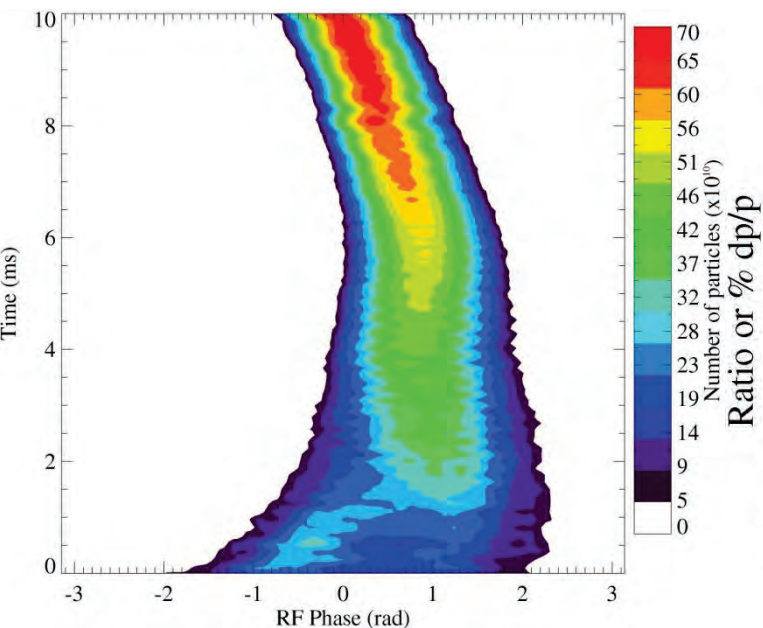
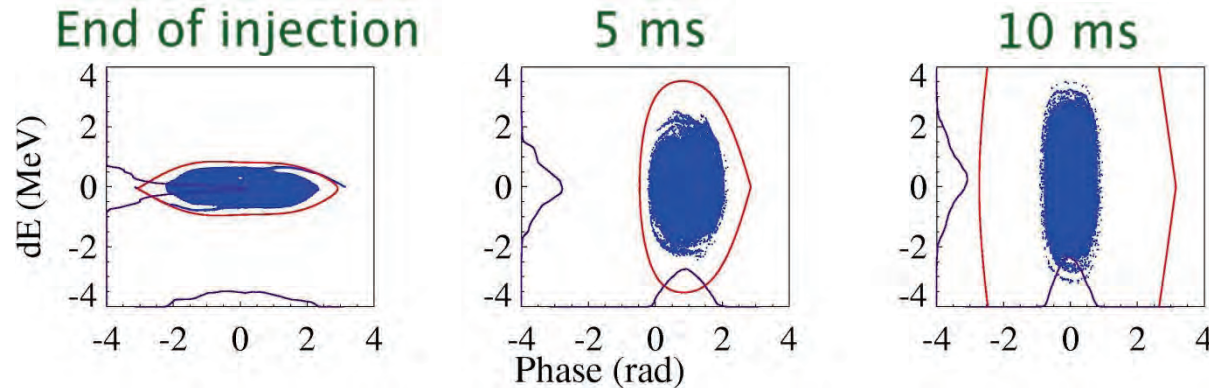
- Stability of each 'slice'
- Average stability along bunch
- Assumptions on transverse distribution





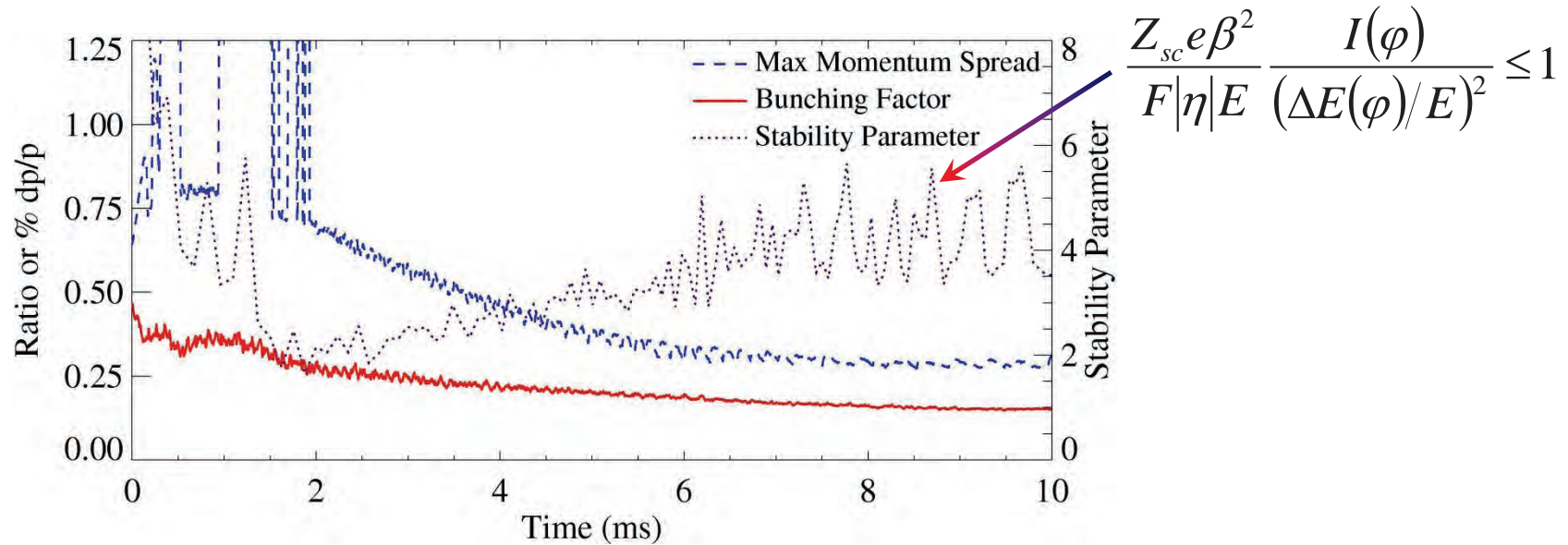
# ISIS Stability Simulations

- Approximate current working parameters





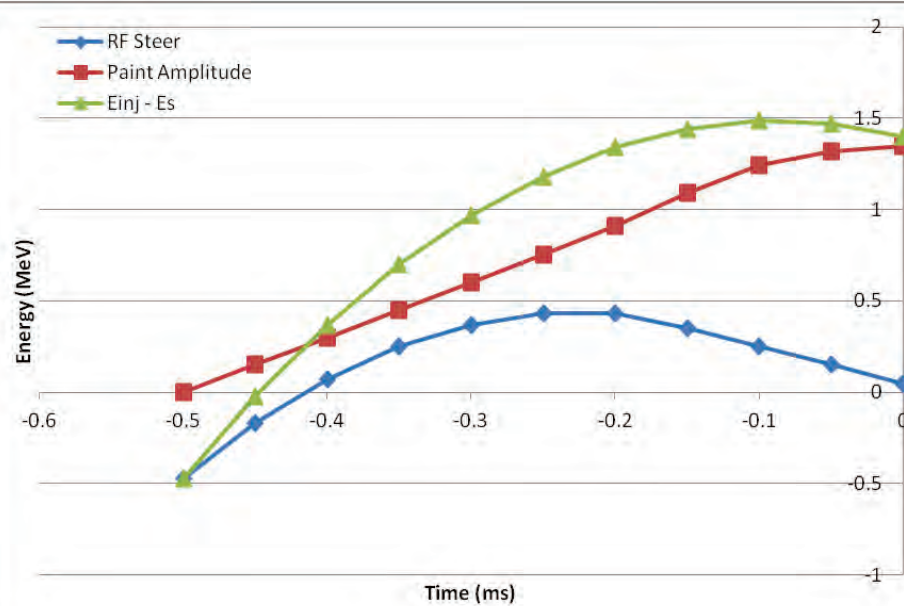
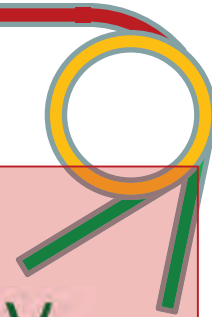
# ISIS Stability Simulations



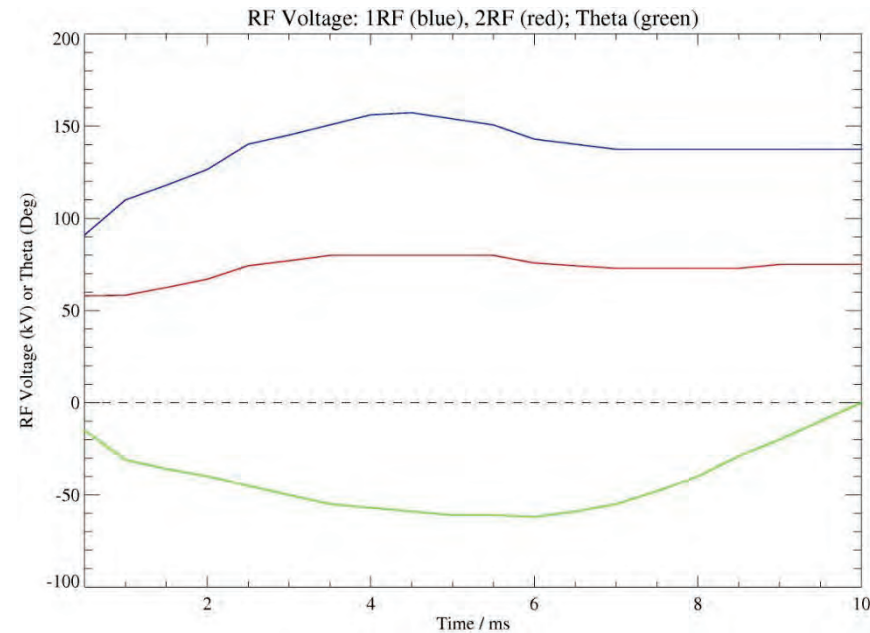
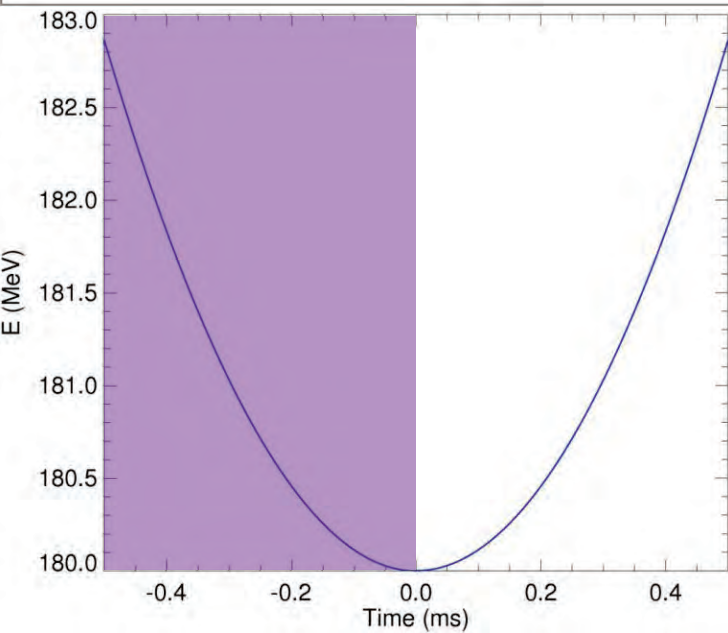
- Above stability threshold by a factor ~6
- Coasting beam criterion (KS) exceeded during injection
- Safety margin for stability simulations



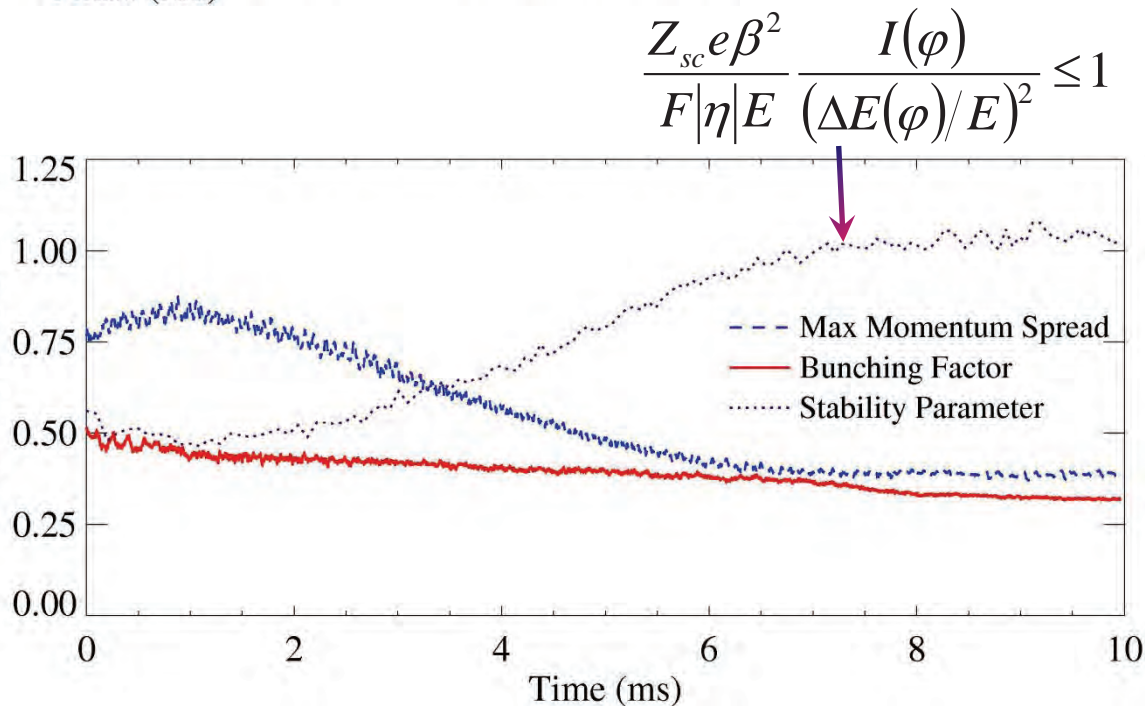
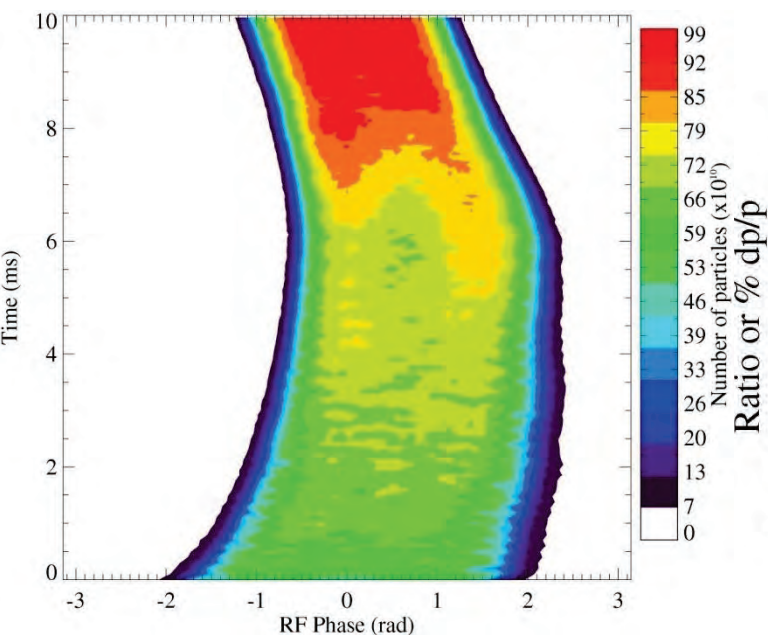
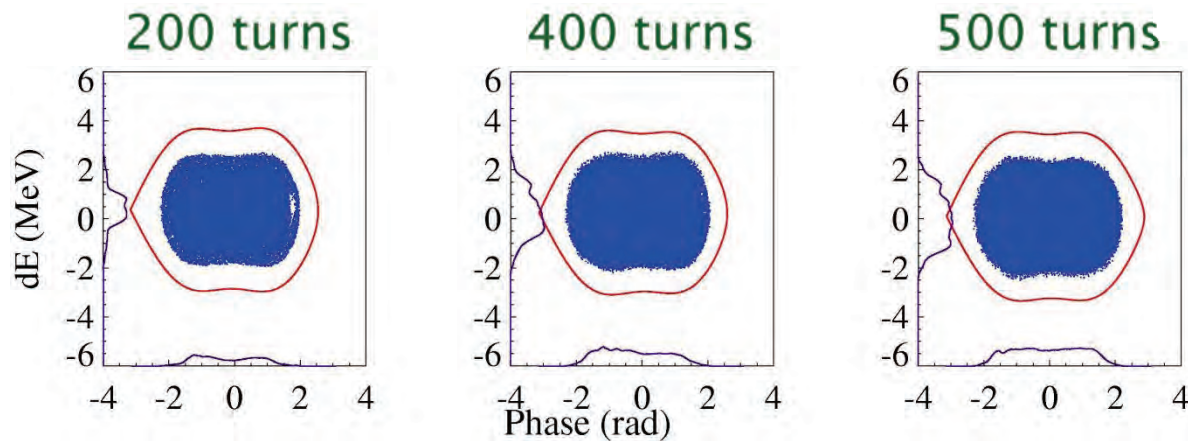
# Injection Scheme One



- -0.5 - 0 ms
- 182.4 - 181.4 MeV
- Non-linear RF steer
- 72 & 57.6 kV per turn
- $\theta$ , maximise bunching factor

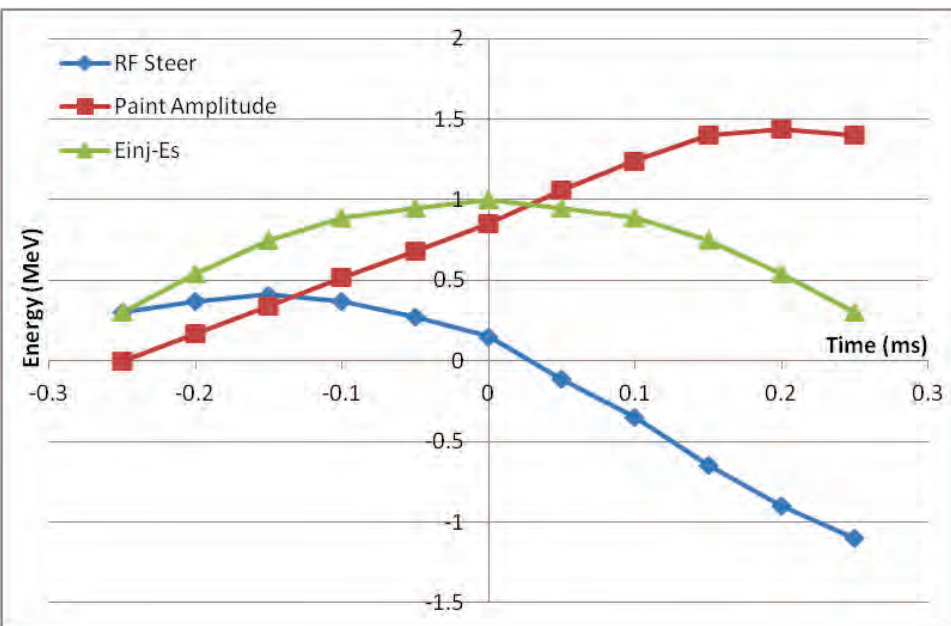
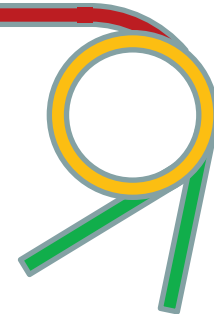


# Injection Scheme One

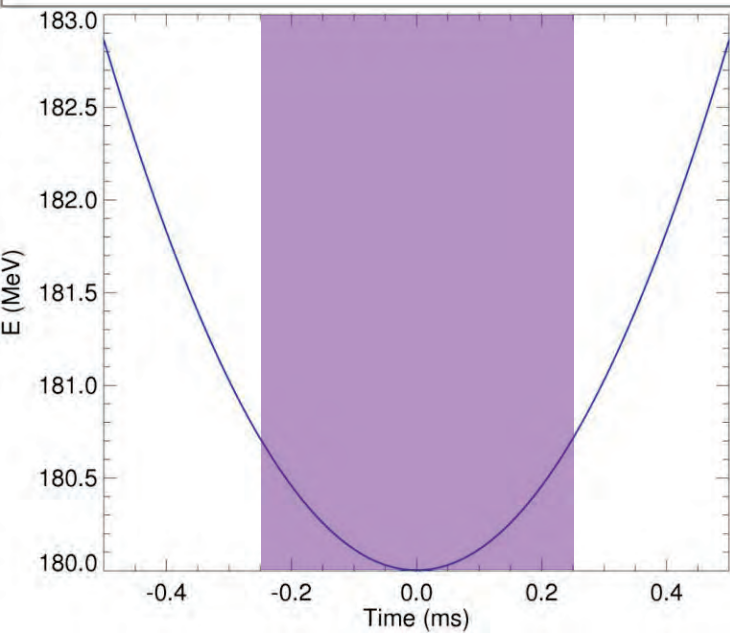




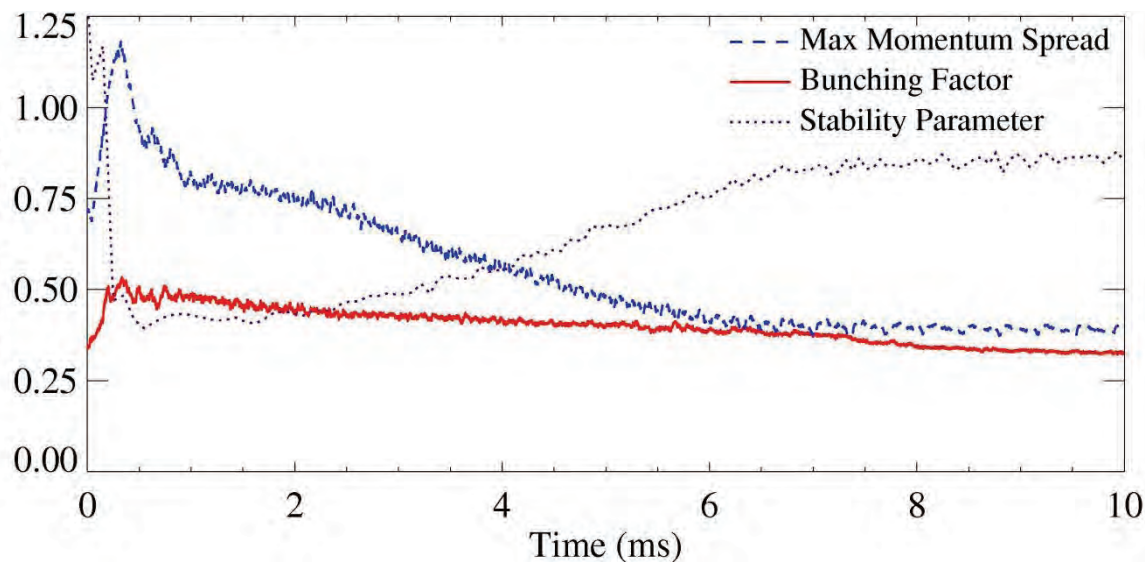
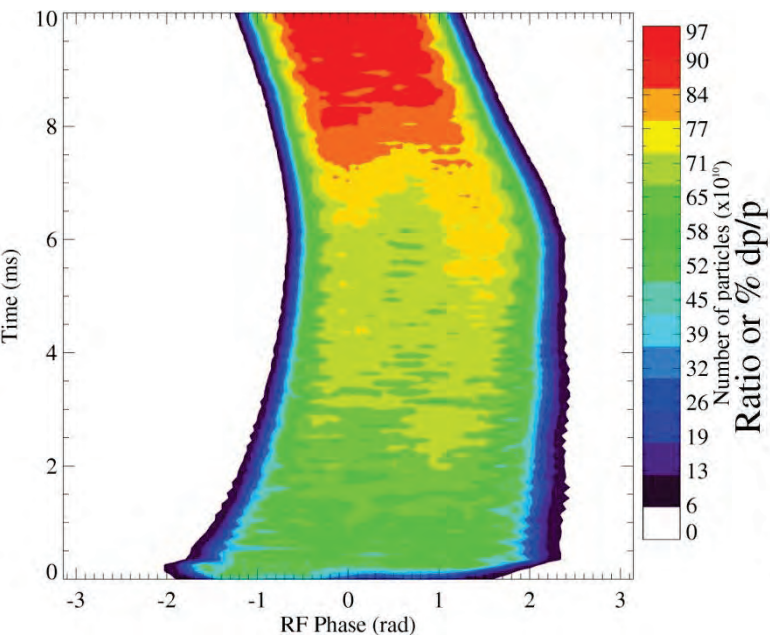
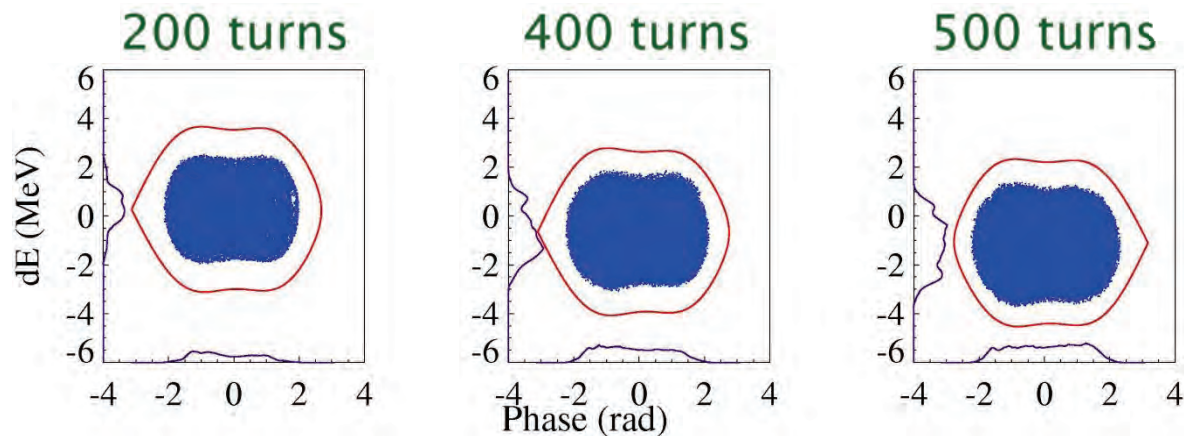
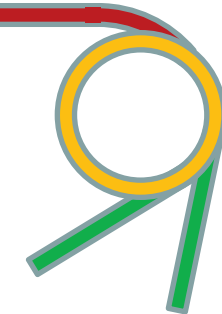
# Injection Scheme Two



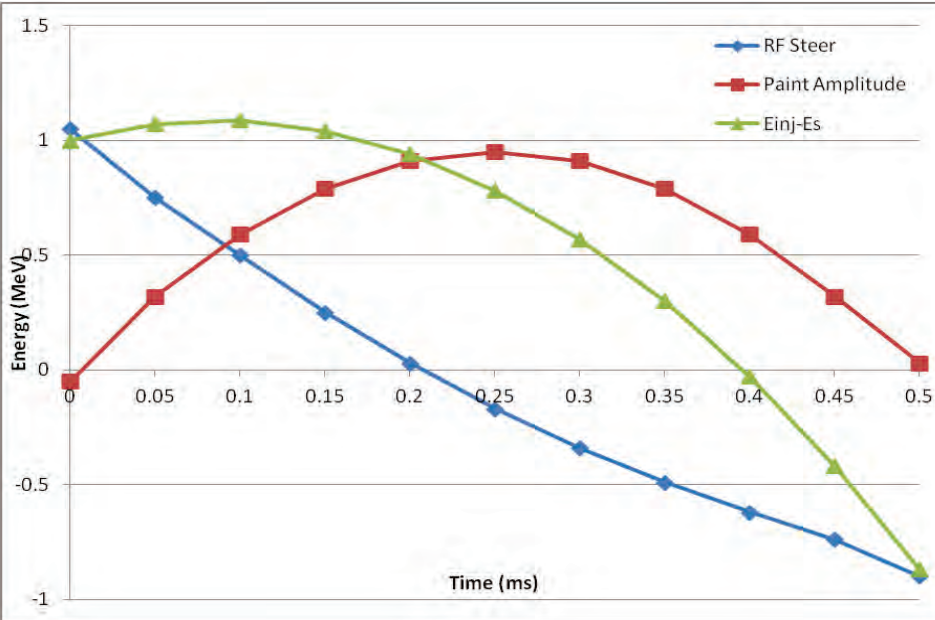
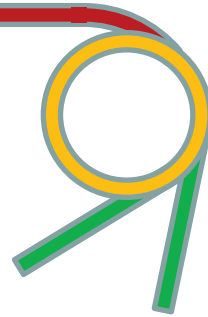
- -0.25 – 0.25 ms
- Constant 181 MeV
- Non-linear RF steer
- 72 & 57.6 kV per turn
- $\theta$ , maximise bunching factor



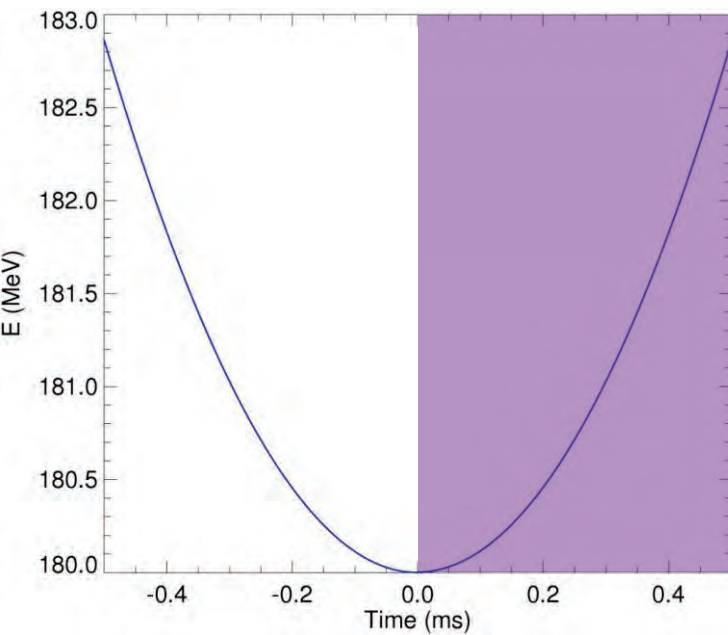
# Injection Scheme Two



# Injection Scheme Three

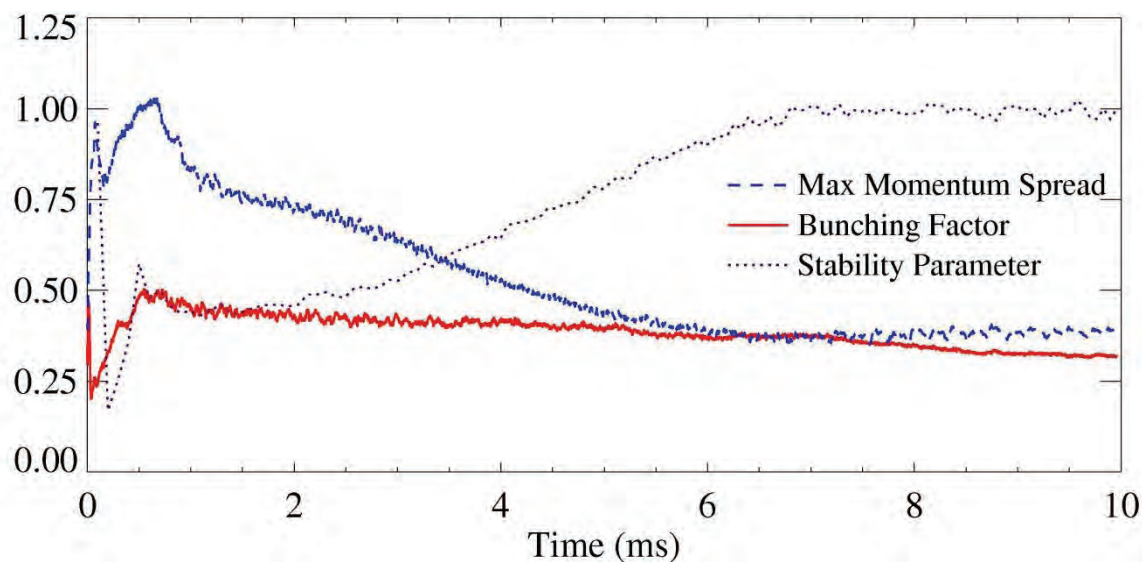
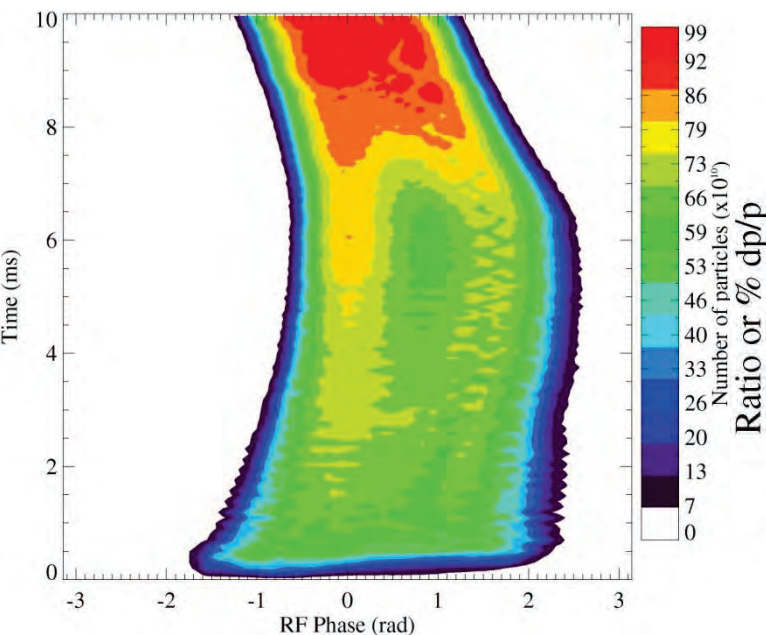
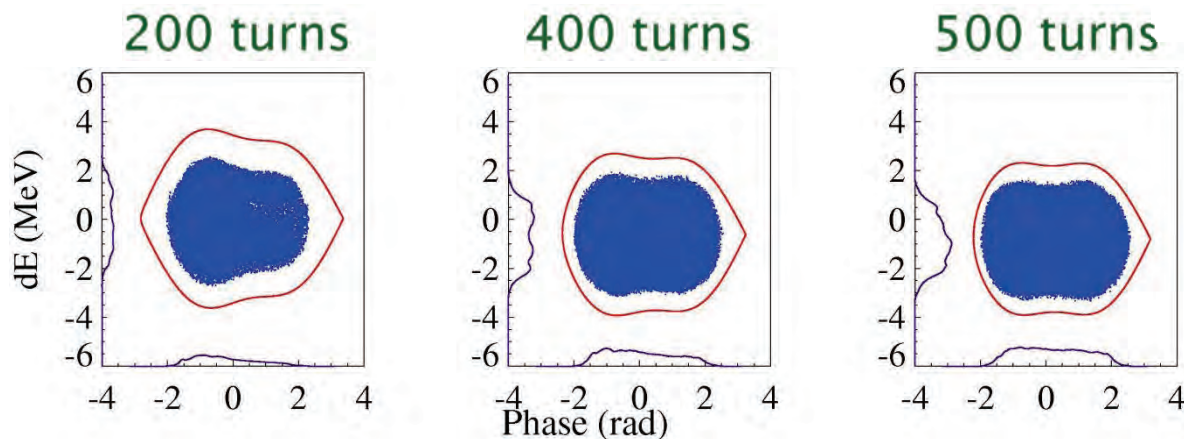


- 0 – 0.5 ms
- 181 – 182 MeV
- Non-linear RF steer
- 72 & 57.6 kV per turn
- $\theta = -60^\circ - 0^\circ$  wrt symmetric bucket



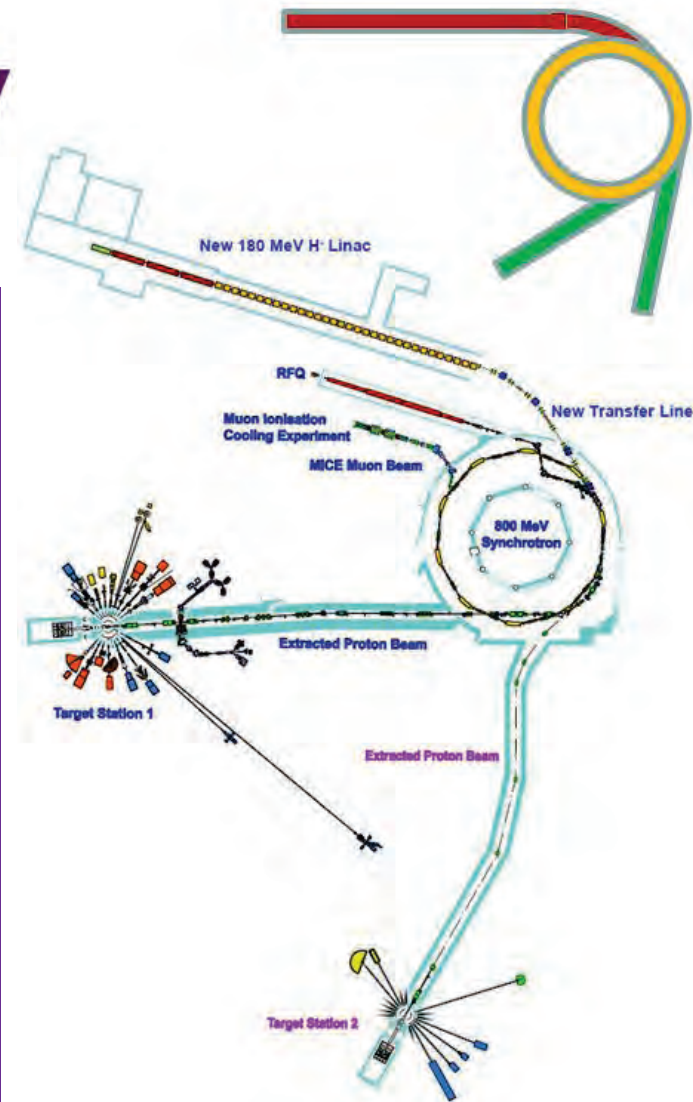


# Injection Scheme Three



# Summary

- Longitudinal dynamics: 3 injection schemes
- Longitudinal constraints met
- In-house dynamics code developed
- Results suggest 180 MeV injection realisable
- 3D dynamics studies ongoing
- Further instabilities research required





# Current Work and Plans

- Experimental program to investigate longitudinal instabilities on ISIS.
- Storage ring mode, DC main magnet:
  - With RF on at fixed frequency (KSB test).
  - With RF off (KS test).
- In-house 3D PIC code being developed

