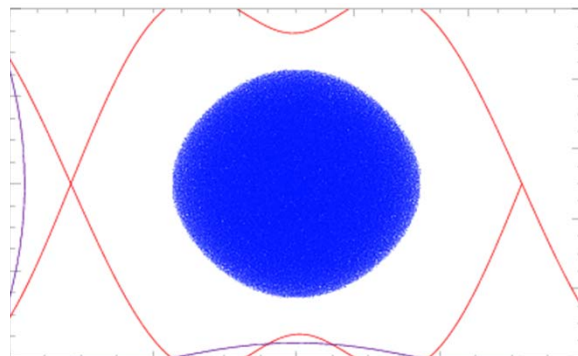


Longitudinal Dynamics Studies for ISIS Upgrades



R.E. Williamson,
D.J. Adams & C.M. Warsop

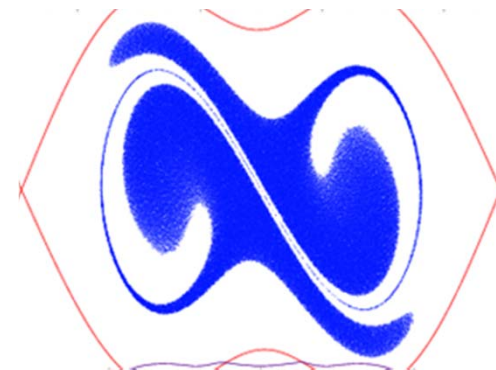
Space Charge Workshop 2013
16 – 19 April, CERN



Science & Technology Facilities Council

ISIS

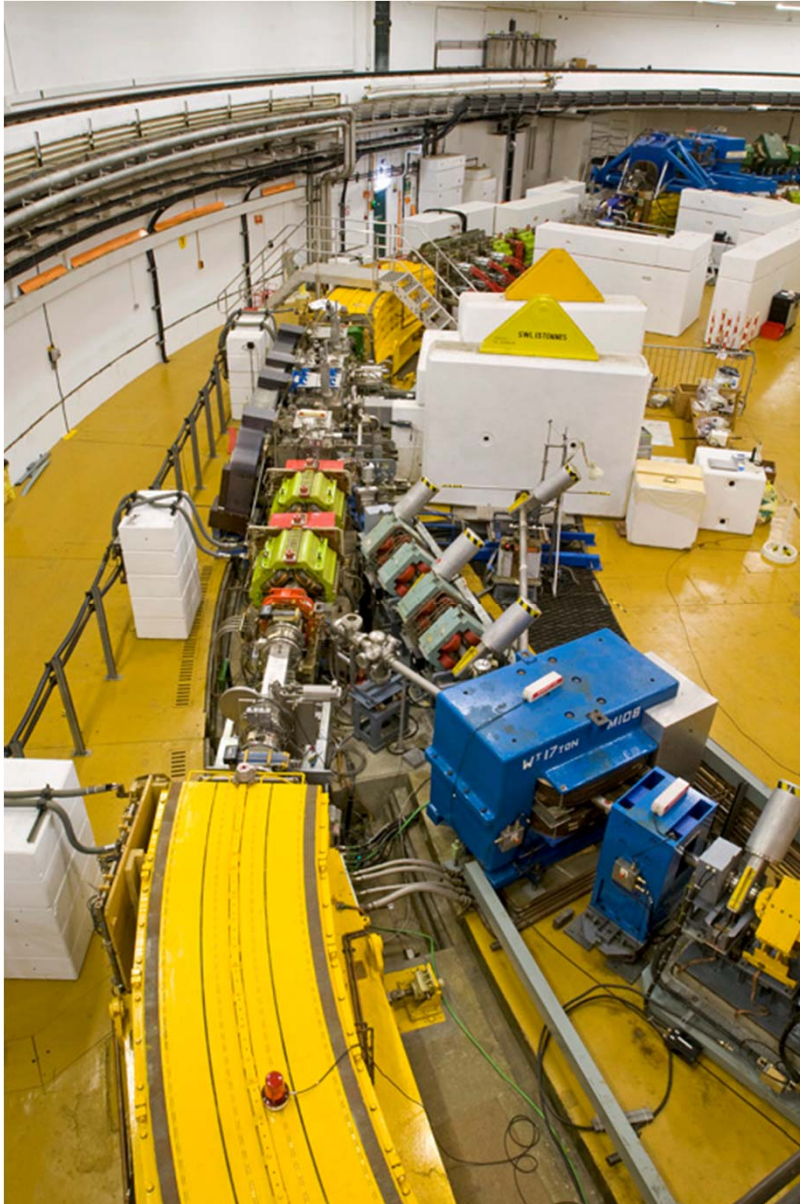
Contents



- Introduction to ISIS longitudinal injection
- Main details of injection upgrade
- Keil-Schnell-Boussard stability criterion
- Longitudinal simulations of ISIS
- Simulations of injection upgrade
- Summary and work plans



ISIS Injection - Longitudinal



- ~ 200 μs pulse length
- ~ 135 turns
- ~ 98 % efficiency
- 3×10^{13} protons per pulse
- RF frequency constant
- 'Adiabatic' capture



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ISIS

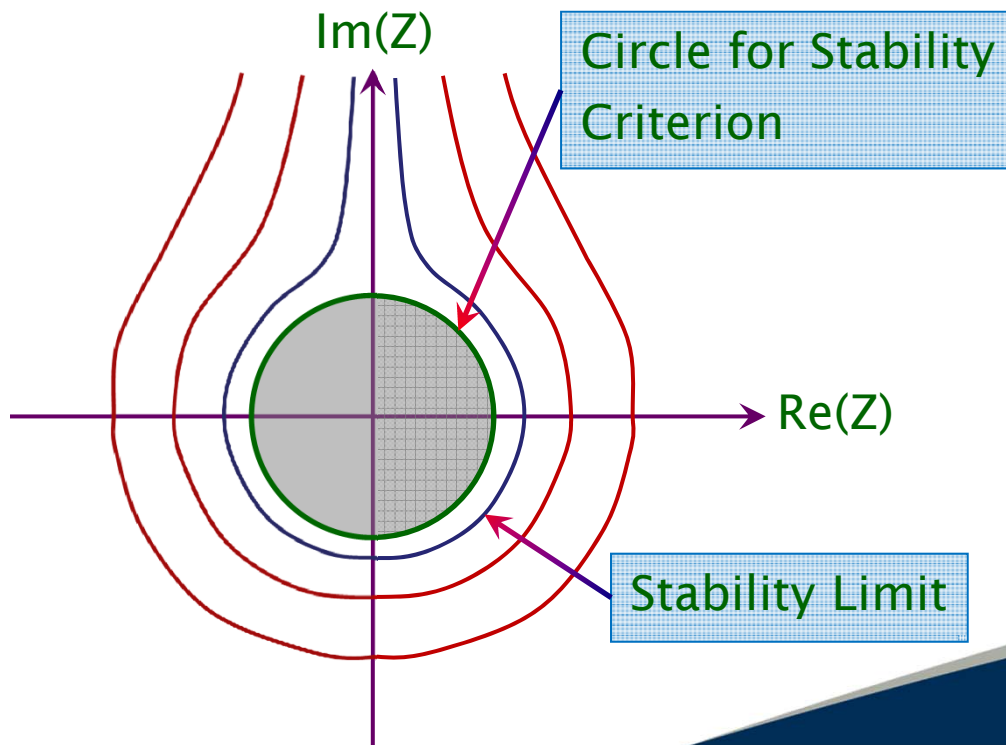
KSB Stability Parameter

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

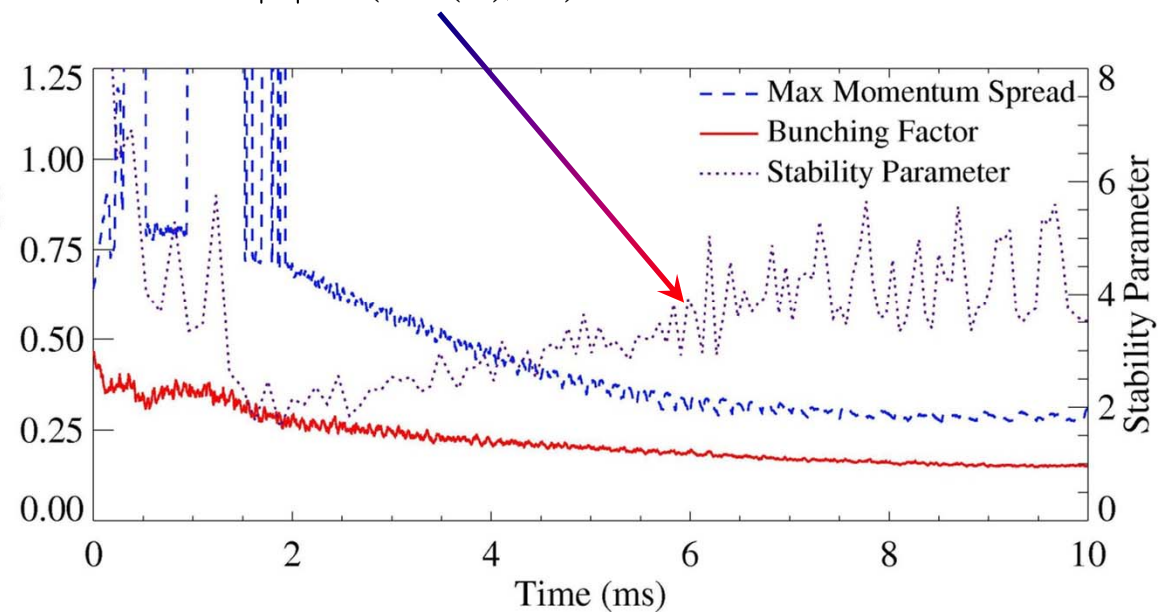
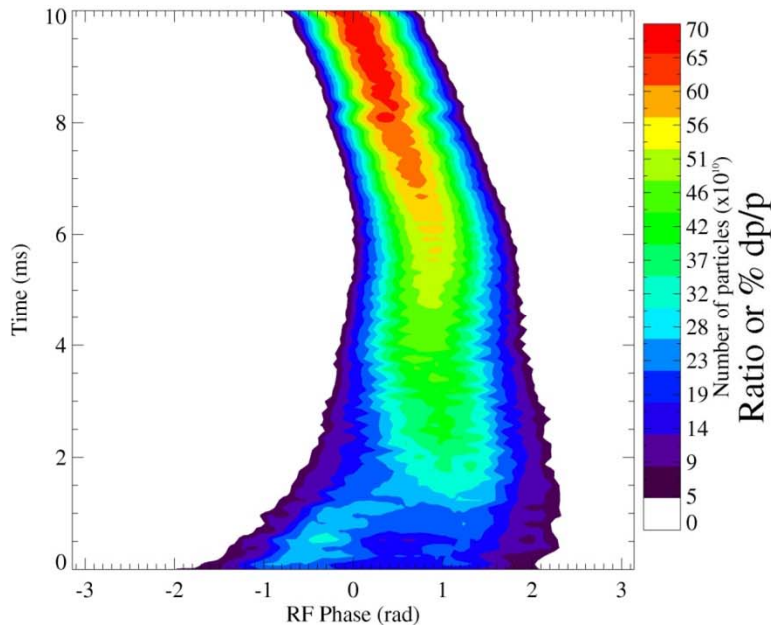


ISIS Stability Simulations

- Approximate current working parameters

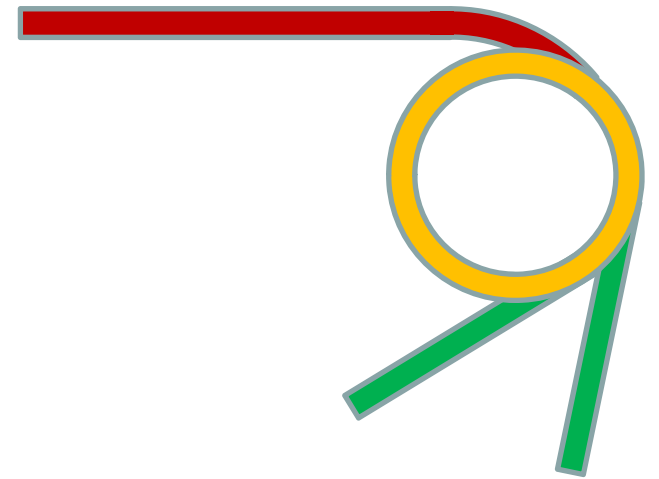
- Above stability threshold by a factor ~6
- Safety margin for stability simulations

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



ISIS 180 MeV Injection Upgrade

- 0.5 MW \Rightarrow 8×10^{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

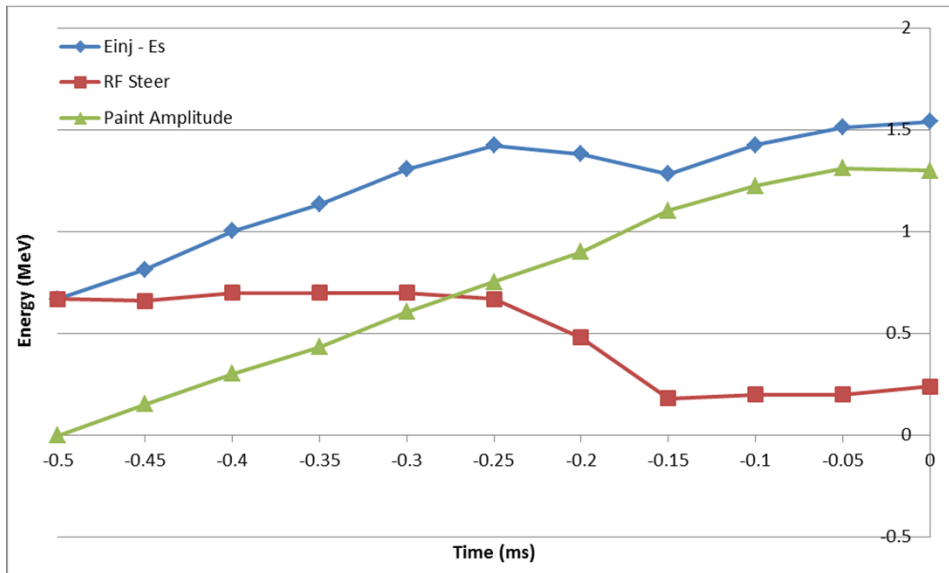
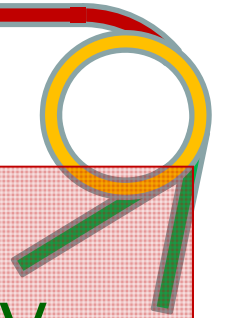


Constraints:

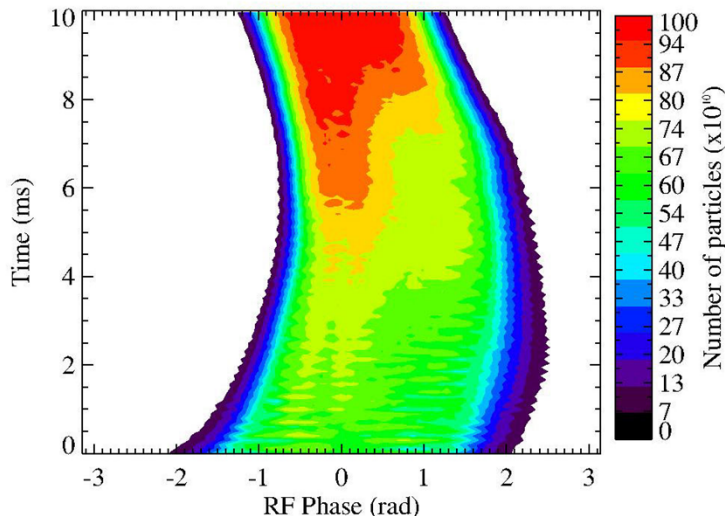
- Adiabatic changes
- Beam loss
- Bunching factor
- Instability threshold
- Momentum spread
- RF parameters



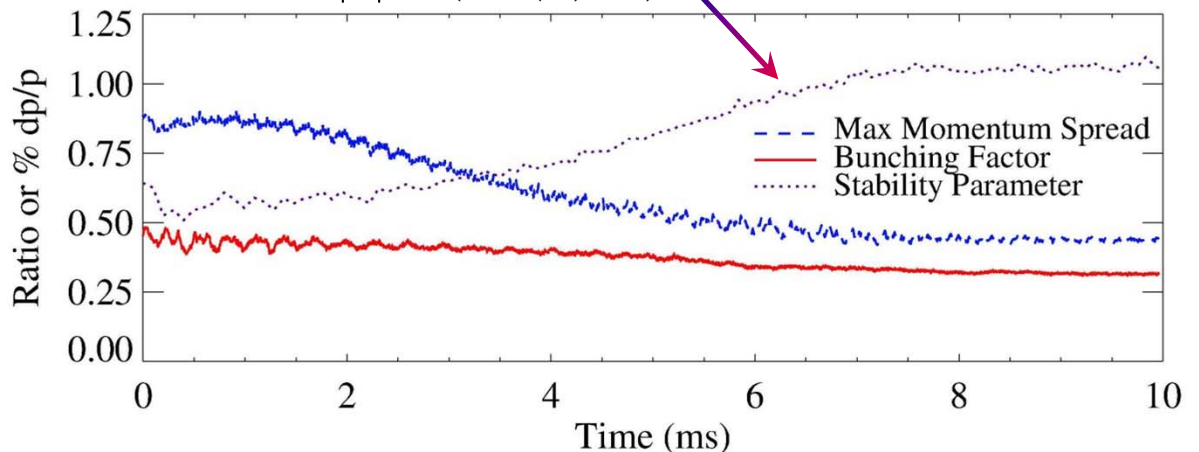
Example Injection Scheme



- -0.5 – 0 ms
- 183.5 – 181.5 MeV
- Non-linear RF steer
- 72 & 36 kV per turn
- θ , maximise bunching factor

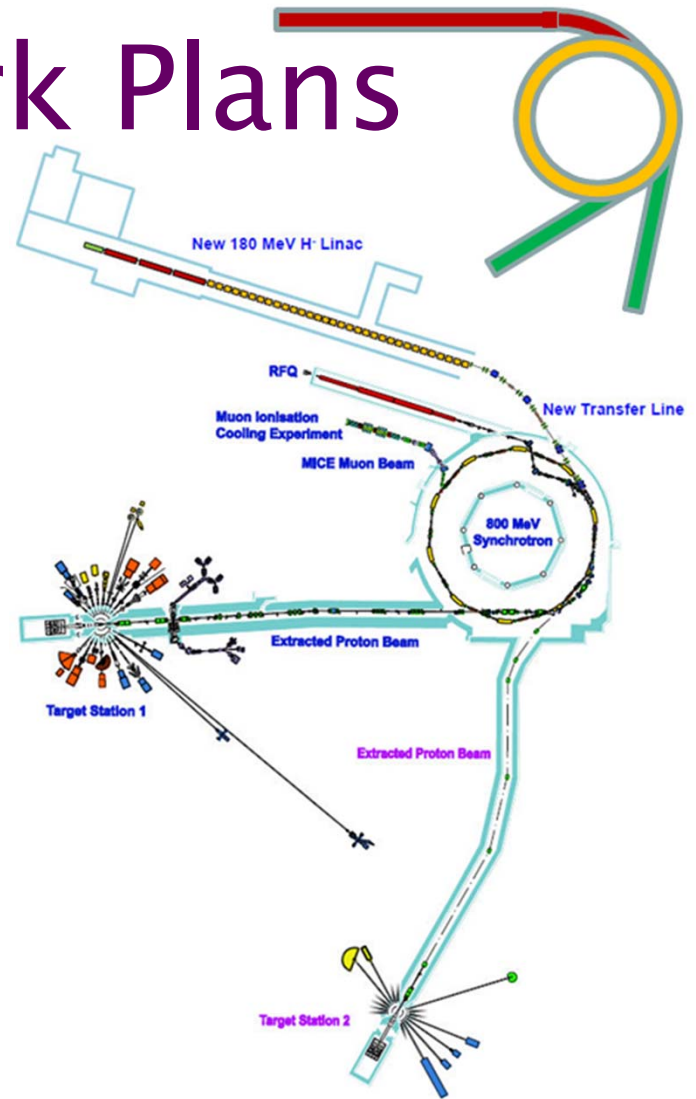


$$\frac{Z_{sc} e \beta^2}{F |\eta| E} \frac{I(\varphi)}{(\Delta E(\varphi)/E)^2} \leq 1$$

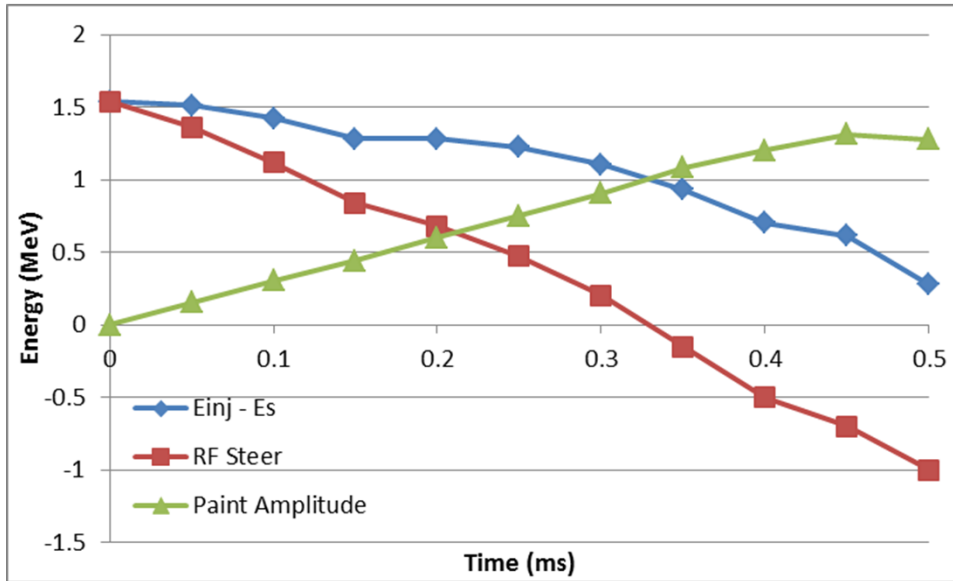


Summary and Work Plans

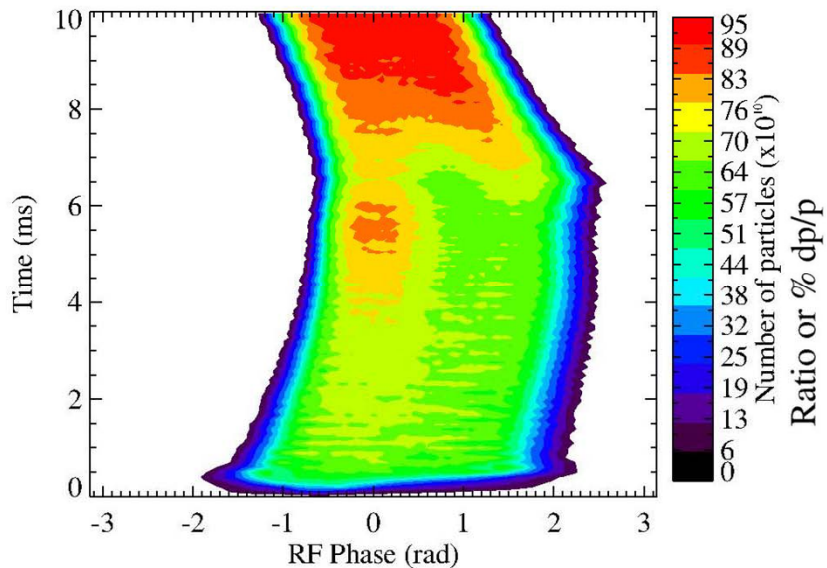
- Longitudinal dynamics for ISIS and injection upgrade
- Optimising for further constraints
- 3D dynamics studies ongoing
- Further instabilities research required
- Storage ring mode, DC main magnet:
 - With RF off (KS test).
 - With RF on at fixed frequency (KSB test).



Example Injection Scheme



- 0 - 0.5 ms
- 181.5 - 183.1 MeV
- Non-linear RF steer
- 72 & 36 kV per turn
- $\theta = -60^\circ - 0^\circ$ wrt symmetric bucket



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

