

INJECTION AND STRIPPING FOIL STUDIES FOR A 180 MEV UPGRADE AT ISIS

BEN PINE

ON BEHALF OF

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- The ISIS Facility
- ISIS Injection
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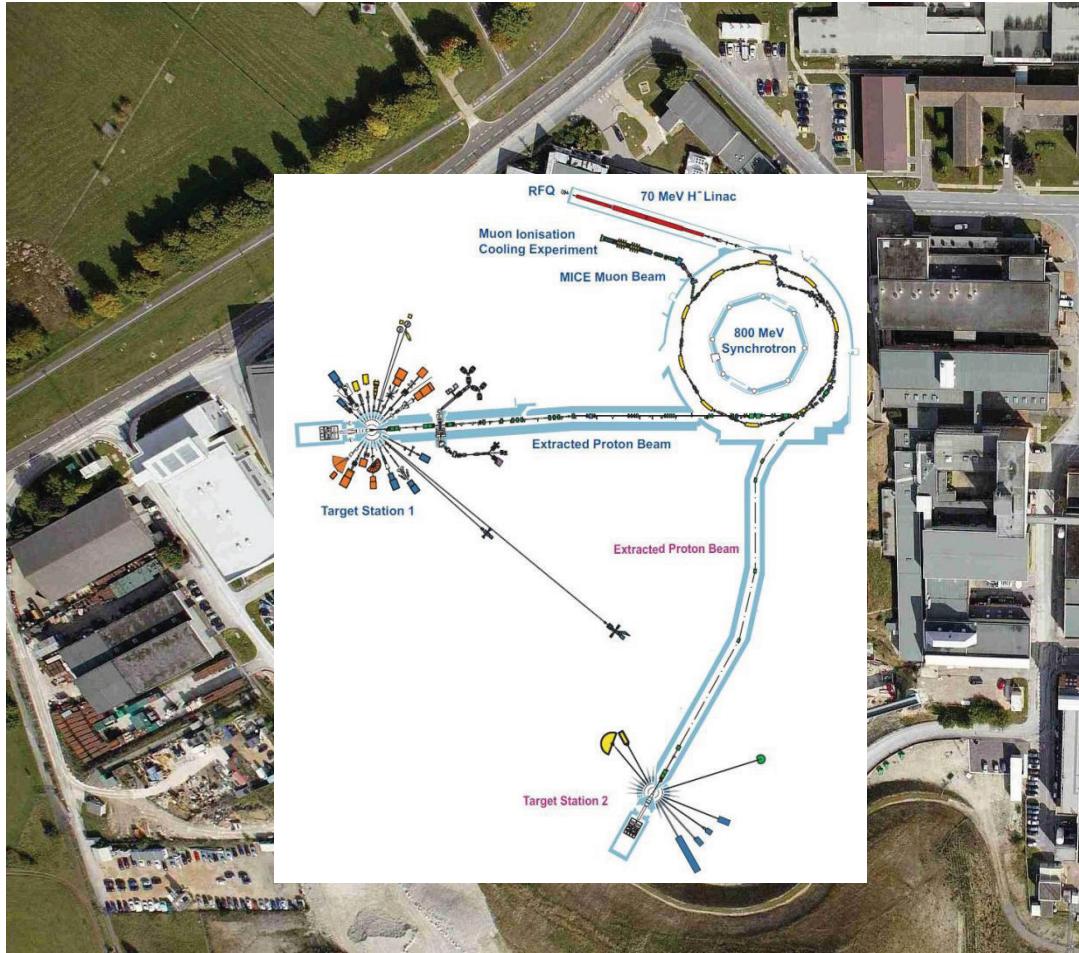


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ISIS



ISIS



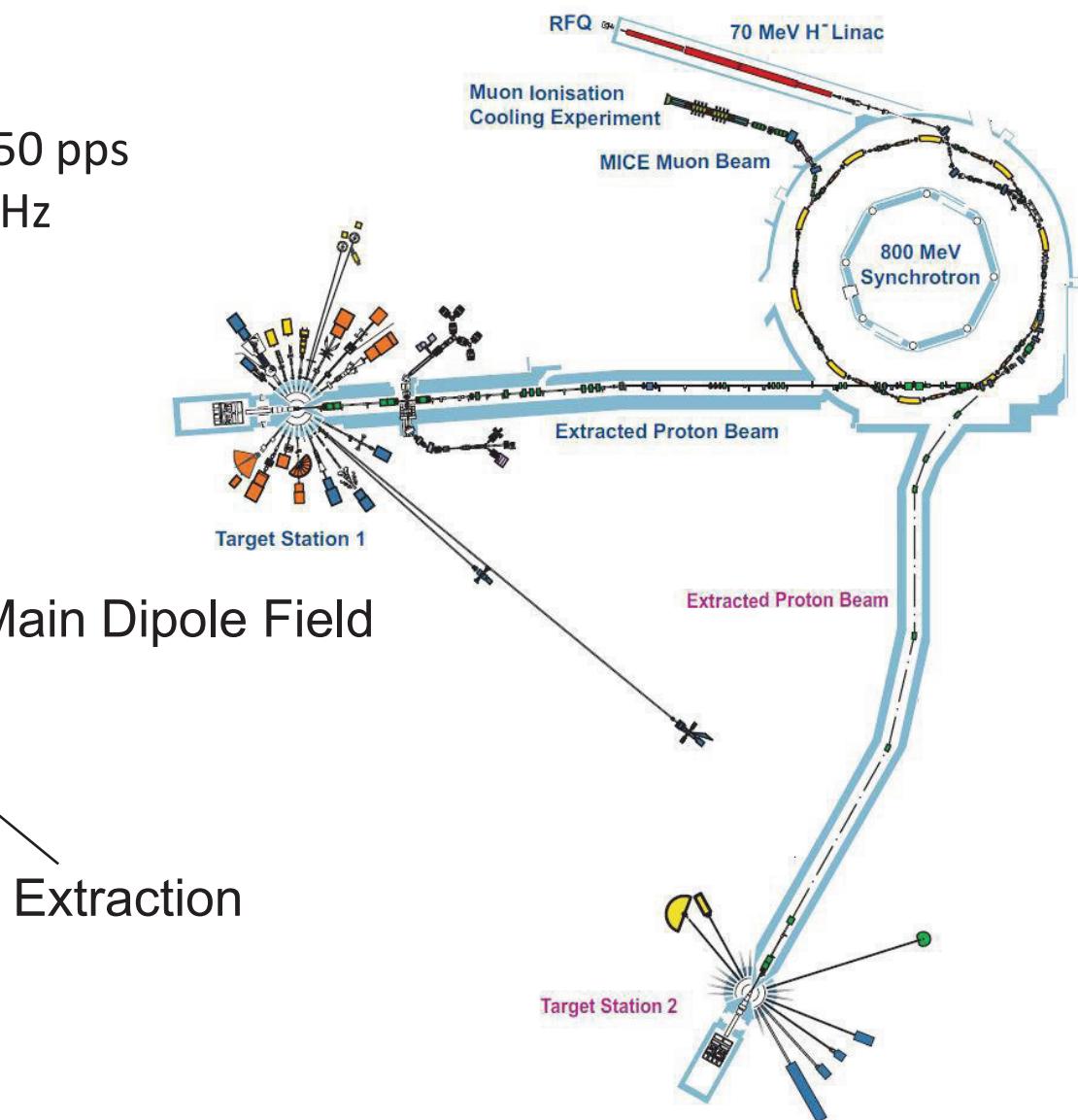
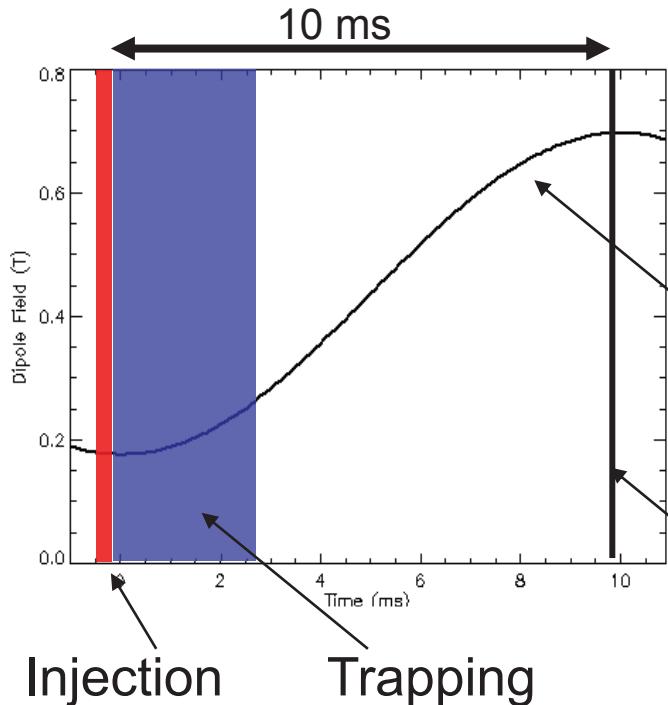
ISIS Acceleration

Accelerators:

RFQ: 665 keV H⁻

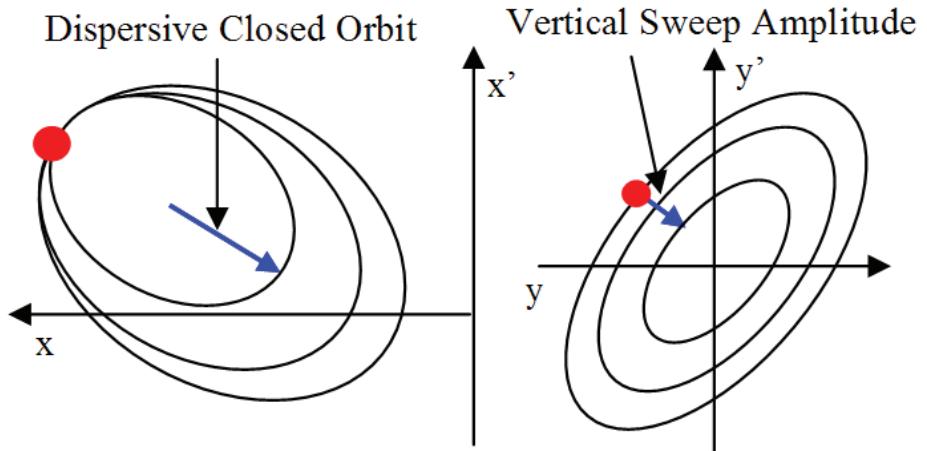
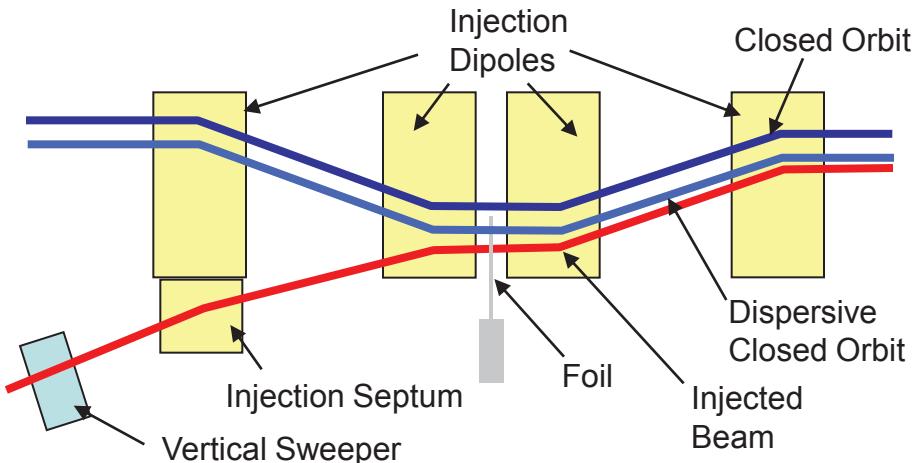
Linac: 70 MeV H⁻, 25 mA, 200 μ s, 50 pps

Synchrotron: 800 MeV proton, 50 Hz



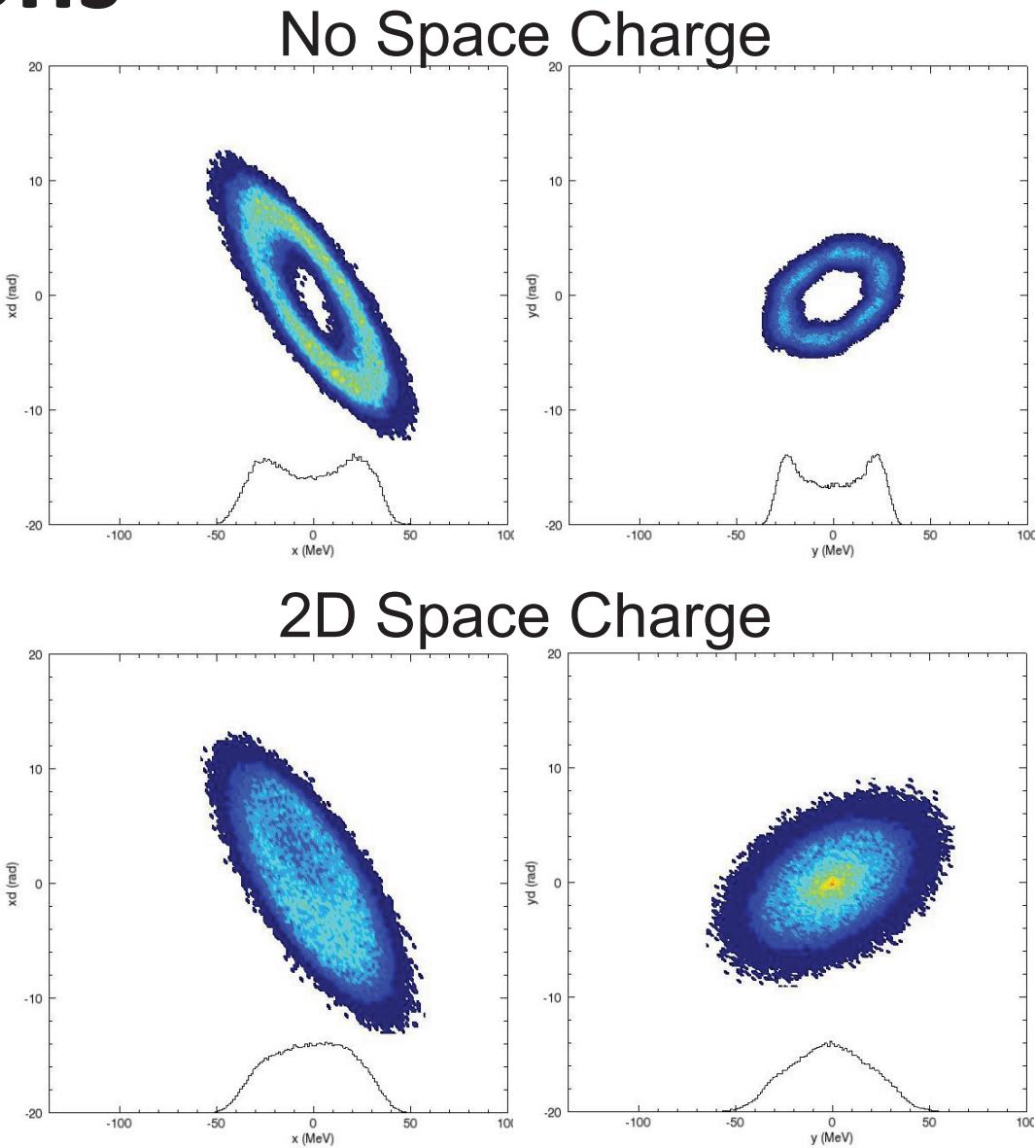
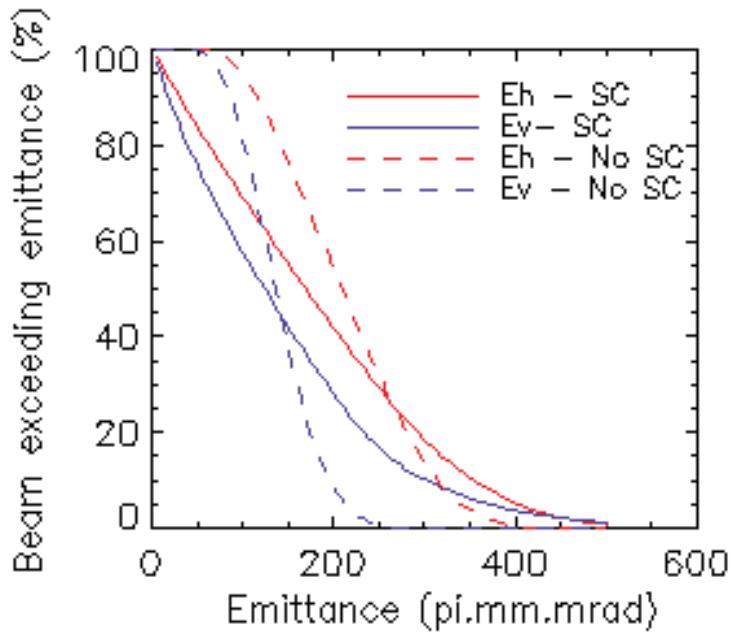
ISIS Injection

- Serially powered dipoles
- 45 mrad - 65mm bump
- 50 $\mu\text{g}/\text{cm}^2$ Al_2O_3 foil
- Vertical 'sweeper' magnet
- Horizontal painting via closed orbit movement

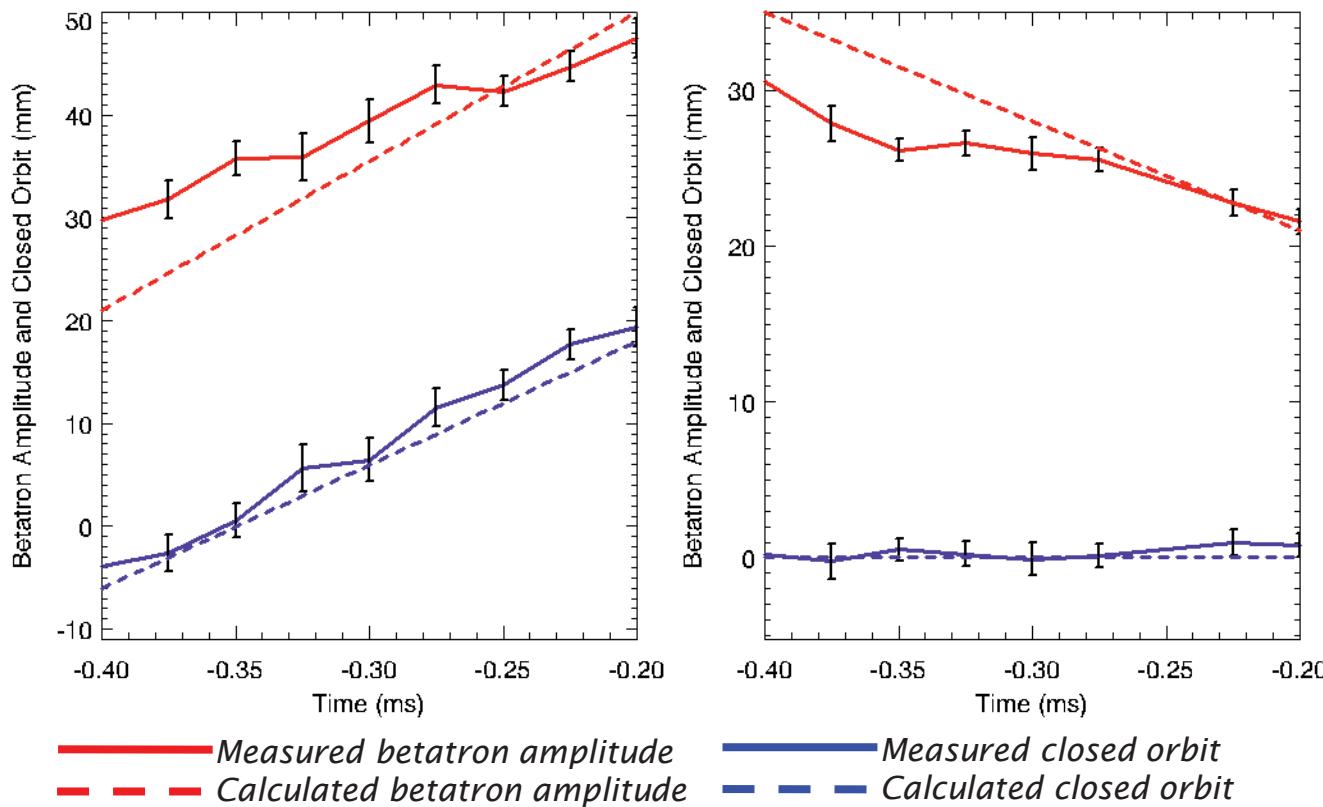


ORBIT Simulations

- ✓ 2D Space Charge
- ✗ Foil Scattering
- ✗ Lattice Errors



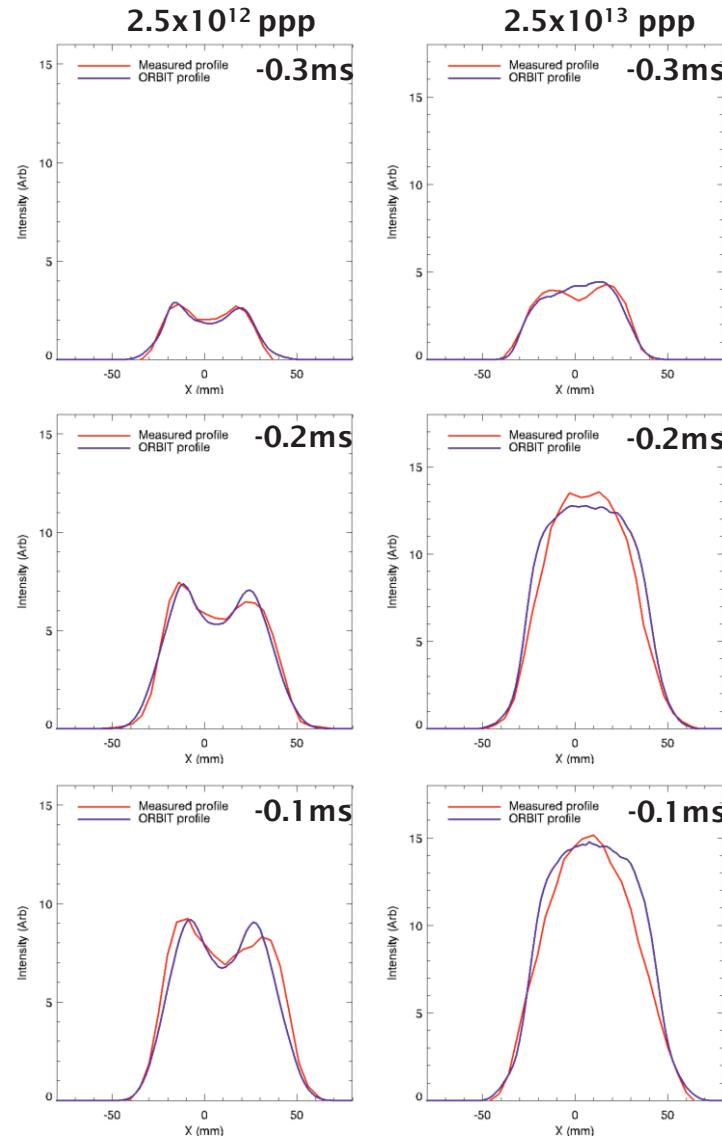
Painting Measurement



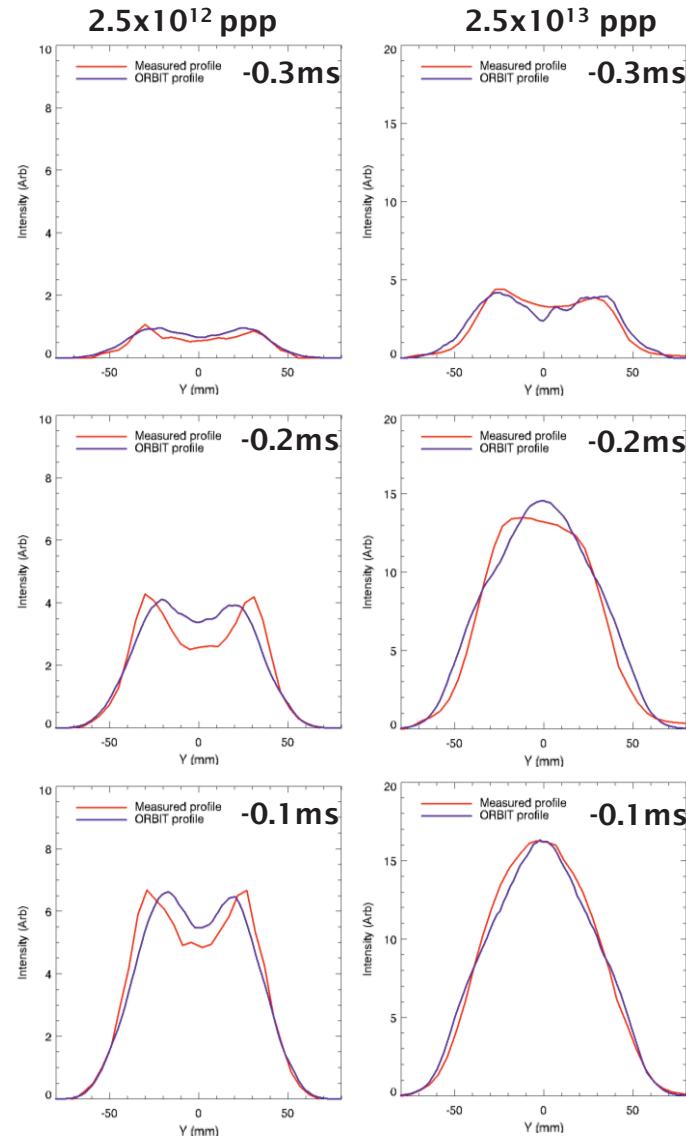
- Chopped beam, <1 turn – intra beam motion observable
- Direct measure of painting
- Added to ORBIT model

ORBIT

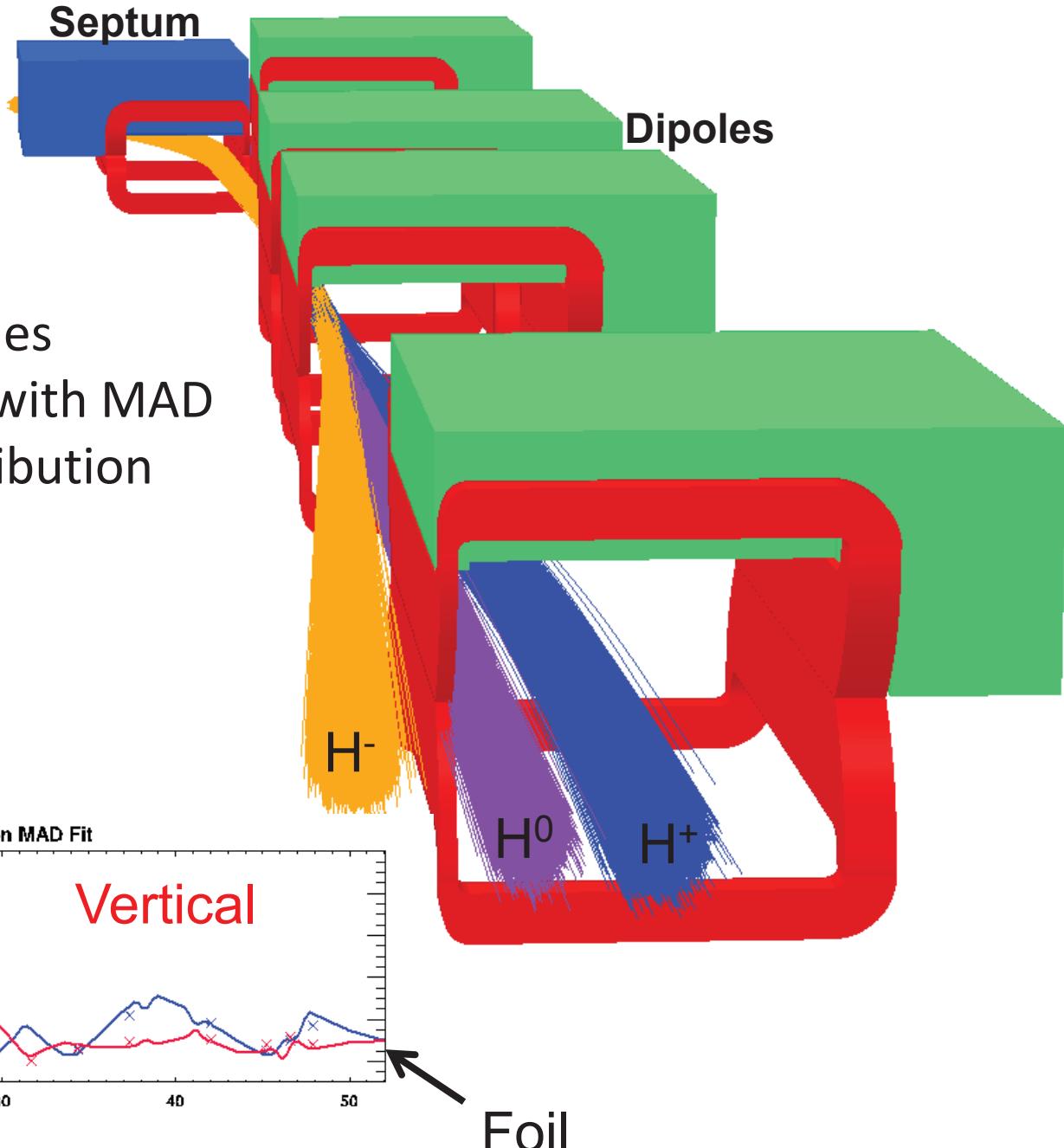
Horizontal



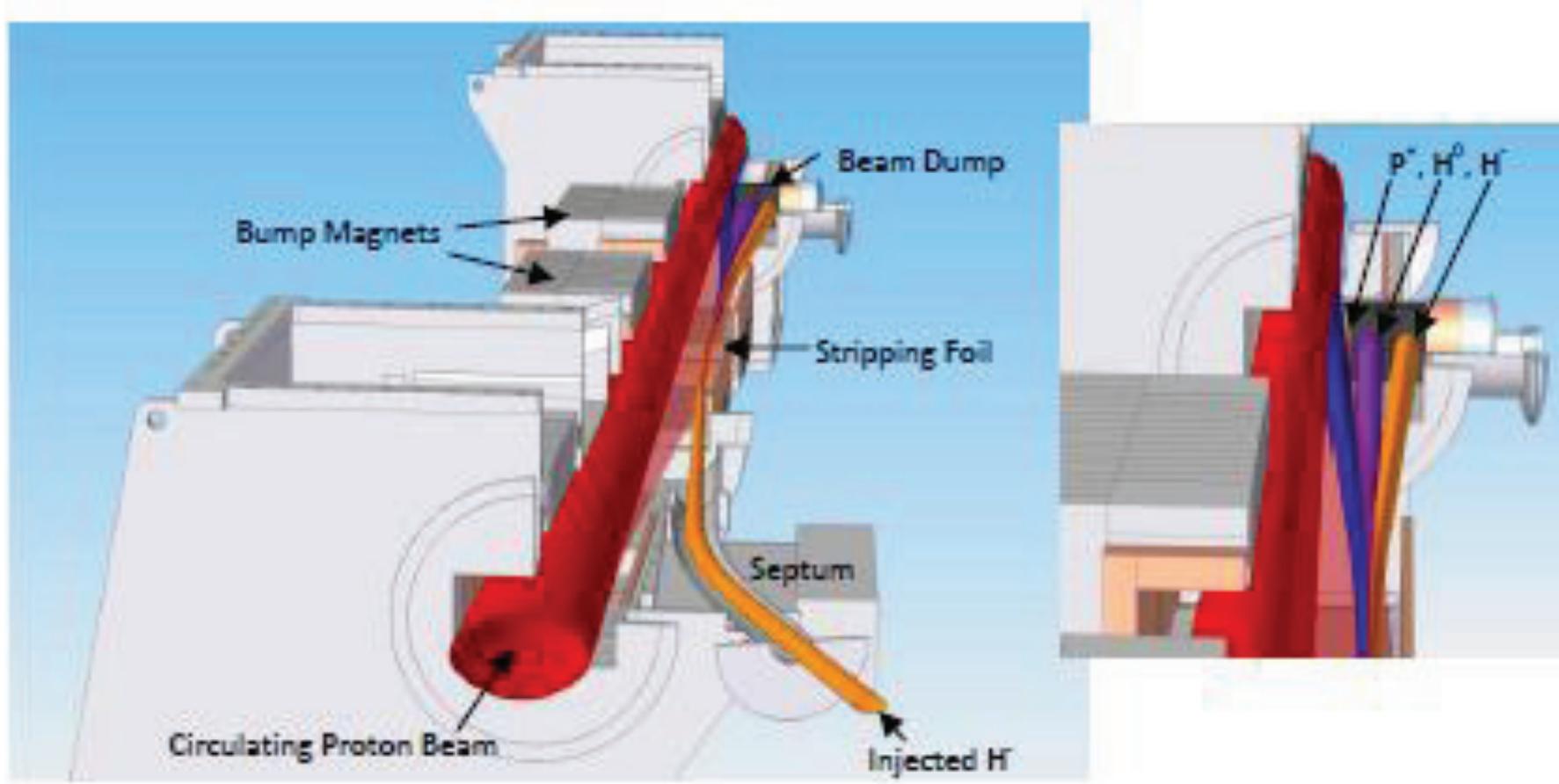
Vertical



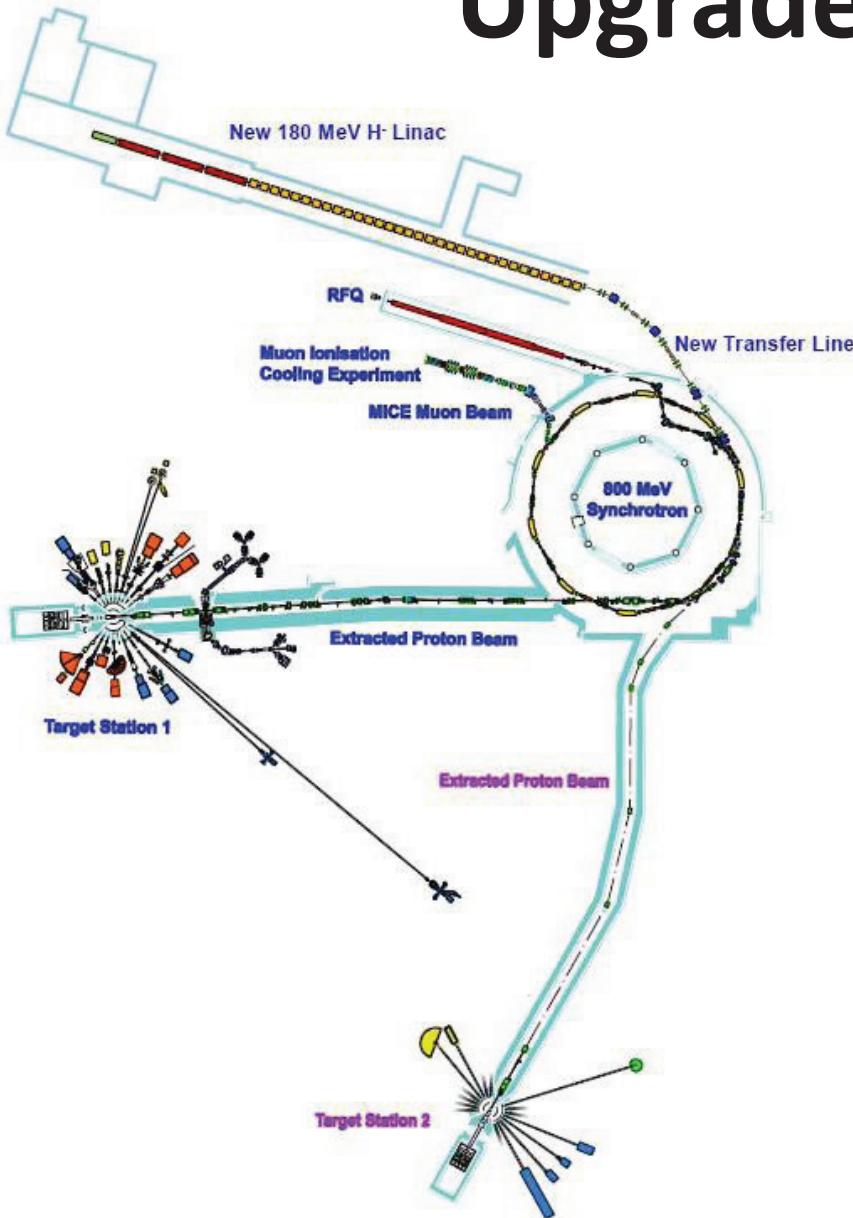
OPERA



CAD Model



Upgrade plans

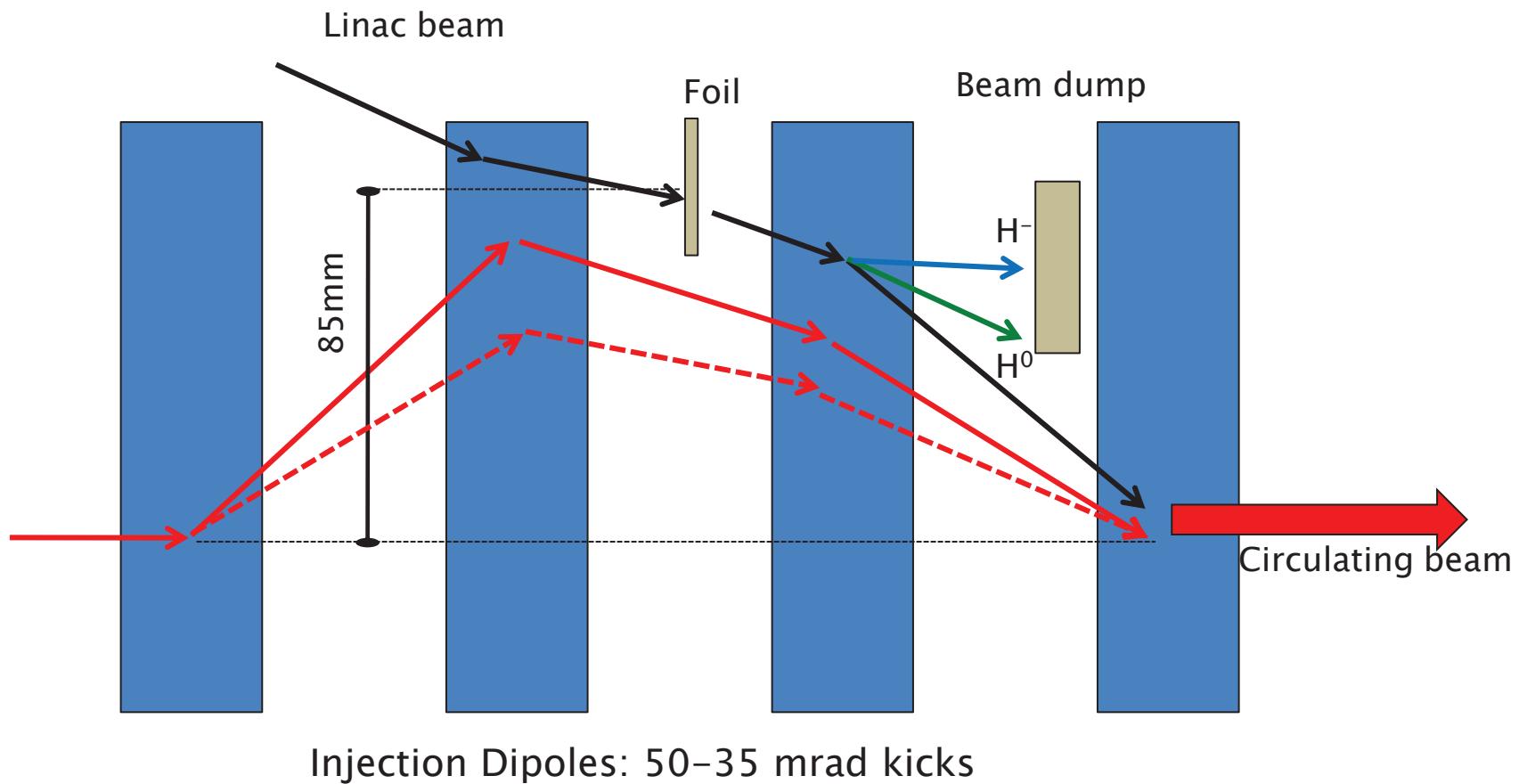


New Injector
3 MeV RFQ
75 MeV DTL
180 MeV CCL

Effect
 $\beta^2 \gamma^3 \times 2.6$
70% Chopping

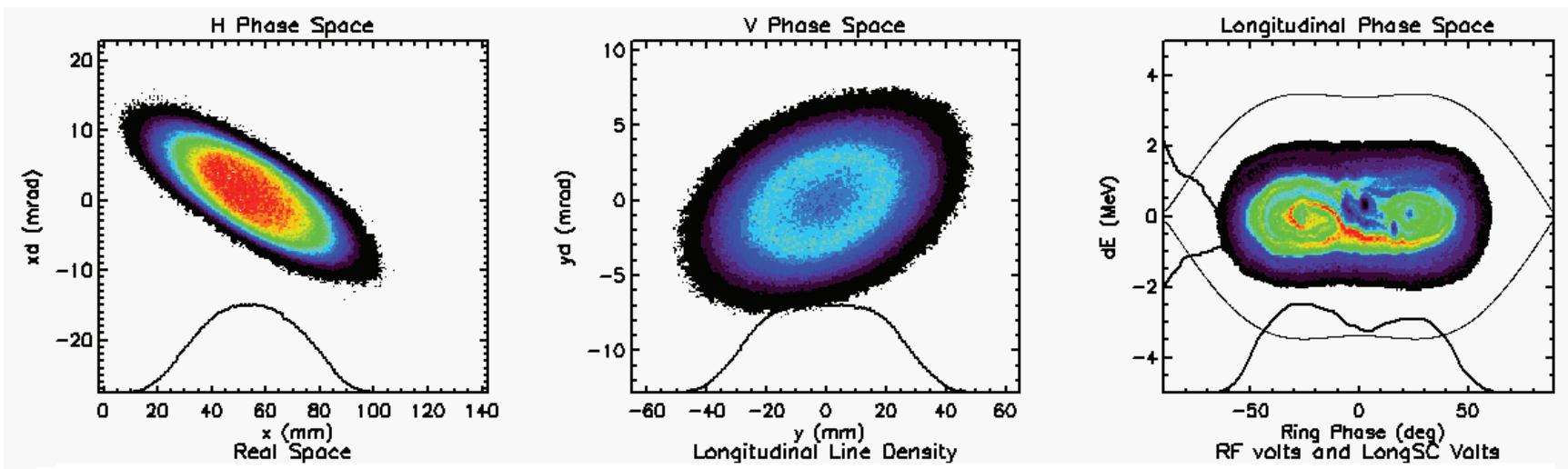
Result
 $< 8 \times 10^{13}$ ppp
 < 0.5 MW

180 MeV Painting



H Painting: $75\text{--}105 \pi \text{ mm mrad}$
V Painting: $107\text{--}80 \pi \text{ mm mrad}$

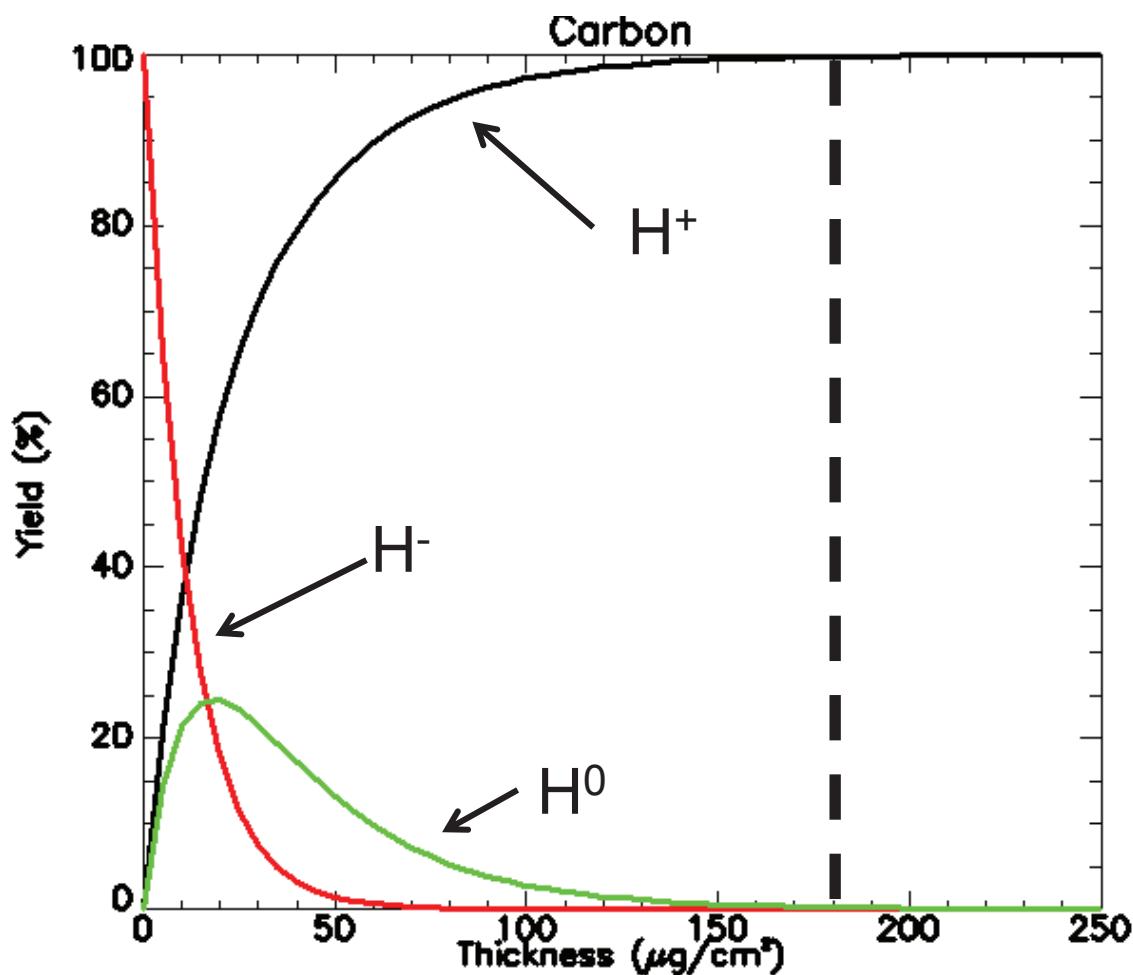
3D ORBIT



500 turns

- 2.5D space charge
- Realistic RF manipulation
- Collimators set to 85 % aperture,
- Vacuum vessels
- Foil scattering
- Injection dipoles

Stripping Efficiency:

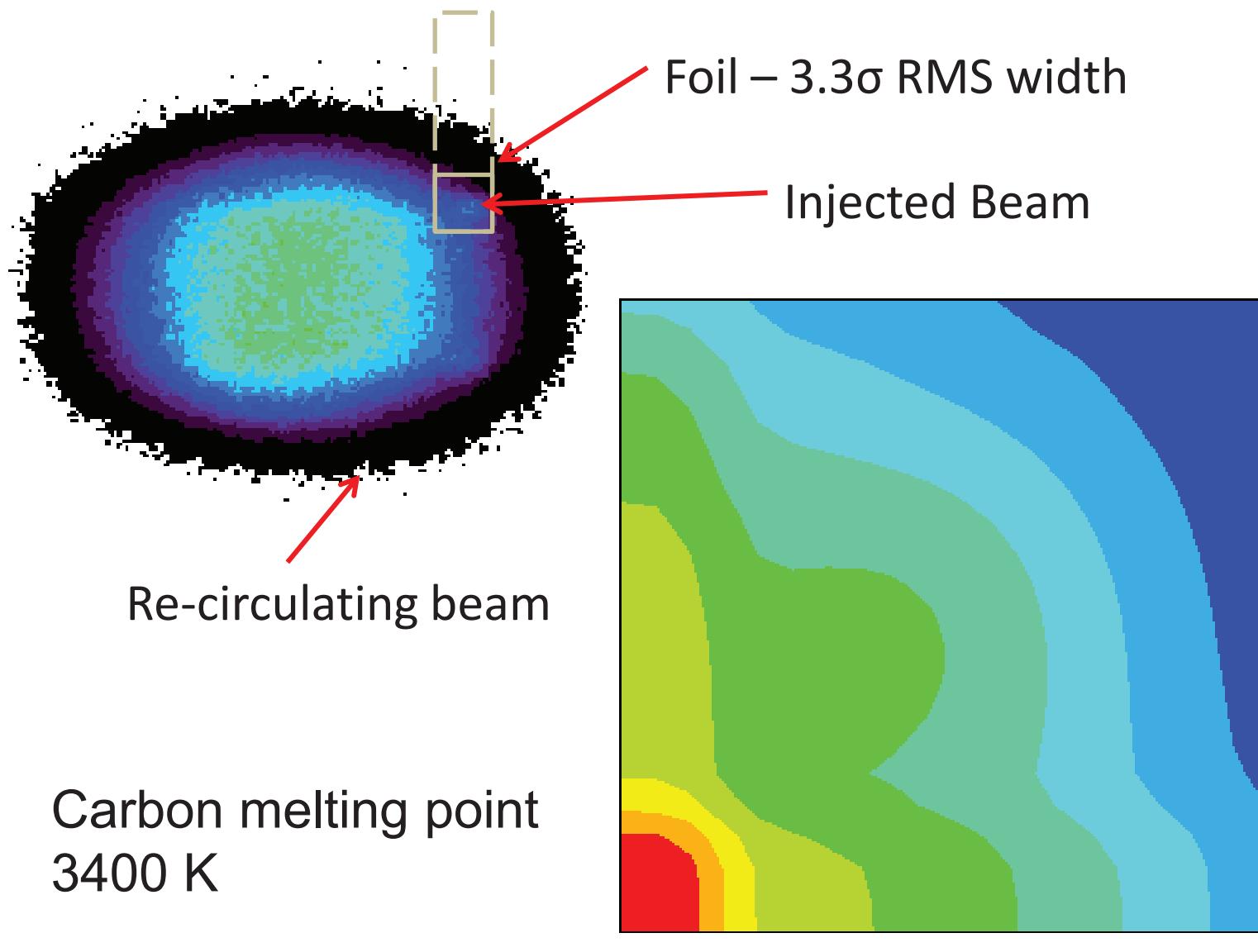


Aluminium 70 MeV
50 $\mu\text{g cm}^{-2}$
Operations: 97-98 %

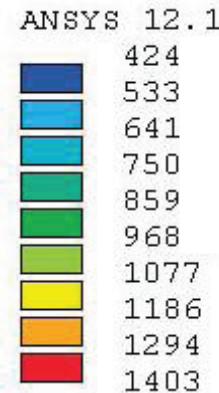
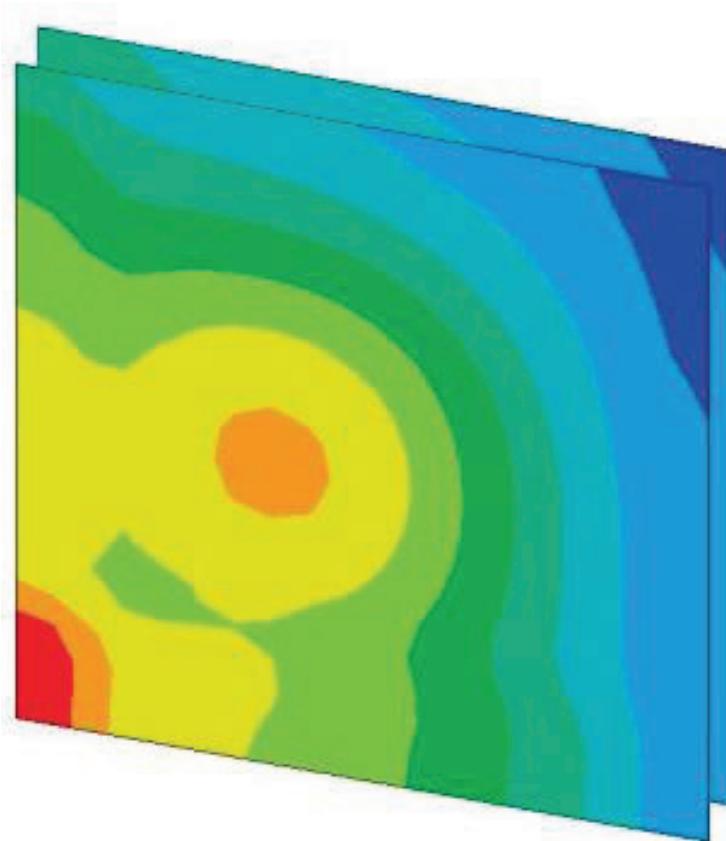
Activation x5
Stripping > 99.7%

Carbon 180 MeV
> 180 $\mu\text{g cm}^{-2}$

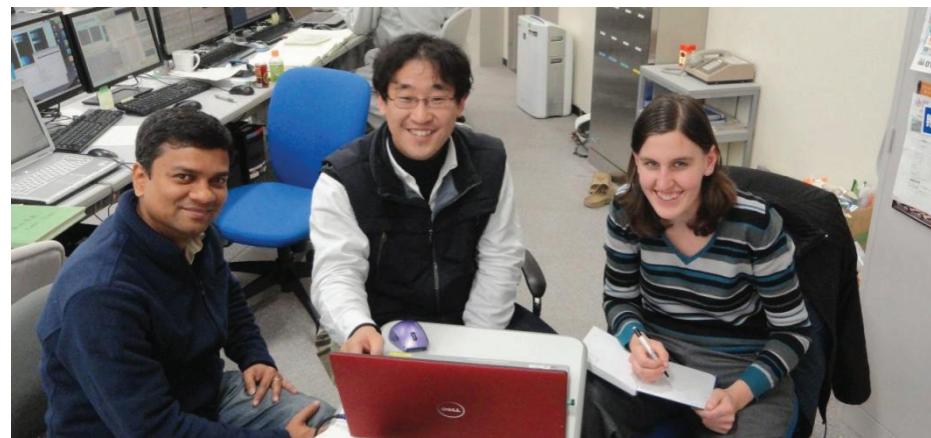
Foil Heating



Double Layer Foils – J-Parc collaboration

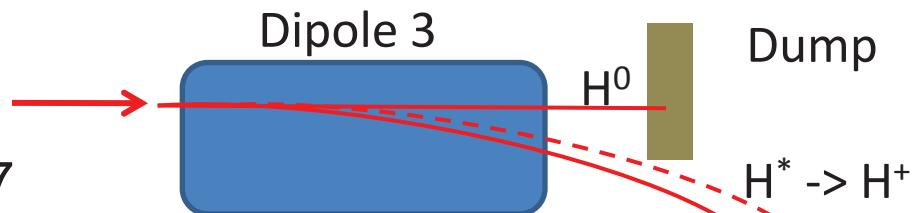
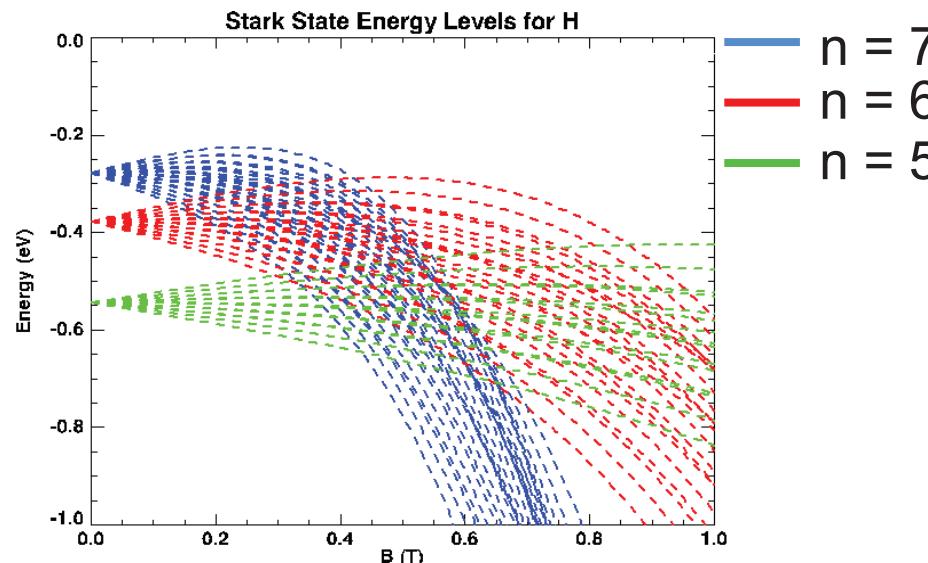


Peak T reduced
~250 K



Other effects

Stark effect



	70 MeV	180 MeV
Dipole 3 field (T)	0.11	0.18
Survival of n = 2-9	96.9%	70.8%
No. stripped parts	5.6e9	1.5e10
Power to dump	12 W	16W

Delta ‘knock-on’ electrons

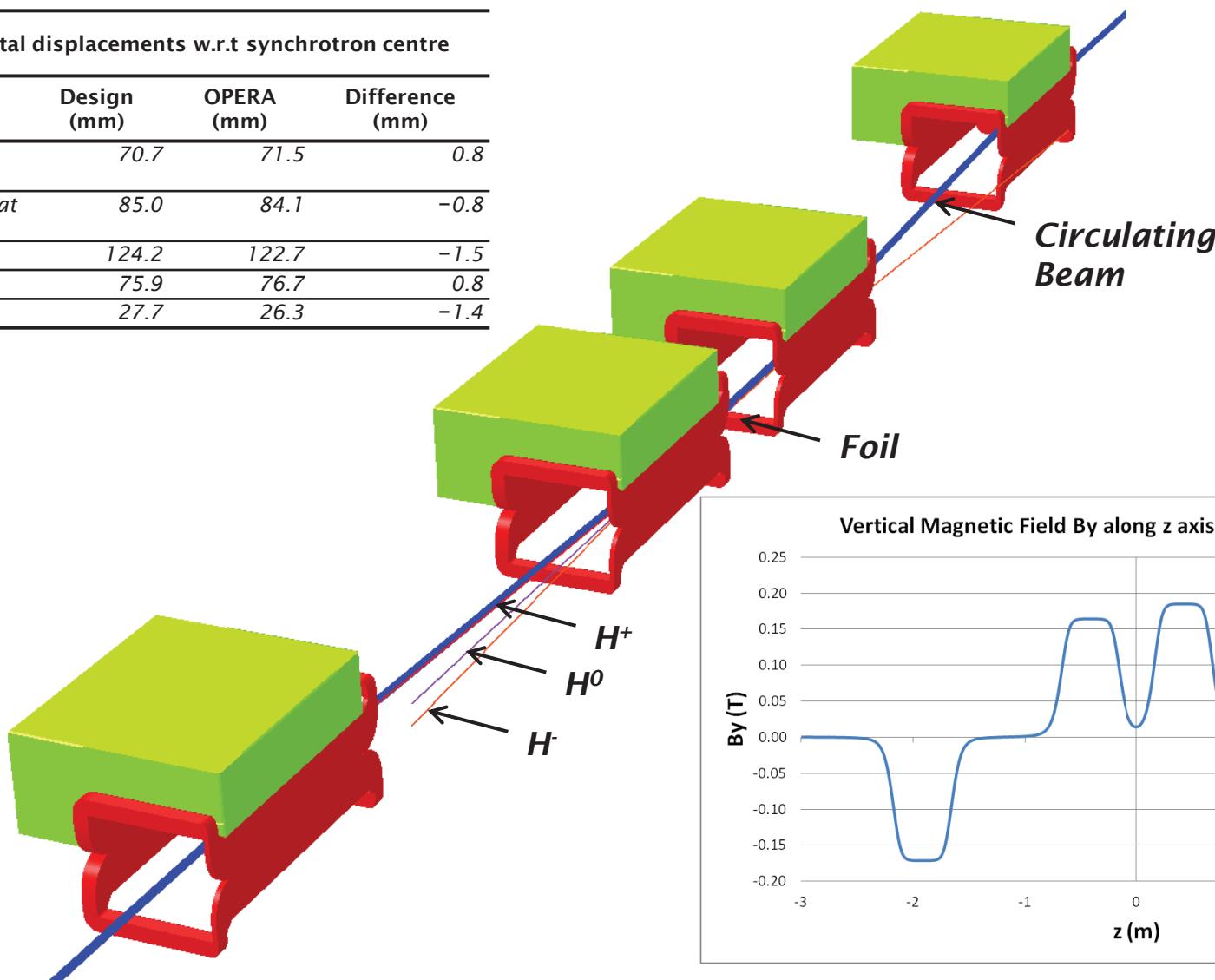
$$E_{MAX} = 2m_e \gamma^2 \beta^2 c^2$$

- 0.43 MeV max E
- 1.1×10^{-5} e⁻ per p⁺ @ 0.27 MeV average
- 10K reduction in T

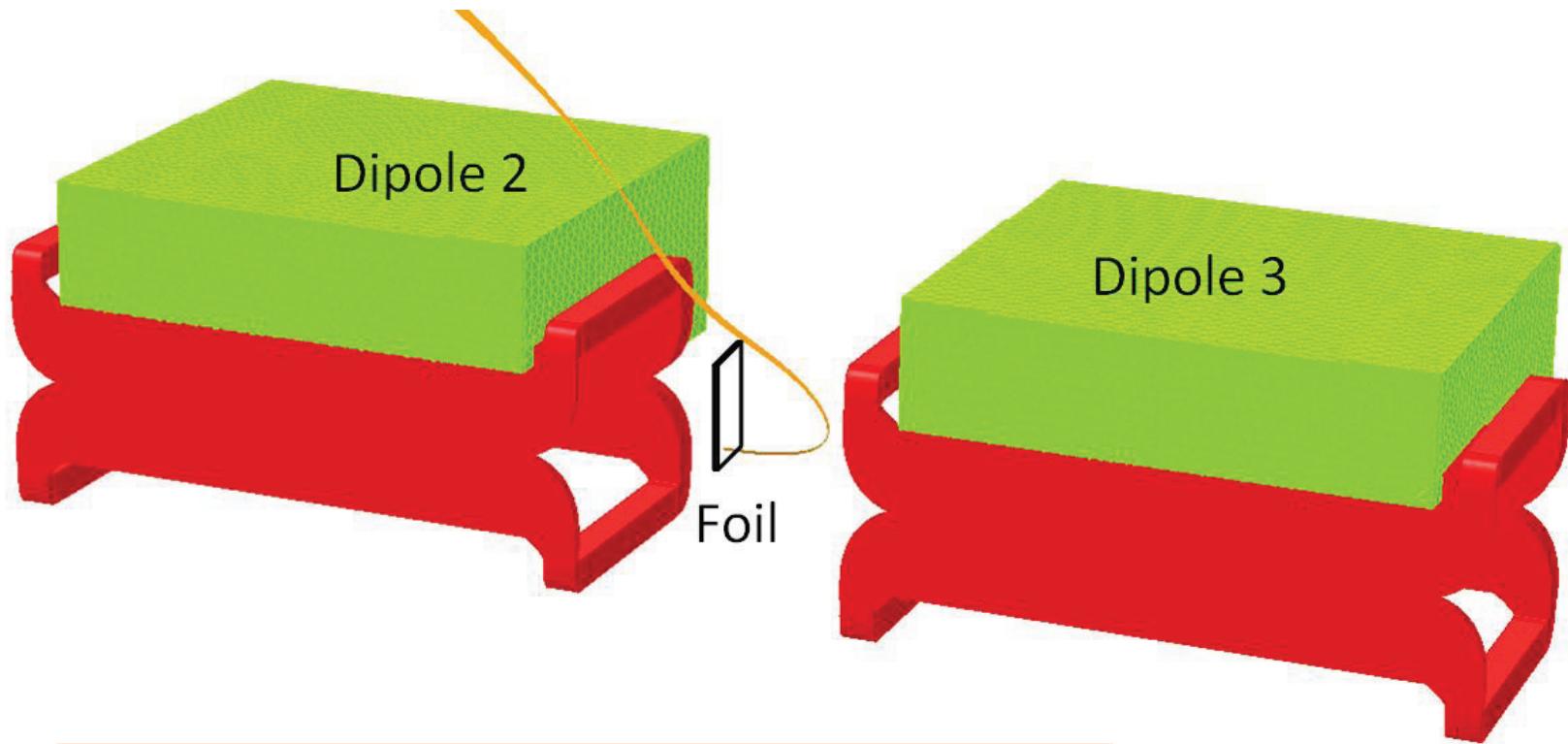
180 MeV Hardware

Horizontal displacements w.r.t synchrotron centre

	Design (mm)	OPERA (mm)	Difference (mm)
Circulating H^+ at foil	70.7	71.5	0.8
Injected H^+ at foil	85.0	84.1	-0.8
H^- at dump	124.2	122.7	-1.5
H^0 at dump	75.9	76.7	0.8
H^+ at dump	27.7	26.3	-1.4



Electrons



- Assume $v_e = v_{H^-} \therefore E_e = 100\text{keV}$
- For $8 \times 10^{13} \text{ ppp} = 125 \text{ W}$
- Do not intersect foil

Summary and Next Steps

- Injection and foil studies have enabled new 180 MeV design
- Project is challenging but achievable
- Bid for funding in UK CSR2013/14

Still to do -

- Tracking of uncontrolled lost particles
- Detailed activation study
- Design of electron catcher and $H^{0/-}$ dump
- Design of dipole coils and septum
- Electrical power supply design



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Thank You



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