# Neutrino Factory: Interim Design Report (IDR) Front-End

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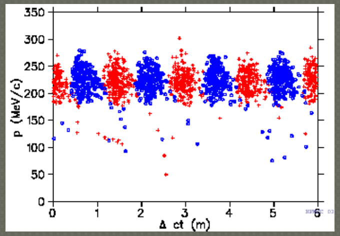
For the EUROnu WP3 and IDS-NF collaborations.

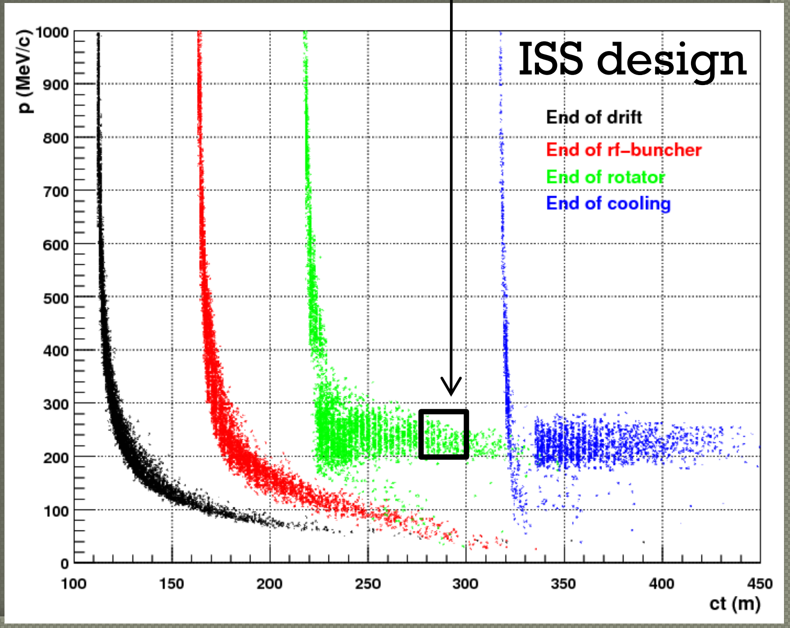
# Plan

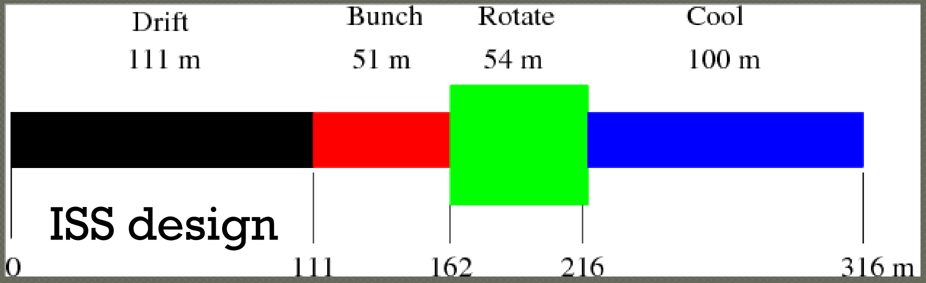
- Front-end baseline description
- Revised front-end (a.k.a. IDR)
- Alternative lattices
  - bucked coil lattice
  - insulated lattice
  - high-pressure RF lattice
- Other mitigations developments
- Conclusion (for the IDR)
- Next step (IDR to RDR)

# Front-end baseline description

- Capture in 20 T solenoid field with adiabatic taper.
- Drift in 1-2 T field over ~100 m.
- Adiabatically bring on RF voltage to bunch beam.
- Phase rotation using variable RF frequency.
  - high-energy front tail sees –V
  - low-energy tail sees +V
  - ends up with smaller energy spread
- Ionization cooling.
  - reduces transverse beam size

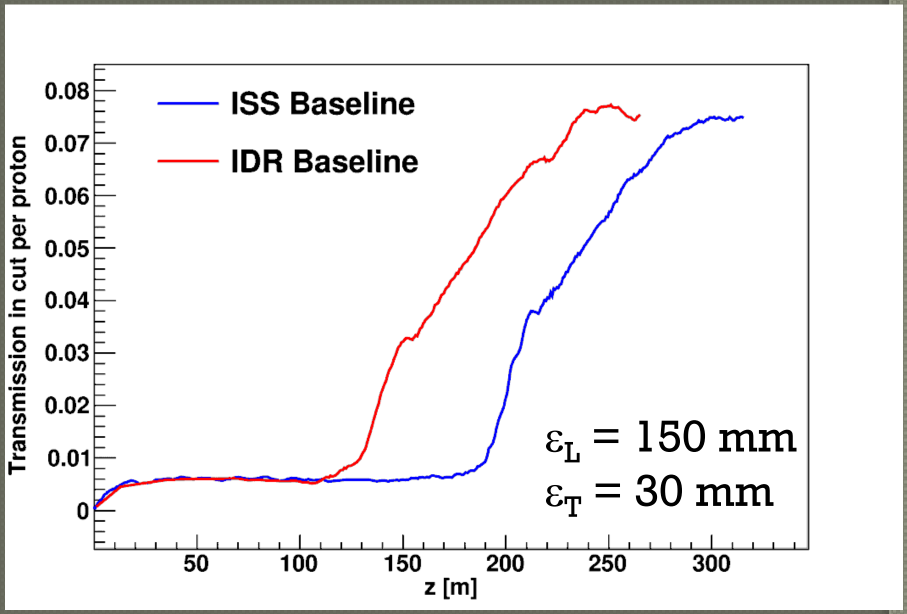


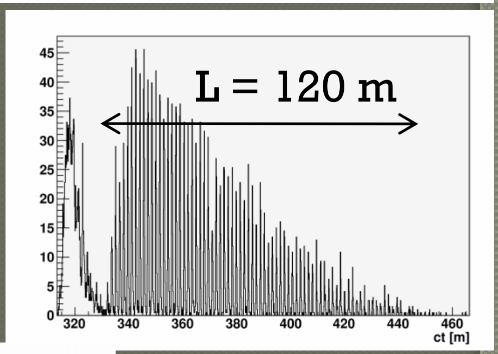
# Revised front-end (a.k.a. IDR)

- Shorter drift and modified taper:
  - drift length ~ 80 m.
  - tapering field down to 1.5 T
  (ST2 =1.25 T and ST2a = 1.75 T).



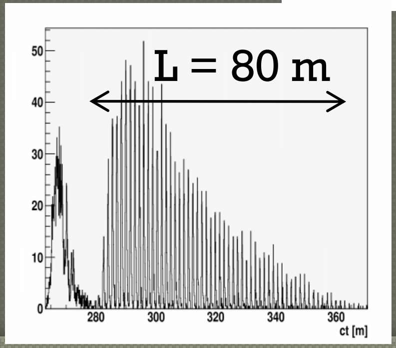

- Shorter bunch section:
  - buncher length ~ 33 m in 1.5 T solenoid field.
  - 320-232 MHz (0 to 9 MV/m).

- Shorter rotator section:
  - rotator length ~ 42 m in 1.5 T solenoid field.
  - 232-202 MHz (12 MV/m).




- Revised cooling section:
  - cooling channel length ~75 m.
  - 201 MHz (15 MV/m).

Shorter bunch train ~ 80 m instead of 120 m.

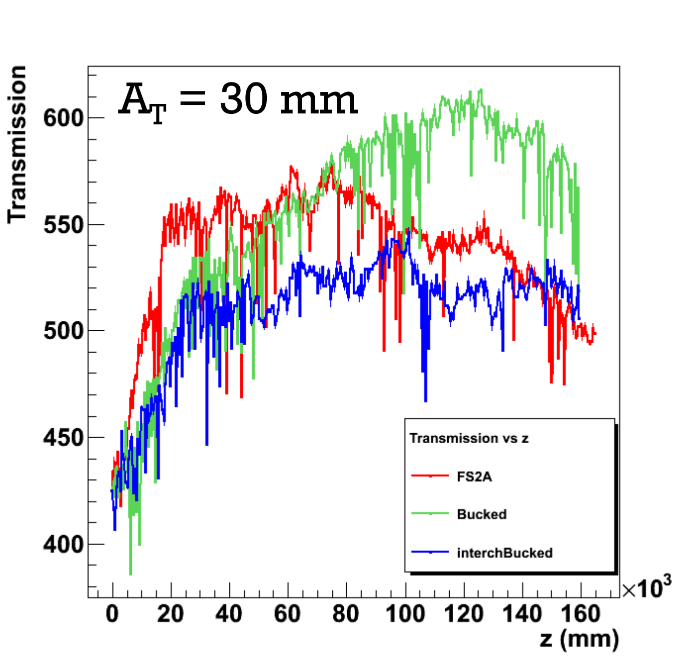


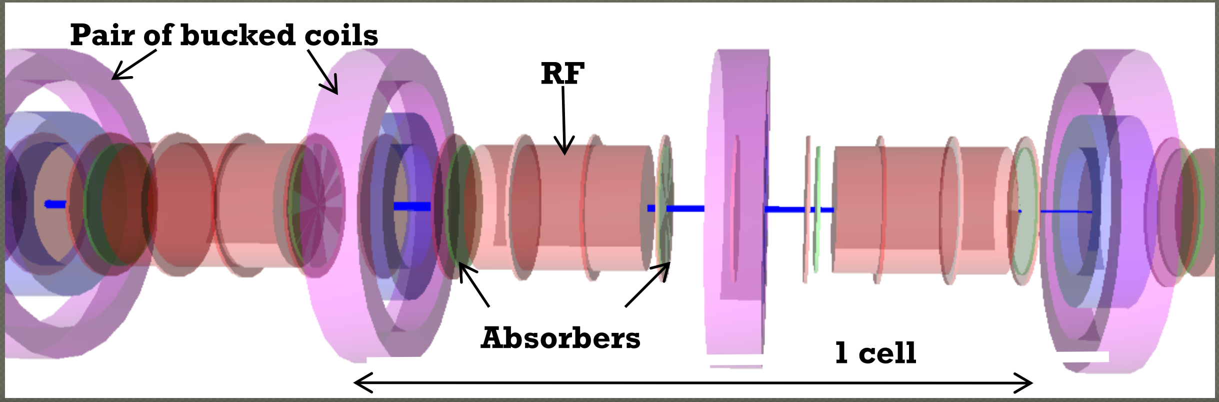

$\Rightarrow$ RF in high-magnetic field.

# Alternative lattices (1/3)

- Bucked coil lattice (A. Alekou):
  - reduced magnetic field in the RF
  - 2.10 m long cell
  - 2 cooling cells simulation in G4MICE
  - 1000 initial muons
  - two configurations:
    - 128 A/mm$^2$ (IC) - 112.8 A/mm$^2$ (OC)
    - current densities exchanged

$\Rightarrow$ need simulation with a realistic beam.

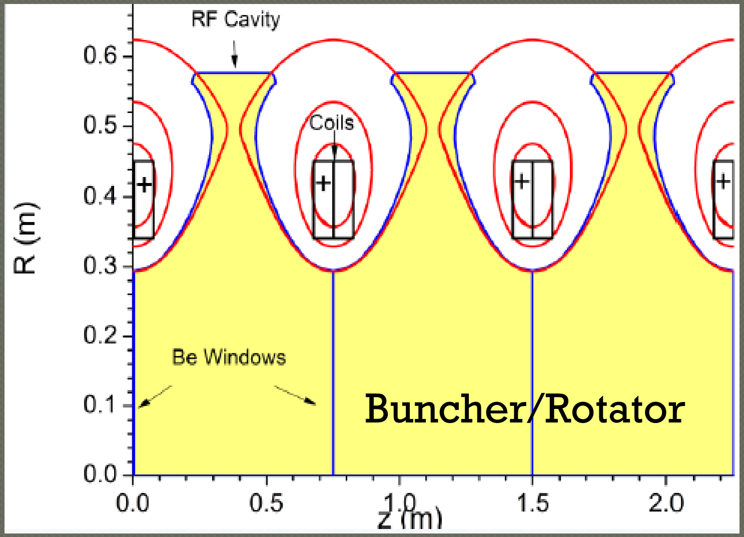


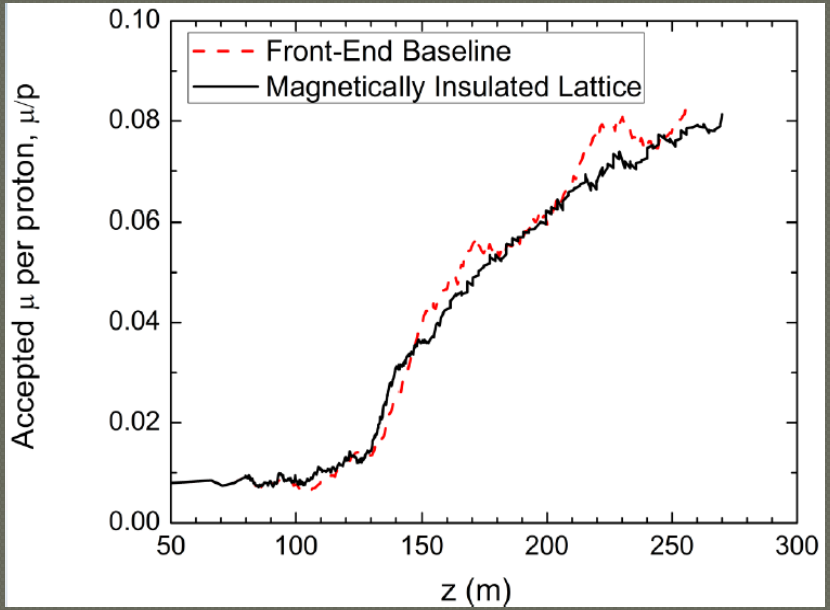



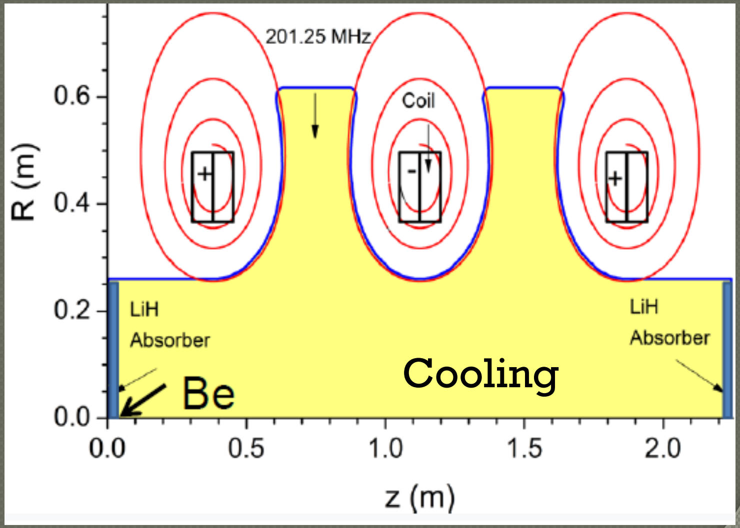
# Alternative lattice (2/3)

- Magnetically insulated lattice (D. Stratakis):
  - E ⊥ B field in cavity
  - similar performance to ISS lattice
  - tested E to B angle at the MTA.

  ⇒ need to solve some engineering issues



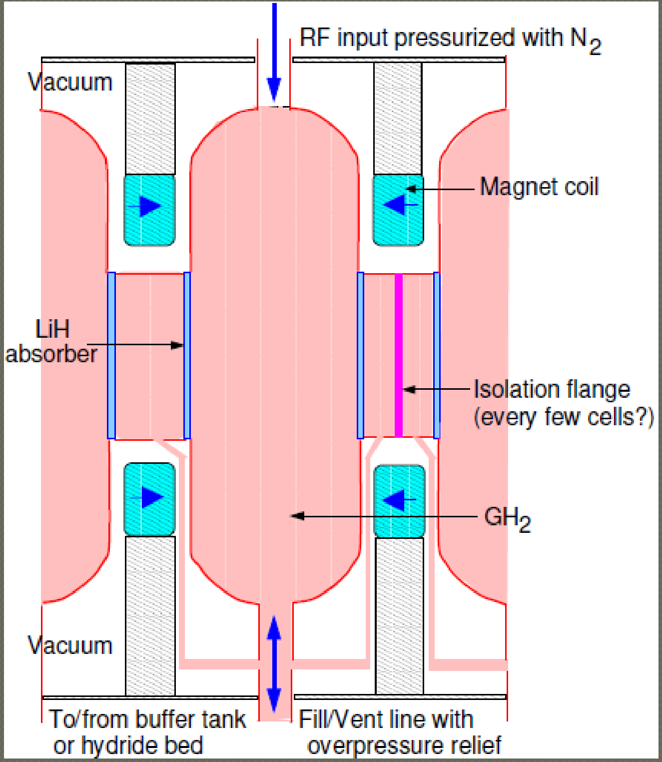



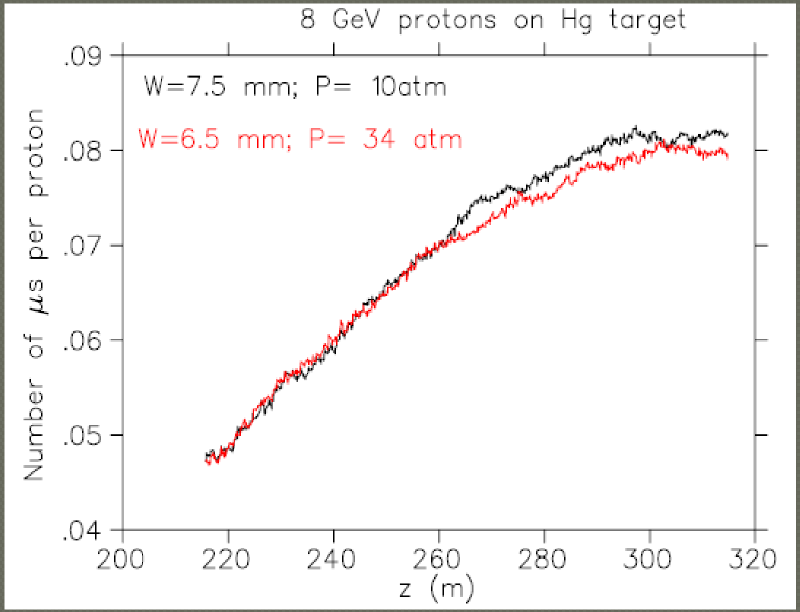

D. Stratakis et al., PRSTAB 14, 011001 (2011)

# Alternative lattice (3/3)

- HPRF lattice (M. Zisman/J. Gallardo):
  - cavity filled with high-pressure $H_2$ gas
  - use LiH absorbers for cooling
  - study of windows material
  - study of pressure and windows thickness

$\Rightarrow$ need to send a beam as PoP

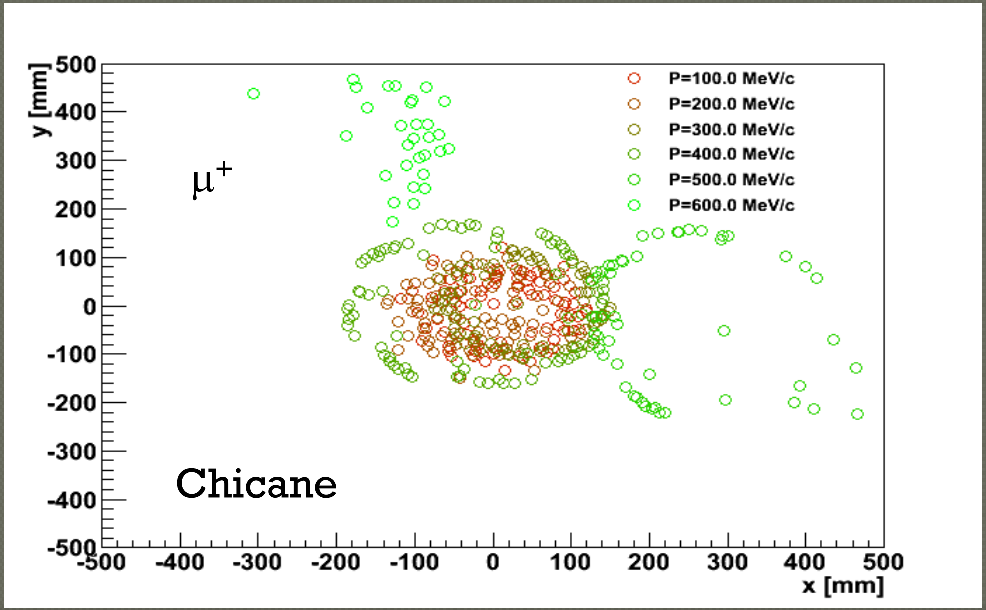


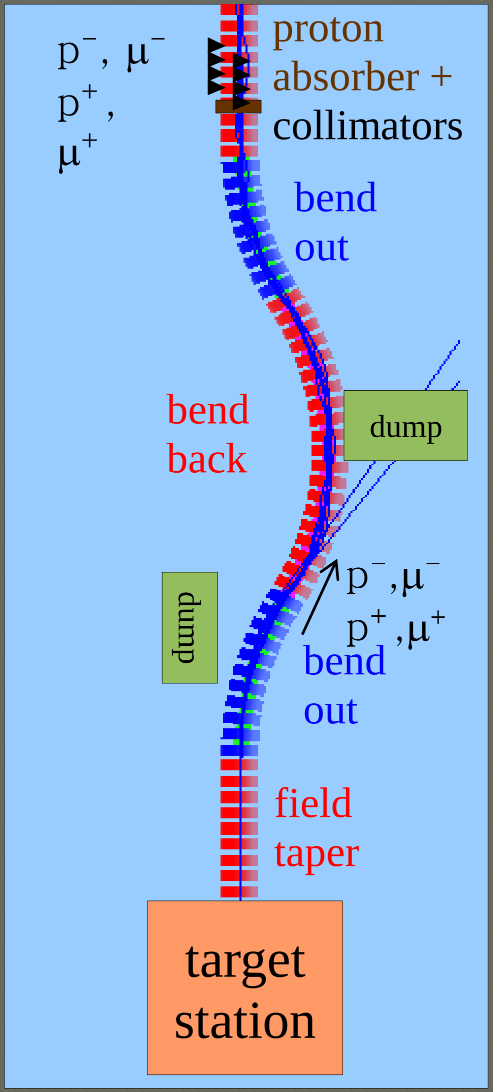



# Other developments (mitigations)

- Activation/Heat load/Radiation damage issues:
  - beam power very high (several tens of kW)
  - heat deposition important (2-3 order of magnitude higher than limit < 1 W/proton).

- Mitigation strategies:
  - proton absorber for low-momentum protons
  - chicane for high-momentum particles
  - transverse collimation



# Conclusion (for the IDR)

- Revised lattice in good shape and performance reviewed.
- Code validated & compared.
- Three alternative discussed as mitigation to the high-magnetic field in RF issues.

Thanks to A. Alekou, J. Gallardo, D. Neuffer, C. Rogers, P. Snopok, D. Stratakis, M. Zisman (and for letting me steal material from their slides).

# Next step (IDR to RDR)

- Hope for new measurements of RF in magnetic field to assess better the gradient limitations.

- Need to continue the work on proton absorber + chicane + collimator to mitigate heat deposition and activation problems.

- Need to address engineering design and costing:
  - magnet
  - absorbers
  - RF cavity
  - chicane+proton absorber+collimator