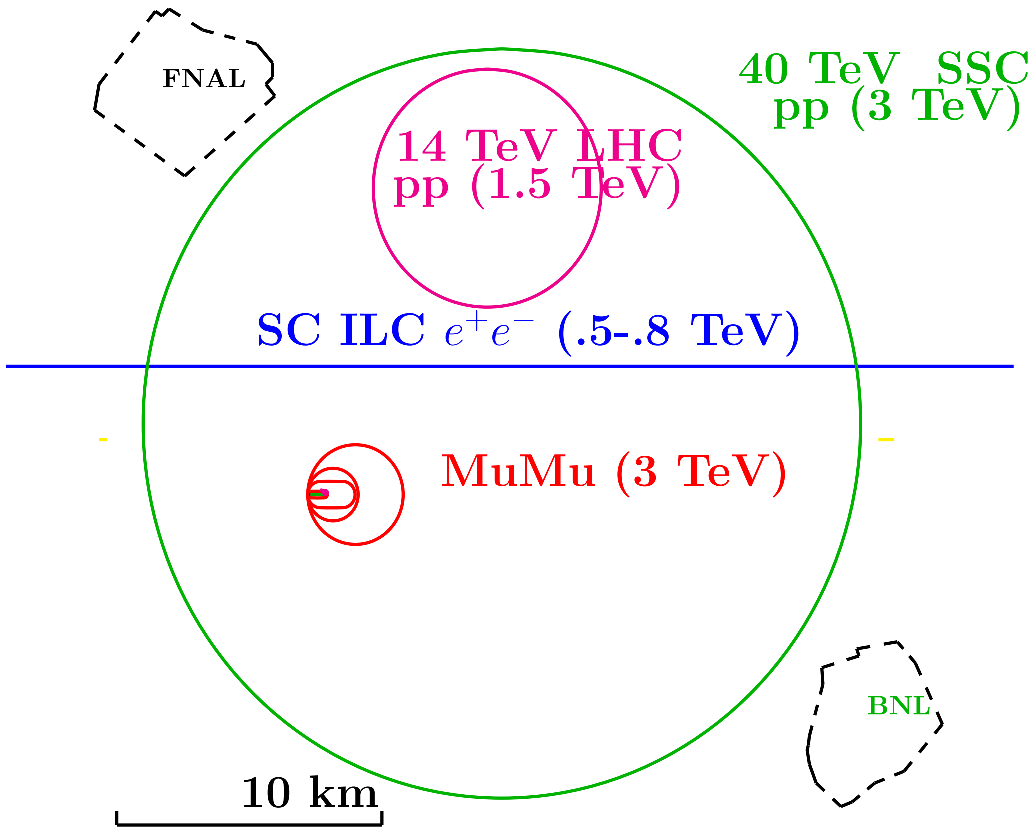
Advanced Accelerator Group

R B Palmer 10/2/07

Muon Colliders

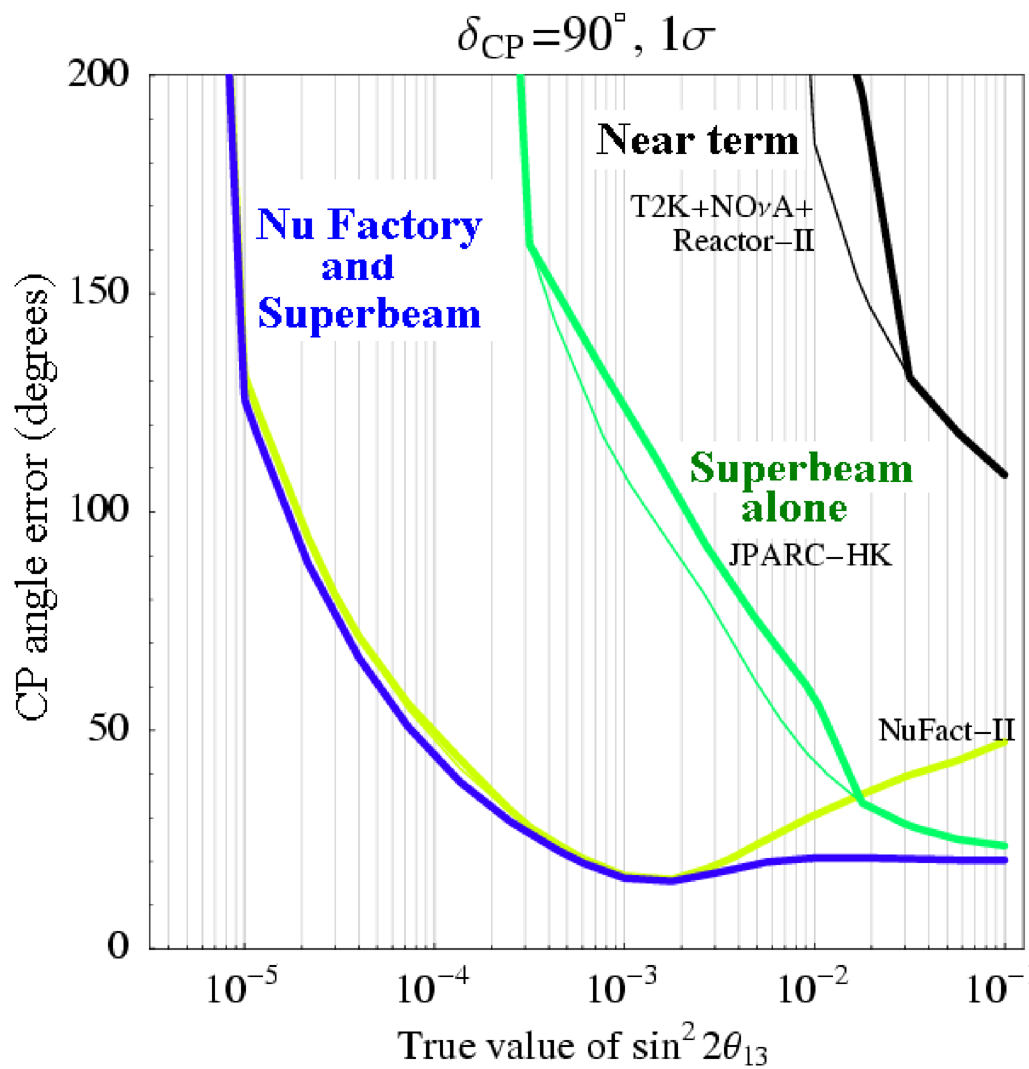
- Muons are point like
- Same physics as e^+e^-, plus some
- But 40,000 less radiation
- So Muon Colliders circular and much smaller than linear



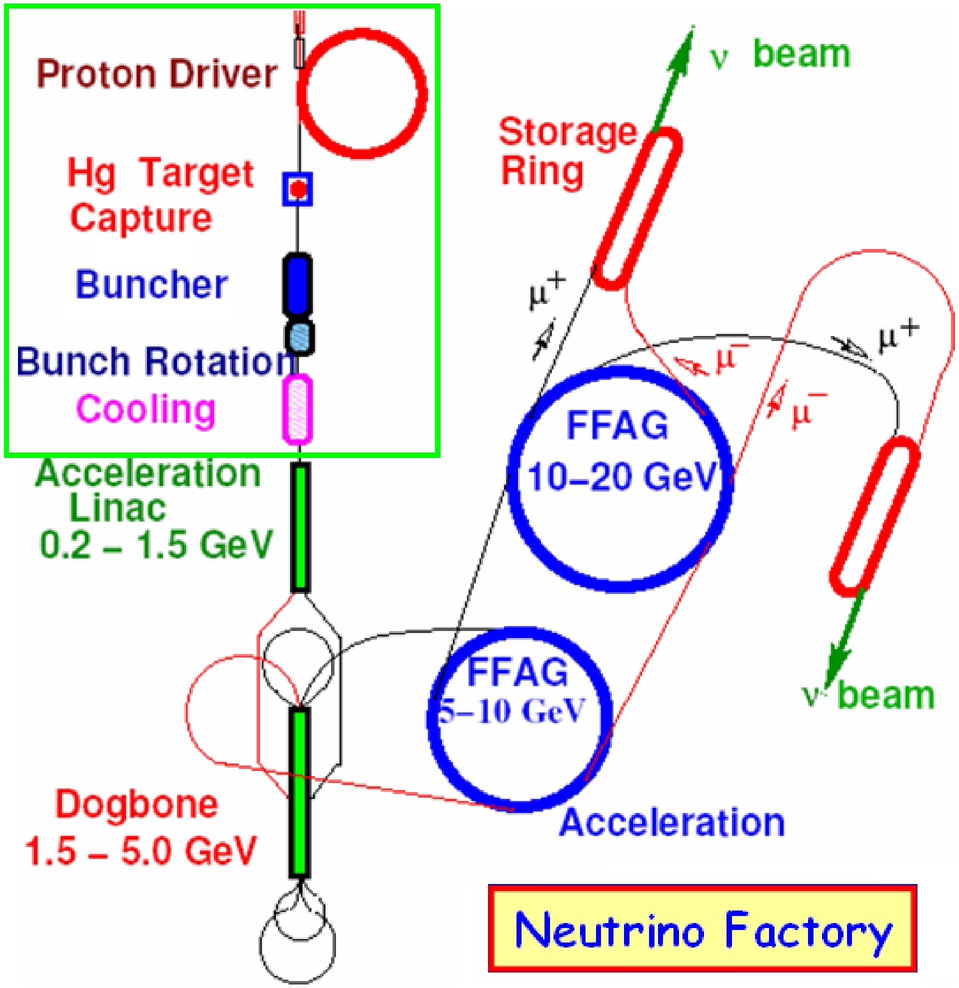
Neutrino Factories

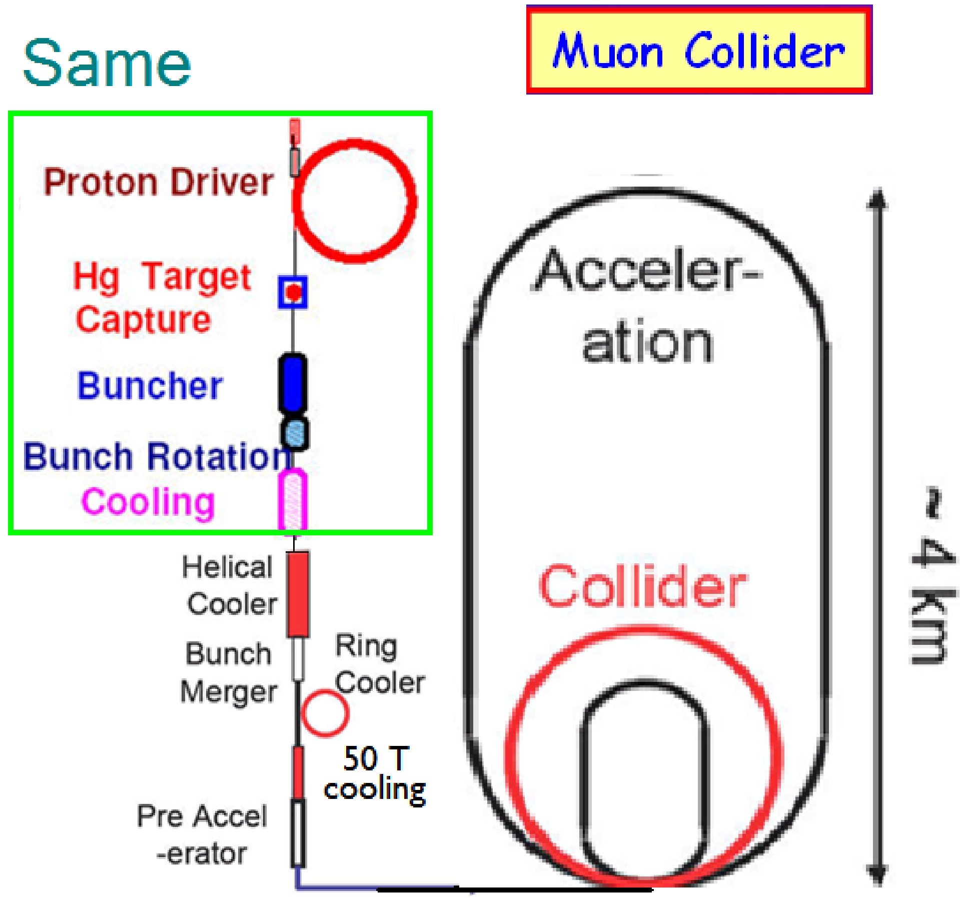
- Lower Backgrounds than Conventional Beams
- Only way to study CP Violation if θ_{13} small

Errors in CP angle δ



Neutrino Factory & Muon collider share technologies





Collider Parameters

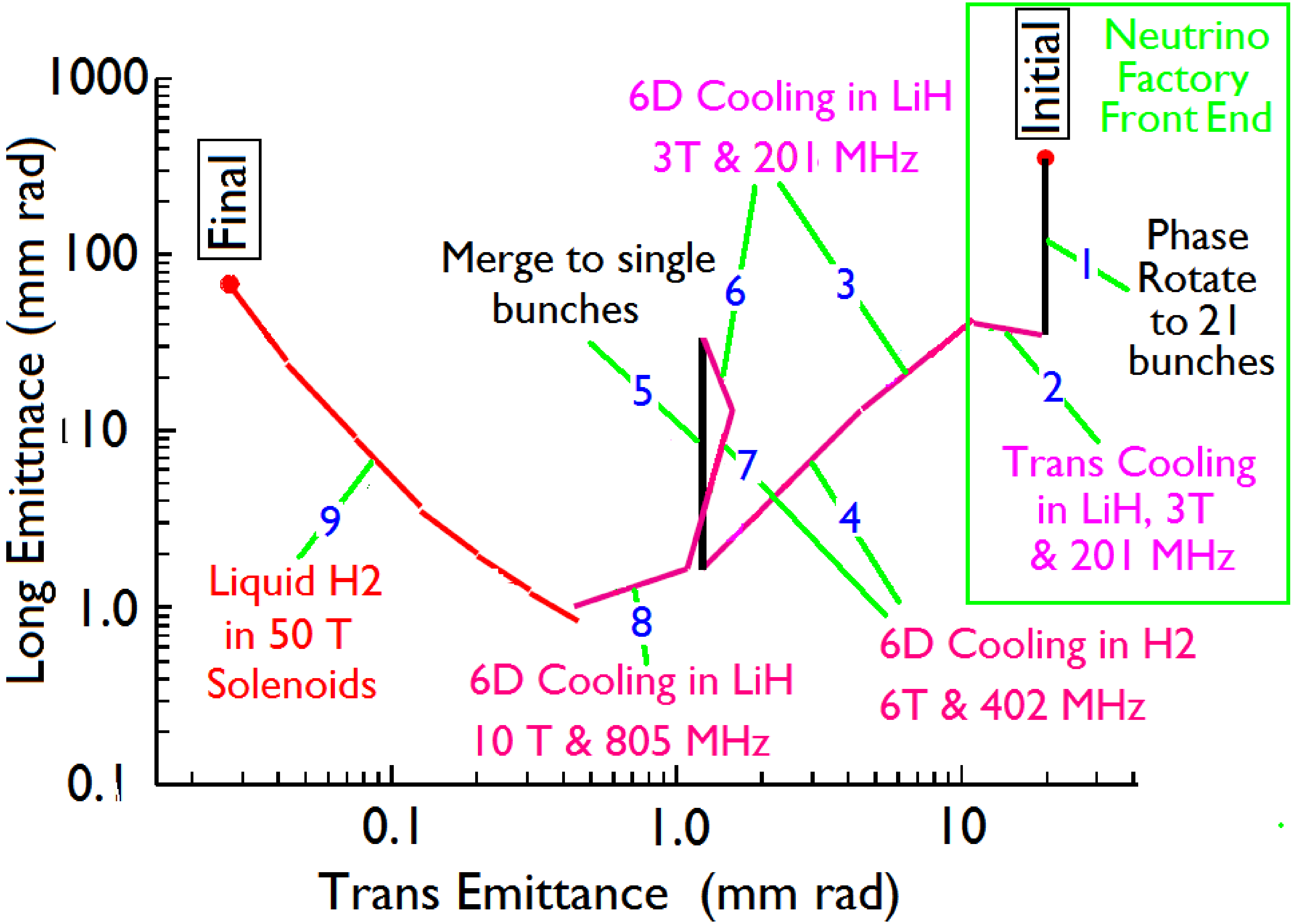
	This Paper	Snowmass	Extrapolation	
C of m Energy	1.5	4	8	TeV
Luminosity	1	4	8	10^{34} cm^{2}sec^{-1}
Beam-beam Tune Shift	0.1	0.1	0.1	
Muons/bunch	2	2	2	10^{12}
Ring <bending field>	5.2	5.18	10.36	T
Ring circumference	3	8.1	8.1	km
Beta at IP $= \sigma_z$	10	3	3	mm
rms momentum spread	0.09	0.12	0.06	%
Muon Beam Power	7.5	9	9	MW
Required depth for ν rad $(^1)$	13	135	540	m
Muon survival $(^2)$	0.07	0.07	0.07	
Repetition Rate	12	6	3	Hz
Proton Driver power	≈4	≈ 1.8	≈ 0.8	MW
Trans Emittance	25	25	25	pi mm mrad
Long Emittance	72,000	72,000	72,000	pi mm mrad

- Emittance and bunch intensity requirement same for all examples

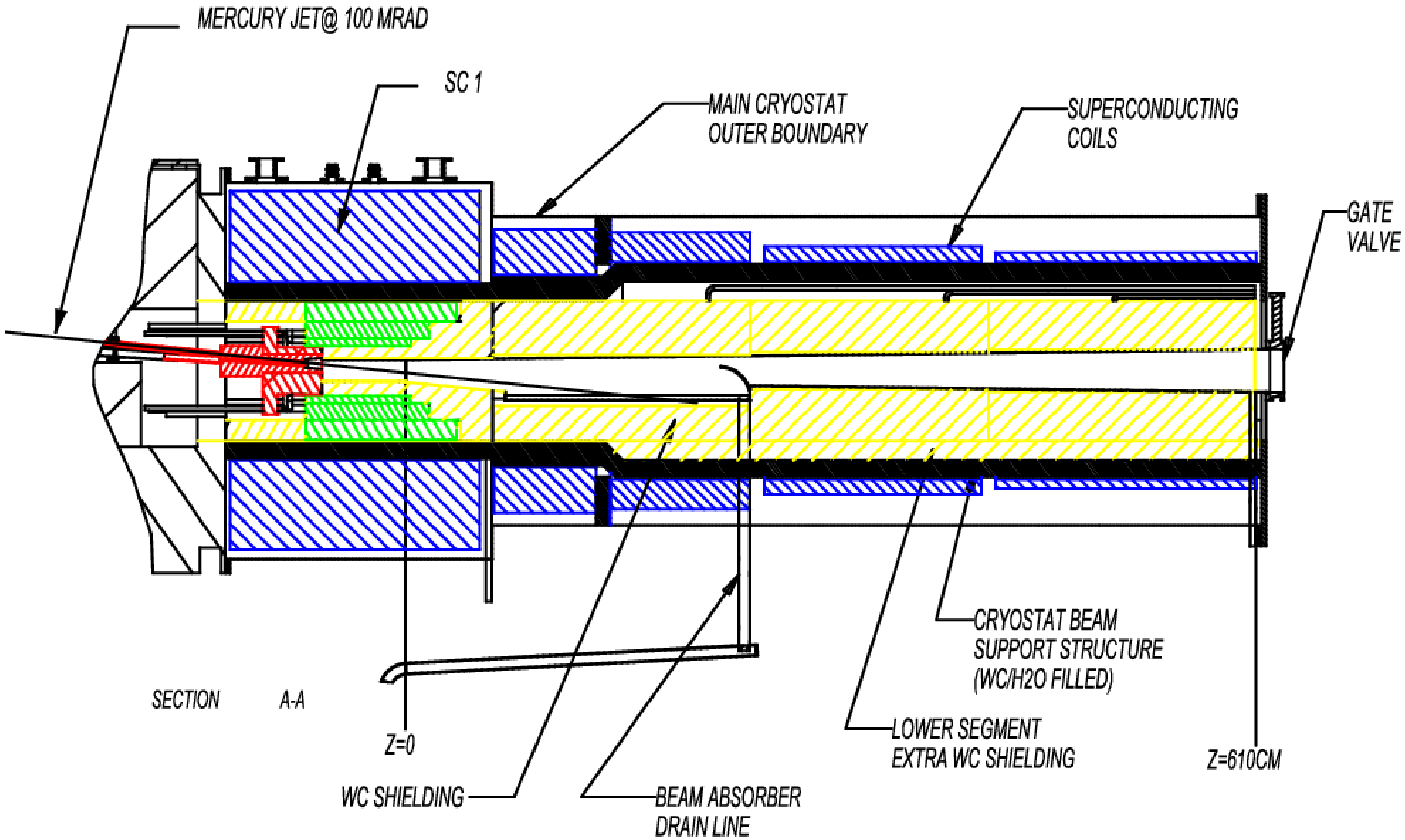
$(^1)$ With respect to any low lying nearby land. e.g. Fox river at FNAL

$(^2)$ From capture to collider: through cooling, manipulations , and acceleration

Capture and Cooling Scheme



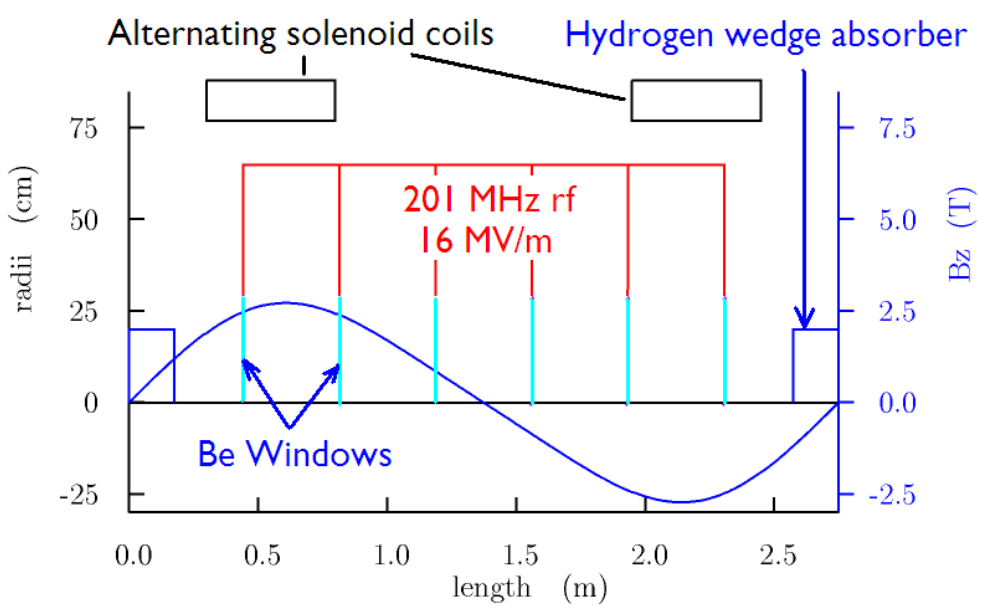
Target and Capture and Phase Rotate



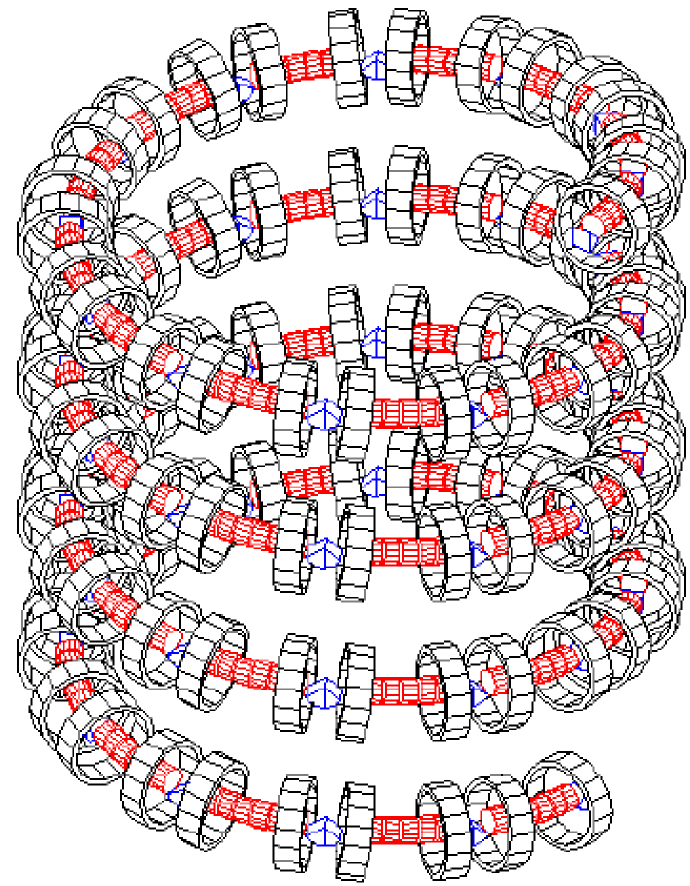
- Liquid mercury Jet 'destroyed' on every pulse
- 20 T Solenoid captures all low momentum pions
- Field subsequently tapers down to approx 2 T
- Target tilted to maximize extraction of pions
- MERIT Experiment at CERN will test this concept

6D Cooling in Guggenheim helices

- RFOFO lattices
- Bending gives dispersion
- Wedge absorbers give emittance exchange → Cooling also in longitudinal
- Use as 'Guggenheim' helix
  - Because bunch train fills ring
  - Avoids difficult kickers
- MICE Will demonstrate



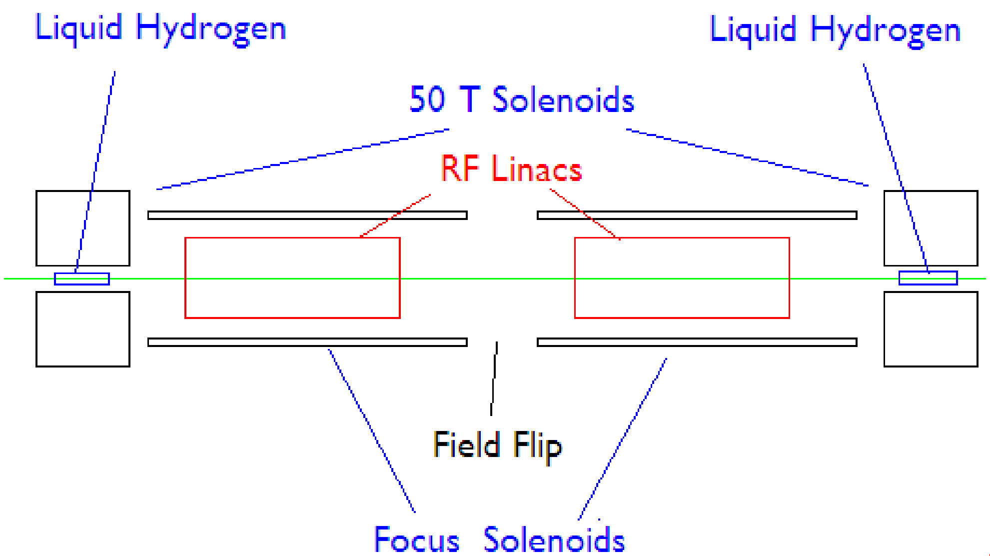
RFOFO Lattice

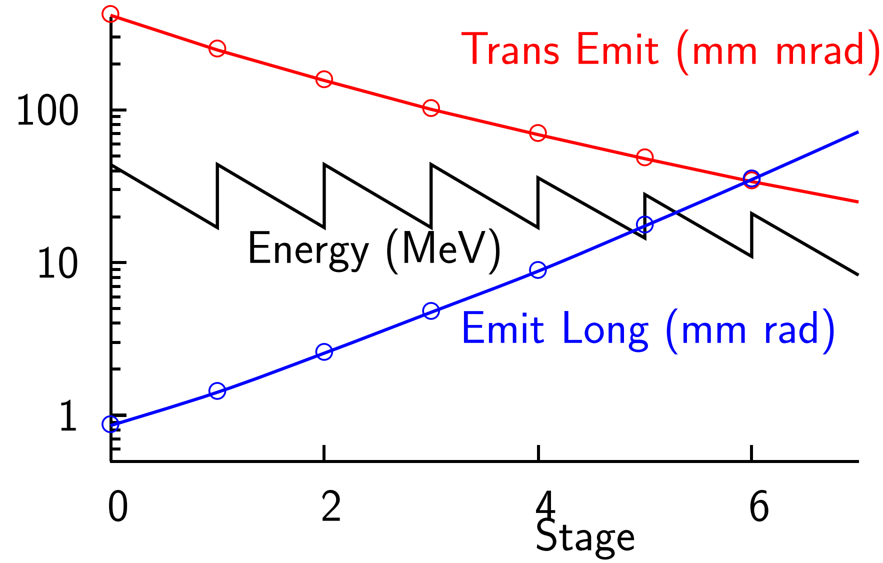


'Guggenheim'

Transverse Cooling in Very High Field Solenoids

- Lower momenta allow strong transverse cooling, but long emittance rises:
- Effectively reverse emittance exchange





- 50 T HTS Solenoids
  - Current and ss support varied with radius to keep strain constant
  - Design using existing HTS tape at 4.2 deg. gave 50 T with rad=57 cm
  - 45 T hybrid with Cu exists at NHFML, but uses 20 MW
  - 30 T all HTS under construction
- 7 solenoids with liquid hydrogen
- ICOOL Simulation (Ideal Matching and reacceleration, Transmission 97%)

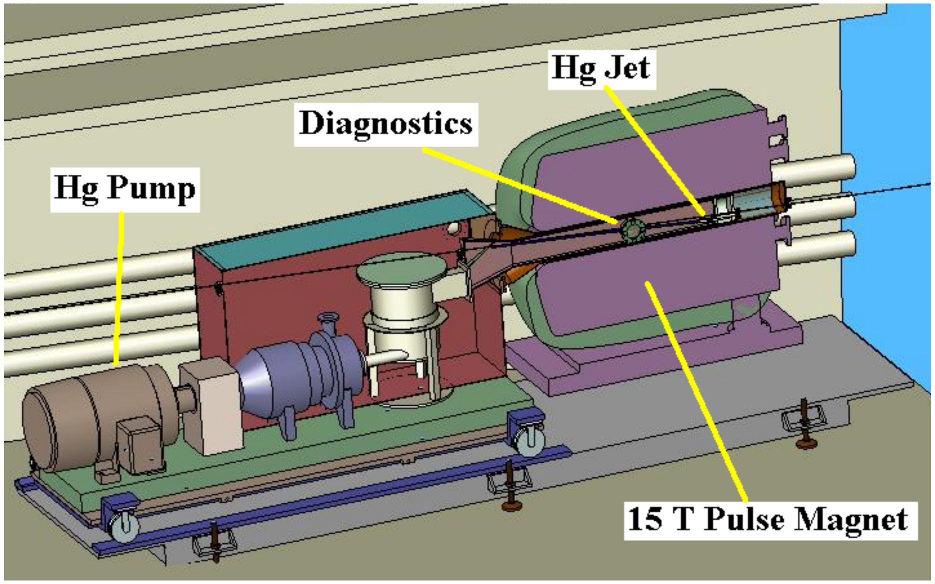
BNL Involvement

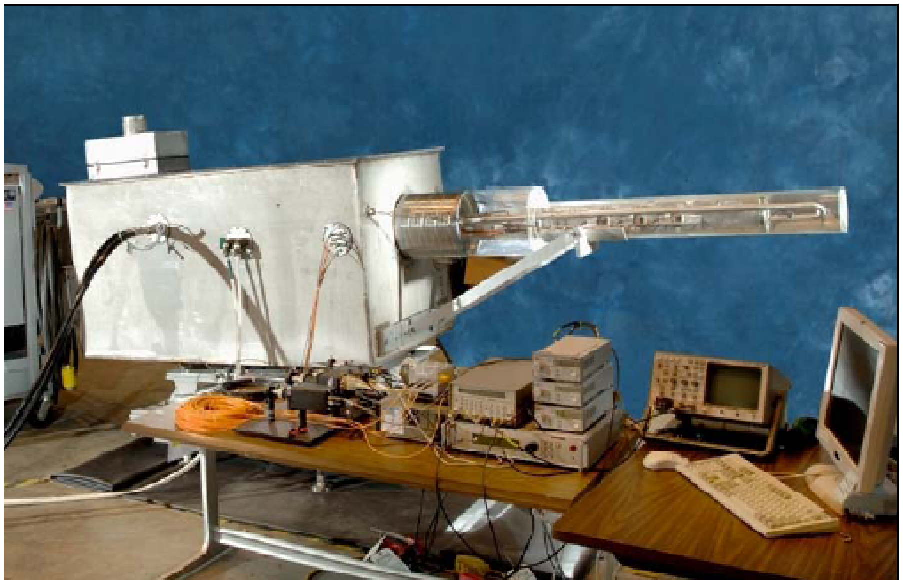
- Design and simulation: now mostly on Collider
  including lattices that should avoid rf breakdown problems
- Mercury target Experiment MERIT
  next transparency
- Solid target studies
- 50 T magnet design
  with BNL and FNAL magnet groups, and Muons Inc.
- Work on FFAG accelerator design
  and involvement in FFAG electron model (EMMA) in UK
- Some involvement with cooling demonstration (MICE) at RAL

Liquid Target Experiment MERIT

BNL,MIT,CERN,RAL,Princeton,Oak Ridge Collaboration

- Harold Kirk is one of two Spokespersons
- Will expose mercury Jet to CERN proton beam
- Probably only practical target at 4 MW
- Magnet (right) tested at MIT
- BNL Instrumentation Department built Optics
- Mercury system tested at Oak Ridge & MIT
- All components installed at CERN





Conclusion

- Progress on MERIT Target Experiment
  System complete and installed at CERN - almost ready to go
- New 1.5 TeV Collider parameters with more conservative ring
  - Luminosity 1×10^{34} achieved with bunch rep rate ≈12 Hz
  - Proton driver (≈ 4 MW) is challenging
- Complete cooling scheme achieves required muon parameters
  - All components simulated (at some level) with realistic parameters
  - Much work remains
- Probable problem with rf breakdown in specified magnetic fields
  - Solutions with gas in cavities appear to work for early stages
    but may breakdown with beam - experiemt at FNAL soon
  - Designs with open cell rf are promising for all stages