Advanced Accelerator Group R&D

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DOE HEP Program Review

17 April 2007

Outline of major group activities

1. Machine design and simulation of future μ-based facilities
   - neutrino factory (NF)
   - muon collider (MC)
2. Fixed field alternating gradient (FFAG) acceleration theory and simulations
3. MERIT experiment
   - test of liquid jet targetry at CERN
4. EMMA experiment
   - demonstration of non-scaling FFAG acceleration at Daresbury Laboratory

- most of group's work is done as part of U.S. NF& MC Collaboration
- collider work also done in collaboration with Fermilab MC Task Force and Muons Inc

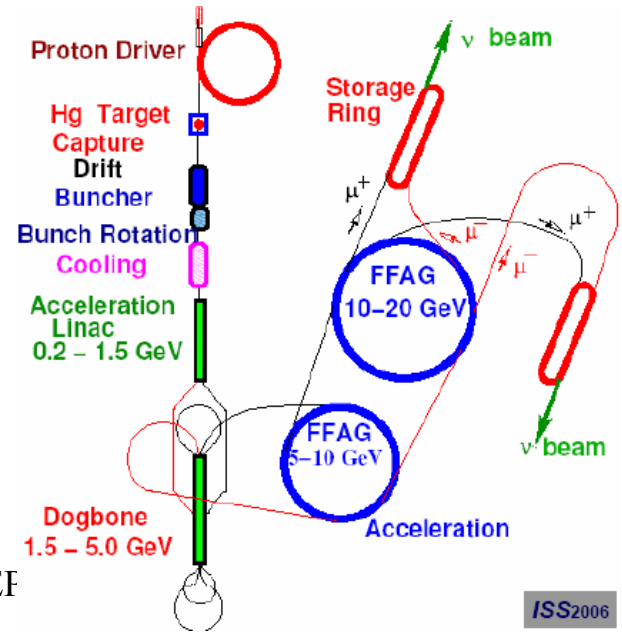
Staff

R. Palmer – group leader
J.S. Berg – FFAG, EMMA
R. Fernow – facility simulations
J. Gallardo – facility simulations
H. Kirk – NFMCC co-spokesman & MERIT co-spokesman

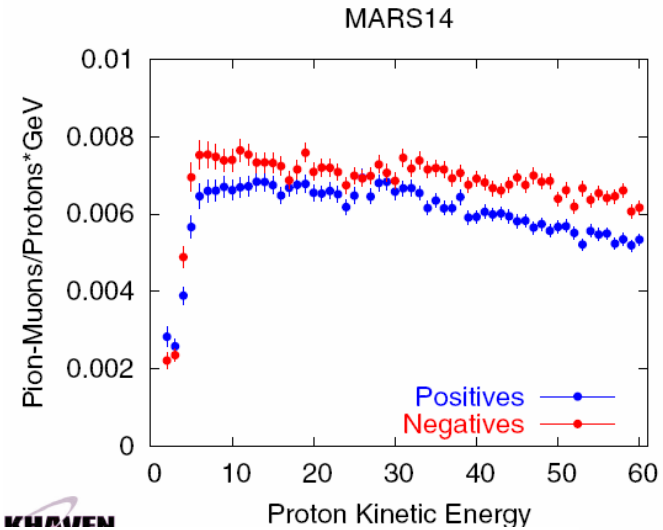
Neutrino factory overview

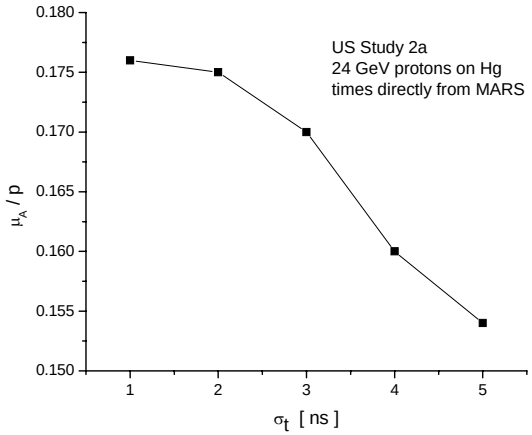
- NF can provide good measurements of θ_{13}, ν mass hierarchy, CP Violation (particularly if $\sin^2 2\theta_{13}$ is ≤0.01)
- optimum parameter measurements require two detectors
- BNL is playing major role in machine design and simulation effort
- present design provides 10^{21} useful μ decays / year and both μ signs
- just completed International Scoping Study (ISS): consolidate designs
- adopted baseline machine design for continued studies
  → International Design Study (IDS)

Schematic view

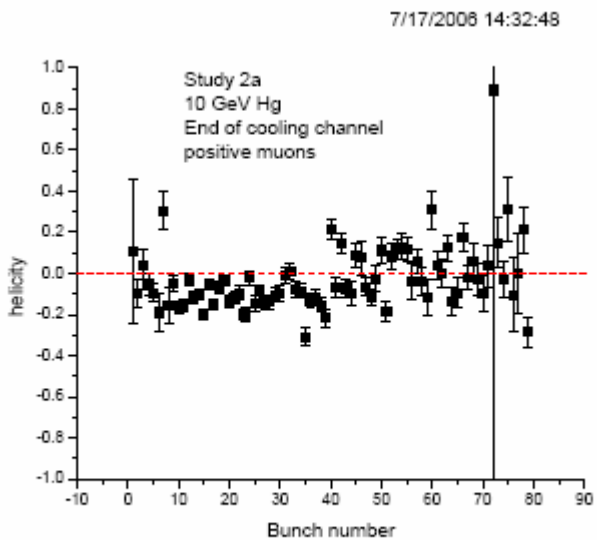


BNL neutrino factory simulations





10 GeV optimum energy



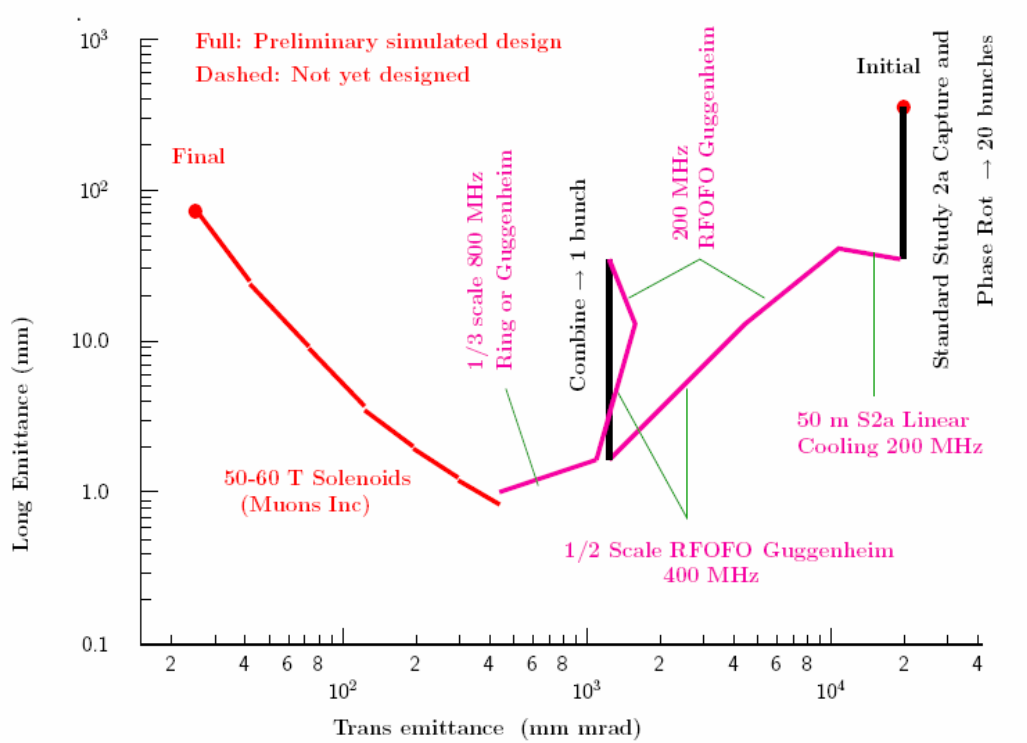
2 ns optimum pulse length

μ polarization is small here. Other designs produce more.

Muon collider overview

- since μ are pointlike leptons → get at same physics as e+e-
- but much less radiation than electrons
- can use rings → smaller than linear colliders (cheaper?)
- may be only way to make very high energy lepton collider
- BNL working on 4 TeV collider scenario and required cooling

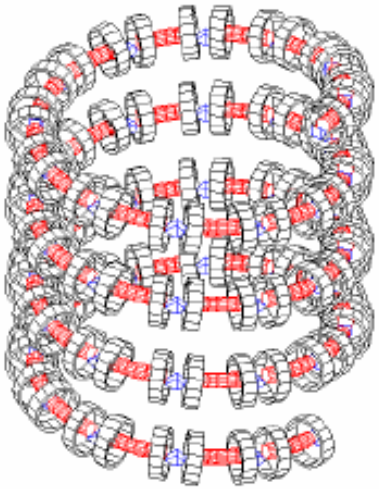
Longitudinal emittance per bunch



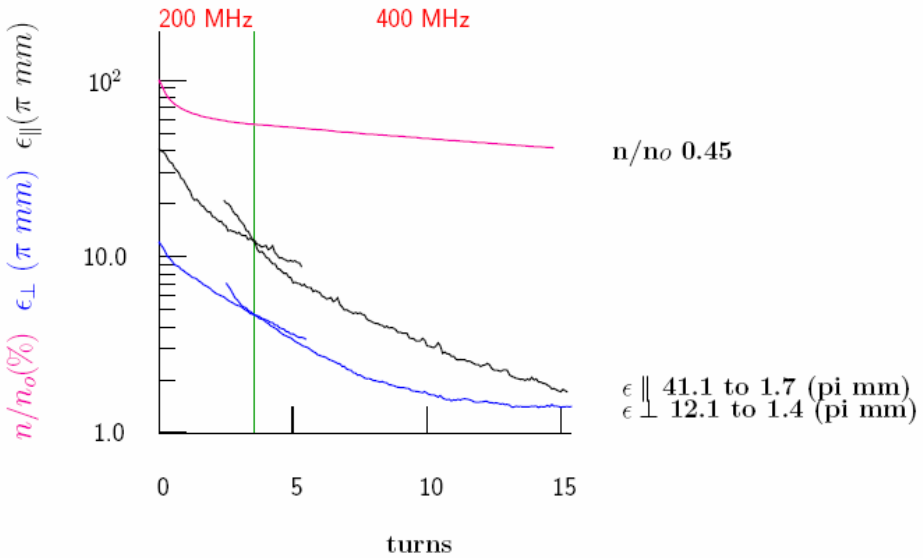
Bob Palmer's Collider scenario

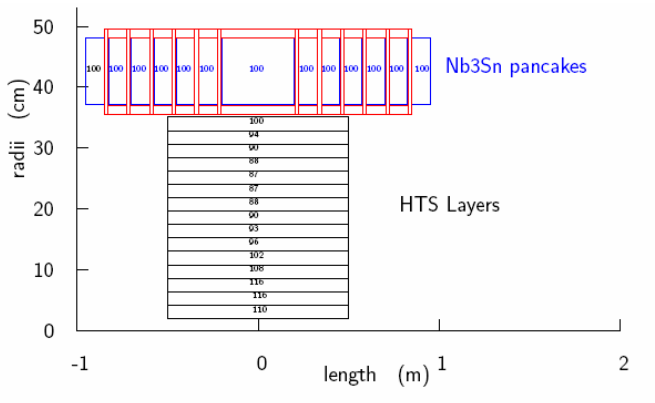
Transverse emittance

BNL cooling simulations



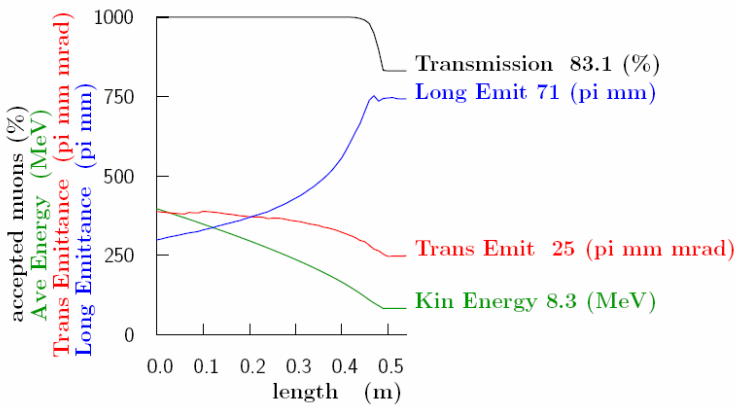
6D cooling with Guggenheim channels





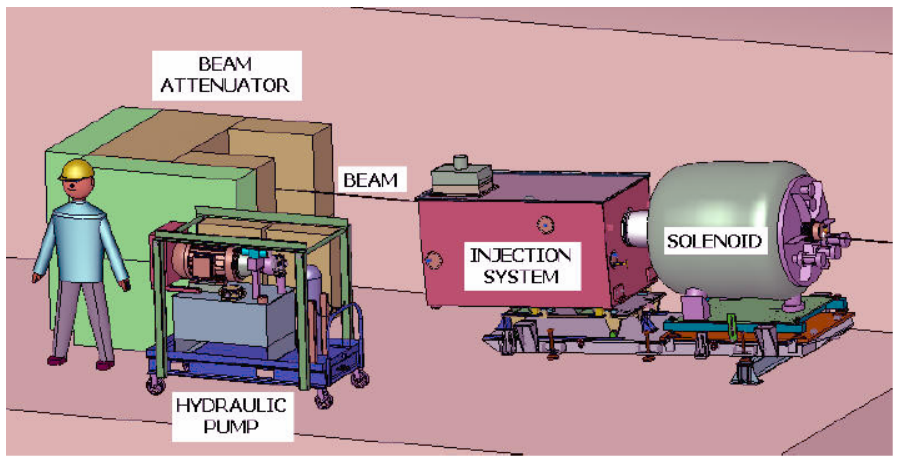
Final cooling with 50 T HTS solenoids

Needs lots of R&D (BNL SMD, FNAL)

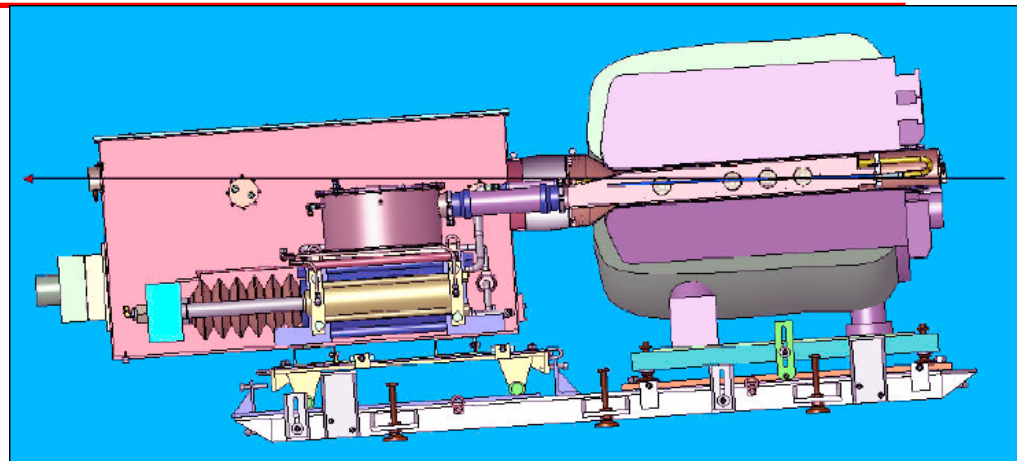


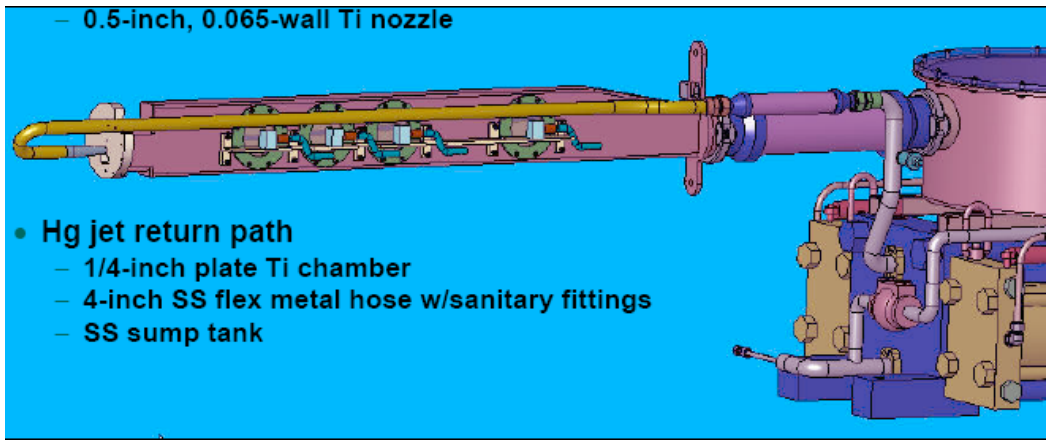
MERIT overview

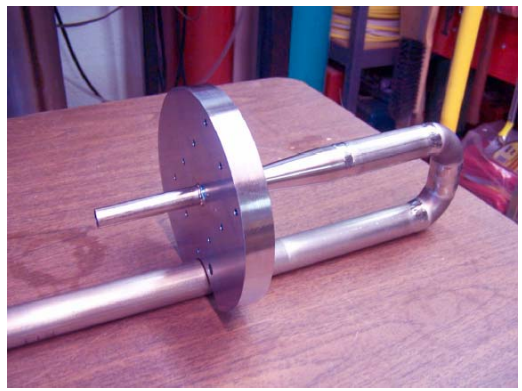
- purpose: demonstrate feasible target system for 4 MW proton beam
- proposed solution: 1 cm diameter, 20 m/s Hg jet in 15-20 T solenoid field
- MERIT collaboration: BNL, CERN, MIT, ORNL, Princeton
- BNL provided oversight of 15 T pulsed magnet acquisition
- BNL Instrumentation Division built optical diagnostics
- BNL Computational Science Center provides MHD simulations of jet



MERIT components

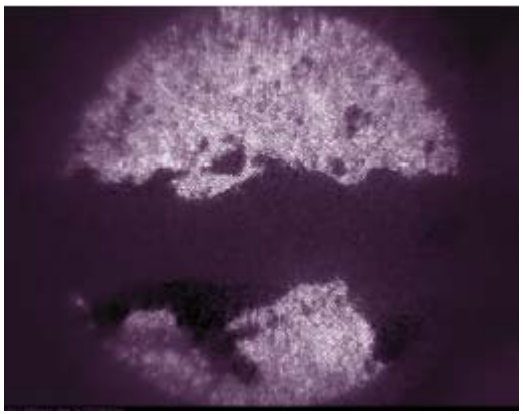




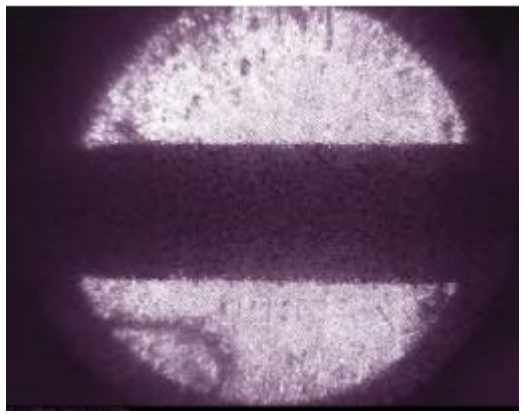


MERIT status

- installation at CERN underway now
- expect first beam on target in July 2007
- expect Hg running to finish this year
- considering further studies using PbBi

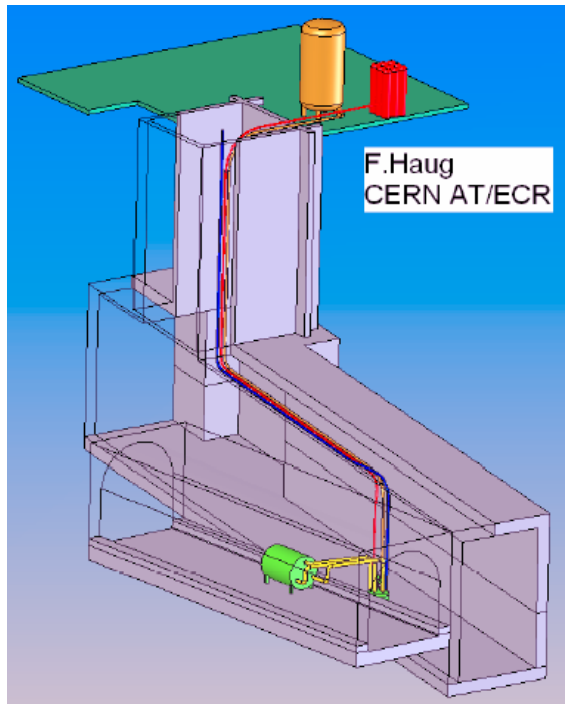


15 m/s Hg jet, 0 T



15 m/s Hg jet, 15 T

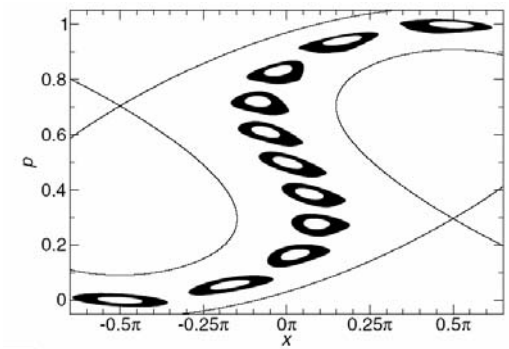
Test at MIT, February 2007



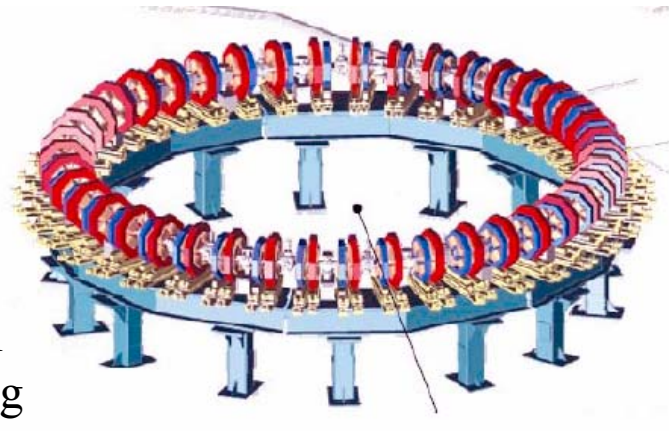
Cryogenic layout at CERN

EMMA

- first demonstration of non-scaling FFAG accelerator
- FFAG has large momentum acceptance, rapid acceleration
- want to understand underlying FFAG dynamics
  - resonance crossing
  - acceleration outside RF bucket
  - TOF-dependence on transverse amplitude
    - reduce tune range during acceleration?
    - increase energy gain per cell?
    - add higher harmonic RF?
- designing 10-20 MeV electron model
- £5.6M is available for construction
- commissioning in 2010
- BNL playing major role in design of experiment



Longitudinal phase space



Conceptual EMMA ring

Group Budget

FY	04	05	06	07	08
μ ops [K$]	1056	990	925	900	1029
non-μ op [K$]	250	250	250	250	315
total DOE base [K$]	1306	1240	1175	1150	1344
Director Office [K$]	240	195	198	202	206
FTE	6.5	5.7	5.2	5.2	5.2

- operating budget down by 12% since FY04
- forced to lose 1 person in middle of FY05
- short this FY ~$40K for travel & materials
- need significant increase next year or additional RIF possible
- ideally would like extra money for a postdoc

Summary

- neutrino factory
  - ISS completed – lead to baseline machine design
  - organization starting on next phase - IDS
- muon collider
  - have complete scenarios for a high luminosity collider
  - more detailed tracking studies now underway
- MERIT experiment
  - made successful demonstration of Hg jet in 15 T field
  - being installed at CERN now
- EMMA experiment
  - approved and design underway

- Long term goals
  - IDS to lead to a NF conceptual design report in 2012
  - collider studies to lead to a complete cooling channel design report by 2010