Front End: Summary and Plans

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Outline

- what did we learn about the front end?
- what studies are still ongoing?
- what are topics for additional R&D?

Reference beam

- examined matrix of input beams (E_p vs Z_t)
- adopted 10 GeV p interactions on Hg as reference beam
- found that reabsorption in target is important
- performance is similar to Study 2a (24 GeV)

  μ_A/p GeV = 0.0073 for positives

  μ_A/p GeV = 0.0088 for negatives
- prepared beam files at end for acceleration tracking

Theoretical FE comparison

- identified CERN bunch structure as a problem

f (MHz)	Neuffer	n bunches	A_{bucket} (pi m)	$A_{bucket}/A_{\parallel}$	
5	No	1	13	3.2	very good
88	No	1	0.3	0.08	bad
88	Yes	25	$0.3\times 25=7.5$	1.8	good
201	Yes	50	$0.15\times 50=7.5$	1.8	good

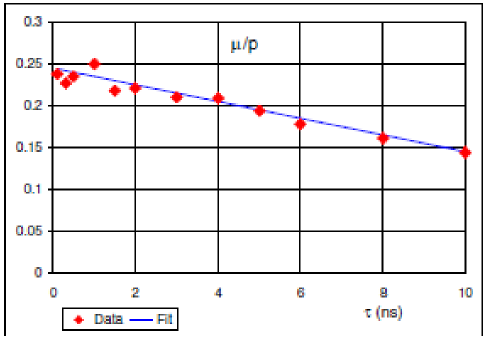
(R. Palmer)

Front end comparison

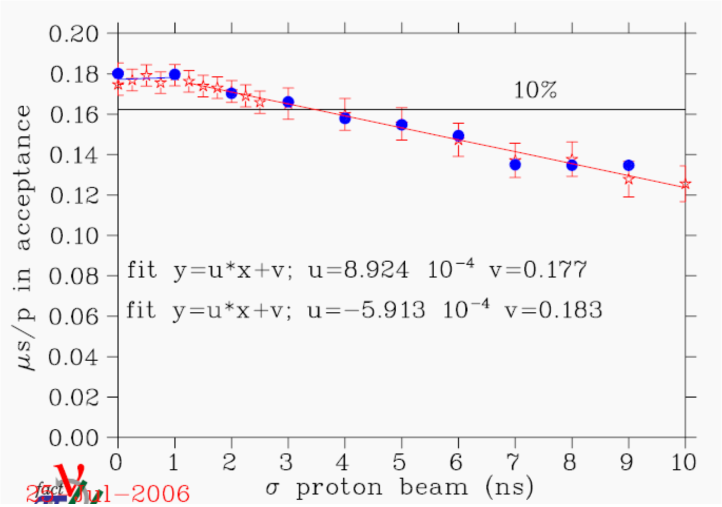
- compared Study 2a and CERN designs
  - same code, beam file, level of detail
- chose Study 2a front end as baseline
- performance was ~x6 better than CERN front end
  - for 10 GeV p interactions
- believe improvements in CERN design are possible
  - reoptimization for higher energy
  - matching from horn to solenoid channel
  - abandon “bunch to bucket” philosophy
  - add field flips

Effect of proton bunch length

- theoretical studies of longitudinal phase space (S. Berg, J. Gallardo)
  - longer bunches cause fewer particles to end up in rf bucket
  - biggest effect on high energy muons
  - adding gaussian spread at end of target is OK
- ICOOL tracking studies
  - ~linear loss after rotator and after cooler
  - 3 ns bunch loses 10%
  - knee is around 1 ns



(after PR; D. Neuffer)



(after cooling; J. Gallardo)

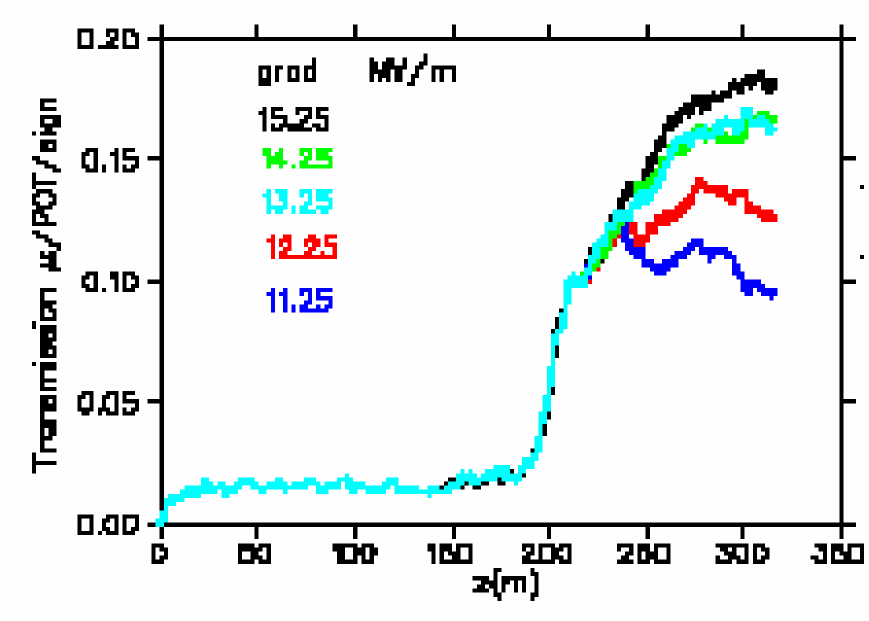
Effect of reduced rf gradient

- what if we can't achieve 15.25 MV/m in a magnetic field?
- operation with 2/3 gradient reduces performance by 20%

  compensated by adjusting amount of absorber and rf phase
- another study assumed construction gives distribution of gradients

  best to put highest gradients at start of channel

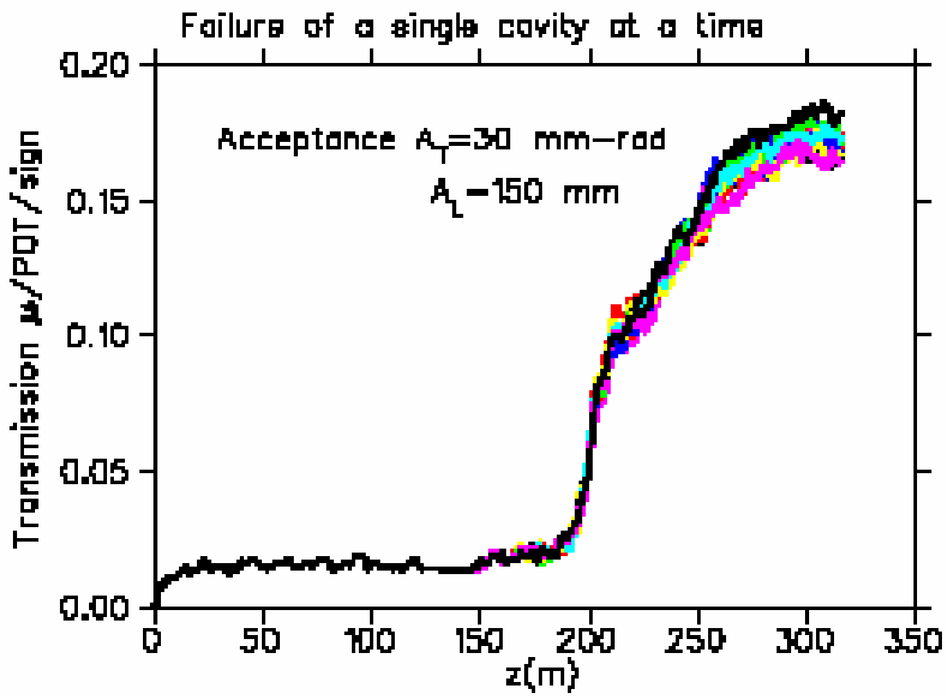
  12 full gradient cavities restored performance loss



(J. Gallardo)

Failure of an rf cavity in Study 2a

- looked at failure of single cavities in rotator or cooling channel
- find ~3% loss in μ_A/p



(J. Gallardo)

Muon helicity

- the μ helicity is small
  - average polarization ~8% for both signs
  - correlation of helicity with bunch number is small

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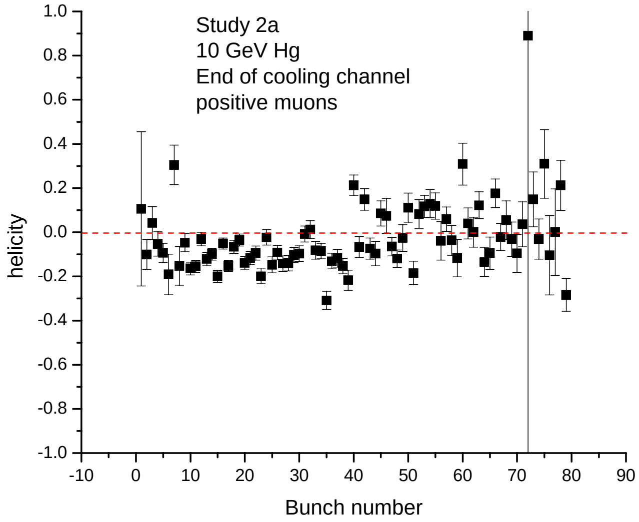
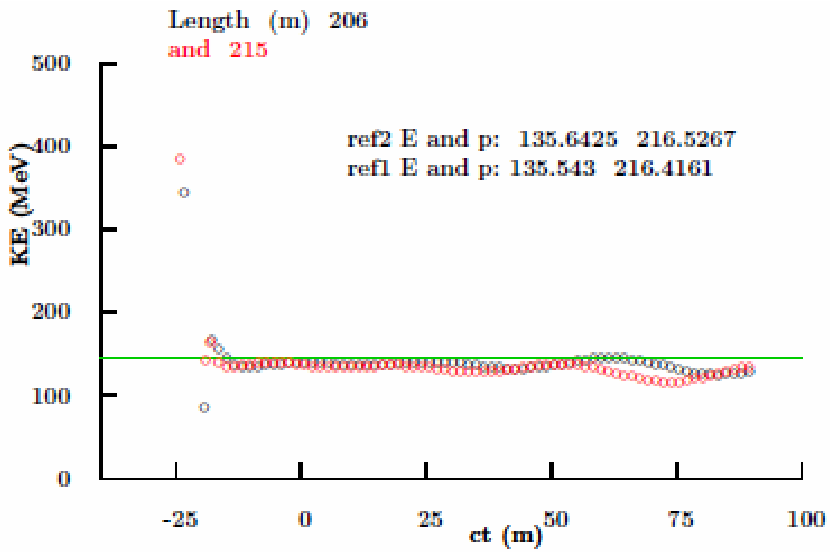


Phase rotation optimization (1)

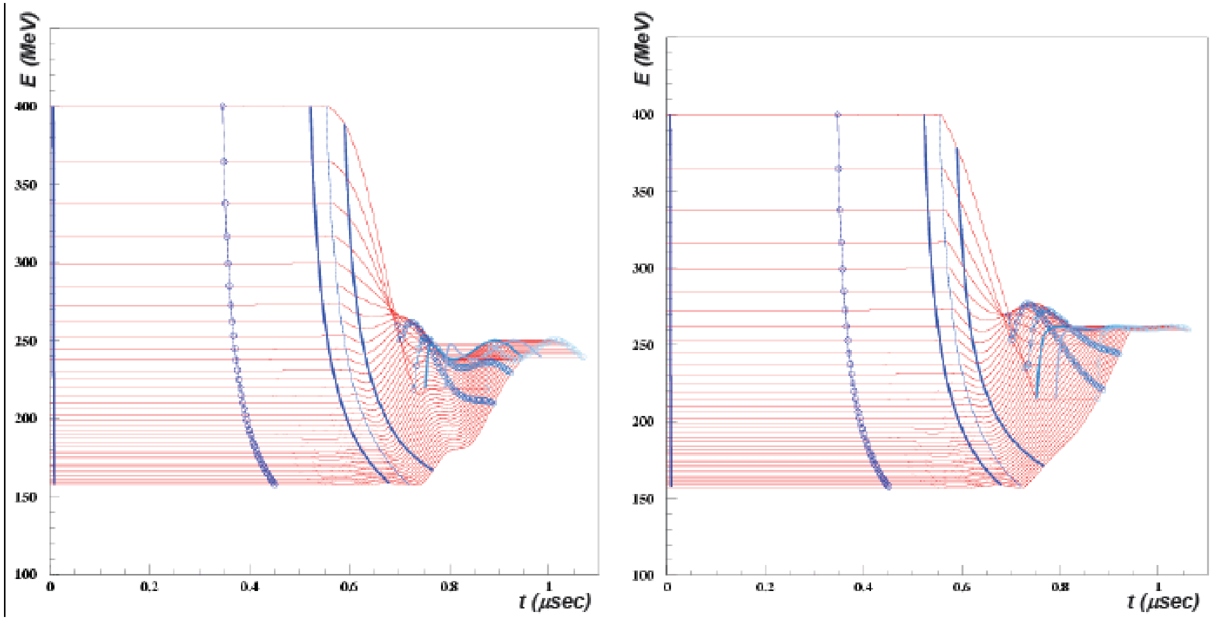
- simplified 1D model of phase rotation
- examine behavior of bunch centers
- only small gain in performance
- higher gradient didn't help
- shorter (30 m) rotator had worse performance
- changing reference momenta adiabatically helped



(R. Palmer)

Phase rotation optimization (2)

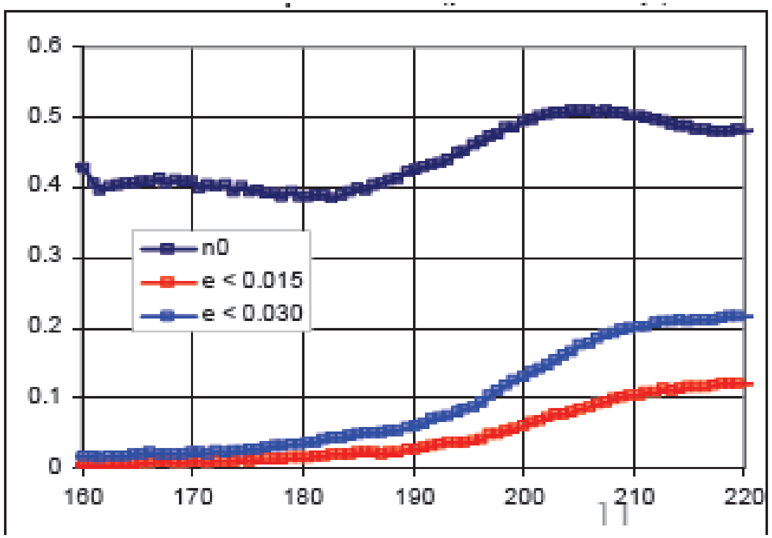
- wrap MINUIT around ICOOL+ENDOF9+ECALC9
- chose 5 parameters to vary
- minimized energy spread after rotation
- found Study 2a parameters were sensible
- should be able to make small improvements in performance



(M. Apollonio)

Gas-filled cooling channel

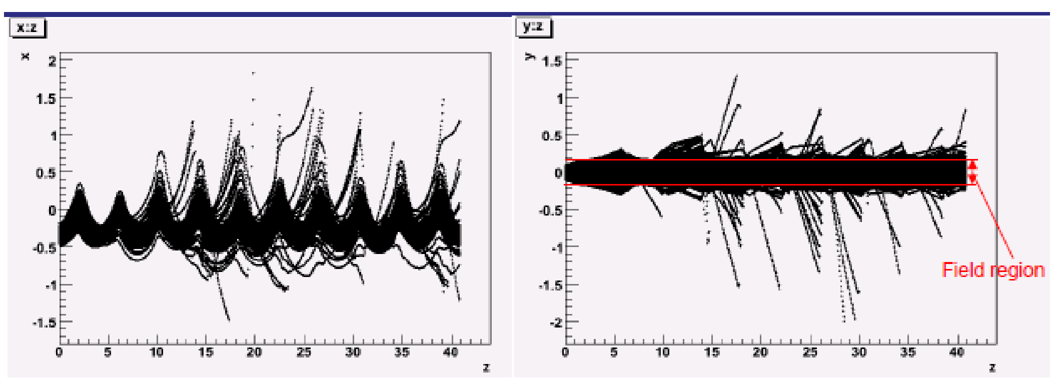
- combine buncher and cooler
- use 150 atm hydrogen gas as absorber
- increase rf gradient to 24 MV/m
- found same performance as simplified Study 2a



(D. Neuffer)

Scaling FFAG phase rotation

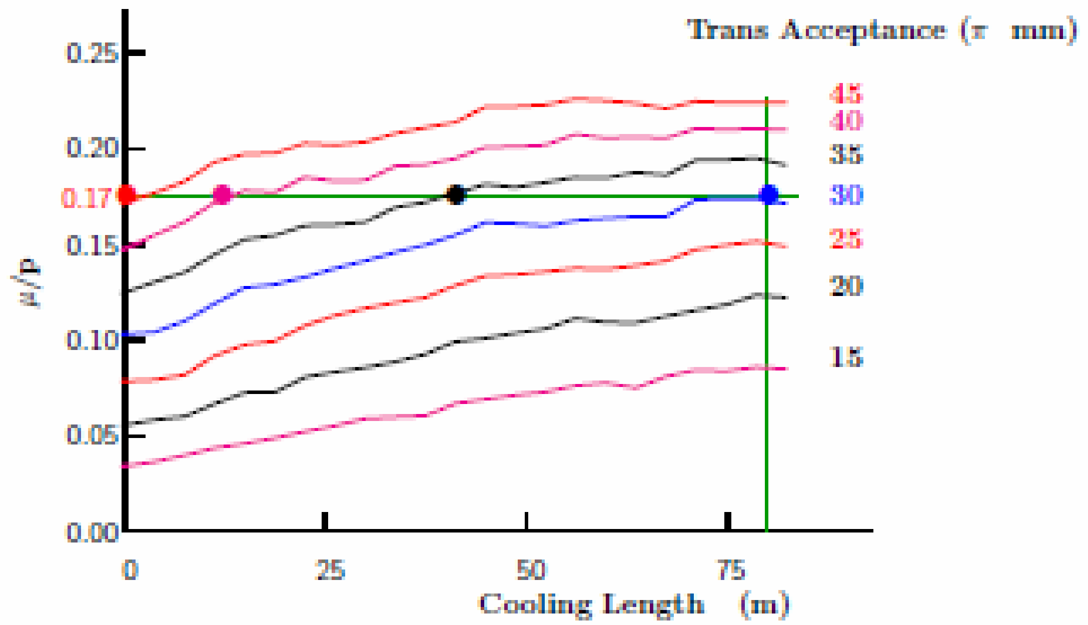
- made model of PRISM ring
- used 3D field map from OPERA
- tracked using ICOOL
- looking at closed orbits and dynamic aperture
- scaling PRISM field map for neutrino factory (68->200 MeV/c)



(Early tracking, A. Kurup)

Cooling versus accelerator acceptance

- this started out as a critical item
- not clear now that large FFAG transverse acceptances are possible
- cost model needs to take large A_T difficulties into account
- not clear now what the tradeoff really is



(R. Palmer)

Other front end results

- possible to include longitudinal cooling (A. Klier)
  Guggenheim modification of RFOFO ring
- reexamined parameters of JNF 0.3->1 GeV ring (S. Berg et al)
- curved pillbox windows do not degrade 201 MHz performance
- effect of magnetic field and gradient errors (J. Gallardo)
  preliminary: % performance loss ~ % error

Ongoing studies (I think)

- phase rotation using scaling FFAG (A. Kurup)
  understand neutrino factory acceptance
- optimization of adiabatic bunching (M. Apollonio)
  add cooling stage to optimization
- 31 MHz phase rotation for both signs (S. Brooks)
- performance of carbon at 5 GeV (H. Kirk, J. Gallardo)
- combined buncher/cooler (D. Neuffer)
  effects of pressure windows, more details

Future R&D topics

- simulations
  - continue trying to improve phase rotation
  - backup: channel with more cooling
    - taper J(z)
  - backup: gas-filled cooling channel
    - higher B at windows to reduce radius?
  - more error analysis
  - revisit cooling versus accelerator acceptance
- experiments
  - LiH absorber/rf windows for 2 signs, 4 MW
    - test gas-cooled scheme?
  - rf cavity gradient in magnetic field