Front End – present status

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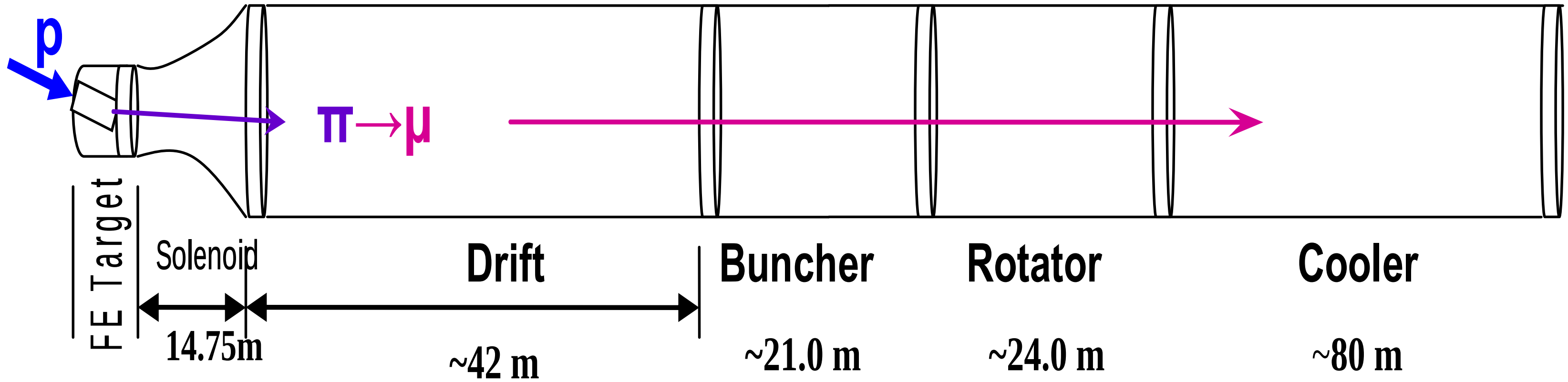
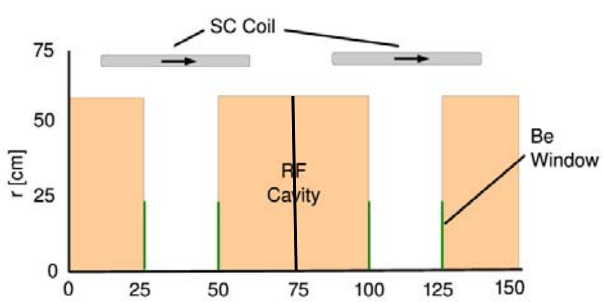
Outline

- **Front End for Muon Collider/ Neutrino Factory**
  - Baseline for MAP
    - 8 GeV proton beam on Hg target
  - 325 MHz
    - With Chicane/Absorber
- **Current status**
  - New targetry
    - 6.75 GeV on C target
  - New Mars generated beams
    - Mars ouput much different from previous version

325MHz System “Collider”



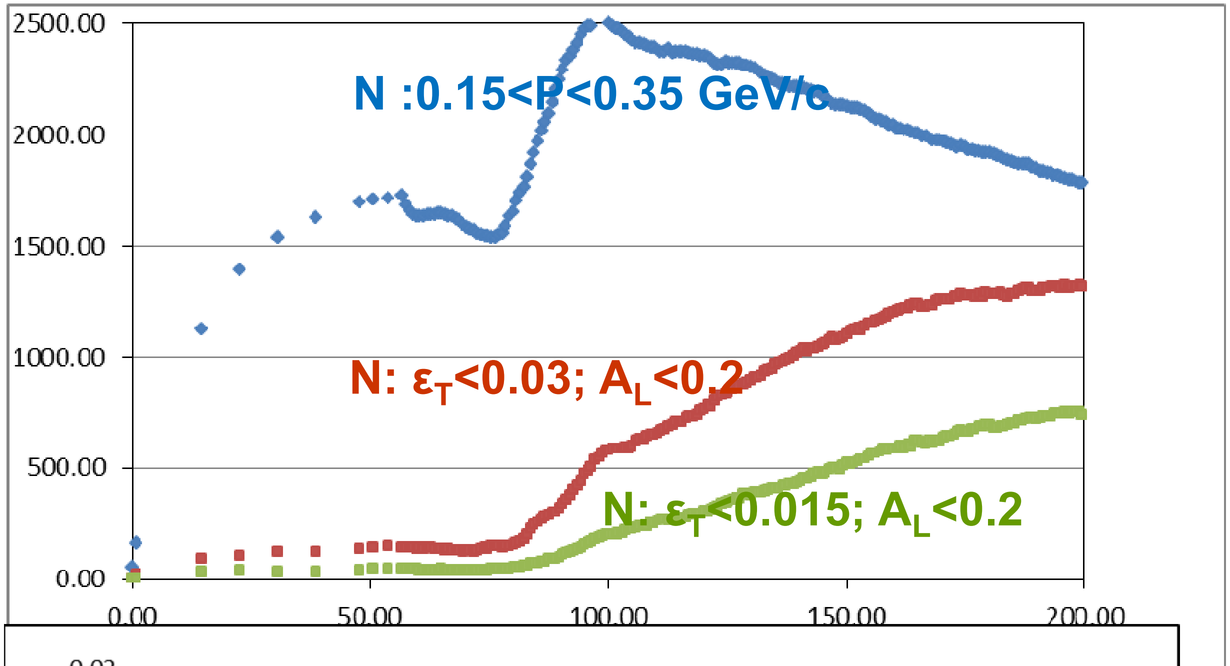
- **Drift**
  - 20 T → 2 T
- **Buncher**
  - P_o= 250 MeV/c
  - P_N= 154 MeV/c; N = 10
  - V_{rf} : 0 → 15 MV/m
    - (2/3 occupied)
  - f_{RF} : 490→ 365 MHz

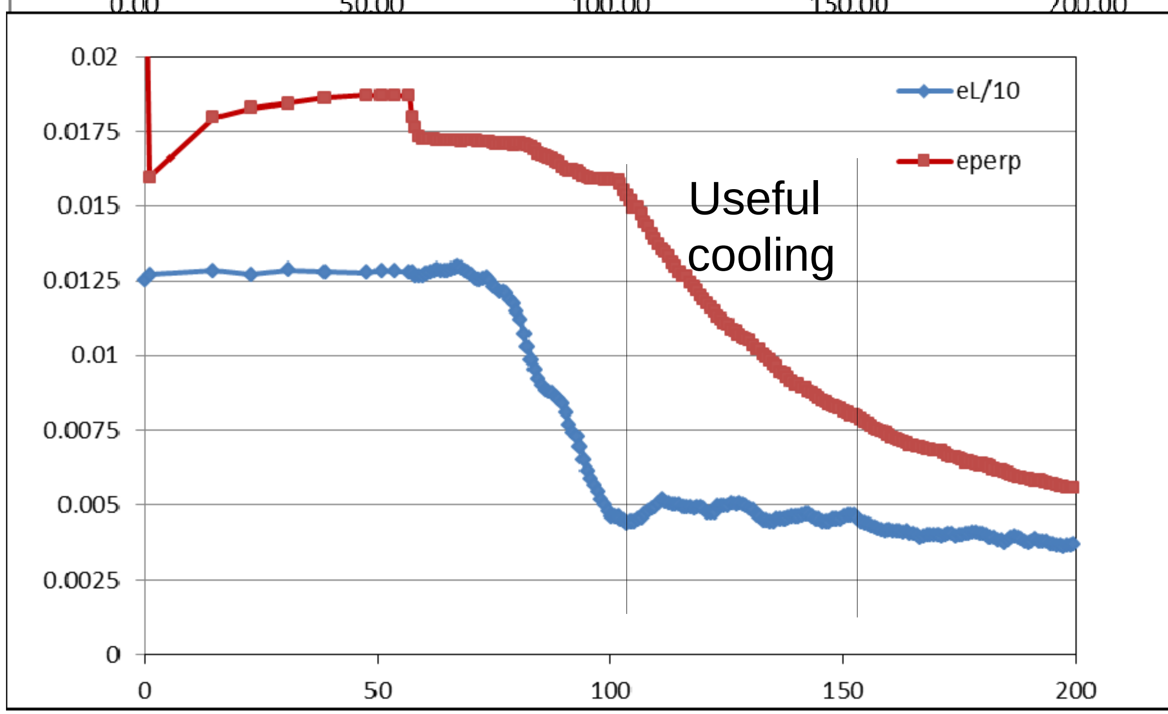


- **Rotator**
  - V_{rf} : 20 MV/m
    - (2/3 occupied)
  - f_{RF} : 364→ 326 MHz
  - N = 12.045
  - $P_{0,}$ P_N → 245 MeV/c
- **Cooler**
  - 245 MeV/c
  - 325 MHz
  - 25 MV/m
  - 2 1.5 cm LiH absorbers /0.75m

Simulation Results

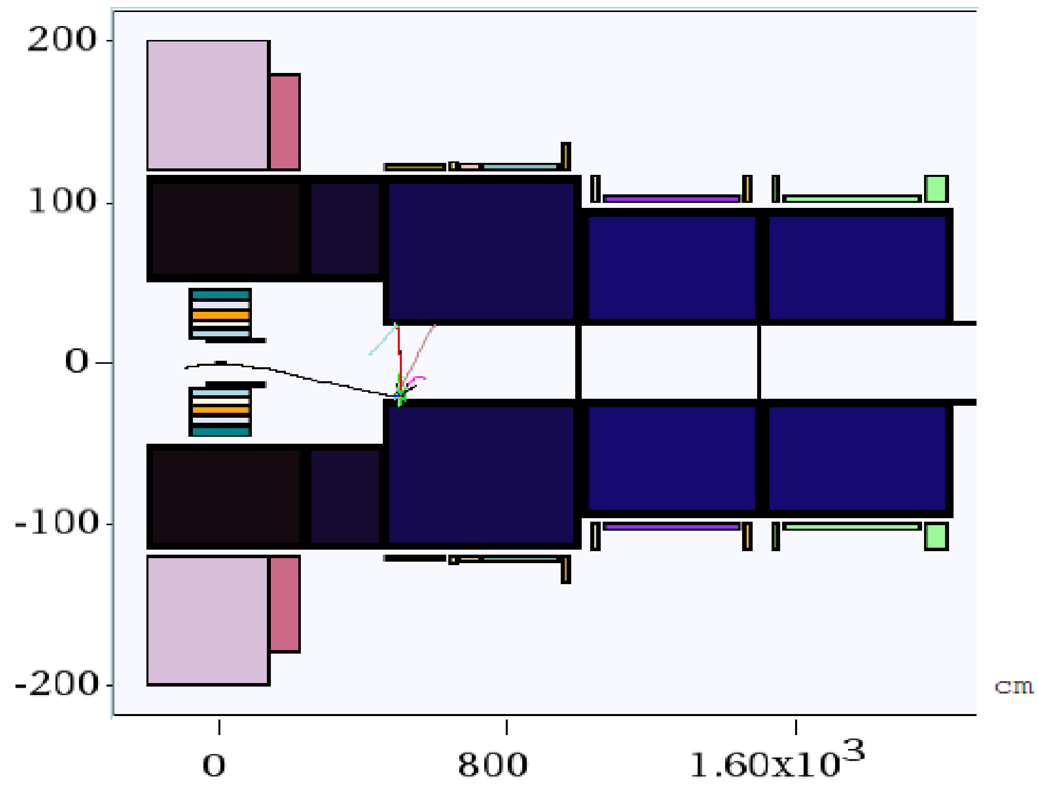
- **Simulation obtains**
  - ~0.125 μ/p within acceptances
  - with ~60 m Cooler
  - 325 MHz – less power
  - shorter than baseline NF
- **But**
  - uses higher gradient
  - higher frequency rf → smaller cavities
  - shorter than baseline NF
  - more bunches in bunch train

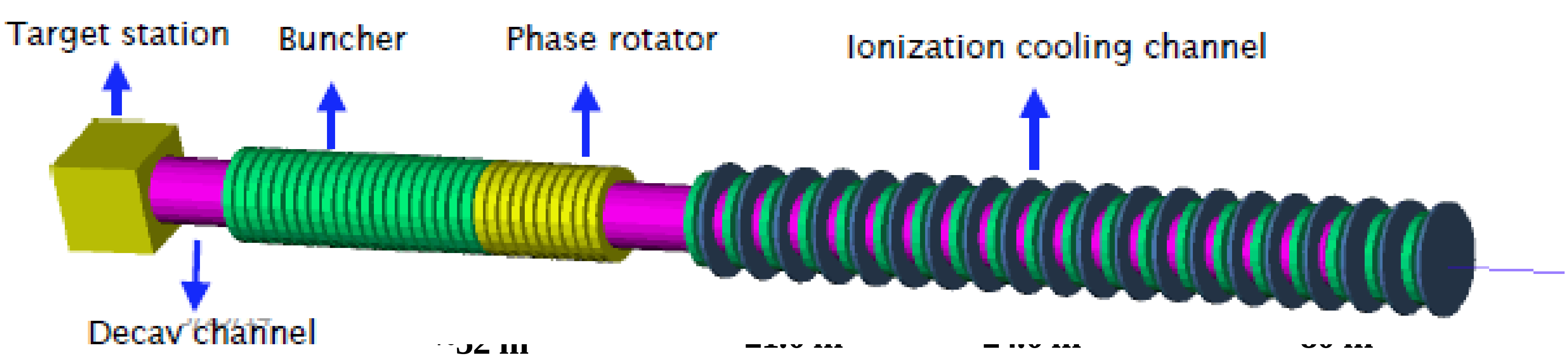




New Proton Driver parameters

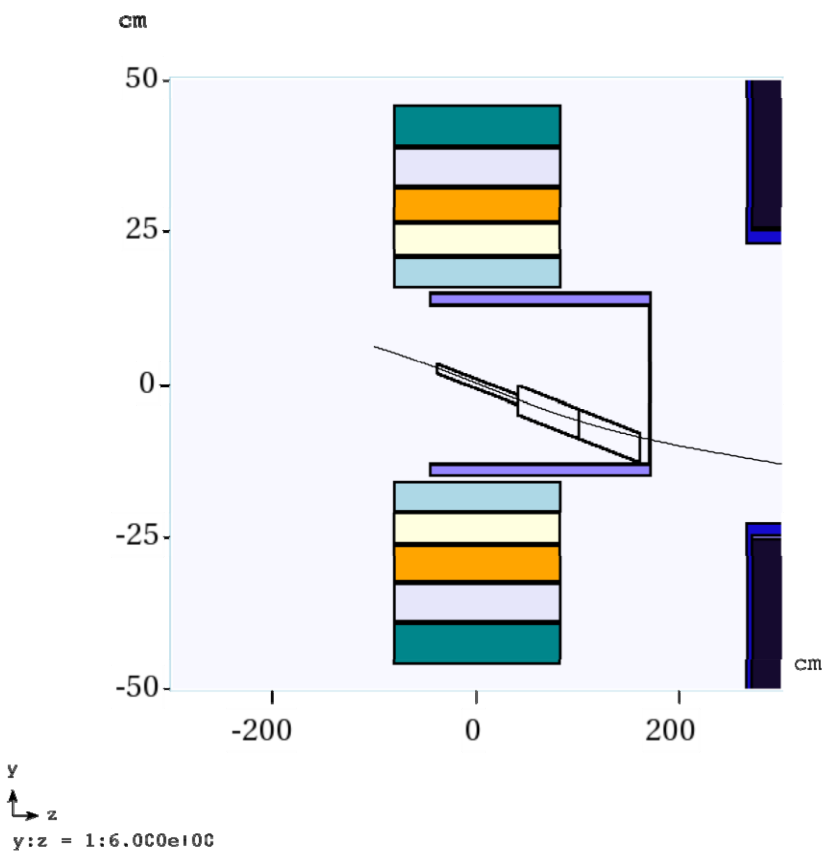
- **6.75 GeV p, C target**
  - 20 → 2 T short taper
    - ~5 m (previously 15)
  - X. Ding produced particles at z = 2 m using Mars
  - short initial beam
- **Redo ICOOL data sets to match initial beam**
  - ref particles redefined
    - in for003.dat
    - and for001.dat





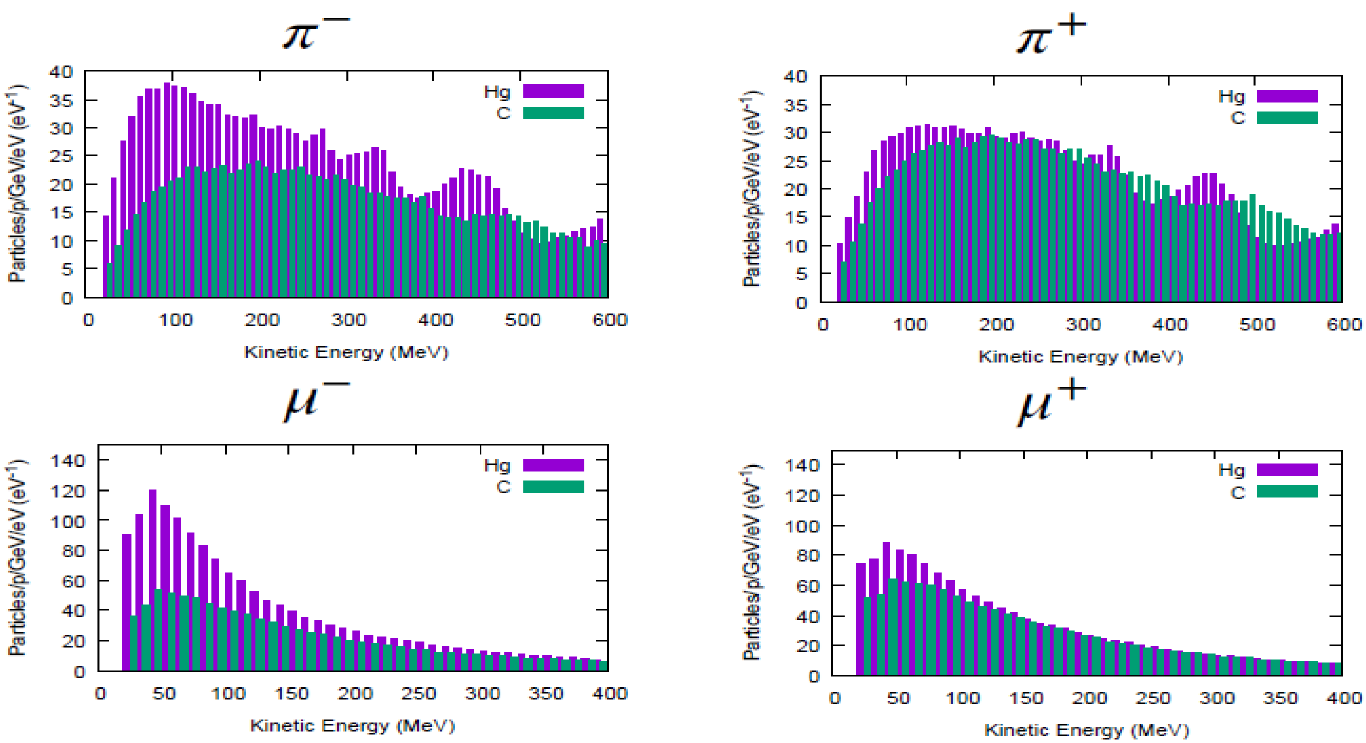
Use old FE with new initial beam

- **New beam based on Mars 15**
  - different apertures than baseline scenarion
  - ~half of initial beam lost in <6m
    - aperture cut off
- **Large amount of secondaries at larger apertures at start**
  - Did not see in previous runs because of cut-offs near target
  - Lost at 23 cm aperture used downstream



Following Scott's review of front end

- Use his initial distributions (obtained by X. Ding)
  - 8 GeV protons on Hg target
    - + and minus
  - 6.75 GeV protons on C target
  - Start beam from z =10 m
    - must retranslate into ICOOL reference particles
  - Early losses on apertures have already occurred
    - 23 cm apertures



ICOOL translation tips

- **start at "z=10 m"**
  - (particle time zero is at -1 m; launch point is z = - 1 m.)
- **reference particles**
  - 250 MeV/c ; 154 MeV/c μ^+
    - 165.75 MeV ; 81.1 MeV μ^+
  - time set by 1 m as 6.75 GeV proton + 10 m as μ^+
  - reference particles set in for003.dat, not for001.dat

```
01-Feb-2015 X. Ding C 10 m -
0.0 0.250 3.95709E-08 0.0 0.154 4.381345E-08 2
    1   1 -3 0  4.354479e-008  1.000000e+000    0.03737
0.03656 0  7.861861e-004  2.558375e-002  2.189235e-001 0 0 0
    3   1 -3 0  3.712592e-008  1.000000e+000   -0.03459  -
0.11247 0  1.617131e-001  3.506310e-002  4.670452e-001 0 0 0
    6   1 -3 0  3.748837e-008  1.000000e+000    0.00304  -
0.04460 0 -1.827203e-002 -5.931789e-002  7.809555e-001 0 0
0
   10   1 -3 0  3.738523e-008  1.000000e+000    0.07979
0.13944 0 -4.890422e-002  3.733585e-001  1.515145e+000 0 0
0
```

In ICOOL for001.dat

```
REFP
2 0 0 0 3
REF2
2 0 0 0
```

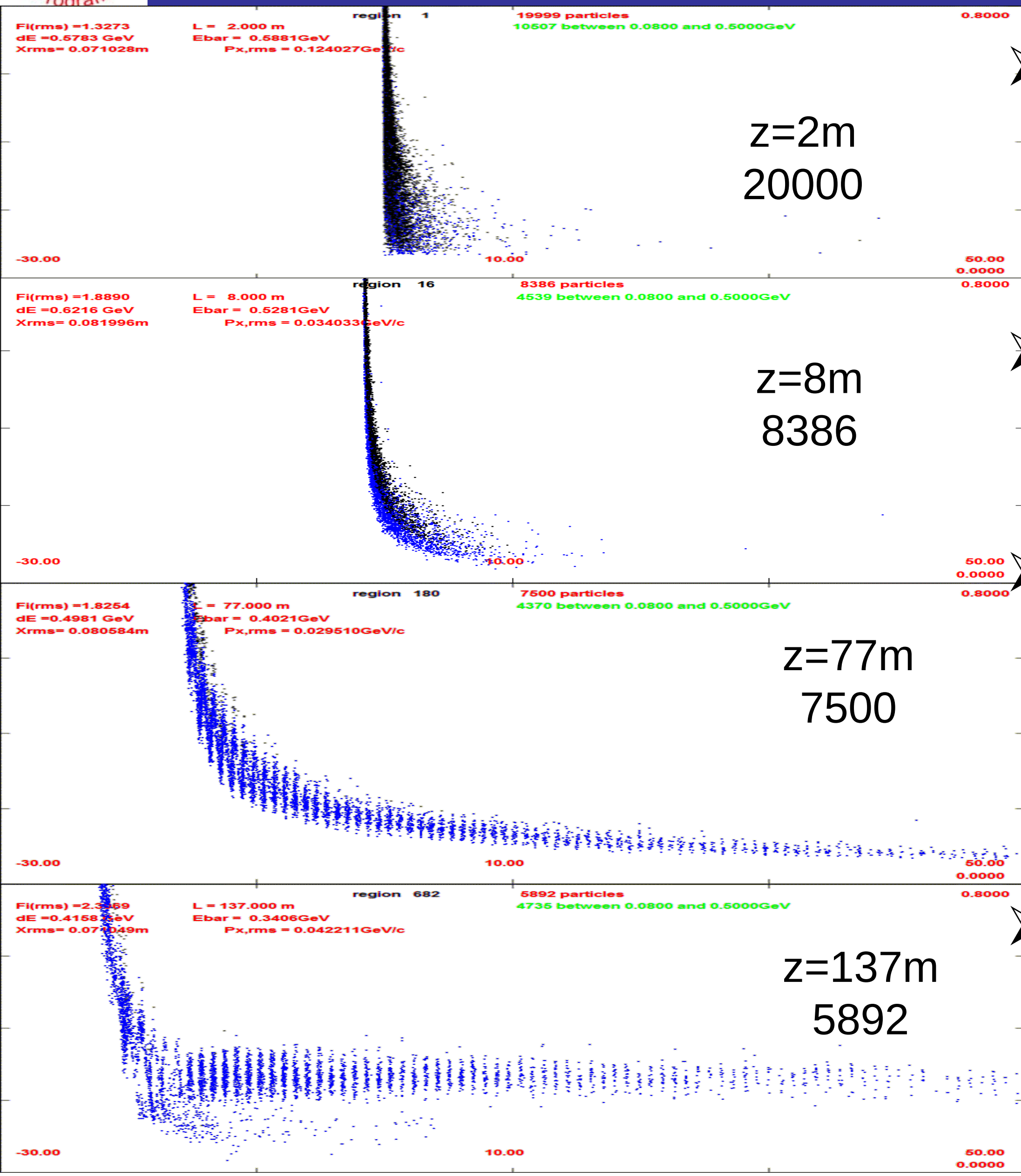
ICOOL features

- **ecalc9.for has an error [Better to use ecalc9f.for.]**
  - 10.e09 should be 1.0e09
    - affects value of L in eV-s
- **After correction can use L to get ε^+, ε^-**
  - L_m= 0.3L/2/0.10566 (= ½ of the angular momentum)
  - $\varepsilon_p = (\varepsilon_t^2 + L_m^2)^{1/2}$
  - $\varepsilon^+ = \varepsilon_p + L_m$; $\varepsilon^- = \varepsilon_p - L_m$;

First simulation results

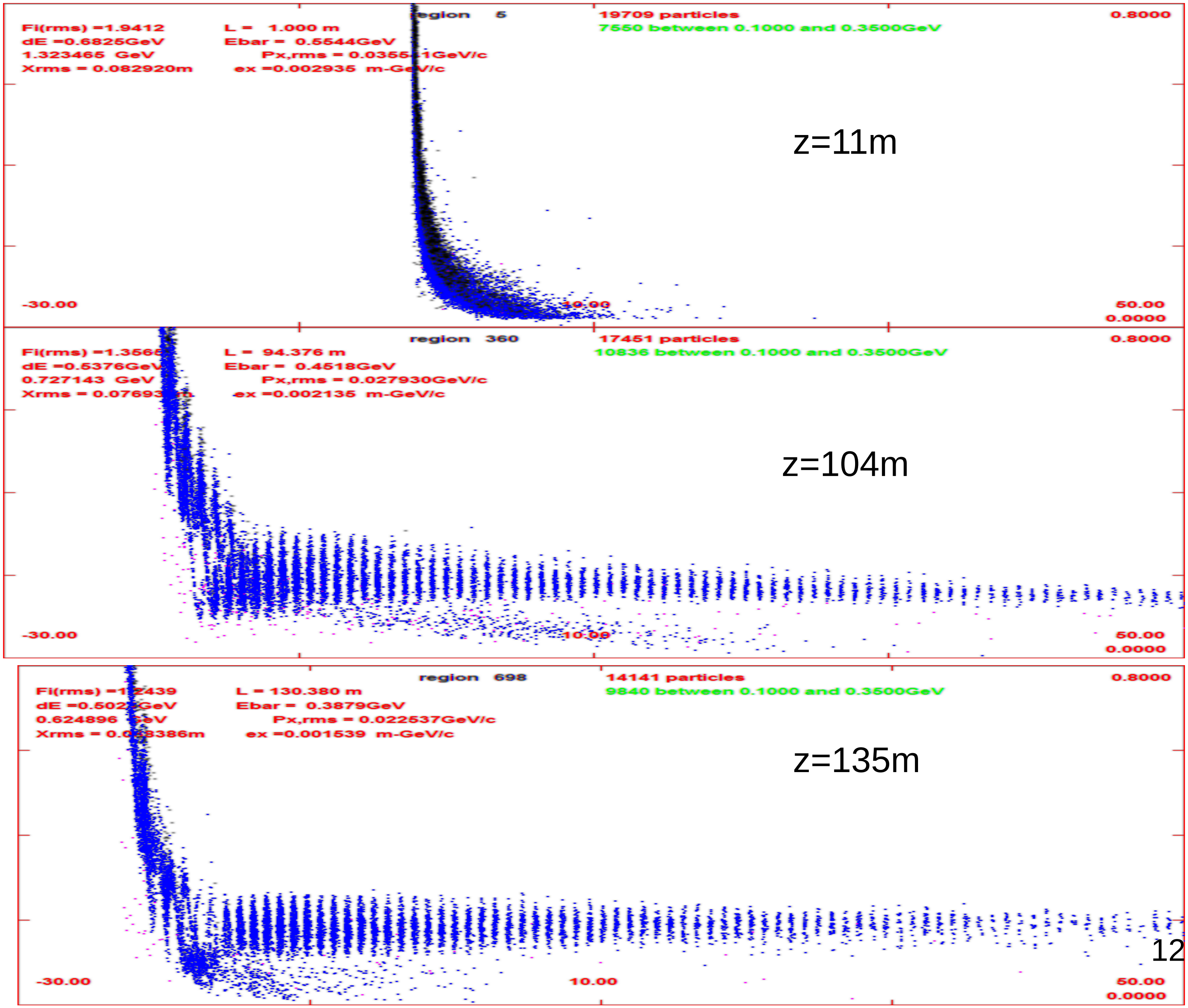
- **Simulation results**
  - Hg target 8 GeV –end of cooling
  - **~0.0756 μ^+/p; ~0.0880 μ-/p;**
  - C target 6.75 GeV p
  - **~0.0613 μ^+/p; ~0.0481 μ^-/p;**
    - 0.0726 μ^+/p; ~0.0570 μ^-/p when multiplied by 8/6.75 to compare beams of the same power.
  - **Previous front ends had ~0.1 to ~0.125 μ/p**

First simulations results



- ~60% of initial particles are lost in first 6 m
  - previous front end lost ~20%
- Beam starts out very large
  - previous much smaller in
  - front end simulations
- μ/p reduced
  - → ~0.061 μ^+/p
  - ~0.048 μ^-/p
    - μ^- less than μ^+ for C
- Not fully reoptimized for new initial beam

Progression of beam through system



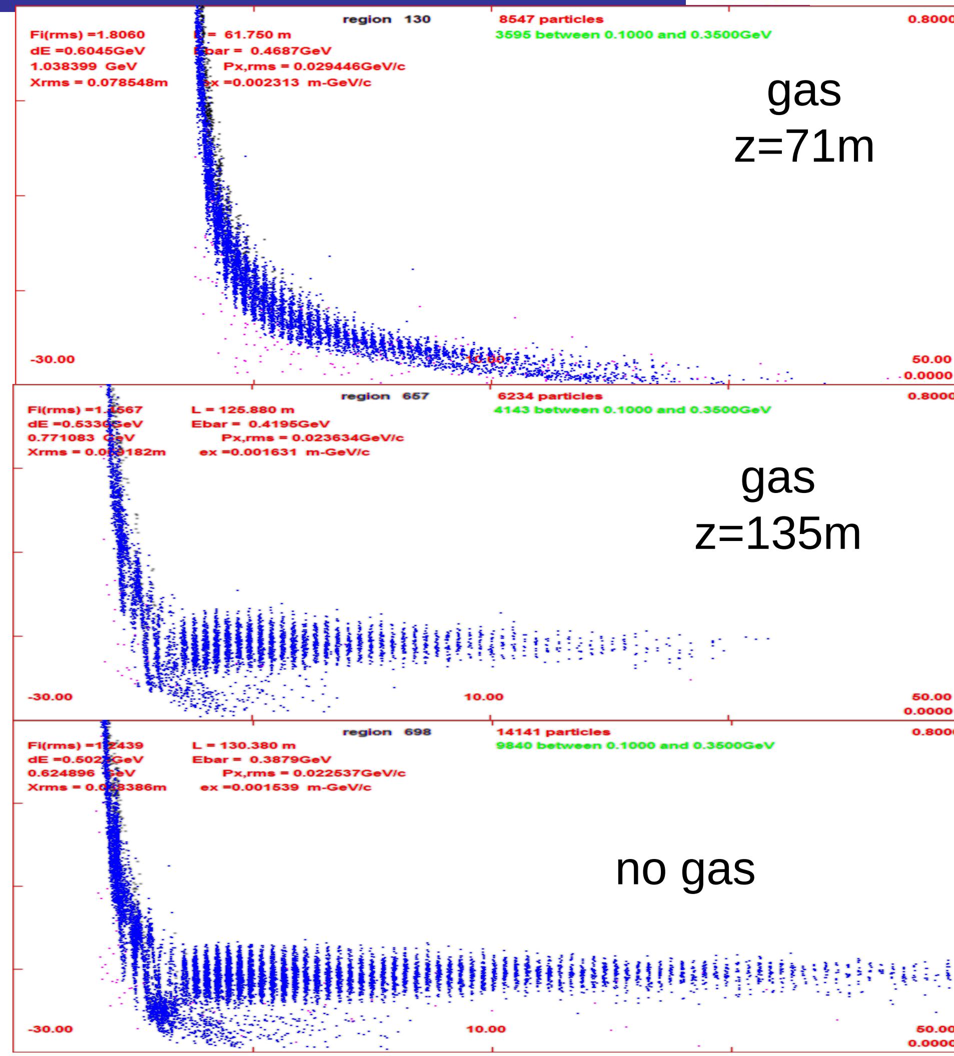
6.75 GeV p/ C target – 8 GeV Hg

- Simulations capture typically somewhat less than before
  - Big difference in MARS production model
    - MARS Inclusive → LAQGSM=1
  - Drop in production for ~8 GeV
    - Are previous MARS simulations that showed an advantage in production for ~8 GeV still true ?

- IQGSM=0: exclusive CEM (cascade exciton model?) for $E < 3$ GeV, MARS inclusive for $E > 5$ GeV, LAQGSM for some special cases. Old MARS default.
- IQGSM=1: CEM for $E < 0.3$ GeV, LAQGSM for $0.5 \text{ GeV} < E < 8$ GeV, MARS inclusive for $E > 10$ GeV. New MARS default.

Add gas-filled rf in buncher/rotator

- **34 – 100 atm equivalent**
  - 1.14 MeV/m
    - 34 atm
  - 3.45 MeV/m
    - 100 atm
  - for 34 atm
    - add ~2 MV/m to rf
- **First tries with ICOOL**
  - GH_2 in buncher 1 atm
    - no change in capture
  - Change to 34 atm by
    - DENS GH_2 34.0
  - Runs OK but
    - reduces capture by 20%
    - mostly from low-E muons
      - shorter bunch train



Other topics to explore

- **Replace vacuum rf with gas-filled rf**
  - Also use gas in phase rotator
  - Do Buncher / phase rotation function as well ?
- **Replace initial 4-D Cooler with 6-D cooler**
  - Has been initiated by Yuri
  - Would like a reference version to use as acceptance baseline
- **Integrate Buncher / Phase-rotation / Cooling**
  - more compact system
  - adiabatic → snap rotation
- **Transform to general R&D**
  - initial beam →???
    - lower B-field, lower energy
  - other uses (mu2e … LFV expts.

Any questions?