# Optimization of phase rotation parameters for the $\nu$-factory

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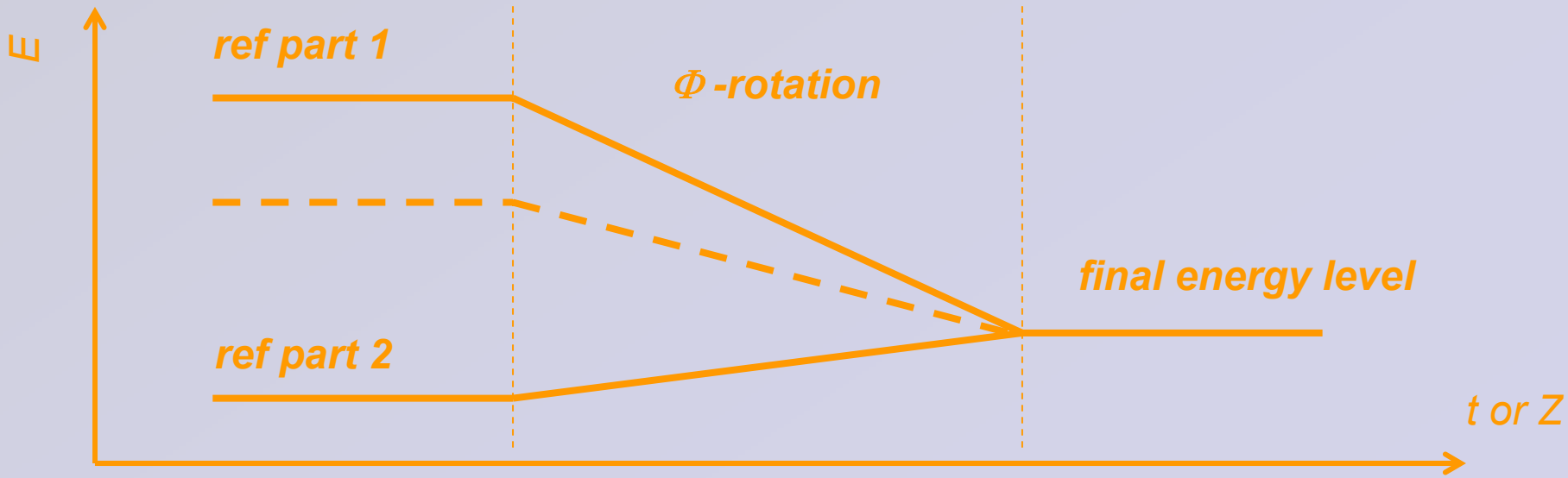
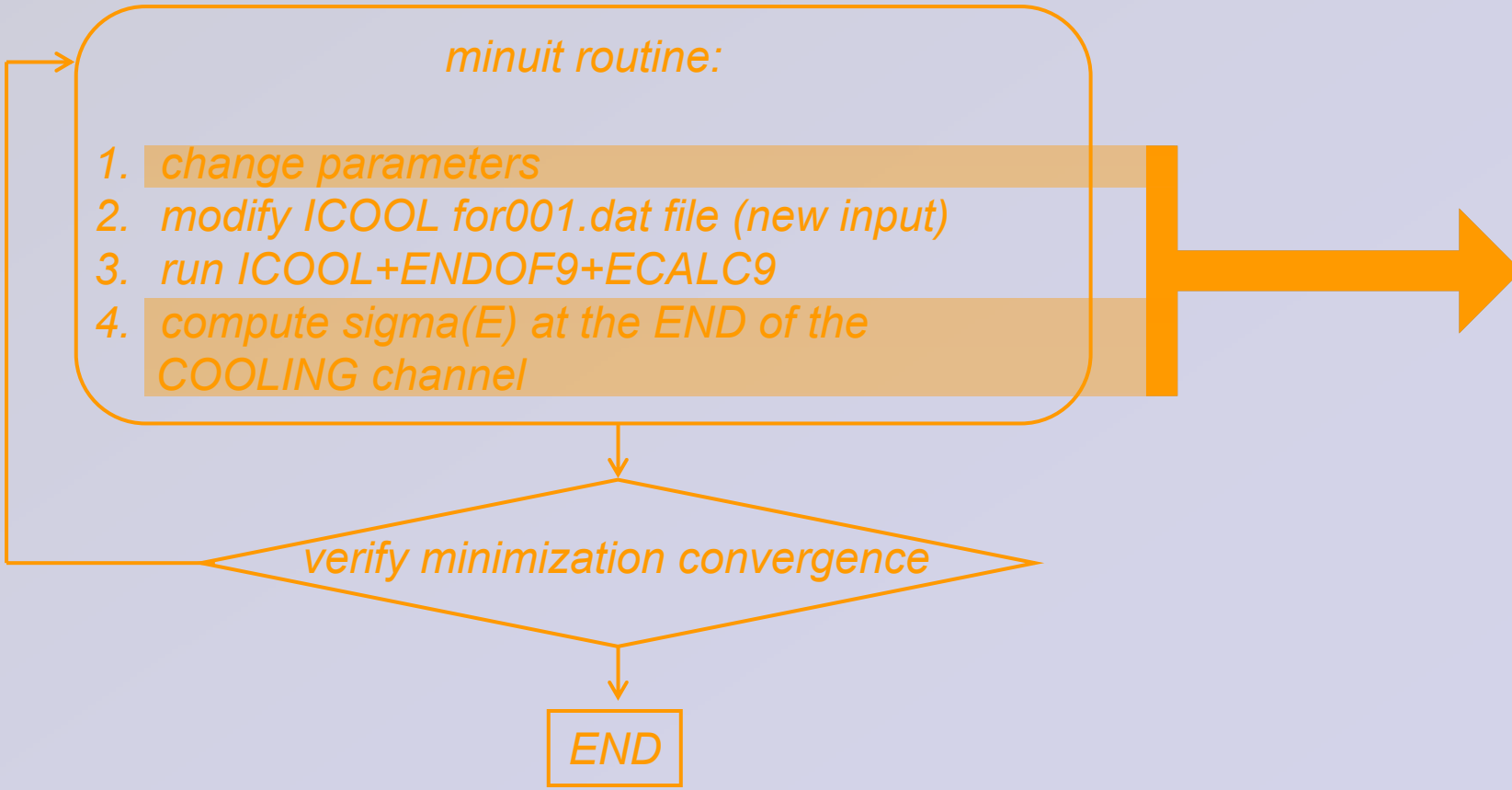
- ***Leading idea:***
  - ***5 figures used to parametrize the Φ-rotation***
  - ***Goal:***
    - ***Trying to reach the "best" combination of these values to produce an "ideal" muon beam***
  - ***Instead of doing it by hand (lengthy/tedious) use a minimization procedure → MINUIT***
  - ***Wrap ICOOL+endof9+ecalc9 in a MINUIT main routine***
  - ***Discuss results ...***

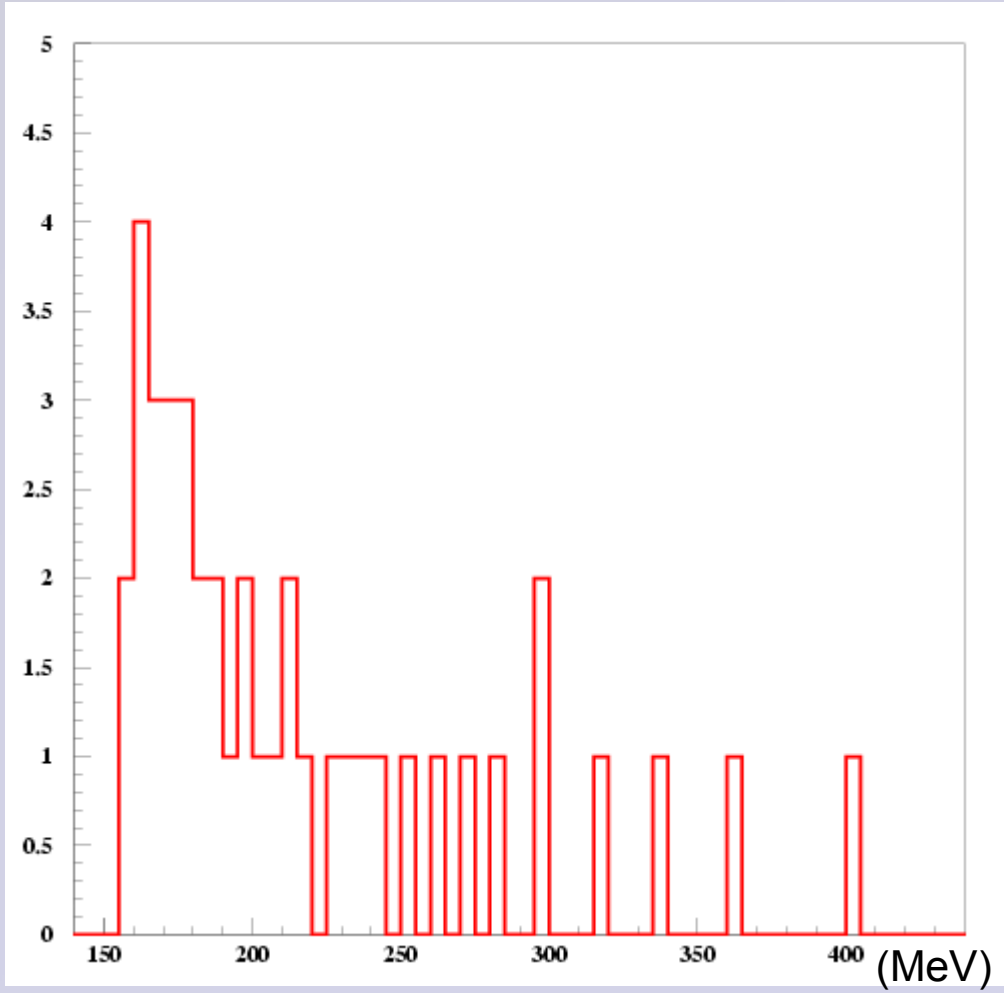
- **Parameters** *initial ("typical") values* *meaning/function*
  - *ref1 ---------- -.48* *reduce energy (negative ramp)*
  - *ref2 ---------- 2.64* *increase energy (pos. ramp)*
  - *delta ---------- 18.04* *# of w.l. separating the ref. particles*
  - *grad ---------- 12* *RF gradient*
  - *ref1(2)=ref2(2) -------- .214* *energy level in the cool. section*



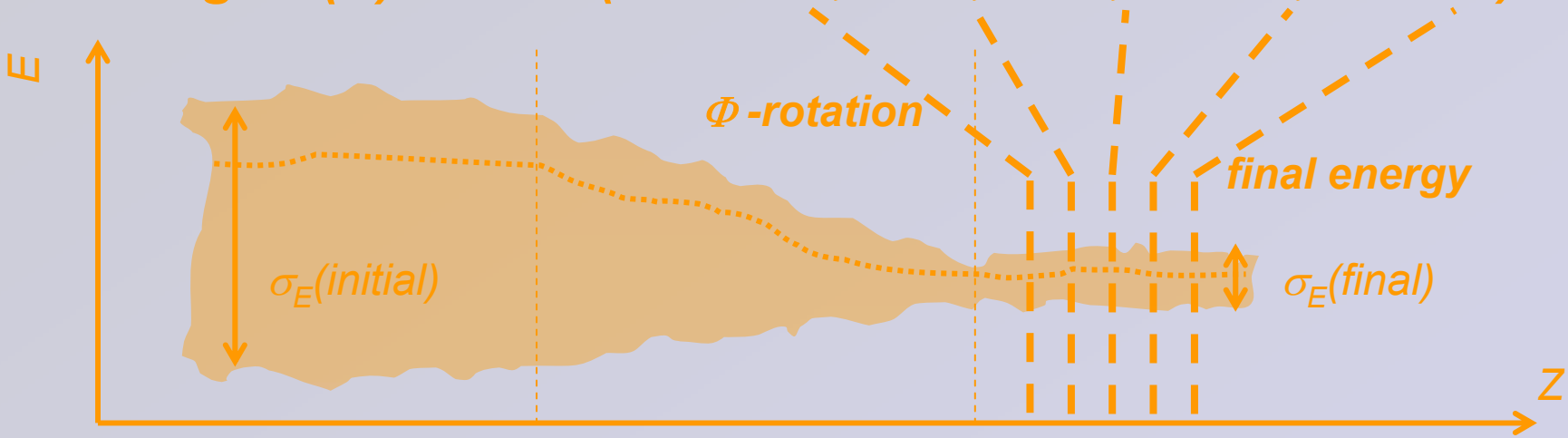
- ***Which minimization?***
  - ***Probably a matter of taste, but I ended up with a SIMPLEX minimization which looks faster than usual MINImize and reliable***
- ***Structure of the program***



- *Technical note:*
  - *To speed the algorithm up I used a smart set of 40 muons (only) provided by Bob*
  - *Energy distribution at the beginning of the channel*
  - *Muons are injected at the beginning of the drift channel*

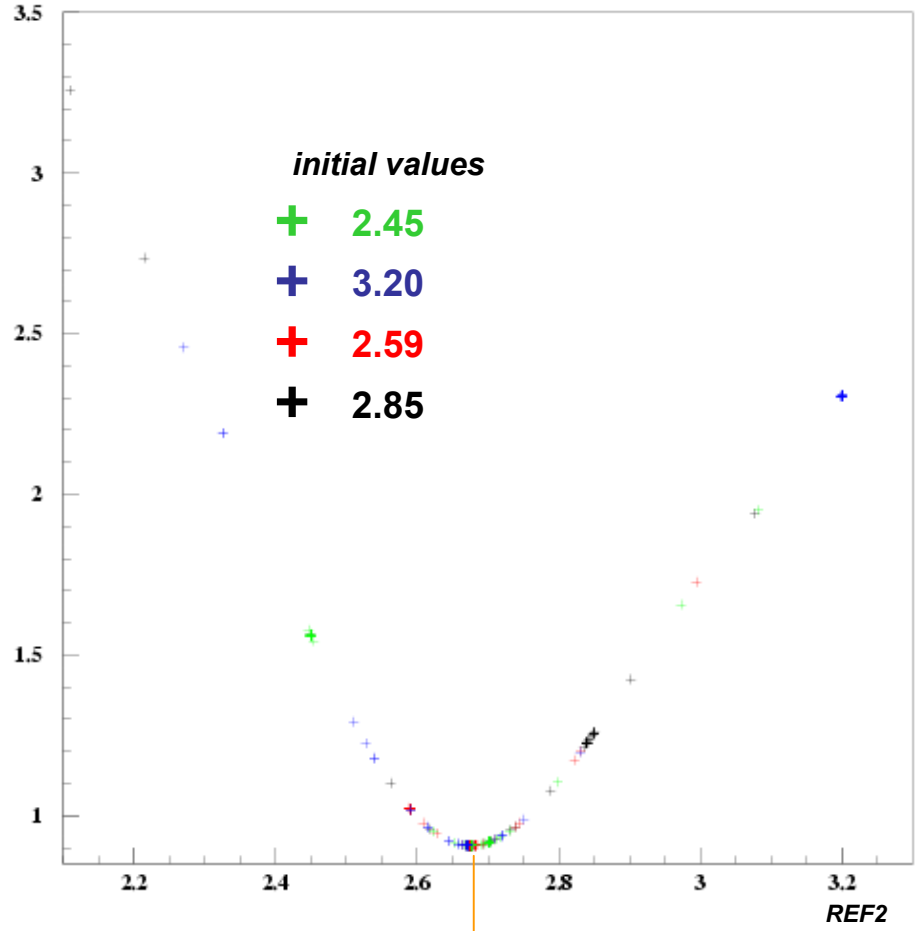


- **Function to minimize:**
  - **Sigma(E)/3 MeV (at z=216, 226, 232, 239.6, 247 m)**



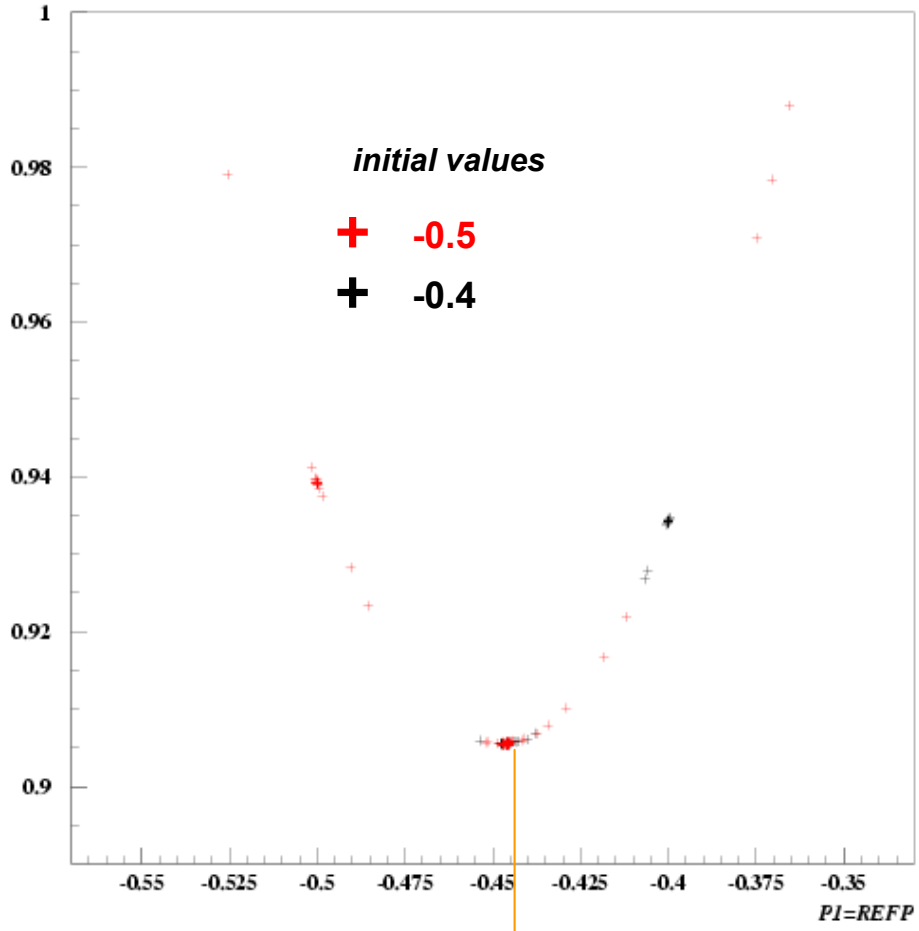

- **1st attempt: leave 1 or 2 running while fixing the other par's**
  - **Check shape of minimized function**
- **Subsequently release 1-4 par's (p5 fixed) and run minimization**
  - **Results**

## Fix all but P2=REF2




~2.67

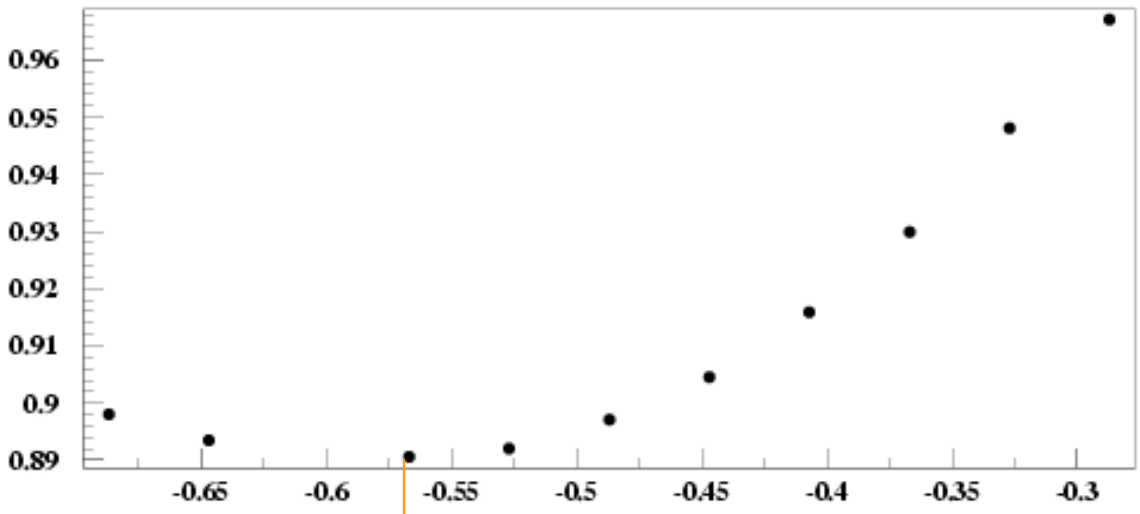
## Fix all but P1=REFP



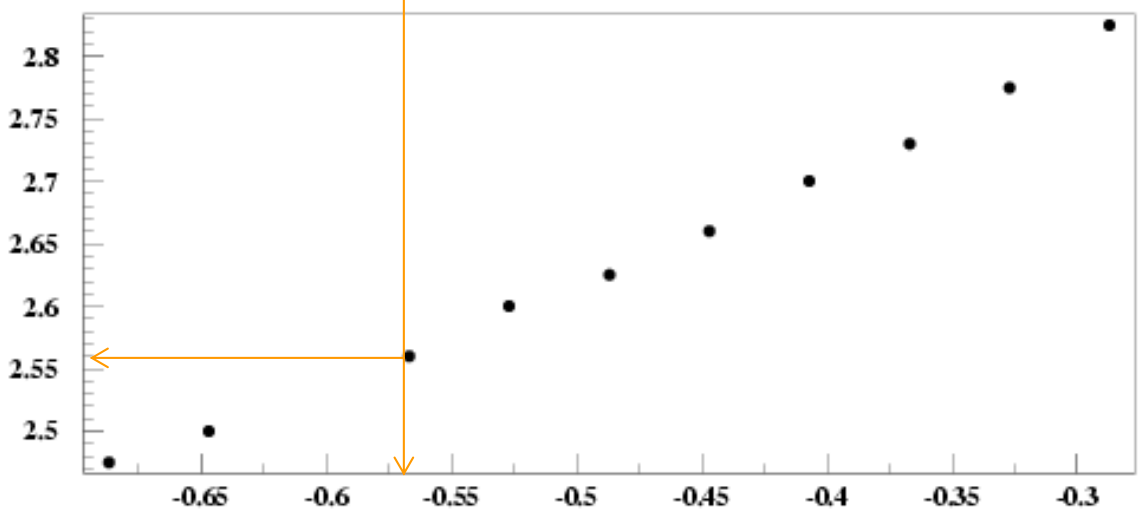

~-0.446

NB: MINImize routine used here

## *Fix 3,4,5 and minimize over P2 scanning on P1*




***FCN vs P1***




***P2 vs P1***

***Comment: when fixing all the parameters but one minimization produces a new value which is very close to the starting one***

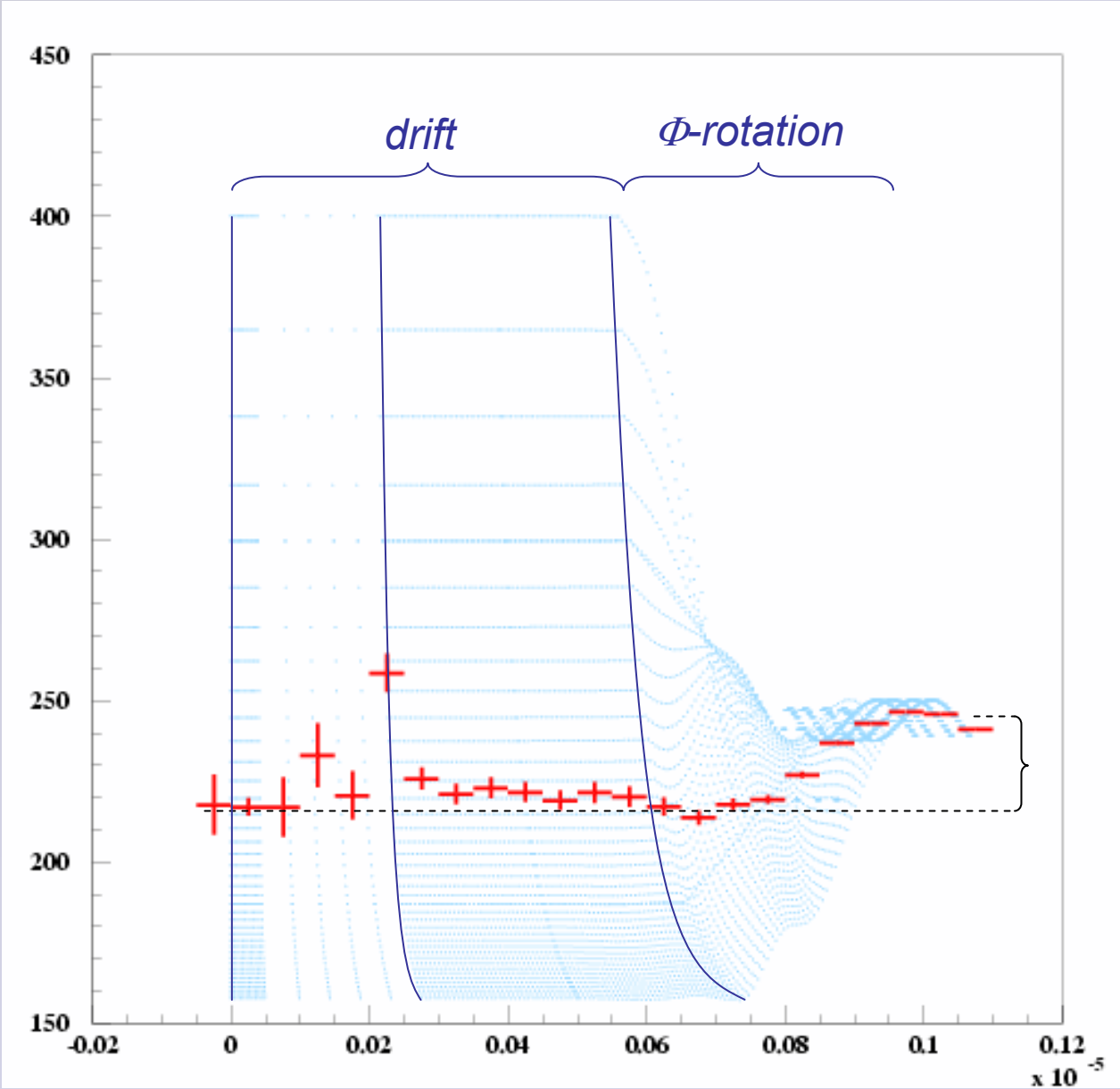
***i.e.: the initial choice of parameters is sensible***

***BUT parameters can be correlated …***

***Also, P5 is related to energy in the cooling section: for the moment cooling is ignored therefore P5 is set (and fixed) to its original value .214. Focus only on the energy spread reduction after Φ-rotation***

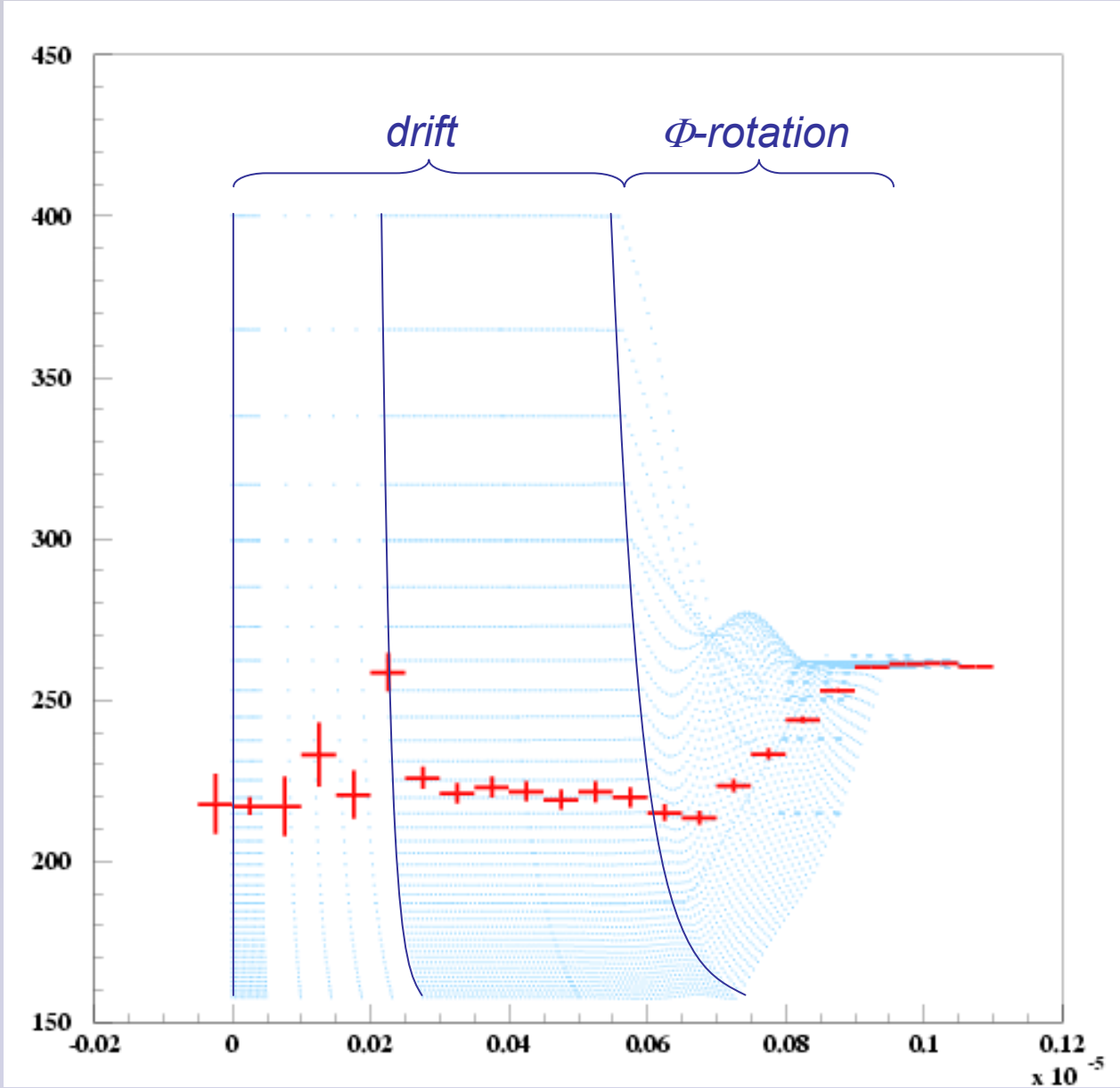
**Evolution of the set of 40 muons with *NON* optimized parameters**

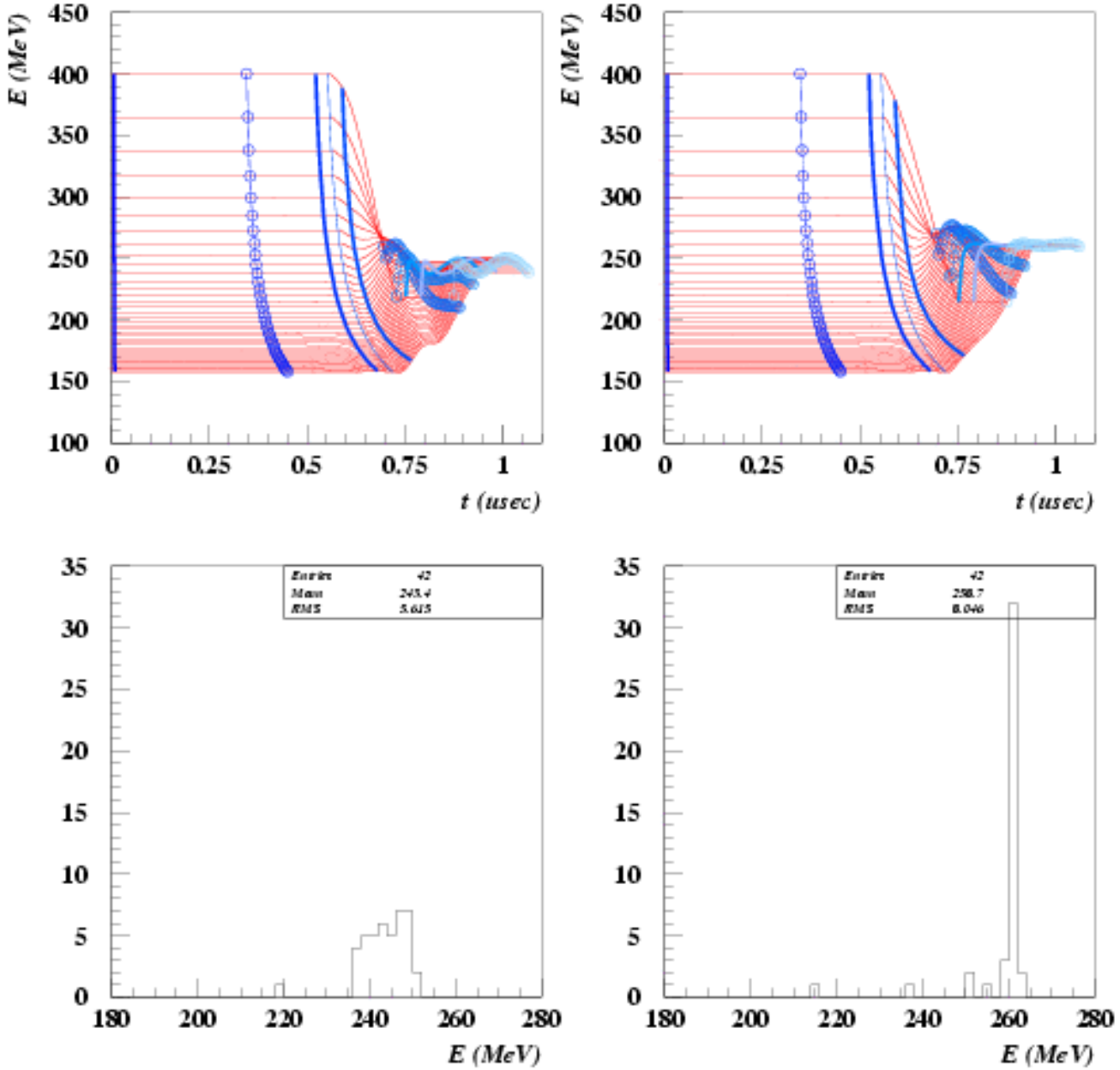
**N.B. there's a shift in the average value of the energy (~30 MeV) [?]**



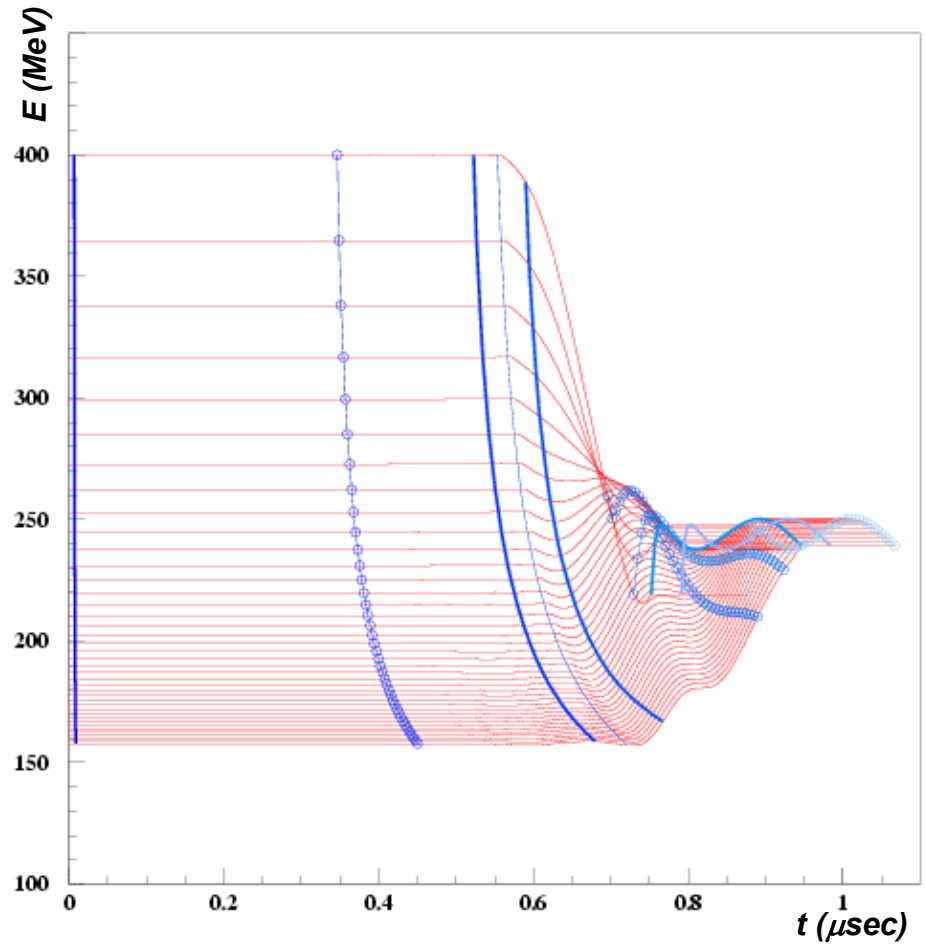
*P5=fixed and minimzation run over P1, P2, P3 and P4*

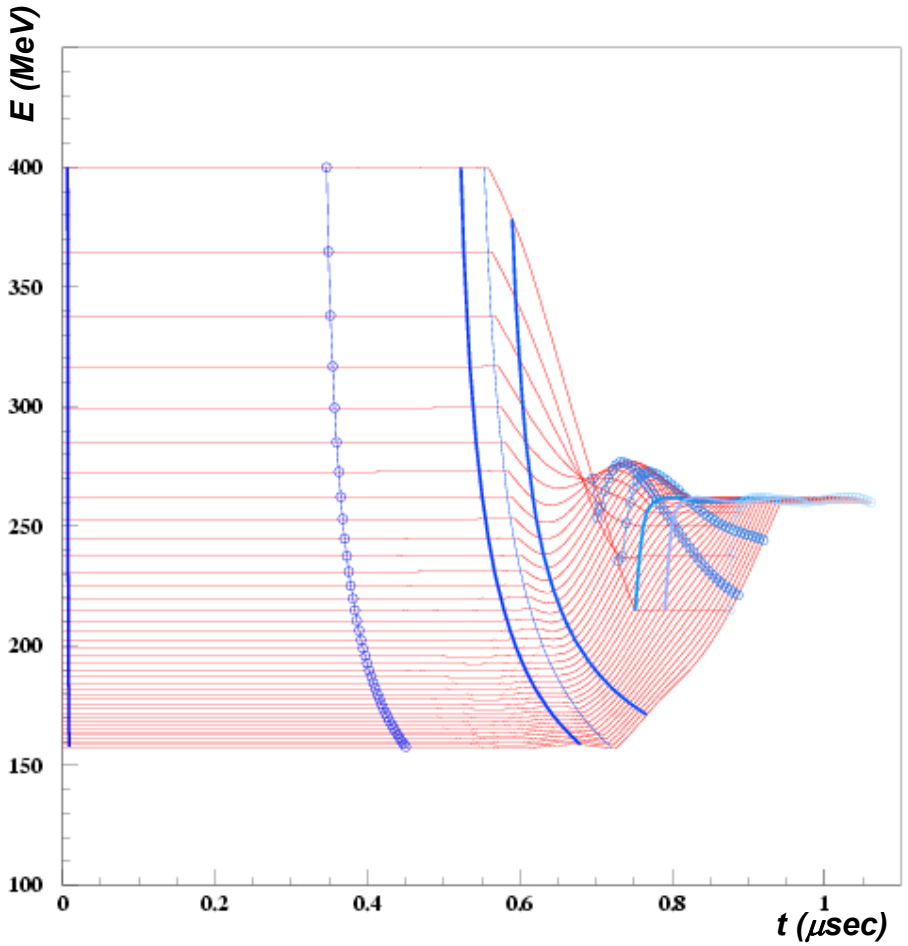
| | ini. | final |
|---|---|---|
| P1 | -0.567 | -0.43 |
| P2 | 2.57 | 3.11 |
| P3 | 18.01 | 18.11 |
| P4 | 8.93 | 6.327 |
| P5 | 0.214 | 0.214 |




E (MeV)
t (usec)
Entries 42
Mean 245.4
RMS 5.615
Entries 42
Mean 258.7
RMS 8.046
E (MeV)

# Evolution of the ensemble of muons through the channel regions



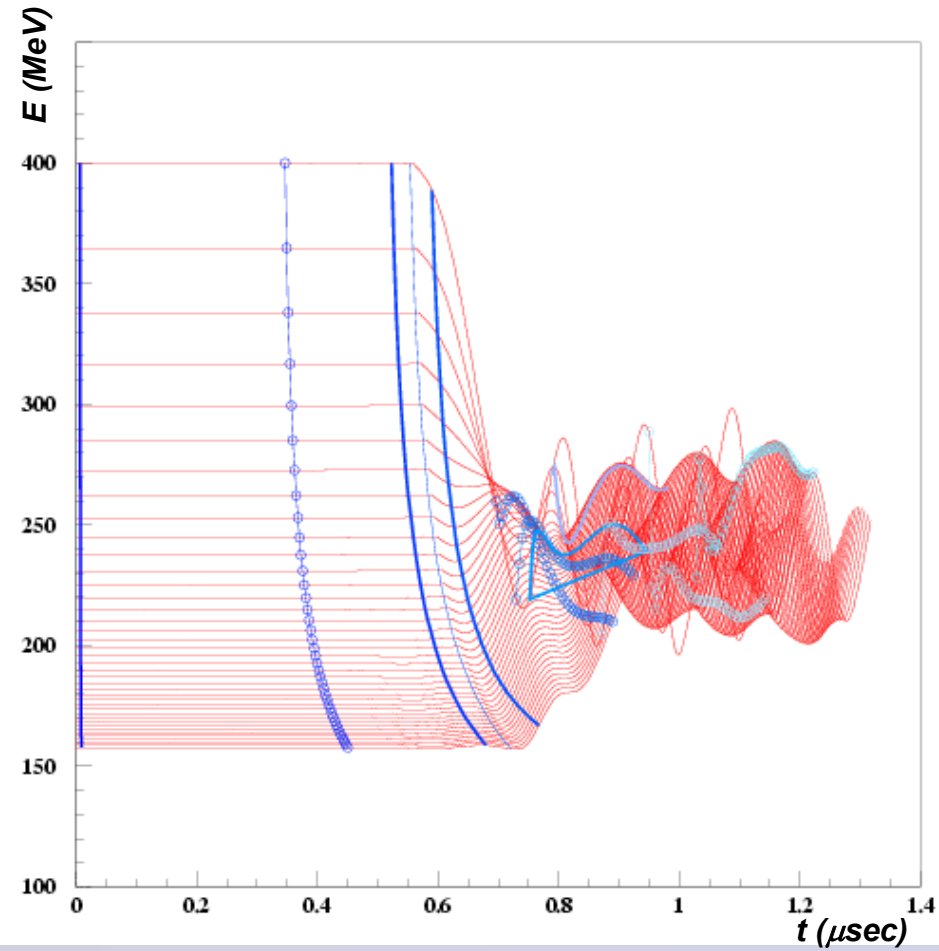



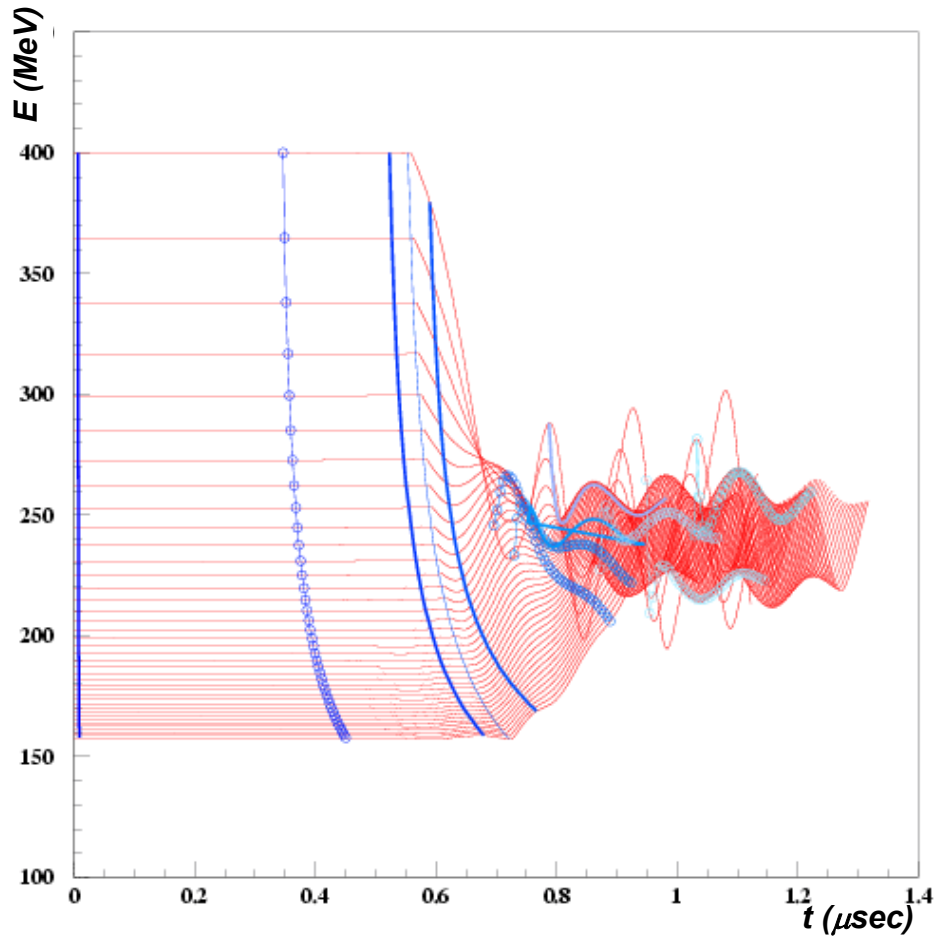

*non optimized parameters*
*-0.567, 2.57, 18.016, 8.93, 0.214*

*optimized parameters*
*-0.43, 3.11, 18.116, 6.33, 0.214*

## Now turn the COOLING ON …

| drift | Φ-rotation | cooling |
|---|---|---|




***non optimized parameters***
***-0.567, 2.57, 18.016, 8.93, 0.214***

***optimized parameters***
***-0.57, 2.57, 18.06, 9.88, 0.214***

# Conclusions:

- ICOOL+endof9+ecalc9 wrapped in MINUIT:
  - Optimization of parameters for $\Phi$-rotation
- PAR5 fixed, PAR1-4 optimized requiring sigmaE to be minimized
  - At first optimization is done ignoring the cooling (interesting/promising)
  - Then cooling is switched on (to be understood)
- Pretty fast: couple of hours with 4 param's
- Ultimately we want to understand how many muons are left after the cooling stage, and -possibly- to optimize this number

# To be done:

- *Verify the new parameters on a full and more realistic simulation*
- *Think about a better function to minimize (taking into account also the number of muons)*