Front End US scheme: Study 2A dependence on the proton bunch length

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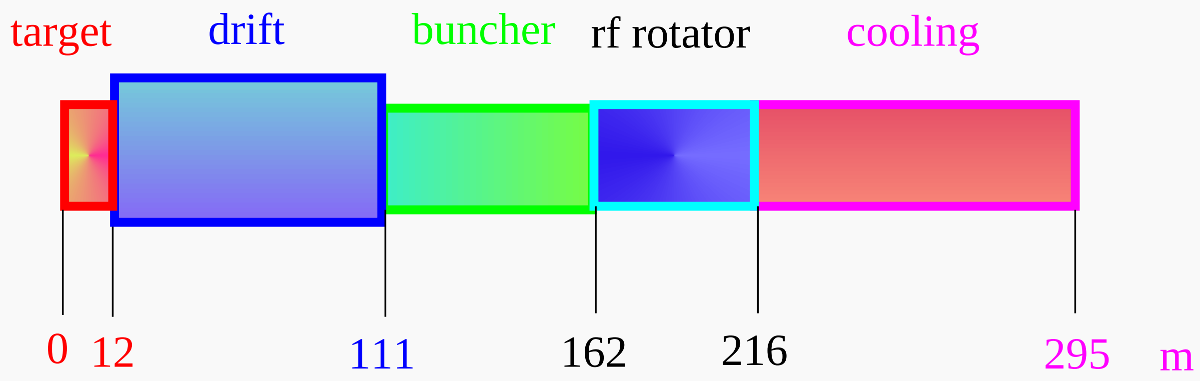
BROOKHAVEN NATIONAL LABORATORY

Neutrino Factory Muon Collider

Outline

- Reminder: brief description of the Front End
- Pion distribution for different proton bunch length
- Icool results

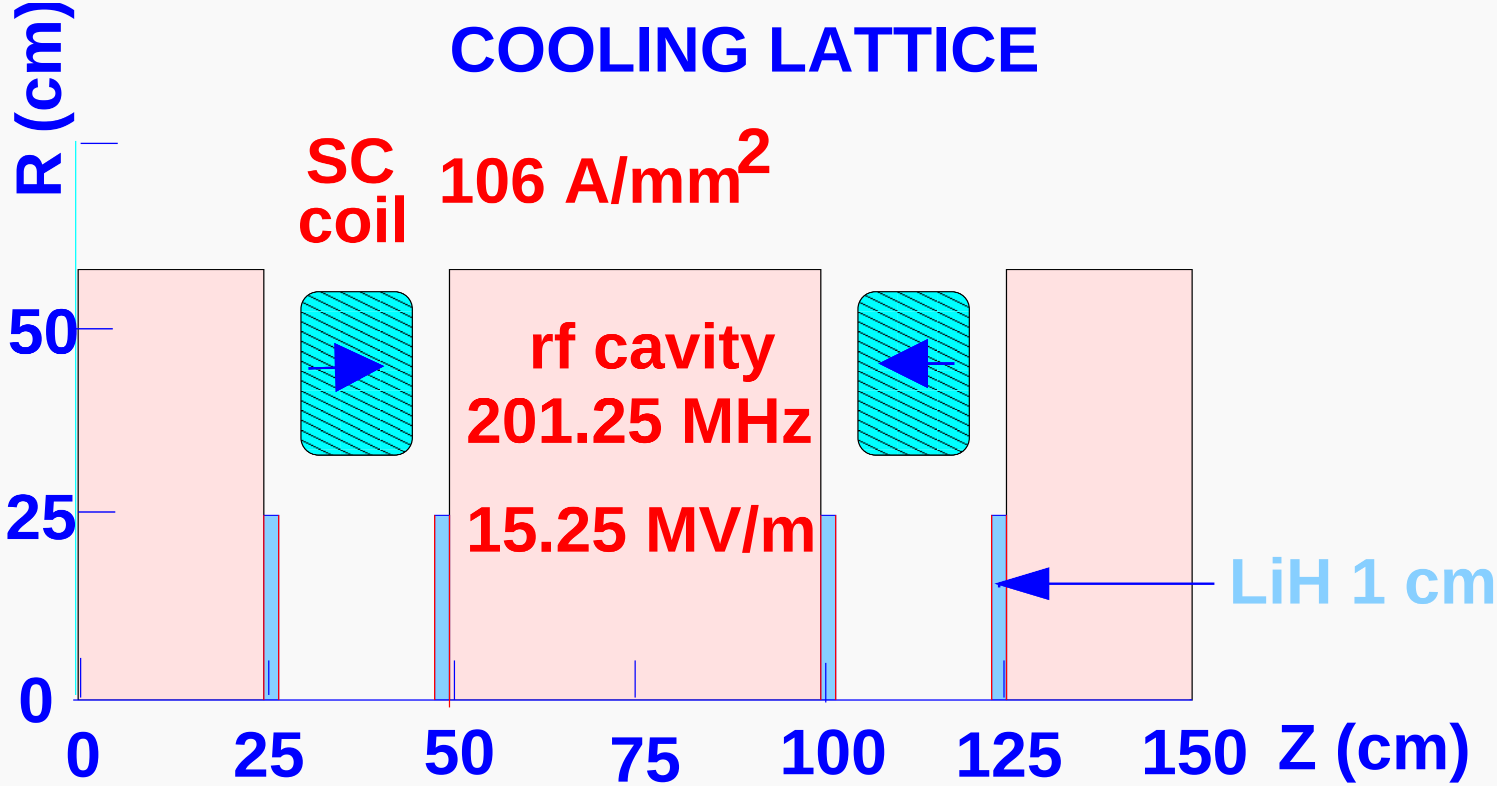
Layout of Front End



- Capture Section: Hg jet target; AGS type proton beam. Length ≈ 12m $20 < B_z < 1.75$ T
- Decay Drift: Length≈ 100 m $B_z = 1.75$ T
- Adiabatic Bunching: 27 cavities with 13 different $\Downarrow$ frequencies and changing $\Uparrow$ gradients. Length ≈ 50 m
- Phase Rotator: 72 cavities with 15 different $\Downarrow$ frequencies; constant gradient. Length ≈ 50 m
- cooling section: Length ≈ 8 m

Cooling Section

Schematic of one cell of the cooling section



Beta function is constant ≈ 80 cm. Window are absorbers; they are 1 cm LiH with coating, 25μm of Be.

General comments

The secondary pions create in the proton-target interaction is described by

$$\rho_\pi\left(\{x\},t\right) = \int d\{y\}dt'\mathcal{G}\left(\{x\}-\{y\},t-t'\right)\rho_P(\{y\},t') \tag{1}$$

where ρ_P is the initial proton distribution and $\mathcal{G}(\{x\},t)$ represents the hadrons physical processes. For different initial proton temporal distributions, we write

$$\rho_P^\delta(\{y\},t') = \Delta_P(\{y\})\delta(t') \quad \textit{delta-function} \tag{2}$$

$$\rho_P^G(\{y\},t') = \Delta_P(\{y\})\exp(-t'^2/2\sigma^2)/\sqrt{2\pi}\sigma \quad \textit{Gaussian} \tag{3}$$

General comments

From Eqs.1 and 2 we can write

$$\rho_\pi^\delta\left(\{x\},t\right) = \int d\{y\}dt'\mathcal{G}\left(\{x\}-\{y\},t-t'\right)\Delta_P(\{y\})\delta(t') \qquad (4)$$

for a proton delta-function distribution and from Eqs. 1 and 3

$$\rho_\pi^G\left(\{x\},t\right) = \int d\{y\}dt'\mathcal{G}\left(\{x\}-\{y\},t-t'\right)\Delta_P(\{y\})\exp\left(-t'^2/2\sigma^2\right)/\sqrt{2\pi}\sigma \qquad (5)$$

for a proton Gaussian distribution.

General comments

From Eqs. 4 and 5 we conclude that

$$\rho_\pi^G\left(\{x\},t\right) = \int dt' \rho_\pi^\delta\left(\{x\},t'\right) \exp\left(-(t-t')^2/2\sigma^2\right)/\sqrt{2\pi}\sigma \qquad (6)$$

hence the Gaussian proton distribution yield identical pion distribution as a Gaussian distribution of pions convoluted with a delta-function pion distribution (*Green function method*).

Implementation

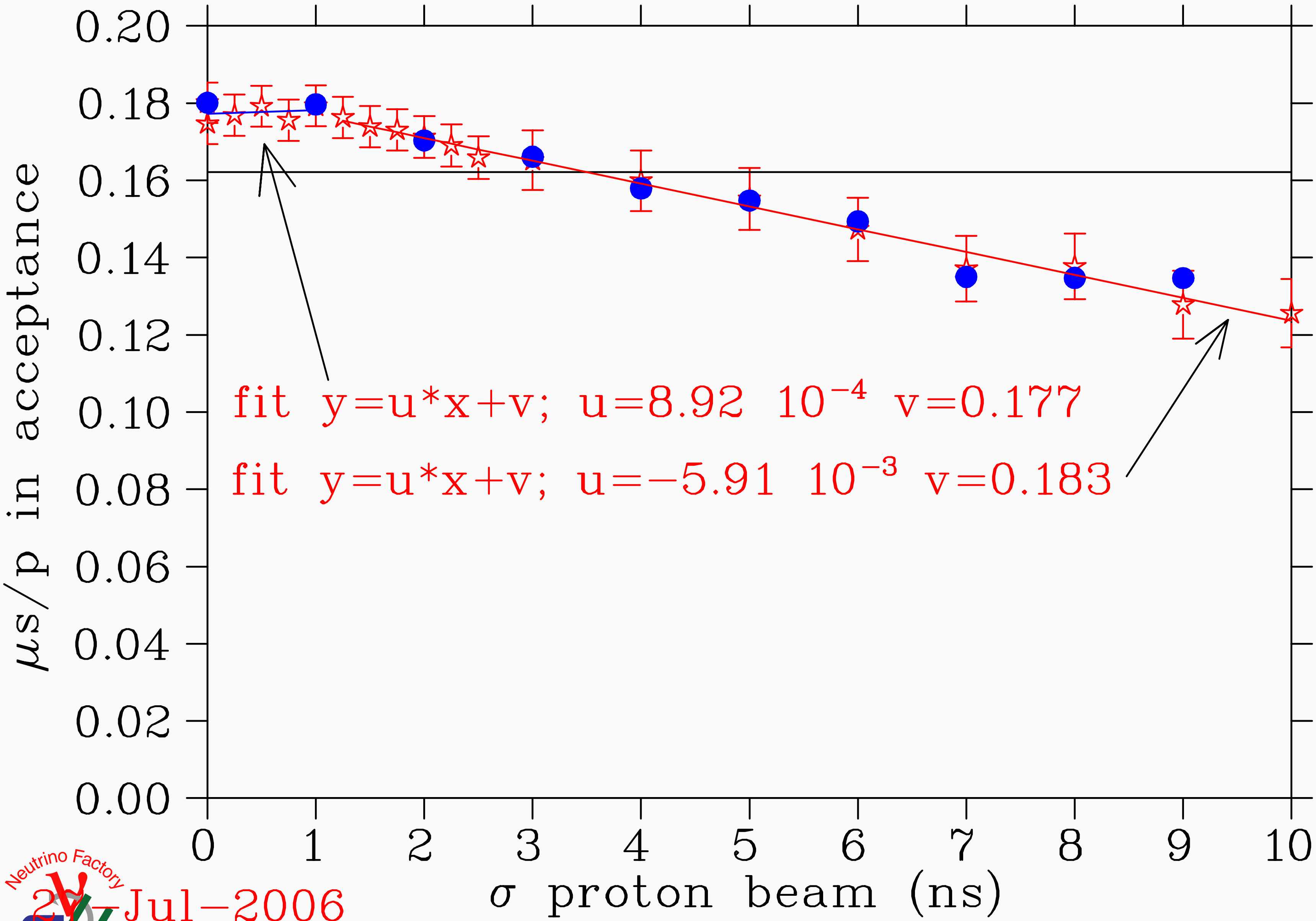
How do we implement this? Each time t_i associate to one pion in ρ_π^δ is replaced by $u_i = t_i + \sigma G_i$.
The probability density for the random variable t_i is a *(discrete)* pion distribution (see Eq. 4)

$$\rho_\pi^\delta(\{x\}, t) = \frac{1}{\sum_i \omega_i} \sum_i A(\{x\}, t_i) \omega_i \delta(t - t_i) \quad (7)$$

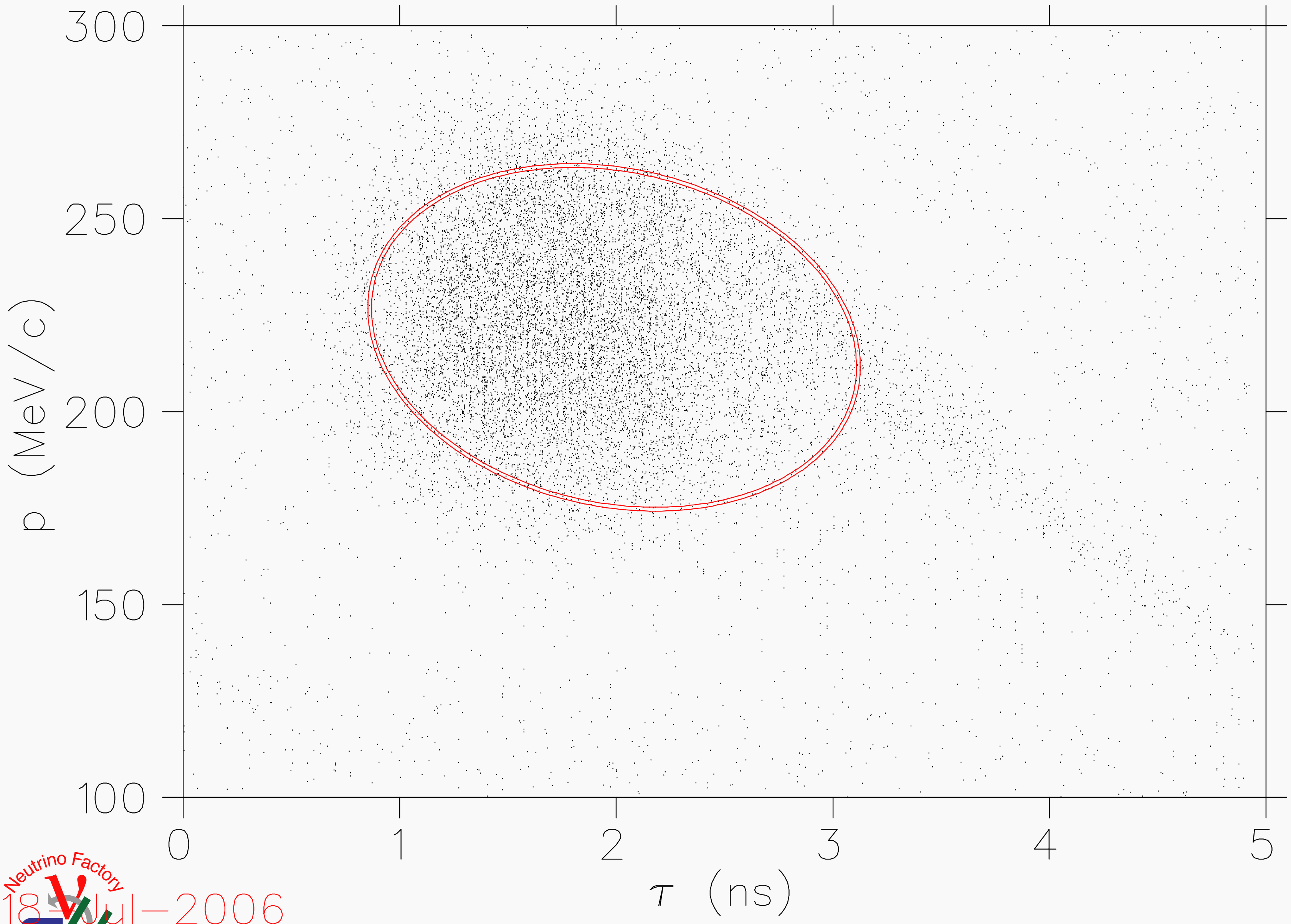
with $A(\{x\}, t_i) = \int d\{y\} \mathcal{G}(\{x\} - \{y\}, t_i) \Delta_P(\{y\})$.
The probability density for the second random variable is $G(t) = \exp\left(-t^2/2\right)/\sqrt{2\pi}$.
The probability density for the addition u is (see Eq. 6)

$$\rho_\pi^G(\{x\}, u) = \frac{1}{\sum_i \omega_i} \sum_i A(\{x\}, t_i) \omega_i \exp\left(-(u - t_i)^2/2\sigma^2\right)/\sqrt{2\pi}\sigma \quad (8)$$

ICOOL results



ICOOL results:Long. phase space



ICOOL results:Helicity