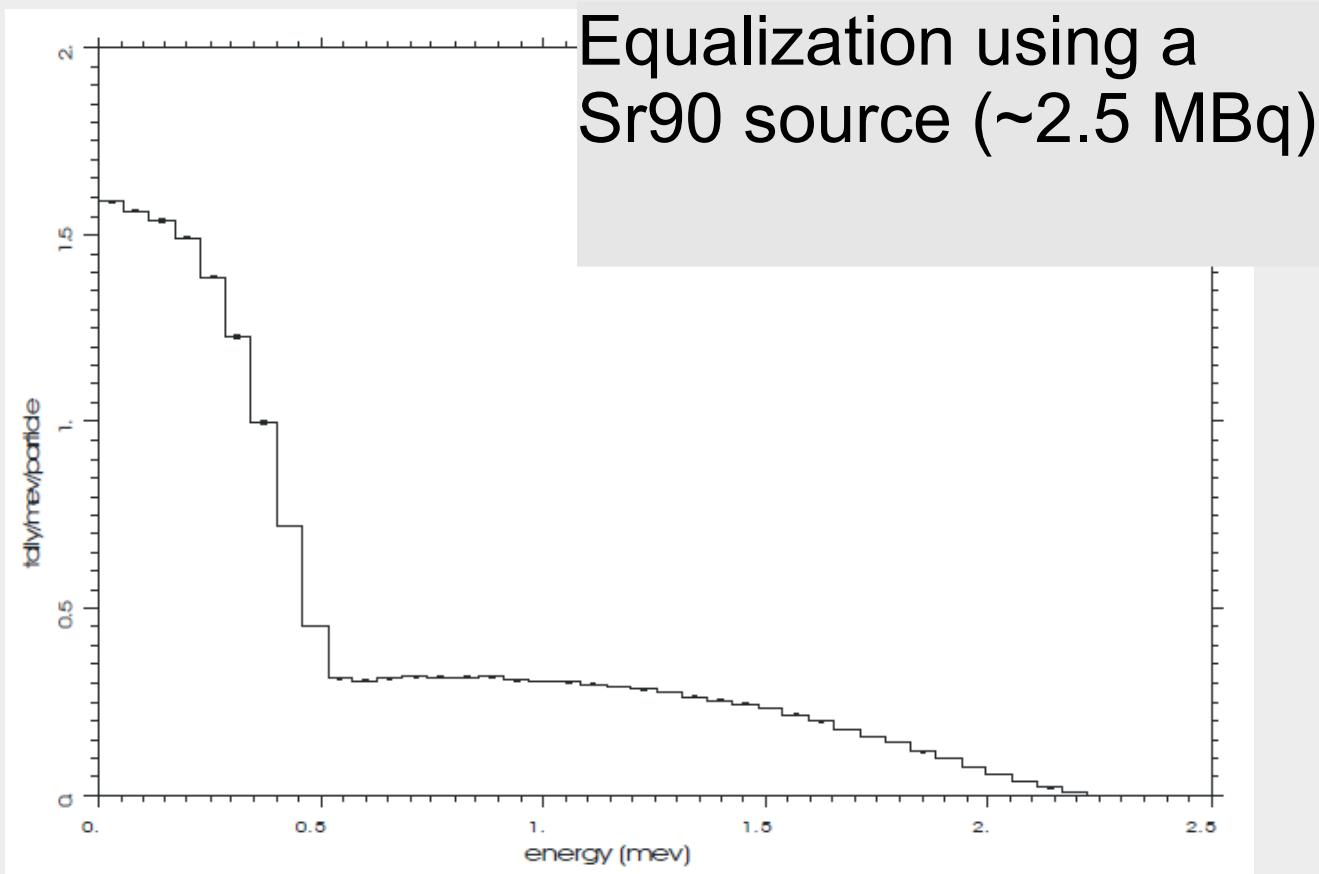


SPS Scintillator Counters

Equalization
Rate linearity

R.Santacesaria, L.Ludovici, for the Rome Group

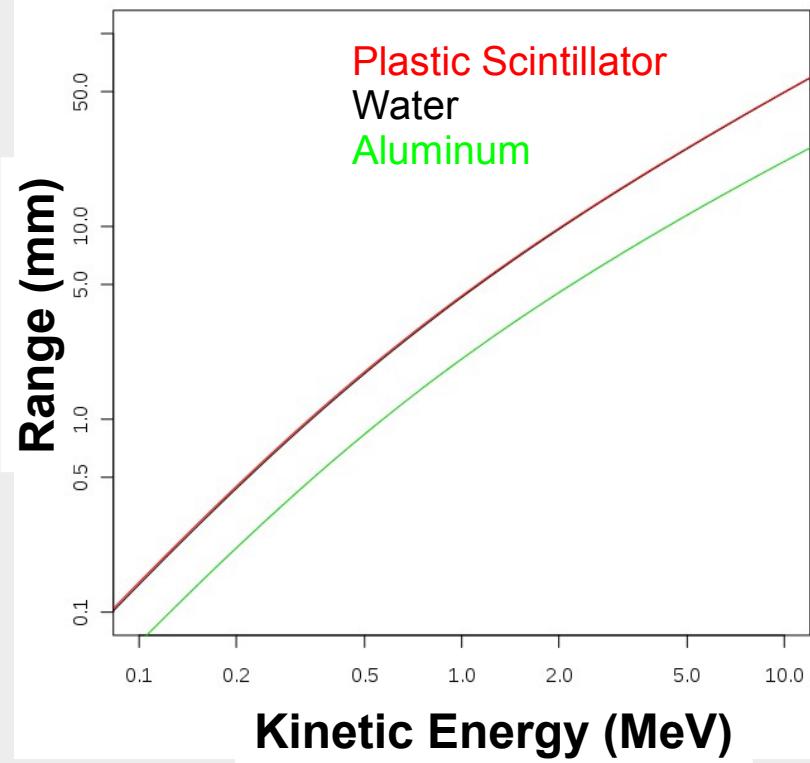
Thanks to: Simone, Jerome, Fabrizio,...



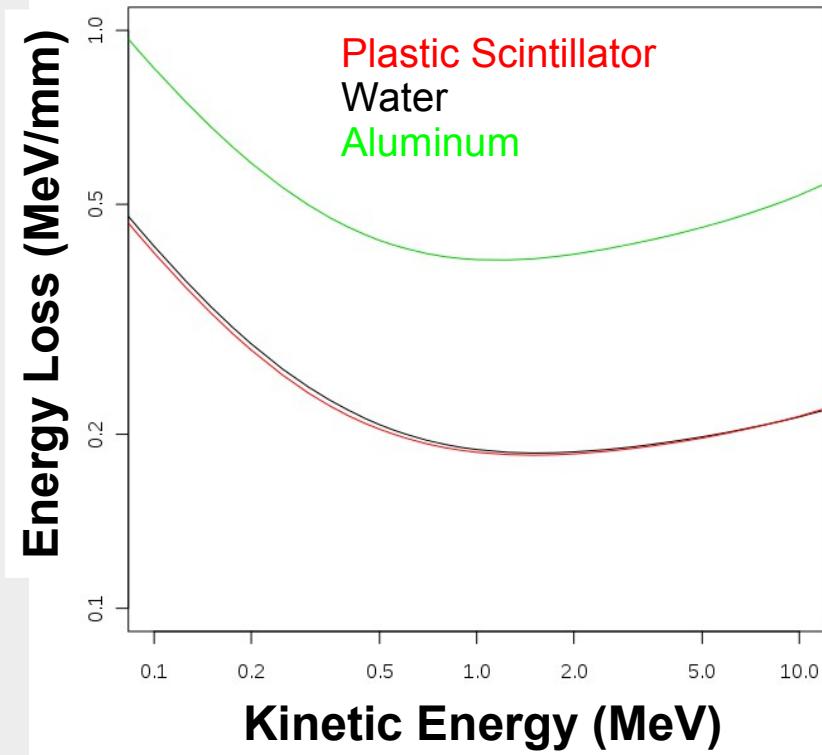
Sr⁹⁰ end point E_{kin}=0.53 MeV, γ =2.05, E=1.05 MeV

Y⁹⁰ end point: E_{kin}=2.23 MeV, γ =5.37, E=2.74 MeV

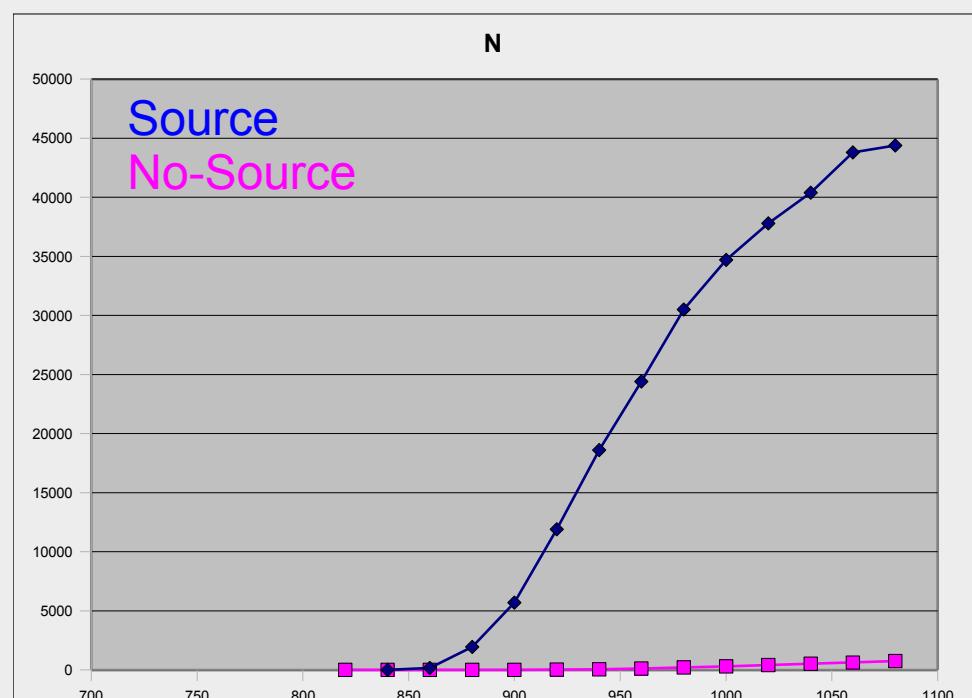
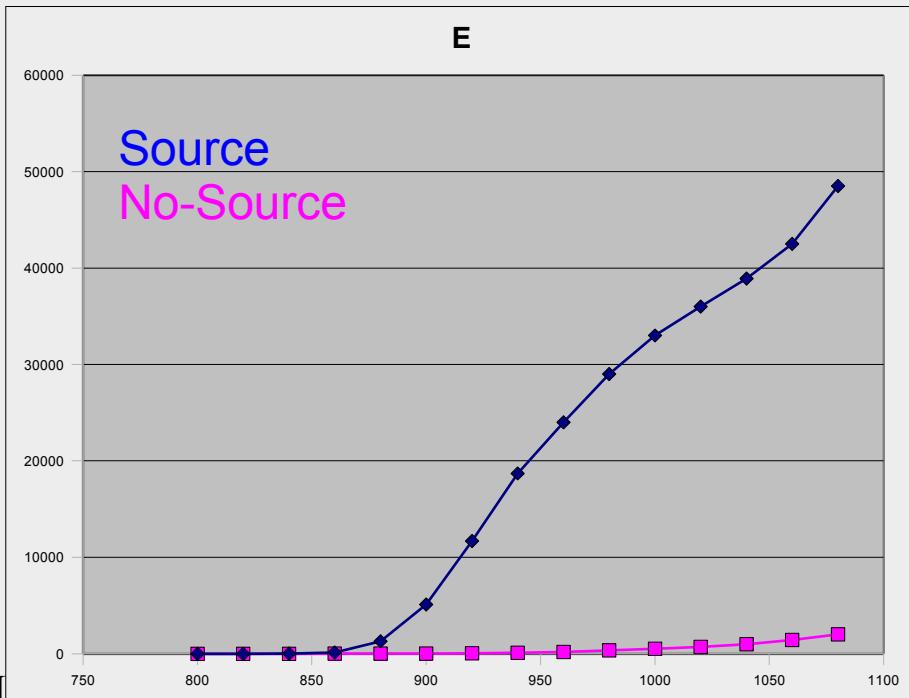
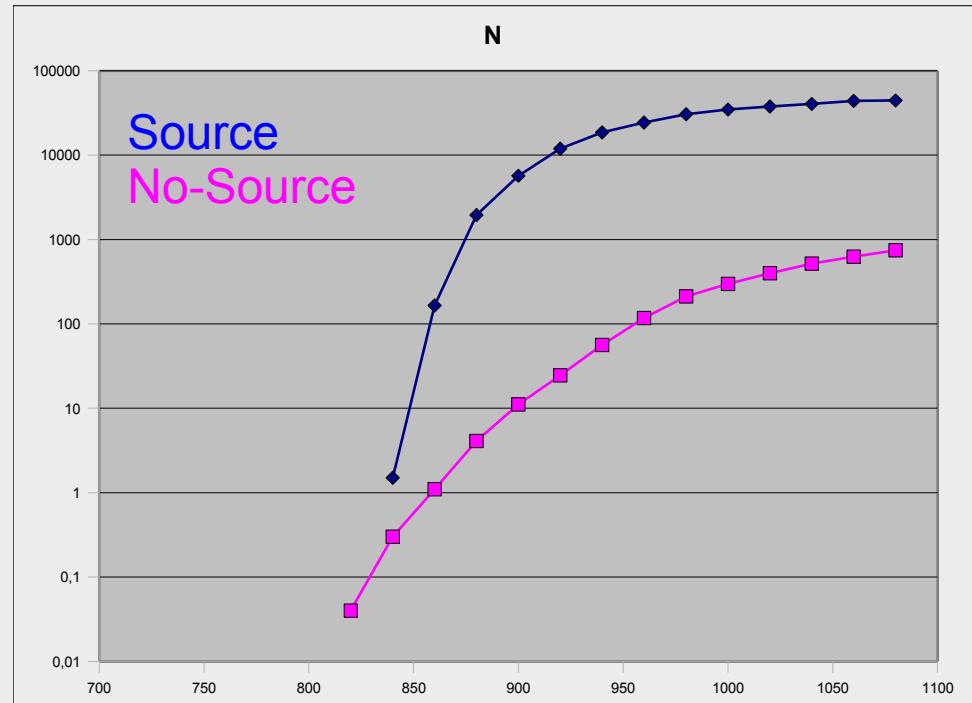
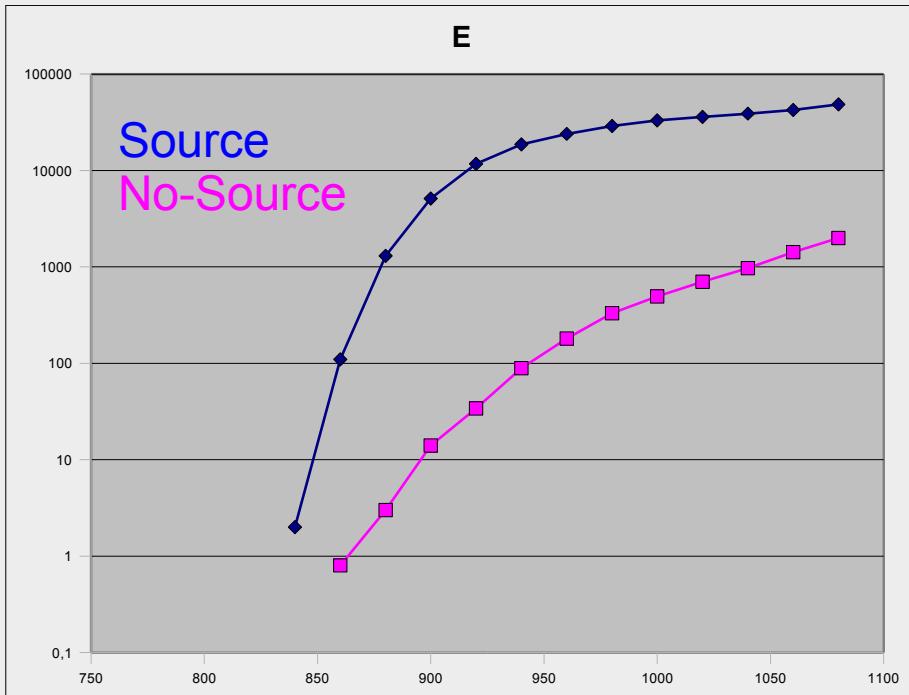
Electron range



Stopping power



Rate vs HV (E&N)

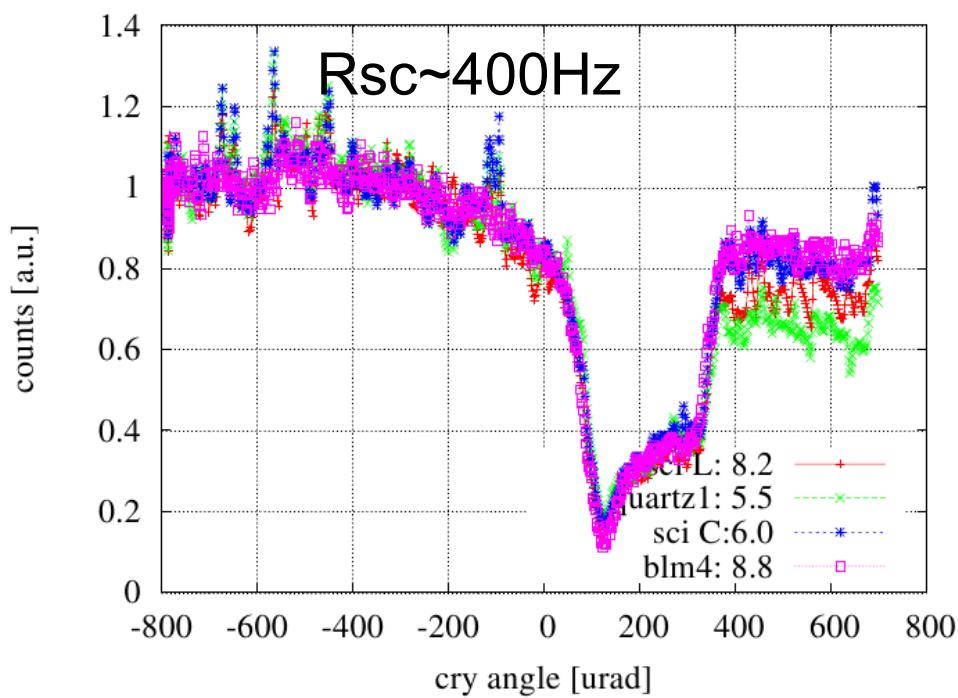


- No plateau
- Noise is important (10-600 Hz)
 - Similar to source as a function of HV setting
 - Depends on counter position and shielding
 - It is physics, due to radioactivity in the SPS tunnel
 - Coincidence kill the noise

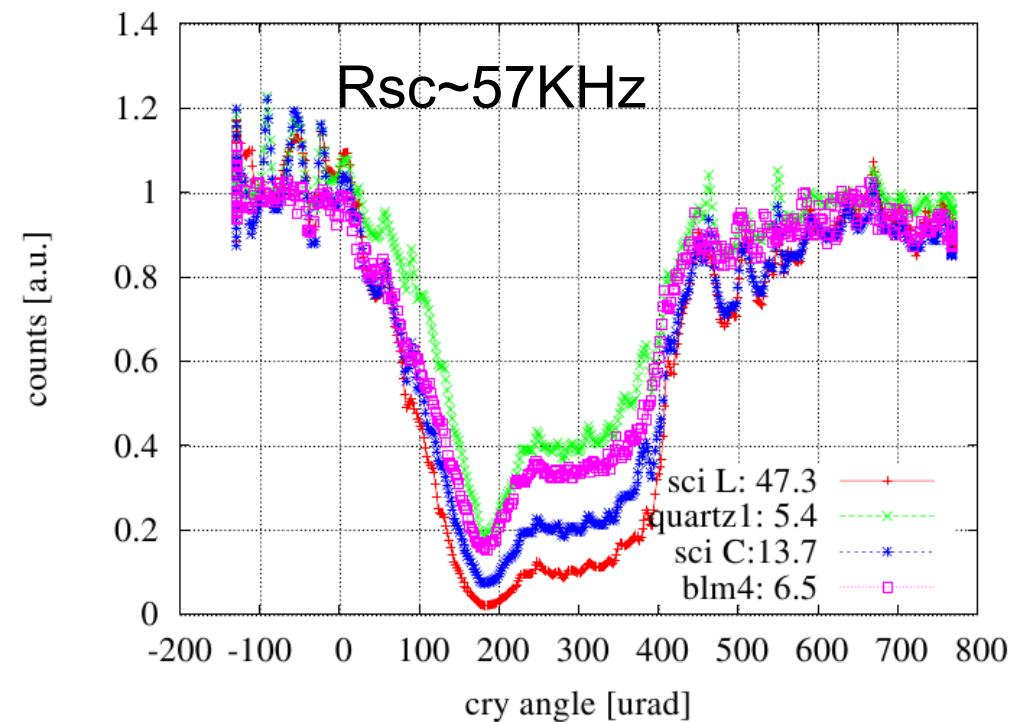
Equalization

- Adjust HV to match the same rate (tentatively 12 Khz) with the Sr90 source
- Different wrappings: small effect on the endpoint, small also on the total rate
- Different scintillator thicknesses (5-15mm) (large effect but easy to evaluate)
- Threshold rough estimation: 1/10(1/2) of a MIP for new(old) counters

$I = 2.7 \cdot 10^6$



$I = 1.3 \cdot 10^7$



Pile-up and saturation

Since the bunch length is smaller than our time resolution, the readout scalers count the number of bunches with 1 or more interactions.

The maximum rate we can have with a single bunch, neglecting de-bunched protons, is $1/(T_{\text{sp}}=23\mu\text{s}) \sim 43.5\text{KHz}$.

Non-linearity

The relation between scintillator rates and interaction rate, depends on the scintillator acceptance (size, distance, geometry,...) and the efficiency.

Effects to be modeled

- Scintillator response to single protons
- Pile-up
- Saturation
- Off bunch protons
(Others?)

A few numbers

$$T_{SPS} = 23\mu s$$

Typical values for the rate of protons on crystal and crystal thickness:

$$I_o = 10^7 \text{ protons/s} \quad L_{Si} = 0.2\text{cm} \quad \lambda_{int} = 46.52\text{cm}$$

The interaction rate on crystal is (i.e. interacting protons/s):

$$R_{int} = I_o \cdot L_{Si} / \Lambda_{int} = 42992\text{Hz}$$

Average # of interactions per bunch is (all protons in a single bunch):

$$I_{int/b} = < \frac{\text{interactions}}{\text{bunch}} > = R_{int} \cdot T_{SPS} = 0.989$$

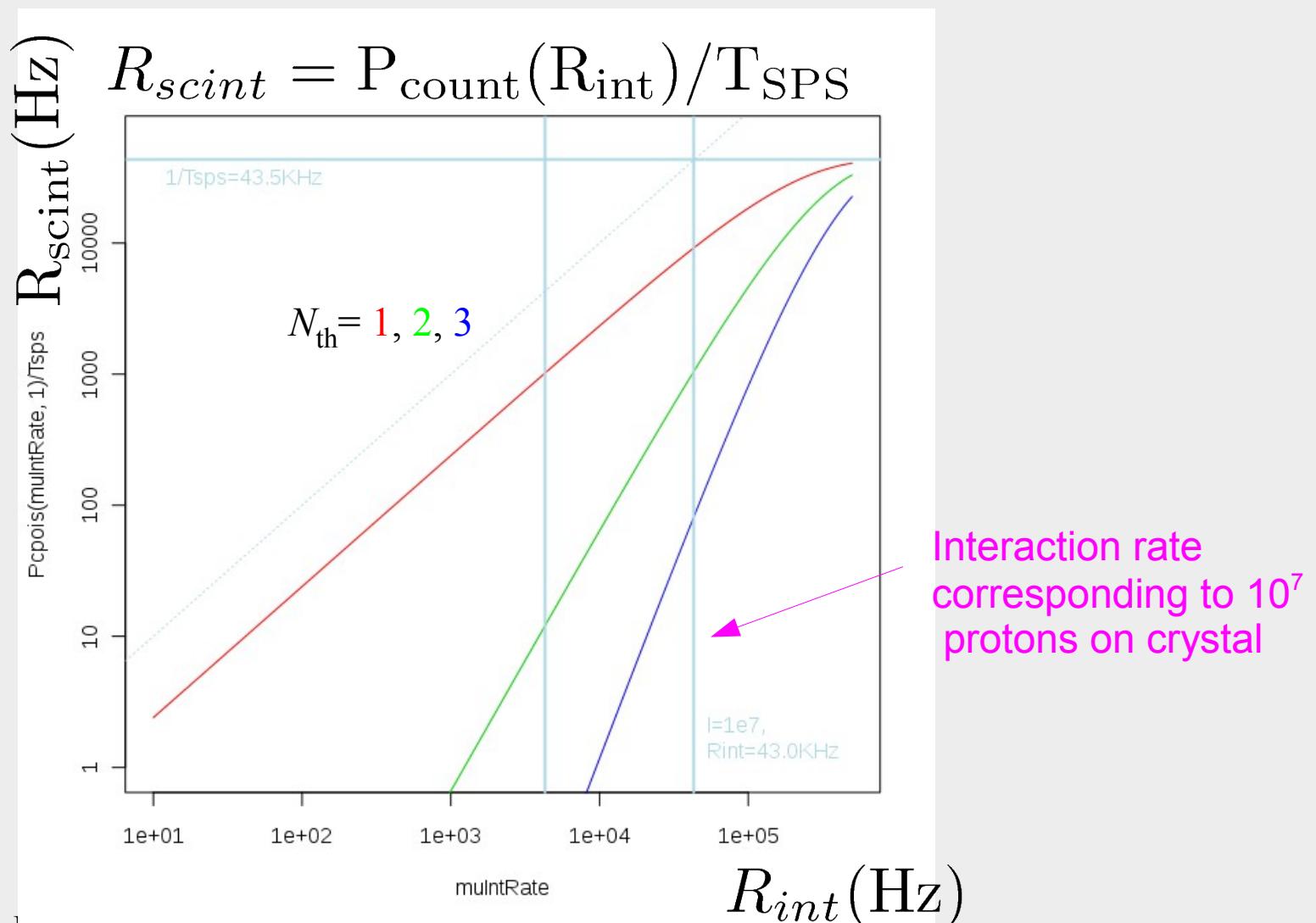
The average number of mips on a 100cm^2 scintillator at a typical distance from the crystal ($\sim 1\text{m}$) is $a_{\text{mips}} \sim 0.24$ per proton (Y.Ivanov)

$$\mu_{mips/b} = < \frac{\text{mips}}{\text{bunch}} > = I_{int/b} \cdot a_{\text{mips}} \sim 0.237$$

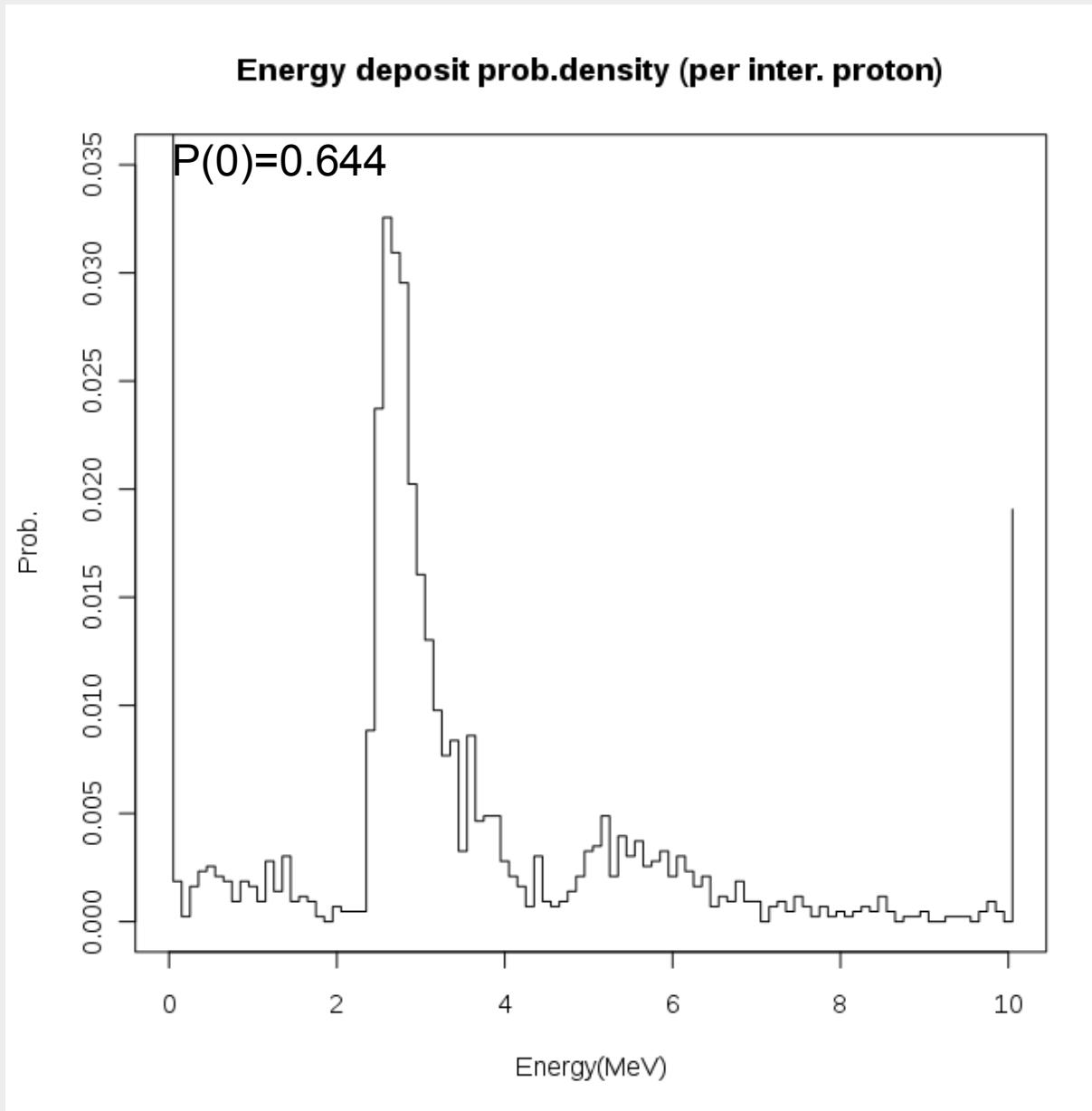
A straw-man model of pile up

From a simple Poissonian model of the scintillator response as a threshold at n_{th} mips, the probability to tag/count a bunch is:

$$P_{\text{count}}(R_{\text{int}}) = \sum_{k \geq n_{th}}^{\infty} \text{Poiss}(k, \mu_{\text{mips/b}}) = \sum_{k \geq n_{th}}^{\infty} \text{Poiss}(k, R_{\text{int}} \cdot T_{\text{SPS}} \cdot a_{\text{mips}})$$

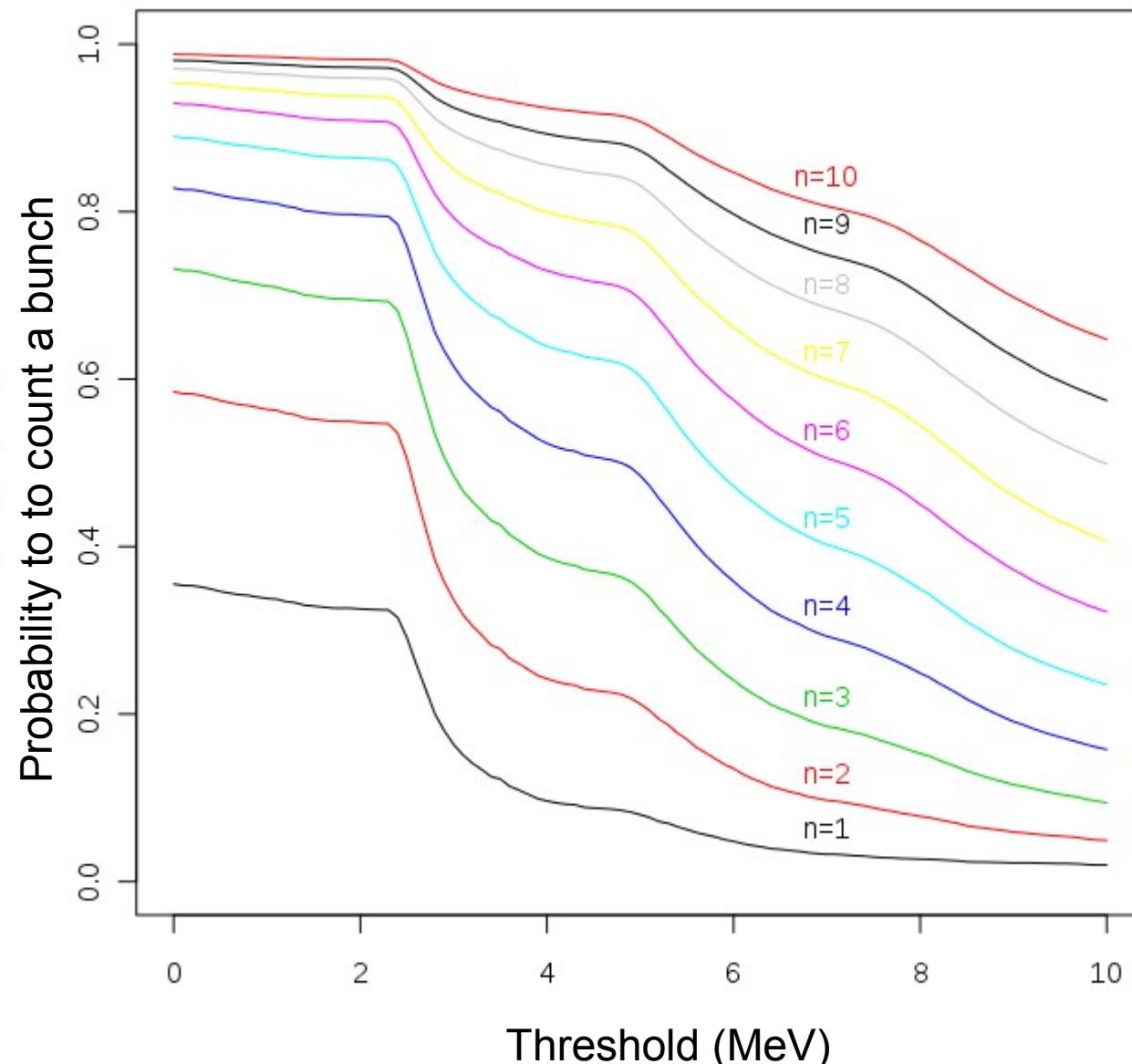


A more realistic calculation using G4 Energy deposit (GC)



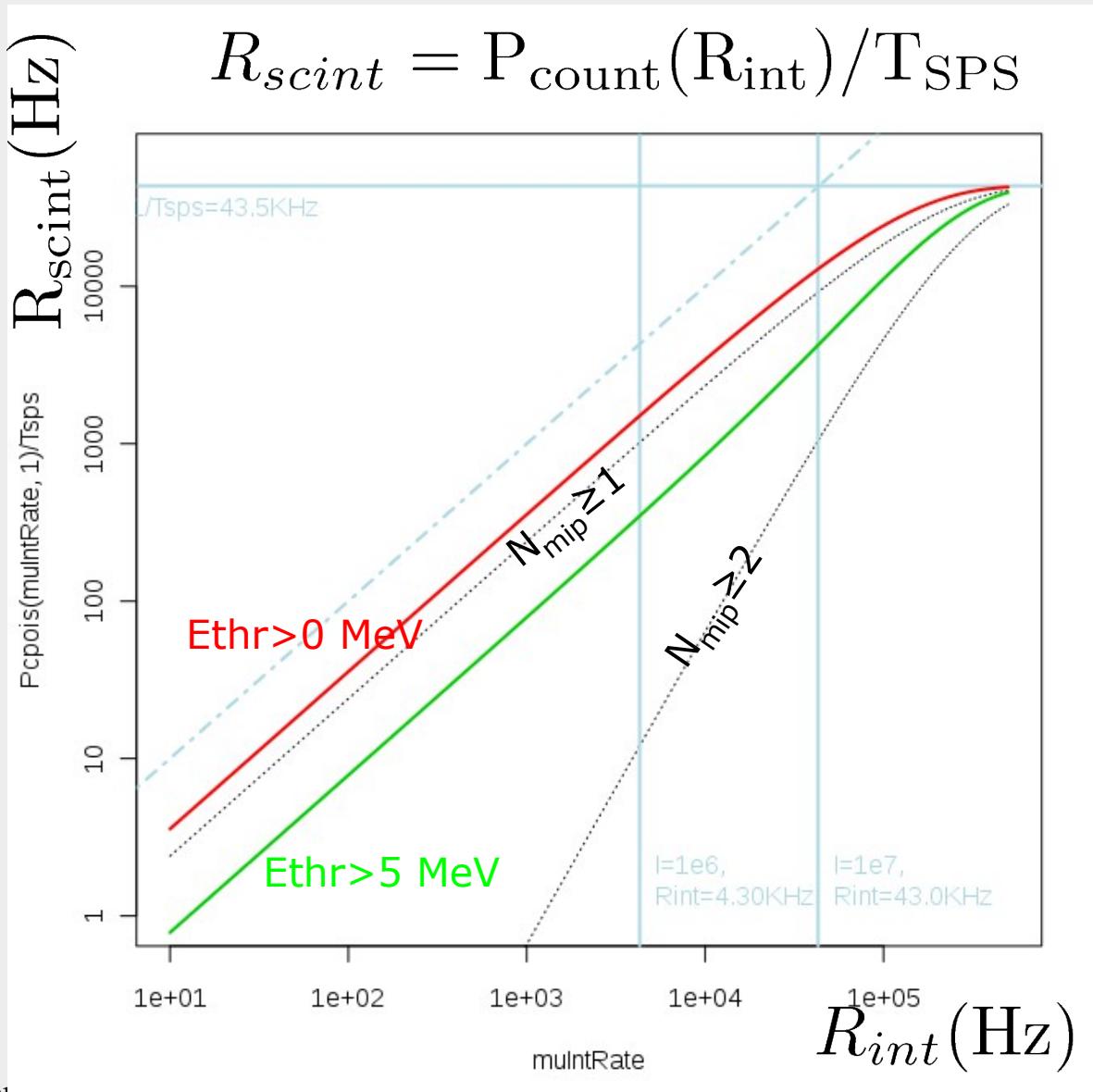
Pile-up

$$P(n_{int.\text{prot.}}, E_{\text{thresh}})$$



Scintillator rate

$$P_{\text{count}}(R_{\text{int}}) = \sum_{n_{\text{ip}}=0}^{\infty} \text{Poiss}(n_{\text{ip}}, R_{\text{int}} \cdot T_{\text{SPS}}) \cdot P(n_{\text{ip}}, E_{\text{thresh}})$$



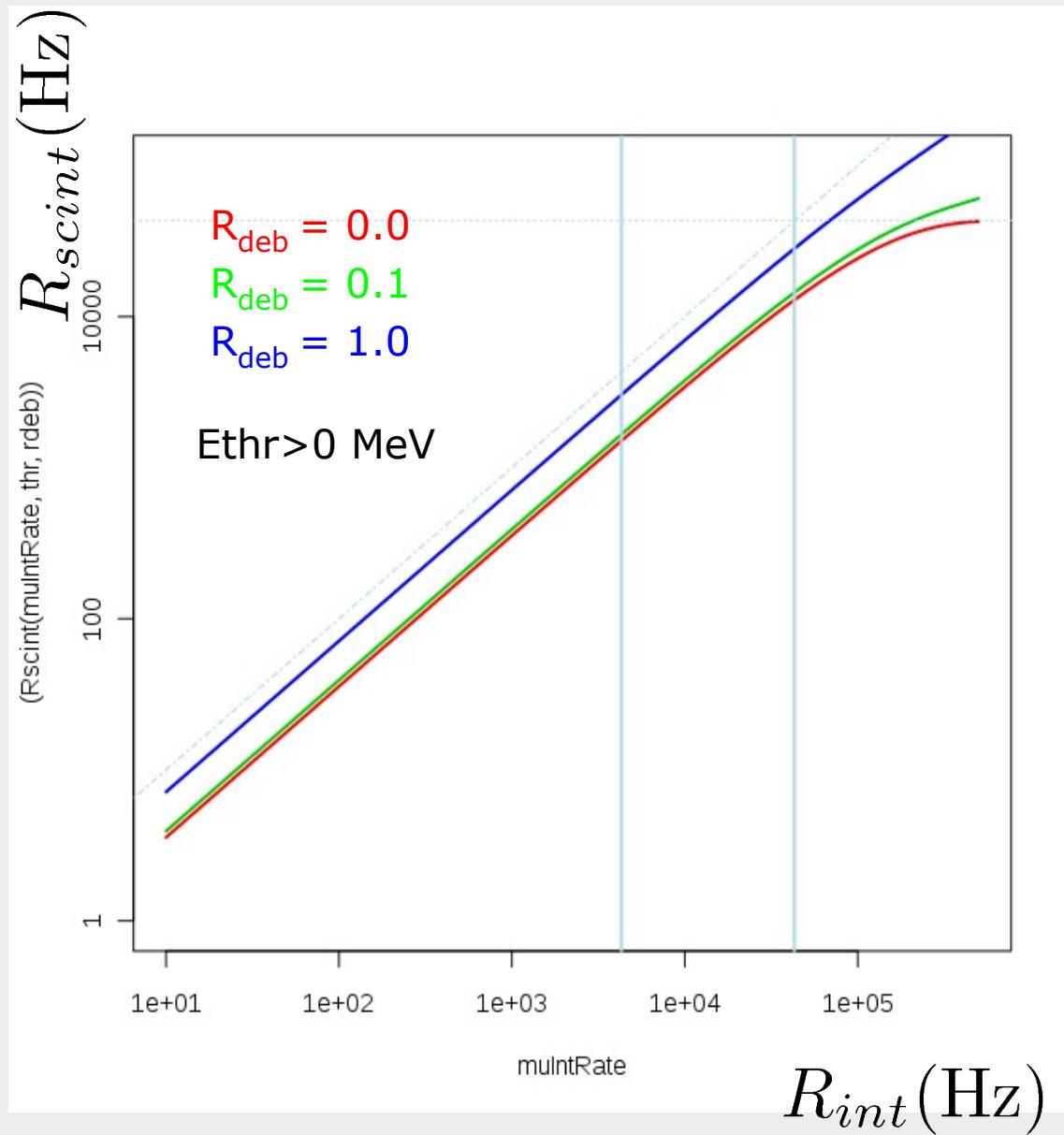
Effect of debunched protons

$$r_{deb} = I_{debunched}/I_{\circ}$$

$$R_{debunch} = r_{deb} \cdot R_{int} \cdot P(1, E_{thresh})$$

$$R_{bunch} = P_{count}(R_{int}) \cdot \frac{1}{T_{SPS}}$$

$$R_{scint} = R_{bunch} + R_{debunch}$$



Action list

- Apply gate to the SPS timing and count both bunched and debunched rates.
- Comparison with existing data (?)
- Take some dedicated data (different rates in reproducible conditions)
- Optimize new counter size (\rightarrow dynamic range)
- Measure charge ?