Ion accumulation and cooling at low energy

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FLUX

- The Design Study is aiming for:
  - A beta-beam facility that will run for a "normalized" year of 10^7 seconds
  - An integrated flux of $10*10^{18}$ anti-neutrinos (^6He) and $5*10^{18}$ neutrinos (^{18}Ne) in ten years running at $\gamma=100$

with an Ion production in the target to the ECR source:

- $^6He= 2*10^{13}$ atoms per second
- $^{18}Ne= 8*10^{11}$ atoms per second

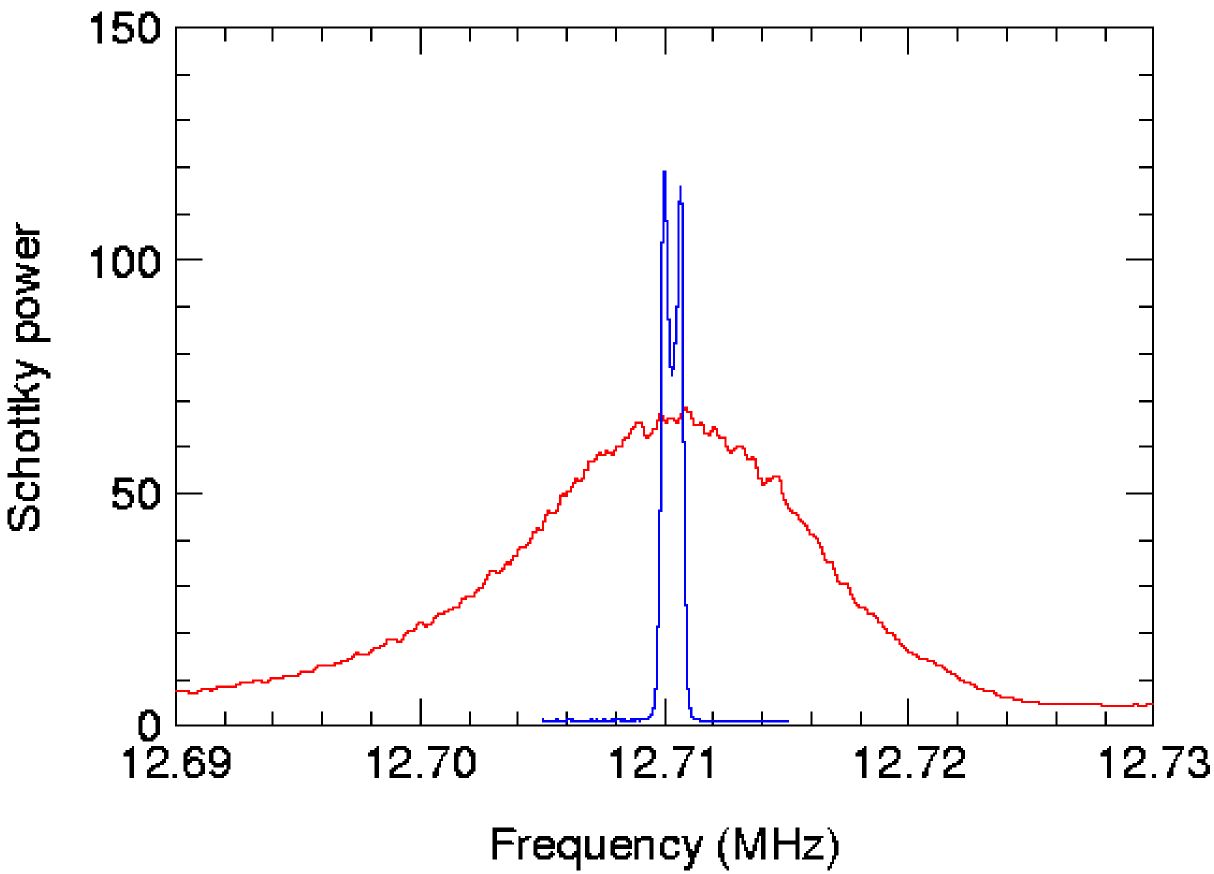
- Baseline 2: anti-neutrinos $15*10^{18}$, neutrinos $0.23*10^{18}$ in ten years

Basic ideas

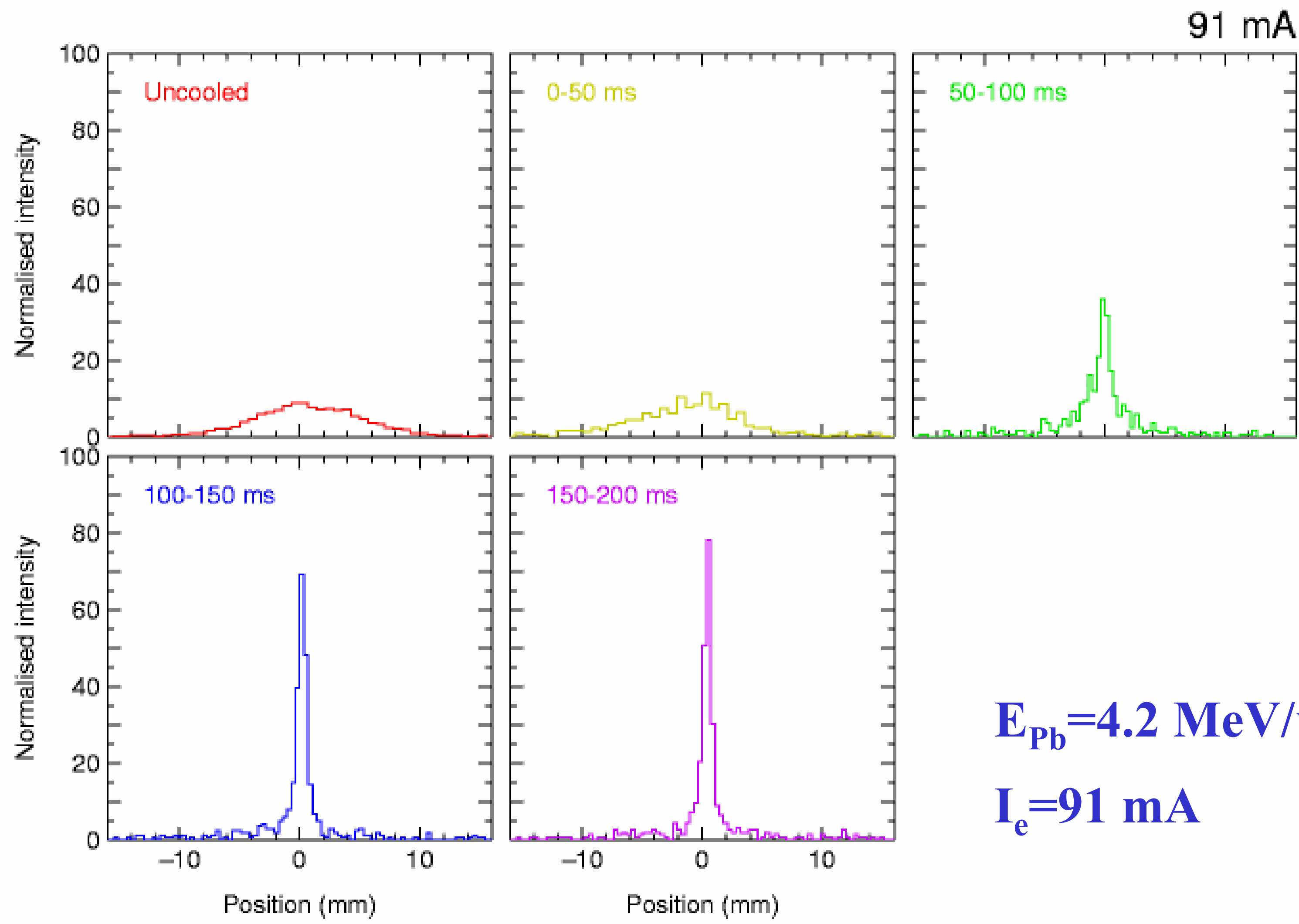
- Use ^{19}Ne – production 20 times higher than ^{18}Ne (lifetime 10 times longer)

- Accumulation of ions in (or before) the RCS
  - Electron cooling of the ions in the RCS makes accumulation possible
  - The ions are continuously cooled in all dimensions which gives space for the injection of more ions

Longitudinal cooling of d^+



Transverse cooling of Pb^{54+}



E_{Pb}=4.2 MeV/u

I_e=91 mA

Requirements

- **The electron cooling needs to be fast enough. The cooling time should be of the same order as the repetition time of the injected pulses (1/10 Hz).**
- **Transverse cooling is normally slower than longitudinal**
- **Cooling time depends on the initial emittance**
- **@ 100 Mev/u: $U_{e\text{-}gun} \approx 55$ kV, $I_{e\text{-}gun} = 1\text{-}2$ A**

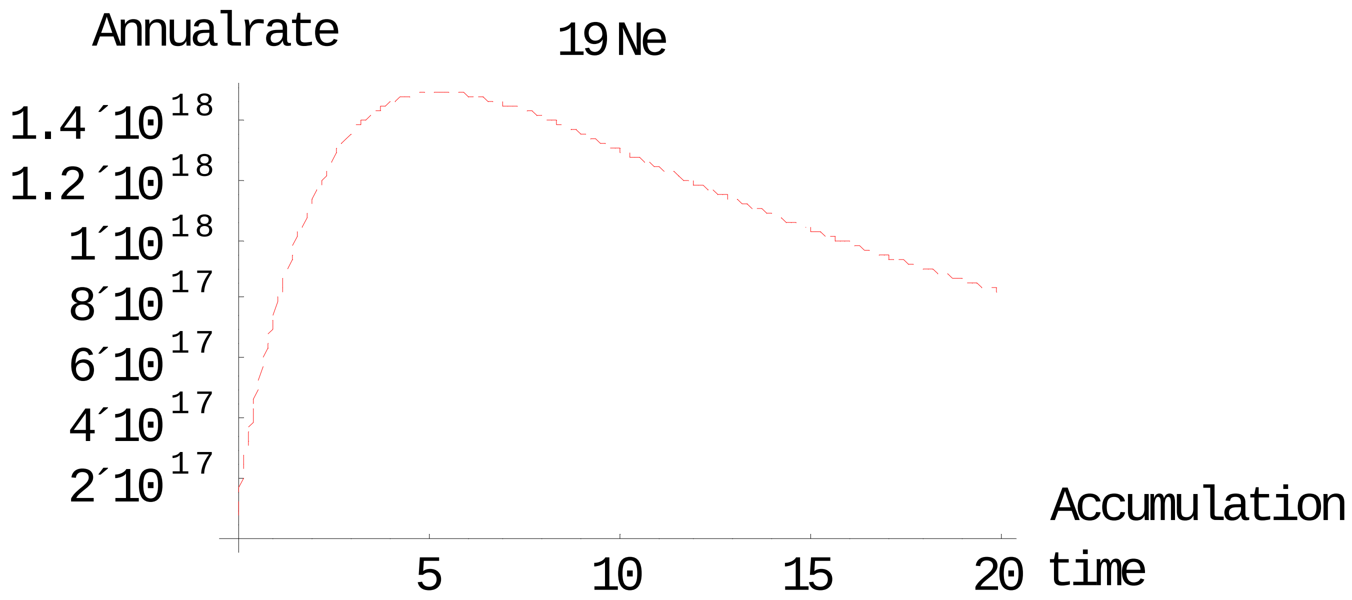
Limitations

- **Radioactive halflife of the ions. Balance between accumulation and decay is achieved after ≈ $3*t_{½}$**
- **The full benefit of the accumulation is achieved by using more long lived ions, like ^{19}Ne with $t_{½}$=17 s**
- **Intensity gain also for the short-lived ^{18}Ne and ^{6}He**
- **Instabilities and space-charge limitations.**

Parameters to vary

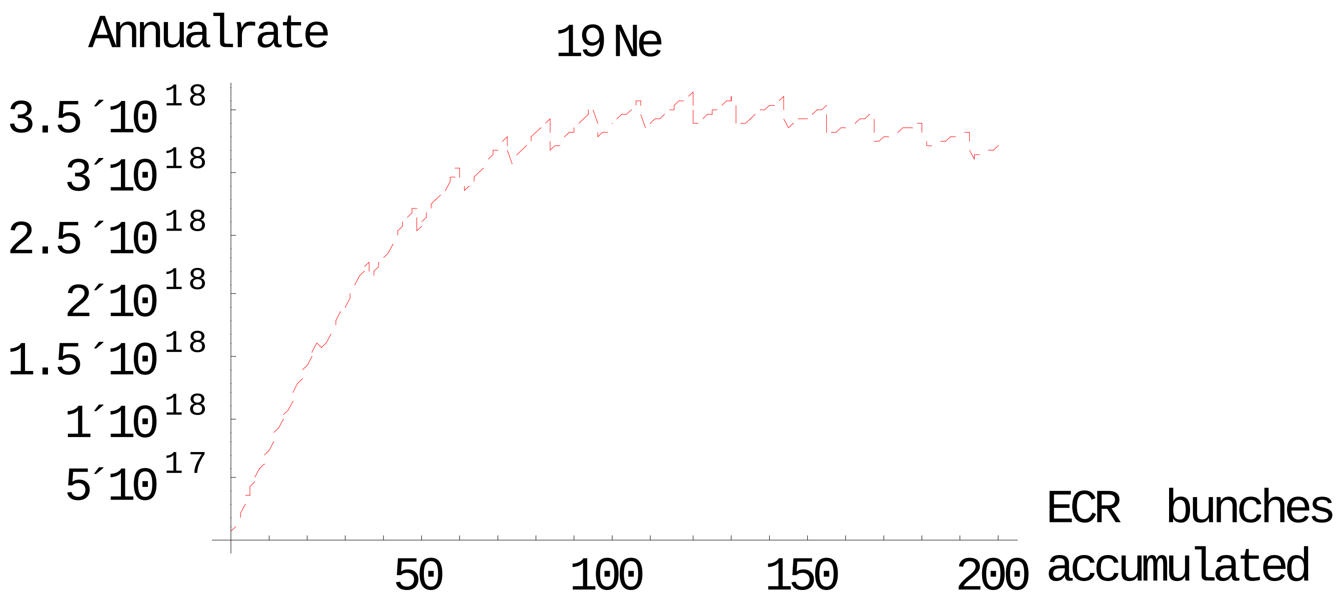
- **Number of pulses accumulated in the EC-RCS**
- **Further accumulation in the PS or SPS? Or both?**
- **Number of accumulations in PS/SPS**
- **...**

Accumulation of ^{19}Ne



The annual neutrino rate as a function of the accumulation time in the EC-RCS and stacked in **PS** at 10 Hz injection.

The annual rate depends on the combined effects of the whole accelerator chain.



The annual neutrino rate as a function of the number of ECR bunches accumulated in the EC-RCS and stacked in **SPS**

Intensities, ^{18}Ne, ^{19}Ne

Machine	Total Intensity ^{18}Ne (10^{10})	Total Intensity ^{19}Ne with accumulation (10^{10})
Source	80	1600
ECR	2.3	47
RCS inj	1.1	1170
RCS	1.1	1160
PS inj	19	10300
PS	18	10200
SPS	18	10200
Decay ring	311	157000

Intensities ^{18}Ne, without and with accumulation

Machine	Total Intensity ^{18}Ne (10^{10})	Total Intensity ^{18}Ne with accumulation (10^{10})
Source	80	80
ECR	2.3	2.3
RCS inj	1.1	18
RCS	1.1	18
PS inj	19	18
PS	18	17
SPS	18	127
Decay ring	311	1120

Intensities ^{6}He, without and with accumulation

Machine	Total Intensity (10^{12}) without accumulation	Total Intensity (10^{12}) with accumulation
Source	20	20
ECR	1.9	1.9
RCS inj	0.93	10
RCS	0.90	10
PS inj	11	10
PS	9.6	8.6
SPS	9.1	27.5
Decay ring	97	190

Further investigations

- **Intensity limitations**
- **Emittances and cooling times. Need for special design of the electron cooler?**
- **Accumulation in RCS or in a separate cooler ring?**
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