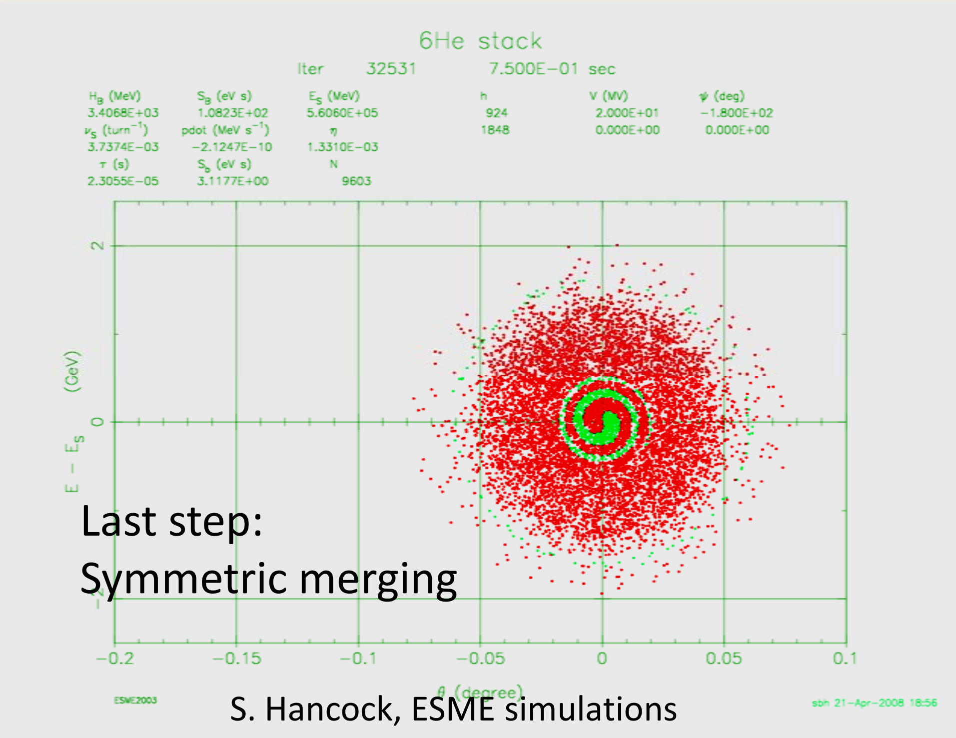
Decay Ring momentum collimation

Pierre Delahaye and

Elian Bouquerel, CERN

Asymetric bunch merging



Last step:
Symmetric merging

S. Hancock, ESME simulations

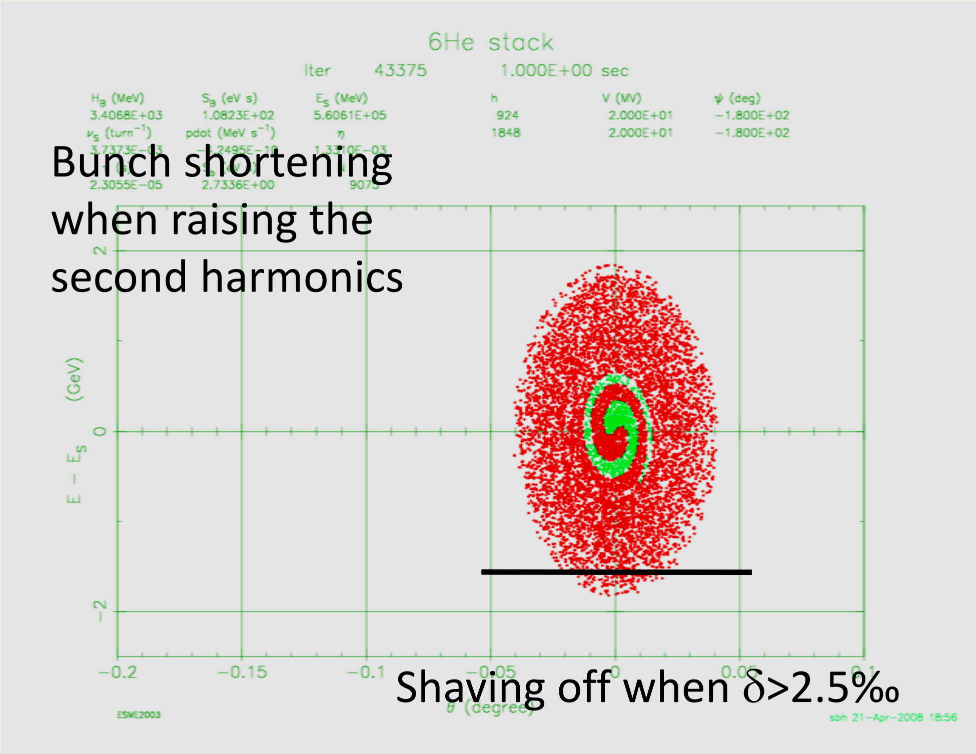
Steady –state stack amounts to:

- 8.9 shots accumulated for ^{6}He
- 14.0 for ^{18}Ne

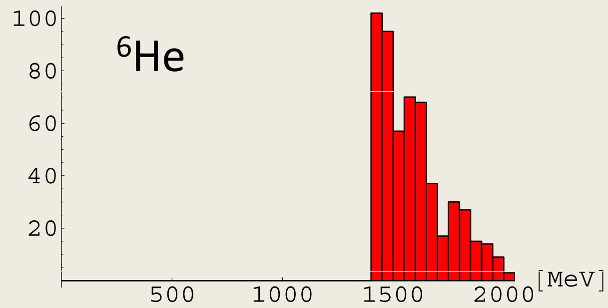
M. Benedikt, S. Hancock, [A novel scheme for injection and stacking of radioactive ions at high energy](), NIM A 550 (2005) 1–5

S. Hancock et al., [Stacking Simulations in the Beta-beam Decay Ring](), EPAC 2006

Momentum collimation



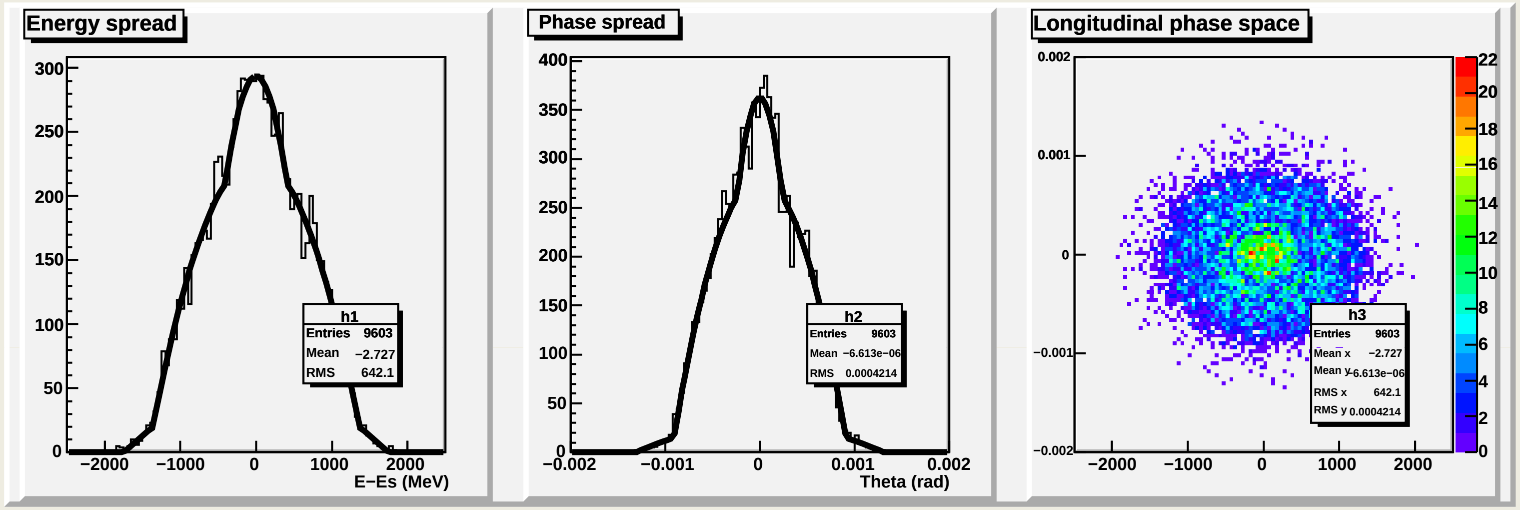
- The collimation duration can be tuned according to the RF program
- Energy distribution of the stack halo was calculated with ESME for 6He and 18Ne



Recently Fred Jones implemented the bunch shortening step into ACCSIM for ^{6}He starting from a longitunal distribution generated by ESME (when second harmonics=0)

ACCSIM calculation

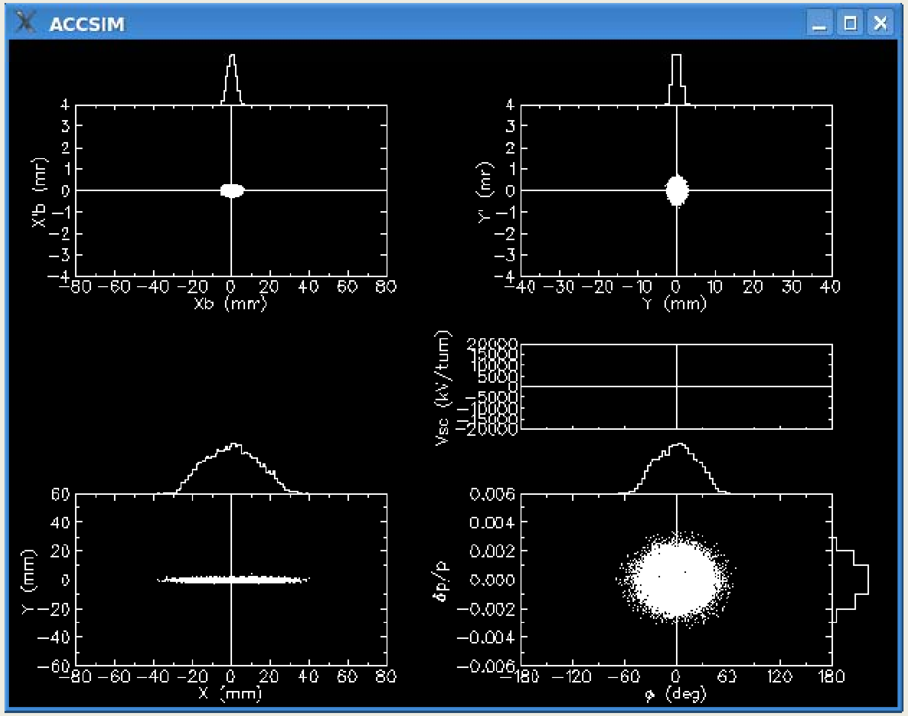
- Longitudinal phase space before bunch shortening from Steve

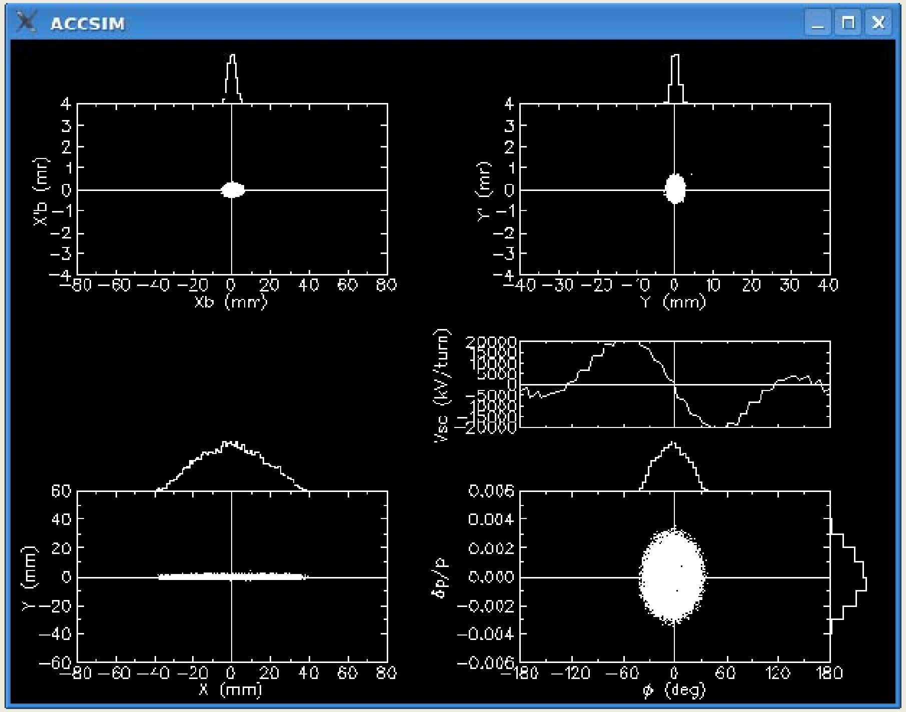


- Shortened RF program – 12ms instead of typically 300ms (~2 synchrotron periods)

ACCSIM calculation

- Repeated for ^{18}Ne





« Taking care that the longitdunal emittance doesn't filament »

Results

• Placement of the primary collimator as defined by A. Chancé in the lattice

• Condition (B. Jeanneret et al.)

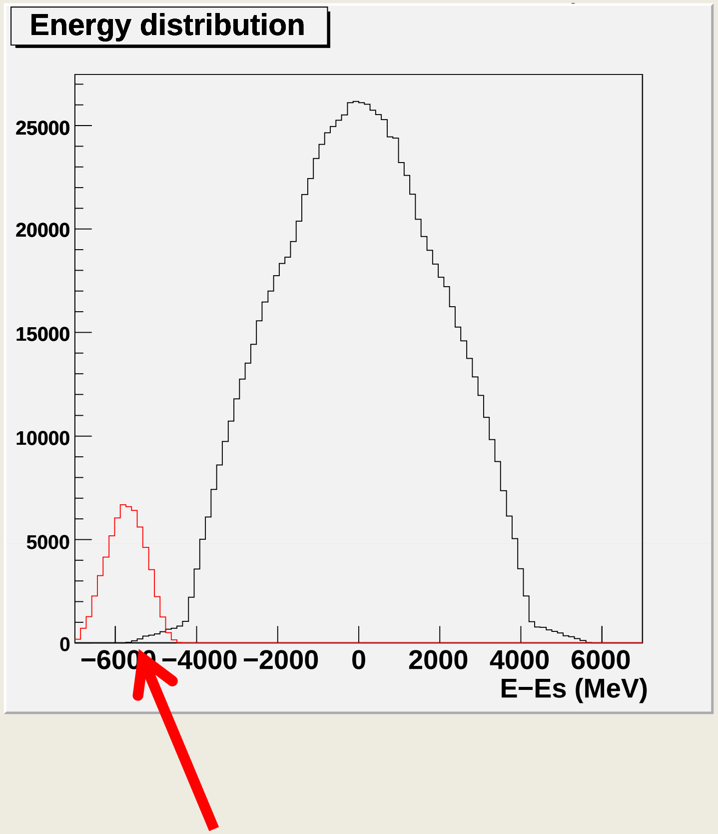
$$\frac{D'}{D} = -\frac{\alpha}{\beta}$$

Has been verified

• Collimator element +-X under ACCSIM has been modified/corrected and validated

• Loss maps were created and adapted for an easy use under FLUKA

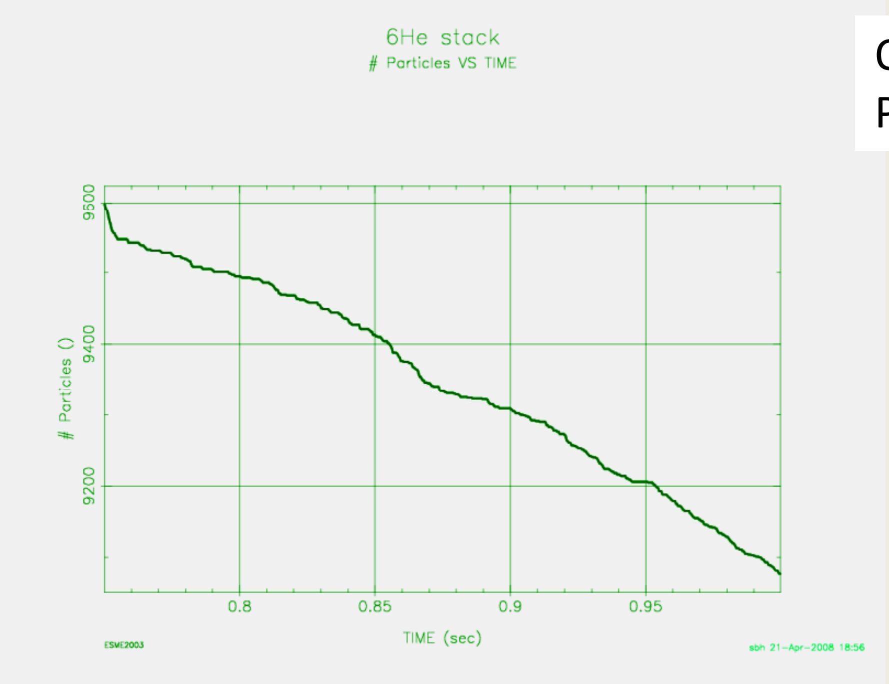
- Number of element where lost, number of turn, X, Y, Z(S), T_X,T_Y, T_Z direction cosinuses and T_k



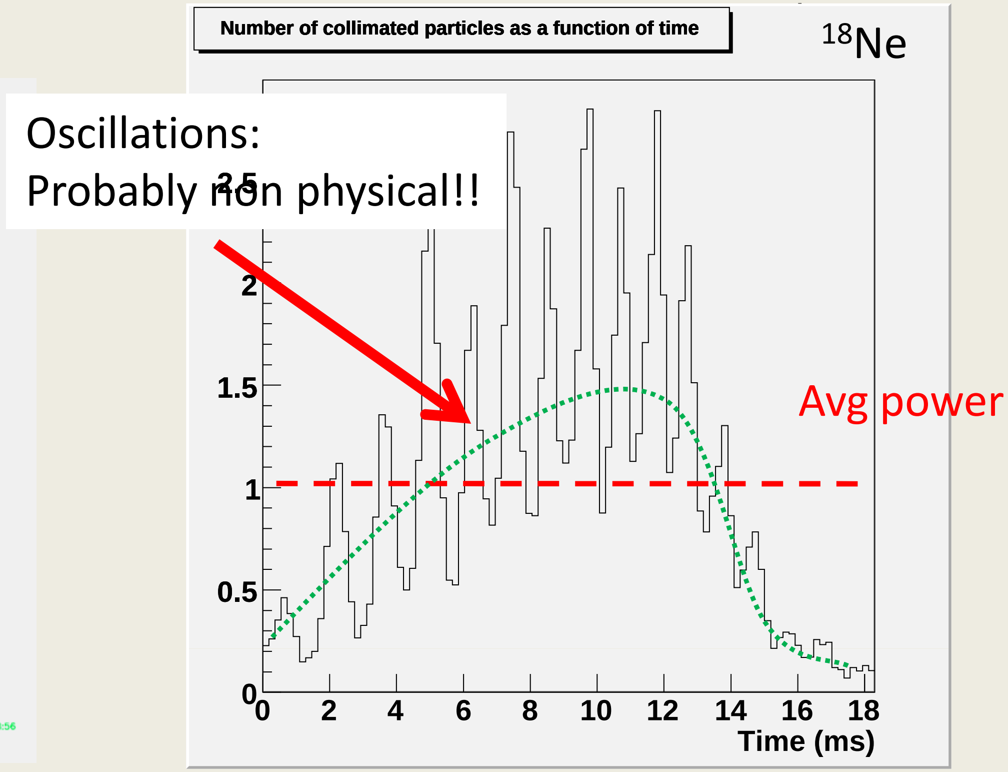
Cut after bunch shortening

Total deposited power

From ESME (S. Hancock):
Number of scraped ions increases linearly with time = quite constant power



ACCSIM

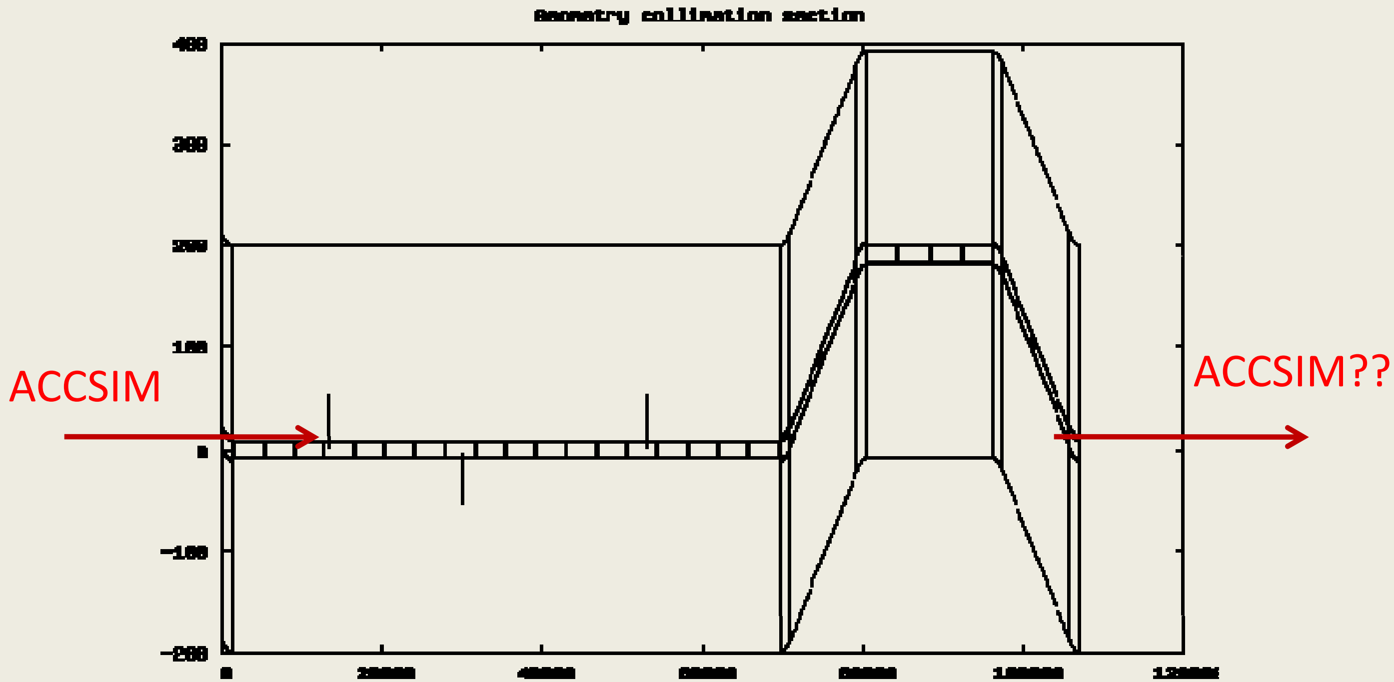


Variation +-50% according to average

Similar pattern for ^{6}He

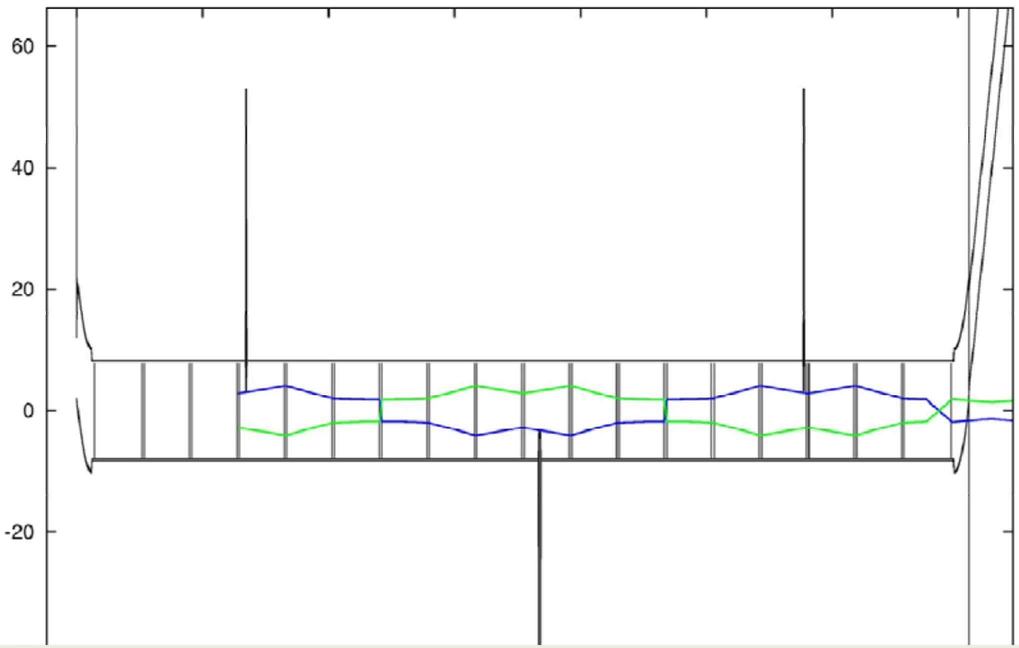
FLUKA simulations

- « Minimal » collimation section
  - Straight section + 2nd bump
  - Magnetic fields, beam pipe and collimators



Placement of the collimators

- Primary and « secondary » collimators placed according to the beam enveloppe at δ=2.5‰



- In blue:
Negative energies
- Beam enveloppe:

$$X_{max} = D\delta_{max} + X_{\beta max}$$
$$= D\delta_{max} + \sqrt{\frac{\varepsilon\beta}{\pi}}$$

- δ_{max}=-2.5‰
- ε=2.6π.mm.mrad (100%)

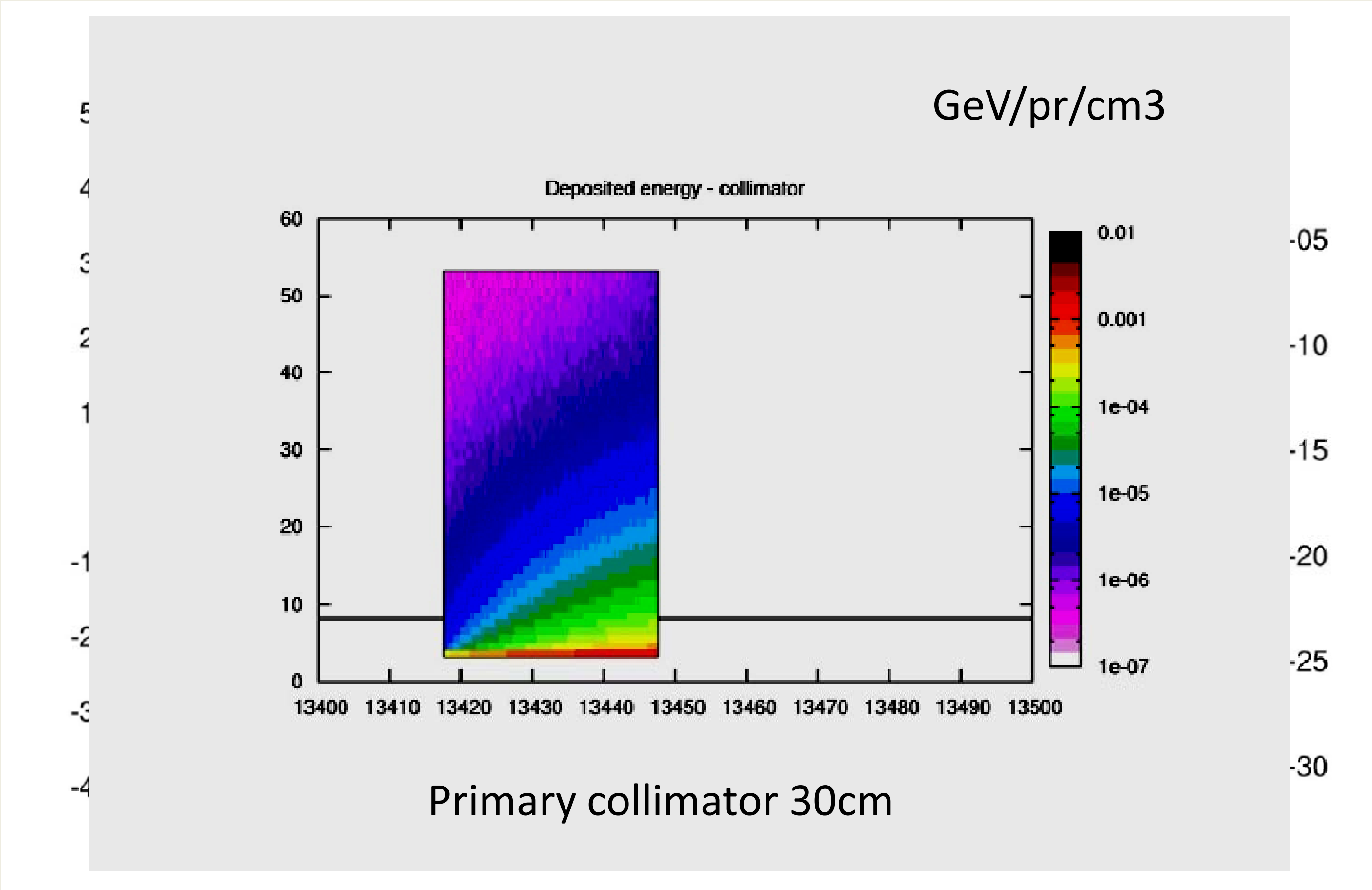
1) Only horizontal collimation
2) Not so much effect of the secondary if too far away from the beam enveloppe!!

Different sets of conditions

- Thickness of the primary collimator (10, 20, 30, 50 and 100cm blocks)
- Distance from the beam enveloppe for the secondary collimators
- Material of the collimators (^{12}C as for LHC, Copper)

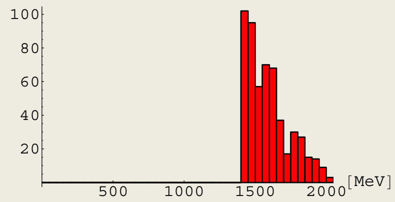
Loss map for a typical set-up

- ^{6}He



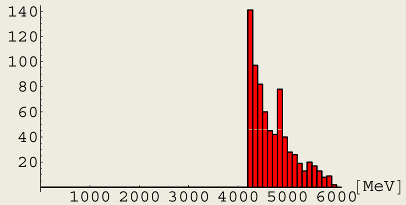
Results

- ACCSIM (primary collimator)
  - Primary collimator on the beam enveloppe as defined above
  - ^{6}He: ~5.6% of the bunch is collimated



ESME: 6.3%

  - ^{18}Ne: ~6.0% of the bunch is collimated



ESME: 5.4%

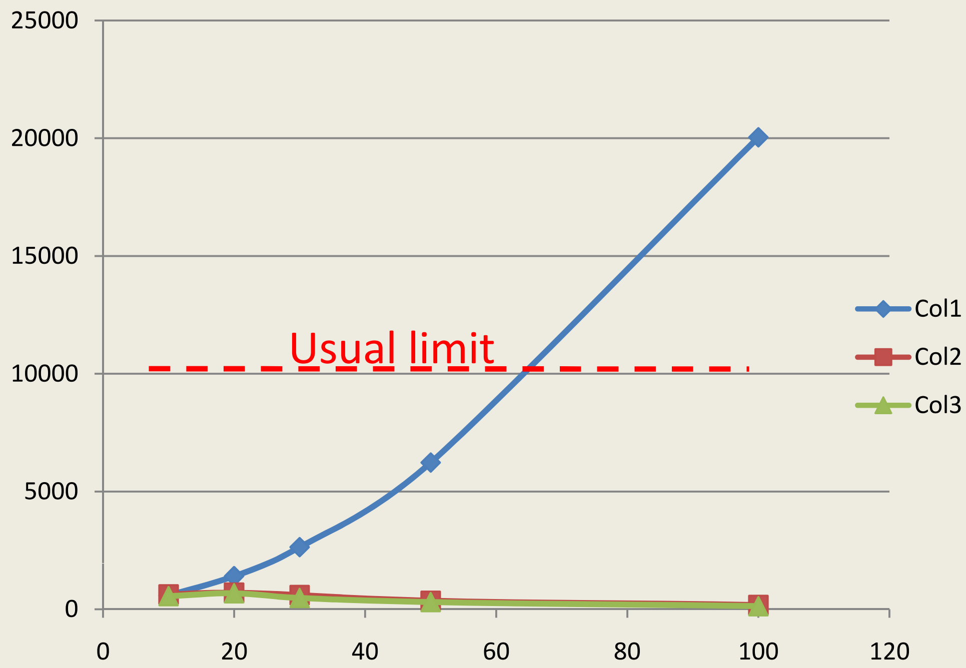
Average power ^{6}He

^{12}C collimators, secondaries 1m long at 4mm from beam enveloppe

^{6}He: 5 10^{12} particles lost/cycle

Average power (W)

1s collimation time (300ms:3X more!!)



Thickness primary (cm)

Average power ^{18}Ne

^{12}C collimators, secondaries 1m long at 4mm from beam enveloppe

^{18}Ne: 3.4 10^{12} particles lost/cycle

Average power (W)

1s collimation time (300ms:3X more!!)

Thickness primary (cm)

Energy balance

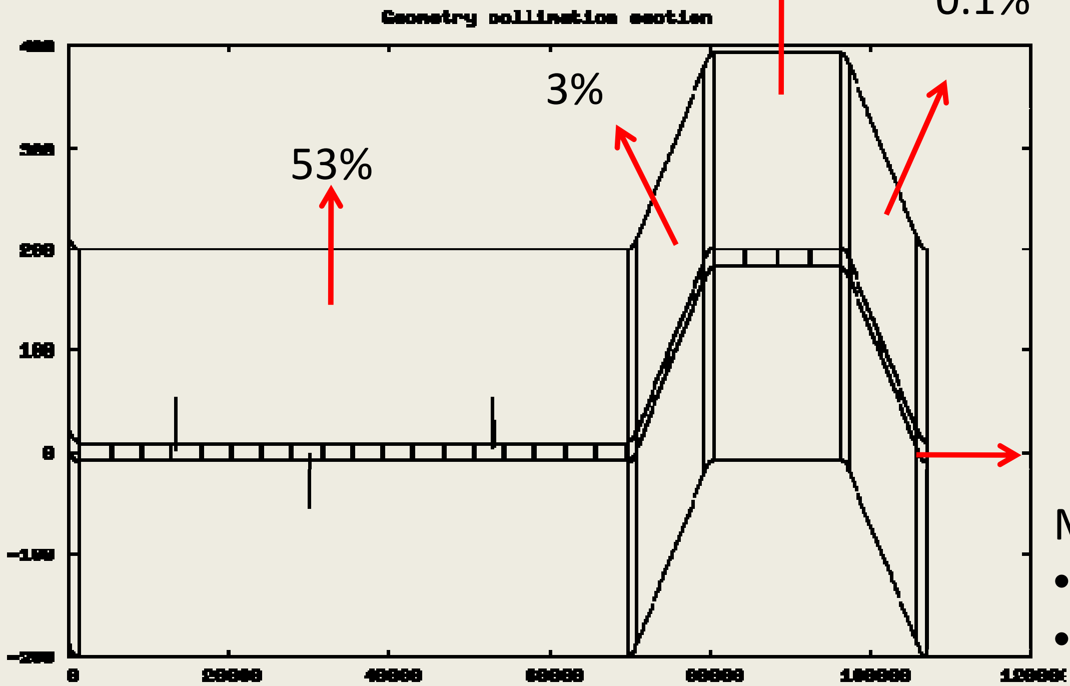
- Taking 30 cm as the reference case, only 27% (32%) of energy is dissipated in the system (mainly collimators and beam pipe) for ^{6}He (^{18}Ne)
- In reality the rest will be dumped in the surrounding materials, and in the bump

Escaping energy

^6He 30 cm primary collimator

3%

0.1%



13%

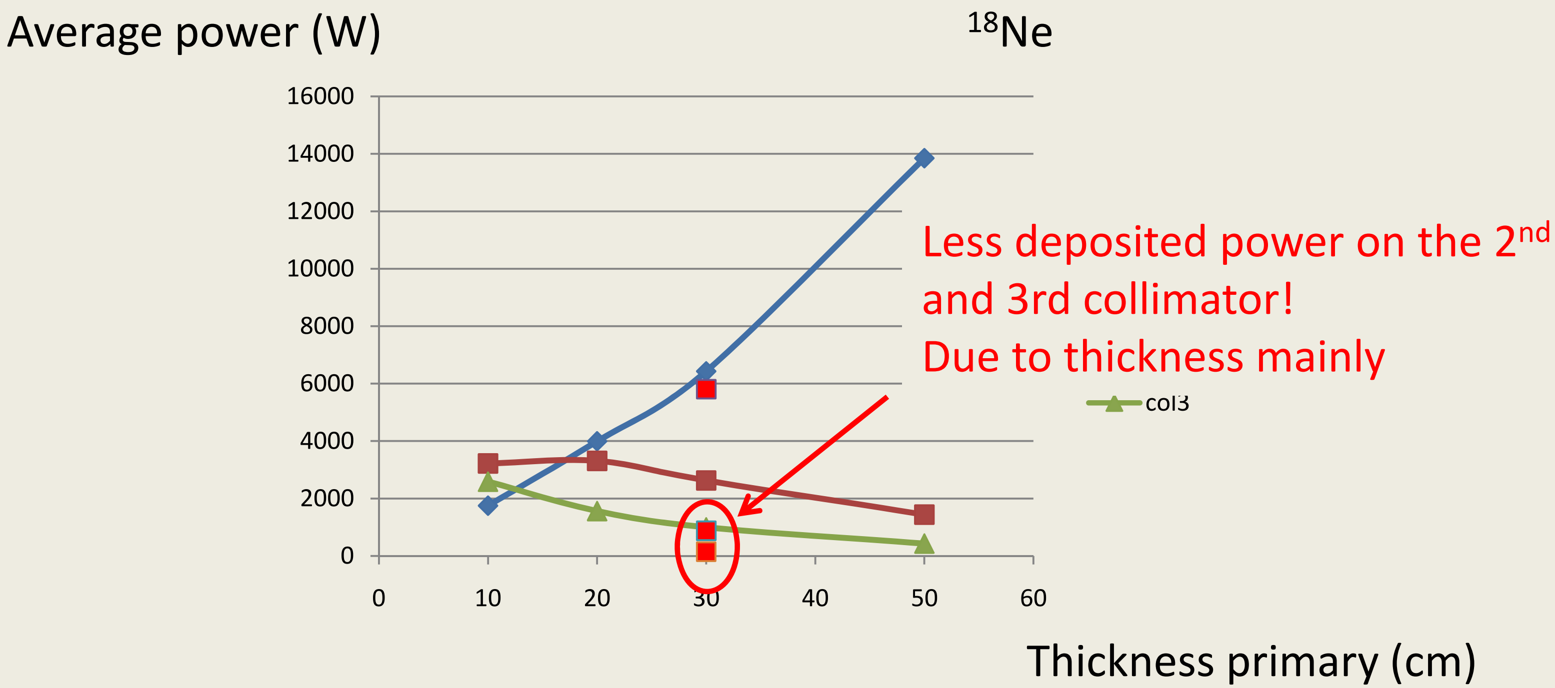
Mainly ^6He or ^{18}Ne with

- no interaction
- small scattering angles

Corrected for in the calculation of the deposited power!!

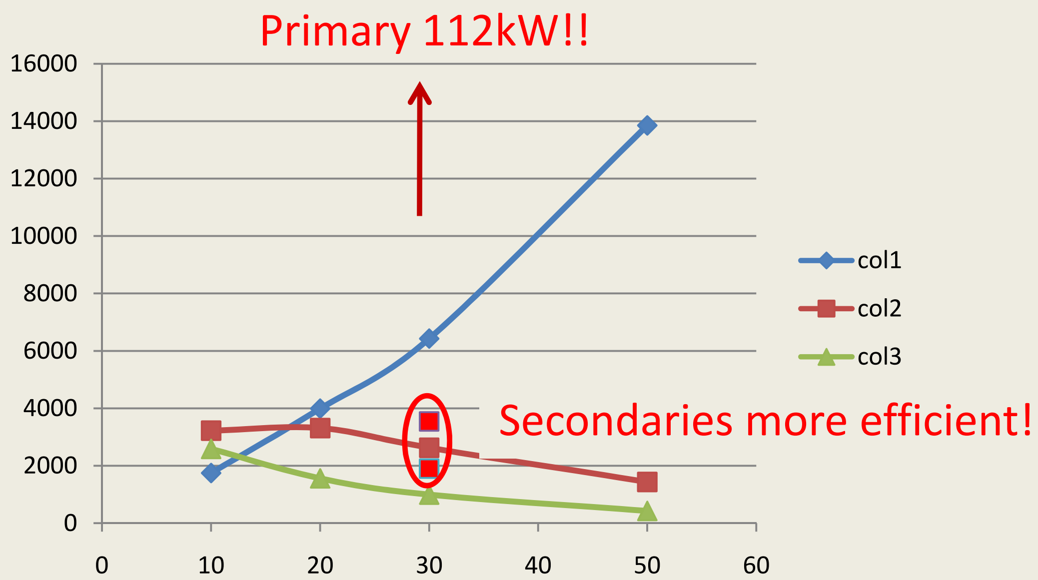
More collimation and less dump…

- 3 primaries (30cm) instead of 2 secondaries
  - 2nd and 3rd Collimators are placed on the beam enveloppe



More collimation and less dump…

- Trying another material: $_{29}$Cu
  - 1 primary 30 cm 2 secondaries 100cm



Conclusions

- A primary collimator of 30cm will probably stand the deposited power for ^{6}He and ^{18}Ne
- Efficient collimation on the secondaries implies probably the use of other material (Cu?)
- Absorber materials after the primary collimator
- A detailed study of the losses in the surrounding material (magnets in particular!) is absolutely needed
- The losses at the bump might be quite critical
- Not so many fragments passing the bump (^{3}H: 5‰ per primary ^{6}He)