HIE Beam Commissioning Planning and Preparation Work

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ISOLDE Workshop and Users Meeting – 17-19th Dec 2012

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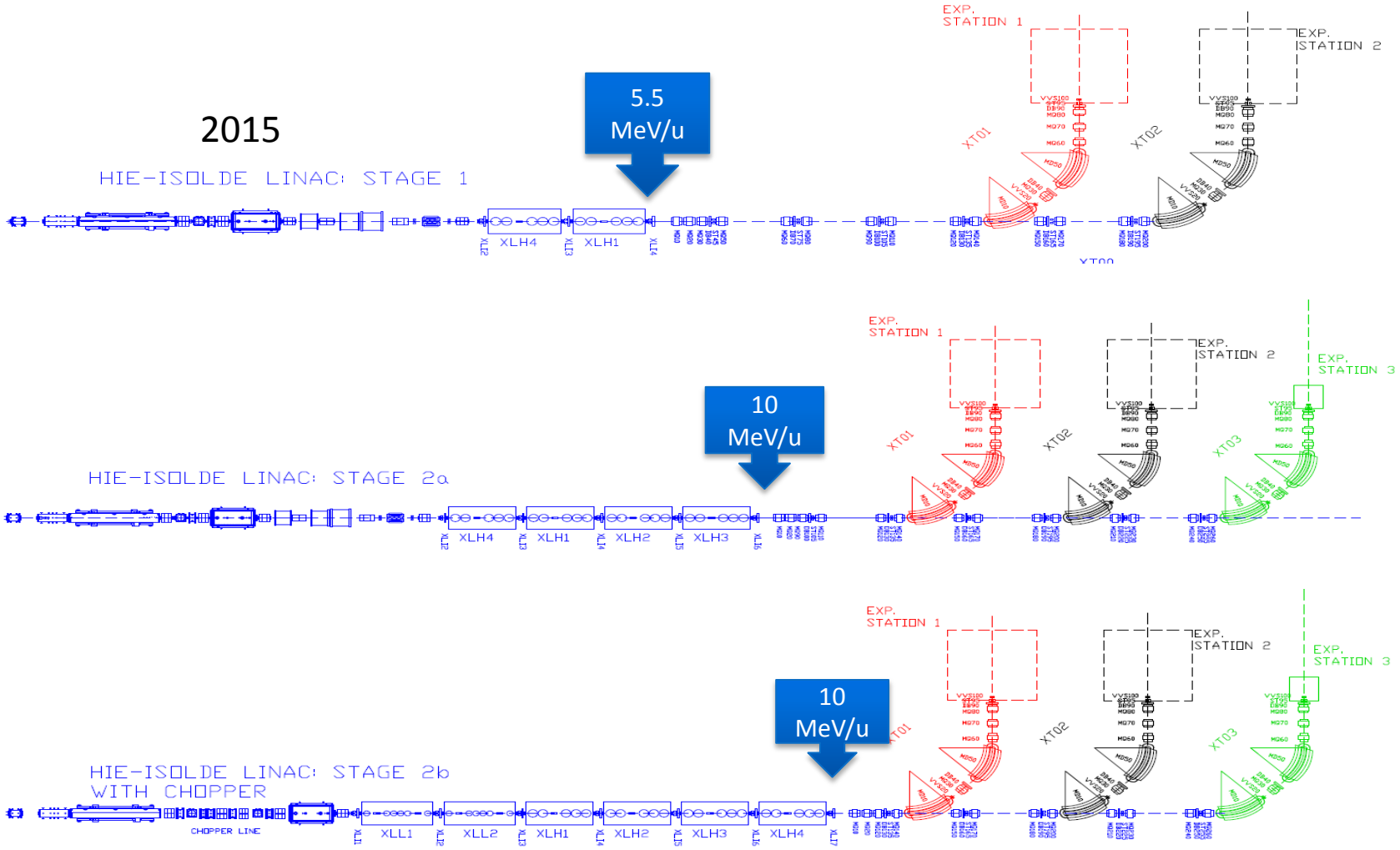
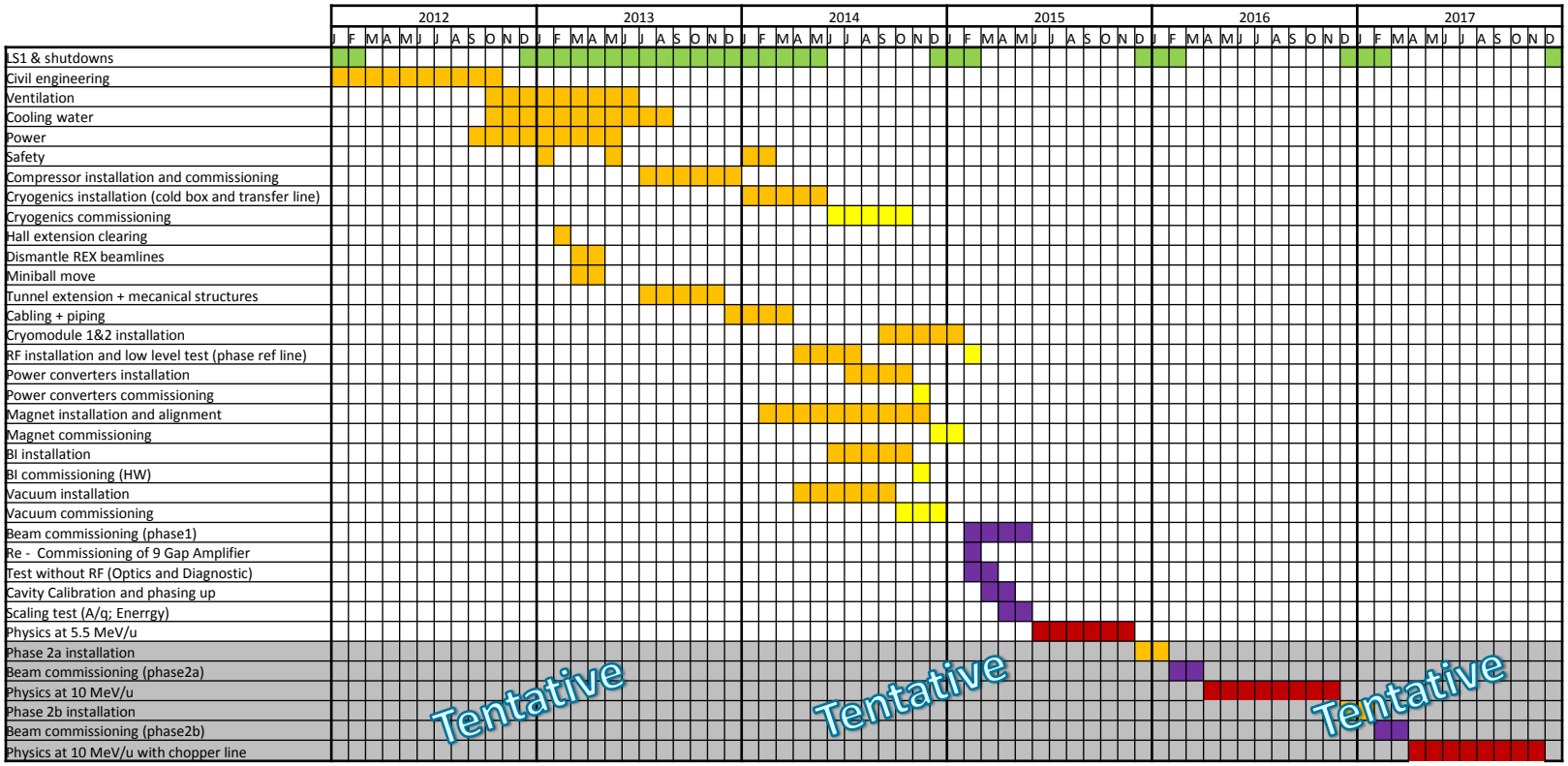
- Introduction
- Commissioning Plan, when and how…
- Preparation Work for the commissioning
  - Beam Diagnostics
    - ✓ Faraday Cups
    - ✓ TOF (Time of Flight)
  - Emittance Measurements
  - Stripping Foil
  - Software Upgrade
- Summary and Conclusions

Introduction



Commissioning Plan



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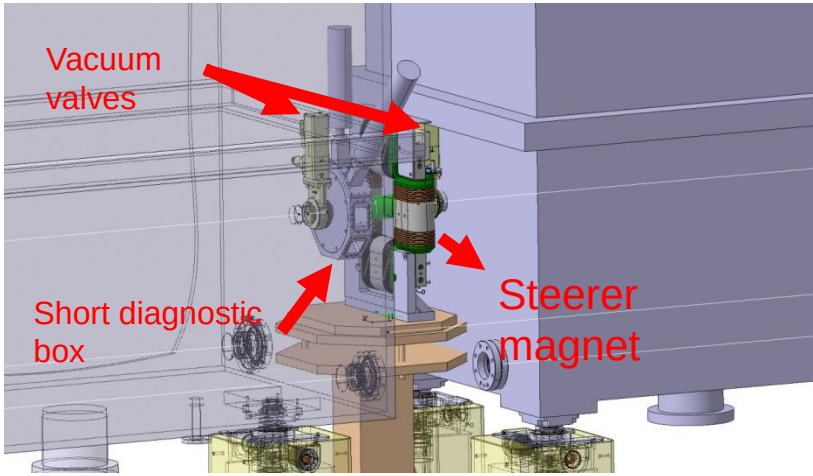
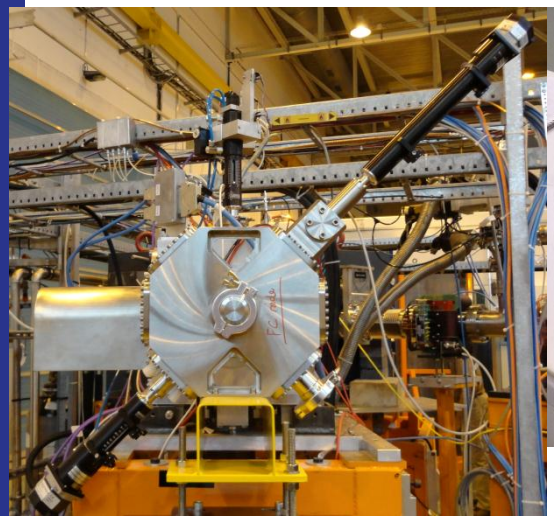
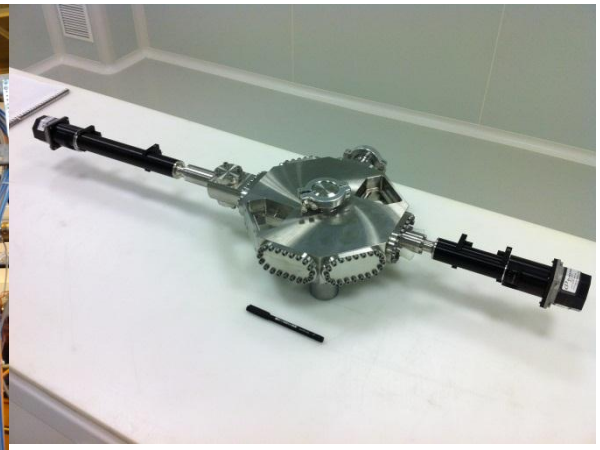
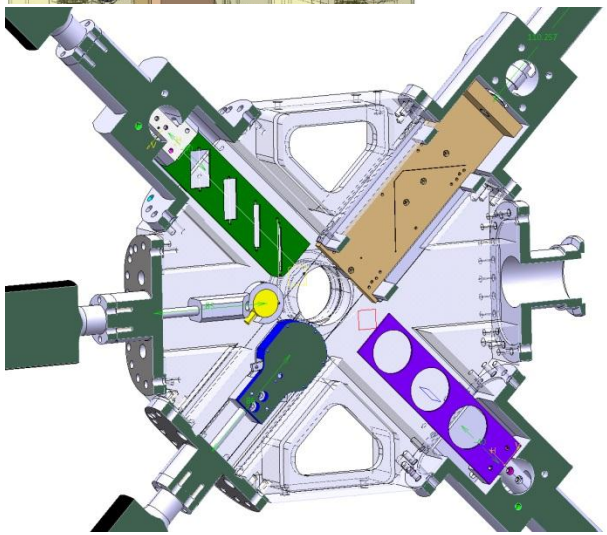
Beam Diagnostics: Faraday Cup

- Instrument for machine setting up (beam intensity & transmission)
- Short DBs's design for the SC Linac was needed due to space constraint
- Stage 2a: 17 DBs (5 Linac; 12 HEBT)
- Test at REX during dedicated MD with stable beam from EBIS at A/q = 4 and different energies







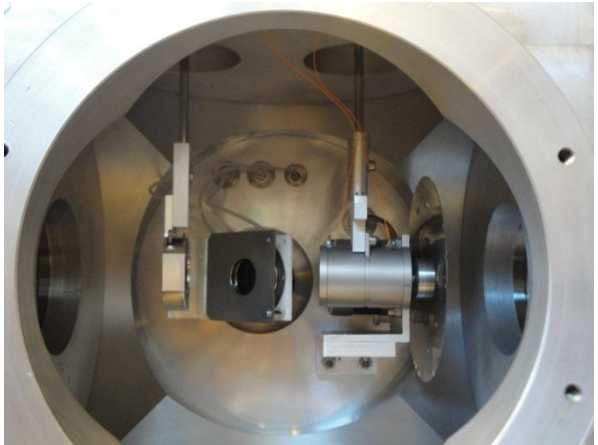


Faraday Cup Comparison

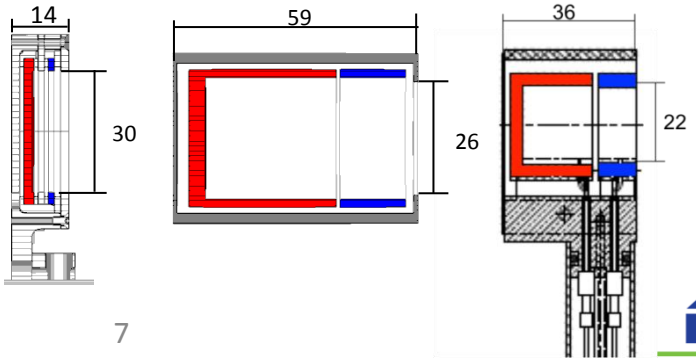
- Direct beam intensity comparison between the 2 cups → Different readings

Test	Advantage	Disadvantage	Conclusion
Biasing Repeller Ring	Simple electronics	Low potential in the cup centre	Loosing high energy secondary electron, capturing low energy electron
Biasing Signal Plate	Field distribution more homogeneous in the cup	Capture free electron, electronics need to be build	Loosing high energy secondary electron, capturing low energy electron
Biasing Both	Homogeneous field distribution, strong potential	2 power supply needed, electronics to be build	Better resolution but still different readings

Conclusion:
Need two DBs design short DB for the intertank long DB for the HEBT

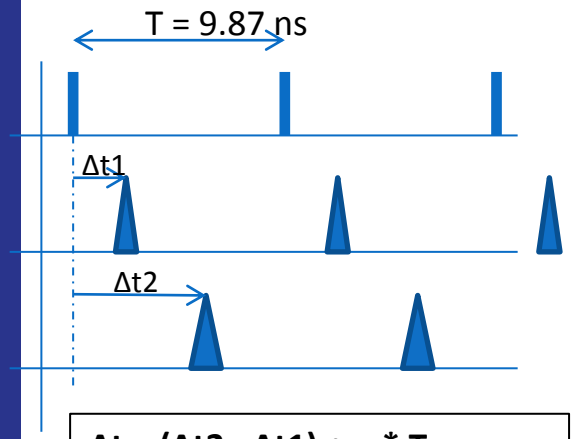


HIE-ISOLDE REX-ISOLDE ISAC 2



Time Of Flight measurements with Si Detectors

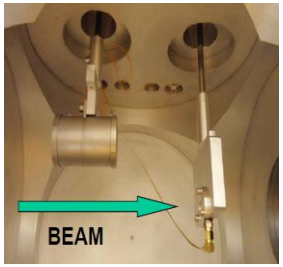
The idea:

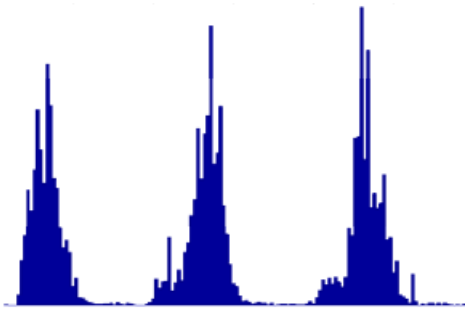


Δt = (Δt2 - Δt1) + n * T

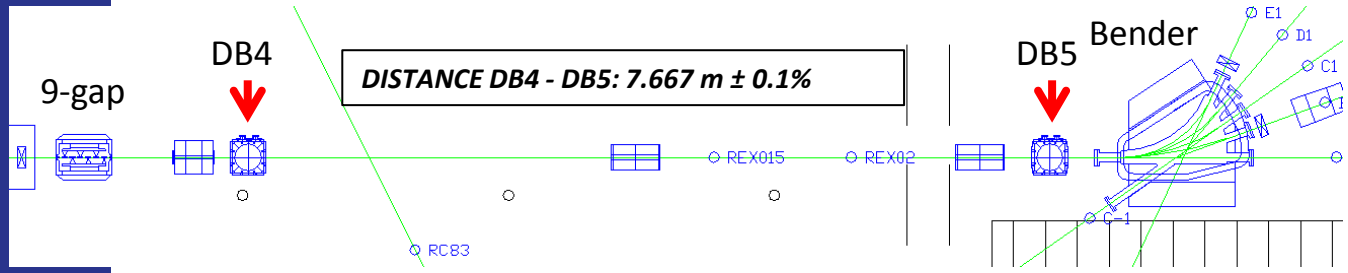
- Get n from bender energy calibration (uncertainty on energy: few %)
- 0.5 ns uncertainty on Δt <=> +/- 0.3% energy resolution [1]

PIPS (Passivated Implanted Planar Silicon) detector from Canberra
Estimated timing resolution < 140 ps





The set-up:



Time spectra in DB5 for a 2.85 MeV/u beam

[1]F. Zocca, M.A. Fraser, et all." Development of a Silicon Detector Monitor for the HIE-ISOLDE Superconducting Upgrade of the REX-ISOLDE Linac", CERN-HIE-ISOLDE-PROJEJECT-Note-0008

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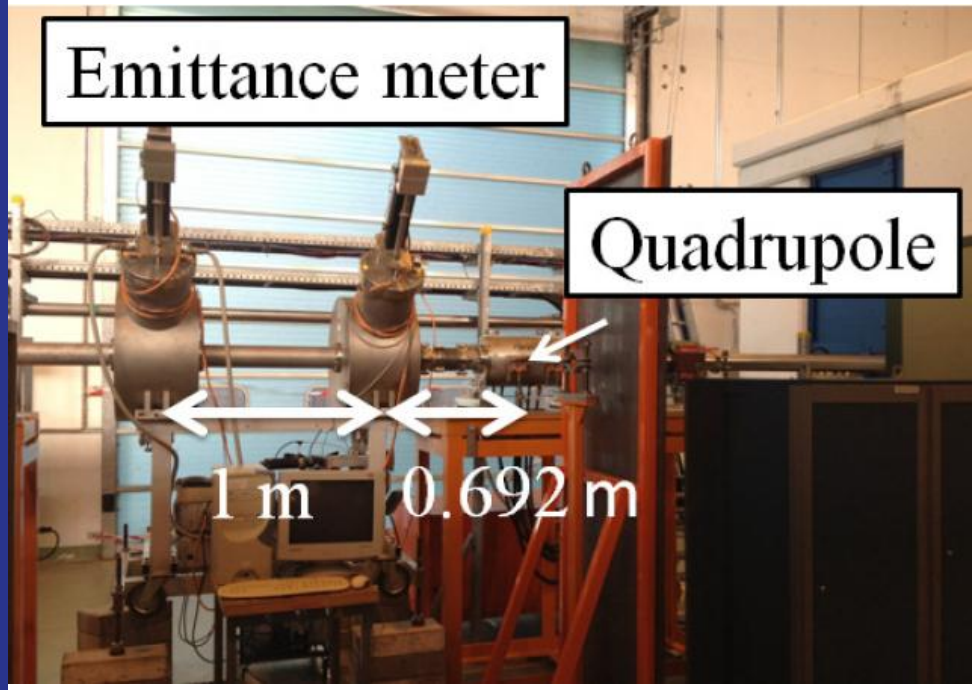
Emittance

- Emittance after actual Linac will be the input emittance for the SC part
- Longitudinal emittance measurement's result published in 2011 [3]
- Transverse emittance measured with 2 different methods
- Aim: compare the 2 methods and find an alternative method for measuring transverse emttiance

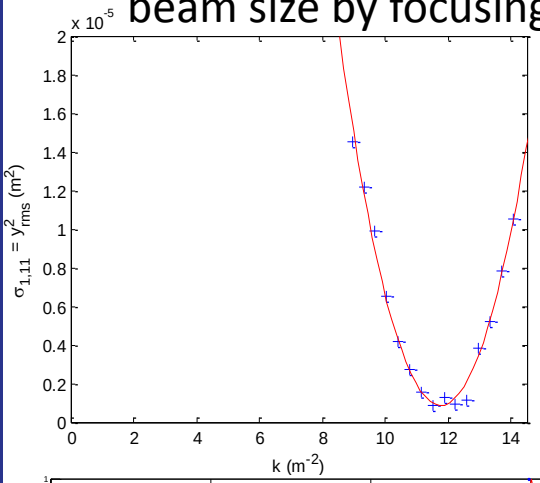


- Slit & grid method
  NTG Emittance meter [1]
  Slit: H-V width of 0.2mm each
  Grid: 30 wires in each plane
  0.2mm thickness and 2mm spaced
- Quadrupole scan method [2]
  XBEN.MQ70

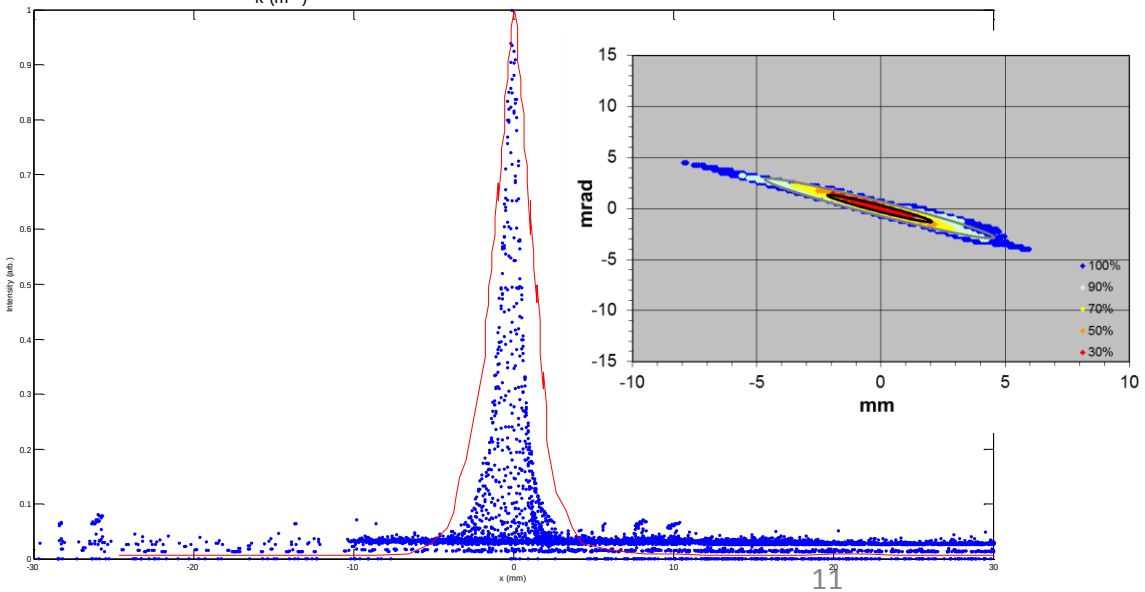
- [1] J.Dietrich et all.,"High Sensitive Beam Emittance Analyzer", Proceedings of EPAC 2002
- [2] T.Olsson et all."Three Gradient Emittance Measurement at REX-ISOLDE", CERN-HIE-ISOLDE-PROJEJECT-Note-0016
- [3] M. Fraser et all."Longitudinal Emittance Measurement at REX - ISODLE", CERN-HIE-ISOLDE-PROJECT-Note-0010

Three Gradient Method

- Measure beam size at one point and use an upstream quad to change the beam size by focusing and defocusing the beam



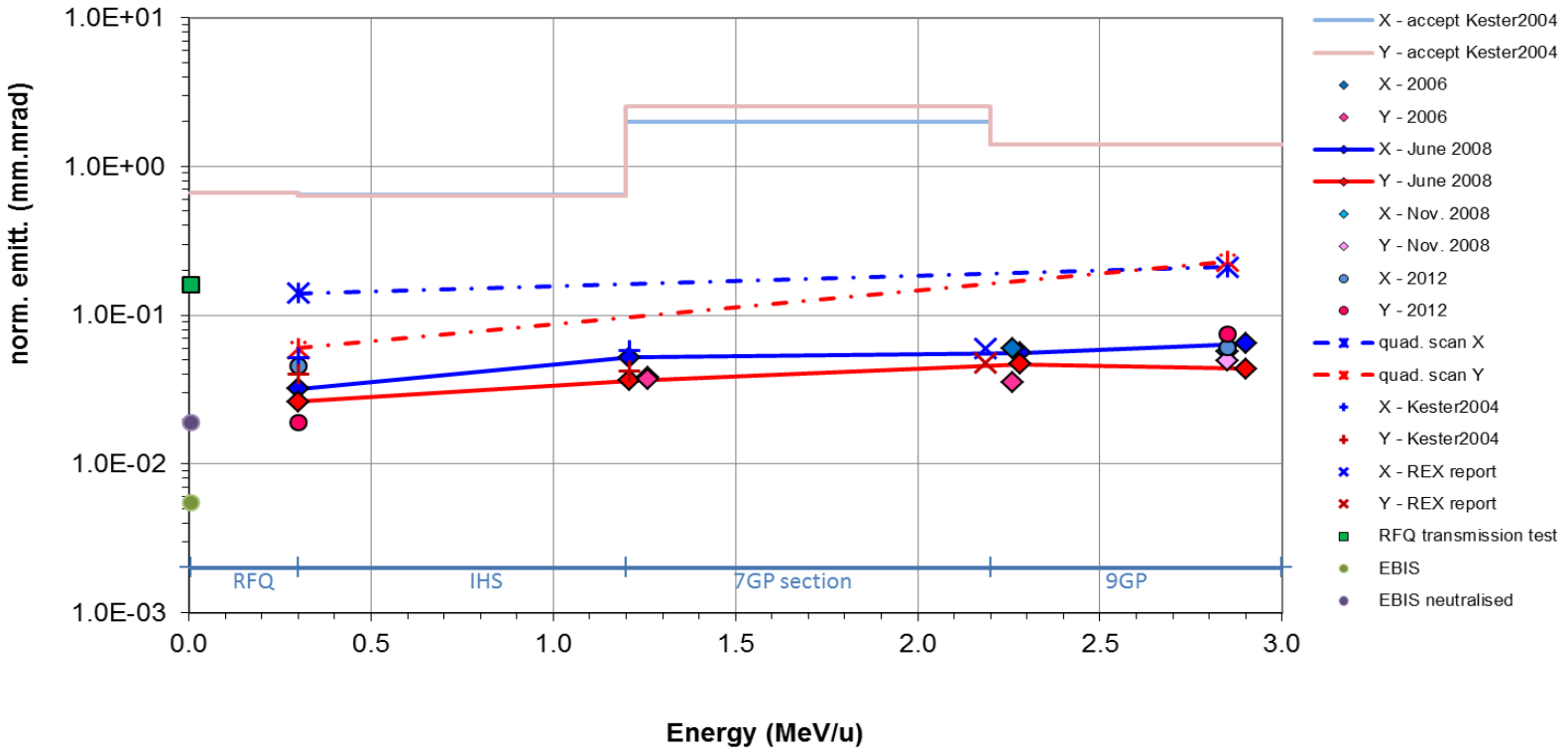
- $\gamma x^2 + 2\alpha x x' + \beta x'^2 = \varepsilon$ (Emittance equation)
- $\sigma_{22} x^2 + 2\sigma_{12} x x' + \sigma_{11} x'^2 = \varepsilon^2$ (Emittance equation for a 2-dimensional phase space)
- $\varepsilon = \sqrt{\sigma_{11}\sigma_{22} - \sigma_{12}^2}$
- σ_{11} is the root mean square (rms) of the beam profile



2.85 MeV/u
≈1 nA
A/q = 4

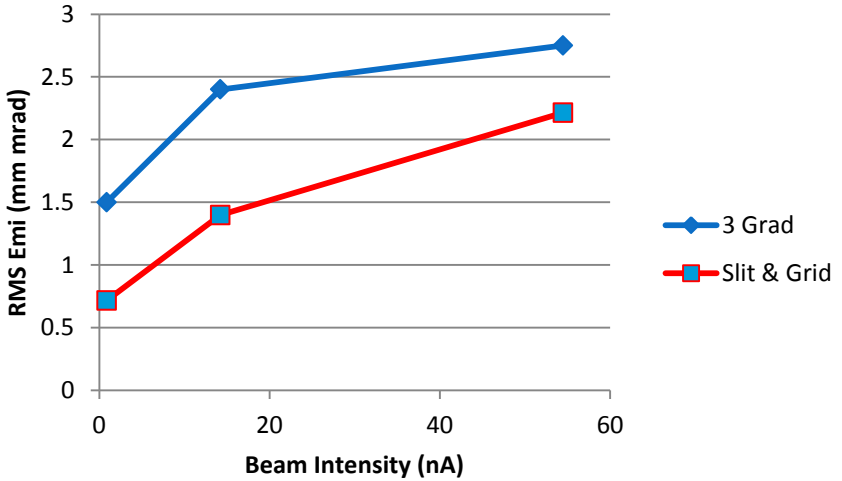
Emittance

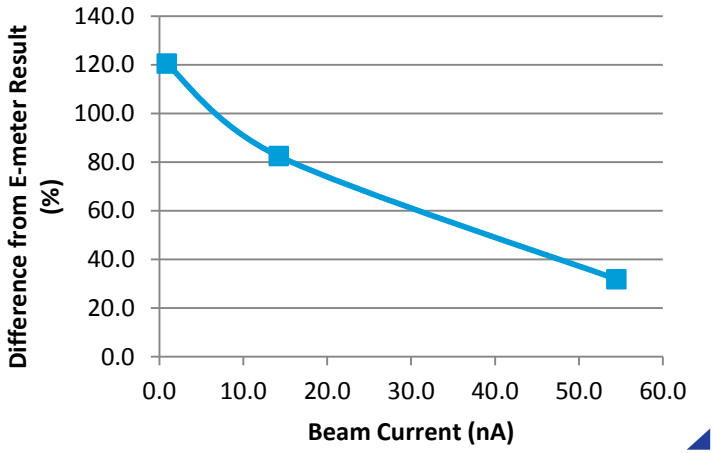
- Emittance measured with the 3 Gradient method is bigger than the one measured with Slit -Grid Emittancemeter
- Intensity problem with Slit –Grid Emittancemeter



Test on LA1

- $^{40}Ar^{+}$ at 30.29 kV, ie, 0.757 keV/u
- Three range of current, ie, ≈ 60 nA, ≈ 15 nA, ≈ 1 nA
- Very high SNR





Emittance Conclusion and Further work

- Quads scan method very promising for on line measurements with weak beams
- Measurement with the emittance meter are reproducible in the long scale
- Quads scan method and RFQ injection tests [1] suggest an emittance between 3 – 4 times larger
- Test on LA1 confirms that Slit – Grid emittance meter is intensity limited
- Next ⟶ Change slits dimension in the emittance meter and repeat test at REX and measure profile with indipendent tool

[1] M. Fraser, F. Wenander, "Study of the effect of Ion Source Energy Spread on RFQ beam dynamics at Rex Isolde" CERN-HIE-ISOLDE-Project-Note

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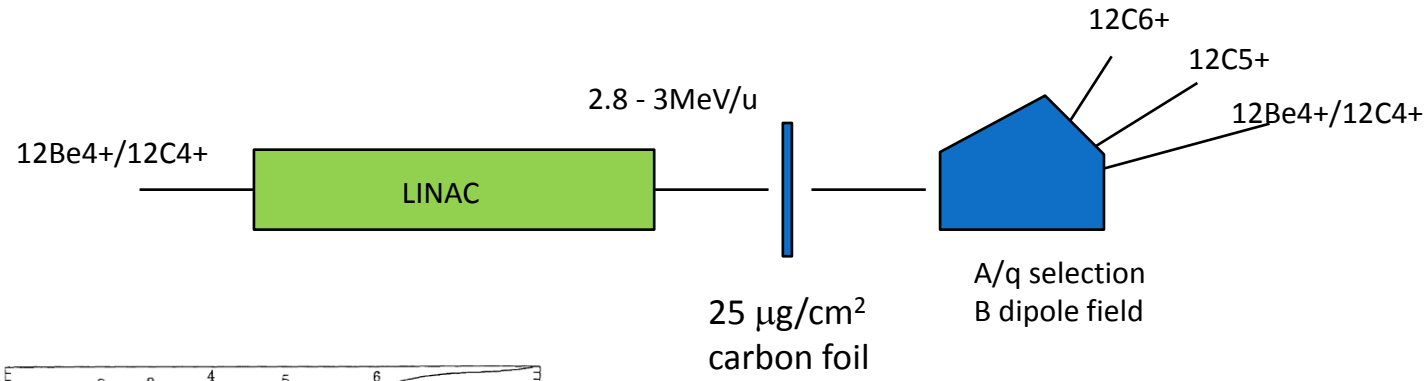
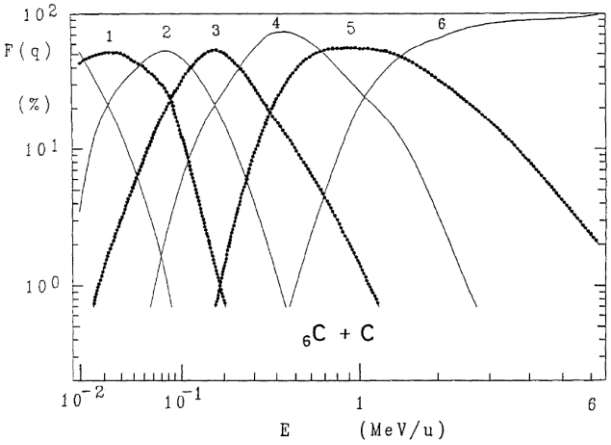
Stripping Foil

- Beam purification technique.
- Stripping foil can be inserted between the Linac and the last bender to remove contamination in A/q
- Different energies and different foil thickness were tested





Shima et al, Atomic data and nuclear data tables, 51, 173-174 (1992)

- Efficiency can vary from few % to 100% depending on the case
  - * ideal case 10C/20Ne: fully stripped 10C has no Ne contamination -> 100% separation
  - * 11Be/22Ne -> some 22Ne will remain as 8+
- Only works for light beams (charge state distribution)
- Energy straggling significant at low energy -> need to retune the optics

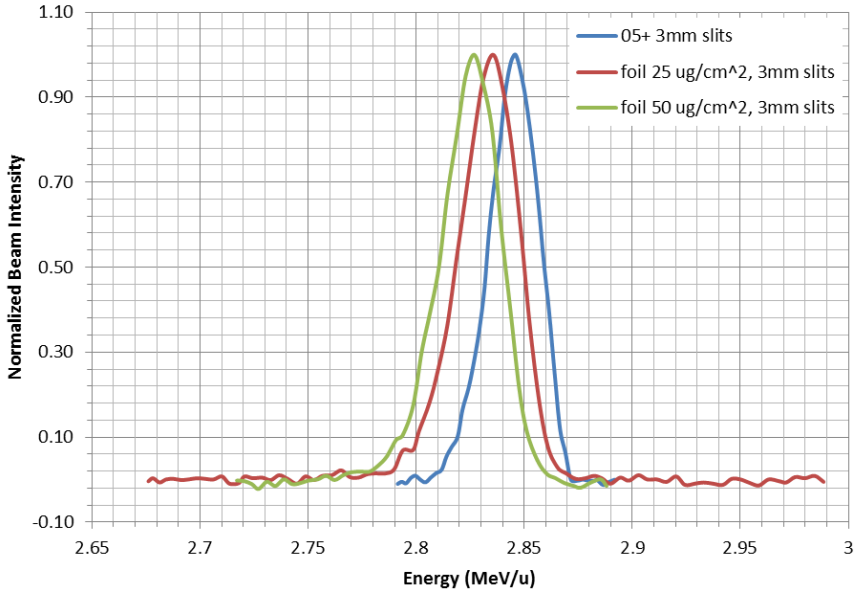
Stripping Foil

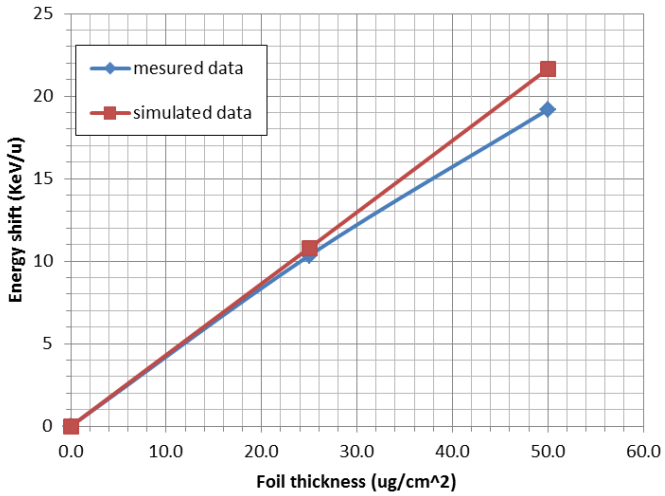
25 $\mu g/cm^2$

q	A/q	Field (mT)	Intensity (ppA)	Transmission (%)
5	3.2	859.68	0	0
6	2.6667	716.40	0.041	7.4
7	2.2857	614.06	0.214	38.3
8	2	537.30	0.300	53.6
				Total: 99.3

50 $\mu g/cm^2$

q	A/q	Field (mT)	Intensity (ppA)	Transmission (%)
4	4	1074.60	0	0
5	3.2	859.68	0	0
6	2.6667	716.40	0.034	6
7	2.2857	614.06	0.207	37
8	2	537.30	0.287	51.3
				Total: 94.3





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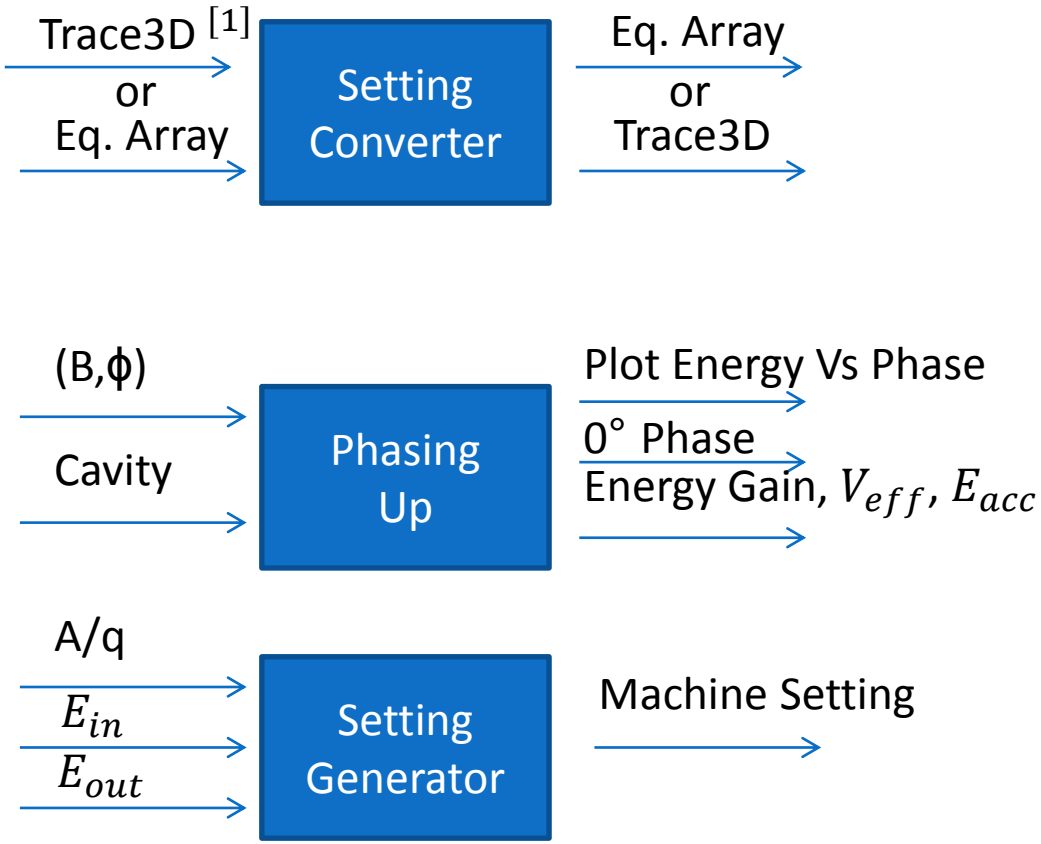
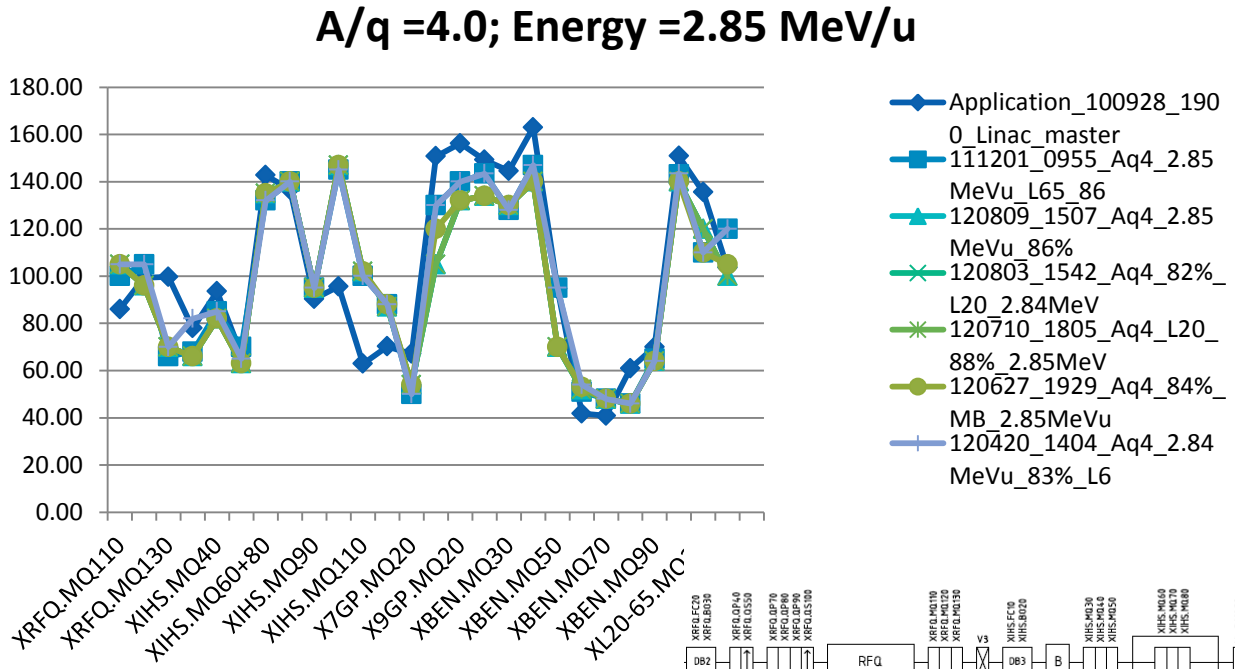
Software Upgrade

- Specific software application needed in order to ensure a fast machine set up

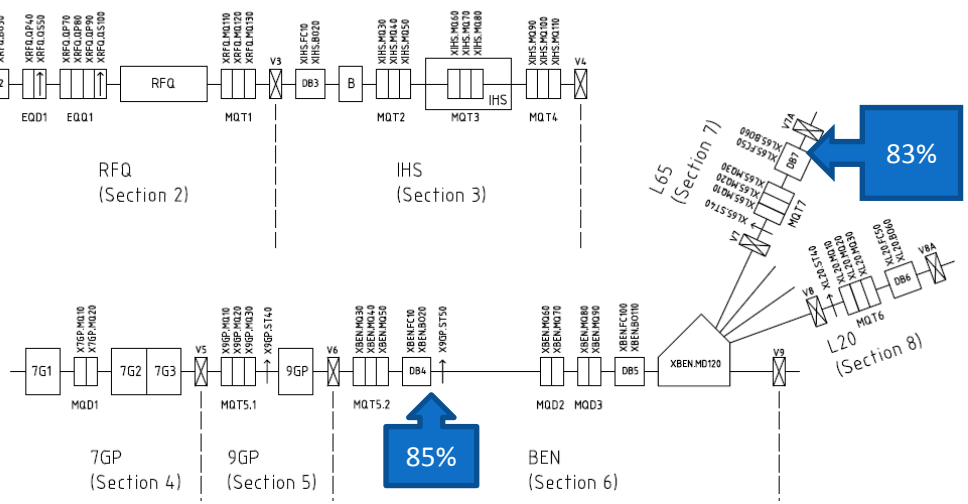


[1] Software Trace3D provided by the Los Alamos Accelerator Code Group (LAACG) of Los Alamos National Laboratory.

Setting Converter(Trace3D to Eq. Array)

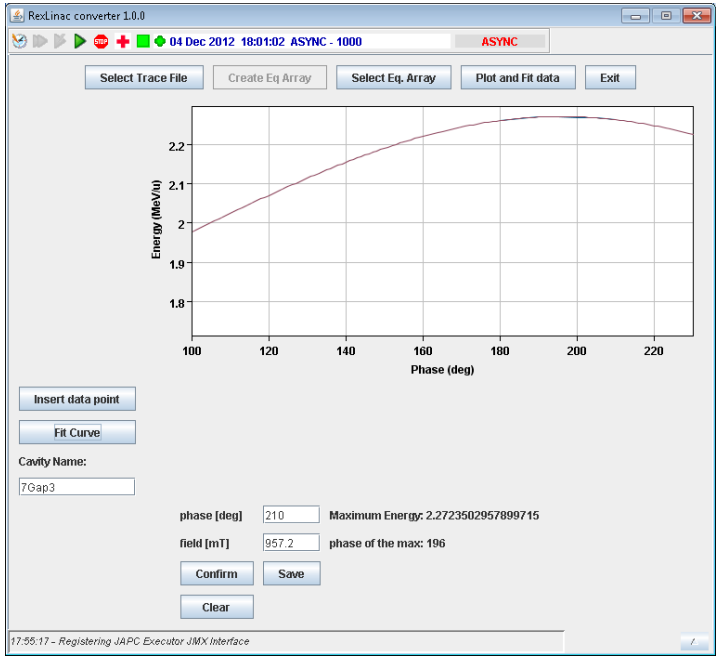


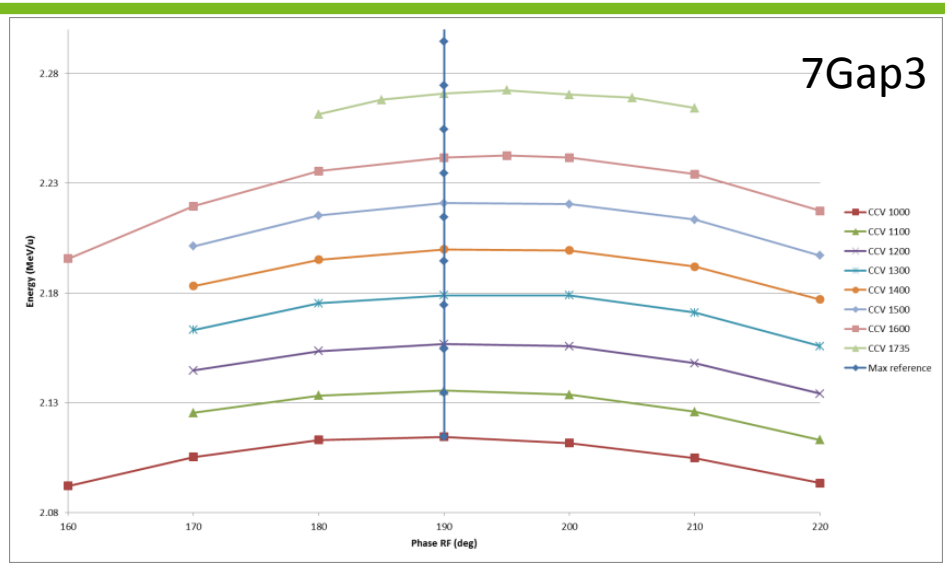
- 85% Transmission in DB4
- Big loss in the last section
- Fine tuning of XBEN.MQ60 back to 83% in the DB6

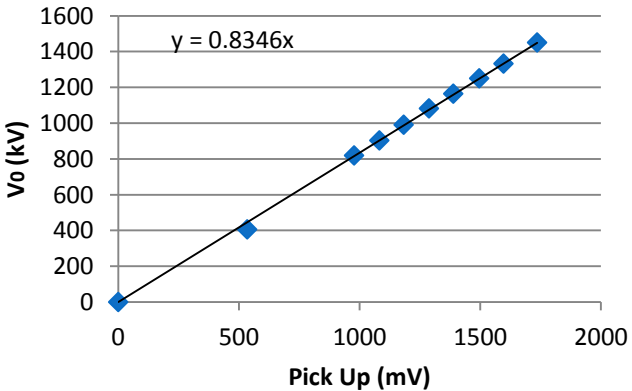


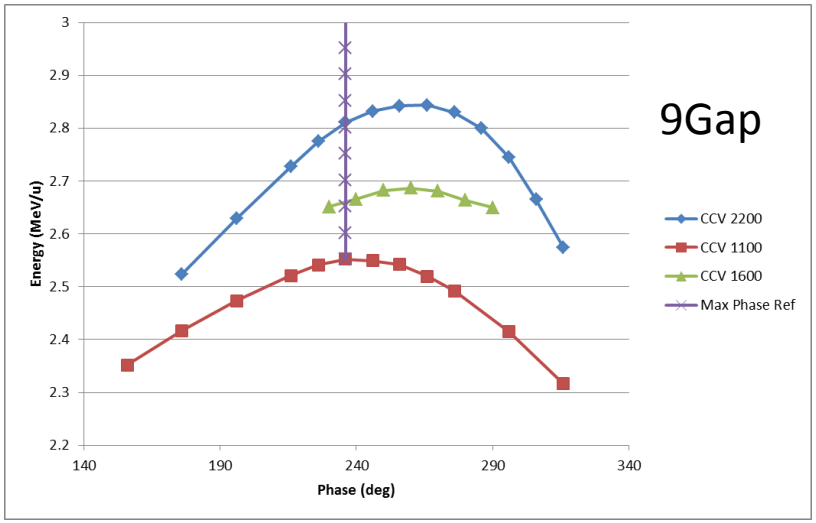
Phasing Up

0° phase's shift are negligible for 7Gap but not for 9Gap
SC Cavities behave as the 7Gap









Summary and Conclusion

- Beam commissioning: Foreseen 02-2015 and last for 4 months;
- Faraday Cups: Present short design for the intercryomodule region and new design for HEBT;
- TOF: Set up installed and preliminary test done. Other test in the beginning of next year;
- Emittance: Test at different beam energy, beam intensity, have been carried out. NTG E-meter underestimate emittance. Still in the acceptance limit. Next change NTG slits size and measure profile with independent method;
- Stripping foil: Test have been performed at different beam energy. No big beam loss and emittance blow up for high energy beam. Need thinner foils at low energy. Next use double stripping for HIE;
- Software: Specific application for the SC Linac have been written and tested with the NC Linac. Good preliminary results. To be finalize during LS1.

Acknowledgments

- Special thanks for help and support to:
  - Didier Voulot
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  - Emiliano Piselli
  - Miguel Lozano Benito
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  - Esteban Cantero
  - Fredrik Wenander
  - Erwin Siesling
  - All ISOLDE team






Thank you for your attention