# Commissioning of the New Heavy Ion Linac HILac at the NICA Project

XXV. Russian Particle Accelerator Conference

Saint Petersburg

26.11.2016

Holger Höltermann, BEVATECH GmbH
on behalf of the team

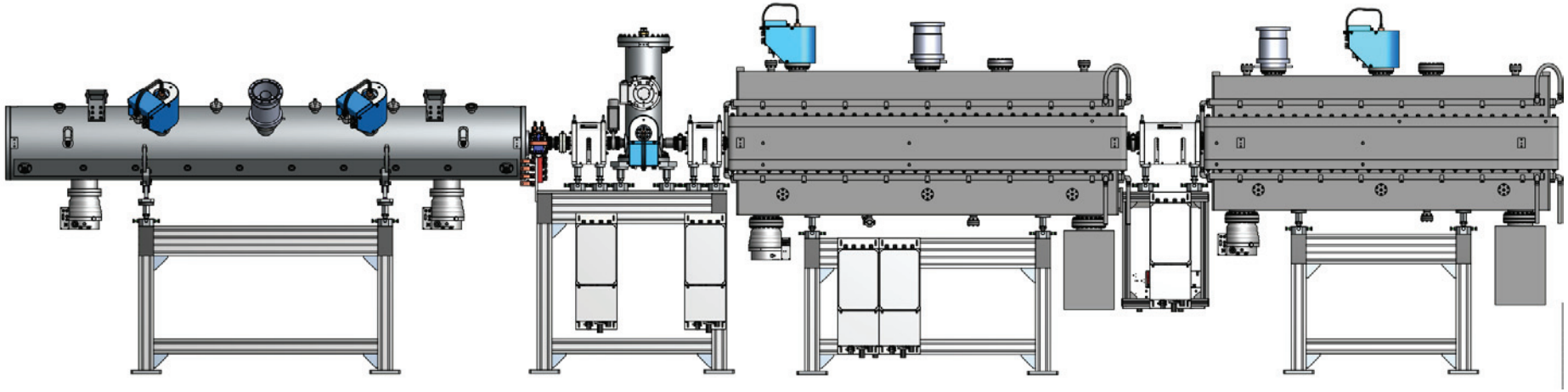
JOINT INSTITUTE FOR NUCLEAR RESEARCH 1956 · 2016

NICA

BEVATECH

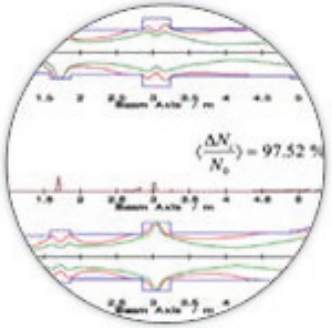
# Table of Contents

- Heavy Ion Linear accelerator HILac Background
- Design + Production
- HILac RF amplifiers
- HILac Commissioning

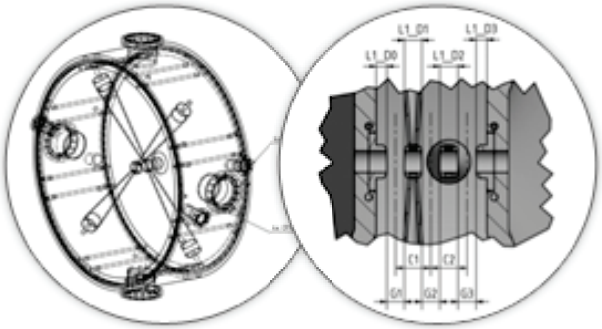


BEVATECH

Accelerator Components



Simulations & Codes

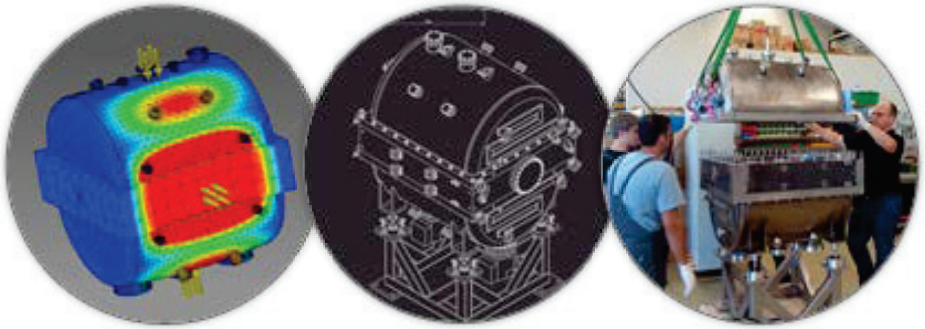


Vacuum Design

BEVATECH

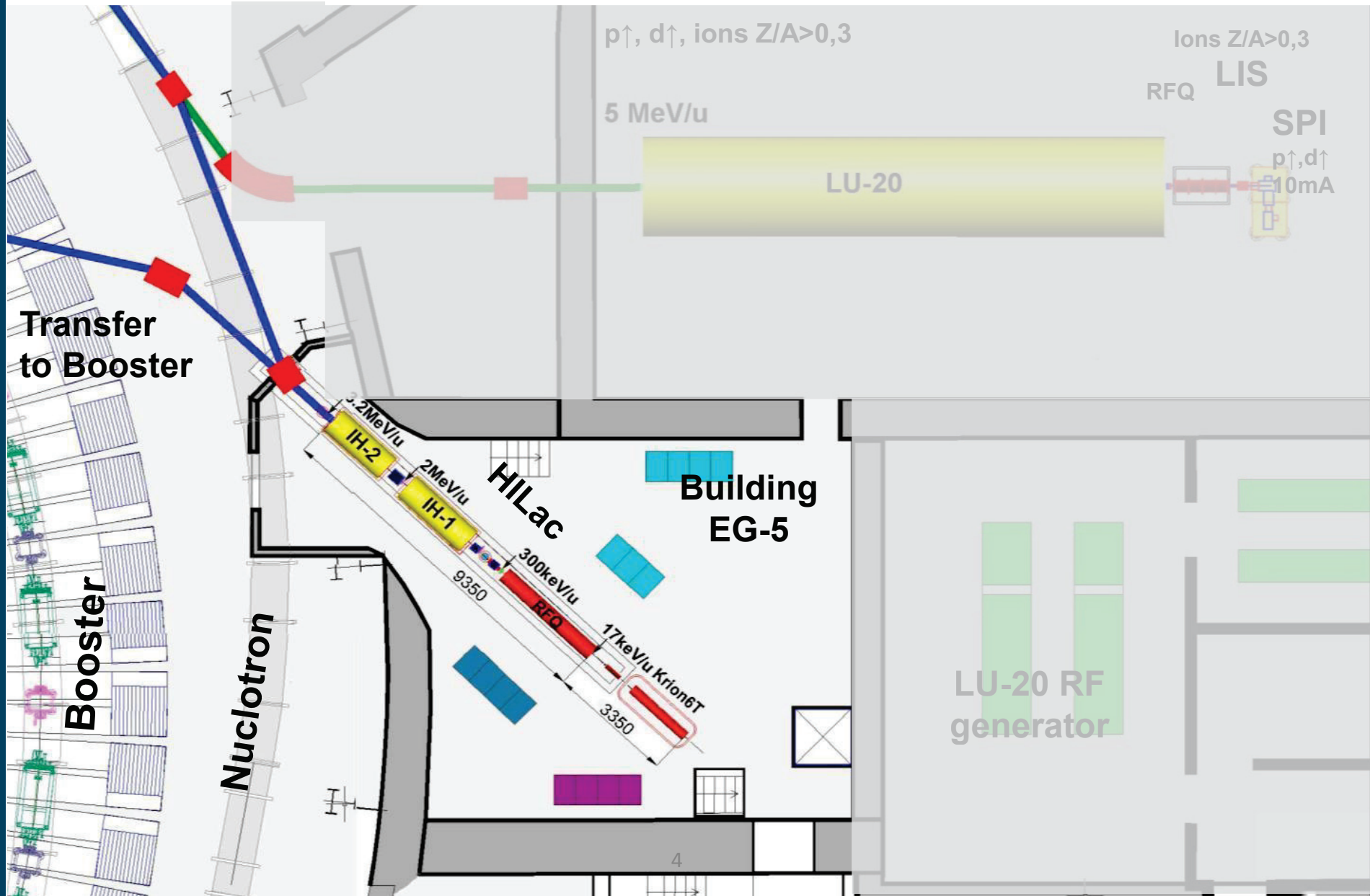
U. Ratzinger
H. Podlech
A. Schempp
H. Höltermann

Cooperations for Industry, Medicine & Research



Linac Development & Turn Key Solutions

# NICA Injector Complex



# HILac Design Parameters

| Parameter | Value |
|---|---|
| A/q (max) | 6.25 for 10 mA $A^{32+}$ |
| A/q (min) | 1 for ⩽ 2 mA p |
| Frequency | 100.625 MHz |
| RF amplifier (RFQ/IH) | 140kW / 2*340kW |
| Repetition rate | ⩽ 10 Hz |
| Max. pulse length RF | 200 µs |
| Pulse length beam | 30 µs |
| $E_{in}$ RFQ/$E_{out}$ RFQ | 17 AkeV/300 AkeV |
| Transmission RFQ | 90% |
| $E_{out}$ IH-DTL (2xIH) | 3.2 AMeV |
| Total Transmission HILac after LEBT | ≥80 % |
| Length RFQ to end of 2nd IH DTL | Approx. 9 m |
| $\varepsilon_{in}$ (trans, norm) | 0.6/0.4 π mm mrad |

BEVATECH

# Krion-6T ESIS

1) Magnetic field in ESIS: up to B= 6.0 T, (5.4 T, 2016)
2) Electron injection energy: $E_e \leq 25$ keV. ($E_e \leq 12$ keV, 2016)

E.D.Donets, E.E.Donets

| | |
|---|---|
| **Working element/charge state** | $Au^{32+}$, $Au^{51+}$/ $Au^{32+}$ $Au^{51+}$ $Tm^{41}$ (2015) |
| **Expected ion int. *N_i*** | $1 \div 4 \times 10^9$ ppp $Au^{31+}$ ($5 \times 10^8$, 2015)<br>($1 \div 3 \times 10^8$ ppp for $Tm^{41+} \sim Au^{51+}$, 2015) |
| **Repetition rate** | 50 Hz (for $Au^{31+}$) 50÷100 Hz, 2015<br>3÷5 Hz for $Tm^{41+}$-$Au^{51+}$, 2015 |
| **Extraction time form the ESIS** | $8 \div 30 \times 10^{-6}$ s/ $8 \div 30 \times 10^{-6}$ s, 2016 |
| **RMS emittance** | 0.6 π mm mrad<br>(for $8 \times 10^{-6}$ s extraction time);<br>0.15 π mm mrad<br>(for $30 \times 10^{-6}$ s extraction time). |
| **Peak current in pulse** | up to 10 mA |

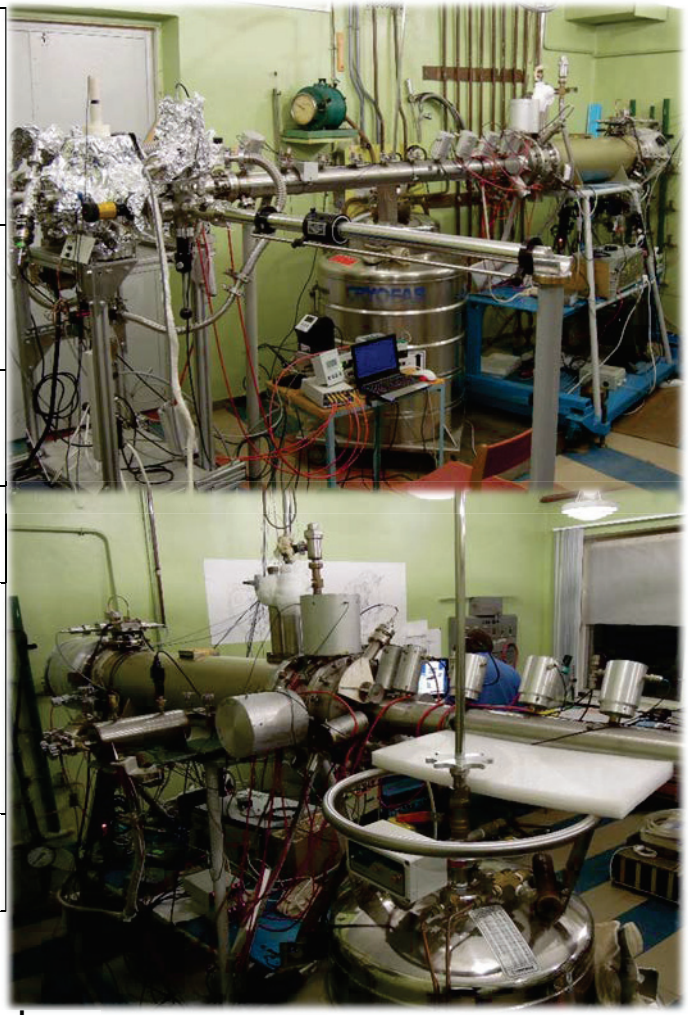


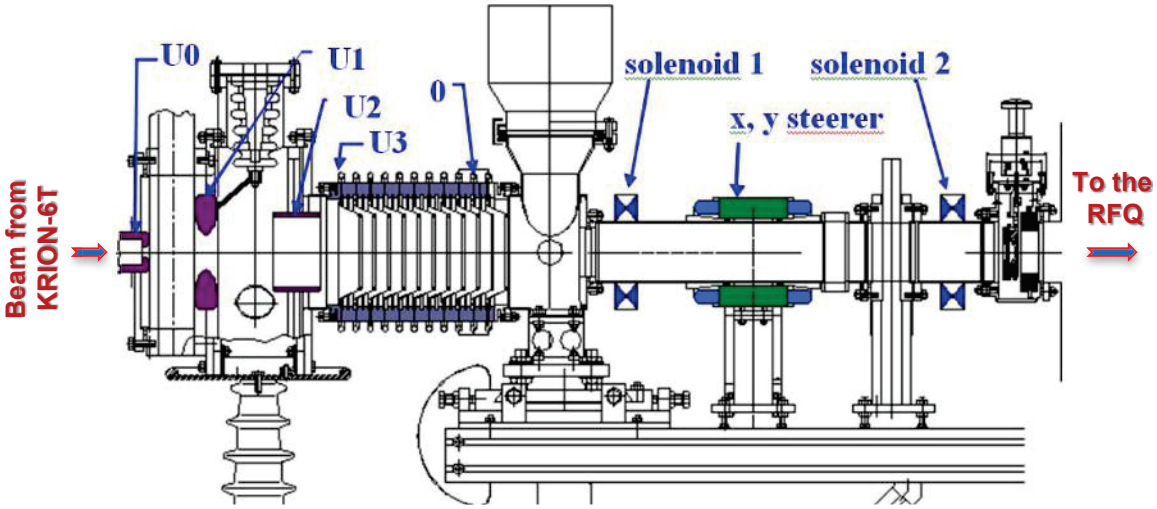
Table: Project & Obtained Parameters

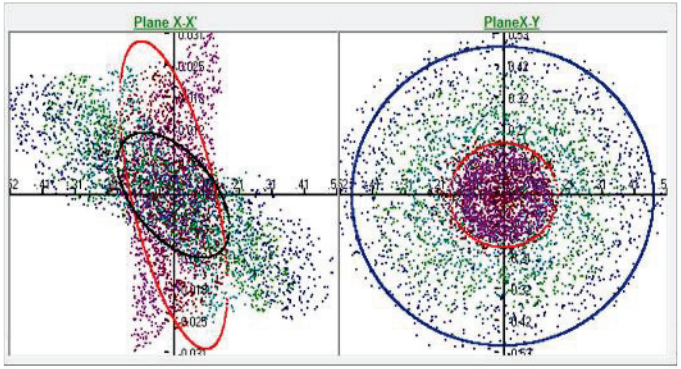
**Next Steps:**

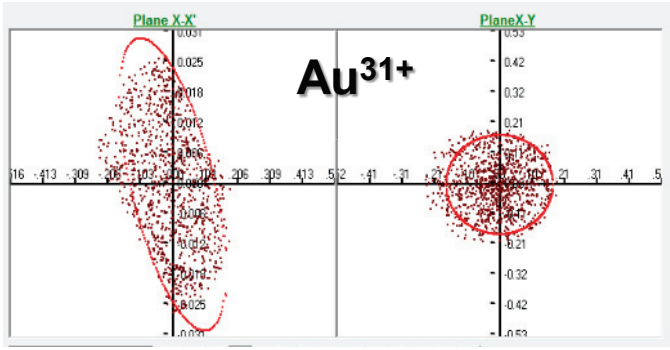
1) Further improvement of the Au, (Bi) internal injection technology.
2) Experiments with ion production with a solenoid magnetic field up to 6T& electron energy up to 15KeV towards the expected trap capacity & Au beam intensity.

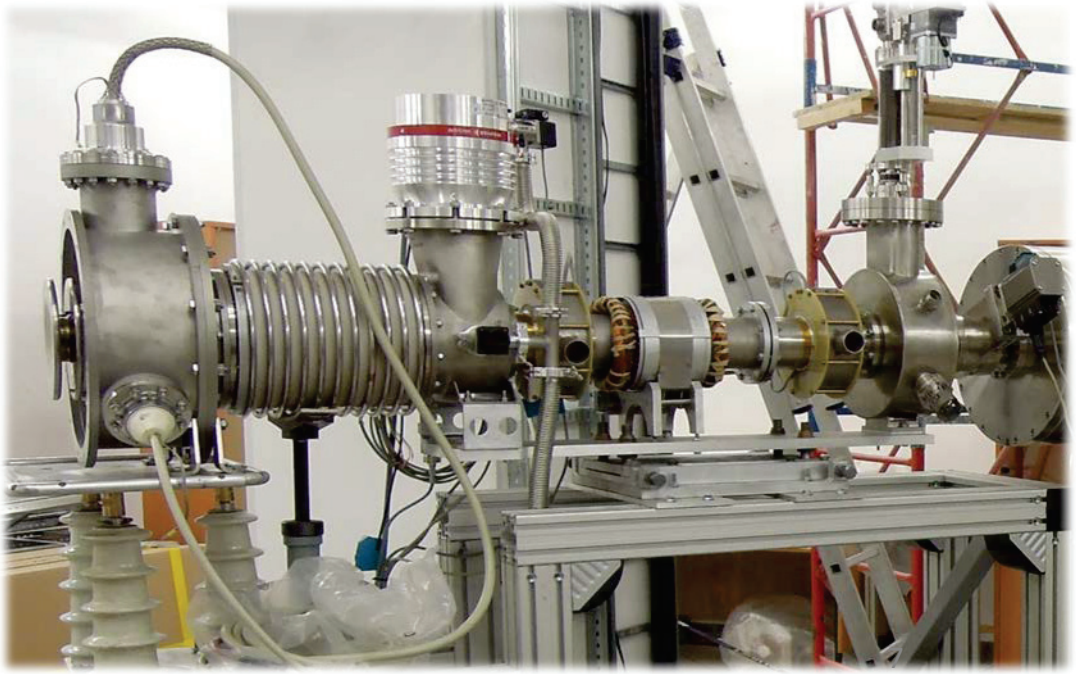
# LEBT for HILac

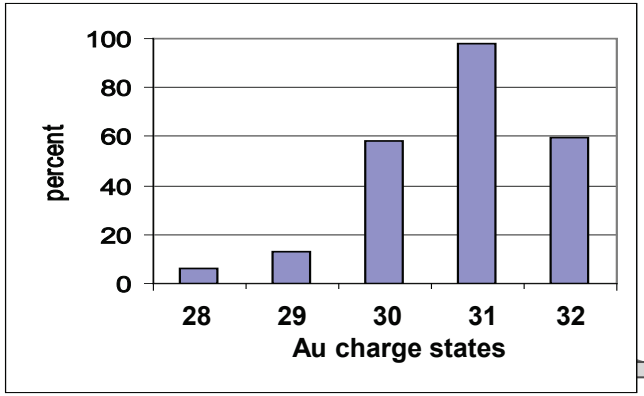
A.Butenko, V.Aleksandrov





# HILac Project Schedule

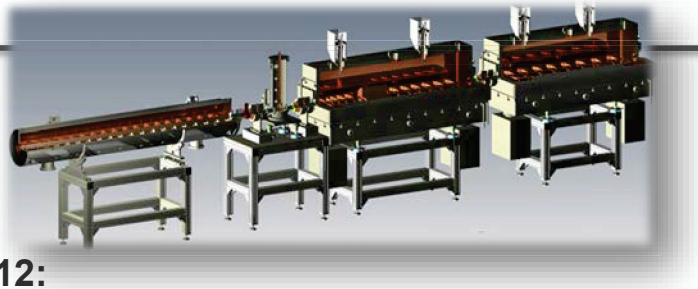
Project Duration: 50 Months

**Start: Mai 2012**

Phase I

**Milestone I** **Milestone II**

BD + RF Design → Technical Design



**August 2012: Beam Dynamics + RF Design**

**Dezember 2012: Technical Design**

Phase II

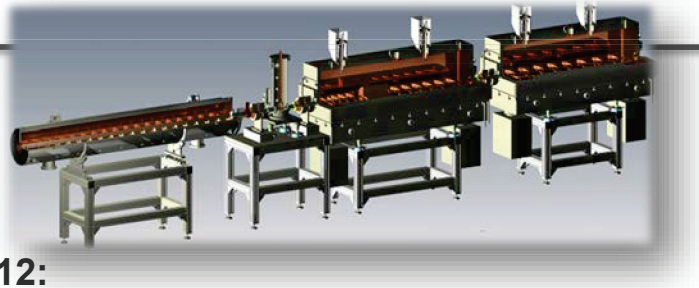
Phase III

BEVATECH

# HILac Project Schedule

Project Duration: 50 Months

**Start: Mai 2012**



## Phase I

**Milestone I**

BD + RF Design

**Milestone II**

Technical Design

**August 2012: Beam Dynamics + RF Design**

**Dezember 2012: Technical Design**

## Phase II

Amplifier Decision

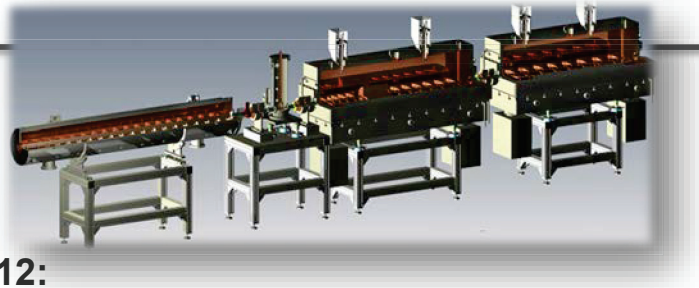
## Phase III

BEVATECH

# HILac Project Schedule

Project Duration: 50 Months

**Start: Mai 2012**



## Phase I

**Milestone I** — BD + RF Design

**Milestone II** — Technical Design

**August 2012: Beam Dynamics + RF Design**

**Dezember 2012: Technical Design**

## Phase II

Amplifier Decision

**Q3 2013:** RF Order

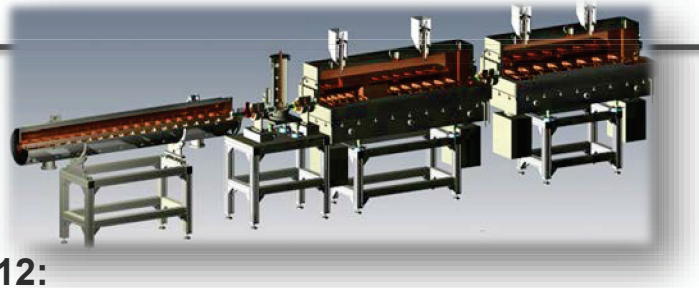
## Phase III

BEVATECH

# HILac Project Schedule

Project Duration: 50 Months

**Start: Mai 2012**



## Phase I

**Milestone I**

BD + RF Design

**Milestone II**

Technical Design

**August 2012: Beam Dynamics + RF Design**

**Dezember 2012: Technical Design**

## Phase II

**Milestone III**

Amplifier Decision

**Q3 2013:** RF Order

## Phase III

BEVATECH

# HILac Project Schedule

Project Duration: 50 Months

**Start: Mai 2012**

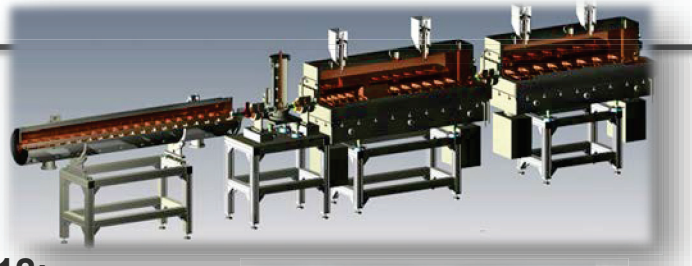
Phase I

**Milestone I**

BD + RF Design

**Milestone II**

Technical Design



**August 2012: Beam Dynamics + RF Design**

**Dezember 2012: Technical Design**

Phase II

**Milestone III**

Amplifier Decision

**Q3 2013:** RF Order

Phase III

BEVATECH

# HILac Project Schedule

Project Duration: 50 Months

**Start: Mai 2012**

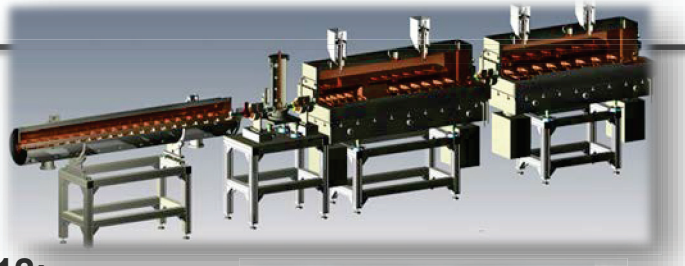
## Phase I

**Milestone I**

BD + RF Design

**Milestone II**

Technical Design



**August 2012: Beam Dynamics + RF Design**

**Dezember 2012: Technical Design**

## Phase II

**Milestone III**

Amplifier Decision

RF Amplifiers

**Q3 2013:** RF Order

## Phase III

BEVATECH

# HILac Project Schedule

Project Duration: 50 Months

**Start: Mai 2012**

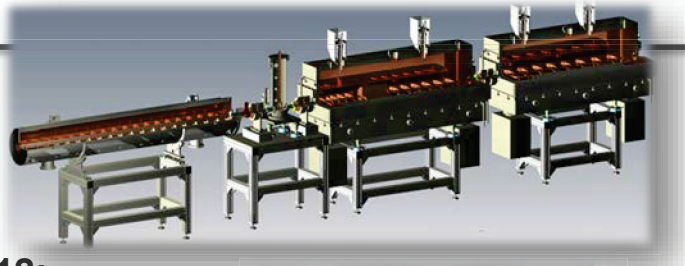
Phase I

**Milestone I**

BD + RF Design

**Milestone II**

Technical Design



**August 2012: Beam Dynamics + RF Design**

**Dezember 2012: Technical Design**

Phase II

**Milestone III**

Amplifier Decision

RF Amplifiers

**Q3 2013:** RF Order

Phase III

BEVATECH

# HILac Project Schedule

Project Duration: 50 Months

**Start: Mai 2012**

Phase I

**Milestone I**

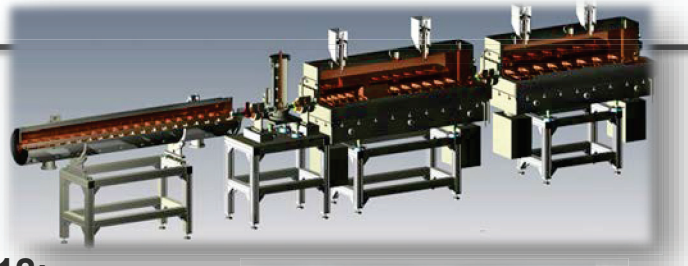
BD + RF Design

**August 2012: Beam Dynamics + RF Design**

**Milestone II**

Technical Design

**Dezember 2012: Technical Design**



Phase II

**Milestone III**

Amplifier Decision

RF Amplifiers

**Q3 2013:** RF Order

**March 2015: FAT RF Amplifier**

Phase III

BEVATECH

# HILac Project Schedule

Project Duration: 50 Months

**Start: Mai 2012**

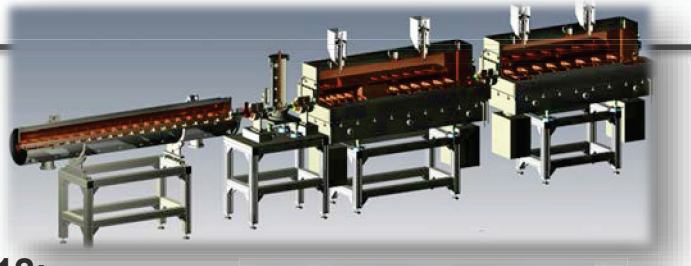
Phase I

**Milestone I**

BD + RF Design

**Milestone II**

Technical Design



**August 2012: Beam Dynamics + RF Design**

**Dezember 2012: Technical Design**

Phase II

**Milestone III**

Amplifier Decision

RF Amplifiers

**Q3 2013:** RF Order

**March 2015: FAT RF Amplifier**

Cavity and Magnet Development

Phase III

BEVATECH

# HILac Project Schedule

Project Duration: 50 Months

**Start: Mai 2012**

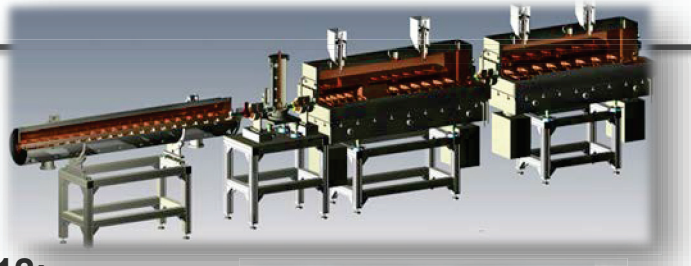
## Phase I

**Milestone I**

BD + RF Design

**Milestone II**

Technical Design



**August 2012: Beam Dynamics + RF Design**

**Dezember 2012: Technical Design**

## Phase II

**Milestone III**

Amplifier Decision

RF Amplifiers

**Q3 2013:** RF Order

**March 2015: FAT RF Amplifier**

**Milestone IV**

Cavity and Magnet Development

## Phase III

BEVATECH

# HILac Project Schedule

Project Duration: 50 Months

**Start: Mai 2012**

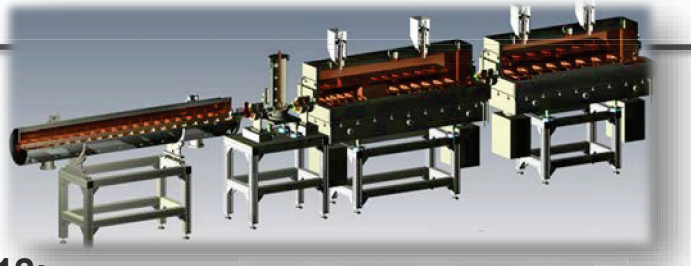
## Phase I

**Milestone I**

BD + RF Design

**Milestone II**

Technical Design



**August 2012: Beam Dynamics + RF Design**

**Dezember 2012: Technical Design**

## Phase II

**Milestone III**

Amplifier Decision

RF Amplifiers

**Q3 2013:** RF Order

**March 2015: FAT RF Amplifier**

**Milestone IV**

Cavity and Magnet Development

## Phase III

BEVATECH

# HILac Project Schedule

Project Duration: 50 Months

**Start: Mai 2012**

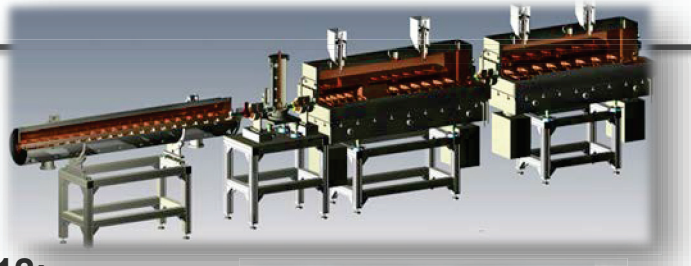
## Phase I

**Milestone I**

BD + RF Design

**Milestone II**

Technical Design



**August 2012: Beam Dynamics + RF Design**

**Dezember 2012: Technical Design**

## Phase II

**Milestone III**

Amplifier Decision

RF Amplifiers

**Q3 2013:** RF Order

**March 2015: FAT RF Amplifier**

**Milestone IV**

Cavity and Magnet Development

**May 2015: FAT Cavities Completed**

## Phase III

BEVATECH

# HILac Project Schedule

Project Duration: 50 Months

**Start: Mai 2012**

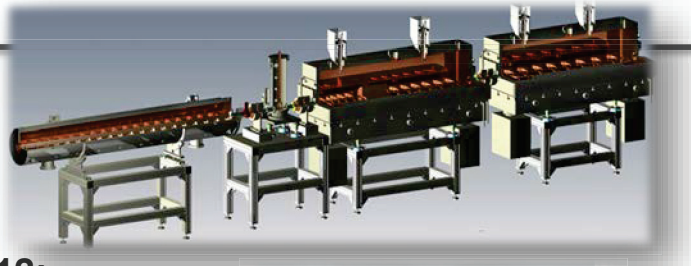
## Phase I

**Milestone I**

BD + RF Design

**Milestone II**

Technical Design



**August 2012: Beam Dynamics + RF Design**

**Dezember 2012: Technical Design**

## Phase II

**Milestone III**

Amplifier Decision

RF Amplifiers

**Q3 2013:** RF Order

**March 2015: FAT RF Amplifier**

**Milestone IV**

Cavity and Magnet Development

**May 2015: FAT Cavities Completed**

3. HILac FAT

## Phase III

BEVATECH

# HILac Project Schedule

Project Duration: 50 Months

**Start: Mai 2012**

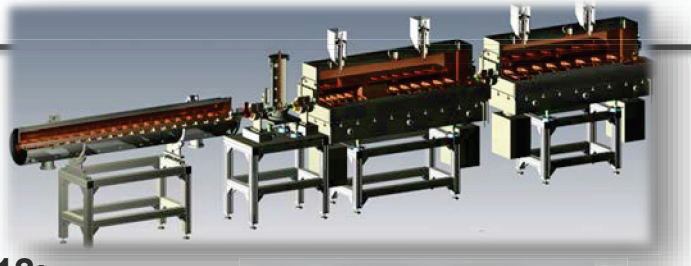
## Phase I

**Milestone I**

BD + RF Design

**Milestone II**

Technical Design



**August 2012: Beam Dynamics + RF Design**

**Dezember 2012: Technical Design**

## Phase II

**Milestone III**

Amplifier Decision

RF Amplifiers

**Q3 2013:** RF Order

**March 2015: FAT RF Amplifier**

**Milestone IV**

Cavity and Magnet Development

**May 2015: FAT Cavities Completed**

2. Copperplating 3. HILac FAT

## Phase III

BEVATECH

# HILac Project Schedule

Project Duration: 50 Months

**Start: Mai 2012**

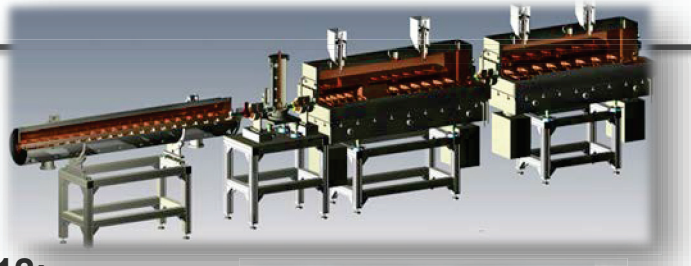
## Phase I

**Milestone I**

BD + RF Design

**Milestone II**

Technical Design



**August 2012: Beam Dynamics + RF Design**

**Dezember 2012: Technical Design**

## Phase II

**Milestone III**

Amplifier Decision

RF Amplifiers

**Q3 2013:** RF Order

**March 2015: FAT RF Amplifier**

**Milestone IV**

Cavity and Magnet Development

**May 2015: FAT Cavities Completed**

1. Production 2. Copperplating 3. HILac FAT

## Phase III

BEVATECH

# HILac Project Schedule

Project Duration: 50 Months

**Start: Mai 2012**

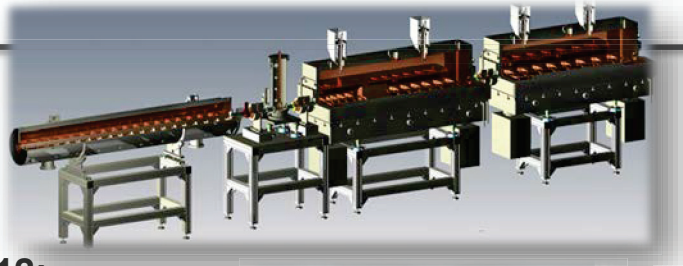
## Phase I

**Milestone I**

BD + RF Design

**Milestone II**

Technical Design



**August 2012: Beam Dynamics + RF Design**

**Dezember 2012: Technical Design**

## Phase II

**Milestone III**

Amplifier Decision

RF Amplifiers

**Q3 2013:** RF Order

**March 2015: FAT RF Amplifier**

**Milestone IV**

Cavity and Magnet Development

**May 2015: FAT Cavities Completed**

1. Production 2. Copperplating 3. HILac FAT

## Phase III

BEVATECH

# HILac Project Schedule

Project Duration: 50 Months

**Start: Mai 2012**

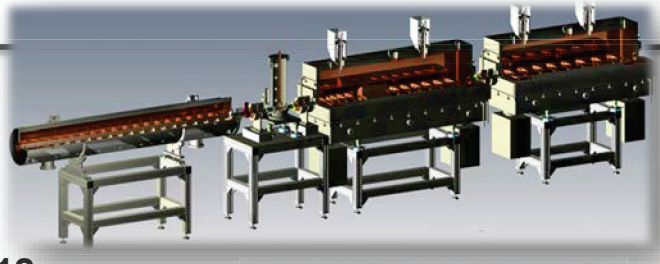
## Phase I

**Milestone I**

BD + RF Design

**Milestone II**

Technical Design



**August 2012: Beam Dynamics + RF Design**

**Dezember 2012: Technical Design**

## Phase II

**Milestone III**

Amplifier Decision

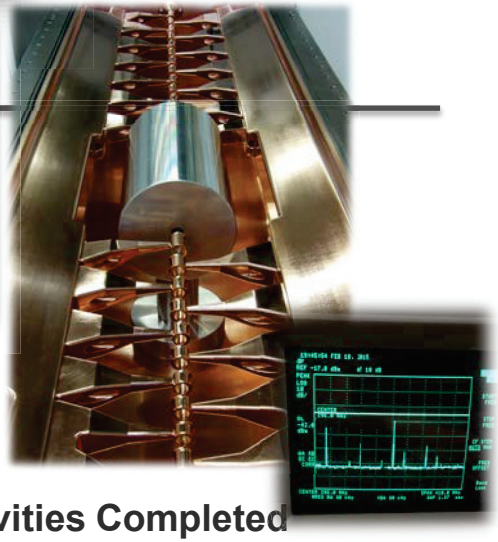
RF Amplifiers

**Q3 2013:** RF Order

**March 2015: FAT RF Amplifier**

**Milestone IV**

Cavity and Magnet Development



**May 2015: FAT Cavities Completed**

1. Production 2. Copperplating 3. HILac FAT

## Phase III

BEVATECH

# HILac Project Schedule

Project Duration: 50 Months

**Start: Mai 2012**

## Phase I

**Milestone I**

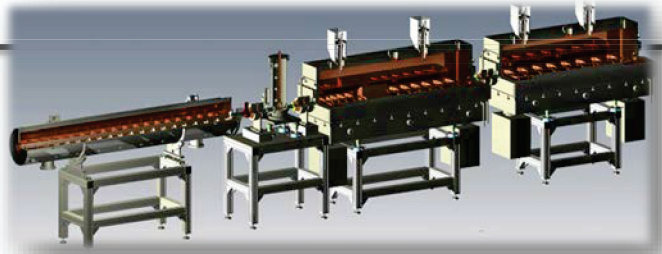
BD + RF Design

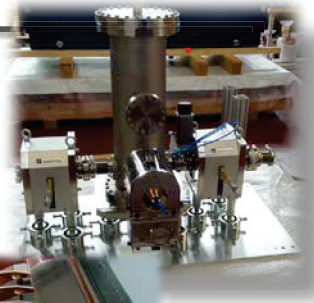
**Milestone II**

Technical Design

**August 2012: Beam Dynamics + RF Design**

**Dezember 2012: Technical Design**





## Phase II

**Milestone III**

Amplifier Decision

RF Amplifiers

**Q3 2013:** RF Order

**March 2015: FAT RF Amplifier**

**Milestone IV**

Cavity and Magnet Development

**May 2015: FAT Cavities Completed**

1. Production 2. Copperplating 3. HILac FAT

## Phase III

BEVATECH

# HILac Project Schedule

Project Duration: 50 Months

**Start: Mai 2012**

## Phase I

**Milestone I**

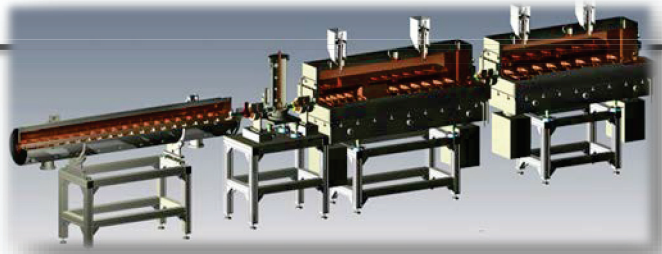
BD + RF Design

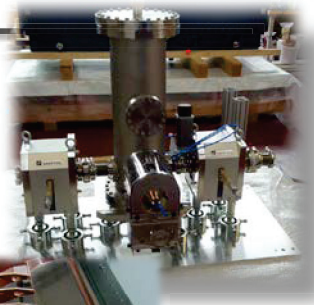
**Milestone II**

Technical Design

**August 2012: Beam Dynamics + RF Design**

**Dezember 2012: Technical Design**





## Phase II

**Milestone III**

Amplifier Decision

RF Amplifiers

**Q3 2013:** RF Order

**March 2015: FAT RF Amplifier**

**Milestone IV**

Cavity and Magnet Development

**May 2015: FAT Cavities Completed**

1. Production 2. Copperplating 3. HILac FAT

## Phase III

BEVATECH

# HILac Project Schedule

Project Duration: 50 Months

**Start: Mai 2012**

## Phase I

**Milestone I**

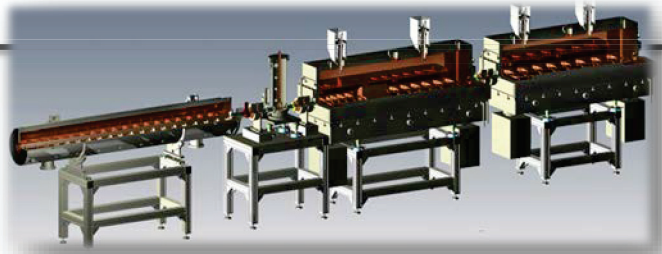
BD + RF Design

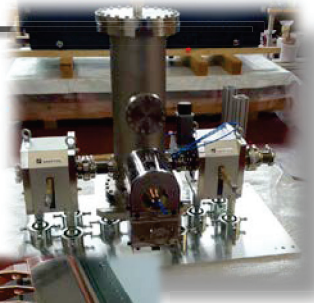
**Milestone II**

Technical Design

**August 2012: Beam Dynamics + RF Design**

**Dezember 2012: Technical Design**





## Phase II

**Milestone III**

Amplifier Decision

RF Amplifiers

**Q3 2013:** RF Order

**March 2015: FAT RF Amplifier**

**Milestone IV**

Cavity and Magnet Development

**May 2015: FAT Cavities Completed**

1. Production 2. Copperplating 3. HILac FAT

## Phase III

Transport & Commissioning

BEVATECH

# HILac Project Schedule

Project Duration: 50 Months

**Start: Mai 2012**

## Phase I

**Milestone I**

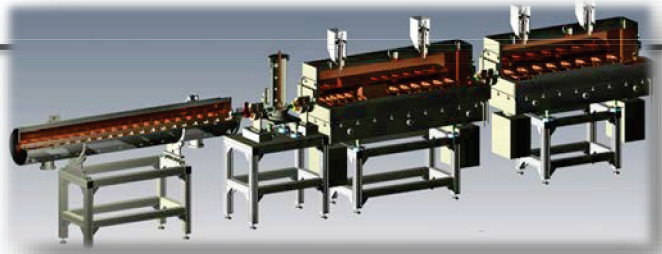
BD + RF Design

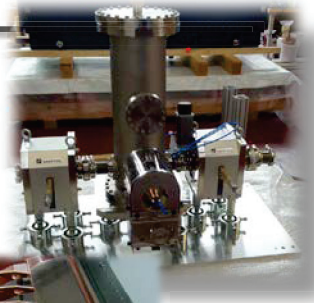
**Milestone II**

Technical Design

**August 2012: Beam Dynamics + RF Design**

**Dezember 2012: Technical Design**





## Phase II

**Milestone III**

Amplifier Decision

RF Amplifiers

**Q3 2013:** RF Order

**March 2015: FAT RF Amplifier**

**Milestone IV**

Cavity and Magnet Development

**May 2015: FAT Cavities Completed**

1. Production 2. Copperplating 3. HILac FAT

## Phase III

Transport & Commissioning

IH1 DTL + IH2 DTL

BEVATECH

# HILac Project Schedule

Project Duration: 50 Months

**Start: Mai 2012**

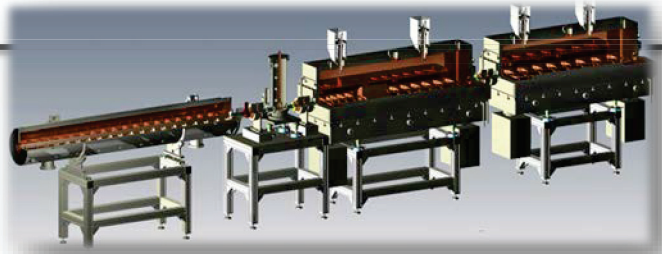
## Phase I

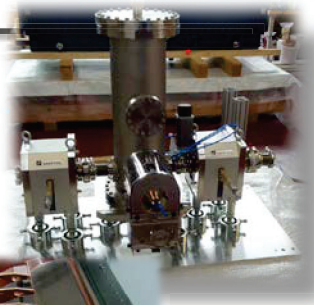
**Milestone I**

BD + RF Design

**Milestone II**

Technical Design





**August 2012: Beam Dynamics + RF Design**

**Dezember 2012: Technical Design**

## Phase II

**Milestone III**

Amplifier Decision

RF Amplifiers

**Q3 2013:** RF Order

**March 2015: FAT RF Amplifier**

**Milestone IV**

Cavity and Magnet Development

**May 2015: FAT Cavities Completed**

1. Production 2. Copperplating 3. HILac FAT

## Phase III

Transport & Commissioning

RFQ + MEBT

IH1 DTL + IH2 DTL

BEVATECH

# HILac Project Schedule

Project Duration: 50 Months

**Start: Mai 2012**

## Phase I

**Milestone I**

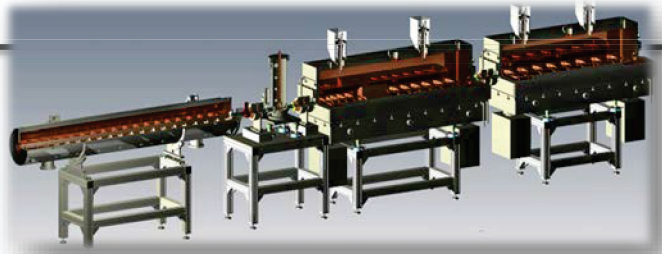
BD + RF Design

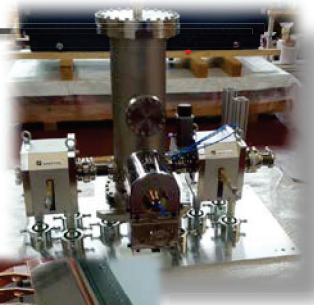
**Milestone II**

Technical Design

**August 2012: Beam Dynamics + RF Design**

**Dezember 2012: Technical Design**





## Phase II

**Milestone III**

Amplifier Decision

RF Amplifiers

**Q3 2013:** RF Order

**March 2015: FAT RF Amplifier**

**Milestone IV**

Cavity and Magnet Development

**May 2015: FAT Cavities Completed**

1. Production 2. Copperplating 3. HILac FAT

## Phase III

Transport & Commissioning

RFQ + MEBT

RF Commissioning IH1 DTL + IH2 DTL

BEVATECH

# HILac Project Schedule

Project Duration: 50 Months

**Start: Mai 2012**

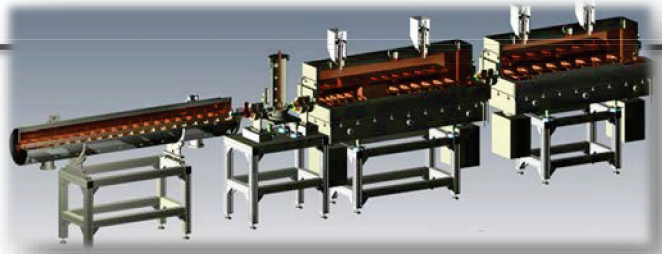
## Phase I

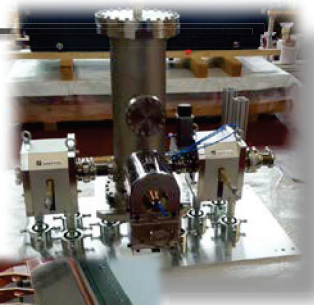
**Milestone I**

BD + RF Design

**Milestone II**

Technical Design





**August 2012: Beam Dynamics + RF Design**

**Dezember 2012: Technical Design**

## Phase II

**Milestone III**

Amplifier Decision

RF Amplifiers

**Q3 2013:** RF Order

**March 2015: FAT RF Amplifier**

**Milestone IV**

Cavity and Magnet Development

**May 2015: FAT Cavities Completed**

1. Production 2. Copperplating 3. HILac FAT

## Phase III

Transport & Commissioning

Shipment RFQ + MEBT

RF Commissioning IH1 DTL + IH2 DTL

BEVATECH

# HILac Project Schedule

Project Duration: 50 Months

**Start: Mai 2012**

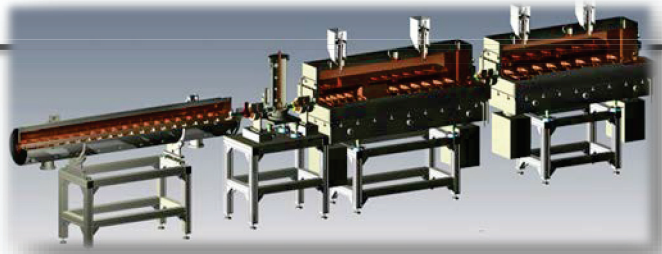
## Phase I

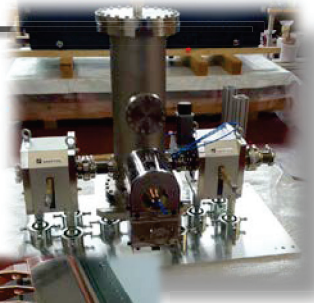
**Milestone I**

BD + RF Design

**Milestone II**

Technical Design





**August 2012: Beam Dynamics + RF Design**

**Dezember 2012: Technical Design**

## Phase II

**Milestone III**

Amplifier Decision

RF Amplifiers

**Q3 2013:** RF Order

**March 2015: FAT RF Amplifier**

**Milestone IV**

Cavity and Magnet Development

**May 2015: FAT Cavities Completed**

1. Production 2. Copperplating 3. HILac FAT

## Phase III

**Milestone V**

Transport & Commissioning

Shipment RFQ + MEBT

RF Commissioning IH1 DTL + IH2 DTL

BEVATECH

# HILac Project Schedule

Project Duration: 50 Months

**Start: Mai 2012**

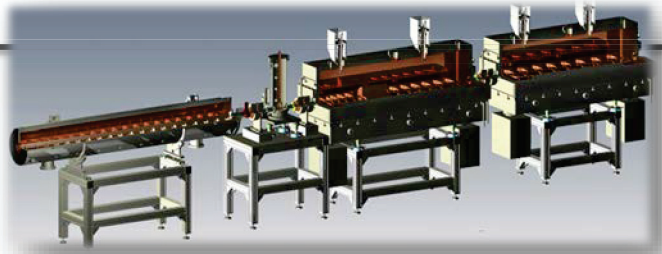
## Phase I

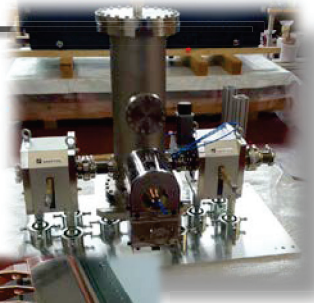
**Milestone I**

BD + RF Design

**Milestone II**

Technical Design





**August 2012: Beam Dynamics + RF Design**

**Dezember 2012: Technical Design**

## Phase II

**Milestone III**

Amplifier Decision

RF Amplifiers

**Q3 2013:** RF Order

**March 2015: FAT RF Amplifier**

**Milestone IV**

Cavity and Magnet Development

**May 2015: FAT Cavities Completed**

1. Production 2. Copperplating 3. HILac FAT

## Phase III

**Milestone V**

Transport & Commissioning

Shipment RFQ + MEBT

RF Commissioning IH1 DTL + IH2 DTL

BEVATECH

# HILac Project Schedule

Project Duration: 50 Months

**Start: Mai 2012**

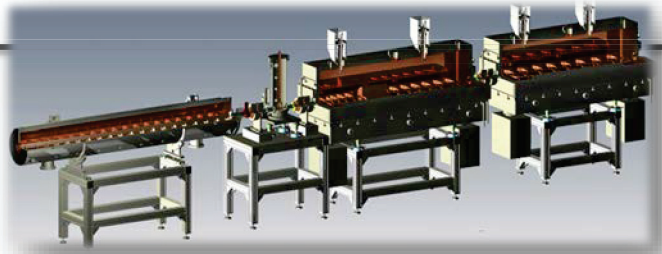
## Phase I

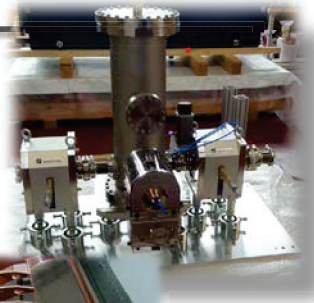
**Milestone I**

BD + RF Design

**Milestone II**

Technical Design





**August 2012: Beam Dynamics + RF Design**

**Dezember 2012: Technical Design**

## Phase II

**Milestone III**

Amplifier Decision

RF Amplifiers

**Q3 2013:** RF Order

**March 2015: FAT RF Amplifier**

**Milestone IV**

Cavity and Magnet Development

**May 2015: FAT Cavities Completed**

1. Production 2. Copperplating 3. HILac FAT

## Phase III

**Milestone V**

Transport & Commissioning

**October 2016: Commissioning**

Shipment RFQ + MEBT

RF Commissioning IH1 DTL + IH2 DTL

BEVATECH

# HILac Project Schedule

Project Duration: 50 Months

**Start: Mai 2012**

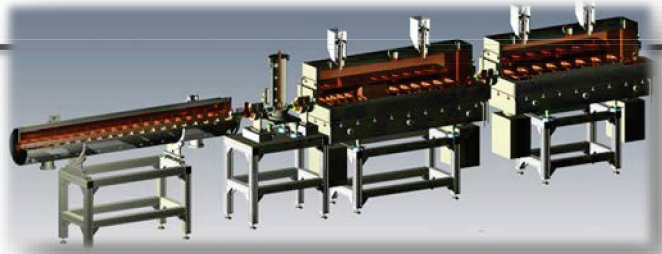
## Phase I

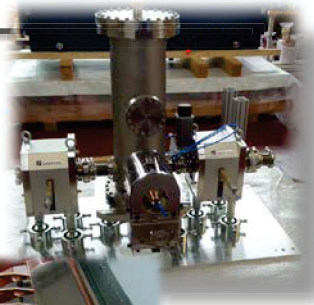
**Milestone I**

BD + RF Design

**Milestone II**

Technical Design





**August 2012: Beam Dynamics + RF Design**

**Dezember 2012: Technical Design**

## Phase II

**Milestone III**

Amplifier Decision

RF Amplifiers

**Q3 2013:** RF Order

**March 2015: FAT RF Amplifier**

**Milestone IV**

Cavity and Magnet Development

**May 2015: FAT Cavities Completed**

1. Production 2. Copperplating 3. HILac FAT

## Phase III

**July/August 2015: HILac delivered to JINR**

**Milestone V**

Transport & Commissioning

Shipment

RF Commissioning

RFQ + MEBT

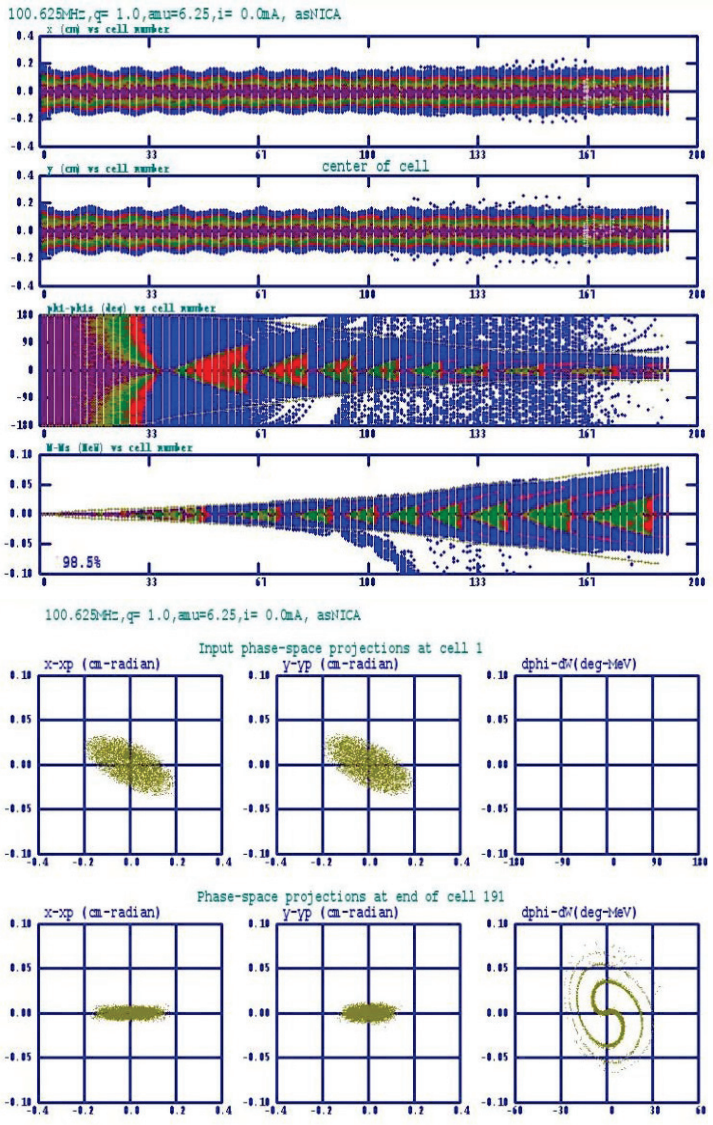
IH1 DTL + IH2 DTL

**October 2016: Commissioning**

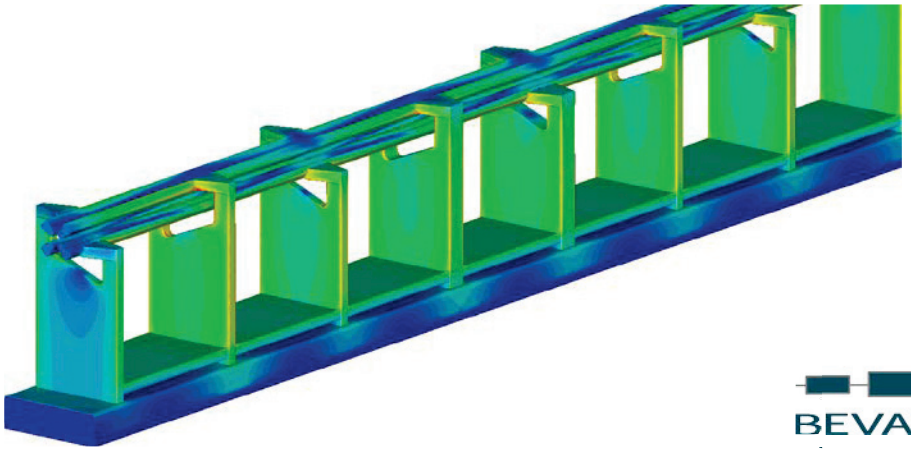
BEVATECH

# RFQ for HILac

**Transmission 10 mA: 97%**

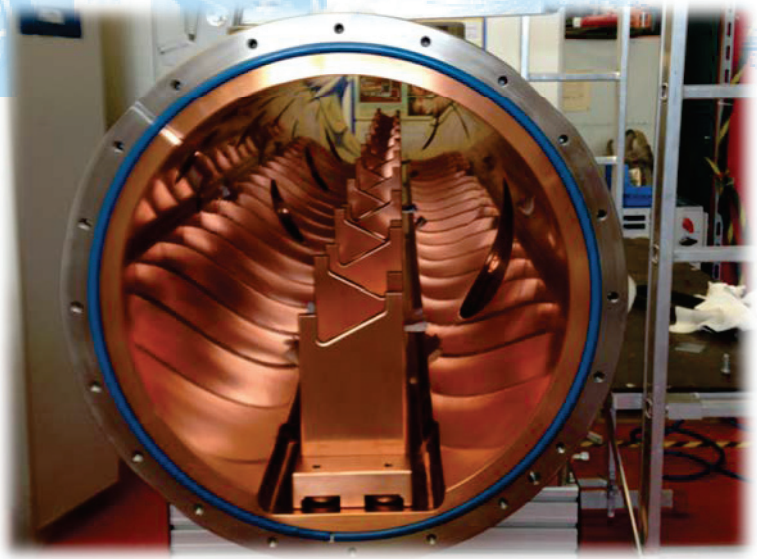


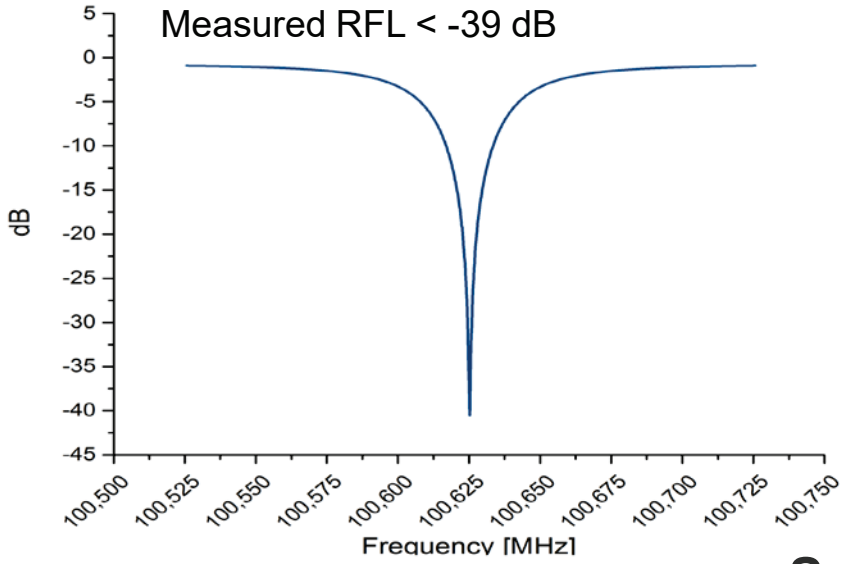

| Parameter | Value |
|---|---|
| Frequency 4-Rod RFQ | 100.625 MHz |
| Input- / Output-energy | 17 AkeV / 0.3 AMeV |
| Output rad. Emittance norm. 90% | 0.45 π mm mrad |
| Output long. emittance 90% | 250 deg keV |
| Transmission | 90 % (design) |
| Electrode voltage | 70 kV |
| RFQ length /diameter | 3.05m / 0.35m |
| RFQ RF Power | 110kW (10mA $Au^{32+}$) |
| Shunt Impedance | 149 kΩm |

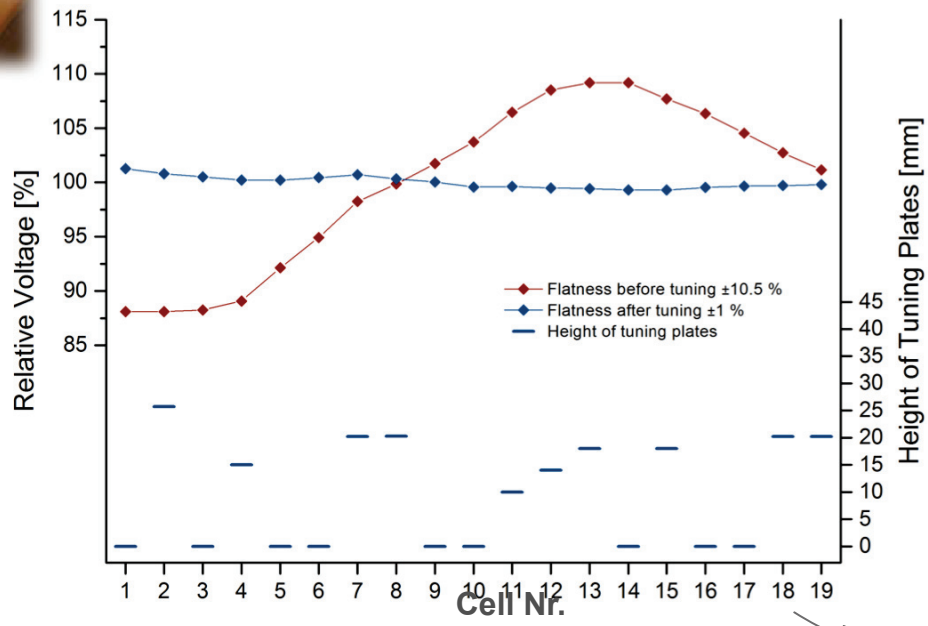


BEVATECH

# RFQ Production






**Summer 2014**

BEVATECH

# MEBT for HILac

**Spring 2015**

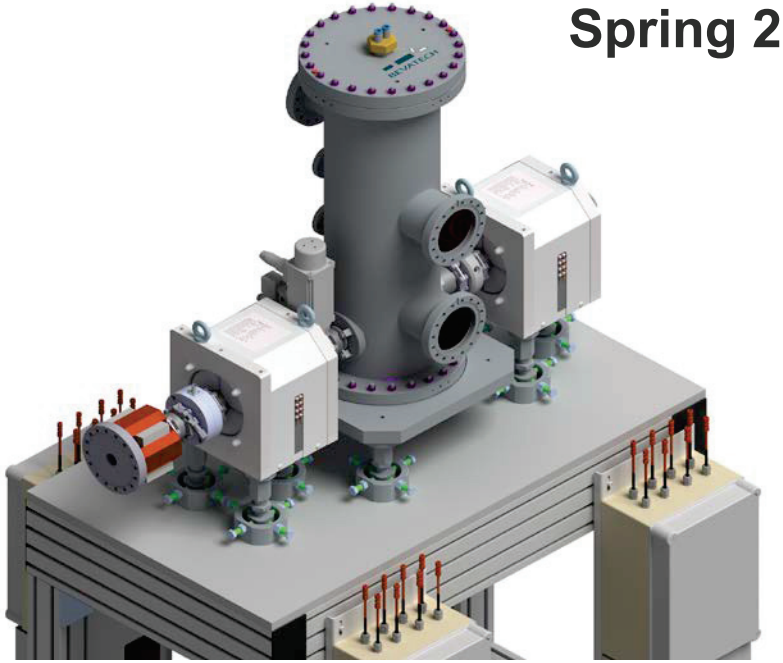
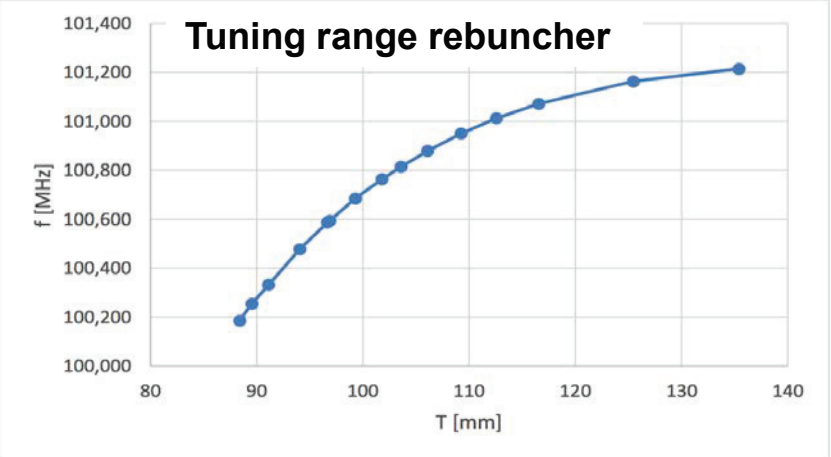
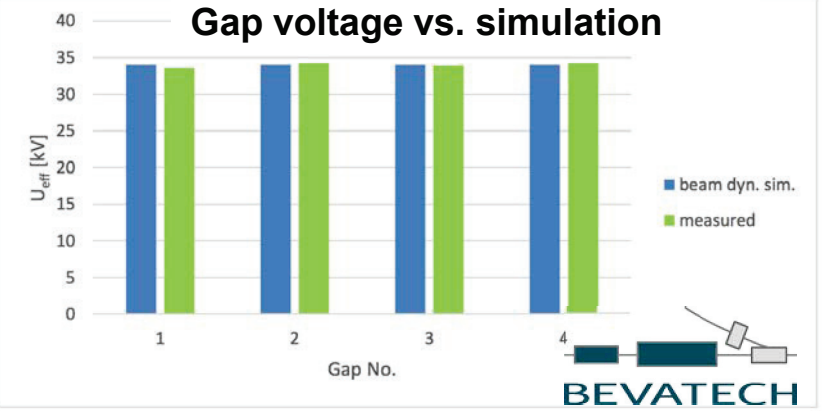


**Table: HILac MEBT elements**

| | |
|---|---|
| **Nr. of Doublets** | 2 pulsed @ max. 800A |
| **Magnetic Center Offset** | < 0.04 mm |
| **Rebuncher** | 4-gap quarter-wave |
| **Rebuncher RF** | 4kW SSA |
| **Current Transformer** | Bergoz ICT |
| **Phase Probe** | Capacitive type |
| **Steerer** | Magnetic Window type |

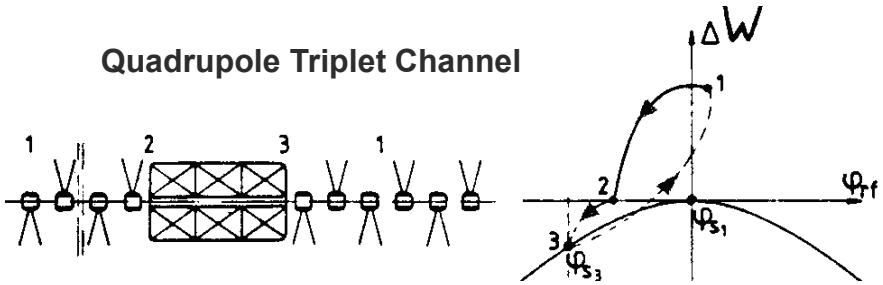


# IH-DTL Design for HILac

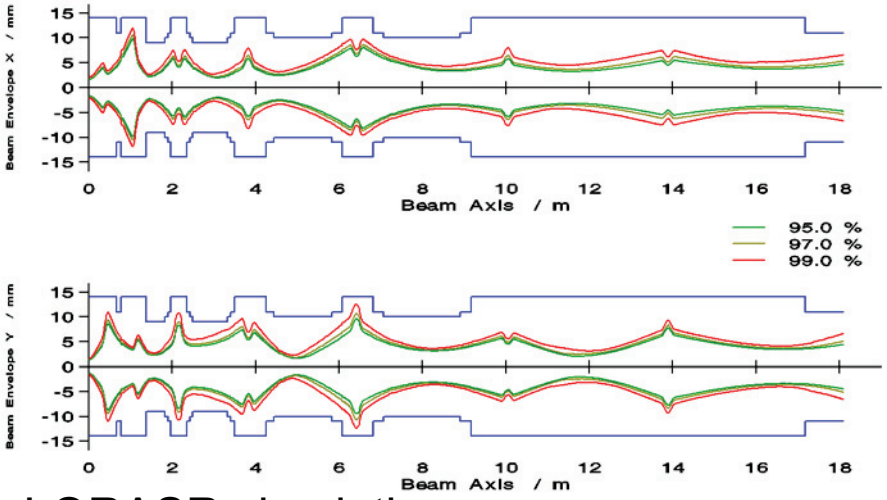
**IH-Type DTL** with **KONUS beam dynamics,** each lattice period divided into 3 regions with separated tasks:

1. Main acceleration at $\Phi_s$ = 0°, by a multi-gap structure
2. Transverse focusing by a quadrupole triplet or solenoid
3. Rebunching: 2 - 7 drift tubes at $\Phi_s$ = - 35° , typically (3).

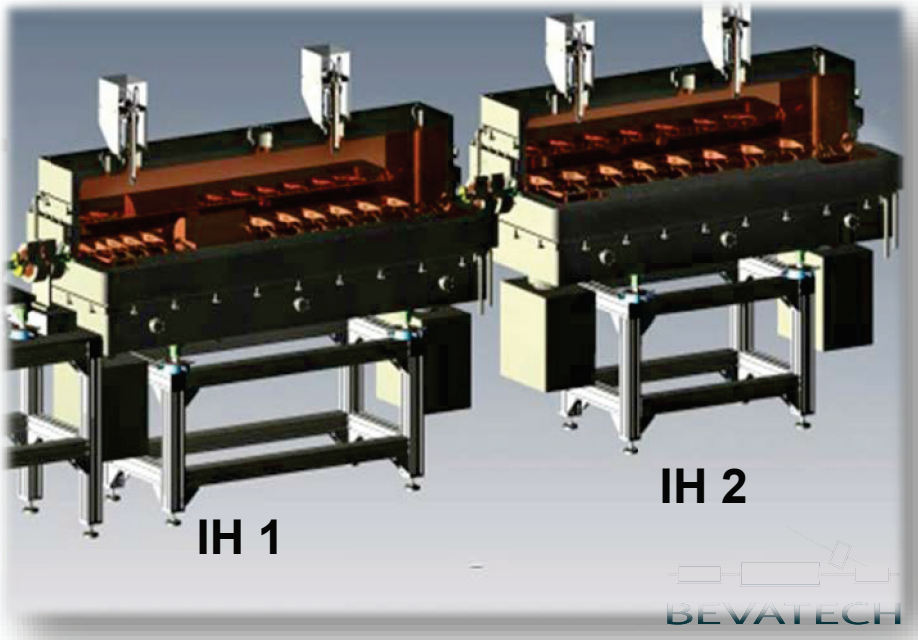



**'KONUS' – Combined 0° Structure**

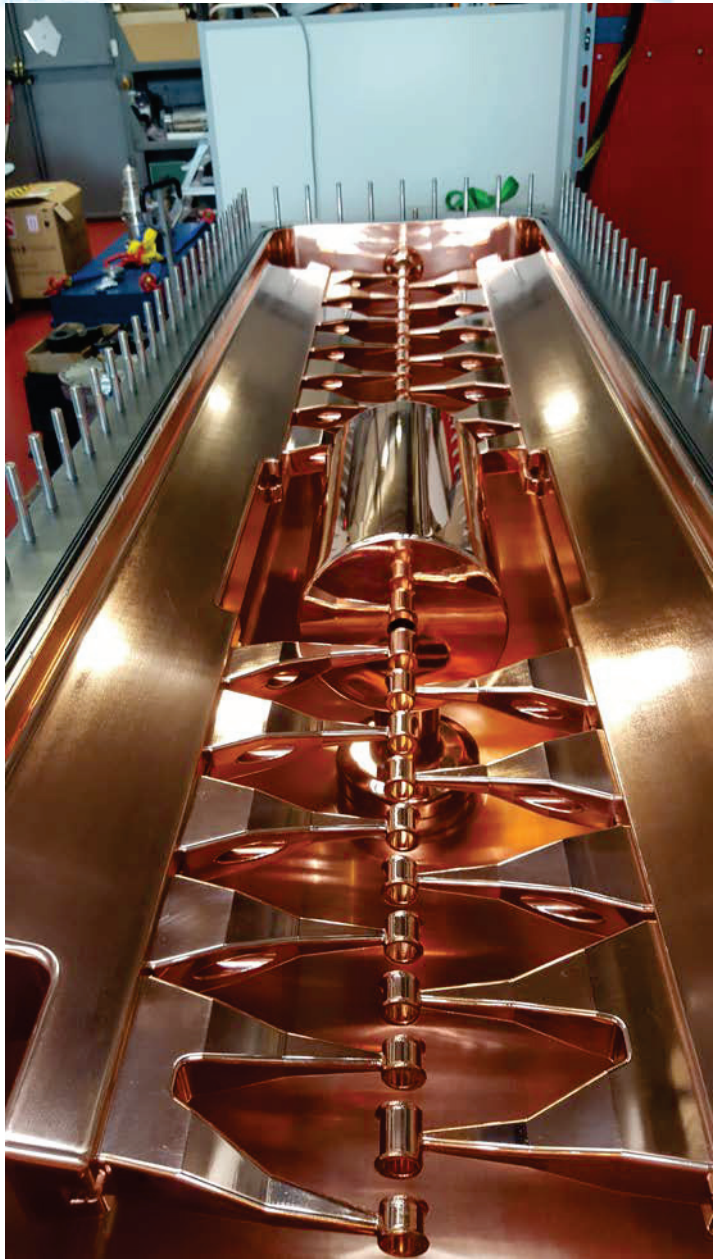
$AU^{32+}$, 10 mA, T=96.7%



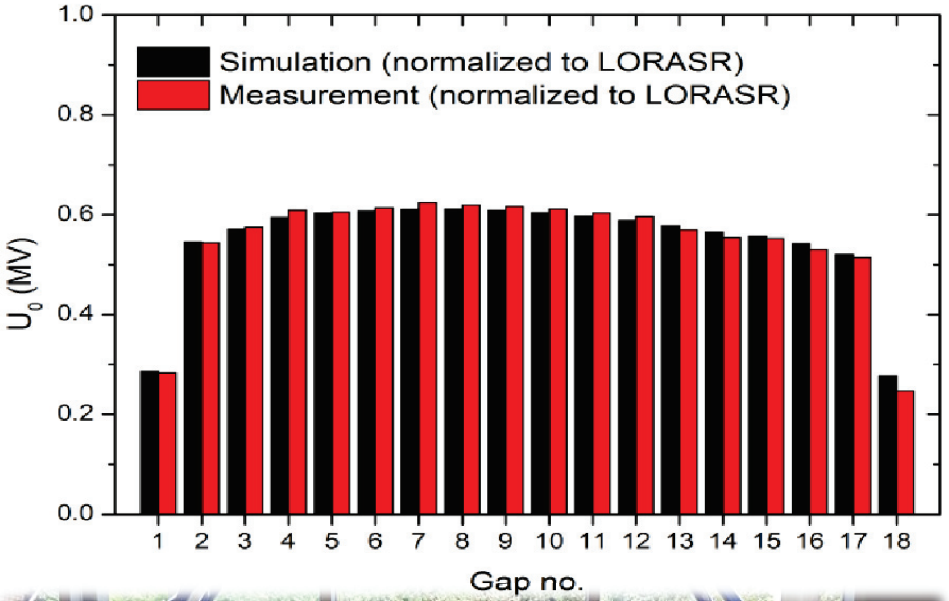

LORASR simulation

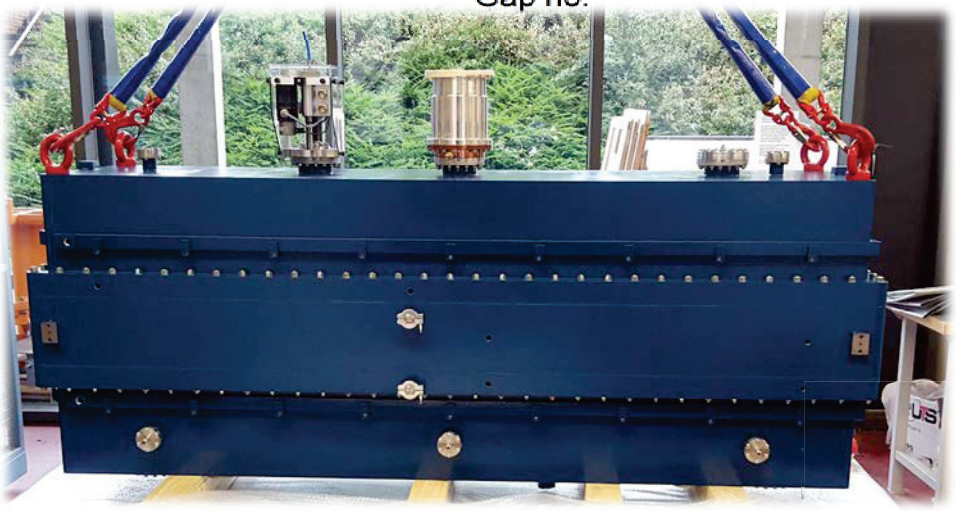


# IH-DTL Production



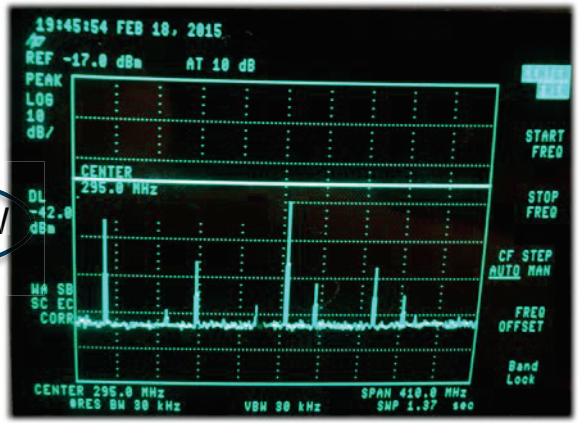
| | Type | Weight | Length | RF power | Exit energy |
|---|---|---|---|---|---|
| **IH1** | DTL + QT | 5.4 t | 2.47 m | 300 kW | 2 AMeV |
| **IH2** | DTL | 4.8 t | 2.2 m | 280 kW | 3.2 AMeV |

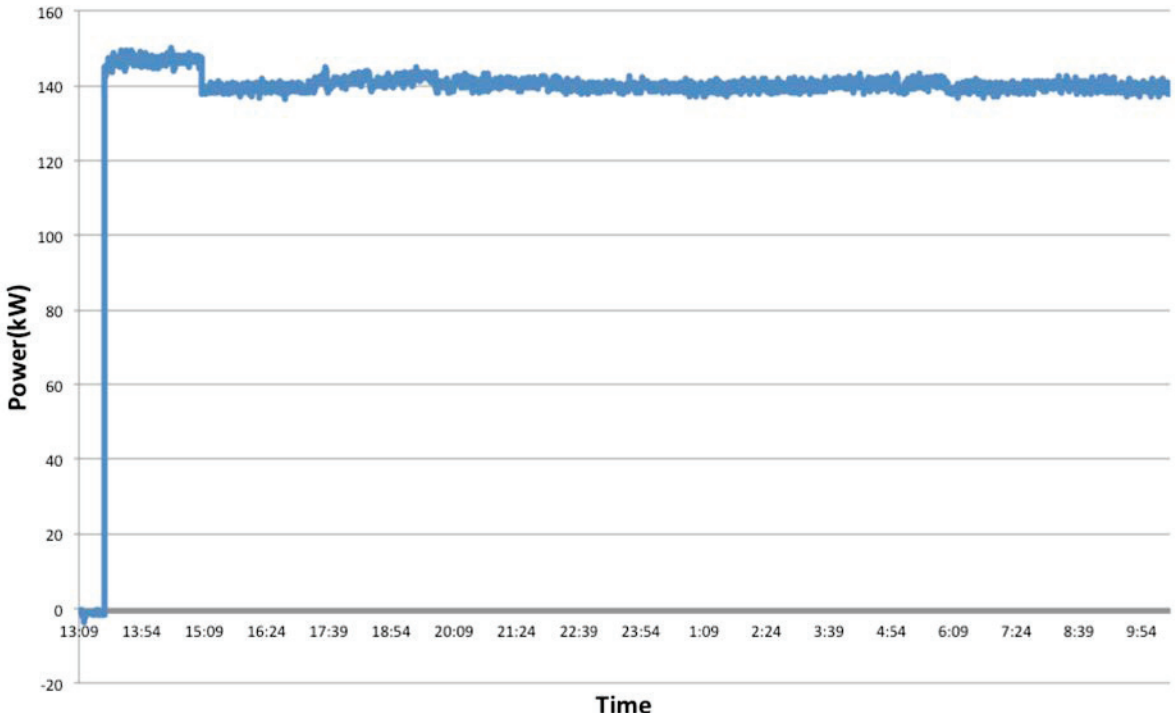


# Power-amplifier FAT

| | |
|---|---|
| **Operating frequency** | 100.625MHz |
| **Bandwidth (-3dB)** | +/-1.5MHz |
| **Rated Output Power** | 1*140kW /2*340 kW |
| **Amplifier type** | All solid-state. |
| **Duty-cycle** | 0.2% maximum |



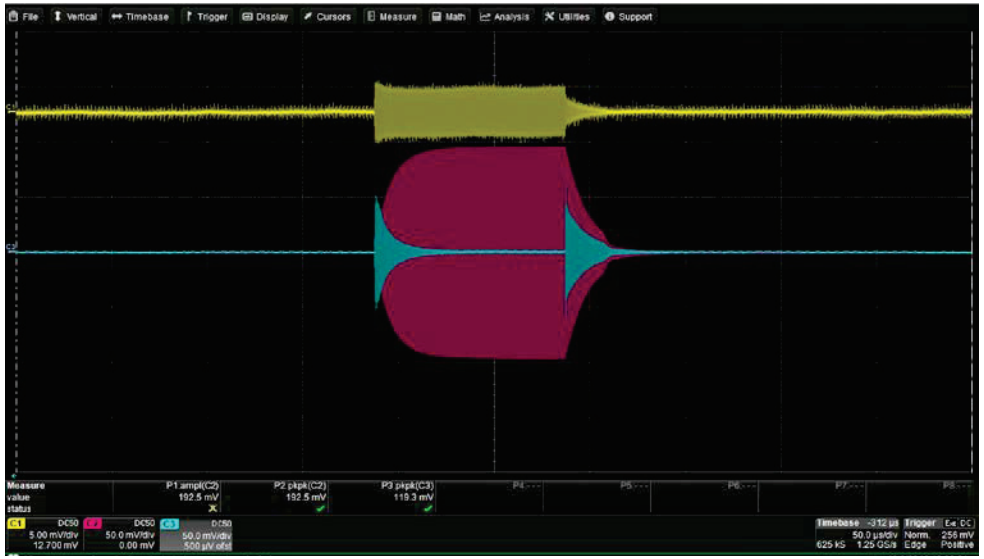

**36 kW 0,2% duty cycle**

BEVATECH

# RF Amplifier Commissioning

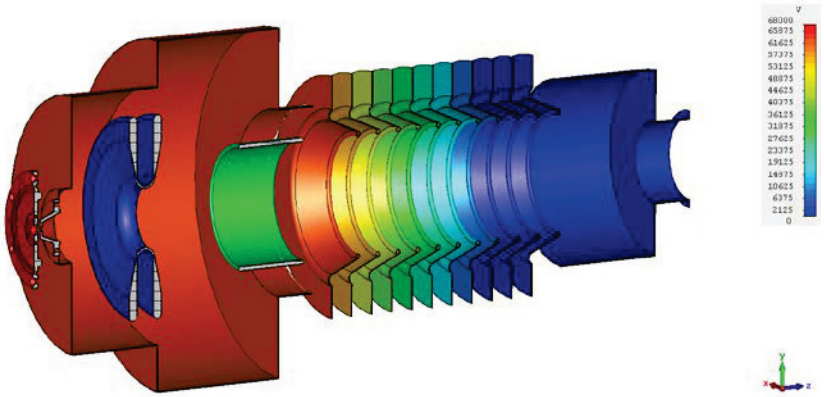
**RFQ sample:**

- Rf conditioning up to 120kW (RFQ) in 1 ½ d
- Minimize reflected average power < 0,3%
- Stress test without baseplate cooling 2 days (P≧120kW)
- Power reflection of -39dB
- Operational vacuum @ 5,5*10-7 mbar
- Base vacuum @ 7*10-8 mbar
- Commissioning of Digital LLRF system from ITEP

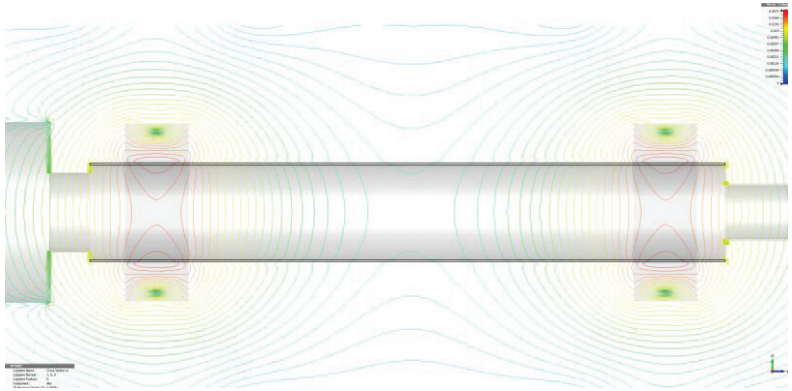


BEVATECH

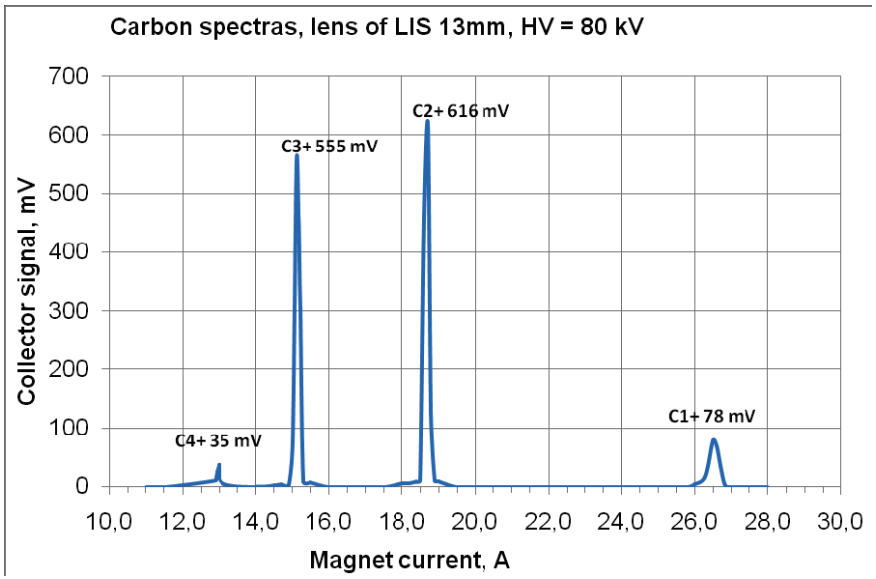
# LEBT with LIS for Commissioning with $C^{3+}$

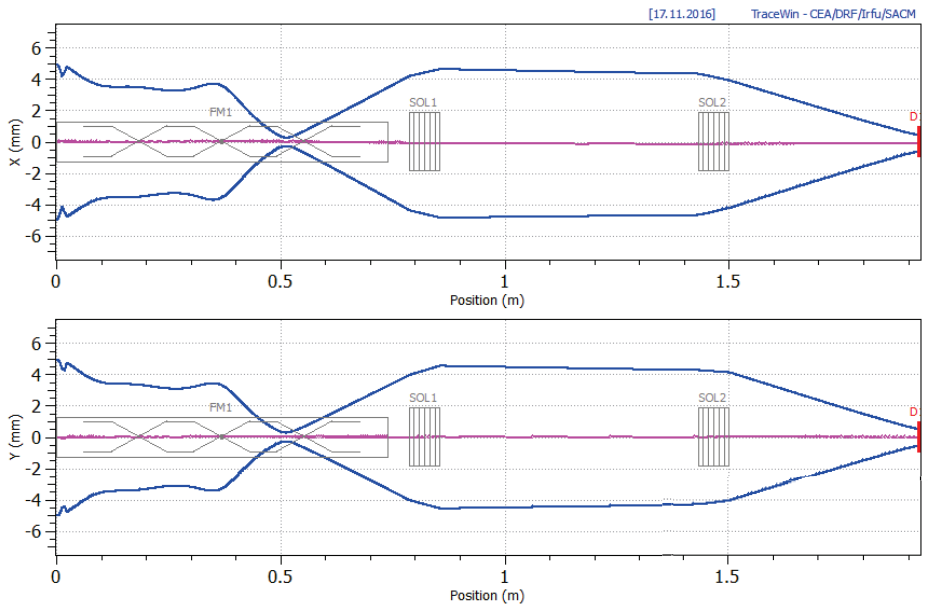


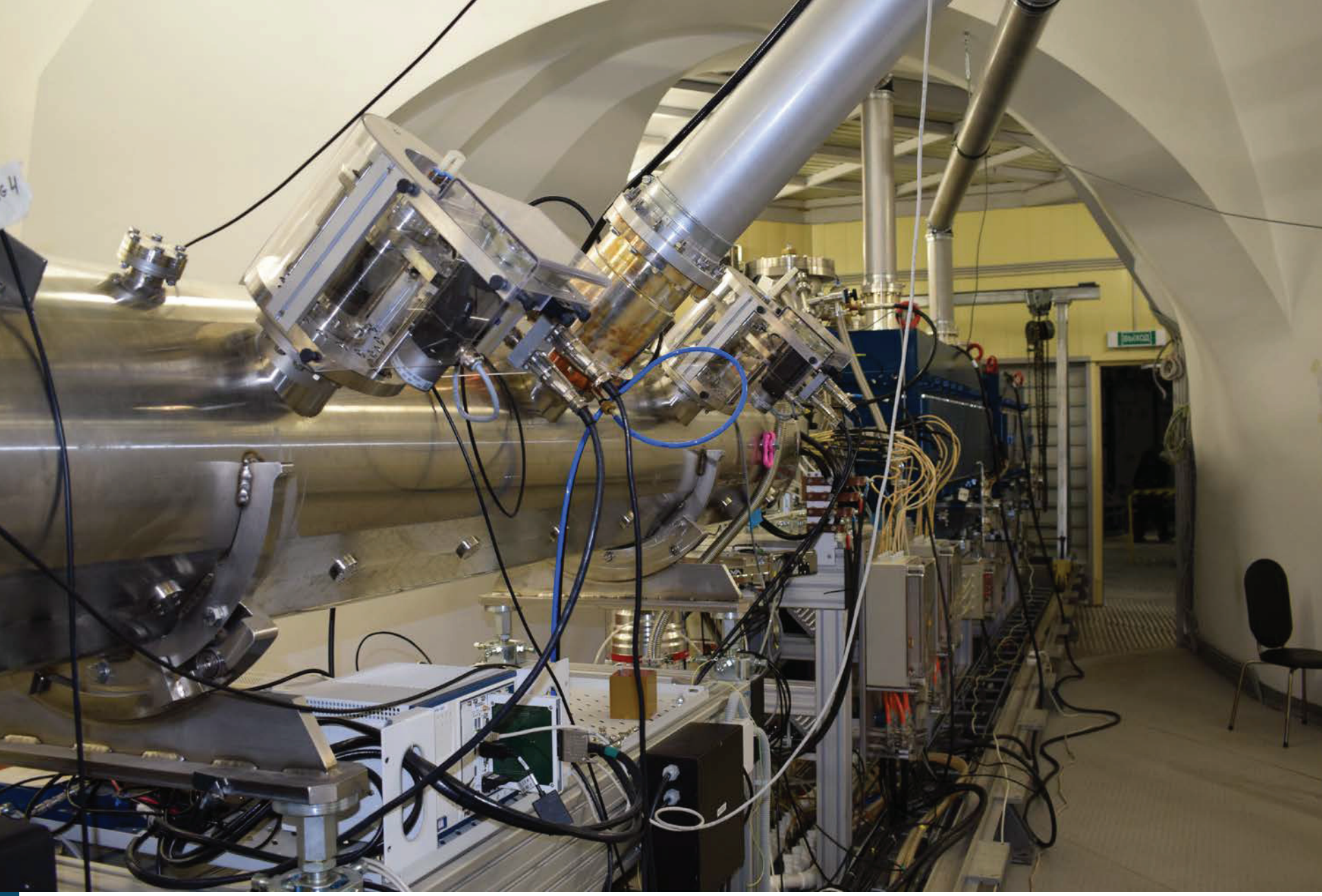
1. Electrostatic accelerator after LIS



2. Solenoids 2·1.23T in front of RFQ

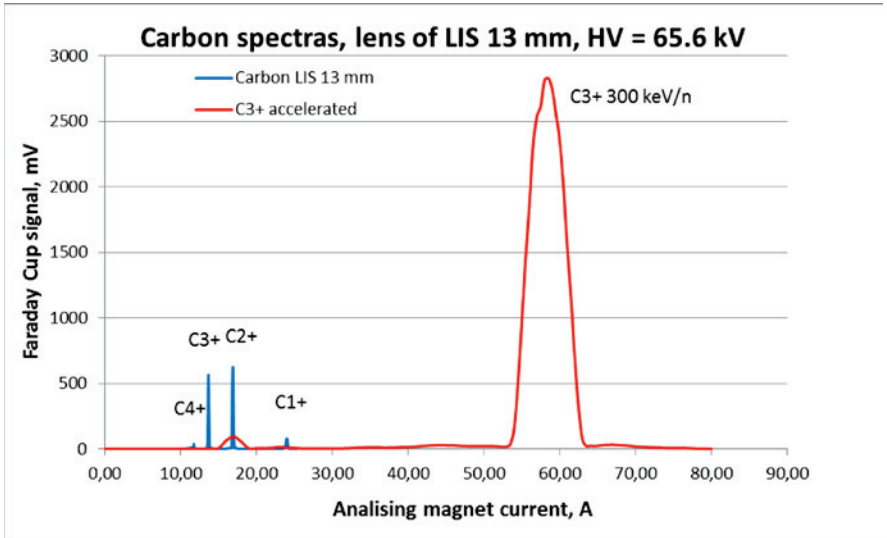


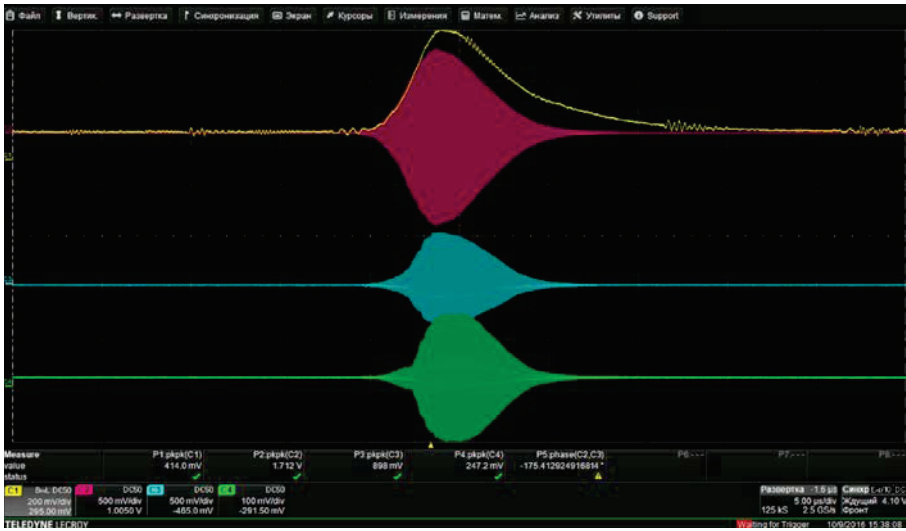


BEVATECH

# Commissioning 1 of 2

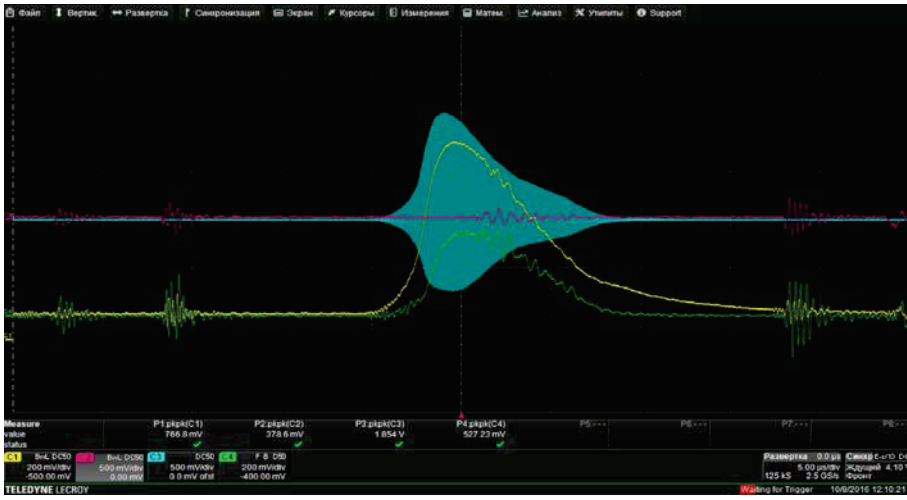



1. RFQ at nominal energy of 300 AKeV



3. Phaseprobe Signals MEBT, IH 1 & IH 2

2. All 4 cavities are in transient oscillation

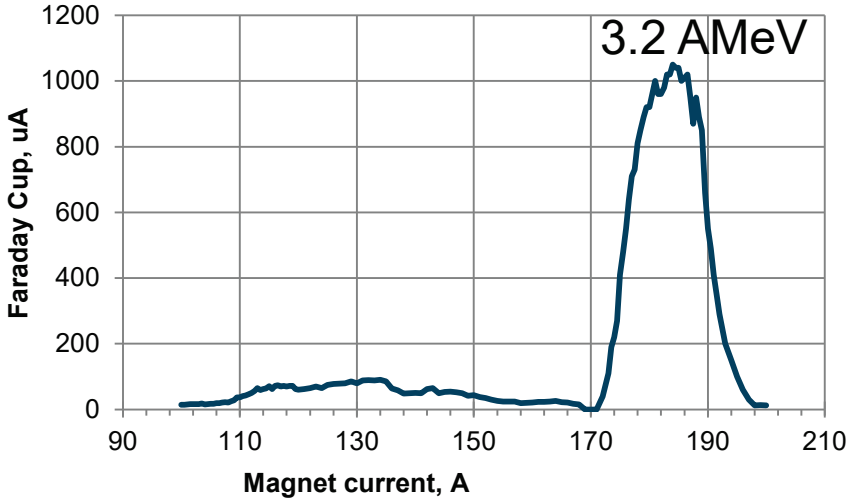


4. ICTs RFQ & IH 2

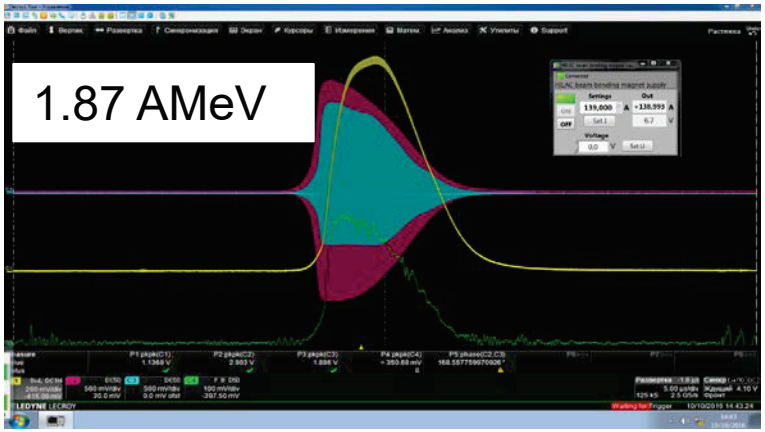
BEVATECH

# Commissioning 2 of 2

1.a. Energy spectrum after HILac

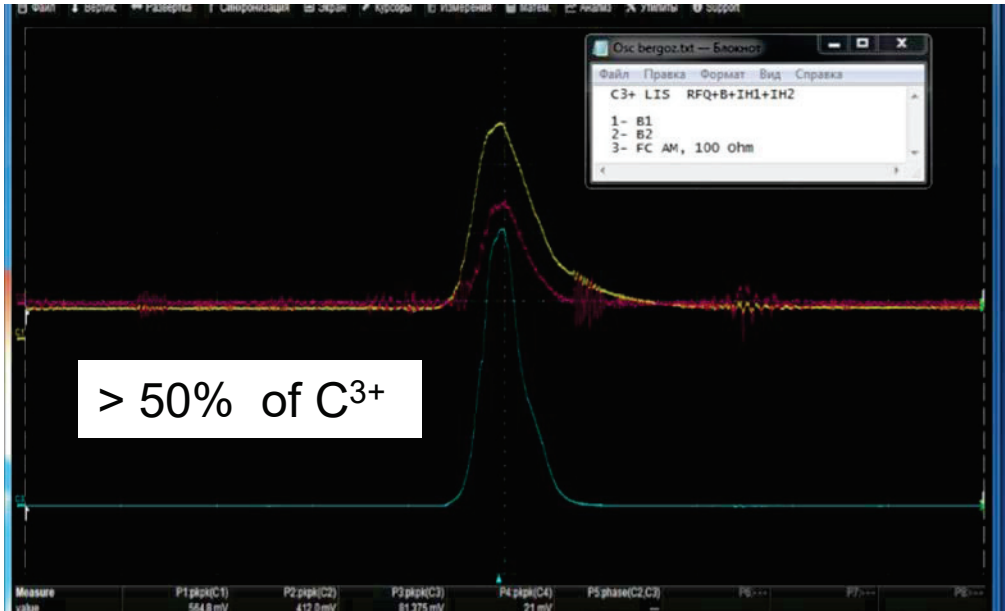



1.b. Corresponding phase probe signals

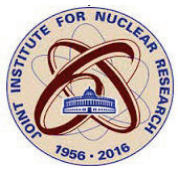



2. Energy spectrum IH 1 only
Magnet spektrometer @ 139 A

3. Transmission measurement with Faraday Cup



# Summary





BEVATECH

# Summary

- ✓ After 4.5 years of design and development work the Heavy Ion Linac - HILac – or NICA has been successfully commissioned
- ✓ All elements are in good agreement between simulations and measurements
- ✓ Vacuum-, electrical-systems and alignment have been performed in best practice

**Main results from the injector commissioning:**

- ✓ Vacuum conditions were at the $10^{-8}$ mbar level after three days 90% RFQ transmission for mixed beam from the LIS
- ✓ Total transmission of accelerated beam after LEBT > 50% of $C^{3+}$ was measured
- ✓ Nominal energy behind the RFQ and for each IH cavity was validated
- ✓ All accelerating structures, rf power amplifiers and the digital LLRF run stable

**Next Steps:**

- ◆ Optimization process for HILac will start in 2017
- ◆ ESIS source will be added with $Au^{32+}$ beam of A/Q = 6.25
- ◆ Goal of the next steps is to optimize all settings for maximum beam transmission

JOINT INSTITUTE FOR NUCLEAR RESEARCH 1956 · 2016

NICA

BEVATECH

# Acknowledgement Подтверждение

**The Team behind HILac:**

**JINR Team, Dubna, Russia:**
A.M. Bazanov, A.V. Butenko, B.V. Golovenskiy, D.E. Donets, V.V. Kobets, A.D. Kovalenko, K.A. Levterov, D.A. Lyuosev, A.A. Martynov, V.A. Monchinskiy, D.O. Ponkin, K.V. Shevchenko, A.O. Sidorin, I.V. Shirikov, A.V. Smirnov, G.V. Trubnikov and **many other colleagues from JINR institute**

**ITEP, Moscow, Russia:**
D.A. Liakin

**BEVATECH Team, Frankfurt, Germany:**
U.Ratzinger, A.Schempp, H.Podlech, D. Mäder, W. Schweizer, I. Müller, F. Dziuba, M. Busch, J. Schmidt, B. Koubek, D. Bänsch, A. Almoumani

# Спасибо! Thank You! Vielen Dank!