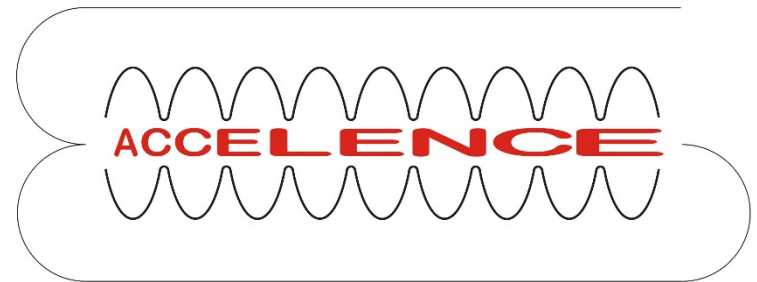


Status of the S-DALINAC



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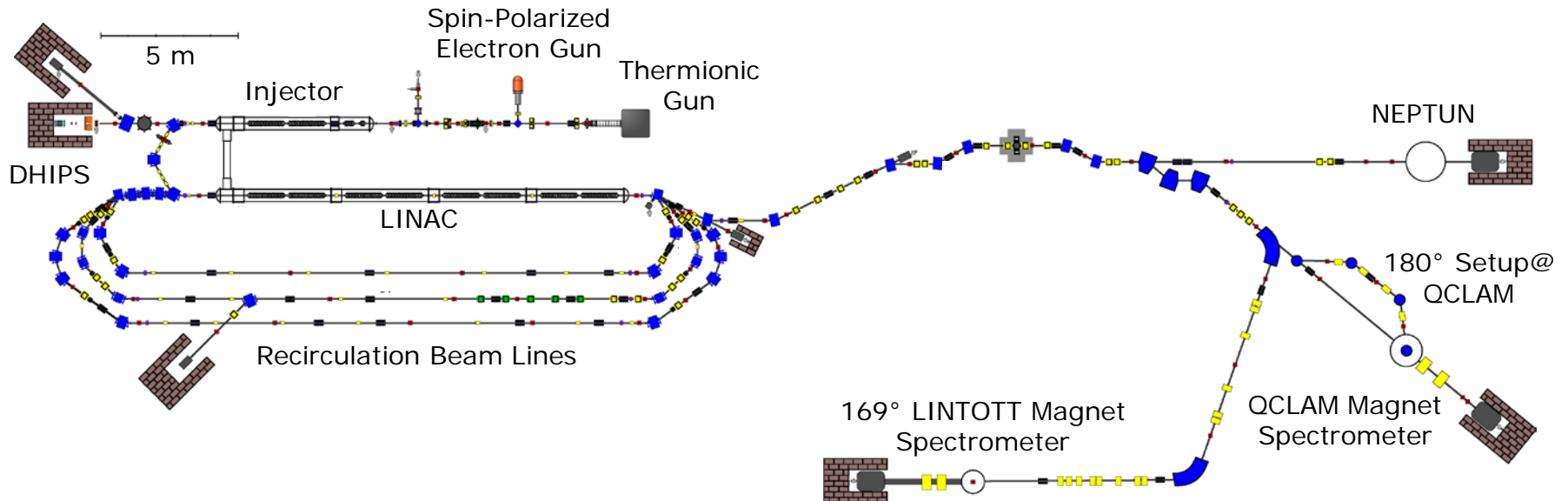


Photograph: Jan-Christoph Hartung

Gefördert durch die DFG im Rahmen des GRK 2128

S-DALINAC

Superconducting-**D**armstadt-**L**INear-**A**ccelerator



Thrice recirculating operation

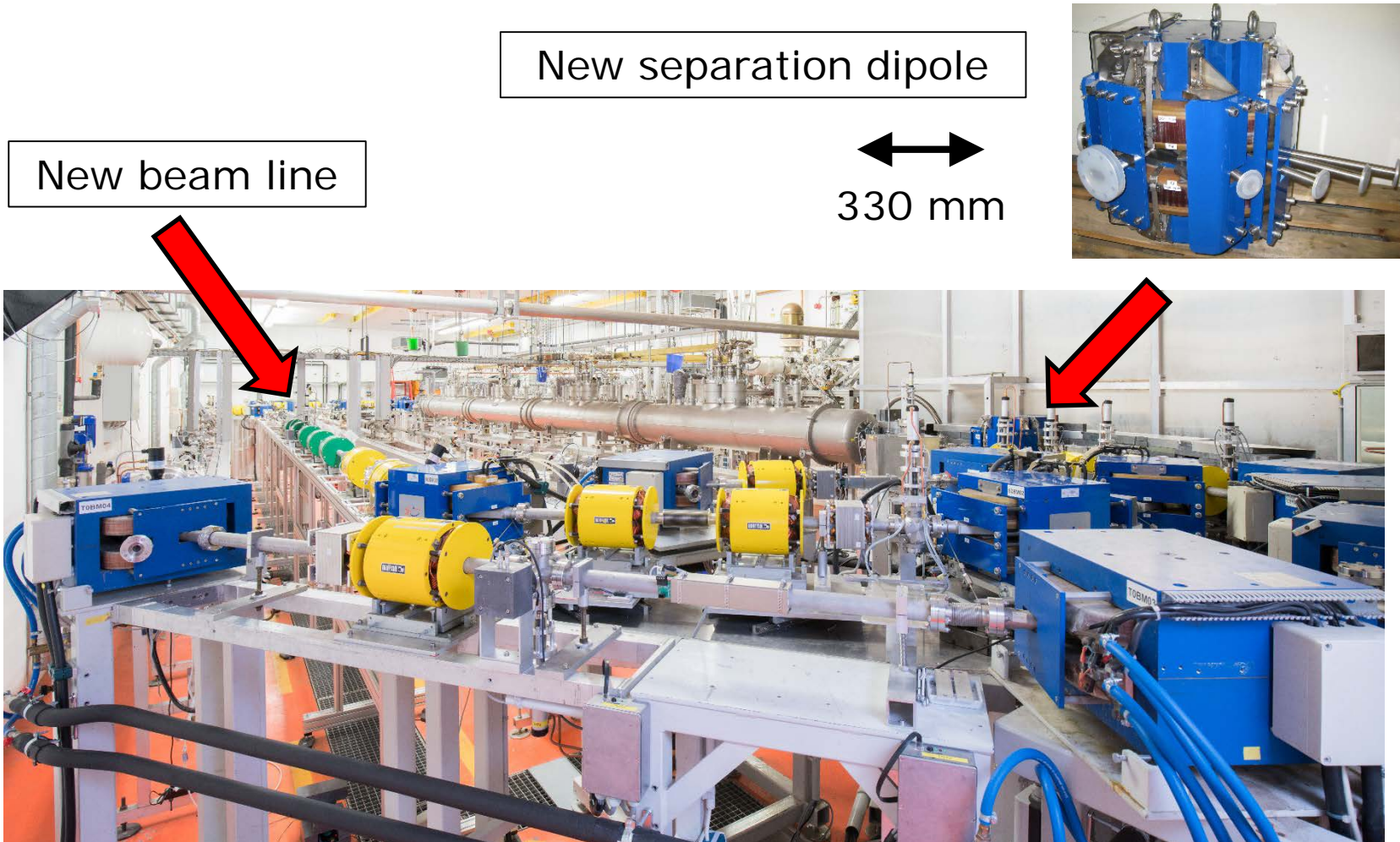
Energy gain injector: 7.6 MeV

Energy gain LINAC: 30.4 MeV

Maximum energy: 129.2 MeV

Beam current: 20 μ A

Commissioning of New Lattice



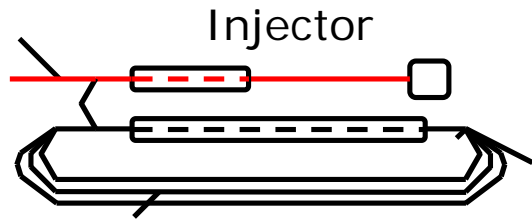
Overview Operation Modes / Commissioning

- Modification lattice 2015/2016
- Refurbishment cryoplant 2018
- Commissioning of modes following beam time schedule

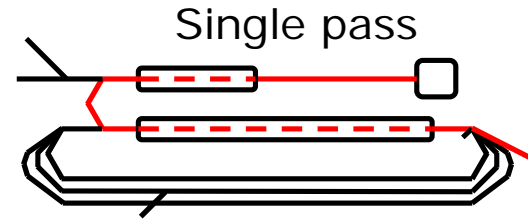
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- Modification lattice 2015/2016
- Refurbishment cryoplant 2018

- Commissioning of modes following beam time schedule



December
2016

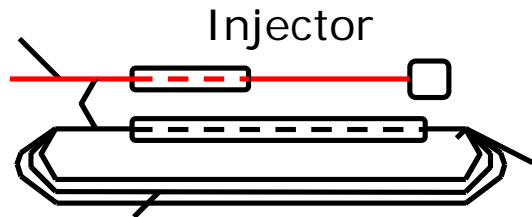


December
2016

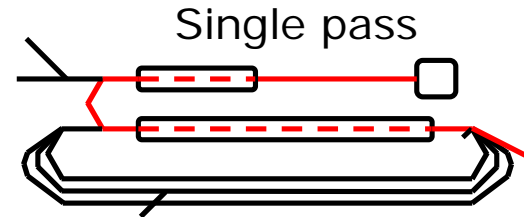
Overview Operation Modes / Commissioning

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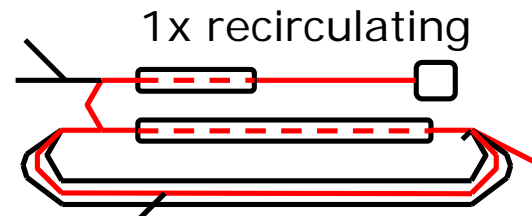
- Commissioning of modes following beam time schedule



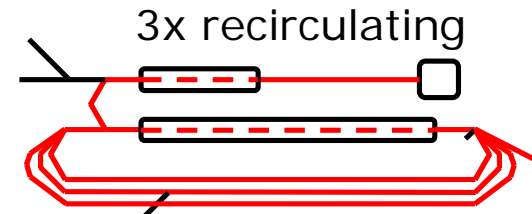
December
2016



December
2016



May
2017

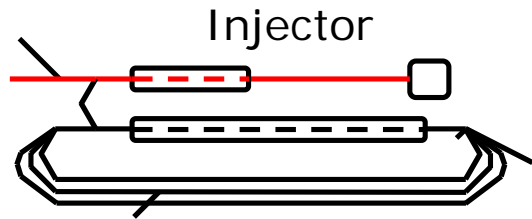


November
2018

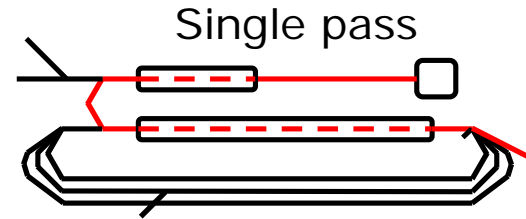
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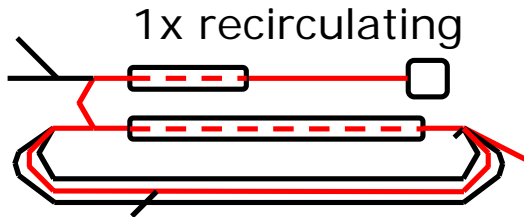
- Commissioning of modes following beam time schedule



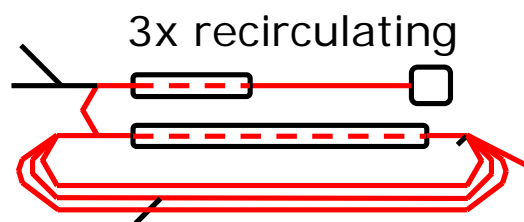
December
2016



December
2016

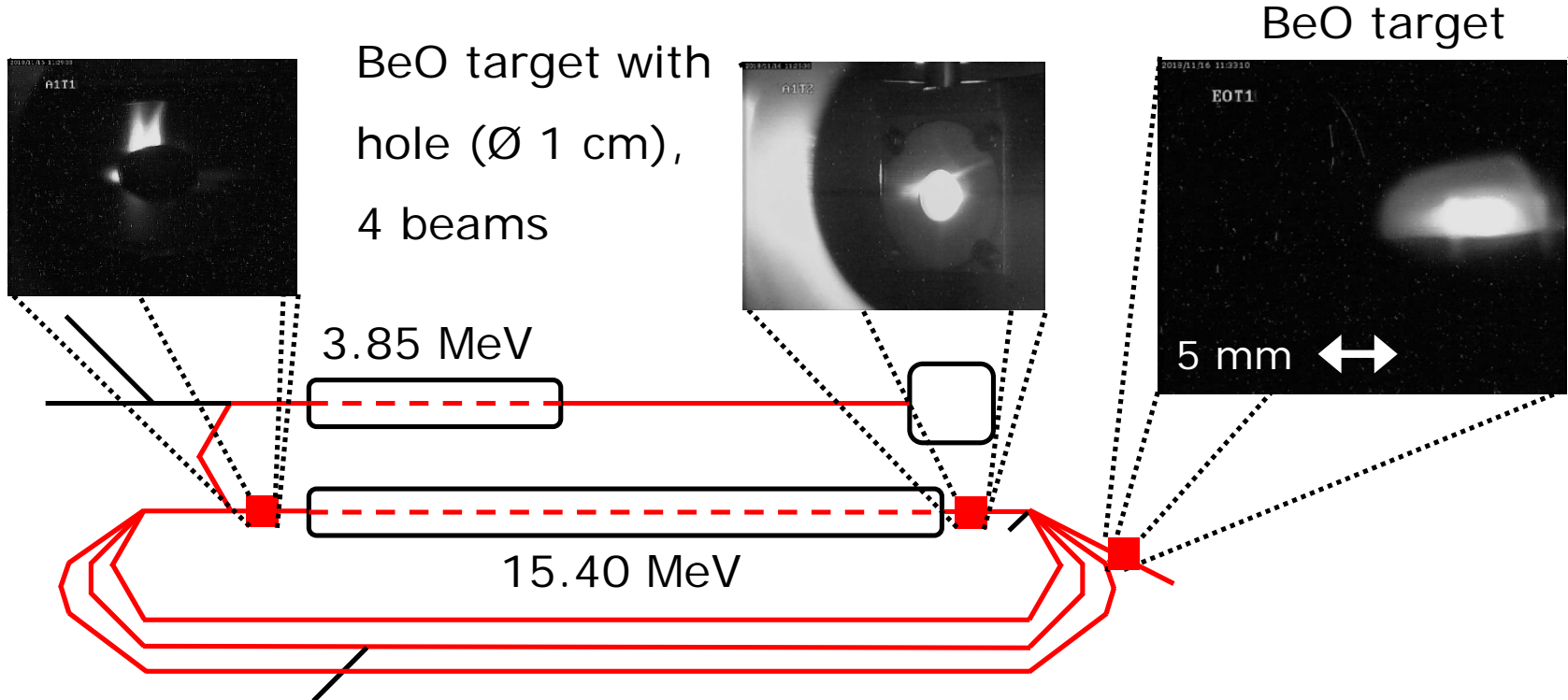


May
2017



November
2018

First Thrice-Recirculating Operation



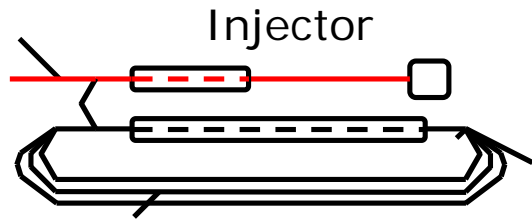
- Up to $2.5 \mu\text{A}$ with $>90\%$ transmission (100% reached for smaller beam currents)
- Beam parameters measured

publication in preparation

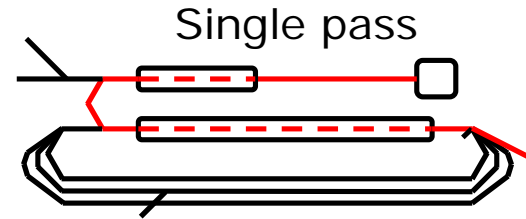
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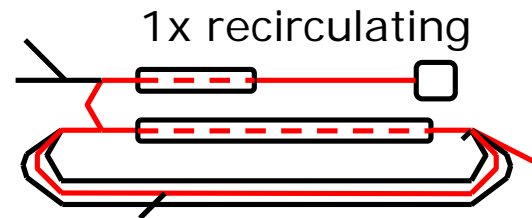
- Commissioning of modes following beam time schedule



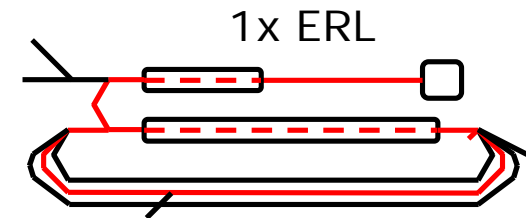
December
2016



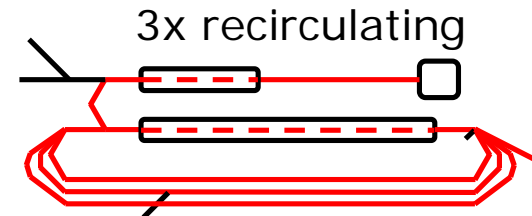
December
2016



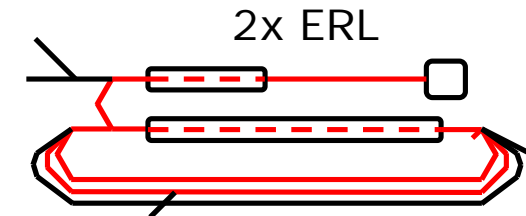
May
2017



August
2017



November
2018

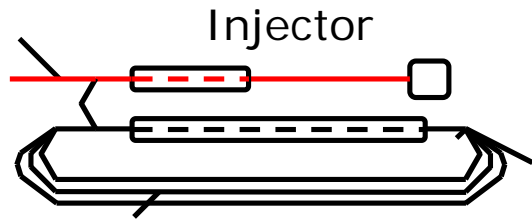


Test
Oct. 2018

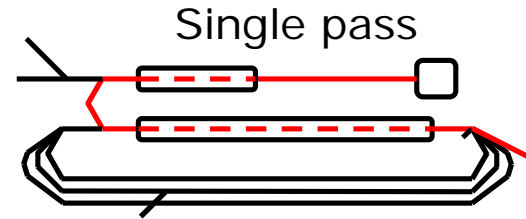
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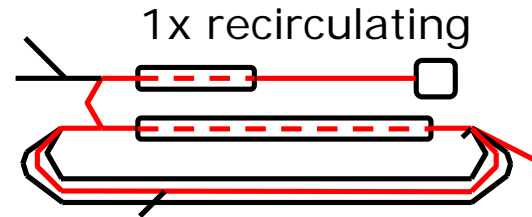
- Commissioning of modes following beam time schedule



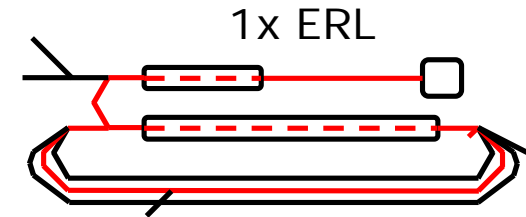
December
2016



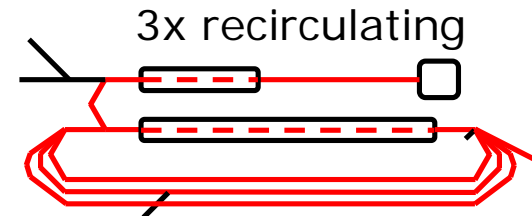
December
2016



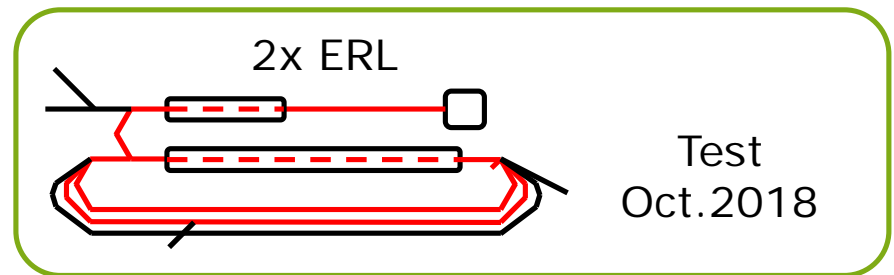
May
2017



August
2017



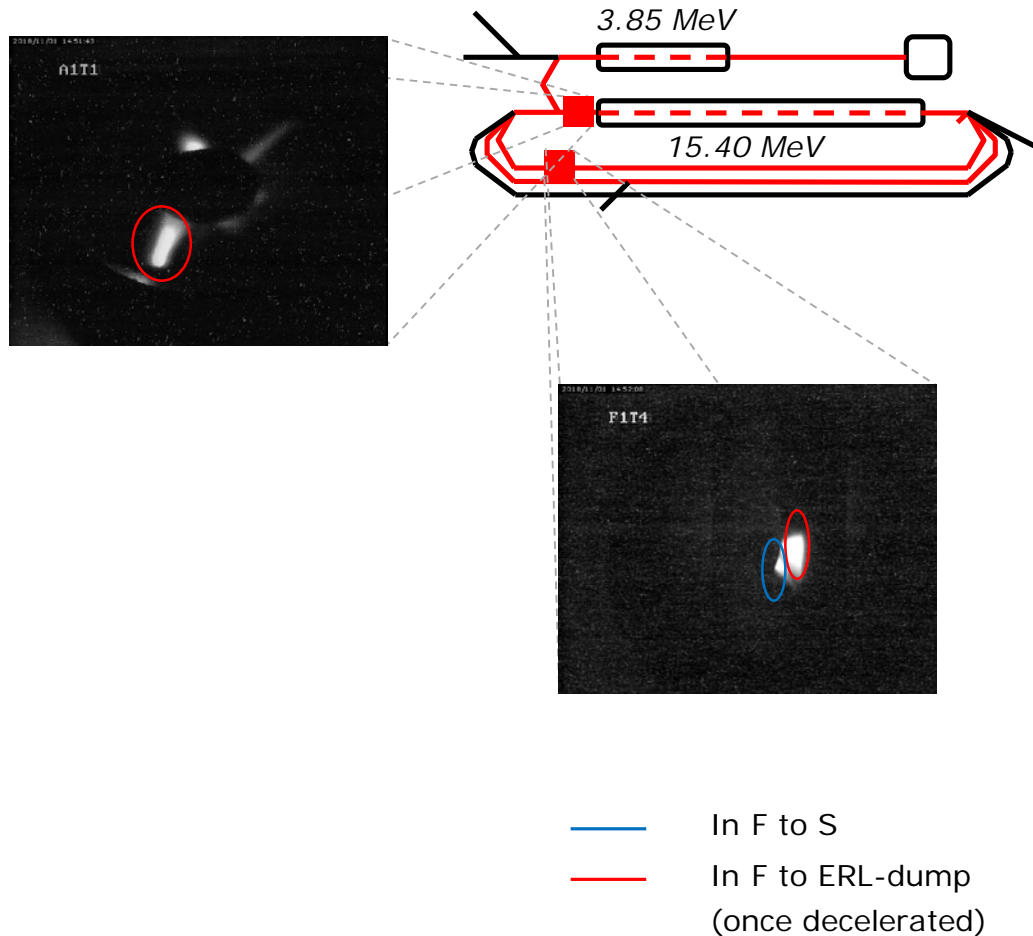
November
2018



Test
Oct. 2018

Test Phase Twice-Recirculating ERL

Example and Diagnostics

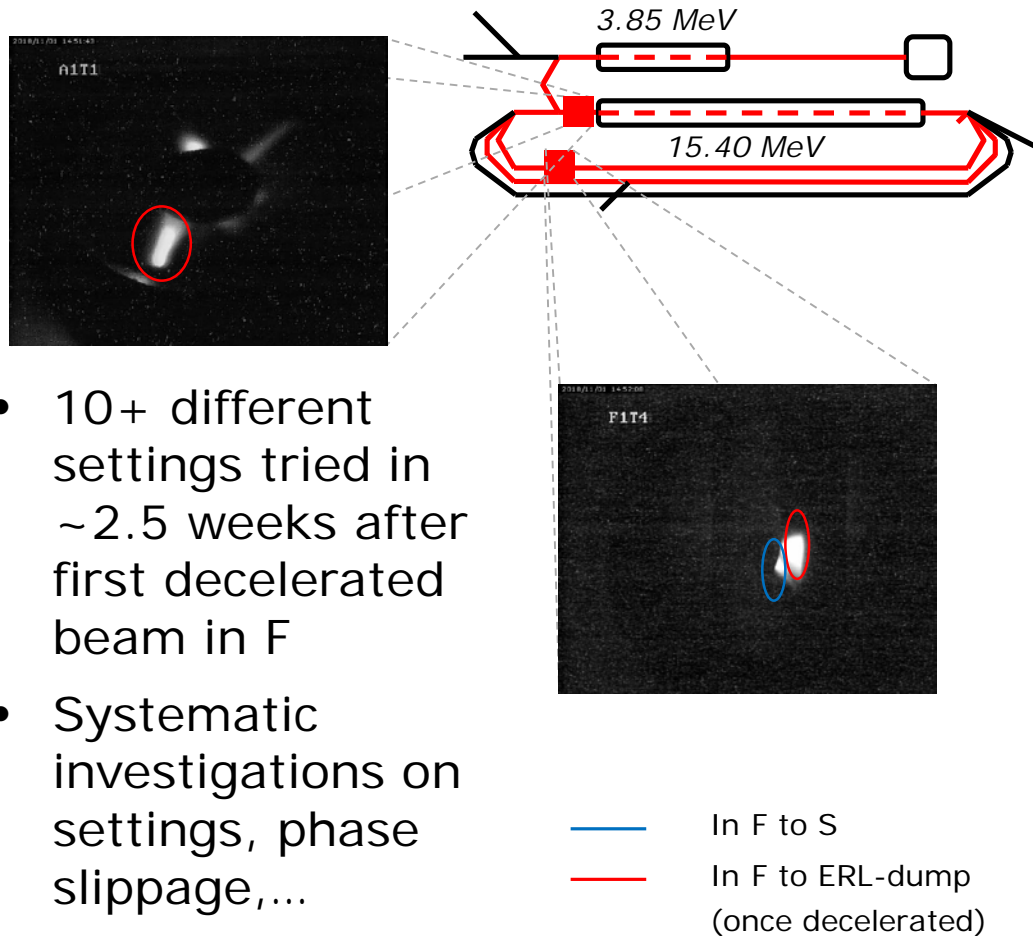


Diagnostics

- Beam loading cavities (first decelerated beam in A1SC07 up to ~90% recovered)
- RF monitor system
- Beam loss monitor system
- BeO targets with hole on F1
- Check of path-length adjustment system position in S on T0 ($\rightarrow 180^\circ$)

Test Phase Twice-Recirculating ERL

Example and Diagnostics



- 10+ different settings tried in ~2.5 weeks after first decelerated beam in F
- Systematic investigations on settings, phase slippage,...

Diagnostics

- Beam loading cavities (first decelerated beam in A1SC07 up to ~90% recovered)
- RF monitor system
- Beam loss monitor system
- BeO targets with hole on F1
- Check of path-length adjustment system position in S on T0 ($\rightarrow 180^\circ$)

Test Phase Twice-Recirculating ERL

Example and Diagnostics

Learned so far:

- ❖ Beam “blocked” in front of second deceleration
- Momentum deviation of centre particle
- Momentum spread increases starting with first deceleration
- ✓ Phase slippage must be controlled properly

Plans:

- Further simulations to optimize setting
- Extension of beam diagnostics
- Test will repeated during next cool-down of sLHe target
- **World-wide first multi-turn SRF-ERL**

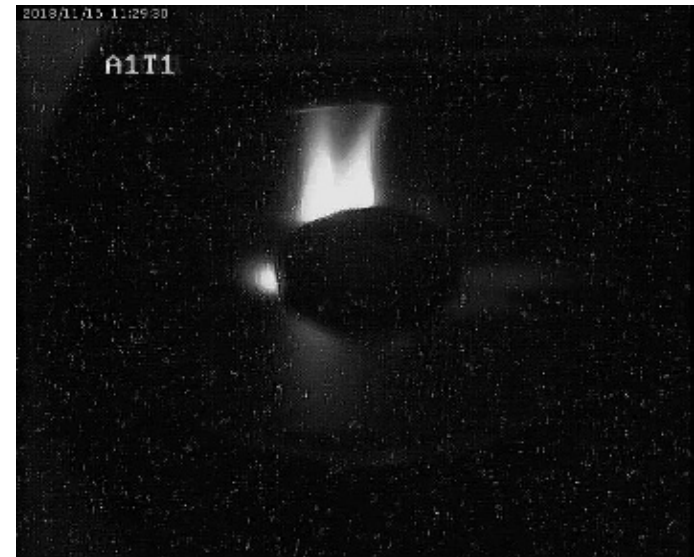
Further Improvements for Next Beamtime

- Alignment of warm injector section, extraction beam line, DHIPS, NEPTUN, QCLAM, LINTOTT and correction of elements moved over time
- Learned: accelerator hall is „shrinking“ by $\sim 1\text{mm}/3\text{ years}$
- Improvement of stability
 - Ventilation and cleanliness in gun cage
 - Piping for LN2 exhaust (no temperature drifts for SMA-cables)
 - Less vibrations on beam in warm injector section



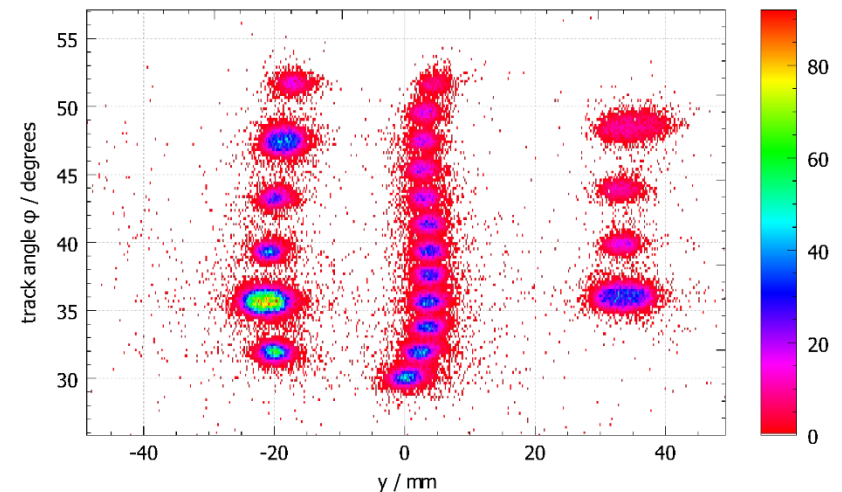
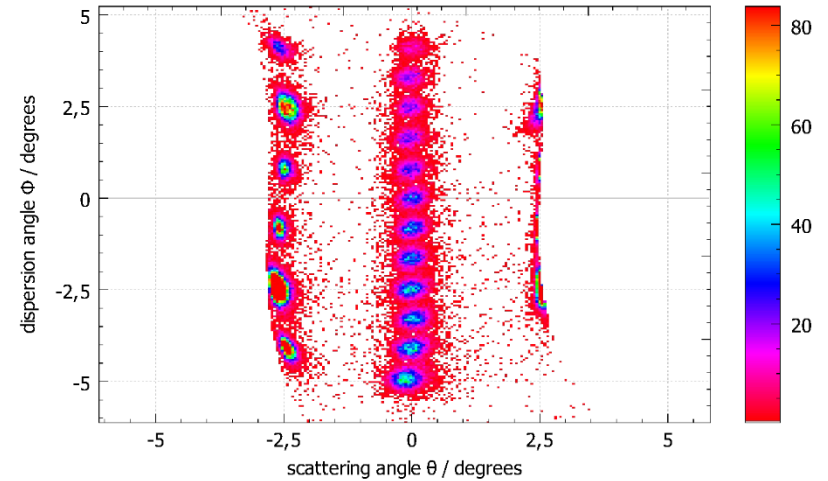
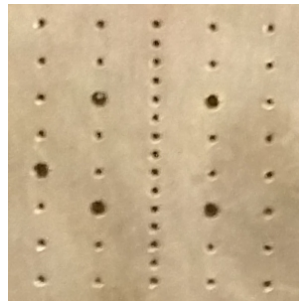
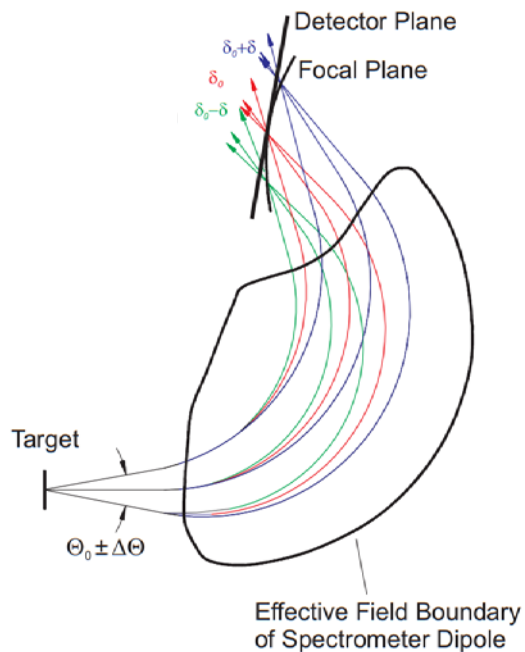
Further Improvements for Next Beamtime

- Extension of beam diagnostics
(additional targets, more beam-loss monitors,...)
- Learned a lot during first setting of thrice-recirculating operation
(complete new machine!)
→ more experience and knowledge



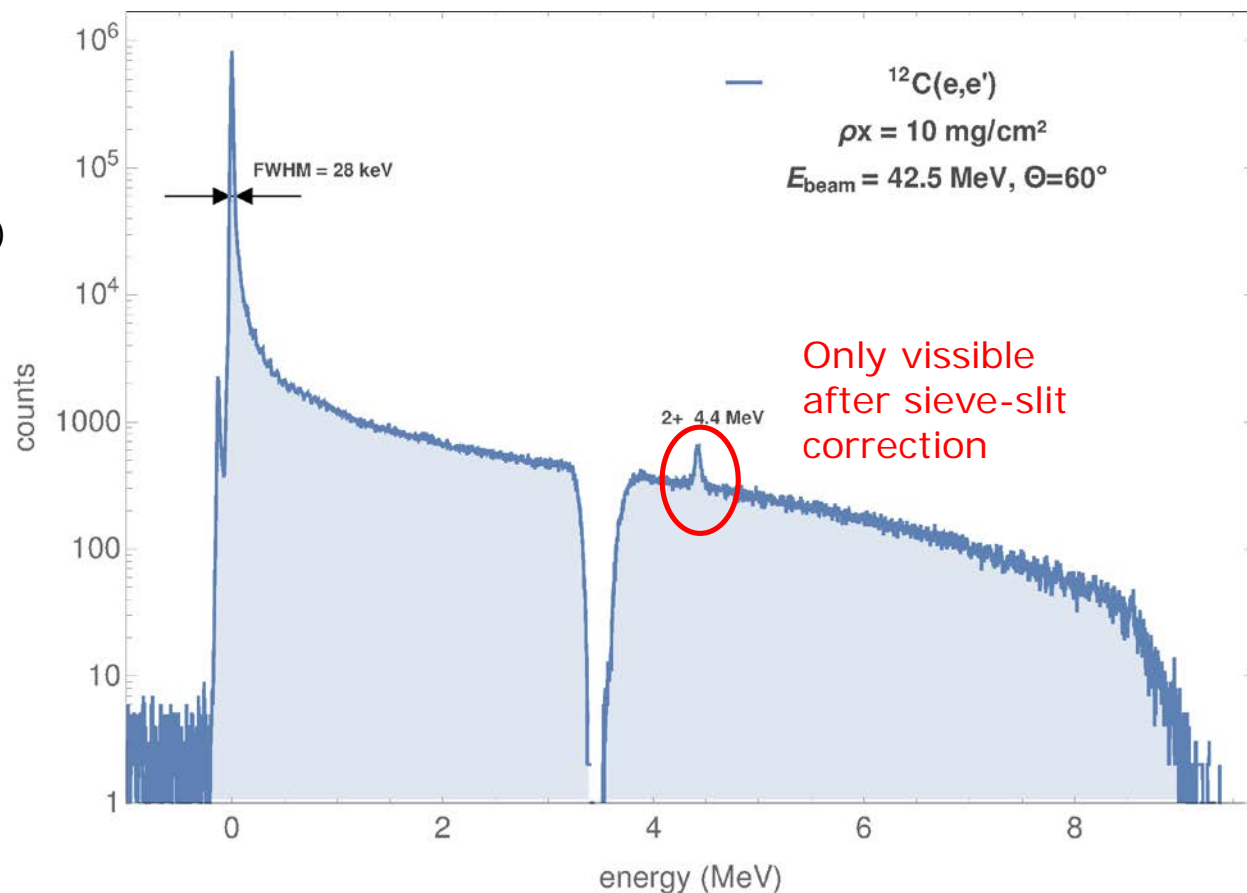
QCLAM Sieve Slit Measurement

- Needed for correction of curved focal plane



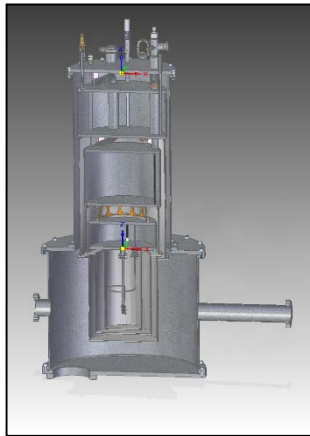
QCLAM ^{12}C Measurement

- Energy resolution:
 $6.6 \cdot 10^{-4}$
(best value so far: $7.6 \cdot 10^{-4}$,
Dissertation Hummel, 1992)
- Gap at ~ 3.5 MeV:
4 broken wires

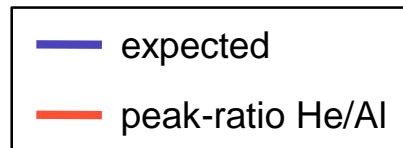
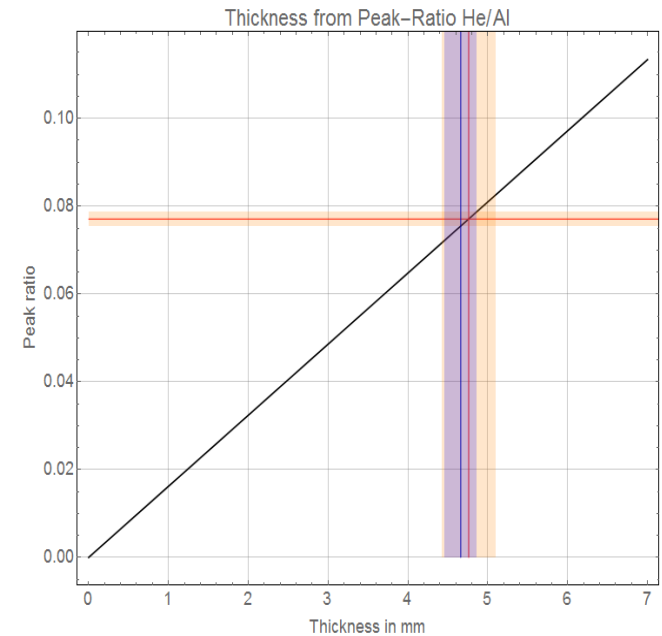
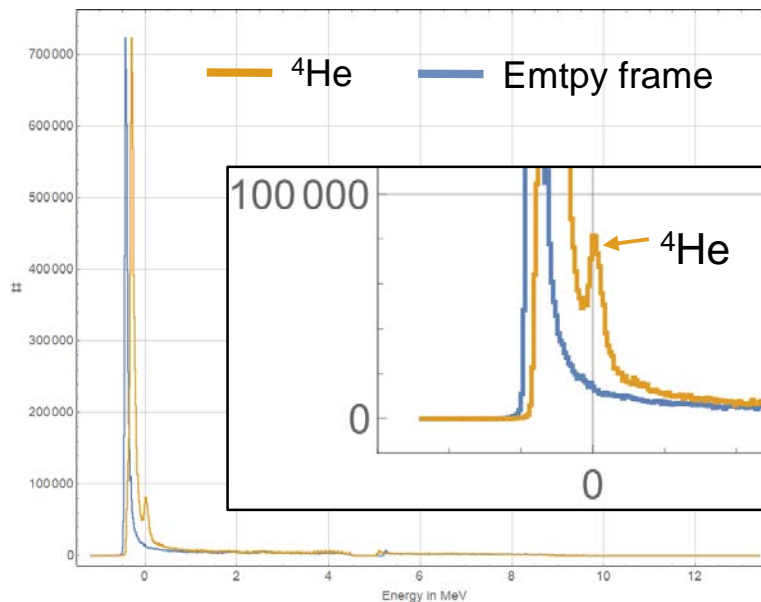


QCLAM ^4He Measurement

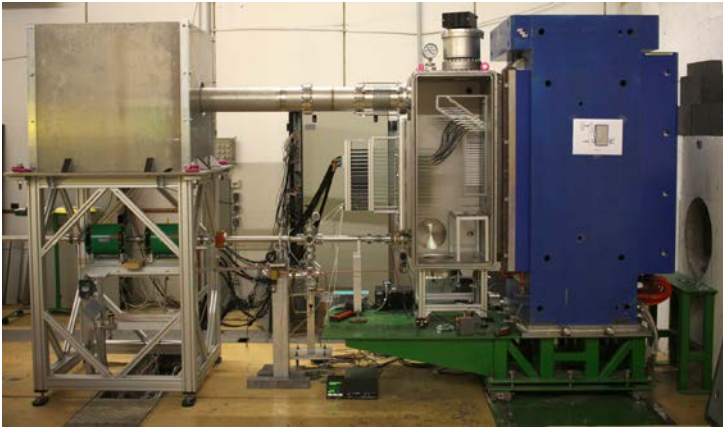
- Beam energy: 42.5 MeV
- Control of target thickness, no boiling-bubbles due to superfluid liquid helium



CryoVac (2017)

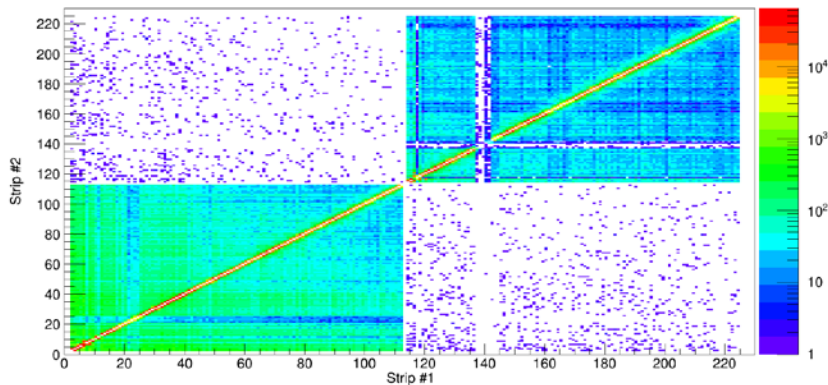


NEPTUN Commissioning 2018

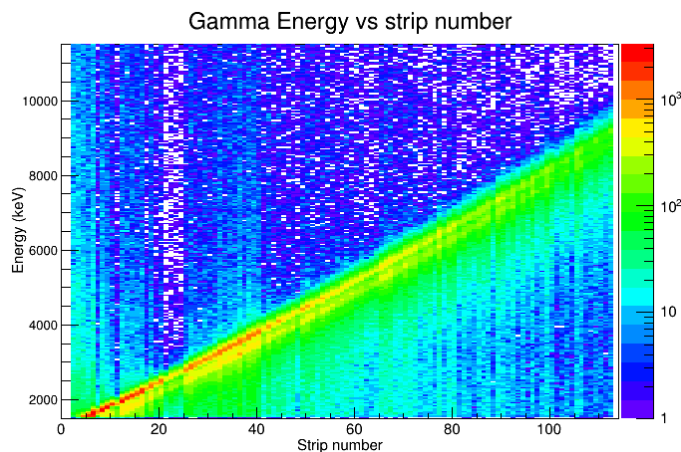
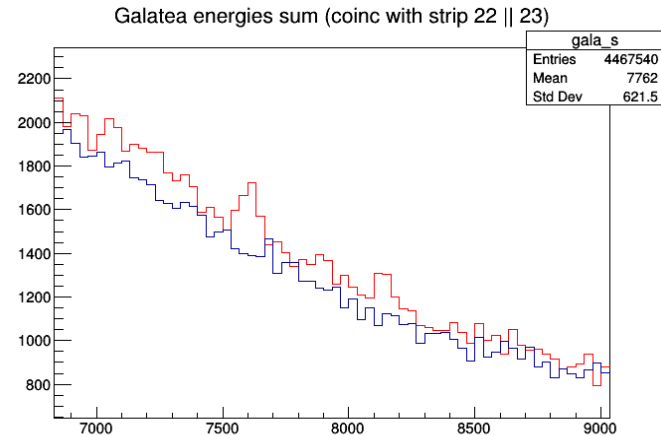


- Completed commissioning runs with 68 and 65 MeV e- beams
- 1st run (August 2018) with 20% of the new focal plane detectors
- 2nd run (December 2018) with complete focal plane
- Investigated the response of large CeBr detector to high energy gamma rays
- Tagged 8125 keV 1^+ state in ^{32}S ;
- Performed first test of the setup for photoabsorption experiment (PROTEUS)

Coincidences between stripes



NEPTUN Commissioning 2018



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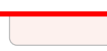




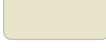




Beam Time Schedule 2019

3	14	15	16	17	18	19	20	7	11	12	13	14	15	16	17	11	11	12	13	14	15	16	17	16	15	16	17	18	19	20	21
4	21	22	23	24	25	26	27	8	18	19	20	21	22	23	24	12	18	19	20	21	22	23	24	17	22	23	24	25	26	27	28
5	28	29	30	31	1	2	3	9	25	26	27	28	1	2	3	13	25	26	27	28	29	30	31	29	30	1	2	3	4	5	
4	5	6	7	8	9	10	4	5	6	7	8	9	10	1	2	3	4	5	6	7	6	7	8	9	10	11	12				

MAI							JUNI							JULI							AUGUST							
M	D	M	D	F	S	S	M	D	M	D	F	S	S	M	D	M	D	F	S	S	M	D	M	D	F	S	S	
18	1	2	3	4	5	6	27	28	29	30	31	1	2	27	1	2	3	4	5	6	7	29	30	31	1	2	3	4
19	6	7	8	9	10	11	12														32	5	6	7	8	9	10	11
20	13	14	15	16	17	18	19														33	12	13	14	15	16	17	18
21	20	21	22	23	24	25	26														34	19	20	21	22	23	24	25
22	27	28	29	30	31	1	2														35	26	27	28	29	30	31	
3	4	5	6	7	8	9	10														2	3	4	5	6	7	8	
SEPTEMBER														DEZEMBER														
M	D	M	D	F	S	S								M	D	M	D	F	S	S								
26	27	28	29	30	31	1								25	26	27	28	29	30	1								
36	2	3	4	5	6	7	8								49	2	3	4	5	6	7	8						
37	9	10	11	12	13	14	15								50	9	10	11	12	13	14	15						
38	16	17	18	19	20	21	22								51	16	17	18	19	20	21	22						
39	23	24	25	26	27	28	29								52	23	24	25	26	27	28	29						
30	1	2	3	4	5	6								30	31	1	2	3	4	5								

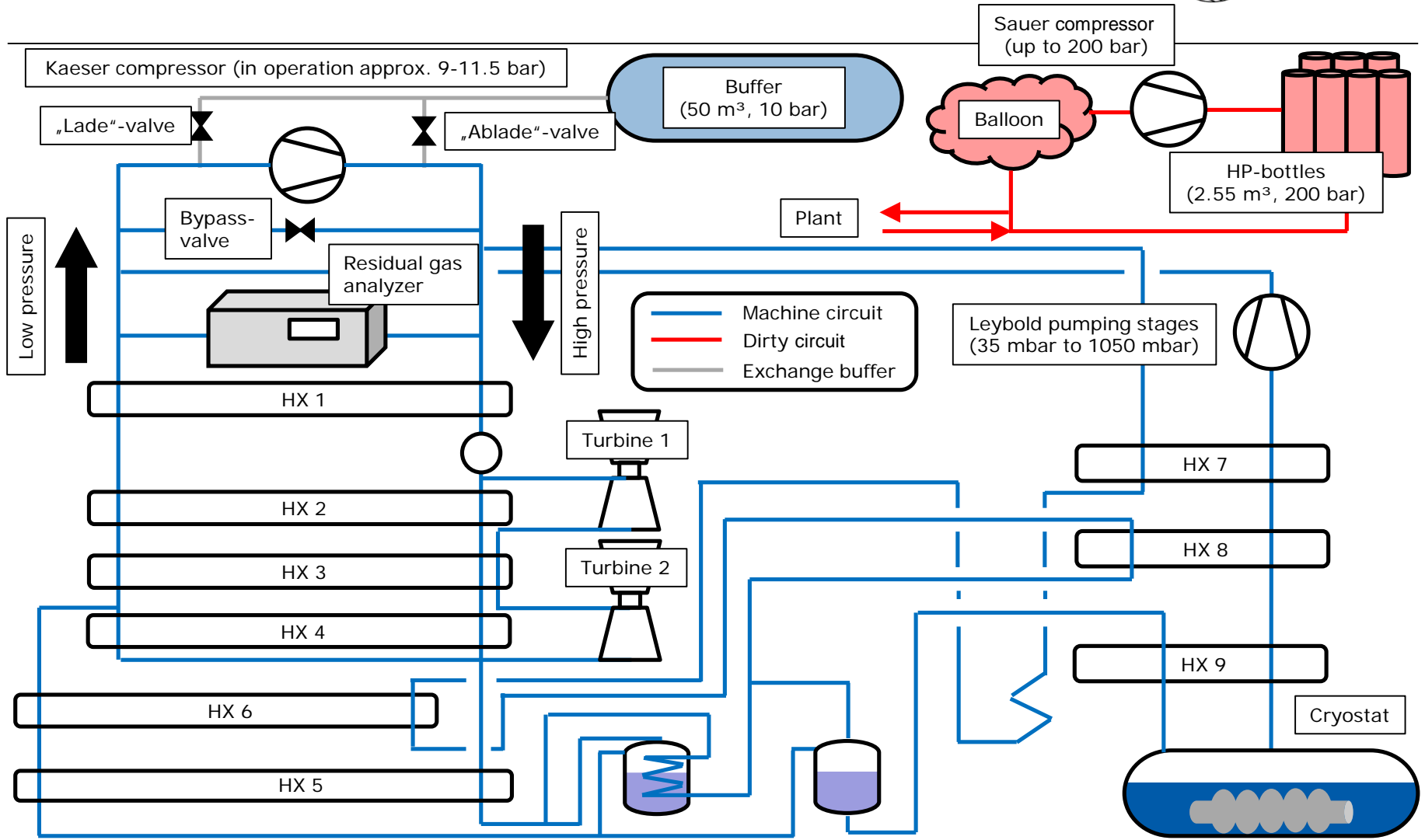
Possible issues:

- Heat exchanger
- Pumping stages

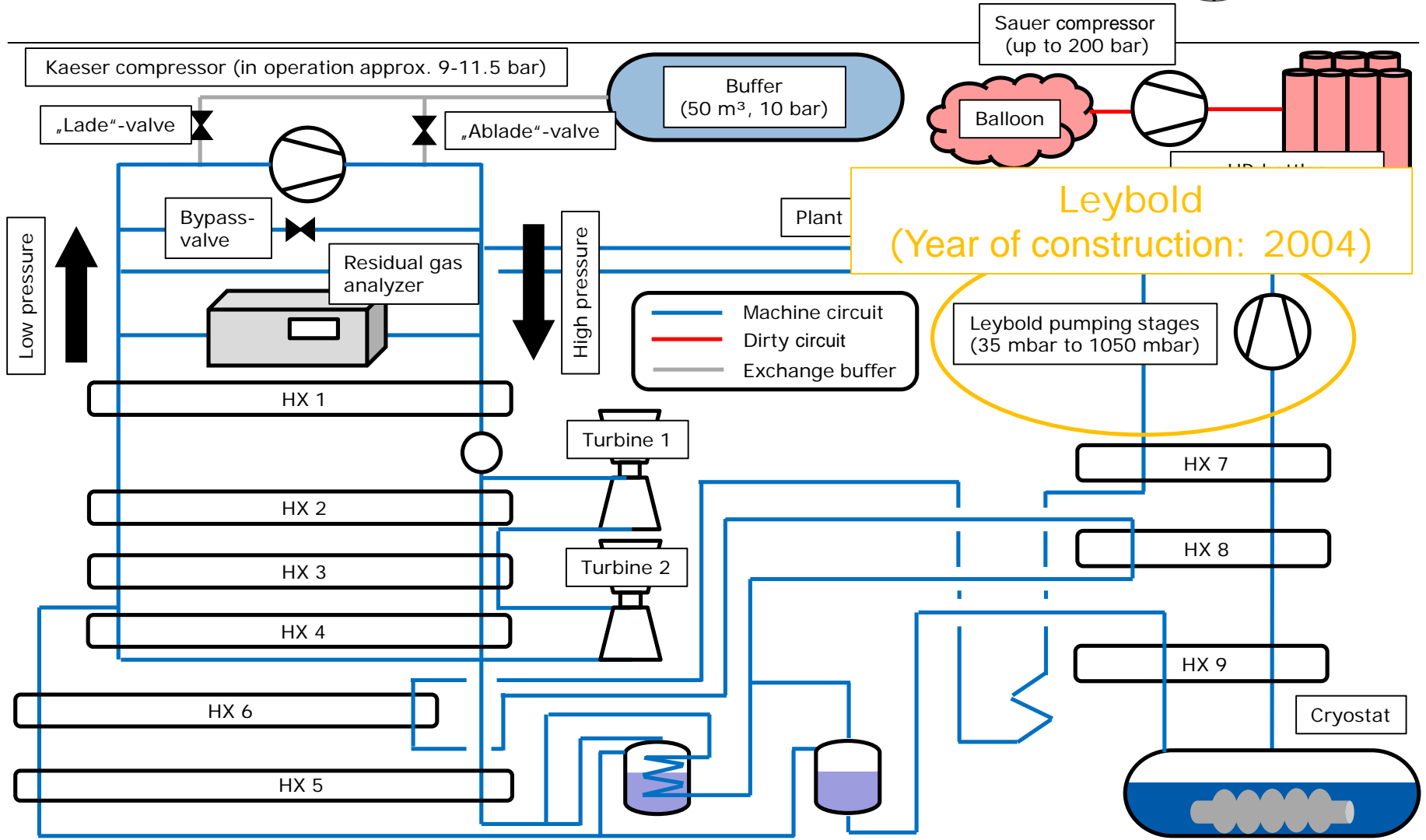
	Maintenance / cooldown / warm-up		Q-CLAM normal
	Tests cavities + He-refrigerator, beam tuning, modification experiment		Q-CLAM He-Target
	Development accelerator + experiments		Q-CLAM 180°
	DHIPS		Q-CLAM (e,e'g)
	NEPTUN		LINTOTT
			Detector tests



Simplified Scheme

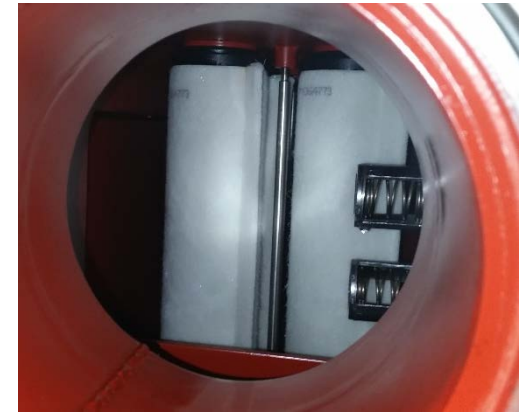


Simplified Scheme



Leybold Pumping Stages

- Filter elements (4x14) have been replaced beginning of 2018
- ~ 8 weeks after start of operation: heavy oil loss of modules → too much oil at compressor
- Situation was controllable (refilling of oil at pumping stages, releasing of oil at compressor), contamination with oil was expected
- To ensure beam time for CRC: continuation of operation
- Information given to Leybold:
August/September 2018



Leybold Pumping Stages

- Huge contamination of pipings with oil
- Causing a risky warm-up procedure in December 2018
- ~ 6 weeks of work to get rid of the oil contamination



Leybold Pumping Stages

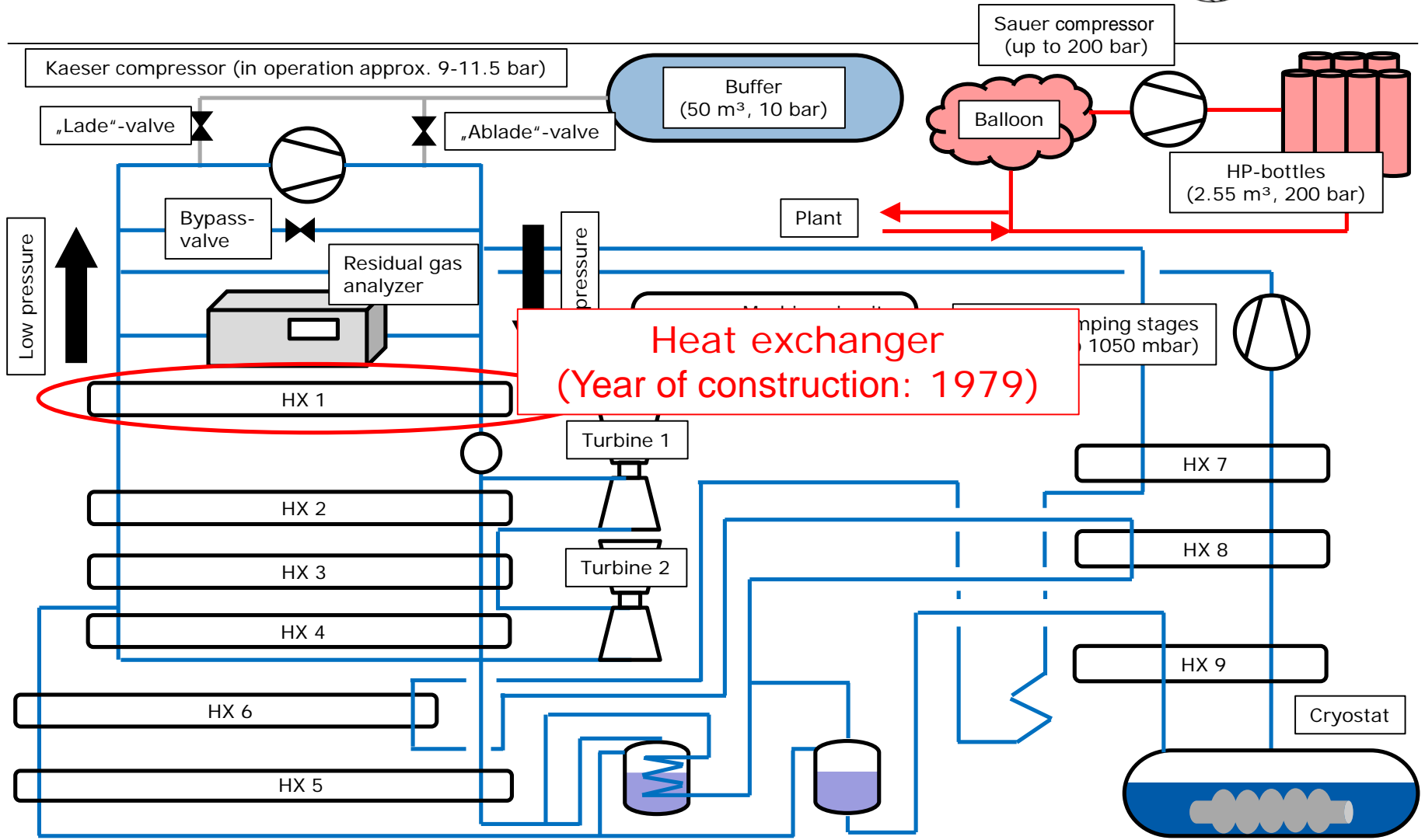
Status

- New filter elements installed by Leybold (but the same version)
- Guess by IKP: aggressive Breox oil is destroying glue/plastic parts of filter elements
- Long-term tests at Leybold to solve problem
- **Problem not fixed yet!**

If dramatic oil loss occurs again:

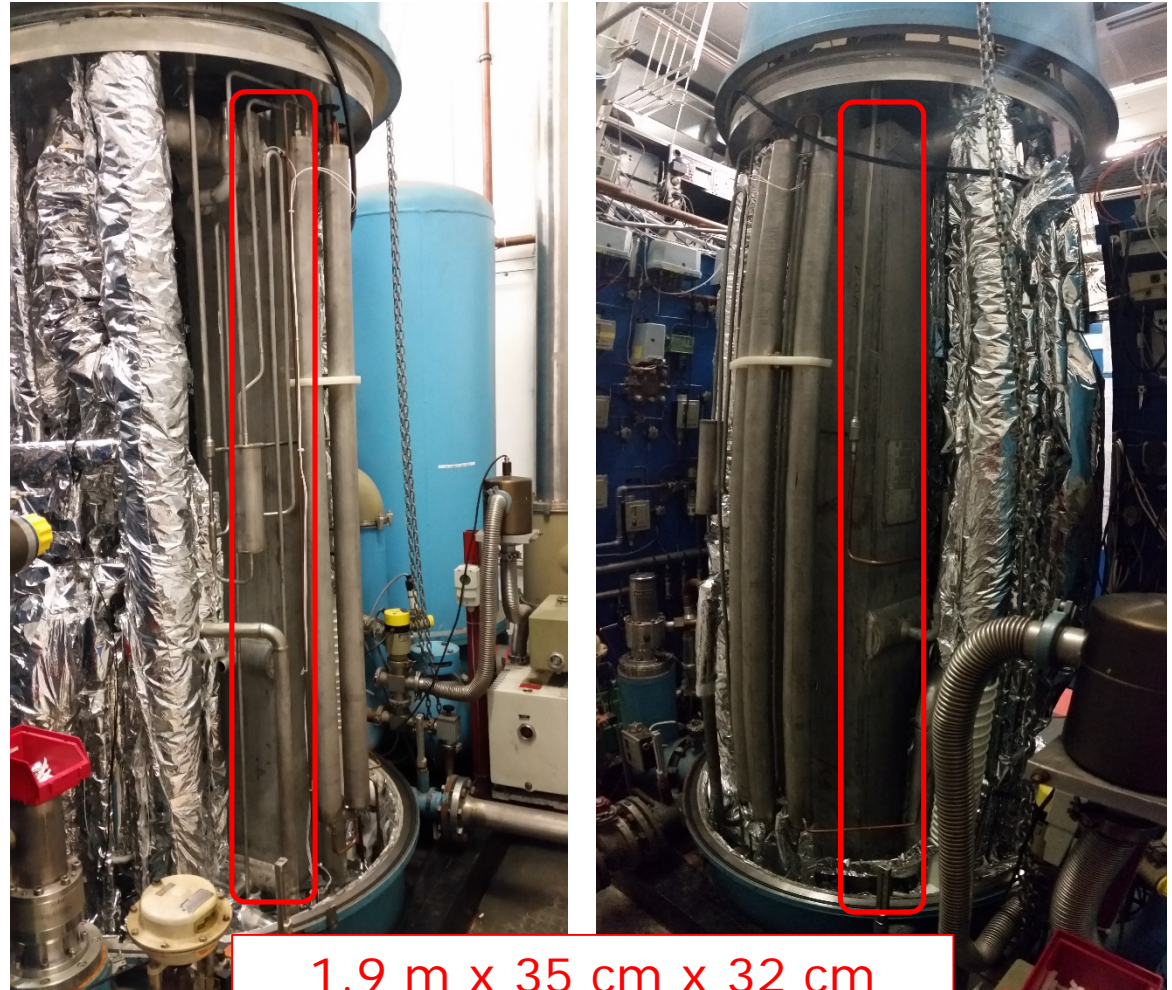
- Stop of operation to protect machine
- Use new set of filter elements (hopefully improved version)
- Clean piping if necessary (< 6 weeks due to improvements)
- Continue operation

Simplified Scheme



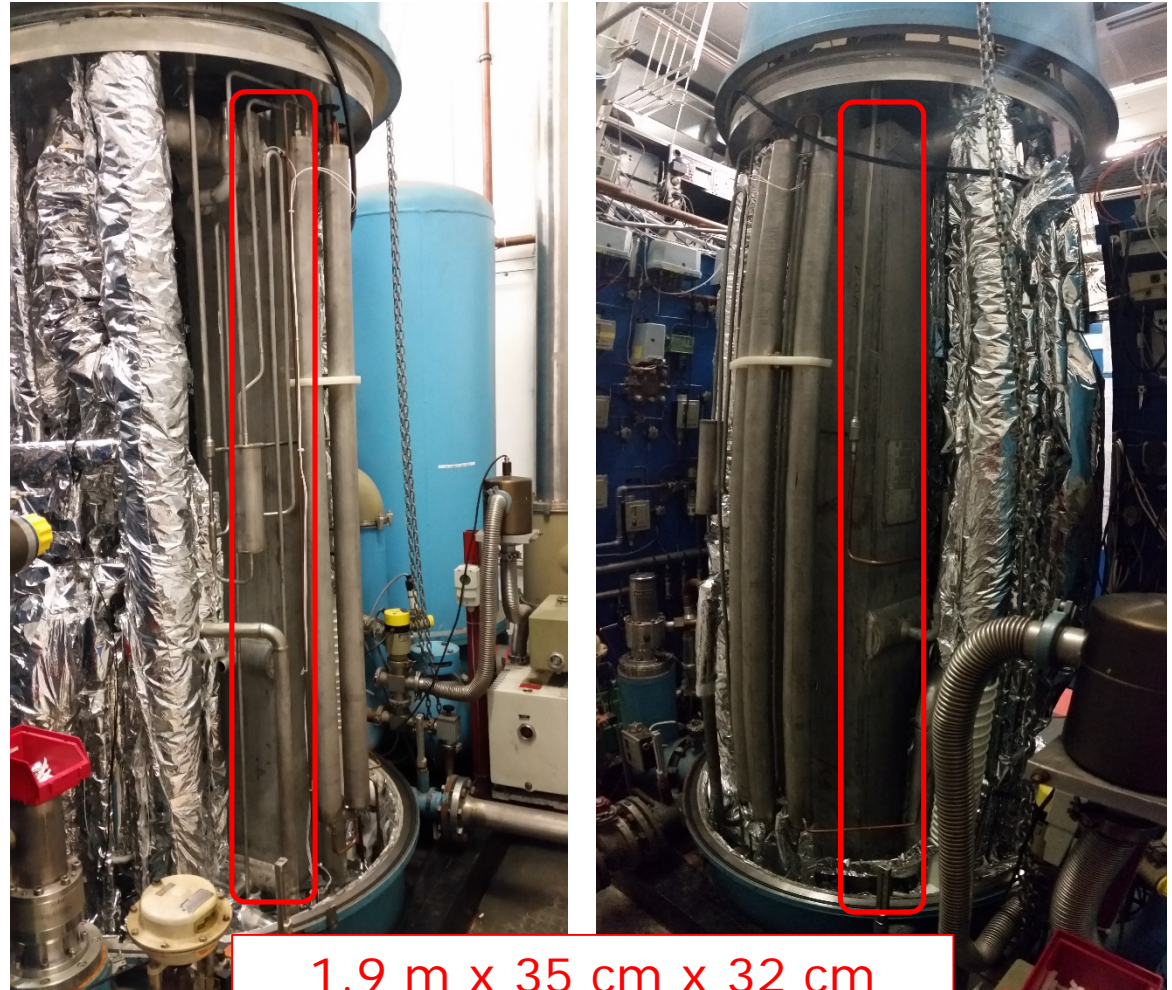
Heat Exchanger

- Most probably damaged during warm-up in Dec. 2018
- 4 leaks to insulating vacuum
- Tiny leak between high pressure and low pressure
- Very complicated to repair
- Replacement: delivery time of 8-9 months, 100 k€



Heat Exchanger

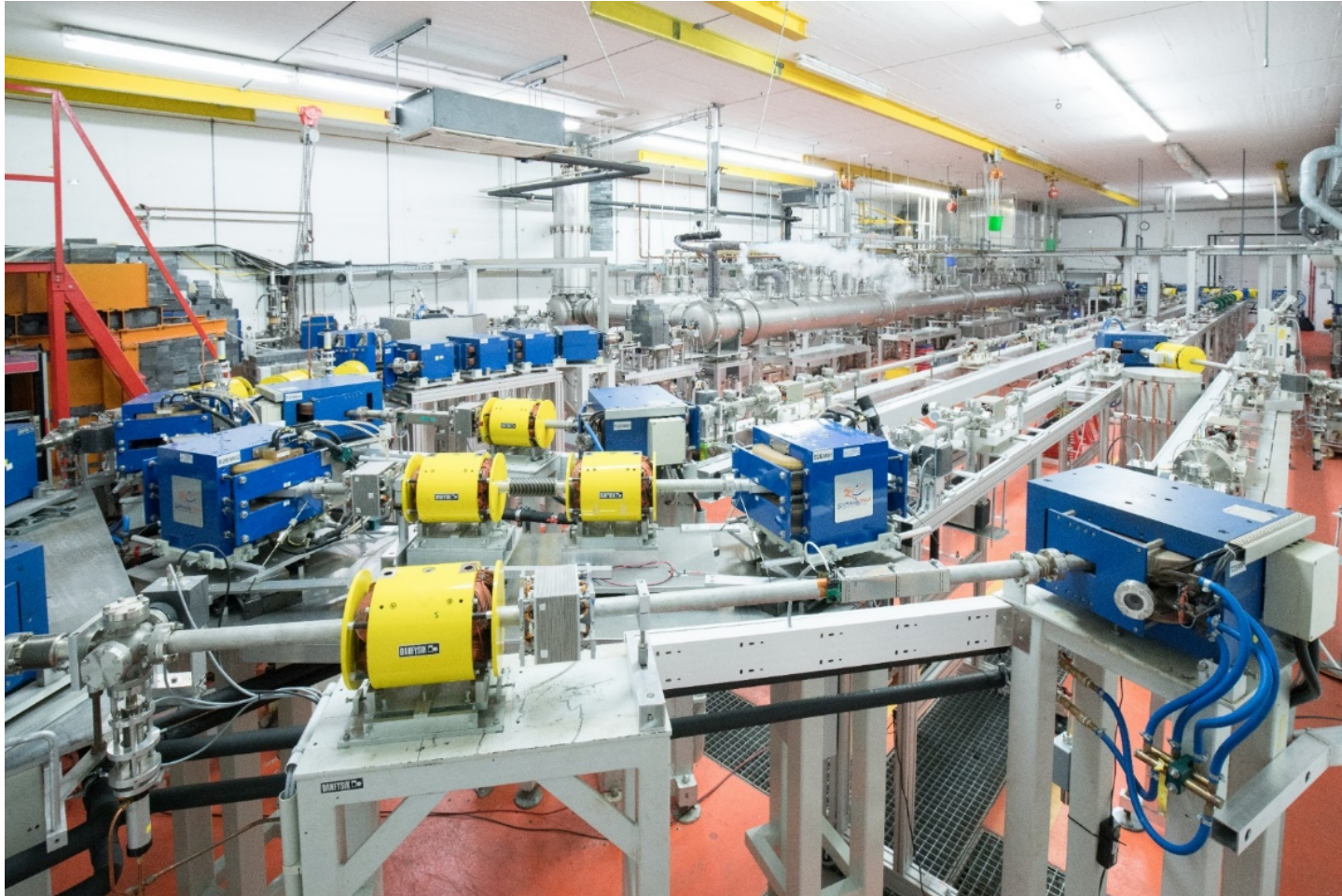
- 4 leaks to insulating vacuum have been closed
- Tiny leak between high pressure and low pressure is irreparable
- Cool down to check if cryo plant is working and has enough cooling power
 - If yes: proceed
 - If no: done for the year



Thank you for your attention!

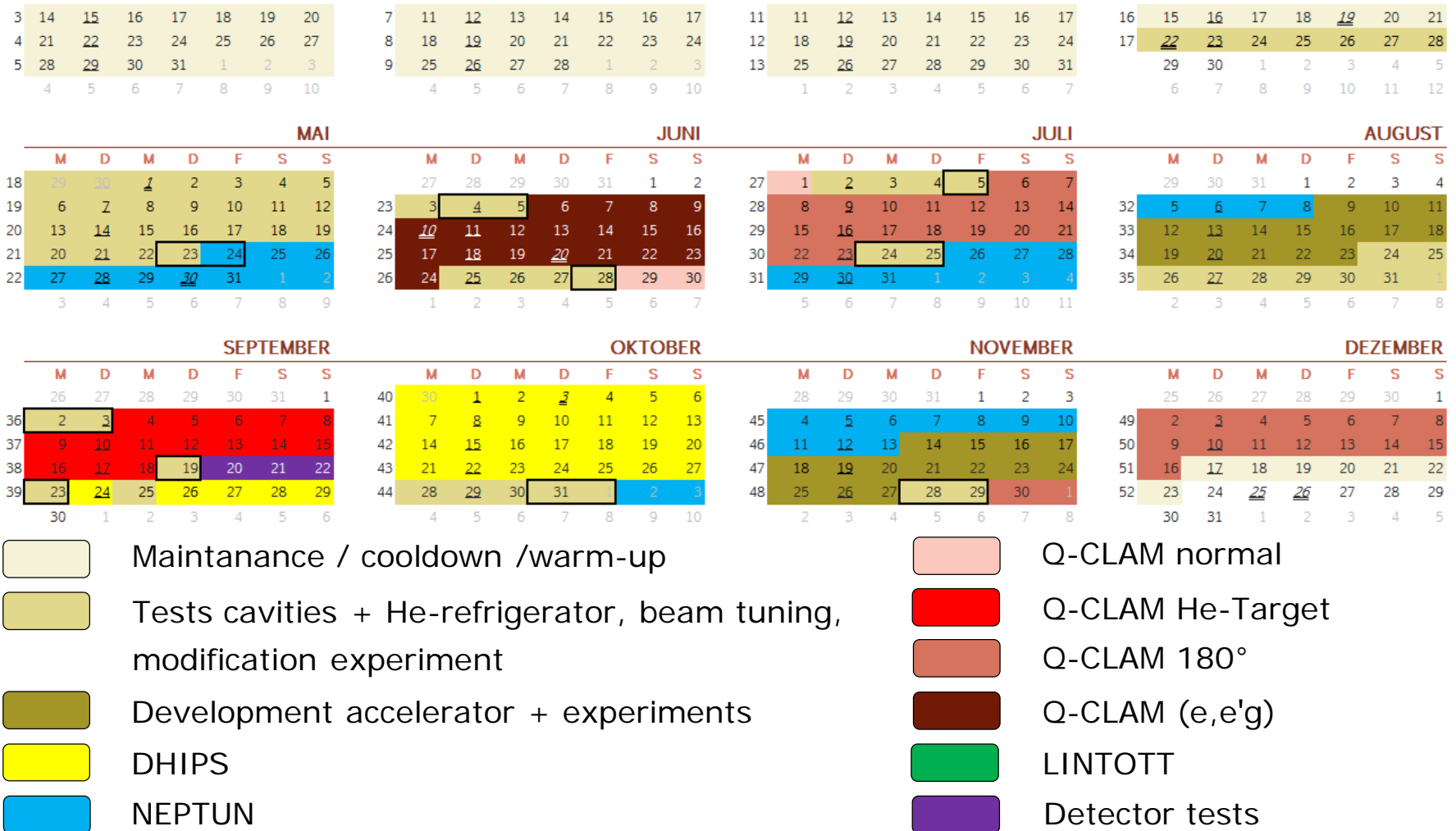


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Picture: Jan-Christoph Hartung

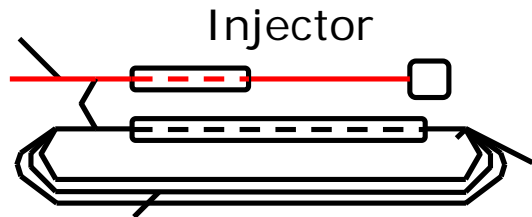
Beam Time Schedule 2019



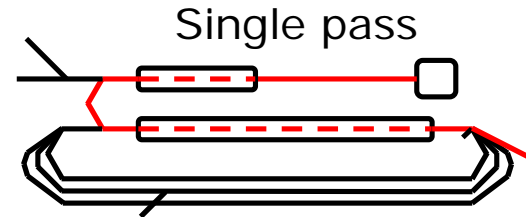
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- Refurbishment cryoplant 2018

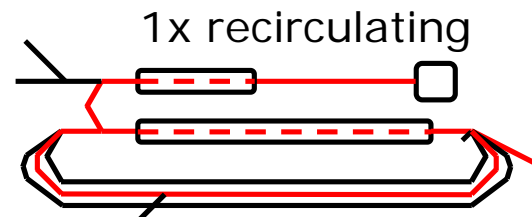
- Commissioning of modes following beam time schedule



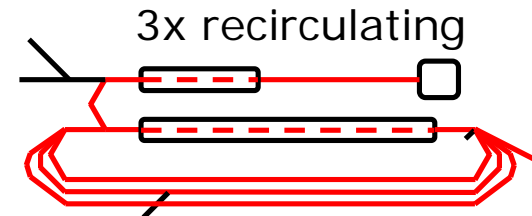
December
2016



December
2016



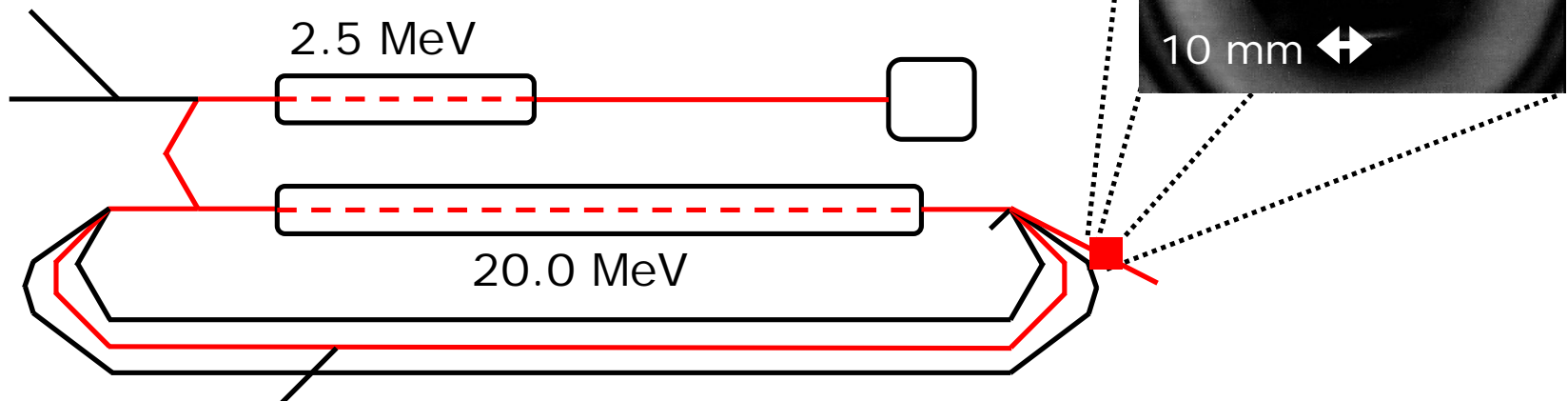
May
2017



November
2018

Once-Recirculating Operation

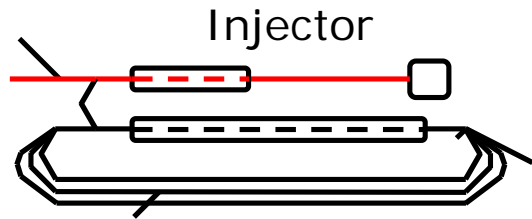
- Test of maximum beam current:
~98 % transmission to extraction
at design current for recirculating
operation (20 μA) \rightarrow new record
- Beam losses very small



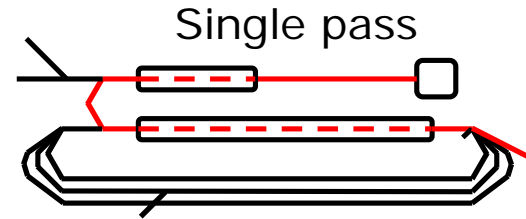
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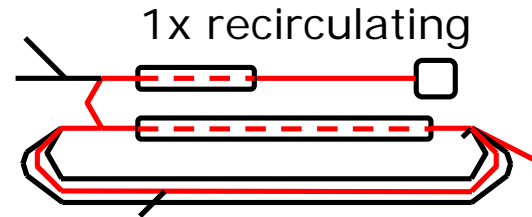
- Commissioning of modes following beam time schedule



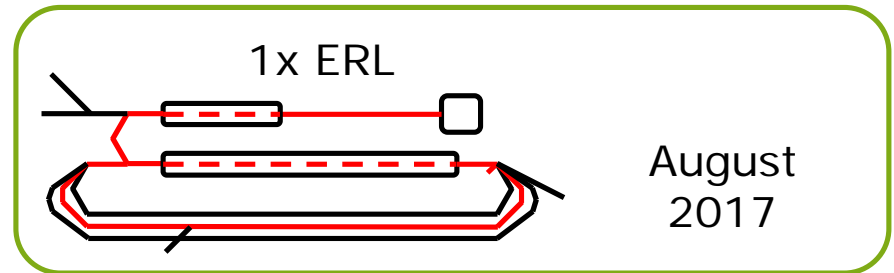
December
2016



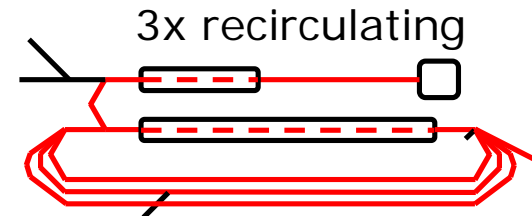
December
2016



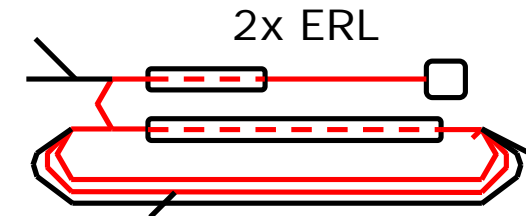
May
2017



August
2017

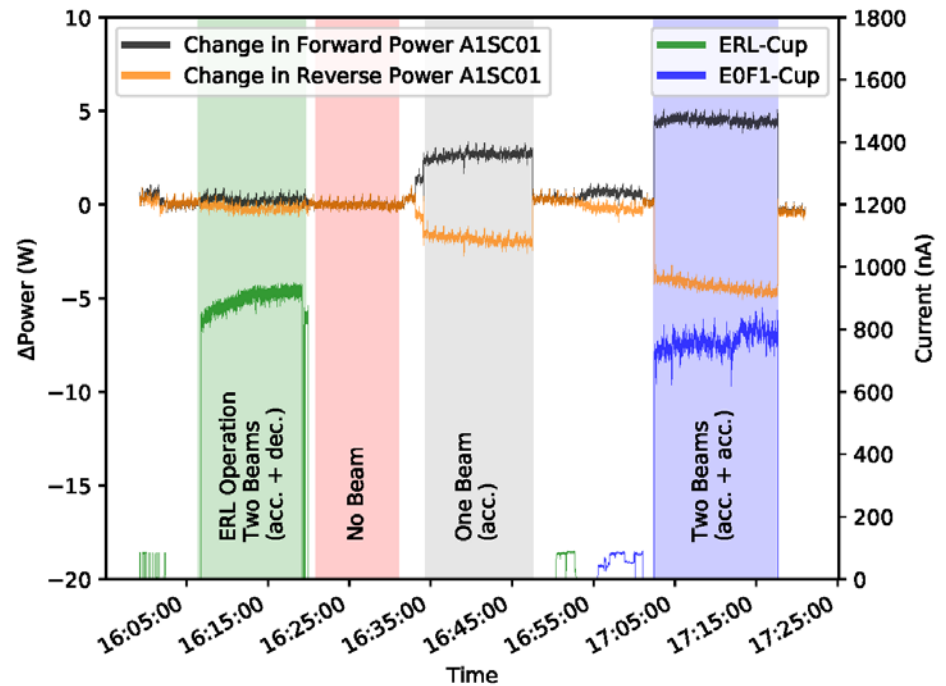
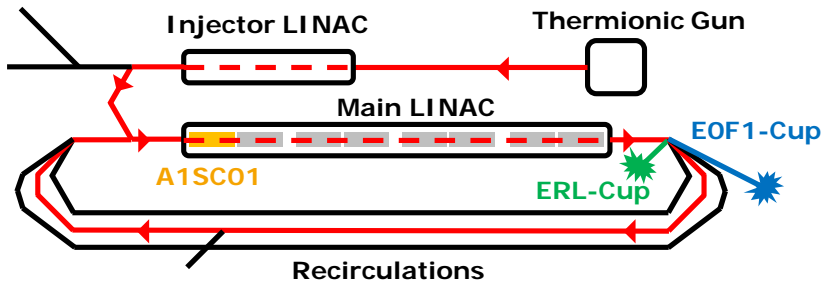


November
2018



Test phase

Once-Recirculating ERL Operation



August 2017:

First ERL in Germany!

- Energy gain injector: 2.5 MeV
- Energy gain LINAC: 20.0 MeV
- Current (before SRF): $\sim 1.2 \mu\text{A}$

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