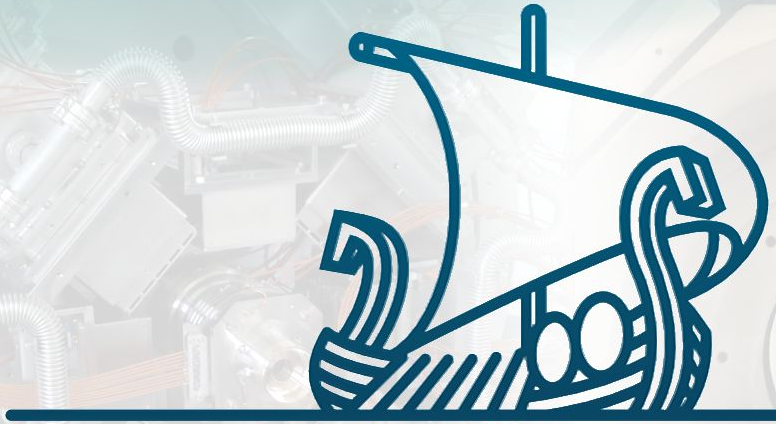


THE MORA PROJECT

MATTER'S ORIGIN FROM RADIOACTIVITY

MORA commissioning:

An odyssey of optimisation

Sacha Daumas-Tschopp
- LPC Caen -

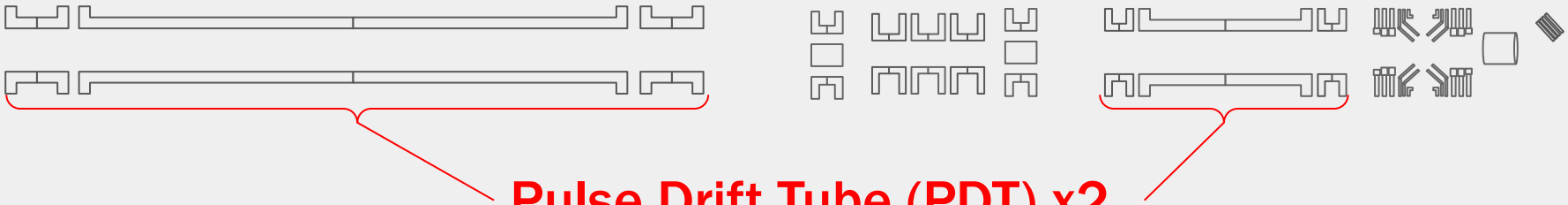
MORA workshop, JYFL, Jyväskylä - 02/05/2022 -

- Table of contents -

- Table of contents -

- Overview of the line -

MORA line is composed of:



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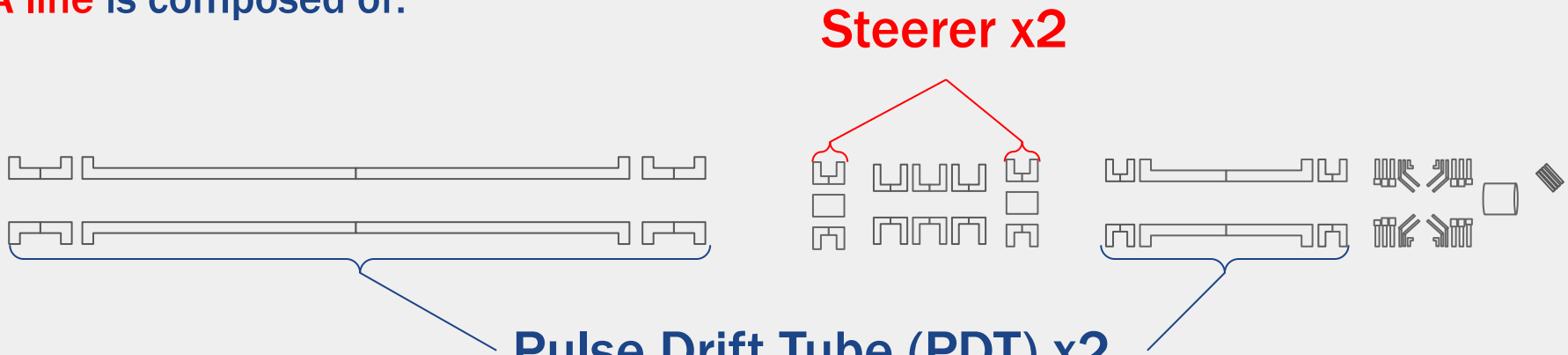

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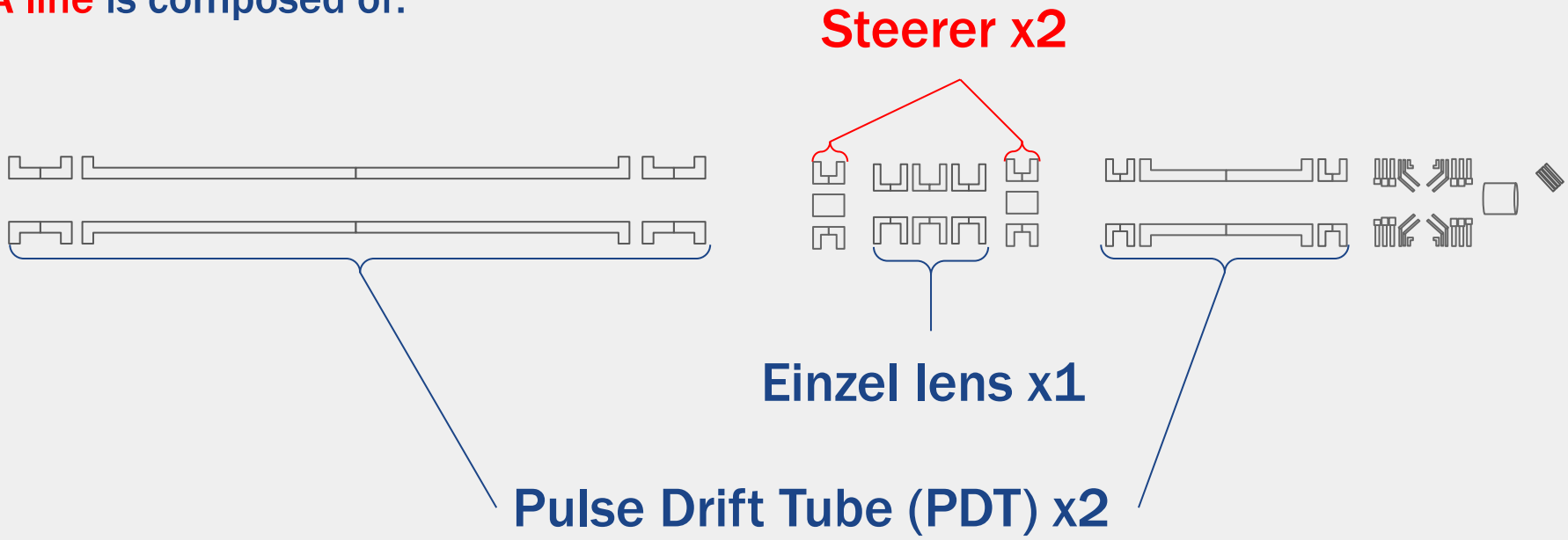
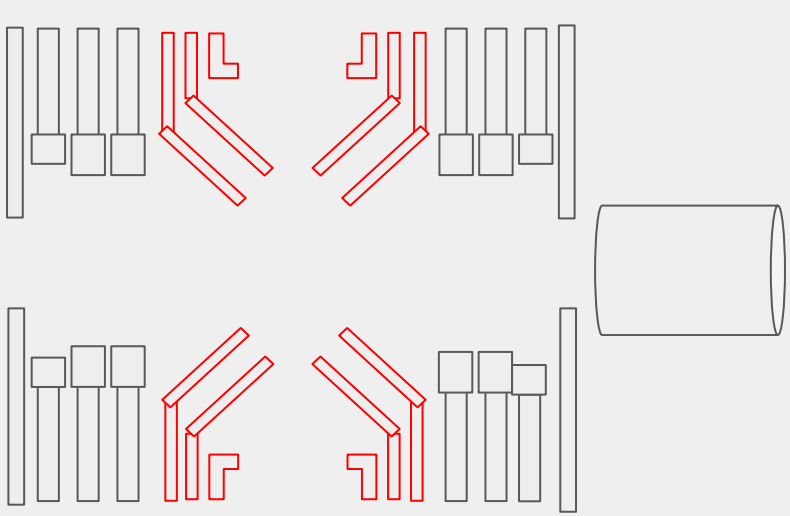
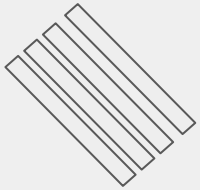


MORA Paul trap is composed of:

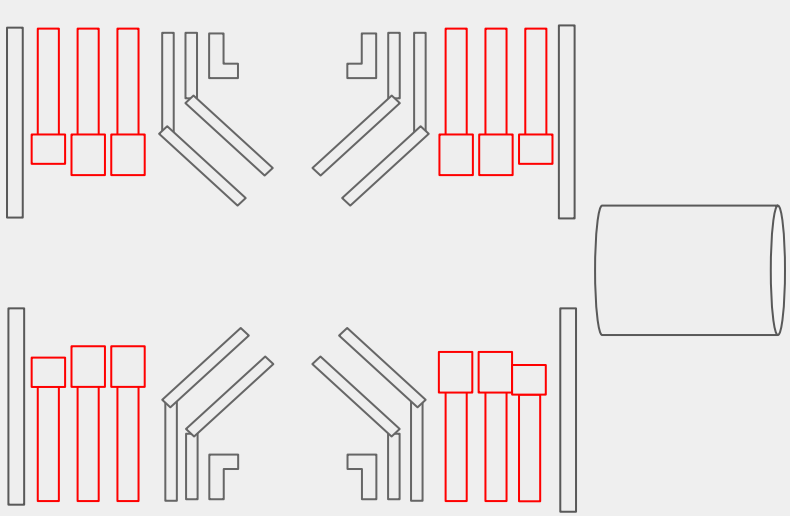


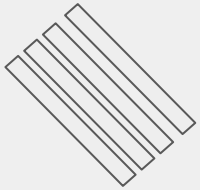


Electrode x6

MORA Paul trap is composed of:

- Electrode x6

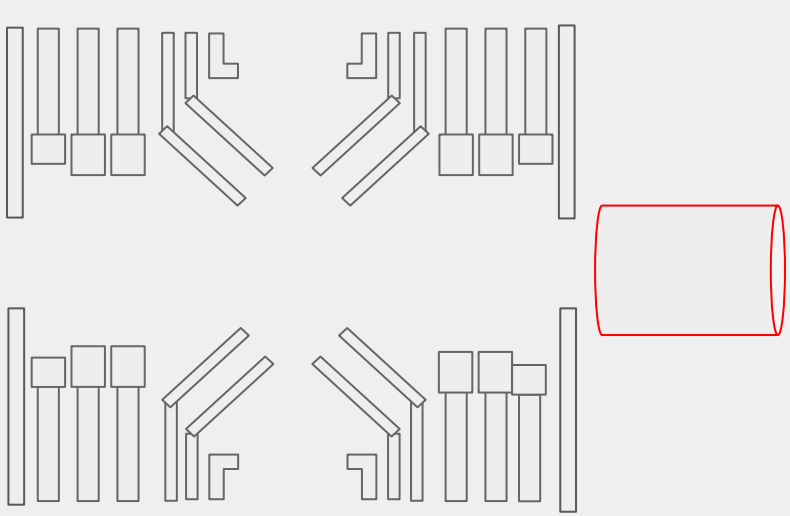


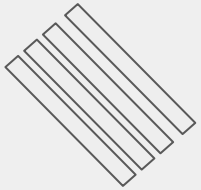


Einzel lens x2

MORA Paul trap is composed of:

- Electrode x6
- Einzel lens x2





Deflector x1

Some extra:

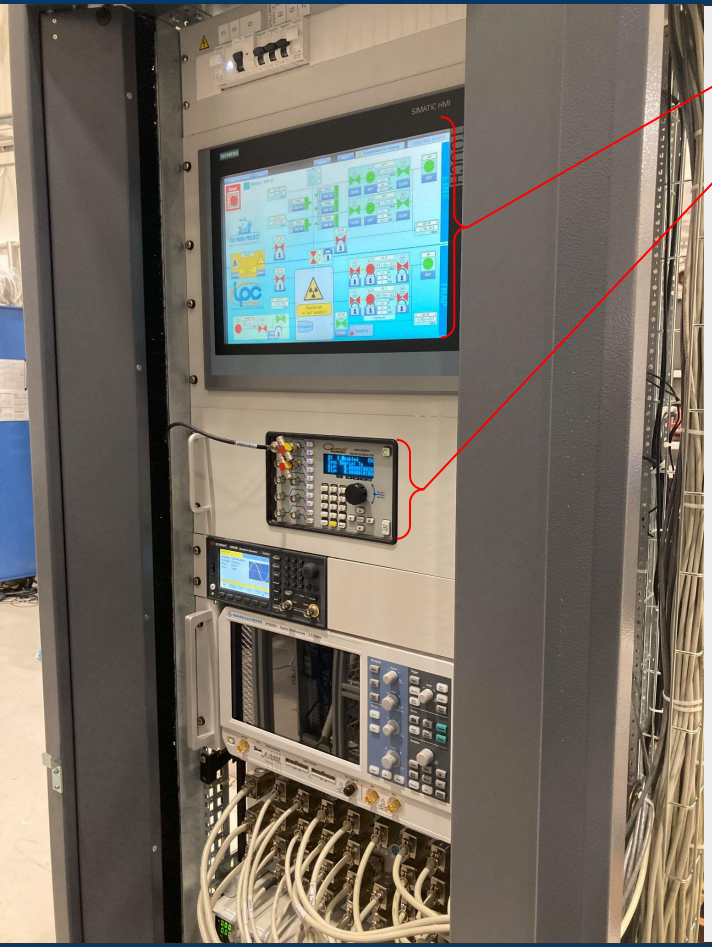
- Attenuator x4 (10% of transmission)

- Micro-Channel Plate (50% efficiency) + Phosphorus device

- Mirror apparatus x1

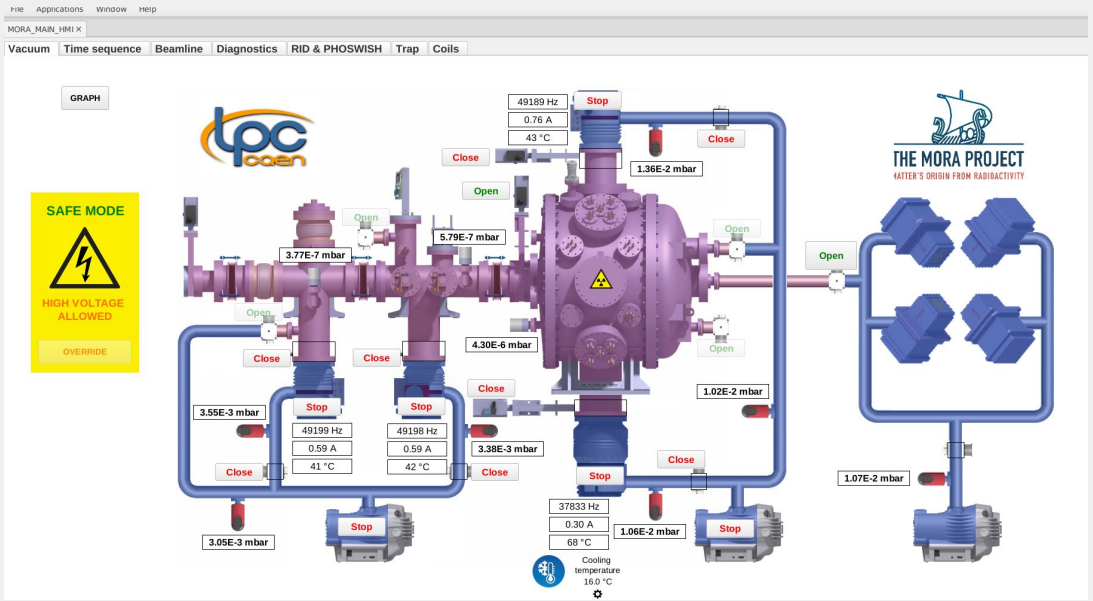
They can be set inside the line remotly

- Overview of the line: Paranoïd Androïd -



Direct readout of the pressure status inside the line and chamber

Great flexibility with 10 channels of time sequence



Very restrictive protocol under EPICS = No major user mistakes

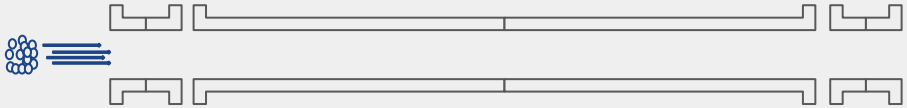
⇒ **Physicists proof**

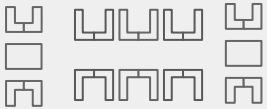
How to trap?

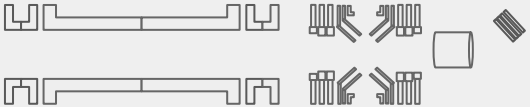
- Overview of the line: How to trap? -

T_0

Timings and voltages found by SIMION simulations





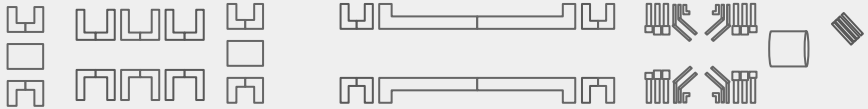


Travelling along the line:

- Overview of the line: How to trap? -

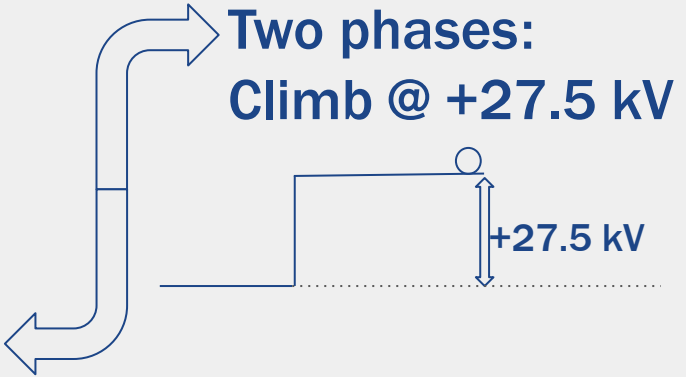
T_0

IGISOL energy @ 30 keV

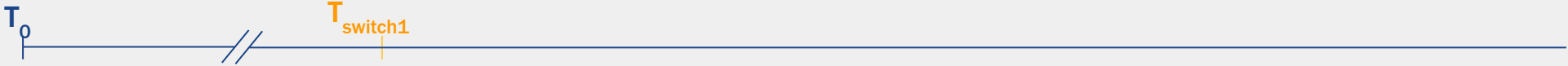


Travelling along the line:

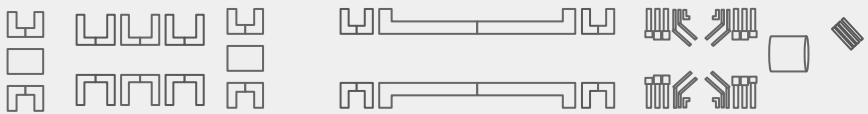
- Pulse Drift tube



- Overview of the line: How to trap? -

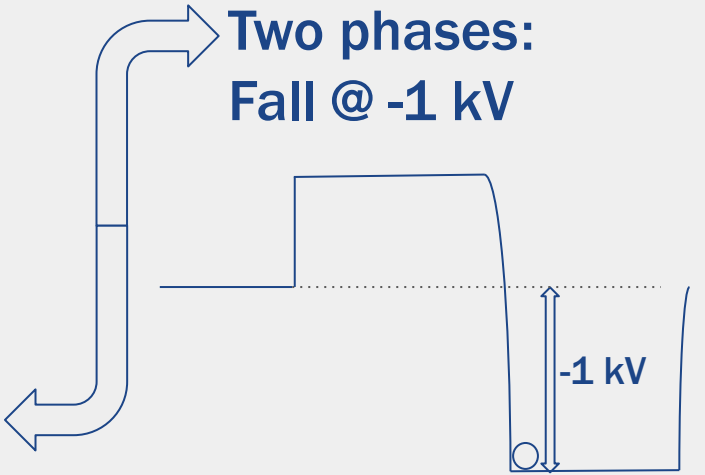


IGISOL energy @ 30 keV



Travelling along the line:

- Pulse Drift tube



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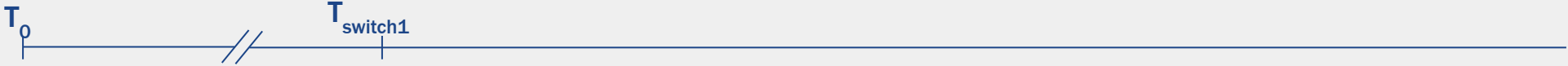
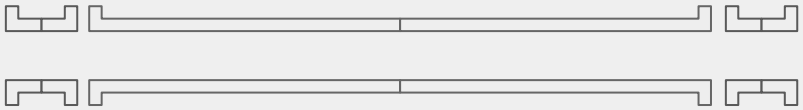
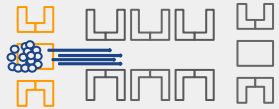
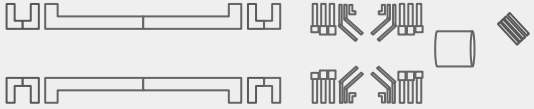


1.5 keV



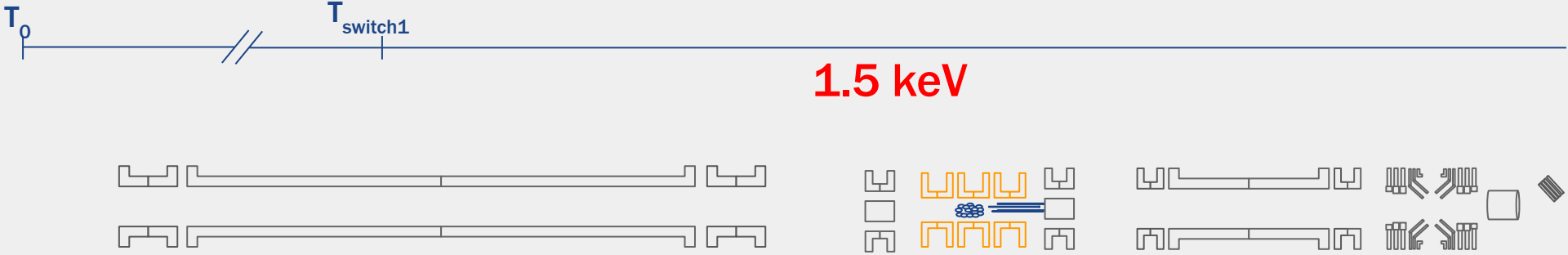




Travelling along the line:

- Pulse Drift tube
- Steerer 1 to correct the beam direction

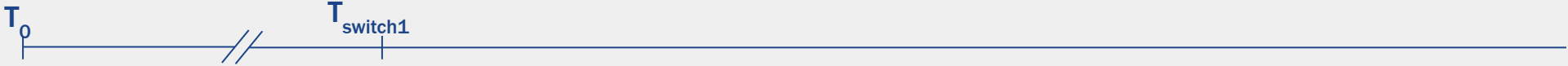
- Overview of the line: How to trap? -



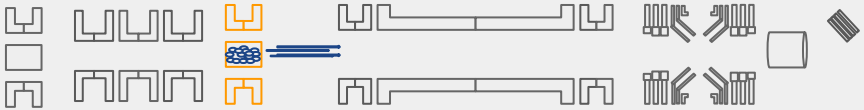
Travelling along the line:

- Pulse Drift tube (act as a lens in LPC configuration)
- Steerer 1 to correct the beam direction
- Lens 1 to refocalise the beam

- Overview of the line: How to trap? -



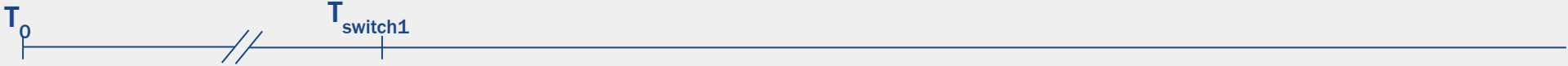
1.5 keV



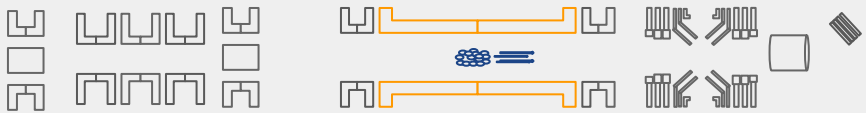
Travelling along the line:

- Pulse Drift tube (act as a lens in LPC configuration)
- Steerer 1 to correct the beam direction
- Lens 1 to refocalise the beam
- Steerer 2 to adjust the beam

- Overview of the line: How to trap? -

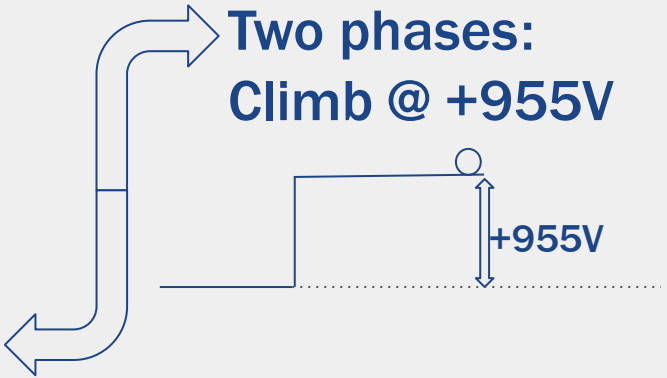


1.5 - 0.955 = 545 eV

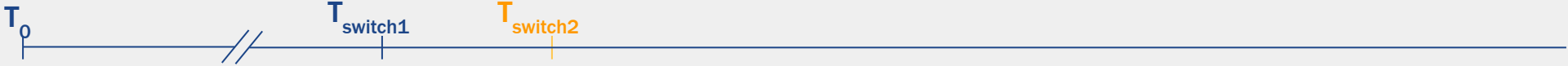


Travelling along the line:

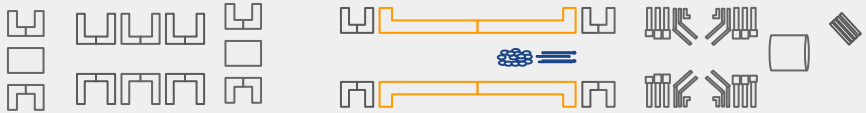
- Pulse Drift tube (act as a lens in LPC configuration)
- Steerer 1 to correct the beam direction
- Lens 1 to refocalise the beam
- Steerer 2 to adjust the beam
- Pulse Drift tube 2 to slow down the beam



- Overview of the line: How to trap? -

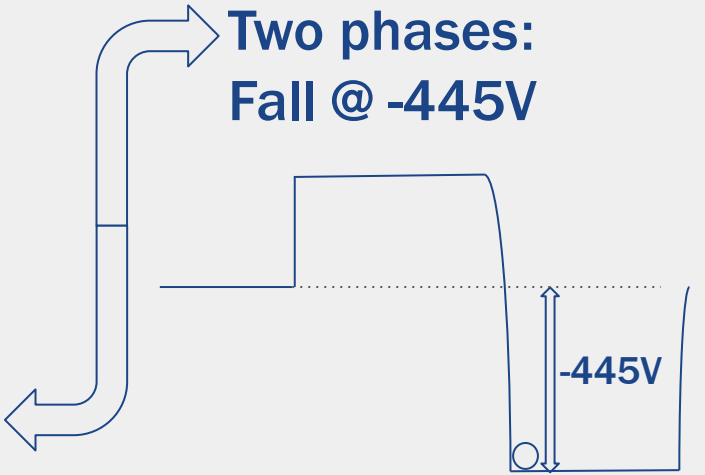


545 - 445= 100 eV



Travelling along the line:

- Pulse Drift tube (act as a lens in LPC configuration)
- Steerer 1 to correct the beam direction
- Lens 1 to refocalise the beam
- Steerer 2 to adjust the beam
- Pulse Drift tube 2 to slow down the beam



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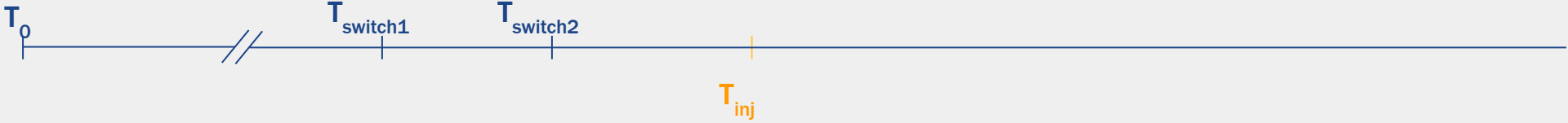
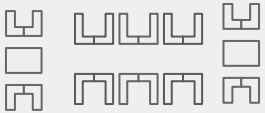
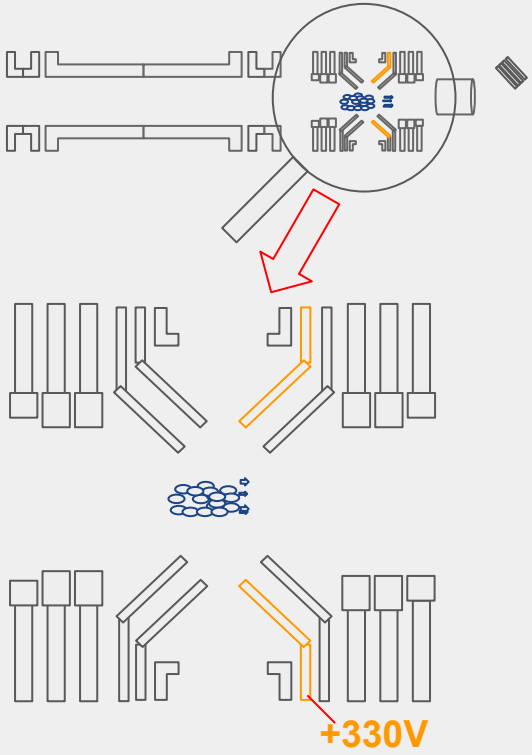


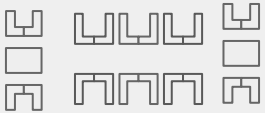


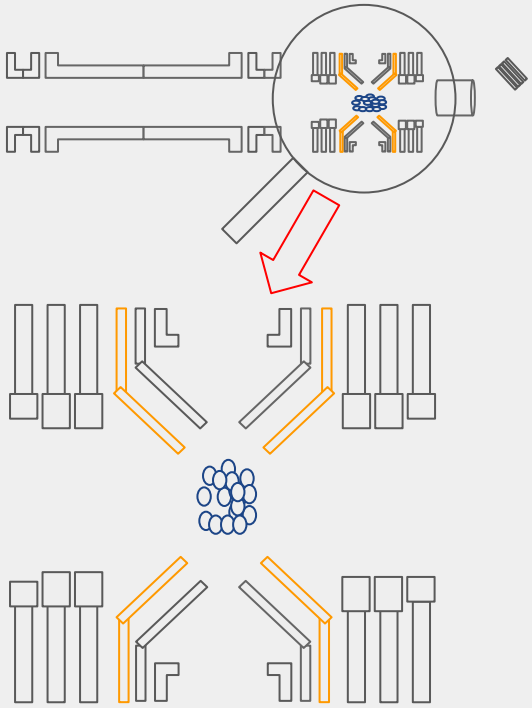


Trapping phase:

1) Approaching the center ⇨ Get repelled

- Overview of the line: How to trap? -



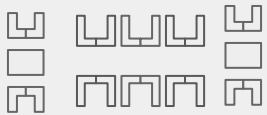


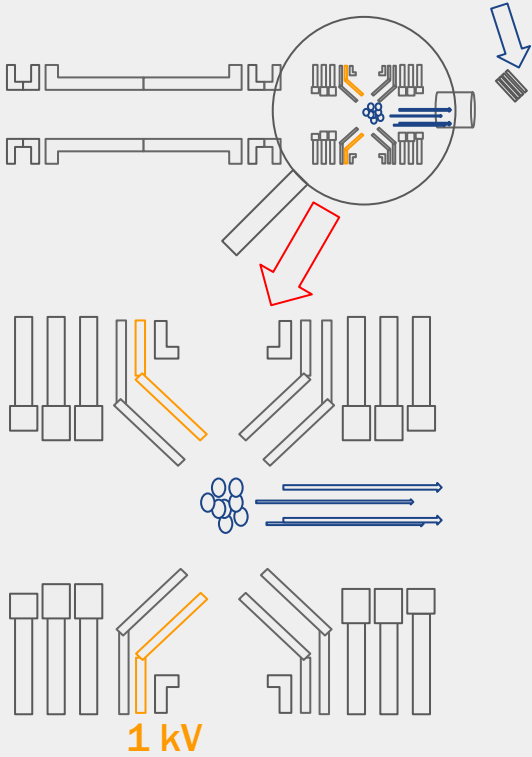
Trapping phase:

1) Approaching the center ⇨ Get repelled

2) Starting the RF when E_{ions} ~ 0 eV

- Overview of the line: How to trap? -





Trapping phase:

1) Approaching the center ⇨ Get repelled

2) Starting the RF when E_{ions} ~ 0 eV

3) Extraction phase @ **1 keV**

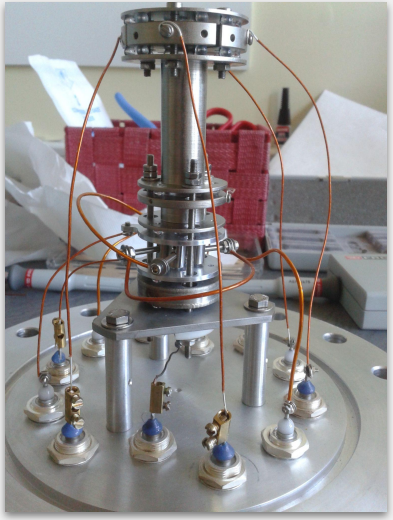
- Table of contents -

- Commissioning @ LPC CAEN: Characteristics-

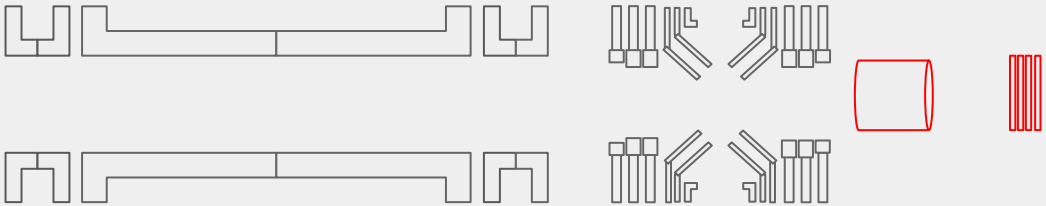
Trapping in commissioning phase @ LPC Caen

Use of a very low energy configuration:

- Ions emitted @ 1.5 keV
- Pulse Drift Tube 1 used as a lens
- No deflector + MCP2 in direct configuration



MORA @ LPC Caen

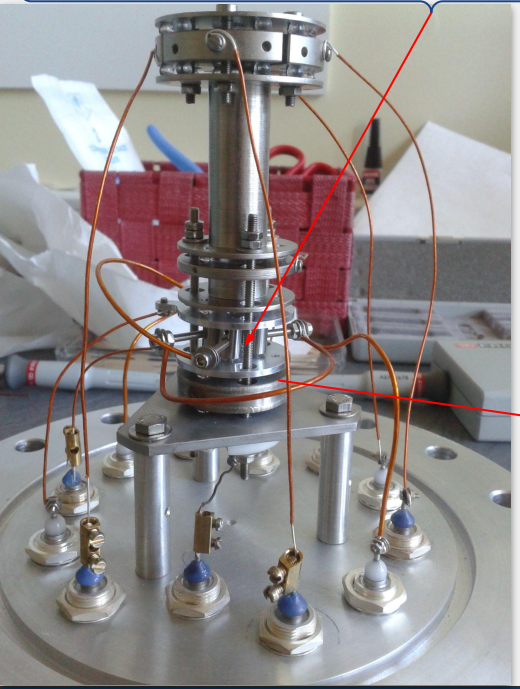


- Commissioning @ LPC CAEN: Offline source -

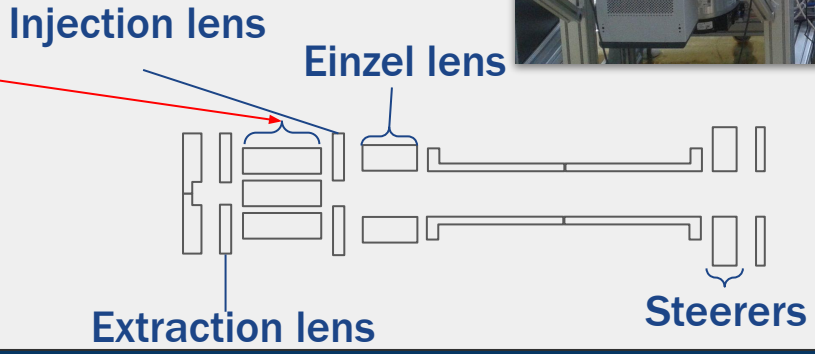
THE MORA PROJECT
MATTER'S ORIGIN FROM RADIOACTIVITY

Trapping in commissioning phase @ LPC Caen

Add a RFQ on the source to bunch ^{23}Na ions
(ex: every 10 ms for a 60µs trap duration)



MORA @ LPC Caen

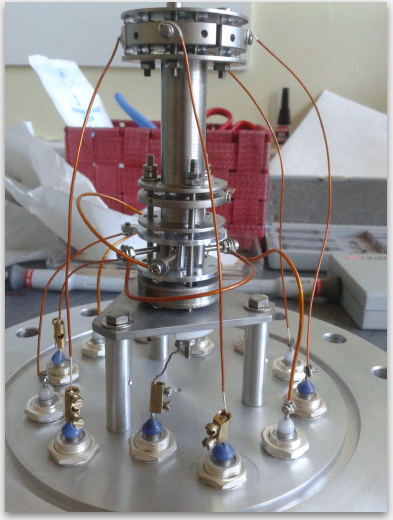


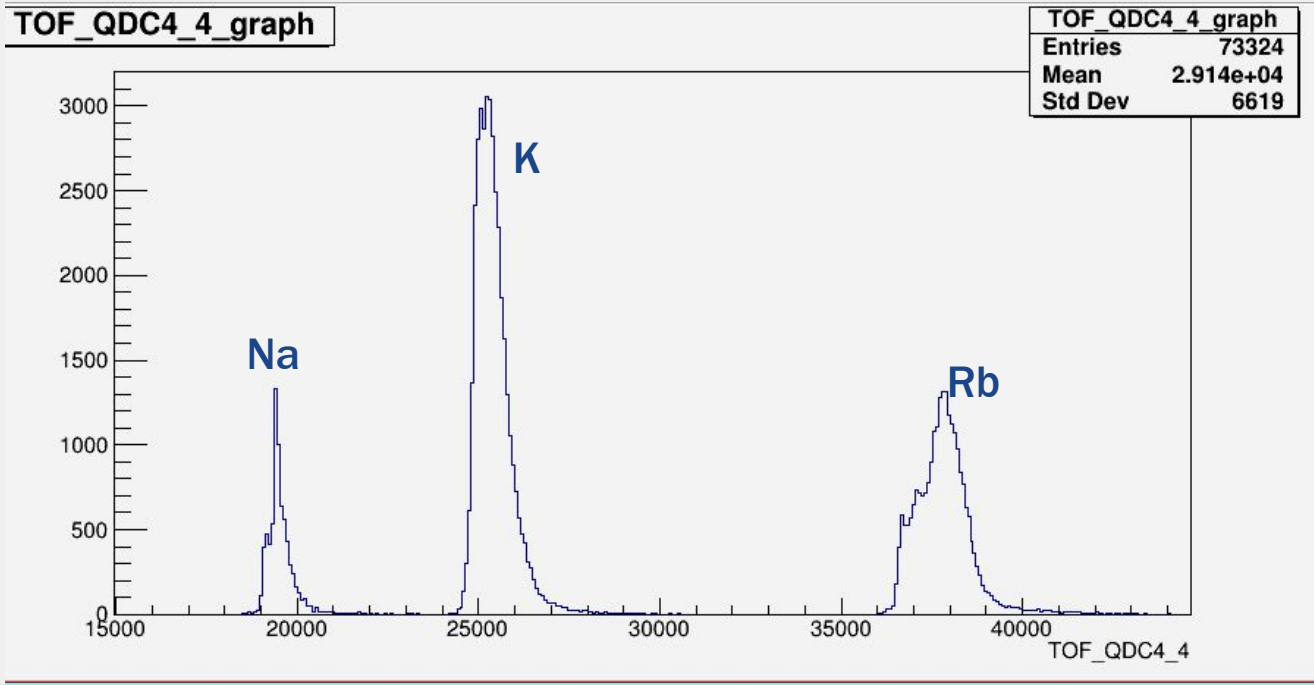
- Commissioning @ LPC CAEN: Offline source -

Trapping in commissioning phase @ LPC Caen

Use of a stable source (Surface ionization) of ^{23}Na

But not pure: contaminants = K + Rb

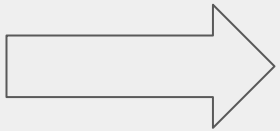




SIMULATION COMPARISON

- Comparison with SIMION simulations -

Timings	Experiment	SIMION
PDT2 switch	19.9µs	20.6µs
Injection	25.5µs	26.2µs
RF	27.3µs	26.4µs

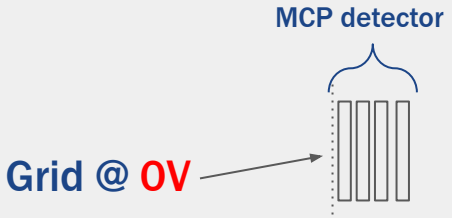


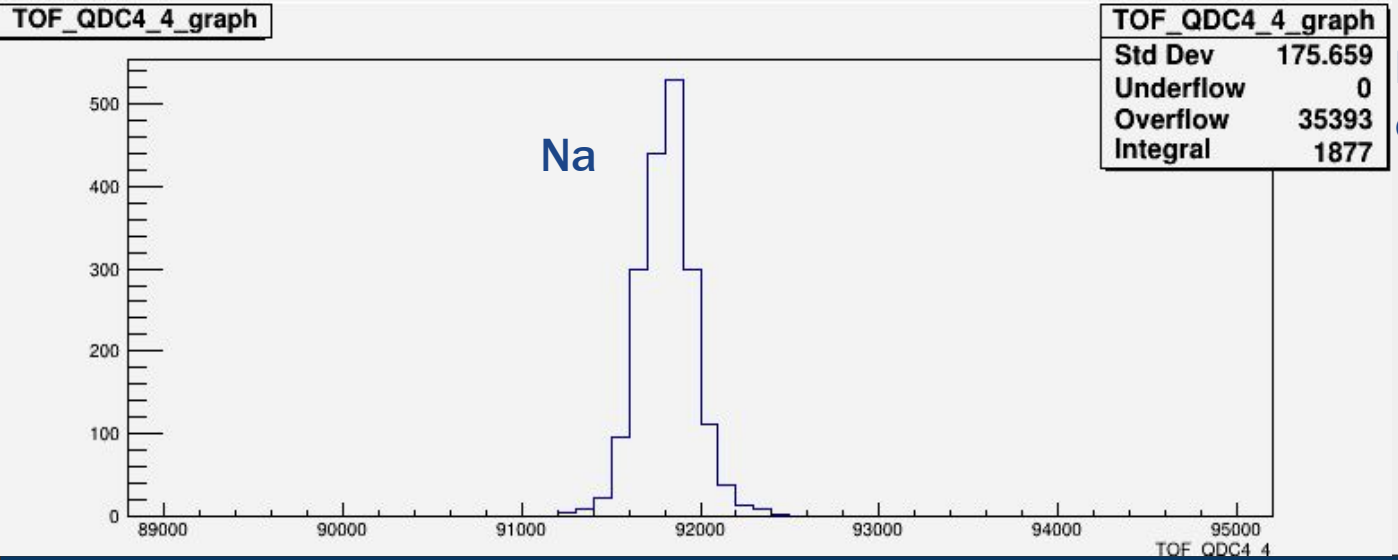
Difference could be explained by the bunch shape

Trapping efficiency evaluation

Four steps:

Collect data from the trapping process





Data collected with trap: only Na

Single peak

Trapping process “on”

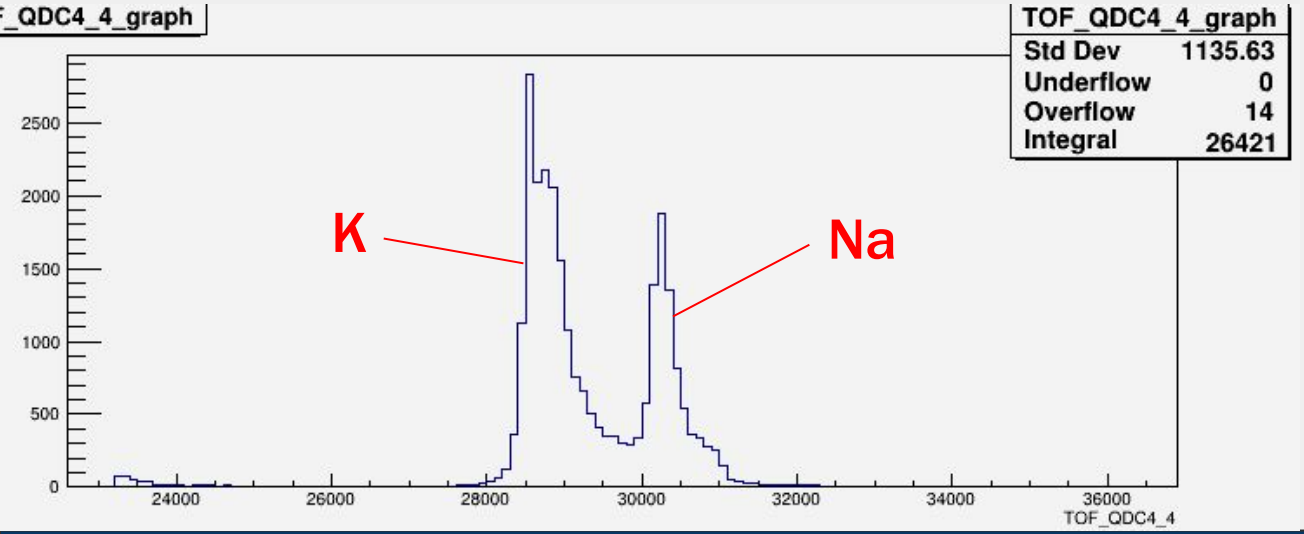
Trapping efficiency evaluation:

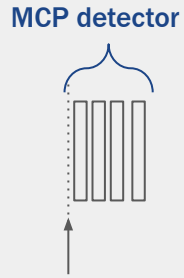
Four steps:

Collect data from the trapping process

Disable the trap voltages and let ions passing through

Collecting data of the double peak (Na @ 112 eV + K @ 1.5 keV)





Data collected w/o trap:
Na + K

Double peak

Na slowed down by the PDT2 while not K

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MATTER'S ORIGIN FROM RADIOACTIVITY

Trapping efficiency evaluation:

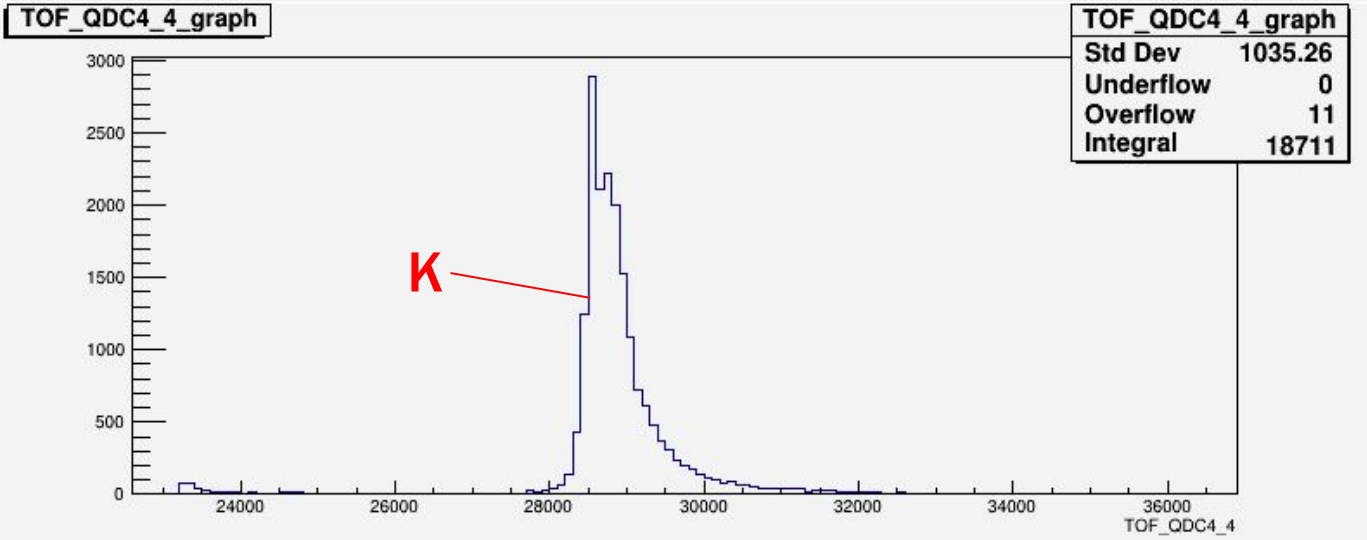
Four steps:

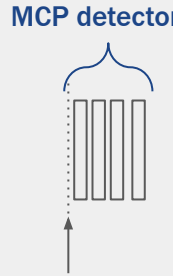
Collect data from the trapping process

Disable the trap voltages and let ions passing through

Collecting data of the double peak (Na @ 112 eV + K @ 1.5 keV)

Filter the ion: only K and Rb will pass





Grid @ 150V

Data collected w/o trap:

⇨ only K

Single peak

$$\varepsilon_{trap} = \frac{\text{Nb of trapped Na}}{\text{Nb of direct Na}}$$

- Trapping and optimization: Trapping efficiency -

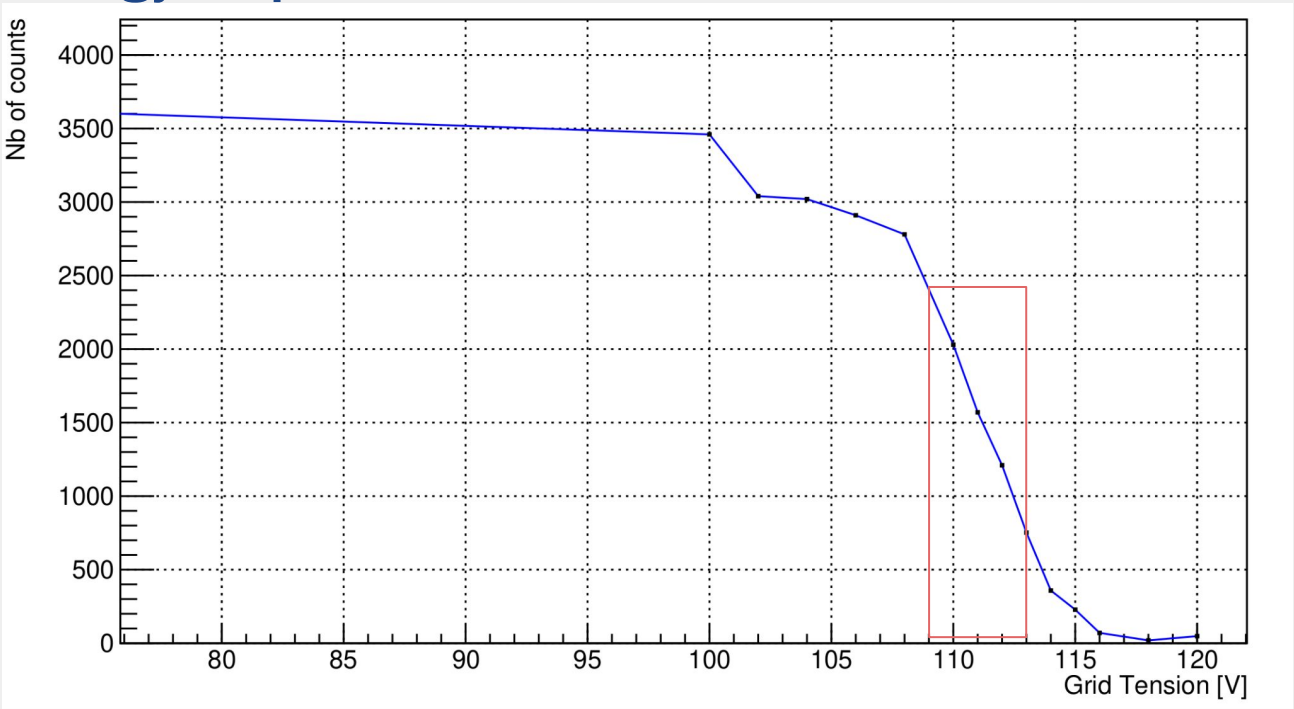
THE MORA PROJECT
MATTER'S ORIGIN FROM RADIOACTIVITY

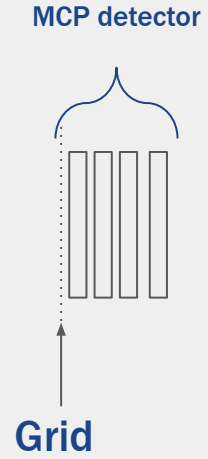
@ LPCC:

ε_{trap} = 56% for 60 µs trapping time
ε_{trap} = 22% for 90 ms trapping time
ε_{trap} = 10% for 450 ms trapping time

} Evaporation phase (~1 ms)
Half-life ≃ 350 ms

Energy dispersion after PDT2 switch on MCP2

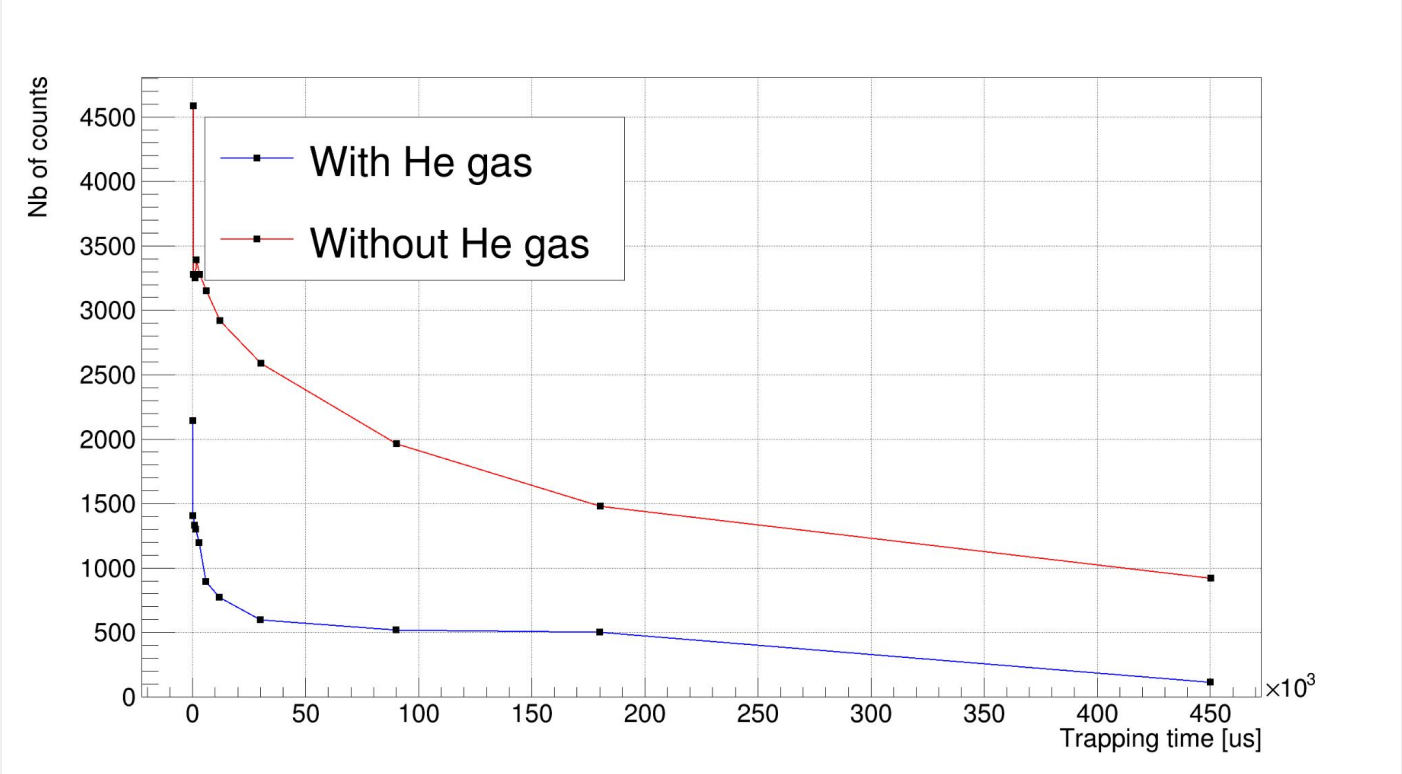




Integral of ^{23}Na during a 30s acquisition

⇨ Mean energy ~111 +/- 2 eV after the switch

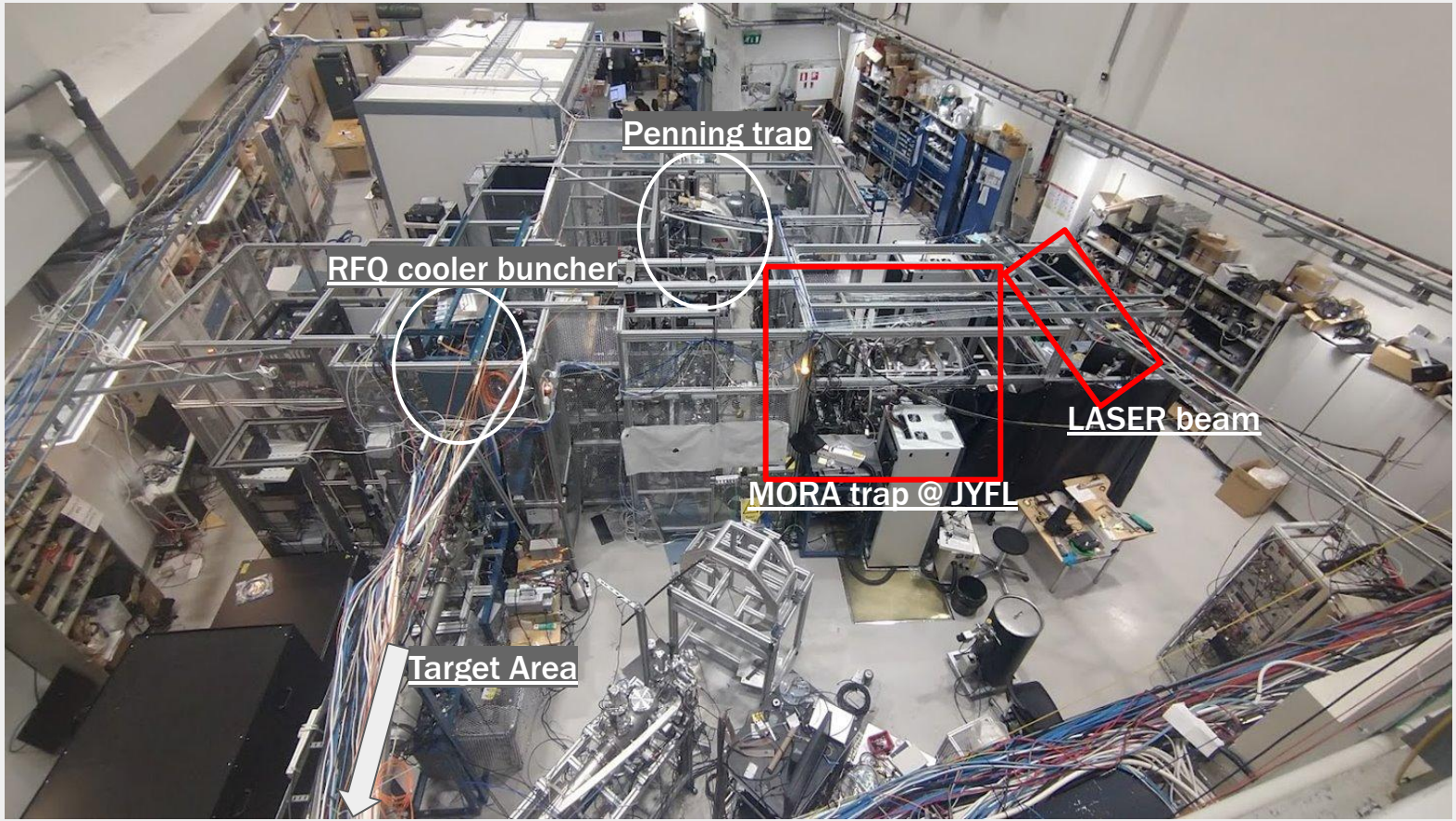
- Trapping and optimization: Half life -



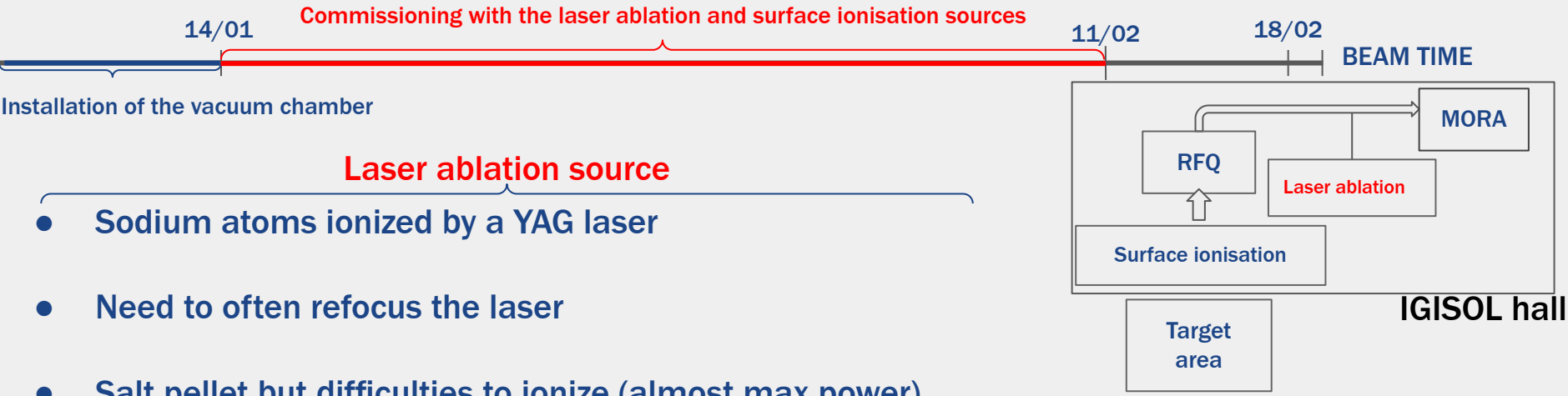
The gas seems to have an impact on trapping efficiency

- Table of contents -

- Installation in IGISOL hall -



- Commissioning @ JYFL: Laser ablation source -

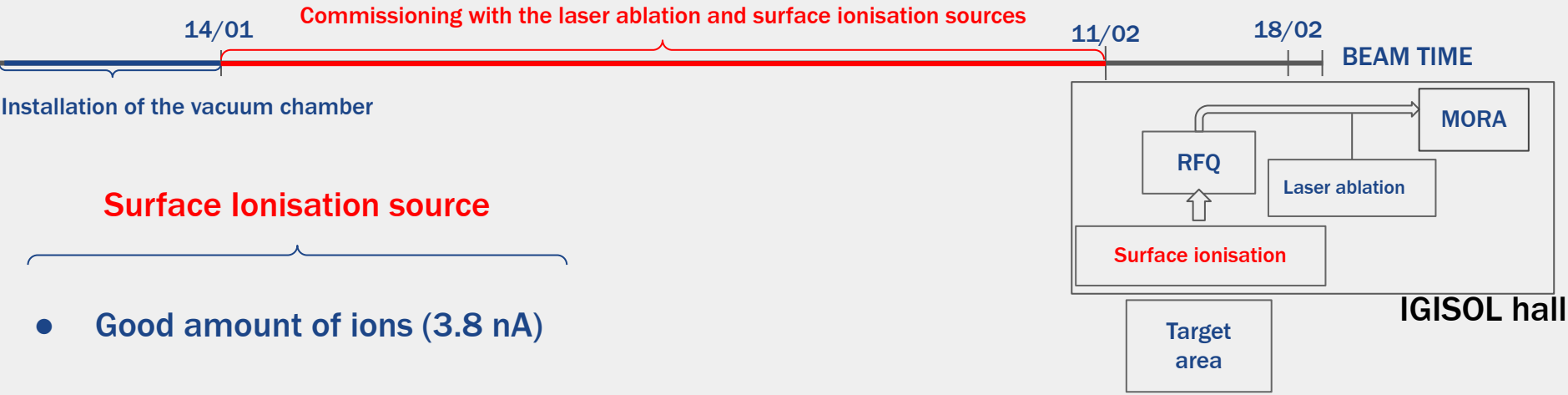


Laser ablation source

- Sodium atoms ionized by a YAG laser
- Need to often refocus the laser
- Salt pellet but difficulties to ionize (almost max power) and induced some current instabilities on the main HV
- Metallic pellet -> easier to use but uncertainties on the mass

Salt pellets

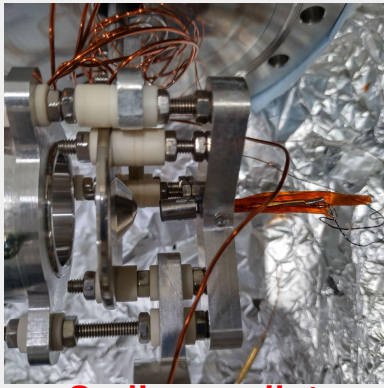
- Commissioning @ JYFL: Surface ionization -



Surface Ionisation source

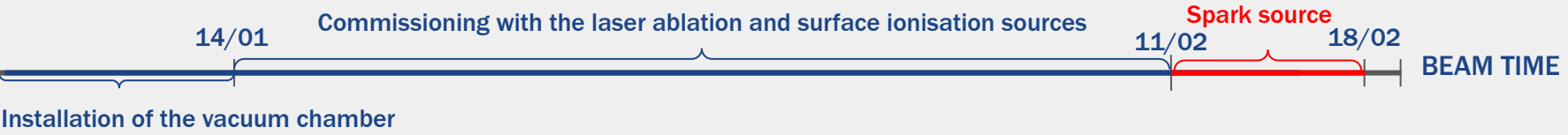
- Good amount of ions (3.8 nA)
- Use of RFQ
- But mostly Potassium according to ToF calculations

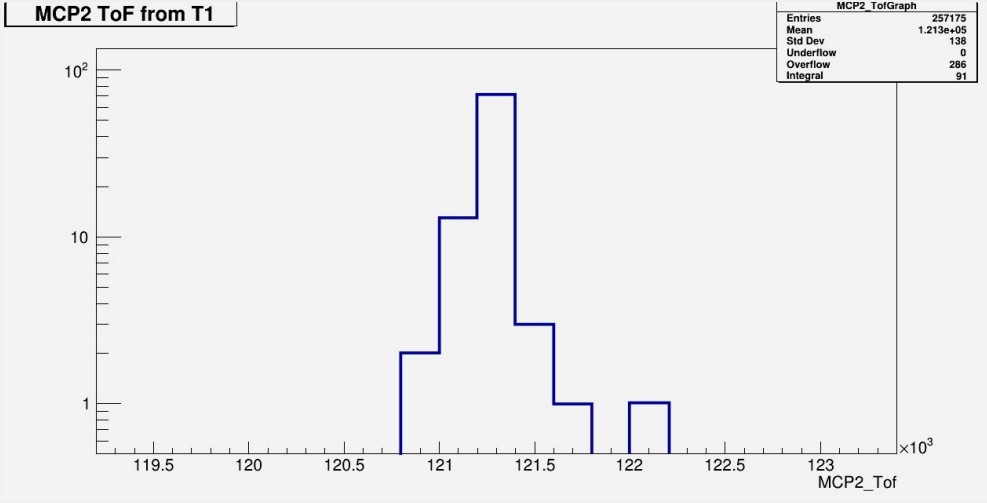
⇨ Trouble to detect due to an inverted logic of PDT1



Sodium pellet

- Commissioning @ JYFL: Results Spark source -





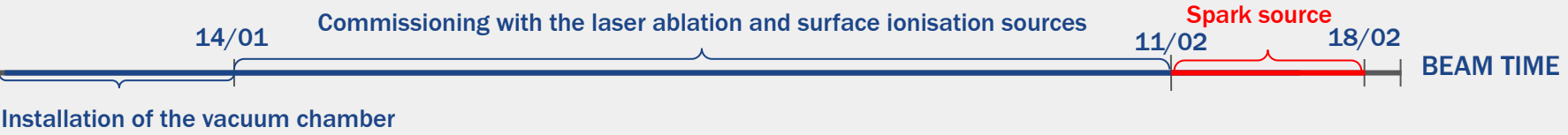
Spark source:

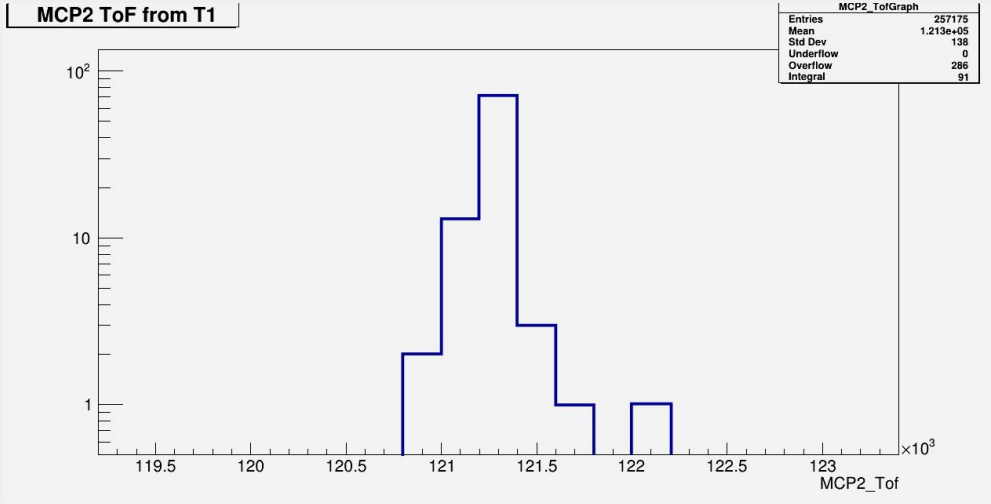
- Target area location: same path than ^{23}Mg
- Bunched by the IGISOL RFQ cooler

First ions(^{23}Na) trapped by MORA at JYFL

- Trapping parameters from the LPC Caen commissioning adapted and reproducible

- Commissioning @ JYFL: Results Spark source -





Spark source:

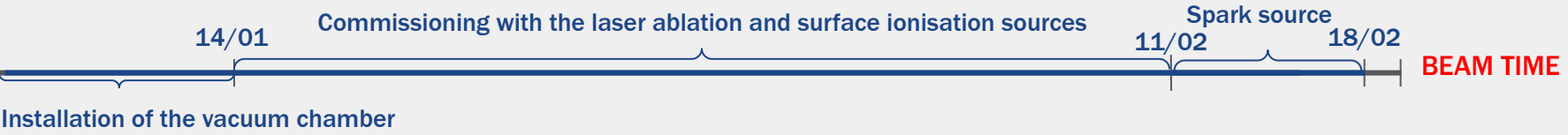
- 62.5% of transmission in MORA line
- ~110 eV after PDT2

First ions(^{23}Na) trapped by MORA at JYFL

- 15.2% trapping efficiency @ V_{RF} = +/- 65 V, 0.3 MHz and 60 µs of trapping time

Beam Time

- Results @ JYFL: Comparison with simulations-



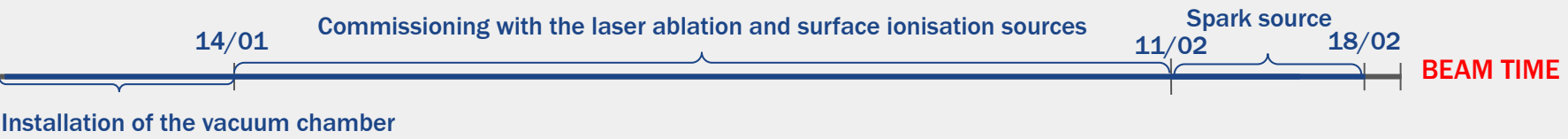
^{24}Mg (p,d) ^{23}Mg reaction with a high production rate ~10^5 pps/µA of p

Large ^{23}Na contamination : 1/2000 of ^{23}Mg (in the best conditions)

Pulsing down large bunch (20-100µs) from the saturated RFQ is inefficient due to MORA acceptance (~3µs)

Timings	Experiment	SIMION
PDT2 switch	13.0 µs	12.0 µs
Injection	18.4 µs	18.5 µs
RF	20.1 µs	19.0 µs

- Results @ JYFL: During the experiment-

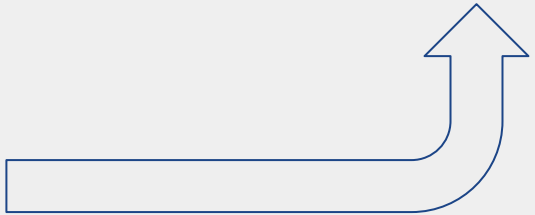


Trying to improve the trapping efficiency by increasing the RF voltage and frequency:

Tension	Half period	Nb of count
65 V	1500 ns	1794
100 V	1500 ns	46
100 V	1250 ns	2573
100 V	1140 ns	1860
100 V	1040 ns	1542
100 V	1250 ns	1753
100 V	1250 ns	1917
100 V	1040 ns	1097
100 V	1140 ns	2925
100 V	1310 ns	1272
100 V	1310 ns	1278
100 V	1140 ns	1820

⇨ Fluctuations of the buncher voltages

Connect the PDT1 directly on the cooler line HV



- Online measurement: Results -

^{24}Mg (p,d) ^{23}Mg reaction with a high production rate ~10^5 pps/µA of p

Trapping efficiency:

- 5 % for a 500 ms trapping time
- reached 50% in specific conditions (continuous RF during R3/R4 phase)

Conclusion: The trap is working correctly with radioactive conditions

However:

- Large ^{23}Na contamination: 1/2000 of ^{23}Mg (in the best conditions)
- Pulsing down large bunch (20-100µs) from the saturated RFQ is inefficient due to MORA acceptance (~3µs for A = 23)
- RF noises seen on recoil ion detectors

- Table of contents -

- How to improve? -

Things to be improved for the next beam time (27/05 to 31/05):

- Better ratio $^{23}Mg/^{23}Na$ (1/100 max according to the article)
  - Full cleaning of the target area
- The width of bunch via the RFQ (IGISOL side)
  - Adapt the RF of the mini buncher (work in progress)
- Fix the RF issue on the recoil ion detector
  - Test another RF generator/amplifier √
  - Strongly reduce the distance between the RIDE output signals and their PA boxes √
- Install a source for offline tests (w/o RFQ)

Thank you for your attention!

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