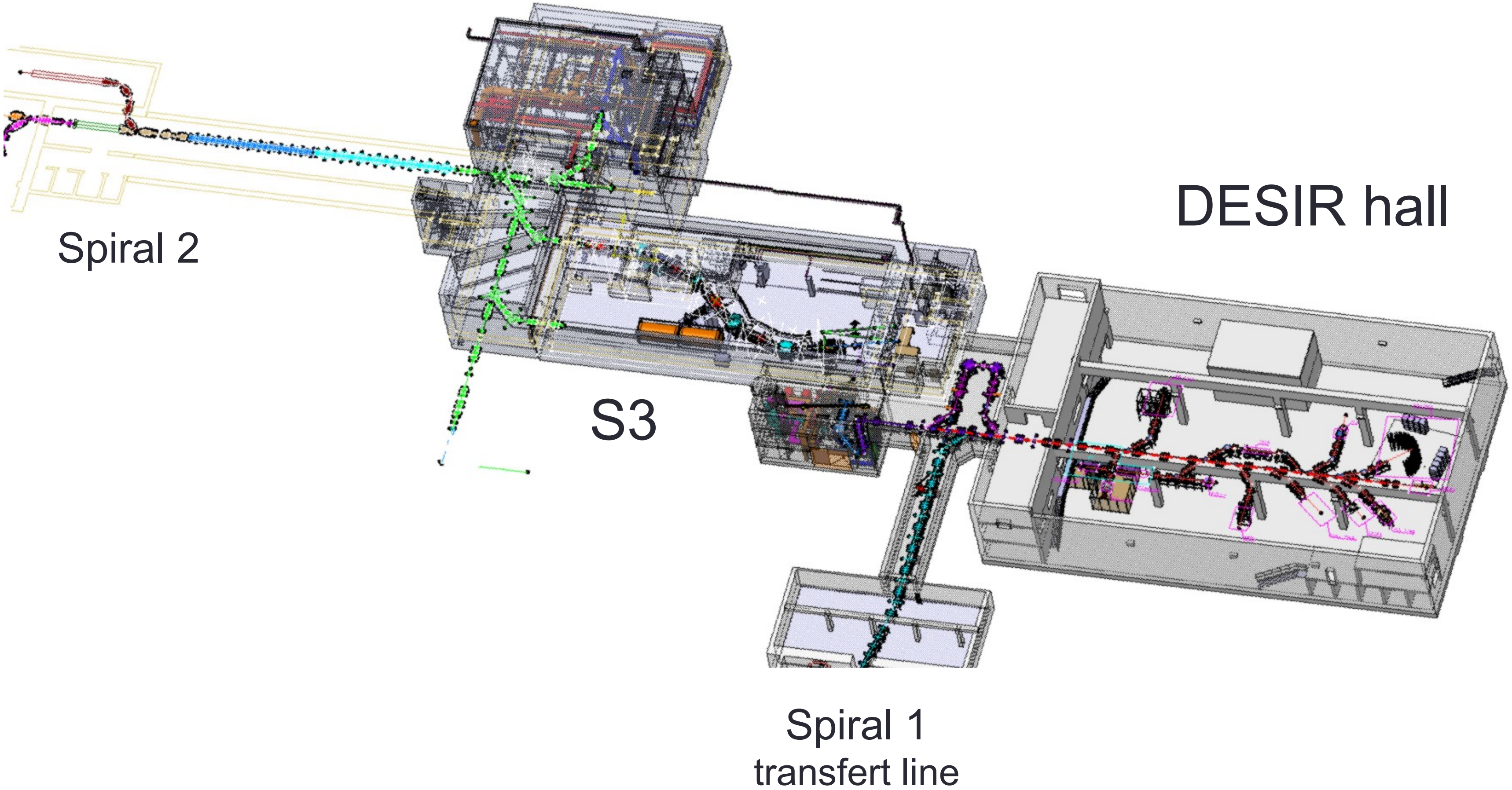
GPIB + PIPERADE apparatus

A. Husson – ISOL France Meeting, 18th March 2021

DESIR



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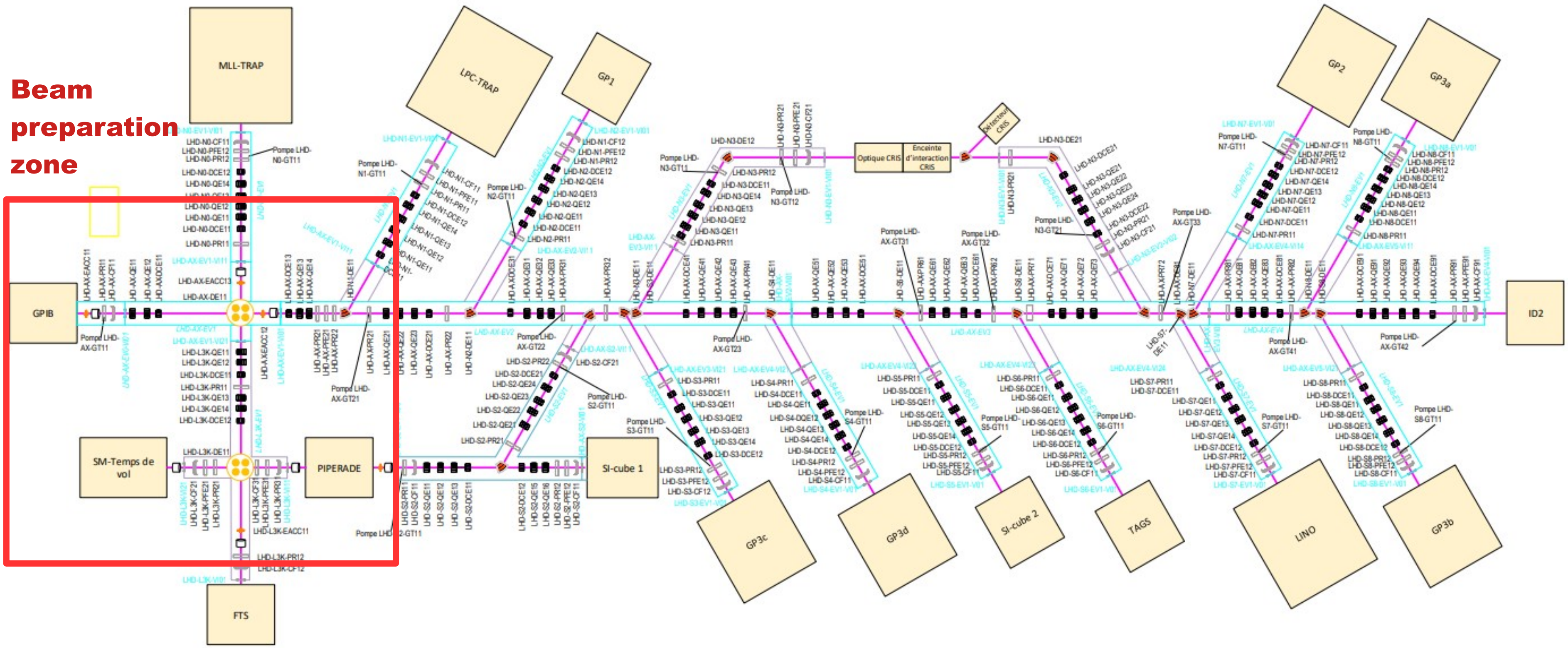
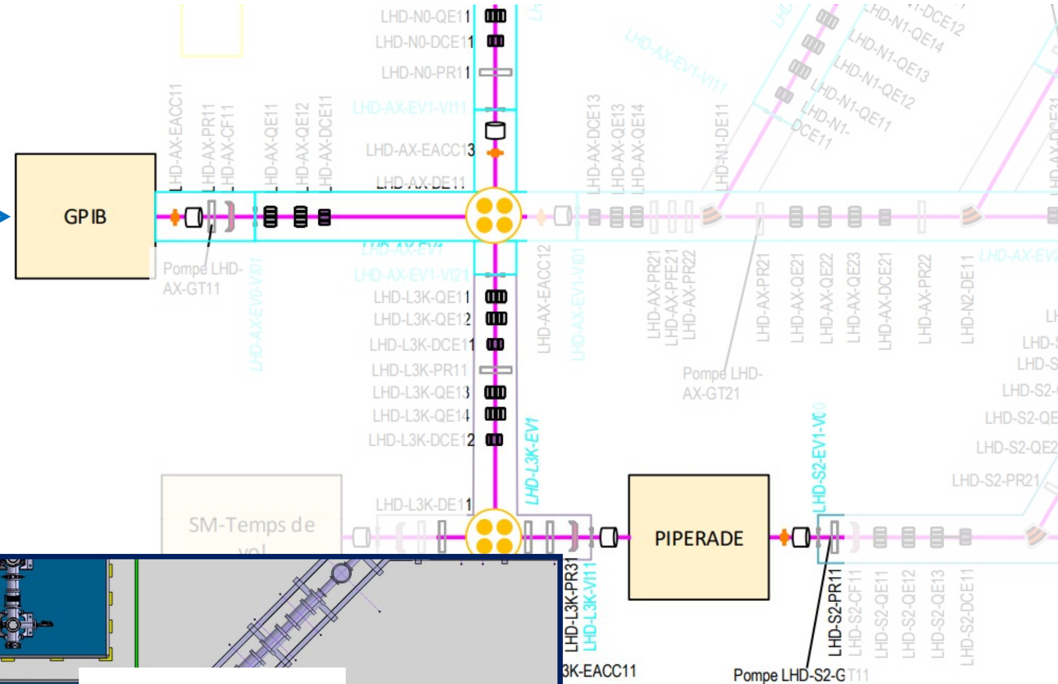
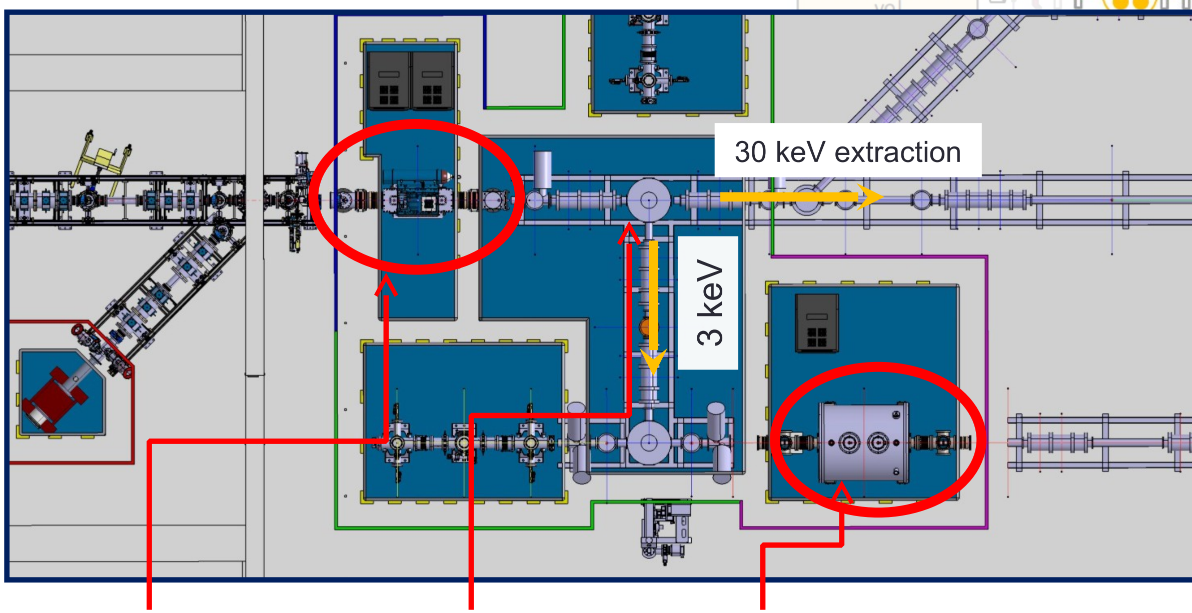


PIPERADE installed on a parallel beam line
downstream reconnection to main beam line for high purification

DESIR @ CENBG





GPIB cooler-buncher

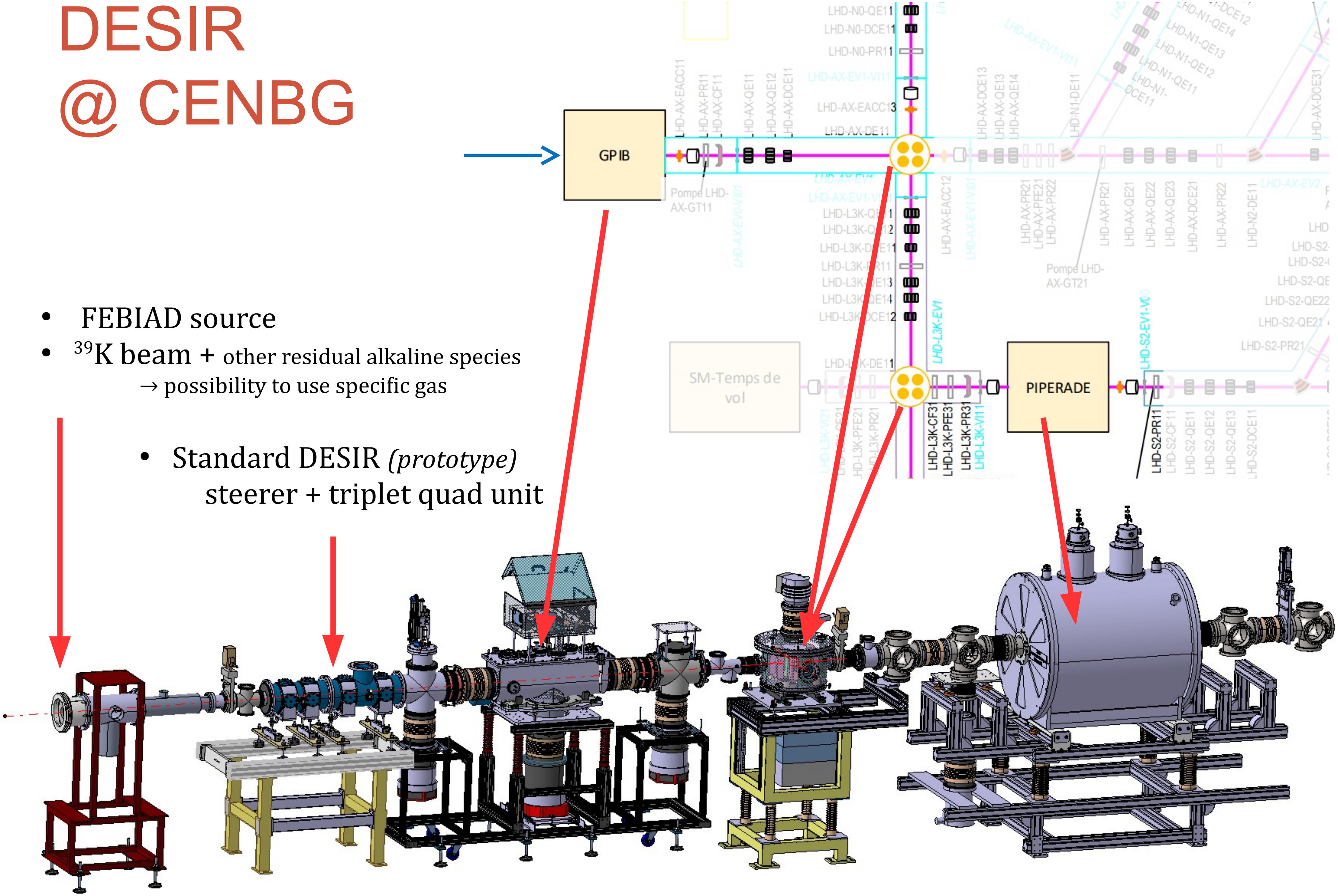
Deflector 90°

PIPERADE

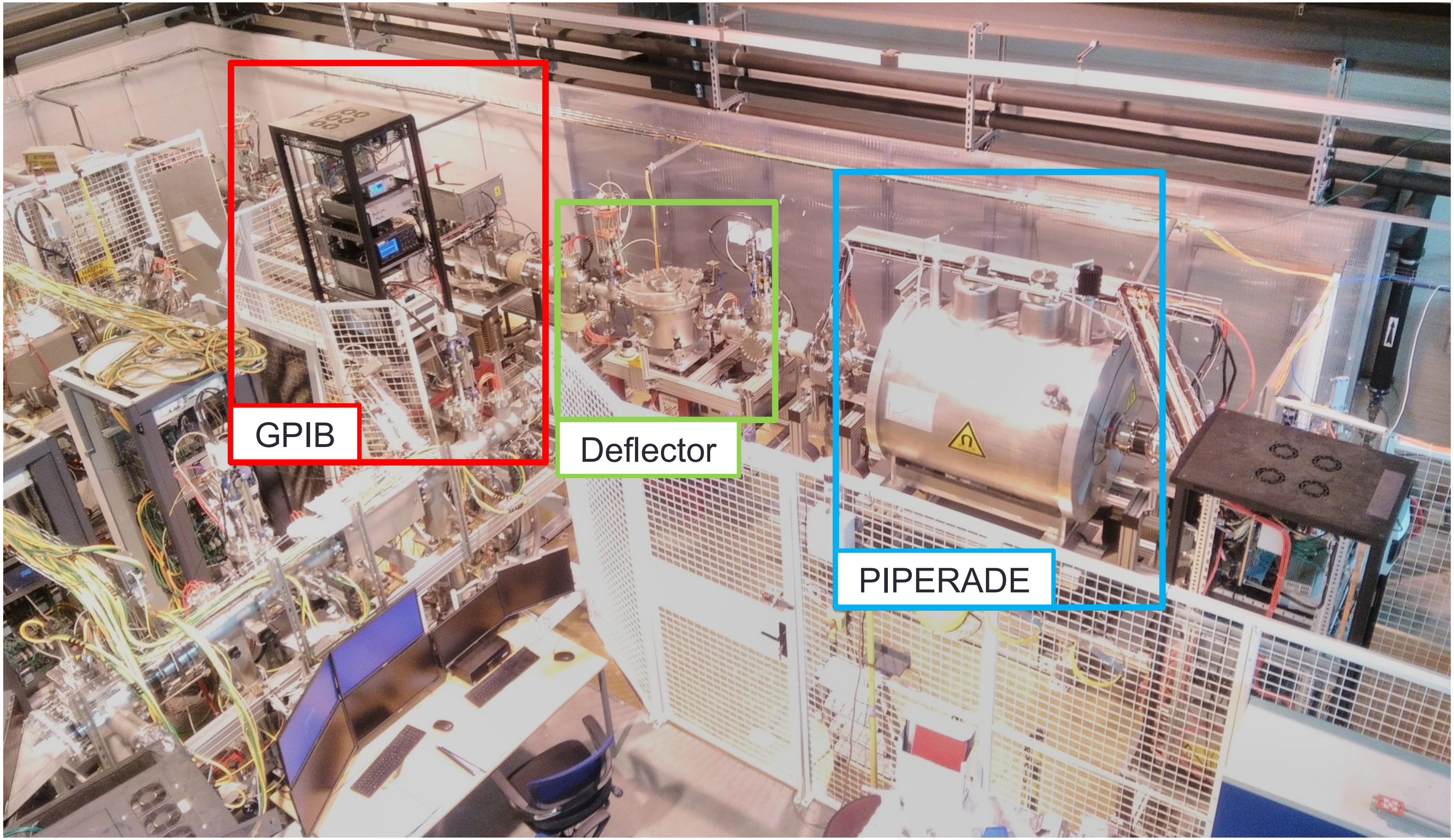
- 30keV beam from HRS
- Off-line source for DESIR
- Systems on HV platforms, designed for 60kV
- Deflection 90° for E <5keV

DESIR @ CENBG

- FEBIAD source
- ^{39}K beam + other residual alkaline species
  → possibility to use specific gas
  - Standard DESIR *(prototype)* steerer + triplet quad unit

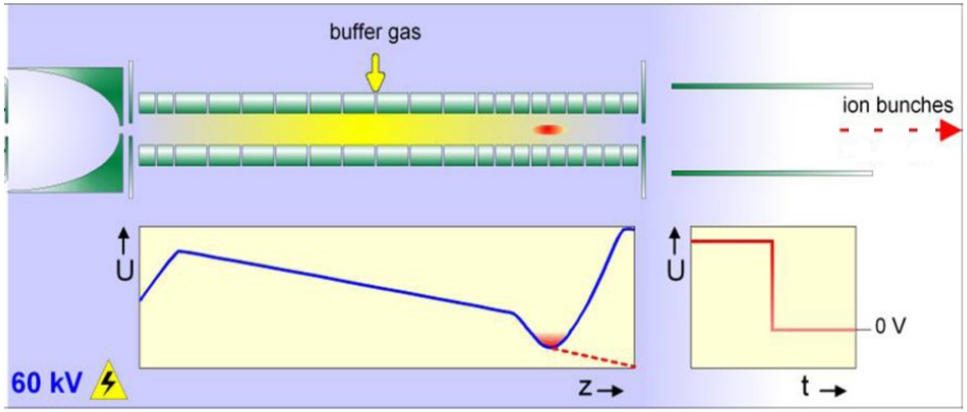


CENBG - PIPERADE

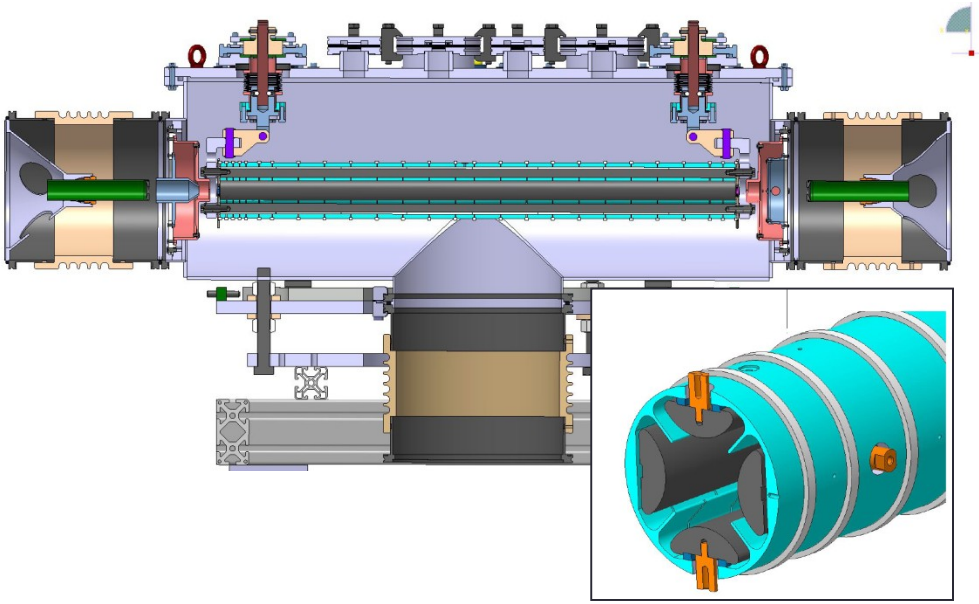


GPIB - status

- ISCOOL Mechanical design
  - Larger r_0=20mm for high-intensity beam
  - New development : high U_{RF} , up to 4kVpp
  - Frequency: 220kHz – 2MHz
  - Mathieu parameter q=0.6



- Beam cooling
  - 3π mm.mrad @ 60keV
  - 4.5π mm.mrad @ 30keV
  - 10π mm.mrad @ 3keV



Two operation modes:

- CW mode:
  - Test and characterization with A=39/40
  - Intensity up to 10^8pps (~20pA)
  - Transmission:

    80% @ 30 keV
    92% @ 3keV

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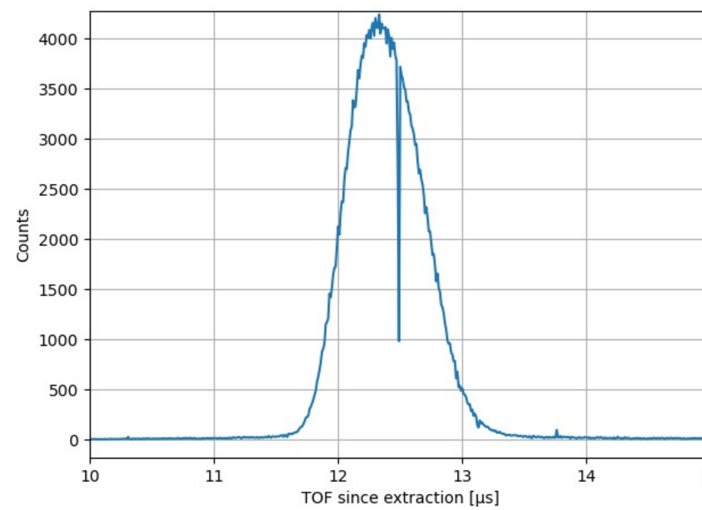
- Bunching mode:
  - Beam gate implemented upstream of the GPIB
  - <u>Rep. Rate</u> : 1 – 100 Hz
  - Meas. bunch size :

    - Extraction 30keV : 0.7µs FWHM

    - Extraction 3keV : ~ 1-2 µs

  → Extraction potential to be optimized for bunch compression



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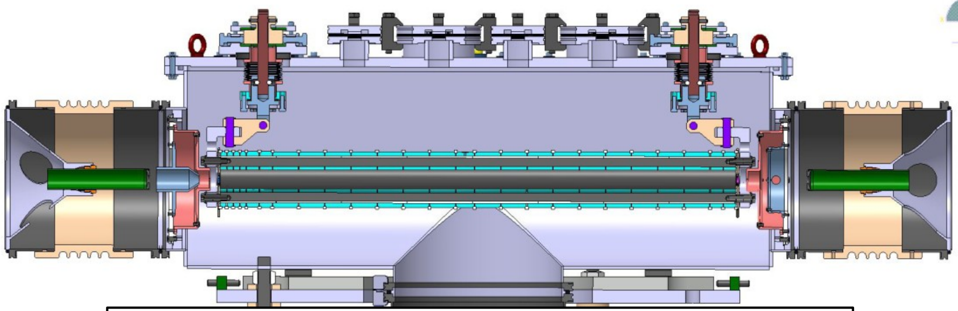

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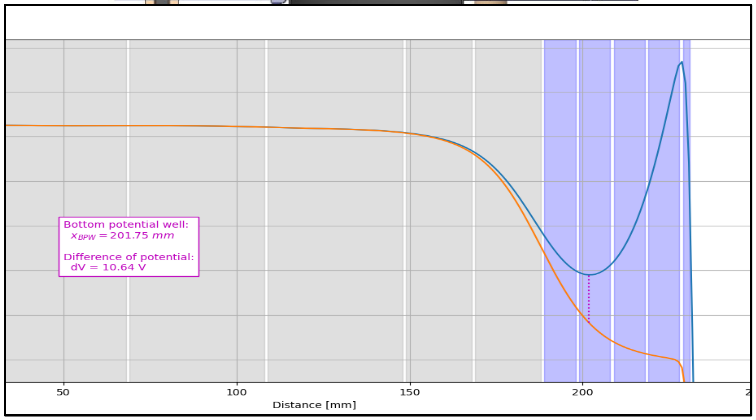

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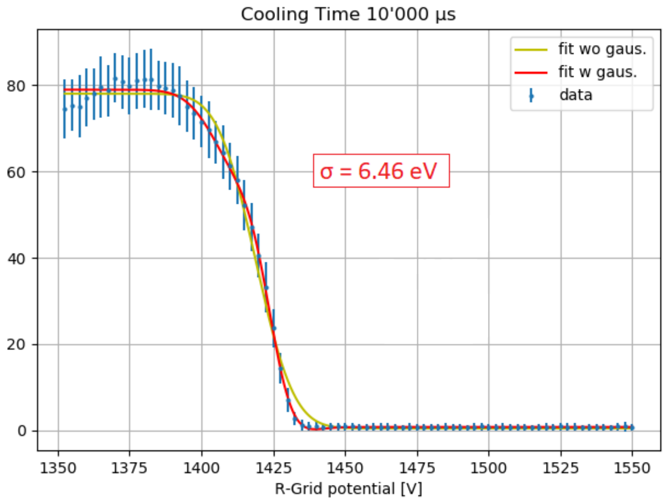

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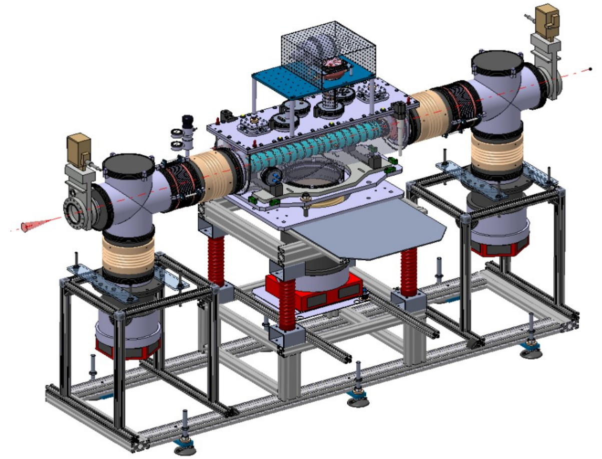
    → Extraction potential to be optimized for bunch compression
  - Meas. Energy spread : <10eV in 10ms

    → Cooling sequence to be optimized

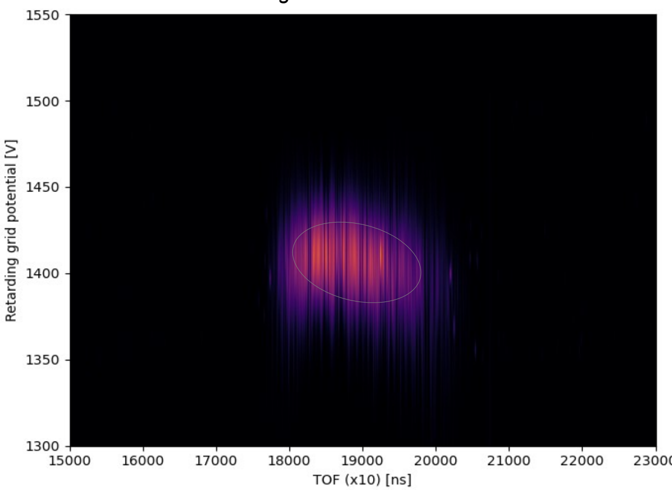
GPIB - status

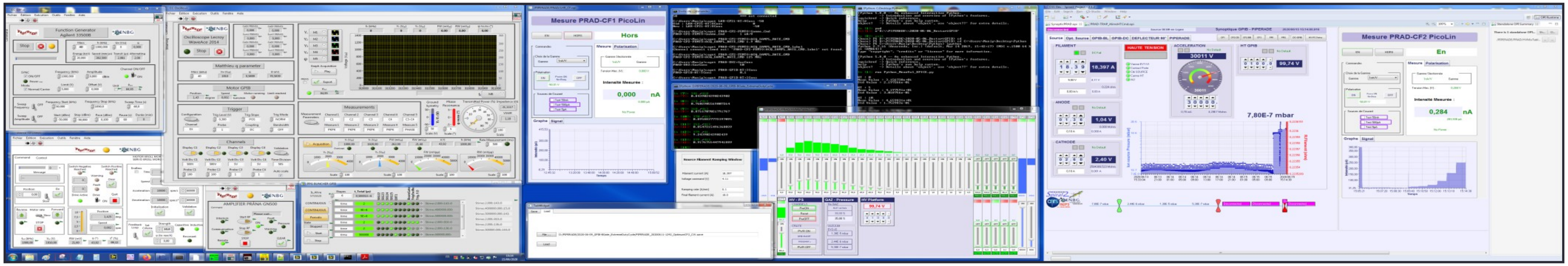
<u>Remaining tasks</u>:

- Effectiveness of the cooling:
  - Transverse emittance measurement @ 3keV/30keV
  - Longitudinal emittance improvement
- Bunching mode:
  - Optimization of the GPIB extraction potential
  - Implement the slow and time focusing extractions
  - Ion stacking - increase the number of ions per bunch
- RF system:
  - SPIRAL2-type control & EPICS compatible
  - Upgrade of the RF system towards U_{RF} = 4kVpp
- Validation of the DESIR requirements before installation at GANIL



Longitudinal emittance test measurement





PIPERADE trap

- PIPERADE double Penning trap,
  - 7T superconducting magnet
  - mass measurements /accumulation/beam purification (statistics increase for measurements)

- First trap - Purification trap
  - large inner radius (>10^4 ions/bunch)

- 2nd trap – Accumulation trap
  - used for measurements

- TOF-ICR and PI-ICR detection

  + study of purification methods
  + study of the charge space effects

Flexible purification adapted to DESIR requirements

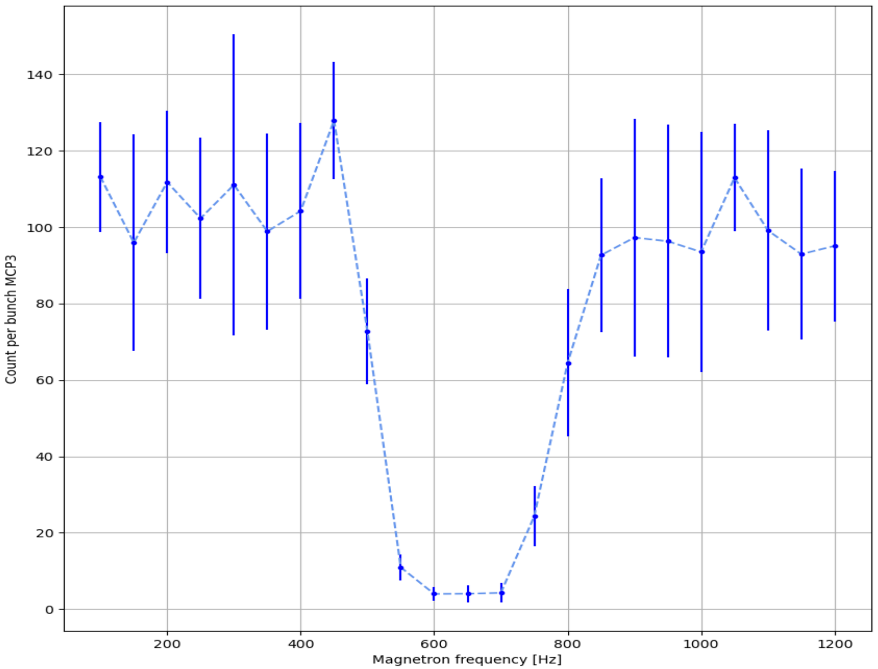
PIPERADE trap

- 7T superconducting magnet installed
- Shimming to optimize the field homogeneity on both trap regions, < 1 ppm for ~1cm3 volumes
  → warm coil to compensate the magnetic field drift ΔB/B from 4.10^{-8}/h to $<1.10^{-9}$/h
- Installation of the full beam line and detection chamber downstream of the trap,
  → MCP+FC detectors
- EPICS control system, beta version - now operational

  - September 2020 - First trapped bunch in PIPERADE

- RF systems + switching electronics, operational
  → Bunches sent via GPIB,
  daily trap operations
  → First magnetron excitation

First magnetron excitation measurement



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- Installation of the full beam line and detection chamber downstream of the trap,
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- RF systems + switching electronics, operational
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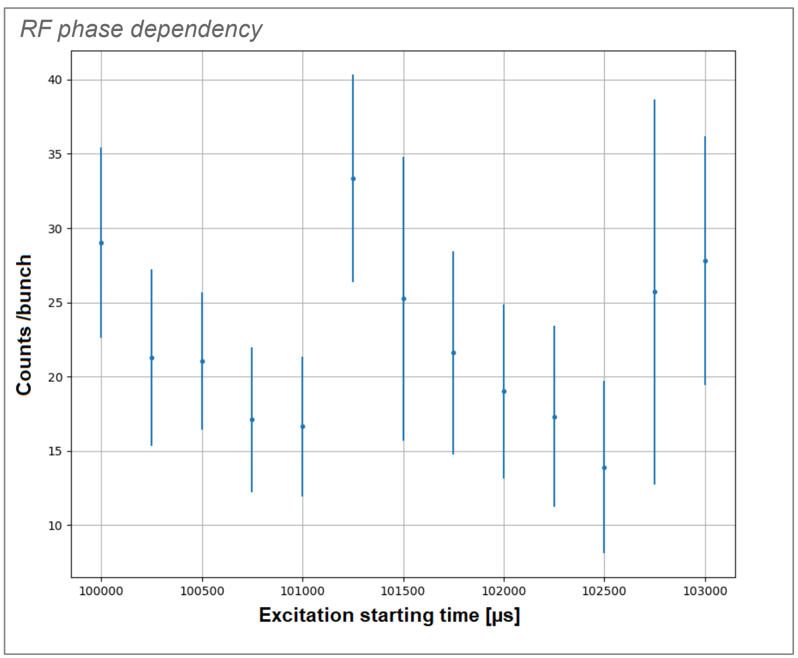
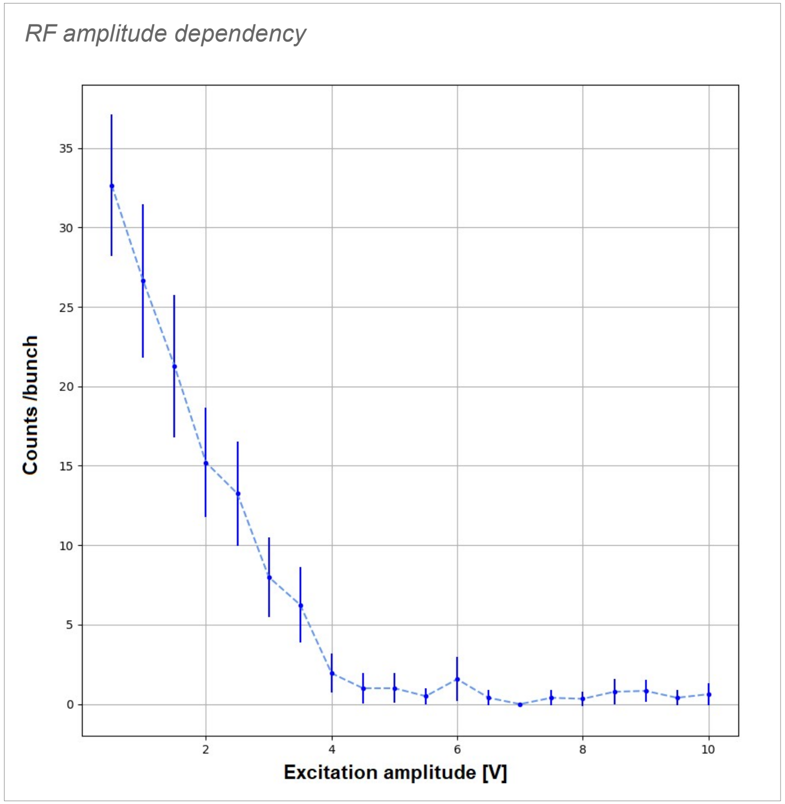
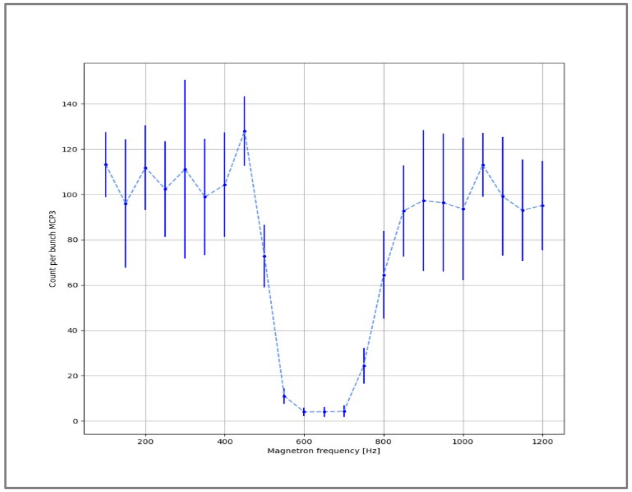
=> beginning of more systematical studies





PIPERADE trap

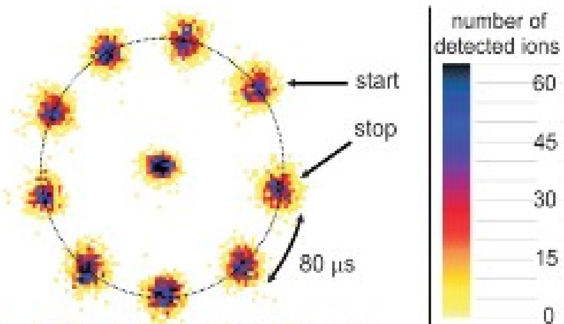


<u>Remaining tasks</u> :

- Improve in-trap cooling + ion recentering
- Implementation of the purification techniques:
  - Ramsey cleaning
  - PI-ICR cleaning ← installation of a dedicated position sensitive detector
- Transfert to 2nd trap.
- High-precision mass spectrometry:
  standard TOF-ICR/Ramsey and PI-ICR
- TRAP specific application software (Python-EPICS) to be developped,
  same scheme as the JYFLTRAP CC-software (Jyväskylä)

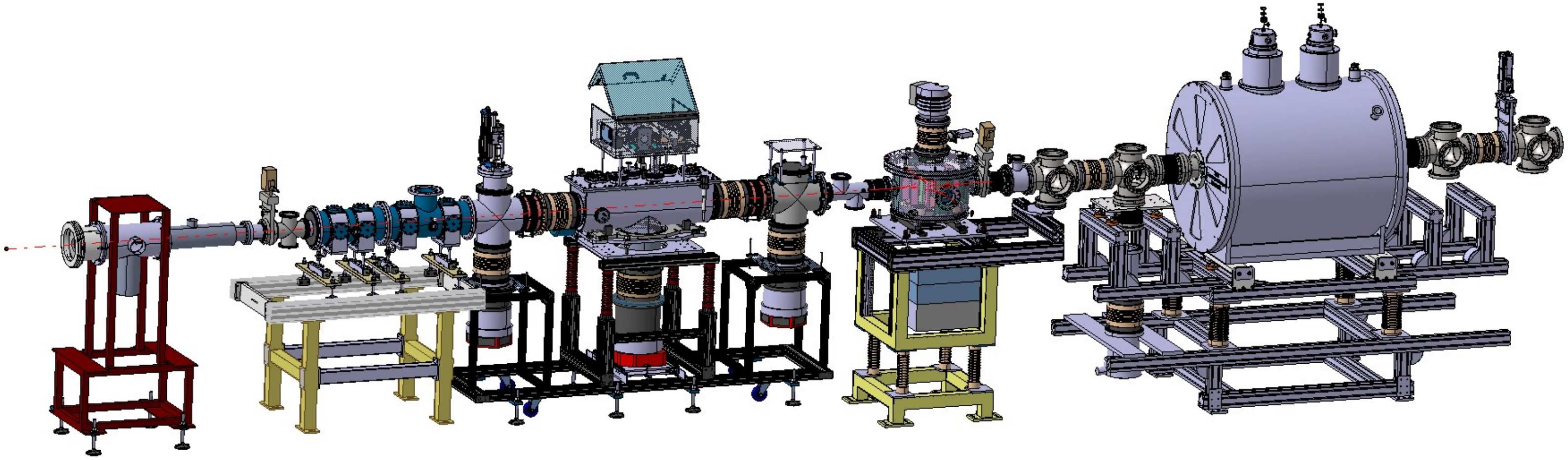
<u>Timeline</u> :

- Commissioning at CENBG + systematical studies : **now – 2023**
- Move to DESIR :
- Installation/Commissioning at DESIR : **2024 - 2025**
- First online experiment at DESIR : **2026**



S. Eliseev et al., PRL 110, 082501 (2013)

Thank you



CENBG team

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Mechanics (BE)
S. Perard

PostDocs
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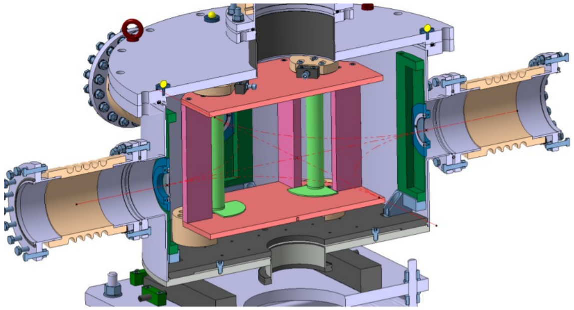
PhD
Marjut Hukkanen



Deflector 90° extracted from PIPERADE beamline

Purchase of a Kimball alkaline ion gun

<u>Tests</u> :

- Transverse emittance conservation
- Energy conservation
  → no spread induced by deflection
- Time spread negligible

- Operations at 3keV and max 5keV

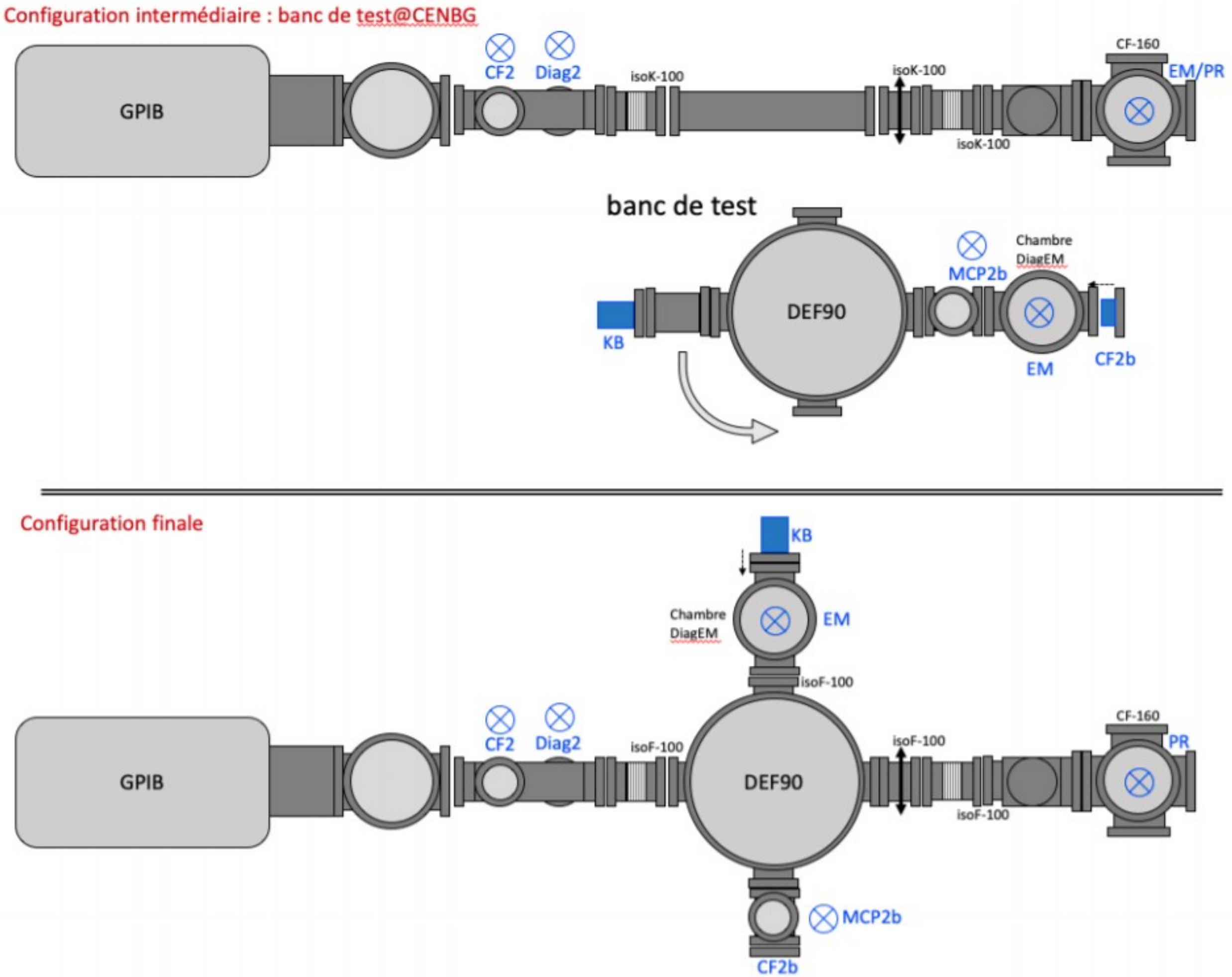
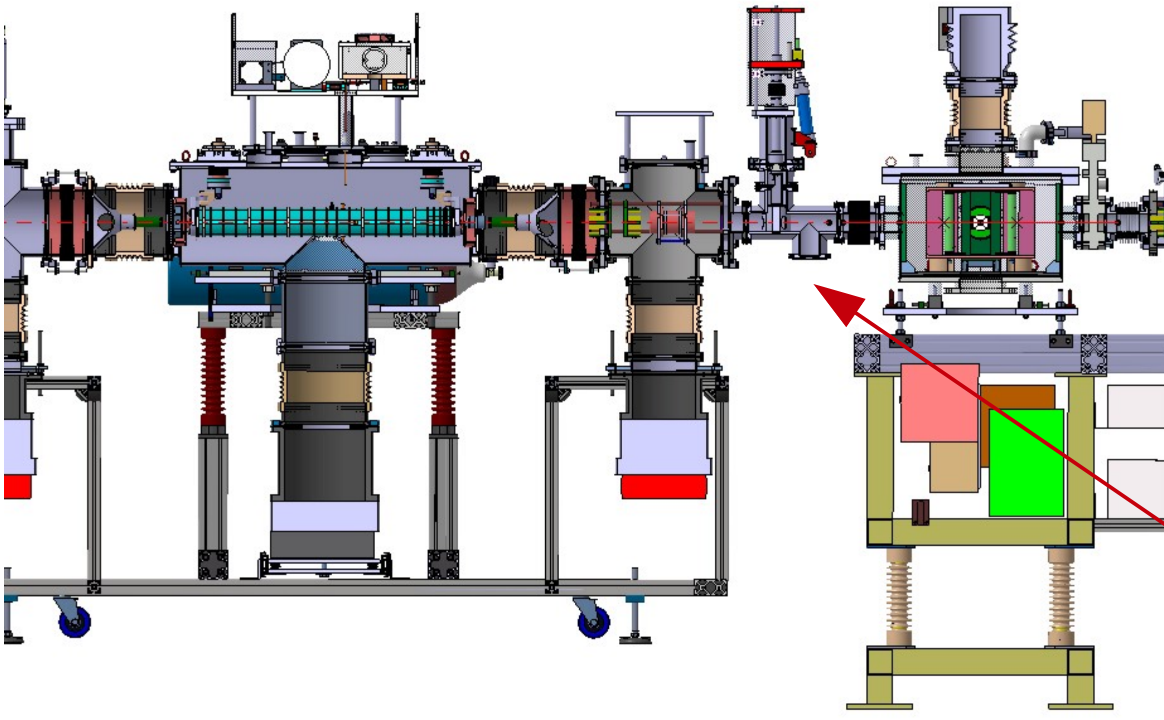
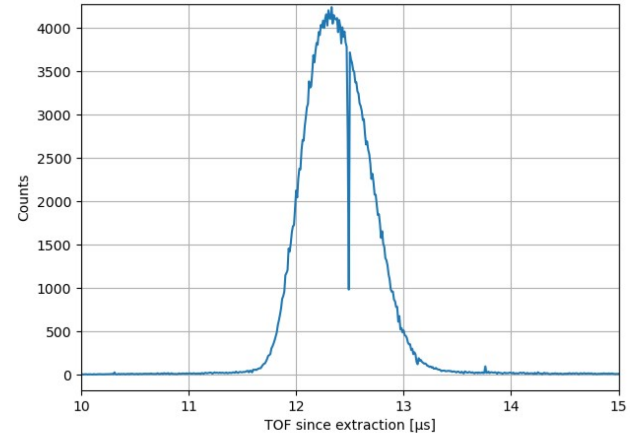
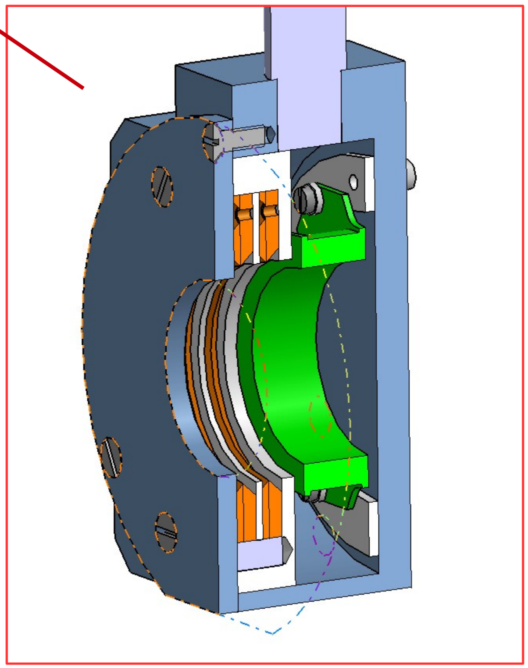


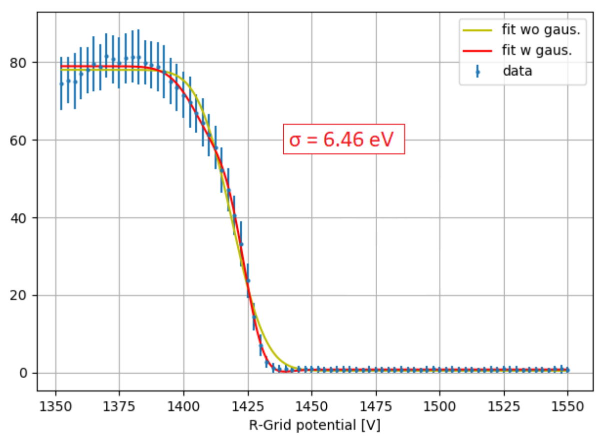
Figure 1: schéma d'évolution proposé pour la ligne PIPERADE au CENBG.



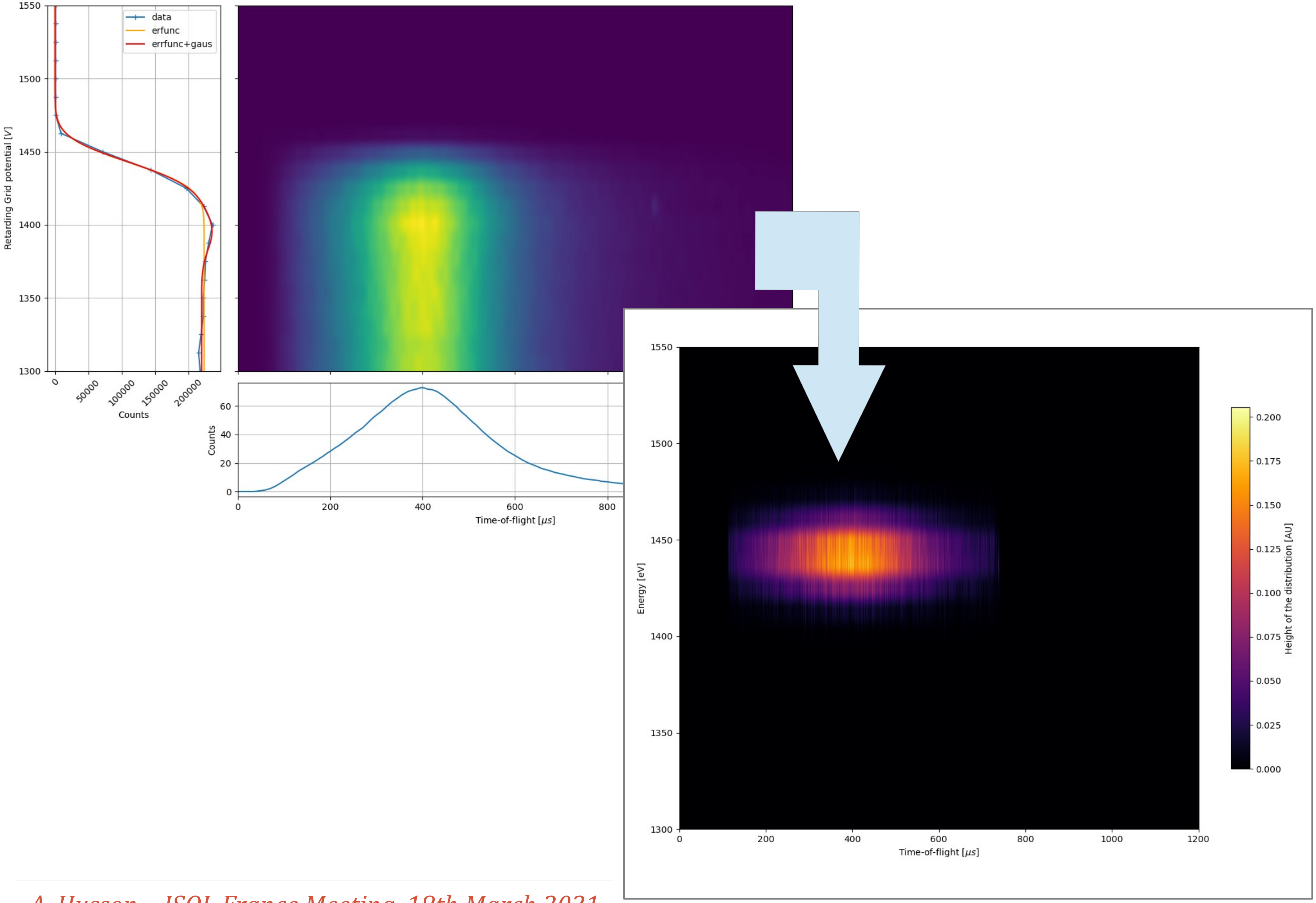

4000
3500
3000
2500
2000
1500
1000
500
0
Counts
10
11
12
13
14
15
TOF since extraction [µs]

time




fit wo gaus.
fit w gaus.
data
σ = 6.46 eV
80
60
40
20
0
1350
1375
1400
1425
1450
1475
1500
1525
1550
R-Grid potential [V]

energy



data
erfunc
errfunc+gaus
Retarding Grid potential [V]
Counts
Time-of-flight [μs]
Energy [eV]
Height of the distribution [AU]