First results from electron emission channeling on-line experiments

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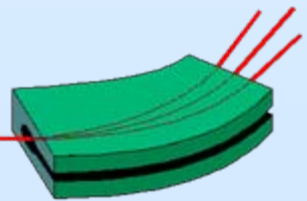


Partial motivation and outline of the EC-SLI proposal in 2006

EC-SLI = Emission Channeling with Short-Lived Isotopes

Extend electron emission channeling experiments to...

- **short-lived isotopes ($t_{1/2}$ < 6 h)**

New equipment to be used:

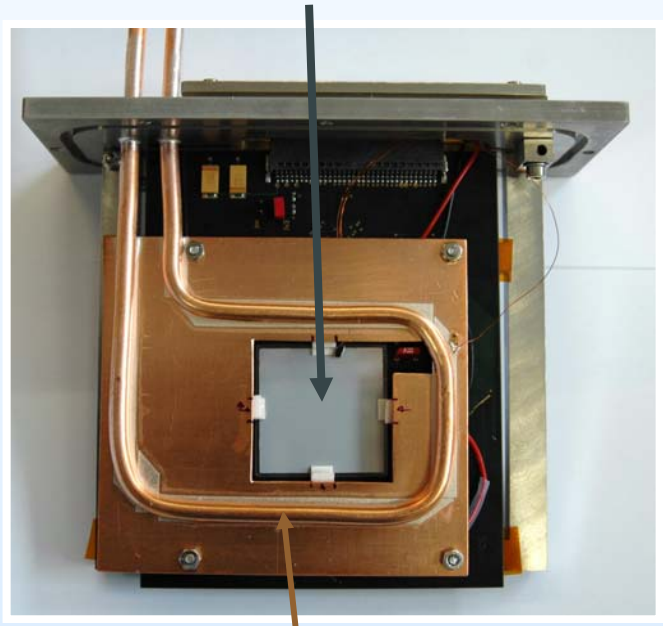
- **Position-sensitive self-triggered Si pad detectors (capable of count rates > 1 kHz)**
- **new Lisbon on-line emission channeling setup**

Physics cases:

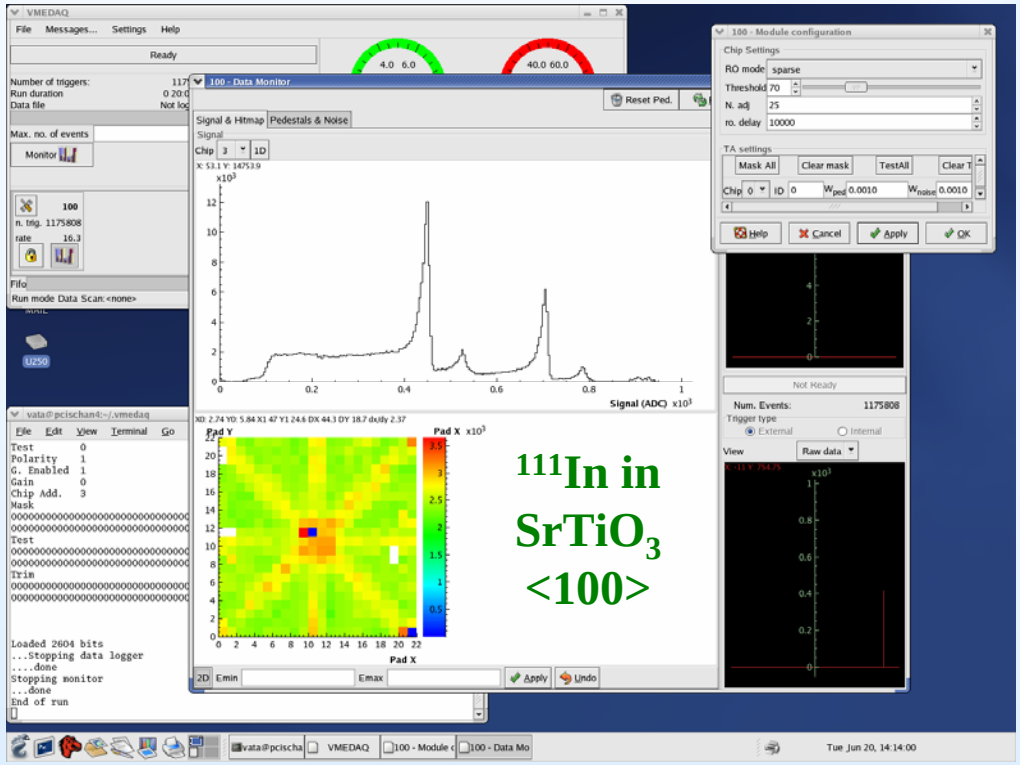
- **lattice location of transition metals in semiconductors**
- **lattice location of Mg in GaN**

New self-triggering position sensitive Si pad detector

22×22 pixels (1.3×1.3 mm^2)
Si pad detector



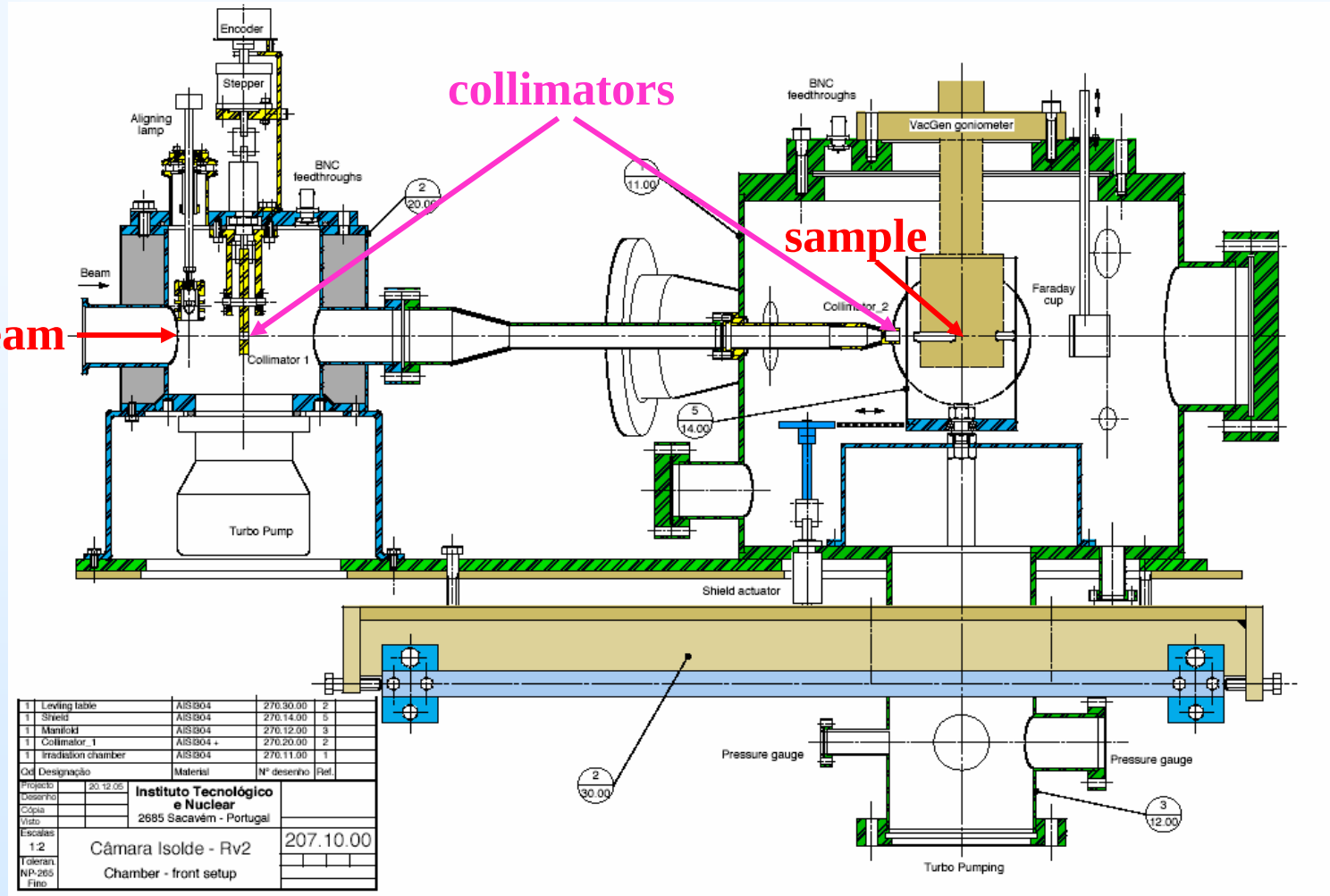
water & Peltier cooling (–30°C)

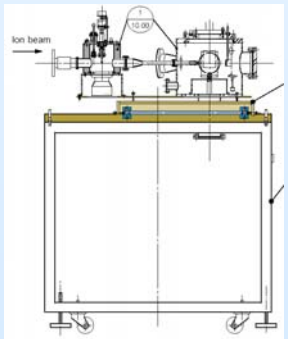


new readout via VME and optolink,
LINUX based software for on-line display

- selftriggering pre-amplifier chips
- maximum count rate: kHz range
- energy resolution: photons ~1.2 keV
  electrons ~3 keV

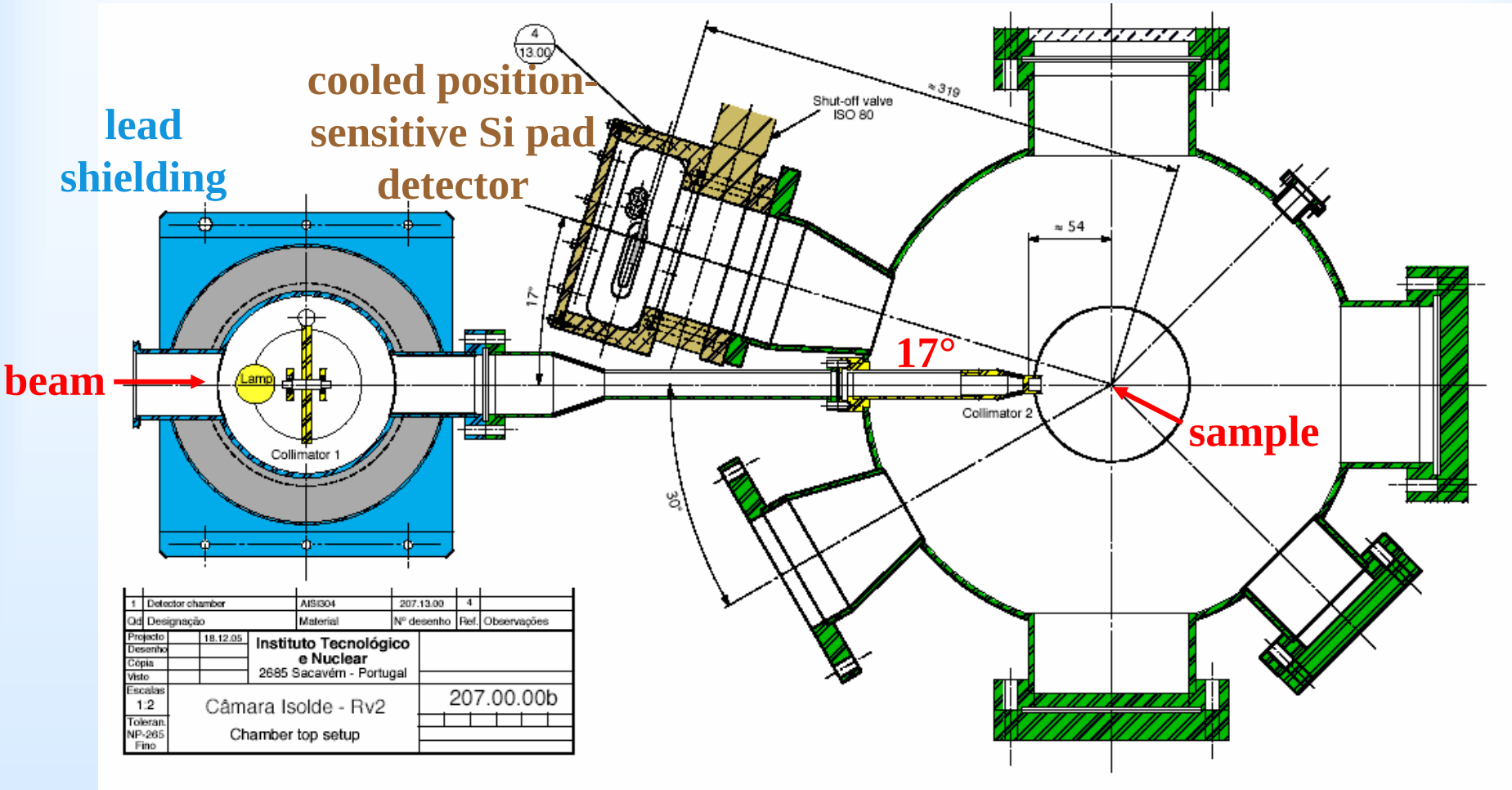
New Lisbon on-line emission channeling setup: side view





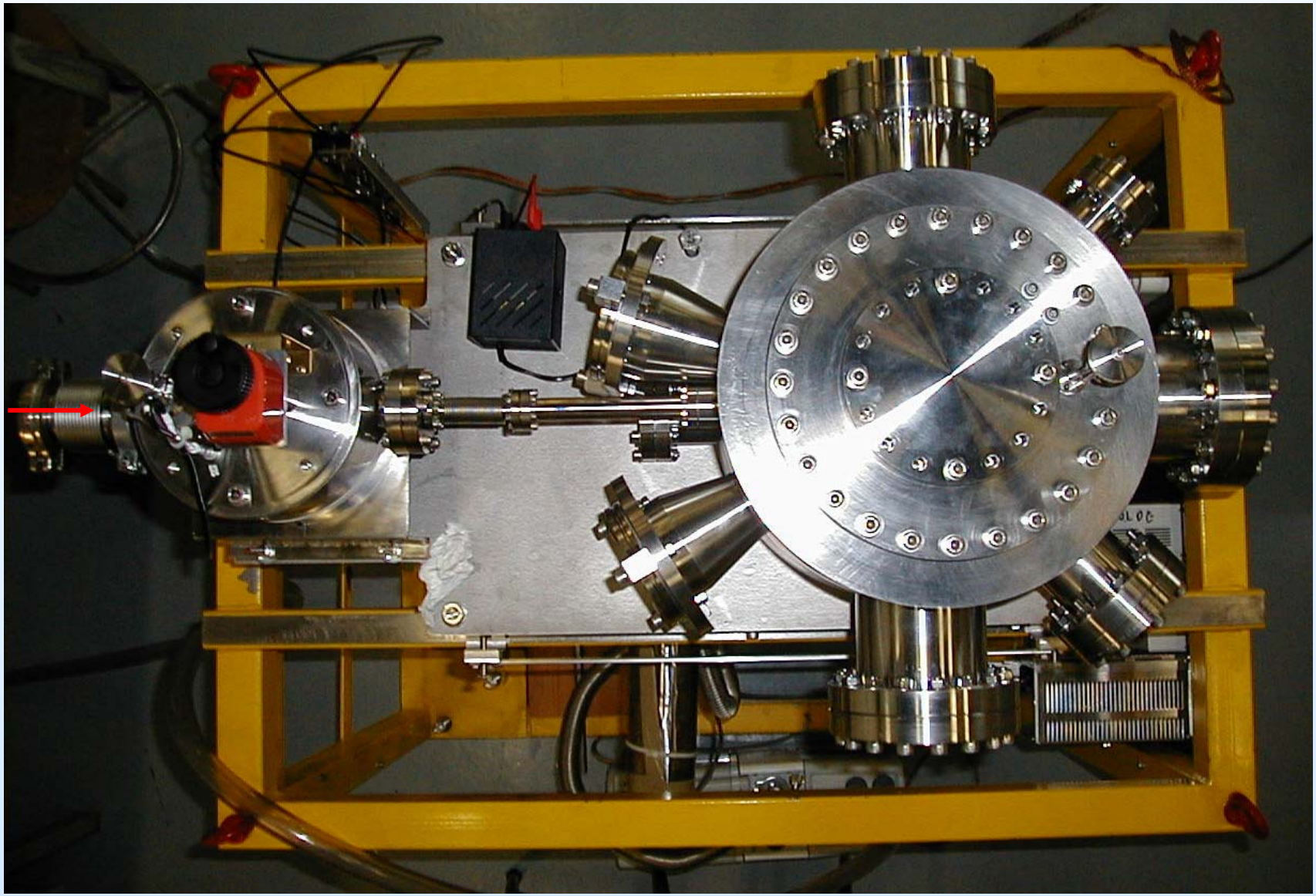
- ISOLDE beam is collimated by 2 apertures (1st variable size, 2nd ∅ 1 mm) on the sample
- sample mounted in remote-controlled 3-axis goniometer from U Göttingen
- fast load-lock floor positioning system for easy coupling to ISOLDE beam line

New Lisbon on-line emission channeling setup: top view

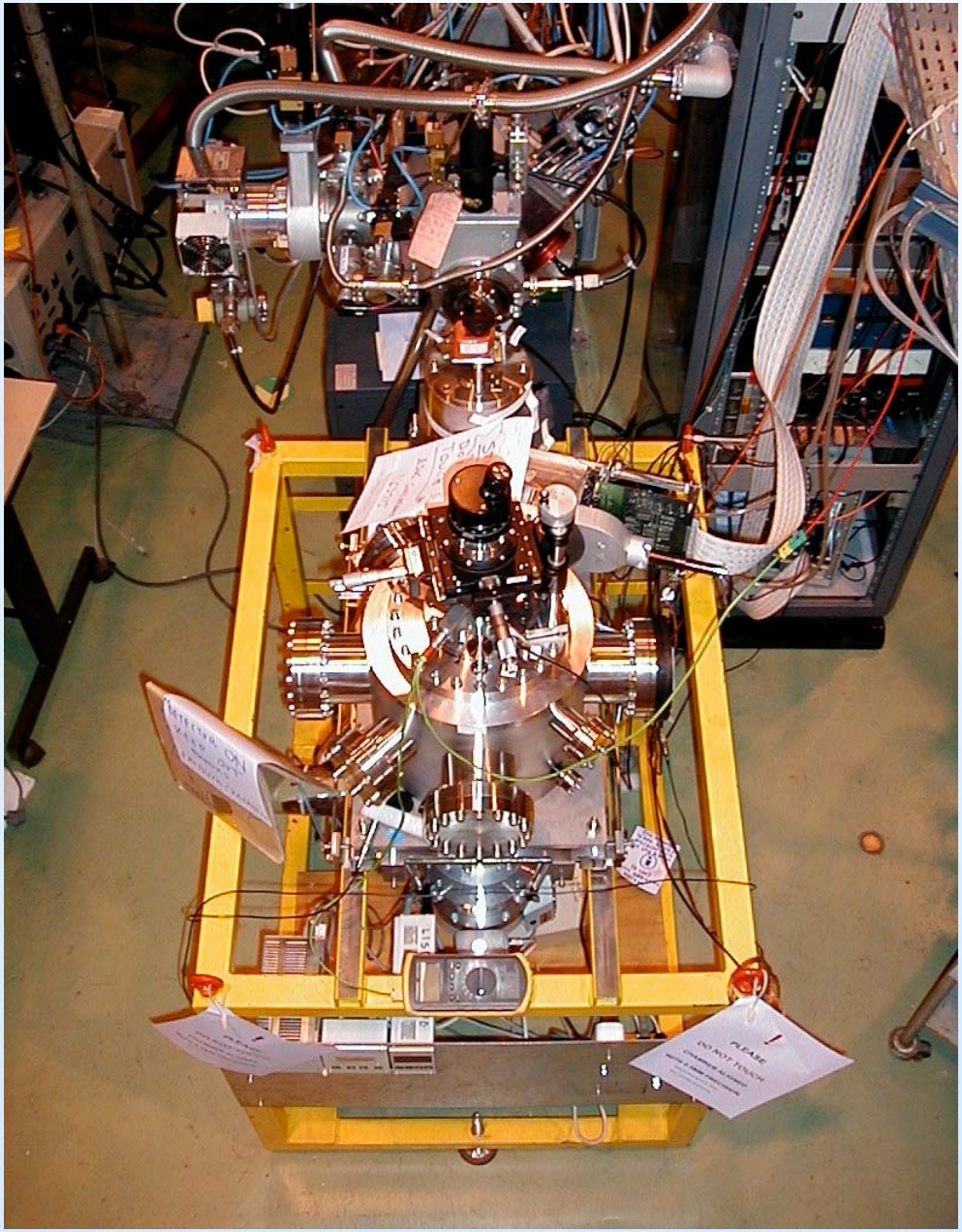


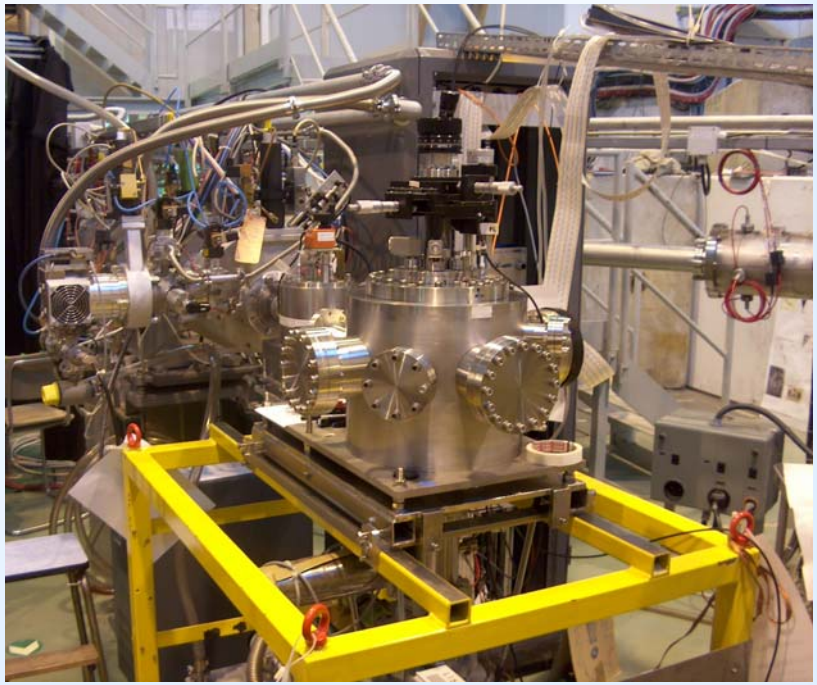
- detector at 17° backward geometry for simultaneous implantation and measurement
- valve in front of detector allows to maintain detector vacuum during sample exchange
- lead shielding around 1st collimator lowers background

New Lisbon on-line emission channeling setup: top view



New on-line setup coupled to LA2 beam line in June 2007

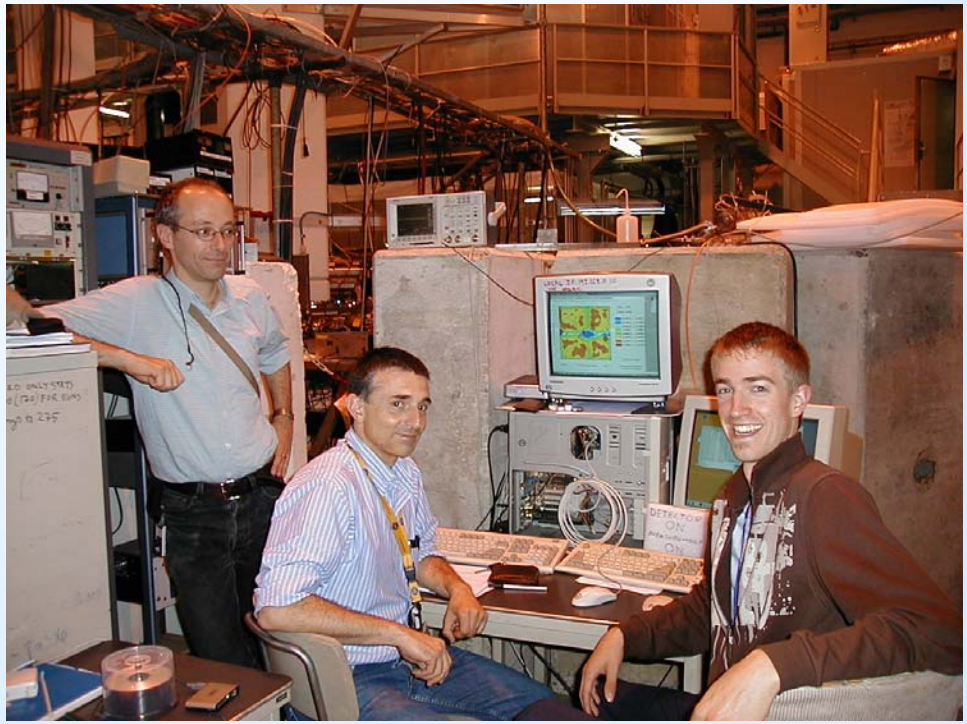




old goniometer
new vacuum chamber
new detector
new readout electronics
new readout software
new analysis software

would it work?

Happy faces during the Mn beam time June 2007



data taking of emission channeling patterns with 3 kHz is obviously lots of fun, especially for our students…

Physics case 1 of EC-SLI proposal:
Lattice location of transition metals in semiconductors

Main motivation to study transition metals (TMs):

- **TM-doped ZnO and GaN are dilute magnetic semiconductors showing room-temperature ferromagnetism ($\rightarrow$ spintronics)**

$\Rightarrow$ Knowledge on the lattice location of TMs is crucial for understanding the magnetism in these materials

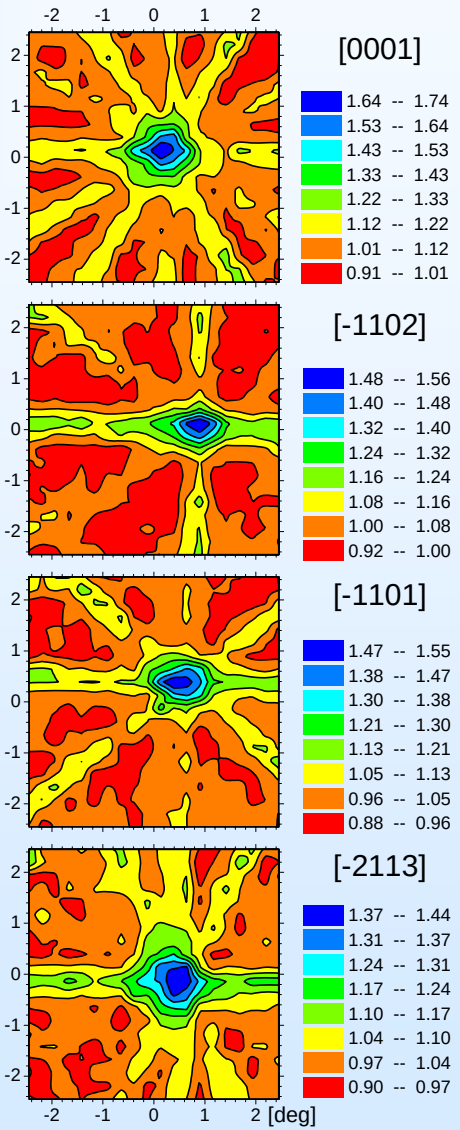
We have previously obtained results (IS368) on the β^- emitters

- **^{59}Fe (45 d), ^{67}Cu (2.6 d), ^{111}Ag (7.5 d) , ^{121}Sn (27 h) in Si, Ge, diamond, GaN, ZnO, $SrTiO_3$**

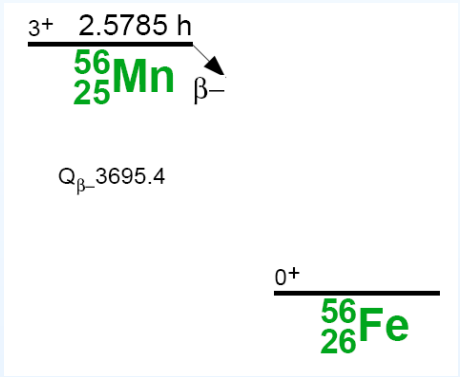
On-line experiments make additional probe atoms accessible:

- **^{65}Ni (2.5 h) β^-**
- **^{56}Mn (2.6 h) β^-**
- **^{61}Mn (4.6 s) $\rightarrow$ ^{61}Fe (6 min) $\rightarrow$ ^{61}Co (1.6 h) β^-**

β⁻ emission channeling patterns from ^{56}Mn in GaN

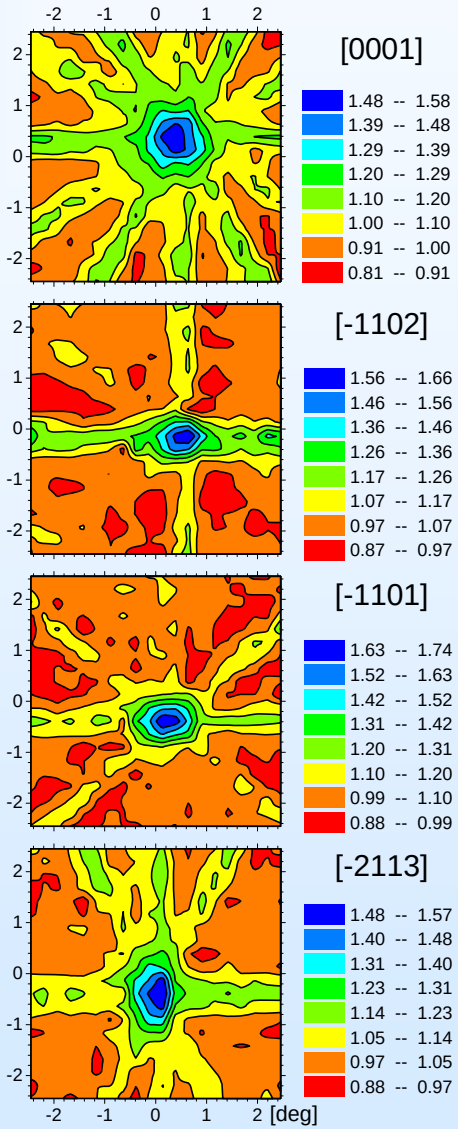


T_A=900°C

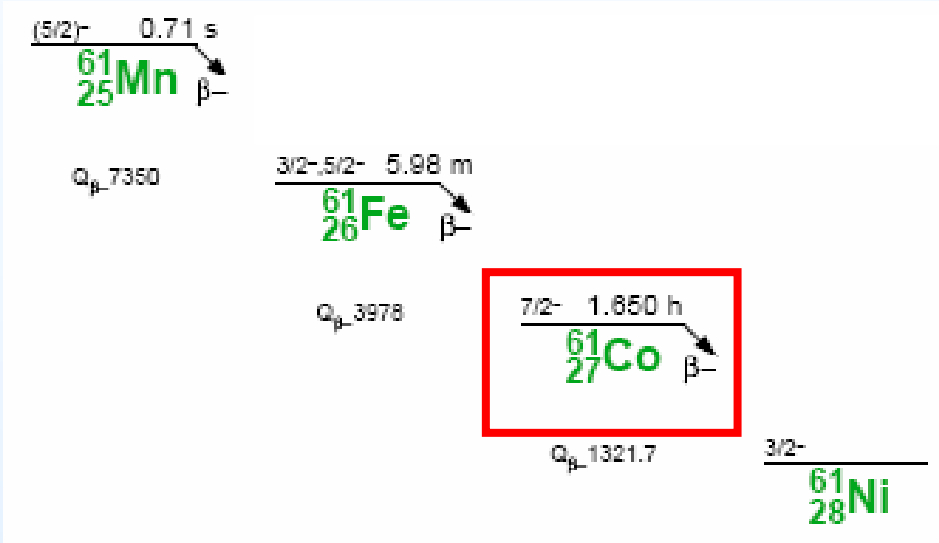


- ^{56}Mn implanted directly
- emission channeling patterns measured from ^{56}Mn β⁻ particles
- qualitative result: ^{56}Mn on substitutional Ga sites

β^- emission channeling patterns from ^{61}Co in ZnO



T_A=800°C



- ^{61}Mn implanted
- wait 25 min
- emission channeling patterns measured from ^{61}Co β^- particles
- qualitative result: ^{61}Co on substitutional Zn sites

Problems encountered

- **beam optics of ISOLDE beam does not allow to close 1st collimator more than ~1 cm**
- **gamma radiation from activity deposited on ∅ 1 mm nozzle (5 cm in front of sample) contributes to background**

⇒ good focusing of ISOLDE beam is essential ! (attempt to run with HV=30 kV after GPS HV breakdown was unsuccessful)

- **attempt to use ^{27}Na (301 ms) → ^{27}Mg (9.5 min) β^- decay chain from UC-W target failed due to massive contamination from stable ^{27}Al (>90%)**

⇒ will have to ask for ^{27}Mg beams from different target/ion source (RILIS?)

Conclusions

- **the first on-line run of EC-SLI was highly successful**
- **electron emission channeling now feasible for all short-lived isotopes where ISOLDE provides sufficient yields and clean beams**
- **good focusing of ISOLDE beam is essential**
- **need to discuss suitable target + ion source for ^{27}Mg beams**