High Resolution Electron Spectrometry at the NESR

Stored Particles Atomic Physics Research Collaboration

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Outline

- Scientific goal
- Instrumentation
- Costs / Manpower

Scientific goal

Measurements of conversion electrons

Test of QED contribution for 1s energy levels upto 0.1 % accuracy

- **by determination of binding energy of 1s electron with an accuracy of ≤ 10^{-5} in H-like ions**

Conversion electrons (1..4 e-) in high Z atoms: probing wave functions

Measurements of hyperfine splitting of 1s state

- **Can determine magnetic momenta of excited nuclear states within a 5 % error level**

Scientific goal

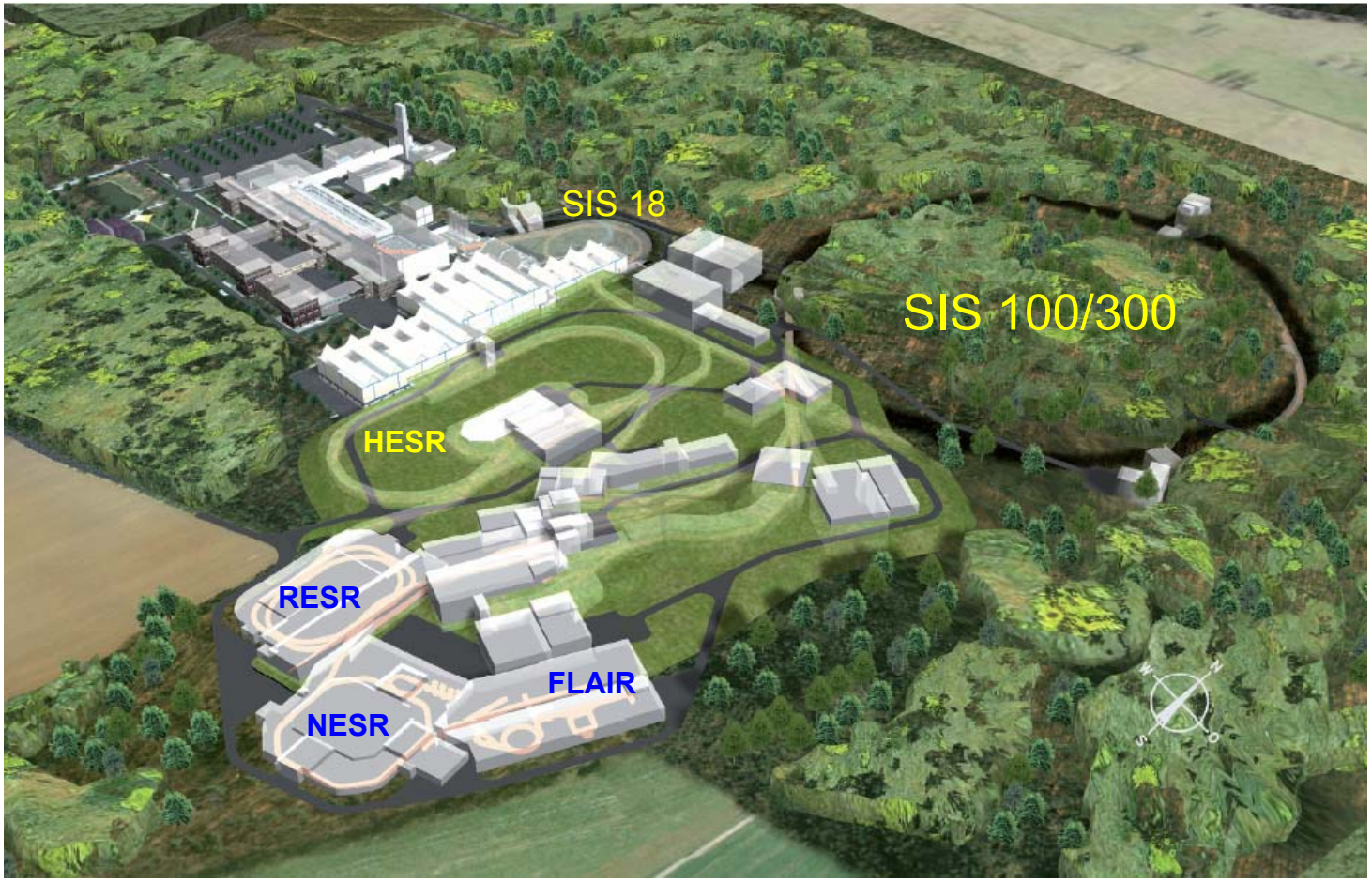
Auger electron emission from few electron heavy ions

- Allows to proof the quality of current calculations on Auger decay

C.Z. Dong *et al.* J. Phys. B 39 (2006) 3121

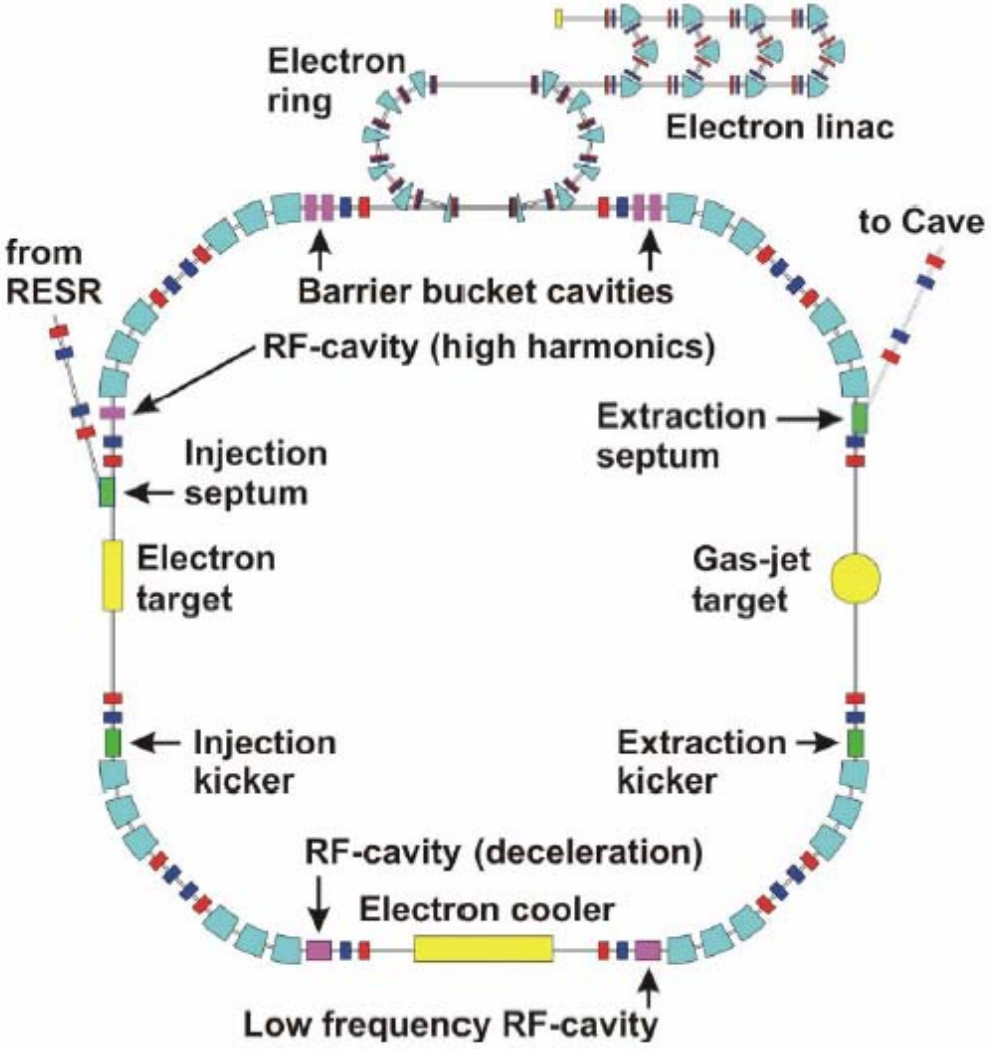
Rydberg states formed at cooler and detected at gas-jet section

Future FAIR accelerator facility



talk by C. Dimopoulou

New Experimental Storage Ring (NESR)



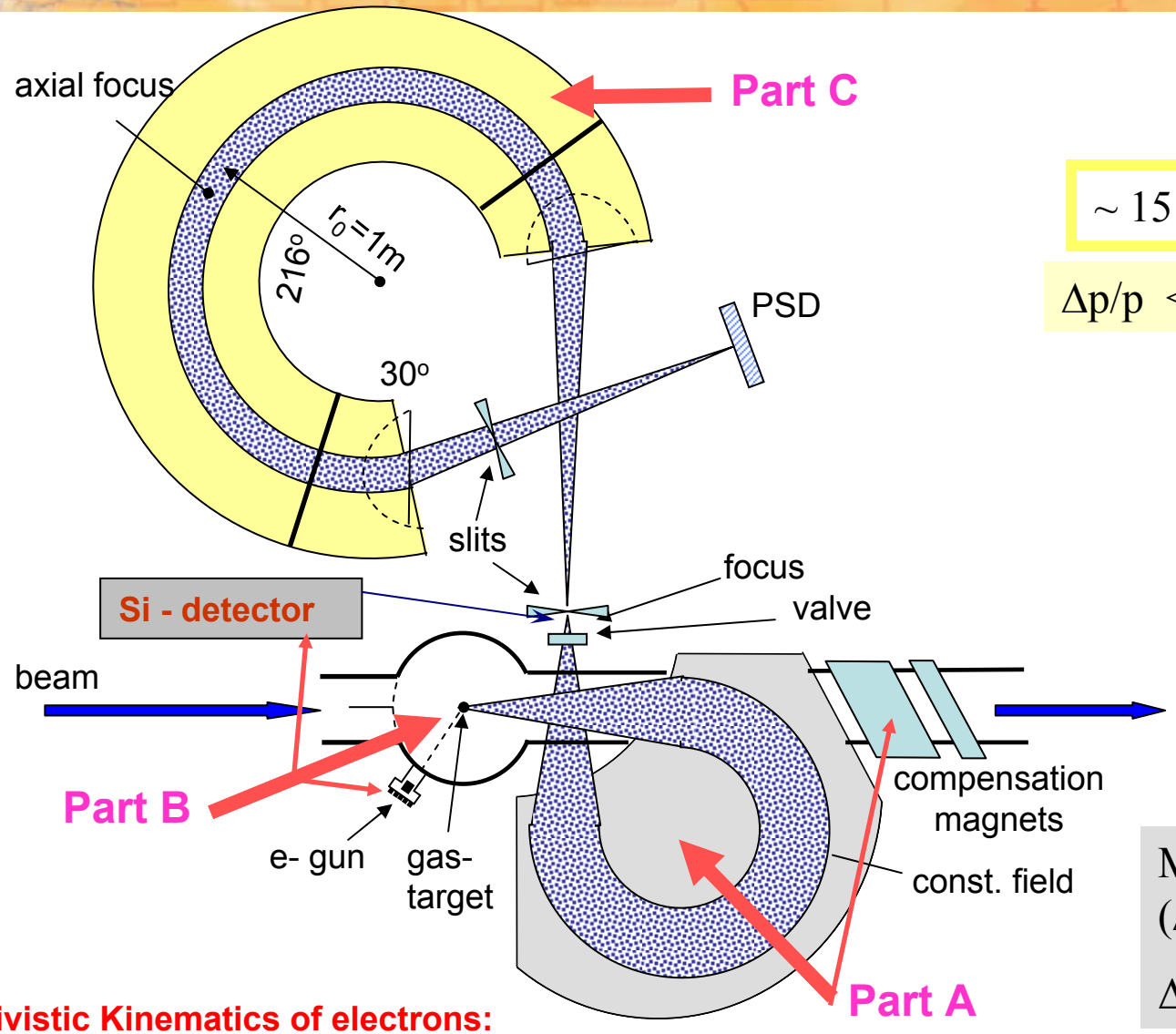
Circumfrance: 222 m

Beam energy : ~ 1 GeV/u U^{92+}

3 GeV antiproton

talk by C. Dimopoulou

Proposed Electron Spectrometer



~ 15 keV ... 10 MeV

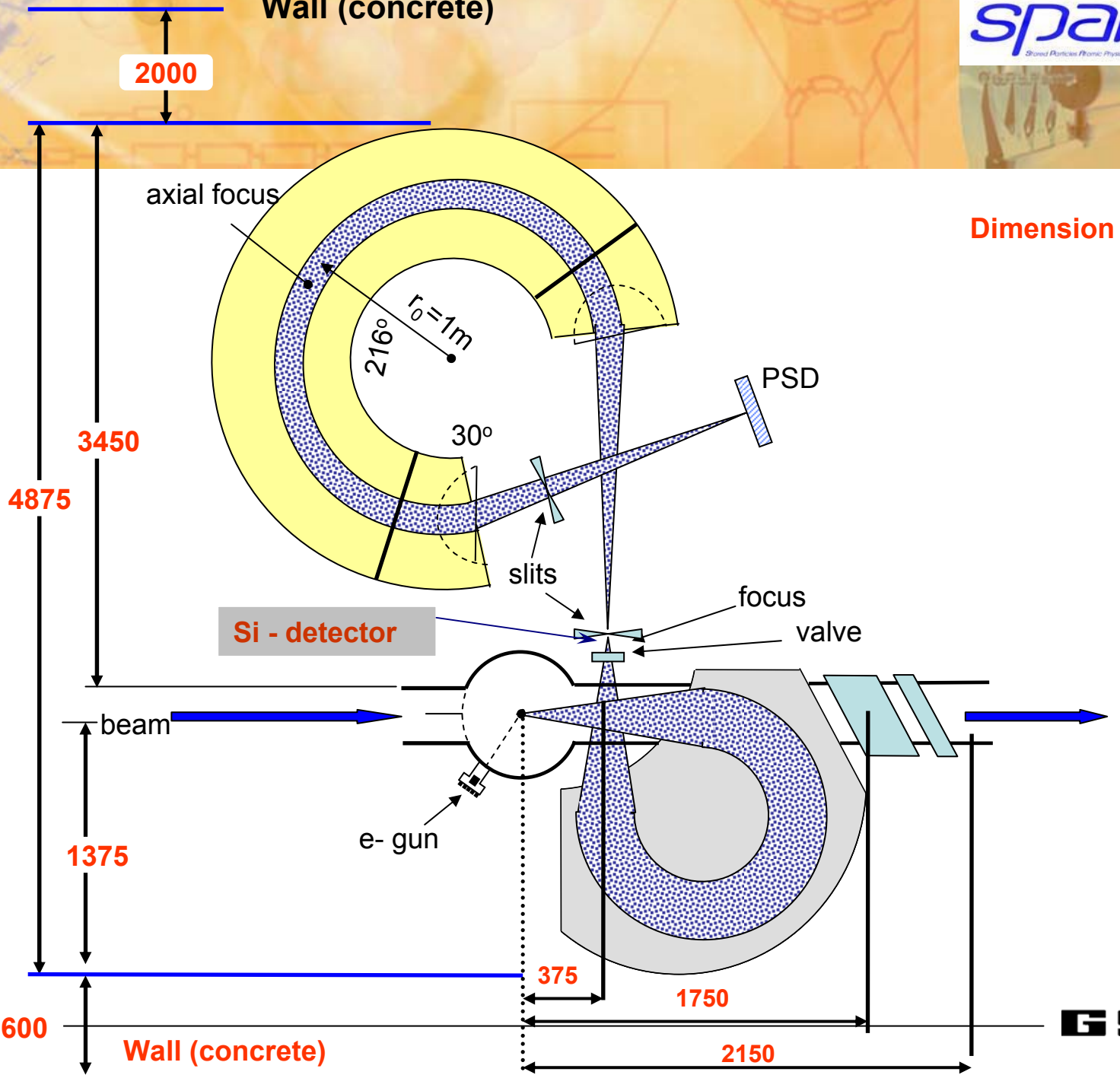
$\Delta p/p < 10^{-4}$, reprod.: 10^{-5}

~ keV ...10 MeV

Momentum acceptance $(\Delta p/p) \sim 2.5$

$\Delta\Omega \sim 1.5\ \%$

Relativistic Kinematics of electrons:
see poster no. PS32 (T.J.M. Zouros et al)


Wall (concrete)
2000
axial focus
Dimension is in mm
r0=1m
216°
30°
PSD
3450
4875
slits
focus
valve
Si - detector
beam
e- gun
1375
375
1750
2150
3600
Wall (concrete)

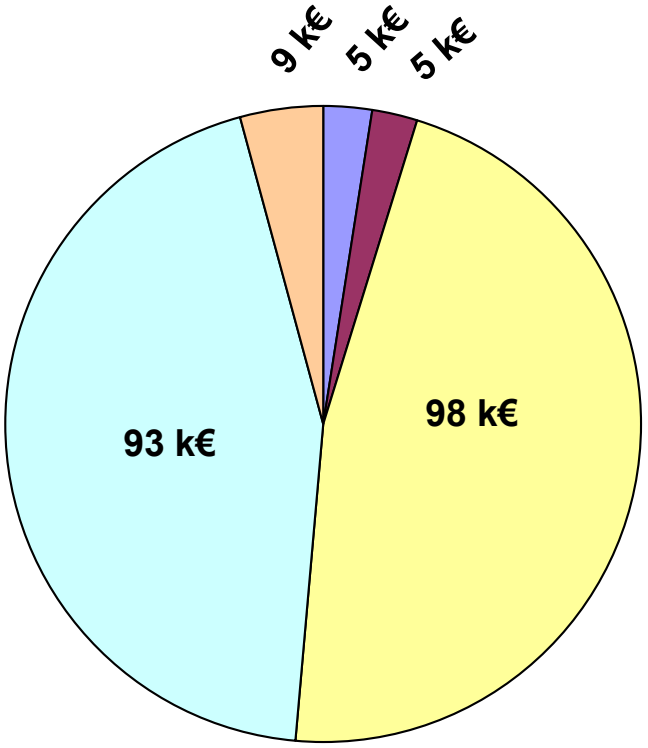
Schedule and Milestones Related to Electron Spectrometer

Task	Year
Design Studies (Part A + B)	until 2008
Construction of Transport Magnet and Chamber	end 2008
Purchase of Detectors, Power Supplies, Controlling Electronics and Parts, Mounting and Testing at Laboratory	2008/09
Design and Construction of High Resolution Spectrometer (HRS), Ordering Parts, Chamber, Valve and Electronics (Part C)	2008 / 2009
Mounting and Test HRS	2009 /2010
Ready to Operate	2010

Responsibilities and Obligations Related to Electron Spectrometer

Tasks	Contributing Groups
Design Studies	Uni. of Crete CSIC Madrid GSI TIFR, Mumbai
Construction of Transport Magnet and Chamber	IMP-Lanzhou GSI
Purchase of Detectors, Power Supplies, Controlling Electronics and Parts, Mounting and Testing at Laboratory	GSI TIFR, Mumbai ATOMKI Debrecen MPI-K, Heidelberg
Design and Construction of High-Resolution Spectrometer (HRS), Ordering Parts, Chamber, Valve and Electronics	GSI ATOMKI, Debrecen MPI-K Heidelberg
Mounting and Test HRS	GSI IMP-Lanzhou ATOMKI, Debrecen TIFR, Mumbai MPI-K Heidelberg

Cost Estimate
of Electron Spectrometer



- Design Studies
- Construction of Transport Magnet and Chamber
- Purchase of Detectors, Power Supplies, Controlling Electronics and Parts, Mounting and Testing at Laboratory
- Design and Construction of High Resolution Spectrometer (HRS), Ordering Parts, Chamber, Valve and Electronics
- Mounting and Test of HRS

Total : 210 k€

Personnel in Full Time Equivalent (FTE) Required for the Project

GSI (AP) FTE	Collab. FTE	GSI (Add) FTE	Total
0.5	3	0.5	4

Specified cost estimates

Part A (270° dipole magnet + compensation magnets)

Dipole	Iron: ~ 476 kp Copper: ~ 68 kp	2380 € 1360 €
Compensation magnets	Iron: ~ 44 kp Copper: ~ 50 kp	220 € 1000 €
supports (frame) stainless steel rods, plates	~60 kp	~ 200 €
Engeneering, design	1 week	1200 €
Construction	2 weeks	2400 €
Simulation calculations	2 weeks	1200 €
Magnet power supplies (3 pieces)		~ 6000 €
3 B-field probes		~ 1500 €
Manufactoring	4 weeks	9600 €
	Sum	**27060** €

Specified cost estimates

Part B: Chamber

material costs including manufactoring		30,000 €
Corresponding design studies	~ 1,5 weeks	1,800 €
Construction	~ 2 weeks	2,400 €
Electron gun		~ 2,000 €
Electron gun's high voltage supply		~ 4,000 €
Si detector support		~ 300 €
Si - detector (UHV compatible)		~ 20,000 €
UHV valve (CF35 , electron exit)		~ 2,500 €
Chamber support frame		~ 1,000 €
Vacuum detection and heating system		~ 12,000 €
	Sum	**76,000** €

Mounting and transport costs (hired persons)

a) at test place 6 days 2000 €
b) at (N)ESR 6 days 2000 €
Sum : **4000** €

Tests and commissioning:

3 weeks of testing the basic properties of **A** and of **B** are foreseen for a). One or two members of the collaboration should conduct this. If achievable, a granted member carries this manpower costs. Commissioning is performed at (N)ESR. Costs for hired manpower outside the collaboration are not considered. First experimental results will be taken without the second spectrometer, part ***C***.

Total costs for **A + B** = **107060 Eu**

Time planning

Parts A + B

The **dipole – transport magnet** with the **reaction chamber,** will be realized at first. It already allows orientation measurements for electrons from atomic collisions and nuclear conversion. After some experience the high resolution spectrometer, part C, will be added later on.

Design, construction, manufactoring

- Dec. 2009

Specified cost estimates

Part C:

High-Resolution Double Focusing Magnetic Spectrometer

Material	Iron 5,7 t copper 297 kp	15000 € 1485 €
supports (frame) stainless steel rods, plates	~120 kp	~ 600 €
vacuum chamber (magn. free stainless steel)		~ 8000 €
heating system, vacuum control		12000 €
magnetic field probes		1000 €
magnet power supplies (2 pieces)		~ 4000 €
calibration source (e- gun)		6000 €
electron detector (pos. channelplate + electronic)		~ 30000 €
	Sum	**78085** €

Specified cost estimates

Part C:

High-Resolution Double Focusing Magnetic Spectrometer

Personal costs		
Engeneering, design, case studies (spectrometer, HV-chamber, mounting + heating)	2 months	10000 €
Construction	1 month	~ 4000 €
Simulation calculations	2 weeks	1200 €
	Sum	**15200** €
Mounting and transport costs (hired persons)		
a) at test place	6 days	2000 €
b) at (N)ESR	6 days	2000 €
	Sum	**4000** €

Total cost of part C: 97,285 €

Part C:

High-Resolution Double Focusing Magnetic Spectrometer

tests and commissioning

4 weeks for testing Spectrometer resolution and transmission.
1-2 weeks for heating and vacuum tests (R&D basis).
If achievable, a granted member carries the manpower costs.

Commissioning is performed at (N)ESR. Costs for hired manpower outside the collaboration are not considered.

Time Planning 2007 – 2010

Total project costs: **204,375** €

Expected experimental values from measurements of conversion electrons under zero degree observation angle for E_p=200MeV/u projectile energy.

projectile	E_c(keV)	$E_e^+(keV)$	E_e^-(keV)	S^+(keV)	ΔE_c(eV)	E_{1s}(keV)	ΔE_{1s}(ppm)
$^{155}_{64}Gd^{63+}$	0.857	131.174	76.581	21.458	0.17	59.153	2.9
$^{195}_{78}Pt^{77+}$	5.4	167, 638	44.302	57.922	0.9	93.46	9.6
$^{212}_{83}Bi^{82+}$	10.77	195.525	29.911	85.809	1.8	104.4	17.2
$^{228}_{90}Th^{89+}$	3.450	154.923	53.295	45.206	0.6	125.6	4.8

projectile	self energy L_s(eV)	$\Delta L_s(10^{-3}L_s)$	Z_p
$^{155}_{64}Gd^{63+}$	96.2	1.8	64
$^{195}_{78}Pt^{77+}$	186.9	4.8	78
$^{212}_{83}Bi^{82+}$	239.6	7.5	83
$^{228}_{90}Th^{89+}$	326.6	1.8	90

Outline

- ***Scientific goal:***

  x-ray –complementarity: Strong Fields
  Few e- States,
  QED- test
  Reaction-Collision Dynamics
  Nuclear:
  Conversion Electrons (ne-, Z)
  Atomic – Nuclear Interplay HFS..

- ***Instrumentation***

- ***Costs / Manpower***

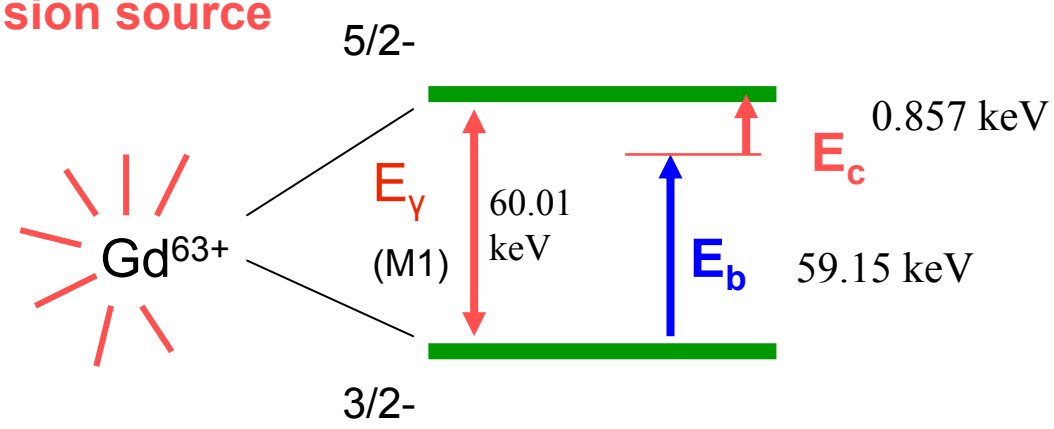
Interplay between nuclear and atomic structure

Conversion electrons (1..4 e-) in high Z atoms: probing wave functions, magnetic moments of excit.nuclei (HFS, τ < 1ns)

precision measurement of E_b (1s) – QED test ~ 2 x 10^{-3}

excited nucleus → precision transfer (conversion e^-) → error reduction (E_c << E_b)

precision source



10^{-4} → 10^{-6}

instrum. resolution

of E_b

corresponds to 1 % of 1s – self energy

Some adressed physics

Auger electron spectroscopy (high Z regime) :

projectile continuum states → mechanisms (excitation, capture, decay branches- fluorescence yields) Breit effect on FS – splitting (ΔFS < 1%), metastable states, Rydberg states → Laser induced photo ionization, ...

echo of dielectronic recombination experiments

electron continua at 0^o (target, projectile)