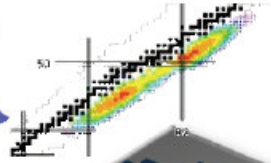
THE SUPER SEPARATOR SPECTROMETER

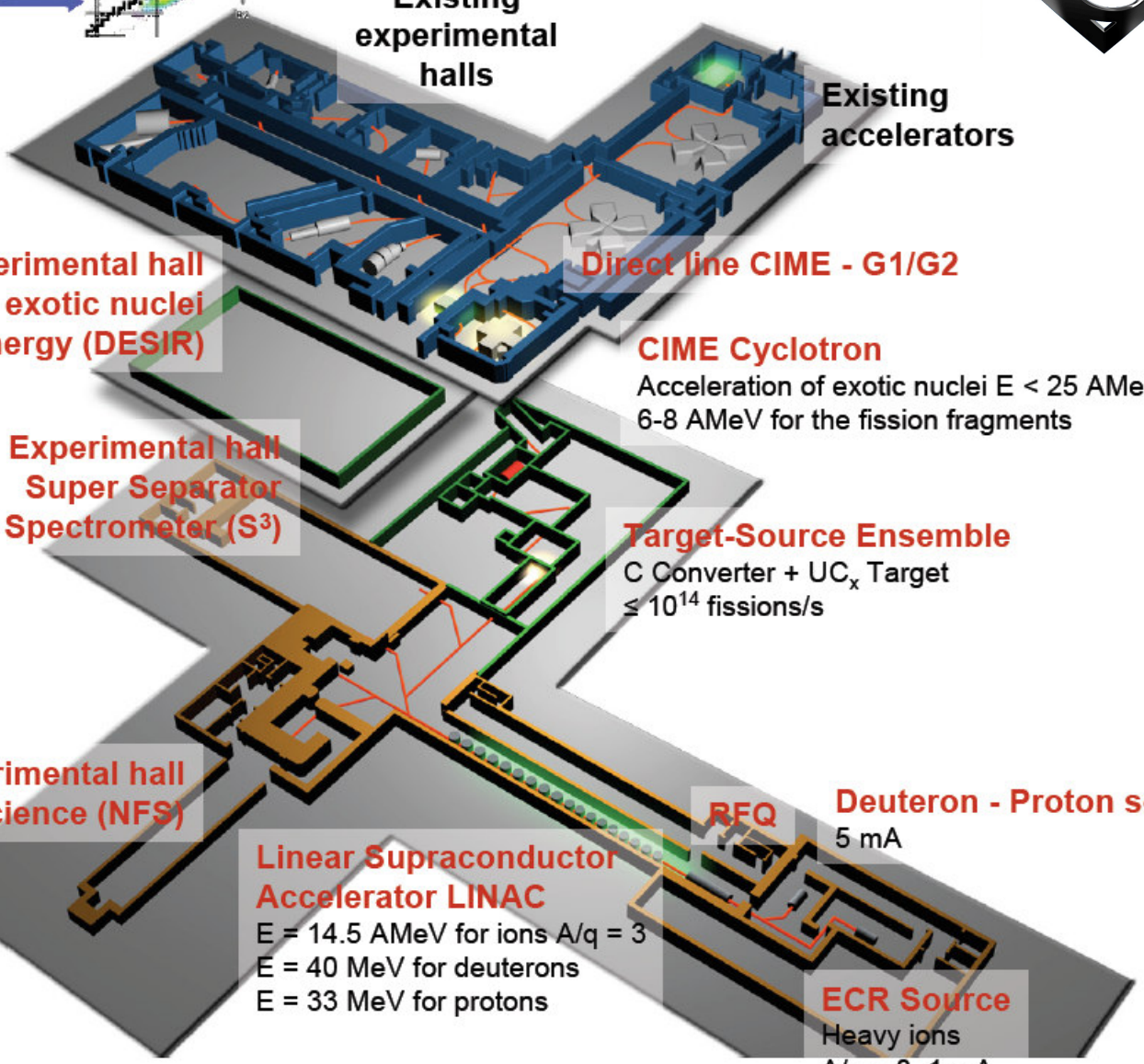
S^3

Hervé Savajols
(GANIL)

http://pro.ganil-spiral2.eu/spiral2/instrumentation/s3

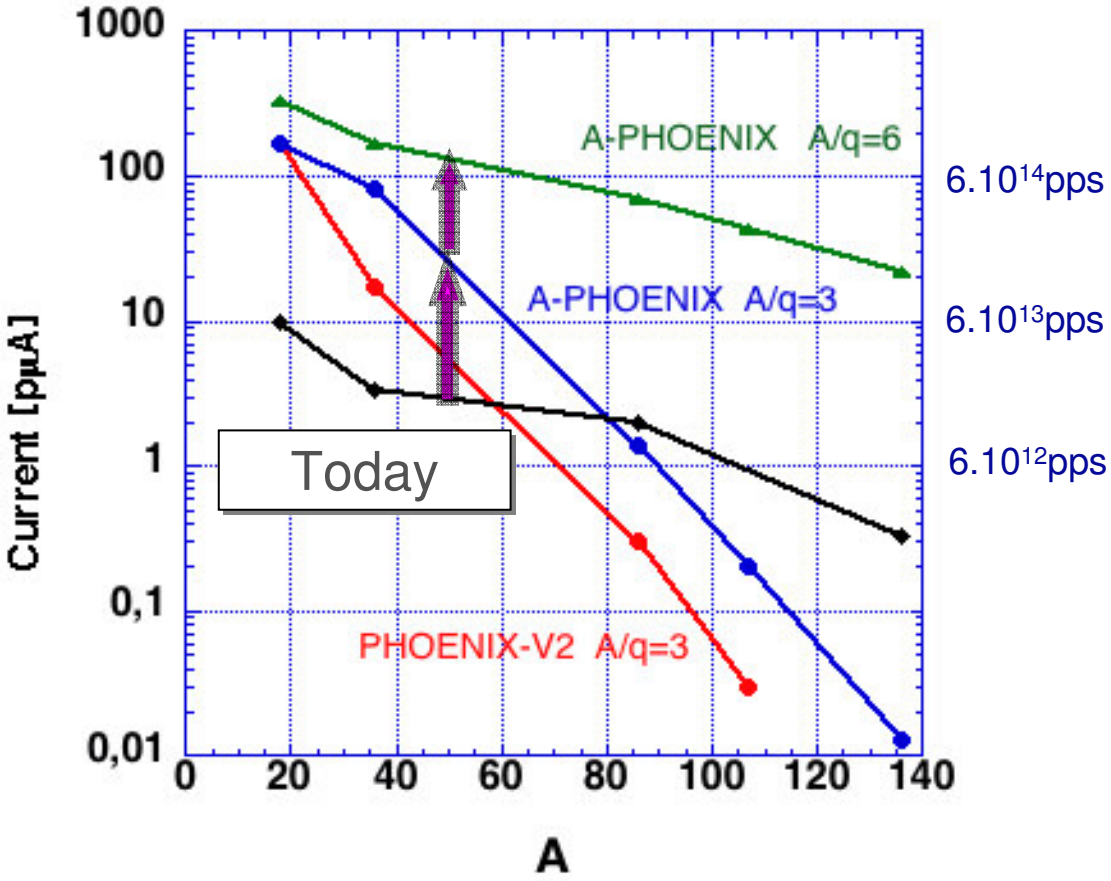
Spiral2




Existing experimental halls
Existing accelerators
Experimental hall with exotic nuclei at low energy (DESIR)
Direct line CIME - G1/G2
CIME Cyclotron
Acceleration of exotic nuclei E < 25 AMeV,
6-8 AMeV for the fission fragments
Experimental hall Super Separator Spectrometer (S3)
Target-Source Ensemble
C Converter + UCx Target
≤ 10^14 fissions/s
Experimental hall Neutrons For Science (NFS)
RFQ
Deuteron - Proton source
5 mA
Linear Supraconductor Accelerator LINAC
E = 14.5 AMeV for ions A/q = 3
E = 40 MeV for deuterons
E = 33 MeV for protons
ECR Source
Heavy ions
A/q = 3, 1 mA

LINAC stable beams

Very high intensity stable beams over a wide mass range



Energy = 2-15 *A.MeV*

Above one or two order of magnitudes higher than present facilities

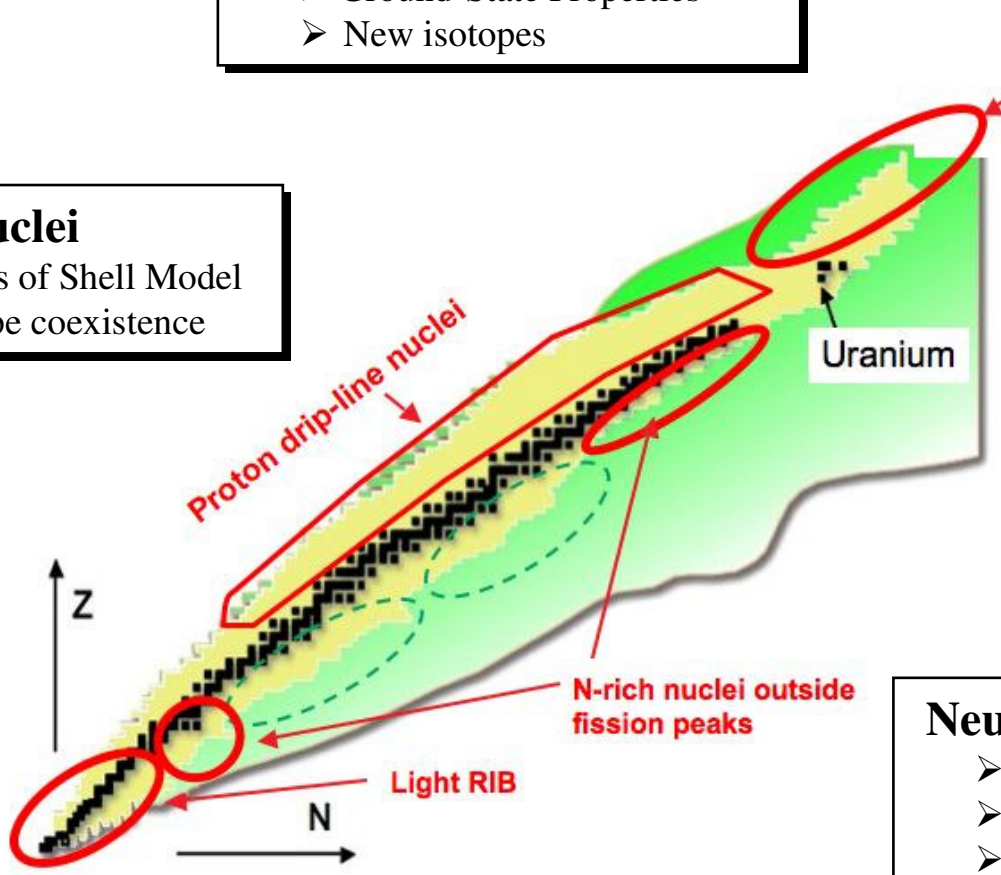
⇨ Open new opportunities in several physics domains

Physics objectives

Proton Dripline
- Single-Particle structure
- Development of Collectivity
- Ground-State Properties
- New isotopes

10^{14}part/s → 10evt/day @ 1pb

N=Z nuclei
- Tests of Shell Model
- Shape coexistence



Heavy and Superheavy Elements
- Synthesis
- Spectroscopy and Structure
- Ground-State Properties
- Chemistry

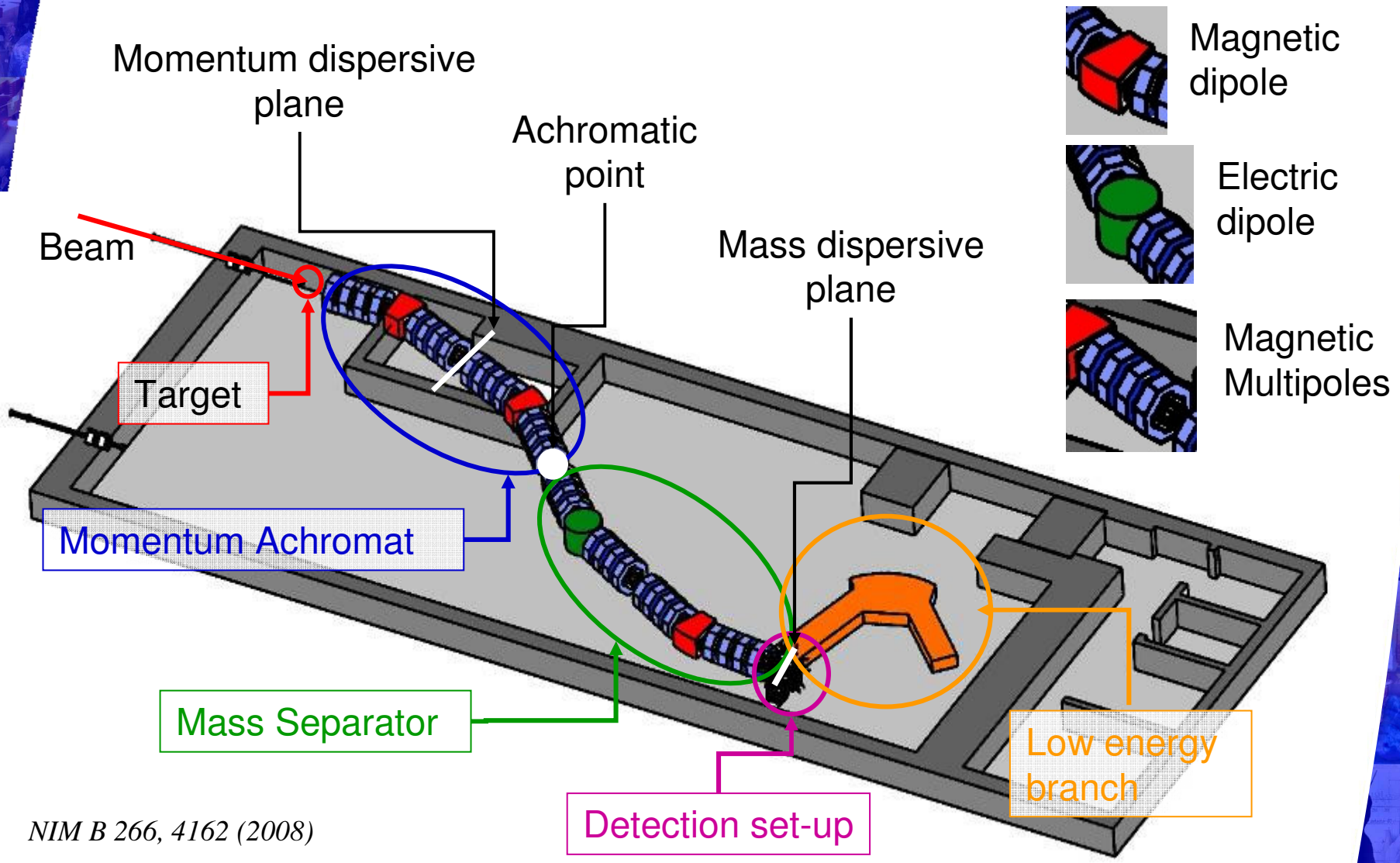
Neutron-Rich Nuclei
- Single-Particle structure
- Quenching of Shell Gaps
- Ground-State Properties
- New isotopes

- S3 Letter of Intent for SPIRAL2, 2006
- S3 Physics white book, June 2008
- LINAC/SPIRAL2 Day1 LoIs, Sept 2009

http://www.ganil.fr/research/developments/spiral2/loi_texts.html

Optics : Basic design (Argonne NL)

Principle : Two-stage selection (Bp & m/q) that will achieve very good rejection of both the beam and adjacent mass channels of reaction products

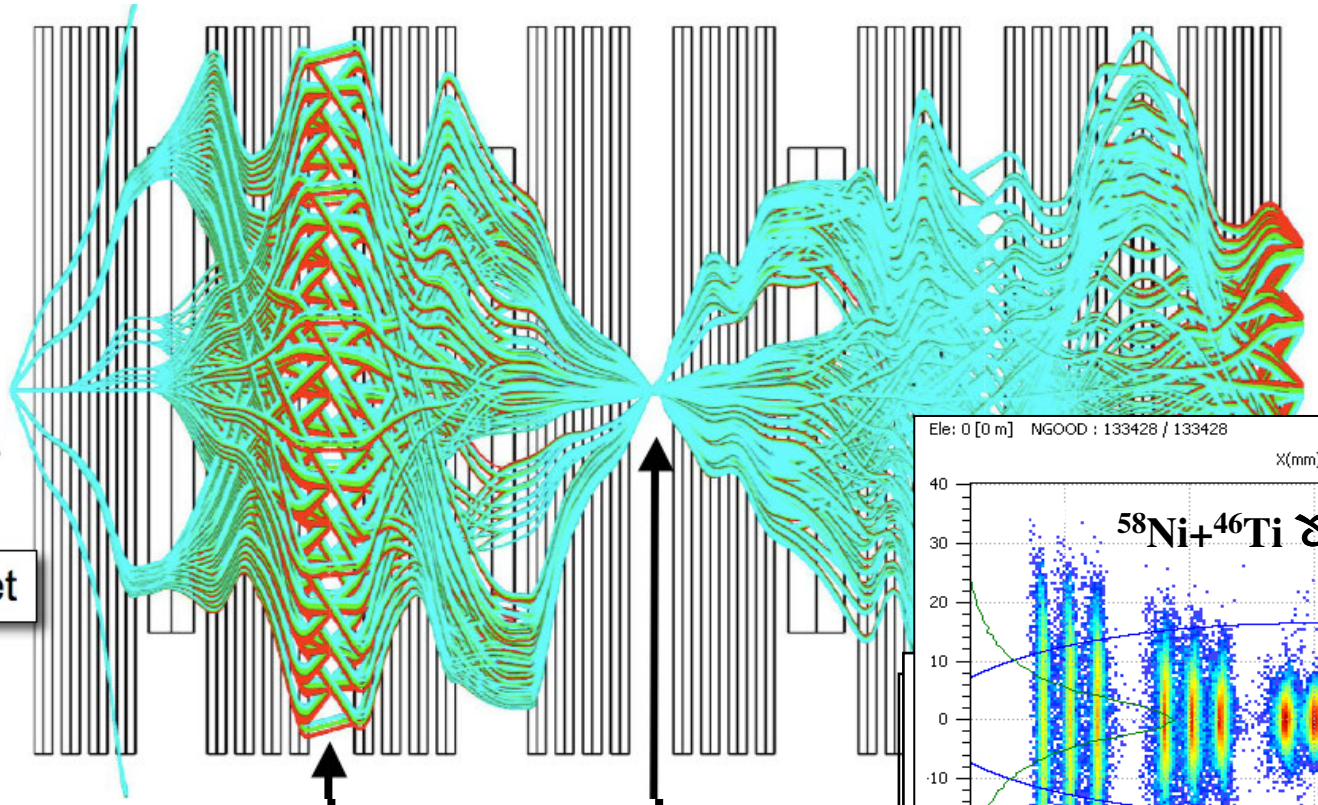


NIM B 266, 4162 (2008)

Mass resolution of the full system

$^{48}Ca+^{248}Cm \rightarrow {}^{292}116 + 4n$

	E [MeV/n]	 [Tm]	<Er> [MV]	<Q>	<V> [cm/ns]	²q (±2σ) [mrad]	dQ	dp/p[%] (±2σ)
Beam parameters ^{48}Ca	4.92	0.88	27	+17	3.0	± 8		±0.2
Recoil parameters $^{292}116$	0.131	0.58	3	+25	0.5	± 50 (Y) ± 50 (X)	± 2	±2.3

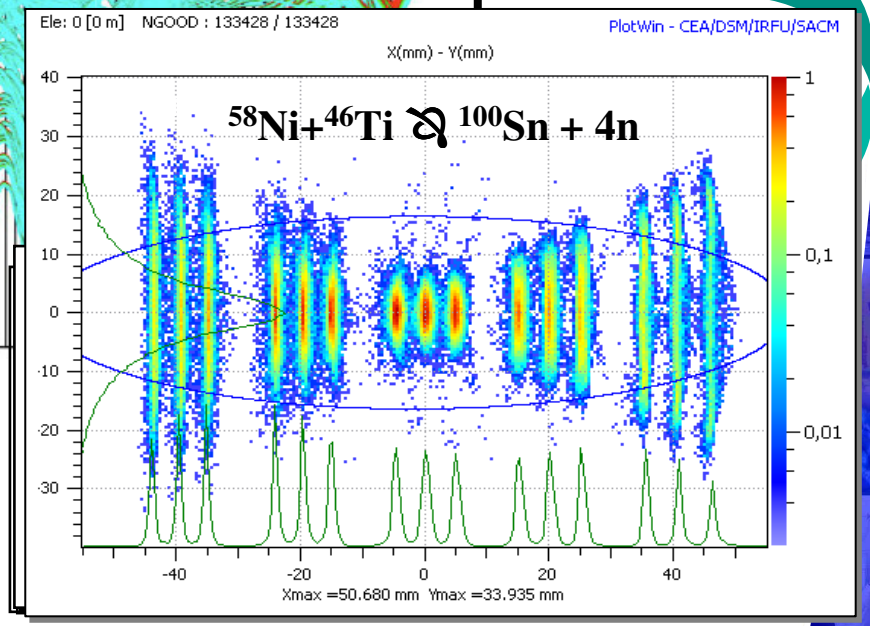


Target

Momentum Dispersion [x/δ=13 mm/%]

Intermediate Focal point

M/q dispersion (For 5Q)



High power target stations

Stable

^{208}Pb, ^{209}Bi, Ni, Ca, C

(R ≈ 35 cm)

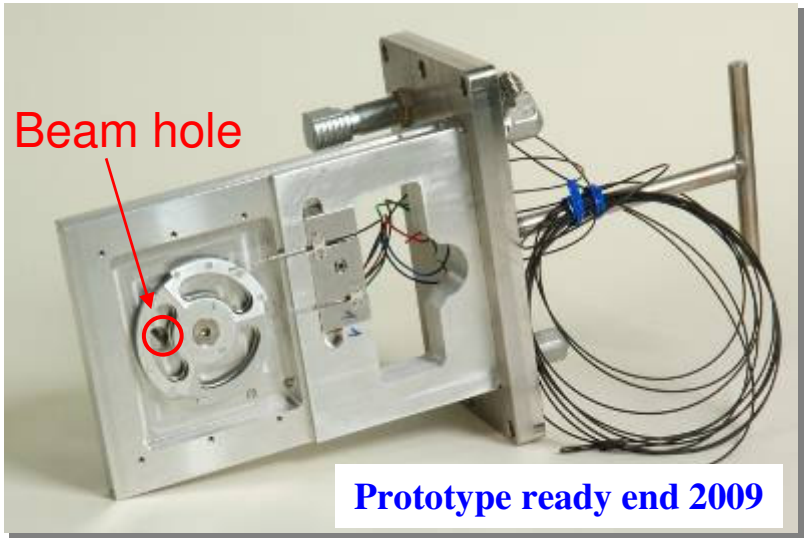
Used as prototype in 2009

Actinides

^{232}Th, ^{238}U, ^{239}Pu, ^{242}Pu, ^{244}Pu, ^{248}Cm, ^{249}Cf

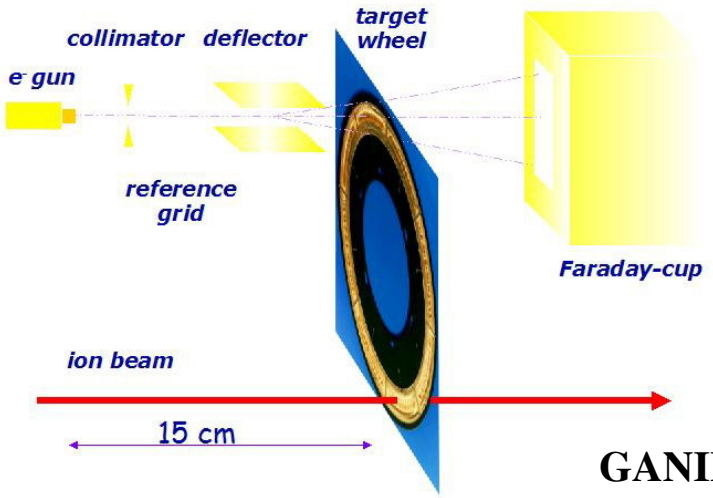
≈ 45 mg ≈ 10^2 – 10^9 Bq

(R=4-15 cm)



Prototype ready end 2009

Target thickness and homogeneity
- RBS method
- Electron gun
- Pyrometer
- Infrared cameras
- Scintillators …



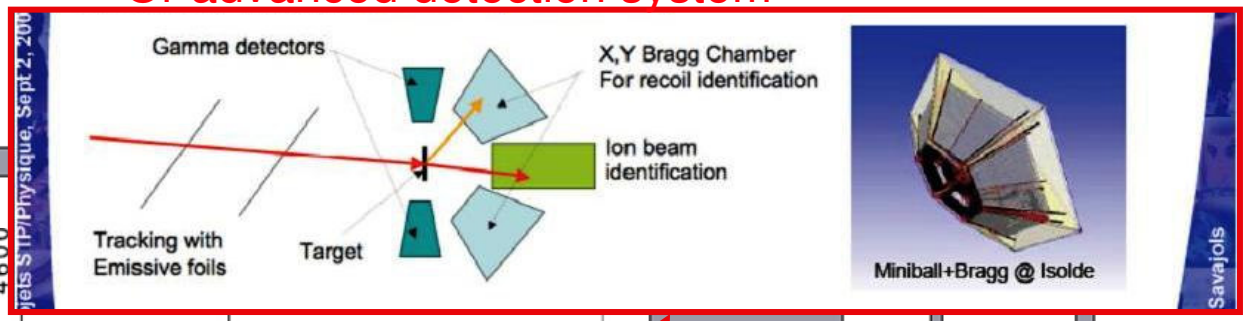
e- Beam Diagnosis
R. Mann (patent # DE 102 42 962 A1)

GANIL & Irfu

Basic of the project

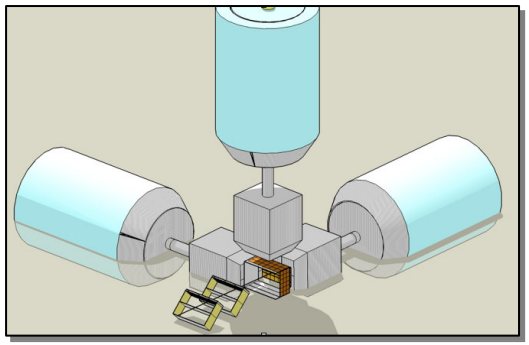
Primary target

Or advanced detection system



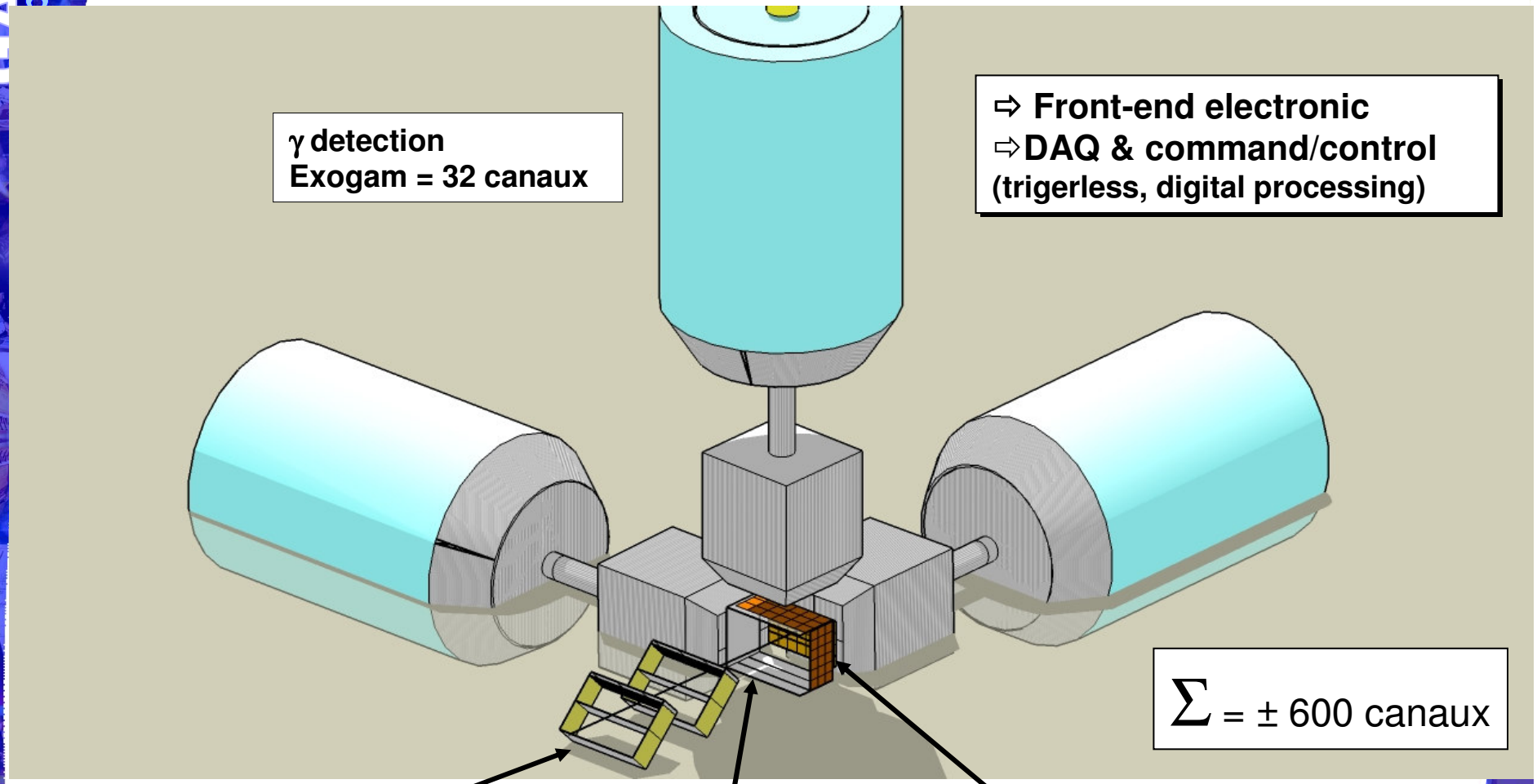
Decay spectroscopy - Implantation Set-up

Have a "simple" detection to concentrate on the separator spectrometer



Base detection system

Decay spectroscopy setup α,γ,e⁻ (Gabriella-Dubna,Great-JYFL…)



γ detection
Exogam = 32 canaux

⇨ Front-end electronic
⇨DAQ & command/control
(trigerless, digital processing)

Σ = ± 600 canaux

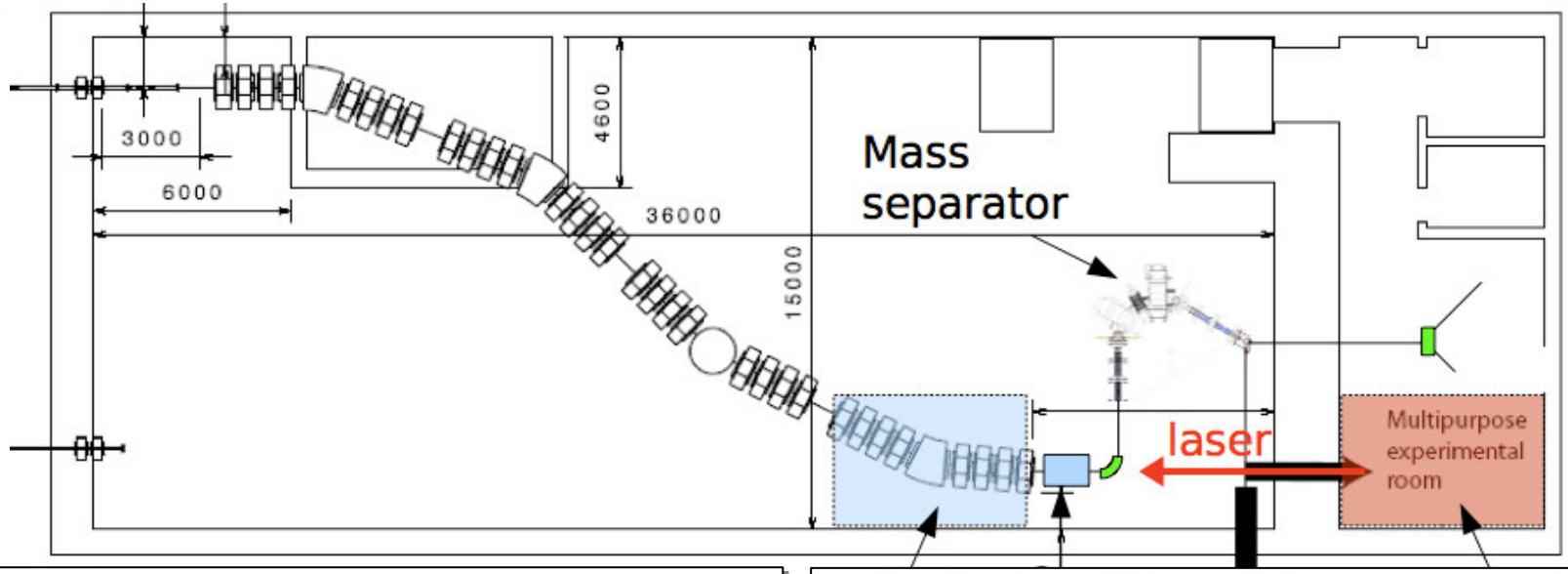
Time of flight + tracking detection
= 200 canaux

Tunnel detector for escaped e⁻ and α
= 40 canaux

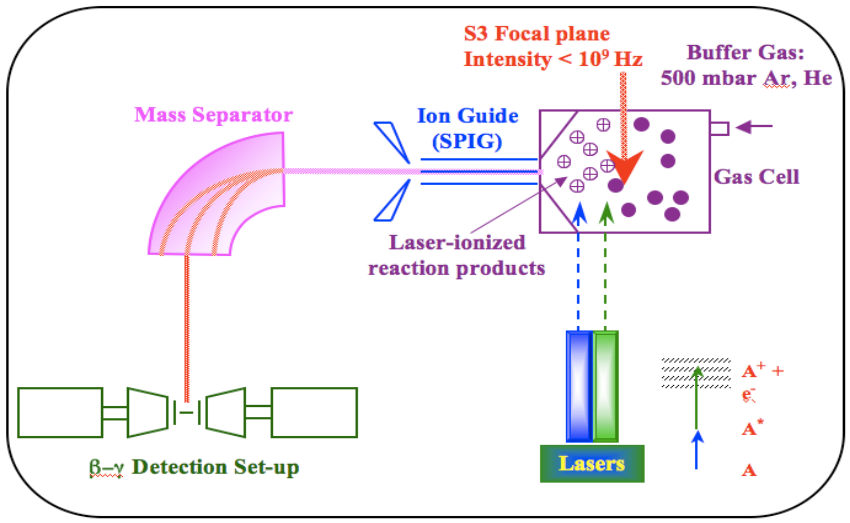
Implantation detector (HI, α and e⁻ decay)
= 300-650 canaux

IPHC/CSNSM/Irfu/GANIL/GSI/JYFL

S^3 Low energy branch



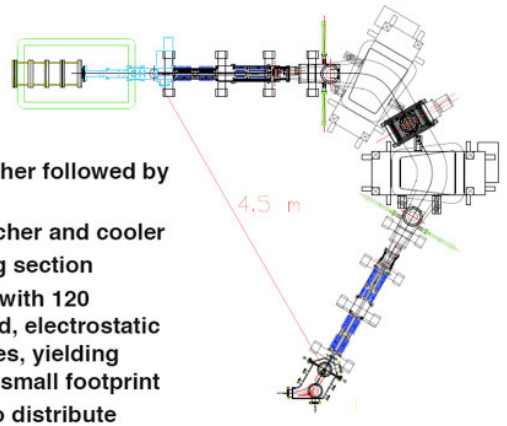
Laser ion source + mass separation



LISOL (Leuven)

Gas Catcher + high-resolution mass separation

Possible gas catcher and mass separator layout for S^3



- High intensity RF gas catcher followed by gas cooler
- 50 kV platform for gas catcher and cooler
- Acceleration and matching section
- High resolution separator with 120 degree total magnetic bend, electrostatic quadrupoles and multipoles, yielding 20000 mass resolution on small footprint
- Electrostatic switchyard to distribute beam to experiments in S3 hall, or in DESIR hall, or to post-accelerator

ANL/KU Leuven/GANIL

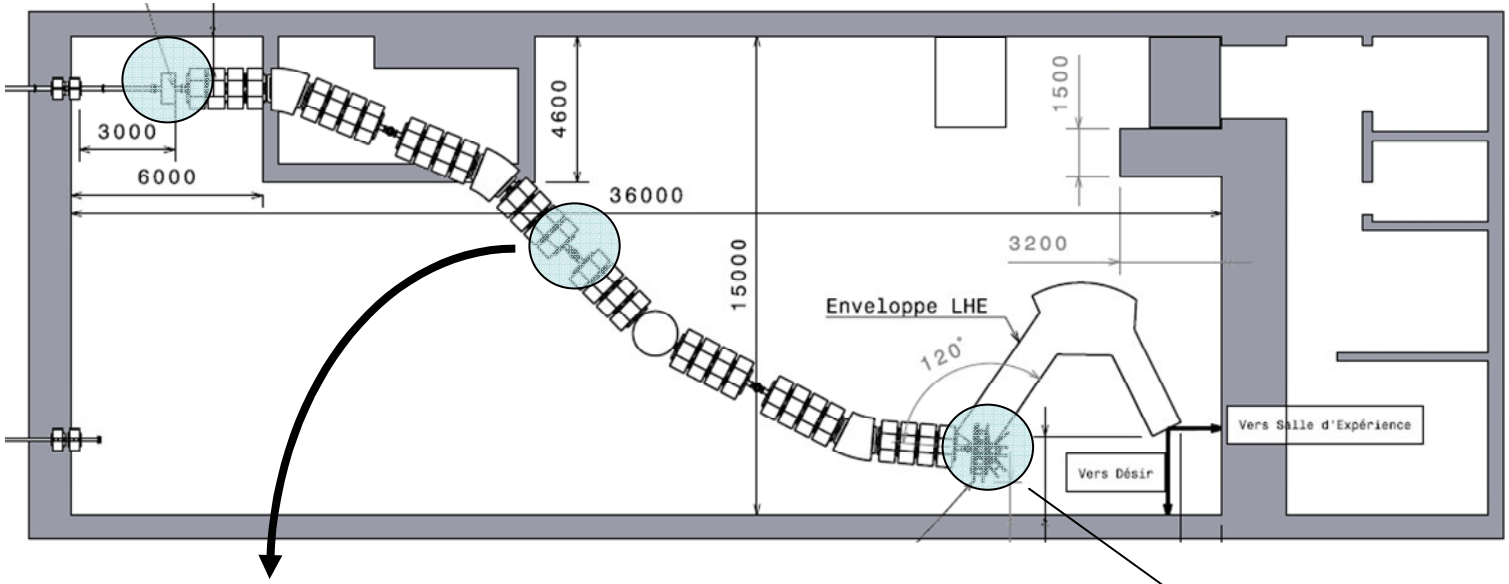
Two step reactions

low energy secondary products

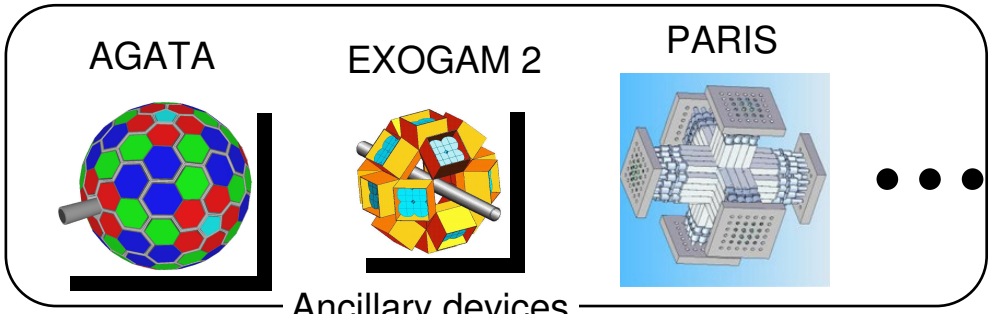
$E\rho_{max}$ = 12 MV

$E\rho = 2T/q$

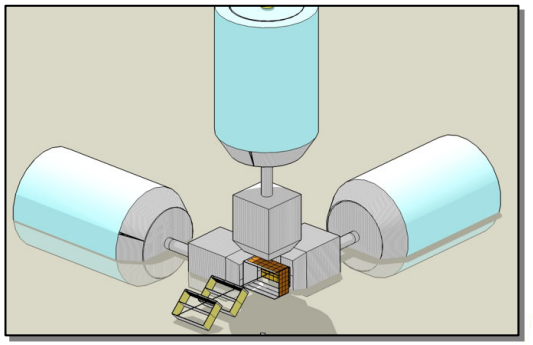
Production target



Secondary target for fusion/evaporation reactions



Decay Identification

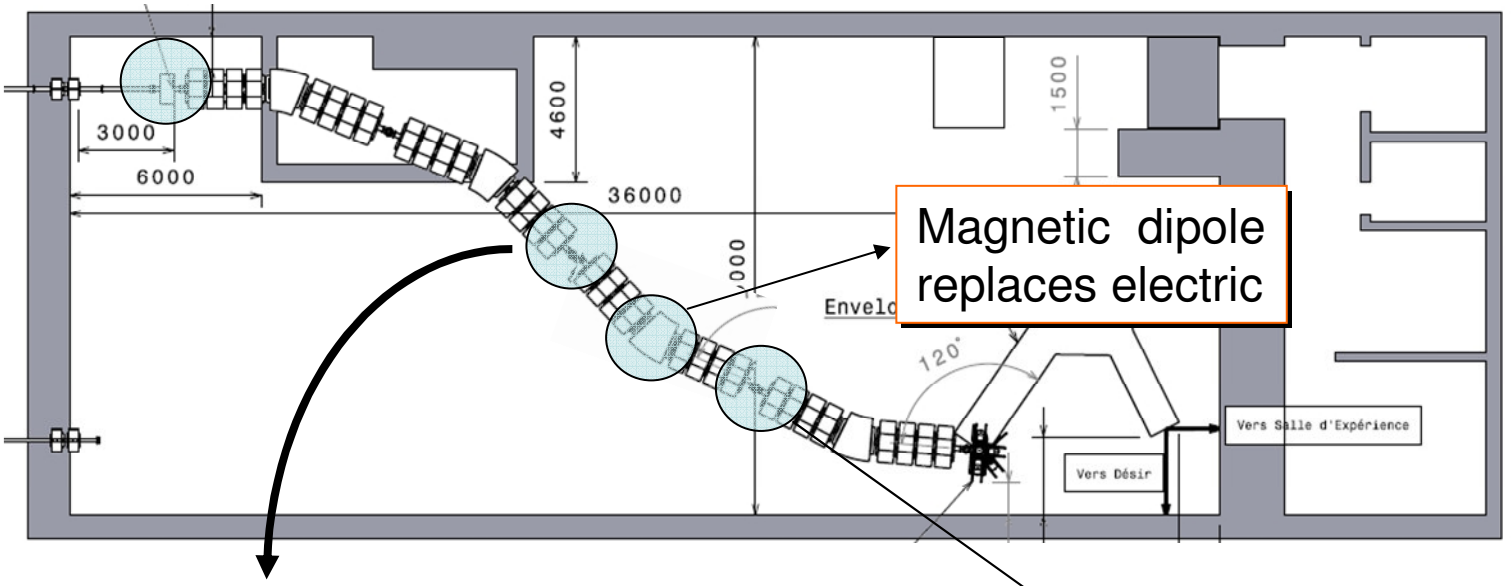


Two step reactions

high energy secondary products

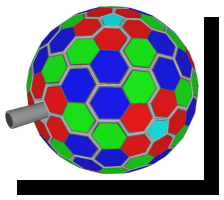
$B\rho_{max}$ = 1.8 Tm

Production target

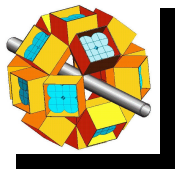


Secondary target for direct reactions

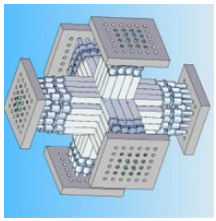
AGATA



EXOGAM 2



PARIS



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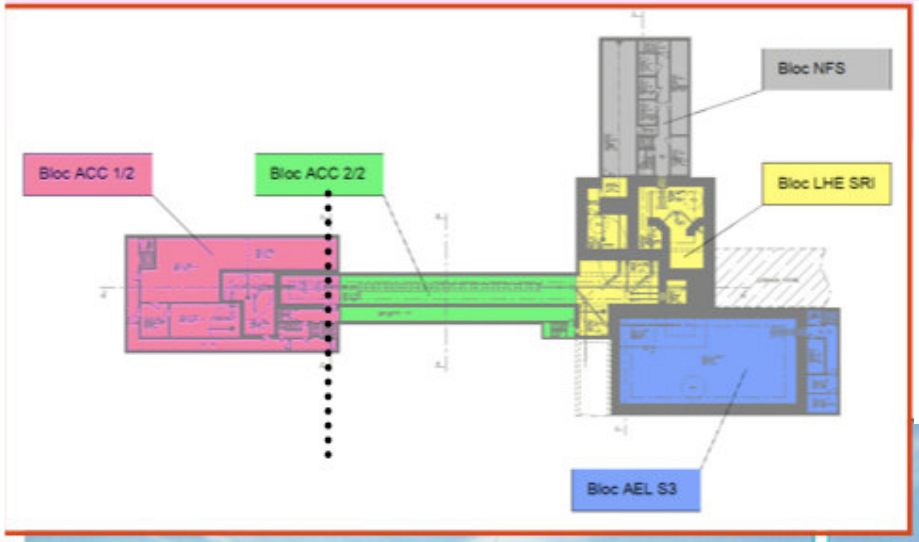
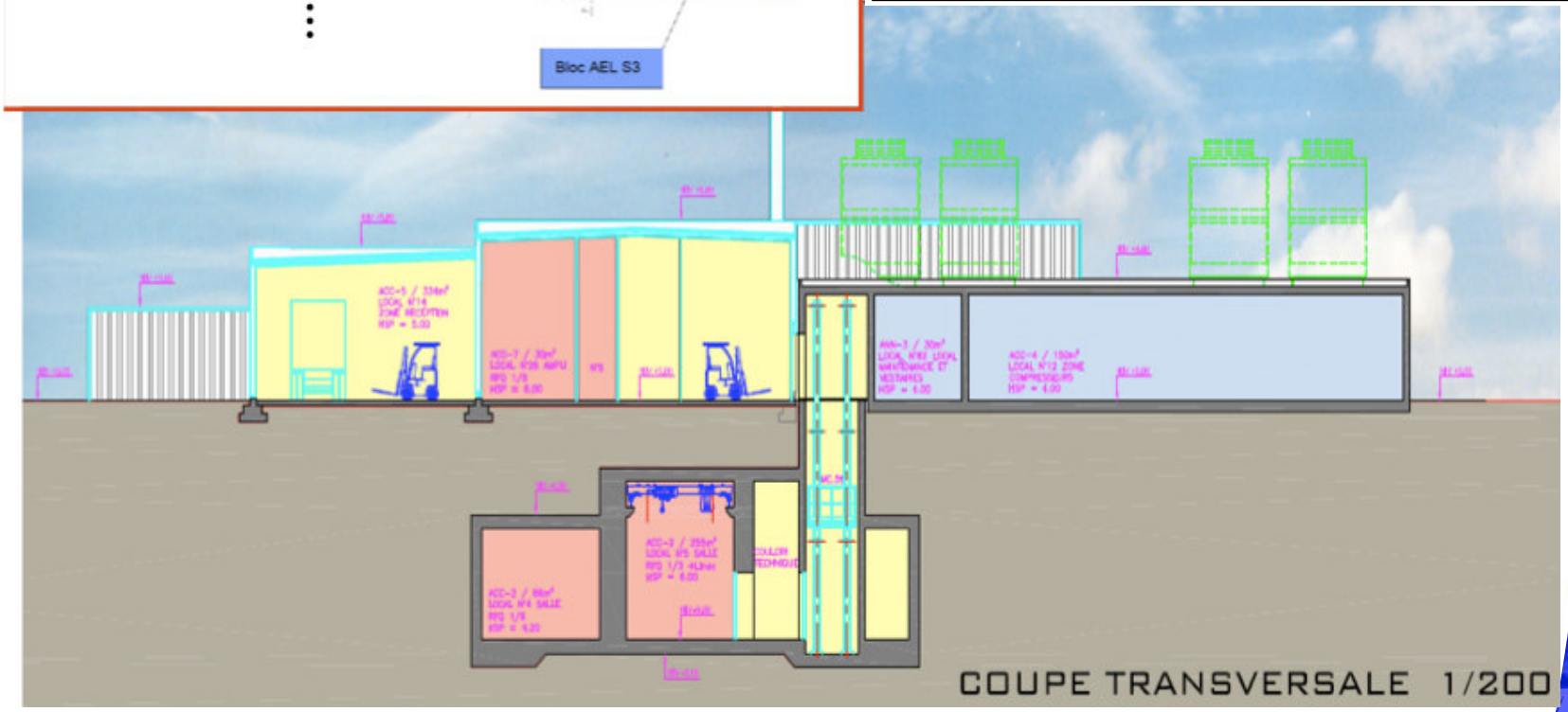
Ancillary devices

Intermediate focal plane of the spectrometer Identification Station (Bρ, A, Z)

Infrastructure



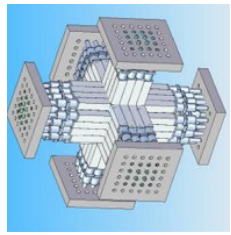


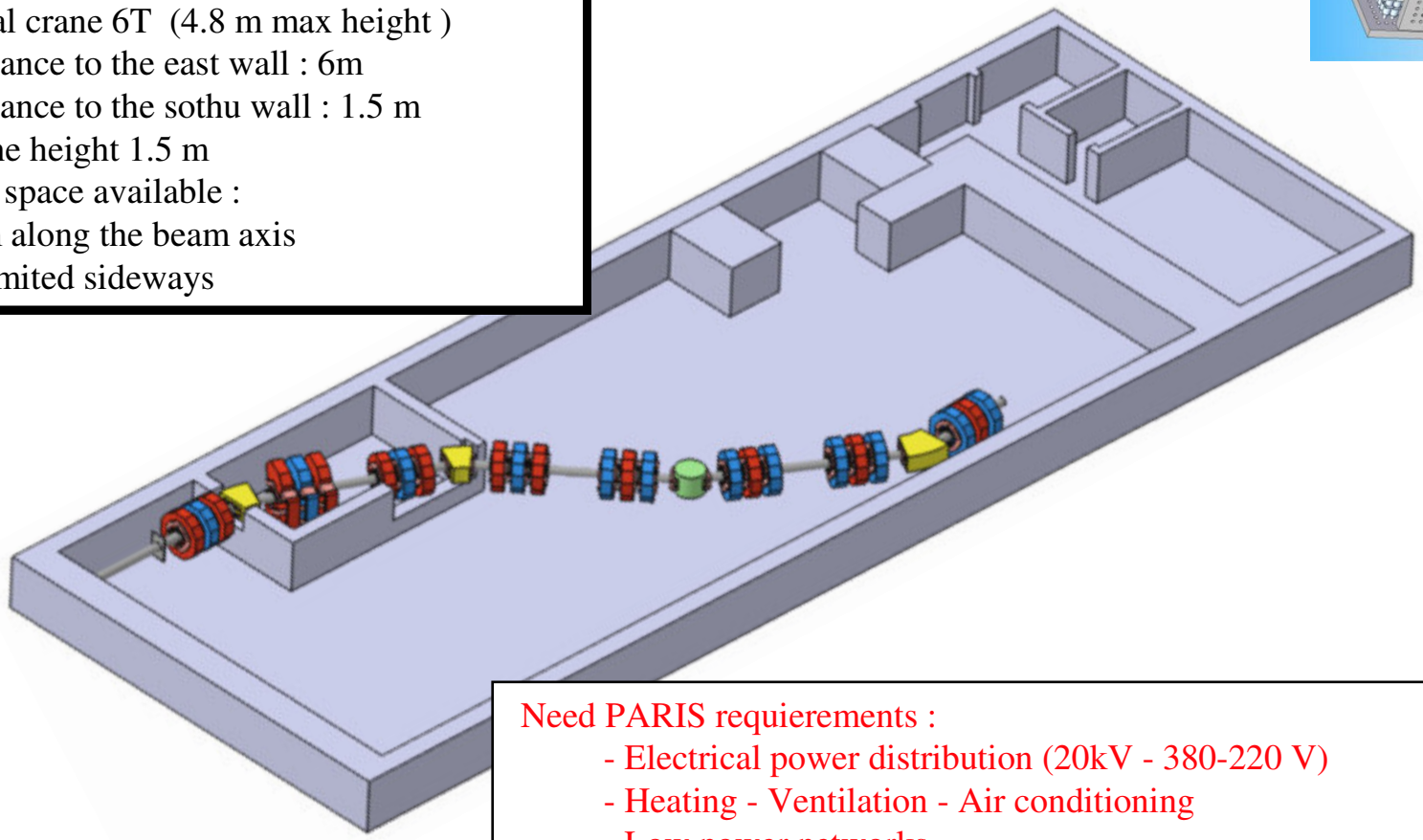
September 08 : Choise of the Project Management Team (“MOE”)
July 09 : request for the building permit

S3 project and relations to PARIS

Infrastructure

- Room size 36 m × 15 m × 6 m (height)
- Elevator size 2.2 m×3 m, 6T capability
- Industrial crane 6T (4.8 m max height)
- Min distance to the east wall : 6m
- Min distance to the sothu wall : 1.5 m
- Beam line height 1.5 m
- Image 2 space available :
  - -1.6 m along the beam axis
  - Unlimited sideways





North

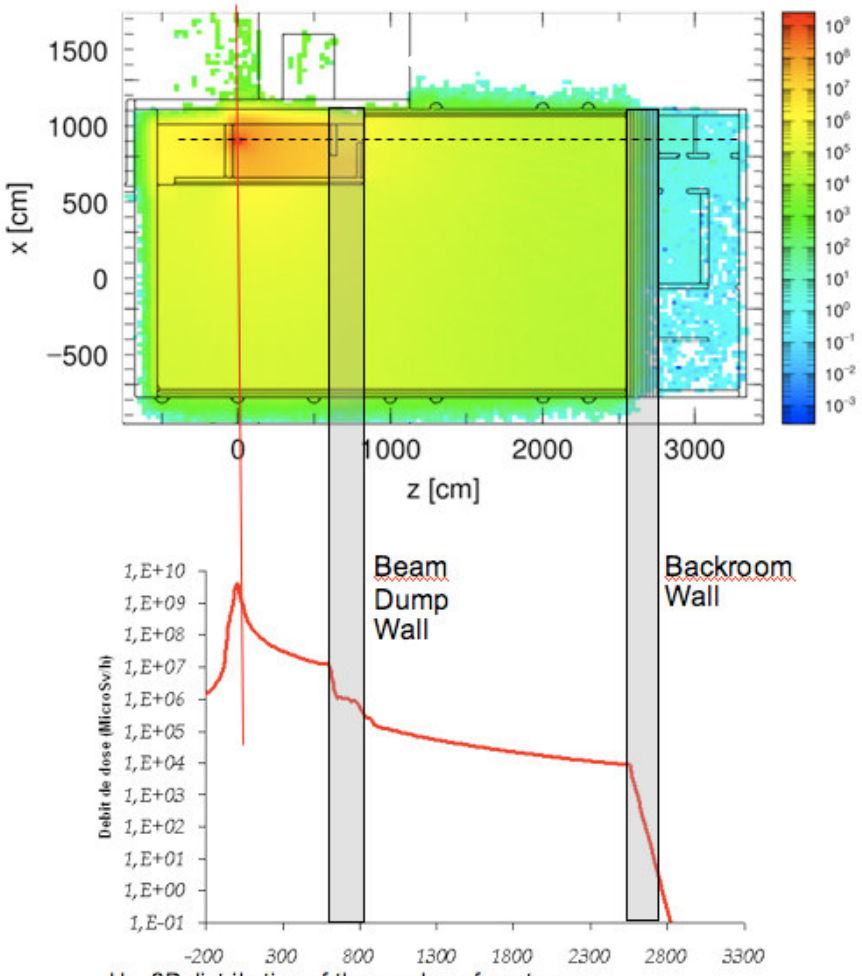
Need PARIS requierements :

- Electrical power distribution (20kV - 380-220 V)
- Heating - Ventilation - Air conditioning
- Low power networks
- Water cooling system
- Security
- Electronics racks, cables, …

S3 project and relations to PARIS

Reference beam ⇨ ^{12}C @ 14.5 MeV/u
Intensity = 1mA (1.6×10^{15} pps)

Neutrons fluxes in the S³ cave vicinity



Up: 2D distribution of the number of neutrons
Down: Dose (μSv/h) due to the neutrons on the 0° (beam) direction (corresponding ot the dashed line)

Safety Design

- Beam dump casemate to reduce the neutron flux (50 cm concrete wall)
- Local shielding around the beam dump ⇨ dose is compatible with immediate human intervention
- Additional Local shielding for the detection system

Need PARIS requierements :

- Acceptable neutron flux level (vs energy range) for LaBr3 and associated Photomultiplier
- Acceptable gamma-background level
- Acceptable neutron flux level (vs energy range) for the associated electronics (10^{11}n/cm2)

EXOGAM2/AGATA

- Energy > 16 MeV limit = 2-5 10^8 n/cm²
- Energy [5-16] limit = 0.5 – 1. 10^9 n/cm²
- Energy < 5 MeV limit = 10^9 n/cm²

⇨ Before maintenance

S3 project and relations to PARIS

Need PARIS requierements :

- Acceptable magnetic field level
- Position of the closest Photomultiplier

Field at the target position (To be scaled by the quadrupole gradient) :
Bρ = 1.5 Tm (G=2.8T/m)

Cas Moteur:
Distance/axe faisceau: 87.5mm
Distance/Quadrupôle: 50mm / 1163G, 350mm / 56G, 570mm / 10G, 970mm / 0G

- Cas Ferrofluidic:
Distance/axe faisceau: 100mm
Distance/Quadrupôle: 30mm / 1660G, 330mm / 75G, 840mm / 0G

- Roue Cibles:
Distance/axe faisceau: 170mm
Distance/Quadrupôle: 270mm / 195G, 570mm / 18G

- Roue Stripping:
Distance/axe faisceau: 170mm
Distance/Quadrupôle: 170mm / 511G, 0mm / 4780G
470mm / 35G, 270mm / 195G

S³: Letter of Intents (LoIs)
Day 1 experiments - SPIRAL2 phase 1

S3 Letters of Intent in numbers:

- **11 LoIs** submitted *(16 experimental programs)*
- LoIs signed by **156 physicists**
- Spokespersons: **4** France, **7** foreigners
- Requested Number of 8h shifts : **1020**
- Experimental setup :
  - Momentum achromat : **1 LoI**
  - Momentum achromat + Mass separator : **4 LoIs**
  - Momentum achromat + Mass separator + Low energy Branch : **4 LoIs**
  - Momentum achromat + Spectrograph : **2 LoIs**

Collaboration : Irfu, CSNSM, GANIL, JYFL, IPHC, GSI, U. Liverpool, FLNR JINR, ANL, U. Nanjing, U. Ankara, IFJ PAN Krakow, IPN Lyon, KU Leuven, RIKEN, IPNO, Varsaw, Uppsala, IFIC Valencia, LNL legnaro, IFJ PAN Krakow, ATOMKI, U. York, Weizmann Inst, INRNE, CENBG, INSP-UPMC, CIMAP, U. Lund, U. Firenze, U. Padova, U. Paisley.

List of LoI for S3

LoI_Day1_1 : Fast ion-slow ion collisions -FISIC project (E. LAMOUR)

LoI_Day1_2 : Production and spectroscopy of heavy and superheavy elements using S3 and LINAG
(P. GREENLEES)
- Neutron deficient nuclei around Z=92 N=126
- K-isomerism studies in the Z=100-110 region
- Study of neutron rich isotopes produced by asymmetric reactions
- Production of SHE with Z=10-108-112 with Uranium target.

LoI_Day1_3 : In-source resonant laser ion spectroscopy of ^{94}Ag (I. G. DARBY)

LoI_Day1_4 : In-source resonant laser ion spectroscopy of the light Sn isotopes A =101-107 (I. G. DARBY)

LoI_Day1_5 : In source resonant laser ion spectroscopy of Z >=92 (I. G. DARBY)

LoI_Day1_6 : Single particle states and proton-neutron interaction in the ^{100}Sn region (L. CACERES, F. Azaiez)

LoI_Day1_7 : In-beam gamma spectroscopy of neutron-rich nuclei studied with PARIS at the intermediate focal plane of S3 (I. STEFAN, B. Fornal)

LoI_Day1_8 : Shell structure, Isospin symmetry and shape changes in N=Z nuclei (G. DE ANGELIS, B. Wadsworth)
- Coulomb excitation of ^{104}Sn: probing large scale shell model calculation
- Coulomb excitations of the T=1 bands of the odd-odd ^{62}Ga, ^{66}As and ^{70}Br nuclei

LoI_Day1_9 : Quadrupole Moments of isomeric states using the Tilted-foils Technique at S3
(G. GEORGIEV, M. Hass)

LoI_Day1_10 : Precision study of the superallowed beta decay of heavy odd-odd N=Z nuclei (B. BLANK)

LoI_Day1_11 : ^{100}Sn factory - studies of the structure of nuclei in the ^{100}Sn region (D. SEWERYNIAK)

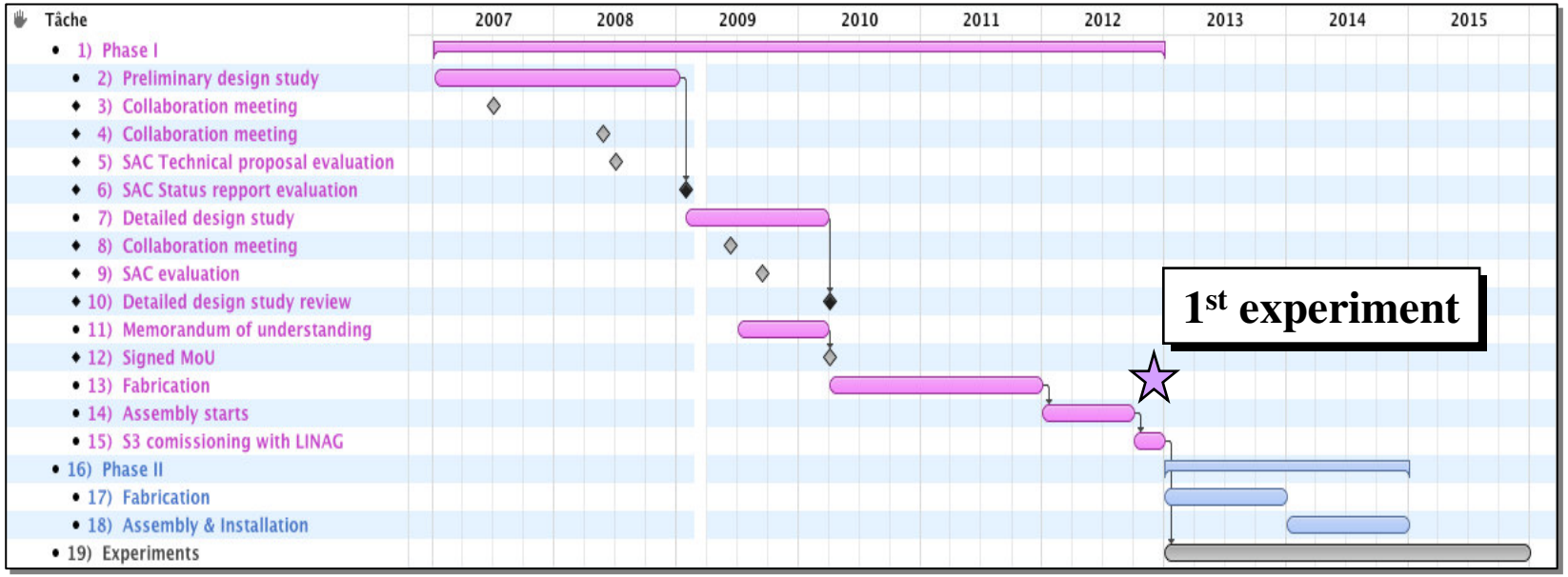
LINAC beams for Day 1 experiments

LINAC beams for the Day 1 SPIRAL2 Phase 1 experiments*)
Based on the recommendations of SPIRAL2 SAC for the LoI
M.L. version 05/10/2009

Ion(s)	Energy Range (MeV/nucleon)	Maximum Intensity (pμA)	Date of availability***)	Remarks
$^{1}H^{1+}$	20-33	2-10	December 2012	NFS beam line; Intensity with fast chopper 1/100
$^{2}H^{1+}$	10-20	2-10	December 2012	NFS beam line; Intensity with fast chopper 1/100
$^{4}He^{2+}$	10-20	2-10	December 2012	NFS beam line; Intensity with fast chopper 1/100
$^{12}C^{4+}$	5-7	10 **)	February 2013	S3 beam line
$^{18}O^{6+}$	5-7	10 **)	February 2013	S3 beam line
$^{22}Ne^{8+}$	5-7	10 **)	February 2013	S3 beam line
$^{40}Ar^{14+}$	4-5	10 **)	February 2013	S3 beam line
$^{28\text{-}30}Si^{10+}$ or $^{32\text{-}36}S^{12+}$	5-7	10 **)	November 2013	S3 beam line
$^{40}Ca^{14+}$	5-7	10 **)	November 2013	S3 beam line
$^{48}Ca^{16+}$	5-7	10 **)	November 2013	S3 beam line
$^{58}Ni^{18+}$	4-14	1 **)	November 2013	S3 beam line

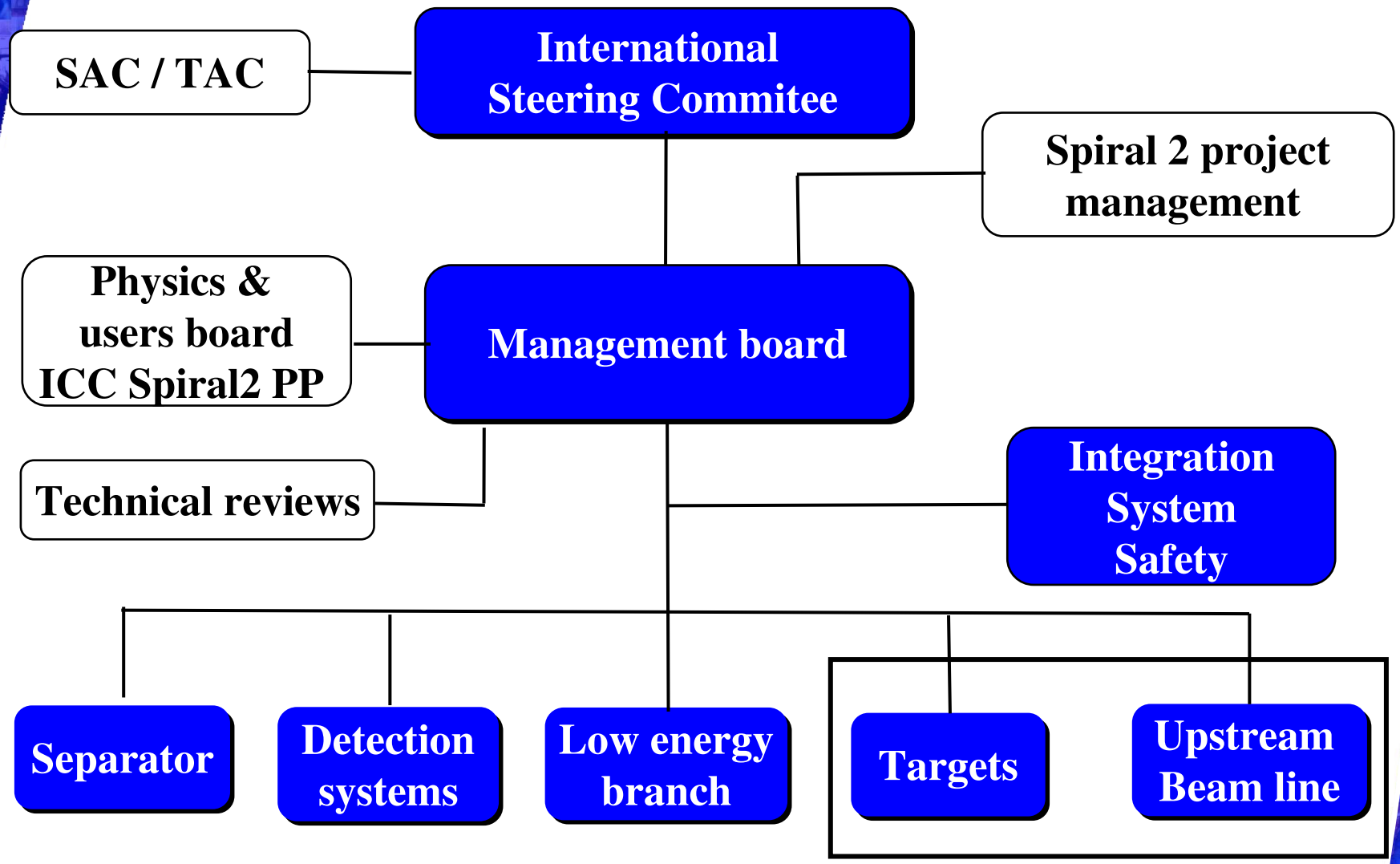
S^3 global schedule

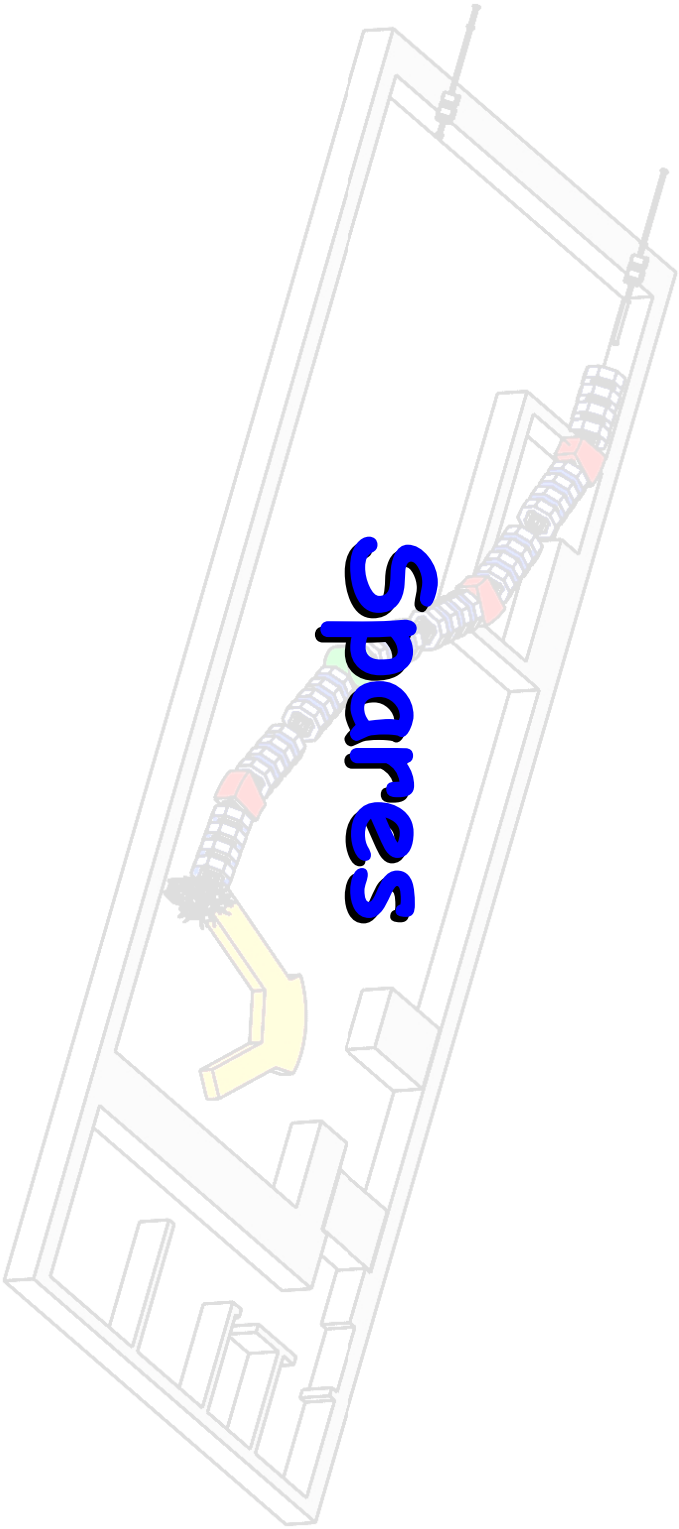
- Phase I [2008-2012] ⇨ **Target system + Separator + Implentation setup + LISOL low energy branch**
- Phase II [2013-2014] ⇨ **Low energy-High Resolution Separator**
- ⇨ Design & Construction of the optical elements will be done within 3 years



- Technical proposal evaluation by SPIRAL2 SAC (June 2008)
  - ⇨**S3 recommended for construction with high priority**
- Status report evaluation by SPIRAL2 SAC (January 2009)
  - ⇨**S3 collaboration is encouraged to apply for funds**
- Project evaluation by IN2P3 SC (January 2009)
  - ⇨**S3 recommended for construction**

S³ project management



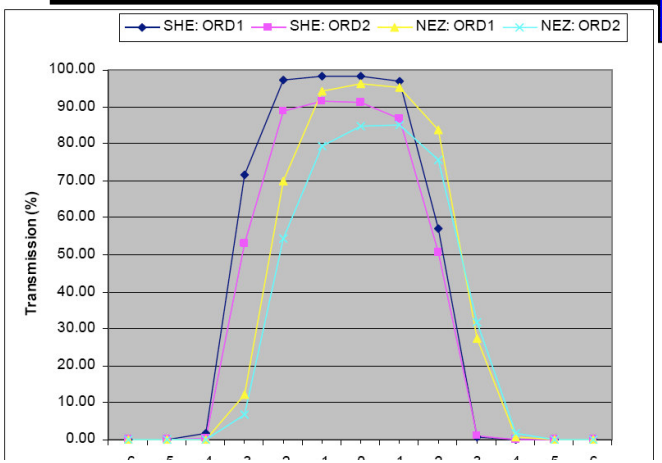


Spares

Transmission of the full system

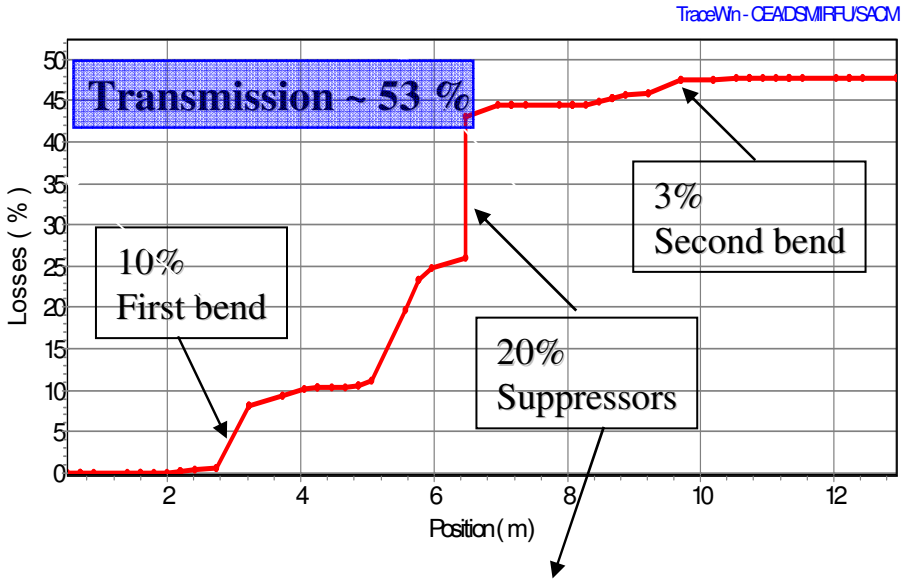
$^{48}Ca+^{248}Cm \rightarrow {}^{292}116 + 4n$

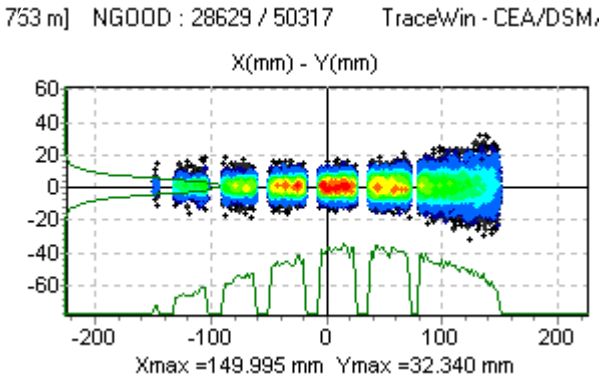
Δq		Transmission for SHE (%) 48Ca+248Cm				%
	%	Order 1	Order 2	Order 3	Order 5	
-6	0	0.00	0.00	0		0.00
-5	0	0.00	0.00	0		0.00
-4	0	1.60	0.31	0.545		0.00
-3	3.5	71.67	53.20	57.71		2.51
-2	6.6	97.44	88.74	85.58		6.43
-1	10.5	98.39	91.57	85.6		10.33
0	14.1	98.31	91.26	85.19	80.91	13.86
1	16.1	96.99	86.84	77.01		15.62
2	15.6	57.00	50.66	38.57		8.89
3	12.8	0.51	1.14	1.35		0.07
4	8.9	0.00	0.00	0		0.00
5	5.2	0.00	0.00	0		0.00
6	2.6	0.00	0.00	0		0.00
						57.70



ANL & GANIL Monte Carlo simulations

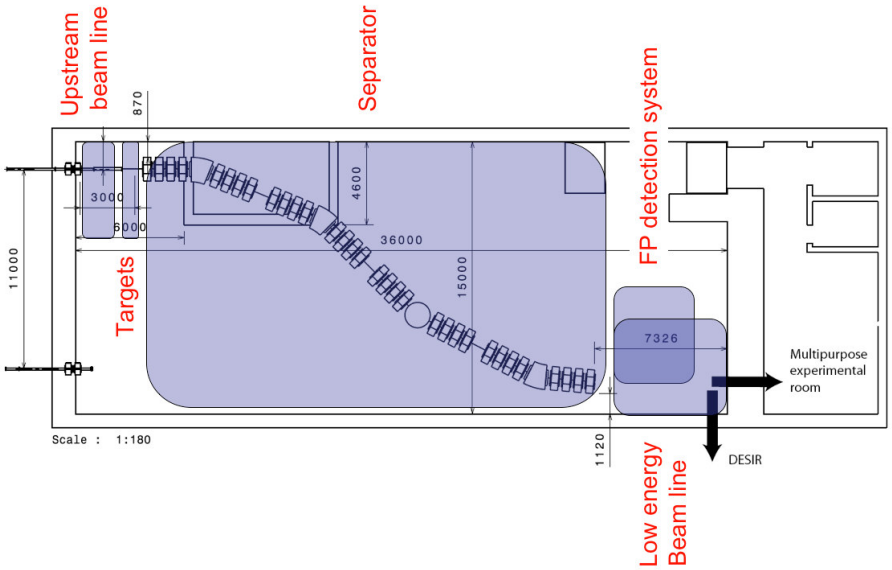
$^{58}Ni+^{46}Ti \rightarrow {}^{100}Sn + 4n$





Irfu Monte Carlo simulations

S³ Product Breakdown Structure



Code PBS	Arborescence Produits / Product breakdown structure						
	Niv 1	Niv 2	Niv 3	Niv 4			
8500	S3 - PBS						
8510	GENERAL						
8511		Project control					
8512		Organization					
8513		Meetings					
8514		Safety					
8515		System engineer					
8520	INFRASTRUCTURE						
8521		Building interface					
8522		Power supplies (<380V)					
8523		Water supplies					
8524		Gas supplies					
8525		Communication networks					
8526		Storage					
8530	SEPARATOR						
8531		Magnets					
8532		Vacuum					
8533		Diagnostics					
8534		Mecanics					
8535		Beam dumps and slits					
8536		Power converters					
8540	TARGETS						
8541		Target materials					
8542		Wheels-Chambers					
8543		Target diagnostics					
8544		Mecanics					
8545		Vaccum					
8550	DETECTION SYSTEMS						
8551		Focal plane spectroscopy					
8552		In beam spectroscopy					
8553		Ancillary detectors					
8554		Acquisition & software					
8555		Mecanics					
8556		Vaccum					
8560	LOW ENERGY BRANCH						
8561		Ion catcher					
8562		Mass separator					
8563		Laser system					
8564		Gas handling					
8565		Power supplies					
8566		Mecanics					
8567		Vaccum					
8568		Multipurpose experiments					
8569		DESIR connection					
8570	UPSTREAM BEAM LINE						
8571		Magnets					
8572		Vacuum					
8573		Diagnostics					
8574		Mecanics					
8575		Power supplies					
8580	COMMANDS & CONTROLS						
8600	DECONSTRUCTION						

Preliminary Workpackage Structure

Code WP	S3 WP		GANIL	Irfu	ANL	CSNSM	IPHC	LPSC	KU Leuven	BARC	Target users (CACAO, GSI, Dubna, LLNL)	GSI
	S3 - project											
WP 1	GENERAL											
		Scientific coordination	■	■	■							
		Tecnical coordination		■								
		Safety coordination	■									
		Layout integration	■									
		Infrastructure integration	■									
WP 2	SEPARATOR											
	2.1	Optics Simulations	■	■	■							
	2.2	Magnetic dipole design	■									
	2.3	Electric dipole design	■		■							
	2.4	Multipoles design										
		SC option		■	■					■		
		Warm option	■	■								
	2.5	General beam dump		■								
	2.6	Momentum focal plane fingers		■						■		
	2.7	Slits	■	■								
	2.8	Diagnostics/Profilers	■									
	2.9	Diagnostics/FC&TI	■				■					
	2.10	Mechanical design	■									
	2.12	Power supplies	■									
	2.14	Vaccum system	■									
WP 3	TARGETS											
	3.1	Simulations	■									
	3.2	Target materials	■								■	
	3.3	Wheel chamber/Stable	■	■							■	
	3.4	Wheel chamber/Actnide	■								■	
	3.5	Target diagnostics	■				■					■
	3.6	Mechanical design	■	■								
	3.7	Glove box	■									
	3.9	Beam spot on target	■									
WP 4	DETECTIONS											
	4.1	Simulations				■	■					
	4.2	Tracking detectors	■	■								
	4.3	Implentation detectors & tunnel detectors		■	■	■		■				■
	4.4	Gamma detectors	■				■					
	4.5	Front end electronics	■	■	■	■						
	4.6	Back end electronics	■			■						
	4.7	Slow control	■			■						
	4.8	Acquisition and software	■			■						
	4.10	Mechanical design	■	■	■	■	■					
WP 5	LOW ENERGY BRANCH											
	5.1	Ion Catcher			■				■			
	5.2	Mass separator							■			
	5.3	Laser system	■						■			
	5.4	Gas handling system	■		■				■			
	5.5	Roots pumps	■						■			
	5.6	Mechanical design	■		■				■			
	5.7	Diagnostics										
	5.8	DESIR connection										

Base detection system

- ❑ Number of channels ~ 650
- ❑ Counting rate = 1kHz/channel
- ❑ Charge pre-amps
- ❑ 20 keV@ 5 MeV α
- ❑ 5-10 MeV Heavy ions
- ❑ 2 gains
- ✓ High gain for α
- ✓ low gain for HI
- ❑16384 channels ADC
- ❑ Energy, Time Stamp, PSA
- ❑ Sampling 100 MHz 14 bits

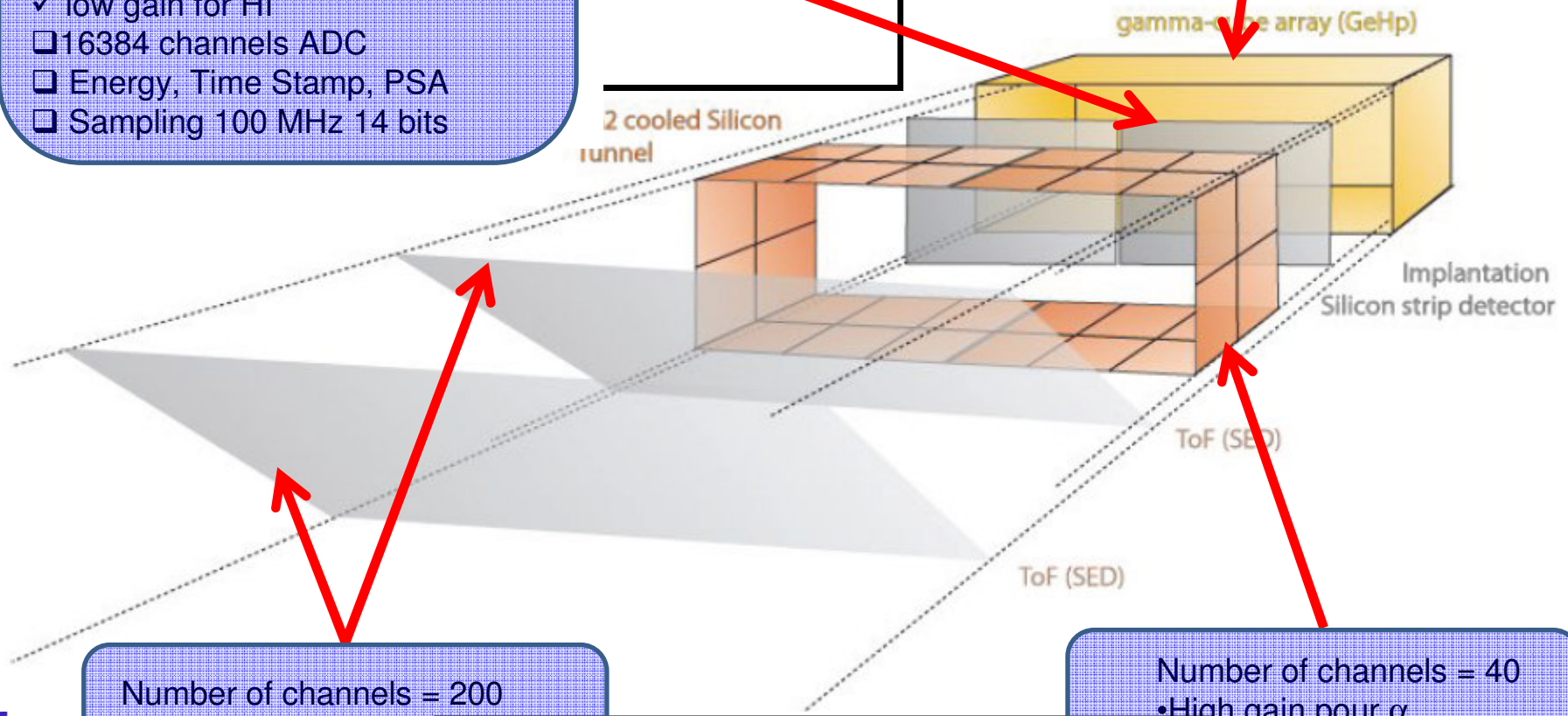
…scopy setup :

…tection

…d e⁻ and α

…pectroscopy

- ❑ Number of channels = 32
- ❑ Counting rate = 1kHz/core
- ❑ 2.3 keV @ 1.3 MeV
- ❑ Energy, Time Stamp, PSA
- ❑ Sampling 100 MHz, 14 bits
- ❑ Triggerless



Number of channels = 200
Counting rate = 1kHz/channel
Resolution : 10%

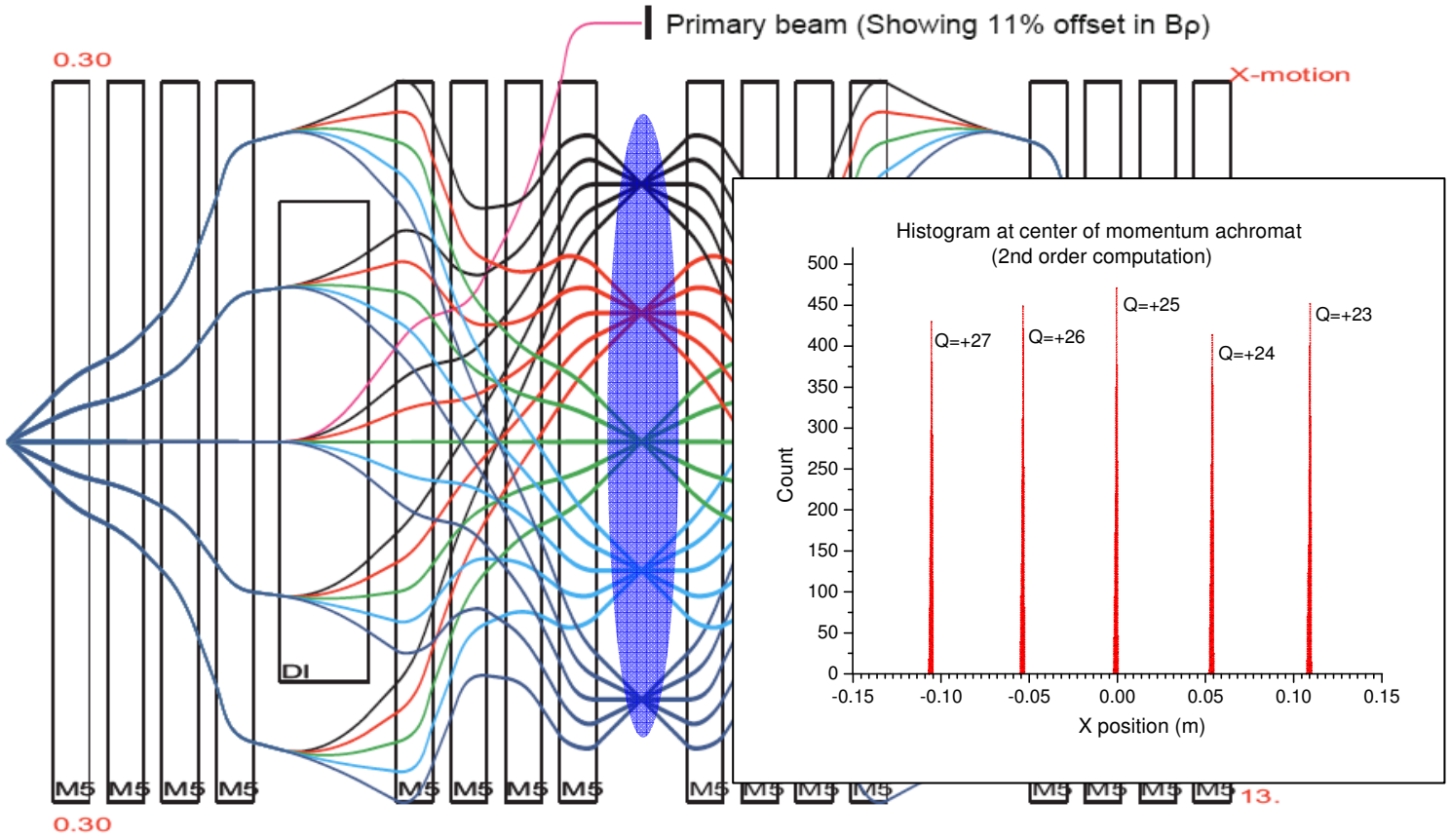
Number of channels = 40
•High gain pour α
•Low gain pour HI

⇨ 5 charge states are expected in 14×6 cm²

Momentum Achromat

Momentum achromat : First order

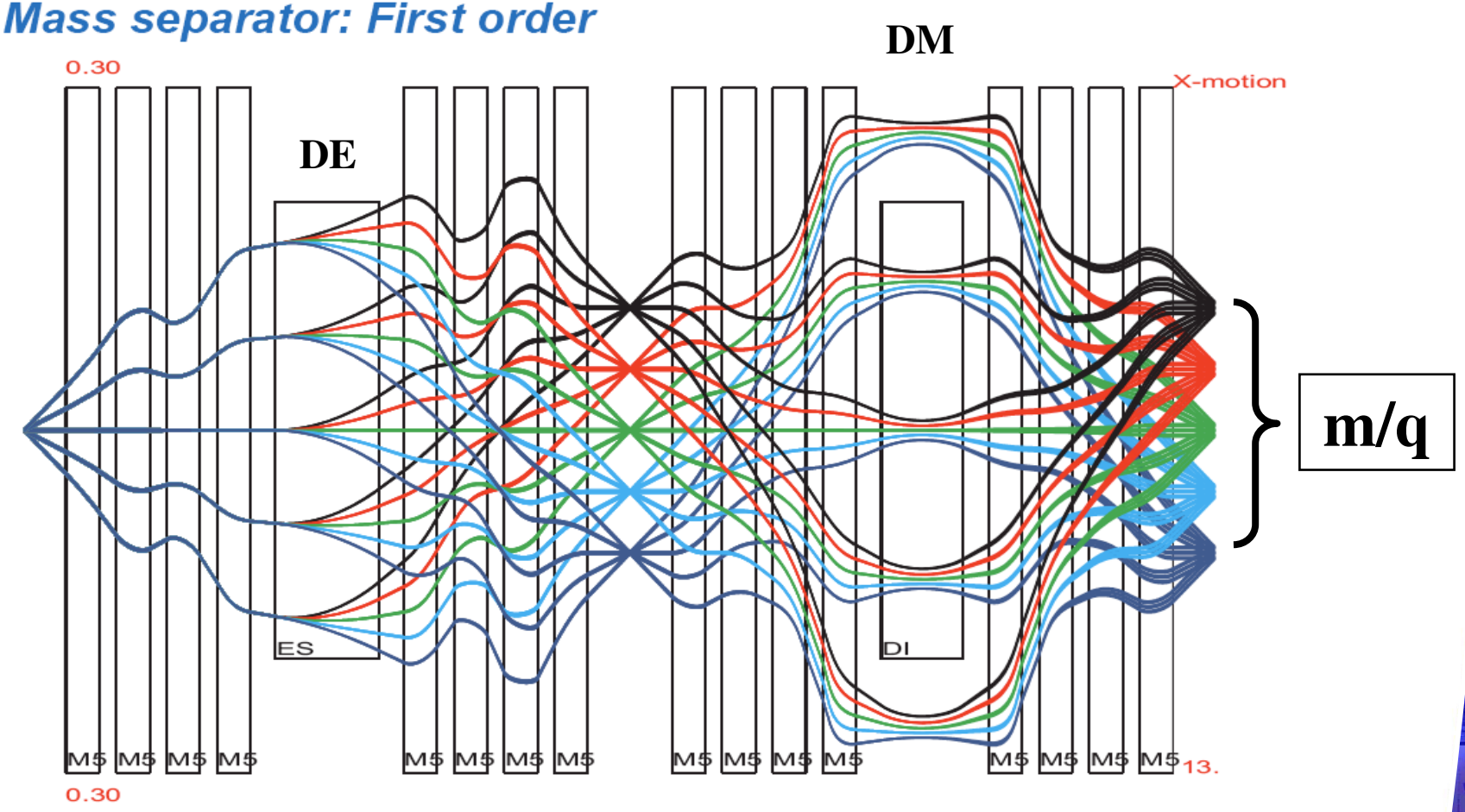
1:1000 beam suppression



- Double mirror symmetric layout with 13 mm/% momentum dispersion at the center
- Beam dump is a water cooled bar following the first dipole
- The final image is fully achromatic in momentum, charge state, and unit magnifications in both planes

Mass Separator

Mass separator: First order



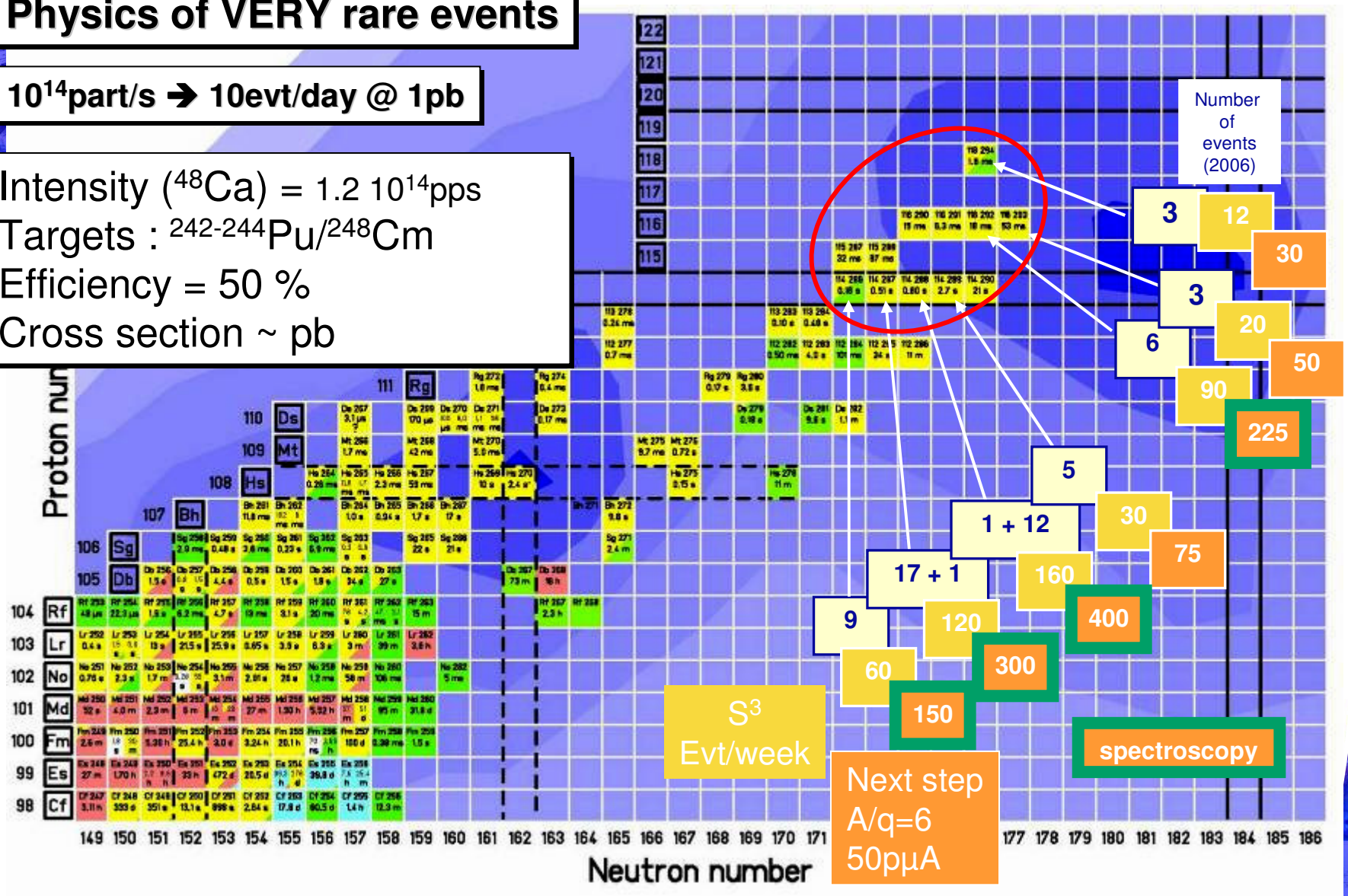
❍ Mirror symmetric layout with 6.7 mm/% m/q dispersion at the mass focal plane

Studying, completing, enlarging

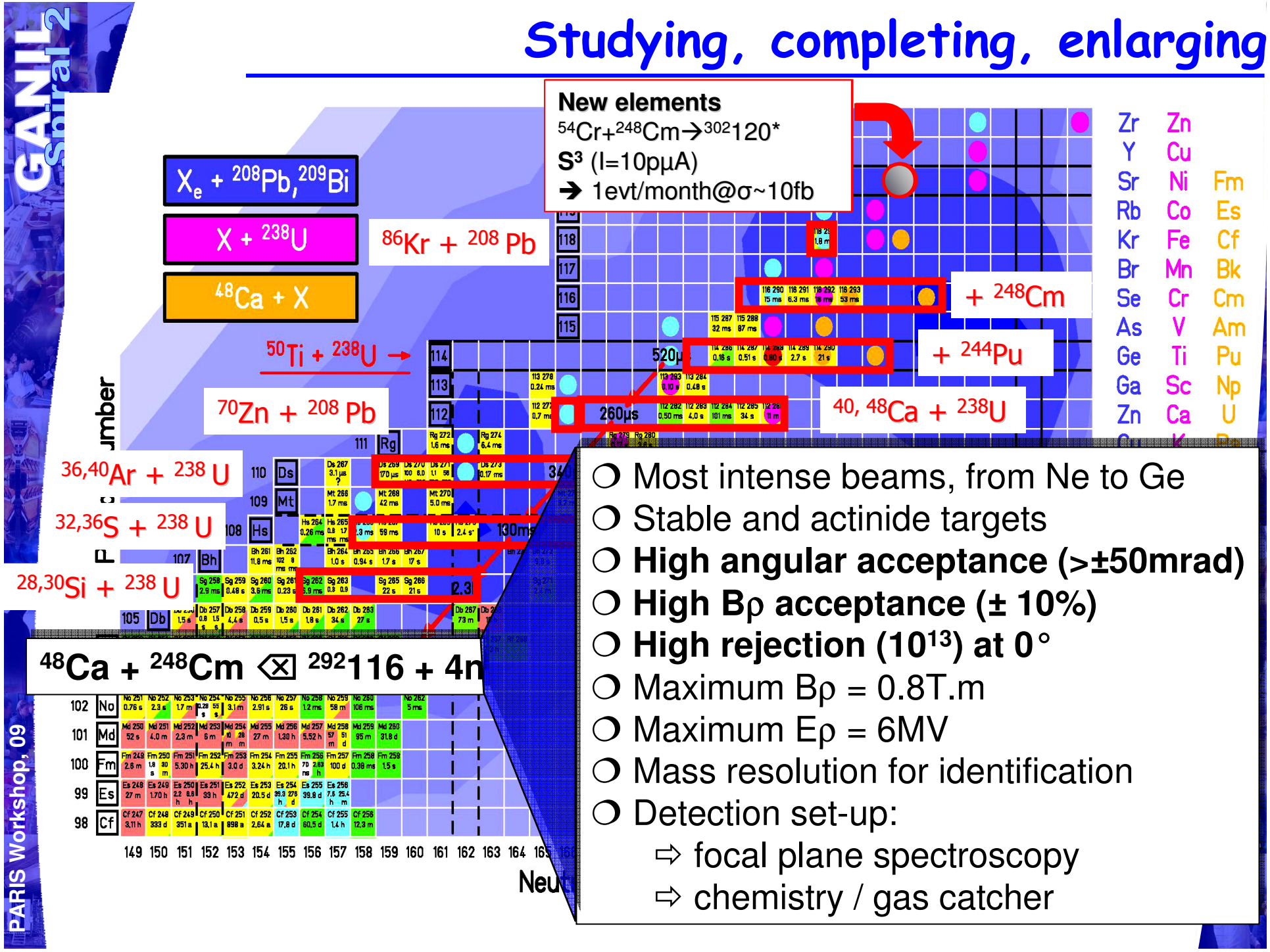
Physics of VERY rare events

10^{14}part/s ➔ 10evt/day @ 1pb

Intensity (^{48}Ca) = 1.2 10^{14}pps
Targets : $^{242\text{-}244}$Pu/^{248}Cm
Efficiency = 50 %
Cross section ~ pb



Studying, completing, enlarging

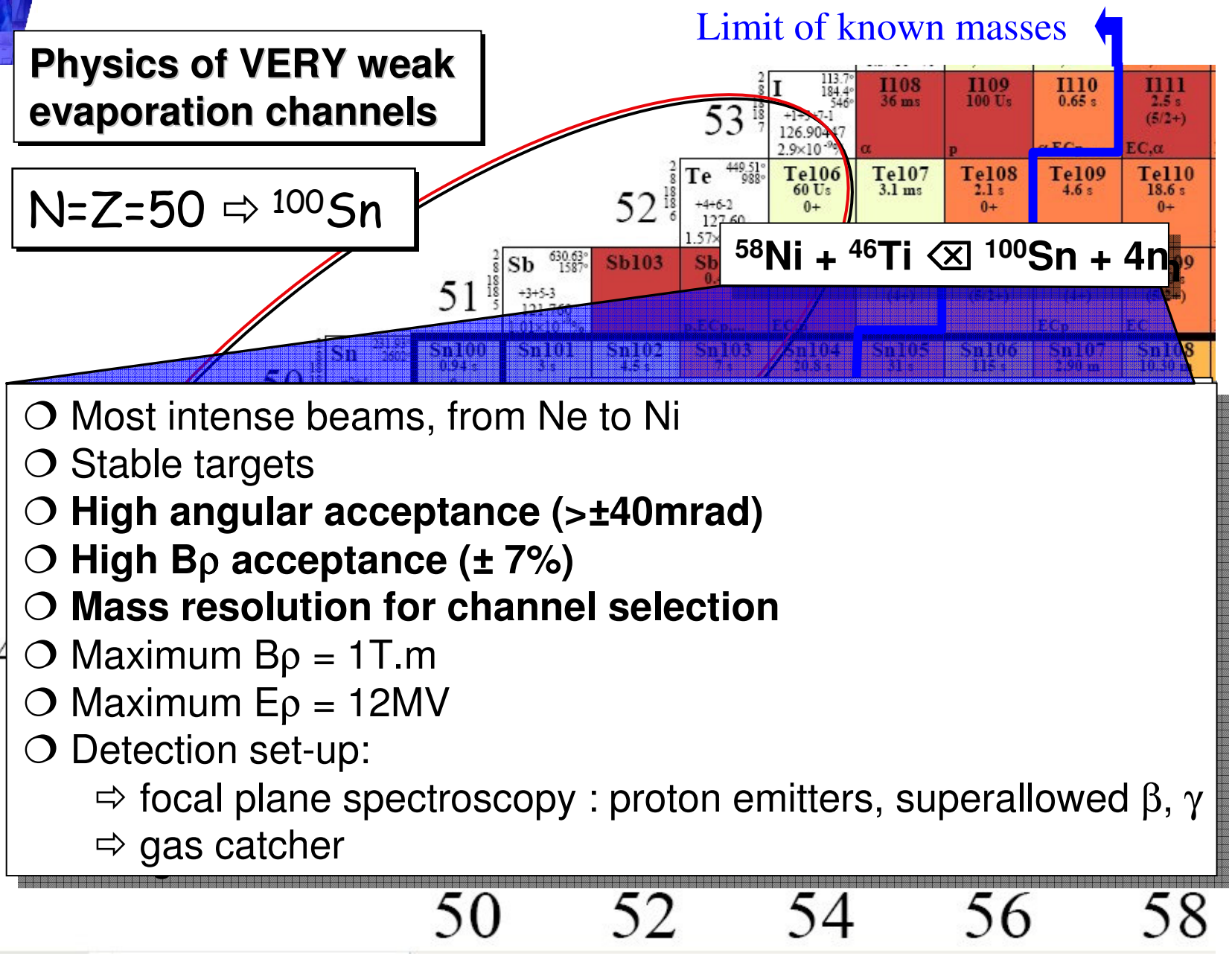


- Most intense beams, from Ne to Ge
- Stable and actinide targets
- **High angular acceptance (>±50mrad)**
- **High Bρ acceptance (± 10%)**
- **High rejection (10^{13}) at 0°**
- Maximum Bρ = 0.8T.m
- Maximum Eρ = 6MV
- Mass resolution for identification
- Detection set-up:
  - ⇨ focal plane spectroscopy
  - ⇨ chemistry / gas catcher

Self conjugate doubly magic ^{100}Sn

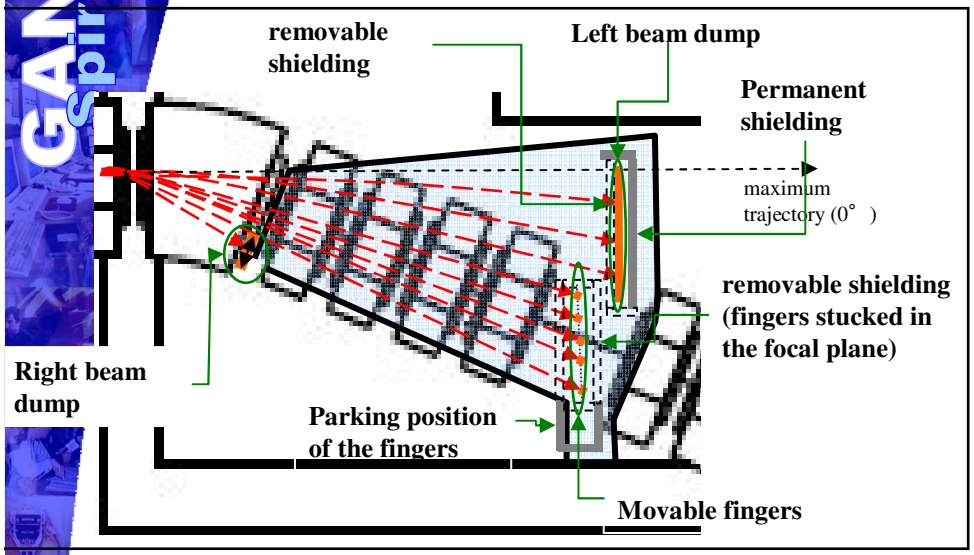
Physics of VERY weak evaporation channels

N=Z=50 ⇨ ^{100}Sn



- Most intense beams, from Ne to Ni
- Stable targets
- **High angular acceptance (>±40mrad)**
- **High Bρ acceptance (± 7%)**
- **Mass resolution for channel selection**
- Maximum Bρ = 1T.m
- Maximum Eρ = 12MV
- Detection set-up:
  - ⇨ focal plane spectroscopy : proton emitters, superallowed β, γ
  - ⇨ gas catcher

Nuclear Design

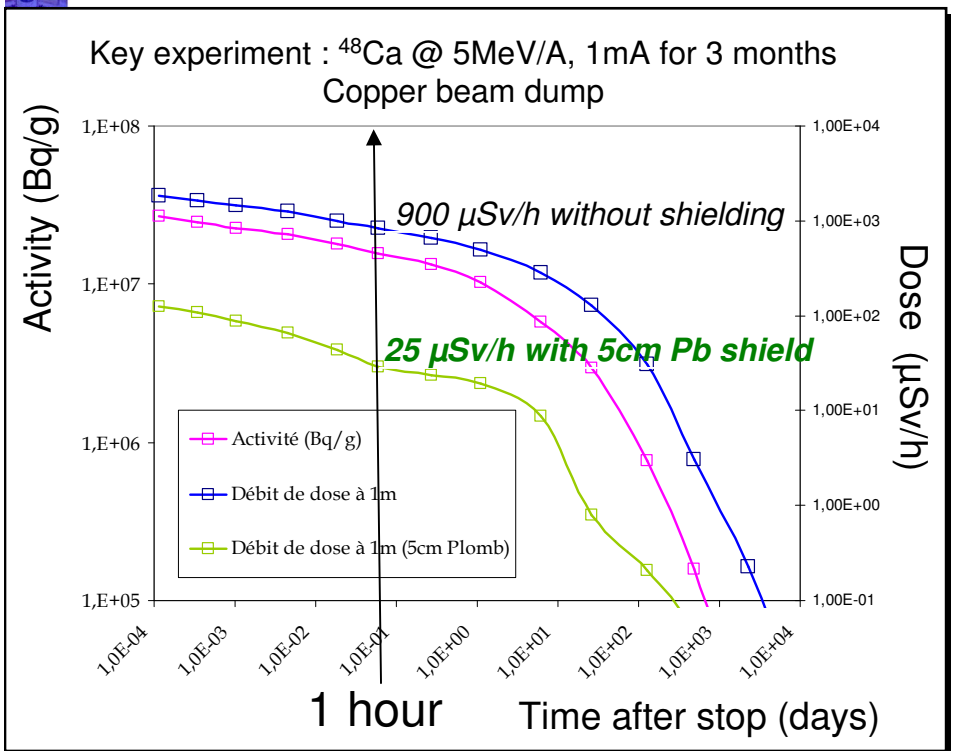


Conceptual design

- Open multipoles to extract the beam
- Local shielding (static and movable parts)

First calculations on a realistic case show that :

- Dose is compatible with immediate human intervention
- No major impact on the spectrometer design
- No major impact on the cost estimate



Under progress

- detailed calculations with other realistic physics cases
- optimization of the beam dump material (dose divided by 6 with Tungsten)
- optimization of the geometry

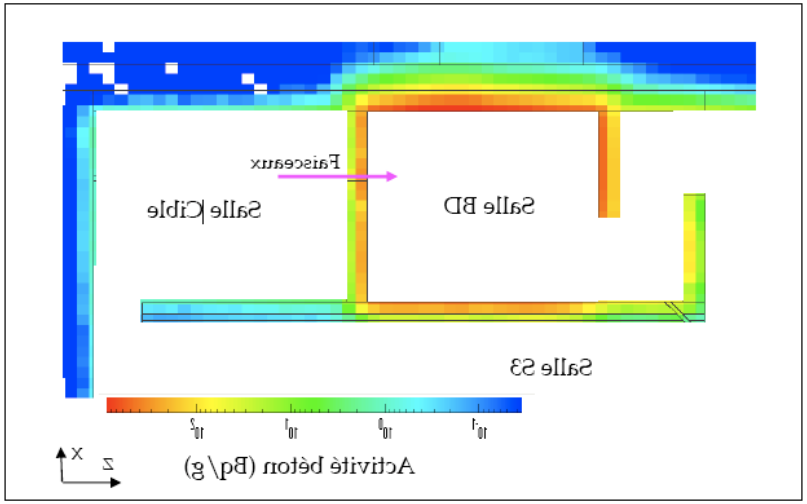
⇨ **Technical design before end of 2009**

H. Savajols

Nuclear Design

Heavy ion beams from LINAG
- ⇨ from C to U
- ⇨ 2 to 15 A.MeV
- ⇨ up to 10^{15}ions/sec
- ⇨ up to 50kW

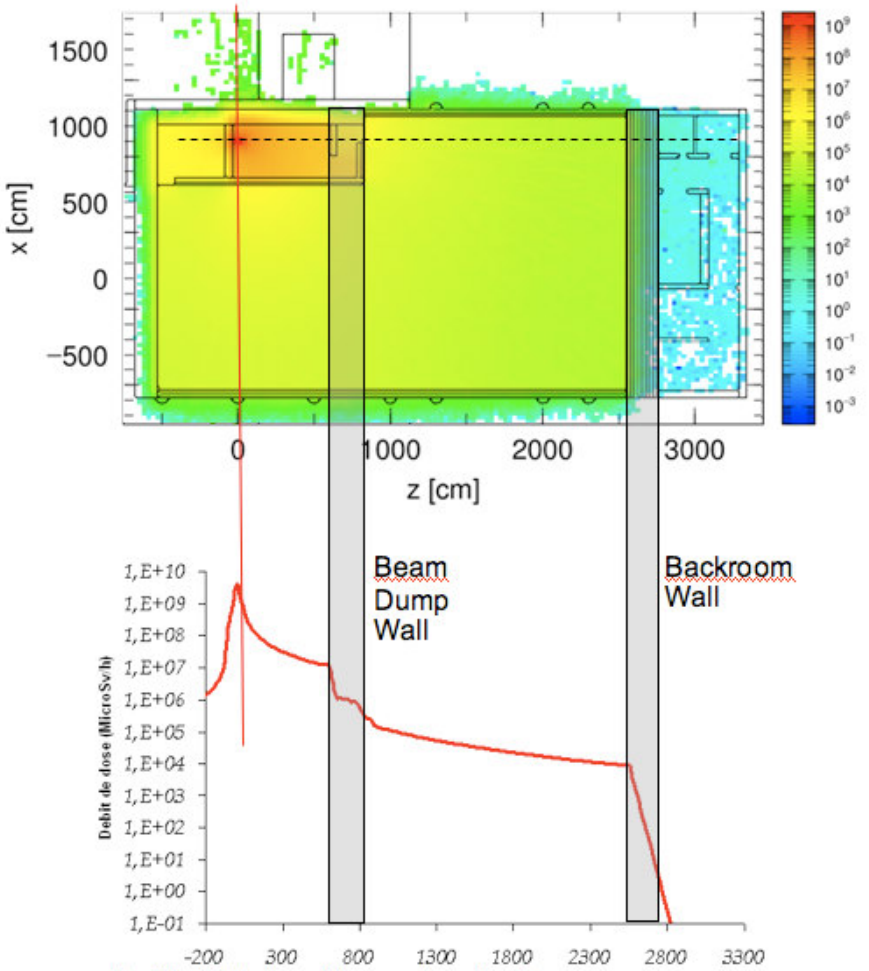
Reference beam ⇨ ^{12}C @ 14.5 MeV/u
Intensity = 1mA (1.6×10^{15} pps)



Concrete activation

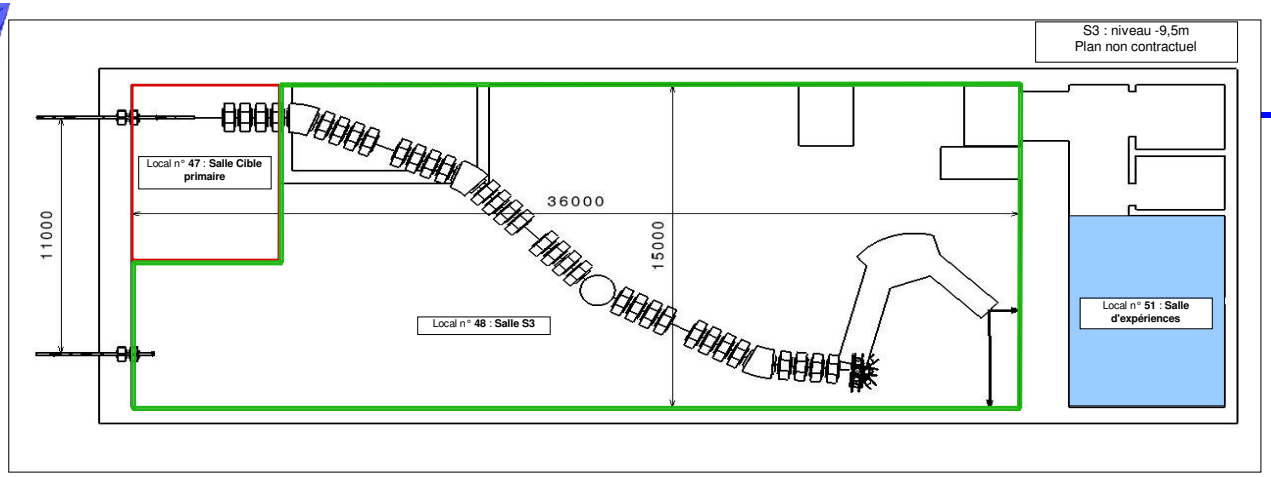
⇨ Preliminary safety report (April09)

Neutrons fluxes in the S^3 cave vicinity

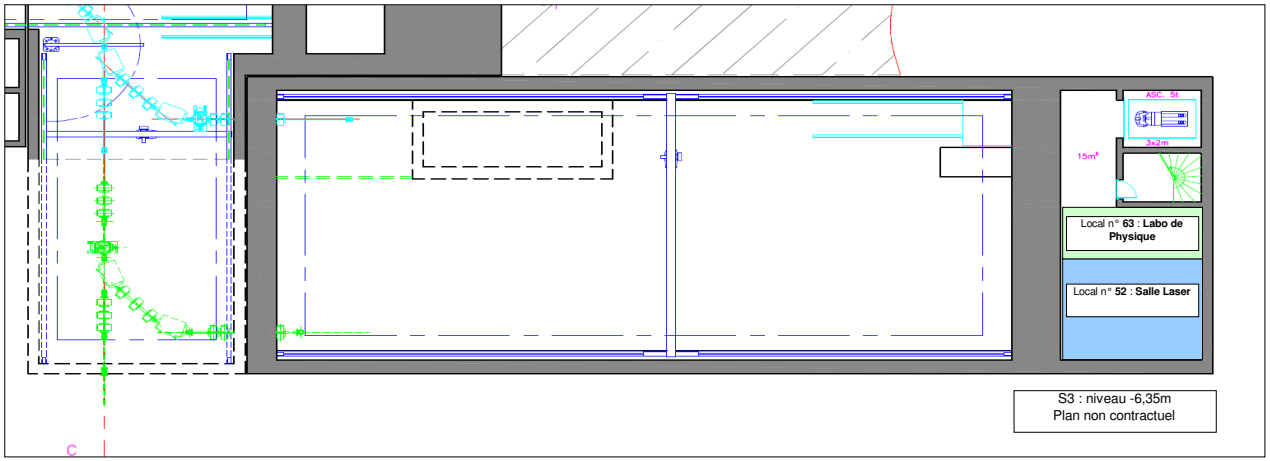


Up: 2D distribution of the number of neutrons
Down: Dose (μSv/h) due to the neutrons on the 0° (beam) direction (corresponding ot the dashed line)

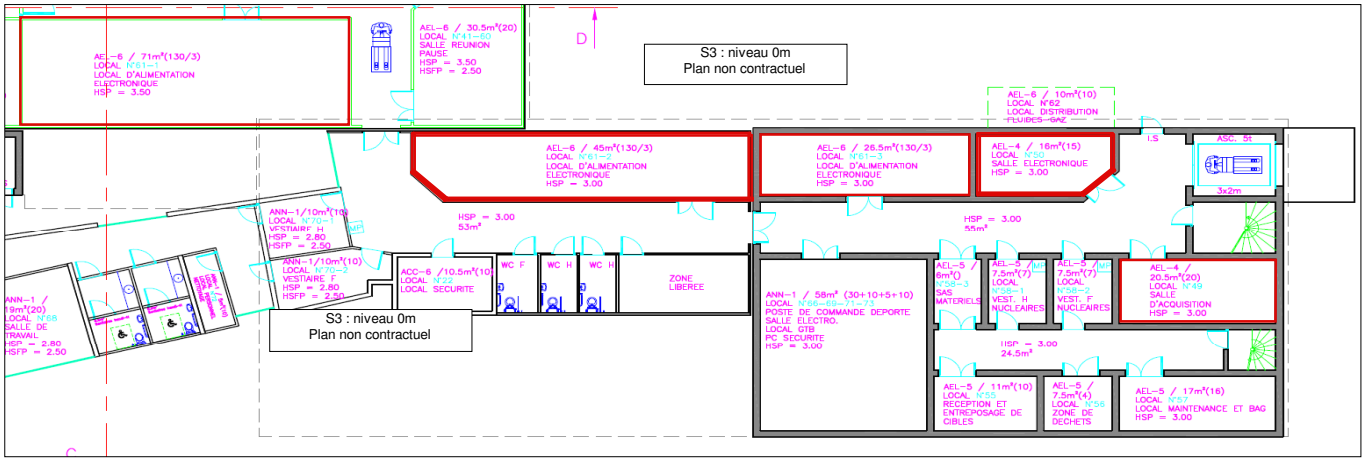
phase 1



Level : -9.5m



Level : -6m

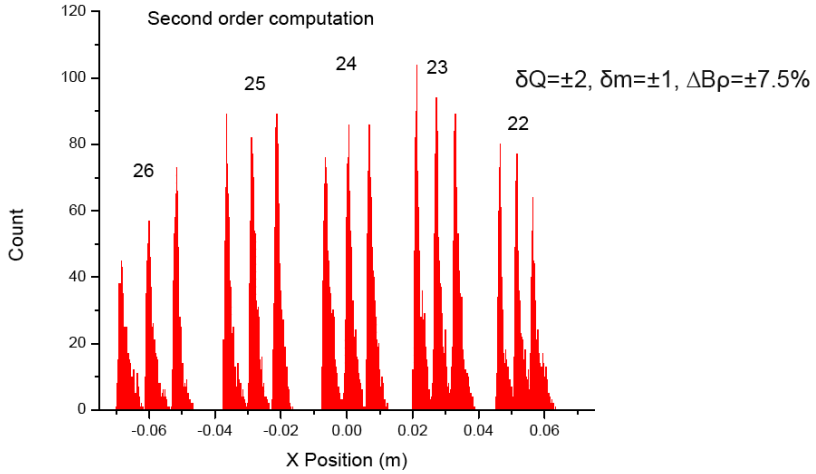


Ground level

Transmission of the full system

⇨ 5 charge states will be transmitted to the focal plane covering a 14Lx6H cm2 area.
⇨ The expected transmission efficiency is of the order of 50%.

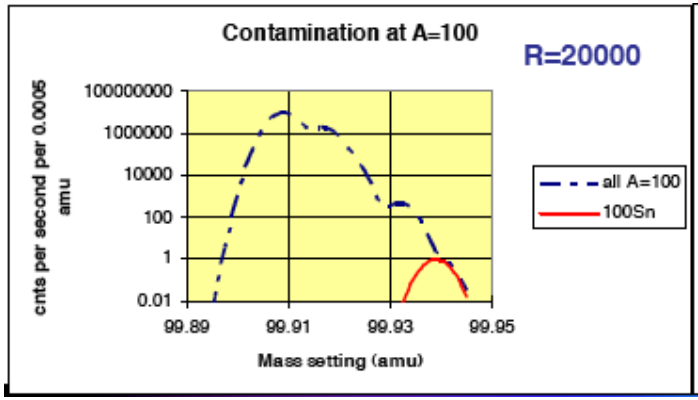
^{58}Ni + Ti ⇨ ^{100}Sn (1 Mev/A, 20 pps + 10^8 isobars/s)

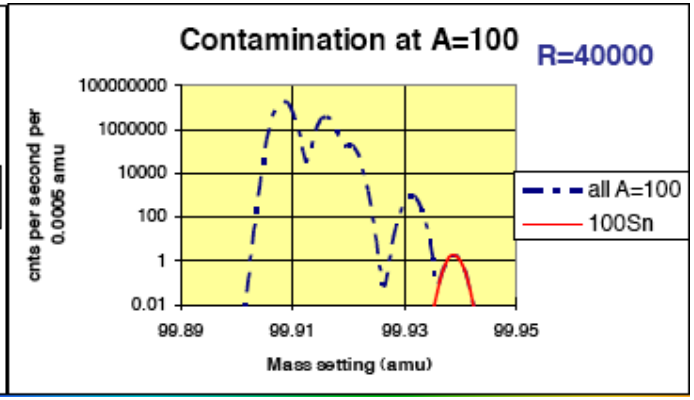


Plot showing position of mass line

Isotope	Mass (amu)	Separation (M/ΔM)
Sn100	99.938954	-----
In100	99.931149	12800
Cd100	99.920230	5330
Ag100	99.916069	4370
Pd100	99.908505	3280

A=100 Isobar mass contamination @ FP



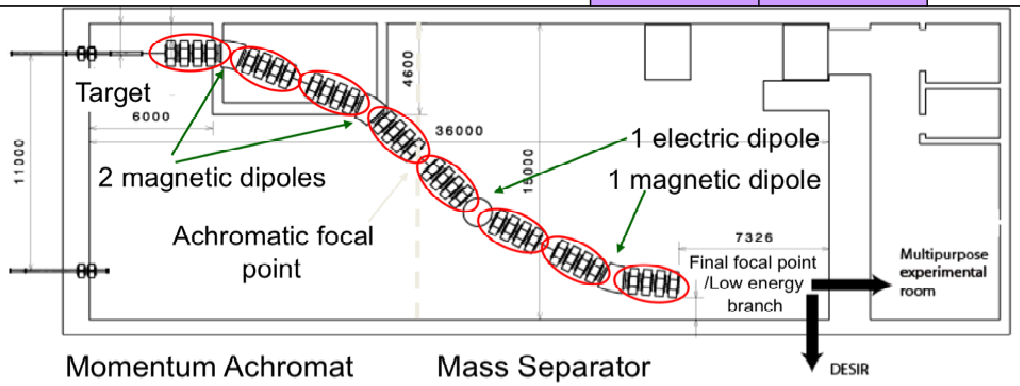


LINAC parameters

Letter	Title	Requested beam	Requested bear energy	Beam Intensity i mic.A	Requested Numb of 8h Shifts
LoI_Day1_1	Fast ion-slow ion collisions –FISIC project	18O6+ or 20Ne7+ or 36Ar12+	4-14	50, 25, 15	42
LoI_Day1_2	Production and spectroscopy of heavy and superheavy elements using S3 and LINAC	12C 18O 19F 22Ne 28-30Si 32-36S 40-48Ca 40Ar	5-7 5-7 5-7 5-7 5.64 5.69-5.05 5.75-4.8 4.88	10 10 40 30 10 10 10 10	84 84 84 84 84 84 84 84
LoI_Day1_3	In-source resonant laser ion spectroscopy of 94Ag	40Ca14+ or 58Ni18+	4.78 or 4.74	10 or 1	21
LoI_Day1_4	In-source resonant laser ion spectroscopy of the light Sn isotopes A = 101-107	58Ni18+	3.67	1	21
LoI_Day1_5	In source resonant laser ion spectroscopy of Z >=92	22Ne7+	4-5	25	21
LoI_Day1_6	Single proton states and proton-neutron interaction in 100Sn	58Ni	10	1	60
LoI_Day1_7	In-beam gamma spectroscopy of neutron-rich nuclei studied with PARIS a intermediate focal plane of S3	48Ca	10	10	30
LoI_Day1_8	Shell structure, Isospin symmetry and shape changes in N=Z nuclei: Coulomb excitation of 104Sn: probing large scale shell model calculation Coulomb excitations of the T=1 bands of the odd-odd 62Ga, 66As and 70	58Ni	3.5	1	30
LoI_Day1_9	Quadrupole Moments of isomeric states using the Tilted-foils Technique at S3	?	?	?	?
LoI_Day1_10	Precision study of the superallowed beta decay of heavy odd-odd N=Z nuclei	28Si, 36Ar, 40Ca, 46Ti, 50Cr, 58Ni, 64Zn	5 A.MeV	> 1	~ 25
LoI_Day1_11	^{100}Sn factory – studies of the structure of nuclei in the ^{100}Sn region	58Ni	4.31 3.71 4.14	1 10	39 39

S3 operation modes

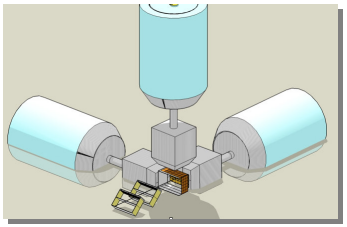
Letter	Title	Momentum achromat	Mass Separator	Low Energy Branch	Spectrograph
LoI_Day1_1	Fast ion-slow ion collisions –FISIC project	■			■
LoI_Day1_2	Production and spectroscopy of heavy and superheavy elements using S3 and LINAG		■		
LoI_Day1_3	In-source resonant laser ion spectroscopy of 94Ag	■	■	■	
LoI_Day1_4	In-source resonant laser ion spectroscopy of the light Sn isotopes A = 101-107	■	■	■	
LoI_Day1_5	In source resonant laser ion spectroscopy of Z >=92	■	■	■	
LoI_Day1_6	Single proton states and proton-neutron interaction in 100Sn	■	■		
LoI_Day1_7	In-beam gamma spectroscopy of neutron-rich nuclei studied with PARIS at th intermediate focal plane of S3	■			■
LoI_Day1_8	Shell structure, Isospin symmetry and shape changes in N=Z nuclei: Coulomb excitation of 104Sn: probing large scale shell model calculation Coulomb excitations of the T=1 bands of the odd-odd 62Ga, 66As and 70Br	■	■		
LoI_Day1_9	Quadrupole Moments of isomeric states using the Tilted-foils Technique at S3	■			
LoI_Day1_10	Precision study of the superallowed beta decay of heavy odd-odd N=Z nuclei	■	■	■	
LoI_Day1_11	^{100}Sn factory – studies of the structure of nuclei in the ^{100}Sn region	■	■		



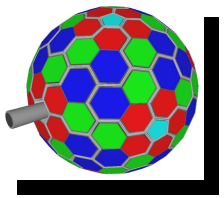
S3 Detection systems

Letter	Title	Mass Focal Plane			Achromatic point	
		Implantation decay station	Gas Cell	other devices	Secondary target	Ancillary detectors
LoI_Day1_1	Fast ion-slow ion collisions –FISIC project				Chamber for ion-ion collision	
LoI_Day1_2	Production and spectroscopy of heavy and superheavy elements using S3 and LINAG					
LoI_Day1_3	In-source resonant laser ion spectroscopy of 94Ag			Laser Ion Source		
LoI_Day1_4	In-source resonant laser ion spectroscopy of the light Sn isotopes A = 101-107			Laser Ion Source		
LoI_Day1_5	In source resonant laser ion spectroscopy of Z >=92			Laser Ion Source		
LoI_Day1_6	Single proton states and proton-neutron interaction in 100Sn				Phase 2	Ge array Charge particle array
LoI_Day1_7	In-beam gamma spectroscopy of neutron-rich nuclei studied with PARIS at the intermediate focal plane of S3					PARIS Demonstrator + EXOGAM2 /AGATA Demonstrator
LoI_Day1_8	Shell structure, Isospin symmetry and shape changes in N=Z nuclei: Coulomb excitation of 104Sn: probing large scale shell model calculation Coulomb excitations of the T=1 bands of the odd-odd 62Ga, 66As and 70Br nuclei			Coulex target Ge array (AGATA or EXOGAM)		
LoI_Day1_9	Quadrupole Moments of isomeric states using the Tilted-foils Technique at S3					Implantation host Ge array (EXOGAM2 - PARIS - AGATA)
LoI_Day1_10	Precision study of the superallowed beta decay of heavy odd-odd N=Z nuclei			Beta-gamma decay station		
LoI_Day1_11	^{100}Sn factory – studies of the structure of nuclei in the ^{100}Sn region				Phase 2	Ge array Charge particle array

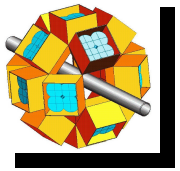
S3 decay station



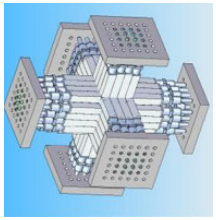
AGATA



EXOGAM 2



PARIS



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Ancillary devices