HYDE

I. Martel
University of Huelva (Spain)
for the HYDE Collaboraboration

<u>HYDE COLLABORATION (OPEN!!):</u>

GSI-Darmstadt, Germany
Universidad de Huelva, Spain
Universidad de Sevilla, Spain
Instituto de Estructura de la Materia, CSIC-Madrid, Spain
Instituut Voor Kern- en Stralingsfysica, University of Leuven, Belgium
Soltan Institute for Nuclear Studies, Warsaw, Poland
Cyclotron Research Center, Louvain la Neuve, Belgium

Reactions with drip-line nuclei using the HYbrid DEtector-BALL array HYDE

Motivation:

Study elastic and inelastic scattering, break-up, transfer reactions, Coulonb dissociation

→Neutron and proton drip line nulclei, **half life around/below ms.**

→ Direct and inverse kinematics techniques

Low energies radioactive beams → 3-10 MeV/u

B(El) values, quadrupole deformations, clustering configurations→ collective phenomena/nucleon-nucleon correlations

Physics at the border lines of nuclear stability

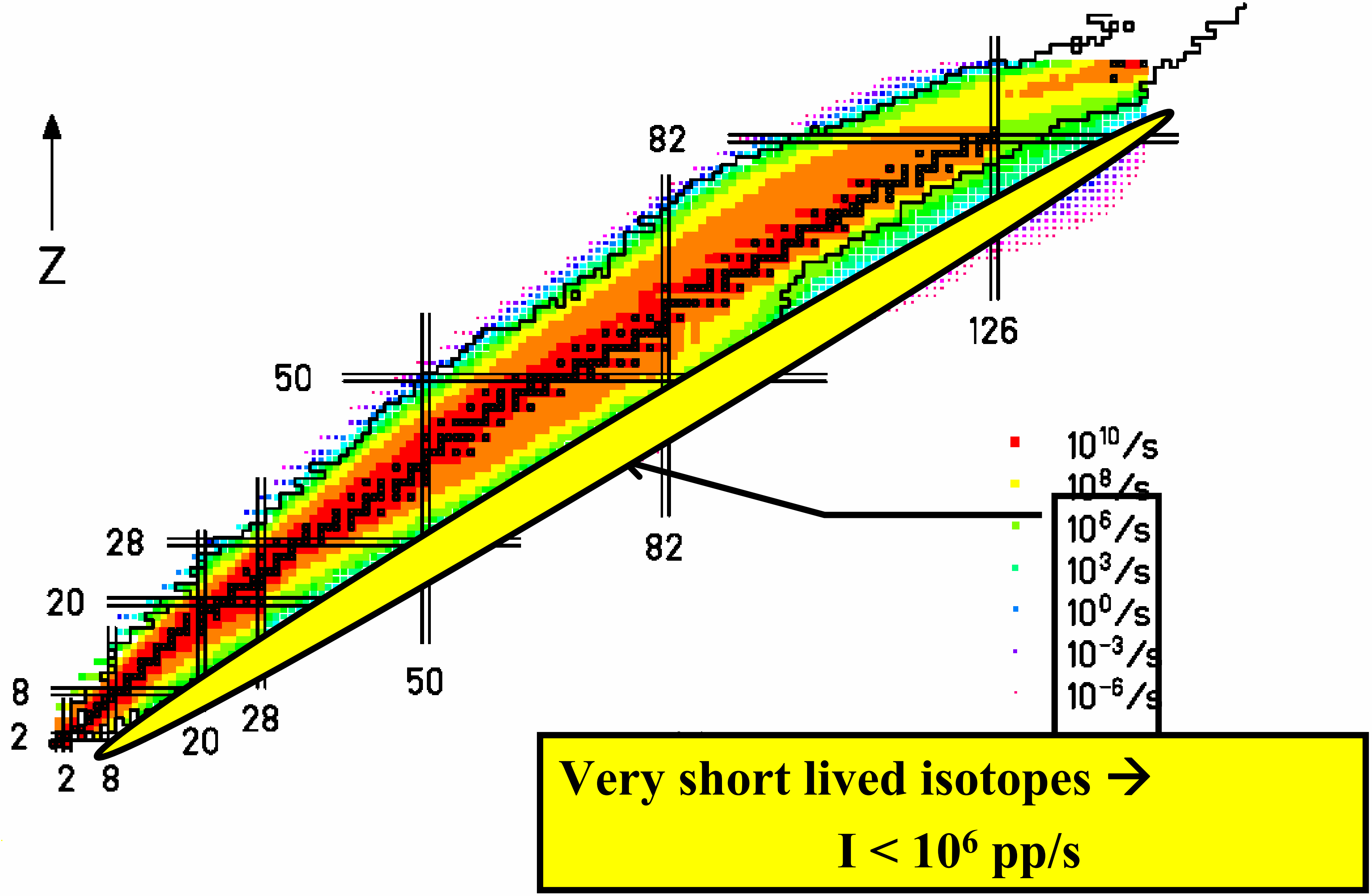
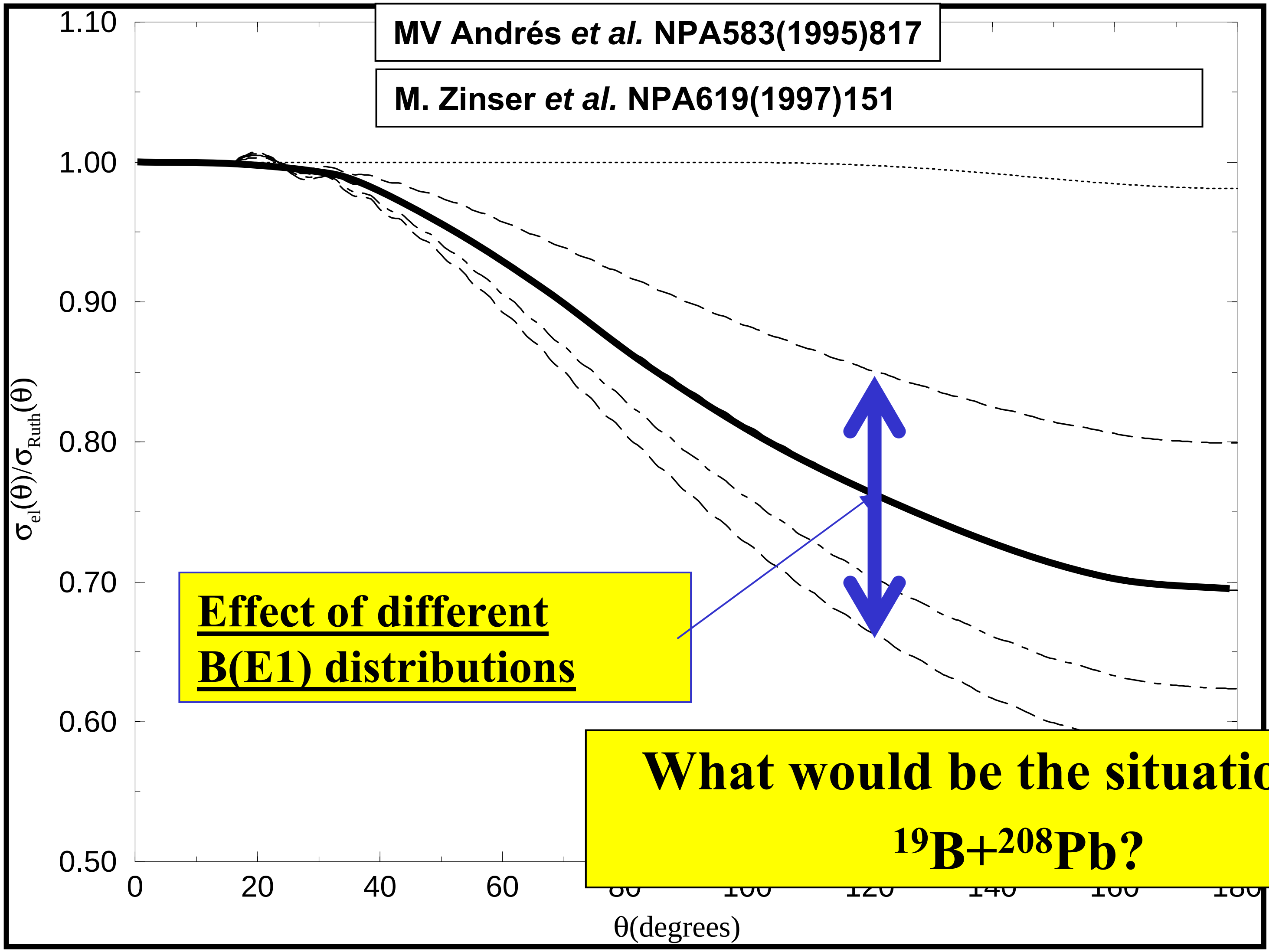


Figure 1.17: Predicted productions rates (for nuclei with half-lives larger than 100 ns) at the proposed facility. Primordial nuclei, closed shells, and the limits of known nuclei are indicated in black.

Elastic scattering of $^{11}Li+^{208}Pb$ at 3 MeV/u



What would be the situation for $^{19}B+^{208}Pb$?

Coulomb dissociation of light neutron rich nuclei

-Study Coulomb dissociation by kinematically complete measurements of breakup particles.

- GSI, RIKEN, 15C,19C at high energies → small scattering angles.
T. Nakamura et al., NPA722 (2003) 301-307, U. Datta Pramanik et al., PLB 551 (2003) 63.

→Study B(El) strength and spectroscopic information about ground state.

$$\frac{d\sigma_{\mathrm{CD}}}{dE_{\mathrm{rel}}} = \frac{16\pi^3}{9\hbar c} N_{\mathrm{E1}}(E_{\mathrm{x}}) \frac{dB(\mathrm{E1})}{dE_{\mathrm{rel}}}.$$

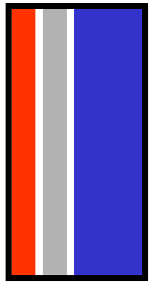
-At low beam energies, Coulomb interaction will become the dominant reaction mechanism → reduce interference arising from nuclear interaction.

Need neutron and charge particle detection:
→ HYDE+ Neutron Detector←

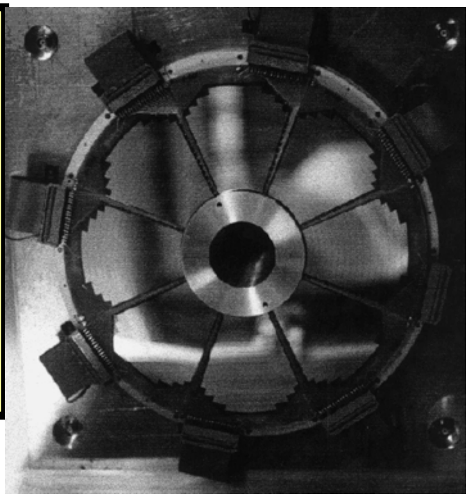
HYDE Detector concept

Detector telescope:
- dE1: gas/thin Si-10um??
- dE2: DSSSD (40 μm)
-E: DSSSD (2mm)

New solid state detectors?:
Diamond detectors → GSI?

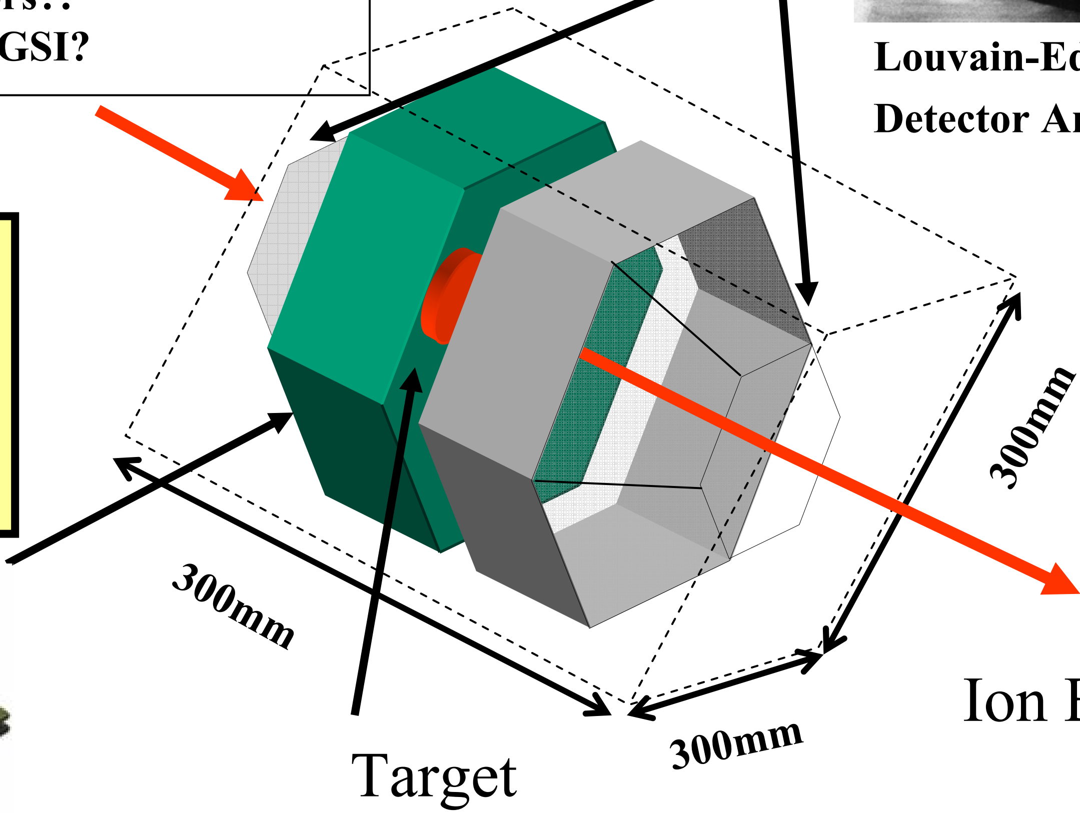


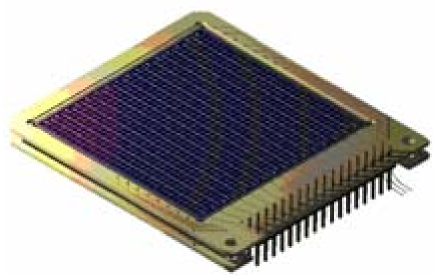
LAMP-telescopes
150 mm outer diameter
50mm inner diameter
ΔE1: 10 μm
ΔE2: 40 μm, position Sensitive
E: PAD 2000 μm



Louvain-Edinburgh Detector Array (LEDA)

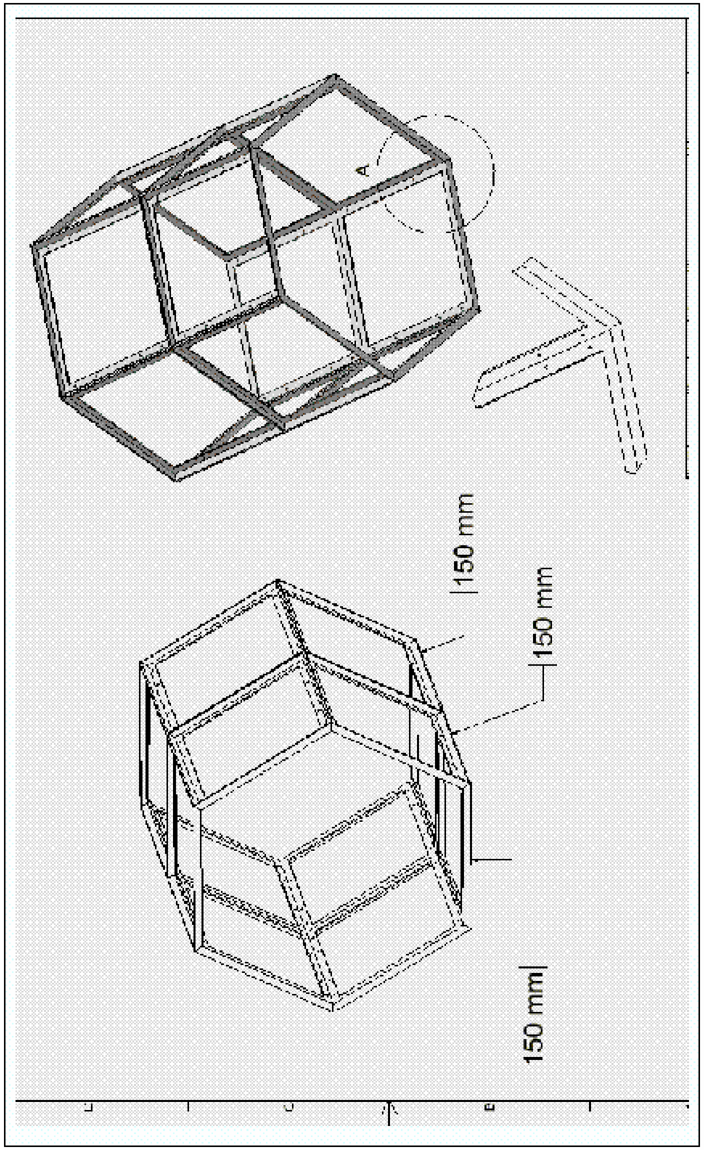
DSSSD-telescopes
50x50 mm^2,
ΔE1: 10 μm or gas
ΔE2: 40 μm, position sensitive
E: PAD 2000 μm

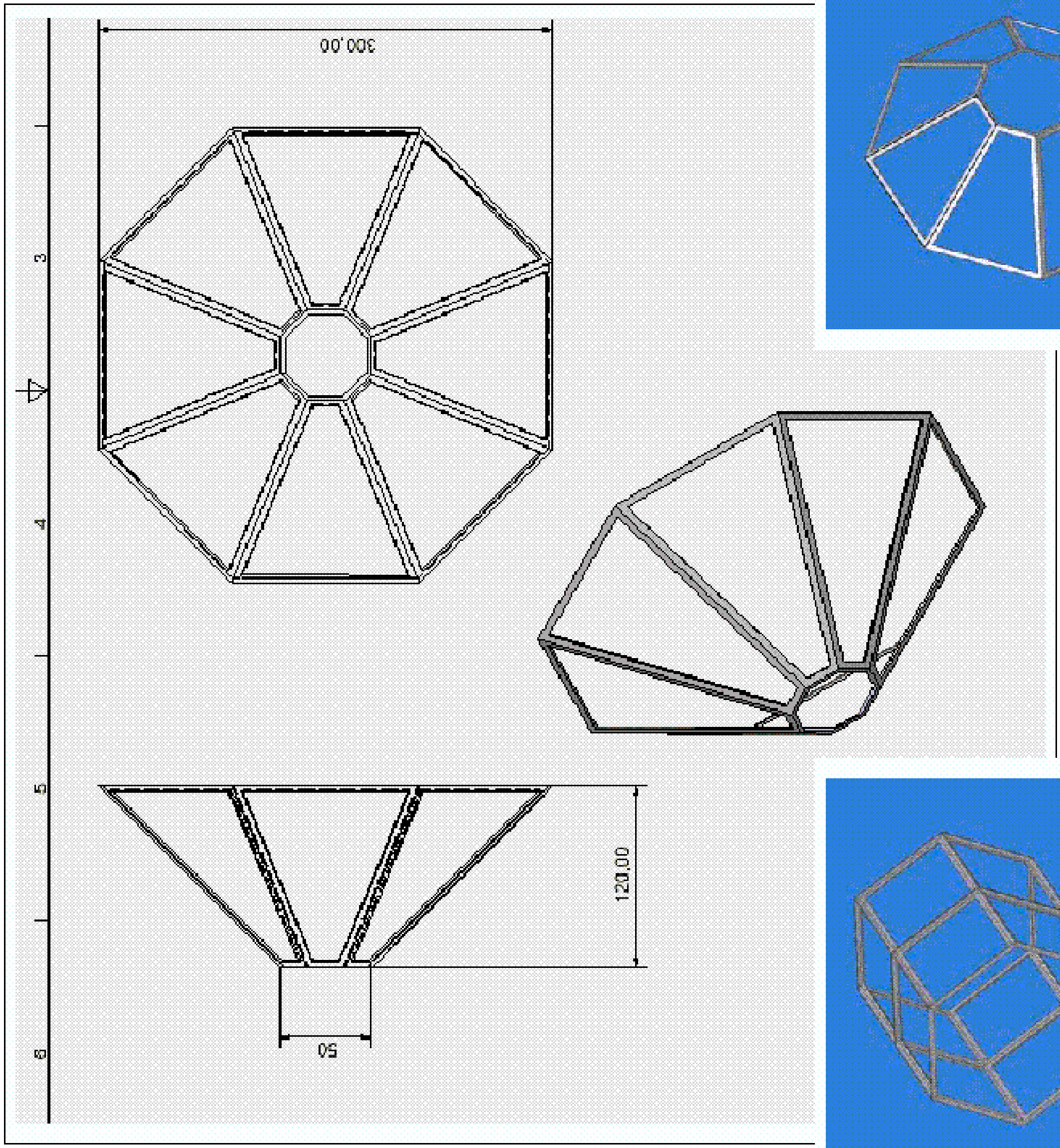


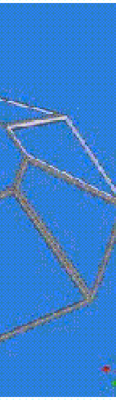


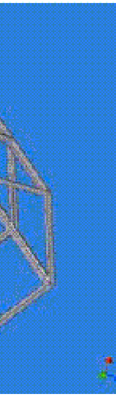
PRELIMINARY DESIGN

A. Labrador, CNA-Sevilla









RELATION TO OTHER PROJECTS

The design of HYDE detector foresees the possibility to be used together with:

- **AGATA**

- **NEUTRON DETECTOR (TOF)**

HYDE PHYSICS

Experimental magnitudes to be measured:

Elastic scattering, inelastic scattering, break up cross sections, transfer, Coulomb dissociation.

Low energies → from 3 to 10 MeV/u

Projectile nuclei: very short half live nuclei at neutron/proton drip lines.

Target nuclei: Stable nuclei, chosen to:

a) Maximize the effect of nuclear or Coulomb fields.

b) Properties (binding energy, angular momentum) of the single particle states to which protons and neutrons could be transferred.

Beam requirements:

Intensity >100 pps on target

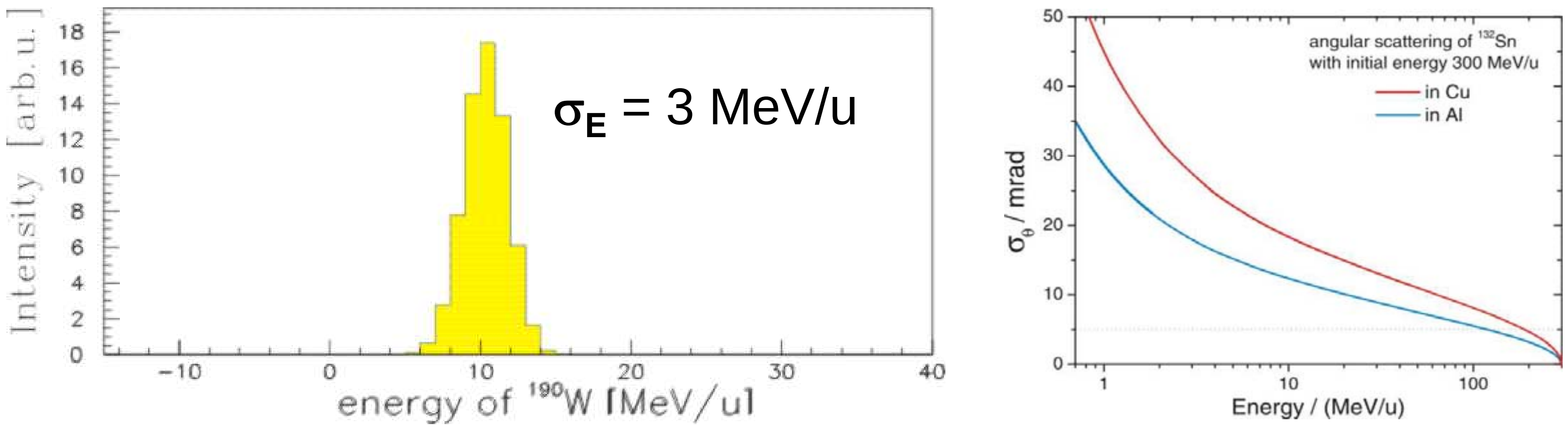
Energy resolution ≈ 10 % or better (eg, 1 MeV for 10 MeV/u)

Spot size < 1 x 1 cm2

} Instrument shared with SPIRAL II?

FAIR→Beam tracking system: position + energy

Characteristics of low-energy beams: energy and angular spread

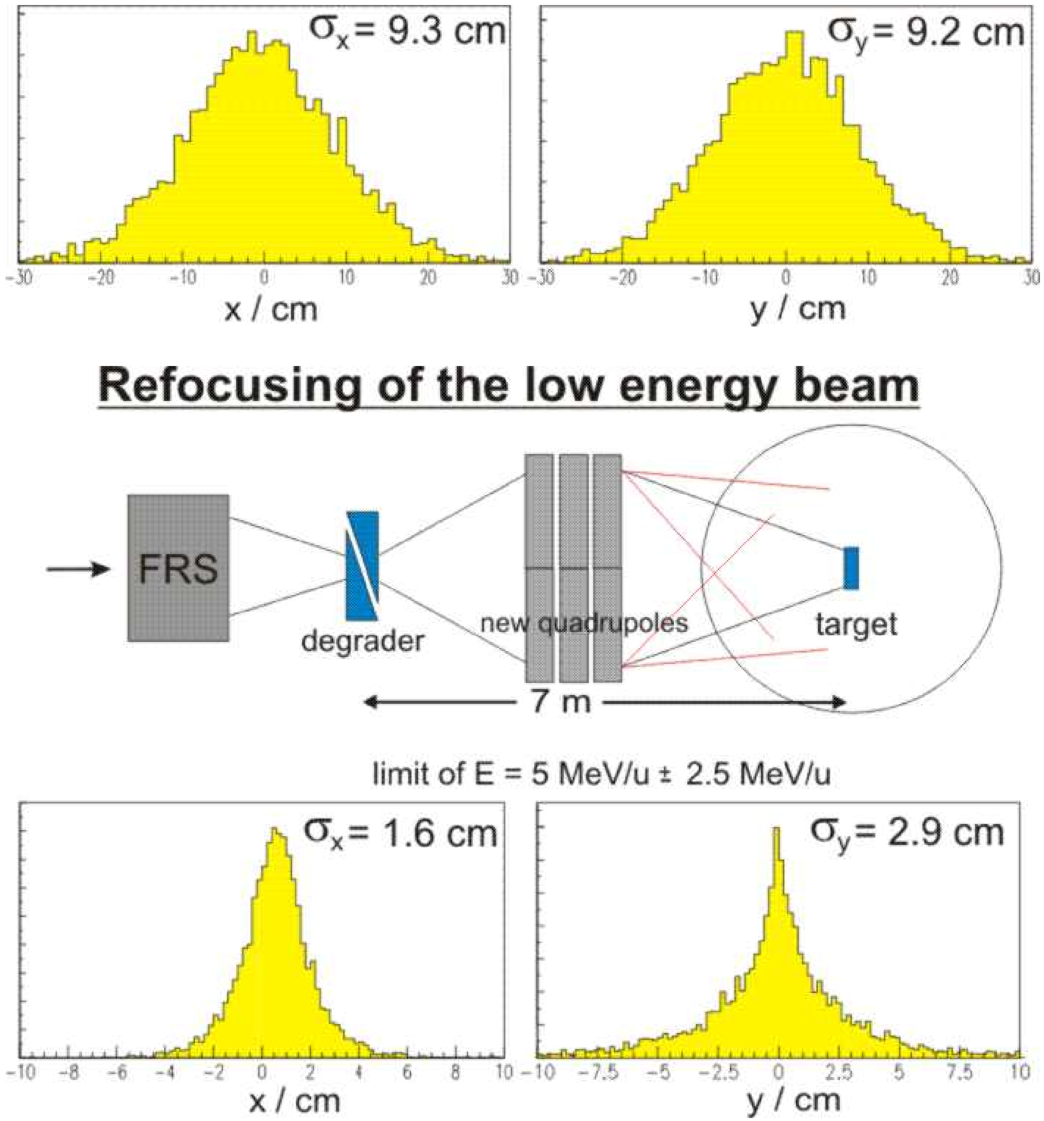


<u>Typical numbers:</u>

300 MeV/u:	$\sigma_E \sim 0.3$ MeV/u	$\sigma_\alpha \sim$ 5 mrad
5 MeV/u:	$\sigma_E \sim$ 3 MeV/u	$\sigma_\alpha \sim$ 20 mrad

Courtesy of C. Scheidenberger

Refocusing system



Courtesy of C. Scheidenberger

HISPEC

This LOI proposes to study the structure of exotic nuclei through high resolution gamma and particle spectroscopy of the isotopes produced at the super-FRS. This study would use multiple Coulomb excitation, direct reactions and compound reactions at barrier energies as well as single step Coulomb excitation and fragmentation reactions at intermediate beam energies. The physics goals are excellent. The collaboration is extensive and expert.

The two beam energy regimes need to be considered on different footings.

Near the barrier:

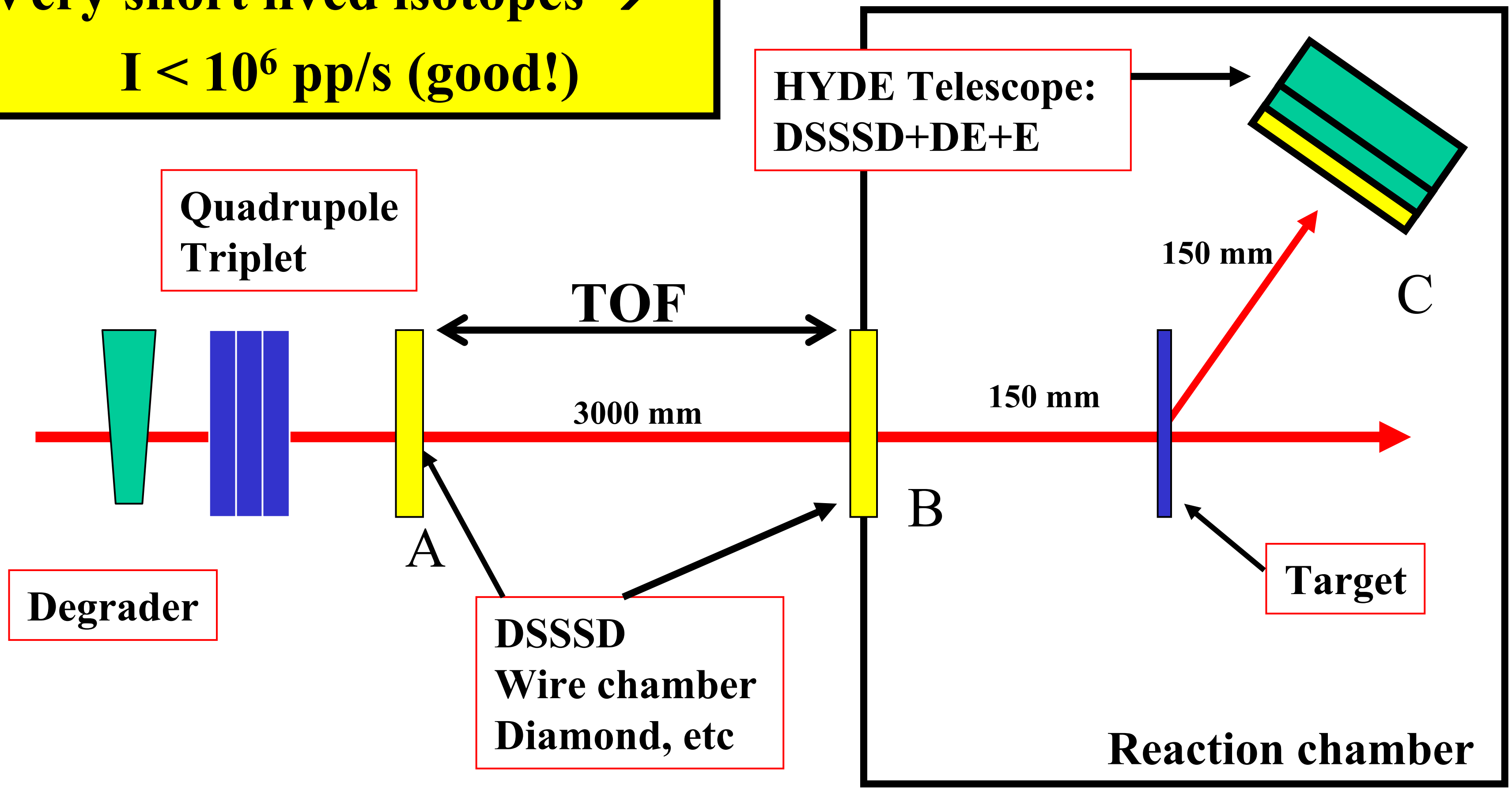
The proposal could indeed benefit from the short-lived nuclei and refractory nuclei that will not be available from typical RNB facilities based on the ISOL method. But at the Coulomb barrier these beams may not have the required qualities for high resolution in-beam studies and will need beam tracking and identification devices well adapted to low energies (down to few MeV/A) and to relatively high counting rates (as high as 10^7 p/s). The collaboration should detail the planned R&D for the beam tracking and identification detectors. Developing such beam diagnostics is a strong recommendation for the future of this project. Using beams from the NESR will not suffer from this beam quality limitation but will lose the advantage (with respect to ISOL facilities) of access to the shorter lifetime nuclei.

At Intermediate energies:

This case is more straightforward and the collaboration should be encouraged to proceed with a detailed design study for the gamma and particle detector arrays, with the dipole magnet (ALADIN) and its focal plane detectors. Limitations (if any) due to different backgrounds, feeding, etc. should be investigated.

Beam tracking system- concept

Very short lived isotopes → $I < 10^6$ pp/s (good!)



WORKING GROUPS FOR BEAM SLOWING DOWN & TRACKING.

GSI: J. Gerl, C. Scheidenberger
USE: J. Gómez-Camacho, JM. Quesada
UHU: I.-Martel, F. Pérez-Bernal, JR García-Ramos
CNA: J.A. Labrador

1. BEAM TRACKING

Simulate ion tracking using 2 position sensitive detectors. Optimize distance; study detector response, detection efficiency.

2. SLOWING DOWN IONS

Simulate/optimize slowing down of a beam of 100MeV/u down to 3 MeV/u with a degrader. Study particular case of light ions. Output (ion distributions) to be transferred to working group 1.

3. HYDE PERFORMANCE

Full simulation of HYDE detector from outputs 1+2

"STAND BY" STAGE since December 2004
→Submission of Technical Proposals

PRESENT FUNDING APPLICATIONS: R+D STAGE 2005-2007

Universidad de Sevilla (J. Gómez-Camacho, J.M. Quesada)	Universidad de Huelva: (I. Martel)
Date of application: December 2004 - Man power for 1 year (postdoc) -Tracking detectors -Simulations/travel Status: waiting → **TRACKING**	Date of application: December 2004 - Man power for 1 year (engineer) Status: Funded (OK). → **TRACKING** Date of application: March 2005 Man power for 3 year (Post-doc, Physics) Status: waiting → **SILICON ARRAY/HYDE**

FUTURE FUNDING APPLICATIONS

Project for collaboration: December 2005

- Sevilla-Huelva → Spanish Research Council before end of 2005
- man power (postdoc + engineer) for 3 years
- travelling
- detectors and electronics

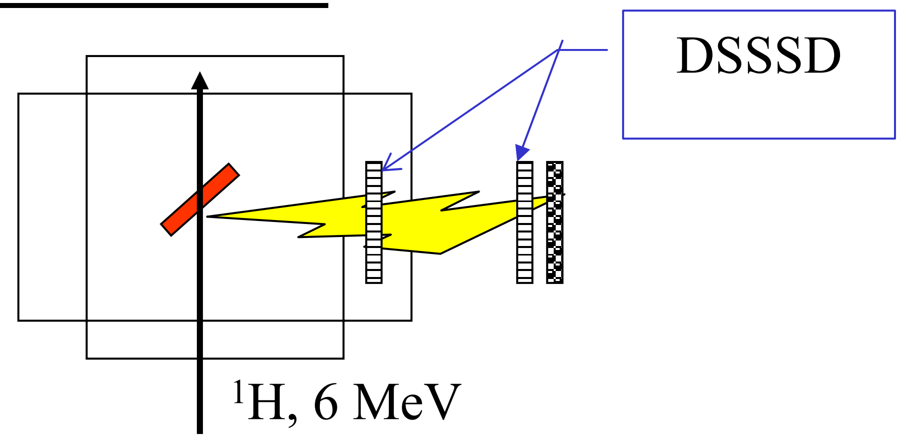
TRACKING+PROTOTYPES

PRESENT RESEARCH PLANS

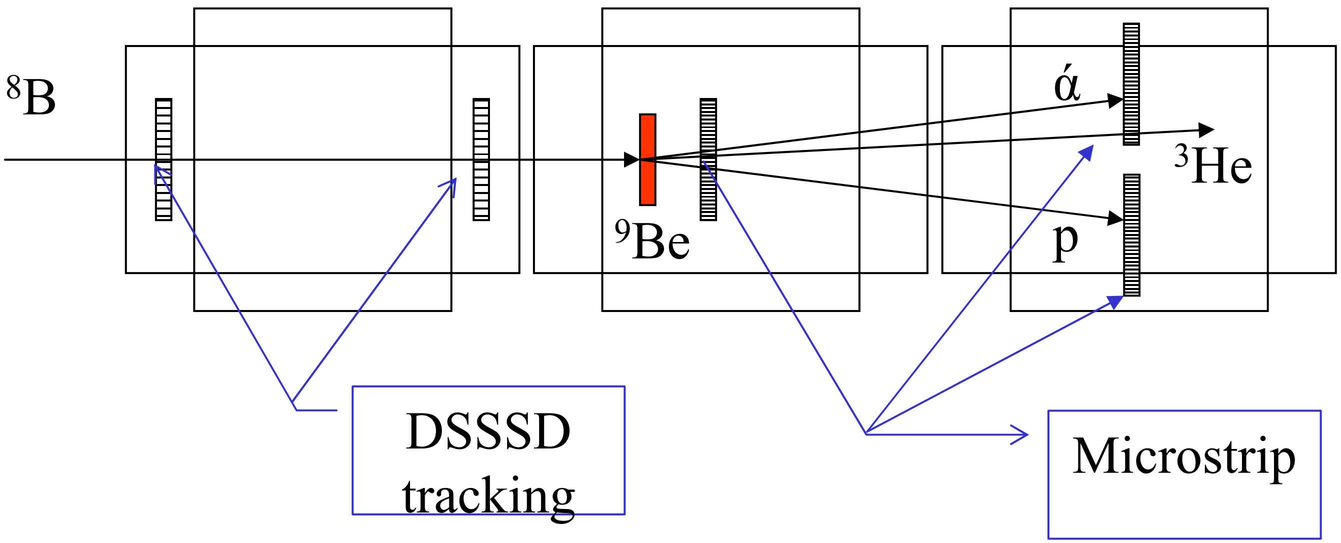
R+D STAGE 2005-2007

Tracking:

-Experiment at local Tandem with DSSSD detectors Centro Nacional de Aceleradores Sevilla→ 3 MV Tandem



- Test run for S271 (19Mg decay) at GSI- (November ?) 2005, S2-FRS



PRESENT RESEARCH PLANS
I+D STAGE 2005-2007

Hyde prototype:

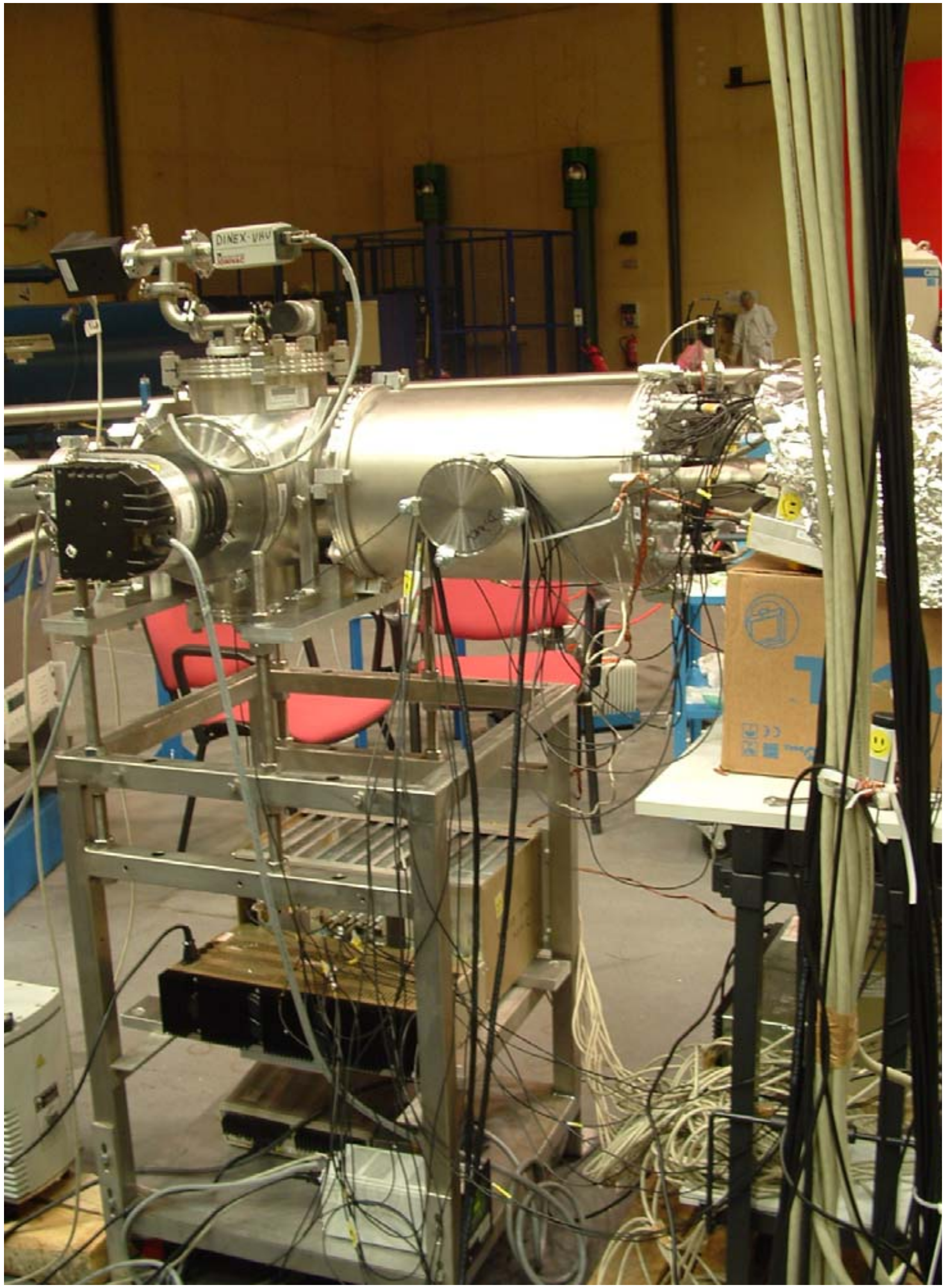
-Available 20 DSSSD telescopes (5cm x 5cm) from previous projects → small silicon ball → HYDE prototype

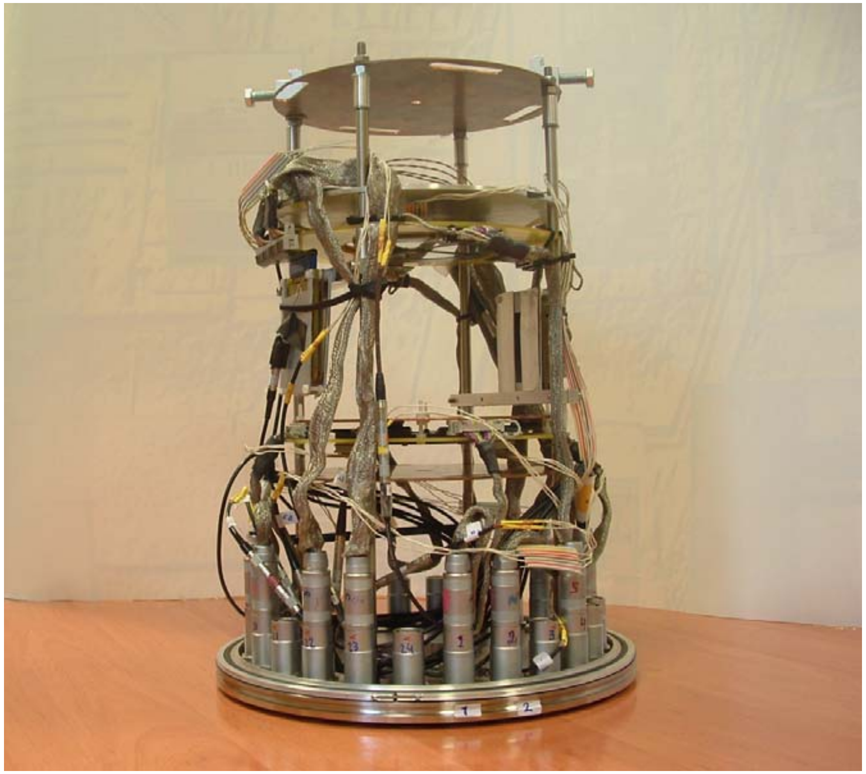
- Montecarlo simulations (Geant, mocadi,..)

-Test at local 3MV Tandem (Sevilla)

-Research program at existing radioactive beam facilities

-Specific man power





"Prototype" using 2 CD end-cup's and 2 DSSSD telescopes

C.N.A. (Sevilla) June 2005
Test with stable beams

Summary:

HYDE R&D STAGE IS GOING ON

Need for experts:

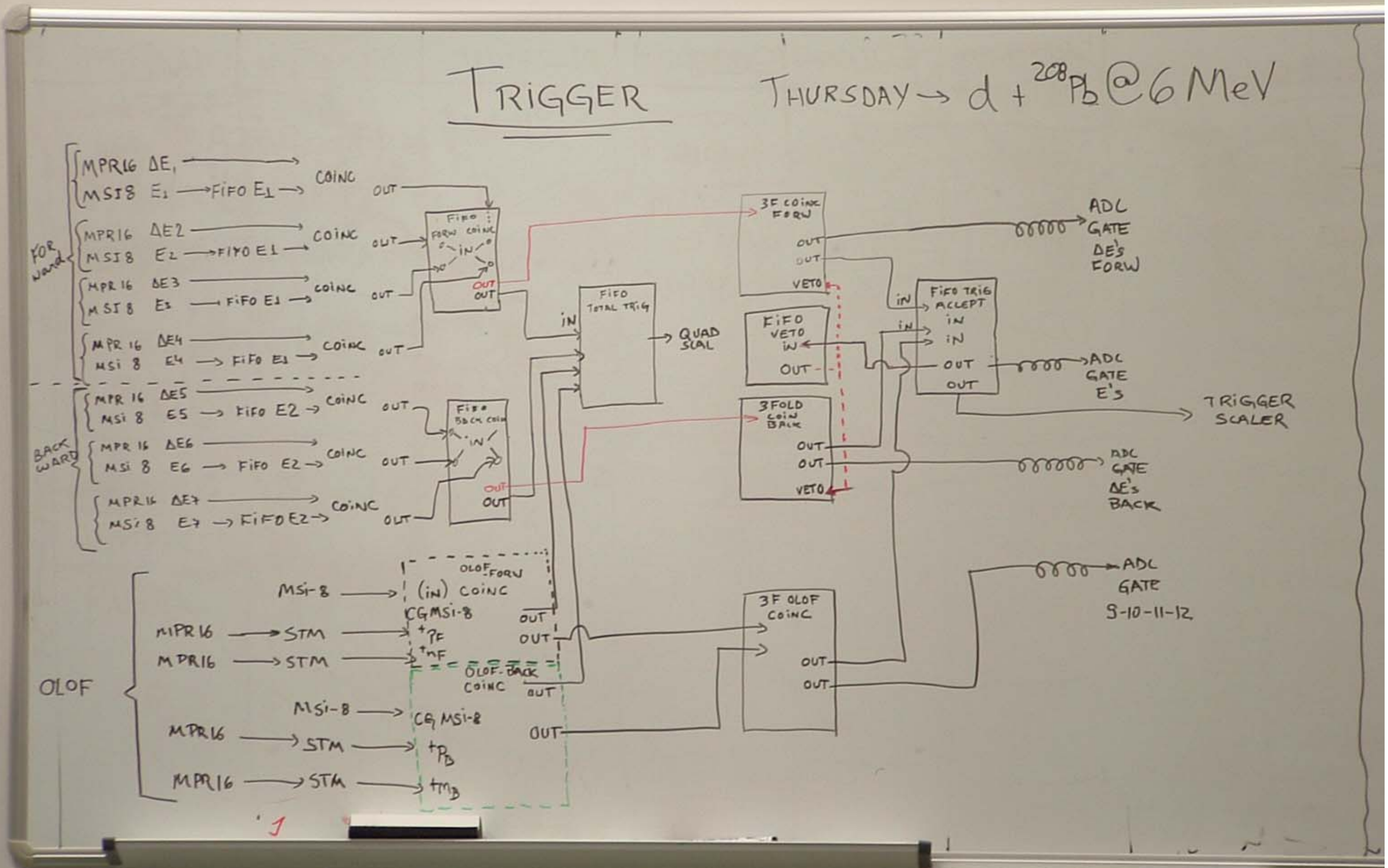
-Simulations

- Tracking detectors

-Detector design/electronics

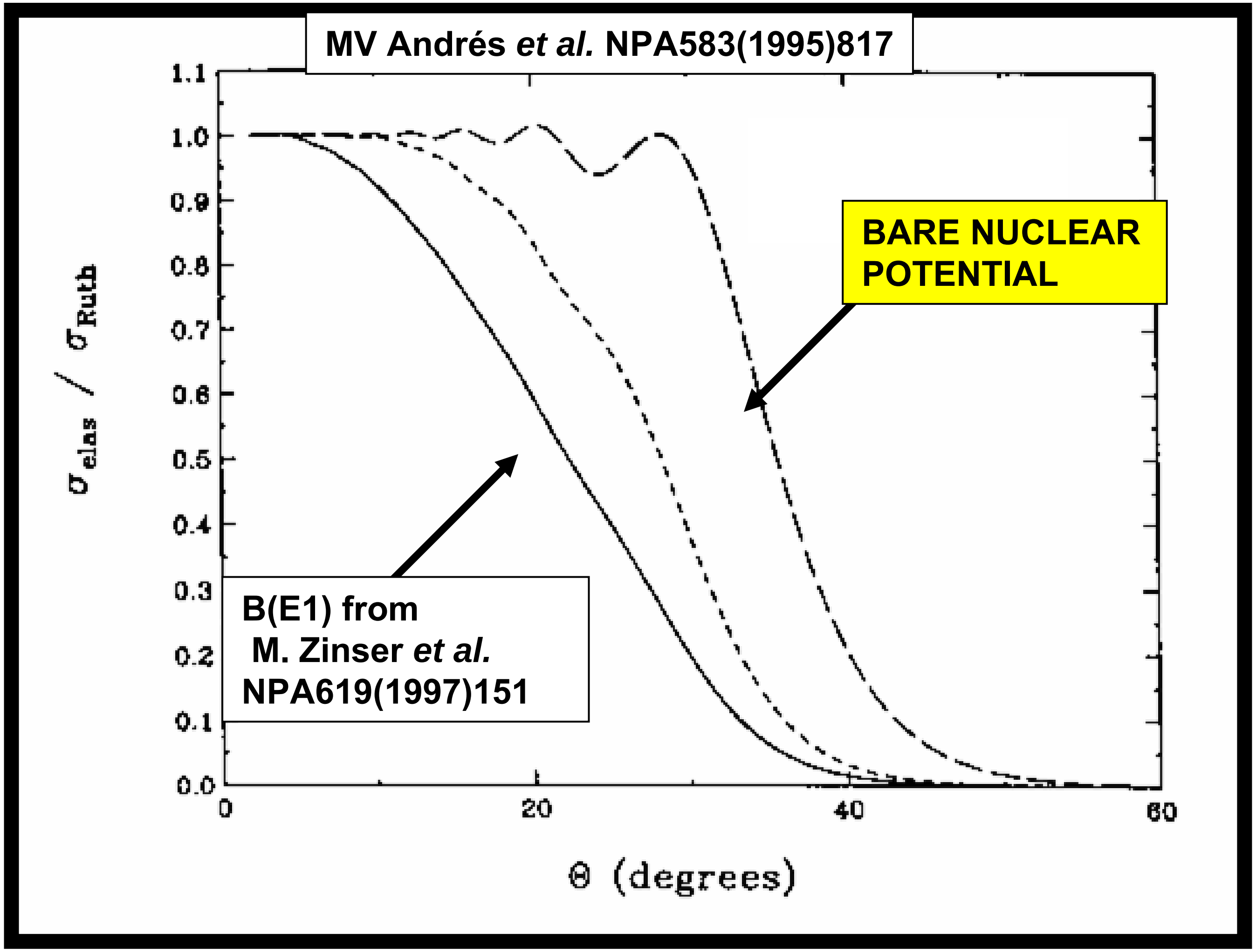
HYDE → SPIRALII?

THE END



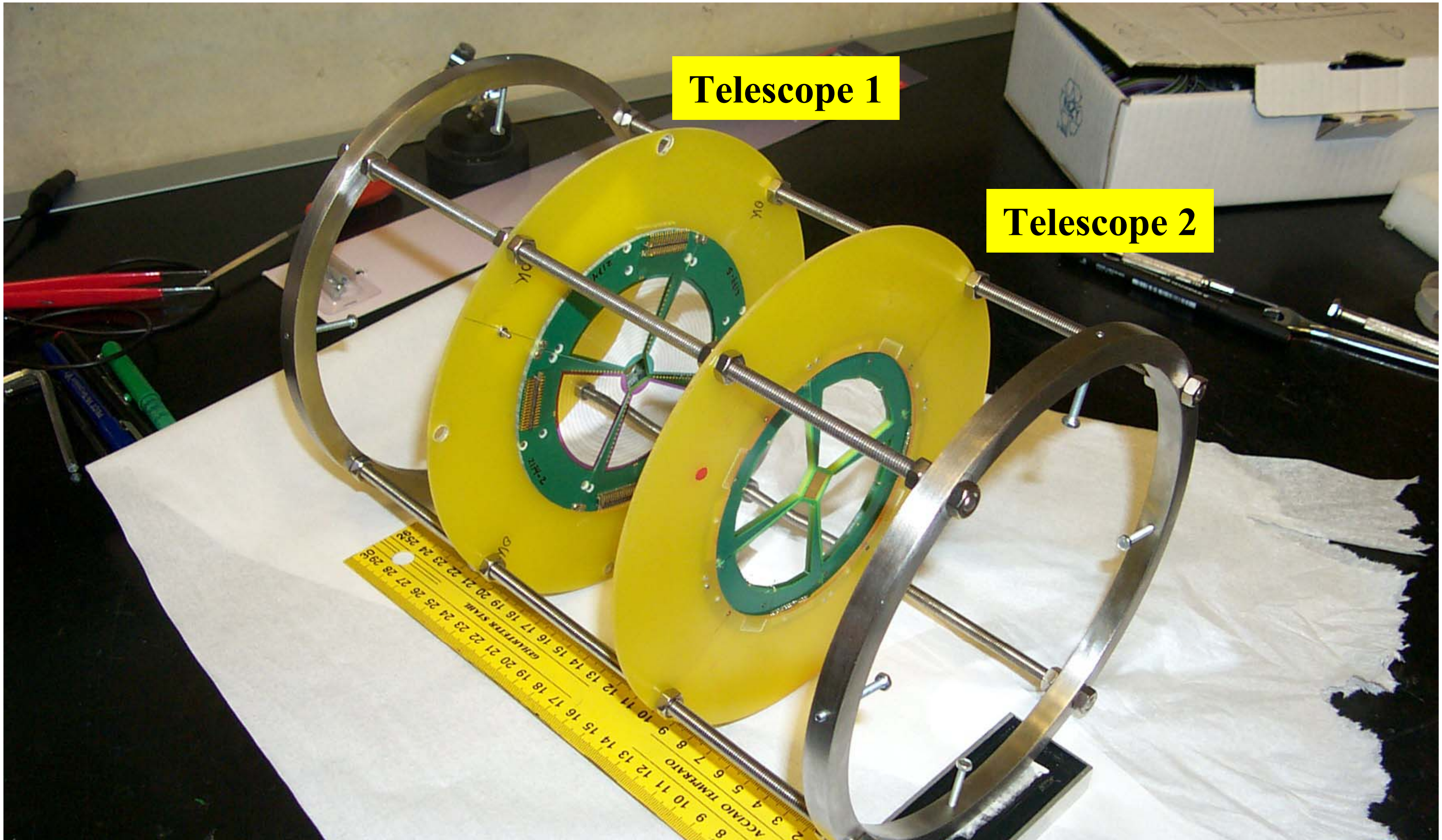
TRIGGER
THURSDAY → d + 208Pb @ 6 MeV
FORward
MPR16 ΔE1
MSI8 E1 → FIFO E1 →
COINC
OUT
MPR16 ΔE2
MSI8 E2 → FIFO E1 →
MPR16 ΔE3
MSI8 E3 → FIFO E1 →
MPR16 ΔE4
MSi 8 E4 → FIFO E1 →
BACKWARD
MPR16 ΔE5
MSi 8 E5 → FIFO E2 →
MPR16 ΔE6
MSi 8 E6 → FIFO E2 →
MPR16 ΔE7
MSi 8 E7 → FIFO E2 →
FIFO FORW COINC
IN
FIFO BACK COIN
FIFO TOTAL TRIG
IN
QUAD SCAL
3F COINC FORW
VETO
FIFO VETO
3FOLD COIN BACK
FIFO TRIG ACCEPT
ADC GATE ΔE's FORW
ADC GATE E's
TRIGGER SCALER
ADC GATE ΔE's BACK
OLOF
MSi-8
(IN) COINC
OLOF FORW
CG MSi-8
MPR16 → STM
+PF
+nF
OLOF-BACK COINC
CG MSi-8
+PB
+mB
3F OLOF COINC
ADC GATE 9-10-11-12

Elastic scattering of $^{11}Li+^{208}Pb$ at 5 MeV/u



DINEX-I CD telescopes

UNIV. HUELVA-UNIV. SEVILLA-CSIC IEM Madrid



2 telescopes: front → 4 quadrants x 40 um x 16 strips

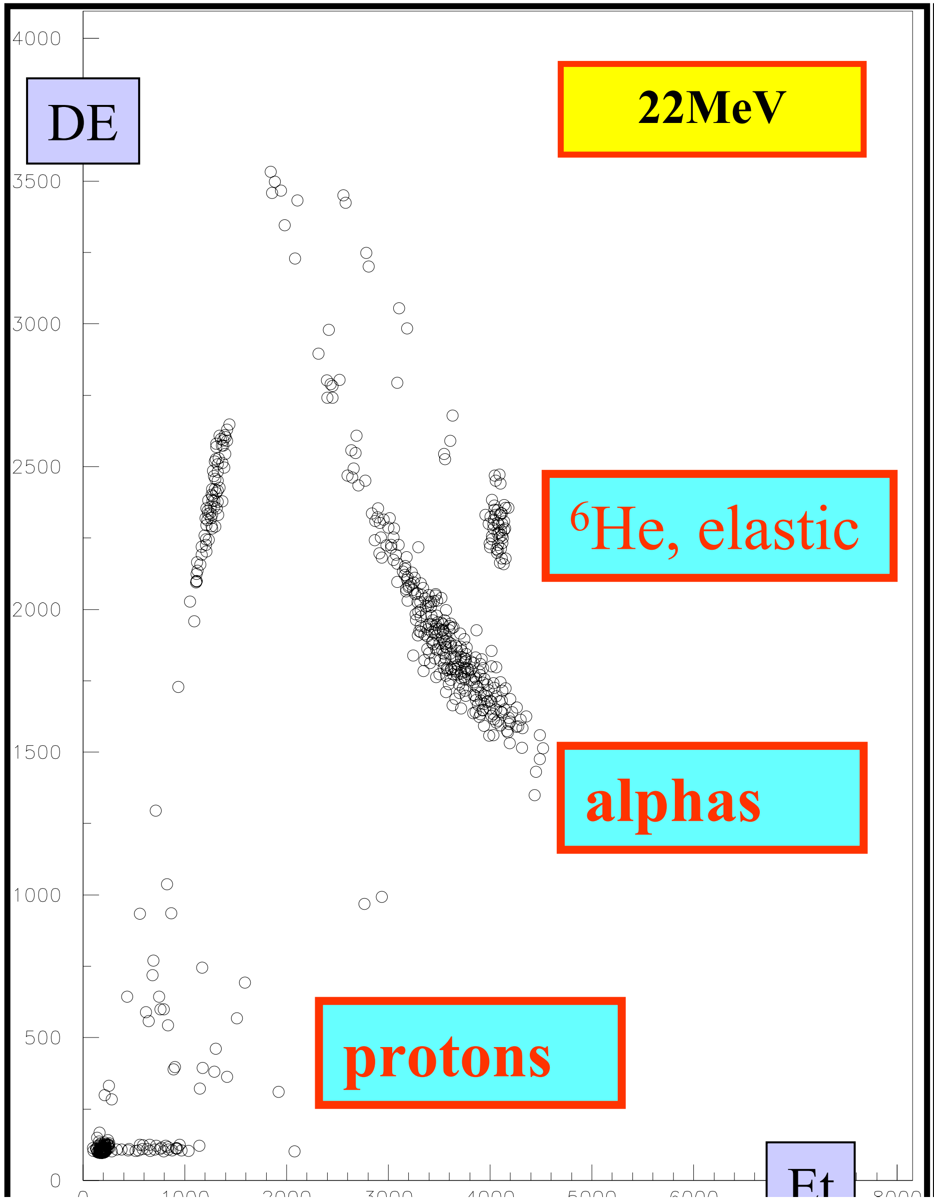
DINEX- I Reaction Chamber

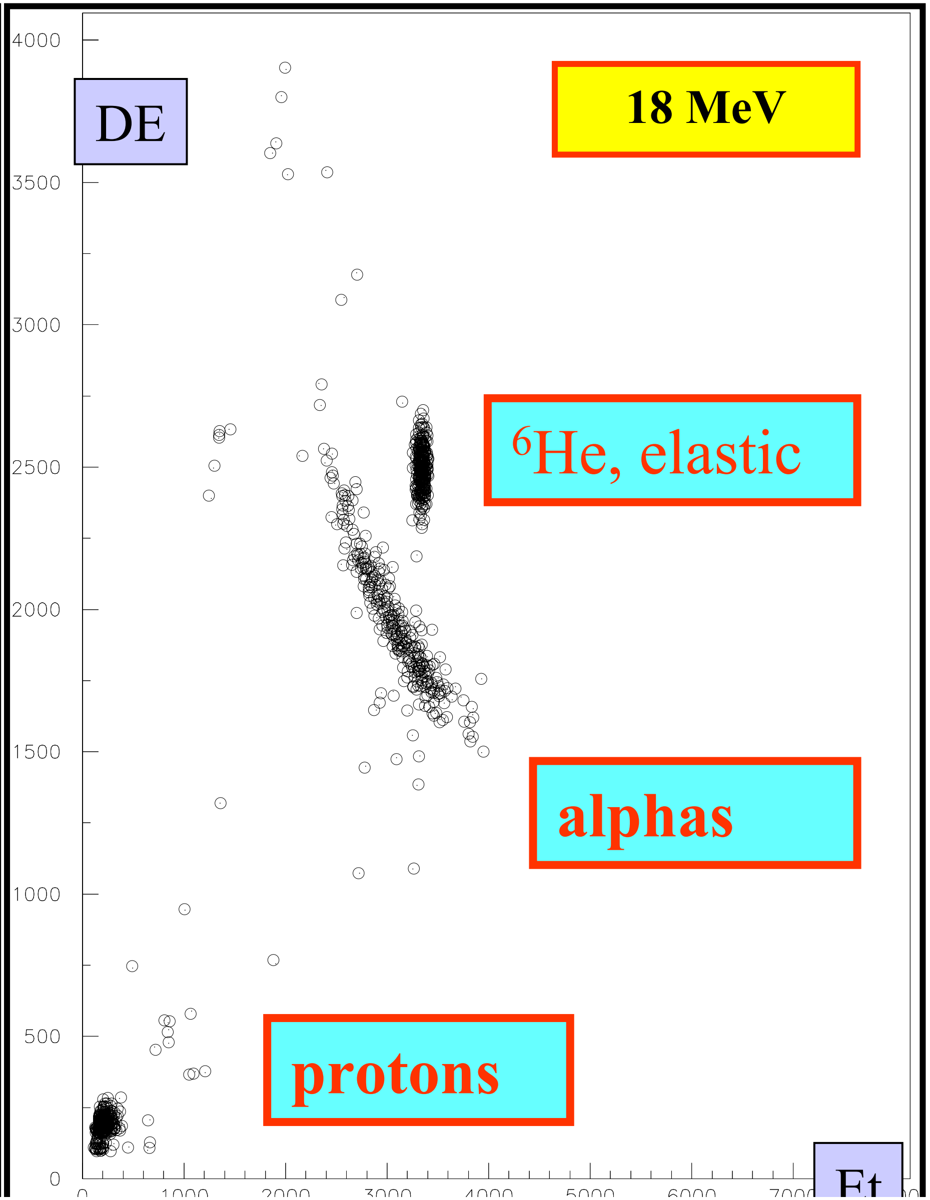
CNA
Seville-Spain

- 224 channels preamp+amp+ADC
- DACQ-VME-RIO2 processor

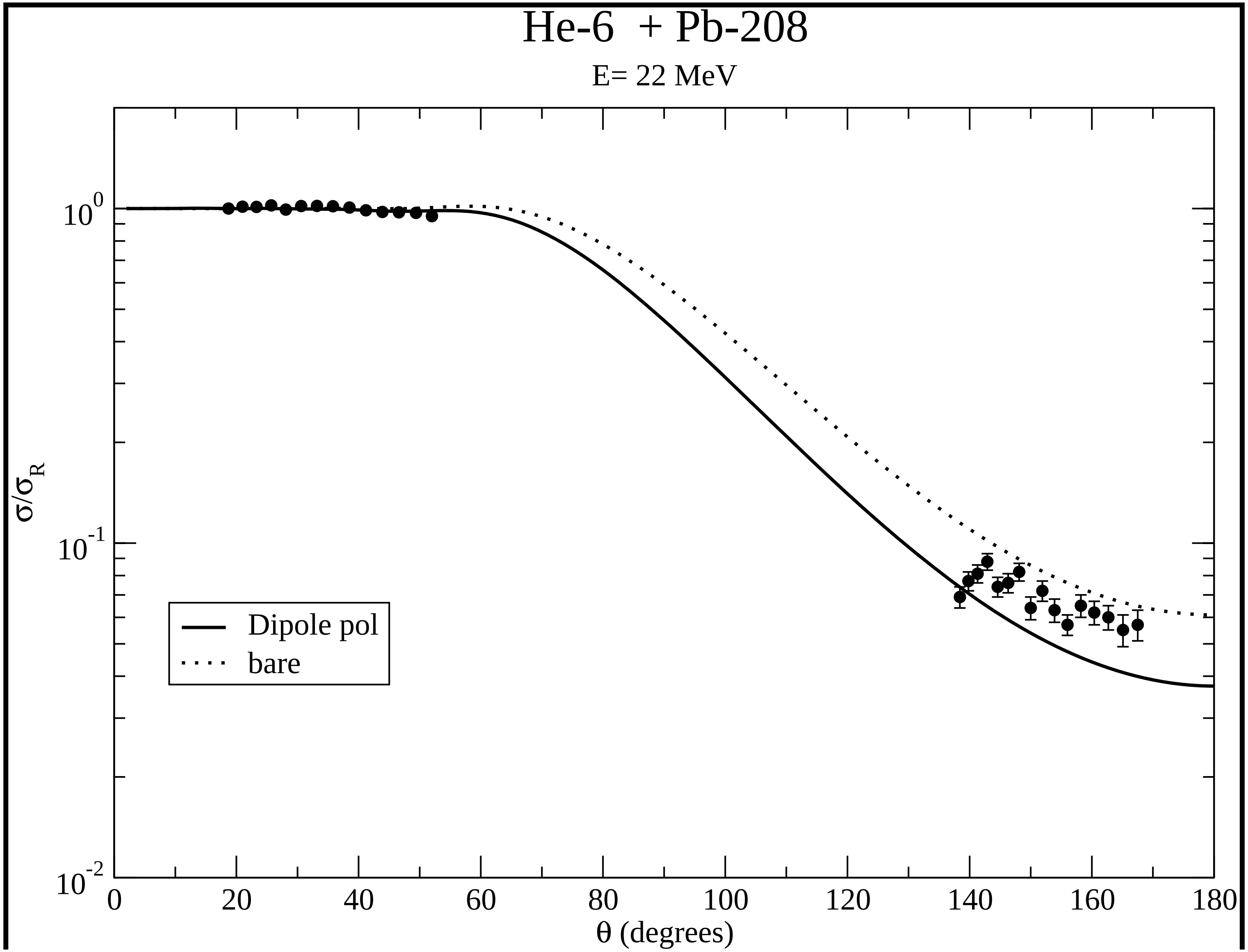
- Mesytec
- CES
- CAEN

DINEX CD at CRC Louvain la Neuve (Belgium)
$^{6}He + ^{208}Pb$ "MASS SPECTRUM"





Elastic Cross Sections



HYDE organization

- Coordinator: Univ. Huelva -- GSI
- Construction
  - Mechanical design: National Accelerator Center, Seville
  - Detectors, electronics: Univ. Huelva, Univ. Seville
  - Dacq: CSIC-Madrid
  - Tests: Univ. Huelva + National Accelerator Center, Seville
  - Final setup: GSI
- Simulations
  - Slowing down of ions (degraders, mocadi): National Accelerator Center, Seville
  - Beam tracking system: Univ. Seville
  - HYDE detector simulation (mocadi): Univ. Huelva

RADIATION HARDNESS

- Beam intensity 10**7 atom/s

-Amplifiers, logic and dacq system → away from experimental area

-Detectors, preamplifiers, detector bias, preamplifier power supplies → close to the reaction chamber.

REQUEST FOR TEST BEAMS.

Prototypes, detector array, electronics and dacq can be initially tested at our local Tandem (3MV) in Seville (CNA) using low energy stable beams of H, He, Li, B and C.

Shipping to GSI for testing with stable/radioactive isotopes at higher beam energies.

IMPLEMENTATION AND INSTALLATION

Not require the use of specific civil engineering, cranes, etc

Need:

Gas system: → gas detectors (in case) + electrical power supplies

Specific cave: → radiation shielding for dacq and electronics

Beam dump: → with beam monitor (detector)

DETECTOR- MACHINE INTERFACE

Vacuum system: P< 10-6 mb + vacuum chamber (included in budget)

Connection to beam line: mechanical bellow (eg, ISO100 metric)

Beam monitors: thick (2000um) silicon detectors: before chamber, target position, beam dump. → tracking of beam alignment and intensity.

ASSEMBLY AND INSTALLATION

Assembling: University of Huelva

First tests: CNA tandem accelerator laboratory at Seville

Final installation: GSI cave → **Space needed: 20 m2.**

- mechanical structure for chamber + vacuum system.
- racks for electronics
- tables, small cabinets for tools and equipment.

Size of mechanical equipment at beam line→ 2 x 2 m2

HYDE Budget -Beam tracking not included!!

<u>Mechanical workshop + vacuum system</u>: 6 k€ + 18 k€= **24 k€**
<u>DE-detectors:</u> 60 x 5 k€= **300k€**
2 barrels x 6 sides x 4 DSSDs = 48 → 48 x 32 = 1536 readouts
2 endcaps x 6 sectors (doublesided) = 12 → 12 x 32 = 384 readouts
<u>E-detectors:</u> 60 x 4k€ = **240 k€**
12 + 48 = 60 → 60 readouts
<u>Electronics:</u> Total 1980 readouts
Preamp+amps: 1980 /16 = 124 x 4 k€ = **496 k€**
TFA – CFD: (*multiplexing 4 channels*) = 1980/4 = 495 /16 x 4k€ = **124 k€**
Cabling: **12 k€**
<u>Dacq</u>
ADC: *(multiplexing 4 channels)* = 495 channels/32 = 16 x 4k€ = **64 k€**
TDC: *(multiplexing 4 channels)*= 495 channels/128 = 4 x 6k€ = **24 k€**
SCALERS: 495/32 channels = 16 x 3k€ = **48 k€**
3 x VME + logic = 3 x 30 k€ = **90k€**

<u>Summa</u>:

Mechanics: 24 k€
Electronics: 632 k€
VME: 90 k€

Detectors: 540 k€
ADC-TDC-SCAL: 226 k€

TOTAL: <u>1512 k€</u>

Electronics + daq- old example

VME crate 21 slots , V430 , 3U/ 6U
1500 W / 3000 W

+/- 5 V, -2 V, +/- 12V, and +/- 15 V

FAN tray

VME CPU

Power PC minimum 400 MHz, min 64 MB DRAM

SCSI adapter ultra wide single ended, cables

Ethernet adapter, ehternet cables

SCSI disc minimum 9 Gbyte

RS232 with cables

LYNX OS operating system latest version

Including X/ Motif for PPC

ADC

VME, 12 bit peak sensing,

fast conversion < 5 microsec

Differential non-linearity:better than 2%

16 ch / modules minimum

Zero Suppression

TDC

VME 12 bit, similar readout as the ADC

Similar to the ADC

Amplifiers/TFA:

Compact modules (16 ch / module minimum)

pos/ neg input and output,

should accept input risetime in the range 10 –600 ns

input output signal consistent with ADC input and

TFA output negative polarity or consistent with available CFD inputs

Pre Amplifiers:

Charge sensitive, pos or negative input, 16 channel minimum

To fit detector input capacitance of 40 – 400 pF.

Sensitivity in the range 10 – 100 mV/MeV

With motherboards, compact solution

Must include preamp bias

Detector bias:

HV: Si-detector bias, 0 – 200 V, 20 μA, low noise,

Modular system minimum 4 channels each, 1 bin NIM module

Logic:

CFD

Fan in / Fan out

Coincidence

NIM-ECL converter

Gate&Delay

Dual Timer

HYDE Man Power (4 years)

1 Postdoc	30k€/Year
1 PhD	15 k€/Year
1 Technical	25 k€/Year
TOTAL	70 k€ x 3 = **210 k€**

RELATION TO OTHER PROJECTS

The design of HYDE detector will foresee the possibility to be used together with **AGATA**.

HYDE BALL- Time scale

Research activity	First year	Second year	Third year	Fourth year
1. Design and building				
2. Electr. and DAQ set up				
3. Test of HYDE BALL				
4. GSI set-up at LEB cave				
5. Theoretical calculations				
6. Submission of proposals				
7. Experiments				
8. Publications				

ORGANIZATION, FUNDING

(Present) Coordinator: I. Martel, University of Huelva

Institutions participating in the project:

Experimental:

GSI (Germany) , U. Sevilla (Spain), U. Huelva (Spain), CSIC-IEM (Spain), CRC Louvain (Belgium), U. Leuven (Belgium), Soltan Institute for Nuclear Studies (Poland)

Theory:

U. Sevilla (Spain), U. Huelva (Spain), Soltan Institute for Nuclear Studies (Poland),U. Surrey (United Kingdom), U. Padova (Italy), U. Lisboa (Portugal), Michigan State Univ. (USA)

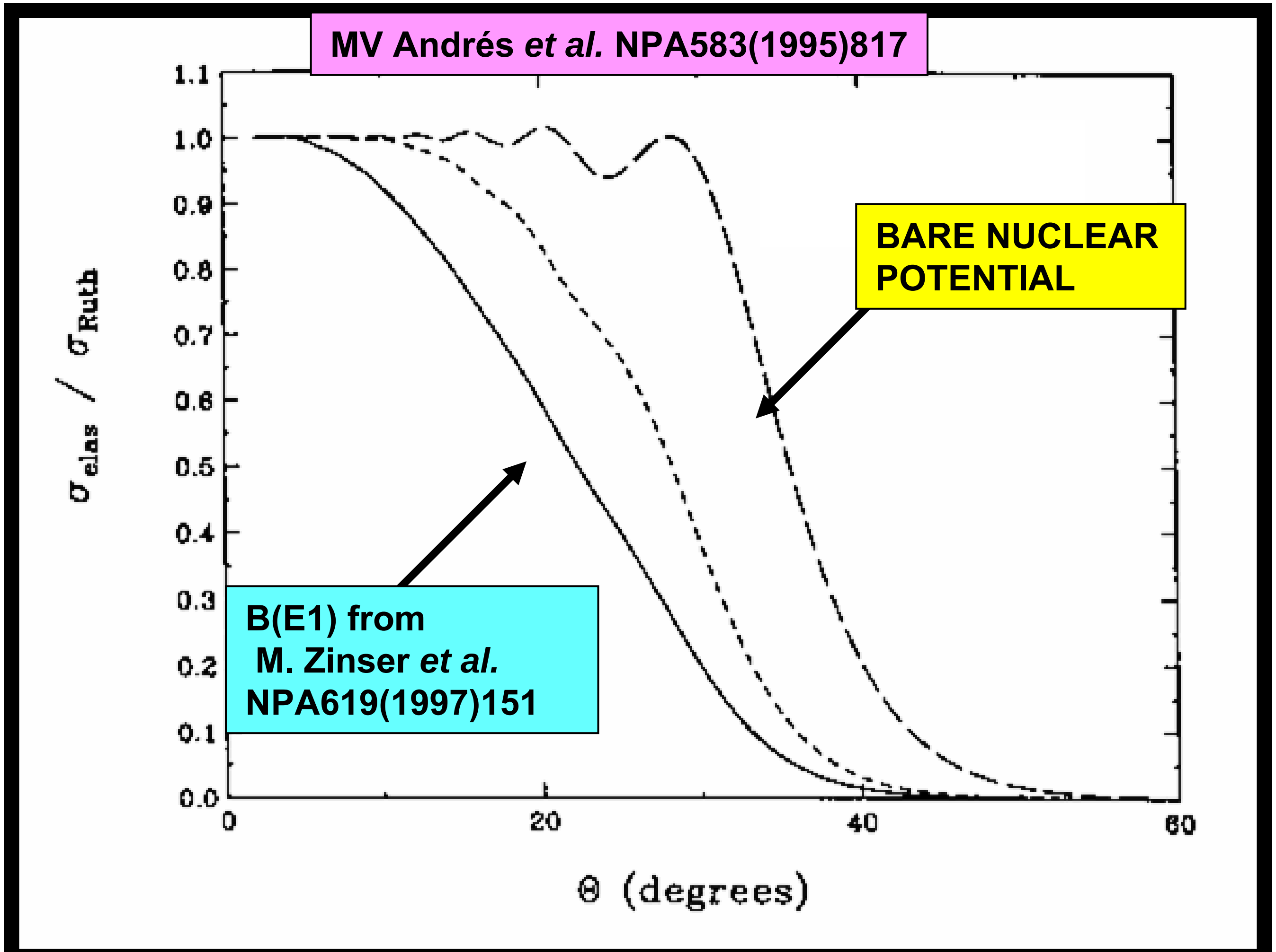
Funding of HYDE is being arranged with authorities of the Spanish government.

Estimates for DE maximum depth

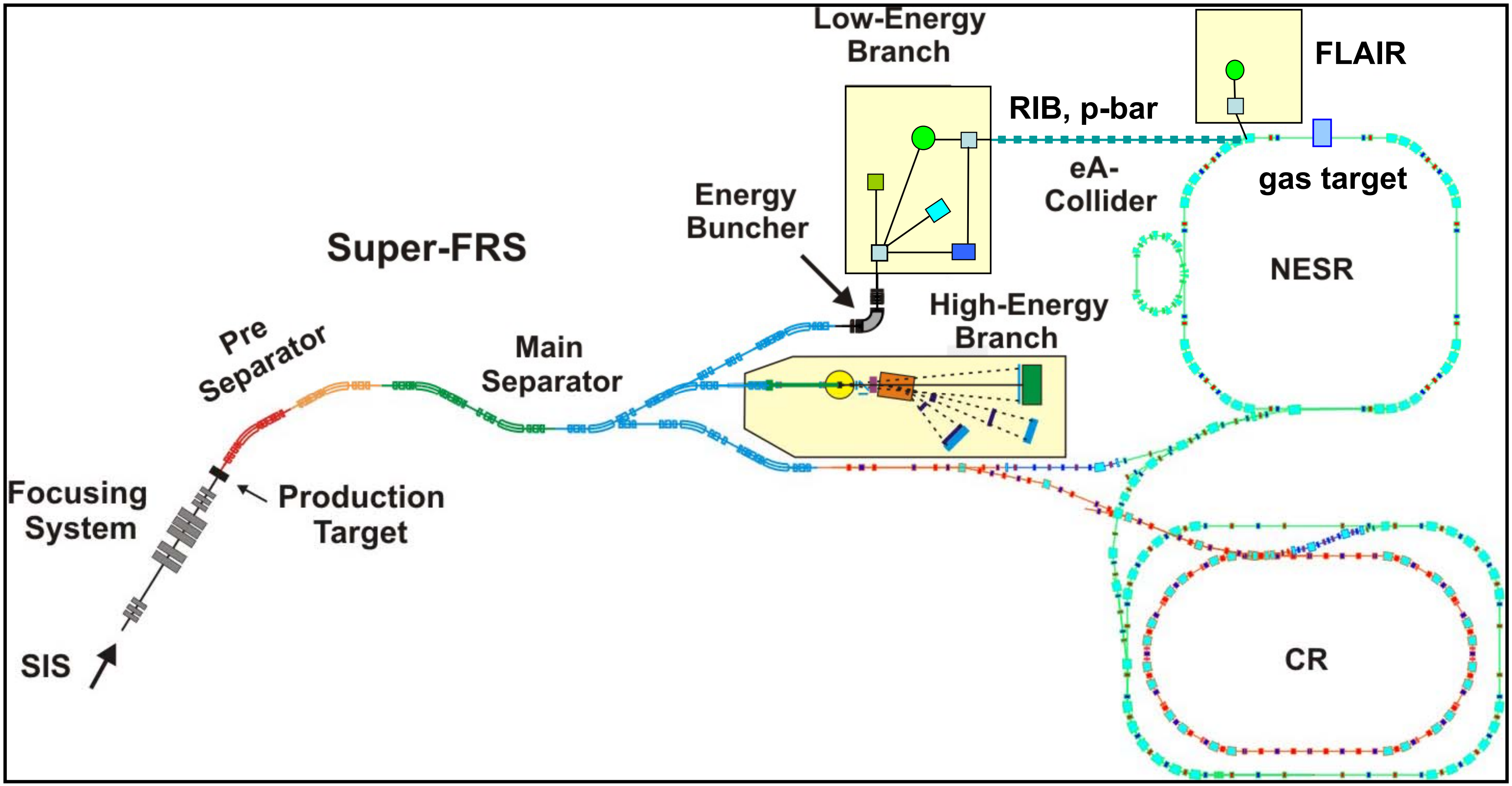
							T=30um	T=40um
Element	**Mp**	**Zp**	**Mt**	**Zt**	**Rb**	**Vb**	**Emin**	**Emin**
H	1	1	208	82	10,39	11,37	1,7	2,2
He	4	2	208	82	11,27	20,96	6,5	8
Li	7	3	208	82	11,76	30,13	13	15
Be	9	4	208	82	12,01	39,34	15	24
Be	11	5	208	82	12,22	48,30	28	33
C	12	6	208	82	12,32	57,50	33	38
N	14	7	208	82	12,50	66,11	38	50
O	16	8	208	82	12,67	74,57	50	60
F	19	9	208	82	12,89	82,44	55	70
Ne	20	10	208	82	12,96	91,12	60	80
Na	23	11	208	82	13,15	98,75	70	90
Mg	24	12	208	82	13,21	107,23	80	100
Al	27	13	208	82	13,39	114,66	90	110
Si	28	14	208	82	13,44	122,98	100	120
P	31	15	208	82	13,60	130,24	100	130
S	32	16	208	82	13,65	138,41	110	140
Cl	35	17	208	82	13,79	145,52	120	150

THE END

$^{11}Li+^{208}Pb$ at 50 MeV
Effect of Dipole Polarizability



The NUSTAR facility



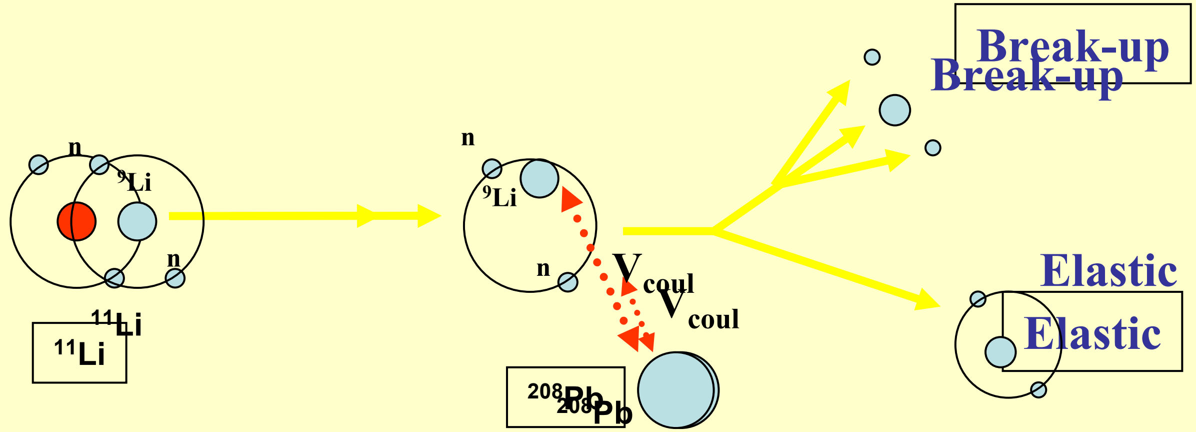
EXAMPLE for Light neutron rich nuclei: Complementary tests of B(E1) values

•Study the characteristics of the scattering of drip line neutron rich nuclei at low collision energies → Li, Be, B, C, …

Few (if any) bound excited states → nuclear reaction studies

Weakly bound nuclei → Coupling to continuum states

• Study the effect of DIPOLE POLARIZABILITY



Theoretical description

(MV Andrés *et al.* NPA**583**(1995)817)

- **Optical model:**
  - **Monopole Coulomb potential**
  - **Nuclear Saxon-Woods form factors**

- **Dipole polarization potential: coulomb breakup + virtual excitations**

$$U_{pol} = -\frac{4\pi Z_t^2 e^2}{9\hbar v r (r-a_0)^2} \int_{\varepsilon b}^{\infty} d\varepsilon \frac{dB(E1,\varepsilon)}{d\varepsilon} \left[g(r/a_0,\varepsilon) + i\ f(r/a_0,\varepsilon) \right]$$

$$f(z,\xi) = 4\xi^2 z^2 \exp(-\pi\xi) K''_{2i\xi}(2\xi z)$$

$$g(z,\xi) = \frac{P}{\pi} \int_{-\infty}^{+\infty} d\xi' \frac{f(z,\xi')}{\xi - \xi'}$$

$$\xi = \frac{\varepsilon a_0}{\hbar v}$$

Elastic cross section is sensitive to B(E1) Distribution

- **Depends on collision energy and breakup energy ε_b**
- **Independent of angular momentum**
- **No free parameters**

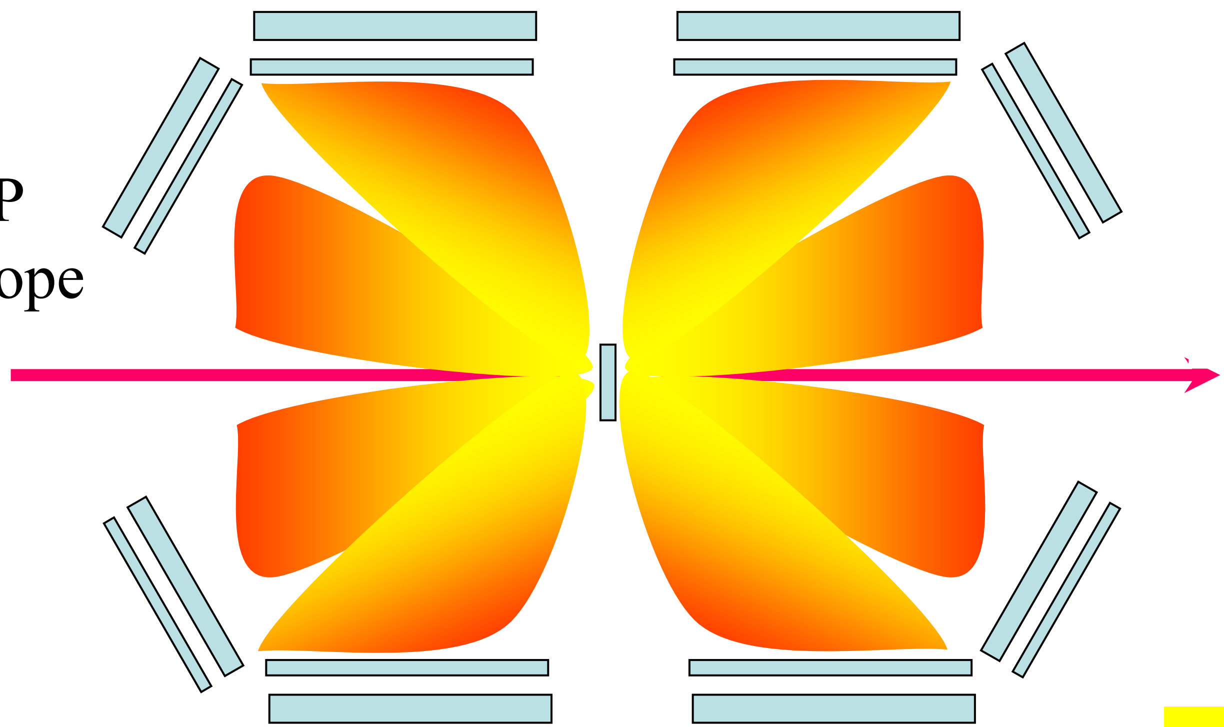
A real physics case:

DINEX DETECTOR ARRAY

Univ. Huelva
Univ. Sevilla
CSIC-IEM-Madrid

EXPERIMENTAL SETUP

16x16 strips of 3 mm width
Range: 10º to 70º / 110º to 170º, Δθ <2.0º



Ω~70%

HYDE organization

- Coordinator: Univ. Huelva -- GSI
- Construction
  - Mechanical design: National Accelerator Center, Seville
  - Detectors, electronics: Univ. Huelva, Univ. Seville
  - Dacq: CSIC-Madrid
  - Tests: Univ. Huelva + National Accelerator Center, Seville
  - Final setup: GSI
- Simulations
  - Slowing down of ions (degraders, mocadi): National Accelerator Center, Seville
  - Beam tracking system: Univ. Seville
  - HYDE detector simulation (mocadi): Univ. Huelva

ELECTRONICS AND DAQ-EXAMPLE

RADIATION HARDNESS

REQUEST FOR TEST BEAMS.

IMPLEMENTATION AND INSTALLATION

DETECTOR- MACHINE INTERFACE

ASSEMBLY AND INSTALLATION

HYDE Budget -Beam tracking not included!!

Summa:

Mechanics: 24 k€
Electronics: 632 k€
VME: 90 k€

Detectors: 540 k€
ADC-TDC-SCAL: 226 k€

TOTAL: 1512 k€

HYDE Man Power (4 years)

1 Postdoc	30k€/Year
1 PhD	15 k€/Year
1 Technical	25 k€/Year
TOTAL	70 k€ x 3 = **210 k€**

RELATION TO OTHER PROJECTS
The design of HYDE detector will foresee the possibility to be used together with **AGATA**.

HYDE BALL- Time scale

Research activity	First year	Second year	Third year	Fourth year
1. Design and building				
2. Electr. and DAQ set up				
3. Test of HYDE BALL				
4. GSI set-up at LEB cave				
5. Theoretical calculations				
6. Submission of proposals				
7. Experiments				
8. Publications				