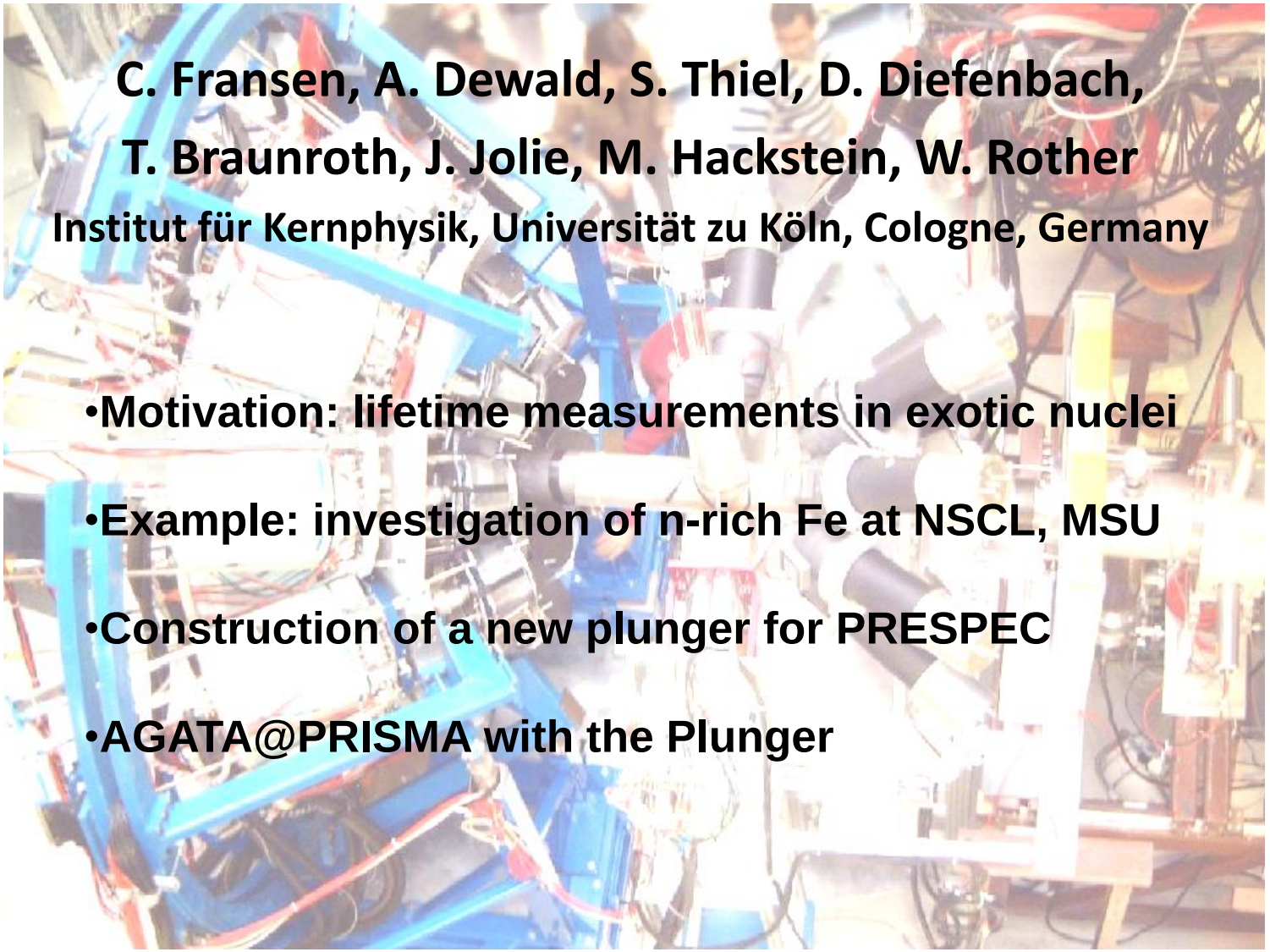
The Plunger Setup for AGATA at PRESPEC



C. Fransen, A. Dewald, S. Thiel, D. Diefenbach,
T. Braunroth, J. Jolie, M. Hackstein, W. Rother
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- **Motivation: lifetime measurements in exotic nuclei**
- **Example: investigation of n-rich Fe at NSCL, MSU**
- **Construction of a new plunger for PRESPEC**
- **AGATA@PRISMA with the Plunger**

Studies of Exotic Nuclei

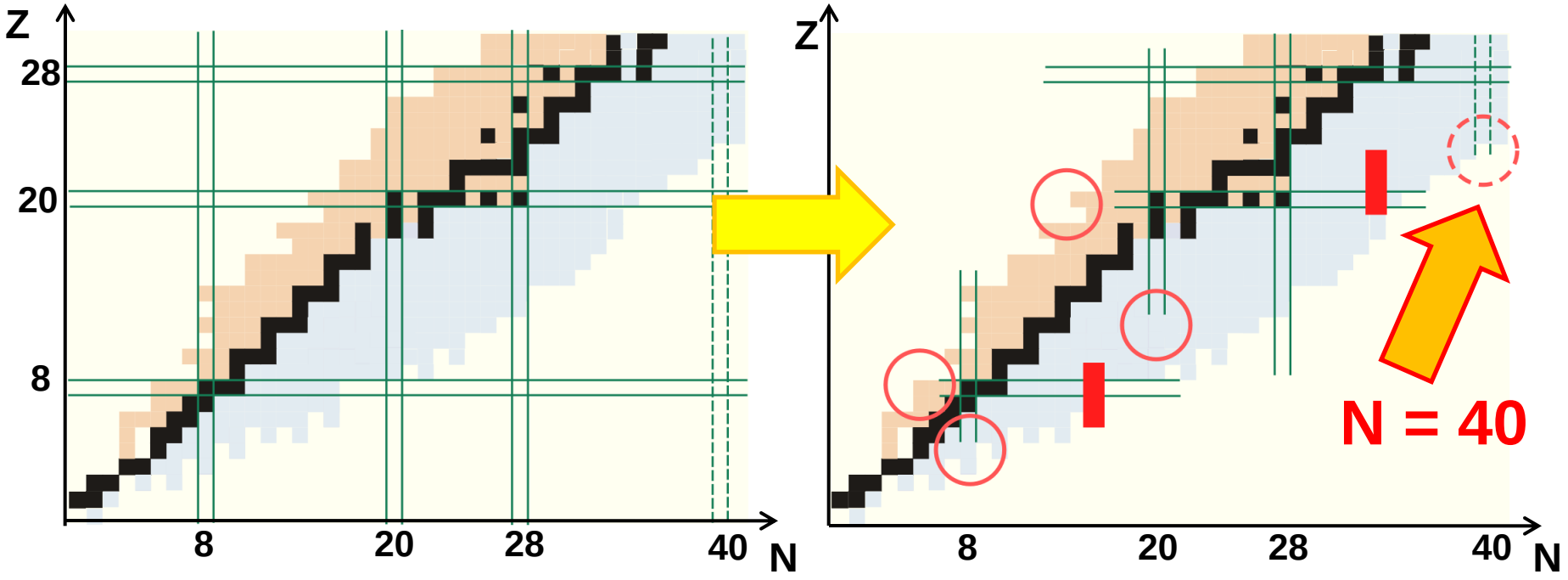
Many-body problems for strongly-interacting system with protons and neutrons

Stable nuclei

Shell structure
magic number (2,8,20…)

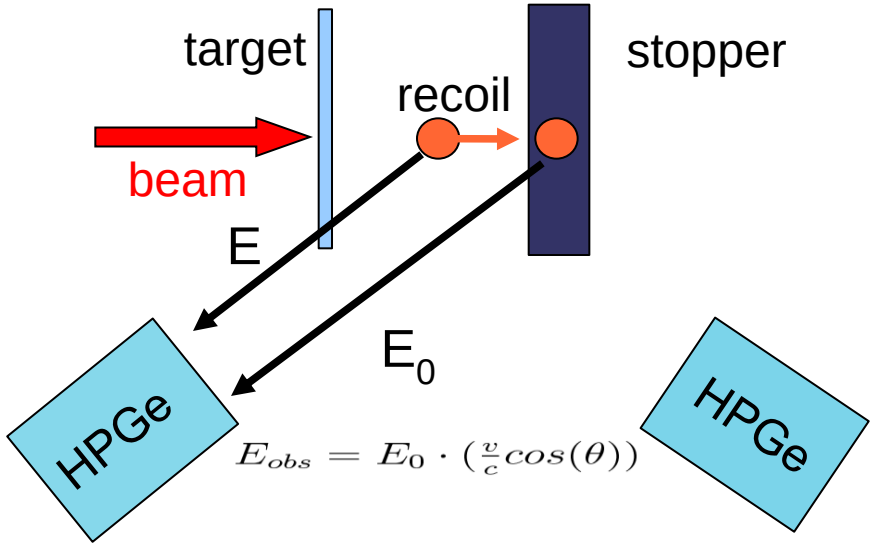
Exotic nuclei

Drastic change of shell structure
disappearance (N=8,20,..) and
appearance of magic numbers N=16,34



What is the driving force responsible for the shell evolution ?
Can we characterize the structure changes in a simple manner ?

The recoil distance Doppler-shift method (RDDS): lifetimes, absolute transition strengths



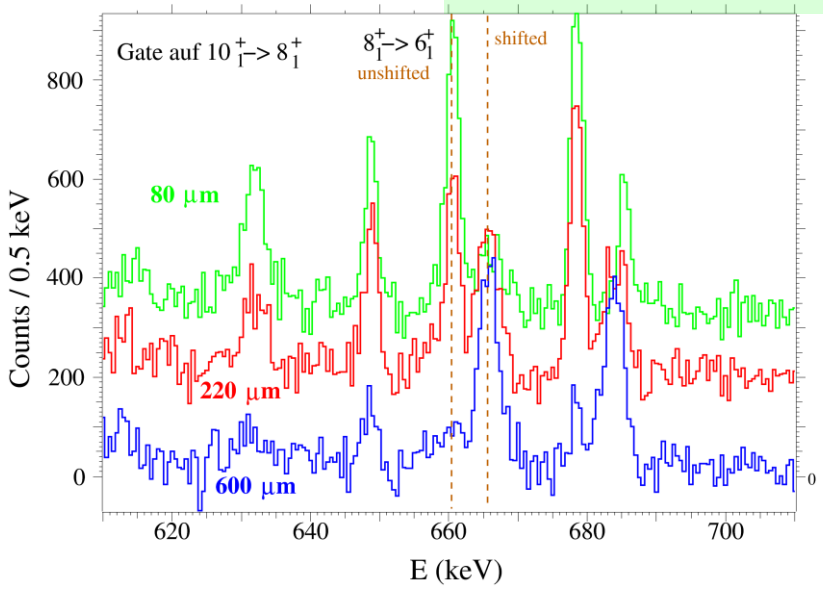
$$E_{obs} = E_0 \cdot (\tfrac{v}{c} cos(\theta))$$

$$\tau(t_k) = \frac{I^{\mathrm{us}}(t_k)}{\frac{d}{dt} I^{\mathrm{sh}}(t_k)}$$

I^{us} = Intensity of the unshiftet γ-ray line

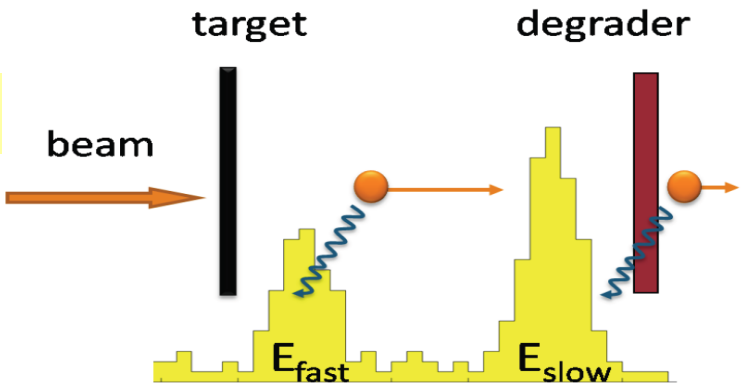
I^{sh} = Intensity of the Doppler-shifted component

^{92}Mo(^{10}B,3np)^{98}Pd



Differential Plunger

Use degrader instead of stopper to allow identification of recoils



Particle ident.:
LYCCA
S800 (MSU)

Example (NSCL, MSU): Neutron-rich Fe isotopes

In the vicinity of N=40, only Ni isotopes show a typical signature of magicity with high E(2⁺) and small B(E2) .

Low E(2⁺) for other isotopes indicate a fragility of the N=40 (sub) shell closure.

Collectivity at N=40 seems to be increased toward lighter isotopes (Ni → Fe → Cr).

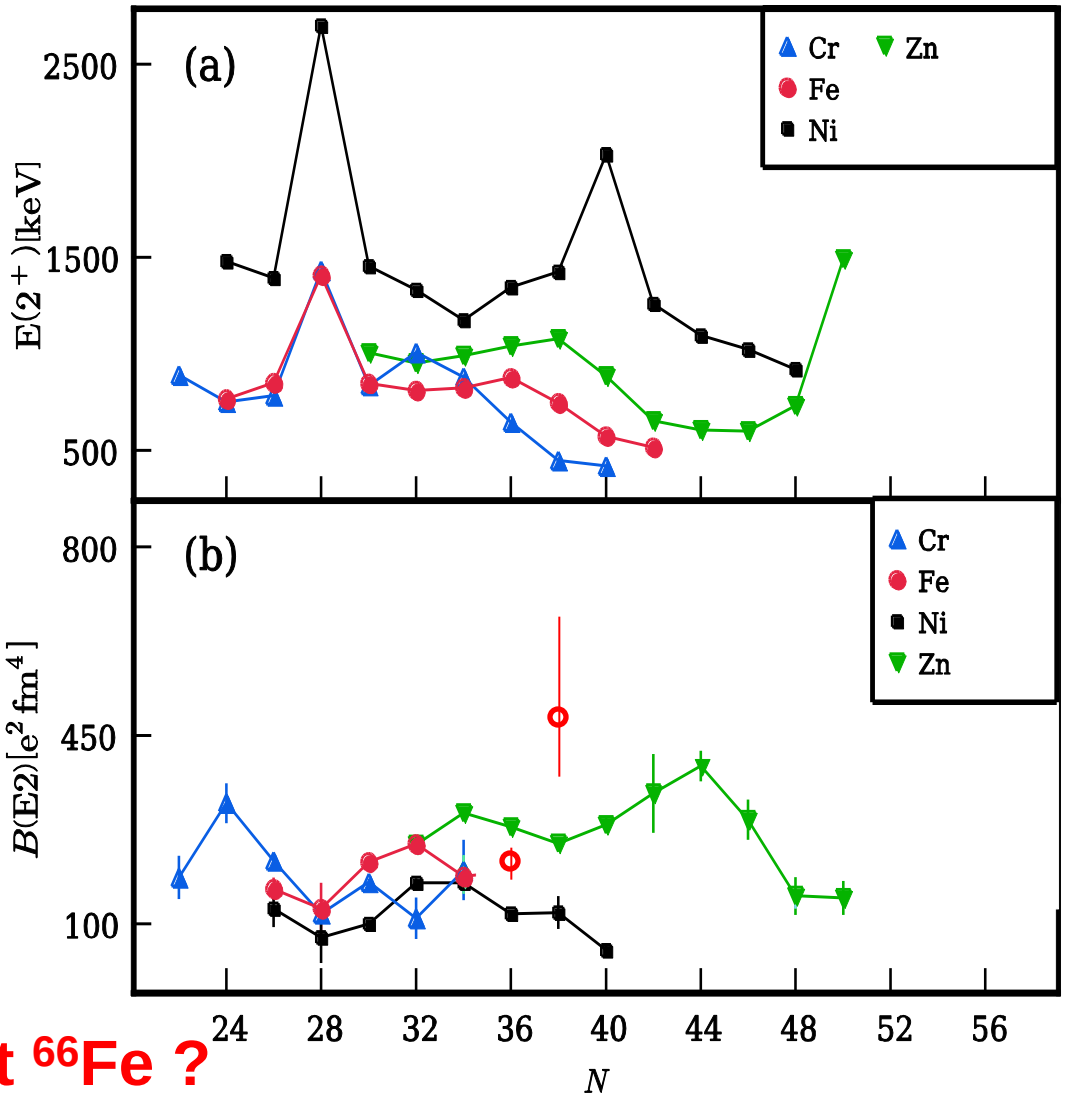
(E(2+) ^{66}Fe : M.Hannawald et al., PRL82(99)1391
^{64}Cr : A.Gade et al., PRC81(10)051304R)

But, B(E2) data are still scarce.

Recent B(E2) data on ^{62,64}Fe
(J.Ljungvall et al., PRC81(10)061301R)
suggest an increse of collectivity towards N=40.

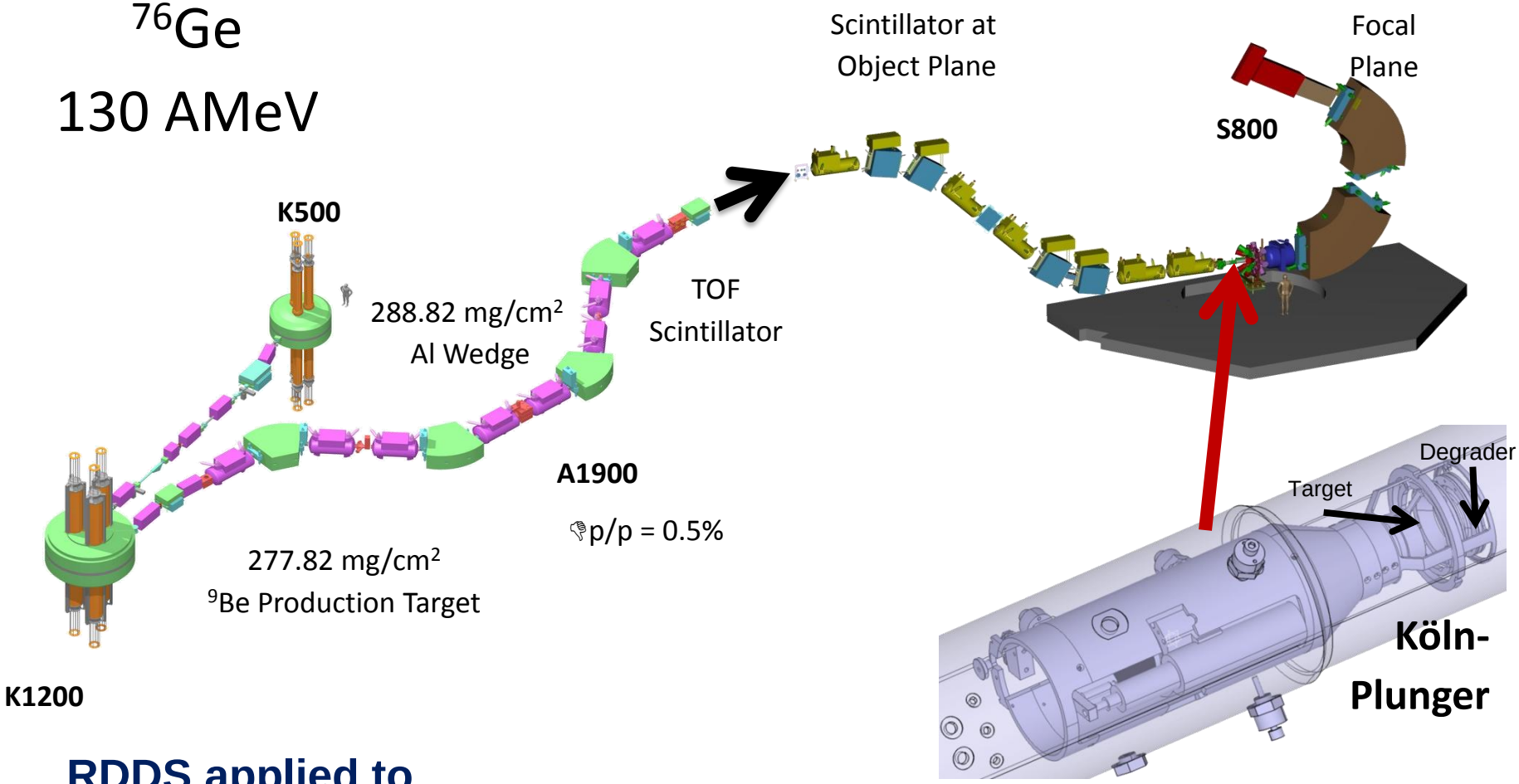
How about ^{66}Fe ?

Systematics E(2⁺) and B(E2)



^{62,64,66}Fe: 2_1^+ lifetime measurement at NSCL

NSCL coupled cyclotron facility + A1900; MSU

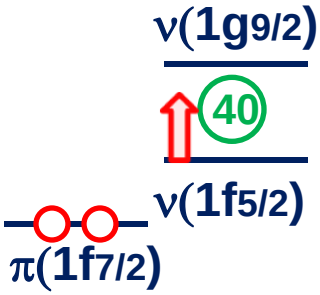


RDDS applied to projectile (^{62,64,66}Fe) Coulomb excitation reactions at intermediate energies (88-98 AMeV)

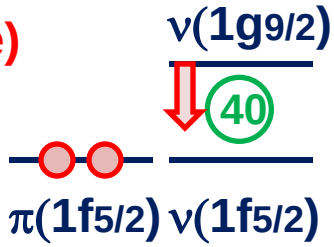
Comparison with shell model in the *fpgd* space

Symmetry with respect to Z ≈ 30, and shell evolution at N=40

Z ≤ 26 (Fe)

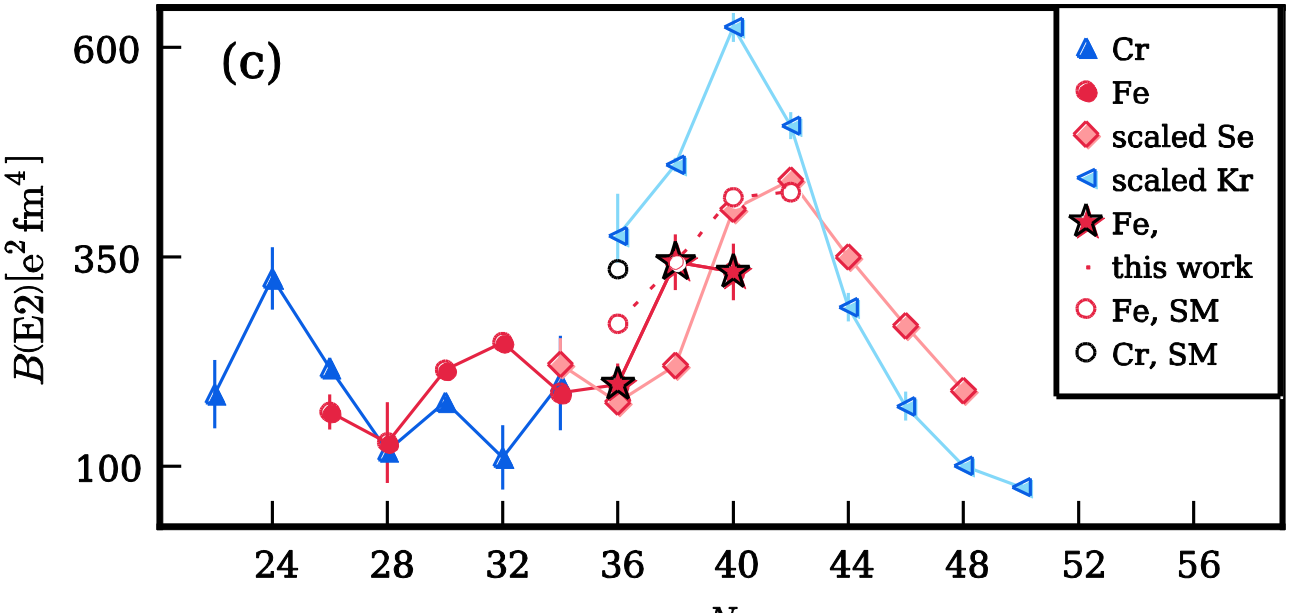


34 ≤ Z (Se)



proton-neutron monopole tensor int.

Recent shell model calculations with new effective LNPS interaction (by S.M.Lenzi, F.Nowacki, A.Poves, K.Sieja) **well explain the trends of B(E2) for ^{62,64,66}Fe at N=40**



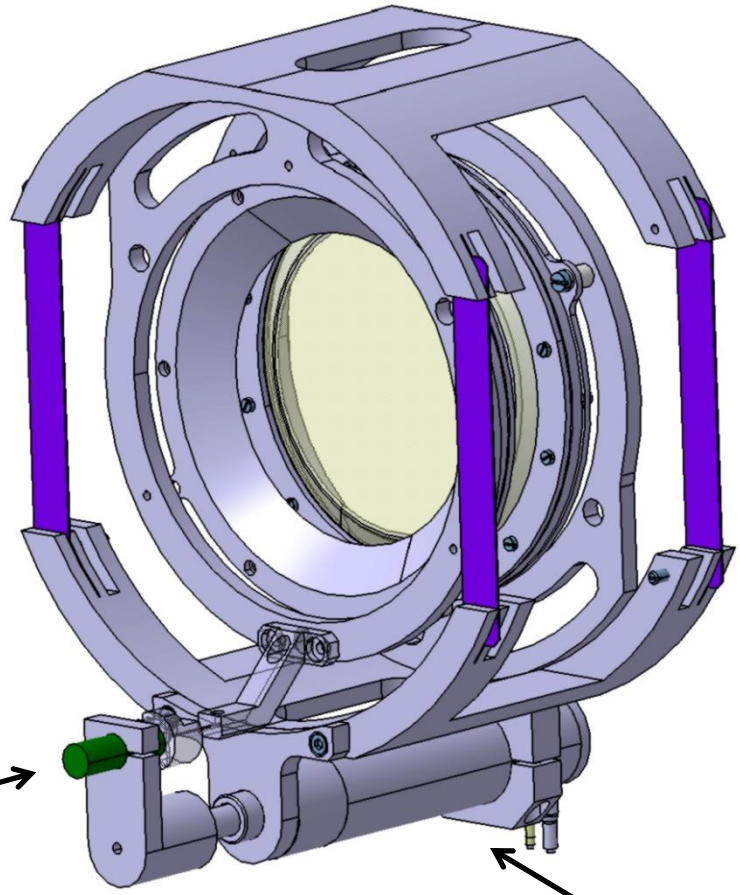
W. Rother et al., submitted to Phys. Rev. Lett., arXiv:1006.5297v1

Construction of a new plunger for PRESPEC

Requirements:

- No material in front of plunger target due to beam halo: avoid scattering on plunger structure
- Inner target/degrader diameter: 80 mm
- Thick, massive targets and degraders: thickness in mm range, weight up to 50-100 g: need stable construction
- Recoil velocities: typically around 100 MeV/u
  corresponding to v/c = 0.5 or v = 1.5 mm/ns = 1.5 µm/ps
  Need precision of a few 10 µm for short lifetimes in ps range
  for long lifetimes up to few 100 ps: large distances up to cm range
- Mount DSSD detector close to plunger

New plunger for PRESPEC



Flat spring

Piezo crystal for feedback system

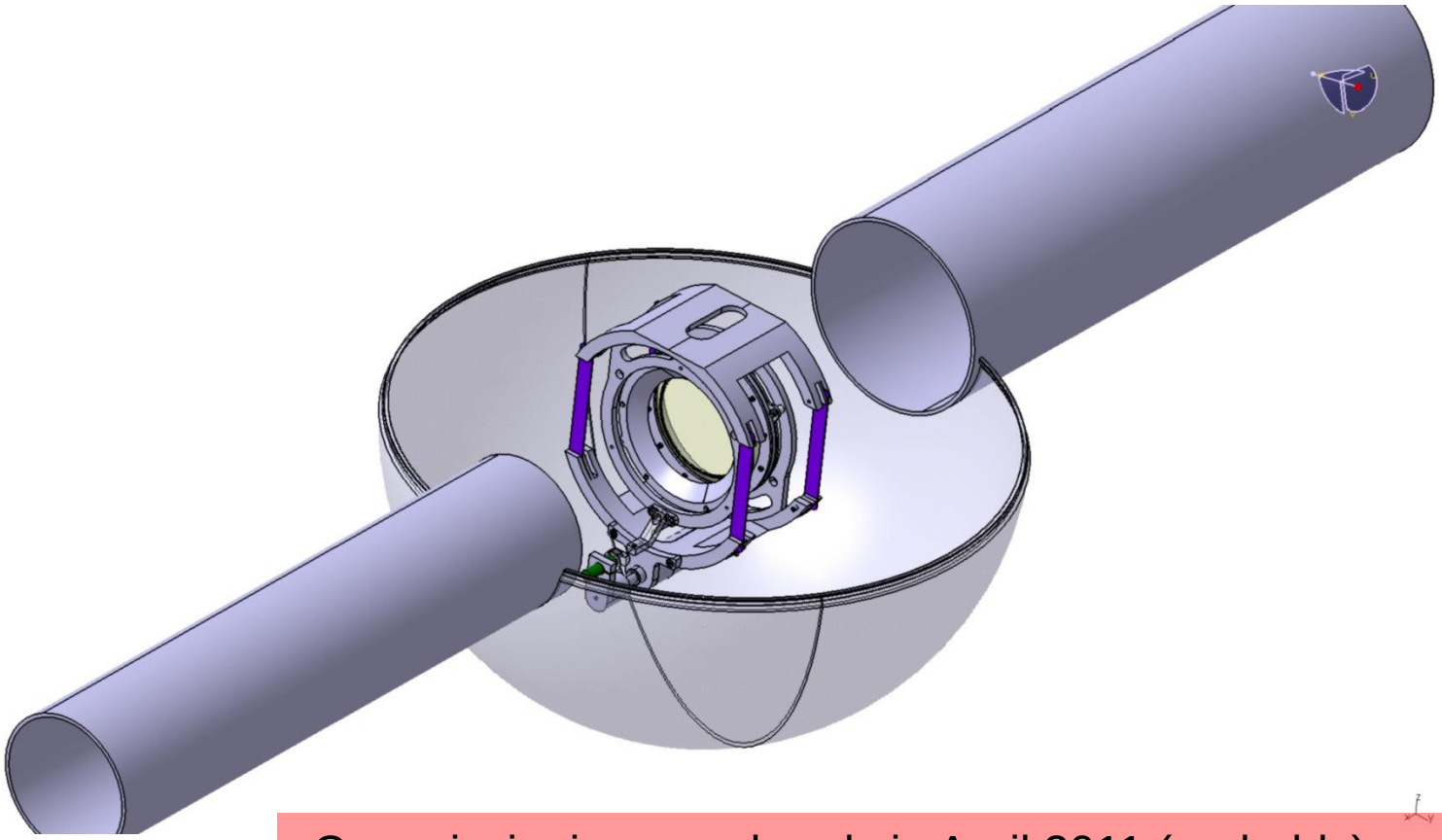
Inchworm motor (Piezo Instruments)

Construction:
S. Thiel, IKP, Cologne

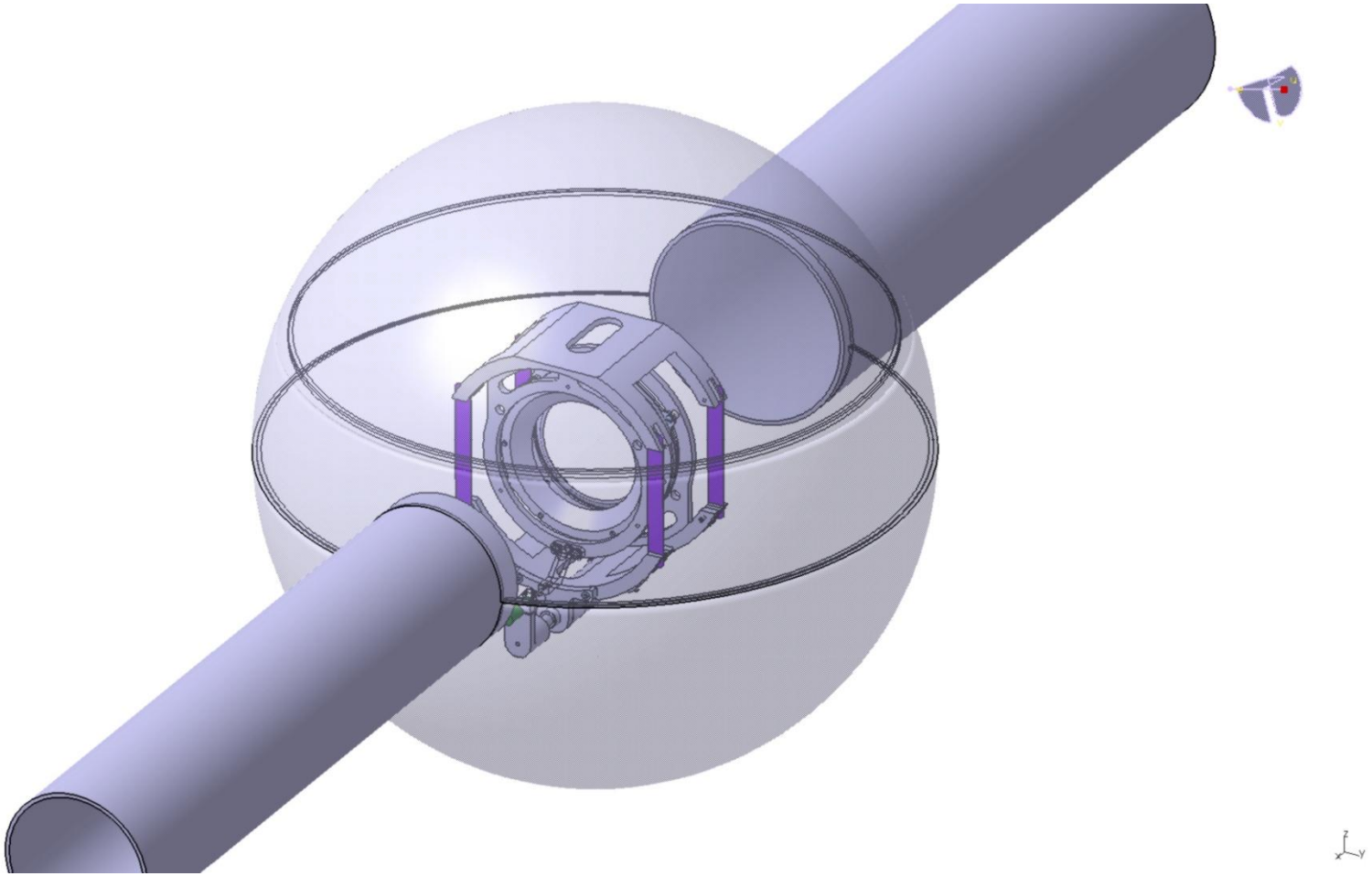
Open questions:

- Construction warp resistant?
- If not: further inchworm needed to make construction precise enough?
- In that case: need to run inchworm motors in parallel: teststand under development

New PRESPEC plunger mounted in chamber

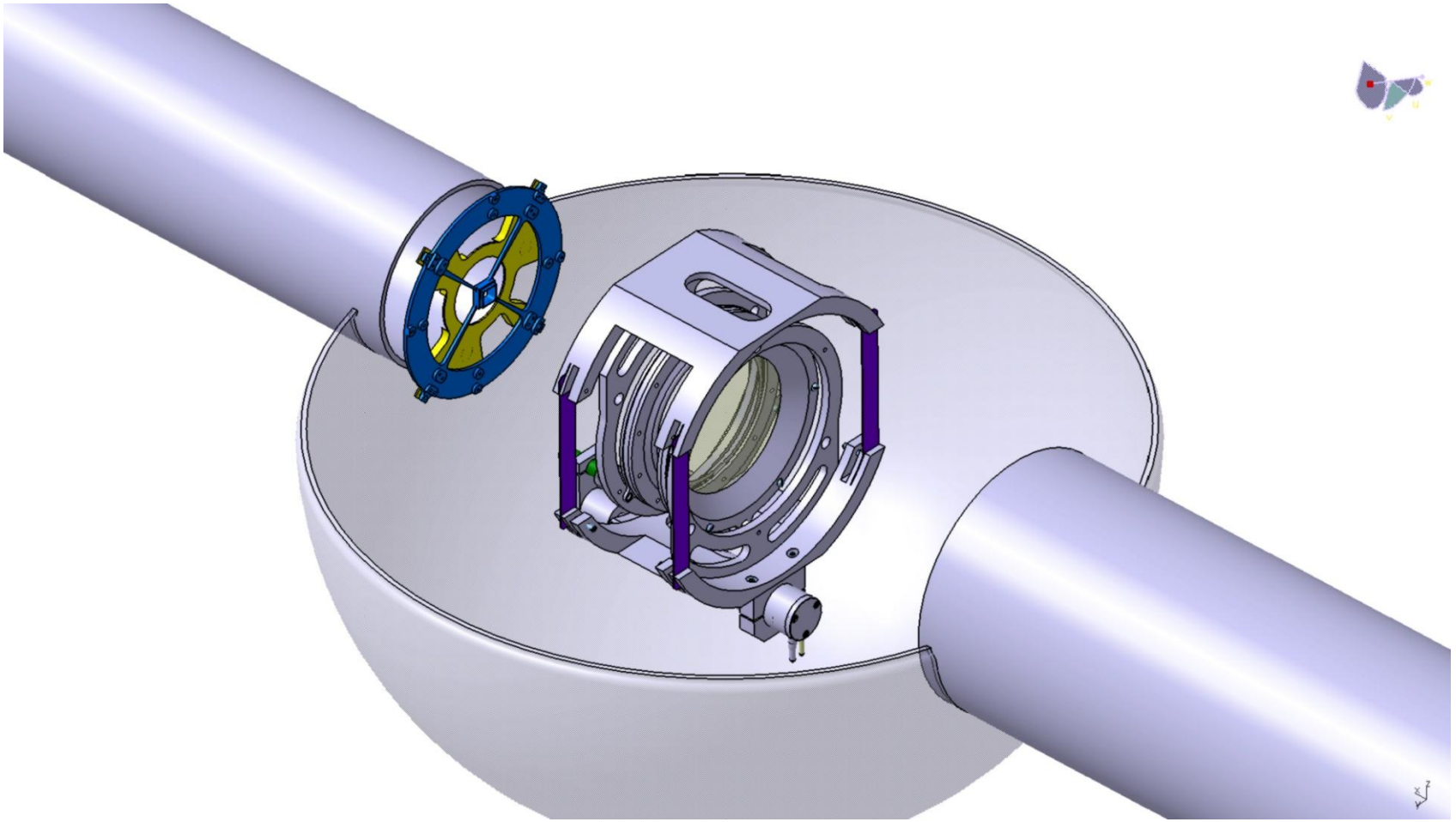


- Commissioning run already in April 2011 (probably)
- New PRESPEC chamber will not be finished till this run
- Construct own chamber for plunger for existing setup: with smaller diameter of 30 cm.
- Thus can be made in Cologne



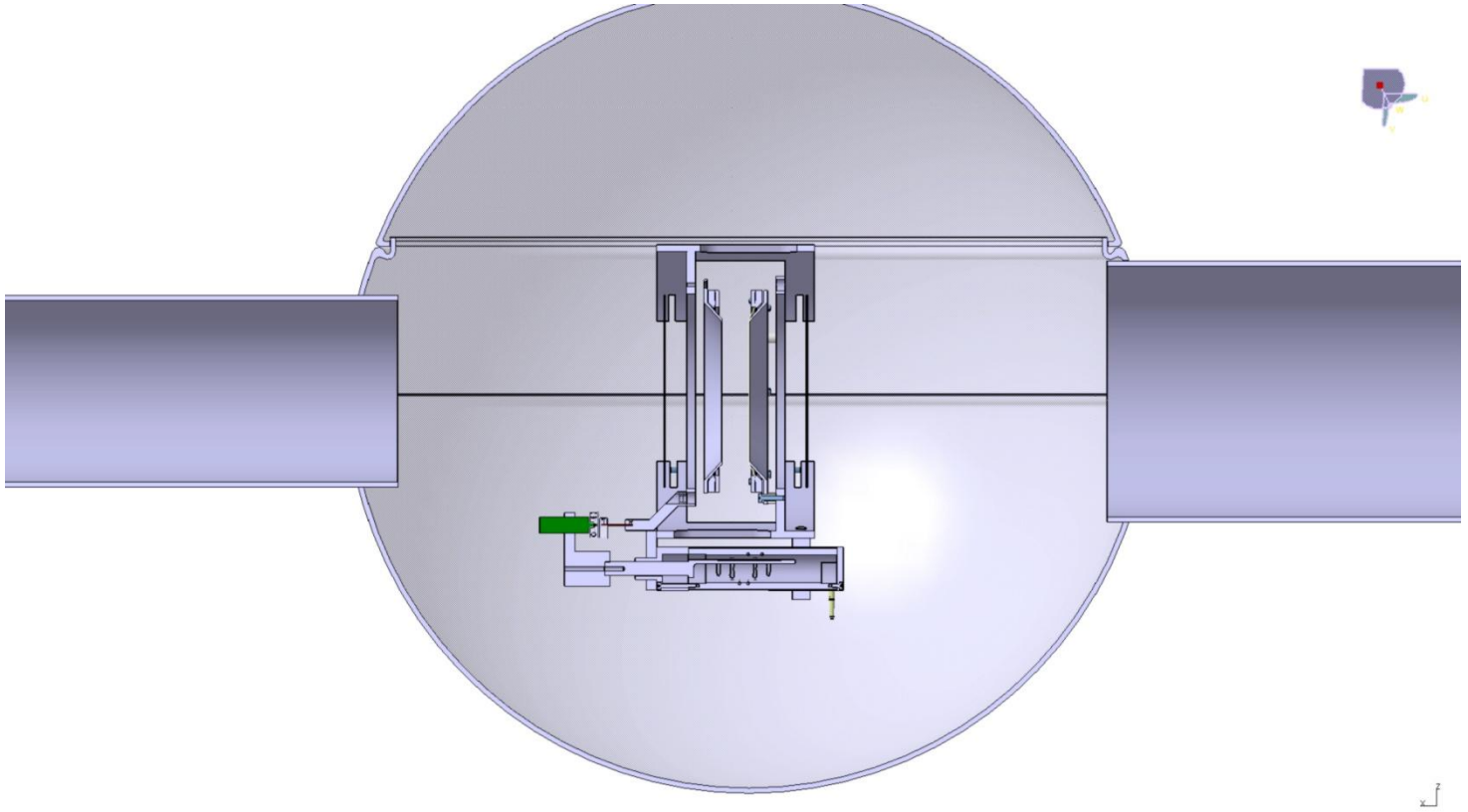
New chamber will have lid that can be removed for aligning and adjusting plunger

Possibility to mount Si-detector up- or downstream from plunger: where?



Propose: construct holding structure to support Si detector from beam pipe

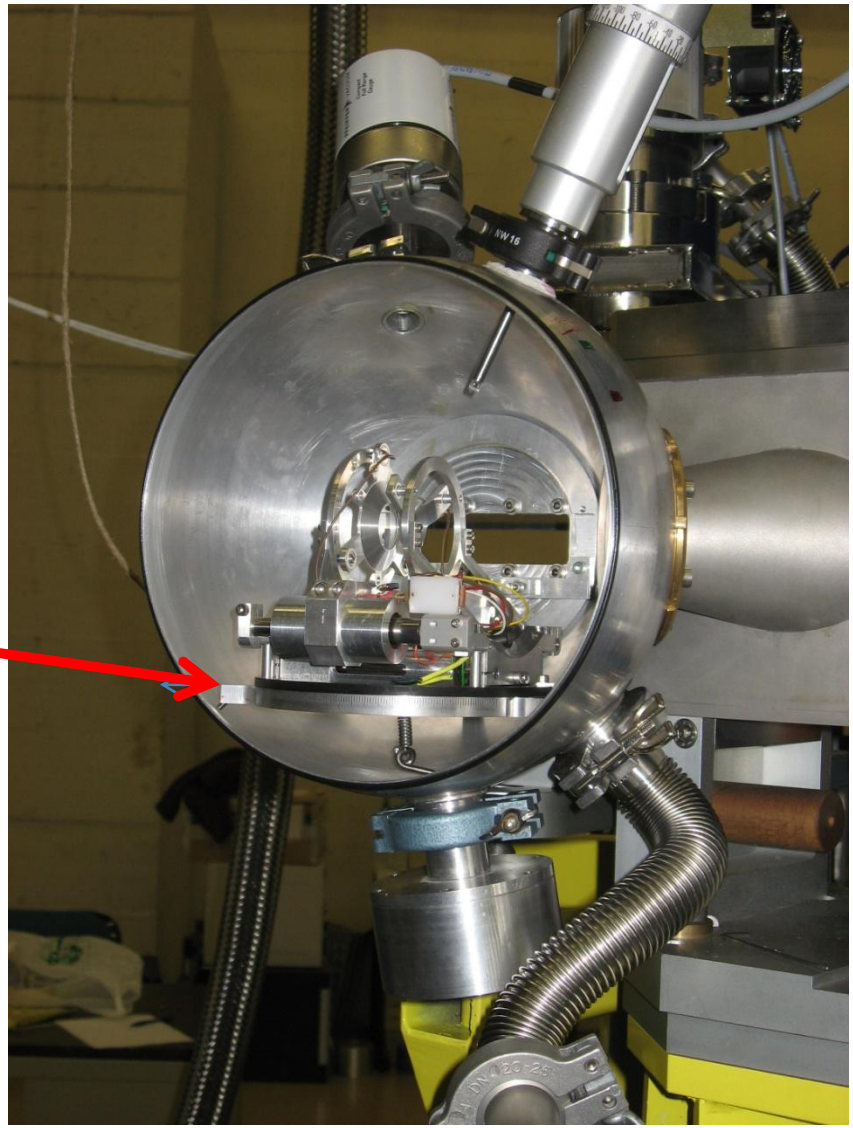
Side view



Missing so far: support structure for plunger.
will be done similar to LNL/GANIL plunger.
Modification: possibility to move plunger upstream to increase angular resolution

LNL/GANIL plunger

Adjustable
ring for plunger



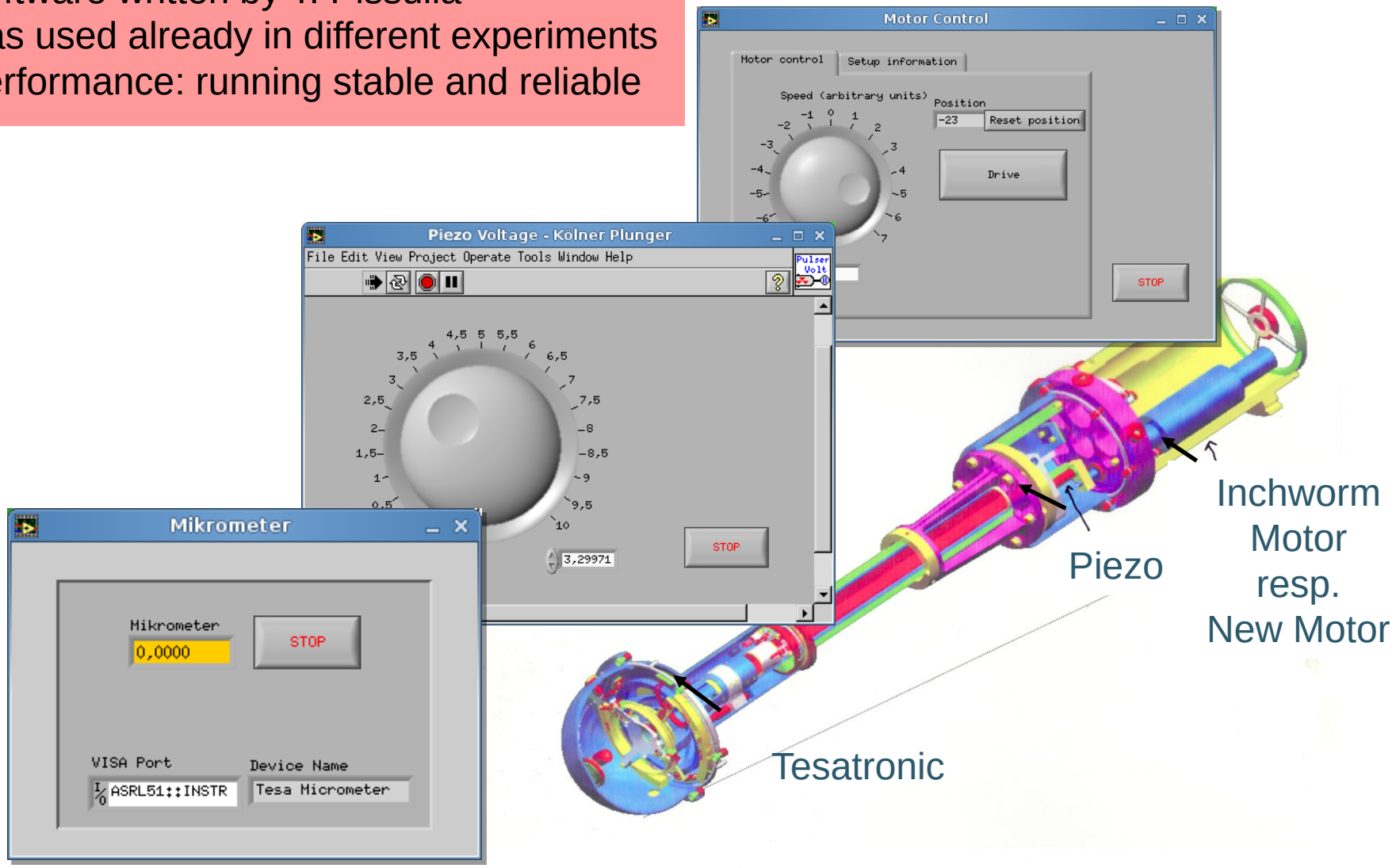
New inchworm motor: performance

New type of inchworm motor was tested
manufactured by PI Piezo Instruments, type N381 K001

- Accuracy: <= 0.5µm (reproducable)
- Accordance between motor and micrometer distance measurement: <= 0.5µm
- Maximum driving distance: 30mm
- Dimensions:
  diameter: 25 mm
  length: 119 mm (only motor)

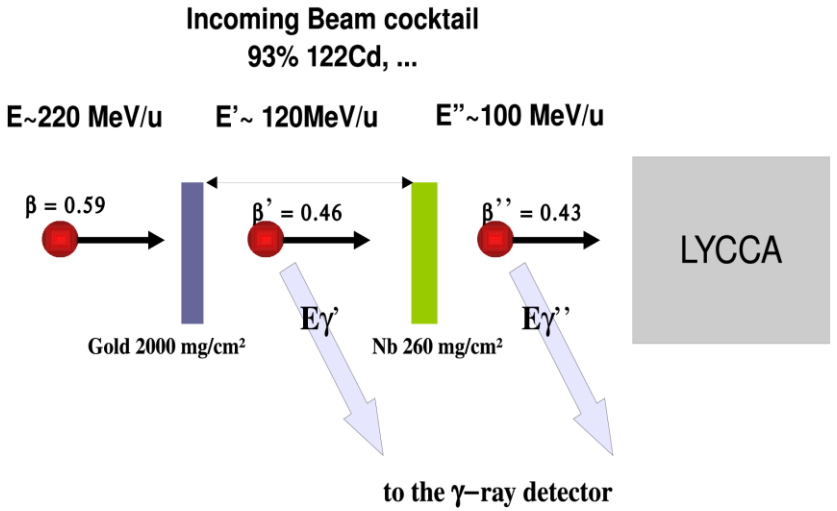
Tools for Hardware Control and Measurement

Software written by T. Pissulla
was used already in different experiments
Performance: running stable and reliable



Approved commissioning experiment: Investigation of ^{122}Cd with the RDDS method and new Cologne differential plunger at PRESPEC

Aim: application of Cologne differential plunger for lifetime measurements at HISPEC/PRESPEC with Coulex in inverse kinematics



Measure B(E2,0_1^+ -> 2_1^+) in ^{122}Cd:

Determine from lifetimes measured with plunger

Compare to B(E2,2_1^+ -> 0_1^+) from Coulex

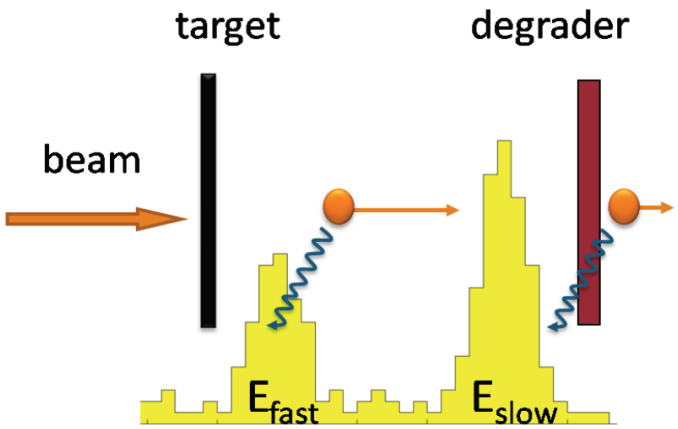
Lifetime τ [ps]	14.4
Doppler-shiftet γ-ray energy after plunger-target at 15° [keV]	914.2
PRESPEC γ-ray energy resolution [%]	4
Averaged cross section for Coulex in target [mb]	300
Cross section for Coulex in degrader [mb]	140
Number of detected good PRESPEC-LYCCA coincidences/h	172
Shifts per single target-degrader data point	1
Estimated number of shifts	3

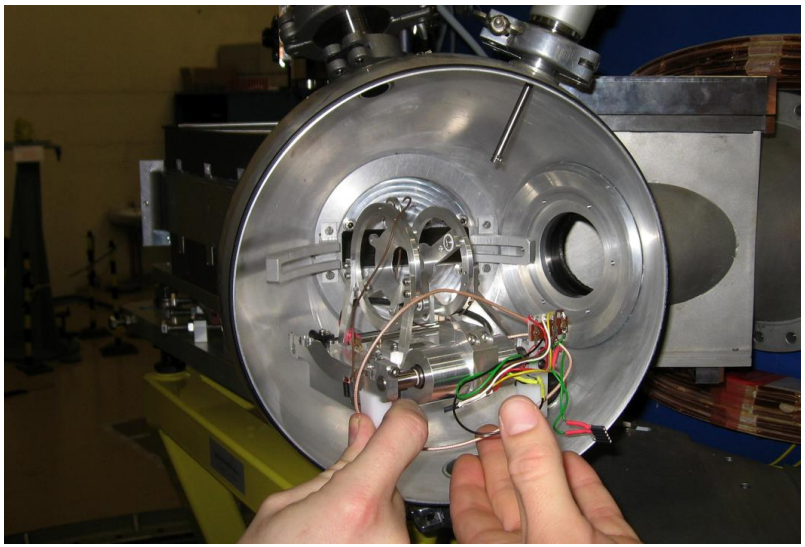
Approved parasitic experiment
21 parasitic shifts (Spring 2011)

A new plunger at PRESPEC: conclusion

- New plunger for PRESPEC under development
- PRESPEC plunger will allow precise lifetimes measurements of excited 2+ state in very exotic nuclei: knockout reactions, Coulex(?)
- New inchworm motors will be used: testing finished
- Software for operating plunger existing and performing well.
- Some questions still to be solved:
  construction with flat springs stable enough?
  Alternatively: need construction with 2 inchworm motors.
  In parallel: construction of test stand to run 2 inchworms.

The new Cologne differential compact plunger @ PRISMA





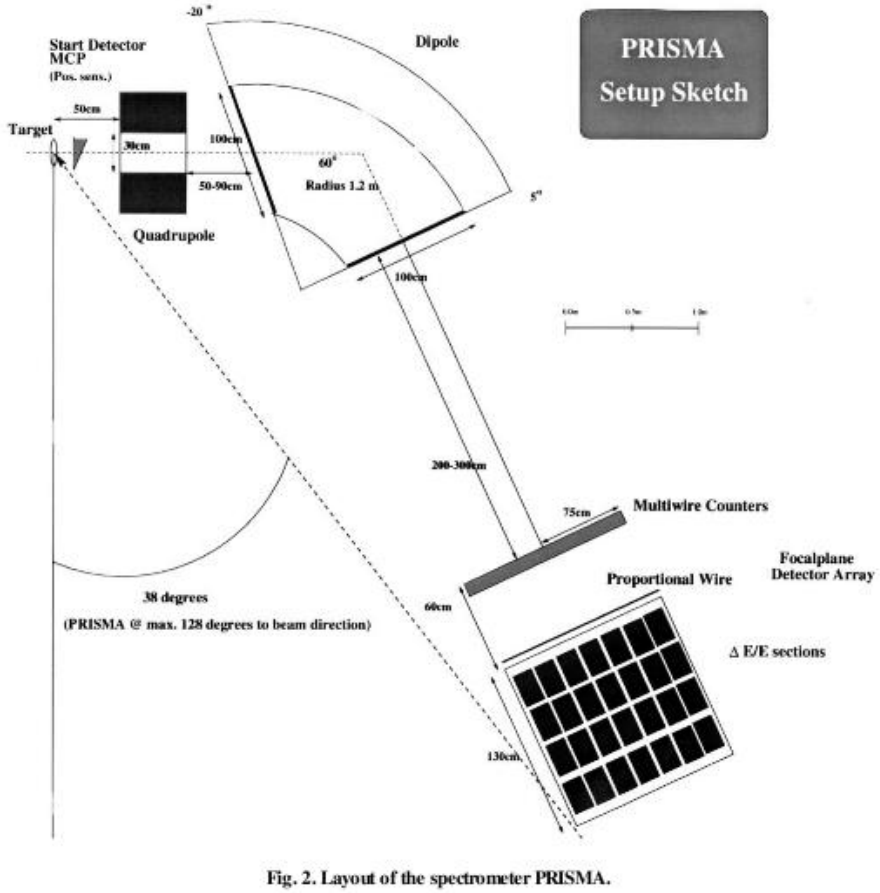


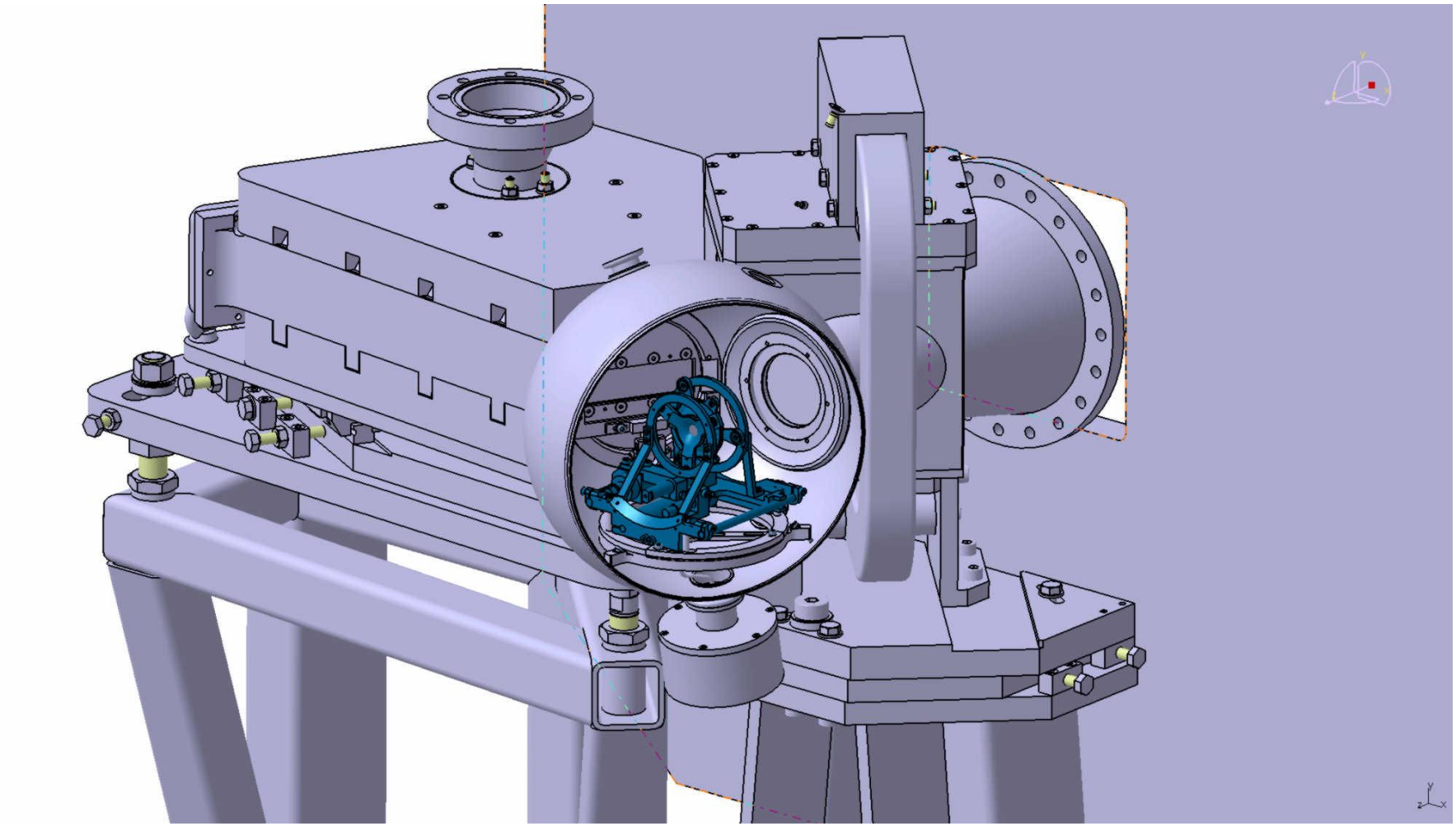
Fig. 2. Layout of the spectrometer PRISMA.

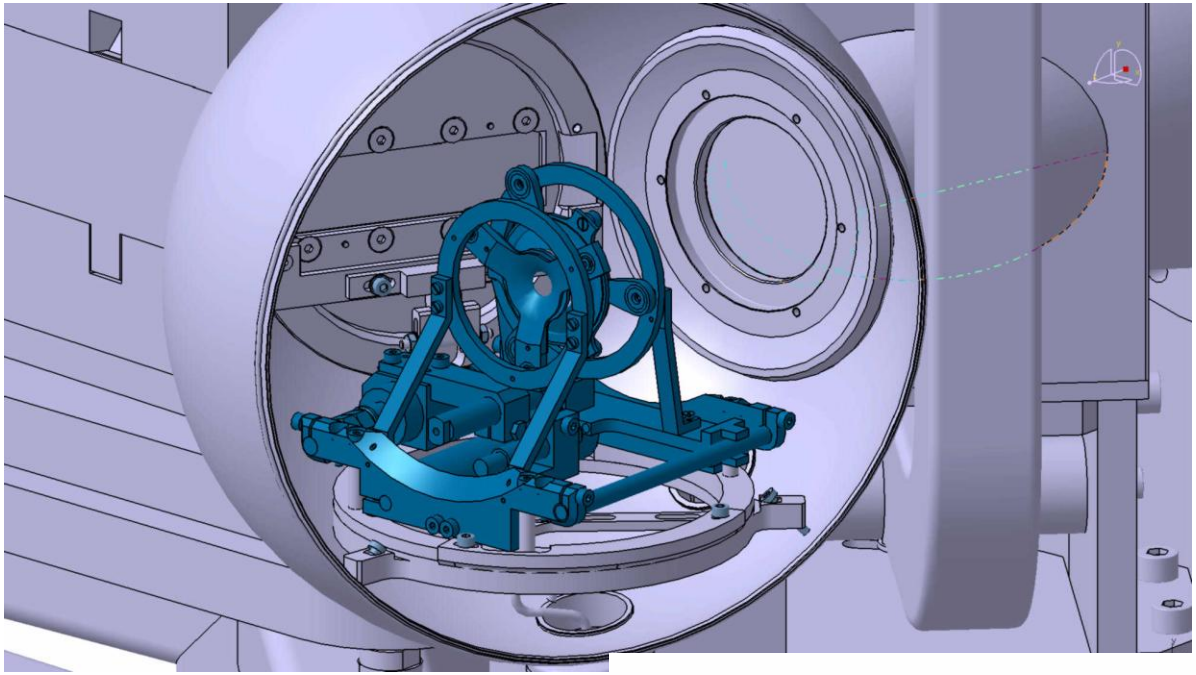
(from A. Stefanini et al., Nucl. Phys. A 701, 217c (2002))

Compact plunger for proposed experiments
already successfully used at GANIL and at LNL
in last campaign in June 2010
(E. Sahin, J.J. Valiente-Dobon).
Modifications for large grazing angles up to 60 deg.

Proof of principle with fixed Plunger with PRISMA/CLARA
(J.J. Valiente-Dobon et al., PRL 102, 242502 (2009)

Compact plunger at PRISMA





Plunger at PRISMA:
More drawings…

Several experiments performed with this new plunger at LNL (see, e.g., talk by E. Farnea)

A. Gadea, et al., to be submitted to NIM (will contain section on plunger by A. Dewald, T. Pissulla)