ERNA2

Lucio Gialanella - University of Campania and INFN

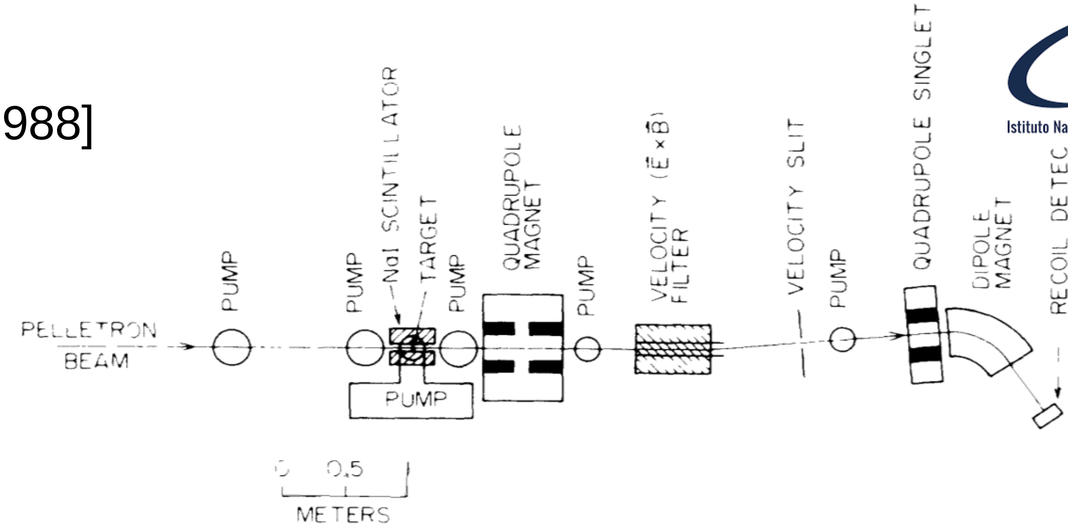
> design, construction, and upgrade of ERNA to ERNA2

> what does work and what does not

> some old and some new results

> conclusions and outlook

CTAG at Caltech
[Kremer et al PRL1988]



NaBoNA – Naples [Gialanella et al. NIMA 1996]

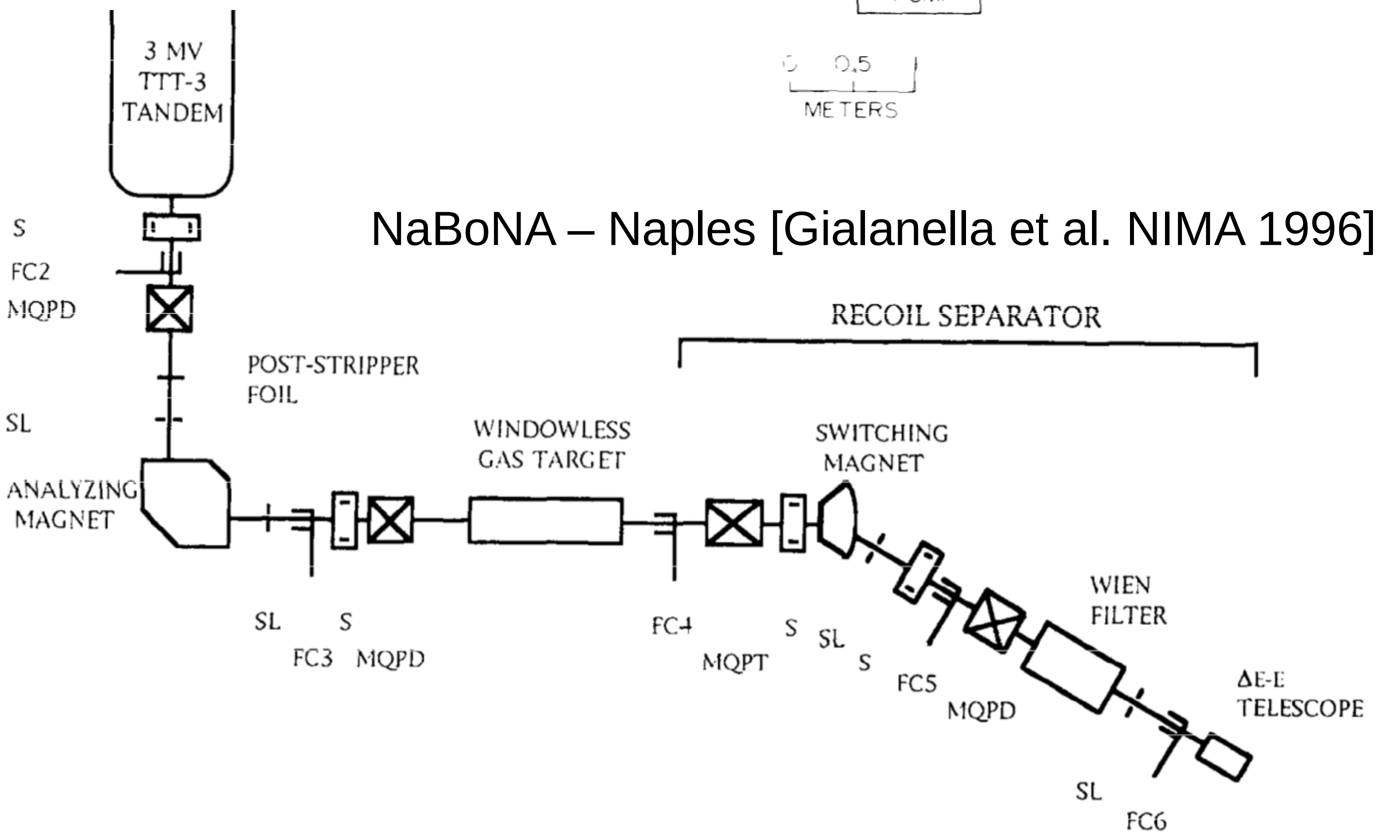


Fig. 1. Schematic diagram of the setup at the 3 MV tandem accelerator in Naples including a windowless gas target and a recoil separator (S = *X*–*Y* steerers, SL = slits, FC = Faraday cup, MQPD = magnetic quadrupole doublet, MQPT = magnetic quadrupole triplet).

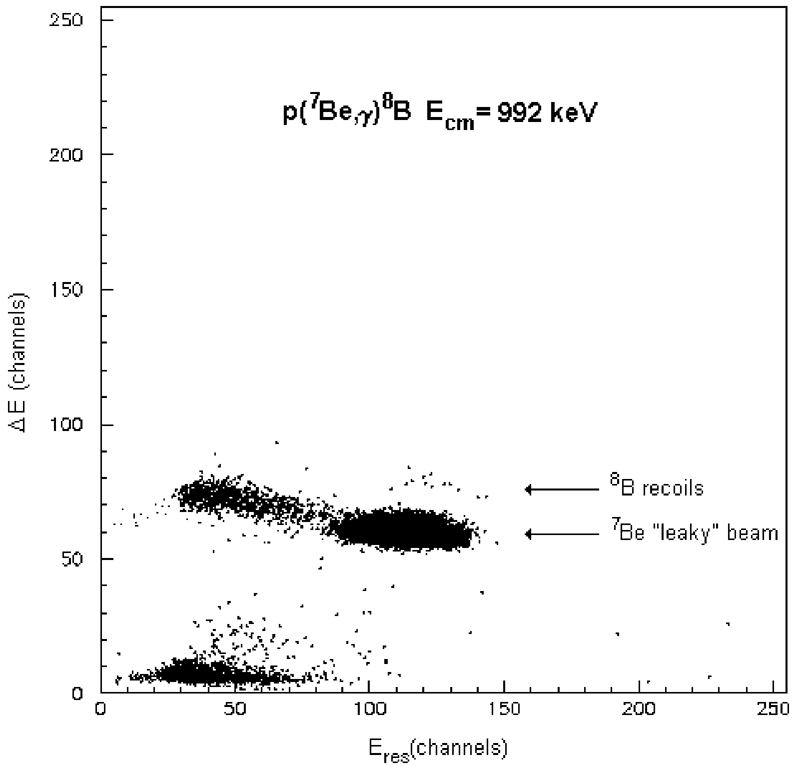
V:

Achievements:

> measurements without γ-ray coincidence
> first albeit incomplete documentation of the recoil acceptance
> investigation of charge exchange

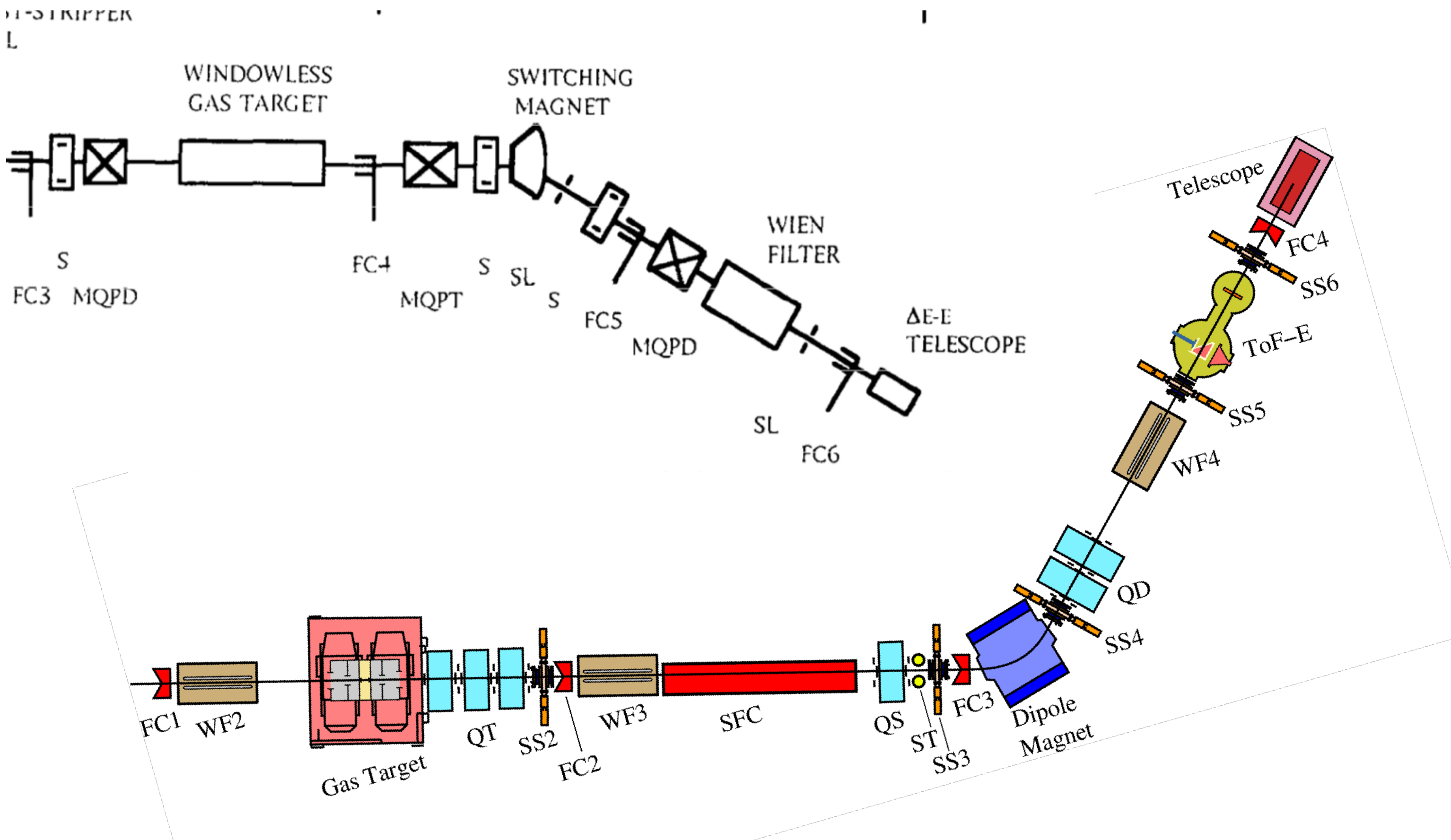
Open issues:

> missing documentation of the angular acceptance
> good suppression only for recoil charge states unaccessible to beam ions
> no extensive optical calculations



LG et al, Eur. Phys. J. A **7,** 303**, 2000**

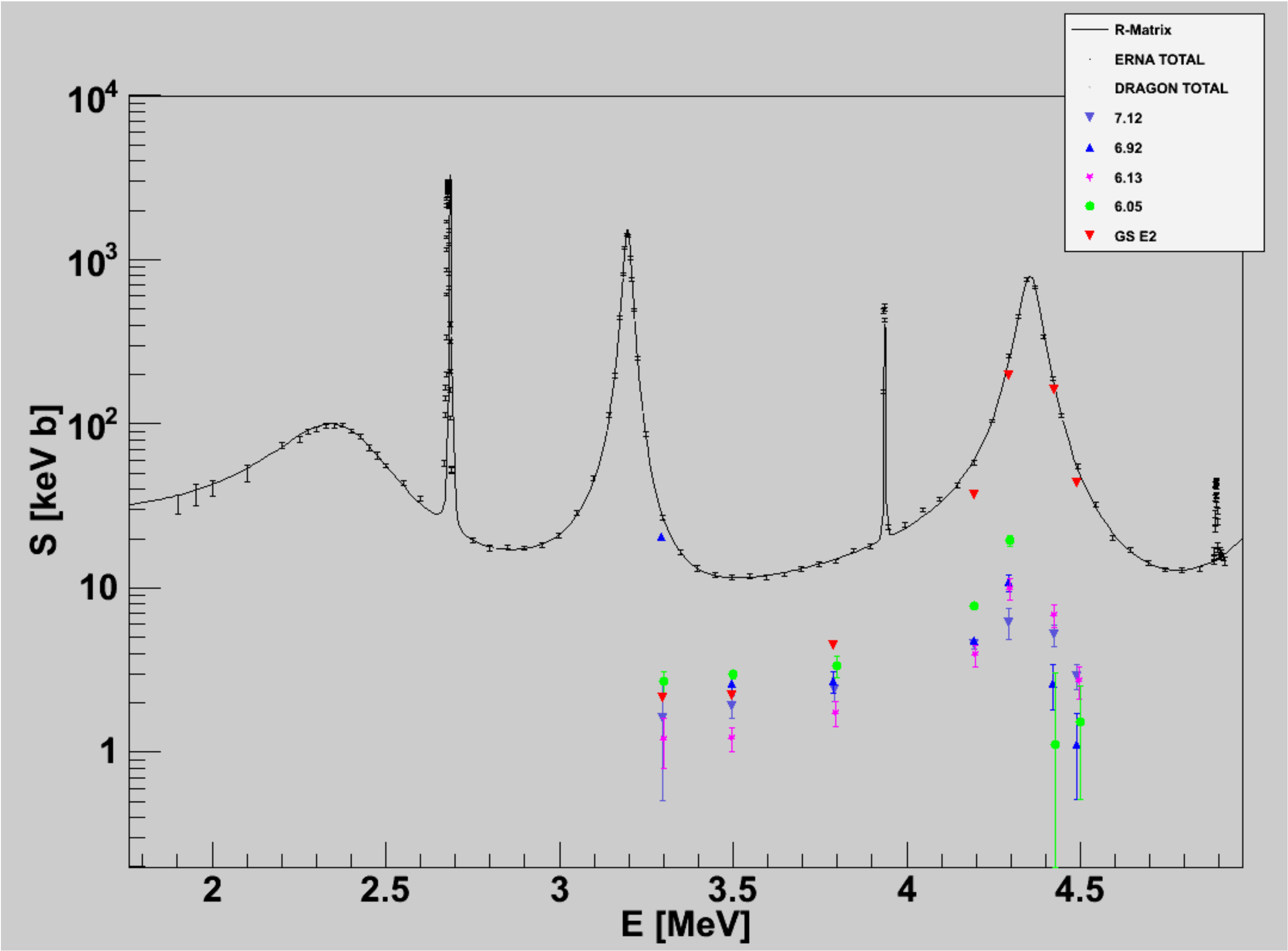
From NABONA to ERNA



> dedicated, specifically designed facility
> one additional filter element
> all analysis elements bend on the same plane
> partially computer controlled

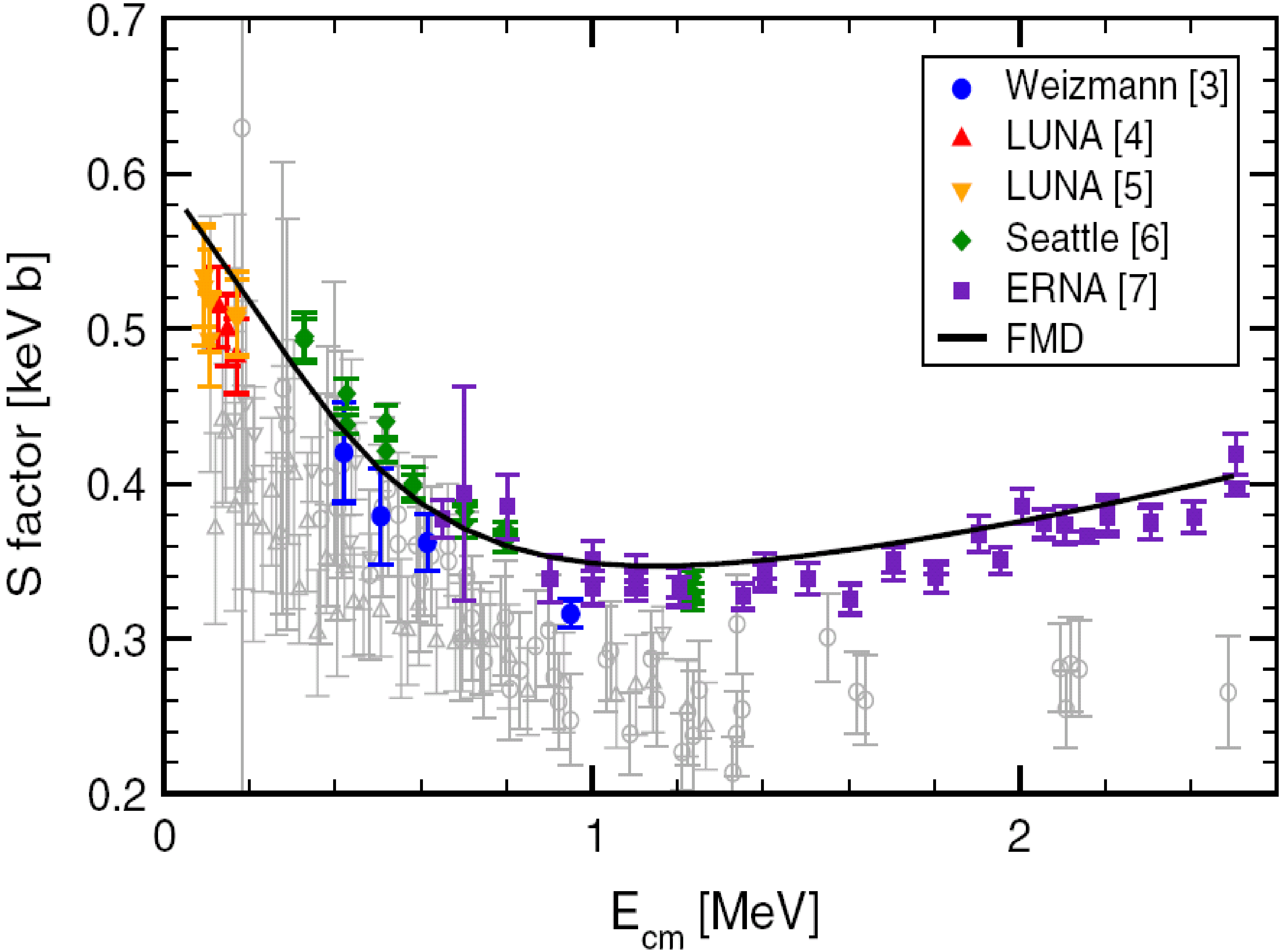
V:

$^{12}C(\alpha,\gamma)^{16}O$



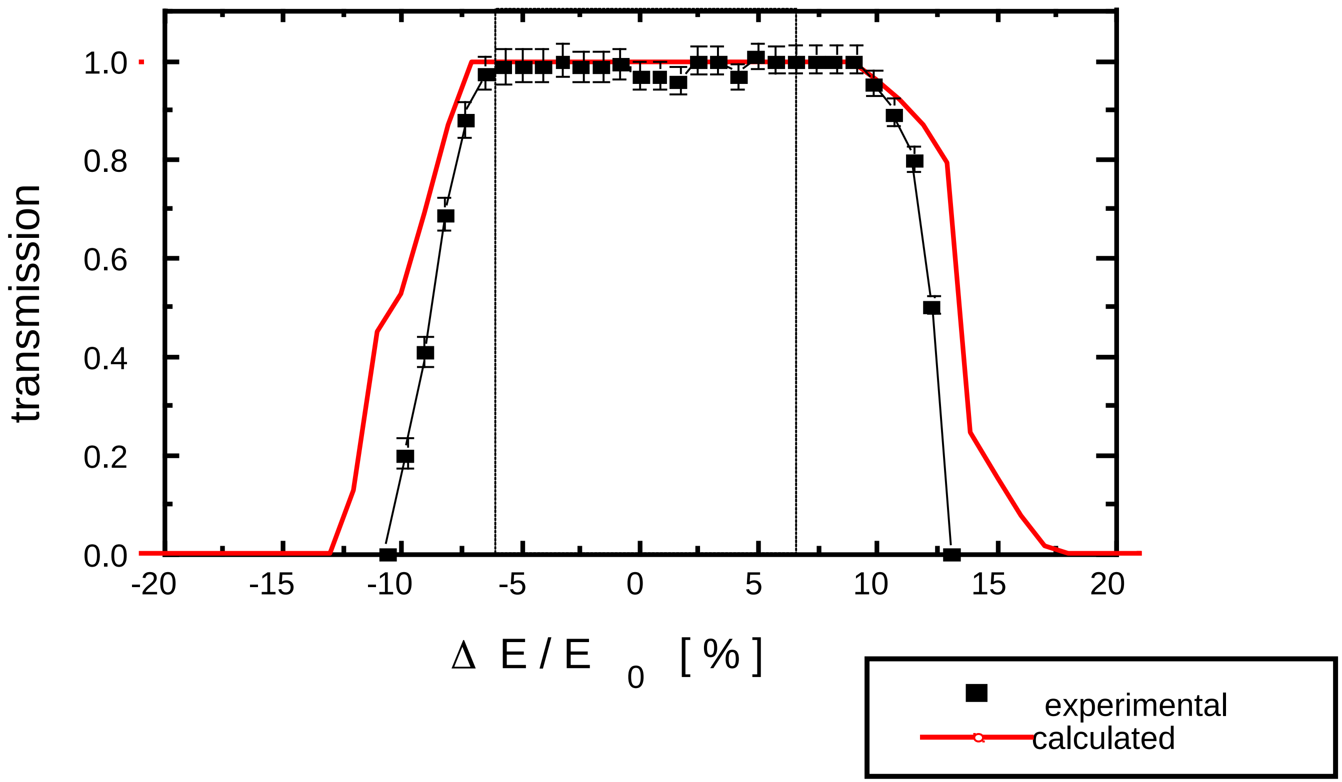
V:

$^3He(\alpha,\gamma)^7Be$



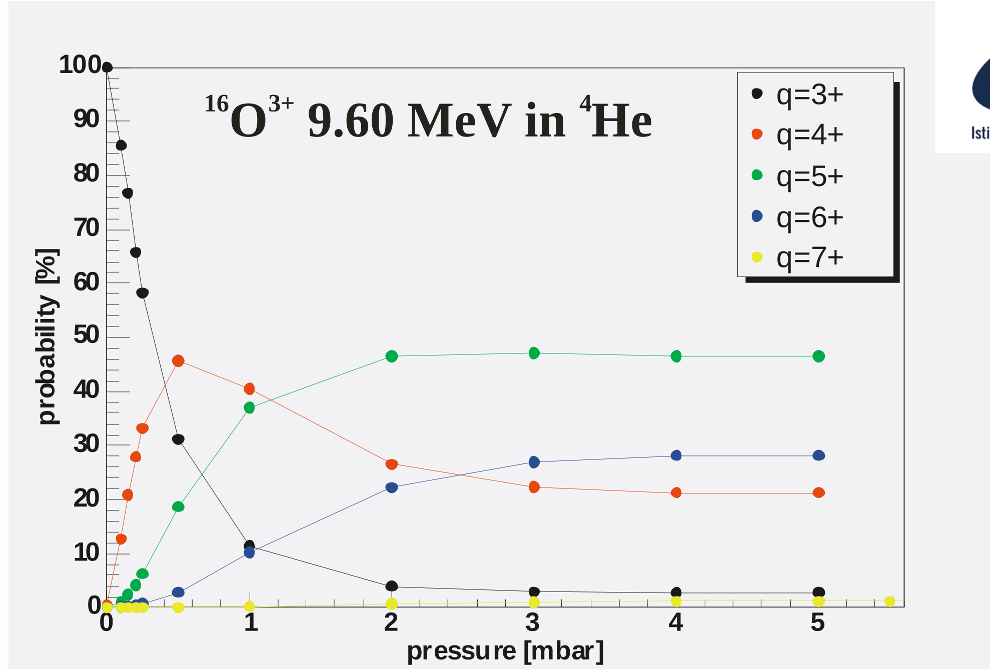
T.Neff ,PRL 106 (2011)

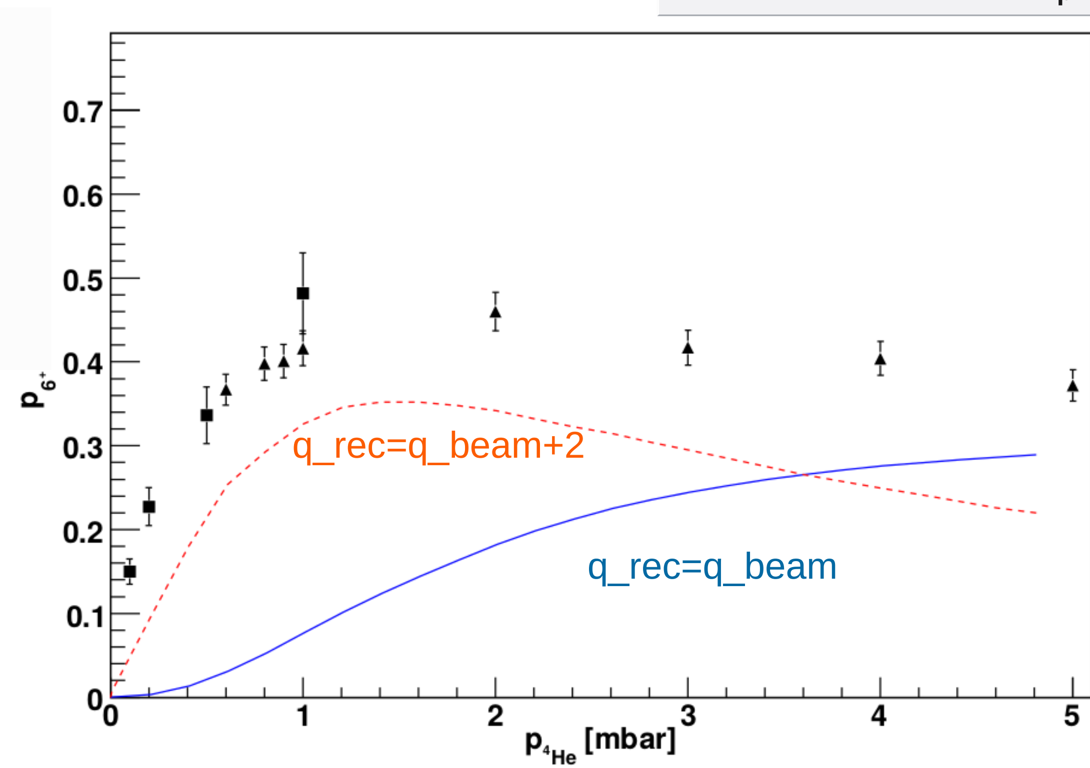
Energy acceptance: change beam energy

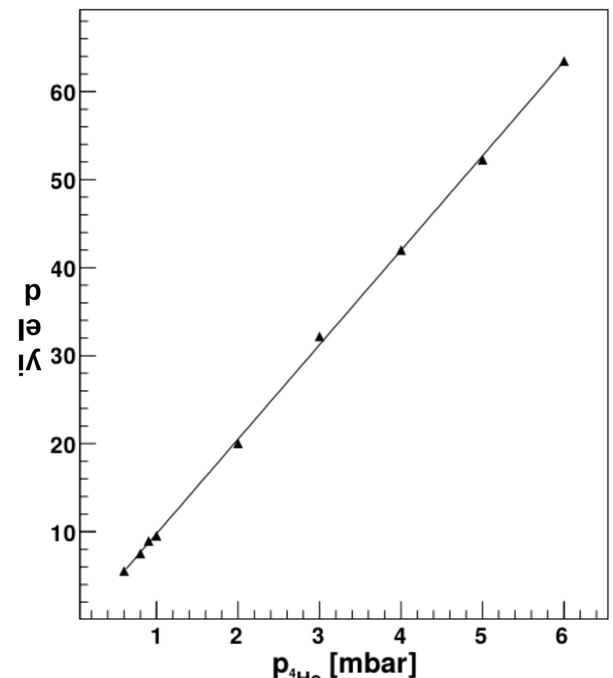


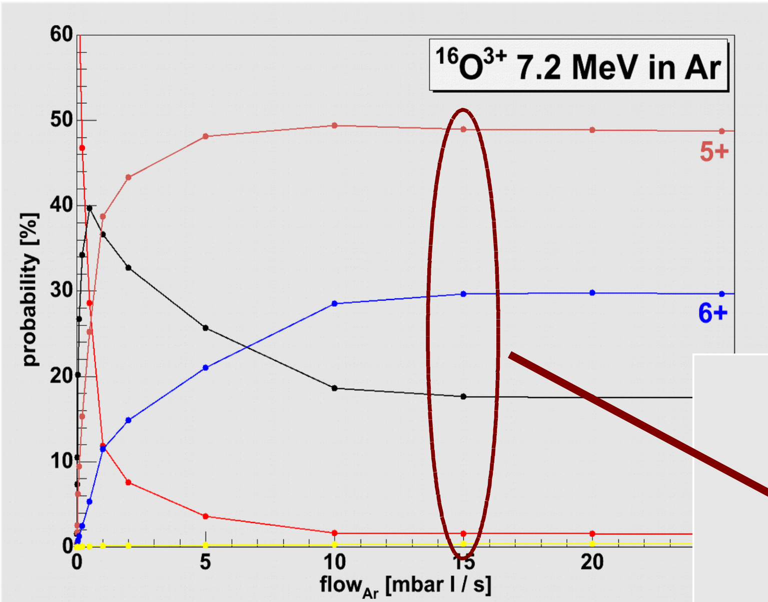
V:

Investigation of the charge state of the recoils

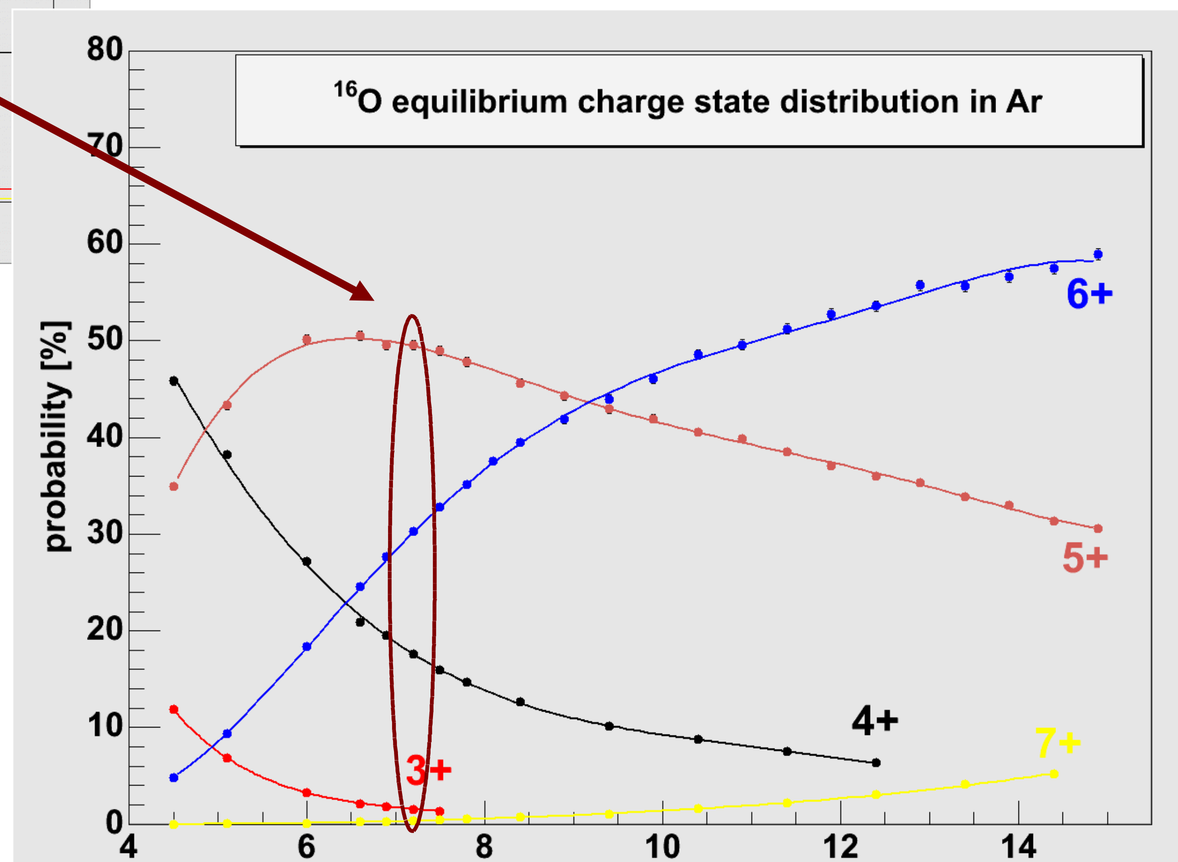




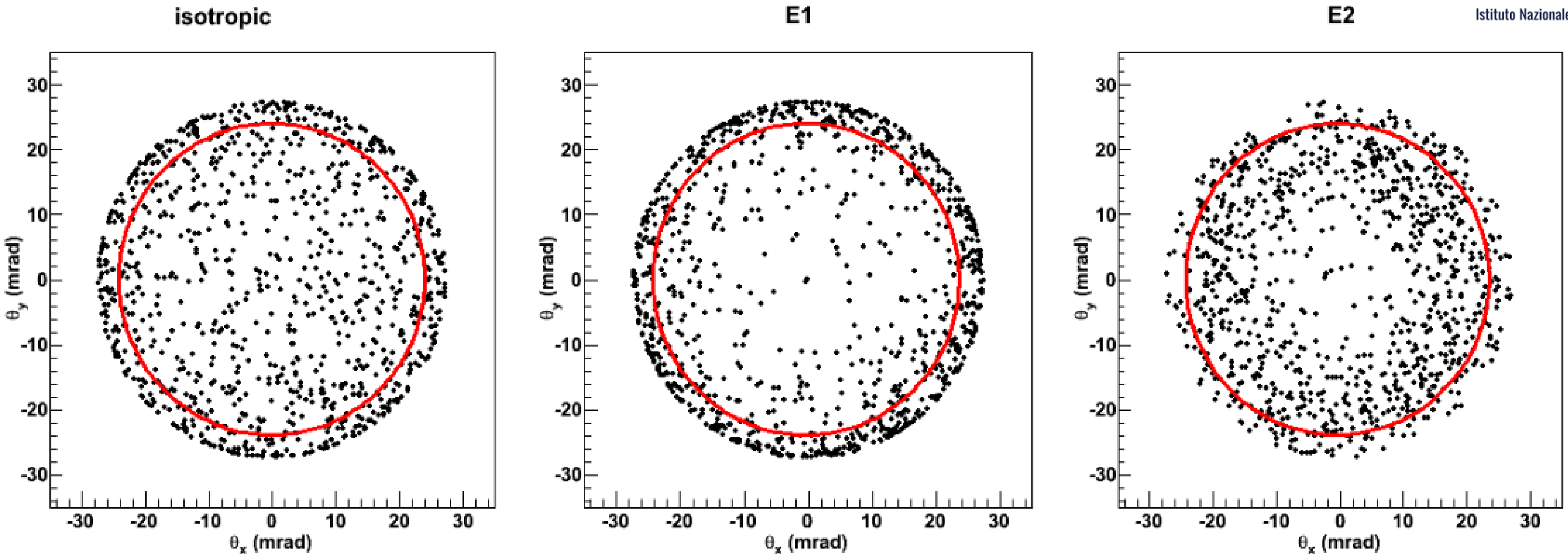




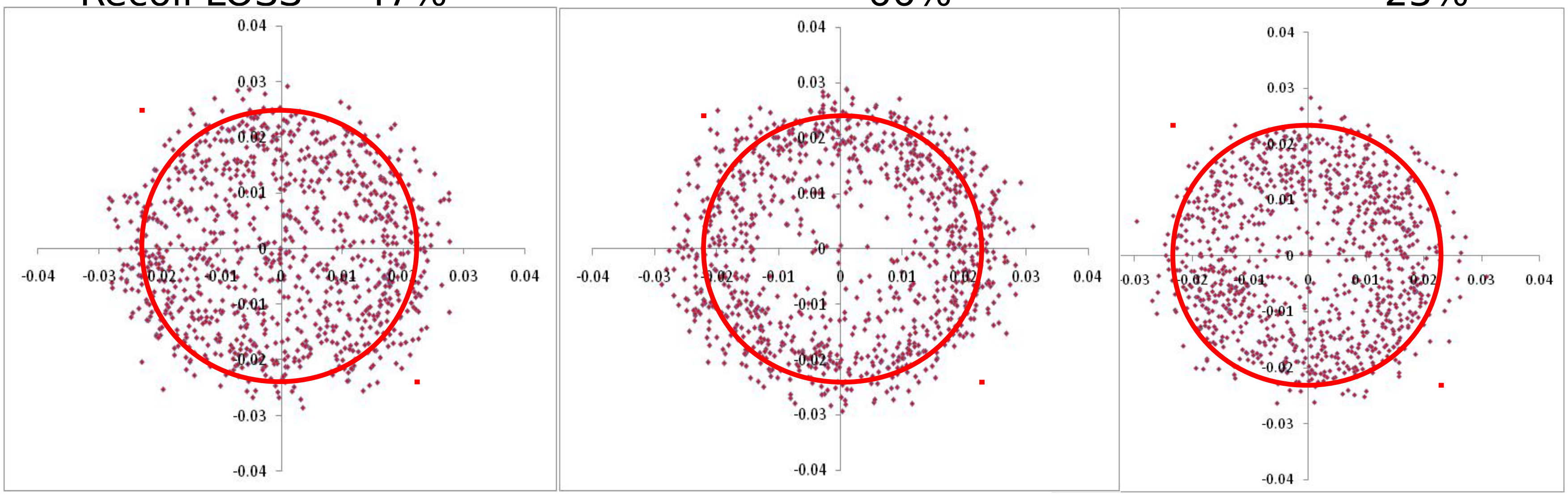
^{16}O in Ar post stripper



V: If you measure a transmission of 80% with an α source



Recoil LOSS 47% 66% 23%



for a specific target: 21% 36% 7%

LG and D. Schuermann PoS(ENAS 6)058v

Recoil detection

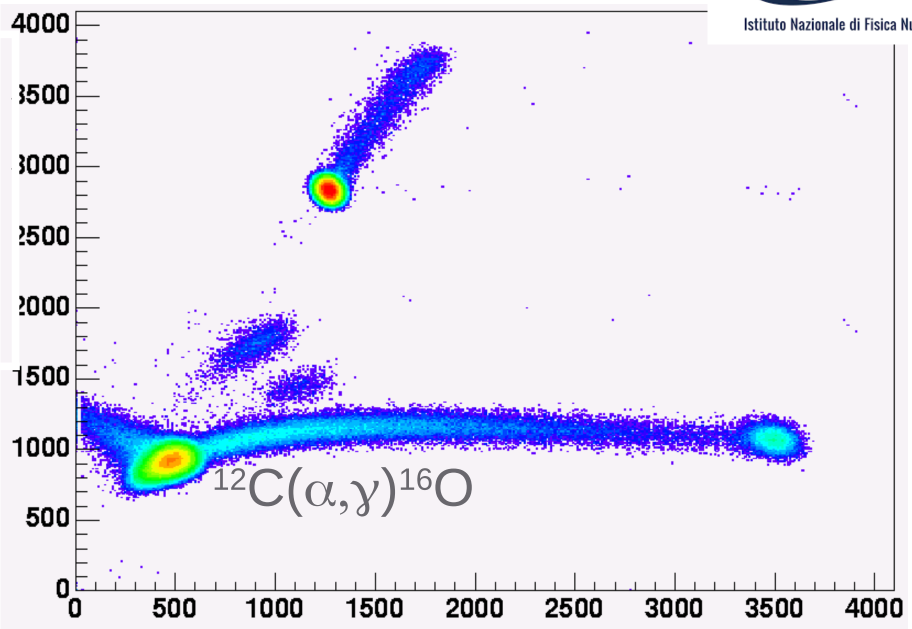
Full acceptance

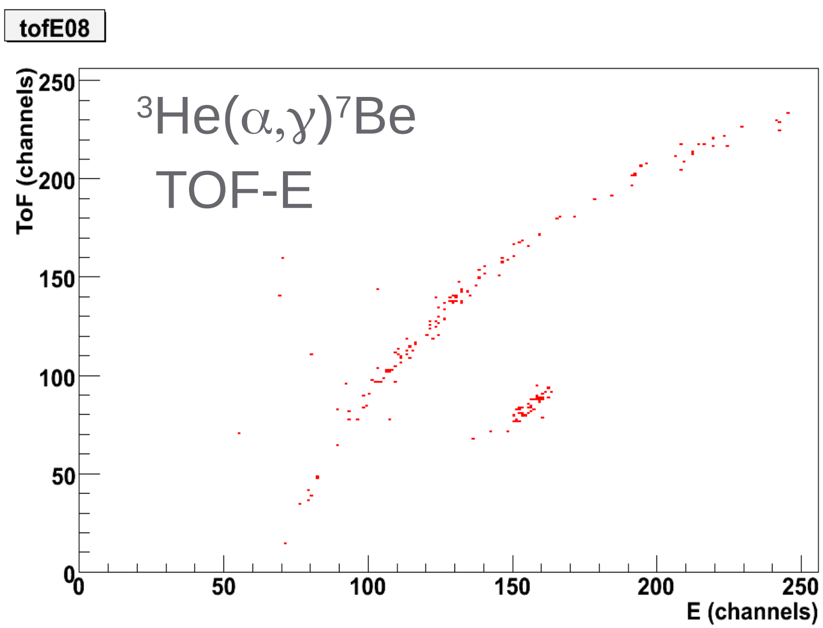
Suppression

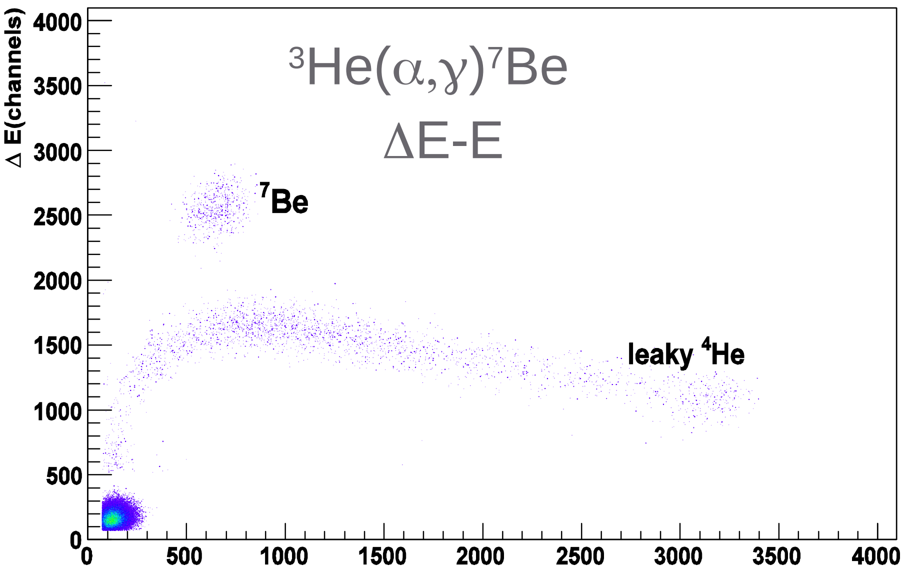
Separator: 10^{-10}-10^{-13}

Detector : 10^{-3}-10^{-6}

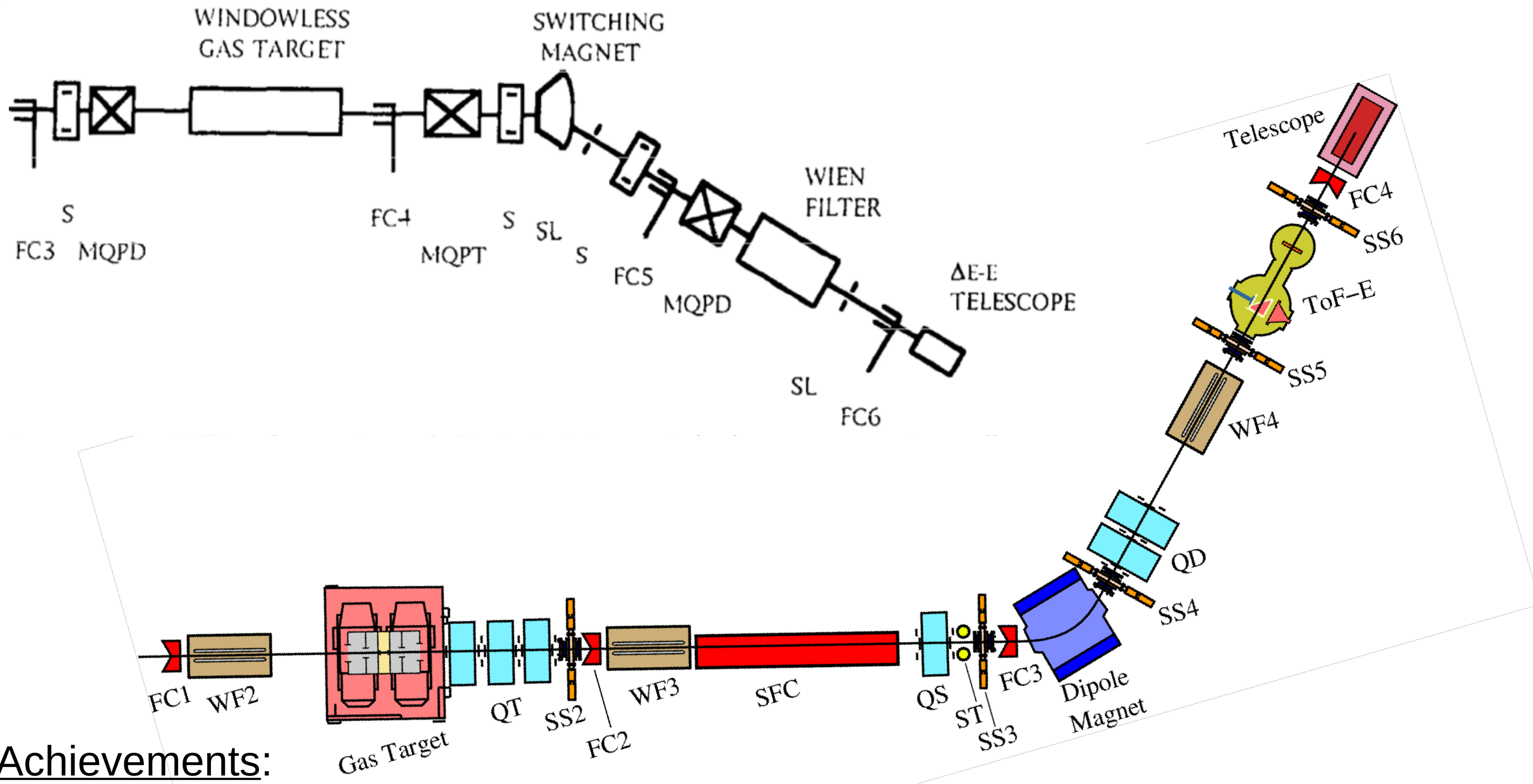
Mass resolution is not a good design parameter for ERNA







From NABONA to ERNA



Achievements:

> cross section measurements without γ-ray coincidence (optional)

> documentation of the full recoil acceptance

> control of charge exchange using a post stripper

> good suppression with a nearly free choice of the recoil charge state

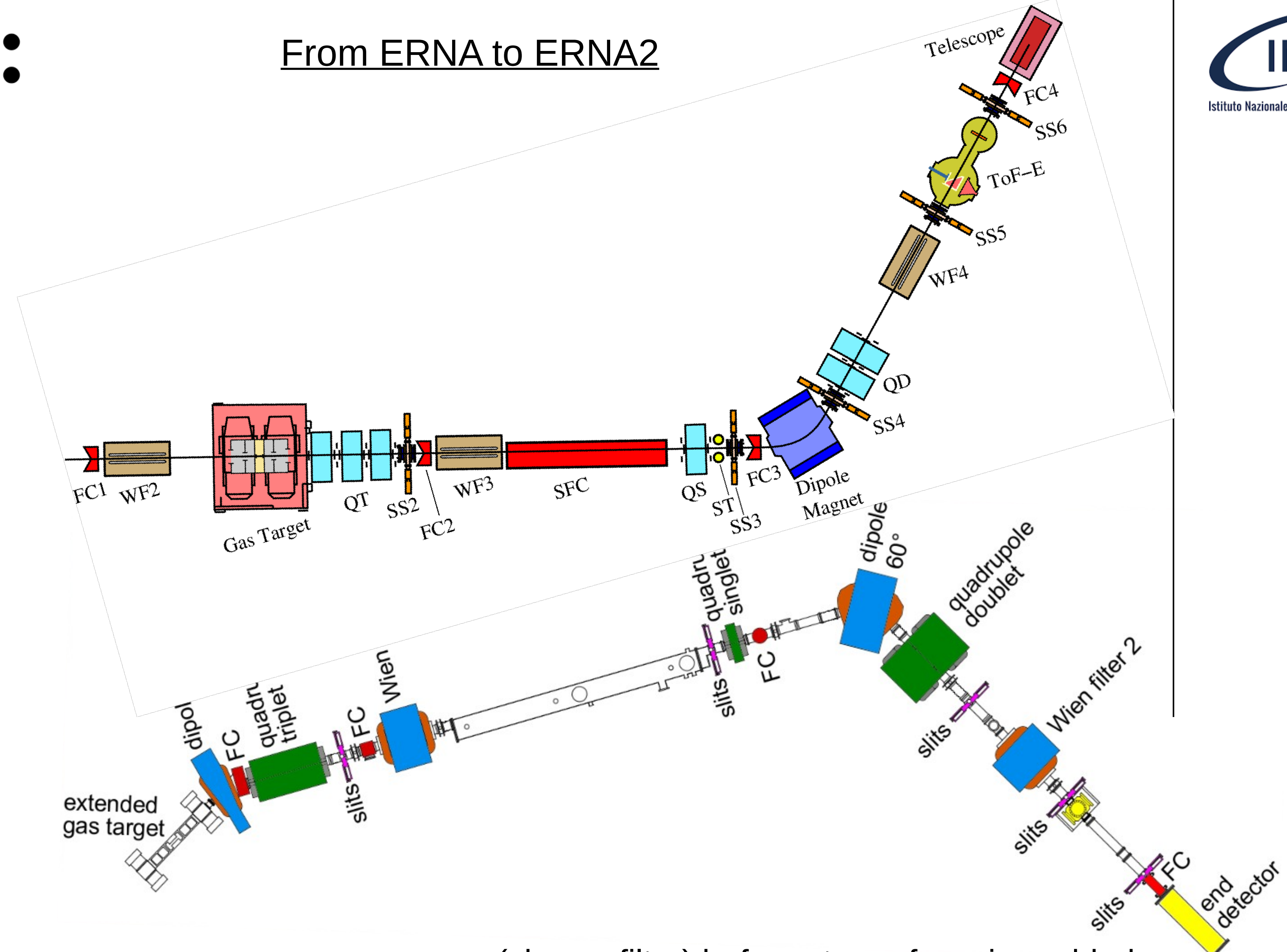
> extensive optical calculations

Open issues:

> extensive experimetal tuning required, scaling possible over relatively small ranges

> poor suppression and background production for low recoil charge states

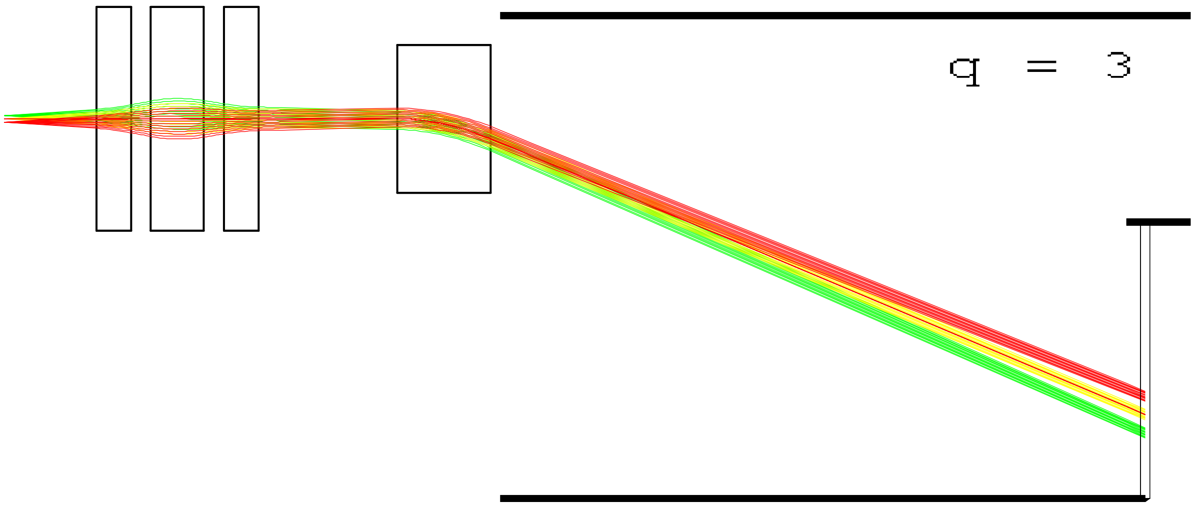
From ERNA to ERNA2



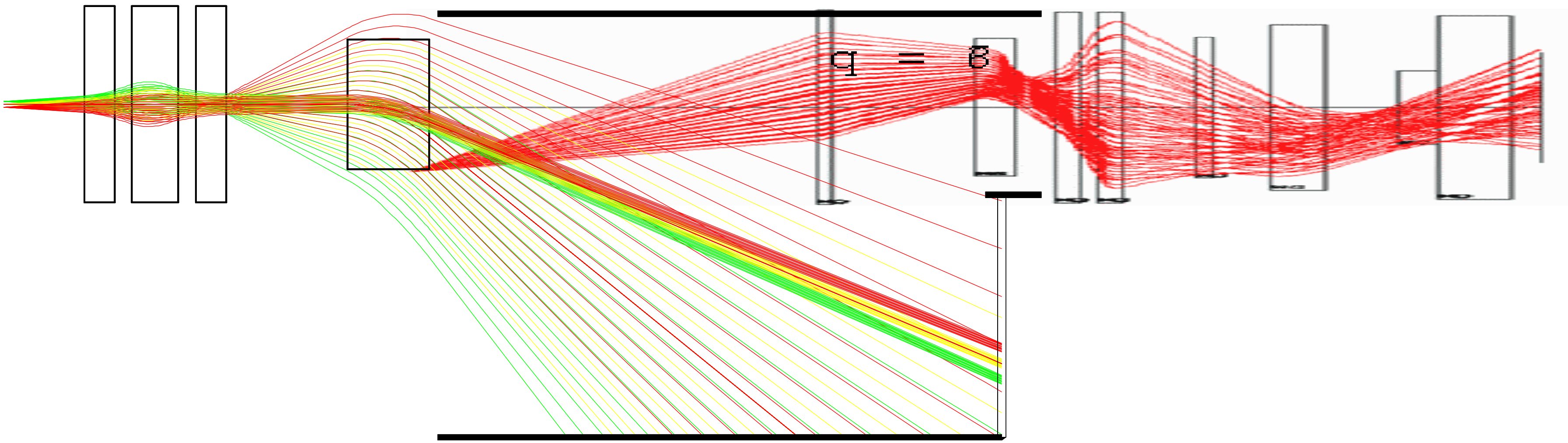
> one more (charge filter) before strong focusing added
> full computer controlled
> both extended and jet gas target
> more complex ancillary detectors (gamma ray, e^+, e^-)

V:

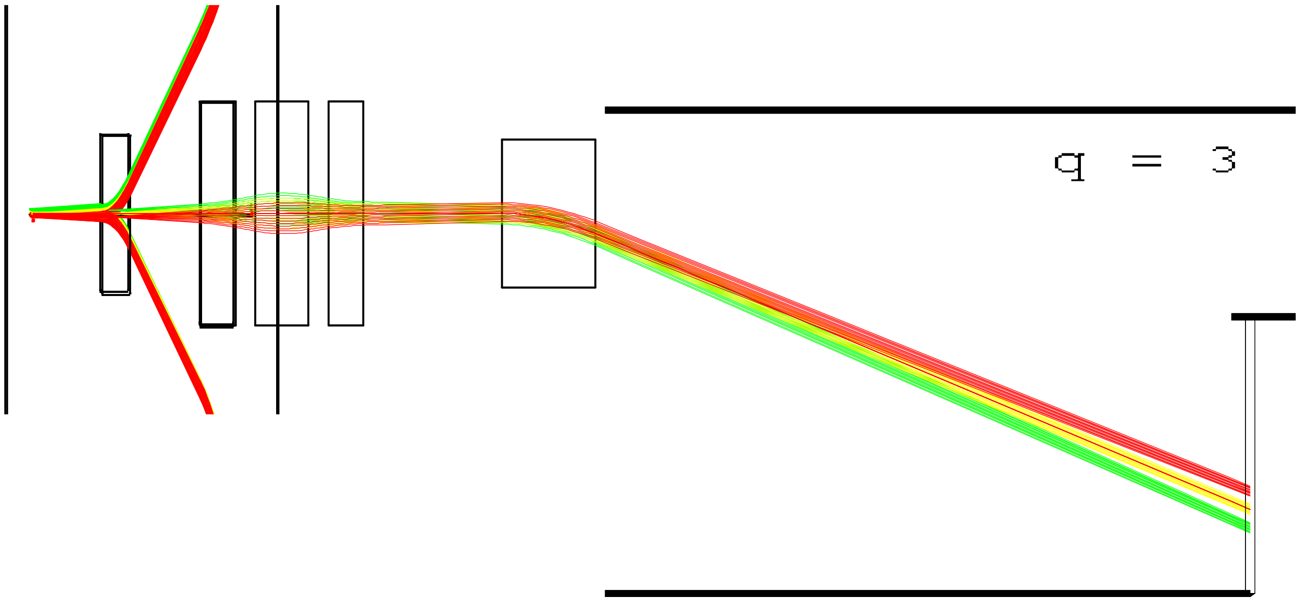
Background and leaky beams at low recoil charge state



Background and leaky beams at low recoil charge state



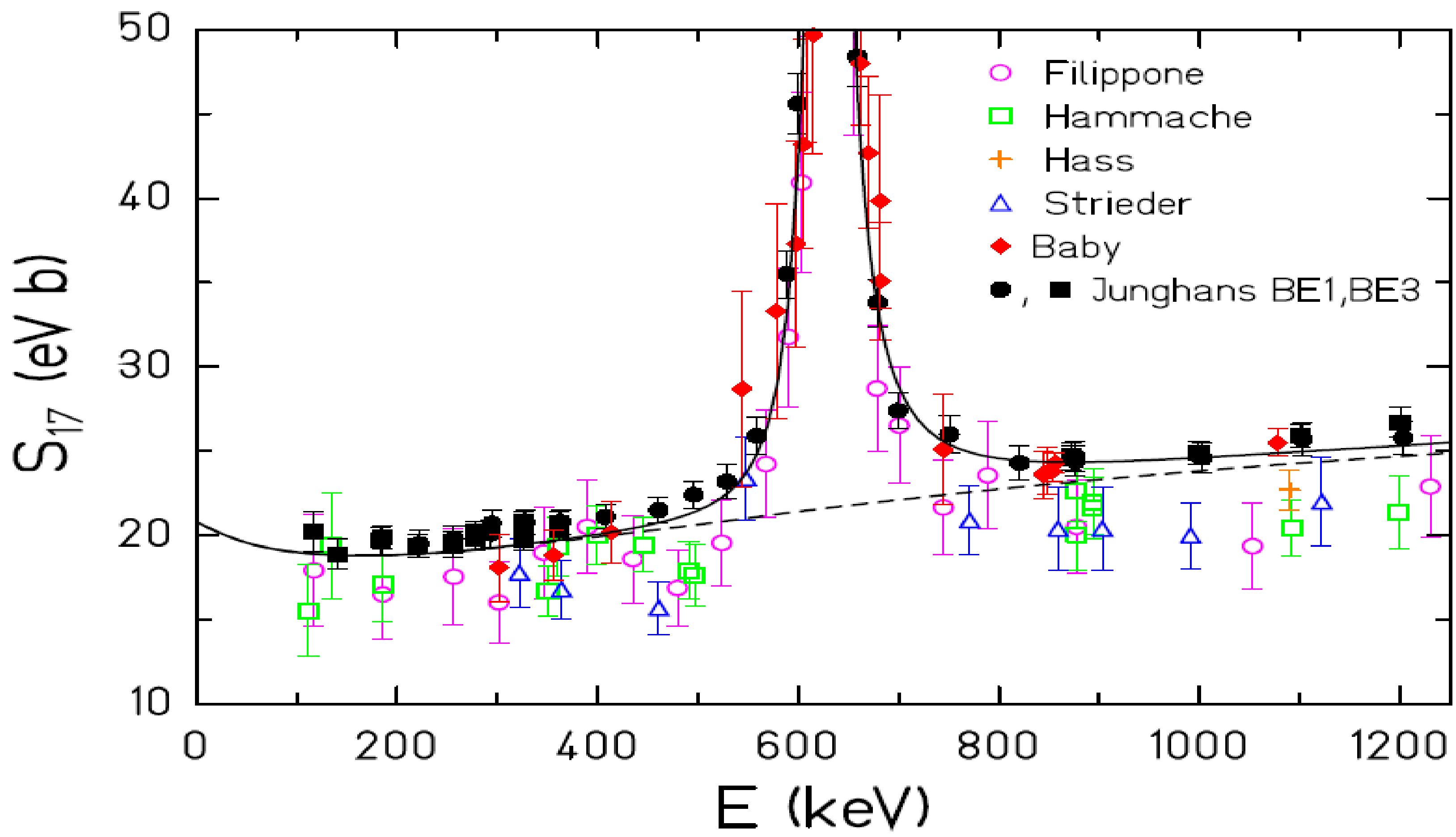
Background and leaky beams at low recoil charge state



V:

$^{7}Be(p,\gamma)^{8}B$

Istituto Nazionale di Fisica Nucleare

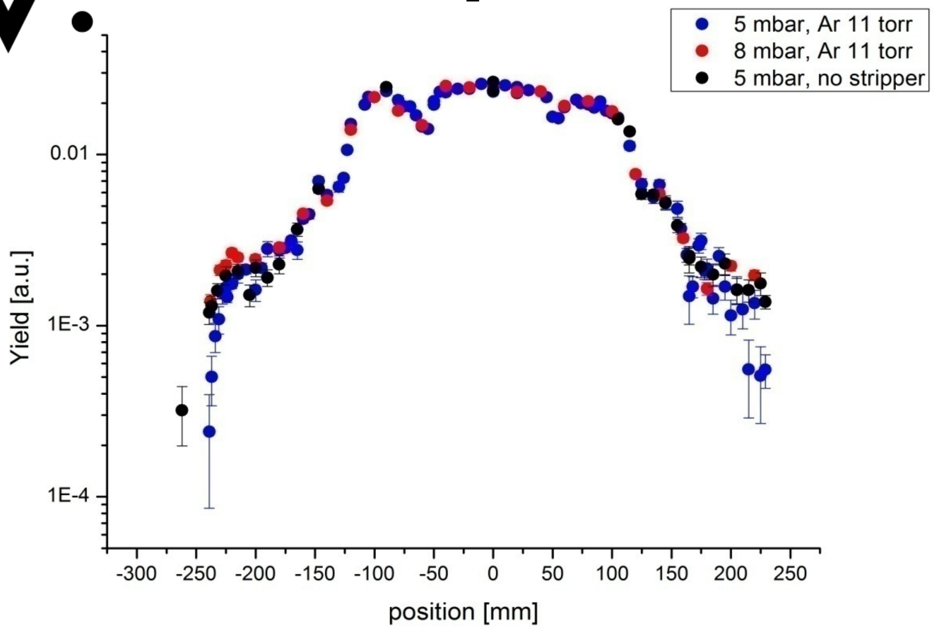


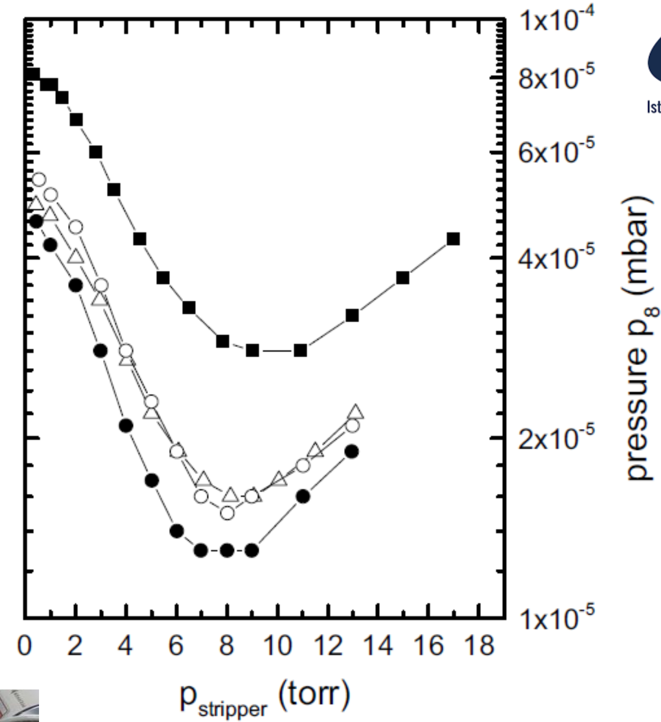
$$S_{17}(0) = 20.8 \pm 0.7(\text{expt}) \pm 1.4(\text{theor}) \ \ \text{eV b}.$$

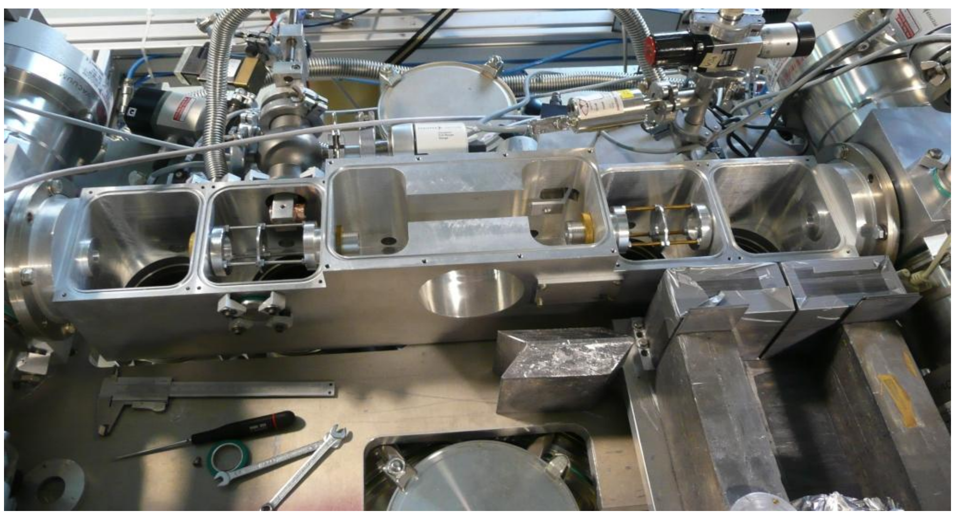
Adelberger et al 2011

V:

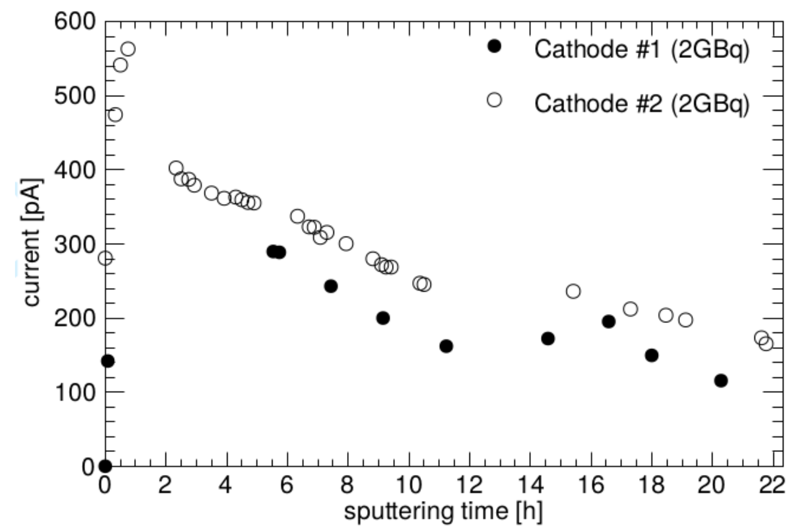
H_2 gas target



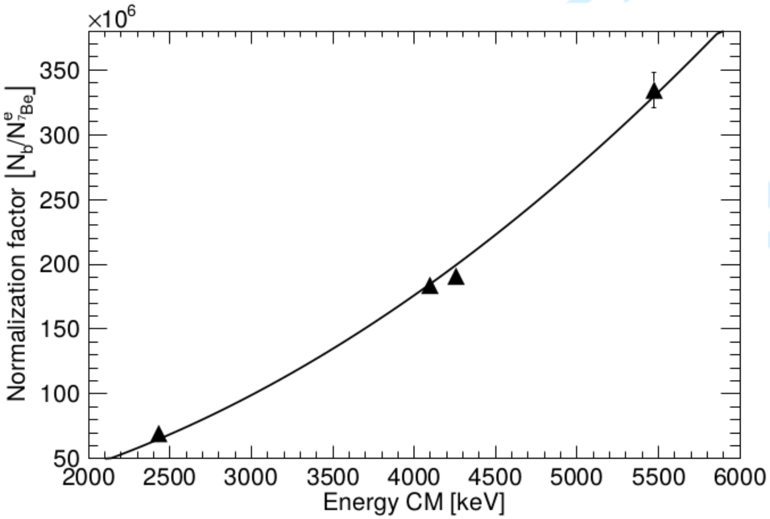




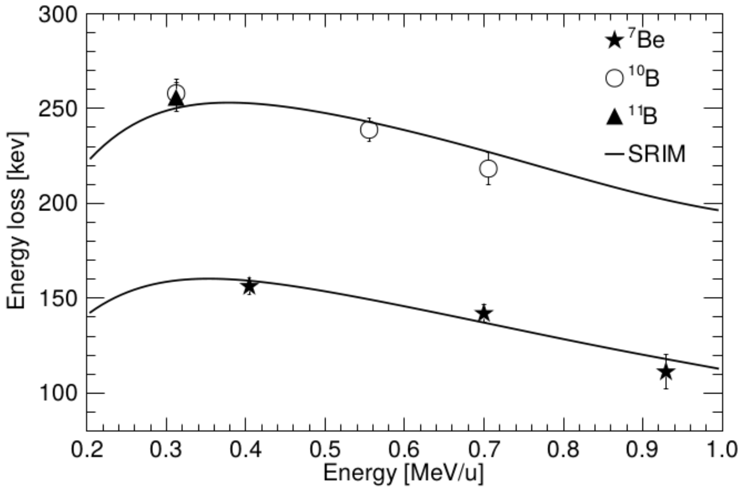
Intense beam



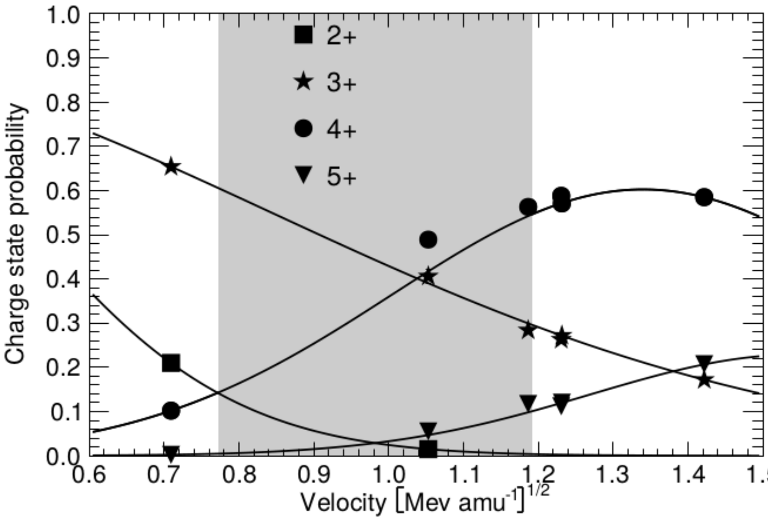
normalization



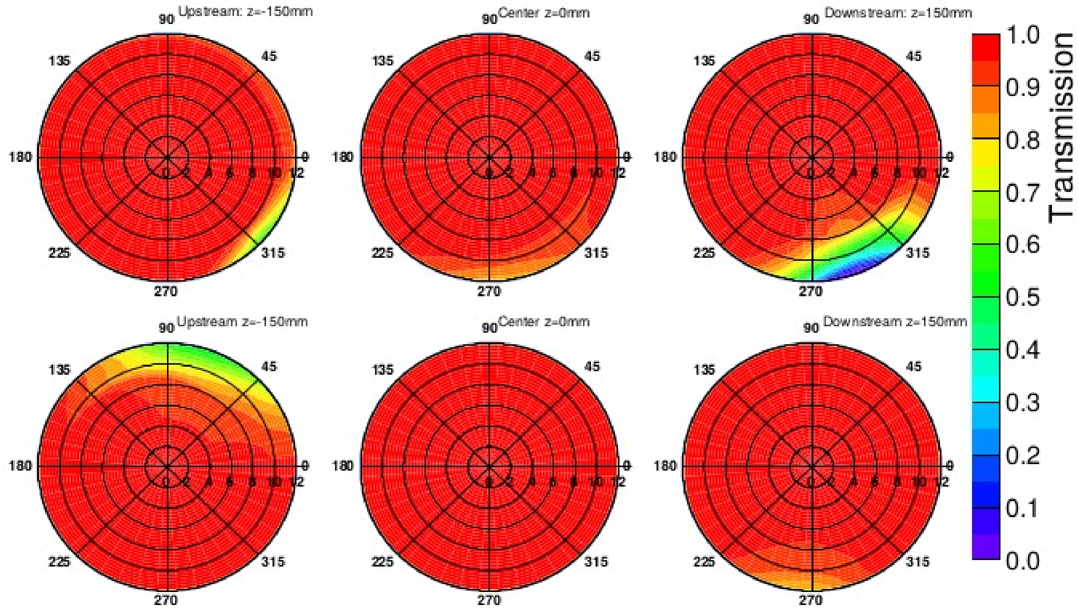
Energy loss



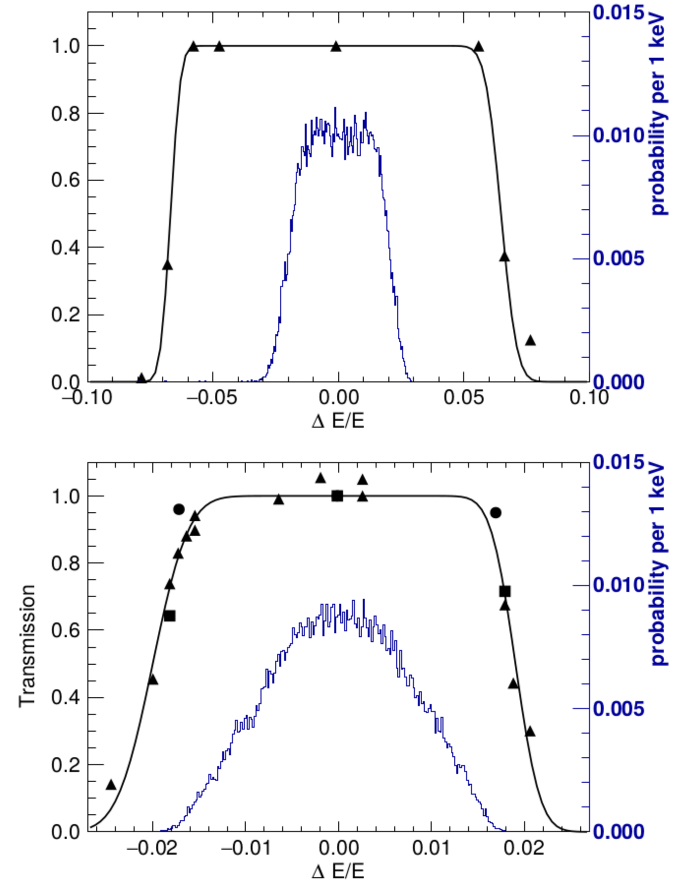
Charge state distribution



Angular acceptance



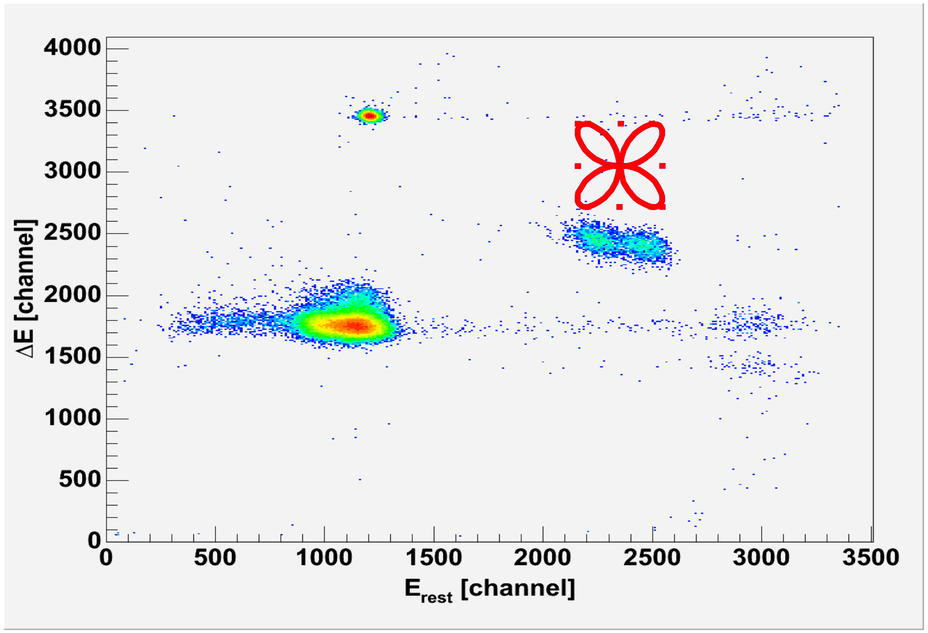
Energy acceptance

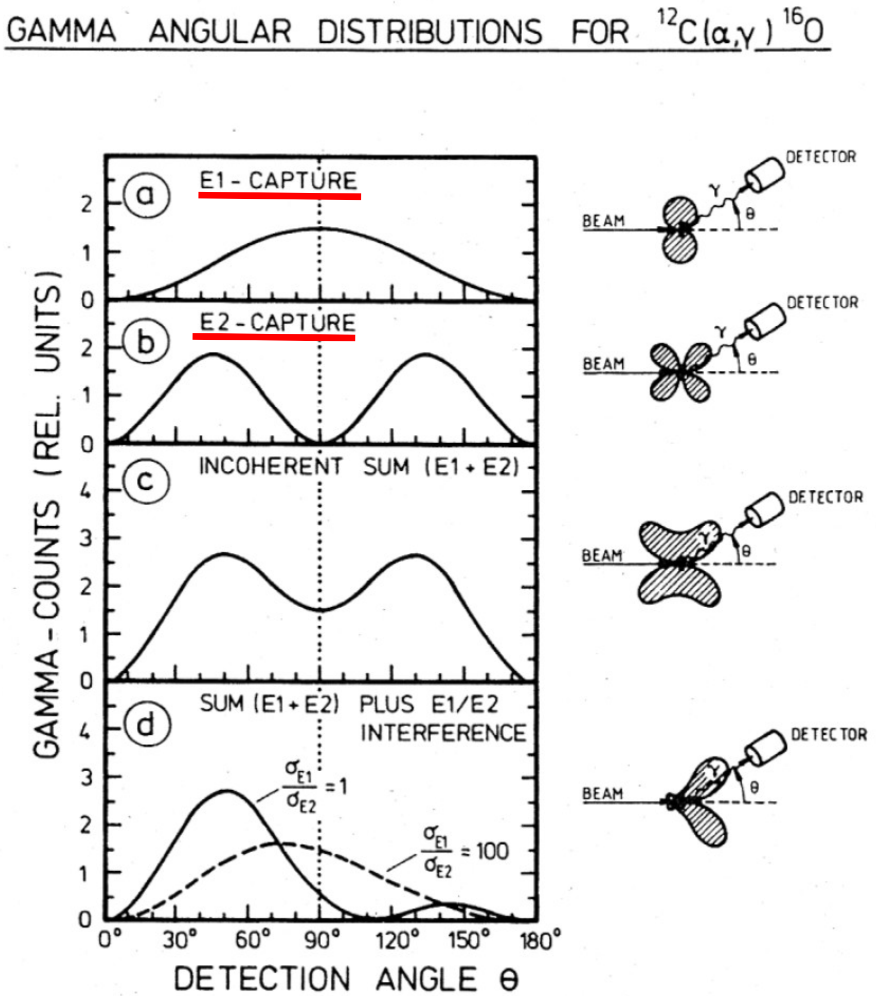


The resulting overall systematic uncertainty is 4%

V:

$^{12}C(\alpha,\gamma)^{16}O$, again
Tracking detector - J. G. Duarte

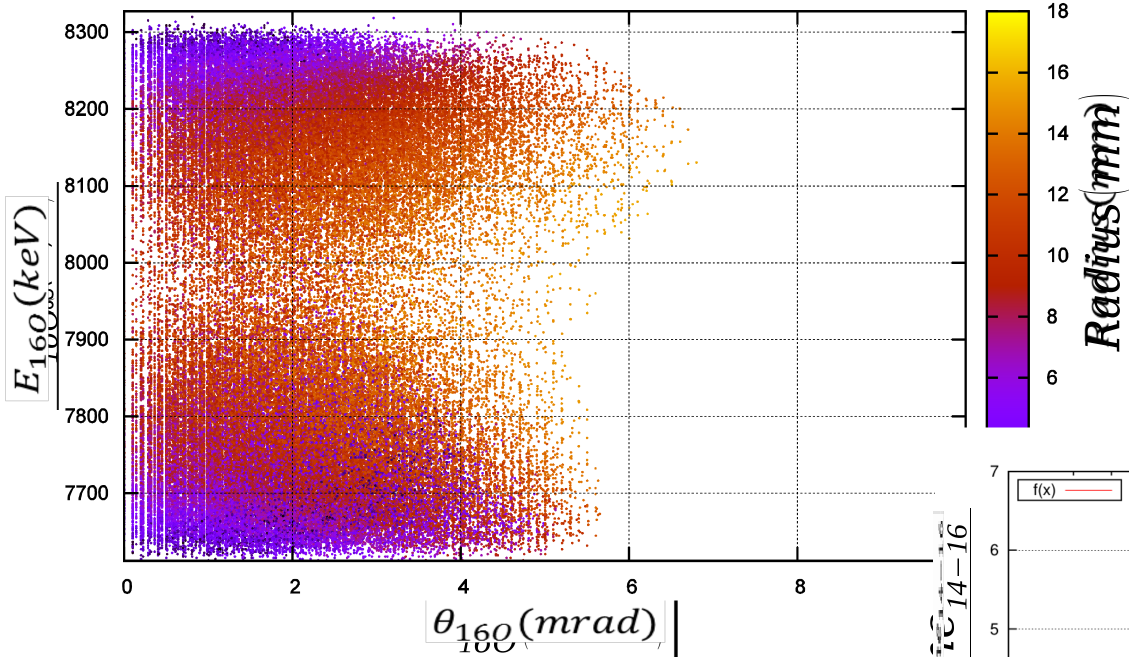


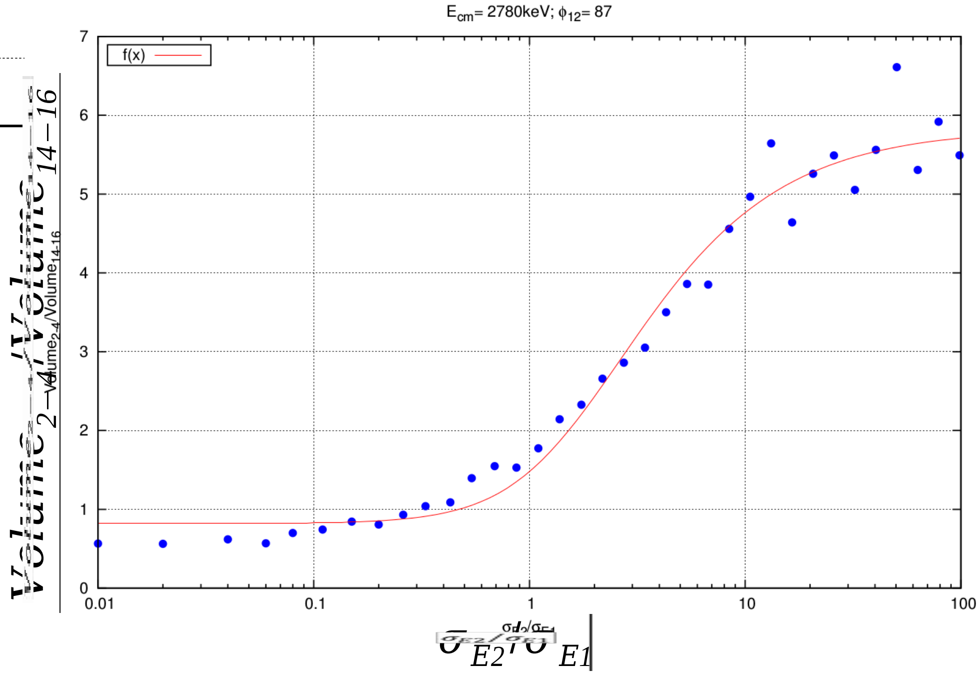


Cauldrons in the Cosmos – Nuclear Astrophysics, Claus E. Rolfs

V:

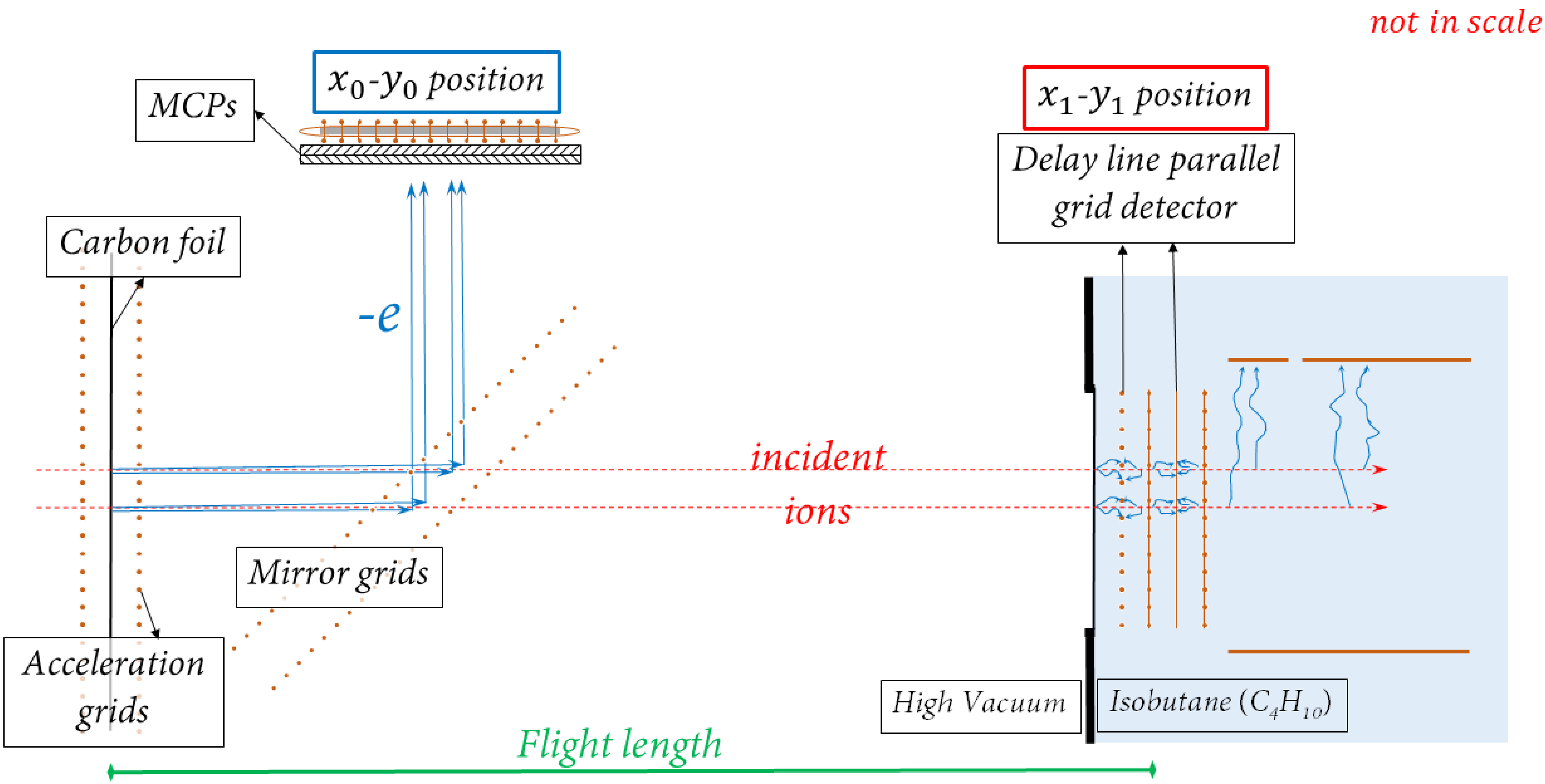
$E_{cM} = 2780keV$





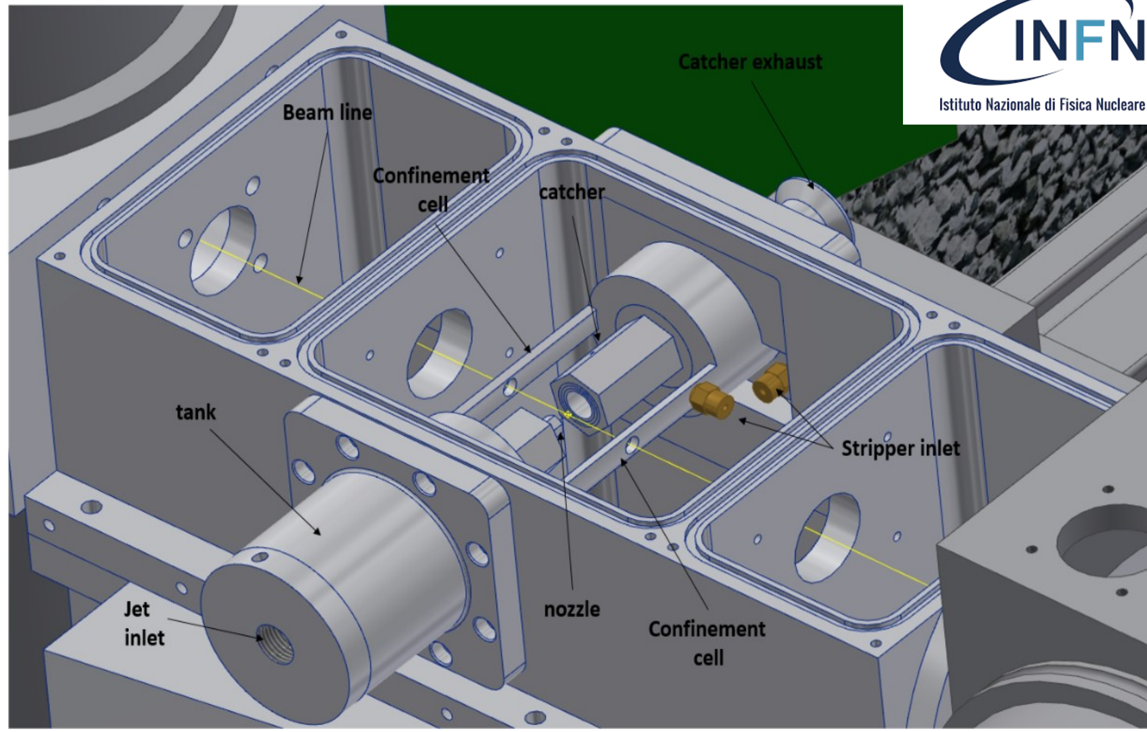
V:

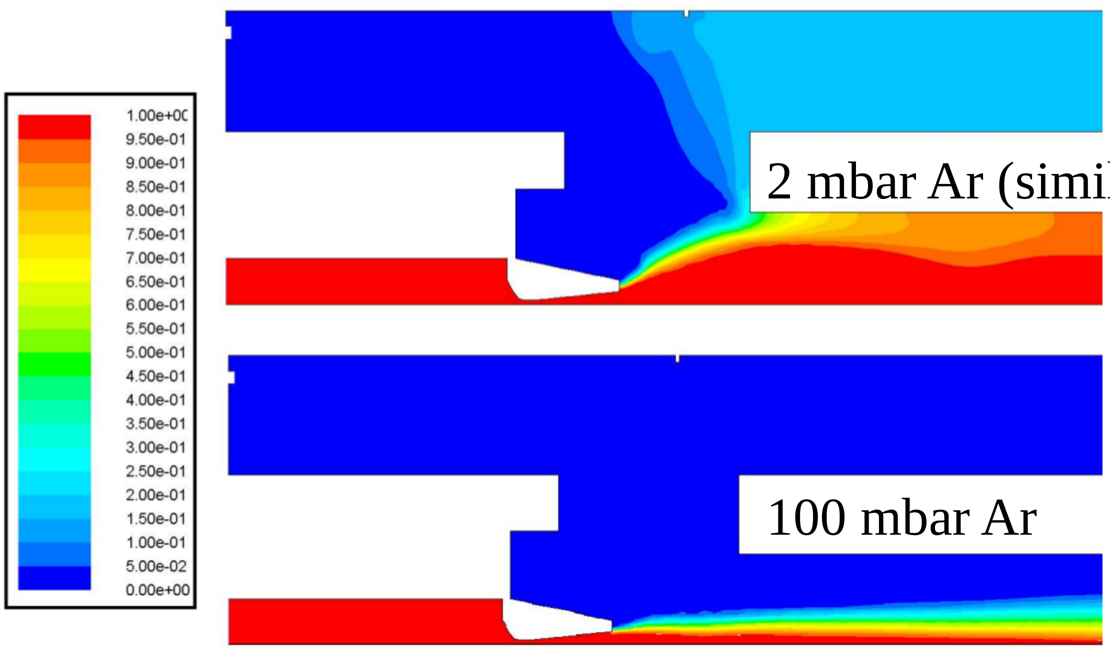
Detector design



New He jet target
D. Rapagnani

- full CFD
- jet profile tailoring
- optimized for gamma-ray and e+e- detection

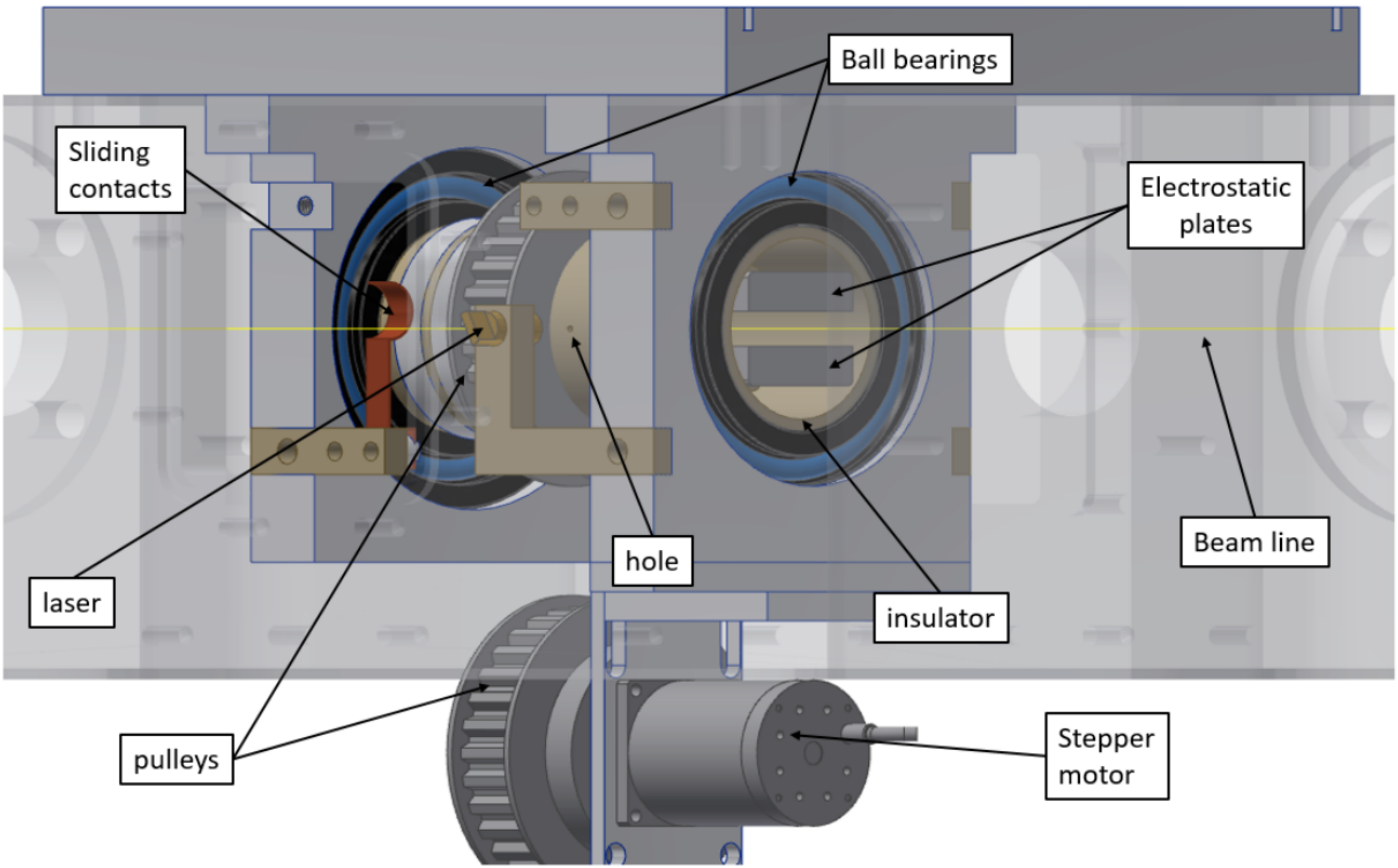




2 mbar Ar (similar with selfconfinement)

100 mbar Ar

Compact rotating scanning unit



Conclusions and outlook

> ERNA2 has considerably improved performances
> for the first time p capture could be studied
> scaling does not work yet, we are working on that
> still remain the problems of a very challenging approach, requiring a lot of skilled manpower

Collaborating Institutions: Atomki, INFN, University of Edinburgh, University of Naples, University of Campania, University of Perugia, University of Sao Paulo, Ruhr University Bochum

Credits for the presentation: R. Buompane, A. Di Leva, J. G. Duarte, E.L. M. Gallegos, D. Rapagnani, D. Rogalla, D. Schuermann