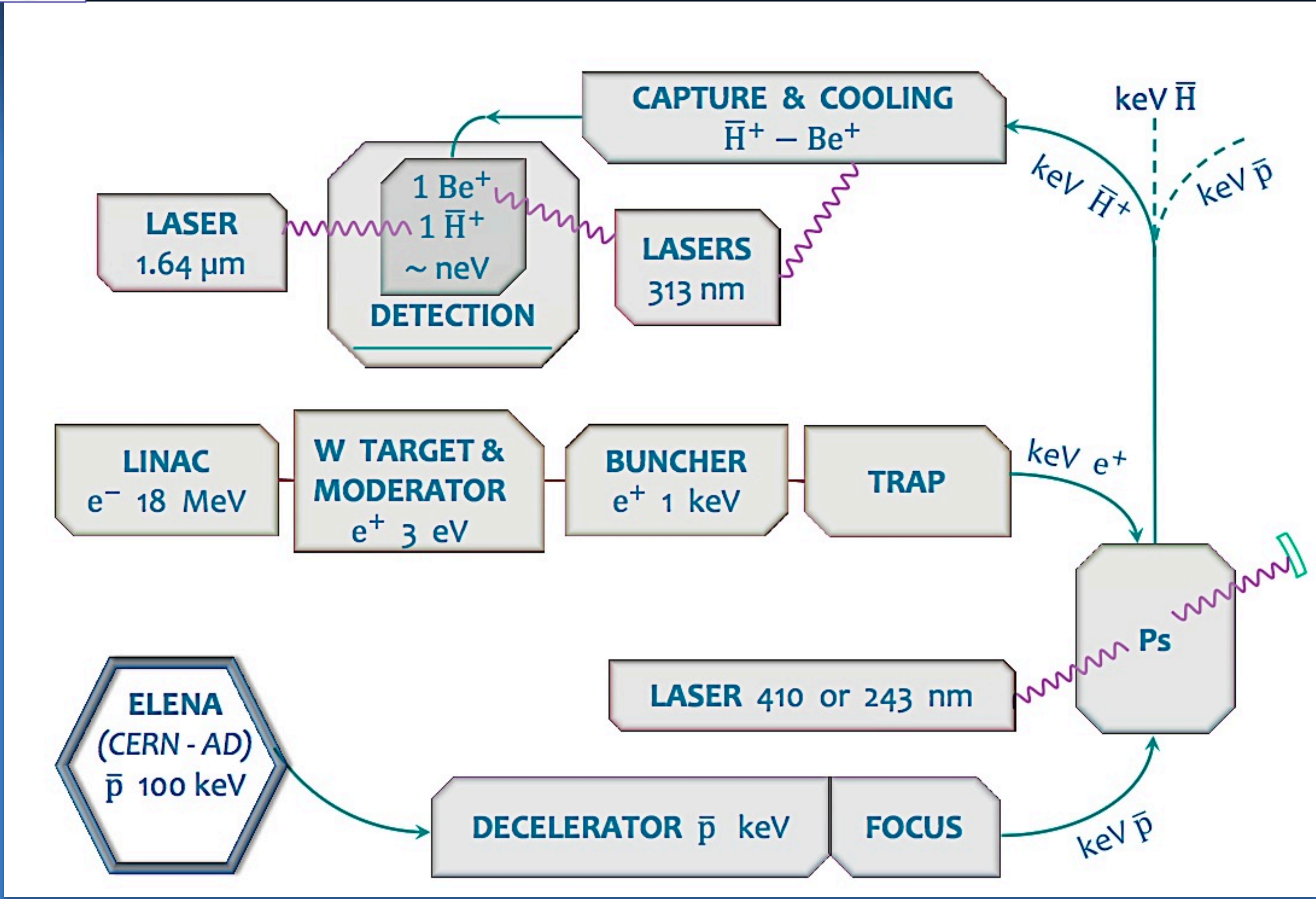
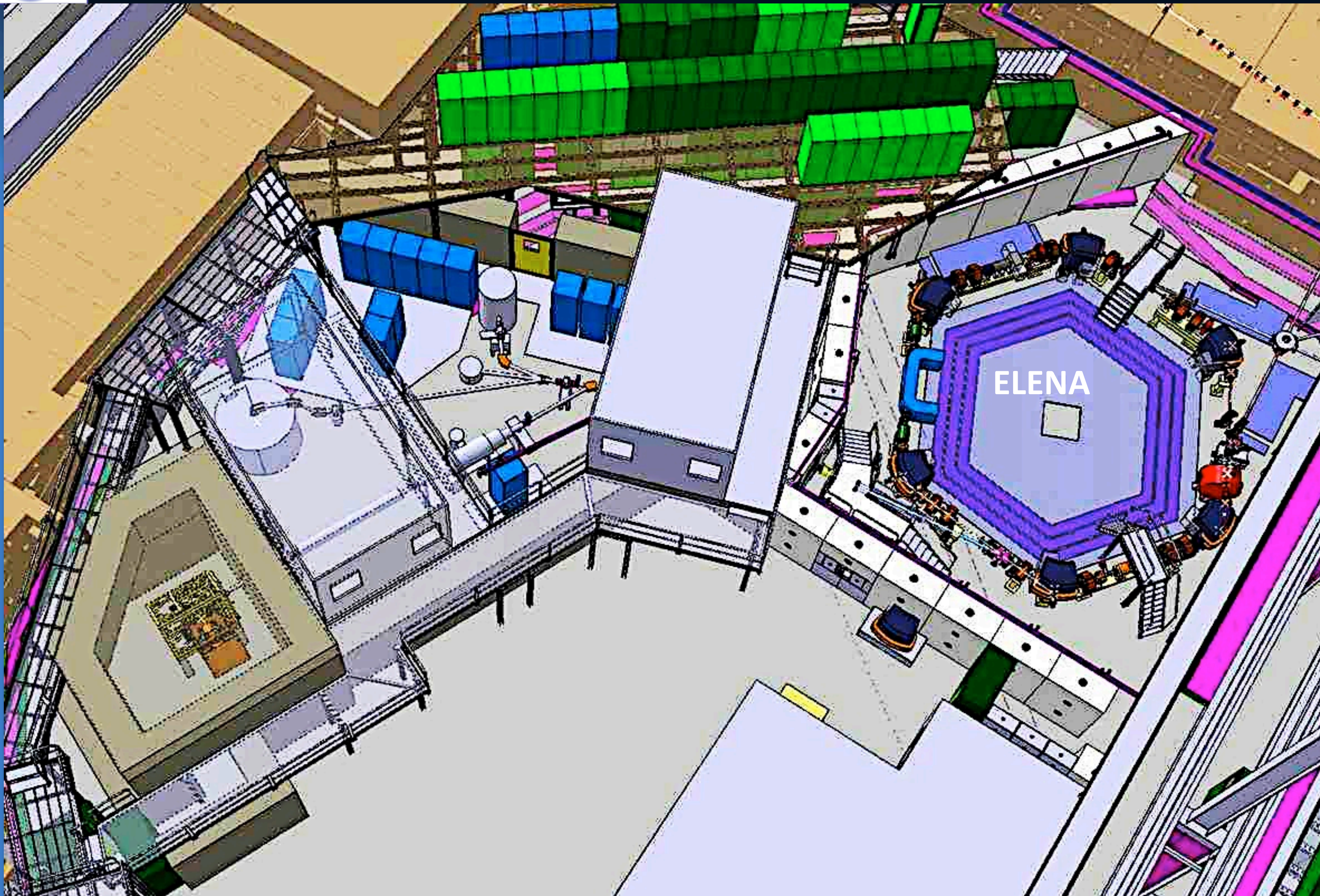
GBAR overall scheme



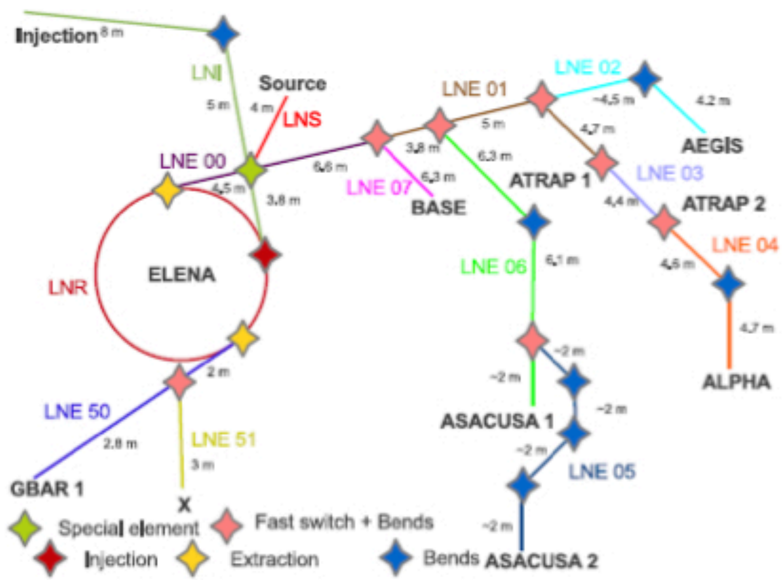
Layout

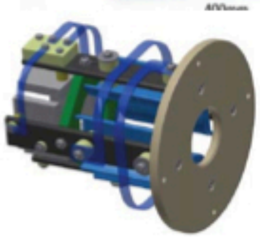
O. Choisnet
F. Butin

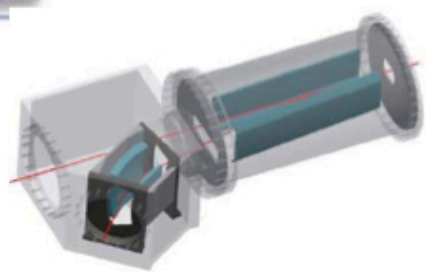


ELENA transfer-line optics

D. Lunney
ADUC Jan. 2014







Sigma matrix for GBAR

Glenn Vanbavinckhove, TE-ABT-BTP

October 28, 2013

1 Introduction

The data below is computed using the following parameters:

Parameter	Unit	Value
Horizontal Geometric emittance [95%]	π.mm.mrad	6
Vertical Geometric emittance [95%]	π.mm.mrad	4
$\frac{\delta p}{p}$ [95%]	-	$2.5 * 10^{-3}$

2 4x4 sigma matrix and dispersion

The 4x4 sigma matrix is calculated as follows [1]:

$\epsilon_x\beta_x[m^2]$	$-\epsilon_x\alpha_x[m^2]$	0	0
$-\epsilon_x\alpha_x[m^2]$	$\epsilon_x\gamma_x[m^2]$	0	0
0	0	$\epsilon_y\beta_y[m^2]$	$-\epsilon_y\alpha_y[m^2]$
0	0	$-\epsilon_y\alpha_y[m^2]$	$\epsilon_y\gamma_y[m^2]$

The results for the 4x4 sigma matrix and dispersion for GBAR are:

4e-07 $[m^2]$	-4.5e-06 $[m^2]$	0 $[m^2]$	0 $[m^2]$
-4.5e-06 $[m^2]$	0.0001416 $[m^2]$	0 $[m^2]$	0 $[m^2]$
0 $[m^2]$	0 $[m^2]$	8e-07 $[m^2]$	-3.2e-06 $[m^2]$
0 $[m^2]$	0 $[m^2]$	-3.2e-06 $[m^2]$	3.16e-05 $[m^2]$

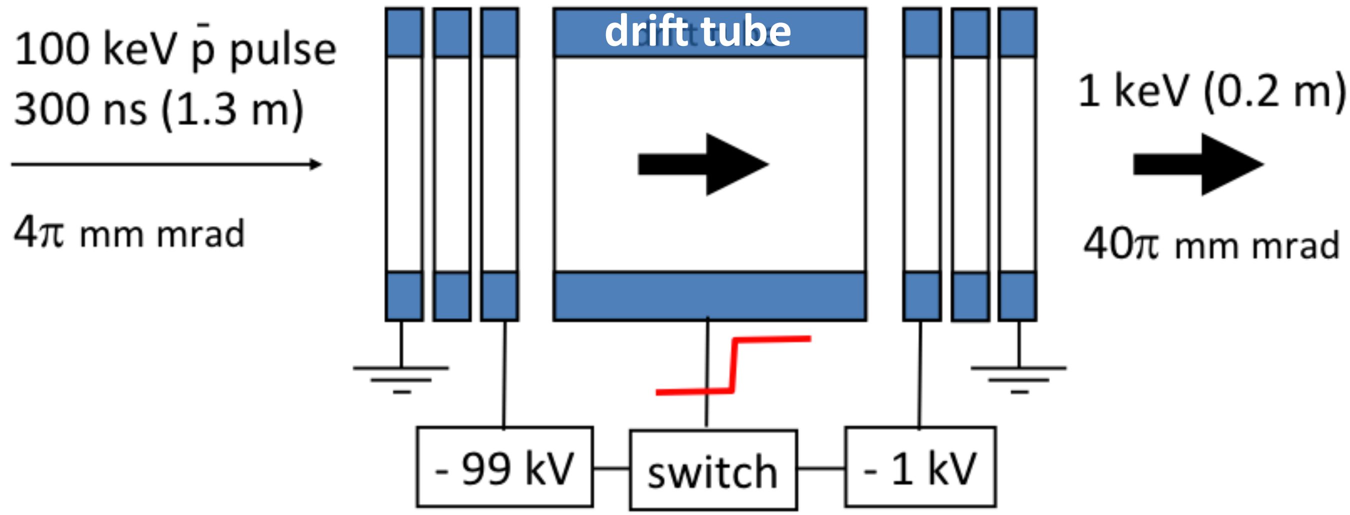
$x_D = D_x * \frac{\delta p}{p} = 0.0002566$ m

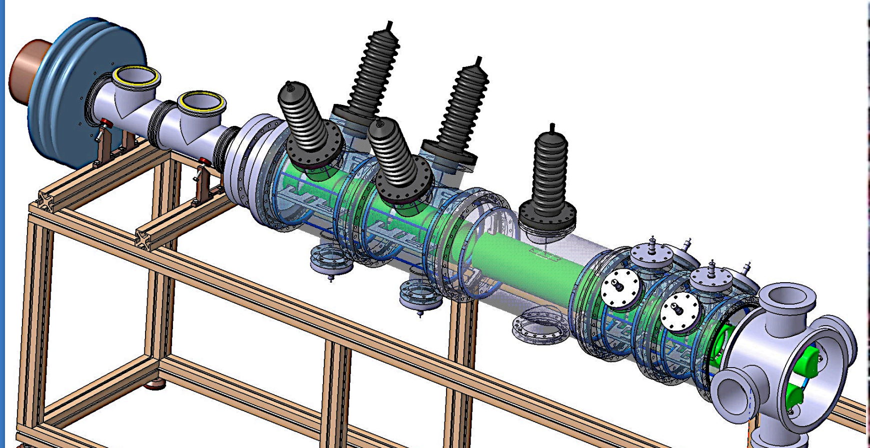
$y_D = D_y * \frac{\delta p}{p} = 2\text{e-}07$ m

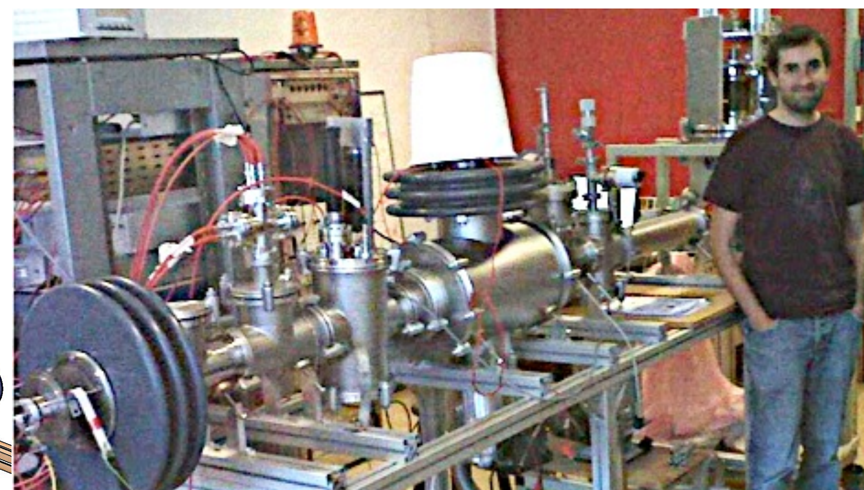
G. Vanbavinckhove et al., Proceedings of IPAC2013 (CERN-ACC-2013-0107)
J. Borburgh et al., Proceedings of IPAC2013 (CERN-ACC-2013-0082)

GBAR antiproton decelerator

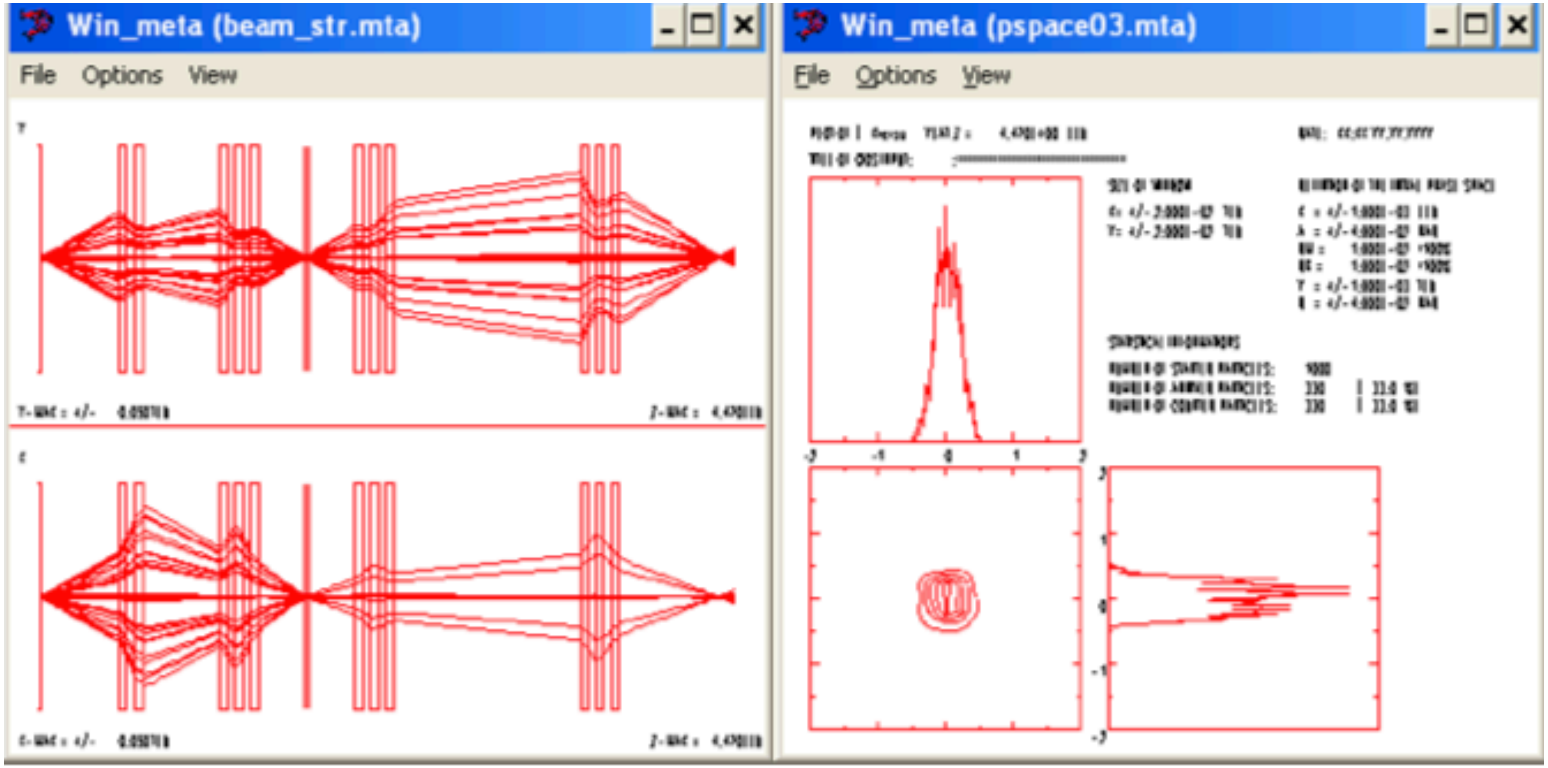
D. Lunney
P. Dupré





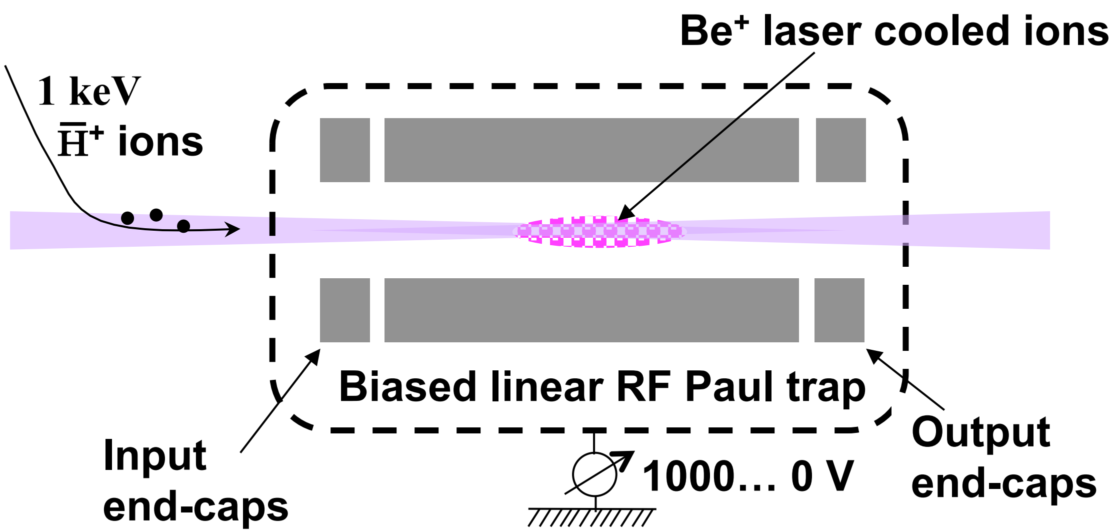


$\bar{p}$ transport to reaction chamber (GIOS)



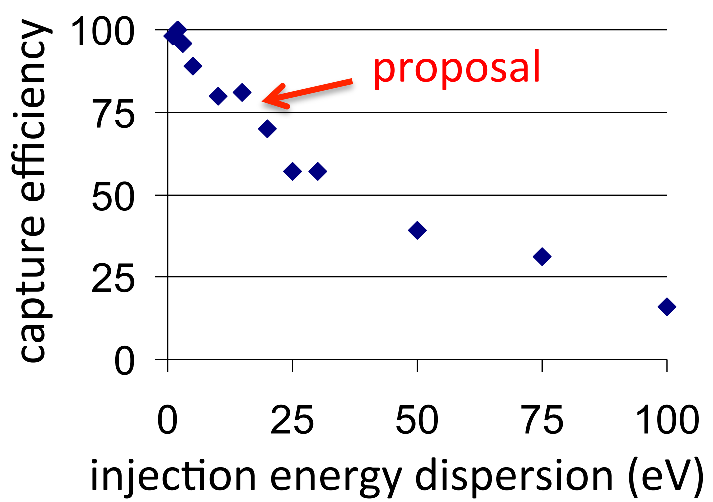
ELENA $\bar{p}$ beam emittance = 4 π mm mrad
decelerating beam to 1 keV → 40 π mm mrad
acceptance of the 1-mm diameter, 20-mm long Ps target chamber = 25π mm mrad
decelerator optics → 33-38 % transmission through Ps target
decelerating beam to 6 keV → 16π mm mrad
transverse emittance orientation no problem (good matching with decel)

$\bar{H}^+$ transport to capture trap



ELENA δp/p dispersion of 0.25% is still a MAJOR problem for $\bar{H}^+$capture

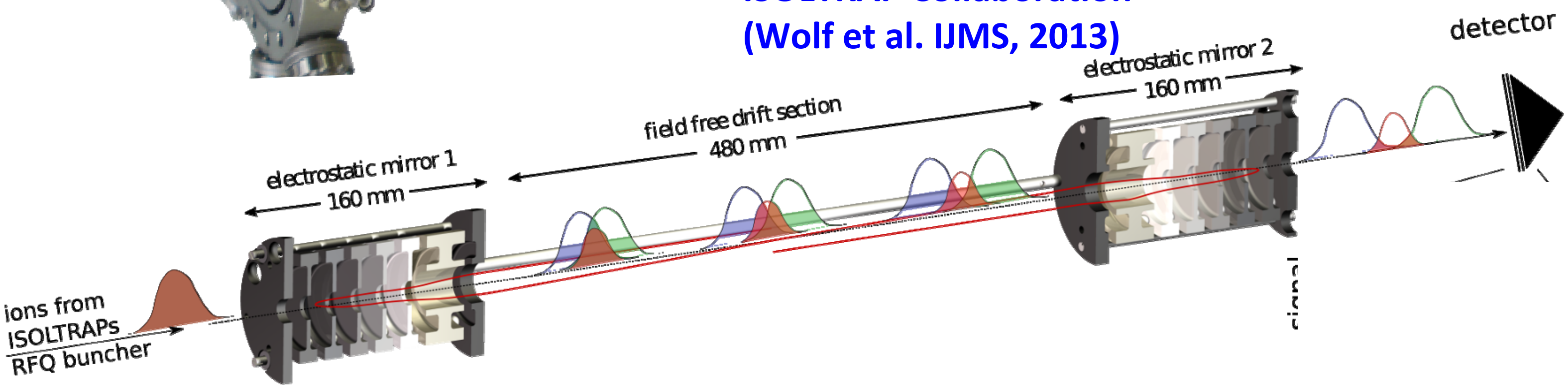
new idea: using a fast-ion beam trap (EIBT) with resistive cooling

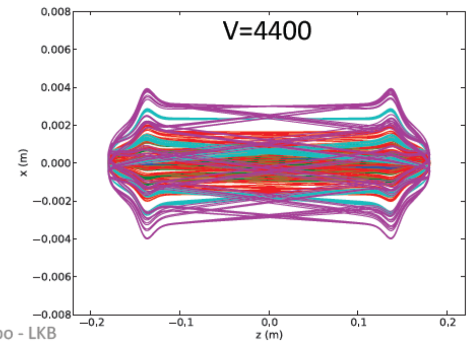


Multi-Reflection Time-of-Flight separator (Electrostatic Ion Beam Trap)

P. Indelicato, C. Szabo
P. Dupré, D. Lunney

ISOLTRAP Collaboration
(Wolf et al. IJMS, 2013)

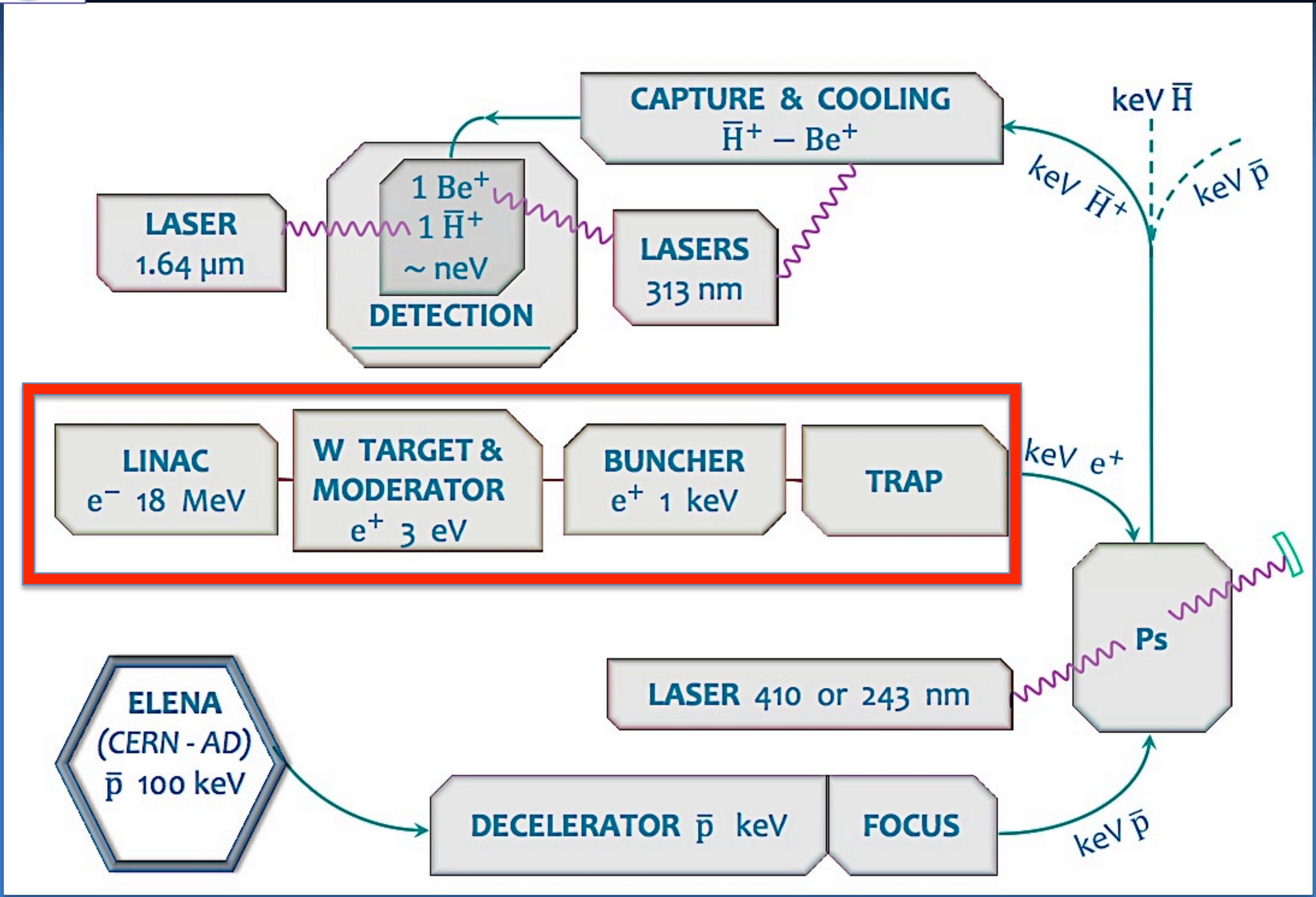




Szabo - LKB

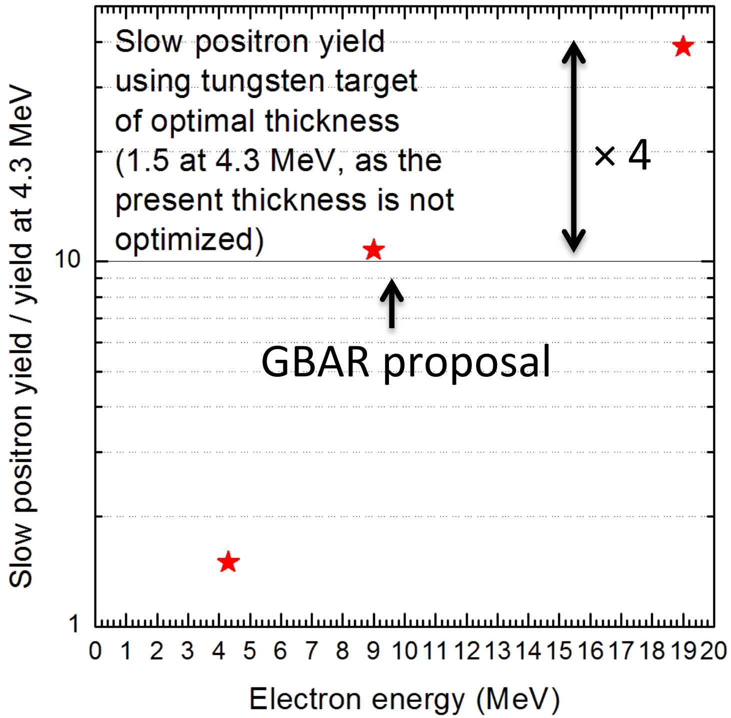
EIBT: Zajfman et al. Phys. Rev. A (1997)
HCI: Vallette, Szabo & Indelicato, EPL (2013)
Cooling: Pedersen et al. Phys. Rev. A (2002)

Positron production & accumulation



Slow e^+ yield

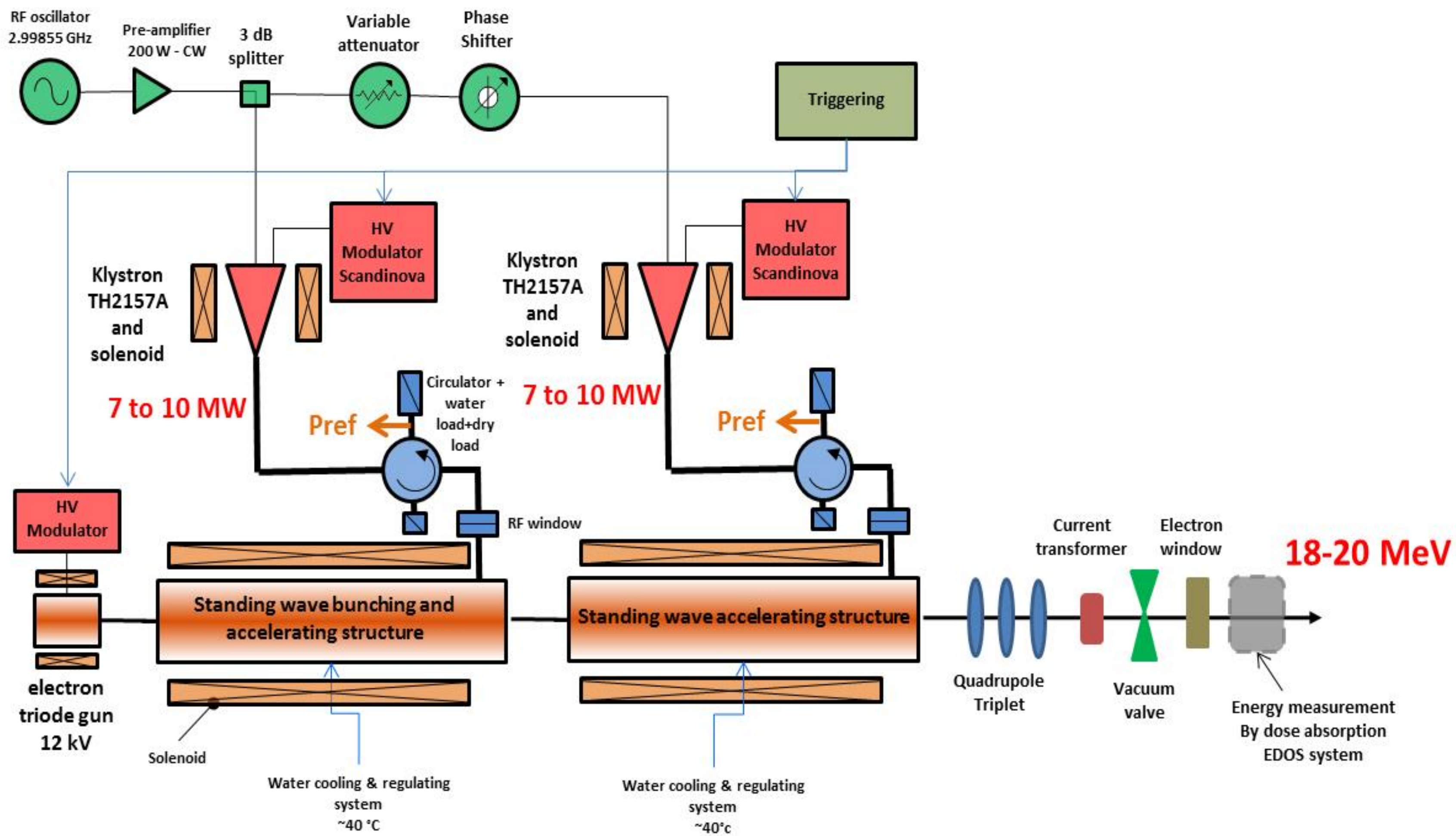
fast e^+ rate increases with electron energy
fast → slow e^+ : efficiency decreases with incident fast e^+ energy



Parameter	Specification
Energy	10 → 20 MeV
Peak current	300 mA
Beam Pulse length	2 µs
Repetition rate	300 Hz
Availability	24/24 h 7/7 days

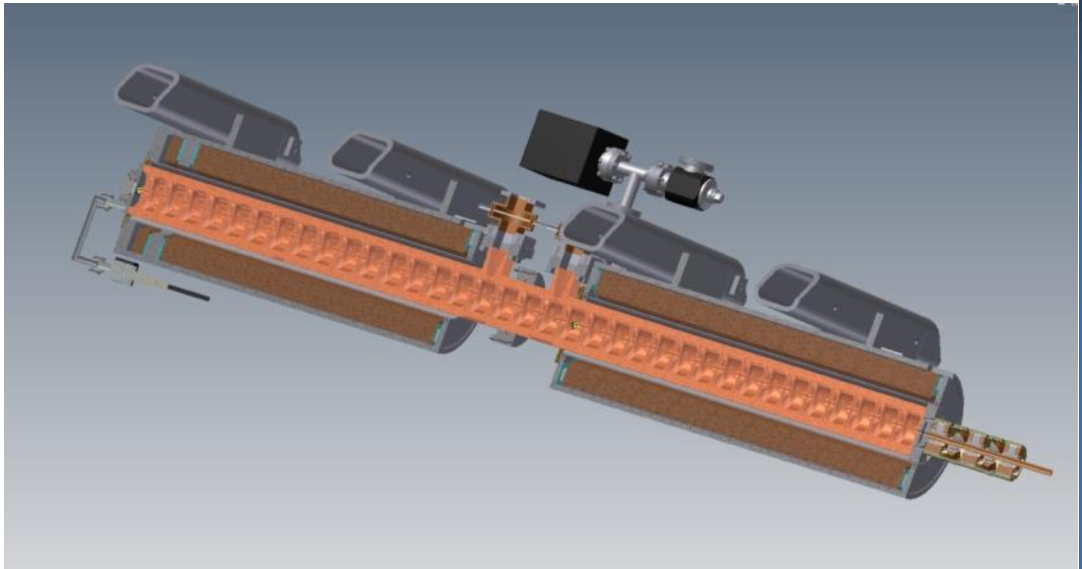
SAccelerator layout

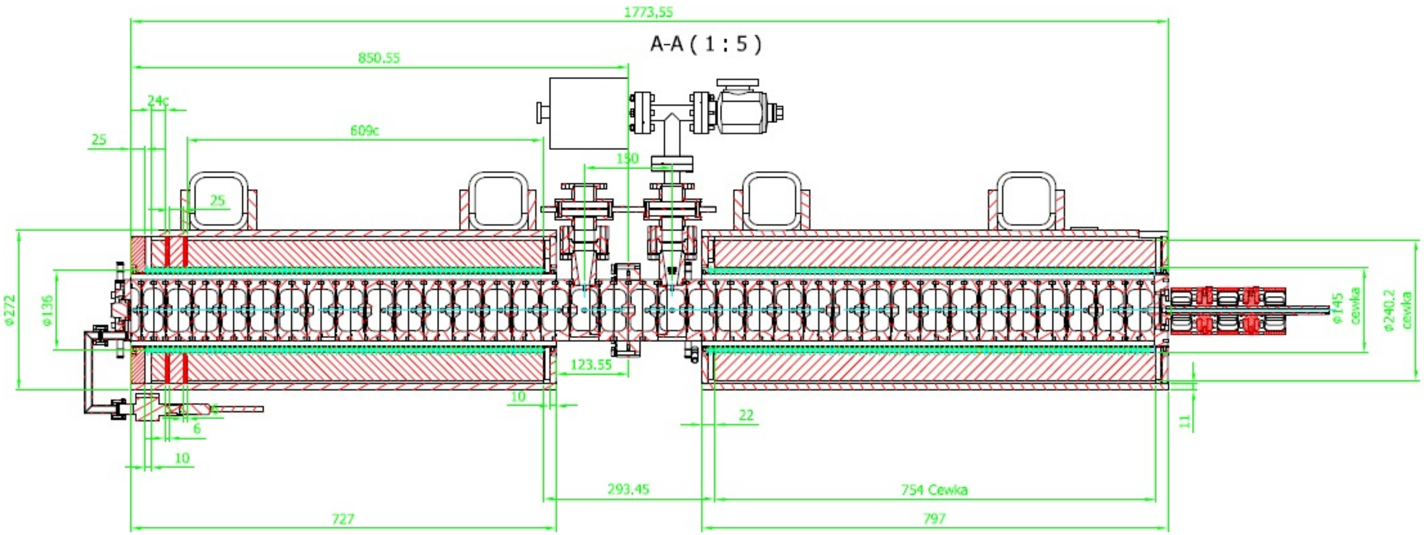
S. Wronka
F. Peauger



S. Wronka
P. Krawczyk

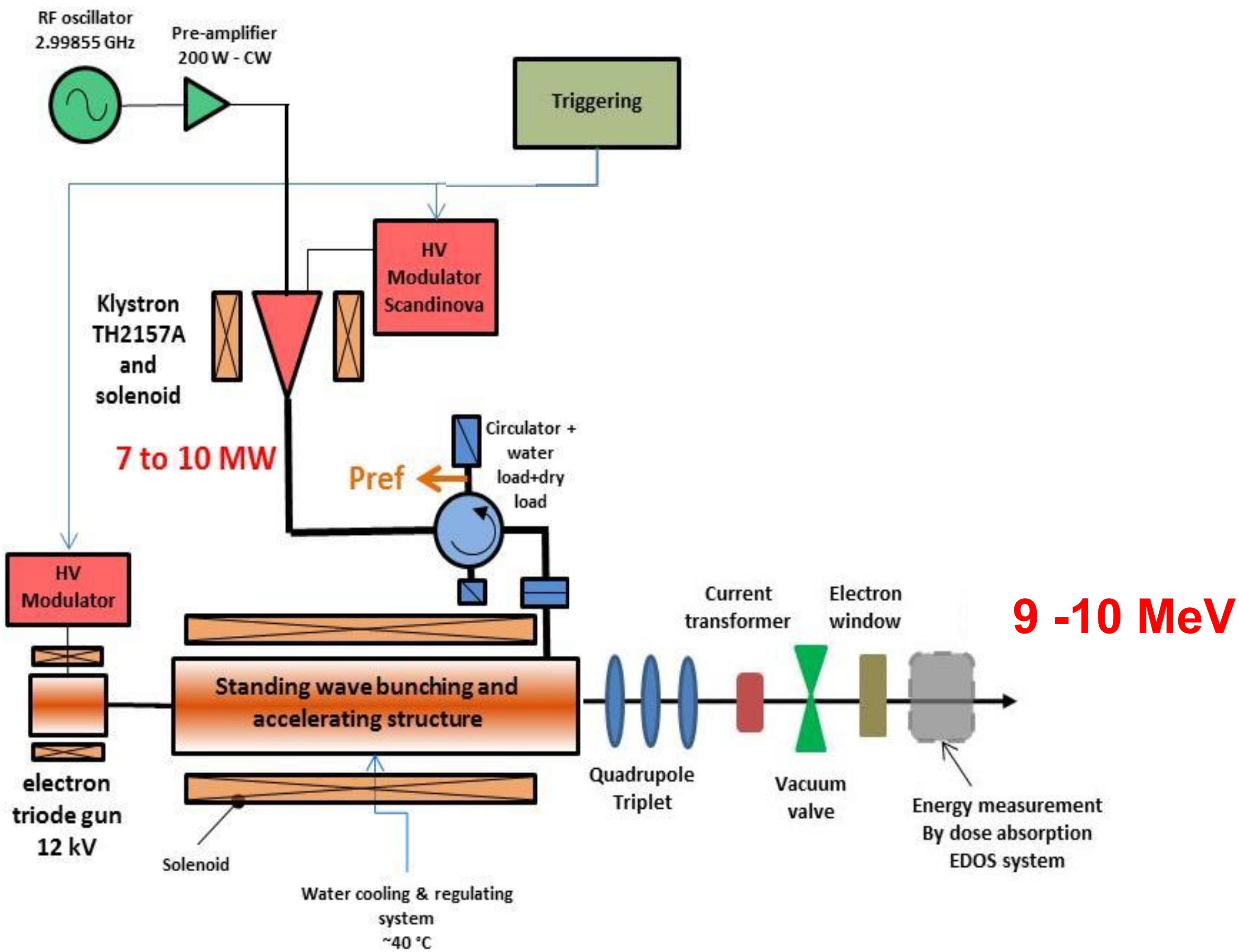
Two accelerating structures one after another (2 x 18 cavities). Two RF power inputs





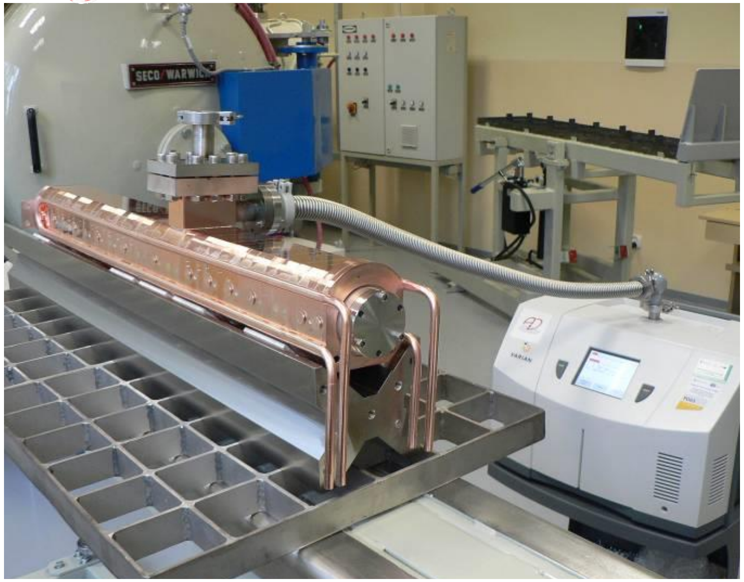
Option for start-up

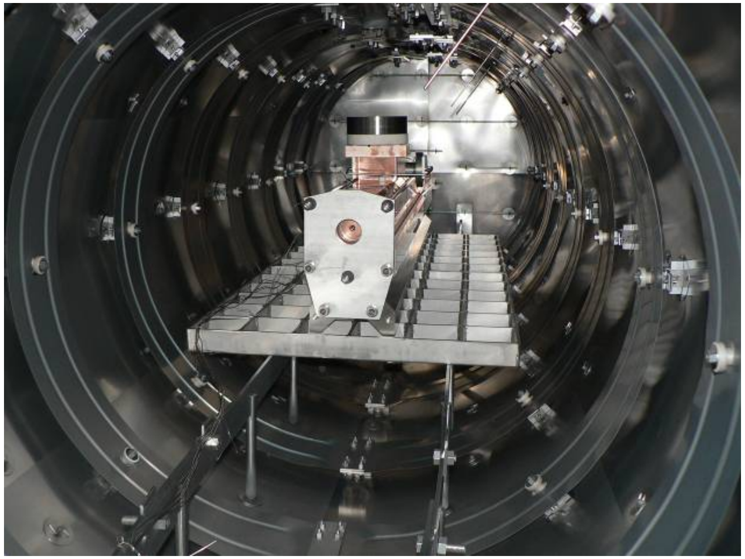
S. Wronka
P. Krawczyk

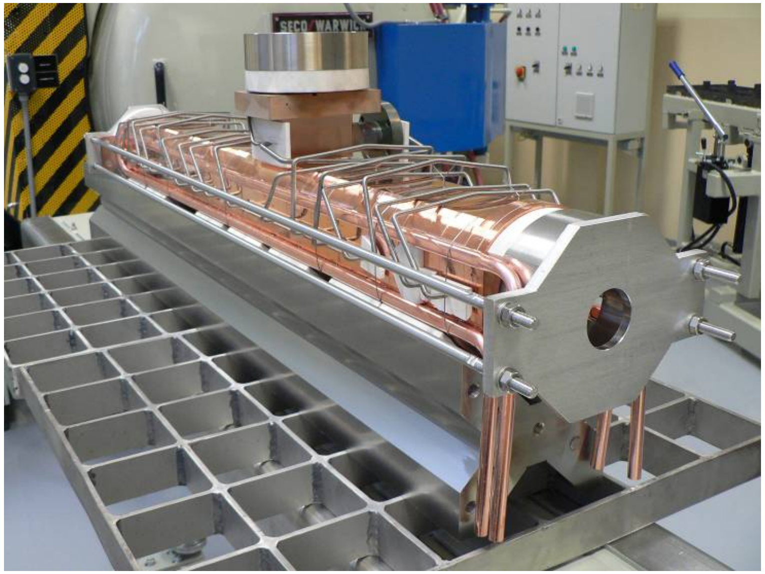


S. Wronka
P. Krawczyk

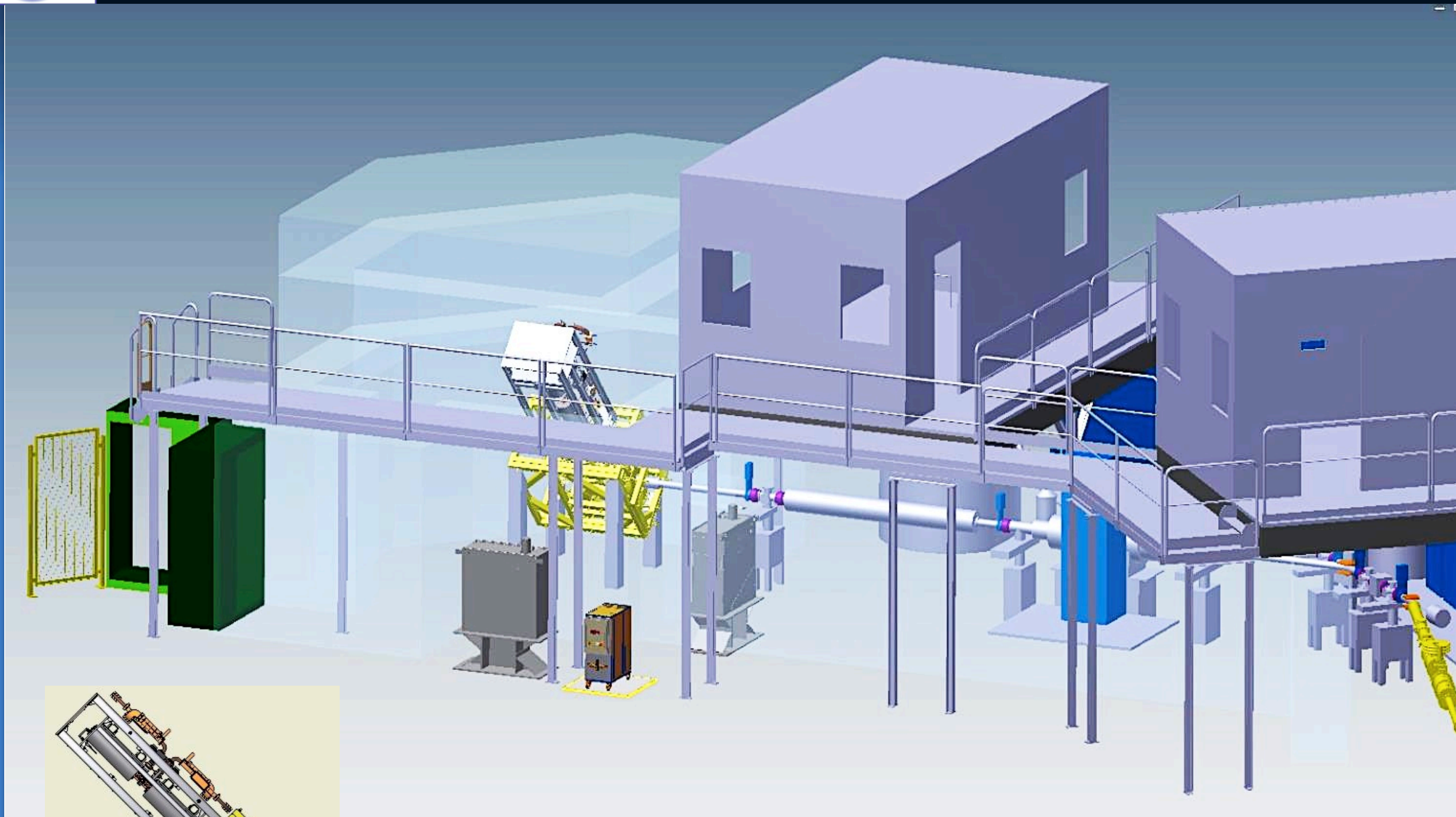
NCBJ workshops

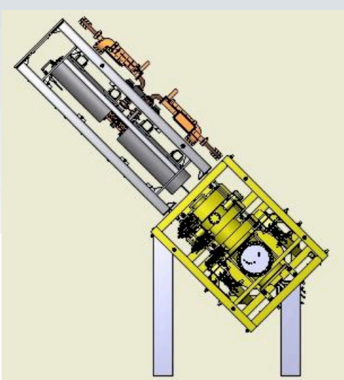






Layout



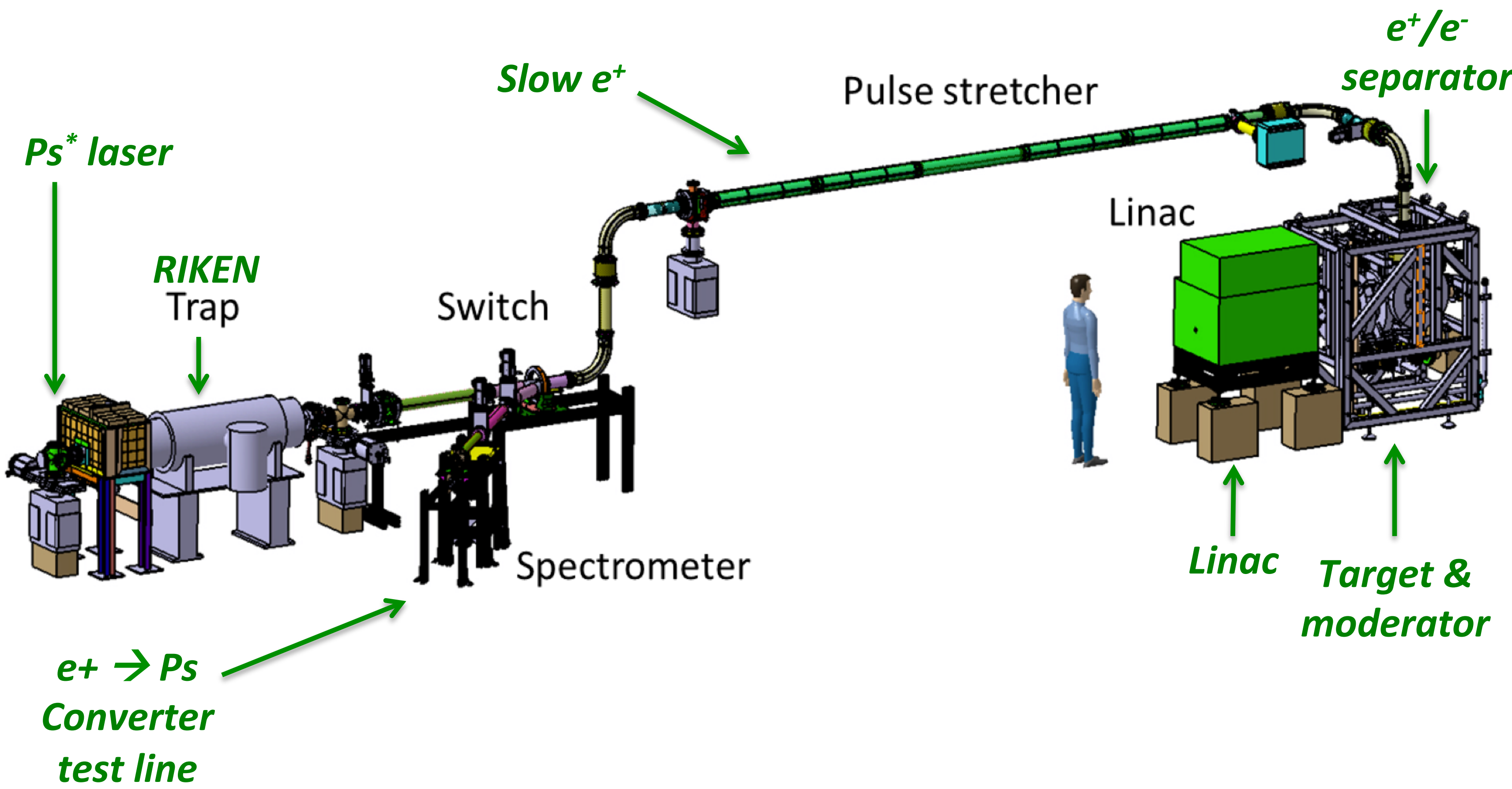


45° orientation to minimise height and shoot toward ground

Preliminary radiation safety report (R. Froeschl / CERN)

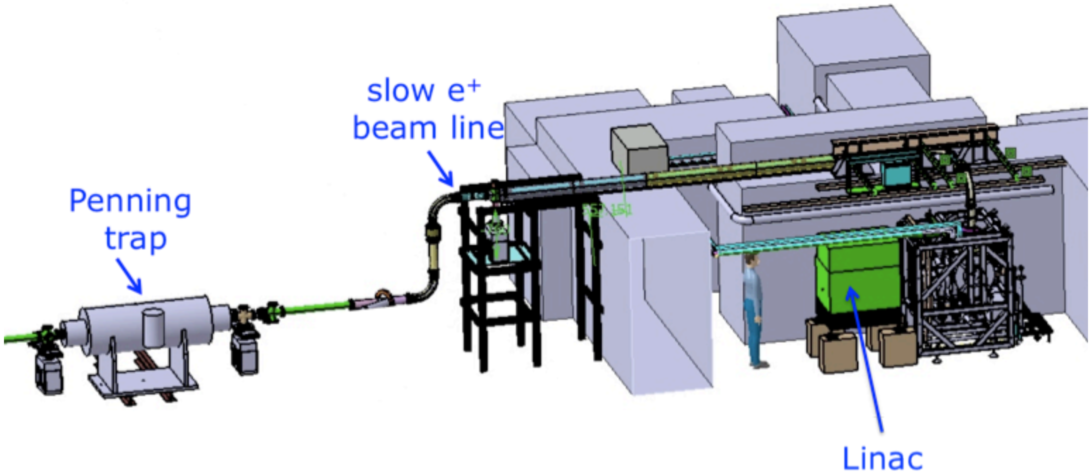
e^+ / Ps demonstrator at Saclay

L. Liszkay
Y. Sacquin
P. Debu



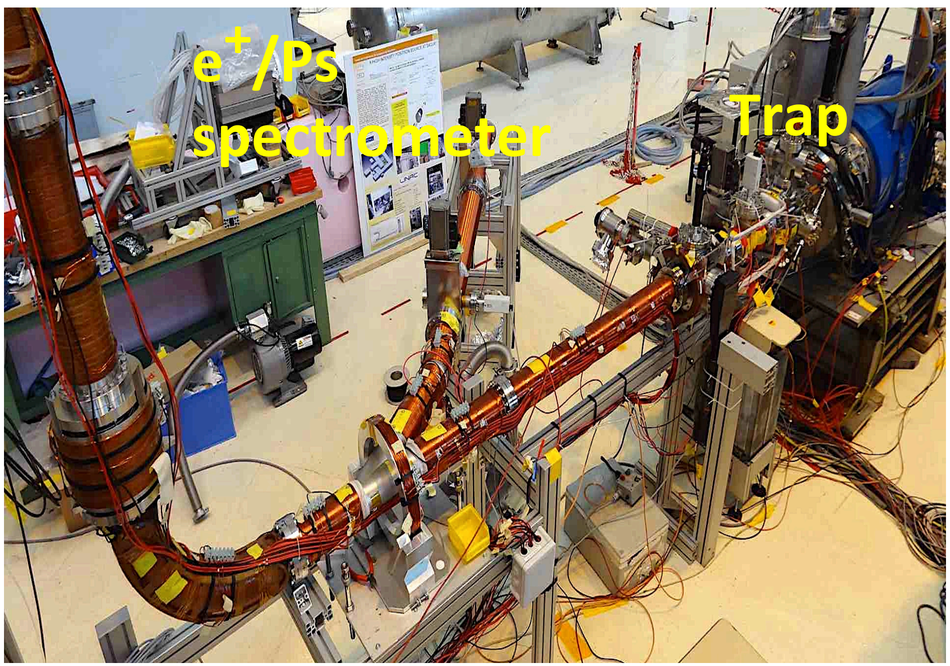
e^+ / Ps demonstrator at Saclay

T. Mortensen
B. Vallage



- 4.3 MeV / 200 Hz / 2.5 µs / 120 µA
- $3\ 10^6$ slow e^+/s
- with first W mesh moderator

- Penning trap on beam line (from RIKEN)
- First trapping trials



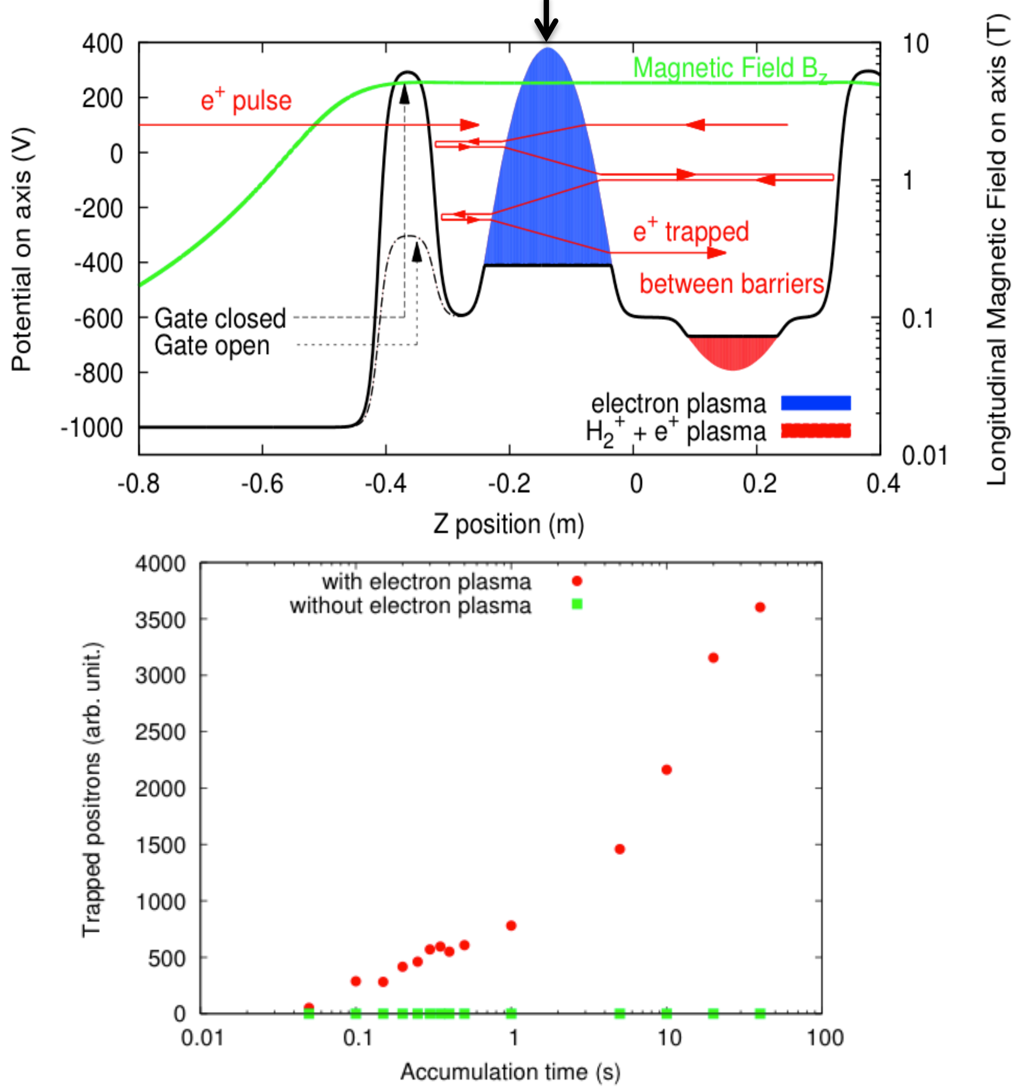
- Secondary beam line
- → moderator developments
- → e+/Ps converters

- Ps* laser being prepared at LKB (Paris)

e^+ trapping

P. Dupré
P. Grandemange

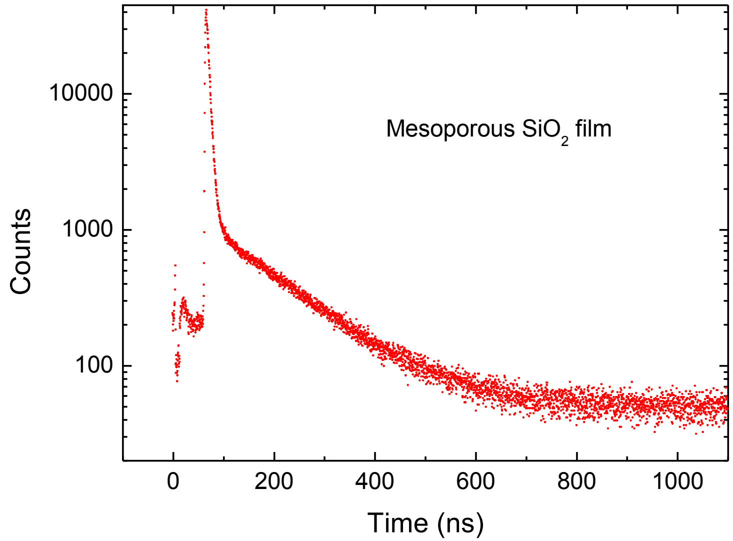
electron plasma for cooling

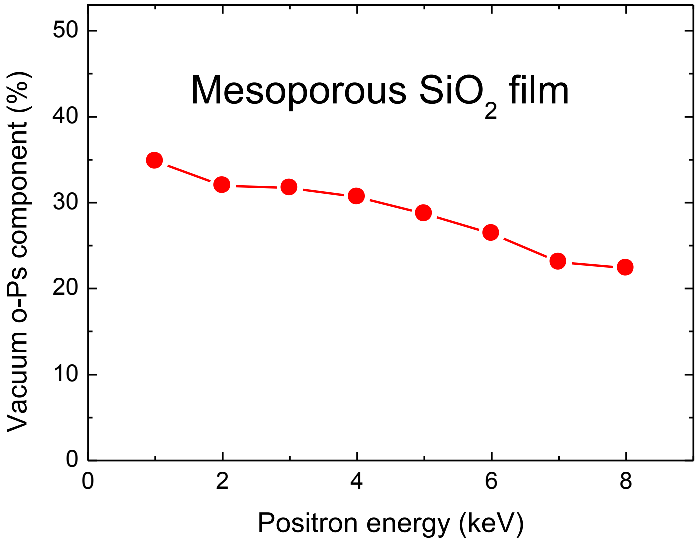


e^+ spectrometer beamline

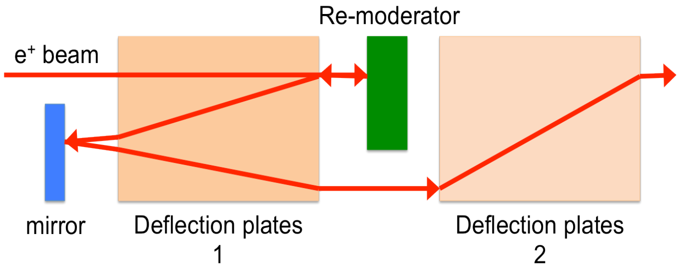
L. Liszkay
D. Brook-Roberge

Results obtained with ETHZ beam reproduced
Now preparing for GBAR specific studies

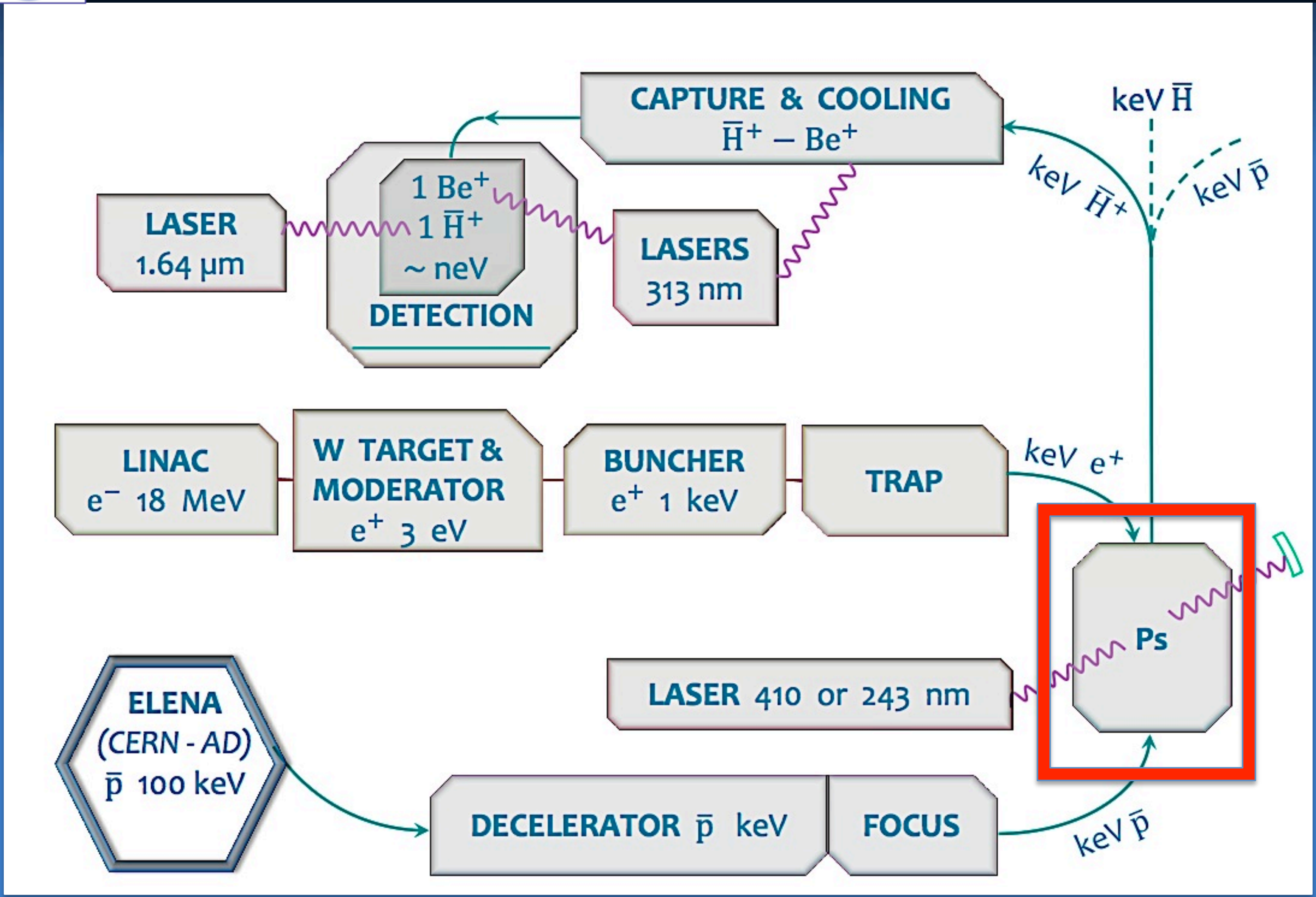




Examples:
- remoderator for beam E spread
- SiN window / reaction chamber

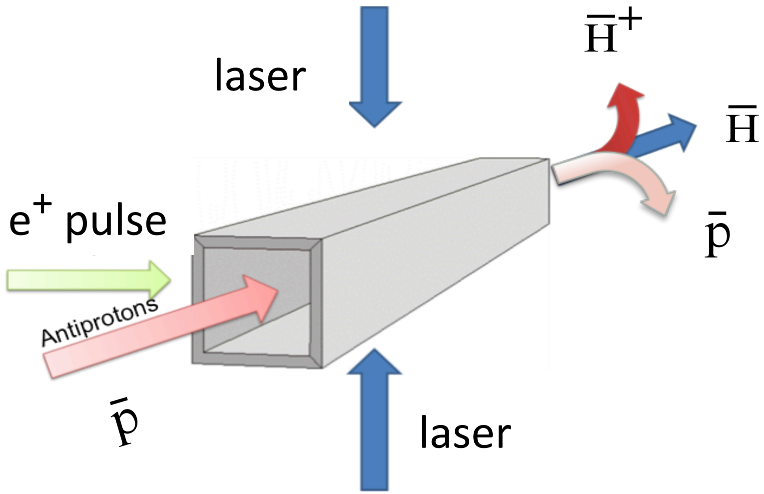


Positronium production



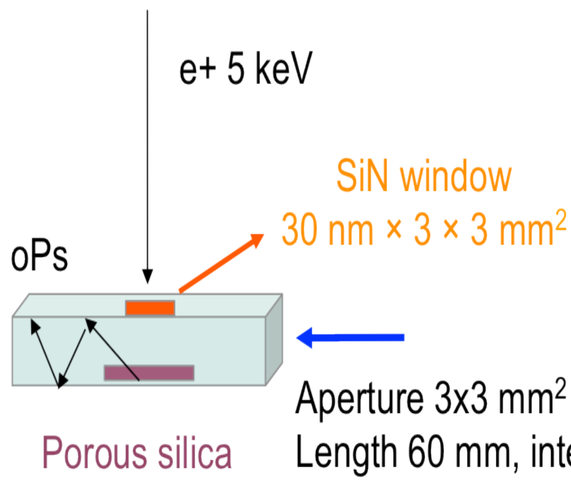
Ps formation

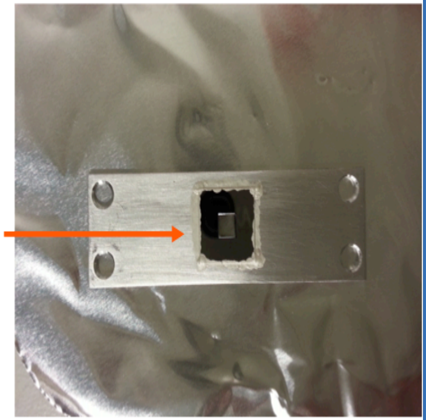
P. Crivelli
L. Liszkay



1 mm × 1 mm × 2 cm
Si with mesoporous SiO_2 coating

P. Crivelli, WAG2013

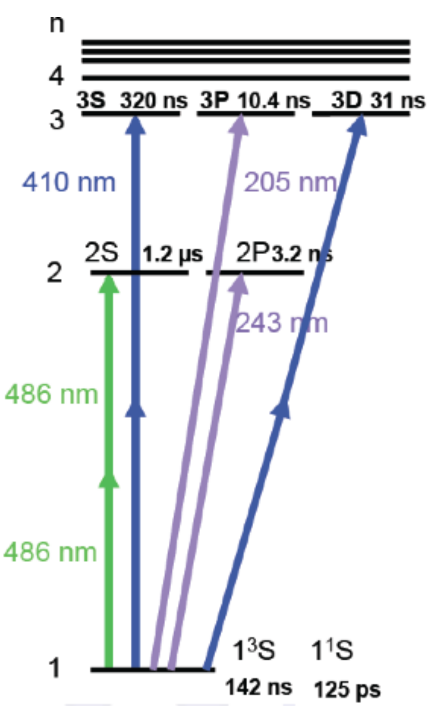


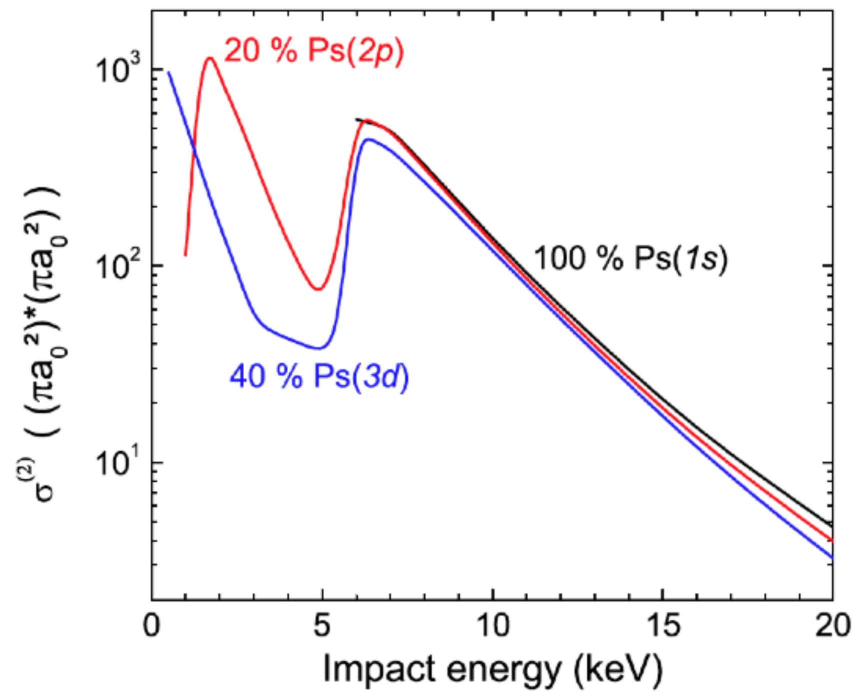


<u>Test on ETHZ beam line</u>
Transmission @ 5 keV ~ 100%
Ps formation efficiency as for bare SiO_2
Same Ps lifetime distribution

a possibility to enhance $\overline{\mathrm{H}}^+$ production

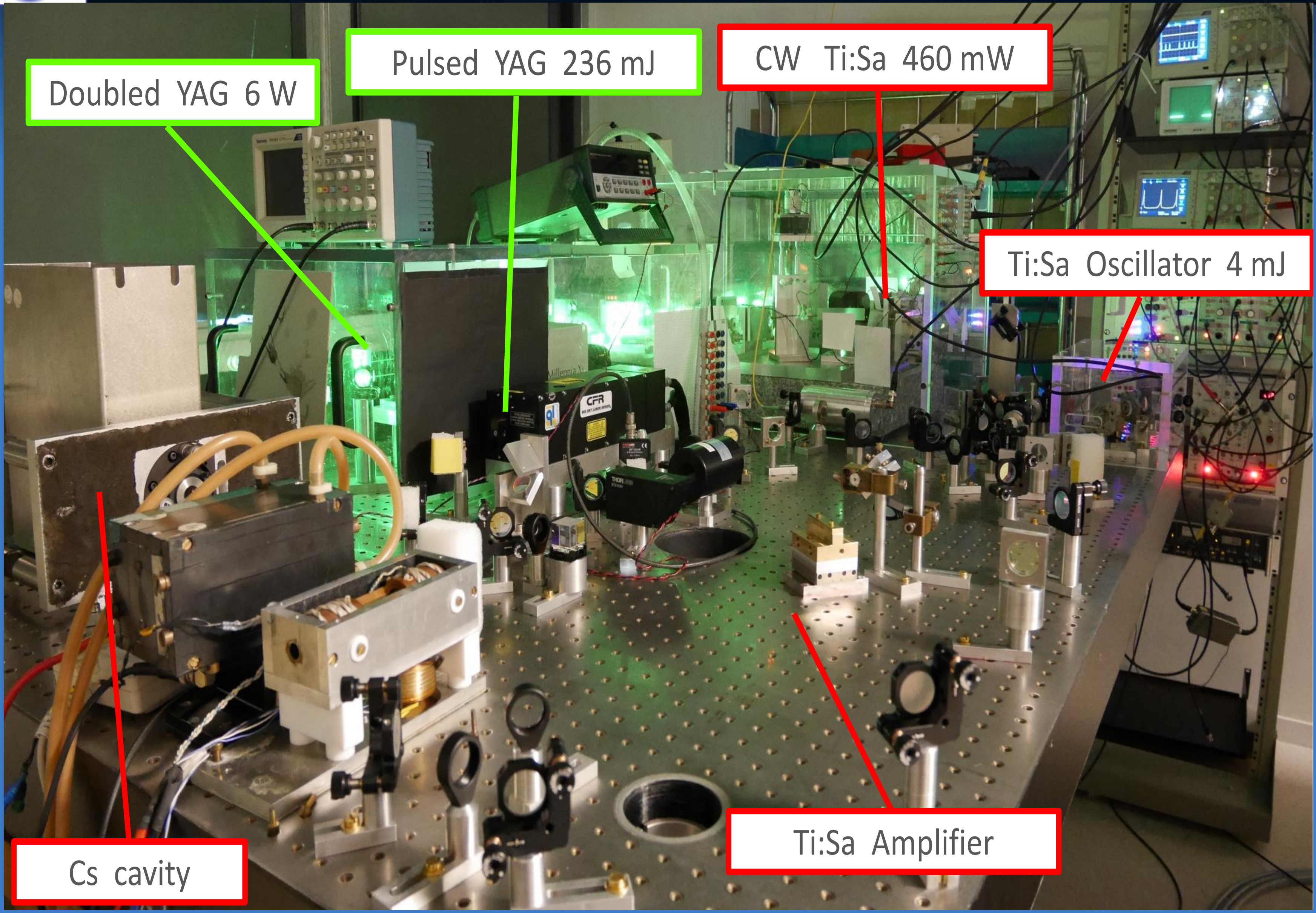
- $\bar{p} + Ps(n_{Ps}, l_{Ps}) \longrightarrow \overline{H}(n_H, l_H) + e^-$ (3-body)
- $\overline{H}(n_H, l_H) + Ps(n_{Ps}, l_{Ps}) \longrightarrow \overline{H}^+ + e^-$ (4-body)



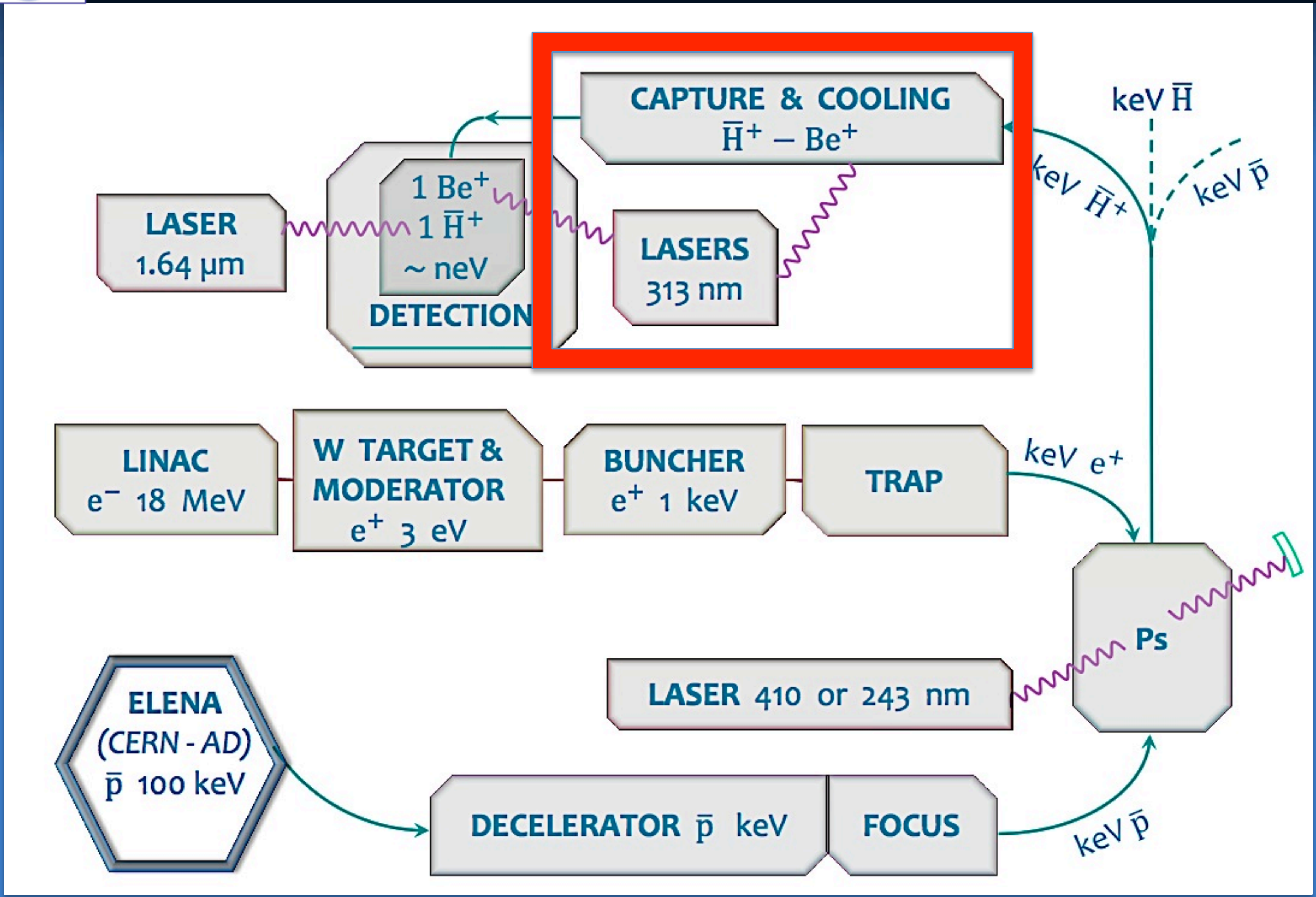


P. Comini and P-A. Hervieux, J. Phys.: Conf. Ser. **443**, 012007 (2013)
P. Comini, P-A. Hervieux and F. Biraben, LEAP 2013

Ps excitation laser

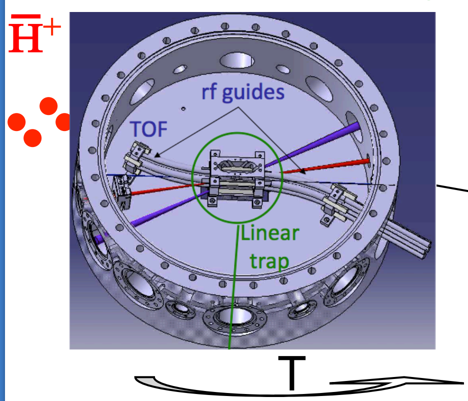


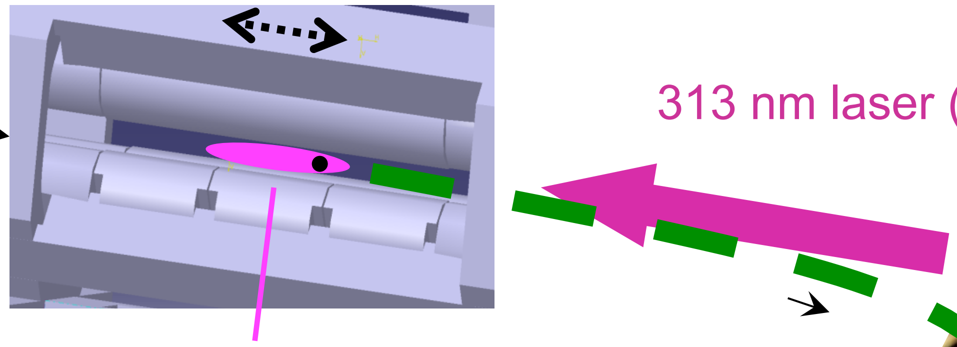
$\overline{H}^+$ cooling



L. Hilico
F. Schmidt-Kaler

First step Capture and sympathetic Doppler cooling by laser cooled Be^+ ions in the linear **capture trap** (Paul trap, r_0 = 3.5 mm, Ω = 13 MHz)

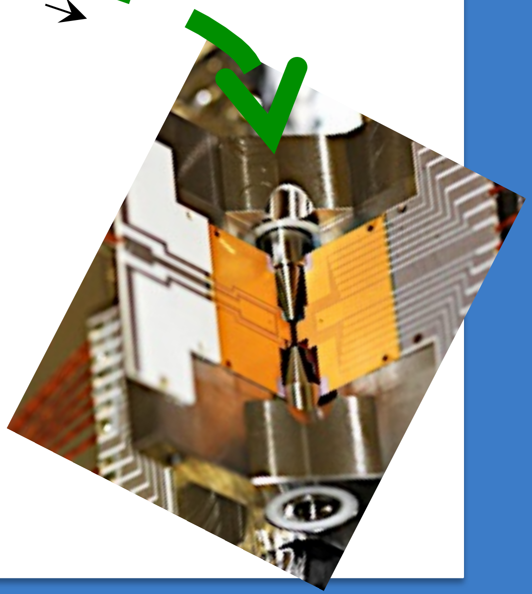




Second step

Transfer and ground state cooling of a $Be^+/\overline{H}^+$ ion pair in the **precision trap**

tests with H_2^+ / H^+ REMPI source
joint ANR and DFG grant



$\overline{H}^{+}$ cooling simulations

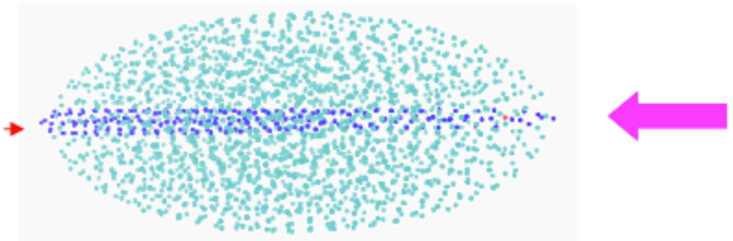
9/1 mass ratio : bad mechanical coupling

9/2 mass ratio : much better mechanical coupling

→ Idea : try an intermediate ion 9 / 3 / 1

C. B. Zhang, D. Oenberg, B. Roth, M. A. Wilson, and S. Schiller, Phys. Rev. A 76, 012719 (2007).
L. Hilico et al., IJMPCS 2014

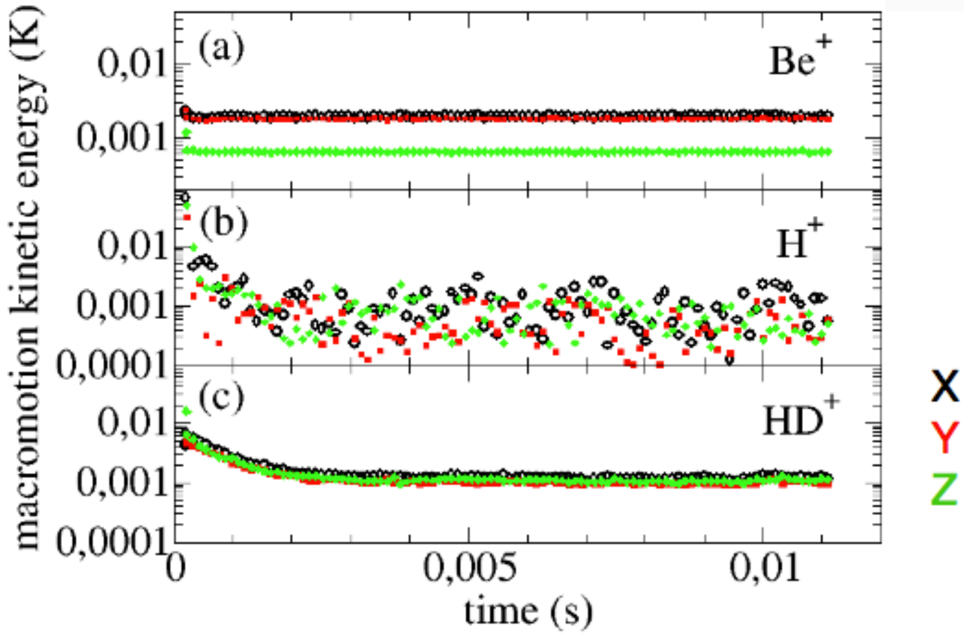
few meV $\overline{H}^{+}$

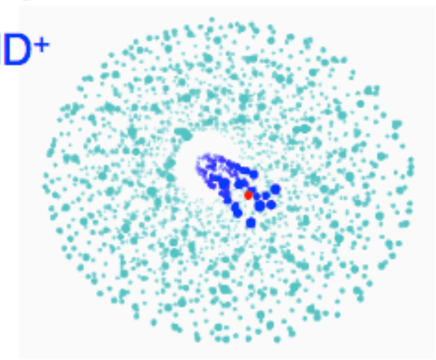


1800 Be^{+}

200 HD^{+}

1 $\overline{H}^{+}$



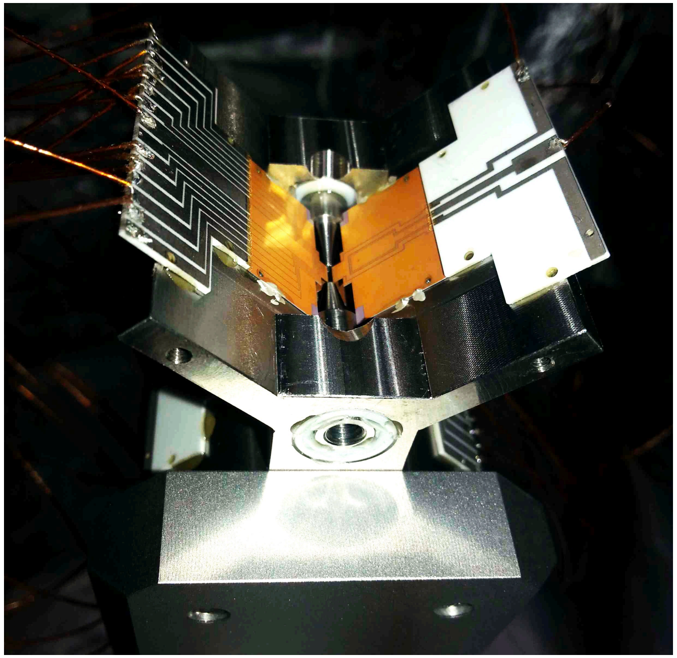


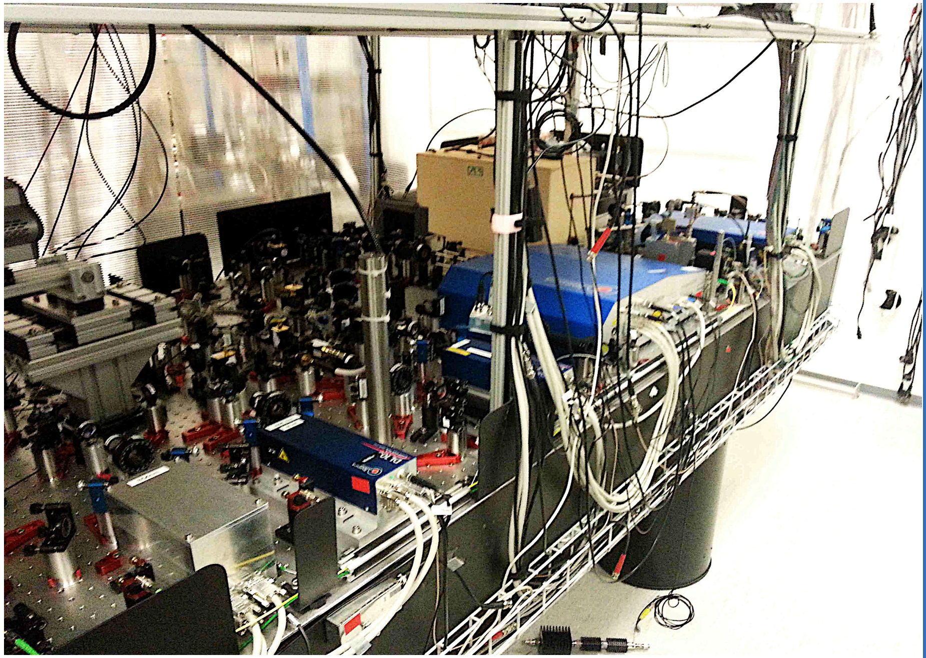
L. Hilico et al., (2014)
arXiv:1402.1695 [physics.atom-ph]

Precision trap

S. Wolf
F. Schmidt-Kaler

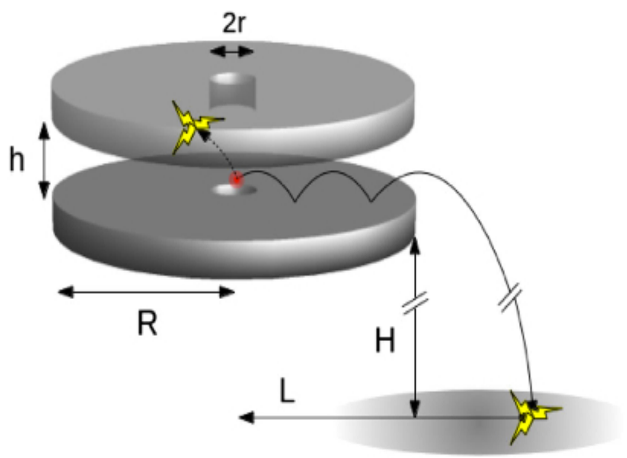
Precision trap being prepared at Mainz
Laser table ready for tests with Ca^{+}/Be^{+}, later Sr^{+}/Be^{+}

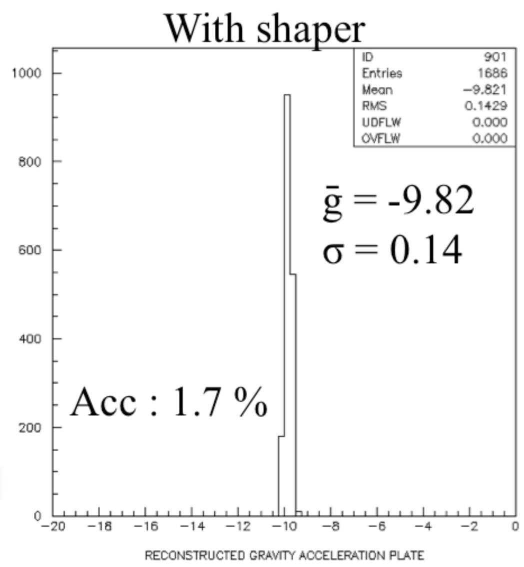


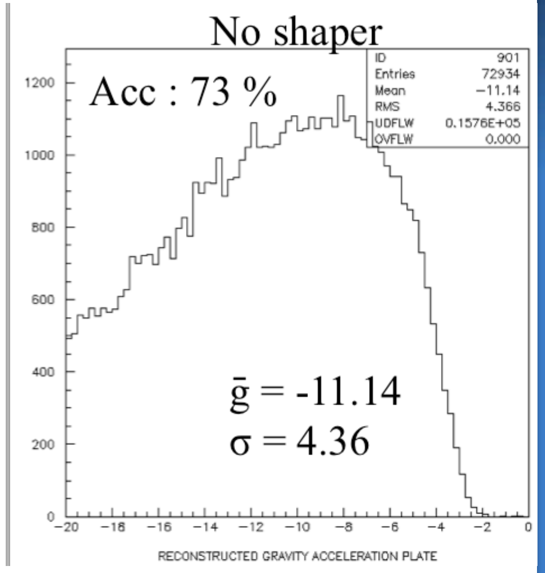


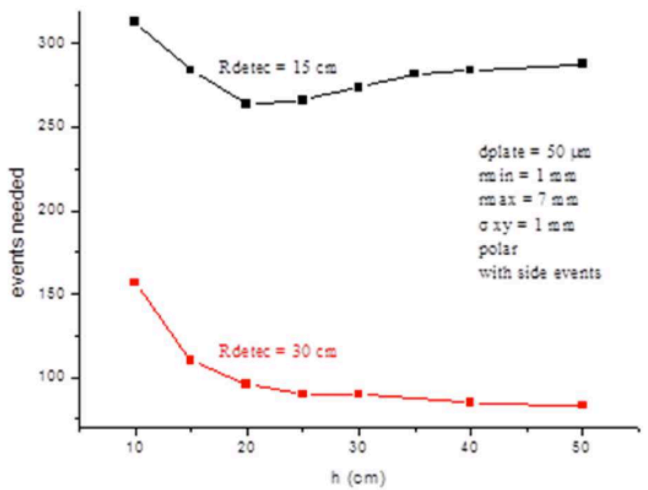
Velocity selector

G. Dufour et al., Eur. Phys. J. C 74 (2014) 2731









First simulations → optimise dimensions with experimental constraints

h = 50 µm

H = 20 cm , Rdetector = 20 cm

Shaper Rmin = 1 mm, Rmax = 7 mm

→ need 150 produced $\overline{\mathrm{H}}^+$ for Δg/g = 1%

10 times less than in proposal

MicroMegas detector

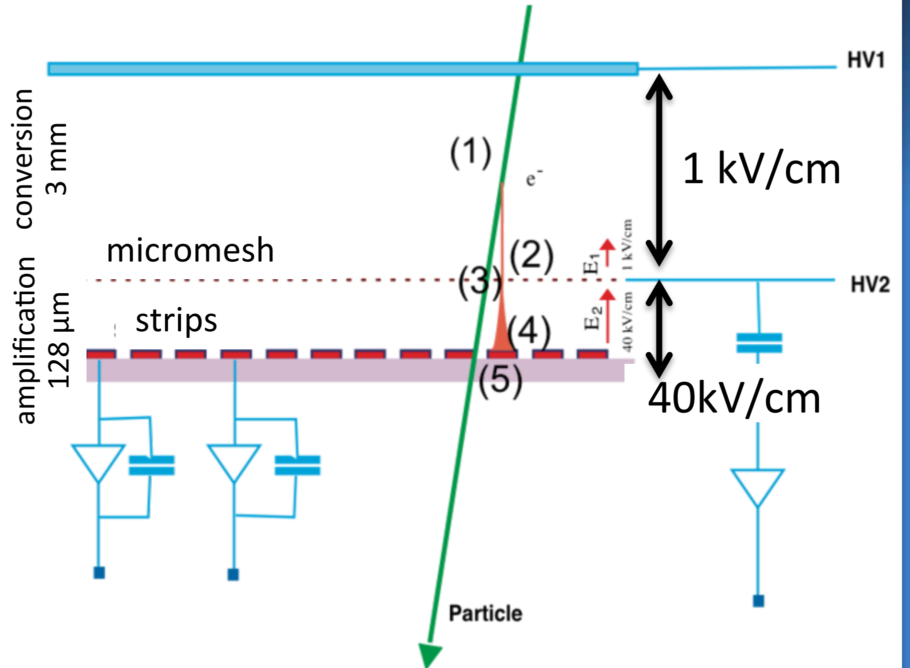
D. Banerjee, P. Crivelli
S. Aune, B. Vallage

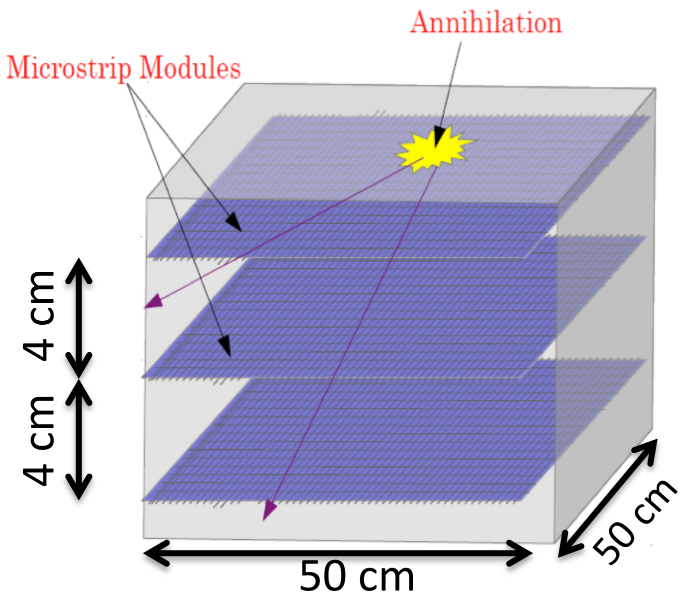
Argon Isobutane (95% , 5%)

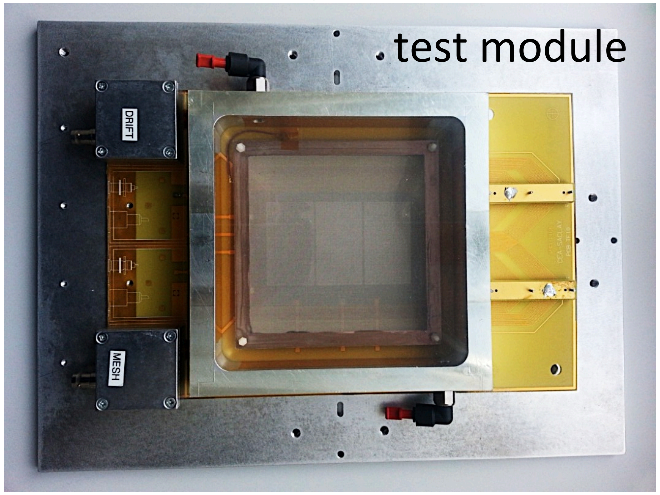
Pitch of strip ~ 400 microns

X and Y strips give track position directly

Genetic multiplexing of strips
S. Procureur et al, NIM **A** 729 (2013) 888







MoU signatures coming to CERN