Status of the GBAR experiment at CERN

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on behalf of the

GBAR Collaboration

Principle of GBAR at CERN

- Produce a high density positronium (Ps) plasma
- Use slow antiprotons ($\bar{p}$) from ELENA [decelerated, stored in $\bar{p}$ trap]

- Two reactions:
  - 1) $\bar{p}$ + Ps => $\bar{H}$ + e^- *[intense source of $\bar{H}$ atoms for other measurements]*
  - 2) $\bar{H}$ + Ps => $\bar{H}^+$ + e^- [possibly enhanced with laser Ps excitation]

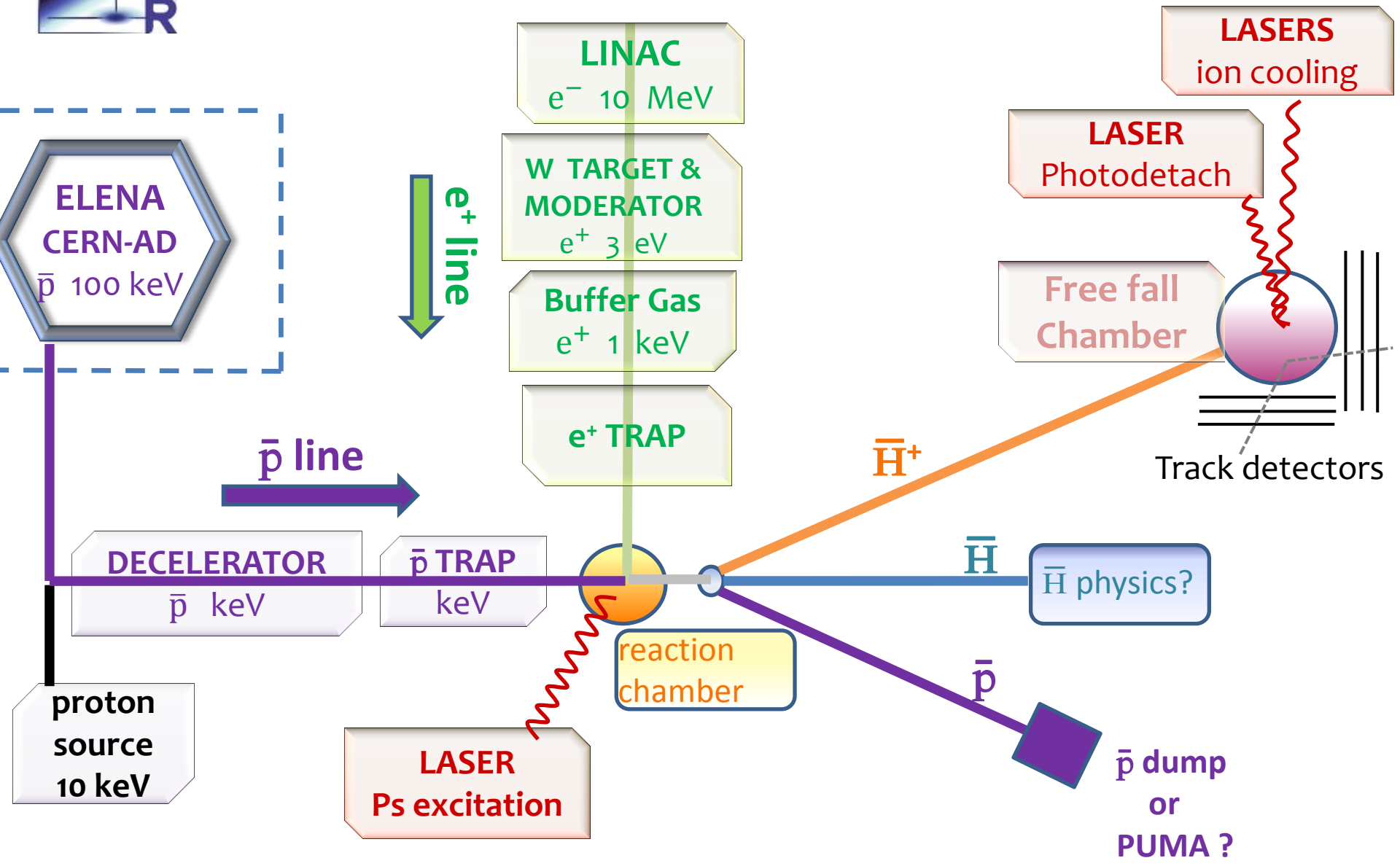
- Guide $\bar{H}^+$ ions to free-fall chamber and cool them
  - [sympathetic laser-cooling to 10μK ~ 1 neV]

- Photodetach the excess e^+ : t_0
  - *free fall over ~ 20 cm*

- Detect the $\bar{H}$ atom annihilation [tracking detectors + T-O-F]
  - location + time

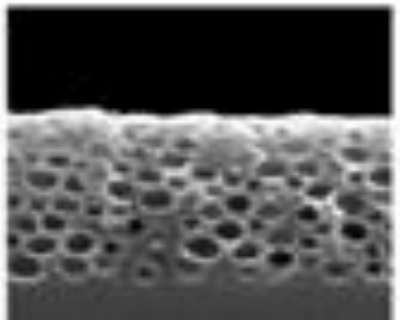
- Goal $\Delta g/g \leq 1\%$

GBAR elements

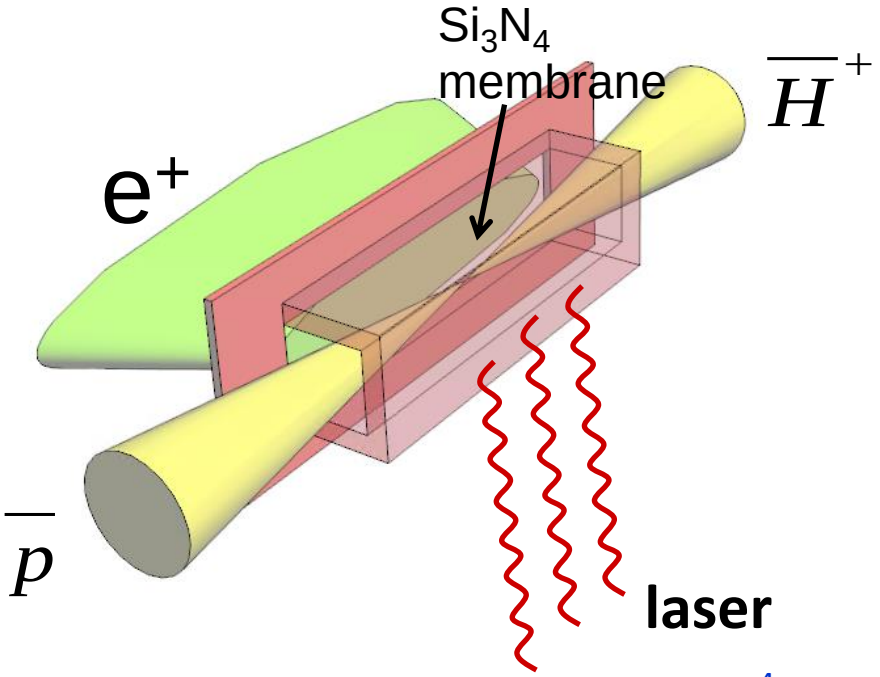


Ps plasma production

- **Ps production**
  - **pure Silica (SiO_2) with nanometer size pores**
  - **emits Ps upon e^+ implantation, with ~ 30% efficiency**



- **Ps Plasma in reaction tube**
  - **typical size l = 20 mm, diameter 1-2 mm**
  - **Si_3N_4 window for e^+ implantation**
  - **window and mirror for excitation laser**

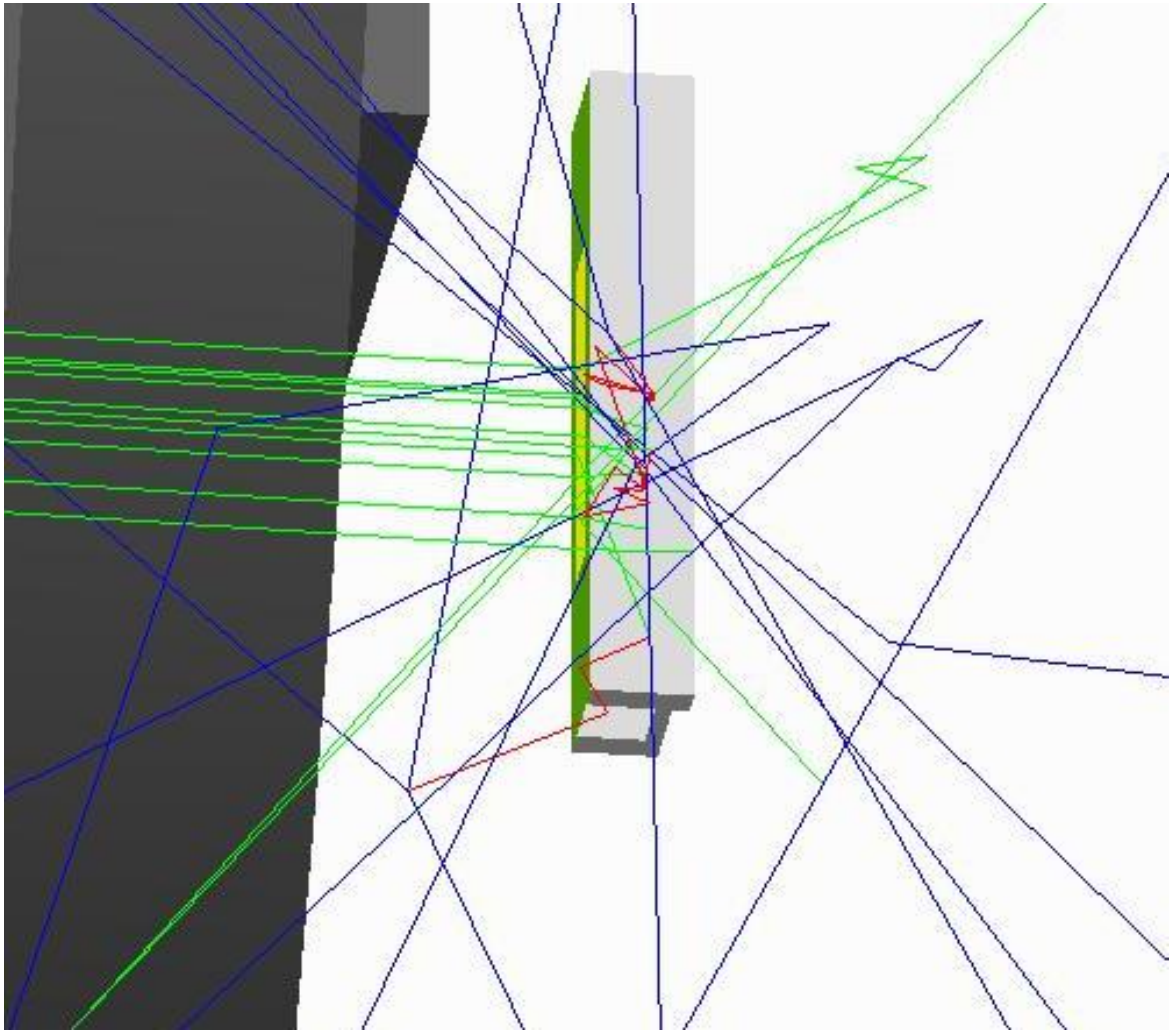


Ps plasma production

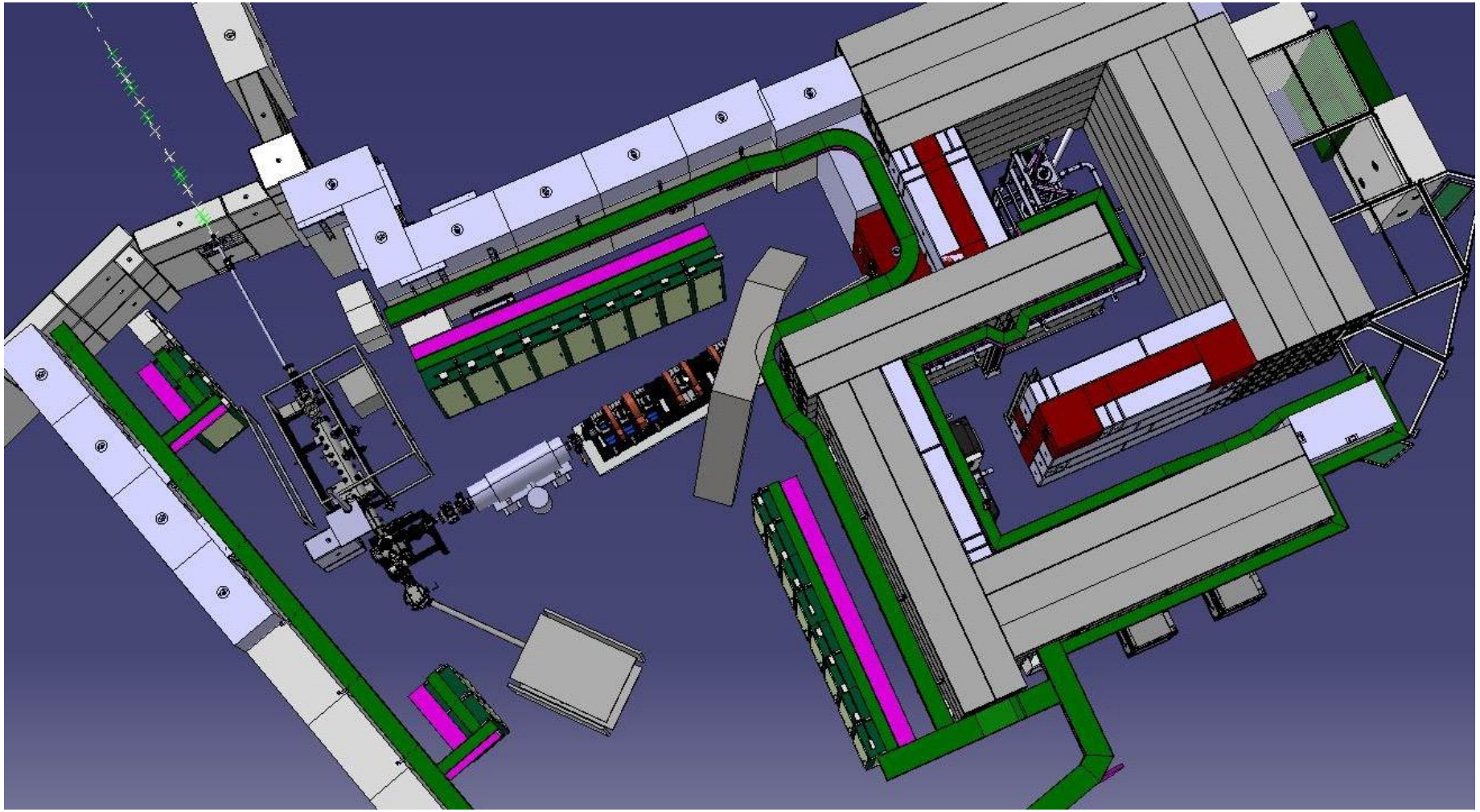
e^+

Ps

γ

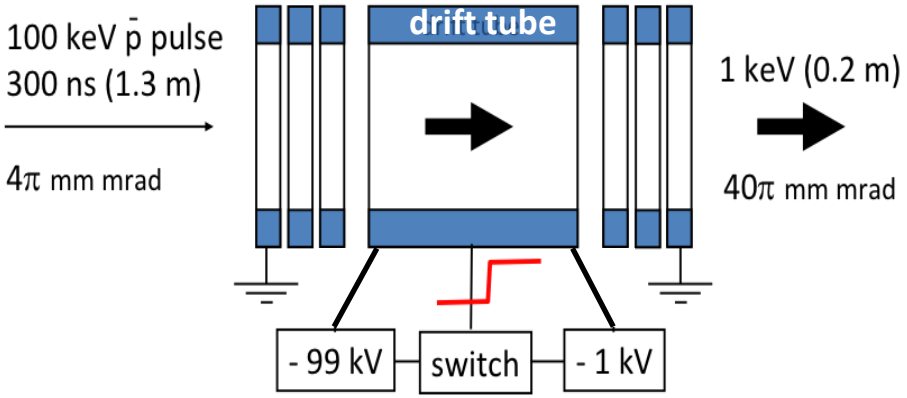


Layout in the CERN AD hall



Installation

Antiproton decelerator



- **ELENA $\bar{p}$ 100 keV => 1-10 kV**
- **Preliminary version in place, tested for 100 kV**
  - **new vessels expected April (better vacuum for connection to ELENA)**
- **designing and installing proton source**

Antiproton trap

- 7 T superconducting magnet with active shielding (Korea University Seoul) operated at 3 T in GBar
- being equipped as a trap
- to be tested with electrons
- ship to CERN in 2018 (?)

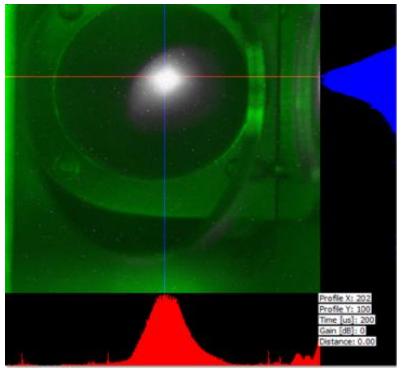
Electron LINAC

- Installed in 2017 with temporary cavity

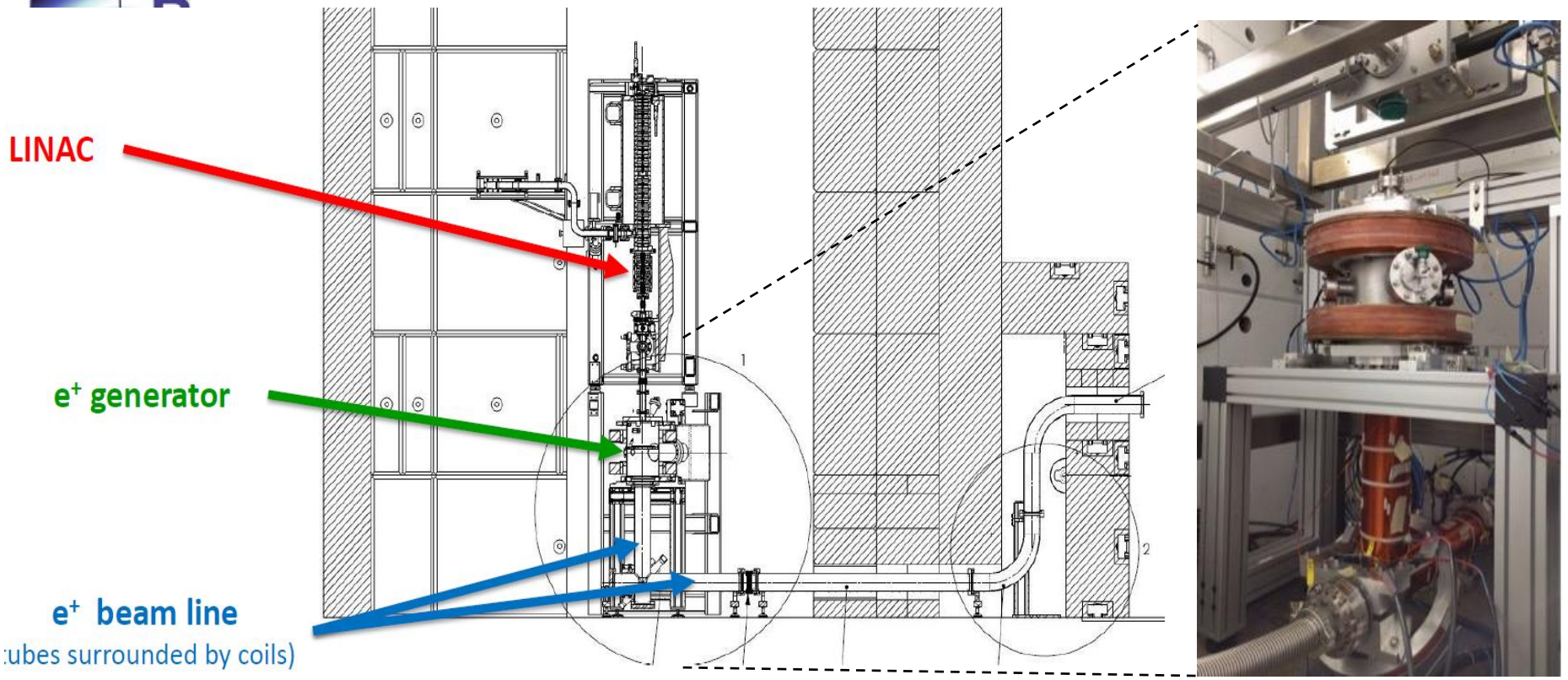
- limited to 100 Hz (nominal 300 Hz)
  8.3 MeV (nominal 10 MeV)
  100 mA current

- final structure

tested at 10 MeV, 300 mA, 300 Hz
now in GBAR (Feb 2018)
under commissioning

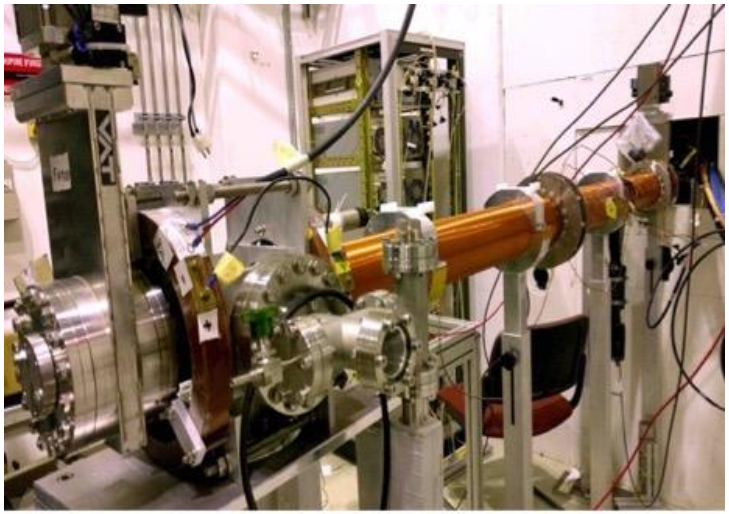


Positron production

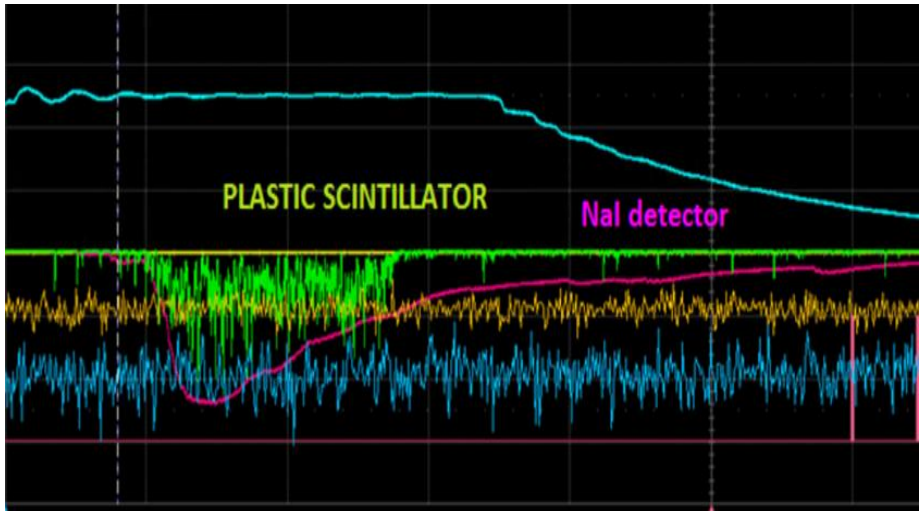


- Water-cooled Tungsten target
- Tungsten mesh moderator
- 8 mT solenoids guide the slow e^+ out of bunker

Positron production measurements



e^+ beam line exiting the bunker

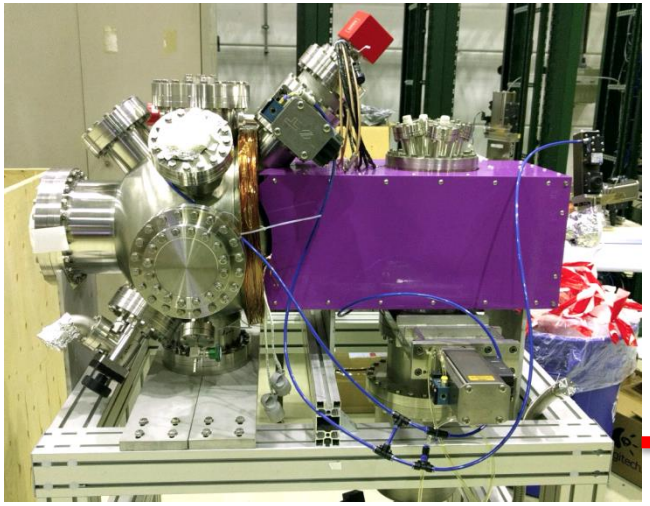


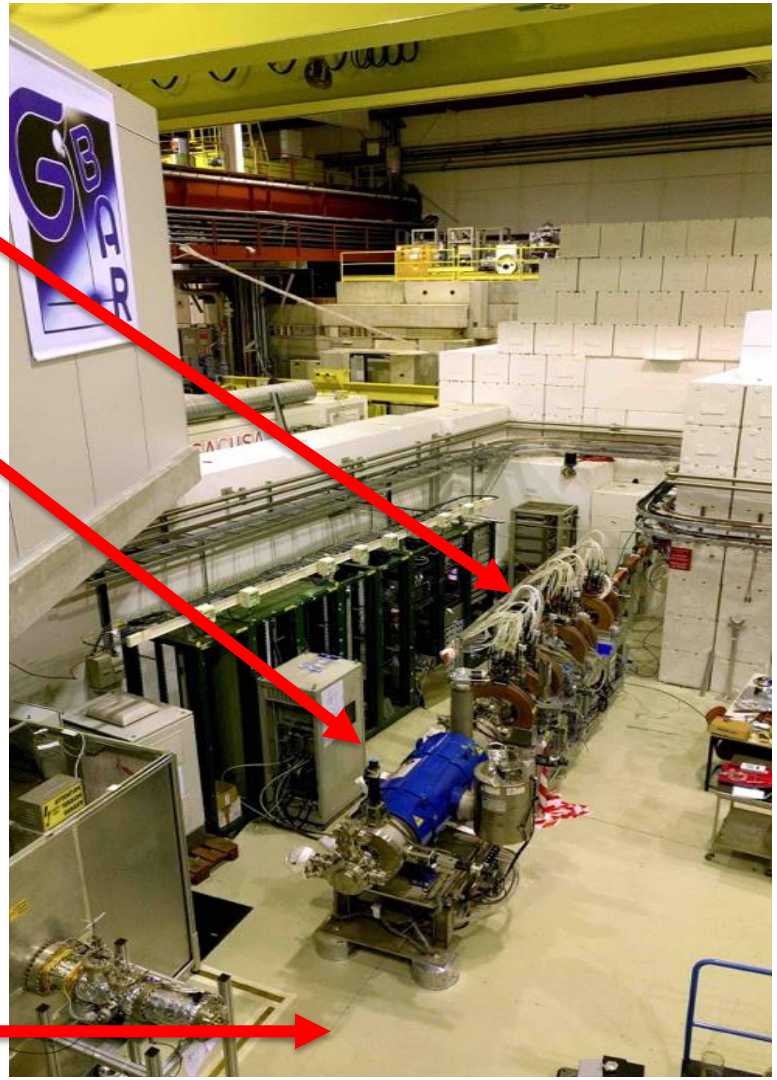
first e^+ signals on Nov. 17

- **e^+ yield outside the bunker measured by annihilation γ's**
  - **energy measured by potential grid: 1.3 eV RMS (OK for trapping in buffer-gas trap)**
  - **demonstrated ~ 10^5 e^+ /pulse with temporary linac**
  - **expect ~ 3 10^5 e^+ /pulse with present linac, i.e. 10^8 e^+ / s at 300 Hz**

Positron traps, reaction chamber

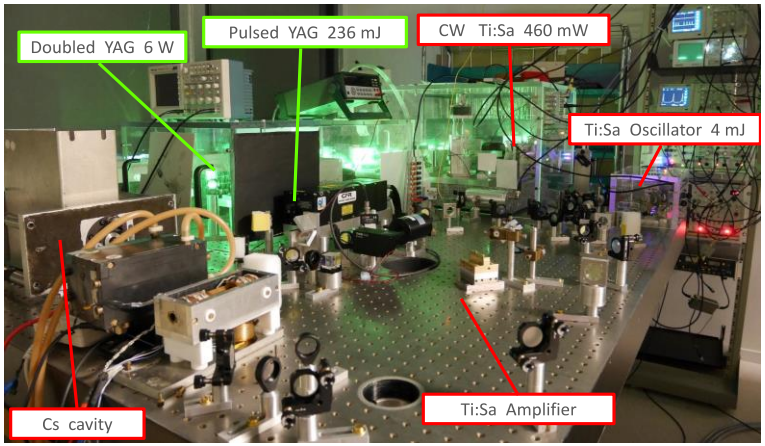
- **Buffer Gas trap built and operated at Saclay**
  - **ready to accept e^+**
- **High field positron trap from Riken**
  - **connecting and commissioning**
- **Reaction chamber**
  - **finalizing inner parts, instrumentation**





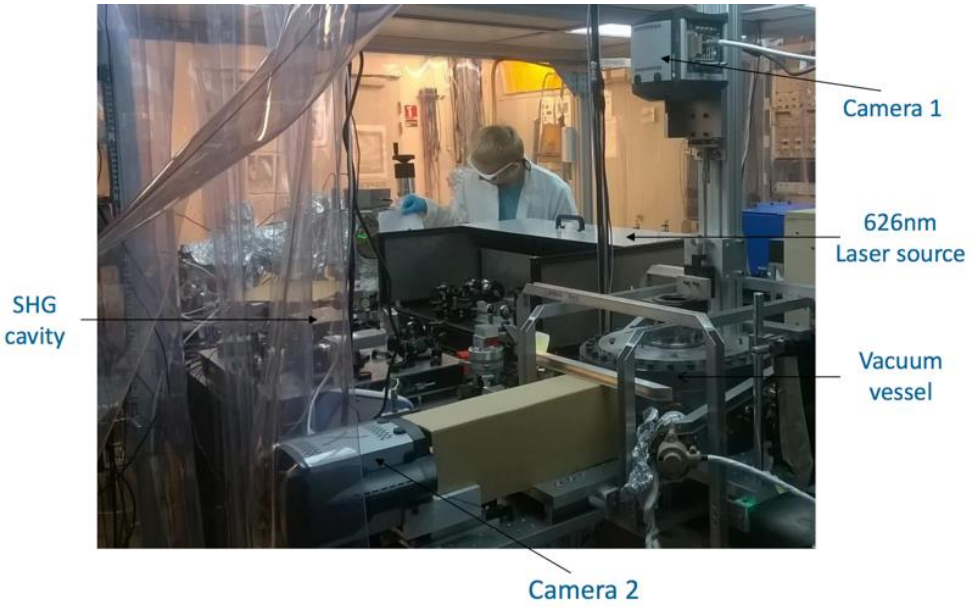
Ps excitation laser

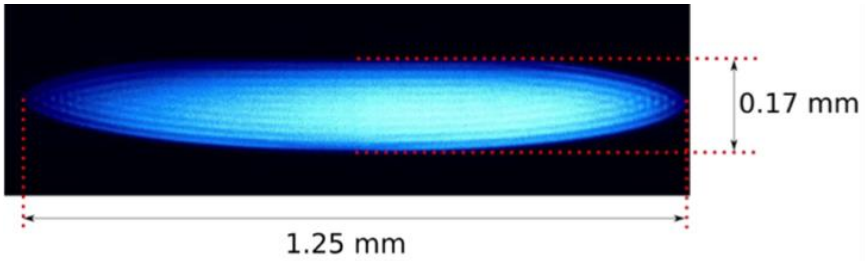
- Laser ready at LKB Paris
- Hut and tables installed
- will move to CERN before summer
- install and commission
- bring beam down to reaction chamber



cooling of $\bar{H}^+$ ion

- **Be^+ crystal cooling**





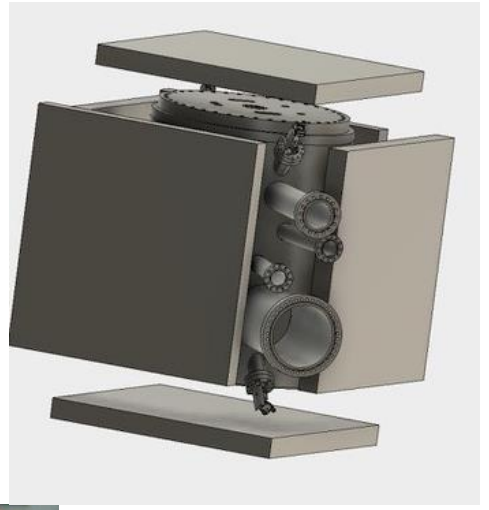
Be^+ crystal

For details ask LKB experts here!

- **Precision cooling trap**

  => see Sebastian's talk tomorrow

Free-fall chamber and detection



Free fall chamber : h = 60 cm (20 cm fall), Ø 50 cm

- **Inner cooling traps**
  - **Be crystal trap**
  - **precision trap**
- **lasers: for traps, and photodetachment**
- **active magnetic shielding**
- **track detectors**
  - **MicroMegas chambers (6 triplets)**

    Five double plane prototypes made. (one in GBar)
    - **Triplet "0" soon available**
  - **Time-of-Flight counters (4 large walls):**
    - **First plane operational in Gbar area**

Outlook

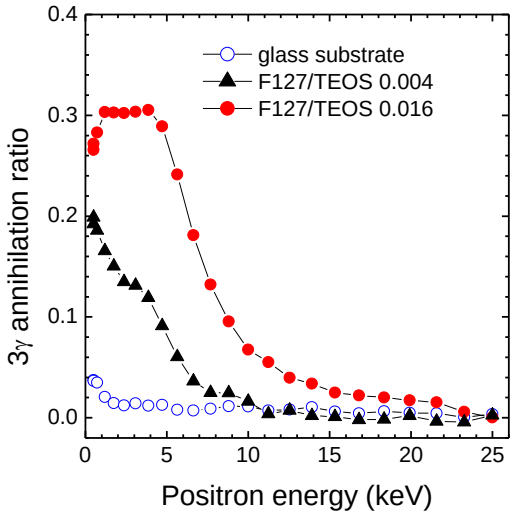
- **Spring 2018**
  - e^+
    - finish conditioning of new LINAC
    - exercise buffer-gas trap
    - exercise e^+ trap
  - $\bar{p}$
    - accept H^- from ELENA
    - install new decelerator and proton source
- **Summer**
    - e^+ to reaction chamber ; study Ps
    - accept $\bar{p}$ from ELENA
    - install Ps excitation laser
- **Fall**
  - e^+, $\bar{p}$, laser to reaction chamber => $\bar{H}$ beam; a few $\bar{H}^+$?
- **LS2 : optimize, install Free Fall chamber (including ion cooling, etc.)**
- **2021: free fall !**

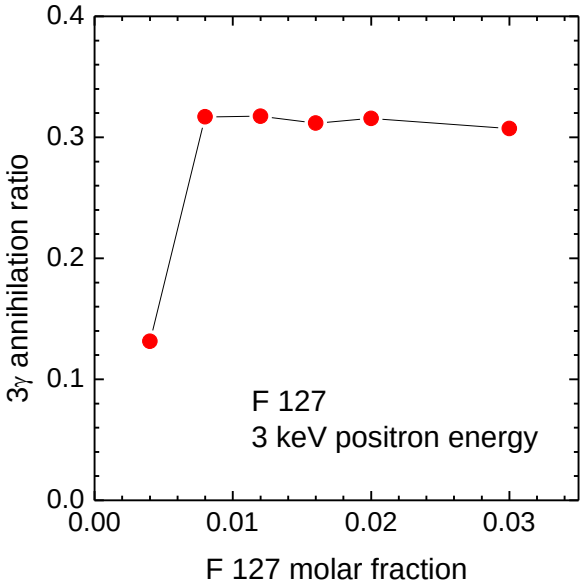
Additional slides

The GBAR Collaboration

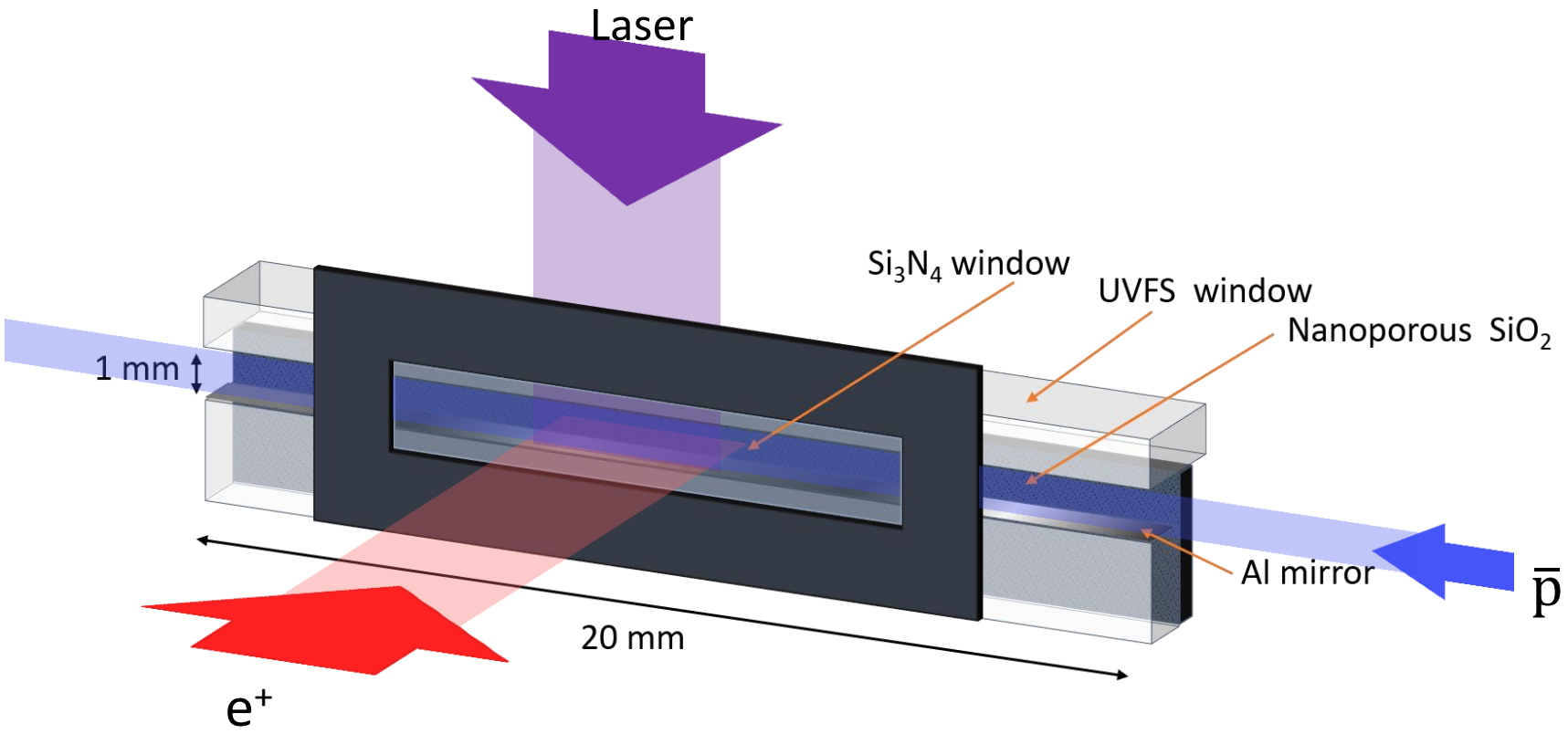
D. Banerjee, F. Biraben, M. Charlton, M. Chung, P. Cladé, P. Comini, P.-P. Crépin, P. Crivelli, O. Dalkarov, P. Debu, L. Dodd, A. Douillet, G. Dufour, P. Dupré, P. Froelich, S. Guellati, R. Guérout, J. M. Heinrich, P.-A. Hervieux, L. Hilico, A. Husson, J. Hwang, P. Indelicato, G. Janka, S. Jonsell, J.-P. Karr, K. Khabarova, B.H. Kim, S.K. Kim, Y. Kim, E. Kim, N. Kolachevsky, N. Kuroda, A. Lambrecht, B. Latacz, A. Lee, J. Lee, A.M.M. Leite, K. Lévêque, L. Liszkay, P. Lotrus, T. Louvradoux, D. Lunney, N. Madsen, G. Manfredi, B. Mansoulié, Y. Matsuda, A. Mohri, G. Mornacchi, V. Nesvizhevsky, F. Nez, K. Park, P. Pérez, B. Radics, C. Regenfus, J.-M. Rey, J.-M. Reymond, S. Reynaud, J-Y Roussé, A. Rubbia, J. Rzadkiewicz, Y. Sacquin, F. Schmidt-Kaler, N. Sillitoe, M. Staszczak, H. Torii, B. Vallage, M. Valdes, D.P. van der Werf , A. Voronin, S. Wolf, S. Wronka, Y. Yamazaki

Ps production in SiO_2





Reaction chamber



$\overline{H}$ and $\overline{H}^+$ transport

- **Switchyard (electrostatic)**