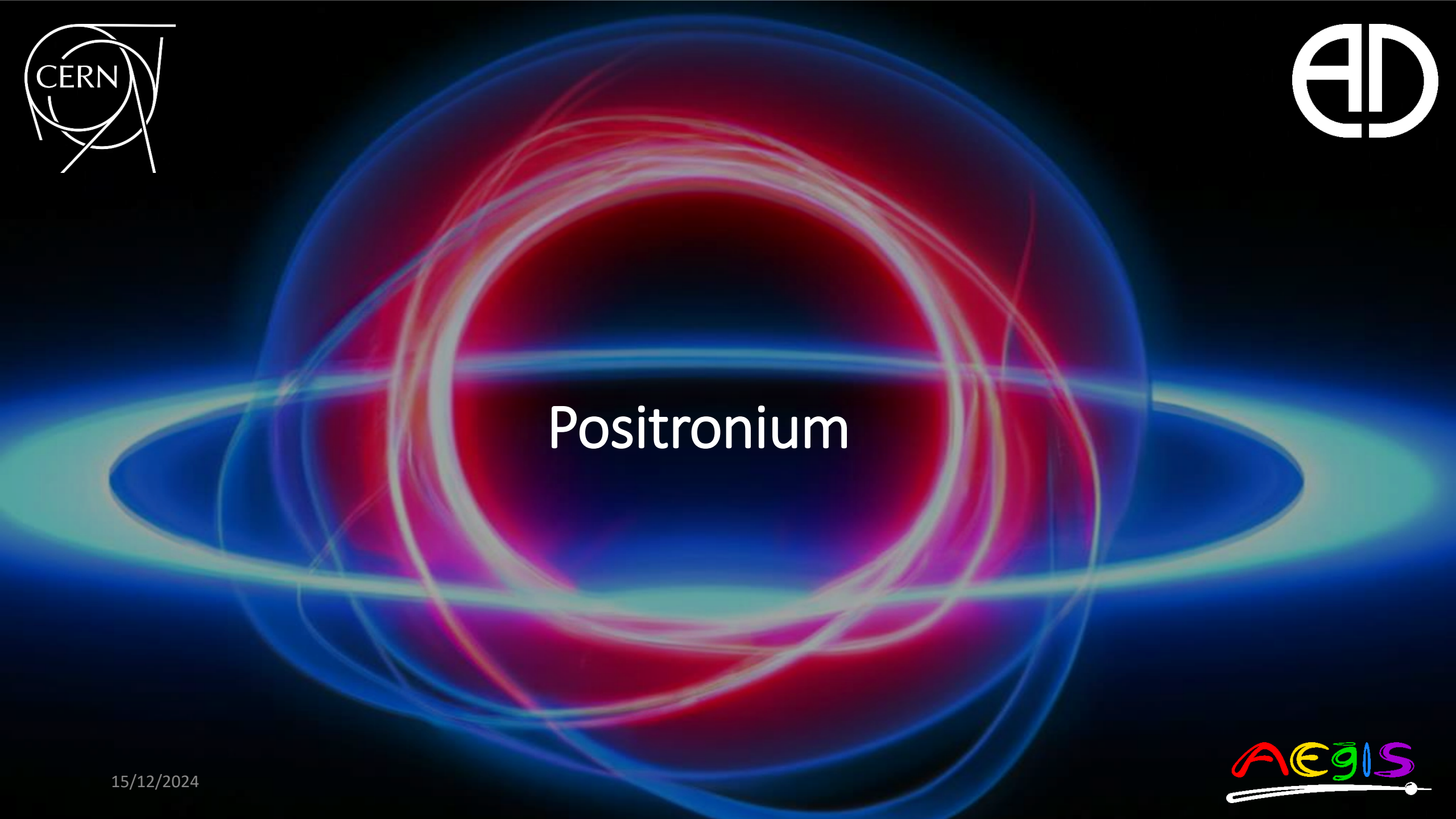
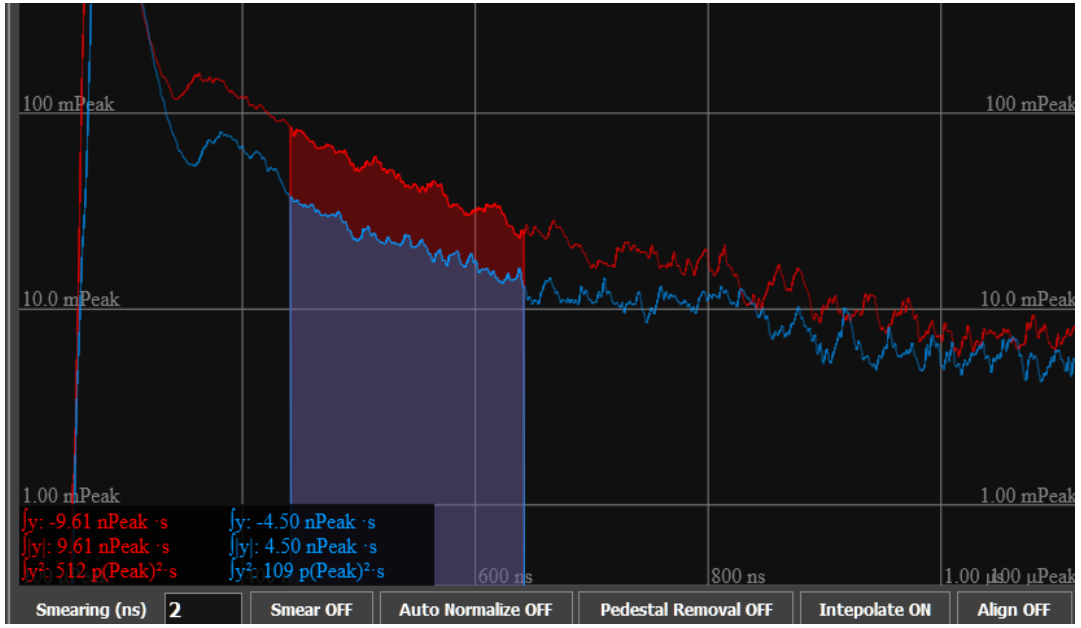

Positronium

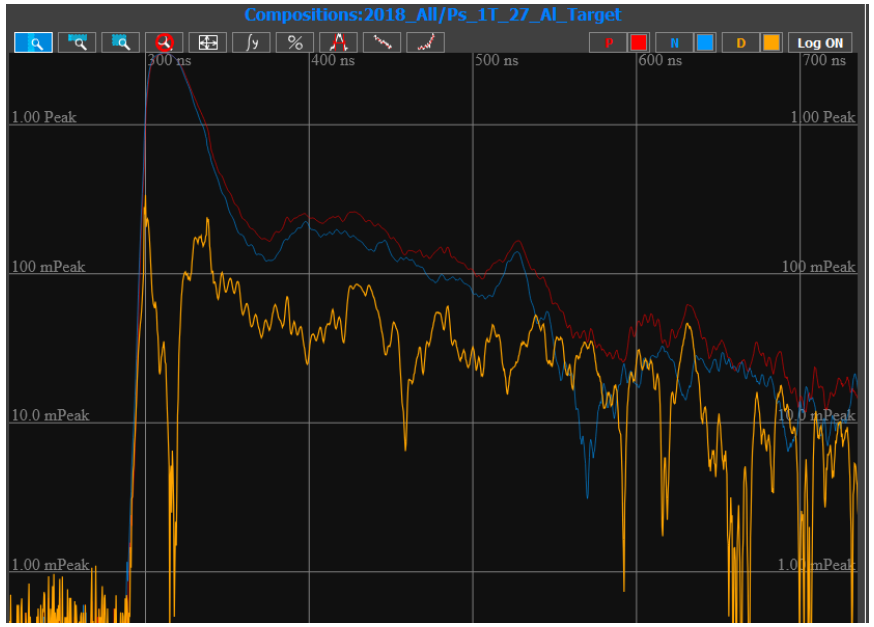
Ps in 1T in 2018

2018: May



- 21% Ps (solid angle to PMT20?)
- POS Peak larger by 2% only …

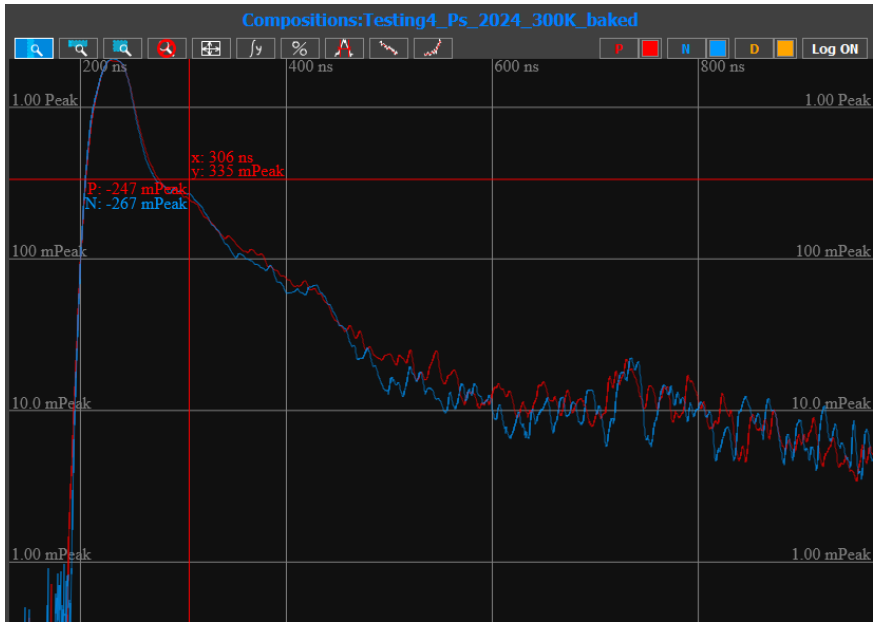
2018: Dec

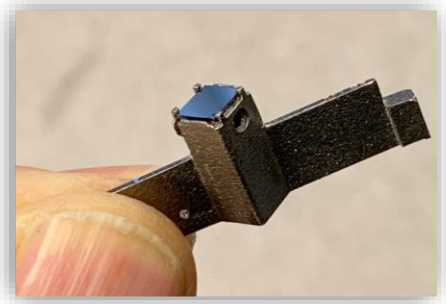


- 11% Ps (solid angle to PMT20 the same)

Ps in 1T

May 2024





- **Basically no Ps ☹ at cold and about 3-4% at 300K**
- What is the Ps formation target compared to?
  -> Different position can mean a different solid angle to PMT20
  -> Possible reason for the 21% of the first 2018 measurement
- Same material and recipe as in 2018: Si(111)
  -> Confirmed by Seba
- 10x less positrons
  -> shouldn't affect Ps, but the S/N ratio
- Same or better vacuum as in 2018
  -> cannot clog the nanochannels more than before
- Same temperature as in 2018
  -> Only surface Ps emission has a strong temperature dependence
  -> At cold, target can get covered by ice … this is why we bake
- Different implantation angle
  -> Adjusted the implantation energy
- Same magnetic field B=1T
  -> is there a new effect due to the angle and Ps density?
- Different target breaking method
  -> my main suspect

Ps in 1T

The effect of temperature on Ps from nanostructures

PhD thesis F. Guatieri

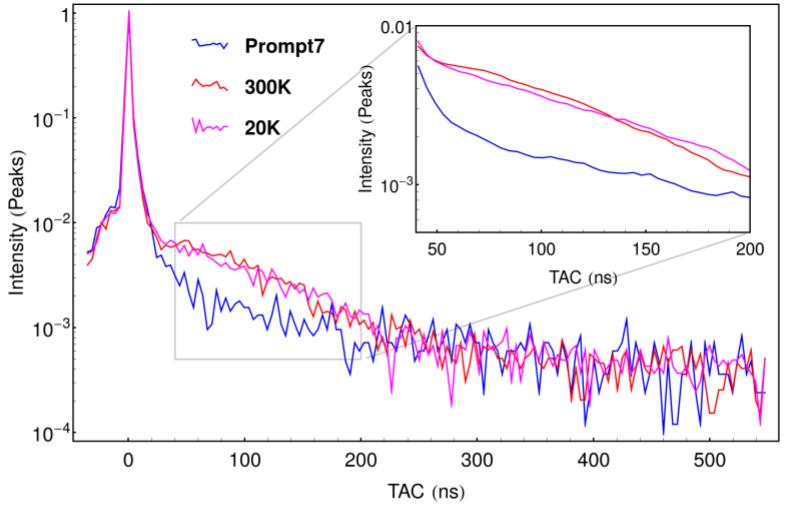


Figure 2.9: 7 keV ToF prompt spectrum measured on a silicon chip (blue) superimposed to the **300K** (red) and **20K** (magenta) spectra. In the inset the same spectra are presented averaged over a moving window of width 64 ns.

POSITRONIUM PRODUCTION IN CRYOGENIC ENVIRONMENTS

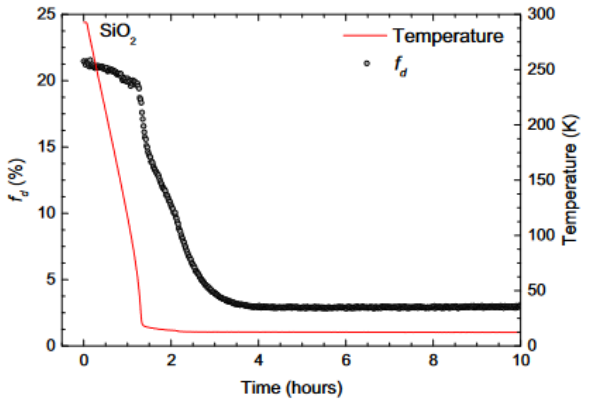


FIG. 4. Delayed fraction f_d from cooled mesoporous SiO_2 measured in the high-pressure (5×10^{-6} mBar) chamber. The delayed fraction error bars (±0.1%) are not shown.

expected to work with similar efficiency at any temperature. In mesoporous materials, as well as metal oxide powders,

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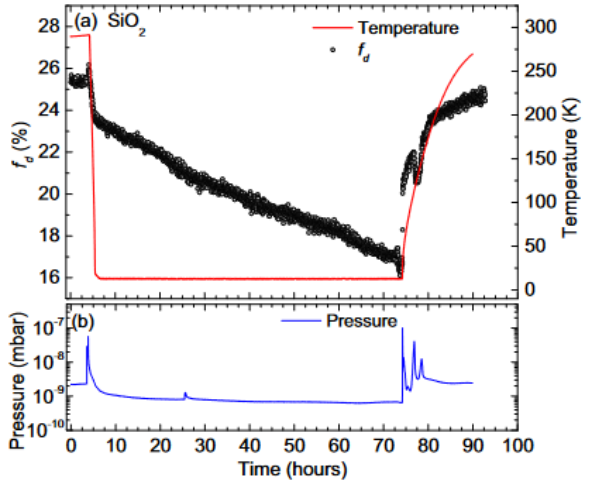


FIG. 5. (a) Delayed fraction f_d from cooled SiO_2 measured in the low-pressure (10^{-9} mBar) chamber. (b) Pressure in the target chamber associated with the cooling and heating cycle of (a).

Ps in 1T

Enhancement of Ps-Ps interaction in nanoporous materials:

- Spin exchange during collisions -> become 2x short-lived p-Ps: tau=125ps
- Magnetic quenching of m=0 states: tau=125ps
- Formation of Ps_2: tau=250ps

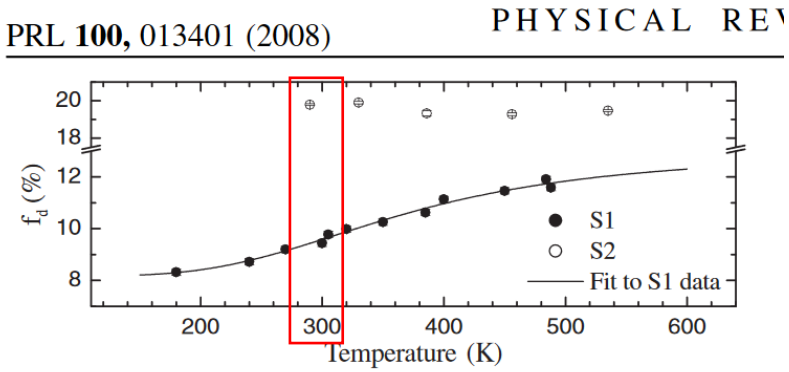


FIG. 2. f_d as a function of temperature for $S1$ (filled circles) and $S2$ (open circles) taken at the low beam density. The $S2$ data were taken using a reduced magnetic field of 0.15 T to minimize the effect of radiation damage, which leads to an increase in f_d. A fit was made to the $S1$ data using the procedure described in the text.

- S1 (at **1.5 T**): chaotic nanopores
  S2 (**0.15 T**): structured channels
- At 300K, Mills/Cassidy saw more than a doubling at lower fields … more than mag. quenching **could** explain

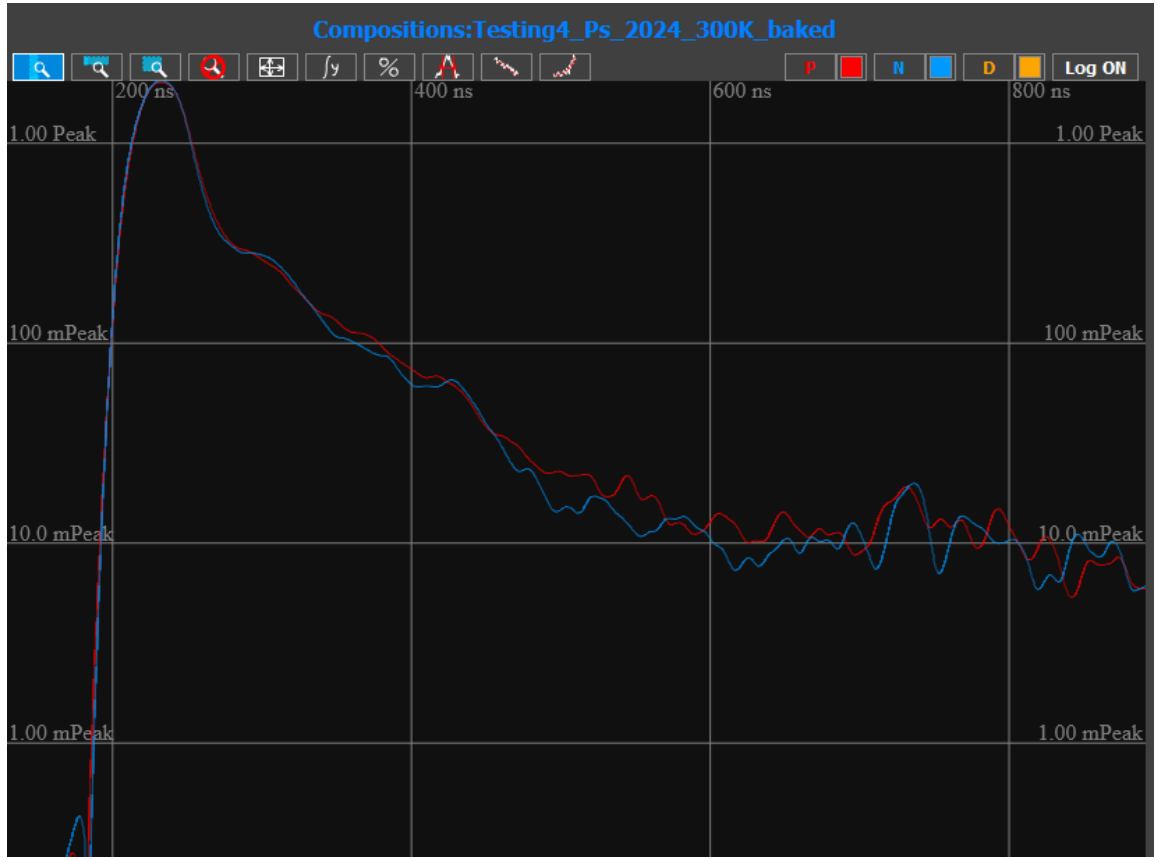
=> „Interactions Between Positronium Atoms in Porous Silica" can **reduce** the Ps amount by a factor of **2 (300K) – 2.5 (150K)**

Ps in 0.2T

Testing Ps in 0.2T with a baked target at 300K

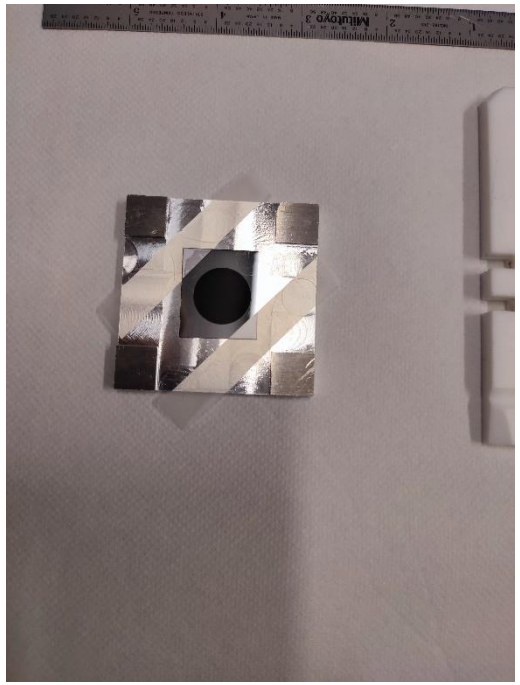
300K, 0.2T, integrate 350-650
There is 1.3% less signal in POS **Peak foPs=(3.3+/-0.5)%**

⇒ The same amount as before (very disappointingly)

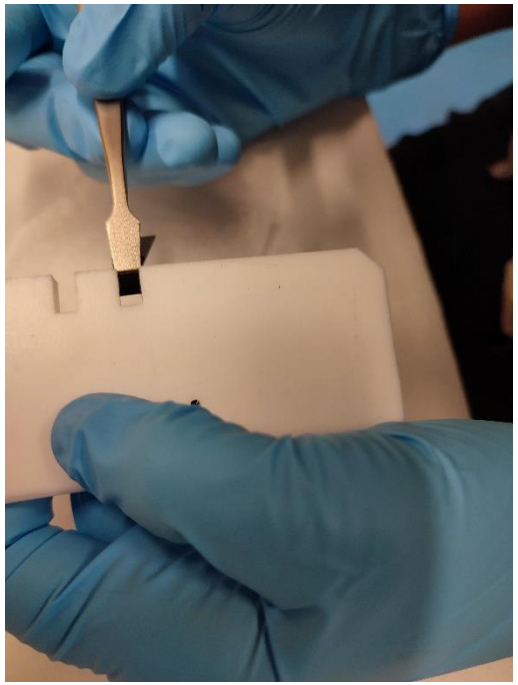


Target breaking procedure

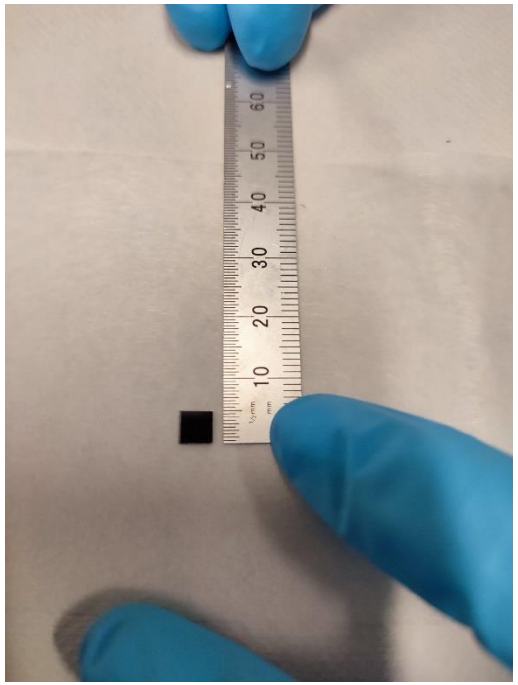
Sandra's & Alice's work: The sensitive area is always up now!



Surface scratching mask



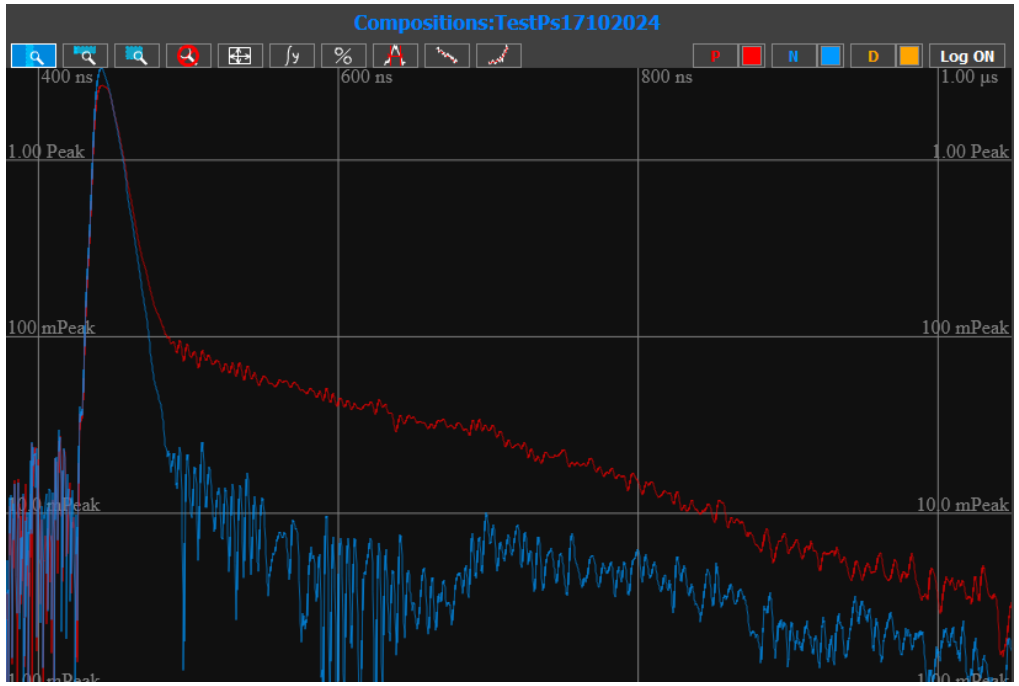
final edge



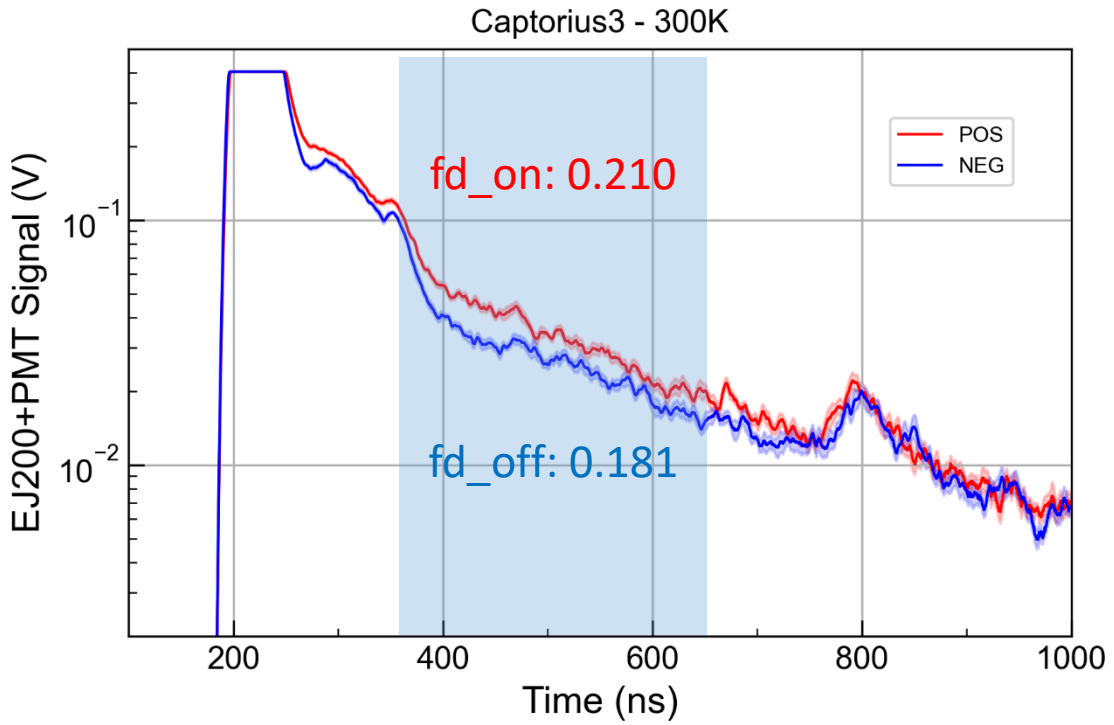
4.8 x 4.8 mm

With new target breaking procedure

BB: TestPs17102024



Nov 2024



300K, 0T, integrate 500-700
There is 16% less signal in POS **Peak**
foPs=(23.1+/-0.5)%

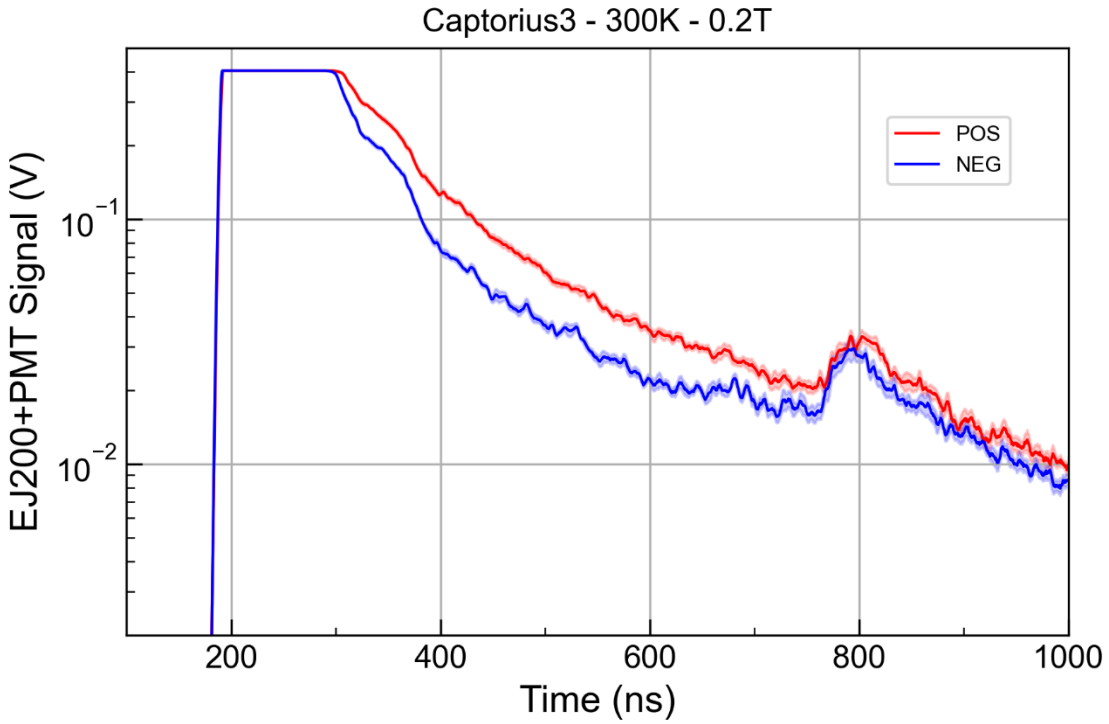
Twin target!

300K, 1T, integrate 360-660
There is 6.4% less signal in POS **Peak**
foPs=(9.8+/-0.7)% -> Hbar conditions
(at cold it was even less, so we kept the target at 300K)

What else?

- Different target breaking method-> my main suspect -> solved
- Same magnetic field B=1T -> is there a new effect due to the angle and Ps density?

Again, at 0.2T …



Different target temperatures:

300K, 0.2T, integrate 360-660
foPs=(23.0+/-0.7)%.

220K, 0.2T, integrate 360-660
foPs=(23.1+/-0.4)%.

150K, 0.2T, integrate 360-660
foPs=(20.8+/-0.5)%.

50K, 0.2T, integrate 360-660
foPs=(20.0+/-0.6)%.

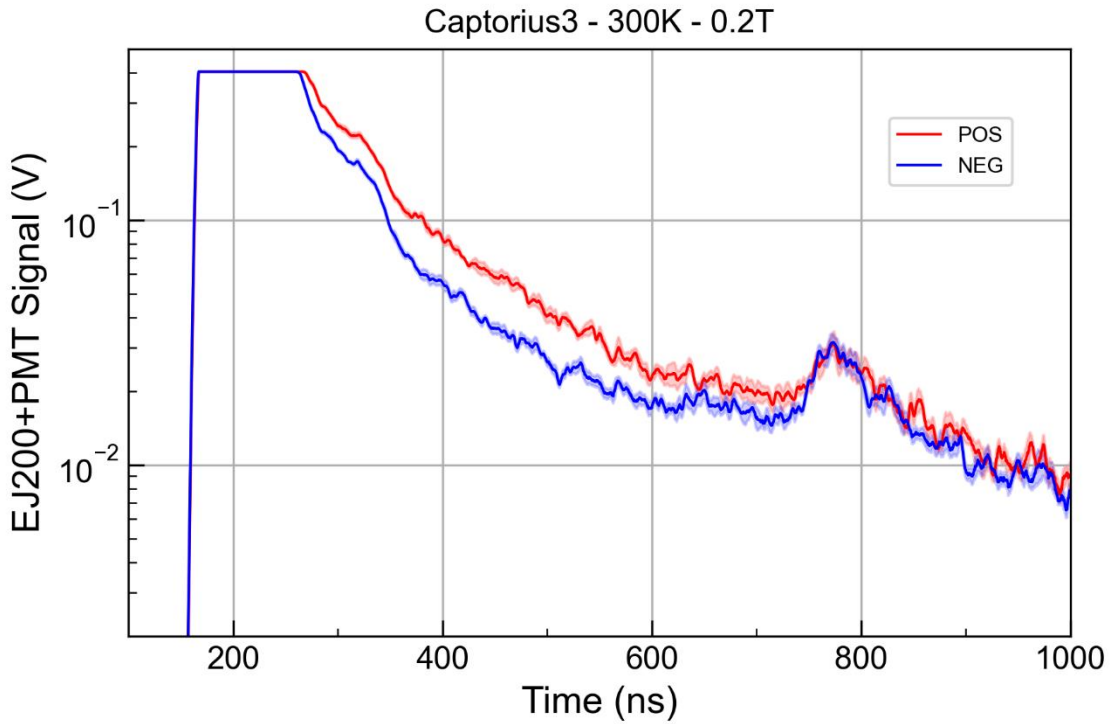
What else?

Different kicker potentials:

300K, 0.2T, **Kicker=5000V**,integrate 360-660
There is 6.9% less signal in POS Peak.
foPs=(15.9+/-1.7)%.

300K, 0.2T, **Kicker=500V**,integrate 360-660
There is 7.2% less signal in POS Peak.
foPs=(20+/-1)%.

⇒ Higher potential = less, but probably colder Ps



In conclusion:

- The target recipe works! ☺
- We observe an effect that is not present in the BB, but in the 1T, in 2024 and probably also in 2018
- It is correlated to the magnetic field B.
- Is it an effect of the target angle, i.e. the Ps density inside the nanochannels?

⇒ We could try working at lower B-fields in the future

⇒ We could try to slant the target again, but…
Pay attention to self-ionization!!