Main Research Projects

Projects of Grant in Aid for Scientific Research (S)

1. “Development of High-brightness and High-intensity Positron Diffraction and its Application to Surface Studies”
   (project leader: T. Hyodo)
   → all the experiments conducted in KEK

2. “Evolution of the positronium beam science using the technique of photodetachment of the positronium negative ion”
   (Project leader: Y. Nagahisma)
   → part of experiments conducted in KEK

Main Project 1

"Development of High-brightness and High-intensity Positron Diffraction and its Application to Surface Studies"

RHEPD: leading the world → better with brightness enhancement

LEPD : starting with higher brightness than others

→ hope catching up soon and leading the others

(1)Structure analysis of surfaces where heavy elements are involved (topological insulator, giant Rshba surface)

(2)Direct determination of the structures (Patterson analysis with RHEPD; positron hollography with LEPD)

Superiority of positron diffractions

Precise determination of the surface atomic arrangement is the key to surface science.

The positron is the most sensitive to the surface structure.

Comparison of 3 Beams

(e: excellent, g: good, p:poor)

Characteristics	e^+	e^-	X-rays	Notes on e^+
Surface sensitivity	e	g	p	inelastically scattered easily
Information of the topmost layer through total reflection	e	–	p	positive crystal potential
Easiness in high precision analysis	g	p	e	scattering factor as simple as for X-rays
Analysis of the position of heavy elements	e	p	g	not attracted by nuclei
Intensity	p	g	g	anti-particle

ideal

Resolved by using high intensity beam at KEK

Brightness Enhancement by Remoderation

輝度

$$B = \frac{I}{\pi r^2 E \sin^2 \theta}$$

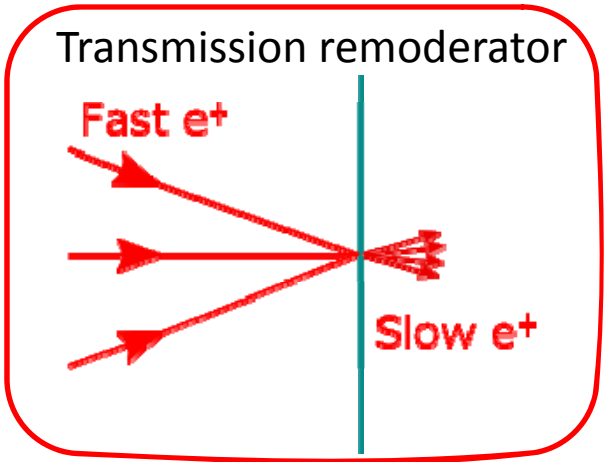
I : beam intensity （ → /10）

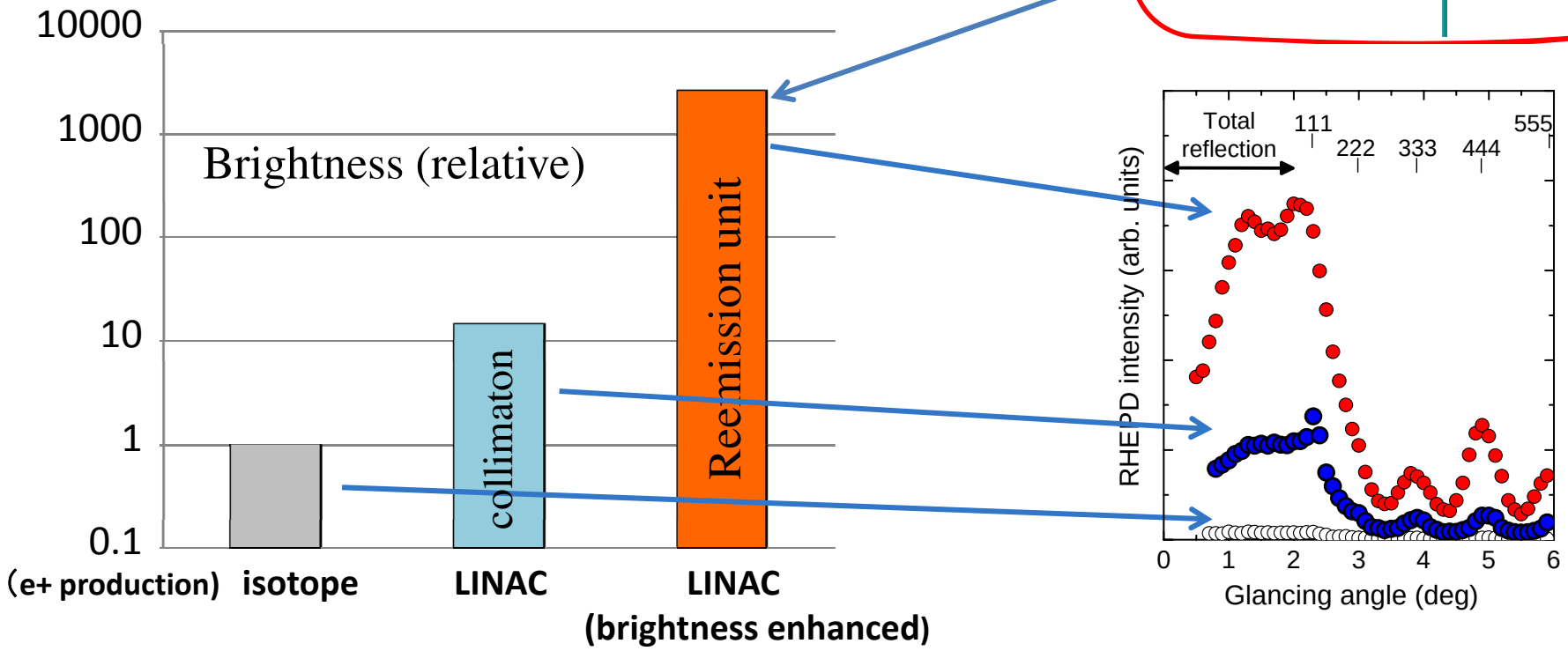
: beam radius （ → ）

: beam energy(5keV→1eV)

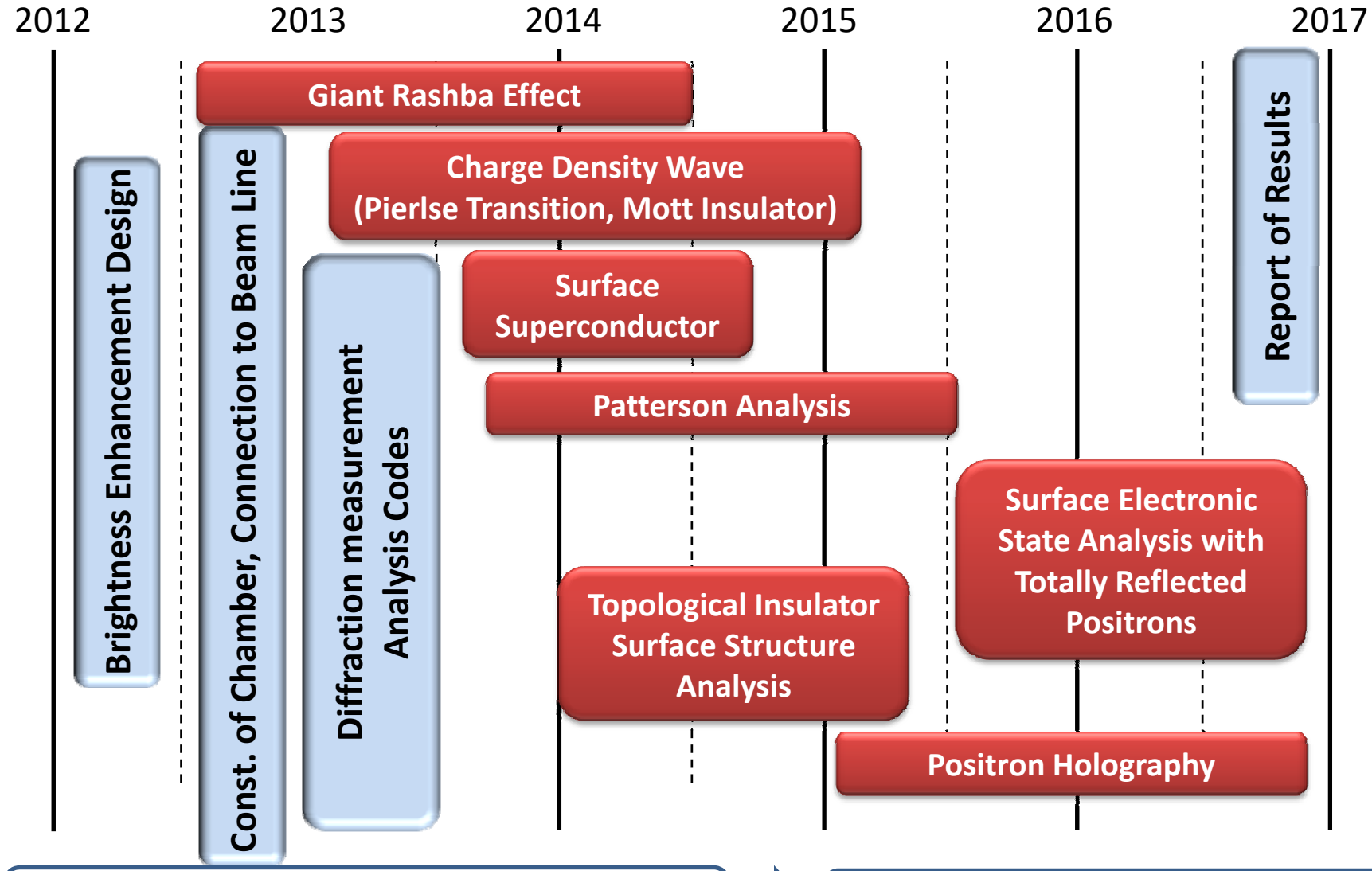
θ : beam divergence angle

（～50° → ～10°）





Positron Diffraction Schedule



Establishment of Surface Structure Analysis with Positron Diffraction → **Direct determination of Surface Structure**

Main Project 2

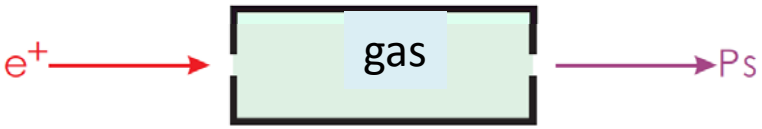
Positronium Science with Photodetachment of Positronium Negative Ions

Ps beam production so far

Ps, electrically neutral, cannot be accelerated with electric field

Use of molecular scattering with a positron

$e^+ + M \rightarrow Ps + M^+$



Intensity is low.

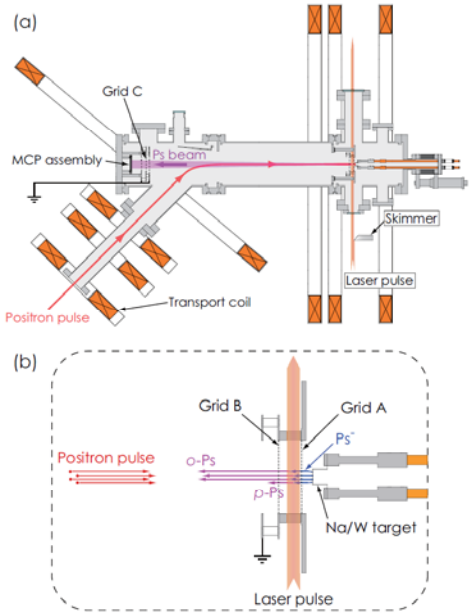
Incompatible with ultra high bacuum

Limited to the energy range lower than 100 eV

Ps Beam Production with Ps^-

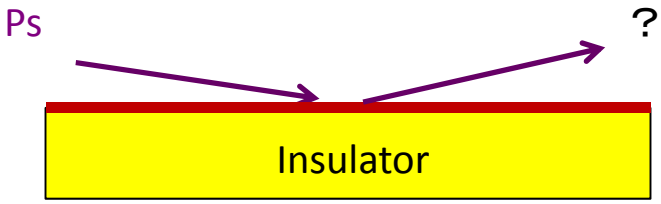
Accelate Ps^- ions and the photodetach them to produce Energy-tunable Ps Beam

- **Higher intensity available**
- **Compatible with ultra-high vacuum**
- **Beam with energy higher than 1 keV available**

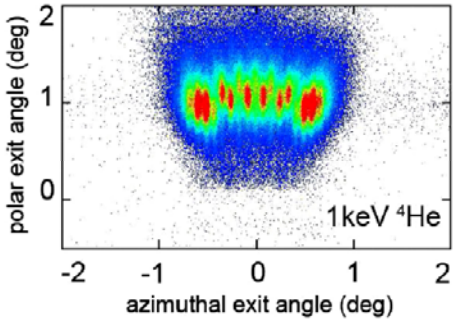


Applications of Energy-tunable Ps Beam

1. Ps reflection from insulator surfaces



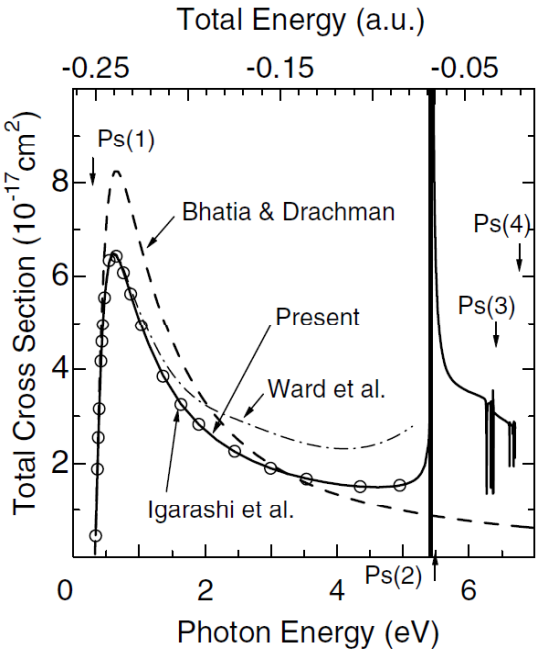
2. Reflected High Energy Ps Diffraction (RHEPsD)



Fast atomic beam diffraction from solid surface

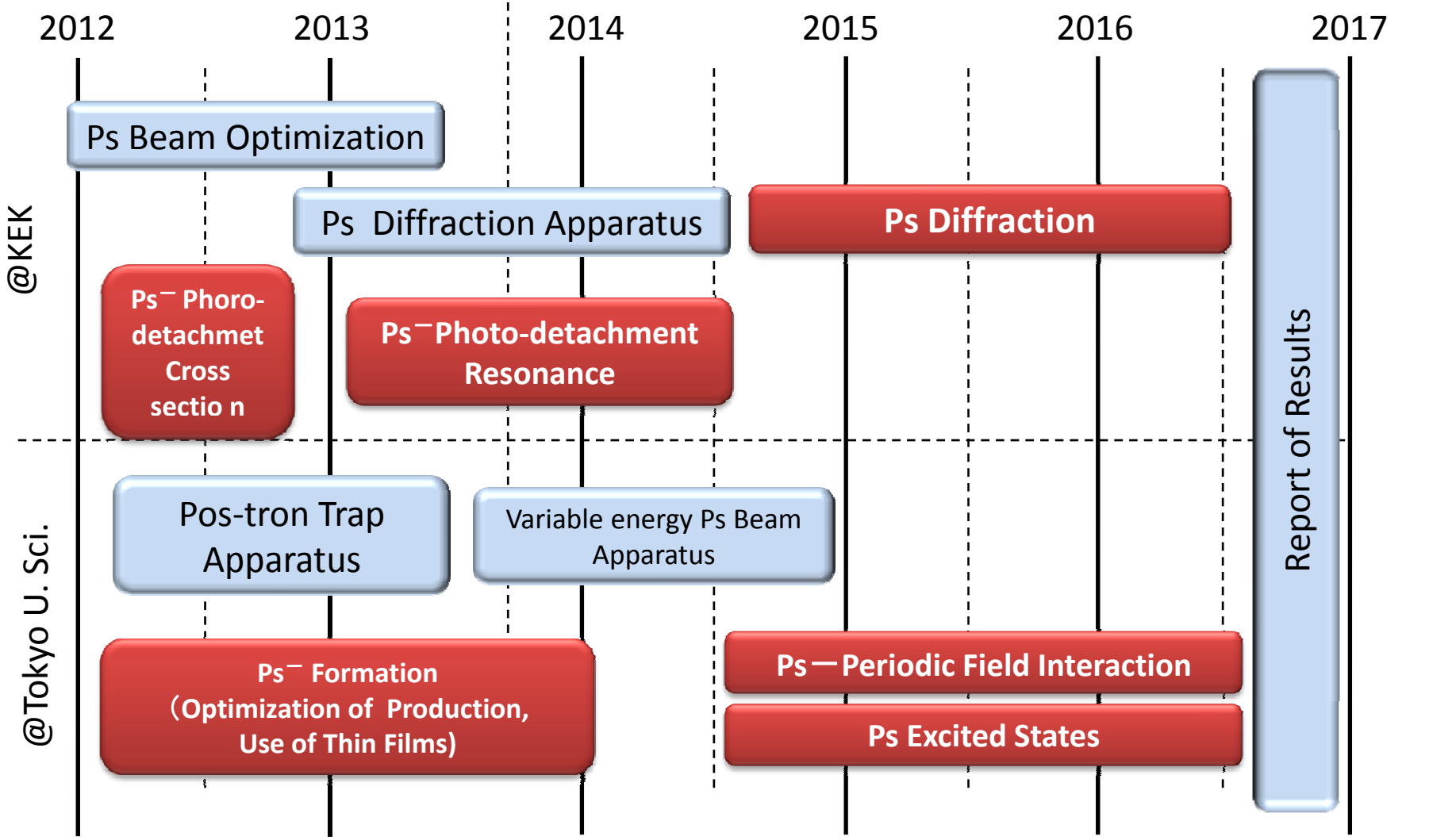
Attempts to get Ps diffraction image

3. Fundamental researchs on Ps and Ps^-



- **Ps^- photodetachment**
- **Ps^--periodic feld interactions**
- **Ps excited states**

Ps Negative Ion Schedule



Energy Variable Ps Beam Production → **Ps Diffraction, Ps, Ps^- Basic processes**

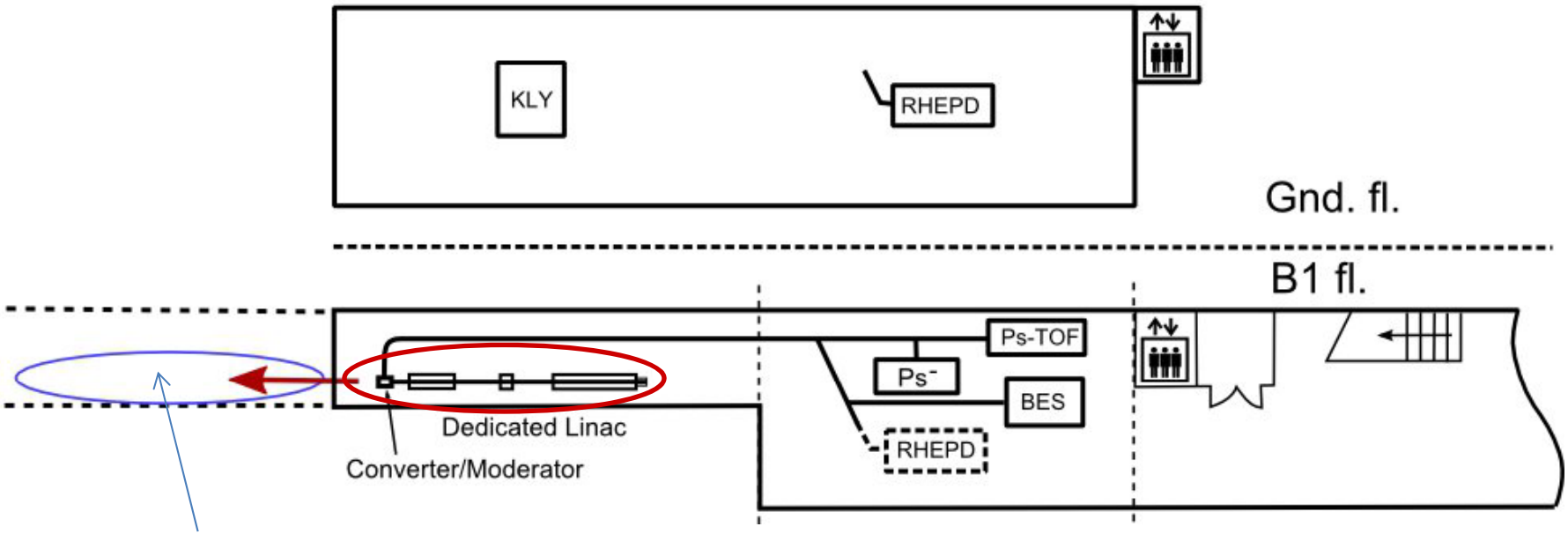
Plans for Other Beam Line Branches

- Construction of Linear Trap for DC Beam
  - Pulse / DC beam both available
  - Doppler Broadening Station
  - Coincidence Doppler Broadening Station
- Construction of short pulse Section
  - Positron Lifetime Station
  - Angular Correlation of Annihilation Radiation Station

10-fold Increase in Intensity

Even 10 more time increse posible → $5x10^8$ slow e+/s

Enhanced Linac Power and Sufficient Shield
→ Relocate the Dedicated Linac to Next Door Space



Possible Linac Relocation