LAMPS START COUNTER R&D STATUS

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1st RAON User Workshop
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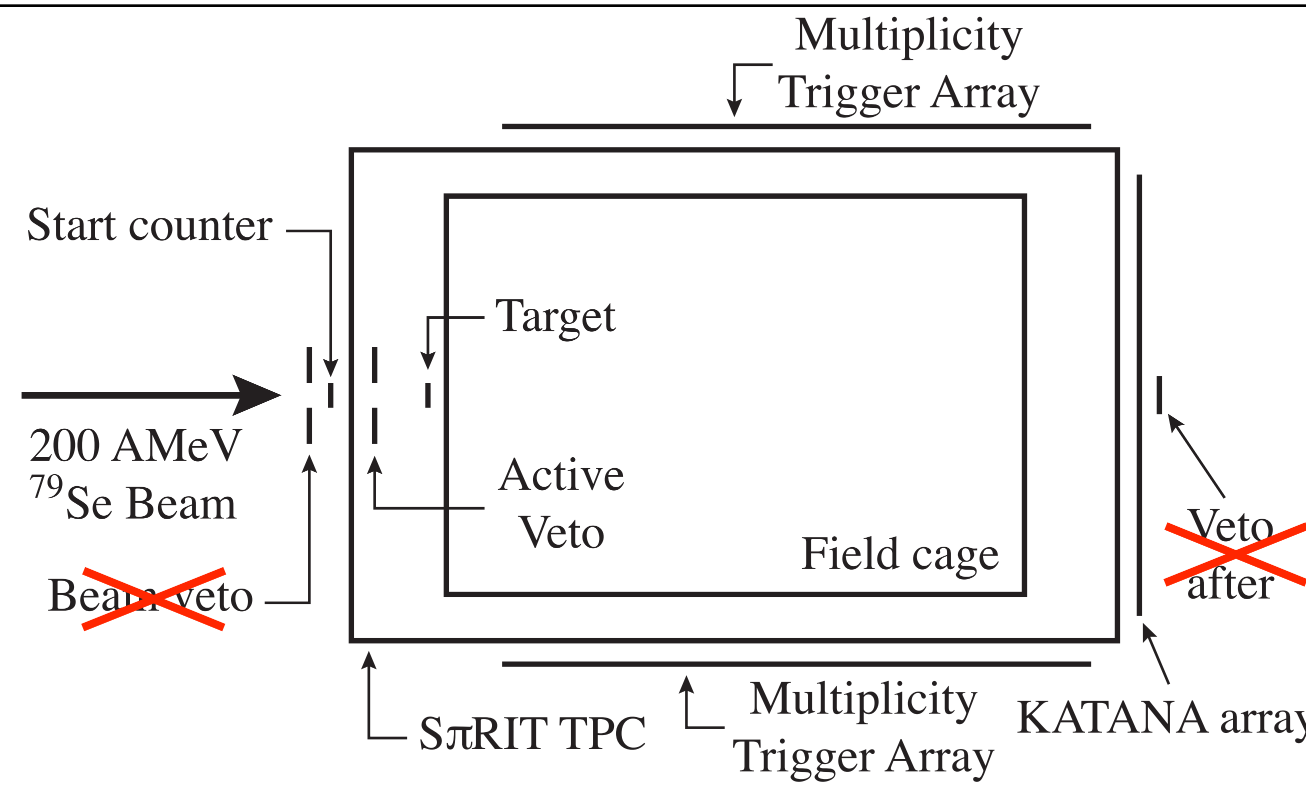
SπRIT Detectors

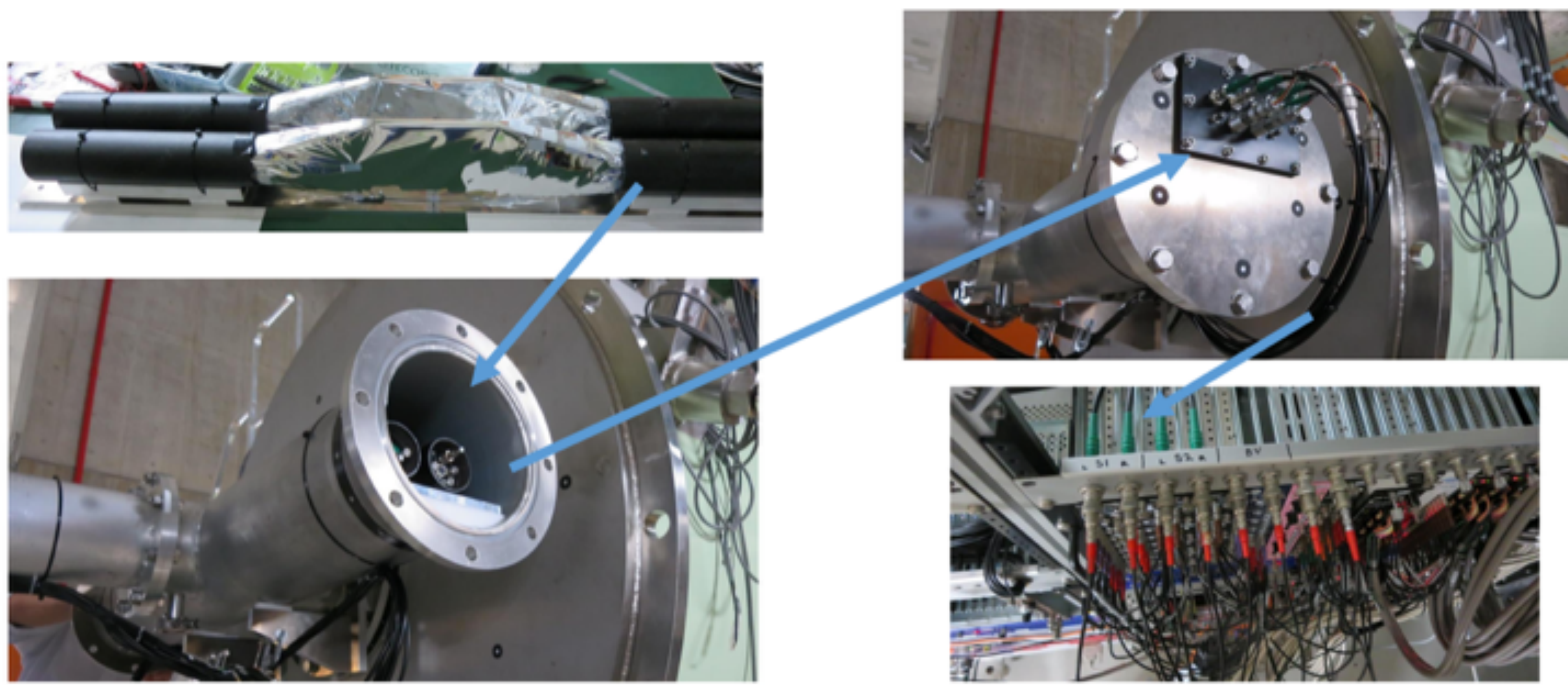


At the moment. A part of KATANA arrays play a role of beam veto

In the beam line, start counters added: two scintillators (200μm width), four photodetectors

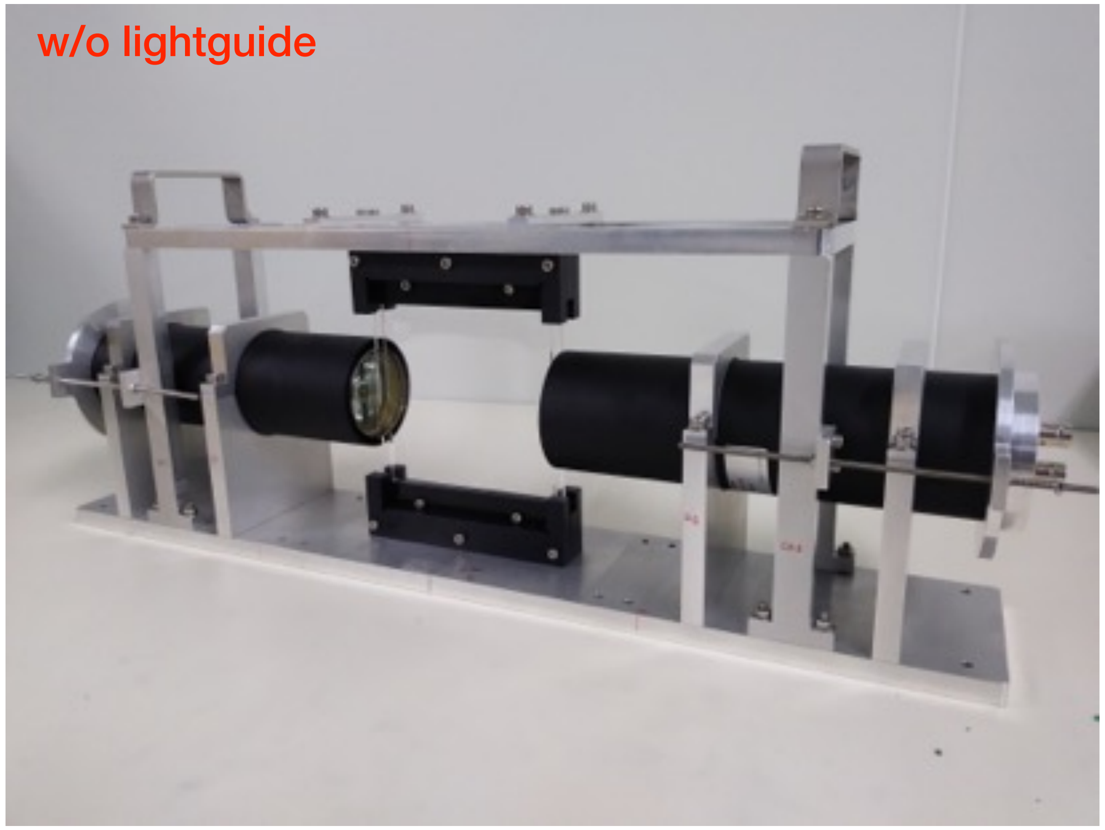
270 AMeV beams.
Ex. Sn-132 with 50% purity, the trigger rate at the final stage of beam line ~ 1k pps.

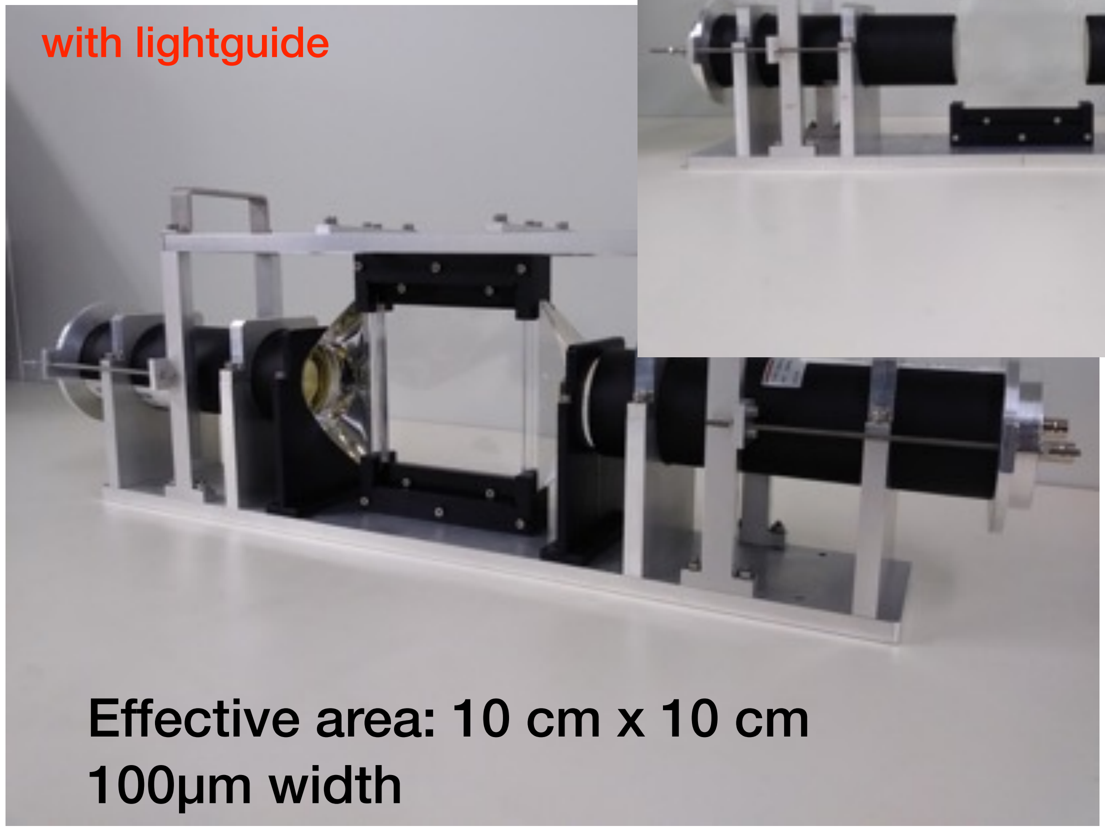
Beam profile at SBT: x~4.6 mm, y~4.4 mm gaussian

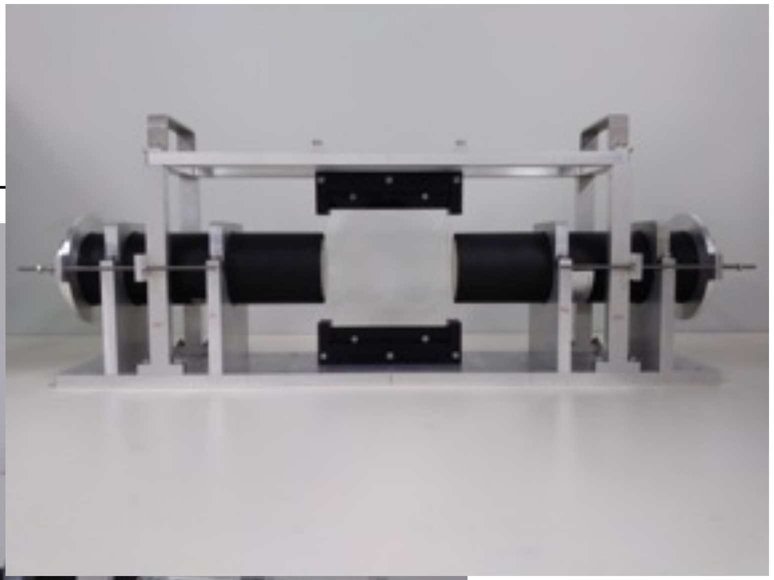


Example of some physics run trigger rates ~ 50 Hz

KOBRA Start Counter





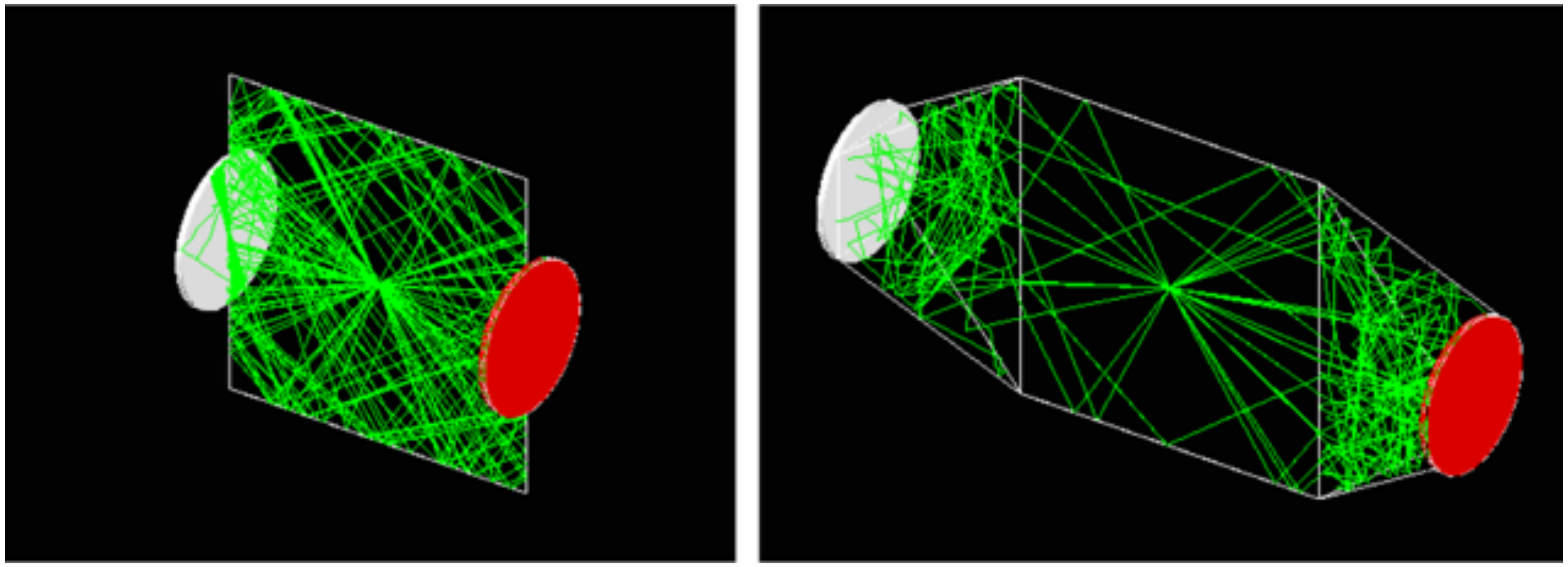


KOBRA Requirement for plastic detector
-Time resolution : ~ 50 ps (RMS) or ~100 ps (FWHM)
-Active area : 10 cm x 10 cm (required minimum area = 5 cm x 5 cm)

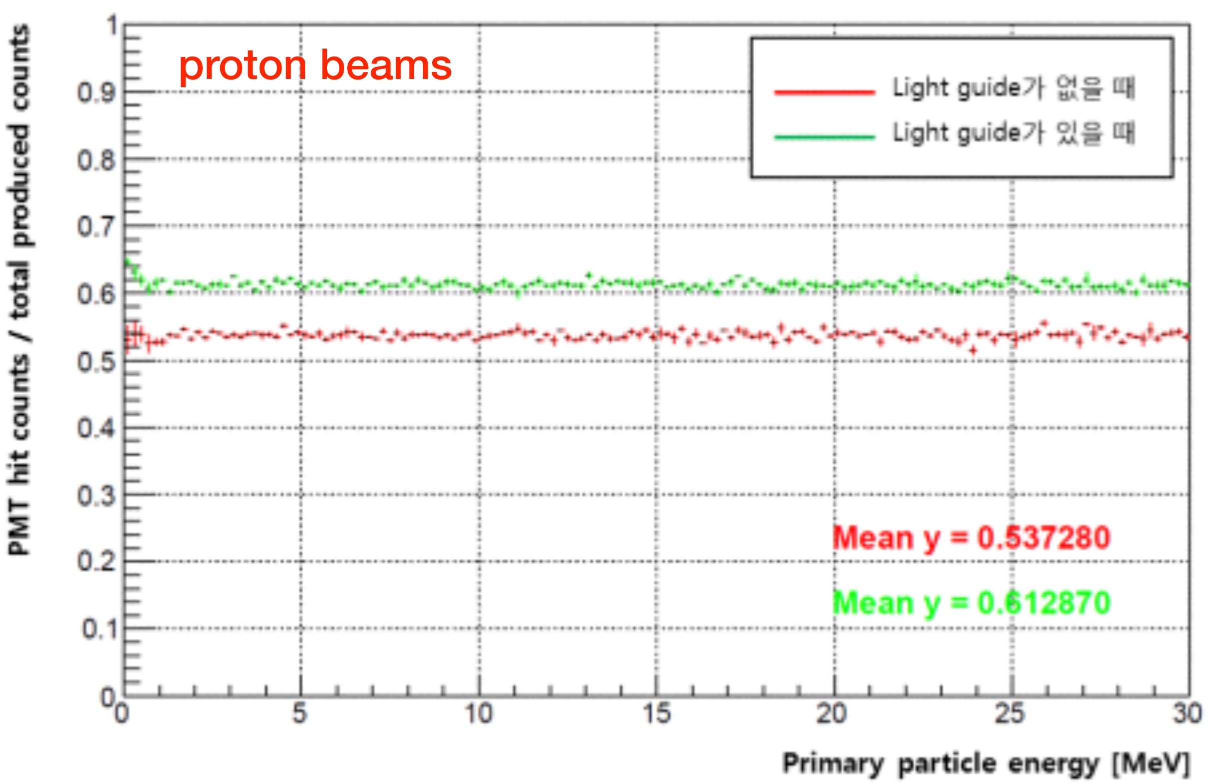
Performance test with Am-241
-Time resolution ~61ps with light guide, ~44 ps w/o light guide.

Plastic scintillator : EJ-230
PMT : H2431-50

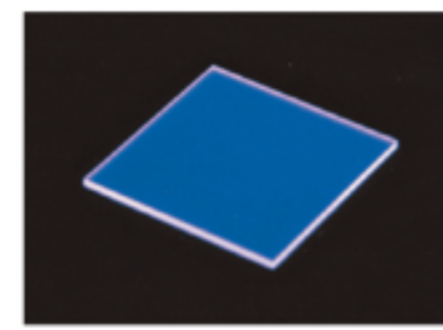
KOBRA Start Counter - GEANT4 Simulation



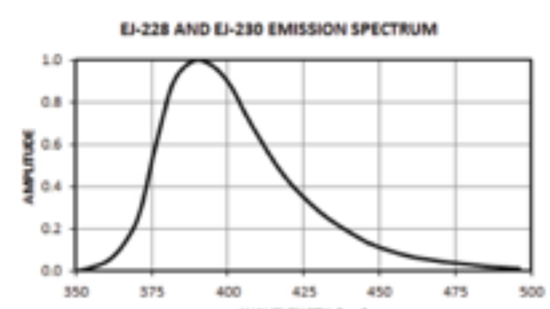
Mainly to understand the efficiency with light guide. The width was already defined via beam optics.



PROPERTIES	EJ-228	EJ-230
Light Output (% Anthracene)	67	64
Scintillation Efficiency (photons/1 MeV e⁻)	10,200	9,700
Wavelength of Maximum Emission (nm)	391	391
Light Attenuation Length (cm)	-	120
Rise Time (ns)	0.5	0.5
Decay Time (ns)	1.4	1.5
Pulse Width, FWHM (ns)	1.2	1.3
H Atoms per cm³ (×10²²)	5.15	5.15
C Atoms per cm³ (×10²²)	4.69	4.69
Electrons per cm³ (×10²³)	3.33	3.33
Density (g/cm³)	1.023	1.023



Polymer Base	Polyvinyltoluene
Refractive Index	1.58
Softening Point	75°C
Vapor Pressure	Vacuum-compatible
Coefficient of Linear Expansion	7.8×10^{-5} below 67°C
Temperature Range	-20°C to 60°C
Light Output (L.O.) vs. Temperature	At 60°C, L.O. = 95% of that at 20°C No change from -60°C to 20°C



<그림 2> Plastic scintillator EJ-228 및 EJ-230 특성 (Eljen Technology Data Sheet)

Beam energy loss estimation

- Consider a Sn-124 beam with kinetic energy 230 AMeV going through polyvinyltoluene (EJ230 ⇒ $1.023 g/cm^3$). Compute the beam energy loss for the given width.

➡ KE = E−M ⇒ 230AMeV = E−940 AMeV ⇒ E = 1170 AMeV

⇒ p = 697 AMeV/c ⇒ $\beta\gamma = p/M = 0.74$

$dE/dx(\beta\gamma = 0.74) \sim 6\ MeVcm^2/g$

$\Delta E/\Delta x = 1.023 g/cm^3 \times 6\ MeVcm^2/g$

$\sim 6 MeV/cm$

For 100 μm width, 0.06 MeV beam energy loss.

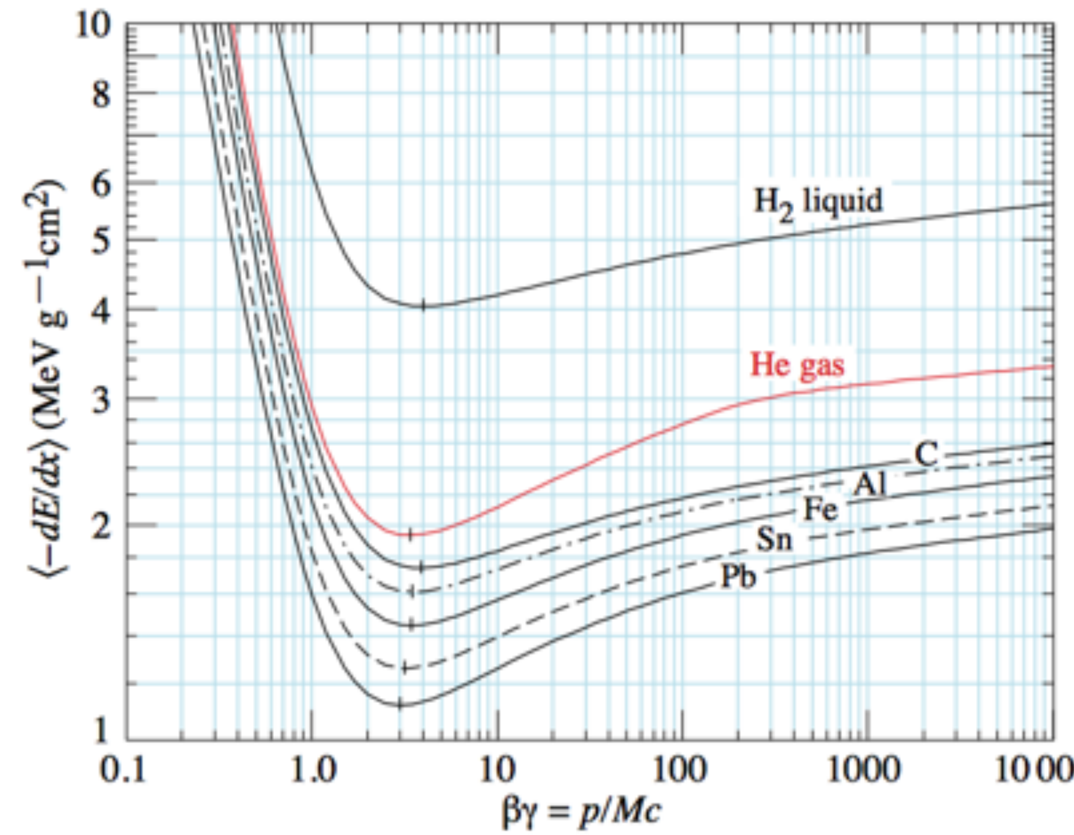


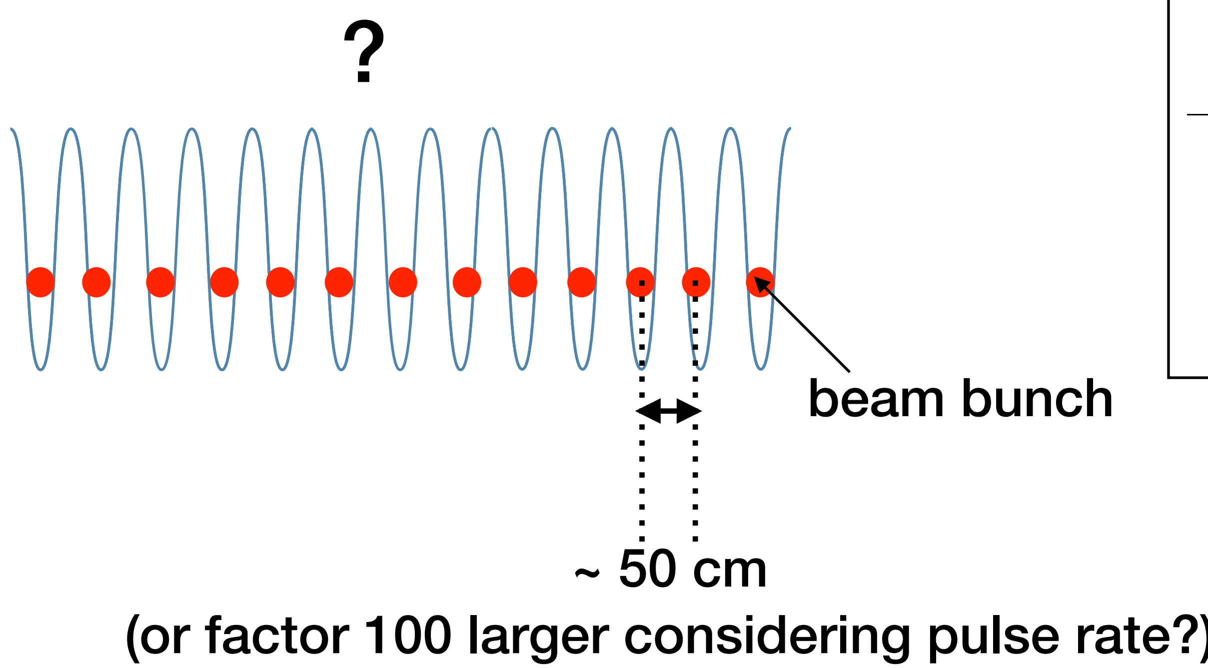
Table 24.2: Properties of several inorganic crystal scintillators.

	NaI(Tl)	BGO	BaF_2	CsI(Tl)	CsI(pure)	$PbWO_4$	CeF_3
Density ($g\ cm^{-3}$):	3.67	7.13	4.89	4.53	4.53	8.28	6.16
Radiation length (cm):	2.59	1.12	2.05	1.85	1.85	0.89	1.68
Molière radius (cm):	4.5	2.4	3.4	3.8	3.8	2.2	2.6
dE/dx (MeV/cm) (per mip):	4.8	9.2	6.6	5.6	5.6	13.0	7.9

For several hundred μm width design, the beam energy loss is negligible

Time resolution requirement estimation

- RF frequency ~ 325 MHz ~ 3 ns



Characteristics	Requests
Time Resolution	0.5 ns/bunch (FWHM) upper limit ~ 1 ns
Time Structure: pulse rate and chopping	- 100~200 ns (5~10 MHz) - chopping 12 ns ~ 1 ms

beam bunches are spread…
Let's assume continuous beam.

Time resolution requirement estimation

- Beam list

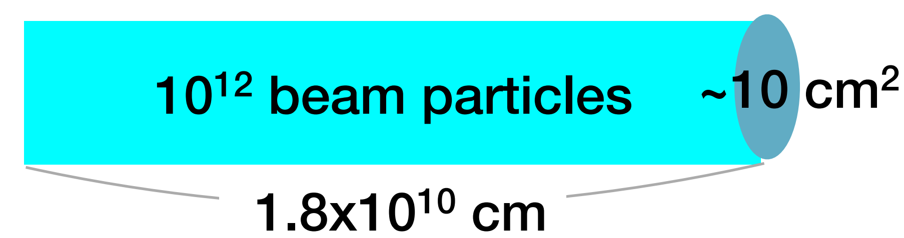
IF RI beam list

Fragment	Decay Type	Primary beam (400 kW)		Production Reaction	RI beam eneryg	RI beam Intensity	RI Beam purity
		Type	□□□(MeV/u)		(MeV/u)	(pps)	(%)
132Sn	Beta- decay	238U	200	in-flight fission	133.2	8.21E+06	1.4661
130Sn	Beta- decay	238U	200	in-flight fission	133.1	3.74E+08	13.6
124Sn	stable	124Sn	230	transmission	230	8.77E+13	100
112Sn	stable	112Sn	263	transmission	263	8.49E+13	100
106Sn	Beta+ decay	124Xe	252	fragmentation	155.9	5.31E+08	18.5
100Sn	Beta+ decay	112Sn	263	fragmentation	161.1	1.41E+01	0.0128
96Zr	stable	96Zr*	248	transmission	248	1.05E+14	100
82Cu	Beta- decay	96Zr	248	fragmentation	166.8	2.72E-03	1.2557
81Cu	Beta- decay	238U	200	in-flight fission	140	5.91E+00	0.000012
80Cu	Beta- decay	238U	200	in-flight fission	139.9	6.17E+01	0.0002
79Ni	Beta- decay	96Zr	248	fragmentation	167.1	2.64E-03	1.3223
78Ni	Beta- decay	238U	200	in-flight fission	140.3	8.99E+00	0.000045
72Ni	Beta- decay	82Se	256	fragmentation	167.5	5.63E+06	77.8
70Ni	Beta- decay	76Ge	260	fragmentation	169.4	2.57E+08	15.7
68Ni	Beta- decay	76Ge	260	fragmentation	168.4	2.65E+09	18.6
11C	Beta+ decay	16O	333	fragmentation	219.4	7.85E+11	100
10C	Beta+ decay	16O	333	fragmentation	215.8	7.75E+10	100
12B	Beta+ decay	18O	299	fragmentation	203	3.61E+11	100
12Be	Beta- decay	18O	299	fragmentation	208.3	3.63E+09	80.67
11Be	Beta- decay	18O	299	fragmentation	206.5	3.07E+10	100
10Be	Beta- decay	18O	299	fragmentation	205.7	1.35E+11	100
8He	Beta- decay	18O	299	fragmentation	212.3	7.29E+07	100
3H	Beta- decay	16O	333	fragmentation	235.8	8.74E+09	100

Neutron rich

Proton rich

Stable



$\rho = 10^{12}/1.8 \times 10^{11}\ cm^3 \sim 5/cm^3$

between beam particles of distance 0.5 cm

$\Rightarrow$ 0.5 cm/ (0.6 * 3*10^{10} cm/s)

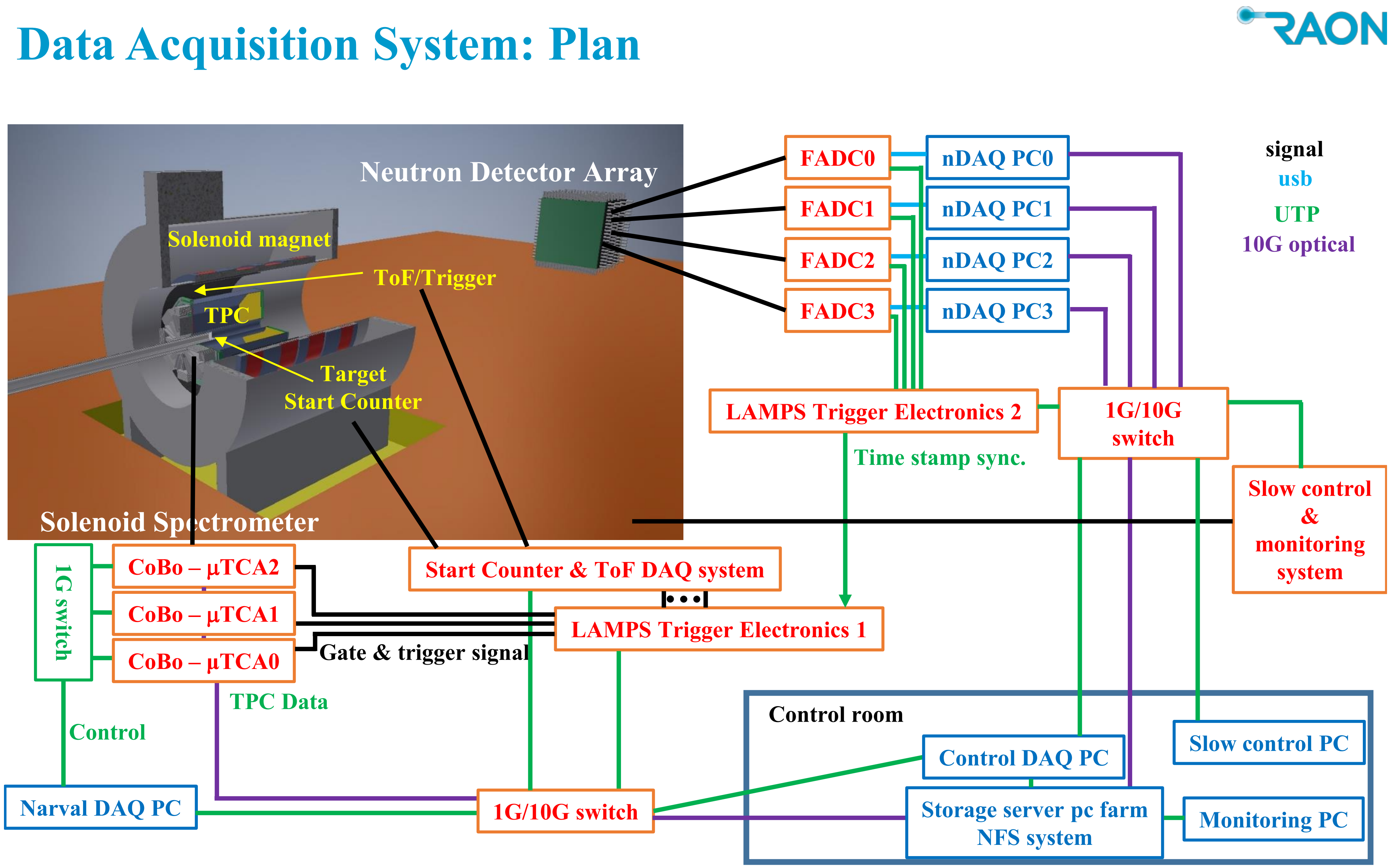
~ 30 ps

- Assume continuous Sn-124 beam of 230 AMeV with the intensity of 10^{12} pps.

  $\Rightarrow \beta \sim 0.6$

Outlook

- Other trigger detectors to generate trigger logic: TOF detector, and …



- Geant4 simulation is being prepared, however at the moment, not sure anymore if it is necessary to be done (if we take the KOBRA specification already studied).