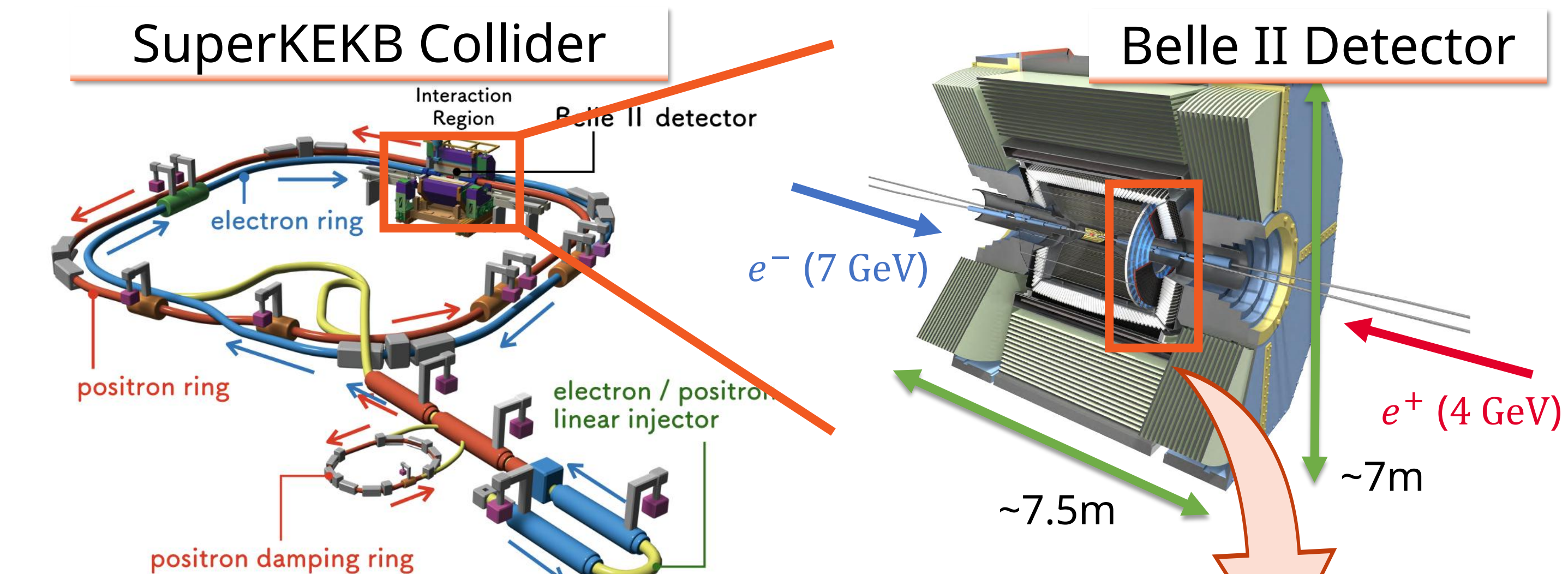


Development and Performance Evaluation of Readout Systems for Belle II ARICH Upgrade

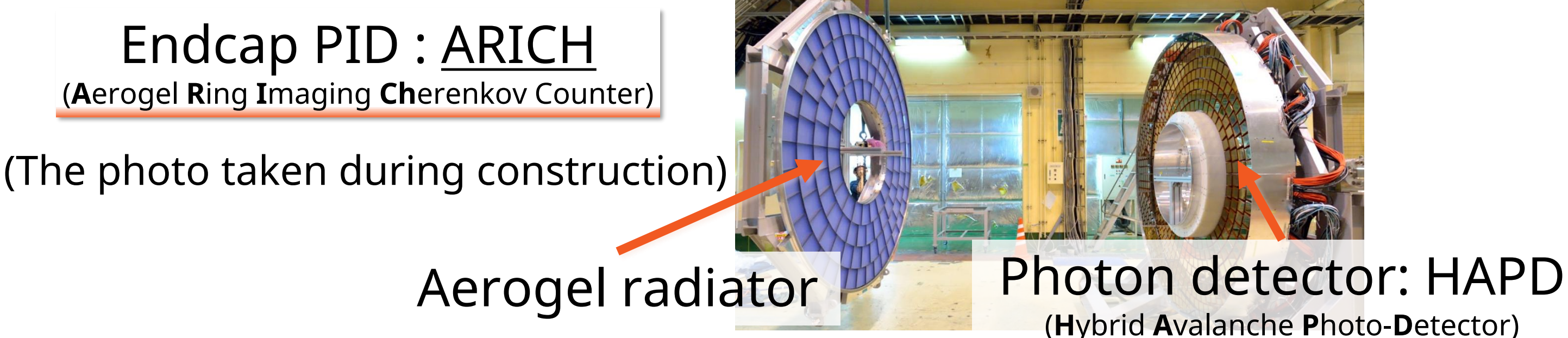
Shunsuke KUROKAWA for the Belle II ARICH Group, Tokyo Metropolitan University
Hidekazu KAKUNO (TMU), Shohei NISHIDA (KEK), Samo KORPAR (IJS)

1. The Belle II Experiment

- Flavor physics experiment for the BSM searches @KEK

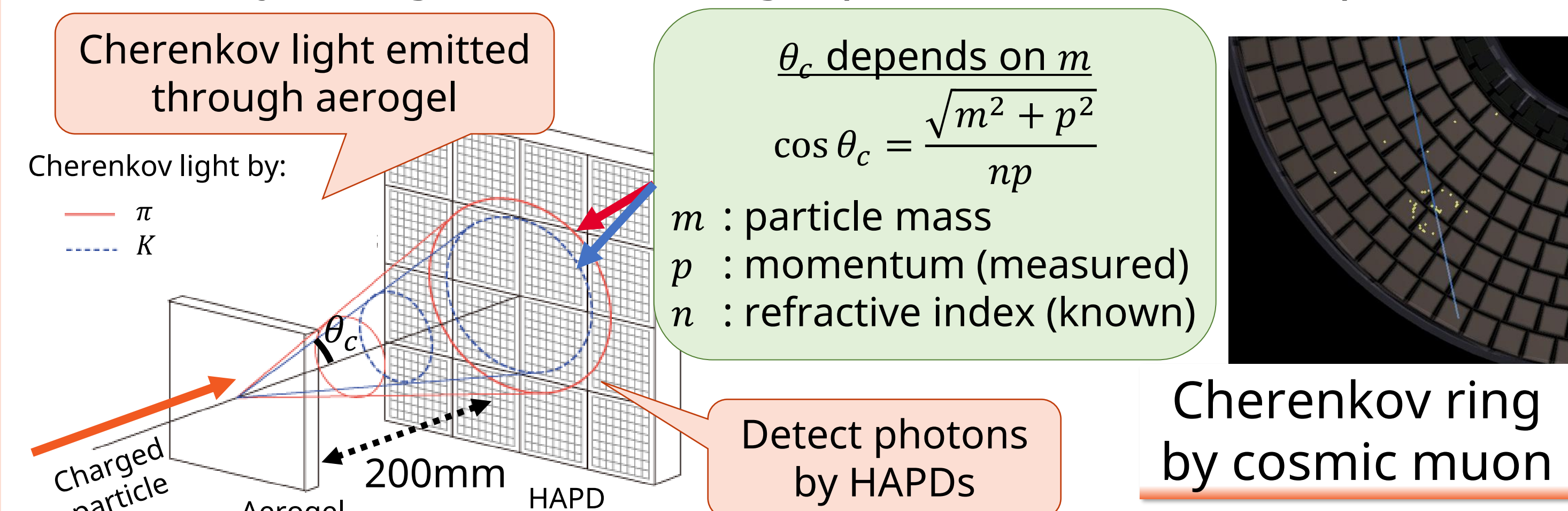


- Particle identification** takes an important role

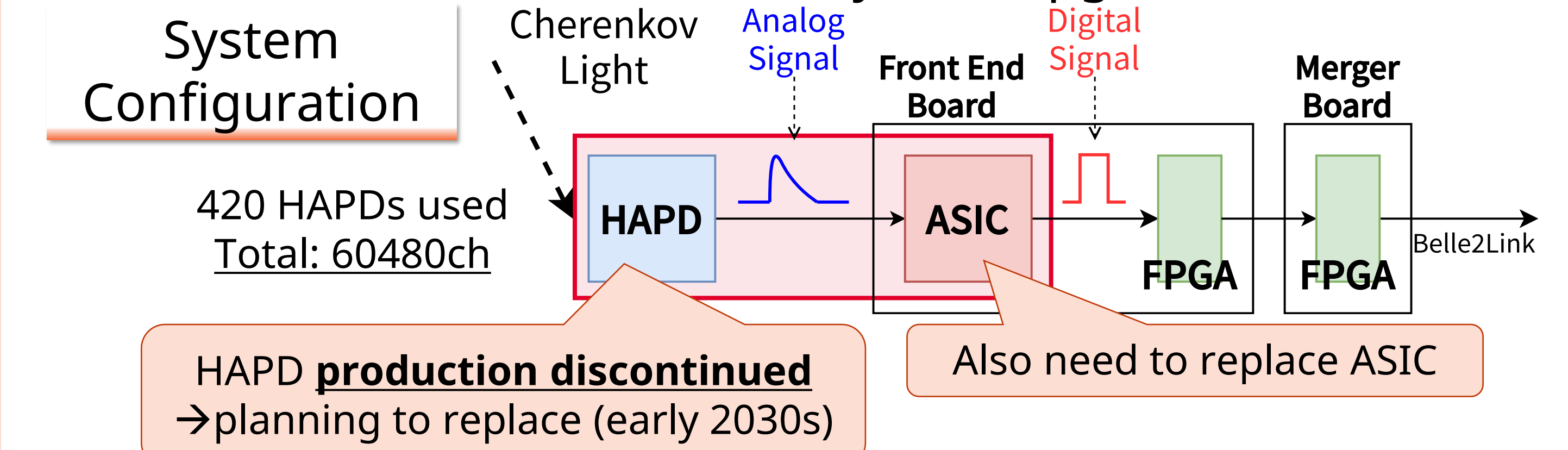


2. ARICH Counter and Its Upgrade Plan

- Identify charged $K, \pi \rightarrow$ Single photon detection required



- Photon detector and readout system upgrade

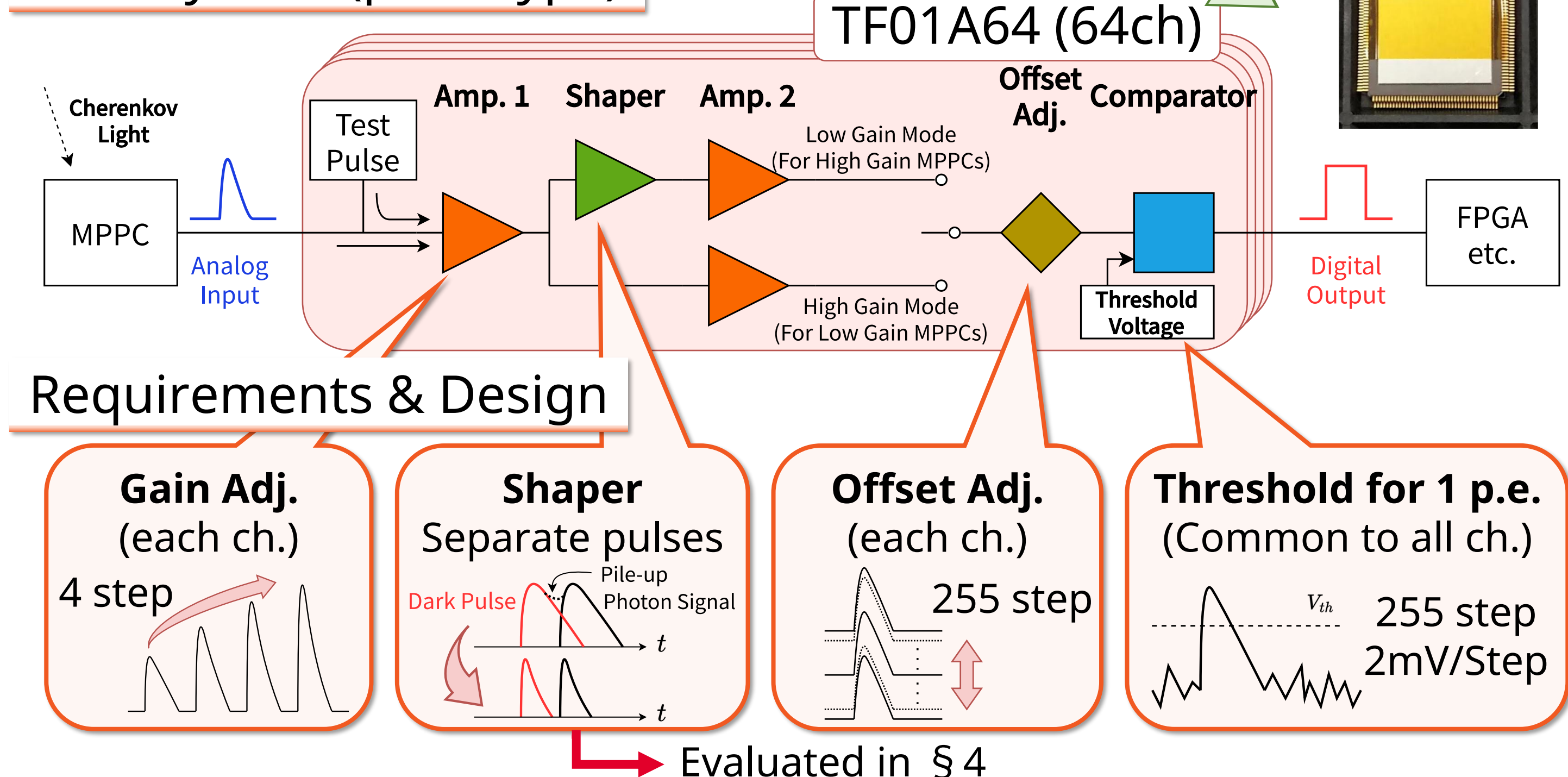


Photon Detector Candidates

HAPD	MPPC	LAPPD
~7cm	HAMAMATSU (S13361-3075AE) 3cm	INCOM ~20cm
144ch	<ul style="list-style-type: none"> Low operation voltage PDE improvement High dark count rate Requires countermeasure for neutron damage 	<ul style="list-style-type: none"> Low dark count rate Tolerant of neutron irradiation Hardly fit in a circular sector
Status	Readout development	Under performance evaluation

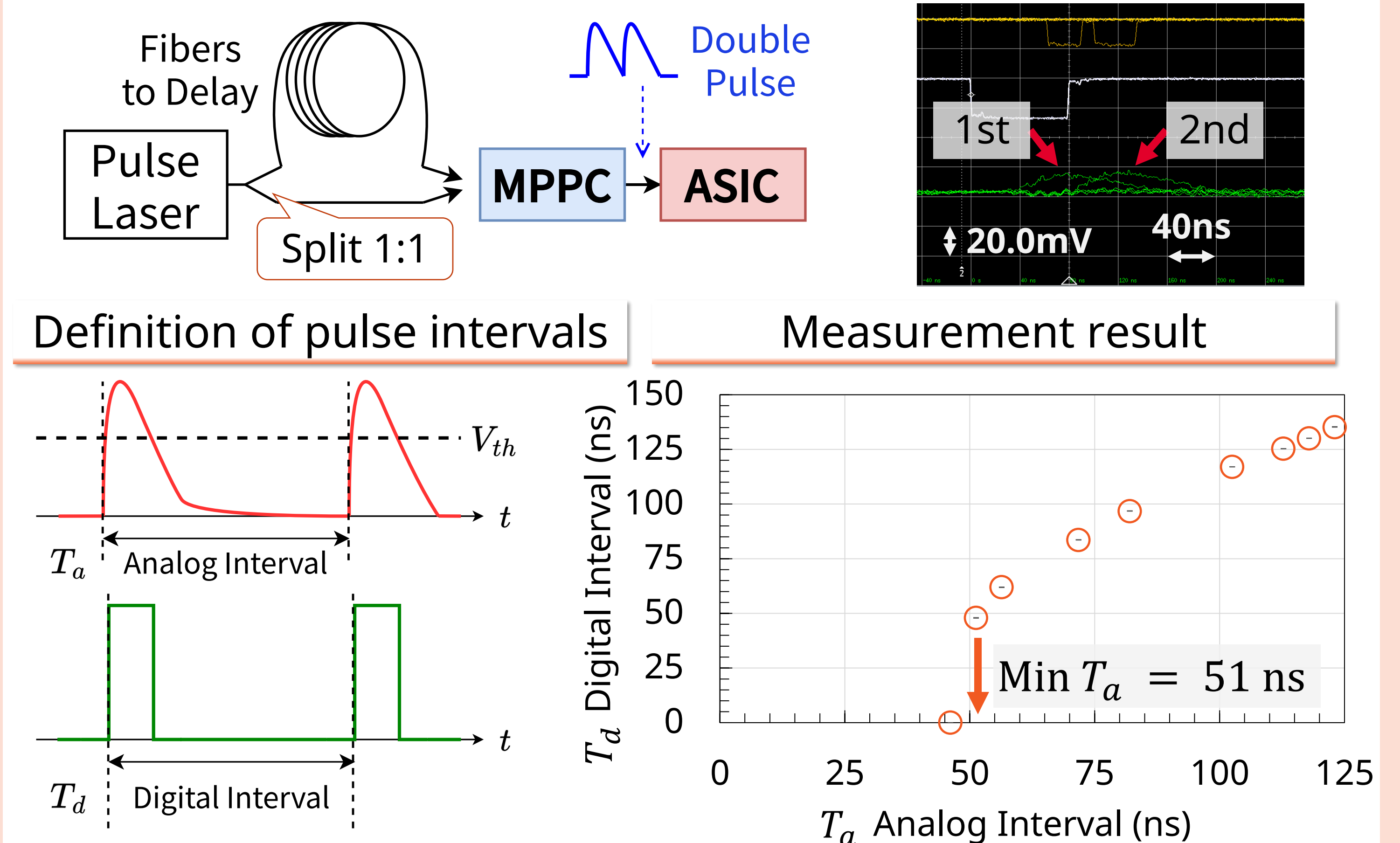
Planning **beam tests** using prototype ARICH systems to evaluate these candidates & readout electronics

3. Custom ASIC "TF01A64" for MPPC Readout ASIC system (prototype)



4. Pulse Separation Ability for MPPC Signals

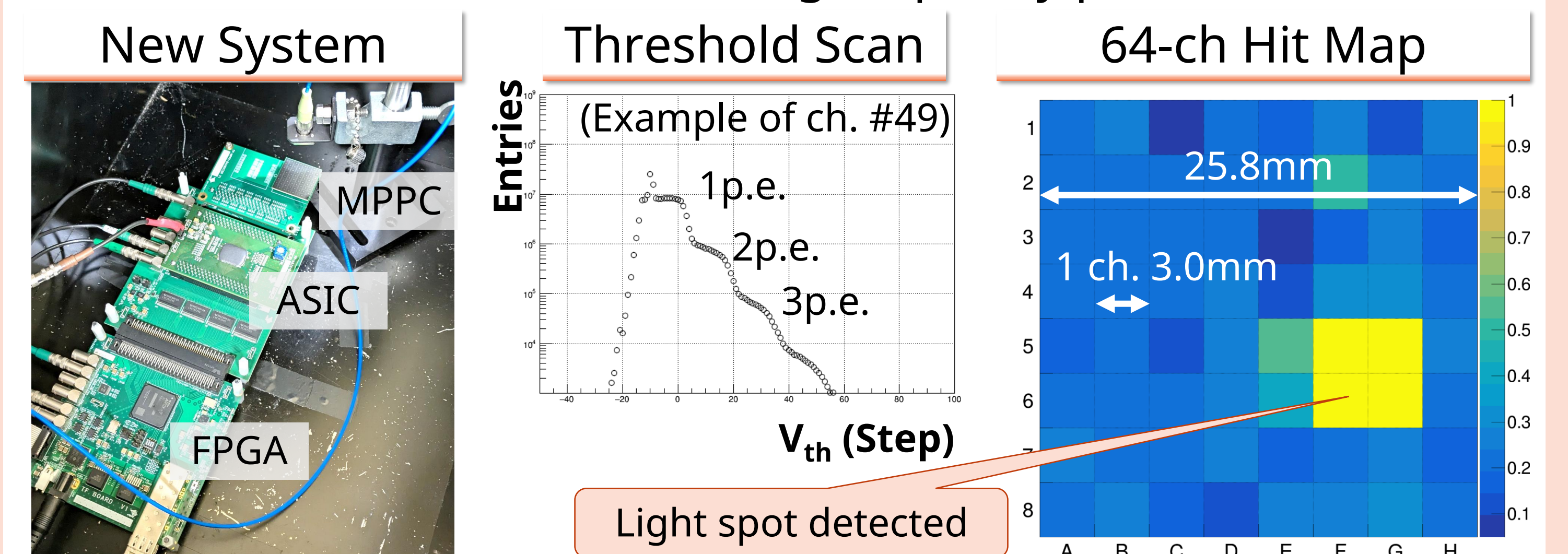
- Need to separate photon signals from dark pulses of an MPPC
- Evaluated by double pulses generated using optical fibers



- Dead time ratio D when dark count rate: $N = 1$ Mcps
(Measurement) $D \equiv N \times T_a = 1 \text{ Mcps} \times 51 \text{ ns} \sim 5\%$
(Simulation) $D \equiv N \times T_a = 1 \text{ Mcps} \times 39 \text{ ns} \sim 4\%$
- Sufficiently low

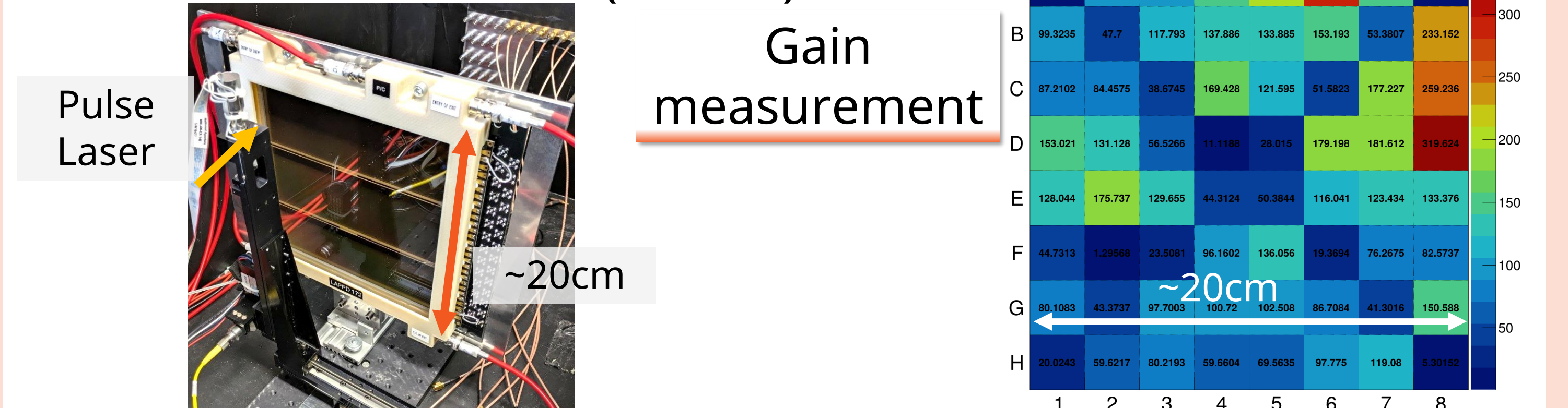
5. New MPPC Readout System Development

- Newly developed towards the beam test for "MPPC-ARICH"
- Working with TF01A64 & compatible with 64-ch array-MPPC
- Confirmed detection of the light spot by pulse laser

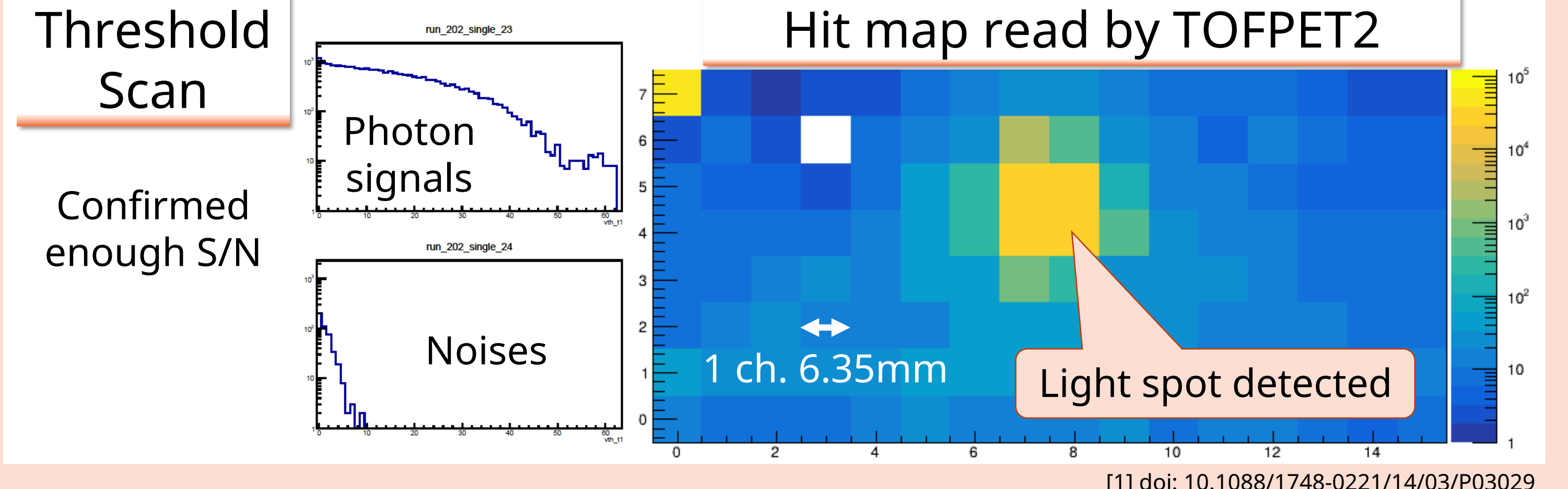


6. Evaluation of LAPPD & TOFPET2 ASIC

- Confirmed the uniformity of gain for whole sensitive area
- Enough pulse height for single photon detection
- Spacer structures inside LAPPD may affect the gain level
- Sensitive area $\sim 92\%$ ($>$ HAPD)



- Readout by frontend system using TOFPET2 ASIC^[1] by PETsys



7. Summary and Plan

- Confirmed that ASIC "TF01A64" has almost **enough performance** for MPPC readout considering ARICH system.
- Both readout systems for MPPC/LAPPD seem to be **suitable for beam tests**, being planned in 2025/2026.