LEPS I and II GeV photons for hadron physics

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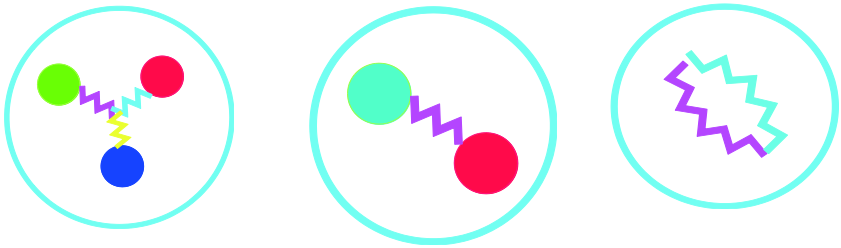
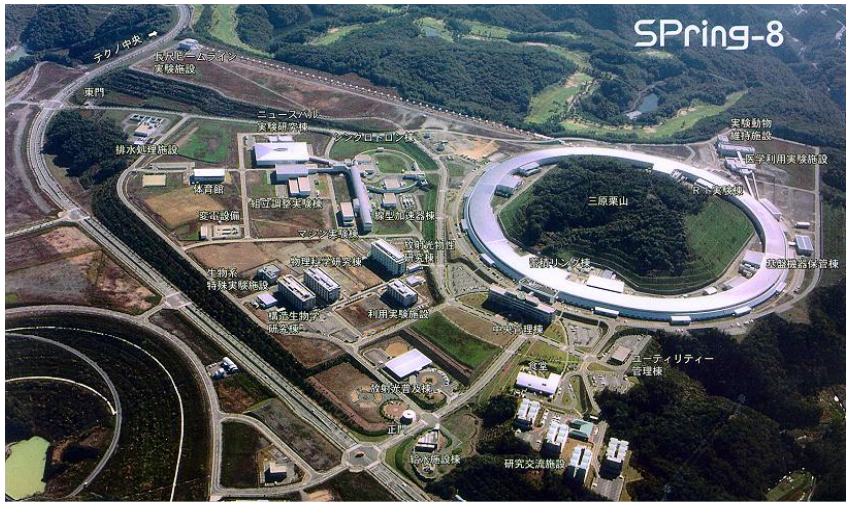
Photon beam for hadron physics

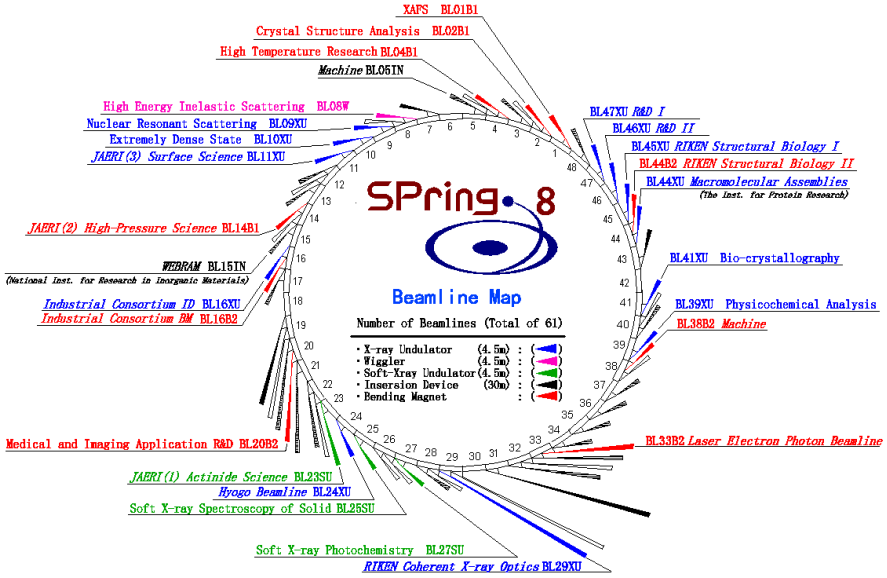
- **Hadron**
  - Quark model (QCD)
    - 3 quarks (baryon), quark-antiquark (meson)
    - Missing resonance
  - Exotic hadrons
    - glue ball, tetra-quark, penta-quark
  - **Study QCD beyond Quark model**



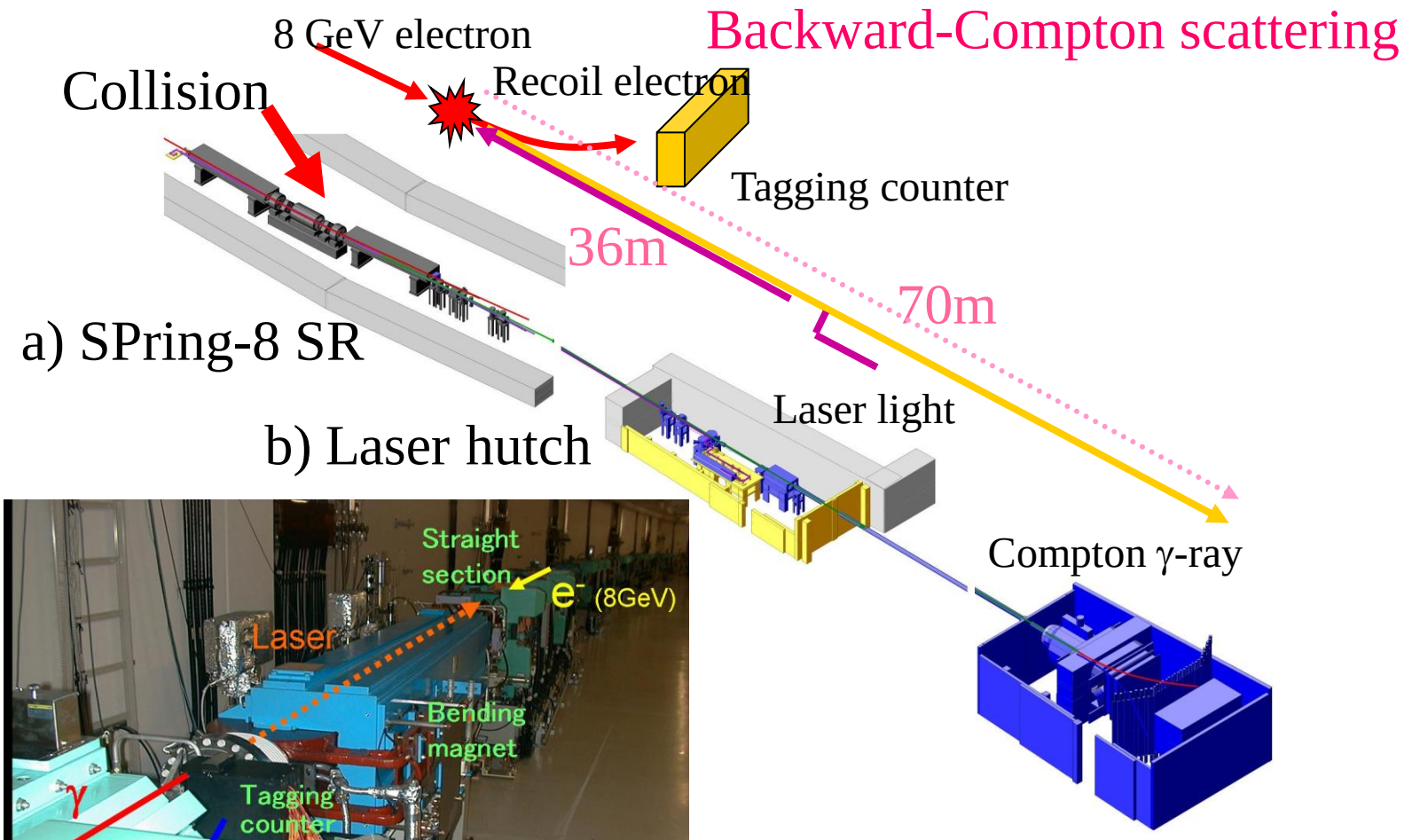
- **Photon beam**
  - Sensitive to the charge of hadrons or quarks
  - Polarization → Parity filter for exchanged particle
  - Backward Compton : narrow beam,
    good for forward angle measurement

Super Photon Ring 8 GeV (SPring-8)





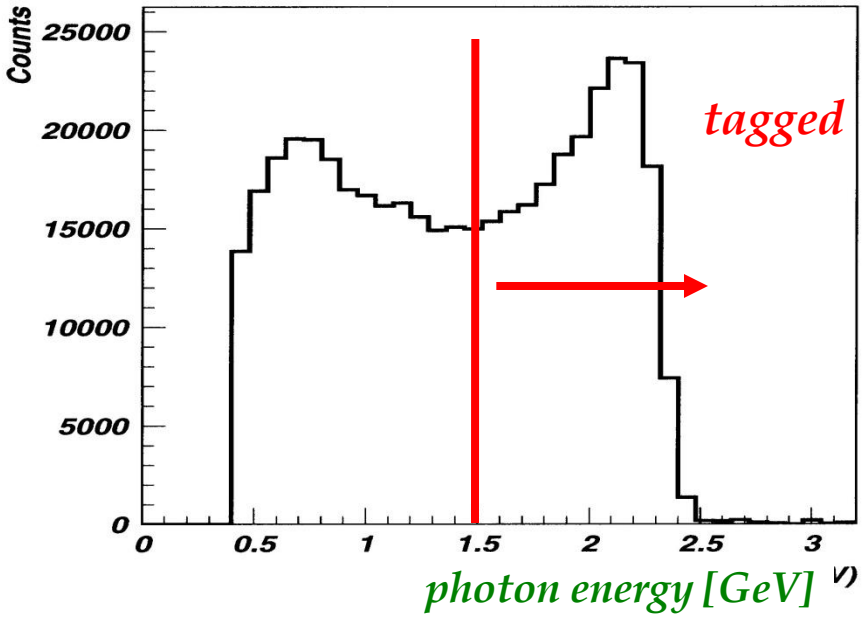
Schematic View of LEPS I Facility



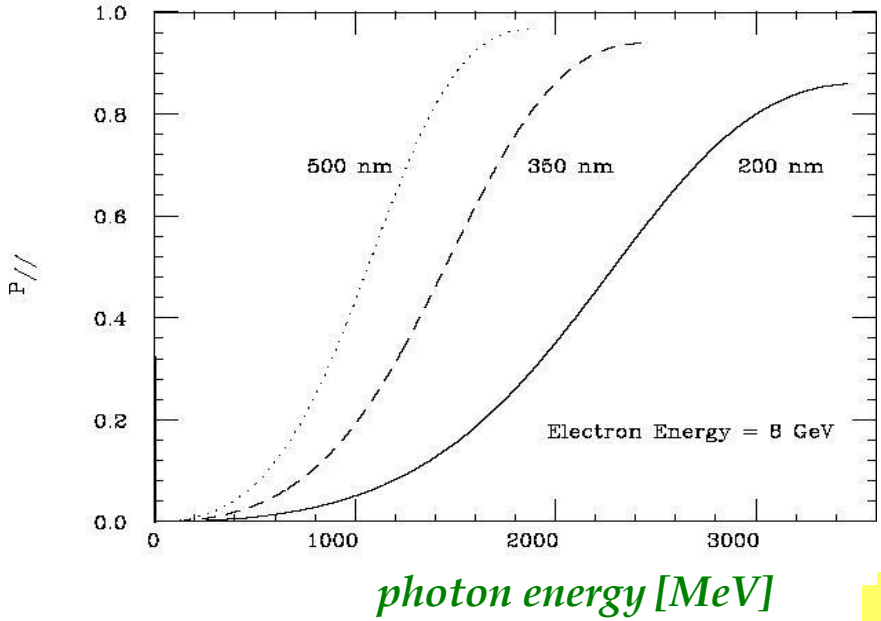
Backward-Compton Scattered Photon

- 8 GeV electrons in SPring-8
  - + 351nm Ar laser (3.5eV) ➔ maximum **2.4 GeV** photon
  - + 266nm Ar laser (4.6eV) 1W➔ maximum **3.0 GeV** photon
- Laser Power ~6 W (351nm) ➔ Photon Flux ~1 Mcps (2.4 GeV)
- Eγ measured by tagging a recoil electron ➔ Eγ>1.5 GeV, **ΔEγ ~10 MeV**
- Laser linear polarization 95-100% ⇒ **Highly polarized γ beam**

PWO measurement

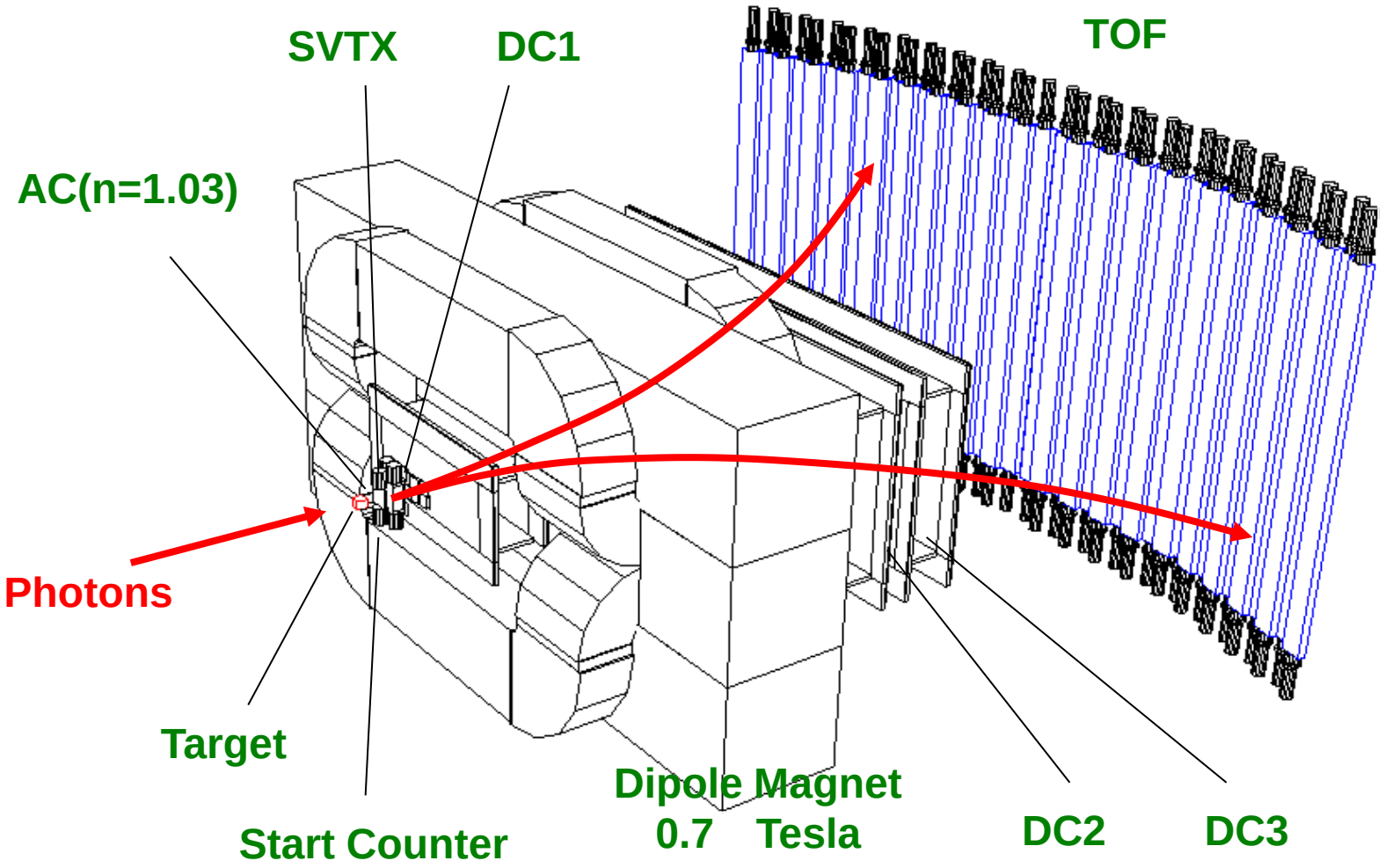


Linear Polarization of γ beam



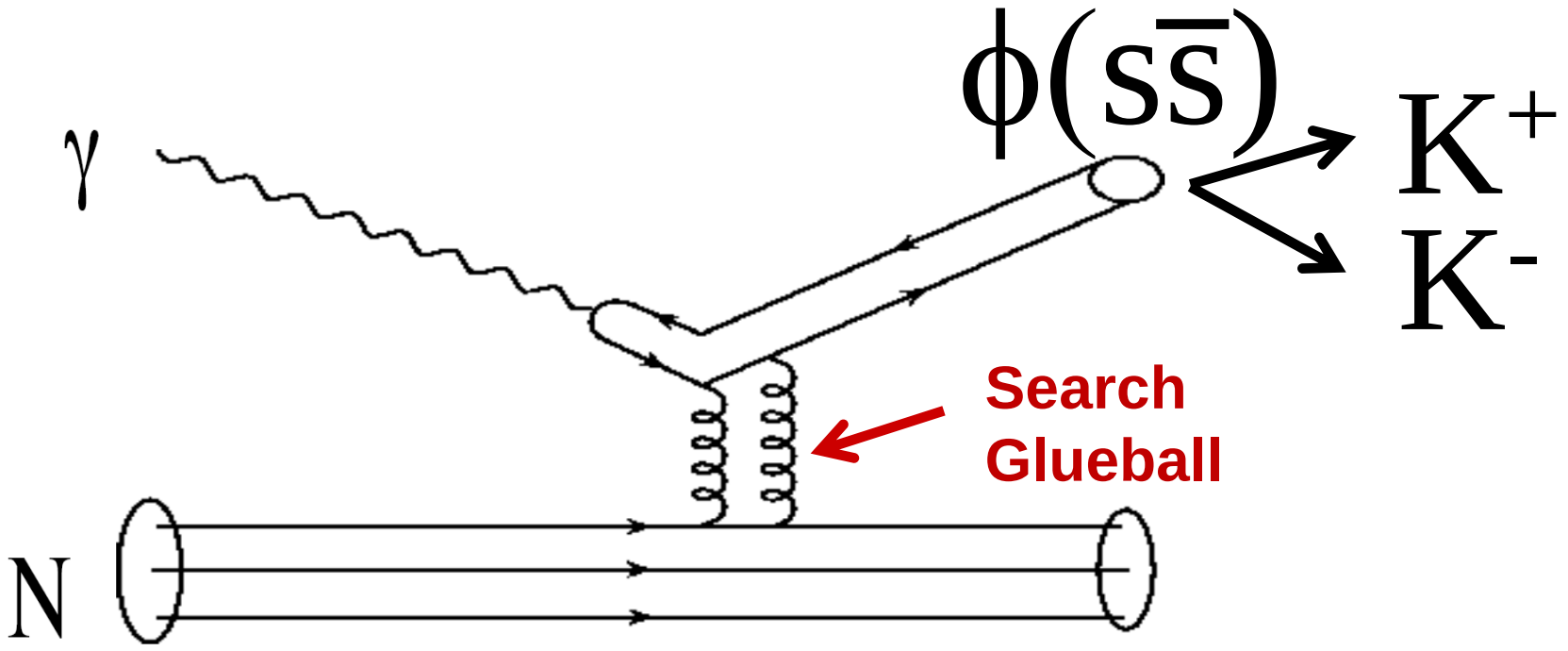
LEPS spectrometer

Charged particle spectrometer with forward acceptance
PID from momentum and time-of-flight measurements



Original motivation for LEPS I

- **Glueball hunt in diffractive ϕ photoproduction**
- **Detect ϕ meson at very forward**

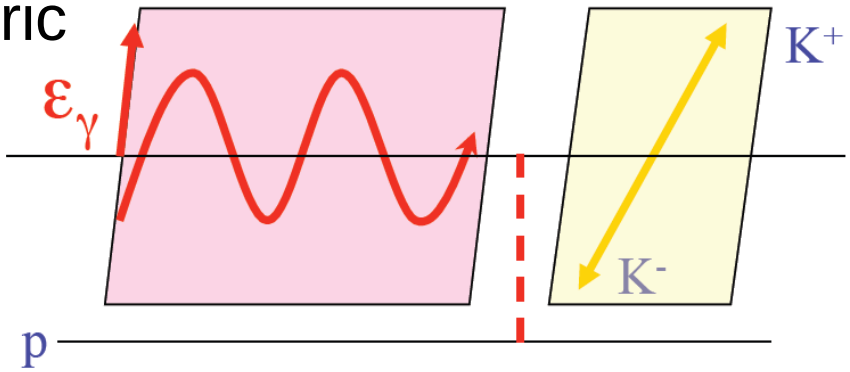


ϕ production @ LEPS I

- **Parity filter for exchanged particle in t-channel**

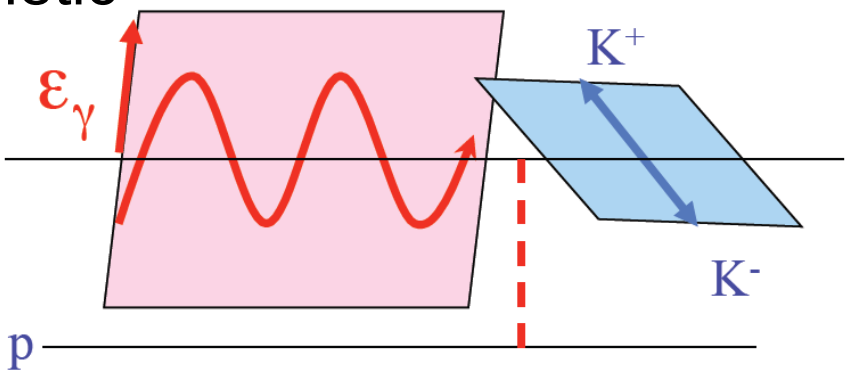
ϕ meson rest frame

Electric



Decay Plane // $\vec{\gamma}$
natural parity exchange $(-1)^J$
(Pomeron, Scalar Glueball,
Scalar mesons)

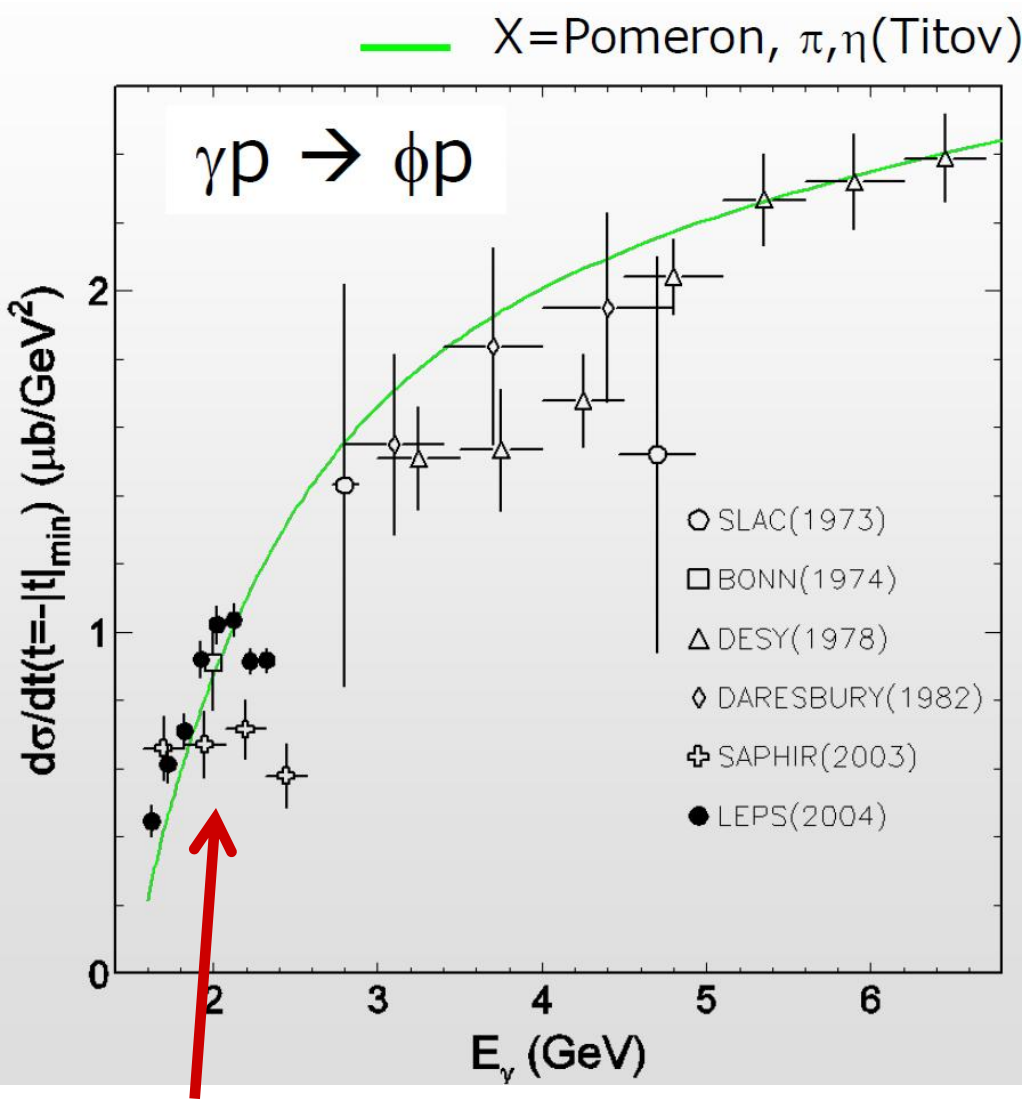
Magnetic



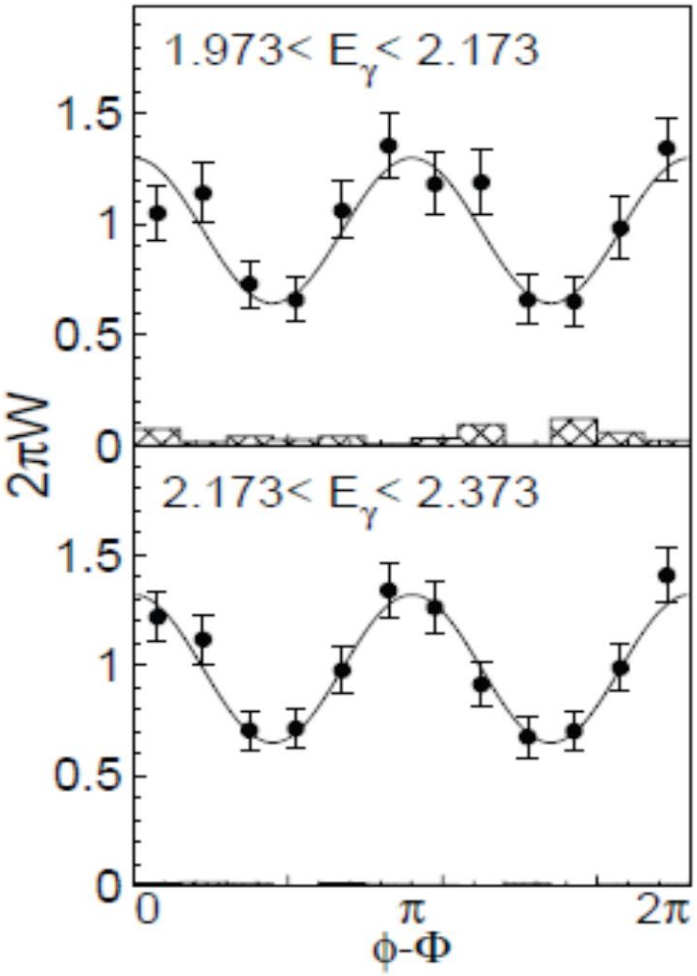
Decay Plane $\perp$ $\vec{\gamma}$
unnatural parity exchange $-(-1)^J$
(Pseudoscalar mesons π,η)

Decay angular distribution of ϕ → Relative contributions from natural, unnatural parity exchanges

LEPS I



netural parity (0+ glueball) dominant

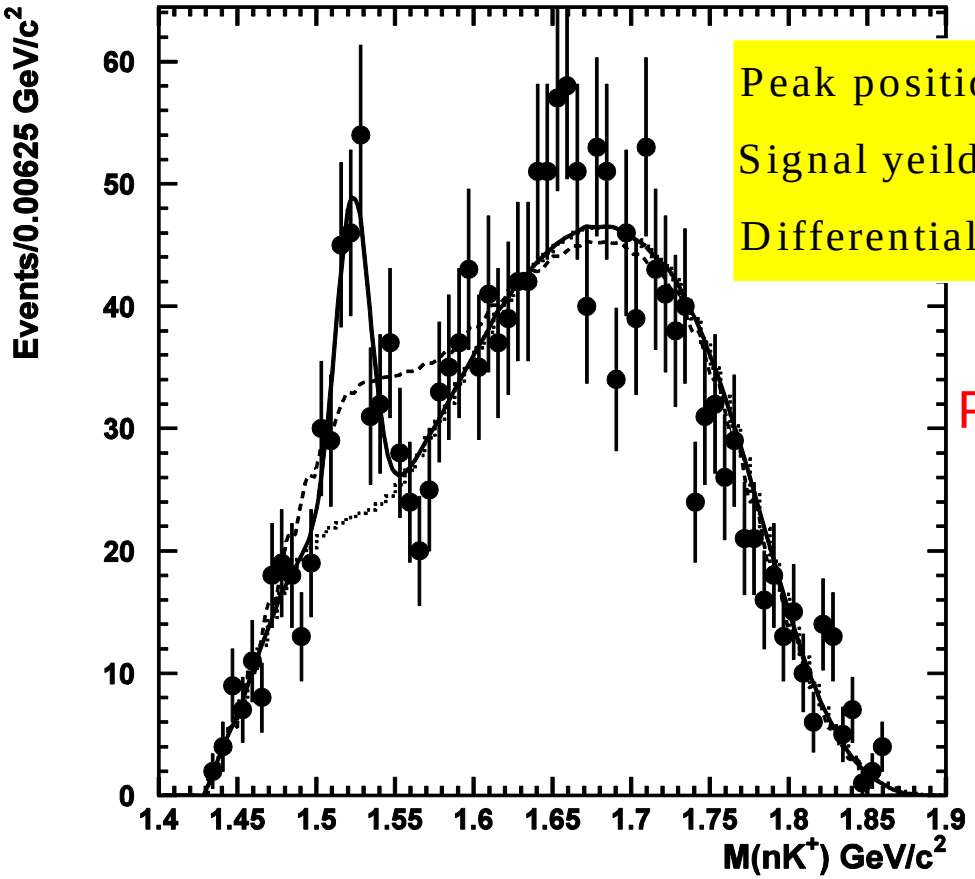


Unexpected bump → Spin decomposition with polarized target

LEPS I Results of Θ^+ analysis

(Details are in Prof.Nakano's talk on Friday)

nK^+ invariant mass with MMSA: Fermi motion effect corrected.



Peak position: 1.527 ± 0.002 GeV/c^2

Signal yeild: 116 ± 21 events

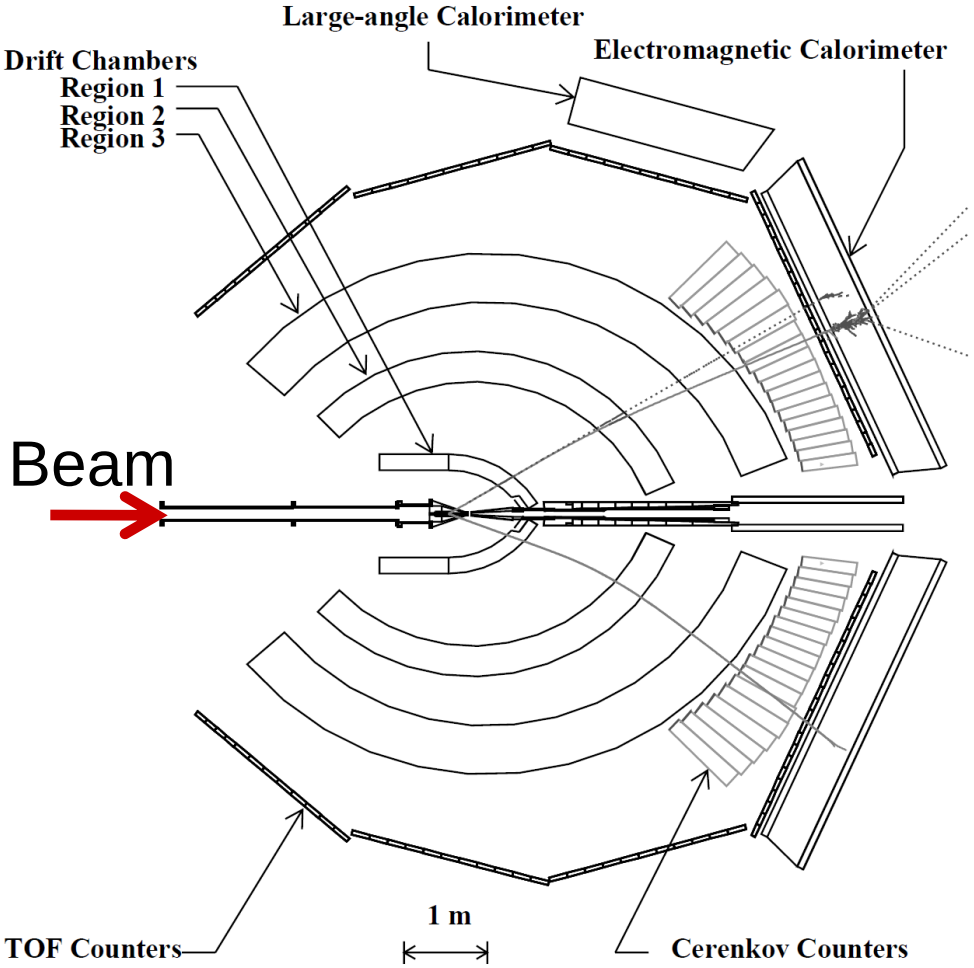
Differential cross-section: 12 ± 2 nb/sr

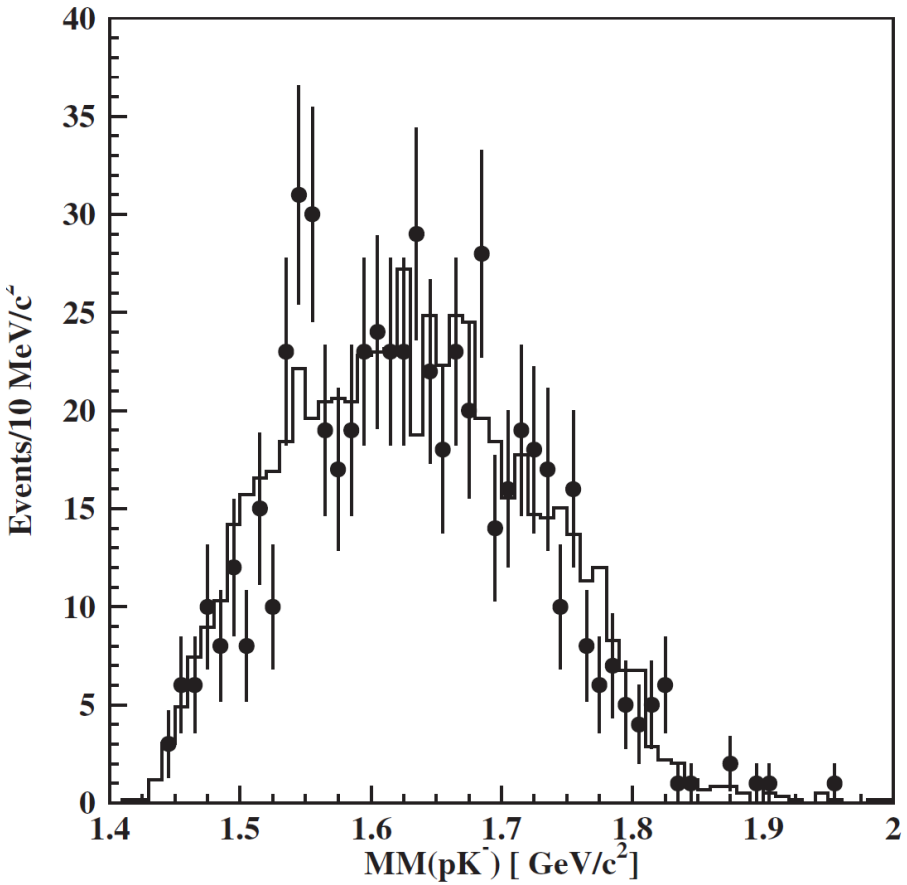
PRC **79,** 025210 (2009)

"The narrow peak appears only after Fermi motion correction."

$\Delta(-2\ln L) = 31.1$ for $\Delta ndf = 2 \longrightarrow 5.2\sigma$ $\quad \mathrm{Prob}(5.2\sigma) = 2 \times 10^{-7}$

Counter evidence of Θ^+ from CLAS J-Lab





Acceptance in large scattering angle region

Difference between LEPS and CLAS for $\gamma n \rightarrow K^- \Theta^+$ study

LEPS		CLAS
Good forward angle coverage	⟷	Poor forward angle coverage
Poor wide angle coverage	⟷	Good wide angle coverage
Low energy	⟷	Medium energy
Symmetric acceptance for K^+ and K^-	⟷	Asymmetric acceptance
$M_{KK} \gtrsim 1.04$ GeV/c^2	⟷	$M_{KK} > 1.07$ GeV/c^2
Select quasi-free process	⟷	Require re-scattering or large Fermi momentum of a spectator

K^- coverage:

LEPS: $\theta_{LAB} < 20$ degree

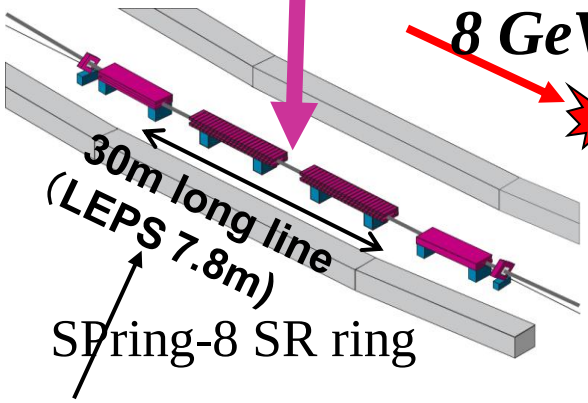
CLAS: $\theta_{LAB} > 20$ degree

Detector with wide angular coverage → LEPS2

LEPS2 @ SPring-8

High intensity:
~10 ^{7} photons/s
(LEPS ~10 ^{6})

Backward Compton Scattering

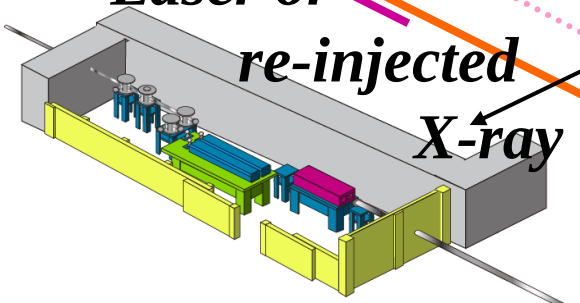


8 GeV electron

Recoil electron
(Tagging)

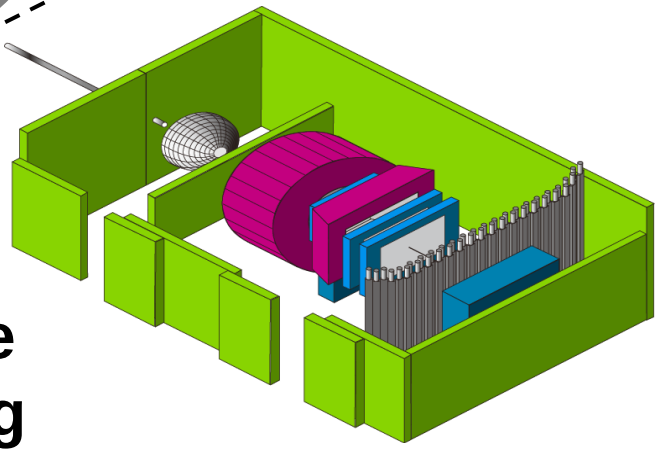
Laser or
re-injected
X-ray

BL31ID



150m

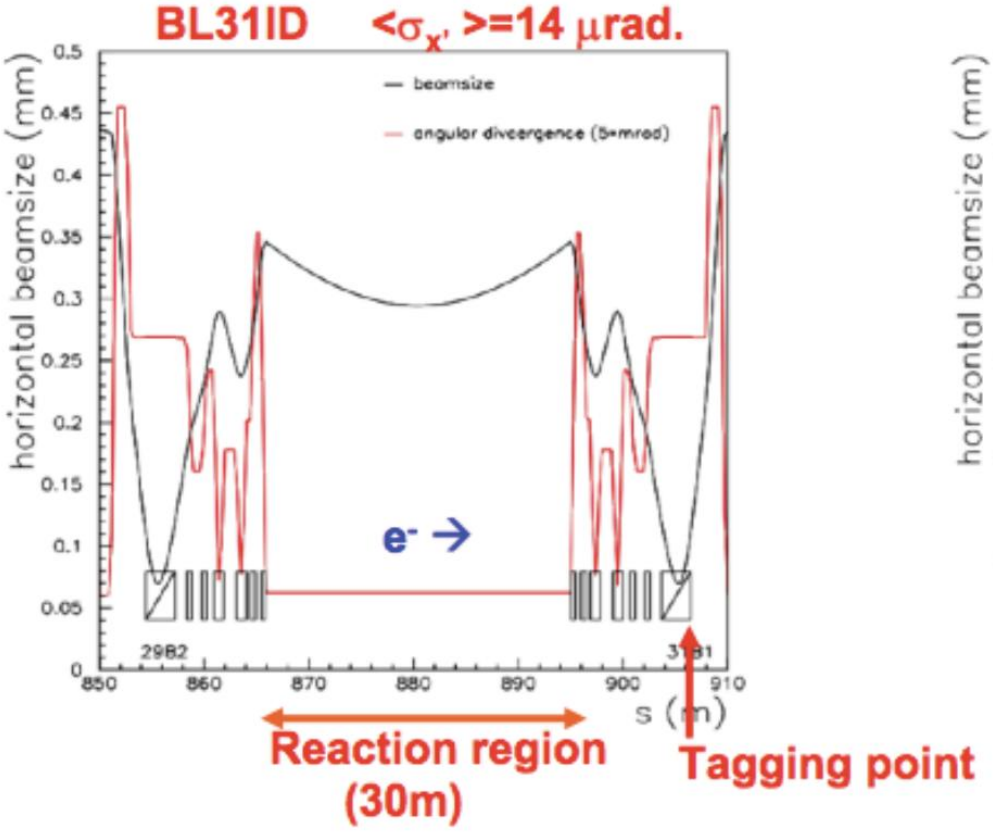
Inside building

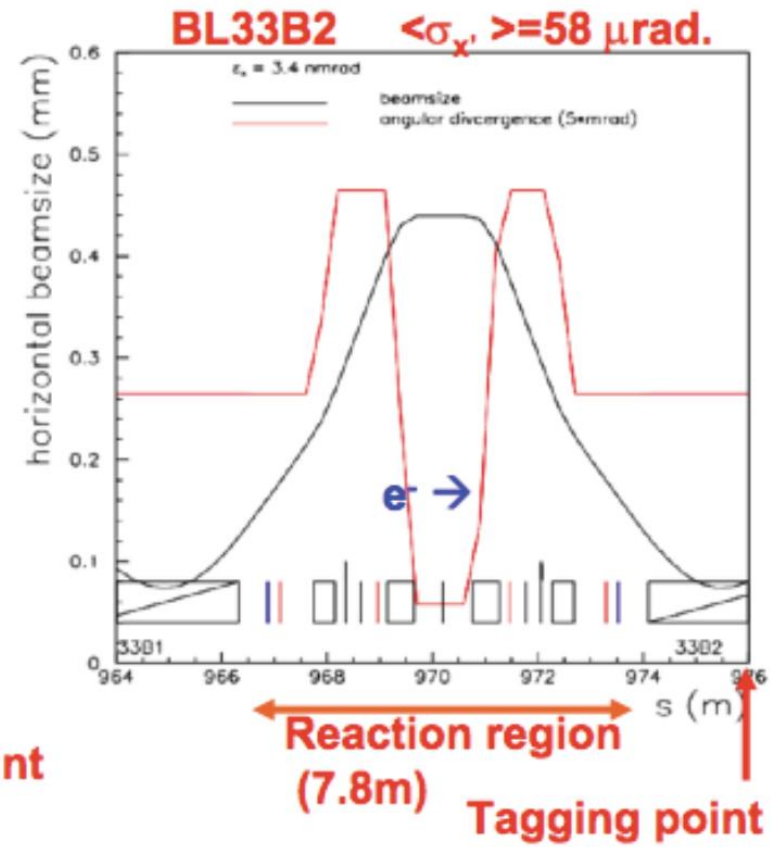


Outside building

Experimental hutch

Interaction region (BL31ID)



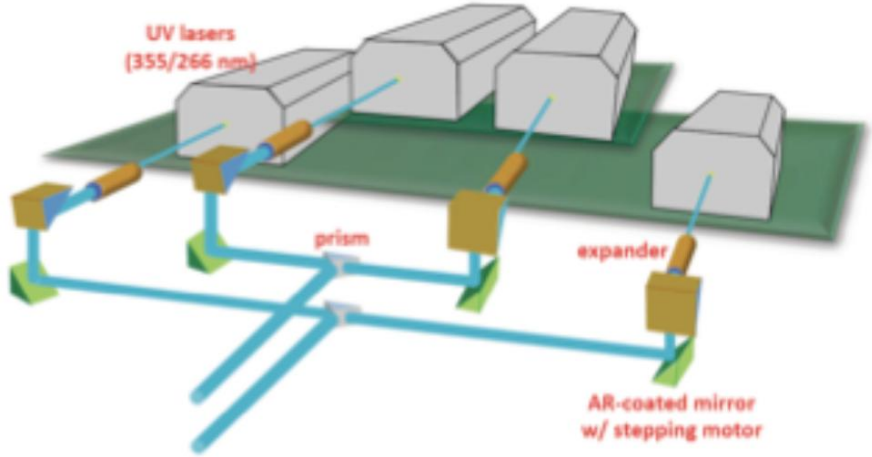


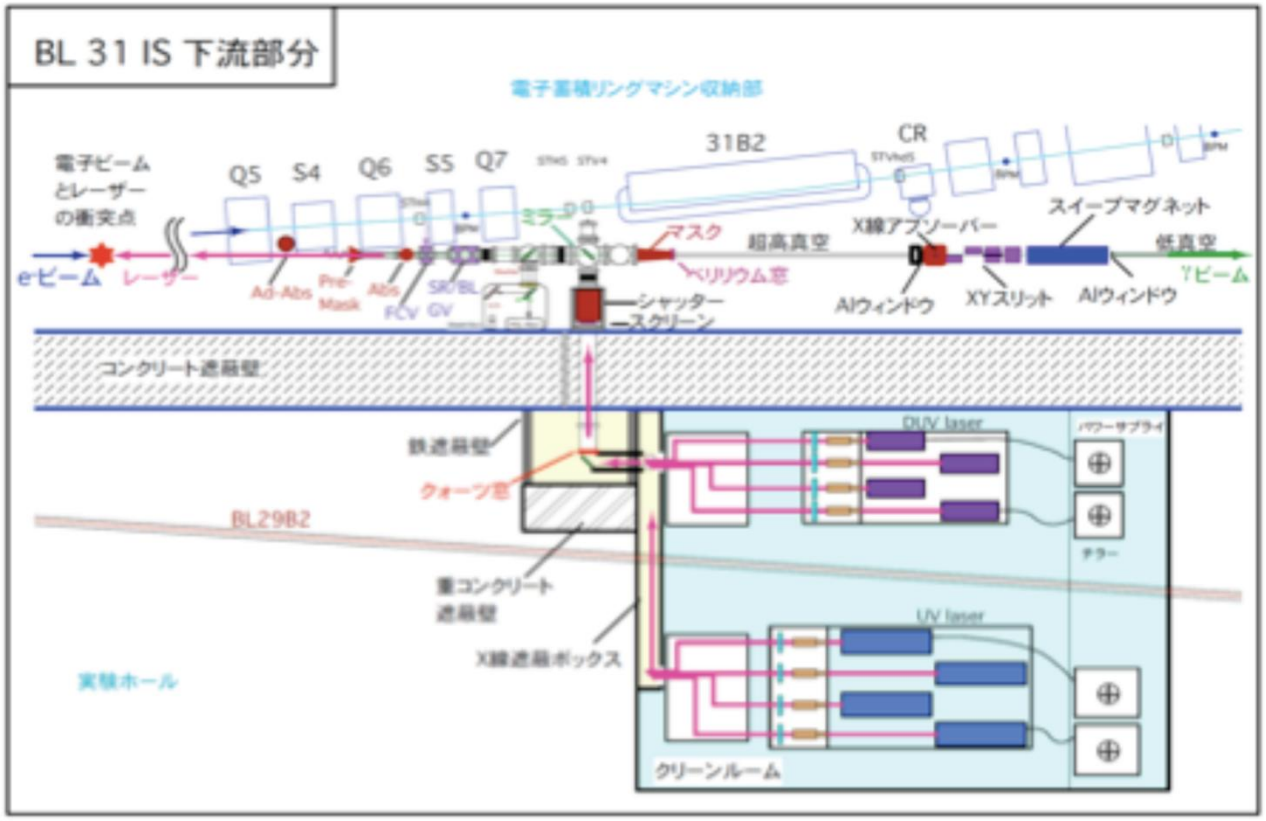
Beam size @ target (RMS): x ~2cm, y~1cm

34

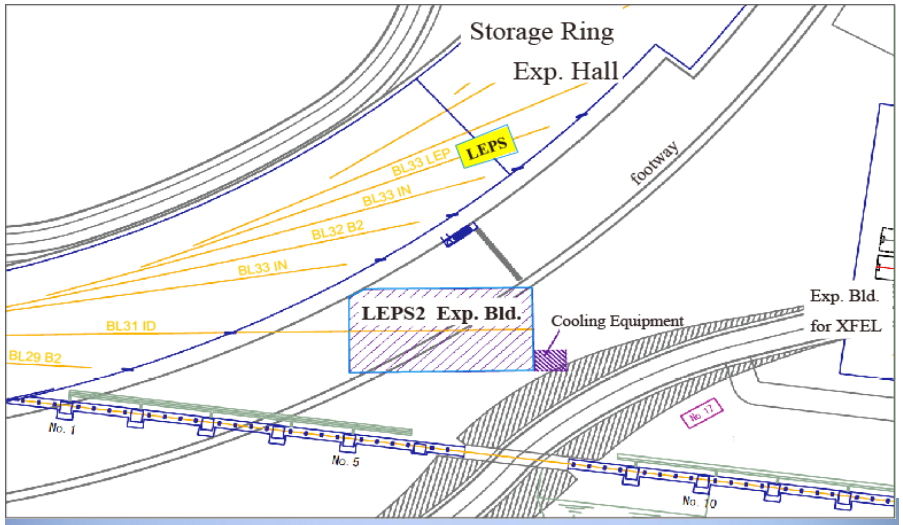
4 laser injection

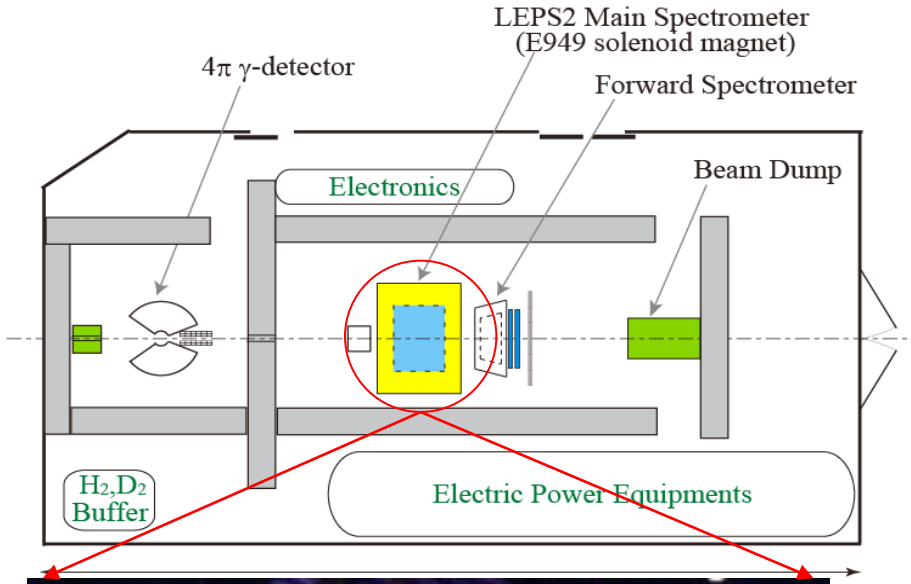
Thanks to large aperture
in BL31IS.



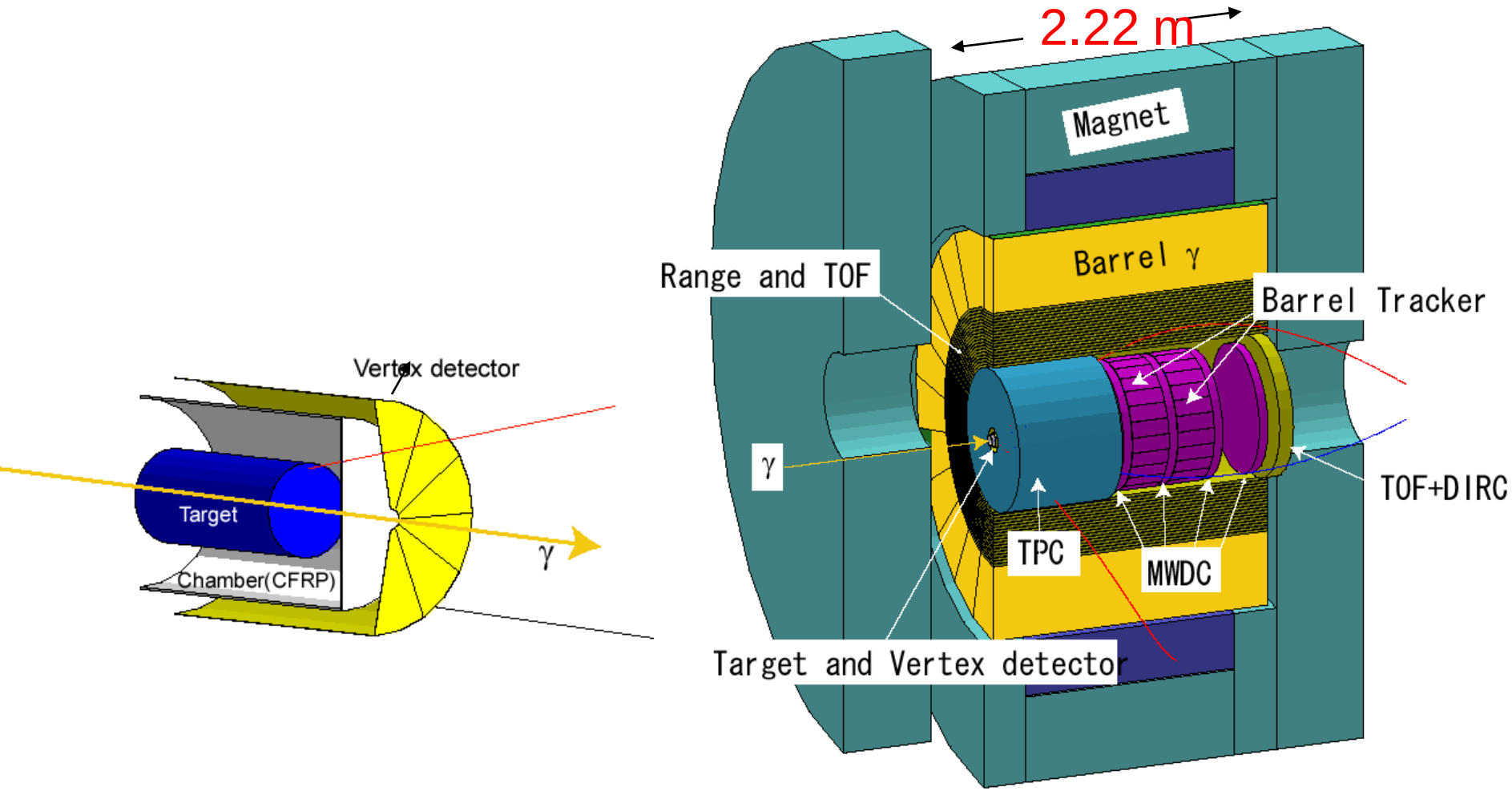


Experimental building for LEPS2





LEPS II detector setup

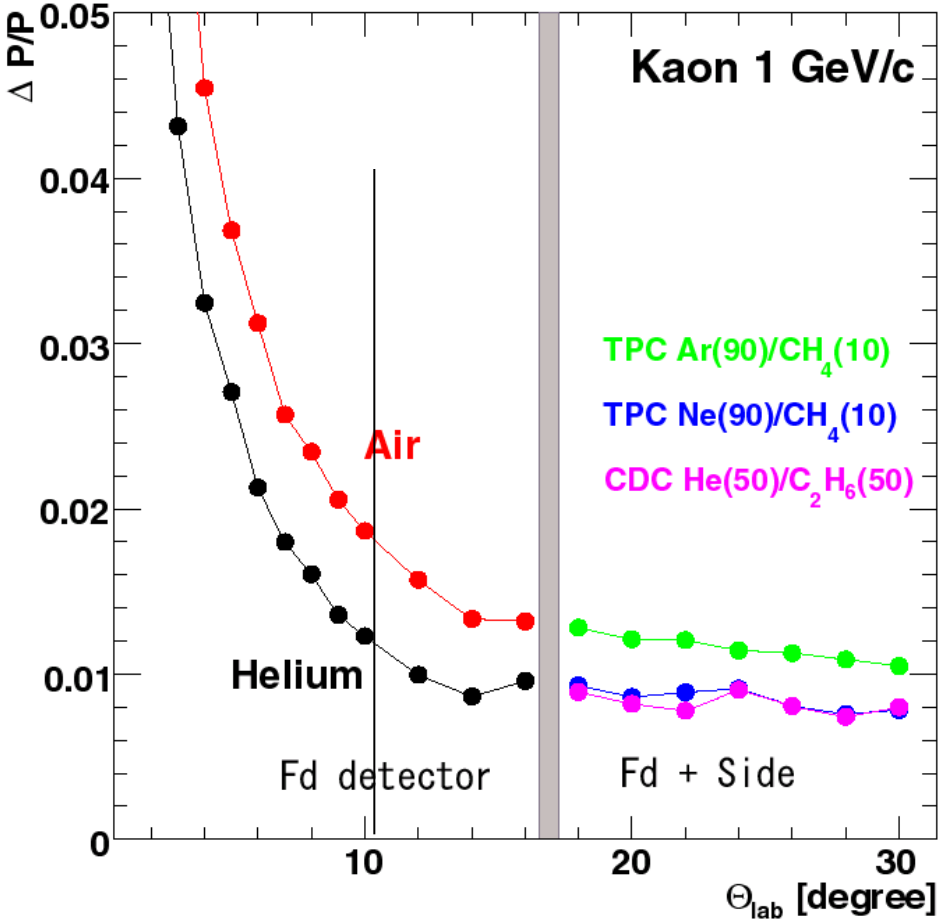


Summary

- LEPS I
  - Hadron physics with linear polarized photons
  - Motivated hadron production at forward angles
  - Penta-quark Θ is in controversial with CLAS J-Lab
- LEPS II
  - 10 times higher intensity with 3 GeV photons
  - Large angular coverage up to CLAS region to measure Θ production
  - Large solenoid magnet will be shipped from US to SPring-8 in this fiscal year.

Back up

ΔP/P at forward region



- $2^o < \theta < 17^o$

  Vertex + Fd MWDC

  No SW tracker

  At 10 degree

  ΔP/P = 1.3% (He4 gas)

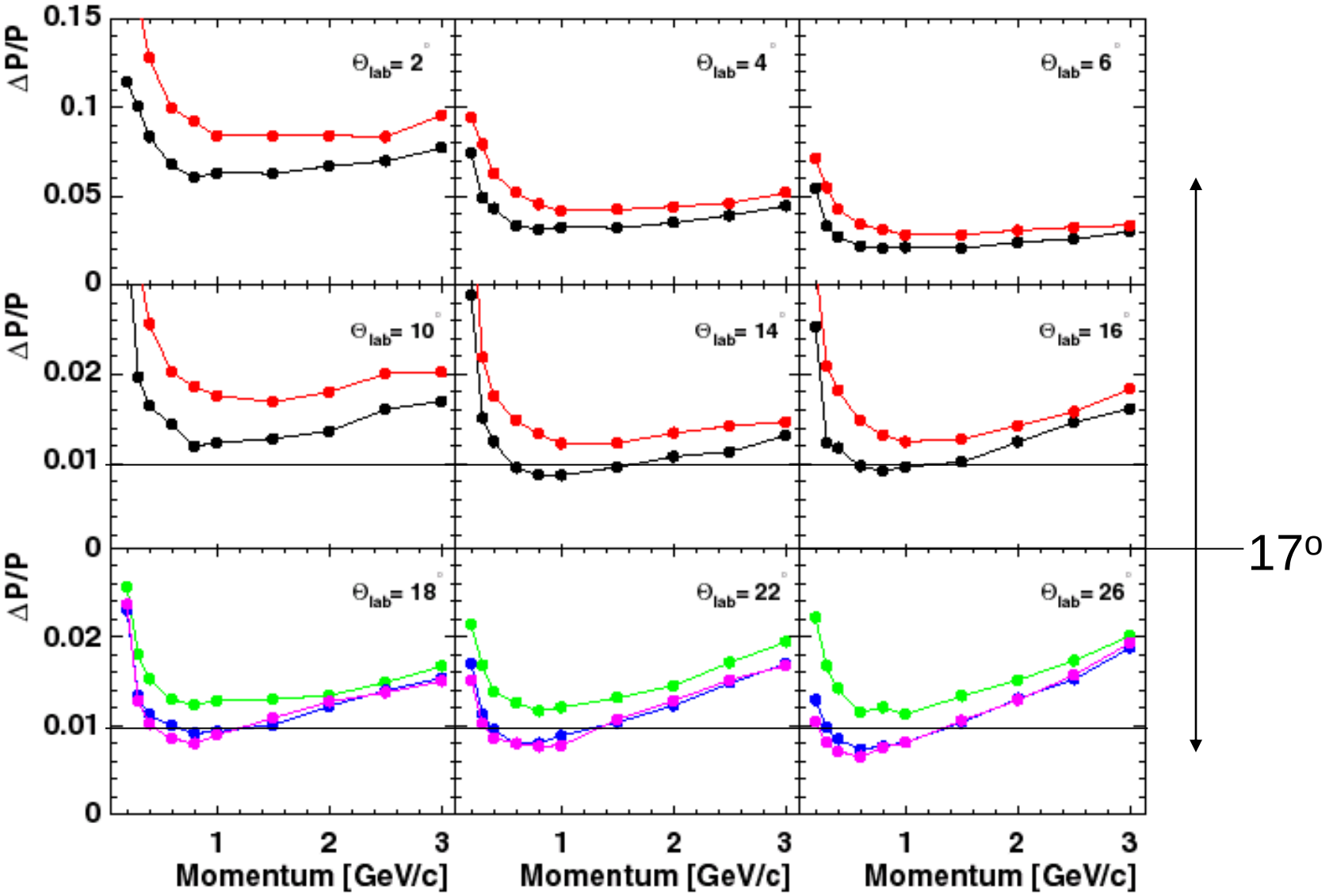
  1.9% (Air)

- $\theta > 17^o$

  MS effect in SW tracker

  TPC ⇒ Ar/CH_4 or Ne/CH_4

Momentum dep. of ΔP/P



Requirement

- Detection of the multi-charged particles and neutral particles
  - Reaction (MM) $\Rightarrow$ $\Delta P/P$~1% for 1GeV/c kaon
    at forward θ
    + π/K separation.
  - Decay (IM) $\Rightarrow$ Low momentum down to 0.1GeV/c
- Wide polar angle, smooth and full acceptance for azimuthal direction
  - Coplanarity
  - Decay distribution
  - Polarization measurement