The possible experiments with internal thin targets at the BEPCII storage rings

Hai-Bo Li

Institute of High Energy Physics

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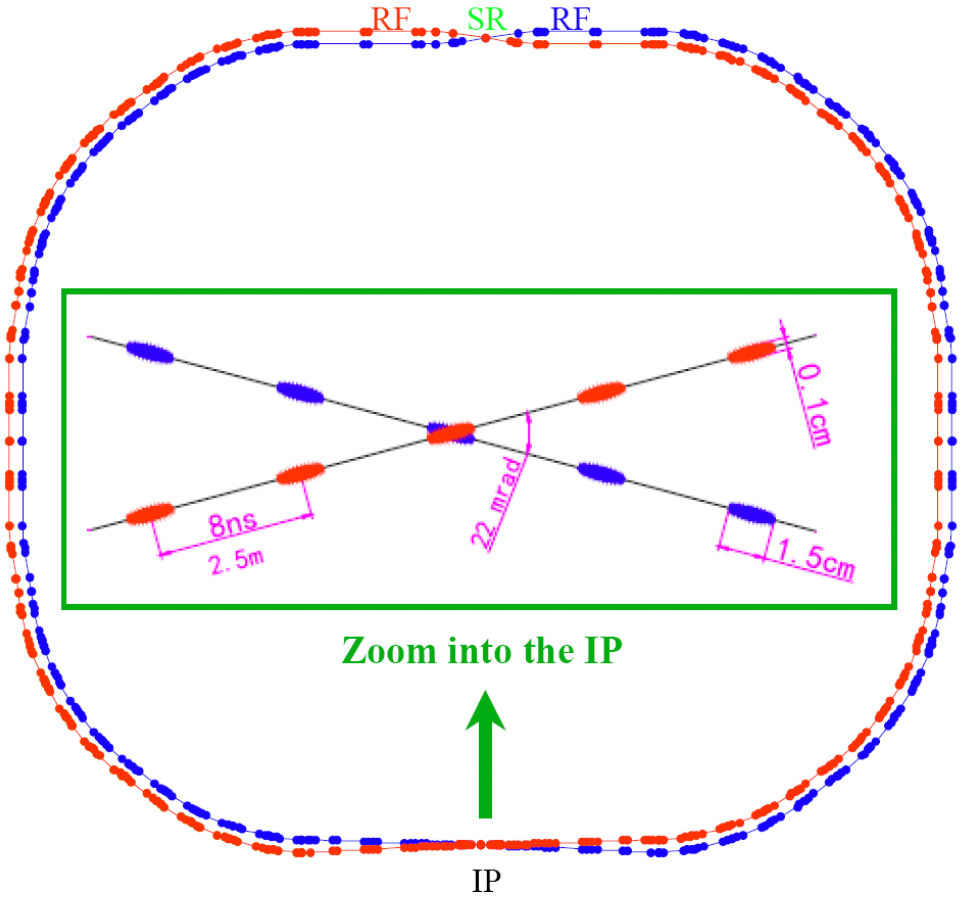
This survey is based on many discussions with Jianping Ma, Feng Yuan Haiyan Gao, Jianping Chen, and Alexander V. Gramolin

Outline

Main purpose: possible experiments using a thin gas (Hydrogen or Deuteron or Helium) targets internal to the BEPCII electron/positron storage ring.

- Introduction
- Elastic electron–deuteron scattering
- Two-body deuteron photodisintegration
- Coherent photoproduction of π^0 on the deuteron
- ABC effect in photoproduction of $\gamma d \rightarrow d\pi\pi$ (see Fei Huang's talk)
- Two-photon exchange and
  the proton electromagnetic form factors (see Marc's talk)
- Charged Lepton Flavor violation (cLFV): electron to $\mu(\tau)$ conversion:
  $e\ N \rightarrow \mu(\tau)\ N$
- Dark photon in $e^+e^- \rightarrow \gamma A'$ at low mass 10-50 MeV
- Charge radius of proton (see Haiyan Gao's talk)
- Summary

The BEPCII electron-positron double storage rings



Beam energy: 1.0-2.3 GeV
Design Luminosity: 1×10^{33} $cm^{-2}s^{-1}$
Optimum energy: 1.89 GeV
Energy spread: 5.16×10^{-4}
No. of bunches: 93
No. e^+ or e^-/bunch 4.5×10^{12}
Bunch length: 1.5 cm
Bunch distance 2 m
Beam size σ_x/σ_y 380/5.7 μm
Current/bunch 9.8 mA
Total current: 0.91 A
Circumference: 237m
Injection rate for e+ 50 mA/s
Injection rate for e- 200 mA/s

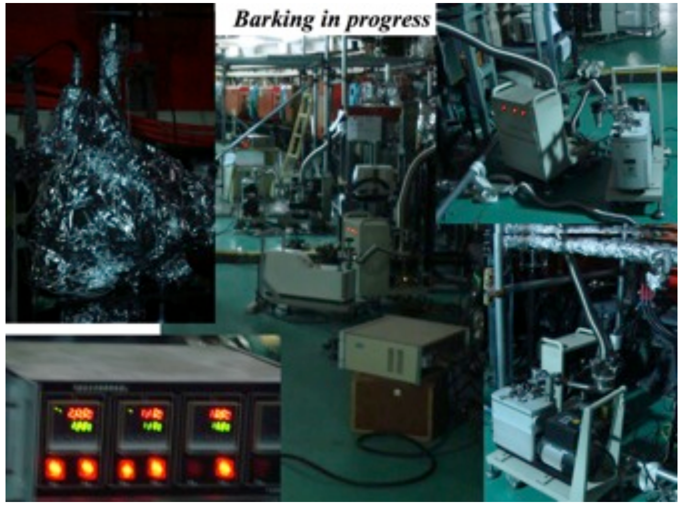
Only running experiment: BESIII
Start data taking: 2009
Estimated end of BESIII life time: 2022
Can we do more experiments using BEPCII?

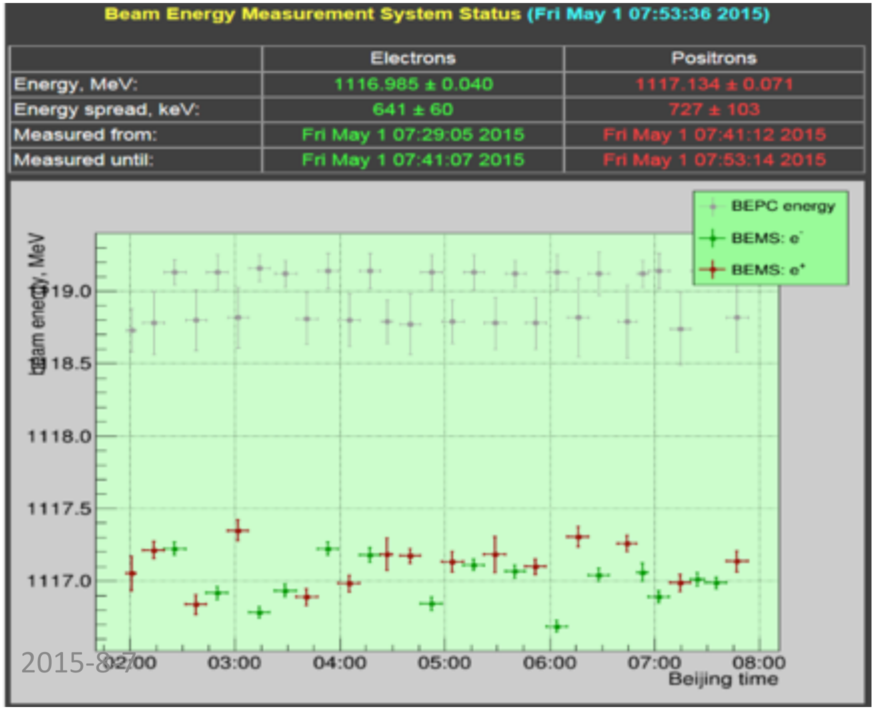
Beam energy measurement

- Reconstruction of the beam energy from an energy spectrum of laser photons backscattered on beam particles:

$$E_{beam} = \frac{\omega_{max}}{2} \times (1 + \sqrt{1 + m_e^2/\omega_0\omega_{max}})$$

- Achieved accuracy is $\Delta E/E \approx 4 \times 10^{-5}$
- This allows us to monitor the beam energy, and to apply corrections during data analysis .

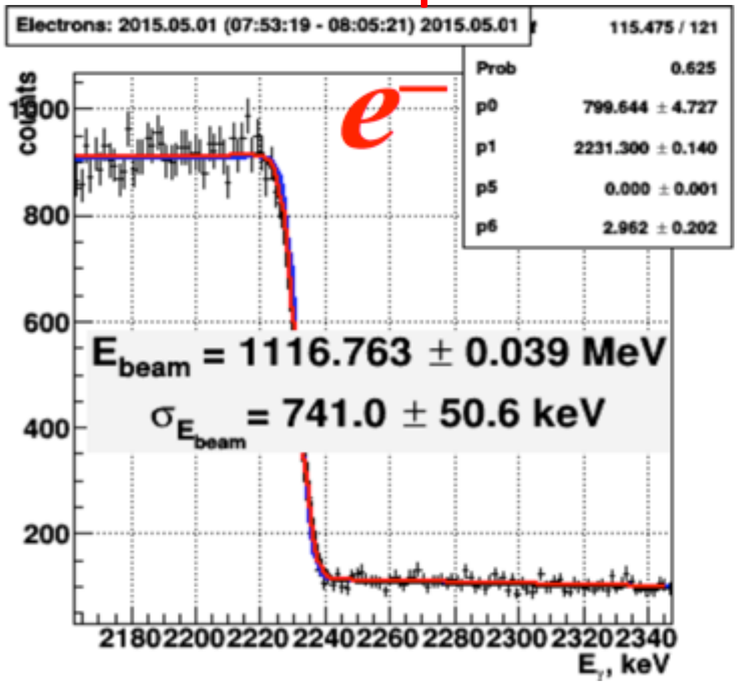




Beam Energy Measurement System Status (Fri May 1 07:53:36 2015)

	Electrons	Positrons
Energy, MeV:	1116.985 ± 0.040	1117.134 ± 0.071
Energy spread, keV:	641 ± 60	727 ± 103
Measured from:	Fri May 1 07:29:05 2015	Fri May 1 07:41:12 2015
Measured until:	Fri May 1 07:41:07 2015	Fri May 1 07:53:14 2015

Photon spectrum

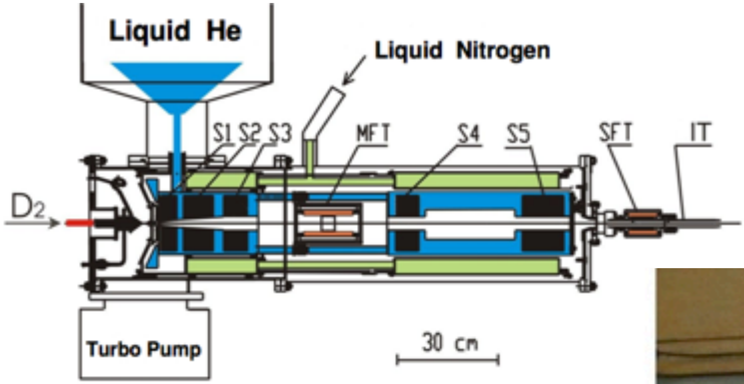


Method of a superthin internal target

- ✧ Consider the case of a target installed inside a storage ring, the beam crosses the target repeatedly
- ✧ In the case of a "superthin" internal target, additional energy losses of the beam are compensated by a RF cavity
- ✧ The method was proposed, first tested (at VEPP-1), and further developed (at VEPP-2 and VEPP-3) in Novosibirsk, starting from the late 1960s
- ✧ Later, the method was used in many laboratories worldwide, both at electron (NIKHEF, MIT-Bates, HERMES and OLYMPUS experiments at DESY, etc.) and ion (IUCF, CELSIUS, TSR Heidelberg, COSY Jülich, RHIC, etc.) rings
- ✧ The method allows one to substantially increase the efficiency of utilization of the target material and beam particles
- ✧ Therefore, the method makes it feasible to perform measurements
  – with exotic targets: polarized ones; of rare isotopes, etc.
  – with exotic beams: positrons; antiprotons; rare-isotope ions, etc.
  – detecting slow, heavy, or strong-ionizing reaction products in coincidence

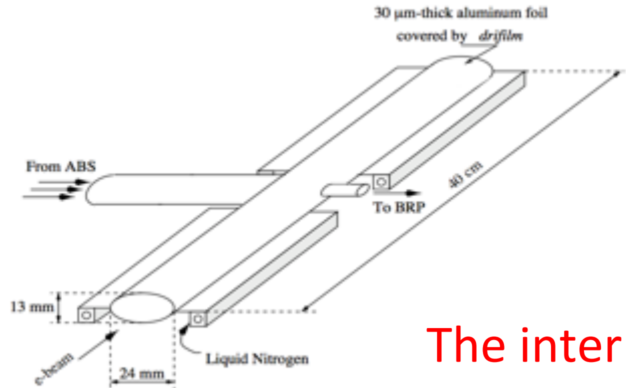
Internal polarized deuterium target at VEPP3

Polarized atomic beam sources (ABS):

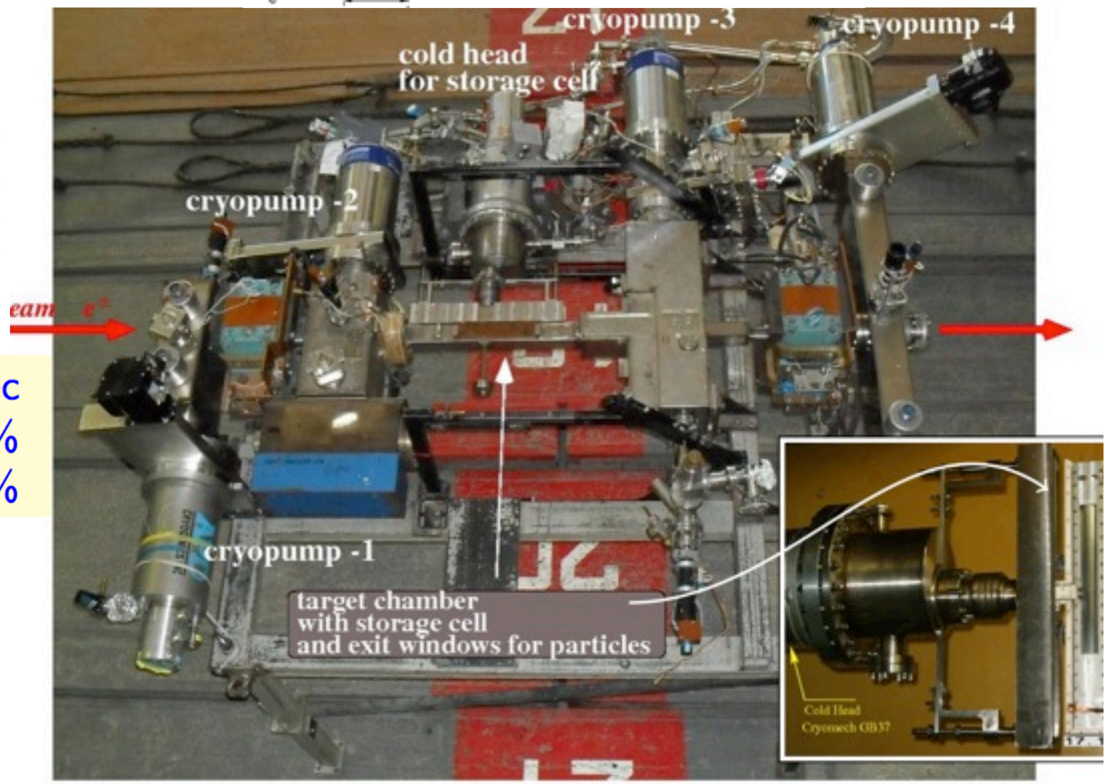


S1–S5 – sextupole magnets
MFT, SFT – RF-transition units
IT – inlet tube

Flux of deuterium atoms	$8 \cdot 10^{16}$ at/sec
Degree of tensor polarization	$> 98\%$
Degree of vector polarization	$< 2\%$



The internal target



target thickness $\approx 10^{15}$ at/cm^2, luminosity $\approx 10^{32}$cm^{-2}s^{-1}

Elastic electron-deuteron scattering

- The deuteron is the simplest nucleus, the only two-nucleon bound state
- Elastic *ed* scattering is a powerful tool to study the deuteron
- In the case of unpolarized (spin-averaged) *ed* scattering:

$$\frac{d\sigma_0}{d\Omega} = \frac{d\sigma_{\text{Mott}}}{d\Omega}\left[A(Q^2) + B(Q^2)\tan^2\frac{\theta_e}{2}\right],$$

$$A = G_C^2 + \frac{8}{9}\tau^2 G_Q^2 + \frac{2}{3}\tau G_M^2, \quad B = \frac{4}{3}\tau(1+\tau)G_M^2, \quad \tau = \frac{Q^2}{4M_d^2}$$

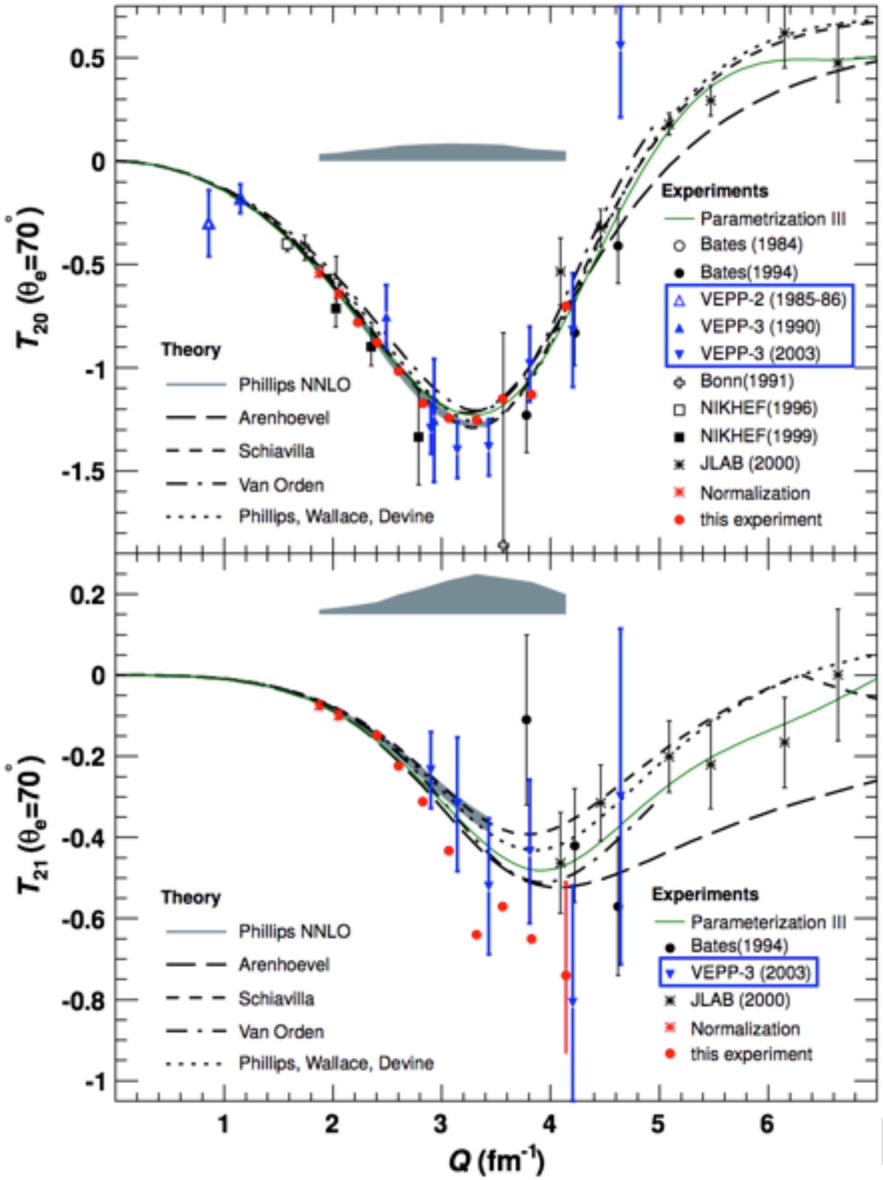
- Three form factors of the deuteron, G_C (charge monopole), G_Q (quadrupole), and G_M (magnetic), completely describe its electromagnetic structure
- In the case of scattering on a tensor-polarized deuterium target:

$$\frac{d\sigma}{d\Omega} = \frac{d\sigma_0}{d\Omega}\left\{1 + \frac{P_{zz}}{\sqrt{2}}\left[\frac{3\cos^2(\theta_H) - 1}{2} T_{20} - \sqrt{\frac{3}{2}}\sin(2\theta_H)\cos(\phi_H) T_{21} + \sqrt{\frac{3}{2}}\sin^2(\theta_H)\cos(2\phi_H) T_{22}\right]\right\},$$

  where T_{20}, T_{21}, and T_{22} are the deuteron tensor analyzing powers
- The form factors G_C and G_Q can be separated only using polarized scattering

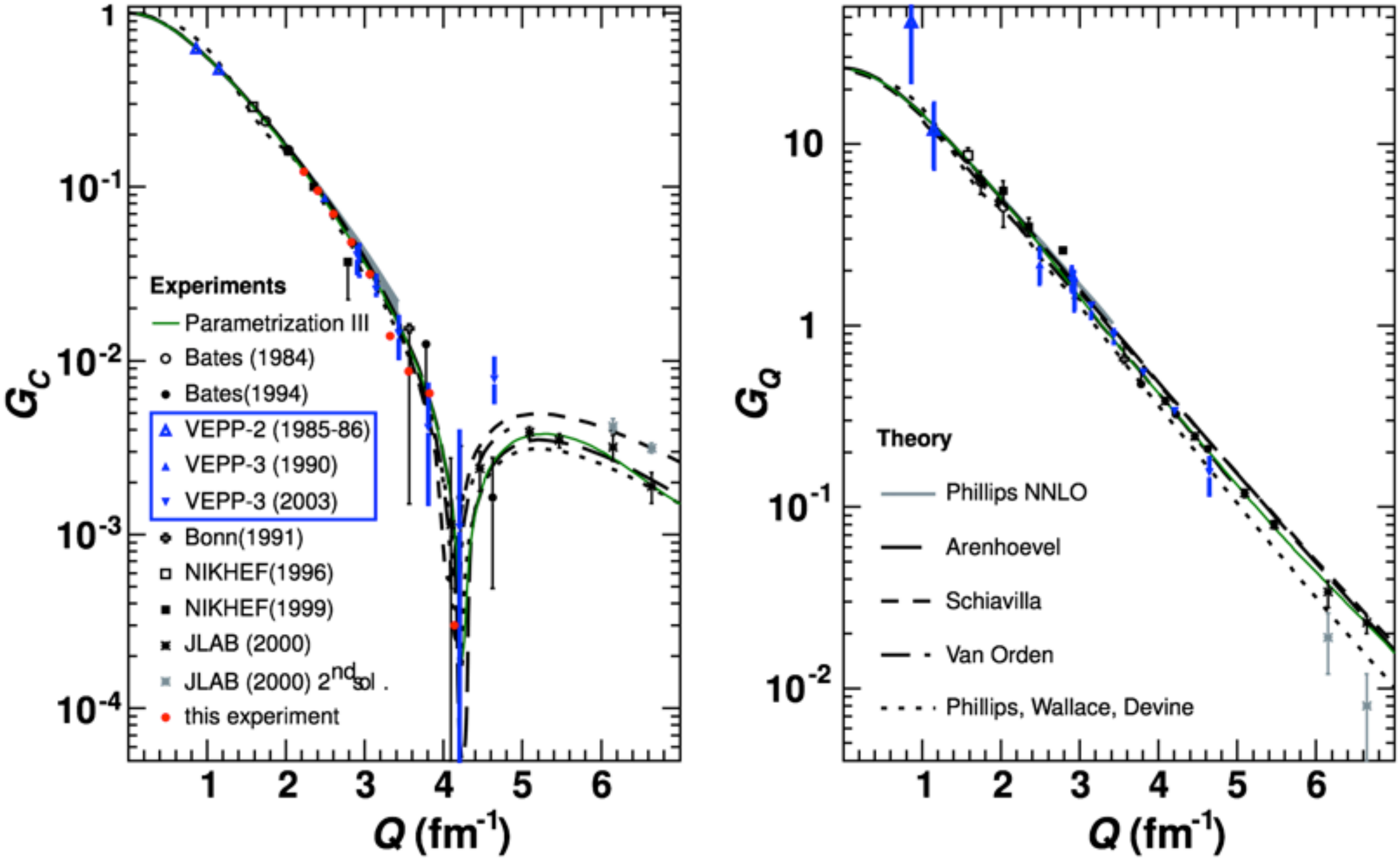
Slides from Alexander V. Gramolin

The world data for $T_{20}(Q)$ and $T_{21}(Q)$



From PRL **107**, 252501

The world data for $G_C(Q)$ and $G_Q(Q)$



The figures are from C. Zhang et al., Phys. Rev. Lett. 107, 252501 (2011)

The form factors can be measured between Q= 3 – 5 fm^{-1} at BEPCII with 2.5 GeV electron beam.

Two-body deuteron photodisintegration

Deuteron photodisintegration: $\gamma d \to pn$

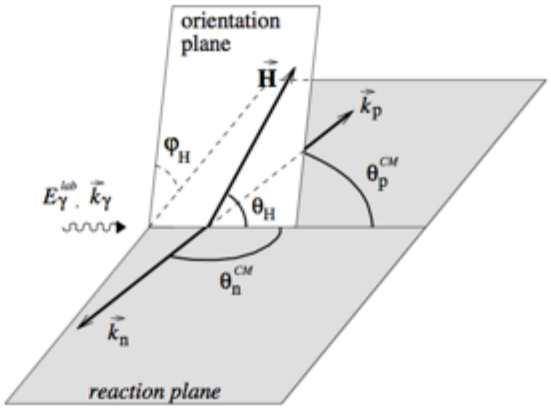
In the case of polarized spin-1 target and unpolarized photon beam:

$$\frac{d\sigma}{d\Omega} = \frac{d\sigma_0}{d\Omega}\left\{1 - \sqrt{\frac{3}{4}}\, P_z \sin(\theta_H)\sin(\phi_H)\; T_{11}(E\gamma, \theta_p^{CM}) + \sqrt{\frac{1}{2}}\, P_{zz}\left[\frac{3\cos^2(\theta_H) - 1}{2}\; T_{20}(E\gamma, \theta_p^{CM}) - \sqrt{\frac{3}{8}} \sin(2\theta_H)\; \cos(\phi_H)\; T_{21}(E\gamma, \theta_p^{CM}) + \sqrt{\frac{3}{8}} \sin^2(\theta_H)\; \cos(2\phi_H)\; T_{22}(E\gamma, \theta_p^{CM})\right]\right\}$$

$P_z = n_+ - n_-$ – degree of vector polarization: $-1 \ldots +1$

$P_{zz} = 1 - 3 \cdot n_0$ – degree of tensor polarization: $-2 \ldots +1$

n_+, n_-, n_0 – population numbers for the spin projections $+1$, -1 and 0, respectively



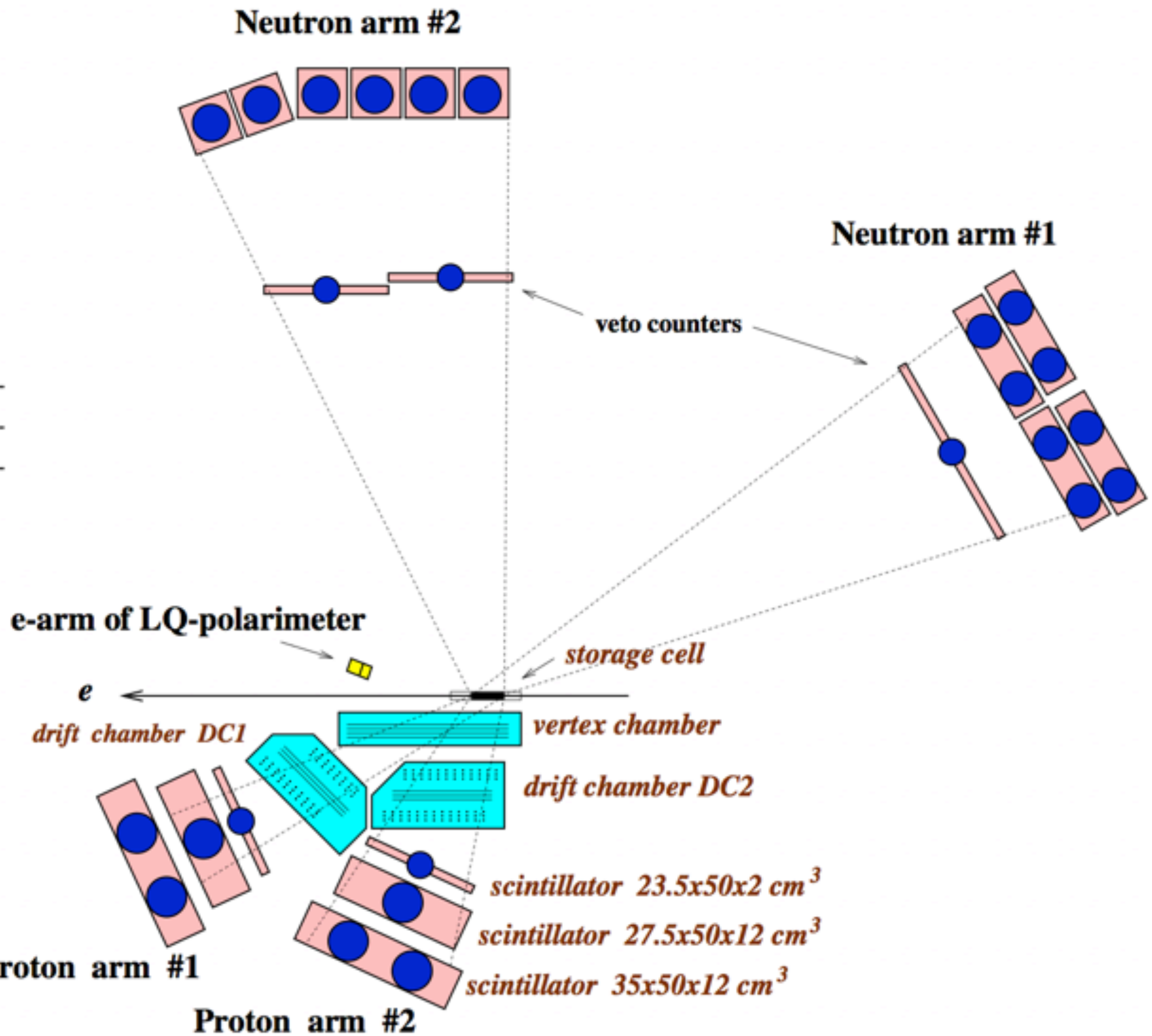
Detector layout for deuteron photodisintegration

- 2 pairs of arms in vertical plane:

arm	I	II
θ_p	20°-40°	55°-95°
θ_n	127°-145°	68°-92°
Δ_ϕ	25°	19°

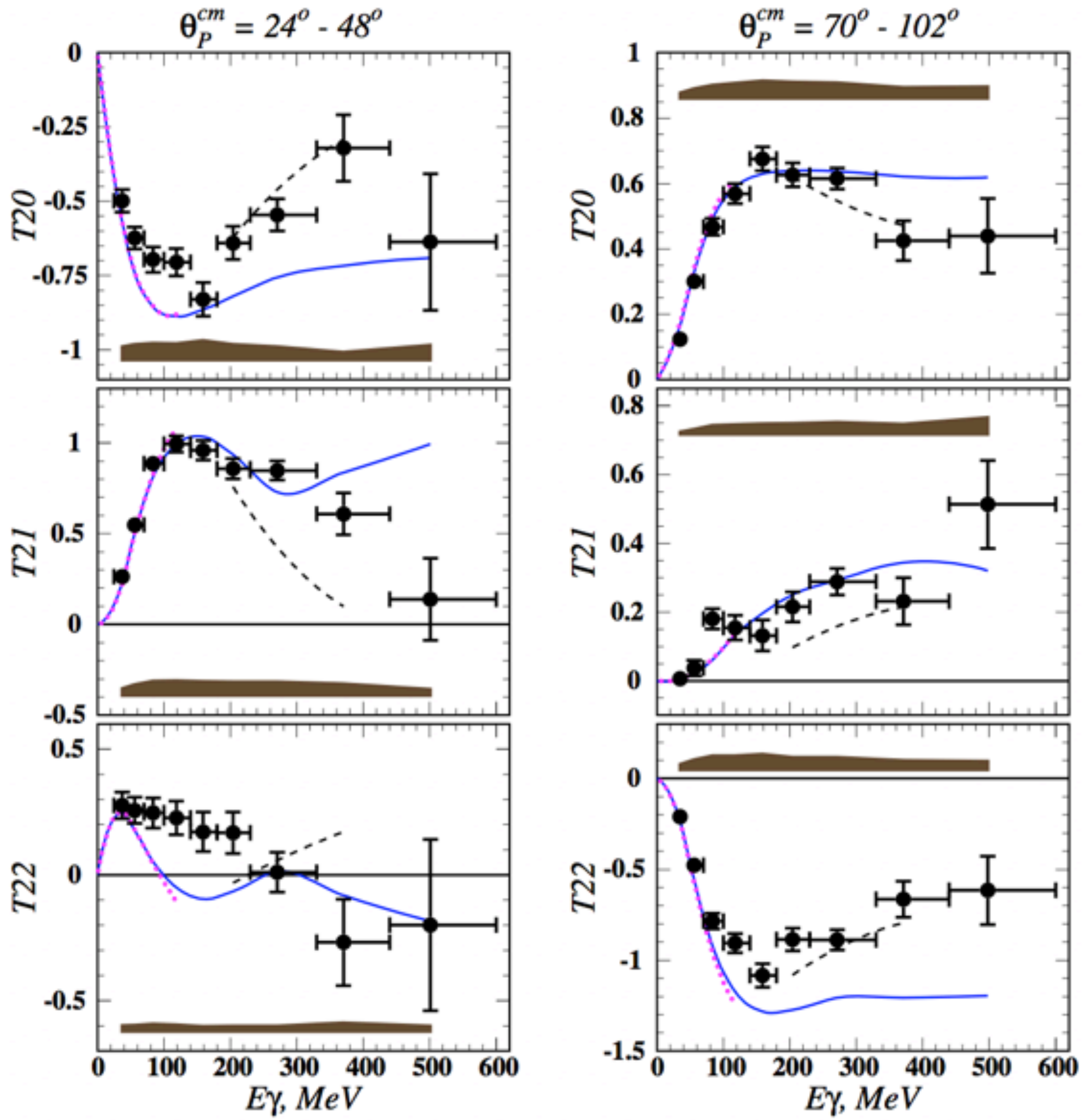
- proton arm:
drift chambers + 3 scintillator layers

- neutron arm:
thin veto-counter + thick scintillator



Slides from Alexander V. Gramolin

Results: T_{20}, T_{21}, and T_{22} as functions of E_γ



vertical bars – statistical errors

horizontal bars – bin sizes

shaded bands – systematic errors

Theoretical curves:

solid – K.-M.Schmitt & H.Arenhövel (1990), full calculation

dotted – M.Levchuk (1995), full calculation

dashed – M.Schwamb (2006)

Experiments at BEPCII will improve the precision with 2.5 GeV electron beam.

I. A. Rachek *et al.*, Phys. Rev. Lett **98**, 182303 (2007)

Coherent neutral pion photoproduction on the deuteron

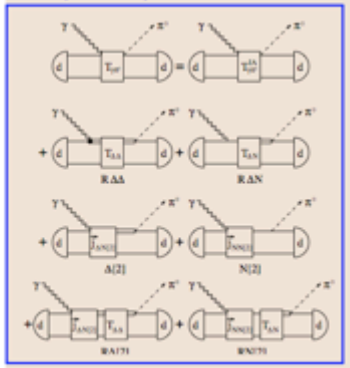
$\gamma + \vec{d} \rightarrow \pi^0 + d$

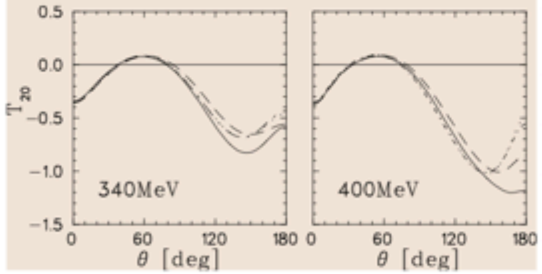
One of the simplest photonuclear reactions, the only pion photoproduction process off the deuteron having two final-state particles

Issues addressed:

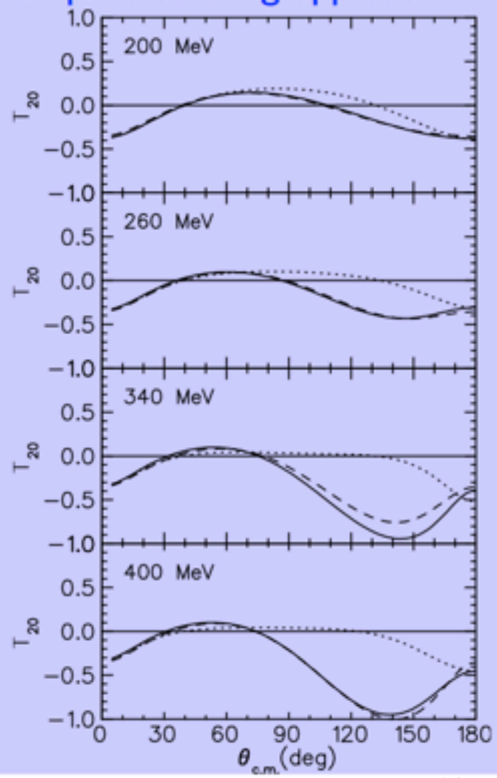
- deuteron structure
- π^0 – deuteron elastic scattering
- pion photoproduction off neutron
- at threshold – chiral dynamics on neutron
- . . .

P.Wilhelm and H.Arenhövel, Nucl. Phys. A **609**, 469 (1996)
couple-channel approach:
NN, $N\pi$, $N\Delta$





S.S.Kamalov, L.Tiator and C.Bennhold,
Phys. Rev. C **55**, 98 (1997)
with FSI treated in the KMT multiple scattering approach

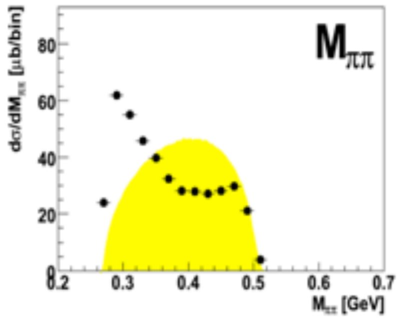


With 2.5 GeV electron beam, BEPCII allow measurement of these TAP between Eγ=200-600 MeV

ABC effects in $\gamma d \rightarrow d\pi\pi$?

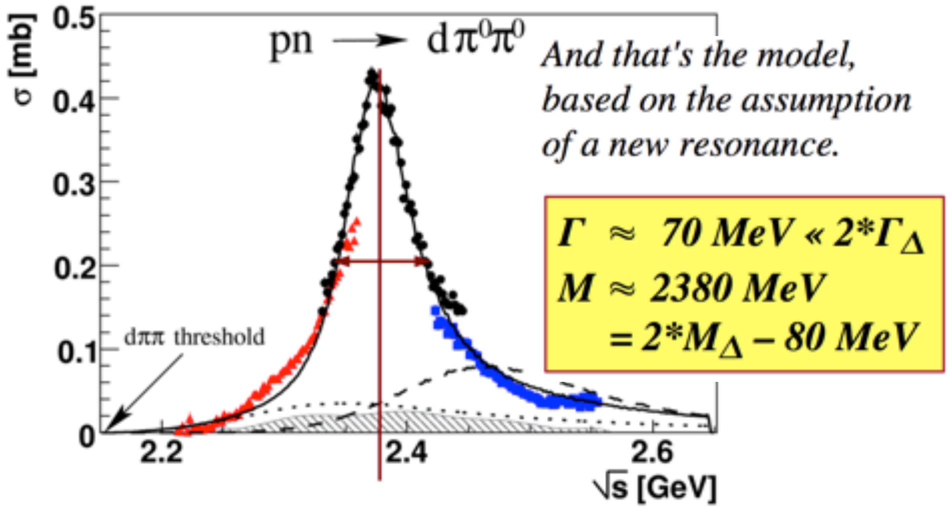
Many theoretical prediction:
F. Wang et al
Z. Y. Zhang et al.
…

$pn \rightarrow d\pi^0\pi^0$
@ $\sqrt{s}$ = 2.38 GeV



P. Adlarson et. al
PRL 106:242302, 2011

Phasespace (always)

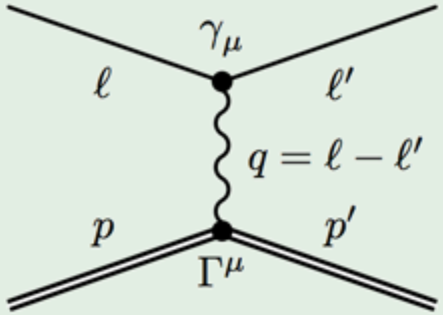


$$\gamma d \rightarrow d\pi\pi$$

The real photon energy will be at least 0.6 GeV
Can we do it at BEPCII with internal gas deuteron targets with 2.5 GeV electron beam?

Proton electromagnetic form factors (spacelike region)

Elastic *ep* scattering in the one-photon exchange (Born) approximation



Vertex operator $\Gamma^\mu(q)$

$$\Gamma^\mu(q) = \gamma^\mu F_1(q^2) + \frac{i\sigma^{\mu\nu}q_\nu}{2M} F_2(q^2)$$

$F_1(q^2)$ – non-spin-flip Dirac form factor

$F_2(q^2)$ – spin-flip Pauli form factor

Sachs form factors

- Electric form factor:
  $G_E(Q^2) = F_1(Q^2) - \frac{Q^2}{4M^2} F_2(Q^2)$
- Magnetic form factor:
  $G_M(Q^2) = F_1(Q^2) + F_2(Q^2)$
- Dipole formula:
  $G_E \approx \frac{G_M}{\mu} \approx \left(1 + \frac{Q^2}{0.71}\right)^{-2}$

In the Breit frame, G_E and G_M describe
charge and magnetization distributions in proton

Two methods of measuring the proton form factors

- The Rosenbluth separation method at constant Q^2

Rosenbluth Formula *Rosenbluth, 1950*

$$\frac{d\sigma}{d\Omega} = \frac{1}{\varepsilon(1+\tau)}\left[\varepsilon G_E^2 + \tau G_M^2\right]\frac{d\sigma_{\mathrm{Mott}}}{d\Omega},$$

where $\boxed{\tau = Q^2/4M^2}$ and $\boxed{\varepsilon = \left[1 + 2(1+\tau)\tan^2(\theta/2)\right]^{-1}}$

- Polarized beams and targets or recoil polarimeters

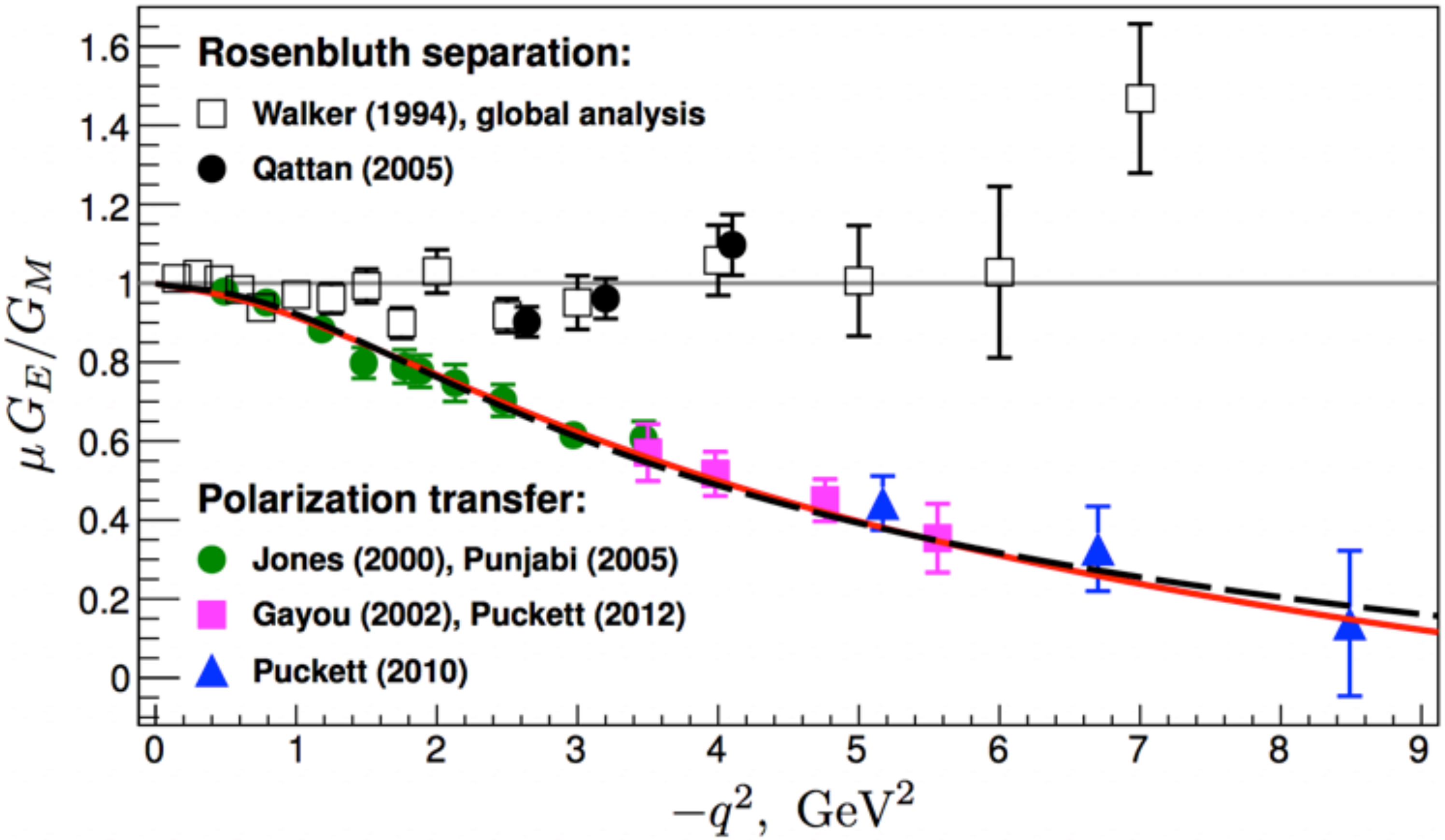
Form factor ratio from polarization transfer *Akhiezer & Rekalo, 1968*

$$\frac{G_E}{G_M} = \frac{P_T}{P_L} \times K,$$

where P_T and P_L are transverse and longitudinal polarization components of the proton, $K = -\sqrt{\tau(1+\varepsilon)/2\varepsilon}$ is a kinematic factor

Inconsistency?

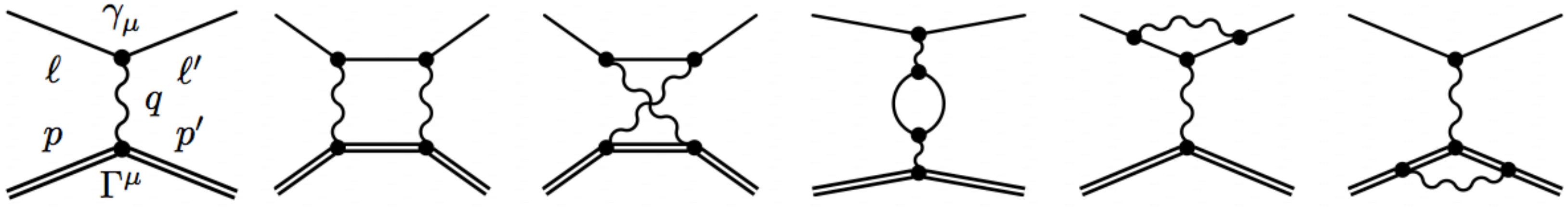
A clear discrepancy between the two experimental data sets was observed:



Radiative corrections, in particular a Two-Photon Exchange (TPE) effect, is a likely origin of the discrepancy

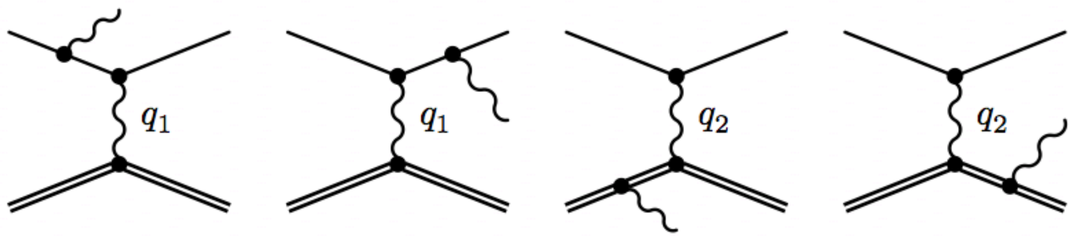
First-order radiative corrections to elastic ep scattering

"Elastic" scattering ($e^{\pm}p \rightarrow e^{\pm}p$):



$\mathcal{M}_{\text{Born}}$ $\quad$ $\mathcal{M}_{2\gamma}$ $\quad$ $\mathcal{M}_{\text{vac}}$ $\quad$ $\mathcal{M}^{\ell}_{\text{vert}}$ $\quad$ $\mathcal{M}^{p}_{\text{vert}}$

First-order bremsstrahlung ($e^{\pm}p \rightarrow e^{\pm}p\,\gamma$):



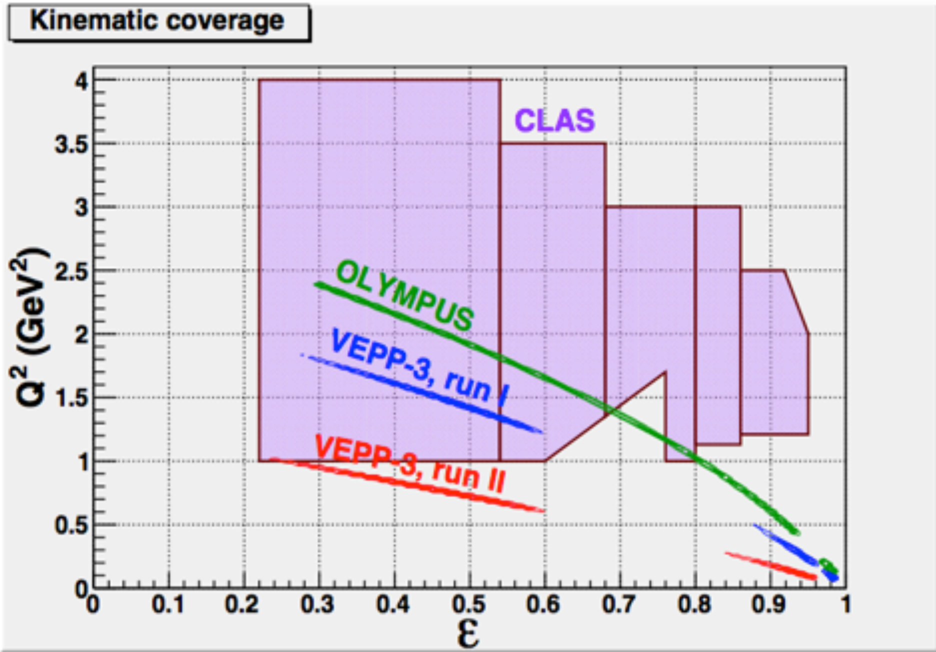
$\mathcal{M}^{\ell}_{\text{brems}}$ $\quad$ $\mathcal{M}^{p}_{\text{brems}}$

$$\sigma(e^{\pm}p) \propto |\mathcal{M}_{\text{Born}}|^2 \pm 2\,\text{Re}\left(\mathcal{M}^{\dagger}_{\text{Born}}\mathcal{M}_{2\gamma}\right)$$
$$+\,2\,\text{Re}\left(\mathcal{M}^{\dagger}_{\text{Born}}\mathcal{M}_{\text{vac}}\right) + 2\,\text{Re}\left(\mathcal{M}^{\dagger}_{\text{Born}}\mathcal{M}^{\ell}_{\text{vert}}\right) + 2\,\text{Re}\left(\mathcal{M}^{\dagger}_{\text{Born}}\mathcal{M}^{p}_{\text{vert}}\right)$$
$$+\,|\mathcal{M}^{\ell}_{\text{brems}}|^2 + |\mathcal{M}^{p}_{\text{brems}}|^2 \pm 2\,\text{Re}\left(\mathcal{M}^{\ell\dagger}_{\text{brems}}\mathcal{M}^{p}_{\text{brems}}\right) + \mathcal{O}(\alpha^4)$$

✓ Cancellation of infrared divergences (corresponding terms are marked in color)

✓ Some of the terms are of different signs ("$\pm$") for $e^{+}p$ and $e^{-}p$ scattering

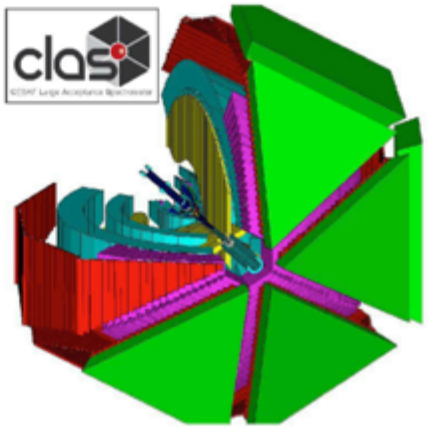
Three new experiments to measure $R = \sigma(e^+p)/\sigma(e^-p)$

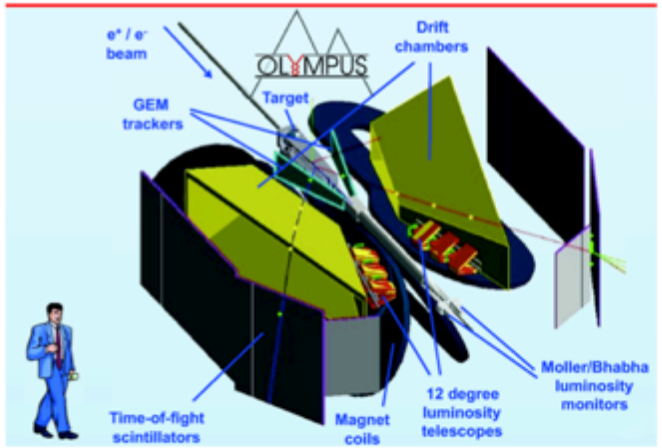


1. Novosibirsk: VEPP-3
   Two runs: $E_{\text{beam}} = 1.6$ and 1.0 GeV
2. JLab: CLAS at Hall B
   $E_{\text{beam}} = 0.5$—4 GeV
3. DESY: OLYMPUS at DORIS
   $E_{\text{beam}} = 2$ GeV

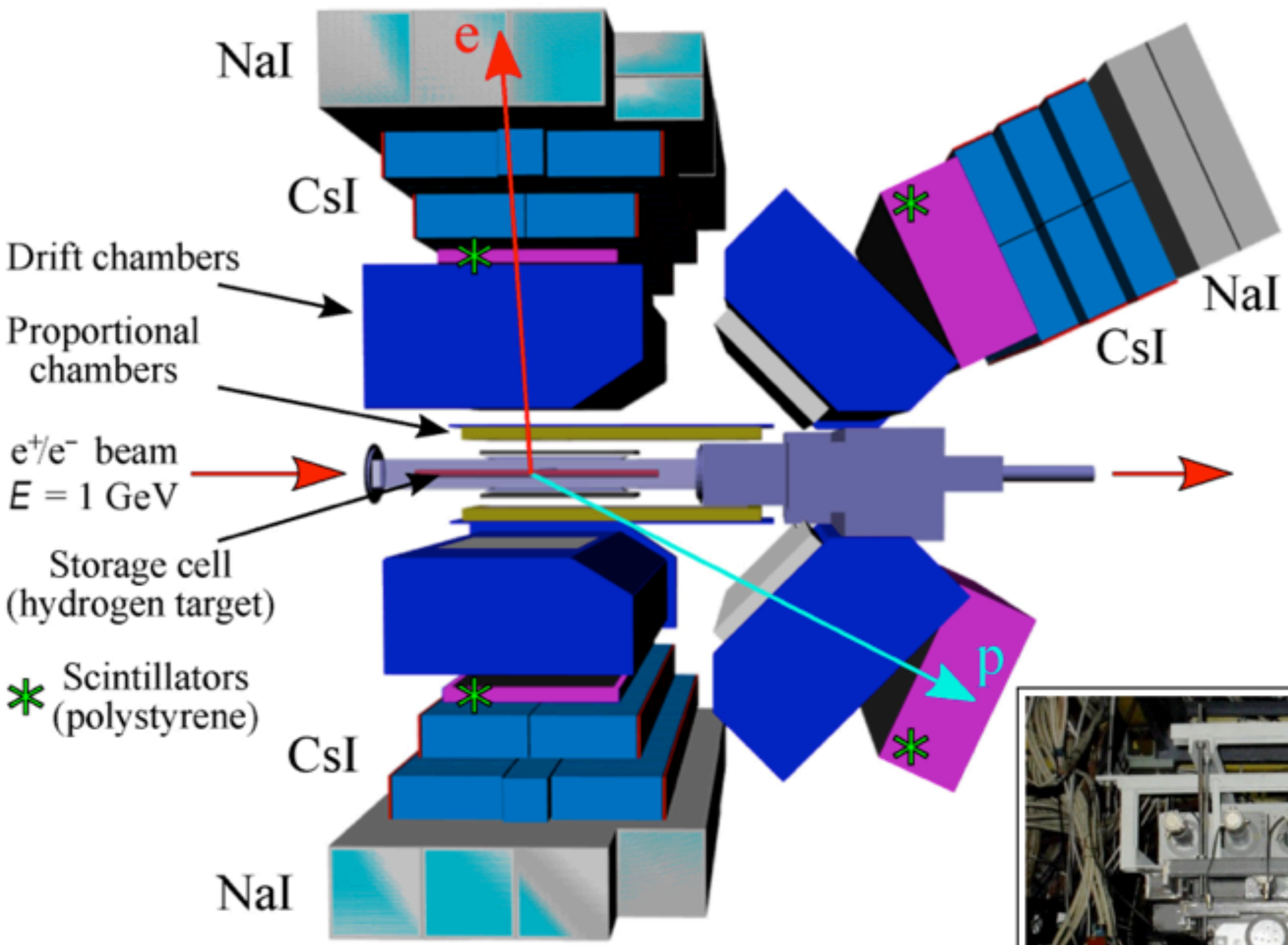
$$\delta_{2\gamma} = \frac{2\text{Re}\left(\mathcal{M}_{1\gamma}^{\dagger}\mathcal{M}_{2\gamma}^{\text{hard}}\right)}{|\mathcal{M}_{1\gamma}|^2}$$

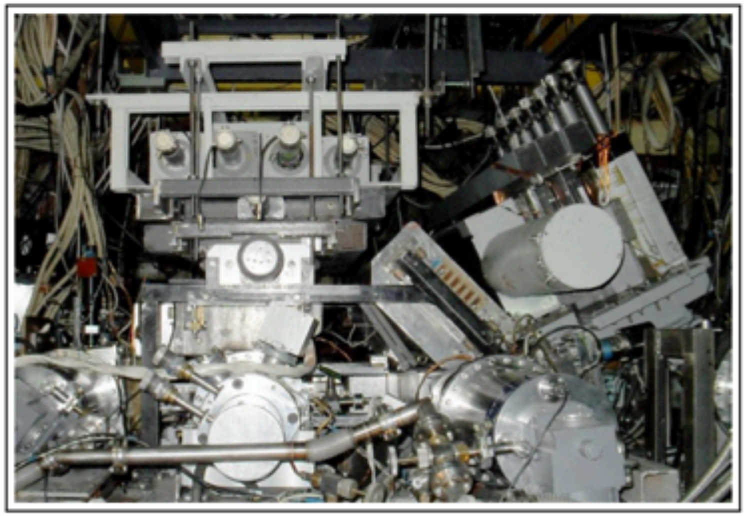
$$R_{2\gamma} = \frac{1-\delta_{2\gamma}}{1+\delta_{2\gamma}}$$





The detector configuration for run II ($E_{\text{beam}} = 1.0$ GeV)



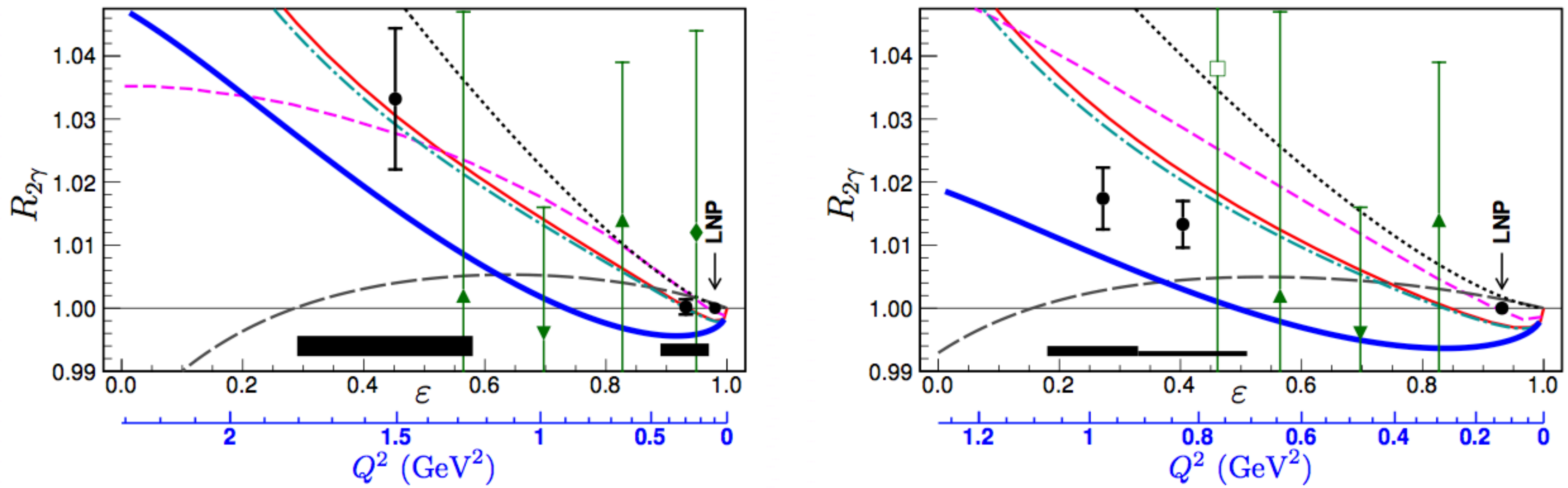


θ_e acceptance: 15° – 30° and 65° – 105°

ϕ_e acceptance: 2 × 60°

Results of the Novosibirsk TPE experiment

Run I : $E_{beam} = 1.594$ GeV — Run II: $E_{beam} = 0.998$ GeV



Curves:

red solid	*P. G. Blunden, et al.,*	Phys. Rev. **C72** (2005) 034612	:hadronic TPE calculation
dash-dot	*D. Borisyuk and A. Kobushkin,*	Phys. Rev. **C78** (2008) 025208	:dispersion relations
grey dashed	*E. Tomasi-Gustafsson, et al.,*	Phys. Atom. Nucl. 76 (2013) 937	:"analytical model"
magenta dashed	*J. Arrington and I. Sick,*	Phys. Rev. **C70** (2004) 028203	:Coulomb corrections
dotted	*I. A. Qattan, et al.,*	Phys. Rev. **C84** (2011) 054317	:Parametrisation
blue thick	*J. Bernauer, et al.,*	Phys. Rev. **C90** (2014) 015206	:Global *ep*-data fit

Data: □ SLAC, 1965; ▼ Cornell, 1966; ◆ DESY, 1967; ▲ Cornell, 1968; ● VEPP-3, 2015.

- LNP – Luminosity Normalization Point – set to $R_{2\gamma} = 1$
- Error bars are statistical errors, shaded bands show ε-bin width and systematic uncertainties
- The radiative corrections are applied according to J. Phys. G **41**, 115001 (2014)

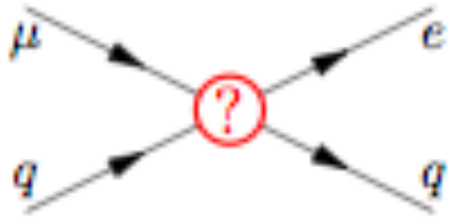
Search for cLFV $e^+ + N \rightarrow \mu^+(\tau^+) + N$

$$L_{\mathrm{CLFV}} = \frac{1}{1+\kappa}\frac{m_\mu}{\Lambda^2}\bar{\mu}_{\mathrm{R}}\sigma^{\mu\nu}e_{\mathrm{L}}F_{\mu\nu} + \frac{\kappa}{1+\kappa}\frac{1}{\Lambda^2}(\bar{\mu}_{\mathrm{L}}\gamma^\mu e_{\mathrm{L}})(\bar{q}_{\mathrm{L}}\gamma_\mu q_{\mathrm{L}})$$

Photonic (dipole) interaction

cLFV is a SM-free process

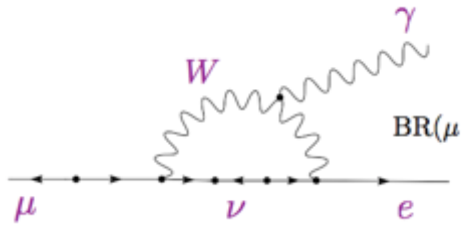
Contact interaction



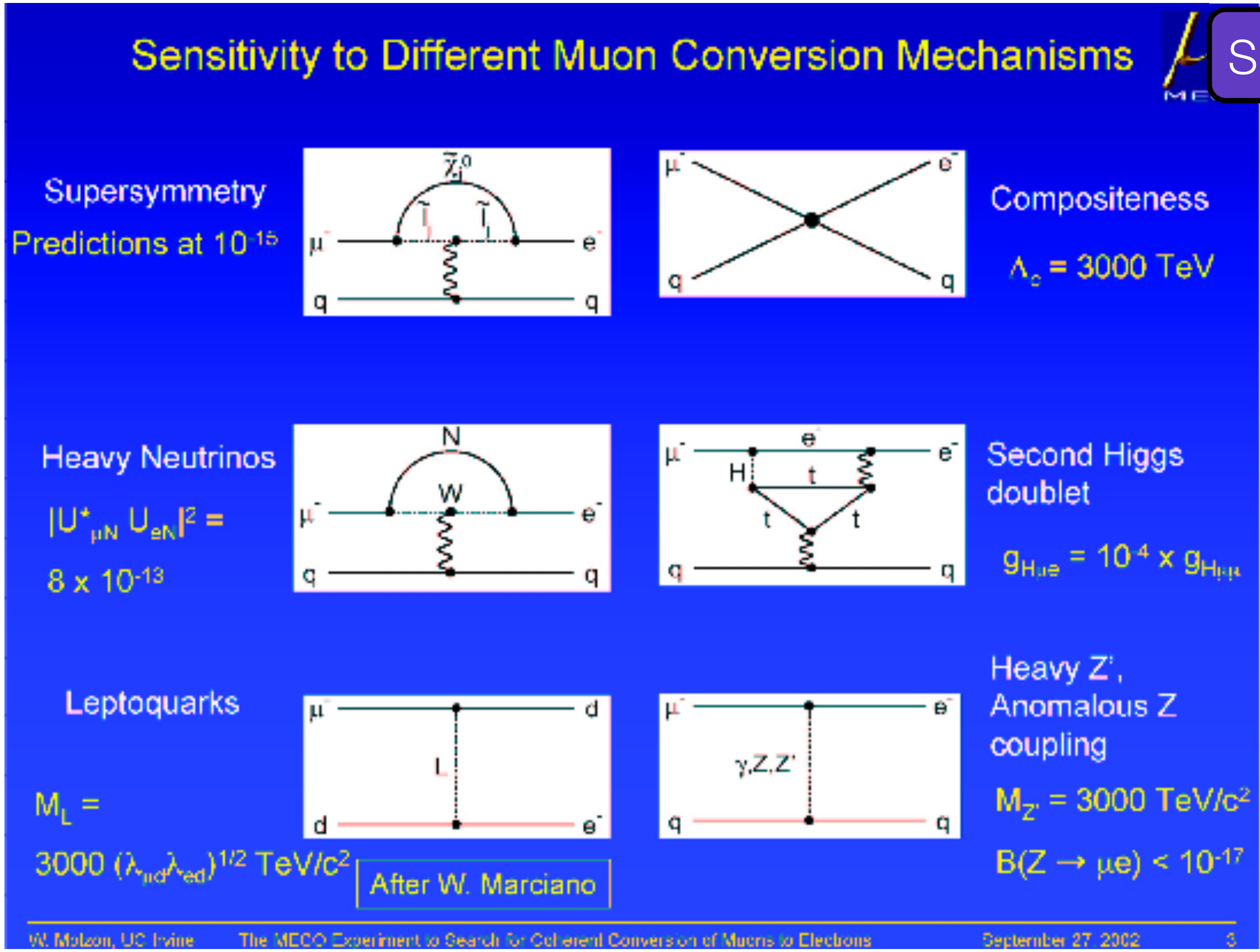
process	present limit	future	
$\mu \rightarrow e\gamma$	$<5.7 \times 10^{-13}$	$<10^{-14}$	MEG at PSI
$\mu \rightarrow eee$	$<1.0 \times 10^{-12}$	$<10^{-16}$	Mu3e at PSI
$\mu N \rightarrow eN$ (in Al)	none	$<10^{-17}$	Mu2e / COMET
$\mu N \rightarrow eN$ (in Ti)	$<4.3 \times 10^{-12}$	$<10^{-18}$	PRISM
$\tau \rightarrow e\gamma$	$<1.1 \times 10^{-7}$	$<10^{-9} - 10^{-10}$	superKEKB
$\tau \rightarrow eee$	$<3.6 \times 10^{-8}$	$<10^{-9} - 10^{-10}$	superKEKB
$\tau \rightarrow \mu\gamma$	$<4.5 \times 10^{-8}$	$<10^{-9} - 10^{-10}$	superKEKB
$\tau \rightarrow \mu\mu\mu$	$<3.2 \times 10^{-8}$	$<10^{-9} - 10^{-10}$	superKEKB/LHCb

SM and New physics contributions

$$B(\mu \to e\gamma) = \frac{3\alpha}{32\pi}\left|\sum_l (V_{MNS})^*_{\mu l}(V_{MNS})_{el}\frac{m^2_{\nu_l}}{M^2_W}\right|^2$$



SM: BR~O(10^{-54})



Many new physics model can make sizable and measurable contributions .

e to $\mu(\tau)$ conversion: $e^+ + N \rightarrow \mu^+(\tau^+)+N$ at BEPCII

Typical cLFV processes with different targets

$$e^+ + p \rightarrow \mu^+(\tau^+) + p$$

$$e^+ + d \rightarrow \mu^+(\tau^+) + d$$

$$e^+ + He \rightarrow \mu^+(\tau^+) + He$$

Mini. E_{beam} for tau production

E_{beam} > 3.5 GeV for τ

E_{beam} > 2.6 GeV for τ

E_{beam} > 2.2 GeV for τ

- ✧ **2.5 GeV positron/electron beam incident on the targets**
- ✧ **Estimated luminosity reaches 10^{35} $cm^{-2}s^{-1}$ → 1 ab^{-1} /year**
  (Beam current of 600 mA, and target thickness of 5×10^{15} atom/cm^2

Rough estimations of the expected sensitivities for E_{beam}=2.5 GeV:

$$\sigma(e^\pm + p \rightarrow \mu^\pm + p) <\sim 30ab$$

$$\sigma(e^\pm + d \rightarrow \mu^\pm + d) <\sim 20ab$$

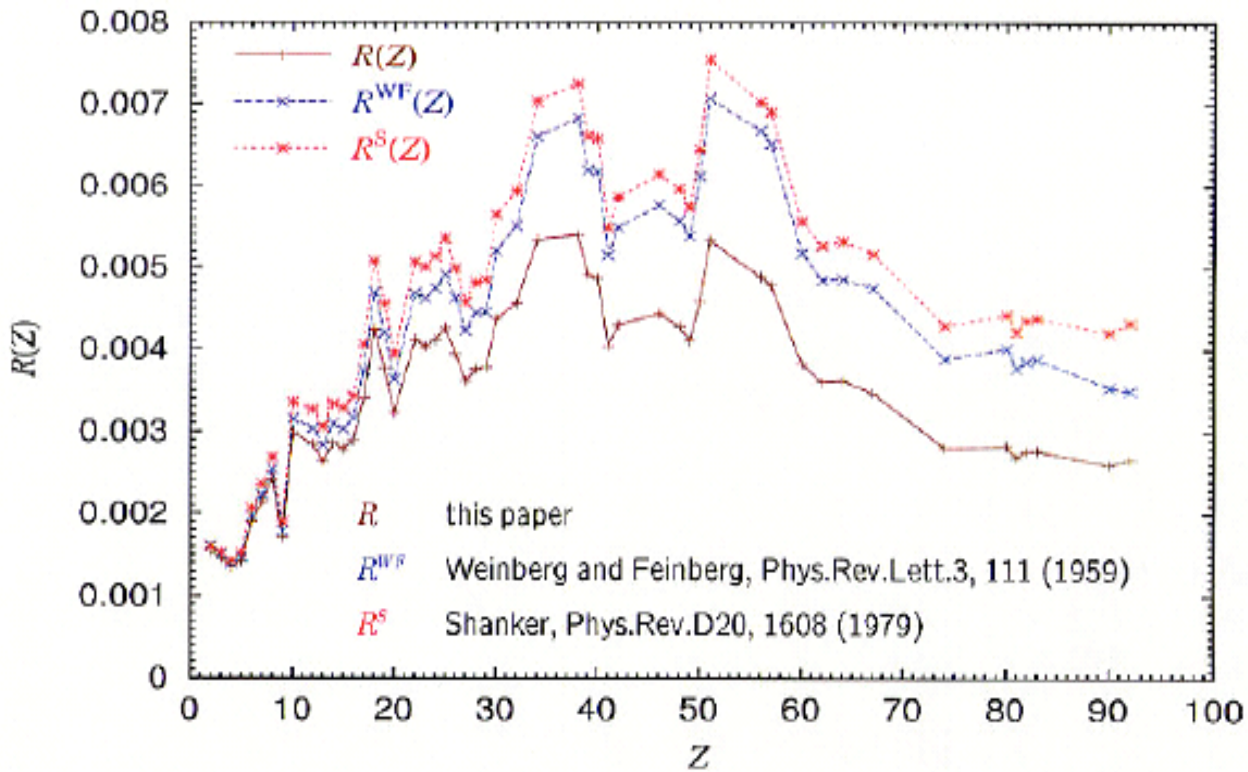
$$\sigma(e^\pm + He^4 \rightarrow \mu^\pm(\tau^\pm) + He^4) <\sim 10ab(0.1 - 1.0)fb$$

Argon or Nitrogen target should be better!

The QED and beam-related backgrounds should be studied, and theoretical estimations from different New Physics models are important!

Targets dependent production rates

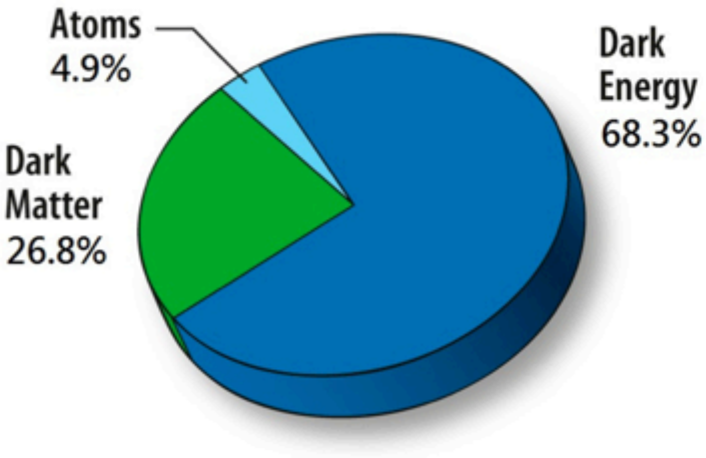
$R \equiv B_{\mu e}/B_{\mu \to e\gamma}$



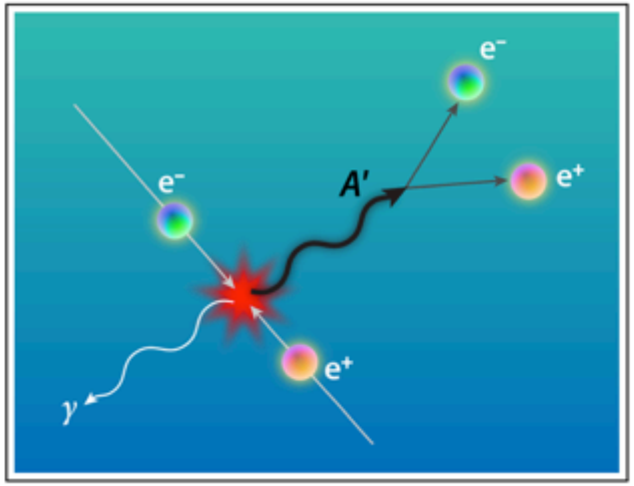
These results are valid for a photonic dipole operator as found in many SUSY models.

R. Kitano, M. Koike and Y. Okada, Phys. Rev. D66, 096002 (2002)

Search for dark photon at BEPCII



Wikipedia



APS/Alan Stonebraker

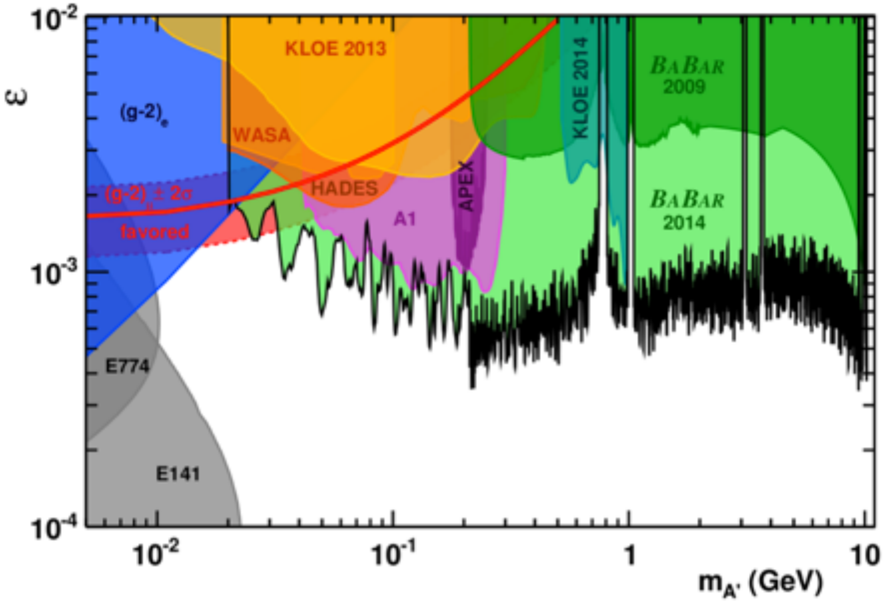
- One needs to extend the Standard Model to explain Dark Matter
- Additional $U'(1)$ symmetry is one of the simplest extensions:

$$\boxed{U(1)_Y \times SU(2)_W \times SU(3)_s} \times \boxed{U'(1)_D}$$

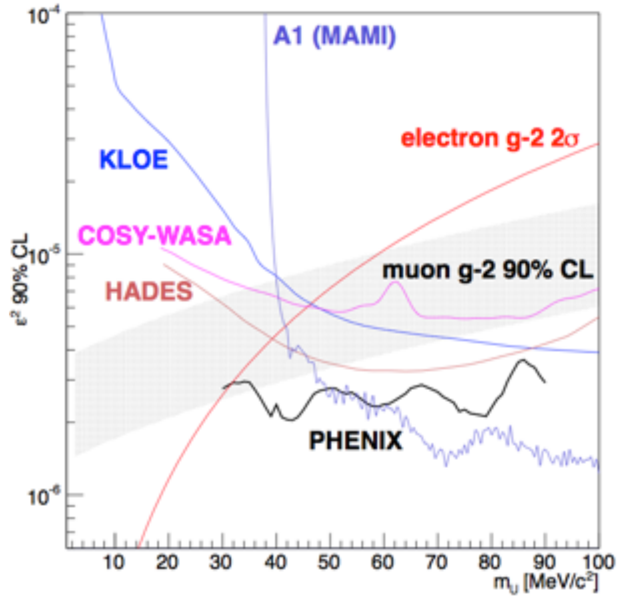
- It requires a new gauge boson, A' ("dark photon"), with the mass $m_{A'} > 0$
- A' may couple to SM particles via kinetic mixing with the photon
- Expected: $m_{A'} = 1 \ldots 10^4$ MeV, $\varepsilon = 10^{-6} \ldots 10^{-2}$ (kinetic mixing parameter)
- Both collider and fixed-target experiments can search for A'

Recent experimental constraints

BABAR (2014): $e^+e^- \to \gamma A', A' \to e^+e^-, \mu^+\mu^-$



PHENIX (2014): $\pi^0, \eta \to \gamma e^+e^-$



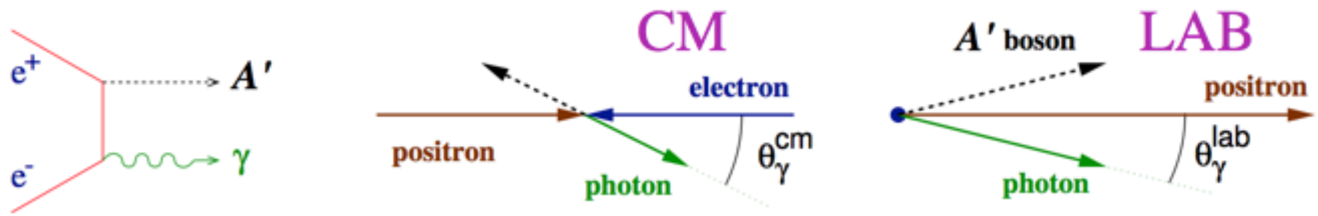
Recent experimental results (2013–2015):

WASA 2013	$\pi^0 \to \gamma(e^+e^-)$	PLB 726 (2013) 187
KLOE 2013	$\phi \to \eta(e^+e^-)$	PLB 720 (2013) 111
KLOE 2014	$e^+e^- \to \gamma(\mu^+\mu^-)$	arXiv:1404.7772
MAMI-A1 2014	$e^-N \to e^-N(e^+e^-)$	PRL 112 (2014) 221802
PHENIX 2014	$\pi^0, \eta \to \gamma(e^+e^-)$	arXiv:1409.0851
HADES 2014	$pN \to X(e^+e^-)$	PLB 731 (2014) 265
KLOE 2015	$e^+e^- \to \gamma(e^+e^-)$	arXiv:1501.05173

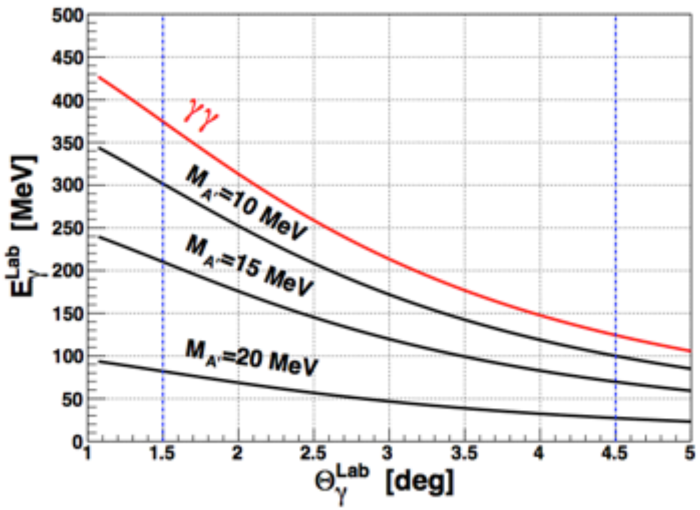
No evidence of A' so far!

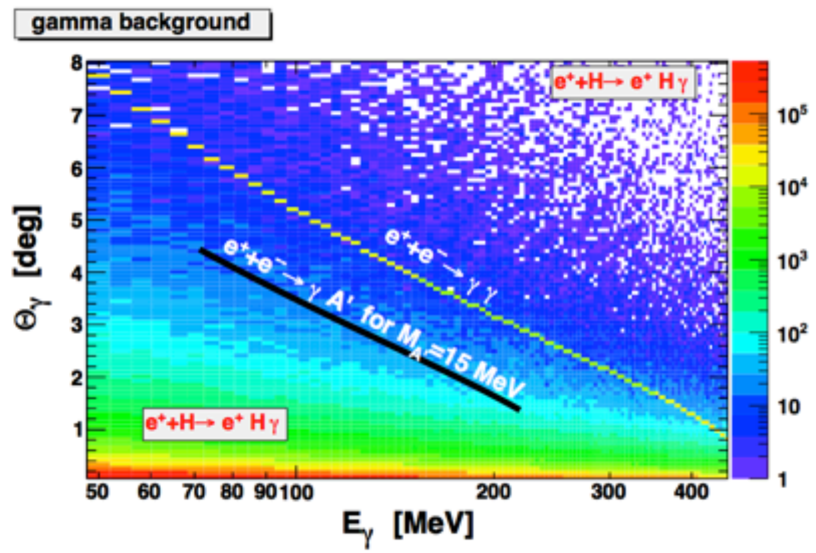
A' from the process $e^+e^- \to \gamma A'$

The process $e^+e^- \to \gamma A'$ is similar to the two-photon annihilation $e^+e^- \to \gamma\gamma$:



The photon energy, E_γ^{lab}, depends on its polar angle, θ_γ^{lab}, the mass of the second particles $(\gamma\ or\ A')$. In the case of $E_{beam} = 1.0 - 2.5\,GeV$ $(\sqrt{s} = 31.5 \sim 50\,MeV)$.



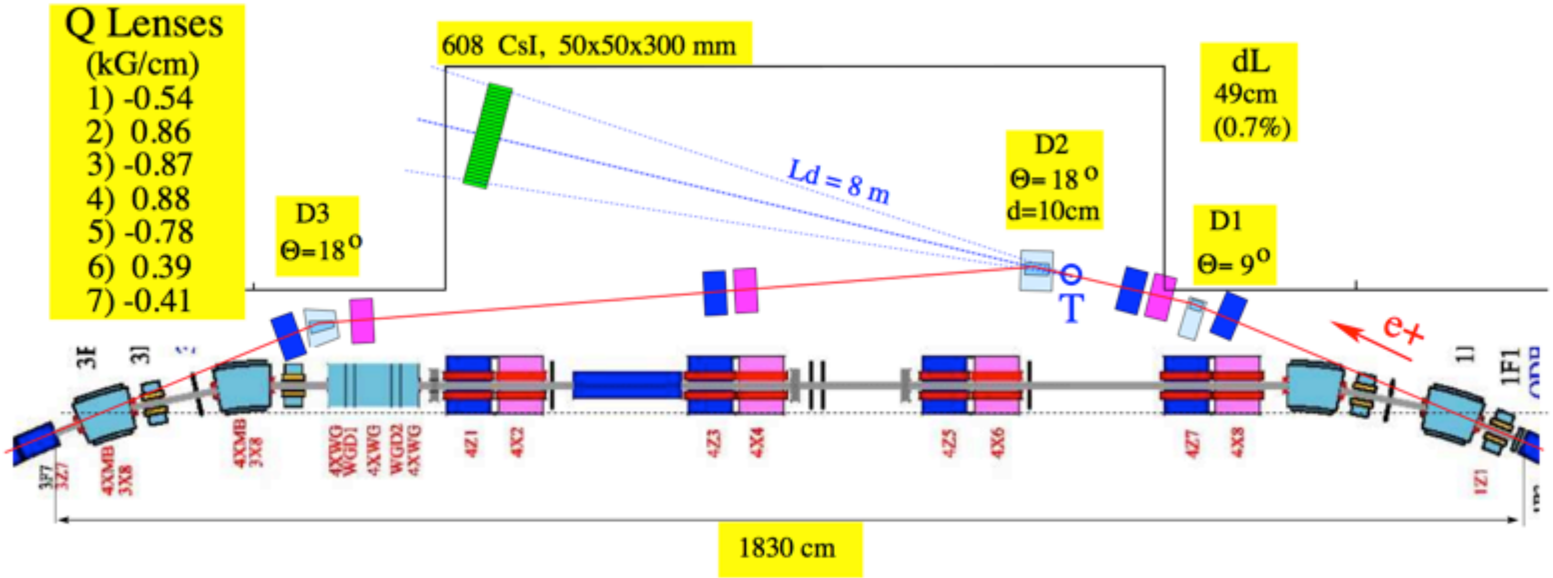


Therefore, one can search for dark photons measuring $E_\gamma\, and\, \theta_\gamma$ of the photon.
However, there are large QED backgrounds:

$$e^+p \to e^+p(\gamma),\ e^+e^- \to e^+e^-(\gamma),\ e^+e^- \to \gamma\gamma(\gamma).$$

Concept of the experimental technique

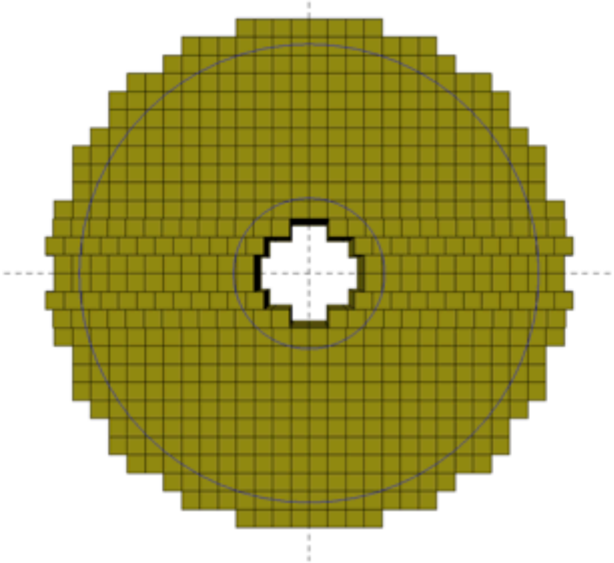
Example of the concept design from VEPP3 (arXiv:1207.5089)

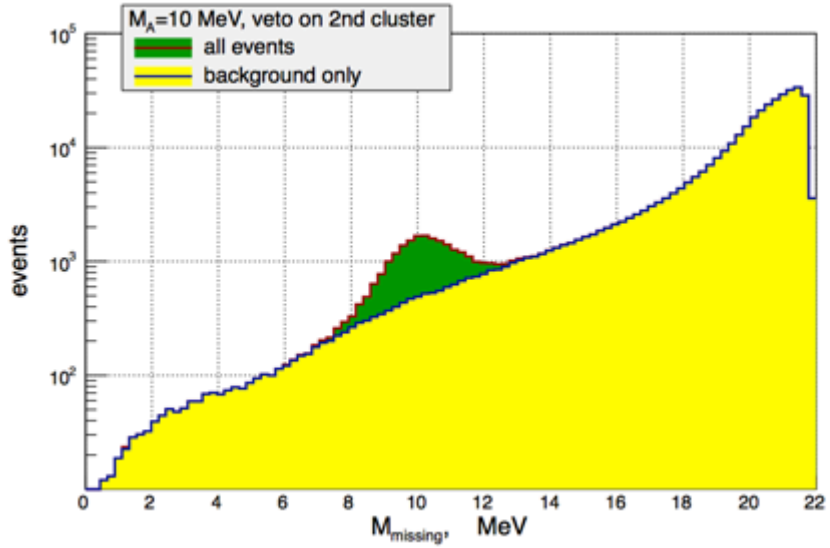


- ✧ **2.0 GeV positron beam incident on an internal hydrogen target**
- ✧ **Estimated luminosity reaches 10^{35} cm^{-2}s^{-1}**
  (Beam current of 600 mA, and target thickness of 5×10^{15} atom/cm^2
- ✧ **New bypass bending the beam and directing photons to the calorimeter**
- ✧ **Segmented EM calorimeter placed at a distance of 8-10 m from the target**

Concept of the experimental technique

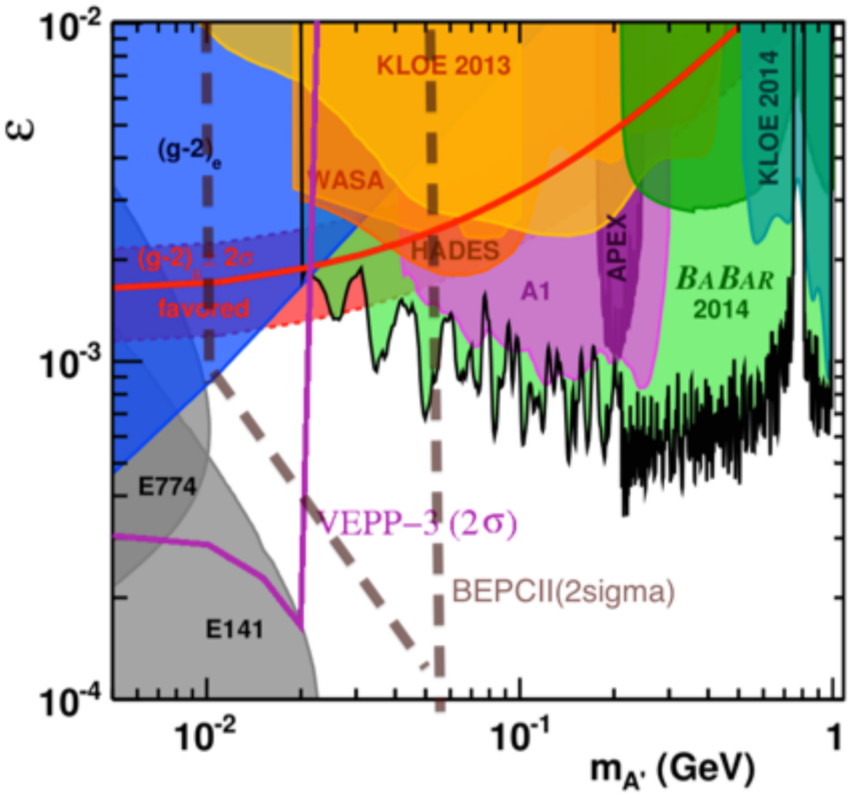
Example of the concept design from VEPP3 (arXiv:1207.5089)





- Energy resolution required: $\sigma_E/E < 0.5\%\ for\ E_\gamma = 100 - 600 MeV.$
- Angular acceptance: $\theta_\gamma = 1.5^0 - 5.0^0$ (corresponding to $\theta_\gamma^{CM} = 90^0 \pm 30^0$)
- 800 crystals from BESIII?
- The peak width is determined by the calorimeter resolutions
- An accurate Monte Carlo simulation of the QED background is required
- Some of the background processes can be substantially suppressed
- The experiment will cover a mass range $m_{A'} = 10 - 40\, MeV.$

Sensitivity of the BEPCII experiments



If there is a light dark matter particle, χ, with the mass $m_\chi < 0.5 m_{A'}$, then the invisible decay $A' \to \chi\bar{\chi}$ can be dominant!

Existing constraints:

- $(g-2)$ of the muon
- $(g-2)$ of the electron
- BaBar: $\Upsilon(1S) \to \gamma A'$
- BNL: $K \to \pi A'$

Proposed new measurements:

	$\mathcal{L}$, $cm^{-2}s^{-1}$	Duration, s
VEPP-3	10^{33},	10^7
CESR	10^{34},	10^7
DAΦNE	10^{28},	$2 \cdot 10^7$
DarkLight	$6 \cdot 10^{35}$	$2 \cdot 10^6$
BEPCII	**1 10^{35}**	**10^7**

Summary

- Possibilities of physics programs are discussed at BEPCII with internal thin gas targets after BESIII shutdown
- Among them, cLFV, dark photon, and charge radius of proton are competitive and strong motivated.
- We need detailed MC simulations to dig out important physics which should be done as soon as possible
- BEPCII was there, cost of these projects will be relative cheap, and the BEPCII life time will be extended, and we may achieve more important physics.
- A proposal should be considered before BESIII shutdown, and some of them may run simultaneously with BESIII.

Thanks for many useful discussions with Jianping Chen, Haiyan Gao, Jianping Ma, Feng Yuan, Alexander V. Gramolin, Marc Vanderhaeghen and Wei Liao !

Preliminary discussions

- Refine/optimize physics
- Detectors: many arms (forward, SA, MA, LA)
- Internal gas targets (polarization):
  atomic beam sources, polarimeter, scattering chamber
- The luminosity monitor
- Upgrade of BEPCII?
- Prepare framework for MC simulations
- Collaboration between theorists and experimenters
- A focused workshop at IHEP in Beijing?

Thanks!