WG7 Highlights: Future Experiments

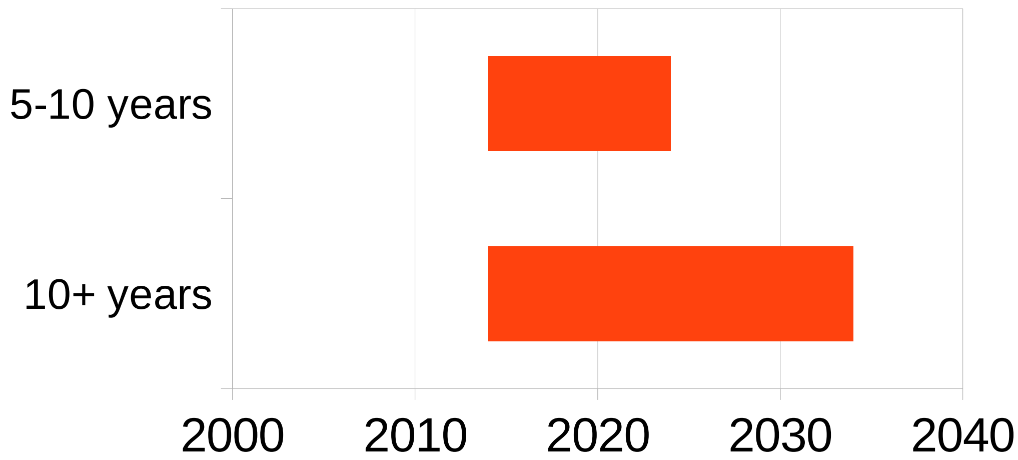
Conveners:
Alexei Prokudin, Abhay Deshpande, Alice Valkarova

May 2, 2014

WG7

32 extremely well prepared talks

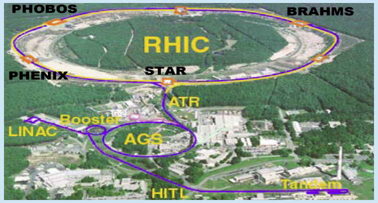
10 existing and future facilities represented



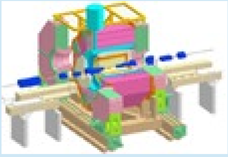
I greatly appreciate conversations with
Abhay Deshpande, Pawel Nadel-Turonski, Ernst Sichtermann, Alice Valkarova
during preparation of this summary

WG7: Facilities

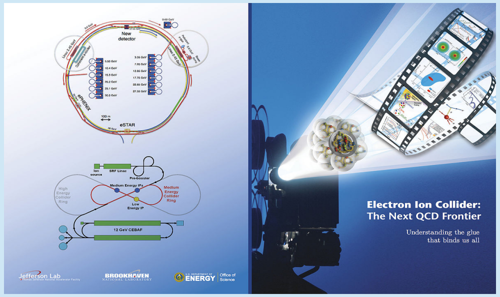
BNL:
sPHENIX,
ePHENIX, eSTAR



KEK:
BELLE II



Electron Ion Collider
eRHIC(BNL) MEIC(JLAB)



CERN:
LHC, LHCb, ATLAS,
COMPASS,NA62,
LHeC, AFTER@LHC,
FCC

JLAB: JLAB 12,
HALL A,B,C,D

CERN

LHC: ATLAS, LHCb

COMPASS, NA62

LHeC, AFTER@LHC, FCC

LHC

*"Europe's top priority should be **exploitation of the full potential of the LHC**, including the high-luminosity upgrade of the machine and detectors with a view to **collecting ten times more data** than in the initial design, by around 2030."*

European Strategy for Particle Physics

Current luminosity $L \sim 10^{33}\ (\mathrm{cm}^{-2}\mathrm{s}^{-1})\quad \int L \sim 30\ (\mathrm{fb}^{-1})$

Planned $L \sim (1 \div 5) \cdot 10^{34}\ (\mathrm{cm}^{-2}\mathrm{s}^{-1})$

$$\sqrt{s} = 13 \sim 14\ (\mathrm{TeV})$$

ATLAS Upgrade: Diane CINCA, Julio VIEIRA DE SOUZA

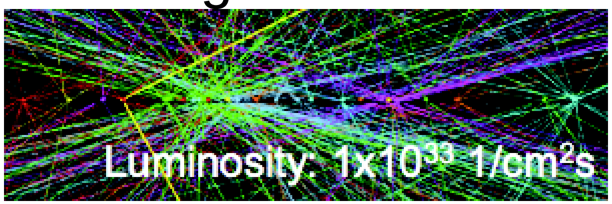
LHCb Upgrade: Tomasz SZUMLAK

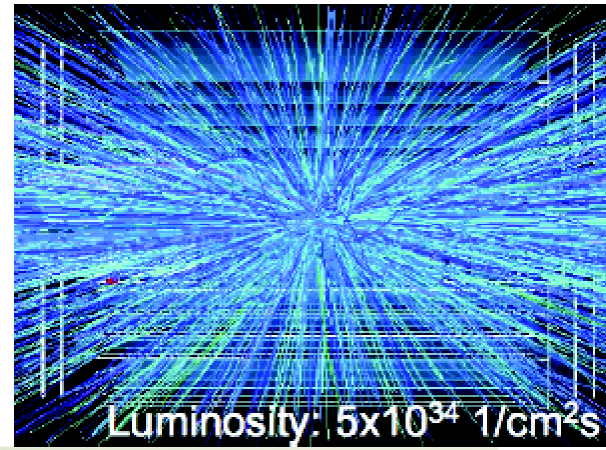
ATLAS Upgrades

Study EWSB Mechanism
Probe for signatures of New Physics
Measure rare decay modes

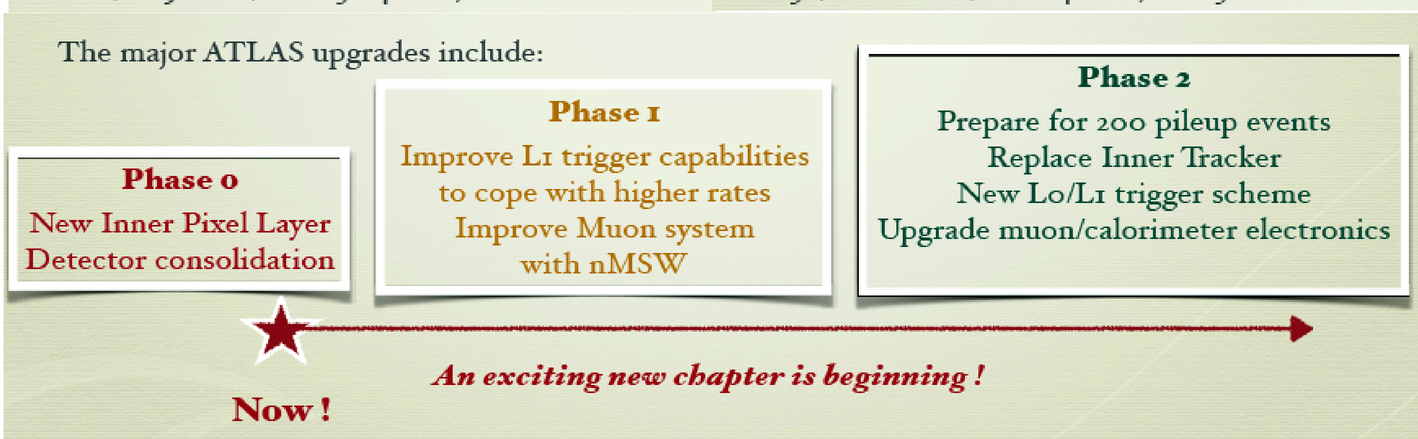
Diane CINCA, Julio VIEIRA DE SOUZA

The challenge:





Run 2 (2015-2018): $\sqrt{s}$=13-14 TeV, L~1.10^{34} cm^{-2}s^{-1} Run 3 (2020-2022): $\sqrt{s}$=14 TeV, L~2-3.10^{34} cm^{-2}s^{-1}



Example

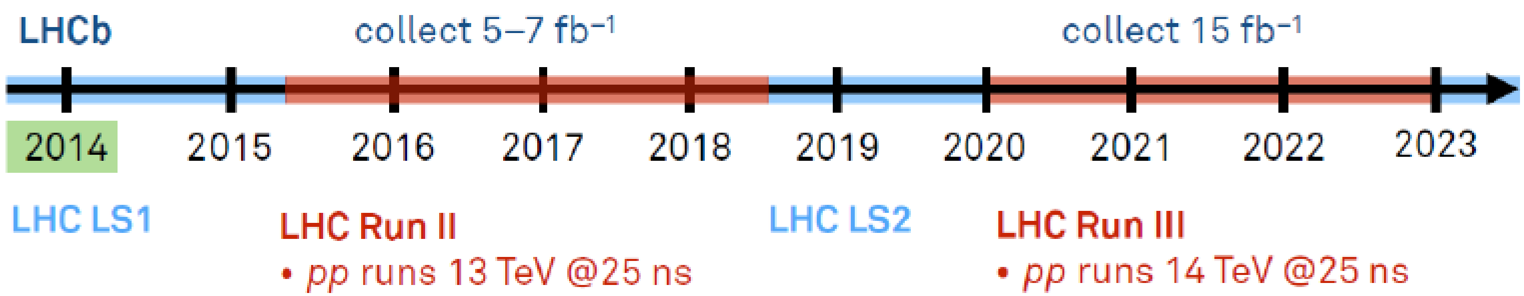
- Higgs-top coupling can be measured to about 10%

LHCb Upgrades

Tomasz SZUMLAK

Physics Programme

- *CP* violation
- rare decays
- electroweak physics
- lepton flavour violation
- charm physics
- production and spectroscopy



Upgrade target

- ❑ full event read-out@40 MHz (flexible approach)
- ❑ completely new front-end electronics needed (on-chip zero-suppression)
- ❑ redesign DAQ system

Example

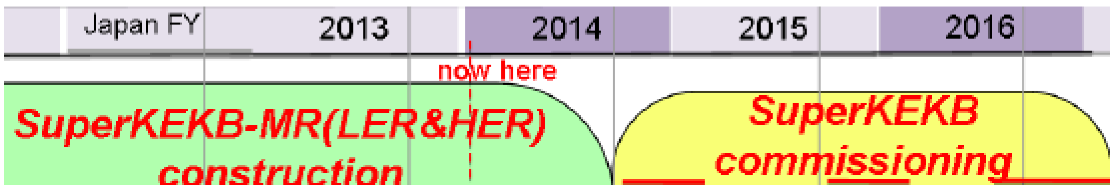
Observable	Current precision	LHCb (5 fb^{-1})	Upgrade (50 fb^{-1})	Theory uncertainty
$S(B_s \to \phi\phi)$	-	0.08	0.02	0.02

KEK: BELLE II

BELLE II

Maria ROZANSKA

SuperKEKB – major upgrade of the KEKB *B* factory at KEK (Tsukuba)



$L = 8 \times 10^{35}\ \mathrm{cm^{-2}s^{-1}}$

$E(e^+) = 4$ GeV, $E(e^-) = 7$ GeV

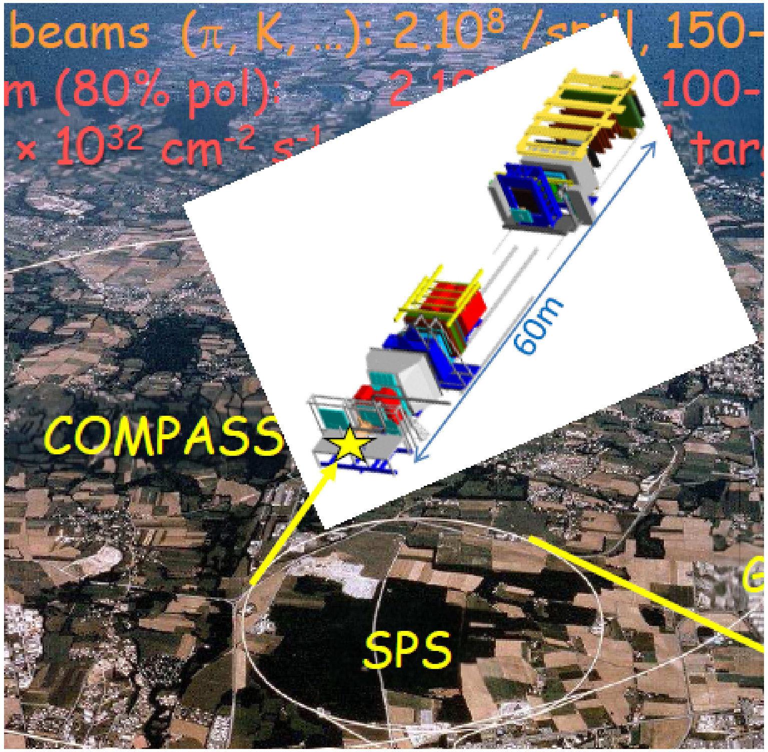
Belle II – upgraded Belle detector

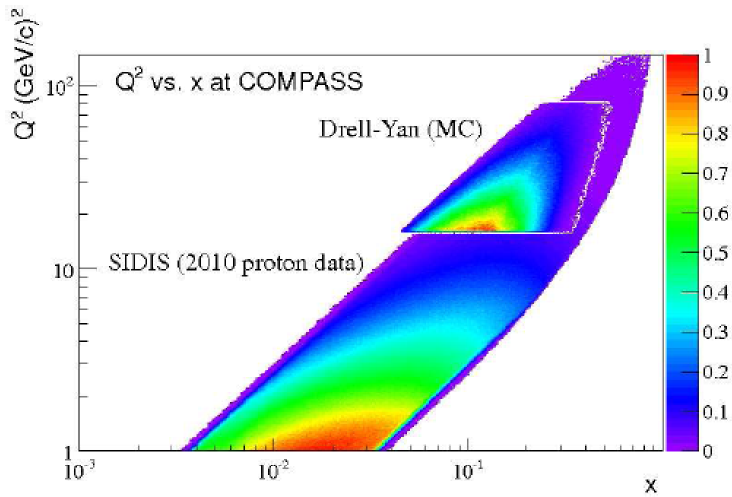
to accumulate $L_{int} \approx 50\ \mathrm{ab^{-1}}$ by 2022

55 billion $B\bar{B}$ pairs, 47 billion $\tau^+\tau^-$ pairs

Complementary to direct searches of NP in energy frontier: Indirect searches of NP in rare decays

COMPASS II





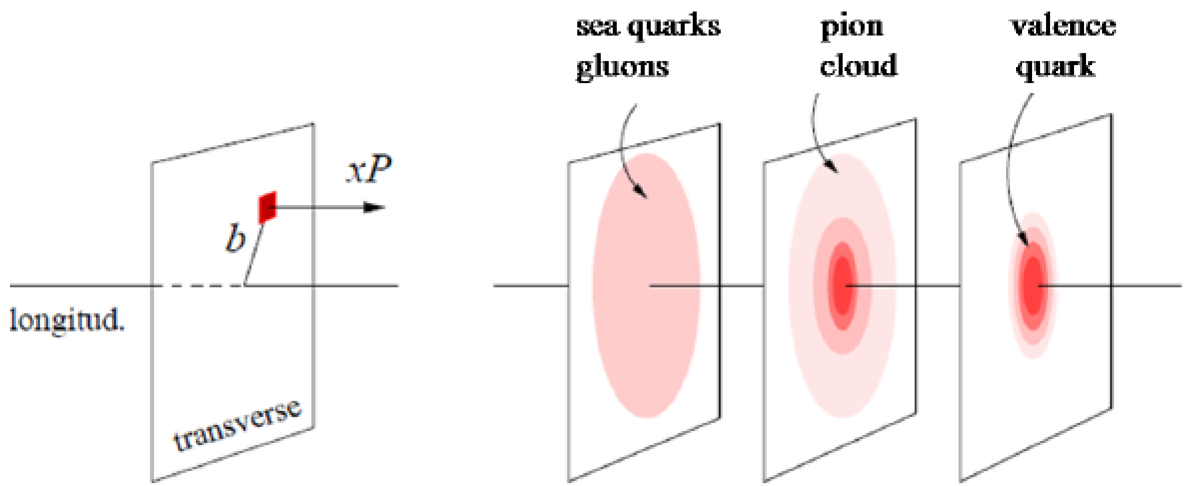
Eva-Maria KABUSS
Catarina QUINTANS

$$L \sim 5 \cdot 10^{32}\ (\mathrm{cm}^{-2}\mathrm{s}^{-1})$$

Polarised target

DVCS data taking in 2016/17

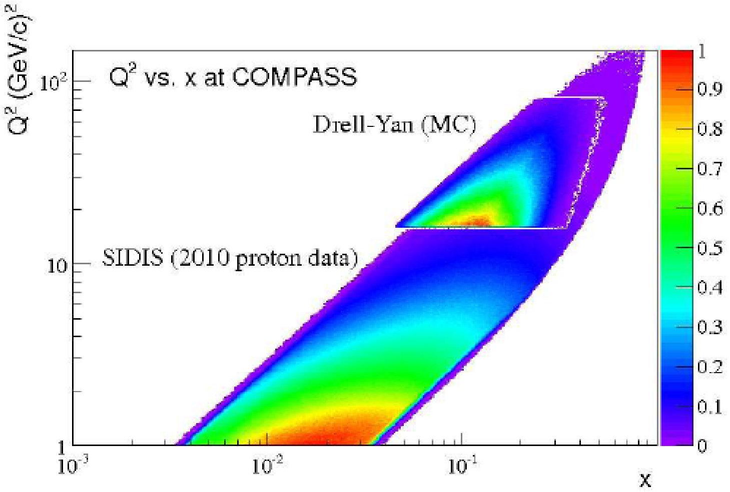
Nucleon tomography



COMPASS II approved
for initially 3 years of data taking
in 2015 – 2017

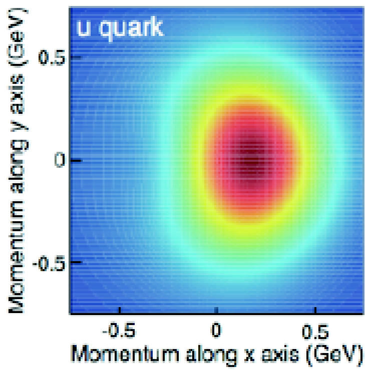
– new target region for DVCS
– hadron absorber and target
for Drell-Yan

COMPASS II

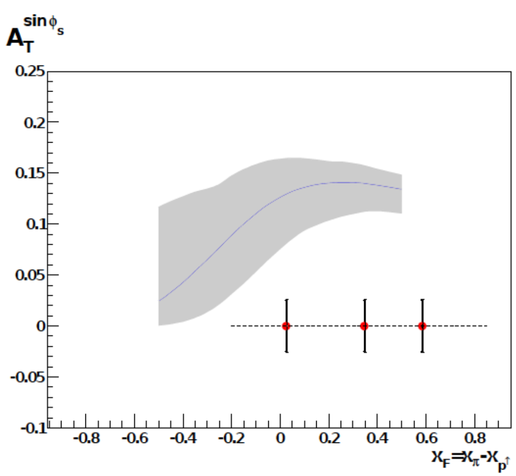


Eva-Maria KABUSS
Catarina QUINTANS

The COMPASS Drell-Yan measurement will start in October this year, and continue during the whole 2015 Run.



The goal: nucleon tomography, 3D partonic structure in momentum space. Confirmation of a fundamental QCD prediction of a sign change due to initial-final state interactions

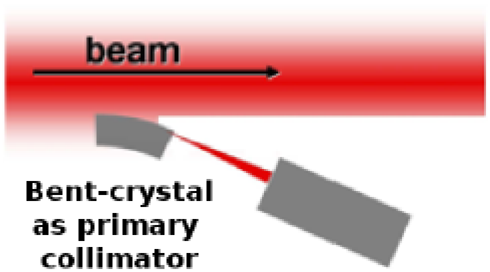


AFTER@LHC

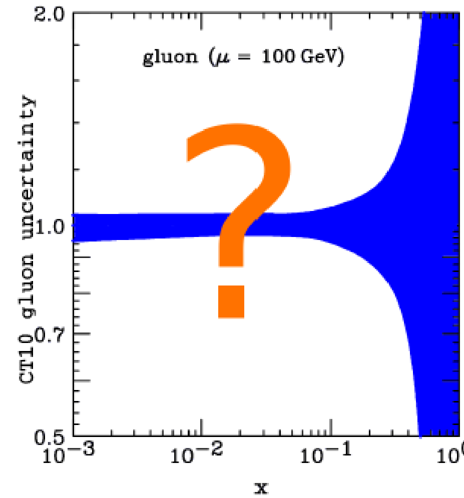
Jean-Philippe Lansberg

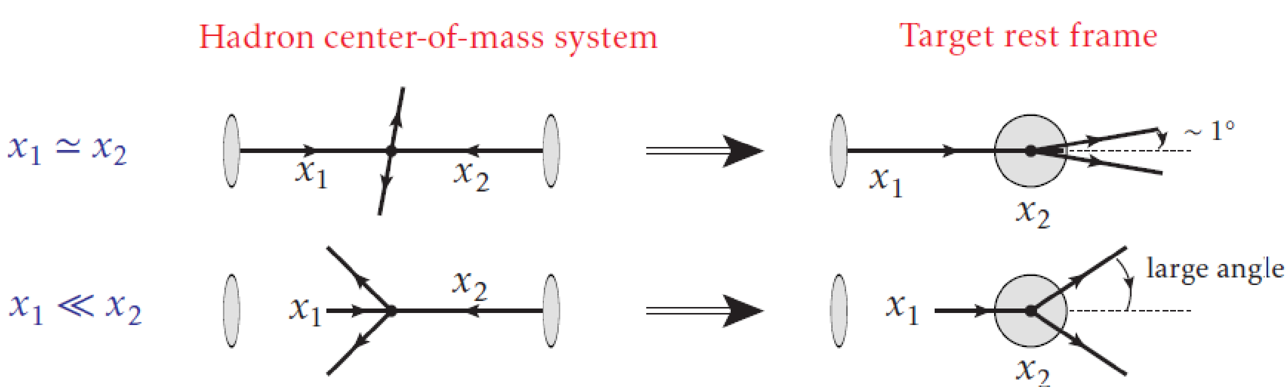
Precision proton-proton and proton-nucleus collision studies at A Fixed-Target ExpeRiment at the LHC (AFTER@LHC)

$\sqrt{s} = \sqrt{2m_N E_p} \simeq 115$ GeV   7 TeV p $\mathcal{L}_{H_2/D_2} \simeq 20\ \text{fb}^{-1} y^{-1}$



Accessing large-x gluons





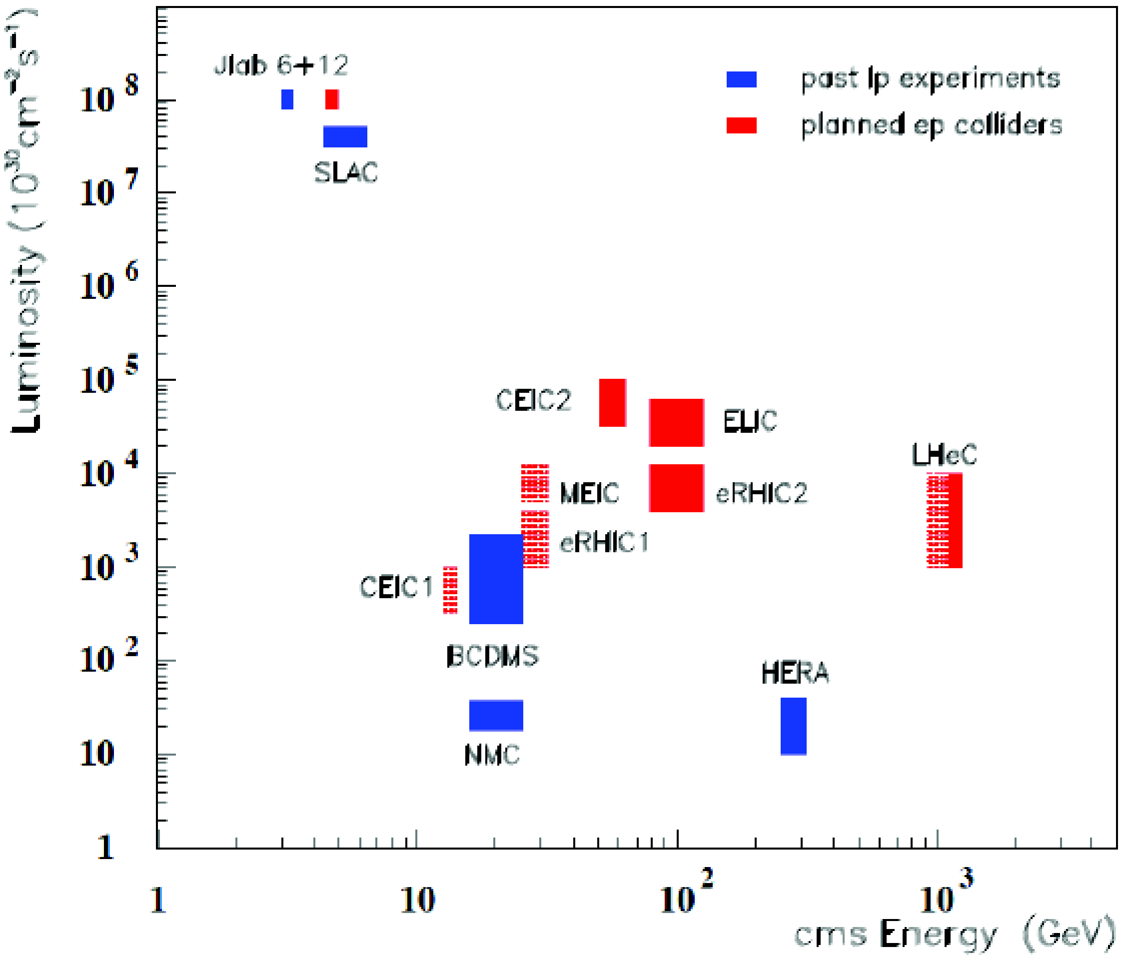
backward physics = large-x_2 physics

Important for high-mass BSM particle searches:

$$M^2 \sim x_1 x_2 s$$

LHeC

Emilia CRUZ ALANIZ
Christian SCHWANENBERGER
Voica Ana Maria RADESCU
Guilherme MILHANO
Monica D'ONOFRIO
Paul NEWMAN
Matthew WING



- Lepton-hadron scattering at the TeV centre of mass scale (60 GeV electrons x LHC protons & ions)

- High luminosity: 10^{33} - 10^{34} cm^{-2} s^{-1}

- Runs simultaneous with ATLAS / CMS in post-LS3 HL-LHC period

LHeC

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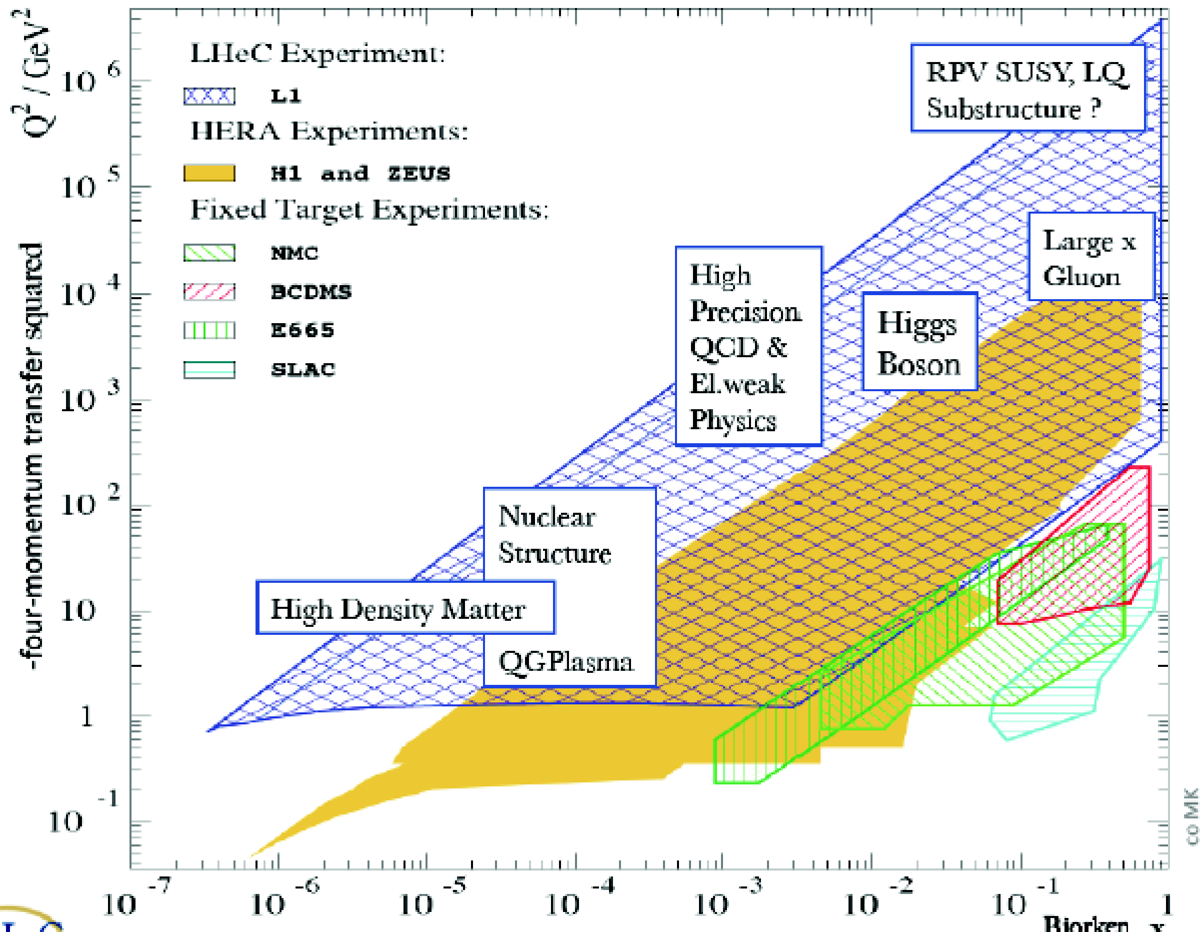
Christian SCHWANENBERGER
Voica Ana Maria RADESCU
Guilherme MILHANO
Monica D'ONOFRIO
Paul NEWMAN
Matthew WING



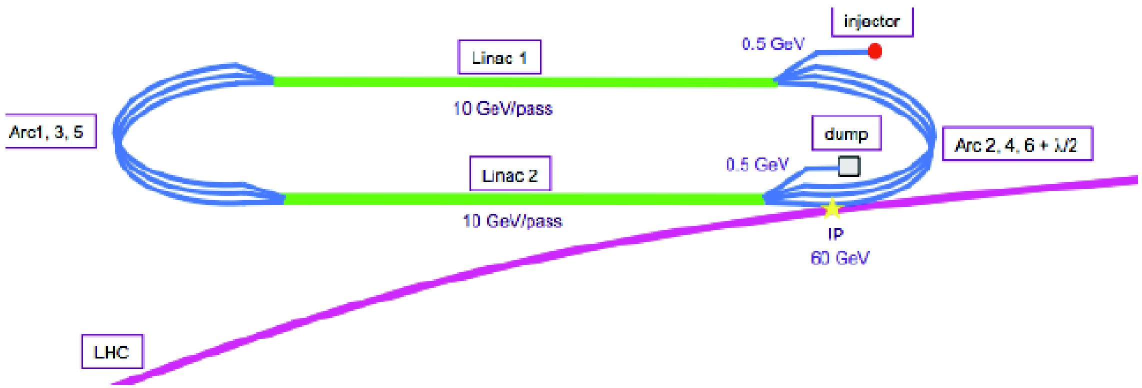
Varied physics goals require precise measurements throughout kinematically accessible region.

3

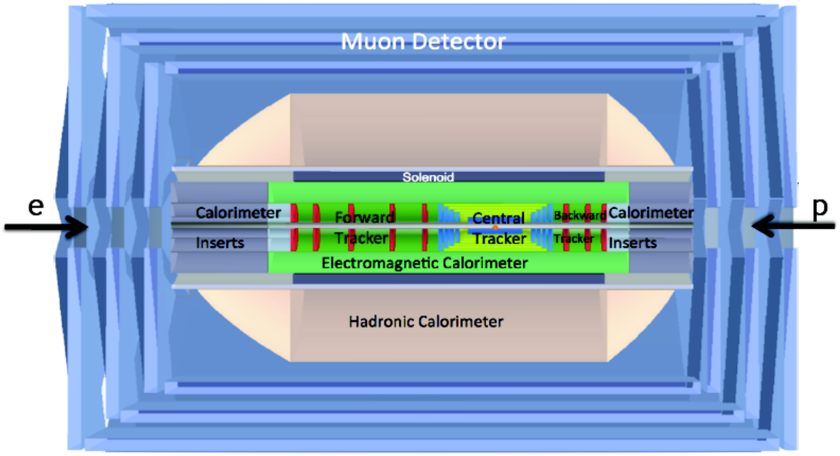
Emilia CRUZ ALANIZ Paul NEWMAN

Ring-Ring option, feasible but impact LHC operation during installation

Linac-Ring option, the baseline solution exists, will now have to find the best solution



Detector designed to fulfill physics

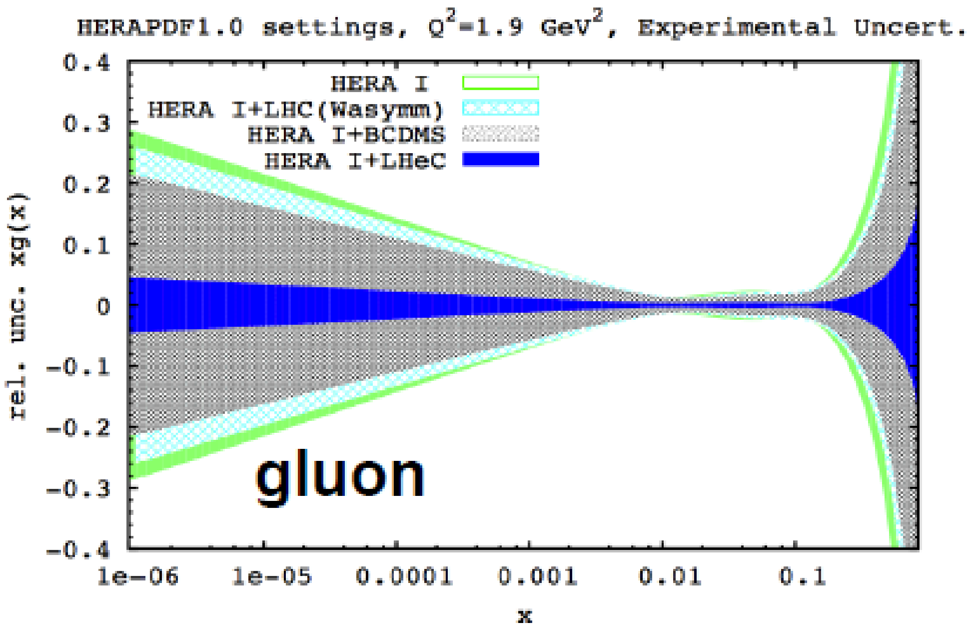


Strong collaboration with US laboratories

LHeC

Voica Ana Maria RADESCU

Impact on gluon distribution precision:



Monica D'ONOFRIO

Higgs couplings:

Hbb coupling measurements with

1% statistical precision (1 ab^{-1})

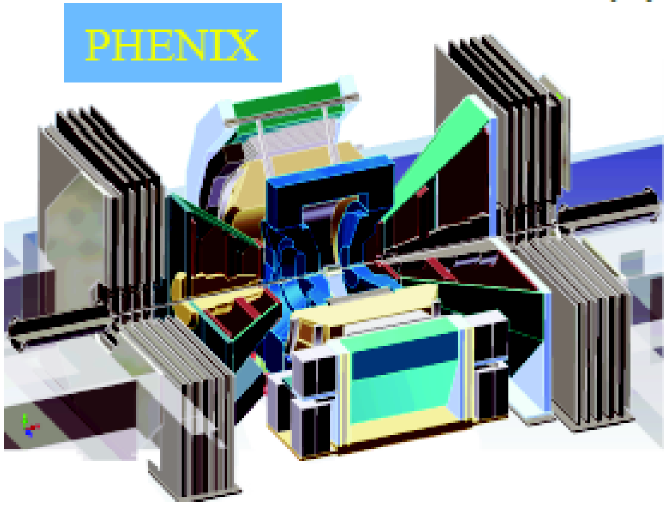
in 10 years of operation

BNL: RHIC

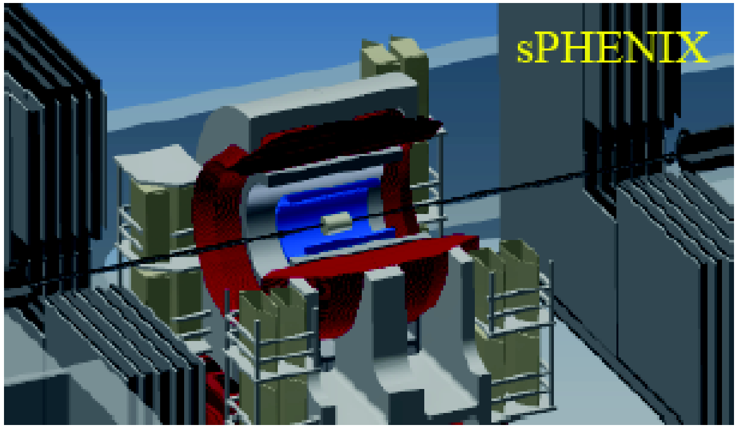
sPHENIX+fsPHENIX

Alexander BAZILEVSKY
John LAJOIE

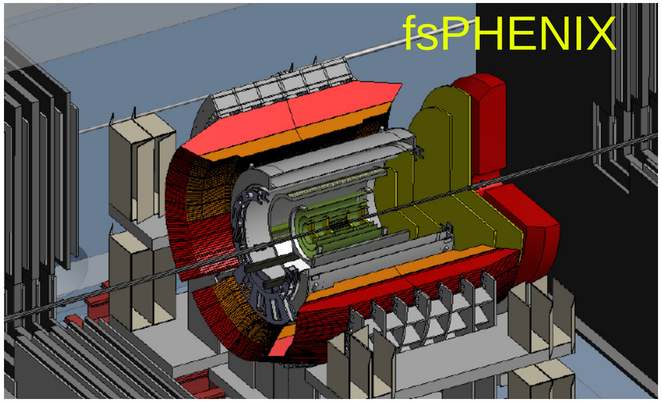
PHENIX → sPHENIX (2020)



By ~2020



New detector based on BaBar magnet around PHENIX



2021-2022	• Long 200 GeV Au+Au w/ upgraded detectors • p+p/d+Au at 200 GeV	• Jet, di-jet, γ-jet probes of parton transport and energy loss mechanism • Color screening for different QQ states	• sPHENIX

- Drell-Yan

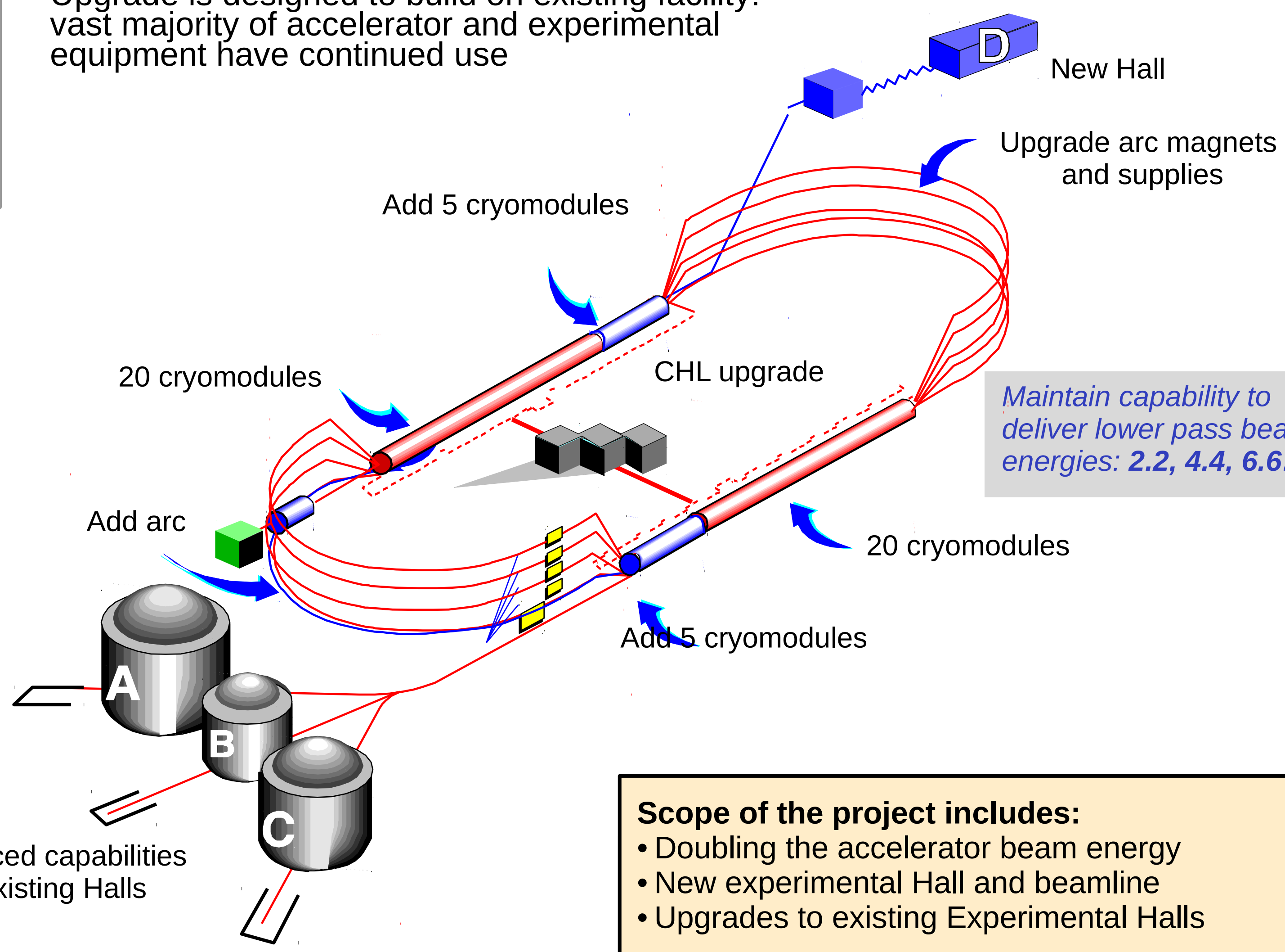
JEFFERSON LAB

12 GeV Upgrade Project

Highest priority in the 2007 NSAC Long Range Plan.

12 GeV electrons

Upgrade is designed to build on existing facility: vast majority of accelerator and experimental equipment have continued use



Maintain capability to deliver lower pass beam energies: ***2.2, 4.4, 6.6….***

Scope of the project includes:
- Doubling the accelerator beam energy
- New experimental Hall and beamline
- Upgrades to existing Experimental Halls

JLab: 21st Century Science Questions

- What is the role of gluonic excitations in the spectroscopy of light mesons? Can these excitations elucidate the origin of quark confinement?

- Where is the missing spin in the nucleon? Is there a significant contribution from valence quark orbital angular momentum?

- Can we reveal a novel landscape of nucleon substructure through measurements of new multidimensional distribution functions?

- What is the relation between short-range N-N correlations and the partonic structure of nuclei?

- Can we discover evidence for physics beyond the standard model of particle physics?

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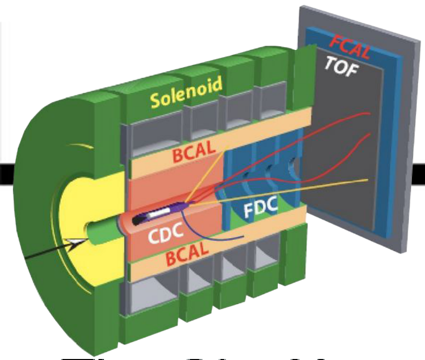


JLAB: GlueX in HALL D

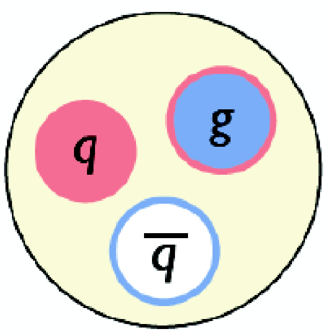
GlueX
CITATIONS
PERIMENT
Hall D@JLab

Justin Stevens

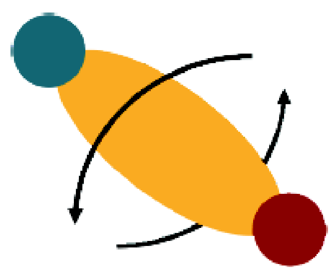
The GlueX experiment in Hall D at JLab is designed to search for and study hybrid mesons for which a rich spectrum is predicted by Lattice QCD

- Some have “exotic” J^{PC} which cannot be formed by $q\bar{q}$:

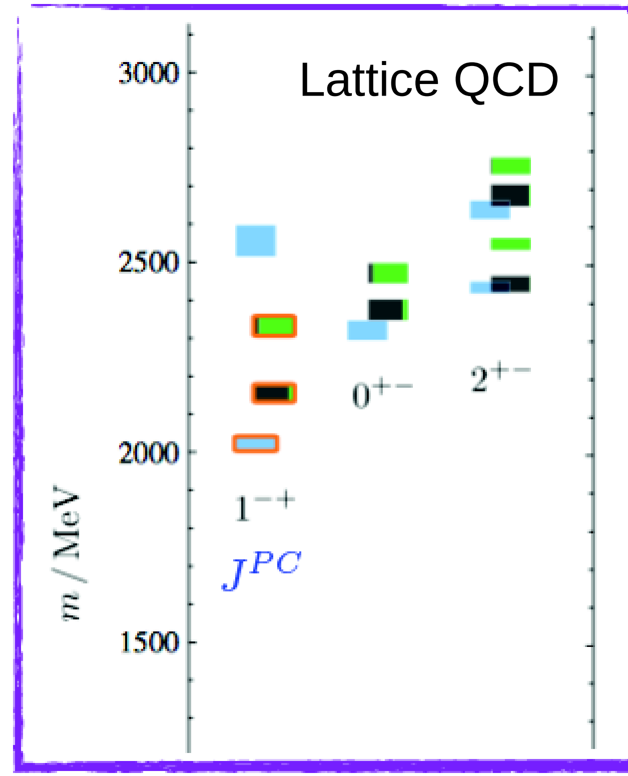
$$J^{PC} = 0^{+-}, 1^{-+}, 2^{+-} \ldots$$



Hybrid Meson



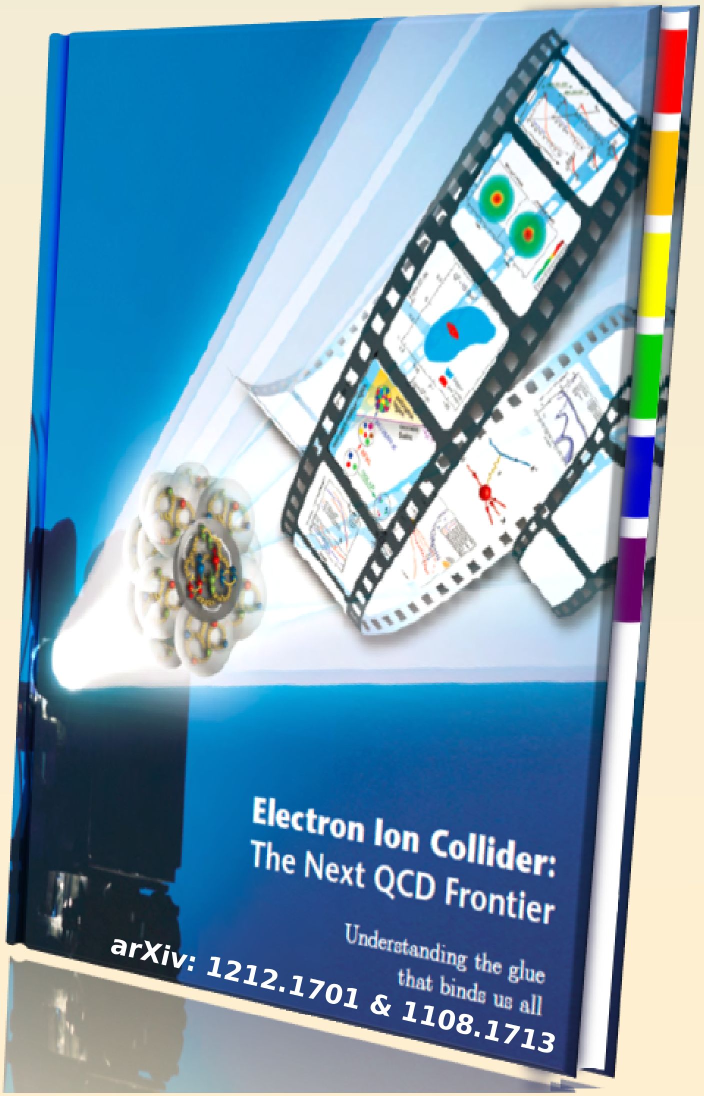
$$\vec{J} = \vec{L} + \vec{S}$$
$$P = (-1)^{L+1}$$
$$C = (-1)^{L+S}$$



- Expect first physics data in 2015 and full intensity running in 2017

ELECTRON ION COLLIDER

Electron Ion Collider in the USA



Broad agreement of nuclear physics community that the next facility should be Electron Ion Collider

– high luminosity

$$L \sim 10^{33} \div 10^{34}\ (\mathrm{cm}^{-2}\mathrm{s}^{-1})$$

– energy range

$$\sqrt{s} = 20 \div 140\ (\mathrm{GeV})$$

– polarized, longitudinal and transversed, for the proton, deuterium, He3

– Ion beams up to U or Pb

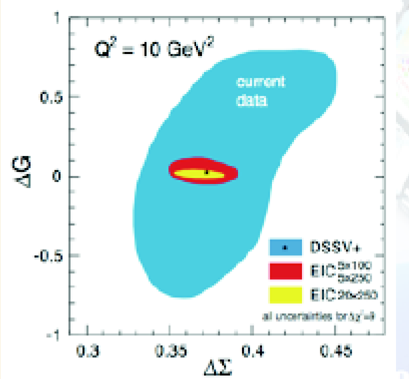
– wide acceptance detector and good PID

Elke ASCHENAUER, Pawel NADEL-TURONSKI

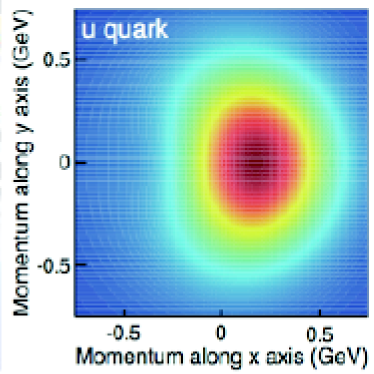
Electron Ion Collider in the USA

Physics driven design

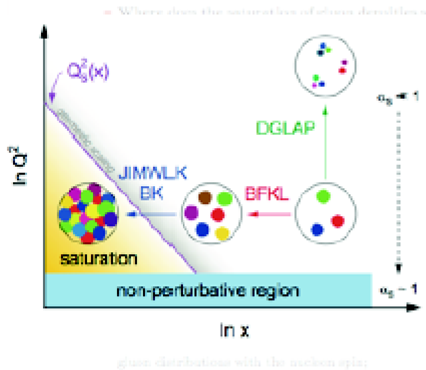
EIC White Paper arXiv:1212.1701



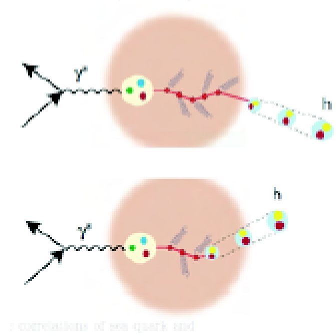
Gluon spin



3D tomography of the nucleon



Dynamics of color fields in nuclei



Emergence of hadrons from color charge

… prospects of EW and BSM physics under study

Elke ASCHENAUER
Pawel NADEL-TURONSKI
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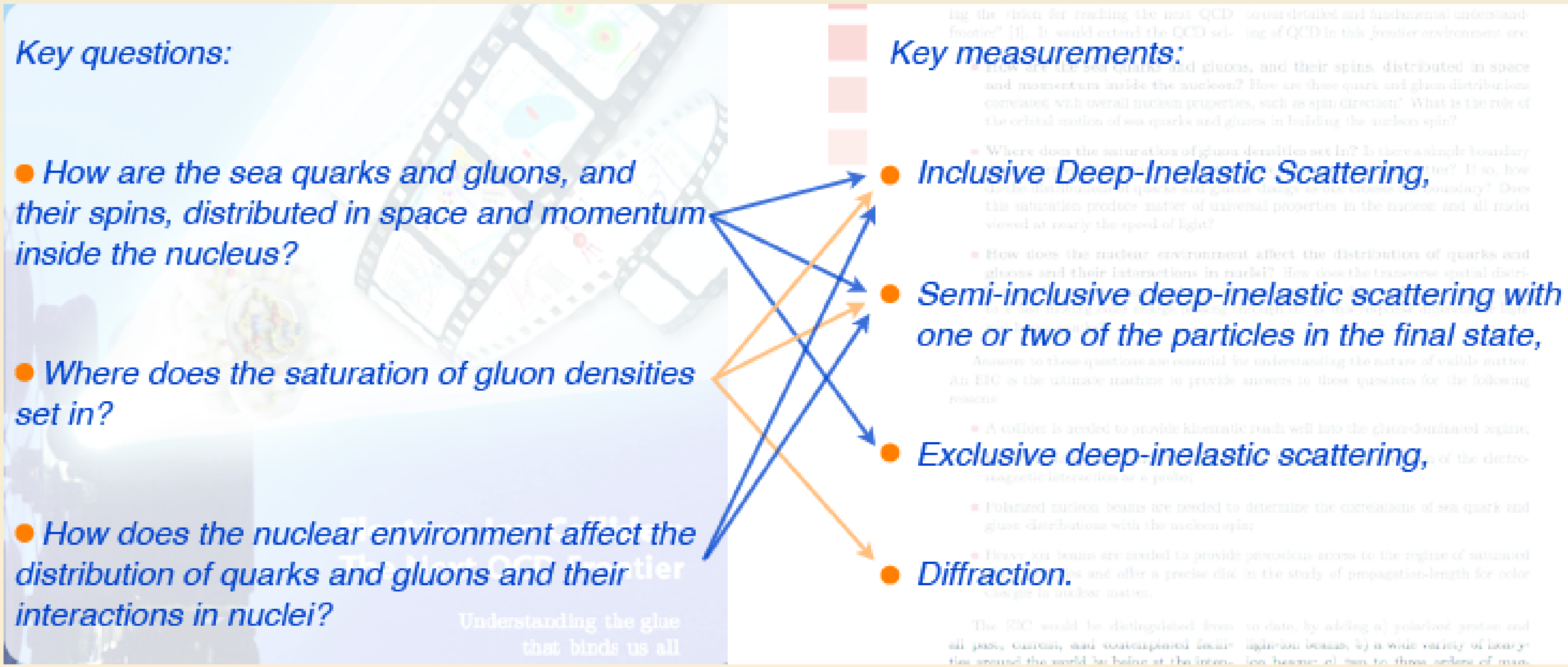

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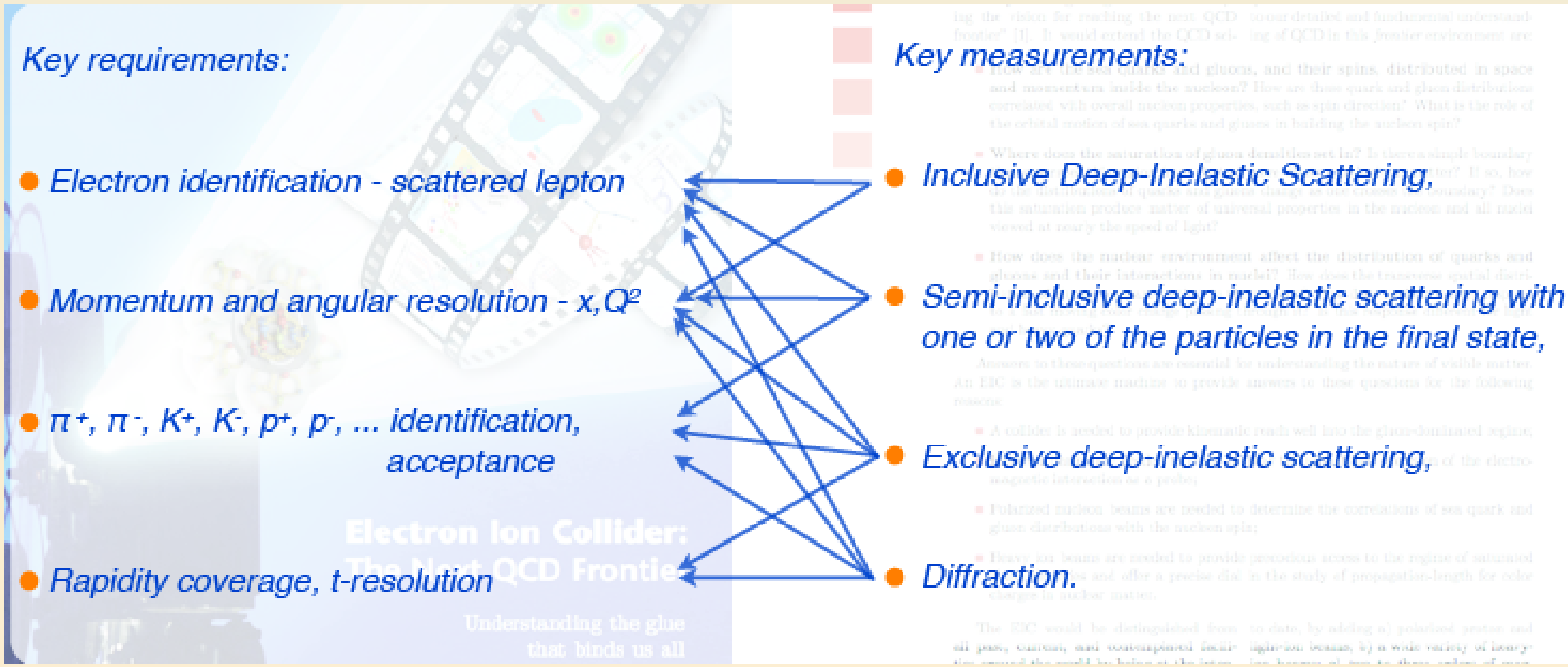

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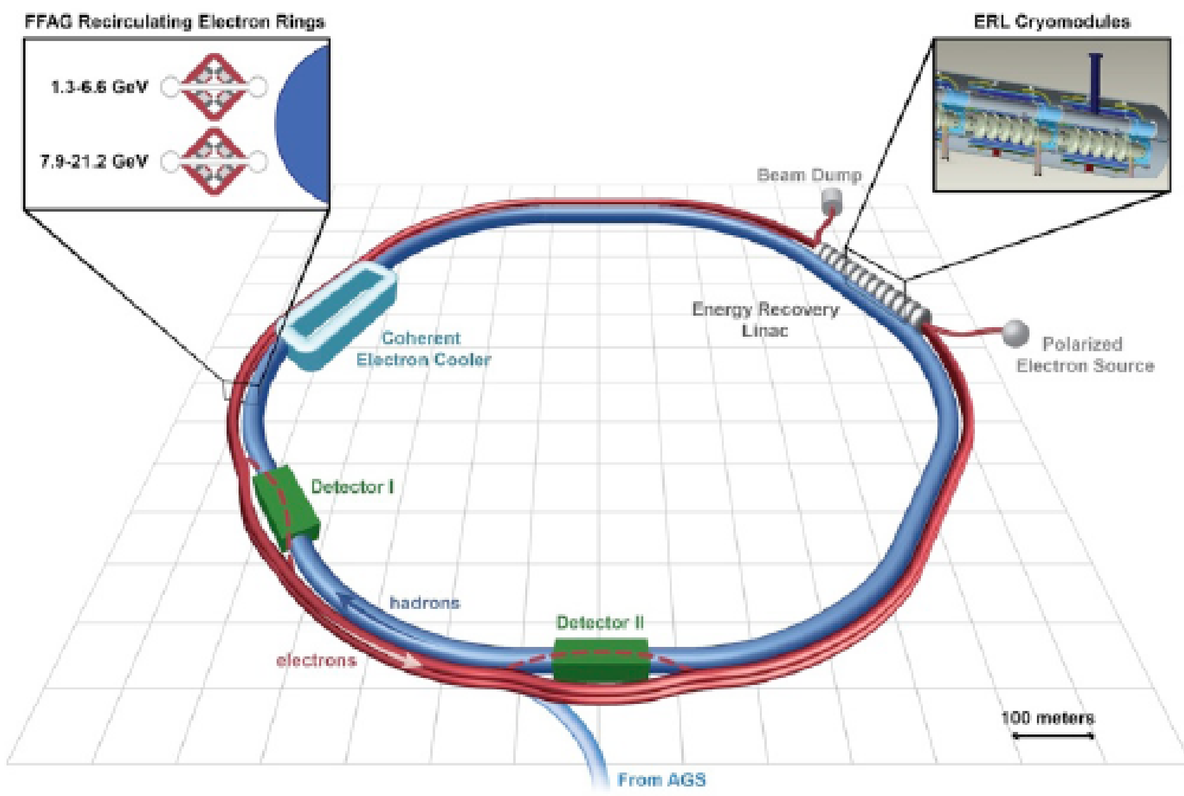
Thomas BURTON

eRHIC at BNL

eRHIC: add an electron accelerator to the existing RHIC

Elke ASCHENAUER
Alexander BAZILEVSKY
Ernst SICHTERMANN
Alexander KISELEV

ep/eA



In current design:

Energy:
- Electron: 6.6–21.2 GeV
- Proton: 25–250 GeV
- Ions: 10–100 GeV
- √s: up to 145 GeV

Polarization:
- Electrons: 80%
- Protons and He3: 70%

Luminocity:
- $>10^{33}$ cm^{-2} s^{-1}

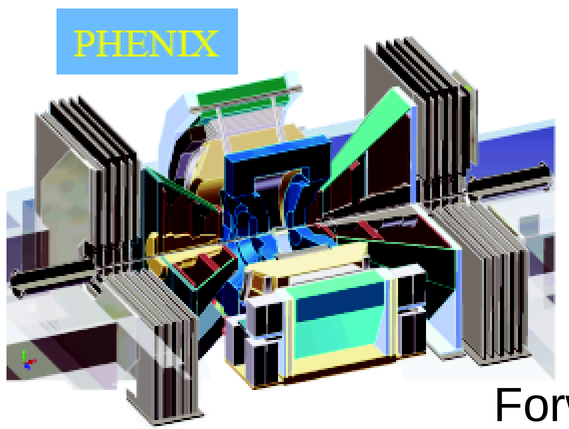
… Still evolving

ePHENIX

"An Electron Ion Collider Detector built around the BaBar detector"

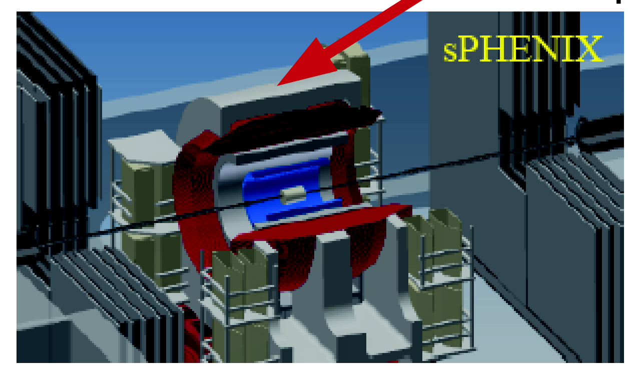
Alexander BAZILEVSKY

PHENIX -> ePHENIX Path



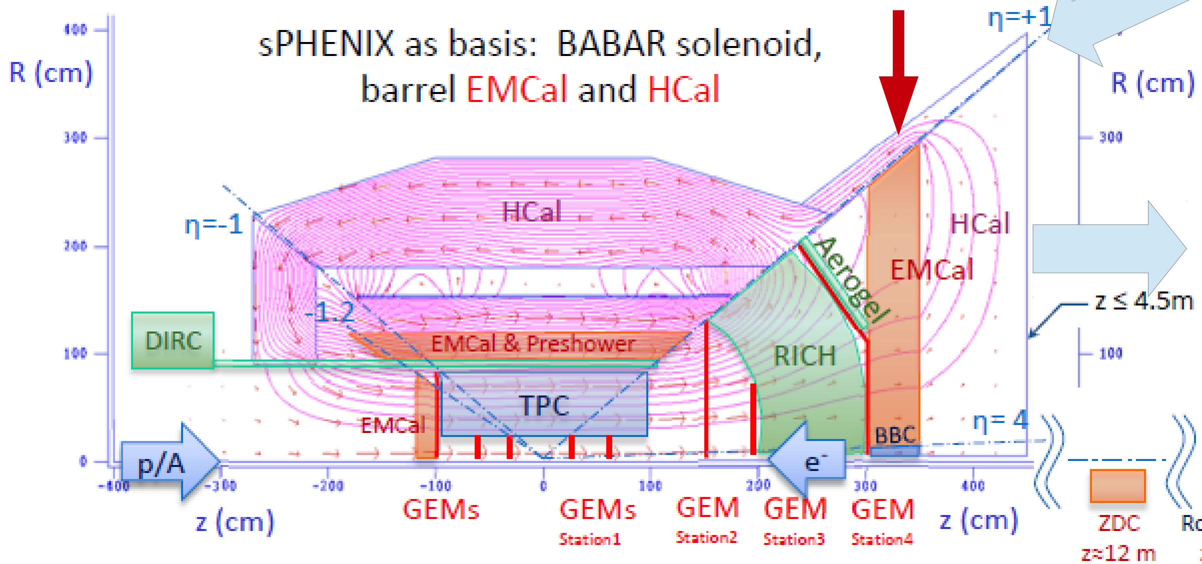
By ~2020

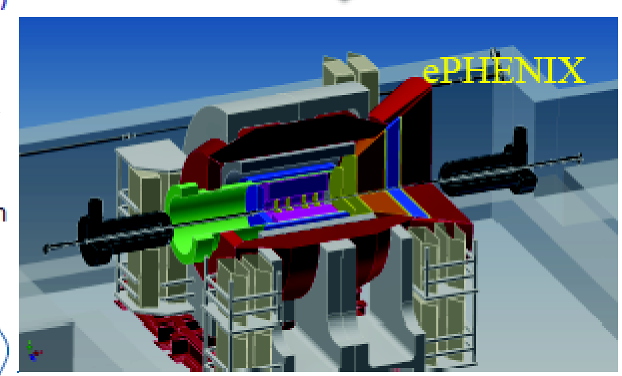
Central arm completion



By ~2025

Forward arm fsPHENIX





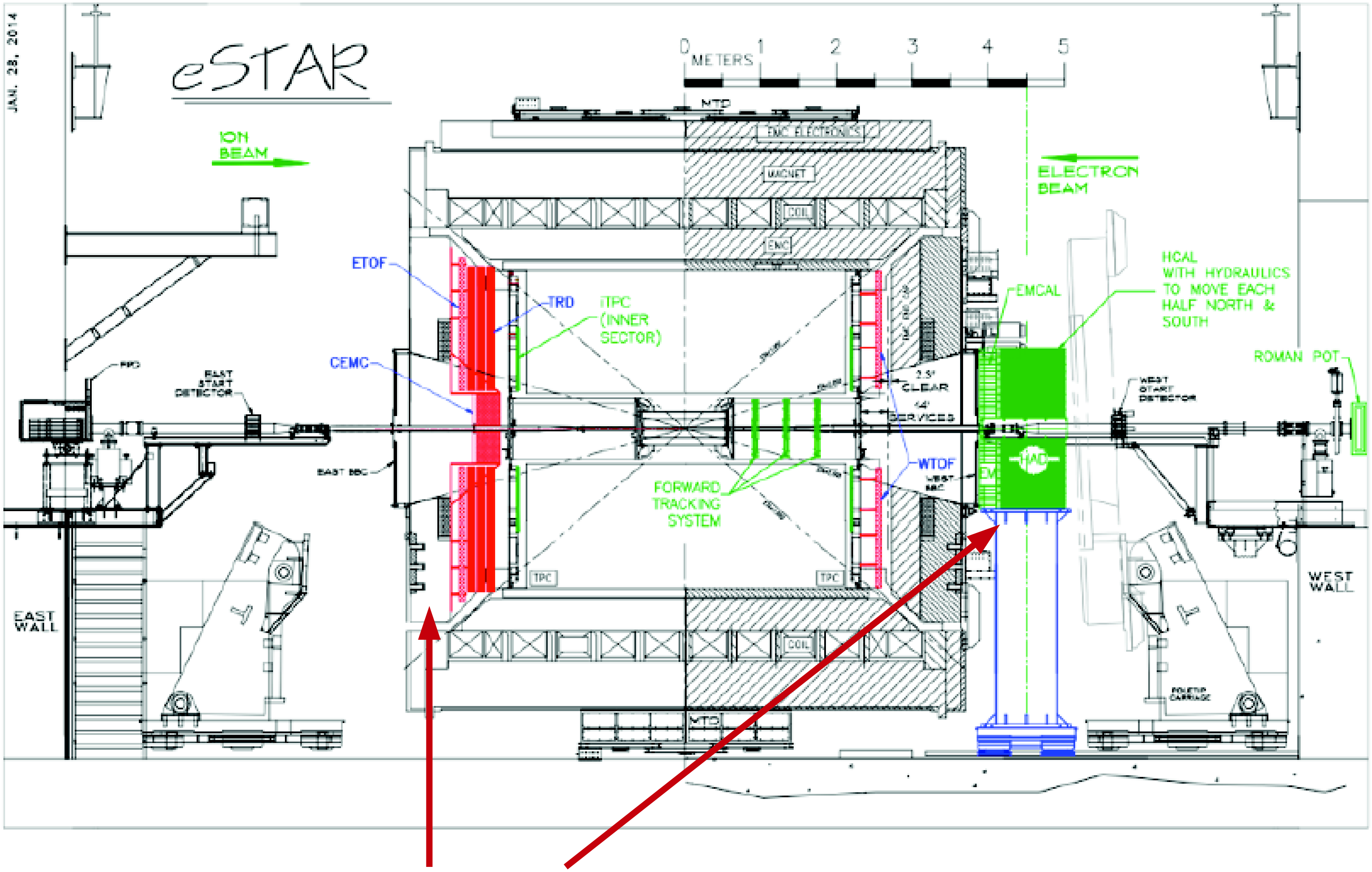
Forward and backward arms

eSTAR

Ernst SICHTERMANN

eSTAR - Concept

~2025

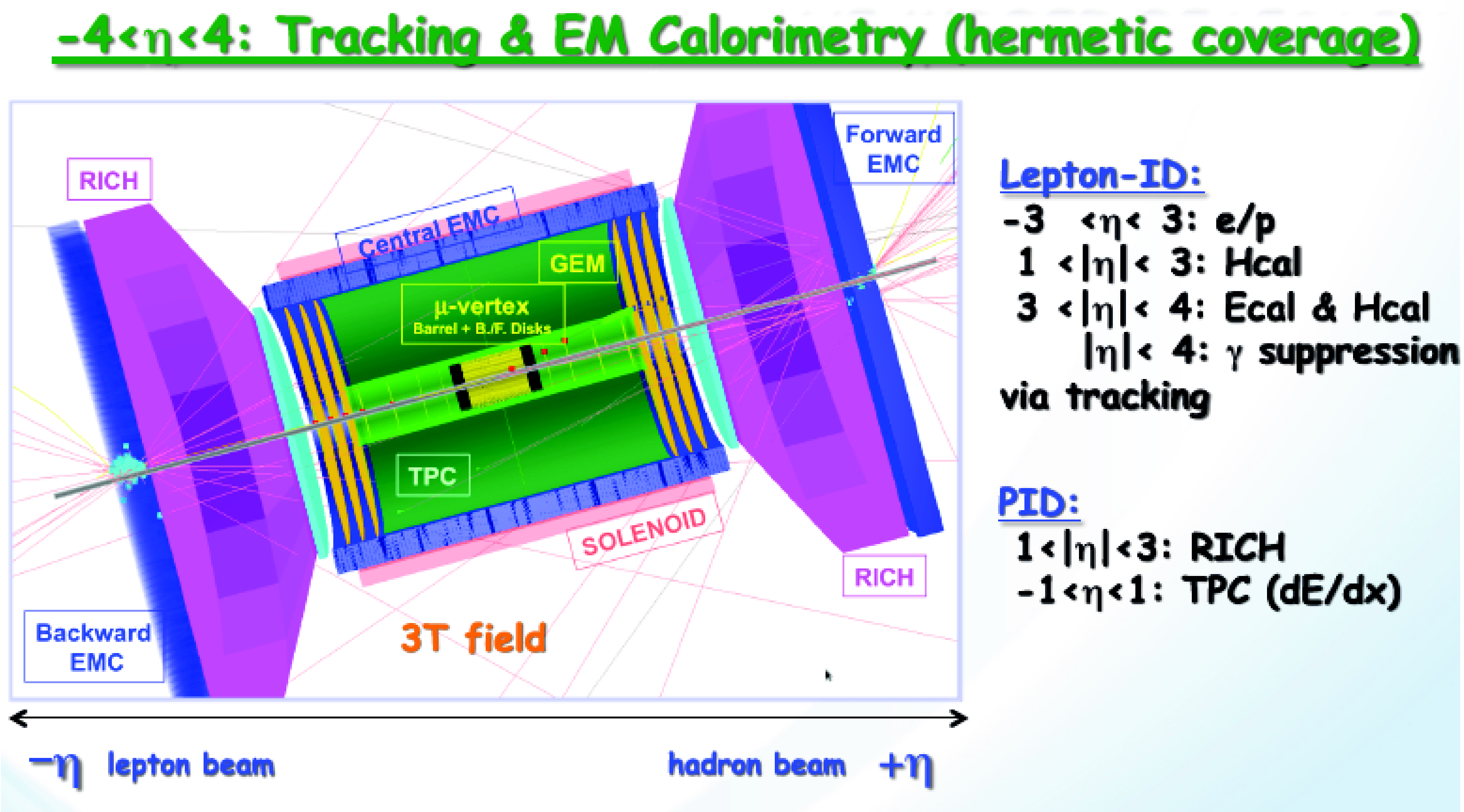


New detector elements

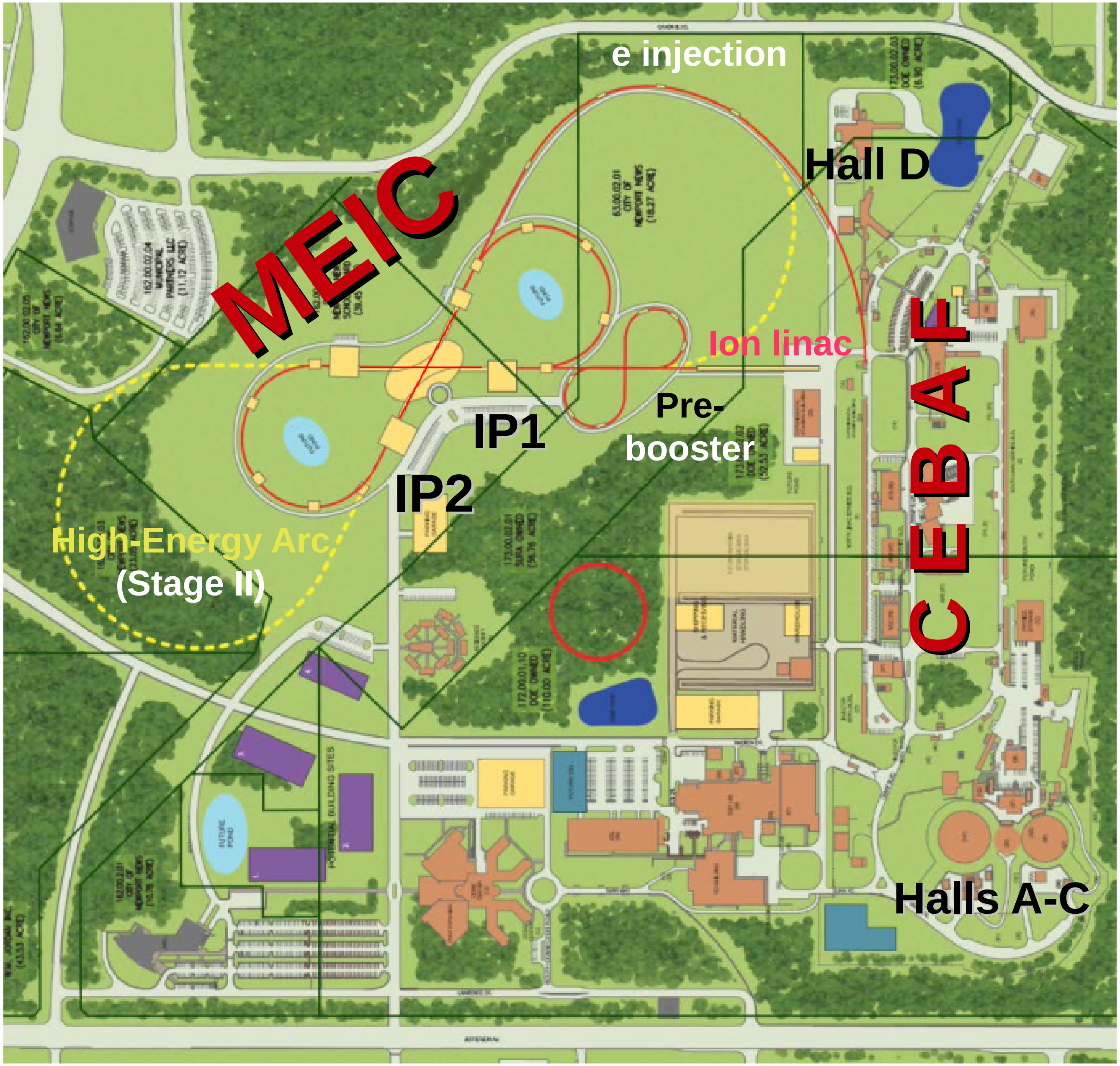
eRHIC at BNL

Alexander KISELEV

Dedicated detector



The EIC at JLab



Pawel NADEL-TURONSKI

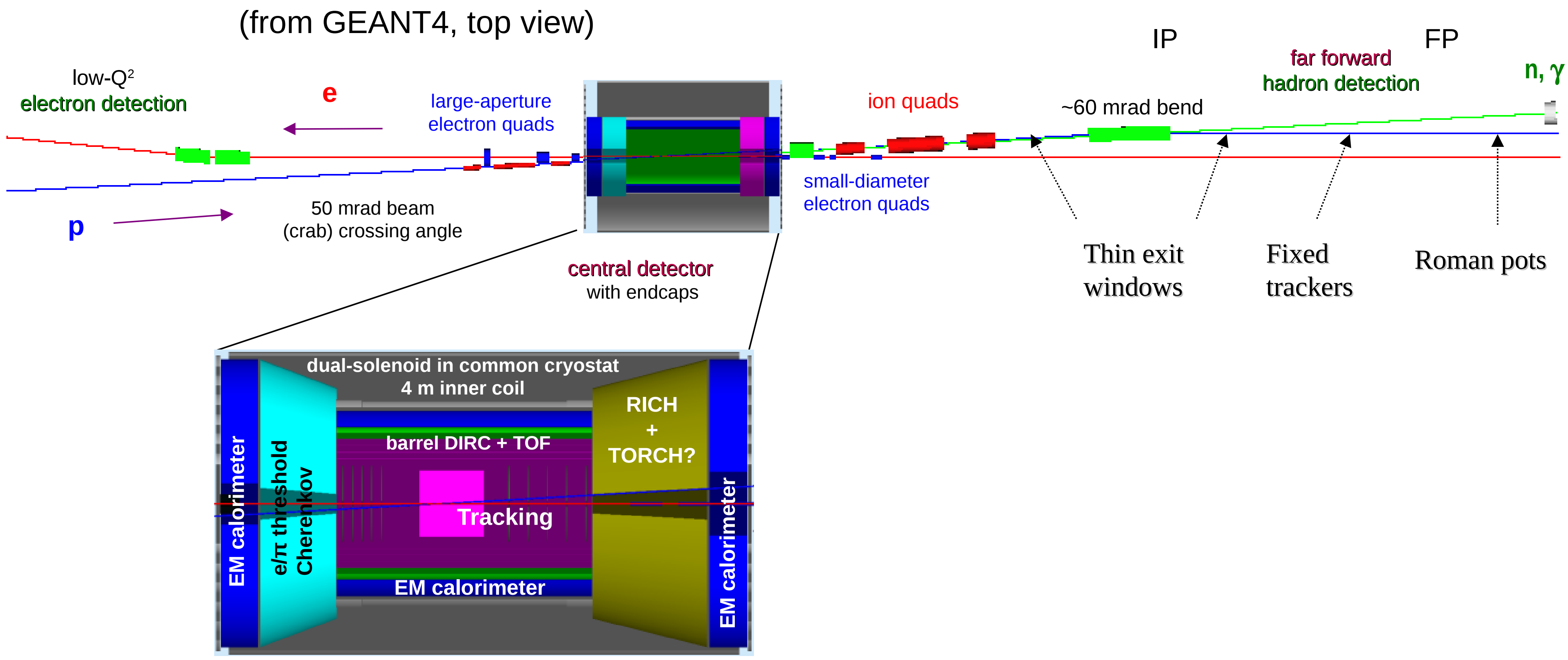
- 12 GeV CEBAF is a full-energy lepton injector
  - Parallel running with fixed target possible
- MEIC and CEBAF both have a 1.4 km circumference
- MEIC can store 20-100 GeV protons, or heavy ions up to 40 GeV/A.
- Figure 8 design to preserve polarisation of deuterium

The EIC at JLab

Full-acceptance detector design at JLab

Pawel NADEL-TURONSKI

1. **Detection/identification of complete final state**
2. **Spectator p_T resolution << Fermi momentum**
3. **Low-Q^2 electron tagger for photoproduction**

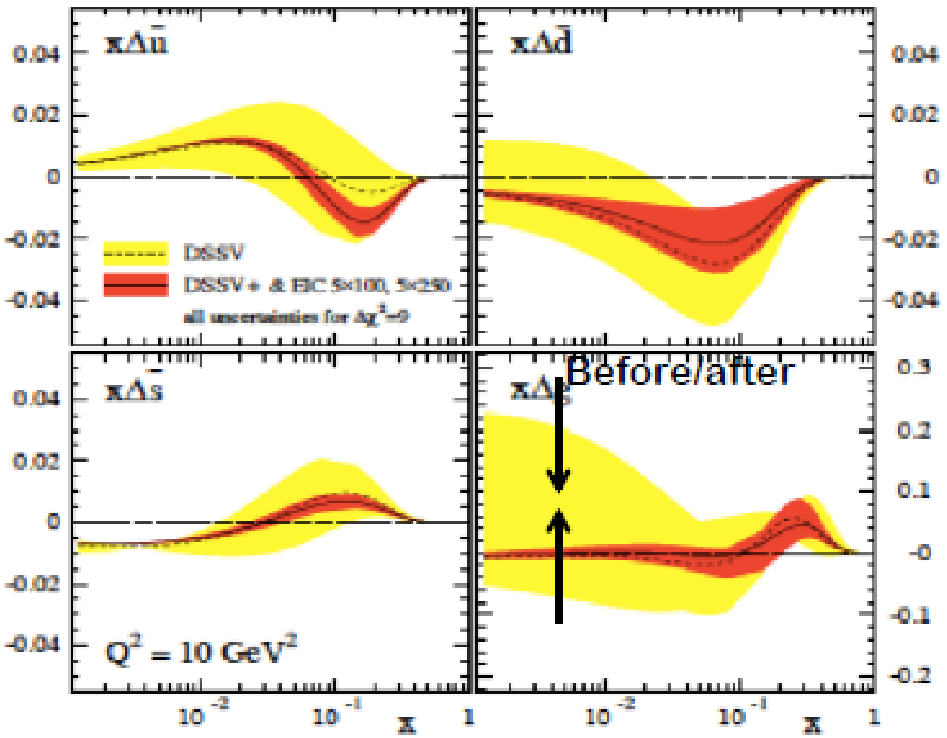


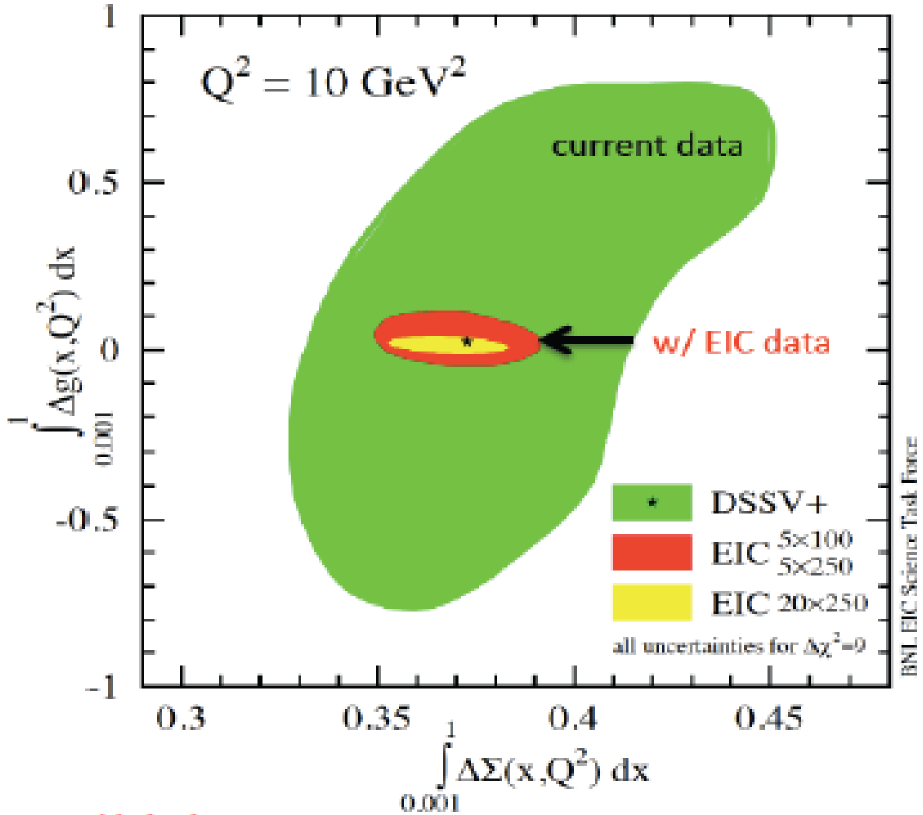
Jianwei QIU
Ernst SICHTERMANN

An examples of physics result:

EIC White Paper arXiv:1212.1701

Only one year of operation!





No other machine in the world can achieve this!

CONCLUSIONS

There is a lot of enthusiasm, cooperation and support in our community towards future facilities

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Future facilities complement each other's mission and serve to better understanding of the nature

Our mission resembles the First New World voyage of Columbus, we have determination, clear goals and a plans. I believe, on this voyage discoveries are awaiting us

THANK YOU!

Spares

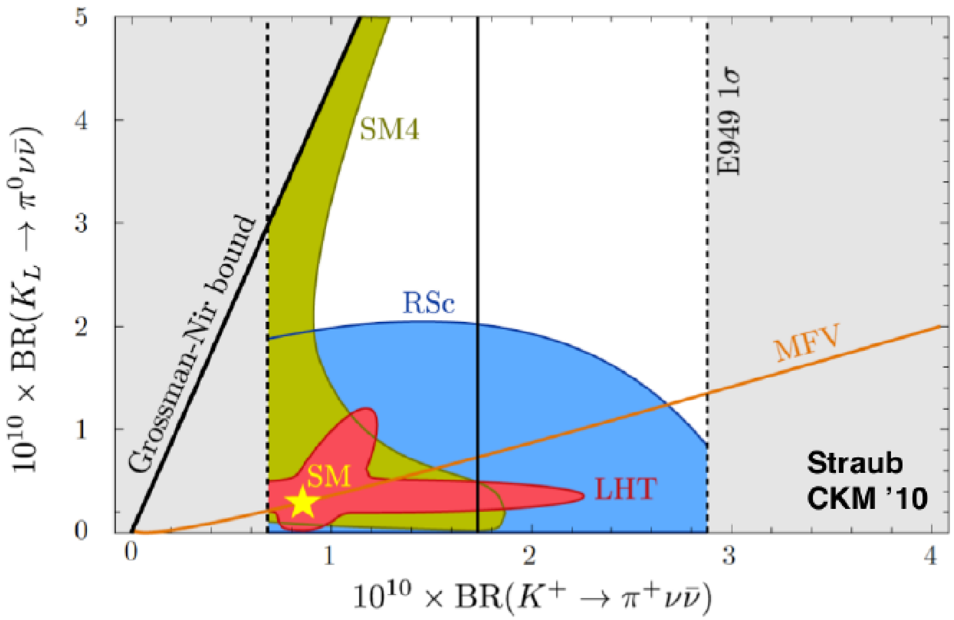
NA62 experiment

Prospects for the $K^+ \to \pi^+ \nu \bar{\nu}$ Measurement

Carim MASSRI

$BR(K^+ \to \pi^+ \nu \bar{\nu}) \sim |V_{ts}^* V_{td}|^2$

SM prediction:
$BR(K^+ \to \pi^+ \nu \bar{\nu}) = (0.781 \pm 0.075 \pm 0.029) \times 10^{-10}$



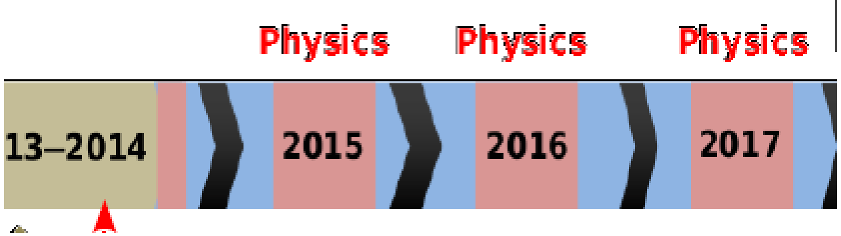
Sensitive to New Physics

$K^+ \to \pi^+ \nu \bar{\nu}$ signature:

Kaon track +
Pion track +
NOTHING ELSE

Very difficult experimental measurement

Decay	Events/year
$K^+ \to \pi^+ \nu \bar{\nu}$ [SM] (flux 4.5×10^{12})	45



Future Circular Collider Study - SCOPE

80-100 km tunnel infrastructure in Geneva area – design driven by pp-collider requirements (FCC-hh)
with possibility of e+- e- (FCC-ee)
and p - e (FCC-he)

LHeC could operate as injector for FCC-ee

LHeC could potentially provide collisions with FCC-hh

8 T	**⇒**	**40 TeV in**		**80 km**
16 T	**⇒**	**80 TeV in**		**80 km**
20 T	**⇒**	**100 TeV in**		**80 km**
16 T	**⇒**	**100 TeV in**		**100 km**

Monica D'ONOFRIO