Recent EIC Planning at BNL; Expectations from EICAC

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EICAC Meeting

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BROOKHAVEN NATIONAL LABORATORY

a passion for discovery

Office of Science
U.S. DEPARTMENT OF ENERGY

Developments at BNL Since February 2009 EICAC Meeting

March '09: ***Elke Aschenauer on board to co-lead EIC Task Force with Thomas Ullrich. Task Force comprises ~15 Physics Dept. scientific staff.***

April '09: ***Participated in panel discussions of EIC, LHeC, ENC at DIS09.***

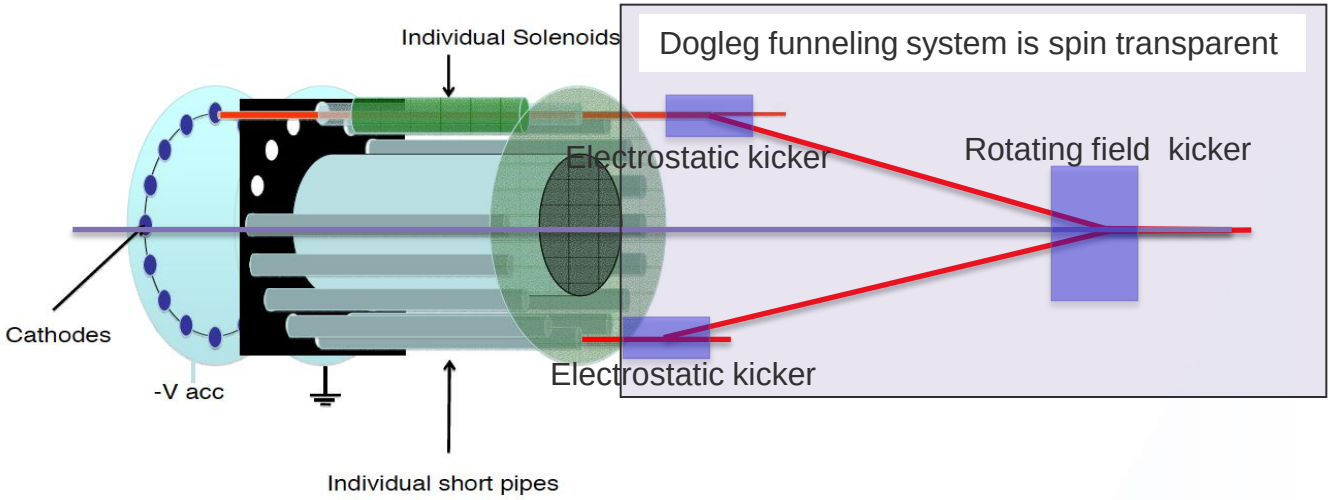
August '09: ***Targeted LDRD program provides $1.2M for FY10 (~same anticipated for FY11, 12) toward selected EIC proposals (6 chosen from 15 submitted). Post-doc hires in progress. Over and above previous LDRDs for developing e+A and e+p theory and small-gap eRHIC magnets.***

October '09: ***Internal BNL review of first bottoms-up cost estimate for 1st stage (MeRHIC) machine design.***

Ongoing:

- ***Heavily involved in organization of Oct. 2009 and Fall 2010 INT Workshops on EIC science***
- ***Launched discussions with users of possible generic detector R&D projects (e.g., compact calorimetry, GaSiP detectors)***
- ***R&D high-current ERL project, including 704 MHz SRF cavity development, under way with funds from ONP, Navy, BNL***

Targeted LDRD Proposals Selected for Funding



I. Ben-Zvi *et al*., EIC Polarized Electron Gun

T. Rao and T. Tsang, Development of a laser system for driving the photocathode of the polarized electron source for the EIC

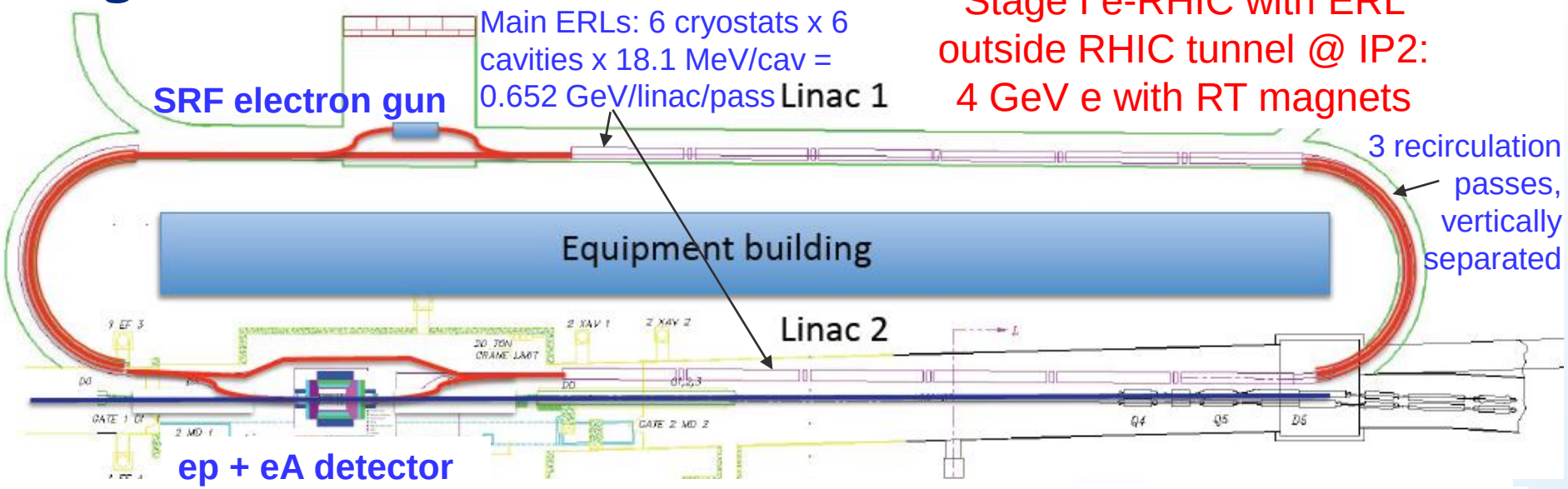
V. Litvinenko *et al*., Simulation, design and prototyping of an FEL for proof-of-principle of Coherent Electron Cooling

T. Ullrich and R. Venugopalan, Realization of an e+A Physics Event Generator for the EIC

R. Venugopalan *et al*., Exploring signatures of saturation and universality in e+A collisions at eRHIC

W. Marciano *et al*., Electroweak Physics with an Electron Ion Collider

Medium Energy (MeRHIC) Stage Design & Costing Progress



1.5-day internal cost review Oct. 2009:

- ***Detailed bottoms-up estimate ⇒ TPC ≅$350M, including: SRF cavities + power + cryogenics; magnets + vacuum; power supplies, diagnostics, controls; injector; IR mods to accommodate detector + spin rotators; civil constr'n; install'n + pre-ops; project management; ~45% overall contingency***
- ***Major cost uncertainties: detector, exp't hall, beam cooling not included; significant R&D hurdles on path to some reliable contingency estimates***
- ***Major conclusion: will cost enough that Long Range Plan endorsement essential; shift focus to R&D milestones in preparation, while continuing discussion of cost-saving options and design optimization***

What We Need From EICAC

- ***Feedback on progress toward realization path for EIC (see following slides, from Hawaii DNP presentation)***
- ***Recommendations regarding viable, coherent R&D program and funding level for next ~5 years***
- ***Comparative evaluation of different machine design options (best at future meetings with expanded accel. physics membership of EICAC)***

Articulate the Basic Science Themes More Clearly

- ***Which parts of the program are "discovery", which parts "characterization"?***
- ***How does EIC go beyond the QCD programs at RHIC, JLab, LHC, HERA (EIC will have much higher luminosity, polarized ion and heavy ion beams)?***
- ***What new aspects of QCD matter will be revealed/ explored?***

Note INT workshops on EIC science, Fall '09 and '10.

Choose "Golden" Experiments That Set Machine/Detector Performance Requirements

e.g.,

- ***inclusive DIS for indirect (F_2) determination of gluon densities in heavy nuclei, extension of spin structure (g_1)***
- ***direct determination of gluon densities by F_L (emphasis on energy variability of machine, detector)***
- ***diffractive measurements to probe spatial distribution of gluons in e+A***
- ***deep exclusive reactions to map GPD's, transverse spatial features as a function of longitudinal mom. fraction***
- ***parity-violating asymmetries at high Q^2***

Detailed simulations needed to demonstrate feasibility, determine requirements

Settle on Preliminary Machine & Detector Designs, Staging and Cost Estimates

- ***Machine designs further along than detector designs***
- ***Two quite distinct designs from BNL and JLab, each with well-defined staging plan***
- ***Bottoms-up cost estimates in progress at each lab, with emphasis now on 1st-stage machines – likely several hundred million dollar projects***
- ***Detector integration into lattice critical for realistic luminosity estimates***

Is there one affordable machine that can cover the whole science program? If not, what is optimal tradeoff of science vs. cost? Is stand-alone science return for 1st stage sufficiently compelling?

Delineate Coherent Program of Essential R&D and Obtain Funding

Priorities:

1) ***Proof of principle for large improvements over present state of the art – needed for technical plausibility by next LRP:***

- ***Polarized electron source current (50 mA eRHIC vs. 1 mA at best present sources)***
- ***ERL operation at high energies and 100's mA @ eRHIC***
- ***Hadron beam β^* in collider (5 mm @ JLab vs. ~25 cm at existing hadron colliders)***
- ***Detector operation/backgrounds at 500 MHz @ JLab***

2) ***Proof of principle of high-energy hadron beam cooling techniques (e.g., Coherent electron Cooling – CeC) to improve luminosity from initial design***

3) ***Technology developments to reduce costs, e.g., in SRF cavity fabrication, stability***

Backup Slides

EICAC Advice from Feb. 09 Meeting

EICAC requested next meeting on Fall '09 schedule, for 2 days to allow deeper discussion, and with following major deliverables:

- ❑ ***Coherent R&D plan, timeline, milestones & resource needs***
- ❑ ***Short list of "golden measurements" & what will be learned***
- ❑ ***Initial cost-performance-science reach matrix***
- ❑ ***Implications of golden exp'ts for detector requirements + R&D***

Other EICAC recommendations:

- Further develop the schedule including approximate resource-loading, to provide a timeline for major decisions (including, if at all possible, site decision), technical developments, and (staged) realization
- In particular, strive for a timeline (under reasonable assumptions) that provides for data taking before 2020

eRHIC parameters

	MeRHIC		eRHIC with CeC	
	p (A)	e	p (A)	e
Energy, GeV	250 (100)	4	325 (125)	20 <30>
Number of bunches	111		166	
Bunch intensity (u) , 10^{11}	2.0	0.31	2.0 (3)	0.24
Bunch charge, nC	32	5	32	4
Beam current, mA	320	50	420	50 <10>
Normalized emittance, 1e-6 m, 95% for p / rms for e	15	73	1.2	25
Polarization, %	70	80	70	80
rms bunch length, cm	20	0.2	4.9	0.2
β*, cm	50	50	25	25
Luminosity, x 10^{33}, $cm^{-2}s^{-1}$	0.1 -> 1 with CeC		2.8	

< Luminosity for 30 GeV e-beam operation will be at 20% level>, limited by synchrotron radiation loss rate

JLab EIC Parameters

Beam Energy	GeV	12/3	60/5	60/3	250/10
Collision freq.	MHz		499		
Particles/bunch	10^{10}	0.47/2.3	0.74/2.9	1.1/6	1.1/3.1
Beam current	A	0.37/2.7	0.59/2.3	0.86/4.8	0.9/2.5
Energy spread	10^{-4}		~ 3		
RMS bunch length	mm	50	5	5	5
Horz. emit., norm.	μm	0.18/80	0.56/85	0.8/75	0.7/51
Vert. emit. Norm.	μm	0.18/80	0.11/17	0.8/75	0.03/2
Horizontal β^*	mm	5	25	25	125
Vertical β^*	mm			5	
Vert. b-b tuneshift/IP		.015/.013	0.01/0.03	.015/.08	0.01/0.1
Laslett tune shift	p-beam	0.1	0.1	0.054	0.1
Peak Luminosity/IP, 10^{34}	$cm^{-2}s^{-1}$	0.59	1.9	4.0	11

⇒ Very strong final focus!

Low energy MEIC High energy

Courtesy of G. Krafft

Factor 50 difference in assumed β^* for colliding beams fully accounts for difference in projected luminosity between the two designs.