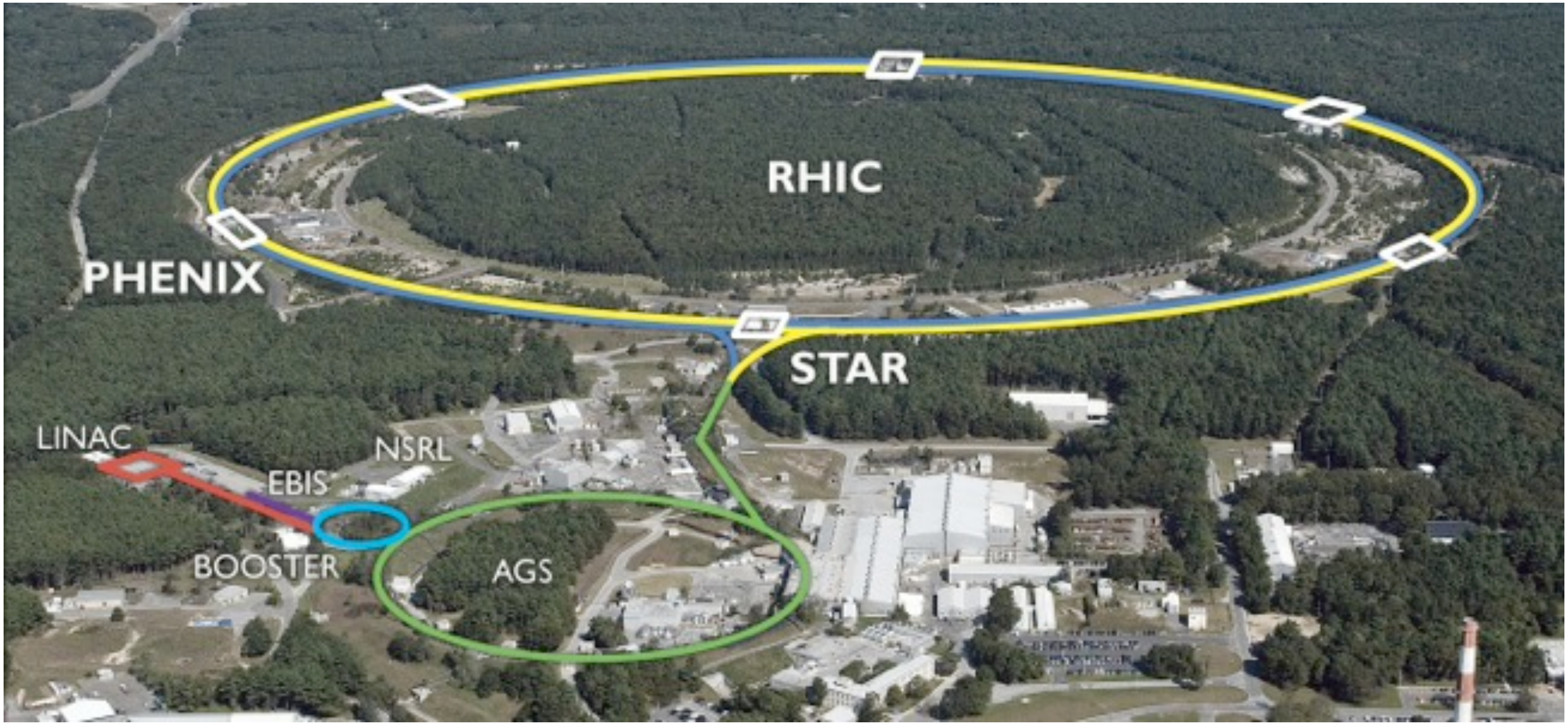
BROOKHAVEN NATIONAL LABORATORY

Possibilities for nTOF @ BNL

Steve Peggs, Mei Bai, Phil Pile

BNL accelerators, big & small



From 0.75 MeV to 250 GeV.

From biology to isotope production, radiobiology, chemistry, basic energy sciences, & nuclear physics.

From electrons to Uranium.

Accelerator inventory

Nuclear Physics, Radiobiology, Isotope Production		
Relativistic Heavy Ion Collider (2 rings)	250	GeV (2nd only to LHC)
Alternating Gradient Synchrotron	28	GeV
Booster	5	GeV/c
Proton linac	200	MeV
Accelerator Test Facility electron linac	70	MeV
Tandem Van de Graaff (2 accelerators)	15	MeV
RFQ linac	0.75	MeV
Chemistry, Isotope Production		
Electron linac	10	MeV
Cyclotron	35	MeV
Cyclotron	19	MeV
Cyclotron	17.5	MeV
Van de Graaff	2	MeV
Basic Energy Sciences		
National Synchrotron Light Source II	3.0	GeV (in construction)
Electron storage ring (X-ray)	2.5	GeV
Electron storage ring (UV)	750	MeV
Electron booster synchrotron	750	MeV
Electron linac (DUV-FEL)	230	MeV
Electron linac	200	MeV
Electron linac	80	MeV
Biology		
Scanning Transmission Electron Microscopes (3)		

Why do nTOF @ BNL?

From Guererro et al, Eur. Phys. J. A (2013) 49: 27

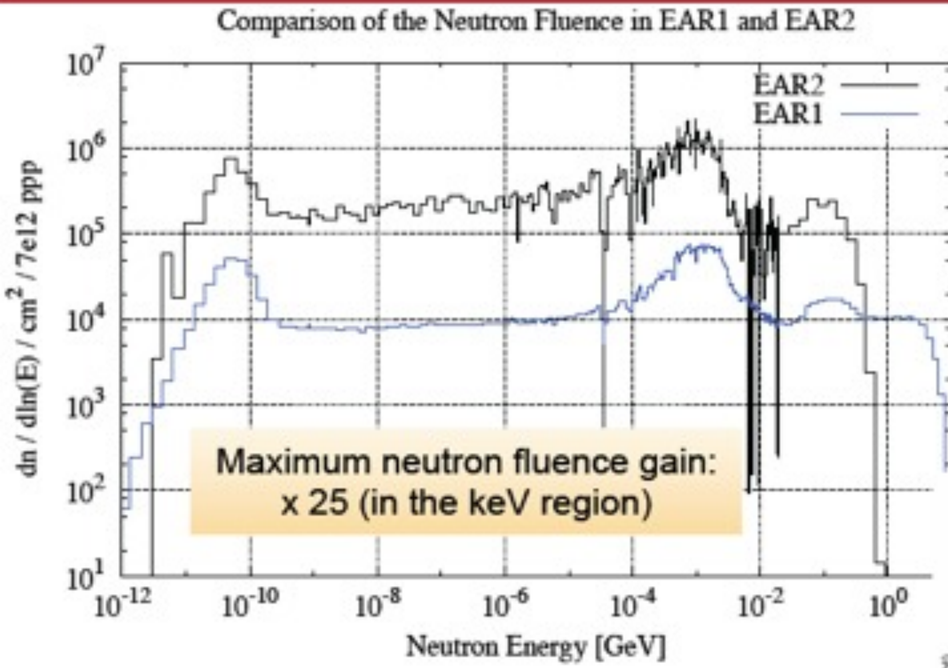
“The cross sections available in different nuclear libraries (for instance, JEFF, ENDF, JENDL [7] for nuclear technologies and KADoNiS [8] for astrophysics) are …. frequently incompatible and their accuracy is lower than needed. This makes it necessary to perform new and more accurate measurements of many isotopes and reactions, which are summarized for instance by the Nuclear Energy Agency in its High Priority Request List [9], but also in review papers on data needs for fusion [10] and astrophysics [1].”

“…. energy ranges of interest span from **thermal (25 meV) to hundreds of MeV**, depending on the application.”

From Fiorina et. al., Annals of Nuclear Energy *62* (2013)

"[...] implementation of a Th cycle needs to overcome formidable challenges. A first aspect requiring further investigation relates the accuracy of the nuclear data. …. limited experimental data are available for the U-233 capture cross-section at **energies above 100 eV**, with significant discrepancies among …. different libraries"

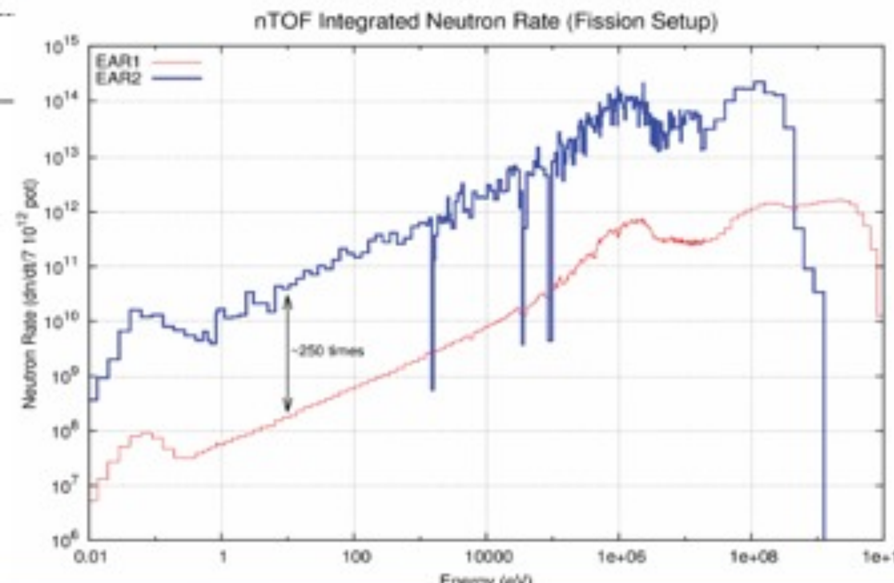
EAR2 enhanced flux



Higher flux, by a factor of 25, relative to EAR1.

The **shorter flight path** implies a factor of 10 smaller time-of-flight.

Global gain by a factor of **250 in the signal/background ratio** for radioactive isotopes!



The huge gain in signal-to-background ratio in EAR2 allows to measure radioactive isotopes with **half lives as low as a few years.**

Frank Gunsing, CEA/Saclay   Oslo, 4th Workshop on Nuclear Level Density and Gamma Strength, May 29, 2013   52

From “SAMMY Workshop”, N. Larsen, ORNL, July 2005

Cross-Section Measurement Facilities

Closed (ORELA) **Closed 2009 (ANL facility)** (IPNS)

Facility Parameters	United States				Europe	
	ORELA	LANSCE	IPNS	RPI	GELINA	n_TOF
Source	e^- linac	p spallation	p spallation	e^- linac	e^- linac	p spallation
Particle E (MeV)	140	800	450	>60	120	20000
Flight Path (m)	10-200	7-55	~6-20	10-250	8-400	185
Pulse Width (ns)	2-30	125	40	15-5000	1-2000	7
Max Power (kW)	50	64	6.3	>10	11	45
Rep Rate (Hz)	1-1000	20	30	1-500	Up to 900	0.278-0.42
Best Intrinsic Resolution (ns/m)	0.01	3.9	2.0	0.06	0.0025	0.034
Neutrons/s	1×10^{14}	7.5×10^{15}	8.1×10^{14}	4×10^{13}	3.2×10^{13}	8.1×10^{14}

Slide borrowed from Klaus Guber of ORNL

Compare CERN & BNL

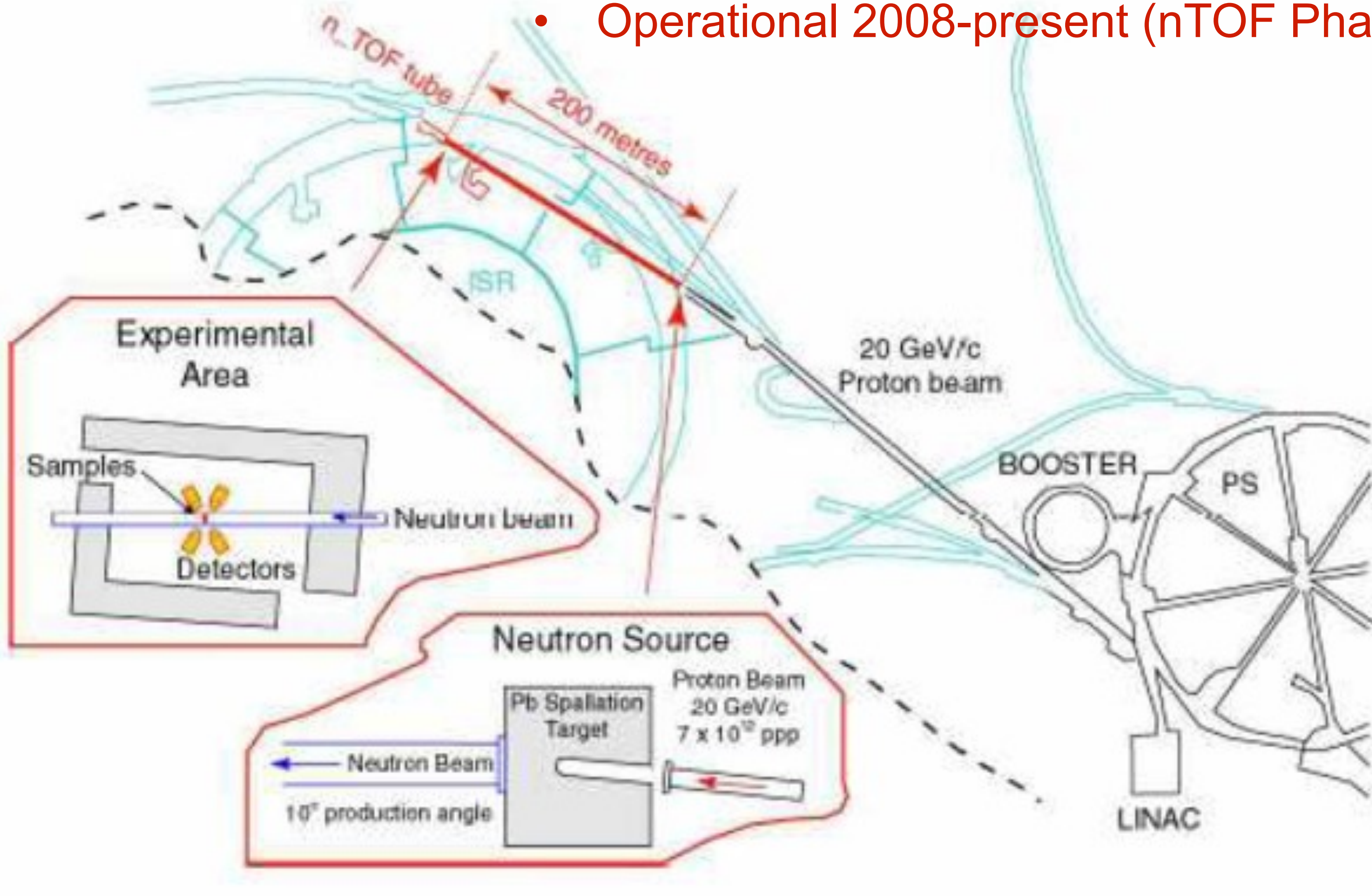
Parameter	Unit	CERN	BNL
Length	m	200, 20	200, 20
Proton energy	GeV	20	24 (max ~28)
Bunches per pulse		1	1 to 12
Protons per bunch	E12	7	5 to 10
Repetition period	s	1.2	2.8
Target power	kW	19	14 to 84

CERN & BNL capabilities are very similiar at first glance

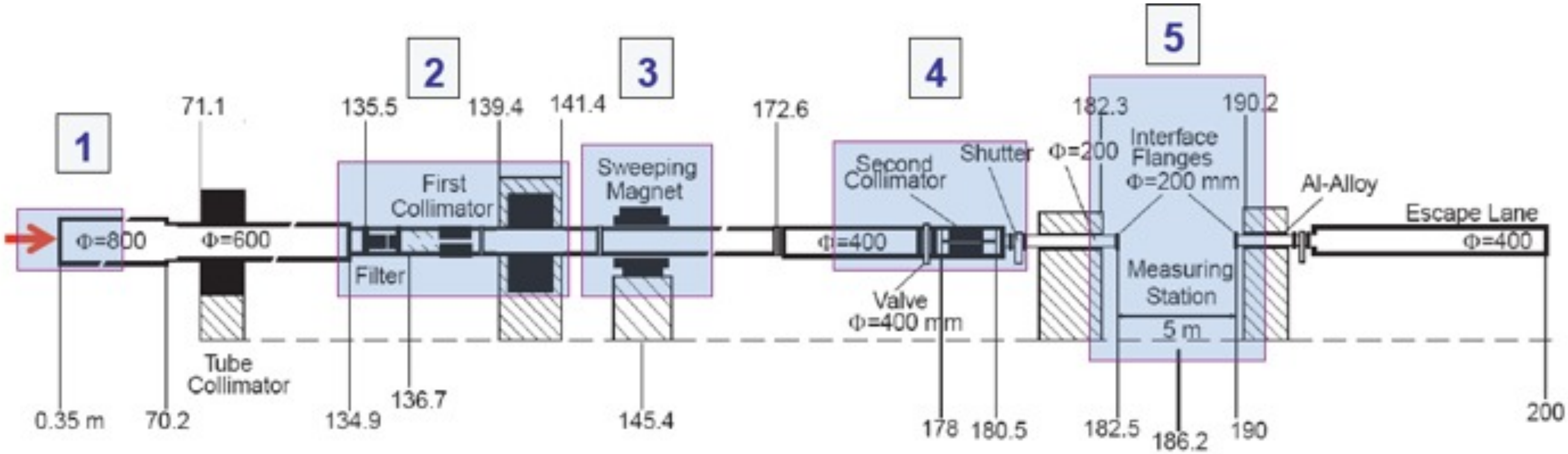
- with significant enhancements possible at BNL

The n_TOF facility at CERN

- Operational 2001-2004 (nTOF Phase 1)
- 2004-2008 off (Upgrade production target)
- Operational 2008-present (nTOF Phase 2)



CERN beamline EAR 1

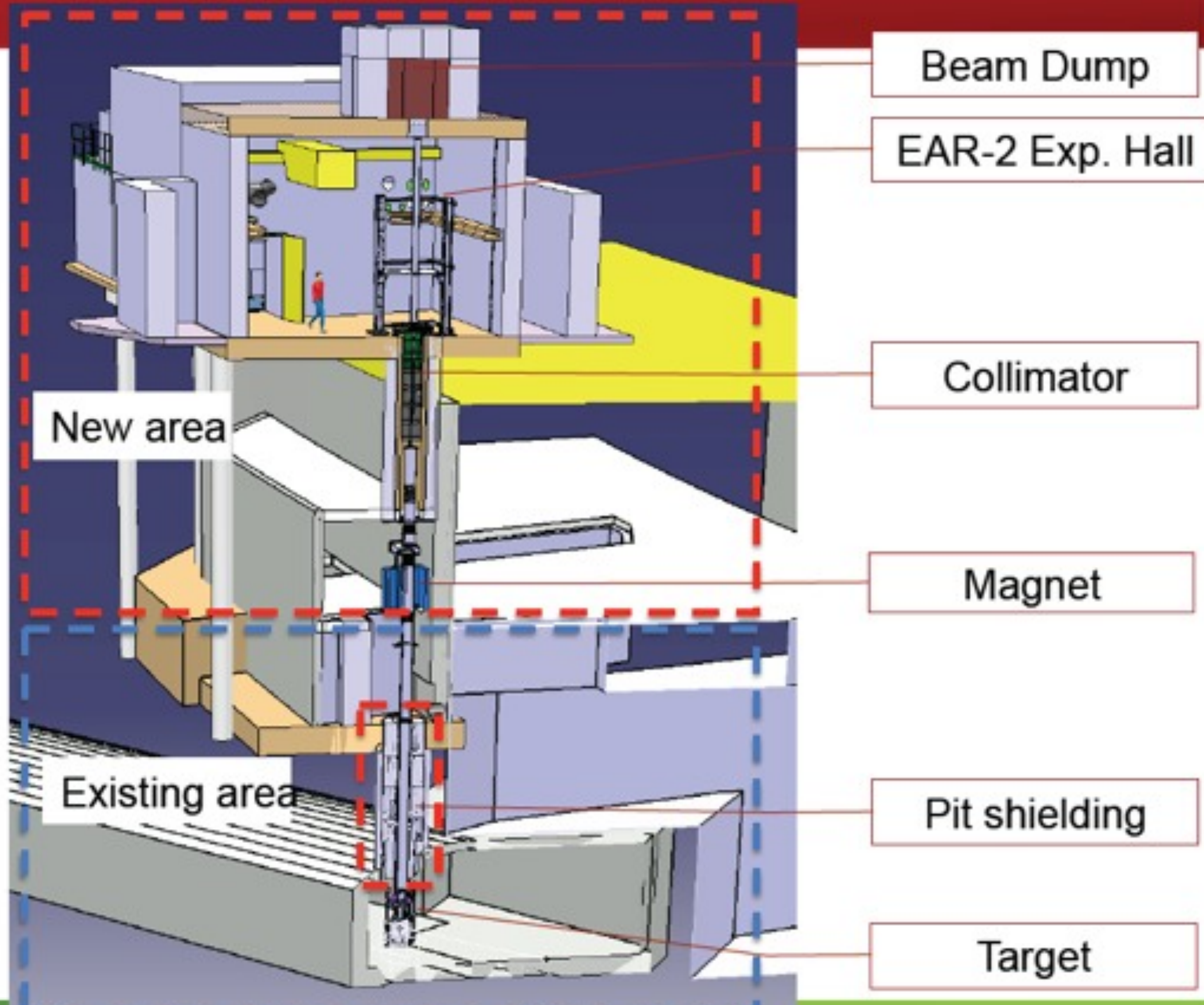


1. Spallation target and moderator producing neutrons with energies from thermal up to several GeV
2. first collimator (Ø=11 cm) for first shaping of the beam + filter station
3. Sweeping magnet
4. Second variable collimator (Ø=1.8/8 cm) – final beam shaping
5. Experimental Area 1 (EAR1), with samples and detectors

Frank Gunsing, CEA/Saclay Oslo, 4th Workshop on Nuclear Level Density and Gamma Strength, May 29, 2013

Layout EAR2

Nov 11, 2013



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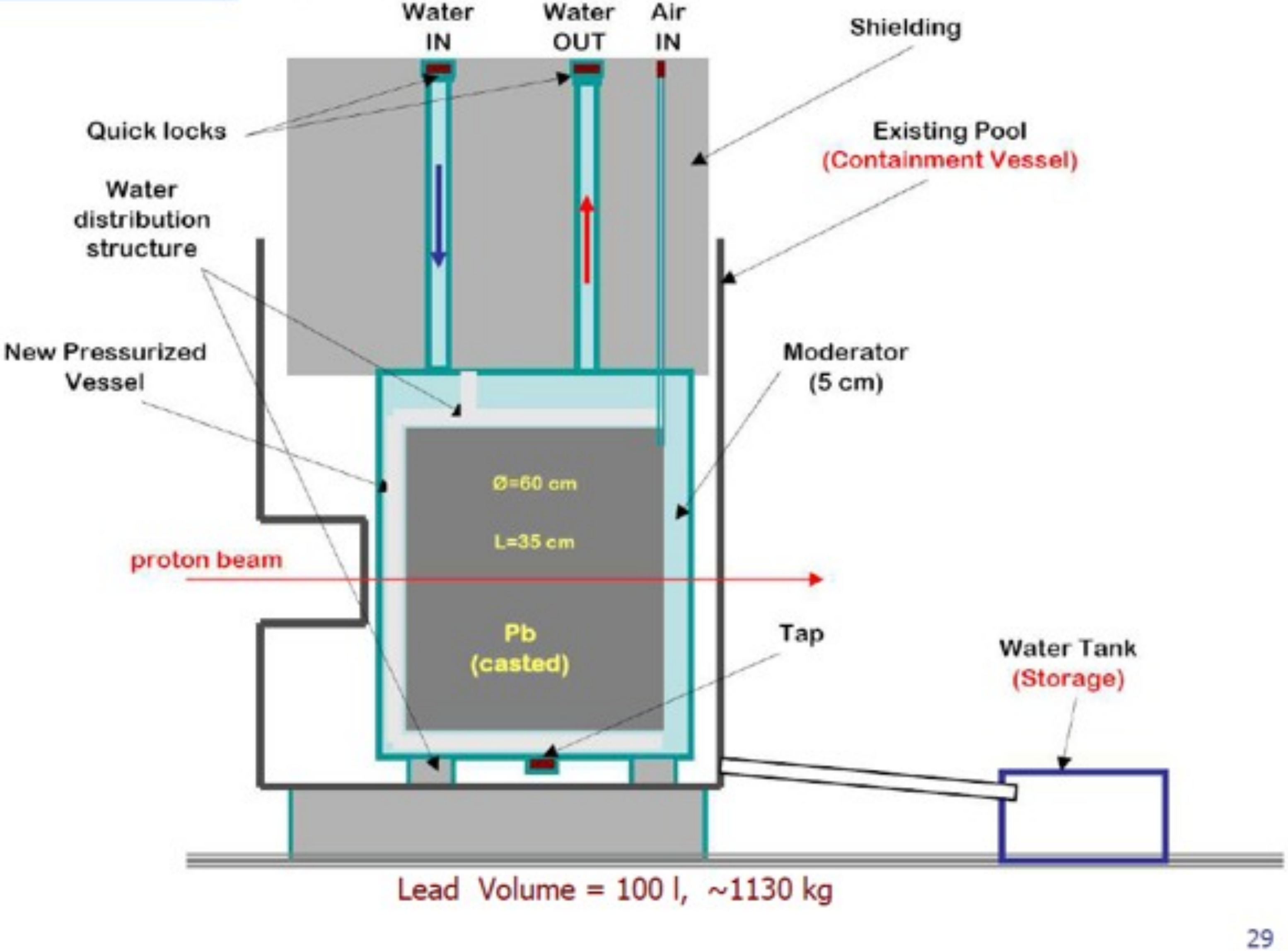
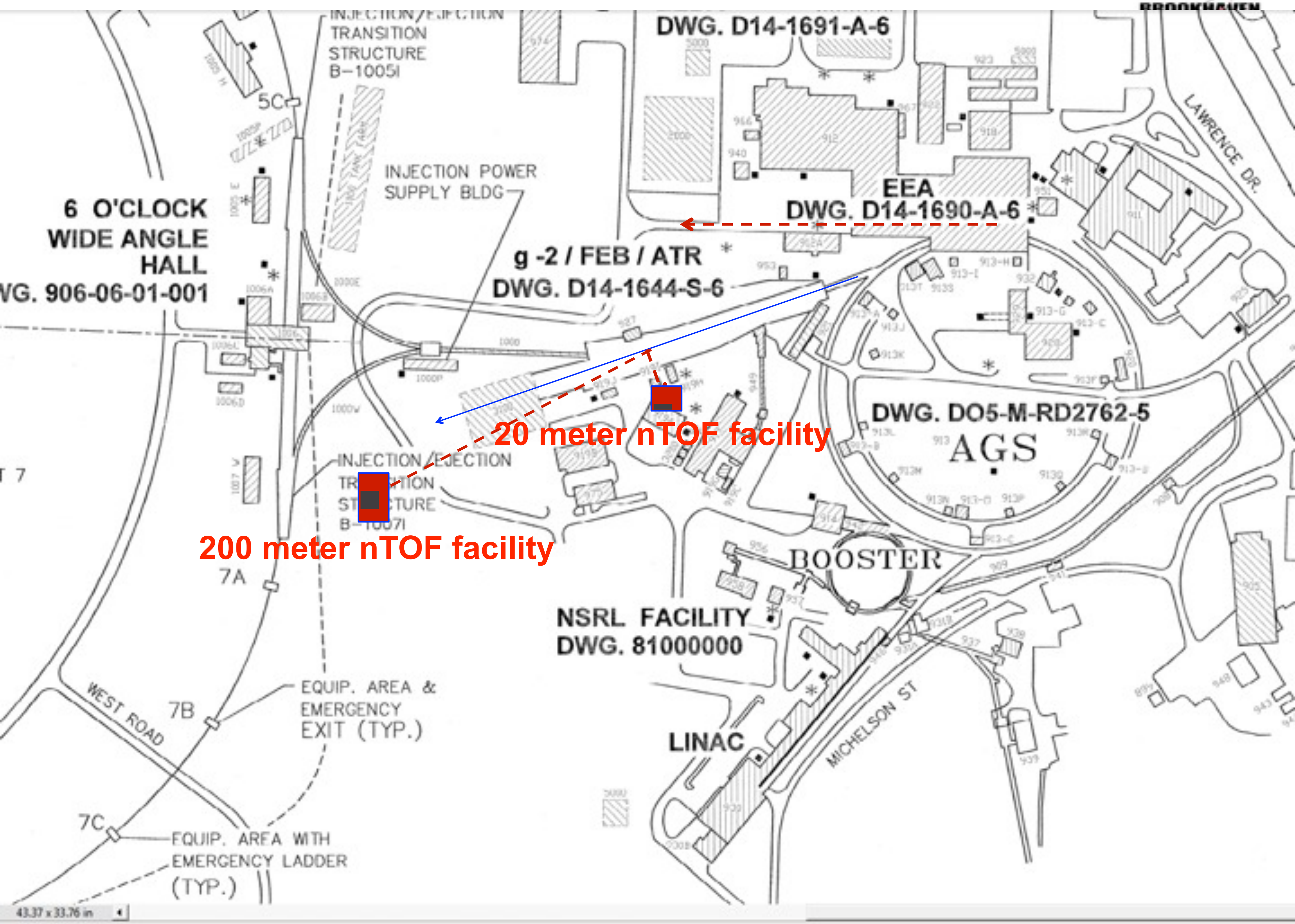
New Target Design

CERN nTOF Facility



BNL U-line (ex-neutrino beamline)

100 meters


DWG. D14-1691-A-6
INJECTION/EJECTION
TRANSITION
STRUCTURE
B-1005I
INJECTION POWER
SUPPLY BLDG
6 O'CLOCK
WIDE ANGLE
HALL
WG. 906-06-01-001
EEA
DWG. D14-1690-A-6
g -2 / FEB / ATR
DWG. D14-1644-S-6
LAWRENCE DR.
DWG. DO5-M-RD2762-5
AGS
20 meter nTOF facility
INJECTION/EJECTION
TRANSITION
STRUCTURE
B-1007I
200 meter nTOF facility
7A
BOOSTER
NSRL FACILITY
DWG. 81000000
7B
WEST ROAD
EQUIP. AREA &
EMERGENCY
EXIT (TYP.)
LINAC
MICHELSON ST
7C
EQUIP. AREA WITH
EMERGENCY LADDER
(TYP.)
43.37 x 33.76 in

Unique advantages at BNL

Organizationally:

- Booster & AGS in a Nuclear Physics lab
- (U.S.) access to samples unavailable in Europe
- Beamline and experimental facility support
- Nuclear Science & Technology Department
  - National Nuclear Data Center
  - Target design expertise
- CSEWG community

Technical potential under exploration:

- High neutron intensities (peak & annual)
- Exchangeable targets
- Bunch compression towards 1 ns
- Flexible neutron pulse structure
  - More than 12 pulses per cycle
  - Adjustable pulse separation

"Transformative Hadron Beamlines"

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A mini-workshop in planning for early 2014 "To explore the physics & technology potential of new beamlines in the BNL hadron complex"

1) Muon spin resonance	T. Uemura, W. Fischer
2) Neutron-antineutron oscillations	G. Brooijmans, TBC
3) Radio-biological beamline 2	D. Brenner, A. Rusek
4) nTOF@BNL	Y. Danon, M. Bai
5) Radioisotope R&D	S. Smith, TBC
6) Spallation target R&D	?, F. Meot
7) Test beamline	D. Lissauer?

There is significant overlap between some beamlines/interest groups.

Please show your interest! peggs@bnl.gov

Backup slides

Past (g-2) & potential performance

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	FY97	FY98/99	FY2000	FY2001	New
Energy (GeV)	24	24	24	24	24
# bunches/pulse	6	6	12	12	12 or 24
Rep. Time (sec)	3.6	2.4/2.8	2.8	2.8	2.7
Intensity (protons/ pulse)	46×10^{12}	58×10^{12}	61×10^{12}	63×10^{12}	60×10^{12}
Average Availability /Best Week	58 % 67 %	55 % 83 %	74 % 87 %	83 % 88 %	*60 % 60 %
Integrated Intensity (# protons)	0.13×10^{20}	0.48×10^{20}	0.5×10^{20}	0.6×10^{20}	**1.3×10^{20}

* Assumes concurrent operation with RHIC.

**g-2 proposal.