



EUROPEAN
SPALLATION
SOURCE

ESS Linac WP8 Radio Frequency Systems and Test Facilities

ESS TAC

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- **Work Package description**
 - Objectives
 - Organization
 - Technical planning
- **Scientific challenges**
 - Design baseline
 - Development steps
- **Planning and prototyping**
 - Test facilities
 - Resources estimation
 - Possible partners

WP8: Work Package Description Objectives



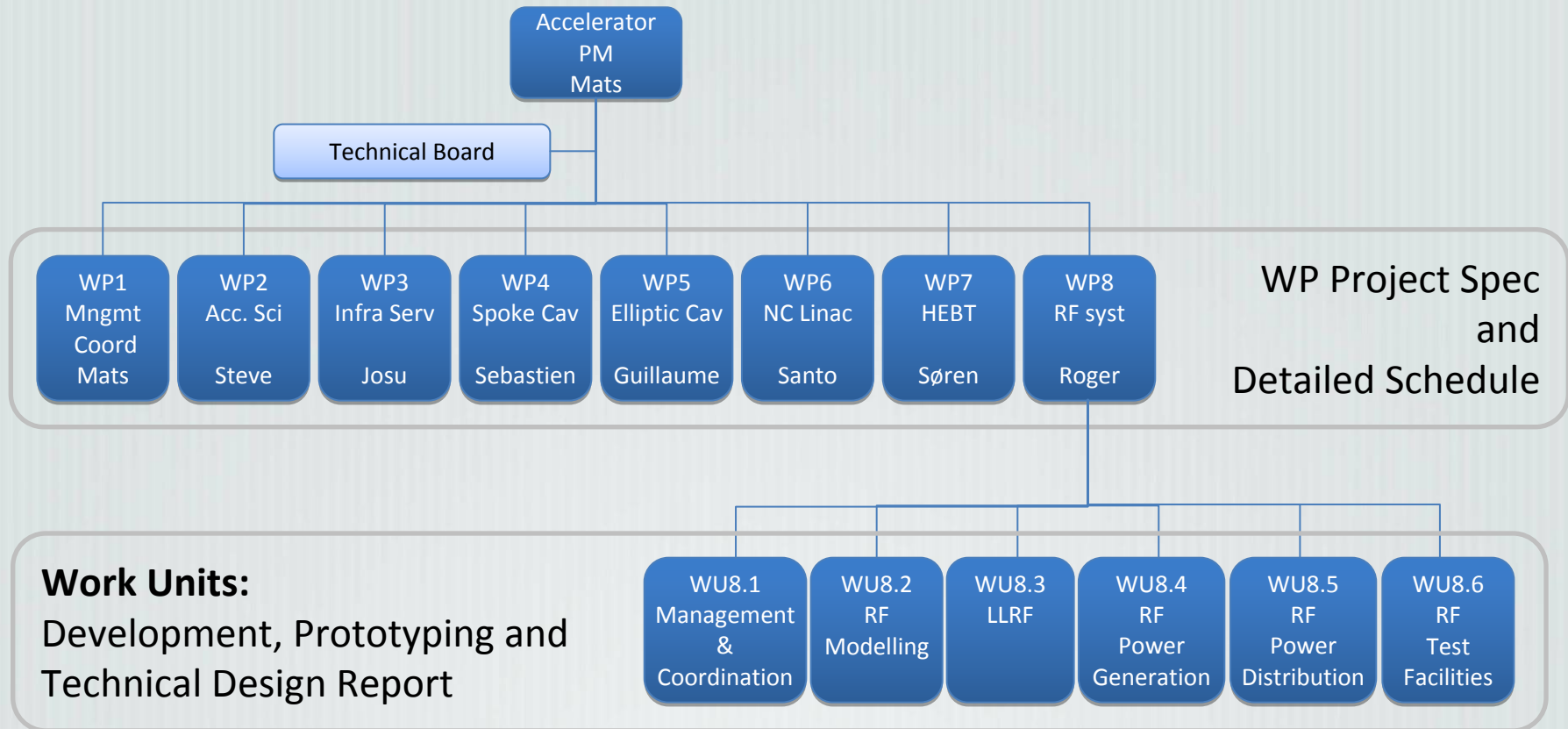
- **Issues to be addressed**

- 200 cavities/distribution points, required reliability above 95%
 - minor fault might create a major risk
- low beam loss operation
 - prevent activation accelerator components
- RF system is a major part of the budget
 - must be cost, energy and resource effective
- training future staff

- **R&D focus**

- RF modelling
 - LLRF & RF-beam interaction simulations
- resource efficiency and reliability
 - alternative RF power generation, distribution and controls
 - prototype RF system
 - two-cavities-per-klystron concept
 - efficient power generation & energy recovery

WP8: Work Package Description Organization



- **Uppsala University**

- Scandinavia's oldest university: 1477
- Long history: Carl von Linné, Anders Celsius, Olof Rudbeck
- Nobel prizes: Manne & Kai Siegbahn, The Svedberg, ... (8)
- 40,000 students (2,000 doctoral students)
- 5,500 staff (3,600 researchers/teachers)

- **Accelerator related research**

- TSL: nuclear and neutron physics laboratory, cancer therapy (180 MeV cyclotron, 3.6 GeV CELSIUS)
- CLIC/CTF3: Two-beam Test Stand, RF breakdown issues
- FLASH: Optical Replica Synthesizer
- XFEL: Laser heater
- ESS intention: RF development test stand

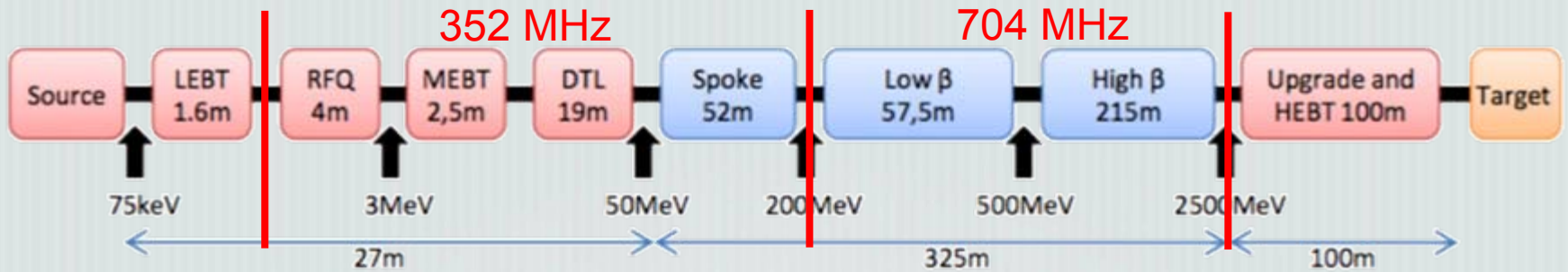
WP8: Work Package Description Technical Planning



- **WU8.1: Management**
 - coordination
 - TDR contribution
 - specifications for tendering
- **WU8.2: RF Modelling**
 - RF parameter list
 - LLRF mathematical model
 - RF simulations & HOM studies
 - multipacting studies
- **WU8.3: LLRF**
 - alternative architectures
 - 352 MHz prototype
 - 704 MHz prototype
- **WU8.4: RF Power Generation**
 - alternative schemes
 - 352 MHz prototype
 - 704 MHz prototype
- **WU8.5: RF Power Distribution**
 - alternative schemes
 - 352 MHz prototype
 - 704 MHz prototype
- **WU8.6: Test Facilities**
 - 352 MHz NC/spoke cavities
 - 704 MHz elliptical cavities

WP8: Scientific Challenges

Design Baseline



- **ESS proton linac: high reliability above 95%**

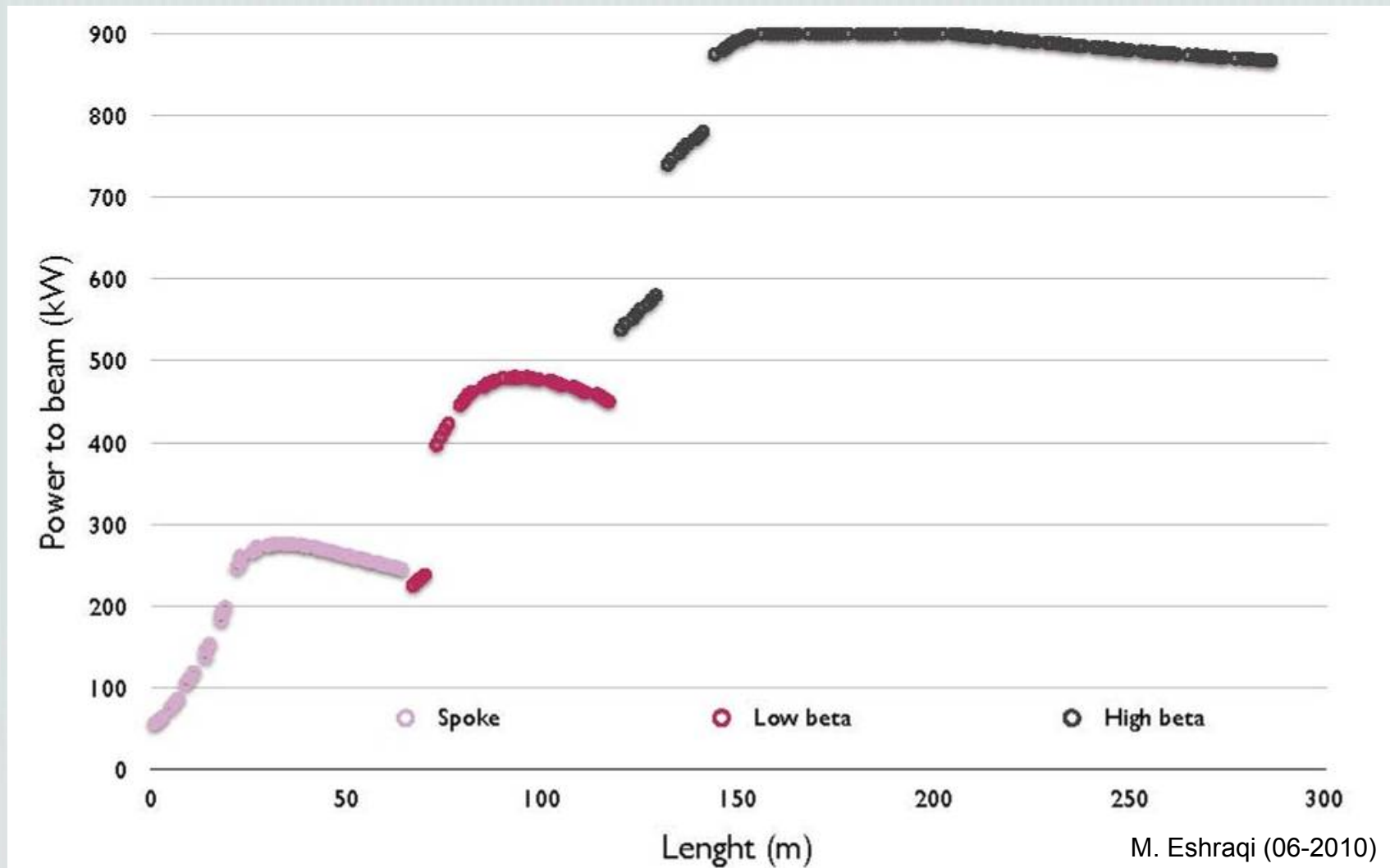
- 20 Hz, 2.0 ms beam pulses (~2.3 ms RF pulse)
- 50 mA, 5.0 MW average (beam loss <1 W/m)
- future upgrade to 75 mA, 7.5 MW

- **Power provided by RF system**

- about 200 cavities
 - 352 MHz: 1 RFQ, 2 bunching cavities, 3 DTL, 56 SC spoke cavities
 - 704 MHz: 136 SC elliptical cavities
- baseline with conservative off-the-shelf technology
 - one power source per cavity; peak power up to 1.2 MW

WP8: Scientific Challenges

RF Power to Beam



M. Eshraqi (06-2010)



- **RF modelling and LLRF**

- piggy back on existing systems & developments
- RF modelling and simulation, design update/enhancements to
 - minimize beam loss
 - decrease power usage
 - cavity & coupler design

- **RF power generation and distribution**

- baseline with conservative off-the-shelf technology
- investigate alternatives
 - solid state technology
 - phase locking magnetrons (ideas A. Dexter/Lancaster)
- investigate energy/resource efficiency and recovery
 - two-cavities-per-klystron concept
 - RF-to-DC recovery in loads (ideas F. Caspers/CERN)
 - heat recovery from high temperature cooling water (power sources, loads)

- 352 MHz NC Linac
 - piggy back on existing facilities/development work
- 352 MHz Spoke cavities
 - CEA Saclay: existing
 - IPN Orsay: new
 - prototype RF system (after 2012)
- 704 MHz Elliptical cavities
 - CEA Saclay: existing
 - upgrade for cryomodule testing (after 2012)
 - CERN: upgrade for 704 MHz
 - prototype RF system (by 2012) ESS contributing with pulse modulator
 - Uppsala University: new
 - prototype RF system (after 2012) two-cavity-per-klystron concept

WP8: Planning and Prototyping Uppsala Test Facility (FREIA)

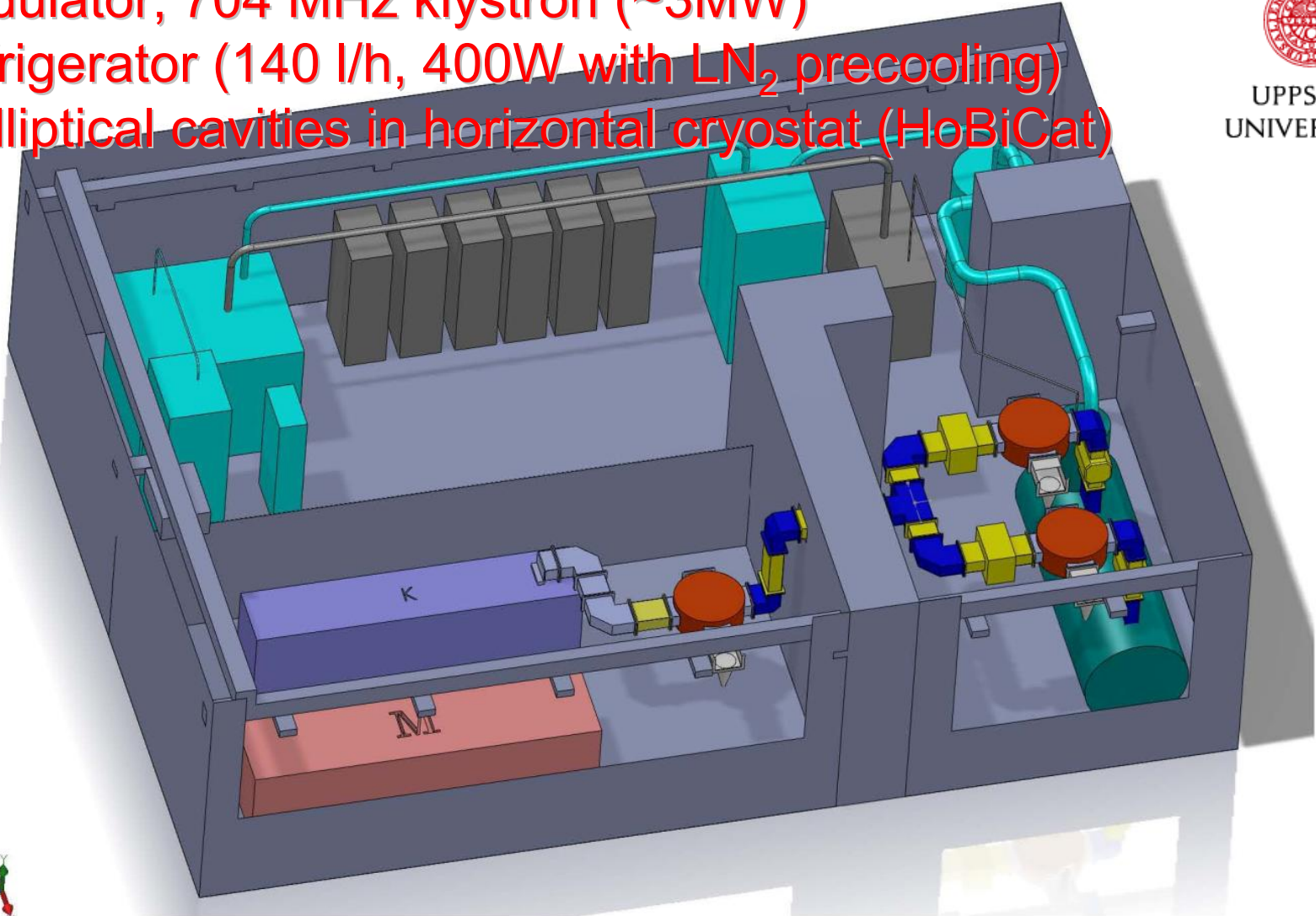


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- Modulator, 704 MHz klystron (~3MW)
- Refrigerator (140 l/h, 400W with LN₂ precooling)
- 2 Elliptical cavities in horizontal cryostat (HoBiCat)



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WP8: Planning and Prototyping Timeframe



	2010 Year 0		2011 1st Year		2012 2nd Year		2013 3rd Year		2014 4th Year		2015 5th Year	
WU8.1 Coordination and Communication												
Coordination												
Technical design report												
Technical specifications												
WU8.2 RF Modelling												
RF parameter list												
Mathematical model												
RF simulations												
WU8.3 Low Level RF												
Investigation alternatives												
352 MHz prototype												
704 MHz prototype												
704 MHz prototype 2 cavities concept												
WU8.4 RF Power Generation												
Investigation alternatives												
352 MHz prototype												
704 MHz prototype												
704 MHz prototype 2 cavities concept												
WU8.5 RF Power Distribution												
Investigation alternatives												
352 MHz prototype												
704 MHz prototype												
704 MHz prototype 2 cavities concept												
WU8.6 RF Test Facility												
352 MHz test facility												
704 MHz test facility												
704 MHz test facility 2 cavities concept												
704 MHz test facility 8 cavities cryomodule												

WP8: Planning and Prototyping Resources Estimation



2010 Year 0		2011 1st Year		2012 2nd Year		2013 3rd Year		2014 4th Year	

									TOTAL
Material	[kSEK]	0	14,694	33,867	26,345	0			74,906
Travel	[kSEK]	349	2,719	2,427	867	852			7,215
Other	[kSEK]	10	1,405	6,342	10,180	10,180			28,116
Sum	[kSEK]	359	18,818	42,636	37,392	11,032			110,237
Material	[kEUR]	0	1,427	3,288	2,558	0			7,272
Travel	[kEUR]	34	264	236	84	83			701
Other	[kEUR]	1	136	616	988	988			2,730
Sum	[kEUR]	35	1,827	4,139	3,630	1,071			10,703
Personnel (*)	[FTEyear]	1	25	29	29	28			111
	[FTEmonth]	12	302	344	344	332			1,336

(*) 1 FTEyear ~ 850 kSEK

111 FTEyear == 94,605 kSEK
TOTAL BUDGET: 204,842 kSEK
19,888 kEUR

WP8: Planning and Prototyping

Possible Partners



Institute	Work Package Task						
	WU8.1	WU8.2	WU8.3	WU8.4	WU8.5	WU8.6	
ESS	X	X	X	X	X	X	
Uppsala U.	X	X	X	X	X	X	
Europe							
CEA		X	X	X	X	X	
CERN		X	X	X	X	X	
CI / UM		X		X			
DESY			X			X	
IPN Orsay		X	X	X	X	X	
JAI / RHAL		X					
Linkop. U.			X				
Lund U.		X	X				
Rostock U.		X					
Soltan INS		X					
Stockh. U.			X				
TU Darm.		X					
U. Oslo					X		
Asia							
KEK						(X)	
U.S.A							
SNS			X		X		
ANL					X		
FNAL			X		X		
JLAB					X		
LBNL			X				

