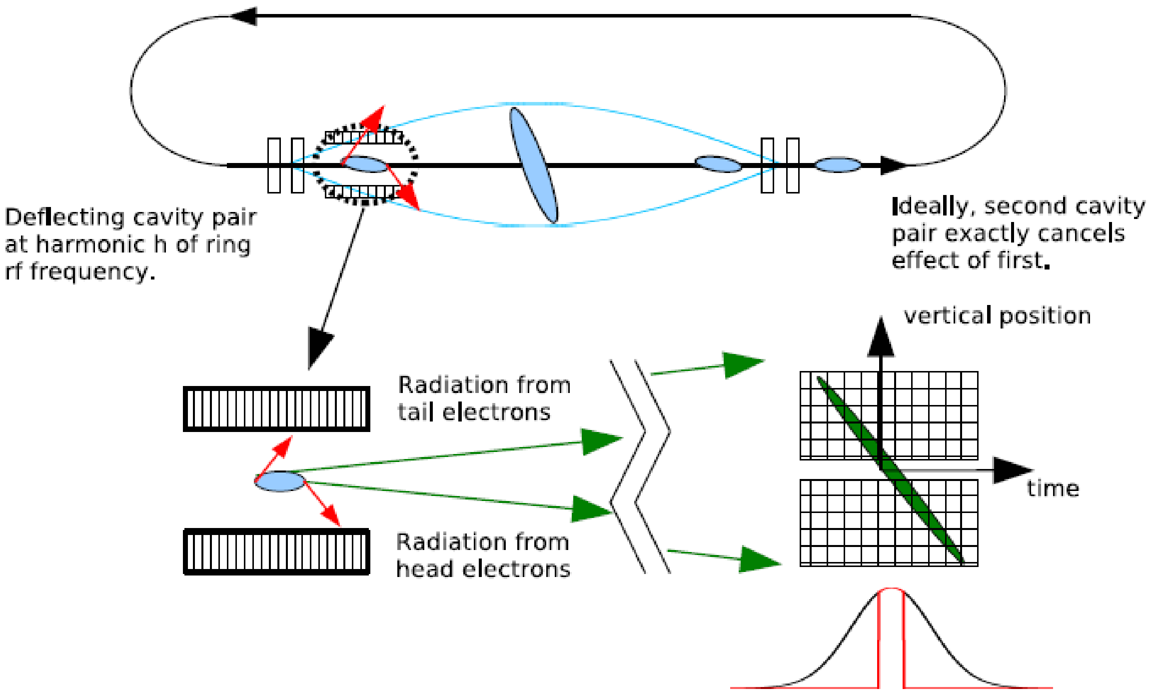
APS Short Pulse X-ray (SPX) Design Study



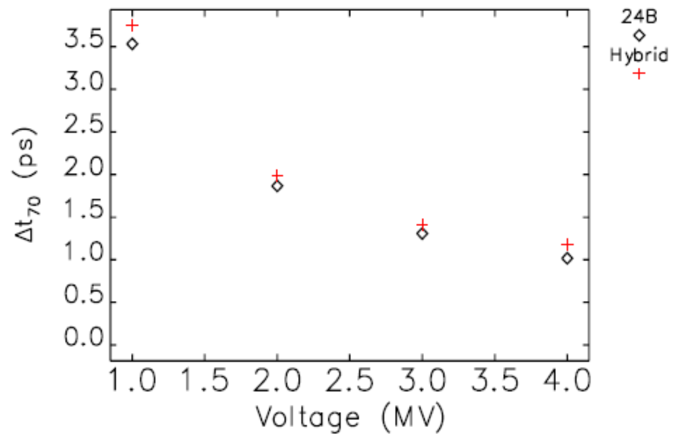
July 27-29, 2010

SPX Scientific Goal

Generate short x-ray pulses using crab-cavity-based method.

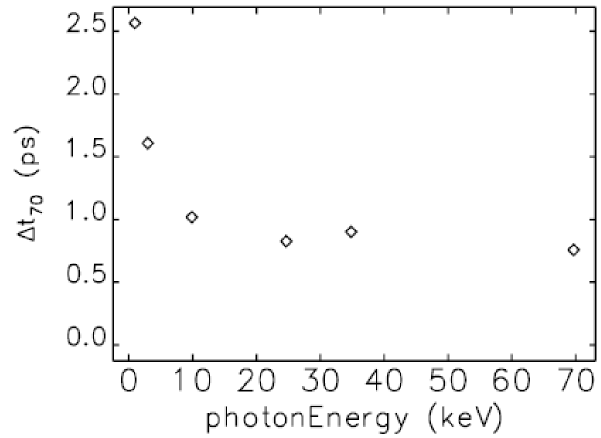
SPX Technical Goal

Conduct R&D to demonstrate proof of concept which will lead to design and implement of a fully integrated SRF deflecting cavities system for the APS storage ring.



SPX Fundamental Parameters

Beam current	202 mA (24singlets)	
Beam energy	7 GeV	
Revolution frequency	271.55 kHz	
RF deflecting voltage	2 MV (Initial implementation)	
Two cryomodules		
4 cavities/cryomodule		
RF deflecting voltage	4 MV (Final implementation)	
Two cryomodules		
8 cavities/cryomodule		
RF frequency		2815.4856 MHz
		(8^{th} harm of SR frequency (351.9357 MHz)

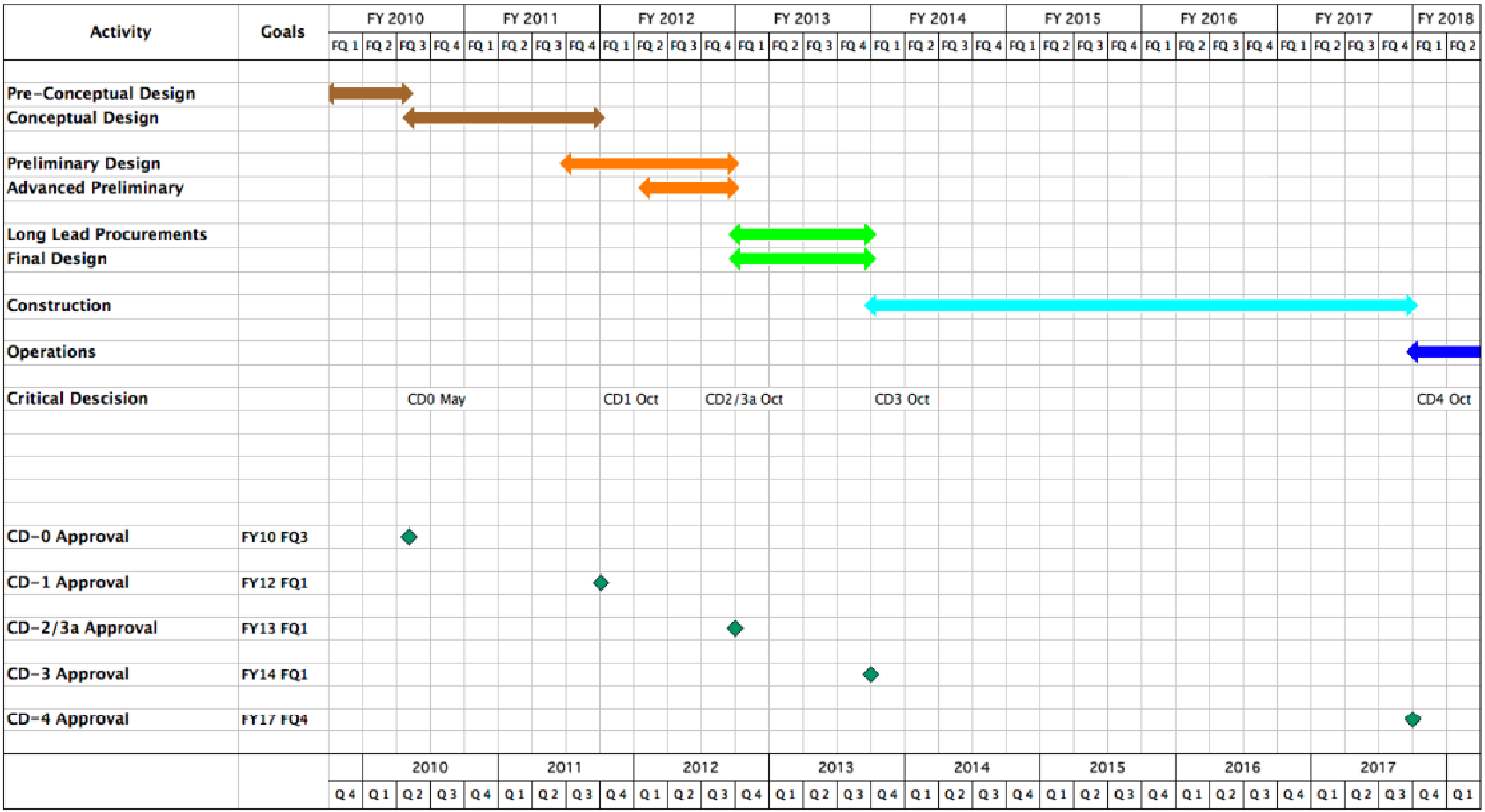


Technical Systems

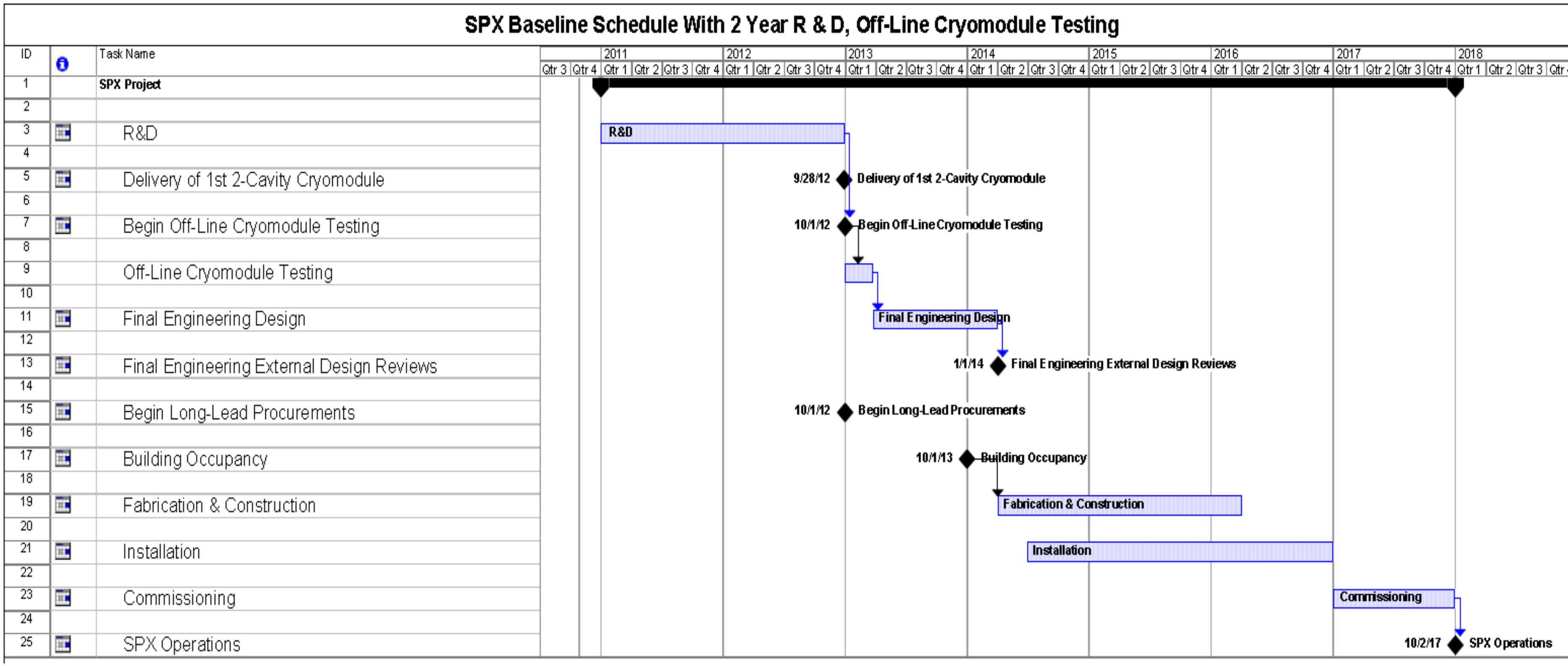
- Cavities
- Cryomodule
- Cryogenics
- Low-level RF
- High-power RF and waveguide distribution
- Beam diagnostics
- Timing and synchronization
- Controls/Interlocks/ Machine Protection System

APS-U Timeline

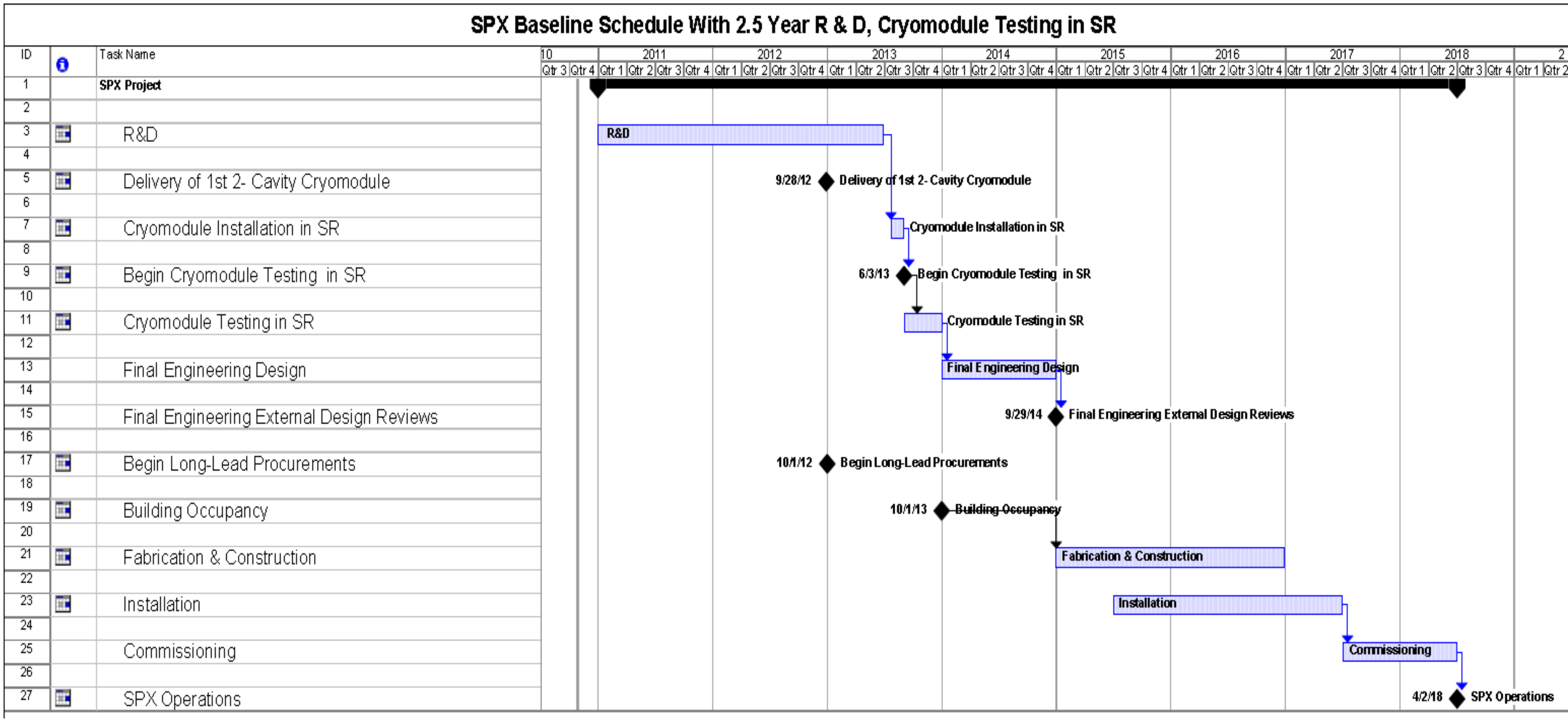
APS Upgrade Expected Timeline and Milestones



SPX Timeline with Milestones



SPX Timeline with Milestones -2



R&D. What do we have to learn?

	Offline Testing					On-Line Testing
Information Learned	Non-Cryo Tests	Single bare Cavity Vertical Test Stand (PHY 24" bucket dewar)	Single dressed Cavity Horizontal Test Stand (PHY TC3)	Multiple dressed Cav Horizontal Test Stand (PHY TC3)	LEUTL Test with beam (Multi. Dressed cav)	Storage Ring Test, passive/active (Mult. dressed Cav)
Cavity resonant frequency at operating temperature		x	x	x	x	x
Cavity Q vs E at temperatures down to 2K		x	x	x	x	x
Cavity resonant freq. across slow tuner range			x	x	x	x
Helium vessel performance			x	x	x	x
Check of clean assembly			x	x	x	x
Test of actual input coupler	x		x	x	x	x
Cavity pickup probe cabling drift measurements		x	x	x	x	
Test of actual pickup probe				x	x	x
Cavity microphonics and Lorentz transfer function				x	x	x
Cavity impedance test (low power, test imped., at select freq)						
Cavity impedance test (w/beam, beam stability, narrowband, broadband)						
Cavity high power damper test (test rf props, mech. Issues)						
Impedance budget (cavities, taper transitions, bellows)						
Cavity damper design	x			x	x	x
Cavity damper test w/beam (multipact., narrowband, broadband loading					x	x
Cavity impedance effects (damper performance)					x	x
Cold mass checkout					x	x
Cavity alignment scheme checkout				x	x	x
Cavity electrical center	x					
Cryomodule static heat loads				x	x	x
Cavity multipacting		x	x	x	x	x
Cavity quench levels		x	x	x	x	x
Cavity multpacting with beam					x	x
Cavity quench levels with beam					x	x
Klystron phase noise measurements	x	x	x	x	x	x
Will the SRF cavity meet operating gradient spec ?				x	x	x
Will the cavity/cryomodule meet microphonics spec ?				x	x	x
What is the ground vibration spectrum in Sector 6 and 8 ?	x	x	x	x	x	x
How do ground vibrations couple to the cavity microphonics ?			x	x	x	x
Is active microphonics suppression necessary to meet the RF system performance specification ?			x	x	x	x
Can 0.03deg rms differential phase stability be achieved with an S-band SRF system without beam loading?			x	x		
Can 0.03deg rms differential phase stability be achieved with an S-band SRF system under beam loading ? (i.e. 2 cavity, 1 sector test, can chirp be held to zero?)					x	x
Development of SRF cavity control algorithms	x		x	x	x	x
Development of LLRF cable calibration schemes	x		x	x	x	x
Development of RF system beam-based calibration schemes	x					
Cavity tuner system development	x					
Cavity microphonics suppression	x	x	x	x	x	x
Full-power test of klystron, characterize for rf gain, eff., p/a modulation sensitivity to HVPS ripple, collector full beam test	x	x	x	x	x	x
Characterize phase stability of WG components	x				x	x
Test circulator and load at full power/full reflection	x					
Test WG shutters at full power and certify PPS	x					
Test and characterization of high power I/Q moulator	x					
Development and te of fast rf interlock system	x					
Beam Diagnostics					x	x
To what extent can the real-time orbit feedback system relax the medium to long-term phase stability spec?						x
Timing and reference distribution System					x	x

Agenda

Tuesday, July 27 – A1100

8:45 AM – 8:50 AM	Welcome	Zholents
8:50 AM – 9:00 AM	APS-U – Accelerator systems	Borland
9:00 AM – 9:15 AM	SPX Project Overview	Nassiri
9:15AM– 9:45 AM	Constraints, performance requirements, and tolerances	Sajaev
9:45 -10:15 AM	Collective effects – multi-bunch stability	Harkay
10:15AM – 10:30 AM	Coffee break	
10:30AM – 11:15 AM	SPX deflecting cavities	Waldschmidt
11:15AM – 11:35 AM	Cryomodule concepts and cryogenics	Fuerst
11:35 AM– 12:15 PM	Discussion	
12:15 PM – 1:30 PM	No-host lunch	
1:30 PM – 2:00 PM	LLRF concept	Berenc
2:00PM – 2:20PM	RF source and rf power distribution scheme	Horan
2:20 PM – 2:50 PM	Timing and synchronization	Lenkszus
2:50 PM – 3:20 PM	Beam diagnostics	Yang
3:20 PM – 3:30 PM	Coffee break	

Agenda - 2

Wednesday, July 28

9:00 AM – 10:30 AM	WG summary reports and discussion
10:30 AM – 10:45 AM	Coffee break
10:45 AM – 12:15 PM	Working groups
12:15 -1:45 PM	Lunch
1:45 PM – 3:15 PM	Working groups
3:15 PM – 3:30 PM	Coffee break
3:30 PM – 5:30 PM	Working groups
7:00 PM	No-host dinner

Thursday, July 29

9:00 AM – 10:30 AM	WG summary reports and discussion
10:30 AM – 10:45 AM	Coffee break
10:45AM – 12:30 PM	Discussion
12:30PM -1:30 PM	No-host lunch
1:30 PM – 2:30 PM	Discussion and summary
2:30 PM	Meeting adjourned

Agenda - 3

Working Groups

WG1: Cavity/Cryomodule/Cryogenics/HLRF - A1100
Coordinators: Rimmer, Waldschmidt, Mammosser

WG2: LLRF/Timing-Synchronization/Diagnostics & Controls - B3100A&B
Coordinators: Doolittle, Berenc,Byrd

Additional discussion topics if time permits:

1) **Partially driving the cavities with beam**
2) **Ideas on system commissioning**

Study Group Goals

- Focus entirely on the SPX technical goals.
- Study and evaluate feasibility of proposed solutions based on beam physics requirements imposed by the APS storage ring operation.
- Identify high-risk technical activities and suggest means of mitigating those risks.
  - Design modifications and/or alternative solutions
- Identify and discuss key R&D elements in each technical system that are necessary for proof-of-the-concept demonstration.
- Study and evaluate design and performance of each system. Highlight engineering design weaknesses that need improvements/modifications to be realizable and cost effective.
- To what degree, if any, can the physics specifications be somewhat relaxed to ease the tolerances on the technical systems? Can design deliver technical performance?
- Are there any potential show stoppers?