T2K program

1207 PAC

- We want to improve significance and precision of our **APPEARANCE** signal as soon as possible
  - Ahead of NOvA
- Precision measurement of appearance
  - Tighter constraint in theta13-delta plane
  - Compare with reactor results
  - First trial to detect possible hint on CPV and mass hierarchy
  - Determination of Δm_{13}^2
- Precision measurement of disappearance
  - θ_{23}, Δm_{23}
  - Whether maximal mixing or not?
- Various cross section measurements at near detector

NOνA

A broad physics scope

Using $\nu_\mu \to \nu_e$, $\bar{\nu}_\mu \to \bar{\nu}_e$ ...

- **Measure θ_{13}** via ν_e appearance
- Determine the **ν mass hierarchy**
- Search for **ν CP violation**
- Determine the **θ_{23} octant**

Using $\nu_\mu \to \nu_\mu$, $\bar{\nu}_\mu \to \bar{\nu}_\mu$ ...

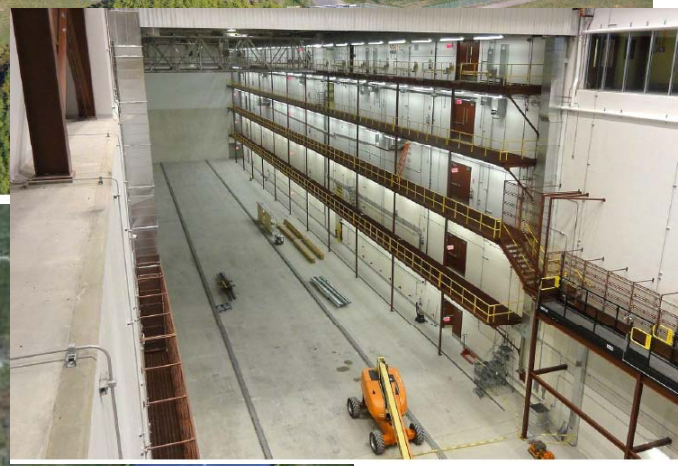
- **Atmospheric parameters:** precision measurements of θ_{23}, $|\Delta m^2_{atm}|$. (*Exclude $\theta_{23}=\pi/4$?*)
- **Over-constrain** the atmos. sector (*four oscillation channels!*)

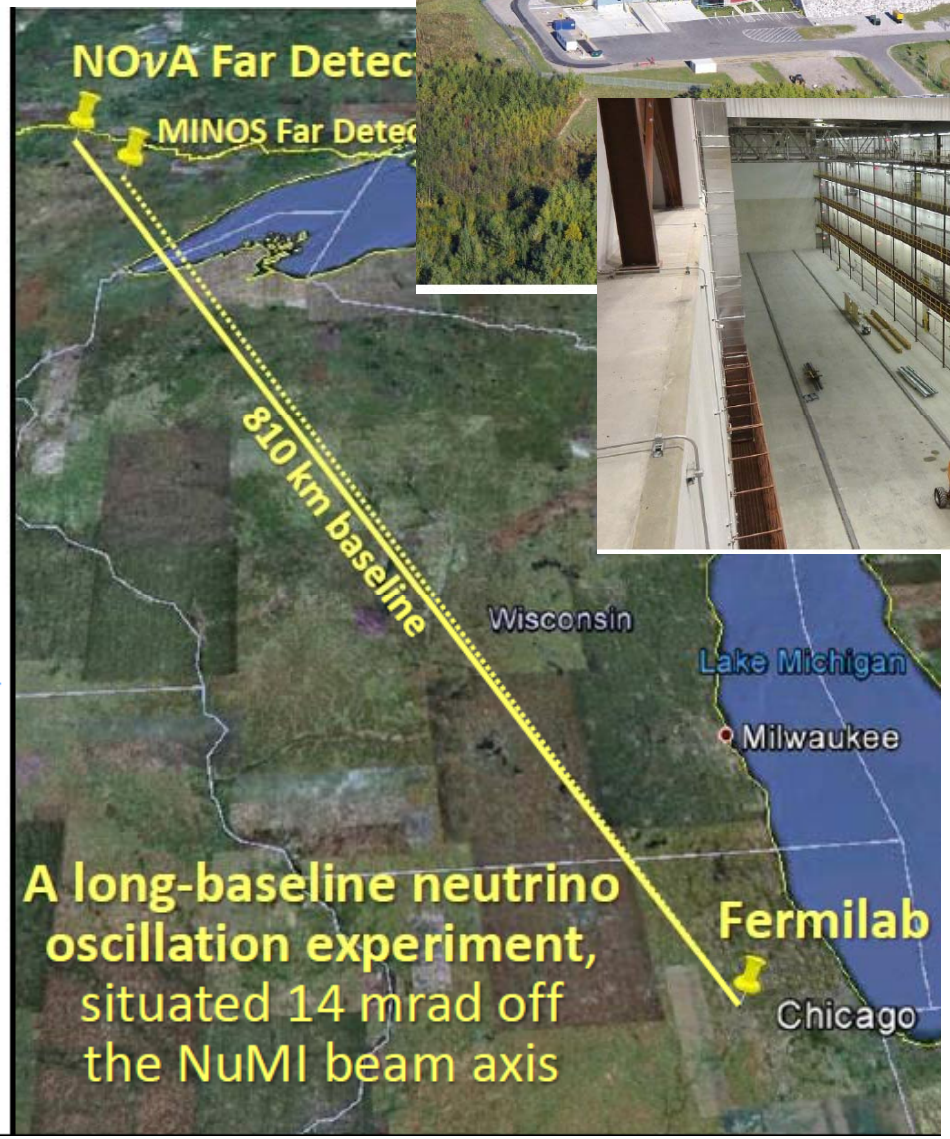
Also ...

- Neutrino cross sections at the NOνA Near Detector
- Sterile neutrinos
- Supernova neutrinos
- Other exotica

Ryan Patterson, Caltech

Far Detector Building – Complete

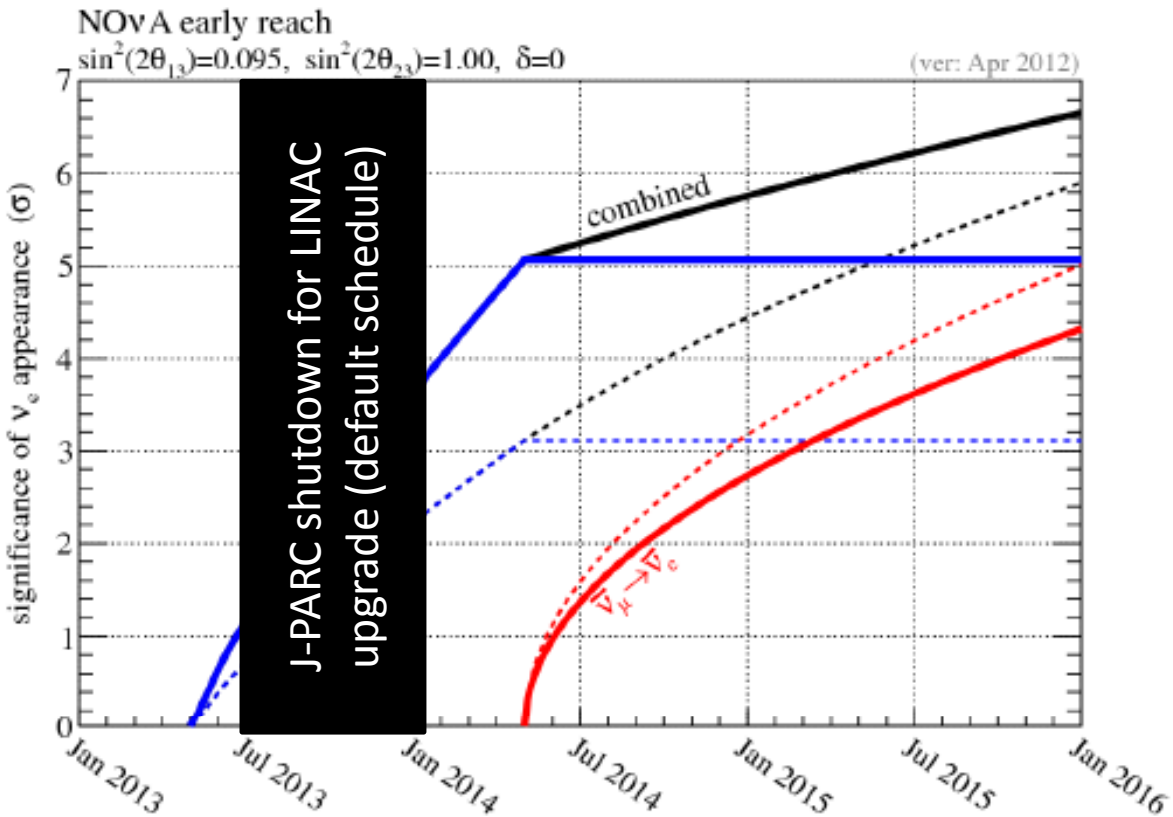




Early Reach

Will start with ν running

- Can switch to $\bar{\nu}_\mu$ any time, optimizing the run plan based on our or others' results
- 5σ observation of $\nu_\mu \rightarrow \nu_e$ in first year if NH
  (even with partial detector and beam commissioning!)



And beyond...

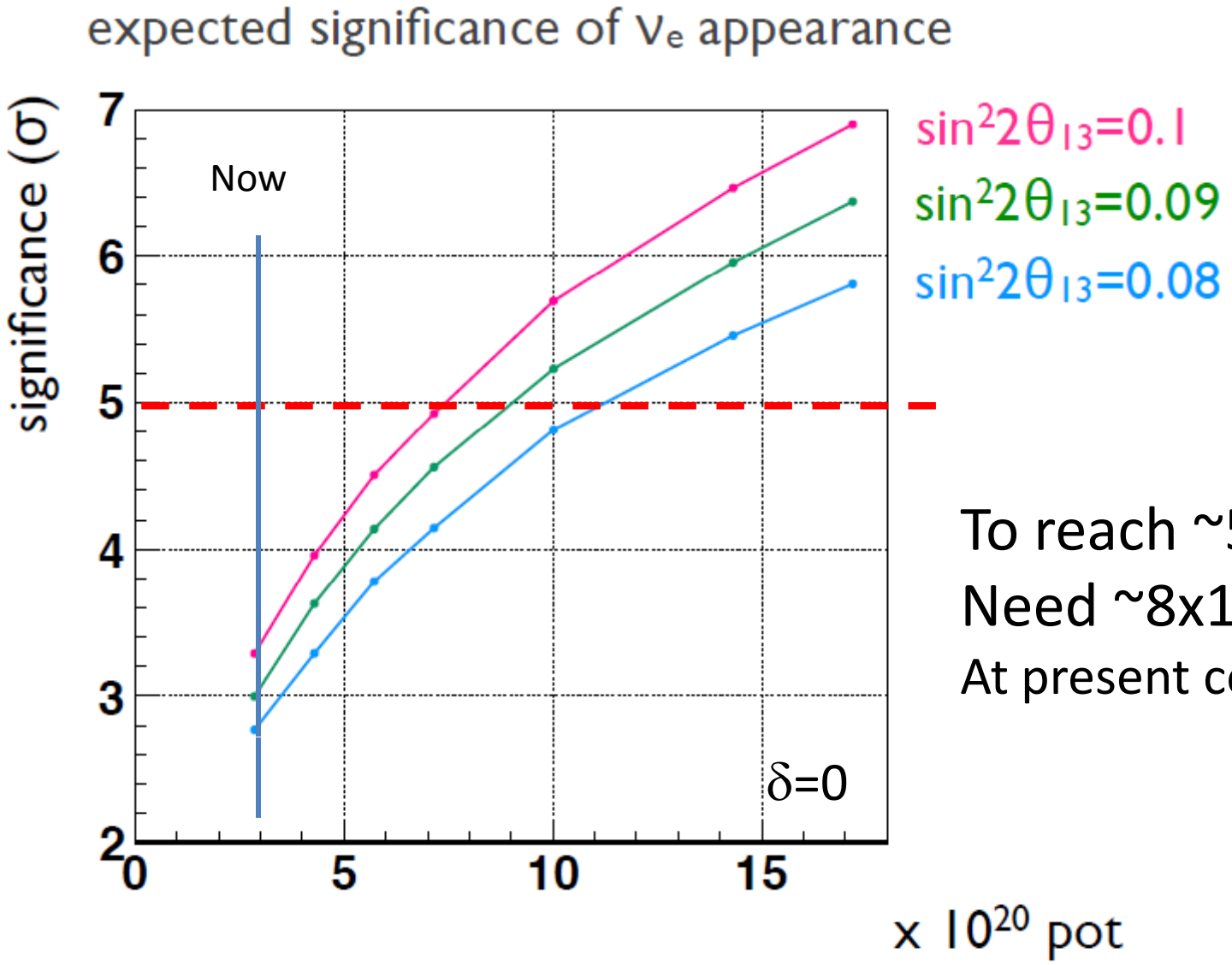
Nominal run plan: 3 yr (ν) + 3 yr ($\bar{\nu}$) (with 6×10^{20} p.o.t./year)

- In this talk: using *earlier analysis methods*, but including new θ_{13} knowledge
  ⇨ Taking $\sin^2(2\theta_{13}) = 0.095$
- Representative event counts for $\nu_\mu \rightarrow \nu_e$ analysis →
  ⇨ *These depend greatly on the specific oscillation parameters*
- Signal efficiency: 45%
  NC fake rate: 0.1%

3 yr + 3 yr

beam =	ν	$\bar{\nu}$
NC	19	10
ν_μ CC	5	<1
ν_e CC	8	5
tot. BG	32	15
$\nu_\mu \rightarrow \nu_e$	68	32

T2K Near term expected sensitivity



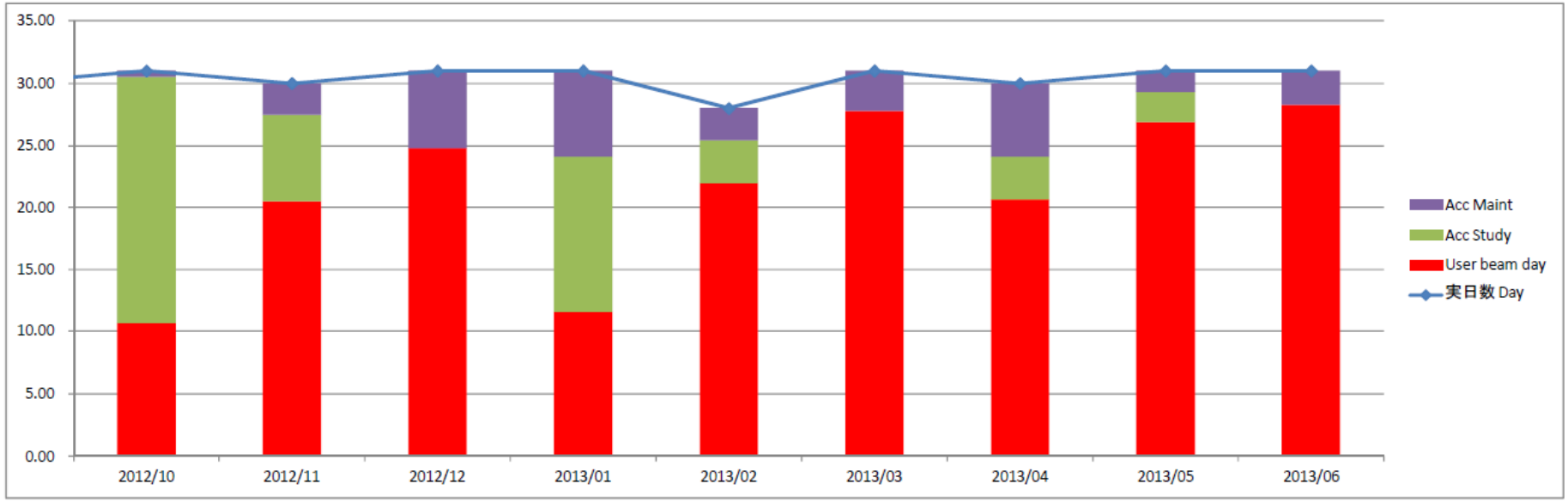
To reach ~5σ level

Need ~8x10^{20}POT

At present central value

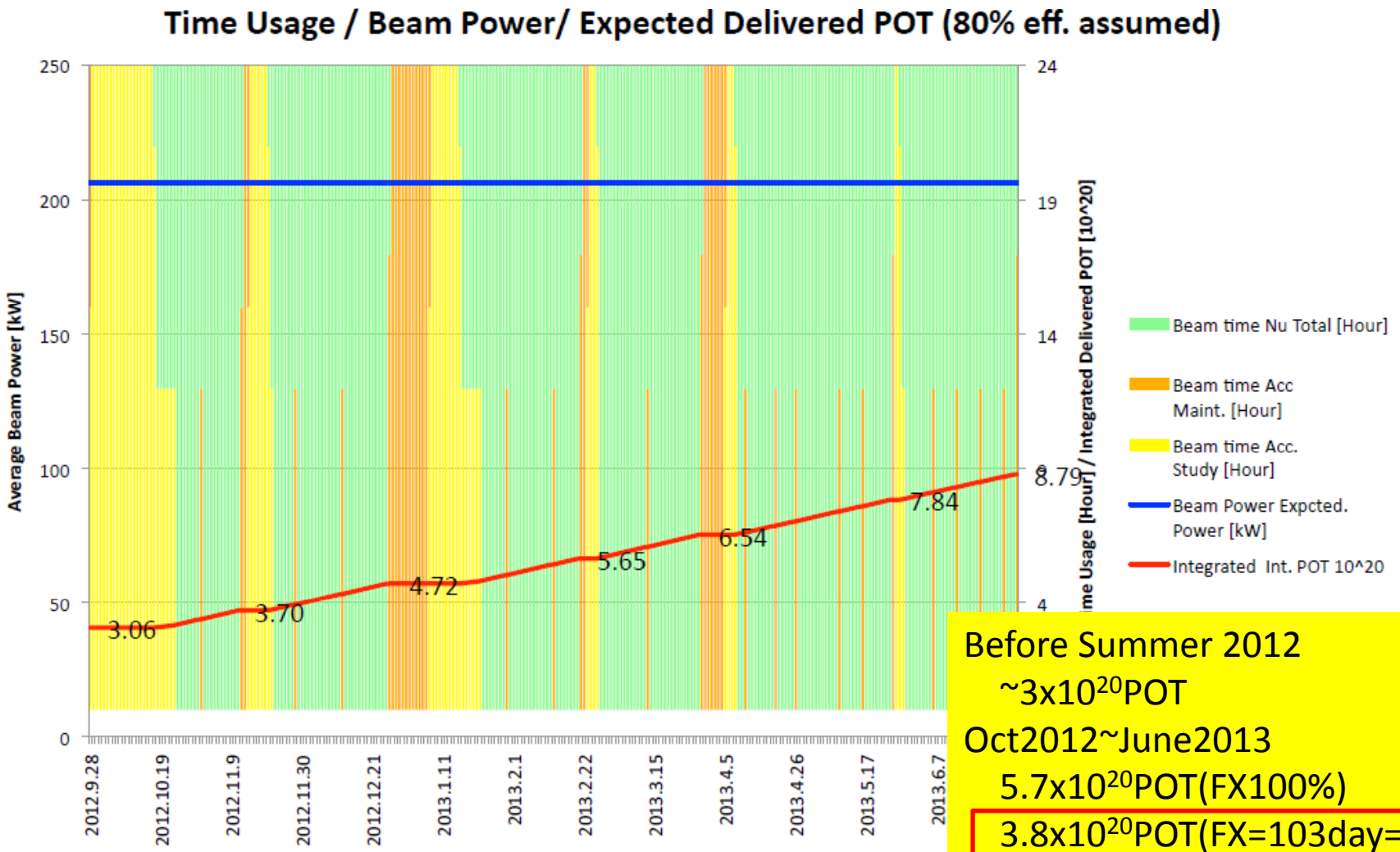
Expected machine time & assumed beam power

	実日数	実時間	Acc Study		Acc Maint		User beam		Running Eff	Eff. Running time		Rep rate	Power	POT/hr	POT/24h	POT/mon	
	Day	Hr	Hr	day	hr	day	hr	day		hr	day	s	kW				
2012/06												2.56	190.0	1.42E+17	3.42E+18	3.06E+20	2012/6までの実績と積分POT
2012/09	30	720	63	2.6	9	0.4	0	0.00	80%	0.0	0.0	2.48	206.5	1.55E+17	3.71E+18	0.00E+00	
2012/10	31	744	477	19.9	12	0.5	255	10.63	80%	204.0	8.5	2.48	206.5	1.55E+17	3.71E+18	3.15E+19	
2012/11	30	720	168	7.0	60	2.5	492	20.50	80%	393.6	16.4	2.48	206.5	1.55E+17	3.71E+18	6.09E+19	
2012/12	31	744	0	0.0	149	6.2	595	24.79	80%	476.0	19.8	2.48	206.5	1.55E+17	3.71E+18	7.36E+19	
2013/01	31	744	300	12.5	165	6.9	279	11.63	80%	223.2	9.3	2.48	206.5	1.55E+17	3.71E+18	3.45E+19	
2013/02	28	672	84	3.5	62	2.6	526	21.92	80%	420.8	17.5	2.48	206.5	1.55E+17	3.71E+18	6.51E+19	
2013/03	31	744	0	0.0	77	3.2	667	27.79	80%	533.6	22.2	2.48	206.5	1.55E+17	3.71E+18	8.25E+19	
2013/04	30	720	84	3.5	141	5.9	495	20.63	80%	396.0	16.5	2.48	206.5	1.55E+17	3.71E+18	6.12E+19	
2013/05	31	744	57	2.4	41	1.7	646	26.92	80%	516.8	21.5	2.48	206.5	1.55E+17	3.71E+18	7.99E+19	
2013/06	31	744	0	0.0	65	2.7	679	28.29	80%	543.2	22.6	2.48	206.5	1.55E+17	3.71E+18	8.40E+19	7/1含む
Total	274	6576	1170	51.4	772	32.5	4634	193.08		3707.2	154.5					5.73E+20	10月～
実験開始からのトータル																8.79E+20	



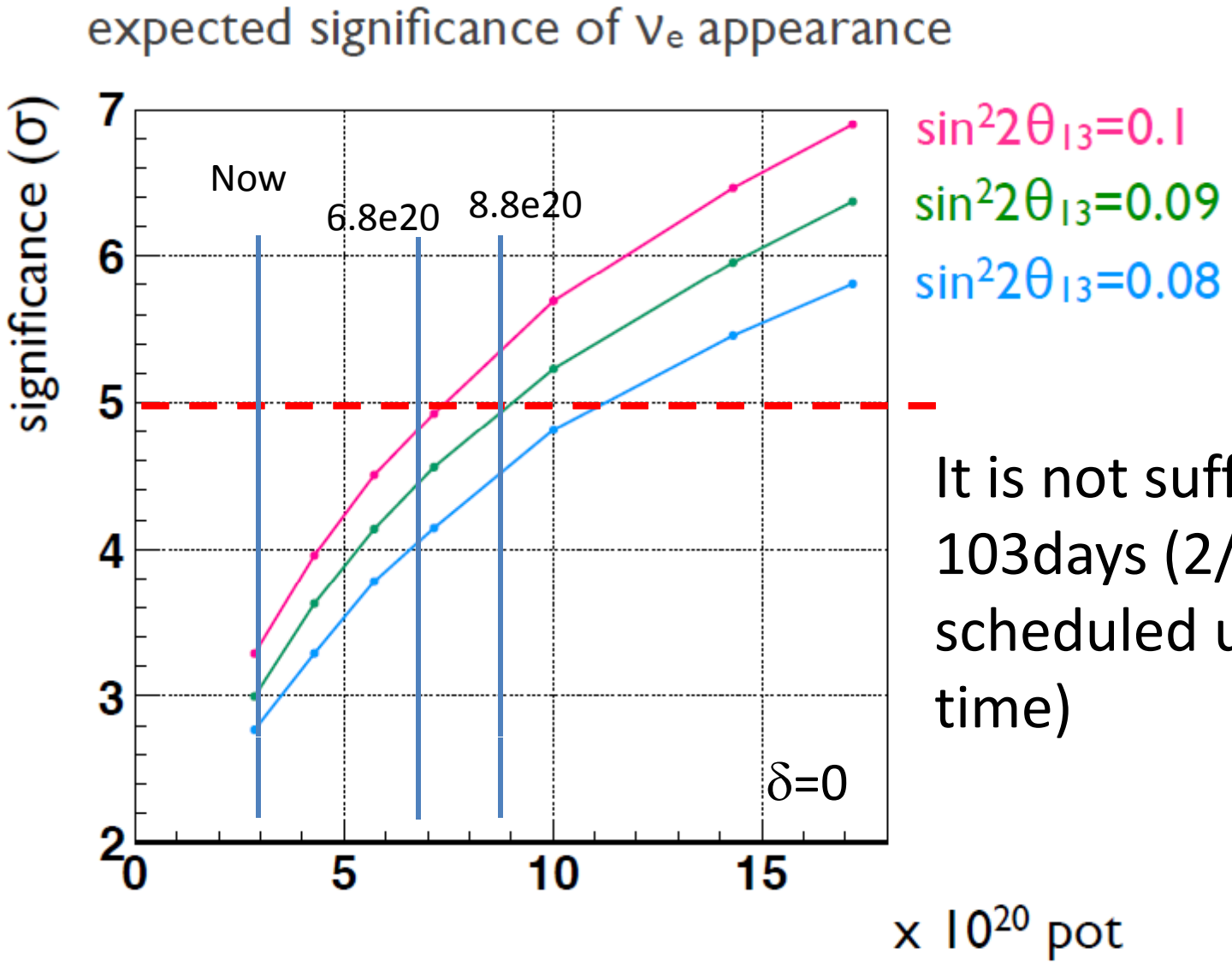
- Assume beam power = (achived) x (rap rate increase) = 206kW
  - Can accumulate 3.7×10^{18}POT/day ➔ >135 days(net) is necessary to reach $>8\times10^{20}$POT
- Assume operation schedule of JFY2012, both for JFY2012 and 2013
- Assume accelerator/beamline running efficiency = 80%
- ➔ 154days for SX+FX effective running time

Expected POT

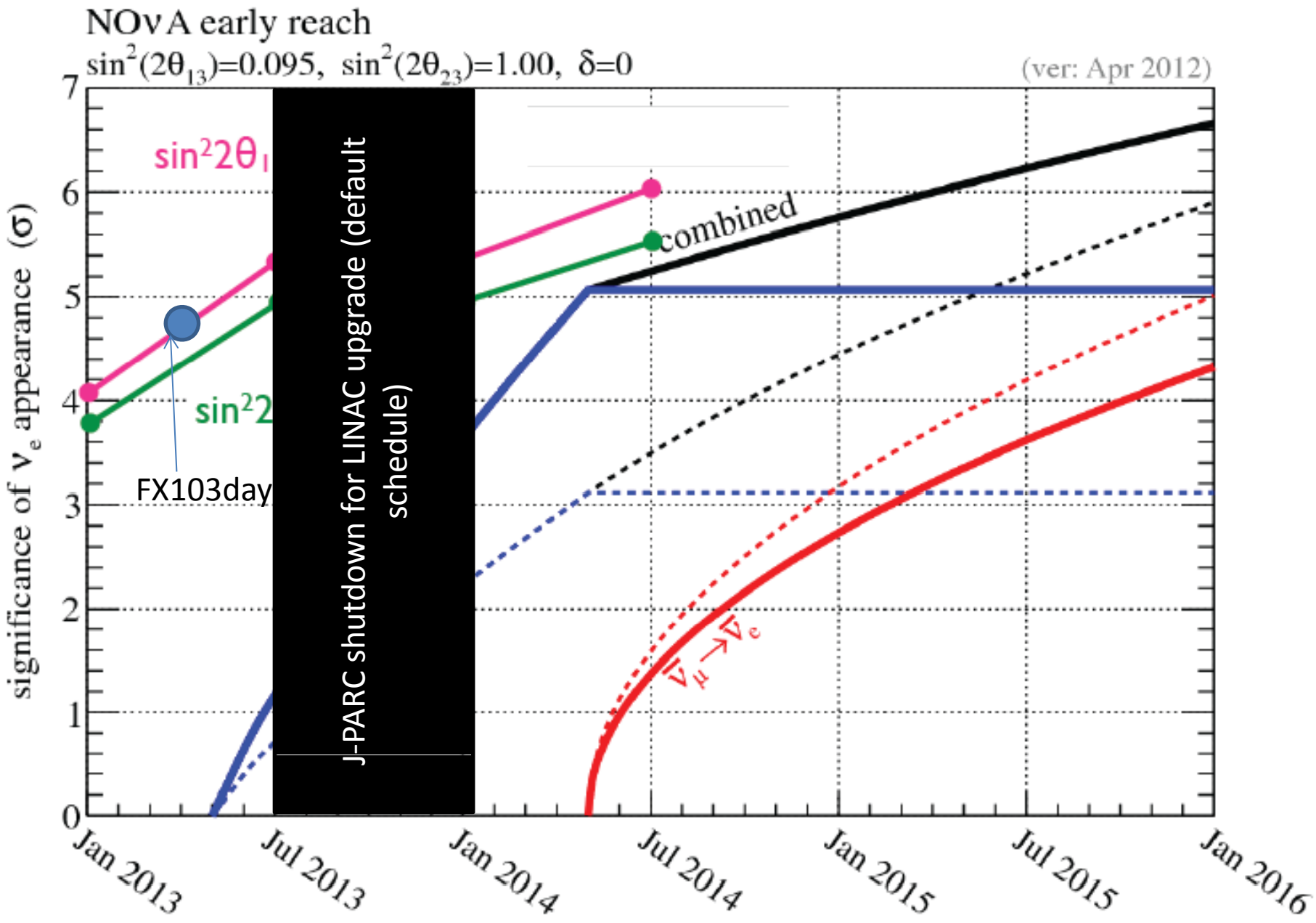


Before Summer 2012
~3×10^{20}POT
Oct2012~June2013
5.7×10^{20}POT(FX100%)
3.8×10^{20}POT(FX=103day=67%)
Total
8.8×10^{20}POT(FX100%)
6.8×10^{20}POT(FX=103day=67%)

Near term expected sensitivity



It is not sufficient w/ 103days (2/3 of scheduled user beam time)


NOνA early reach
sin²(2θ13)=0.095, sin²(2θ23)=1.00, δ=0
(ver: Apr 2012)
significance of νe appearance (σ)
sin²2θ1
sin²2
combined
FX103day
J-PARC shutdown for LINAC upgrade (default schedule)
ν̄μ→ν̄e
0
1
2
3
4
5
6
7
Jan 2013
Jul 2013
Jan 2014
Jul 2014
Jan 2015
Jul 2015
Jan 2016

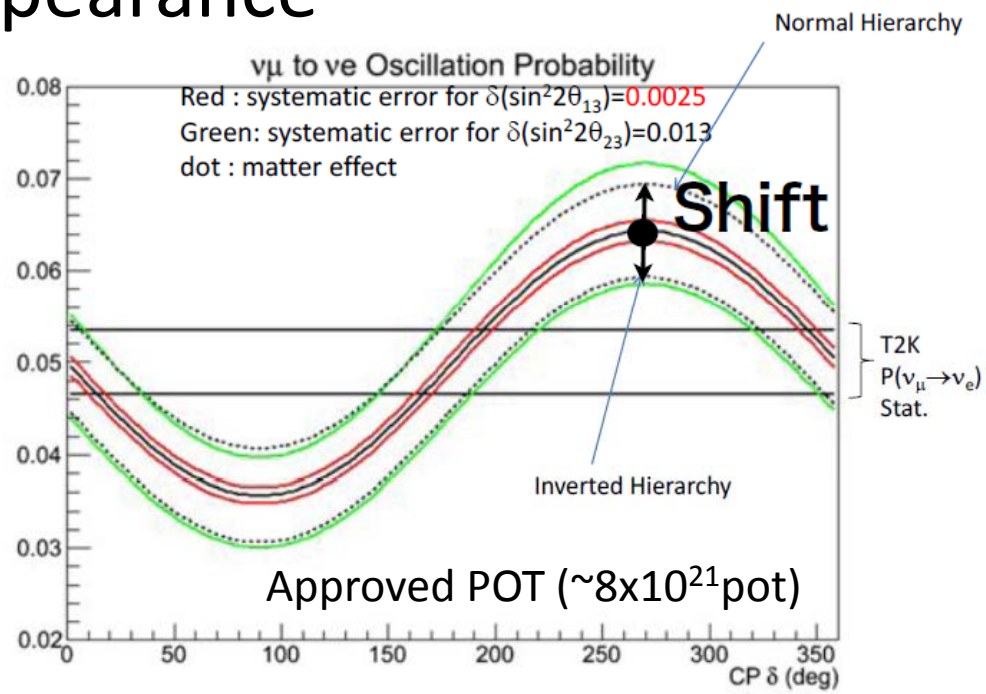
Mid term program
Precision measurements of appearance and disappearance

Acc ν_e appearance measurement
- ➔ $P_{\mu\rightarrow e}=f(s_{12}s_{23}s_{13}s_{\delta})$

ν_μ disappearance measurement
- ➔ Precise θ_{23}

Reactor ν_e disappearance measurement
- ➔ Precise θ_{13}

➡ Could give hint on δ_{CP}



G.Fogli@Nu2012

Fractional 1σ accuracy [defined as 1/6 of ±3σ range]

δm^2	$\sin^2\theta_{12}$	$\sin^2\theta_{13}$	$\sin^2\theta_{23}$	Δm^2
2.6%	5.4%	13%	13%	3.5%

Already similar precision!

Improving precision of both $P(\nu_\mu\rightarrow\nu_e)$ and θ_{23} are important

Necessary beam power to accumulate ν_e events beyond NOνA

(~30% (stat) err argument)

- T2K
  - 7.27 evts @ 2.56 x 10^{20} POT
- NOvA expectation
  - 23 evts / yr (= 6x10^{20}POT)
- Then, for T2K to accumulate >23evt/yr
  - Need > (23/7.23) x 2.56e20 = **~8x10^{20}POT/yr =** (380 kW x 1e7s)
- (A case study to give you idea)
  - If beam time of 1.3e7sec (~3700hr~154d) in 9month (17d/month) can be used after accelerator running efficiency (as in the previous case study) for either SX or FX
  - We need
    - >420kW if SX:FX = 1:2 (FX~2500h~100d~9e6s)
    - >560kW if SX:FX = 1:1 (FX~1850h~76d~6.7e6)

Request (Summary)

- **We would like to accumulate >8x10^{20}POT (5x10^{20} more from now) before LINAC shutdown**
  - To go ahead NOvA (~5σ level at present central value)
  - We would like to thank IPNS/KEK and J-PARC the effort to increase user beam time
- After LINAC upgrade, we need to accumulate >8x10^{20}POT /year (30% error argument) (Corresponds to > 400kW if SX:FX=1:2 case)
  - To keep producing leading physics output
    - COMPARISON between T2K and NOVA is very important for possible hint of matter effect, CPV
    - BOTH EXPERIMENTS need to HAVE HIGH / SIMILAR SENSITIVITIES.
- Early realization of design power of 750kW