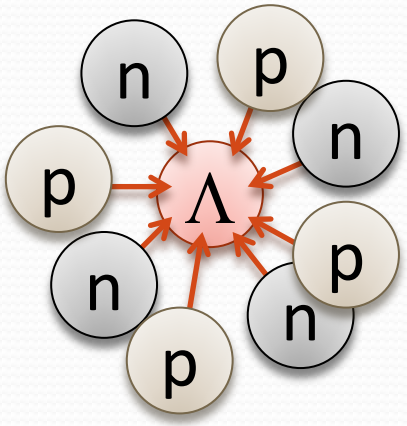
E10 status

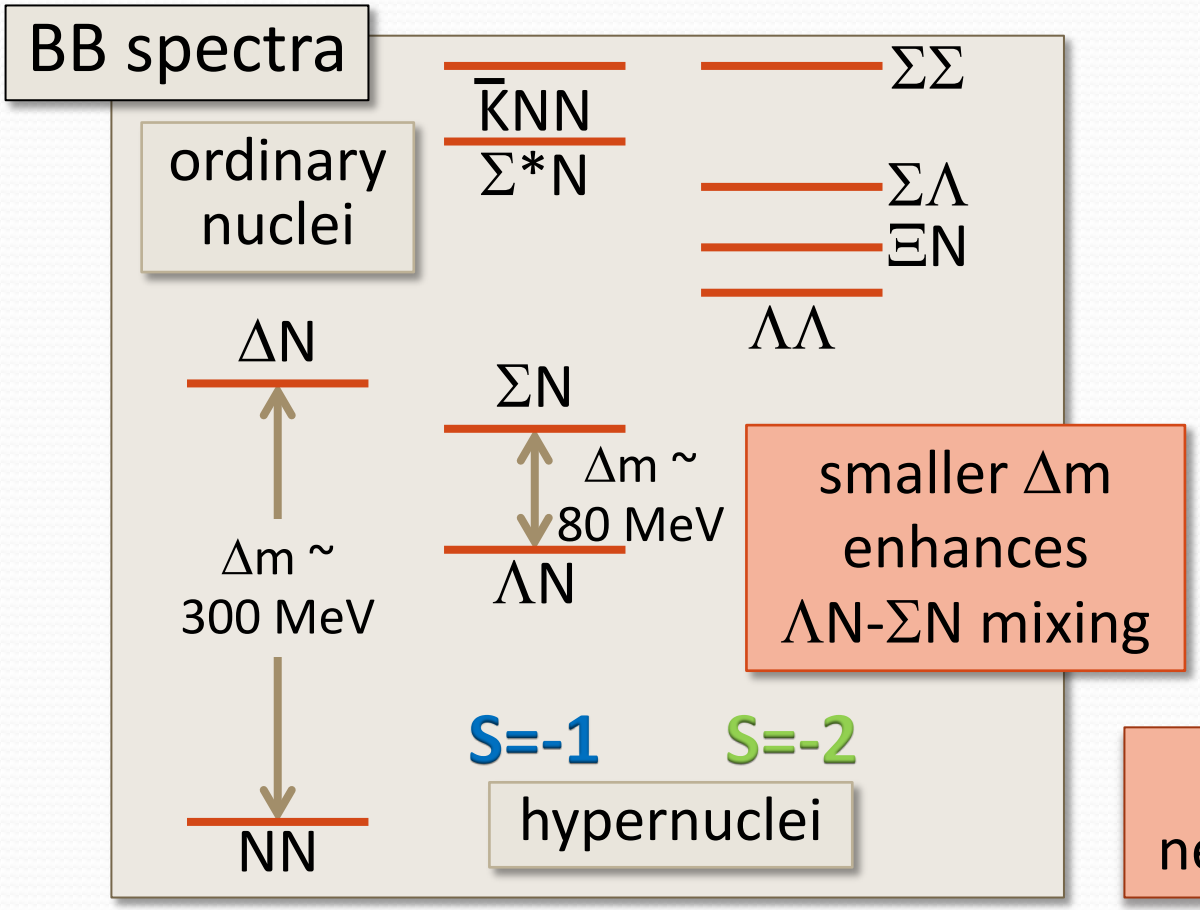
Atsushi Sakaguchi (Osaka University)
for the E10 Collaboration

Hypernuclei and issues of studies

- What is Hypernuclei?
  - Hypernucleus is a new category of "nucleus" which contains hyperons as new ingredients
    - candidate hyperons are Λ, Σ, Ξ and Ω
  - Λ hypernuclei
    - have very clear "nuclear" structure as normal nuclei
    - many studies and interesting phenomena
- "glue-like role" of Λ hyperon
  - Λ hyperon resides deep inside nucleus
  - additional attractive Λ-N interaction
  - glue effect may extend boundary of stability of "nuclei"

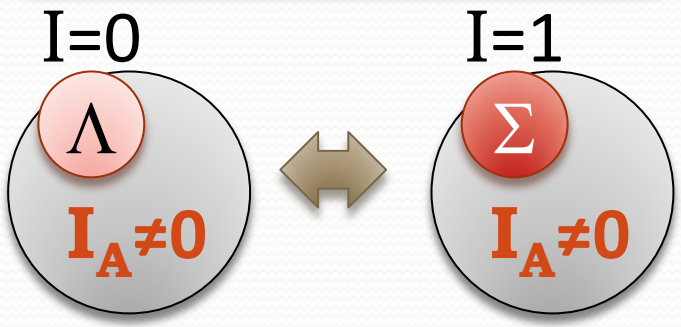


- ΛN-ΣN mixing in hypernuclei
  - Strong mixing of ΛN and ΣN pairs both have I=1/2



smaller Δm enhances ΛN-ΣN mixing

overall conservation of isospin is required



larger mixing expected in nuclei with larger I_A

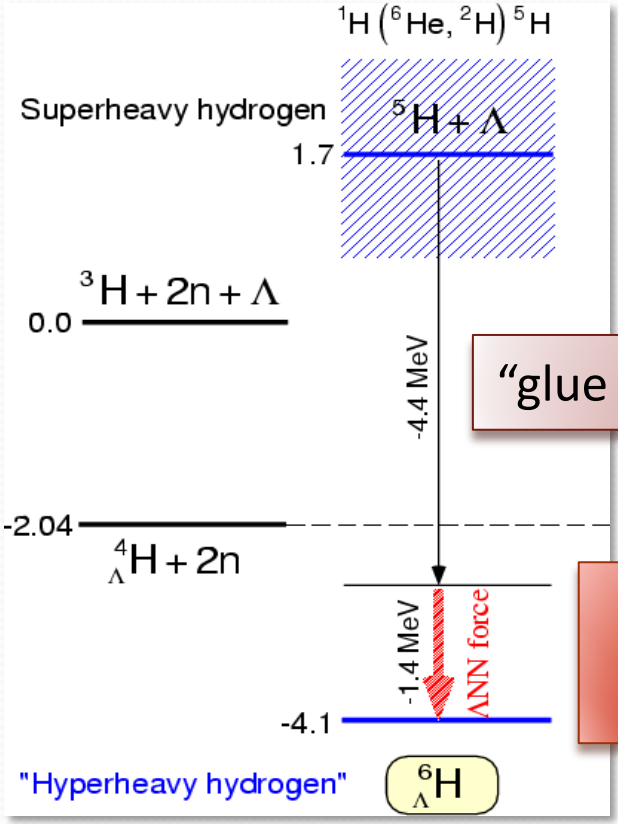
How large is mixing in neutron-rich hypernuclei?

Aims of E10 experiment

- **Aim 1**: production of Λ hypernuclei close to the neutron drip-line, ${}^{6}_{\Lambda}\mathrm{H}$ and ${}^{9}_{\Lambda}\mathrm{He}$
  - E10 may produce highly neutron-rich Λ hypernuclei
    - ${}^{6}_{\Lambda}\mathrm{H}$ (1p, 4n and 1Λ), ${}^{9}_{\Lambda}\mathrm{He}$ (2p, 6n and 1Λ)
    - These are exotic hypernuclei we have never seen clearly
  - "glue like role" of Λ hyperon is critical in such loosely bound hypernuclei
- **Aim 2**: Λ-N interaction at the extreme condition
  - The ΛN-ΣN mixing effect may be observed in the hypernuclear structures
  - Neutron-rich Λ hypernuclei are good laboratories to study the ΛN-ΣN mixing

ΛN-ΣN mixing effects in ${}^{6}_{\Lambda}$H

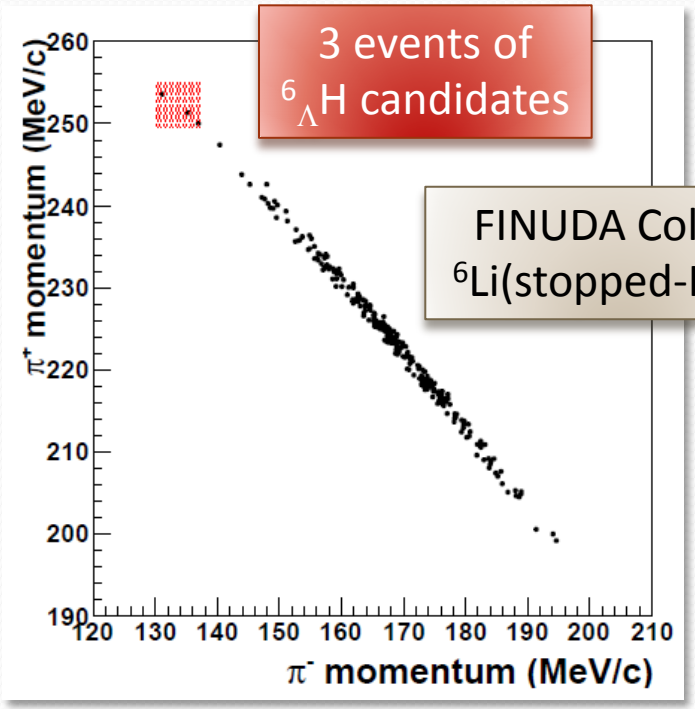
- Structure and cross section of neutron-rich hypernuclei may give us information of the ΛN-ΣN mixing



"glue like role" of Λ

coherent ΛN-ΣN mixing

K. Swe Myint and Y. Akaishi, PTP Supplement 146 (2002) 599



M. Agnello et al., FINUDA Collaboration, PRL 108 (2012) 042501

E10 provides decisive conclusion

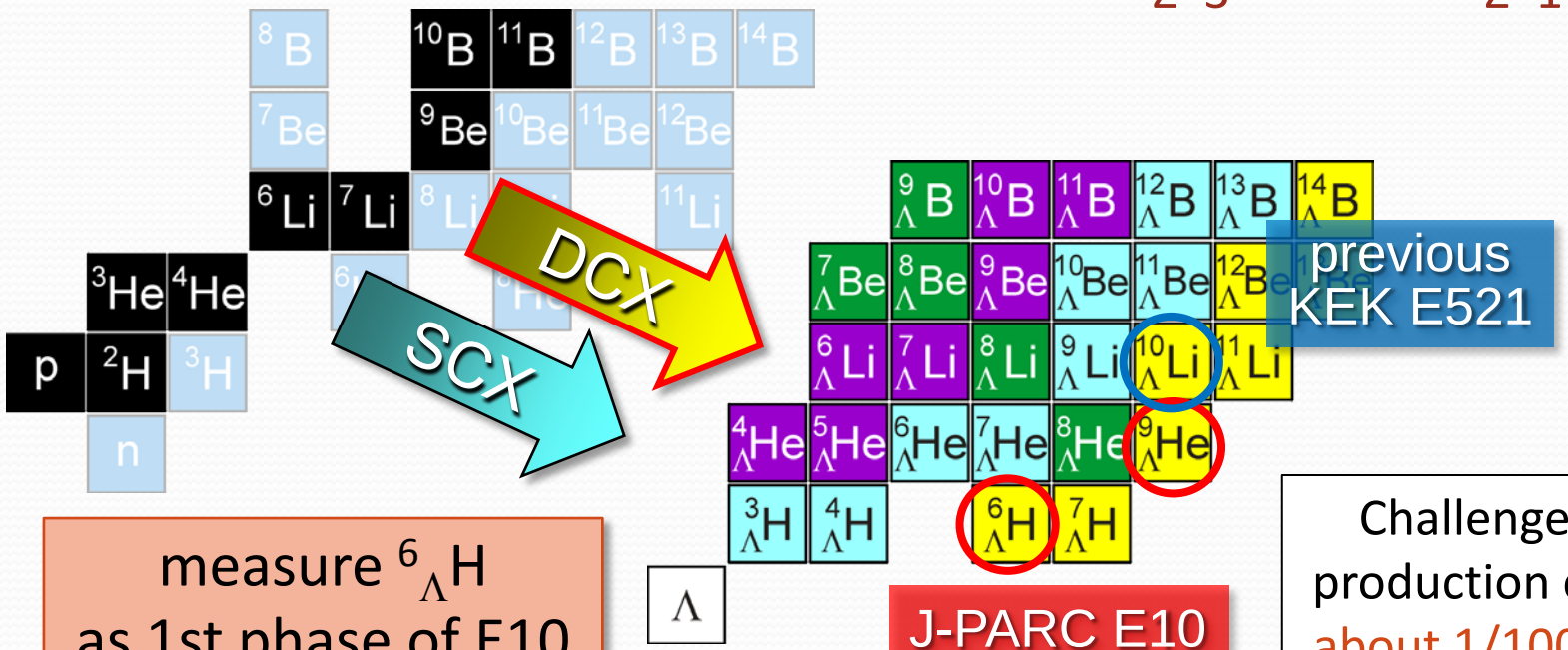
Method of production of n-rich Λ hypernuclei

- How to produce?
  - Use Double Charge-eXchange (DCX) reaction

$$\pi^- + p + p \rightarrow K^+ + \Lambda + n$$

$$^{6}Li\left(\pi^-, K^+\right)\,^{6}_{\Lambda}H$$

Z=3 Z=1



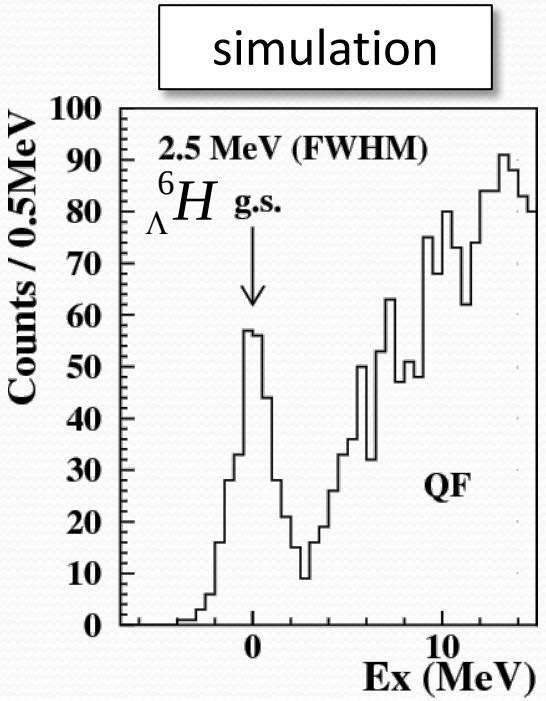
measure $^{6}_{\Lambda}$H as 1st phase of E10

Challenge is the tiny production cross section about 1/1000 of Non-CX

E10 run plan written in proposal

- High intensity pion beams are necessary
  - to override the tiny production cross section
- 10M/spill pion beams, 3 weeks beamtime → 3T pions

Parameters	Values
Pion beam momentum	1.2 GeV/c
Pion beam intensity	10M/spill
Total number of pions (6 s acc. cycle)	3T pions
Target thickness (^{6}Li)	3.5 g/cm^2
DCX cross section (assumed)	10 nb/sr
SKS acceptance	100 msr
Spectrometer efficiency (due to K decay)	0.5
Analysis efficiency	0.5
Estimated $^6_\Lambda$H yield	265

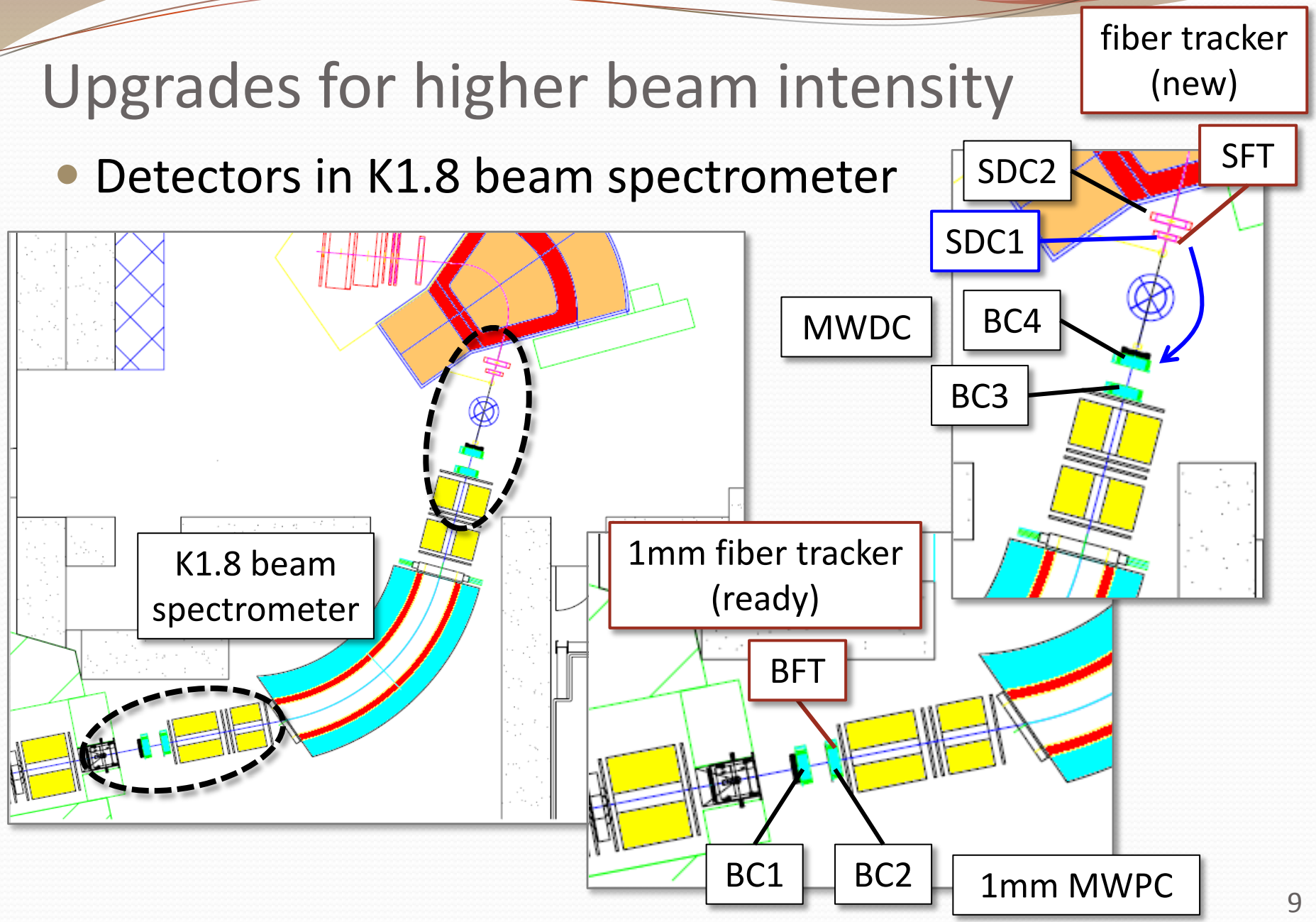


Practical problems and current status

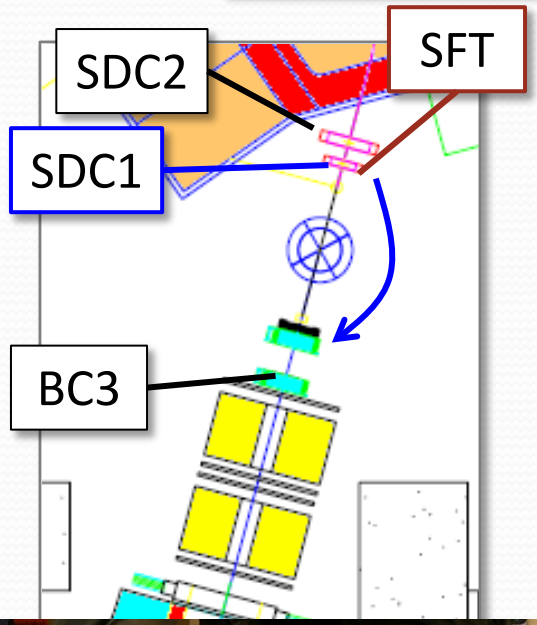
- Ripples of 50GeV PS magnet affect duty factor of SX
  - SX duty factor was 25-30% during beamtime in June
    - Instantaneous beam rate is 3-4 times larger than average
- Beam rate study in 2012 June beamtime
  - Confirmed tracking system was OK up to 7M/spill (reported in the last PAC meeting)
- Beam rate study in 2012 December beamtime
  - Several detector upgrades before the December beamtime (see next slide)
  - Beam rate studies done at 7, 8, 9, 10, 11 and 12M/spill
  - Production runs at 10M/spill (conservative choice)

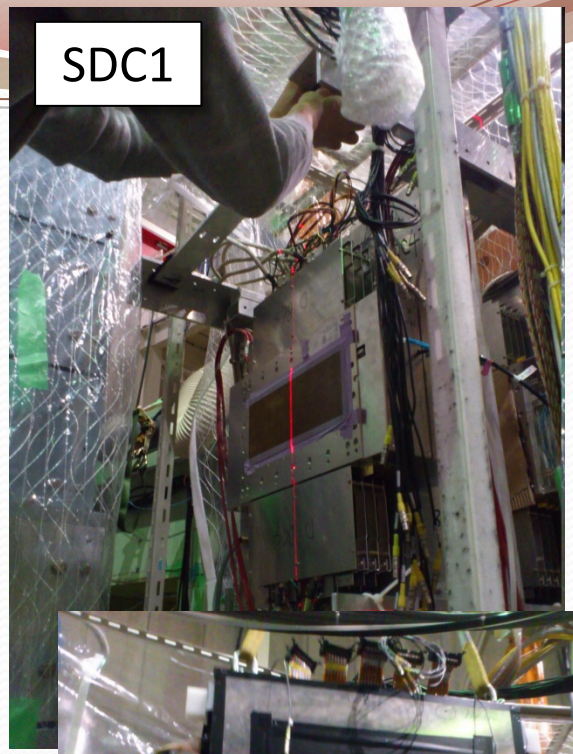
Upgrades for higher beam intensity

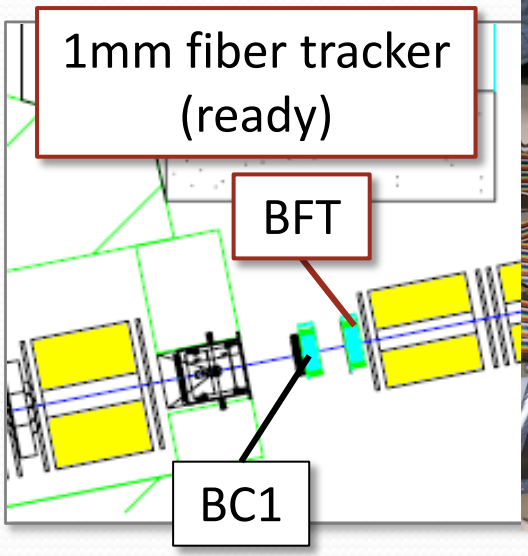
- Detectors in K1.8 beam spectrometer

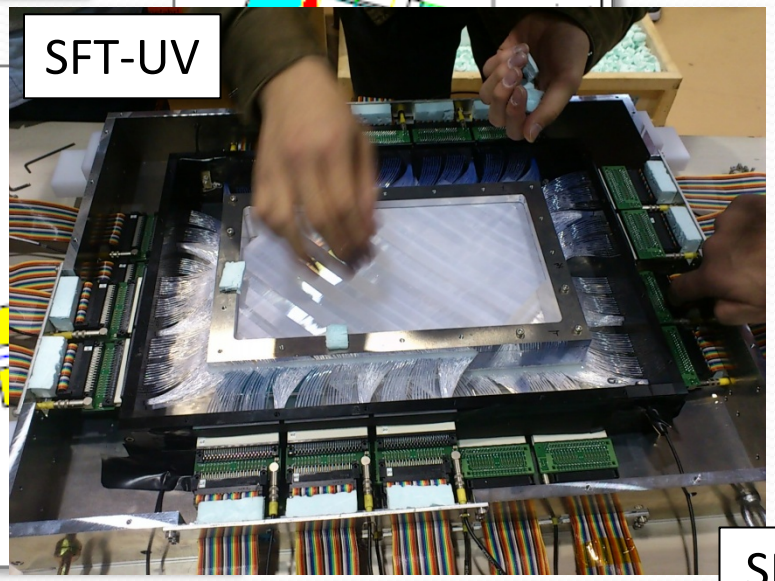


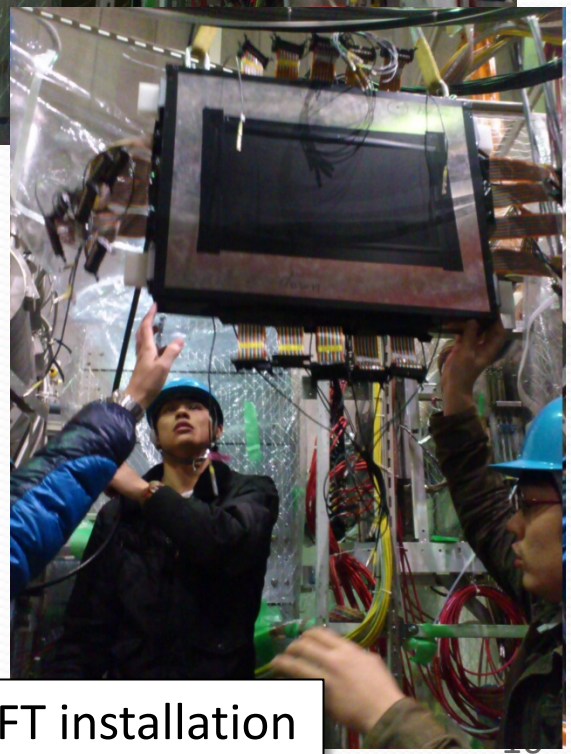
fiber tracker (new)







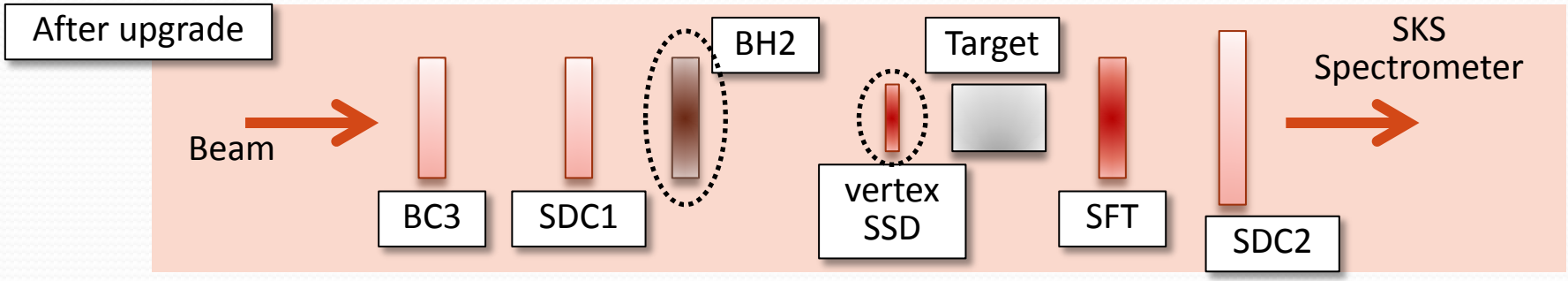




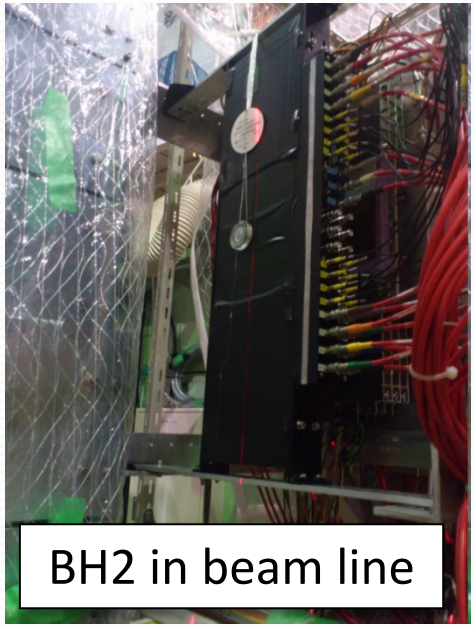
SFT installation

Upgrade of other detectors

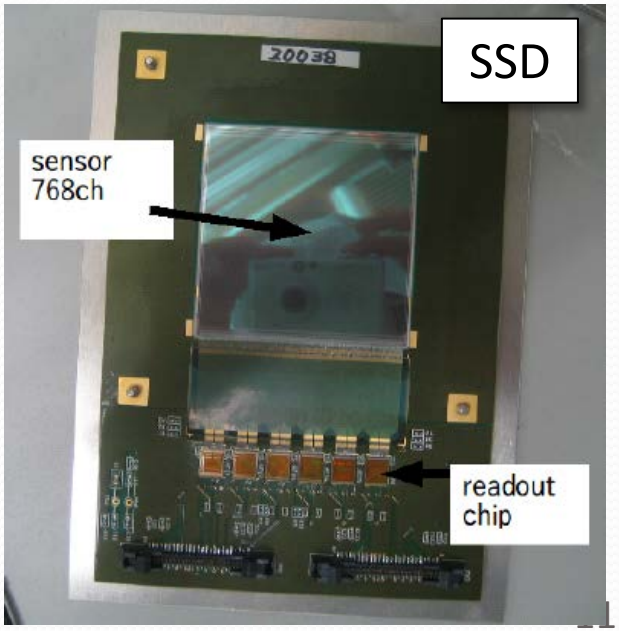
- New timing-counter BH2 and tracking SSD



BH2 inner frame

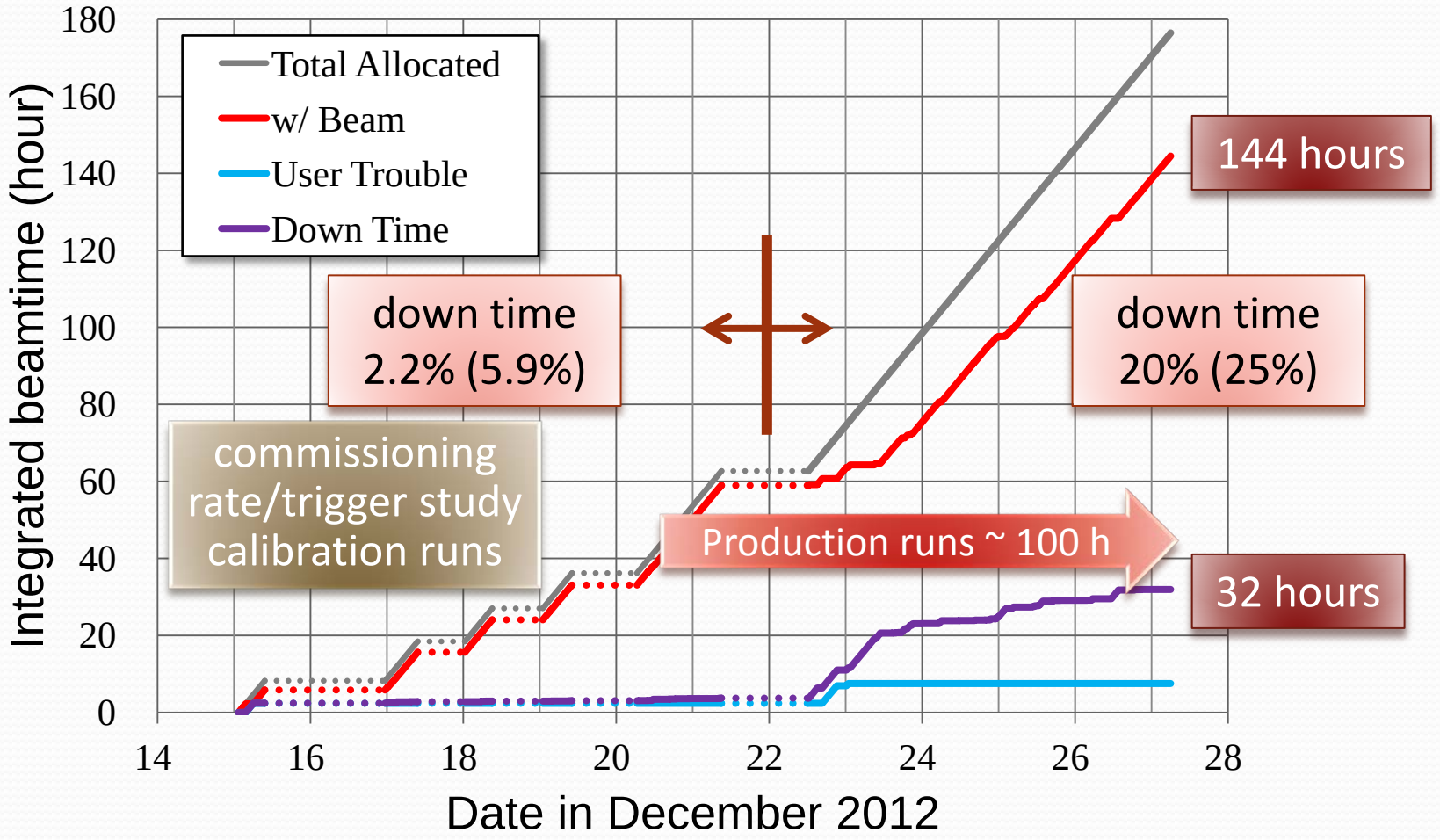


BH2 in beam line



Summary of 2012 December beamtime (1)

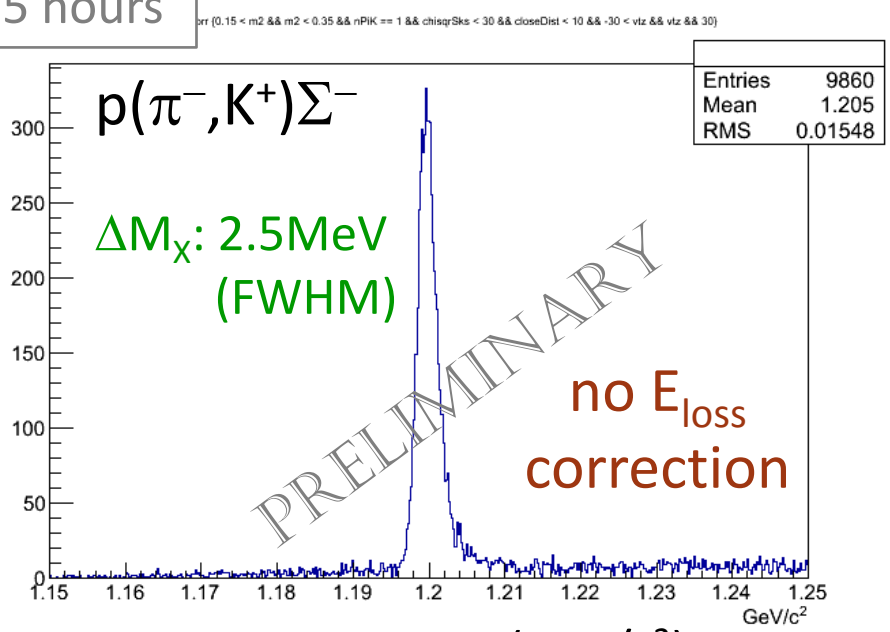
- Beamtime summary (from 15/Dec to 27/Dec)



Summary of 2012 December beamtime (2)

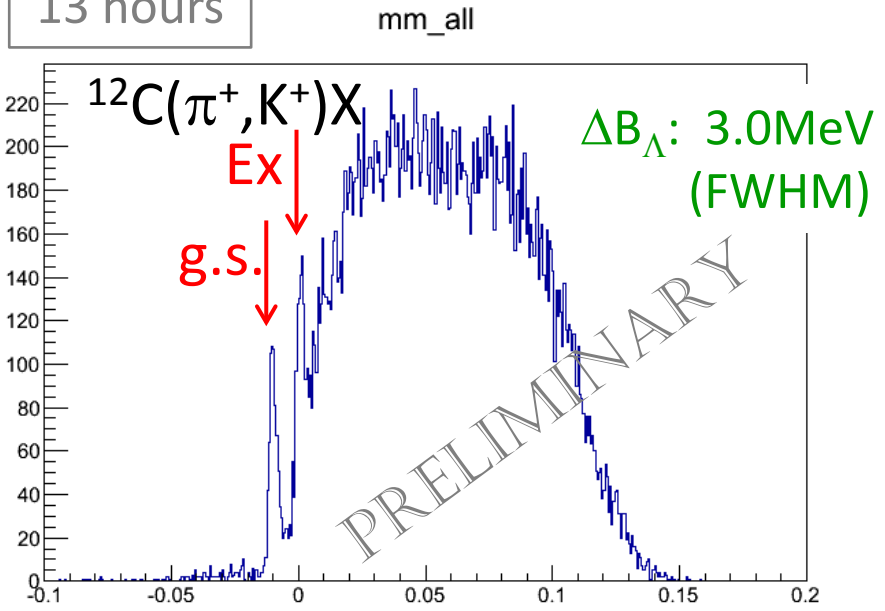
- Results of quick analyses of calibration runs
  - Σ^- production (energy scale)
  - $^{12}_{\Lambda}$C production (energy scale and resolution check)

5 hours



Missing Mass (GeV/c^2)

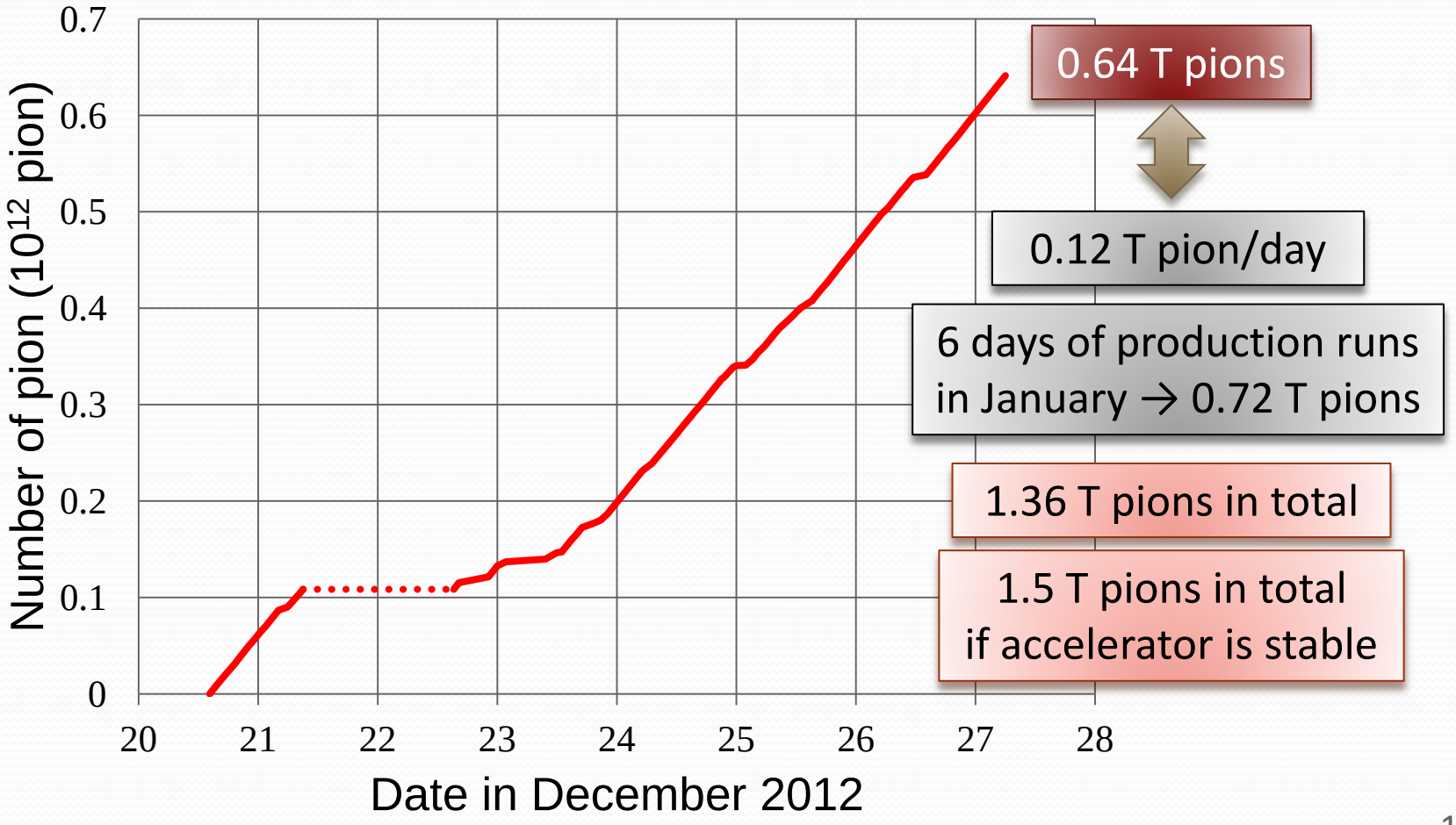
13 hours



Λ Binding Energy (GeV)

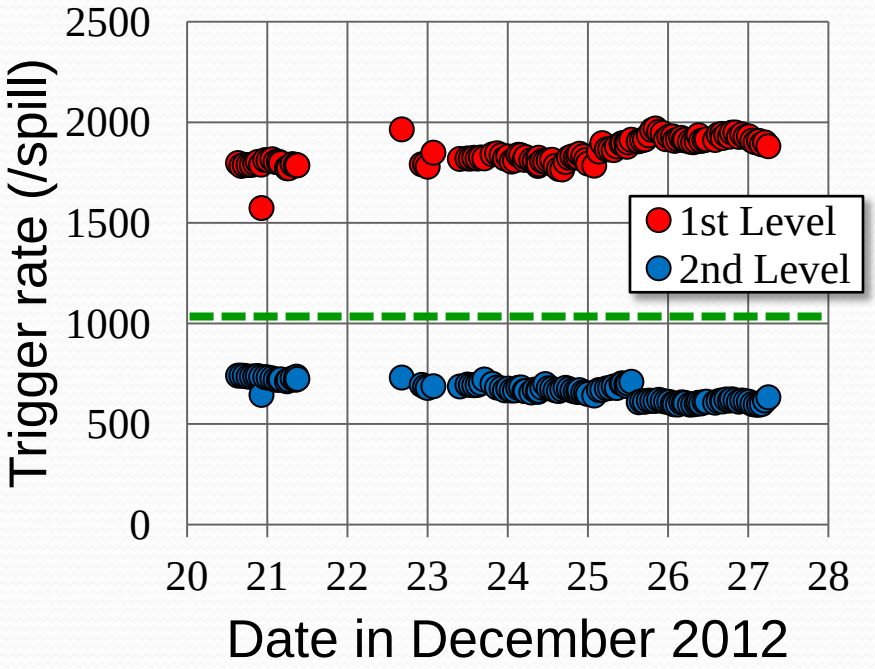
Summary of 2012 December beamtime (3)

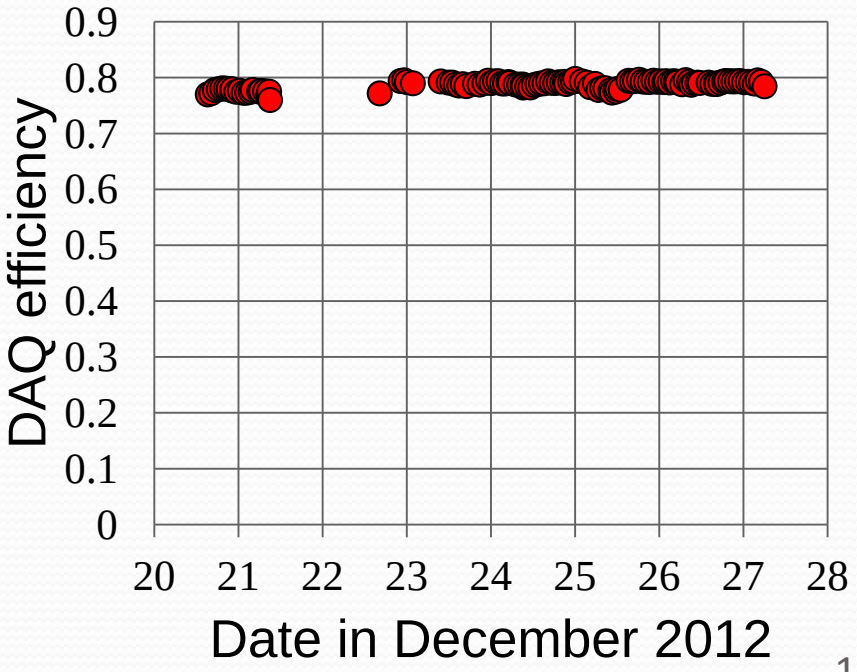
- Number of pion beams on target in production runs



Summary of 2012 December beamtime (4)

- Trigger rates and DAQ efficiency
  - 1st Level trig.: 1.8k/spill, 2nd Level trig.: 700/spill
    - Our goal of <1000/spill (2nd Level) was achieved
  - DAQ efficiency: 80%





Summary and prospects

- December beamtime done successfully, and we continue production runs in January.
  - Obtained 0.64 T pion beams on target in December
  - Prospect of total pion beams > 1.36 T pions
- We could run at 10M/spill beam intensity on target even at the low duty factor (about 30%?).
- Calibration runs were done successfully
  - Measured Σ^- and ${}^{12}_{\Lambda}\mathrm{C}$ production reactions
  - Energy resolution was about 3 MeV (FWHM)
- Analysis of ${}^{6}_{\Lambda}\mathrm{H}$ production data in Dec. is in progress
  - Λ QF production ~ 1400 events, Σ QF ~ 16k events